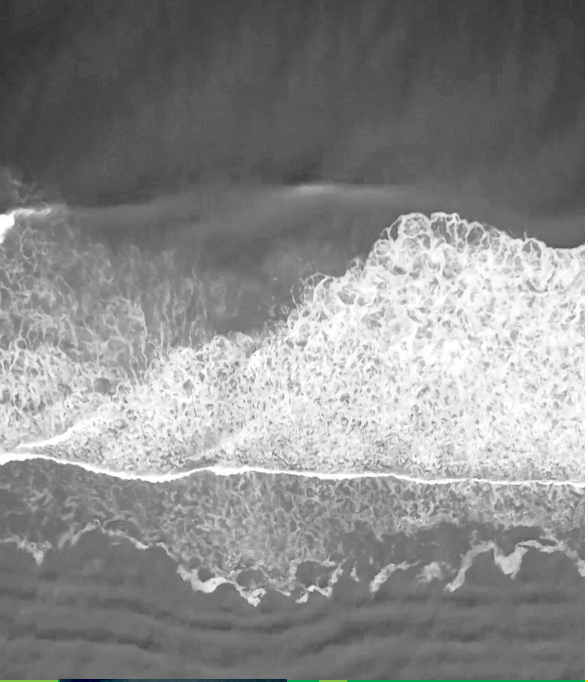


République Islamique de
Mauritanie

Honneur-Fraternité-Justice

Ministère de l'Environnement et du Développement Durable

Direction du Contrôle Environnemental

République du
Sénégal

Un peuple-Un but-Une foi

Ministère de l'Environnement et du Développement Durable

Direction de l'Environnement et des Établissements Classés

Greater Tortue / Ahmeyim Phase 1 Gas Production Project

Environmental and Social Impact Assessment

Consolidated Final Report Including Regulatory Reviews from Mauritania and Senegal

June 2019

Volume 4 of 7

bp

In partnership with

KOSMOS ENERGY

PETROSEN

SMHPM

ESIA report produced by

GOLDER

CSA Ocean Sciences Inc.

Ecodev

Environmental TROPICA Consultants

The report on the environmental and social impact assessment for the Greater Tortue/Ahmeyim Phase 1 Gas Production Project is divided into 7 volumes as follows:

Volume 1: The Non-Technical Summary, the list of Main Contributors to the ESIA, the Table of Contents, the list of Abbreviations and Acronyms, as well as Chapters 1 to 6

Volume 2: Chapter 7

Volume 3: Chapters 8 to 11 as well as the Bibliography and References

Volume 4: Appendices A to J

Volume 5: Appendices K to O

Volume 6: Appendices P to R

Volume 7: Appendices S to Y

The present document is **Volume 4** which contains:

- Appendix A - Terms of Reference of the ESIA approved by the Direction du Contrôle Environnemental (DCE) of Mauritania and the Direction de l'Environnement et des Établissements Classés (DEEC) of Senegal
- Appendix B - Technical Specifications of the Project's Infrastructure, Vessels, Helicopters and Other Equipment, and Support Documentation
- Appendix C - BP's Health, Safety, Security, Environmental & Operating Policy for Mauritania and Senegal
- Appendix D - Environmental Baseline Survey Report
- Appendix E - Fishery Resources, Fisheries and Fishing Communities Reports
- Appendix F - Notes on Protected Areas
- Appendix G - Biophysical Baseline Support Material
- Appendix H - Social Baseline Support Material
- Appendix I - Hydrodynamic (Coastal Erosion) Baseline Situation and Modeling Reports
- Appendix J - Air Emissions Modeling Report

APPENDIX A: TERMS OF REFERENCE OF THE ESIA APPROVED BY THE DIRECTION DU CONTRÔLE ENVIRONNEMENTAL (DCE) OF MAURITANIA AND THE DIRECTION DE L'ENVIRONNEMENT ET DES ÉTABLISSEMENTS CLASSÉS (DEEC) OF SENEGAL

Appendix A
Terms of Reference of the ESIA approved by the Direction du Contrôle Environnemental (DCE) of Mauritania and the Direction de l'Environnement et des Établissements Classés (DEEC) of Senegal

APPENDIX CONTENTS

Notes:

Terms of Reference (ToR) of the ESIA were initially submitted to the Ministry of Environment and Sustainable Development of Mauritania's *Direction du Contrôle Environnemental* (DCE) and to the Ministry of Environment and Sustainable Development of Senegal's *Direction de l'Environnement et des Établissements Classés* (DEEC) on May 24, 2016 by Kosmos[1].

The DEEC issued a letter of approval on the initial ToR on June 30, 2016, subject to the fact that the comments listed in its letter be taken into account in the ESIA preparation.

Revised ToR were prepared to meet the DCE's requirements and the document was submitted to both the DCE and the DEEC on October 19, 2016. The Revised ToR include two appendices: Appendix A – Provisional Schedules and Appendix B – List of the DEEC's requirements for the ESIA.

The DCE issued an approval letter for the Revised ToR on November 4, 2016.

[1] At that time, BP was not yet a co-venturer in the project.

APPENDIX A-1: REVISED TERMS OF REFERENCE (ToR) OF THE ESIA (IN FRENCH)

République Islamique de Mauritanie
****
Honneur-Fraternité-Justice
****
MINISTÈRE DE L'ENVIRONNEMENT ET DU DÉVELOPPEMENT DURABLE
****
Direction du Contrôle Environnemental

République du Sénégal
****
Un peuple-Un but-Une foi
****
MINISTÈRE DE L'ENVIRONNEMENT ET DU DÉVELOPPEMENT DURABLE
****
Direction de l'Environnement et des Établissements Classés

Projet Ahmeyim/Guembeul de production de gaz offshore en Mauritanie et au Sénégal

Termes de référence révisés de l'étude d'impact environnemental et social

Soumis par
Kosmos Energy Mauritania et Kosmos Energy Senegal

19 octobre 2016

TABLE DES MATIÈRES

LISTE DES TABLEAUX

LISTE DES FIGURES

LISTE DES CARTES

LISTE DES ANNEXES

Abréviations

AMP	Aire Marine Protégée
BGP	Biodiversité, Gaz et Pétrole
BPII	Bonnes pratiques internationales de l'industrie
bbl	Baril
CCLME	*Canary Current Large Marine Ecosystem*
CE	Commission Environnementale
CRODT	Centre de Recherches Océanographiques de Dakar-Thiaroye
DCE	Direction du Contrôle Environnemental
DEEC	Direction de l'Environnement et des Etablissements Classés
EIE	Étude d'impact environnemental
EIES	Étude d'impact environnemental et social
EIS	Étude d'impact social
FEED	*Front End Engineering and Design*
FID	Décision finale d'investissement (FID : *Final Investment Decision*)
FLNG	Navire de liquéfaction et d'entreposage flottant de gaz naturel (FLNG : *Floating Liquefied Natural Gas*)
FOI	Facteur à l'origine des impacts
FSO	Vaisseau d'entreposage et de déchargement flottant (FSO : *Floating Storage and Offloading*)
g	Gramme
GNL	Gaz naturel liquéfié
ha	Hectare
HASSMAR	Haute Autorité chargée de la Coordination de la Sécurité maritime, de la Sûreté maritime et de la Protection de l'Environnement marin
ICPE	Installation Classée pour l'Environnement
IMROP	Institut Mauritanien de Recherches Océanographiques et des Pêches
km	Kilomètre
LME	Grand écosystème marin (LME : *Large Marine Ecosystem*)
m	Mètre
MEG	Monoéthylène glycol
MMSCFD	Millions de pieds cubes standards par jour (MMSCFD : *Million Standard Cubic Feet per Day*)

ONG	Organisation non gouvernementale
ONISPA	Office d'Inspection Sanitaire des Produits de la Pêche et de l'Aquaculture
PAD	Port Autonome de Dakar
PGES	Plan de gestion environnementale et sociale
PIB	Produit intérieur brut
PETROSEN	Société des Pétroles du Sénégal
po	Pouce
PRCM	Programme Régional de Conservation Maritime
PRE-FEED	*Pre-Front End Engineering and Design*
SAPCO	Société d'Aménagement et de Promotion des Côtes et Zones Touristiques du Sénégal
SFI	Société Financière Internationale
SMHPM	Société Mauritanienne des Hydrocarbures et de Patrimoine Minier
SPS	Système de production sous-marin
TdR	Termes de référence
UICN	Union Internationale pour la Conservation de la Nature
WWF	*World Wild Fund*
ZEE	Zone économique exclusive
ZICO	Zone importante pour la conservation des oiseaux

1.0 Contexte

Kosmos Energy Mauritania et Kosmos Energy Senegal ont l'intention de mener un projet de production de gaz offshore[1], c'est-à-dire en mer.

L'objectif du projet est de produire du gaz naturel dont une portion sera exportée sous forme de gaz naturel liquéfié (GNL) et l'autre portion servira les marchés domestiques de la Mauritanie et du Sénégal. Le gaz naturel sera extrait en mer profonde à partir de réservoirs qui s'étendent des deux côtés de la frontière de la Mauritanie et du Sénégal. L'ensemble des infrastructures, tous les équipements et toutes les opérations nécessaires, en Mauritanie ou au Sénégal, feront partie d'un seul projet.

Un protocole d'entente, signé en 2016 par la Société Mauritanienne des Hydrocarbures et de Patrimoine Minier (SMHPM) et la Société des Pétroles du Sénégal (Petrosen), fournit les détails sur leur accord pour poursuivre ce projet commun de GNL.

Les ministères de tutelle de ce projet sont le Ministère du Pétrole, de l'Energie et des Mines de la Mauritanie et le Ministère de l'Energie et du Développement des Energies Renouvelables du Sénégal.

Étant donné qu'une étude d'impact environnemental et social (EIES) approfondie sera nécessaire pour le projet, Kosmos présente ci-dessous sa proposition de Termes de référence (TdR) pour l'EIES à la Direction du Contrôle Environnemental (DCE) du Ministère de l'Environnement et du Développement Durable de la Mauritanie et à la Direction de l'Environnement et des Etablissements Classés (DEEC) du ministère de l'Environnement et du Développement Durable du Sénégal.

Les TdR proposés tiennent compte des exigences environnementales des deux pays, notamment :

- En Mauritanie : les lignes directrices de l'Article 11 du Décret n° 2004-094, complété par le Décret n° 2007-105, précisant les exigences en matière de TdR pour les études d'impact sur l'environnement;
- Au Sénégal : les lignes directrices de l'Arrêté Ministériel n° 9471 MJHEP-DEEC du 28 novembre 2001 portant contenu des termes de référence des études d'impact.

2.0 Vue d'ensemble du promoteur et du projet

2.1 Promoteur du projet

En Mauritanie, le promoteur du projet est Kosmos Energy Mauritania et au Sénégal, le promoteur du projet est Kosmos Energy Senegal. Ces deux compagnies sont des filiales appartenant à 100 % à Kosmos Energy Operating (Kosmos).

Kosmos est une société internationale d'exploration et de production pétrolière et gazière. Son portefeuille d'actifs comprend sa production actuelle et d'importants projets en développement au large du Ghana, ainsi que des licences d'exploration pétrolière et gazière avec un potentiel

[1] Dans ce document, les promoteurs du projet, les pays et les localités sont généralement présentés en ordre alphabétique.

important d'hydrocarbures en mer au Maroc, en Mauritanie, au Portugal, au Sahara Occidental, à Sao Tomé et Principe, au Sénégal et au Surinam.

Le principal bureau d'opération de Kosmos est basé à Dallas (Texas), aux États-Unis. La société a été créée en 2003. Elle a découvert du pétrole dans le gisement Jubilee au large du Ghana, en 2007, et elle produit du pétrole dans ce pays depuis 2010.

En Mauritanie, Kosmos Energy Mauritania sera l'opérateur et détient jusqu'à 90 % des droits économiques du projet en vertu du Contrat d'Exploration-Production du bloc C8 signé avec la République Islamique de Mauritanie. Le partenaire de l'opérateur de Mauritanie est la SMHPM qui détient 10% (pouvant aller à 14 %) des intérêts économiques.

Au Sénégal, Kosmos Energy Senegal détient jusqu'à 60 % des droits économiques du projet, en vertu du Contrat de recherche et de partage de production d'hydrocarbures signé avec la République du Sénégal. Les autres partenaires sont Petrosen ayant jusqu'à 10 à 20 % des intérêts économiques et Timis Corporation Limited jusqu'à 30 %.

Les détails sur le promoteur du projet sont présentés dans le **tableau 1-1** ci-dessous.

Tableau 1-1 : Promoteur du projet

Nom officiel du projet	Projet Ahmeyim/Guembeul de production de gaz offshore en Mauritanie et au Sénégal
Nom officiel du promoteur	Kosmos Energy Mauritania et Kosmos Energy Senegal
Adresse du bureau principal du promoteur	Kosmos Energy Operating 8176 Park Lane Suite 500 Dallas, Texas 75231 Etats-Unis
Contact principal pour l'EIES	M. Gary Brooks Vice-Président, HSES Kosmos Energy, LLC Email : gbrooks@kosmosenergy.com Téléphone : +1-214-445-9748
Adresse du promoteur en Mauritanie	Immeuble El Emel ZRA N° 433 BP 5485, Tevragh Zeina, Nouakchott, Mauritanie
Chef de direction en Mauritanie	Mohamed Limam Country Manager Kosmos Energy Mauritania Email : mlimam@kosmosenergy.com Téléphone : +222 45 25 15 35
Adresse du promoteur au Sénégal	47, boulevard de la République 2e étage, Dakar, Sénégal
Chef de direction au Sénégal	Guillaume Defaux Country Manager Kosmos Energy Senegal Email : gdefaux@kosmosenergy.com Téléphone : +221 33 859 54 00

2.2 Description préliminaire du projet

2.2.1 Vue d'ensemble

Le projet comporte trois principales composantes:

- La **zone offshore** où se trouve le gisement de gaz et où se situeront les centres de forage;
- La **zone près des côtes** où seront localisées les installations de prétraitement du gaz et de fabrication de GNL; et
- La **zone de pipelines** où se trouveront les pipelines qui relieront la zone offshore à la zone près des côtes.

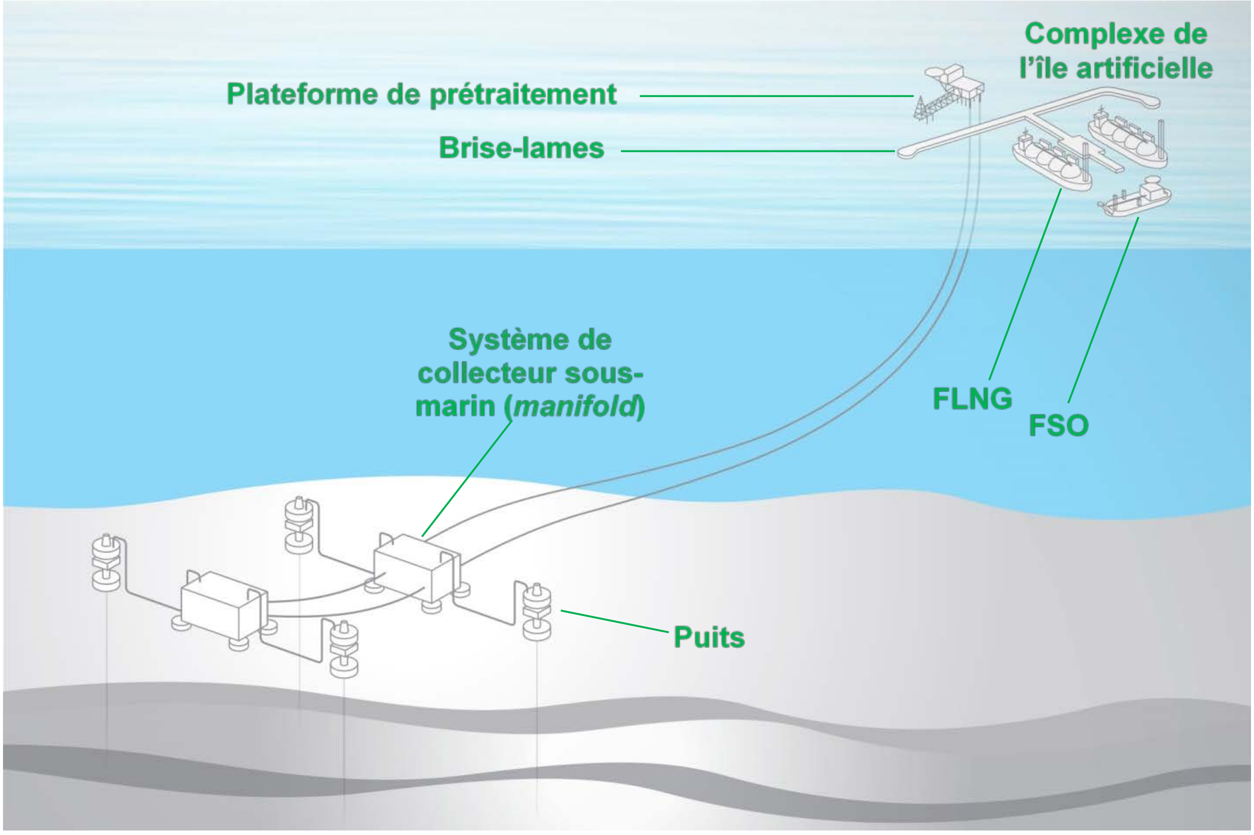
Le gisement offshore englobe la superficie des réservoirs du Cénomanien inférieur et de l'Albien situés à environ 125 kilomètres (km) au large des côtes à la frontière maritime de la Mauritanie et du Sénégal. Le gisement fait partie du bloc C8 de la Mauritanie et du bloc de Saint-Louis offshore profond du Sénégal. La profondeur de l'eau au niveau du gisement est d'environ 2 600 mètres (m). Il est prévu de mettre le gisement en production à travers 5 centres de forage, reliés dans le fond marin par un système double de pipelines de 20 pouces (po)[2]. Ceux-ci seraient ensuite reliés à une installation en mer à une profondeur d'eau de 20 m localisée à environ 8 km au large des côtes (voir la **figure 2-1**). De plus, une conduite d'amenée de 4 po sera incluse dans la zone de pipelines pour fournir le monoéthylène glycol (MEG) servant à traiter le gaz produit afin d'éviter les dépôts d'hydrates dans les pipelines.

Les installations dans la zone près des côtes comprendront un centre de prétraitement de gaz sur une plateforme offshore typique montée sur une armature en acier (plateforme de prétraitement). L'installation de prétraitement du gaz séparera et stabilisera le condensat à partir du flux de puits et conditionnera le gaz pour la liquéfaction. Le gaz et le condensat seront ensuite canalisés séparément vers un complexe constitué d'une île artificielle et de son brise-lames également situé dans la zone près des côtes. L'emplacement de l'infrastructure illustrée à la **figure 2-1** est basé sur la conception au niveau pré-faisabilité. L'emplacement exact de l'infrastructure et la justification de son emplacement seront fournis dans la section Description du projet du rapport d'EIES.

L'installation de prétraitement de gaz sera réalisée en prévoyant deux gazoducs pour le gaz domestique; l'un pour la Mauritanie, et l'autre pour le Sénégal. La conception de ces gazoducs et leurs tracés ne sont pas inclus dans le cadre du projet. Selon les directives des Ministères de l'Énergie de la Mauritanie et du Sénégal, les pipelines nationaux ne font pas partie du projet de Kosmos. Les pipelines nationaux seront évalués dans des EIES distinctes.

[2] 1 pouce correspond à 2,54 centimètres.

Figure 2-1 : Illustration conceptuelle du projet



Le complexe de l'île artificielle comprendra des postes d'amarrage pour deux navires de liquéfaction et d'entreposage flottants de gaz naturel (FLNG), un vaisseau d'entreposage et de déchargement flottant (FSO) pour l'entreposage et le prélèvement de condensat stabilisé, un quai pour petits navires, et un poste d'amarrage de méthanier pour l'exportation de cargaisons. Une illustration conceptuelle du complexe de l'île artificielle dans la zone près des côtes est présentée à la **figure 2-2**. D'autres études préciseront la conception du site, au besoin, afin de maximiser l'efficacité opérationnelle et minimiser les impacts potentiels sur la sécurité et l'environnement. Les navires n'ont pas encore été sélectionnés, mais leurs spécifications seront fournies dans le rapport d'EIES.

Le condensat sera stocké sur le FSO, puis exporté par déchargement de navire à navire vers un navire-citerne. Le complexe de l'île artificielle comprendra des canalisations et des passerelles entre les navires pour faciliter le transfert des flux de productions et du personnel et pour soutenir les opérations d'exportation de GNL. Le complexe de l'île artificielle et tous les vaisseaux qui y seront amarrés seront à l'abri des vagues grâce à un système de brise-lames.

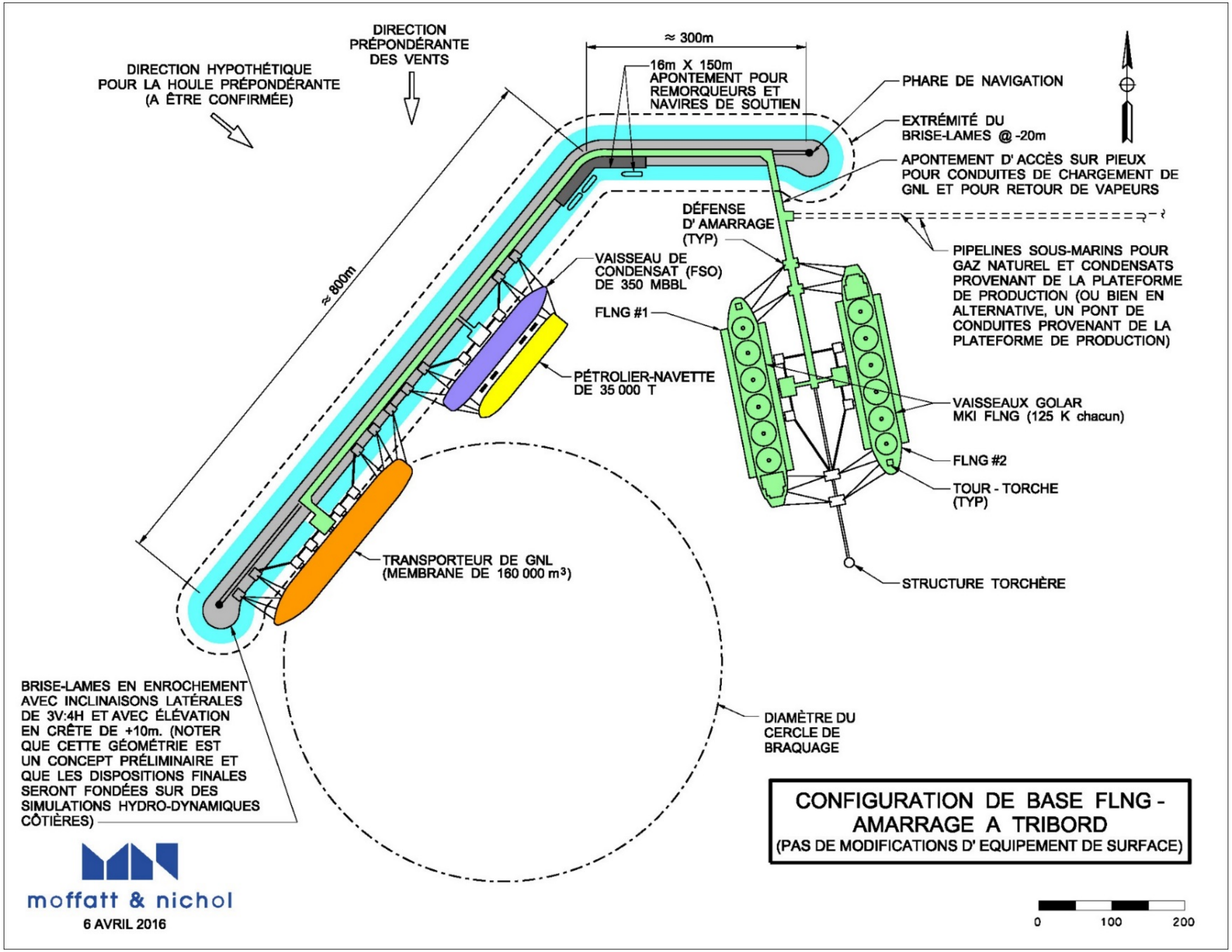
Il est prévu que toutes les installations et tous les systèmes fonctionnent pendant 30 ans. La production initiale prévue en 2020 est de 470 millions de pieds cubes standards par jour[3] (*Million Standard Cubic Feet per Day*, MMSCFD), augmentant à 870 MMSCFD en 2022.

---

[3] Unité de mesure de gaz : 1 million de pieds cubes standards par jour à 15°C équivaut à 1 177,77 m^3/heure.

KOSMOS ENERGY

Figure 2-2 : Illustration conceptuelle de l'île artificielle



2.2.2 Préparation/construction/installation

Zone offshore

Il est prévu que le système de production sous-marin (SPS) soit installé par plusieurs navires d'installation. Le système inclura jusqu'à 20 puits, dont 4 à 5 qui seront initialement prévus pour la première phase de production de gaz. Des puits supplémentaires seront ajoutés par étape selon la performance du ou des réservoir(s). Le système comprendra des têtes de puits, des conduites de raccordements, des collecteurs et des lignes d'écoulement sous-marins reliant ensemble jusqu'à cinq centres de forage, dans un arrangement en boucle, afin de faciliter le raclage de conduites en cas de nécessité. Les commandes de puits et les lignes d'injection de produits chimiques seront acheminées au niveau du gisement à l'aide d'un ombilical lié à la plateforme de traitement du gaz. Le MEG sera acheminé au niveau du gisement par un pipeline de petit diamètre. Les commandes et l'injection de produits chimiques, y compris du MEG, seront distribuées entre les centres de forage par des ombilicaux et des raccords flexibles. La production initiale pourrait provenir des puits d'exploration et d'évaluation qui ont déjà été forés en 2015 et 2016. Jusqu'à 60 jours seront nécessaires pour reprendre les opérations au niveau de ces puits, les tester et compléter les forages. Il est prévu que les nouveaux puits nécessitent jusqu'à 120 jours pour le forage, les tests et la finalisation. Le temps d'installation totale du SPS pour la première phase de production de gaz est estimé entre 8 et 10 mois.

Zone de pipelines

La pose des pipelines sous-marins nécessitera plusieurs navires d'installation. Pour l'instant, il est prévu qu'un navire de pose verticale (*J-Lay*) soit utilisé pour installer les pipelines à partir de l'emplacement du gisement en eau profonde jusqu'à 200 m de profondeur d'eau. Ensuite, un navire de pose horizontale (*S-Lay*) installera les pipelines restants, de 200 m à environ 20 m, pour aboutir ainsi au niveau de l'installation de prétraitement de gaz. Les fluides provenant des puits seront transférés à l'installation de prétraitement de gaz à travers des conduites standards à partir du fond marin vers le pont de traitement. L'installation des pipelines et la période de mise en service sont estimées entre 9 et 11 mois si les conditions météorologiques le permettent.

Zone près des côtes

L'installation de la plateforme de prétraitement du gaz nécessitera probablement un seul navire de levage gros porteur. Ce navire sera utilisé pour la pose des pieux afin de soutenir les fondations de l'armature en acier immergée (*jacket*) et d'installer l'armature immergée et les structures en surface (*topsides*). Il est prévu que l'armature en acier immergée et les structures en surface soient amenées sur le site par des barges. La fabrication de l'armature en acier immergée est estimée entre 9 et 12 mois, et les structures en surface devraient être fabriquées entre 18 et 24 mois. Trois à quatre navires de soutien, incluant des navires de soutien général et des remorqueurs, seront probablement sur place lors de l'installation. L'installation sur site est censée nécessiter de 6 à 9 mois.

Le complexe de l'île artificielle et du brise-lames nécessitera également le soutien d'une importante flotte de navires lors de son installation. L'île artificielle nécessitera le soutien d'un navire de construction lourde afin d'enfoncer les pieux de fondation et pour la construction du brise-lames. Pour le moment, il est envisagé que le brise-lames soit une digue à talus ou alors une conception en caissons. Les deux options nécessiteront une quantité importante de matériaux, de type roche de carrière, provenant des pays d'accueil. S'il y a suffisamment de capacité de carrière disponible, la roche de carrière sera extraite à terre et transportée par camion ou par train à un chantier de construction sur la côte. Selon la disponibilité de la ressource de roche, cette opération peut nécessiter deux ans ou plus. La roche sera alors chargée sur deux ou plusieurs barges de transport de matériaux, puis transférée de la côte à l'emplacement du brise-lames, pour être déposée sur le fond marin selon l'option de la digue à talus, ou pour remplir des caissons à brise-lames. L'opération de transfert de roche par barges sera probablement mise en œuvre en continu pendant 12 à 18 mois pour l'installation du brise-lames. En plus de la roche de carrière, il est également prévu d'utiliser des blocs de béton armé pour le brise-lames. Les blocs de béton armé pourront être fabriqués localement à terre, possiblement au niveau d'un chantier de construction sur la côte, et ils seront ensuite chargés sur des barges pour leur transfert vers l'emplacement du brise-lames.

Le brise-lames nécessitera une préparation du fond marin, une fondation faite de roches de carrière. Le navire de construction lourde sera également utilisé pour installer la tuyauterie, les passerelles, et d'autres composantes du complexe de l'île artificielle et du brise-lames. Le navire de levage gros porteur, utilisé pour l'installation du SPS, pourrait être mobilisé aux installations de la zone près des côtes, après que le SPS soit installé, avec deux barges de construction lourde travaillant en tandem au site de la zone près des côtes.

L'installation des deux navires de GNL flottants (FLNG) et du FSO de stockage de condensats nécessitera des opérations de moindre envergure. Ces navires navigueront au site avec toutes les structures de surface et leurs équipements déjà en place. L'installation requerra de tracter les FLNG et le FSO aux côtés de l'île artificielle, avec l'assistance de deux à trois remorqueurs. Une fois aux côtés de l'île artificielle, les lignes d'amarrage et la tuyauterie de connexion seront déployées entre l'île artificielle et les navires. L'amarrage et la tuyauterie devraient nécessiter un temps d'installation de l'ordre de quatre à huit semaines par navire.

2.2.3 Opérations

Zone offshore

Des puits supplémentaires seront forés et complétés puis ajoutés au système SPS. Le système initialement installé sera conçu pour être perturbé le moins possible lorsque les puits supplémentaires seront connectés au réseau. Par conséquent, la portée des travaux additionnels, en sus du forage et de l'achèvement des puits, sera d'installer des conduites de raccordement des têtes de puits aux collecteurs et des ombilicaux pour les commandes et l'injection de produits chimiques. La durée estimée pour forer et compléter un puits est de 120 jours, incluant 10 jours pour installer les conduites de raccordement et les ombilicaux.

Au cours des phases initiales de développement, un programme d'entretien des puits (workover), si nécessaire, serait prévu en coordination avec d'autres activités de forage et d'achèvement de puits. Si l'entretien des puits s'avérait nécessaire au-delà de la phase initiale de développement, il serait effectué en utilisant des navires semblables à la plateforme de forage et peut-être un navire à positionnement dynamique de service de puits. Les services de soutien entraîneraient l'utilisation de navires opérationnels existants, de navires offshores supplémentaires et d'hélicoptères, selon la nature des travaux de puits.

Si nécessaire, une plateforme de forage en eaux profondes peut être utilisée pour intervenir sur les puits. Selon la nature de l'opération menée pour remédier à un problème, la plateforme pourrait être sur place, pour accéder à un puits, entre 20 et 90 jours.

Zone de pipelines

Potentiellement, des opérations de raclage pourraient être effectuées périodiquement, soit environ une fois tous les cinq ans, afin de nettoyer et d'inspecter les pipelines. Le cochon (instrument de raclage) sera placé dans l'un des pipelines et lancé à partir de l'installation de prétraitement de gaz jusqu'à l'emplacement des puits en eau profonde d'où il sera ensuite acheminé à travers l'autre pipeline pour revenir vers l'installation de prétraitement de gaz. Le volume de dépôts raclés par le cochon sera atténué au moyen de la séparation des gaz au niveau de l'installation de prétraitement, combinée à l'entreposage temporaire des fluides sur le FSO. Les fluides collectés seront traités dans les installations de traitement. Tout solide résiduel ou impureté retiré des pipelines sera traité selon les réglementations, les Bonnes pratiques internationales de l'industrie (BPII) et les normes en vigueur. Aucun navire supplémentaire n'est prévu pour les opérations de raclage.

Zone près des côtes

Il est prévu que la mise en service de l'installation de prétraitement de gaz nécessitera de 3 à 6 mois.

La pré-mise en service du FSO devrait être terminée avant son arrivée sur le site et être finalisée une fois amarré et la tuyauterie connectée. La connectivité de la tuyauterie à l'île artificielle sera testée au démarrage de l'installation. La mise en service des installations de tuyauterie de la zone près des côtes est censée prendre 3 mois pour le raccordement et la mise en service.

Les opérations de soutien en continu pour les deux navires de FLNG, le FSO, et l'installation de prétraitement de gaz nécessiteront des opérations typiques des installations offshores. Cela inclut des rotations régulières de navires d'approvisionnement en équipements et de transfert d'équipage. Les principaux transferts d'équipage sont seront effectués avec des navires d'équipage mobilisés à partir de Dakar ou de Nouakchott. Il y aura également une héliplateforme pour le transfert aérien du personnel selon les besoins, avec des vols prévus à partir de Nouakchott ou Rosso en Mauritanie et de Dakar ou Saint-Louis au Sénégal.

Trois remorqueurs devraient être basés à l'île artificielle au niveau d'un quai pour petits navires, afin d'être disponibles sur demande pour les opérations de soutien. Deux remorqueurs seraient utilisés pour les opérations normales pour aider à l'arrivée et au départ du méthanier ou des navires-citernes de condensat. Le méthanier devrait avoir une capacité de transport de cargaison comprise entre 160 000 m^3 et 180 000 m^3, et un port en lourd d'environ 100 000 tonnes. Les exportations de GNL devraient se faire à peu près tous les sept jours au taux de production maximal. Les navires-citernes de condensat seront attendus tous les 20 à 25 jours et ils déchargeront environ 325 000 barils (bbl) de condensat. Le port en lourd des navires-citernes de condensat est prévu d'être d'environ 50 000 tonnes.

Les opérations et la logistique à terre devraient être exécutées à partir des ports de Dakar ou de Nouakchott.

2.2.4 Fermeture

Zone offshore

La mise hors service du SPS sera faite selon les BPII et les normes au moment de l'abandon. Les puits seront colmatés et scellés selon les BPII et les normes d'abandon de puits en vigueur au moment de l'abandon. Si les BPII et les normes au moment de l'abandon le permettent, toutes les conduites sous-marines seront vidées de leurs hydrocarbures et abandonnées sur place avec leurs extrémités enterrées.

Zone de pipelines

La mise hors service des pipelines sera faite selon les BPII et les normes au moment de l'abandon. Les pipelines seront raclés et vidés de leurs hydrocarbures avant d'être abandonnés sur place avec leurs extrémités scellées et enterrées, si les BPII et les normes au moment de l'abandon le permettent.

Zone près des côtes

La mise hors service des installations près des côtes prendra de multiples formes selon les BPII et les normes en vigueur au moment de l'abandon. Les structures en surface des navires seront nettoyées de leurs hydrocarbures et coupées de leurs connexions à l'armature en acier immergée pour être démantelées et éliminées dans une installation à terre. Si les BPII et les normes au moment de l'abandon le permettent, l'armature en acier immergée pourrait être sectionnée au niveau du fond marin et laissée sur place, considérant qu'il est anticipé qu'une croissance marine significative aura eu lieu à la fin de vie du gisement et cela bénéficiera à la vie du milieu marin.

Les FLNG et le FSO seront remorqués du site vers un chantier de récupération pour être éventuellement démantelés. Tous les hydrocarbures et toutes les matières dangereuses seront retirés de l'île artificielle et du brise-lames, afin d'éviter la contamination de l'environnement. La tuyauterie, les systèmes d'éclairage et d'autres matériaux seront retirés du site. Des bouées marines de signalisation de danger seront déployées sur le site afin de marquer l'emplacement du complexe de l'île artificielle et de brise-lames lors de leur abandon.

2.3 Localisation du projet

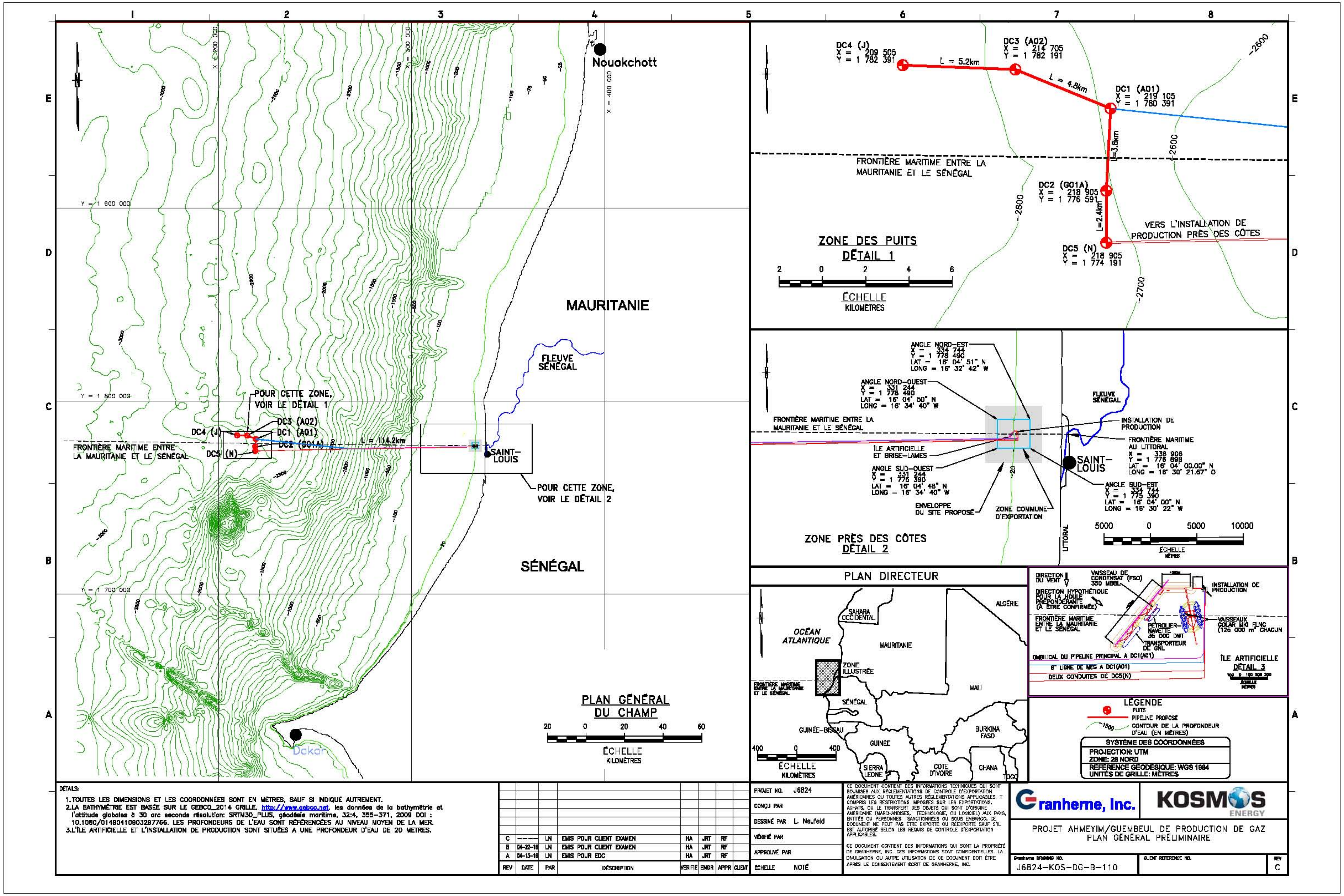
La localisation proposée du projet se situe en mer, de part et d'autre de la frontière Mauritanie-Sénégal, tel qu'illustré à la **carte 2-1**. Des sites alternatifs pour la localisation du projet seront présentés, si nécessaire, dans la section Alternatives du projet du rapport d'EIES.

Les conduites sous-marines entre les puits et la plateforme de prétraitement mesureront environ 115 km. La plateforme de prétraitement et le complexe de l'île artificielle seront situés à approximativement 8 km des côtes dans l'aire du site indiquée.

La localisation proposée pour le site de projet a été identifiée en fonction des conditions météorologiques et océanographiques favorables, la proximité des infrastructures et des futurs points de livraison du gaz domestique en Mauritanie et au Sénégal. Le site proposé répond également aux besoins d'une zone d'exportation commune aux deux pays.

Des alternatives de localisation de site dans la zone près des côtes seront évaluées, si nécessaire, sur la base de l'EIES.

Carte 2-1 : Carte de localisation du projet



2.4 Calendrier et durée prévus du projet

Les activités de forage d'évaluation et d'études préliminaires d'ingénierie d'avant-projet (PRE-FEED : *Pre-Front End Engineering and Design*) ont commencé au quatrième trimestre de 2015 et se poursuivront avec d'autres activités de la phase de préparation jusqu'à la décision finale d'investissement (FID : *Final Investment Decision*) prévue à la fin de 2017. La finalisation des études PRE-FEED est prévue au mois de juin 2016. La phase suivante d'ingénierie, la FEED, va alors commencer et se poursuivre jusqu'à la FID. Les travaux au cours de cette période exigeront des études spécifiques au niveau du site, incluant une collecte d'échantillons de sol de la zone près des côtes et une analyse de la stabilité, une collecte de données météorologiques et océanographiques, un relevé bathymétrique détaillé de portions des zones offshore, de pipelines et près des côtes, ainsi que toute étude de référence environnementale requise. La fabrication, l'installation et la mise en service de toutes les infrastructures décrites auront lieu au cours des 36 prochains mois afin d'avoir la première livraison de gaz sur le marché intérieur et l'exportation de GNL en 2020.

Un calendrier préliminaire du projet figure à l'**annexe A-1**.

3.0 Description préliminaire de l'environnement

3.1 Zone d'étude préliminaire

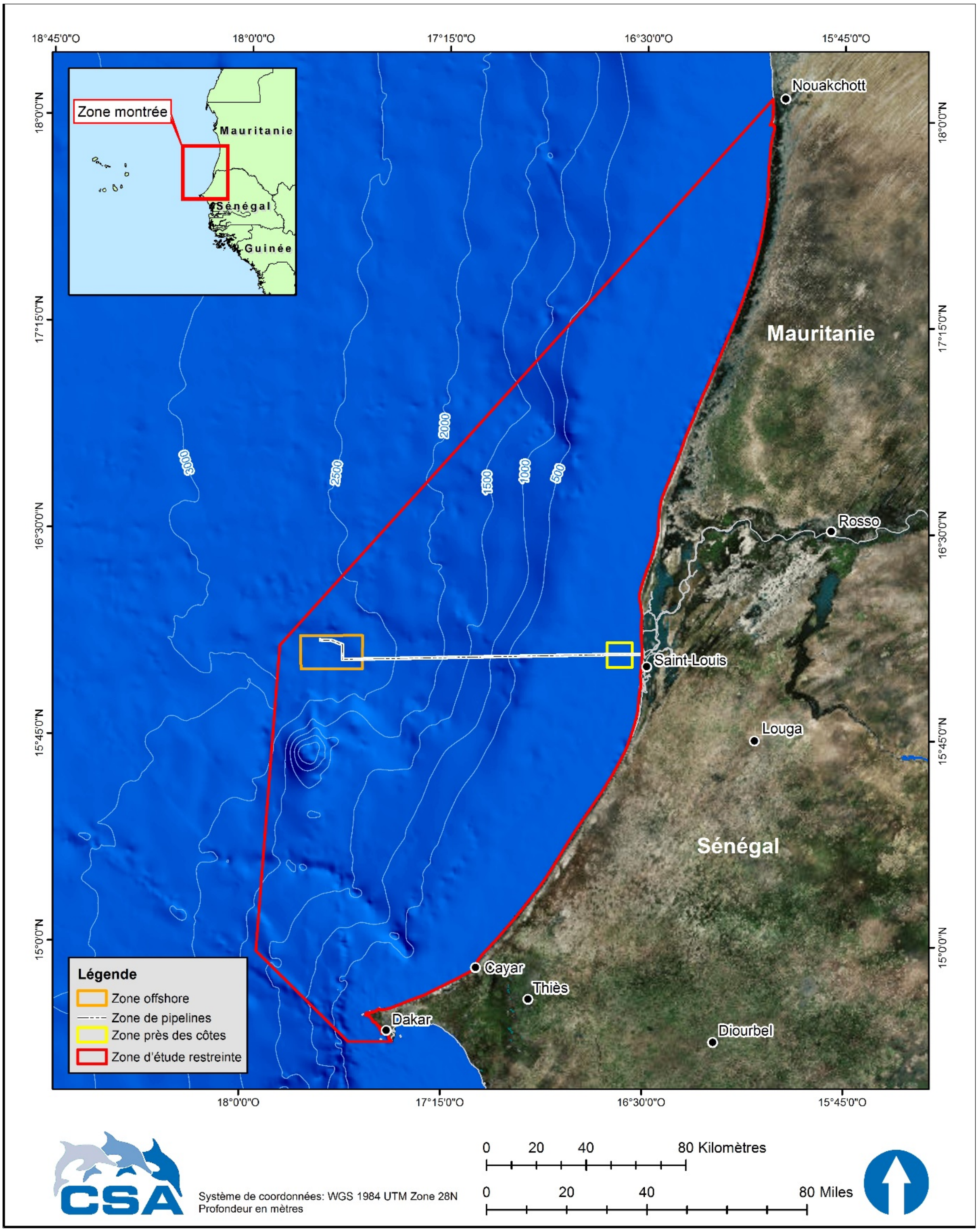
La zone d'étude préliminaire a été déterminée de sorte à inclure à l'avance tous les secteurs susceptibles d'être affectés par le projet. La zone d'étude préliminaire comprend :

- Une zone d'étude restreinte applicable aux activités de routine du projet et leurs impacts potentiels. La zone d'étude restreinte inclura les infrastructures et les opérations prévues dans la zone offshore, la zone de pipelines, la zone près des côtes et toute zone terrestre utilisée pour les activités de soutien au projet, pendant toutes les phases : la phase de préparation (installation), la phase des opérations et la phase de fermeture. La zone d'étude restreinte s'étendra de Nouakchott en Mauritanie à Dakar au Sénégal (voir la **carte 3-1**); et
- Une zone d'étude élargie établie pour les impacts d'accidents imprévus qui pourraient potentiellement survenir. La zone d'étude élargie inclut la zone d'étude restreinte et se prolonge le long de la côte de Nouakchott en Mauritanie à la frontière entre le Sénégal et la Guinée-Bissau (voir la **carte 3-2**).

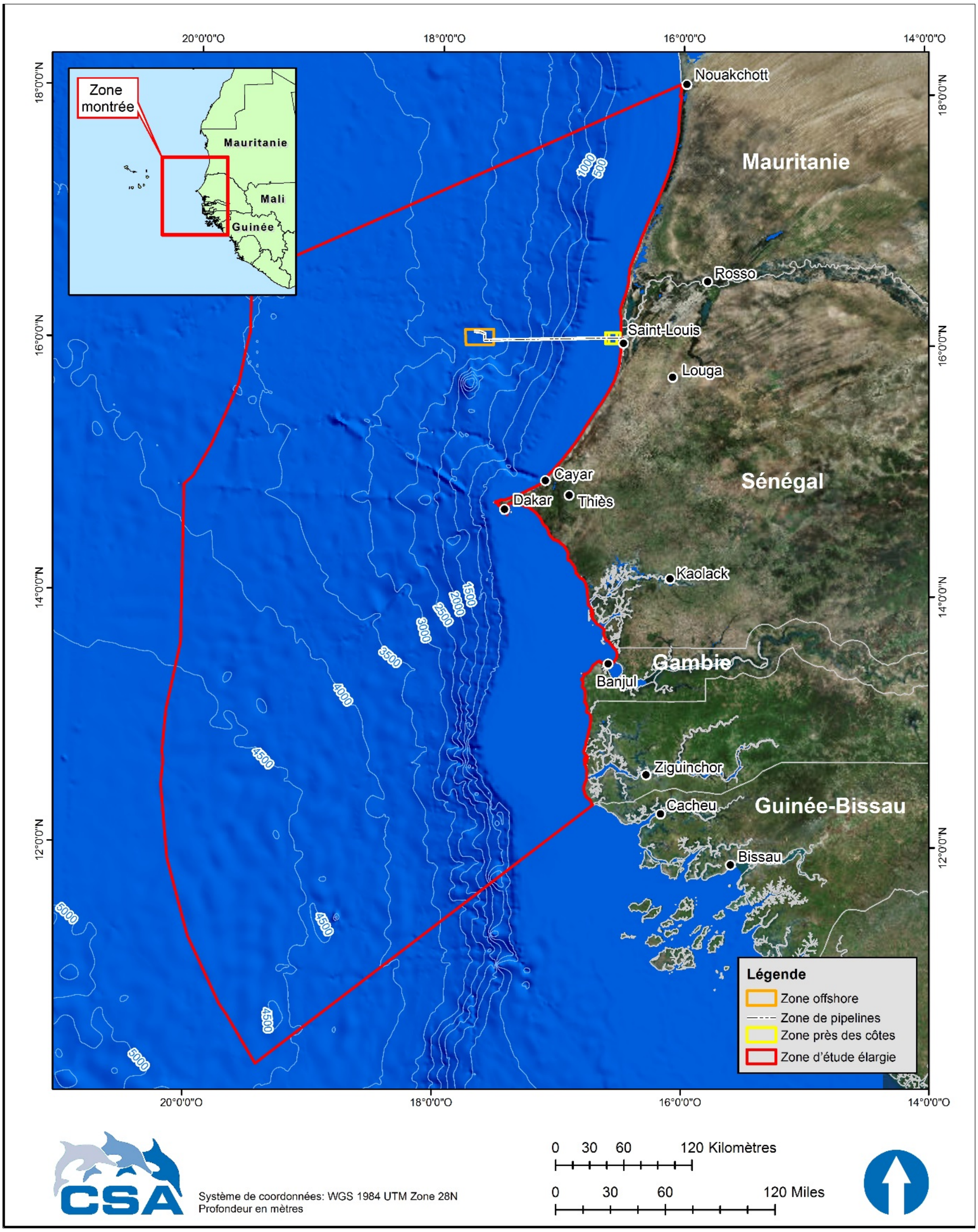
Le milieu biophysique de la zone d'étude préliminaire inclut le plateau continental et sa pente au large de la Mauritanie et du Sénégal. Les principales composantes, les caractéristiques environnementales importantes et les zones côtières protégées sont décrites ci-dessous. Le milieu social de la zone d'étude préliminaire comprend la zone côtière, les eaux du littoral et les eaux au large des côtes de la Mauritanie et du Sénégal, s'étendant entre Nouakchott et la frontière du Sénégal avec la Guinée-Bissau.

Les caractéristiques biophysiques et socio-économiques pour la Mauritanie ont été résumées principalement à partir des données de RPS Energy (2014 ; 2016) et les caractéristiques biophysiques et socio-économiques pour le Sénégal ont été résumées principalement à partir des données de CSA Ocean Sciences, Golder Associés et Tropica Environmental Consultants (2015), avec certaines sources additionnelles telles qu'indiquées. Les références complètes des documents et des études cités sont présentées à la **section 10**.

Carte 3-1 : Zone d'étude restreinte préliminaire



Carte 3-2 : Zone d'étude élargie préliminaire



Les sections suivantes fournissent des informations générales qui offrent un aperçu des milieux biophysique et social de la zone d'étude préliminaire.

3.2 Milieu biophysique

Le milieu biophysique de la zone d'étude restreinte préliminaire comprend la côte, les eaux du littoral et les eaux au large de la Mauritanie et du Sénégal, entre Nouakchott et Dakar. La zone d'étude élargie préliminaire s'étend de Nouakchott à la frontière du Sénégal avec la Guinée-Bissau.

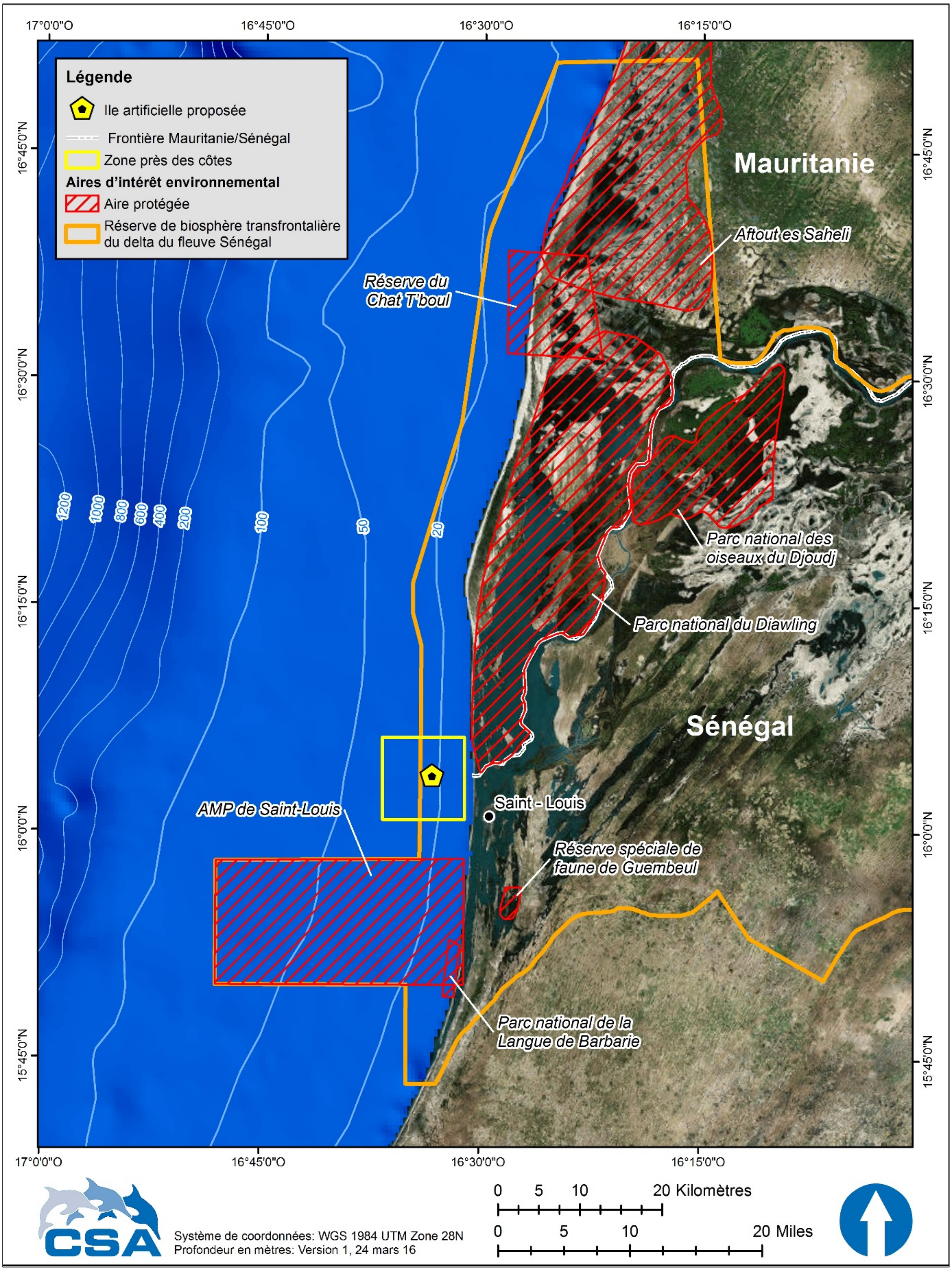
Ces zones d'étude sont situées à l'intérieur du grand écosystème marin du courant des Canaries (*Canary Current Large Marine Ecosystem* ou CCLME). Ce dernier s'étend vers le sud de la côte Atlantique du Maroc à l'archipel des Bijagos en Guinée-Bissau et vers l'ouest aux Iles Canaries (Espagne) et à la limite occidentale du plateau continental nord-ouest (correspondant approximativement aux zones économiques exclusives [ZEE] des Etats côtiers). Les pays compris dans les limites reconnues du CCLME sont l'Espagne (Iles Canaries), la Gambie, la Guinée-Bissau, le Maroc, la Mauritanie et le Sénégal. Le Cap-Vert et les eaux de la Guinée sont considérés comme des zones adjacentes à l'intérieur de la zone d'influence du CCLME.

Le CCLME est l'un des principaux grands écosystèmes marins mondiaux de courants transfrontaliers avec des upwellings d'eaux froides. Il se situe au troisième rang mondial en termes de productivité primaire, après les grands écosystèmes marins de Humboldt et Benguela, et enregistre la plus importante production de pêche de tous les grands écosystèmes marins africains, avec une production annuelle comprise entre 2 et 3 millions de tonnes. Le CCLME est classé comme un écosystème très productif de Classe I avec une production primaire importante (supérieure à 300 grammes (g) de carbone par mètre carré par année - $gC/m^2/an$). Le CCLME fournit également des produits et des services écosystémiques importants, y compris l'habitat pour les poissons et autres espèces côtières, l'approvisionnement en eau douce des rivières côtières et des estuaires, le bois de mangroves et la fourniture d'espaces côtier et marin pour l'agriculture, l'aquaculture, le développement urbain, le tourisme et transport. Le CCLME est une source vitale alimentaire et économique non seulement pour les populations côtières qui bordent le grand écosystème, mais aussi pour une grande partie de l'Afrique de l'Ouest et au-delà (Canary Current LME Project, 2016).

Une caractéristique majeure de la zone d'étude restreinte est le fleuve Sénégal et son delta. Le delta du fleuve Sénégal inclut une réserve de biosphère transfrontalière désignée par l'UNESCO comprenant 641 768 hectares (ha) qui couvrent une mosaïque d'écosystèmes deltaïques et côtiers à l'embouchure du fleuve Sénégal, ce dernier formant la frontière entre la Mauritanie et le Sénégal. Les zones principales de la réserve de biosphère incluent des parcs nationaux et des réserves naturelles tels que le Parc national du Diawling et la Réserve du Chat T'boul en Mauritanie et le Parc national des oiseaux du Djoudj au Sénégal. Ces trois parcs sont tous des sites Ramsar. La réserve de biosphère, chevauche la Mauritanie et le Sénégal. La réserve se situe principalement dans des zones continentales, cependant une portion est constituée de zones marines. Les principaux types d'écosystèmes à l'intérieur de la réserve comprennent des zones humides, de la savane tropicale, des mangroves, des lagunes et des systèmes côtiers et marins. L'objectif de la réserve est de combiner le développement durable d'activités humaines dans la région, telles que l'agriculture et la pêche, avec la préservation et la conservation de ses écosystèmes qui sont nombreux et interreliés. L'étendue géographique de la réserve de biosphère transfrontière est représentée à la **carte 3-3**. D'autres détails concernant les caractéristiques des zones côtières protégées sont fournis dans les sections suivantes, à la fois pour la Mauritanie et le Sénégal.

KOSMOS ENERGY

Carte 3-3 : Localisation de la Réserve de biosphère transfrontière du delta du fleuve Sénégal et des zones côtières protégées



3.2.1 Milieu biophysique en Mauritanie

Caractéristiques du milieu marin au large

Parmi les caractéristiques importantes du milieu marin au large des côtes sud de la Mauritanie (plus précisément, au sud de Nouakchott), il faut noter les récifs au sud de Nouakchott (notamment des récifs coralliens d'eau froide), ainsi que le delta et le bassin du delta du fleuve Sénégal. Les récifs au large sont composés de monticules de carbonate linéaires dans des profondeurs d'eau d'environ 500 m. Ces monticules sont parallèles à la côte, s'étendent sur environ 190 km du nord au sud, sont d'environ 500 m de large et peuvent atteindre 100 m au-dessus du fond marin. Bien que seuls des fragments morts de quatre espèces de coraux d'eau froide aient été documentés dans ce milieu (*L. pertusa*, *M. oculata*, *S. variabilis*, *Desmophyllum* sp.), il est possible que des colonies vivantes puissent être présentes (Colman et al., 2005).

Les ressources clés de cette zone d'étude à caractériser incluent notamment les caractéristiques au large et celles du littoral, la bathymétrie et les sédiments, la géologie et la géomorphologie côtières, l'océanographie (y compris l'upwelling côtier saisonnier, les températures de surface de la mer, les caractéristiques des marées, des vagues et de la houle, les niveaux ambiants de bruit) et les paramètres physico-chimiques (qualité des sédiments, qualité de l'eau, nutriments, profils de colonne d'eau).

Caractéristiques environnementales importantes

Le milieu biologique de la section mauritanienne de la zone d'étude préliminaire comprend les stocks de poissons hautement productifs ciblés par les pêcheries artisanales et industrielles. FishBase (2014) répertorie un total de 739 espèces de poissons marins en Mauritanie, dont 31 sont des espèces sur la Liste Rouge de l'Union Internationale pour la Conservation de la Nature (UICN). Les espèces de poissons sont présentées dans des catégories générales qui reflètent les habitats préférés. Ces catégories incluent les espèces pélagiques (c.-à-d., les espèces pélagiques côtières, épipélagiques, infrapélagiques et bathypélagiques) et démersales (c.-à-d., les espèces de fond mou et de fond dur). Aux fins des TdR, l'information sommaire se concentrera sur les espèces pélagiques et les démersales, compte tenu de leur importance en quantité et de leur valeur pour les pêcheries artisanales et industrielles.

Les principales espèces de poissons pélagiques que l'on retrouve en Mauritanie incluent :

- Maquereau espagnol (*Scomber japonicus*);
- Tassergal (*Pomatomus saltatrixa*);
- Sardinelle plate (*Sardinella madarensis*);
- Sardinelle ronde (*Sardinella aurita*);
- Chinchard (*Trachurus trachurus*);
- Chinchard noir (*Trachurus trecae*);
- Chinchard jaune (*Caranx rhonchus*);
- Sardine (*Sardina pilchardus*);
- Thon albacore (*Thunnus albacares*);

- Bonite à ventre rayé (*Katsuwonus pelamis*);
- Thon obèse (*Thunnus obesus*);
- Thon rouge de l'Atlantique (*Thunnus thynnus*);
- Anchois (*Engraulis encrasicolus*); et
- Mulet (*Mugil cephalus*).

Les principales espèces de poissons démersaux que l'on retrouve en Mauritanie incluent :

- Maigre (*Argyrosomus regius*);
- Otolithe sénégalais (*Pseudotolithus senegalensis*);
- Otolithe nanka (*Pseudotolithus typus*);
- Diagramme gris (*Plectorhinchus mediterraneus*);
- Pageot à taches rouges (*Pagellus bellottii*);
- Pagre rayé (*Pagrus auriga*);
- Grondeur sompat (*Pomadasys jubelini*);
- Rombou podas (*Bothus podas*); et
- Sole-langue sénégalaise (*Cynoglossus senegalensis*).

En plus des poissons, plusieurs espèces de crustacés et de céphalopodes sont également importantes pour la pêche locale en Mauritanie et les intérêts internationaux de pêche (par exemple : la crevette rose du Sud, *Farfantepenaeus notialis*; la crevette rose du large, *Parapenaeus longirostris*; la langouste rose, *Panulirus mauritanicus*; la langouste verte, *Panulirus regius*; le poulpe commun, *Octopus vulgaris*; le calmar commun, *Loligo vulgaris*; la seiche commune, Sepia officianalis).

Une liste détaillée des espèces démersales et pélagiques de poissons et d'invertébrés sera fournie dans le rapport d'EIES.

Caractérisée par la présence d'upwellings saisonniers ou continus, la région se distingue par les productivités primaire et secondaire élevées des eaux marines. Les zones très productives fournissent des proies pour les consommateurs de niveau supérieur, y compris les oiseaux marins et côtiers, les tortues marines et les mammifères marins.

La Mauritanie répertorie plus de 500 espèces d'oiseaux, y compris des résidents et des migrants saisonniers. Ce nombre total inclut 131 espèces d'oiseaux d'eau et 36 espèces d'oiseaux de mer. Parmi les espèces d'oiseaux de mer, notons : des pétrels, des puffins, des goélands, des fous de Bassan, des pétrels tempête (océanites), des pélicans, des mouettes tridactyles, des labbes, des skuas et des fous.

Six espèces de tortues marines ont été répertoriées en Mauritanie, et celles étant les plus observées sont la tortue verte (*Chelonia mydas*), la tortue luth (*Dermochelys coriacea*) et la tortue caouanne (*Caretta caretta*). L'observation des autres espèces de tortues marines est rare. Les eaux au large de la Mauritanie sont des corridors de migration nord/sud pour plusieurs espèces de tortues durant la période de ponte. Seule la tortue caouanne est répertoriée comme ayant sa nidification dans ou près de la zone d'étude restreinte préliminaire (c.-à-d., près de Nouakchott).

Plus de 30 espèces de mammifères marins sont potentiellement présentes dans les eaux mauritaniennes, y compris des cétacés (baleines, dauphins, et marsouins), des pinnipèdes (phoques et lions de mer) et des siréniens (lamantins et dugongs). Plusieurs de ces espèces sont énumérées par l'UICN (Liste Rouge).

Aires côtières protégées

Plusieurs aires ont été désignées protégées ou sont reconnues dans la région côtière du sud de la Mauritanie en raison de leur importance pour les mammifères marins, les tortues, et/ou les oiseaux marins et côtiers dont notamment la Réserve de biosphère transfrontière du delta du fleuve Sénégal, la Réserve du Chat T'boul, l'Aftout es Saheli et le Parc national du Diawling. Plusieurs de ces sites se chevauchent ou ont des désignations multiples (par exemple, certains sont désignés comme des zones humides importantes Ramsar et des sites du patrimoine mondial). En plus d'être une aire importante ayant trait à la biologie, l'Aftout es Saheli fournit de l'eau à la ville de Nouakchott.

La **carte 3.3** illustre les zones côtières protégées du sud de la Mauritanie.

Les principales ressources de la zone d'étude à caractériser comprennent le plancton (le phytoplancton, la productivité primaire, le zooplancton), la flore marine, la faune marine (les communautés benthiques, les poissons et les ressources halieutiques [espèces démersales, espèces pélagiques]), les espèces en danger critique (y compris la distribution, les voies migratoires, les nourriceries et les zones de frai), les oiseaux marins et côtiers, les tortues marines, les mammifères marins (y compris leurs statuts de protection), les zones importantes de biodiversité, les zones côtières protégées et les zones d'intérêt en mer.

Il y a un total de 24 zones importantes pour la conservation des oiseaux (ZICO) en Mauritanie, dont 5 ZICO côtières : le Cap Blanc, le Parc national du Banc d'Arguin, l'Aftout es Saheli, la Réserve du Chat T'boul et le Parc national du Diawling. Seuls l'Aftout es Saheli, la Réserve du Chat T'boul et le Parc national du Diawling se trouvent à l'intérieur ou à proximité de la zone d'étude restreinte préliminaire. Leurs principales caractéristiques sont décrites ci-dessous.

- Aftout es Saheli : L'Aftout es Saheli est le seul site de nidification connu du flamant nain (*Phoeniconaias minor*) en Afrique de l'Ouest et il abrite jusqu'à 2 000 flamants par an en fonction des quantités d'eau douce et d'eau de mer dans le bassin (Birdlife International, 2016).
- Réserve du Chat T'boul : Elle abrite diverses espèces d'oiseaux, y compris *Pelecanus onocrotalus*, *Phoenicopterus ruber*, *Larus genei* et *Recurvirostra avosetta*. Des grèbes, des cormorans, des hérons, des aigrettes, des spatules, des sternes, des goélands et des échassiers se trouvent également dans la Réserve du Chat T'boul. La Réserve du Chat T'boul abrite jusqu'à 20 000 oiseaux migrateurs par an.
- Parc national du Diawling : Le parc s'étend sur environ 16 000 ha et se trouve sur la rive nord du fleuve Sénégal, directement au nord du barrage de Diama. Pendant l'hivernage, les eaux de crue de l'estuaire de N'Thiallakh assurent sa connexion avec le fleuve. Il

constitue un lieu de reproduction et de nourricerie pour plusieurs espèces marines et estuariennes.

Caractérisation du milieu biophysique de la Mauritanie

Les ressources biologiques mauritaniennes clés à caractériser comprennent le plancton (le phytoplancton, la productivité primaire, le zooplancton), la flore marine, la faune marine (les communautés benthiques, les poissons et les ressources halieutiques [espèces démersales, espèces pélagiques]), les espèces en danger critique (y compris la distribution, les voies migratoires, les nourriceries et les zones de frai), les oiseaux marins et côtiers, les tortues marines, les mammifères marins (y compris leurs statuts de protection), les zones importantes de biodiversité, les zones côtières protégées et les zones d'intérêt en mer.

3.2.2 Milieu biophysique au Sénégal

Caractéristiques du milieu marin au large

Parmi les caractéristiques importantes que l'on retrouve au large des côtes du Sénégal, il faut inclure la fosse de Cayar, le mont sous-marin de Cayar, la fosse de Dakar, et le *slide* de Dakar, ainsi que le bassin du delta du fleuve Sénégal. La fosse de Cayar prend naissance près des côtes (10 à 20 m de profondeur) en amont de la presqu'île du Cap-Vert et s'étend en pente descendante vers le bassin océanique. Le mont sous-marin de Cayar, situé au large Cayar, comprend trois monts et est l'un des rares monts sous-marins au large de la côte du Sénégal caractérisés par une importante biodiversité et un hydrodynamisme fort. Les conséquences positives de cet hydrodynamisme sont notamment une biodiversité et une productivité primaire importantes (UNEP, 2014). La fosse de Dakar est une fosse relativement rectiligne, profondément incisée (jusqu'à 1 000 m), orientée dans une direction sud-est à partir de Dakar et de la presqu'île du Cap-Vert. Le *slide* de Dakar est situé au large du Sénégal central et de la Gambie. Au nord-ouest, le *slide* est limité par la fosse contiguë de Dakar et au sud par la fosse de Diola (Meyer et al., 2012).

Les principales ressources physiques et chimiques de cette zone à caractériser incluent notamment la qualité de l'air et la météorologie, les caractéristiques au large et celles du littoral, la bathymétrie et les sédiments, la géologie et la géomorphologie côtières, l'océanographie (y compris l'upwelling côtier saisonnier, les températures de surface de la mer, les caractéristiques des marées, des vagues et de la houle, les niveaux ambiants de bruit) et les paramètres physico-chimiques (qualité des sédiments, qualité de l'eau, nutriments, profils de colonne d'eau).

Caractéristiques environnementales importantes

Le milieu biologique de la section sénégalaise de la zone d'étude préliminaire comprend les stocks de poissons hautement productifs ciblés par les pêcheries artisanales et industrielles. FishBase (2015) répertorie un total de 660 espèces de poissons marins au Sénégal, y compris 656 espèces endémiques, indigènes et introduites ou réintroduites ainsi que 4 espèces probablement présentes. Les espèces de poissons sont présentées dans des catégories générales qui reflètent les habitats préférés. Ces catégories incluent les espèces pélagiques (c.-à-d., les espèces pélagiques côtières, les épipélagiques, les infrapélagiques et les bathypélagiques) et les espèces démersales (c.-à-d., les espèces de fond mou et de fond dur). Aux fins des TdR, l'information sommaire se concentrera sur les poissons pélagiques côtiers et les poissons épipélagiques, compte tenu de leur importance en quantité et de leur valeur pour les pêcheries artisanales et industrielles.

Poissons pélagiques côtiers. Dans un contexte régional, une grande partie des ressources pélagiques du CCLME migre à travers les frontières politiques : les poissons pélagiques de plus petite taille (notamment les sardines, les sardinelles, les maquereaux et les chinchards) tendent à rester à proximité de la côte, bien qu'ils migrent d'une ZEE à l'autre. Les sardines, les sardinelles, les anchois, les maquereaux espagnols et les chinchards constituent plus de 60 % des captures à l'intérieur du CCLME. Près des côtes, certaines espèces pélagiques littorales de plus grande taille (p. ex., les mulets, les maigres et les tassergals) effectuent des mouvements migratoires entre le nord et le sud.

Les petits poissons pélagiques les plus fréquemment pêchés dans les eaux littorales du Sénégal sont les suivants, par ordre d'importance :

- La sardinelle (*Sardinella aurita* et *S. maderensis*), qui représente entre 80 % et 90 % des captures totales de petits poissons pélagiques;
- L'ethmalose (*Ethmalosa fimbriata*);
- Le maquereau espagnol (*Scomber japonicus*);
- Le chinchard (*Trachurus trachurus* et *Trachurus trecae*); et
- L'anchois (*Anchoa guineensis*).

Poissons épipélagiques. Les poissons épipélagiques ou pélagiques océaniques incluent les requins (le requin-taupe bleu, le petit requin-taupe, le requin blanc, le requin soyeux et le requin longimane), les voiliers (le makaire, le pèlerin et l'espadon), les exocoetidés, les coryphènes, les thonidés et les centrarchidés. Certaines de ces espèces sont importantes pour les pêches régionales ou sont prisées par les pêches récréatives basées à l'étranger. Toutes les espèces épipélagiques sont migratrices.

L'UICN répertorie actuellement plus de 40 espèces vulnérables, en danger ou en danger critique. Bien que les taxons de poissons listés représentent une variété d'espèces, celles trouvées dans les eaux sénégalaises sont dominées par les requins, les raies, les raies-guitare et les mérous.

La portion sénégalaise de la zone d'étude préliminaire contient potentiellement plus de 600 espèces d'oiseaux, y compris les résidents et les migrants saisonniers; 5 espèces de tortues marines; et plus de 30 espèces de mammifères marins, y compris les cétacés (baleines, dauphins, et marsouins), les pinnipèdes (phoques et lions de mer), et les siréniens (lamantins et dugongs). Plusieurs de ces espèces sont répertoriées par l'UICN (Liste Rouge).

Les oiseaux marins et côtiers incluent des espèces représentatives des ordres taxonomiques suivants (extrait de Lepage, 2007) : Podicipédiformes – Grèbes ; Procellariiformes – Puffins, pétrels et pétrels-tempête (océanites) ; Pélécaniformes – Pélicans, cormorants, frégates, fous et fous de Bassan, dards ; Ciconiiformes – Butors, hérons, aigrettes, ombrettes africaines, cigognes, ibis et spatules ; Phoenicopteriformes – Flamands ; Anseriformes – Canards, oies et cignes ; Falconiformes – Balbuzard pêcheur, faucons, milans et aigles ; Gruiformes – Grues, râles, râles à bec jaune, gallinules, foulques d'Amérique, grébifoulques d'Amérique et grébifoulques d'Afrique ; et Charadriiformes – Jacanas, rhynchées peintes, huîtriers, avocettes élégantes, échasses, œdicinèmes, glaréoles, courvites, pluviers, vanellinés, bécasseaux et maubèches, laridés, sternes et becs-en-ciseaux.

La faune aviaire de la bande littorale du Sénégal est relativement bien connue, car les estuaires et les zones humides associés aux fleuves Casamance, Gambie, Saloum et Sénégal ont été l'objet de campagnes de recherche et de baguage au cours des dernières décennies et ils sont régulièrement visités par des ornithologues européens et africains (Zwarts et al., 2010).

Les tortues caouannes sont les espèces les plus communes de la région, avec les tortues imbriquées et les tortues olivâtres. La nidification des tortues marines est connue pour se produire le long de la côte du Sénégal. Aucune enquête nationale d'observation ou de nidification des tortues n'a été entreprise au Sénégal. Les observations et les aires de ponte relevées dans la documentation disponible incluent entre autres :

- Parc national de la Langue de Barbarie – site fréquenté par les tortues.
- Parc national des îles de la Madeleine – aire de ponte et de nidification des tortues marines.
- Parc national du delta du Saloum et réserve de biosphère – site de ponte très important pour quatre espèces de tortues marines.
- Sanctuaire ornithologique de la Pointe de Kalissaye – établi pour protéger les sites de reproduction des tortues marines (et des colonies d'oiseaux de mer nicheurs).

Un total de 19 espèces de mammifères marins sont susceptibles d'être présentes dans la zone d'étude restreinte préliminaire, avec 7 autres espèces dont la présence est considérée comme possible en raison des préférences relatives à l'habitat, des limites de l'aire ou des schémas migratoires saisonniers. Sept espèces de mammifères marins de la zone d'étude préliminaire sont répertoriées par l'UICN comme en danger critique, en danger ou vulnérable.

Aires côtières protégées

Il existe cinq Aires Marines Protégées (AMP) désignées au Sénégal, y compris Cayar, Saint-Louis, Joal, Abéné et Bamboung. Il existe également deux réserves marines communautaires : Somone et Palmarin (Dieng et Ndiaye, 2012). Deux AMP à l'intérieur de la zone d'étude restreinte préliminaire s'étendent en mer dans les eaux côtières, y compris l'AMP de Cayar et l'AMP de Saint-Louis. Ces AMP s'étendent d'environ 12 à 32 km en mer, respectivement. Les autres aires protégées à l'intérieur ou à proximité de la partie sénégalaise de la zone d'étude restreinte préliminaire sont le Parc national de la Langue Barbarie, le Parc national des oiseaux du Djoudj, le Parc national des Îles de la Madeleine, la Réserve naturelle de Popenguine, la Réserve spéciale de faune de Guembeul, et la Réserve de biosphère transfrontière du delta du fleuve Sénégal. Plusieurs de ces sites se chevauchent ou ont des désignations multiples (par exemple, certains sont également désignés comme des zones humides importantes Ramsar et des sites du patrimoine mondial). La **carte 3-3** indique les zones côtières protégées.

Le Sénégal possède 17 ZICO désignées, dont 7 sont des zones marines et 4 sont situées le long des côtes de la zone d'étude restreinte préliminaire. Les Niayes, composés de dunes et de dépressions le long de la côte entre Dakar et Saint-Louis, ne sont pas considérés comme des zones marines. Les ZICO font partie de l'un des programmes de conservation aux échelles mondiale et régionale mis en œuvre par Birdlife International (Birdlife International, 2015). Elles sont définies comme des sites nécessaires à la survie de populations viables pour la plupart des espèces d'oiseaux à l'échelle mondiale. Les ZICO comprennent également une proportion importante et représentative d'autres formes de biodiversité. Certaines de ces ZICO sont décrites ci-dessous.

- Réserve spéciale de faune de Guembeul et les lagunes de Saint-Louis : La réserve se compose d'une lagune étendue et d'une mangrove résiduelle le long des côtes. Outre la réserve officielle, un certain nombre de lagunes saumâtres autour de la ville de Saint-Louis, toutes reliées à l'estuaire du fleuve, sont incluses dans la ZICO. Les lagunes sont très productives et celles à l'extérieur de la réserve soutiennent d'importantes économies de pêche locales. Le site abrite une grande variété de canards migrateurs du paléarctique, d'échassiers et un nombre important d'espèces de mouettes et de sternes.
- Le Parc national des oiseaux du Djoudj est un site Ramsar et patrimoine mondial de l'UNESCO, avec 3 millions d'oiseaux visiteurs chaque année représentant près de 400 espèces d'oiseaux; une zone humide comprenant un grand lac entouré de ruisseaux, d'étangs et de mares qui offrent un habitat pour de nombreuses espèces d'oiseaux, y compris les pélicans blancs, les hérons pourprés, les spatules d'Afrique, les grandes aigrettes et les cormorans.
- Parc national de la Langue de Barbarie : ce parc national est composé d'une étroite bande de plaines intertidales et de dunes de sable de 20 km de long qui s'est formée à travers l'embouchure du fleuve Sénégal. Il comprend à la fois des eaux marines et fluviales (saumâtres). Ce site est particulièrement important pour un grand nombre de mouettes et de sternes en reproduction et hivernantes, y compris la *Sterna nilotica* en reproduction à la limite méridionale de son aire de reproduction.
- Parc national des îles de la Madeleine : Le parc est composé de trois îles volcaniques rocheuses situées à environ 4 km à l'ouest de la côte du Sénégal, au large de l'extrémité méridionale de la presqu'île du Cap-Vert; les 30 couples ou plus de *Phaethon aethereus* sont les seuls oiseaux nicheurs de cette espèce connus d'un pays continental africain. Les îles abritent une avifaune variée, incluant une colonie en reproduction (400 nids) de *Phalacrocorax carbo*, et les *Corvus albus*, *Milvus migrans*, *Galerida cristata* et *Euplectes orix* en reproduction. La *Sterna anaethetus* se reproduit sur les îles et des *Sula leucogaster*, *Morus bassanus*, *Larus cachinnans*, *L. cirrocephalus* et *L. fuscus* y ont été répertoriés.

Le delta du fleuve Sénégal inclut une réserve de biosphère transfrontalière désignée par l'UNESCO – la Réserve de biosphère transfrontalière du delta du fleuve Sénégal - comprenant 641 758 ha qui couvrent une mosaïque d'écosystèmes deltaïques et côtiers à l'embouchure du fleuve Sénégal. Les zones principales de la réserve de biosphère incluent des parcs nationaux et des réserves naturelles qui font partie du réseau national des aires protégées, telles que le Parc national des oiseaux du Djoudj (Sénégal), qui est aussi un site du patrimoine mondial et une zone humide Ramsar, de même que le Parc national du Diawling et la Réserve du Chat T'boul (Mauritanie), qui sont tous deux des zones humides Ramsar.

Caractérisation du milieu biophysique du Sénégal

Les principales ressources biologiques sénégalaises à caractériser comprennent le plancton (phytoplancton, productivité primaire, zooplancton), la flore marine, la faune marine (communautés benthiques, poissons et ressources halieutiques [espèces démersales, espèces pélagiques]), les espèces en danger critique (y compris la distribution, les voies migratoires, les nourriceries et les zones de frai), les oiseaux marins et côtiers, les tortues marines, les mammifères marins (y compris leurs statuts de protection), les zones importantes de biodiversité, les zones côtières protégées et les zones d'intérêt en mer.

3.3 Milieu social

Bordant l'Atlantique, la zone d'étude élargie préliminaire englobe la côte de trois pays : la Mauritanie, le Sénégal et la Gambie. L'occupation du sol est caractérisée par un fort contraste de densité entre des centres urbains importants et un littoral peu peuplé de villages et de hameaux de pêcheurs. Des activités importantes de pêche artisanale sont menées dans les eaux du littoral en raison de la productivité élevée de ces eaux en ressources halieutiques. En Gambie et au Sénégal, la côte héberge d'importantes zones de tourisme balnéaire. Une navigation maritime et un transport maritime intenses sont menés au large de la côte, ainsi que la pêche industrielle.

La zone d'étude restreinte préliminaire traverse deux pays : la Mauritanie et le Sénégal.

3.3.1 Milieu social en Mauritanie

Vue d'ensemble de la Mauritanie

La Mauritanie est bordée à l'ouest par l'océan Atlantique avec un littoral de 754 km. Le pays est délimité par le Sénégal au sud, par le Maroc, le Sahara occidental et l'Algérie au nord, et par le Mali à l'est.

Le territoire de la Mauritanie est divisé administrativement en 15 *wilayas* (régions). La wilaya est divisée en moughataa (départements), qui sont divisés en communes urbaines ou rurales. Les communes comprennent plusieurs localités. Le littoral de la zone d'étude restreinte préliminaire traverse la *wilaya* du Trarza et les trois *wilayas* de Nouakchott.

En 2013, la population totale de la Mauritanie était d'environ 3,5 millions (ONS-Mauritanie, 2014). La densité moyenne est de 3,3 habitants par kilomètre carré (PNUD-Mauritanie, 2013). Une part importante de la population est concentrée dans les villes de Nouakchott et Nouadhibou.

En 2015, le produit intérieur brut (PIB) de la Mauritanie a été de 4,5 milliards de dollars (BAD, 2016). L'économie est dominée par les ressources naturelles et est caractérisée par une structure de production relativement faible et ainsi qu'un faible niveau d'industrialisation. Cette configuration rend le pays vulnérable aux chocs extérieurs tels que les variations des prix internationaux et de la demande extérieure (MAED, 2015). La Mauritanie est le plus grand exportateur de minerai de fer en Afrique.

Les eaux côtières de la Mauritanie sont parmi les zones de pêche les plus riches du monde, et les produits de la pêche font partie des principales exportations. Récemment, le secteur de la pêche a bénéficié de la finalisation, en juillet 2015, d'un accord bilatéral longuement négocié avec l'Union européenne. La pêche artisanale et la pêche industrielle sont toutes deux pratiquées (Banque Mondiale, 2016).

En Mauritanie, le suivi scientifique des activités de pêche maritime et la recherche océanographique sont effectués par l'Institut Mauritanien de Recherches Océanographiques et des Pêches (IMROP). Il a été créé à l'origine, en 1950, avec le Laboratoire des Pêches qui est devenu plus tard le Centre National de Recherches Océanographiques et des Pêches

(CNROP) en 1978, avant de devenir l'IMROP en 2002. L'IMROP a une importante équipe de scientifiques et de techniciens qui effectuent des recherches sur les écosystèmes marins, sur les ressources halieutiques et l'environnement, et sur la planification des pêches en Mauritanie (IMROP, 2015). L'IMROP dispose de données qui doivent être prises en compte pour comprendre la situation de référence de la zone d'étude de l'EIES du projet de production de gaz.

En plus de la pêche artisanale et industrielle, la navigation maritime et le transport maritime sont des activités importantes au large de la Mauritanie. La circulation maritime concerne un grand nombre de navires-cargos et de pétroliers. Enfin, des activités d'exploration pétrolière et gazière sont également réalisées au large de la Mauritanie.

Il existe sur le fond océanique de la Mauritanie plusieurs câbles sous-marins de télécommunication qui assurent les connexions entre divers pays, dont la Mauritanie. Il y a également dans le fond marin plusieurs épaves, surtout au large de Nouadhibou.

Du côté mauritanien de la zone d'étude restreinte préliminaire, la zone côtière est délimitée au nord par la ville de Nouakchott et au sud par le village de N'Diago.

Nouakchott

La ville de Nouakchott est la capitale de la Mauritanie. Elle est la principale zone urbaine du pays. Sa population est estimée à 899 887 habitants en 2013 (ONS/ UNFPA Mauritanie, 2013).

Nouakchott est le centre des échanges commerciaux du pays et est également un centre important pour la transformation, la vente et l'exportation des produits de la pêche. À Nouakchott, une population estimée à 28 000 habitants vit du secteur de la pêche (RPS 2016).

Le port de pêche artisanale de Nouakchott est le deuxième plus important du pays après le port de Nouadhibou, une ville côtière située à l'extrême nord du pays. Le port de pêche de Nouakchott est situé à la périphérie de la ville.

La pêche artisanale est réalisée à partir de Nouakchott à une distance allant de 2 à 30 km de la côte, selon le type d'engin de pêche utilisé (RPS, 2016).

Nouakchott a un port commercial, le Port Autonome de Nouakchott, également connu sous le nom de Port de l'Amitié. Il a été agrandi en 2014 pour gérer une capacité de 6 millions de tonnes (RPS, 2016). Une nouvelle infrastructure portuaire dans le sud de la Mauritanie (à N'Diago), est à l'étude et devrait être construite dans les années à venir.

Nouakchott dispose d'un aéroport international ayant une capacité de 300 000 passagers par an et un terminal aéroportuaire de 3 000 m^2 (RPS 2016). Un nouvel aéroport international, appelé Oum Tounsi, a été récemment construit à 20 km au nord de Nouakchott et il entrera sous peu en opération.

Au sud de Nouakchott, la côte est très peu peuplée, à l'exception du village de N'Diago qui est le plus grand établissement humain dans cette zone.

N'Diago

Le village côtier de N'Diago est situé à plus de 300 km au sud de Nouakchott, très près de la frontière du Sénégal. Il est situé sur le prolongement nord de la Langue de Barbarie, à moins de 20 km de Gokhou Mbath du côté sénégalais de la frontière.

Le village de N'Diago appartient à la commune de N'Diago qui fait partie de la *moughataa* (département) de Keur Macene. La commune de N'Diago regroupe 33 petites localités. Le village de N'Diago est la plus grande localité de la commune. En 2013, le village comptait 1 240 habitants, tandis que l'ensemble de la commune comptait 6 137 personnes (ONS Mauritanie, 2014).

Les moyens de subsistance des habitants du village de N'Diago sont liés à la pêche en mer. N'Diago est la plus grande communauté de pêcheurs dans le sud de la Mauritanie. Les pêcheurs de N'Diago et de Saint-Louis partagent de nombreuses caractéristiques culturelles, y compris la langue, le Wolof. Ils mènent également le même type de pêche artisanale, en utilisant des pirogues, des engins de pêche et des techniques similaires.

A partir de N'Diago, la pêche artisanale est pratiquée à une distance allant de 3 à 40 km de la côte, selon le type d'engin de pêche utilisé (RPS, 2016).

Près de N'Diago, quelques petits villages de l'intérieur mènent de la pêche artisanale fluviale dans certaines zones du Parc national du Diawling et des affluents du fleuve dans le delta du fleuve Sénégal. En plus de la pêche fluviale, ces villages de l'intérieur ont pour moyens de subsistance l'agriculture et l'élevage. Le plus grand de ces villages de l'intérieur est Keur Macene qui appartient à la commune de Keur Macene et à la *moughataa* du même nom. En 2013, le village comptait 2 049 habitants alors que la commune, qui comprend 13 localités, comptait un total de 4751 habitants (ONS Mauritanie, 2014).

Établissements humains côtiers et activités entre N'Diago et Nouakchott

Le long de la côte mauritanienne, entre N'Diago et Nouakchott, il y a 13 petits villages et 5 campements de pêche maritime (RPS, 2016).

Les villages côtiers sont situés sur une plaine inondable, bordée à l'est par un affluent du fleuve Sénégal et à l'ouest par les dunes côtières qui protègent les villages de la mer. La pêche est une activité importante pour 3 des 13 villages : Khantour (200 habitants), Foum Lebhar (200 habitants) et Arafat (84 habitants) (RPS 2016).

Les dix autres villages côtiers vivent de l'élevage, du maraîchage et des transferts d'argent des membres de leur famille travaillant à Nouakchott et Nouadhibou, et de ceux à bord des navires de pêche opérant à partir de ces deux villes.

Les 5 campements de pêche sont situés au PK28, PK65, Legoueichiche, PK144 et Mouly. Ces campements n'ont pas d'infrastructures publiques. La glace, l'eau et les produits de base sont fournis aux habitants des campements par les propriétaires des embarcations de pêche, les grossistes de poissons et les transporteurs de Nouakchott. Les populations des campements sont largement composées par des personnes de la classe d'âge de 18-30 ans, principalement Wolofs, qui ne sont pas originaires de ces campements côtiers. Plus de 80 % de ces habitants sont des ressortissants sénégalais (RPS 2016).

3.3.2 Milieu social au Sénégal

Vue d'ensemble du Sénégal

Le Sénégal occupe la pointe occidentale de l'Afrique. Il est bordé à l'ouest par l'océan Atlantique. Le pays est limitrophe de la Mauritanie au nord, du Mali à l'est, et de la Guinée ainsi que la Guinée-Bissau au sud.

Le Sénégal a un littoral de 531 km. Son domaine maritime est divisé en deux zones aux caractéristiques topographiques distinctes, se trouvant au nord et au sud de la presqu'île du Cap-Vert. Au nord de la presqu'île, le plateau continental est compact et a une orientation nord-nord-est. Dans cette partie, la côte est appelée Grande Côte. Au sud de la presqu'île, le plateau s'élargit et la pente continentale est orientée nord-sud. Cette côte méridionale est appelée Petite Côte.

Le territoire du Sénégal est divisé en 14 régions administratives. Les régions administratives sont scindées en départements qui sont divisés en arrondissements. Les arrondissements se composent de communes et de communautés rurales. Le littoral de la zone d'étude restreinte préliminaire s'étend, du nord au sud, sur quatre régions administratives : Saint-Louis, Louga, Thiès et Dakar.

En 2012, le Sénégal comptait plus de 13 millions d'habitants avec une densité moyenne de 68 habitants au kilomètre carré (ANSD/EDS, 2013).

Avec un PIB de 14,4 milliards de dollars en 2013, le Sénégal est la deuxième plus grande économie de l'Afrique de l'Ouest francophone, derrière la Côte d'Ivoire.

La pêche contribue fortement à l'économie et à la sécurité alimentaire du pays. L'activité de pêche est organisée en deux sous-secteurs : la pêche artisanale, qui est conduite à partir de pirogues, et la pêche industrielle qui se déroule sur des navires de grande taille (chalutiers domestiques et étrangers) (ANSD, 2008). Le secteur de la pêche compte au niveau primaire (capture de la ressource) environ 52 000 pêcheurs artisanaux et 5 000 pêcheurs dans le sous-secteur industriel. Avec le niveau secondaire (transformation, vente), le secteur de la pêche emploie plus de 650 000 personnes, ce qui représente environ un cinquième de la population active du Sénégal (FAO, 2013). En plus des pêcheurs, les principaux acteurs de la pêche artisanale sont les mareyeurs, les transporteurs et les petits transformateurs qui sont principalement des femmes.

Au Sénégal, le suivi scientifique des activités de pêche maritime et de recherche océanographique est réalisé par le Centre de Recherches Océanographiques de Dakar-Thiaroye (CRODT). Le CRODT détient des données de recherche sur l'environnement maritime sénégalais s'étalant sur plusieurs décennies, notamment des informations sur la localisation de la pêche artisanale. Les données du CRODT montrent que la pêche artisanale se pratique très près de la côte et qu'elle ne va pas au-delà de 50 km du littoral.

Au large du Sénégal, la pêche industrielle, la navigation maritime et le transport maritime sont des activités importantes. La circulation maritime concerne un grand nombre de navires-cargos et des pétroliers. Enfin, des activités d'exploration pétrolière et gazière sont également réalisées au large du Sénégal.

Il existe plusieurs câbles sous-marins de télécommunication sur le fond océanique au large du Sénégal. Les câbles qui sont reliés au Sénégal sont opérés localement par la Société

Nationale des Télécommunications (SONATEL). Trois importants systèmes à fibres optiques sont présents dans les fonds marins du Sénégal : ACE (*Africa Coast to Europe*), Atlantis II et SAT 3/WASC.

La bande côtière de la zone d'étude restreinte préliminaire commence à partir de Dakar, située sur la presqu'île du Cap-Vert, et s'étend jusqu'à Saint-Louis, à l'extrémité nord de la Grande Côte.

Dakar

La ville de Dakar est la capitale du Sénégal et, avec sa banlieue, elle constitue la région de Dakar. Dakar est à la fois la ville la plus peuplée et la plus petite région du pays en termes de superficie (elle couvre une superficie de 550 km², soit 0,28 % du territoire national). Dakar compte environ 3 millions d'habitants (ANSD/EDS, 2013).

Au total, 80 % des infrastructures de transport du Sénégal sont concentrées à Dakar (SRSD Dakar, 2009) et, de même, il est estimé que la ville concentre entre 70 % et 80 % des activités économique et administrative du Sénégal. Son économie est diversifiée et la ville concentre la plupart des usines du pays, des installations gouvernementales, des bureaux des ONG ainsi que des entreprises de commerce et de services. Les établissements hôteliers de la capitale en font également un important centre de transit et de destination du tourisme d'affaires.

Dakar a un port commercial, le Port Autonome de Dakar (PAD). Il est situé dans le bord continental le plus avancé de l'Afrique de l'Ouest, un carrefour de nombreuses routes maritimes entre l'Europe, l'Amérique du Nord, l'Amérique latine et l'Afrique. La circulation maritime transitant dans le PAD est très dense.

L'aéroport international Léopold Sédar Senghor, situé à Dakar, est également une infrastructure majeure du pays.

Saint-Louis

La ville de Saint-Louis, sise à plus de 250 km au nord de Dakar, près de la frontière avec la Mauritanie, est située sur la côte de l'Atlantique, à l'embouchure du fleuve Sénégal. La ville a une superficie de 45,8 km^2. En 2013, Saint-Louis comptait plus de 230 000 habitants (ANSD/EDS, 2013).

Construite dans les années 1600, la ville de Saint-Louis est l'ancienne capitale de l'Afrique-Occidentale-Française (AOF). La ville a également été la capitale de la Mauritanie de 1920 à 1960 et la capitale du Sénégal de 1872 à 1957. Elle est encore une ville administrative qui héberge plusieurs bureaux du gouvernement. L'île de Saint-Louis a été classée comme un site du patrimoine culturel mondial de l'UNESCO en 2000. Le tourisme, les services publics et la pêche artisanale sont les moteurs de l'économie de la ville.

Saint-Louis dispose d'un aéroport national, récemment rénové, mais ce dernier contribue peu au développement économique de la région.

Sur le territoire de Saint-Louis, il y a quatre communautés de pêcheurs vivant dans des quartiers adjacents sur la Langue de Barbarie : Guet Ndar, Ndar Toute, Gokhou Mbath et l'Hydrobase qui est une zone d'extension de Guet Ndar. La Langue de Barbarie est une bande de terre très étroite délimitée par l'océan Atlantique sur la côte ouest et par le fleuve Sénégal sur la côte est. La limite nord de la Langue de Barbarie est la frontière avec la Mauritanie, située à moins de 3 km de Gokhou Mbath, tandis qu'au sud, la bande de terre se termine à l'embouchure du fleuve Sénégal.

Les quatre quartiers de pêcheurs de la Langue de Barbarie regroupent la plus grande concentration de pêcheurs au Sénégal. La subsistance de la majorité de leurs habitants dépend de la pêche en mer (ANSD/EDS, 2013).

Etablissements humains côtiers et activités entre Dakar et Saint-Louis

Sur la côte entre Dakar et Saint-Louis, on retrouve certains établissements humains. Cinq de ces villages côtiers ou petites villes côtières sont connus pour être très impliqués dans des activités de pêche : Lompoul-sur-Mer, Fass Boy, Mboro Ndeundekat, Cayar et Niayam (près de Potou). Les données disponibles indiquent que près de 40 000 personnes vivent à l'intérieur de ces 5 sites côtiers, Cayar étant le plus important avec plus de 20 000 habitants.

Près de ces établissements côtiers, les habitants des villages de l'intérieur du pays gagnent leur vie principalement de l'agriculture, notamment du maraîchage et de l'élevage. Ces villages sont situés dans la zone des Niayes qui fournit près de 75 % de la production horticole du Sénégal (Agence de développement municipal, 2003). Le tourisme est encore sous-exploité dans la zone, bien que le gouvernement projette de le développer sur la Grande Côte (SAPCO, 2016).

Bien qu'elles ne soient pas situées sur le bord de mer, l'industrie du phosphate et l'industrie des sables minéralisés sont deux activités économiques très importantes menées sur la côte, dans la zone entre Dakar et Saint-Louis. Le phosphate est exploité au Sénégal depuis 1960, tandis que l'exploitation des sables minéralisés (zircon, ilménite, etc.) se fait depuis 2014 et durera pendant une période d'environ 20 ans (Agence Ecofin, 2012).

4.0 Description préliminaire des impacts potentiels

4.1 Méthodologie d'évaluation d'impact

L'évaluation d'impact analysera les activités de routine du projet, en faisant un examen critique des données disponibles publiées et non publiées se rapportant aux ressources physiques, chimiques, biologiques et socio-économiques (p. ex., les conditions océanographiques, les habitats marins, les espèces présentes et les activités socio-économiques côtières et en mer) prévues dans la zone d'étude restreinte. La zone d'étude élargie sera considérée pour l'analyse des impacts potentiels des accidents tels qu'un déversement de carburant diesel ou une fuite de condensat.

L'évaluation d'impact identifiera les dangers et les risques environnementaux qui pourraient découler des activités de routine liées au projet et des activités non courantes (c.-à-d., accidents ou imprévus) associées aux trois phases du projet - la préparation, les opérations et la fermeture. Sur la base de la description du projet, une série de facteurs à l'origine des impacts (FOI) ont été identifiés. Comme mécanisme de sélection, et en vue de centrer l'étude d'impact, une matrice a été élaborée afin d'identifier les sources particulières d'impact (c.-à-d., les FOI) de chaque phase du projet et les ressources potentiellement affectées par chaque FOI. Une identification préliminaire des impacts potentiels du projet sur les milieux biophysique et socio-économique est présentée respectivement dans les **sections 4.2** et **4.3** des présents TdR.

L'EIES comprendra une caractérisation complète des milieux biophysique et socio-économique, décrivant les conditions initiales de la zone d'étude restreinte (c.-à-d., y compris la zone offshore, la zone de pipelines et la zone près des côtes), et les voies de transit des navires et des hélicoptères vers la côte, de même que le littoral et les communautés qui pourraient être affectés par une ou plusieurs phases du projet (la préparation, les opérations, et la fermeture). Des caractéristiques de la zone d'étude élargie seront présentées, au besoin, pour servir de référence durant l'analyse des impacts relatifs aux accidents.

La conséquence et la probabilité sont deux facteurs qui sont utilisés pour déterminer l'importance d'un impact afin de servir de base à une détermination du risque environnemental. La conséquence d'un impact correspond à une évaluation et une détermination des caractéristiques d'un impact sur une ressource spécifique (p. ex., la qualité de l'air, la qualité de l'eau, les communautés benthiques et les communautés côtières). Ces déterminations tiennent compte de la sensibilité particulière des ressources ou des composantes à un impact, de leur capacité de récupération et de leurs occurrences spatiale et temporelle. La conséquence d'un impact, qu'elle soit positive ou négative, prend en compte les caractéristiques suivantes de l'impact :

- direct ou indirect;
- réversible ou irréversible;
- à court terme (correspond généralement à la durée de la préparation ou de la fermeture, qui peut s'échelonner sur plusieurs semaines ou plusieurs mois) ou à long terme (opérations du projet, généralement de l'ordre de plusieurs décennies); et
- dans le cas des ressources socio-économiques, le nombre de parties prenantes affectées (plusieurs ou seulement quelques-unes).

Les définitions des conséquences éventuelles d'un impact sont fournies au **tableau 4-1**. Le classement de la conséquence d'un impact est le suivant : **bénéfique**, **négligeable**, **mineure**, **modérée** et **sévère**. Les conséquences des impacts représentent les impacts documentés ou anticipés pour une ressource (c.-à-d., individu, population ou communauté dans un contexte biologique; élément, attribut ou service social, économique ou culturel dans un contexte socio-économique) découlant d'un ou de plusieurs FOI, indépendamment de la probabilité de l'impact.

La probabilité de l'impact correspond à la probabilité d'occurrence et les différentes catégories de probabilité sont basées sur l'échelle suivante :

- **Probable** (>50 % à 100 %);
- **Occasionnelle** (>10 % à 50 %);
- **Rare** (1 % à 10 %); ou
- **Rarissime** (<1 %).

L'EIES considérera la conséquence et la probabilité d'impact pour déterminer l'importance globale de cet impact. L'importance des impacts sera déterminée suivant la relation suivante :

Conséquence de l'impact × Probabilité de l'impact → Importance de l'impact

Tableau 4-1 : Définitions des conséquences éventuelles applicables aux différentes catégories de ressources

Catégorie de la conséquence	Catégorie de ressource		
	Milieu physique	**Milieu biologique**	**Milieu socio-économique**
Bénéfique	Susceptible d'améliorer l'environnement ou d'accroître des avantages sociaux/économiques (p. ex., améliorer les conditions socio-économiques des parties prenantes).		
Négligeable	Aucun changement ou légers changements défavorables qui ne risquent pas d'être remarqués ni mesurés par rapport aux activités de fond.		
Mineure	Des changements défavorables qui peuvent être suivis et/ou remarqués, mais qui sont dans le champ d'application de la variabilité existante, et qui ne correspondent à aucune des définitions d'impacts « sévères » ou « modérés » (ci-dessous). Dans le cas des composantes socio-économiques, peu de parties prenantes sont affectées; l'impact est essentiellement localisé, réversible et à court terme.		
Modérée	Donnera vraisemblablement lieu à une ou plusieurs des circonstances suivantes : Violations occasionnelles et localisées des normes ou des directives relatives à la qualité de l'air ou de l'eau; Contamination localisée des sédiments par des hydrocarbures, des métaux toxiques ou d'autres substances toxiques.	Donnera vraisemblablement lieu à une ou plusieurs des circonstances suivantes : Dommages localisés aux récifs coralliens, mangroves, marais, herbiers marins ou à d'autres habitats sensibles. Quelques morts ou blessures parmi les espèces protégées; perturbation épisodique temporaire de leurs activités critiques (p. ex., reproduction, nidification, allaitement) et/ou dommages localisés à leurs habitats critiques ou à des habitats sensibles.	Changement défavorable important. Affecte plusieurs parties prenantes locales. Ce changement défavorable est réversible, mais peut avoir lieu à moyen terme.
Sévère	Donnera vraisemblablement lieu à une ou plusieurs des circonstances suivantes : Violations systématiques et continuelles des normes ou des directives relatives à la qualité de l'air ou de l'eau; Contamination généralisée des sédiments par des hydrocarbures, des métaux toxiques ou d'autres substances toxiques.	Donnera vraisemblablement lieu à une ou plusieurs des circonstances suivantes : Dégâts importants causés aux récifs coralliens, mangroves, marais, herbiers marins ou à d'autres habitats sensibles. Dégâts considérables aux habitats non sensibles dans la mesure où la fonction de l'écosystème et ses relations écologiques seraient modifiées; De nombreuses morts ou blessures chez une espèce protégée et/ou perturbation continue de ses activités critiques (p. ex., reproduction, nidification, allaitement) et/ou destruction de son habitat critique.	Changement défavorable considérablement profond et largement reconnu. Il touche la plupart des parties prenantes locales du secteur. Le changement défavorable est irréversible et/ou à long terme.

L'importance globale d'un impact est spécifique à une ressource. Les impacts négatifs ont un classement numérique compris entre 1 et 4, sur une échelle d'importance croissante. Les impacts bénéfiques sont notés, mais n'ont pas de classement numérique. Une matrice intégrant la conséquence d'un impact ainsi que sa probabilité, comme le montre le **tableau 4-2**, sera développée et constituera la base de détermination de l'importance globale d'un impact tant pour les impacts environnementaux que socio-économiques.

Tableau 4-2 : Matrice de détermination de l'importance globale des impacts

(*En se basant sur un jugement professionnel, chaque combinaison de conséquence et de probabilité se voit attribuer une valeur d'importance comprise entre 1 et 4 (de la plus faible à la plus élevée) pour les impacts négatifs.*)

Probabilité vs conséquence		← **Conséquence décroissante de l'impact**				
		Positive	**Négative**			
		Bénéfique	**Négligeable**	**Mineure**	**Modérée**	**Sévère**
Probabilité décroissante de l'impact ↓	Probable	Positive (aucun classement numérique n'est appliqué)	1 – Négligeable	2 – Faible	3 – Moyenne	4 – Élevée
	Occasionnelle		1 – Négligeable	2 – Faible	3 – Moyenne	4 – Élevée
	Rare		1 – Négligeable	1 – Négligeable	2 – Faible	4 – Élevée
	Rarissime		1 – Négligeable	1 – Négligeable	2 – Faible	3 – Moyenne

Selon cette matrice, l'importance globale d'un impact, dans le cas des impacts négatifs environnementaux et socio-économiques utilisant une approche numérique, descriptive et codée par couleurs, sera classée comme suit :

- 1 – Négligeable;
- 2 – Faible;
- 3 – Moyenne, et
- 4 – Élevée.

Les impacts négatifs classés 3 (importance globale moyenne d'un impact) ou 4 (importance globale élevée d'un impact) constitueront des priorités en matière d'atténuation. Bien que les impacts négatifs dont la valeur d'importance est de 1 ou 2 ne nécessitent pas de mesures d'atténuation, ils seront quand même évalués afin de réduire davantage la probabilité ou la conséquence des impacts. Des mesures de bonification seront également considérées dans le cadre des mesures d'amélioration relatives aux impacts positifs.

À la suite de l'application des mesures d'atténuation disponibles, l'importance globale de l'impact sera réévaluée. Les impacts « post-atténuation », appelés impacts résiduels, pourraient refléter une réduction de la probabilité ou de la conséquence de l'impact.

L'EIES, en général, et le processus d'analyse des impacts et d'identification des mesures d'atténuation, en particulier, seront menés en référence et selon les exigences des Normes de Performance et règles de la Société financière internationale (SFI, 2012). Les Normes de Performance fournissent des indications sur la façon d'identifier les risques et les impacts et sont conçues pour aider à éviter, atténuer et gérer les risques et les impacts afin que les projets puissent être réalisés de manière durable, y compris en ce qui concerne la gestion des relations avec des parties prenantes et les obligations du client par rapport à la transparence des activités menées relativement au projet. Dans le cas de ses investissements directs (y compris le financement de projets et d'entreprises fournis par des intermédiaires financiers), la SFI exige que ses clients appliquent ses Normes de Performance pour gérer les risques et les impacts environnementaux et sociaux de sorte que les opportunités de développement soient améliorées.

4.2 Relations potentielles entre des composantes du projet et des ressources environnementales

L'approche à adopter lors de l'analyse d'impact sera basée sur plusieurs étapes, y compris :

1) l'identification et la caractérisation complètes des phases du projet (c.-à-d., la préparation, les opérations et la fermeture);
2) la détermination détaillée des activités spécifiques aux phases qui ont le potentiel d'affecter une ou plusieurs ressources biophysiques et/ou socio-économiques (c.-à-d., l'identification des FOI);
3) l'évaluation des impacts en utilisant la méthodologie décrite à la **section 4.1**;
4) l'identification des mesures d'atténuation viables pour réduire ou éliminer les impacts; et
5) l'évaluation des impacts résiduels « postatténuation ».

La détermination de la relation entre les composantes du projet et les ressources environnementales (biophysiques et socio-économiques) sera basée sur une matrice combinant les FOI et les ressources, tel que décrit dans les sections suivantes. Ces matrices visent à identifier le lieu où les impacts sont les plus susceptibles de se produire. En conséquence, l'analyse d'impact met l'accent sur ces FOI répertoriés ainsi que sur les ressources susceptibles d'être affectées.

4.3 Impacts potentiels préliminaires sur le milieu biophysique

Le **tableau 4-3** énumère les FOI pour les ressources biophysiques qui pourraient être affectées par le projet Ahmeyim/Guembeul de production de gaz offshore.

Tableau 4-3 : Matrice des impacts potentiels sur les ressources biophysiques

(Un « ● » indique un impact potentiel à une ressource; un « ○ » indique qu'il existe peut-être un doute quant à la possibilité d'un impact.)

Activités du projet/ Facteurs à l'origine des impacts (FOI)	Ressources biophysiques								
	Physique/Chimique			Biologique					
	Qualité de l'air	Sédiments/qualité des sédiments	Qualité de l'eau	Plancton, poisson et ressources halieutiques	Communautés benthiques	Mammifères marins	Tortues marines	Oiseaux marins et côtiers	Espèces marines protégées, aires marines protégées et habitats d'intérêt
ACTIVITÉS DE ROUTINE DU PROJET									
PHASE DE PRÉPARATION									
Arrivée et mouvements des navires (entre le site de forage, l'installation de pipelines, l'installation du brise-lames et des autres installations)	-	●	●	●	●	●	●	●	●
Travaux de génie civil dans la zone près des côtes	-	●	●	●	●	●	●	●	●
Zone tampon	-	-	-	-	-	-	-	-	-
Présence physique, y compris l'éclairage	-	-	-	●	-	-	●	●	●
Bruit des navires (transit, positionnement, relocalisation)	-	-	-	-	-	●	●	○	●
Émissions	●	-	-	-	-	-	-	-	●
Rejets (rejets courants y compris les boues et les déblais)	-	-	●	●	-	●	●	-	●
Déchets solides (perte accidentelle)	-	-	●	●	●	●	●	-	●
Circulation et bruit des navires de soutien	-	-	-	-	-	●	●	●	●
Circulation et bruit de l'hélicoptère	-	-	-	-	-	●	-	●	●
PHASE DES OPÉRATIONS									
Présence physique, y compris l'éclairage	-	-	-	●	-	●	●	●	●
Bruit	-	-	-	●	-	●	●	●	●
Émissions	●	-	-	-	-	-	-	-	●
Rejets (rejets courants y compris les boues et les déblais)	-	●	●	●	●	●	●	●	●
Déchets solides (perte accidentelle)	-	●	●	●	●	●	●	●	●
Circulation et bruit des navires de soutien	-	-	-	-	-	●	●	●	●
Circulation et bruit de l'hélicoptère	-	-	-	●	-	●	●	●	●
PHASE DE FERMETURE									
Présence physique, y compris l'éclairage	-	-	-	●	-	●	●	●	●
Bruit	-	-	-	-	-	●	●	●	●

Activités du projet/ Facteurs à l'origine des impacts (FOI)	Ressources biophysiques								
	Physique/Chimique			Biologique					
	Qualité de l'air	Sédiments/qualité des sédiments	Qualité de l'eau	Plancton, poisson et ressources halieutiques	Communautés benthiques	Mammifères marins	Tortues marines	Oiseaux marins et côtiers	Espèces marines protégées, aires marines protégées et habitats d'intérêt
Émissions	●	-	-	-	-	-	-	-	●
Rejets (rejets courants)	-	-	●	●	-	●	●	-	●
Déchets solides (perte accidentelle)	-	-	●	●	●	●	●	-	●
Circulation et bruit des navires de soutien	-	-	-	-	-	●	●	●	●
Circulation et bruit de l'hélicoptère	-	-	-	-	-	●	●	●	●
EVENEMENTS ACCIDENTELS - Les impacts suivants sont « conditionnels » – ils ne se produisent que dans le cas peu probable d'un déversement.									
Déversement de diesel	●	○	●	○	○	●	●	●	●
Fuite de condensat	●	●	●	●	●	●	●	●	●

4.4 Impacts potentiels préliminaires sur le milieu social

Le **tableau 4-4** énumère les FOI pour les ressources socioéconomiques qui pourraient être affectées par le projet Ahmeyim/Guembeul de production de gaz offshore.

Tableau 4-4 : Matrice des impacts potentiels sur les ressources socio-économiques

(Un « ● » indique un impact potentiel par rapport à une ressource)

Activités du projet/ Facteurs à l'origine des impacts (FOI)	**Ressources socio-économiques**												
	Utilisation et occupation du territoire et des fonds marins	**Moyens de subsistance des communautés**	**Emploi**	**Activités de pêche**	**Navigation et transport maritime**	**Tourisme et loisir**	**Entreprises locales**	**Santé, sécurité et sûreté des communautés**	**Santé, sécurité et sûreté des travailleurs**	**Services et infrastructures locaux**	**Paysage**	**Climat social et politique**	**Ressources archéologiques**
ACTIVITÉS DE ROUTINE DU PROJET													
PHASE DE PRÉPARATION													
Travaux de génie civil dans la zone près des côtes	●	●	●	●	●	●	●	●	●	●		●	●
Arrivée et mouvements des navires (entre les sites de forage, l'installation de pipelines, l'installation du brise-lames et des autres installations)	-	-	-	●	●	-	-	●	-	-	-	-	-
Positionnement du navire de forage et de l'équipement de forage	●	-	-	●	●	-	-	-	●	-	-	-	●
PHASE DES OPÉRATIONS													
Activités logistiques terrestres	-	-	●	-	-	-	●	●	●	●	-	●	-
Présence physique et opérations de la plateforme de prétraitement, des FLNG, des méthaniers et des navires de soutien	-	●	-	●	●	●	-	●	●	-	-	●	-
Zone tampon autour des installations	-	●	-	●	●	-	-	-	-	-	-	●	-
Présence de travailleurs étrangers	-	-	-	-	-	-	-	●	-	-	-	●	-
Rejets courants en mer	-	-	-	●	-	-	-	-	-	-	-	-	-
Élimination des déchets	-	-	-	-	-	-	-	●	-	●	-	-	-
Bruits et vibrations sous-marins	-	-	-	●	-	-	-	-	-	-	-	-	-
Mouvement des méthaniers et des navires de soutien	-	-	-	●	●	-	-	-	-	●	-	-	-
Mouvement, circulation et bruit de l'hélicoptère de soutien	-	-	-	-	-	-	-	●	-	●	-	-	-
PHASE DE FERMETURE													
Abandon ou démantèlement d'installations et de pipelines	●	-	-	●	●	-	-	-	●	-	-	-	-
Bruit	-	-	-	-	-	-	-	●	●	-	-	-	-
Rejets	-	-	-	-	-	-	-	●	●	-	-	-	-
Mouvement, circulation et bruit de l'hélicoptère de soutien	-	-	-	-	-	-	-	●	●	-	-	-	-

Activités du projet/ Facteurs à l'origine des impacts (FOI)	Ressources socio-économiques												
	Utilisation et occupation du territoire et des fonds marins	Moyens de subsistance des communautés	Emploi	Activités de pêche	Navigation et transport maritime	Tourisme et loisir	Entreprises locales	Santé, sécurité et sûreté des communautés	Santé, sécurité et sûreté des travailleurs	Services et infrastructures locaux	Paysage	Climat social et politique	Ressources archéologiques
EVENEMENTS ACCIDENTELS - Les impacts suivants sont « conditionnels » – ils ne se produisent que dans le cas peu probable d'un déversement.													
Déversement de diesel	●	●	-	●	●	●	-	-	-	-	-	-	-
Fuite de condensat	●	●	●	●	●	●	●	-	-	●	●	●	-

5.0 Objectif de l'étude d'impact environnemental et social

Compte tenu des caractéristiques spécifiques du projet de production de gaz offshore et le fait que ces caractéristiques pourraient affecter l'environnement, Kosmos a l'intention de commander une EIES complète qui couvrira à la fois le milieu biophysique et le milieu social du projet. L'EIES sera menée par un bureau d'études en environnement.

L'objectif de l'EIES est de prédire les effets environnementaux des activités du projet avant qu'il ne soit réalisé et d'intégrer des considérations environnementales dans la prise de décision. L'EIES devra :

- Identifier les impacts négatifs potentiels sur les milieux physiques, biologiques et sociaux;
- Proposer des mesures pour atténuer les impacts négatifs sur l'environnement;
- Prédire s'il y aura des impacts environnementaux négatifs importants après que les mesures d'atténuation soient mises en œuvre;
- Inclure un programme de suivi pour vérifier l'exactitude de l'évaluation environnementale et l'efficacité des mesures d'atténuation.

Le projet comprendra des opérations, des infrastructures et des équipements communs à la Mauritanie et au Sénégal. Par conséquent, l'EIES se conformera à la réglementation environnementale applicable de chaque pays. Étant donné que Kosmos est à la recherche de financement international pour son projet, l'EIES sera également conforme aux exigences environnementales et sociales de la Société financière internationale (SFI).

En Mauritanie, l'EIES sera conforme à :

- La Loi n° 2000-45 portant Code de l'environnement;
- Le Décret n° 2004-094 du 24 novembre 2004 relatif à l'étude d'impact environnemental;
- Le Décret n° 2007-105 modifiant et complétant certaines dispositions du Décret n° 2004-094 du 24 novembre 2004 relatif à l'étude d'impact environnemental;
- La Loi n° 2010-033 du 20 juillet 2010, portant Code des hydrocarbures bruts; et
- Le Contrat d'exploration-production entre la République Islamique de Mauritanie et Kosmos Energy Mauritania Bloc C8, C12 ou C13.

Au Sénégal, l'EIES sera conforme à :

- La Loi n° 2001-01 du 15 janvier 2001 portant Code de l'environnement;
- Le Décret n° 2001-282 du 12 avril 2001 portant application du Code de l'environnement;
- L'Arrêté ministériel no 9472 MJEHP-DEEC du 28 novembre 2001 portant contenu du rapport de l'étude d'impact environnemental[4];
- La Loi n°98-05 du 8 janvier 1998 portant Code Pétrolier; et
- Le Contrat de partage d'exploration et de production d'hydrocarbures entre la République du Sénégal et Kosmos Energy Senegal pour le bloc de Saint-Louis offshore profond.

Par rapport à la SFI, l'EIES sera conforme aux :

- Normes de performance environnementale et sociale de la SFI (2012);
- Directives environnementales, sanitaires et sécuritaires de la SFI pour les installations de gaz naturel liquéfié (GNL) (2007);
- Directives environnementales, sanitaires et sécuritaires de la SFI pour les ports et les terminaux (2007); et
- Directives environnementales, sanitaires et sécuritaires de la SFI pour l'extraction des matériaux de construction (2007).

Dans le cas d'un écart entre les réglementations nationales et les exigences de la SFI, les exigences les plus strictes seront appliquées à l'EIES.

Les normes pour le projet seront identifiées et présentées en détail dans la section du Cadre réglementaire et institutionnel du rapport d'EIES.

[4] La Loi portant Code de l'environnement et son décret d'application font référence à une étude d'impact environnemental (EIE). Cependant, le contenu de l'EIE comprend une forte composante sociale. Par conséquent, elle est désignée comme une EIES dans les présents termes de référence.

6.0 Portée de l'étude

6.1 Exigences générales

Le Consultant préparera un rapport d'EIES approfondie. Ce rapport sera conforme aux présents TdR et aux commentaires éventuels que la DCE, la DEEC et la SFI feront sur ces TdR. Par ailleurs, tout commentaire exprimé par ces parties lors du processus d'examen de l'étude d'impact sera pris en compte.

L'EIES couvrira notamment les sujets généraux suivants :

- Les cadres juridique et institutionnel, particulièrement les lois et les règlements environnementaux applicables au projet;
- Les normes qui s'appliqueront au projet;
- Une description du projet;
- Une description des milieux physique, biologique et social de la zone du projet qui peuvent être défavorablement affectés par le projet;
- Une description des approvisionnements en matières premières, en eau et en énergie requis pour le projet (s'il y a lieu) qui peuvent avoir des effets sur l'environnement;
- Une description des changements qui peuvent se produire sur les populations locales et le milieu biophysique résultant de la réalisation du projet;
- Une identification des impacts positifs ou négatifs sur l'environnement;
- Les solutions/variantes proposées au projet afin d'éviter ou atténuer les impacts négatifs sur l'environnement;
- Les mesures planifiées pour gérer les émissions, les rejets et les déchets;
- Une évaluation des possibilités qui s'offrent pour œuvrer à l'amélioration de l'environnement;
- Le plan de gestion environnementale et sociale;
- Le plan de surveillance et suivi; et
- Les résultats de la consultation publique pendant la préparation de l'EIES.

En outre, l'EIES comprendra une étude de dangers pour se conformer aux exigences spécifiques du Sénégal.

6.2 Exigences particulières

En plus des exigences générales mentionnées ci-dessus, le consultant :

- présentera une analyse des écarts entre les exigences de la Mauritanie, du Sénégal et de la SFI en matière d'EIES et identifiera les exigences les plus strictes applicables à l'EIES.
- fournira une description détaillée du projet pour chacune des trois phases principales : i) la préparation; ii) les opérations, à savoir, la production de gaz; et iii) la fermeture.

- pour la phase de préparation, fournira des informations sur l'extraction des matériaux de construction, y compris le type et le volume requis, et l'emplacement et la description des carrières qui pourraient être utilisés. Il indiquera les modes potentiels de transport, les routes à utiliser pour le transport des matériaux de construction aux sites de construction, et le nombre et la fréquence des voyages.
- pour la phase de préparation, fournira des informations sur les infrastructures au large et près des côtes (et à terre, le cas échéant) à construire : les puits, le système sous-marin, la plateforme de prétraitement, le brise-lames de FLNG, l'île artificielle, les stations d'amarrage marines/l'installation de chargement près des côtes, etc.
- pour la phase de préparation, fournira des informations sur les travaux de génie civil à mener au large, près des côtes et à terre (le cas échéant).
- pour la phase des opérations, fournira des informations sur les équipements, les processus, les produits chimiques et les autres produits qui seront utilisés pour l'ensemble de l'activité de production de gaz, à partir de l'extraction de gaz jusqu'au transport de GNL.
- pour la phase des opérations, fournira des informations sur les activités de soutien : le transport par hélicoptère, le transport par navire (avec les spécifications des navires), la base logistique terrestre, l'hébergement, etc.
- pour la phase des opérations, fournira une description complète de l'équipement et des produits utilisés, incluant les navires de stockage et leurs spécifications, pour les opérations de forage et de production de GNL. Cette description fournira les informations nécessaires pour déterminer la nomenclature et le régime de classification de ces équipements et produits selon la réglementation applicable aux installations classées pour la protection de l'environnement (ICPE) au Sénégal.
- pour la phase de fermeture, fournira une description de toutes les opérations concernées et fournira un plan de mise hors service.
- pour les trois phases du projet, fournira des informations sur l'emplacement, la taille et l'empreinte physique de toutes les infrastructures ou installations, et fournira des informations sur toute zone d'exclusion en mer (au large), près des côtes ou à terre.
- pour les trois phases du projet, fournira des informations sur le nombre et le type d'employés requis par composantes du projet ainsi que des informations sur les possibilités d'embauche locales.
- pour les trois phases du projet, fournira des informations par composante du projet sur les possibilités de contrats d'approvisionnement locaux; par exemple, pour la fourniture de matériaux de construction lors de la phase de préparation.
- pour les opportunités d'emploi et d'affaires locales, fournira des données désagrégées pour Dakar et Nouakchott, et pour les autres communautés cotières, en particulier les villages de pêche.
- fournira une description de référence des milieux physique, biologique et social dans la zone du projet : aux niveaux offshore, près des côtes et terrestre.
- fournira une description géologique de la région dans laquelle le projet sera mené, en fournissant notamment des informations sur la composition, la structure et les propriétés

physiques du plancher océanique jusqu'à la profondeur de forage en mer et de la profondeur de construction de la zone près des côtes.

- fournira une description complète au niveau marin et au niveau côtier des milieux biophysique et social.
- procédera à une analyse complète de la sensibilité socio-environnementale de la zone du projet en indiquant toutes les zones de sensibilité et leur situation par rapport aux activités du projet.
- procédera à une analyse approfondie des impacts potentiels sur les environnements marins et côtiers. Une attention particulière sera accordée à la flore et à la faune marines, aux établissements humains et aux activités socio-économiques. L'analyse identifiera les impacts potentiels durant les trois phases du projet : i) préparation et construction; ii) opérations; iii) fermeture.
- évaluera les impacts cumulatifs du projet vis-à-vis des autres activités en cours ou prévues dans la zone de projet, notamment les activités liées aux opérations pétrolières et gazières, les activités de pêche, etc.
- identifiera les localités potentiellement touchées et les communautés locales affectées.
- procédera, durant la préparation de l'EIES, à des séances de consultation avec les parties prenantes du projet. La consultation publique est un élément essentiel de l'évaluation d'impact. Elle assure que le projet intègre les préoccupations environnementales et sociales des parties prenantes. La transparence de l'information relative au projet est nécessaire pour aider les communautés concernées et les autres parties prenantes à comprendre les impacts et les opportunités du projet. Pendant les séances de consultation, le projet sera présenté en utilisant un langage simple et non technique afin d'être compris par les parties prenantes. Leurs commentaires et leurs suggestions seront pris en compte. Un résumé des séances de consultation ainsi que la liste des personnes consultées seront annexés au rapport de l'EIES.
- pour répondre aux exigences du Sénégal, procédera à une analyse des risques/dangers liés aux opérations à chaque phase du projet, notamment les incendies et les explosions, les collisions avec des navires et les déversements. Il identifiera les mesures de prévention et d'intervention liées à ces dangers. L'étude de dangers sera présentée en conformité avec le guide sénégalais pour les études de dangers.

Des exigences spécifiques et additionnelles, requises par la DEEC, le 30 juin 2016, sont indiquées à l'annexe B des présents TdR.

6.3 Plan de consultation publique

La consultation publique sera une partie importante de l'EIES. La consultation publique sera un processus en deux tournées :

1) au début de l'EIES : identification des enjeux et des préoccupations éventuels des parties prenantes qui devraient être couverts par l'EIES;

2) après qu'une version provisoire du rapport d'EIES soit réalisée : présentation des résultats préliminaires aux parties prenantes pour s'assurer que leurs enjeux et leurs préoccupations aient été correctement traités et à ce que les mesures d'atténuation proposées soient appropriées. Cette seconde tournée sera effectuée au cours du processus d'enquête publique réglementaire en Mauritanie et au cours du processus d'audience publique réglementaire au Sénégal.

En Mauritanie, les parties prenantes ciblées seront notamment les suivantes :

- Les communautés de pêcheurs artisanaux potentiellement affectées de N'Diago et des villages côtiers et campements de pêche près de N'Diago;
- Les représentants des associations de pêcheurs dans ces localités;
- Les représentants des pêcheurs au niveau national;
- Les représentants locaux de la commune de N'Diago et des villages côtiers et campements de pêche près de N'Diago;
- Les représentants locaux de la commune de Keur Macene (au besoin);
- Le *Wali* (gouverneur) et le *Hakem* (préfet) de la *wilaya* et de la *moughataa* de la zone d'étude restreinte;
- Les associations professionnelles des secteurs de la pêche industrielle;
- Les services techniques nationaux ou déconcentrés, dont ceux de la pêche, de la navigation maritime, de la marine nationale, de la garde côtière, du tourisme, de l'environnement (incluant les aires protégées), des télécommunications, de la protection civile, etc.;
- Les ONG nationales et internationales en Mauritanie, notamment la WWF, l'UICN et le Programme Régional de Conservation Maritime (PRCM);
- Les centres de recherche nationaux, notamment l'IMROP et l'ONISPA;
- L'Université de Nouakchott ;
- La Commission Environnementale; et
- Le programme national Biodiversité-Gaz-Pétrole.

Au Sénégal, les parties prenantes ciblées seront notamment les suivantes :

- Les communautés de pêcheurs artisanaux potentiellement affectées de Saint-Louis;
- Les représentants des associations de pêcheurs de Saint-Louis;
- Les représentants des pêcheurs au niveau national;
- Les représentants locaux de Saint-Louis (conseil départemental, mairie, et conseils de quartier);
- Les gouverneurs et les préfets des régions et des départements de la zone d'étude restreinte;

- Les associations professionnelles des secteurs du tourisme et de la pêche industrielle;
- Les services techniques nationaux ou déconcentrés, dont ceux de la HASSMAR, de la marine nationale, de la garde côtière, de la pêche, de la navigation maritime, du tourisme, de l'environnement (incluant les aires protégées), des télécommunications, de la protection civile, etc.;
- Les ONG environnementales nationales et internationales;
- L’Université de Saint-Louis ; et
- Les centres de recherche nationaux, notamment le CRODT.

Avant de préparer et de mener les consultations, un plan de consultation détaillé sera élaboré. Le plan comprendra une description et un calendrier des activités prévues. Les activités comprendront des rencontres individuelles ou des réunions en petits groupes avec les acteurs institutionnels, des groupes de discussion avec des acteurs susceptibles d'être affectés (les pêcheurs, par exemple), et de grandes assemblées publiques avec les communautés susceptibles d'être affectées.

Pour la première tournée de consultations, et quel que soit le format utilisé, les séances de consultation consisteront à :

- faire une présentation sur le projet, le promoteur, la zone d'intervention, la méthode d'exploitation du gaz, les mesures de sécurité prévues autour des sites du projet, les zones d’exclusion définies autour de ces sites ainsi que sur l’échéancier du projet;
- apporter des clarifications sur les sujets d'intérêt soulevés par les participants ou des réponses aux questions posées par les participants; et
- recueillir les avis, les préoccupations et les recommandations émis par les participants.

L’information sera présentée aux participants en utilisant un langage simple et non technique. Des comptes rendus seront rédigés et les résultats seront résumés dans le rapport provisoire de l'EIES.

Pour la deuxième tournée de consultations, les séances de consultation consisteront à :

- donner une présentation des résultats préliminaires de l'EIES, notamment les impacts sur les milieux biophysique et social et les mesures d'atténuation proposées;
- fournir des éclaircissements supplémentaires, ainsi que des réponses aux questions soulevées par les participants; et
- recueillir les avis, les préoccupations et les recommandations émis par les participants afin de les prendre en considération dans une version révisée du rapport d’EIES.

Similairement à la première tournée de consultations, l'information sera présentée aux participants dans un langage simple et non technique. Des comptes rendus seront rédigés et les résultats seront résumés dans la version révisée du rapport d’EIES.

6.4 Méthodologie de l'EIES

Pour réaliser l'EIES, le consultant effectuera plusieurs activités notamment les suivantes :

- Examen du cadre réglementaire et institutionnel : revue de la littérature ;
- Étude de référence environnementale et sociale
  - Revue de la littérature.
  - Collecte de données secondaires disponibles en Mauritanie et au Sénégal, notamment à l'IMROP, à l'Office d'inspection Sanitaire des Produits de la Pêche et de l'Aquaculture (ONISPA), à la Commission Environnementale (CE) et au programme national Biodiversité-Gaz-Pétrole pour la Mauritanie (programme BGP) et au CRODT pour le Sénégal.
  - Étude de référence environnementale océanographique menée en Mauritanie et au Sénégal à l'intérieur de la zone du projet, pour évaluer la situation avant le début du projet dans les zones marines potentiellement affectées (zones offshore, de pipeline et près des côtes). Cette étude de référence environnementale océanographique comblera les lacunes de données pour la description de référence du milieu. Cette étude scientifique définira les caractéristiques physiques, chimiques, et biologiques dans la zone du projet. Un profilage de la colonne d'eau sera effectué pour déterminer les caractéristiques par profondeur (température, salinité, oxygène dissous, chlorophylle et turbidité). De plus, un échantillonnage de la colonne d'eau permettra de déterminer les matières en suspension, les métaux totaux et dissous et les hydrocarbures. L'échantillonnage net caractérisera l'ichthyoplancton. L'échantillonnage de sédiments sera effectué pour déterminer les caractéristiques physiques et chimiques des sédiments (granulométrie, carbone organique total, métaux, hydrocarbures), ainsi que la composition faunistique (endofaune).
  - Collecte de données sociales sur le terrain : travail de terrain pour la caractérisation des communautés susceptibles d'être touchées, par exemple sur le nombre et les caractéristiques des habitants, l'organisation sociale, les conditions économiques, l'emploi et des moyens de subsistance, les activités dépendantes de la mer et de la côte, les infrastructures et les services publics existants, la santé et la sécurité publiques, les rapports de genre, les groupes vulnérables, etc.
  - Exercices de modélisation (c.-à-d., la modélisation d'un déversement, la modélisation d'émissions).
  - Production de données SIG et cartographie. Plusieurs cartes seront préparées afin d'illustrer les résultats de la collecte de données et de montrer et localiser les impacts potentiels. Les cartes incluront notamment une carte illustrant spécifiquement toutes les infrastructures du projet, les blocs pétroliers voisins ainsi que les licences de pêche dans la zone.
- Révision de la description finale détaillée du projet : travail d'analyse ;
- Consultation publique : voir la **section 6.3** ci-dessus ;

- Évaluation des impacts biophysiques et sociaux et des mesures d'atténuation : travail d'analyse (y compris des résultats de la consultation publique) ;
- Soumission du rapport provisoire d'EIES aux autorités de la Mauritanie et du Sénégal pour examen ;
- Enquête publique en Mauritanie + audiences publiques au Sénégal ; et
- Dépôt du rapport d'EIES révisé aux autorités des deux pays et à la SFI.

7.0 Profil du consultant menant l'EIES

L'EIES sera menée par un bureau international agréé pour les études en environnement, avec les informations de Kosmos, et en collaboration avec des firmes mauritanienne et sénégalaise.

L'équipe multidisciplinaire, avec une vaste expérience dans la conduite d'EIES pour des projets pétroliers et gaziers en mer, comprendra des spécialistes dans les domaines d'expertise suivants :

- Évaluation d'impact environnemental et social;
- Ingénierie;
- Océanographie;
- Biologie marine;
- Gestion des pollutions et nuisances;
- Qualité de l'air;
- Socio-économie;
- Consultation publique;
- Données SIG et cartographie ; et
- Études de dangers.

D'autres experts pourraient être ajoutés à l'équipe selon les besoins.

8.0 Livrables

La version française du rapport provisoire d'EIES sera soumise à :

- la DCE pour examen et enquête publique en Mauritanie; et
- la DEEC pour examen par le Comité technique au Sénégal.

À la suite des commentaires de la DCE et du Comité technique, une version révisée du rapport d'EIES sera soumise à la DCE et à la DEEC avec un tableau de concordance indiquant comment les commentaires ont été traités dans le rapport révisé.

Le rapport d'EIES sera probablement divisé et présenté comme suit:

1) Page de garde - indiquant le nom du projet, le promoteur du projet, l'auteur de l'EIES, les ministères et les départements à qui le rapport est soumis et la date;
2) Résumé non technique de l'EIES avec les principaux résultats et recommandations;
3) Table des matières;
4) Liste des tableaux, figures, annexes et acronymes / abréviations;
5) Introduction;
6) Description du projet, y compris une justification et une description détaillées des composantes et des activités du projet;
7) Alternatives du projet - une description et une évaluation des variantes possibles pour le projet et la description de celles retenues;
8) Cadre réglementaire et institutionnel - un résumé des règlements et des lois applicables en Mauritanie et au Sénégal, des conventions et des protocoles internationaux ainsi qu'un résumé des normes applicables de la SFI;
9) Description de l'environnement - une caractérisation de la situation de référence dans la zone du projet : le milieu physique, le milieu biologique et le milieu social;
10) Consultation publique et engagement des parties prenantes - un résumé des consultations publiques menées au cours de l'EIES;
11) Analyse d'impact - présentation de la méthodologie d'évaluation d'impact, des classifications d'impact (niveaux d'impact), et des résultats de l'évaluation de l'impact;
12) Mesures d'atténuation - discussion sommaire de l'identification des mesures d'atténuation à mettre en œuvre de manière à éviter, réduire ou compenser les impacts négatifs et à renforcer les impacts positifs;
13) Étude de dangers et risques professionnels – évaluation des risques d'accidents technologiques et des mesures de sécurité proposées. Cette étude respectera le modèle sénégalais pour les études de dangers.
14) Plan de gestion environnementale et sociale (PGES) et plan de suivi et de surveillance (PSS) – présentation détaillée des composantes du PGES et du PSS, dont l'identification des responsabilités pour chaque institution impliquée;
15) Conclusions - un résumé des conclusions de l'EIES, en indiquant les principales mesures pour éviter ou réduire les négatifs impacts les plus importants, et en identifiant des incertitudes qui pourraient nuire à la fiabilité des résultats de l'étude; et
16) Annexes, y compris les pièces justificatives (rapports sectoriels) préparées pour l'EIES, les références, les TdR approuvés de l'EIES, la liste des experts impliqués dans l'EIES,

une liste des personnes consultées et les résumés des réunions de consultation, les plans (le cas échéant), les résultats de laboratoire (le cas échéant), et toute autre information nécessaire pour une bonne compréhension du projet.

9.0 Calendrier de l'EIES

La durée de l'EIES est estimée à environ huit mois entre la date de l'approbation des TdR et la présentation du rapport provisoire d'EIES à la DCE et à la DEEC. Toutefois, la durée totale de la mission d'EIES dépendra du processus d'examen par les autorités de la Mauritanie et du Sénégal et du temps requis pour l'approbation finale du rapport d'EIES.

Un calendrier préliminaire de l'EIES est inclus à l'**annexe A-2**.

10.0 Références

Pour ses projets d'exploration pétrolière et gazière en Mauritanie et au Sénégal, Kosmos a fait faire plusieurs évaluations environnementales et sociales depuis 2014. Celles-ci, ainsi que l'EIES et son annexe menée par Woodside en 2003 pour le projet Chinguetti en Mauritanie, fournissent une importante base de données biophysique et socio-économique pour l'EIES à venir du projet de production de gaz proposé. Elles seront des sources importantes d'information pour le projet de production de gaz.

Les références utilisées pour les présents TdR comprennent les documents énumérés ci-dessous.

Agence de développement municipal. 2003. Audit urbain de la ville de Cayar, Agence de développement municipal. 2003. Consultation au : www.geradsn.org/etudes/audit/audit_cayar.pdf.

Agence Ecofin. 2013. Sénégal: mise en production en 2013 de la troisième réserve mondiale de zircon et ilménite. Consultation au : www.agenceecofin.com/investissement/2704-4575-senegal-mise-en-production-en-2013-de-la-troisieme-reserve-mondiale-de-zircon-et-ilmenite.

ANSD/EDS. 2013. Agence nationale de la statistique et de la démographie (ANSD) [Sénégal] et ICF International. 2012. Enquête démographique et de santé continue (EDS-continue 2012-2013). Calverton, Maryland, USA: ANSD et ICF International. 216 p.

BAD. 2016. Profil de la Mauritanie, 2016, Banque Africaine de Développement. Consultation au : http://www.afdb.org/en/countries/north-africa/mauritania/.

Banque mondiale. 2014. Revue par pays de la Banque mondiale, Présentation du Sénégal. Consultation au : www.worldbank.org/en/country/senegal/overview.

Banque mondiale. 2016. Profil de la Mauritanie, 2016, Banque Mondiale. Consultation au : http://www.worldbank.org/en/country/mauritania/overview.

BirdLife International. 2015. Country profile: Sénégal. Consultation au : http://www.birdlife.org/datazone/country/senegal. Consulté le : 6 mars 2015.

Birdlife International. 2016. Sites – Important Bird and Biodiversity Areas (IBAs). Aftout es Sâheli. Consulté au : http://www.birdlife.org/datazone/sitefactsheet.php?id=6634. Consulté en : Avril 2016.

Canary Current LME Project. 2016. The (CCLME) Region. Consulté au : http://www.canarycurrent.org/en/the-region. Consulté le : 16 mars 2016.

CSA Ocean Sciences, Golder Associés et Tropica Environmental Consultants, 2015. Étude d'impact environnemental pour le projet de forage exploratoire dans les blocs de Saint-Louis offshore profond et Cayar offshore profond, au large du Sénégal. Rapport révisé, Rapport produit pour Kosmos Energy Senegal, octobre 2015, 602 pages.

Dieng, N., and S. Ndiaye. 2012. Recognition and support of ICCAs in Senegal. In: Kothari, A. with Corrigan, C., Jonas, H., Neumann, A., and Shrumm, H. (eds). Recognising and Supporting Territories and Areas Conserved By Indigenous Peoples and Local Communities: Global Overview and National Case Studies. Secretariat of the Convention on Biological Diversity, ICCA Consortium, Kalpavriksh, and Natural Justice, Montreal, Canada. Technical Series No. 64.

Diouf, S. 2014. Senegal: Sardinella fishery should be reserved for the artisanal fishing sector. Coalition For Fair Fisheries Arrangements. Consulté au : http://www.cape-cffa.org/new-blog/2014/11/11/senegal-sardinella-fishery-should-be-reserved-for-the-artisanal-fishing-sector. Consulté le : 27 février 2015.

Encyclopædia Britannica. 2016. Mauritania Online Profil, Encyclopædia Britannica, 2016. Consulté au : http://www.britannica.com/place/Mauritania.

FAO. 2013. Rapport du groupe de travail de la FAO, l'Organisation des Nations Unies pour l'alimentation et l'agriculture, sur l'évaluation des petits poissons pélagiques au large de l'Afrique du Nord-Ouest, Dakar, Sénégal. 21-25 mai 2012. FAO, Rapport nº 1036 sur la pêche et l'aquaculture.) 256 p.

FishBase. 2014. FishBase. Froese, R. and D. Pauly. Editors. World Wide Web electronic publication.

FishBase. 2015. FishBase, vers. 02/2105. Consulté au : http://www.fishbase.org/. Consulté le : 10 mars 2015.

Institut Mauritanien de Recherches Océanographiques et des Pêches (IMROP), 2015. A propos de l'IMROP. Historique. Consulté au : http://www.imrop.mr/index1,0.html Consulté le : 19 mars 2015.

Lepage, D. 2007. Checklist of birds of Senegal. Avibase. Consulté en : avril 2015.

MAED. 2015. Ministère des Affaires Économiques et du Développement de la Mauritanie, Rapport National sur la Mise en œuvre du Programme d'action d'Istanbul, 2015.

Meyer, M., J. Geersen, S. Krastel, T. Schwenk, and D. Winkelmann. 2012. Dakar Slide offshore Senegal, NW-Africa: Interaction of stacked giant mass-wasting events and canyon evolution. Submarine mass movements and their consequences, pp. 177-188. In: Yamada, Y. et al. (eds.), Advances in Natural and Technological Hazards Research, 31, Springer.

Office National de la Statistique (ONS) de Mauritanie. 2014. Recensement Général de la Population et de l'Habitat (RGPH) 2013, Excel spreadsheet.

ONS/ UNFPA Mauritania, 2013. Résultats provisoires du RGPH4 en Mauritanie. Rapport conjoint de l'Office National de la Statistique (ONS) et du Fonds des Nations Unies pour la Population (UNFPA) (2013). Consulté au : http://countryoffice.unfpa.org/filemanager/files/mauritania/rgph4/4.doc.

PNUD. 2015. Présentation. Rapport sur le développement humain 2015. Le travail au service du développement humain, 36 pages. Consulté au : hdr.undp.org/sites/default/files/2015_human_development_report_overview_-_fr.pdf. Consulté le: 19 mars 2016.

PNUD-Mauritanie. 2013. Rapport Annuel 2013, 37 pages. Consulté au : http://www.mr.undp.org/content/mauritania/fr/home/library/rapport-annuel-pnud-2013/. Consulté le 19 mars 2016.

RPS Energy. 2014. Environmental Impact Assessment of Proposed Exploration Wells in Block C8, Offshore Mauritania. Preparé pour Kosmos Energy Mauritania, Octobre 2014, rev 02, 286 pp. et annexes.

RPS-Energy. 2016. Social Impact Assessment of Exploration wells in Block C12, offshore Mauritania, Rapport préparé pour Kosmos Energy Mauritania, Mars 2016, rev 02, 174 pages (incluant les annexes).

SAPCO. 2016. Projets de la zone nord, Société d'Aménagement et de Promotion des Côtes et Zones Touristiques du Sénégal. Consulté au : http://www.sapco.sn/articles/zone_nord.php.

United Nations Environment Programme (UNEP). 2014. Report of the South-Eastern Atlantic Regional Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas. South-Eastern Atlantic Regional Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas, Swakopmund, Namibia, 8-12 April 2014. 327 pp.

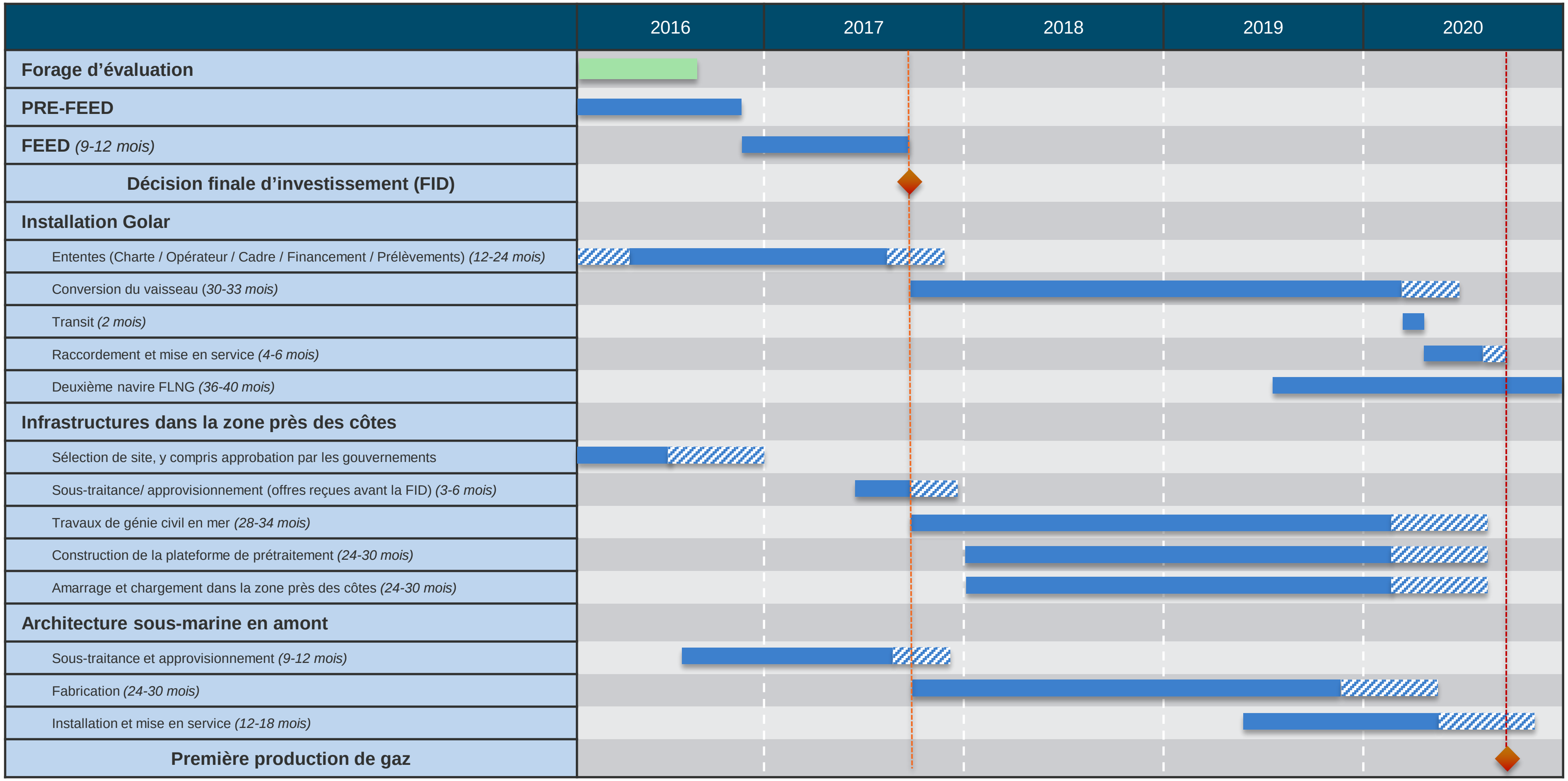
Zwarts, L., R.B. Bijlsma, J. van der Kamp, and E. Wymenga. 2010. Living on the Edge. Wetlands and Birds in a Changing Sahel. KNNV Publishing, Zeist, Switzerland.

ANNEXE A :

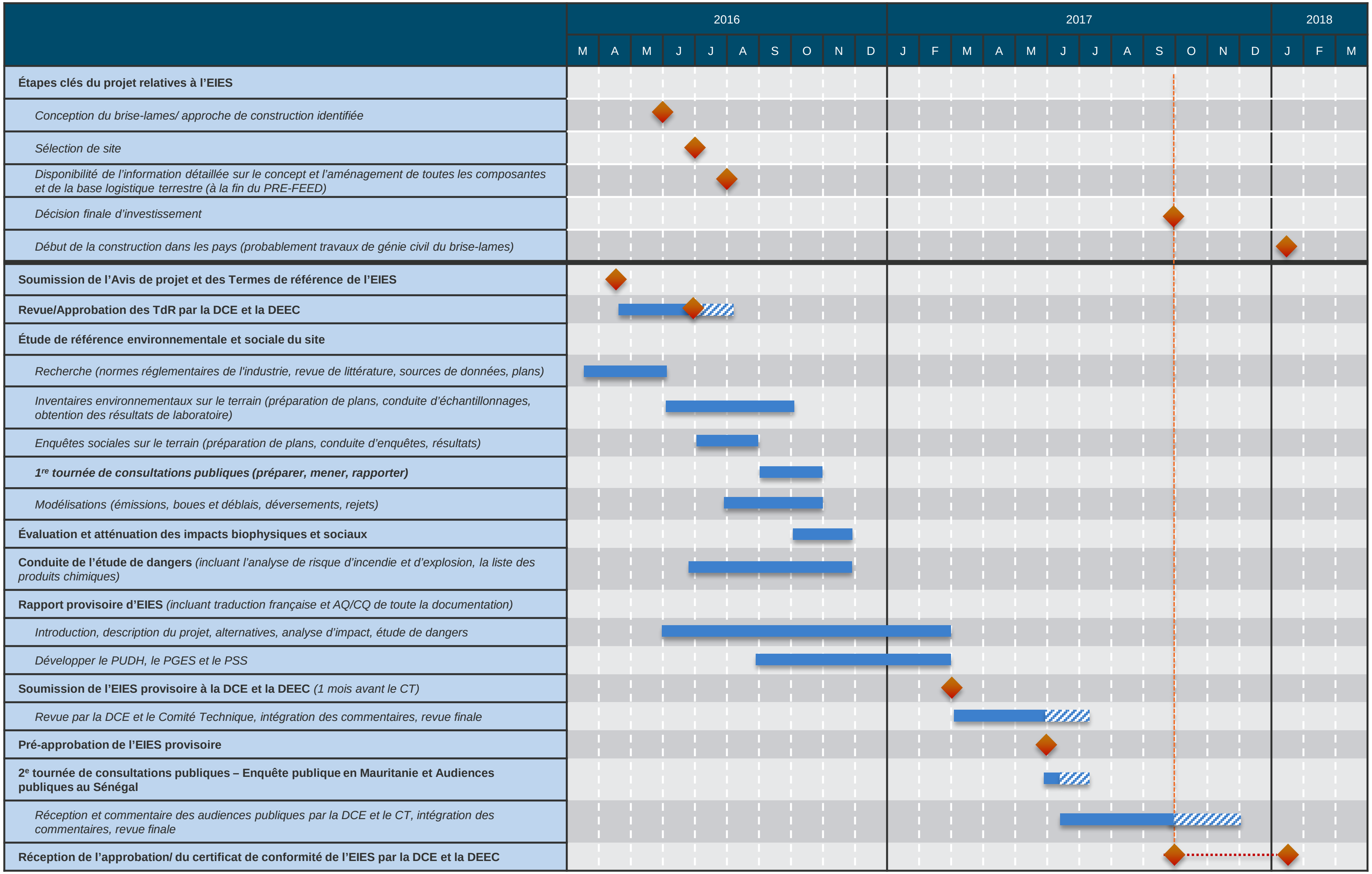
CALENDRIERS PROVISOIRES

- A-1 : Calendrier préliminaire du projet
- A-2 : Calendrier préliminaire de l’EIES

A-1 : Calendrier préliminaire du projet



A-2 : Calendrier préliminaire de l’EIES



ANNEXE B :

LISTE DES EXIGENCES DE LA DEEC POUR L'EIES

KOSMOS ENERGY

Observations de la Direction de l'Environnement et des Etablissements Classés sur les Termes de Référence de l'Étude d'Impact Environnemental et Social du Projet Ahmeyim/Guembeul de Production de Gaz Offshore au Sénégal et en Mauritanie du 30 juin 2016

Apres examen du document, la Direction de l'Environnement et des Etablissements Classés (DEEC) vous demande en sus des observations contenues dans les termes de référence soumis, de mettre l'accent sur les éléments ci-après :

1. Description du projet

L'étude devra décrire l'ensemble des composantes du projet ou infrastructures prévues en précisant au plan juridique leur localisation dans les différentes zones maritimes du droit international de la mer (Eaux intérieures, mer territoriale, Zone Economique Exclusive, Plateau continental, etc.).

Dans cette description du projet, le consultant devra mettre l'accent sur :

- les éléments constitutifs du projet et de ses aménagements connexes, en donnant les renseignements suivants : emplacement, délimitation, plan d'ensemble, taille ;
- les activités d'installation, les travaux de construction et d'exploitation y compris de maintenance ;
- les investissements de soutien hors site nécessaires etc.
- etc.

Cette description détaillée devra se faire par composante du projet (composante on-shore et composante off-shore) également couvrir l'ensemble du processus d'exploitation avec notamment des informations relatives :

- aux modalités d'exploitation et identification des émissions de la plate-forme et de ces infrastructures annexes ;
- la plate-forme de forage et principales caractéristiques ;
- les différentes étapes de développement incluant, l'implantation, les essais,
- l'exploitation et le repli ;
- etc.

Elle devra également donner des informations sur :

- le plan de mobilisation du personnel ;
- les capacités organisationnelles et techniques prévues pour la prise en charge des aspects HSE durant les différentes phases du projet et/ou tout autre arrangement prévu avec des structures spécialisées ;
- l'application des meilleures techniques disponibles et des meilleures pratiques environnementales ;
- les installations et le matériel de chantier indispensable pour une analyse des impacts en phase chantier ;
- etc.

NB : une attention particulière devra être accordée aux installations / composantes qui seront installées sur le bief sénégalais avec une localisation précise de ces dernières.

→ **Description de la plate-forme et services auxiliaires du projet**

- les composantes ;
- les différents intrants et rejets des activités (source, caractéristiques, modes de gestion des déchets solides, des eaux usées et des émissions atmosphériques) ;
- produits chimiques et conditions de stockage ;
- appareils/équipements pouvant contenir éventuellement des matières dangereuses ;
- besoin en énergie et mode d'alimentation ;
- diagramme des flots et des processus ;
- processus d'émission de polluants dans l'air, eaux usées, et autres rejets
- approvisionnement en matériaux et autres intrants ;
- etc.

2. Description des conditions environnementales de base et détermination des incidences environnementales

Il sera procédé à :

- la délimitation et à la justification de la zone d'étude (zone d'étude restreinte et zone d'étude élargie) ;
- l'identification et la délimitation des sites sensibles ou présentant un intérêt écologique ou économique particuliers dans la ou les zones d'étude avec des informations précises sur leur statut ;
- l'analyse de l'état initial de l'environnement sur les plans naturel, socio- économique et humain ;
- l'analyse des activités socio-économiques actuelles et planifiées dans la zone d'implantation du projet et ses infrastructures connexes avec une analyse des interrelations avec le projet
- l'analyse de la sensibilité environnementale et sociale du projet et ses composantes connexes au regard de la sensibilité de son milieu d'accueil ;
- l'analyse des effets économiques et sociaux lies aux choix des sites d'implantation des différentes composantes et installations de chantier ;
- l'analyse des incidences directes ou indirectes des installations sur l'environnement en particulier sur les milieux naturels.

Les composantes environnementales à cibler sont :

➢ **Air :**

- identifier les composantes du projet qui affecteront la qualité de l'air ;
- identifier les sources d'émission ;
- évaluer les quantités de polluants dans les conditions normales de fonctionnement et hors normes de fonctionnement ;
- discuter la conformité des rejets avec la règlementation nationale et/ou les bonnes pratiques internationales, et leurs effets potentiels sur l'environnement et le milieu humain

➢ **Eau :**

- identifier les activités du projet qui peuvent affecter les eaux de surface, aussi bien en phase chantier que fonctionnement ;
- déterminer les besoins en eau et leur source ;
- donner les estimations des besoins en eau et décrire les moyens pour minimiser la consommation ;
- décrire et quantifier les eaux usées à rejeter ainsi que les effets de ces rejets sur les différents milieux.

➢ **Bruit :**

- identifier les activités qui vont affecter le niveau actuel du bruit, durant les phases d'implantation, de fonctionnement et de repli ;
- déterminer le niveau sonore prévisible des installations ;
- commenter et discuter l'impact du bruit sur le milieu.

➢ **Gestion des déchets :**

- évaluer la production des déchets à chaque étape du projet (travaux, exploitation et repli) ;
- pour chaque type de déchets : désignation, quantité, volume, mode de conditionnement, de transport, d'élimination ou de valorisation interne ou externe ;
- les effets potentiels mesures prises pour le traitement.

➢ **Faune et Flore :**

Une description de la flore et de faune du milieu naturel sur le site sera réalisée. Une attention particulière devra être portée à la présence d'aires protégées, de zones de reproduction dans l'environnement de la plateforme et ses composantes annexes ainsi que les couloirs de migration des espèces.

Une cartographie claire de ces zones sensibles et couloirs de migration devra être effectuée et leur situation par rapport aux différentes composantes du projet matérialisées.

3. Analyse des variantes

L'analyse des variantes prendra en compte à minima la variante "sans projet" et celle "avec projet".

Par ailleurs, l'analyse sera axée sur les techniques/équipements de conception et d'exploitation, les sites d'implantation des différentes composantes, sur la base d'une grille multicritère tenant compte des aspects économiques, sociaux, environnementaux, etc.

Aussi, Elle prendra également en compte, selon la durée du projet, le planning d'exécution du projet suivant les différentes saisons météo-océaniques et les effets potentiels sur les écosystèmes et en particulier les espèces protégées et les espèces migratoires.

Les variantes retenues devront être justifiées et détaillées.

NB : cette analyse des variantes devra permettre entre autres, de définir les éléments environnementaux OU de sécurité qui devront être prise en compte dans le design du projet.

4. Analyse des impacts

L'analyse des impacts devra se faire par composante du projet (A titre d'exemple : composante plate-forme offshore et transport, composante forage, composante plate-forme de traitement du gaz, composante ile artificielle, composante on shore, etc.) et en fonction des différentes phases opérationnelles du projet (installation, travaux et mise en service, exploitation y compris la maintenance, fermeture et repli).

Suivant l'importance des impacts, le recours a des modélisations est recommandé afin de déterminer l'étendu spatiale de l'impact (Par exemple : érosion côtière, etc.). Cet aspect devra être pris en compte dans la consultation des services techniques compétents.

En raison de la présence dans la zone du projet de problématiques environnementales très aigues, une attention particulière devra être accordée aux effets cumulatifs. Ainsi, l'étude devra prendre en compte tous les projets en cours de réalisation ou prévus dans la zone.

Dans la mesure du possible, les impacts devront être quantifiés (Exemple : taux de recul de trait de côte, etc.)

5. Étude de dangers

L'étude de dangers devra donner pour chaque scénario, les défaillances, les causes et !es conséquences ainsi que l'occurrence initiale, la gravité initiale, le risque initial, les barrières de prévention, l'occurrence finale, les barrières de protection, la gravité finale, le risque final et enfin le scenario résiduel et la cinétique. En outre, il sera procédé à une modélisation de la propagation des effets desdits scénarii sur fonds cartographique à une échelle permettant une identification claire des zones susceptibles d'être touchées. La modélisation intégrera :

- les incendies ;
- les explosions ;
- les déversements accidentels de produits.

Dans cette analyse, une attention particulière devra être accordée à l'environnement du site comme source externe de dangers pour !es installations de « KOSMOS ENERGY » et vice versa avec des risques d'effets domino en cas d'incidents.

L'étude de dangers devra prendre en charge toutes installations (installations électriques, réseau hydrocarbures, manutention produits hydrocarbures, appareils à pression, etc.) présentes sur le site.

Par ailleurs, en raison du risque ATEX, l'étude de dangers procédera à la classification ATEX des différents sites / composantes avec des indications claires sur les caractéristiques des installations à mettre en place pour prendre en compte ce risque ATEX.

L'étude de dangers devra fournir tous les éléments permettant la réalisation du Plan d'lntervention d'Urgence en phase exploitation.

Outre, cette étude de dangers, il sera procédé à une analyse exhaustive des risques professionnels du projet.

En définitive, le consultant produira :

- un plan de gestion des risques et des dangers ;
- un plan de gestion des risques professionnels.

NB : Cette étude de dangers devra se faire par composante. Par ailleurs, le Guide méthodologique des Études de dangers du Ministère en charge de l'environnement pourra être utilisé.

6. Plan de Gestion Environnementale et sociale

Ce chapitre doit définir les mesures qui seront prises pour supprimer, réduire si possible, compenser les conséquences dommageables du Projet sur l'environnement.

Les mesures prises doivent être clairement définies. Cette définition comportera :

a. une description détaillée de la mesure ;
b. l'échéance ou le calendrier de mise en œuvre ;
c. une désignation de l'organisme exécutant cette mesure.

Ces mesures concernent en particulier (liste non exhaustive) la prévention, la réduction, voire l'élimination :

- des rejets dans le milieu marin en vue de prendre en charge les impacts potentiels sur le milieu naturel, en particulier, la faune, la flore, l'équilibre des écosystèmes et sur le milieu humain ;
- des nuisances et/ou désagréments occasionnés aux riverains, aux utilisateurs de la zone et des ressources ;
- etc.

Elles concernent également la bonification des effets socio-économiques potentiels

Le PGES devra présenter l'ensemble des mesures d'atténuation durant les différentes phases du projet (installation, exploitation et repli projet) pour éliminer les impacts négatifs ou les ramener à un niveau acceptable. Le cas échéant, l'étude décrira les mesures envisagées pour optimiser les impacts positifs ; pour les impacts résiduels, elle présentera les mesures de compensation.

Elle présentera une évaluation de l'efficacité des mesures d'atténuation, de compensation et d'optimisation des impacts identifiés ainsi que les coûts et modalités de mise en oeuvre de ces mesures. En définitive, le PGES sera présenté sous la forme d'un tableau récapitulatif avec les principaux résultats et recommandations du PGES, les impacts et mesures d'atténuation, les coûts afférents à chaque mesure d'atténuation de même que les responsabilités de mise en oeuvre.

Dans ce plan de gestion environnementale et sociale, une attention particulièrement devra être accordée aux procédures de gestion et d'intervention en cas de fuites / déversement accidentelles de produits dangereux en mer.

Le PGES devra comporter un plan détaillé de démantèlement et de remise en état de toutes les zones perturbées par le projet ainsi que toute la stratégie de gestion des pollutions et déversements accidentels.

NB : afin de faciliter son exploitation et le suivi de sa mise en oeuvre, le PGES devra se faire par composante du projet (Cf. Point 4 : analyse des impacts) et en fonction des différentes phase du projet (installation, travaux decontruction, exploitation, fermeture et repli).

7. Plan de Surveillance et de Suivi Environnemental

Il devra indiquer les liens entre les impacts identifiés et les indicateurs à mesurer, les méthodes à employer, la fréquence des mesures et la définition des seuils déclenchant les modalités de correction. Le plan de suivi doit identifier les paramètres de suivi ainsi que les coûts relatifs aux activités de suivi. Ce plan devra être présenté sous forme de tableau avec tous les aspects des modalités de surveillance et de suivi évaluées en termes de coûts et les responsabilités clairement définies.

Ce programme de suivi vise à s'assurer que les mesures d'atténuation sont effectivement mises en oeuvre, qu'elles génèrent les résultats escomptés et qu'elles sont soit modifiées ou annulées si elles ne produisent pas de résultats satisfaisants.

A cet effet, des indicateurs chiffrés et mesurables devront être dans la mesure du possible proposés. Par ailleurs pour chaque indicateur, le lieu de monitoring (suivi) devra être défini de manière précise ainsi que le protocole de suivi.

Des rapports de surveillance et de suivi environnemental devront être planifiés à toutes les phases du projet pour vérifier le niveau d'exécution des mesures d'atténuation et évaluer les effets des travaux sur l'environnement.

NB : à l'image du PGES, afin de faciliter le suivi, le plan de surveillance et de suivi devra se faire par composante.

8. Participation Publique

La participation du public est un élément essentiel du processus d'évaluation environnementale et un moyen de s'assurer que le projet intègre les préoccupations du public. Aussi, le consultant devra respecter les directives du Sénégal en matière de consultation et de participation des communautés impliquées et des services étatiques concernées.

Pour cette raison, des séances d'information seront organisées avec les parties concernées afin de leur présenter le projet dans un résumé simple et de recueillir leur avis et suggestions afin de les prendre en compte si possible. Un accent particulier devra être mis sur les mesures de sécurité prévues autour des différentes composantes du projet et les zones de servitudes définies à cet effet.

En outre, le consultant devra développer en annexe dans le rapport :

- ✓ un plan de consultation publique ;
- ✓ les informations sur la prise en compte des observations formulées par les différentes parties rencontrées lors de la consultation publique.

La liste des personnes consultées devront être annexée au rapport d 'EIES.

9. Elaboration de clauses HSE à insérer dans les DAO des entreprises et dans les contrats avec les fournisseurs et/ou autres prestataires sur la plateforme

Le consultant devra proposer des recommandations spécifiques à l'attention des entreprises de réalisation des travaux pour la protection de l'environnement, lesquelles directives devront être insérées au niveau du cahier des prescriptions techniques pour permettre le respect et la protection de l'environnement pendant l'exécution du chantier (installation de la plate forme).

Il proposera également les mesures en matière d'HSE que toute tierce entreprise prestataire de services et intervenant sur le projet devra respecter.

10. Renforcement des capacités

Le consultant devra évaluer la capacité des acteurs impliqués dans la mise en oeuvre du PGES et proposer des mesures pour le renforcement institutionnel et/ou le renforcement des capacités techniques des parties prenantes concernées par cette mise en oeuvre du PGES.

A cet effet, préparer un budget récapitulatif de toutes les actions et activités proposées dans le PGES.

11. Bilan Environnemental du projet

Une conclusion de l'étude d'impact dégageant les risques majeurs du projet sur l'environnement, l'efficacité des mesures proposées et les avantages que procure la réalisation de ce projet devra être présentée. En définitive, le consultant renseignera sur l'acceptabilité du projet sur site.

12. Structuration du rapport

L'étude d'impact environnemental et social devra être succinct, documenté sur le plan cartographique et devra comprendre les parties suivantes :

- Sommaire
- Résumé non technique
- Introduction
- Description et justification du projet
- Cadre légal et institutionnel (contraintes juridiques de la zone d'implantation)
- Description du milieu récepteur
- Analyse des variantes et description du projet retenu
- Consultations Publiques
- Identification et analyse des impacts (situation sans projet comprise)
- Étude de dangers et analyse des risques professionnels ;
- Plan de Gestion Environnementale et Sociale ;
- Plan de Suivi et de Surveillance ;
- Conclusion
- Annexes :

- Abréviations
- Liste des Experts ayant participé à l'élaboration du rapport
- Bibliographie et référence
- Personnes consultées
- TDR de l'étude
- Plans (situation etc.) ;
- Etc.

13. Produits attendus

Le Consultant fournira au promoteur, le rapport provisoire de l'étude d'impact environnemental en cinquante (50) exemplaires pour son dépôt à la Direction de l'Environnement et des Etablissements Classés (DEEC), qui convoquera les membres du Comité technique à une réunion de pré-validation.

Le rapport final de l'étude, après intégration des observations, sera déposé en dix (10) exemplaires à la Direction de l'Environnement et des Etablissements Classés, en plus d'une copie électronique.

14. Equipe de consultant

L'étude devra être menée par un consultant ou bureau d'études agrée par le Ministère de l'Environnement et du Développement Durable (MEDD). L'équipe d'experts devra comporter, en plus des experts déjà mentionnés :

- un océanographe ayant une bonne connaissance de la dynamique marine au niveau de la zone du projet et au niveau régional ;
- un spécialiste en gestion des pollutions et nuisances ;
- un cartographe
- un socio-économiste.

L'expert en étude de dangers devra avoir de fortes références en étude des risques I dangers et mesures d'urgence en exploitation off-shore.

NB : Prise en compte des pertes d'actifs

Si la mise en place des installations va nécessiter la perte d'actifs, le consultant devra élaborer un Plan de compensation des populations impactées avec toutes les modalités de réinstallation, les mesures de compensation, etc.

APPENDIX A-2: DEEC ToR APPROVAL LETTER (IN FRENCH)

République du Sénégal
Un Peuple - Un But - Une Foi
....
MINISTERE DE L'ENVIRONNEMENT
ET DU DEVELOPPEMENT DURABLE
....
DIRECTION DE L'ENVIRONNEMENT
ET DES ETABLISSEMENTS CLASSES

DEEC

N° 1469 MEDD/DEEC/DEIE

Dakar, le 30 JUIN 2016

La Directrice

A
Monsieur Guillaume DEFAUX
Vice-président et Country Manager
KOSMOS ENERGY

DAKAR

Réf : *V/L KES-GD-2016_05_24_DEEC du 24 mai 2016*

Objet : *Validation des termes de référence de l'étude d'impact environnemental et social du projet Ahmeyim/Guembeul de production de gaz offshore au Sénégal et en Mauritanie.*

Monsieur le Vice-président,

J'accuse bonne réception des termes de référence de l'étude d'impact environnemental et social (EIES) du projet cité en objet.

Veuillez trouver, ci-joint, les observations de la Direction de l'Environnement et des Etablissements Classés (DEEC) sur lesdits termes de référence (TDR).

La DEEC donne son accord pour le démarrage de l'étude sous réserve de l'intégration de ces points aux termes de référence. A cet effet, veuillez nous faire parvenir une copie des TDR finalisés.

Pour rappel, les TDR amendés devront être annexés au rapport d'EIES.

Je vous prie d'agréer, **Monsieur le Vice-Président,** l'assurance de ma considération distinguée.

P.J : *Observations de la DEEC sur les TDR*

P/ La Directrice de l'Environnement et des Etablissements Classés, pi

Directrice

Cheikh FOFANA

Ampliation : *(pour information)*

- *DGL ;*
- *DIC ;*
- *DCPN ;*
- *DREEC/ Saint-Louis.*

Direction de l'Environnement et des Etablissements Classés (DEEC)
Parc Forestier de Hann, route des Pères Maristes BP : 6557 Dakar Tél : +(221) 33 859 17 58
106, rue Carnot - tél : +(221) 33 821 63 49
Web :www.denv.gouv.sn e-mail : cellulecom.deec@gmail.com

République du Sénégal
Un Peuple - Un But - Une Foi
....
MINISTERE DE L'ENVIRONNEMENT
ET DU DEVELOPPEMENT DURABLE
....
DIRECTION DE L'ENVIRONNEMENT
ET DES ETABLISSEMENTS CLASSES

DEEC

N° 1469 MEDD/DEEC/DEIE

Dakar, le 30 JUIN 2016

Observations de la Direction de l'Environnement et des Etablissements Classés sur les Termes de Référence de l'Etude d'Impact Environnemental et Social du Projet Ahmeyim/Guembeul de Production de Gaz Offshore au Sénégal et en Mauritanie

Après examen du document, la Direction de l'Environnement et des Etablissements Classés (DEEC) vous demande en sus des observations contenues dans les termes de référence soumis, de mettre l'accent sur les éléments ci-après :

1. Description du projet

L'étude devra décrire l'ensemble des composantes du projet ou infrastructures prévues en précisant au plan juridique leur localisation dans les différentes zones maritimes du droit international de la mer (Eaux intérieures, mer territoriale, Zone Economique Exclusive, Plateau continental, etc.).

Dans cette description du projet, le consultant devra mettre l'accent sur :

- les éléments constitutifs du projet et de ses aménagements connexes, en donnant les renseignements suivants : emplacement, délimitation, plan d'ensemble, taille ;
- les activités d'installation, les travaux de construction et d'exploitation y compris de maintenance ;
- les investissements de soutien hors site nécessaires etc.
- etc.

Cette description détaillée devra se faire par composante du projet (composante on-shore et composante off-shore) également couvrir l'ensemble du processus d'exploitation avec notamment des informations relatives :

- aux modalités d'exploitation et identification des émissions de la plate forme et de ces infrastructures annexes ;
- la plate-
- forme de forage et principales caractéristiques ;
- les différentes étapes de développement incluant, l'implantation, les essais, l'exploitation et le repli ;
- etc.

Elle devra également donner des informations sur :

- le plan de mobilisation du personnel ;

- les capacités organisationnelles et techniques prévues pour la prise en charge des aspects HSE durant les différentes phases du projet et/ou tout autre arrangement prévu avec des structures spécialisées ;
- l'application des meilleures techniques disponibles et des meilleures pratiques environnementales ;
- les installations et le matériel de chantier indispensable pour une analyse des impacts en phase chantier ;
- etc.

NB : une attention particulière devra être accordée aux installations /composantes qui seront installées sur le bief sénégalais avec une localisation précise de ces dernières.

→ **Description de la plate-forme et services auxiliaires du projet**

- les composantes ;
- les différents intrants et rejets des activités (source, caractéristiques, modes de gestion des déchets solides, des eaux usées et des émissions atmosphériques) ;
- produits chimiques et conditions de stockage ;
- appareils/équipements pouvant contenir éventuellement des matières dangereuses ;
- besoin en énergie et mode d'alimentation ;
- diagramme des flots et des processus ;
- processus d'émission de polluants dans l'air, eaux usées, et autres rejets
- approvisionnement en matériaux et autres intrants ;
- etc.

2. Description des conditions environnementales de base et détermination des incidences environnementales

Il sera procédé à :

- la délimitation et à la justification de la zone d'étude (zone d'étude restreinte et zone d'étude élargie) ;
- l'identification et la délimitation des sites sensibles ou présentant un intérêt écologique ou économique particuliers dans la ou les zones d'étude avec des informations précises sur leur statut ;
- l'analyse de l'état initial de l'environnement sur les plans naturel, socio-économique et humain ;
- l'analyse des activités socio-économiques actuelles et planifiées dans la zone d'implantation du projet et ses infrastructures connexes avec une analyse des interrelations avec le projet
- l'analyse de la sensibilité environnementale et sociale du projet et ses composantes connexes au regard de la sensibilité de son milieu d'accueil ;
- l'analyse des effets économiques et sociaux liés aux choix des sites d'implantation des différentes composantes et installations de chantier ;
- l'analyse des incidences directes ou indirectes des installations sur l'environnement en particulier sur les milieux naturels.

Les composantes environnementales à cibler sont :

➢ **Air :**

- identifier les composantes du projet qui affecteront la qualité de l'air ;
- identifier les sources d'émission ;
- évaluer les quantités de polluants dans les conditions normales de fonctionnement et hors normes de fonctionnement ;
- discuter la conformité des rejets avec la réglementation nationale et/ou les bonnes pratiques internationales, et leurs effets potentiels sur l'environnement et le milieu humain

➢ **Eau :**

- identifier les activités du projet qui peuvent affecter les eaux de surface, aussi bien en phase chantier que fonctionnement ;
- déterminer les besoins en eau et leur source ;
- donner les estimations des besoins en eau et décrire les moyens pour minimiser la consommation ;
- décrire et quantifier les eaux usées à rejeter ainsi que les effets de ces rejets sur les différents milieux.

➢ **Bruit :**

- identifier les activités qui vont affecter le niveau actuel du bruit, durant les phases d'implantation, de fonctionnement et de repli ;
- déterminer le niveau sonore prévisible des installations ;
- commenter et discuter l'impact du bruit sur le milieu.

➢ **Gestion des déchets :**

- évaluer la production des déchets à chaque étape du projet (travaux, exploitation et repli) ;
- pour chaque type de déchets : désignation, quantité, volume, mode de conditionnement, de transport, d'élimination ou de valorisation interne ou externe ;
- les effets potentiels mesures prises pour le traitement.

➢ **Faune et Flore :**

Une description de la flore et de faune du milieu naturel sur le site sera réalisée. Une attention particulière devra être portée à la présence d'aires protégées, de zones de reproduction dans l'environnement de la plateforme et ses composantes annexes ainsi que les couloirs de migration des espèces.

Une cartographie claire de ces zones sensibles et couloirs de migration devra être effectuée et leur situation par rapport aux différentes composantes du projet matérialisées.

3. Analyse des variantes

L'analyse des variantes prendra en compte à minima la variante "sans projet" et celle "avec projet".

Par ailleurs, l'analyse sera axée sur les techniques/équipements de conception et d'exploitation, les sites d'implantation des différentes composantes, sur la base d'une grille multicritère tenant compte des aspects économiques, sociaux, environnementaux, etc.

Aussi, Elle prendra également en compte, selon la durée du projet, le planning d'exécution du projet suivant les différentes saisons météo-océaniques et les effets potentiels sur les écosystèmes et en particulier les espèces protégées et les espèces migratoires.

Les variantes retenues devront être justifiées et détaillées.

NB : cette analyse des variantes devra permettre entre autres, de définir les éléments environnementaux ou de sécurité qui devront être prise en compte dans le design du projet.

4. Analyse des impacts

L'analyse des impacts devra se faire par composante du projet (A titre d'exemple : composante plate-forme offshore et transport, composante forage, composante plate-forme de traitement du gaz, composante île artificielle, composante on shore, etc.) et en fonction des différentes phases opérationnelles du projet (installation, travaux et mise en service, exploitation y compris la maintenance, fermeture et repli).

Suivant l'importance des impacts, le recours à des modélisations est recommandé afin de déterminer l'étendu spatiale de l'impact (Par exemple : érosion côtière, etc.). Cet aspect devra être pris en compte dans la consultation des services techniques compétents.

En raison de la présence dans la zone du projet de problématiques environnementales très aigues, une attention particulière devra être accordée aux effets cumulatifs. Ainsi, l'étude devra prendre en compte tous les projets en cours de réalisation ou prévus dans la zone.

Dans la mesure du possible, les impacts devront être quantifiés (Exemple : taux de recul de trait de côte, etc.)

5. Etude de dangers

L'étude de dangers devra donner pour chaque scénario, les défaillances, les causes et les conséquences ainsi que l'occurrence initiale, la gravité initiale, le risque initial, les barrières de prévention, l'occurrence finale, les barrières de protection, la gravité finale, le risque final et enfin le scénario résiduel et la cinétique. En outre, il sera procédé à une modélisation de la propagation des effets desdits scénarii sur fonds cartographique à une échelle permettant une identification claire des zones susceptibles d'être touchées. La modélisation intégrera :

- les incendies ;
- les explosions ;
- les déversements accidentels de produits.

Dans cette analyse, une attention particulière devra être accordée à l'environnement du site comme source externe de dangers pour les installations de « **KOSMOS ENERGY** » et vice versa avec des risques d'effets domino en cas d'incidents.

L'étude de dangers devra prendre en charge toutes installations (installations électriques, réseau hydrocarbures, manutention produits hydrocarburés, appareils à pression, etc.) présentes sur le site.

Par ailleurs, en raison du risque ATEX, l'étude de dangers procédera à la classification ATEX des différents sites / composantes avec des indications claires sur les caractéristiques des installations à mettre en place pour prendre en compte ce risque ATEX.

L'étude de dangers devra fournir tous les éléments permettant la réalisation du Plan d'Intervention d'Urgence en phase exploitation.

Outre, cette étude de dangers, il sera procédé à une analyse exhaustive des risques professionnels du projet.

En définitive, le consultant produira :

- un plan de gestion des risques et des dangers ;
- un plan de gestion des risques professionnels.

NB : Cette étude de dangers devra se faire par composante. Par ailleurs, le Guide méthodologique des Etudes de dangers du Ministère en charge de l'environnement pourra être utilisé.

6. Plan de Gestion Environnementale et sociale

Ce chapitre doit définir les mesures qui seront prises pour supprimer, réduire si possible, compenser les conséquences dommageables du Projet sur l'environnement.

Les mesures prises doivent être clairement définies. Cette définition comportera :

a. une description détaillée de la mesure ;
b. l'échéance ou le calendrier de mise en œuvre;
c. une désignation de l'organisme exécutant cette mesure.

Ces mesures concernent en particulier (liste non exhaustive) la prévention, la réduction, voire l'élimination :

- des rejets dans le milieu marin en vue de prendre en charge les impacts potentiels sur le milieu naturel, en particulier, la faune, la flore, l'équilibre des écosystèmes et sur le milieu humain ;
- des nuisances et/ou désagréments occasionnés aux riverains, aux utilisateurs de la zone et des ressources ;
- etc.

Elles concernent également la bonification des effets socio-économiques potentiels

Le PGES devra présenter l'ensemble des mesures d'atténuation durant les différentes phases du projet (installation, exploitation et repli projet) pour éliminer les impacts négatifs ou les ramener à un niveau acceptable. Le cas échéant, l'étude décrira les mesures envisagées pour optimiser les impacts positifs ; pour les impacts résiduels, elle présentera les mesures de compensation.

Elle présentera une évaluation de l'efficacité des mesures d'atténuation, de compensation et d'optimisation des impacts identifiés ainsi que les coûts et modalités de mise en œuvre de ces mesures. En définitive, le PGES sera présenté sous la forme d'un tableau récapitulatif avec les principaux résultats et recommandations du PGES, les impacts et mesures d'atténuation, les coûts afférents à chaque mesure d'atténuation de même que les responsabilités de mise en œuvre.

Dans ce plan de gestion environnementale et sociale, une attention particulièrement devra être accordée aux procédures de gestion et d'intervention en cas de fuites / déversement accidentelles de produits dangereux en mer.

Le PGES devra comporter un plan détaillé de démantèlement et de remise en état de toutes les zones perturbées par le projet ainsi que toute la stratégie de gestion des pollutions et déversements accidentels.

NB : afin de faciliter son exploitation et le suivi de sa mise en œuvre, le PGES devra se faire par composante du projet (Cf. Point 4 : analyse des impacts) et en fonction des différentes phase du projet (installation, travaux decontruction, exploitation, fermeture et repli).

7. Plan de Surveillance et de Suivi Environnemental

Il devra indiquer les liens entre les impacts identifiés et les indicateurs à mesurer, les méthodes à employer, la fréquence des mesures et la définition des seuils déclenchant les modalités de correction. Le plan de suivi doit identifier les paramètres de suivi ainsi que les coûts relatifs aux activités de suivi. Ce plan devra être présenté sous forme de tableau avec tous les aspects des modalités de surveillance et de suivi évaluées en termes de coûts et les responsabilités clairement définies.

Ce programme de suivi vise à s'assurer que les mesures d'atténuation sont effectivement mises en œuvre, qu'elles génèrent les résultats escomptés et qu'elles sont soit modifiées ou annulées si elles ne produisent pas de résultats satisfaisants.

A cet effet, des indicateurs chiffrés et mesurables devront être dans la mesure du possible proposés. Par ailleurs pour chaque indicateur, le lieu de monitoring (suivi) devra être défini de manière précise ainsi que le protocole de suivi.

Des rapports de surveillance et de suivi environnemental devront être planifiés à toutes les phases du projet pour vérifier le niveau d'exécution des mesures d'atténuation et évaluer les effets des travaux sur l'environnement.

NB : à l'image du PGES, afin de faciliter le suivi, le plan de surveillance et de suivi devra se faire par composante.

8. Participation Publique

La participation du public est un élément essentiel du processus d'évaluation environnementale et un moyen de s'assurer que le projet intègre les préoccupations du public. Aussi, le consultant devra respecter les directives du Sénégal en matière de consultation et de participation des communautés impliquées et des services étatiques concernées.

Pour cette raison, des séances d'information seront organisées avec les parties concernées afin de leur présenter le projet dans un résumé simple et de recueillir leur avis et suggestions afin de les prendre en compte si possible. Un accent particulier devra être mis sur les mesures de sécurité prévues autour des différentes composantes du projet et les zones de servitudes définies à cet effet.

En outre, le consultant devra développer en annexe dans le rapport :

- ✓ un plan de consultation publique ;
- ✓ les informations sur la prise en compte des observations formulées par les différentes parties rencontrées lors de la consultation publique.

La liste des personnes consultées devront être annexée au rapport d'EIES.

9. Elaboration de clauses HSE à insérer dans les DAO des entreprises et dans les contrats avec les fournisseurs et/ou autres prestataires sur la plateforme

Le consultant devra proposer des recommandations spécifiques à l'attention des entreprises de réalisation des travaux pour la protection de l'environnement, lesquelles directives devront être insérées au niveau du cahier des prescriptions techniques pour permettre le respect et la protection de l'environnement pendant l'exécution du chantier (installation de la plate forme).

Il proposera également les mesures en matière d'HSE que toute tierce entreprise prestataire de services et intervenant sur le projet devra respecter.

10. Renforcement des capacités

Le consultant devra évaluer la capacité des acteurs impliqués dans la mise en œuvre du PGES et proposer des mesures pour le renforcement institutionnel et/ou le renforcement des capacités techniques des parties prenantes concernées par cette mise en œuvre du PGES.

A cet effet, préparer un budget récapitulatif de toutes les actions et activités proposées dans le PGES.

11. Bilan Environnemental du projet

Une conclusion de l'étude d'impact dégageant les risques majeurs du projet sur l'environnement, l'efficacité des mesures proposées et les avantages que procure la réalisation de ce projet devra être présentée. En définitive, le consultant renseignera sur l'acceptabilité du projet sur site.

12. Structuration du rapport

L'étude d'impact environnemental et social devra être succinct, documenté sur le plan cartographique et devra comprendre les parties suivantes :

- Sommaire
- Résumé non technique
- Introduction
- Description et justification du projet
- Cadre légal et institutionnel (contraintes juridiques de la zone d'implantation)
- Description du milieu récepteur
- Analyse des variantes et description du projet retenu
- Consultations Publiques
- Identification et analyse des impacts (situation sans projet comprise)
- Etude de dangers et analyse des risques professionnels ;
- Plan de Gestion Environnementale et Sociale ;
- Plan de Suivi et de Surveillance ;
- Conclusion
- Annexes :
  - Abréviations
  - Liste des Experts ayant participé à l'élaboration du rapport
  - Bibliographie et référence
  - Personnes consultées
  - TDR de l'étude
  - Plans (situation etc.) ;
  - Etc.

13. Produits attendus

Le Consultant fournira au promoteur, le rapport provisoire de l'étude d'impact environnemental en cinquante (50) exemplaires pour son dépôt à la Direction de l'Environnement et des Etablissements Classés (DEEC), qui convoquera les membres du Comité technique à une réunion de pré-validation.

Le rapport final de l'étude, après intégration des observations, sera déposé en dix (10) exemplaires à la Direction de l'Environnement et des Etablissements Classés, en plus d'une copie électronique.

14. Equipe de consultant

L'étude devra être menée par un consultant ou bureau d'études agrée par le Ministère de l'Environnement et du Développement Durable (MEDD). L'équipe d'experts devra comporter, en plus des experts déjà mentionnés :

- un océanographe ayant une bonne connaissance de la dynamique marine au niveau de la zone du projet et au niveau régional ;
- un spécialiste en gestion des pollutions et nuisances ;

- un cartographe
- un socio-économiste.

L'expert en étude de dangers devra avoir de fortes références en étude des risques / dangers et mesures d'urgence en exploitation off-shore.

NB : Prise en compte des pertes d'actifs

Si la mise en place des installations va nécessiter la perte d'actifs, le consultant devra élaborer un **Plan de compensation des populations** impactées avec toutes les modalités de réinstallation, les mesures de compensation, etc.

APPENDIX A-3 DCE ToR APPROVAL LETTER (IN FRENCH)

République Islamique de Mauritanie
Honneur – Fraternité – Justice

Ministère de l'Environnement et du Développement Durable

Direction du Contrôle Environnemental

الجمهورية الإسلامية الموريتانية
شرف – إخاء – عدل

وزارة البيئة والتنمية المستدامة

إدارة المراقبة البيئية

الرقم : .... إ.م.ب/و.ب.ت.م.

N°......... - 234 - .... / DCE/MEDD

Nouakchott ,le 04 NOV 2016 واكشوط في

N/Réf
V/Réf

Le Directeur المدير

A Monsieur
Le Directeur de la Société Kosmos Energy Mauritanie

Objet *: Validation des termes de référence de l'EIE relative au projet d'Ahmeyin/Guembeul de gaz offshore en Mauritanie et au Sénégal au profit de Kosmos Energy, Mauritanie*

Réf.1 : Lettre n° 526/MPEMi/M 2016 du 16 juin 2016
Réf.2 : lettres n°165 /DCE/MEDD du 13 juin 2016
Réf.3 : Lettre n° 0383/VP/KEM/1016 du 26 octobre 2016

Suite à la transmission (Réf.1) des termes de références de l'étude d'impact environnemental du projet Ahmeyin/Guembeul, au profil de la société Kosmos Energy Mauritanie, j'ai l'honneur de vous informer que deux réunions de cadrage des dits termes de référence ont été organisées par la Direction du Contrôle Environnemental de la Mauritanie le 26 juin 2016 (Réf.2) à Nouakchott et la deuxième réunion conjointe avec la Direction de l'Environnement et des Etablissement Classés (DEEC) du Sénégal, organisée le 28 juin 2016 à Saint Louis.

A l'issue de ces deux réunions, une nouvelle version des TDR, tenant compte des remarques des participants, a été transmise à la DCE (Réf.3). Elle a été jugée conformes à la réglementation environnementale en vigueur et par conséquent satisfaisante.

A cet effet, j'ai l'honneur de vous annoter notre approbation des termes de référence de l'étude d'impact environnemental pour le projet cité en objet de la société Kosmos Energy Mauritanie.

Cheikh Tourad Ould Mohamed SAAD BOUH

المدير
Directeur
Direction du Contrôle Environnemental

Ampliations :
-Ministre
-SG /MEDD
-MEPMi

ص : 170 – هاتف/فاكس : 39 31 24 45 222 + - شارع 185 – 21 رقم : 838 – لكصر انواكشوط – موريتانيا
BP : 170 Tél./Fax : +222 45 24 31 39 Rue 21-185 – Ksar Nouakchott – Mauritanie

République Islamique de Mauritanie

Ministère de l'Environnement et du Développement Durable

Direction du Contrôle Environnemental

Projet Ahmeyim/Guembeul de production de gaz offshore en Mauritanie et au Sénégal
Commentaires sur l'avis de projet et les termes de référence de l'EIES soumis par Kosmos Energy Mauritania et Kosmos Energy Senegal (25 mai 2016)

Le 16 août 2016

N.B. : Les commentaires ci-dessous concernent les TDRs de l'EIES et l'avis de projet en tant que documents de références mais ils incluent également des commentaires et remarques plus générales en lien avec le projet lui-même

1. Les TDR envisagent des impacts potentiels sur des écosystèmes marins potentiellement de haute valeur et sensibles : identifier un programme de recherche

Dans les TDR de l'EIES, il convient d'insérer un paragraphe spécifiant que, au vu de l'état des connaissances aujourd'hui, une étude océanographique préliminaire d'ensemble doit être réalisée dans le cadre de l'EIES, dans les deux pays, dans les zones marines potentiellement affectées. Cette étude doit être menée par les centres de recherche des deux pays concernés, en partenariat avec des centres de recherche océanographique de référence internationale. Selon les résultats de l'étude océanographique préliminaire, celle-ci sera suivie d'autres études détaillées complémentaires, soit dans le cadre de l'EIES avant travaux, soit après le début des activités, dans le cadre d'un programme de recherche scientifique à définir avec les centres de recherche nationaux et internationaux impliqués. Dans cette perspective la bibliographie de référence pour ces TdRs mérite d'être enrichie.

2. Les TDR envisagent des impacts potentiels sur des aires protégées terrestres.

Dans ce cadre, il serait utile de rappeler les recommandations du Panel Scientifique sur les activités pétrolières et gazières (2007-2009) concernant les règles de No Go dans les espaces protégés en Mauritanie. Ce Panel avait été mobilisé par l'UICN à la demande du Ministère de l'Environnement de la Mauritanie. La version finale du rapport, avril 2009 indiquait notamment :

"Interdiction («NO GO»)
Toute activité d'exploration et de production d'hydrocarbures doit être interdite à l'intérieur des parcs nationaux existants (PNBA, parc national du Diawling).

"L'obligation de protection que la Mauritanie a édictée et à laquelle elle s'est engagée vis à vis de la Convention sur le Patrimoine mondial lors de la désignation du PNBA sur la liste du Patrimoine mondial l'oblige non seulement à contrôler les activités à l'intérieur de l'aire classée mais également à éviter que des activités menées à l'extérieur soient de nature à menacer l'intégrité de la zone protégée.

"En conséquence, dans le cas du PNBA, toute activité doit être interdite » au sein du parc e dans les blocs adjacents. (...).

"De même, au sud du pays, la réserve de Biosphère du programme l'Homme et la Biosphère (MAB), qui inclut le Parc national du Diawling comme zone centrale, devrait faire l'objet d'une attention particulière vis à vis des risques pétroliers. En conséquence, le Parc national de Diawling devrait être tenu à l'écart de toute activité pétrolière ; de même, la zone de transition, délimitée suivant l'accord entre le gouvernement et l'Unesco, ne peut accueillir selon les règles du MAB que des activités traditionnelles, ce qui exclut l'exploitation pétrolière."

La politique du Sénégal concernant les activités extractives dans les aires protégées maritimes et terrestres du pays mérite également d'être rappelée.

3. Aucune référence n'est faite aux blocs pétroliers / concessions de pêche/ concessions de chaque pays concerné.

Il serait utile de transposer les 4 éléments du projet KOSMOS (exploitation, transport, l'éventuelle île artificielle, mais aussi les éventuels gazoducs et éventuelles installations terrestres) sur une carte officielle portant les blocs pétroliers, et concessions de pêche en Mauritanie et au Senegal[1]... Cela permettrait de mieux mettre en lumière les acteurs concernés ainsi que les risques pour les uns et les autres (en matière juridique, ou de coordination en cas d'accident etc.).

[1] Rappelons que le rapport du Panel scientifique de 2009 fait référence à la carte des blocs pétroliers et gaziers qui était valide cette année là. Or, cette carte a été mise à jour depuis (voir notamment celle qui figure sur le site de l'ITIE (2014) : http://itie-mr.org/index.php/en/2014-06-10-08-10-15/secteur-petrolier).

Une carte claire aiderait à la fois à construire une cartographie des conflits et pourrait servir de base pour les dialogues et les négociations futurs.

4. Pourquoi les gazoducs vers la Mauritanie et le Sénégal et ne sont-ils pas inclus dans le projet ?

En quoi un développement rapide pour l'exportation permet-il d'envisager une disponibilité plus rapide du gaz pour le marché intérieur ? Ce paragraphe (p.6 de l'avis de projet) n'est pas très convaincant ; la mise en place dès le début de l'approvisionnement du marché intérieur peut être bien plus bénéfique en même temps que l'exportation ; ou avant (cf. CNPC au Tchad et Niger). En termes de développement, il est sans doute plus important pour les deux pays d'avoir de l'électricité abondante et bon marché qu'une rente de plus…

Le fait de repousser à plus tard la satisfaction des marchés intérieurs en gaz est un grand risque pour les pays hôtes. En général, tous les projets à plusieurs phases sont risqués (quel que soit l'ordre des phases : dans le cas du Tchad et du Niger la CNPC n'exporte pas encore, après avoir choisi d'alimenter d'abord les marchés intérieurs …). La part de production exportée par rapport à celle qui sera réservée pour les besoins domestiques n'est précisée nulle part (or la transparence doit aussi s'appliquer à ce niveau-là). Avoir une idée plus précise sur le sujet serait utile y compris pour appréhender les risques dans le cadre de l'EIE.

C'est pourquoi, pour le bien des pays hôtes, la question relative à l'approvisionnement intérieur-extérieur doit être examinée sans limite ni préalable. Cette analyse pourrait ensuite déboucher sur une conclusion : celle d'impliquer l'inclusion des gazoducs vers les côtes mauritano- sénégalaises dans le projet. Cela serait d'autant plus logique que ce sont ces deux investissements-là qui pourraient avoir le plus d'impacts (notamment d'impacts cumulatifs).

La notion **d'impact cumulatif** (de différentes activités gazières; d'activités simultanées de pêche et gazières;) mérite d'ailleurs d'être abordée explicitement dans l'avis de projet et dans les TDR.

5. Pourquoi avoir choisi la construction d'une île artificielle au lieu d'envisager des installations terrestres en bout de gazoduc dans chaque pays?

Sans faire abstraction des enjeux politiques bien présents à l'esprit des commentateurs, on aurait pu, dans la continuation de la réflexion antérieure, au lieu de l'île artificielle (plateforme d'exportation commune... p. 7), envisager des installations de transformation à terre, en bout de chaque gazoduc (Mauritanie et Sénégal), loin des aires protégées, loin de l'embouchure du fleuve Sénégal et dans des zones plus sûres... Pourquoi cette alternative-là ne fait fait-elle plus partie des options à étudier dans l'EIES?

« Empreinte du projet : il est estimé que la solution d'une installation près des côtes réduit les risques en matière d'environnement, de sécurité et de sûreté ».
Cela semble même a priori plutôt contre-intuitif. Il faut donc le démontrer, car cette île présente aussi des risques. La justification de cette option doit apparaître clairement avec une comparaison entre les impacts d'une telle installation et ceux d'autres designs.

- Risque environnemental
    - faible profondeur, proximité des côtes
    - impact "foncier marin" sur la pêche (industrielle et artisanale)
    - impact navigation qui va augmenter entre Nouakchott, Dakar et l'île artificielle (plus près des côtes que le rail de navigation international)
    - accentuation potentielle de la menace qui plane sur la Langue de Barbarie et Saint Louis : l'érosion littorale, qui sera accentuée par la hausse du niveau marin liée au changement climatique (risque de disparition des quartiers de pêcheurs puis de l'ile). **L'île artificielle et surtout les futurs aménagements entre celle-ci et la côte ainsi que les aménagements à la côté auront-ils des conséquences sur les courants, les vagues, le transport sédimentaire, notamment autour de St Louis ? C'est une question à laquelle l'EIES devra apporter des réponses à la condition d'inclure à son périmètre la partie côtière du projet…**

6. Un effort immense de renforcement des capacités pour la gestion des impacts et la préservation des espaces marins et terrestres fragiles.

Le grand nombre d'aires protégées terrestres de différents types et statut dans la zone d'influence du projet est bien montré dans le document. Cependant, l'enjeu de préservation des espaces marins n'est pas assez mis en exergue. Les TDR de l'EIES doivent inviter à mieux faire apparaître les enjeux de préservation, aussi bien des espaces marins que des espaces terrestres (en termes de participation / implication / coordination, etc.). Les TDR doivent exiger un inventaire de l'état actuel de la coordination des activités de préservation des espaces marins et terrestres dans les deux pays et des propositions de feuille de route et d'investissements pour leur renforcement.

7. Quel référentiel pour le projet et les TDR?

Aussi bien dans l'avis de projet que dans les TDR, il convient d'insérer un tableau qui précise explicitement l'ensemble des normes de référence par type d'opérations ou d'équipements (SFI, BPII, autres, projet de normes nationales, sous-régionales etc.).

8. Les documents se réfèrent à des projets sociaux sans les préciser.

Dans la p. 2 (paragraphe 3) l'avis de projet se réfère à des projets sociaux : selon une logique de RSE (démarche volontaire) ou conformément à la réglementation en vigueur ? Il serait bon de le préciser et de préciser la nature des projets sociaux déjà réalisés, en cours et en préparation.

9. Commentaires spécifiques

p. 3 de l'avis: carte
- la bathymétrie mériterait peut-être d'être affichée pour qu'on comprenne bien les raisons de la séparation entre les 2 zones de production (zone offshore) et transformation (iles artificielles)

p. 4 : caractéristiques des navires d'entreposage ? (cf. discussion sur le FPSO simple / double coque)

Figure 2.1 : pourquoi la plateforme de prétraitement est-elle en « amont » du brise-lames ?

Le paragraphe 2.2.2 confirme l'impression que l'ile artificielle près de la côte concentrera une bonne partie des impacts, notamment durant la construction…

Question : caractéristiques de tous les bateaux mobilisés pour phases construction et production ? (double coque?... quels référentiels?)

Quid des capacités opérationnelles, organisationnelles et équipements (navires) d'intervention en cas d'accident ?

Le fait que la SFI et la loi mauritanienne ne rendent pas obligatoire un volet consacré à l'intervention d'urgence en cas de danger / d'accident n'est pas suffisant pour justifier de placer cette dimension en annexe. Au contraire, la complexité des coordinations en cas de sinistre (2 Etats ; nombreuses administrations d'aires protégées, etc.) milite pour qu'un Plan de réponse en cas d'accident soit élaboré dans le cadre de l'EIES et fasse partie du document principal.

Dans le 6.0., il manque peut-être des éléments (où le placer ? dans le 6.2 exigences particulières ?)

- sur les possibilités d'emploi et d'affaires locales. Prendre en compte la différence entre Dakar et Nouakchott d'une part ; mais aussi d'autres localités, et notamment les villages de pêcheurs
- dans la liste des parties prenantes en Mauritanie au Sénégal et. Ajouter les universités de Nouakchott et Saint Louis

P16 et 17 des TdRs la liste des espèces pélagiques et démersales n'est pas très représentative. La liste des démersaux omet par exemple la principale ressource halieutique de Mauritanie : le poulpe… de même il faudrait mentionner à tout le moins crevette et crabe. La courbine est plutôt pélagique (même s'il est vrai qu'elle dépend principalement de ressources démersales au moins à certains stades de son cycle. En tout cas, il serait logique de la classer avec le mulet et non séparément).

APPENDIX B : TECHNICAL SPECIFICATIONS OF THE PROJECT'S INFRASTRUCTURES, VESSELS, HELICOPTERS AND OTHER EQUIPMENT, AND SUPPORT DOCUMENTATION

Appendix B
Technical Specifications of the Project's Infrastructures, Vessels, Helicopters, and other Equipment, and Support Documentation

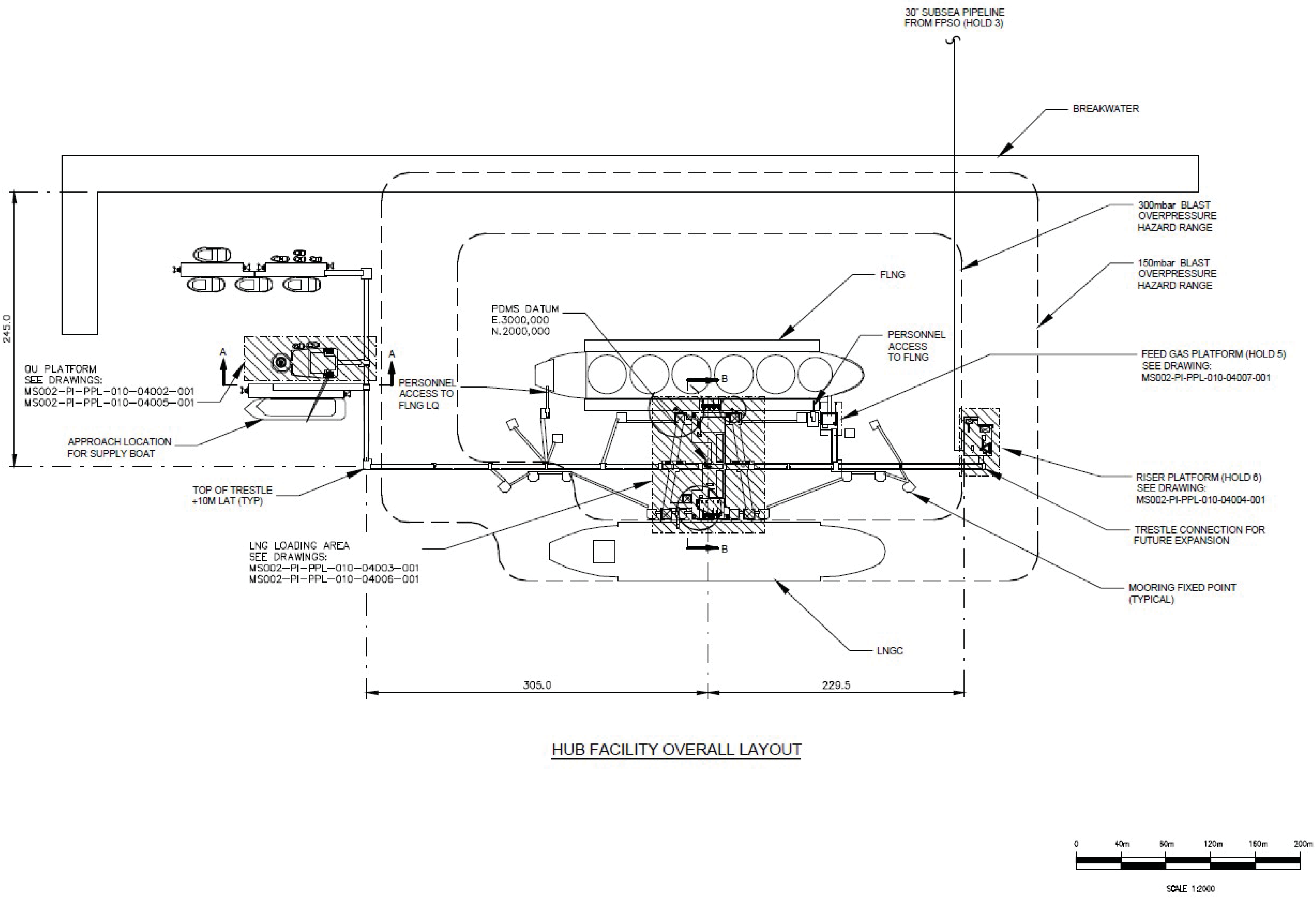
NOTICE

This Appendix presents the specifications of the main elements of the GTA gas project installations. These specifications are presented by way of indication for similar typical infrastructure since the supplier selection process is not yet completed.

APPENDIX CONTENTS

B.1
Diagrams and Details of Infrastructure

B.1.1
Breakwater (including trestle, riser platform, and QU platform)



HUB FACILITY OVERALL LAYOUT

B.1.2
Floating Production, Storage, and Offloading Vessel

BERGE HELENE - FPSO

03.11.2017

MAIN CONTRACTORS

Topside Module Design:	
M12, M50, M60, M70	Vetco Aibel
M71, M76	Moss Maritime
M30	Inocean
M46	ABB
Hull	Inocean
Fabrication Yard:	
Conversion/Integration:	Jurong & Keppel
Conversion Year:	2003 & 2005
Turret Supplier/Swivel Manufacturer:	Framo Engineering

WELL INFORMATION

Total Wells:	12
Production Wells:	6
Gas Injection Wells:	1
Water Injection Wells:	4
Tree Installation Type:	Wet Tree

HULL INFORMATION

Classification:	DNV GL
Dimensions:	
Length:	349 m
Width:	52 m
Depth:	27 m
Max operating draft:	22 m
Hull Construction Type:	Single Hull
Deadweight:	278,734 t
Construction Type:	Conversion
Original Hull Fabrication Year:	1976

PROCESS AND STORAGE CAPACITY

Oil Production Capacity:	75 Mbpd
Gas Compression Capacity:	54 MMscfd
Oil Handling Capacity:	80 Mbpd
Gas Injection:	0 MMscfd
Water Injection:	100 Mbpd
Storage Capacity:	2000 Mbbl

RISER INFORMATION

Total Risers and Umbilicals:	11
Production Risers:	4
Water Injection Risers:	2
Gas Injection Risers:	1
Gas Lift Risers:	2
Import/Export Risers:	0
Other:	0
Umbilicals:	2

TOPSIDE INFORMATION

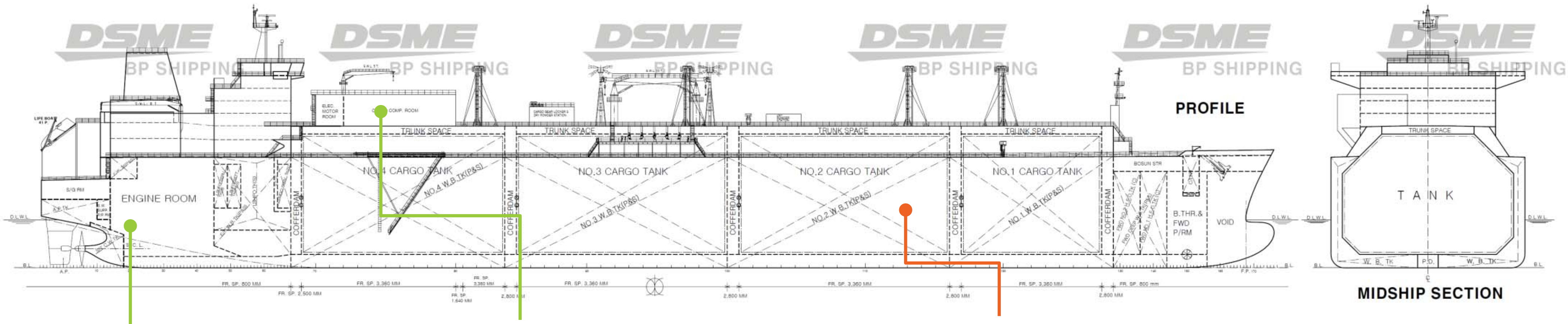
Installed Power:	48 MWe
Power System Design:	2 x Caterpillar Engines 1 x KKK Steam Turbine 2 x PBL Steam Turbine
Topside Module Weight:	7,138 t
LQ Capacity:	100 people
LQ Location:	Afterward
Gas Deposition:	Flared, Export
Type of Flare:	Flare Tower
Offloading System:	Tandem
Mooring System Type:	External Turret
Permanent or Disconnectable Mooring:	Permanent
Number of Anchor Legs:	9

B.1.3
Liquefied Natural Gas Carrier

Project Delphi – BP Shipping's 173,400m^3 LNG Carriers

Main Engines: MAN 2x 5G70ME-C9.5-GI
SMCR: 13,470 kW x 70.8 rpm
NCR: 12,120 kW x 68.4 rpm (90% of SMCR)

Auxiliary Engines: Wartsila W34DF
2x 9L34DF : 2 x 4100 kW (MCR: 4320 kW)
2x 6L34DF : 2x 2700 kW (MCR: 2880 kW)



Full re-liquefaction Sys

CCS NO96 GW
BoR 0.123%~ 209 m³/day

Exhaust Gas Recirc
NOx Tier III compliance

Delphi vs mid-2000s LNG Carrier:

- 0.123% BoR ~18% reduction in 'boil-off' gas
- ~15%-20% reduction in fuel consumption

HÖEGH LNG

ARCTIC LADY

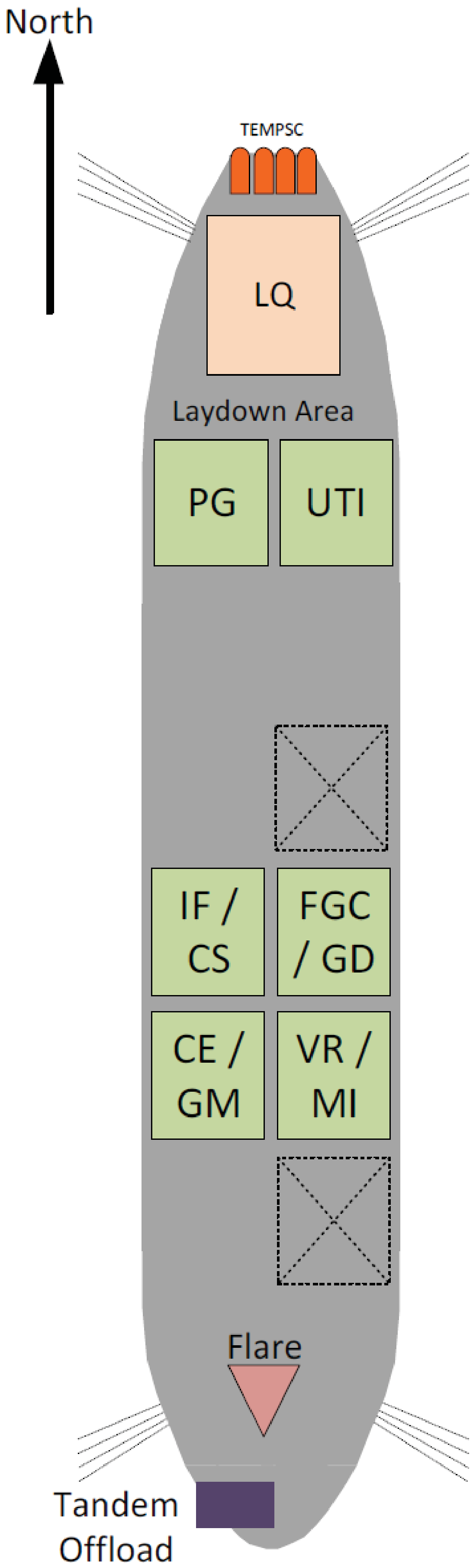
Disponent Ownership and Manager	Leif Hoegh (U.K) Limited
Vessel Operation	LNG Carrier
Year Built	2006
Builder	Mitsubishi Heavy Industries
Containment System	Moss
Cargo Capacity	147,980m^3
Regas Capacity	N/A
Classification	DNV-GL
Flag	NIS
Engine	Steam Turbine
Speed	19.5 knots
LOA	288 m
Beadth Moulded	49 m
Summer Draught	12.3 m
Gross Tonnage	121,597
Summer Deadweight	84,878 mt

HÖEGH LNG

ARCTIC PRINCESS

Disponent Ownership and Manager	Leif Hoegh (U.K) Limited
Vessel Operation	LNG Carrier
Year Built	2006
Builder	Mitsubishi Heavy Industries
Containment System	Moss
Cargo Capacity	147,980m^3
Regas Capacity	N/A
Classification	DNV-GL
Flag	NIS
Engine	Steam Turbine
Speed	19.5 knots
LOA	288 m
Beadth Moulded	49 m
Summer Draught	12.3 m
Gross Tonnage	121,597
Summer Deadweight	84,878 mt

B.1.4
Mooring Arrangement



FPSO Preliminary Spread Moored layout:

Water depth of 128 meters

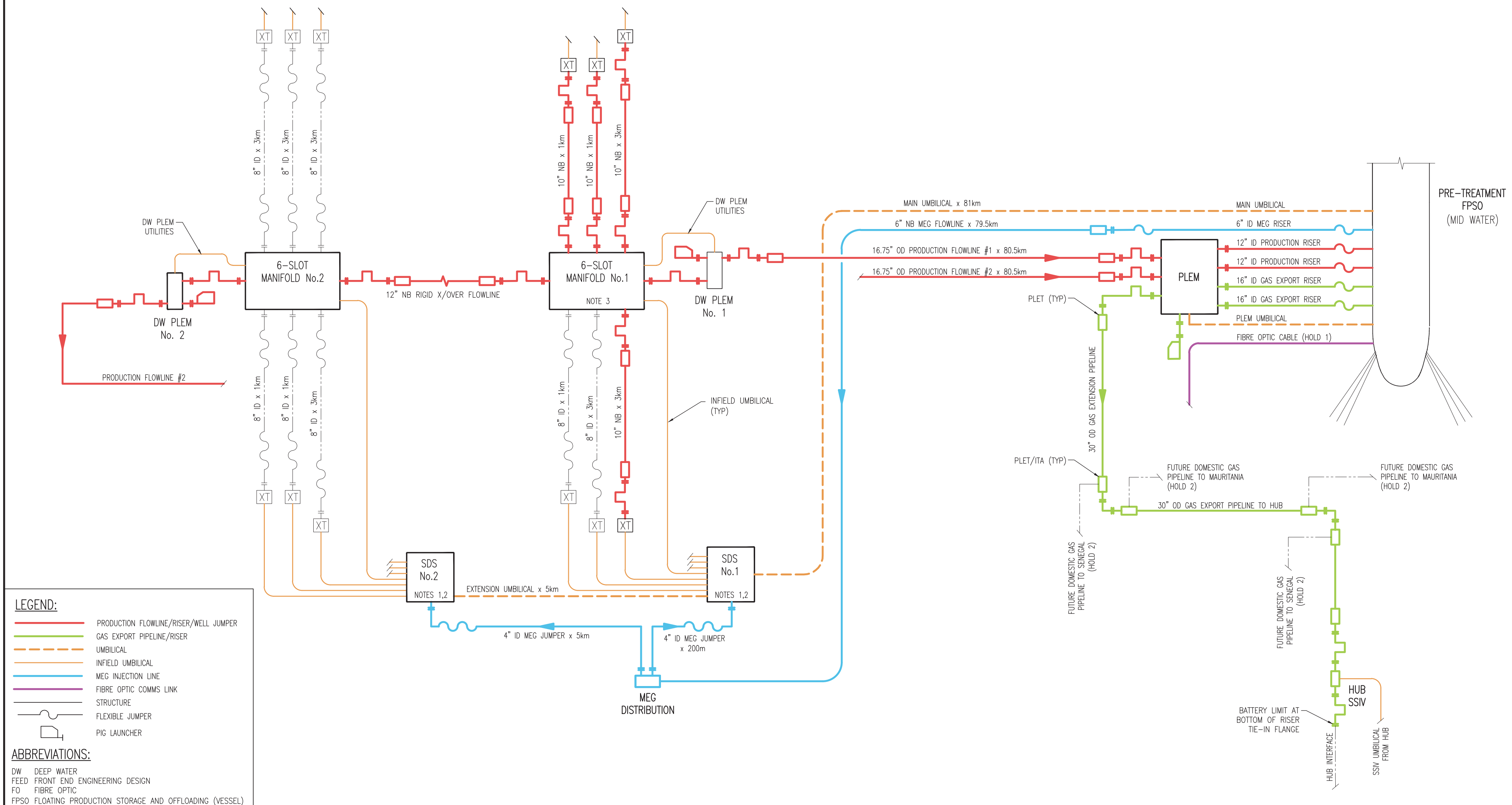
4 clusters of 4 mooring chains (total 16 mooring lines, all chain)

Chain size of 162mm diameter, grade R3

Length of each mooring line chain of 600 meters

Anchor type is driven piles, each Approx: 2 meters diameter, 30 meters depth, 55 tonne.

B.1.5
Subsea Production System



LEGEND:

- PRODUCTION FLOWLINE/RISER/WELL JUMPER
- GAS EXPORT PIPELINE/RISER
- UMBILICAL
- INFIELD UMBILICAL
- MEG INJECTION LINE
- FIBRE OPTIC COMMS LINK
- STRUCTURE
- FLEXIBLE JUMPER
- PIG LAUNCHER

ABBREVIATIONS:

DW	DEEP WATER
FEED	FRONT END ENGINEERING DESIGN
FO	FIBRE OPTIC
FPSO	FLOATING PRODUCTION STORAGE AND OFFLOADING (VESSEL)
FTA	FLOWLINE TERMINATION ASSEMBLY
ID	INSIDE DIAMETER
ITA	INLINE TERMINATION ASSEMBLY
MEG	MONOETHYLENE GLYCOL
NB	NOMINAL BORE
OD	OUTER DIAMETER
PLEM	PIPELINE END MANIFOLD
PLET	PIPELINE END TERMINATION
SDS	SUBSEA DISTRIBUTION SYSTEM
SSIV	SUBSEA ISOLATION VALVE
TYP	TYPICAL
XT	XMAS TREE

HOLDS:

1. *FIBRE OPTIC DISTRIBUTION TO BE CONFIRMED IN FEED.*
2. *DOMESTIC GAS TAKE-OFF LOCATIONS TO BE CONFIRMED IN FEED. BOTH OPTIONS ARE SHOWN FOR THE PURPOSE OF THIS SCHEMATIC.*

REVISION B01 OF THIS SCHEMATIC REFLECTS THE DEVELOPMENT CONCEPT AS PER THE LATEST BP COST ESTIMATE AT THE TIME OF ISSUE

1. SUBSEA DISTRIBUTION DETAILS AND PROTECTION STRUCTURES OMITTED FOR CLARITY.
2. FROM EACH OF THE SDS, HYDRAULIC, CHEMICAL, ELECTRICAL POWER AND FIBRE OPTIC SUPPLIES WILL BE DISTRIBUTED TO EACH MANIFOLD AND XT.
3. 4 WELLS CONNECTED TO MANIFOLD No. 1 REQUIRED FOR FIRST GAS (2021) SHOWN IN BOLD.
4. THIS SCHEMATIC DOES NOT GEOGRAPHICALLY REPRESENT THE CURRENT LAYOUT.
5. FUTURE CENTRAL TORTUE DEVELOPMENT NOT SHOWN.
6. TO BE USED IN CONJUNCTION WITH MS002-UZ-MTO-010-02002.
7. MAXIMUM XMT JUMPER LENGTH SHOWN IS 5km.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
B01	30.11.17	ADM	ISSUED FOR INFORMATION	ADM	ZZ	PL	

PROJECT NO.	H037
DESIGNED BY	A.MACKAY
DRAWN BY	A.MCKEACHAN
CHECKED BY	S.MACGREGOR
APPROVED BY	Z.ZANTI
SCALE	NTS

KBR

bp

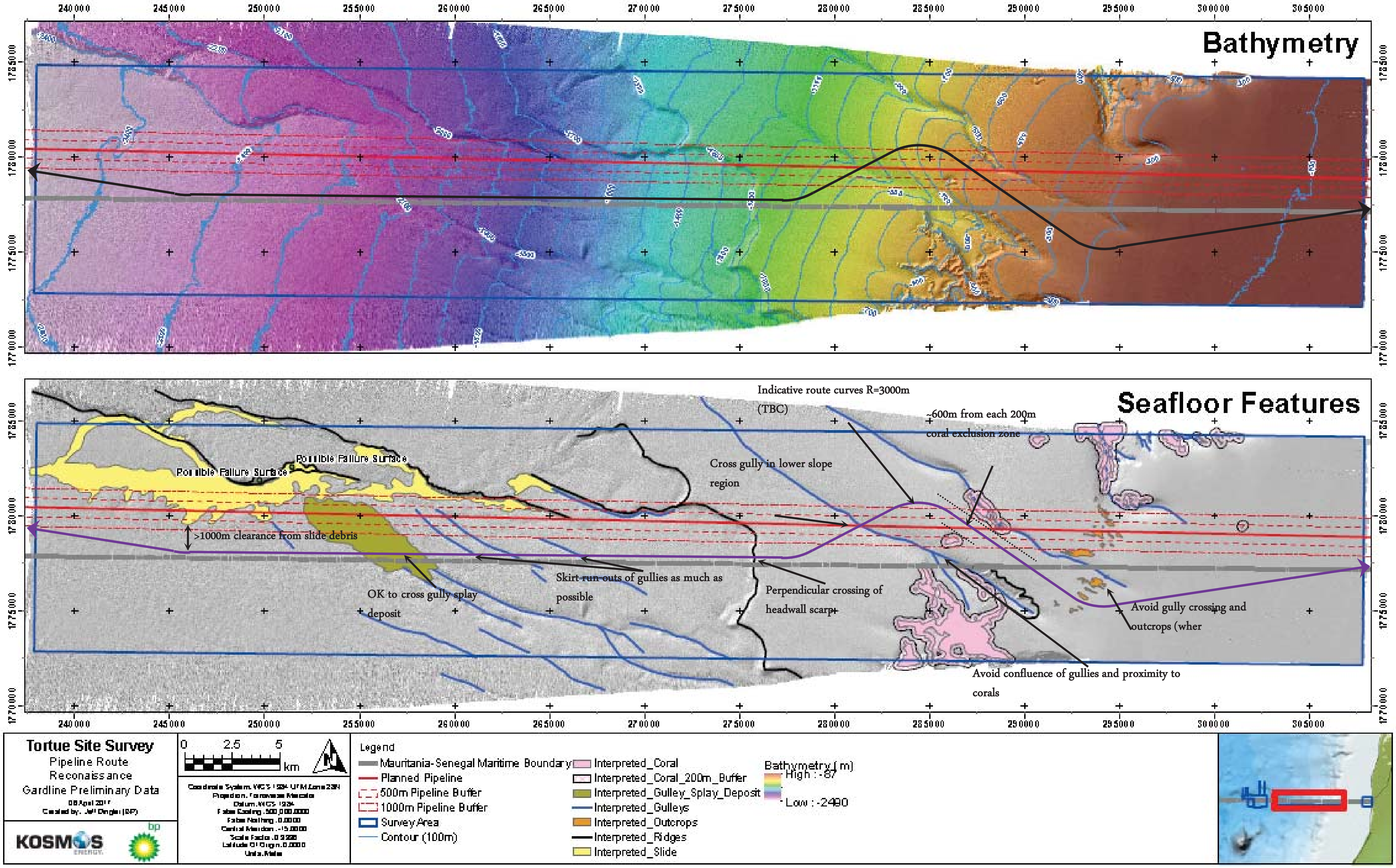
TORTUE DEVELOPMENT – PRE-FEED PHASE
FIELD LAYOUT SCHEMATIC
PHASE 1A

Grantherne DRAWING NO. MS002-UZ-SKE-010-02020-001

REV B01

B.1.6
Pipeline

Main export pipeline route (bathymetry / seabed features)



B.2
Vessel Specifications

Vessel	Preparation and Installation	Operation	Decommissioning
Dredger	✓	-	-
Rock Dumper	✓	-	-
Support Boat	✓	-	-
Crane Barge	✓	-	✓
HLD Barge	✓	-	-
Anchor Vessel	✓	-	✓
Tug Boat	✓	✓	✓
Guard Vessel	✓	✓	-
Standby Vessel	✓	-	✓
Supply Vessel	✓	✓	✓
Crew Boat	✓	✓	✓
Flotel	✓	-	-
Piling Vessel	✓	-	-
Derrick Barge	✓	-	-
Multi-Service Vessel	✓	-	✓
S-Lay Vessel	✓	-	-
J-Lay Vessel	✓	-	-
Heavy Lift Vessel	✓	-	-
ROV Survey Vessel	✓	-	✓
Pipe Carrier Vessel	✓	-	-
Dive Support Vessel	✓	-	-
Umbilical Installation Vessel	✓	-	-
Drillship	✓	-	✓
Liquefied Natural Gas Carrier	-	✓	-
Condensate Carrier	-	✓	-
Mooring Line Vessel	-	✓	-
Floating Production, Storage, and Offloading Vessel	-	✓	-

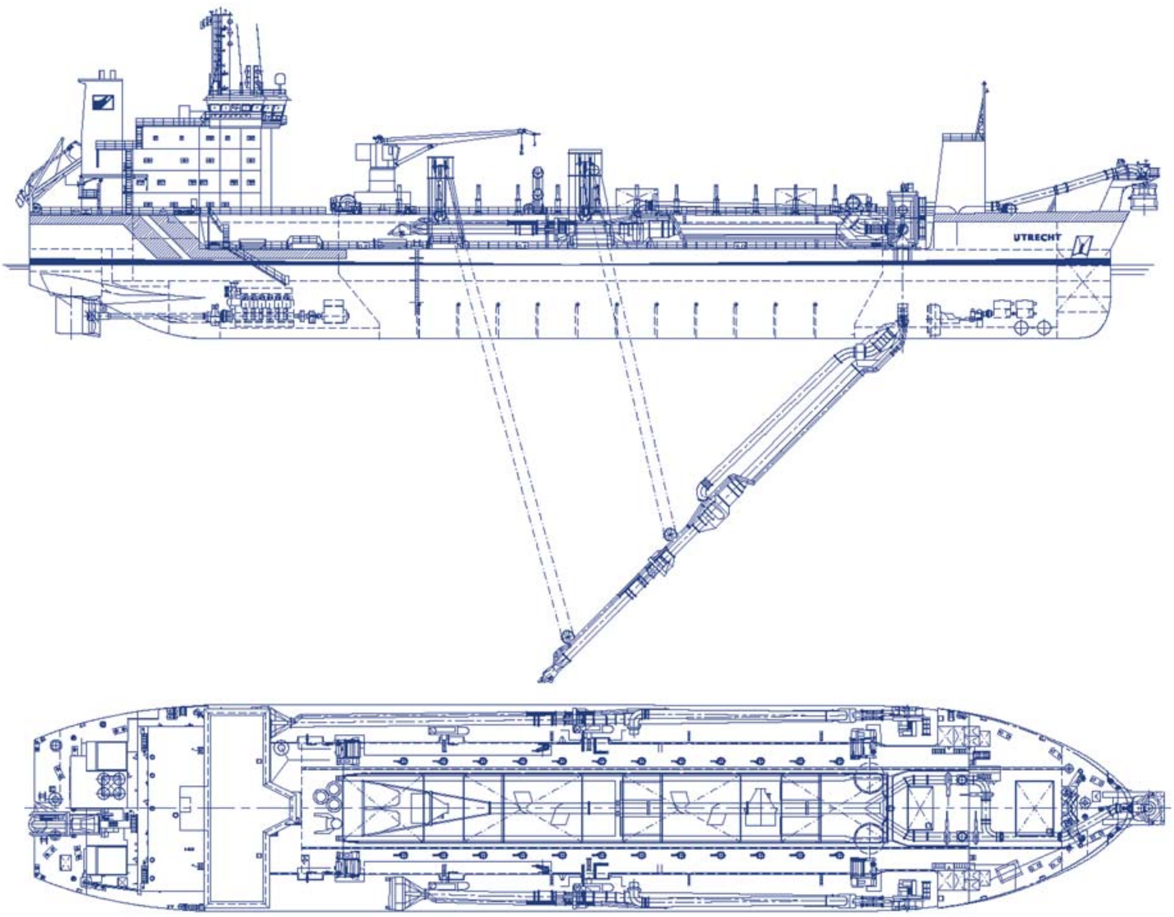
B.2.1
Dredger

Van Oord
Marine ingenuity

Equipment

Trailing suction hopper dredger
Utrecht

Van Oord
Marine ingenuity



Utrecht

Name	Utrecht
Type	Trailing suction hopper dredger
Classification	Bureau Veritas, I ✠ Hull ✠ Mach ✠ AUT-UMS, hopper dredger, unrestricted navigation, dredging over 15 miles from shore at draught 10.384 m, dredging within 8 miles from shore and dredging over 8 miles from shore with H.S. < 2.0 m at draught 10.806 m
Year of construction	1996
Dimensions	Length overall 159.65 m
	Breadth overall 28.03 m
	Moulded depth 11.85 m
	Draught – dredging mark I – 15 miles 10.38 m
	Draught – dredging mark II – 8 miles 10.80 m
Hopper capacity	18,292 m^3
Deadweight	26,016 tons
Maximum dredging depth	60/74.6 m

Suction pipes	2 x ø 1,100 mm
Discharge pipe	ø 1,000 mm
Speed loaded	15.5 kn
Propulsion	2 x 7,000 kW
Bow thrusters	2 x 750 kW
Total power installed	23,807 kW
Inboard dredge pumps	2 x 2,600 kW
Submerged dredge pumps	2 x 1,800 kW
Jet pumps	2 x 1,250 kW

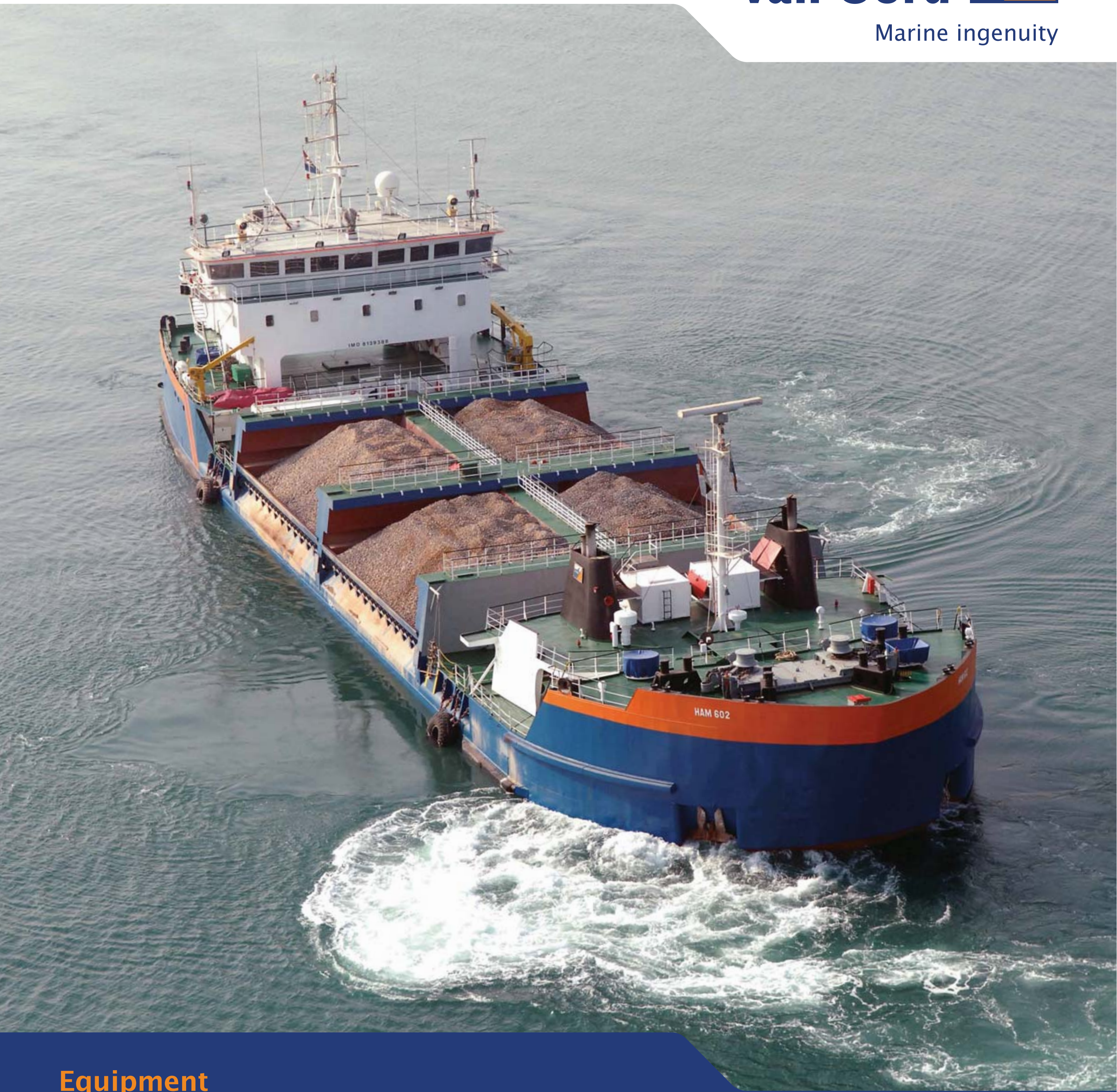
Contact

Van Oord
PO Box 8574
3009 AN Rotterdam
The Netherlands
T +31 88 8260000
F +31 88 8265010
E info@vanoord.com
I **www.vanoord.com**

August 2015

B.2.2
Rock Dumper

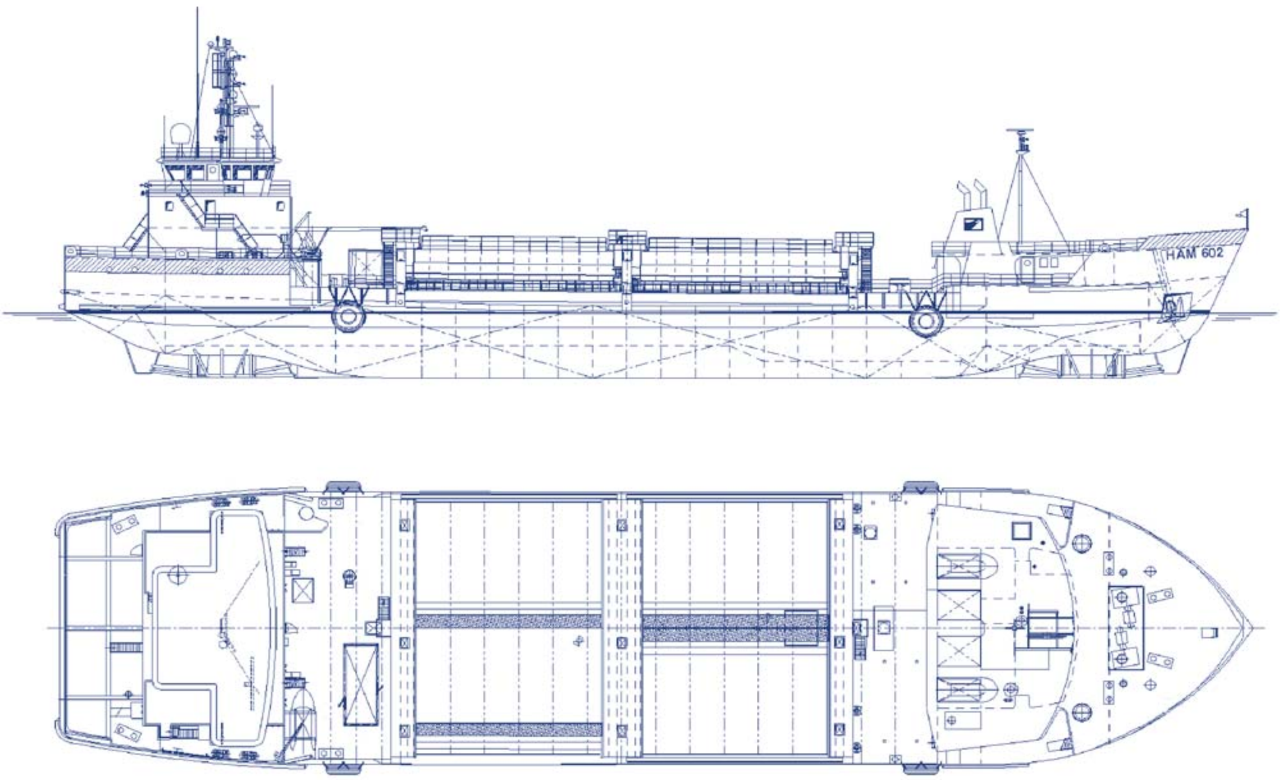
Van Oord
Marine ingenuity



Equipment

Side stone dumping vessel
HAM 602

Van Oord
Marine ingenuity



HAM 602

Name	HAM 602
Type	Side stone dumping vessel
Classification	Bureau Veritas, I ✠ Hull ✠ Mach, special service, unrestricted navigation
Year of construction	1968
Year of upgrading	2006
Dimensions	Length overall 83.39 m
	Breadth overall 21.04 m
	Moulded depth 6.30 m
	International draught 4.80 m
Deadweight	2,605 tons
Tonnage	2,601 GT - 780 NT
Speed loaded	6.5 kn
Propulsion	2 x 882 kW
Total power installed	4,129 kW
Positioning	DP

Contact

Van Oord
PO Box 8574
3009 AN Rotterdam
The Netherlands
T +31 88 8260000
F +31 88 8265010
E info@vanoord.com
I **www.vanoord.com**

Van Oord Offshore
PO Box 458
4200 AL Gorinchem
The Netherlands
T +31 88 8265200
F +31 88 8265210
E area.off@vanoord.com

August 2015

B.2.3
Support Boat

DAMEN CONSTRUCTION SUPPORT VESSEL 8019

GENERAL

Basic Functions	Light Offshore Construction Works by means of Offshore rated knuckle boom crane and ROV support on a stable DP-2 platform
Classification	Lloyds Register ✠ 100A1, ECO, WDL(5 T/M2), ✠ LMC, UMS, *IWS, DP(AA), CAC(3), Helicopter Landing Area

DIMENSIONS

Length o.a.	84.20	m
Beam mld.	19.00	m
Depth mld.	8.00	m
Draught summer	6.00	m
Deadweight (summer)	3200	t
Deck area	550	m^2
Deck load (VCG at 1 m above deck)	1000	t

TANK CAPACITIES

Ballast water	1600	m^3
Fuel oil (service)	850	m^3
Potable water	980	m^3
Fuel oil cargo	730	m^3

PERFORMANCES (APPROX.)

Speed (at 5.00 m draught)	13.5	kn

PROPULSION SYSTEM

Main engines	Diesel-electric, 690 V, 60 Hz	
Propulsion power	2x	electric motors of 2200 kW each
Azimuting thrusters	2x	2800 mm FP propellers in nozzles
Bow thrusters	3x	900 kW, 2000 mm, FP

AUXILIARY EQUIPMENT

Networks	690 V, 440 V and 230 V - 60 Hz	
Main generator sets	4x	1880 ekW at 900 rpm
Emerg./Harbour generator set	1x	430 ekW at 1800 rpm
Shore Supply	1x	400A

DECK LAY-OUT

Anchor mooring winch	1x	electric-hydraulic, with rope drum and two warping heads
Capstans	2x	electric, each 5 t pull
Store crane	1x	knuckle boom 3 t at 16 m (harbour)

CARGO HANDLING SYSTEM

Offshore crane	1x	offshore knuckle boom crane, max 100 t at 10 m. Active heave compensated winch with 3000 m wire
Tugger winch	2x	electric-hydraulic, 10 t pull

ROV SUPPORT

Launch and recovery	1x	hydraulic operated A-frame, 12 t
Operational	1x	ROV control station
	1x	ROV workshop

HELICOPTER FACILITIES

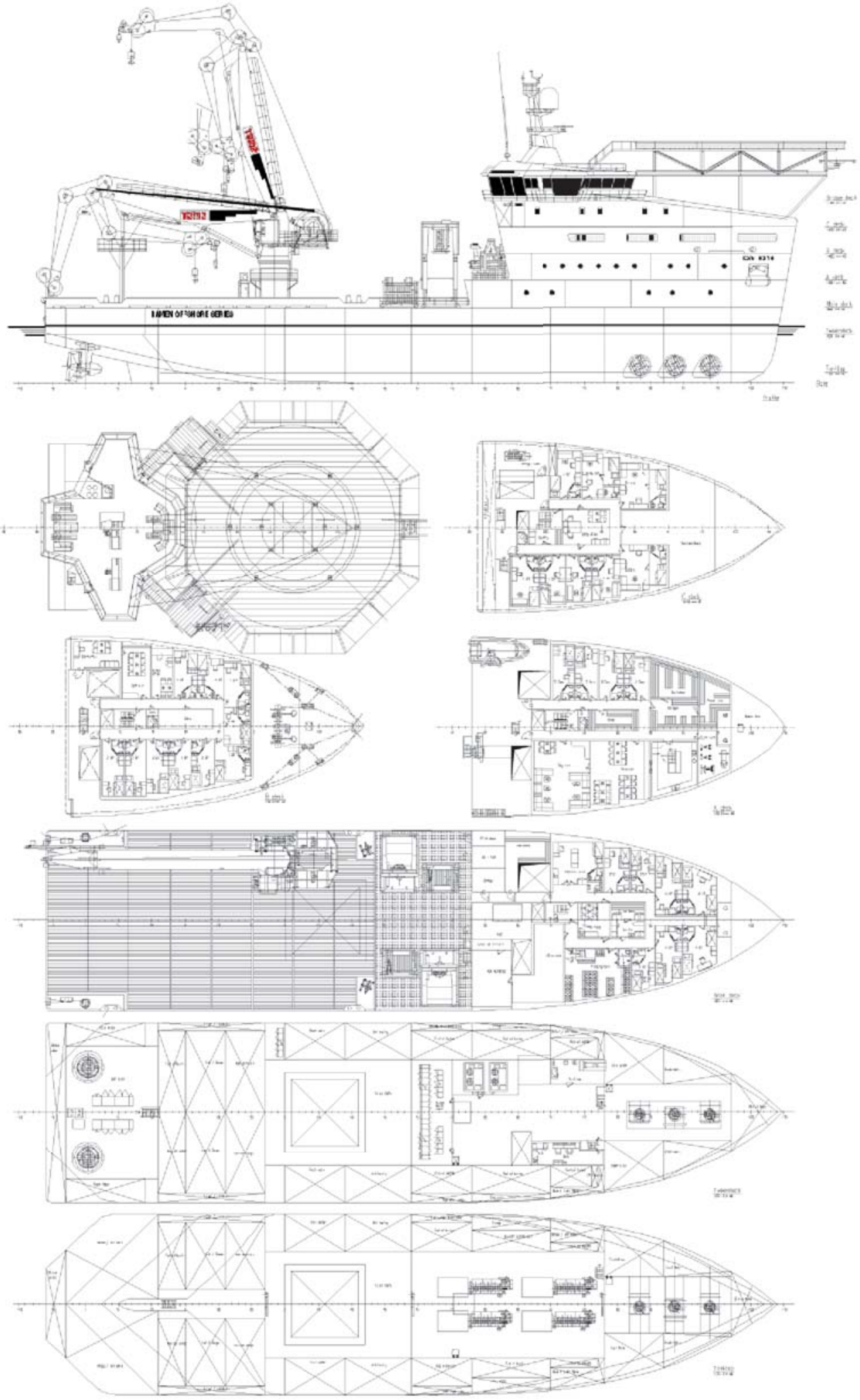
Helicopter deck capacity	D-factor 21 m, take-off weight 12 ton

ACCOMMODATION

Single berth cabins	10x
Double berth cabins	14x
4 berth cabins	4x
	Offices, conference room, recreation rooms all cabins provided with internet, telephone and satellite tv.

NAUTICAL AND COMMUNICATION EQUIPMENT

Nautical	radar X-band + S-band, ECDIS, Conning
DP-system	DP-2 with Hydro-Acoustic and Laser reference systems
GMDSS	Area A3



DAMEN CONSTRUCTION SUPPORT VESSEL 8019

DAMEN

DAMEN SHIPYARDS GORINCHEM

Member of the DAMEN SHIPYARDS GROUP

Industrieterrein Avelingen West 20
4202 MS Gorinchem

P.O. Box 1
4200 AA Gorinchem
The Netherlands

phone +31 (0)183 63 99 11
fax +31 (0)183 63 21 89

info@damen.nl
www.damen.nl

B.2.4
Crane Barge

TRANSSHIPMENT CRANE BARGE 6324

“STOCK - YN 522002 / YN 522003”

GENERAL

Yardnumber	522002 / YN 522003
Delivery date	June and October 2017
Basic functions	Transshipment of bulk cargoes, containers and breakbulk
Classification	Lloyd’s Register of Shipping: ✠ 100 AT, Pontoon, *IWS
Descriptive note	Crane Pontoon, manned working up to 20 nm offshore, unmanned towing
Performance dry cargo	Dry bulk transshipment up to 1000 tonnes per hour
Performance containers	20 ft and 40 ft containers, handling with chains, manual-, semi- of full automatic spreader.
Flag	St. Vincent and the Grenadines

DIMENSIONS

Length moulded	63,00 m
Beam moulded	23.50 m
Depth at sides	4,50 m
Draught scantling	3,50 m
Draught design	2.50 m
Deadweight max.	1.720 ton
Working deck area	880 m2 (10 ton/m²)
Gross tonnage	1.970 GT

TANK CAPACITIES

Fuel oil	220 m3
Fresh water	85 m3
Sewage & Grey water	80 m3
Lub. oil	5 m3
Dirty oil / Sludge	10 m3
Bildge water	5 m3
Water ballast	1.760 m3

CRANE PERFORMANCE

Make and type	Liebherr CBG 350
Operation	Prepared for Grab, Containers or hook
SWL sheltered operation	45 ton @ 12-36 m (excl. attachments)
SWL open sea operation	35 ton @ 12-36 m (excl. attachments)
Hoisting speed (35 T)	0-60 m/min
Hoisting speed (45 T)	0-46 m/min
Luffing time 12-36 M	63 sec.

AUXILIARY EQUIPMENT

Main generator sets	2 x Caterpillar C18
Back-up generator	1 x Caterpillar C18
Power each	545 kVA / 436 ekW (1800 rpm), 440 V-60 Hz
Habour generator set	1 x Caterpillar C4.4
Power	119 kVA / 95 ekW (1800 rpm), 440 V, 60 Hz

DECK LAY-OUT

Anchor mooring system	4 DMT Electric double drum winches
Anchors	3 Anchors
Towing brackets	3 Towing brackets SWL 100 ton
JIB rest	Slim design, with optional positioning system
Deck covering	440 m2 fir wood
Container fittings	For 28 TEU or 14 FEU locations or a combination With a stack load of 50 ton
Fendering	Third pipe steel fenders, Tyre fenders
Life rafts	2 inflatable rafts for 12 persons

ACCOMMODATION

Accommodation with pantry, change room, office and cabins for a maximum of 12 persons, provided with ventilation, air conditioning and heating.

NAUTICAL AND COMMUNICATION EQUIPMENT

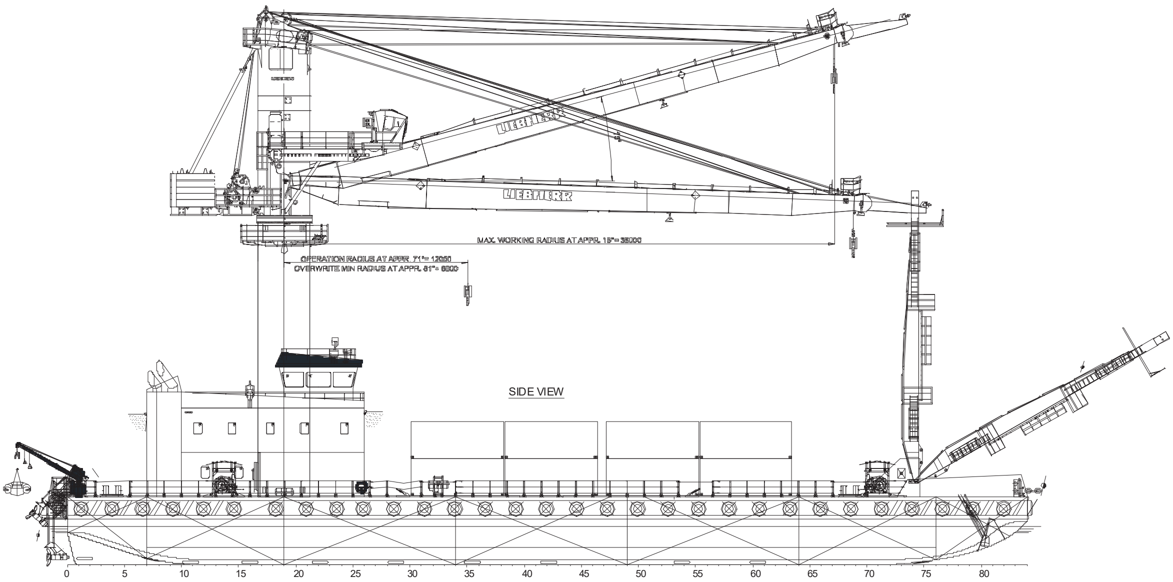
Navigation lighting and communication system according Classification

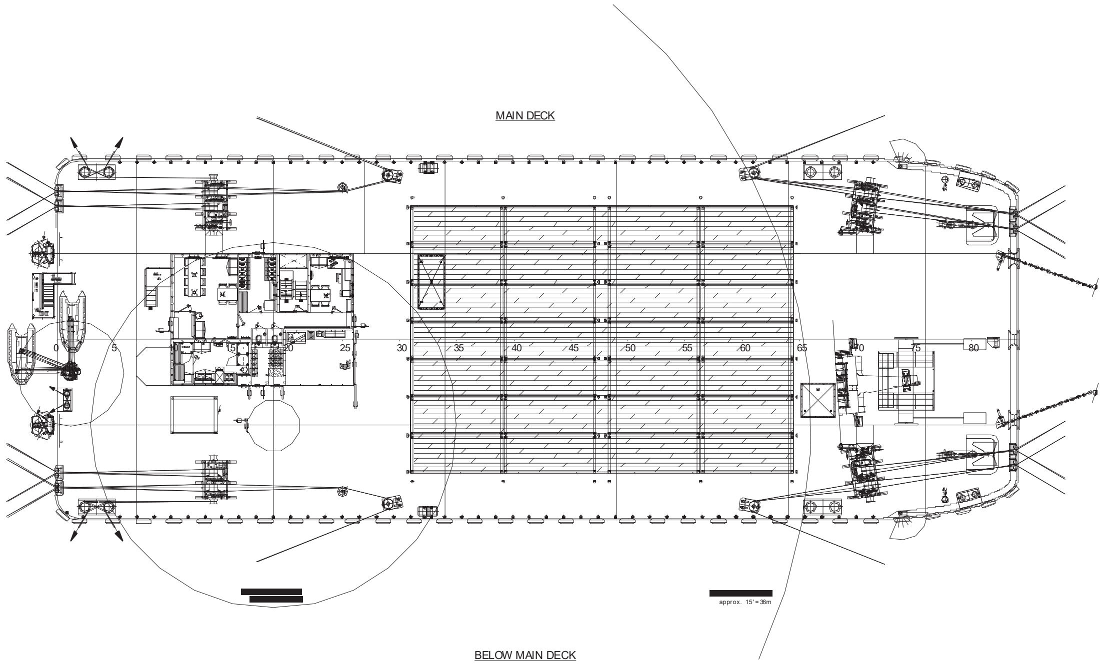
OPTIONAL EQUIPMENT

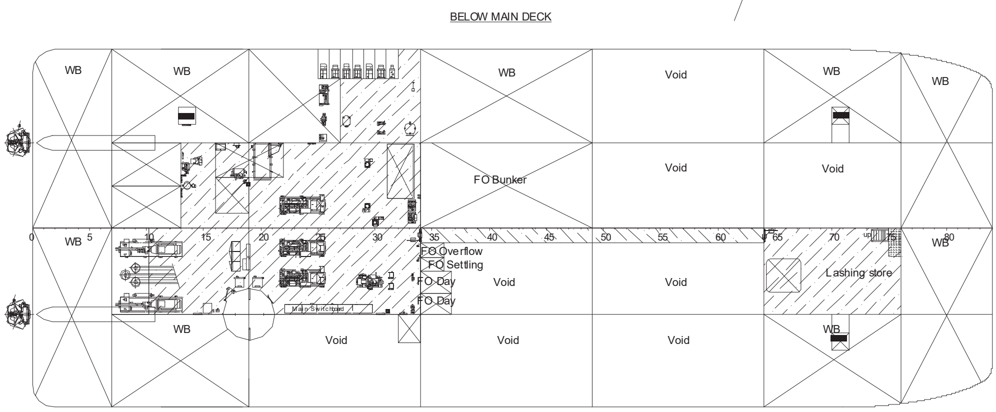
JIB rest inclination system	Hydraulic cylinder and controls for positioning the JIB rest forward to have more clearance and 5° backward for servicing the sheaves
Classification	Lloyd’s Register of Shipping: Assisted Propulsion
Thrusters aft	2 x 323 kW deck mounted thruster system
Workboat	Inflatable dinghy with davit on aft deck
Grab equipment	Grabs, grab storage
Container equipment	Semi-, of Full Automatic Container spreader
Towing gear	Towing bridle
Navigation	Navigation equipment in combination with the optional thrusters

TRANSSHIPMENT CRANE BARGE 6324

“STOCK - YN 522002 / YN 522003”







DAMEN

DAMEN SHIPYARDS GROUP

Avelingen-West 20
4202 MS Gorinchem
The Netherlands

P.O. Box 1
4200 AA Gorinchem
The Netherlands

phone +31 (0)183 63 99 22
fax +31 (0)183 63 21 89

info@damen.com
www.damen.com

02-2017

B.2.5
HLD Barge

EQUIPMENT SHEET

BOKALIFT 1,
3,000MT DP-2 CRANE VESSEL

CONSTRUCTION/CLASSIFICATION

Vessel built by	Guangzhou Shipyard International Co. Ltd. 2012
Year of conversion	2017
Classification	BV | ✠ Hull ✠ Mach, Cleanship Ice, Class 1D
IMO	9592850
Call sign (flag)	5BVH4 (Cyprus)

FEATURES

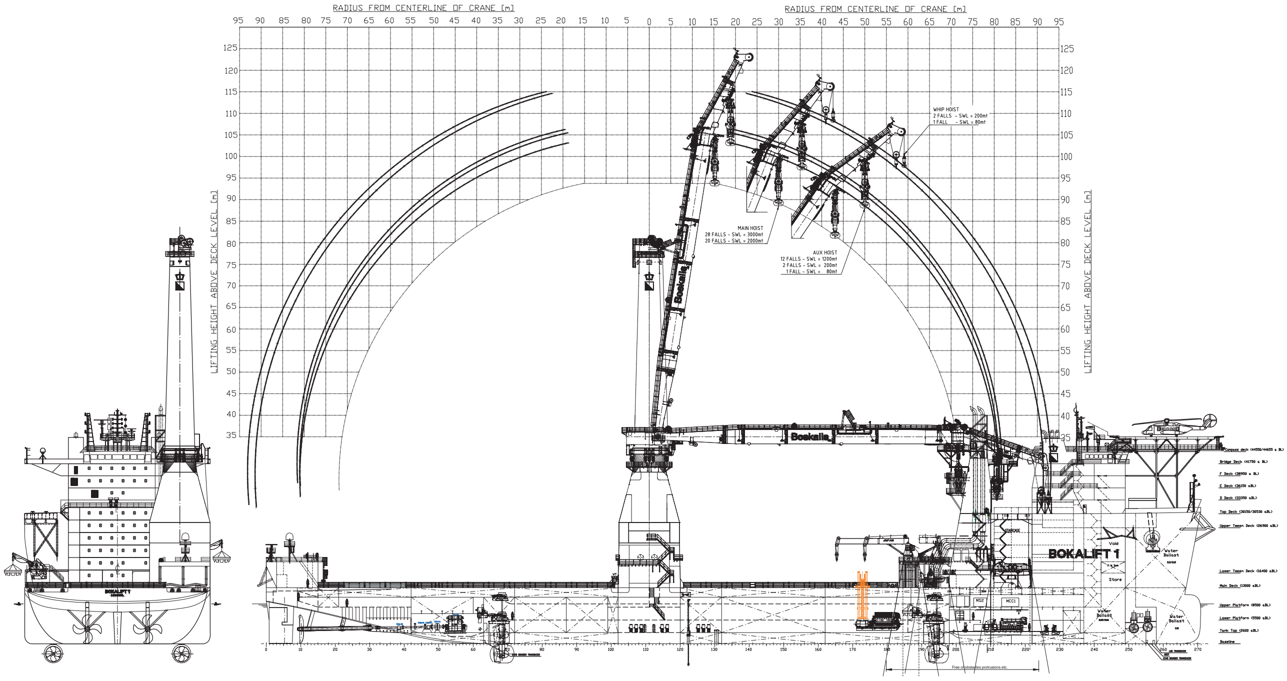
Accommodation	150 persons SPS compliant
Lifting Capacity main block auxiliary block	3,000 T up to 28 m radius 1,200 T up to 50 m radius 800 T up to 81 m radius
whip hoist (double fall) whip hoist (single fall)	200 T up to 92 m radius 80 T up to 94 m radius
Lift height above deck main block auxiliary block	 90 m at 30 m radius 99 m at 35 m radius
Depth range auxiliary block	1,128 T at 230 m water depth
Aux block, re-reeved for max. depth range	330 T at 900 m water depth Depth range whip block single line 1,900 m water depth
Cargo deck Size Rated Max deck load	 6,300 m² 25 T/m² 15,000 T
Max. transit speed	12.5 kn
Store crane	2 x 30 T at 10 m radius 20 T at 16.5 m radius
Air draft	85 m
Helideck	Suitable for S-61N and S-92 max take-off weight: 12.8 T

MAIN VESSEL DATA

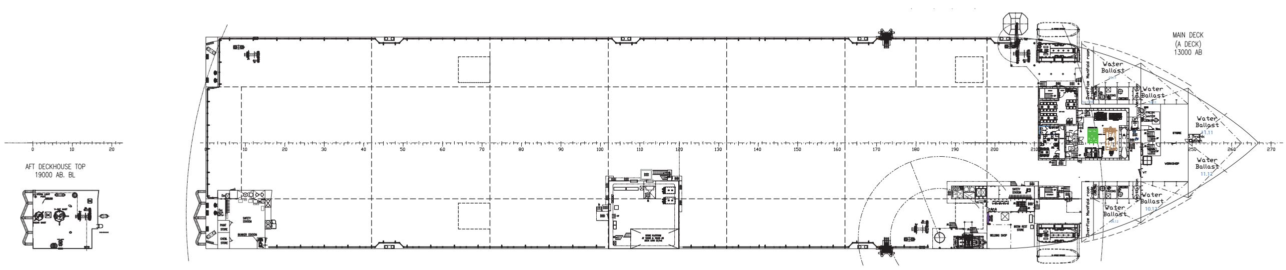
DP System	Kongsberg DP-2
Reference systems	DGPS HiPaP
Vessel dimensions Length oa Breadth Depth moulded Operating draft	 216 m 43 m 13 m 8.5 m (expected)
Installed power Main engines Auxiliary engine	 4 x 3,840 kW 2 x 4,800 kW 1,110 kW
Propulsion Main sailing Retractables Bow thrusters	 2 x 5,250 kW 4 x 3,500 kW 2 x 1,200 kW
Mooring system	Optional 8-point mooring system
Ballast capacity	2 x 1,500 cum/hr
Anti-heeling system	8 x 2,000 cum/h

Boskalis

BOKALIFT 1,
3,000MT DP-2 CRANE VESSEL



SIDE VIEW



TOP VIEW

Royal Boskalis Westminster N.V.
PO Box 43
3350 AA Papendrecht
The Netherlands

T +31 78 69 69 000
F +31 78 69 69 555

royal@boskalis.com
www.boskalis.com

B.2.6
Anchor Vessel

DAMEN ANCHOR HANDLING TUG SUPPLY 180

AHTS 18000

GENERAL

Basic functions	Offshore supply, towing and anchor handling operations
Classification	Lloyds Register ✠100 A1 Anchor Handler, Offshore Supply Ship, Tug, *IWS, ✠ LMC UMS DP(AM)

DIMENSIONS

Length o.a.	79.20	m
Length b.p.p.	73.50	m
Beam mld.	20.00	m
Depth mld.	8.40	m
Draught summer (base)	6.80	m
Draught summer (keel)	7.40	m
Deadweight (summer)	2700	t
Cargo deck area	545	m^2
Deck load (at 1 m above deck)	800	t

TANK CAPACITIES

Ballast water	900	m^3
Fuel oil	1045	m^3
Potable water (service)	220	m^3
Potable water (cargo)	540	m^3
Chain lockers	280	m^3

PERFORMANCES (APPROX.)

Speed (at summer draught)	15.4	kn
Bollard pull	180	t

PROPULSION SYSTEM

Main engines	4x	MAN 7L27/38
Propulsion power	4x	2555 bkW
Propellers	2x	4300 mm, CPP in optima nozzels
Bow thruster	2x	750 kW, 1740mm, FPP
Stern thruster	1x	820 kW,1740mm, FPP

AUXILIARY EQUIPMENT

Networks		690 V, 440 V and 230 V
Shaft generators	2x	1500 ekW at 1800rpm
Main generator sets	2x	Caterpillar C18, 550 ekW each at 1800 rpm, 690 V, 60 Hz
Emerg./ harbour generator set	1x	Caterpillar C9, 238 ekW at 1800 rpm, 440 V, 60 Hz

DECK LAY-OUT

Deck crane	1x	5 t @ 10 m
	1x	2.9 t @ 9m / 1.6 t @ 16.4 m
Anchor mooring winch	1x	Electric-hydraulic, with rope drum and two warping heads
AH/Towing winch	1x	electric, double drum, 410 t pull, 450 t brake, 5600 m of 86 mm wire
Secondary winch	2x	electric, 130 t pull, 130 t brake, 1100 m of 203 mm rope
Towing pins	4x	SWL, 180 t, hydraulic
Chain fork	2x	SWL, 500 t, hydraulic
Stern roller	1x	SWL, 500 t, split drum, ø 3.0 m, 6 m length
Tugger winches	2x	electric, each 15 t pull
Capstans	2x	electric-hydraulic, each 10 t pull

CARGO HANDLING SYSTEM

Ballast pump	2x	100 m³/hr at 3 bar
Fuel oil pump	1x	100 m³/hr at 9 bar
Fresh water pump	1x	100 m³/hr at 9 bar

ACCOMMODATION

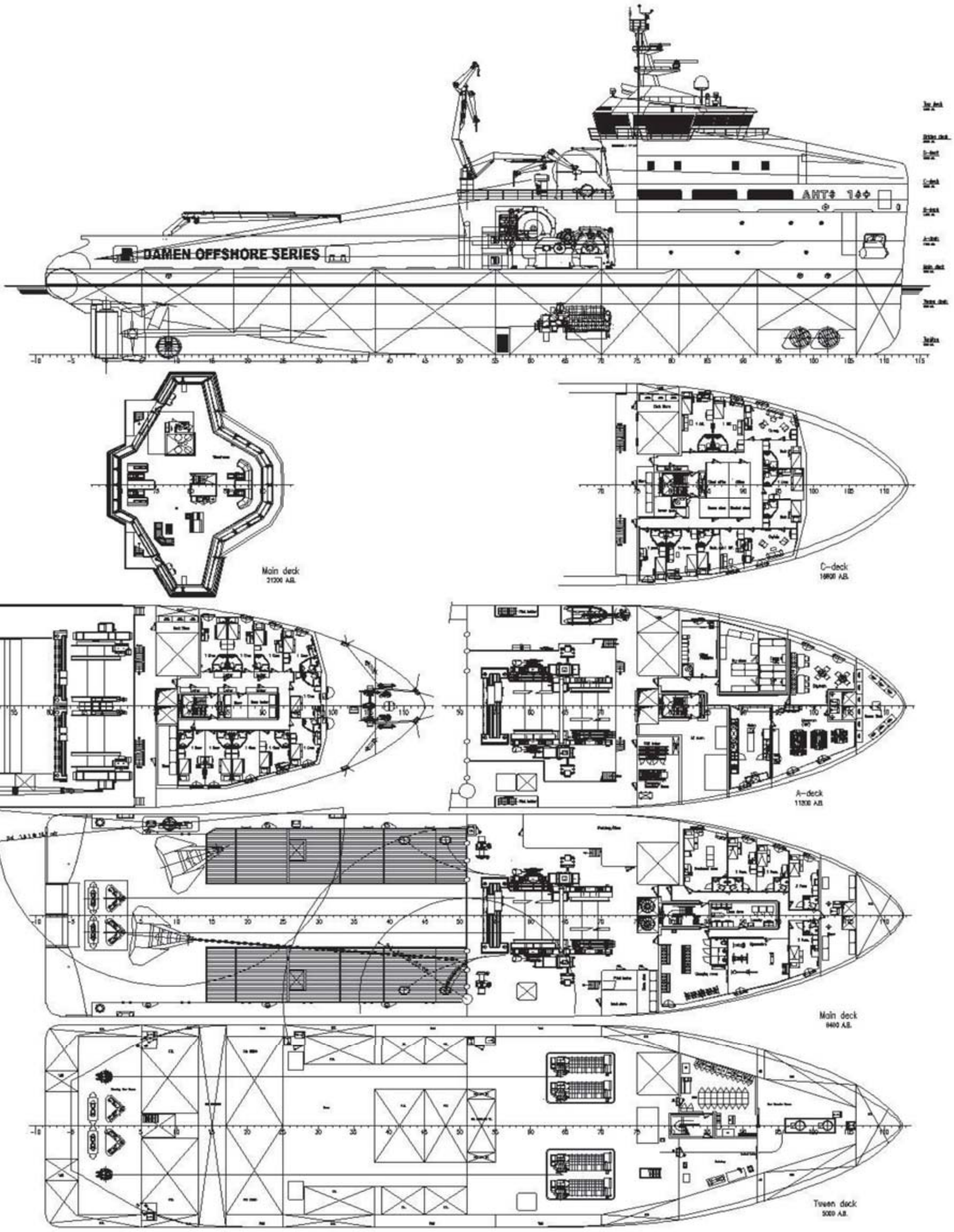
Crew	16	persons
Passengers	11	persons

NAUTICAL AND COMMUNICATION EQUIPMENT

Radar systems	1x X- band + S-band
DP – system	DP 1
GMDSS	Area A3

OPTIONS

Fire Fighting Ship 1 or 2
IMO DP Class 2
Travelling cranes
Hybrid propulsion
Hydraulic AHT Winch
Extended accomodation



DAMEN ANCHOR HANDLING TUG SUPPLY 180

AHTS 18000

DAMEN

DAMEN SHIPYARDS GORINCHEM

Member of the DAMEN SHIPYARDS GROUP

Industrieterrein Avelingen West 20
4202 MS Gorinchem

P.O. Box 1
4200 AA Gorinchem
The Netherlands

phone +31 (0)183 63 99 11
fax +31 (0)183 63 21 89

info@damen.nl
www.damen.nl

DSGo-D&P-3.0-0612

B.2.7
Tug Boat

AZIMUTH TRACTOR DRIVE TUG 2412 TWIN FIN

“CAPE LEEUWIN”

GENERAL

Yard number	545018
Delivery date	March 2017
Basic functions	Towing, mooring and fire-fighting operations
Classification	Lloyd’s Register ✠ 100 A1 Tug [✠] LMC UMS IWS
Flag	Australia
Owner	Mackenzie Marine & Towage Pty Ltd

DIMENSIONS

Length overall	24.74 m
Beam overall	12.63 m
Depth at sides	4.60 m
Displacement	503 t

TANK CAPACITIES

Fuel oil	69.5 m^3
Fresh water	8.0 m^3
Lubrication oil	6.9 m^3
Bilge water	5.9 m^3
Foam	5.5 m^3
Dirty oil	3.0 m^3
Sewage	3.4 m^3

PERFORMANCES

Bollard pull	70.4 t
Speed ahead	12.5 kn
Speed astern	12.7 kn

PROPULSION SYSTEM

Main engines	2x Caterpillar 3516C TA HD+/D
Total power	4200 bkW (5632 bhp) at 1600 rpm
Azimuth thrusters	Rolls Royce US 255 FP
Slipping clutches	Rolls Royce ‘built in’ type
Propeller diameter	2600 mm
Forced ventilation	60.000 m^3/h

AUXILIARY EQUIPMENT

Generator sets	2x Caterpillar C4.4 TA, 230/400 V, 86 kVA, 50 Hz
Bilge/general service pumps	2x Sterling AKHA 5101, 20 m^3/h
Fuel oil pumps	2x Sterling R35/40, 3.4 m^3/h
Fuel oil filters	2x Coalester filters incl. water separator
Sewage pump	Libellula L1-3H, 6.6 m^3/h
Cooling system	Box cooling + anti-growth system
Hydraulic system	Double main engine driven pumps
Fifi set	Diesel driven pump 600 m^3/h
Fifi monitor	1x 600 m^3/h, water/foam

DECK LAY-OUT

Anchors	2x 360 kg Pool (High Holding Power)
Anchor winch	Electrically driven 10 m/min incl. warping head
Towing winch aft	Hydraulically driven split drum 33 ton at 11 m/min, slack rope speed up to 51 m/min, 150 ton brake
Fendering	Cylinder + block stern fender, D-fender side/fore and tyre fendering

ACCOMMODATION

For 4 persons, completely insulated and finished with durable modern linings, acoustical ceiling in the wheelhouse, floating floors and air-conditioning. Accommodation above main deck with a captain’s cabin, chief engineer’s cabin, one double crew cabin, galley, mess/dayroom and sanitary facilities.

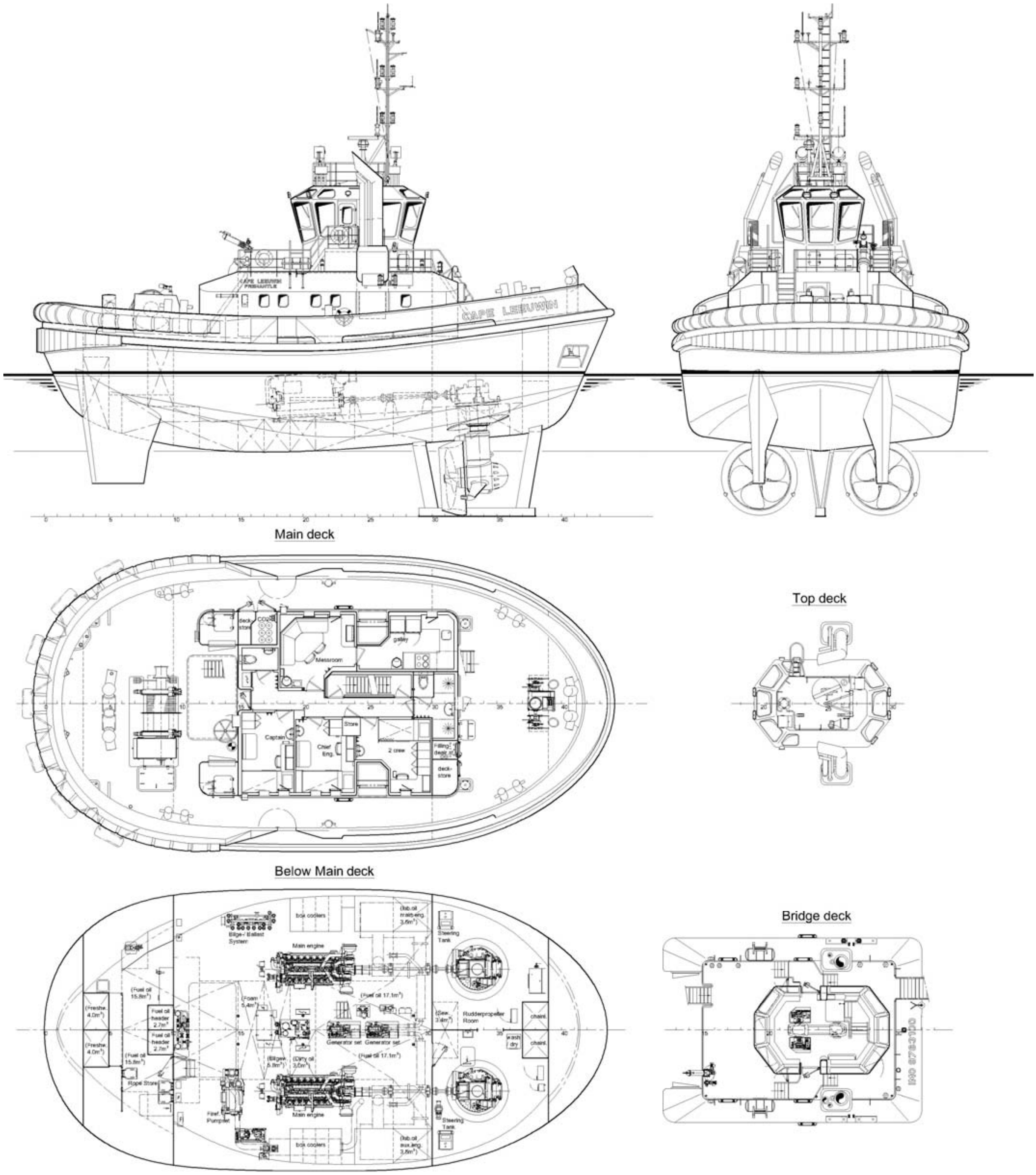
NAUTICAL AND COMMUNICATION EQUIPMENT

Searchlights	2x Pesch 1000 W
Radar system	Furuno FAR 2117
Compass	Magnetic Kotter
Autopilot	Simrad AP-70
GPS	Furuno GP-170
Echo sounder	Furuno LS-6100
VHF radio telephone	2x Sailor Compact 6222, 25 W
VHF hand-held	2x Jotron TRON TR-20, GMDSS approved
Inmarsat	Furuno Felcom 18
AIS	Furuno FA-150
Navtex	Furuno NX-700A
EPIRB	Jotron Tron-60S
Sart	Jotron Tron Sart 20

DAMEN

AZIMUTH TRACTOR DRIVE TUG 2412 TWIN FIN

“CAPE LEEUWIN”



DAMEN SHIPYARDS GROUP

Avelingen-West 20
4202 MS Gorinchem
The Netherlands

P.O. Box 1
4200 AA Gorinchem
The Netherlands

phone +31 (0)183 63 99 22
fax +31 (0)183 63 21 89

info@damen.com
www.damen.com

AZIMUTH STERN DRIVE TUG 3212

“MARS”

GENERAL

Yard number	512531
Delivery date	February 2017
Basic functions	Push-pull, escorting, towing and fire-fighting operations
Classification	I ✠ HULL • MACH Escort Tug Unrestricted Navigation AUT UMS IWS Fire Fighting Ship 1 (2400 m^3/h)
Flag	The Netherlands
Owner	Sleepdienst B. Iskes & ZN B.V.

DIMENSIONS

Length overall	32.70 m
Beam overall	12.82 m
Depth at sides	5.35 m
Draught aft	5.53 m
Displacement	793 t

TANK CAPACITIES

Fuel oil	132.6 m^3
Fresh water	15.2 m^3
Sewage	5.2 m^3
Lubrication oil	8.2 m^3
Dirty oil	4.8 m^3
Sludge	2.5 m^3
Bilge water	6.8 m^3
Foam	10.4 m^3

PERFORMANCES

Bollard pull ahead	82.5 t
Bollard pull astern	76.1 t
Speed ahead	14.1 kn
Speed astern	14.0 kn

PROPULSION SYSTEM

Main engines	2x Caterpillar 3516C HD+ TA/D
Total Power	5050 bkW (6772 bhp) at 1800 rpm
Thrusters	2x Rolls Royce US 255 P30 FP Special
Propeller	2800 mm Fixed Pitch
Forced ventilation	20.000/40.000 m^3/h

AUXILIARY EQUIPMENT

Generator sets	2x Caterpillar C6.6 TA, 230/400 V, 125 kVA, 50 Hz
Bilge pumps	2x Sterling AKHA 6101, each 34 m^3/h
Fuel pumps	Sterling AKHA 5101 and AOHA 3101
Cooling system	Box cooling + anti-growth system
Fresh water pressure set	Sterling HBK 111 / AOHA 3101
Hydraulic system	Main engine driven pumps
Fifi set	Fire-fighting pump (FIFI 1 2400 m^3/h) driven by independent fixed mounted diesel engine combined with foam mixer
Fifi monitor	2x 1200 m^3/h water and 2x 300 m^3/h foam

DECK LAY-OUT

Anchor	2x 495 kg Pool (High Holding Power)
Anchor/towing winch	Hydraulically driven double drum winch, two speed winch, pull 38 ton at 12 m/min at second layer, 200 ton brake
Capstan	5 ton at 15 m/min, electrically driven
Crane	Heila HLRM 20-3S + winch MW 22
Towing hook aft	Mampaey SWL 100 ton
Towing winch aft	Hydraulically driven single drum winch with spooling device and warping head, pull 38 ton at 12 m/min at second layer and 200 ton brake
Fendering	D-fender at sides, cylinder fender at transom corners, cylinder bow fender with waterspray

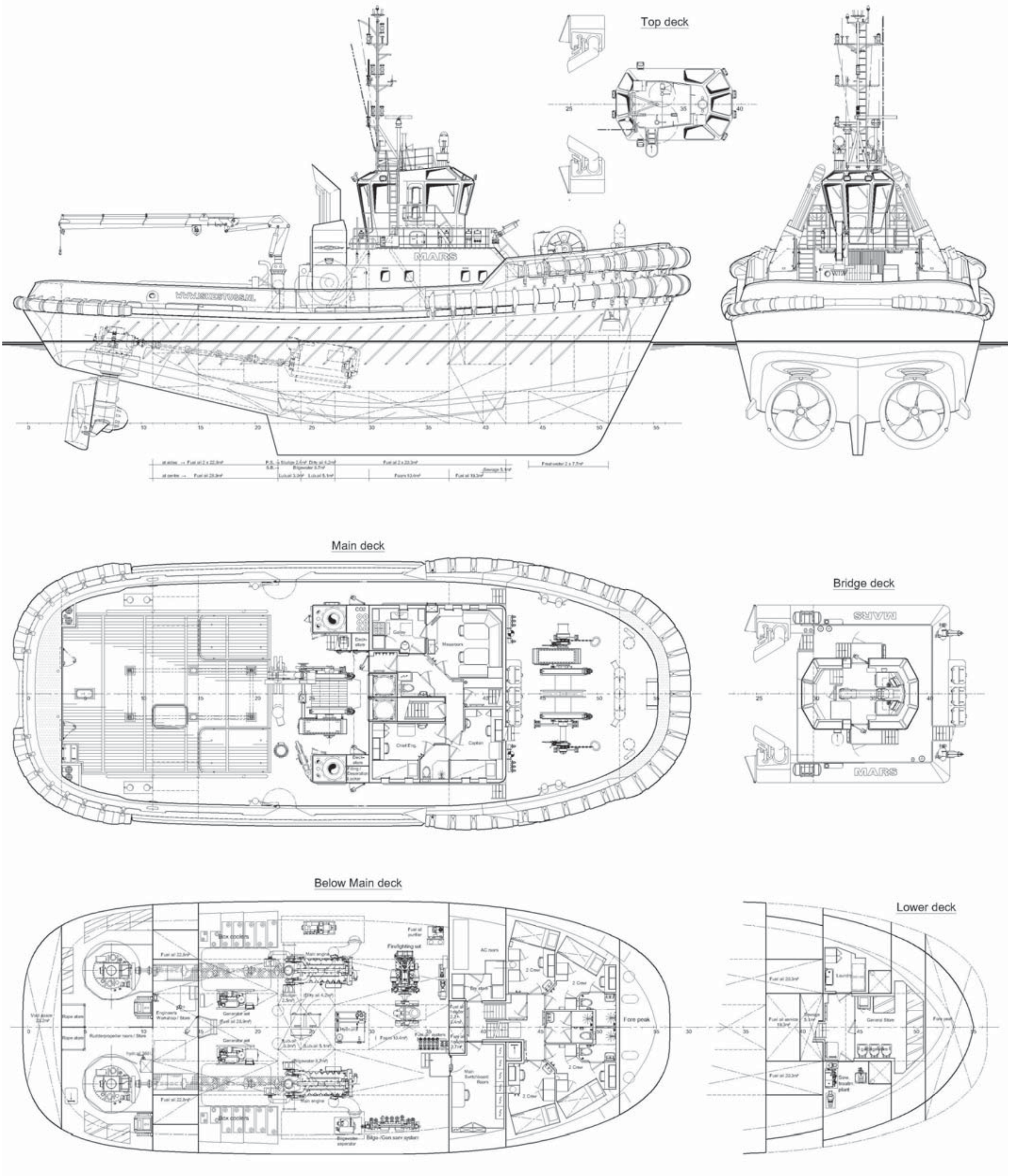
ACCOMMODATION

For 10 persons, insulated and finished with durable modern linings, acoustical Dampa ceiling in the wheelhouse, floating floors and air-conditioned. With 6 cabins, galley, mess/dayroom, switchboard room, dry store and sanitary facilities.

NAUTICAL AND COMMUNICATION EQUIPMENT

Searchlights	2x 450 W Xenon
Radar system	1x Furuno FAR-2117 with 19” screen and 4 ft scanner 1x Furuno FAR 2117 with 19” screen and 6.5 ft scanner
Compass	Magnetic Kotter
Satellite compass	Furuno SC-50
Autopilot	Robertson AP-70
GPS	Furuno GP-150
Echosounder	Furuno FE-800
VHF	2x Sailor Compact 6222
VHF hand-held	2x Jotron Tron TR-20
VHF	Motorola DM4401
UHF hand-held	2x Motorola DP4401 DP
Navtex	Furuno NX-700A
Speed log	Furuno DS-80
AIS	Furuno FA-150
Inmarsat	2 Furuno Felcom 18 (one with DSC)
SSB	Furuno FS-1575
EPIRB	Jotron Tron-40S
Sart	Jotron Tron Sart 20
GSM telephone booster	Rosenvelt RF EW 13-F

AZIMUTH STERN DRIVE TUG 3212
"MARS"



DAMEN SHIPYARDS GROUP

Avelingen-West 20
4202 MS Gorinchem
The Netherlands

P.O. Box 1
4200 AA Gorinchem
The Netherlands

phone +31 (0)183 63 99 22
fax +31 (0)183 63 21 89

info@damen.com
www.damen.com

B.2.8
Guard Vessel

M/V SANCO CHASER

YOUR PARTNER IN MARINE SEISMIC OPERATIONS

TECHNICAL SPECIFICATION FOR M/V SANCO CHASER

Built:	2002
Length:	51,30 M
Breadth:	12,00 M
Gross Tonnage:	1346 T
Fuel oil capacity:	1100 m3
Accommodation:	28 persons sleeping / 40 persons for 24 hrs trip

Sanco Shipping AS | Industriparken | N-6083 Gjerdsvika | Norway | Tel +47 70 02 63 90 | E-mail: office@sanco.no

TECHNICAL SPECIFICATION
M/V SANCO CHASER

MAIN DIMENSIONS	
Length O.A (LOA):	51,30 M
Length P.P.:	43,80 M
Breadth:	12,00 M
Draft loaded:	5,50 M
Draft in ballast:	3,2 M
Moulded depth:	6,20 M
Air draft:	23,0M
Gross Tonnage	1346 T
Deadweight:	1223 T
Net Tonnage:	404 T

PROPULSION MACHINERY	
Main engines:	2x1800 BHp, ABC Diesel 6 MDZC, 1000 RPM
Main Gear:	2 x Scana Volda CP/564 ACG 450/PF565/1
Shaft generators:	2 x Stamford Type.HC.M734 F2,1000kW each
Propeller:	2 x 4 bladed Scana Volda, Ø= 3100, 220 RPM

AUXILLIARY MACHINERY	
Aux. 1:	1 x Scania, 170kW
Emergency Gen:	1 x Moes, 6,4kW
Bow thruster:	1 x Brunvoll, 500 kW
Stern thruster:	1 x Brunvoll, 300 kW
Rudder:	2 x Volda highlift rudders
Steering Gear:	2 x Ulstein Tenfjord SR 622

CAPACITIES	
Fuel Oil (MGO):	MGO 1050 m3 + Autodiesel 17 m3
Fresh water:	35,4 m3
Ballast water:	440,5 m3
Fuel pump capacity:	200 m3/h at 8 bar

NAVIGATION & COMMUNICATION EQUIPMENT	
Sat C:	Skanti TT3020C
HF/MF/DSC:	Skanti TRP1250, TCU1000
VHF:	4 x Sailor RT2048 / RT4822
VHF, portable:	3 x Simrad SRH50
UHF:	4 x Entel HT783
Radar 10 cm:	Furuno FR 2137 S –BB, Arpa
Radar 3 cm:	Furuno FR 2117 -BB, Arpa
Gyro:	Simrad GC-80 / Furuno SC 50
GPS:	Furuno GP 80 + Furuno GP 36
Auto. Id. System:	Furuno FA-100 AIS
El.Chart:	Dual-Tecdis T-2138 A
Navtex:	Mc Murdo Nav7
Epirb:	Jotron, Tron 40S
Sart:	2 x Tron sart
Pos.control:	Joystick, Simrad
Autopilot:	Simrad AP-70
Echo sounder:	Furuno FE-700 & FCV-611
E-mail to use:	bridge.chaser@sanco.no

CLASS	
DNV + 1A1, SPS IMO A. 534 (13), EO	
Built:	Larsnes Mek.Verksted, Norway, build no. 38, Year 2002
Call sign:	ZDHH 3
Flag:	GIBRALTAR
Port of register:	GIBRALTAR
IMO Number:	9250206
DNV ID Number:	23264
MMSI Number:	236317000

SPEED & CONSUMPTION	
Max speed:	13 knots = 12 m3/ day
Service speed:	11 knots = 10 m3/ day
Chasing speed:	4,5 knots = 3,5 m3/ day
Bollard pull:	31 tons (Tested by 75% pitch)

DECK MACHINERY	
Deck crane:	Dreggen folded jib crane, SWL 10 tonnes at 14 meter
Streamer winch:	Capacity 3000 m. of Ø= 64 mm cable
Fuel winch:	Capacity 210 m with 5" hose
Auxiliary winch:	Capacity 50 m with 16 mm rope
Rope storage winch:	Capacity 200m with 100mm rope
Towing hook:	Strainstall, SWL 45 tonnes
Incinerator:	Teamtec Golar OG120
Workboat davit:	Vestdavit, SWL: 15 tonns

ELECTRIC POWER
440 V, 230 V all 60 Hz

RESCUE EQUIPMENT	
MOB-boat:	DSB 3.9 SR/IRB with 25 Hp outboard, approved for 6 persons
Liferafts:	4 x 25 persons
Liferafts:	2x10 persons
Lifesaving capacity:	40 persons

ACCOMMODATIONS
4 x 1 bed cabin with bathroom
6 x 2 bed cabin with bathroom
2 x 6 bed with bathroom

MANAGEMENT COMPANY	
Sanco Shipping AS Industriparken N-6083 Gjerdsvika, NORWAY	
Telephone:	+47 700 26 390 Mobile: + 47 95706032 / + 47 90976808
E-mail:	office@sanco.no
Internet:	www.sanco.no

SANCO

B.2.9
Standby Vessel

M/V Thor Modi

SPECIFICATIONS

Name:

M/V Thor Modi

Call sign:

C6BI4

Home port:

Nassau

Flag:

Bahamas

MMSI:

311 000 271

IMO no:

967 9036

Class:

DNV *1A1, EO, SF, SPS, CLEAN DESIGN, NAUT-AW, ICE-1A, RP, BWM-T,TMON, RECYCLABLE

Built:

2015 Besiktas Shipyard

DW:

About 1750

Light ship weight:

1810 tons

LOA:

64.40 m

LBP:

57.60 m

Beam:

14.50 m

Breadth Moulded:

Cargo on deck:

- Deck cargo: 5 T/M2
- Deck area:: 25.8 x 12.1 m, Ca. 300 m2 Cargo Space

Bollard pull:

50 TONNES

Accommodation:

- Crew: 8 x 1 man
- Extra berths: 2 x 2 men, + 48 berths
- Extra people allowed on board: 52 (Total 60 persons incl, crew)

Deck equipment:

- Deck crane: A-BUS LIFTING 12T SWL 2,3-10M - 10T SWL 2,3-17M
- Rope winch: DMT 200M /6 LAYER 10 KN
- Capstan: DMT 50 KN (3 PIECES)
- Anchor winches: DMT 61.5 KN 101-H36K3 (2 PIECES)
- Towing hook: MAMPAEY 50/65 T
- Davits: VESTDAVIT - MOB PLR7000- PLR 15000
- Gypsies: Ø36
- Bow anchors: YAPAS 2850KG SPEK TYPE ANCHOR
- Chains: 27.5 x 8 m, same length both side

Rescue boat:

- MARITIME PARTNER -ALUSAFE 770 MK II TWIN

Sewage Treatment plant:

- JETS VACUUM - ECOMOTIVE for 60 persons

14.50 m

Depth Moulded:

7.20 m

Depth boat deck:

9.90 m

Depth main deck:

7.20 m

Draft:

5.70 m max

Main engine:

4 x 1000 kW Yanmar, 6EY22ALW

Aux. engine:

260 kW, Scania DI12 62 M

Generators:

4 x 1250 KVA Hyundai 1250. AC 690 V, 1045.6 Amp, 60 HZ

Speed:

- Max: 19.56 m3/ 24h @13.7 knots
- Economy: 9.6 m3/ 24h @ 10.8 knots
- Chase: 3.5 m3/ 24h @ 4.5 knots

Propellers:

BERG PROPULSION BCP760 F (2 PIECES)

Rudder:

ROLLS ROYCE FM (2 PIECES)

Steering gear:

ROLLS ROYCE SR622 FCP (2 PIECES)

Thruster:

SCHOTTEL PUMP JET TYP SPJ 132 RD-L

Water generator:

ENWA MT 20 TSRH

Bunkers:

- Heavy Fuel 1104 Cbm, Diesel 437 Cbm
- Lubes: 19 Cbm
- Fresh water: 75 Cbm

All specifications given without guarantee and subject to changes!

- Liferafts: VIKING MODEL DK 7x25 PERSON , 1x16 PERSON
- Life-jackets: VIKING SOLAS RIGID LIFE JACKET 64 ADULT, 2 CHILD
- Immersion suits: VIKING PS 5002 64 Suits

FRC safety equipment:

- FRC working suits: Viking PS 4170 4 Suits
- Inflatable lifejackets: Viking PV 9320 8 Lifejackets

Firefighting equipment:

- Water Mist Fire Suppression System

Radio and Navigation equipment:

GMDSS equipment:

- FURUNO, RC 1800T

Radar:

- FURUNO, FCR 2119-BB

Echosounder and speed-log:

- FURUNO, FE-700

Gyro / autopilot:

- ANSCHUTZ, 108-010 (2PIECES)

Bridge alarm:

- ULSTEIN

Pumps:

- Fuel Oil: ALLWEILLER, IEC 250M-2, 189M3/H 5 BAR (2 FOR HFO + 1 FOR MDO)
- Fresh Water: ALLWEILLER, NB20-160 IEC80, 5M3/H 2.5 BAR
- Seawater ballast pump: ALLWEILLER, NB65-160IEC132M,80M3/H 2.5 BAR

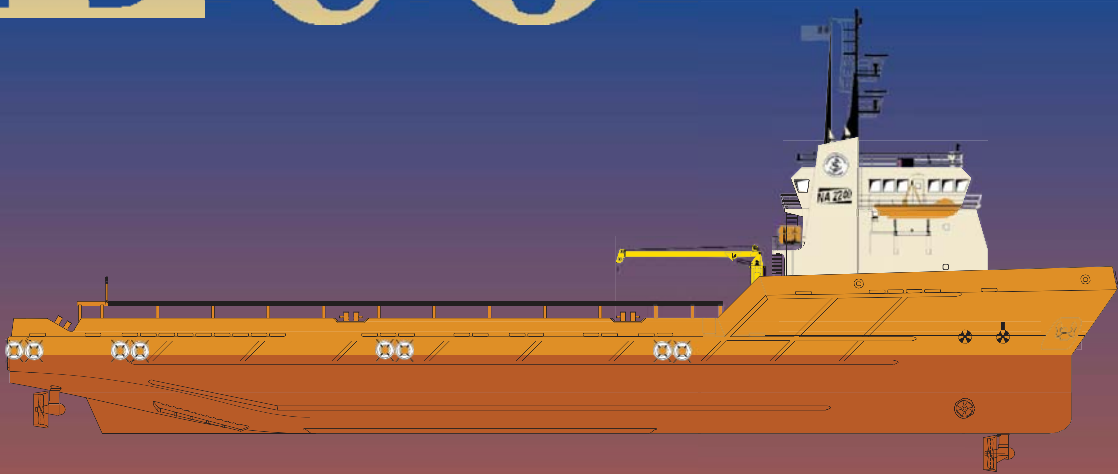
Communication:

- Email Sat: thormodi@thor.fo
- E-Mail Captain: thormodi.captain@thor.fo
- E-Mail Engine: thormodi.engine@thor.fo
- Tel. IP Bridge: +44 203 695 5265
- Tel. IP Engine: +44 203 695 5266
- Tel. FBB: +870 773 233 052
- InmarsatC: 431102468 / 431102469

B.2.10
Supply Vessel

ECO

240' OFFSHORE SUPPLY VESSEL



M/V C-EMPRESS

EDISON CHOUEST OFFSHORE

M/V C-EMPRESS

Specifications

REGISTRATION: Hull #179 | Vessel Type: Offshore Supply Vessel | Year Built: 1998, North American Fabricators

	U.S. MEASUREMENTS	METRIC EQUIVALENTS
DIMENSIONS	240' X 56' X 21'	73.15 m X 17.07 m X 6.40 m
Draft (Loadline):	18'	5.49 m
Draft (Lightship):	6'6"	1.98 m
Clear Deck:	165' x 46'	50.29 m x 14.02 m
Clear Deck Area:	7,672 sq. ft.	712.75 m^2
Deck Cargo Capacity:	1,750 LT	1,778.08 MT
Deadweight Tonnage:	3,220 LT	3,271.67 MT
CAPACITIES		
Fuel Oil:	309,826.4 gals.	1,172.82 m^3
Ballast:	234,153.1 gals.	886.36 m^3
Potable Water:	24,031.6 gals.	90.97 m^3
Dry Bulk:	8,103.5 cu. ft. @ 80 psi	229.47 m^3 @ 5.5 bars
Liquid Mud:	6,063 barrels	963.94 m^3

MACHINERY	
Main Engines:	Two (2) 3516 CAT Diesels, 1,710 BHP
Bow Thrusters:	One (1) 340 HP CP Tunnel
	One (1) 1,200 HP Dropdown
Stern Thrusters:	Two (2) Ulstein 1,350H Azimuthing, 1,600 HP
Speed:	14.2 knots
Generators:	Two (2) x 500 kW, One (1) x 170 kW

CLASSIFICATION	
ABS	Maltese Cross A1 (Hull)
ABS	Loadline
ABS	Maltese Cross AMS (Machinery)
USCG	Subchapter L (OSV)
MARPOL	
SOLAS	

SPECIAL FEATURES	
Ship Motion:	Two (2) Passive Type Anti-Roll Tanks,
	Bilge Keels
Positioning:	DP 2
Tuggers:	Two (2) x 8,000 lb (3.63 MT)
Crane:	One (1) 3,100 lb SWL Hydraulic Deck Crane
Firefighting:	Two (2) x 8,000 GPM Monitors
	(Two CAT 3508 1,150 HP Drive Engines)

ACCOMMODATIONS:	29

LIFESAVING EQUIPMENT

- Two (2) x 25-Man Inflatable Life Rafts
- Two (2) x 20-Man Inflatable Life Rafts
- Two (2) x 10-Man Inflatable Life Rafts
- One (1) x 5.8 m Rescue Boat
- Other gear as required by USCG and SOLAS

ECO

304' PLATFORM SUPPLY VESSEL

MMC 887 L

M/V BONGO · M/V ELAND · M/V GEMSBOK · M/V KUDU
M/V ORYX · M/V SABLE · M/V SPRINGBOK · M/V WILDEBEEST

M/V MMC 887 L

Specifications

Vessel Type: Platform Supply Vessel

Year Built: 2013, Remontowa Shipbuilding S.A., Poland

U.S. MEASUREMENTS		METRIC EQUIVALENTS
DIMENSIONS	304' X 62' X 24'	92.65 m X 18.80 m X 7.40 m
Work Deck Area:	11,302 sq. ft.	1,050 m²
Deadweight Tonnage:	5,186.77 LT @ 19.85 ft max draught	5,270 MT @ 6.05 m max draught
Gross Tonnage (Convention):	3,825 GT	1,802 GT
CAPACITIES		
Fuel Oil:	329,702.9 gals.	1,248.06 m³
Ballast/Drill Water:	539,949.7 gals.	2,043.93 m³
Potable Water:	44,224.2 gals.	167.41 m³
Fresh Water:	134,926.1 gals.	510.75 m³
Dry Bulk:	14,683.84 cu. ft. @ 84.12 psi	415.8 m³ @ 5.8 bars
Liquid Mud/Methanol/Brine/Oil Recovery:	2,700.86 barrels	429.40 m³
Liquid Mud/Oil Recovery:	12,357.89 barrels	1,964.75 m³
Methanol:	113,436.2 gals.	429.4 m³

MACHINERY	
Bow Thrusters:	One (1) x 800 kW Retractable, 1,072 HP
	One (1) x 1,250 kW CP, 1,676 HP
	(ELAND, GEMSBOK, SPRINGBOK and WILDEBEEST)
	or One (1) x 910 kW CP, 1,220 HP
	(BONGO, KUDO, ORYX and SABLE)
Z-Drives:	Two (2) x 2,000 kW, 2,680 HP
	RR US255FP, FPP without nozzle
Speed:	14.3 knots
Generators:	Four (4) x 1,700 ekW CAT 3512;
	One (1) x 400 ekW CAT C18 emergency and harbor

SPECIAL FEATURES	
Positioning:	DP 2
Tuggers:	Two (2) x 10 MT
Crane:	One (1) x 3 MT @ 10 m (straight arm) Noreq
Windlasses:	Two (2) x combined windlass/mooring winch
Capstans:	Two (2) x 8.6 MT NDM

PUMPS WITH DISCHARGE RATES	
Fuel Oil:	One (1) x 150/20 m³/h @ 9 bar, electric driven
Ballast/Drill Water:	One (1) x 150/80 m³/h @ 9 bar, electric driven
Fresh Water:	One (1) x 150 m³/h @ 9 bar, electric driven
Liquid Mud Transfer:	Three (3) x 150 m³/h @ 14 bar
Liquid Mud Recirculation:	Four (4) x 75 m³/h @ 6 bar
Liquid Mud/ORO:	Two (2) x 75 m³/h @ 14 bar
	with safety valve @ 17.5 bar
Methanol Pump:	One (1) x 75 m³/h @ 0.9 MPa
Dry Bulk:	Two (2) x compressors 1,134 m³/h 5.6 bar
Firefighting Pumps:	Two (2) x 1,770 m³/h @ 1.22 MPa
Firefighting Monitors:	Two (2) x 1,200 m³/h

CLASSIFICATION	
ABS	✠+A1(E) Offshore Support Vessel
ABS	✠ AMS
ABS	✠ ACCU
ABS	✠ DPS-2
ABS	✠ FFV Class 1
ABS	✠ Oil Recovery Capability Class 2
	2008 SPS Code of Safety (Special Purpose Ships)

ACCOMMODATIONS: 52

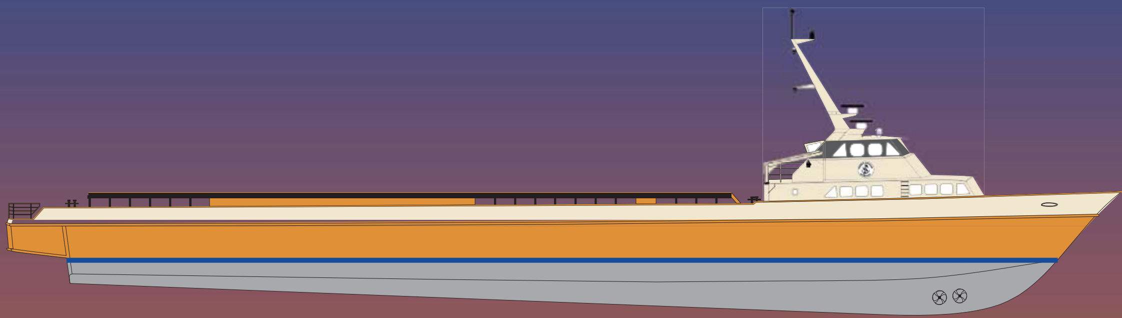
LIFESAVING EQUIPMENT
- 6-Person SOLAS-type MOB
- Single Arm Rescue Boat Crane

NAVIGATION/COMMUNICATION EQUIPMENT
- ARPA S-Band Radar
- ARPA X-Band Radar
- Inmarsat-C
- Three (3) Gyro Compasses
- GPS
- GMDSS A3 Radio Installation
- AIS (Automatic Identification System)
- VDR (Voyage Data Recorder)
- SSAS Distress Alarm
- Three (3) Wind Sensors
- VSAT

B.2.11
Crew Boat

ECO

194' FAST SUPPLY VESSEL



M/V FAST HAULER

EDISON CHOUEST OFFSHORE

M/V FAST HAULER

Specifications 07/14

REGISTRATION: Hull #60 | Vessel Type: Fast Supply Vessel | Year Built: 2013, Breaux Brothers Enterprises

	U.S. MEASUREMENTS	METRIC EQUIVALENTS
DIMENSIONS	194' X 30' X 14'	59.13 m X 9.14 m X 4.27 m
Clear Deck:	132' x 24'6"	40.23 m x 7.62 m
Clear Deck Area:	3,234 sq. ft.	300.45 m^2
Deck Cargo Capacity:	380 LT	386.10 MT
Deadweight Tonnage:	455 LT	462.30 MT
CAPACITIES		
Fuel Oil:	34,000 gals.	128.7 m^3
Ballast:	63,500 gals.	240.37 m^3
Potable Water:	900 gals.	3.41 m^3
Lube Oil:	350 gals.	1.32 m^3

MACHINERY

Main Engines:	Four (4) 3512C-HD CAT Diesels, 7,240 BHP
Auxiliary Engine:	One (1) CAT C9, 503 BHP
Bow Thrusters:	Two (2) 200 HP Thrustmaster 30TT175H Tunnels
Speed:	28 knots
Generators:	Two (2) x 80 kW

SPECIAL FEATURES

Positioning:	DP 2
Steering and Controls:	Four (4) IMS 5 HP Electro/Hydraulic Steering Units, Three (3) Stations
Firefighting:	One (1) Monitor @ 2,500 GPM

CLASSIFICATION

ABS	Loadline
ABS	A1 Class
ABS	AMS (HSC Crewboat)
ABS	DP2
USCG	

ACCOMMODATIONS: 12

Passengers: 58

LIFESAVING EQUIPMENT

Four (4) x 25-Man Life Rafts
Personnel Rescue Davit
Other gear as required by USCG

ELECTRONICS

Two (2) Furuno FAR-2117 Radars
Furuno GP150D DGPS Navigator
Furuno FA150 AIS Transponder
Furuno FM-8800S VHF Radiotelephone
SEA 235 SSB Radio
Icom IC-M504 VHF Radio
Depth Recorder
Furuno NX700P Navtex Receiver
Color Video Sounder
RLB-32 EPIRB
RC1815 GMDSS
Furuno LH3000 Loud Hailer
Two (2) Furuno GC10 Gyro Converters
Marine Technologies DP 2 Integrated Vessel Control System

B.2.12
Flotel

ELISA

Accommodation Barge - Self propelled / 8P - mooring
138 persons / 914 mt deadweight
2006

NAME : ELISA

TYPE : Accommodation Barge self-propelled
Diesel electric propulsion

OWNER : Elisa Shipping Ltd. (IMO: 5215460)

FLAG : St Vincent & The Grenadines

PORT OF REGISTRY : Kingstown

BUILDER'S YARD : Gelibolu Shipyard / Turkey

KEEL LAID / YEAR : May 2006

OFFICIAL NO. : 9900

CALL SIGN : J8B3428

HULL NO. : 029

IMO NO. : 9381689

CLASS SOCIETY : Bureau Veritas

CLASS ID NUMBER : 08142C

CLASS NOTATION : I ✠Hull ✠Mach, Offshore service ship
Accommodation, Costal area

DIMENSIONS

LOA	70 m
LBP	65.88 m
MOULDED BREADTH	20 m
MOULDED DEPTH	4.30 m
MAX. DRAUGHT	2.30 m
CLEAR DECK AREA	Abt 300 m^2

TONNAGE

GT	2956
NT	886
DECK CARGO	150 mT
DECK STRENGTH	220 m^2 @ 5 mT / m^2
DECK STRENGTH FWD	80 m^2 @ 10 mT / m^2 (option crawler crane)
DEADWEIGHT	914 mT
LIGHT WEIGHT	1834 mT

MACHINERY / PERFORMANCE

SERVICE SPEED / CONSUMPTION	Abt 6 knots at 6 m^3 /day gasoil at sea, without boat landing fitted. Abt 1.3 m^3/day at anchor.
MAIN PROPULSION	Diesel electric, 2 x 525 kW HRP Azimut propellers
GENERATORS	4 x 571 kW, Baudouin 12M26SR V-type 1 x 175 kW Emrg. DG A.C. 3-ph, 400 V, 50 hz
BOW THRUSTER	1 x 270 kW
CARGO FO-PUMP	65 m^3 / hr
CARGO FW-PUMP	50 m^3 / hr

ABC Maritime AG
Rue Perdtemps 1
1260 Nyon Switzerland
Phone: +41 (0)22 365 71 00
Email: info@abcmaritime.ch
Website: www.abcmaritime.ch

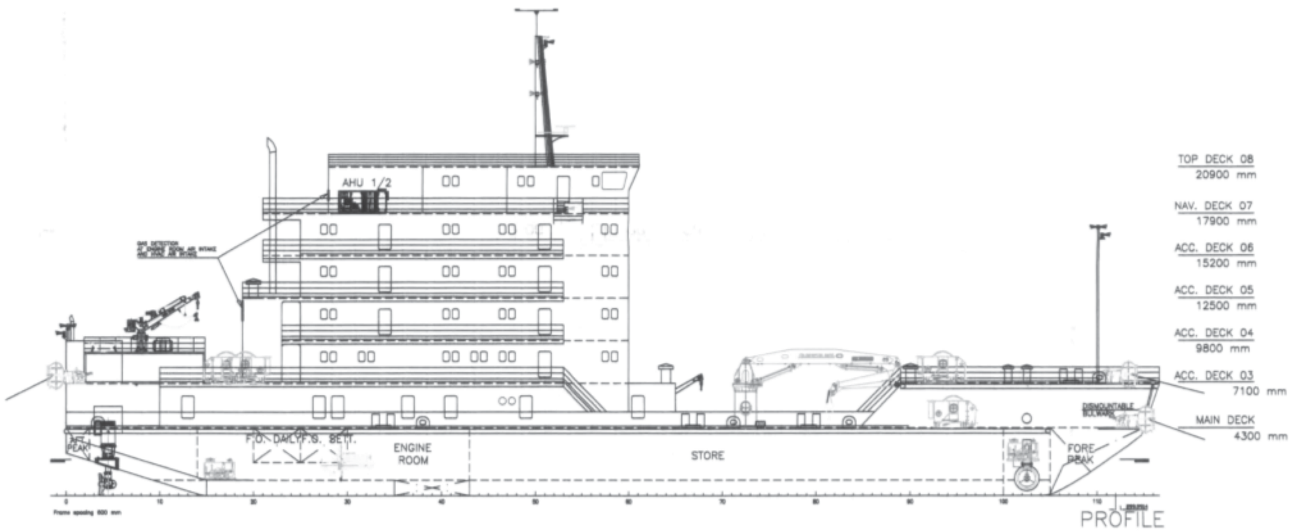
TANK	VOLUME
FUEL OIL (MGO)	277 m^3
BALLAST (F.W.)	810 mT
FRESH WATER	500 m^3
FRESH WATER PRODUCTION	max 22 tons/day
DIRTY OIL	7 m^3
ENGINE LO	NIL
HYDRAULIC OIL	NIL
FOAM	NIL
DETERGENT	NIL

ACCOMMODATION

PASSENGERS	112
CREW	14
CATERING STAFF	12
CABINS 8 x single, 7 x double, 20 x 4 beds, 6 x 6 beds = 41	
PEOPLE CAPACITY	Total: 138

ADDITIONAL INFORMATION

ANCHORS	8 x 5 tons Flipper-Delta
MOORING GEAR	8-point mooring: 8 X 1600 m, 38 mm ø, 90 tons, 1st layer
BOW RAMP	Open - manual operated N/A
DECK CRANE	9.3 tons outreach 13.3 m (stb side)
RESCUE BOATS	2 x 10 knots, 6 persons each
FIFI	N/A but deluge fitted for accommodation & main deck
STORE ROOM UNDER DECK	CO^2 / Sprinkler / Bilge suction
BOAT LANDINGS	2 x Surfer landings








ABC Maritime AG
Rue Pertemps 1
1260 Nyon - Switzerland

Phone: +41 (0)22 365 71 00
Email: info@abcmaritime.ch
Website: www.abcmaritime.ch

B.2.13
Piling Vessel

GeoSea

Geotechnical & Offshore Solutions

Thor

OFFSHORE HEAVY LIFT DP2 JACK-UP VESSEL

Thor

OFFSHORE HEAVY LIFT DP2 JACK-UP VESSEL

CONSTRUCTION YEAR	2010
TYPE	Offshore Heavy Lift DP2 Jack-Up Vessel
CLASSIFICATION	Germanischer Lloyd

MAIN DIMENSIONS	length breadth depth	70.00 m 40.00 m 6.00 m
JACKING SYSTEM	type capacity pre load speed leg length	Hydraulic Positive Engagement 10,000 ton 4 x 4,350 ton 1.2 m/min 82.00 m
CRANE	capacity	500 ton
POWER & PROPULSION	dynamic positioning propulsion installed power	Kongsberg DP2 2 x 2,560 kW Azimuth Thrusters 2 x 750 kW Azimuth Thrusters 10,530 kW
OPERATIONAL CONDITIONS	pay load (max) free deck area operating draft (max)	2,700 ton 1,850 m^2 8.46 m
OTHER	accommodation helideck moonpools auxiliary crane other	56 persons installed 2 x 900 mm 6.5 ton, manriding 4 points mooring system

GeoSea
Geotechnical & Offshore Solutions

MEMBER OF THE DEME GROUP
GEOSEA NV Haven 1025 - Scheldedijk 30 | B-2070 Zwijndrecht, Belgium | T +32 3 250 53 12 | F +32 3 250 55 41
www.deme-group.com/geosea | info.geosea@deme-group.com

B.2.14
Derrick Barge

Derrick Barge 30

Derrick/lay barge with heavy-lift and pipelay capabilities

Derrick Barge 30

Official Flag: Malaysia
Built/Year: Japan - 1975, Conversion - 1999
Class: ABS + A1, Barge

HULL
Dimensions:
LOA: 420 ft [128 m]
Beam: 158 ft [48.2 m]
Depth: 28 ft [8.5 m]
Operating Draft: 12 ft [3.65 m] minimum / 19 ft maximum [5.79 m]

TOWING
Storm Anchor: 1 to meet regulatory body approval
Anchor System: 12 @ 35,714 lb [11,339.8 kg] anchor; 5,500 ft [1,676.4 m] of 2.5 in wire

COMMUNICATION & NAVIGATION
Communication: data / fax / phone / VSAT
Radio: VHF, GMDSS, SSB
Radar: 1
Gyro Compass: 1
Echo Sounder: 1

ACCOMMODATION
Berths (air conditioned & heated): 302
Medical: clinic with two beds
Other Facilities: galley, mess room, laundry, movie room, conference room, exercise room, internet café, customer offices

POWER
Distribution: 440 V, 220 V, 110 V, 60 Hz
Main Generator: 3 @ 910 kW + 1 @ 1,360 kW
Emergency Generator: 1 @ 320 kW
Speed: Towing Speed: 6 kts

SAFETY
Life Raft: 38 @ 25-person
Rescue Boat: 2
Safety System: Meets flag and regulatory body requirements

TANKS
Fuel: 423,521 usg [1,603,214 L]
Ballast Water: 3,550,375 usg [13,439,734 L]
Potable Water: 147,748 usg [521,437 L]
Fresh Water: 557,273 usg [2,109,523 L]
Lube Oil: 10,000 usg [37,854 L]

CRANES
Crane: Clyde Model 76
Boom Length Main: 235 ft [71.6 m]
Boom Length Aux: 270 ft [82.3 m]
Boom Length Whip: 300 ft [91.4 m]
Main Hook Capacity Fixed: 3,080 ST [2,794.1 MT]
Main Hook Cap Revolving: 2,450 ST [2,222.6 MT]
Aux Capacity: 750 ST [680.4 MT]
Aux Whip: 250 ST [226.8 MT]
Deck Crane: 2 AH&D 203 gantry cranes; 110-ft [33.5 m] boom

PIPELAY EQUIPMENT
Min OD: 4 in
Max OD: 60 in
Tension Machine: 2 @ 275 kip [124.74 MT]
Tension Capacity: 550 kip [249.5 MT]
A & R Hoist: 700 kip [317.5 MT]
Wire Rope: 2,500 ft [975.4 m] @ 3.0 in
Ramp Station: welding (5); repair/x-ray (1); field joint (3)
Davits: Portable (installed as required)
Max Water Depth: Case-by-case Min Water Depth: 17 ft [5.2 m]
AWE: Manual or automatic per project requirement

EQUIPMENT
Air Compressor: 2 @ 670 cfm, 120 psi, 1 @ 600 cfm, 120 psi [2 @ 19 m^3/min, 8.3 bar; 1 @ 17 m^3/min, 8.3 bar]
Jet Pump: 1 @ 1,250 gpm, 250 psi [1 @ 4,731.8 L/min, 17.2 bar]
Welding Machine: manual and automatic
Boilers: 2,000 hp; 69,000 lb steam/hr @ 275 psi [2,000 hp; 31,297.9 kg steam/hr @ 19 bar]
Anti Pollution: oil spill response kit
Water Maker: 2 @ 18,492 usg/day [70,000 L/day]
Helideck: 72 ft x 72 ft [22 m x 22 m], suitable for Sikorsky S61 & S92
Construction Equipment:The DB30 spread is outfitted with assisting tugs, material barges, survey equipment, diving systems, x-ray, NDT, and hammer equipment as required on a project-specific basis.

B.2.15
Multi-Service Vessel

M/V SANCO SEA

YOUR PARTNER IN MARINE SEISMIC OPERATIONS

TECHNICAL SPECIFICATION FOR M/V SANCO SEA

Built:	1999
Length:	51,30 M
Breadth:	12,00 M
Gross Tonnage:	1129 T
Fuel oil capacity:	1038 m3
Accommodation:	24 persons

Sanco Shipping AS | Industriparken | N-6083 Gjerdsvika | Norway | Tel +47 70 02 63 90 | Fax +47 70 02 63 99 | E-mail: office@sanco.no
www.sanco.no

TECHNICAL SPECIFICATION M/V SANCO SEA

MAIN DIMENSIONS	
Length O.A (LOA):	51,30 M
Length P.P.:	43,80 M
Breadth:	12,00 M
Draft loaded:	5,20 M
Draft in ballast:	4,00 M
Moulded depth:	6,20 M
Air draft:	27,50 M
Gross Tonnage	1129 T
Deadweight:	1127 T
Net Tonnage:	339 T

PROPULSION MACHINERY	
Main engines:	2 x 1800 BHp, ABC Diesel 6MDZC, 1000 RPM
Main Gear:	2 x Scana Volda CP/54 ACG 450/PF565/1
Shaft generators:	2 x Stamford Type.HC.M634H2,700 kw each.
Propeller:	2 x 4 bladed Scana Volda, Ø= 2500, 200RPM

AUXILLIARY MACHINERY	
Aux. 1:	1 x Caterpillar 3306, 184 kw
Bow thruster:	1 x Schottel water/jet, 550kw
Rudder:	2 x Volda high lift rudders
Steering Gear:	2 x Ulstein Tenfjord SR 622

CAPACITIES	
Fuel Oil (MGO)	1038 m3
Fresh water:	32 m3
Ballast water:	485 m3
Fuel pump capacity:	90 m3/h at 3,5 bar

NAVIGATION & COMMUNICATION EQUIPMENT	
HF/MF/DSC:	Skanti TRP1000, TT3020C and TT 3617A
VHF:	2 x Sailor 1 x Sailor DSC 1 x Skanti DSC
VHF, portable:	3 x Jotron
UHF:	4 x Motorola
Radar:	3 cm Furuno FAR-2117, Arpa
Radar:	10 cm Furuno FAR-2137S, Arpa
Gyro:	Anschutz STD 20 / Furuno SC-60
DGPS:	Furuno GP 80
GPS Compass:	Furuno GP 35
El.Chart:	Telchart 2026
Navtex:	ICS Nav 5
Auto. Id. System:	Furuno FA-100. AIS
Epirb:	Tron 40S MK II
Sart:	2 x Tron sart
Autopilot:	Robertson AP9MK III
Sat C:	Skanti
Echo Sounder:	Skipper GDS 101
E-mail in spare:	bridge.sea@sanco.no
E-mail to use:	captain.sea@sanco.no

CLASS	
DNV + 1A1, EO	
Built:	Voldnes Skipsverft AS, Norway, build no. 57, Year 1999
Call sign:	ZDHF 4
Flag:	GIBRALTAR
Port of register:	GIBRALTAR
IMO Number:	IMO 9204295
DNV ID Number:	21819
MMSI Number:	236310000

SPEED & CONSUMPTION	
Max speed:	13 knots = 12 m3/ day
Service speed:	11 knots= 10m3/ day
Chasing speed:	4,5 knots = 4 m3/ day
Bollard pull:	31 tons

DECK MACHINERY	
Deck crane:	Dreggen folded jib crane, SWL 8 tonnes Max outreach: 12m
Streamer winch:	Capacity 6000m. of Ø = 63mm cable
Fuel winch:	Capacity 210 m with 5" hose
Auxiliary winch:	Capacity 75m with 14m. rope, 3 tons
TS-Dip winch:	High speed testing winch, 2400m.rope
Towing hook:	Strainstall, SWL 45 tonnes
Incinerator:	Teamtec Golar OG120
Workboat davit:	Vestdavit, SWL: 15 tonns

ELECTRIC POWER
440 V, 230 V all 60 Hz

RESCUE EQUIPMENT	
MOB-boat:	Narwhale SV-400 with 25 Hp outboard, approved for 6 persons.
Liferafts:	4 x 25 persons
Lifesaving capacity:	46 persons

ACCOMMODATIONS
4 x 1 bed cabin with bathroom
4 x 2 bed cabin with bathroom
2 x 6 bed with bathroom

MANAGEMENT COMPANY	
Sanco Shipping AS Industriparken N-6083 Gjerdsvika, NORWAY	
Telephone:	+ 47 700 26 390 Mobile: + 47 95706032 / + 47 90976808
Telefax:	+47 700 26 399
E-mail:	office@sanco.no
Internet:	www.sanco.no

SANCO

ALL SPECIFICATIONS GIVEN WITHOUT GUARANTEE AND SUBJECT TO CHANGES
Updated: August 2014

B.2.16
S-Lay Vessel

DLV 2000

Combination heavy lift and pipelay vessel with efficient transit speeds to effectively execute projects in all major oil and gas basins around the globe

DLV 2000

Official Flag: Panama
Built/Year: 2016
Class: ABS

HULL
Dimensions:
LOA: 604 ft [184 m]
LWL: 591 ft [180 m]
Beam: 127 ft [38.6 m]
Min/Max Operating Draft: 18 ft / 26 ft [5.5 m / 7.9 m]
Deck Area: Approximately 40,000 sq ft [4,000 m^2]

COMMUNICATION & NAVIGATION
Radio: GMDSS radio system suitable for sea area A1, A2 and A3 service UHF, VHF, NAVTEX, EPIRB, SSAS, SART and Vessel LAN systems

ACCOMMODATION
Berths: 341 persons (2-man rooms), or 401 persons (4-man rooms)
Medical: 2 clinics with 5 beds total

POWER
Main Generator: 33 MW (6 @ 5.5 MW in two engine rooms)
Emergency Generator: 1.5 MW (Cummins)
Distribution: 6.6 kV (switchboard in “Ring Main” configuration to minimize worst case failure loss of thrusters)

DYNAMIC POSITIONING
DP Class: DP3
System: Kongsberg (Power management and Vessel Automation System)

PROPULSION
Total Power: 25.5 MW
Main Propulsion: 2 @ 5,500 kW
Thrusters:
Drop Down: 6 @ 2,000 kW
Tunnel: 2 @ 1,250 kW
Transit Speed:
Maximum:13.5 knots
Economical: 12 knots

SAFETY
Life Boat: 6 @ 106-man
Life Raft: 6 @ 35-man and 2 @ 20-man
Rescue Boat: 2 @ 10-man capacity FRC
Safety System: In accordance with SOLAS and other regulatory body requirements

CRANES
Main Crane: 2,200 ST [2,000 MT] (NOV / Am Clyde) on stern
Auxiliary: 660 ST [600 MT]
Whip: 275 ST [250 MT]
Secondary Cranes: 275-ST [250-MT] knuckle boom Active Heave Compensation boom crane on starboard side, 10,000-ft [3,000-meter] water depth rated. 110 ST [100 MT] SWL fixed boom deck crane.
Lowering System: Large A&R wire can also be used for lowering with a capacity of 465 ST [425 MT] at the surface.

PIPELAY EQUIPMENT
Tension Capacity: 496 ST (3 @ 165 ST) [450 MT (3 @ 150 MT)]
A & R Winch: 550 ST/275 ST (cable length to suit 9,800 ft water depth) [500 MT/250 MT (cable length to suit 3,000 m water depth)]
Bottom Tension: 193 ST [175 MT] (DP2 rating in worst case failure)
Single Work Stations: 12
Double Joint Work Stations: 6 (prefabricated double joints)
Stinger length: ~328 ft [~100 m]
Min and Max OD: 4.5 inches to 60 inches [114.3 mm to 1,524 mm]

B.2.17
J-Lay Vessel

Amazon

Fast-transit, dynamically positioned (DP2) construction vessel with two 440 ST [400 MT] Offshore Mast Cranes (OMC) and a 625 ST [570 MT] Vertical Lay System (VLS) for installation of flexible pipe and umbilicals.

Highlights

- Two 440 ST [400 MT] Offshore Mast Cranes for crane operations up to 9,840 ft [3,000 m] water depth complete with Active Heave Compensation and Tandem Operations Capability
- 625 ST [570 MT] Dual (Retractable) Tensioner Lay System over moon pool for installation of umbilicals and flexible pipe in water depths up to 9,840 ft [3,000 m]
- Large storage capacity in two below deck holds and a 49,514 ft² [4,600 m²] deck area with deck load capacity up to 1.64 ST/ft² [16 MT/m²]

Amazon

Official Flag: Gibraltar Built/Year: 2014
Class: DNV-GL, ✠ 100A5, BWM(D2), HC(3), NAV, SPS, OFFSHORE SERVICE VESSEL, ✠ MC, AUT, HELIL, DP2
Helideck: compatible with EH-101, S-92, or similar
IMO Number: 9698094

HULL
Dimensions:
LOA: 654.2 ft [199.4 m]
Beam: 105.6 ft [32.2 m]
Depth: 48.2 ft [14.7 m]
Max. Draft: 31.16 ft [9.5 m]
Typ. Operating Draft: 26.25 ft [8.0 m]
Deck Area: 49,514 ft² @ 1.024 - 1.64 ST/ft² [4,600 m² @ 10-16 MT/m²]

DYNAMIC POSITIONING
System: Kongsberg K-Pos DP 21
DP Class: IMO Class 2
DP Reference System: 2x HiPAP, 4x DGPS, 1x Taut Wire, 1x Radius

COMMUNICATION & NAVIGATION
Navigation System: NACOS Platinum Communication: email / fax/ phone (VSAT) Radio: GMDSS, UHF, VHF, VSat
Radar: 2 (X,S Band)
Gyro Compass: 3
GPS: 2
Echo Sounder: 1
Doppler Speed Log: 1
Autopilot: 1
NAVTEX: 1
ECDIS: 2
AIS: 1
Weather Fax: 1
VDR: 1

ACCOMMODATION
Berths (air conditioned & heated): 200 overall POB, 1 & 2 man cabins Medical: hospital treatment room & office, 2 sick bay rooms Other Facilities: gymnasium, game room, conference rooms, library, internet room, sauna, construction, customer offices

POWER
Distribution: 28 MW, 37,500 HP, 60Hz Main Generator: 3 x MAN 9L 32/44 @ 5,040 kW 4 x MAN 8L 32/44 @ 4,480 kW
Emergency Generator: 1 @ 1,250 kVa Shore Connection: 440V, 400A, 60Hz

PROPULSION
Stern: 3 @ 3,500 kW Azimuth Steerprop SP 50 D
Forward: 3 @ 2,400 kW Retractable Azimuth, Brunvoll AR-100-LNC-2600
Bow: 1 @ 1,800 kW Tunnel, Brunvoll FU-93-LTC-2500 Max. Transit Speed: 13 knots

SAFETY
Life Boat: 4 x 100 man each, 2 each side
Life Raft: 8 x 25 man each, 4 each side
Fast Rescue Boat: 2, 1 each side

TANKS
Fuel: 964,228 usg [3,650 m³], 45 day endurance

CRANES
Main Crane: 2 x Huisman Offshore Mast Crane, 440 ST [400 MT] at 67.25 ft [20.5 m] (double fall), 220 ST [200 MT] at 120 ft [36.6 m] (single fall), AHC, Tandem mode, PS

LAY EQUIPMENT
Maximum Line Pull Including Dynamics: 490 ST [445 MT]
Min. Product OD (2-track): 1.96 in [50 mm]
Min. Product OD (4-track): 3.9 in [100 mm]
Max. Product OD: 24.8 in [630 mm]
Max. Lay Speed: 52.5 ft/min [16 m/min] @ full load, 78.7 ft/min [24 m/min] @ red. load
Tower Lay Angle: 90 degrees (vertical) – 60 degrees
A&R Winches: 1 x 660 ST [600 MT] traction, 1 x 137 ST [125 MT] drum

PRODUCT STORAGE
Reel Drive System: mobilized as per project requirements
Carousel On-Deck: mobilized as per project requirements
Carousel In-Hold: mobilized as per project requirements

MOON POOL
Dimensions: 44.95 ft [13.5 m] (l) x 27.23 ft [8.3 m] (w)

REMOTE OPERATED VEHICLES
Deck mounted, mobilized as per project requirements

B.2.18
Heavy Lift Vessel

Specifications

Name	Stanislav Yudin		
Operator	Seaway Heavy Lifting		
Flag state	Cyprus		
Classification	1A1 Crane Vessel Ice-1C DK+		
Accommodation	151 people		
Helicopter deck	Equipped for S61-N		
Dimensions	Length overall	m	183.3
	Length of vessel	m	173.2
	Breadth	m	36.0
	Depth from deck	m	13.0
	Draught	m	5.5-8.9
Propulsion/ Power	Main engines (three)	kW	4,095
	Main thrusters (two)	kW	2,800, fixed pitch, 360°
	Bow thrusters (two)	kW	1,335, tunneled
	Maximum transit speed	knot	9
Ballast system	Ballasting tanks	m^3	24,100
	Anti-heeling tanks	m^3	11,800
	Ballast pumps (six)	m^3/h	850
	Anti-heeling pumps (two)	m^3/h	12,800
Positioning system	Eight-point system		
	Anchors	t	10
	Maximum pull winches	kN	1,800
	Brake holding capacity	kN	2,590
Crane	Make	Gusto	
	Main hoist		
	- Maximum revolving capacity	mt	2,500
	- Maximum lift height above Water level	m	78,04
	Auxiliary hoist		
	- Maximum capacity	mt	660
	- Maximum lift height above Water level	m	97,82

Seaway Heavy Lifting
Albert Einsteinlaan 50
2719 ER Zoetermeer
The Netherlands
Tel: +31 (0)79 363 77 00
Fax: +31 (0)79 363 77 99
E-mail: info@shl.nl
www.seawayheavylifting.com

B.2.19

ROV Survey Vessel

Normand Subsea

IMR, Survey & Light Construction

i-Tech 7

Normand Subsea, with its module handling system and extensive moonpool deployed ROV suite is an enclosed hangar, is specifically designed for inspection, maintenance and repairwork.

- Length 113m x breadth 24m
- Deck area 705m^2
- 140t AHC crane
- 2 x work-class / 4 x observation class ROVs
- Module handling tower
- Well treatment system

Deeper Challenges,
Wider Horizons

Normand Subsea

i-Tech 7

i-Tech Services is a Subsea 7 company.

General Information

Classification	DNV+1A1, ICE-1C, SF, COMF-V(2) C(2), HELDK-SH, Crane, Deice, E0, Dynpos-Autr, NAUT-OSV(A), Clean Design, DK(+), Well Stimulation
Built	Flekkefjord, Norway 2009
Flag State Authority	Isle of Man Government
Port of Registry	Douglas

Dimensions

Length	113.05m
Breadth	24m
Depth	11m
Draught (summer)	6.75m
Deadweight	6,300t

Dynamic Positioning Systems

The vessel has DNV notation DYNPOS-AUTR, equivalent with DP Class II, with dual redundant DP system.

The vessel has 3 DP operator stations. 1 main station aft with 2 operator stations and all position reference systems. 1 station forw. with 1 operator station.

Full DP capability operation is also available from port and starboard bridgewing.

DP System	Kongsberg K-Pos
Reference Systems	2 x Seatex DPS 200 GPS 1 x Seapath 200 GPS 2 x Taut wire 2 x HiPaP 500 (Dual) 1 x RadaScan

Tank Capacities (100%)

Fuel Oil (approx)	2,315m^3
Fresh Water (approx)	1,020m^3
Ballast Water (approx)	5,720m^3
Lub. Oil (approx)	30m^3

Manoeuvring & Propulsion Systems

Main Engines / Generators	4 x Wärtsila 8L32 engines with generators, each 3690 kW (Diesel Electric)
Propulsion	2 x Rolls Royce azipull, each 3500kW
Thrusters	1x tunnel forw. Rolls Royce 2000kW 2 x Rolls Royce retractable azimuth thrusters forw., each 1500kW 1 x tunnel aft Rolls Royce, 1500kW

Speed / Consumptions

Economical Speed (approx)	12 knots

Cargo Deck

Deckspace (approx)	705m^2
Deck Strength	10mt/m^2 on maindeck 5mt/m^2 inside hangar

Deck Cranes

Main Winch	150t at 11m (double fall) 140t at 11m (single fall) 40t at 30m (single)
Whip Line	24t at 32m (slip to slip) 12t at 32m

ROV Systems

The vessel has 6 ROV handling system - 2 work-class and 4 eyeball - fully integrated and with active heave compensation. 4 ROV systems deployed from enclosed hanger via moonpools and 2 cursor guided ROV systems deployed from port side.

Module Handling System

Module handling tower for 35t (upgradeable to 60t) deployment/ recovery in 5 mHs via enclosed moonpool.

Module handling and ROV support to 1,200m depth.

Well Treatment Equipment

Chemical / Acid Storage Tanks	5 tanks, each 20,000L capacity
Chemical / Acid Mixing Tanks	2 tanks, each 10,000L capacity
Injection Pump 1200hp	1000 l/min 345bar
Injection Pump 600hp	320 l/min 345bar

Life Saving Appliances

Lifeboats	2 lifeboats, Norsafe, each 90 persons
Liferafts	6 life rafts, Viking, total capacity 170 persons
MOB / FRC	1 Norsafe

Accommodation

90 persons

State Cabins	8
Single Cabins	34
Double Cabins	24
Hospital	1

Helideck

The vessel is fitted with an approved and certified helideck. The helideck has a D value of 22.20 and is approved for Sikorsky S-61 and Sikorsky S-92 operations.

Communications

The ship is equipped with all necessary installation and systems for communication onboard a vessel, according to rules, regulations and Buyer requirement. Radio installation according to GMDSS-requirements is provided.

February 2017

www.i-tech7.com

B.2.20

Pipe Carrier Vessel

TIDEWATER®
HART TIDE
MMC-887 PLATFORM SUPPLY VESSEL

Last update: 1/21/2016

Vessel Characteristics

Length, Overall:	285.8 ft	87.1 m
Beam:	61.8 ft	18.8 m
Depth:	24.3 ft	7.4 m
Maximum Draft:	19.8 ft	6.1 m
Light Draft:	7.6 ft	2.3 m
Minimum Height:	91.2 ft	27.8 m
Freeboard:	4.6 ft	1.4 m
Displacement:	7,600 lt	7,720 mt
Deadweight:	5,050 lt	5,130 mt
Clear Deck Space:	200 x 52 ft	59.7 x 16 m
Clear Deck Area:	9,980 ft^2	930 m^2
Deck Strength:	1,020 lb/ft^2	5 t/m^2
Class Notations: ABS: +A1, (E), +AMS, +DPS-2, FFV-1, OSV, UWILD		

TIDEWATER® HART TIDE

Capacities

Deck Cargo:	2,800 lt	2,840 t
Fuel Oil:	240,000 gal	910 m^3
Potable Water:	44,300 gal	170 m^3
Fresh Water:	530,000 gal	170 m^3
Drill/Ballast Water:	86,700 gal	330 m^3
Bulk Tanks (5 tanks):	14,700 ft^3	420 m^3
Liquid Mud (20 lbs/gal):	15,200 bbl	2,410 m^3
Methanol:	2,700 bbl	430 m^3

Machinery

Diesel Electric Vessel			
Propulsive/Total HP:			5,360 / 10,200
Z-Drives:			Yes
Propellers (2):			4-Blade FP Rolls-Royce
Kort Nozzles:			Yes
Primary Generators (4):	1,820 kw	480 v	60 hz
Driven by:			Cummins QSK60-D(M)
Emergency Generators (1):	150 kw	480 v	60 hz
Driven by:			Cummins 6CTA8.3-D(M)
Bow Thruster (2):			1220 Hp CPP TT, 1073 Hp CPP DD
Driven by:			Electric Motor Driven
Total Thrust:		28.7 st	26 mt

Deck. Equip.

Anchors (2):	5458 lbs HHP
Anchor Chain:	250 m of 50 mm chain per side
Crane:	2 t @ 10.1 m
Capstans (2):	7.5 t Electric, 328 ft. of .5 in.
Tugger (2):	10 t Electric, Plimsoll

Accommodations

Nº of Berths:	52
1-man cabins:	16
2-man cabins:	10
4-man cabins:	4
Certified to Carry:	52
Hospital:	Yes

Performance

(Approximate values assuming Ideal Conditions)		
Fuel Consumption Vs Speed		
Maximum:		30 m^3/day (330 gph) @ 14 knots
Cruising:		25 m^3/day (280 gph) @ 13 knots
Economical:		16 m^3/day (180 gph) @ 11 knots
Range @ 11 Knots:		15,200 nm
Transfer Rates		
Fuel Oil:	660 gpm @ 300 ft	150 m^3/h @ 92 m
Fresh Water:	660 gpm @ 300 ft	150 m^3/h @ 92 m
Drill/Ballast Water:	660 gpm @ 300 ft	150 m^3/h @ 92 m
Bulk:	49 cfm @ 180 ft	83 m^3/h @ 56 m
Liquid Mud:	660 gpm @ 470 ft	150 m^3/h @ 140 m
Methanol:	330 gpm @ 300 ft	74.9 m^3/h @ 92 m

Nav/Comms Equip.

Radar(s):	2
Depth Sounder:	1
Gyro Compass:	3
Doppler Log:	1
Radio:	3 x VHF; 1 x SSB

Special Equip.

Firefighting:	FiFi-1
Dynamic Positioning:	DPS-2
Ref. Systems:	2 x MRU; 2 x DGPS 1 x Laser-based; 1 x Radar-based
Tank Cleaning:	YES
Rescue Boat:	Solas Approved

Registration

Flag:		VANUATU
IMO Nº:		9533579
Year Built:		2011
Builder:		FUJIAN MAWEI
Call Sign:		YJQW3
Tonnage (ITC):	3601 GT	1429 NT

Last update: 1/21/2016

B.2.21
Dive Support Vessel

Seven Atlantic

Diving

Seven Atlantic is one of the most advanced diving vessels in the world.

- Length 145m x breadth 26m
- Deck area 1,200m^2
- Accommodation for 150 persons
- Heave compensated 120t crane
- 2 x air diving systems
- 2 x eyeball ROV systems
- Equipped for well treatment operations
- 24-man twin-bell saturation diving system rated to 350m with two hyperbaric lifeboats.

seabed-to-surface

Seven Atlantic

subsea 7

General Information

Classification	Lloyds Register, +100A1 DSV, UD strength for load of 10 t/m², Heli Landing Area, +LMC, UMS, DP(AAA), CAC(2), EP, ICC
Built	Merwede, Holland 2009
Flag State Authority	Isle of Man Government

Dimensions

Length Overall	144.79m
Breadth (moulded)	26m
Depth to maindeck	12m
Draught design	7m
Deadweight	8,700t

Manoeuvring and Propulsion Systems

Main Engines / Generators	6 x 3,360kW (Diesel Electric)
Propulsion	3 x 2,950kW stern azimuth thrusters 2 x 2,400kW retractable bow azimuth thrusters 1 x 2,200kW bow tunnel thruster

Dynamic Positioning Systems

DP Classification	DP (AAA) - Class III
DP System	Kongsberg K-pos 22 + as back-up system for Class III, Kongsberg K-pos 12
Reference Systems	3 x DGPS 2 x HiPAP 2 x taut wire 2 x Cyscan Radascan HPR interface Fanbeam interface

Speed / Consumptions

DP	17-20m³/day
Full transit speed	15.5 knots (55-60m³/day)
Normal transit speed	13.0-13.5 knots (45m³/day)
Economical Speed	12 knots (35m³/day)
In port consumption	8m³/day

Tank Capacities

Marine Gas Oil	2,289.733m³
Fresh Water	1,051.592m³
Ballast Water	4,736.674m³
Heeling tanks (55%)	663.80m³
Stabilising tanks (operational	600m³
Technical fw/ waterballast	135m³
Low sulphur diesel oil	135m³

Well Treatment Equipment

Chemical/Acid Tanks (5)	20,000 ltr each
Injection pumps (1)	1800HP
Injection pumps (1)	600HP

Cargo Deck

Deck Area (main deck)	1,200m²
Deck Strength	10t/m²

Deck Cranes

Main Deck heave compensated Crane	120t
Whip Line	24t
Two provision cranes.	2.5t
Auxiliary Deck Crane I & II	10t

ROV Systems

The vessel is fitted with two permanently installed moonpools launching eyeball ROV heave compensated systems rated to 1,200 metres.

Diving System

The 24-person saturation diving system includes four 3-man twin lock living chambers, two 6-man twin lock decompression chambers and two horizontal transfer under pressure chambers, (chambers are 2.4m internal diameter) 54,000m³ of gas storage and up to six split levels of saturation storage. The system is designed for compliance with Norwegian NORSOK requirements, and features much improved living conditions compared to previous systems. Two Hyperbaric Life Boats are provided (one port and one starboard). The bells have 7m³ internal capacity and are launched through two athwartships moonpools, positioned near the minimum motion point of the vessel. There are two fully integrated air diving systems, including chambers, one port and one starboard.

A comprehensive system of mechanical handling aids is fitted to support saturation and air diving operations, including port and starboard T bars, A-frames, hose reels, tugger winches and umbilical management hoop booms (20m reach from ship side).

Accommodation

150 persons

Captain Class Cabins	6
Officer	5
Single Cabins	9
Double Cabins	65

All cabins with own private facilities
One 2-berth sick bay

Helideck

Helideck of aluminium construction suitable for regular operations of S61 and S92 helicopters and equipped with a fixed foam fire fighting system in accordance with CAP 437.

Communications Systems

The vessel is fitted with Inmarsat Fleet 77 and KU Band systems. The KU Band system has the option to be converted to C Band as operational requirements demand.

Extensively equipped operations and client office suites; IT network and facilities / video conferencing. The vessel also has dedicated crew WiFi internet access.

Life Saving Appliances

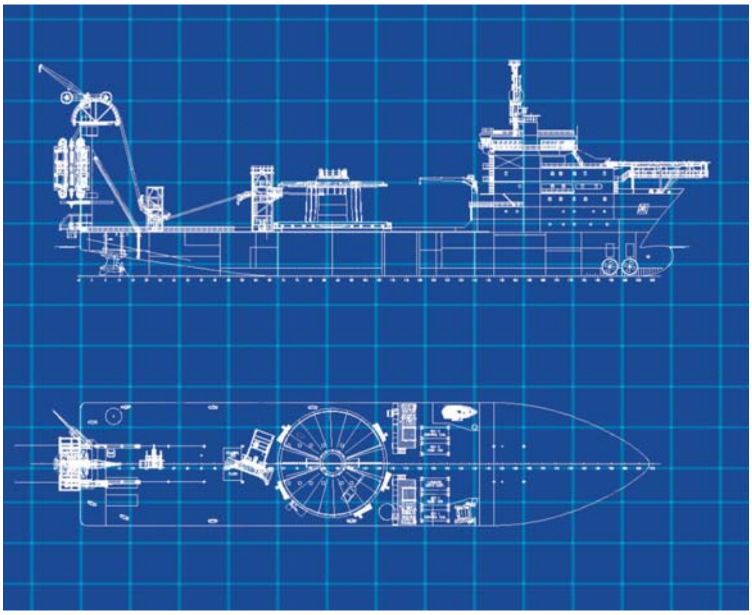
Four davit launched lifeboats	75 persons each
Twelve life rafts	25 persons each
One life raft	10 person
Two hyperbaric lifeboats	18 persons each

February 2017

www.subsea7.com

B.2.22
Umbilical Installation Vessel

Lay Vessel North Ocean 102



Official Flag: Malta
Built/Year: Spain - 2009
Class: DNV 1A1 HELIDK, DYNPOS-AUTR, EO, DK (+), CLEAN, COMF-(V3), NAUT-OSV(A)

HULL

Dimensions:
- LOA: 438 ft [133.6 m]
- Beam: 89 ft [27 m]
- Depth: 32 ft [9.7 m]

Max. Operating Draft: 22.5 ft [5-6 m]
Deck Area: 25,833 ft^2 @ 11 ST/ft^2 [2,400 m^2 @ 10 MT/m^2]

DYNAMIC POSITIONING

System: Kongsberg, K-Pos Dual Dynamic Operating System
DP Class: Class 2, DNV Dynpos AUTR, also compliant with NMD
DP Reference System: 1 @ HIPAP 500; 2 @ DGPS; 1 @ Tautwire; 1 @ Fanbeam

POWER

Distribution: 690 V, 440 V, 230 V, 60 Hz
Main Generator: 4 @ 3,330 kW
Emergency Generator: 1 @ 600 kW
Shore Connection: 440 V, 3 @ 250 A

COMMUNICATION & NAVIGATION

Communication: email / fax / phone
Radio: Inmarsat C- complies with DNV NAUT OSV (A). Radio area A1, A2, A3, worldwide
Radar: 2
Gyro Compass: 3
Echo Sounder: 1
Doppler Speed Log: 1

ACCOMMODATION
Berths (air conditioned & heated): 199 persons total - 81 berths with private bathroom, CD/DVD player, TV and fridge
Medical: clinic with four beds
Other Facilities: galley, mess room, gym, sauna, recreation room, movie room, conference room, internet cafe, reception rooms, customer offices, survey offices, dedicated diving project office, workshops

PROPULSION
Main Propeller: 2 @ 3,500 kW Azipull thrusters
Bow Thrusters: 1 @ 1,500 kW swing up azimuth; 2 @ 1,500 kW tunnel
Speed: 12 kts (economical); 15 kts (max)

SAFETY
Life Boat: 2 @ 106-person
Life Raft: 8 @ 25-person
MOB: 1
Rescue Boat: 1
Safety System: meets flag and regulatory body requirements

TANKS
Fuel: 528,344 usg [2,000 m^3]
Ballast Water: 1,408,037 usg [5,330 m^3]
Potable Water: 366,143 usg [1,386 m^3]

Lay Vessel North Ocean 102

CRANES
Knuckle Boom Crane: 1 @ 110 ST AHC 7,283 ft wire [1 @ 100 MT AHC 2,220 m wire]
Provision Crane: 2 @ 2.2 ST @ 39 ft reach, 275 ST AHC Port aft crane (knuckle boom), max radius 118 ft (Main Hoist), 131 ft (Whip Line) 9,840 ft wire [2 @ 2 MT @ 12 m reach 250 MT AHC Port aft crane (knuckle boom), max radius 36 m (Main Hoist), 40 m (Whip Line) 3,000 m wire]

PIPELAY EQUIPMENT
Control Systems: fully integrated central control room for all lay components with local remote intervention
Lay System: Flex-Lay tower consisting of 330 ST [300 MT] single tensioner and 386 ST [350 MT] hang-off clamp, work platform complete with 2 @ 5.5 ST [2 @ 5 MT] winches, 2 @ 5.5 ST [2 @ 5 MT] gantry cranes
Horizontal Carousel Reel: 6,600 ST [6,000 MT] capacity; Level wind tower with 22 ST [20 MT] spooling tensioner and spooling platform
Min OD: 2 in
Max OD: 16.5 in
Compensator: product tension 1 to 22 ST [1 to 20 MT] with 9.5 ft [3 m] stroke HC
Winchs: 33 ST; 22 ST and 11 ST winch, 2 @ 5.5 ST tugger winches mounted on work platform, workshop container [30 MT; 20 MT and 10 MT winch, 2 @ 5 MT tugger winches mounted on work platform, workshop container]
Min Water Depth: 33 ft [10 m]
Max Water Depth: 10,000 ft [3,000 m]

EQUIPMENT
Water Maker: 2 @ 18,756 usg / day max fresh water [2 @ 25 m^3 / day max fresh water]
Helideck: compatible with Super Puma AS 332/Sikorsky S 92A
Anti-pollution Equipment: per class requirement
Deck Equipment: Including deck chute, tools/ spares container, compensated underbender and deck HPU

B.2.23
Drillship

Ensco Middle East & Africa
Al Moosa Tower 2, Suite 2601
Sheikh Zayed Road
Dubai U.A.E.
Phone: +971 4 403 7300 Fax: +971 4 403 7305
E-mail: marketing.ap@enscoplc.com
www.enscoplc.com

ENSCO DS-12 (formerly Atwood Achiever)

GENERAL INFORMATION

Flag: Marshall Islands
Previous Name(s): Atwood Achiever
Year Built: 2013
Builder: DSME Okpo Shipyard - Geoje, South Korea
Upgrade: N/A
Design: DSME 12000 Double-Hull DP Drillship
Classification: DNV, @ 1A1 Ship Shaped Drilling Unit, DYNPOSAUTRO, CRANE, E0, HELDK-SH, DRILL, BIS, BWMT, DPS-3

MAIN DIMENSIONS

Length: 780 ft (238 m)
Breadth: 137 ft (42 m)
Depth: 62 ft (19 m)
Moon Pool: 22.15 m x 9.75 m

DRAFT AND DISPLACEMENT

Operating Draft: 39 ft (12m)
Displacement: 104,000 mT @ 12 m draft

MACHINERY

Main Power: Six (6) HHI 14H32/40V 14 cylinder engines rated 7,000 kW each, driving six (6) Siemens HSJ71209-10P generators rated at 6,750 kW each
Power Distribution: Three (3) Siemens Switchboard 11 kV for generator control and distribution
Emergency Power: One (1) Caterpillar, 3516B 16 cylinder emergency diesel engine rated 1,889.2 kW driving One (1) Leroy Somer, Brushless/Revolving Field generator rated at 1,765 kW

OPERATING PARAMETERS

Water Depth: maximum 12,000 ft (3,657 m); outfitted for 10,000 ft (3,048 m)
Drilling Depth: 40,000 ft (12,192 m)
Transit Speed: 12.5 knots at transit draft
Survival Conditions: 48,201 kips (21,863 mT)

DRILLING EQUIPMENT

Derrick: One (1) NOV Galvanized Derrick, 18m x 24m x 64m (approx. 59ft x 80ft x 210ft) working height static hook load 2,500 kips
Drawworks: One (1) Main Well, NOV 1,250 sTon, 6 motor, AHD-1250 Active Heave Drawworks System
Continuous rating is 1,120 kW (1,500 HP), 690 VAC
Rotary: One (1) Main, NOV Rotary table 75.5", hydraulic drive, 5 rpm continuous/15 rpm intermittent, 1,375 sTon load capacity
One (1) Aux, NOV Rotary table 60.5", hydraulic drive, 5 rpm continuous/15 rpm intermittent, 1,000 sT on load capacity
Top Drive: One (1) Main, NOV TDX – 1250 top drive (1,250 sTon Capacity
One (1) Aux, NOV TDX – 1000 top drive (1,000 sTon Capacity)
Mud Pumps: Four (4) NOV 14P-220 HP mud pumps, 2,200 HP, 7,500 psi
Handling: Two (2) NOV Hydra-Racker IV-ER Automated pipe handling/racking system
Two (2) NOV ST-160 Iron Roughnecks (one Main and one Aux well)
Cementing: Schlumberger – 3.75"=15K / 5"-10K (3rd party)
Drill Pipe: 5 7/8" x 4,572 m (15,000 ft) V-150 R3 uGPDS55
6 5/8" x 3,048 m (10,000 ft) V-150 R3 uGPDS65
6 5/8" x 2,438 m (8,000 ft) V-150 R3 uGPDS65
Landing String: 6 5/8" x 3,048 m (10,000 ft) V-150 R3 6-5/8 FH
HWDP: 5 7/8" x 32 standard R2 uGPDS55
6 5/8" x 32 standard R2 uGPDS65
Drill Collars: 7" x 32 spiral, NC50
8 ¼" x 24 spiral, 6 5/8 Reg
9 ½" x 8 spiral, 7 5/8 Reg

HOISTING EQUIPMENT

Cranage: Three (3) NOV Knuckle boom crane 100 mT lifting capacity at 20 m
One (1) NOV Active Heave Crane for subsea lifts, 165 mT deck load at 18.2 m radius to 600 m water depth, 103 mT deck load at 3,000 m water depth

CAPACITIES

Variable Deck Load: 23,000 mT
Tubulars in Pipe Rack: One (1) NOV Pipe Catwalk Machine 15 mT x 50' length c/w tail-in arm
One (1) NOV Riser Catwalk Machine with tail in arm and flat bed service cart
Liquid Mud: 2,991.1m^3 (includes slug tanks but not processing tanks)
Barite/Bentonite: 480 m^3
Bulk Cement: 320 m^3
Drill water: 3,190 m^3
Potable Water: 1,634.3 m^3
Brine Storage: 1,033.4 m^3
Base Oil Capacity: 815 m^3
Fuel: 8,415.6 m^3
Sacks: 10,000 sacks

WELL CONTROL SYSTEMS

BOP: Two (2) GE/Hydril 18-3/4" 15 ksi 7 ram BOP stack c/w two (2) 10 Ksi annulars and an 18-3/4" Super HD-H4 wellhead connector
BOP Handling: One (1) NOV BOP bridge crane 2 x 250 mT c/w 2 ea. 30 mT auxiliary winches
One (1) NOV bulkhead guidance system for capturing BOP movement
Control System: Hydril Control System 3,000/5,000 psi
One (1) Hydril BOP Test Pump
One (1) Hydril Diverter closing unit c/w pumps, accumulator, and operator/test panel
Choke and Kill: One (1) Techdrill 15k x 10k choke and kill manifold with glycol injection
Diverter: One (1) GE/Hydril CSO type 75.5" diverter housing with 18" flowline, 16" divert line
One (1) GE/Hydril full closure diverter assy c/w 20" thru bore and rated to 500 psi

HELIDECK

Size: Octagonal 22.8 x 22.8; D-Value 22.8
Capacity: 14.6 mT
Design: Designed for S-61N, S-92, EH101

ACCOMMODATION

Total Beds: 200 persons

ADDITIONAL DATA

Thrusters: Six (6) Rolls Royce thrusters with steering motors, control panel and Hydraulic power unit, c/w Siemens 5,500 kW drive motors @ 750 rpm

B.2.24
Condensate Carrier

M/T Kirkeholmen

BALTICSHIPPING.COM

World's most advanced and fastest growing seafarers database

KIRKEHOLMEN

IMO number	9553402
MMSI	355320000
Name of the ship	KIRKEHOLMEN
Former names	KIRKEHOLMEN BB (2012) CF SOPHIA (2012)
Vessel type	Chemical/Oil tanker
Operating status	Active
Flag	Panama
Gross tonnage	11908 tons
Deadweight	17136 tons
Length	144 m
Breadth	23 m
Draft	9 m
Engine type	MAN-B&W
Engine model	6K80MCC
Engine power	5180 KW
Year of build	2010
Builder	ZHEJIANG JINGANG SHIPBUILDING - WENLING, CHINA
Class society	BUREAU VERITAS
Owner	KIRKEHOLMEN SHIPPING - TORTOLA, BRITISH VIRGIN ISLANDS
Manager	NORBULK UK - GLASGOW, United Kingdom (UK)

 E-mail: support@balticshipping.com

B.2.25

Mooring Line Vessel

DAMEN ANCHOR HANDLING TUG SUPPLY 180

AHTS 18000

GENERAL

Basic functions	Offshore supply, towing and anchor handling operations
Classification	Lloyds Register ✠100 A1 Anchor Handler, Offshore Supply Ship, Tug, *IWS, ✠ LMC UMS DP(AM)

DIMENSIONS

Length o.a.	79.20	m
Length b.p.p.	73.50	m
Beam mld.	20.00	m
Depth mld.	8.40	m
Draught summer (base)	6.80	m
Draught summer (keel)	7.40	m
Deadweight (summer)	2700	t
Cargo deck area	545	m^2
Deck load (at 1 m above deck)	800	t

TANK CAPACITIES

Ballast water	900	m^3
Fuel oil	1045	m^3
Potable water (service)	220	m^3
Potable water (cargo)	540	m^3
Chain lockers	280	m^3

PERFORMANCES (APPROX.)

Speed (at summer draught)	15.4	kn
Bollard pull	180	t

PROPULSION SYSTEM

Main engines	4x	MAN 7L27/38
Propulsion power	4x	2555 bkW
Propellers	2x	4300 mm, CPP in optima nozzels
Bow thruster	2x	750 kW, 1740mm, FPP
Stern thruster	1x	820 kW,1740mm, FPP

AUXILIARY EQUIPMENT

Networks		690 V, 440 V and 230 V
Shaft generators	2x	1500 ekW at 1800rpm
Main generator sets	2x	Caterpillar C18, 550 ekW each at 1800 rpm, 690 V, 60 Hz
Emerg./ harbour generator set	1x	Caterpillar C9, 238 ekW at 1800 rpm, 440 V, 60 Hz

DECK LAY-OUT

Deck crane	1x	5 t @ 10 m
	1x	2.9 t @ 9m / 1.6 t @ 16.4 m
Anchor mooring winch	1x	Electric-hydraulic, with rope drum and two warping heads
AH/Towing winch	1x	electric, double drum, 410 t pull, 450 t brake, 5600 m of 86 mm wire
Secondary winch	2x	electric, 130 t pull, 130 t brake, 1100 m of 203 mm rope
Towing pins	4x	SWL, 180 t, hydraulic
Chain fork	2x	SWL, 500 t, hydraulic
Stern roller	1x	SWL, 500 t, split drum, ø 3.0 m, 6 m length
Tugger winches	2x	electric, each 15 t pull
Capstans	2x	electric-hydraulic, each 10 t pull

CARGO HANDLING SYSTEM

Ballast pump	2x	100 m³/hr at 3 bar
Fuel oil pump	1x	100 m³/hr at 9 bar
Fresh water pump	1x	100 m³/hr at 9 bar

ACCOMMODATION

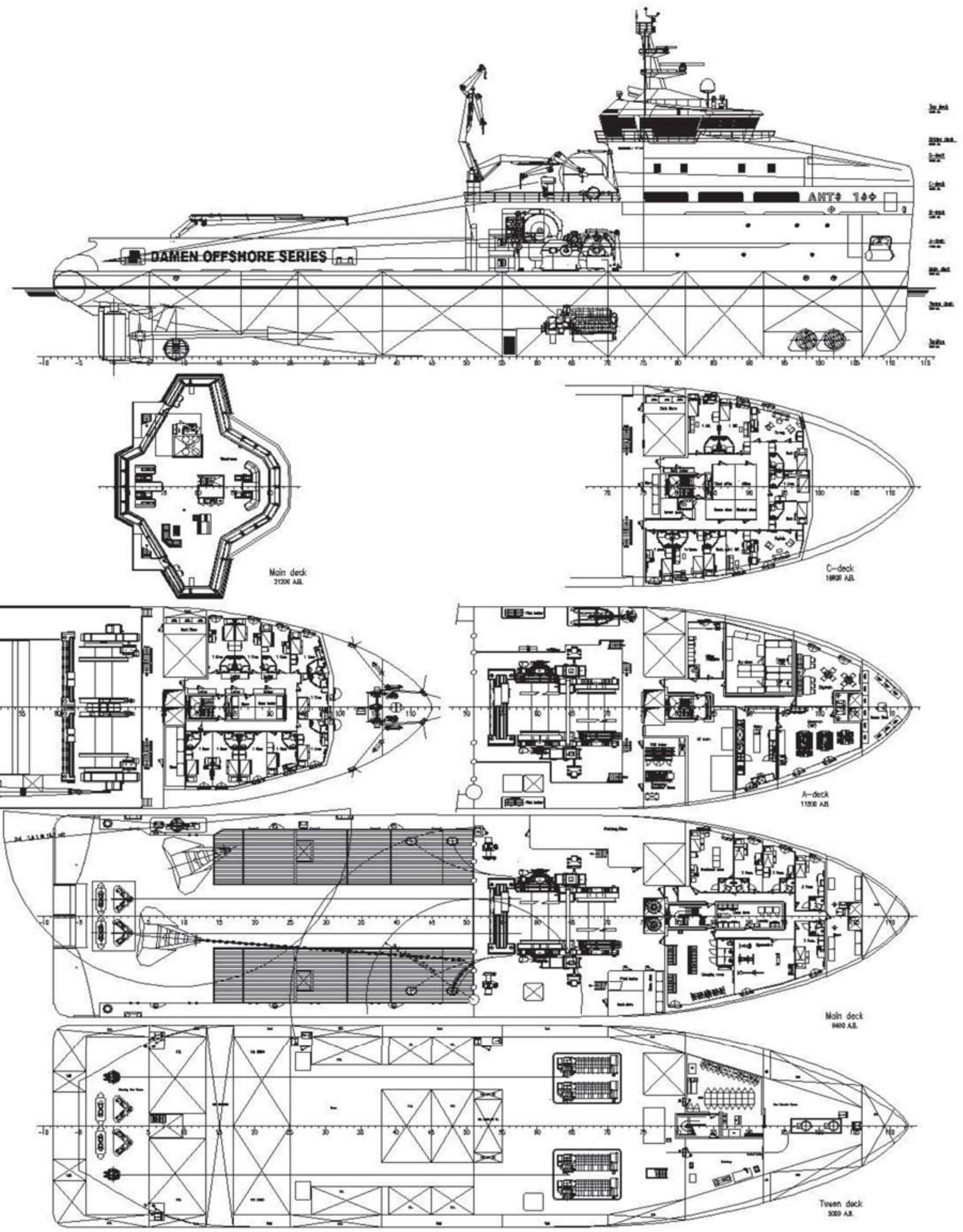
Crew	16	persons
Passengers	11	persons

NAUTICAL AND COMMUNICATION EQUIPMENT

Radar systems	1x X- band + S-band
DP – system	DP 1
GMDSS	Area A3

OPTIONS

Fire Fighting Ship 1 or 2
IMO DP Class 2
Travelling cranes
Hybrid propulsion
Hydraulic AHT Winch
Extended accomodation



DAMEN ANCHOR HANDLING TUG SUPPLY 180

AHTS 18000

DAMEN

DAMEN SHIPYARDS GORINCHEM

Member of the DAMEN SHIPYARDS GROUP

Industrieterrein Avelingen West 20
4202 MS Gorinchem

P.O. Box 1
4200 AA Gorinchem
The Netherlands

phone +31 (0)183 63 99 11
fax +31 (0)183 63 21 89

info@damen.nl
www.damen.nl

DSGo-D&P-3.0-0612

B.3
Helicopter Specifications

B.3.1
AgustaWestland AW 139

OFFSHORE IN SAFE HANDS

- Payload / Range - new generation of capability; long range tank available to extend reach
- Maximised all weather operation, with capability for flight into known ice conditions
- Vertical CAT A perfomance at Sea Level up to 40°C at MGW
- Spacious and bright cabin
- Ease of access and egress
- Low operating costs
- Modern equipment optimises TBO and Retirement Lives
- High useful load and high speed for increased productivity
- Next generation Safety - design, construction, operability and crashworthiness.

WORLWIDE SUPPORT

AW139 is designed to maximise operational capability and minimise cost. Maintenance operations have been minimized by design, as have components subject to overhaul and replacement; reducing downtime for flight-intensive Offshore schedules. A worldwide network of service and support centres is already serving the Offshore industry, worldwide. Four full Level-D flight simulators are available for pilot training and maximised safety.

AW139 OFFSHORE CHARACTERISTICS

Dimensions		
Overall length (1)	16.66 m	54 ft 8 in
Overall height (1)	4.98 m	16 ft 4 in
Rotor diameter	13.8 m	45 ft 3 in
Propulsion		
Powerplant	(2) Pratt & Witney PT6C-67C Turboshafts with FADEC	
Engine Ratings		
AEO Take off power	2 x 1,252 kW	2 x 1,679 shp
OEI 2.5 min contingency power	1,396 kW	1,872 shp
Weights (MTOW)		
Max ramp weight	6,450 kg	14,219 lb
Internal load (2)	6,400/6,800 kg	14,110/14,991 lb
External Load	6,800 kg	14,991 lb
Typical mission equipped weight	4,400 kg	9,700 lb
Capacity		
Crew	1-2	
Passenger seating	Up to 15	
Stretchers	4 stretchers (up to 5 attendants)	
Baggage compartment	3.4 m^3	120 ft^3
Performance (ISA, S.L., MTOW)		
VNE (IAS)	310 km/h	167 kt
Cruise Speed	306 km/h	165 kt
Max Rate of Climb	10.9 m/s	2,140 ft/min
HOGE	2,478 m	8,130 ft
Service Ceiling	6,096 m	20,000 ft
OEI service ceiling	3,536 m	11,600 ft
VTOL cat. A	945 m	3,100 ft
Maximum range (3)	1,250 km	675 nm
Maximum endurance (3)	5 h 56 min	

(1) Rotors turning
(2) An optional MTOW (internal) of 7,000 kg (15,430 lb) is available as a kit
(3) at 6,000 ft, No reserve, with Auxiliary fuel

B.4
Supporting Documentation

B.4.1
Air Emissions, Total – Preparation, Construction, and Installation

Summary of Emissions for Construction and Installation (Hookup and Commissioning)

	CO_2 t/y	CH_4 t/y	N_2O t/y	NO_x t/y	CO t/y	VOC t/y	SO_2 t/y	GHG t/y
FPSO	20,480	1.28	0.60	403	107.52	10.37	128	20,691
Subsea	62,163	3.89	1.83	1,224	326	31.47	389	62,805
Hub	174,027	10.88	5.11	3,426	914	88.10	1,088	175,822

From: MS002-EV-REP-010-01002, Rev A01

Abbreviations:

CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
GHG	Greenhouse Gas
N_2O	Nitrous Oxide
NO_x	Oxides of Nitrogen
SO_2	Sulphur Dioxide
t/y	Tonnes per year
VOC	Volatile Organic Compound

B.4.2
Air Emissions, Total – Operation

Summary of Emissions for Operations

	CO_2 t/y	CH_4 t/y	N_2O t/y	NO_x t/y	CO t/y	VOC t/y	SO_2 t/y	GHG t/y
FPSO	178,051	13	5	700	182	10	98	179,780
HUB	9,429	14	6	1,033	418	67	132	739,940
FLNG	548,919	-	-	119	178	51	-	
TOTAL	736,400	14	6	1,033	418	67	132	739,940

From: MS002-EV-REP-010-01002, Rev A01

Abbreviations:	
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
GHG	Greenhouse Gas
N_2O	Nitrous Oxide
NO_x	Oxides of Nitrogen
SO_2	Sulphur Dioxide
t/y	Tonnes per year
VOC	Volatile Organic Compound

B.4.3

Air Emissions, Total – Decommissioning

Summary of Emissions for Decommissioning (projected*)

	CO_2 t/y	CH_4 t/y	N_2O t/y	NO_x t/y	CO t/y	VOC t/y	SO_2 t/y	GHG t/y
FPSO	2,867	0.18	0.08	56.42	15.05	1.45	18	2,897
Subsea	8,703	0.54	0.26	171.36	45.64	4.41	54	8,793
Hub	24,364	1.52	0.72	479.64	127.96	12.33	152	24,615

Adapted from: MS002-EV-REP-010-01002, Rev A01

* - based on estimates that emissions associated with decommissioning will be 14% of emissions projected for construction and installation (i.e., 406 days for decommissioning; 2,915 days for construction/installation)

Abbreviations:

CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
GHG	Greenhouse Gas
N_2O	Nitrous Oxide
NO_x	Oxides of Nitrogen
SO_2	Sulphur Dioxide
t/y	Tonnes per year
VOC	Volatile Organic Compound

APPENDIX C : BP'S HEALTH, SAFETY, SECURITY, ENVIRONMENTAL & OPERATING POLICY FOR MAURITANIA AND SENEGAL

bp

Mauritania and Senegal Region Health, Safety, Security, Environmental (HSSE) & Operating Policy

BP has a clearly stated aim of no accidents, no harm to people and no damage to the environment. We are fully committed to the health, safety and security (HSSE) of our staff and the communities and the protection of the natural environment in which we operate. Delivery of these goals underpins our vision to be a good operator that consistently delivers safe, compliant and reliable production operations, wells and projects. We work in a systematic and disciplined way as One Team in the Region.

We commit to:

- Demonstrate leadership in health, safety, security and environmental protection and pursue business with integrity in accordance with the BP Code of Conduct.
- Safeguard employees, customers, communities, the environment and BP's assets against risks of injury, pollution, loss or damage. Operational safely is our first priority, and our line managers are accountable for safety and protection of the environment.
- Systematically applying BP's Operating Management System (OMS) across our business to deliver safe, compliant and reliable operations, wells and projects.
- Ensure our employees and contractors are competent and trained to carry out their work safely with due regard to the environment.
- Complying with applicable laws and regulations, and conforming to other requirements as set out in the OMS and company policies, practices and procedures in relation to our activities, products and services.
- Maintaining emergency response plans and resources, practice and manage emergency situations resulting from our activities.
- Set annual HSSE objectives, targets and management programs and openly report performance, good and bad.
- Consulting, listening and responding openly to our employees, contractors and those that work with us – our partners, suppliers, competitors and regulators – sharing best practice to raise the standard of our operations and our industry.
- Recognizing those who contribute to improve HSE and operating performance and support those who stop work that they consider unsafe or likely to cause loss of primary containment or damage to the environment.
- Continuously improving our HSSE and Operating performance by strengthening the leadership, capability and capacity of our organization, thoroughly investigating incidents and implementing lessons learned.
- Using audits to test for conformance with BP's Operating Management System, policies, practices and procedures and to applicable external standards (e.g. ISO 14001 Environmental Management System standard) and take corrective actions where required

Working safely is a legal requirement and a condition of employment. We expect all staff and contractors working in the Region to understand and comply with this Policy.

We expect all staff and contractors to stop work when there is an unsafe act or behavior, non-compliance with applicable laws or regulations, or when unable to meet BP requirements or HSE commitments. We expect all supervisors to verify that their staff and contractors know what is expected of them. These expectations exist to protect our staff and contractors, the environment and to safeguard the integrity of our production operations, wells and projects. Failure to comply with these expectations may result in disciplinary action up to and including termination.

No activity is so important that it cannot be done in a healthy, safe, secure and environmentally responsible manner.

Emma Delaney

Emma Delaney, Regional President
November 2017

APPENDIX D : ENVIRONMENTAL BASELINE SURVEY

AHMEYIM/GUEMBEUL LNG DEVELOPMENT

ENVIRONMENTAL BASELINE SURVEY REPORT

November 2017

Prepared for:

Kosmos Energy LLC
8176 Park Lane, Suite 500
Dallas, Texas 75231
Telephone: 214-445-9600

Prepared by:

CSA Ocean Sciences Inc.
8502 SW Kansas Avenue
Stuart, Florida 34997

Author Certification Signature

Bruce Graham
Senior Scientist/Marine Specialist
CSA Ocean Sciences Inc.
E-mail: bgraham@conshelf.com

AHMEYIM/GUEMBEUL LNG DEVELOPMENT ENVIRONMENTAL BASELINE SURVEY REPORT

DOCUMENT NO. CSA-KOSMOS-FL-17-80098-3047/3048-07-REP-01-FIN

Version	Date	Description	Prepared by:	Reviewed by:	Approved by:
01	3/28/17	Initial draft for review	B. Graham/ D. Snyder	B. Balcom B. Graham	B. Balcom
02	4/04/17	Post draft review	B. Graham/ D. Snyder	M. Cahill	B. Balcom
03	4/21/17	Client review	B. Graham/ D. Snyder	B. Balcom	B. Balcom
FIN	11/15/17	Final	B. Graham/ D. Snyder	B. Graham	B. Balcom

Table of Contents

Page

List of Tables

List of Figures

List of Figures (Continued)

List of Photos

Photo **Page**

Acronyms and Abbreviations

A/G	Ahmeyim/Guembeul
Al	aluminum
ALS	ALS Environmental
As	arsenic
ASTM	American Society for Testing and Materials
Ba	barium
CCC	criterion continuous concentration
Cd	cadmium
CoC	chain-of-custody
Cr	chromium
CSA	CSA Ocean Sciences Inc.
CTD	conductivity-temperature-depth (profiler)
Cu	copper
DGPS	differential global positioning system
DO	dissolved oxygen
DP	dynamic positioning
DRO	diesel range organics
EBS	environmental baseline survey
ECEQS	European Commission Environmental Quality Standards
EHS	Environmental, Health, and Safety
EOM	extractable organic matter
ERL	effects range low
ERM	effects range median
ESIA	environmental and social impact assessment
Fe	iron
FFPI	Fossil Fuel Pollution Index
GC-FID	gas chromatography, flame ionization detector
GC-MS	gas chromatography, mass spectrometry
GIS	geographic information system
GLP	Good Laboratory Practice
GPS	global positioning system
GRO	gasoline range organics
HCl	hydrochloric acid
HDPE	high density polyethylene
HF	hydrofluoric acid (digestion)
Hg	mercury
HNO_3	nitric acid
ICP-MS	inductively coupled plasma mass spectrometry
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
LPIL	lowest practical identification level
µ	micron
NA	Nearshore Area
NELAP	National Environmental Laboratory Accreditation Program
Ni	nickel
NMDS	non-metric multidimensional scaling
NOAA	(U.S.) National Oceanic and Atmospheric Administration

NPD	naphthalene, phenanthrene, dibenzothiophene
NTU	nephelometric turbidity unit
OA	Offshore Area
OSPAR/ICES	Convention for the Protection of the Marine Environment of the North-East Atlantic/International Council for the Exploration of the Sea
PA	Pipeline Area
PAH	polycyclic aromatic hydrocarbons
Pb	lead
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
psu	practical salinity unit
QA	quality assurance
QC	quality control
RPD	relative percent difference
RRO	residual range organics
S	Seimen
SAP	Sampling and Analysis Plan
SBE	Sea-Bird Electronics
SOP	Standard Operating Procedure
SW	solid waste
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TSS	total suspended solids
USBL	ultra-short baseline
USEPA	U.S. Environmental Protection Agency
V	vanaduim
VOA	volatile organic analysis (vial)
Zn	zinc

1.0 Introduction

Kosmos Energy LLC (Kosmos) is the operator of the Ahmeyim/Guembeul Field (A/G Field), formerly the Greater Tortue Field, located along the offshore maritime boundary between Mauritania and Senegal (**Figure 1**).

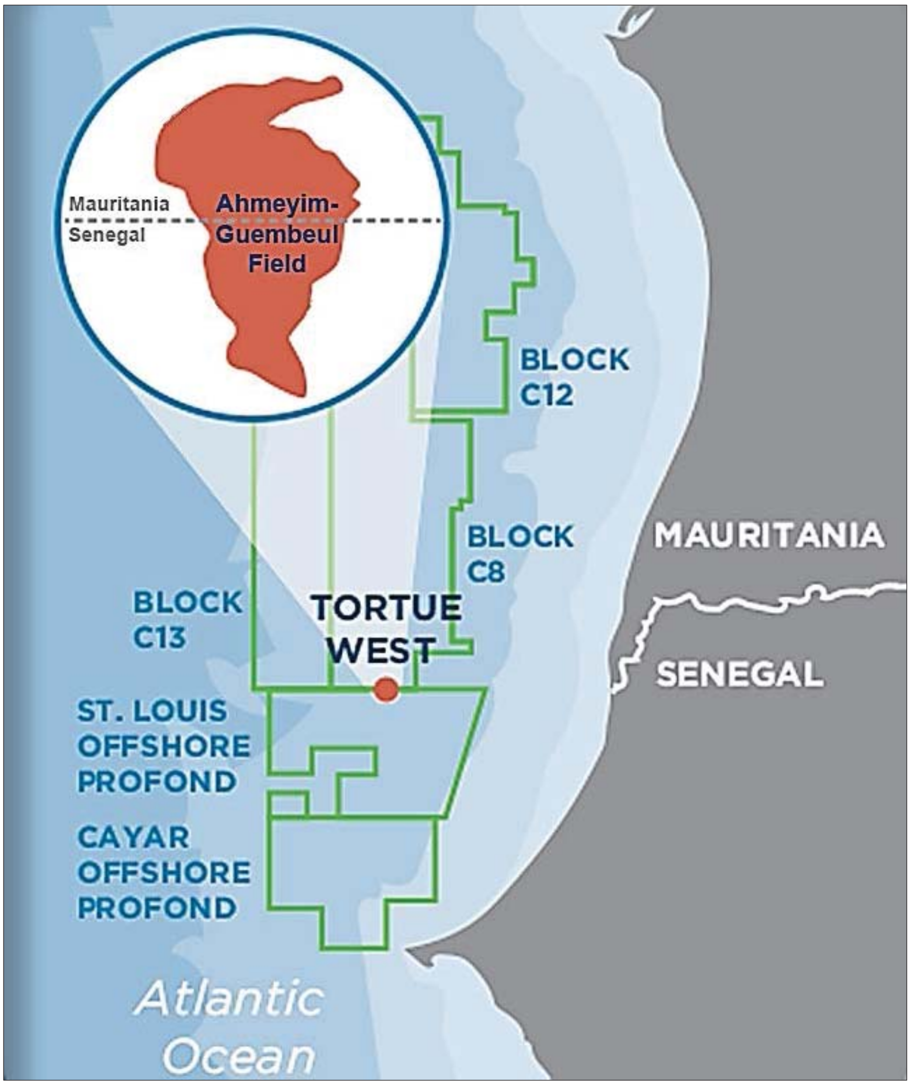


Figure 1. Location of the Ahmeyim/Guembeul Field relative to the coasts of Mauritania and Senegal (map provided by Kosmos Energy LLC).

As part of its efforts to maintain high standards of environmental stewardship, Kosmos contracted CSA Ocean Sciences Inc. (CSA) to conduct an Environmental Baseline Survey (EBS) for activities relating to the development of the A/G Field; the scope of the development, termed the project area, includes the offshore field (Offshore Area), a pipeline corridor towards shore (Pipeline Area), and a nearshore sea island and associated gas processing facilities (Nearshore Area). The EBS was designed to generally characterize the baseline environment in the area of proposed offshore development facilities and provide site-specific information to be utilized in the development of the pending A/G Gas Production environmental and social impact assessment (ESIA). The EBS was conducted from 25 November to 4 December 2016 with sampling directed at characterizing the baseline conditions for marine water and sediment quality, ichthyoplankton (fish eggs and larvae), and benthic macroinfaunal communities.

1.1 OBJECTIVES

The purpose of the EBS was to provide a baseline description of existing environmental conditions within the A/G Field development area. Data collected during the EBS will be used to characterize select components of the biological, physical, and chemical environment of the project area, and may be used to assess and potentially monitor the effects of future operations. The EBS scope of work (SOW) is intended for regional application to address collection of baseline data with the purpose of:

- Determining environmental baseline conditions (i.e., biological, chemical, and physical) prior to development activities;
- Providing baseline conditions of the environment against which effects from future operations can be compared; and
- Identifying parameters within the ecosystem that may be sensitive to change and provide a reference point to evaluate future claims of impacts.

The specific objectives of the EBS are to:

- Determine water column characteristics through the collection of hydrographic profiling data and water samples at depth across a designated study area where oil and gas development activities will take place;

- Determine characteristics of the seabed sediment, with specific reference to grain size, total organic carbon (TOC) content, metals (aluminum [Al], arsenic [As], barium [Ba], cadmium [Cd], chromium [Cr], copper [Cu], iron [Fe], lead [Pb], mercury [Hg], nickel [Ni], vanadium [V], and zinc [Zn]), hydrocarbon content (total petroleum hydrocarbons [TPH]) and polycyclic aromatic hydrocarbons [PAHs], and faunal (infauna) analysis; and

- Characterize ichthyoplankton communities.

The objective of the EBS report is to provide information relative to baseline conditions within the survey area. The EBS survey design was developed specifically to identify spatial gradients and the data are presented based on the defined sampling stratification (see **Section 1.2**). The EBS data will be used, as appropriate, in the ESIA to address data gaps for baseline information and to support the impact assessment. There is a dearth of regionally specific historical data for the EBS sampling parameters. To provide context for EBS analytical results, the report will use applicable data from previous international programs, benchmark values, and regression analyses to support interpretation of the presented data.

1.2 SURVEY DESIGN

The EBS study area as shown in **Figure 2** is composed of three contiguous locations as follows:

- Offshore Area, the 16.7-km × 10-km area encompassing the floating, production, storage, and offloading (FPSO) unit, mooring spread, and subsea flowlines;
- Pipeline Area, is the 102-km long pipeline corridor extending from the FPSO to the nearshore production and processing facility; and
- Nearshore Area, the 2.4-km × 6.4-km area encompassing the sea island, gas processing equipment and vessels, and berthing/storage facilities.

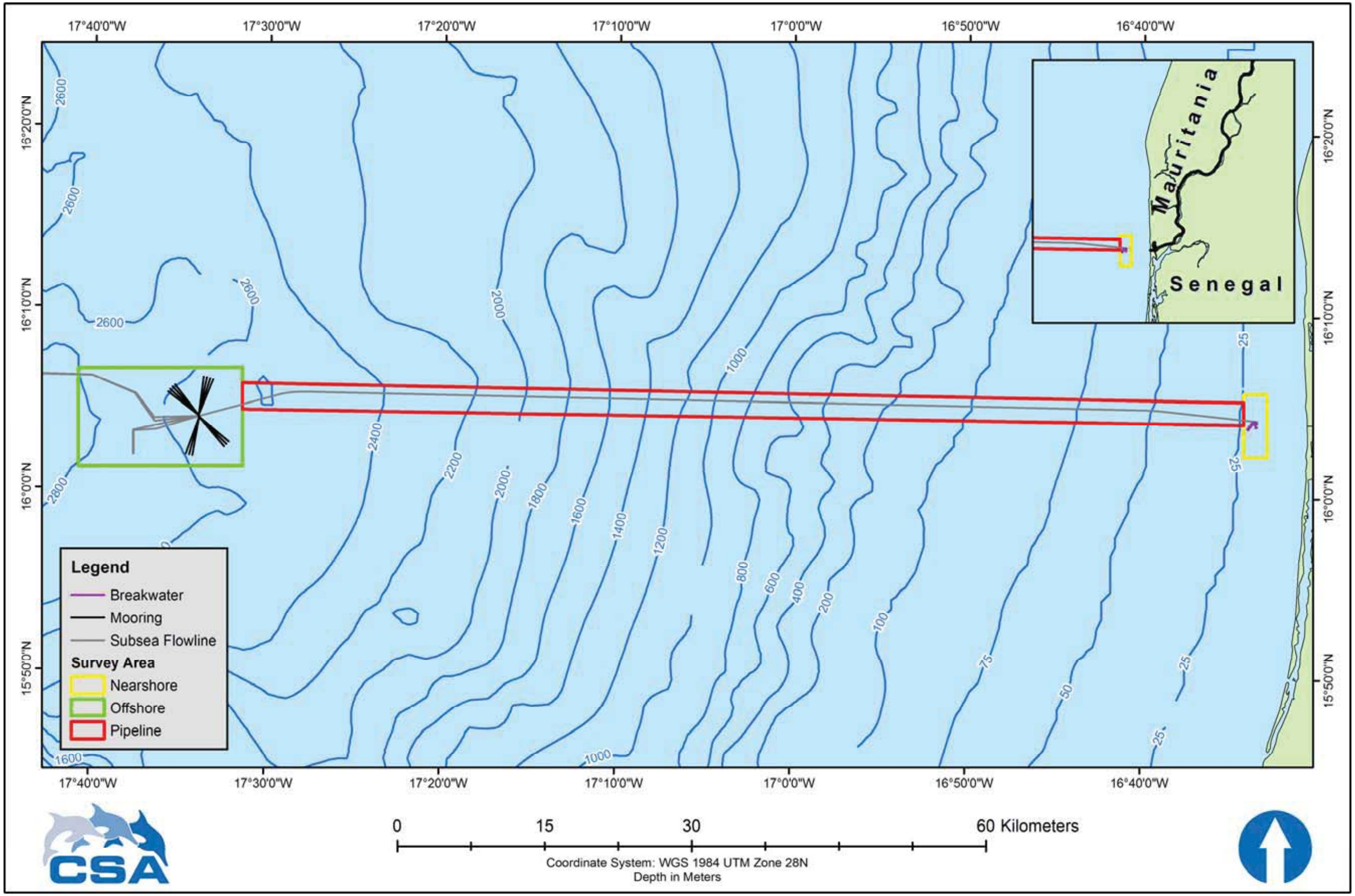


Figure 2. Environmental Baseline Survey study area showing the general sampling locations relative to the coastline of Mauritania and Senegal.

The survey design for water column characterization provides a general, single point in time characterization (i.e., "snap-shot") of the conditions within the water column at the time of the EBS. Water sampling included collection from two or three locations within the water column depending on station water depth. Stations in $\leq$ 20 m water depth were sampled near surface (approximately 10% of water depth) and near bottom (down to approximately 90% of water depth); stations in $\geq$ 20 m water depth were sampled near surface, mid-water (approximately 50% of water depth), and near bottom. Water samples were analyzed for total suspended solids (TSS), 10 total and dissolved metals, and select hydrocarbons. At each water sampling station a water column profile was conducted for conductivity (salinity), temperature, pH, dissolved oxygen, turbidity and chlorophyll fluorescence. This level of effort for water column sampling is considered adequate to generally characterize the water mass present within the EBS study area.

The survey design for sediment characterization provides data on the existing physical, chemical, and biological conditions for the substrate matrix. Sediment samples were analyzed for grain size, TOC, 12 metals, select hydrocarbons, and infauna. These analytes provide a thorough characterization of the benthic environment of the EBS study area.

The survey design for ichthyoplankton characterization provides a "snap shot" characterization of fish eggs and larvae presence and relative abundance within these water masses. Of particular interest are depth-related distribution data for ichthyoplankton; two different water depths were sampled during both day and night, providing insight into the diurnal and depth-related distribution of fish eggs and larvae.

Details of the survey design within each area sampled are provided below.

Offshore Area:

The Offshore Area is 167 km^2, bounded by a 16.7-km × 10-km rectangle (i.e., length is east to west), and is located in a water depth range of approximately 2,500 to 2,800 m. Sediment sampling stations were positioned at 5 random locations within and in close proximity to the 167 km^2 rectangle in water depths greater than 2,500 m. Offshore Area water column sampling was conducted during each day of EBS operations within the 167 km^2 rectangle. Ichthyoplankton sampling was conducted within the upper 30 m of the water column at 3 randomly selected locations within the 167 km^2 rectangle. Ichthyoplankton samples were collected during day time and night time from 0 to 15-m and 15 to 30-m water column strata.

Pipeline Area:

The Pipeline Area is defined as the 102-km long pipeline corridor extending from the Offshore Area to the Nearshore Area. Positioning of Pipeline Area sediment sampling locations was based on water depth (i.e., water depth strata). Within the Pipeline Area (**Figure 2**), three randomly located stations were positioned within each of the following water depth strata:

- 25 to 100 m;
- 100 to 200 m;
- 200 to 500 m;
- 500 to 1,000 m;
- 1,000 to 1,500 m;
- 1,500 to 2,000 m; and
- 2,000 to 2,500 m.

Sediment sampling within the 200 to 500 m depth strata took into account the potential presence of carbonate mounds between 450 and 500 m; sediment collection was purposely not attempted within this depth range. A single Pipeline Area water sampling station was positioned within the 25 to 200 m, 200 to

1,000 m, and 1,000 to 2,000 m water depth strata. No ichthyoplankton sampling was conducted in the Pipeline Area.

Nearshore Area:

The Nearshore Area is approximately 15.4 km^2, bounded by a 2.4-km × 6.4-km rectangle (i.e., length is north to south parallel to the shoreline), and is located in a water depth range of 0 to 25 m. Sediment sampling stations were positioned at 5 random locations within the 15.4 km^2 rectangle. Nearshore Area water column sampling was conducted at 3 of the 5 randomly located sediment sampling stations. Ichthyoplankton sampling was conducted within the upper 20 m of the water column at 3 randomly selected locations within the 15.4 km^2 rectangle. Ichthyoplankton samples were collected during day time and night time from 0 to 10- m and 10 to 20-m water column strata.

2.1 VESSEL OPERATIONS, REQUIRED PERSONNEL, AND NAVIGATION

The M/V *Acamar*, a dynamically positioned (DP) vessel, was used as the work platform during the survey. The M/V *Acamar* provided positional stability and maintenance under system-specified environmental conditions. Specifications for the M/V *Acamar* are provided in **Appendix A**. The survey vessel was mobilized with personnel and equipment in Dakar, Senegal.

The survey involved 24-hr operations during the field sampling effort. A six-person field operations crew with three people on each 12-hr shift was required staffing to meet Environmental, Health, and Safety (EHS) considerations. CSA provided six experienced personnel including a Chief Scientist, Field Scientists, a Marine Supervisor, and Operational Specialists.

Methods for accurate positioning was used during the collection of all cruise data. A modular computer software and hardware package interfaced various data collection sensors with a differential global positioning system (DGPS) receiver. Prior to cruise mobilization, all sampling locations were pre-plotted and stored in the navigation software program. A DGPS receiver was used to navigate the survey vessel to all sampling stations. Positional accuracy of ±30 m was targeted for stations. The DGPS and vessel fathometer were connected to an on-board computer equipped with Hypack navigation and data acquisition software.

2.2 FIELD SAMPLING METHODS

2.2.1 Sediment Sampling

Sediment samples were collected with a Gray O’Hara box core (**Image 1**). The Gray O’Hara stainless steel box core is well suited for sampling consolidated (i.e., hard packed) muddy sediments as generally observed within the EBS study area. The Gray O’Hara box core opening is 0.5 m × 0.5-m (0.25 m^2) and provides adequate sediment for concurrent collection of physicochemical and biological samples.

Sediment sampling gear was deployed and retrieved using an articulating A-frame and winch system. Each box core sample was visually examined upon retrieval to determine if the sample was acceptable. Grab/core samples with significant sediment loss (e.g., corner “wash out”) and/or over penetration were considered unsuitable for processing. Once a grab/core was accepted, the overlying water, if present, was siphoned off using flexible tubing (e.g., Tygon) to expose the sediment surface. Overlying water was siphoned through a 0.3-mm or 0.5-mm sieve depending on sampling water depth; organisms trapped on the sieve were included with the benthic infaunal sample.

Processing for the Gray O’Hara box core included insertion of a 0.35-m × 0.35-m stainless steel insert to separate physicochemical and infaunal subsamples (**Image 2**). Sediment for sediment physical and chemical subsampling was collected from outside of the 0.35-m × 0.35-m insert; sediment for infaunal subsampling was collected from the top 12 to 15 cm of sediment within the 0.35-m × 0.35-m insert.

Image 1. The Gray O'Hara box core used for sediment sampling provided adequate sediment for concurrent collection of physicochemical and biological sampling parameters.

Image 2. Processing for the Gray O'Hara box core included placement of a 0.35-m × 0.35-m stainless steel insert to separate physicochemical and infaunal sediment samples.

Infauna sediment samples were elutriated and wet-sieved on board through a 0.3-mm or 0.5-mm mesh sieve with gentle streams of seawater using a floatation technique that minimizes trauma to infaunal organisms and facilitates separation from the sediment (**Image 3**). The sieving procedure for each infaunal sample was as follows:

- A sieve with a 0.3-mm or 0.5-mm mesh screen, depending on sampling station water depth, was placed above the lower spillover barrel of the sieving apparatus.
- Filtered seawater hose (i.e., input hose) was pumped into an upper holding barrel, and water from the upper holding barrel exited through a spillover pipe to pass directly into the sieve.
- The infauna sediment sample material was placed within the upper holding barrel was stirred by hand to create a slurry to suspend all sediment, infauna, and debris.
- All infauna sediment sampling material was processed, exited from the upper holding barrel, and filtered through the sieve.
- The sieved sample (containing infauna, residual sediment, and debris) was transferred to a sample container(s) to be fixed and preserved using a 10% borax-buffered formalin solution.

Samples for infauna were stored in appropriate-size containers depending on the amount of residual sediment volume. Sample jars were labeled, taped, and properly stored aboard the vessel.

Image 3. Sediment for infaunal analysis was processed using a sieving apparatus consisting of an upper holding/flotation barrel and sieve.

All chemical and physical (geological) subsamples were collected from the top 2 to 3 cm of sediment using a pre-cleaned stainless steel sampling spoon. Samples were placed in appropriate containers, labeled, and properly stored aboard the vessel. Granulometric and chemistry subsamples were collected following proper protocols as detailed in CSA's Standard Operating Procedures (SOPs). Sediment field processing/storage was compliant with applicable sampling guidelines and protocols (e.g., U.S.

Environmental Protection Agency [USEPA] guidelines; Convention for the Protection of the Marine Environment of the North-East Atlantic/International Council for the Exploration of the SEA [OSPAR/ICES] protocols). **Table 1** summarizes sample handling and storage requirements for seawater and sediment samples for physical, chemical, and biological parameters.

Table 1. Summary of handling and storage requirements for seawater and sediment samples.

Analyte(s)	Container Type and Size	Handling, Storage Conditions, and/or Preservation Method	Holding Times
Seawater			
Total suspended solids	1-L plastic bottle	Cool to 4°C; in-field filtration with 1.5 µm particle retention glass-fiber filter; store pre-weighed filter frozen; ship on ice	Indefinite when filtered and frozen
Total metals (As, Ba, Cd, Cr, Cu, Pb, Ni, V, Zn)	1-L plastic bottle	HNO_3 (to pH <2); ship on ice and store at 4°C	6 months
Dissolved metals (As, Ba, Cd, Cr, Cu, Pb, Ni, V, Zn)	1-L plastic bottle	In-line filtration with disposable 0.45 µm pore size filter capsule; HNO_3 (to pH <2); ship on ice and store at 4°C	6 months
Total Hg	250-L HDPE plastic bottle	HCl (to pH <2); ship on ice and store at 4°C	28 days
Dissolved Hg	250-L HDPE plastic bottle	In-line filtration with disposable 0.45 µm pore size filter capsule; HCl (to pH <2); ship on ice and store at 4°C	28 days
Hydrocarbons (TPH, PAHs includes NPD and decalins)	1-L amber glass bottle	Preserve with dichloromethane; ship on ice and store at 4°C	28 days
Sediment			
Grain size, TOC	250-mL wide-mouth plastic jar	Freeze, ship on ice, and store frozen	Indefinite when frozen
Total metals (Al, As, Ba, Cd, Cr, Cu, Fe, Pb, Hg, Ni, V, Zn)	250-ml wide-mouth plastic jar	Freeze, ship on ice, and store frozen	Indefinite when frozen
Hydrocarbons (TPH, PAHs includes NPD and decalins)	250-mL wide-mouth glass jar with Teflon coated lid	Freeze, ship on ice, and store frozen	28 days
Infauna	250-mL, 500-mL, or 1-L wide-mouth screw-top plastic jars	Fix with 10% borax-buffered formalin solution; ship and store at room temperature. Transfer to/preserve with ethanol in laboratory	Indefinite
Plankton			
Ichthyoplankton	1-L plastic bottle	Fix with 5 to 7% borax-buffered formalin; ship and store at room temperature. Transfer to/preserve with ethanol in laboratory	Indefinite

Al = aluminum; As = arsenic; Ba = barium; Cd = cadmium; Cr = chromium; Cu = copper; Fe = iron; HDPE = high density polyethylene; Hg = mercury; HNO3 = nitric acid; Ni = nickel; NPD = naphthalene, phenanthrene, dibenzothiophene; PAH = polycyclic aromatic hydrocarbons; Pb = lead; TOC = total organic carbon; TPH = total petroleum hydrocarbons; V = vanadium; Zn = zinc.

2.2.2 Water Sampling

Water sampling included direct collection of seawater and water column profiling for various hydrographic parameters. Seawater samples were collected at two or three water depths within the water column depending on the depth of the sampling station. Water samples were collected in pre-cleaned, 5-L Niskin or GO-Flo water samplers mounted on a carousel or rosette sampler (**Image 4**). Field and quality control (QC) samples were collected in appropriate containers and processed as summarized in **Table 1**.

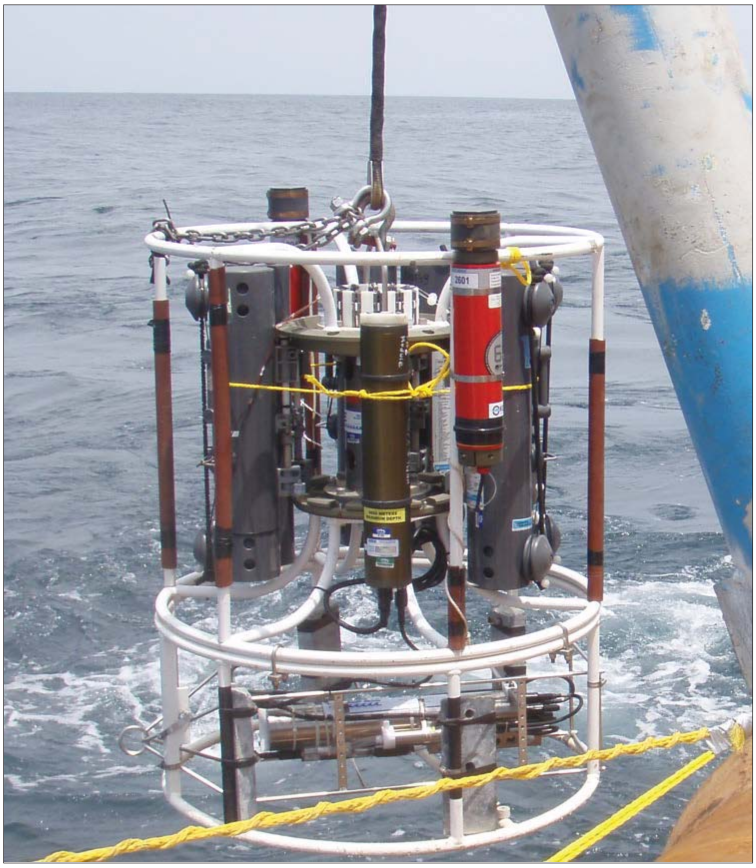


Image 4. Water samples were collected in pre-cleaned, 5-L Niskin and GO-Flo water bottles mounted on a rosette sampler. A conductivity-temperature-depth (CTD) water column profiler was mounted along the base of the rosette sampler.

Hydrographic measurements were collected with a factory-calibrated Sea-Bird Electronics (SBE) SBE 19*plus* V2 SeaCAT (or equivalent) conductivity-temperature-depth (CTD) water column profiler equipped with a dissolved oxygen (DO) sensor (concentration and percent saturation) and a standard sensor package to measure depth, temperature, conductivity/salinity, turbidity, pH, and chlorophyll (fluorescence). The CTD instrumentation is maintained and calibrated following the recommended factory specification and schedule. The CTD was mounted on a carousel or rosette sampler (**Image 4**). Hydrographic parameters (**Table 2**) were measured and recorded at 0.5-s intervals as the profiler was lowered through the water column at a relatively constant speed.

Table 2. Hydrographic sampling parameters and measurement units.

Parameter	Unit
Depth	m
Temperature	ºC
Conductivity (salinity)	µS/cm (psu)
Dissolved oxygen	mg/L/ percent saturation
pH	Standard unit
Chlorophyll (fluorescence)	mg/m^3
Turbidity	NTU

NTU = nephelometric turbidity unit; psu = practical salinity unit; S = Siemen.

2.2.3 Ichthyoplankton Sampling

Plankton sampling gear consisted of a 500-µ mesh plankton net attached to a standard 1 m diameter circular, stainless steel frame (ring net) (**Image 5**). A flow meter was fixed inside the mouth of the net to quantify the volume of water filtered during the tows. A double-trip system was used to collect discrete-depth samples at each station. Discrete samples were collected in the upper (0 to 10 m and 0 to 15 m) and lower water (10 to 20 m and 15 to 30 m) column at each station; depth range of water column strata depended on the water depth of the station.

Image 5. Plankton sampling gear consisted of a 500-µ mesh plankton net attached to a standard 1 m diameter circular, stainless steel frame. A double-trip (open-close) system was used to collect discrete-depth samples at each station.

To collect ichthyoplankton samples, a closed net was lowered at a constant payout speed (~10 m/min) from the surface to within the proper water depth strata. At the proper sampling depth, a messenger (weight) was sent down the tow wire to trip the net open. The vessel then proceeded to tow the net for an approximate 10-minute period at a slow speed. Once the tow was completed, the open net was retrieved, within the sampling strata depth range, along an oblique path with the tow wire at a 45º angle (depths were determined from wire angle and wire out). At the upper depth limit of the sampling strata (i.e., upper and lower water), a second messenger was sent down the tow wire to close the net. Discrete lower and upper water tows were collected from each station location both day and night.

Material collected from the net was transferred to appropriate sample containers. All samples were fixed in 5% formalin in the field. Sample jars were labelled with collection date and project-specific sample codes that indicate station, water depth, and time of day.

2.3 QUALITY ASSURANCE/QUALITY CONTROL

2.3.1 Quality Assurance

A Quality Assurance (QA) program was undertaken to ensure that the project generates scientifically defensible data of known quality that meet the project objectives. CSA's QA program included the selection of a qualified analytical laboratory(s), deployment of an experienced field team, and detailed preparation during mobilization.

Analytical Laboratories

The proposed analytical laboratories have established QA programs and extensive experience in the analysis of marine samples. Sediment and seawater analytical laboratories and accreditations are presented in **Section 2.4.1**.

Field Personnel

The field survey team was composed of well-qualified and highly experienced CSA personnel. The use of experienced staff who follow appropriate precautions and are attentive to detail when conducting field operations minimizes error, enhances quality, and maximizes efficiency in conducting the survey. The EBS was conducted on a 24-hour basis and field team members worked in 12-hour shifts with between-shift briefings to ensure program continuity.

Mobilization

Prior to the survey, the scope of work was reviewed by the project team to ensure that all field survey operations and individual responsibilities were familiar to team members. The requirements for the survey included provision for and access to the following: appropriate numbers and types of containers, chemicals, and other field supplies; field methods and procedures; sample identification labels; checklists; chain-of-custody (CoC) forms; sample disposition and shipping arrangements; and QC measures. Responsibilities for documenting each of these survey components, as an integral part of mobilization, were assigned to field team members, as appropriate.

2.3.2 Quality Control

QC measures included the following:

- Preparation of equipment blanks to determine the potential of sample contamination by the sampling equipment;
- Preparation of field blanks to determine the potential of sample contamination from containers and general sample handling;
- Use of field duplicates (i.e., homogenized splits) to check reproducibility of laboratory and field procedures;
- Preparation and completion of sample/data checklists;

- Equipment performance and data checks;
- Use of CoC processes for sample handling; and
- Post-survey shipment and sample tracking.

QC samples (e.g., blanks, duplicates) were prepared for water and sediment metals and hydrocarbon parameters. An approximate 10% level of QC was attained for appropriate sample parameters. Post-survey shipment and sample tracking ensured delivery of samples to designated laboratories within the recommended holding times and conditions.

Sea-Bird Electronics Profiler Data Check

During or soon after a water column profile cast was completed, hydrographic data were examined by a CSA scientist to check that the collected data were within expected ranges (for the conditions at the EBS study area), the equipment was functioning normally, and the configuration of data files was in good order.

Data and Sample Collection Checklists

Prior to the survey, data and sample checklists were prepared by the Chief Scientist and completed in the field as appropriate for QC. Prior to departing each sampling station, the Chief Scientist or his designee reviewed the checklist and ensured collection and proper storage of the required station data and samples.

Sample Preservation and Holding Times

Samples were preserved as specified by the appropriate analytical laboratory or industry best practices. Samples were transported to the various analytical laboratories for analysis under appropriate handling conditions.

2.3.3 Sample Handling and Transport

After sample collection, proper sample handling was followed to ensure safe delivery of the shipped samples. The Field Scientist (or his designated representative) was responsible for sample handling and transport of samples under a CoC process. Proper CoC was maintained for all samples, and a CoC record accompanied all samples. Each sample had a unique identifier that could be directly tracked to the field logs. Labels were waterproof, securely fastened to the sample container, and contained information concerning date of collection, sample type, and location (i.e., station designation). Shipping containers were secured to be leak proof, avoid cross contamination, and prevent sample loss during shipment. Premium coolers were used for shipping frozen samples to increase the likelihood that samples remain at the required temperature during shipment.

Sample analysis requests/instructions were prepared by the Field Scientist to accompany all samples shipped to the laboratories. Samples were shipped to the appropriate laboratory for analysis as soon as possible after collection. Shipping was coordinated to avoid or minimize the potential for exceeding holding time limits.

2.3.4 Document and Data Security

Station designation, location, and sampling date was indicated on all data sheets used for the sample logs and CoC sheets. Upon completion of the survey, the field logs which were completed or acquired in the field were copied and the copy archived along with the project files. Copies of completed CoC forms were requested from the respective laboratories and stored with the project files.

Navigation and positioning data, along with field data files, were regularly saved to a computer file and backed up on a separate removable medium (e.g., flash memory/data stick or CD-R/RW). Backup media was stored and transported separately from the field computer. Upon return to CSA Headquarters (Florida), the Chief Scientist ensured that all data were properly backed up or archived on CSA's local area network file server.

Following submittal of the final EBS report, CSA will identify and compile data files of interest and will coordinate submittal with Kosmos and BP. Processed data will be provided in Excel format. Field notes will include log books, sampling checklist, and chain of custody forms; these data will be scanned and provided in Acrobat (pdf) format.

2.4 DATA PROCESSING AND LABORATORY METHODS

2.4.1 Sediment and Seawater

Sampling Parameters

Table 3 summarizes the expected detection limits and methods for the seawater and sediment sampling parameters.

Table 3. Analytical parameters, analysis methods, reporting units, and reporting/limits of quantification for seawater and sediment samples.

Parameter/Analyte	Digestion/ Extraction Method	Analytical/Detection/ Quantification Method	Quantification Limit	Units	Analytical Laboratory
Seawater					
Total suspended solids	N/A	Analytical balance	0.01	ppm	CBL
Total and dissolved As	N/A	ICP-MS	7	ppb	ALS Environmental – Kelso
Total and dissolved Ba	N/A	ICP-MS	0.2	ppb	
Total and dissolved Cd	N/A	ICP-MS	0.1	ppb	
Total and dissolved Cr	N/A	ICP-MS	5	ppb	
Total and dissolved Cu	N/A	ICP-MS	1	ppb	
Total and dissolved Pb	N/A	ICP-MS	0.1	ppb	
Total and dissolved Hg	N/A	Based on USEPA 1631E	0.01	ppb	
Total and dissolved Ni	N/A	ICP-MS	0.1	ppb	
Total and dissolved V	N/A	ICP-MS	2	ppb	
Total and dissolved Zn	N/A	ICP-MS	2	ppb	
TPH	Methylene chloride	USEPA/SW-846 Modified 8100/8015C	13	ppb	TDI Brooks
PAHs	Methylene chloride	USEPA SW-846/8260/GC-MS	0.74–2.91	ppt	
Sediment					
Grain size	N/A	Laser diffraction	0.02	μ	Weatherford
Total organic carbon	N/A	European Standard Norm 1484	5	ppm	
Aluminum	HF digestion	Based on ISO 11885	25	ppm	ALS Environmental – Kelso
As, Zn	HF digestion	Based on ISO 11885	8	ppm	
Ba, Cd	HF digestion	Based on ISO 11885	0.16	ppm	
Cr, Ni, V	HF digestion	Based on ISO 11885	3.2	ppm	

Table 3. (Continued).

Parameter/Analyte	Digestion/ Extraction Method	Analytical/Detection/ Quantification Method	Quantification Limit	Units	Analytical Laboratory
Copper (Cu)	HF digestion	Based on ISO 11885	1.6	ppm	
Iron	HF digestion	Based on ISO 11885	0.005	%	
Lead (Pb)	HF digestion	Based on ISO 11885	0.8	ppm	
Mercury (Hg)	HF digestion	Based on ISO 11885	2.6	ppb	
TPH	Hexane	USEPA 1664/8100/8015/GC-MS	1.4	ppm	TDI Brooks
PAHs	Hexane	USEPA Sw-846/8260/GC-MS	0.04 – 0.342	ppb	

As = arsenic; Ba = barium; CBL = Chesapeake Biological Laboratory; Cd = cadmium; Cr = chromium; GC-MS = gas chromatography mass spectrometry; HF = hydrofluoric acid; ICP-MS = inductively coupled plasma mass spectrometry; ISO = International Organization for Standardization; mm = millimeters; μ = micron; N/A = not applicable; Ni = nickel; PAH = polycyclic aromatic hydrocarbons; ppb = parts per billion; ppm = parts per million; ppt = parts per trillion; SW = solid waste; TPH = total petroleum hydrocarbons; USEPA = U.S. Environmental Protection Agency; V = vanadium; Zn = zinc.

Analytical Laboratories

Chesapeake Biological Laboratory (CBL) provided pre-weight filters and conducted analysis for seawater TSS. CBL provides a wide range of water quality analyses on state-of-the-art instrumentation while following strict QA/QC procedures. CBL provides services to several U.S. governmental agencies (U.S. Environmental Protection Agency [USEPA], U.S. Geological Survey, and U.S. Fish and Wildlife Services), local regulatory agencies (Maryland Department of Natural Resources, Maryland Department of the Environment), and many private environmental firms. CBL is a national leader in environmental chemistry and toxicology and ecosystem science and restoration ecology.

ALS Environmental-Kelso (ALS) laboratories in Kelso, Washington, conducted seawater and sediment metals analyses. ALS is a National Environmental Laboratory Accreditation Program (NELAP) accredited contract laboratory with extensive experience in seawater and marine sediments analyses. ALS provides sophisticated, modern analytical services specific to the minerals (i.e., geochemistry), life sciences (i.e., environmental), and energy (i.e., oil and gas) industries. Over 20 million samples per year are analyzed by ALS's staff of 13,000 in 350 locations in 55 countries around the world. ALS's major hub facilities are located in Australia, Asia, North America, South America, Europe, the Middle East, and Africa. ALS's certifications and accreditations include International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) 17025:2005, National Environmental Laboratory Accreditation Program (NELAP), and conformance with Good Laboratory Practice (GLP).

TDI-Brooks International, Inc., located in College Station, Texas, owns and operates B&B Laboratories which conducted seawater and sediment hydrocarbon analyses. B&B Laboratories with state-of-the-art equipment and an accomplished staff, specialize in the analysis of organics, including petroleum hydrocarbons, with extensive experience in analysis of seawater and marine sediments. B&B Laboratories operates a Quality Management System that complies with the requirements of ISO 9001:2008 for the analysis of geochemical, geotechnical, and environmental samples. They have certification validating that all our analytical processes are fully established, functional, and meet international standards. B&B Laboratories has participated in the highly rigorous U.S. National Institute of Standards and Technology (NIST) intercalibration exercise for trace organics since 1997 and has always ranked in the top group for this exercise.

Weatherford Laboratories Inc. (Weatherford) conducted sediment grain size and TOC analyses. Weatherford is a long-established geochemical service laboratory with extensive experience supporting the oil and gas industry, universities, consultants, and consortiums. Weatherford offers laboratory services at multiple locations in North America, Latin America, Asia/Pacific Rim, Middle East/North Africa, and in Europe. Weatherford Laboratories Inc. combines a global team of geoscientists, engineers, technicians, and researchers with the industry's most comprehensive, integrated laboratory services worldwide.

Benchmark Values

Sediment chemistry analytical results were interpreted in the context of the actual values relative to benchmark values to evaluate their biological relevance. Metals and hydrocarbon concentrations were compared to the USEPA sediment quality benchmarks. A benchmark is a chemical concentration in sediment above which there is the possibility of harm to organisms in the environment. The USEPA recommends benchmark values such as the effects range low (ERL) and effects range median (ERM) to assess the potential risk to fish and other marine life (Long and Morgan, 1990). These sediment quality guidelines are based on marine sediment chemistry paired with sediment toxicity bioassay data. The benchmarks represent points on a continuum of chemical concentrations ranked from lowest (least toxic) to highest (more toxic) concentrations defined as follows:

- ERL is indicative of concentrations below which adverse effects rarely occur; and
- ERM is indicative of concentrations above which adverse effects frequently occur.

Analytical results of seawater metals are compared to USEPA Criterion Continuous Concentration (CCC) toxicity reference values (Buchman, 2008). The USEPA CCC for seawater analytes is the chronic criteria that is based on average chemical concentration estimates in water that does not adversely affect aquatic organisms during an extended exposure period (i.e., 96 hours). Survey results for seawater metals analyses are presented in context with international environmental quality standards to evaluate potential toxicity risks within the EBS study area.

Summary Data Presentation

For summary presentation of the sediment sampling results, the EBS study area stations were grouped based on water depth. In a sequence from most-shoreward stations to most-seaward stations, the groupings are as follows:

- Nearshore Area: in water depths <25 m;
- Pipeline Area: Stations 1 through 6 in water depths from 25 to 200 m (i.e., on the continental shelf);
- Pipeline Area: Stations 7 through 12 in water depths from >200 to 1,000 m (i.e., upper continental slope); and
- Pipeline Area (Stations 13 through 21) and Offshore Area: in water depths from >1,000 m (i.e., margin of relatively static water column physical conditions concerning temperature and salinity).

These bathymetric groupings were generally established on spatial features of the continental margin with consideration for characteristics of physical conditions. The intent for these groupings were to generate summary statistics to better distinguish depth-related gradients for sampling parameter, if present.

Normalization of Metals Data

To determine the relationship between individual pairs of parameters, metal concentrations were normalized with aluminum. Concentrations of aluminum and other metals vary naturally in ambient seafloor sediments, primarily due to differences in sediment grain size. Clay sediments are composed primarily of aluminosilicates and typically have higher concentrations of metals. Sediments classified as silt or sand are primarily composed of quartz and fragments of carbonate shell, which dilute ambient metals concentrations (Herut and Sandler, 2006). Aluminum concentration is assumed to correlate linearly with other metals concentrations when there is no anthropogenic input (Trefry, 2003, 2013). It is reasonable to assume that a particular metal concentration is enhanced by anthropogenic activity if the metal concentration deviates greatly from the linear regression of that metal versus sediment percent concentration of aluminum.

2.4.2 Hydrographic Profiles

Digital data files from hydrographic casts taken with the CTD profiler was processed by a CSA scientist or technician using SBE Data Processing software, a proprietary modular family of data processing software specific to SBE oceanographic instruments. The SBE Data, Loop Edit, and Bin Average Modules were used to convert the data from the raw hexadecimal format to engineering units in a text file, extract the appropriate cast section, remove any loops in the record, smooth the data, and import the file into a spreadsheet. Hydrographic profile graphics were generated from the spreadsheet.

2.4.3 Infauna

EcoAnalysts, Inc. (EcoAnalysts) conducted the benthic infauna analyses. Their team of taxonomists comprises 10 taxonomists with 20 North American Benthological Society certifications and over 190 years of combined taxonomy experience. In addition to their taxonomy capabilities, they employ 15 full-time professional sorting technicians, including specially trained QC technicians. This allows EcoAnalysts to minimize the potential for introducing sorting error in the bioassessment process. As the largest bioassessment laboratory in North America, EcoAnalysts processes more than 6,000 benthic samples annually and has completed projects throughout North America as well as in Cameroon, Congo, Suriname, Peru, Brazil, Mexico, Dominican Republic, Australia, and India. Certifications or accreditations are not applicable for taxonomic analytical laboratories.

Specimens were sorted, counted, and identified to the lowest practical identification level (LPIL). Specimens were sent to taxonomic experts for identification and a voucher collection of selected specimens was developed, as appropriate. The infaunal samples were transferred from the formalin preservative to denatured alcohol for archival. EBS voucher specimens will be archived with EcoAnalysts, Inc.

Infauna assemblage structure in the project areas was assessed with univariate diversity indices and multivariate analysis of species composition. Three diversity indices that capture different aspects of species-abundance relationships were used to analyze the samples (Magurran, 2004). The Shannon-Wiener index (H’) emphasizes species in the middle (not common or rare) of the species rank abundance sequence. Pielou’s evenness index (J’) measures how evenly the number of individuals are distributed among the species, and inverse of Simpson’s index (N_2) measures numerical dominance by individual species. Indices were calculated from data pooled over samples (n=5 for nearshore and offshore areas, n=3 for pipeline strata). Diversity indices were calculated using PRIMER-E (Clarke and Gorely, 2006).

For multivariate analyses, a raw data matrix composed of samples by taxa was created, then transformed (log x+1) prior to calculating pairwise similarity among all samples using the Bray-Curtis similarity index (Bray and Curtis, 1957). The similarity matrix was analyzed with group-average cluster analysis and non-metric multi-dimensional scaling (NMDS) ordination. The influence of environmental variables on the NMDS ordination were examined using a linear model fits between the variables and NMDS axes.

Cluster analysis was performed using PRIMER-E software (Clarke and Gorely, 2006) and the NMDS and linear fits were performed with the vegan package (Oksanen et al., 2016).

Indicator Species Analysis (Dufrêne and Legendre, 1997) was used to identify individual taxa associated with the groups identified with the multivariate analyses. Indicator Species Analysis characterizes groups of samples based relative frequency and abundance of taxa. Significance of indicator species is tested by Monte Carlo permutations of the data (999 random permutations). Indicator species analysis was performed with the R package LabDSV software (Roberts, 2016).

2.4.4 Ichthyoplankton Analysis

Ichthyoplankton samples were processed and analyzed by plankton expert Ms. Talat Frooqi. Ichthyoplankton samples were analyzed for taxonomic composition (LPIL) and total biomass. The samples were normalized to the volume of sample filtered based on the flowmeter record to estimate density (individuals/m^3). Samples were divided successively into equal splits with a Folsom plankton splitter as many times as required to result in manageable sub-samples. All ichthyoplankton were identified to the LPIL and enumerated using a stereozoom microscope, as appropriate. After analysis, samples were returned to the preservative for long-term storage pending deposition according to the client's direction.

3.1 SEDIMENT AND SEAWATER ANALYSIS

Sediment and seawater sampling stations within the EBS study area are shown in **Figures 3** through **5**. **Figure 3** shows the locations of the five sediment and three seawater sampling stations within the Nearshore Area; one of the station locations was sampled for both sediment and seawater. **Figure 4** shows the locations of the 21 sediment and three seawater sampling stations within the Pipeline Area. **Figure 5** shows the locations of the five sediment sampling stations and one seawater sampling station within the Offshore Area (includes one station in the Pipeline Area in water depths >2,500 m). Sampling location specifications are presented in **Appendix B**.

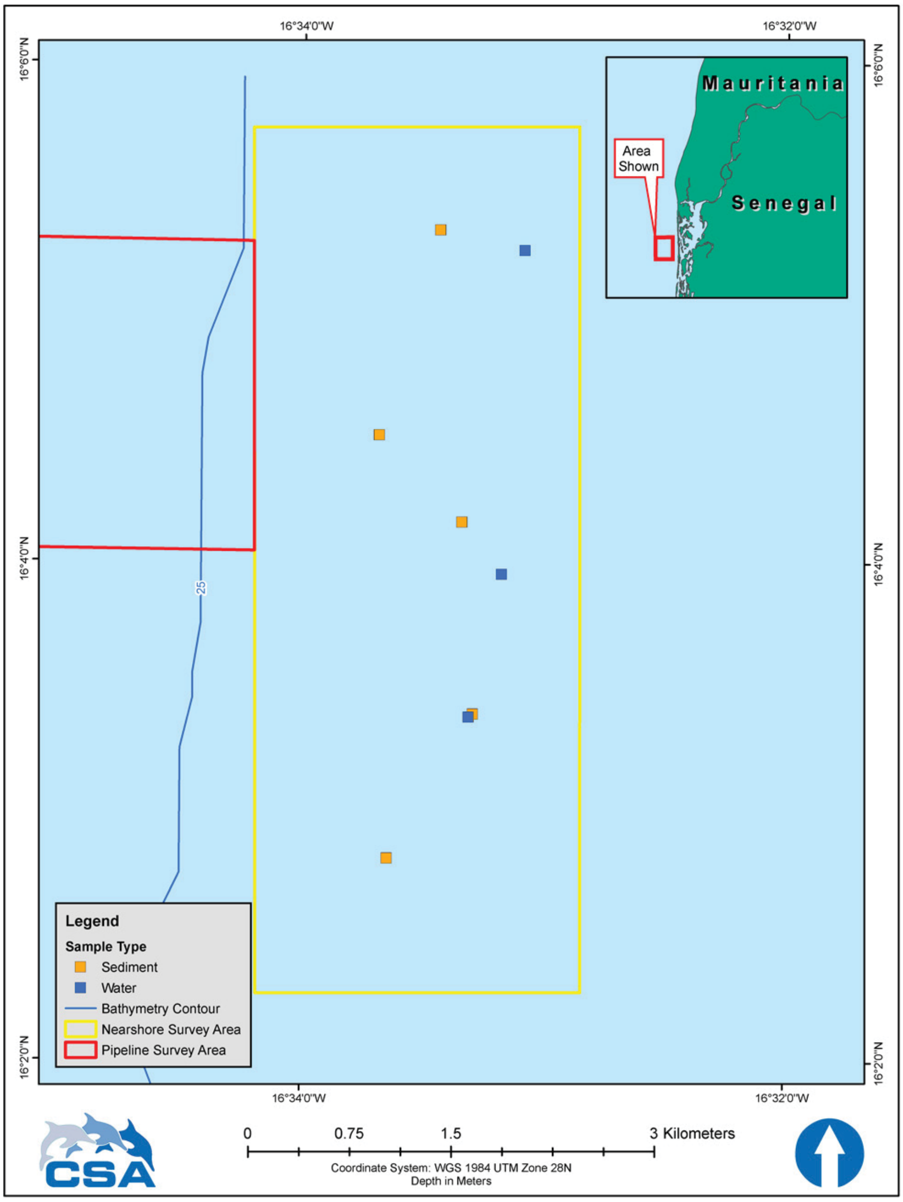


Figure 3. Locations of sediment and seawater sampling stations within the Nearshore Area.

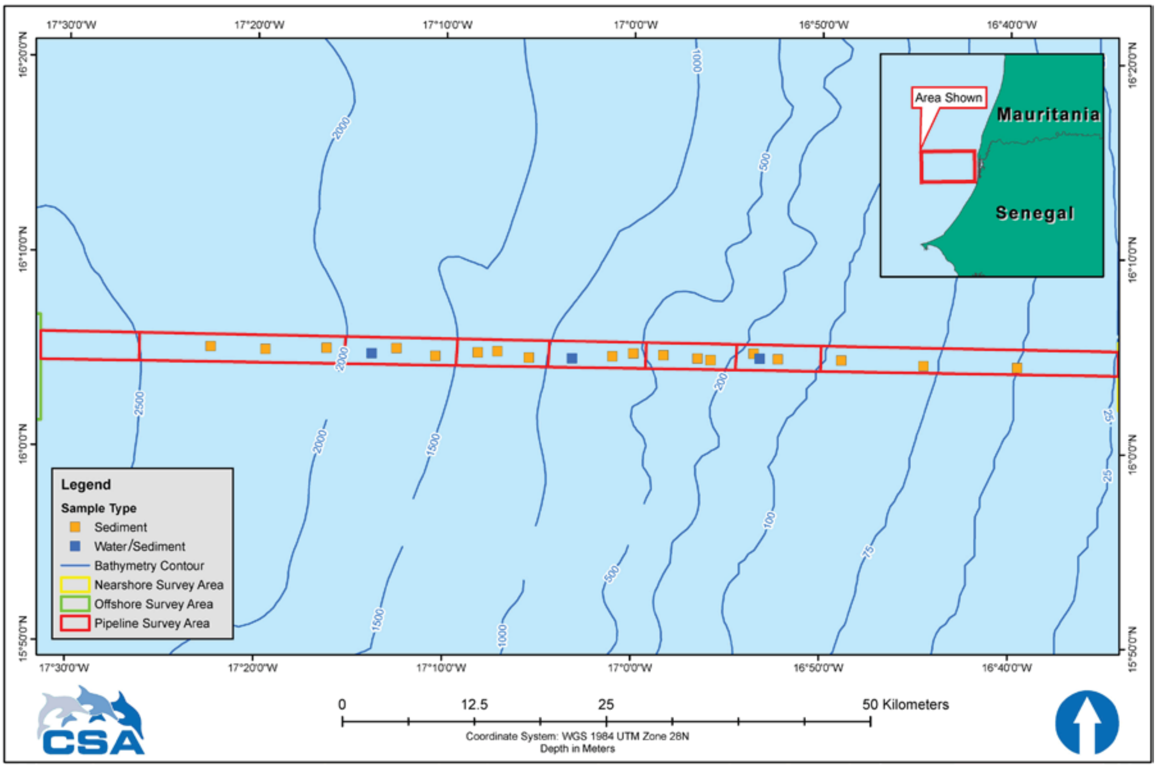


Figure 4. Locations of sediment and seawater sampling stations within the Pipeline Area.

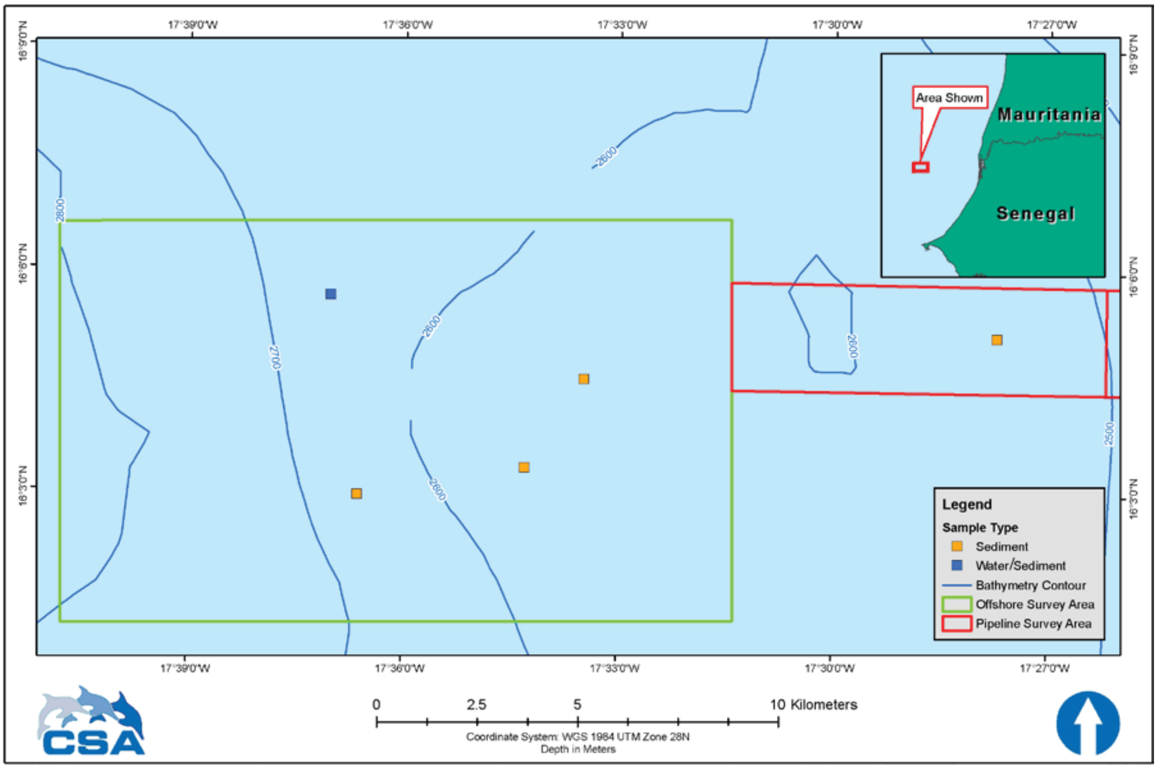


Figure 5. Locations of sediment and seawater sampling stations within the Offshore Area and Pipeline Area in water depths >2,500 m.

All Offshore Area sediment stations were pre-plotted within a water depth range of approximately 2,500 to 2,800 m, based on available regional bathymetric contour data. The water depth of one of the pre-plotted Offshore Area sediment stations was in a water depth that precluded sampling with the provided survey equipment (i.e., winch cable); the station was moved to a location within the Pipeline Area that was in a water depth >2,500 m.

3.1.1 Sediment

Total Organic Carbon and Grain Size

Results of sediment TOC and grain size analyses for each of the EBS sampling stations are presented in **Table 4**.

Table 4. Total organic carbon content, grain size distribution, and sediment classification based on Shepard (1954) for sediment samples from the Environmental Baseline Survey.

Station	Water Depth (m)	TOC (%)	Sand (%)	Clay (%)	Silt (%)	Classification
NA-1	<25	0.26	54.8	7.0	38.1	Silty Sand
NA-2	<25	0.24	47.2	9.8	43.0	Silty Sand
NA-3	<25	0.17	52.4	7.8	39.8	Silty Sand
NA-4	<25	0.23	48.2	8.7	43.1	Silty Sand
NA-5	<25	0.22	48.8	8.7	42.5	Silty Sand
PA-1	25 to 100	0.80	4.3	17.6	78.0	Silt
PA-2	25 to 100	1.80	70.2	7.1	22.7	Silty Sand
PA-3	25 to 100	0.60	1.7	18.2	80.1	Silt
PA-4	100 to 200	0.68	56.5	9.7	33.8	Silty Sand
PA-5	100 to 200	0.76	57.4	9.6	33.0	Silty Sand
PA-6	100 to 200	0.68	71.6	4.3	24.2	Silty Sand
PA-7	200 to 500	0.50	52.7	10.8	36.5	Silty Sand
PA-8	200 to 500	0.45	64.1	8.3	27.6	Silty Sand
PA-9	200 to 500	0.58	43.1	13.9	43.0	Silty Sand
PA-10	500 to 1,000	0.82	30.3	14.4	55.3	Sandy Silt
PA-11	500 to 1,000	1.09	43.1	13.2	43.6	Sandy Silt
PA-12	500 to 1,000	1.49	20.3	12.5	67.2	Sandy Silt
PA-13	1,000 to 1,500	1.19	28.6	10.0	61.3	Sandy Silt
PA-14	1,000 to 1,500	2.70	0.3	19.9	79.8	Silt
PA-15	1,000 to 1,500	2.55	3.7	16.2	80.1	Silt
PA-16	1,500 to 2,000	2.39	5.1	15.9	79.0	Silt
PA-17	1,500 to 2,000	2.39	3.3	17.1	79.6	Silt
PA-18	1,500 to 2,000	2.38	3.8	16.7	79.6	Silt
PA-19	2,000 to 2,500	2.27	2.8	18.8	78.5	Silt
PA-20	2,000 to 2,500	2.39	1.5	20.9	77.6	Silt
PA-21	2,000 to 2,500	2.16	4.6	18.5	77.0	Silt
OA-1	>2,500	2.19	1.8	17.8	80.4	Silt
OA-2	>2,500	2.01	2.1	20.5	77.4	Silt
OA-3	>2,500	2.13	1.1	19.4	79.5	Silt
OA-4	>2,500	2.03	1.7	20.0	78.3	Silt
OA-5	>2,500	2.05	1.9	23.1	75.0	Clayey Silt

NA = nearshore area; OA = offshore area; PA = pipeline area; TOC = total organic carbon.

TOC had a general trend of increasing concentrations with increasing water depth and distance from shore and decreasing sediment particle size. With few exceptions, stations with higher percentage of sand had lower concentrations of TOC. This inverse correlation between TOC concentration and sediment sand content has been previously documented along a pipeline corridor offshore Ghana (CSA International, Inc., 2011) and may be an artifact of the higher porosity and permeability of coarser sediments (Tyson, 1995).

Figures 6 and **7** are ternary diagrams depicting the relative proportions of the primary sediment components (sand, silt, and clay) from the sampling stations of the Nearshore and Offshore Areas and Pipeline Area, respectively. Based on Shepard's classification (Shepard, 1954), all sediment within the Nearshore Area was silty sand and within the Offshore Area, silt or clayey silt with a ≥ 75% silt fraction (**Table 4**). The Pipeline Area traverses a water depth differential of nearly 2,500 m and subsequently the sediment grain size composition is quite variable. Most of the deeper Pipeline Area stations in water depths > 1,000 m had fine textured sediments classified as silt similar to the Offshore Area. The sediment sand component of the Pipeline Area stations increased with decreasing water depth with the shallower stations in water depths < 500 m having coarser textured sediments classified as silty sand similar to the Nearshore Area.

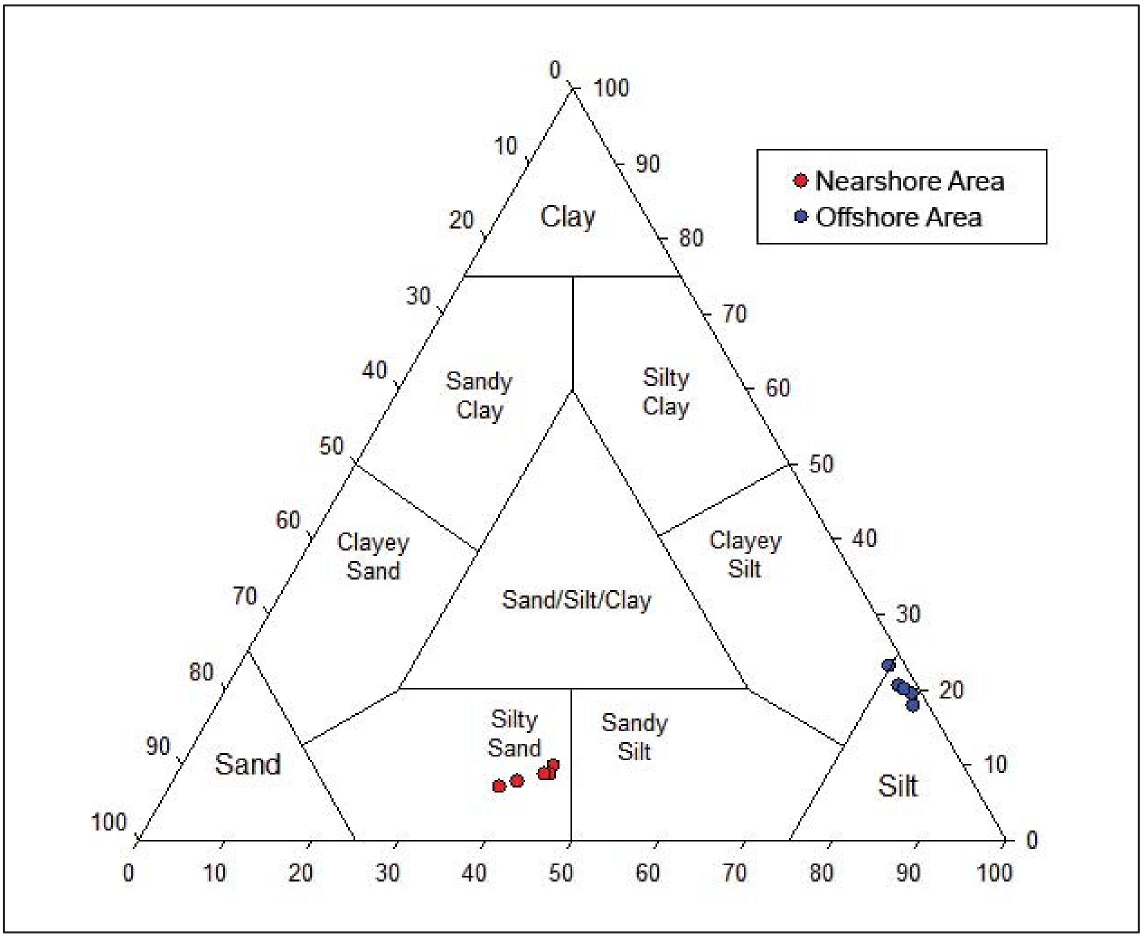


Figure 6. Ternary diagram depicting grain size characteristics of sediment from the Nearshore and Offshore Areas.

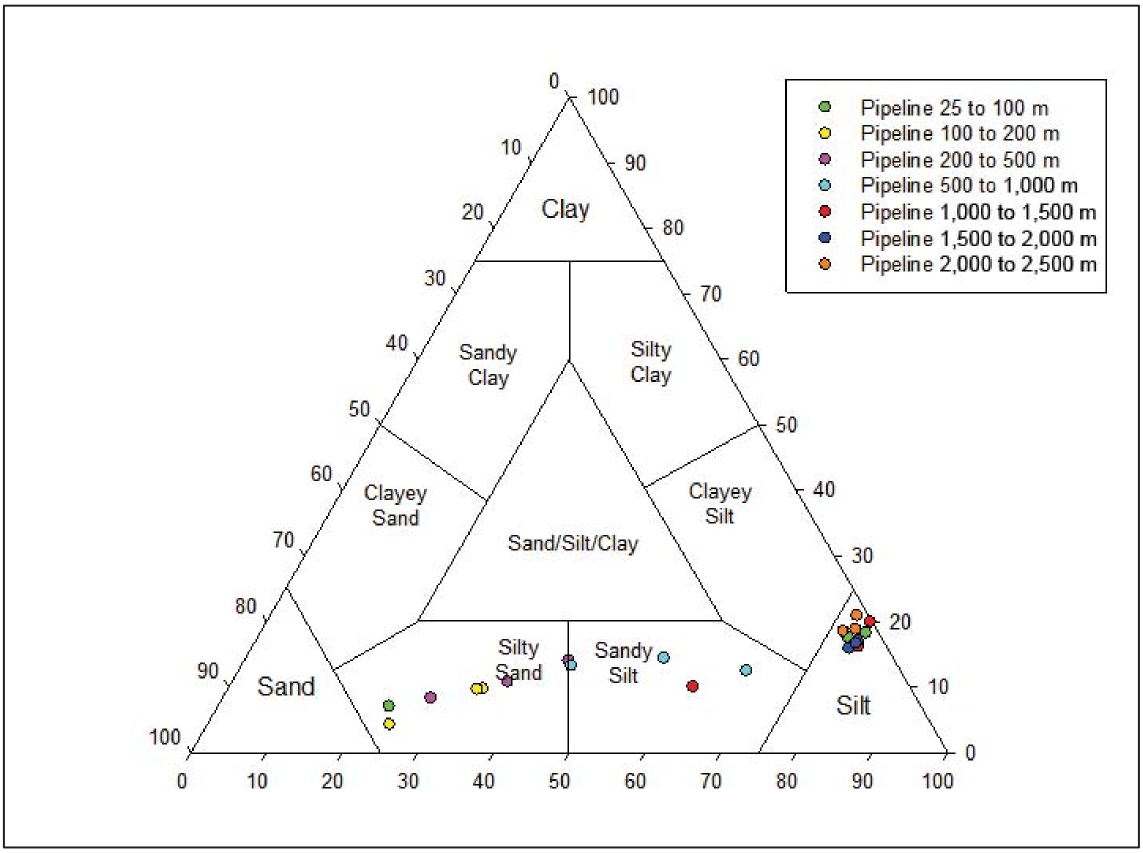


Figure 7. Ternary diagram depicting grain size characteristics of sediment from the Pipeline Area.

Total Metals

Sediment metals concentrations from the EBS sampling stations are presented in **Table 5**; unprocessed summary data as reported by the analytical laboratory can be provided upon request. Sediment metals concentrations from the EBS stations and summary statistics (i.e., average ± standard deviation) for various station groupings compared to ERL and ERM concentrations are presented in **Table 5**. Several samples had metal levels below detection limits and for summary presentation of these data, the non-detect sample was estimated as 1/2 of the method reporting limit (USEPA, 2000).

Metal analytes include potential contaminants associated with offshore oil and gas activities, priority pollutants, and primary mineralogical indicators. Barite [barium sulfate ($BaSO_4$)] is a common weighting agent for all types of drilling fluids used in the oil and gas industry. Subsequently, barium (Ba) is an important tracer of drilling fluids that may be discharged during offshore drilling activities. Compared with marine sediments, commercial drilling mud barites may contain elevated concentrations of several metals, including cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), and lead (Pb) and, in addition to arsenic (As) and nickel (Ni), are all priority pollutants. Aluminum (Al) and iron (Fe) are useful in interpreting metals concentrations because they are good indicators of the sediment mineral type.

Table 5. Metals concentrations (mg kg^{-1} or %) in sediment from the Environmental Baseline Survey stations with average ± standard deviation for various depth strata within the EBS study area. Concentrations are compared to effects range low (ERL) and effects range median (ERM) (Buchman, 2008). **Bold** entries indicate concentrations greater than the ERL; values in red are above the ERM.

Station (Depth [m])	Al (%)	As	Ba	Cd	Cr	Cu	Fe (%)	Hg	Ni	Pb	V	Zn
Nearshore Area (< 25 m Depth)												
NA-1 (23 m)	1.95	5.4	278	0.04	31.6	4.16	1.16	0.00425*	7.3	5.79	17.0	11.9
NA-2 (23 m)	2.32	**8.5**	285	0.08	50.6	7.00	1.30	0.00425*	12.9	9.27	29.4	20.4
NA-3(22 m)	2.02	6.9	260	0.08	41.0	5.32	1.06	0.0047*	9.8	7.99	23.4	16.5
NA-4 (21 m)	2.22	8.0	268	0.06	48.2	6.27	1.14	0.00395*	11.4	9.37	27.3	18.4
NA-5 (22 m)	2.41	**9.7**	285	0.07	50.6	7.39	1.24	0.0065*	13.2	10.2	31.0	21.0
Average ± SD	2.2 ± 0.2	7.7 ± 1.6	275 ± 11	0.07 ± 0.02	44.4 ± 8.2	6.0 ± 1.3	1.2 ± 0.1	0.005 ± 0.001	10.9 ± 2.4	8.5 ± 1.7	25.6 ± 5.6	17.6 ± 3.7
Pipeline Area, Stations PA-1 thru PA-6 (25 to 200 m Depth)												
PA-1 (51 m)	3.90	**12.4**	272	0.18	98.5	15.1	2.33	0.0027*	**29.1**	15.2	67.3	34.9
PA-2 (79 m)	5.70	**11.8**	209	0.24	**107**	18.0	3.34	0.015	**37.9**	12.3	70.0	39.1
PA-3 (96 m)	1.74	**12.9**	87.3	0.21	48.4	7.62	2.46	0.0058	**21.1**	5.50	30.7	27.5
PA-4 (135 m)	1.56	**11.2**	83.8	0.29	50.1	7.99	2.38	0.0070	20.0	4.85	29.8	34.7
PA-5 (119 m)	1.77	**15.0**	88.7	0.24	54.0	7.73	2.85	0.0062	**22.1**	5.11	35.0	35.5
PA-6 (126 m)	1.54	**9.9**	81.0	0.23	50.7	8.31	2.11	0.0068	**20.5**	5.21	31.9	33.3
Average ± SD	2.7 ± 1.7	12.2 ± 1.7	137 ± 83	0.23 ± 0.04	68.1 ± 27.0	10.8 ± 4.6	2.58 ± 0.45	0.008 ± 0.004	25.1 ± 7.1	8.3 ± 4.5	44.1 ± 19.1	34.2 ± 3.8
Pipeline Area, Stations PA-7 thru PA-12 (200 to 1,000 m Depth)												
PA-7 (240 m)	1.86	**10.8**	88.8	0.08*	**82.7**	6.78	3.27	0.0034	17.8	6.36	31.5	43.5
PA-8 (290 m)	2.21	**15.5**	97.9	0.08*	**117**	7.23	4.26	0.0072	18.6	7.22	38.7	48.8
PA-9 (415 m)	2.77	**8.5**	164	0.22	**89.0**	11.8	2.59	0.0042	**24.9**	10.6	42.1	37.7
PA-10 (500 m)	3.87	**8.9**	241	0.22	**88.6**	16.8	2.27	0.0093	**35.2**	13.3	53.8	39.4
PA-11 (600 m)	2.66	**13.2**	177	0.08*	**104**	10.4	4.71	0.0014	**23.4**	10.9	51.3	44.5
PA-12 (850 m)	3.80	7.4	285	0.21	**81.9**	15.9	2.66	0.0022	**33.4**	13.1	50.8	40.7
Average ± SD	2.9 ± 0.8	10.7 ± 3.1	176 ± 77	0.15 ± 0.08	93.9 ± 13.8	11.5 ± 4.23	3.29 ± 0.98	0.005 ± 0.003	25.6 ± 7.3	10.3 ± 2.9	44.7 ± 8.7	42.4 ± 4.0

Table 5. (Continued).

Station (Depth [m])	Al (%)	As	Ba	Cd	Cr	Cu	Fe (%)	Hg	Ni	Pb	V	Zn
Pipeline Areas, Stations PA-13 thru PA-21 and Offshore Area (> 1,000 m Depth)												
PA-13 (1,120 m)	3.49	7.8	261	0.22	**86.0**	19.0	2.09	0.0258	**37.6**	15.8	59.1	45.5
PA-14 (1,300 m)	6.06	**10.3**	410	0.28	**136**	32.5	3.4	0.0046*	**63.2**	21.8	86.8	72.6
PA-15 (1,400 m)	6.08	**8.2**	414	0.22	**112**	27.1	3.23	0.0316	**52.0**	17.1	70.7	60.7
PA-16 (1,600 m)	5.85	7.3	437	0.23	**107**	27.2	3.33	0.026	**51.0**	15.6	69.4	60.6
PA-17 (1,780 m)	6.50	7.2	461	0.26	**120**	30.3	3.37	0.028	**56.0**	17.4	76.8	67.4
PA-18 (1,880 m)	6.58	5.9	487	0.19	**93.8**	24.6	3.43	0.027	**44.5**	13.0	61.2	53.9
PA-19 (2,080 m)	6.50	6.7	492	0.25	**113**	30.4	3.42	0.030	**54.4**	16.2	74.1	66.0
PA-20 (2,250 m)	7.08	7.5	529	0.24	**133**	**36.2**	3.73	0.030	**63.7**	19.2	86.6	77.8
PA-21 (2,370 m)	7.33	6.3	534	0.18	**122**	33.3	3.77	0.032	**55.4**	16.4	77.8	70.5
OA-1 (2,530 m)	7.99	4.6	610	0.20	**107**	29.9	4.11	0.0633	**48.5**	14.5	70.4	65.6
OA-2 (2,660 m)	7.91	6.0	709	0.24	**137**	**39.1**	4.05	0.005*	**61.6**	19.9	94.0	83.8
OA-3 (2,660 m)	7.72	6.2	661	0.21	**140**	**39.6**	4.00	0.060	**63.5**	21.1	95.7	85.4
OA-4 (2,585 m)	7.73	5.1	597	0.17	**114**	32.4	3.95	0.026	**51.4**	16.1	77.3	68.9
OA-5 (2,580 m)	7.67	6.3	612	0.22	**128**	**35.9**	4.05	0.020	**58.0**	18.0	87.7	76.7
Average ± SD	6.75 ± 1.20	6.81 ± 1.42	515 ± 118	0.22 ± 0.03	117.8 ± 16.3	31.25 ± 5.7	3.57 ± 0.53	0.03 ± 0.01	54.3 ± 7.6	17.3 ± 2.5	77.7 ± 11.3	68.2 ± 11.0
ERL	--	8.2	--	1.2	81	34	--	0.15	20.9	46.7	--	150
ERM	--	70	--	9.6	370	270	--	0.71	51.6	218	--	410

* = calculated using one half of the method reporting limit (MRL).
NA = Nearshore Area; OA = Offshore Area; PA = Pipeline Area; SD = standard deviation.

The metals concentrations within the EBS study area are variable, which is likely a function of sediment grain size, organic carbon content, and mineralogy. Higher metal concentrations are typically associated with fine-grained aluminosilicates (clays) and lower metal concentration with coarse-grained quartz sand. Aluminum concentration should correlate linearly with other metals concentrations when there is no anthropogenic influence (Trefry, 2003, 2013). Average concentrations of most metals within the EBS study area are below ERL benchmarks, with the exception of arsenic, chromium, copper, and nickel (**Table 5**). The concentration of nickel in some of deepwater stations in >1,000 m water depth were elevated above the ERM benchmark (**Table 5**). The upper range for average concentrations for arsenic, chromium, copper, and nickel in deep sea sediments exceeds the ERL for arsenic, chromium, and copper and exceeds the ERM for nickel.

To determine if observed metal concentrations are regionally anomalous, a regression analysis was conducted correlating sediment percent aluminum with other metals concentrations to assess the potential for influence by anthropogenic inputs. Metals concentrations correlate linearly with aluminum in the EBS study area and are likely indicative of ambient regional values (**Figures 8** through **11**). The positions of regression plots are based on a probability distribution relative to the 99% prediction interval; there is less than 1% probability that plots inside the prediction interval are due to chance. Subsequently, station plots outside the prediction interval could be considered anomalous to expected natural variation for specific metal concentrations. The prediction interval range is a function of the number of samples. The EBS sediment sample size is sufficient for this type of regression analysis to provide a high degree of certainty; any outliers, beyond the 99% prediction interval, would be considered anomalous. Results from regression analyses indicate EBS metal concentrations are considered regionally ambient and do not represent a hazard to marine organisms and the general offshore marine ecosystem.

Hydrocarbons

Sediment hydrocarbon concentrations within the EBS study area are presented in **Table 6**; unprocessed summary data as reported by the analytical laboratory can be provided upon request. Hydrocarbons analyzed in sediments included alkanes, TPH, extractable organic matter (EOM), and PAHs.

Alkanes are saturated hydrocarbons in the carbon range C9 through C40. Alkanes are a component of TPH and are considered relatively nonreactive.

TPH is a group of several hundred organic compounds that come from crude oil. The TPH value as presented is the collective total of extractable petroleum hydrocarbons from carbon range C9 through C40, similar to the alkane group.

EOM is an operationally defined parameter that is equivalent to, or an index of, oil and grease content.

PAHs are constituents of crude oil and the PAHs found in the marine environment are divided into two groups, petrogenic and pyrogenic. Petrogenic PAHs are present in oil and oil products. Typically the presence of petrogenic PAHs in offshore environments are associated with oil seeps, oil spills, and produced water discharges from offshore oil installations (Pampanin and Sydnes, 2013). PAHs analyzed from EBS sediment samples include 16 USEPA priority pollutants as listed in **Appendix C**. PAHs are a component of the TPH value.

Summary data from the sediment hydrocarbon analyses show lowest concentrations at the Nearshore Area and highest concentration at “deepwater” stations in water depths greater than 1,000 m (**Table 6**). Alkane average concentration for the Nearshore Area and deepwater stations were 1.7 $\pm$ 0.3 µg g^{-1} and 5.3 $\pm$ 1.1 µg g^{-1}, respectively.

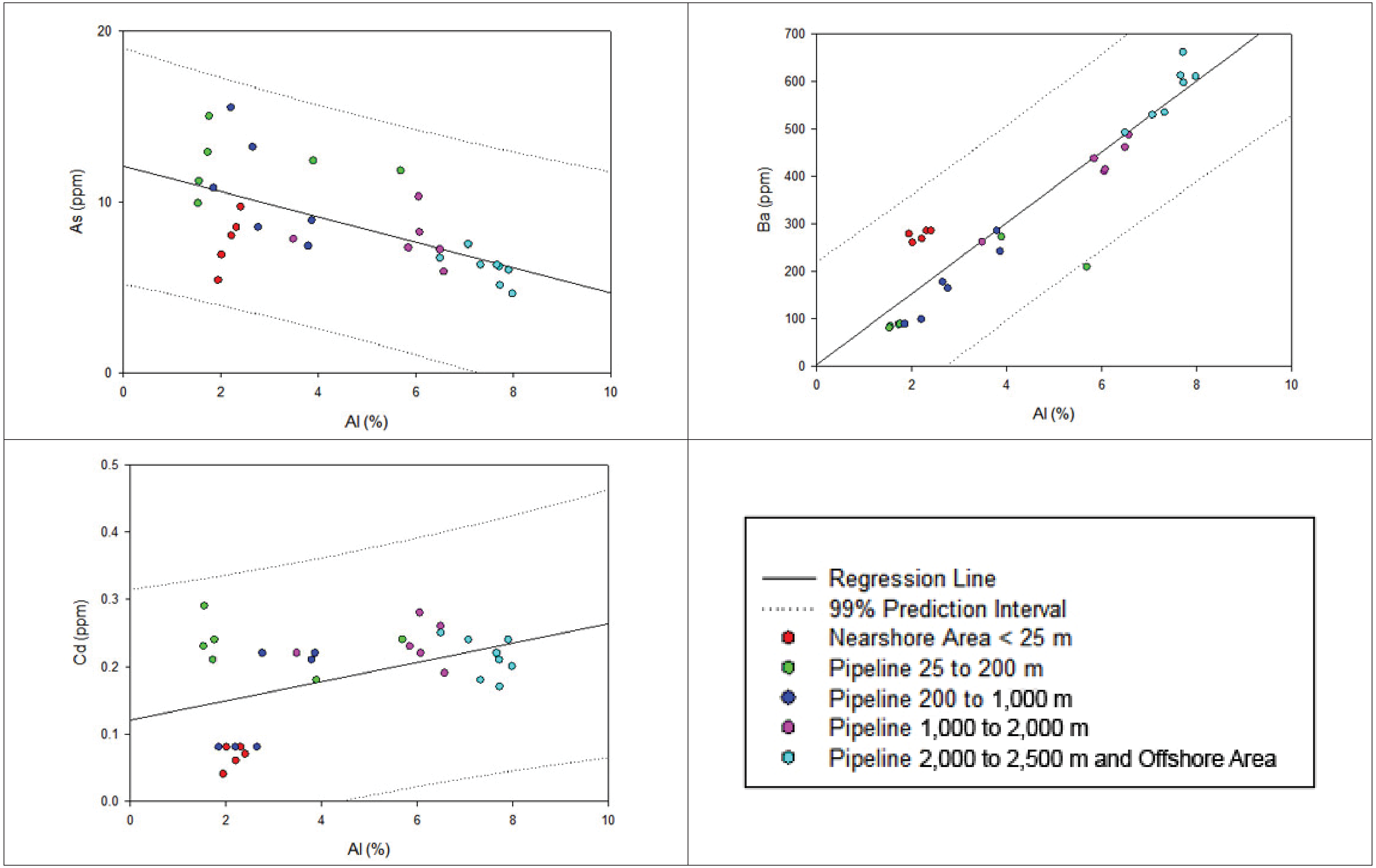


Figure 8. Linear regression for relationship between sediment percent aluminum (Al) and parts per million (ppm) concentrations of arsenic (As), barium (Ba), and cadmium (Cd). Stations outside the prediction interval could be considered anomalous to expected natural variation for specific metal concentrations.

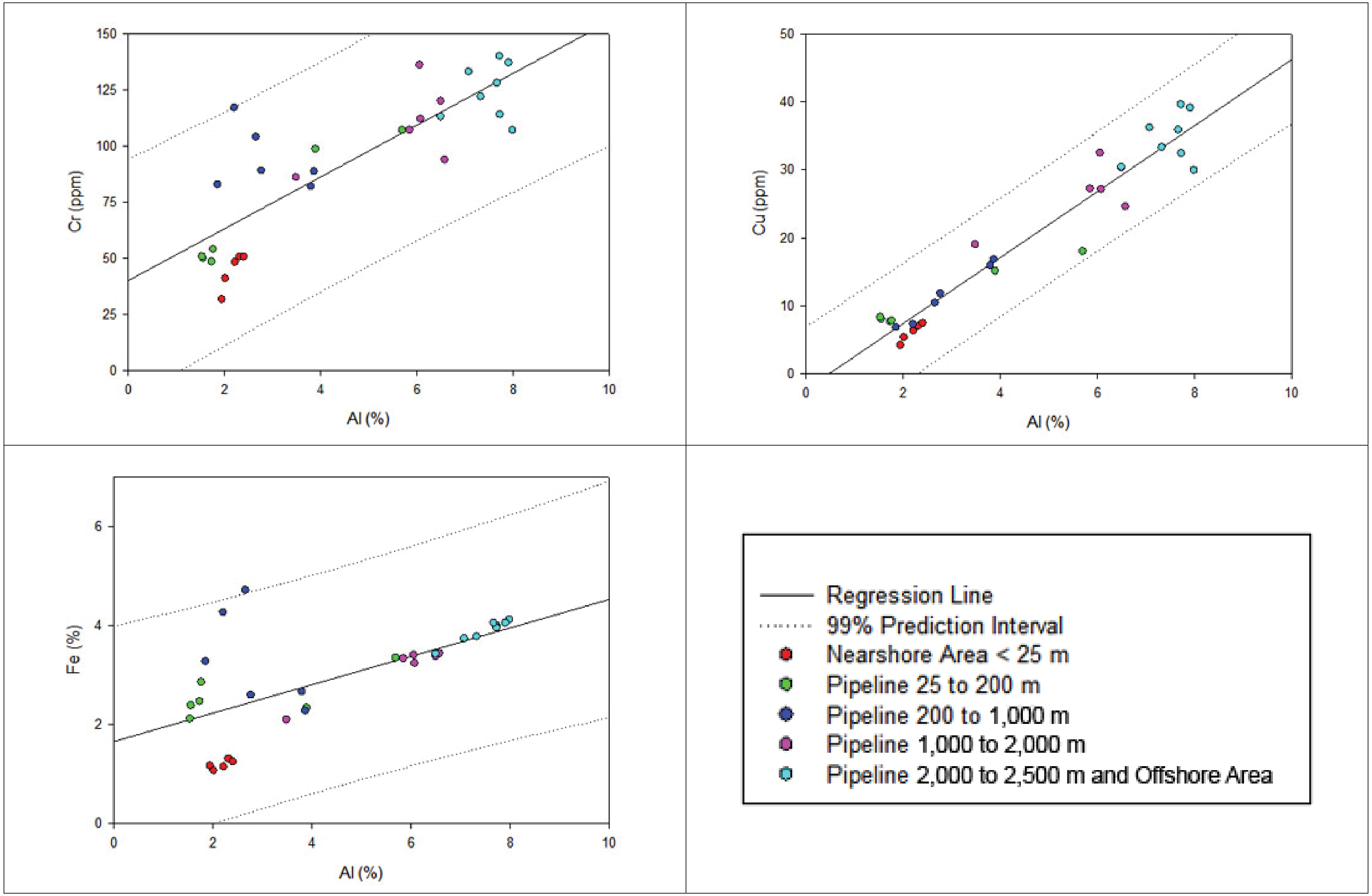


Figure 9. Linear regression for relationship between sediment percent aluminum (Al) and parts per million (ppm) concentrations of chromium (Cr), copper (Cu), and iron (Fe). Stations outside the prediction interval could be considered anomalous to expected natural variation for specific metal concentrations.

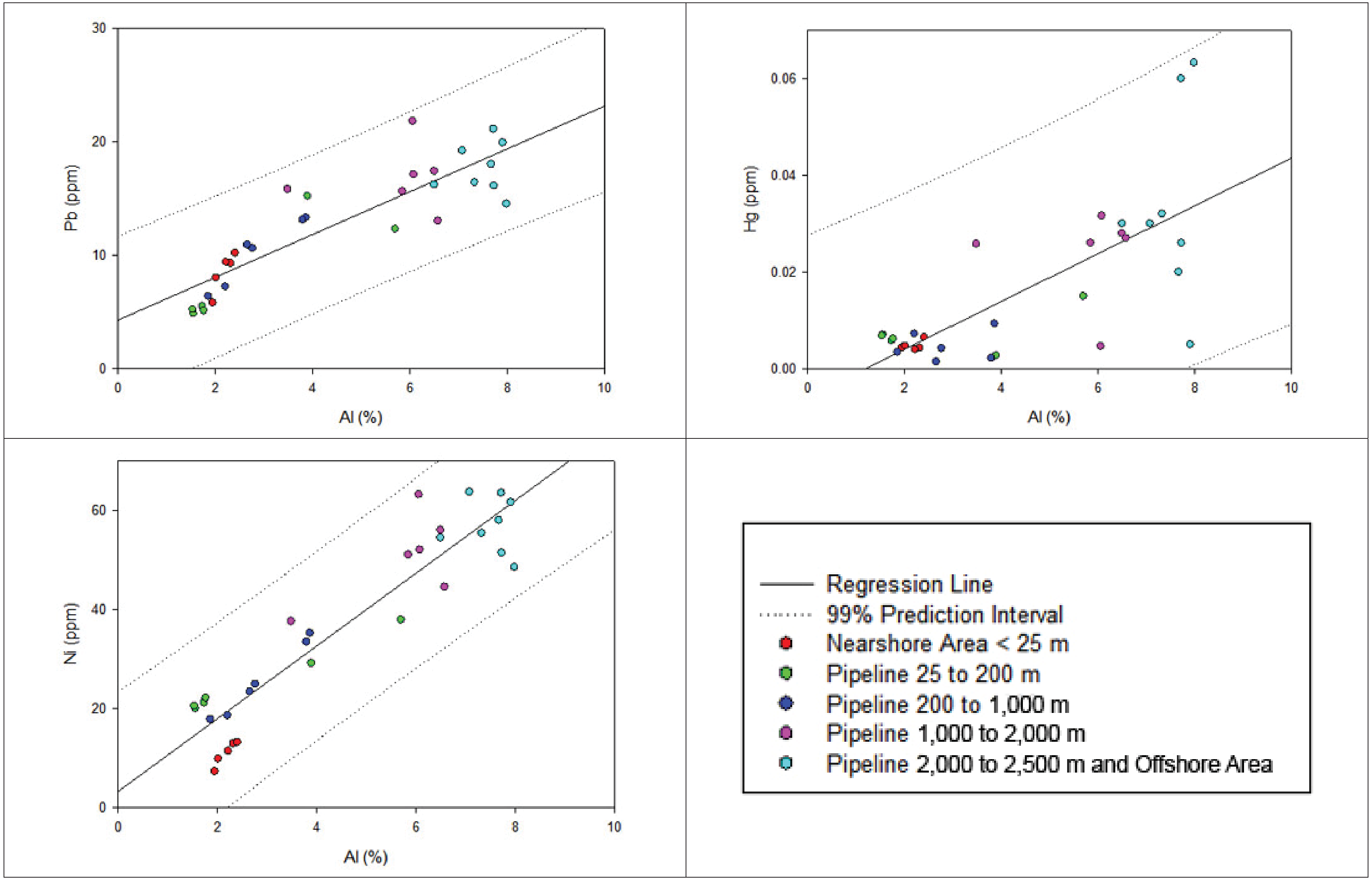


Figure 10. Linear regression for relationship between sediment percent aluminum (Al) and parts per million (ppm) concentrations of lead (Pb), mercury (Hg), and nickel (Ni). Stations outside the prediction interval could be considered anomalous to expected natural variation for specific metal concentrations.

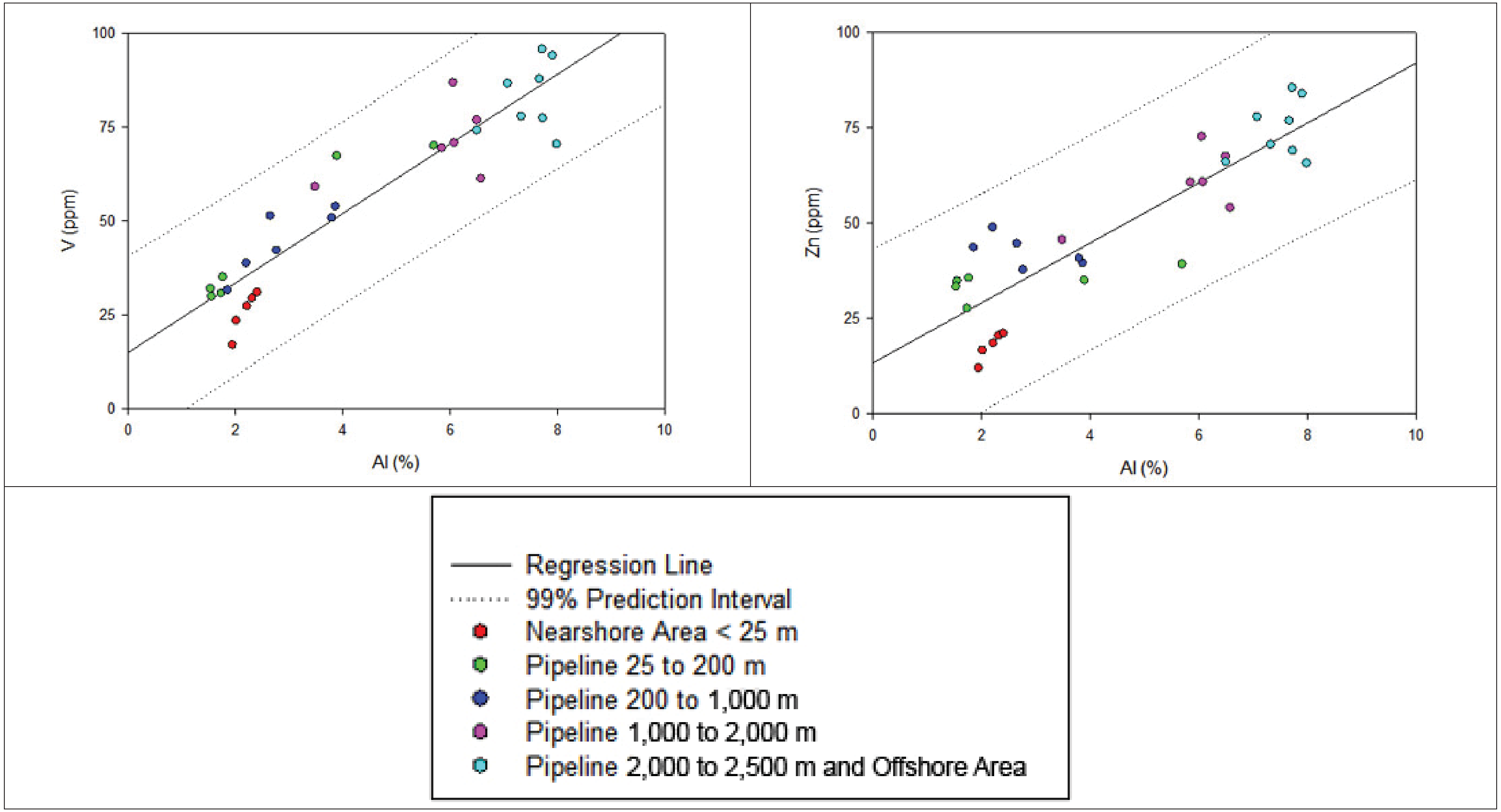


Figure 11. Linear regression for relationship between sediment percent aluminum (Al) and parts per million (ppm) concentrations of vanadium (V) and zinc (Zn). Stations outside the prediction interval could be considered anomalous to expected natural variation for specific metal concentrations.

Table 6. Hydrocarbon concentrations in sediment with average ± standard deviation for various depth strata within the Environmental Baseline Survey study area.

Station	Total Alkanes ($\mu g\ g^{-1}$)	TPH ($\mu g\ g^{-1}$)	EOM ($\mu g\ g^{-1}$)	PAHs ($ng\ g^{-1}$)
Nearshore Area (< 25 m Depth)				
NA-1	2.2	13	62	12.3
NA-2	1.8	10	38	11.5
NA-3	1.4	8	28	10.1
NA-4	1.7	7	54	10.3
NA-5	1.3	6	50	8.35
Average ± SD	**1.7 ± 0.3**	**8.8 ± 2.5**	**46.4 ± 12.0**	**10.5 ± 1.3**
Pipeline Area, Stations PA-1 thru PA-6 (25 to 200 m Depth)				
PA-1	3.3	19	118	39.2
PA-2	8.4	79	396	83.7
PA-3	1.8	15	88	25.2
PA-4	2.5	16	84	28.1
PA-5	2.7	19	116	28.3
PA-6	2.2	15	112	27.1
Average ± SD	**3.5 ± 2.2**	**27.2 ± 23.2**	**152.3 ± 109.8**	**38.6 ± 20.7**
Pipeline Area, Stations PA-7 thru PA-12 (200 to 1,000 m Depth)				
PA-7	1.8	12	88	22.2
PA-8	1.8	12	74	18.0
PA-9	2.3	13	118	31.0
PA-10	2.6	19	128	35.6
PA-11	2.2	16	116	32.2
PA-12	3.3	40	198	55.8
Average ± SD	**2.3 ± 0.9**	**18.7 ± 17.1**	**120.3 ± 67.8**	**32.5 ± 20.9**
Pipeline Area, Stations PA-13 thru PA-21 and Offshore Area (> 1,000 m Depth)				
PA-13	3.2	32	144	60.5
PA-14	6.5	75	313	107
PA-15	6.2	81	310	108
PA-16	3.9	81	244	108
PA-17	5.0	60	244	90.8
PA-18	6.2	72	275	88.9
PA-19	6.2	68	224	84.1
PA-20	6.7	70	188	82.6
PA-21	6.1	55	161	74.1
OA-1	4.4	28	136	43.1
OA-2	6.0*	29*	178*	2,054*
OA-3	5.5	28	150	67.5
OA-4	4.8	25	127	45.6
OA-5	4.5	27	112	41.6
Average ± SD	**5.3 ± 1.1**	**54.0 ± 21.7**	**202.2 ± 67.6**	**77.1 ± 23.2**

EOM = extractable organic matter; NA = Nearshore Area; OA = Offshore Area; PA = Pipeline Area; PAHs = polycyclic aromatic hydrocarbons; SD = standard deviation; TPH = total petroleum hydrocarbons.
* Potentially contaminated sample was removed from summary statistic calculations.

TPH average concentrations measured in sediments for the Nearshore Area and deepwater stations were 8.8 $\pm$ 2.5 µg g^{-1} and 54.0 $\pm$ 21.7 µg g^{-1}, respectively. The relatively high TPH concentrations observed at the deepwater stations are comparable to levels observed offshore Ghana in slightly shallower water depths (CSA, 2016). EOM average concentrations measured in sediments for the Nearshore Area and deepwater stations were 46.4 $\pm$ 12.0 µg g^{-1} and 202.2 $\pm$ 67.6 µg g^{-1}, respectively. Similar to TPH concentrations, there is a roughly 5-fold increase in EOM levels between the Nearshore Area and the deepwater stations.

Average PAH concentrations measured in the EBS study area sediments ranged from 10.5 ng g^{-1} (parts per billion [ppb]) in the Nearshore Area to 77.1 ng g^{-1} at the deepwater stations (**Table 6**). The higher PAH concentrations observed at the deepwater stations are comparable to levels observed offshore Ghana in slightly shallower water depths (CSA, 2016) and within deep waters of the eastern Mediterranean Sea (CSA, 2013). The USEPA has listed 16 PAHs that are considered a priority pollutant (Keith and Telliard, 1979). None of the sediment samples had priority pollutant PAHs that exceeded the ERL concentration with the exception of the contaminated sample collected at Offshore Area Station 2; fluorene levels at this station exceeded the ERL of 19 ppb. The hydrocarbon analytical laboratory indicated that the Offshore Area Station 2 sample was suspect due to a diesel-related signature in the PAH analyses.

There are no defined standards or guidelines for alkanes, TPH, and EOM/total oil and grease levels in marine sediment. The lack of defined standards for hydrocarbons is related to difficulties associated with developing standards for parameters that are operationally defined and vary depending on location, anthropogenic activities, natural seeps of hydrocarbons, and, where applicable, the nature or composition of the hydrocarbons.

3.1.2 Seawater

Total Suspended Solids

TSS results are presented in presented in **Table 7**. TSS is a water quality parameter to characterize or assess solid materials that are suspended within the water column.

Table 7. Total Suspended Solids (TSS) determinations.

Station	Depth Range	Sample Depth	TSS (mg L^{-1})
NA-1	<25 m	Surface	7.8
		Near Bottom	20.2
NA-2	<25 m	Surface	19.4
		Near Bottom	3.3
NA-3	<25 m	Surface	9.6
		Mid-depth	19.6
		Near Bottom	22.2
PA-1	25 to 200 m	Surface	14.2
		Mid-depth	11.2
		Near Bottom	17.2
PA-2	200 to 1,000 m	Surface	13.6
		Mid-depth	14.6
		Near Bottom	12.2
PA-3	1,000 to 2,000 m	Surface	7.9
		Mid-depth	2.6
		Near Bottom	4.2
OA-1	>2,500 m	Surface	2.6
		Mid-depth	2.5
		Near Bottom	2.6

NA = Nearshore Area; OA = Offshore Area; PA = Pipeline Area.

Materials considered in TSS measurements include potential silt from discharges, plankton, and organic matter produced by dead or dying animals and plants. High concentration of TSS can affect water clarity and various water column biological processes (e.g., photosynthesis and respiration). High TSS concentrations and subsequent potential effects are not expected in an open ocean environment such as the offshore portion of the EBS study area.

The TSS levels are quite variable within the EBS study area, as would be expected, due to the extensive depth range and “from-shore” distance gradient. Higher TSS levels were observed at stations in water depths less than 1,000 m, with the highest TSS levels noted at the Nearshore Area stations. The lowest TSS levels, just above method detection limits, were observed at the Offshore Area characterized by a relatively uniform column of clear water.

Metals

Seawater samples were analyzed to estimate the levels of both total and dissolved metals. Total metals includes metals content both dissolved in the water and present in the water matrix particulates. In open ocean conditions, the dissolved fraction could be a very significant portion of the total metals. As a subset of total metals, the dissolved fraction is generally considered more mobile and biologically available. The dissolved fraction being a better representation of the biologically active portion of the metal is considered most useful for understanding potential health risks and studies specific on fate and effects.

Results of the analysis for dissolved metals in seawater are presented in **Table 8**; unprocessed summary data as reported by the analytical laboratory can be provided upon request. All dissolved metal concentrations are reported as lower than the CCC toxicity reference values (Buchman, 2008) with a single exception of lead in surface waters of the Offshore Area. This anomalous result is likely due to contamination from an unknown source. Other than this exceptional lead concentration, levels of all metals are relatively consistent throughout the EBS survey area. Dissolved mercury was undetectable and vanadium concentration were below method detection limits within the EBS study area. Concentrations of dissolved cadmium, chromium, and zinc were very low and below method detection limits at most of the EBS sampling stations.

Results of the analysis for total metals in seawater are presented in **Table 9**; unprocessed summary data as reported by the analytical laboratory can be provided upon request. The total metals and dissolved metals concentrations are very similar and indicative of a predominance of the dissolved metals fraction in seawater.

Where reported levels of a total metal (**Table 8**) are less than the dissolved fraction for that metal (**Table 9**), the results are within the laboratory-specified analytical relative percent difference (RPD) for a particular metal analyte. The RPD provides an indication of analytical precision for sampling measurements of two identical samples and was specified as 20%. Analytical results for total and dissolved metals from the same sampling station that are within the RPD are essentially the same. All total metal concentrations are reported as lower than the CCC toxicity reference values (Buchman, 2008) and are relatively consistent throughout the EBS survey area. Mercury was undetectable and vanadium concentrations were below method detection limits. Concentrations of dissolved cadmium, chromium, and zinc were very low and below method detection limits at most of the EBS sampling stations.

Table 8. Dissolved metals concentrations in seawater by sampling depth, with comparisons to Criterion Continuous Concentration (CCC) toxicity reference values. Units presented in µg L^{-1} with the exception of mercury (Hg). **Bold** entry indicates anomalous result likely due to contamination from an unknown source.

Station	Depth Range	Depth	As	Ba	Cd	Cr	Cu	Hg (ng L^{-1})	Ni	Pb	V	Z
NA-1	<25 m	Surface	1.26	13.90	<0.003	<0.03	0.26	ND	0.26	0.04	<0.4	0.58
		Bottom	1.36	12.10	<0.003	<0.03	0.31	ND	0.29	0.04	<0.4	0.92
NA-2	<25 m	Surface	1.32	13.20	<0.003	<0.03	0.25	ND	0.26	0.03	<0.4	0.66
		Bottom	1.35	10.40	<0.003	<0.03	0.20	ND	0.24	0.02	<0.4	0.68
NA-3	<25 m	Surface	1.28	10.00	<0.003	<0.03	0.25	ND	0.23	0.03	<0.4	<0.07
		Middle	1.34	8.20	<0.003	<0.03	0.19	ND	0.25	0.02	<0.4	<0.07
		Bottom	1.23	7.70	<0.003	<0.03	0.14	ND	0.22	0.04	<0.4	0.52
PA-1	25 to 200 m	Surface	1.10	17.00	<0.003	<0.03	0.23	ND	0.22	0.04	<0.4	<0.07
		Middle	1.27	12.30	<0.003	<0.03	0.22	ND	0.27	0.02	<0.4	<0.07
		Bottom	1.52	8.30	<0.003	<0.03	0.25	ND	0.23	0.03	<0.4	<0.07
PA-2	200 to 1,000 m	Surface	1.45	9.50	<0.003	<0.03	0.23	ND	0.27	0.04	<0.4	<0.07
		Middle	1.30	8.10	0.040	<0.03	0.15	ND	0.30	<0.004	<0.4	<0.07
		Bottom	1.36	8.80	0.051	<0.03	0.14	ND	0.35	0.02	<0.4	<0.07
PA-3	1,000 to 2,000 m	Surface	1.26	10.50	<0.003	<0.03	0.22	ND	0.21	0.04	<0.4	<0.07
		Middle	1.43	9.40	0.055	<0.03	0.23	ND	0.36	0.02	<0.4	<0.07
		Bottom	1.38	11.50	0.039	<0.03	0.22	ND	0.34	0.05	<0.4	<0.07
OA-1	>2,500 m	Surface	1.45	9.60	0.058	0.23	0.22	ND	0.44	**1.12**	<0.4	<0.07
		Middle	1.43	10.40	0.054	0.20	0.19	ND	0.38	0.07	<0.4	<0.07
		Bottom	1.43	8.80	0.023	<0.03	0.24	ND	0.25	0.03	<0.4	<0.07
CCC value			36	200 BC	8.8	50[1]	3.1	8.1	50 BC	0.94	8.2	81

As = arsenic; Ba = barium; BC = British Columbia Water Quality Guidelines as sourced from Buchman (2008); Cd = cadmium; Cr = chromium; Cu = copper; Hg = mercury; NA = Nearshore Area; ND = non-detect, value below method detection limit; Ni = nickel; OA = Offshore Area; PA = Pipeline Area; Pb = lead; V = vanadium; Zn = zinc.
[1] CCC specific to chromium oxide.

Table 9. Total metals concentrations in seawater by sampling depth, with comparisons to Criterion Continuous Concentration (CCC) toxicity reference values. Units presented in µg L^{-1} with the exception of mercury (Hg).

Station	Depth Range	Depth	As	Ba	Cd	Cr	Cu	Hg (ng L^{-1})	Pb	Ni	V	Zn
NA-1	<25 m	Surface	1.31	9.20	<0.003	0.28	0.27	ND	0.15	0.29	<0.4	0.71
		Bottom	1.38	12.60	<0.003	0.37	0.33	ND	0.12	0.35	<0.4	0.79
NA-2	<25 m	Surface	1.34	7.00	<0.003	0.26	0.30	ND	0.05	0.26	<0.4	0.51
		Bottom	1.30	8.60	<0.003	0.39	0.26	ND	0.07	0.30	<0.4	0.60
NA-3	<25 m	Surface	1.39	8.30	<0.003	0.28	0.24	ND	0.04	0.24	<0.4	<0.07
		Middle	1.38	9.50	0.021	0.33	0.36	ND	0.06	0.31	<0.4	0.51
		Bottom	1.42	8.20	0.022	0.65	0.32	ND	0.10	0.39	<0.4	0.61
PA-1	25 to 200 m	Surface	1.12	10.20	<0.003	<0.03	0.26	ND	0.04	0.20	<0.4	0.62
		Middle	1.46	7.80	<0.003	<0.03	0.18	ND	0.02	0.21	<0.4	<0.07
		Bottom	1.57	7.30	<0.003	0.21	0.17	ND	0.04	0.29	<0.4	0.79
PA-2	200 to 1,000 m	Surface	1.42	14.00	<0.003	0.21	0.22	ND	0.07	0.25	<0.4	1.27
		Middle	1.44	7.60	0.044	0.21	0.24	ND	0.06	0.35	<0.4	0.77
		Bottom	1.41	10.30	0.052	0.24	0.29	ND	0.08	0.38	<0.4	0.98
PA-3	1,000 to 2,000 m	Surface	1.31	11.70	0.023	<0.03	0.20	ND	0.03	0.26	<0.4	<0.07
		Middle	1.27	7.60	0.051	<0.03	0.14	ND	0.02	0.37	<0.4	<0.07
		Bottom	1.32	8.10	0.037	0.20	0.21	ND	0.03	0.35	<0.4	<0.07
OA-1	>2,500 m	Surface	1.33	11.60	<0.003	0.21	0.20	ND	0.12	0.20*	<0.4	<0.07
		Middle	1.36	7.70	0.051	0.21	0.31	ND	0.78	0.36	<0.4	1.80
		Bottom	1.34	10.90	0.036	0.20	0.16	ND	0.05	0.33	<0.4	<0.07
CCC value			36	200 BC	8.8	50[1]	3.1	8.1	50 BC	0.94	8.2	81

As = arsenic; Ba = barium; BC = British Columbia Water Quality Guidelines as sourced from Buchman (2008); Cd = cadmium; Cr = chromium; Cu = copper; Hg = mercury; NA = Nearshore Area; ND = non-detect, value below method detection limit; Ni = nickel; OA = Offshore Area; PA = Pipeline Area; Pb = lead; V = vanadium; Zn = zinc.
[1] CCC specific to chromium oxide.

Hydrocarbons

Results of the analysis for hydrocarbons in seawater are presented in **Table 10**; unprocessed summary data as reported by the analytical laboratory can be provided upon request.

Table 10. Hydrocarbon concentrations in seawater, by sampling depth. Units presented in µg L^{-1} with the exception of total PAHs.

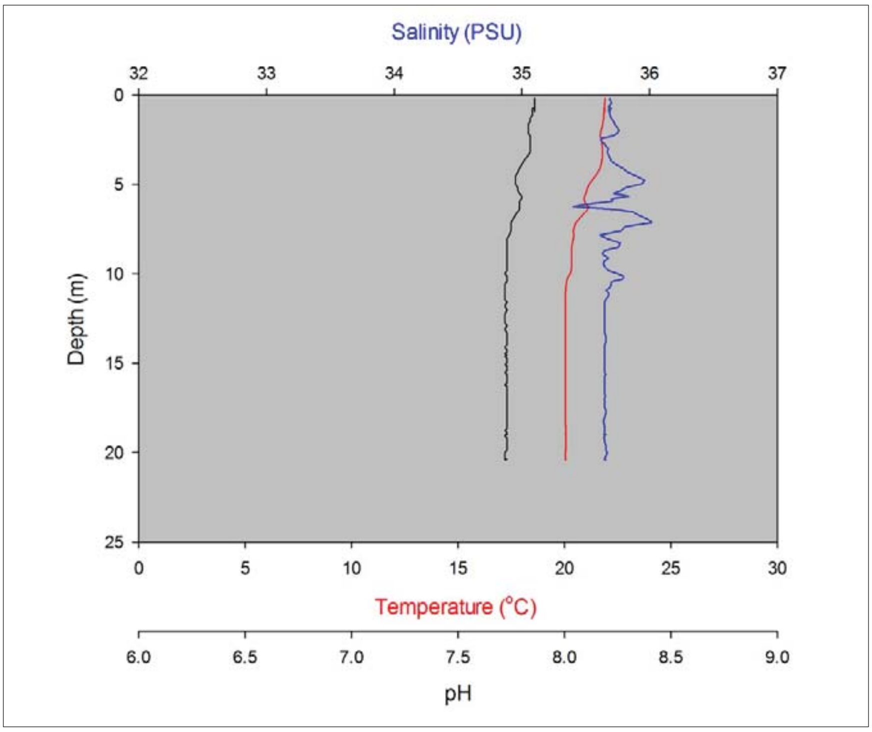
Station	Depth Range	Depth	Total Alkanes	TPH	EOM	Total PAHs (ng L^{-1})
NA-1	<25 m	Surface	ND	<15.854	293	39.9
		Bottom	ND	<13.83	287	41.1
NA-2	<25 m	Surface	ND	<13.402	371	37.4
		Bottom	ND	<14.286	264	39.3
NA-3	<25 m	Surface	ND	<13.402	247	34.0
		Middle	ND	<13.265	153	40.3
		Bottom	ND	<13	270	29.2
PA-1	25 to 200 m	Surface	ND	<13	294	50.9
		Middle	ND	<13	683	44.3
		Bottom	ND	<13.265	31	32.3
PA-2	200 to 1,000 m	Surface	ND	<13	29	40.1
		Middle	ND	<13	210	38.9
		Bottom	ND	<13	240	36.6
PA-3	1,000 to 2,000 m	Surface	ND	<13	210	41.5
		Middle	ND	<13.131	212	33.8
		Bottom	ND	<13	270	42.1
OA-1	>2,500 m	Surface	ND	<13.131	333	43.7
		Middle	ND	<13.684	253	33.8
		Bottom	ND	<13.542	94	25.0

EOM = extractable organic matter; NA = Nearshore Area; ND = non-detect, value considered below method detection limit; OA = Offshore Area; PAHs = polycyclic aromatic hydrocarbons; PA = Pipeline Area; PAHs = polycyclic aromatic hydrocarbons; TPH = total petroleum hydrocarbons.

Individual alkane samples were at levels below the method detection limits at all EBS stations which precluded the calculation of total alkanes. TPH concentrations are low throughout the EBS study area and a number of individual TPH samples were qualified by the analytical laboratory as less than the limit of detection (i.e., below method detection limit). While EOM levels were variable ranging from 31 to 683 µg L^{-1}, the total PAH levels were relatively consistent in the EBS study area ranging from 25 to 50.9 ng L^{-1}. The total PAH concentrations observed within the EBS study area were much lower than the average PAH concentrations observed at reference stations offshore Ghana (CSA, 2016). There are no internationally accepted toxicity reference values for TPH or total PAHs.

3.2 HYDROGRAPHIC PROFILES

Representative profiles are presented for the Nearshore Area (in water depths <25 m; **Figure 12**), within the Pipeline Area (in water depths <1,000 m; **Figure 13**), and for the Offshore Area (in water depths >2,500 m; **Figure 14**). Improper voltage to the sensor during collection of profile data precluded the presentation of values for DO percent saturation and concentration.



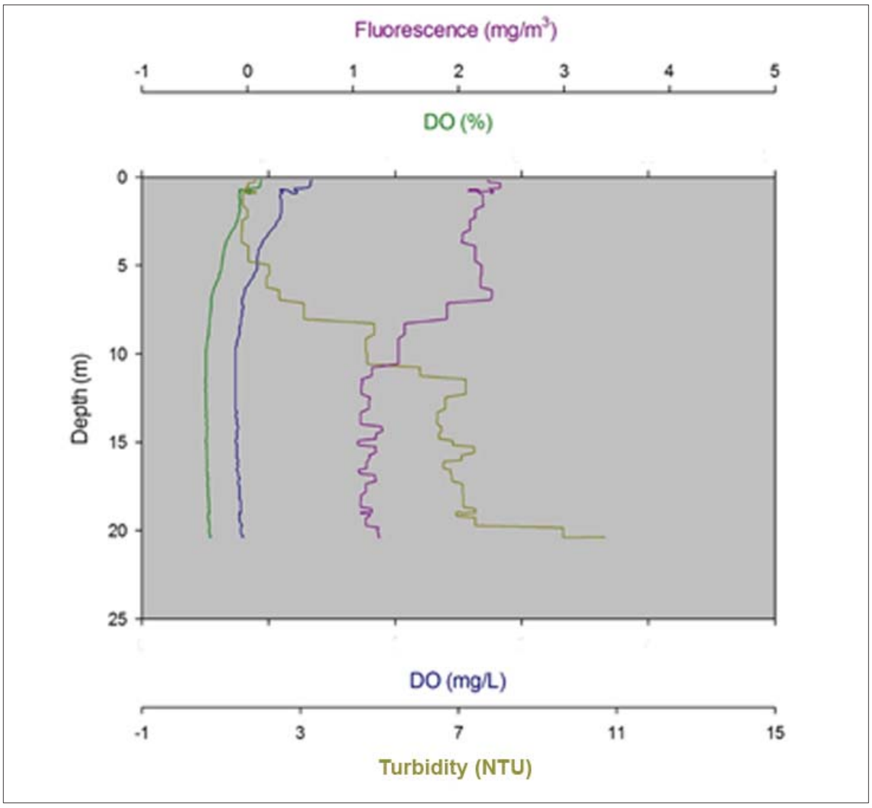
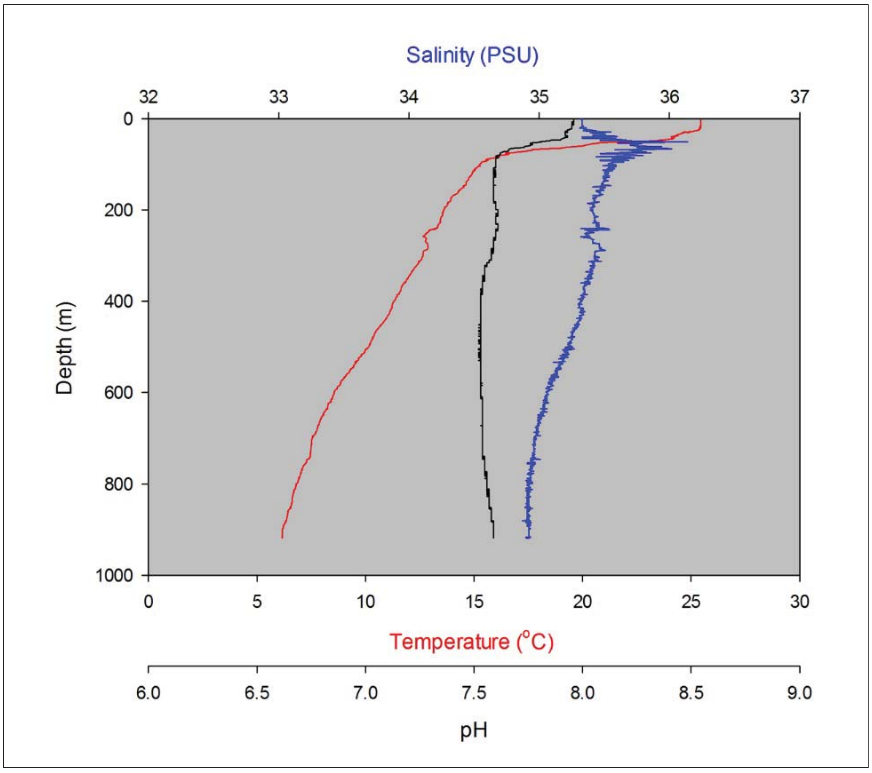


Figure 12. Water column profiles for temperature, salinity, pH, fluorescence, turbidity, and dissolved oxygen (concentration and saturation) for the Nearshore Area in water depths of <25 m.



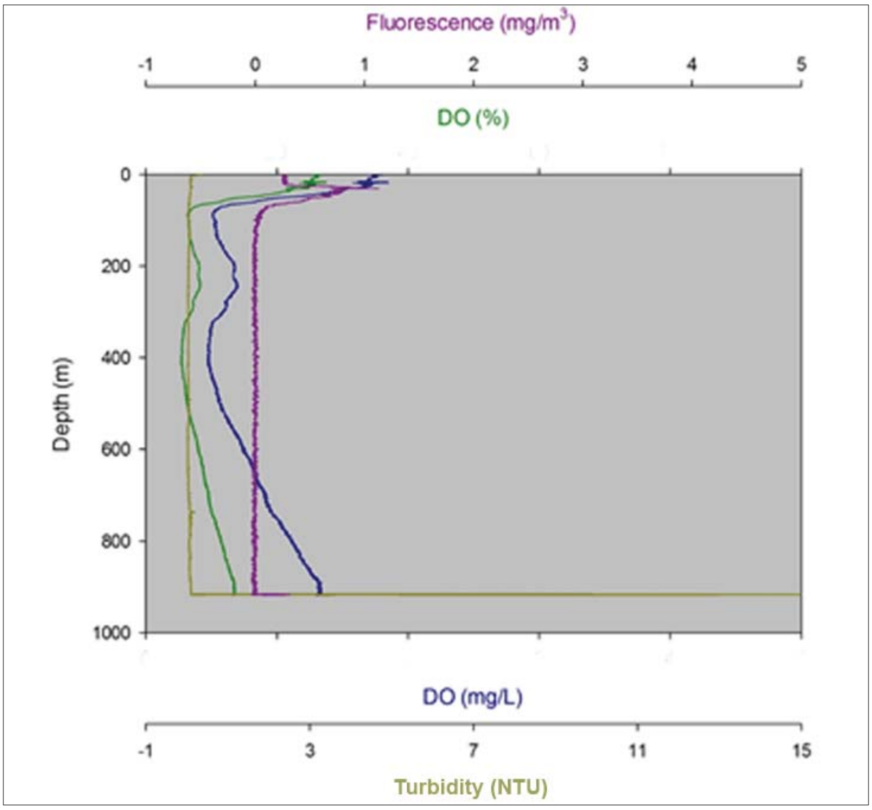


Figure 13. Water column profiles for temperature, salinity, pH, fluorescence, turbidity, and dissolved oxygen (concentration and saturation) for the Pipeline Area in water depths <1,000 m.

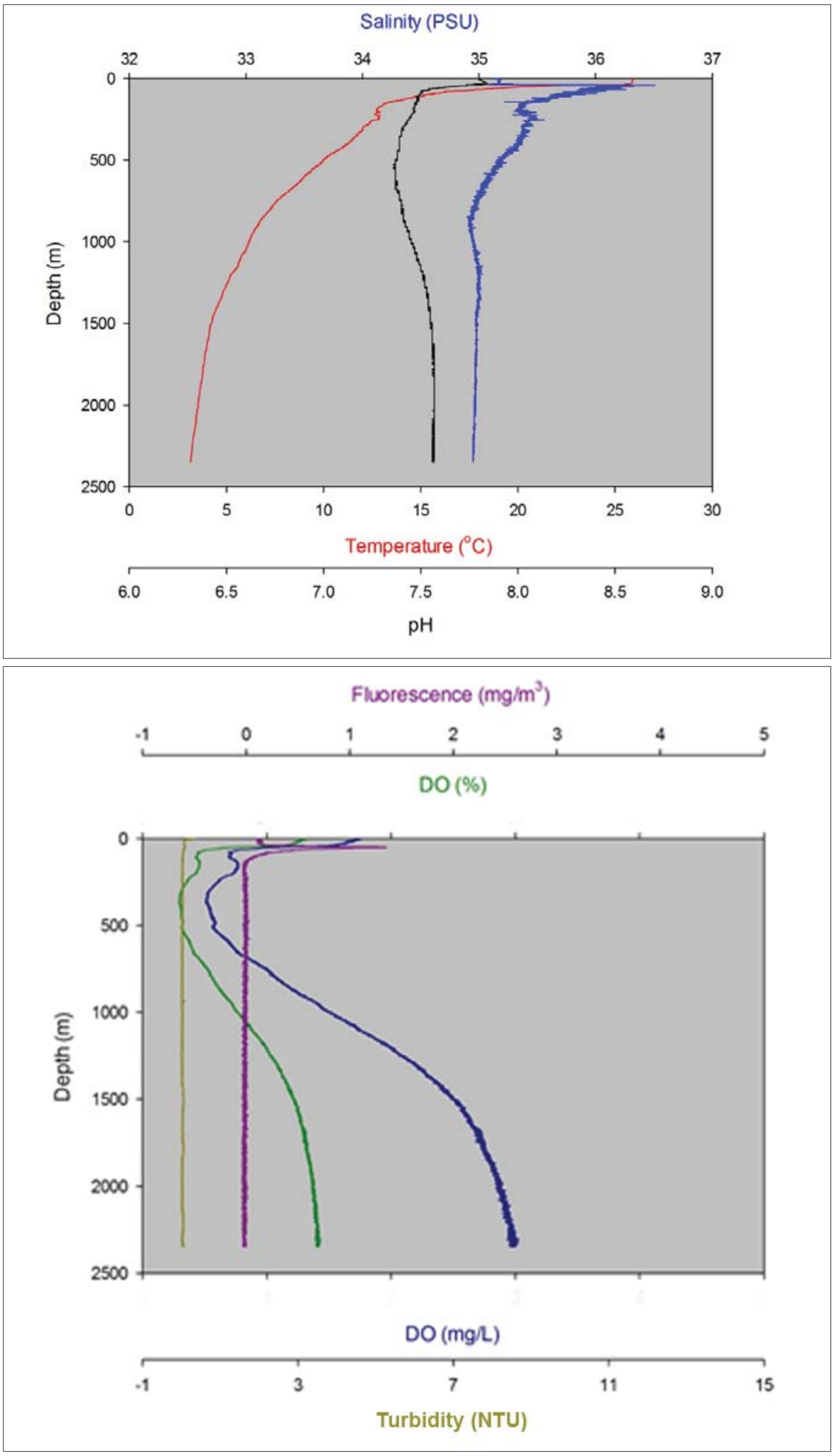


Figure 14. Water column profiles for temperature, salinity, pH, fluorescence, turbidity, and dissolved oxygen (concentration and saturation) for the Offshore Area in a water depth >2,500 m.

Water column profiles of Nearshore Area showed relatively uniform conditions concerning temperature, salinity, pH, and DO. The fluorescence signal and turbidity are indirectly correlated with decreasing fluorescence associated with increasing turbidity. There is a noticeable increase in turbidity at about 5 m water depth which consequently reduces light penetration and the fluorescence signal.

The water column profiles from the deeper water locations (**Figures 13** and **14**) are similar. The pH ranged from about 7.5 to less than 8. Turbidity with a negligible signal was extremely low and relative constant throughout the water column. Fluorescence had a peak signal at a water depth of about 50 m; fluorescence was limited to the upper portion of the photic zone with no indication of fluorescence below about 80 m. There is a distinct shallow thermocline below about 20 m water depth. Water temperature within the thermocline feature had a rapid decline from over 25°C to below 15°C at about 90 m water depth. Water temperature had a steady decline with depth below the thermocline feature with minimum temperatures near 5°C (**Figure 13**) and below 5°C (**Figure 14**).

Water temperature range and profile trajectory were consistent throughout the deeper portion of the EBS study area. There was a wedge of lower salinity water (<35 psu) on the surface down to a halocline at approximately 35 m. Below the halocline, salinity decreased to a minimum near 35 psu at a depth of approximately 700 m, below which salinity remained relatively constant to near bottom depths.

The DO profiles reflect water column processes of primary productivity, respiration, and mineralization. Typically in the open ocean DO is highest at the near-surface where sunlight allows the highest rates of primary production (resulting in oxygen evolution). DO is greatest not at the surface but just below the water surface due to the actinic effects of sunlight on photosynthesis. Below the surface-mixed layer, decreasing light availability depresses primary productivity, and mineralization of organic matter results in lower DO concentration down to the oxygen minimum at a water depth of approximately 350 m. DO decreases with depth as organic matter from the productive photic surface layers is mineralized and oxygen is consumed in the process. Below the DO minimum, DO increased gradually with increasing depth; within the Offshore Area, near bottom DO levels exceed those observed on the surface (**Figure 14**). Although the DO values were in error due to improper sensor voltage, there is a high degree of certainty that the profiles for DO percent saturation and concentration are correct as related to the depth-related trends.

3.3 INFAUNA

Infauna samples collected from the Nearshore Area (n=5) and from the seven strata within the Pipeline Area (n=3 x 7 strata=21) were sieved through 0.5 mm mesh screen. Samples from the Offshore Area (n=5) were sieved through a 0.3 mm screen. The two data sets were analyzed separately. Different sieve sizes were used because deepwater infauna are typically smaller than fauna collected in shallower water. The intent was to have all samples in water depth greater than 1,000 m processed with a 300-micron sieve. Due to a processing error, only the Offshore Area samples were screened using the 300-micron sieve; these samples are considered to be representative of the more comprehensive deepwater infauna community. Station locations for Nearshore Area, Pipeline Area, and Offshore Area are provided in **Figures 3** through **5**, respectively; station coordinates are provided in **Appendix B.**

Data from all samples were used to describe the basic infaunal assemblage structure for the sedimentary substrata around the Nearshore Area, Pipeline Area, and Offshore Area. Infaunal assemblage structure was characterized based on species diversity, relative abundance, and composition across the project area.

Nearshore Area

Five nearshore samples yielded a total of 1,753 individuals and 70 taxa from seven phyla. Densities of infauna among the five nearshore samples ranged from 2,147 to 2,988 individuals m^{-2}.

Diversity indices calculated for pooled samples are given in **Table 11**.

Table 11. Diversity indices and percent contribution of major phyla for the Nearshore Area (<25m) and depth strata within the Pipeline Area. Sample size for the Nearshore Area was n=5; all other strata n=3; all samples sieved with 0.5 mm screen mesh.

Metric	Depth Strata (m)							
	Nearshore Area	Pipeline Area						
	< 25	25-100	100-200	200-500	500-1,000	1,000-1,500	1,500-2,000	2,000-2,500
S	70	110	108	83	93	117	89	99
N	1,753	1,118	2,157	1,461	599	1,002	771	746
J'	0.78	0.80	0.78	0.69	0.84	0.74	0.84	0.83
H'	3.31	3.74	3.67	3.04	3.80	3.52	3.76	3.83
N_2	17.1	19.5	23.0	10.4	26.5	13.7	26.0	26.9

The total number of taxa per sample ranged from 39 to 56 with a mean of 46.4. Total individuals per sample averaged 350.6 and ranged from 263 to 476. The Shannon-Weiner diversity index (H') averaged 3.12. Mean evenness (J') per sample was high (0.82) indicating relatively equitable relative abundance per species. The N_2 index measures the degree to which a small number of individual taxa numerically dominate the samples.

Annelida, Arthropoda, and Mollusks collectively contributed over 91% of the total individuals in the nearshore area samples. The annelids were represented mostly by polychaetes and, to a much lesser extent (<1% of total abundance), oligochaete worms (Class Clitilleta). Arthropods were predominantly represented by members of the class Malacostraca which includes shrimps, crabs, lobsters, and other crustaceans (e.g., amphipods, isopods, tanaids, etc.). Mollusks were represented by gastropods, bivalves and scaphopods (tusk shells). The percent contribution of different phylogenetic classes to abundance in the samples from the nearshore area (<25 m stratum) is depicted in **Figure 15**.

The ten most abundant taxa recorded from the nearshore area accounted for 61.2 % of the total number of individuals (1,753). The three most abundant included two polychaetes (*Scolopsis* sp. and *Magelone* sp.) and the shrimp-like crustacean *Ogyrides rarispina* (**Table 12**).

Pipeline Area

Diversity indices for the seven depth strata within the Pipeline Area are given in **Table 11**. These samples produced 7,854 individuals from 279 taxa and eight phyla. Densities of infauna within the Pipeline Area ranged from 808 to 6,906 individuals m^{-2}.

Mean number of taxa per sample varied from shallow to deep water. The lowest mean number of taxa (47.5) was recorded for the 500-1,000 m stratum and the highest (75.0) in the 100-200 m stratum. Numbers of individuals also varied considerably across the depth strata but generally decreased with increasing water depths (**Table 11**). Mean Shannon H' diversity ranged 2.7 in the 200-500 m stratum to 3.6 in the 2,000-2,500 m stratum. Evenness was lowest (0.7) in the 200-500 m and highest (0.9) in the

2,000-2,500 m strata. Mean N infinity generally declined with increasing water depth corresponding to the higher evenness and less numerical dominance by a few taxa.

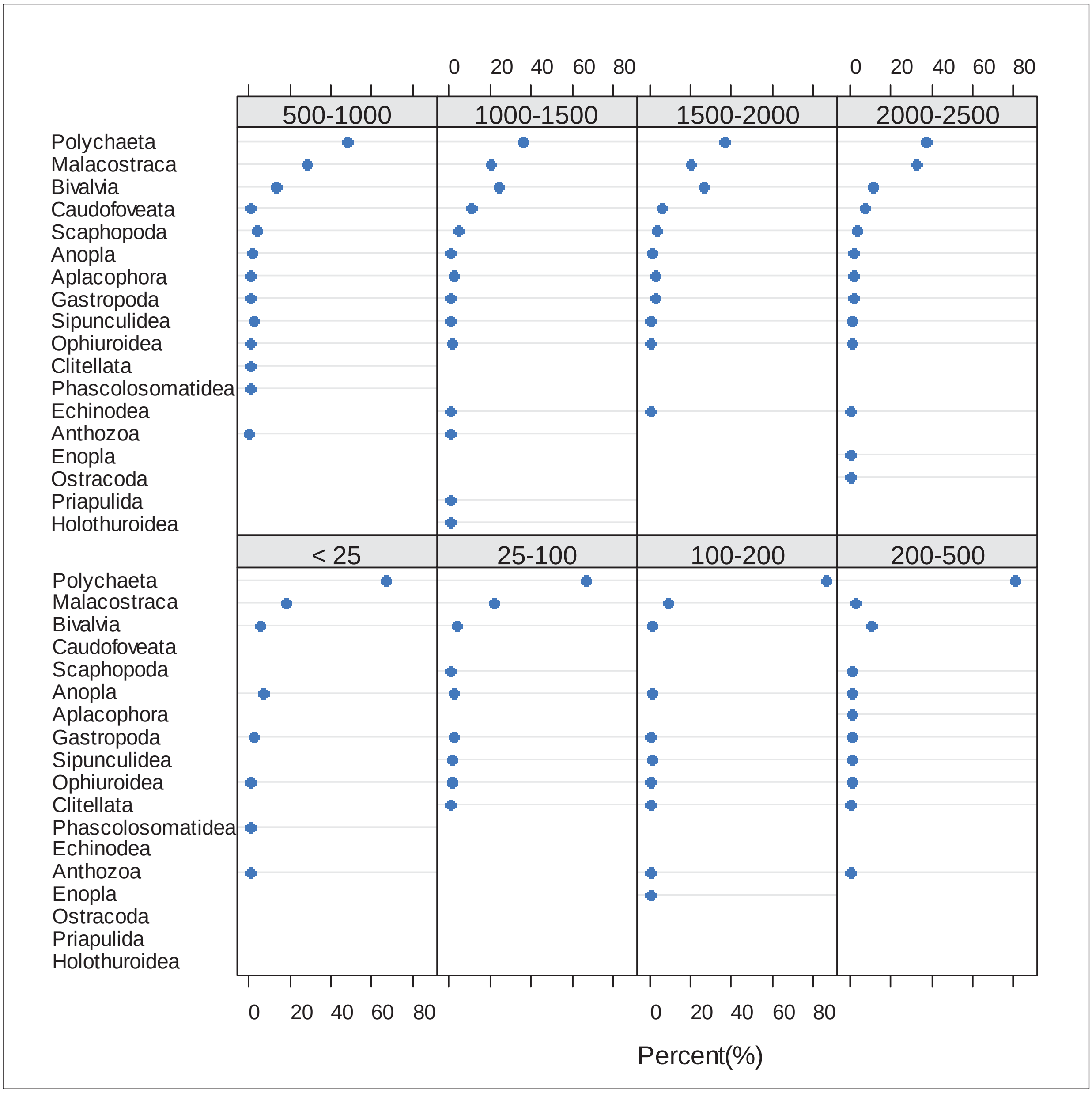


Figure 15. Percent abundance by phylogenetic class from the Nearshore Area and Pipeline Area strata samples.

Table 12. Top ten most abundant taxa for the Nearshore Area (<25 m) and seven depth strata within the Pipeline Area. Sample size for Nearshore Area was n=5; for all Pipeline Area strata n=3; all samples sieved with 0.5 mm screen mesh). **Bold** entries represent the top ten abundance rank (R) for each sampling location (Nearshore Area and Pipeline Area strata).

Class	Taxon	Depth Strata (m)																	
		Nearshore Area		Pipeline Area															
		<25	R	25-100	R	100-200	R	200-500	R	500-1,000	R	1,000-1,500	R	1,500-2,000	R	2,000-2,500	R	Total	Freq
Polychaeta	*Prionospio* sp.	**103**	**4**	**190**	**1**	**199**	**2**	**67**	**7**	**19**	**7**	13	--	**25**	**8**	**34**	**4**	650	8
Polychaeta	*Aricidea* sp.	46	--	**28**	**9**	**226**	**1**	**144**	**3**	**37**	**4**	**18**	**8**	15	--	**32**	**5**	546	8
Polychaeta	Cirratulidae	11	--	26	--	**151**	**4**	**74**	**6**	**17**	**9**	15	--	9	--	**22**	**8**	325	8
Polychaeta	*Levinsenia* sp.	3	--	3	--	**72**	**9**	**79**	**5**	**40**	**2**	15	--	7	--	1	--	220	8
Polychaeta	Tubulanidae	**88**	**6**	18	--	16	--	15	--	9	--	3	--	8	--	9	--	166	8
Polychaeta	*Sigambra* sp.	**87**	**7**	2	--	1	--	3	--	1	--	4	--	1	--	1	--	100	8
Polychaeta	*Spiophanes* sp.	2	--	2	--	16	--	16	--	**36**	**5**	13	--	5	--	3	--	93	8
Polychaeta	*Notomastus* sp.	5	--	3	--	19	--	3	--	3	--	2	--	7	--	**24**	**7**	66	8
Bivalvia	Thyasiridae	0	--	15	--	11	--	**138**	**4**	**39**	**3**	**198**	**1**	**92**	**1**	**49**	**3**	542	7
Malacostraca	*Ampelisca* sp.	**103**	**5**	12	--	49	--	17	--	**16**	**10**	**30**	**5**	1	--	0	--	228	7
Malacostraca	Paratanaoidea	0	--	1	--	31	--	1	--	**65**	**1**	**16**	**9**	**28**	**6**	17	--	159	7
Polychaeta	*Aglaophamus lyrochaeta*	19	--	**46**	**5**	14	--	19	--	3	--	0	--	10	--	11	--	122	7
Polychaeta	Heteromastus sp.	**80**	**9**	0	--	7	--	7	--	7	--	1	--	2	--	1	--	105	7
Polychaeta	*Lumbrineris* sp.	0	--	2	--	26	--	4	--	8	--	6	--	2	--	**21**	**9**	69	7
Polychaeta	*Ampharete* sp.	0	--	11	--	**83**	**7**	**150**	**2**	0	--	13	--	**25**	**9**	20	--	302	6
Malacostraca	*Harpinia* sp. 1 EcoA	0	--	1	--	8	--	0	--	**24**	**6**	**38**	**4**	**20**	**10**	20	--	111	6
Polychaeta	*Spiochaetopterus* sp.	55	--	**93**	**2**	57	--	**27**	**10**	1	--	1	--	0	--	0	--	234	6
Polychaeta	*Magelona* sp.	**221**	**2**	5	--	11	--	**32**	**9**	4	--	0	--	0	--	0	--	273	5
Polychaeta	*Monticellina* sp.	22	--	4	--	**59**	**10**	**41**	**8**	1	--	0	--	0	--	0	--	127	5
Bivalvia	*Cadulus* sp.	0	--	0	--	0	--	10	--	8	--	**16**	**10**	2	--	2	--	38	5
Caudofoveata	*Prochaetoderma* sp.	0	--	0	--	0	--	0	--	3	--	**104**	**3**	**46**	**3**	**53**	**2**	206	4
Polychaeta	*Scoloplos* sp.	**230**	**1**	**46**	**4**	21	--	2	--	0	--	0	--	0	--	0	--	299	4
Polychaeta	Fauveliopsidae	0	--	0	--	0	--	0	--	5	--	**123**	**2**	**29**	**5**	4	--	161	4
Scaphopoa	Dentaliida	0	--	0	--	0	--	0	--	8	--	**22**	**7**	16	--	6	--	52	4
Polychaeta	Tachytrypane sp.	0	--	0	--	0	--	0	--	3	--	**30**	**6**	7	--	2	--	42	4
Polychaeta	*Eunice* sp.	0	--	**34**	**7**	**160**	**3**	14	--	0	--	0	--	0	--	0	--	208	3
Polychaeta	*Chone* sp.	0	--	**37**	**6**	**95**	**6**	4	--	0	--	0	--	0	--	0	--	136	3

Table 12. (Continued).

Class	Taxon	Depth Strata (m)																	
		Nearshore Area		Pipeline Area															
		<25	R	25-100	R	100-200	R	200-500	R	500-1,000	R	1,000-1,500	R	1,500-2,000	R	2,000-2,500	R	Total	Freq
Malacostraca	*Apseudopsis* sp.	0	--	**66**	**3**	0	--	0	--	**19**	**8**	2	--	0	--	0	--	87	3
Bivalvia	*Saccella* sp.	0	--	0	--	0	--	0	--	1	--	0	--	**53**	**2**	**20**	**10**	74	3
Malacostraca	Desmosomatidae	0	--	0	--	0	--	0	--	0	--	16	--	**27**	**7**	**24**	**6**	67	3
Polychaeta	*Eusyllis* sp.	4	--	4	--	**75**	**8**	0	--	0	--	0	--	0	--	0	--	83	3
Bivalvia	Veneridae	0	--	0	--	0	--	0	--	1	--	13	--	**43**	**4**	0	--	57	3
Polychaeta	*Diopatra* sp.	3	--	**31**	**8**	3	--	0	--	0	--	0	--	0	--	0	--	37	3
Polychaeta	*Paradiopatra* sp.	0	--	6	--	0	--	**347**	**1**	0	--	0	--	0	--	0	--	353	2
Polychaeta	*Isolda* sp.	0	--	5	--	**107**	**5**	0	--	0	--	0	--	0	--	0	--	112	2
Polychaeta	*Lysippe bipennata*	**85**	**8**	8	--	0	--	0	--	0	--	0	--	0	--	0	--	93	2
Malacostraca	Haploniscidae	0	--	0	--	0	--	0	--	0	--	1	--	0	--	**86**	**1**	87	2
Malacostraca	*Gammaropsis* sp.	0	--	**28**	**10**	15	--	0	--	0	--	0	--	0	--	0	--	43	2
Malacostraca	*Ogyrides rarispina*	**104**	**3**	0	--	0	--	0	--	0	--	0	--	0	--	0	--	104	1
Malacostraca	Anthuridae sp. 2 EcoA	**57**	**10**	0	--	0	--	0	--	0	--	0	--	0	--	0	--	57	1
	Total top ten	1,073		599		1,227		1,099		312		579		388		365		6,834	
	Total	1,753		1,118		2,157		1,461		599		1,002		771		746		9,607	
	Percent (%)	61.2		53.6		56.9		75.2		52.1		57.8		50.3		48.9		71.1	

Freq = frequency of occurrence.

Polychaete worms, crustaceans (Malacostraca), and bivalve mollusks, accounted for an average of 88.1% of the total individuals in stations within the Pipeline Area. Percent numerical contribution of polychaetes ranged from 35.9% in the 1,000-1,500 m stratum to 85% in the 200-500 m stratum. Percentage of crustaceans was lowest (2.9%) at the 200-500 m stations and highest (32.3%) in the 2,000-2,500 m stratum. The ten most abundant taxa differed among the strata, but some such as the polychaetes *Prionospio* sp., *Aricidea* sp. and Cirratulidae were found in most strata. Others including the mollusks, Thyasiridade and *Prochaetoderma* sp. were more abundant in the deeper strata (**Table 12**). The percent contribution of different phylogenetic classes to abundance in the samples from all seven pipeline strata is depicted in **Figure 15**. The relative contribution of polychaetes decreases with increasing water depth as the abundance of bivalves and malacostracans increases with increasing water depth.

Multivariate analyses were used to compare proportional abundances and taxonomic composition of samples across the water depth gradient that extends from (and includes) the Nearshore Area and along the Pipeline Area to water depths of 2,500 m. Samples from the Nearshore Area and Pipeline Area were combined into a 26 sample x 302 taxa data matrix which was converted into a similarity matrix by calculating all pairwise Bray-Curtis similarities among stations. The similarity matrix was analyzed with NMDS and group average cluster analysis to visualize patterns in the data. Five sample groups formed at the 30% similarity level on the dendrogram (**Figure 16**). Two of the groups (2 and 4) were single, outlying stations from 25-100 m and 1,000-1,500 m depth strata, respectively. The remaining three groups were composed of stations from deep, intermediate, and shallow water depths. The deep water group consisted of 11 stations ranging from the four deepest strata (500-1,000 m, 1,000-1,500 m, 1,500-2,000 m, and 2,000-2,500 m). The intermediate depth group was composed of 7 samples from 200-500, 100-200, and 25-100 m depth strata. The shallow group included all five of the nearshore area samples and one from the 25-100 m depth stratum. The NMDS plot (**Figure 17**) corroborates the cluster analysis depicting a depth-related trend along the horizontal axis (NMDS axis 1) with the three main cluster groups enveloped in polygons.

Indicator species analysis of the five cluster groups revealed taxa that were significant as indicators for those groups (abundance and frequency) ($p<0.05$, 1,000 permutations). The results of the analysis is shown in **Table 13**.

Water depth and substrate characteristics (TOC, % sand, % clay, and % silt) were strongly inter-correlated among stations. Relationships between TOC, % silt, % clay, and % sand with the NMDS axes were displayed as a biplot (**Figure 18)**. The arrows show the strength (arrow length) and direction of the correlations. Stations located on the right side of the plot exhibited the highest TOC and % silt levels and were in located in deepest water, as opposed to stations with higher percentages of sand and located in shallow water. All of these variables are correlated with water depth.

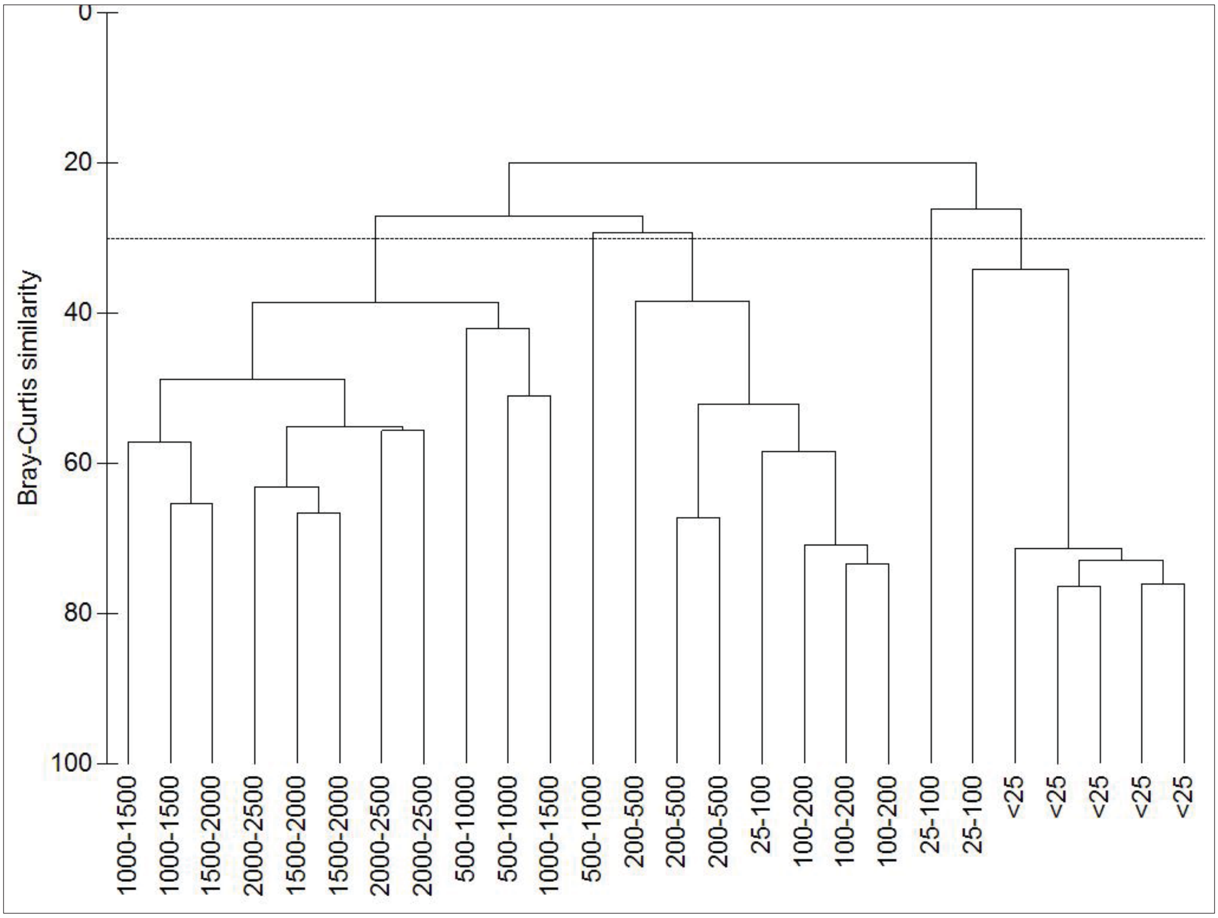


Figure 16. Cluster analysis of samples from the nearshore area (<25 m) and pipeline strata. Horizontal line represents 30% similarity.

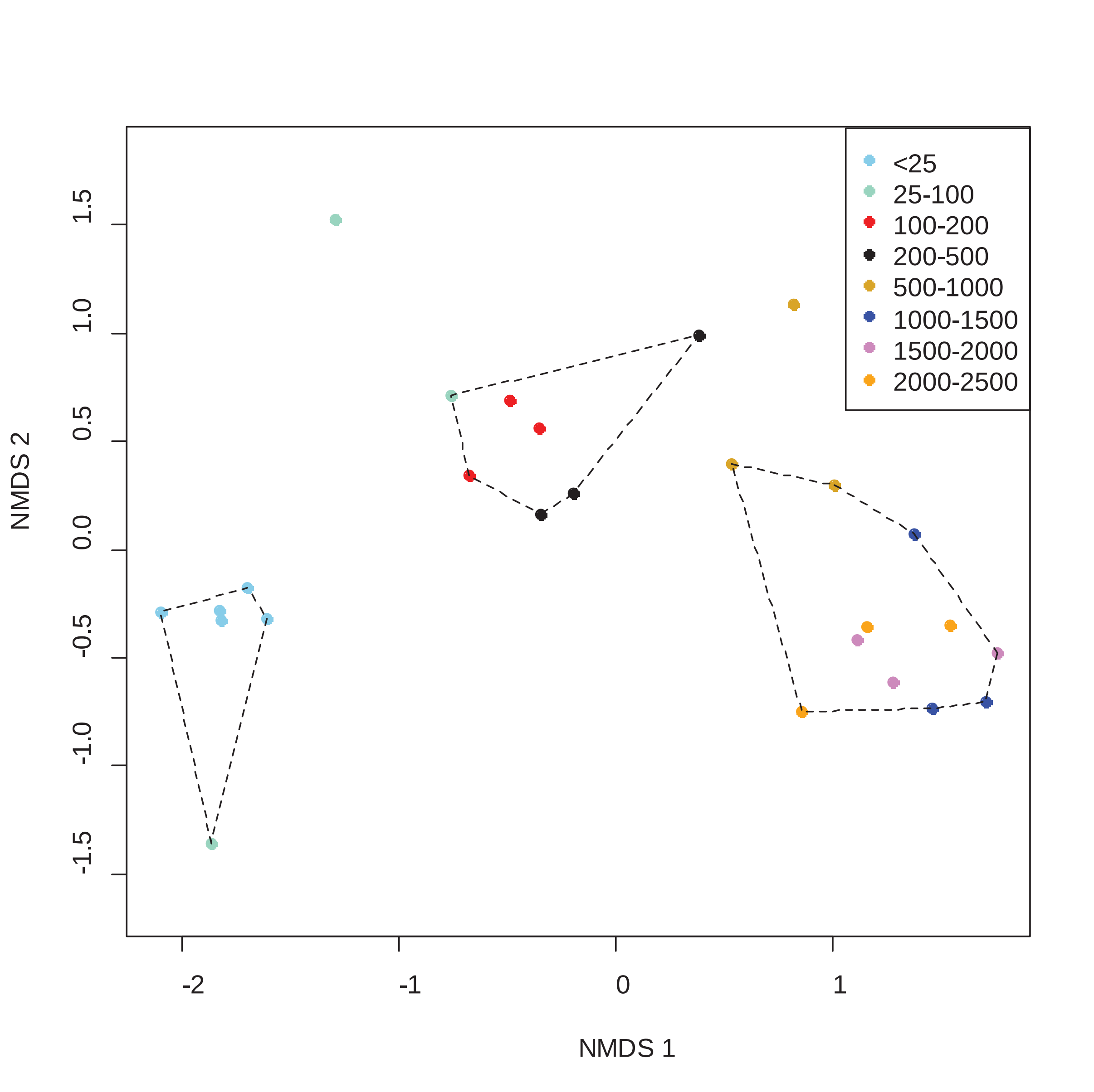


Figure 17. Ordination plot of samples from the Nearshore Area and Pipeline Area depth strata. Dashed line polygons envelope sample groups.

Table 13. Taxa with significant ($p<0.05$) indicator species values for the five station groups (All samples sieved with 0.5 mm screen mesh).

Phylum	Taxon	1	2	3	4	5	P-Value
Malacostraca	*Harpinia* sp. 1 EcoA	0.88	--	--	--	--	0.001
Caudofoveata	*Prochaetoderma* sp.	0.86	--	--	--	--	0.001
Malacostraca	*Collettea* sp.	0.82	--	--	--	--	0.039
Malacostraca	Desmosomatidae	0.82	--	--	--	--	0.002
Malacostraca	*Paranarthrura* sp.	0.82	--	--	--	--	0.002
Scaphopoda	Dentaliida	0.75	--	--	--	--	0.023
Malacostraca	*Pseudotanais* sp.	0.73	--	--	--	--	0.028
Polychaeta	*Mediomastus* sp.	--	0.93	--	--	--	0.049
Malacostraca	Gammaridea	--	0.85	--	--	--	0.041
Malacostraca	Nannastacidae	--	0.72	--	--	--	0.022
Polychaeta	*Ceratocephale* sp.	--	0.72	--	--	--	0.001
Polychaeta	*Ninoe* sp.	--	0.62	--	--	--	0.002
Polychaeta	*Lysippe* sp.	--	--	1.00	--	--	0.001
Polychaeta	*Ampharete* sp.	--	--	0.87	--	--	0.001
Polychaeta	*Chone* sp.	--	--	0.86	--	--	0.041
Polychaeta	*Eunice* sp.	--	--	0.86	--	--	0.021
Polychaeta	*Exogone* sp.	--	--	0.86	--	--	0.001
Polychaeta	*Monticellina* sp.	--	--	0.76	--	--	0.002
Polychaeta	*Aricidea* sp.	--	--	0.75	--	--	0.001
Sipuncula	*Nephasoma* sp.	--	--	0.73	--	--	0.006
Polychaeta	*Levinsenia* sp.	--	--	0.71	--	--	0.012
Polychaeta	Cirratulidae	--	--	0.65	--	--	0.031
Polychaeta	*Cirrophorus* sp.	--	--	0.64	--	--	0.003
Malacostraca	*Apseudopsis* sp.	--	--	--	0.97	--	0.007
Gastropod	Cephalaspidea	--	--	--	0.88	--	0.007
Bivalvia	Bivalvia	--	--	--	0.76	--	0.026
Polychaeta	*Lysippe bipennata*	--	--	--	--	1.00	0.001
Polychaeta	Sternaspidae	--	--	--	--	0.95	0.001
Bivalvia	*Pitar* sp.	--	--	--	--	0.94	0.001
Polychaeta	*Scoloplos* sp.	--	--	--	--	0.93	0.001
Polychaeta	*Glycinde kameruniana*	--	--	--	--	0.83	0.037
Malacostraca	*Ogyrides rarispina*	--	--	--	--	0.83	0.016
Mollusca	*Diplodonta* sp.	--	--	--	--	0.83	0.047
Mollusca	*Nassarius elatus*	--	--	--	--	0.83	0.039
Polychaeta	*Oxydromus* sp.	--	--	--	--	0.75	0.002
Polychaeta	*Sigambra* sp.	--	--	--	--	0.72	0.043

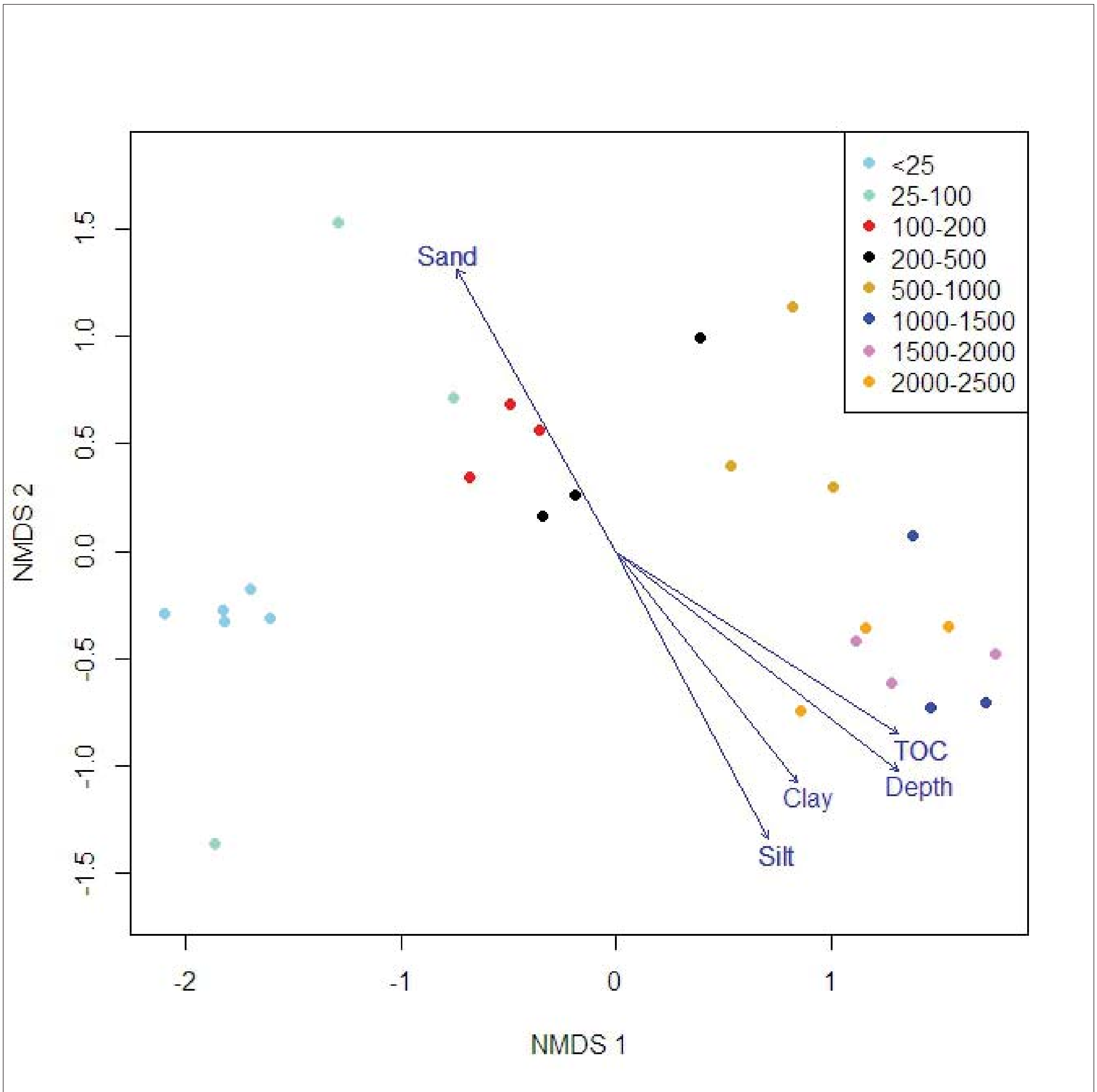


Figure 18. Relationships between environmental variables and the ordination axes shown by biplot arrows.

Offshore Area

Five samples from the Offshore Area were sieved with a 0.3 mm screen mesh. These samples yielded a total of 1,274 individuals and 100 taxa from eight phyla. Densities of infauna within the Offshore Area ranged from 1,559 to 2,441individuals m^{-2}.

Diversity indices and summary statistics are provided in **Table 14**. Means for H' suggest a diverse assemblage with most species present in low numbers and no numerical dominance. Evenness (J') was also relatively high affirming the equitable distribution of individuals among taxa. As with the 0.5 mm samples, major classes were polychaetes, malacostracans, and bivalves. Polychaetes contributed about 12% more to the total abundance than arthropods and about 30% more than mollusks (**Figure 19**).

Table 14. Diversity indices for the Offshore Area (samples sieved with 0.3 mm screen mesh).

Index	Value
S	100
N	1,274
J'	0.826
H'	3.77
N_2	27.5

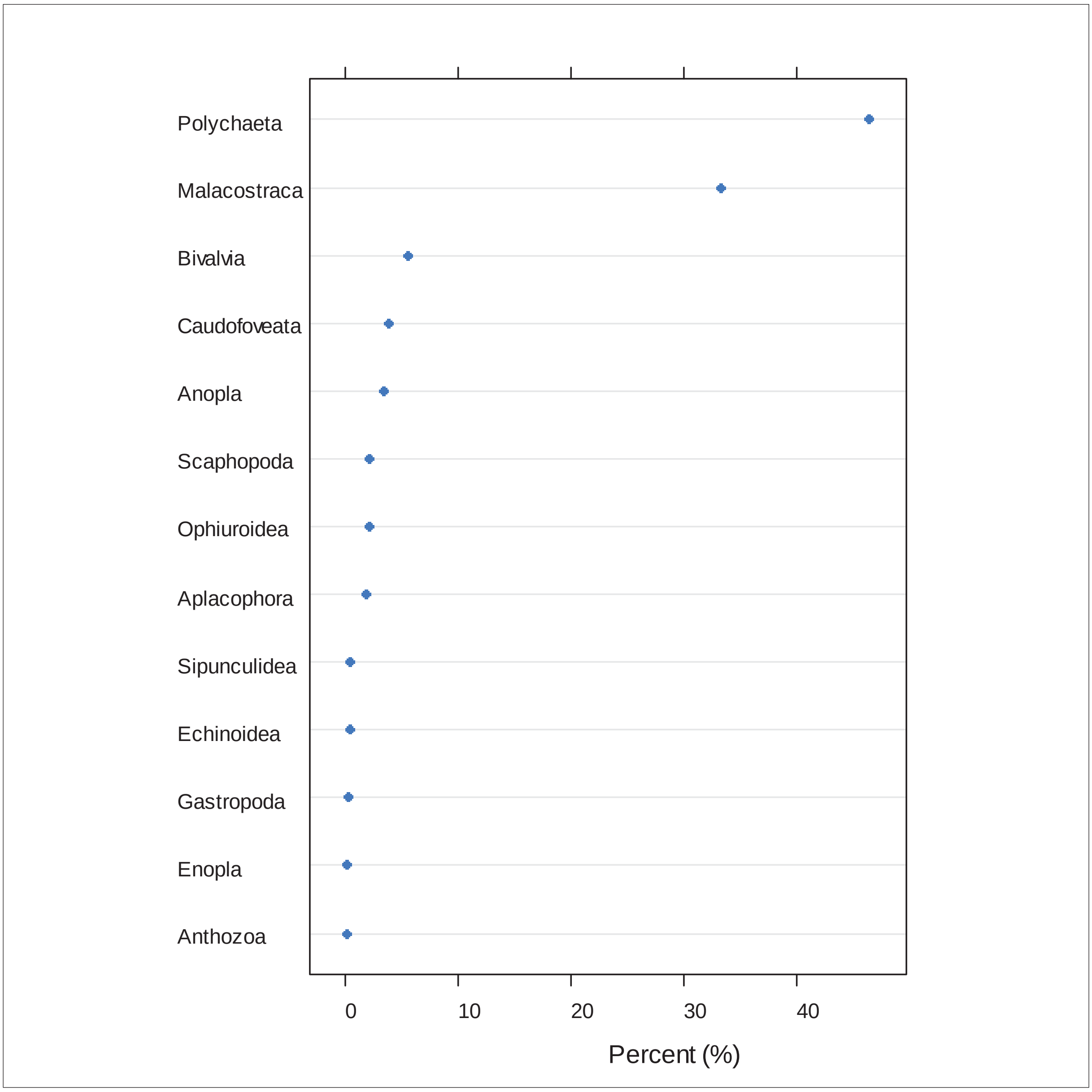


Figure 19. Percent abundance contributed by phylogenetic class in the Offshore Area samples.

The top ten most abundant taxa (**Table 15**) accounted for just over 50% of the overall abundance (1,274 individuals). Individual taxa from this list which were also common in the 0.5 mm samples included the polychaetes *Prionospio* sp., *Aricidea* sp., and Cirratulidae. The arthropod *Leptognathiella* sp. was the only taxon listed that was not recorded in the 0.5 mm samples. Overall these samples were most similar in taxonomic composition to samples collected from the deepest depth strata within the Pipeline Area (1,500-2,000 and 2,000-2,500 m).

Table 15. Top ten most abundant taxa collected from the Offshore Area (n=5) and sieved with 0.3 mm screen mesh.

Phylum	Taxon	N	Percent	Cumulative Percent
Polychaeta	*Prionospio* sp.	115	9.0	9.0
Malacostraca	Paratanaoidea	111	8.7	17.7
Polychaeta	*Aricidea* sp.	68	5.3	23.1
Polychaeta	*Cirrophorus* sp.	66	5.2	28.3
Polychaeta	*Abyssoninoe* sp.	63	4.9	33.2
Malacostraca	*Leptognathiella* sp.	55	4.3	37.5
Malacostraca	*Pseudotanais* sp.	44	3.5	41.0
Anopla	Tubulanidae	43	3.4	44.3
Caudofoveata	*Niteomica* sp.	42	3.3	47.6
Polychaeta	Cirratulidae	41	3.2	50.9

The diversity, abundance, and taxonomic composition revealed by the analysis of infauna assemblages from the Nearshore Area, Pipeline Area, and Offshore Area were broadly similar to patterns observed for the region (Thiel et al., 1982; Duinveld et al., 1990; Le Leouff and von Cosel, 1998; Dabi, 2015; CSA, 2016). The proportional abundance of polychaetes, crustaceans, bivalves, and gastropods in the samples reflects the general pattern phylogenetic pattern found off West Africa and other shelf-slope areas with similar substrates and water depths (Thiel et al., 1982; Duinveld et al., 1990; Le Leouff and von Cosel, 1998; Michel et al., 2011). The aforementioned studies pertain primarily to coastal and shelf waters (<200 m); very little is known about the regional infauna in deeper water depths of the Pipeline Area and Offshore Area.

3.4 ICHTHYOPLANKTON

Nearshore Area

Twelve samples from the nearshore area yielded 110 individuals from 32 fish taxa in 20 families and nine orders (**Table 16**). The locations of the ichthyoplankton sampling in the Nearshore Area are shown in **Figure 20**. The most species-rich orders were the perch-like fishes (Perciformes) and the flatfishes (Pleuronectiformes) represented by eleven and nine taxa, respectively. Individual taxa contributing most to the total larval density at the nearshore location included croakers and drums (Sciaenidae) (29.1 %), sardines (*Sardinella* spp.) (7.5%), horse mackerels (*Trachurus* spp.) (7.2%), sea basses (Serranidae) (4.6%), and codlets (*Bregmaceros cantori*) (4.6%).

Numbers of larvae per 100 m^3 ranged from 1.7 to 113.5 and averaged 35.7. The highest numbers of larvae were collected at night from both 0-10 and 10-20 m depth strata **Table 17**. Mean numbers of larvae per 100 m^3 were higher in the 0-10 m stratum during both day and night sample periods. Day/Night and depth stratum or their interaction were not significantly different (two-way analysis of variance, F= p>0.05) (**Table 18**). The number of fish eggs in the samples from the nearshore area ranged from 0 to 100 eggs per cubic meter (expressed as number [n] 100 m^{-3}) and averaged 22.3 eggs 100 m^{-3} (**Table 17**). Egg densities were significantly higher in the 0-10 m depth stratum (**Table 19**).

Table 16. Phylogenetic listing of larval fish taxa collected at the Nearshore Area. Numbers are densities (n 100 m^{-3}).

Order	Family	Taxon	Depth Strata				Grand Mean
			0-10 m		10-20 m		
			Day	Night	Day	Night	
Anguilliformes	Muraenidae (Moray eels)	Muraenidae	0	0.8	0	0	0.20
Elopiformes	Elopidae (Tarpons)	*Elops*	0	0	0	1.1	0.28
Aulopiformes	Synodontidae (Lizardfishes)	*Saurida*	0	0.7	0	0	0.18
Clupeiformes	Clupeidae (Herrings)	Clupeidae	0	5.8	0	1.0	1.70
		Sardinella	10.1	0.7	0	1.9	3.18
		Sardinella aurita	0	3.9	0	1.1	1.25
	Engraulidae (Engraulidae)	*Engraulis encrasicolus*	1.9	0.8	0	2.3	1.25
		Clupeiformes	4.3	0	4.4	0	2.18
Gadiformes	Bregmacerotidae (Codlets)	*Bregmaceros cantori*	4.0	0	0	0	1.00
Myctophiformes	Myctophidae (Lanternfishes)	*Diaphus*	0.9	0	0	0	0.23
Perciformes	Ephippidae (Spadefishes)	Ephippidae	0	0.7	0	0	0.18
	Gobiidae (Gobies)	Gobiidae	0.8	4.0	1.5	3.0	2.33
	Haemulidae (Grunts)	Haemulidae	1.9	0	0	2.8	1.18
		Perciformes	3.4	1.7	4.4	0	2.38
	Labridae (Wrasses and parrotfishes)	Labridae	2.6	2.5	1.7	1.2	2.00
		Sciaenidae	4.6	42.2	23.5	32.8	25.78
		Umbrina	0	0.8	0	0.9	0.43
	Serranidae (Seabasses)	Serranidae	0	4.1	0	0	1.03
	Sparidae (Porgies)	Sparidae	0.6	0	0	0	0.15
	Trachinidae (Weaverfishes)	Trachinidae	0	0	0	1.1	0.28
	Carangidae (Jacks and scads)	*Trachurus*	6.4	0	0	0	1.60

Table 16. (Continued).

Order	Family	Taxon	Depth Strata				Grand Mean
			0-10 m		10-20 m		
			Day	Night	Day	Night	
Pleuronectiformes	Bothidae (Lefteye flounders)	*Monolene*	0.6	0	0	0	0.15
	Cynoglossidae (Tonguefishes)	Cynoglossidae	1.6	2.0	0	0.9	1.13
		Cynoglossus monodi	0.8	0	0	0	0.20
		Symphurus	1.9	0	0	0	0.48
	Paralichthyidae (Sand flounders)	*Citharichthys*	0.8	0	0	0	0.20
		Paralichthyidae	1.2	0	2.9	0	1.03
		Syacium papillosum	0	0	0	1.2	0.30
		Pleuronectiformes	0.8	0	0	1.2	0.50
	Pleuronectidae (Righteye flounder)	Pleuronectidae	0	3.3	1.5	1.1	1.48
		Unidentified	0	0	0	1.7	0.43
Lampridiformes	Lophotidae (Crestfishes)	Lophotidae	0	0.8	0	0	0.20

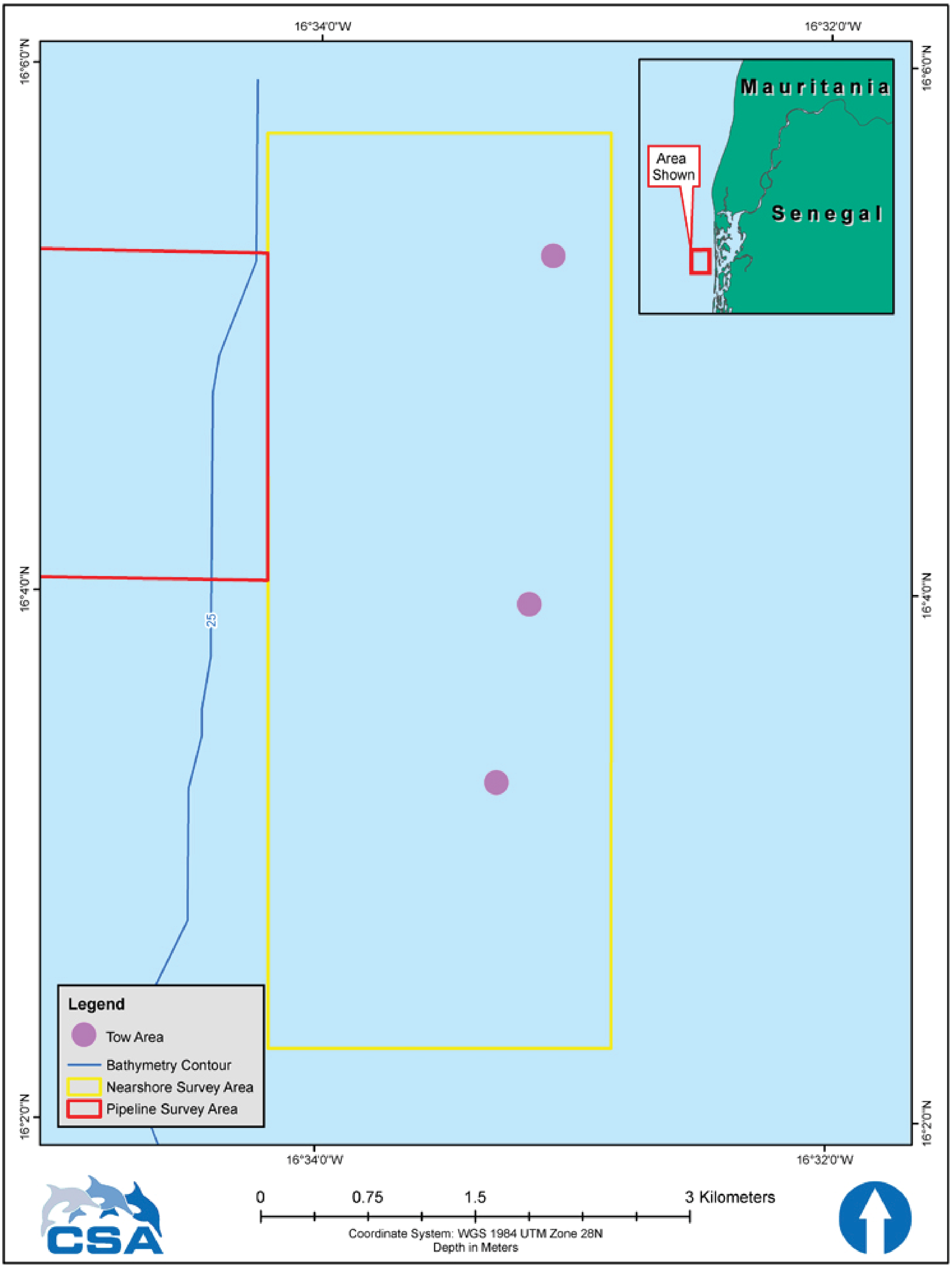


Figure 20. Locations of plankton sampling stations (i.e., tow area) within the Nearshore Area.

Table 17. Means and standard deviations (SD) for total fish larva and egg densities (n 100 m^{-3}) collected at the Nearshore Area.

Time	Stratum (m)	Larvae		Eggs	
		Mean	SD	Mean	SD
Day	0-10	28.4	19.0	68.1	49.5
Day	10-20	20.7	17.2	2.6	3.3
Night	0-10	54.7	52.7	16.1	15.5
Night	10-20	39.0	19.0	2.2	3.1

SD = standard deviation.

Table 18. Results of two way analysis of variance for density of fish larvae collected at the Nearshore Area.

Parameter	Degrees of Freedom	F-value	p-value
Time	1	1.6	0.25
Depth Stratum	1	0.4	0.53
Time x Depth Stratum	1	0.05	0.83
Residuals	8	-	-

Table 19. Results of two way analysis of variance for density of fish larvae collected at the nearshore area. Significant results are in **bold**.

Parameter	Degrees of Freedom	F-value	p-value
Time	1	3.0	0.12
Depth Stratum	1	**6.9**	**0.03**
Time x Depth Stratum	1	2.9	0.12
Residuals	8	--	--

The taxonomic composition and abundance of larval fishes taken at the Nearshore Area was dominated numerically by the larvae of soft bottom species which collectively contributed about 50% of the numbers of larvae collected. Soft bottom species were represented by Sciaenidae (drums, croakers, and seatrouts), Paralichthyidae (sand flounders), Sparidae (porgies), and Aulopiformes (lizardfishes). The coastal pelagic species (herrings, sardines, anchovies, jack mackerels) contributed an additional 16% of the larvae collected.

Offshore Area

Samples from the Offshore Area produced 34 taxa from 17 families and eight orders (**Table 20**). The locations of the ichthyoplankton sampling in the Offshore Area are shown in **Figure 21**. The most abundant family was the lanternfishes (Myctophidae) accounting for 48% of the mean density. Four lanternfish taxa *Myctophum affine*, *Myctophum nitidulum*, *Diaphus* sp., and *Hygophum macrochir* accounted for 35% of the total abundance.

Table 20. Phylogenetic listing of larval fish taxa collected at the Offshore Area. Numbers are densities (n*100 m^{-3}).

Order	Family	Taxon	Depth Strata				Grand Mean
			0-15 m		15-30 m		
			Day	Night	Day	Night	
Beloniformes	Exocoetidae (Flyingfishes)	Exocoetidae	0	0	0	0.89	0.22
	Hemiramphidae (Halfbeaks)	*Hemiramphidae*	0	0	0	0.89	0.22
Gadiformes	Gadidae (Cods)	Gadidae	0	1.64	0	0	0.41
		Gadiformes	0	1.59	0	0	0.40
	Myctophidae (Lanternfishes)	*Diaphus*	11.23	17.75	2.86	4.92	9.19
		Hygophum	1.73	0	0	0	0.43
		Hygophum macrochir	0	0	2.03	4.26	1.57
		Lampanyctus	0	1.22	0	1.52	0.69
		Myctophidae	0.87	3.27	0	1.80	1.49
		Myctophum	0	0	2.86	0	0.72
		Myctophum nitidulum	0	0	2.03	10.64	3.17
		Myctophum affine	8.46	0	0	0	2.12
		Nanobrachium	0	0	0	0.89	0.22
		Notoscopelus	0	1.59	2.00	0	0.90
Perciformes	Gempylidae (Snake mackerels)	*Gempylus*	0	1.64	0	0	0.41
	Gobiidae (Gobies)	Gobiidae	0	1.22	2.00	0.90	1.03
	Nomeidae (Driftfishes)	*Cubiceps*	0.87	0	1.02	1.78	0.92
		Perciformes	1.73	0	1.02	0	0.69
	Labridae (Wrasses)	Labridae	0.87	0	0	0	0.22
	Trichiuridae (Cutlassfishes)	*Lepidopus*	0	0	0	1.06	0.27
Pleuronectiformes	Bothidae (Lefteye flounders)	Bothidae	0	0	0	0.90	0.23
		Bothus	0	3.25	0	0	0.81

Table 20. (Continued).

Order	Family	Taxon	Depth Strata				Grand Mean
			0-15 m		15-30 m		
			Day	Night	Day	Night	
Stomiiformes	Gonostomatidae (Bristlemouths)	*Cyclothone*	4.23	1.41	0	2.68	2.08
		Diplophos taenia	0	1.22	0	0	0.31
		Gonostomatidae	0	0	1.02	0	0.26
		Stomiiformes	0	0	0	0.98	0.25
	Melanastomiidae (Black dragonfishes)	Melanastomiidae	0	0	2.75	0	0.69
	Stomiidae (Dragonfishes)	*Stomias*	0	0	2.00	0	0.50
	Phosichthyidae (Lightfishes)	*Vinciguerria*	3.77	4.07	1.02	1.87	2.68
		Vinciguerria nimbaria	0	3.67	0	6.24	2.48
Anguilliforms	Muraenidae (Morary eels)	Muraenidae	0	0	0	0.98	0.25
Aulopiformes	Paralepididae	Paralepididae	0	0	0	2.13	0.53
Scorpaeniformes	Scorpaenidae (Scorpionfishes)	*Scorpaena*	0	0	2.00	0	0.67
Unidentified	Unidentified	Unidentified	2.00	1.88	1.22	0.89	1.50

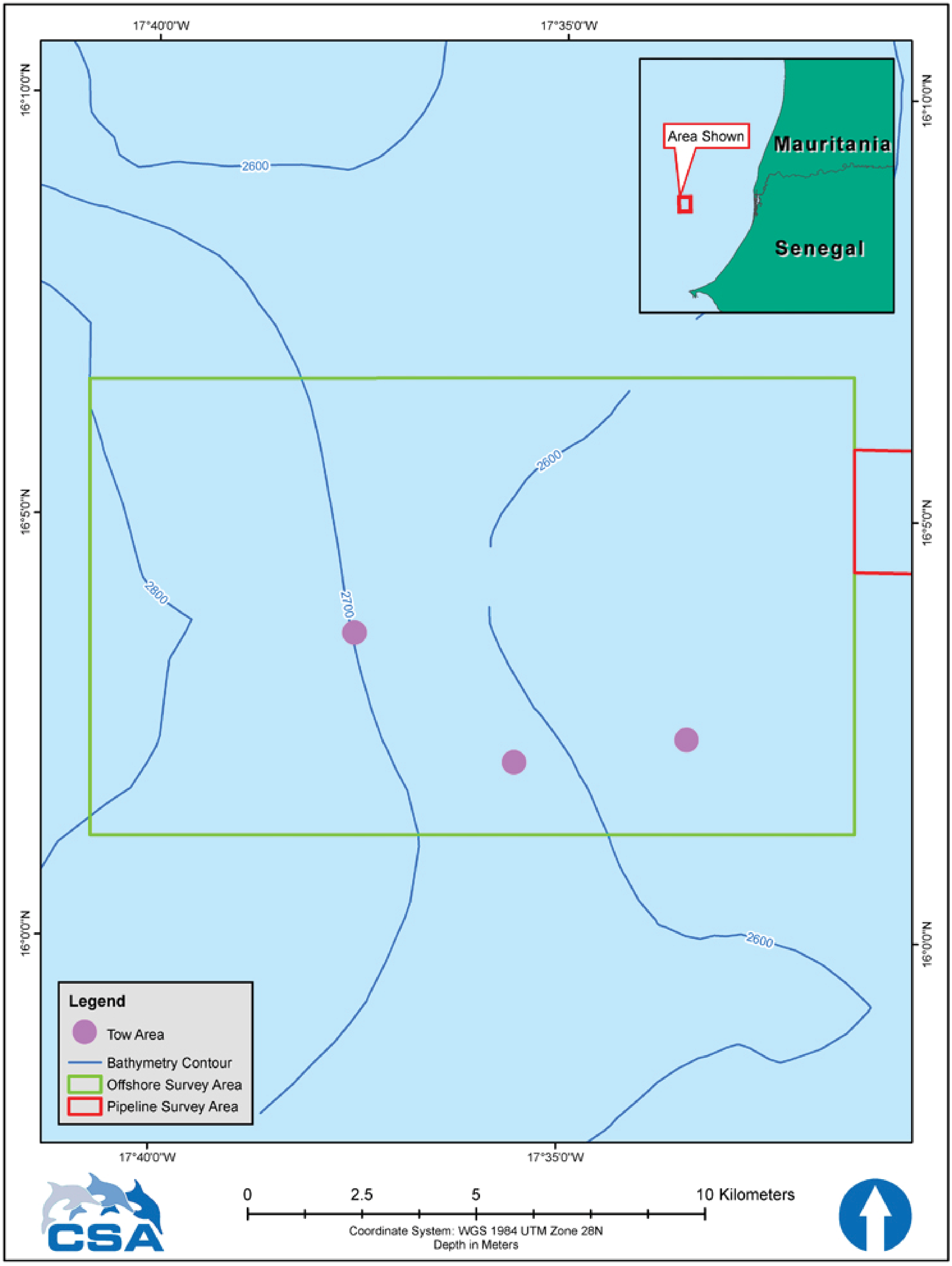


Figure 21. Locations of plankton sampling stations (i.e., tow area) within the Offshore Area.

Members of the mesopelagic group typically migrate from deep waters towards the surface at night. Lanternfishes and bristlemouths numerically dominate midwater assemblages worldwide. Most (60%) of the taxa collected at the offshore site could be classified as mesopelagic. The oceanic pelagic group includes tunas and billfishes, dolphinfishes, but from this group the only halfbeaks and flying fishes were collected.

Samples from the offshore location yielded higher larval densities in the night samples from both depth strata (**Table 21**). The upper stratum (0-15 m) produced the higher numbers than the lower stratum (15 to 30 m). However, larval density did not differ significantly among the depth strata, day vs night or their interaction (**Table 22**). The density of fish eggs collected at the offshore area averaged 5.8 and ranged from 0 to 19.6 eggs 100 m^{-3}. Two way analysis of variance found egg density differed significantly between the 0-15 m and the 15-30 m strata (**Table 23**).

Table 21. Means and standard deviations (SD) for total fish larva and egg densities (n 100 m^{-3}) collected at the Offshore Area.

Time	Stratum (m)	Larvae		Eggs	
		Mean	SD	Mean	SD
Day	0-15	21.9	21.4	9.4	2.7
Day	15-20	9.9	2.9	1.2	1.1
Night	0-15	31.1	8.5	11.4	9.1
Night	15-20	19.4	8.3	1.2	2.1

SD = standard deviation.

Table 22. Results of two way analysis of variance for density of fish larvae collected at the Offshore Area.

Parameter	Degrees of Freedom	F-value	p-value
Time	1	1.7	0.223
Depth Stratum	1	2.8	0.133
Time × Depth Stratum	1	0.0	0.984
Residuals	8	--	--

Table 23. Results of two way analysis of variance for density of fish eggs collected at the Offshore Area. Significant ($p<0.5$) results are in **bold**.

Parameter	Degrees of Freedom	F-value	p-value
Time	1	0.1	0.724
Depth	1	**10.7**	**0.011**
Time × Depth Stratum	1	0.1	0.732
Residuals	8	--	--

The larval fish assemblages sampled at Nearshore and Offshore Areas were composed of species expected for the local environmental conditions at each area. Others have reported similar taxa from surveys in the region (Jimenez et al., 2014; Arkhipov et al., 2015). Nearshore Area samples were represented primarily by larvae of soft bottom species that inhabit the adjacent shelf and coastal waters. Coastal pelagic species were also frequently collected at the Nearshore Area. Both soft bottom and coastal pelagic species area important to the local and regional fisheries. Lack of a significant effect of depth stratum suggests that the water column was well mixed at the time of sampling. Significantly higher numbers of fish eggs in the upper water column is expected as the eggs are generally buoyant and will accumulate in the upper layers until hatching and transformation into larvae is complete.

The Offshore Area samples were dominated by lanternfishes – the main component of vertically migrating mesopelagic fish assemblages worldwide. No larvae of oceanic species such as tunas, billfishes, or dolphinfishes were collected at the sites. The taxonomic composition of the samples generally agreed with other findings from similar water depths in the region (e.g., Hanel et al., 2010). As with the Nearshore Area, egg numbers were higher in the upper water column presumably due to their buoyancy.

4.0 References

Arkhipov, A.G., A.A. Mamedov, T.A. Simonova, and V.N. Shnar. 2015. Species composition and features of ichthyoplankton distribution in the waters of Senegal and Guinea-Bissau. Journal of Ichthyology 55(3):346–354.

Bray, J.R. and J.T. Curtis. 1957. An ordination of the upland forest communities of southern Wisconsin. Ecol. Monogr. 27(4):325-349.

Buchman, M.F. 2008. Screening quick reference tables. NOAA OR&R Report 08-1. NOAA, Office of Response and Restoration, Seattle, WA. 34 pp.

Clarke, K.R. and R.N. Gorely. 2006. PRIMER version 6 User manual/Tutorial. Primer-E Ltd: Plymouth, U.K. 190 pp.

CSA International Inc. 2011. Tweneboa, Enyenra, and Ntomme Final Environmental Baseline Survey. November 2011.

CSA Ocean Sciences Inc. 2013. Karish-1 Environmental Monitoring Program, Pre-Drilling Survey. Report prepared for Noble Energy International Ltd, April 2013. 46 pp. + apps.

CSA Ocean Sciences Inc. 2016. Jubilee Field Marine Environmental Monitoring Program, Initial Monitoring Survey. Report prepared for Tullow Ghana Limited, April 2016. 85 pp. + apps.

Dabi, M. 2015. Preliminary assessment of Benthic Infauna at Cape Three Points in the Western Region of Ghana. The International Journal of Science and Technoledge, 3(7), p.123.

Dufrene, M. and P. Legendre. 1997. Species assemblages and indicator species: the need for a flexible asymmetrical approach. Ecol. Monogr. 67(3):345-366.

Duineveld, G.C.A., P.A.W. J.de Wilde, E.M. Berghuis, and A. Kok. 1993. The benthic infauna and benthic respiration off the Banc d'Arguin (Mauritania, Northwest Africa). Hydrobiologia 258: 107-117.

Hanel, R., J. Hans-Christian, O. Meyer-Kaeden, and U. Piatkowski. 2010. Larval fish abundance, composition and distribution at Senghor Seamount (Cape Verde Islands). J. Plankton Research 32(11):1541-1556.

Herut, B. and A. Sandler. 2006. Normalization methods for pollutants in marine sediments: review and recommendations for the Mediterranean. Israel Oceanographic & Limnological Research and Geological Survey of Israel IOLR Report H, 18.

Jimenez, M.P., R. Sanchez-Leal, C. Gonzalez, E. Garcia-Isarch, and A. Garcia. 2014. Oceanographic scenario and fish larval distribution off Guinea-Bissau (north-west Africa). Journal of the Marine Biological Association of the United Kingdom, 1-18.

Le Loeuff, P. and R. von Cosel. 1990. Biodiversity patterns of the benthic fauna on the Atlantic coast of tropical Africa in relation to hydroclimatic conditions and paleogeographic event. Acta Oceanologica. 309-321.

Long, E.R. and L.G. Morgan. 1990. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program. NOAA Tech. Memo. NOS OMA 52. U.S. National Oceanic and Atmospheric Administration, Seattle, WA. 175 pp.

Magurran, A.E. 2004. Measurement of biological diversity. Blackwell Publishing. 264 pp.

Michel, J., H. Westphal, and R. Von Cosel. 2011. The mollusk fauna of soft sediments from the tropical upwelling-influenced shelf of Mauritania (Northwestern Africa). Palaios 26:447-460.

Neff, J. 1997. Ecotoxicity of arsenic in the marine environment. Environmental Toxicology and Chemistry 16(5);917-927.

Oksanen, J., F.G. Blanchet, M. Friendly, R. Kindt, P. Legendre, D. McGlinn, P.R. Minchin, R.B. O'Hara, G.L. Simpson, P. Solymos, M.H. Stevens, E. Szoecs and H. Wagner. 2016. vegan: Community Ecology Package. R package version 2.4-1. https://CRAN.R-project.org/package=vegan.

Pampanin, D.M. and M.O. Sydnes. 2013. Polycyclic Aromatic Hydrocarbons a Constituent of Petroleum: Presence and Influence in the Aquatic Environment. In: Hydrocarbon. Kutcherov, V. and A. Kolesnikov (eds.). InTech. doi:5772/48176. Accessed 8 February 2016 at: http://www.intechopen.com/books/hydrocarbon/polycyclic-aromatic-hydrocarbons-a-constituent-of-petroleum-presence-and-influence-in-the-aquatic-en.

Roberts, D.W. 2016. labdsv: Ordination and Multivariate Analysis for Ecology. R package version 1.8-0. https://CRAN.R-project.org/package=labdsv.

Shepard, F.P. 1954. Nomenclature based on sand-silt-clay ratios: Journal of Sedimentary Petrology 24:151-158.

Theil, H. 1982. Zoobenthos of the CINECA area and other upwelling regions. Rapp. P.-v. Reun. Cons. Int. Explor. Mer, 180: 323-334.

Trefry, J.H., R.D. Rember, R.P. Trocine, and J.S. Brown. 2003. Trace metals in sediments near offshore oil exploration and production sites in the Alaskan Arctic. Environmental Geology 45:149–160.

Trefry, J.H., K.H. Dunton, R.P. Trocine, S.V. Schonberg, N.D. McTigue, E.S. Hersh, and T.J. McDonald. 2013. Chemical and biological assessment of two offshore drilling sites in the Alaskan Arctic. Marine Environmental Research 86:35-45.

Tyson, R.V. 1995. Sedimentary Organic Matter: Organic facies and palynofacies. Torquay, Devon, England: Chapman and Hall.

U.S. Environmental Protection Agency. 2000. Guidance for Data Quality Assessment – Practical Methods for Data Analysis. EPA/600/R-96/084.

Appendices

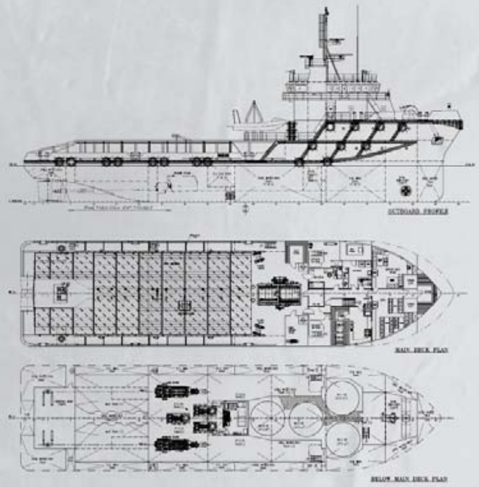
Appendix A

M/V *Acamar* Specification Sheet

GO MARINE GROUP

GO ACAMAR
DP1 AHTS

General Arrangement



Key Features

- DP1
- 5,150 HP
- 315 SQM Deck Space
- 550 T Max Deck Cargo

GO ACAMAR
DP1 AHTS

Class Notation	✠A1, Towing Vessel, Fire-Fighting Vessel Class 1, Offshore Support vessel AH, E,✠ AMS, DPS 1
Place of Build	WEIHAI XINGHAI SHIPYARD
Year of Build	2009
Flag	Belize

Main Particulars	
Design	Conan WV
LOA	57.5 m
Breadth	13.8 m
Depth	5.5 m
Max Loaded Draft	4.79 m

Performance	
Max Speed	13 knots – 19 m3/24hrs
Economical Speed	10 knots – 12 m3/24hrs
Bollard Pull	65 t

Capacities	
Deadweight	1,200 t
Gross Tonnage	1,373 t
Deck Cargo	550 t
Cargo Deck Dim.	30.6 m x 10.3 m
Deck Area	315 m2
Deck Strength	7 t / m2
Dry Bulk Capacities	4x 45m3
Drill / Ballast Water	373 m3
Potable Water	200 m3
Oil Based Mud	n/a
Brine	n/a
Base Oil	n/a
Fuel Oil	603 m3
Freezer Room	10 m3
Cooler Room	10 m3

Deck Equipment	
Capstans	2 x 5 mt @ 0 - 15m/min electro-hydraulic; Zicom / HCAP-5
Tugger Winch	2 x 10 mt @ 15m/min electro-hydraulic Sicom / HTUG - 10/20
Deck Crane	Palfinger 5 t @6 m
FRC	FRC/Davit Heave Comp

Anchoring Equipment	
Windlass	Hydraulic 9t @12 m/min

Dynamic Positioning System	
DP System	IMO Class DP1
References	2 x DGPS

Discharge	
Dry Bulk	2 x 20.5 m3/min
Fresh Water	1 x 75 m3/hr @ 60 m head
Ballast / Drill Water	2 x 60 m3/hr @ 45 m head
Liquid Mud / Brine	n/a
Base Oil	2 x 75 m3/hr
Fuel Oil	1 x 100 m3/hr @ 60 m head

Propulsion and Machinery	
BHP	5,150 bhp
Main Engines	2
Main Engines: Make / Type	Cat 3516B
Propellers	CPP in Kort Nozzles

Thruster	
Bow	650 hp, 6 t thrust
Stern	Nil
Azimuth	Nil

Auxiliary Engines	
Shaft Generator	n/a
Diesel Generator	2x320 kw @ 1800 rpm Caterpillar
Emergency Generators	1 x 74 kw @ 1800 rpm Caterpillar
Supply System - Voltage	440 V

Accommodation	
Single Berth Cabins	6 x 1
Double Berth Cabins	2 x 2
Four Berth Cabins	6 x 4
Total Accommodation	34 persons

Towing and Anchor Handling Winch	
AHT Winch	Electro Hyd. Double Drum
Line Pull	150t@0-2.5m/min@1st layer 30t@0-10m/min@1st layer 10t@0-40m/min@1st layer
Stall Pull	165 t @ 1st layer
Break Capacity	200 m static 1st layer
Towing Drum	1,000 m (L) x 52 mm (O) SWR
Anchor Handling Drum	1,000 m (L) x 52 mm (O) SWR
Speed	0-2.5m/min@150t 0-10m/min@30t 0-40m/min@10t
Shark Jaw	300 t
Towing Pin	2x elec/hyd. W turntable flap SWL160t
Spare Wire Reel	1,000 m (L) x 53 mm (O) SWL
Stern Roller	3.5 m (L) x 1.6 m (O) SWL 300 t

Head Office
Suite 1, Level 4 South Shore Centre
85 The Esplanade, SOUTH PERTH WA 6151

w: www.gomarinegroup.com.au
e: info@gomarinegroup.com.au
p: +61 8 9474 3600

GO MARINE GROUP

Appendix B

Sampling Station Locations

Table B-1. Sediment sampling stations.

Station	Date	Time	X (UTM)	Y (UTM)	Latitude (DMS) N	Longitude (DMS) W	Depth (m)	Depth Strata (m)	Type
NA-1	11/28/2016	22:11:20	333,447.29	1,779,388.04	16°05'19.77"	16°33'25.98"	23	<25	Sediment
NA-2	11/28/2016	21:27:15	332,992.09	1,777,873.92	16°04'30.40"	16°33'40.91"	23	<25	Sediment
NA-3	11/28/2016	20:48:41	333,602.43	1,777,229.56	16°04'09.58"	16°33'20.21"	22	<25	Sediment
NA-4	11/28/2016	20:11:29	333,663.47	1,775,793.55	16°03'22.88"	16°33'17.80"	21	<25	Sediment
NA-5	11/28/2016	19:36:28	333,042.62	1,774,746.22	16°02'48.66"	16°33'38.42"	22	<25	Sediment
PA-1	11/29/2016	12:25:58	322,512.03	1,777,802.84	16°04'25.43"	16°39'33.51"	51	25 to 100	Sediment
PA-2	11/29/2016	13:45:27	313,641.18	1,777,992.73	16°04'29.24"	16°44'32.02"	79	25 to 100	Sediment
PA-3	11/29/2016	14:42:46	305,845.73	1,778,498.40	16°04'43.50"	16°48'54.44"	96	25 to 100	Sediment
PA-4	11/29/2016	17:07:12	297,556.67	1,779,160.22	16°05'02.61"	16°53'33.51"	135	100 to 200	Sediment
PA-5	11/29/2016	18:50:22	299,856.53	1,778,626.75	16°04'45.94"	16°52'15.98"	119	100 to 200	Sediment
PA-6	11/29/2016	19:30:25	298,125.62	1,778,680.19	16°04'47.17"	16°53'14.23"	126	100 to 200	Sediment
PA-7	11/29/2016	22:22:24	293,484.64	1,778,546.46	16°04'41.43"	16°55'50.32"	240	200 to 500	Sediment
PA-8	11/29/2016	22:58:56	292,239.13	1,778,707.18	16°04'46.27"	16°56'32.27"	290	200 to 500	Sediment
PA-9	11/29/2016	23:57:30	289,011.30	1,779,009.72	16°04'55.12"	16°58'20.95"	415	200 to 500	Sediment
PA-10	11/30/2016	1:01:06	286,161.88	1,779,182.29	16°04'59.84"	16°59'56.86"	500	500 to 1,000	Sediment
PA-11	11/30/2016	1:52:10	284,186.51	1,778,913.52	16°04'50.48"	17°01'03.23"	600	500 to 1,000	Sediment
PA-12	11/30/2016	3:04:15	280,348.41	1,778,729.33	16°04'43.26"	17°03'12.28"	850	500 to 1,000	Sediment
PA-13	11/30/2016	6:20:36	276,268.87	1,778,787.58	16°04'43.82"	17°05'29.53"	1120	1,000 to 1,500	Sediment
PA-14	11/30/2016	7:46:21	273,296.16	1,779,401.71	16°05'02.81"	17°07'09.74"	1300	1,000 to 1,500	Sediment
PA-15	11/30/2016	9:07:20	271,443.38	1,779,289.89	16°04'58.56"	17°08'12.02"	1400	1,000 to 1,500	Sediment
PA-16	11/30/2016	10:48:39	267,425.46	1,778,964.80	16°04'46.62"	17°10'27.06"	1600	1,500 to 2,000	Sediment
PA-17	11/30/2016	12:50:10	263,742.99	1,779,702.78	16°05'09.35"	17°12'31.19"	1780	1,500 to 2,000	Sediment
PA-18	11/30/2016	14:33:51	261,384.72	1,779,209.27	16°04'52.48"	17°13'50.33"	1880	1,500 to 2,000	Sediment
PA-19	11/30/2016	18:17:13	257,112.94	1,779,708.66	16°05'07.21"	17°16'14.20"	2080	2,000 to 2,500	Sediment
PA-20	11/30/2016	20:17:17	251,337.04	1,779,620.13	16°05'02.24"	17°19'28.44"	2250	2,000 to 2,500	Sediment
PA-21	11/30/2016	22:16:07	246,134.58	1,779,898.58	16°05'09.37"	17°22'23.52"	2370	2,000 to 2,500	Sediment
OA-1	12/1/2016	1:03:25	236,645.97	1,779,958.36	16°05'07.71"	17°27'42.66"	2530	>2,500	Sediment
OA-2	12/1/2016	19:36:59	220,053.95	1,781,112.89	16°05'38.61"	17°37'01.12"	2660	>2,500	Sediment
OA-3	12/1/2016	17:26:41	220,695.84	1,776,132.11	16°02'56.94"	17°36'37.42"	2660	>2,500	Sediment
OA-4	12/1/2016	15:15:35	224,865.83	1,776,791.73	16°03'20.09"	17°34'17.49"	2585	>2,500	Sediment
OA-5	12/1/2016	13:08:10	226,361.07	1,778,991.41	16°04'32.21"	17°33'28.13"	2580	>2,500	Sediment

XY Coordinate System: WGS84 UTM Zone 28N
Unit(s): Meters
Latitude-Longitude Coordinate Sytem: WGS84
Unit(s): Degrees, Minutes, Seconds.

Table B-2. Water column sampling stations.

Station	Date	Time	X (UTM)	Y (UTM)	Latitude (DMS) N	Longitude (DMS) W	Depth (m)	Depth Strata (m)	Type
NA-1	11/28/2016	23:09:22	334,068.12	1,779,236.09	16°05'14.98"	16°33'05.05"	20	<25	Water
NA-2	11/29/2016	0:12:21	333,894.45	1,776,842.47	16°03'57.06"	16°33'10.29"	21	<25	Water
NA-3	11/29/2016	1:01:14	333,647.83	1,775,788.45	16°03'22.71"	16°33'18.32"	21	<25	Water
PA-1	11/29/2016	20:17:47	298,126.74	1,778,679.83	16°04'47.16"	16°53'14.19"	126	100 to 200	Water
PA-2	11/30/2016	4:06:58	280,350.75	1,778,730.02	16°04'43.28"	17°03'12.20"	920	500 to 1,000	Water
PA-3	11/30/2016	15:50:19	261,383.35	1,779,217.30	16°04'52.74"	17°13'50.38"	1550	1,500 to 2,000	Water
OA-1	12/1/2016	20:53:02	220,053.25	1,781,112.90	16°05'38.61"	17°37'01.14"	2347	>2,500	Water

XY Coordinate System: WGS84 UTM Zone 28N
Unit(s): Meters
Latitude-Longitude Coordinate Sytem: WGS84
Unit(s): Degrees, Minutes, Seconds.

Table B-3. Ichthyoplankton sampling stations.

Station	Cycle	Date	Time	X (UTM)	Y (UTM)	Latitude (DMS) N	Longitude (DMS) W	Depth Strata
NA-1	Daytime start	11/29/2016	07:44:22.649	333,680.83	1,775,566.22	16°03'15.49"	16°33'17.15"	deep
NA-1	Daytime stop	11/29/2016	07:55:10.825	333,676.63	1,775,675.27	16°03'19.04"	16°33'17.32"	deep
NA-1	Daytime start	11/29/2016	08:09:48.716	333,680.38	1,775,578.84	16°03'15.90"	16°33'17.17"	shallow
NA-1	Daytime stop	11/29/2016	08:16:13.138	333,675.62	1,775,678.33	16°03'19.14"	16°33'17.36"	shallow
NA-2	Daytime start	11/29/2016	08:47:52.522	333,906.93	1,776,790.54	16°03'55.38"	16°33'09.86"	deep
NA-2	Daytime stop	11/29/2016	08:54:41.950	333,942.17	1,776,890.17	16°03'58.63"	16°33'08.70"	deep
NA-2	Daytime start	11/29/2016	09:08:04.779	333,914.18	1,776,788.72	16°03'55.32"	16°33'09.61"	shallow
NA-2	Daytime stop	11/29/2016	09:13:43.154	333,939.65	1,776,869.38	16°03'57.95"	16°33'08.78"	shallow
NA-3	Daytime start	11/29/2016	09:53:22.855	334,065.71	1,779,214.29	16°05'14.27"	16°33'05.13"	deep
NA-3	Daytime stop	11/29/2016	10:01:37.156	334,064.63	1,779,338.80	16°05'18.32"	16°33'05.19"	deep
NA-3	Daytime start	11/29/2016	10:25:24.635	334,073.41	1,779,226.84	16°05'14.68"	16°33'04.87"	shallow
NA-3	Daytime stop	11/29/2016	10:31:16.607	334,072.35	1,779,315.97	16°05'17.58"	16°33'04.93"	shallow
NA-1	Night start	11/29/2016	05:51:59.028	333,684.64	1,775,559.89	16°03'15.28"	16°33'17.02"	deep
NA-1	Night stop	11/29/2016	05:59:07.848	333,679.00	1,775,663.94	16°03'18.67"	16°33'17.24"	deep
NA-1	Night start	11/29/2016	02:08:15.356	333,679.61	1,775,592.05	16°03'16.33"	16°33'17.20"	shallow
NA-1	Night stop	11/29/2016	02:12:41.170	333,670.87	1,775,658.20	16°03'18.48"	16°33'17.51"	shallow
NA-2	Night start	11/29/2016	05:14:46.871	333,904.48	1,776,769.58	16°03'54.69"	16°33'09.93"	deep
NA-2	Night stop	11/29/2016	05:22:09.466	333,898.85	1,776,889.16	16°03'58.58"	16°33'10.15"	deep
NA-2	Night start	11/29/2016	02:47:48.039	333,903.97	1,776,817.85	16°03'56.26"	16°33'09.96"	shallow
NA-2	Night stop	11/29/2016	02:57:13.072	333,903.52	1,776,953.70	16°04'00.68"	16°33'10.01"	shallow
NA-3	Night start	11/29/2016	04:05:18.263	334,070.16	1,779,252.79	16°05'15.52"	16°33'04.99"	deep
NA-3	Night stop	11/29/2016	04:12:34.528	334,055.74	1,779,373.60	16°05'19.45"	16°33'05.50"	deep
NA-3	Night start	11/29/2016	03:33:47.060	334,077.00	1,779,216.89	16°05'14.35"	16°33'04.75"	shallow
NA-3	Night stop	11/29/2016	03:39:31.279	334,066.81	1,779,290.95	16°05'16.76"	16°33'05.11"	shallow
OA-1	Daytime start	12/1/2016	10:08:27.184	219,059.12	1,777,358.99	16°03'36.16"	17°37'32.97"	shallow
OA-1	Daytime stop	12/1/2016	10:13:55.538	219,098.11	1,777,433.18	16°03'38.59"	17°37'31.69"	shallow
OA-1	Daytime start	12/1/2016	10:26:17.008	219,061.76	1,777,365.82	16°03'36.38"	17°37'32.88"	deep
OA-1	Daytime stop	12/1/2016	10:31:57.824	219,100.27	1,777,442.67	16°03'38.90"	17°37'31.62"	deep
OA-2	Daytime start	12/1/2016	09:23:37.980	222,570.17	1,774,567.62	16°02'06.85"	17°35'33.74"	deep
OA-2	Daytime stop	12/1/2016	09:28:42.637	222,595.68	1,774,640.98	16°02'09.24"	17°35'32.92"	deep
OA-2	Daytime start	12/1/2016	09:04:09.044	222,564.18	1,774,542.05	16°02'06.01"	17°35'33.93"	shallow
OA-2	Daytime stop	12/1/2016	09:10:16.178	222,589.23	1,774,631.58	16°02'08.93"	17°35'33.13"	shallow

Table B-3. (Continued).

Station	Cycle	Date	Time	X (UTM)	Y (UTM)	Latitude (DMS) N	Longitude (DMS) W	Depth Strata
OA-3	Daytime start	12/1/2016	08:16:21.873	226,347.97	1,774,984.53	16°02’21.93”	17°33’26.91”	deep
OA-3	Daytime stop	12/1/2016	08:22:20.105	226,371.92	1,775,072.42	16°02’24.79”	17°33’26.14”	deep
OA-3	Daytime start	12/1/2016	07:54:30.403	226,340.79	1,774,975.23	16°02’21.62”	17°33’27.15”	shallow
OA-3	Daytime stop	12/1/2016	08:00:15.923	226,365.09	1,775,055.26	16°02’24.23”	17°33’26.36”	shallow
OA-1	Night start	12/1/2016	03:42:03.597	219,068.06	1,777,360.15	16°03’36.20”	17°37’32.67”	deep
OA-1	Night stop	12/1/2016	03:48:20.500	219,084.14	1,777,459.10	16°03’39.42”	17°37’32.17”	deep
OA-1	Night start	12/1/2016	03:21:57.888	219,064.38	1,777,335.71	16°03’35.40”	17°37’32.78”	shallow
OA-1	Night stop	12/1/2016	03:27:34.900	219,077.69	1,777,418.79	16°03’38.11”	17°37’32.37”	shallow
OA-2	Night start	12/1/2016	04:48:43.716	222,559.35	1,774,487.21	16°02’04.23”	17°35’34.07”	deep
OA-2	Night stop	12/1/2016	04:53:55.950	222,575.83	1,774,566.71	16°02’06.82”	17°35’33.55”	deep
OA-2	Night start	12/1/2016	04:33:12.310	222,560.93	1,774,484.70	16°02’04.15”	17°35’34.02”	shallow
OA-2	Night stop	12/1/2016	04:38:51.757	222,578.45	1,774,568.81	16°02’06.89”	17°35’33.46”	shallow
OA-3	Night start	12/1/2016	05:31:39.169	226,346.45	1,774,973.45	16°02’21.57”	17°33’26.95”	deep
OA-3	Night stop	12/1/2016	05:37:08.258	226,361.80	1,775,055.46	16°02’24.24”	17°33’26.47”	deep
OA-3	Night start	12/1/2016	06:16:11.618	226,352.02	1,775,021.66	16°02’23.14”	17°33’26.79”	shallow
OA-3	Night stop	12/1/2016	06:21:22.731	226,366.10	1,775,100.89	16°02’25.72”	17°33’26.35”	shallow

XY Coordinate System: WGS84 UTM Zone 28N
Unit(s): Meters
Latitude-Longitude Coordinate Sytem: WGS84
Unit(s): Degrees, Minutes, Seconds.

Appendix C

USEPA Priority Pollutants

List of polycyclic aromatic hydrocarbons (PAHs) that are designated as priority pollutants by the U.S. Environmental Protection Agency.

Naphthalene
Acenaphthene
Acenaphthylene
Fluorene
Anthracene
Phenanthrene
Fluoranthene
Pyrene
Benz(a)anthracene
Chrysene/Triphenylene
Benzo(b)fluoranthene
Benzo(k,j)fluoranthene
Benzo(a)pyrene
Dibenzo(a,h)anthracene
Benzo(g,h,i)perylene
Indeno(1,2,3-c,d)pyrene

APPENDIX E: FISHERY RESOURCES, FISHERIES AND FISHING COMMUNITIES REPORTS

Appendix E
Fishery Resources, Fisheries and Fishing Communities Reports

APPENDIX CONTENTS

This appendix provides information compiled from reports by national experts in Mauritania and Senegal on fishery resources, fisheries and fishing communities in the Mauritanian and Senegalese portions of the core study area of the project.

APPENDIX E-1: REPORT ON FISHERIES AND FISHERIES RESOURCES IN THE MAURITANIAN PORTION OF THE CORE STUDY AREA OF THE AHMEYIM/ GUEMBEUL GAS PRODUCTION PROJECT

AHMEYIM/GUEMBEUL OFFSHORE GAS PRODUCTION PROJECT
IN MAURITANIA AND SENEGAL

2017

Environmental and Social Impact Assessment

Fisheries and Fisheries Resources in the Mauritanian Portion of the Core Study Area of the Ahmeyim/Guembeul Gas Production Project




Ecodev

Ecodev
Ext Ilot K 155 - TVZ
BP 41 74
Nouakchott, Mauritania
Phone: (222) 529 30 54

Mahfoudh Taleb Sidi

April 12, 2017

Revised October 2017

Table of Contents

1. Introduction

The Mauritanian Exclusive Economic Zone (MEEZ) covers an area of over 234,000 km². The Mauritanian coast is a vast area stretching over nearly 720 km from the mouth of the Senegal River (16° 04') to the tip of Cap Blanc (20° 36'N) (Sanyo, 2002). North of Cap Blanc, the coast is rocky while south of Cap Timiris, it is sandy and rectilinear. The continental shelf south of Cap Blanc is between 40 and 60 miles wide but narrows towards Cap Timiris where the isobath 200 is located at no more than 10 miles from the coast. Several pits deeply cut the continental shelf up to the bank where depths of 10 m are located next to those of 300 to 400 m. In the central zone of the MEEZ, the plateau beyond depths of 200 m shows a clear drop with a marked slope followed by an even steeper slope. There are more rock formations here than at the north of Cap Timiris between the probes located at 15 and 30 m. These rock formations form particular longitudinal reliefs south of 18° 00'N. The plateau is much more regular, however underwater canyons can be found between 18° 40'N and 18° 50'N. Further south, many smaller pits are present at the edge of the plateau; the most important being found between 16° 30’N and 16° 50’N (Dubrovin et al., 1991).

The continental shelf, with a total surface area of 39,000 km², is more extensive in the north than in the south (Bonin et al., 2013).

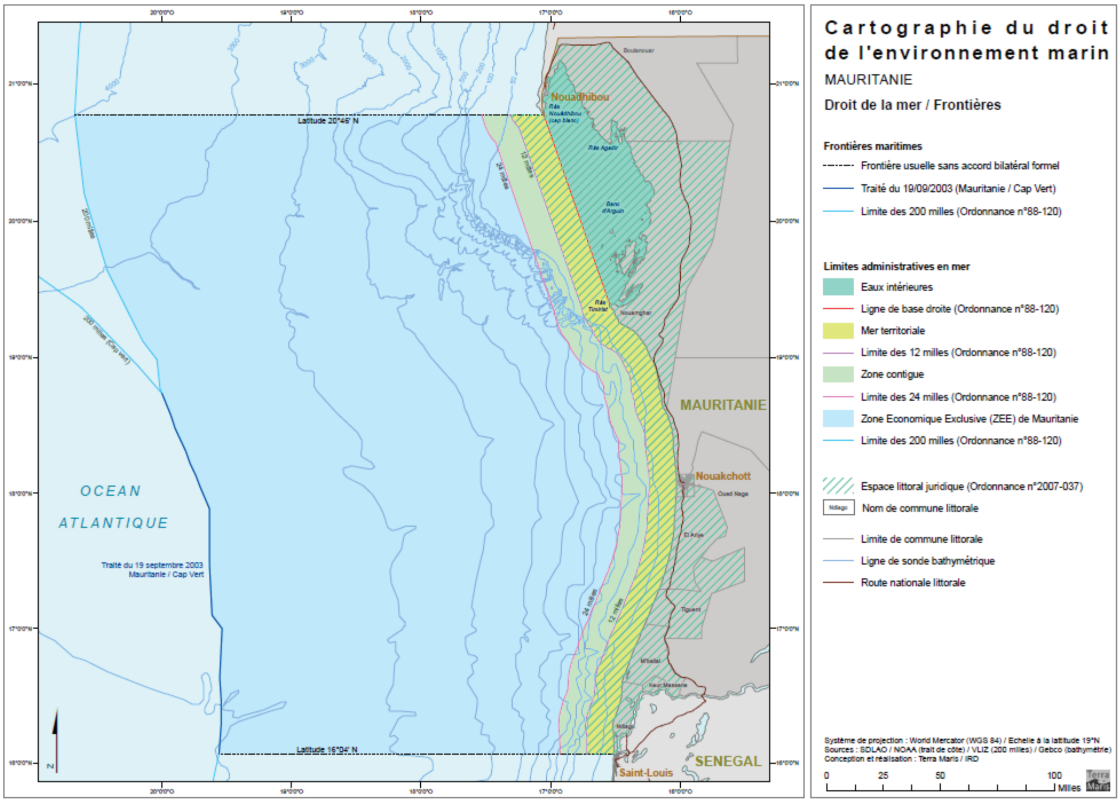


Fig. 1. The Mauritanian Exclusive Economic Zone (Bonnin, 2013).

The study area for the Ahmeyim/Guembeul gas production project considers all sectors potentially affected by the project. The study area includes:

1) The core study area (Fig. 2); which is the area immediately around the planned infrastructure and operations in the offshore area, the pipeline area and the nearshore area; the transit corridors, the ports, docking and storage facilities occupied or located near the logistic bases of Nouakchott (port and airport);

the maritime corridor between the proposed infrastructure and the port of Nouadhibou from where rocks might be shipped during the construction phase of the project; and, the coastal communities located between Nouakchott and N'Diago.
2) The extended study area includes the sensitive areas located in the vicinity of the planned infrastructure including the Senegal River Delta and the protected area of the Diawling National Park (DNP) and the Chatt Tboul Reserve.

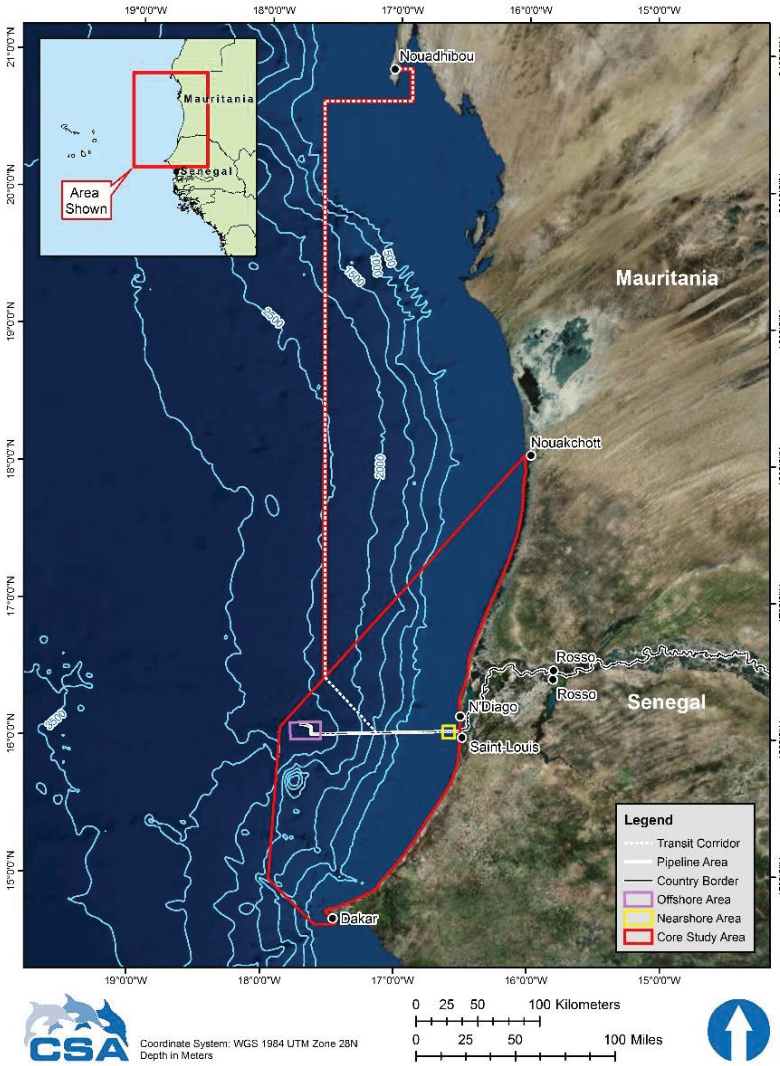


Fig. 2. Location of the Study Area for the Ahmeyim/Guembeul Gas Production Project.

The maritime region of the Islamic Republic of Mauritania is one of the two most productive upwelling systems of the Atlantic Ocean. It supports large commercial fisheries (Pauly and Christensen, 1995). In 2010 and 2011, catches reached 1,200,000 tonnes per year (IMROP, 2014). Catches have considerably decreased as a result of the introduction of protection measures to protect this resource. These measures are considered to be very restrictive by foreign boat owners responsible for the majority of the catches in the MEEZ.

Despite this temporary downward conjecture, fishing remains a structured activity for the national economy.

This MEEZ has a marine and coastal biological diversity of international importance. The coastal upwelling is the main source of this biodiversity. The upwelling is present year round in the northern area of the MEEZ and is seasonal in the coastal region of the center and the south of the MEEZ, which concerns the core study area of the Ahmeyim/Guembeul project.

Mauritania is also an exceptional biogeographic transition zone, especially in the Cap Blanc-Cap Timiris areas where dozens of tropical and temperate species from all levels of the animal and plant kingdoms coexist (Inejih et al.; 2014). In general, fishery resources are very fragile, especially when they are found at the limit of their distribution range.

The advent of offshore exploration in the late 1990s raised a lot of hopes but also many fears to the extent that many players were asking the question: offshore oil or fish, which to choose? Fortunately, with the hindsight and experience accumulated around the world, notably in Norway and Brunei, the authorities, the civil society as well as professionals have pondered the possibility of reconciling fishing activities and oil. Moreover, they consider that hydrocarbon exploitation allows them to incorporate sustainability concerns with foreign partners (European Union, Japan, Russia, etc.) since the Mauritanian state is no longer dependent solely on fishing as a source of currency input.

From the perspective of this reconciliation, environmental impact assessments for all offshore activities of a certain scale have become mandatory. It is in response to this obligation that the present study on fishery resources and fisheries is presented. The main objective of this study is to establish the detailed situation of fishery resources and sea fishing in the area between Nouakchott and the southern border of Mauritania in the context of the Ahmeyim/Guembeul gas production project proposed by Kosmos Energy.

This report will help answer several questions related to the potential impacts of the project including:

1. Will the project area and the core study area of the environmental and social impact assessment overlap the distribution range of important fish species or will they impact marine and coastal biodiversity which supports the fisheries substantial resource? This issue is addressed in the current report by assessing biodiversity, resources and catches distribution in the MEEZ. The main focus is the project's core study area and the adjacent areas particularly the Diawling National Park and the Chatt Tboul Reserve.
2. What is the state of the pelagic and demersal fishery resources which is of high commercial importance and which has a very limited migration; what is the exploitation level in the MEEZ, especially in the Ahmeyim/Guembeul gas production project core study area.

This approach uses available documents and data but also data from experts and it aims to provide information to answer these questions. But beforehand, an inventory of the various bathymetric compartments for the demersal species will be carried out.

The report briefly presents the general context but focuses mainly on marine and coastal biodiversity. A particular attention is given to exploited species and their spatio-temporal dynamics in the project's core study area.

2. Current Context

In an extreme desert environment, fishing in Mauritania constitutes the main activity that exploits renewable natural resources. The national economy is thus highly dependent on the availability and the exploitation of its fishery resources. This activity responds not only to the growing domestic food demand, but also contributes to the creation of wealth and employment. While limiting its ecological footprint, this activity must respond to several challenges and threats to meet the needs of current generations without compromising those of future generations.

In addition to significant population growth, the country is facing a process of urbanization, coastalization and rapid development, therefore changing the already challenging socio-economic context in the coastal zone. The employment situation is one of the biggest national concerns considering the high unemployment rate (31%, EPCV 2008) which was "only" 13% in 2014, according to the National Statistics Office (ONS)'s survey, which is still quite high. The training system and the production capacity of fisheries must therefore be adapted in order to offer permanent employment opportunities.

Climate change may manifest itself through an increase in extreme "natural" events (droughts, flooding, rising sea levels) and this could lead to an increase in the rural exodus towards the coast. There is also a possibility of additional pernicious effects, such as ocean acidification (Scott et al., 2016) and the raise of the minimal oxygen zone and the decrease in upwelling intensity (Birane et al, 2016). For the southern zone of the MEEZ, these changes may affect the biomass and distribution of several fish species of commercial interest.

Currently in the MEEZ, the fishing activity takes place within a global context marked by overexploitation of several demersal species and more seldomly of pelagic species, but also within an increasing demand for fish products, especially fatty fish. The nutritional qualities of fatty fish and their high amounts of Omega 3 make the pelagic species increasingly sought-after. Therefore, real opportunities for development exist, and these fishery opportunities excerpt such an attraction on foreign flagged-ships that some are willing to fish there even while breaking the law.

In order to establish a policy for fisheries management and development, including demersal species, the Government of Mauritania introduced new management measures in 2015 based on individual quotas. To increase social acceptability, this evolution takes place in the context of institutional and organizational innovations that favor new forms of organization and coordination and thus good governance: (i) creation in 2013 of the Mauritanian Coast Guards and the Nouadhibou Free Zone, with its cluster of fisheries competitiveness, (ii) reorganization in 2015 of the Ministry of Fisheries and Maritime Economy (MPEM) with increased decentralization of its various directions along the coast taking into account the preservation and sustainability imperative of these strategic resources and the expectation of operators in the sector wherever they may be.

Mauritania fisheries can be distinguished by the five following characteristics:

- An MEEZ among the richest fishing grounds in the world;
- A rich and diversified marine and coastal biodiversity including dozens of underexploited species with two notable exceptions: octopus (*Octopus vulgaris*) and round sardinella (*Sardinella aurita*);
- More than 97% of the fish caught in Mauritanian waters are destined for export;
- More than 80% of the catches are performed by foreign fleets operating under a fishing agreement or chartering agreement;
- The fisheries sector accounts for about 18% of the national budget, 40% of foreign exchange earnings, about 4-5% of Gross Domestic Product (GDP) and 36% of so-called modern employment. These statistics give an indication of the sector's contribution but do not constitute a real performance index of the economic health of this sector, the benefits of which may be even greater.

The main objective of this diagnosis is to carry out an assessment of the fisheries sector in Mauritania and, in particular, to capture the possible impacts or interactions with the Ahmeyim/Guembeul offshore gas production project off the extreme south of the MEEZ. In order to achieve these objectives, we are providing a brief overview of the situation of the fisheries sector, particularly the marine sector in

Mauritania, dealing successively with aspects of marine and coastal biodiversity, fishery resources and their exploitation system. A particular emphasis will be given to the core study area of the Ahmeyim/Guembeul offshore gas production project off the coast at the Mauritanian-Senegalese maritime border.

Given the importance of the spatial component of this study, we begin by presenting the breakdown of the MEEZ, established a priori for both experimental scientific campaigns which constitute the basis of the biodiversity study and for the fisheries component. It is therefore not possible to change it a posteriori.

3. Breakdown of the MEEZ

3.1. Breakdown in the Scientific Campaigns

During the scientific campaigns, the MEEZ was divided into three zones: northern, central and southern (Fig. 3).

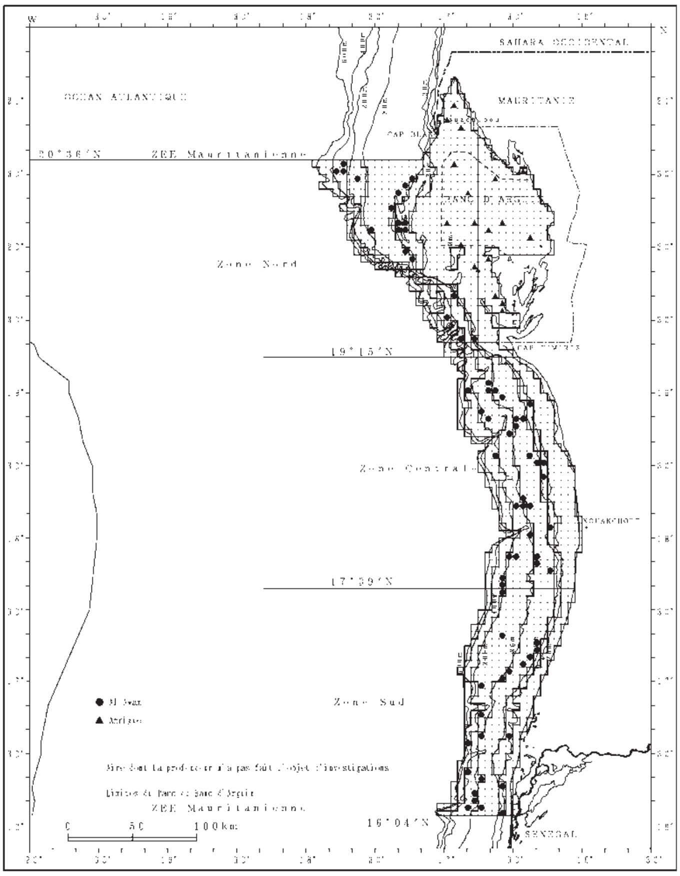


Fig. 3. Breakdown of the MEEZ Used during the Scientific Campaigns.

In each zone, five depth stratum were defined (Table 1). For the total surface area, a north-south gradient was established due to the greater width of the continental shelf in the northern zone.

Table 1. Surface Area (km²) for each Zone Relative to the Bathymetric Stratum.

Depth	Northern Zone	Central Zone	Southern Zone	Total
0- 30 m	7,110	2,730	1,550	15,820
30-80 m	2,830	2,980	2,910	8,720
80-200 m	1,300	2,560	2,730	6,590
200-400 m	980	1,720	1,060	3,760
400-600 m	730	710	440	1,880
Total	**12,950**	**10,700**	**8,690**	**36,770**

3.2. Breakdown Used for Industrial Fishing Activities

The data provided from the fishing logbooks managed by the Mauritanian Coast Guards includes reports of catches by species, or group of species and fishing effort (in number of hours of trawling, number of operations and fishing days) on a daily basis for vessels since 1991. These statistics describe the activity by geographical zone.

To describe the spatial distribution of fishing activity in the MEEZ, only the industrial fishery data are geo-referenced (statistical square of 30 nmi sides, Fig. 4).

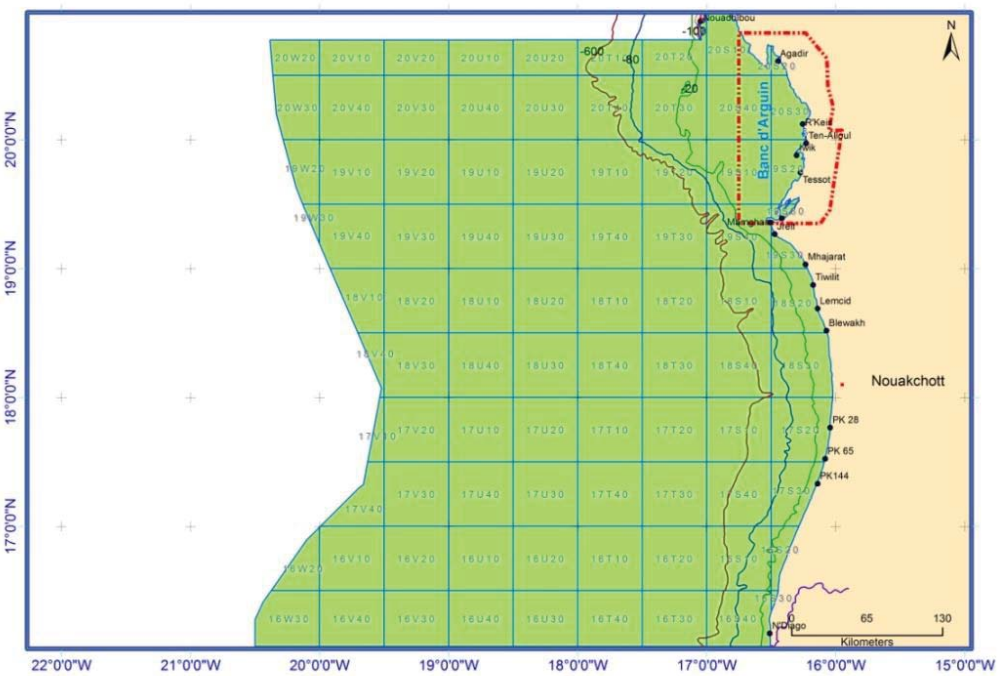


Fig. 4. Breakdown of the MEEZ by Statistic Sectors of 30 nmi X 30 nmi Used for the Monitoring of Industrial Fishing Activities.

3.3 Sectors Used for Artisanal Fishing

Sampling at the landing area is the main source of information for artisanal and coastal fisheries. It does not cover all landing sites and fishing sectors because of the informal nature of this subsector and the insufficient implemented monitoring means. No official information on the fine spatial-seasonal distribution of this segment, with a very small radius of action, is available due to a lack of a specific register or a dedicated survey. Therefore, it is not possible to follow the distribution of the artisanal fishing effort or to precisely recognize the fishing zones of this segment. Instead, IMROP identifies 5 landing regions.

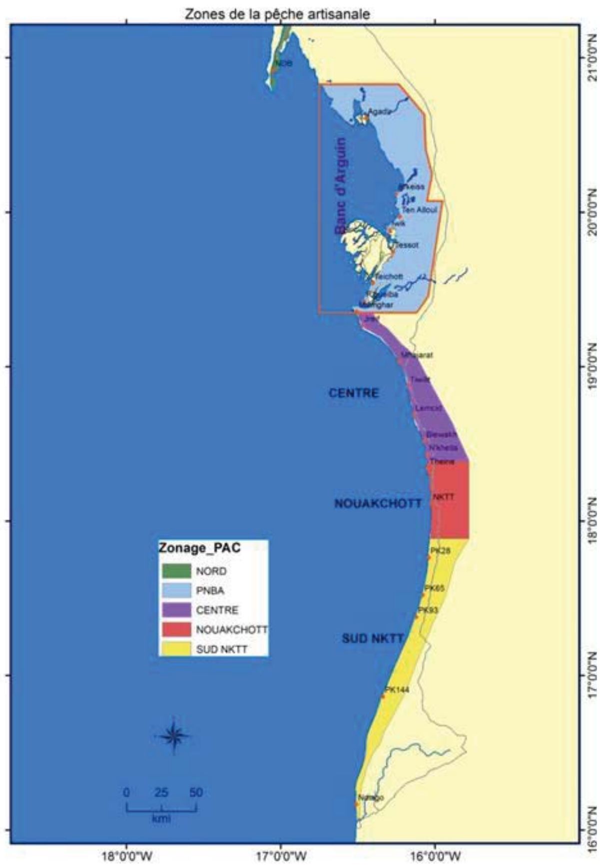


Fig. 5. Breakdown Used for the Monitoring of Artisanal Fishery Activities.

It is a fact that the central and southern part of the Mauritanian coastline still lacks landing infrastructure and boat services. Projects are under way to alter this situation and to distribute artisanal fishing efforts to better exploit resources in the central and southern part of the MEEZ and thus lighten the pressure on resources and biodiversity in the northern part of the MEEZ.

Zoning allows a coherent spatial organization to avoid the concentration of fishing effort on a single resource during a given season and in a single sector, thus avoiding the overexploitation of this fishery resource and, in addition, the conflicts between the different fishing segments (artisanal, coastal and offshore). An exclusive coastal zone is dedicated for artisanal fishing. This exclusive zone is located within 6 nautical miles in the southern part of the Mauritanian EEZ and within 9 nautical miles elsewhere on the coast. However, artisanal and coastal fisheries are not limited offshore beyond these dedicated zones.

Given the growing depths of artisanal and coastal fisheries and the absence of restriction in a particular fishing area, the loss of octopus traps and pots remains quite frequent. Indeed, the interaction is particularly strong with pelagic trawlers but also demersal trawlers. In addition, collisions, often fatal, are also reported, particularly at night between industrial trawlers and artisanal boats which do not have radar reflectors nor traffic lights. These boats are therefore not detectable by large vessels. Zoning is established in a logic to preserve the depths below 20 meters, rich in biodiversity, from trawling activities.

4. Marine and Coastal Biodiversity

Biodiversity is first considered on the basis of the definition of the Convention on Biological Diversity (CBD), as defined by in its Article 2. From a scientific point of view, this definition depicts three levels of organization: the genes level (genetic variability within species), the species level (taxon diversity), and the ecosystem level (diversity of species communities and their non-living environment). It is the second level that is considered here.

The Mauritanian Exclusive Economic Zone (MEEZ) is characterized by a great diversity of fishery resources, gathering nearly 500 species, 50 of which are subject to more or less targeted exploitation. These resources are distributed throughout the maritime territory, though very unevenly. Given the presence of the upwelling, which is permanent North of Mauritania and seasonal to the South (Table 2), and the presence of nutrients brought by the Senegal River in the southern zone, this ecosystem is very productive and is host to a great biodiversity. It offers a wide range of habitats for algae, seagrasses, invertebrates and fish species: small pelagic, demersal coastal, and offshore highly migratory species, such as tunas. It is also a shelter to emblematic species, such as marine mammals, birds and sea turtles.

Table 2. Upwelling Intensity Period on the Northwest African Coast (Canary Current area) and Annual Primary Production (Sanyo, 2002).

Zone	Upwelling Intensity Period (months)	Length of Coast (km)	Offshore zone under Upwelling Influence (km)	Surface Area (km^2)	Annual Primary Production (tonnes of C /year)
Freetown – Dakar	10, 11, 12, 1, 2	800	50	40×10^3	$34{,}80\times10^6$
Dakar – Cap Blanc	10, 11, 12, 1, 2, 3, 4	700	150	105×10^3	$12{,}19\times10^6$
Cap Blanc – Canaries	4, 5, 6, 7, 8, 9	1,020	300	306×10^3	$31{,}40\times10^6$
Canaries – Casablanca	4, 5, 6, 7, 8, 9	1,000	150	150×10^3	$12{,}83\times10^6$
Cap St. Vincent – Vigo	6, 7, 8, 9, 10	600	150	90×10^3	

4.1. Distribution of Coastal Biodiversity

In the coastal area, the upwelling explains the great wealth of exploitable marine resources but also the biological diversity, notably coastal, which is just as remarkable. Thus, in the project area (southern zone, Fig. 6) a decreasing coast-offshore gradient, measured relative to the average number of species encountered in the IMROP's trawling campaigns between 2011 and 2015, is observed. Below the 400 m deep stratum, 426 species of marine fauna were identified in the core study area of the project. The maximum specific diversity is found between 30 and 80 m. It subsequently drops considerably beyond 200 m.

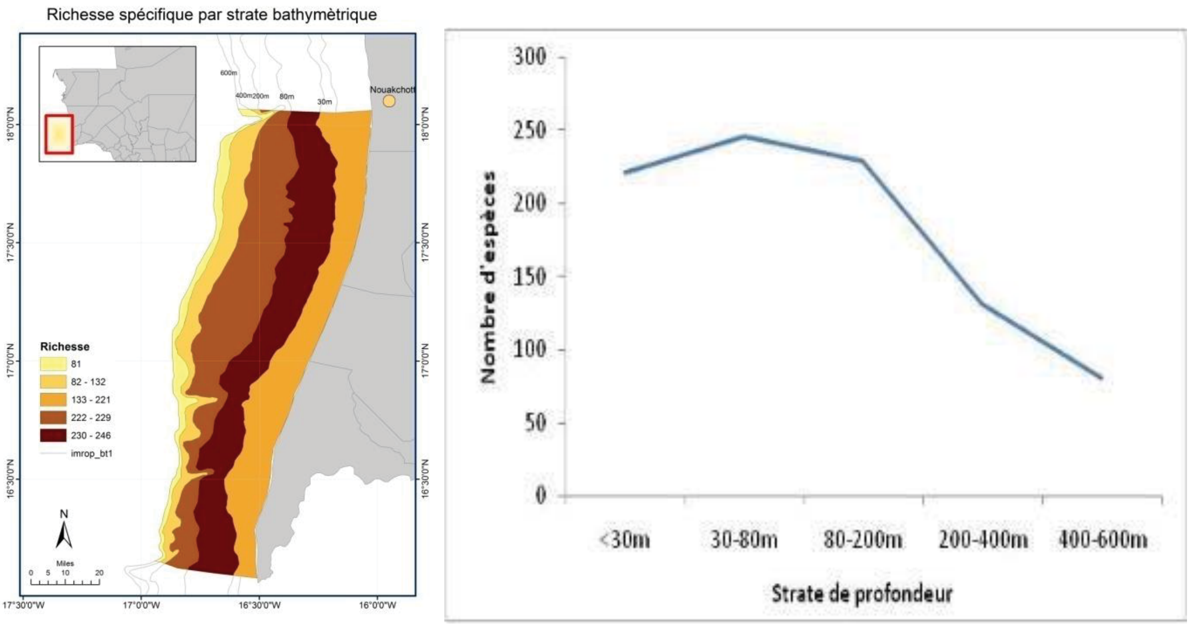


Fig. 6. Bathymetric Variation of the Species Diversity (in number of species) in the South of the MEEZ.

Given its direct economic and social importance, the biodiversity of exploitable marine and coastal species has been monitored continuously in the MEEZ since the early 1980s by the Institut Mauritanien de Recherches Océanographiques et des Pêches (IMROP). Knowledge of geographical distribution of species is crucial for the purposes of the exploitation, conservation and management of biodiversity.

At the scale of the MEEZ and its adjacent zone, biodiversity inventories remain limited. Inejih et al. (2014) listed about 2,403 species in the entire MEEZ against more than 7,700 species in neighboring Morocco. This difference is mainly due to the insufficient research efforts conducted in the Mauritanian zone. **Also some species may have disappeared before they could be listed.**

4.2. Marine Biodiversity

Overall, the state of knowledge on the deep-sea beyond 400 m is rather fragmentary and in some cases deficient. Oil exploration in increasingly deep ocean floors have led to the discovery of the richness of these ecosystems in the MEEZ. In the past two decades, we witnessed an important increase in studies reflecting the interest of the scientific community in understanding the biological diversity of these ecosystems.

In this context, the discovery of the world's longest cold water coral habitat in the MEEZ has aroused a renewed interest from scientists for this zone. These mounds are about 100 m high, 500 m wide at the base, and cover a linear distance of at least 190 km (Colman et al., 2005). Thus, in order to assess this important biodiversity, Spanish, German, Norwegian and French scientific research campaigns took place during the last decade. The publication of the results of these investigations will likely bring new knowledge in this respect but already, the first results available are quite striking.

The Spanish research vessel Vizconde de Eza carried out a scientific campaign between November 15 and December 12, 2007 in the Mauritanian zone between 200 and 2,000 meters (Ramil and Ramos, 2007). The objective of their work was to assess fauna richness as well as the abundance and biomass of the benthic community (Table 3). This type of comprehensive inventory of the benthic community can serve as a basis for the study and monitoring of the environmental impact of anthropogenic activities, such as fishing and oil exploitation.

The objective of the Spanish N/O Vizconde de Eza campaigns was to understand the importance of the specific richness of the macrofauna and the determinism of the spatial organization of wildlife populations from 200 to 2000 m off the Mauritania shore, as well as its spatio-seasonal variation. Like any fishing gear, the demersal trawl used in this case does not allow a qualitative and quantitative study of all the present diversity. Meiobenthos, for example, was not concerned in this case.

Table 3. Diversity by Large Taxonomic Groups between 200 and 2,000 m Offshore of the MEEZ (Ramil and Ramos; 2007).

Phylum	Abundance in Numbers %	Biomass by Weight (%)
Echinoderms	94,583	97,298
Cnidaria	4,476	2,625
Crustaceans	0,507	0,065
Pycnogonids	0,229	0,002
Mollusca	0,136	0,006
Annelid	0,045	0,003
Bryozoa	0,013	0,000
Porifera	0,008	0,001
Sipuncula	0,003	0,000

During this campaign 206 benthic species were recorded. On average, the species richness for benthic invertebrate species was 29 per trawl. In the southern part of the MEEZ, 79 species are recorded with much lower yields per trawl (13 species). In this sector, Holothurians (echinoderms) dominated both in abundance (number of individuals) and in biomass (weight), with 94% of the total number of individuals and 98% of the total biomass (Table 4).

Table 4. Main Results by Zones Obtained during the Vizconde de Eza Campaign in 2007.

Zones	Number of Trawls	Number of Species	Species/ Number of Trawls	Individuals/ Number of Trawls	Biomass (kg)/ Number of Trawls
Northern	28	138	14	1448	90
Central	26	81	11	458	26
Southern	23	79	13	2930	327
Total (mean)	77	206	29	1556	150

For the entire study area, 70 different species were recorded for the stratum between 801 and 1200 m (11 species per trawl). Echinoidea: regularia was found to be the dominant species with 70% of occurrences, followed by Ophiuroidea (21%) and Holothuroidea (4%). In terms of biomass of the dominant group, it was Holothuroidea with 78% of the total, followed by Echinoidea: regularia (17%).

Biomass (in Kg) and abundance (in numbers) increase while heading offshore (Fig. 7, Ramil and Ramos, 2007). A priori, this result is surprising considering that the influence of upwelling weakens in areas of greater depth. However, it can be observed that the effect of fishing, especially trawling, decreases as further away from the coast. Areas of great depth, located between 1,200 and 2,000 m, which are spared from all anthropogenic activities, develop the most important biomass and abundance.

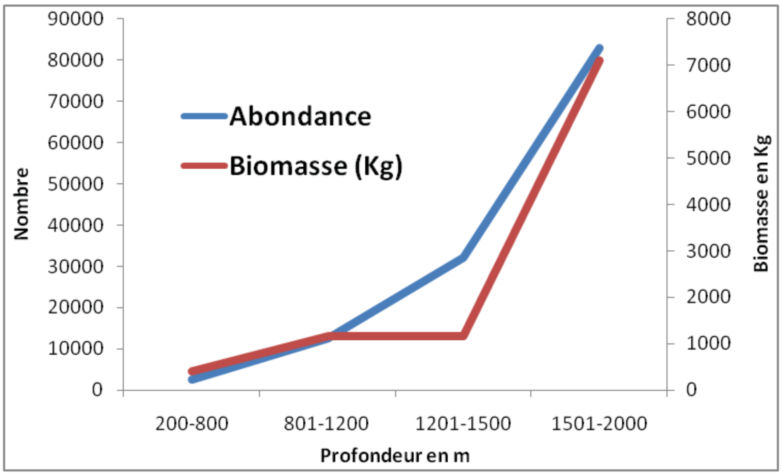


Fig. 7. Evolution of Biomass and Abundance (in numbers) in Different Stratums.

5. Status of Marine and Coastal Biodiversity (IUCN Red List)

The International Union for Conservation of Nature (IUCN) Red List of Threatened Species is widely recognized as one the most relevant and reliable sources of information to assess the global, regional or national status of all marine and coastal animal and plant species.
The IUCN Red List categories are applied to species assessments taking into account different criteria (ecology and life cycle, distribution, habitat, threats, current population trends and conservation measures) to determine the relative risk of extinction of these species.

In a regional approach such as that of the West African region (Sidibé, 2010), the species evaluated can be classified into 9 different categories. Taxa that are declared permanently extinct and/or facing a very high risk of extinction on the basis of the relevant scientific data are classified as Extinct (EX), Extinct in the wild (EW), Critically Endangered (CR), Endangered (V) or Vulnerable (VU). Taxa whose assessments are close to threat thresholds or threatened, or for which there are no conservation programs, are classified as Near Threatened (NT). Taxa assessed as having a low risk of extinction are classified as Least Concern (LC). The IUCN Red List also lists taxa that cannot be assessed due to a lack of knowledge or information, and therefore they belong to the Data Deficient (DD) and Not Evaluated (NE) categories. These last two categories do not necessarily mean that the species is not threatened, but that its risk of extinction cannot be scientifically evaluated with the data currently available.

The analysis of the situation for central-eastern Atlantic or focused on West Africa carried out or commissioned by the IUCN and published in 2016 (Sidibé, 2010) clearly indicates that the main threats to the marine biodiversity of this region are largely attributable to significant degradation and loss of habitat due mainly to overfishing, climate change, species introduction and pollution. Thus, the erosion of the marine biodiversity, in addition to its catastrophic consequences on the population of these countries who depend heavily on these resources for their food supply and employment, also weakens the marine ecosystems and consequently affects the climate of the entire planet as the oceans are essential components of the different biogeochemical cycles, including the oxygen cycle.

These studies focus on demersal species and more globally on species of marine bony fishes. We will also briefly address cartilaginous fish.

5.1. Bony Fish

This group contains the largest number of species. It is important both ecologically and economically. Loss of these species would pose a serious threat to the food security and means of subsistence of more than 340 million people living in these areas. Polidoro et al., 2016, assessed the status of bony fish species from central eastern Atlantic in Mauritania to the north of southern Angola. The assessment of 1,400 marine bony fishes, including fish from the coastal and deep waters of the Central East Atlantic, reveal that less than 1% are endangered or threatened with extinction. Only one species is critically endangered and ten are endangered (Table 5). More than 83% of these are considered of least concern. No extinction has been recorded. This situation translates into a relatively overall undisturbed situation.

Table 5. Status of Bony Fish Species in the East Central Atlantic according to the IUCN Red List Categories (Polidoro et al., 2016).

Red List Categories	Number of Species	Species Ratio	Number of Endemic Species	Endemic Species Ratio
Critically Endangered(CR)	1	0.1%	0	0.0%
Endangered(EN)	10	0.8%	5	2.2%
Vulnerable(VU)	26	2.0%	10	4.3%
Near Threatened (NT)	14	1.1%	2	0.9%
Least Concern (LC)	1,073	83.3%	145	62.8%
Data Deficient (DD)	164	12.7%	69	29.9%
Total	1,288		231	

Within this area, the maximum diversity density is 757 species per 100 km². This very high concentration has been recorded in the vicinity of the Cape Verde Islands and on the Senegalese-Mauritanian border. This area also contains the highest density of endemic species (Fig. 8). However, only a limited number of endemic species of bony fish have been observed offshore in the core study area of the Ahmeyim/Guembeul gas production project.

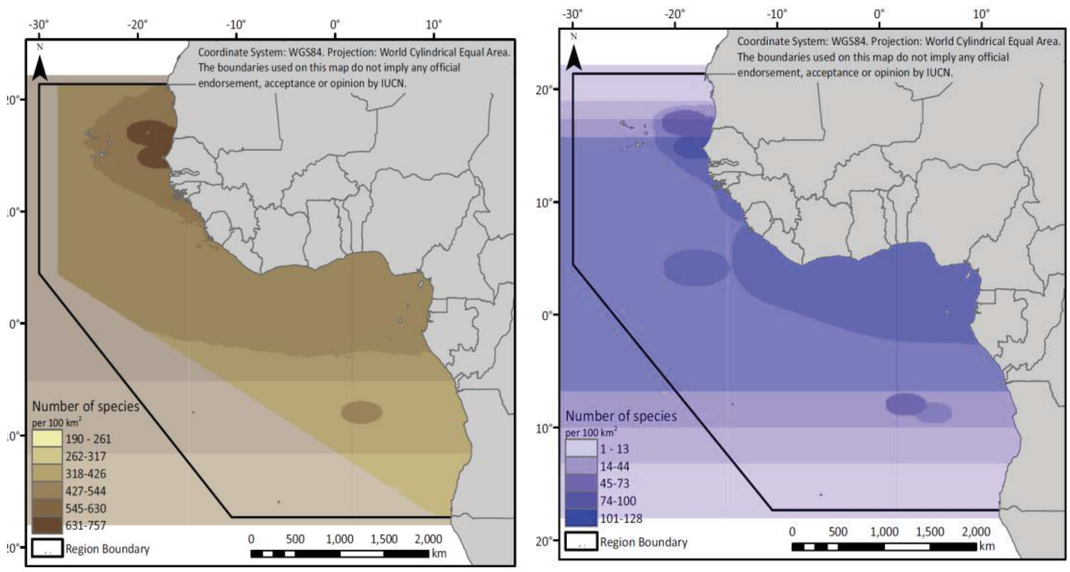


Fig. 8. Distribution of 1,288 Bony Fish Species (left) and of 231 Endemic Marine Species in the Central East Atlantic Ocean (right) (Source: Polidoro et al, 2016).

5.2. Cartilaginous Fish

Fourteen species of rays and sharks living in the Canary Current Large Marine Ecosystem (CCLME) area are listed on the IUCN Red List as either "Endangered" or "Critically Endangered". These notably include two of the three species of sawfish (*Pristis pectinata* and *P. perotteti*). In the past, smalltooth sawfish were found along the coast of West Africa, from Angola to Mauritania (Faria et al., 2013). There has been only one confirmed observation for the region in the last 10 years in Sierra Leone in 2003. Unconfirmed observations of *Pristis* sp. have been reported in Guinea-Bissau in 2011 and in Mauritania in 2010 (CCLME, 2013). Three species of guitarfish are listed as being "in danger of extinction". These species are targeted by all artisanal fisheries and caught as by-catch by bottom trawlers. At the scale of the West African subregion from Mauritania to Guinea, the situation of the Selachians is the same: the blackchin guitarfish (*Rhinobatos cemiculus*) and the wedgefish (*Rhinchobatos lübberti*) are found only in Mauritania, while sawfish (*Pristis* sp) only exist in three countries (Gambia, Guinea and Guinea-Bissau) (CCLME, 2013).

In the tropical and subtropical East and West Atlantic, *Pristis pristis* appears to be in danger of extinction in all 6 distribution regions where it can be found. The risk of extinction is quantitatively detected in three of these regions: the United States coast, the northern part of South America, and West Africa (Carvalho et al., 2013).

Marine and coastal biodiversity has become a major cause for concern at the global level. For marine bony fish, much of the human activities, particularly fisheries, seem to be compatible with preserving a relatively undisturbed biodiversity. However, this is not the case for cartilaginous fish species (rays and sharks), of which about fifteen of some fifty species listed are in critical condition despite the presence of marine protected areas, notably that of the Banc d'Arguin, one of the largest Selachians sanctuaries of the West African coast. This in situ conservation is often seen as the ideal strategy, but it is rarely possible. The generalization of trawling has, in many cases, led to the destruction of habitats of these rare or endangered species. The status of invertebrates does not yet require much scientific and political attention, apart from cephalopods, crustaceans and gastropods, which are exploited and have a fairly satisfactory level of conservation.

6. Fisheries Resources

Considering their habitat, these resources are categorized into two major groups, pelagic and demersal resources.

A. Pelagic Resources

We will deal successively with the species present and their potential.

A.1. Pelagic species include the following groups:

a) Small pelagic species are in turn divided into two subgroups according to their biogeographic affinity:
   - Six species with tropical water affinity: two species of sardinella (*Sardinella aurita* and *S. maderensis*), two species of chinchards, cunene horse mackerel (*Trachurus trecae*) and false scad (*Caranx rhonchus*), the Atlantic chub mackerel (*Scomber japonicus*), and the ethmalose (*Ethmalosa fimbriata*). These species are essentially fished during the warm season. Their concentration is greater south of Cap Timiris. **These small pelagic species are therefore most likely to be impacted by the development of the new Kosmos project.**
   - Four species with temperate water affinity: the sardine (*Sardina pilchardus*), the anchovy (*Engraulis encrasicolus*), the Atlantic horse mackerel (*Trachurus trachurus*) and the silver sword (*Trichiurus lepturus*). These species are found mainly north of

Cap Timiris during the cold season (20° N15). **These species are therefore not likely to be present in the core study area.**

b) Coastal tuna species: Five species belonging to the Scombridae family. These species are fished as by-catch, more and more regularly, in Mauritanian waters, in particular by industrial fleets fishing small pelagic species. These include the Atlantic bonito (*Sarda sard*a), *Auxis* (*Auxis rochei* and *Auxis thazzard*), plain bonito (*Orcynopsis unicolor*) and little tunny (*Euthynnus alletteratus*). The potential of small tuna species is unknown, but more than 16,000 tonnes have been captured as by-catch by industrial pelagic fleets in 2011.

c) Meagre, mullets and bluefish, are also largely caught by industrial pelagic fleets as by-catch. The estimated potential per year is 15,000 tonnes based on historical catches.

d) Species of deep-sea tuna: Deep-sea tuna undertake very large migrations in the East Atlantic zone between southern Morocco and the Gulf of Guinea. These species include yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*) and skipjack tuna (*Katsuwonus pelamis*). The International Commission for the Conservation of Atlantic Tunas (ICCAT) is responsible for the assessment and management of these stocks. ICCAT diagnosis reveals a slight overexploitation of yellowfin tuna, a near-sustainable exploitation of bigeye tuna and an exploitation just below sustainable level for skipjack tuna. For skipjack tuna, very large catches were harvested off Mauritania.

e) Mesopelagic species are among the most abundant marine organisms and are the least studied and therefore largely underused by humankind (Venecia et al.; 2011). According to the results of the N/O French Thalassa survey carried out in 2014 (unpublished data), there are over 100 species in the Mauritanian-Senegalese zone. These fish migrate vertically between the meso- (200-2,000 m) and epi-pelagic (10-100 m) zones. Myctophids are important ecologically (food for marine mammals, birds, tunas ...) and economically for global fisheries by providing raw materials to the fish meal industry (Venecia et al., 2011). The northern Mauritanian zone combines the mesopelagic fauna for tropical, subtropical and temperate origins which is the most diverse from the tropical and subtropical Atlantic from Brazil to Cape Verde, (Pilar et al., 2017). This region is also characterized by the highest number of individuals, although no single species dominates numerically. Mesopelagic species are probably the last major groups of fish that are not exploited in the MEEZ despite their impressive potential of millions of tonnes (6-18 million tonnes per year).

A.2. Status of Pelagic Stocks

The stocks of small pelagic species exploited in Mauritania are cross-border. They migrate seasonally between the different countries of the subregion according to their biogeographic affinity. They are therefore exploited successively by several fleets in the EEZs from Morocco to Senegal (IMROP, 2013).
Given the cross-border nature of these species, it is difficult to calculate a specific potential for Mauritania as it can be extremely variable. Nonetheless, the current study presents the state of pelagic stocks for which assessments by direct method (acoustic surveys) and/or indirect surveys are available. The results that are presented come from the last IMROP working group held in December 2014 (Table 6), they estimated that 1,340,000 tonnes of pelagic fish represent the overall potential that can be harvested in Mauritania, according to recent fishery statistics.

Conducting simultaneous evaluations of the potential of all pelagic species is quite complex as the maximum biomass corresponding to peak production for different species does not occur at the same time, and probably not always exactly in the same geographical area. The Madeiran sardinella and the sardine appear to be underexploited and justify the development of a specific segment. This is not the case for round sardinella and chinchards despite the significant decline in industrial fishing efforts. Given the high degree of exploitation of round sardinella, it can be concluded that the current outlook for expansion for this species are nil in order to avoid the risk of actual collapse in pelagic species.

Table 6. Diagnosis and Recommendations for Pelagic Resources (in tonnes, IMROP 2014, ICCAT, 2014).

Stocks	***Sub-regional Maximum Sustain-able Yield (COPACE 2014)***	***BIOMASS Scientific Campaigns (Mean :2008-2012)***	***Capture Potential (acoustic 2008/2012)***	***Average Catches of Mauritania (tonnes, 2008/2012)***	***Diagnostic***	***Management Recommendations***
Sardine Stock C	509,000	3,980,000	1,592,000	120,000	Not fully exploited	Possibility to increase to 320,000
Mackerel	228,000	510,000	204,000	69,000	Fully exploited	As precautionary measure, do not exceed current captures
Anchovy				98,000		
Atlantic horse mackerel	134,000	233,000	69,900	52,000	Fully exploited	Do not exceed 260,000 tonnes
Cunene horse mackerel	270,000	368,000	110,400	248,000	Overexploited	
Caranx rhonchus				31,000		
Round sardinella	375,000	2,040,000	816,000	289,000	Fully exploited / Overexploited	Do not exceed the average of previous years (290,000 tonnes)
Madeiran sardinella	265,000	758,000	303,000	35,000	Not fully exploited	Captures up to 150,000 tonnes per year
Ethmalose	67,000		67,000	28,000	Overexploited	Do not exceed the 2013 captures of 90,000 tonnes
Tropical tuna				30,000		
Total	1,848,000		3,161,000	980,000		

A.3 Distribution of Small Pelagic Biomass

Acoustic surveys carried out in the MEEZ by Mauritanian and foreign research vessels provide indications on the spatial and seasonal distribution of biomass or abundance indices of some of these highly mobile small pelagic species. These include the trawl surveys carried out by the Alawam, IMROP' research vessel. This assessment method, although oriented towards demersal species, gives very good results for chinchards, in particular Cunene horse mackerel. This species is relatively well distributed in the southern part of the MEEZ with high concentrations in the extreme southern sector, at the border with Senegal (Fig. 9, left), which corresponds to the core study area of the Ahmeyim/Guembeul project. A similar distribution is shown in the results obtained by a Russian oceanographic research vessel (AtlantNiro) using the acoustic method, which is a method more appropriate for small pelagic species (Fig. 9, right).

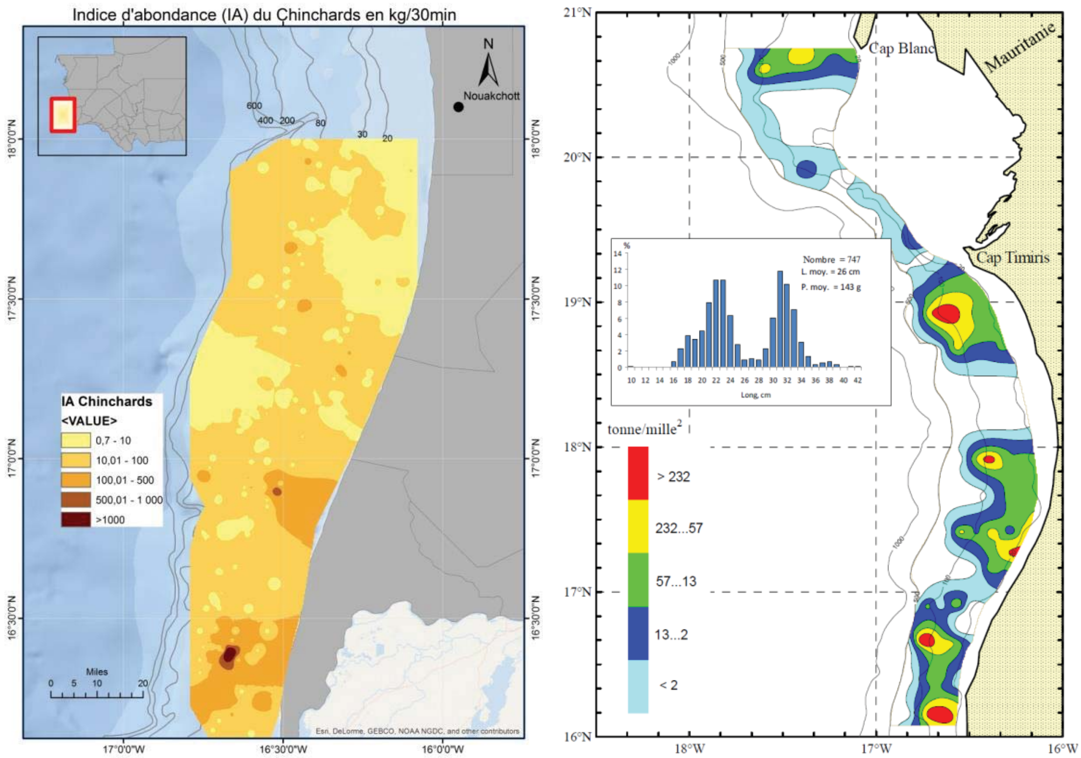
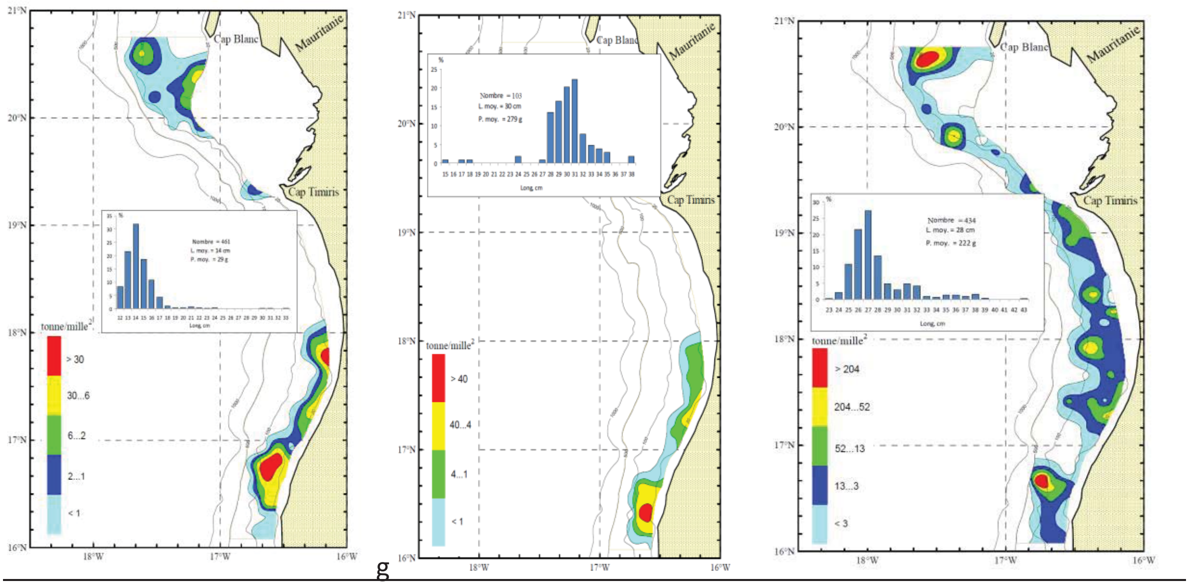


Fig. 9. Distribution of Cunene Horse Mackerel according to the Abundance Index in Different Seasons and Years for IMROP's Alawam Research Vessel and AltantNiro the Russian Oceanographic Vessel.

The other small pelagic species encountered in the southern part of the MEEZ are round sardinella (Fig. 10, left), mackerel (Fig. 10, center) and False scad (Fig. 10, right). The largest concentrations are located in the coastal fringe below depths of 100 m. Important biomasses are also located in the southern part, at the border with Senegal.



g

Fig. 10. Distribution of Concentration of Selected Small Pelagic Tropical Species. Left figure: round sardinella; Center figure: mackerel; Right figure: false scad (AtlantNiro, 2012).

A.4. Summary of Pelagic Resources

Pelagic resources represent more than 3 million tonnes of biomass, or approximately 1,300,000 tonnes per year according to IMROP assessments conducted in 2014. Given their very important migratory behavior, their behavior in schools, adults can flee sources of pollution or adverse conditions (decreased oxygen levels, sudden changes in temperature ...).

Small pelagic species, which live closer to the surface, are distributed according to the nature and characteristics of the water (salinity and temperature) as well as their physiological preferences (feeding, reproduction, predation) that lead them to latitudinal or longitudinal (zonal) migrations in search of ideal conditions (Table 7). Their abundance is also related to the seasonality of the hydroclimate.

Table 7. Synthesis of the Distribution and Potential of the Main Small Pelagic Species in the Region and in the MEEZ (Chavance et al, 1991 a; Machu et al, 2009 ; Yeslem, 2013).

Specie/Stock	Distribution (Region)	Spawning Period and Area	Availability for Fishing in the MEEZ	Bathymetric Distribution
European horse mackerel : Saharo-mauritanian stock	Between 26°N and 10°N	December to April 20 to 26°N	Throughout the MEEZ from October to May ; Only in the northern zone during the warm season	From the coast to more than 300 m, preferably in depths of over 100 m
African horse mackerel : Senegalese-Mauritanian stock	23°N to 9°N	All year 2 peaks : (March-June and August-Oct.) ; Cape Verde and Cap Timiris	All year Moves in the MEEZ in function of the thermal front	Above depths below 100 m. More coastal than the European horse mackerel.
False scad	23°N to 9°N	June to October South of Cap Timiris	All year, more southern than other chinchards ; from January to June only in southern zone	From the coast to the 150 m isobath, in schools near the bottom by day, disperses and rises to the surface at night.
Round sardinella: Senegalese-Mauritanian stock	26°N-10°N	2 main periods : July to August and December to January in the North of Mauritania	All year (Lévrier Bay, Banc d'Arguin); essentially adults in the MEEZ	Above sea floor at less than 50 m. Adults above 100 to 200 m sea floors.
Madeiran sardinella: Senegalese-Mauritanian stock	26°N to 10°N	Main period between May and September nurseries (North of Cap Timiris)	All year	Above depths less than 100 m, preferably less than 30 m
Sardine : stock C	Cap Juby-Cap Blanc (28°N to 21°N).	Principal in December and secondary in March in northern Mauritania	Cold season, start and end of the transition period	Generally above 100 m
Mackerel	12°N-24°N	October to May in Guinea Bissau, Gambia Senegal and Western Sahara.	Moves in the MEEZ all year following the 19-20° C isotherm	Above sea floor from 15 to 30 m to 350-400m
Anchovy	Eastern Atlantic from Norway north of Bergen (62° N) to South Africa (23° S).	April to October Cap Blanc in Cap Timiris	Practically all year	Very coastal species

B. Demersal species

Demersal resources are mainly composed of cephalopods (cuttlefish, squid and octopus), demersal fish (grunts, groupers, soles, rays and sharks, red mullets, hakes), crustaceans (shrimps, lobsters, crabs), bivalve mollusks (clams, Cymbium) and others. In general, these species are of high commercial value. These species, which live near the bottom, are distributed according to the nature of the substrate and the characteristics of the water (salinity and temperature). Their abundance is also related to the seasonality of the hydroclimate. They consist of demersal fishes from the coast and the slope as well as coastal and deep-sea cephalopods, crustaceans and Selachians.

B.1. Coastal Demersal Fish

The most important coastal demersal fish species are:

- On hard and rocky bottoms: groupers (*Epinephelus guaza, Epinephelus goreensis, Epinephelus aeneus*), sparidae (*Diplodus bellotii, Sparus caeruleosticus pagres, Lithognathus mormyrus, Dentex canariensis*), and soles (*Solea spp, Synaptura punctatissima*) ;
- On soft bottoms: mullets (Pseudupeneus prayensis).

Some demersal species (groupers, bluespotted seabream, red pandora, Rubberlip grunt, Canary dentex) have relatively large migratory patterns. It should also be noted that many demersal species migrate between the coast and offshore generally for breeding or feeding purposes.

In the southern part of the MEEZ, the coastal area located between 3 and 30 m accounts for more than 56% of the biomass of the species studied (Sanyo, 2002). A decreasing coast-to-offshore gradient is highlighted. The deepest stratum, located between 200-400 m, contributes only slightly with 7% (Table 8).

Table 8.Distribution of Demersal Resources by Bathymetric Stratum in the Southern Part of the MEEZ between January and May (cold season) (Sanyo, 2002).

Species		Stocks in Tonnes	Stock Distribution by Stratum (m)			
			3-30	30-80	80-200	200-400
Plectorhinchus mediterraneus	Commercial	6,900	98%	2%	(0.1)%	0%
*Trachurus trecae**	Highly commercial	5,864	9	40	50	1
Brachydeuterus auritus	Idem	3,893	100	(0.2)	0	0
Chloroscombrus chrysurus	Commercial	3,071	100	0	0	0
Chlorophthalmus agassizi	Idem	2,827	0	(0.1)	94	6
Galeoides decadactylus	Commercial: fresh, dried, salted or smoked.	2,262	100	0	0	0
Pomadasys incisus	Commercial minor	2,103	96	4	0	0
*Pagellus bellottii**	Commercial: important edible fish	2,054	6	94	(0.1)	0
*Pagrus caeruleosítictus**	Commercial	1,716	99	1	0	0
Hoplostethus cadenati	Idem	1,479	0	0	0	100
Trichiurus lepturus	Highly commercial: frozen, salted/dry.	1,330	50	38	10	2
Pontinus kuhlii	Commercial	1,251	0	1	97	2
*Octopus vulgaris**	(Highly commercial)	1,079	1	47	52	0
Merluccius polli(*)	Commercial minor: fresh, frozen, fish meal, oil.	1,051	0	34	44	22
Synagrops microlepis	-	943	0	12	86	1

Dentex macrophthalmus	Commercial	926	0	50	49	(0.4)
*Zeus faber**	Commercial: excellent.	698	2	28	70	0
*Pseudupeneus prayensis**	Commercial	376	75	25	0	0
*Sepia officinalis**	(Highly commercial)	151	100	0	0	0
*Parapenaeus longirostris**	(Commercial)	268	0	3	43	53
Other	-	20,870	63	14	16	7
Total		**61,112**	**56**	**16**	**21**	**7**

Note: Target species for different fisheries (*).

B.2. Distribution of the Biomass of Demersal Species

For coastal species, grouper and red mullet are located very close to the coast within 80 m depth (Fig. 11).

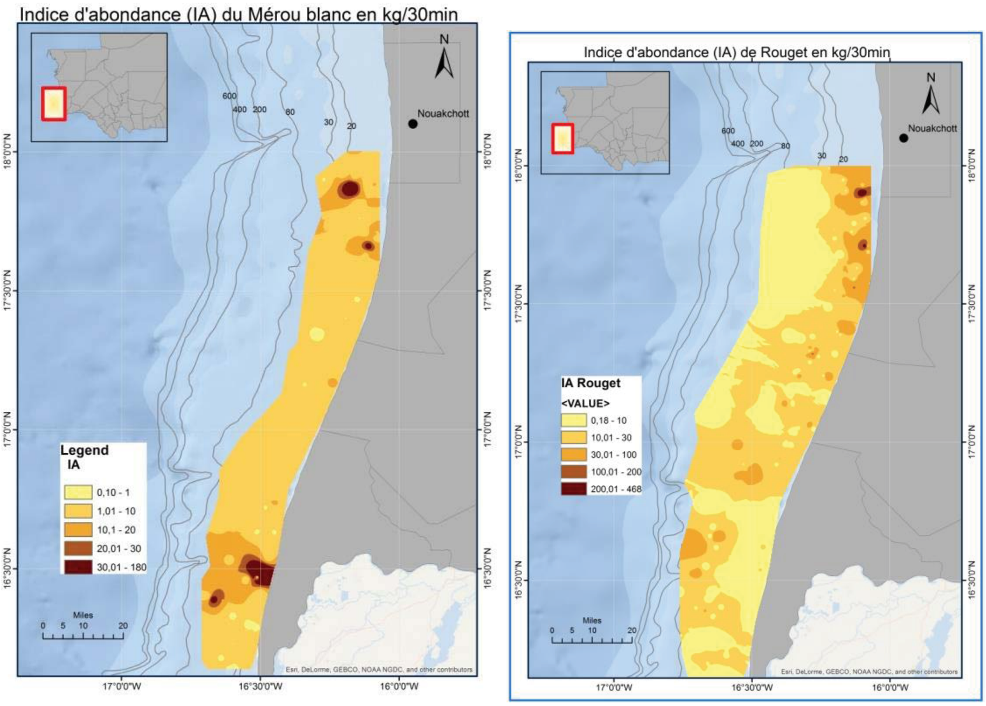


Fig. 11. Distribution of Densities of the White Grouper (rocky bottom) and the Red Mullet (soft bottom) in the Southern Part of the MEEZ.

A large concentration of grouper near the extreme south is observed. The red mullet has a more diffuse distribution (Fig.11).

B.2. Demersal Fish from the Slope: The continental slope community consists of species encountered beyond 200 m and up to 600-800 m (Bast et al., 1983). This community is notably composed of *Merluccius senegalensis*, *Helicolenus dactylopterus* and *Chlorophthalmus agassiz* (Table 9). Apart from the Senegalese hake (*Merluccius senegalensis*) which is distributed along the coast of Northwest Africa in the depths of 18 to 500 m (Sanyo, 2002, Meiners et al, 2010), none of these species has been targeted for exploitation.

Table 9. Bathymetric Distribution of the Resources of the Continental Slope (layer 200-400 m) during the Warm Season (Sanyo, 2002).

Species	Type of Fishing	Stocks in tonnes	Relative Biomass per Zone		
			Northern	Central	Southern
Helicolenus dactylopterus	Commercial : fresh	29,511	32%	63%	5%
Merluccius senegalensis	Highly commercial	10,610	12	69	19
Chlorophthalmus agassizi	Commercial : fresh, fish meal	7,247	3	71	27
Synagrops microlepis	-	5,319	3	68	29
Caelorinchus caelorhinchus	Commercial minor	3,622	52	36	11
Capras aper	No interest	3,005	99	1	0
Other species	-	9,333	32	47	21
Total		**68,856**	**27**	**60**	**14**

B.3 Coastal Cephalopods: The main target species in the cephalopod fisheries are octopus (*Octopus vulgaris*), squid (*Loligo vulgaris*) and cuttlefish (*Sepia* spp., *Sepia officinalis, Sepia bertheloti, Sepia hierredda*). The proportion of the latter decreases towards the south. *Sepia bertheloti* is rather important in the West Africa subregion. It is marketed under the name "sepiola".

Among the coastal cephalopods, octopus is the most abundant and commercially valuable species in the cephalopod fisheries of the subregion, with 65-75% of total landings (FAO, 2012). The octopus is a ubiquitous species, present on almost all the Mauritanian coastline in water rarely exceeding 200 m deep. Its importance decreases towards the south as it is replaced by increasing proportions of *Sepia hierredda*. Squid also disappears from landings in southern Senegal.

For cephalopods, three main fishing grounds are present along the coast of Northwest Africa which more or less coincides with the distribution zones of the three octopus stocks that appear in the subregion (FAO, 2012). From north to south, these are: i) the area between Cap Boujdour (26 °N) and Cap Blanc (21°N); (ii) the area between Cap Blanc (21°N) and the mouth of the Senegal River (16°N); and, (iii) the area between the mouth of the Senegal River (16°N) and the border with Guinea-Bissau (12°N).

The three species of cephalopods are coastal species. The main concentrations are observed below 200 m. Only the squid and especially the cuttlefish appear to be abundant in the core study area of the project (Fig. 12).

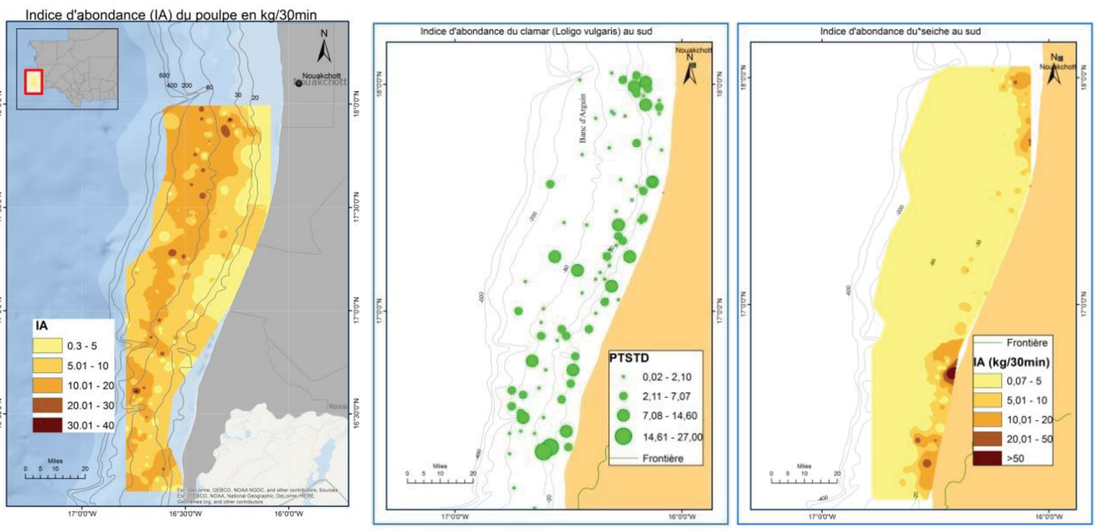


Fig. 12. Distribution of Densities of Octopus, Squid and Cuttlefish in the Southern Part of MEEZ (source IMROP).

B.4. Deepwater Cephalopods (oceanic): Some of the oceanic cephalopods have an important pelagic behavior. Others live permanently on the bottom or near the sea floor, or descend to the bottom only in adulthood to lay eggs (Nesis, 2003). For example, the squid *Todarodes sagittatus*, which is widely distributed in the Eastern Atlantic between 70° N and 10° S, was captured incidentally by Russian trawlers looking for chinchards (pelagic) and hake (demersal) in the Mauritanian zone. Between Cap Blanc in northern Mauritania and up to 23° N 30' in southern Morocco, the peak catches between 300 and 500 kg per fishing day were recorded between June and July (Arkhipkin et al., 2015). In 1974, according to the same authors, Russian trawlers caught 18,000 tonnes of this species off Cap Blanc. Scientific surveys carried out by the research vessel AtlantNIRO between 1995-1998 reported the main concentrations were between 18 and 32° N at depths between 400 and 800 m, while the waters of less than 300 m were occupied by different ommastrephid species. These authors also note that this species was also occasionally caught by the Russian fleet in Mauritania until 1983, when the country introduced a ban on incidental catches of cephalopods.

The small flying squid *Todaropsis eblanae* is widely distributed between 61° N and 36° S in the Eastern Atlantic. It is a medium-sized demersal species, associated with sandy and muddy bottoms. It prefers temperatures between 9 and 18°C and lives between 20 and 850 m approximately (Arkhipkin et al., 2015). Typically, it is associated with the continental slope break. No seasonal migration or any other type of major migration has been documented. It is probably the least mobile of ommastrephidae squids.

The species *Illex coindetii* is also widely distributed in the east Atlantic between 20°S and 60°N (Arkhipkin et al., 2015).

B.5. Crustaceans: This group consists of coastal crustaceans (royal spiny lobster, costal shrimps) and deep crustaceans (deep shrimps, pink spiny lobster and deep crab). For example, two lobster species are present on the MEEZ: royal spiny lobster (*Panulirus regius*) and pink spiny lobster (*Palinurus mauritanicus*). The royal spiny lobster has been fished for several decades by a Mauritanian artisanal fleet from La Guerra, near Nouadhibou where fishing is practiced throughout the year, unlike south of Cap Timiris where it is seasonal and occurs in spring and fall (Pencalet-Kerivel, 2008). The collapse of the royal spiny lobster stocks resulted in the abandonment of this fishery in 1993 (Julien, 2002). Fishing for this species has resumed intermittently in particular by European Union vessels operating under an agreement between Mauritania and that State. An improvement in catches was observed from 2006 onwards with exceptional catches of more than 400 tonnes recorded in 2014. A significant drop has been observed from 2015 (IMROP data, unpublished).

B.5.1. Coastal Crustaceans: In the southern part of the MEEZ, there is a stock of royal spiny lobster (*Panulirus regius*) and coastal shrimps (*Penaeus notialis, Panaeus kerathurus*). For royal spiny lobsters, the annual potential does not exceed a few hundred tonnes. Coastal shrimps are mainly represented by the species *Penaeus notialis*. This species lives on muddy or sandy bottoms up to 100 m deep, but more generally between 10 and 75 m. In March, the main concentrations are observed between Cap Timiris and the southern limit of the MEEZ between 50 and 100 m deep. The 19-20°N sector contributes more than 70% of the catches for the two species of "langostino" (*Penaeus notialis* and *P. kerathurus*) in the most coastal stratum (0-80 m). Two stocks are generally accepted: a southern stock between Nouakchott and Saint-Louis, which is in relation with the Senegal stock, and a northern stock between 18°50 N and 20°00 N which would come from the nurseries of the Banc d'Arguin. Pink shrimp, the most landed of the two coastal shrimps is abundant especially at the mouth of the Senegal River below the 20 m isobath (Fig. 13). It is therefore present in the core study area of the Ahmeyim/Guembeul project.

B.5.2. Deep Crustaceans: These include pink spiny lobsters, deep-sea shrimps and crabs. The highest densities of deep-sea shrimp and pink spiny lobster are located offshore and north of Mauritania (Fig. 13). These two species are therefore only partially concerned by the project's core study area.

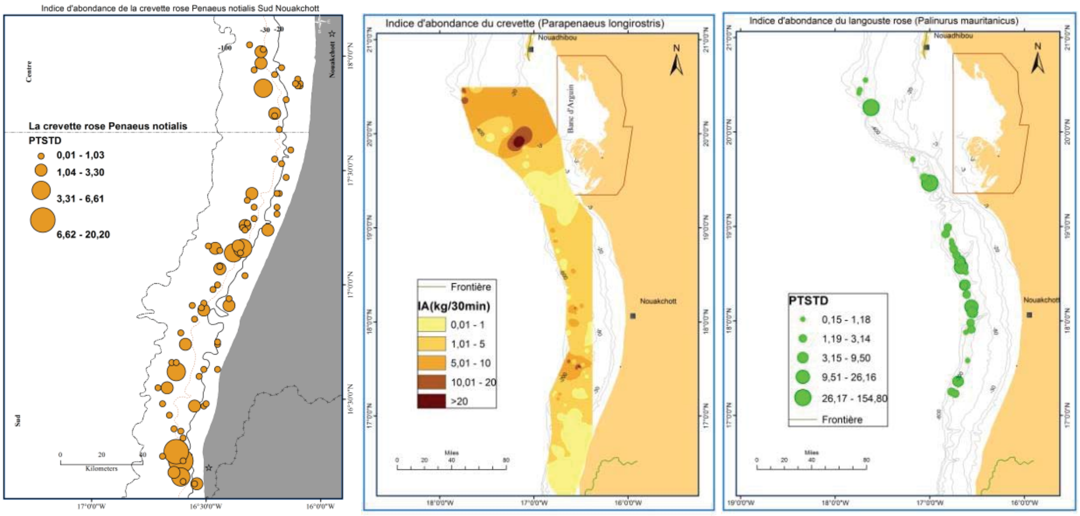


Fig. 13. Distribution of Coastal Shrimp, Deep-sea Shrimp and Offshore Lobster.

B.6. Selachians

Selachians (rays and sharks) are highly vulnerable species. Indeed, Selachians are characterized by low fertility, late maturity, long life span and slow growth. These characteristics of rays and sharks result in a very low resilience toward directed management. Issues related to coastal and deep-sea Selachians species will be addressed separately.

B.6.1. Coastal Selachians: The highest concentrations of coastal Selachians are observed in the bathymetric stratum of less than 20 m, particularly in the northern and southern zones, where the core study area of the Ahmeyim/Guembeul project is located. A fairly pronounced coast-to-offshore gradient is present in these two zones up to 200 m in depth, after which, the yield rapidly increases between depths of 200 m to 400 m in the northern and central zones of the MEEZ but not in the southern zone (Fig. 14).

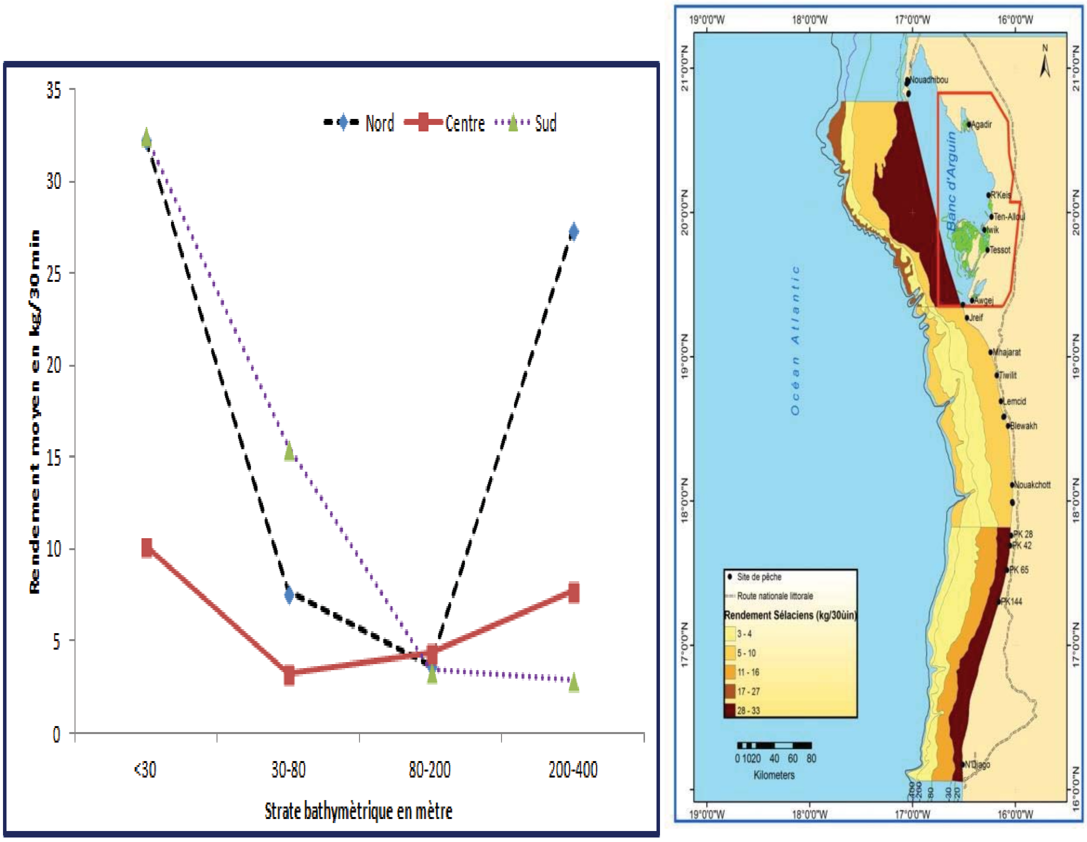


Fig. 14. Spatial Distribution of the Coastal Selachians Yields by Large Zones (IMROP campaign, communication presented by Mr. Yeslem at the Teichott Workshop, February 2017).

B.6.2. Deep-sea Selachians: The demersal campaign carried out by the Spanish vessel Vizconde de Eza in 2007 identified 28 species of Selachians in the MEEZ in depths between 400 and 2,000 m. For the three zones, yields are relatively low in the stratum from 400 to 1,000 m probably due to the impact of industrial fishing, notably trawlers. Yields for the northern zone are especially important between 1,200 and 1,400 m and then decline before recording a fairly clear recovery between 1,801 and 2,000 m. For the central zone, the yields increase between 400 and 1,800 m. No fishing activities take place between 1,800 and 2,000 m (Fig. 15) for the central zone and in the southern zone, where the core study area of the Ahmeyim/Guembeul project is located. Maximum yields in the southern zone have been recorded between isobaths 1,001-1,200 m. This yield remains less important than the yield measured in the northern zone in deeper layers (Fig. 15). Interestingly, no specimens of Selachians were found in catches from the central and southern zones, unlike the northern zone which is under the direct influence of intense and permanent upwelling that can be felt far offshore (Pilar et al., 2017).

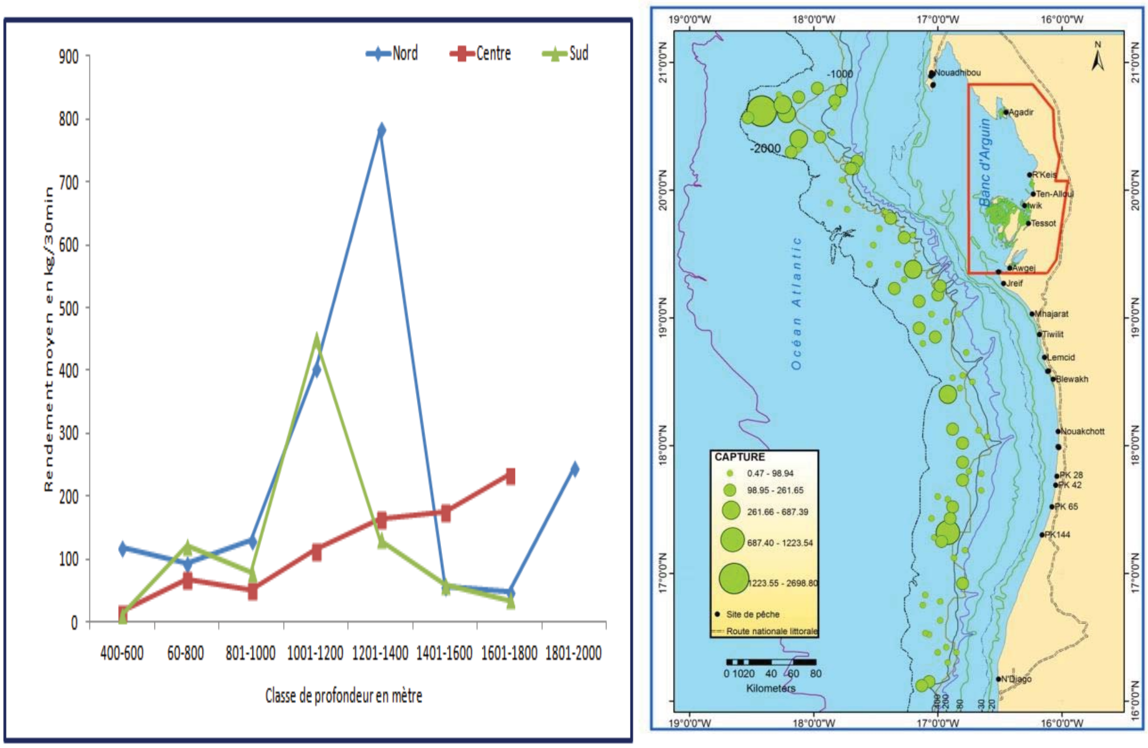


Fig. 15. Spatial Distribution of Deep-sea Selachians Yields (Vizconde de Eza Campaign, 2007 communication presented by Yeslem at the Teichott Workshop, February 2017).

B.7. Demersal Stock Status

This section presents the evolution of the stock of cephalopods, crustaceans and some of the main demersal fish species.

B.7.1. Cephalopods: Consists of octopus, cuttlefish and squid. Octopus populations are distributed from Senegal to Western Sahara. They are the most important group in the world. The octopus potential varies between 20,000 and 40,000 tonnes per year, depending on the hydro-climatic conditions and on fishing pressure. Two stocks of octopus are identified in the MEEZ: the stock of the northern zone, located offshore and which is the most abundant and a coastal stock located between Cap Timiris and Nouakchott. For octopus, stocks are overexploited but are being reconstituted according to the results of the 2014 IMROP working group (Table 10). For squid and cuttlefish, artisanal and coastal fisheries (ACF) could produce more.

B.7.2. Shrimps: Coastal (*P. notialis*) and Deep-sea (*P.longirostris*) shrimps are also underexploited (Table 10).

Table 10. Diagnosis, Stock Status and Recommendations for Demersal Resources.

Stock	2013 Captures in tonnes (mean 2009-2013)	Potential (MSY)	Evaluation	Recommendations
Octopus *Octopus vulgaris*	25,000 (26,218) Trends show improvement since 2006	32,000	Overexploited with an excess of 17% compared to 25% in 2010 of the maximization efforts.	Progressive replenishment of stocks. Maintain the level of efforts corresponding to the current catch level.
Cuttlefish *Sepia spp.*	3,200 (2,800)	3, 800	Underexploited	Gradually increase fishing effort
Squid *Loligo vulgaris*	2,000 (1,600)	3, 430	Underexploited	Gradually increase fishing effort
Langostino *P. notialis*	200 (1,020)	2,000	Underexploited	Gradually increase fishing effort
Gamba *P. longirostris*	290 (1,690)	2,400	Underexploited	Gradually increase fishing effort
Hake *Merluccius spp.*	4,400 (5,860)	11,700	Underexploited	Gradually increase fishing effort

Source : IMROP, 2014

B.7.3. Other Demersal Fish

Globally, the abundance of demersal resources in West African countries has been divided by 4 over the past 30 years. Gascuel et al. (2007) have also confirmed the very high degradation of Mauritanian demersal resources.

According to these authors, the decline is particularly important for species of high trophic levels and reaches factors of 10 or even 20 for the most affected species. These authors conclude that this decline compromises the capacity of demersal, industrial and artisanal fisheries to contribute to the development of the concerned countries.

In Mauritania, different conservation measures for demersal fishery resources and their habitat[1] appear to be working with a reversal of declining trends since 2006 at the level of the whole MEEZ for some 20 demersal species (Fig. 16).

[1]This is the case with the trawl ban which sought to address a range of concerns, including the conservation of resources and the attenuation of conflicts between artisanal and industrial fisheries. This measure, introduced in 2002 and effectively implemented from 2005 onwards with the introduction of the VMS (Vessel Monitoring System), should also improve the abundance of target species and restore degraded habitats, which would preserve the health and the integrity of the rich coastal ecosystem (56% of the total demersal biomass according to Sanyo (2002)) with a very high specific diversity (Kidé *et al.* 2015) but also very fragile.

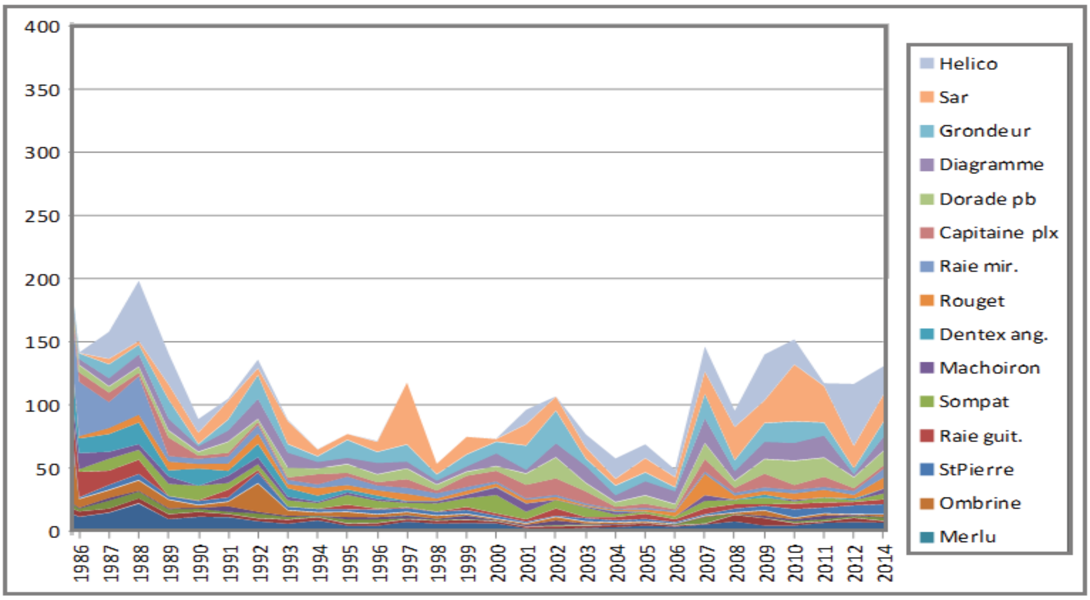


Fig. 16. Evolution of the Abundance Index (in thousands of tonnes) of About 20 Demersal Species in the MEEZ (Source: IMROP, 2014).

B.8. Summary of Demersal Species

The severe degradation of global fisheries resources, particularly for demersal resources (FAO, 2010), does not seem to be inevitable. The alarmist trends in the evolution of the global fishery resources can be nuanced in the case of Mauritania, where it is clear that this trend can be reversed, with significant improvements in biomass of around 20 demersal species as of 2006, following the application of binding and easily controllable regulatory measures (VMS). The bottom trawling ban on sea floor less than 20 m seems to have been very successful. Recovery of the environment could have benefited demersal fish, but less some opportunistic species (such as octopus) whose dynamics are more effective in times of disturbance.

Apart from species such as coastal shrimp, squid and cuttlefish, most of the fishery resources are mostly located in the northern part of Mauritania and more incidentally in the central part, but less in the southern region. The relative absence of Selachians comprising fragile and emblematic species, as reported by Pilar et al. (2017), in the project's core study area, is a major result to be reported despite their presence in the northern zone at identical depths in relatively large concentrations. It would seem that the influence of the upwelling, which is permanent and intense in the northern part of the MEEZ could explain this important difference.

7. Management and Exploitation Systems of Fishing Resources

A. Management Systems

In Mauritania, the objective of the fisheries management system is to have:

- a better regulation of access to resources
- a better control of fishing activities
- a distribution in time and space of the fishing pressure applied on the resources.

A.1. Right of Use of Fishery Resources

The 2015 Fisheries Code defines user rights corresponding to individual catch quotas, means of production (vessels, fishing gears) and fishing zones by type of resource. These user rights are allocated according to the volume of investments and the level of integration of activities into the national economy. For the administration of the right of use, two access regimes are provided:

- **The national regime** is granted to any concession holder whose quota is caught by a vessel flying the Mauritanian flag, landing, dealing and marketing the products from Mauritania.
- **The foreign regime** is an uncommon regime granted to foreign concession holders who possess a right of use. In this case, fishing vessels may obtain derogations from the obligation to land the products but are required to go through transhipment in Nouadhibou, under the supervision of the competent authorities. The foreign regime excludes cephalopods.

A.2. Fishing Licenses

Concerning licenses, vessels operate under three types of operating regime:

- **The acquisition regime** concerns the units, regardless of the type of fishing (artisanal, coastal or offshore), acquired by the Mauritanian operators or acting in the framework of mixed companies under the Mauritanian law.
- **The Charter regime** allows a Mauritanian operator to charter a foreign vessel. It is mainly used for pelagic fishing or demersal fish.
- **The free license regime,** including the licenses issued to units operating mainly in the framework of fisheries agreements.

Each vessel must also obtain at least one fishing license, granted for a maximum of one year, by fishing type and by fishery, depending on the species targeted. The fisheries resources of the Mauritanian EEZ are administred by a wide variety of operating systems, both national and foreign. Fisheries regulation classifies these systems into three main categories:

- Artisanal fishing (domestic and chartered)
- Coastal fishing (domestic, chartered and foreign) - including purse seine fishing units operating from undecked vessels
- Industrial fishing (domestic, chartered and foreign)

A.3. Fishing Agreements

For the different categories, the foreign component remains important even if the Mauritanian government encourages by multiple incentives the constitution and modernization of artisanal, coastal and offshore fleets, in order to gradually take the place of foreign fleets. The use of foreign fleets is still required under public fisheries agreements or other arrangements with one or more countries or a foreign private entity:

- Public agreement: free license regime under the protocol of agreement with Senegal, 2013, expired in 2016. It has not been renewed.
- Public agreement: free license regime with the EU, 2015 for 4 years
- Private agreement: a free license regime under the agreement with the Japan Association of Tuna Fishery Cooperatives, the latest of which was passed in 2016.
- Private agreement: free license regime under the agreement with the Chinese company Poly-HonDone of 2010 (ratified by the National Assembly in 2011).

A.3.1 Fishing Agreement with Senegal

The first Convention in the field of fisheries and aquaculture signed between Mauritania and Senegal dates from 1983. Its purpose is to encourage cooperation between the two countries in the fields of fisheries and aquaculture. The last protocol to the Convention was signed on June 1, 2013 for one year and for 40 000 t of small pelagic species except mullets for up to 300 boats under quarterly license, with a royalty of 10 € per ton caught. 18 boats (6% of the authorized fleet) are obliged to land in Mauritania. This is also the case for chartered units. The main conditions imposed to Senegalese pirogues can be summarized as follows: (i) to pay 10 € per ton caught (i.e. 400 000 € per year for the 40 000 ton of annual quota); (ii) to have a voucher issued by the competent Senegalese authorities; (iii) to pass at the point of entry and exit of waters under Mauritanian jurisdiction, located off N'Diago (a village bordering Senegal, 11 km north of Saint Louis); (iv) to report catches at the end of each tide at the N'Diago crossing point; and (v) to ensure that 6% of the authorized fleet disembarks at Nouakchott.

The last protocol of agreement was signed between the two parties on December 4, 2014. It concerns both the migratory stocks of small pelagic species in the South Zone, but also of pole-and-line boats that catch tunas. Several novelties have to be reported with respect to the former protocols. This protocol allocates a quota of 50 000 ton, which can be exploited by 200 purse seines, i.e. 400 boats targeting small pelagic species (Southern stocks), with the exception of mullet, in order to supply the Saint Louis market. The other clauses of the 2013 protocol remain unchanged.

A.3.2. Private Agreement between Mauritania and Japan Tuna

The last fisheries agreement with the Japan Tuna Fisheries Cooperatives Association was signed in 2016. It covers 36 months (3 years). Twenty Japanese longliners are allowed to operate in Mauritanian waters. The characteristics of these units are defined (equipment on board, type and number of fishing gear, storage capacity, number of seamen).

A.3.3 Private Agreement with Poly-HonDone Chinese Company

In June 2010, Mauritania signed a 100 million USD Settlement Agreement with the Chinese Company Poly-HonDone Pelagic Fishery Co. Ltd. Part of the Chinese group Poly Technologies Inc[2].

The investment objectives are based on three components: (i) construction of a processing unit (a refrigeration complex, an ice plant, two processing units and a fishmeal production unit) with a capacity of 6,000 tonnes of fish, (ii) development and construction of a landing wharf and boat dock, and (iii) a workshop for the construction of 100 artisanal fishing pirogues and the acquisition of coastal and industrial units.

The fishing quotas authorized under this scheme are between 80 000 tonnes and 100 000 tonnes per year, mainly consisting of small pelagic species (80%), but also of demersal species including octopus (20%). The

[2] This agreement is criticized by fishing professionals, NGOs and some parliamentarians on several aspects:
- its duration, which extends over 25 years.
- the possibility of marketing its products, and even those of other domestic producers, in direct competition with national operators and the SMCP.
- absence of specifications with respect to the fishing units operating in the area, the species to be fished and the opportunities concerned;
- Introduction to pair trawl fishery, a fishing gear likely to have negative effects on resources and their environment.

agreement commits the investor to create 2,463 permanent jobs and to guarantee the professional training of the Mauritanian nationals that will have to be employed.
The Protocol of Investment Agreement attached to the Convention refers to the processing and upgrade in Nouadhibou of 100 000 tonnes of fishery products. In addition to 26 offshore vessels[3], about 100 artisanal fishing boats and approximately 20 coastal boats are authorized to work within this scheme, including 4 "caseyeurs", 8 longliners and 8 "fileyeurs". The fleet to be engaged includes 146 boats and fishing vessels[4] that will be subject to the acquisition regime and will therefore be registered in Mauritania.

A.3.4 Agreement with European Union

Since 1987, the date of the first conclusion of a fisheries agreement with the European Union (EEC), Mauritania has not ceased to renew this privileged partnership. The last one signed in 2006, the biggest signed by the European Union with a third country, has already been the subject of 4 signed protocols, the last of which runs from November 2015 to November 2019. It covers small pelagic species, hake, bottom fish, shrimp and deep-sea tuna. Fishing volumes are based either on the capacities (GT and/or number of boats) or more recently on quota by species or group of species.

Fishing opportunities are being reduced near the conclusion of a new protocol[5]. The current protocol is structured around the access to 8 categories of fisheries related to highly migratory species (tuna and associated species), crustaceans, demersal fishes, small pelagic species and cephalopods (no fishing opportunities currently allocated to this category), for a total annual authorized catch of 274 000 tonnes allocated to a maximum of approximately 135 fishing boats per year.

Table 11: Annual fishing opportunities granted to EU boats since November 2015

Fishing Categories	Total Admissible Catches and Reference Tonnages
1 Crustacean fishing boats (excluding lobster and crab)	5,000 tonnes
2 Trawlers (non-freezer) and black hake longliners	6,000 tonnes
3 Fishing vessels of demersal species other than black hake with gear other than trawls	3,000 tonnes
4 Tuna seiners	12,500 tonnes
5 Pole-and-line tuna boats and surface longliners	7,500 tonnes
6 Freezer trawlers for pelagic fishing	225,000 tonnes (*)
7 Non-freezer pelagic fishing vessels	15,000 tonnes (**)
8 Cephalopods	(pm) tonnes
(*) With an authorized exceedance of 10% without affecting the financial contribution paid by the European Union for access; (**) If these fishing opportunities are used, they shall be deducted from the total allowable catch in Category 6	

[3] 5 bottom trawlers, 5 pairs of pelagic trawlers and 16 seiners.
[4] The constantly postponed arrival of small pelagic fishing boats created a dispute between the two parties. The agreement was suspended at the end of October 2012 by the Mauritanian side for non-compliance with contractual commitments. In April 2013, the Chinese company was allowed to resume fishing after some commitments
[5] The annual fishing opportunities for small pelagic species, which corresponded to 450 000 tonnes in 2006, were reduced to 300 000 tonnes in 2012 and then 225 000 tonnes for the last 2015/2019 protocol. The cephalopod fishery, which was historically important, and which corresponded to catches in the order of 25 000 tonnes in 2011, was excluded from the new protocol. Since 2012, these resources are now allotted to domestics only.

A.3.5. Biological Rest

The **biological Rest** refers directly to the **octopus** and the **shrimp**, but other demersal species, given the large by-catch of octopus by shrimpers. In Mauritania, fisheries management plans have favored short-lived species (octopus, shrimp, small pelagic species, etc.) whose exploitation is based solely on 1 or 2 annual cohorts due to the importance of the economic and social issues tied to their exploitation, the management difficulties and the over-exploitation state of the octopus. Stock size is directly linked to the recruitment success of new cohorts of fish, which present strong seasonal and inter-annual variations, the determinants of which are still poorly known. However, these species can withstand a high level of exploitation and, in the event of a collapse, as observed for octopus in the Dakhla area of Western Sahara, the population can recover quickly if, on the one hand, fishing efforts are placed under strict control and on the other hand if environmental conditions become favorable again. The other small pelagic species (sardinella, chinchards, mackerel), which have a significantly longer lifespan, also belong to this group which is characterized by its great instability linked to the dynamics of the upwelling.

A.3.6. Illegal, Unregulated and Unreported Fishing

A National Action Plan aimed at combating, deterring and eliminating illegal, unregulated and unreported fishing has been developed by the MPEM. Pauly et al. (2014), for example, estimated the actual harvest levels of Chinese fisheries around the world. For the West African zone, the Chinese fisheries would harvest 2.9 million tonnes per year. These estimates are provided without distinction between the affected countries and the species concerned, making them problematic for evaluation purposes. Illegal, unregulated and unreported fishing could alter both the perception of the situation for scientists and the dynamics of resources and fisheries at the national and subregional levels.

The Mauritanian Coast Guard and the Fisheries Department are well aware of these issues and the appropriate arrangements have been put in place (new radar stations with the German cooperation support, coordination of the landing data collection of artisanal and coastal fishing in real time, surveillance of fishing sites, port of N'Diago to better secure the southern borders etc.).

B. Exploitation System

The fishing fleet active in the Mauritanian zone includes an **artisanal and coastal fishing fleet (ACF)** and an **industrial pelagic and demersal fleet**.

The decree on the General regulations for the application of Law No. 017-2015 of July 29, 2015 establishing the Fisheries Code stipulates that commercial fishing includes artisanal, coastal and industrial fishing. This decree states that:

- Maritime artisanal fishery includes any fishery conducted on foot or by means of vessels of an overall length (LHT) of less than or equal to fourteen (14) meters, not motorized or with an engine of lesser power or equal to 40 horse-power and operating with passive fishing gear, with the exception of the purse seine. There are four categories of artisanal fisheries: cephalopods, crustaceans, bottom dwellers fishes and pelagic fishes.
- Maritime coastal fishery includes fishing conducted by a vessel (i) of less than or equal to 26 meters in length for demersal fishing and (ii) of absolutely less than 60 m in length for pelagic fishing. They operate with passive or non-passive gear except for bottom trawl and dredge. Coastal fishery produces solely fresh produce that are landed and marketed from Mauritania. The coastal fishery consists of four (4) categories: cephalopods, crustaceans, bottom dweller fishes and pelagic fishes. Pelagic fishes include three segments: seiners of

LHT less than 26 m, seiners of LHT from 26 to 40 meters, and pelagic seiners and trawlers of LHT of 40 to 60 m.

- Industrial maritime fishing includes any commercial fishery using vessels having characteristics other than those defined above.

B.1. Artisanal Fisheries

Due to their very adaptable nature, in a very dynamic environment (migration of fishermen, fishery resources, market, etc.), Mauritanian artisanal fisheries have been rapidly developing particularly during the last ten years, despite the scarcity of some demersal resources, especially octopus.

In more than thirty years of existence, the IMROP surveys conducted twice a year have highlighted the spectacular development of artisanal fisheries. **The active pirogue fleet increased from 530 units in 1982 to 4,182 vessels in 2010. The number of units continues to rise, with more than 6,000 pirogues in 2014.** The growth factors for this type of fishing are particularly important: increasing of the size of pirogues, motorization, navigation aids. It is estimated that the **fishing effort of this fleet has increased by more than 15 times over the last 30 years**. Long considered to be relatively marginal, artisanal fishing has taken a very important place in Mauritania, with a production volume equivalent to that of industrial fishing for some years.

Senegalese artisanal fishing, operating in the Mauritanian zone in accordance with the 2001 convention or under charters, reinforces the pressure of this segment. In the new protocol signed in June 2013, Mauritania authorizes 300 Senegalese pirogues to fish in Mauritanian waters under the same conditions as the Mauritanian units. No spatial constraints are imposed on this segment outside the Banc d'Arguin, where only non-motorized artisanal fishing is permitted. On the other hand, it has an exclusive coastal zone reserved. This reserved area is located within 6 miles in the southern part of the MEEZ which concerns the Ahmeyim/Guembeul project and less than 9 miles elsewhere (Fig. 17). Since early February 2017, Senegalese boats and fishermen are no longer allowed to operate in the Mauritanian zone.

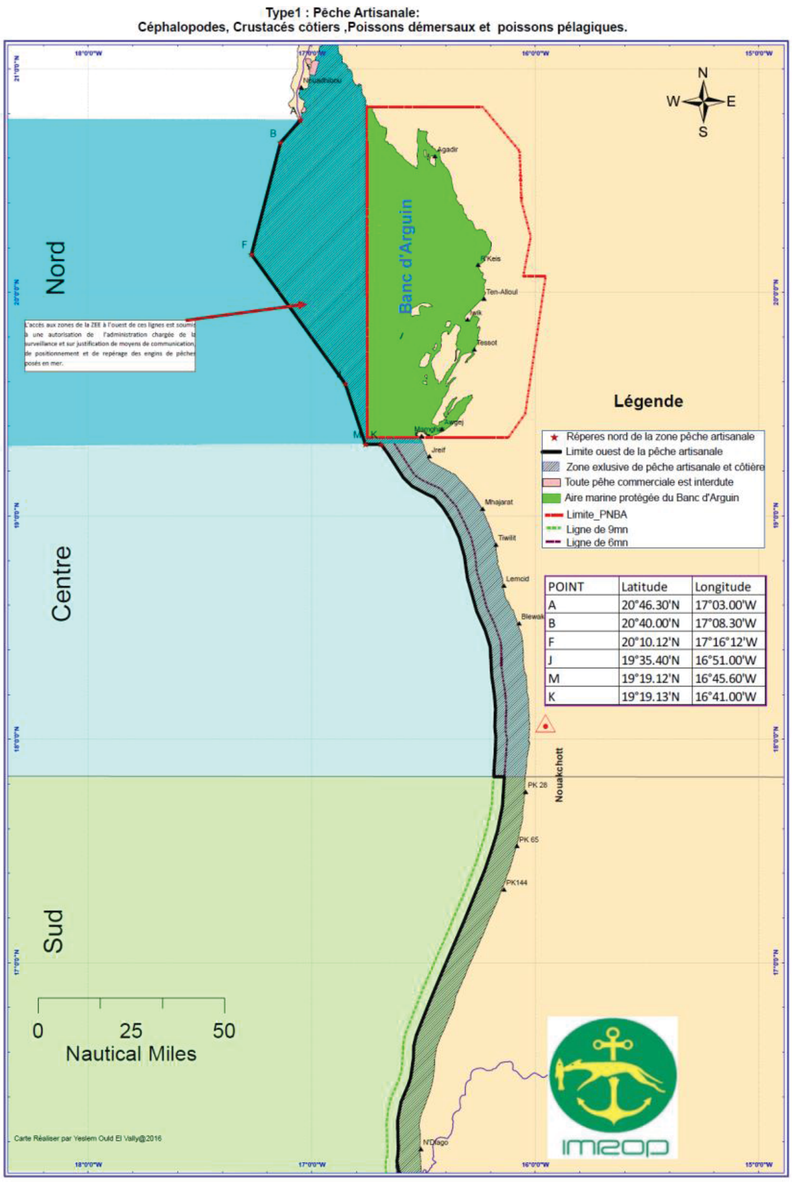


Fig. 17. Area Reserved for Artisanal Fishing.

B.1.1 Evolution of the Size of Artisanal Fishing Fleet

The pirogue park has more than doubled in 10 years from 3,008 units in 2006 to 6,244 units in 2016. This increase is mainly due to the increased number of plastic boats, which was 850 units in 2006 and reached 3,900 units in 2016 representing 3,100 more units (310 new units each year) (IMROP, 2012, 2013 and 2014). These plastic boats are mainly built in Nouadhibou on a dozen construction sites.

Located in the northernmost part of Mauritania, the Nouadhibou area is the first Mauritanian maritime area for artisanal and coastal fishing, where more than 53% of the fishing units are concentrated (Fig. 18). All types of vessels are represented, with the exception of sailing units (lanche). There is a clear dominance of plastic boats (77% of these units were concentrated in this area in 2014), followed by wooden boats (12%). On the other hand, in the Nouakchott, central and southern zones, the artisanal and coastal fleet is dominated by wooden pirogues, representing 86% of the total fleet in this sector. With the important decline of the wooden pirogues fleet following the non-renewal of the protocol agreement between Mauritania and Senegal, and following the withdrawal of Senegalese fishermen and pirogues, the port of Tanit to be completed by the end of 2017 and located 60 km north of Nouakchott, will generate some interest for the increasing number of plastic boats that cannot easily land on the beach. Artisanal fishermen in the southern zone of Nouakchott who choose to settle there should benefit from an increase in income resulting from the demand for fish of better quality and in greater quantities. In the medium term, it will be the port of N'Diago’s turn. Despite certain achievements and a better safety for goods and people, these types of infrastructure such as the autonomous port of Nouakchott, are likely to alter the sedimentation regimes and the ecological characteristics of the littoral zone. In addition, it would disrupt local marine ecosystems and oblige fishermen to change gear and targeted species.

In all cases, it is clear that following these recent developments (departure of the Senegalese pirogues and their crew, opening of the port of Tanit) a decrease in artisanal fishing activity in the southern zone of Nouakchott will be recorded. This activity is currently already quite small with a density of 20 fishing units per km of coast against 138 units per km in Nouakchott and 350 units per km in Nouadhibou.

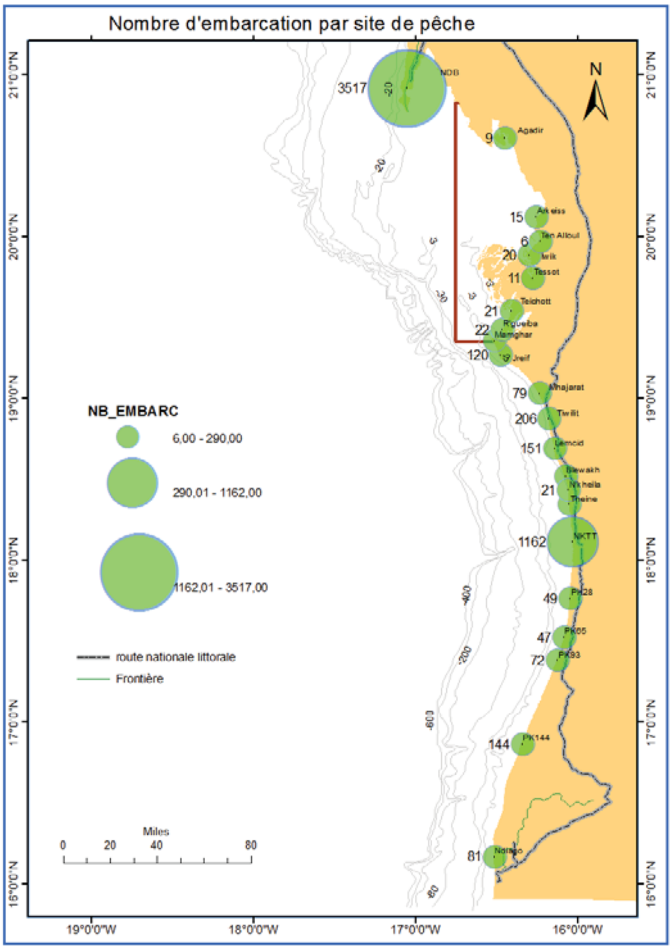


Fig. 18. Distribution of Artisanal Fishing Units by Landing Site throughout the MEEZ
(source IMROP April 2016).

The sites south of Nouakchott (Pk 28, Pk 65, Pk 93, Pk 144, and N'Diago, Fig. 19), which are of interest for the Ahmeyim/Guembeul project, spread out over 200 km, and include only 400 boats which are mostly wooden pirogues that can fairly easily land on the beach without any specific infrastructure. The range of these small-scale fishing units is relatively small due to the proximity of the fishing zones and their limited engine power dominated by 15 horse-power engines (IMROP, 2016). Conservation methods, which use ice in the best case scenario, when it is available, prohibits a prolonged stay at sea.

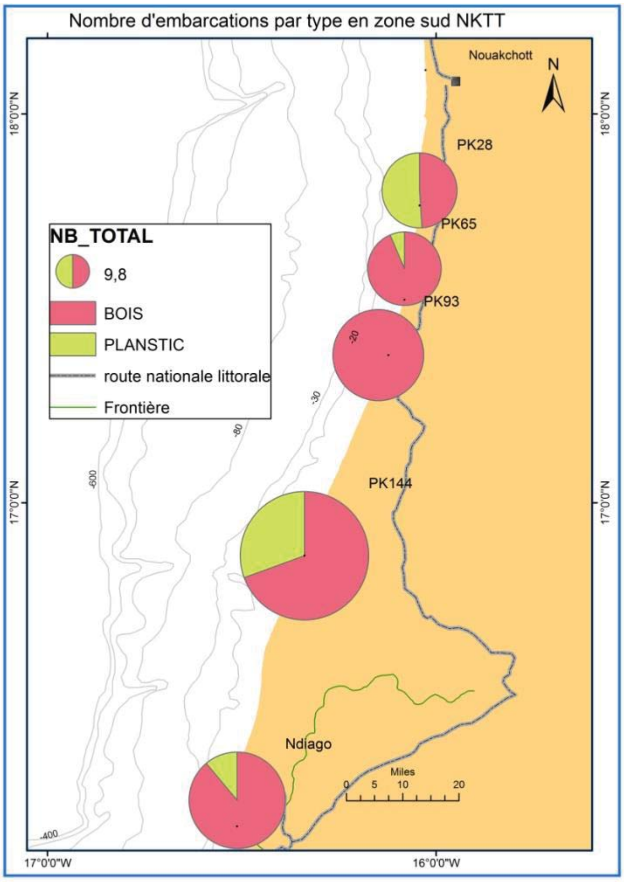


Fig. 19. Distribution of Artisanal Fishing Units by Landing Site in the Southern Part of the MEEZ (source IMROP April 2016).

B.1.2. Evolution of Artisanal and Coastal Fishing Gear

Over the past ten years, there has been a rapid evolution in the frequency of use of some passive fishing gear such as octopus traps, nets and longlines. The octopus trap was already very present in 2006 (60.2% of the pirogue fleet was using this technique) and literally exploded to represent more than 83% in 2016. The number of these octopus traps was multiplied by a factor of 4.6 within 10 years. The ground nets and the drifting gillnets, generally in mono-filament (but also in wired nylon nets), have also become widespread despite the ban. The number of units with ground nets has increased by 80% within the two years. The units fishing for clupeidae with purse seine, which were absent in 2006, reached 134 units in 2016 following the development of the fish meal industry. On the other hand, the use of courbine nets has registered a fall of more than 60% following the prohibition of the exporting of several species of fresh fish including the meagre.

It, therefore, seems clear that the practice of artisanal and coastal fishing with passive fishing gear (fixed nets, traps, longlines) is becoming increasingly important. This evolution has been to the detriment of handlines, whose catches are of better quality but whose implementation requires endurance and technique which is not always mastered by Mauritanian fishermen due to lack of adapted training and maritime tradition. The departure of Senegalese fishermen following the non-renewal of the fisheries agreement between Mauritania and Senegal and the Mauritanian government's decision to increase the Mauritanian presence in this segment, is expected to accentuate this trend in the short and medium terms.

B.1.3 Artisanal Fishing Catches

Catches for artisanal and coastal fisheries have more than doubled between 2011 and 2013, rising from around 160,000 tonnes to more than 330,000 tonnes in 2013, seizing the void left by foreign industrial boat owners as a result of the non-renewal of the fisheries agreements. From 2012 to 2015, the average annual catches of artisanal fisheries landing in Mauritania was about 300,000 tonnes (Table 12).

Table 12. Average Annual Production and Size of Pirogues (2012/2015) and Contribution of each Zone.

Zone	Production (tonnes)	Number of pirogues	Yields per pirogue (tonnes)	Contribution of the zone to the production (%)
Northern	229,125	3,517	65	76
PNBA	3,233	221	15	1
Central	7,454	951	8	2
Nouakchott	53,861	1,162	46	18
Southern	6,161	393	16	2
General Total / Average	299,834	6,244	48	100

Landings by artisanal and coastal fisheries in the northern zone account for more than 76% of all catches in this segment, with a yield per pirogue four times greater than in the southern zone, which directly concerns the Ahmeyim/Guembeul project. The contribution in the area south of Nouakchott, which is of direct interest to the Ahmeyim/Guembeul project, remains marginal (2%).

In order to characterize the catches of artisanal fisheries by landing site, Table 13 presents the average annual production for the period 2012/2015 for Nouakchott and each of the small villages. Apart from Nouakchott, it is the village of N'Diago where landings are the most important.

Table 13. Average Annual Production (2012/2015) per Site in the Project Core Study Area.

	Production in Tonnes
Nouakchott	53,861
PK 28	1,481
PK65	515
PK93	1,429
PK144	345
N'Diago	2,391
General Total	60,022

In the northern zone, artisanal and coastal fisheries landed 180 different species. However, the first seven species accounted for more than 93% of the catches on an annual average for the period between 2010 and 2014. The three main species of clupeidae (small pelagic species) account for 92% of these seven species, whereas demersal species account for 6%. The remainder are distributed between the meagre and the mullet, two semi-pelagic species (Fig. 20).

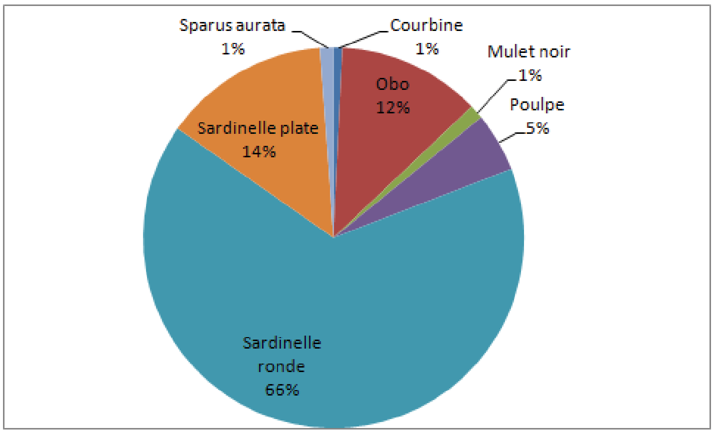


Fig. 20. Proportion of Average Catch per Species for the Artisanal Fisheries Segment in the Northern Zone (Nouadhibou) between 2010 and 2014 (Source: IMROP).

B.1.4 Biodiversity of Aquatic Fauna and Artisanal Fishing in the Diawling National Park (DNP)

The Diawling National Park is located in the deltaic part of the Senegal River. This river flows through four countries of West Africa: Guinea, Mali, Mauritania, and Senegal. Recurring drought and numerous developments have considerably altered its natural functioning over the last few decades. For example, the construction of important hydro-agricultural infrastructure (dams in Manantali and Diama), and various developments (breach) often carried out in a curative way contributed to the salinization of land and water. This creates serious difficulties for agriculture and artisanal fisheries (Jacout, 2006) as well as for the biodiversity of aquatic fauna, mostly for anodromous species.

B.1.4.1. Aquatic Fauna Biodiversity in the DNP

There are 141 different species of fish at the level of the Senegal River (Hoga, 2013). For this author, none of these species is endemic. Benthopelagic species, between 92 and 170 cm in total length, are represented by North African catfish (*Clarias gariepinus*), electric catfish (*Malapterurus electricus*) and African carp (*Labeo coubie*). Demersal species present in the river's basin and measuring between 150 and 204 cm in length include *Gymnarchus niloticus*, Nile perch (*Lates niloticus*) measuring 183 cm and Sampa (*Heterobranchus longifilis*), and *Mormyrops anguilloides*. Pelagic species, whose maximum size varies between 16 and 65 cm, include *Brycinus macrolepidotus* and Pellonulin (*Odaxothrissa ansorgii*). Scientific monitoring of aquatic fauna in the various sectors of the DNP and in the peripheral areas, were carried out over several years (IMROP, 2005) and revealed the presence of 87 different species including 47 freshwater species and 40 estuarine and marine species. Freshwater fish are represented by *Clarias* sp., *Tilapia* sp., *Lates niloticus*, *Citharinus citharus*, *Labeo coubie*, *Hydrocunus brevis*, etc. Estuarine and marine species include *Mugil cephalus*, *Ethmalosa fimbriata*, *Albula vulpes*, *Liza* sp., *Enneacampus kaupi*, etc. Aquatic invertebrates are represented by crustaceans of the decapod order including *Syciona carinata*, *Penaeus notialis* and *Paneus kerathurus*. In total, about ten species of shrimp belonging to the *Peneidae* family are reported to the DNP (FFEM 2005). These species are targeted by fisheries during the decrease in water levels, mainly between November and March.

B.1.4.2. Artisanal Fisheries in the DNP

Prior to the construction of the Diama dam on the Senegal River in the mid-1980s, fishing was considered to be the emblematic activity for people of the Lower Delta (André, 2007) where the current DNP is located. Fishery resources were very important. Since the completion of this structure, these resources have sharply decreased and changed.

Marine fish species have replaced estuarine fish species downstream of the dam, whereas freshwater fish species subsist upstream of the dam.

Virtually every village has a fraction, even a small one, of fishermen.

Several sites are suitable for fishing, particularly at the level of the different types of infrastructure (Chayal, Lemer, Lekser, Bell) and in the N'Tiallakhe basin (Fig.21). The Cheyal and Lemer infrastructure concentrate the main part of the fishing activities from November onwards following decrease in water levels. The Gambar site, where intense fishing was once practiced, is now invaded by typha and is exploited only very occasionally.

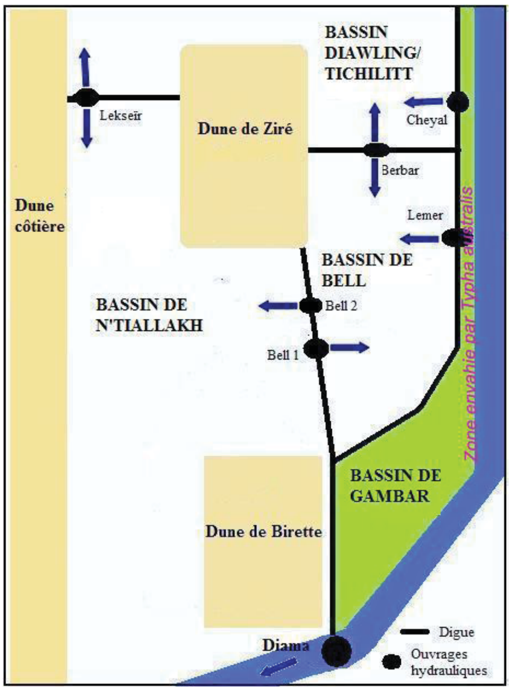


Fig. 21. Main Fishing Areas in the DNP Area.

The main fishing techniques used in these infrastructure are small cast nets[6], longlines and gillnets. Unbaited longlines of about 100 m long are equipped with several hooks measuring between 10 and 12 mm. Passive gillnets measuring between 50 and 100 m in length are the most common fishing gear. As for longlines, the gillnet is installed for several days and lifted in late morning and in the afternoon.

The pirogue fleet in the Ntiallakhe estuary consists of about fifteen Senegalese pirogues, one third of which are motorized. They are used occasionally for the installation of passive nets. They are mainly used to transport people and goods between the villages of the coastal dune and the town of Saint-Louis. Also, fishing is often practiced on foot. The main species of fish caught are: *Tilapias zilii*, *Oreochromis niloticus*, *Lates niloticus*, *Synodontis schall* and *Heterotis niloticus*.
Estimated fishery production, based on the results of surveys carried out by the ecological monitoring service at DNP fishing sites, are available from 2013 to 2016 (only for January for this last year). The volume of catches for the 2009/2010 season reached 64 tonnes of fish. The volume of catches increased significantly in 2013 and 2014 to 147 tonnes in each of these two years before declining rapidly in 2015 (Fig. 21) regardless of the increase in fishing effort. Table 13 shows the annual evolution of the fishery production for the two main fishing areas in the DNP.

[6] between 2.5 and 3 m high, with a circumference of 3 to 5 m, mesh between 30 and 40 mm.

Table 14. Evolution of Catches (in kg) in the Two Main Fishing Sites of the DNP.

	Cheyal	Lemer	Total général
2013	**94349**	**49799**	**144148**
2014	**95058**	**49711**	**144769**
2015	**44523**	**31364**	**75887**
2016	**2655**	**1778**	**4433**

Also, the daily yields per fisherman, which averaged between 21 and 24 kg in 2013 and 2014 respectively, were no more than 17 kg in 2015, a decrease of 29% (Table 15). The fisheries in Cheyal were the most affected (-50%), whereas it was the most important fishing site with about two thirds of the production in 2013 and 2014.

Table 15. Evolution of Yields (in kg/fisherman and per day) in the Two Main Fishing Sites of the DNP.

	Cheyal	Lemer	Autres sites (Crevettes)	Rendement moyen
2013	22	22	8	21
2014	21	28	8	24
2015	11	23		17
2016	6	11		9

With less than 2 tonnes of production in 2013 and 2014, shrimp catches fell by more than 50% from their 2009/2010 production level of 4 tonnes. Such a decline appears to be persistent in time as IMROP (2005) reported an annual output approaching 20 tonnes in the early 2000s.

Fresh fish is sold on the spot where fish merchants from Saint-Louis (Senegal), Keur Macene and Rosso come to fetch it. It is also used for self-consumption and can also be sold to supply surrounding villages. The unsold portion is transformed into dried fish (Guedj) which is sold in Saint-Louis and/or in Nouakchott.

In the end, despite the low catches in this sector compared to the marine environment, the economic, social and nutritional benefits to the local population are far from negligible.

B.1.4.3. Migratory Species

Migratory species such as mullets, coastal shrimps and most likely eels make the DNP unique at the fishery level and constitute a natural heritage to be promoted for present and future generations. Although these resources are still relatively large in some DNP basins[7], they have faced multiple aggressions and disruptions. These have led to the degradation of the aquatic environment (hydro-agricultural development[8], sand dunes, explosion of the typha invasive species, intensive fishing at critical times of development) and hamper their migratory circuit. In view of this, the DNP's administration, with the

[7] Some DNP basins are known to host almost exclusively one or the other of these species, such as the mullet lake or the shrimp basin

[8] This environment suffered for about half a century from the 1970s to a severe drought interrupted by short episodes of wet conditions. The estuarine processes have also undergone another ecological attack: the construction of the anti-salt Diama dam at 50 km upstream of the mouth of the Senegal River.

support of its technical and financial partners, has for many years supported restoration actions in favor of these fisheries resources and their habitat.

Before the construction of the dam, the lower delta was colonized by marine and estuarine euryhaline fishes, outside of the flood period. These are mainly *Sarotheron melanotheron, Ethmalosa fimbriata, Elops lacerta, Mugil cephalus, Liza falcipinis, Tilipia guineensis, Dicentrarchus punctatus* (Anonymous, 1988). During the flood period, marine species give way to euryhaline estuarine freshwater species. With the construction of the Diama dam, the settlement living off the estuary and the species with marine affinity stop at the Diama dam. Continental species have progressed further downstream and are now living there throughout the year.

The yellow mullet and the coastal shrimp are both of great commercial importance to sea fishing, where two fisheries have developed for several decades. These different species are anadromous. These amphibiotic migratory species can live in fresh water and sea water. They spend most of their lives in the sea and migrate to fresh water to reproduce. Other mullet species such as sicklefin mullet (*Liza falcipinnis*) and ethmalose (*Ethamalosa fimbriata*) may also be considered anadromous species.

In the absence of targeted studies, it is not possible to conclude whether all these species are potamodromes, i.e. that they only spawn in fresh water and they grow in sea water or that part or all of the breeding occurs in the sea and they have their eggs and larvae are carried away by tidal currents[9] towards the mouth of the Senegal River.

The absence of eggs and larvae of these species in the few plankton samples makes it possible to conclude that the egg laying of the yellow mullet is probably carried out in the sea on the coastal highlands and all the studies carried out in the lower delta of the Senegal River have highlighted the importance of the estuary in the life cycle of the mullet, due to having observed several cohorts of juveniles (Mohamed Vall, 2004).

The young European glass eel, *Anguilla anguilla*, has been reported by several fishermen and scientists in the Senegal River Delta and in the R'kiz Lake, the only perennial pond located on the right bank of that river, at more than 200 km from its mouth. The young glass eels start their life in the Sargasso Sea and cross the Atlantic to reach Europe and Africa. In 2009 the glass eel was listed on the Red List of Endangered Species by IUCN (International Union for Conservation of Nature). These fry are highly in demand in several countries.

Due to the importance of the DNP area in the life cycle of the *Mugil cephalus* and the coastal shrimp (DNP presumed to be the reproducing area of these species of great economic and social importance, but also potentially as a growth area for juveniles of the European glass eel, which are of very high commercial value), the sustainable management of these species and the protection of these areas against all sources of pollution is therefore of strategic interest to both Mauritanian and Senegalese fishermen. An adapted management system should therefore be put in place quickly, as is the case for the coastal fishing fleet.

[9] For yellow mullets, currents play an important role in their migration, particularly for juveniles. Thus, after spawning in the southern part of the coast, pelagic eggs and larvae drift with the current towards the growth area in the lower delta of the river. They must stay there until the age of two years before returning again to the sea, leaving by the Langue de Barbarie near Saint-Louis (Mohamed Vall, 2004).

B.2. Coastal Fishing Fleet

In Mauritania, coastal fishing is a relatively poorly known sub-sector and little statistical or economic data are currently available. This activity, which has been limited in the past to approximately 100 old fishing units, inherited from Canary fishermen or acquired through support from foreign development partners, was classified as artisanal. The captains of these boats were not required to fill the fishing logbooks until 2015. This situation has been positively evolving since the appearance of foreign Chinese coastal vessels in 2012 and Turkey coastal vessels in 2015. Indeed, since the beginning of the 2010s, a process of changes in the production structures of the coastal fishery segment have begun. This reorganization was associated with the opening of this segment to foreigners, which was not accessible for them for the last thirty years, towards non-domestic (Chinese, Spanish, Portuguese, Moroccan and Turkish) gearing types that are much more efficient, resulting in a new weighting of these different players in the overall production of this sub-sector. This evolution was largely favored by the Mauritanian State's desire to accelerate the change in the exploitation of the coastal zone by selective fishing techniques (seines, nets, longlines, traps), in the wake of the distancing of the offshore fleets that occurred mainly in 2012. These techniques are better for preserving fisheries resources and their marine environment. The coastal fishery has a non-aggressive exploitation system for the seabed. It contributes little to the degradation of the marine ecosystem. It is also very selective both in terms of the sizes of the species caught, which generally comply with the regulations, and in terms of the specific composition of catches, which are limited to the species targeted with very few discards. In 2015, this subsector was officially recognized as an individualized segment with respect to other artisanal and offshore segments.
The overall finding is that the historical development of coastal fishing results from a threefold process:

- Exploitation by old domestic fishing boats looking for noble and/or most abundant and closest to Nouadhibou species (octopus, soles, croakers, mullets, etc.);
- Diversification since 2012 through the mobilization, within the framework of an agreement with a private partner, of new and more efficient fishing units of Chinese origin for the octopus fishery (traps), demersal fish (longlines) and croaker (nets) and the acquisition of second-hand units or chartering of foreign units, in particular Spanish, Portuguese and Moroccan units, for the pink lobster fishing;
- Geographical extension of operations, with the deployment further offshore of units and by targeting small pelagic species with large-scale seine vessels (40m) from China since 2012, but mainly from Turkey since 2015;

The Mauritanian coastal fishery covers a great diversity (fleets, catches, techniques). 4/5 of its catches are carried out in the extreme north of the Mauritanian EEZ. This mode of fishing therefore operates very incidentally in the central zone and not at all to the south of the Nouakchott area, which is of concern for the Ahmeyim/Guembeul project. Coastal fishery lands 100% of its catch in Nouadhibou. This situation is bound to evolve when the port of Tanit, located 60 km north of Nouakchott, will be inaugurated in February 2019 and later those of N'Diago and Pk28 south of Nouakchott.

This mode of fishing, whose landings did not previously exceed 10,000 tonnes, landed 62,500 tonnes of fish, crustaceans and molluscs in 2016. Small pelagic fish represent over 90% of these landings. This remarkable improvement is the result of the entry into operation of the chartered boats from Turkey, which serve to supply the fish and fish oil production units in Nouadhibou.
Taking into account the caracteristics of the fishing units used, their origin and the crew embarked, we can distinguish three types of coastal fishing.

B.2.1. Mauritanian Coastal Fishing

The coastal fleet consists of approximately 100 boats operating exclusively from Nouadhibou. Given the poor outdated condition of most of them (+ 70%), the richness of the coastal zone, the crew that is mainly from Nouadhibou, the absence of fishing ports in the central and southern zones, this activity takes place exclusively in the north of the Mauritanian EEZ. Therefore it does not concern the Ahmeyim/Guembeul project.

This type of fishing is using fishing boat units from Spanish or Japan, made of wood or aluminum. The average age of units is over 35 years. They are approximately 20 m long and 350 hp. They use different fishing techniques depending on the seasonality of the target species: traps for octopus, nets for croakers, mullets, sole and lobsters. Their number, which was closed to a hundred, is in great decline due to repeated breakdowns. Their activity is mainly restricted to peak production periods during each fishing season.

A new shipyard was set up in 2014 in Nouadhibou with the support of a Japanese corporation (Yamaha). Fiber coastal vessels for octopus fishing are built. About thirty units have been produced so far, designed on a Japanese model. This first phase is planning for the construction of about fifty units in total. A second phase is planned and aims for the construction of about fifty more units specialized in the fishing of small pelagic species. The units that are already operational are used exclusively in the northern zone of the Mauritanian EEZ.

A coastal fishery for pink lobster began in February 2015. It consists of 23 “fileyeurs” under 25 m LOA, operating under two different regimes: 12 domestic and 11 chartered vessels operating at depths of 300 to 400 m. The 763 tonnes of live lobsters harvested in 2015 are transferred and transported to Portugal in trucks equipped with refrigerated fish tanks.

B.2.2. Chinese Coastal Fishing

Under the agreement with Poly-HonDone Pelagic Fishery Co. Ltd., part of the Chinese group Poly Technologies Inc., Mauritania allows 20 Chinese coastal vessels to operate in its EEZ. These units have an LOA of 25.9 m, a gross tonnage of 85 tonnes and engine power of 220 KW. This fleet consists of “fileyeurs”, “caseyeurs” and longliners, which differ only in the fishing techniques used.

A follow-up by the scientific observers of the Mauritanian IMROP that were on board these vessels in 2012 allowed to determine that the fishing zone of these vessels is located almost exclusively in the northern zone. In addition to the northern zone, the “fileyeurs” also operated in the center zone. The average depths are 23 m for longliners, 24 m for “fileyeurs” and 28 m for the “caseyeurs”. The daily yields are very low for longliners and usually do not exceed an average of 131 kg per day. Fished species consist of 45% of bluespotted seabream and 25% of tollo. Discards are estimated at 1%.

The “fileyeurs” are very efficient. The daily yield is 1121 kg, consisting mainly of 98.4% of demersal, 1.4% of pelagic species and 0.2% of cephalopods. The croakers and the sweetlips represent respectively 38% and 25% of the total captured. Almost all (99%) of the fished croakers have sizes below the minimum allowed size. Discards are estimated at 2%.
The “caseyeurs” are efficient, very selective and mainly target cephalopods. Daily yields increased from a minimum of 989 kg to a maximum of 1510 kg, composed of 95% octopus, 3.70% cuttlefish and 1.50% of the various other demersals.

B.2.3. Turkish Coastal Fishing

The first seine vessels authorized to work in the Mauritanian zone, chartered by Mauritanian operators, are reported for the first time in 2015. By 2017, there were 22 seine vessels (Ozturk, 2017). The seiners, most of them considered to be coastal units, despite their size (40m), are mainly looking for small pelagic species (sardinella, sardines, horse mackerel) to supply the fish and fish oil production units installed in Nouadhibou. In 2016, production reached more than 52,000 tonnes, including 54% sardinella and 23% sardines. Horse mackerels also represent an essential component (15%) (Table 16).

Table 16: Production in tonnes of the small pelagic fleet in 2016 (source: fishing logbook)

Species	Sardinella	Sardine	Horse Mackerel	Mackerel	Other Pelagics	Mullets	Hake	TOTAL
Production	28,181	12,158	7,944	340	1,902	1,191	519	52,235
Contribution (%)	54	23	15	1	4	2	1	100

B.3. Industrial Fishing

This segment includes pelagic and demersal fisheries. Access of foreign interests to Mauritanian resources is granted under various fisheries agreements with the European Union (EU), Russia (small pelagic species), Japan (tuna) and Senegal (tuna and small pelagic species). Other foreign vessels operating in the area operate under free licenses.

The most important Memorandum of Understanding with the EU covers a period of 4 years (from 16/11/2015 to 15/11/2019) and allows the EU fleet to fish for shrimp, demersal fish, tuna and small pelagic fish in Mauritanian waters, for up to a total of 281,500 tonnes per year. Quotas of squid and cuttlefish have recently been allocated to the EU following the revision of the financial compensation paid to Mauritania. For the Mauritanian government, foreign fleets do not constitute overcapacit

B.3.1. Industrial Pelagic Fishing

These fisheries include small pelagic fisheries and tuna fishing. Industrial fishing of small pelagic species contributes to most of the landings.

B.3.1.1. Industrial Fishing Efforts

Small industrial pelagic fishing vessels freeze their catches on board. They mainly have two origins: Russian boats, specialized in the fisheries of chinchards and mackerel, and EU vessels which mainly search for clupeids[10]. Until recently only trawlers were present. A slow entry of purse seiners, mainly of Chinese origin, has been observed since 2013. This activity, which takes place within the framework of experimental fishing (case of the Chinese), is still inconclusive, and will not be discussed in the present report.

Therefore, the activity remained almost exclusively the one of trawlers. These devices are designed and armed to operate in midwater. For Dutch units, the rig ensures sufficient buoyancy for the surface trawl (Ould Taleb Sidi, 2005). To target chinchards and mackerel, Russian industrial fishing units use trawls with a fall at 72-80 m.. These Dutch fishing units use large pelagic trawls, with a vertical opening of 30 to 40 m, and a horizontal opening of 60 to 95 m. In the shallow waters, the vertical opening is reduced to 20 m.

[10]The EU exploitation has been extended to those of mackerel and chinchards, following the subscription of the Baltic countries to this Union in which the large fleets of Russian origin already operated in the MEEZ from the mid-1990s.

Trawls are trailed near the surface[11], with emerging panels. The sardinella shoals, found near the surface, constitute the main target. Horse mackerels are secondary targets.

To target horse mackerels and mackerel, the Russian industrial fishing units use trawls with a fall of 72 to 80 m. This gives them a perimeter at the entrance of more than 1000 m and the possibility of reaching a depth of 300 to 400 m. They therefore operate at a certain depth, and at the same time bring back demersal species and other neritic species which are found in the intermediate water layers swept by their trawls.

The number of industrial vessels in the foreign fleet fishing for small pelagic species has an irregular progression, with an overall downward trend. The industrial pelagic fleet decreased from 64 units in 2011 to 45 units in 2015. This development follows the introduction of new regulatory measures deemed restrictive by foreign boat owners. On the other hand, the Mauritanian fleet, absent in 2011, increased very rapidly with 13 units in 2015 (DARE, unpublished data).

Fishing efforts, measured in number of fishing days, is concentrated in the northern zone. The use of free licenses is standard practice whereas chartering is in sharp decline (Fig. 22).

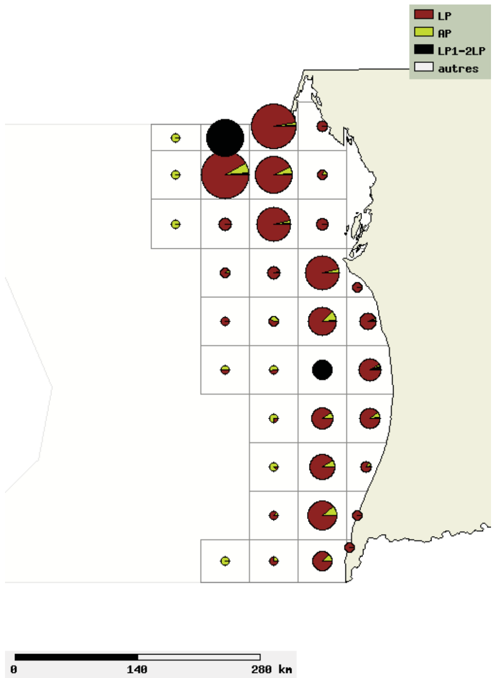


Fig. 22. Distribution of Fishing Efforts (in fishing days) for Industrial Fleet Seeking Small Pelagic Fish by Statistical Sectors of 30 nmi x 30 nmi in 2013.

B.3.1.2. Catches of the Industrial Segment

Reported catches by small pelagic industrial fleets amounted to about 1,000,000 tonnes in 2011 (Fig. 23, left). In 2012, the decrease in catches compared to 2011 reached 39%. A record drop was recorded in 2013 when catches in this segment did not exceed 300,000 tonnes. This situation is consecutive to the

[11] The rigging ensures a sufficient buoyancy to work at the surface. A float of 2000 liters is fixed at the end of each upper wing. There are also floats on the back rope attached by hooks called Tanvest (having roughly the dimensions and buoyancy of a domestic fuel tank).

withdrawal in cascade of foreign fleets as a result of the introduction, in the framework of a new 2-year protocol of agreement between Mauritania and the European Union signed in July 2012 and applicable to all industrial segments including pelagic, of regulatory measures considered to be very restrictive by the foreign boat owners. Catches recovered in 2014 to subsequently decline in 2015, when the agreement with the European Union was renewed only at the end of the year.

Chinchards represent the main target of pelagic industrial fisheries with average catches of 35% over the last five years, whereas sardinellas and sardines account for 27% of catches (Fig. 23, right). This probably does not reflect the difference in resource potential but is linked to the demand from international markets which pays better for chinchards (Eastern Europe and West Africa). With 12% of the catch, mackerel remains an important species, fished simultaneously as chinchards. The anchovy section, mainly constituted of chinchards juveniles, contributes on average to 7% of the total catches.

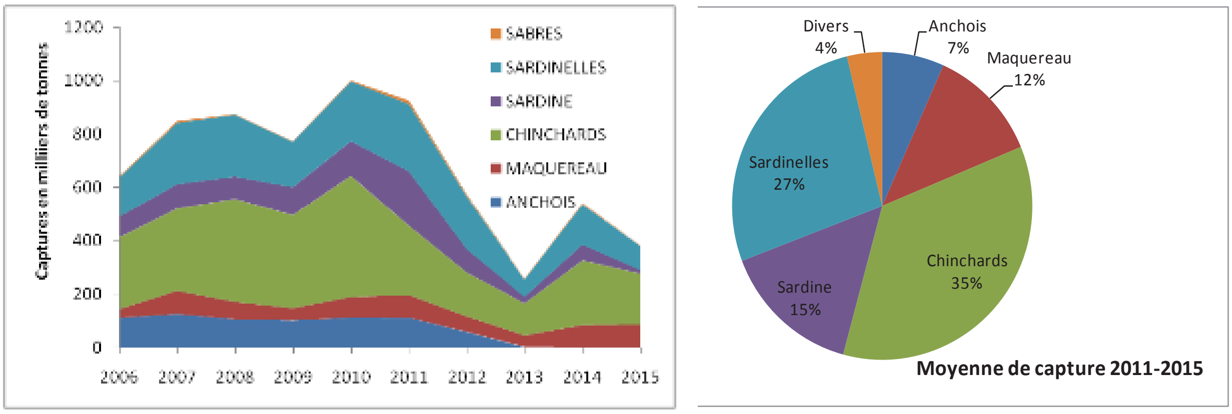


Fig. 23. Trends for Small Pelagic Catches by the Industrial Segment in the MEEZ (left) and Contribution of the Averages for the Main Species or Groups of Species (right) GCM, 2016, Unpublished Data.

B.3.1.3. Spatial Distribution of Small Pelagic Catches

Increase in catches is quite clear from south to north. This last zone (19 and 20°N) contributes with 60% of the catch on average (Fig. 24).

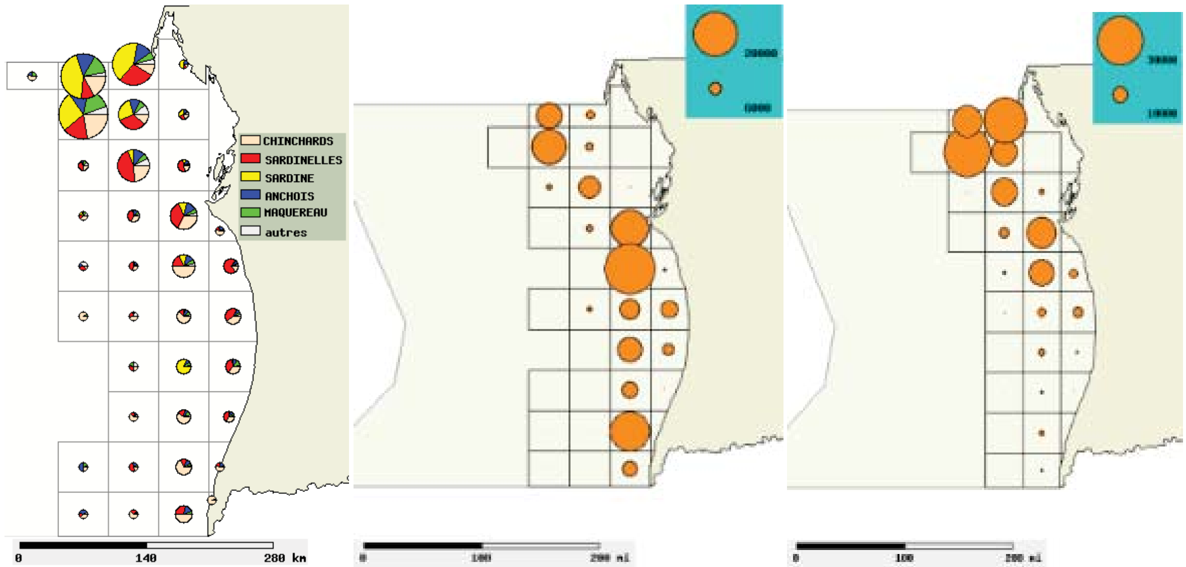


Fig. 24. Distribution of Catches per Statistical Square Group for Small Pelagic Species with a Zoom on Chinchard and Sardinella respectively (Sources: GCM 2016, unpublished data).

It is clear that **about 60% of small pelagic catches are made in the northern zone** (19 and 20°N) which is accessible from Nouadhibou. More specifically, sardinellas (Fig. 24, right), sardines and anchovies are the most concerned. The chinchard has a better distribution throughout the coastal zone including the project's core study area.

B.3.2. Industrial Fishing of Tuna

Three species of deep-sea tuna are exploited offshore of Mauritania exclusively by foreign fleets (European Union, Japan and Senegal) operating under a fisheries agreement. Skipjack (SKJ, *Katsuwonus pelamis)* dominates catches (94% on average), followed by yellowfin tuna (YFT, *Thunnus albacares*) and finally the bigeye tuna (BET, *Thunnus obesus*) (Ould Taleb Sidi, 2015).

Improvements in catches of these species were particularly notable in 2012 and 2013. Catches, which were negligible in 2011, reached over 21,000 tonnes in 2012 before rising by more than 47,000 tonnes in 2013 (+ 23%).

The skipjack fishery is currently practiced in large quantities with a fish-aggregating device (FAD) (98% and 94%, respectively, in 2012 and 2013), whereas in the past the resource was mainly caught in open banks (99% in 2004). In the case of pole-and-line vessels and longliners, the fishing period has spread over most of the year, but also offshore in latitude. The sizes and weights of fish caught are also exceptional (more than 3-4 kg per individual). Usually using FAD, the skipjack tuna are usually mixed with species of smaller size. In the Mauritanian zone, the schools of fish are composed of bigger and more homogeneous skipjack tuna. It seems that one of the main reasons for these extremely rapid changes is the better availability of food which could attract these almost insatiable species (Ould Taleb Sidi, 2015).

In 2014 and 2015, the EU fleet did not formally frequent the Mauritanian zone due to the end of the fishing protocol of 2012-2014, which took place at the end of July and coincided with the period of deep-sea tuna fishing in this area. The agreement with Japan, which expired in December 2013, was renewed only in 2015. Therefore, tuna fishing has been severely disrupted in the area in recent years after record levels of catches, particularly for skipjack using FADs.

B.3.3. Demersal Industrial Fishery

This mode of fishing targets both coastal and deepwater demersal resources. In the coastal area, there are national fleets that mainly target cephalopods and fish from the plateau. European fleets are present on the slope and target shrimp and hake. The number of European units decreased dramatically from 2012 to 2015 (from 38 to 5), following the non-renewal of cephalopods fishing licenses for European fleets. **The decline in the number of units in the national fleet is attributable to the advanced age which obliges several craft to be immobilized.** Their number decreased from 105 to 94 between 2012 and 2015.

The domestic industrial fishing fleet consists of freezer trawlers and wet stern trawlers. It approached 250 units in the mid-2000s (IMROP, 2013). In the recent period this segment is now composed of approximately 100 units. Due to its age, this fleet is characterized by frequent immobilizations or definitive shutdowns. It mainly targets cephalopods (octopus, cuttlefish and squid) and demersal fish from the continental shelf.

As for the industrial foreign fleet, it has seen an irregular, but generally downward trend. While 199 vessels were in operation in 2002, this segment was composed of only fifty vessels in 2015. This fleet consists mainly of vessels of European origin operating under the Memorandum of Understanding, covering a period of 4 years (from 16/11/2015 to 15/11/2019) and which allows this fleet to fish for shrimp, demersal fish and hake.

Industrial demersal catches are mainly carried out in a single statistical sector located in the northern zone (Fig.25). Catches in this sector alone account for more than half of the total catches.

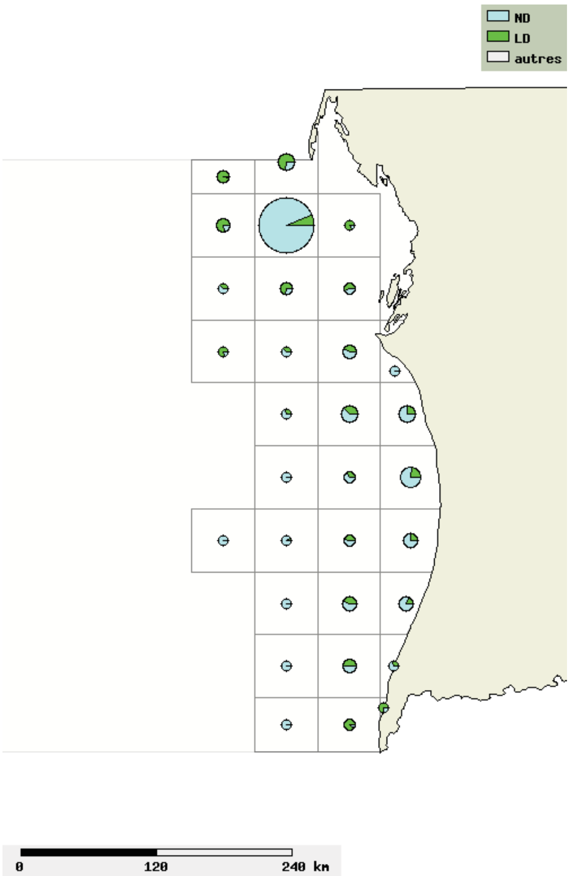
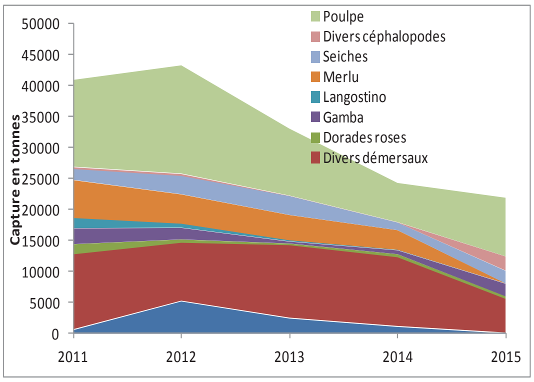


Fig. 25. Distribution of the Fishing Effort (in fishing days) of the Demersal Industrial Fleet by Statistical Sector of 30 nmi X 30 nmi in 2013 (ND : Domestic Demersal ; LD :Foreign Vessels).

Within 5 years, the demersal industrial fishery catches have been divided in two (Fig. 26, left). This decline is due to the withdrawal of the European cephalopod segment in August 2012 and the significant disruption of the national fleet activity due to frequent immobilizations caused by repeated outages. Cephalopods contribute an average of 44% equal to demersal fish if hake is included. The various crustaceans represent 12% (Fig. 26, right).



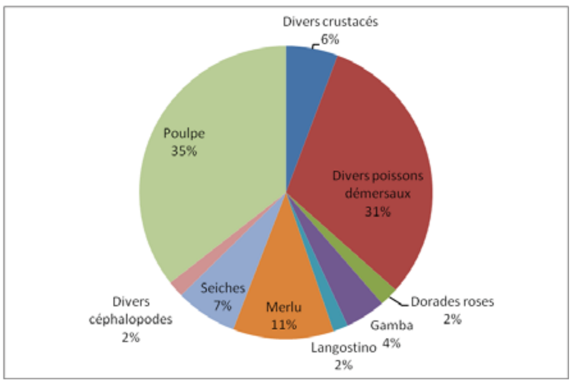


Fig. 26. Evolution of Catches of Demersal Industrial Fishery and Average Distribution of Catch Categories in the MEEZ by Species between 2011 and 2015 in Tonnes (CGM, unpublished data).

In the next section, we return to a fishery by fishery description. We briefly analyze catch and effort statistics in the Mauritanian EEZ with an emphasis on the southern zone, which is more directly concerned by the Ahmeyim / Guembeul project.

B.3.3.1. Cephalopod Fishery

Since August 2012, it is exclusively the three national segments that target cephalopods (octopus, cuttlefish and squid). These include industrial trawl fishing, artisanal fishing with pots and inshore trap fishing. These last two segments capture only octopus, and very rarely cuttlefish.

1. **Industrial Fishing Effort**
   A declining trend in the number of cephalopod vessels has been observed since 2006. The number of vessels has decreased from 200 in 2006 to 128 in 2012, including 25 European vessels. This reduction in effort was emphasized in 2013 with the total departure of the European cephalopod fleet. At present, about a hundred vessels, mostly aged and in poor conditions, are engaged in this activity, especially during peak production periods.

2. **Catches**
   The exploitation of octopus started in the late 1960s in northern Mauritania. Its high commercial value is at the origin of a rapid development of the industrial fleets, initially foreign and domestic, and thereafter Mauritanian artisanal. The octopus is now the main demersal species in Mauritania. On average, with 14,000 tonnes per year, the octopus constitutes more than 74% of the catches of cephalopods (Fig.27). This species plays a leading role at the economic and social level. Given the multispecies nature of the fishery, management of all demersal resources is based on regulatory measures targeting octopus.

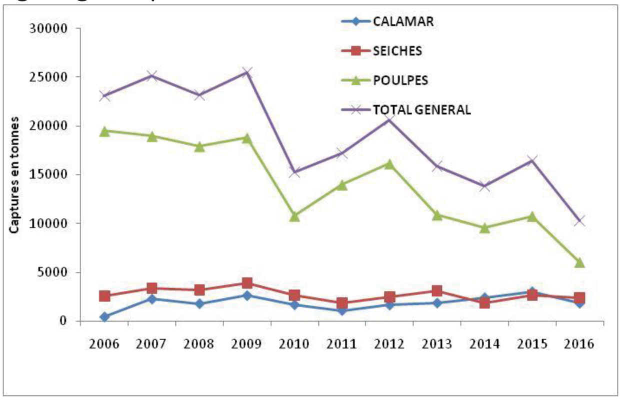


Fig. 27: Evolution of catches of deep-sea cephalopod vessels in the MEEZ (DARE, 2016)

In 2012, there was a production of 16,420 tonnes of octopus, 25% of which is harvested by the European Union fleet, despite its definitive departure in August. Since then, octopus catches have been carried out solely by the domestic fishery and are only going down, to reach approximately 6,000 tonnes in 2016. Obviously, the domestic industrial fleet has not been able to take the place of the European fleet.

For cuttlefish and squid, the catches reported for the recent period remain fairly stable, at around 2,000 tonnes per year for each of them (Fig.27).

B.3.3.2. Shrimp Fishery

Two main groups of shrimps are commercially important: coastal shrimps, including pink shrimp *Farfantepenaeus notialis* (Langostino), and deep sea shrimp, including the most abundant *Parapenaeus longirostris* (Gamba). Other species of shrimps are also caught incidentally: *Penaeus kerathurus, Aristeus varidens, Plesionika heterocarpus* and *Plesiopenaeus edwardsianus*.

The fishing opportunities granted to the European Union by the Memorandum of Understanding 2015-2019 are set at 5,000 tonnes per year for a maximum of 36 vessels. According to data provided to the Joint Mauritania / EU Working Group, the utilization rate is low (9.36%), with reported catches of 468 tonnes in 2016 (CSC, 2016).

1. **Fishing Effort**
   The shrimp fleet operating in the Mauritanian EEZ is composed exclusively of units of the European Union, in particular the Spanish ones. This fleet, which reached 90 units in 2002 (IMROP, 2013), was reduced to only 5 vessels authorized in 2015 and 6 vessels (out of a possibility of 13 vessels authorized) in 2014 (CSC, 2016). The activity of this segment was located at the northern and central zone in 2015. In 2016, this fleet extended its activity further south (Fig.28).

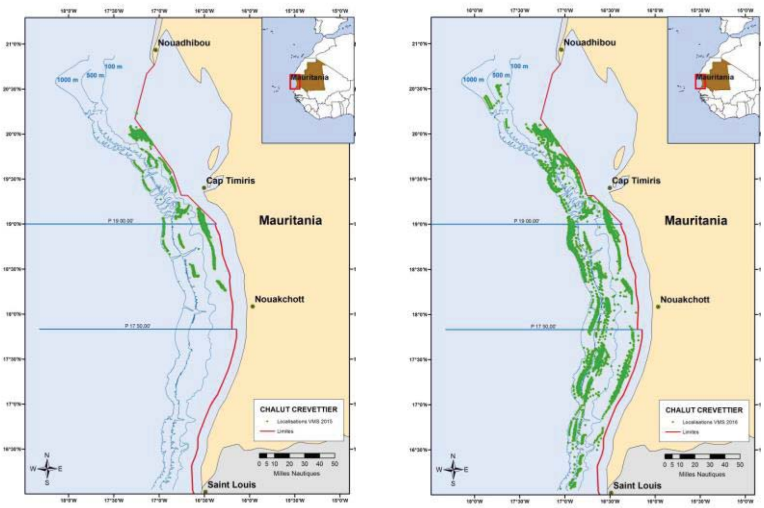


Fig.28 - Mauritania's fishing zone in 2015 (map on the left) and 2016 (map on the right). The red lines indicate the limits of the authorized fishing zone (CSC, 2016).

2. **Catches**
   The reported volumes (all species combined) were about 9,000 tonnes (including more than 75% Gamba and Langostino shrimp) before falling to approximately 600 tonnes in 2013 and 468 tonnes in 2016. This decline in production in recent years is mainly due to the drastic reduction in the number of European shrimp vessels and the conversion of Mauritanian shrimp vessels to cephalopods vessels.

B.3.3.3. Hake Fishery

Two species, *Merluccius senegalensis* and *Merluccius polli*, are fished and marketed under the generic name of black hake. This resource is exploited only by the European fleet, essentially Spanish. The average utilization rate of fishing opportunities was 76% in 2014 and 67% (4,027 tonnes) in 2016.

1. **Fishing Effort**

The annual fishing opportunities granted as part of the the 2015/2019 Protocol to the European Union are 6,000 tonnes. Since 2015, only the Spanish fleet has been exploiting hake, mobilizing 4 to 6 boats[12].

These vessels operate preferentially at depths between 550 and 800 m (Fig.29). These fishing units may operate occasionnaly at depths between 100 and 200 m, targeting various demersal fish species (CSC, 2016).

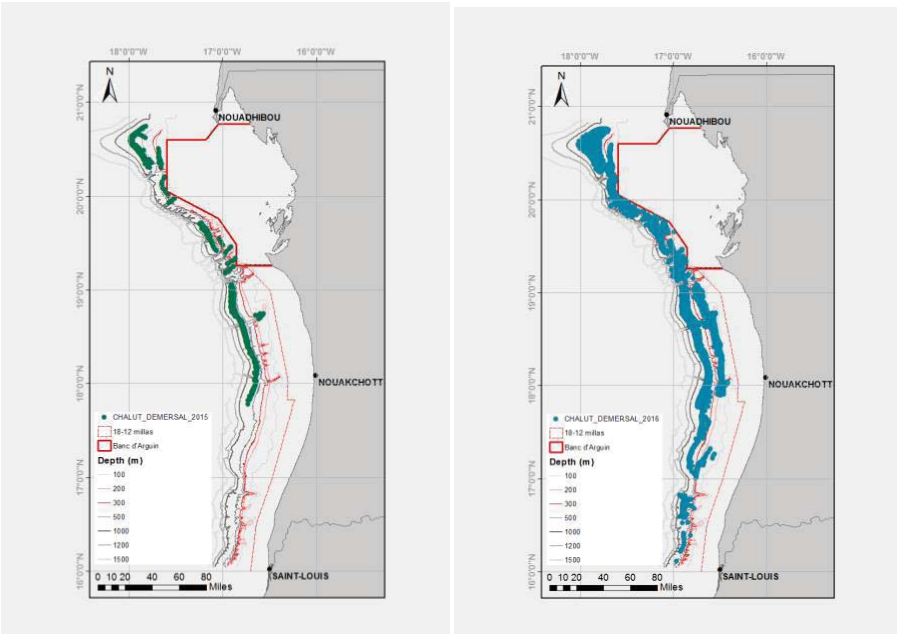


Fig.29 - Fishing area of Spanish hake boats targeting black hake in the Mauritanian fishing zone during 2015 (map on the left) and 2016 (map on the right). The red lines indicate the limit of the authorized fishing areas (CSC, 2016).

2. **Catches**

The peak of hake catches was recorded in 1993 (approximately 14,600 tonnes) (IMROP, 2013). Since then, catches have fallen sharply to their lowest level in 2016 at 4,027 tonnes. This level of catch is lower than the fishing opportunities granted to the European Union party.

B.3.3.4. Demersal Fishery

For the European Union fleets, the demersal fishery corresponds to the longline fishery targeting the seabream or palometa *Brama brama* with annual fishing opportunities of 3,000 tonnes.
For the other fleets concerned, in particular the domestic fleets, authorized fishing gear are longlines as well, but also gillnet, hand lines, traps and seines for bait fishing. These fish belong mainly to the families of Sparidae, Sciaenidae, Serranidae, Lutjianidae, Soleidae, Cynoglobidae, etc.

[12] The values recorded in 2015 are not representative of the catches because they correspond to a single month of activity.

1. **Fishing Effort**
   Since 2012, there has been an increase in the number of boats associated with the arrival of 20 Chinese fishing units (Poly Hondone fishing industrial complex) but which are flying the Mauritanian flag.

2. **Catches**
   In 2012, catches in this segment recorded more than 8,000 tonnes, for 1,735 fishing days. The average catch in the industrial fishery over the past five years is approximately 5,114 tonnes, for approximately 2,228 days at sea (CSC, 2016).

   For European Union longliners, consisting exclusively of *Brama brama* fishing boats, similar volumes of catches were reported for the years 2014 and 2016. The level of catches achieved indicates an under-utilization of the fishing opportunities granted to the EU fleet in this category, catches representing approximately 50% of the catch limit set in the 2015-2019 Memorandum of Understanding.

8. Summary and General Conclusions

This study has helped to characterize the evolution, the state of the marine and coastal biodiversity, the fisheries resources and the main fisheries operating in the MEEZ. At the biodiversity level, this report highlights the following findings:

The state of the marine and coastal biodiversity is carried out for the different relevant spatial scales of observation (coastal zone including DNP, slope and deep sea) with particular focus on the southern part of the MEEZ which concerns the Ahmeyim/Guembeul project zone. It includes the inventory and the characterization of:

- Endemic, fragile or threatened species as well as key species for the functioning of the ecosystem, particularly the Selachians.
- Critical habitats and areas of interest for biodiversity, particularly the DNP.
- The assessment of biodiversity, which is considered globally with reference to the IUCN Red List, particularly for bony fish, which are the main resources exploited by the fisheries but also cartilaginous fish.
- At the spatial level, the specific diversity index shows a downward trend from north to south of the MEEZ and from coast to offshore to a 400-600 m depth. This trend would reflect both a greater diversity of the northern and coastal parts of the MEEZ, but also a greater effort of biodiversity-oriented scientific investigations and research in these sectors. The few scientific campaigns carried out in the great depths between 800 and more than 2,000 m show an improvement of the biodiversity indices (number of species). This indirectly highlights the important role of the fisheries, especially trawling, in biodiversity. Indeed, since the fisheries are absent from the deep-sea, the overall state of biodiversity improves.

In terms of fisheries resources and their exploitation, the report draws attention to:

- An important upward trend for the abundance indices of some 20 demersal species since 2006 following a long period of continuous decrease. This favorable development is the result of the application of appropriate management measures (prohibition of trawling in the coastal zone below the 20 m depth, introduction of VMS and installation of several radar stations on the coast).

- Ongoing concerns about the status of octopus stocks, a strategic species for Mauritania's fisheries sector, despite a clear improvement in trend due to regulatory measures initiated by research (introduction of a biological rest, Mauritanization of the activities leading to a reduction in fishing effort) and tighter surveillance.
- Pelagic resources (coastal and deep-sea) which are in a suitable exploitation state, with the exception of round sardinella which is in an overexploitation state. The situation of the latter species is likely to deteriorate further due to the very rapid development of the fishmeal and fish oil industries mainly supplied by artisanal fisheries, with repercussions on the remainder of the sector, but also due to negative external factors that must be imperatively mitigated.
- The absence of large meso-pelagic stock exploitation, which amounts to tens of millions of tonnes of biomass, located mainly off the MEEZ.
- A widespread decrease in fishing pressure following the introduction of management measures deemed restrictive by foreign boat owners, who were the key players in the MEEZ.

In the MEEZ, fisheries, both artisanal and industrial, remain a major activity despite the ups and downs recorded following the withdrawal of some foreign industrial segments since 2012, dominated by very large pelagic units. More recently, the departure of Senegalese artisanal fisheries from the Mauritanian maritime waters has also been recorded following the non-renewal of the fisheries agreement between the two countries. Year by year, the total Mauritanian fishery production is close to one million tonnes, one-third of which is landed by artisanal fisheries.

More than 2/3 of the total volume production is fished in the northern part of the MEEZ for both the artisanal and industrial sectors despite a quasi-homogeneous coverage of the industrial fleets throughout the MEEZ (Fig.30).

Along the coast of Senegal, Mauritania and The Gambia, between the beginning of 2012 and the end of March 2017, the observations of the Global Fishing Watch, to which there is open access, give instantaneously very valuable information on the distribution of industrial fishing fleets, to the image of the VMS (Fig.30). In terms of concentration levels, there are dramatic differences between the concentrations in Senegal compared to the concentrations in Mauritania and the Gambia (Fig. 30). In Mauritania, concentrations of industrial boats are a good indicator for mapping the richer areas, especially at the slope and canyons and off Cap Blanc.

The 18,000 or so active Senegalese pirogues in the EEZ of this country cannot be located and thus do not appear on this map. Compared to the Mauritanian EEZ, the Senegal zone appears relatively deserted. In fact, the vessel tracking tool is based on data from the Automatic Identification System (AIS), whereby vessels communicate their position, direction and speed to one another via a satellite network. This system, widely used throughout the world for different types of vessels to avoid collisions between them, has been adapted for the purpose of fishing monitoring. The pirogues do not have this service and are therefore not visible.

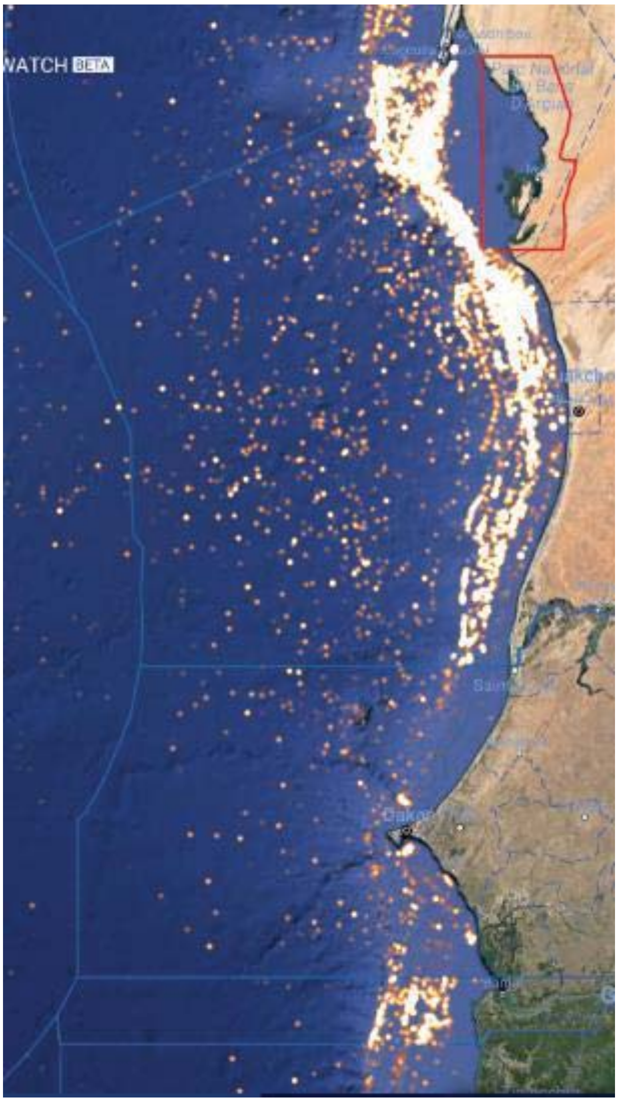


Fig. 30. Concentrations of Industrial Fishing Vessels in the Mauritanian-Senegalese Zone during the 2012/2017 Period (source Global Fishing Watch).

In Mauritania, the artisanal fisheries boom over the past ten years, from 2006 to 2015, with almost a fivefold increase in fish catches, is largely due to the considerable increase in prices and in the production capacity of fish flour and fish oil.

This segment offers a new outlet for small pelagic species that were not targeted previously (ethmalose (*Ethmalosa fimbriata*), flat sardinella (*Sardinella maderensis*)), but also for species often referred to as overexploited, particularly round sardinella. Artisanal fishery benefited from an exceptional conjecture following the withdrawal of foreign industrial fleets, both pelagic and demersal, as a result of the introduction of new regulatory measures considered too binding by these fleets, which harvested more than one million tonnes in 2011, but less than 300,000 tonnes in 2013.

Data from artisanal fisheries are not georeferenced and units are not trackable by Radar or by the Global Fishing Watch system. It is therefore not possible to locate these fishing zones. Nevertheless, in the core study area of the Ahmeyim/Guembeul project, scientific investigations (IMROP, 2016) reveal the presence quasi-exclusive of 15 horse-power engines. In a survey conducted in April 2017, N'Diago fishermen indicated that they generally fish at a distance of about 3 km from the coast and at most 7 to 9 km from the coast (Taleb Heidi, 2017). It is thus concluded that the range of action of these boats is limited.

Northern Mauritania concentrates most fishing activities and landings (or transhipment) for both small pelagic species and demersal species for all the different segments concerned. This enthusiasm for the northern zone is explained by historical, geographical, physical and biological considerations. For artisanal fisheries, for example, it is mainly linked to the following factors:

- The high productivity of this area (width of the continental shelf, permanence of upwelling); average yield per fishing trip is 474 kg which is 4 times more than in the southern zone (Table 16).
- The existence of receiving infrastructure and the presence of the only real fishing ports, both artisanal and industrial, in Nouadhibou.
- The relative proximity of Europe and the Canary Islands in particular.
- The relative clemency of maritime conditions in this zone compared to the southern zone where the presence of a violent bar is reported.
- Prices paid at first sale are two and a half times greater in the northern zone than in the southern zone.

Table 16: Comparative Table of Some of the Performance Indicators for Artisanal Fisheries in the Different Zones (IMROP data, Average 2006-2015).

	Northern	PNBA	Central	Nouakchott	South Nouakchott	General Total
Kg/Outing	474	163	71	323	121	337
Fishing effort (%)	49	16	4	24	6	100
Catches (%)	69	2	3	23	2	100
Price (Um/Kg)	768	136	401	536	299	334

In the Diawling National Park, fisheries remain necessarily limited for obvious reasons of conservation, but they are also limited to satisfy various conflicting needs of water resource users (farmers, cattle breeders and fishermen) where releases of water from the dam take place late in relation to the fishing season, by the rudimentary nature of the low-productivity fishing techniques and processing, the predominance of fishing on foot and the lack of knowledge of stocks and the rate of renewal of fish resources (Ly, 2009). Infrastructure on the Senegal River and the severe disturbances, due in particular to climatic damage and the accidental introduction of invasive plants such as typha, which have colonized important fishing grounds (Gambar), also contribute to the deterioration of this activity. Moreover, the difficulties of regular scientific monitoring of this activity, which is sometimes rather uncertain, prohibits an accurate or a precise data compilation in order to determine a reliable estimate of the scale of this activity, whose production is often underestimated. Fishing takes place mainly at night, therefore, it is difficult to have access to the actual quantities landed.

Despite these findings, fishing in the DNP remains an important source of employment and income for the residents of the various villages. These fishermen, who are residents of the Diawling National Park, do not generally practice sea fishing because of lack of technical and financial means and for historical and cultural considerations. Accustomed to a subsistence fishing conducted by foot in a calm waterway related to agriculture, gardening and/or cattle breeding, the conversion of these fishermen to the maritime environment is very difficult.

9. Bibliography

Barton, E., 1998. Eastern boundary of the North Atlantic: Northwest Africa and Iberia. Coastal segment (18, E). In: Robinson, A., Brink, K.H. (Eds.), The Sea, vol. 11. John Wiley & Sons Inc., pp. 633–657.

Birane S, M. Tandstad, A. M. Caramelo and B. E. Brown (2016) Variations in productivity of the Canary Current Large Marine Ecosystem and their effects on small pelagic fish stocks Environmental Development 105–117.

Bonnin M., Le Tixerant M., Ly I. and Ould Zein A., Atlas cartographique du droit de l'environnement marin CSRP- IUCN, 2013.

Carvalho J.F; J. L. Imohoff, V. V. Faria, J. K. Carlson and G.H. Burgess (2013) Status and the potential for extinction of the largetooth sawfish Pristis pristis in the Atlantic Ocean. Aquatic Conserv: Mar. Freshw. Ecosyst. (2013).

Colman, J. G., Gordon, D. M., Lane, A. L., Forde, M. J., and Fitzpatrick, J. J. 2005. Carbonate mounds off Mauritania, Northwest Africa: status of deep-water corals and implications for management of fishing and oil exploration activities. In Cold-water Corals and Ecosystems, pp. 417 – 441.

Chavance, P., and Girardin. (1991). Environnement, Les Ressources et les Pêcheries de la ZEE Mauritaniennes .Bulletin N° 23 Centre National de Recherches Oceanographiques et des pêches. 215 P.

Gascuel, D., Labrosse, P., Meissa, B., Taleb Sidi, M.O., Guénette, S., 2007. Decline of demersal resources in northwest Africa: an analysis of Mauritanian trawl-survey data over the past 25 years. African Journal of Marine Science 29, 331–345.

Goffinet T. 1991 Development and Fisheries Management: The Case of Northwest Africa. Ocean & Coastal Management 17 (1992) 105-136.

Inejih C.A., Taleb Ould Sidi M. and H. Diadhou (2014) Evaluation de l'état de la biodiversité marine dans la région du grand écosystème des Courants des Canaries, du Nord du Maroc au Sud de la Guinée. Rapport scientifique et technique FAO/PNUE, 175 pages.

IMROP : 2010. Synthèse du 7ème groupe de travail sur l'évaluation des ressources, l'aménagement des pêcheries Mauritaniennes et la gestion de leur environnement. Nouadhibou (MR) : IMROP, 28p.

IMROP 2013. Bulletin statistique de la pêche industrielle en Mauritanie pour l'année 2012. Document de travail N°5. 46 pages.

IMROP, 2014. Rapport de synthèse du huitième Groupe de Travail d'Evaluation des Ressources et l'Aménagement des Pêcheries Mauritaniennes et la Gestion de leur Environnement Nouadhibou 30 Novembre au 5 décembre 2014 ; 41 pages.

Julien.S. (2002). Contribution à la mise en place d'un observatoire de la pêche artisanale en Mauritanie. Rapport interne IMROP13 P.

Kidé, S. O., C. Manté, L. Dubroca, H. Demarcq, B. Mérigot. 2015. Spatio-Temporal Dynamics of Exploited Groundfish Species Assemblages Faced to Environmental and Fishing Forcings: Insights from the Mauritanian Exclusive Economic Zone. Plos ONE http://dx.doi.org/10.1371/journal.pone.0141566.

Ould Taleb Sidi M. 2015 Le Listao (Katsuwonus pelamis) ou l'explosion des captures d'une espèce de thons hauturiers dans la ZEE mauritanienne sous DCP, SCRS/2015/077.10 pages.

Ould Taleb Ould Sidi M. Meissa B. M. Bouzouma et C. B Isselmou 2013 (Eds). Evaluation des Ressources et Aménagement des Pêcheries de la ZEE Mauritanienne Rapport du septième Groupe de travail de l'IMROP /Nouadhibou, Mauritanie, 5-11 Rapport de synthèse. December 2010. 236 pages.

Ould Taleb Ould Sidi M.M.. (2005). Les ressources des petits pélagiques en Mauritanie et dans la zone nord-ouest africaine (variabilité spatiale et temporelle, dynamique et diagnostic). Doctoral thesis.

Meiners C, L. Fernández , F.Salmerón , A Ramos (2010) Climate variability and fisheries of black hakes (Merluccius polli and Merluccius senegalensis) in NW Africa: A first approach Journal of Marine Systems 80 (2010) 243–247.

Ramil F. B. and A.M. Ramos (2007) LA FAUNA BENTÓNICA MAURIT-1107 Compte rendu de campagne scientifique Vigo, España, 29 pages.

Pencalet-Kerivel, F. (2008).La mort et le deuil de la pêche langoustière bretonne en Mauritanie. Article p 173-200.

Pilar M. O.; P. A. L.Hulley, A. Castellón, M. Emelianov, C.López, V. M. Tuset , T. Contreras , B. Molí (2017) Mesopelagic fishes across the tropical and equatorial Atlantic: Biogeographical and vertical patterns Progress in Oceanography 151 ; 116–137.

Pauly, D., Christensen, V.,1995, Primary production required to sustain global fisheries. Nature 374,255–257.

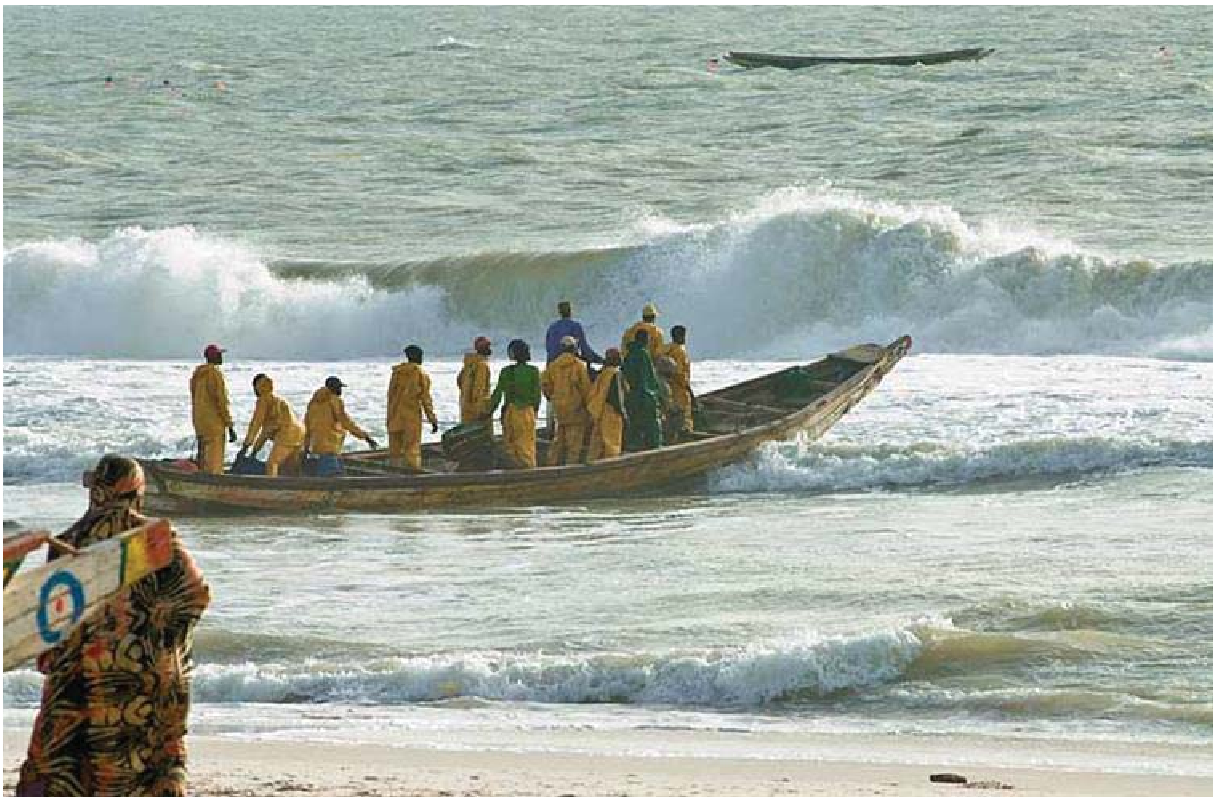
Beth Polidoro, Gina M. Ralph, Kyle Strongin, Michael Harvey, Kent E. Carpenter, Titus Ayo Adeofe, Rachel Arnold, Paul Bannerman, Jean Noel Bibang Bi Nguema, Jack R. Buchanan, Khairdine Mohamed Abdallahi Camara, Youssouf Hawa Camara, Kadiatou Cissoko, Bruce B. Collette, Mia T. Comeros-Raynal, Godefroy De Bruyne, Madeleine Diouf, Roger Djiman, Mathieu Ducrocq, Ofer Gon, Antony S. Harold, Heather Harwell, Craig Hilton-Taylor, Andrew Hines, P. Alexander Hulley, Tomio Iwamoto, Steen Knudsen, Jean De Dieu Lewembe, Christi Linardich, Ken Lindeman, Ebou Mass Mbye, Jean Egard Mikolo, Vanda Monteiro, Jean Bernard Mougoussi, Thomas Munroe, Jean Hervé Mve Beh, Francis K. E. Nunoo, Caroline Pollock, Stuart Poss, Richmond Quartey, Barry Russell, Alphonse Sagna, Catherine Sayer, Aboubacar Sidibe, William Smith-Vaniz, Emilie Stump, Mor Sylla, Luis Tito De Morais, Jean-Christophe Vié and Akanbi Williams (2016). Red List of Marine Bony Fishes of the Eastern Central Atlantic. Gland, Switzerland: IUCN. viii + 80 pp.

Scott C. D. Y, Victoria J. F., R A. Feely, and J. A. Kleypas (2009) Ocean Acidification: The Other CO2 Problem Annu. Rev. Mar. Sci. 2009. 1:169–92.

Venecia C. Gauns M. et P.K Karuppasamy 2011 A Review on Mesopelagic Fishes belonging to family Myctophidae nev. Fish Biol. Fish., vol.21; 2011; 339–354.

APPENDIX E-2: REPORT ON FISHERY RESOURCES AND FISHERIES IN THE SENEGALESE PORTION OF THE CORE STUDY AREA OF THE AHMEYIM/ GUEMBEUL GAS PRODUCTION PROJECT

Fishery Resources and Fisheries in the Senegalese Portion of the Core Study Area of the Ahmeyim/Guembeul Gas Production Project



By

Dr. Papa Samba Ndieub DIOUF

For

TROPICA Environmental Consultants

Liberté VI, Villa No. 8181 • BP 5335 Dakar-Fann SENEGAL
Phone: (221) 33 867 18 98 - Fax: (221) 33 867 18 99
Email: tropica@tropica-ec.com

September 2017

Project and Study Details	
Project	ESIA for Ahmeyim/Guembeul Offshore Gas Production Project in Mauritania and Senegal
Study for which report is being issued	Study pertaining to "Fishery Resources and Fisheries in the Senegalese Portion of the Project's Core Study Area" Expert study; contribution to the characterization of baseline environmental conditions
Report version	Final (Revised)
Author of report	Dr. Papa Samba Ndieub DIOUF, Tropica expert

Distribution List		
Recipient 1	Golder Associates	Project Director
Recipient 2		

Signatories	
Production	Dr. Papa Samba Ndieub DIOUF
Review:	Samba YADE, Project Coordinator, Tropica
Approval:	Samba YADE, Project Coordinator, Tropica
Date of transmission:	September 12, 2017

This report is submitted by Tropica Environmental Consultants (Tropica) in the context of a subcontract with Golder Associates for a contribution to the description of baseline environmental conditions, which is part of the environmental and social impact assessment (ESIA) of the Ahmeyim/Guembeul Offshore Gas Production Project in Mauritania and Senegal initiated by Kosmos Energy Mauritania (KEM) and Kosmos Energy Senegal (KES).

It has been prepared (1) by Dr. Papa Samba Ndieub DIOUF, biologist and expert in fisheries, the environment and personal development, (2) in compliance with Tropica's terms of reference, and (3) with data and information obtained from literature and field investigations. In the course of preparing this document, Tropica and its expert have drawn from their competences, professionalism, rigor and due diligence.

The data and information contained in the document are based on site visits, interviews with competent individuals, document reviews and experience in similar studies and projects.

In any case, Tropica assumes no responsibility or liability for the use of the content of this report by any person other than its recipient(s).

List of Abbreviations

BDGN: Bottom drift gillnet
CECAF: Fishery Committee for the Eastern Central Atlantic
CEP: Study and Planning Unit
CLP: Local Fishermen's Committee
CLPA: Local Artisanal Fishing Council
CNCR: National Rural Consultation Framework
CNDMS: National Collective of Fish Wholesalers for Development of Senegal
CNPS: National Collective of Artisanal Fishermen of Senegal
COMFISH: Collaborative Management for a Sustainable Fisheries Future in Senegal
CONIPAS: National Interprofessional Council of Artisanal Fishing in Senegal
CRODT: Dakar-Thiaroye Centre for Oceanographic Research
DAMCP: Department of Protected Community Marine Areas
DPM: Department of Maritime Fisheries
DPN: Department of National Parks
EEZ: Exclusive Economic Zone
EGN: Encircling gillnets
EMV: Estimated Market Value
ENSA: National Higher School of Agriculture
ESIA: Environmental and Social Impact Assessment
EU: European Union
FAO: Food and Agriculture Organization
FENAGIE: National Federation of Economic Interest Groups of Fishermen
FENAMS: National Federation of Fishmongers of Senegal
FENATRAMS: National Federation of Women Fish Processors
FFEM: French Facility for Global Environment
GAIPES: Senegalese Association of Ship Owners and Industrial Fisheries
GPS: Global Positioning System
ICCAT: International Commission for the Conservation of Atlantic Tunas
IUCN: International Union for Conservation of Nature
LPS/PA: Sector Policy Letter for Fisheries and Aquaculture
MPAM: Ministry of Fisheries and Maritime Affairs
MPEM: Ministry of Fisheries and Maritime Economy
OLAG: Guiers Lake Office
OMVS: Organization for the Development of the Senegal River
PN: Passive Net

PS: Purse Seine

REFEPAS: National Network of Women in Artisanal Fisheries in Senegal

SDGN: Surface drift gillnet

SRFC: Sub-Regional Fisheries Commissioning

UNAGIEMS: National Union of Fish Wholesaler EIGs of Senegal

UNESCO: United Nations Educational Scientific & Cultural Organization

UPAMES: Employer's Union of Fish Exporters of Senegal

USAID: United States Agency for International Development

WARFP: West Africa Regional Fisheries Program

List of Tables

List of Figures

Summary

As part of the environmental and social impact assessment (ESIA) of the Ahmeyim/Guembeul Offshore Gas Production Project initiated by Kosmos Energy Mauritania and Kosmos Energy Senegal, a study of the fishery resources and the fisheries was conducted in the Senegalese portion of the core study area and more generally in the extended study area on the Senegalese side.

The Grande Côte, also called Côte Nord, stretches from Pointe des Almadies (14°36 N) in the Dakar region northward to Saint-Louis (16°04 N). This coastline presents a succession of dunes and barrier beaches, the most important of which is Langue de Barbarie.

The continental shelf off the Grande Côte is relatively narrow. The shelf break between the continental shelf and the continental slope is situated at approximately 200 m. The shelf presents a reduced extension in the immediate vicinity of the Cap-Vert Peninsula and on either side of Cayar Canyon, which cuts into it.

The strong swell that dominates on the northern coast during the cold season creates an important bar, especially if there are conducive topographic conditions, as is the case in Saint-Louis. The Grande Côte is dangerous for navigating and landing pirogues due to this bar. The latter is a roll of waves close to shore that causes numerous accidents and damage when artisanal fishermen try to cross it.

The resources harvested in the core study area include two broad groups having different bioecological characteristics: pelagic resources and demersal resources.

The Grande Côte benefits from hydroclimatic conditions (upwelling and trophic enrichment by the Senegal River) that can potentially result in high productivity. However, as a result of decades of overfishing, anthropogenic modification of the Senegal River's hydrology via the commissioning of major hydro-agricultural infrastructure, and the effects of climate change, the health of most fish stocks is of concern.

Artisanal fishermen in Senegal are essentially from one of three groups: the Lebu, who reside in Dakar and on the Petite Côte, the inhabitants of Guet Ndar in the north (Saint-Louis) and the Niominka in the Centre (islands of the Saloum River). These three groups represent more than 90% of all fishermen (58% Lebu, 18% Guet Ndarians and 15% Niominka) (Mbaye, 2002)[1].

Artisanal fishermen travel from one port to another in pursuit of fishery resources as they migrate. Some travel outside Senegal to fish, notably to Mauritania, The Gambia, Guinea-Bissau, Guinea and even to Sierra Leone and Angola. Some fishermen, notably those from Saint-Louis, work for *bateaux ramasseurs*, for which they catch prized fish such as Serranidae, Sparidae, etc.

Along the Grande Côte Sud, fishing is practiced with a wide array of gear, the most important of which are nets (bottom gillnets, encircling gillnets [*saïna*], purse seines, beach seines), lines (hook-and-line and longlines) and spear guns.

On the Grande Côte Nord, fishermen use nets (purse net, bottom set gillnet [*mbal ser*], surface drift gillnet [*félé félé*] and trammel), lines and longlines.

The areas where industrial fishing is authorized are stipulated in Decree n° 2016-1804 implementing Maritime Fishing Code Law n° 2015-18 of July 13, 2015, Section 3 (Fishing Zones), Articles 39 to 51. These zones lie beyond the 6-7 nautical miles from the reference line defined by Article 39 of the said decree.

Notwithstanding those areas prohibited by the Fishing Code, industrial fishing goes wherever the resource is, and can thus be found practically throughout the entire zone authorized by the type of license obtained.
With regard to artisanal fishing, fishing grounds are abundant and the only limitation that fishermen have is their ability to navigate and ensure that their activities remain profitable. Artisanal fishing grounds have been mapped.

[1] Mbaye A., 2002. Analyse sociologique de la différenciation technique dans la pêche artisanale maritime sénégalaise. Séminaire C3ED-OA, 7 p.

Statistical data collected from DPM reveal that of the four regions that cover the core study area, the Thiès region generates the largest landings from artisanal fishing, followed by the Saint-Louis and Dakar regions. The lowest volume of landings is from the Louga region. However, considering the fact that the Thiès region covers only part of the core study area and taking into account only those data that pertain to the core study area, the Thiès region ranks 3rd on the Grande Côte in terms of landings.

It appears that the quantities traded are relatively high in the Saint-Louis region. In terms of fishery product processing, Thiès seems to be the top region.

Analysis of the evolution of landed catches generated by artisanal fishing over the past five years shows inter-annual fluctuations. With regard to industrial fishing, activity is essentially concentrated around the Cap-Vert Peninsula.

Although it plays an extremely important economic and social role, the maritime fishing sector is currently facing serious challenges.
One major constraint for fishermen in the core study area is the difficulty they face in accessing fishing grounds in Mauritania, where they were accustomed to operating until early 2017. In light of the difficulty of reaching agreements with Mauritania, Senegal must find the means of restoring stocks that have been over-exploited by creating and properly managing marine protected areas and artificial reefs, in addition to conceiving and executing fishery management and development plans.

Fishing plays a crucial role in the social and economic lives of the communities of the Grande Côte. Unfortunately, due to excessive fishing that has strongly reduced fishery resources and the difficulty of accessing Mauritania's more productive fishing grounds, this sector is presently undergoing a very difficult period.

It is indispensable that measures be promptly taken to restore habitats and allow over-exploited stocks to recover. Additionally, it would also be wise to strive for greater diversification of income-generating activities that are unrelated to fishing. This should be done as part of a co-management approach, where the CLPAs could play a major role.

Introduction

As part of the environmental and social impact assessment (ESIA) of the Ahmeyim/Guembeul Offshore Gas Production Project initiated by Kosmos Energy Mauritania and Kosmos Energy Senegal, a study of the fishery resources and the fisheries was conducted in the Senegalese portion of the core study area and more generally in the extended study area on the Senegalese side. The study is based on document research, site visits to communicate with various stakeholders in the fisheries sector, and data collected from the Department of Maritime Fisheries, the Dakar-Thiaroye Centre for Oceanographic Research, the University of Dakar and the Ministry of the Environment and Sustainable Development.

This report consists of five sections:

- Biophysical context;
- Fishery resources in the area;
- Critical habitats: reproduction areas, nurseries and migration corridors ;
- State of exploitation and conservation status of fishery resources;
- Fisheries (artisanal[2] and industrial)

1. Physical Context

1.1. Description of environment

The Grande Côte, also called Côte Nord, stretches from Pointe des Almadies (14°36 N) in the Dakar region northward to Saint-Louis (16°04 N). This coastline presents a succession of dunes and barrier beaches, the most important of which is Langue de Barbarie (Fall, 2009)[3]. With regard to the latter, a breach was cut in an effort to control the floods of October 2003. Within a short period, the breach widened dramatically and became the new mouth of the river (Durant et al., 2010)[4].

It should be noted that the Senegal River Delta region, which is of critical importance for migratory bird conservation as well as marine and coastal biodiversity (Diouf, 2015)[5], has undergone profound changes in the recent decades due to drought in the 1970s and 80s on one hand and hydraulic modifications on the other hand, namely the construction and commissioning of the Diama and Manantali dams. Currently, large-scale agricultural expansion driven by agrobusiness' growing interest in the region and food self-sufficiency programs represents a serious threat to the area's natural habitats and their associated biodiversity. Moreover, the growing degradation of the delta ecosystems has driven the governments of Mauritania and Senegal to extend their networks of protected areas in

[2] Focus is placed on artisanal fishing. A definition of the two types of fisheries will be given.
[3] Fall M., 2009. Pêcherie démersale côtière au Sénégal – Essai de modélisation de la dynamique de l'exploitation des stocks. PhD thesis, University of Montpellier 2, 231 p.
[4] Durand P., Anselme B. and Thomas Y-F., 2010. "L'impact de l'ouverture de la brèche dans la langue de Barbarie à Saint-Louis du Sénégal en 2003 : un changement de nature de l'aléa inondation ?", Cybergeo: European Journal of Geography [Online], Environment, Nature, Landscape, document 496, posted online April 27, 2010, consulted March 24, 2017. URL: http://cybergeo.revues.org/23017; DOI: 10.4000/cybergeo.23017.
[5] Diouf P.S., 2015 a. Module de formation sur les peuplements ichtyologiques du système fleuve Sénégal, lac de Guiers et le Ndiaèl. IUCN/OLAG, 22 p.

order to preserve several representative samples and to take a certain number of common measures to safeguard biodiversity (Agblonon et al., 2015)[6].

Off the Grande Côte, the continental shelf, which is 27 nautical miles wide at Saint-Louis, narrows to 5 nautical miles off the Cap-Vert Peninsula (Diouf et al., 2016)[7].

The seabed presents a certain number of topographic features, namely:

- Several underwater canyons, the most remarkable of which is Cayar (3,294 m deep and spanning up to 9 km);
- A few 10 to 15 m high underwater cliffs in the vicinity of the Cap-Vert Peninsula;
- The Cayar Seamount located off the coast of Cayar, 100 km northwest of the Cap-Vert Peninsula. It is located at depths of 200 to 500 m and comprises three peaks: Mont Cayar, Mont Petit Cayar and Mont Médina.

[6] Agblonon G., Van Leeuwen M., Hoffmann F., Racz N., 2015. Plan stratégique pour la conservation de la biodiversité des oiseaux d'eau migrateurs dans le delta du fleuve Sénégal - période 2015-2025. Wetlands International, OMVS, Diawling National Park, Senegal Department of National Parks, 64 p.
[7] Diouf P.S., Diop N. and Diop H., 2016. Plan national d'adaptation du secteur de la pêche et de l'aquaculture face au changement climatique horizon 2035. MEDD / MPEM / USAID/COMFISH Project, 143 p.

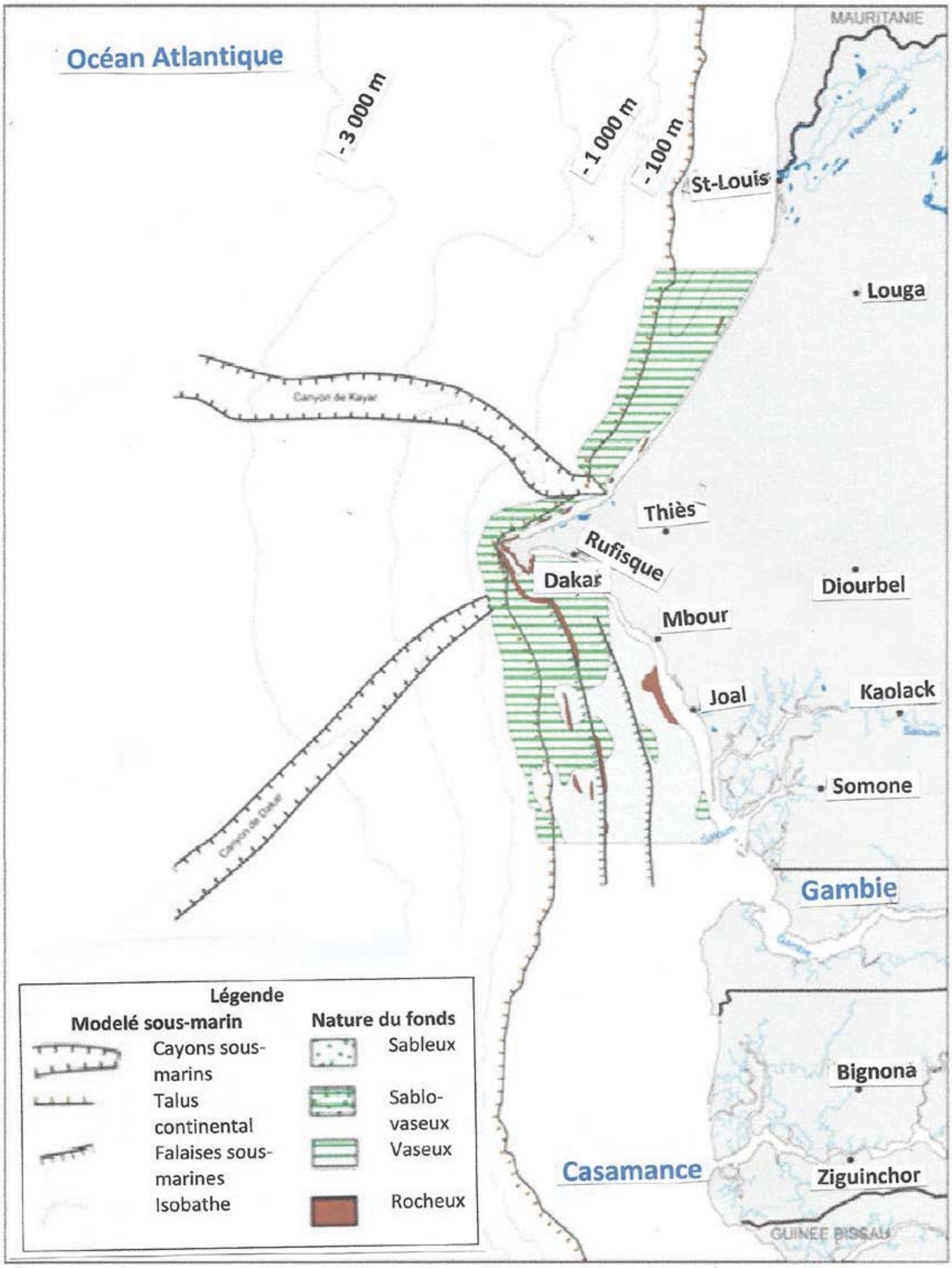


Figure 1: Morphology of Senegalese Continental Shelf

Source: Niang (2008)[8]

[8] Niang N.A., 2008. Dynamique socio-environnementale et gestion des ressources halieutiques des régions côtières du Sénégal : l'exemple de la pêche artisanale. UNESCO/MAB and UCAD, 68 p.

The Grande Côte is generally sandy and is characterized by well developed coastal dunes that encompass an expanse of hydromorphic sediment called the Niayes wetlands. The only exceptions are the rocky projections of the Cap-Vert Peninsula and the mangrove relics located in the vicinity of Saint-Louis (between Diama and Khor in Saint-Louis and at the mouth of the river)[9].

1.2. Bathymetry

The continental shelf off the Grande Côte is relatively narrow. The shelf break between the continental shelf and the continental slope is situated at approximately 200 m. The shelf presents a reduced extension in the immediate vicinity of the Cap-Vert Peninsula and on either side of Cayar Canyon, which cuts into it.

From north of this canyon to Saint-Louis, the continental shelf gradually widens from 20 km to approximately 40 km opposite the Senegal River estuary.

Between Cayar and Dakar, 15 km separates the edge of the continental shelf from the coastline. The tip of Cap-Vert is a mere 9 km from the 200 m isobath (Kouamé, 1983)[10].

---

[9] Diouf P.S., 2016. Mangrove et Aires Marines Protégées de la Casamance et du Sine-Saloum. COFREPECHE – SEANEO, 56 p.

[10] Kouamé A., 1983. Bathymétrie, sédimentologie et structure géologique du plateau continental de l'Afrique de l'Ouest. Intergovernmental Oceanographic Commission of UNESCO, 5 p.

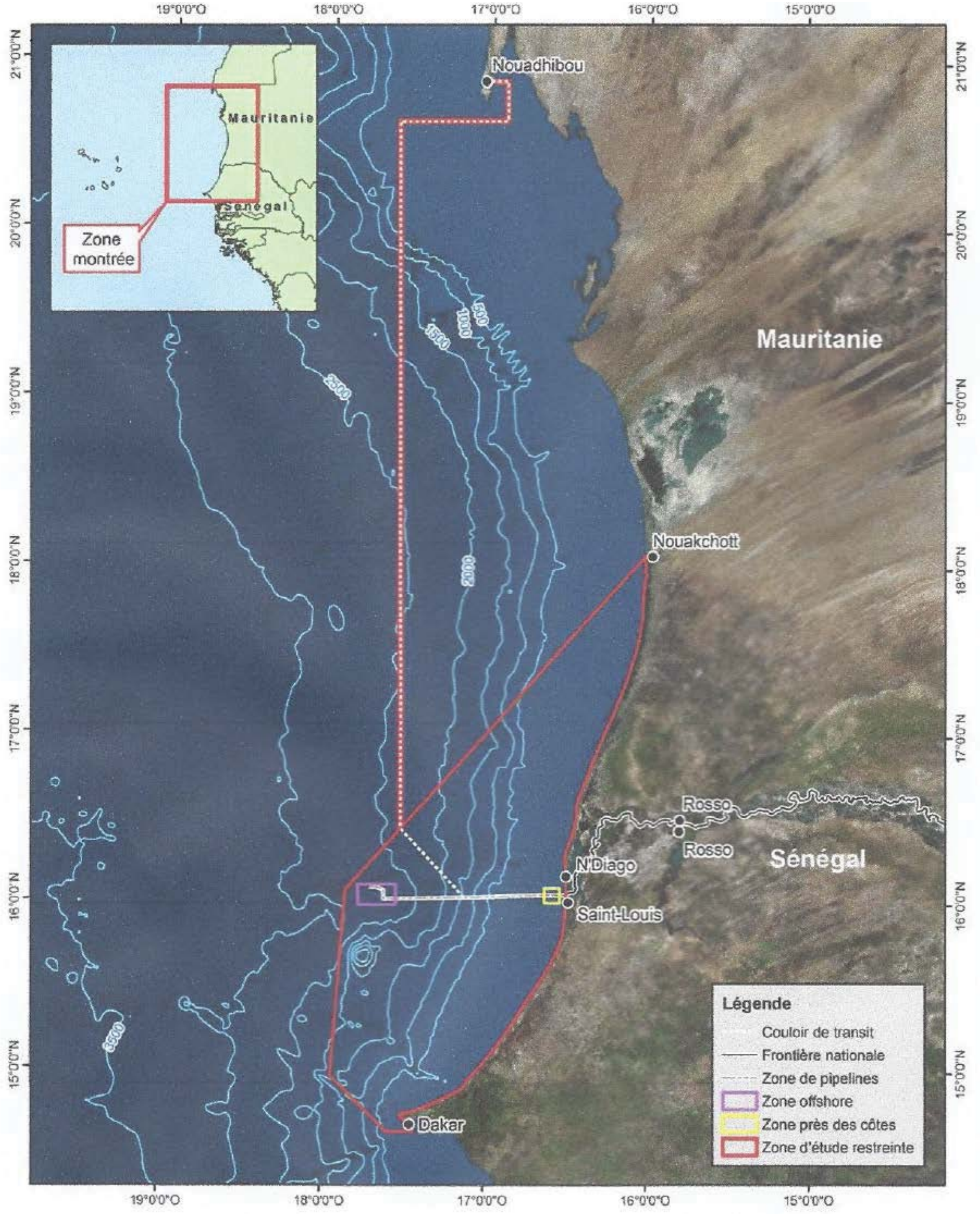


Figure 2: Core Study Area

Source: Golder Associates (2017)[11]

[11] Golder Associates, 2017. Projet Ahmeyim/Guembeul de production de gaz offshore en Mauritanie et au Sénégal. Etude d'impact environnemental et social. Termes de référence des experts nationaux. Golder Associates, 28 p.

1.3. Sedimentology

The sedimentology of the Grande Côte is characterized by two types of facies:

- Terrigenous facies, which are fed either by continental sources (winds, watercourses) or by breakdown of the existing rock. On the Senegambian continental shelf the terrigenous facies, made up primarily of quartz elements, extend from the coast out to depths of 100 m from 17'00'N to Cayar Canyon. South of the canyon, this zone quickly narrows to the coastal fringe. An important silty area exists on the continental shelf off the Grande Côte. This area covers both sides of the mouth of the Senegal River, from 16'30'N to 15'15'N between the 20 m and 80 m isobaths. It is fed by silt particles transported by the river to the sea, where they are swept up by the current and carried southwest. When the floodwaters of the Senegal River recede, which can last several months after the rainy season ends, the particles reaching the sea are believed to be swept up by the undercurrent towards the north-northeast.
- Organogenous facies exist on the north coast beyond depths of 90 m. They form a relatively narrow strip that runs along the contour of the shelf break. They are rich in shelly material and sea urchin spicules (Domain, 1977)[12].

Rocky banks extend from south of Cayar Canyon to the latitude of Popenguine. Off the Cap-Vert Peninsula is a series of rocky formations that are believed to be an extension of the volcanic relief in this region. Moreover, north of Cayar Canyon is a series of small rocky banks at depths of 15-20 meters. These banks run parallel to the coast and are covered in parts by sediment. This formation is well pronounced opposite Saint-Louis (at depths of 10-15 meters) and the Toumbos marshes (at depths of 20-30 m). When fractured, the rock composing these banks resembles a shelly sandstone. In all likelihood, this is beachrock that was formed during a regression (Domain, 1977).

[12] Domain F., 1977. Carte sédimentologique du plateau continental sénégambien. Extension à une partie du plateau continental de la Mauritanie et de la Guinée-Bissau. ORSTOM / ISRA / CRODT, Explicative Notice n° 68, 37 p.

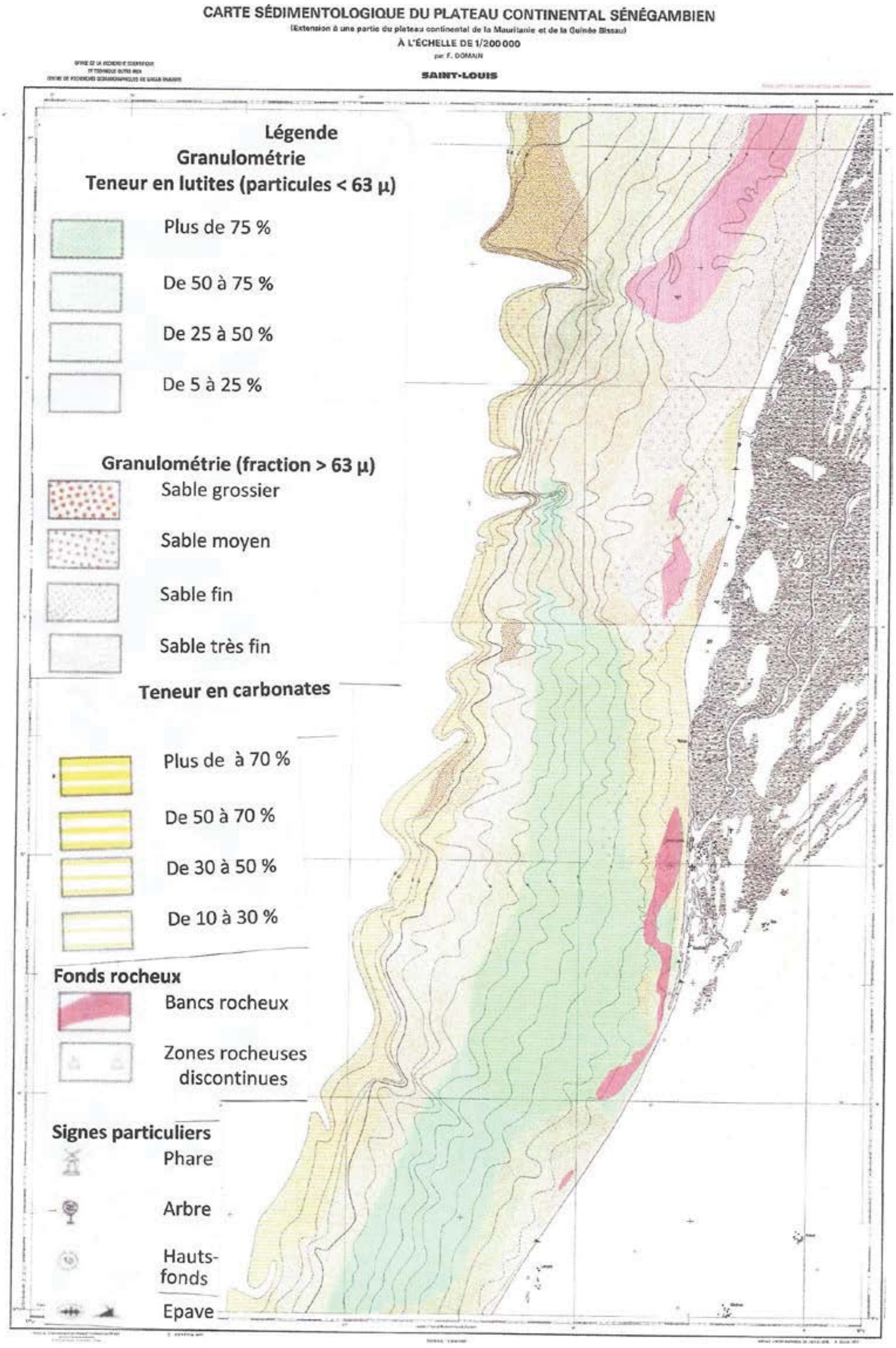


Figure 3: Sediment Map of Grande Côte Nord (Saint-Louis area, including Saint-Louis).

Source: Domain (1977)[13]

[13] Domain F., 1977. Carte sédimentologique du plateau continental sénégambien. Extension à une partie du plateau continental de la Mauritanie et de la Guinée-Bissau. ORSTOM / ISRA / CRODT, Explicative Notice n° 68, 37 p.

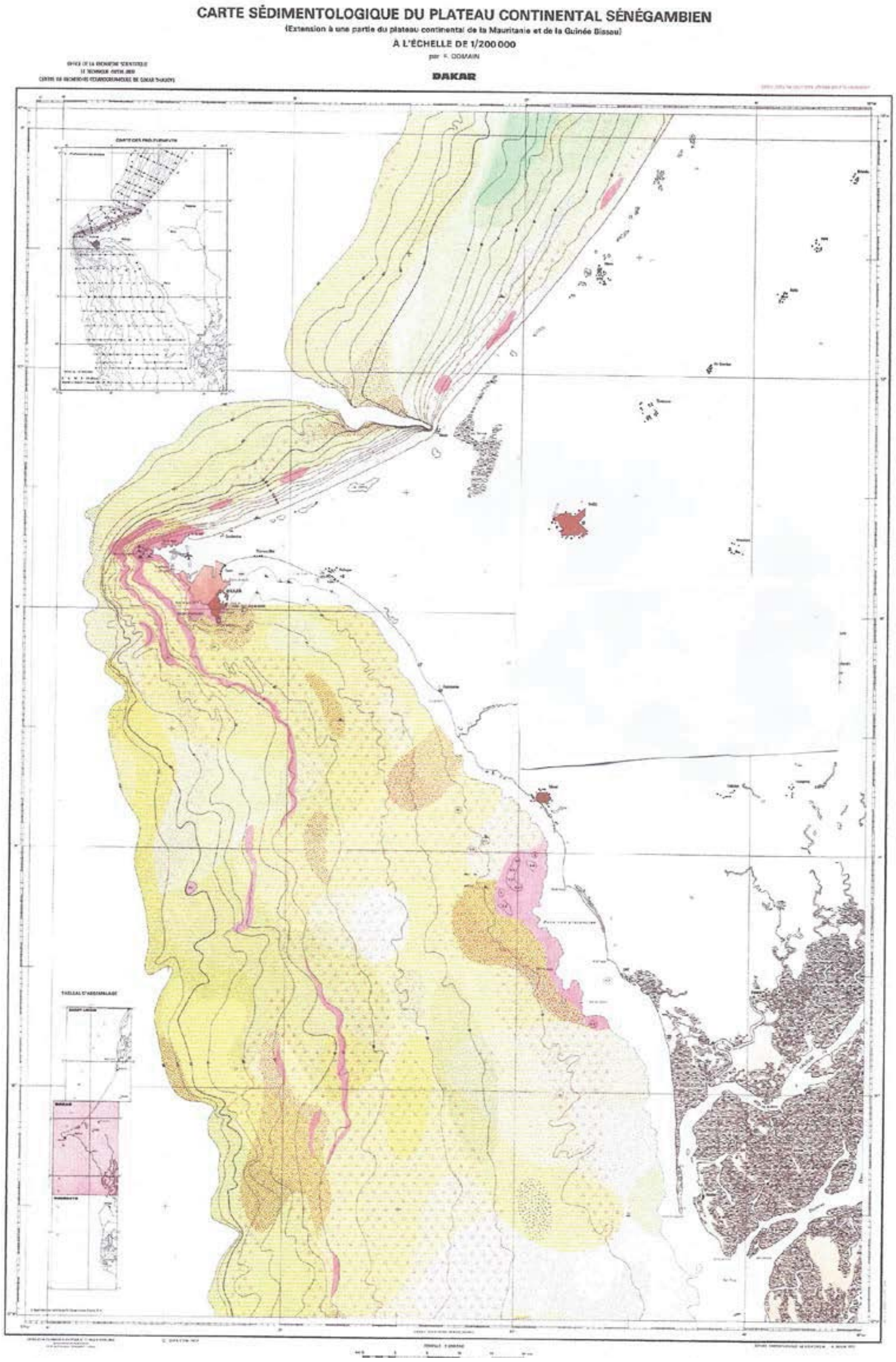


Figure 4: Sediment Map of Grande Côte Sud and Petite Côte

(Same legend as preceding figure)
Source: Domain (1977)

1.4. Hydrology and Hydrodynamics

Surface temperatures

Like the Earth's temperatures, the sea surface temperatures, due to global warming, increased from 1980 to 2015. Comparing all parts of the Senegalese coast, it appears that the warming of the coastal waters is more important at the north and gradually decreases to the south (Diouf et al., 2016)[14]. This finding justifies the recovery of temperature-sensitive species to the north or their increasing retreat from the coast.

The analysis of sea surface temperatures shows an increase in temperatures throughout the year. This situation leads to an increase in salinity. Thus, the modification of these two parameters has affected the distribution of fishery resources and fishing seasons in Senegal. Indeed, it has been shown that the increase in sea surface temperatures is correlated with the decline of "chlorophyll a" (nutrient) and the index of upwelling (to a lesser degree) (Diouf et al., 2016).

Salinity of sea water

The analysis of salinity surveys carried out by CRODT in four main coastal stations (Saint Louis, Kayar, Thiaroye, Mbour) during the period 1970-1997 (Sambou et al., 2012) and the data collected in the bibliography between 1998 and 2016 (Diouf et al., 2016)[15] highlights a process of gradual salinization of seawater on the Senegalese coasts.

Indeed, there are clearly increasing trends at the four coastal stations. The rate of salinization seems to be more accelerated in Mbour with an annual increase of 0.032 g/l. At the Grande Côte, the annual increase in salinity is slightly greater than 0.020 g/l (0.023 g/year in Saint Louis and 0.022 g/l/year in Cayar). In Cape Verde, with an annual increase of 0.011 g/l, the surveys carried out at the Thiaroye station show a relatively more moderate salinization rate compared to the other stations.

Winds

Wind has an important impact on the trophic enrichment of Senegal's marine and coastal zones through its role in upwellings. The analysis of the wind speed shows an evolution in four periods. The period 1981 - 1995 is characterized by strong winds with an average of 5.45 m / s followed by a decrease until 2001. Between 2002 and 2004, there is a slight increase with an average of 5.41 m / s. s before decreasing between 2005 and 2010 with an average of 5 m / s (Figure 8). There is therefore a strong variability of the wind over the period 1981-2010 (Sambou et al., 2012). The strength of the wind remains on a downward slope between 2010 and 2016 with peaks of up to more than 6 m / s (Diouf et al., 2016). The Great Coast is sometimes swept by strong winds (January to July) whose speed can exceed 40 kilometers per hour. These winds can generate swells more than 2.5 m in height.

Currents

In the tradewind period (October to June-July), the surface current is stable and sets southwest between Saint-Louis and Dakar. It is stronger offshore, where its velocity is in the order of 0.5 knots.

---

[14] Diouf P. S., Diop N. et Diop H., 2016. Plan national d’adaptation du secteur de la pêche et de l’aquaculture face au changement climatique horizon 2035. MEDD / MPEM / Projet USAID COMFISH, 143 p
[15] Diouf P. S., Diop N. et Diop H., 2016. Plan national d’adaptation du secteur de la pêche et de l’aquaculture face au changement climatique horizon 2035. MEDD / MPEM / Projet USAID COMFISH, 143 p

In the winter period, the surface current is poorly defined and is occasionally reversed following prolonged southwesterly winds. As in all regions of intense upwelling, below the surface current is a counter-current that, in the present case, is particularly pronounced along Senegal's northern shore. Its average velocity is in the order of 0.3 to 0.4 knots.

Swell and Longshore Current

Two types of swells can be distinguished:

- the northwest swell, whose average wave length is 302 m, which corresponds to an average period of 14 seconds and a velocity of 22 m/s.
- the southwest swell, which is masked by the first swell and of lesser magnitude.

On the coast, north of Cayar Canyon, the northwest swell induces a longshore drift toward the southwest.

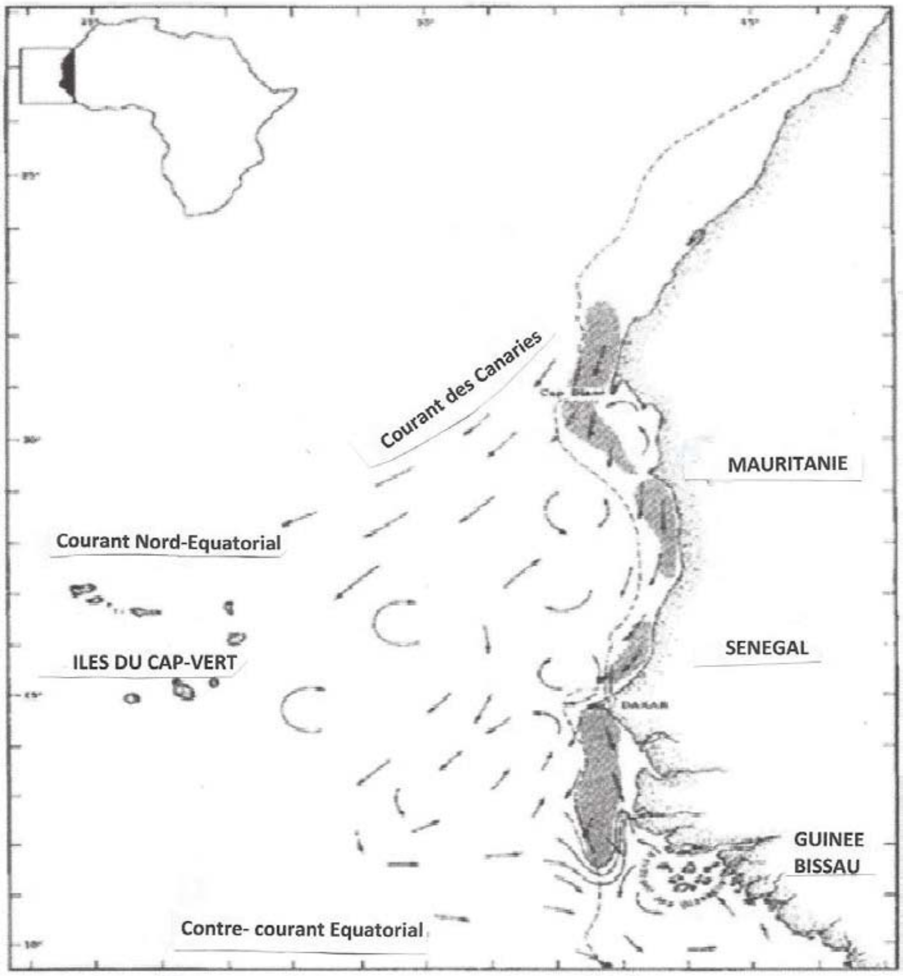


Figure 5: Ocean Circulation and Water Masses in Cold Season on Senegalese Coast

Source: Rebert J.P., 1974 (in Niang, 2008)16.

16 Niang N. A., 2008. Dynamique socio-environnementale et gestion des ressources halieutiques des régions côtières du Sénégal : l'exemple de la pêche artisanale. UNESCO/MAB and UCAD, 68 p.

Effects of the Bar on Fishing Activity on the Grande Côte

The strong swell that dominates on the northern coast during the cold season creates an important bar, especially if there are conducive topographic conditions, as is the case in Saint-Louis. The strong winds which sometimes blow on the Grande Côte with speeds exceeding 40 kilometers per hour, generate swells of more than 2.5 m in height which reinforce the bar.

The Grande Côte is dangerous for navigating and landing pirogues due to this bar. The latter is a roll of waves close to shore that causes numerous accidents and damage when artisanal fishermen try to cross it. The presence of the bar on the Grande Côte renders fishing conditions difficult (launching, landing, etc.). The bar also causes a number of pirogue accidents, and every year fishermen sustain human losses, especially at Saint-Louis.

Faced with these ecological constraints, fishermen deploy strategies to avoid or mitigate the harmful effects of hydroclimatic factors (Niang, 2008). The most commonly used tactic is to postpone fishing activities when the bar intensity is high. Surveys revealed that 57% of fishermen in Saint-Louis and 95% in Cayar use this strategy. Some fishermen (14%) use GPS to reach fishing areas during strong bars linked to the magnitude of the swell. Only 24% of interviewed fishermen in Saint-Louis and 5% in Cayar affirm that they risk confronting strong bars.

1.5. Trophic Enrichment Mechanisms

The primary enrichment mechanism of the Grande Côte continental shelf is coastal upwelling, which, thanks to the extraordinary nutrient supply that it brings, spurs development of the entire marine food chain (Cury and Roy, 1991[17], Diouf et al., 2016[18]).

It should also be mentioned that terrigenous input from the Senegal River (mitigated by the effect of the Diama dam) enhances the trophic richness of the continental shelf, especially during the rainy season. The upwelling phenomenon largely explains the importance of fishing on the Grande Côte.

2. Fishery Resources in the Core Study Area

The resources harvested in the Core Study Area include two broad groups having different bioecological characteristics: pelagic resources and demersal resources.

2.1. Pelagic Species

Pelagic resources include migratory organisms living in deep waters or near the surface. Based on their spatial distribution, these resources are subdivided into two groups: deep-sea pelagics and coastal pelagics.

Deep-sea pelagic resources mainly include the three tropical species of tuna, namely yellowfin tuna (*Thunnus albacares*), skipjack tuna (*Katsuwonus pelamis*) and bigeye tuna (*Thunnus obesus*). These are migratory species that are targeted by international fishing on a far-reaching scale, most often outside the countries' Exclusive Economic Zones (EEZ).

The most recent assessments of tropical tuna stocks conducted by the International Commission for the Conservation of Atlantic Tunas (ICCAT) shows that these species (yellowfin, skipjack and bigeye) are fully exploited, even over-

[17] Cury P. and Roy C., 1991. Pêcheries ouest-africaines : variabilité, instabilité et changement. ORSTOM, 527 p.
[18] Diouf P.S., Diop N. and Diop H., 2016. Plan national d'adaptation du secteur de la pêche et de l'aquaculture face au changement climatique horizon 2035. MEDD / MPEM / USAID/COMFISH Project, 143 p.

exploited in certain areas. Opting for the principle of precaution, the ICCAT recommended: (i) a freeze of current fishing efforts, (ii) spatial/temporal closings and monitoring of juveniles (MPAM, 2013[19]; ICCAT, 2016[20]).

Coastal pelagic resources represent over 70% of the harvest within the core study area as well as the majority of catches from artisanal fishing activities. These resources also represent the greatest share of the annual fish consumption of the Senegalese populations, notably with round sardinella *Sardinella aurita* (35%), Madeiran sardinella *Sardinella maderensis* (25%) and ethmalose *Ethmalosa fimbriata* (2%) (Diouf, 2017)[21].

Despite significant standing stock, these species, which migrate mostly at the sub-regional level, remain vulnerable due to their sensitivity to environmental conditions and to fishing that targets only a limited number of age classes. It is for this reason that the combination of climatic degradation (rising water temperatures) and excessive fishing intensity can lead to population collapse, as has already been observed in other upwelling regions (Barry et al., 2003)[22].

The most recent scientific assessments conducted by CECAF/FAO at the sub-regional level revealed a state of over-exploitation for sardinella, and recommended reducing the total fishing effort in sardinella fisheries by 50%. A 20% reduction in fishing effort was advocated for horse mackerel (*Trachurus trachurus* and *Trachurus trecae*) and false scad (*Caranx rhoncus*) (Diouf, 2017).

The Senegalese continental shelf is subject to seasonal coastal upwelling that is closely interlinked with the tradewind regime. Rich in nutrients, the resurgent water in the euphotic zone partially dictates the intensity of the primary and secondary production and its effects on the abundance and distribution of pelagic fish, notably sardinella (Madeiran and round), which represent an important share of the catches on the West African continental shelf. The consequences are all the more rapid given that the two most targeted species of sardinella are found in the lowest links of the food chain.

Surface temperature monitoring by remote sensing and acoustic measurements of the densities of pelagic species revealed that in the core study area, fish schools are found in the active upwelling zone, which is not the case on the Côte Sud (Demarcq and Samb, 1991)[23] (Figures 6 and 7).

[19] Ministry of Fisheries and Maritime Affairs, 2013. Conseil Interministériel sur la pêche. MPAM, 40 p.
[20] ICCAT, 2016. Recueil de recommandations de gestion et résolutions annexes adoptées par l'ICCAT pour la conservation des thonidés et espèces voisines de l'atlantique. ICCAT, 352 p.
[21] Diouf P. S., 2017. Stratégie de mise en œuvre du plan national d'adaptation du secteur de la pêche et de l'aquaculture aux effets du changement climatique. MPEM, 114 p.
[22] Barry M., Bousso T., Dème M., Diouf T., Fontana A., Samb B. and Thiam D., 2003. Le contexte des ressources halieutiques. CRODT, 17 p.
[23] Demarcq H. and Samb B., 1991. Influence des variations de l'upwelling sur la répartition des poissons pélagiques au Sénégal. Cury P. and Roy C. (Editors) in Pêcheries ouest-africaines : Variabilité, instabilité et changement : 290-306.

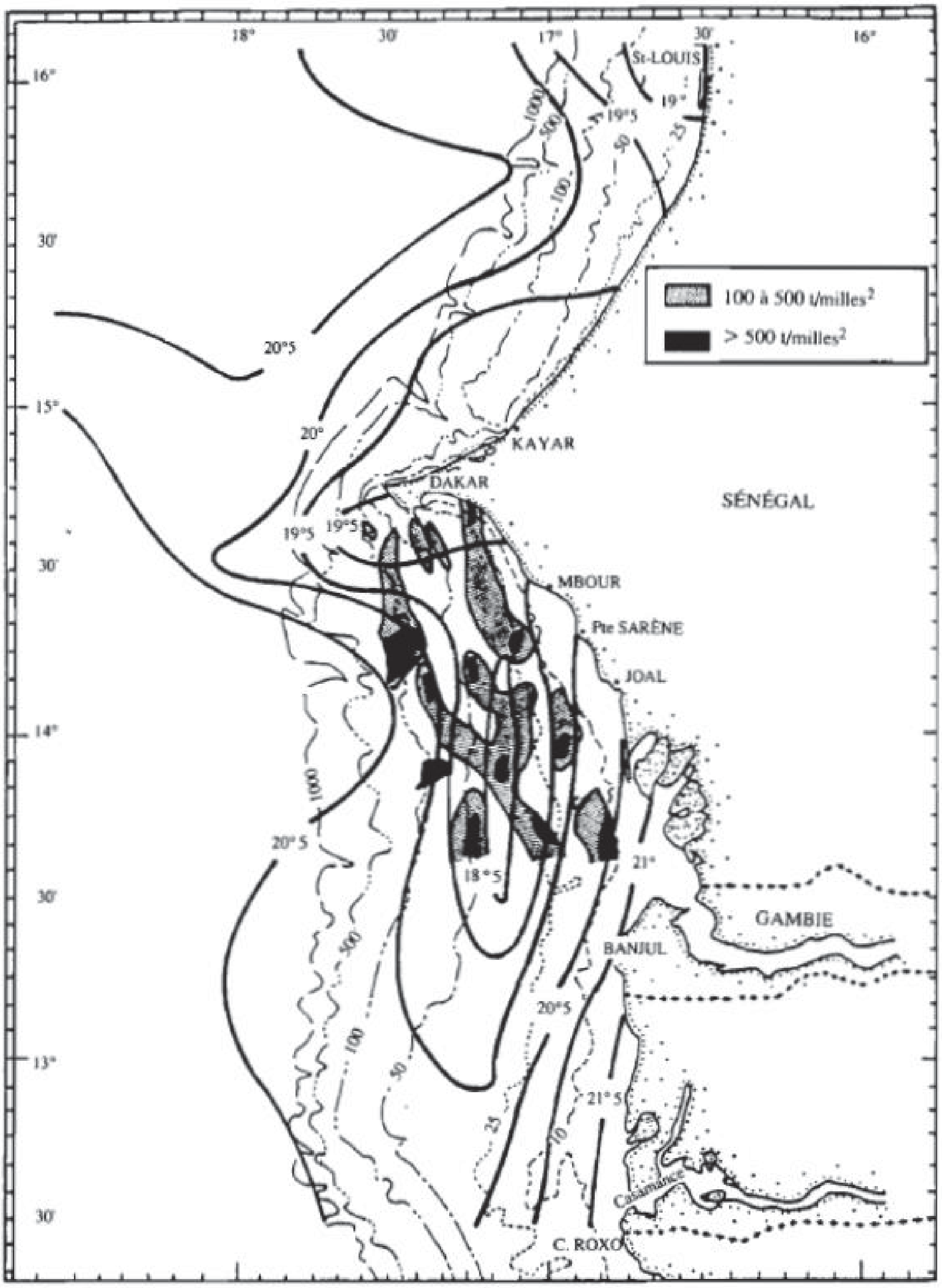


Figure 6: Distribution of Fish Densities Measured by Echo-integration and Upwelling Superficial Structure in January

Source: Demarcq and Samb, 1991

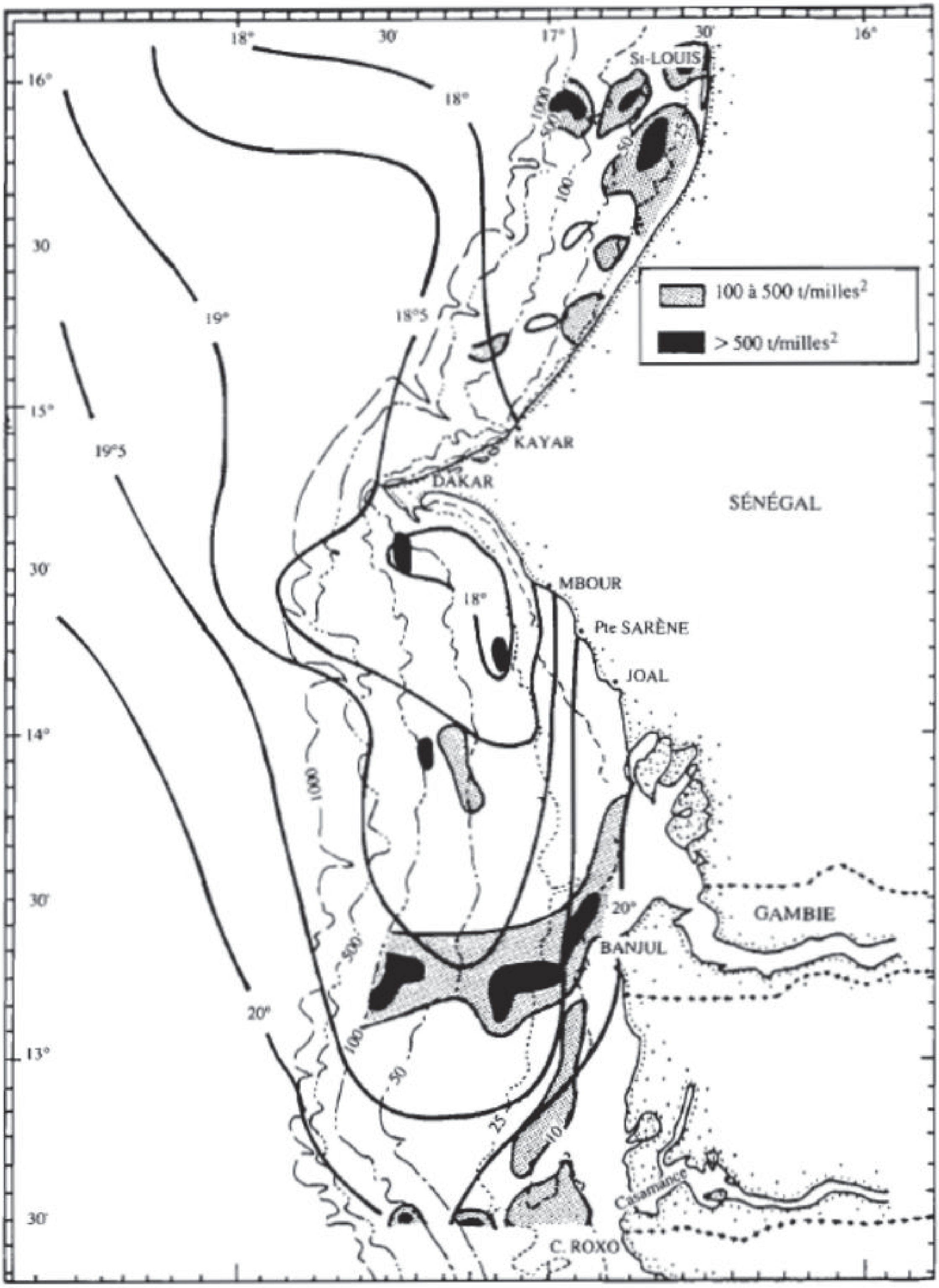


Figure 7: Distribution of Fish Densities Measured by Echo-integration and Upwelling Superficial Structure in February

Source: Demarcq and Samb (1991)

An assessment of the stocks of small pelagic species conducted on the whole Senegalese coast in October 2015 (Toresen et al., 2015)[24] showed that sardinella were found in two large areas between Casamance and Saint-Louis (Figure 8). The total biomass for Senegal was estimated at 373,000 tonnes, of which 33% is *Sardenella aurita*.

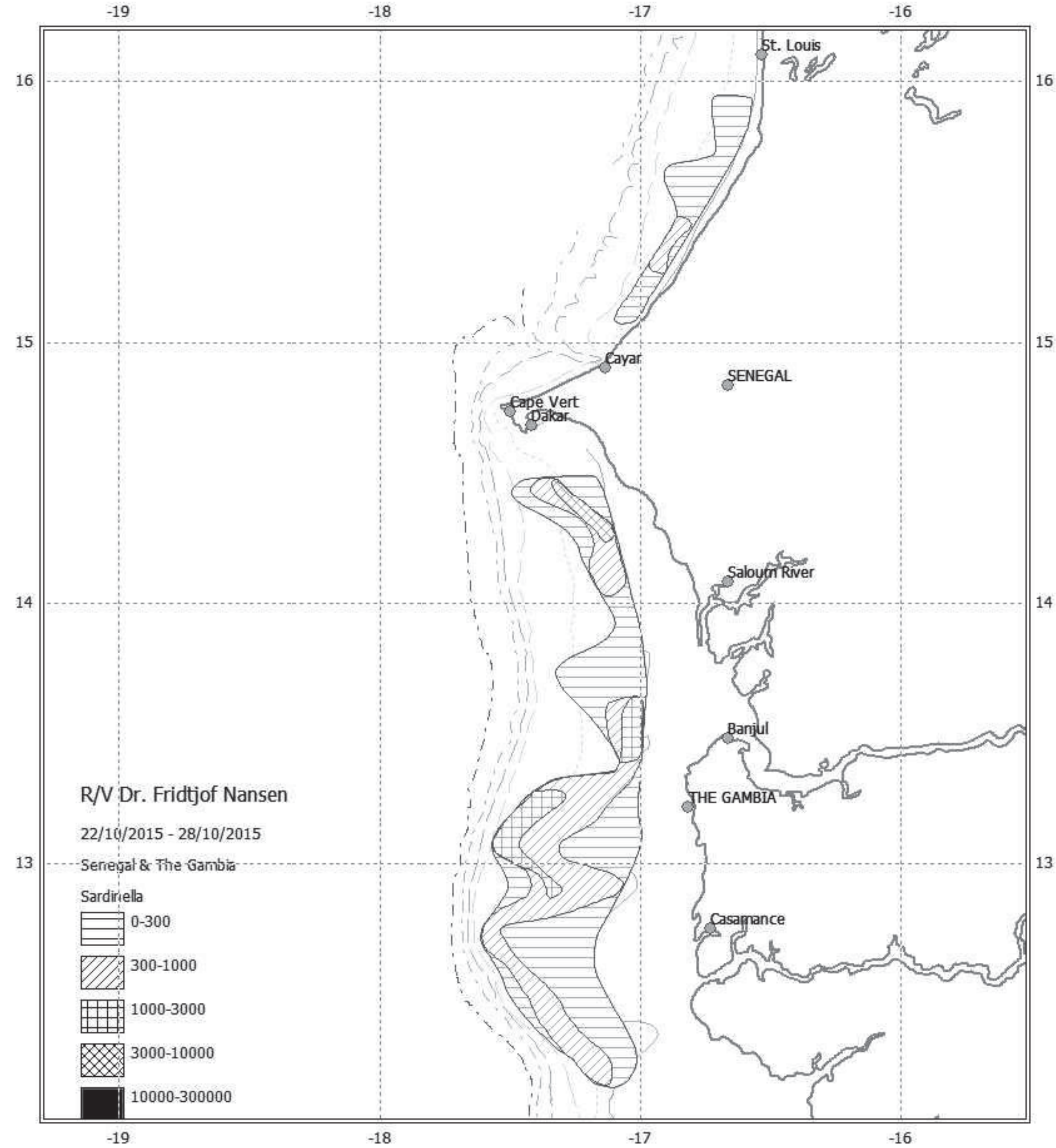


Figure 8: Biomass Distribution for Sardinella (October 2015).

Source: (Toresen et al., 2015).

[24] Toresen R., Sarre A., Ceesay S. and Zaera D., 2015. Survey of the Pelagic Fish Resources off North West Africa. Part I. Senegal - The Gambia 21 - 30 October 2015, Institute of Marine Research / Centre de Recherches Océanographiques de Dakar-Thiaroye / Department of Fisheries, 45 p.

Trachurus trecae was encountered in one main area located between The Gambia and the Cap-Vert Peninsula and in two areas of lower concentration between the northern part of Cayar Canyon and Saint-Louis (Figure 9). The total biomass of *Trachurus trecae* was 138,000 tonnes, 98.6% of which was found south of Cap-Vert.

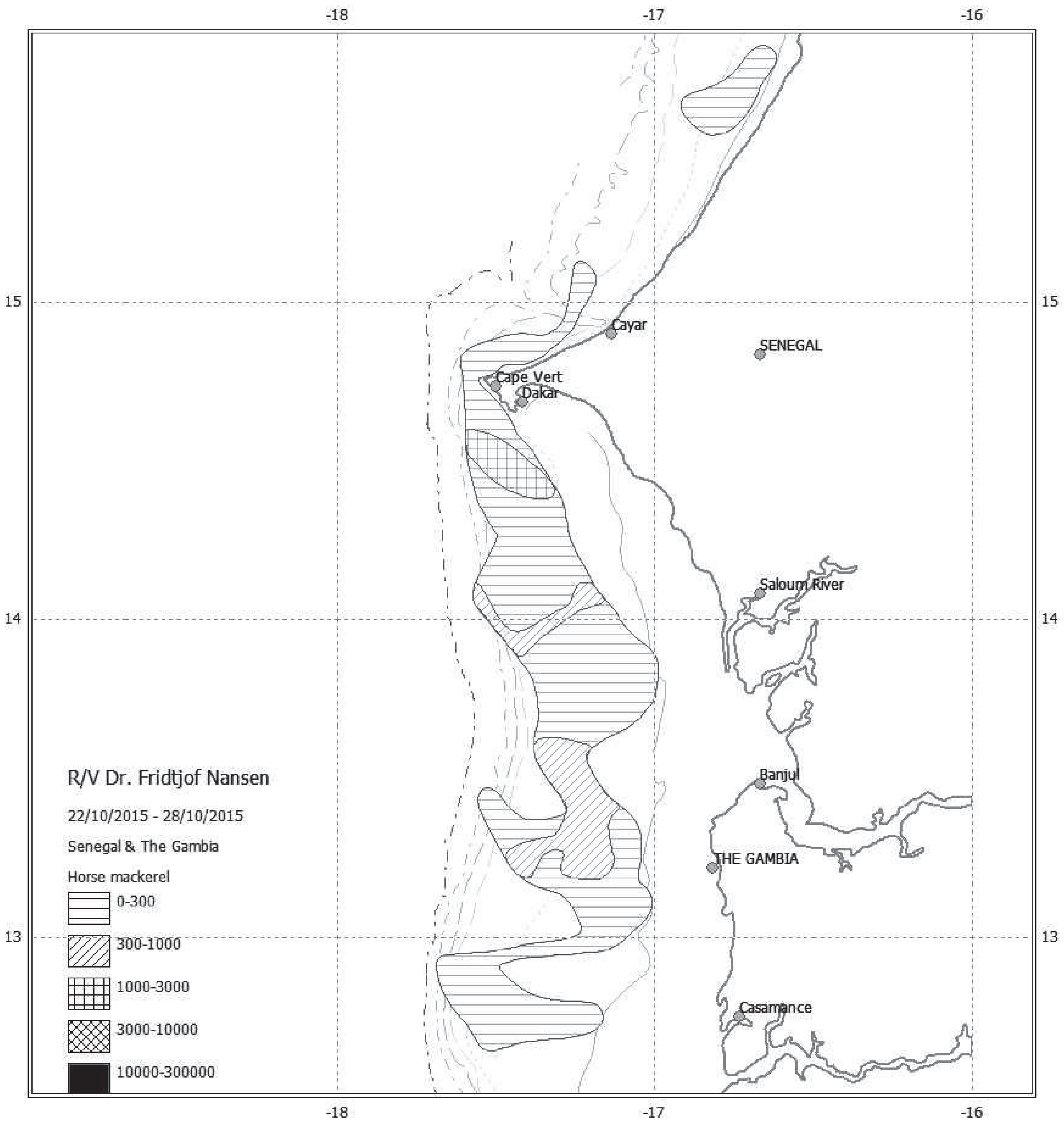


Figure 9: Distribution of *Trachurus trecae* Biomass (October 2015).

Source: (Toresen et al., 2015)

Carangidae, other pelagics and associated species showed moderate to high densities (Figure 10). The main species of this group were Cloroscombrus chrysurus, Brachydeuterus auritus, Decapterus rhonchus and Selene dorsalis. The total biomass of this group was estimated at 454,000 tonnes.

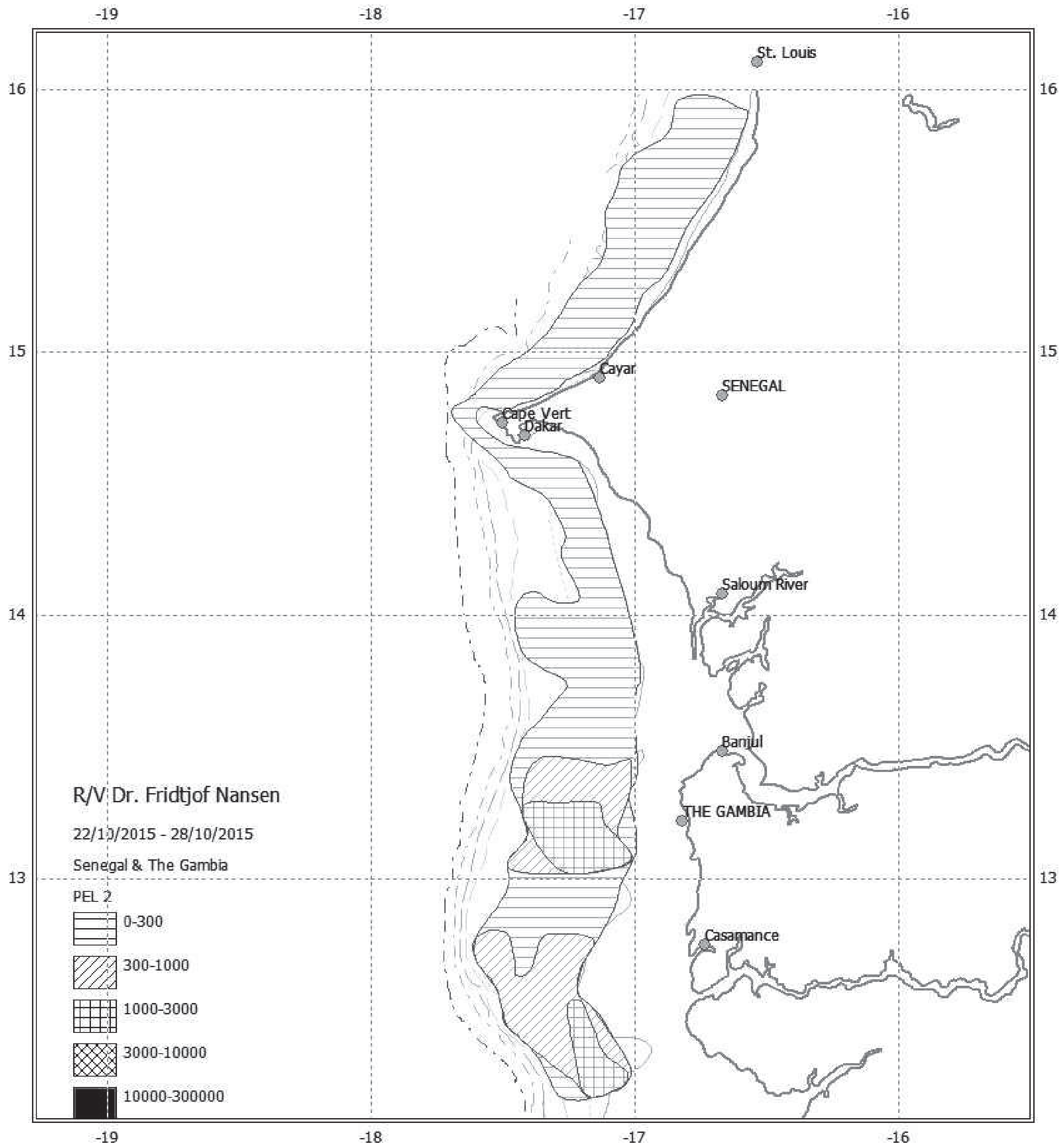


Figure 10: Distribution of Carangidae and Associated Species (October 2015).

Source: (Toresen et al., 2015)

The following Table 1 summarizes the biomasses of stocks of various groups of small pelagic species in Senegal in October 2015.

Table 1: Biomass Estimates for Pelagic Fish Species in Senegal and the Gambia (1,000s tonnes)

Zone	*Sardinella madertensis*	*Sardinella aurita*	Mackerel	Carangidae and associated species
Saint-Louis to Cap-Vert	10	23	2	27
Cap-Vert to The Gambia	39	55	74	23
The Gambia	86	45	49	220
Casamance	115	-	13	184
Total	250	123	138	454

Source : (Toresen et al., 2015)

This corresponds to a "snapshot" of the situation in October 2015. As these species are migratory, it is clear that the distribution of biomass changes during the year depending on the movements of the fish. Similar data are not available in Senegal for other periods of the year in order to be able to characterize the variability in biomass during the year.

2.2. Demersal Species

Demersal resources are present on or in the vicinity of the seafloor. They can be divided into coastal demersal and deep-water demersal species.

Coastal demersal resources in the core study area include mainly crustaceans such as southern pink shrimp (*Penaeus notialis*), Caramote prawn or triple-grooved shrimp (*Penaeus kerathurus*), Caribbean spiny lobster (*Panulirus argus*), gladiator swimcrab (*Callinectes pallidus*), sharptooth swimcrab (*Callinectes marginatus*), and big-fisted swimcrab (*Callinectes amnicola*); most prized fish, notably Senegalese tongue sole (*Cynoglossus senegalensis*), West African goatfish (*Pseudupeneus prayensis*), white grouper (*thiof* in Wolof, *Epinephelus aeneus*), dusky grouper (*Epinephelus guaza*), dungat grouper (*Epinephelus goreensis*), gilt-head seabream (*Sparus aurata*), bluespotted seabream (*Pagrus caeruleostictus*), red pandora (*Pagellus bellottii*), large-eye dentex (*Dentex macrophthalmus*); and cephalopods such as common octopus (*Octopus vulgaris*), common cuttlefish (*Sepia officinalis*) and Guinean thumbstall squid (*Lolliguncula mercatoris*). The main species of this group suffer from over-exploitation. Under the direction of the FAO and in the context of CECAF, the scientific community made the recommendation to significantly reduce the fishing effort of the fleets that target these over-exploited species (MPEM, 2013).

Deep demersal resources consist essentially of deep-sea shrimp or gambas (*Parapenaeus longirostris*), royal spiny lobster (*Panulirus regius*) and fish including Benguela hake (*Merluccius polli*), Senegalese rockfish (*Scorpaena laevis*), slender rockfish (*Scorpaena elongata*), offshore rockfish (*Pontinus kuhlii*), and blackbelly rosefish (*Helicolenus dactylopterus*); requiem sharks such as bignose shark (*Carcharhinus altimus*), pigeye shark (*Carcharhinus amboiensis*), copper shark (*Carcharhinus brachyurus*), spinner shark (*Carcharhinus brevipinna*); as well as shortspine African angler (*Lophius vaillanti*) and longspine African angler (*Lophiodes kempi*).

As a precautionary measure, it has been recommended not to exceed the current fishing effort level for the deep-sea shrimp fishery. For hake stocks, which is showing clear signs of over-exploitation, freezing the fishing effort at its current level was also recommended (MPAM, 2013)[25].

Overall, the current situation on the Grande Côte in terms of the fishery resource offers very limited potential for developing harvests in terms of quantity; rather, emphasis will have to be placed on valorization.

Important efforts are being made by the State and its partners to address this situation through the establishment of Marine Protected Areas (DAMCP, 2013)[26] and artificial reefs[27], development of a new Fishing Code and support for the creation of local governance bodies (CLPAs and CLPs) (Ndiaye et al., 2012),[28] as well as the registration of pirogues (Diouf, 2015).

A number of authors have studied the specific compositions of West African demersal communities. In the specific case of Senegal, notably in the core study area, seasonal, ecological and even economic classification criteria may be retained (Fall, 2009).

At the seasonal level, two types of communities can be distinguished: *Saharan species* and *Guinean species.*

Saharan species show positive tropism toward cold salt water (December to May, cold season), while Guinean species prefer warm, non-saline water (August to December, warm season).

Table 2 summarizes the main migrations of these 2 groups, the typology of which is rather schematic, however.

Table 2: Classification of Specific Communities according to Seasonal Criteria

Community	Examples	Characteristics
Saharan species	Rubberlip grunt, bluefish, Sparidae (seabream, red pandora, dentex), Serranidae (white grouper [*thiof*], other groupers), Carangidae (leerfish), Sciaenidae, etc.	Centre of gravity between 20°N and 23°N, August to October. Southward movement in November. Stabilization in February – March to 10° - 16°N. Northward movement in April (reproduction). Subsistence of young south of 19°, July to November (1st reproduction for some)
Guinean species	Mostly Sciaenidae community, and *Sompatt, brochetscanadum, Alectis alexandrinus, Rachycentron canadum, Caranx carangus,* etc.	Concentration (mouth of Senegal River and Saloum River in Guinea) from January to June. Rapid northward movement in June of semi-pelagic adults. Reproduction between Senegal River and Cap Timiris, Mauritania. Return to estuary in December

According to Fall (2009), at the ecological level, there exist the Sciaenidae community, the eurybathic community, the Sparidae community (split into 3 sub-communities), and the deep-water community, the main characteristics of which are summarized in Table 3.

---

[25] Ministry of Fisheries and Maritime Affairs, 2013. Inter-ministerial Council on Fisheries. MPAM, 40 p.
[26] DAMCP, 2013. Stratégie Nationale pour les Aires Marines Protégées du Sénégal. DAMPC, 48 p.
[27] Plan Stratégique National d'immersion des récifs artificiels le long des côtes sénégalaises et les réalisations du PRAO et de l'Association de la Pêche Sportive sur les récifs artificiels.
[28] Ndiaye O., Diouf P. S., Niamadio I., and S. Diouf. 2012. Stratégie de renforcement des capacités des CLPA dans le cadre de la mise en œuvre des Unités de Gestion Durables des Ressources. USAID/COMFISH Project, Senegal, University of Rhode Island, Narragansett, RI 47 p.

Table 3: Classification of Specific Communities according to Ecological Criteria

Community	Preferred locations	Major species	Observations
Sciaenidae community Synonyms: Longhurst community, Coastal community	Warm coastal waters (0-40 m deep), sandy-silty bottoms, proximity to mangrove areas (growing and hiding places for juveniles), heavy flood zones, estuaries (especially with important hydrographic networks); extension to base of thermocline; preferred location: Gulf of Guinea (highly favorable conditions, more than 50% of demersal catches, 2 components (coastal and estuarine))	* Fish: Mostly Sciaenidae, or croakers in industrial catches) + Polynemidae + Ariidae + Cynoglossidae + Haemulidae + Drepanidae + Clupeidae + Carangidae + Tetraodontidae + Mugilidae, etc. * Molluscs: volutes, cuttlefish, squid * Echinoderms (sea urchins, starfish) and other anthozoans (jellyfish, gorgonians) NB: Specific make-up is highly variable depending on the authors and the zones	Guinean affinity Warm waters year round (> 26°C); salinity < 35‰; depths rarely < 20 m and mostly silty or sandy-silty High tolerance for salinity (euryhaline species) and other endogenous factors, in general
Eurybathic community Synonym: Thermocline community	Straddles coastal community and coastal paridae sub-community	Southern pink shrimp, sole, cutlassfish, skates, common smooth-hound, bigeye grunt, etc.	Species difficult to categorize
Sparidae community Synonym: Intermediate community	Coastal Sparidae: soft, notably muddy bottoms	Blackspot seabream, goatfish, thiof, red pandora, flying fish	- Occupation of central part of continental shelf, generally - Particular importance of the seabed's calcium carbonate content - Some forty species of Saharan affinity (cold waters): Sparidae, Serranidae, Mullidae, Dactylopteridae, Balistidae, Lutjanidae, etc. - 3 discriminating biotopes, > 35‰, < 24°C, depths of 15-120 m, and especially 20-80 m
	Deep-water Sparidae: soft, notably sandy bottoms. Below thermocline, between 40 and 100 m deep	Deep-water Sparidae; Carangidae, Triglidae (gurnards) and Uranoscopidae	
	Lutjanidae: hard, rocky bottoms. Sub-group characteristic of areas of outcrops and fossil sandstone banks or proximity thereto (West Africa)	Lutjanidae *sensu stricto*, octopus, Acanthuridae and Chaetodontidae	
Deep-water community Synonym: Continental shelf break community	Deep waters: 70-200 m Bottoms: silty and sandy-silty Environmental factors relatively stable	John Dory, silvery John Dory, bearded brotula, hake, rockfish, dog-tooth grouper, deep-water *Dentex* (especially *Dentex angolensis* and *D. macrophtalmus*), etc.	14 to 15°C, salinity in the order of 36‰, seabed rich in mudstone and carbonates Approximately thirty species, sort of transition between Saharan species and deep-water fauna of the slope

Source: Fall (2009).

3. Critical Habitats: Reproduction Areas, Nurseries and Migration Corridors

The Senegalese coast is one of the most productive maritime zones in the world. This abundance is attributable to the rise of cold, nutrient-rich waters (a phenomenon known as upwelling and driven by the tradewinds) that occurs along the coast from November to May. The seasonal alternation of these cold waters with warm waters of tropical origin that invade the surface layers in summer results in a highly contrasting seasonal cycle, the temperature variation of which can reach 15°C. The result is a profound modification of the ecosystem throughout the course of the year: the tropical situation encountered in the warmer months (July to October) gives way in the cooler months to an ecosystem in which the influence of water masses from more temperate regions can at times be dominant.

In some species, this change in the ecosystem is their cue to migrate.

Indeed, during the tradewind period, when the Senegalese upwelling begins, species of Saharan or cold water affinity (*Dentex gibbosus, sparus coeruleostictus, Pagellus bellottii, Epinephelus aeneus, Pomatomus salfator*) that are observed from August to October in Mauritanian waters (between 20' and 30 N) migrate southward in November, settling in the range of 10°-16°N in February-March. In June, the tradewinds abate and warm tropical waters invade the surface layers, pushing cold water species northward. For species of Guinean or warm water affinity (*Selene dorsalis*, *Scyris alexandrinus, Sphyraena* spp., *Drepane africana, Pomadasys jubelini*), migratory patterns are less distinct.

These movements seem to affect a certain number of species, especially those of the Sciaenidae community. From January to June, the concerned populations are concentrated in a very coastal strip near the mouth of the Senegal River, and particularly in an estuarine complex that stretches from the Saloum River to Guinea. In June, a rapid movement northward takes shape. This movement only affects the adults of species with semi-pelagic behavior that migrate very close to the coast. These fish reproduce between the mouth of the Senegal River and Cap Timiris before dispersing in this region. They reach the estuarine zones beginning in December. The triggering factor and intensity of the migrations seem to be related to the spatial and temporal dynamics of the upwelling (Barry, 1994)[29].

Figures 11 to 16 illustrate the reproduction grounds, nurseries and the migratory corridors of a few fish species (Boely et al., 1978)[30]. *Sardinella aurita, Sardinella maderensis, Caranx rhonchus, Trachurus trecae, Trachurus trachurus* and *Scomber japonicus*.

---

[29] Barry M., 1994. Migration des poissons le long du littoral sénégalais. CRODT, 20 p.

[30] Boely T., Chabane J. and Fréon P., 1978. Schémas migratoires, aires de concentrations et périodes de reproduction des principales espèces de poissons pélagiques côtiers dans la zone sénégalo-mauritanienne. FAO document archive, 11 p.

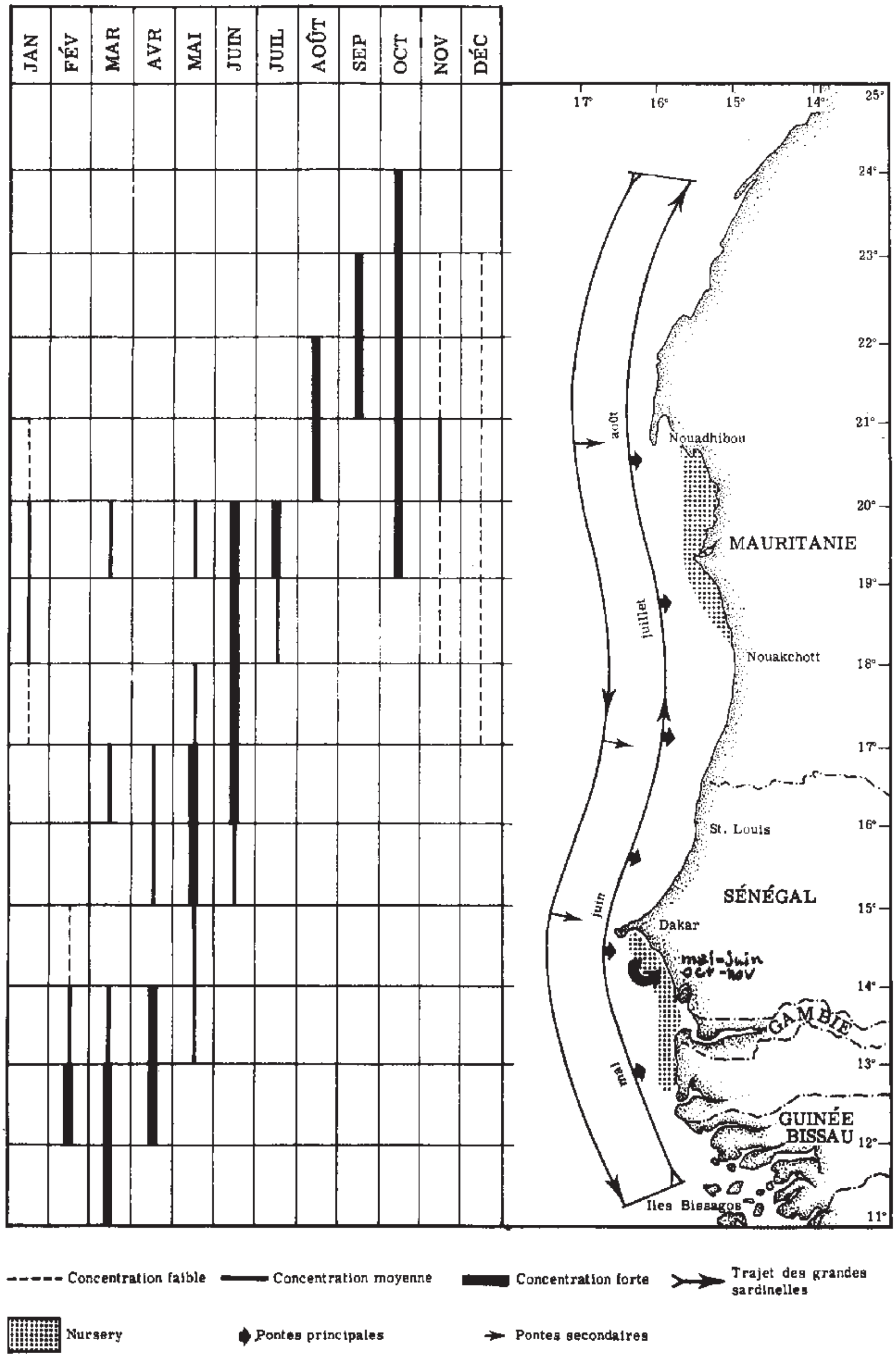


Figure 11: Migratory Cycle, Spawning Periods, Nurseries and Monthly Locations of Largest Concentrations of Adult *Sardinella aurita* in Senegal/Mauritania

Source: Boely et al. (1978)

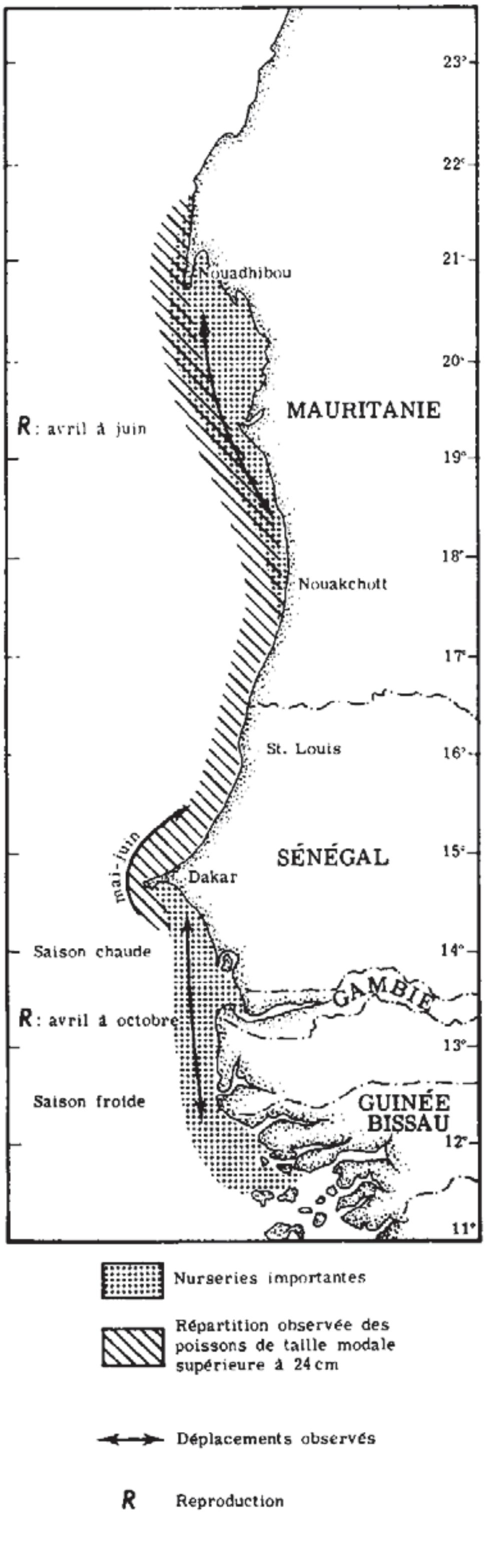


Figure 12: Movements, Main Reproduction Periods and Nurseries of *Sardinella maderensis* in Senegal/Mauritania

Source: Boely et al. (1978)

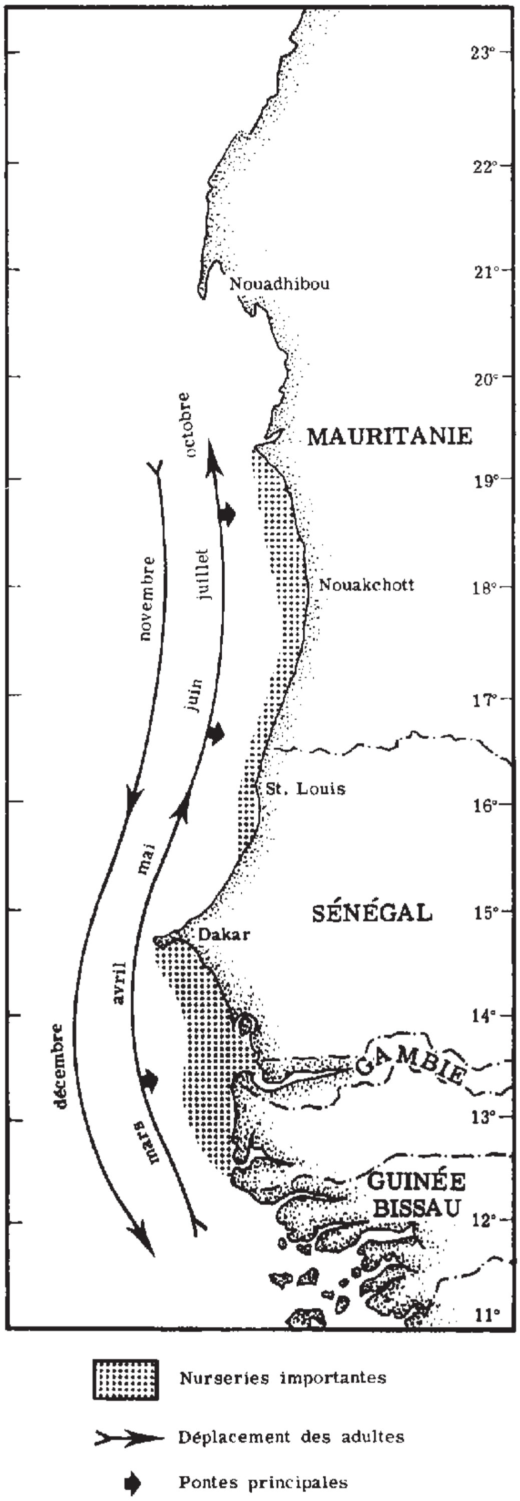


Figure 13: Migratory Cycle, Spawning Periods, Nurseries and Locations of Largest Concentrations of Adult *Caranx rhonchus* in Senegal/Mauritania

Source: Boely et al. (1978)

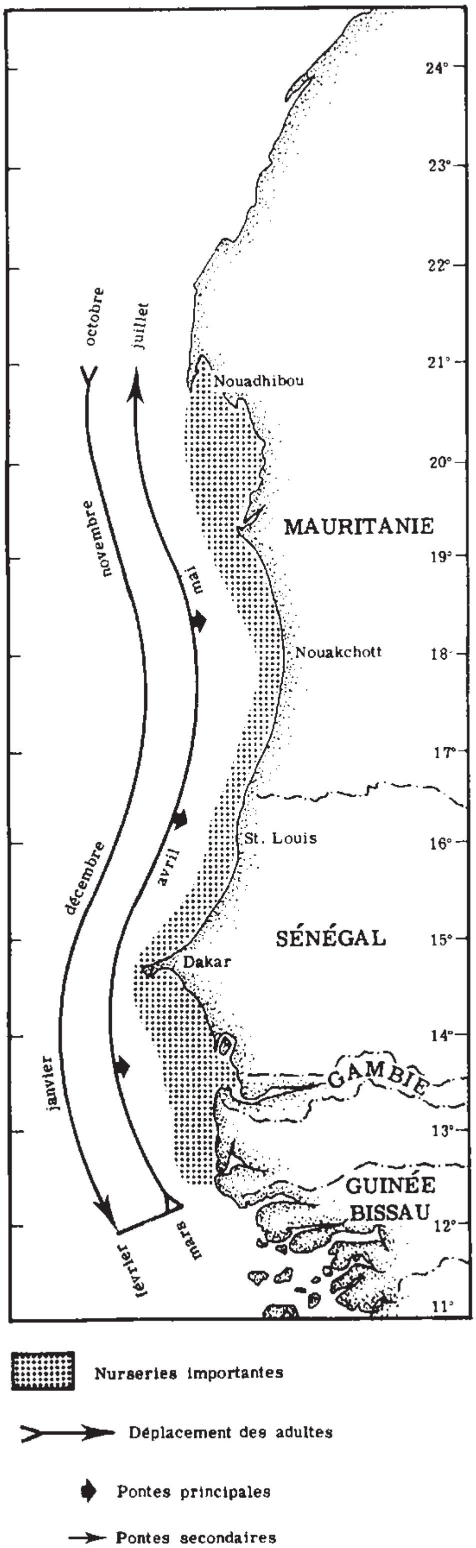


Figure 14: Migratory Cycle, Spawning Periods and Locations of Largest Concentrations of Adult *Trachurus trecae* in Senegal/Mauritania

Source: Boely et al. (1978)

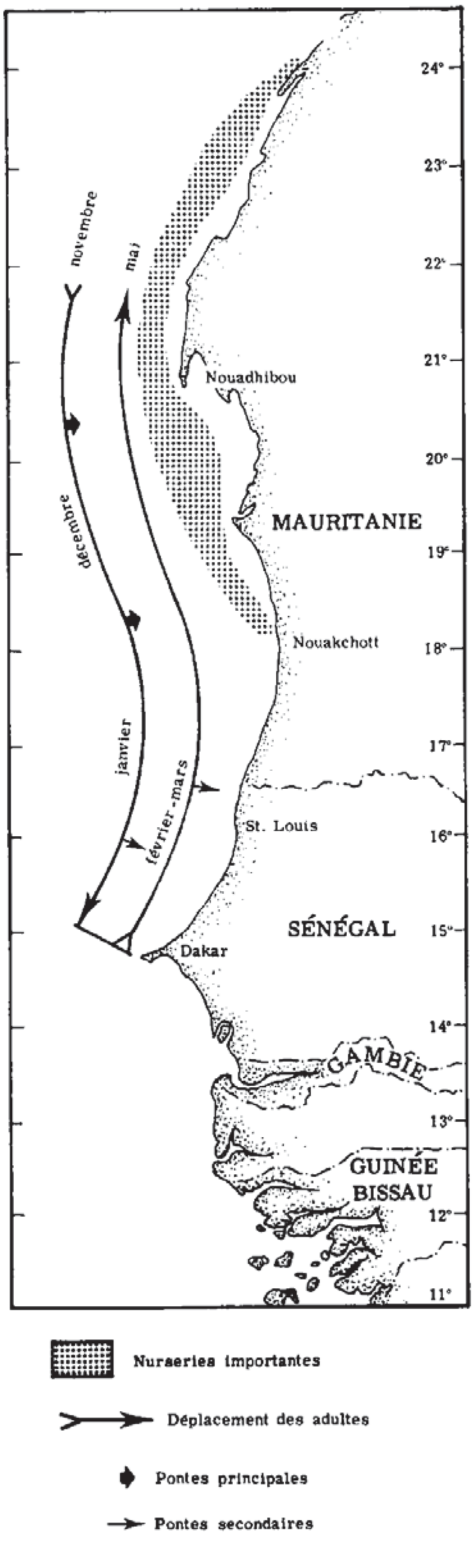


Figure 15: Migratory Cycle, Spawning Periods and Locations of Largest Concentrations of Adult *Trachurus trachurus* in Senegal/Mauritania

Source: Boely et al. (1978)

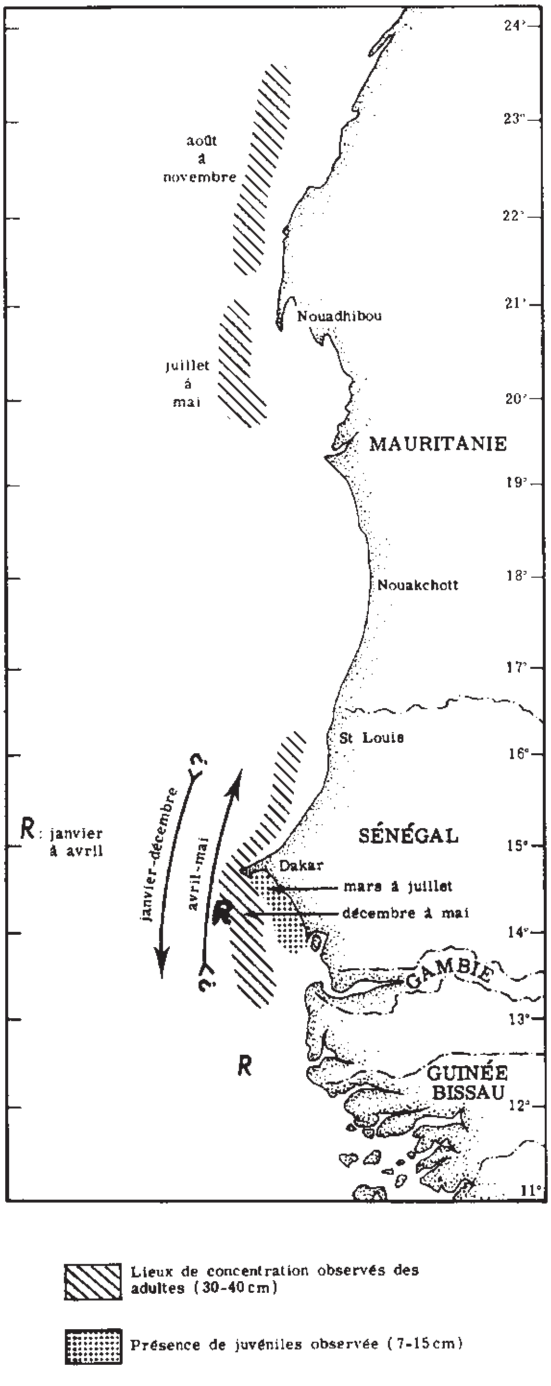


Figure 16: Probable Shifts of Main Concentration and Reproduction Areas for *Scomber japonicus* in Senegal/Mauritania

Source: Boely et al. (1978)

Discussions with fishermen and observations made in recent years confirm the current validity of these migration patterns, oftentimes with a one- or two-month time lag compared to the 1970s and 80s.

Historically, the Senegal River delta and the adjacent coastal marine zone played an important role as a nursery and reproduction ground for mullet, ethmalose, sardinella and shrimp (Thiaw, 2010[31]; Diouf et al., 2016).[32] With the construction of the Diama and Manantali dams and the opening of the breach in Langue de Barbarie, this ecological function has been severely disrupted.

Also worth mention is the role of migration route, nursery, and feeding/reproduction grounds for sea turtles that migrate along the core study area to return to the Banc d'Arguin Marine Protected Area.

Figure 17 summarizes priority conservation areas that were identified by mapping and superimposing the nurseries, reproduction grounds, migration corridors and feeding grounds of fish, shrimp, sea turtle and marine mammal species.

The area around St. Louis, by its nursery roles for many species of fish and shrimp, migratory corridor of several species of fish and sea turtles, feeding area and nesting birds (some of which come from Europe and Asia), has a regional (West Africa) and global interest in the conservation of biodiversity.

[31] Thiaw M., 2010. Dynamique des ressources halieutiques à durée de vie courte : cas des stocks de poulpe et de crevettes exploités au Sénégal. Thesis, European University of Brittany, 228 p.
[32] Diouf P. S., Ngom M. and Fall M., 2016. Ichtyofaune et pêche dans le lac de Guiers et la réserve du Ndiaèl. IUCN/OLAG, 58 p.

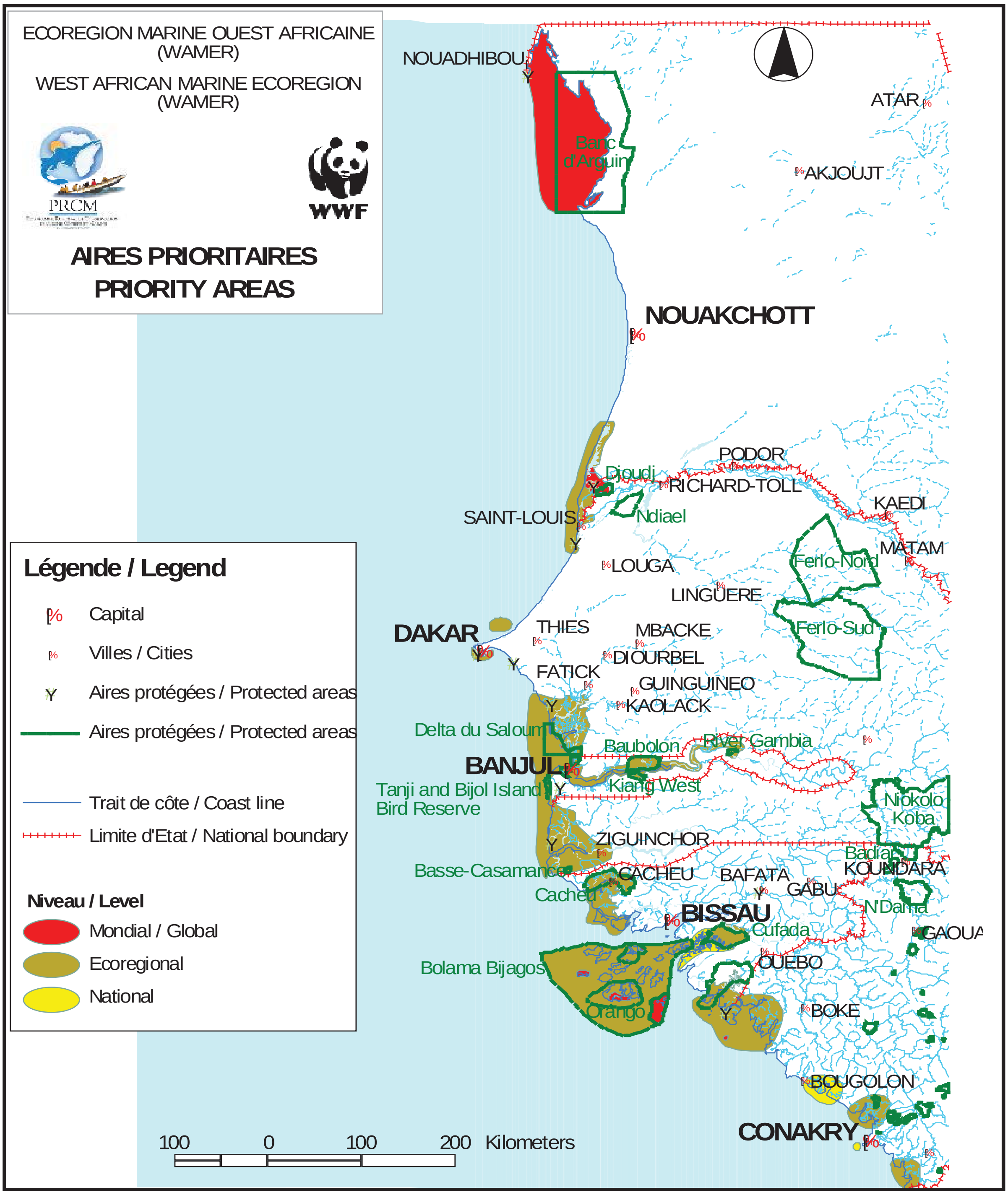


Figure 17: Map of Priority Conservation Areas

(Red indicates that the zone is of global importance, green, of sub-regional importance and yellow, of national importance)

Source: Diouf (2012)[33]

33 Diouf P. S., 2012. Plan Stratégique de l'Eco-région WAMPO (Western African Marine Ecoregion) 2012-2017. WAMPO, 230 p.

4. State of Exploitation and Conservation Status of Fishery Resources

4.1. State of Exploitation of Resources

Like much of the Senegalese coast, the Grande Côte benefits from hydroclimatic conditions (upwelling and trophic enrichment by the Senegal River) that can potentially result in high productivity. However, as a result of decades of overfishing, anthropogenic modification of the Senegal River's hydrology via the commissioning of major hydro-agricultural infrastructure, and the effects of climate change, the health of most fish stocks is of concern.

Pelagic resources – of crucial importance for feeding the most disadvantaged strata of society and for maintaining the ecological balance of the marine environment – are in a state of over-exploitation or full exploitation.

Table 4: State of Exploitation of Select Pelagic Species

Species	2012	2013	2014
Sardina pilchardus	Not over-exploited	Not over-exploited	Not over-exploited
Sardinella aurita	Over-exploited	Over-exploited	Over-exploited
Sardinella maderensis	Over-exploited	Over-exploited	Over-exploited
Scomber japonicus	Fully exploited	Fully exploited	Fully exploited
Trachurus trachurus	Fully exploited	Fully exploited	Over-exploited (amended)
Trachurus trecae	Over-exploited	Over-exploited	Over-exploited
Engraulis encrasicolus	Over-exploited	Over-exploited	Over-exploited
Ethmalose	Over-exploited (Mauritania); not fully exploited (Senegal)	Over-exploited (Mauritania); not fully exploited (Senegal)	Over-exploited in Senegal

Source: Caillart and Beyens (15)[34]

Demersal resources, which are often of high commercial value, are particularly sought by fishermen. Most of these species are in a state of over-exploitation.

[34] Caillart B. and Beyens Y., 2015. Etude sur l'évolution des pêcheries de petits pélagiques en Afrique du Nord-Ouest et impacts possibles sur la nutrition et la sécurité alimentaire en Afrique de l'Ouest. EU / DAI, 78 p.

Table 5: State of Exploitation of Some Demersal Species

Species	State of exploitation				
	2004	2007	2008	2010	2014
Red pandora *Pagellus bellottii*	Fully exploited	Heavily over-exploited	Over-exploited	Over-exploited	Over-exploited
Bluespotted seabream *Sparus caeruleostictus*	Over-exploited	Over-exploited	Over-exploited	Over-exploited	Over-exploited
Catfish *Arius spp*.	Risk of over-exploitation	Inconclusive	Inconclusive	Fully exploited	Fully exploited
Croakers *Pseudotolithus* spp.	Overfished	Overfished	Fully exploited	Over-exploited	Fully exploited
Thiof *Epinephelus aeneus*	At risk of extinction	Facing extinction	Endangered	Severely over-exploited	Severely over-exploited
Southern pink shrimp *Penaeus notialis*	Signs of over-exploitation	Over-exploited	Over-exploited	Over-exploited	Over-exploited

Source: CRODT (2015)[35]

With regard to deep-water demersal resources, the state of exploitation of deep-sea shrimp requires that further precautions be taken. As for hake stocks, they are over-exploited and a freeze in fishing effort is imperative to avoid a collapse of this fishery (MPAM, 2013).

According to the most recent scientific notice issued by CECAF (2014), the majority of stocks of small pelagic species in Northwest Africa are fully exploited or over-exploited (sardinella, chinchard, mackerel). The only exception is the sardine. The recommendations are to reduce the fishing effort (sardinella) or to limit the catches to former levels (chinchard, mackerel) (Caillart and Beyens, 2015).

Overall, the governance framework of these small pelagic fisheries is deficient. Although according to the Law of the Sea, coastal nations should cooperate to define and implement management and conservation measures that would allow regional stocks to be maintained at sustainable levels, at the present time there is a complete absence of suitable frameworks. Existing regional fishing organizations only have an advisory mandate and the degree of collaboration between the coastal countries concerned (Morocco, Mauritania, Senegal, The Gambia) is low (Caillart and Beyens, 2015). It should be noted, however, that the SRFC is making significant efforts in this regard.

Notably, CECAF, which is the primary institution mandated to provide scientific advisories, suffers from a chronic lack of resources to carry out its mission. CECAF's powerlessness is aggravated by a lack of data that member countries are supposed to make available for the analysis of stock levels.

[35] Dakar-Thiaroye Centre for Oceanographic Research

4.2. Special Status Species

The IUCN Red List assesses the risk of extinction of a given species on the basis of a set of objective and measurable criteria. There are eight categories (+ "data deficient"), based on criteria related to population numbers, trends and structures, as well as geographic range. Species assessed in the "Critically Endangered", "Endangered" and "Vulnerable" categories are collectively designated "Threatened" (Sidibé, 2010)[36].

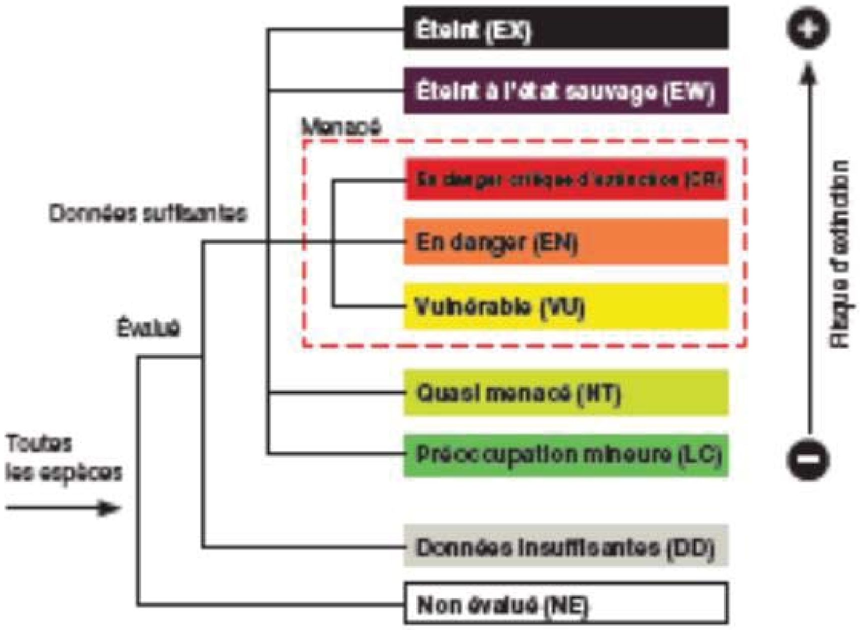


Figure 18: Structure of Red List Categories

Source: IUCN[37]

Three species of hammerhead sharks present in the core study area are on the Red List, namely:

- Smooth hammerhead (*sphyrna zygaena*), on the IUCN Red List of Threatened Species in the "Vulnerable" (VU) category;
- Scalloped hammerhead (*sphyrna lewini*), on the IUCN Red List of Threatened Species in the "Endangered" (EN) category, but also in the "Vulnerable" (VU) category for the Eastern Central Atlantic subpopulations;
- Squat-headed hammerhead (*sphyrna mokarran*), on the IUCN Red List of Threatened Species in the "Endangered" (EN) category globally, but now in the "Critically Endangered" (CR) category for the Eastern Central Atlantic, including in West African waters (http://www.ndarinfo.com/Tortues-et-requins-a-Ndar-le-commerce-d-especes-en-voie-de-disparition-perdure_a10248.html).

Moreover, although considered widespread, *E. aeneus* (thiof) has already been evaluated by IUCN as being relatively close to being threatened. It is assessed as "Near Threatened" on the Red List. The species' status is confirmed in the region by its state of over-exploitation as well as the sharp decline in its abundance (nearly 70% of its initial numbers) and the contraction of its geographic range. A significant decline in mature individuals is also being

[36] Sidibé A., 2010. Utilisation de la Liste Rouge de l'UICN pour le suivi des risques de perte de biodiversité : application aux poissons démersaux exploités d'Afrique du Nord-Ouest. IUCN, 64 p.
[37] IUCN, n.d. La liste rouge des espèces menacées de l'UICN. IUCN, 2 p.

observed within the Senegalese population of the species. The status means that the species is considered to face a high risk of becoming extinct in the wild if it continues to be exposed to the same conditions (Sidibé, 2010).

Table 6 gives an idea of the most threatened species on the Senegalese Gande Côte area.

Table 6: Conservation Status of Some Species of the Grande-Côte

Species	Conservation Status
Ray and Sawfish	
Rhinobatos rhinobatos (Common Guitarfish)	Statut : Endangered Populations trend : In decline
Pristis pectinata (Smalltooth Sawfish)	Statut : Critically Endangered Populations trend : In decline
Pristis Pristis (Largetooth Sawfish)	Statut : Critically Endangered Populations trend : In decline
Sharks	
Sphyrna zygaena (smooth hammerhead)	Statut : Vulnerable Populations trend : in declin
Sphyrna lewini (Scalloped Hammerhead)	Statut : Endangered Populations trend : in declin
*Sphyrna mokarran (*Great Hammerhead)	Statut : Critically Endangered Populations trend : In decline
*Carcharhinus brevipinna (*Spinner Shark*)*	Statut : Near Threatened Populations trend : Unknown
*Carcharhinus isodon (*Finetooth Shark*)*	Statut : Least concern Populations trend : Unknown
*Carcharhinus leucas (*Bull Shark*)*	Statut : Near Threatened Populations trend : Unknown
*Carcharias taurus (*Sand Tiger Shark*)*	Statut : Vulnerable Populations trend : Unknown
*Carcharodon carcharias (*Great White Shark*)*	Statut : Vulnerable Populations trend : Unknown
Bony Fish	
Epinephelus aenus (White grouper)	Status : Near Threatened Populations trend : In decline
Epinephelus marginatus (Dusky Grouper)	Status : Endangered Populations trend : In decline
Pomatomus saltatrix (Bluefish)	Status : Vulnerable Populations trend : In decline
Dolphins	
Sousa teuszii (Atlantic Humpbacked Dolphin)	Status : Vulnerable Populations trend : In decline

Species	Conservation Status
Delphinus delphis (Short-beaked Common Dolphin)	Status : Least concern Populations trend : Unknown
Tursiops truncatus (Common Bottlenose Dolphin)	Status : Least concern Populations trend : Unknown
Phocoena phocoena (Harbour Porpoise)	Status : Least concern Populations trend : Unknown
Seals	
Monachus monachus (Mediterranean Monk Seal)	Status : Endangered Populations trend : Increasing
Sea Turtles	
Caretta caretta (Loggerhead Turtle)	Status : Endangered Populations trend : In decline
Chelonia mydas (Green Turtle)	Status : Endangered Populations trend : In decline
Lepidochelys kempii (Kemp's Ridley)	Status : Critically Endangered Populations trend : Update needed
Lepidochelys olivacea (Olive Ridley)	Status : Vulnerable Populations trend : In decline
Dermochelys coriacea	Status : Vulnerable Populations trend : In decline

Source : The IUCN Red List of Threatened Species. Version 2017-1. <www.iucnredlist.org>. Downloaded on 13 September 2017

It would appear that a conservation effort is needed to improve the conservation status of several species. Measures to advocate include the creation and improved management of marine protected areas and a formal prohibition of harvesting threatened species.

5. Fisheries

5.1. Stakeholders in the Fisheries

Artisanal fishermen in Senegal are essentially from one of three groups (Mbaye, 2002)[38]: the Lebu, who reside in Dakar and on the Petite Côte, the inhabitants of Guet Ndar in the North (Saint-Louis) and the Niominka in the Centre (islands of the Saloum River). These three groups represent more than 90% of all fishermen (58% Lebu, 18% Guet Ndarians and 15% Niominka) (Diouf et al., 2016). Additionally, there are representatives from all parts of the country, with variable degrees of specialization such as the natives of Gandiole (6%), a village near Saint-Louis, and others affected by unemployment, academic failures, past droughts or difficult living conditions (Diouf, 2017).

[38] Mbaye A., 2002. Analyse sociologique de la différenciation technique dans la pêche artisanale maritime sénégalaise. Séminaire C3ED-OA, 7 p.

Artisanal fishermen travel from one port to another in pursuit of fishery resources as they migrate. Some of them travel outside Senegal to fish, notably in Mauritania, The Gambia, Guinea-Bissau, Guinea and even Sierra Leone and Angola[39]. Some fishermen, notably those from Saint-Louis, work for *bateaux ramasseurs*[40], for which they harvest prized fish such as *Serranidae*, *Sparidae*, etc. (WARFP, 2013)[41].

[39] For Angola, vessels load pirogues onboard and once they reach their destination, the pirogues set out to fish for these same vessels.

[40] The *bateaux ramasseurs* make agreements with the artisanal fishermen and buy their catches from them.

[41] WARFP-SN, 2013. Etude sur l'état des pêcheries côtières, des stocks clés et de leurs habitats. Final Report, CRODT / World Bank, 91 p.

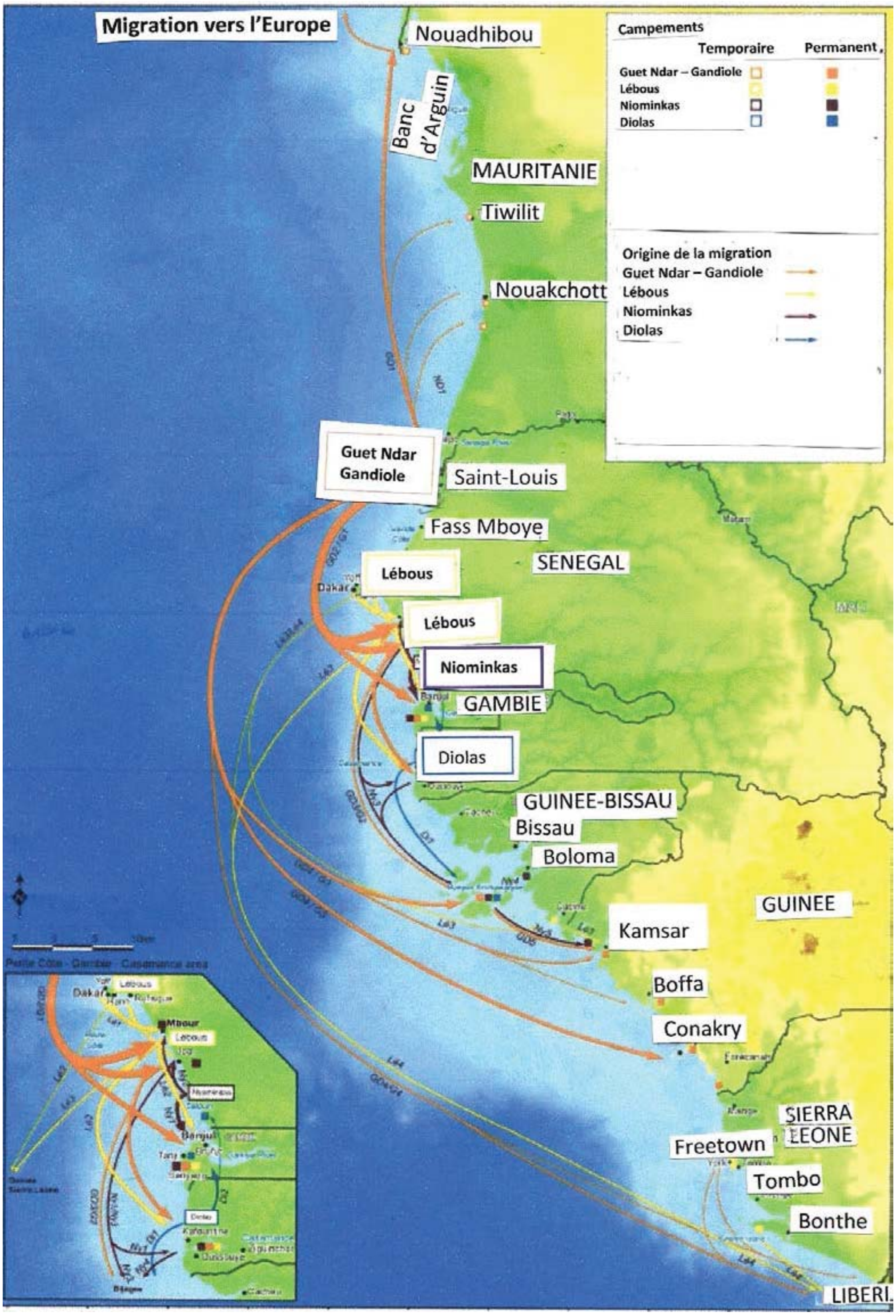


Figure 19: Main Migration Routes of Senegalese Artisanal Fishermen

Source: Binet et al. (2012)[42]

[42] Binet T., Failler P., Thorpe A., 2012 Migration of Senegalese fishers: a case for regional approach to management. Maritime Studies 11, 1.

Fishmongers perform a number of functions: financing artisanal fishing, procuring fish on the beaches, packaging and transport to plants, domestic sales and exports. The fish trade is strongly dominated by men between the ages of 40 and 60.

Artisanal processors are mostly women. Processing represents an important social function. Limited numbers of foreigners are also involved in processing, valorizing species such as sharks and skates, which are not typically part of the Senegalese diet (FAO, 2008)[43].

Table 7: Workforce for Various Fishing-related Social/Professional Categories on the Grande Côte

	Grande Côte Nord (Saint-Louis to Lompoul)	Grande Côte Sud (Fass-Boye to Yoff)	Total, Grande Côte
Fishing	22,000	12,232	34,232
Fish trade	788	1,006	1,794
Artisanal processing	1,522	865	2,387
Service providers (carpenters, fuel attendants, mechanics, marine hardware managers, pirogue offloaders and porters, cart operators, fish scalers, ice plant owners and their staff, etc.)	703	1,453	2,156
Total	25,013	15,556	40,569

Source: Compilation of USAID/COMFISH Project data[44]

Fishery resource processing plants and exporting fishmongers have a strong impact on artisanal fishing, notably in terms of the species that are targeted by fishermen. Under their influence, numerous fisheries have been developed for export. The most striking examples are cephalopods and cutlassfish (*talar*). A number of plant owners have been affected by the scarcity of the resource and have been experiencing difficulties forcing them to close their business.

While the majority of industrial fishing activities are concentrated in the Dakar-Pikine urban area, artisanal fishing is present along the entire Senegalese coastline and plays a critical role in the organization of this coastal space (Cormier-Salem, 2013)[45].

Industrial fishermen are either nationals or foreigners who often have greater technological and financial means than their artisanal counterparts. The following table presents an overview of the numbers, catches and landings for trawlers, sardine boats and tuna boats.

[43] FAO, 2008. Vue générale du secteur des pêches nationales. Profil des pêches et de l'aquaculture par pays. FAO, 27 p.
[44] USAID/COMFISH Project, 2015. Plan de Gestion Participatif de la Pêcherie de sardinelles dans la Grande Côte Sud. USAID/COMFISH and DPM, 35 p.
USAID/COMFISH Project, 2016. Plan de Gestion Participatif de la Pêcherie de sardinelles dans la Grande Côte Nord. USAID/COMFISH and DPM, 52 p.
[45] Cormier-Salem., 2013. L'aménagement du littoral un enjeu crucial pour les pêcheries artisanales. Fontana and Samba (Edits), 163 p.

Table 8: Numbers, Catches and Landings for Trawlers, Sardine Boats and Tuna Boats (industrial fishing)

Type of ship		Senegal	European Union		Other									Total	2014 Report	Variation
			Spain	France	Neth. Antilles	Guatemala	Panama	Cabo Verde	El Salvador	Curaçao	Brazil	Belize	Côte d'Ivoire			
Trawlers	Number	96	2											98	87	13%
	Catch	35,326	1,226											36,552	46,650	-22%
	Landing	35,326	1,226											36,552	46,650	-22%
Sardine boats	Number	1												1	4	-75%
	Catch	461												461	1605	-71%
	Landing	461												461	1605	-71%
Tuna boats	Number	8	**11	***6		2	3	3	2	4		2		41	15	173%
	Catch	11,657*	5,994	3,983										21,594	12,056	79%
	Landing	11,657	8,099	2,481		3,976	4,422	1,822	1,335	12,429		1,861		48,082	37,002	30%
TOTAL	Number	105	13	6	0	2	3	3	2	4	0	2	0	140	106	32%
	Catch	47,444	7,220	3,943	0	0	0	0	0	0	0	0	0	58,607	60,311	-3%
	Landing	47,444	9,325	2,481	0	3,976	4,422	1,822	1,335	12,429	0	1,861	0	85,095	85,257	0%
2014 Report	Number	98	7	1	0	0	0	0	0	0	0	0	0	106		
	Catch	52,700	6,469	1,142	0	0	0	0	0	0	0	0	0	60,311		
	Landing	52,454	11,678	1,968	6,233	4,592	1,935	5,084	0	0	984	0	328	85,257		
Evolution	Number	7%	86%	500%	0%	0%	0%	0%	0%	0%	0%	0%	0%	32%		
	Catch	-10%	12%	245%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-3%		
	Landing	-10%	-20%	26%	-100%	-13%	129%	-64%	0%	0%	0%	0%	-100%	0%		

(Source: DPM[46])

* including 5,059 tonnes (Senegalese seiners)
** including 4 seiners (Spanish) and 7 foreign vessels (Spanish)

* including 6,598 tonnes (Senegalese pole-and-line vessels)
*** including 5 seiners (French) and 1 seiner (French)

[46] DPM, 2015. Résultats généraux des pêches maritimes. MPEM, 138 p.

Moreover, Senegal has numerous professional fishing organizations. Their involvement in fishing management, though still insufficient, has been one of the main developments observed in recent years.

With regard to industrial fishing, the best known organizations are the Senegalese Association of Ship Owners and Industrial Processors (GAIPES) and the National Union of Exporting Fishmongers of Senegal (UPAMES).

In the artisanal fishing sector, the most active professional organizations are the National Federation of Economic Interest Groups of Fishermen (FENAGIE-PECHE), the National Federation of Fishmongers of Senegal (FENAMS), the National Collective of Fishmongers for Development of Senegal (CNDMS), the National Collective of Artisanal Fishermen of Senegal (CNPS), the National Union of Fishmongers EIGs of Senegal (UNAGIEMS), the National Network of Women in Artisanal Fisheries in Senegal (REFEPAS), the National Federation of Women Fish Processors (FENATRAMS). These organizations operate under the National Inter-professional Council of Artisanal Fishing in Senegal (CONIPAS).

Also noteworthy is the existence of Local Artisanal Fishing Councils (CLPA) and Local Fishermen's Committees (CLP), which, thanks to the USAID/COMFISH Project, WARFP project and the fisheries administration, have been becoming increasingly active.

The national NGOs and projects most active in the field include, but are not limited to, the USAID/COMFISH Project, PRAO, Repao, APTE, IDEE Casamance, etc.).

5.2. Fishing Gear and Fishing Fleet

5.2.1. Artisanal Fishing

Grande Côte Sud

Along the Grande Côte Sud (from Fass Boye to Yoff), fishing is practiced with a wide array of gear, the most important of which are nets (passive bottom nets, encircling gillnets [*saïna*], purse seines, beach seines), lines (hook-and-line and longlines) and spear guns. In terms of numbers, hook-and-line prevails, with approximately 5,758 units (Figure 20), i.e. 68.45%, followed by longlines and encircling gillnets, with 21.11% and 4.47%, respectively.

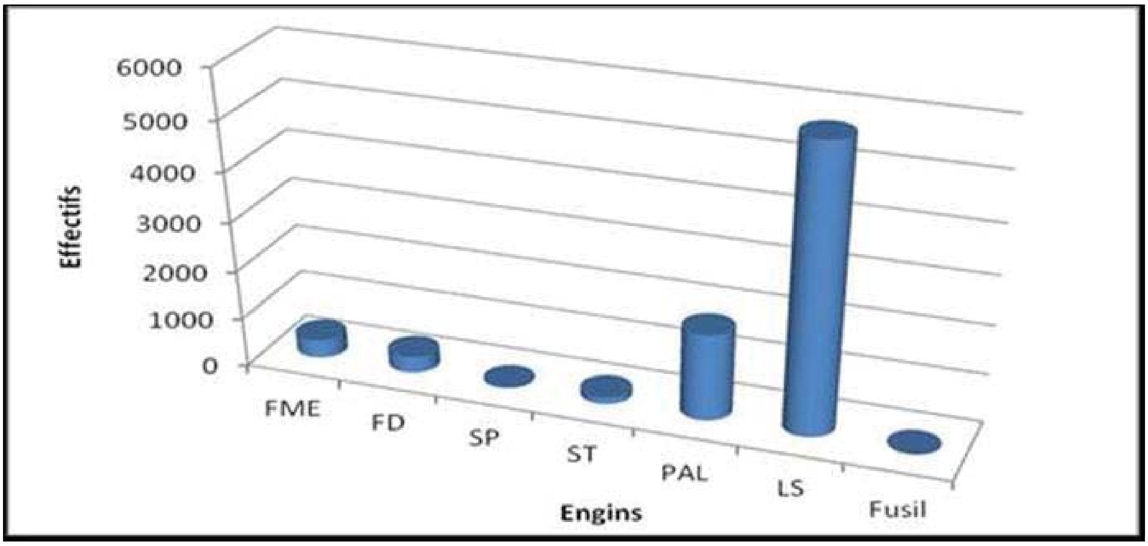


Figure 20: Distribution of Fishing Gear

Source: USAID/COMFIH (Survey, May 2013)

Legend : FME = Encircling Gill Net ; FD = Passive Net ; SP = Beach Seine ; ST = Purse Seine ; PAL = Longline ; LS = Single Line, Fusil = underwater speargun.

The use of fishing gear is not homogeneous from one site to another. In the zone covered by the Cayar CLPA, five (5) types of fishing gear were identified: nets (purse seines and beach seines) and lines (hook-and-line and longlines). In terms of numbers, hook-and-line prevails with 69.37%, followed by longlines with 29.55%. None of the other fishing gear represented exceeds 1% individually (purse seines, spearguns and beach seines with 0.95%, 0.11% and 0.02%, respectively).

For the CPLA of Dakar West, six (06) types of fishing gear were identified: nets (passive bottom nets, encircling gillnets [*saïna*], purse seines, beach seines), and lines (hook-and-line and longlines).

The pirogue fleet on the Grande Côte Sud is one of the largest in the artisanal fishing sector. According to the national pirogue registration program (PNI), in 2013 the fleet was estimated to number approximately 4,300 pirogues. Boats vary in size, and can reach up to 25 meters in length. Most of them are motor-driven (USAID/COMFISH Project, 2015).

Grande Côte Nord

Fishing along the Grande Côte Nord (from Saint-Louis to Lompoul) is practiced with a diverse range of gear, including nets (purse seine, passive bottom net "*Mbal Ser*", surface drift gillnet "*félé félé*" and trammel), lines and longlines.
In terms of numbers, the survey conducted in 2014 by the USAID/COMFISH Project shows that purse seines for sardinella represent only 21% of all fishing gear (Figure 21). This type of gear was introduced in Senegal in 1972 through an FAO project. The fishing technique consists of encircling fish shoals and then unloading them into carrier pirogues with a crew of about thirty on average. The size of these nets varies from 300 to 1,200 m, with an average of 750 m.

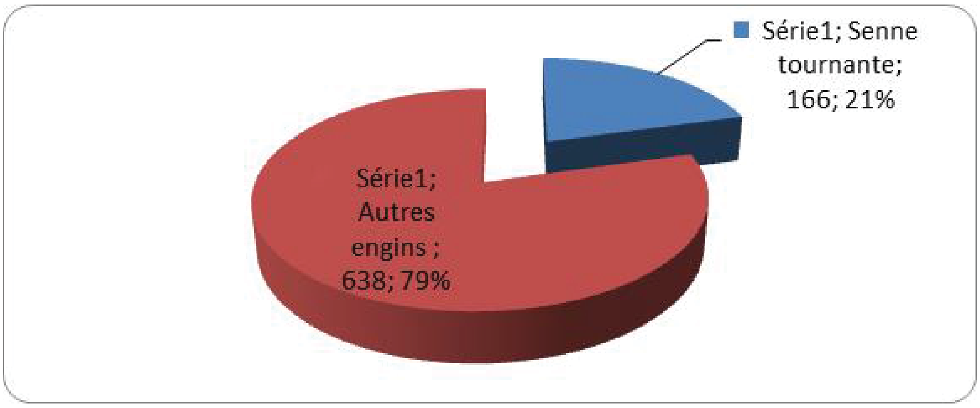


Figure 21: Distribution of Various Fishing Gear Types – CLPAs of Saint-Louis

Sources: USAID/COMFIH (Survey, May 2014)

The following Table 9 summarizes the characteristics of the artisanal fishing gear.

Table 9: Presentation of Artisanal Fishing Gear Studied

Name and Composition	Technical Specifications	Operating Modes	Targeted Species
Purse Seine (PS)	Net from 250 to 400 m long, 40 m dept and 30 mm mesh at the netting. With a purse string and a large pocket.	2 pirogues, one for the net, the other for the catches. Nearly 30 people. Effective for capturing round sardinella, which tends to dive deep when encircled.	Mostly Clupeidae (*Sardinella aurita, S. maderensis* and *Ethmalosa fimbriata*). Secondarily, Carangidae, sompatt, Grunt *B. auritus*, barracuda *Sphyryaena sp*, little tuna Euthynnus alleterratus, West African Spanish mackerel *Scomberomorus tritor*, Silver sword *Trichiurus lepturus*.
Encircling Gillnet (EGN)	Rectangular, length 300 m, drop 9 m and mesh 36-40 mm	One ± powerful motor pirogue. No purse string. Active fishing. 9 people on average. Up to 15m of depth. Can also be used as SDGN (see below).	Nearly 80% of the catches consist of ethmalose and sardinella, which are their main targets. The rest = catfish *Arius sp*, croakers *Pseudotolithus sp*, barracudas *Sphyraena sp*, , etc.
Active Net (Surface drift gillnet – SDGN - and Bottom drift gillnet – BDGN)	The SDGN or fish *félé-félé* has a dept of 2 m, a length and a variable mesh. Lead laden, many floats (floatability + drift). The *Yolal* or BDGN : 100 to 1000 m, depth from 4 to 4.5 m, 46 mm mesh for barracudas.	SDGN often operated by 2 people from a pirogue, often on foot. Possible day and night outings with monofilament; multifilament efficient at night. BDGN or *Yolal* drift more in the intermediate than deep water layer.	Mostly Mullet (*Mugil sp* and *Liza sp*), some ethmaloses, sompatt, sardinella, barracuda, etc. for the SDGN. The SNGD target barracudas (July - September) and/or <u>*Scombridae*</u> (little tuna and west African Spanish mackerel, December to April). Other catches: mullet, Threadfish, *Carangidae*, croakers, Tilapias (*Tilapia guineensis*, *Sarotherodon melanotheron heudelotii*), *Arius sp*.
Passive Net (PN) (Bottom and surface set gillnet and trammel)	"Fish" PN (FPN, 110 m, 50 mm, nylon), soles PN (SPN, 1-2 km, depth of 1 m, nylon or monofilament), rays and sharks PN (RSPN, 6 to 7 gears = 100 to 150 m , nylon), *yeet PN* (YPN, 20 m, dept from 1 to 1.2 m, mesh of 300 mm, braided nylon, 10-15 m deep.) Cheap (mainly nets + repairs and maintenance), ± fuel (install/lift), 2 to 4 people.	FPN: Mostly night fishing, nets set at the bottom or at the surface. SPN: set at sea for many months, set back after each harvest. RSPN: Mainly a Saint-Louis and Sine-Saloum practice. YPN: stay for several months at sea, harvest every 2-3 days.	FPN: Croakers, catfish, barracudas and Carcharhinidae like *M. mustellus*. SPN: tonguesoles *Cynoglossus sp*. RSPN: rays and sharks. YPN: *Cymbrium sp*. Poor quality due to stay of 24-48 h in the water - a certain decomposition, so products intended mostly for artisanal transformation and local consumption.
Longlines (Longlines and wet longlines)	Main line 300-500 m long, nylon, braided most of the time, 0.3 m lead-outs spaced at 1.8 m, floats and lead at each end. Baited hooks (sardinella as bait).	Cuttlefish = bait of choice or Clupeidae (sardinella and ethmaloses). Immersion for 5-6 hours, hauled and set back of the longline. Risk of being swept away by bottom trawl, seine or driftnet.	*Rhinobatidae, Carcharhinidae* (rays and sharks), catfish, Threadfish Polydactylus quadrifilis, *Drepane africana*, Barracuda, thiof Epinephelus aeneus, etc.
Other lines (Cuttlefish trap lines, octopus line, haul line, Rhinobatos sp. line, simple line motorized pirogue and simple line non-motorized pirogue)	Classic lines : nylon or monofilament + hooks + lead + bait. Octopus lines (OL, line + lead + lures + hooks. Cuttlefish trap lines (CTL, foldable or non-foldable traps with lure). Length of lines and number of hooks depending of the targeted species and water depth.	Often used in combination with longlines, drift or fixed gillnets. Fresh fishing (of the day), wet lines (3-5 days, up to 100 km from the Senegalese coast, some tide lines at Saint-Louis (pick-up boats).	Classic motorized or non-motorized pirogue lines: thiof, sompatt, catfish, seabreams, pandoras, Carangideas, barracudas, big sharks, Lutjanidae, etc. Octopus lines: *Octopus vulgaris*. Cuttlefish Lines: *Sepia officinalis hierredda*. Rhinobatos line: guitarfish. Haul line: sailfish, marlin, mackerels, bars, etc.

Sources: Massal (2009)

The Saint-Louis CLPA has a large pirogue fleet. Approximately 943 pirogues were identified during surveys conducted in 2014 as part of the development of a local convention. The size of the boats varies from 4 to 25 meters and are motor driven with engines rated 15 hp, 40 hp and 60 hp.

In the other CLPAs in the area, 68 pirogues were tallied in Potou, 120 in Lompoul and 193 in Gandiole.

Every year, these pirogues are required to pay a fee, which varies from 5,000 CFA francs for fishing by foot, 15,000 CFA francs for pirogues measuring up to 13 meters and 25,000 CFA francs for pirogues exceeding 13 meters. Likewise, in 2016 (January to April) 1,567 sea fishing permits and 78 continental fishing permits were purchased, versus a total of 1,137 in 2015, which reflects a notable increase in this sector (USAID/COMFISH Project, 2011).

With regard to industrial fishing, in compliance with Decree n° 2016-1804 implementing Maritime Fishing Code Law n° 2015-18 of July 13, 2015, fishermen operating in the core study area have four categories of licenses: coastal demersal fishing license (three options: shrimp trawlers, fish and cephalapod trawlers, bottom longliners), deep demersal fishing license (five options: shrimp trawlers, fish trawlers, bottom longliners, pink spiny lobster boats, deep-sea deep crab boats), coastal pelagic fishing license (two options: seiners, trawlers), deep-sea pelagic fishing license (pole-and-liners, seiners, tuna longliners, swordfish longliners).

5.2.2. Industrial Fishing

The exploitation of fishery resources in Senegalese waters is the result of artisanal and industrial fisheries. The main characteristic of the Senegalese fishing system is the predominance, in terms of landings, of the artisanal subsector which is responsible for more than two thirds of landings (Dème, 2016)[47].

The industrial fisheries consist in 2017 of 161 vessels including 128 nationals and 33 foreign vessels. It includes deep-sea pelagic fisheries, coastal pelagic fisheries, deep-sea demersal fisheries and coastal demersal fisheries.

Offshore pelagic fisheries are essentially tuna fisheries which catch yellowfin, skipjack and bigeye tuna. Coastal pelagic fishing is done by sardine fishermen who mainly target sardinella and horse mackerel.

Coastal demersal fishing is conducted by shrimp trawlers looking for coastal shrimp *Penaeus notialis* and fish trawlers targeting coastal demersal fish species and cephalopods.

Deep demersal fishing is carried out by deep-sea shrimp trawlers (*Parapenaeus longirostris*) and bottom-fishing trawlers (*Merluccius senegalensis* and *Merluccius polli*), which exploit the banks resources between 150 and 800 m depth (Dème, 2016).

Table 10 gives the distribution of the types of fishing gear used by these vessels.

[47] Dème M., 2016. Les systèmes d'exploitation de la pêche sénégalaise. CRODT, 17 p.

Table 10 : Number of active boats in Senegal using different fishing gears

Fishing Gear	Number of boat using this type of fishing gear	TJB
Seiner	32	Generally between 512 and 2863 Small TJB, in the order of 40, are national vessels
Fish and Cephalopod Trawler	52	29 to 536 Small TJB correspond to national vessels
Coastal Shrimp Trawler	28	Generally between 119 and 317. The only small TJB found were 2 national vessels (74.93 and 96)
Deep-sea Shrimp Trawler	18	Genrally between 148 and 413,66. The only small TJB found is a Senegalese vessel (98)
Longline Tuna	1	625
Longline Swordfish	1	512
Bottom Fish Trawler (Hake)	08	Between 171 and 555
Pelagic Trawler	06	737
Pole-and-liners	14	155 à 472
Deep crab boats	01	169

(Data Sources : DPM)

Industrial fishing boats are characterized by their mobility in the area where they are allowed to fish in Senegal by the type of license they have acquired. Presence by industrial fishing vessels, within the extended study area, is relatively high as shown in the following map.

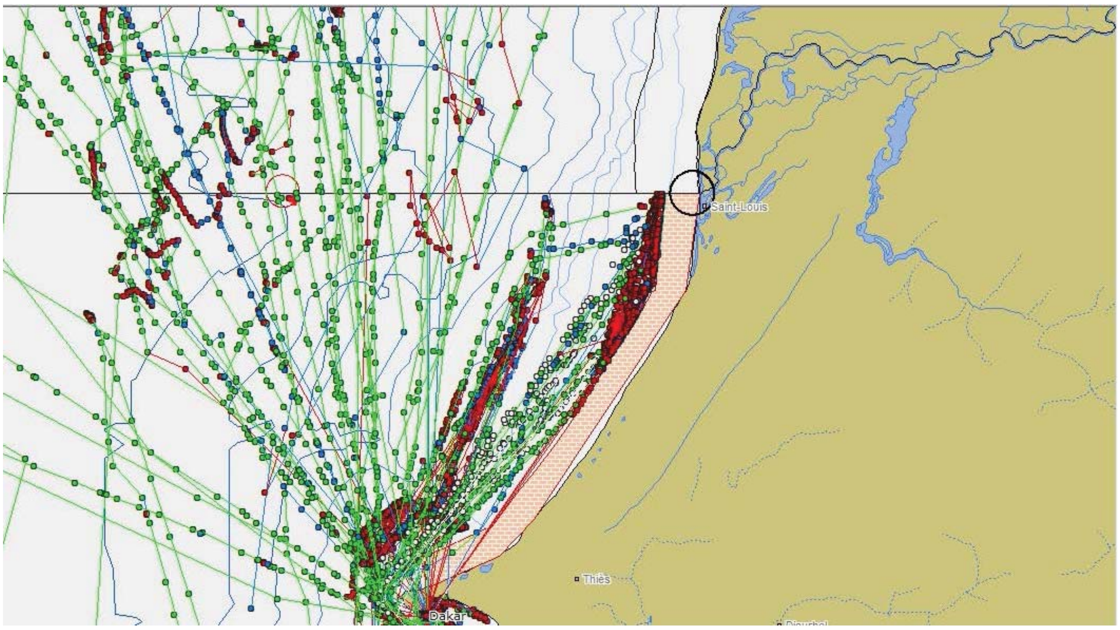


Figure 22 : Activity of industrial fishing vessels in the vicinity of the offshore area (circled red dot) between 1 July and July 25, 2017

(Blue = fishing activity, Green = transit speed and Red = travelling)

5.3. Fishing Zones

Section 3 (Articles 39 to 51) of Decree n° 2016-1804 implementing Maritime Fishing Code Law n° 2015-18 of July 13, 2015 defines the industrial fishing zones.

Article 39. Fishing zones are measured from a reference line that connects the points below, which are determined by means of hydrographic surveys conducted by the competent national authorities:

1°) From Point P1 (16°04'00"N – 16°31'30",8W) to Point P2 (15°45'00"N – 16°33'12"W).

2°) From Point P3 (15°00'00"N – 17°04'06"W) to Point P4 (14°52'48"N – 17°11'12"W).

3°) From Point P5 (14°46'42"N – 17°25'30"W) to the northern tip of Île de Yoff (14°46'18"N –17°28'42"W);

- from the northern tip of Île de Yoff (14°46'18"N – 17°28'42"W) to the tip of Île de Ngor (14°45'30"N – 17°30'56"W);
- from the northern tip of Île de Ngor (14°45'30"N – 17°30'56"W) to Feu des Almadies (14°44'36"N – 17°32'36"W);
- from Feu des Almadies (14°44'36"N – 17°32'36"W) to Cap Manuel (14°39'00"N – 17°26'00"W);
- from Cap Manuel (14°39'00"N – 17°26'00"W) to Pointe Rouge (14°38'12"N – 17°10'30"W);
- from Pointe Rouge (14°38'12"N – 17°10'30"W) to Pointe Gombaru (14°29'50"N – 17°05'30"W);
- from Pointe Gombaru (14°29'50"N – 17°05'30"W) to Pointe Sarène (14°17'05"N – 16°55'50"W);
- from Pointe Sarène (14°17'05"N – 16°55'50"W) to Pointe Senti (14°11'10"N – 16°52'00"W);
- from Pointe Senti (14°11'10"N – 16°52'00"W) to Pointe de Sangomar (13°50'00"N – 16°45'40"W);
- from Pointe de Sangomar (13°50'00"N – 16°45'40"W) to Point P6 20 (13°35'24"N – 16°40'30"W).

4°) From the Senegal-Gambia border (13°03'54.3"N – 16°44'54"W) to Point P7 (12°45'10"N – 16°47'30"W);

– from Point P7 (12°45'10"N – 16°47'30"W) to Point P8 (12°36'12"N – 16°48'00"W);

- from Point P8 (12°36'12"N – 16°48'00"W) to Pointe Djimbéring (12°29'00"N – 16°47'36"W);

5°) From Cap Skirring (12°24'30"N – 16°46'30"W) to the border with Guinea-Bissau (12°20'20",8N – 16°43'03",2W).

Article 40. For those sections of Senegalese coast located beyond the boundaries given by the reference points indicated in Article 39 of this decree, fishing zones are measured from the low water mark, which is an integral part of the reference line.

Article 41. Distances measured from the reference line or from the low water mark are expressed with respect to the closest point to the line, regardless of the zone in which the ship is sailing.

Article 42. To meet the requirements of a sustainable exploitation of resources, the Ministry responsible for maritime fisheries may issue a decree to close a given fishing zone for a determined period of time.

Article 44. Subject to the provisions contained in Article 43 of this decree, the fishing zones of ships operating in waters under Senegalese jurisdiction are defined according to the license types stipulated in Articles 45 through 51 of this decree.

Article 45. The demersal fishing license grants:

1. Wetfish or freezer trawlers ("shrimp" option) with a gross registered tonnage (GRT) of up to 250 tonnes the right to fish:

- beyond six nautical miles from the reference line, from the Senegal-Mauritania border to the latitude of Cap Manuel (14°39'00"N);

- beyond seven nautical miles from the reference line, from the latitude of Cap Manuel (14°39'00"N) to the northern Senegal-Gambia border;

- beyond six nautical miles from the reference line, from the southern Senegal-Gambia border to the Senegal-Guinea-Bissau border.

2. Wetfish or freezer trawlers ("shrimp" option) of between two hundred fifty (250) and four hundred (400) gross registered tonnage (GRT) the right to fish beyond twelve nautical miles from the reference line in all waters under Senegalese jurisdiction.

3. Wetfish or freezer bottom trawlers ("fish and cephalopods" option) of between fifty (50) and two hundred fifty (250) gross registered tonnage (GRT) the right to fish beyond ten nautical miles from the reference line in waters under Senegalese jurisdiction.

4. Wetfish or freezer bottom trawlers ("fish and cephalopods" option) of between two hundred fifty (250) and three hundred (300) gross registered tonnage (GRT) the right to fish beyond twelve nautical miles from the reference line in waters under Senegalese jurisdiction.

5. Wetfish or freezer bottom trawlers ("fish and cephalopods" option) of between three hundred (300) and five hundred (500) gross registered tonnage (GRT) the right to fish beyond fifteen nautical miles from the reference line in waters under Senegalese jurisdiction.

6. Wetfish or freezer bottom trawlers ("fish and cephalopods" option) of more than five hundred (500) gross registered tonnage (GRT) the right to fish:

- beyond fifteen nautical miles from the reference line, from the Senegal-Mauritania border to latitude 14°25'00"N;

- west of longitude 17°22'00"W, in the area between latitude 14°25'00"N and the northern Senegal-Gambia border;

- west of longitude 17°22'00"W, in the area between the southern Senegal-Gambia border and the Senegal-Guinea-Bissau border;

7. Bottom longliners of up to fifty (50) gross registered tonnage (GRT) the right to operate their fishing gear:

- beyond twelve nautical miles from the reference line, from the Senegal-Mauritania border to latitude 14°44'36"N;

- beyond fifteen nautical miles from the reference line, from latitude 14°44'36"N to the northern Senegal-Gambia border;

- beyond twelve nautical miles from the reference line, from the southern Senegal-Gambia border to the Senegal-Guinea-Bissau border;

8. Bottom longliners exceeding fifty (50) gross registered tonnage (GRT) the right to operate their fishing gear:

- beyond twelve nautical miles from the reference line, from the Senegal-Mauritania border to latitude 14°44'36"N;

- beyond fifteen nautical miles from the reference line, from latitude 14°44'36"N to latitude 14°25'00"N;

- west of longitude 17°22'00"W, from latitude 14°30'00"N to the northern Senegal-Gambia border and from the southern Senegal-Gambia border to the Senegal-Guinea-Bissau border;

Article 46. The coastal demersal fishing license grants wetfish bottom trawlers of up to (50) gross registered tonnage (GRT) ("fish/cephalopods" option) the right to fish:

- beyond six nautical miles from the reference line, from the Senegal-Mauritania border to the latitude of Cap Manuel (14°39'00"N);

- beyond seven nautical miles from the reference line, from the latitude of Cap Manuel (14°39'00"N) to the northern Senegal-Gambia border;

- beyond six nautical miles from the reference line, from the southern Senegal-Gambia border to the Senegal-Guinea-Bissau border;

Article 47. Fishing in the waters between the latitude of the northern rim of Cayar Canyon (15°00'00"N) and latitude 13°50'00"N is off-limits to coastal demersal trawlers ("shrimp" option).

Article 48. The deep-water demersal fishing license grants:

1. Shrimp trawlers targeting deep-sea shrimp, fish trawlers and bottom longliners targeting hake, and crab boats targeting deep-sea red crab, the right to fish:

- west of longitude 16°53'42"W, between the Senegal-Mauritania border and latitude 15°40'00"N;
- beyond 15 nautical miles from the reference line, between latitude 15°40'00"N and latitude 15°15'00"N inclusive;
- beyond 12 nautical miles from the reference line, between latitude 15°15'00"N and latitude 15°00'00"N;
- beyond 8 nautical miles from the baselines, from latitude 15°00'00"N to latitude 14°32'30"N;
- west of longitude 17°30'00"W, in the area between latitude 14°32'30"N and latitude 14°04'00"N;
- west of longitude 17°22'00"W, in the area between latitude 14°04'00"N and the northern Senegal-Gambia border;
- west of longitude 17°35'00"W, in the area between the southern Senegal-Gambia border and latitude 12°33'00"N;
- south of the 137° azimuth drawn from Point P9 (12°33'00"N; 17°35'00"W).

2. Crab boats targeting pink spiny lobster the right to fish:

- beyond fifteen nautical miles from the reference line, from the Senegal-Mauritania border to latitude 15°15'00"N;
- beyond twelve nautical miles from the reference line, between latitude 15°15'00"N and latitude 15°00'00"N;
- beyond six nautical miles from the reference line, between latitude 15°00'00"N and latitude 14°32'30"N;
- west of longitude 17°30'00"W, in the area between latitude 14°32'30"N and latitude 14°04'00"N;
- west of longitude 17°22'00"W, in the area between latitude 14°04'00"N and the northern Senegal-Gambia border;
- west of longitude 17°35'00"W, in the area between the southern Senegal-Gambia border and the Senegal-Guinea-Bissau border;

Article 49. The coastal pelagic fishing license grants:

1. Wetfish sardine seiners up to one hundred (100) gross registered tonnage the right to fish:

- beyond three nautical miles from the reference line, from the Senegal-Mauritania border to the latitude of Île de Yoff (14°46'20"N);

- beyond seven nautical miles from the southern reference line, from latitude 14°44'20"N to the northern Senegal-Gambia border;

- beyond three nautical miles from the reference line, from the southern Senegal-Gambia border to the Senegal-Guinea-Bissau border;

2. Wetfish sardine seiners of between one hundred (100) and two hundred fifty (250) gross registered tonnage the right to fish:

- beyond six nautical miles from the reference line, from the Senegal-Mauritania border to the latitude of Île de Yoff (14°46'20"N);

- beyond twelve nautical miles from the southern reference line, from latitude 14°44'20"N to the northern Senegal-Gambia border;

- beyond six nautical miles from the reference line, from the southern Senegal-Gambia border to the Senegal-Guinea-Bissau border;

3. Wetfish sardine seiners exceeding two hundred fifty (250) gross registered tonnage the right to fish beyond twelve nautical miles from the reference line in waters under Senegalese jurisdiction.

4. Freezer sardine seiners the right to fish:

- beyond twelve nautical miles from the reference line, from the Senegal-Mauritania border to the latitude of Île de Yoff (14°46'20"N);

- beyond twenty-five nautical miles from the reference line, from latitude 14°46'20"N to the northern Senegal-Gambia border;

- beyond twelve nautical miles from the reference line, from the southern Senegal-Gambia border to the Senegal-Guinea-Bissau border;

5. Coastal pelagic trawlers the right to fish:

- beyond twenty nautical miles from the reference line, from the Senegal-Mauritania border to the latitude of Île de Yoff (14°46'20"N);

- beyond thirty-five nautical miles from the reference line, from the southern Senegal-Gambia border to the Senegal-Guinea-Bissau border;

Article 50. Coastal pelagic trawlers are not authorized to fish in the zone between the latitude of Île de Yoff (14°46'20"N) and the northern Senegal-Gambia border.

Article 51. The deep-sea pelagic fishing license grants:

1. Wetfish and freezer pole-and-liners and seiners targeting tuna the right to fish for tuna in all waters under Senegalese jurisdiction.

2. Surface longliners targeting swordfish the right to operate their fishing gear:

- beyond fifteen nautical miles from the reference line, from the Senegal-Mauritania border to latitude 14°25'00"N;

- west of longitude 17°15'00"W, in the area between latitude 14°25'00"N and the northern Senegal-Gambia border;

- west of longitude 17°15'00"W, in the area between the southern Senegal-Gambia border and the Senegal-Guinea-Bissau border;

3. Surface longliners targeting tuna the right to operate their fishing gear:

- beyond twenty-five nautical miles from the reference line, from the Senegal-Mauritania border to latitude 14°44'36"N;

- beyond thirty nautical miles from the reference line, from latitude 14°44'36"N to the northern Senegal-Gambia border;

- beyond fifty nautical miles from the baselines, from the southern Senegal-Gambia border to the Senegal-Guinea-Bissau border;

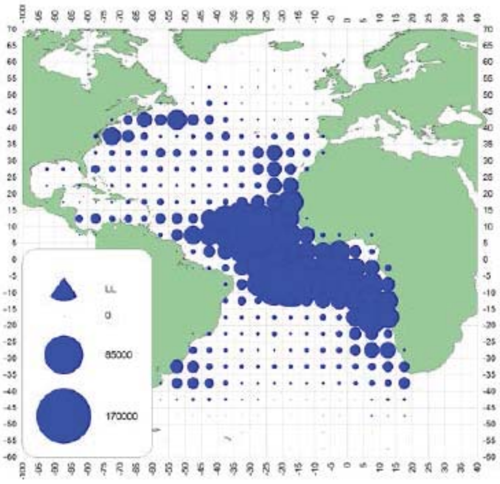
4. Live bait fishing is authorized exclusively for pole-and-line tuna vessels holding a valid license, in all waters under Senegalese jurisdiction, with the exception of the zone delineated by the low water mark and the line connecting the following coordinates:

Point 1: L = 14°40'08"N and G = 17°25'02"W;

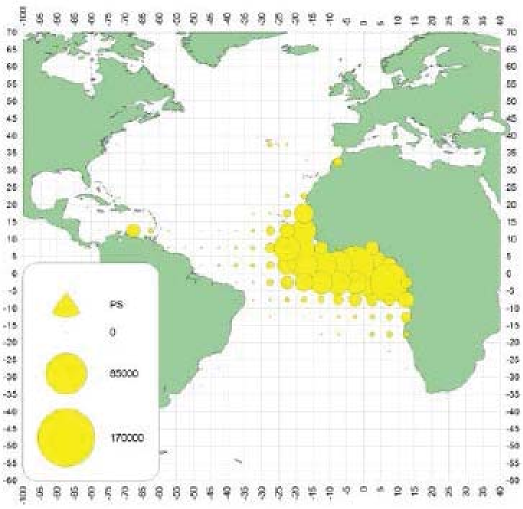
Point 2: L = 14°44'18"N and G = 17°21'00"W.

Conditions attached to live bait fishing are established by decree by the Ministry responsible for maritime fisheries.

Notwithstanding the areas prohibited by the Fishing Code, industrial fishing goes wherever the resource is, and can thus be found practically throughout the entire zone authorized by the type of license obtained. This is illustrated in the following figure.



Patudo



Albacore

Figure 23: Examples of Tuna Catch Locations (bigeye and yellowfin) in the Atlantic Ocean and in Senegal

Source: ICCAT (2016)

With regard to artisanal fishing, suitable areas are abundant and the only limitation that fishermen have is their ability to navigate and ensure that their activities remain profitable. Artisanal fishing grounds have been mapped (Figure 24).

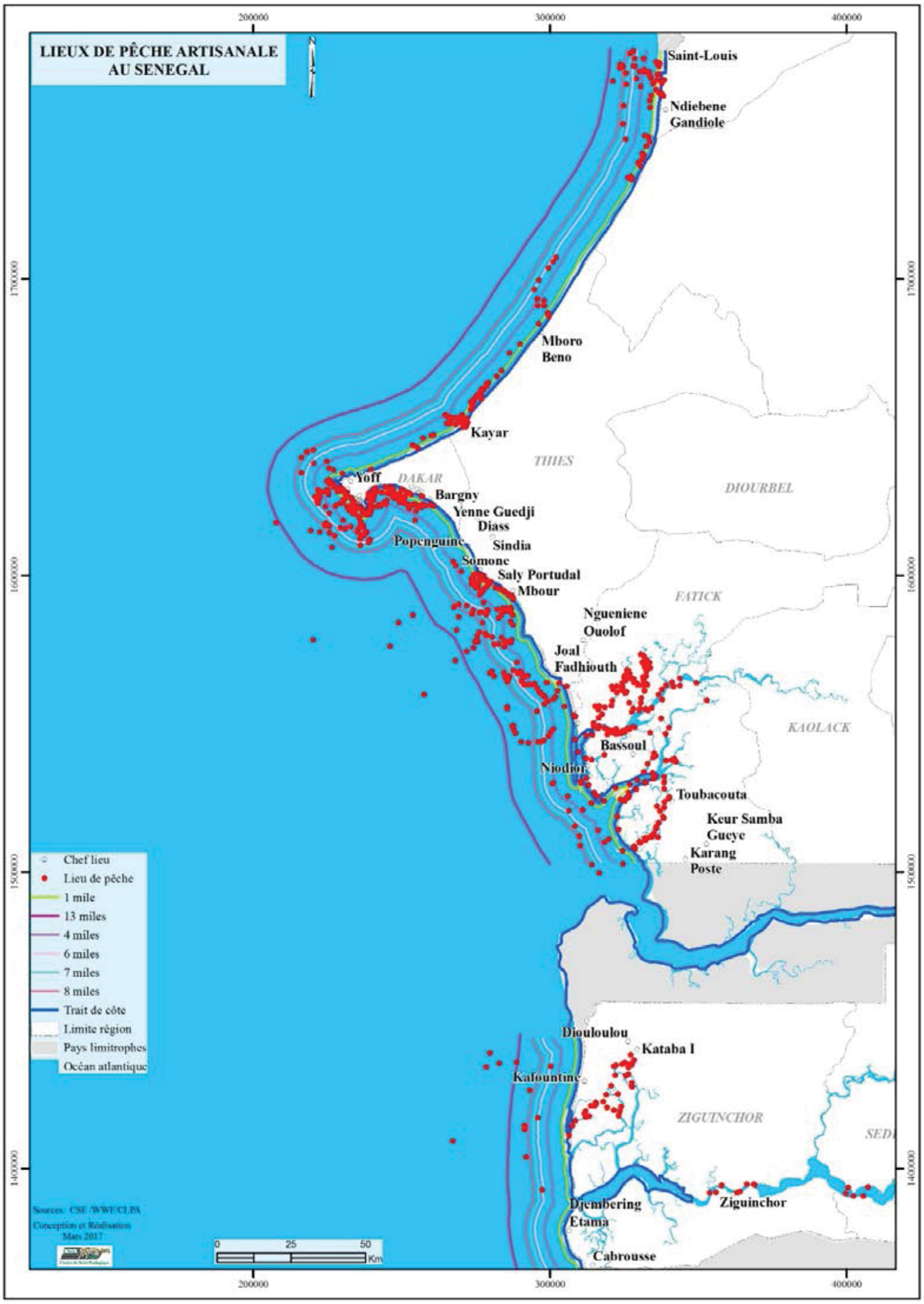


Figure 24: Map of Artisanal Fishing Grounds48

48 Map created in the context of the present study

N.B. *The lines indicating the distance from the reference line illustrate how far out artisanal fishing is practiced, in addition to providing an idea of the industrial fishing zones defined in Section 5.3 (5.3. Fishing Zones). For example, wetfish or freezer trawlers ("shrimp" option) of up to 250 gross registered tonnes (GRT), are authorized to fish:*

- *Beyond six nautical miles from the reference line, from the Senegal-Mauritania border to the latitude of Cap Manuel;*
- *Beyond seven nautical miles from the reference line, from the latitude of Cap Manuel to the northern Senegal-The Gambia border;*
- *Beyond six nautical miles from the reference line, from the southern Senegal-Gambia border to the Senegal-Guinea-Bissau border;*

For all other types of industrial fishing, details are presented in Section 5.3. (5.3 Fishing Zones).

5.4. Evolution of Production

Statistical data collected from DPM reveal that of the four regions (Tables 11, 12 and 15) that cover the core study area, the Thiès region generates the largest landings from artisanal fishing, followed by Saint-Louis and Dakar. The lowest volume of landings is from the Louga region. It appears that the quantities traded are relatively high in the Saint-Louis region. In terms of fishery product processing, Thiès seems to be the top region.

However, considering the fact that the Thiès region covers only part of the core study area and taking into account only those data that pertain to the core study area, the Thiès region ranks 3rd on the Grande Côte in terms of landings.

Analysis of the evolution of landings generated by artisanal fishing in the past five years shows fluctuations from one year to the next.

Table 11: Statistical Data of Saint-Louis Region (1999 to 2016)

Year	Landing [tonnes]	Fish trade [tonnes]	Local consumption (tonnes)	Processing [tonnes]	Processed products (tonnes)	EMV of landings [1000s CFA francs]
1999	32,487	24,684	5,508	5,598	1,866	6,024,066
2000	34,285	21,655.07	5,865.60	6,071.04	2,023.68	6,294,233
2001	32,752	18,835	6,362	7,167	2,389	6,202,300
2002	35,807	20,078	11,076	6,891	2,297	5,906,254.7
2003	34,558	22,999	4,749	8,043	2,681	5,298,270
2004	53,788	25,809	25,809	15,258	5,086	6,913,418
2005	49,305	27,352	8,645	13,782	4,594	8,346,752.07
2006	49,466	29,369	7,505	13,398	4,466	12,275,129
2007	47,582	29,131	5,238	13,014	4,338	8,704,142
2008	66,039	41,969	3,480	20,589	6,863	9,891,867
2009	59,611	43,208	3,901	12,501	4,167	10,673,411
2010	38,623	26,015	2,904	9,717	3,239	5,967,767
2011	60,944	46,468	3,125	11,496	3,832	8,564,007
2012	79,854	30,659	3,618	16,419	5,473	7,380,527
2013	70,707	49,224	2,595	19,629	6,543	11,725,893
2014	58,017	46,746	2,176	8,850	2,950	11,008,888
2015	75,755	64,616	2,689	8,448	2,816	13,863,527
2016	63,731	55,580	2,795	4,239	1,413	11,904,906

Table 12: Statistical Data – Louga Region (1999 to 2016)

Year	Landing [tonnes]	Fish trade [tonnes]	Local consumption (tonnes)	Processing [tonnes]	Processed products (tonnes)	EMV of landings [1000s CFA francs]
1999	2,636	624	405	1,602	534	481,330
2000	2,023.68	555,305	328.41	1,683.33	561.11	555,305
2001	2,531	659	328	1,437	479	602,030
2002	2,242	715	445	1074	358	848,347.5
2003	2,888	1,022	462	1,326	442	1,254,525
2004	3,626	980	980	1,545	515	1,546,186
2005	2,876	864.11	580.57	1,215	405	1,507,766.51
2006	2,469	976.02	473.07	1,019.67	339.89	1,629,657
2007	2,431	1,077	473	897	299	1,629,612
2008	2,065	752	286	519	173	1,369,378
2009	2,523	1,230	420.26	829.635	276.545	1,644,594
2010	1,695	511	593	576	192	865,708
2011	2,214	955	204	582	194	1,738,574
2012	2,264	358	180	702	234	1,152,212
2013	2,652	1,573	216	819	273	1,237,815
2014	3,523	2,100	324	841.347	280.449	1,351,883
2015	2,562	1,483	322	651	217	837,825
2016	2,526	1,613	306	537	179	998,820

Table 13: Statistical Data – Thiès Region (1999 to 2016)

Year	Landing [tonnes]	Fish trade [tonnes]	Local consumption (tonnes)	Processing [tonnes]	Processed products (tonnes)	EMV of landings [1000s CFA francs]
1999	219,908	106,735	12,121	78,282	26,094	29,103,011
2000	246,775	138,730	23,309	83,730	27,910	24,777,103
2001	235,606	122,698	23,447	89,271	29,757	25,261,922
2002	202,920	119,284	26,416	57,240	19,080	40,655,772.0
2003	276,199	158,133	30,804	85,359	28,453	42,930,062
2004	271,237	149,163	149,163	87,585	29,195	41,337,135
2005	266,925	145,348	38,984	84,279	28,093	45,018,973
2006	213,196	114,519	27,103	76,101	25,367	45,242,602
2007	246,221	129,807	36,918	88,497	29,499	52,416,173
2008	231,568	109,431	35,674	86,463	28,821	57,618,287
2009	234,674	109,078	35,657	89,388	29,796	71,983,695
2010	230,319	119,699	28,489	75,549	25,183	56,228,875
2011	215,911	113,065	20,910	103,692	34,564	54,761,486
2012	209,797	70,214	18,375	87,705	29,235	45,036,068
2013	209,693	50,783	10,948	103,389	34,463	39,446,862
2014	190,016	88,057	22,191	78,612	26,204	41,918,181
2015	180,888	107,923	12,856	57,429	19,143	48,205,935
2016	194,364	86,965	11,410	67,128	22,376	59,959,644

Table 14: Contribution of Grande Côte to Landings in Thiès Region

Year	Landings in Grande Côte portion of Thiès region [tonnes]	Landings of Thiès region [tonnes]	Contribution of Grande Côte to the landings in Thiès region [%]
2007	51,263	246,221	21
2008	-	231,568	-
2009	35,045	234,674	15
2010	28,876	230,319	13
2011	26,513	215,911	12
2012	32,676	209,797	16
2013	33,404	209,693	16
2014	33,477	190,016	18
2015	29,474	180,888	16
2016	34,643	194,364	18

Source: Regional Fishery Service – Thiès (Joal)

Table 15: Statistical Data – Dakar Region (1999 to 2016)

Year	Landing [tonnes]	Fish trade [tonnes]	Local consumption [tonnes]	Processing [tonnes]	Processed products (tonnes)	EMV of landings [1000s CFA francs]
1999	41,388	2,509	12,118	5,214	1,738	9,907,739
2000	29,280.32	13,310.24	11,217.40	5,947.74	1,982.58	12,002,846
2,001	33,929	5,180	14,280	5,826	1,942	16,571,830
2002	34,761	7,538	14,366	4,395	1,465	15,105,565.0
2003	40,373	5,125	18,439	7,491	2,497	20,254,483
2004	38,700	14,101	14,101	7,038	2,346	14,198,219
2005	51,232	19,551	24,203	9,267	3,089	16,099,612.58
2006	34,143	16,819	10,889	8,331	2,777	12,587,327
2007	33,378	15,792	13,299	5,136	1,712	18,548,022
2008	37,854	23,959	10,795	7,506	2,502	16,115,202
2009	55,590	22,171	25,839	8,253	2,751	21,581,907
2010	50,487	17,185	23,911	8,079	2,693	19,892,195
2011	42,955	19,683	11,933	6,588	2,196	23,779,710
2012	54,087	23,795	22,215	8,298	2,766	20,845,809
2013	46,519	19,079	8,216	11,304	3,768	16,293,247
2014	46,447	23,997	8,216	6,354	2,118	10,459,469
2015	44,140	24,599	9,059	5,529	1,843	17,994,696
2016	57,734.76	33,345	11,929.61	7,201.68	2,400.56	21,776,218.09

Analyzing the species composition landed in each region (Tables 16 to 19), it can be seen that the most abundant species are similar. Sardinella are often abundant, while chinchard, cutlassfish and mackerel are also represented (see following tables).

Table 16: Landings of Main Species (top 10) of Saint-Louis Region (2015) – Artisanal Fishing

Species	Landing [tonnes]	EMV [1000s CFA francs]
Madeiran sardinella	31,277	2,726,630
Round sardinella	26,112	3,816,557
Atlantic chub mackerel	3,818	327,803
Cutlassfish	2,900	2,139,563
False scad	2,021	277,125
Atlantic bumper	1,810	162,115
Blackspot seabream	1,081	1,392,993
Cunene horse mackerel	781	78,125
Red pandora	574	452,980
Bluefish	507	393,285

Table 17: Landings of Main Species (Top 10) of Louga Region (2015) – Artisanal Fishing

Species	Landing [tonnes]	EMV [1000s CFA francs]
Round sardinella	393	48,455
Madeiran sardinella	320	25,935
Cutlassfish	248	209,708
Bigeye grunt	185	10,997
Flagfin mojarra	182	182
Sompat grunt	114	41,937
Lesser African threadfin	106	35,962
Tongue sole	102	84,498
Cassava croaker	78	44,511
Blue crab	72	29,455

Table 18: Landings of Main Species (top 10) of Thiès Region (2015) – Artisanal Fishing

Species	Landing [tonnes]	EMV [1000s CFA francs]
Round sardinella	93,582	11,071,098
Madeiran sardinella	28,051	3,372,151
Cutlassfish	8,529	2,500,965
Ethmalose	7,090	1,740,800
Cunene horse mackerel	5,080	637,294
Atlantic chub mackerel	4,251	549,225
Tongue sole	2,664	2,612,210
Octopus	2,628	4,241,653
Volute	2,111	744,242
False scad	1,929	279,211

Table 19: Landings of Main Species (top 10) of Dakar Region (2015) – Artisanal Fishing

Species	Landing [tonnes]	EMV [1000s CFA francs]
Round sardinella	13,334	1,577,513
Cunene horse mackerel	4,490	563,176
Atlantic chub mackerel	3,996	516,242
Madeiran sardinella	2,219	266,737
Cutlassfish	2,044	599,472
Octopus	1,432	2,312,105
False scad	1,093	158,150
Anchovy	1,017	25,413
White grouper (*thiof*)	865	2,824,044
Red pandora	539	250,723

With respect to industrial fishing, landing activities are mostly concentrated in the Cap-Vert Peninsula. Landings in other regions are low or even nil, despite the fact that industrial fishing takes place off the coasts of all of Senegal's maritime regions. Table 20 gives an idea of the evolution of the number of industrial boats (national and foreign) and their landings.

Table 20: Industrial Fishing Statistics

Year	Number of foreign boats	Number of domestic boats	Landing from foreign boats	Landing from domestic boats
1999	96	174	16,836	64,488
2000	83	177	10,764	41,388
2001	80	161	15,731	48,125
2002	104	148	17,147	46,709
2003	66	139	11,987	41,819
2004	3	132	10,540	45,202
2005	37	108	14,382	43,962
2006	18	134	5,508	36,257
2007	18	118	5,508	37,738
2008	10	91	2,300	36,877
2009	8	86	4,983	41,214
2010	8	84	9,457	38,981
2011	31	98	12,238	48,456
2012	37	87	Data not available	41,987
2013	26	99	43,830	43,040
2014	8	98	13,646	52,454
2015	35	105	37,651	47,444
2016	Data not available	102	Data not available	83,722

Source: DPM

As shown in Figure 25 below, the general trend is a decline in the number of industrial fishing vessels, both for domestic as well as foreign boats.

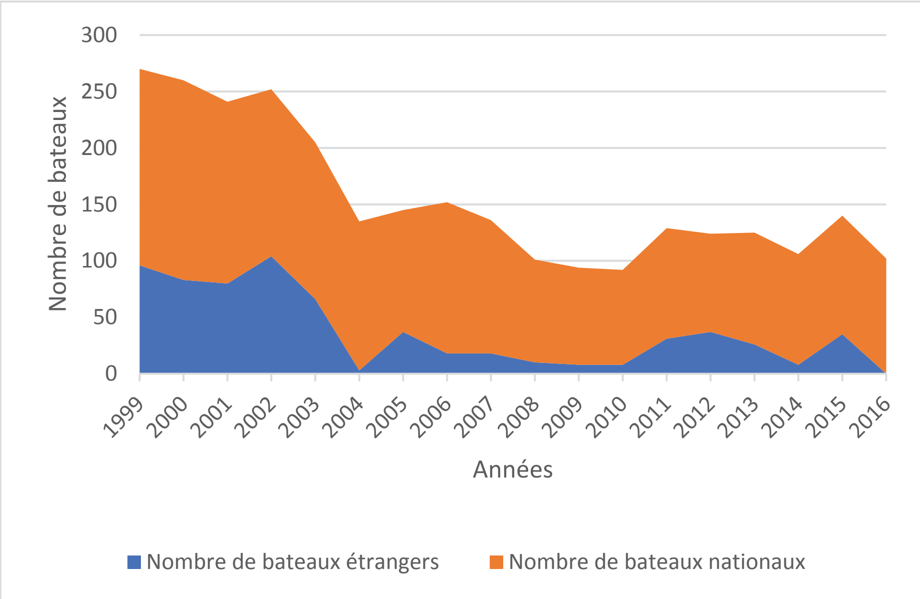


Figure 25: Evolution in the Number of Industrial Fishing Boats in Senegal

In terms of landings, those generated by domestic boats are always much greater than those of foreign boats (Figure 26). From 1999 to 2008, there was a downward trend, while from 2009 onward, the general trend has been increasing. This increase in recent years may be attributable to a number of factors, namely:

- Beneficial effects of the management measures taken such as the creation of MPAs, development of artificial reefs, biological recovery periods, promotion of co-management;
- Suspension of fishing agreements with the European Union for several years;
- Increase in fishing in neighboring countries with catches being landed in Senegal.

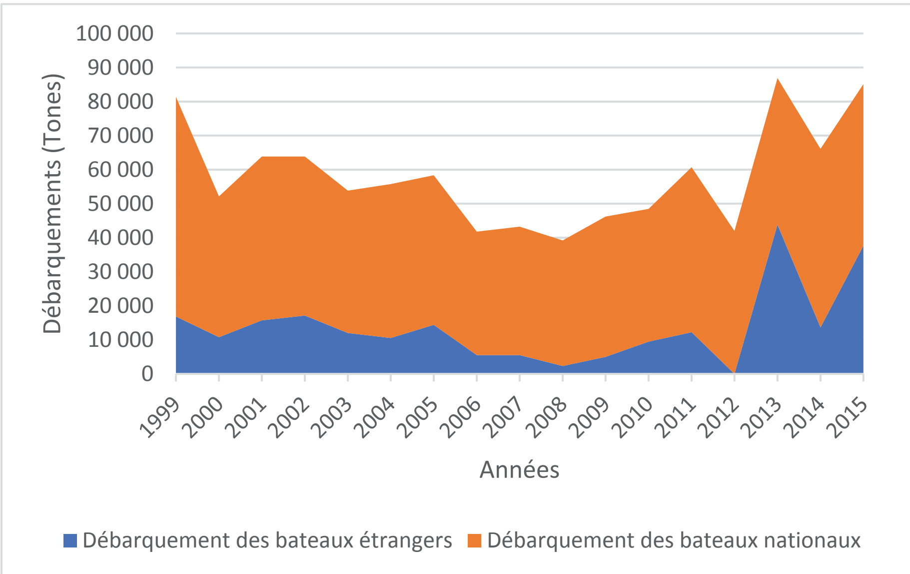


Figure 26: Evolution of Landings from Domestic and Foreign Boats

Landings from industrial fishing encompass trawler fishing, tuna fishing and sardine fishing. Trawler fishing represents the bulk of industrial landings (70 to 86%). Tuna fishing accounts for approximately 10 to 15%. Landings from the sardine fishery are the lowest (DPM, 2015[49] and ANSD, 2015)[50].

5.5. Fishing Constraints

Although it plays an extremely important economic and social role, the maritime fishing sector currently faces serious challenges (Diouf, 2010)[51]. Research conducted to identify the contributing factors of the Senegalese fishing crisis show that the latter is attributable to overfishing (17.86%), non-compliance with regulations (14.29%), free access to fishery resources (10.71%), overcapacity of harvest techniques (10.71%), climate change (8.14%), destruction of marine habitats (7.28%), pollution (6%), and destructive fishing practices (4.57%) (Diouf, 2010). Practically all of these problems, with the exception of climate change, are directly related to fishery resource management. It thus appears crucial to improve fishery resource management in order to preserve this national wealth, which plays such a critical social and economic role (Diouf, 2015; Diouf et al., 2016).

Additional constraints include the shortage of human resources (in quantity and quality) and the ensuing difficulties of implementing policies, projects and programs in the sector. In this regard, the implementation rate of the Sector Policy Letter for Fisheries and Aquaculture (LPS/PA) adopted by the Government of Senegal in 2008 and subsequently executed is very telling (see Table 21).

Table 21: Implementation Rate of Sector Policy Letter for Fisheries and Aquaculture

Objectives	Execution rate
Objective 1: Sustainably manage and restore fishery resources and their habitats	A mere 10% of activities have been entirely executed, 60% have been partially implemented and 30% have not been completed.
Specific Objective 2: Satisfy national demand	Implementation rate of 50% for about a dozen planned activities.
Specific Objective 3: Valorize catches as much as possible	The implementation rate of activities planned under Objective 3 was 28%. Only the activity related to dock upgrades was carried out in a satisfactory manner.
Specific Objective 4: Improve qualifications of professionals in the sector	Only 20% of the activities associated with Objective 4 were carried out
Specific Objective 5: Improve financing mechanisms for fisheries and aquaculture	None of the scheduled activities was completed.

Source: CEP (2015)[52]

[49] DPM, 2015. Résultats généraux des pêches maritimes. MPEM, 138 p.
[50] ANSD, 2015. Situation économique et sociale du Sénégal – Pêche, ANSD, 18 p.
[51] Diouf B., 2010. Crise du secteur de la pêche maritime au Sénégal : facteurs explicatifs et propositions de solutions. End-of-study dissertations, ENSA-Thiès, 85 p.
[52] CEP, 2015. Bilan de mise en œuvre de la Lettre de Politique Sectorielle des Pêches et de l'Aquaculture et Actualisation du Diagnostic Sectoriel. MEPM, 50 p.

Problems related to fishery resource management manifest themselves as follows:

- Decline in fish stocks (50 to 80%, depending on the species);
- Degradation of their habitat;
- Non-sustainable fishing practices (use of monofilament nets[53], fishing with explosives, harvest of juveniles, unauthorized fishing in marine protected areas, etc.) to compensate for reduced catches;
- An increase in illegal fishing by foreign boats (Senegal loses over 145 billion a year due to illegal fishing) (Koutob et al., 2013)[54];
- Distance to fishing zones (fishermen travel to Mauritania[55], Guinea-Bissau, and Guinea to work and land their catches in Senegal. This masks the depletion of fishery resources in Senegal. Production costs increase due to the distances travelled);
- Impoverishment of fishing communities;
- The increase in the price of fish and its negative impact on the diets and health of the most underprivileged strata of society, who are unable to afford minimum protein requirements (Diouf, 2015).

One major constraint for fishermen in the core study area is the difficulty they face in accessing fishing grounds in Mauritania, where they were accustomed to operating. In light of the difficulty of reaching agreements with Mauritania, Senegal must find the means of restoring stocks that have been over-exploited by creating and properly managing marine protected areas and artificial reefs, in addition to conceiving and executing fishery management and development plans.

Conclusion

Fishing plays a crucial role in the social and economic lives of the communities of the Grande Côte. Unfortunately, due to excessive fishing that has strongly reduced fishery resources and the difficulty of accessing Mauritania's most productive fishing grounds, this sector is presently undergoing a very difficult period.

It is indispensable that measures be promptly taken to restore habitats and allow over-exploited stocks to recover. Additionally, it would also be wise to strive for greater diversification of income-generating activities that are unrelated to fishing. This should be done as part of a co-management approach, where CLPAs could play a major role.

[53] Non-biodegradable nets made of monofilament nylon that continue to capture fish for decades after being lost at sea = ghost fishing.
[54] Koutob V., Belhabib D., Mathews C., Ndiaye V., and Lazar N., 2013. Estimation préliminaire des captures de la Pêche Illicite Non Déclarée et Non Réglementée au Sénégal. USAID/COMFISH Project, 74 p.
[55] Senegalese fishermen continue to fish illegally in Mauritania.

Bibliography

Agblonon, G., M. Van Leeuwen, F. Hoffmann, N. Racz, 2015. Plan stratégique pour la conservation de la biodiversité des oiseaux d'eau migrateurs dans le delta du fleuve Sénégal - période 2015-2025. Wetlands International, OMVS, Diawling National Park, Senegal Department of National Parks, 64 p.

ANSD, 2015. Situation économique et sociale du Sénégal – Pêche, ANSD, 18 p.

Barry M., 1994. Migration des poissons le long du littoral sénégalais. CRODT, 20 p.

Barry M., T. Bousso, M. Dème, T. Diouf, A. Fontana, B. Samb and D. Thiam, 2003. Le contexte des ressources halieutiques. CRODT, 17 p.

Boely T., J. Chabane and P. Fréon, 1978. Schémas migratoires, aires de concentrations et périodes de reproduction des principales espèces de poissons pélagiques côtiers dans la zone sénégalo-mauritanienne. FAO document archive, 11 p.

Caillart, B. and Y. Beyens, 2015. Etude sur l'évolution des pêcheries de petits pélagiques en Afrique du Nord-Ouest et impacts possibles sur la nutrition et la sécurité alimentaire en Afrique de l'Ouest. EU / DAI, 78 p.

Cormier-Salem M.-C., 2013. L'aménagement du littoral un enjeu crucial pour les pêcheries artisanales. Fontana and Samba (Editors), 163 p.

DAMCP, 2013. Stratégie Nationale pour les Aires Marines Protégées du Sénégal. DAMPC, 48 p.

Demarcq, H. and B. Samb, 1991. Influence des variations de l'upwelling sur la répartition des poissons pélagiques au Sénégal. Cury, P. and C. Roy (Editors) in Pêcheries ouest-africaines : Variabilité, instabilité et changement : 290-306.

Demarcq, H. and B. Samb, 1991. Influence des variations de l'upwelling sur la répartition des poissons pélagiques au Sénégal. Cury P. and C. Roy (Editors) in Pêcheries ouest-africaines : Variabilité, instabilité et changement : 290-306.

Diouf P.S., 2012. Plan Stratégique de l'Eco-région WAMPO (Western African Marine Ecoregion). WAMPO, 230 p.

Diouf P.S., 2016. Mangrove et Aires Marines Protégées de la Casamance et du Sine-Saloum. COFREPECHE – SEANEO, 56 p.

Diouf P.S., 2017. Stratégie de mise en œuvre du plan national d'adaptation du secteur de la pêche et de l'aquaculture aux effets du changement climatique. MPEM, 114 p.

Diouf P.S., N. Diop and H. Diop, 2016. Plan national d'adaptation du secteur de la pêche et de l'aquaculture face au changement climatique horizon 2035. MEDD / MPEM / USAID/COMFISH Project, 143 p.

Diouf P.S., M. Ngom and M. Fall, 2016. Ichtyofaune et pêche dans le lac de Guiers et la réserve du Ndiaèl. IUCN/OLAG, 58 p.

Domain F., 1977. Carte sédimentologique du plateau continental sénégambien. Extension à une partie du plateau continental de la Mauritanie et de la Guinée-Bissau. ORSTOM / ISRA / CRODT, Explicative Notice n° 68, 37 p.

DPM, 2015. Résultats généraux des pêches maritimes. MPEM, 138 p.

Durand P., B. Anselme and Y.F. Thomas, 2010. "L'impact de l'ouverture de la brèche dans la langue de Barbarie à Saint-Louis du Sénégal en 2003 : un changement de nature de l'aléa inondation ?", Cybergeo: European Journal of Geography [Online], Environment, Nature, Landscape, document 496, posted online April 27, 2010, consulted March 24, 2017. URL: http://cybergeo.revues.org/23017; DOI: 10.4000/cybergeo.23017.

Fall M., 2009. Pêcherie démersale côtière au Sénégal – Essai de modélisation de la dynamique de l'exploitation des stocks. PhD thesis, University of Montpellier 2, 231 p.

Fontana A. and A. Samba, 2013. Artisans de la mer. Une histoire de la pêche maritime sénégalaise. Fontana and Samba (Editors), 163 p.

Fonteneau A., 1991. Pélagiques côtiers, pélagiques hauturiers et fluctuations environnementales : quelques éléments de comparaison. Cury, P. and C. Roy (Editors) in Pêcheries ouest-africaines : Variabilité, instabilité et changement : 311-318. Fonteneau.

Kosmos Energy, 2015. Etude d'impact environnemental pour un projet de forage exploratoire dans les blocs de Saint-Louis offshore profond et Cayar offshore profond, au large du Sénégal. Report produced by CSA, Golder and Tropica, Volume 1 (710 p.) and Volume 2 (appendices).

Kouamé A., 1983. Bathymétrie, sédimentologie et structure géologique du plateau continental de l'Afrique de l'Ouest. Intergovernmental Oceanographic Commission of UNESCO, 5 p.

Mbaye A., 2002. Analyse sociologique de la différenciation technique dans la pêche artisanale maritime sénégalaise. Séminaire C3ED-OA, 7 p.

Ministry of Fisheries and Maritime Affairs, 2013. Inter-ministerial Council on Fisheries. MPAM, 40 p.

MPEM, 2015. Lettre de Politique Sectorielle de Développement des Pêches et de l'Aquaculture (LPSD/PA). MPEM /FAO, 47 p.

MPEM, 2016. Code de la pêche maritime du Sénégal Loi n° 2015-18 du 13 juillet 2015. MPEM, 35 p.

MPEM, 2017. Décret n° 2016-1804 portant application de la loi n° 2015-18 du 13 juillet 2015 portant Code de la Pêche maritime. MPEM, 31 p.

Ndiaye O., P.S. Diouf, I. Niamadio, and S. Diouf. 2012. Stratégie de renforcement des capacités des CLPA dans le cadre de la mise en œuvre des Unités de Gestion Durables des Ressources. USAID/COMFISH project, Senegal, University of Rhode Island, Narragansett, RI 47 p.

Niang N.A., 2008. Dynamique socio-environnementale et gestion des ressources halieutiques des régions côtières du Sénégal : l'exemple de la pêche artisanale. UNESCO/MAB and UCAD, 68 p.

Plan Stratégique National d'immersion des récifs artificiels le long des côtes sénégalaises et les réalisations du PRAO et de l'Association de la Pêche Sportive sur les récifs artificiels.

WARFP-SN, 2013. Etude sur l'état des pêcheries côtières, des stocks clés et de leurs habitats. Final Report, CRODT / World Bank, 91 p.

USAID/COMFISH Project, 2015. Plan de Gestion Participatif de la Pêcherie de sardinelles dans la Grande Côte Sud. USAID/COMFISH and DPM, 35 p.

USAID/COMFISH Project, 2016. Plan de Gestion Participatif de la Pêcherie de sardinelles dans la Grande Côte Nord. USAID/COMFISH and DPM, 52 p.

Sidibé A., 2010. Utilisation de la Liste Rouge de l'UICN pour le suivi des risques de perte de biodiversité : application aux poissons démersaux exploités d'Afrique du Nord-Ouest. IUCN, 64 p.

Thiaw M., 2010. Dynamique des ressources halieutiques à durée de vie courte : cas des stocks de poulpe et de crevettes exploités au Sénégal. Thesis, European University of Brittany, 228 p.

Thiaw M., K. Ba, M. Fall, N. Thiam, M. Thiam and D. Jouffre, 2015. Evaluation des principaux stocks démersaux exploités au Sénégal. CRODT / ADUPES, 27 p.

Toresen R., A. Sarre, S. Ceesay and D. Zaera, 2015. Survey of the Pelagic Fish Resources off North West Africa. Part I. Senegal - The Gambia 21 - 30 October 2015, Institute of Marine Research / Dakar-Thiaroye Centre for Oceanographic Research / Department of Fisheries, 45 p.

IUCN, n.d. La liste rouge des espèces menacées de l'UICN (available in English as: The IUCN Red List of Threatened Species). IUCN, 2 p.

APPENDIX E-3: REPORT ON FISHING COMMUNITIES IN MAURITANIAN PORTION OF CORE STUDY AREA OF THE AHMEYIM/GUEMBEUL GAS PRODUCTION PROJECT

Fishing Communities in Mauritanian Portion of Core Study Area of the Ahmeyim/Guembeul Gas Production Project

Moustapha Taleb Heidi

October 2017

Ecodev

Summary

List of Abbreviations

IGA	Income-Generating Activities
GER	Gross Enrolment Ratio
Est.	Estimate
$US	United States dollar
HP	Horsepower
CQFMP	Qualification and Training Center for Fishing Trades
FNP	National Fisheries Federation
FAO	Food and Agriculture Organization of the United Nations
FLPA	Free Federation of Artisanal Fishing
RN	National Highway
PK	Kilometer point (in reference to the distance of a site from Nouakchott)
DNP	Diawling National Park
MEN	Ministry of National Education
MPEM	Ministry of Fisheries and Maritime Economy
MAED	Ministry of Economic Affairs and Development
MRO	Monetary unit of Mauritania
m^2	Square meter
GPS	Global Positioning System
CC	Commune census
IMROP	Mauritanian Institute of Oceanographic Research and Fisheries
AF	Artisanal Fishing
ONS	National Statistics Office
SSPAC	Monitoring System for Artisanal and Coastal Fisheries (IMROP database)

List of Tables

List of Illustrations

1. Introduction

1.1 Context and Terms of Reference

This study consists of providing a detailed portrait of the maritime fishing communities established between Nouakchott and Mauritania's southern border, notably the community of N'Diago. Topics to be covered were specified in a document establishing the Terms of Reference of national experts for the project's environmental and social impact assessment (ESIA) in February 2017.

1.2 Performance of Mission

The study was performed from existing documentation and field work in order to update and expand upon existing data. The field work was performed between April 24 and May 2, 2017, during which time a number of fishing localities were visited.

2. Objectives

The study describes and analyzes the living conditions of communities in the core study area as understood in their dynamic character, which we will attempt to elucidate in this report.

3. Methodology

3.1 Approach and Implementation

The investigations that provided the material for this report were carried out by means of a qualitative investigation (Huberman, A.M., Miles, M.B., 1991) that lasted eight days with a single visit to each locality. Appendix 1 provides a list of the localities visited as well as their geographic coordinates.

We combined the techniques of i) in-depth individual interviews with community contacts and ii) group discussions with representatives of various interest groups (cooperatives, leaders, youth and women). Appendix 2 provides a list of the individuals consulted.

Secondary sources were also used to complete the data or provide additional detail. For the city of Nouakchott, sources were limited to the bibliography, which covers several aspects of our interest and which is relatively recent (2015).

3.2 Data Limitations

This report is mainly focused on the coastal population whose means of existence are directly linked to the harvesting of fishery resources. We are aware that within the study area there are other population categories with pastoral and agricultural economies, but these were not addressed in this mandate.

4. Study Area

The GPS coordinates of the localities visited during the field mission are presented in Appendix 2.

5. General Data on Study Area

5.1 Administrative Situation

The study area overlaps two wilayas (regions), namely Nouakchott and Trarza. Nouakchott, the national capital, constitutes an urban community as per Law 2001-51 of July 19, 2001, with nine communes that also correspond to moughataas (departments). A decree issued on November 25, 2015 sets out a new sub-division of the city. The city now forms three wilayas, namely: Nouakchott-Nord (North) Nouakchott-Ouest (West) and Nouakchott-Sud (South).

The coastal zone of Nouakchott is split between two wilayas: Nouakchott-Ouest (which includes the area of artisanal fishing activity near the Fishermen's Beach port complex in Tevragh-Zeina Commune), and Nouakchott-Sud, which is home to two other important port sites, namely the Autonomous Port of Nouakchott / Port of Friendship (PANPA) and the Wharf (former port of Nouakchott: 18°02'08 / 16°04'43, which after the 1987 construction of PANPA is used by subsistence fishermen in particular).

The remainder of the study area is part of the wilaya of Trarza (southwest, bordering Senegal). The latter has a surface area of 67,800 km^2 and is composed of six moughataas, three of which have access to the coast: Méderdra, Keur-Macène and Ouad-Naga. The moughataas encompass coastal and non-coastal communities and, consequently, are substantially more expansive than the coastal communities that lie within the area. The administrative affiliation of the sites under study is presented in Table 1.

Table 1: Administrative Affiliation of Sites under Study

SITE	MOUGHATAA	COMMUNE
Fishermen's Beach in Nouakchott	Tevragh-Zeina	Tevragh-Zeina
PK 28 / Vernana	Ouad-Naga	El Arye
PK 65	Méderdra	Tiguint
PK 93 / Legweichich	Méderdra	Tiguint
PK 144	Méderdra	M'balal
Mouly	Keur-Macène	N'Diago
N'Diago	Keur-Macène	N'Diago
Mboyo 1 and 2	Keur-Macène	N'Diago
Diahos 1 and 2	Keur-Macène	N'Diago
Lorme	Keur-Macène	N'Diago

5.2 Demography

Nouakchott is by far the largest metropolis in Mauritania. Due to its status as political capital, but also the fact that it is home to the majority of the country's socio-economic infrastructure, it continually draws large numbers of people from inland areas in search of better living standards. In this regard, in one-and-a-half decades, for example, the city's population doubled, rising from 558,195 in 2000 to 1,043,177 in 2015 (ONS, 2017). Driven largely by domestic migration, Nouakchott's strong demographic growth is a reflection of the endemic poverty in the country, where in reality this phenomenon affects rural areas in particular (44.4% versus 16.7% in urban areas, MAED, 2014). In this regard, emigration to Nouakchott represents a survival strategy adopted by thousands of people every year.

In 2013, the population of the wilaya of Trarza was estimated at 272,773. The population of the moughataas in which the fishing communities under study are found are as follows: Méderdra (30,440 inhabitants), Keur-Macène (27,760 inhabitants) and Ouad-Naga (23,698 inhabitants) (ONS, 2015).

On the coast between Nouakchott and N'Diago (far south), besides the PK 93 site (or Legweichich), the remaining human establishments consist of seasonal fishing camps. The size of the population forming these coastal fishing communities varies as a function of the fishing seasons. It can increase significantly in the peak seasons. Likewise, at PK 144, the number of fishermen can reach 500 during the sole-fishing season (generally from January to May).

5.3 Household Income

According to the results of the last permanent survey on living conditions (EPCV, 2014), the labor force participation rate[1] was estimated at 46.6% at the national level and was higher in urban areas (54%) than in rural areas, and with large gender disparities (27.5% for women versus 69% for men).

At the regional level, the Nouakchott wilaya had one of the highest rates (52.22%), while Trarza was the lowest (29.42%).

As the only income indicator, this EPCV survey provides results on average annual household expenditures. The table below shows the structure of this indicator for the wilayas of Nouakchott and Trarza (broken down by expenditure categories).

Table 2: Structure of annual household expenditure averages at Nouakchott and Trarza (in thousands of MRO and percentage for year 2014)

	Annual Own Production	Daily Diet	Education	Health	Housing	Transpor-tation	Communi-cation	Clothing	Transfers	Others	Annual Total Expenditures
Nouakchott	1.4%	36.0%	4.2%	2.6%	25.6%	3.8%	5.9%	4.9%	5.3%	10.4%	2 164.84
Trarza	9.5%	39.8%	6.5%	7.7%	17.1%	0.9%	5.6%	5.8%	1.3%	6.0%	1 521.53

Source: ONS, 2015

However, in order to better understand the above numbers for the wilayas of Nouakchott and Trarza, some key findings of the survey at the national level should be highlighted. For instance, that poverty is

[1] Labor force participation rate: this corresponds to the ratio between the active population and the working age population (14-64 years). It is also the level of participation of the labor force in the production of goods and services.

still a rural phenomenon: the percentage of people living below the poverty line[2] in this environment is 44.4% versus 16.7% in urban areas.

In addition, the contribution of poverty increases with the index in rural areas. That is, poverty in rural areas is not only more extensive in terms of numbers than in urban areas, but also the conditions of the rural poors are more severe (the quality of the phenomenon).

Since the ranking on the incidence of poverty refers to monetary data, it may be useful to situate here the two wilayas that are our study area. Nouakchott is part of the group of wilayas which have a rate of less than 20%, while Trarza was among the "fairly poor" group with poverty rates between 30 and 40%.

5.4 Catches Statistics

During the 2009-2013 period, the Nouakchott area contributed for 26% of the catches made in the Mauritanian Exclusive Zone. The main species caught was sardinella, which accounted for 61% of the volumes followed by far by pandora (8%), seabream (4%), croaker (4%) and the rubberlip grunt. In terms of value, seabream was in the lead with 22% of total landing values, while grouper (thiof), although contributing only 2% to catches, ranked second with 17%. It is followed by the octopus and the croaker (12% each).

In the southern zone of Nouakchott (from PK 28 to N'Diago), the IMROP artisanal fisheries monitoring system recorded, between 2006 and 2016, a range of 208 marine species landed at the various sites. In 2016, the volume of catches reached 8408 tons, compared with 2631 in 2006, reflecting a constant development of fishing activity in this zone. Considering that shore-based infrastructures are rudimentary, this situation depicts a strong deployment of fishing campsites in this area and therefore a major private investment in artisanal fisheries. In terms of volumes, the main species caught in this area were: Arius heudoloti (smoothmouth sea catfish), Sparus caeruleostictus / ehrenbergeri (Blue-spotted sea bream), Sepia officinalis (cuttlefish), Cynoglossus monodi (Guinean tonguesole) and Octopus vulgaris (octopus). The latter species, which is exclusively an export product (mainly to Japan), recorded in 2015, for example, a catch volume of about 1418 tons. Table 3 below details the evolution over the last ten years in terms of catch volumes in this area.

Table 3: Main species caught in the southern zone (from 2007 to 2016) in tons

Species	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Arius heudoloti	194.897	229.449	426.486	366.899	234.463	376.571	404.273	398	673	1545.45
Sparus caeruleostictus/ehrenbergeri								374	1477.916	1775.838
Sepia officinalis	109.028	70.717	5.465	24.658	19.224	302.818	34.432	185	2526.197	128.781
Sparus caeruleostictus	704.439	244.778	517.982	468.828	399.608	673.764	394.387			
Cynoglossus monodi	20.561	236.572	113.33	231.062	66.455	272.877	266.782	230	548.153	844.644
Octopus vulgaris		0.795	3.04	0.206	0.104	209.133	593.763	113	1417.978	274.492
Plectorhynchus mediterraneus	613.084	261.865	187.477	231.179	287.764	260.325	265.879			

[2] It was fixed by this survey at 169,445 MRO per household and per year.

Epinephelus aeneus	576.47	363.225	71.005	91.708	149.631	98.423	128.4	68	199.441	210.717
Pseudotolithus brachygnatus	18.367	40.02	73.624	105.452	0.124	0.247	47.472	114	917.334	417.752
Trichiurus lepturus			0.141	0.276			1.02	1718	2.676	7.433
Cymbium Cymbium	33.29	43.473	91.027	87.368	141.969	125.272	135.66	93	342.684	586.665
Plectorhyncus mediterraneus								154	649.051	227.109
Pagellus bellotti								49	504.672	435.243

Source: SSPAC of IMROP

5.5 Fish Price Statistics

There is no monitoring of local fish market prices in Mauritania. On the other hand, other indicators such as prices at landing sites are available. These are statistics on prices for fishmongers, which are the first prices in the fish marketing chain[3]. These prices typically account for one-third of retailers' prices in outlets located in urban centers such as Nouakchott or Tiguent (opposite side of Legweichich).

In the area south of Nouakchott, we can notice that, between 2012 and 2016 (Table 4 and Figure 2), except for some rare species such as the largehead hairtail (Trichiurus lepturus), prices have not been subject to high variability. Taking into account the rather rich fishery potential, this situation reflects the stability of both the production systems and the marketing channels which did not undergo great changes during this period. However, in 2017, which saw the departure of foreign boats, it is very likely that prices have increased in consequence of the lower fishing effort and/or fishing quality.

Table 4: Average price of main species caught in the southern zone in MRO and by kg

Species	2012	2013	2014	2015	2016	Overall Average
Arius heudoloti	97	151	172	164	150	147
Cymbium cymbium	32	71	89	69	50	67
Cynoglossus monodi	575	511	583	671	600	579
Epinephelus aeneus	1149	1163	956	911		1046
Octopus vulgaris	1555	827	940	1092		1049
Pagellus bellotti	120	177	185	197		175
Plectorhyncus mediterraneus	62	98	108	153	100	111
Pseudotolithus brachygnatus	200	251	229	459	200	359
Sepia officinalis	638	476	443	538		532
Sparus caeruleostictus/ehrenbergeri	298	328	318	333	213	320
Trichiurus lepturus	30	285	278	300		275
Overall Average	**405.480609**	**381.244973**	**328.960986**	**397.779729**	**248.837209**	**383.206724**

[3] This is the price agreed upon between fishermen and fishmongers on the beach immediately after the landing and in which it is necessary to consider the prefinancing received in general by the fishermen in the form of fishing equipment and food from these fishmongers (who come to buy and retrieve the product they ordered).

Figure 2 below gives an idea of landing prices for reference species in Mauritania such as the croaker (heavily in demand in the Nouakchott local market) and octopus (the top frozen export product).

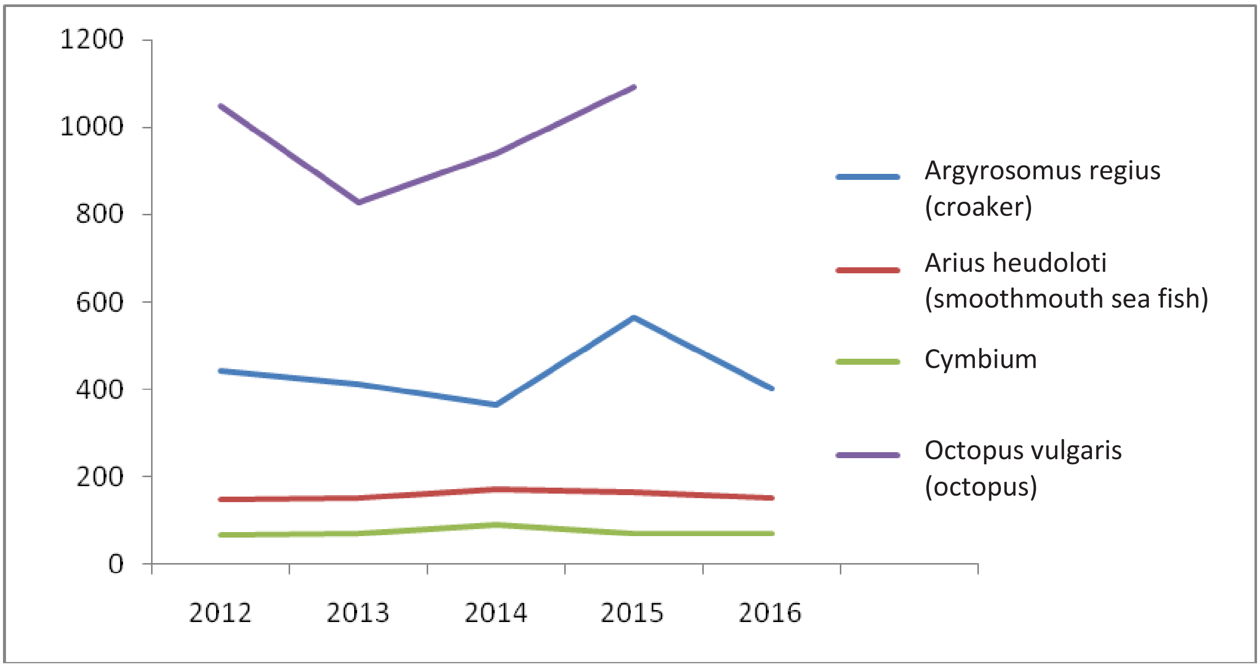


Figure 2: Price Evolution of Certain Species between 2012 and 2016 (in MRO)

5.6 Education/Health

At the national level, in 2014, the Gross Enrollment Ratio (GER) reached 76.8%, compared with 90.9% in 2008 and 76.7% in 2004. The gender analysis shows a more or less equal distribution, with 76.4% for boys and 77.2% for girls (ONS, 2016). The wilayas of Nouakchott and Trarza present satisfactory results with regard to education. More specifically, they have gross enrolment ratios of 96.7% and 79.7%, respectively, which is above the national average (72.4%).

Moreover, the wilayas of Nouakchott and Trarza exhibit low illiteracy rates compared to other regions of Mauritania (17.1% and 24.6%, respectively). With regard to formal schooling, data from a 2013 census (RGPH 2013) show that approximately 64.73% of the Mauritanian population aged 6 and above have attended or are still attending primary school.

There are 4 primary schools within the study area, only one of which (in N'Diago) offers a complete course of education (6 grades). The three other schools are in the localities of Legweichich, Mboyo and Diahos. The total number of students is 285. With regard to secondary education, there is a middle school in

N'Diago, which is attended by students from the locality and throughout the commune. Also noted is the presence of two professional training centres for fishing trades at PK 28 and PK 144. At the preschool level, the highest enrolment is observed in Nouakchott (+41%).

In terms of health, Nouakchott's epidemiological and health profile is not fundamentally different from other regions of the country, including that of Trarza. Acute respiratory infections, diarrhea, malaria, and tapeworm infection have a significant impact. As for health care, Trarza and the coastal zone in particular are characterized by quantitative and qualitative shortages of staff, equipment, consumables and medication. Within the study area, three villages (N'Diago, Mboyo and Diahos) have health outposts, but with very few resources both in terms of technical capacity and staffing. In N'Diago, for example, the staff of the health outpost is directed by an advanced technician and is half composed of health care assistants[4]. According to the individuals consulted at this structure, the doctor who had been assigned is still absent. In these conditions, care is very rudimentary and patients are frequently transferred to Nouakchott and especially to Saint-Louis.

5.7 Main Socio-economic Activities

Among the major features of the economic system are the domination of the tertiary sector (commercial and service activities) and the preponderance of the informal sector. Most businesses in the informal sector are family owned, often small in size, highly labor-intensive and use intermediate technology. The female workforce is concentrated in agricultural activities, handicrafts, trade and dyeing (ONS, 2015). The sex distribution of the employed population shows a very large disparity between men (70.59%) and women (22.41%) according to the latest national surveys (ONS, 2015)

The disparity between economic sectors in Nouakchott is significant. The informal sector occupies 61% of the labor force (Choplin and Vincent, 2015). The spatial distribution of these activities within Nouakchott is disproportional: economic activities (services, public sector, transport, finance) are highly concentrated in the older central districts (Ksar, Sebkha, El Mina and Capitale).

The national unemployment rate was estimated at 12.85% in 2014. This figure is 16% in Nouakchott and 5% in Trarza (ONS, 2015). Like the city itself, economic activities in Nouakchott are highly diverse, and include commerce, fishing and transportation. Indeed, several key spheres that structure the local economy can be distinguished:

- Commerce: a large number of Nouakchott residents earn their living in commercial activities, i.e. at the markets, the number of which reached 53 in 2012 (Choplin and Vincent, 2015), or in small family boutiques in homes or even in the street. A significant portion of this trade concerns the sale of foodstuffs. Stores (grocery), fuel stations and informal stands of imported fruits and vegetables from Morocco line the main arteries. In certain communes of Nouakchott, e.g. Sebkha,

[4] Health care assistants, most of whom are midwives, are staff members that have only basic qualifications. They are officially engaged in the medical field to provide preventive care and play a supporting role, e.g. educating users. However, the shortage of qualified human resources results in greater involvement of this category, notably with regard to maternal health, where midwives (who in reality have traditional know-how in their specialty) are often called upon.

those engaged in commerce can represent up to 60% of the total population (Choplin and Vincent, 2015).

- Fisheries: offers the population a number of opportunities, notably with regard to the wholesale trade and marketing professions such as fish counting or scaling, as well as transporting fishery products between landing points and the districts.

5.8 Socio-professional Groups

Socio-professional organizations related to artisanal fishing include mainly:

- ✓ Artisanal chapters of the National Fisheries Federation (FNP), the Free Federation of Artisanal Fishing (FLPA) and the Federation of Fishmongers of Mauritania;
- ✓ Various fishermen's cooperatives: the most well organized are those of Nouakchott, in particular the purse seine commission. The Legweichich project established a relatively well functioning production and commercialization cooperative, but today it is practically non-existent.
- ✓ There are a few formal structures such as women's groups and NGOs that co-exist with networks and associations run by diverse social groups along the coastal region and that engage in income-generating activities (IGA) related to fish processing and market gardening. These types of initiatives are observed in N'Diago. In Nouakchott, the NGO "Mauritanie 2000" has become actively involved in training and supporting women engaged in artisanal fishing and in establishing small microcredit structures.

6. Specific Data on Study Area

6.1 Land Use / Human Establishments

This section describes the territorial dynamic of the coast between Nouakchott and N'Diago.

Nouakchott

Nouakchott represents an important center of economic activity including with regard to trade, commerce, fishing as well as the processing, sale and export of fishery products. In addition to contributing to the city's economic diversity, fisheries represent an important means of subsistence in Nouakchott.

PK 28

This site, also known by locals as Vernana and/or Tervaya, has existed since 1989, date of the conflict between Mauritania and Senegal,[5] which was marked by a massive and reciprocal return of migrants from

[5] This conflict arose from serious political tensions between the two countries and was followed by a severance of diplomatic relations, which were only resumed in 1993.

the two neighboring countries. At the time, authorities decided to make PK 28 the headquarters of an integration program for young returnees who wanted to take up artisanal fishing, which was suffering a downturn after the sudden departure of the Senegalese. Indeed, this activity was dominated by foreign fishermen, in particular Senegalese from the Saint-Louis region (Guet Ndar) who are renowned for their fishing know-how[6].

Today, it can be observed that the site exhibits a certain vitality in its fishing activities as evidenced by the presence of one of the artisanal fishing training centers which is part of the Qualification and Training Center for Fishing Trades (CQFMP), as well as a few fishing camps, the number of which varies with the seasons.

The central core of the site is this training center, which is the only administrative presence. Residents including fishmongers, processors and merchants occasionally find here certain conveniences such as water, transport or phone communication. Three fishing camps are currently present on site, as are five general trade stores.

Moreover, in an effort to outsource processing activities, PK 28 was chosen by public authorities to host the fish meal establishments (Photo 1) and artisanal processing workshops (Photo 2). These were formerly located in the vicinity of the Nouakchott fish market.

There are currently 10 fish meal and fish oil plants whose products are exported (mainly to Eastern Europe) for animal consumption. These plants, which belong to foreign investors, have a daily processing capacity in the order of 100-150 tonnes of fishery products. They are supplied by Senegalese charter pirogues specializing in small pelagics. Notwithstanding the jobs created by the fishing activities carried out for these plants, other jobs are limited on account of the use of an advanced technology. Thus, existing jobs consist essentially of the services of labourers to transport production after docking. Indeed, each plant has its own landing jetty that allows pirogues to dock and offload their products (Abdel Hamid and Braham, 2015).

[6] For illustrative purposes, in March 2016, Senegalese fishermen represented over half (57.36%) of the artisanal fishing crews in the South Zone. IMROP, 2016

Photo 1: Fish Meal Plants at PK 28

Artisanal fish processing activities were officially transferred to PK 28 in 2012. However, the lack of water, irregularity of landings at the site, and issues related to transportation to the markets have driven the majority of displaced processors to leave the site. There are currently 20 workers who run small processing workshops. This workforce is mostly foreigners, particularly Malians and Gambians.

Photo 2: Artisanal Fish Processing Workshop at PK 28

Besides fishing and business activities, certain economic operators have been tempted by the tourism sector (development of beaches, water sports, etc.) at PK 28 and PK 65, but the results have not been particularly encouraging (interview with Mr. Lemine at PK 28, 2017-04-24). An extensive hotel infrastructure – no longer in operation – is testimony to this attempt to develop tourism at PK 28.

PK 65

Like the preceding site, PK 65 is an official landing site. A Coast Guard unit is present. The site traditionally hosted camps of Senegalese fishermen, but it is now nearly deserted. Malian processors arrive periodically to develop their activities while taking advantage of easier access to products in the absence of competition. In the course of our field investigation, we met two individuals with such a profile who source their fish from pirogues currently based at this site.

PK 93 (Legweichich)

This site is located 17 km west of the locality of Tiguint (Trarza) and is part of the same commune. With an estimated population of 400 according to the Village Chief (interview with Mr. Gueye, 2017-04-25), PK 93 owes its sedentary development to the creation in 2003 by the Ministry of Fisheries and Maritime Economy (MPEM) and Spanish Cooperation of an artisanal fishing services complex, including accommodations for fishermen and fish marketing halls. The idea was to offer a development model for artisanal fishing based on fisherman autonomy through the provision of services (ice, lures, a refrigerated truck to facilitate marketing of production, etc.) by a self-managed cooperative. This model thus eliminated, at least partially, the intermediaries (fishmongers) and was supposed to increase the value chain for fishermen. This cooperative no longer exists.

The PK 93 (Legweichich) hub currently forms a fishing village with 65 dwellings, a primary school (one classroom for multiple grades), a mosque and 4 grocery stores. Some of the women of the village are engaged in salt-cured fish processing (*guedj*).

A maritime surveillance unit is also based at the site.

In addition to the fishing activity practiced by residents, Legweichich also has camps (five were identified), which boosts the economic dynamic of this village that receives a significant influx of fishmongers from Nouakchott as well as from Rosso (capital of wilaya of Trarza) to purchase fish.

According to the Village Chief, Legweichich occupies a surface area of 500 to 600 m^2 (interview with Mr. Gueye, 2017-04-25).

Photo 3: General View of Village of Legweichich

PK 144

Located in M'balal Commune, this is also a hub of development that was designed by MPEM in 1994 for the settlement of fishermen and their socio-economic advancement. To this end, it was planned to develop lots to house families and a credit line for fishermen for the construction of dwellings.

The infrastructures built are now used for the offices and staff accommodations of an artisanal fishing training center (CQFMP) as well as for a Coast Guard base.
Contrary to its history of being an active landing point with 900 or even 1,000 fishermen in a single season, today, with just 3 fishermen's camps, the PK 144 site is relatively sparsely populated. For instance, in April 2016, 571 fishermen were tallied, making it the top landing point in Nouakchott's South Zone. At the time, this figure represented more than 42% of all fishermen in Nouakchott's South Zone (Wagne and Braham, 2016).

Immediately upon leaving the facilities of PK 144, a small locality named Khantour *(خنطور)* faces the site's official facilities (fishermen's training center, fish hall and Coast Guard station). This is actually the inland part of PK 144, as the latter is sometimes referred to by this name. Khantour is composed of a few wooden shanties; its residents raise small ruminants and camels.

	
Photo 4: Facilities at PK 144	Photo 5: Locality of Khantour

The land along the dirt road that runs from PK 144 to the national highway (27 km away) is occupied by more or less rudimentary structures (shanties) that are used to accommodate families who arrive from Nouakchott to vacation during the rainy season (which generally begins in mid-July) and enjoy the cool coastal air. Many of these shanties, some of which are equipped with latrines, belong to inhabitants of Khantour who rent them out for a period of 1 to 3 months, which corresponds to the rainy season.

Mouly

This is a small camp located between PK 144 and N'Diago; it consists of 4 scattered wooden shanties of variable size. These structures are used as accommodation for fishermen who are not working and other camp employees (counters, labourers). Currently, activity here has dropped off considerably.

N'Diago

N'Diago is the capital of the commune of the same name and the largest human settlement on the coast south of Nouakchott.

The history of the locality is probably linked to the general settlement of the Langue de Barbarie region and the island of Saint-Louis, as it was the same social structure historically. According to Bonnardel (1985), in the mid 17th century, shortly before the French founded a trading post on Île Saint-Louis (1659), fishermen from Walo (historic region in present-day Senegal and Mauritania) would set up camp every year from February to May toward the southern end of today's Guet Ndar district. The latter's earliest encampments on the Langue de Barbarie are believed to date from the mid-16th century and thus pre-date the founding of the Saint-Louis trading post. These fishermen were in reality peasants in their villages of the lower Senegal valley and traded with the Moors, exchanging fish caught in the river for salt and dates. In order to increase their means of exchange, fishermen from Walo migrated in search of more fertile fishing grounds and this is how they developed a habit of moving seasonally down river to near its mouth during the agricultural off-season. Bonnardel cited a Guet Ndar tradition according to which the people of Walo were apparently subjects of the monarch of Trarza. For him, a large part of the community settled in Guet Ndar, while a few families made their homes in N'Diago. As fishermen they had only ever operated in the rivers, and it was only well after their arrival in the 19th century that they ventured offshore (Bonnardel, 1985: 20).

This site has a number of basic infrastructures:

- ✓ A drinking water network;
- ✓ A health outpost;
- ✓ A complete primary school and a middle school;
- ✓ A telephone antenna;
- ✓ A hybrid (thermal and solar) power plant;
- ✓ An ice-making facility.

In recent years, the existence of these various basic infrastructures has given rise to a genuine socio-economic dynamic in N'Diago, particularly with regard to artisanal fishing. Indeed, since 2014 a trend has been observed whereby hundreds of native fishermen have been returning to this site to develop their artisanal fishing activities (Photo 6). In the past, N'Diago was barely a landing point at all, as only one or two pirogues per season were observed[7]. On the other hand, fishermen from N'Diago settled the fishing

[7] IMROP statistics confirm this trend of N'Diago fishermen returning to their native region. In 2010, there were just 18 local fishermen in N'Diago, compared to 2,500 who were from N'Diago but fished in Nouakchott. In 2014, a larger uptick was recorded, with the return of 308 fishermen in this category (IMROP, 2014).

centers along the northern Mauritanian coast, from Nouakchott to Nouadhibou. This return was driven by the availability of a significant octopus stock in the fishing grounds near N'Diago as well as already existing fishing activities at the Mouly site.

Photo 6: Pirogue Launching in N'Diago

Another facet of this economic momentum is the magnitude of movements between N'Diago and neighboring localities. Indeed, the village is also increasingly becoming a service hub for various localities in proximity and within the same commune: Ebden, Moidina, Ghahra, etc.

N'Diago's economic space is now focused on the maritime fishing sector, notably with the presence of 10 fishing camps, all belonging to locals. The camps are physically characterized by hangars situated on N'Diago's beach (Garaw district) and where landed fish catches are received. Fishmongers or their representatives work in these hangars (administration, storage of fishing equipment, etc.). Fishermen affiliated with these camps are either inhabitants of N'Diago or migrants from other parts of the commune.

Furthermore, artisanal fish processing (Photo 7) and market gardening activities are noted as being present in the immediate vicinity of the locality. These latter two sectors are occupied by women who, despite the lack of resources, strive to make their activities profitable and eek out a livelihood. There are a total of 85 processors, who collectively deal in a diversity of fish species, but especially elasmobranchs. Their production is marketed in Saint-Louis, Senegal and sometimes in Nouakchott as well.

The high level of processing activity is one of the direct results of the revitalized harvest sector at the N'Diago site, with this strong presence of local fishermen backed by fishmongers who have an in-depth understanding of the mechanics of Mauritania's fish markets.

Market gardening in N'Diago represents a most timely initiative. In fact, with the steep decline of agriculture due to the effects of salinity intrusion from receding flood waters of the Senegal River (since construction of the Diama dam in the 1980s), market gardening offers the residents of N'Diago a good opportunity for dietary diversification and mitigates their food dependency on the markets of Saint-Louis and Nouakchott.

Photo 7: Rudimentary Fish Processing Facilities in N'Diago

Market gardening is practiced by fifty or so women who have teamed up in a cooperative called "*Diappo Gu Yalla*" ("solidarity" in Wolof*).* With a surface area of 1,600 m^2 , the latter was offered by the municipal administration a few years ago but only began operating in December 2016. Members of the cooperative work themselves and grow a number of crops including eggplant, leaf vegetables and various types of peppers to satisfy the needs of the N'Diago market (Photo 8). This vegetable plot is served by a water line.

Photo 8: In the village of N'Diago, market gardening is practiced by women.

Mboyo 1 and 2

According to community sources, the localities of Mboyo 1 and 2 are very old. Mboyo 1 in particular dates back to 1622, when it was founded by farmers and fishermen of Fulani (Peul) ancestry. The number of inhabitants in the two localities is currently estimated at 600.

The two localities of Mboyo are separated by the river. Mboyo 1 is located on the Senegal River while Mboyo 2 lies on the Langue de Barbarie. Most of the two localities' trade is conducted with the neighboring city of Saint-Louis, including drinking water, which is supplied via Senegalese bush taxis that serve N'Diago.

The two localities have one primary school with five grades, while the only provision of health care consists of a single matron (head nurse) recruited by N'Diago Commune and who keeps a small supply of medication.

Diahos 1 and 2

These two localities are located on the island of Mboyo. They are only accessible by pirogue. According to people spoken to in the community, the etymology of the name "Diahos" evokes a connection with the sea (*Dia* = sea and *Hos* = grass). The first locality, Diahos 1, was created circa 1900 and, at a time when local medicine was widely used, was renowned as the place to find a highly sought after medicinal herb. The second locality was created later, i.e. in 1960.

Based on the 2015 commune census, the total number of residents was estimated at 356 (163 for Diahos 1 and 193 for Diahos 2). The total surface area of the two localities is 10.5 km^2.

Existing public infrastructures here notably include a primary school and a health outpost with one State nurse and two assistants. To preserve equality between the two villages, these services were constructed in the middle (Photo 9).

Lorme

This small locality, also known as Mboyo Peulh, is located 1 km south of Mboyo 2, after the border post of the Gendarmerie and the police. Its residents are Fulani farmers and number 100 according to the most recent commune census conducted in 2015. Cattle raising represents the means of subsistence in this locality. Like the residents of Mboyo, those of Lorme have a relatively old claim to the land (100 years). They live here year round, even if they roam up to 60 km as they practice their pastoral activities.

6.2 Population

The population of the study area is highly varied in terms of demographics, ethnicity and socio-economic categories, similar to the administrative statuses of these sites which include the nation's capital (Nouakchott), one arrondissement (N'Diago), developing villages (PK 93), landing points for artisanal fishing, camps and other minor sites.

The main characteristics of this population for each site are presented below.

Nouakchott

According to ONS, the population of Nouakchott was 1,043,177 in 2015. Official statistics do not allow for a breakdown based on ethnicity. In reality the latter is not particularly meaningful for Nouakchott, as the city is a genuine melting pot of all of Mauritania's ethnic groups. The city was built following the country's independence (1960) as a symbol of national unity. However, the existing economic categories, even if they do not necessarily correspond to ethnic identities, are close and can provide indications of a differentiation in the working population based on geographic or even ethnic origins.

At fishermen's beach (8 km west of Nouakchott), the only landing point for artisanal fishing in Nouakchott, the number of seamen in 2016 reached 4,807, of whom 42.65% were Wolofs from N'Diago while 19.55% were Senegalese. The remainder were from Nouakchott and other diverse regions of Mauritania or countries of West Africa (Mali and Guinea-Bissau). (Wagne and Braham, 2016).

A survey conducted in 2012 on employment in artisanal fishing in Mauritania showed that Nouakchott represented 23.5% of jobs at sea and 19.3% of jobs on land in this sub-sector (Ould Dahmed and Ely, 2014).

Other than fishermen, the remaining working population on the Nouakchott beach is composed of ship (pirogue) owners as well as fishmongers including a large number of women who resell fish in the districts of Nouakchott[8]. The fishmongers are generally ethnic Moors (traditionally agro-pastoralists with little or no affinity to the coast), but the majority of ship owners are Wolofs. The latter sometimes have significant financial resources thanks to their collaboration with the fish processing plants in Nouakchott which they help supply through the fishermen. Other fishmongers are engaged in marketing these products to inland cities or abroad.

It should be noted that the majority of this working population, fishermen in particular, do not live directly on this site, but rather in districts of Nouakchott of variable proximity such as Basra (Sebkha) or Les Pikat[9] (moughtaa whose official name is Riyadh) on the road to Rosso. This fact stems from the administration's ban of makeshift housing at this site out of consideration for the fragile environmental conditions of the dune ridge in Nouakchott.

Unfortunately, detailed statistics characterizing these social groups are not available as they are for fishermen.

N'Diago

As of 2013, the arrondissement of N'Diago had 1,240 inhabitants according to the most recent census (ONS, 2015).

The site's current population is mainly composed of Wolofs who are especially engaged in fishing and associated commercial activities as well as agriculture, the latter exclusively during the rainy season (July and August).

In fact, like the rest of the lower Senegal River delta, the lands of N'Diago are unsuitable for agriculture due to the aforementioned salinity phenomenon. Fishing, especially offshore, is the badge of socio-economic life of this locality. It molds the local social order, which is relatively and fundamentally egalitarian, as is Wolof society in general. However, the influence of the geographic and cultural proximity of the highly hierarchical Moorish and Fulani ethnic groups brings about a few minor changes in the ambient social structure. In this case, fishermen are at the forefront in terms of social distinction, boosted by the significant revenues generated by their activities and the prestige of their migratory experiences in remote regions.

Legweichich (PK 93)

With an estimated population of 600 in 2015 according to the Village Chief, Legweichich is composed mostly of Wolofs from N'Diago and Nouakchott. It is a village with an effective presence of fishing families established here since 2004 in the context of efforts by public authorities to foster development of the coast through a permanent human presence. In this regard, Legweichich has benefited from Spanish Cooperation, which in 2006 conducted a novel experiment here for fishermen autonomy and development

[8] According to estimates by the fish market director, 60% of the fishmongers at the Nouakchott fish market are women (interview with M.A. Mahmoud, MPN, 2017-05-05).
[9] Plural in Hassaniya Arabic of the French abbreviation "PK" (*point kilométrique*).

as well as improved living standards (via access to housing, water and electricity) by funding a cooperative for fishermen and income-generating activities for their wives.

Camps (PK 28, PK 65, PK 144 and Mouly)

The population of these sites is generally seasonal and composed of fishermen and employees who work for the fishmongers.

Permanent presence is reported at PK 28 of tenants of four food shops that supply the camps, which are set up according to the fishing seasons. Fish processors also remain on site as long as they have access to products. The number of workers in these two categories (merchants and fish processors) can be evaluated at 25 people.

The three fishmongers of PK 28 are also nearly sedentary, remaining on site through the different seasons of the year while managing to collaborate with a reasonable number of pirogue captains interested in the fisheries in question. The latter are mobile, following the fish as they migrate.

Unlike the preceding groups, fishermen are mobile and only remain for the duration of a season as per the contracts signed with the fishmongers in Nouakchott. At the time of our visit, there were sixty fishermen, but this figure can easily increase ten-fold during the octopus season in June-July. In fact, the latter attracts large numbers on account of its high profitability and low technical requirements given that it is practiced using plastic traps[10]. The total population of PK 28 was approximately 400 at the time of our visit.

The PK 65 site hosts camps, but this is not the case currently, with reports of only two pirogues as well as two Malian processors. The number of inhabitants at this site is about 20, including the Coast Guard staff that maintains a checPKoint on site.

The situation at PK 144 is no different, as the site had, at the time of our investigation in April 2017, three fishing camps with a population of 65 including fishermen and fishmongers. In addition to this population, there are some sixty interns from the maritime training center (apprentice fishermen) completing a three-month on-the-job training, and about ten instructors. There are also breeders of small ruminants, whose numbers become significant during the rainy season, reaching two hundred or more. We estimate the population of this site at 100 people.

In Mouly, 26 km from N'Diago, the camp contains only thirty individuals with five pirogues that are currently fishing for sole and that are actually approaching the end of their "campaign" (which began in March). The site hosts a higher population of fishermen during the spiny lobster or octopus "campaigns" (beginning in June)).

[10] The octopus pot technique was introduced in Mauritania in the late 1970s following an FAO project designed to protect the octopus. Female octopuses approached the coasts at two times of the year to reproduce and the project sought to keep them in shallow waters to protect them from trawlers. Ideas developed under the project for protection purposes were used by fishermen of Nouadhibou to create plastic traps to attract this species.

Other Sites

The population of the island of Mboyo and in particular Mboyo 1 and 2 (600 inhabitants) and the two Diahos localities (356 inhabitants) belongs to different ethnic groups: Wolof, Fulani and Moor. The inhabitants' ethnic identity is intertwined with their professions. In this sense, the Wolofs of the two Mboyo localities and Diahos 1 are mostly fishermen, while the Fulani of Lorme (1 km from Mboyo 2*)* are pastoralists, and, lastly, the Moors of Diahos 2 are farmers and merchants.

Table 5: Summary of Demographics in Study Area

Site	Number of inhabitants	Data sources
PK 28	400	Est. Field data, 2017
PK 65	40	Est. Field data, 2017
PK 93	600	Est. Field data, 2017
PK 144	100	Est. Field data, 2017
Mouly	20	Est. Field data, 2017
N'Diago	1240	DNP, 2013
Mboyo 1	200	Est. Field data, 2017
Mboyo 2	400	Est. Field data, 2017
Diahos 1	161	Commune census, 2015
Diahos 2	193	Commune census, 2015
Lorme	100	Est. Field data, 2017
Total	3434	

Source: Field data, 2017, DNP, 2013 and CC, 2015

6.3 Education

Nouakchott

The statistics on the situation in Nouakchott date from before its most recent sub-division into three wilayas. In 2015, Nouakchott was one of those regions that had gross enrolment ratios (GER) at the primary [11]and secondary school levels that were superior to national averages, which are 72.4% and 34% for primary and secondary, respectively). Indeed, Nouakchott presented ratios of 96.7% for primary and 59.9% for secondary levels (Table 6). Nouakchott's net enrolment ratios[12] confirmed this situation. In this regard, this wilaya was one of the regions where this indicator was higher than the national average (47.2% for primary school and 30.3% for secondary school).

This result reflects the decent state of education offered in this city, where public authorities supported by international cooperation have made enormous efforts in this sector through the construction of schools and mass recruitment of teachers (ONS, 2015).

[11]Gross Enrolment Ratio (GER): The GER of a given level of education at a date (t) is the ratio of the student population (regardless of age) enrolled at this level at a date (t) to the official school-age population corresponding to this same level of education. It is expressed as a percentage.
[12] Net Enrolment Ratio (NER): The NER of a given level of education at a date (t) is the ratio of the student population of a given age group (6-11 as per UNESCO or 6-12 as per the school legislation) to the total population of this age group. It is expressed as a percentage.

However, these favorable education results in Nouakchott might mask disparities between moughataas, in which case their importance would be rather relative.

Table 6: Education Indicators in Nouakchott

Criterion	Masc. [%]	Fem. [%]	Total [%]
Gross Enrolment Ratio – primary	95.4	98.1	96.7
Net Enrolment Ratio – primary	64.6	66.6	65.6
Gross Enrolment Ratio – secondary	60.9	58.9	59.9
Net Enrolment Ratio – secondary	60.9	58.9	59.9

ONS, 2015

When looking at the other sites, there is, unfortunately, no disaggregated data, such as the weight of female students in the overall pupil population. In relation to this aspect, we shall confine ourselves to describe the situation at the regional level. For example, in the Trarza wilaya, girls accounted for 50% of the pupils in the primary cycle (53984) during the 2015/2016 school year. The number of pupils reached 11240 in the first cycle of secondary education, 49 % of whom were girls, while in the second cycle the number of pupils reached 3156, 51% of whom were girls.

The wilaya has 407 schools, 24 colleges and 18 high schools. The number of teachers in the wilaya reached 1487 instructors during the indicated period, 33% of whom were women, and 1294 professors (MEN, 2017).

N'Diago

The wilaya in which N'Diago is located, i.e. Trarza, also exhibited gross enrolment ratios in primary and secondary schools that were higher than the national average. However, it was noted that ratios in rural areas were lower; for example, the GER for primary schools was 58% (ONS, 2015). This might also be the case for N'Diago and its commune.

The locality of N'Diago contains one school offering a complete teaching cycle, one Quranic school and one middle school that also hosts students from 22 localities in the surrounding area.

Legweichich (PK 93)

Legweichich has one public school with two grades as well as one Quranic school.

Other Sites

On the island of Mboyo, children attend primary school and at the end of their curriculum can go to middle school in N'Diago or Keur-Macène. In fact, two multi-grade schools (the same classroom receives students of different pedagogical levels, for example 4th and 5th grades) exist in this area: one in Mboyo 2 and the other in Diahos. However, the absence of institutionalized care for these children (boarding school system) in N'Diago represents a major problem for parents, particularly in the case of girls. In Lorme, children do not attend school, but receive a Quranic education provided by an individual from the village.

Photo 9: School in Diahos

6.4 Economic Conditions

The majority of economic activities in the study area are associated with artisanal fishing. The latter presents sharply contrasting characteristics. In fact, it is an undeniable contributor to the fight against poverty with the thousands of job opportunities that it creates, but also remains largely informal and thus does not lend itself particularly well to economic assessments.

As the following section of this report (Point 6.5) will provide detailed discussion of fisheries and various aspects thereof, this section is dedicated to other activities such as fish processing, river transport and market gardening.

- **Fish Processing:**

Processing is performed for species of low market value such as skates (*toumboullan*), *tollo* (small shark) and other species (sardinella and various demersal fish). Techniques include drying, salting, fermentation and smoking.

Even if it can be observed that domestic and foreign processors use different processing techniques, they work on practically the same species and it is at this level that there is competition between the two groups. This competition is magnified by the absence of a common framework of cooperation and coaching between local and foreign processors.

The majority of processors pool their efforts by working in groups, especially for procurement from fishermen. At PK 28, the quantities processed are in the order of 100 kg / person/ day (field interview data, April 2017). In fishing villages such as N'Diago and PK 93, a significant number of women are engaged in this activity (85 processors in N'Diago and 10 at PK 93). Compared to their male colleagues at other sites, these women seem to have easier access to products due to the fact that they belong to family networks of fishermen. In this regard, these processors can purchase quantities of fish on credit, which is not the case in the camps, where transactions are not individually tailored. In these relatively easy conditions, a processor can produce one tonne a week (field interview data, April 2017).

The women processors in N'Diago are organized in a savings association in which a group of 10 women forms a single economic unit. These units produce and market their products together. Marketing mostly takes place in nearby Saint-Louis. Representatives of a women's production group may make 4 trips a month and generate a total income of 120,000 MRO, i.e. approx. US$334 per group per month (field interview data, April 2017).

- **River Transport (passengers and fish)**

N'Diago's river pirogue fleet is made up of 25 pirogues that serve the island of Mboyo as well as Saint-Louis. Captains of these pirogues are paid by their bosses based on a share ratio, i.e. 1/3 of earnings (after each trip). The other shares go to the pirogue and to the owner. A trip to Saint-Louis costs 500 MRO (approximately US$1.40) per person.

- **Market Gardening**

This activity, which is found only in N'Diago and is still in its infancy, is practiced by women with great courage. Monthly revenues generated for the entire collective (composed of 50 women) reach 150,000 MRO (i.e. US$417)/month; these earnings are invested in infrastructures (construction of water storage basins) and materials.

- **River Fishing**

This is the main activity of the residents of Diahos 1, taking place in the Senegal River all year and involving approximately twenty fishermen. This fishing is especially for subsistence (the daily maximum can be 15-20 kg/person). Catches consist mainly of catfish, varieties of tilapia and striped mullet.

- **Small-scale Wholesaling**

Here we qualify the wholesale trade as small-scale in reference to the capital that it generates. However, this fresh fish wholesaling is practiced by women in the villages of the study area. This is the case in N'Diago and at PK 93. In N'Diago, approximately 250 women are engaged in this activity. The species generally commercialized are seabream and other species (especially tilapia) and their market is Saint-Louis. Like fish processors, these fishmongers are organized in a savings association. Monthly incomes generated reach an average of 20,000 to 30,000 MRO per woman, i.e. approximately $US55.50 to 83.40 (field interview data, April 2017).

6.5 Fisheries

6.5.1 Typology of Fisheries

Maritime fishing represents the main economic activity in the study area. Based on the sites and the resources targeted, several types of fisheries can be distinguished, namely:

- Net fishing: November to July;
- Line fishing: August to November;
- Croaker fishing with Senegalese nets;
- Octopus pots: August to September;
- Cuttlefish and squid with trammel nets: April to June

The octopus fishery is common to nearly all the sites, while the others are characteristic of one or a few sites. For example, the sole and spiny lobster fisheries are characteristic of the camps at PK 28, PK 144 and Mouly. The small pelagic fishery is dominated by Nouakchott. The latter provide bait (sardinella) for the other sites, including N'Diago.

Table 7: Fishing Calendar at PK 28

Month / Fishery	J	F	M	A	M	J	J	A	S	O	N	D
Mullet	Yellow											Yellow
Sole/Squid		Yellow	Yellow	Yellow	Yellow							
Octopus							Yellow	Yellow	Yellow / X	X	Yellow	Yellow

Source: In situ interview data, April 2017

Yellow = month fishing is practiced

XX = fishing moratorium

Table 8: Fishing Calendar at PK 93

Month / Fishery	J	F	M	A	M	J	J	A	S	O	N	D
Scaly fish	Yellow	Yellow	Yellow	Yellow	Yellow							Yellow
Mullet		Yellow	Yellow	Yellow	Yellow							
Octopus					Yellow		Yellow	Yellow	Yellow / X	X	Yellow	Yellow

Source: Field interview data, April 2017

Table 9: Fishing Calendar in N'Diago

Month / Fishery	J	F	M	A	M	J	J	A	S	O	N	D
Mullet	X	X										X
Sole ("tide")		X	X	X								
Grouper, *thiof*	X	X	X	X	X	X	X	X	X	X	X	X

Source: Field interview data, April 2017

6.5.2 Number of Fishermen and Pirogue Fleet

Surveys conducted by IMROP show that the number of fishermen in Nouakchott was estimated at 4,804 in April 2016 while the pirogue fleet stood at 1,162. In this same period, the Nouakchott South area totalled 1,358 fishermen, 67% of whom were Senegalese (IMROP, 2016). The current situation of crews (April 2017) south of Nouakchott is summarized in Table 10 below.

Table 10. Number of Fishermen per Site

Zone	Number of units	Number of fishermen
PK 28	13	60
PK 65	2	10
PK 93	200*	340
PK 114	12	65
Mouly	5	26
N'Diago	40	136
Total	272	637

Source: Field interview data, April 2017

*At least half of these units are inactive (due to lack of means to maintain them).

6.5.3 Existing Infrastructure

In terms of fishing infrastructure, Nouakchott occupies the highest rank within the study area given that it is the second most important artisanal fishing center in Mauritania after Nouadhibou. Nouakchott is the leading hub of the fresh fish industry and in this regard boasts several logistical facilities to carry out this function in which artisanal fishing plays a major role.

The largest fishing infrastructure in Nouakchott is the fish market, which mainly consists of the following:

- Two central halls for fish vendors;
- Wholesale stores with storage facilities;
- A fresh fish market divided into several wings located south of the hall;
- Stalls for fishing equipment north and south of the hall;
- Administrative offices;

- A Coast Guard station;
- Premises for professional organizations;
- A fuel station;
- An ice-making facility;
- Sanitary facilities;
- Victualing stores;
- Shipbuilding sites;
- Mechanical repair workshops;
- Spaces for artisan carpenters;
- Mosques;
- Shops.

At the other sites, the most important infrastructures encountered are the ice-making facility in N'Diago as well as hangars used by fishmongers for their services (product receiving, fishing material storage, etc.) at all localities. These hangars are the work of the fishmongers and not the public sector.

6.5.4 Main Fishing Gear and Techniques

Table 11: Main Fishing Gear Types Used in Study Area

Fishing gear type	Nouakchott	PK 28	PK 65	PK 93	PK 144	Mouly	N'Diago
Longline	■	■					
Octopus pot		■					■
Trammel net	■	■					
Tollo net		■					
Handline	■			■	■	■	■
Mullet gillnet				■	■		■
Sole net			■	■	■	■	
Purse seine	■						

Source: Field interview data, April 2017

6.5.5 Fishing Seasons, Practices and Areas

As described in the preceding sections, artisanal fishing in Mauritania is characterized by a strong seasonality. For instance, octopus are harvested in two seasons that are particularly prized by fishermen. There are other fishing seasons such as those dedicated to sole or *thiof* or grouper (in Mouly and PK 65 areas).

Fishing practices are many and varied. Fishermen participate in two-day "tides" (offshore trips) when targeting scaly fish using handlines. There is also day fishing, which is more widespread in the area and relatively less costly.

Generally, a craft will take 5 persons including a captain who is responsible for the trip (for octopus fishing, the crew is composed of 4 persons, as less effort is needed compared to more active fishing trades). The fishing grounds and the times of departure and return to shore are determined by the captain.

In N'Diago, fishermen venture up to 35 km north of the locality and approximately 3 km offshore. "The farthest offshore we can go is 7 km" (interview with M.L., fisherman, 2017-04-29 in Mouly camp).

However, other fishermen in N'Diago suggest otherwise, saying their fishing grounds lie 45-60 km north of N'Diago and that trips can be up to 9 km from shore (discussion with a group of fishermen in N'Diago, 2017-04-29). The motors used are often 15 HP and 18 HP, which indicates that the fishing grounds are not excessively far.

In the absence of an offshore weather service as exists in Nouakchott, fishermen in N'Diago use information broadcast by Senegalese FM radio, in particular out of Saint-Louis. The information is given on an hourly basis and is considered by the fishermen to be relevant. In order to improve their access to information on offshore safety, certain N'Diago fishermen subscribe to the weather bulletins proposed by the Senegalese mobile phone networks, Orange in particular.

6.5.6 Catches and Revenues

Data on catch volumes and values are generally available only for zones (North, Center, Nouakchott, South, etc.) and not on a disaggregated basis to obtain information on individual sites.

In Nouakchott, landings have reached 53,861 tonnes per year. They show rather considerable variation from one year to another. Likewise, they went from 60,070 tonnes in 2012 to 27,734 in 2013, 60,761 in 2014 and 66,869 in 2015. Sardinella is by far the main species landed in Nouakchott, with 61% of catches. It is followed by common pandora (8%), red pandora (4%), croaker (4%), and black seabream (3%). These five species combined represent 80% of the total catches of Nouakchott-based artisanal fishing units.

Table 12: Evolution of Catches and Corresponding Values in Nouakchott

Main indicators	2012	2013	2014	2015	Average
Volumes of catches [tonnes]	60,077	27,734	60,761	66,869	53,861
Value of catches [MRO]	15,112,604,285	6,976,666,580	14,811,195,300	16,821,147,231	13,430,403,349
Active pirogues	1,288	1,451	1,180	1,293	1,162

Source: Baldo et al., 2017

Results for the other sites are presented in Table 13 below.

Table 13: Catch Volumes and Values in South Zone (2015)

Site	Volumes of catches [tonnes]	Value [MRO]
PK 28	3,307	1.65 billion
PK 65	849	424 million
PK 93	3,307	1.6 billion
PK 144	500	268 million
N'Diago	3,620	1.8 billion

Source: Baldo et al., 2017

With regard to remuneration, fishermen are paid in accordance with the arrangements made between the ship owners (or the fishmongers that represent them) on one hand and the captains and fishermen on the other hand. Remuneration will also depend on the fishery being targeted. For example, in the sole fishery, each fisherman has the production of a single net. During a good "campaign" (lasting approximately two months), fishermen in camps can generate net earnings of at least 250,000 MRO, i.e. approx. US$695 (discussion with a group of fishmongers in N'Diago, 2017-04-30).

6.5.7 Fishmongers and Other Fishing-related Activities

Fishmongers represent an essential link of artisanal fishing activity in Mauritania in general and in the study area in particular. Fishmongers finance the pirogues' operations and ensure the fishermen's living conditions. This financing can go beyond trips offshore to cover the purchase of motors or fishing gear, or even repairs made to craft. Fishmongers are also the ones that decide on camp locations when it is necessary to leave the large groups. In exchange for his or her services, the fishmonger will obtain the price of the first sale for the entire production landed by the pirogues under contract. The margins between the fishmongers' prices and market prices can be very significant (200 or even 300 MRO (US$0.83/kg), but not when one considers the conveniences fishmongers bring, especially in camps where there is a lack of means of transport, ice and other essential items for this activity.

In Nouakchott, there were 635 fishmongers in 2015, broken down as follows: 526 collectors, 95 exporters and 14 distributors[13] (Baldo et al., 2017).

In N'Diago, there are currently 12 fishmongers, half of whom are from the region and who primarily market at processing plants in Nouakchott (for export) and to a lesser extent in Saint-Louis, in association with Senegalese fishmongers.

The fish trade can be a highly lucrative activity in N'Diago, as competition is low and fishermen's needs for financing are limited, as they are professionals who often keep their fishing equipment in good condition. However, the fact that the Nouakchott market is relatively far (250 km), the limited availability of inputs (including ice and lures), and the difficulties of accessing the neighboring Senegalese market are limiting factors to the development of this activity.

6.5.8 Current State of Fishery

The importance of artisanal fishing for the country's economy makes this sector of key importance to national policy on natural resources management, at times creating pressure on stakeholders with the objective of maximizing profits for a country where half of the population is poverty-stricken. Occasionally, policy decisions trigger major changes that at first sight disrupt the socio-economic structures of this activity, which is heavily capitalized but uses artisanal technology.

In 2008, authorities banned the export of products derived from certain fish species of high market value such as croaker and *thiof* to encourage local consumption and food security through financial access to these products. According to economic assessments, this measure was very damaging to commercial stakeholders in these sectors and to marketing channels in general (IMROP, 2010).

In 2017, a series of pirogue inspections cost the jobs of Senegalese fishermen engaged in artisanal fishing in Mauritania, whereas the latter represented the majority of crews in Nouakchott and camps southward as far as N'Diago.

At the time of our field mission, we observed that the camps were highly affected by the departure of the Senegalese, who formed a qualified workforce that Mauritanian fishmongers relied on for supplying land-based plants. This was acutely felt at PK 144, Mouly and N'Diago.

Several fish meal plants at PK 28 (formerly dependent on Senegalese charter crews) are currently idle due to procurement difficulties.

6.6 Social Organization

In the study area and notwithstanding Nouakchott (where there is a free federation of artisanal fishing), ship owners (some of whom are active fishermen) and fishmongers are the only artisanal fishing

[13] These categories refer to Law 2009-172 on the wholesale fish trade, which divides stakeholders into four main categories, namely: **i) finance fishmongers**, who equip and/or finance the pirogues; **ii) export fishmongers**, who are individual exporters who pay plants to export their products; **iii) collector fishmongers (intermediaries)**, who are financed by plants or export fishmongers; and **iv) distributor fishmongers to the inland market (wholesalers)**, who use refrigerated trucks to distribute products within the country and sometimes to neigboring countries (Mali and Senegal).

stakeholders who are structured. Fishermen who do not own their own craft form the majority of the working population in this sector, but they are not organized. In fact, they are merely a workforce offering their labor, but most often do not benefit from practical guidance for their advancement, according to some of their representatives (interview with A. Diop, head of cooperative in N'Diago, 2017-05-01). Admittedly, initiatives have been made in the past to establish fishermen's organizations, but were not truly successful. Ethnic and tribal affiliations thus remain a fundamental element for this category in terms of accessing work at sea and obtaining better working conditions from captains or ship owners (group discussion in Mboyo, 2017-04-27).

In Nouakchott, the purse seine commission is the core organization for managing fishing practiced by purse seine pirogues. It was created in 1991 to regulate this fishery and optimize sardinella production by implementing a management system whereby the units (which numbered 80 in April 2016) would take turns making offshore trips in an effort to control the offer to achieve a better price level. Since 2010, the commission has evolved into a cooperative in order to acquire an official status allowing it to participate in debates on fishery management policy organized by the Ministry of Fisheries and Maritime Economy (MPEM) and also as a source of potential support that could be provided by the latter for technical reinforcement or in times of crisis.

With regard to the wholesale trade, there is a fishmongers' federation, but its activity-organizing action is very limited and is rather focused on the institutional level (representation, lobbying, etc.).

Fishmongers play a key role in the camps, as the latter are their initiative and they are the ones who oversee every aspect of the camps' operations, including transporting the catches to marketing centers.

In N'Diago, fishing units are mainly family-owned, but the activity is partially financed by fishmongers established on the premises who have connections with the networks of refrigerating and processing plants in Nouakchott.

According to field data, the experiment of organizing fishermen into cooperatives conducted from 2006 to 2008 by Spanish Cooperation at PK 93 yielded encouraging results, but shows that administrative and technical support should be provided over a longer duration to allow the fishermen to acquire management skills, given that most of them have had limited education. This will therefore require more consolidated interventions that take into account the education factor (group discussion at PK 93, 2017-04-25).

With regard to social and political climate, it can be noted that there is a certain cohesion between the various stakeholders (fishermen, fishmongers, processors, plant managers, etc.). In this regard, very few conflicts between these categories are reported, including in the courts. However, the enormous income disparities between stakeholders, the informal character of commitments between partners, and the sense of injustice felt by some fishermen (notably the highest qualified) represent high risks for social stability in this sector. The fishing and wholesaling organizations mentioned above are not burdened by political undercurrents and are not ethnic or tribal expressions of identity.

Furthermore, a few isolated disputes were pointed out between fishermen in camps (PK 144 in particular) and individuals of the tribe *Ehel Bouhoubeiny* (among the local population on the shores of Nouakchott and the South)[14].

6. Conclusion

The study area encompasses a number of human settlements, the main ones being Nouakchott and N'Diago. Outside of Nouakchott and N'Diago, the other sites have seasonal populations, even if the tendency to become more sedentary is obvious, as is the case for PK 93. The sparsely inhabited sites mainly consist of camps.

Socio-economic life of this area revolves around fishing with intense activity reflected in the large volumes of landings, notably in Nouakchott and N'Diago. Employment generated by artisanal fishing is significant and is characterized by the dynamic involvement of women in the post-harvest stages. Product marketing channels revolve around Nouakchott, but trading also takes place with Senegal, where fishmongers have commercial networks in Saint-Louis.

Among the new phenomena reported in artisanal fishing in the area, two major elements can be noted: the revitalization of the N'Diago site as a landing point with the return of local fishermen and the departure of Senegalese fishermen in 2017.

[14] In the name of customary law, these pastoralists required quantities of fish as compensation for fishing off "their coasts". Although these incidents were resolved by actions taken by the administrative authority, they have a symbolic value that should not be neglected.

7. Bibliography and Other References

I. Bibliographic References

1. Baldo, J., M.L. Abdel Hamid, A.D. Dia, M. Labrador, M. Valles and B. Elabass. 2017. Etude sur la pêche artisanale en Mauritanie pour mutualiser les interventions de l'UE dans ce domaine. Nouakchott.
2. Bonnardel, R., 1985. Vitalité de la petite pêche tropicale, pêcheurs de Saint-Louis du Sénégal, Paris, CNRS Editions, *Mémoires et documents de géographie* collection, 105 p.
3. Choplin, A. and F. Vincent, 2015. Nouakchott, l'avenir pour défi: Adaptation et mutation d'une ville vulnérable. Summary of Nouakchott workshop, Mauritania, 2014.
4. Huberman, A.M., M.B. Miles (1991). Analyse des données qualitatives. Recueil de nouvelles méthodes. Brussels: De Boeck-Wesmael.
5. Ministry of Economic Affairs and Development (MAED). 2014. Profil de la pauvreté en Mauritanie.
6. Ministry of National Education (MEN). 2017. Annuaire des statistiques scolaires 2015-2016.
7. National Statistics Office (ONS). 2017. Annuaire statistique 2015. Nouakchott.
8. National Statistics Office (ONS). 2015. Recensement général de la population (2013). Chapter 8: Alphabétisation, scolarisation et fréquentation scolaire. Nouakchott, 2015
9. Ould Dahmed, K. and T. Ely. 2014. L'emploi dans le sous secteur de la pêche artisanale, MPEM, APAM Project. 44 p.
10. IMROP, 2010. Etude sur l'impact économique de la mesure d'interdiction d'exportation de certaines espèces de poisson. Cas des mareyeurs de Nouadhibou. 22 p.
11. IMROP. 2014. Enquête cadre sur la pêche artisanale. IMROP. Nouadhibou, 11 p.
12. Wagne, H. and C.B. Braham. 2016. Enquête cadre sur la pêche artisanale. IMROP. Nouadhibou, 11 p.

II. Interview/Communication Data

1. Camp at PK 28, south of Nouakchott. 2017. Interview with Mr. Mohamed Lemine, fishmonger.
2. Village of Legweichich (PK 93). Interview with Mr. Moussa Gueye, Village Chief, conducted by Moustapha Taleb, 2017-04-24.
3. Village of Legweichich (PK 93). Discussion with a group of fishermen, Moustapha Taleb, 2017-04-25.
4. Ministry of Fisheries and Maritime Economy. Nouakchott fish market. Interview with Mr. Ahmed Mahmoud, general manager, conducted by Moustapha Taleb, 2017-05-05.
5. Village of N'Diago. Discussion with a group of fishermen, Moustapha Taleb, 2017-04-29.
6. Village of Mboyo. Discussion with a group of residents in Mboyo, Moustapha Taleb, 2017-04-27.
7. Village of N'Diago. Discussion with a group of fishmongers in N'Diago, Moustapha Taleb, 2017-04-30.
8. Village of N'Diago. Interview with M.A. Diop, head of cooperative in N'Diago, conducted by Moustapha Taleb on 2017-05-01.

8. Appendices

Appendix 1

List of Individuals Consulted

Name	Function	Contact
PK 28		
Samba O Dembi	President, processors' association	
Babe O Messoud	Fishmonger	
Houssein	Captain	
Mohamed O Salem	Captain	36359390
PK 93		
Ibrahima Dieye	Fisherman	
Omar Sarr	Fisherman	
Ba Ousmane	Fisherman	
Abdoul Aziz Niang	Fisherman	
Elgawi O ahmedVall	Fisherman	
Ahmed Vall Meissara Diop	Fisherman	
Moussa Gueye	Village Chief	
PK 144		
Cheikna O Seydina Ali	Director, Coast Guard base	
Mohamed Lemine O Moamed	Fishmonger	
Mouly		
Moamed O Beyadh	Fisherman	
Weden O Deya	Fisherman	
Mohamed O Bah	Fisherman	
Mohamed O Mohamed	Fisherman	
Mohmamed O Elghaed	Fisherman	
Elkotb	Fishmonger	
N'DIAGO		
Abdi O N'Diaye	Coordinator, town hall	4152206
Mamadou Ibrahima Gaye	Former president of fishmongers	
Madiop Gaye	Alternate Investigator, IMROP	
Mahmouden Diop	President, fishmongers' association	
Abdoussalam Diop	Vice-President, fishmongers' association	
Saliou Diop	Advanced technician and head of health outpost	47656903
Houlimata Gueye	President, fish processing association	
Roukaya Diop	President, fish vendor association	
Elhadj Adma Diop	Community leader and director of Quranic school	
Ousmane Moustapha Diop	Retired fisherman	
Moussa Boubacar Diop	Fishmonger	
Mboyo 1 and 2		
Aichetteou Cheikh Sidaty Dieye	Merchant	44270870
Fatou Omar N'diaye		
N'Diawar Mamatt Niang		

Name	Function	Contact
N'Deye Fall N'Diaye		
Aida N'Diaye		
Cheikh Sow	Fisherman	41185629
Assane N'Diaye	Fisherman	46912205
Mohamed Diallo	Farmer	46534829
Massada N'Diaye	Fisherman	44279870
Daouda Cisse		49270704
Seydou N'diaye	Fisherman	44023267
Ousmane Diallo	Fisherman	47751696
Ibrahima Sow	Fisherman	48641204
Mamedy Diallo	Fisherman	48467998
Diahos 1 and 2		
Babe Mohameden O Houmeid	School teacher	Diahos 1
Ndior Dieng	Merchant	Diahos 2
Sidi O Amar	Merchant	Diahos 2
Moctar M'bareck	Fisherman	
Doudou Dieye	Fisherman	
Yerg O Houmeid	State-employed nurse	Diahos 2
Yahya Chegran	Merchant	Diahos 2
Youness N'diagne	Fisherman	Diahos 1
Cheikh Dieng	Fisherman	Diahos 1
Doudou Seck Dieng	Fisherman	Diahos 1
Mourat N'diay	Fisherman	Diahos 1
Tal Sall	Fisherman	
Mahfoudh O Hemer	Farmer	Diahos 2
Ibrahim Seck	Fisherman	Diahos 1
N'dey Fall	Nurse	Diahos 1
Souleymane Dadah	Merchant	Diahos 2
Yahya Yatim	Merchant	Diahos 2
Lorme		
Ibrahima Sow	Pastoralist	
Moussa Sow	Pastoralist	

Appendix 2

List of Localities Visited

Locality	Latitude	Longitude
Nouakchott	391,282.59	2,003,014.95
PK 28	389446.5114	1964474.569
PK 65	385158.3207	1937675.709
PK 93	372966.0207	1902322.786
PK 144	356683.4541	1864560.703
Mouly	345820.0032	1824404.998
N'diago	338417	1788108
Mboyo 1	339395	1782354
Mboyo 2	338633	1781727
Diahos 1	343298	1780390
Diahos 2	342593	1782186
Lorme	338985	1780009

Appendix 3

Water Supply in Study Area

NOUAKCHOTT	Drinking water supply from Aftout
PK 28	Drinking water supply project
PK 65	No water, but 5 km from transfer in Aftout.
PK 93	No water, but 16 km from transfer in Aftout / delivery by truck from Tiguint
PK 144	No water, but 16 km from transfer in Aftout / delivery by car belonging to fishmongers
N'Diago	Drinking water supply from Biret treatment station.

APPENDIX E-4: STUDY OF FISHING COMMUNITIES IN SENEGALESE PORTION OF CORE STUDY AREA OF THE AHMEYIM/GUEMBEUL GAS PRODUCTION PROJECT

Environmental and Social Impact Assessment of Ahmeyim/Guembeul Offshore Gas Production Project

Study of Fishing Communities in Senegalese Portion of Core Study Area of the Ahmeyim/Guembeul Gas Production Project

Final Report

Prepared by

Baidy TALL

TROPICA Environmental Consultants

Liberté VI, Villa No. 8181 • BP 5335 Dakar-Fann SENEGAL
Phone: (221) 33 867 18 98 - Fax: (221) 33 867 18 99
Email: tropica@tropica-ec.com

September 20, 2017

Project and Study Details	
Project	ESIA for Ahmeyim/Guembeul Offshore Gas Production Project in Mauritania and Senegal
Study for which report is being issued	Study on fishing communities in the Senegalese portion of the Core Study Area
Report version	Final
Author of report	Baidy TALL, Tropica expert

Distribution List		
Recipient 1	Golder Associates	Project Director
Recipient 2		

Signatories	
Prepared by:	Baidy TALL
Reviewed by:	Samba YADE, Project Coordinator, Tropica
Approved by:	Samba YADE, Project Coordinator, Tropica
Date of transmission:	September 20, 2017

This report has been prepared by Tropica Environmental Consultants (Tropica) in the context of a subcontract with Golder Associates for a contribution to the description of baseline environmental conditions, which is part of the environmental and social impact assessment (ESIA) of the Ahmeyim/Guembeul Offshore Gas Production Project in Mauritania and Senegal initiated by Kosmos Energy Mauritania (KEM) and Kosmos Energy Senegal (KES).

It has been prepared (1) by Mr. Baidy TALL, sociologist and environmentalist, (2) in compliance with Tropica's terms of reference, and (3) with data and information obtained from literature and field investigations. In the course of preparing this document, Tropica and its expert have drawn from their know-how, professionalism, rigor and due diligence.

The data and information contained in the document are based on site visits, interviews with competent individuals, document reviews and experience in similar studies and projects.

In any case, Tropica assumes no responsibility or liability for the use of the content of this report by any person other than its recipient(s).

ADC	Communal Development Agency
ANACIM	National Agency of Civil and Maritime Navigation
ANER	National Agency of Rural Electrification
ARD	Regional Development Agency
ASUFOR	Association of Borehole Users
BDGN	Bottom drift gillnet
CEM	Middle school
CLPA	Local Artisanal Fishing Council
CNCAS	National Fund for Agricultural Credit of Senegal
COOPEL	Léona Fisheries Cooperative
CPC	Cayar Fisheries Committee
CRG	Small Management Committee
CVS	Oversight and Security Committee
DITP	Department of Fish Processing Industries
DPM	Department of Maritime Fisheries
EIG	Economic Interest Group
EMV	Estimated Market Value
ESIA	Environmental and Social Impact Assessment
FENAMS	National Federation of Fishmongers of Senegal
FVO	Food and Veterinary Office
JICA	Japanese International Cooperation Agency
MPA	Marine Protected Area
MPEM	Ministry of Fisheries and Maritime Economy
REMICA	**Group of Industrial Fishmongers of Cayar**
SDGN	Surface drift gillnet
SIRN	Society of Naval Repair Infrastructures
SRPS	Regional Fisheries and Surveillance Service
ToR	Terms of Reference
UGB	Gaston Berger University

TABLE OF CONTENTS

List of Tables

List of Figures

List of Photos

1.0 Introduction

This report is a contribution to the environmental and social impact assessment (ESIA) of the "Ahmeyim/Guembeul Gas Production Project". The document has been prepared by Tropica Environmental Consultants (Tropica) and presents a characterization of fishing communities in the Senegalese portion of the core study area of the ESIA, which comprises a number of villages on the Grande Côte.

1.1 Context of Study

Senegal has a long tradition of fishing, the social and economic importance of which has been growing continually in recent decades (Sonko, 2007). At the same time, the characteristics of fisheries in Senegal have greatly evolved; the traditional activity (Camara, 2008) has undergone rapid change with the advent of new technologies (Laloe and Samba, 1990) and the development of pirogue-based fishing (Le Roux, 2005).

Maritime artisanal fishing is the most dynamic component of the sector and the most important in terms of socio-economic benefits. Indeed, it is an important source of income while at the same time contributing to feeding the country's population. Moreover, artisanal fishing gives rise to the development of numerous related activities, the most important of which include the wholesale fish trade, processing and transport.

The Grande Côte, i.e. the northern portion of the Senegalese coast (from Cayar to Saint-Louis), contains a number of fishing communities including Cayar and Saint-Louis, which are amongst the most dynamic in the country.

However, in recent years, artisanal marine fishing in Senegal has experienced difficulties on a number of levels owing to strong competition from foreign industrial fishing boats, illegal / non-declared / non-regulated fishing, the depletion of fishery resources and the effects of climate change (Gueye, 2016). The main constraint is believed to be the full exploitation (already reached) of most of the fishery heritage (Saint-Louis Commune, 2010).

It is in this context that the recent discoveries of offshore gas and oil and the potential for their extraction have appeared.

1.2 Methodological Approach

Recap of Objectives and Scope of Study

This study essentially aims to provide a detailed portrait of the "fishing communities in the Senegalese portion of core study area of the Ahmeyim/Guembeul gas production project". The ToR stipulate that emphasis be placed on the communities of Saint-Louis. This report provides disaggregated information on fishing activities, including the number of fishermen, their organizations and practices; the pirogue fleet, including registrations; fishing-related activities and the stakeholders involved and their organization; incomes of fisheries stakeholders; fishing safety; etc.

Data Collection Methodology

The methodology adopted in the context of this work involves two stages:

- A field phase during which visits were conducted to all localities in the core study area and certain localities in the extended study area such as the island of Bopp Thior. This field work was an opportunity to communicate with contacts who provided a great deal of information on fishing communities and localities. In the course of these visits, interviews were conducted with municipal authorities, district leaders and councils, heads of organizations for fishermen and women processors, fisheries services, local artisanal fishing councils (CLPA), etc. The field mission also served to visit institutions to collect documentation on the subjects under study, namely: Gaston Berger University (UGB) of Saint-Louis, Regional Development Agency (ARD), Communal Development Agency (ADC), etc.
- A document review, analysis and reporting phase.

2.0 Location of Fishing Communities in Core Study Area

The fishing communities in the ESIA's core study area, as defined in the terms of reference (ToR) of the said study, are represented in the following figure. From north to south they are: Saint-Louis, Potou, Lompoul, Fass Boye, Mboro, Cayar and Dakar. All these communities were studied, with particular emphasis on Saint-Louis, as per the ToR of the study. The characteristics of these localities, the fishing communities and the fishing activities in these localities are described in the sections below.

3.0 Socio-economic Characteristics of Fishing Communities of the Saint-Louis Area

The fishing communities of the city of Saint-Louis are closely linked to the Langue de Barbarie, which is home to the fishing districts.

History and Settlement of Langue de Barbarie and Other Districts of Saint-Louis

Saint-Louis Commune has experienced a period of urbanization that has given rise to four main entities: the island, the Langue de Barbarie, Sor suburb and, recently, the communal outskirts (districts of Khor, Bango and Ngalèle). This division symbolizes the different stages of urban growth of the Commune. The population is distributed unevenly across the four districts over an urban space spanning 4,579 ha, of which 943 ha is water.

Thanks to natural conditions that were favorable for fishing, populations from the village of Aje in the Walo region[1] came to settle on the Langue de Barbarie. Bonnardel (1985) explains that settlement of the Langue de Barbarie by fishermen dates back to the 16th century. In the mid-17th century, shortly before the French established a trading post on the Island of Saint-Louis (1659), the Langue de Barbarie was practically deserted and was used by Moorish herdsmen for grazing their livestock. Beginning at this time, toward the southern end of today's Guet Ndar district, fishermen from Walo would set up camp every year from February to May. The latter's earliest encampments on the Langue de Barbarie are believed to date from the mid-16th century and thus pre-date the founding of the Saint-Louis trading post. These fishermen were in reality peasants in their villages of the lower Senegal valley and exchanged fish caught in the river for salt and dates brought by the Moors. In order to increase their means of exchange, fishermen from Walo migrated in search of more productive fishing grounds and this is how they developed a habit of moving seasonally down river to near its mouth during the agricultural off-season.

[1]Walo is a historic region of Senegal located approximately 100 km northeast of Saint-Louis

It is in this context that the farmer-fishers of Walo decided to abandon their native lands to come and settle on the Langue de Barbarie. A large part of the community then settled in Guet Ndar, with a few families settling in Ndiago (north of the Langue de Barbarie) and others choosing to venture as far as Gandiole. As fishermen they had only ever operated in the rivers, and it was only after their arrival in Guet Ndar in the 19th century that they began to practice maritime fishing.

The Langue de Barbarie is a sand spit measuring 24 km long and 250 m wide that separates the river from the ocean in its final reaches, over a distance that varies considerably over time. It is home to Saint-Louis' four fishing districts, namely, from north to south: Goxxu Mbacc, Ndar Toute, Guet Ndar and Hydrobase.

With the development of economic activities around the river mouth, the population gradually settled and Guet Ndar began to grow. This district is home to their dwellings as well as their activities.

Guet Ndar symbolizes the primitive core of the Langue de Barbarie. In 2014, the census conducted by the Guet Ndar District Council revealed a population of 26,000 residents, including 12,246 men and 13,754 women. This district is home to their dwellings as well as their activities.

Already in 1829, with the return of the French, the first development plan was implemented and Île Nord was created in 1829. After the island, Ndar Toute was created in 1846 with the objective of alleviating congestion on the island and in Guet Ndar, which were already beginning to suffocate. In the local toponymy the name "Santhiaba" ("new city") is used, which reflects its recent creation compared to the older urban centers. Ndar Toute was once a holiday destination and place to relax for island residents. In 1849, Ndar Toute was proclaimed "village of freedom" and welcomed freed slaves (Sy, 2013). This district is divided into two sub-districts: Bas (Lower) Ndar Toute and Haut (Upper) Ndar Toute.

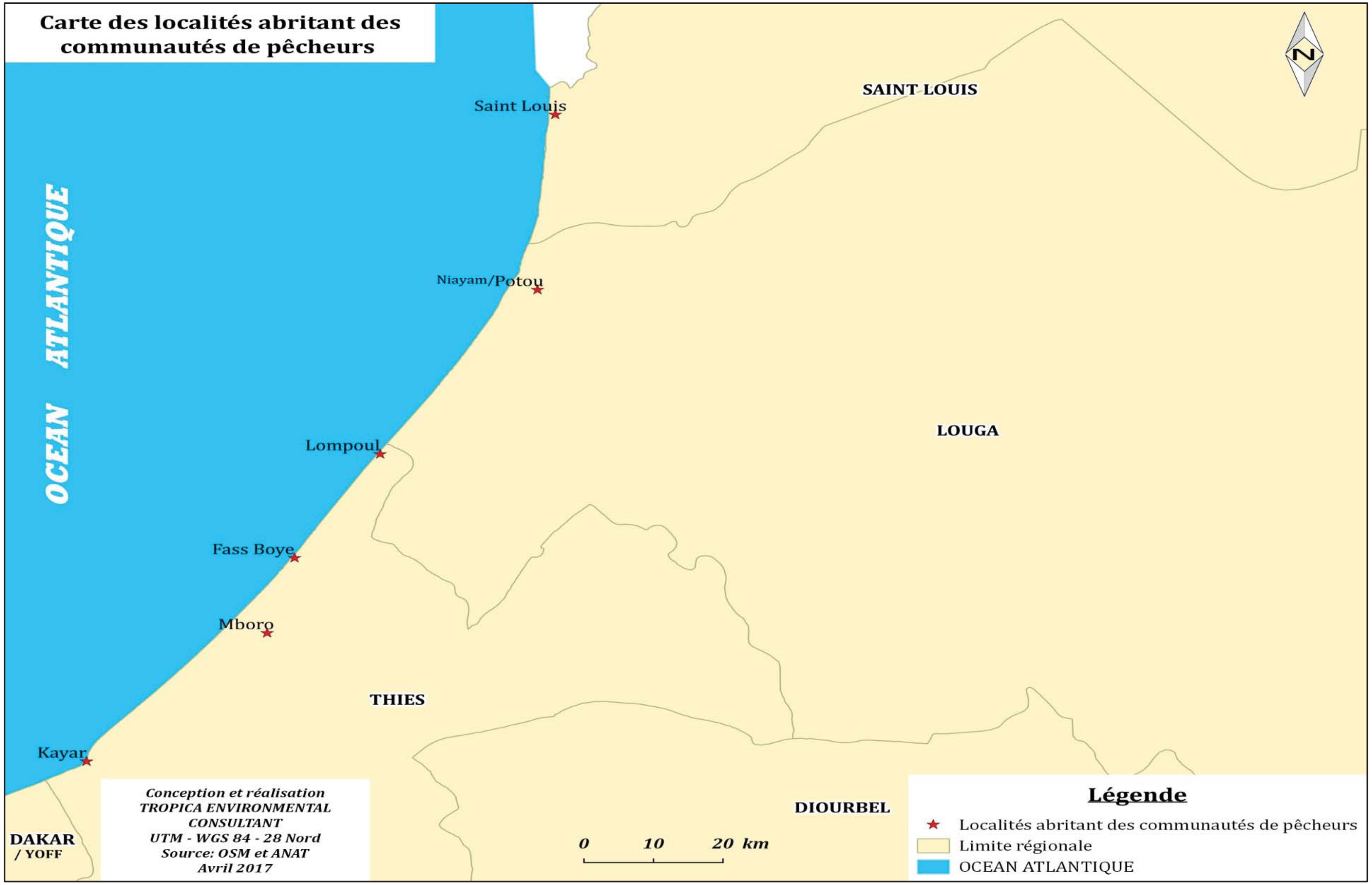


Figure 1: Map of Localities with Fishing Communities in Core Study Area.

In 1886, saturation of the island prompted colonial authorities to parcel out Bas Ndar Toute (a sub-district of Ndar Toute) on the Langue de Barbarie and to create the Sor district, which at the time was called "Bouet Ville" and which became the preferential extension of the city. The first parcelling out in the Sor district took place in 1899 (Khor Road). The urban space of Saint-Louis was thus divided into three zones: the island of Saint-Louis, the Langue de Barbarie and the suburb of Sor. Separated by watercourses, these three areas caused serious problems in terms of connectivity. It was in this context that the bridge built across the river in 1865 was replaced by the current Faidherbe Bridge in 1897.

Faced with the overpopulation of the districts established on the Langue de Barbarie, the Hydrobase district was created in 2012 to ease the crowding suffered by the residents of Guet Ndar. Earlier, Goxxu Mbacc was created in 1884 by colonial authorities in Saint-Louis in the same spirit, i.e. to decongest Guet Ndar (Profil environnemental de la ville de Saint-Louis, 2005).

The figure below illustrates the various districts of the Langue de Barbarie and those of other sectors of Saint-Louis Commune: the island, Sor and the outskirts of the commune.

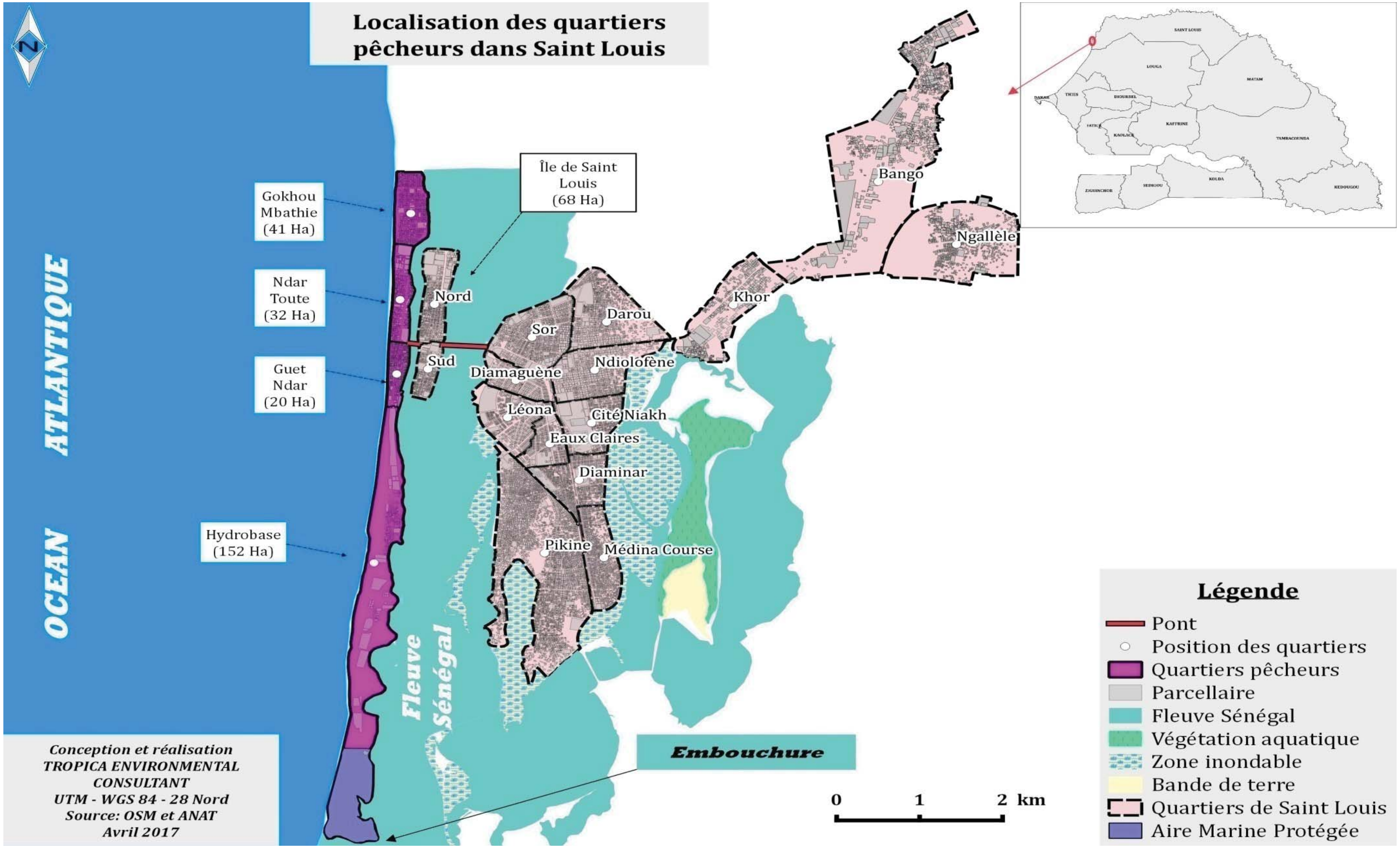


Figure 2: Locations of Districts of Saint-Louis.

3.1 Geographic, Historical and Socio-economic Characteristics of Guet Ndar District

3.1.1 Geographic and Historical Characteristics of Guet Ndar

The district of Guet Ndar is located on the Langue de Barbarie, opposite the island of Saint-Louis. It extends 1 km, between the Atlantic Ocean and the small branch of the Senegal River, from the Moustapha Malick Gaye Bridge and De la République Square (Pointe à Pitre Square) in the north to the cemetery in the south.

With a surface area of 20 ha, the Guet Ndar district is locally divided into three sub-districts:

- Dack, located in the south
- Ponde Khollé, located on the hill (site of current Baateri mosque) and used to keep watch over the colonists, in the middle
- Lodo (which means north), located in the far north and adjacent to Ndar Toute

The climate is semi-temperate, strongly influenced by winds blowing off the sea and river. Vegetation is limited to Australian pine and a few salt-tolerant herbaceous plants on the southern coast.

Historically, Guet Ndar has been considered to be the oldest neighborhood of the city of Saint-Louis. It was founded in the mid-16th century, two hundred years before Saint-Louis was discovered by tribes from Adj (locality near the mouth of the Falémé River (PDQ of Guet Ndar, 2005)), whose immigration ended at Guet Ndar, precisely at the current location of the Ndeugueur mosque.

According to the most well known theory, the name "Guet Ndar" is believed to come from the words "Guet", which means "pastureland" in Wolof, and "Ndar", which designates Saint-Louis. The Fulani (Peul) that inhabited the island at the "Fulani garrison" (present-day location of Cheikh Omar Foutiyou Tall Lycée) brought their livestock to graze on the other side of the river. Another version traces the village's origins to Maguèye Marie, who was the first inhabitant and a native of Adj.

In the past, Guet Ndar has sustained a large number of unfortunate events that have marked the district, most notably:

- The plague epidemics of 1914-1915 and 1929 that decimated part of the population and resulted in a mass exodus to resettlement areas, as well as the intentional burning of the district.
- One of the most catastrophic floods, which occurred in 1950 and which resulted in a major loss of human lives;
- The cholera epidemic of 1978, which caused many deaths.

3.1.2 Socio-economic Characteristics of Guet Ndar

The settlement of Guet Ndar is linked to an ongoing process marked by a multitude of migratory movements, notably from outside to within the district. Inhabitants of the Sud (South) district (on the island) had left their locality to settle in Guet Ndar following a decree by the colonial governor.

Spatial development of Guet Ndar is punctuated by three major phases:

- The first one concerns the massive arrival of seasonal populations from Walo and Cayor as well as Mauritanian tanners toward the mid-16th century;
- The second was marked by operations called seuk, which means "embankment";

- The third is characterized by the decongestion movements and forced relocations to Hydrobase and Goxxu Mbacc that began in the late 20th century.

According to data from the 2014 census conducted by the District Council, Guet Ndar numbers approximately 26,000 inhabitants, including 12,246 men and 13,754 women. The three sub-districts of Guet Ndar contain 1,727 households. The demographic characteristics of this district corroborate those observed both at the communal and national levels, namely the significant proportion of youth. With regard to gender, women slightly outnumber men, making up 53.97% of the population, versus 46.3% for men. This might be attributable to the high degree of mobility of men both within the country and beyond its borders for professional reasons ("campaigns", "tides"), but also, to a lesser extent, the fact that most residents that perish at sea (accidents, capsizing, drownings, etc.) are men.

"Campaigns" and "tides" are terms employed in the fishermen's jargon to refer to the migrations these communities make in search of fish.

A "campaign" refers to a prolonged journey to an area to take advantage of resource availability. A "tide" consists of staying out at sea to fish for a few days or even weeks.

Uninfluenced by Christianity during the colonial era, the residents of the Guet Ndar district are Muslims and maintain 11 mosques and 17 Quranic schools. The population is predominantly Wolof.

Guet Ndar has two primary schools that have largely exceeded their capacity, a functional health center and two private pharmacies.

The level of education in the district is not very high. Humans being shaped by their local environment, it warrants mentioning that the low level of education of the populations of this district is largely due to the fact that the physical and social environment is not always favorable for Guet Ndar children to develop an interest in school. In other words, due to the proximity of the sea and the contact that Guet Ndar children have with currency from an early age, parents experience enormous difficulties enrolling or keeping their children enrolled in school, and most of them prefer that they work in the fishing sector. Likewise, similar to other districts on the Langue de Barbarie, Guet Ndar is confronted with the problem of high dropout rates.

Fishing is an extremely important activity for the populations of the districts established on the Langue de Barbarie in general and in Guet Ndar in particular. It provides the community with employment, a source of revenue and food. Fishing employs a workforce averaging 15,000 in Saint-Louis Commune and generates tens of billions CFA francs a year (Regional Fisheries Service of Saint-Louis, 2016).

In the districts of the Langue de Barbarie, 78% of households are active in this sector, including 3 people per household in Guet Ndar alone (Ndiaye, 2016). Most residents of Guet Ndar are engaged in artisanal fishing. On the Langue de Barbarie, adults and minors are engaged in fishing, landings and fish sales (fishmongers). Women are responsible for supplying the city's markets and fish processing. Older residents and children perform minor repairs of fishing material.

Housing in Guet Ndar is essentially composed of permanent constructions. However, this situation is not synonymous with comfort, as the houses are cramped and families very often live in close quarters, which makes living conditions very difficult at times. The state of the roads is rather chaotic and houses encroach on the roadways. Like other districts, the means of transportation that serve the district are essentially composed of buses commonly known as "Tata", official taxis, unofficial taxis ("clandos"), minibuses and carriages. The majority of households are connected to the Senelec grid and have televisions, radios, mobile phones, etc.

Section 3 of the report presents the characteristics of fishing and related activities in the districts of the Langue de Barbarie.

3.2 Geographic, Historical and Socio-economic Characteristics of Ndar Toute District

3.2.1 Geographic and Historical Characteristics of Ndar Toute

Ndar Toute is one of the four districts on the Langue de Barbarie. It lies between the district of Goxxu Mbacc in the north, the district of Guet Ndar in the south, the ocean in the west and the small branch of the Senegal River in the east. It lies on a spit approximately 1.5 km long and occupies a land area of 32 ha.

One of the oldest districts of Saint-Louis, Ndar Toute was declared "village of freedom" in 1849, as it was designed to accommodate freed slaves. However, the district was created by decree issued by Governor Faidherbe on December 8, 1856 in an effort to relieve overcrowding on the island. The origin of the name of the district is from the Wolof "*Ndar Gou Ndaw*", which means "little Saint-Louis". It is also called Santhiaba, which can be translated as "new city".

The history of the district has been punctuated by numerous events that are now etched in the collective memory of the populations. Milestones in the evolution of the district include the following:

- Construction in 1857 of a camp for the Senegalese Tirailleurs (sharpshooters) named Camp Cazeilles in order to defend against night-time incursions by the Trarza Moors;
- Construction of the Ndar market in 1875;
- Parcelling of Bas (Lower) Ndar Toute in 1886;
- In 1920, the district becomes the seat of the Mauritanian government, which it would remain until 1960;
- In 1929 and 1930, a cholera epidemic strikes;
- Major flooding between 1932 and 1950.

3.2.2 Socio-economic Characteristics of Ndar Toute

Settlement of the Ndar Toute district occurred in successive waves and generally concerned populations from the Senegal River Valley that were composed of Wolofs, Toucouleurs and Moors.

With a population of 11,644 (Source: Saint-Louis Health District, 2016), Ndar Toute is one of the least populated districts in the city of Saint-Louis. It is divided into two sub-districts: the much more heavily populated Bas Ndar Toute in the south (between Moustapha Malick Gaye Bridge and the Ndar Toute market), and Haut Ndar Toute, which makes up the northern half of the district.

In this district, consistent with trends observed at the communal and even national levels, the population is predominantly composed of young people with a relatively low level of education. The absence of spaces that could accommodate relaxation or recreational areas is a common problem for all the districts on the Langue de Barbarie.

Education-related issues include declining levels of schooling and dropout rates. This phenomenon is very common in the area, as pointed out by the president of the District Council: *"The school system in Ndar Toute is seriously plagued by the phenomenon of low enrolment. Living conditions are such that some parents prefer that their children work out at sea instead of staying in school. Last year, one incident created an uproar in the district because the top student at the middle school (CEM) of Ndar Toute was forced to drop out that year because his father preferred to take him to Mauritania to fish. The entire teaching staff deplored the situation, but unfortunately nobody could bring the father to his senses."*

Housing in the Ndar Toute district consists of permanent constructions and includes numerous multi-level homes. The vast majority of homes have modern appliances such as televisions and radios, refrigerators, telephones and, to a lesser extent, automobiles (PDQ of Ndar Toute, 2004). Means of transport essentially consist of buses known as "Tata" (brand name), minibuses, official taxis, unofficial taxis ("clandos") and carriages.

3.3 Geographic, Historical and Socio-economic Characteristics of Goxxu Mbacc District

3.3.1 Geographic and Historical Characteristics of Goxxu Mbacc

Goxxu Mbacc lies between the Sal Sal district in the north (the zone forming the Senegal-Mauritania border), Ndar Toute in the south, the Atlantic Ocean in the west and the small branch of the Senegal River in the east.

The district was founded as part of the Guet Ndar congestion relief policy initiated by Saint-Louis Commune. In terms of geophysics, the Goxxu Mbacc district is one of the most sensitive to the marine erosion that it has been suffering with increasing intensity. Most recently, houses have been engulfed in water and a portion of the fish dock is at serious risk of being destroyed.

3.3.2 Socio-economic Characteristics of Goxxu Mbacc

With an estimated population of 23,288 (Saint-Louis Health District, 2016), Goxxu Mbacc falls under the "heavily populated" category of districts in Saint-Louis Commune. In this category, Goxxu Mbacc ranks behind Pikine and Guet Ndar. Like other districts of the city of Saint-Louis, data on the population structure show that the district is made up mostly of young people. With respect to gender, the District Council reveals that women slightly outnumber men.

Similar to other districts of the Langue de Barbarie, the level of eduction of residents is not high. The Goxxu Mbacc district has been experiencing rather alarming school dropout rates. Students quit school very early in order to take up fishing. Girls also drop out quite early either to get married or to take up fishing-related activities such as the small-scale wholesale trade or artisanal processing. According to some of the contact resources interviewed, the main problem is not so much children's lack of schooling as it is keeping them in school.

With regard to housing, it has been found that dwellings are mostly permanent constructions, even if there are shanties in some places and in some homes people live in overcrowded conditions. Roadway infrastructure is essentially composed of the road that passes through all districts along the Langue de Barbarie, a few cross streets and alleys. The most frequently used means of transport are the so-called "clandos" (unofficial taxis), official taxis, "Tata" buses and carriages. The vast majority of homes are connected to the Senelec grid (electricity) and the SDE system (water). There exists an EIG called Collection, Disposal and Processing of Household Waste (CETOM) that is responsible for collecting domestic refuse (PDG of Goxxu Mbacc, 2003).

3.4 Geographic, Historical and Socio-economic Characteristics of Hydrobase District

3.4.1 Geographic and Historical Characteristics of Hydrobase

Hydrobase represents the last official district on the Langue de Barbarie. It is located between Guet Ndar and the village of Fass Dièye. The district borders the Muslim cemetery of Guet Ndar to the north, the village of Fass Dièye to the south, the small branch of the Senegal River to the east and the Atlantic Ocean to the west.

Hydrobase is the most recent district to appear on the Langue de Barbarie. It was created in 2002 to relieve congestion in Guet Ndar and other districts of the Langue de Barbarie. This is how most Guet Ndar residents came to live in Hydrobase. This situation means that the residents of Guet Ndar and those of Hydrobase are related, since most residents of Hydrobase can trace their families back to Guet Ndar.

3.4.2 Socio-economic Characteristics of Hydrobase

With a population of approximately 15,000 (Source: District Council, 2017), Hydrobase is beginning to experience rather rapid population growth due to its somewhat particular context with respect to the other districts on the Langue de Barbarie. Indeed, most hotel infrastructures in Saint-Louis Commune are concentrated in Hydrobase. This is a factor that draws Saint-Louis residents to this district.

In terms of housing, it is noted that there are high-quality homes and the living standard is rather high in this district compared to other districts on the Langue de Barbarie. Hydrobase is served by a very degraded main road (but which is being upgraded); means of transport essentially consist of "Tata" buses recently introduced in the city, official taxis, unofficial taxis ("clandos") and carriages. Nearly all houses are connected to the Senelec electrical grid and the SDE water system (interview with president of Hydrobase CDQ, 2017) (Translator's note: CDQ = District Development Committee).

On the educational and health care fronts, Hydrobase has one working but struggling primary school and one dispensary.

3.5 Detailed Description of Fishing Activity and Community on Langue de Barbarie

As mentioned in Section 3, the Langue de Barbarie is home to the fishing districts of the city of Saint-Louis. Fishing and its associated stakeholders in this area are described in the sections below.

3.5.1 Importance of Fishing Activity on Langue de Barbarie

Thanks to the presence of the sea and the river, the populations of the Langue de Barbarie have a long fishing tradition. In Saint-Louis, maritime artisanal fishing is practiced by residents of Guet Ndar, who are present throughout the Langue de Barbarie. This activity mobilizes a significant workforce and makes Saint-Louis the second most important fishing region in Senegal after Thiès Region, not only in terms of fishery products but also in terms of the pirogue fleet (DPM, 2014).

It is reminded that Thiès Region is the top fishing area in the country. This region is home to important fishing communities such as Mbour, Cayar and Mboro.

For 2014, fish landings in Saint-Louis are estimated at approximately 60,000 tonnes for an estimated market value of nearly 11 billion CFA francs (DPM, 2014). In 2015, landings were evaluated at more than 92,000 tonnes with a market value of over 13 billion CFA francs. The table below provides quantitative data for landings in Saint-Louis.

Table 1: Landings of Fishery Products in Saint-Louis.

Year	Landing [t]	Wholesale trade [t]	Local consumption [t]	Transformation [t]	Processed products [t]	Estimated market value [CFA francs]
2013	71,446.95	49,224	2,595	19,627.95	6,542	11,725,893,000
2014	57,772	46,746	2,176	8,850	2,950	11,008,888,000
2015	92,652.90	64,616.10	2,689.65	25,347.15	8,449.05	13,379,547,000
2016	63,731.00	Data not available	2,795.00	1,413.00	1,412.65	11,905,000,000
Total	285,602.85	160,586.10	10,255.65	55,238.10	19,353.70	48,019,328,000

Source: Saint-Louis SRPS, extract of general results from 1999 to 2016

Nearly 80% of these landings are generated by purse seine pirogues.

The magnitude of these landings means that Saint-Louis currently supplies fresh and processed fish to all regions of Senegal and even other countries in the sub-region such as Mali and The Gambia.

Table 2: Most Landed Species in Saint-Louis and their Market Values.

		2016		2015		Evolution	
	Species	**Qty (tons)**	**EMV (x1000)**	**Qty (tons)**	**EMV (x1000)**	**Qty (%)**	**EMV (%)**
Fish	Round Sardinella	17,328.50	2,079,420.00	26,111.80	3,816,557.00	-51%	-84%
	Atlantic Chub mackerel	11,325.80	1,132,580.00	3,818.15	327,802.50	66%	71%
	Madeidan sardinella	10,875.35	1,196,288.50	31,276.64	2,726,630.00	-188%	-128%
	False Scad	10,566.65	1,584,997.50	2,020.50	277,125.00	81%	83%
	Ribbonfish	2,989.70	1,494,850.00	2,899.73	2,139,562.50	3%	-43%
	Rubberlip grunt	1,681.75	672,700.00	2.00	1,500.00	100%	100%
Crustaceans	White shrimp	7.85	18,055.00	12.25	26,650.00	-56%	-48%
Molluscs	Volute	16.40	9,840.00	55.45	8,325.00	-238%	15%

Source : DPM 2016 Report, general fishing results

The following table 3 presents the monthly landings for different fish species during the year 2016 as well as their commercial values. This information is taken from the latest report (2016) from the Department of Maritime Fisheries.

Table 3: Monthly Landings by Species (tons) and their Market Values for the Saint-Louis Region

SPECIES	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	TOTAL	Price/ Kg	EMV X1000 CFA francs
FISH															
ETHMALOSE	30.00	26.30	34.75	25.60	37.00	9.00	2.00	1.35	1.50	1.40	1.20	49.00	219.10	200.00	43,820.00
ROUND SARDINELLA	3,691.60	2,550.15	1,537.45	1,552.05	3,558.60	3,851.45	400.00	11.00	7.00	5.00	9.00	155.20	17,328.50	120.00	2,079,420.00
MADEIDAN SARDINELLA	1,252.75	1,531.50	1,324.30	1,100.25	2,810.00	2,059.20	463.95	18.00	9.00	7.50	182.80	116.10	10,875.35	110.00	1,196,288.50
ATLANTIC CHUB MACKEREL	4,400.00	1,980.00	2,000.00	1,800.00	1,000.00	69.00	2.70	2.70	2.00	2.00	1.40	66.00	11,325.80	100.00	1,132,580.00
KING MACKEREL	0.00	0.00	7.00	8.00	7.00	2.00	1.55	0.90	0.70	0.50	0.60	1.50	29.75	250.00	7,437.50
ATLANTIC LITTLE TUNA	750.00	500.00	371.50	142.70	421.50	102.50	53.20	28.05	23.00	11.75	6.50	24.50	2,435.20	300.00	730,560.00
ATLANTIC BONITO	311.05	267.20	158.90	151.30	147.00	87.50	1.70	2.00	1.75	1.50	1.35	2.00	1,133.25	300.00	339,975.00
SAIL FISH	0.30	0.30	0.50	0.50	0.50	0.35	0.10	0.10	0.20	0.20	0.50	0.60	4.15	800.00	3,320.00
SWORD FISH	0.10	0.15	0.35	0.45	0.40	0.40	0.30	1.20	1.70	1.50	0.70	0.70	7.95	600.00	4,770.00
FALSE SCAD	2,031.00	2,133.00	1,451.00	1,500.60	2,000.00	804.70	100.45	77.30	75.00	53.60	37.00	303.00	10,566.65	150.00	1,584,997.50
CUNENE HORSE MACKEREL	218.50	161.30	157.00	133.60	145.50	85.50	11.50	8.00	3.90	2.40	0.90	1.20	929.30	125.00	116,162.50
BLACK-TAILED TREVALLY	2.00	1.40	1.50	1.30	1.50	1.00	0.65	0.70	0.80	0.60	0.70	0.80	12.95	350.00	4,532.50
ATLANTIC BUMPER	85.80	71.50	89.00	90.00	65.30	92.50	9.00	6.80	7.00	6.00	27.50	10.00	560.40	125.00	70,050.00
VADIGO	3.00	2.30	2.50	3.00	2.50	1.00	0.80	0.90	1.00	1.30	1.10	0.90	20.30	250.00	5,075.00
POMPANO	0.10	0.25	0.35	0.50	0.60	0.70	0.30	0.50	0.70	0.80	1.00	1.00	6.80	300.00	2,040.00
ALEXANDRIA POMPANO	0.30	0.40	0.45	0.90	0.90	0.60	0.25	0.70	0.70	0.70	0.70	0.50	7.10	450.00	3,195.00
AMBERJACK	0.10	0.10	0.10	0.25	0.25	0.40	0.30	0.30	0.50	0.50	0.90	1.20	4.90	900.00	4,410.00
GREATER AMBERJACK	0.10	0.15	0.15	0.15	0.15	0.35	0.35	0.35	0.45	0.50	0.50	0.50	3.70	800.00	2,960.00
GRUNTER	0.30	0.50	0.60	0.75	0.75	0.90	0.50	0.50	0.60	0.60	0.60	0.60	7.20	300.00	2,160.00
PIGSNOUT GRUNT	1.00	1.75	3.00	3.30	128.75	137.40	43.50	12.50	14.00	11.05	9.50	0.60	366.35	500.00	183,175.00
BIGEYE GRUNT	17.00	16.00	12.05	9.00	9.00	7.30	2.00	2.00	2.50	2.80	2.00	1.55	83.20	250.00	20,800.00
RUBBERLIP GRUNT	333.05	251.00	233.00	185.00	185.00	100.00	55.00	63.70	65.00	51.70	85.80	73.50	1,681.75	400.00	672,700.00
BIGLIP GRUNT	1.70	1.50	1.70	1.50	1.50	1.50	1.20	1.50	1.70	1.80	1.35	0.90	17.85	300.00	5,355.00
BLUEFISH	0.00	0.00	0.00	0.00	0.00	28.00	35.00	0.50	0.00	0.00	0.00	0.00	63.50	900.00	57,150.00
SEA CATFISH	3.50	4.00	1.90	2.70	12.00	3.00	7.00	1.70	1.80	2.00	1.40	2.90	43.90	300.00	13,170.00
MULLET	36.50	21.00	18.00	21.50	34.50	22.05	16.50	11.00	12.40	13.70	19.00	9.00	235.15	450.00	105,817.50

SPECIES	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	TOTAL	Price/ Kg	EMV X1000 CFA francs
FISH															
COMB GROUPER	0.60	0.50	0.35	0.40	0.30	0.20	0.20	0.30	0.20	0.35	0.40	0.50	4.30	800.00	3,440.00
WHITE GROUPER	2.00	1.30	1.10	0.80	0.30	0.80	3.20	9.10	6.00	1.90	3.60	2.00	32.10	4,000.00	128,400.00
TOOTHED GROUPER	0.10	0.15	0.30	0.50	0.25	0.20	0.20	0.20	0.20	0.20	0.20	0.20	2.70	2,000.00	5,400.00
DUSKY GROUPER	0.50	0.40	0.65	0.50	0.50	0.25	0.20	0.40	1.50	0.70	0.40	0.90	6.90	3,000.00	20,700.00
DUNGAT GROUPER	0.45	0.40	0.40	0.40	0.30	0.30	0.30	0.30	0.45	0.30	0.30	0.30	4.20	1,000.00	4,200.00
SEABASS	0.30	0.35	0.45	0.35	0.35	0.30	0.30	0.30	0.40	0.40	0.40	0.30	4.20	1,200.00	5,040.00
DOLPHIN FISH	6.00	5.00	8.35	9.00	11.40	9.00	6.60	9.00	7.00	2.00	0.50	0.80	74.65	600.00	44,790.00
SNAPPER	0.30	0.30	0.40	0.40	0.40	0.50	0.50	0.50	0.60	0.50	0.50	0.50	5.40	1,200.00	6,480.00
OTHER LUTJANUS	0.30	0.25	0.25	0.30	0.30	0.40	0.30	0.30	0.30	0.30	0.30	0.40	3.70	1,000.00	3,700.00
PUFFER	0.40	0.40	0.40	0.40	0.40	0.30	0.30	0.30	0.40	0.40	0.40	0.60	4.70	400.00	1,880.00
BARRACUDA	1.80	1.60	1.50	2.00	41.50	28.30	8.70	5.40	4.00	3.00	2.70	1.30	101.80	600.00	61,080.00
HUNTER FISH	0.50	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.50	0.40	0.40	0.40	5.00	250.00	1,250.00
THICK CROA KER	1.00	0.80	0.90	1.00	1.30	1.50	1.20	1.00	1.20	1.50	1.40	1.70	14.50	500.00	7,250.00
SMALL CROAKER	1.60	1.40	1.70	1.50	1.50	4.00	2.80	3.00	3.50	3.80	2.75	2.00	29.55	600.00	17,730.00
LAW CROAKER	1.00	1.00	2.00	1.80	1.80	2.00	2.00	5.05	6.00	4.00	0.30	0.90	27.85	400.00	11,140.00
BOBO CROAKER	2.50	0.80	0.80	0.80	0.80	0.50	0.50	0.50	0.50	0.50	0.50	0.50	9.20	600.00	5,520.00
MEAGRE	3.50	3.00	2.60	3.00	2.65	2.00	1.50	2.00	1.60	1.50	1.20	1.50	26.05	1,200.00	31,260.00
SAUPE	1.00	1.20	1.50	2.00	2.35	2.00	1.80	2.00	2.00	1.70	1.80	1.60	20.95	250.00	5,237.50
CANARY DENTEX	1.00	1.00	0.80	0.70	0.70	0.60	0.75	0.60	0.60	0.60	0.60	0.60	8.55	750.00	6,412.50
PUNK DENTEX	0.90	0.80	0.70	0.50	0.50	0.40	0.40	0.50	0.60	0.80	0.90	0.70	7.70	1,200.00	9,240.00
LARGE EYE DENTEX	26.00	22.75	20.50	22.40	25.00	21.50	10.70	14.00	9.00	4.00	23.50	16.40	215.75	925.38	199,650.00
PINK SEABREAM	37.50	31.00	27.40	28.00	28.00	30.70	21.35	195.90	100.35	6.00	32.00	27.50	565.70	1,000.00	565,700.00
GILTHEAD SEABREAM	0.40	0.50	0.50	0.40	0.40	0.40	0.40	0.40	0.40	0.60	0.60	0.60	5.60	900.00	5,040.00
RUBBERLIP GRUNT	0.40	0.40	0.40	0.40	0.40	0.15	0.15	0.15	0.20	0.20	0.20	0.20	3.25	500.00	1,625.00
RED PORGY	0.10	0.25	0.30	0.40	0.40	0.50	0.70	0.80	0.70	0.90	0.90	0.70	6.65	1,000.00	6,650.00
GILTHEAD SEABREAM	0.20	0.20	0.20	0.20	0.20	0.20	0.40	0.50	0.60	0.75	0.75	0.90	5.10	1,000.00	5,100.00
BLUESPOTTED SEABREAM	41.05	35.00	31.00	33.50	27.60	33.55	19.00	15.50	13.70	5.00	4.00	4.00	262.90	1,200.00	315,480.00
PORGY	5.00	4.00	3.40	3.00	3.00	3.65	3.50	3.80	2.00	2.80	2.00	8.55	44.70	700.00	31,290.00
PANDORA	39.00	25.50	23.10	22.40	20.30	23.00	16.00	18.00	14.50	6.00	5.00	4.00	216.80	600.00	130,080.00

SPECIES	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	TOTAL	Price/ Kg	EMV X1000 CFA francs
FISH															
STRIPED SEABREAM	0.80	0.50	0.60	0.50	0.50	0.40	0.40	0.40	0.40	0.40	0.60	0.45	5.95	300.00	1,785.00
SPADEFISH	2.00	2.40	2.70	3.00	3.00	8.80	5.00	3.00	3.50	1.40	1.10	0.90	36.80	200.00	7,360.00
RIBBONFISH	17.05	15.00	12.30	17.00	1,021.75	155.00	122.50	85.60	33.60	9.00	0.70	1,500.20	2,989.70	500.00	1,494,850.00
CONGER	0.30	0.50	0.90	0.70	0.70	0.90	0.70	1.20	1.50	1.70	1.90	2.00	13.00	200.00	2,600.00
MORAY	1.10	1.20	1.05	1.10	1.10	1.60	1.10	1.20	1.30	1.40	1.30	1.50	14.95	150.00	2,242.50
HALFBEAK	0.80	0.60	0.80	0.60	0.60	0.60	0.60	0.50	0.60	0.50	0.60	0.70	7.50	125.00	937.50
CROCODILE NEEDLEFISH	0.50	0.50	0.50	0.40	0.50	0.70	0.60	0.60	0.50	0.50	0.50	0.80	6.60	125.00	825.00
THREAD-FISH	9.00	11.05	12.00	10.00	8.30	2.00	1.30	1.80	2.00	1.70	1.50	2.30	62.95	350.00	22,032.50
MOJARRAS	47.50	30.25	32.45	24.00	25.00	13.00	11.00	13.00	15.00	4.00	1.40	1.60	218.20	100.00	21,820.00
TILEFISH	44.00	41.20	30.80	25.70	21.40	16.50	10.00	7.30	6.00	8.00	6.80	7.00	224.70	600.00	134,820.00
BRILL	0.40	0.50	0.60	0.70	0.50	0.60	0.60	0.80	0.50	0.60	0.35	0.35	6.50	600.00	3,900.00
ATLANTIC EMPEROR	0.30	0.40	0.50	0.40	0.30	0.30	0.30	0.30	0.40	0.50	0.50	0.50	4.70	300.00	1,410.00
TILAPIA	1.70	1.45	1.60	1.50	0.60	0.45	0.50	0.50	0.60	0.50	22.00	6.00	37.40	400.00	14,960.00
SOLE	0.70	0.90	1.00	1.20	1.10	0.90	0.80	0.70	0.80	0.80	0.40	0.40	9.70	1,000.00	9,700.00
TONGUESOLE	9.00	7.40	7.00	4.20	3.00	13.00	6.00	4.00	3.00	1.70	0.70	0.50	59.50	700.00	41,650.00
BUTTERFISH	4.00	3.30	3.50	3.00	3.00	2.40	2.90	3.00	3.50	4.00	3.00	2.00	37.60	400.00	15,040.00
SURGEON-FISH	0.70	0.80	0.80	0.90	0.90	0.70	0.80	0.50	0.40	0.50	0.40	0.40	7.80	1,000.00	7,800.00
STARRY SMOOTH-HOUND	9.00	6.00	7.00	8.00	5.00	3.00	2.00	1.60	1.50	1.30	1.50	1.30	47.20	200.00	9,440.00
NIGHT SHARK	10.00	9.00	8.40	9.00	8.00	8.00	6.00	5.00	4.00	2.40	2.10	2.00	73.90	200.00	14,780.00
HAMMERHEAD SHARK	13.00	12.00	15.00	17.30	7.00	5.00	4.00	3.00	2.40	1.80	1.20	1.00	82.70	150.00	12,405.00
DOGFISH	0.85	0.75	0.85	0.60	0.60	0.90	1.00	1.00	1.00	0.80	0.80	0.90	10.05	200.00	2,010.00
GUITARFISH	1.80	1.50	1.70	1.50	1.50	2.00	1.60	1.20	1.50	0.90	1.50	2.00	18.70	200.00	3,740.00
DEVIL RAY	0.80	0.70	0.80	0.90	0.50	1.00	0.80	0.60	0.60	0.60	0.60	0.75	8.65	150.00	1,297.50
BULL RAY	0.75	0.60	0.60	0.60	0.60	0.75	0.90	0.60	0.60	0.60	0.60	0.60	7.80	150.00	1,170.00
OTHER FISH	2.10	1.85	1.70	1.70	1.40	1.30	0.70	0.85	0.80	0.70	0.80	1.00	14.90	400.00	5,960.00
TOTAL (fish)[2]	13,523.30	9,812.75	7,684.55	7,006.85	11,860.35	7,875.70	1,496.25	682.70	499.90	278.80	535.35	2,441.45	63,697.95		11,867,221.00

Source : DPM 2016 Report, general fishing results.

[2] In addition to the fish species listed on this column, there are other fisheries resources, for example shrimp, lobsters, octopus. These species are also important for artisanal fisheries.

Saint-Louis has a relatively sizable pirogue fleet that ranks second after that of Thiès Region. The number of active artisanal pirogues in Saint-Louis is estimated at approximately 3,411 craft for an estimated workforce of 22,000 fishermen (Source: SRPS Saint-Louis, 2016).

Photo 1: **Pirogues in Guet Ndar (left) and Goxxu Mbacc (right)**

Photos: TEC, March 2017.

The tables below present the Saint-Louis pirogue fleet and its changing dynamics, as well as the number of artisanal fishing permits issued for 2015.

Table 4: **Statistical Data on Fishing Pirogue Fleet in Saint-Louis.**

Control post	Number of forms completed and submitted to SRPS	Number of pirogues identified and never registered Lot 2	*Number of pirogues identified with old number Lot 1
Guet Ndar	1,975	755	1,220
Goxxu Mbacc	1,436	801	635
Total	**3,411**	**1,556**	**1,855**

Source: Saint-Louis SRPS, 2015

In the national nomenclature for pirogues and licences there are the following categories:

- Category C for pirogues exceeding 13 m in length with a capacity of 15 to 20 persons;
- Category B for craft that measure less than 13 m with a capacity of 2 to 6 persons.
- Category A concerns fishing by foot (hook-and-line) and does not involve the use of a craft.

In Saint-Louis, fishing permits awarded in 2015 numbered 9 for Category A, 625 for Category B and 478 for Category C; that same year, 103 fishmonger tags were issued.

Fishing in Saint-Louis, and thus on the Langue de Barbarie, generally takes place in two periods. The first one, called the "big fishing campaign", generally starts around December and continues through June/July, while the other one runs from July/August to November.

The first period is especially marked by landings of pelagic species such as sardinella, chinchard, mackerel, bluefish, etc. The second is especially characterized by fishing using hook-and-line or pirogues equipped with makeshift ice holds, with small quantities landed.

Tables 5 and 6 below show a breakdown of resource values for different species of fish between 2014 and 2016.

Table 5: Landings and Market Values for Different Species of Fish in 2014 for the Saint-Louis Region.

Species	Annual Landed Quantity (tons)	EMV (x1000) CFA francs
ETHMALOSE	186.35	24,872.50
Sardinellas	43,342.00	4,209,761.50
Mackerel	393.70	42,376.00
Atlantic Little Tuna	100.00	18,000.00
Atlantic Bonito	27.20	5,440.00
Chinchard	2,692.90	332,792.50
Blue Runner	137.60	38,300.00
Vadigo	18.30	4,575.00
Pigsnout grunt	244.70	93,255.00
Bigeye grunt	27.40	1,370.00
Rubberlip grunt	269.20	69,992.00
Bluefish	182.25	187,425.00
Sea catfish	180.00	49,500.00
Mullet	324.30	97,290.00
Grouper	3.70	2,220.00
Seabass	25.95	69,690.00

Source : DPM Report 2014, 131 pages

Table 6: Landings and market values for different species of fish in 2015 for the Saint-Louis region.

Species	Annual Landed Quantity (tons)	EMV (x1000) CFA francs
ETHMALOSE	269.90	35,235.00
Sardinellas	57,388.44	6,543,187.00
Mackerel	3,863.65	339,117.50
Atlantic Little Tuna	97.00	15,843.00
Atlantic Bonito	30.70	6,140.00
Chinchard	2,801.75	355,250.00
Blue Runner	1,820.60	169,795.00
Vadigo	13.20	3,300.00
Pigsnout grunt	294.85	117,940.00
Bigeye grunt	214.36	20,946.20
Rubberlip grunt	447.66	178,382.00
Bluefish	506.95	393,285.00
Sea catfish	319.80	74,757.50
Mullet	229.60	70,530.00
Grouper	4.20	2,520.00
Seabass	22.92	61,045.00

Source ; DPM Report 2015, 138 pages

It is important to note that historically, fishing activity in Saint-Louis has been highly dependent on the following two main factors:

- The fishing agreements signed between the Islamic Republic of Mauritania and the Republic of Senegal over the past fifteen (15) years and that are now suspended;
- The artificial mouth (breach) that was created in October 2003.

The first factor is the fact that Mauritania used to authorize Senegalese fishermen from Saint-Louis to fish in waters under its jurisdiction. This explained the large numbers of fish, mainly sardinella, that were once landed in Saint-Louis. Currently, fishing on the Langue de Barbarie is suffering from the effects of the suspension of fishing agreements between Senegal and Mauritania that took force in February 2016. According to some players in the sector, the suspension of these agreements is having a negative impact on the living conditions of the residents of the Langue de Barbarie. With the coasts of Saint-Louis supposedly containing fewer and fewer fish, those of Mauritania were a favorite destination for these fishermen. Since this protocol was suspended, the few fishermen who have taken their chances to fish clandestinely in Mauritania have been caught by the Mauritanian Coast Guard and their fishing material (pirogues, motors and landings) confiscated. In interviews conducted with the heads of certain fishing associations, fishermen are reported to be struggling to make ends meet.

It should be recalled that the two countries have been bound by a fishing convention since 2001. Every year since then, the two countries have been negotiating fishing protocols that concern in particular the unrestricted fishing licences issued to Senegalese fishermen in Saint-Louis. The number of fishing licences issued by Mauritanian authorities to Senegalese fishermen in Saint-Louis has varied over the years between 100 and 400. Article 2 of the memorandum of understanding signed between the two countries stipulated: *"The Mauritanian Party grants a quota of fifty thousand (50,000) tonnes a year to a limited number not to exceed two hundred (200) purse seines or four hundred (400) craft targeting pelagic species with the exception of mullet, in order to supply the Saint-Louis market. Six percent (6%) of these craft (i.e. 24) must land their catches in Mauritania in order to help supply the Mauritanian market. The quantities landed in Mauritania are not counted in the attributed quota."*

Since 2001, this memorandum of understanding has been renewed, most recently in December 2014.

The second factor (artificial mouth or breach) has allowed purse seine fishermen in particular to increase the size of their craft in terms of length and volume. It has also allowed these pirogues to easily navigate this channel and land their catches on the banks of the river branch without any major difficulties. However, crossings of this breach have been the cause of numerous accidents that have cost hundreds of human lives. This has prompted the prefecture to issue an order prohibiting night fishing or crossing the breach at night.

Fishing-related Activities

In Saint-Louis and other fishing localities in Senegal in general, fishing activity stimulates and develops a value chain that entails various players and significant socio-economic benefits.

Besides fishing, other related activities also warrant mention, mainly fish wholesaling, processing, and commercialization.

Further trades and activities taking place around the fish docks include carpenters, outboard motor mechanics, fuel sales, porters to offload products from the pirogues to the docks, cart transport, etc.

Photo 2: Processing Site (left) and Wholesale Fish Trading (right) in Saint Louis.

Photos: TEC, March 2017

Artisanal processing follows the same downward trend as landings in 2016 compared to previous years (2014 and 2015). It recorded a production of 1413 tons against 25 347 tons in 2015, a decrease of 99%. "Kethiakh" (38%), "Guedi" (22%) and "Tambadjang" (26%) are the main processed products of the region. They are consumed exclusively at the national level and are not exported (Source, DPM Report, 2016, page 51).

Fishery Stakeholders, Infrastructures and Challenges in Saint-Louis:

To enable fishing activities in Saint-Louis to function effectively, infrastructures have been installed consisting mainly of landing docks, ice-making facilities, and fishery product processing, packing and storage units. Some of these infrastructures are shown in Figure 3 below.

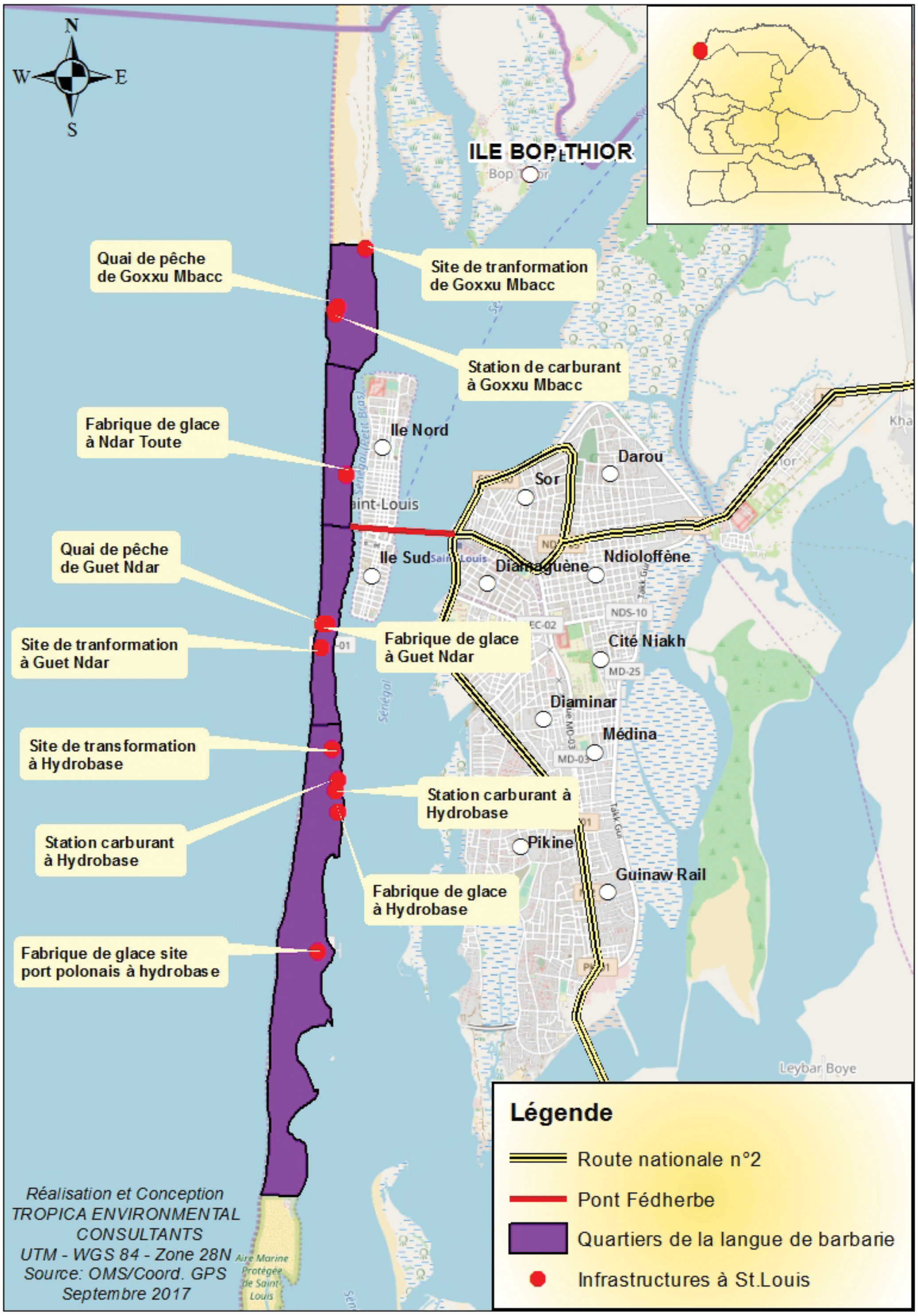


Figure 3: ***Location Map of Infrastructure of the Saint-Louis Fishing Value Chain.***

Main Stakeholders of Artisanal Maritime Fishing in Saint-Louis

Fishermen are the main players and are estimated to number 22,000 (Saint-Louis SRPS, 2015). They manage genuine fishing businesses, even if it is on a family level. Like any entrepreneur, they have employees and incur operating expenses to amortize or maintain/renew their fishing material.

In the fishing communities established on the Langue de Barbarie, the pirogues generally belong to the head of the family, who works with his children and other individuals that they employ. There exists an organization and a distribution procedure for the financial resources generated. For example, after the catch is sold and expenses are deducted (notably fuel), earnings are divided into several parts including for the pirogue, motor and the crew. However, it is recalled that average incomes for fishermen and workers in related sectors are difficult to obtain in the context of this study. The only data available are related to the market values of landings, processing, wholesaling, etc. It might be possible to take this value along with the workforce of each sector to get an idea of average earnings. However, this method in no way guarantees the reliability and validity of data that will be obtained considering the rather unconventional procedure of distributing the resources generated by activity (see above).

Processing of fishery products is largely dominated by women living in Saint-Louis' fishing districts. They are often organized in Economic Interest Groups (EIG).

Within the wholesale fish trade, a distinction is made between fishmongers who have logistical means such as refrigerated trucks and who distribute products within the country or abroad, and small-scale fishmongers, who distribute locally.

Also participating in the dynamism of the fish sector are other players such as truck drivers, cart operators, porters, ice producers, fuel attendants, etc. These different stakeholders are present in all localities along the coast and their contribution to the development of the sector is widely recognized by fisheries stakeholders.

Fishing Practices and Specificity of Saint-Louis Fishermen

Unlike other fishing communities in the core study area, who engage in at least one other activity, most of those on the Langue de Barbarie are exclusively dedicated to fishing. This means that these fishermen travel the entire country in search of fish.

The fishermen of Saint-Louis are renowned migrants; their migrations within Senegal are generally motivated by the search for fish, especially in winter when certain species are locally scarce. The main destinations are Cayar and Yoff, locations known for their rich fishing grounds due to their canyons. Guet Ndar fishermen also settle in Niayam during the fishing "campaign", where they remain with their spouses for the entire period. During the rainy season, they are also found in other localities such as Mbour, Djiffère, Gambia, Joal, etc.

Photo 3: Guet Ndarian Fishermen's Camps in Niayam.

Photo: TEC, March 2017

Fishing seasons and corresponding species in Saint-Louis

The fishing activity is practiced according to seasonality. The fishing seasons in Saint-Louis and the most common fish species during each of these seasons are presented in Table 7 below.

Table 7 : Fishing Seasons and Corresponding Species in the Saint-Louis Area.

Local name of seasons (Wolof) given by fishermen	Corresponding Gregorian month	Main Species Present [3]
« Lolli »	Oct.- Dec.	White grouper (« *coof* »), dungat grouper (« *doy* »), meagre (« *seukhebi* » or « *beur* »), juvenile sardinellas (« *yoos yaboy* »), vadigo (« *cac* ») juvenile bluefish (« *ngal-ngal* ») king mackerel (« *njunë* »), some rare migratory groupers (« *coofu ndax* »)
« Noor »	Jan. - Mar	Bluefish (« *ngot* »), dentex (« *diarègne* »), meagre, atlantic little tuna (« *kiri-kiri* »), round sardinella (« *Yaboy mëtëg* »)
« Coroon »	April- June	Bluespotted seabream (« *kibaro* »), pandora (« *tikki* » or « *youfouf* »), chinchard (« *jay* »), Atlantic moonfish (« *fantar* » or « *yawal* »), ribbonfish (« *tallar* » or « *khouss* »), white grooper (« *coof* » or « *khouthie* » or « *dialague* »)
« Nawet »	July – Sept.	Sail fish (« *navane* ») dolphin fish, croaker (« *feute* »), thread-fish (« *sikéne mbao* »), Pigsnout grunt (« *kcorogne* ») barracudas

Source : Adama Mbaye, 2017, internal document, CRODT

However, with the change in climatic parameters (lengthening of the warm period), the timing of the present fish resources tends to change radically.

[3] In addition to the fish species listed on this column, there are other fisheries resources, for example shrimp, lobsters, octopus. These species are also important for artisanal fisheries.

There are also four marine seasons that are set according to environmental parameters, particularly the continental shelf hydrology which is characterized by spatial, seasonal and inter-annual variability:

- A cold season (December - April),
- A "cold - hot" transition season (May - June),
- A hot season (June - October),
- A "hot - cold" transition season (November - December).

Thus, when establishing connections between marine seasons and fishing seasons, we can consider that:

- The cold season corresponds to the "Noor" season;
- The "cold - hot" transition season corresponds to the "Coroon" season;
- The hot season corresponds to the "Nawet" season;
- The "hot-cold" transition season corresponds to the "Lolli" season.

Organization of Sea Trips

With regard to trips out to sea and their durations, fishermen practice both day fishing and night fishing. Day fishing consists of launching early in the morning (between 06:00 and 08:00) and returning in the late afternoon (approx. 17:00-18:00). Night fishing entails launching around 16:00 and returning the following morning around 08:00 to 09:00. Prior to the termination of the protocol between Senegal and Mauritania (discussed above), fishermen in Saint-Louis set out for Mauritania aboard their pirogues. Those who held fishing licences sailed along the coast and those that did not headed offshore in order to escape detection by the Mauritanian Coast Guard.

Fishermen from Guet Ndar are also found in other countries, notably Gabon and Angola. This fishing practice is somewhat particular, as they do not go aboard their own pirogues. These are generally North Korean vessels called *bateaux ramasseurs* that came to Saint-Louis in search of fishermen to go spend the "campaign" elsewhere in the sub-region. Recruited fishermen boarded these boats, which held fishing licences for their destination countries. After the "campaign", the fishermen are paid as a function of the catch. Currently this fishing practice no longer exists in this area according to some actors interviewed on the issue.

The distinctiveness of Saint-Louis fishermen in general and those of Guet Ndar in particular generally lies in the fact that this community is steeped in a long tradition of fishing. This is a community that is exclusively dedicated to fishing, unlike other fishing communities that practice other activities in parallel to fishing such as market gardening and/or animal farming.

In the view of certain individuals spoken to in the course of this study, overcrowded housing conditions are also believed to be a factor that pushes Guet Ndar residents to migrate.

Fish Docks

Saint-Louis has two fish docks built with the support of Coopération Française in 1999-2000. Today, these two infrastructures are not certified to the health standards of the European Union's Food and Veterinary Office (FVO). Likewise, products landed in Saint-Louis transit through certified docks so they can be exported to Europe.

Subsequently, these infrastructures became too small to accommodate the numerous refrigerated trucks that transport the landed fishery products.

Fish Processing Sites

Besides the Ndèye Aïssatou Sène Fish Processing Center in Hydrobase built by Spanish Cooperation in June 2012, the Senegalese government supported the municipal administration to construct a new and modern fish processing site in Goxxu Mbacc.

Photo 4: Processing Site in Hydrobase

Photos: TEC, March 2017.

In support of women engaged in processing, a multi-purpose women's and children's house was built in Guet Ndar to allow nursing women to keep their children in an acceptably safe and comfortable environment. At the same time, this institution serves to promote capacity-building for these women.

Ice-making Facilities, Fishery Product Conservation and Processing

In Saint-Louis, thanks to investment by the federal government in partnership with the French Development Agency (AFD) and especially thanks to private initiative, the artisanal fishing sector operates eight ice-making units that somehow manage to satisfy fishmongers' demand.

The five existing fish processing, packing and conservation units in Saint-Louis are managed by private economic operators. With these facilities, the said operators oversee the processing, packing, storage and export of fishery products to inland locations or outside the country. They are certified by the competent authority at MPEM's Department of Fish Processing Industries (DITP). Their products are generally intended for export via Dakar.

The following table presents the numbers of players for each link of the fishing value chain in Saint-Louis.

Table 8: Stakeholders, Infrastructures and Facilities in Saint-Louis.

Stakeholder, infrastructure or facility	Number
Number of registered pirogues / licences	3,411
Number of fishermen	22,000
Number of fishmongers	100 (150 during peak fishing "campaign")
Number of women processors	1,000
Number of fish docks	2
Number of processing sites	3
Number of ice plants	8
Number of refrigerated warehouses and packing units for fish products	5
Number of fueling stations for fishing pirogues	19 (including 1 not operational)

Source: Saint-Louis SRPS, 2015

Incomes of Fishermen

As explained in the report (section 3.5.1, update on the main actors of the maritime artisanal fishery in Saint-Louis), the average income of fishermen was a difficult information to obtain at the time of the study.

However, the AWA project (Ecosystem Approach to the Management of Fisheries and the Marine Environment in West African Waters is a tripartite program (France-Germany-West Africa) which includes a section on fishermen's income. Results have not yet been published, but we have been able to obtain some data from the monthly fishermen's income survey according to the type of fishing gear. However, these data must be handled with great reserve because of they are still non-official since they have not yet been published. These data are presented in Table 9 below. They relate to the average monthly income of the fishing unit chiefs in Saint-Louis during the period comprised between March 2015 and June 2017.

Table 9 : Average Monthly Income of Fishing Unit Chiefs in Saint-Louis.

Type of Fishing Gear	Average Monthly Income of Fishing Unit Chiefs (CFA francs)
Beach line	86,012
Purse seine	73,754
Driftnet	79,734
Passive net	62,657
Gillnet	109,376
Long line	67,991
Single line	88,126

Source : Database, CRODT surveys, AWA project (unpublished and subject to subsequent validation)

Fishing Sector Challenges in Saint-Louis

Fisheries stakeholders face certain challenges, notably depletion of the resource and their safety at sea.

It should be noted that fishery resource depletion is a global issue. For this reason, the sustainable management of fishery resources in Senegal is given high priority in the MPEM's Sector Policy Letter. This is also a reason for the establishment of local artisanal fishing councils (CLPAs) to better involve and empower various stakeholders for the sustainable and participatory management of fisheries.

In Saint-Louis, certain initiatives have already been implemented by the CLPA in collaboration with all stakeholders in the fisheries, while others are in the process of being fleshed out. One example is the creation of eight (8) artificial reefs composed of old fishing boats that have been submerged in the maritime fringe opposite Saint-Louis with the objective of restoring resting and spawning areas for demersal species (bottom-dwelling fish). There is also a Marine Protected Area (MPA) where approximately 603 vase-shaped artificial reefs have been submersed in the area in question between the river mouth and Gandiole.

Further, there is an initiative by fishing stakeholders in the CLPA, through the "Diamalaye" Commission, which has set up alternating groups for heading out to sea. This helps avoid landing surpluses on account of the 200 purse seine units. This measure also helps rationalize catches and control the market.

Faced with the recent uptick in the number of accidents at sea and off the coast of Saint-Louis, initiatives have been taken by the entire industry to confront the problem. Indeed, aware that the safety of fishermen and their means of production are of paramount importance in the harvest of fishery resources, the MPEM has set out to offer artisanal fishermen an awareness program promoting the wearing of life vests, the slogan of which is "one fisherman, one life vest". This campaign has allowed fishermen to obtain a life vest for 5,000 CFA francs, i.e. a quarter of the true market price. In the months to come, the Ministry intends to bring this cost down even further, i.e. to half the current amount.

In addition to these measures, and in partnership with the National Agency of Civil and Maritime Navigation (ANACIM), a mechanism for announcing offshore weather alerts has been put into place by the MPEM. Accordingly, fishermen receive daily weather messages through decentralized services of the State and fishing authorities.

In Saint-Louis, as part of the CLPA's activities and with support from the USAID/COMFISH Project, 24 flagpoles were erected on the Langue de Barbarie to inform fishermen of sea conditions. Additionally, mobile phones were distributed to different officials to enhance the delivery of weather messages.

In the event of a hazardous weather warning (special advisory), craft are forbidden from heading out to sea. For this reason, a multidisciplinary surveillance team composed of elements of the Fisheries Service, the Gendarmerie Fluviale (Translator's note: river-based law-enforcement unit), CIRMAR, and CLPA and MPA stakeholders, is responsible for overseeing compliance with this measure, which is backed by a prefectoral order.

In this regard, through the CLPA's Offshore Safety Commission and the "Diamalaye" Commission, fishermen comply with weather warnings in the event of inclement weather.

Ultimately, it should be pointed out that fishery stakeholders, fishermen in particular, are managers of genuine fishing businesses, even if it is on a family level. Like any business, they have employees to pay and incur operating expenditures that help amortize and maintain/renew their fishing material.

Wood, the base material for building artisanal boats, is not easily accessible as it once was. This is why MPEM initiated a program for the construction of new types of craft that are superior in suitability and durability. This program is piloted by MPEM's Society of Naval Repair Infrastructures (SIRN).

A suitable financing system is an issue for modernizing the artisanal fishing sector and making it more professional. In the past, several different forms of financing were tested, though not all were successful. In its time, the State had placed the funds earmarked for the promotion of fisheries in the National Fund for Agricultural Credit of Senegal (CNCAS), but, for various reasons, a significant portion of the sums allocated to fishing stakeholders has yet to be reimbursed.

3.5.2 Organizational Dynamic of Fishing Communities on Langue de Barbarie

Aware of the many issues currently faced by the fishing sector, stakeholders have joined forces in professional organizations to defend their material and moral interests. The organizations established allow the various parties to develop action systems in an effort to overcome concrete issues related to how the sector functions. From this perspective, a number of professional organizations exist in Saint-Louis, notably on the Langue de Barbarie, including those presented below.

Union of Artisanal Fishing Professionals

This organizational entity brings together all stakeholders involved in artisanal purse seine fishing on the Langue de Barbarie. The organization also offers these fishermen a forum to speak with a single voice when they need to defend their material and moral interests.

At the fishing community level, this organization has full authority for all matters related to the activity. The Union president enjoys total confidence and a solid reputation amongst stakeholders. As pointed out by one member of this organization: *"As members of the Union of Artisanal Fishing Professionals, we are highly organized and speak with one voice. We established this association to speak on our behalf and the directors that we have elected have our complete trust. This means that the only spokespersons for any stakeholder in our community are the directors of this association. We simply go along with whatever the latter decide.* According to the Union president, although the members of the association have admittedly placed their trust in him and granted him full authority, all decisions that concern the community are taken by consensus.

The president of this association is the first point of contact for the Ministry on issues that are of direct concern to the fishing communities. Moreover, he was the one who represented fishermen in negotiations between Senegal and Mauritania.

This association, via its directors, has reiterated its commitment of defending the interests of all fishing communities established on the Langue de Barbarie. Its members commonly raised the issue of future activities of oil companies that will probably impact the fishing sector and have expressed their wish to be a direct point of contact with Kosmos Energy.

In addition to this important fishing association, there exist approximately twenty other organizations in Saint-Louis, some of which are presented in the following table.

Fishermen's associations, like most corporate organizations, are usually created to defend the material and moral interests of their members. The birth of several associations has been noted lately. This is not always explained by the supposed frustration of some members but rather for actors part of a same corporation to make their voices heard.

In the opinion of some association leaders, the high number of associations is generally due to the diversity of fishing activities. Each group of actors in a sector is more aware of the difficulties and constraints related to their sector and are much better able to defend their interests.

All these associations are represented at the level of the Local Artisanal Fishing Council (CLPA) chaired by the Prefect of the Saint Louis Department and the general administration of this structure is provided by the department in charge of fisheries. The main function of this committee, which is created by ministerial decree, is "to organize the local fishermen so as to prevent, reduce and settle conflicts at the local level, to participate in the monitoring, control and surveillance of fisheries and related activities in relation to the relevant local and national structures, to organize the artisanal fisheries actors so that they can assist the administration in the monitoring and control of fishing activities, to ensure informing artisanal fishing stakeholders on all measures relating to marine fishing and marine culture in their locality, to give advice on the management of community infrastructures etc. ".

The CLPA is the official interlocutor of all actors (State, NGOs, Technical and Financial Partners, etc.) who intervene at the local level. From this point of view, it is supposed to work for the good organization and the proper conduct of the fishing activities.

Table 10: Fishing Associations on Langue de Barbarie.

Name of Association	Type of Association	District/Headquarters	Year of Creation
Local Council of Artisanal Fishing	Association of Colleges	Saint-Louis	
Association of seamen aboard *bateaux ramasseurs* of Saint-Louis	Association	Ndar Toute	2010
Association of ship representatives and fishermen aboard *bateaux ramasseurs*	Association	Goxxu Mbacc	2010
Regional Collective of Fishmongers of Saint-Louis	Association	Guet Ndar	2010
Cooperative Union of Women Processors	Sub-unit of EIG	Guet Ndar	2010
Regional Union of Fishmonger EIGs of Saint-Louis	Sub-unit of EIG	Ndar Toute	2010
Association of Fishermen and Fishmongers of Santhiaba	Association	Ndar Toute	2009
Association "*Watt Gaal Ak Yeugo*"	Association	Goxxu Mbacc	2009
Association "*Diapalante Dem Ci Kanam*"	Association	Goxxu Mbacc	2008
CNPS II	Local chapter of a national organization	Goxxu Mbacc	2006
MPA Management Committee	Sub-unit of associations	Guet Ndar	2006
Fishing inter-professional	Sub-unit of organizations	Guet Ndar	2003
Young Fishermen of Saint-Louis Movement	Association	Guet Ndar	2003
EIG "*Takku Liguèy*"	Local EIG	Guet Ndar	2001
Union of Fishermen and Fishmongers (Saint-Louis chapter)	Association	Guet Ndar	2,001
FENATRAMS	Local chapter of a national organization	Guet Ndar	2000
EIG "*Téfess Diamalaye*"	Local EIG	Guet Ndar	1999
Local union "*Ande Suxali Sa Gox*"	Sub-unit of EIG	Goxxu Mbacc	1999
Union of Professional Purse Seiners	Association	Guet Ndar	1991
FENAGIE-Pêche	Local chapter of a national organization	Guet Ndar	1991

Name of Association	Type of Association	District/Headquarters	Year of Creation
UNAGIEM	Local chapter of a national organization	Guet Ndar	1989
CNPS I	Local chapter of a national organization	Guet Ndar	1987
EIG "*Diambarou Sine*"	Local EIG	Hydrobase	1970
EIG of Women Processors of *Yabooy* (sardinella)	Local EIG	Goxxu Mbacc	
Local Union of EIG "*Jappo*"	Local EIG	Goxxu Mbacc	
Local Union II of EIG "*Deuguey Moudj*"	Sub-unit of organizations	Goxxu Mbacc	

It can be seen that the majority of these associations have been established in the past ten years, i.e. between 2000 and 2010. Up until the year 2000, it was found that only 8 fishing associations existed in Saint-Louis and they were often sub-chapters of national organizations.

Depending on the districts, it is apparent that Goxxu Mbacc has been the main bastion of emerging organizations in recent years. This district hosts 7 of the 13 professional organizations established between 2006 and 2010. This multitude of organizations in Goxxu Mbacc and Ndar Toute in recent years is attributable, according to professionals, to the fact that they felt a real need to belong to new organizations that would be closer to their realities in order to be able to effectively defend their interests.

Analysis of the circumstances behind the creation of these numerous businesses shows that other organizations will likely be created with the development of gas- and oil-related activities. The motives often given for creating associations are related to the difficult working conditions endured by fisheries stakeholders, as well as the protection of the marine environment, which is their main source of income. These fishermen, in light of the potential impacts of activities of the offshore oil industries, claim they are ready to join forces to defend their interests if their activity (fishing) is threatened.

3.5.3 Feminine Leadership within the Langue de Barbarie Fishing Community

Within the fishing communities, it is generally acknowledged that women are active and are not reluctant to take their destiny into their own hands by establishing professional organizations such as EIGs, which are frameworks for defending their material and moral interests. In Saint-Louis and throughout Senegal, the processing sector is almost exclusively dominated by women.

On the Langue de Barbarie, the first women's organization, "*Diambarou Sine*", was created in 1970. This EIG, which is still active, is testimony to the long tradition of these women in terms of leadership in their sphere of activity.

In addition to the EIG "*Diambarou Sine*", other groups typifying women's leadership exist in Saint-Louis and especially on the Langue de Barbarie. Such groups notably include EIGs for Women Processors of *Yabooy* (sardinella), "*Takku Liguèy*", and "*Téfess Diamalaye*"; Local Union "*Jappo*", Local Union of Women Processors, Local Union "*Ande Suxali sa Gox*", and Local Union II of the EIG "*Deuguey Moudj*".

This multitude of associations is testimony to the dynamism of women within the fishing communities. Unlike what takes place in other communities or localities in the country, they are not relegated to the sidelines and their opinions and recommendations are taken into account in decision-making.

4.0 Characterization of Other Fishing Communities in Core Study Area

The Grande Côte, which stretches from Dakar to Saint-Louis, includes localities that are home to fishing communities, the most important of which are the following: Cayar, Mboro Ndeundekat, Fass Boye, Lompoul-sur-Mer and Niayam Potou (see Figure 1: Map of Localities with Fishing Communities in Core Study Area). These localities as well as the fishing communities found therein are described in the following sections.

4.1 Fishing Community of Cayar

Cayar is located in Thiès Region; it is linked to National Highway n° 2 (RN2) by a departmental road that intersects at KM 50, and by Regional Road n°10, which originates in Rufisque and serves localities such as Sangalkam, Bambilor, Bayakh, and Tivaouane.

Cayar is a commune lying in the southern portion of the Grande Côte, 58 km northeast of Dakar and 40 km northwest of the city of Thiès, capital of the region of the same name. Its seaboard stretches more than 3 km. For more than 1 km, its inland areas develop over a dune sector and an interdunal area. Cayar occupies a surface area of 1604 ha and comprises approximately ten different districts. Its geographic coordinates are: Latitude North: 14°54'; Longitude West: 17°07'. The Commune is bound to the northeast by the Atlantic Ocean and to the south by the line connecting the village of Keur Kalidou Ba, the village of Diamaguène and the southern edge of the Nioulwy dunes.

Cayar was the largest village of the former rural community of Diender (which became Diender Commune under Senegal's Act III of Decentralization), which is part of the arrondissement of Keur Moussa in Thiès Department. It became a commune by Presidential Decree n° 2002/171 of February 21, 2002.

Cayar Commune has a population of 29,810 spread across 10 districts; Wolofs are the ethnic majority (Source: Cayar Commune, 2016).

With regard to basic social services, Cayar has 2 pre-schools, 8 primary schools, 1 middle school, 16 Arabic schools and 15 *daaras* (Quranic schools).

The commune has 1 functional health outpost and 1 dispensary.

These sectors suffer a certain number of constraints. For the education sector, major constraints include: overcrowded classes, high drop-out rates due mainly to fishing which often attracts youth, lack of schools, etc. The trend is the same in the health sector, with demand largely exceeding supply, which means that the existing health facilities are unable to accommodate the entire population.

At the socio-economic level, fishing and agriculture are the dominant activities. In general, residents of Cayar both fish and farm for a living. Practicing these two activities allows the sea to "rest" during the winter. The presence of a canyon makes this area extremely rich in fish. There are both pelagic species for the national market and demersal species (notably coastal demersal), which are generally exported. LIkewise, Cayar is highly frequented by fishermen from other fishing grounds such as those from Guet Ndar.

In the past five years, fishery production has fluctuated substantially, as can be seen in the following table.

Table 11: Landings and Commercial Value between 2012 and 2016 in Cayar.

Year	2012	2013	2014	2015	2016
Tonnage [kg]	29,866,100	29,015,000	33,477,800	29,474,700	34,643,340
Market value [CFA francs]	10,622,893,800	12,987,737,500	14,664,504,000	14,153,343,250	16,421,136,000

Source: Cayar Fisheries Services; 2016

The number of fishermen in Cayar varies depending on the fishing season. In the low season (July to October), when activities are at their lowest level, fishermen number approximately 3,000. In the "campaign" period (November to June) their number can reach up to 6,000 (Source: Cayar Departmental Fisheries Service; 2016

The pirogue fleet is essentially made up of registered pirogues that number 1,032, and pirogues with pending registration, the number of which was estimated at 279 at the time of the March 2017 mission.

The following table presents the workforce for the various fishing sectors.

Table 12: Fishing Stakeholders, Infrastructures and Facilities in Cayar.

Stakeholder, infrastructure or facility	Number
Number of registered pirogues	**1032**
Number of pirogues for which registrations are pending	**279**
Number of ice-making facilities	**04**
Fueling stations for pirogues	**10**
Landing zones or fish docks	**3**
Fish processing complex (drying areas, fermentation tanks and multi-purpose room)	**1**
Fishermen	6,000[4]
Domestic fishmongers	31
Small-scale fishmongers	228
"Industrial" fishmongers	70
Intermediaries (assistant fishmongers)	235
Women processors	
Mechanics	30
Carpenters	12
Cart operators	410
Porters	385
Offloaders	276

Source: Cayar Departmental Fisheries Service, 2016

[4]Number of fishermen during the "campaign". This number is 3,000 in the low season.

This fishing community exhibits a certain organizational dynamic that is reflected in the establishment of organizations that bring together stakeholders based on their activity sector. Some of the organizations identified are described below.

Cayar Fisheries Committee

The Cayar Fisheries Committee (CPC) is a pioneering organization in the field of fishery resource conservation and market regulation. It is composed of active and retired "troller" fishermen (approximately 900 individuals).

Mbaalmi 1 and Mbaalmi *2*

These are EIGs that comprise Cayar-based purse seine owners. The first one was created in 1996. They were created at a time when catches of coastal pelagic species were plentiful and fishing material was costly. Significant quantities of fish rotted on the beach, which serious consequences for the environment and fishermen's revenues. Hence their motivation was to regulate the market, improve fishermen's earnings and facilitate their members' access to fishing equipment.

Group of Industrial Fishmongers of Cayar

The Group of Industrial Fishmongers of Cayar (REMICA) is composed of fishmongers that distribute "noble" species slated for the export industries. These fishmongers occupy "Japanese" fish docks no. 1 and 2. They played an important role in upgrading these docks in the context of the national certification program for exporting fishery products to the European market.

Local FENAMS and Young Fishmongers

The former is a local division of the National Federation of Fishmongers of Senegal (FENAMS), whereas the latter is a unit of the National Collective of Fishmongers for Development of Senegal; these organizations consist of fishmongers that deal in pelagic species intended for the domestic market.

Women Fish Processors

These women belong to two EIGs: those of Mantoulaye Guène and Awa Guèye Kébé, which together comprise a total of 150 women. They are engaged in artisanal fish processing. The main activities are braising and fermentation. Salting and drying are performed as secondary activities. These women also offer young girls excluded from the formal school system the opportunity to learn a trade and enter the job market at a later time. They are members of the inter-professional EIG *Yallay Mbaneer ak Feex-Gui*; in this context, they joined forces in a small management committee responsible for managing and operating artisanal fish processing facilities financed by the Japanese International Cooperation Agency (JICA) in the context of the Cayar fisheries complex. They act as a "social glue" in the conflict-resolution process.

Inter-professional EIG "Yallay Mbaneer ak Feex-Gui"

This EIG includes all professional artisanal fishing organizations in Cayar. It includes a board of directors, a small management committee (CRG), and commissions responsible for specific questions. This structure has the task of managing and operating artisanal fishing infrastructures completed by the Government of Senegal, which entrusted their management to Cayar Commune, and which in turn entrusted management and operation to the inter-professional EIG. The inter-professional EIG played a leading role in activities related to national certification for exporting fishery products to the European market at the Cayar level, which is one of the pilot sites.

Local Artisanal Fishing Council (CLPA)

The principle of creating the CLPA is enshrined in Law 98-32 implementing the Maritime Fishing Code and its Regulatory Decree n° 98-498 in its provision with respect to maritime fisheries bodies. Cayar is one of the pilot sites selected for testing CLPAs in Senegal. These structures are established by Ministerial Order n° 9077 dated October 8, 2010, at the same time as others including those of Saint-Louis and Lompoul. The creation of the CLPA is the result of a long process of collaboration, training and information sharing. It is interesting in terms of its composition and its missions. The CLPA comprises representatives of artisanal fishing professionals, community leaders, the administration and the town council. These stakeholders are organized in panels as a function of their trade. Its bodies are the stakeholder panels and the coordination and advisory body (ICC), which comprises 36 delegates. The CLPA is a structure of joint management, basic planning, project management, fisheries programs, and even local development. Its participation in regulating fishery activities and resolving conflicts is essential. The CLPA is presided by the Prefect of Thiès Department and its secretariat is provided by the head of the Departmental Fisheries and Surveillance Service of Thiès in Cayar. Since its establishment, it has participated in implementing an artisanal fishing permit in Cayar and in creating the Cayar MPA.

4.2 Fishing Community of Fass Boye

Fass Boye is located in the northwestern part of Thiès Region. It borders Louga Region (Kébémer Department) to the north, Thiès Department to the south, National Highway 2 to the east and the Atlantic Ocean to the west.

From an administrative point of view, Fass Boye is part of the commune of Darou Khoudoss, sub-prefecture of Méouane, Tivaouane Department, Thiès Region.

As for the social organization of the village, traditional power is held by the village chief, whose position is inherited. The village chief serves as a bridge between residents and political or administrative authorities. He is called upon to intervene to resolve certain disputes. For certain issues concerning the village as a whole, women are invited to participate in information meetings; such is the case when a project is carried out in the village, when an official authority visits the locality, or when investigations are conducted.

Within the fishing community, presidents of industry stakeholder associations enjoy full power and are the preferred and entitled parties to speak in the name of the structures that they oversee.

With regard to basic infrastructures and social services, the village of Fass Boye has one French primary school, five Quranic schools, one dispensary, a borehole managed by the Association of Borehole Users (ASUFOR), a post office and a fishing center. The village has 8 districts, and practically all ethnic groups are represented in Fass Boye due to fishing, which is the primary job provider at the local level.

Tivaouane Department has two fishing centers: Mboro and Fass Boye. It has 4 fish landing sites: Bono-sur-Mer for the Mboro town center, Fass Boye, Diogo/Mer, and Litt/Mer. All three of these sites revolve around the Fass Boye town center.

The most frequented fishing grounds are the following: Gopp, Dikk and Tankk. They are all located in the area dedicated to artisanal fishing, i.e. approximately 12 km offshore.

With regard to fishing infrastructures, Fass Boye has a fish dock managed by the inter-professional EIG "Cheikh Ndiaga Seck" and a new, recently inaugurated processing site for fishery products.

Photo 5: New Processing Site and Landing Dock for Fishery Products in Fass Boye.

Photos: TEC, March 2017

The following table provides an indication of the importance of this activity in the Fass Boye area.

Table 13: Statistical Data on Landings at Fass Boye (2016).

Tonnage landed [kg]	Estimated Market Value (FCFA)	Local consumption [kg]	Wholesale fish trade (kg)	Reserved for artisanal processing (kg)	Reserved for industrial processing (kg)
21,592,339	8,322,735,500	1,923,800	9,600,402	3,514,050	6,554,087

Source: Fishery Control Post of Fass Boye, 2016

For the past three years, annual fishery production at Fass Boye has averaged in the order of 20,000 metric tonnes of fresh product.

The pirogue fleet is estimated at 513 pirogues[5], and the dominant fishing gear types are passive nets, bottom drift gillnets (BDGN), surface drift gillnets (SDGN) and purse seines.

Currently, the number of fishermen in Fass Boye is in the order of 3,500 and the number of women processors is estimated at 700, as shown in the following table.

Table 14: Fishing Stakeholders, Infrastructures and Facilities in Fass Boye.

Stakeholder, infrastructure or facility	Number
Fishermen	3,500
Women processors	700
Fishmongers	40
Small-scale fishmongers	70
Number of refrigerated trucks	57
Pirogue fleet (registered)	513
Registration pending	100
Fish docks	1
Modern fish processing site	1

Source: Fishery Control and Surveillance Center of Fass Boye

Like other fishing localities, Tivaouane Department has a CLPA (CLPA of Fass Boye) which comprises the villages of Fass Boye, Mboro-sur-Mer, Diogo-sur-Mer and Litt-sur-Mer. This is a consultation framework

[5]Source: Fisheries Service; most recent census conducted in the context of artisanal pirogue registration.

created by the State to promote local governance of fisheries as well as the participation and involvement of professionals in debating and managing important fishery-related issues.

The organizational dynamic of fishing stakeholders in Fass Boye is reflected in the establishment of the following associative structures: a union of women processors (comprising 15 EIGs); an Oversight and Safety Committee (CVS) of passive net fishermen; a CVS of purse seine fishermen; a fishmongers' union, etc.

Female leadership in Fass Boye is reflected in the number of EIGs for women processors. Women established these EIGs with the goal of defending their interests in decision-making bodies such as the CLPA.

4.3 Fishing Community of Mboro Ndeundekat

Mboro is the second fishing center of Tivaouane Department. An important fishing community lives in this village, which numbers close to 2,000 inhabitants, most of whom fish for a living. This community also has a long tradition of agriculture. The inhabitants of Mboro Ndeundekat combine these two activities. Market gardening is practiced in the low season when the fishery resource is less plentiful.

As for basic social services, the village has one primary school (7 grades), an early childhood center, two Arabic schools and a dispensary.

The main activity is fishing, which is practiced over 35 km of coastline and involves a fleet of 229 registered and more than 32 non-registered pirogues (source: Departmental Service of Fisheries of Mboro). Additionally, there are non-local pirogues that arrive in the village from other parts of Senegal, especially during the "campaign" period.

Passive nets, surface drift gillnets, purse seines, octopus pots, longlines and traps are the main types of fishing gear used in Mboro.

Fishing takes place year round, with the peak season extending from March to July. This period coincides with the fishing season for coastal pelagic species (sardinella, chinchard, etc.) as well as sole, octopus, and cuttlefish.

The usual fishing grounds are essentially: Tank, Bop, Xèrou Mboro, etc. These areas are named for their respective communities and their locations are well known by the latter.

The organizational dynamic in Mboro is reflected in the establishment of a structure that brings together the majority of players engaged in fishing and associated activities. Fishermen, fishmongers, small-scale fishmongers, and women processors have joined forces in a group called the Local Union, the primary objective of which is to coordinate their efforts to improve their living standards and working conditions.

Currently, 985 fishermen, 10 fishmongers, 47 small-scale fishmongers and 180 women processors are identified in Mboro.

The following table presents the workforce for the various fishing sectors as well as existing infrastructures and facilities.

Table 15: Fishing Stakeholders, Infrastructures and Facilities in Mboro.

Existing Stakeholders, Infrastructure or Facility	Number
Fishermen	985
Fishmongers	10
Small-scale fishmongers	47
Women processors	180
Pirogues registered	229
Pirogues not yet registered	32

Source: Mboro Fisheries Service, 2016

4.4 Fishing Community of Louga Department

4.4.1 Niayam (Potou)

The village of Potou lies in Louga Department and has 18 km of coastline. The village borders Saint-Louis Region to the northwest. Potou is home to a fishing locality in Niayam that is a sort of hub for approximately a dozen villages. Specifically, Niayam is a fishing area located in the village of Potou and is considered to be a site where fishing is practiced. All around this locality are about a dozen villages whose residents come to Niayam every day to fish. Indeed, notwithstanding the temporary camps built to accommodate the residents of Guet Ndar, this locality contains no dwellings.

Niayam has a newly constructed fish dock (inaugurated in March 2017 by the Senegalese President), plans to install an ice-making facility and cold storage rooms, as well as two fuel stations.

Certification of Potou's dock to European export standards adds a new dimension as well, which may also attract large numbers of fishmongers to encourage their fishermen to land their products on this dock.

Photo 6: New Fish Dock in Niayam Potou.

Photos: TEC, March 2017.

The fishing community includes migrants from other parts of Senegal and natives of the village that belong to the Fulani (Peul) ethnic group. These two communities live in perfect harmony. This co-existence has allowed residents who farmed in the past to switch to fishing-related trades. During the "campaign" period, fishermen from Guet Ndar arrive in Niayam with their families to take advantage of the local resource. The main problem with this cohabitation stems from the fact that in Potou, the dwellings used to house migrant workers are in a rather precarious state. However, this is in the process of being resolved, as the town council has initiated the process of granting them parcels for residential purposes.

Photo 7: Guet Ndarian Fishermen's Camps in Niayam

Photo: TEC, March 2017

The passive net is the main fishing gear used in the region. However, with the decline in catches of bottom-dwelling demersal species, fishing effort is increasingly shifting to pelagic species. This is reflected in the gradual introduction of surface drift gillnets (*félé-félé*), which primarily targets sardinella.

The fishing grounds of the region are generally located in the ten nautical mile zone, between the mouth of the Senegal River and the outskirts of Fass Boye, which is influenced by Cayar Canyon. Several fisheries are present in this area, including sole, catfish, *tallar*, *sompatt*, lesser African threadfin, spiny lobster, crab, etc. Also, fishermen in pursuit of pelagic species sometimes venture beyond these waters. In doing so, they can go up to 20 or 30 nautical miles offshore (Regional Fisheries Service of Louga, 2016).

The following table provides an overview of fishing activity and its stakeholders.

Table 16: Fishing Stakeholders, Infrastructures and Facilities in Potou.

Stakeholder, Infrastructure or Facility	Number or Denomination
Number of active pirogues	- 41 pirogues registered; - 32 pirogues not registered; - 60 pirogues arrive annually during "campaign".
Number of fishing permits delivered	52
Number of fishermen	230
Number of women processors	119
Number of fishmongers	25
Number of EIGs	06
Fish docks	1
Processing area	1 (not completed)

Stakeholder, Infrastructure or Facility	Number or Denomination
Ice plant	Under development
Cold storage rooms	Under development
Fuel stations	2
CLPA	Regional CLPA ("CLPA Terroir")
Associations	- Léona Fisheries Cooperative (COOPEL), - Inter-professional EIG

Source: Regional Fisheries Service of Louga

It should be noted that fishing represents the primary socio-economic activity of the region and provides the populations with the most substantial incomes. The importance of this activity for the region is reflected in the figures presented in the following table.

Table 17: Statistical Data on Landings in Niayam (Potou).

Landings [kg]	587,790
Estimated market value [CFA francs]	418,415,000
Local consumption [kg]	30,400
Reserved for artisanal processing [kg]	163,590
Dry weight obtained [kg]	42,420
Estimated market value [CFA francs]	28,325,000
Wholesale fish trade [kg]	387,390

Source: Regional Fisheries Service of Louga, 2016

4.4.2 Lompoul-sur-Mer

Lompoul is an originally Fulani village that was founded in 1804. Fishing began here just three decades ago, with fishermen from Guet Ndar. The Fulani only began practicing fishing in 1981 with support from the Small Rural Operations Project, which financed the acquisition of fishing craft.

Lompoul-sur-Mer has 38 km of coastline and borders Thiès Region to the southwest.

As far as basic social services, Lompoul-sur-Mer has a primary school, a middle school (CEM), a health outpost under construction, a weekly market that greatly contributes to the local economy, and a large mosque. The transport system is essentially road-based and means of transport include vehicles, motorcycles, carriages, etc. All telephone carriers are represented in Lompoul. Water supply is still provided by rural water engineering and electricity by the Senelec-owned grid. More than half the population owns electronic devices such as televisions and radios.

In terms of fishing infrastructure, the village of Lompoul-sur-Mer has a fish dock, a fish processing area, an ice-making facility, and 3 fuel stations for pirogues.


Photo 8: Fish Dock (left) and Processing Area (right) in Lompoul Photos: TEC, March 2017.

Fishing is the primary activity, while in the low season residents practice agriculture. Animal farming is practiced year round in the locality, which is home to a sizable Fulani community. The following table briefly describes the stakeholders in each sector.

Table 18: Fishing Data at Lompoul-sur-Mer.

Stakeholder, Infrastructure or Facility	Number or Denomination
Number of active pirogues	- 149 pirogues registered - 45 pirogues not registered - 100 pirogues arrive annually for the "campaign"
Number of fishing permits delivered	115
Number of fishermen	420
Number of women processors	300
Number of fishmongers	40
Number of EIGs	27
CLPA	Regional CLPA ("CLPA Terroir")
Fish docks	1
Processing area	1
Ice plants	01
Fuel stations for pirogues	03

Source: Regional Fisheries and Surveillance Service, 2016

With regard to social organization, power is mainly concentrated in the village chief and the heads of the CLPA. The village chief is the primary local authority in the village; this office is hereditary.

In the fishermen's community, authority is held by the inter-professional EIG of fishermen via its president. For women who work in processing, the EIG president has authority. At the EIG level, the decision-making process requires the presence of all members. Women are invited to information or awareness meetings by their leaders; decisions in the community are made in a concerted manner while taking the women's opinions into account.

The Lompoul fishing community is composed of the residents of Lompoul village who are ethnic Fulani, as well as migrant workers who are primarily residents of Guet Ndar who live here during the fishing "campaign", which lasts 6 to 7 months. Thus, these two groups live in harmony, which has allowed the village natives – who were once farmers or herdsmen – to switch to fishing trades while allowing the migrant workers to be perfectly integrated into the local population.

The passive net is the main fishing gear used in the locality. However, with the decline in catches of bottom-dwelling demersal species, fishing effort is observed to be increasingly shifting toward pelagics. This translates into the gradual introduction of surface drift gillnets (*félé-félé*), which target mainly sardinella.

The fishing grounds frequented by fishermen of Louga Region, including those from Lompoul and their counterparts in Niayam, generally lie in an area spanning ten nautical miles between the mouth of the Senegal River and the vicinity of Fass Boye, which is influenced by Cayar Canyon. Several fisheries are present in this area, including sole, catfish, cutlassfish, sompatt, lesser African threadfin, spiny lobster, crab, etc. Also, fishermen in pursuit of pelagic species sometimes venture beyond these waters. In doing so, they can go up to 20 or 30 nautical miles offshore.

Table 19: Statistical Data on Landings at Lompoul-sur-Mer.

Landings [kg]	1,929,500
Estimated market value of landed products [CFA francs]	759,121,000
Local consumption [kg]	273,750
Reserved for artisanal processing [kg]	403,000
Dry weight obtained [kg]	134,312
Estimated market value of processed products [CFA francs]	77,544,000
Quantity intended for trade [kg]	1,258,650

Source: Regional Fisheries Service of Louga, 2016

5.0 Characterization of Communities of Island of Bopp Thior

This island is located in the extended study area; however, considering its proximity to Saint-Louis, it is taken into account in this study.

Blessed with a panoramic position, the island village of Bopp Thior, with its well maintained fine sandy beaches and its mangrove offering refuge to numerous water birds, represents a highly attractive site, but undervalued in terms of tourism. The sole income-generating activity for residents is fishing in the Senegal River, which is becoming less and less appealing by the day.

Photo 9: Mangrove on Island of Bopp Thior

Photos: TEC, March 2017

Bopp Thior is located on the border between Senegal and Mauritania. Less than 2 km from the island of Saint-Louis, it is home to approximately 800 residents.

Administratively speaking, it is part of Gandon Commune (arrondissement of Rao), which is located approximately 20 km away.

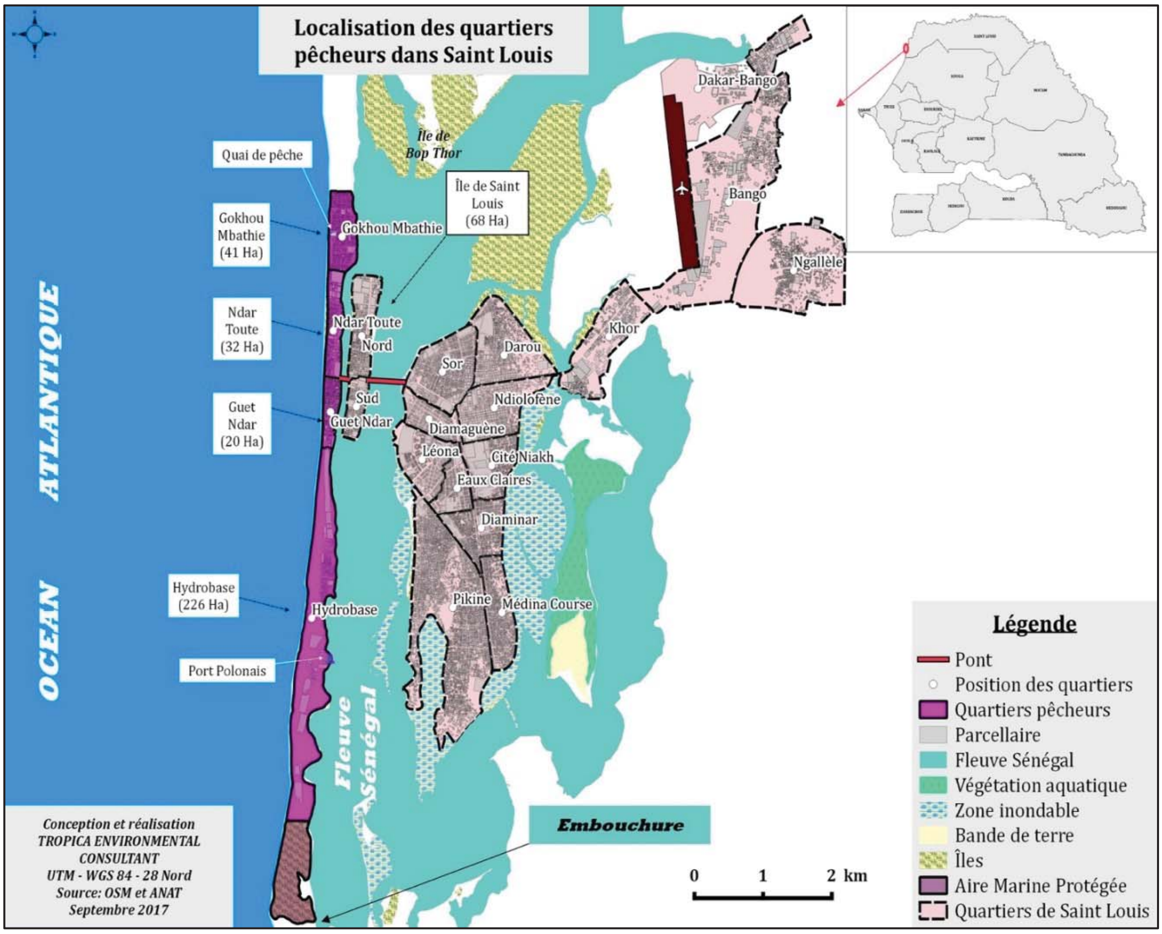


Figure 4: Location Map of Bopp Thior Island.

This island is the site of Saint-Louis' first cemetery, and dignitaries were buried here. The village was once popular amongst Saint-Louis' mulatto community who maintained residences here, as it was a good place to live. At the time, a brickyard was established on this island and provided bricks that were used in the construction of buildings in Saint-Louis in the 18th century. The remains of this brickyard are part of the historic monuments identified by the Senegalese Ministry of Culture.

In terms of the dynamics of the island's demographics, residents (notably the younger generation) have a tendency to leave the village and move to the city of Saint-Louis. Some of them migrate to Mauritania.

With regard to basic social services, there is only one primary school that maintains an incomplete cycle due to the population exodus, as well as a Quranic school. School enrolment for children is low (45%, Source: school director).

The village has a dispensary built by an NGO (Rotary Club). This health care structure is not operational due to a lack of equipment and material. In most cases, even primary care cannot be provided on the premises. Residents must go to health care facilities in Saint-Louis.

The island is sub-divided into three main hamlets: Keur Gou Makk (home of the Ndiaye family, which is the lineage of the village chief), Keur Marième (fief of the Diop family), and Keur Bineta (home of the Ba family).

The social organization of the village is traditional, with a village chief who enjoys complete authority. He also manages disputes and benefits from a casting vote at village meetings. The village chief is considered to be the main spokesperson for stakeholders at the village level (NGOs, development projects, etc.)

The residents' main economic activities are fishing and agriculture. Prior to construction of the Diama dam over the Senegal River, Bopp Thior played a dynamic role in fruit growing, with a sizable production of dates, coconuts, etc. Rising salt water intrusions from the sea has made the lands unsuitable for this type of agriculture. Currently, agriculture is entirely dependent on the rainy season, which, according to residents, only allows for the growing of small quantities of peanuts, beans and watermelon. Each family owns a small land plot which is generally tended by women.

Fishing activity is declining due to the mangrove, which in the past was a reproduction ground for fishery resources (fish, shrimp, crab, spiny lobster,etc) and which is now decimated due to its exploitation for firewood.

With the support of the NGO "Le Partenariat", a fish processing site has been developed on the island of Bopp Thior. The goal of this project was to help women re-enter the workforce. However, in light of the dwindling resource, this site is hardly used and is not maintained.

The island is not connected to the SDE water system or the Senelec electrical grid. According to residents, several requests have been submitted to the National Agency of Rural Electrification (ANER), but have gone unanswered.

Drinking water supply is a major issue. Residents get their water from Saint-Louis. Untreated water from the river is only potable during the winter. During this period, populations also use rainwater that they collect in 20-liter barrels. The rest of the year, residents must go to Saint-Louis to collect water from pay fountains. This shortage of drinking water hampers the development of all activities on the island.

BIBLIOGRAPHY

1. Bonnardel, R., 1985. Vitalité de la petite pêche tropicale, pêcheurs de Saint-Louis du Sénégal, Paris, CNRS Editions, *Mémoires et documents de géographie* collection, 105 p.
2. Camara, M.M. 2008. Quelle gestion des pêches artisanales en Afrique de l'Ouest ? Etude de la complexité de l'espace halieutique en zone littorale sénégalaise. PhD thesis in Geography, UCAD, 339 pages.
3. COGEPAS: "Projet de renforcement des capacités d'organisation et de formation des leaders des professionnels dans le domaine de la pêche artisanale": étude socio-économique auprès des pêcheurs des sites pilotes (Lompoul, Kayar, Joal, Djiffère) au cours de la première année du projet, 2009, 81 pages.
4. Commune de Saint-Louis, 2010. Etude de faisabilité et étude d'impact environnemental et social du projet de développement touristique de la Région de Saint-Louis. Sectoral feasibility – fisheries. 41 pages.
5. Commune de Gandon: Plan de Développement Communal 2015-2020, 84 pages.
6. Local Artisanal Fishing Council of Cayar (CLPA/Cayar): Convention Locale pour la Gestion des Pêcheries de Cayar, developed with the support of the USAID/COMFISH Project, July 2013, 34 pages.
7. Guet Ndar District Council: Recensement des données pour le quartier de Guet Ndar, Année 2014.
8. Diagne M., (no year). Expert Opinion in Diiso Newsletter.
9. Gueye, A., 2016. Éléments d'alerte face à la découverte de Pétrole et de Gaz au Sénégal, 4 pages.
10. Innovation, Environment and Development (IED) and Pathways to Resilience in Semi-Arid Economies (PRISE): Senegal: Revue du contexte socioéconomique, politique et environnemental, 2015, 88 pages.
11. Laloe, F., A. Samba, 1990. La pêche artisanale au Sénégal : Ressource et stratégie de pêche, *Étude et Thèse* collection, ORSTOM Editions, 324 pages.
12. Le Roux, S. 2005. Pêche et territoires au Sénégal, PhD thesis in Geography, University of Nantes, 318 pages.
13. Mbissine, N.: Dégradation et évolution de l'écosystème côtier de la Langue de Barbarie, Master's thesis, Geography Department / Gaston Berger University of Saint Louis, 116 pages.
14. Ndiaye, Mariètou: Dynamique, vulnérabilité socioéconomique et gouvernance des littoraux de Saly Portudal (Mbour) et de la Langue de Barbarie (Saint-Louis), PhD thesis, Geography Department / Gaston Berger University of Saint Louis, 340 pages.
15. Niang, Ndeye Astou: Dynamique socio environnementale et développement local des régions côtières du Sénégal : l'exemple de la pêche artisanale, University of Rouen, Research and Training Unit, Arts and Humanities / Department of Geography, November 2009, 302 pages.
16. NGO "Le Partenariat": Diagnostic des besoins Education et Santé sur la Langue de Barbarie, performed in 2016.
17. Plan de Développement de quartier Ndar Toute (Saint-Louis), PRADEQ, May 2004, 53 pages.

18. Plan de Développement de Quartier Guet Ndar (Saint-Louis), PRADEQ, August 2005, 73 pages.
19. Plan de Développement de Quartier Goxxu Mbacc (Saint-Louis), PRADEQ, December 2003, 61 pages.
20. Plan Local de Développement Ndiébène Gandiole, Study conducted with the technical support of GERAD and the financial support of PACR-Vallée, August 2010, 104 pages.
21. Protocol for the application of the Convention on Fisheries and Aquaculture, signed in Nouakchott on February 25, 2001 between the Government of the Islamic Republic of Mauritania and the Government of the Republic of Senegal, December 2014, 19 articles.
22. Profil environnemental de la ville Saint-Louis, April 2005, Communal Development Agency, 219 pages.
23. Mbaye, A.: Impacts socio-économiques de l'unité améliorée de transformation de produits halieutiques "Adja Ndoumbé SECK *Député*" sur les conditions de vie des femmes transformatrices de Cayar, study conducted with the technical support of USAID, November 2015, 59 pages.
24. Service Départemental des Pêches de Saint Louis, Note préparatoire du Diner-Débats organisé par la Chambre de Commerce, d'Industrie et d'Agriculture de la région de Saint Louis, January 29, 2016.
25. Sonko, M., 2007. Accord de pêche UE/Sénégal, Neptunus, Vol. 13, n°1. 10 pages.
26. Sy, Alioune Badara: Etude sur la contribution socioéconomique de la pêche dans l'économie des collectivités locales côtières : l'étude du cas de la Commune de Cayar, September 2014, 35 pages.
27. WWF West Africa Marine Ecoregion (WAMER) Program Office: Diagnostic organisationnel participatif des organisations de gestion et de conservation des ressources naturelles de Saint Louis, study conducted by Adama Mbaye, research sociology at ISRA, April 2011, 50 pages.
28. WWF West Africa Marine Ecoregion (WAMER) Program Office: Etat de référence socioéconomique de Cayar, study conducted by Adama Mbaye, Sociologist/ISRA, December 2010, 71 pages.

APPENDIX: DATASHEETS OF HUMAN SETTLEMENTS

LOCALITY	Saint-Louis
DISTRICT	Guet Ndar
Location (administrative; geographic)	Guet Ndar is located at the southern end of the Langue de Barbarie (strip of land 24 km long and 250 m wide). It extends 1 km, between the Atlantic Ocean and the small branch of the Senegal River, from the Moustapha Malick Gaye Bridge and De la République Square (Pointe à Pitre Square) in the north to the cemetery in the south.
History	Bonnardel (1985) explains that settlement of the Langue de Barbarie by fishermen dates back to the 16th century. In the mid-17th century, shortly before the French established a trading post on the Island of Saint-Louis (1659), the Langue de Barbarie was practically deserted and was used by Moorish herdsmen for grazing their livestock. Beginning at this time, toward the southern end of today's Guet Ndar district, fishermen from Walo would set up camp every year from February to May. The latter's earliest encampments on the Langue de Barbarie are believed to date from the mid-16th century and thus pre-date the founding of the Saint-Louis trading post. These fishermen were in reality peasants in their villages of the lower Senegal valley and exchanged fish caught in the river for salt and dates brought by the Moors. In order to increase their means of exchange, fishermen from Walo migrated in search of more fertile fishing grounds and this is how they developed a habit of moving seasonally down river to near its mouth during the agricultural off-season. According to Guet Ndar tradition, the people of Walo are believed to be subjects of the monarch of Trarza, who extorted the black populations of the left bank. To escape these heavy tolls, the farmer-fishers of Walo decided to abandon their native region to come and settle on the Langue de Barbarie. A large part of the community then settled in Guet Ndar, several families made their homes in Ndiago and a few others continued as far as Gandiole. As fishermen they had only ever operated in the rivers, and it was only well after their arrival in Guet Ndar in the 19th century that they ventured offshore (*Ibid.*).
Structure (villages, sub-districts)	With a surface area of 20 ha, the district is locally divided into three sub-districts: Dack, Ponde Khollé – located on the hill (present-day Baateri mosque) that was used to keep watch over the colonists – and Lodo (which means north). Guet Ndar Dack alone occupies 10.3% of the urban communal area, making it one of the most extensive districts.

LOCALITY	Saint-Louis
DISTRICT	Guet Ndar
Infrastructures (public, social) and services	**Transportation**: the transportation is road based and consists of unofficial taxis ("clandos"), official taxis (black and yellow), minibuses, carriages, and, recently, "Tata" buses. **Health care**: one health outpost at Guet Ndar that has largely exceeded its capacity. **Education**: 2 French schools that cannot keep up with demand. **Sanitation and sewerage**: the wastewater system is not functional. **Drinking water**: the district is served by the SDE network. **Electricity**: the district is served by the Senelec grid. **Telephony**: the district is covered by fixed-line and mobile phone networks.
Demography (settlement, population, ethnic groups)	According to data from the 2014 census conducted by the District Council, the district of Guet Ndar numbers 26,000 inhabitants, including 12,246 men and 13,754 women. The district consists entirely of Muslims and has 11 mosques and 17 Quranic schools. Guet Ndar has two primary schools, a health outpost and two pharmacies.
Socio-economic activities	The primary activity of this community is fishing.
Socio-cultural activities	Organization of regattas (pirogue races).
Historic/cultural sites	The oldest cemetery in the Commune is found in Guet Ndar.
Social organization	Several organizations comprising players from within the same sector, EIGs of women processors and directors of these various organizations enjoy nearly absolute decision-making power.
Noteworthy events in the locality	Organization of annual religious chants, organization of regattas, etc.

LOCALITY	Saint-Louis
DISTRICT	Ndar Toute
Location (administrative; geographic)	Ndar Toute is one of the districts of the Langue de Barbarie. It lies between the district of Goxxu Mbacc in the north, the district of Guet Ndar in the south, the ocean in the west and the small branch of the Senegal River in the east. It lies on a spit approximately 1.5 km long and occupies a land area of 21 ha.
History	One of the oldest districts of Saint-Louis, Ndar Toute was declared "village of freedom" in 1849, as it was designed to accommodate freed slaves. However, the district was created by decree issued by Governor Faidherbe on December 8, 1856 in an effort to relieve overcrowding on the island. The origin of the name of the district is from the Wolof "*Ndar Gou Ndaw*", which means "little Saint-Louis". It is also called Santhiaba, which can be translated as "new city". The history of the district has been punctuated by numerous events that are now etched in the collective memory of the populations.
Structure	The district is divided into two sub-districts: Haut (Upper) Ndar Toute and Bas (Lower) Ndar Toute.
Infrastructures (public, social) and services	**Transportation**: the transportation is road based and consists of unofficial taxis ("clandos"), official taxis (black and yellow), minibuses, carriages, and, recently, "Tata" buses. **Health care**: one health outpost at Ndar Toute that has largely exceeded its capacity. **Education**: 6 primary schools, 2 middle schools, 3 pre-schools. **Sanitation and sewerage**: the wastewater system is not functional and the rainwater drainage system is deficient. The district faces a household waste management problem. **Drinking water**: the district is served by the SDE network. **Electricity**: the district is served by the Senelec grid. **Telephony**: the district is covered by fixed-line and mobile phone networks. **Other infrastructure**: 1 market
Demography (settlement, population, ethnic groups)	Settlement occurred in successive waves and generally concerned indigenous populations from the Senegal River Valley composed of Wolofs, Toucouleurs and Moors. With a population of 11,644, Ndar Toute is one of the least populated districts in the city of Saint-Louis. This district is divided into two sub-districts: Haut (Upper) Ndar Toute and Bas (Lower) Ndar Toute, which is much more heavily populated.

LOCALITY	**Saint-Louis**
DISTRICT	**Ndar Toute**
	Consistent with trends observed at the communal and even national levels, this district is mostly composed of young people. As is the case throughout Senegal, the young character of its population is attributable to a relatively high birth rate.
Socio-economic activities	The primary activity of this community is fishing.
Historic sites	Saint-Joseph-de-Cluny Institute, Camp Cazeilles which was the stronghold of the Senegalese Tirailleurs (sharpshooters), former governance of Mauritania
Socio-cultural activities	Organization of regattas (pirogue races), Fanal (Translator's note: end-of-year holiday), annual *Gamou* (religious chants), etc.
Social organization	Several organizations comprising players from within the same sector, EIGs of women processors and directors of these various organizations enjoy nearly absolute decision-making power.
Noteworthy events in the locality	Organization of annual religious chants, organization of regattas, etc.

LOCALITY	Saint-Louis
DISTRICT	Goxxu Mbacc
Location (administrative; geographic)	This district is one of the localities on the Langue de Barbarie. It lies between the district of Sal Sal in the north, Ndar Toute in the south, the Atlantic Ocean in the west and the small branch of the Senegal River in the east.
History	The Goxxu Mbacc district came into being following a congestion relief policy for Guet Ndar undertaken by the local authorities in Saint-Louis. This district lies north of Guet Ndar, near the Mauritanian border and marks the starting point of the Langue de Barbarie. In terms of geophysics, the Goxxu Mbacc district is one of the most sensitive to erosion, which it has been suffering from with increasing intensity. Most recently, houses have been engulfed in water and a portion of the fish dock is at serious risk of disappearing. At this level the water table is exposed.
Infrastructures (public, social) and services	**Transportation**: the transportation is road based and consists of unofficial taxis ("clandos"), official taxis (black and yellow), minibuses, carriages, and, recently, "Tata" buses. **Health care**: one health outpost at Goxxu Mbacc that has largely exceeded its capacity. **Education**: 1 French school and one French-Arabic school. **Sanitation and sewerage**: the wastewater system is not functional and the rainwater drainage system is deficient. The district faces a household waste management problem. **Drinking water**: the district is served by the SDE network. **Electricity**: the district is served by the Senelec grid. **Telephony**: the district is covered by fixed-line and mobile phone networks.
Demography (settlement, population, ethnic groups)	With an estimated population of 23,288, Goxxu Mbacc falls under the "heavily populated" category of districts in Saint-Louis Commune. In this category, Goxxu Mbacc ranks behind Pikine and Guet Ndar. Like other districts of the city of Saint-Louis, data on the population structure show that the district is made up mostly of young people.
Socio-economic activities	The primary activity of this community is fishing.

LOCALITY	**Saint-Louis**
DISTRICT	**Goxxu Mbacc**
Socio-cultural activities	Organization of regattas (pirogue races), organization of a ritual "*Maure Havleu*" to express their cultural identity, annual *Gamou*, etc.
Social organization	Several organizations comprising players from within the same sector, EIGs of women processors and directors of these various organizations enjoy nearly absolute decision-making power.
Noteworthy events in the locality	Organization of annual religious chants, organization of regattas, etc.

LOCALITY	Saint-Louis
DISTRICT	Hydrobase
Location (administrative; geographic)	Hydrobase represents the last official district of the Langue de Barbarie and is located between Guet Ndar and the mouth of the Senegal River. It borders the Muslim cemetery of Guet Ndar to the north, the mouth of the Senegal River to the south, the small branch of the Senegal River to the east and the Atlantic Ocean to the west.
History	The most recent district on the Langue de Barbarie, Hydrobase was created in 2002 to ease the crowding suffered by the residents of Guet Ndar. It is a district that was established following demographic growth and in an effort to relieve the Langue de Barbarie of overcrowding. This is how most Guet Ndar residents came to live in Hydrobase, and why Hydrobase and Guet Ndar exhibit practically the same cultural characteristics.
Infrastructures (public, social) and services	**Transportation**: the transportation is road based and consists of unofficial taxis ("clandos"), official taxis (black and yellow), minibuses, carriages, and, recently, "Tata" buses. **Health care**: one dispensary at Guet Ndar that has largely exceeded its capacity. **Education**: 1 primary school. **Sanitation and sewerage**: the wastewater system is not functional and the rainwater drainage system is deficient. The district faces a household waste management problem. **Drinking water**: the district is served by the SDE network. **Electricity**: the district is served by the Senelec grid. **Telephony**: the district is covered by fixed-line and mobile phone networks. **Other infrastructure**: 1 market.
Demography (settlement, population, ethnic groups)	With a population of approximately 15,000, Hydrobase is beginning to experience rather rapid population growth due to its somewhat particular context with respect to the other districts on the Langue de Barbarie. Most hotel accommodations in Saint-Louis Commune are concentrated in Hydrobase. This is one factor that draws Saint-Louis residents to this district, which contributes to the growth of its population.

LOCALITY	**Saint-Louis**
DISTRICT	**Hydrobase**
Socio-economic activities	The primary activity of this community is fishing.
Historic sites	Thiaka Ndiaye Cemetery, Mermoz Hotel, Port of Saint Louis, etc.
Socio-cultural activities	Organization of regattas (pirogue races), Fanal, religious chants, etc.
Social organization	Several organizations comprising players from within the same sector, EIGs of women processors and directors of these various organizations enjoy nearly absolute decision-making power.
Noteworthy events in the locality	Organization of annual religious chants, regattas, etc.

LOCALITY	Saint-Louis
DISTRICT	Khor
Location (administrative; geographic)	Historic district on the outskirts of Saint-Louis, in a swampy area between Ndiolofène and Dakar Bango on the banks of a branch of the Senegal River.
History	The Khor district emerged rather late in the Saint-Louis landscape, created by the Protestant mission circa 1830 that hosted Malian refugees fleeing slavery. The founding father of this district is Ngolo Koné. Platoon under the colonial administration, he settled on this swampy site in the far north of Sor suburb to allegedly avoid becoming a "*sofa*" (soldier) in Almamy Samory Touré's army. His "promised land" was then Khor, or Ngolo *bougou* (Ngolo's village). Upon his death, this "land of freedom", inhabited essentially by Mandé peoples (descendants of the Manding), quickly and harmoniously integrated into greater Saint-Louis.
Structure (villages, sub-districts)	Khor is presently divided into two sub-districts: Khor-Usine, created in 1900 and having three sectors (Ngolobougou, Khor-Cabane, and Khar Yalla); Khor-Église is the original district center and until recently it was a land title belonging to the Saint-Louis Protestant mission. The title was held by the Ouatara family. Khor-Mission is sub-divided into three land titles (Khor-Vauvert, Khor-Séras and Khor-Prolongement.
Infrastructures (public, social) and services	**Transportation:** Transportation is not an issue, with buses and taxis to take people to Saint-Louis, Ngalèle or the university. **Health care:** 1 health outpost in Khor-Mission covering Khor-Usine. **Education**: 2 primary schools, 2 early childhood centers. **Sanitation**: the district does not have a sewerage network but household waste is collected by the EIG CETOM. **Drinking water**: the district is served by the SDE network. **Electricity**: the district is served by the Senelec grid. **Telephony**: the district is covered by fixed-line and mobile phone networks. **Other:** the district has a slaughterhouse in Khor-Seras. There is also the gendarmerie's territorial brigade.

LOCALITY	**Saint-Louis**
DISTRICT	**Khor**
Demography (settlement, population, ethnic groups)	Settlement of the locality is tied to flooding in Saint-Louis, but also to the presence of the SDE plant, which was created well before Khor-Usine was developed. Residents of the island of Diouck arrived to reinforce Khor-Usine with the creation of the sectors of Khar Yalla and Khor-Cabane. The population of Khor-Mission and Khor-Usine was 4,899 in 2013. The main ethnic groups are Bambara, Fulani (Peul), Soninke (Sarakole), Wolof; all other ethnic groups of Senegal are also present.
Socio-economic activities	Economic activity essentially revolves around market gardening and trade. A small minority is engaged in cast-net fishing in the branch of the river that girdles the district on both sides.
Socio-cultural activities	- The cultural history of Khor is marked by the "*koma*", which is a sort of *Kankurang* (which does not look like a *Kankurang* per se) that periodically emerged to exorcize evil spirits and punish cannibalistic sorcerers. Its appearance was well organized and carefully prepared by the sages and the custodians of the cult of Khor. An entire rite and myth surrounded this formidable and dreaded "*koma*". It came from Khor-Église, and its appearance was accompanied by great fanfare. - *Gamou* religious chants are organized annually in Khor-Usine.
Historic/cultural sites	Mixed cemetery in Khor-Vauvert
Social organization	The residents of Khor show great solidarity for one another and live in perfect harmony. There is a district council, which manages claims and disputes in an objective manner.
Noteworthy events in the locality	The only noteworthy event in the locality is the flood of 1950, which inundated ¾ of the district. The disaffected residents were forced to flee by the fury of the waters. It is said that in the course of this drama, a wealthy Moroccan shopkeeper by the name of Lakhou Ahmoudi, who lived in Rosso at the time, lost all of his possessions. To commemorate this unfortunate event, residents of Khor called this flood "Lakhou's flood".

LOCALITY	**Saint-Louis**
DISTRICT	**Dakar Bango**
Location (administrative; geographic)	District on the outskirts of Saint-Louis, on the banks of the river and adjacent to the Bango reserve used by SDE to supply water to the city of Saint-Louis.
History	Locality founded in 1864 by Fouti Guèye, great-grandfather of the current chief of one of the two districts. He arrived from Saloum in pursuit of Moors who had kidnapped his two children, and chose to settle in the area after getting his children back. The name Dakar Bango comes from the settler's distortion of the words *Dakhar Mongo* ("tamarind tree where he dried out his nets"). In 1970, the village was merged with and made a district of Saint-Louis.
Structure (villages, sub-districts)	In 2012, pursuant to a proposal by the City Council of Saint-Louis, the district is divided into two sub-districts: Bango Nord (North) (old district) and Bango Sud (South) (new district). The locality is not parcelled.
Infrastructures (public, social) and services	**Transportation**: the Saint-Louis airport lies within the zone. Buses and taxis shuttle passengers between the locality and Saint-Louis or Ngallèle. Student transportation is a serious problem for the parents of school children due to the high cost that they cannot afford. This problem has resulted in school dropouts. **Health Care**: a health outpost in Bango Nord and a dispensary in Bango Sud. **Education**: 1 pre-school and 1 early childhood center, 2 primary schools, 1 middle school and 9 *daaras*. **Sanitation**: the district does not have a sewerage system; household waste is not collected by the municipality of Saint-Louis, which administers the district; refuse collected by carts is disposed of in inappropriate places. **Drinking water**: the district is served by the SDE network. **Electricity**: the district is served by the Senelec grid. **Telephony**: the district is covered by fixed-line and mobile phone networks.

LOCALITY	Saint-Louis
DISTRICT	**Dakar Bango**
	Other: the oldest and most important military camp (instruction/training) in the country is located in the area and is named after the locality.
Demography (settlement, population, ethnic groups)	Settlement of Dakar Bango is linked to floods that have occurred in Saint-Louis and drought in other localities. As a result of these disasters, people migrated and settled in Bango, which offers favorable conditions. The size of the population is unknown to local authorities, though one resident quoted a figure of 6,000 people. The main ethnic groups are Fulani, Wolofs and Moors, though all other ethnic groups of Senegal are also present.
Socio-economic activities	In order of importance, livestock raising (cows, sheep), agriculture (orchards, market gardening, rice farming) and fishing (river, maritime) are the dominant activities.
Socio-cultural and community profile	The district chief and community leaders play a very important role in the functioning of the district and most conflicts are managed internally under their authority.

LOCALITY	Ndiébène Gandiole
Location (administrative; geographic)	Ndiébène Gandiole Commune is located in northern Senegal in Rao Arrondissement, Saint-Louis Department, and the region of the same name. It lies 18 km south of Saint-Louis Commune, and is sandwiched between the Senegal River to the west, Gandon Rural Community (CR) to the east, Saint-Louis Commune to the north and Léona CR (Louga Region) to the south. It lies in the ecological zone commonly known as *Le Gandiolais*. The latter, located in the maritime fringe, represents the dominant feature of the physical landscape of the Commune. Its eastern portion is located in the *diéri* (Translator's note: areas of a river valley not subject to flooding). It was created under Decree N° 2008-747 of July 10, 2008 implementing administrative, territorial and local reform. It is made up of 30 official villages and nine (9) hamlets.
History	According to information contained in the local development plan (PLD), the village of Ndiol, which is older than Gandiole, was founded by Wolof migrants from Walo. Later, lands continued to be seized and occupied, and the founding family established the villages of Mouit and Ndiébène Gandiole. The fishing and agricultural potential have long attracted many migrants from Walo, other localities in Senegal and even Mauritania. In other words, economic potential and the search for better living conditions strongly influenced the process of territorial conquest and appropriation. Today, all parts of the community territory are occupied by Wolofs, Fulani and Moors. It was merged with Gandon, which contained three other rural communities: Rao, Toube and Ndiawdoum. It became a commune in 2013 under Act III of Decentralization.
Structure (villages, sub-districts)	The Commune comprises 29 villages including Ndiébène Gandiole (the capital) and 9 hamlets; this is the 3rd largest village in Senegal according to the senior deputy mayor of the locality. Nine villages are located on the coast: Pilote Bar, Tassiner, Mouit, Darou Mboumbaye, Moumbaye 1, Degou Niaye, Lakhlar, Ndialigne Mbao and Taré Bond. Doune Baba Dièye was a village in the Commune, but disappeared due to flooding after the breach opened in 2003. Its inhabitants settled in Diele Mbame.
Infrastructures (public, social) and services	**Transportation**: main road linking the locality to Saint-Louis; unpaved roads connect the village to other villages and the latter with one another. Taxis and minibuses are used to shuttle people to or from Saint-Louis; carriages are used for inter-village transportation.

LOCALITY	Ndiébène Gandiole
	Health care: 1 health outpost at Ndiébéne Gandiole and 9 dispensaries in other parts of the Commune. A health center project has been initiated. **Education**: 25 primary schools, 1 middle school (CEM), and 1 high school (lycée). **Sanitation**: wastewater is eliminated by means of septic tanks. **Drinking water**: The locality is served by the national water system (Sénégalaise Des Eaux, SDE). **Electricity**: 4 villages are served by the grid of the national electricity company (Senelec); in most of the other villages, electrification is provided by the Osmogel system (developed by a private Moroccan company). **Telephony**: fixed-line and mobile phone service in most villages.
Demography (settlement, population, ethnic groups)	In 2013, the population was 25,000, mostly composed of Wolofs (nearly 80%), Pulaar (15%) and Moors (5%)
Socio-economic activities	Market gardening is the main activity, and is practiced by nearly 60% of the working population, followed by fishing, animal husbandry (including poultry farming, which is widely practiced) and trade. Onions are the main crop, followed by vegetables (carrots, turnips, cabbage, eggplant, etc.); peanuts and green beans are also grown to a lesser extent. In coastal villages, women are engaged in fish processing, oyster harvesting, etc.
Socio-cultural activities	Annual religious chants are organized during the period of Tabaski, at which time men arrive en masse from throughout the region.
Social organization	Rather dense network of associations composed essentially of neighbourhood community organizations (OCBs): some fifteen EIGs active in diverse fields such as animal fattening, processing, salt trade, market gardening, agriculture, small-scale business, poultry farming, etc.; women's promotion groups (GPFs); village sections noted in ten or so villages that work for the promotion of agriculture, the primary activity of the local economy. There are also sports and cultural associations (ASCs) in all villages and frameworks for cooperation that greatly contribute to the local development process.

LOCALITY	Ndiébène Gandiole
Noteworthy events in the locality	Prior to the opening of the breach, fishermen practiced their activity locally, whereas now they are forced to migrate to other parts of the country or to Mauritania. Additionally, this breach has been seriously detrimental to agriculture due to salinization of the ground and the water table. It is hoped that the (planned) Gandiole canal will help mitigate the impact that this breach has had on agriculture.

LOCALITY	Bopp Thior
Location (administrative; geographic)	The village of Bopp Thior is located on the border between Senegal and Mauritania. It is less than 2 km from the island of Saint-Louis. Administratively speaking, it is part of Gandon Commune, which lies approximately 20 km away, and Rao Arrondissement.
History	From a historical point of view, it is established that this island preceded the city of Saint-Louis. The first inhabitant of the village was from Walo and was named Mama Bâ. It is the first village to be considered a cemetery of Saint-Louis and dignitaries of this city were buried here. It was considered a calm island and a good place to live.
Infrastructures (public, social) and services	**Transport**: pirogues represent the main form of transportation **Health care**: 1 non-functional dispensary **Education**: 1 primary school, no middle schools, much less a high school. **Drinking water**: the district lacks a drinking water network. **Electricity**: no electricity. **Telephony**: mobile phone networks.
Demography (settlement, population, ethnic groups)	The population of Bopp Thior is estimated at 800 inhabitants, the majority of whom are women. The village is composed of three hamlets: Keur Gou Makk (home to the Ndiaye family), Keur Marième (Diop family) and Keur Bineta (Bâ family).
Socio-economic activities	The primary activity of this community is fishing.
Historic sites	Cemetery, former brickyard, Humaalou Rassoul mausoleum, etc.
Socio-cultural activities	*Gamou* and religious chants.
Social organization	The social organization of the village is traditional, with a village chief that enjoys complete authority. He also manages disputes and benefits from a casting vote at village meetings. The

LOCALITY	Bopp Thior
	village chief is considered to be the main spokesperson for stakeholders at the village level (NGOs, development projects, etc.)
Noteworthy events in the locality	Annual organization of religious chants.

LOCALITY	Cayar
Location (administrative; geographic)	Cayar is connected to the national highway via a department highway that links to RN2 at KM 50 and by Regional Highway 10 that originates in Rufisque and passes through localities such as Sangalkam, Bambilor, Bayakh, and Tivaouane. Cayar is bound to the northeast by the Atlantic Ocean and Tivaouane Department, to the northwest by the Atlantic Ocean and to the south by the line connecting the villages of Kalidou Ba, the village of Diamaguène and the southern edge of the Nioulwy dunes. Cayar Commune covers 1604 ha and has ten districts.
History	In the past, Cayar was considered a fishing port of the Cap-Vert Peninsula. It was created by a colonial initiative in 1871. Oral sources credit the 1874 foundation of Cayar village to Jaraff Mbor Ndoye, a Lebu community leader from Dakar who served as jaraff (Translator's note: title of nobility) from 1859 to 1870. Two versions exist for the meaning of the origin of the name Cayar: according to the first version, Cayar comes from the Wolof expression "*kaar ci yii yaar* "; indeed, the founder of the village was roaming the beach in search of place to set up camp. Happening upon some fish and fresh water, he exclaimed "*kaar yii yaar*", which means "May God protect those two, water and Earth." According to the second version, Cayar comes from Kaay Findiw, one of the twelve "penc" (Translator's note: sub-divisions) of Dakar's Lebu communities and where village founder Jaraff Mbor Ndoye is from, thus "*Kaay yaar*" translates literally as Kaay 2. Transported by donkey and camel, a significant portion of its fish production was already feeding the Cap-Vert Peninsula.
Structure (villages, sub-districts)	With a surface area of 1604 ha, Cayar Commune officially has ten (10) districts: Rond Point, Thiossane, Tenty Yoff, Darou Salam, Ndiokhop, Keur Abdou Ndoye 1, Mbawane, Médina Diop, Diamaguène, and Keur Abdou Ndoye 2.
Infrastructures (public, social) and services	**Health care**: Cayar has a health outpost, a maternity facility, a dispensary and a private clinic. **Education**: 8 primary schools, 1 middle school (CEM), 2 pre-schools, 16 Arabic schools, 15 *daaras.* **Sewerage**: community network for collecting and eliminating wastewater; use of individual tanks by residents. **Drinking water**: water supply is still provided by rural water engineering. The Commune is fed by a borehole located in Santhie (Diender) with a reservoir capacity of 200 m^3. The commune has over 1097 individual supply lines and 34 water fountains.

LOCALITY	Cayar
	Electricity: electricity production and distribution is provided by Senelec, with rather low coverage for public lighting. **Telephony**: fixed-line and mobile phone service in most districts.
Demography (settlement, population, ethnic groups)	In terms of socio-demographics, Cayar has 29,810 inhabitants living in various types of housing; Wolofs are the ethnic majority.
Socio-economic activities	At the socio-economic level, fishing and agriculture are the most important activities. Culturally, Cayar residents both fish and farm for a living. Combining fishing and agriculture allowed them to let the sea "rest" during the winter. Cayar is a popular destination for fishermen from other fishing grounds such as those from Guet Ndar. Its waters off the north coast are characterized by a marine biodiversity. There are both pelagic species for the national market and demersal species (notably coastal demersal), which are generally exported. Ranching is also practiced in Cayar and occupies approximately 5% of the urban workforce with a stock composed of 728 cattle, 1,040 goats, and 40 horses. The industrial fabric is nearly non-existent, essentially composed of a non-operational brick and tile facility, a closed-down Chinese fuel production unit, and ice-making facilities, all of which are also closed down.
Social organization	Stakeholders in the Commune have sparked an organizational dynamic that is reflected in the establishment of a large diversity of groups: Cayar Fisheries Committee (CPC), Mbalmi 1 and Mbalmi 2, Group of Industrial Fishmongers of Cayar (REMICA), the local FENAMS chapter and Young Fishmongers, EIG Mantoulaye Guène and EIG Awa Guèye Kébé, inter-professional EIG Yallay Mbaneer ak Feex-Gui, and the Local Artisanal Fishing Council (CLPA).

LOCALITY	Fass Boye
Location (administrative; geographic)	Fass Boye is located in the northwestern part of Thiès Region. It is bound by Louga Region to the north, Thiès Department to the south, National Highway 2 to the east and the Atlantic Ocean to the west. From an administrative point of view, Fass Boye is part of the commune of Darou Khoudoss, sub-prefecture of Méouane, Tivaouane Department.
History	The village of Fass Boye was founded by Mr. Mambaye Boye, a disciple of El-Hadji Malick Sy. The latter had given authorization to found this village in 1929. The elderly Mambaye Boye was a native of Gandiole. The main activity in the village was agriculture. The first fisherman of the village was Ndiaga Seck, who had left Saint-Louis and arrived at Fass Boye at high tide. He decided to stop and wait for the tide to recede so that he could continue his journey. He thus went to fish on the coast of Fass Boye and returned with a large catch, which is how he came to settle in the village. Residents later began to entrust their children with him so that he would teach them the art of fishing.
Structure (villages, sub-districts)	The village has approximately 8 sub-districts, each of which is administered by a district chief who is appointed by the village chief. The latter enjoys a certain decision-making power according to tradition.
Infrastructures (public, social) and services	The village has one French primary school, five Quranic schools, one dispensary, one ASUFOR-managed borehole, a fishing center and a landing site for fishery products. In Fass Boye there are five (5) fuel stations for fishing boats. Fass Boye has just one landing dock, which is managed by the inter-professional EIG "Cheikh Ndiaga Seck".
Demography (settlement, population, ethnic groups)	With approximately 15,000 inhabitants, the population has grown at a considerable pace thanks to the fishing sector that attracts populations to the village of Fass Boye. The village is predominantly Wolof, but due to the demographic surge there are other ethnic groups such as Serer, Jola, Mandinka, etc.
Socio-economic activities	Fishing is the main activity in the locality. Market gardening is also practiced by some fishermen as a secondary activity. The older generation practices market gardening as their primary activity.
Socio-cultural activities	Annual village *Gamou*, wrestling and *navétanes* (athletic and cultural activities organized during the school holidays).

LOCALITY	Fass Boye
Social organization	- Union of Women Processors (comprising 15 EIGs); - Oversight and Security Committee (CVS) of passive net fishermen; - Oversight and Security Committee (CVS) of purse seine fishermen; - Fishmongers' Union.
Shortcomings in the locality	In the absence of a middle school (CEM) or a high school (lycée), school attendance rates are low; the dispensary is unable to satisfy the population's demand for health services.

LOCALITY	Lompoul-sur-Mer
Location (administrative; geographic)	Lompoul is located in the southeastern portion of Thiès Region. It lies between Niayam Potou in the north, Fass Boye in the south, the Atlantic Ocean in the west, and Kébémer Commune in the east. Administratively, Lompoul-sur-Mer is part of Louga Region.
History	According to testimonies of customary authorities, Lompoul-sur-Mer was traditionally a place of fields and residents came there to farm. At the time, the village was called Thiougougne. In order to be closer to their fields, residents decided they needed to come and live on this site. This is how the first inhabitants came to settle there. At the time, Guet Ndar fishermen came there to fish while native residents were generally engaged in agriculture and raising animals. These two communities lived and continue to live in perfect harmony, which has allowed village natives who were once farmers or herdsmen to switch to fishing trades and migrant workers to be perfectly integrated into the local population.
Structure (villages, sub-districts)	The villlage of Lompoul-sur-Mer sub-divided into 6 hamlets.
Infrastructures (public, social) and services	**Transportation**: Transport within the village is essentially provided by carriages and motorbikes. As for inter-city transport, vehicles are used and there is a bus that runs from Lompoul to Dakar and back every day except Wednesday, the day of the weekly market. **Health care**: one health outpost under construction. **Education**: 1 primary school, 1 middle school (CEM). **Drinking water**: The drinking water supply is provided by rural water engineering via a system of boreholes. **Electricity**: electricity is provided by Senelec. **Telephony**: the mobile phone network is used and all mobile phone operators in Senegal are present in the locality. **Other infrastructure**: 1 weekly market that actively contributes to the local economy.
Demography (settlement, population, ethnic groups)	The population is estimated at 2,000 inhabitants. Fulani (Peul) are the majority in the locality, while Serers, Wolofs, Moors, and Jolas are also present. Populations from the West African sub-region are also present in Lompoul-sur-Mer, notably Guineans and Gambians.

LOCALITY	Lompoul-sur-Mer
Socio-economic activities	Lompoul residents are mainly engaged in fishing, especially during the "campaign" period. During the low season, when the fishery resource is less plentiful, residents engage in market gardening and raising animals.
Socio-cultural activities	Annual village *Gamou*, Fulani rituals during wedding ceremonies: *riiti, xalam, tama, sabar*, etc. In this community there is a certain social stratification: "Nénos", "Guers" and "Guéweuls". "Nénos" and "Guéweuls" do not marry "Guers" and vice versa.
Social organization	A certain organizational dynamic is observed in Lompoul. The CLPA is very dynamic and is composed of stakeholders from the various fishing sectors to promote a collaborative management of the resource. The CLPA has an internal commission responsible for managing conflicts that arise between fisheries stakeholders. It also oversees compliance with fishing regulations. In addition to the CLPA, there is the village council directed by the village chief, who has full authority at the local level. There are also sports and cultural associations (ASCs) in the village.
Noteworthy events in the locality	One-day-a-week market that brings together most of the residents and helps reinforce social bonds. This event is a major contributor to the local economy. The annual *Gamou* is also one of the highlights of this locality.

APPENDIX F : NOTES ON PROTECTED AREAS

Appendix F
Notes on Protected Areas

APPENDIX CONTENTS

This appendix provides information compiled from reports by national experts in Mauritania and Senegal on protected areas in the Mauritanian and Senegalese portions of the extended study area of the project.

APPENDIX F-1 : NOTE ON PROTECTED AREAS IN THE MAURITANIAN PORTION OF THE EXTENDED STUDY AREA OF THE PROJECT

AHMEYIM/GUEMBEUL OFFSHORE GAS PRODUCTION PROJECT IN MAURITANIA AND SENEGAL

Note on Protected Areas in the Mauritanian Portion of the Extended Study Area of the Ahmeyim/Guembeul Project

APRIL 2017 (REVISED OCTOBER 2017)

Dr. Khallahi Brahim

Ecodev
Ext Ilot K 155 - TVZ
BP 41 74
Nouakchott, Mauritania
Phone: +222 529 30 54

Table of Contents

Protected areas are spaces dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources (IUCN, 1994). They are inherently fragile and must be carefully protected against any form of degradation (natural or anthropogenic).

Mauritania has a network of protected areas that play a very important ecological role. In the South, in the extended study area for the Ahmeyim/Guembeul gas project, two protected areas located on the coast have been taken into consideration in this ESIA: the Diawling National Park and the Chatt Tboul Reserve.

This document will present a succinct overview of these two areas.

I. Diawling National Park

In the 1960s, alternating flooding of the Senegal River and influxes of salt water helped support an estuarine ecosystem of extraordinarily rich biodiversity in the delta region. This applies not only to vegetation, but to fish and birds as well. The traditional use of natural resources helped meet the needs of more than 10,000 people (Diawara and Diagana in Hamerlynck and Cazottes, 1998).

The region suffered a severe environmental crisis as a result of diminished flooding of the river and a persistent drought in the 1970s. The river's water flows fell and salt water influxes became increasingly frequent (André and Chenaval, 2007). To address this deterioration in climate conditions, the Organization for the Development of the Senegal River (OMVS) spearheaded an ambitious program with the ultimate goal of ensuring better control and proper management of water resources. It is in this context that two dams were built: one on the delta (Diama dam, commissioned in 1986), and the other in Manantali (1988). The former aims to prevent salt water influxes into the river bed. The latter, which is a hydro-electric dam, also serves to control water levels and to enhance the river's navigability.

However, the construction of these two dams, especially Diama, has had significant environmental and social repercussions. For example, the Diama dam inhibited exchanges of fresh and salt water between the river and the ocean with an alternation of species with marine or freshwater affinity. This in turn has led to a degradation of the biophysical environment due to an artificialization of the water system. The lands became unsuitable for agriculture, with sharp declines in flora as well as fauna (Abou, 2005). Local populations grew poorer, with some being forced to migrate to urban centers, Nouakchott in particular.

After deciding in the 1980s to establish a protected area in the Senegal River delta (Hamerlynck, 2003), the Mauritanian government – inspired by various studies, in particular Gannet Fleming (1986) – created a protected area called Diawling National Park (DNP) in 1991. Ultimately, the creation of this park aims to restore this ecosystem and revive the socio-economic activities of the local populations. In other words, restoring, conserving and using natural resources in a sustainable manner (Hamerlynck, 2004). In order to achieve these objectives, the hydrological functioning of the ecosystem must be re-established by implementing the necessary infrastructure and commissioning indispensable water control infrastructure.

In this regard, the DNP, with the support of its technical and financial partners (Deutsche Gesellschaft für Internationale Zusammenarbeit (German Corporation for International Cooperation, GIZ), the Spanish Agency for International Development Cooperation (AECID), Kreditanstalt für Wiederaufbau (German Reconstruction Credit Institute, KfW), Japan International Cooperation Agency (JICA), French Development Agency (AFD), International Union for Conservation of Nature (IUCN), United Nations

Development Programme (UNDP), United Nations Educational, Scientific and Cultural Organization (UNESCO), (FIBA), the Regional Marine and Coastal Conservation Programme for West Africa (PRCM), Wetlands International, World Wildlife Fund (WWF)) has committed to a multiyear program of ecological restoration. The most recent program concerns the convention signed with KfW related to the construction and rehabilitation of hydraulic infrastructure in Diawling National Park. The rehabilitation work has already generated convincing results for all ecosystems (regeneration of vegetation, healthier wildlife populations, return of birds, etc.). The basin surfaces were mostly flooded for the first time in more than 10 years.

I. 1. Legal Framework, Status and Objectives for the Diawling National Park

The Diawling National Park (DNP) was created by Decree No. 91-005 issued by the Ministry of Rural Development on January 14, 1991. The DNP is a public establishment of administrative nature under the authority of the Ministry of Environment and Sustainable Development (formerly the Ministry of Rural Development). As defined in Article 2 of the Decree, the objectives are:

- To preserve and ensure the sustainable use of natural resources in a portion of the lower delta ecosystem;
- To promote the continuous and harmonious development of the range of activities practiced by the local population;
- To co-ordinate pastoral and fishing activities within its boundaries; in this regard the land is not bound by any rights of use.

The DNP is administered by a board of directors that oversees management of the park and exercises its powers to:

- Establish management and research programs;
- Examine the financial performance results of the past fiscal year and the budget of the fiscal year to come; and
- Establish the National Park's internal rules and regulations.

The Ministry of Rural Development and the Environment's Decree No. R-204 (April 2, 2000) approving the internal rules and regulations of the Diawling National Park stipulates rules for the use of resources and for the park's internal operations.

The DNP enjoys an international status allowing a better preservation of the ecosystem in its entirety. As well, its classification as a wetland of international importance in 1994 pressures Mauritania as a Contracting Party to this intergovernmental convention to integrate the conservation of wetlands (DNP and Chatt Tboul for the cases concerned here) in its development plans and to promote their rational uses. Any behavior contrary to these commitments could provoke a reaction from UNESCO (as the depositary of the Convention) asking for corrective measures. In this case, Mauritania is obligated to provide explanations within the deadlines granted by UNESCO.

On the other hand, the integration of the DNP and Chatt Tboul in the Transboundary Biosphere Reserve of the Delta of the Senegal River in 2005 constitutes a recognition that the management model adopted in these areas reconciles the conservation of biodiversity and sustainable development, in the framework of the Program on Man and the Biosphere (MAB) of UNESCO. It is not an international convention but these areas follow the criteria defined in a statute approved by the Member States of UNESCO. These areas are part of the world network of Biosphere Reserves which serves as the framework for the exchange of their experiences at the national, regional and international levels.

The Biosphere Reserve is not binding legislation. It is composed of three distinct sectors: an area of reinforced protection called "**central area**" which is superimposed on an area which already has a strict regulation for nature protection, a "**buffer zone**" where the sustainable human activities are tolerated and a much wider "**transition area**".

The creation of the PND responds to a double objective, namely the restoration/conservation of ecosystems and the development of social activities that preserve the environment. As stressed by IUCN (2007), the PND integrates well in the category II of IUCN in its scope for the protection of the natural biodiversity, ecological structure and environmental processes but also the access to recreational activities and research work. The PND can also be considered as a protected area of type VI because, in addition to the protection of ecosystems, it allows sustainable and limited socio-economic uses. These uses must be respectful of the environment, without prejudice to preserve fauna and flora to acceptable levels (Dudley, 2008; Day et al., 2012).

The PND is one of the few protected areas which take into account the development of local populations in harmony with their environment. This is especially to put in link with the circumstances in which this area has been created.

I. 2. Geographic and Physical Context

The DNP is located on the southern border of Mauritania, on the right bank of the Senegal River. Its central rectangular portion measures 16,000 ha and is bounded by the 16°30’N and 16°10’N parallels and the 16°15’W and 16°25’W meridians of longitude (Map 1).

The park comprises 3 basins of varying size:

- The Diawling-Tichilitt basin (8,000 ha);
- The Bell basin (3,500 to 4,000 ha); and
- The Gambar basin (4,500 ha).

The first two basins are connected to one another, while the Gambar basin is located entirely within the river impoundment.

It is recognized that adjacent to this central portion is a peripheral zone that Decree R-204 makes reference to, though without specifying its boundaries. This peripheral zone, which thus has no legal status, encompasses the entire commune of N’Diago, in which the DNP is located (Map 1). Its surface area measures an estimated 56,000 ha (DNP, 2013).

Generally speaking, relief in the DNP and its vicinity is characterized by:

- Depressions without vegetation and saline soils or sabkhas;
- Dune complexes with shifting dunes formed by eolian transport on the coast and the two large dunes of Ziré and Birette;
- The natural basins of Aftout, Chatt Tboul, Ndiader, N'Tiallakh, Gueyloubou, Diawling-Tichilitt, Bell, and Gambar.

I. 3. Hydrology in the Diawling National Park Region

The hydrology (DNP, 2005) of this region had historically been subject to a climate of two characteristic seasons:

- A flood season, generally lasting from August to November, that was heavily influenced by winter precipitation. Fresh water was abundant and of good quality. Volumes had considerably declined during the drought period.
- A low flow season from December to July, during which period water flows dropped considerably. Influxes of salt water could be observed at distances of up to 240 km from the delta (in Podor, Senegal).

Since the construction of the Diama and Manantali dams, the situation has completely changed. Thanks to a system controlled by a network of hydraulic infrastructure, it is possible to regulate water levels and, more importantly, prevent sea water from infiltrating certain parts of the region. Hence, to supply fresh water to the DNP, the OMVS has put in place the works of Cheyal, Lemer, Bell I and Bell II on the right bank. These works, essential in maintaining the dense vegetation and fauna of the DNP, were fully controlled by the OMVS. Since June 29, 2009, the management of these works has been transferred to the conservation services of the DNP. This enables an effective management of the water needs and a better control of the water level in the Park.

To ensure optimum water feeding in the DNP (as well as in its peripheral area), policy makers have adopted a timetable for the opening of the valve works to simulate nature with an opening on July 1st and a closure on October 31 (natural wet period in the region). The interior valves are managed according to the water levels in the DNP.

The hydrological system of the DNP and its periphery (from which it can hardly be dissociated) includes seven interconnected hydrological units (Ould Limmame, 2011 and DNP, 2013). These are shown on Map 2 and are described below.

I. 3.1. Diawling-Tichilit Basin

The Diawling-Tichilit basin has a surface area of 11,000 ha, 8,000 ha of which lies within the DNP. This basin is fed by the Cheyal sluice gate, which was built in 1994 with funds from the OMVS. The basin is drained at 3 locations:

- The Hassi Baba pool, which continues northward to the Tumbos marshes and Chatt Tboul;
- The Ndernaye pool, which links the pools of Lebatt and Ntok. The latter two flow into Tichilitt Lake. A sluice gate equipped with a valve has been installed to fill Nter Lake and lower the salinity in N'Tiallakh Lake, as well as in the direction of Diawling and Chatt Tboul;
- The Berbar, which represents an extension of Bell basin. An embankment with a gate has been constructed here, which allows for exchanges with the Bell and Diawling basins.

I. 3.2. Bell Basin

Located entirely within the DNP, the Bell basin is fed using the Lemer sluice gate (flow of 15 m^3/s). The Bell basin is drained on the north side through the Berbar and on the west via the sluice gates installed on the embankment.

I. 3.3. Gambar Basin

This basin is located in proximity to the Diama impoundment, of which it is an integral part. It is permanently flooded and has been almost completely taken over by the plant *Typha australis*. Water management is overseen by OMVS' Diama dam use and management company (SOGED).

I. 3.4. N'Tiallakh Basin

Measuring 20,000 ha, this is the largest of the basins. It is fed by the N'Tiallakh pool, which originates downstream of the Diama dam. The N'Tiallakh irrigates several pools, namely: Ghahra, Tweikit, Bell, Ndjorakh, N'digratt, N'deger lekbir, and Khurumbam. This basin opening to the sea is subject to tides. Its salinity thus varies considerably as a function of the flow of the releases from the dam. Prior to October 2003, when a breach was cut into the Langue de Barbarie, fresh water from the N'Tiallakh could reach as far as the Bell basin.

I. 3.5. Gueyloubou Basin

Spanning approximately 4,000 ha, this basin is fed on the east by the Gueyloubou pool, which originates downstream of the Diama dam. It is also partially fed by another pool west of the Mboyo Island.

I. 3.6. N'Diader Basin

This basin covers an estimated 9,000 ha. It is fed by the Aftout Es Sahli sluice gate, which was built to provide drinking water for the city of Nouakchott. The N'Diader floods significant expanses of rice paddies. When it fills up, these waters spill over to feed the Aftout, a breeding site for flamingos and staging grounds for thousands of migrating birds.

1. 3.7. Chatt Tboul (see Part II)

I. 4. Biological Richness of the DNP and its Periphery

This region is characterized by a Sahelian climate. Rainfall is low, with rains generally being limited to the period between July to October, with slight inter-annual fluctuations. The region is located on the 350 mm isohyet. The influence of the coast is a determining factor for rainfall levels. Indeed, the variability of the intertropical front creates two seasons: rainy and dry (Duvail, 2001). The proximity of the Senegal River and the presence of sluice gates allow for an acceptable intake of water.

Likewise, the DNP and its periphery harbor a rich biodiversity in terms of both the animals and plants found throughout the region. The DNP's biodiversity (particularly for birds) has earned it the designation of wetland of international importance (RAMSAR site) in 1994. Since 2005, it has been an integral part of the Senegal River Delta Transboundary Biosphere Reserve.

I. 4.1. Vegetation

Vegetation within the DNP and its periphery is varied and relatively dense in places and depending on the season (winter or dry season). Surveys performed in this area identified 30 species of trees and more than 120 species of bushes. The vegetation can be subdivided into 3 different broad categories based on affinity: dune vegetation, floodplain vegetation and estuarine vegetation.

I. 4.1.1 Dune Vegetation

The make-up of the vegetation is dependent on the location. Indeed, several species of trees and bushes are sparsely scattered throughout the area (Abou, 2005): *Acacia tortilis, Salvadora persica, Boscia senegalensis, Balanites aegyptiaca, Celtis integrifolia, Grewia tenax, Adansonia digitata, Acacia nilotica,* and *Acacia albida.* Estimated at 25%, woody vegetation cover is currently very low. In terms of herbaceous vegetation, the following species are present: *Chloris prieurii, Zygophyllum simplex, Cenchrus biflorus, Indigofera tinctora, Crotalaria podocarpa, Heliotropium ovalifolium, Heliotropium ramosissimum, Schoenefeldia gracilis, Boerhavia erecta, Cleome tenella, Eragrostis* sp.*, Aristida mutabilis, Trianthema pentadra, Trianthema portulacastrum,* and *Dactyloctenium aegyptium.*

On the coastal side, vegetation is sparse, with brightly-colored and seemingly shifting dunes. However, in the areas between the dunes, vegetation is relatively abundant and plays an important role in livestock grazing. The species are: *Euphorbia balsamifera* and *Aerva javanica*. As one moves inland and the continental influence increases, species encountered include *Acacia tortilis, Maytenus senegalensis, Nitraria refusa, Commiphora africana, Anogeissus leiocarpus*.

I. 4.1.2 Floodplain Vegetation

In these plains, the species identified are (Abou, 2005): *Sporobolus robustus, Acacia nilotica, Tamarix senegalensis, Tamarix passerinoides, Cressa cretica, Anogeissus leiocarpus* and certain members of the goosefoot family (Chenopodiaceae). The Gambar basin is invaded by the typha *Typha domingensis*, as well as *Potamogeton nodosus* and *Utricularia inflexa. Nymphaea lotus*, which is used by local populations, is also present in this part of the lower delta.

Work performed in the lower delta has shown that this vegetation is presently evolving due to current developments as well as irrational land use (overgrazing). Hence, species that once dominated the landscape are currently in decline (e.g. *Sporobolus robustus, Acacia nilotica, Anogeissus leiocarpus*) while other plants such as typha (opportunistic species) are colonizing the region, which constitutes an ecological disaster for the river and surrounding areas.

I. 4.1.3. Estuarine Vegetation

Estuarine vegetation consists essentially of mangrove swamp, which is characteristic of tropical estuary regions. The mangrove swamp is an ecosystem of great biodiversity and, thanks to its carbon-storing ability, plays a key role in fighting climate change. In the Mauritanian portion of the lower delta, two species of mangrove are found: *Rhizophora racemosa* and *Avicennia germinans.*

The mangrove swamp is rapidly shrinking in the DNP periphery, where it is used by local populations for various purposes (firewood, construction, etc.). There is believed to be just one last patch remaining, between the N'Tiallakh pool and the Senegal River (Abou, 2005).

A mangrove restoration program has been undertaken with the populations of the communities of Birette, El Gahra and Dar Salam. This pilot experiment has helped to raise the awareness of local populations of the importance of mangroves and to plant 40,000 plants over 20 ha. Sites where reforestation has been successful have been placed under protection (Dia, 2012).

I. 4.2 Fauna

More than 378 species of fauna (birds, mammals, reptiles and fish) have already been identified in the DNP and its periphery. From a biodiversity perspective, the area still has many secrets to be unlocked, as many groups have yet to be studied in depth. This is notably the case for insects and mollusks.

I. 4.2.1. Avifauna

The DNP region (and its periphery) is a site of exceptional importance for avifauna. It is one of the few areas in the world where bird censuses are conducted on a regular basis (Triplet et al., 2010). Over 250 species of birds have been recorded, including year-round residents (52 breeding species) and wintering (migratory) species. Eight of these species are on the IUCN red list (DNP, 2013): 2 species listed as "vulnerable" (aquatic warbler and black-crowned crane), and 6 in the "near-threatened" category (martial eagle, black-tailed godwit, African skimmer, lesser flamingo, ferruginous duck and Audouin's gull). The 2012 census revealed that the threshold of 1% of the global population was surpassed for no fewer than nineteen of the species observed.

Owing to their role in the birds' lifecycle, both the DNP and the Chatt Tboul Reserve have been designated RAMSAR sites as per the criteria of the Convention on Wetlands of International Importance (DNP, 2005).

The avifauna was severely affected by the deterioration in climatic conditions and the construction of the Diama dam. Thanks to restoration efforts undertaken by the DNP and its partners, the situation has improved (Abou, 2005). The bird census conducted in January 2017 revealed a net improvement in the state of the ecosystem. A total of 248,846 birds representing 107 species were identified. Four rare species were reported, including some that had not been observed in the Mauritanian lower delta for several years: tufted duck (*Aythya fuligula*) (last observation in 2012), African skimmer (*Rhynchops flavirostris*) (last observation in 2007), ruddy shelduck (*Tadorna ferruginea*) and Eurasian dotterel (*Charadrius morinellus*)(DNP, 2017).

Five broad groups of water birds are noted (DNP, 2016 and 2017): waterfowl (Anatidae), flamingos, shorebirds, herons (Ardeidae), and Charadriiformes.

I. 4.2.1.1. Waterfowl

This group – the most important in terms of number of individuals – comprises swans, geese, ducks and related species. Species regularly observed in the DNP and its periphery and that are reported in the censuses include (DNP, 2016): comb duck, northern pintail, Eurasian wigeon, northern shoveler, fulvous whistling duck, white-faced whistling duck, spur-winged goose, Egyptian goose, Eurasian teal, garganey, marbled teal, and African pygmy-goose. In 2017, this group has formed 74% of the total number of individuals observed during this campaign. Four species account for the vast majority of this group: the garganey (*Anas querquedula*), the northern shoveler, the northern pintail, and the white-faced whistling duck.

I. 4.2.1.2. Flamingos

Two species of flamingos are present in Mauritania: greater flamingo (*Phoenicopterus roseus)* and lesser flamingo (*Phoeniconaias minor*). The greater flamingo is observed in Mauritania all year long. It breeds in the DNP and the Chatt Tboul (Diawara et al., 2007). The lesser flamingo, which is listed as "near threatened" on the IUCN 2016 red list (http://www.iucnredlist.org/details/22697369/0), is present in large numbers in the delta. It breeds in the Aftout Es Sahli (Diagana and Diawara, 2015).

The good management of water resources in 2016 has resulted in the emergence of islands, privileged sites for flamingos. The 2017 count has noted 27,373 flamingos.

I. 4.2.1.3. Shorebirds

This is a highly diverse group of small wading birds. Surveys revealed 39 species representing 7 families, the most important of which in terms of species diversity are *Scolopacidae* with 24 species and *Charadriidae* with 6 species (Ould Aveloitt, 2014). According to the latter, the majority of the shorebirds observed in Mauritania are of Eurasian origin. The 2017 count has identified 34 species for a total of 15,193 birds in 2017. Shorebirds have increased to 2,779 individuals or 22% compared to last year (2016).

I. 4.2.1.4. Charadriiformes

This group encompasses protected migratory species of sterns and shorebirds. Seven species are reported in the 2016 census.

I. 4.2.1.5. Ardeidae

It comprises in particular the herons (7 species) and egrets (6 species). Some of these species nest in the PND and its periphery, including the Cattle Egret (*Bubulcus ibis*), the Purple Heron (*Ardea purpurea*), the Green-backed Heron (*Butorides striata*), the Western Reef-egret (*Egretta malabarica*) and the Little Egret (*Egretta garzetta*). In 2017, the numbers of this group have reached 4977 birds against 6102 in 2016, thus registering a decrease in the order of 18% (PND, 2016 and 2017).

I. 4.2.2. Mammals, Large Fauna

A large variety of wild species (20 species) is present, some of which have been extirpated from other parts of the country: jackals, warthogs, fennecs, patas monkeys, African wildcats, honey badgers, hares, foxes, and striped ground squirrels (DNP, 2013). The DNP protects the animals from hunting and poaching.

I. 4.2.3. Reptiles and Amphibians

Sow and Brito (2016) identified the presence of 33 species of reptiles and 4 species of amphibians in this area. Species become abundant during the winter season (Abou, 2005): snakes (African rock python, vipers, etc.), tortoises, marsh mongoose, Nile and desert monitors as well as a crocodile found every year in the vicinity of the Mréau pool in the Bell basin. During a site visit made by the ESIA expert committee in December 2016, several baby crocodiles were observed.

I. 4.2.4. Fish and Fishery Resources

The ichthyofauna in the DNP and its periphery is diverse and sufficient to support fishing. The DNP (2013) identified the presence of a number of species, including:

- - Twenty-eight (28) marine species;
- - Forty-one (41) brackish water species; and
- - Sixty-seven (67) freshwater species.

Crustaceans include decapods (*Sicyonia carinata*) and penaeid prawns (dominated by *Penaeus kerathurus*). Abou (2005) noted the presence of ten or so species belonging to the Penaeidae family.

The study performed by IMROP (2005) showed that the DNP and its periphery play an important role in the lifecycles of a number of aquatic species, particularly fish and shrimp. The study revealed that many species undergo a growing stage here, including fresh, brackish and marine water species.

I. 5. Socio-economic Activities in the Region

I. 5.1. Populations of the Mauritanian Lower Delta

The DNP and its surroundings comprise 37 communities throughout the coastal and inland sectors. According to the most recent census data (ONS in 2002), the population is estimated at 10,906 inhabitants. Appendix 1 presents the number of residents in each of the main localities illustrated in Map 1 (PARCE, 2012). Ly and Moulaye Zeine (2009) consider that 26.7% of residents practice an income-generating activity in the lower delta. In this zone characterized by livestock keeping and fishing activities, certain populations that had emigrated have returned and resettled, notably in N'Diago (PND, 2013).

In the Mauritanian portion of the Senegal River Delta, the population is composed of Wolof, Moorish and Fulani people. Wolofs have been the longest settled and are concentrated in villages located along the coast and on the Thiong Island. The village of N'Diago is the largest population center.

The Wolofs of this region who once lived off agriculture turned to fishing with the help of Senegalese fishermen in Guet Ndar, who introduced them to the trade. Today, apparently all men between the ages of 12 and 50 are engaged in fishing. It is becoming the Wolofs' primary activity in the Mauritanian lower delta. Some of them have migrated to the country's large urban centers (Nouakchott and Nouadhibou). Agriculture is becoming their secondary activity and is limited to *maraichage* (vegetable gardening). It is practiced by women and children in garden plots planted on the coastal dune (Abou, 2005).

According to Abou (2005), Moors form the majority in the DNP and its periphery, and are settled throughout the region. Nearly all of the Moors belong to one of two tribes: the Taghredients of Ziré and the Tandghas. The former, originally a warrior tribe, switched to fishing and practice their activities in the flood basins, unlike the Wolofs, who fish off the coast. The Tandghas, on the other hand, are said to have arrived and settled in the 1960s. Herdsmen since ancient times, they made northward migrations in search of pasture land and to avoid flooding in the lower delta.

The Fulani (Peul) represent the smallest community in the lower delta. They have a tradition of being nomadic herdsmen who progressively became sedentary. They co-exist with the Moors. They are most concentrated in Birette, Bariel Sebeikha, Afdeidjir, as well as in Bouhajra (Abou, *op. cit.*).

I. 5.2. Economic Activities – Use of Natural Resources

Income-generating activities are varied and include fishing, crafts, garden marketing, gathering, livestock raising and trade. Fishing, craftwork and garden marketing are the primary activities; the others are practiced on smaller scales (DNP, 2005).

I. 5.2.1. Mainland Fishing

With the drought and the construction of the Diama dam, the fishing industry in the lower delta has drastically declined. Since sluice gates have been installed on the embankments, the situation has gradually returned to normal. Fish harvests are on the rise.

Fishing is practiced in the basins and along the river. In the DNP, the primary and most heavily fished sites are located at the Cheyal and Lemer infrastructure, but also in the N'Tiallakh basin (Abou, *op. cit.*). Species harvested include: catfish (essentially *Clarias gariepinus*), 25% tilapia and 5% other (*Schilbe* sp., *Lates niloticus*, etc.) (Duvail, 2001). Shrimp are also harvested seasonally in the lakes of N'Tok and N'Ter. Fishing gear used in the lower delta includes cast nets, unbaited longlines and fixed gillnets.

It is estimated that approximately 26% of heads of households in the Mauritanian lower delta fish for a living (DNP, 2005). Total fish production in the inland basins is believed to be in the order of 300 tonnes per year, generating a turnover of 15 million ouguiya (Ly and Moulaye Zeine, 2009).

I. 5.2.2. Livestock Keeping

Livestock keeping is a traditional activity widespread in the delta. Long practiced by locals, animal breeding has been confronted with the problems that the region has experienced: lack of water, soil salinization and the grazing crisis.

The hydraulic structures operating along the river have given new life to this activity in this region. Large expanses are now available for grazing (Abou, *op. cit.*). Herds are from the villages of the lower delta or from Keur Macène. Also of note is the presence of camel herds that graze in the northern parts (Hamerlynck, 1996). Duvail (2001) had estimated the active stock in this region at approximately 8,000 head, broken down as follows: 3,100 cattle, 4,000 goats, 120 sheep, and 800 camels.

I. 5.2.3. Vegetable Gardening

The drought, combined with the construction of the Diama dam and the dike on the right bank, have led to the disappearance of *Sporobolus* and a significant decline in fishing catches. This has forced the population to turn toward vegetable gardening, which has become one of the most productive activities in the lower delta. This activity, which is confronted with water shortages, is practiced almost exclusively by women. Water for the garden plots is sourced from a thin water table. In the vicinity of the Diama dam, surface water is used to irrigate the vegetable gardens (DNP, 2005).

Vegetable gardening produces considerable yields of vegetables (turnips, carrots, tomatoes, onions, cabbage, etc.), which are generally sent to Nouakchott.

I. 5.2.4. Gathering

This activity pertains to three plant species: *Sporobolus robustus*, *Acacia nilotica* and *Nymphaea lotus*. The first plant is used in the making of traditional mats. Acacia is used in leather tanning, while *Nymphea lotus* is used in the preparation of couscous. This activity is practiced almost exclusively by women. Women form cooperatives for gathering *Sporobolus* between December and March, as well as for mat weaving.

I. 5.2.5. Crafts

In the lower delta, craftwork plays a very important economic role. It is especially widespread amongst Moorish and Wolof women. The former produce mats from *Sporobolus robustus* and leather. The women operate according to an organizational structure based on mutual assistance (known locally as *Twize*). Wolofs are engaged in dyeing and sewing; they also make local baskets. Craftwork is practiced by more than 20% of residents (DNP, 2013).

I. 5.2.6. Trade

This is mostly small-scale trade that tends to be spreading in the villages of the Mauritanian lower delta. There has thus been a proliferation of small shops, notably in Moidina, Birette and Diemer. This activity has benefited from microcredit offered for local co-ops and is said to be rapidly expanding at the present time (Abou, *op. cit.*).

I. 6. Other Human Activities

A multipurpose port complex was inaugurated by the Mauritanian President on December 6, 2016 in the commune of N'Diago. This project – located near the southern border and awarded to the Chinese company Poly-Technologie – is considered to be strategic for the country. Security and defense oriented, it aims to spur sustainable economic development in an almost completely isolated region. Once built, it will accommodate military buildings as well as fishing, trade and service vessels for refueling, loading and unloading operations. It is also expected to offer a suitable site for ships to undergo repairs and maintenance. This port will comprise:

- a military port with mooring berths on both sides and a naval base;
- a fishing port comprising 7 landing docks;
- a shipyard with a capacity of 70 vessels a year;
- a trade dock that can be used to moor boats up to 180 m long;
- a point of landing for artisanal fishing;
- a landing and transport ship.

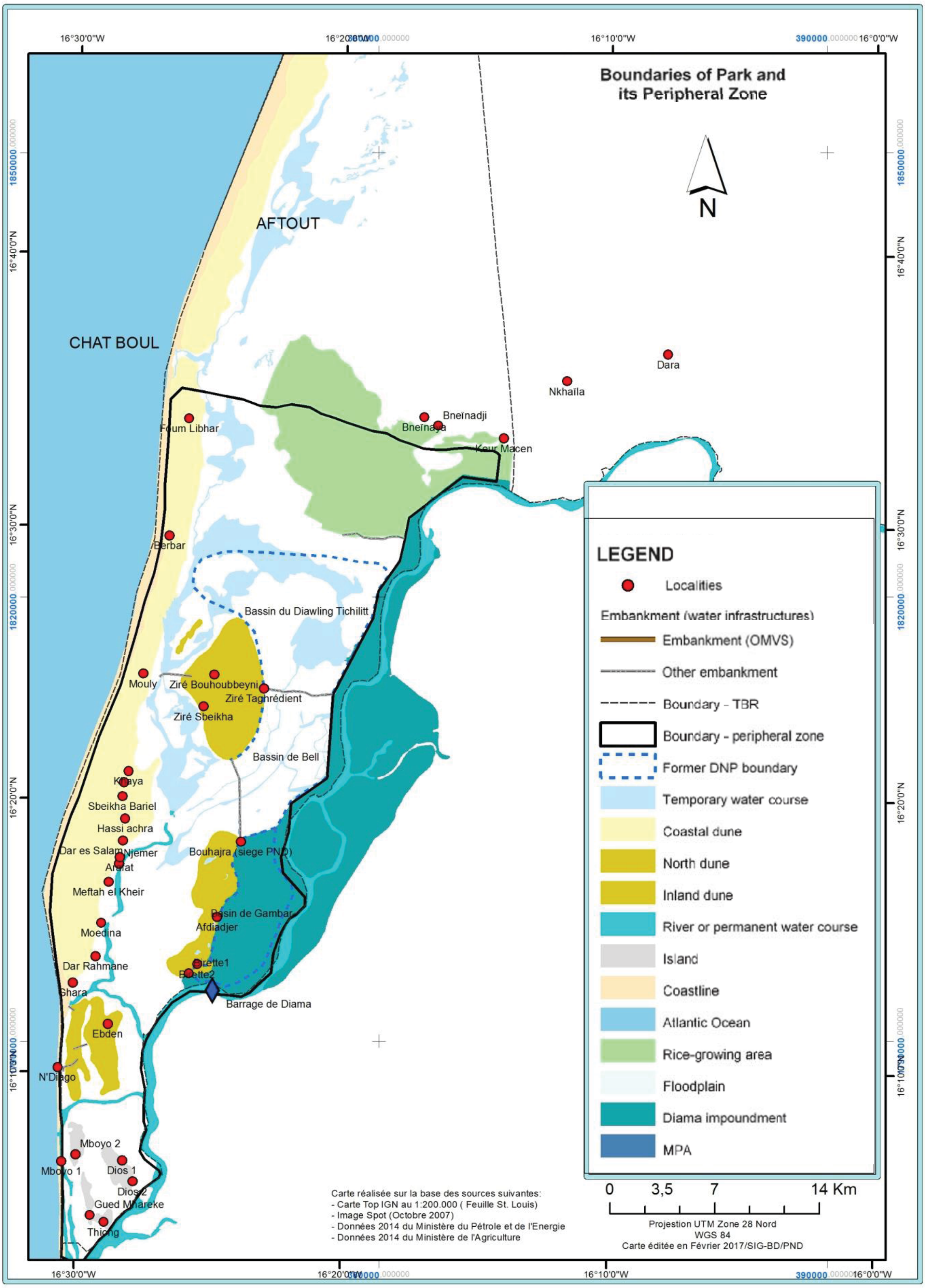
The expert mission responsible for the environmental and social impact assessment of the "Ahmeyim" offshore gas project in Mauritania was able to visit the port project shortly after it was inaugurated. Work commenced with the construction of a wide road in the immediate vicinity of the DNP, which was designed to transport the material needed to erect this infrastructure.

According to information available from authorities, the environmental impact assessment shall be performed in the very near future. The said study is expected to identify the negative impacts of developing port activities on the DNP and the entire region of the Mauritanian lower delta, which represents an extremely fragile ecosystem. The study should also propose mitigation measures to reduce the impact of this infrastructure on the region's flora and fauna.

I. 7. Conclusion

The DNP and its periphery are located in the immediate vicinity of the Senegal River Delta. From an ecosystem disturbed by drought, construction of the Diama dam and embankments, the region, thanks to successful collaboration between the DNP and its technical and financial partners, is now evolving into a harmonious and "balanced" ecosystem featuring a variety of habitats and exceptional biological diversity. Initial assessment results (bird counts and fish landing estimates) suggest a clear improvement in the situation in 2017. Indeed, the bird count conducted in January 2017 reports 248,000 birds, versus 87,000 for the same period in 2016. With regard to fishing, the DNP estimated that between November 2016 and March 2017, catches from the mainland amounted to 112 tonnes vs. 38 tonnes for the same period the year before. This improvement was also qualitatively reflected in the vegetation, with significant regeneration of tiger lotus (*Nymphaea lotus*), jungle rice (*Echinochloa colona*) and dropseed (*Sporobolus robustus*).

This region of great biological diversity remains subject to major challenges such as the spread of typhas in the river and certain basins, misuse by humans of natural resources (wood, fisheries, aquatic, etc.), poaching, development of agriculture (especially the use of pesticides), climate change, etc. Construction of the port at the edge of this region shall take into account the fragile nature of the Mauritanian delta ecosystem in order to mitigate its impact. Uncontrolled development of port-related activities could have dramatic consequences for flora and fauna in this delta region.



Map 1: Hydrology and Locations of Population Centers in the DNP and its Periphery (Source: DNP)

II. Chatt Tboul Reserve

Historically, the Senegal River delta covered an extensive area and flooded a considerable portion of the surrounding lands. The surface area of the basin could reach up to 334,000 km^2. Chatt Tboul (formerly known as the *Embouchure des Maringouins*) was the northernmost of several former mouths of the river. The fluvial and coastal dynamic was the reason for the river's shift during the Holocene (Duvail, 2001).

Chatt Tboul and its region (Aftout Es Sahli in particular) were covered with freshwater in periods of strong river flows. In times of low flow, the influence of the sea dominated, penetrating inland through a navigable waterway (Hamerlynck and Duvail, 2003). Tide waters could submerge the lagoon via this channel, which measured 1.2 km wide. The said waterway gradually contracted. Tricart in Duvail (2001) opines that "*its disappearance is quite recent. Ships may have still been sailing here in the 17th century.*" The channel was navigable as late as the 18th century, according to Hamerlynck (2003). According to Mauny (1961), pirogues could make it upstream as far as Aftout by passing through the pool known as *Marigot des Maringouins*.

Chatt Tboul is now a depression that lies below sea level. It has a floodable surface area estimated at 6,000 ha, split between two lakes: Mulets Lake in the west with stable depth and salinity, and Grand Lac in the east, which is heavily influenced by flooding. The depth and salinity of the latter depend on the fresh water flow (Ould Limmame, 2011). Aftout Es Sahli, from which Chatt Tboul can hardly be dissociated, constitutes a natural northward extension of the depression.

The lands adjacent to Chatt Tboul are uninhabited. A surveillance post belonging to the Mauritanian Navy is found here, which affords better protection against unlawful activities (poaching, discharges, etc.) that might be observed elsewhere. This helps ensure the tranquility needed by certain bird colonies to move into the area and to reproduce.

II. 1. Legal Framework / Status

Chatt Tboul is considered a natural reserve (by internal decree of the Mauritanian Navy) and is managed by the Mauritanian Navy, which operates a surveillance post there. It became a RAMSAR site on November 10, 2000. In 2005, Mauritania's Chatt Tboul and Diawling National Park (DNP) and Senegal's Djoudj National Bird Sanctuary, Langue de Barbarie National Park, Guembeul Natural Reserve and Ndiael Reserve merged to form the UNESCO-created Transboundary Biosphere Reserve of the Senegal River Delta.

The fact that Chatt Tboul belongs to these two entities could improve its national status.

II. 2. Ecological Value of Chatt Tboul

The Chatt Tboul, a former mouth of the Senegal River, which may be flooded via managed flood releases from the Cheyal, Lekser and Aftout Es Sahli sluice gates, as well as by the sea, is part of a broader ecosystem stretching from the basins of the DNP (as well as other basins) to Aftout Es Sahli (Map 2). This ecosystem forms the Mauritanian lower delta, which is an integral part of the Transboundary Biosphere Reserve of the Senegal River Delta.

Chatt Tboul is an important bird conservation area, hosting considerable numbers of migratory birds, notably greater and lesser flamingos (Diagana and Diawara, 2015). Hence, during the dry season, it represents (together with the Diawling basin) a favored site for non-migratory birds due to the permanent presence of water (Barry, 2004).

In 2012, survey efforts revealed significant concentrations of birds at Chatt Tboul, notably gulls/terns and shorebirds (PARCE, 2012). BirdLife International considers Chatt Tboul to be a critical site for waterbirds in West Africa, as it meets the following criteria (BirdLife Int., 2013):

- The site regularly or predictably holds significant numbers of a globally threatened bird species;
- The site regularly or predictably holds more than 1% of a flyway or other distinct population of a waterbird species.

II. 2.1. Vegetation

Chatt Tboul is a lagoon that is heavily influenced by the sea, being submerged by the latter during spring tides. The waters are saline and vegetation is salt-tolerant. It is characterized by plants of the goosefoot family (Chenopodiaceae) associated with the tamarisk *Tamarix senegalensis* and *Nitraria retusa* (PARCE, 2012). IUCN-BRAO (2008) reports remnants of an acacia (*Acacia nilotica*) and tamarisk (*Tamarix senegalensis*) forested floodplain, with swaths of dropseed (*Sporobolus robustus)* and sea rush (*Juncus rigidus*), as well as pockets of black vetivergrass (*Vetiveria nigritana*).

Chatt Tboul is believed to be one of the few parts of the delta that has witnessed strong regeneration of the gum arabic tree (*Acacia nilotica*) since 1994 (Diagana, 2000).

II. 2.2. Fauna

Fauna was studied specifically at Chatt Tboul (versus the remaining parts of the lower delta) only in the case of avifauna and aquatic fauna (fish, crustaceans, etc.). Other animals such as reptiles, terrestrial mammals, amphibians, insects, etc., were only studied in a broader context.

In the absence of such studies, it can be assumed that, given that there is no fence separating Chatt Tboul from the rest of the lower delta, wildlife could freely move between this area and the other parts of the delta. For this reason, in this report, we will limit ourselves to brief descriptions of the avifauna and aquatic fauna.

II. 2.2.1. Avifauna

Avifauna includes eared grebe (*Podiceps nigricollis*), populations of Arabian bustards (*Ardeotis arabs*) and lesser flamingo (*Phoeniconaias minor*) (IUCN-BRAO, 2008). According to Diagana and Diawara (2015), lesser flamingos (near threatened species for IUCN) congregate in the permanent lakes of Nter, Lekser and Chatt Tboul after the waters recede in late January every year. These birds arrive at the aforementioned lakes from the floodplains of the lower delta, where large numbers were identified. In 2004, a team from the Working Group International Waterbird and Wetland Research (WIWO) was able to survey more than 3,000 lesser flamingos in the Diawling basin alone. Their only known breeding site in West Africa is found at Aftout Es Sahli, a site adjacent to Chatt Tboul. Juvenile lesser flamingos have been regularly reported at Chatt Tboul since 1998 (Diagana, 2000).

The black-crowned crane (*Balearica pavonina pavonina*), which is listed as vulnerable on IUCN's red list, nests in low stands of *Sporobolus robustus* surrounded by water. It is a year-round resident in the Mauritanian lower delta. It is believed to be abundant in the Diawling-Tichilitt basin in January, and in Chatt Tboul and Aftout Es Sahli in March-April (Diagana and Diawara, 2015). This species was reported at Chatt Tboul during the surveys performed in January 2016 and January 2017.

The results of the censuses conducted by the DNP and its partners in January 2015, 2016 and 2017 show that 69 species of birds were identified at Chatt Tboul (Appendix 2).

The following birds were relatively abundant in 2017, with more than 100 individuals observed at Chatt Tboul (DNP, 2017): garganey (*Anas querquedula*, 4147 individuals), white-faced whistling duck (*Dendrocygna viduata*, 440), white pelican (*Pelecanus onocrotalus*, 399), northern shoveler (*Anas clypeata*, 373), greater flamingo (*Phoenicopterus ruber roseus*, 358), little stint (*Calidris minuta*, 338), northern pintail (*Anas acuta*, 300), Caspian tern (*Sterna caspia*, 169), ruff (*Philomachus pugnax*, 110), and great cormorant (*Phalacrocorax carbo*, 107).

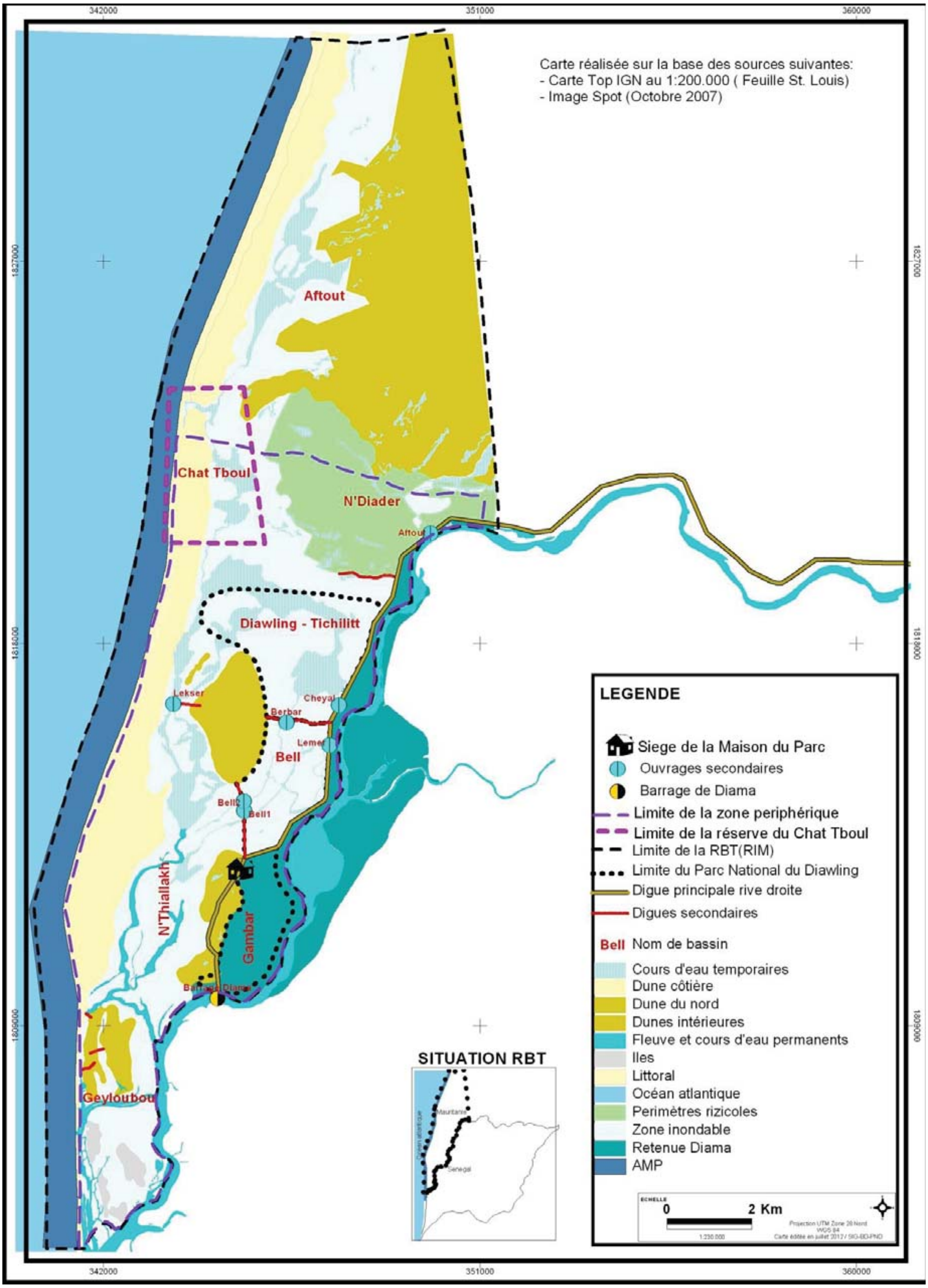
II. 2.2.2. Aquatic Fauna

The aquatic fauna study was conducted by the Mauritanian Institute of Oceanographic Research and Fisheries (IMROP, 2005) with the goal of defining the nursery role of the Mauritanian lower delta.

The results revealed the presence of 84 species affiliated with fresh, brackish or marine water. Several species belonging to several families were observed at Chatt Tboul. These include emblematic families/species such as: Clupeidae (shad), Cichlidae (tilapia), Mugilidae (mullet), Penaeidae (shrimp), etc.

Indeed, the study confirms the delta's importance for the primary species, namely:

- Ethmalose (*Ethmalosa fimbriata*): a euryhaline species capable of living both in marine and estuarine or freshwater environments. This species was heavily fished in the waters of Chatt Tboul, especially in Mulets Lake.
- Mullets: two species were reported in the IMROP study at Chatt Tboul, namely the flathead mullet (*Mugil cephalus*) and the grooved mullet (*Liza dumerili*), species that show high tolerance to variations in salinity.
- Tilapia: belongs to a family (Cichlidae) comprising several euryhaline species. Four species were observed in Chatt Tboul's Mulets Lake (*Tilapia guineensis, Tilapia rendalli*, *Hemichromis fasciatus* and *Sarotherodon melanotheron*).
- Shrimp (*Penaeus notialis* and *Penaeus keraturus*): these species lay their eggs at sea, which hatch into larvae that swim upriver to undergo a growth stage before returning to sea. Indeed, shrimp larvae have been identified entering the lower delta, namely in N'Tiallakh and in Lekser and N'Tock lakes. It is probable that in periods of flooding, these small shrimps occur at Chatt Tboul.



Map 2 – Map of Hydrological Units of the Mauritanian Lower Delta (source: DNP)

II. 3. Conclusion

Chatt Tboul is a former mouth of the Senegal River. Today, it is a lagoon located in the immediate vicinity of the ocean, from which it is separated by no more than a narrow dune ridge. Given that it is connected to the river via two channels, floods help mitigate the salinity of its waters. The vegetation in the area is sparse and low in diversity. However, the wildlife here is more prolific, notably aquatic fauna but especially avifauna.

The site plays a very important role in the lifecycles of waterbirds. For this reason, it was listed as a wetland of international importance (RAMSAR) in 2010. It is a biodiversity hotspot that plays a major role in a larger ecosystem – the lower delta of the Senegal River – where it is an integral part of the Transboundary Biosphere Reserve of the Senegal River Delta.

Various waterbird censuses conducted regularly by the DNP and its technical and financial partners every January have revealed a particularly rich species diversity. A number of special status bird species are observed here (black-crowned crane, lesser flamingo, Arabian bustard, etc.).

Bibliographic References

Abou, A., 2005. Occupation de l’espace de la peripherie du PND : Analyse des conflits et menaces sur le système artificialisé. Master of advanced studies, UNESCO/UCAD Chair in Integrated Management and Sustainable Development in Coastal Regions and in Small Islands: 84 p.

André, A. and N. Chenaval, 2007. Cartographie, caractérisation de la végétation et estimation de l’effectif des phacochères, bassin du Bell, Parc National du Diawling, Mauritanie. DUT (university diploma in technology) internship report, University of Nantes: 123 p.

Barry, E., 2004. Le Parc National du Diawling dans le processus de développement durable du bas delta mauritanien du fleuve Sénégal : conflits d’usages et d’acteurs dans un contexte de changements environnementaux et socioéconomiques. Master of advanced studies thesis, University of Angers, School of Sciences, Department of Geography, 201 p.

BirdLife International, 2013. Projet de conservation des oiseaux migrateurs: examen scientifique des oiseaux migrateurs et de leurs principaux sites et habitats en Afrique de l’ouest. BirdLife International, Cambridge, United Kingdom.

Day J., Dudley N., Hockings M., Holmes G., Laffoley D., Stolton S. & S. Wells. 2012. Application des catégories de gestion aux aires protégées : lignes directrices pour les aires marines. Gland, Suisse: UICN. 36 pp.

Dia, M., 2012. Prise en compte de la gestion environnementale locale dans la planification. Final evaluation of Mauritanian program, Environment and Climate Change thematic window. The Millennium Development Goals (MDGs), September 2012: 95 p.

Diagana, C.H., 2000. Information Sheet on Ramsar Wetlands: Chatt Tboul Natural Reserve (Mauritania). Sheet to be submitted to Ramsar Convention Secretariat, Rue Mauverney 28, CH-1196 Gland, Switzerland.

Diagana, C.H. and Y. Diawara, 2015. Plan d’action national en faveur du Flamant nain *Phoeniconaias minor* et de la Grue couronnée *Balearica pavonina* 2015 – 2020. Nature Mauritanie: 65 p.

Diawara, Y., A. Arnaud, A. Araujo and A. Bechet, 2007. Nouvelles données sur la reproduction et l’hivernage des flamants roses en Mauritanie et confirmation d’échanges avec les populations méditerranéennes. Ostrich, 78(2): pp. 469–474.

DNP, 2005. Définition d’un plan de zonage du Parc National du Diawling et de sa zone périphérique. AFD Group, FFEM. 51 p.

DNP, 2013. Plan d’Aménagement et de Gestion du Parc National du Diawling 2013 – 2017. DNP, GIZ, AECID, ECO-CONSULT, France Volontaires, IUCN and IPADE, Part II, 37 p.

DNP, 2016. Dénombrement international des oiseaux d’eau de la Réserve de Biosphère Transfrontalière du fleuve Sénégal, rive droite (RBT-RIM). Supported by BACoMaB, GIZ and Wetlands International: 30 p.

DNP, 2017. Dénombrement international des oiseaux d’eau de la Réserve de Biosphère Transfrontalière du fleuve Sénégal, rive droite (RBT-RIM). Supported by BACoMaB, GIZ and Wetlands International. Draft report, 34 p.

Dudley, N. (Ed.). 2008. Guidelines for Applying Protected Area Management Categories. Gland, Switzerland: IUCN. x + 86pp.

Duvail, S., 2001. Scenarios hydrologiques et modèles de développement en aval d’un grand barrage: Les usages de l’eau et le partage des ressources dans le delta mauritanien du fleuve Sénégal. PhD thesis in Geography, Louis Pasteur University (Strasbourg I). IUCN, CNRS, FIBA.

Gannett Fleming Environmental Engineers Inc., 1986. . USAID, Dakar, December 1986: 267 p.

Hamerlynck O. and S. Duvail, 2003. La restauration du delta du fleuve Sénégal en Mauritanie. Une application de l'approche écosystémique. IUCN Wetlands and Water Resources Programme (PREZOH) – Blue Series: 95 p.

Hamerlynck, O., 1996. Plan de gestion du Parc National du Diawling et de sa zone périphérique 1996-2001, IUCN-DNP, Nouakchott: 63 p.

Hamerlynck, O., 2004. Mission d'appui à la Révision du Plan de Gestion du Parc National du Diawling et de sa zone périphérique Mauritanie. IUCN and DNP. Mission report: 82 p.

Hamerlynck, O. and F. Cazottes, 1998. Le Parc National du Diawling (Mauritanie) : infrastructures hydrauliques pour la restauration d'une plaine d'inondation et la création d'un estuaire artificiel. Sud Sciences & Technologies n°1 (January 1998): pp. 28-38.

IMROP, 2005. Etude de la fraction juvénile du bas delta mauritanien. Study report prepared by IMROP with contribution from the project for the conservation and sustainable use of mullet in Mauritania. 54 p.

UICN. 2007. Evaluation de l'Efficacité de la Gestion des Aires protégées. Parc National du Diawling, Mauritanie. Tracking Tool, 6p.

IUCN, 1994. Lignes directrices pour les catégories de gestion des aires protégées. IUCN, Gland, Switzerland and Cambridge, UK, 94 p.

IUCN-BRAO, 2008. Evaluation de l'efficacité de la gestion des aires protégées : parcs et réserves de Mauritanie. Publication of Regional Office for West Africa. Protected Areas Programme. ISBN: 978-2-8317-1038-9, 42 p.

Ly, O.K. and S.A.O. Moulaye Zein, 2009. Évaluation économique d'une zone humide : le cas du Diawling, Mauritanie. IUCN, Tenmiya, DNP: 85 p.

Mauny, R., 1961. Tableau géographique de l'Ouest africain au Moyen âge d'après les sources écrites, la tradition et l'archéologie. Mémoires de l'IFAN, n°61, 587 p.

Ould Aveloitt, M., 2014. L'hivernage des limicoles (Aves, Charadrii) des zones humides d'importance majeure en Mauritanie méridionale : Inventaire des espèces et étude phénologique. PhD thesis, Mohammed V University: 195 p.

Ould Limame, A., 2011. Programme en éducation environnementale pour la Réserve de Biosphère Transfrontière (RBT). BAER as part of PARCE project: 91 p.

PARCE, 2012. Synthèse des activités du Projet Appui à la Restauration et à la conservation des écosystèmes de la Réserve de Biosphère Transfrontière du delta du fleuve Sénégal et son aire centrale le Parc National du Diawling. Capitalization report of PARCE project. Spanish Agency for International Development Cooperation (AECID): 129 p.

Sow A.S. and J.C. Brito, 2016. Biodiversité et conservation des amphibiens et des reptiles du Parc National du Diawling et ses zones périphériques. DNP, Research Centre in Biodiversity and Genetic Resources (CIBIO) and RAMPAO, 33 p.

Triplet, P., M. Benmergui and V. Schrike, 2010. Evolution de quelques espèces d'oiseaux d'eau dans le delta du fleuve Sénégal – Période 1989-2010. Faune Sauvage n°289: pp. 6-13.

Appendices

Appendix 1. Results of the 2002 ONS census in the main villages (localities) of the Mauritanian lower delta, as per PARCE (2012)

Locality	ONS 2002
Bneinadji	1140
Mbell village	112
Ebden	434
Ghahra	246
Dar Rahmane	291
Moidina	390
Meftah El Kheir	79
Diemer	89
Arafat	141
Dar es Salam	165
Hassi Aichra	112
Sbeikha Bariel	91
Khaya	55
Meymakh	157
Barbar	53
Mouly	39
Foum Lebhar	95
Ziré Taghredient	543
Ziré Sbeikhat	648
Bouhajra	123
Afdiedier	54
Birette	1001
Diaos 2	340
Diaos 1	254
Gad Mbarek	35
Nemewdiyetou	12
Lorma (Heul Daouda)	31
M'Boyo 2	218
M'Boyo 1	141
Keur Macen	1919
N'Diago	1517
Birette 2	102
Ziré Bouhoubeini	146
Thionk	133
Total	10906

Appendix 2. Number of birds surveyed at Chatt Tboul during censuses conducted on January 15 for the years 2015, 2016 and 2017

Common Name	2017	2016	2015
African fish-eagle *Pygarde vocifer*		*	1
Western reef-heron		2	
Black heron		2	
Little egret	4	120	53
Intermediate egret		6	
Oriental darter		3	
Pied avocet	8		97
Osprey		5	
Black-tailed godwit	60	6	12
Curlew sandpiper		23	518
Little stint	338	418	1359
Sanderling		112	153
Dunlin		32	
Yellow wagtail			28
Montagu's harrier			4
Western marsh harrier	1		1
Northern pintail	300	550	
Northern shoveler	373	554	580
Common greenshank	12	39	64
Spotted redshank	8		
Green sandpiper	2		11
Common redshank		19	5
Common sandpiper	15	7	
Marsh sandpiper			94
Wood sandpiper	6	2	
Ruff	110	5	
Black stork		8	
Long-tailed cormorant	19	121	
Squacco heron	2	1	
White-faced whistling duck	440		250
Black-winged stilt	70	200	191
Black-winged kite	8		
Greater flamingo	358	200	209
Tufted duck		3	
Pratincole sp.		250	
Lesser black-backed gull		132	124
Slender-billed gull	60	101	70
Great cormorant	107	3	89
Common ringed plover	9	114	223
Kentish plover		40	80
Kittlitz's plover		42	

Little grebe		3	
Great egret	63		
Black-crowned crane	2	2	
White-winged tern	20		
Gray heron	50	70	135
Squacco heron			24
Purple heron	10	4	24
Glossy ibis	64		119
Sacred ibis			12
Pied kingfisher		5	2
African jacana	6		
Senegal thick-knee	4		
White pelican	399	171	45
Pink-backed pelican	22		
Little ringed plover	66		
Black-bellied plover		8	
Black crake			8
Garganey	4147	350	463
Eurasian spoonbill	28	292	217
African spoonbill	3		43
Caspian tern	169	29	30
Sandwich tern		24	
Gull-billed tern	4	1	10
Little tern	12	10	
Common tern	27		
Yellow-billed stork	1		
Laughing dove		1	
Spur-winged lapwing	4	7	

* Empty cells indicate that no observations were made

APPENDIX F-2 : NOTE ON PROTECTED AREAS IN THE SENEGALESE PORTION OF THE EXTENDED STUDY AREA OF THE PROJECT

Note on Protected Areas in the Senegalese Portion of the Extended Study Area of the Ahmeyim/Guembeul Project

By

Dr. Papa Samba Ndieub DIOUF

TROPICA Environmental Consultants

Liberté VI, Villa No. 8181 • BP 5335 Dakar-Fann SENEGAL
Phone: (221) 33 867 18 98 - Fax: (221) 33 867 18 99
Email: tropica@tropica-ec.com

August 2017

Project and Study Details	
Project	ESIA for Ahmeyim/Guembeul Offshore Gas Production Project in Mauritania and Senegal
Study for which report is being issued	Note on Protected Areas in the Senegalese Portion of the Extended Study Area of the Ahmeyim/Guembeul Project. Expert study; contribution to the characterization of baseline environmental conditions
Report version	Draft; second version
Author of report	Dr. Papa Samba Ndieub DIOUF, Tropica expert

Distribution List		
Recipient 1	Golder Associates	Project Director
Recipient 2		

Signatories	
Prepared by:	Dr. Papa Samba Ndieub DIOUF
Reviewed by:	Samba YADE, Project Coordinator, Tropica
Approved by:	
Date of transmission:	August 10, 2017

This document has been prepared by Tropica Environmental Consultants (Tropica) in the context of a subcontract with Golder Associates for a contribution to the description of baseline environmental conditions, which is part of the environmental and social impact assessment (ESIA) of the Ahmeyim/Guembeul Offshore Gas Production Project in Mauritania and Senegal initiated by Kosmos Energy Mauritania (KEM) and Kosmos Energy Senegal (KES).

It has been prepared (1) by Dr. Papa Samba Ndieub DIOUF, biologist and expert in fishing, the environment and personal development, (2) in compliance with Tropica's terms of reference, and (3) with data and information obtained from literature and field investigations. In the course of preparing this document, Tropica and its expert have drawn from their know-how, professionalism, rigor and due diligence.

The data and information contained in the document are based on interviews with competent individuals, document reviews and experience in similar studies.

In any case, Tropica assumes no responsibility or liability for the use of the content of this report by any person other than its recipient(s).

Table of Contents

Introduction

This note on the Protected Areas located in the northern portion of the Senegalese coast aims to present these areas of high biodiversity and important socio-economic potential that lie within or partially within the extended study area. Specifically, the note focuses on the following sites:

- Transboundary Biosphere Reserve of the Senegal River Delta;
- Langue de Barbarie National Park (PNLB);
- Djoudj National Bird Sanctuary;
- Saint-Louis Marine Protected Area;
- Guembeul Natural Reserve.

1. Transboundary Biosphere Reserve of the Senegal River Delta

The creation of the Transboundary Biosphere Reserve of the Senegal River Delta (RBTDS) in 2005, with support from UNESCO and IUCN, is the culmination of a long history of cooperation between Senegal and Mauritania for the management of Djoudj National Bird Sanctuary (Senegal), Diawling National Park (Mauritania) and surrounding ecosystems[1].

The general objective of the RBTDS is to promote the conservation of biodiversity and sustainable development based on the participation of local communities and an adapted scientific approach. This is done through the specific objectives of a management policy that are:

- the restoration of hydrological functioning and the promotion of the conservation of ecosystems within a framework of partnership with the different users of the natural resources of the zone;
- conservation of biological diversity and maintenance of the integrity of core areas;
- building the capacity of community structures and experimenting with sustainable development practices ...;
- the establishment of a research partnership with the various structures;
- the appropriation of the Biosphere Reserve concept and its implementation by the various actors;
- the establishment of an efficient coordination structure and management mechanism[2].

The different elements that make up this vast complex of wetlands of international importance are closely interlinked and are subject to threats and degradation processes, the root causes of which are largely shared on both sides of the river.

The RBTDS covers an area of 642,000 ha consisting of a mosaic of protected areas of various status (belonging to different categories of the IUCN classification), agricultural, pastoral and fisheries zones. There are also urban areas, including the city of Saint-Louis, classified World Heritage of Humanity. RBTDS therefore encompasses a great diversity of ecosystems:

- Marine and coastal habitats (Senegal: Saint-Louis Marine Protected Area and Langue de Barbarie National Park; Mauritania: Chatt Tboul Reserve and N'Tiallakh basin);
- Fluvial-lacustrine environments (Senegal: Djoudj National Bird Sanctuary and Trois-Marigots, Ndiaèl Reserve[3]; Mauritania: Diawling National Park, Khouroumbame and N'Dernayé pools);
- Mangroves on the M'Boyo islands in Mauritania, and south and north of Saint-Louis in Senegal;
- Lagoons (Guembeul Natural Reserve and south of Saint-Louis in Senegal);
- Guiers Lake in Senegal and N'ter and N'Tok lakes in Mauritania;

[1] J.F. Noël, 2010. Parc National, quelle faisabilité ? Conséquences en matière de gouvernance de la coexistence Réserve de biosphère/Parc National à l'international. UNESCO, 12 p.

[2] - Anonymous, 2005. Proposal Form for the Transboundary Biosphere Reserve of the Senegal River Delta. UNESCO / MAB, 76 p.
- Pirot J-Y., 2015. Senegal Delta Transboundary Biosphere Reserve: Characteristics, Objective and Opportunities. UICN, 2 p.

[3] The Ndial Reserve lies within RBTDS, but outside the study area.

- Shrub-savanna and shrub-steppe habitats (peripheral zone of Djoudj National Bird Sanctuary and Moïdina forest);
- Coastal and inland dunes: dunes of Ziré and Birette (Mauritania).

In addition to RBTDS's important ecological functions (Palearctic and Afro-tropical migratory birds, fish spawning grounds, etc.), this ecosystem fulfils numerous economic and social functions[4].

From a biodiversity perspective, RBTDS remains a very rich environment despite the constraints of climate change, the construction of the Diama dam and human pressure. Thus, the RBTDS comprises more than 153 plant species, some of which are invasive (*Typha australis*, *Salvinia molesta* and *Prosopis juliflora*). Concerning ichthyofauna, the inventories made mention of more than 87 species, of which 47 species of fresh water and 40 estuarine and marine species. At the level of the crustaceans, about forty species (families of Peneidae and Caridae) are reported. Amphibians are represented by many species of toads (*Bufo sp*.) and frogs (*Rana, Ptychadea*) that are present in the various water points during the rainy season. The reptiles present are mainly turtles (terrestrial, freshwater and marine), snakes, lizards and crocodiles. For marine mammals, different species of dolphins, harbor porpoise (*Phocoena phocoena*), orca whale (*Orcinus orca*), long-finned pilot whale (*Globicephala melas*), are recorded. The listed terrestrial mammals (gazelles, rats, mongooses, jackals, monkeys, Fennecs, warthogs, etc.) belong to 17 species.

The very characteristic avifauna counts 365 species counted on the Senegalese side versus 187 on the Mauritanian side. There are 97 species of Afro-tropical migratory water birds in the Western Palearctic, 8 species of raptors and 56 species of passerines, including 20 migratory birds of the Western Palearctic. This high biodiversity explains the importance of this area[5].

[4] IUCN, 2006. Projet d'appui à la réserve de biosphère transfrontière du delta du fleuve Sénégal. IUCN, 9 p.
[5] PMF/FEM, PNUD and United Nations Foundation, 2012. Contribution de COMPACT dans la Conservation de la Biodiversité - Contribution de COMPACT dans la Conservation de la Biodiversité. PMF/FEM, PNUD et United Nations Foundation, 56 p.

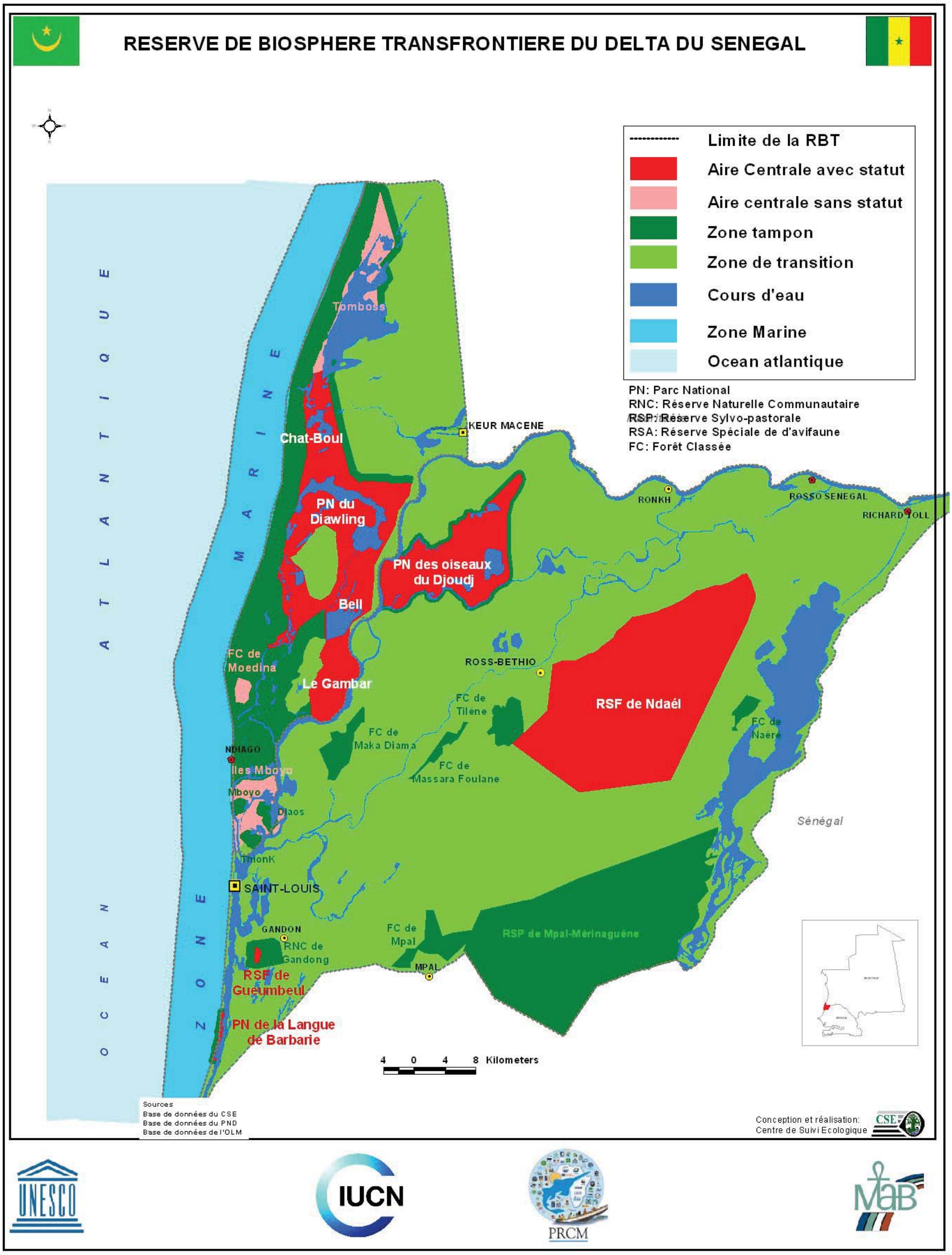


Figure 1. Map of the Transboundary Biosphere Reserve of the Senegal River Delta.
(Source: Revue périodique de la RBTDS réalisée en 2017)

Although RBTDS continues to play an important socio-economic role, numerous constraints threaten its economic balance and may compromise its potential contribution to the sustainable social and economic development of the communities that reside there (COMPACT, n.d.)[6].

The hydro-agricultural infrastructure in RBTDS has contributed to the development of important socio-economic activities. However, at the same time, it has led to an altered surface water regime and a shallow saline groundwater table. This has resulted in a significant ecological disturbance characterized by:

- The degradation of the quality of the river waters due to pollution generated by agriculture[7];
- The development of invasive aquatic plant species (Pistia stratiotes, Salvinia molesta, Typha australis, Prosopis juliflora);
- The degradation of certain woodland areas such as the stands of gum arabic (Acacia nilotica) and the strip of Australian pine (Casuarina equisetifolia) along the coast, partly due to permanent waterlogging and erosion;
- Reduced fishing potential both in fresh and brackish/salt waters[8];
- The decline of grazing lands;
- Soil salinization, notably below the Diama dam.

The administration of the RBTDS is governed by a formal agreement between the government authorities of Mauritania and Senegal. The diversity of legislative texts at the level of each country and their low harmonization are problematic both at national and cross-border level. A special harmonization effort must be undertaken.

The downgrading of protected areas and the encroachment of agribusiness on the central cores (Senhuile for example) constitute a constraint that the inclusion as a biosphere reserve would have prevented, due to the joint involvement of the two countries.

The authorities responsible for coordination / management of the RBTDS are:

- The ministries in charge of the environment of the two countries;
- A Transboundary Management Unit;
- Two focal points from both countries who are conservators.

The governance of the RBTDS is ensured by:

- A Transnational Committee;
- Two National Committees;
- A Scientific Committee;
- A Transboundary Coordination Committee;
- A Transboundary Management Unit.

2. Langue de Barbarie National Park (PNLB)

The Langue de Barbarie National Park (PNLB) is located at approximately 15°55'N – 15°917'N and 16°30'W – 16°5'W. The park was created by a decree on January 9, 1976 (Decree No. 76-0016) and spans approximately 20 km^2, stretching from the Gandiole lighthouse in the north to the former mouth of the Senegal River in the south.

[6] COMPACT, n.d., Projet de documentation et de diffusion des meilleures pratiques des projets COMPACT dans la Réserve de Biosphère transfrontière du delta du fleuve Sénégal (RBT). PIVF/PFEM, UNDP, UN Foundation, 54 p.
[7] Diouf P. S., 2016. Processus de Préparation du projet GEF-UICN RBT fleuve Sénégal. Preliminary report. UICN / PRCM, 16 p.
[8] P.S. Diouf, M. Kébé, L. Le Reste, T. Bousso, H.D. Diadhiou and A.B. Gaye, 1991. Contribution à l'élaboration d'un Plan d'Action Forestier. Pêche et aquaculture continentales. Vol. 1 Diagnostic, CRODT, 325 p.

The objectives in creating PNLB were to ensure the protection of egg-laying sites for sea turtles as well as breeding sites for waterbird colonies (DPN, 2010 a)[9]. PNLB is one of the key components of the Transboundary Biosphere Reserve of the Senegal River Delta.

The park is a fluvial-maritime complex that encompasses:

- A land portion (Langue de Barbarie) consisting of a vast sandy barrier beach between the river and the ocean (between 150 and 500 m wide);
- A maritime/oceanic zone corresponding to a 500 m wide strip;
- The Senegal River (500 m to 1 km wide) with Île aux Oiseaux, the lagoons and tidal marshes of Douti and Lawmar.
- The park's eastern boundary is marked by the shoreline and includes the lagoons of Douti and Lawmar. The southern boundary corresponds to the former mouth of the river.

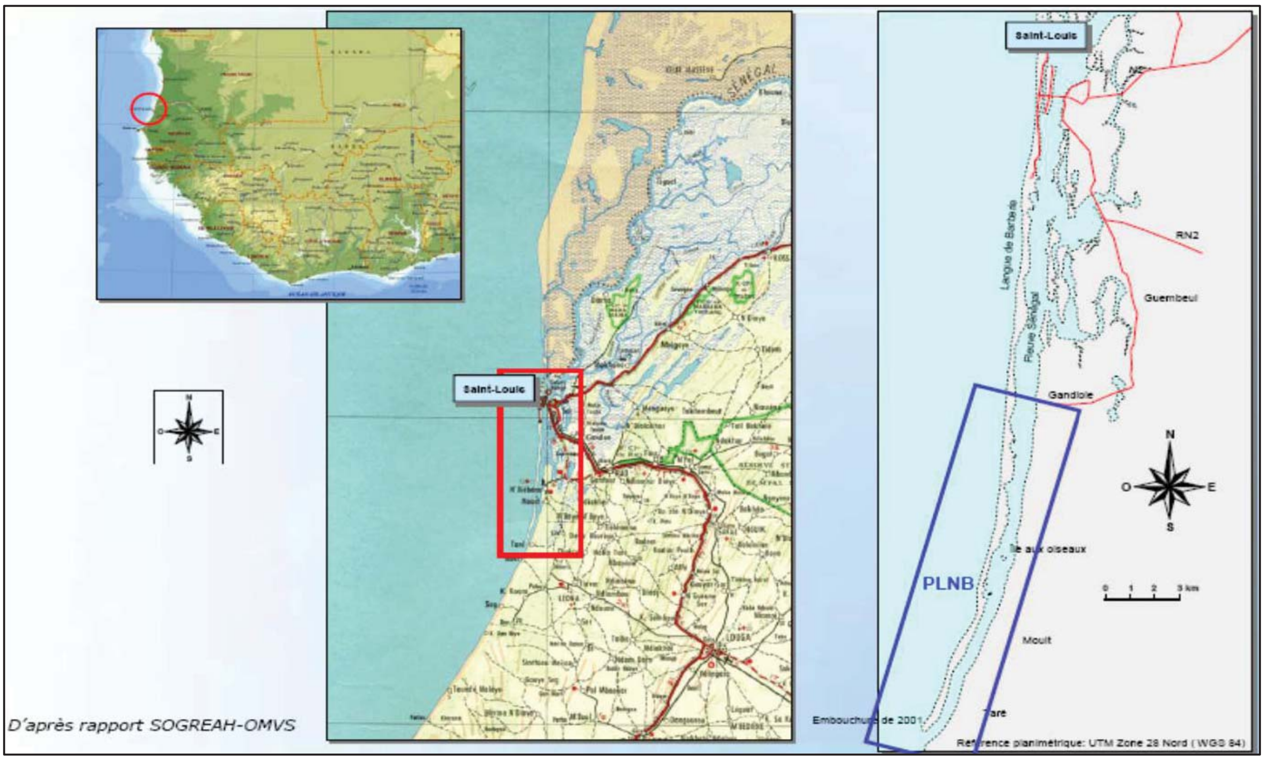


Figure 2. Location of the Langue de Barbarie National Park.

The climate is characterized by a transition between the influences of a continental Sahelian domain and a coastal domain, where isohyets barely reach 300 mm a year.

The park is heavily influenced by the maritime trade wind, which brings with it mild temperatures. Rainfall is low and has been marked by a sharp decline over the past thirty years.

The climate regime is characterized by three main seasons:

- The rainy season, from June to September;
- The cold and dry off-season, from October to February;
- The hot and dry off-season, from March to June.

[9] DPN, 2010 a. Plan de gestion du Parc National de la Langue de Barbarie (2010 – 2014). DPN, 80 p.

The two off-seasons correspond to the migration period of Western Palearctic birds and the breeding season of certain bird species such as gulls and terns.

The opening of a flood relief channel in 2003 located 7 km south of Saint-Louis has resulted in a considerably reduced peak flood level (1.95 m to 1 m). It has also increased the magnitude of the tide in Saint-Louis. Additionally, the Gandiole area no longer experiences very much water flow and now depends almost exclusively on tidal variations and rainfall to improve its water quality.

No rare plant species were identified in PNLB. However, *Salicornia europea* (or *Salicornia senegalensis*) was noted by the IUCN as being endemic to Senegal.

PNLB is home to important breeding colonies of gulls, terns, herons and egrets. Its Îlot aux Oiseaux is home to gulls (Laridae), herons (Ardeidae) and shorebirds. Some of these species are breeders: gray-hooded gull (*Larus cirrocephalus,* 3,000 pairs), slender-billed gull (*Larus genei*, 2,000-3,000 pairs), royal tern (*Sterna maxima*, 2,000-3,000 pairs), Caspian tern (*Sterna caspia*, 150 pairs), little tern (*Sterna albifrons*, 35 pairs), western reef-heron (*Egretta gularis*, 126 pairs in 1998), and gull-billed tern (*Sterna nilotica*, 200 breeding pairs) which is at the southern edge of its breeding range (DPN, 2010).

Audouin's gull (*Larus audouinii*), sandwich tern (*Thalasseus sandvicensis*), little tern (*Sternula albifrons*), greater flamingo (*Phoenicopterus roseus*) and Eurasian spoonbill (*Platalea leucorodia*) have also been reported. The site is also known for its importance in osprey (*Pandion haliaetus*) (DNP, 2010 a).

From a biological perspective, fish populations have changed, with reduced numbers for freshwater species and with increased numbers for brackish water species (COMPACT, n.d.)[10].

Wild mammals of PNLB include the African savanna hare (*Lepus crawshayi*), striped ground squirrel (*Xerus erythsopus*), patas monkey (*Erythrocebus patas*), Egyptian mongoose (*Herpestes ichneumon*), Gambian pouched rat (*Cricetomys gambianus*), striped polecat (*Ictonyx striatus*), common genet (*Genetta genetta*) and golden jackal (*Canis aureus*).

Since 2005, two species of marine mammals have been found to frequent the waters of PNLB: short-beaked common dolphin (*Delphinus delphis*) and Mediterranean monk seal (*Monachus monachus*) (DPN, 2010 a).

Invertebrates frequenting the park were not surveyed. However, the presence of molluscs, crabs, shrimp and various insects is noted.

Land reptiles identified include the Nile monitor (*Varanus niloticus*), puff adder (*Bitis arietans*), elegant sand racer (*Psammophis elegans*), black mamba (*Dendroaspis polylepsis*) and sea turtles (green sea turtle (*Chelonia mydas*) loggerhead sea turtle (*Caretta caretta*) and leatherback sea turtle (*Dermochelys coriacea*)).

The ichthyofauna of PNLB and surrounding areas is not well known. Surveys have revealed 46 marine, estuarine and fluvial species representing 41 genera.

The most abundant species harvested in the estuary are tilapia (*Sarotherodon melanotheron*), mullet (especially *Mugil cephalus*), ethmalose (*Ethmalosa fimbriata*) and bagrid catfish (*Chrysichthys nigrodigitatus*).

Since the flood relief channel was opened, the lower delta has witnessed on one hand, a decline in the numbers of river fish (ethmalose, mullet) and shrimp, and on the other hand, an increase in the carp population.

The park features a certain number of historic sites, notably the lighthouse, the Balacos district and the colonial surveillance canon at the mouth of the river (DPN, 2010 a).

It should be noted that after the difficult episodes for fauna and flora during the drought years, the conservation status of biodiversity in the Langue de Barbarie National Park has significantly improved (Diouf, 2016)[11]

---

[10] COMPACT, n.d., Projet de documentation et de diffusion des meilleures pratiques des projets COMPACT dans la Réserve de Biosphère transfrontière du delta du fleuve Sénégal (RBT). PIVF/PFEM, UNDP, UN Foundation, 54 p.
[11] Diouf P. S., 2016. Efficacité de gestion des Aires Protégées du Sénégal. UICN, 37 p.

3. Djoudj National Bird Sanctuary

Djoudj National Bird Sanctuary (PNOD) is located within RBTDS and covers 16,000 ha[12]. Its long-term management objective is to preserve biodiversity while taking into account the socio-economic aspects and the cultural potentialities of the site and its periphery.

PNOD is registered as:

- A Wetland of International Importance under the Ramsar Convention (1977);
- A UNESCO world heritage site (1981);
- An Important Bird Area (IBA) designated by Birdlife international.

Moreover, this park is one of the cornerstones of RBTDS. However, due to the degradation of its fundamental ecological characteristics owing to the proliferation of *Salvinia molesta*, PNOD was listed in 2000 on the Montreux Record (Ramsar Convention) as well as on the UNESCO's List of World Heritage in Danger. It was removed from the latter in 2006, and from the Montreux Record in 2009 (DPN, 2010b). The problem of the proliferation of *Salvinia molesta* has been solved by biological control and better management of the water level in the Park.

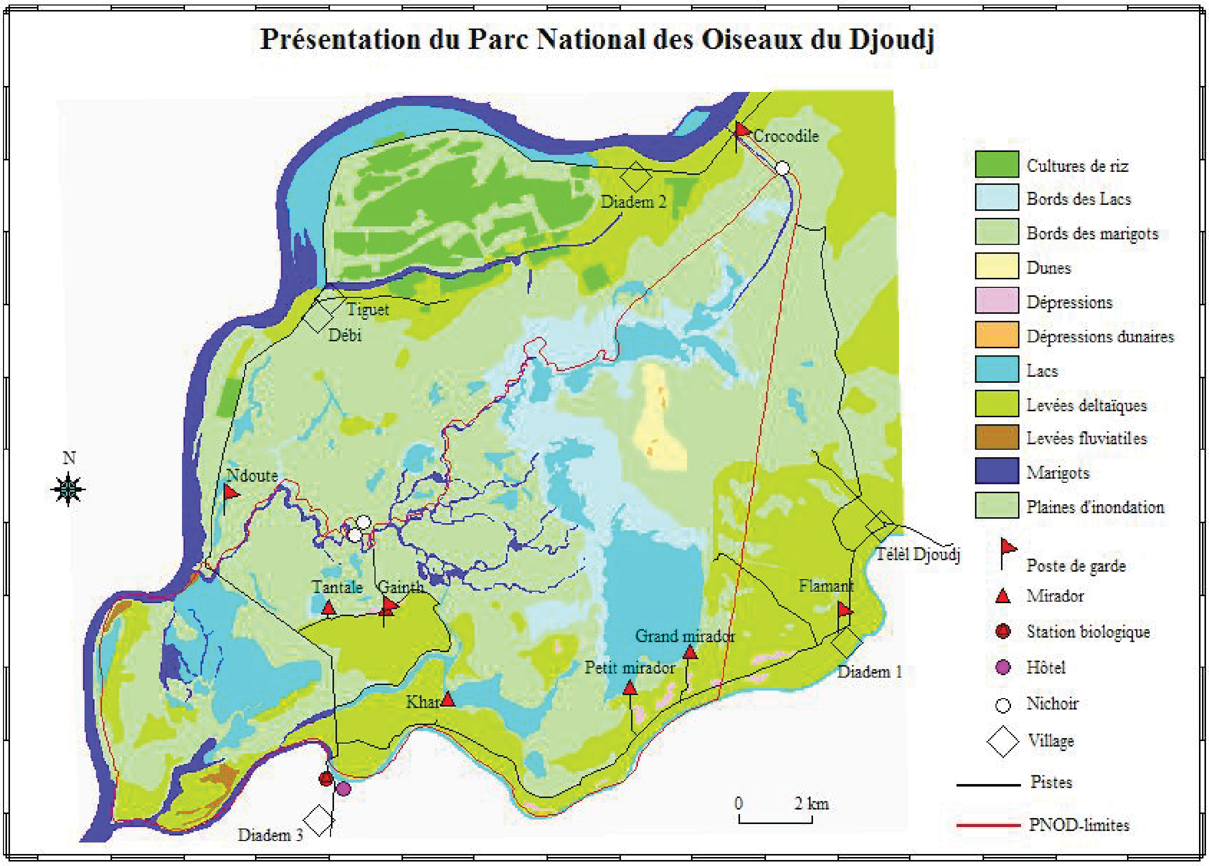


Figure 3. Djoudj National Bird Sanctuary.

[12] DPN, 2010b. Plan de Gestion du Parc National des Oiseaux du Djoudj (2010 – 2014). DPN, 67 p.

The climate is very similar to that of Langue de Barbarie National Park.

The Senegal River delta has been characterized by two different hydrological regimes (the natural regime and the post-dam regime), each of which has shaped the way the PNOD functions.

The artificialized system translates into flood regulation, low water replenishment during the dry season, water flow control throughout the Delta and protection of these lands from salt intrusions. These major modifications have resulted in the proliferation of aquatic plants in the Djoudj depression.

Since the dam has been commissioned, consecutive flooding has created:

- Numerous water bodies rich in fish fauna;
- Fertile lands for growing millet, corn and vegetables;
- A dense and herbaceous vegetation covering the drained areas, which serve as forage for livestock late into the dry season;
- Significant expanses of water covered in tiger lotus, a food supplement enjoyed by local inhabitants;
- Complete colonization of shallow water bodies by Typha australis;
- Colonization of water bodies by numerous invasive species, making it necessary to develop a control strategy based essentially on biological methods.

PNOD's flora consists of 132 species belonging to 99 genera and 48 families. The flora is predominantly herbaceous, with more than half of the species being annuals. Perennial herbaceous and woody species also make up a non-negligible proportion. The flora of PNOD is characterized by a strong presence of pantropical, Afro-Asian and cosmopolitan species at the expense of strictly African species. In this regard, PNOD appears to be a site of rich biodiversity due to the diversity of ecosystems present in a relatively confined area (Noba et al., 2010)[13].

The flooded areas contain stands of *Typha australis, Sporobolus robustus, Phragmites vulgaris, Nymphae lotus*, etc., which are well represented in the park's extensive swamplands.

The exposed banks are covered with herbaceous vegetation (*Sporobolus*, Cyperaceae and Gramineae species).

Avifauna is very diverse, with 327 species having been identified. The site is of international importance for 15 to 20 species, depending on the year.

In West Africa, PNOD is one of the most important wintering grounds for migratory birds of the Palearctic. The diversity of water bodies (pools, *marigots* and lakes) and the availability of food create favorable conditions for numerous migratory birds to spend extended periods here (six months). Others use the site as a staging area before continuing their journey to their wintering grounds in central or southern Africa.

PNOD has proven to be a critical site for the endangered aquatic warbler (*Acrocephalus paludicola*).

Ichthyofauna is represented by 92 species belonging to 26 families, the most diverse of which are Cichlidae (14 species), Characidae (12 species) and Bagridae (9 species).

The rich ichthyofauna of PNOD and its surrounding areas can be best appreciated if one considers the ratio of the number of species to the surface area of the water bodies: 92 species for a water surface area of 380 km^2 versus 116 species and 89 species, respectively, for the Saloum Estuary (29,700 km^2) and the Gambia River (77,100 km^2).

In the long term, the proliferation of aquatic plants (*Typha australis, Pistia stratiotes, Salvinia molesta*) represents a threat to the development of phytoplankton and, consequently, the development of fish populations. Bird predation also places non-negligible pressure on stocks.

---

[13] N. Noba, M.A. Mbaye, M. Coundoul, A. Kane, P.D. Hane, N. Ba, N. Mbaye, A. Guissé, M. Ngom, F. Amadou, T. Ba, 2010. La flore du Parc national des oiseaux de Djoudj – une zone humide du Sénégal. Sécheresse 21 (1): 71-78.

With regard to mammals, gazelles were reintroduced in the PNOD in 1972 (7 dorcas gazelles from Mauritania; 3 dorcas gazelles from the Hann zoo and 4 red-fronted gazelles from the Presidential zoo) and in 1979 (2 red-fronted gazelles from Morocco). They were released in the Tiguet sector (southwest part of park), where they successfully reproduced. With the commissioning of the Diama dam and the permanent submersion of their ecological range (Tiguet sector) by the waters of the Senegal River, they seem to have abandoned the area. Dorcas gazelles, which had been observed regularly until 1985, are now rare.

Warthogs are regularly observed throughout the park, but their preferred habitat is a swampy area. Their number remains to be determined, though they seem to be increasing rapidly.

Bands of patas monkeys roam various sectors of the park. The size of the population and the number of bands are not known.

The jackal, which is considered to be numerous, was not surveyed, and information on the ecology of this species remains vague.

The nocturnal and highly secretive caracal and African wildcat are present in PNOD, but neither their ecology nor their habitat has been studied.

The genet, civet and Egyptian mongoose are present. The permanent presence of water caused by the dam appears to have favored their abundance.

In 1993, the porcupine was observed in daylight hours for the first time in the Flamant sector, east of the park. Its presence is most often noted by the signs it leaves (e.g. shedding of quills).

The manatee, an aquatic mammal, suffered heavily from the drought and the water shortage in the park from 1979 to 1983. Up until 1987, there were no more than 4 animals: two individuals present in PNOD waters at the time the park was created, a third individual from Guiers Lake introduced in 1975, and a calf that was born in the park. Prospecting activities currently being carried out have again revealed the presence of manatees in the river. They reach the water intake structures in the park that prevent them from continuing.

4. Saint-Louis Marine Protected Area

The Saint-Louis Marine Protected Area (MPA) was created by Presidential Decree No 2004-1408 on November 4, 2004. The MPA covers 496 km2 (49,600 ha) and is located in the department of Saint-Louis, on the seaboard of the Commune of Gandon (eastern boundary of MPA) and the Commune of Saint-Louis in Rao arrondissement, on the Langue de Barbarie spit located between the former mouth of the Senegal River and the Guet Ndar fishing district (Ndong et al., 2010[14], COMPACT, n.d.[15]). The objective of the Saint-Louis MPA is to contribute to the conservation of the biodiversity, to increase the fisheries yields and to improve the socio-economic benefits for populations.

The specific objectives are:

- To conserve habitats and species;
- To improving the living conditions of local populations;
- To promote environmental education and public awareness;
- To improve the efficiency of the management of the MPA (DAMPC, 2014)[16].

[14] M.S. Ndong, N. Diop, A. Kane, A. Coly, A.A. Diédhiou, and I. Diallo, 2014. Plan d'aménagement et de Gestion de l'Aire Marine Protégée de Saint-Louis. DAMCP, 40 p.

[15] COMPACT, n.d., Projet de documentation et de diffusion des meilleures pratiques des projets COMPACT dans la Réserve de Biosphère transfrontière du delta du fleuve Sénégal (RBT). PIVF/PFEM, UNDP, UN Foundation, 54 p.

[16] DAMPC, 2014. Plan d'aménagement et de Gestion de l'Aire Marine Protégée de Saint-Louis – Révision 2014-2018, DAMPC / Tropis / Idev, 40 p.

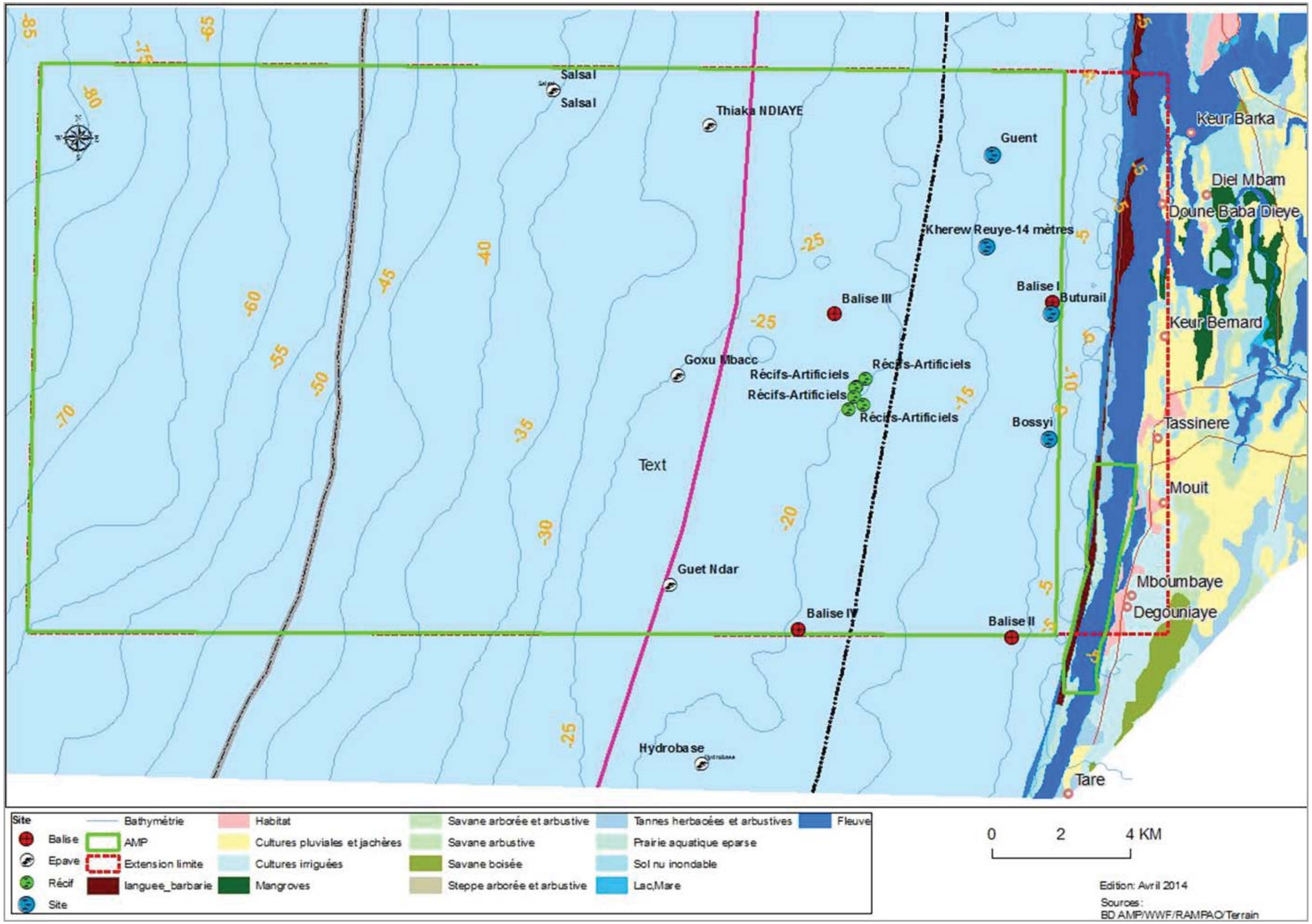


Figure 4. Location of the Saint-Louis MPA. (Source: Sarr, 2015)

The climate is Sahelian. Two main seasons characterize the climate regime: a dry season marked by the maritime trade winds and a rainy season. The evolution of maximum monthly mean temperatures is bimodal, while that of minimal monthly mean temperatures is unimodal.

The winds that drive the upwelling phenomena play an important role in physical, chemical and biological processes and have an effect on many human activities.

The Saint-Louis MPA contains numerous habitats that offer refuge, spawning and nursery grounds, primarily for demersal and benthic species (Sarr, 2015)[17]. This is especially the case of the place known locally as "Xerwu reywi", where the majority of fishing activities take place within the MPA. This site is popular amongst fixed-net fishermen due to its excellent fishery, which is enhanced by the presence of rocks (Ndong et al., 2010).

In light of its extremely rich biological resources, the Saint-Louis MPA harbors an important socio-economic potential.

The flora of the MPA is characterized by a vast expanse of mudflats with grass beds dominated by eelgrass (Zostera noltii) and sea grasses Cymodocea offering a complex food web. Generally speaking, primary phytoplanktonic productivity and that of the epiphytic grass bed complex off the coast of Saint-Louis are still poorly understood and warrant being better quantified through scientific studies and regular ecological monitoring according to the seasons (Ndiaye Diop, 2013).

In the Langue de Barbarie sector, crabs represent the most visible part of the dense and diverse benthic fauna, the specific composition and abundance of which still little is known. They invade the foreshore by the thousands in periods of low tide.

Fluctuations in the fish abundance owing to alternating cold and warm seasons and to reproduction cycles are noted for migratory species, especially pelagic species such as sardinella. On the other hand, a marked decline in the stocks of coastal demersal species has been observed due to overfishing on account of their high commercial value (Ndong et al., 2010) and degradation of their habitats. Fishing is one of the most important traditional uses of the Langue de Barbarie for local inhabitants, especially since river fishing in Saint-Louis has declined.

With regard to coastal demersal species, their distribution is strongly dependent on the sediment characteristics of the sea floor (muddy, muddy-sandy, or rocky) and the depth. Based on these factors, three primary communities can be distinguished: the Sciaenidae community, the Sparidae community, and the continental shelf break community.

Observations of cetaceans at sea and accidental strandings on the beaches of Langue de Barbarie have provided evidence of the presence of whales, common bottlenose dolphin (*Tursiops truncatus*) and Mediterranean monk seal (*Monachus monachus*). These species are ranked by the IUCN as "Vulnerable" and threatened with extinction (Ndong *et al.*, 2010; IUCN, n.d.[18]).

Even if the Atlantic side of the Langue de Barbarie is a nesting site for sea turtles, fishers admit that nowadays, their presence seems to be mostly anecdotal. Strandings, signs and/or carcasses of four species were reported:

- The green sea turtle (*Chelonia mydas*), a herbivorous species, is observed most.
- The hawksbill sea turtle (*Erethmochelys imbricata*) is generally encountered in shallow waters;
- The leatherback sea turtle (*Dermochelys coriacea*) is a species of the high seas that approaches the coast only every other year to lay its eggs.
- *Lepidochelys olivacea* and *Lepidochelys kempii* are species that are observed less frequently.

The Saint-Louis MPA is traversed by bird migration corridors that also pass through Langue de Barbarie National Park and Djoudj National Bird Sanctuary. The presence of large numbers of herons and gulls has been favored by the sand banks that formed after the flood relief channel was cut into the Langue de Barbarie in 2003 (Ndong *et al.*, 2010).

---

[17] Sarr M., 2015. Rapport de suivi écologique de l'AMP de Saint-Louis en saison froide, mars 2015. National Parks Department, 7 p.

[18] IUCN, n.d. La liste rouge des espèces menacées de l'UICN (available in English as: The IUCN Red List of Threatened Species). IUCN, 2 p.

5. Guembeul Natural Reserve

The Guembeul Natural Reserve (RSFG) was created in 1983 by Decree No. 83550. The reserve covers 720 ha with a completely fenced-off perimeter measuring 12 km. Within the reserve is a 340 ha depression that is home to several species of birds. This depression divides the reserve into two adjacent zones.

This reserve was designated a Ramsar Wetland of International Importance in 1986. Indeed, RSFG's depression represents one of the most important nesting and feeding sites for shorebirds and greater flamingos. It is also home to one of the largest concentrations in the world of the pied avocet (*Recurvirostra avocetta*) (DPN, 2010 c)[19].

Since 2005, RSFG has been one of the cornerstones of the Transboundary Biosphere Reserve of the Senegal River Delta (RSFG, 2016)[20].

The management objective of the Guembeul Natural Reserve is to preserve and restore biodiversity while taking into account the socio-economic aspects of the site and its periphery.

The climate is Sahelian-Sudanese with rainfall that varies between 200 and 300 mm a year. Soil is sandy hydromorphic, but halophile along the depression.

Temperatures range from 21°C to 24°C between December and May and from 25°C to 29°C from April to November. The low variability in temperature and the mild weather throughout the year are attributable to the influence of the ocean (RSFG, 2016).

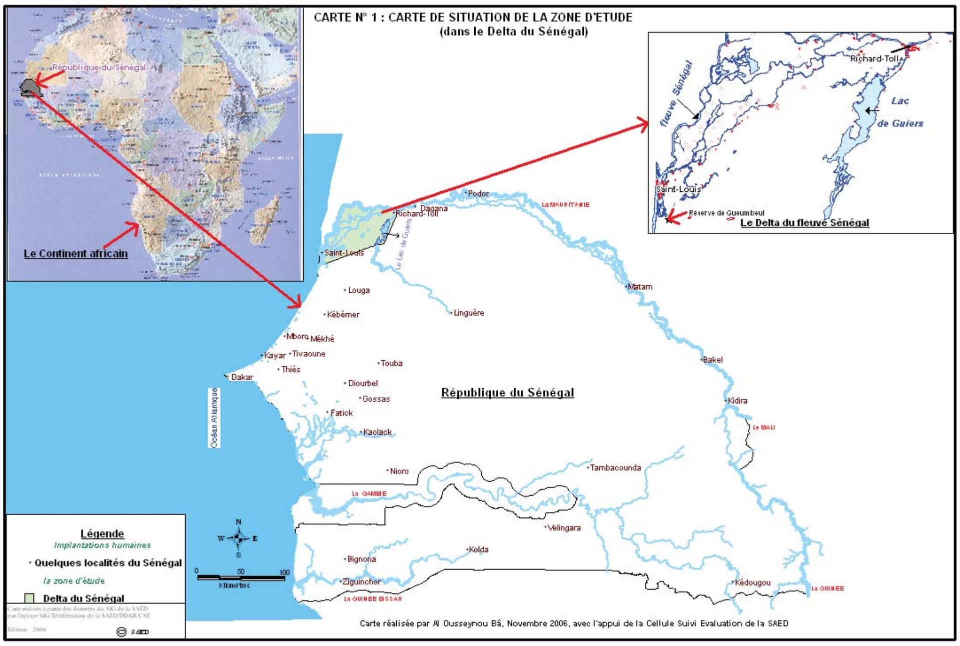


Figure 5. Location of the Guembeul Natural Reserve.

[19] DPN, 2010 c. Plan de Gestion de la Réserve Spéciale de Faune de Guembeul (2010 – 2014). DPN, 67 p.

[20] RSFG, 2016. Template de la situation de référence de la réserve spéciale de faune de Guembeul (RSFG). DPN/RSFG, 7 p.

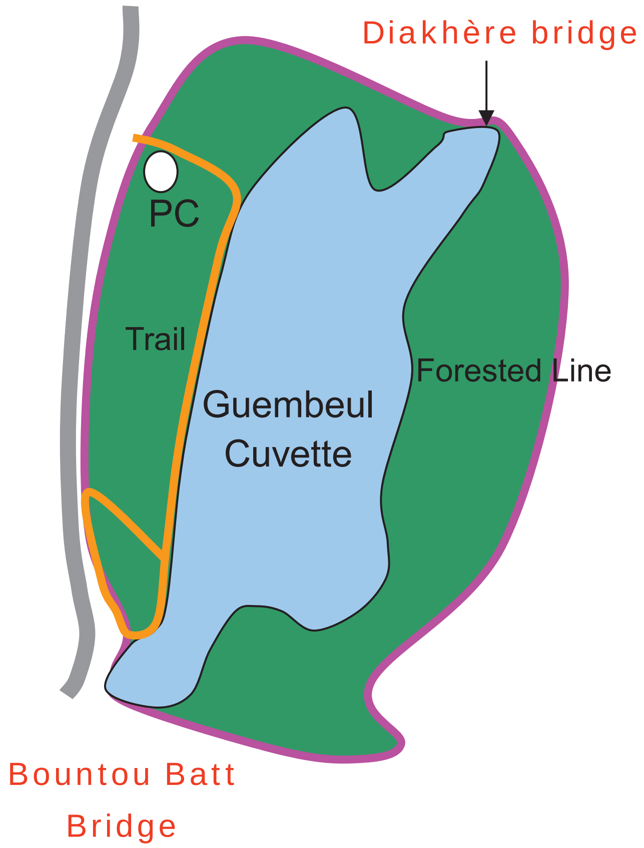


Figure 6. Reserve Map Showing the Cuvette.

RSFG and its adjacent areas lie within the extreme northern part of the Niayes ecosystem, which stretches nearly 180 km, from Dakar to Saint-Louis, across the northern Atlantic fringe of the Senegalese coast. Varying between 30 and 35 km wide, the Niayes are characterized by a succession of dunes and depressions between the dunes located atop a shallow, sometimes visible, groundwater table. These sponge-like wetlands soak up rainwater and then gradually release it during the dry season (RSFG, 2016).

Effects of the Diama dam range from flooding and groundwater salinization to reduced fresh water supply in the mangroves and the disappearance of certain fish species.

The depressions are therefore no longer fed by the fresh water of the river. The waters are brackish or even salty at certain times of the year.

For these seven months, the mangrove swamp is completely submerged in salt water. This situation leads to a high mortality rate of the mangrove, which is a spawning ground for oysters, spiny lobsters and shrimp.

The Sahelian-type vegetation is largely dominated by spinous plants, and consists of two strata: the herbaceous stratum and the shrub stratum (DPN, 2010 c).

- Herbaceous Stratum

The herbaceous stratum is composed of numerous species such as: *Sporobolus festivus, Eragrostis tenella, Dactyloctenium aegyptium, Microchloa indica, Digitaria ciliaris, Echinocholoa obtusiflora, Cenchrus biflorus, Pennisetum pedicellatum, Setaria barbata, Eleusine indica*, etc. The herbaceous stratum is dominated by *Cenchrus biflorus* (known locally as *cram-cram*). *Cenchrus biflorus* is encountered in sandy areas. Most of the other species occupy saline environments, including notably *Salicornia europea*, which grows at the edges of the depressions.

- Shrub Stratum

This layer is made up of four types of species: parasite species, introduced species, salt environment species and non-salt environment species. This woody stratum is dominated by *Acacia, Prosopis* and *Salvadora persica*.

The fauna of RSFG is rich and varied and consists of native fauna and reintroduced fauna (DPN, 2010 c).

- *Native Fauna*

Native fauna consists of the desert warthog (*Phacochoerus aethiopicus*), patas monkey (*Erythrocebus patas*), African spurred tortoise (*Geochelone sulcata*), mongoose, pale fox, genette, reptiles, some birds, etc.

The African spurred tortoise was formerly highly prized by the inhabitants of the Gandiolais for its meat, which led to it nearly being extirpated. This phenomenon was aggravated by the drought in the 1970s. A conservation program for the species has been undertaken at Sangalkam (Noflaay Reserve) and RSFG.

- *Reintroduced Fauna*

Reintroduced fauna is very heterogeneous and consists of wild animals that had disappeared or that have been threatened with extinction in this part of the Sahel since the 1950s. These species are herbivores such as the dama gazelle (*Gazella dama mhorr*), the scimitar oryx (*Oryx algazelle*), as well as the African spurred tortoise (*Centrochelys sulcata*).

Since 1984, RSFG received a herd of seven (7) dama gazelles (mhorr subspecies) offered by the Kingdom of Spain. The reintroduction of these gazelles in the area is the first of its kind in the northern part of Senegal. The favorable conditions of the site have allowed the individuals to adapt well and to successfully reproduce.

Oryx algazelle had been extirpated from the area since 1950. They have been raised in the reserve since 1999. The reintroduction represents the second one after that of the dama gazelles. This reintroduction was carried out as part of an environmental collaboration between the Government of Senegal and the Governments of Israel and France. The initial population numbered eight (8) animals that were imported from the Hai-Bar Nature Reserve in Israel. The oryx have multiplied thanks to a good adaptation to the local environment.

The dorcas gazelles reintroduced in April 2007 with 20 individuals (6 males and 14 females) have also adapted well (DPN, 2010 c).

Addax (*Addax nasomaculatus*), a member of the Bovidae family, were introduced in the reserve on December 17, 2006 with a release of six (6) animals (three (3) males and three (3) females) brought in from Mountain View Farms, Canada. These are white, mid-sized (105-115 cm) antelope with long horns (65-109 cm) and weighing from 70 and up to 150 kg. They proved to be somewhat slow to reproduce, with the first birth taking place on January 2, 2010. It should be noted that this species had never before existed in Senegal (DPN, 2010 c).

The Guembeul depression is an eco-geographical area that is home to major bird colonies. These populations fall into two groups: Ethiopian species and migratory species.

Ethiopian species are those that reproduce on the African continent. They are represented by the pink-backed pelican, white pelican and lesser flamingo. The greater flamingo and especially species of European origin are also present. When the lagoon is under water, it represents the most important roosting site in the entire delta for the Eurasian spoonbill. Individuals of the Banc d'Arguin subspecies have also been observed. The other emblematic species is the pied avocet, local congregations of which have plummeted since the breach was cut into the Langue de Barbarie (DPN, 2010 c).

- *Aquatic Resources*

The Guembeul depression, which is fed by the floods of the Senegal River, represents nearly 1/3 of RSFG's surface area. Fishing is authorized at the farthest reaches of the depression, away from bird nesting grounds. Its water levels are regulated by a system of metal sluice gates located at either end of the depression. Species present include tilapia (*Tilapia zillii, Tilapia dageti* and *Sarotherodon melanotheron*), mullet, *Chrysichthys nigrodigitatus, Elops lacerta*, ethmalose and very small populations of pink glass shrimp, catfish (*Silurus, Arius*) and *Alestes baremoze*. The Senegal bichir (*Polypterus senegalus*) is no longer observed and oysters and cockles have disappeared. The barrier consisting of the sluice gate used to fill the pools, increased salinity and the disappearance of mangroves are the main causes of these losses in biodiversity and productivity. These phenomena are attributable to the construction of the Diama dam and the increasing deterioration of the climate (DPN, 2010 c).

6. Legal and Institutional Framework

6.1 Parks and Reserves under the Supervision of the National Parks Department

National parks and reserves under the management of the National Parks Department of Senegal are under the supervision of the Ministry of Environment and Sustainable Development. They are essentially governed at the national level by two laws, namely the Code of Hunting and Protection of the Fauna and the Forest Code. In addition to these two laws, they often have internal regulations. Some provisions of the Environment and Water Codes are also applicable to the management of parks and reserves.

At the international level, Senegal has ratified a number of conventions related to the management of protected areas, the most important of which are:

- Algiers Convention or the African Convention on the Conservation of Nature and Natural Resources, Algiers, 1968;
- Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar, 1971);
- Paris Convention relative to the Protection of the World Cultural and Natural Heritage (Paris, 1972);
- Washington Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, Washington, 1973);
- Bonn Convention on the Conservation of Migratory Species (Bonn, 1979);
- Berne Convention on the Conservation of European Wildlife and Natural Habitats (Berne, 1979);
- Abidjan Convention on Cooperation in the Protection and Development of the Marine and Coastal Environment of West and Central Africa (Abidjan, 1981);
- United Nations Convention on the Law of the Sea (Montego Bay, 1982);
- Convention on Biological Diversity (Rio, 1992);
- United Nations Framework Convention on Climate Change (Rio, 1992).

According to Law 2013-10 of December 28, 2013, bearing the General Code of Local Collectivities, the peripheral zone of the Parks and the reserves belongs to the terroir zone, placed under the specific competence of the Commune (article 305).

In accordance with the guidelines laid down by the State, local collectivities may, within the framework of their powers, define options for the management of natural resources and the environment.

The management body for parks and reserves consists of a conservator, who coordinates all the activities that take place in the protected area. He is assisted by a deputy, a specialized administrative and technical staff (accountant, drivers, technicians, nurses, etc.).

The conservator ensures the command of the protected area, manages the interfaces between it and the peripheral zones, and is in charge of public relation.

The approach of park and reserve management initially centered primarily on protection, has gradually evolved to give a prominent place to a participatory approach thanks in particular to the strategy of involvement of the shoreline populations initiated by the National Parks Department at the beginning of the years 90.

6.2 Marine Protected Areas

The legal framework governing the management of MPAs relates to the legal regime of the Public Maritime Domain and the legal regime governing sea fishing.

Law 76-66 of 02 July 1976 establishing the State Domain Code defines the legal status of the geographical area erected as an MPA by entering the territorial sea (Art. 5a), i.e., 200 miles (370 km) from the base lines: it is the maritime domain, imprescriptible and inalienable by its nature. Article 20, paragraph 1, of the State Domain Code provides that "No person may, without authorization issued by the competent authority, occupy or exploit a public domain dependency or use it within the limits exceeding the right of use which belongs to all on the parts of this domain assigned to the public ".

Law No. 2015-18 on the Marine Fisheries Code and its implementing decree (No. 2016-1804) constitute the main national instruments for the regulation of sea fishing. The Code applies to all fishing activities in maritime waters under Senegalese jurisdiction.

Article 14 of the Fisheries Code states that the State shall adopt an integrated ecosystem-based management approach, incorporating conservation objectives to ensure the sustainability of species and habitats critical for resource renewal fisheries or the increase of fishery productivity in the fishing zones of maritime waters under Senegalese jurisdiction.

It states in Article 15 that measures for the management and conservation of marine ecosystems shall be taken on the basis of scientific and technical advice. Where necessary, other government departments are involved in the creation and implementation processes. Organizations of professionals in the sector, maritime fishing communities and possibly other stakeholders may be involved in the development and implementation of these measures.

Article 16 of the Fisheries Code empowers the Minister responsible for marine fisheries to establish Marine Protected Areas in the following terms: In order to implement the integrated ecosystem-based management approach, the Minister responsible for maritime fisheries is empowered to create protected marine spaces, fish aggregating devices, artificial reefs and any other system that can participate in the management and conservation of marine ecosystems.

The procedures for setting up and organizing the management of marine protected areas, fish aggregating devices and artificial reefs are laid down by orders of the Minister responsible for sea fishing.

In sub-section 2, entitled "Protected maritime spaces", the code defines protected sea areas as follows: Protected maritime areas are geographically delimited areas to allow free play of the ecological processes, services and functions of protected areas habitats and species to ensure the conservation and sustainable use of the fishery resources therein.

As far as the institutional framework is concerned, the Ministry of Environment and Sustainable Development and the Ministry of Fisheries and Maritime Economy are the main public institutions involved in the creation and management of MPAs. The ministries responsible for the environment and fisheries define the main orientations of the process on the basis of national policies on environmental conservation and socio-economic development. They also have the authority to ultimately decide whether or not to adopt the measures advocated at the end of the process (Sarr, 2005).

The administration of MPAs is now managed by the Department of Marine Protected Community Areas (DAMCP), created in 2012 under the ministry of the environment. This branch is represented by the Conservator (administrative authority) and its team supported by the Department of Fisheries Protection and Surveillance (DPSP) through the Regional Fisheries and Marine Surveillance Service (SRPSM) Management Committee.

In MPAs, for the definition and implementation of concerted management rules, two management bodies are set up: the General Assembly (GA) and the Management Committee (GC), which act under the control and direction of the Conservator.

These bodies have a co-management regime that involves the various stakeholders involved in the creation of the MPA with the support of several partners such as scientific institutions, international organizations and local organizations.

The General Assembly (GA) is the supreme organ of the MPA's participatory management system for lands and natural resources. It is the body which defends the interests of the MPA vis-à-vis the authorities and external users, who reflects and decides on issues that go beyond the peoples' own interests, including joint investment projects. It adopts policies that protect the collective interests of stakeholders and makes decisions on unresolved issues at the level of other decision-making bodies. The AG usually meets once a year. A quorum shall consist of an absolute majority of the members. Decisions shall be taken, if possible by consensus, and in case of impossibility of obtaining it, by the majority of the members present.

The Management Committee is the executive organ of the system and the main decision-making body of the MPA. It is within it that the important issues inherent in the participatory management process of the MPA are debated and "refined", such as monitoring, the application of sanctions, etc. It is also this body which analyzes the proposals for sustainable development initiatives associated with the co-management process that will be submitted to the GA. The Management Committee works in association with all the actors present in the MPA. It creates the conditions of the integrated approach by constituting a place of exchange, information and reflection on the problems of the MPA and the evolution of the marine environment.

The competencies of the GC are as follows:

- Realization of participatory zoning of the MPA;
- Definition of fishing gears to be used in the MPA;
- Management of conflicts between different socio-professional groups;
- Development, adoption and implementation of consensual internal regulations setting out the conditions for access to resources;
- Responsible for day-to-day management of the MPA;
- Assessment of the effectiveness of the proposed management measures;
- Approval and monitoring of management contracts between different stakeholders and conservation services;
- Development of the Annual Work Plan (PTA).

For the sectoral treatment of all these issues, the MPAs have consensually established an executive bureau and technical commissions, divided as follows: a dispute resolution committee, a monitoring committee and a communications committee (DAMPC, 2014)[21].

Conclusion

Pursuant to this review of the Protected Areas along the northern portion of the Senegalese coast, the following conclusions can be made:

- The protected areas constitute expanses of rich biodiversity of local, national and international importance;
- They represent genuine motors of development and a tool for eradicating poverty;
- These sites face a number of anthropogenic and natural threats.

It is indispensable to preserve these sites while further involving the various stakeholders in their management, notably the communities, the private sector, local authorities, local elected officials, technical services and civil society. In doing so, it will be possible to better account for the different, and at times, conflicting priorities of interest groups and to anticipate potential abuse or encroachment of these sites, which are of critical importance for biodiversity and for the social/economic lives of the local populations.

[21] DAMPC, 2014. Plan d'aménagement et de Gestion de l'Aire Marine Protégée de Saint-Louis – Révision 2014-2018, DAMPC / Tropis / Idev, 40 p.

APPENDIX G: BIOPHYSICAL BASELINE SUPPORT MATERIAL

Appendix G
Biophysical Baseline Support Material

APPENDIX CONTENTS

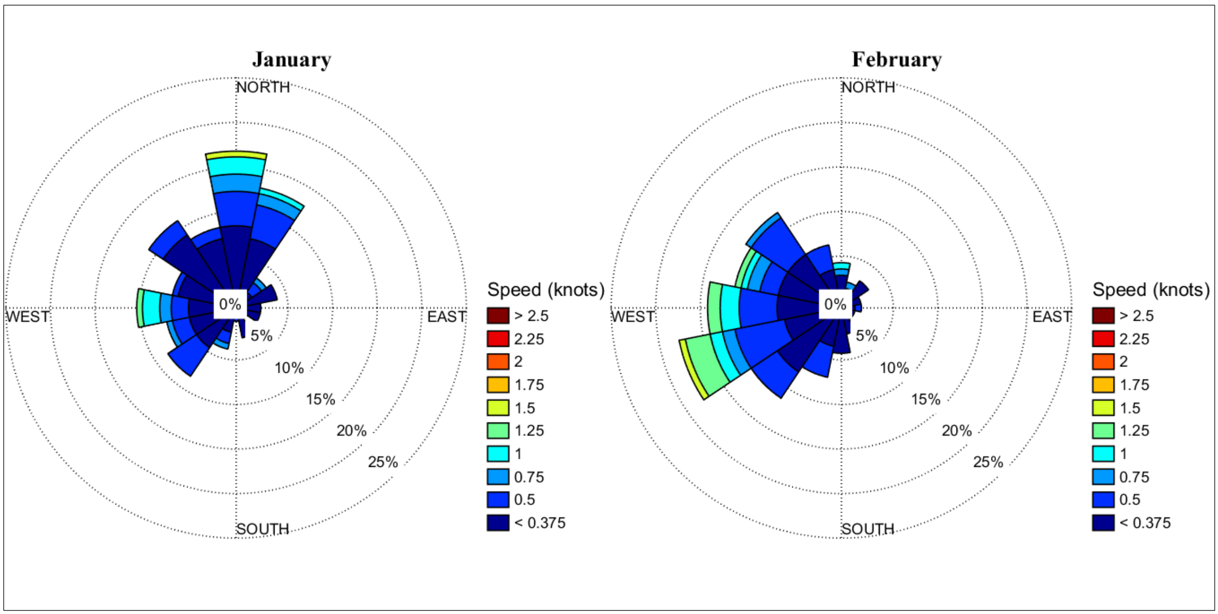
This appendix provides supplementary information compiled from a review of available peer-reviewed literature, grey literature and unpublished reports in support of Chapter 4 of the ESIA report dedicated to the description of the host environment.

The following material covers multiple resource areas of the physical, chemical, and biological environments and it is presented in the following subsections:

- G.1 Oceanography
- G.2 Ichthyoplankton
- G.3 Zooplankton
- G.4 Fishes
- G.5 Marine and Coastal Birds
- G.6 Marine Mammals
- G.7 Sea Turtles
- G.8 Shoreline Characterization
- G.9 Marine Mammals and Sea Turtles and Anthropogenic Sound
- G.10 Sampling Parameters for Seawater and Sediments
- G.11 Literature Cited

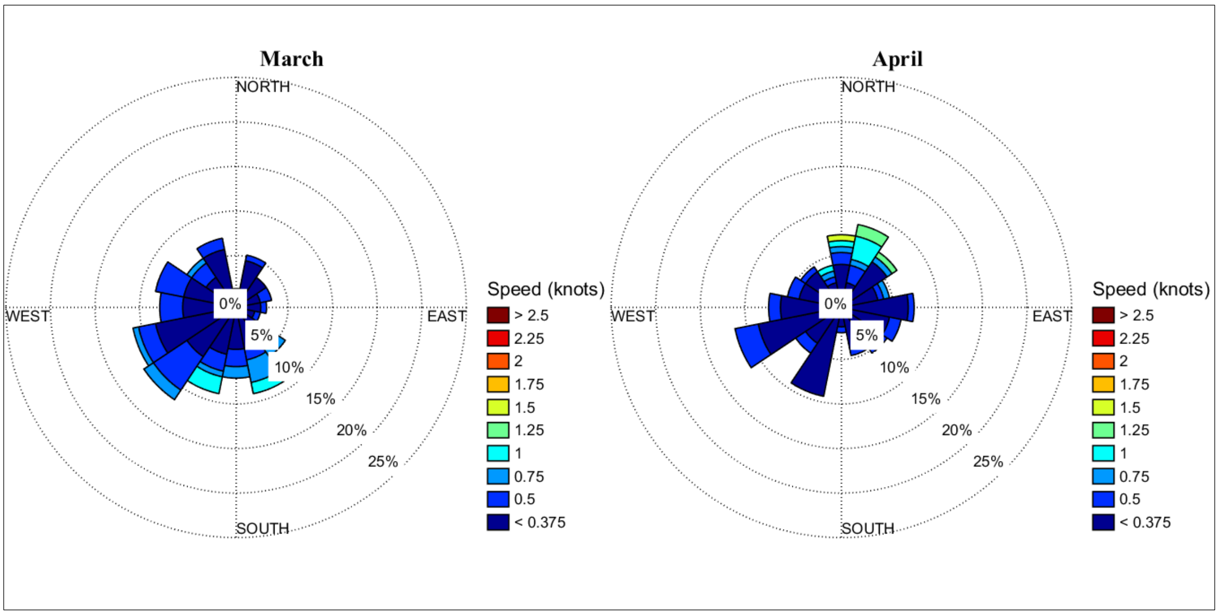
G.1 Oceanography

Current speeds and direction vectors for the Offshore Area, in 2 month groupings, are presented in Figures G-1 through G-6.



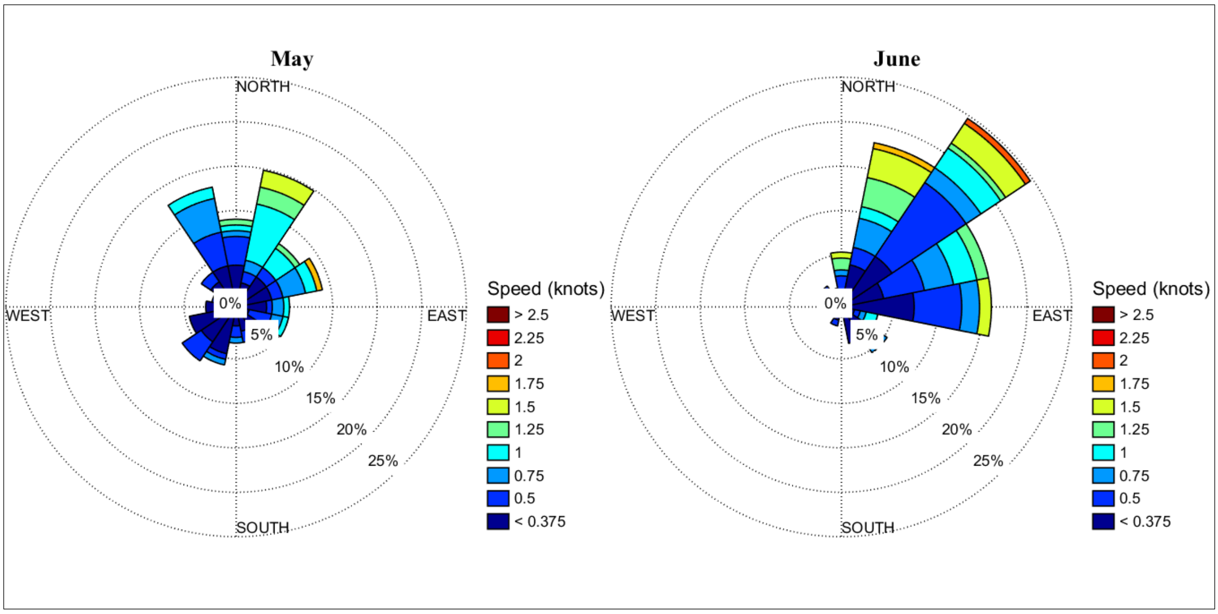
(From: Horizon Marine, Inc., 2015)

Figure G-1. Distribution of surface current speed and direction in the Offshore Area (15.57°N, 17.61°W) from Global HYbrid Coordinate Ocean Model data for January and February.



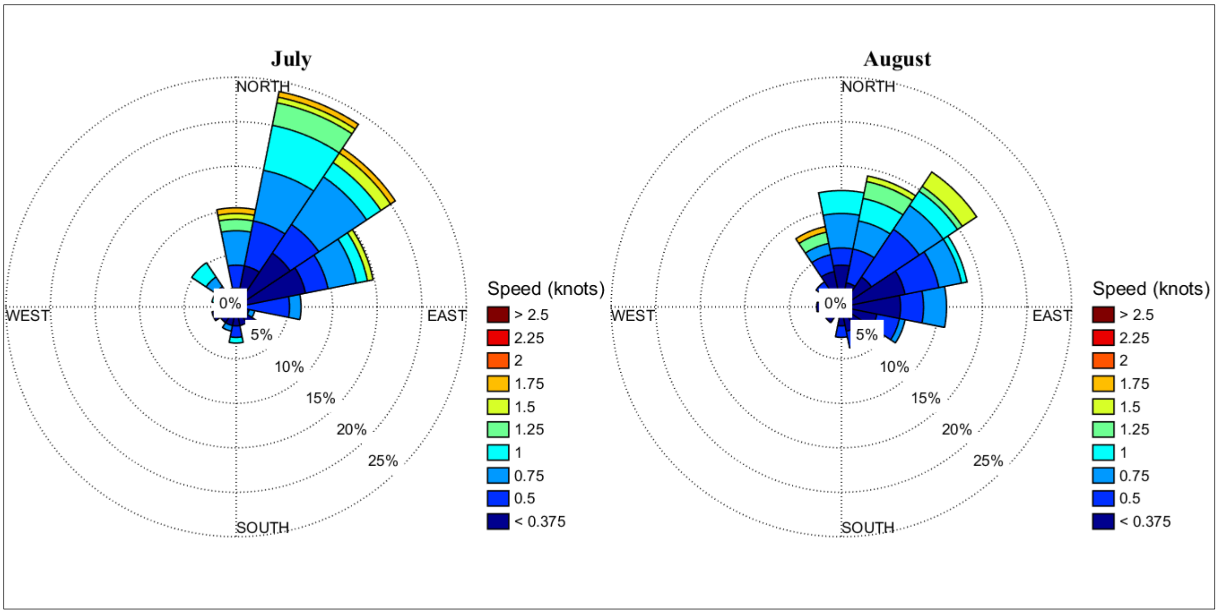
(From: Horizon Marine, Inc., 2015)

Figure G-2. Distribution of surface current speed and direction in the Offshore Area (15.57°N, 17.61°W) from Global HYbrid Coordinate Ocean Model data for March and April.



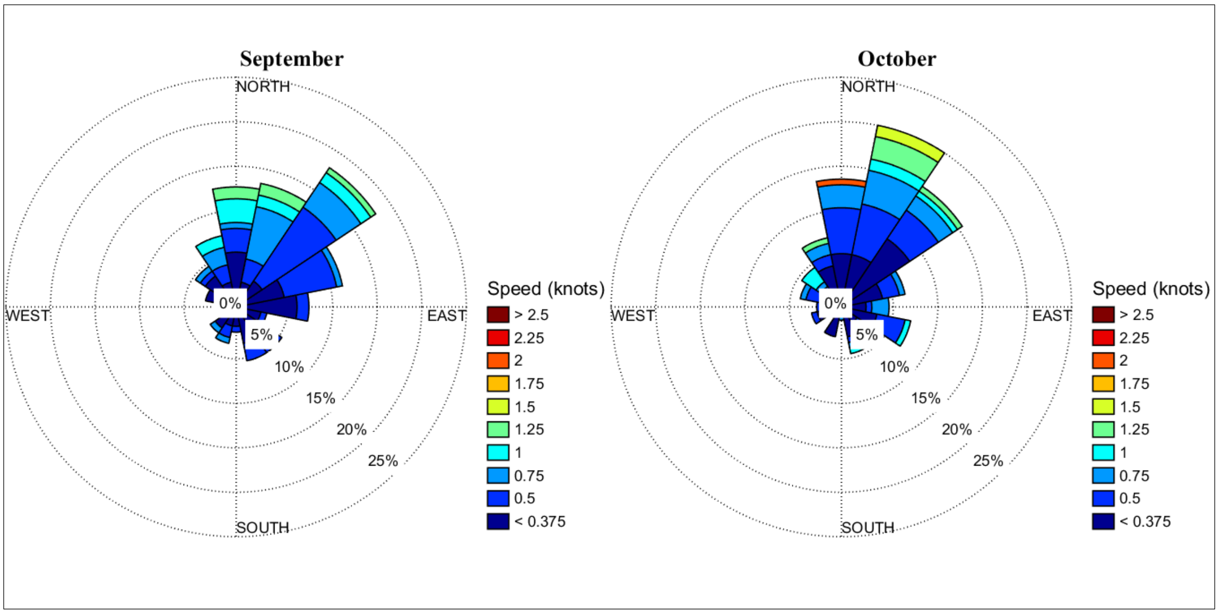
(From: Horizon Marine, Inc., 2015)

Figure G-3. Distribution of surface current speed and direction in the Offshore Area (15.57°N, 17.61°W) from global HYbrid Coordinate Ocean Model data for May and June.



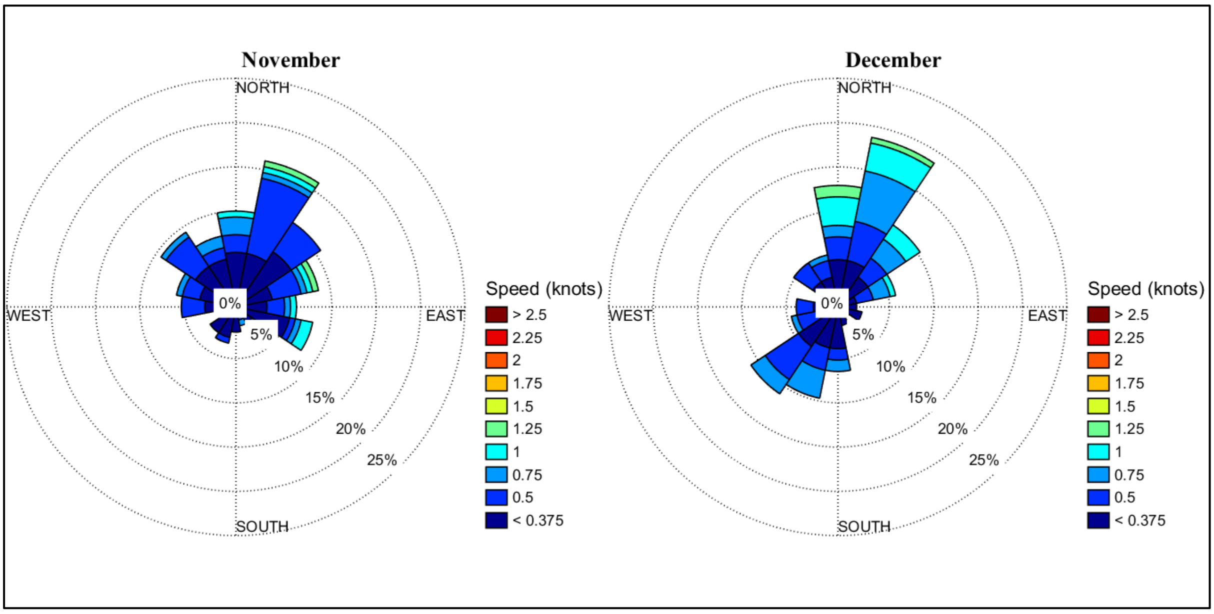
(From: Horizon Marine, Inc., 2015)

Figure G-4. Distribution of surface current speed and direction in the Offshore Area (15.57°N, 17.61°W) from global HYbrid Coordinate Ocean Model data for July and August.



(From: Horizon Marine, Inc., 2015)

Figure G-5. Distribution of surface current speed and direction in the Offshore Area (15.57°N, 17.61°W) from global HYbrid Coordinate Ocean Model data for September and October.



(From: Horizon Marine, Inc., 2015)

Figure G-6. Distribution of surface current speed and direction in the Offshore Area (15.57°N, 17.61°W) from global HYbrid Coordinate Ocean Model data for November and December. (From: Horizon Marine, Inc., 2015).

G.2 Ichthyoplankton

The following text and tabular data support the ichthyoplankton baseline analysis presented in ESIA Chapter 4. Two site-specific surveys were conducted in the project area to support the characterization of the baseline ichthyoplankton and zooplankton environment. CSA Ocean Sciences Inc. (2017) conducted plankton sampling in Winter 2016. An additional set of samples were collected by Gardline during a geophysical survey in Summer 2017. Ichthyoplankton data from these two survey efforts are presented below with emphasis on Offshore and Mid-Depth Areas. Data collected in Winter 2016 and Summer 2017 at the Nearshore Hub/Terminal Area may also be found in Appendix M as part of the entrainment modeling analysis.

Offshore Area

Samples from the offshore area in Winter 2016 produced 34 taxa from 17 families and nine orders (Table G-1). The most abundant family was the lanternfishes (Myctophidae) accounting for 48% of the mean density. Four lanternfish taxa *Myctophum affine*, *Myctophum nitidulum*, *Diaphus* sp., and *Hygophum macrochir* accounted for 35% of the total abundance. Members of the mesopelagic group typically migrate from deep waters towards the surface at night. Lanternfishes and bristlemouths numerically dominate midwater assemblages worldwide. Most (60%) of the taxa collected at the offshore site could be classified as mesopelagic. The oceanic pelagic group includes tunas and billfishes, dolphinfishes, but from this group the only halfbeaks and flying fishes were collected. Samples collected in Winter 2016 yielded higher larval densities in the night samples from both depth strata (Table G-2). The upper stratum (0-15 m) produced the higher numbers than the lower stratum (15 to 30 m). However, larval density did not differ significantly among the depth strata, day vs night or their interaction (Table G-3). The density of fish eggs collected at the offshore area averaged 5.8 and ranged from 0 to 19.6 eggs 100^{-3}. Two way analysis of variance found egg density differed significantly between the 0-15 m and the 15 - 30 m strata (Table G-3).

Summertime collections for the Offshore Area yielded 2,429 individuals from 94 taxa in 43 families and 16 orders (Table G-1). The most abundant taxa included frigate mackerel (*Auxis* sp.) contributing 21.5 % to the total followed by gobies (Gobiidae; 14.8%); mackerels (Scombridae; 7.4%); anchovies (Engraulidae; 5.4%); lightfish (*Vinciguerria nimbaria*; 5.4%); scorpionfishes (Scorpaenidae; 4.6%); and lanternfish (*Diaphus* sp.; 3.0%). Several of these numerically dominant taxa, including gobies, some mackerels, and anchovies, may have originated in shallow waters. Most of the taxa were mesopelagic including lanternfishes, bristlemouths, and lightfishes. The larvae of several members of the oceanic pelagic group were collected during Summer, including tunas (*Thunnus* spp.), billfishes (*Istiophorus* sp.), dolphinfishes (*Coryphaena hippurus*, *C. equiselis*), and wahoo (*Acanthocybium solandri*).

Samples from the Offshore Area yielded larval densities ranging from 2.3 to 216.4 individuals per hundred cubic meters (100 m^{-3}). The average density for these samples was 75.7 individuals 100 m^{-3}. Table G-2 presents summary statistics for total larvae and eggs collected by day/night and within depth strata. A two-way analysis of variance showed that densities differed significantly between night and day sampling periods but depth strata or the interaction between time and depth were not significant (Table G-3). The density of fish eggs collected at the offshore area averaged 19.3 eggs 100 m^{-3} and ranged from 2.2 to 58.2 eggs 100 m^{-3}. Two way analysis of variance found egg density did not differ significantly between the 0-15 m and the 15-30 m strata (Table G-3).

Table G-1. Phylogenetic Listing of Fish Larvae Collected in Plankton Samples during Winter 2016 (n=12) and Summer 2017 (n=10) in the Offshore Area.

Order	Family	Taxon	Winter (Mean n x 100 m^{-3})	Summer (Mean n x 100 m^{-3})
Elopiformes	Elopidae (Tenpounders)	*Elops*	1.1	-
Anguilliformes		Anguilliformes	-	1.1
	Muraenidae (Moray Eels)	Muraenidae	0.8	7.3
	Ophichthidae (Snake Eels)	Ophichthidae		20.0
	Nettastomatidae (Sawtooth Eels)	Nettastomatidae	-	4.8
Clupeiformes		Clupeiformes	4.4	6.4
	Clupeidae (Sardines)	Clupeidae	2.6	9.9
		Sardinella	5.7	-
		Sardinella aurita	3.0	56.6
		Sardinella sp.	-	34.6
	Engraulidae (Anchovies)	Engraulidae	-	6.9
		Engraulis encrasicolus	1.6	-
Myctophiformes	Myctophidae (Lanternfishes)	*Diaphus*	0.9	-
Aulopiformes	Paralepididae (Barracudinas)	Paralepididae	-	1.3
	Synodontidae (Lizardfishes)	*Saurida*	0.7	-
Lampridiformes	Lophotidae (Crestfishes)	Lophotidae	0.8	-
Gadiformes	Bregmacerotidae (Codlets)	*Bregmaceros* sp.	4.0	-
Mugiliformes	Mugilidae (Mullets)	*Mugi*l sp.	-	1.8
		Mugilidae	-	1.5
Beryciformes		Beryciformes	-	1.2
			-	-
	Holocentridae (Squirrelfishes)	Holocentridae	-	1.7
Scorpaeniformes	Scorpaenidae (Scorpionfishes)	Scorpaenidae	-	0.7
Perciformes		Perciformes	3.3	6.9
	Acanthuridae (Surgeonfishes)	*Acanthurus* sp.	-	1.7
	Carangidae (Jacks)	Carangidae	-	0.6
		Caranx sp.	-	10.6
		Caranx/Lichia amia	-	70.8
		Chloroscombrus chrysurus		236.5
		Decapterus sp.	-	3.8
		Naucrates sp.	-	0.9
		Seriola sp.	-	0.7
		Trachurus	6.4	-
		Trachurus sp.	-	67.4
	Ephippidae (Spadefishes)	Ephippidae	0.7	1.8
	Gerreidae (Mojarras)	Gerreidae	-	0.7
	Gobiidae (Gobies)	Gobiidae	2.8	8.2
	Haemulidae (Grunts)	Haemulidae	2.4	94.6
	Labridae (Wrasses)	Labridae	2.2	-
	Sciaenidae (Drums and Croakers)	*Leiostomus xanthurus*	4.0	12.6
		Sciaenidae	24.6	66.7
		Stellifer sp.	-	14.5
		Umbrina	0.9	-

Order	Family	Taxon	Winter (Mean n x 100 m^{-3})	Summer (Mean n x 100 m^{-3})
	Serranidae (Sea Basses)	Serranidae	4.1	11.7
	Sparidae (Porgies)	Sparidae	0.6	0.9
	Sphyraenidae (Barracudas)	*Sphyraena* sp.	-	10.4
		Sphyraena sphyraena		2.8
		Sphyraenidae	-	5.1
	Trachinidae (Weaverfishes)	Trachinidae	1.1	
	Trichiuridae (Cutlassfishes)	*Trichiurus* sp.	-	18.4
Pleuronectiformes		Pleuronectiformes	0.9	2.7
	Bothidae (Lefteye Flounders)	*Monolene*	0.6	-
		Symphurus sp.	-	5.0
	Cynoglossidae (Tonguefishes)	Cynoglossidae	1.5	-
		Cynoglossus monodi	0.8	-
		Symphurus	1.9	-
		Symphurus sp.	-	28.0
	Paralichthyidae (Sand Flounders)	*Citharichthys*	0.8	-
		Paralichthyidae	2.1	-
		Syacium papillosum	1.2	-
		Syacium sp.	-	0.9
	Pleuronectidae (Righteye Flounders)	Pleuronectidae	2.0	-
Tetraodontiformes	Tetraodontidae (Smooth Puffers)	*Sphoeroides* sp.	-	2.3
		Total Taxa	**32**	**43**

Table G-2. Means and Standard Deviations (SD) for Total Fish Larvae and Egg Densities (n x 100 m^{-3}) Collected at the Offshore Area during Winter 2016 and Summer 2017 Surveys.

Samples (n=3) were Collected in each Combination of Day/Night and Upper and Lower Strata in the Water Column. Upper=0-15 m; Lower=15-30 m.

Survey	Time	Depth	Larvae		Eggs	
			Mean	SD	Mean	SD
Winter	Day	Lower	9.1	2.7	1.2	1.1
		Upper	21.3	22.0	9.4	2.7
	Night	Lower	19.1	8.0	1.2	2.1
		Upper	29.3	10.1	11.4	9.1
Summer	Day	Lower	20.6	10.7	23.9	27.3
		Upper	47.7	45.9	31.4	28.1
	Night	Lower	123.8	27.1	12.5	8.6
		Upper	103.9	67.3	9.3	2.9

Table G-3. Results of Two-Way Analysis of Variance for the Effects of Time (Day/Night) and Depth (Water Column Strata) on Density of Fish Larvae and Eggs Collected at the Offshore Area during Winter 2016 and Summer 2017 Surveys.

Df=Degrees of Freedom, MS=Mean Square, F=Fisher's Ratio (MS/Residual). Significant Results (p<0.05) are in Bold.

Survey	Source	Df	MS	Larvae F	p-value	MS	Eggs F	p-value
Winter	Time	1	1416.7	1.48	0.26	3.2	0.13	0.72
	Depth	1	452	0.472	0.51	255.8	10.7	**0.01**
	Time × Depth	1	61.3	0.064	0.81	3	0.13	0.73
	Residual	8	957.4	-	-	23.89	-	-
Summer	Time	1	31810	16.41	0.004	0.05	1.306	0.286
	Depth	1	914	0.47	0.51	0.003	0.082	0.782
	Time × Depth	1	8382	4.32	0.07	0.013	0.327	0.583
	Residual	8	1938	-	-	0.041	-	-

Mid-Depth Area

Mid-Depth samples yielded 88 fish taxa from 47 families in 15 orders (Table G-4). These samples, collected only during the Summer 2017 survey, were similar in composition to those taken at the Offshore Area. The most abundant taxa collected were sardines (*Sardinella* sp.) accounting for 17.4% of the total larvae collected. Other abundant taxa, in order of decreasing contributions to the total, were frigate mackerel (*Auxis* sp.; 6.0%); sardines and anchovies (Clupeiformes; 5.8%); gobies (Gobiidae; 5.1%); driftfishes (*Cubiceps* sp.; 5.1%), mackerels (Scombridae: 5.1%); jacks (*Caranx* sp.; 4.4%); and lanternfishes (*Diaphus* sp.; 3.9%). Larval densities ranged from 28.8 to 277.1 larvae 100 m^{-3} with a mean of 100.3 larvae 100 m^{-3}. Egg densities at the mid-depth area averaged 694.5 eggs 100 $m^{-3}$and ranged from 6.6 to 7,715.0 eggs 100 m^{-3}. Densities are summarized by time (day/night) and depth (upper and lower strata) in Table G-5. No significant differences were found between the factors time (day/night), depth, nor their interaction on the abundance of larvae or eggs (Table G-6).

Table G-4. Phylogenetic Listing of Fish Larvae Collected in Plankton Samples (n=12) at the Mid-Depth Area during the Summer 2017 Survey.

Order	Family	Taxon	Summer (Mean n 100 m^{-3})
Anguilliformes		Anguilliformes	0.4
	Muraenidae (Moray eels)	Muraenidae	0.6
	Ophichthidae (Cusk-eels)	Ophichthidae	2.1
Clupeiformes		Clupeiformes	34.8
	Clupeidae (Sardines)	*Sardinella aurita*	1.2
		Sardinella sp.	52.3
	Engraulidae (Anchovies)	Engraulidae	0.4
Aulopiformes	Chlorophthalmidae (greeneyes)	Chlorophthalmidae	4.3
		Chlorophthalmus sp.	1.3
	Paralepididae (Barracudinas)	Paralepididae	3.6
Myctophiformes		Myctophiformes	0.2
	Myctophidae (Lanternfishes)	*Ceratoscopelus* sp.	1.8
		Diaphus sp.	5.3
		Lampanyctus sp.	1.2
		Myctophidae	0.5
		Nanobrachium sp.	1.1
Gadiformes	Bregmacerotidae (Codlets)	*Bregmaceros* sp.	35.8
Stomiiformes	Gonostomatidae (Bristlemouths)	*Cyclothone* sp.	2.3
	Phosichthyidae (Lightfishes)	*Vinciguerria*	0.4
		Vinciguerria nimbaria	2.5
		Vinciguerria sp.	5.6
	Stomiidae (Dragonfishes)	Stomiidae	0.6

Order	Family	Taxon	Summer (Mean n 100 m^{-3})
Mugiliformes	Mugilidae (Mullets)	*Mugil* sp.	0.5
		Mugilidae	0.8
Ophidiiformes	Ophidiidae (Cusk-eel)	*Brotula* sp.	4.3
		Snyderidia sp.	0.8
Beloniformes		Beloniformes	1.0
	Exocoetidae (Flying fishes)	Exocoetidae	0.5
Gasterosteiformes	Fistulariidae (Cornetfishes)	Fistulariidae	0.4
	Syngnathidae (Pipefishes)	Syngnathidae	0.4
Scorpaeniformes	Scorpaenidae (Scorpionfishes)	Scorpaenidae	2.7
		Scorpaeniformes	3.8
Gobiesociformes	Gobiesocidae (Clingfishes)	*Gobiesox* sp.	0.6
Perciformes		Perciformes	3.6
	Acanthuridae (Surgeonfishes)	*Acanthurus* sp.	1.2
	Apogonidae (Cardinalfishes)	Apogonidae	0.5
	Ariommatidae (Ariommatids)	*Ariomma* sp.	0.4
	Bramidae (Pomfrets)	Bramidae	1.3
	Carangidae (Jacks)	Carangidae	4.8
		Caranx crysos	0.2
		Caranx sp.	26.7
		Caranx/Lichia amia	0.6
		Chloroscombrus chrysurus	2.6
		Decapterus sp.	11.3
		Selar sp.	4.4
		Selene setapinnis	1.8
		Selene sp.	2.3
		Seriola sp.	1.0
		Trachinotus sp.	5.4
		Trachurus sp.	1.3
	Cepolidae (Bandfishes)	*Cepola* sp.	0.8
	Coryphaenidae (Dolphinfishes)	*Coryphaena hippurus*	1.2
		Coryphaena sp.	0.9
		Coryphaenidae	3.6
	Epinephelidae (Groupers)	*Mycteroperca* sp.	1.0
	Gempylidae (Snake mackerels)	Gempylidae	0.2
		Gempylus sp.	0.3
	Gerreidae (Mojarras)	Gerreidae	3.5
	Gobiidae (Gobies)	Gobiidae	6.8
	Istiophoridae (Sailfishes)	*Istiophorus* sp.	0.4
	Labridae (Wrasses)	Labridae	1.5
	Lutjanidae (Snappers)	*Lutjanus* sp.	1.6
	Microdesmidae (Wormfishes)	*Microdesmus* sp.	0.8
	Mullidae (Goatfishes)	Mullidae	0.8
	Nomeidae (Medusafishes)	*Cubiceps* sp.	10.2
		Psenes sp.	6.3
	Polynemidae (Threadfins)	Polynemidae	6.1
	Scaridae (Parrotfishes)	Scaridae	1.2
		Sparisoma sp.	0.6
	Sciaenidae (Drums and Croakers)	Sciaenidae	5.9
	Scombridae (Mackerels and Tunas)	*Acanthocybium solandri*	0.7

Order	Family	Taxon	Summer (Mean n 100 m^{-3})
		Auxis sp.	10.2
		Euthynnus sp.	0.6
		Scombridae	8.7
		Thunnus sp.	1.2
	Serranidae (Sea Basses)	*Rypticus* sp.	0.4
	Sphyraenidae (Barracudas)	*Sphyraena* sp.	0.9
		Sphyraenidae	0.6
	Trichiuridae (Cutlassfishes)	Trichiuridae	0.8
Pleuronectiformes	Bothidae (Lefteye Flounders)	Bothidae	2.3
		Bothus sp.	1.9
		Monolene sp.	0.9
	Cynoglossidae (Tonguefishes)	Cynoglossidae	0.3
	Paralichthyidae (Sand Flounders)	*Syacium* sp.	2.9
Tetraodontiformes	Balistidae (Triggerfishes)	Balistidae	0.7
	Diodontidae (Spiny Puffers)	Diodontidae	0.4
	Tetraodontidae (Smooth Puffers)	*Sphoeroides* sp.	1.3
		Total Taxa	**88**

Table G-5. Means and Standard Deviations (SD) for Total Fish Larvae and Egg Densities (n x 100 m-3) Collected at the Mid-Depth Area during the Summer 2017 Survey.

Samples (n=3) were a Combination of Day/Night and Upper and Lower Strata in the Water Column.

Time	Depth	Larvae		Eggs	
		Mean	SD	Mean	SD
Day	Lower	92.3	52.8	41.4	37.2
	Upper	60.9	40.4	73.6	45.5
Night	Lower	122.7	37.0	2,590.1	4,438.3
	Upper	125.3	131.7	73.1	87.0

Table G-6. Results of Two-Way Analysis of Variance for Density of Fish Larvae and Eggs Collected at the Mid-Depth Area during the Summer 2017 Survey.

MS=Mean Square, F=F (Fisher's) ratio (MS/Residual).

Source	Df	MS	Larvae	p-value	MS	Eggs	p-value
			F			F	
Time	1	6744	1.17	0.312	486.4	0.989	0.349
Depth	1	619	0.11	0.752	463.8	0.943	0.36
Time × Depth	1	868	0.15	0.709	486.4	0.989	0.349
Residuals	8	5781	-	-	491.8	-	-

G.3 Zooplankton

CSA Ocean Sciences Inc. (2017) collected zooplankton along the Mauritania-Senegal boundary from Nearshore Hub/Terminal and Offshore Areas in Winter (November and December) 2016 and Summer (July and August) 2017. Results are presented in the following subsections.

Nearshore Hub/Terminal Area

Twelve samples from the Nearshore Hub/Terminal Area collected in Winter 2016 produced 24 zooplankton groups from several phyla including arthropods, mollusks, cnidarians, and chaetognaths (Table G-7). Groups accounting for the highest densities were copepods. Individual groups contributing most to the total density at the Nearshore Hub/Terminal were copepods (64.0%), *Lucifer* (12.7%), chaetognaths (8.3%), shrimps (2.5%), and ostracods (2.3%). Total zooplankton densities ranged from 179.6 to 1,345.3 individuals per cubic meter (m^{-3}), averaging 522.5 individuals m^{-3}.

Table G-7. Mean Densities of Major Zooplankton Groups in Samples Collected at Nearshore Hub/Terminal, Mid-Depth, and Offshore Areas during Winter 2016 and Summer 2017 Surveys, Listed in Alphabetical Order.

Group	Nearshore Hub/Terminal		Mid-Depth	Offshore	
	Winter	Summer	Summer	Winter	Summer
Amphipods	8.6	7.1	2.7	4.8	1.0
Annelids	1.7	-	4.0	2.7	1.2
Anomurids	-	34.1	-	-	-
Bivalves	1.1	-	-	8.7	-
Caridean shrimps	-	79.4	2.1	-	4.0
Chaetognaths	31.7	39.1	14.6	43.9	19.4
Cladocerans	30.8	33.0	3.3	10.1	1.1
Cnidarians	-	-	9.5	1.7	6.6
Copepod eggs	-	-	45.8	-	14.5
Copepods	276.1	177.5	88.5	331.7	83.4
Crab larvae	25.3	34.3	9.3	1.5	0.8
Crustaceans (unidentified)	-	-	-	2.2	-
Ctenophores	3.1	-	1.5	2.6	2.9
Dolioloids	-	67.3	3.3	-	2.9
Echinoderms	1.6	-	-	0.9	-
Formaminiferans	-	-	4.5	3.7	1.7
Gastropods	4.1	2.2	23.5	0.7	1.7
Heteropods	-	-	1.0	-	1.1
Hydrozoans	1.4	28.0	1.7	2.5	7.4
Isopods	3.1	-	-	-	-
Larvaceans	1.0	6.3	6.8	4.7	1.2

Group	Nearshore Hub/Terminal		Mid-Depth	Offshore	
	Winter	Summer	Summer	Winter	Summer
Lobster Larvae	-	13.5	0.9	-	1.0
Lucifer spp.	116.8	599.9	19.8	6.2	3.5
Macrura	-	8.5	-	-	-
Malacostraca	-	6.1	-	-	-
Mysids	17.4	15.2	-	5.6	0.9
Octopus	-	-	-	1.4	-
Octopus larvae	-	-	-	-	2.2
Ostracods	37.3	-	-	4.2	-
Penaeid shrimps	-	5.4	-	-	0.9
Polychaetes	1.5	2.2	-	1.7	0.6
Pteropods	5.8	-	-	5.3	1.1
Radiolarians	1.3	-	3.3	3.8	4.9
Scyphozans	3.9	-	-	4.8	-
shrimps	15.2	-	-	9.9	-
Siphonophores	7.6	24.7	6.0	11.3	6.6
Squid larvae	0.4	-	3.9	0.6	2.4
Squillids	-	-	1.8	-	0.8
Tunicates	3.3	-	-	3.3	-
Total Groups	**24**	**19**	**22**	**27**	**27**

Summary statistics for total zooplankton densities in the Nearshore Hub/Terminal Area are provided in Table G-8. The highest densities of zooplankters were collected at night from both 0-10 and 10-20 m depth strata. Mean numbers of zooplankters per m^3 were higher in the 0-10 m stratum during both day and night sample periods; however, these differences were not statistically significant (two-way analysis of variance; Table G-9).

Table G-8. Means and Standard Deviations (SD) for Total Zooplankton Densities (n x m^{-3}) Collected at the Nearshore Hub/Terminal, Mid-Depth, and Offshore Areas during Winter 2016 and Summer 2017 Surveys.

Upper Stratum (Upper=0-10 m in the Nearshore Area; 0-15 m at Mid-Depth and Offshore Areas); Lower Stratum (Lower=10-20 m in the Nearshore Area and 15-30 m in the Mid-Depth and Offshore Areas).

Source		Winter		Summer	
Time	Stratum	Mean	SD	Mean	SD
Nearshore Hub/Terminal Area					
Day	Upper	444.13	136.40	1,435.92	735.37
	Lower	395.36	167.63	1,085.24	1,165.43
Night	Upper	598.65	124.52	772.56	912.81
	Lower	652.01	613.44	680.84	889.44
Mid-Depth Area					
Day	Upper	--	--	132.2	19.9
	Lower	--	--	223.0	78.9
Night	Upper	--	--	145.5	81.9
	Lower	--	--	215.1	118.6
Offshore Area					
Day	Upper	645.9	209.6	131.5	107.6
	Lower	370.2	133.0	99.7	44.3
Night	Upper	453.5	159.2	160.2	45.6
	Lower	238.6	126.0	178.7	25.1

Nearshore Hub/Terminal Area samples collected in Summer 2017 produced 19 major planktonic groups (Table G-7). The greatest contributors to overall abundance were *Lucifer* sp. (57.2%), copepods (16.9%), caridean shrimps (7.6%), doliolids (4.5%), cladocerans (3.2%), chaetognaths (3.0%), and crab larvae (2.9%). Zooplankton densities ranged from 51.9 to 2,363.1 individuals m^{-3} and averaged 1,047.0 individuals m^{-3} overall. Means and standard deviations for total zooplankton densities are provided in Table G-8. Two-way analysis of variance did not reveal any significant differences in zooplankton density with day/night or depth stratum (Table G-9).

Table G-9. Results of Two-Way Analysis of Variance for Density of Zooplankton (n x m^{-3}) Collected at the Nearshore Hub/Terminal, Mid-Depth, and Offshore Areas during the Summer 2017 Survey.

Df=Degrees of Freedom, MS=Mean Square, F=F (Fisher's) Ratio (MS/Residual). Significant Results are in Bold. No Samples were Collected at the Mid-Depth Area in Winter.

Source	Df	Winter			Summer		
		MS	F	p-value	MS	F	p-value
Nearshore							
Time	1	16	0.001	0.991	684059	0.757	0.418
Depth	1	12697	1.156	0.314	152644	0.169	0.695
Time × Depth	1	7821	0.071	0.796	40238	0.045	0.84
Residual	8	109629	-	-	903722	-	-
Mid-Depth							
Time	1	--	--	--	23	0.003	0.956
Depth	1	--	--	--	19304	2.818	0.132
Time × Depth	1	--	--	--	338	0.049	0.83
Residual	8	--	--	--	6851	-	-
Offshore							
Time	1	180483	7.02	**0.029**	8701	2.143	0.181
Depth	1	78733	3.06	0.118	133	0.033	0.861
Time × Depth	1	2765	0.1	0.751	1896	0.467	0.514
Residual	8	205714	-	-	4061	-	-

Offshore Area

Samples from the Offshore Area in Winter 2016 produced 27 groups from 9 phyla (Table G-7). The most abundant group was the copepods accounting for 77% of the density followed by chaetognaths (11%), shrimps (2.3%), and siphonophores (2.2%).

Samples from the offshore location yielded higher zooplankton densities in the day samples from both depth strata (Table G-8). The upper stratum (0-15 m) densities were higher than the lower stratum (15-30 m). These results differed significantly between depth strata but day-night and their interactions with depth strata were not (Table G-9). The density of zooplankters collected at the Offshore Area averaged 427.0 individuals m^{-3} and ranged from 118.7 to 848.2 individuals m^{-3}. Two way analysis of variance found zooplankton density differed significantly between day and night in the 0-15 m and the 15-30 m strata (Table G-9).

A total of 27 major planktonic groups were collected at the Offshore Area in Summer. Copepods (63.4%), chaetognaths (13.6%), siphonophores (3.1%), hydrozoans (3.0%), cnidarians (2.7%), copepod eggs (2.5%), and radiolarians (2.3%) contributed the most to total abundance (Table G-7). Sample zooplankton densities for the offshore area averaged 142.5 individuals m^{-3} and ranged from 9.6 to 213.3 individuals m^{-3}. Means and standard deviations for total zooplankton density by day/night and depth stratum are given in Table G-8. Two-way analysis of variance detected no differences between day/night of depth stratum for zooplankton density during the Summer survey (Table G-9).

Mid-Depth Area

Samples collected at the Mid-Depth Area yielded 22 major groups represented, in order of abundance, by copepods (49.5%), chaetognaths (8.2%), gastropods (7.7%), *Lucifer* sp. (7.4%), copepod eggs (6.4%), cnidarians (5.3%), and siphonophores (3.3%) (Table G-7). Zooplankton densities in the samples averaged 179.0 individuals m^{-3} ranging from 70.3 to 351.9 individuals m^{-3}. Summary statistics total zooplankton densities are given in Table G-8. No significant differences in zooplankton density were found among day/night or depth stratum (Table G-9).

Zooplankton assemblages collected at the Nearshore Hub/Terminal, Mid-Depth, and Offshore Areas were typical for the region. The mesh size used (0.5 mm) would retain mostly mesozooplankters which include sergestid shrimps (*Lucifer* spp.), mysid shrimps, and copepods, as well as larvae of other invertebrates such as shrimps, crabs, comb jellies, and mollusks.

G.4 Fishes

The following tabular data (Tables G-10 through G-12) support the fish and fishery resources baseline analysis presented in ESIA Chapter 4.

Table G-10. Fish Assemblages with Sedimentary Types and Depth Stratum.

Depth Strata	Sedimentary Type	Scientific Name	Family
CS	Sandy	*Pseudupeneus prayensis*	Mullidae
		Raja miraletus	Rajidae
		Dentex canariensis	Sparidae
	Sand-muddy	*Chilomycterus orbicularis*	Diodontidae
		Sphoeroides spengleri	Tetraodontidae
		Torpedo torpedo	Torpedinidae
		Microchirus theophila	Soleidae
US	Sandy	*Dentex angolensis*	Sparidae
		Diplodus sargus	Sparidae
		Mustelus mustelus	Triakidae
		Uranoscopus polli	Uranoscopidae
	Sand-muddy	*Cynoglossus spp.*	Cynoglossidae
		Grammoplites gruveli	Platycephalidae
		Umbrina canariensis	Sciaenidae
		Microchirus boscanion	Soleidae
		Dicologoglossa cuneata	Soleidae
		Trachinus draco	Trachinidae
	Muddy	*Priacanthus arenatus*	Priacanthidae
		Zanobatus schoenleinii	Rhinobatidae
	Rocky	*Selene dorsalis*	Carangidae
		Fistularia petimba	Fistulariidae
	Sandy	*Dasyatis marmorata*	Dasyatidae
		Pomadasys incisus	Haemulidae
		Pomadasys jubelini	Haemulidae
		Leptocharias smithii	Leptochariidae
		Boops boops	Sparidae
		Pagellus bellottii	Sparidae
		Chelidonichthys gabonensis	Triglidae
	Sand-muddy	*Galeoides decadactylus*	Polynemidae
MS	Sandy	*Halobatrachus didactylus*	Batrachoididae
		Bothus podas	Bothidae
		Chaetodon hoefleri	Chaetodontidae
		Citharus linguatula	Citharidae
		Dactylopterus volitans	Dactylopteridae
		Fistularia tabacaria	Fistulariidae
		Eucinostomus melanopterus	Gereidae
		Plectorhinchus mediterraneus	Haemulidae
		Stephanolepis hispidus	Monacanthidae
		Brotula barbata	Ophidiidae
		Rhinobatos spp.	Rhinobatidae
		Scorpaena angolensis	Scorpaenidae
		Scorpaena spp.	Scorpaenidae
		Scyliorhinus canicula	Scyliorhinidae
		Epinephelus alexandrinus	Serranidae
		Epinephelus aeneus	Serranidae
		Serranus scriba	Serranidae
		Solea senegalensis	Soleidae
		Lithognathus mormyrus	Sparidae
		Uranoscopus spp.	Uranoscopidae
	Sand-muddy	*Dentex maroccanus*	Sparidae
OS	Muddy	*Merluccius senegalensis*	Merlucciudae
		Pseudotolithus senegalensis	Sciaenidae
	Rocky	*Capros aper*	Caproidae
		Merluccius polli	Merlucciudae
		Scorpaena elongata	Scorpaenidae
		Helicolenus dactylopterus	Scorpaenidae
		Pontinus kuhlii	Scorpaenidae
		Lepidotrigla cadmani	Triglidae
	Sandy	*Pterothrissus belloci*	Albulidae
		Arnoglossus imperialis	Bothidae
		Chlorophthalmus atlanticus	Chlorophthalmidae
		Gobiidae	Gobiidae
		Gymnura altavela	Gymnuridae
		Branchiostegus semifasciatus	Malacanthidae
		Psettodes belcheri	Psettodidae
		Raja straeleni	Rajidae
		Raja undulata	Rajidae
		Rhinobatos rhinobatos	Rhinobatidae
		Scorpaena normani	Scorpaenidae
		Scorpaena stephanica	Scorpaenidae
		Serranus cabrilla	Serranidae

CS: Coastal, US: Upper shelf, MS: Mid-shelf, and OS: Outer shelf
From: Kide et al., 2015

Table G-11. Species and Families of Demersal Fishes Collected from the Outer Continental Shelf and Slope off Mauritania.

Family	Species	Water Depth Range (m)						
		80-200	201-500	501-800	801-1100	1101-1400	1401-1700	>1701-1900
Acropomatidae	*Synagrops microlepis*		+					
Albulidae	*Pterothrissus belloci*	+						
Alepocephalidae	*Alepocephalus agassizii*							+
	Alepocephalus australis						+	
	Alepocephalus bairdii					+		
	Alepocephalus productus						+	+
	Alepocephalus rostratus							+
	Bathytroctes microlepis			+				+
	Conocara macropterum						+	+
	Conocara murrayi							+
	Leptoderma macrops						+	+
	Rouleina attrite						+	
	Talismania antillarum					+		
	Xenodermichthys copei				+		+	
Anoplogasteridae	*Anoplogaster cornuta*					+		+
Aphyonidae	*Barathronus parfait*						+	
Ateleopodidae	*Guentherus altivela*		+					
Bathylagidae	*Bathylagus euryops*						+	
Berycidae	*Beryx splendens*		+					
Blenniidae	*Blennius normani*	+						
Bothidae	*Arnoglossus imperialis*	+						
Bythitidae	*Cataetyx laticeps*						+	
Caproidae	*Antigonia capros*	+						
	Capros aper	+						
Carangidae	*Selene dorsalis*	+						
	Trachurus trachurus	+	+					
	Trachurus trecae	+						
Caristiidae	*Platyberyx opalescens*				+			
Centrophoridae	*Centrophorus granulosus*		+			+		
	Centrophorus squamosus				+			
	Deania hystricosa				+			
	Deania profundorum		+					
Cepolidae	*Cepola macrophthalma*	+						
Chaunacidae	*Chaunax pictus*			+				
Chiasmodontidae	*Chiasmodon niger*						+	
Chimaeridae	*Chimaera monstrosa*				+		+	
	Hydrolagus mirabilis							+
Chlorophthalmidae	*Chlorophthalmus agassizi*		+					
Citharidae	*Citharus linguatula*	+						
Cogridae	*Japonoconger africanus*					+		
Colocongridae	*Coloconger cadenati*				+			
Congridae	*Bathyuroconger vicinus*				+			
	Japonoconger africanus					+		
Cynoglossidae	*Symphurus ligulatus*			+				
Dalatiidae	*Centroscyllium fabricii*					+	+	
	Dalatias licha		+		+			
Diceratiidae	*Bufoceratias wedli*			+				+
Emmelichthyidae	*Erythrocles monodi*	+						
Epigonidae	*Epigonus constanciae*		+					
	Epigonus denticulatus	+		+				
	Epigonus telescopus				+			
Eurypharyngidae	*Eurypharynx pelecanoides*					+	+	
Gempylidae	*Nesiarchus nasutus*					+		
Halosauridae	*Aldrovandia oleosa*					+	+	
	Halosauropsis macrochir						+	+
	Halosaurus attenuatus						+	
	Halosaurus guenteri					+		
	Halosaurus ovenii						+	
Ipnopidae	*Bathypterois dubius*						+	
Lophiidae	*Lophius budegassa*		+					
	Lophius vaillanti			+				
Macrouridae	*Bathygadus melanobranchus*				+			
	Cetonurus globiceps						+	
	Coelorinchus caelorhincus		+	+				
	Coryphaenoides guentheri						+	
	Coryphaenoides mediterraneus						+	+
	Coryphaenoides paramarshalli					+	+	
	Gadomus dispar						+	
	Gadomus longifilis					+		

Family	Species	Water Depth Range (m)						
		80-200	201-500	501-800	801-1100	1101-1400	1401-1700	>1701-1900
	Hymenocephalus italicus			+				
	Malacocephalus occidentalis			+				
	Nezumia duodecim			+		+		
	Nezumia sclerorhynchus			+		+		
	Trachonurus sulcatus					+		
Melamphaidae	*Melamphaes longivelis*						+	
	Poromitra capito					+	+	+
	Scopelogadus beanii	+				+		
Melanocetidae	*Melanocetus johnsonii*					+		
Melanonidae	*Melanonus zugmayeri*				+	+		
Merlucciidae	*Merluccius polli*		+	+				
	Merluccius senegalensis		+					
Moridae	*Gadella imberbis*		+	+				
	Laemonema laureysi			+				
Myxinidae	*Myxine ios*					+		
Nemichthyidae	*Nemichthys curvirostris*					+	+	
	Nemichthys scolopaceus			+	+	+	+	
Neoscopelidae	*Scopelengys tristis*					+		
Nettastomatidae	*Venefica proboscidea*						+	
Notacanthidae	*Notacanthus bonaparte*				+			
	Notacanthus chemnitzii					+		+
Ogcocephalidae	*Dibranchus atlanticus*					+		+
Ophichthidae	*Echelus myrus*		+					
Ophidiidae	*Bassozetus robustus*						+	+
	Brotula barbata	+						
	Dicrolene introniger					+		
	Luciobrotola nolfi					+		
	Monomitopus metriostoma				+			
	Penopus microphthalmus							+
Percichthyidae	*Howella sherborni*					+		+
Phosichthyidae	*Polymetme corythaeola*			+				
	Yarrella blackfordi				+			
Platytroctidae	*Barbantus curvifrons*							+
	Maulisia microlepis						+	+
	Normichthys operosus					+	+	
	Searsia koefoedi							+
Psychrolutidae	*Cottunculus thomsonii*					+		

Family	Species	Water Depth Range (m)						
		80-200	201-500	501-800	801-1100	1101-1400	1401-1700	>1701-1900
	Ebinania costaecanariae			+				
	Psychrolutes inermis						+	
Rajidae	*Leucoraja leucosticta*		+					
	Raja straeleni	+						
	Rajella barnardi		+		+	+		
	Rajella bathyphila				+			
	Rajella bigelowi				+			
	Rajella ravidula						+	
Rhinochimaeridae	*Harriotta raleighana*						+	
	Rhinochimaera atlantica						+	
Scombrolabracidae	*Scombrolabrax heterolepis*					+		
Scorpaenidae	*Scorpaena elongata*	+						
Scyliorhinidae	*Galeus polli*			+				
	Scyliorhinus canicula		+					
Sebastidae	*Helicolenus dactylopterus*			+				
	Trachyscorpia cristulata			+	+			
Serranidae	*Serranus cabrilla*	+						
Serrivomeridae	*Serrivomer beanii*						+	
Soleidae	*Bathysolea profundicola*			+				
Somniosidae	*Centroscymnus coelolepis*						+	
	Centroselachus crepidater					+		
Sparidae	*Boops boops*	+						
Sternoptychidae	*Argyropelecus aculeatus*				+	+		
	Argyropelecus affinis				+	+		
	Argyropelecus olfersii			+			+	
	Polyipnus polli			+				
	Sternoptyx diaphana						+	
	Sternoptyx pseudobscura							+
Stomiidae	*Astronesthes gemmifer*					+	+	
	Chauliodus sloani						+	
	Leptostomias haplocaulus				+	+		
	Malacosteus niger					+		+
	Stomias boa					+	+	+
Synaphobranchidae	*Simenchelys parasitica*					+	+	
	Synaphobranchus kaupii							+
Synodontidae	*Bathysaurus ferox*							+
	Saurida brasiliensis	+						
Tetragonuridae	*Tetragonurus cuvieri*			+			+	

Family	Species	Water Depth Range (m)						
		80-200	201-500	501-800	801-1100	1101-1400	1401-1700	>1701-1900
Tetraodontidae	*Sphoeroides pachygaster*	+						
Trachichthyidae	*Gephyroberyx darwinii*		+					
	Hoplostethus cadenati				+			
	Hoplostethus mediterraneus			+				
Trachinidae	*Trachinus draco*	+						
Trichiuridae	*Aphanopus carbo*			+				
Triglidae	*Lepidotrigla cadmani*		+					
	Lepidotrigla carolae	+						
	Trigla lyra		+					
Zeidae	*Zenopsis conchifer*	+						
Zoarcidae	*Pachycara crassiceps*						+	

Adapted from: Fernandez-Peralta and Sidibe, 2015

Table G-12. Synthesis of the Distribution and the Potential of the Main Species of Small Pelagics in the Region and within the Canary Current Large Marine Ecosystem.

Species/Stock	Distribution (Region)	Period and Presence	Availability for Mauritanian EEZ Fishing	Bathymetric Distribution
Horse mackerel European stock Saharo-Mauritania	26° N to 10° N	December to April 20° N to 26° N	Throughout the Mauritanian EEZ from October to May; only in the northern area during the hot season	From the coast to >300 m, preference of >100 m depths and more
African horse mackerel: Senegalese-Mauritanian stock	23° N and 9° N	Throughout the year 2 peaks: (March to June and August to October); Cape Vert and Cape Timiris	Throughout the year; moves in the EEZ according to the thermal front	<100 m, prefers upper portions of the water column; more coastal than the European horse mackerel
Yellow horse mackerel	23° N and 9° N	June to October South of Cape Timiris	Year-round, more southern than the other horse mackerels; from January to June only in the southern area	From the coast to the 150 m isobath, on the shelf, near the seafloor during the day, disperses and moves towards the surface at night
Round sardinella: Senegalese-Mauritanian stock	26° N to 10° N	2 main periods: July-August and December-January in the North of Mauritania: January-April in Senegal	Throughout the year (Bay of the Banc d'Arguin shelf); adults mainly in the Mauritanian EEZ	<50 m; adults found in depths of 100 to 200 m
Flat sardinella: Senegalese-Mauritanian stock	26° N to 10° N	Main between May and seven nurseries (North of Cape Timiris)	Throughout the year	<100 m deep, preferably less than 30 m depths
Sardine: stock C	Cape Juby to Cape Blanc (28° N to 21° N)	A principal in December and a secondary school in March in the North of Mauritania	Cold season, beginning and end of the season of transition	Usually above 100 m
Mackerel	12° N to 24° N	October to May in Guinea-Bissau, Gambia, Senegal, and Western Sahara	Year-round, moves in the CCLME with the 19 to 20°C isotherm	Depths of 15 to 30 m to 350 to 400 m
Anchovy	Eastern Atlantic from Norway (North of Bergen, 62° N) southward to South Africa (23° S)	April to October; Cape Blanc to Cape Timiris	Practically all year round	Very coastal species

From: Chavance et al., 1991; Machu et al., 2009; Braham and Corten, 2015

G.5 Marine and Coastal Birds

Mauritania Marine and Coastal Birds

Overall species abundance during the 2015 survey (Camphuysen et al., 2015) are noted in Table G-13.

Table G-13. Observed Numbers of Individuals, Density Estimates (Number of Individuals km^{-2}, including Standard Deviation [SD]), and Numeric Proportions (Relative Percent of Individuals per Species) for the Most Numerous Seabirds Observed during the 2015 Survey.

Common Name	Species	Number of Individuals	Density (Individuals km^{-2})/ SD	Numeric Proportion (%)
Black Tern	*Chlidonias niger*	1308	2.01/5.23	26.7
Common Tern	*Sterna hirundo*	1271	2.07/4.94	27.4
Wilson's Storm-Petrel	*Oceanites oceanicus*	522	1.82/2.35	24.1
Red Phalarope	*Phalaropus fulicarius*	192	0.72/1.86	9.5
Pomarine Skua	*Stercorarius pomarinus*	128	0.25/0.79	3.3
Cory's Shearwater (all)*	*Calonectris borealis*	109	0.27/0.73	3.6
Cape Verde Shearwater	*Calonectris edwardsii*	60	0.13/0.28	1.7
Long-tailed Jaeger	*Stercorarius longicaudus*	57	0.09/0.25	1.2
Parasitic Jaeger	*Stercorarius parasiticus*	57	0.08/0.26	1.1
Sandwich Tern	*Thalasseus sandvicensis*	36	0.05/0.34	0.7
Sabine's Gull	*Xema sabini*	23	0.03/0.10	0.4
Royal Tern	*Thalasseus maximus*	10	0.01/0.1	0.2

*- Cory's Shearwater (*Calonectris diomedea*) has been split into a complex of three closely related congeners: one mostly confined to the Mediterranean (Scopoli's Shearwater - *C. diomedea*), one to Macaronesian and Portuguese Atlantic waters (Cory's Shearwater - *C. borealis*) and one endemic to the Cape Verde Islands (Cape Verde Shearwater, *C. edwardsii*) (Seabird Osteology, 2016).
From: Camphuysen et al., 2015

A similar survey program was conducted by Camphuysen in 2012 (between 27 November and 8 December) covering 5 transects from north to south. From these results, a distinct north-south pattern was observed in species abundance, and species composition varied from transect to transect (Camphuysen et al., 2013).

Storm-petrels were the most abundant group observed along the northernmost transects. Shearwaters peaked just south of this area (offshore of Banc d'Arguin), and Northern Gannets, although widespread within the study area, were observed in particularly high densities in offshore Cape Timiris. The highest densities of Grey Phalaropes and Pomarine Skuas were also observed southwest of Cape Timiris. Lesser Black-backed Gulls were encountered in high numbers only near Nouadhibou and off Cape Blanc, while terns reached their highest densities off the Banc d'Arguin and Cape Timiris. In addition, relatively low densities of marine birds were observed in the shallowest regions surveyed.

Wynn and Knefelkamp (2004) characterized hydrographic conditions and seabird observations in offshore waters greater than 50 km offshore Mauritania during the R/V *Meteor* cruise, conducted from April to May 2003; summary results are presented in Table G-14.

Table G-14. Seabirds Observed in Offshore Waters Greater than 50 km from Shore during the R/V *Meteor* cruise, April to May 2003, Showing Relative Abundance (Total Numbers of Individuals) and Migratory Point of Origin. The Order of Species Presented in the Table is by Relative Abundance Observed during the Survey.

Common Name	Species Name	Total Numbers	Origin
Sabine's Gull	*Larus sabini*	>1,000	Greenland, Canada
Black Tern	*Chlidonias niger*	>1,000	Europe, Russia
Common/Arctic Tern	*Sterna hirundo/paradisaea*	>1,000	Europe, Arctic Russia, Greenland, Canada
Cory's Shearwater	*Calonectris diomedea*	100 to 1,000	Mediterranean Sea, East Atlantic islands
Wilson's Storm-petrel	*Oceanites oceanicus*	100 to 1,000	Southern Ocean, Antarctica
Pomarine Skua	*Stercorarius pomarinus*	100 to 1,000	Arctic Russia
Long-tailed Skua	*Stercorarius longicaudus*	100 to 1,000	Northern Europe, Arctic Russia
European Storm-petrel	*Hydrobates pelagicus*	10 to 100	Northwest Europe
Madeiran Storm-petrel	*Oceanodroma castro*	10 to 100	East Atlantic Islands
Northern Gannet	*Morus bassanus*	10 to 100	Northwest Europe
Arctic Skua	*Stercorarius parasiticus*	10 to 100	Northern Europe, Arctic Russia
Royal Tern	*Sterna maxima*	10 to 100	Mauritania (Banc d'Arguin)
Sandwich Tern	*Sterna sandvicensis*	10 to 100	Northern and western Europe
Sooty Shearwater	*Puffinus griseus*	<10	South Atlantic, South Pacific Oceans
Leach's Storm-petrel	*Oceanodroma leucorhoa*	<10	Northwest Europe, Canada
Grey Phalarope	*Phalaropus fulicarius*	<10	Greenland, Iceland, Arctic Ocean
Great Skua	*Stercorarius skua*	<10	Northwest Europe
Lesser Black-backed Gull	*Larus fuscus*	<10	Northern and western Europe
Yellow-legged Gull	*Larus michahellis*	<10	S. Europe, N. Africa, E. Atlantic islands
Roseate Tern	*Sterna dougallii*	<10	UK, France, Azores

Adapted from: Wynn and Knefelkamp, 2004

In total, about 20 seabird species were observed during this survey, which is comparable with previous observations in this region during March through May (Marr and Porter, 1992; Leopold, 1993; Marr et al., 1998). It was noted that the Royal Tern is the only species that breeds locally in large numbers, with a significant population at the Banc d'Arguin National Park (PNBA). All other species breed out of the region, with the majority coming from northwest Europe, Iceland, Arctic Russia, Mediterranean Sea, or North Atlantic islands (e.g., Azores and Canary Islands) (Wynn and Knefelkamp, 2004).

Other offshore surveys have been conducted in the region. Camphuysen et al. (2003) surveyed north-south along much of the Mauritanian shelf and shelf break, from Cape Blanc and south. Western Whale Research and CSR Consultancy (2003) focused on offshore areas across the shelf break in and around the Chinguetti field. Observed seabird diversity was greatest over the shelf (29 species), when compared to the shelf break (19 species) and slope (21 species). Shearwaters occurred in slightly higher numbers over the shelf than over the shelf break and deeper waters. Storm-petrels occurred in almost equal numbers in each area. Northern Gannets concentrated over the shelf and shelf edge, but were uncommon over slope waters. Most skuas and (large) gulls were sparse over slope waters, with considerably higher numbers at the shelf edge and shelf. Terns were sparse and least abundant in slope waters.

Wynn and Knefelkamp (2004) characterized hydrographic conditions and seabird observations in offshore waters >50 km offshore Mauritania (and approximately 100 km north of the A/G LNG offshore area) during the R/V *Meteor* cruise, conducted from April to May 2003; summary results are presented in Table G-15.

Table G-15. Seabirds observed in offshore waters greater than 50 km from shore during the R/V *Meteor* cruise, April to May 2003, showing relative abundance and migratory point of origin. Order presented in the table is by relative abundance.

Common Name	Species Name	Total Numbers	Origin
Sabine's Gull	*Larus sabini*	>1,000	Greenland, Canada
Black Tern	*Chlidonias niger*	>1,000	Europe, Russia
Common/Arctic Tern	*Sterna hirundo/paradisaea*	>1,000	Europe, Arctic Russia, Greenland, Canada
Cory's Shearwater	*Calonectris diomedea*	100 to 1,000	Mediterranean Sea, East Atlantic islands
Wilson's Storm-petrel	*Oceanites oceanicus*	100 to 1,000	Southern Ocean, Antarctica
Pomarine Skua	*Stercorarius pomarinus*	100 to 1,000	Arctic Russia
Long-tailed Skua	*Stercorarius longicaudus*	100 to 1,000	Northern Europe, Arctic Russia
European Storm-petrel	*Hydrobates pelagicus*	10 to 100	Northwest Europe
Madeiran Storm-petrel	*Oceanodroma castro*	10 to 100	East Atlantic Islands
Northern Gannet	*Morus bassanus*	10 to 100	Northwest Europe
Arctic Skua	*Stercorarius parasiticus*	10 to 100	Northern Europe, Arctic Russia
Royal Tern	*Sterna maxima*	10 to 100	Mauritania (Banc d'Arguin)
Sandwich Tern	*Sterna sandvicensis*	10 to 100	Northern and western Europe
Sooty Shearwater	*Puffinus griseus*	<10	South Atlantic, South Pacific Oceans
Leach's Storm-petrel	*Oceanodroma leucorhoa*	<10	Northwest Europe, Canada
Grey Phalarope	*Phalaropus fulicarius*	<10	Greenland, Iceland, Arctic Ocean
Great Skua	*Stercorarius skua*	<10	Northwest Europe
Lesser Black-backed Gull	*Larus fuscus*	<10	Northern and western Europe
Yellow-legged Gull	*Larus cachinnans*	<10	S. Europe, N. Africa, E. Atlantic islands
Roseate Tern	*Sterna dougallii*	<10	UK, France, Azores

Adapted from: Wynn and Knefelkamp, 2004

In total, about 20 seabird species were observed. Royal Tern is the only species that breeds locally in large numbers, with a significant population at the Banc d'Arguin (Mauritania). All other species breed out of the region, with the majority coming from northwest Europe, Iceland, Arctic Russia, Mediterranean Sea, or North Atlantic islands (e.g., Azores and Canary Islands).

Senegal Marine and Coastal Birds

A summary of Senegal IBAs in provided in Table G-16. Important bird species for these IBAs is provided in Table G-17.

G.6 Marine Mammals

Species Range Summaries

Sei whales (*Balaenoptera borealis*) have a cosmopolitan distribution but appear to prefer temperate waters in the Atlantic, Indian, and Pacific Oceans. The movement patterns of this species is not well known. Sei whales migrate between tropical and subtropical latitudes in winter and temperate and subpolar latitudes in summer, staying mainly in water temperatures of 8°C to 18°C, and tend not to penetrate to such high latitudes as other *Balaenoptera* species. Their winter distribution seems to be widely dispersed and is not fully mapped (Horwood, 1987, 2002).

Blue whales (*Balaenoptera musculus*) are a cosmopolitan species, found in all oceans except the Arctic, but are absent from some regional seas such as the Mediterranean, Okhotsk, and Bering Seas. In the North Atlantic, two stocks of blue whales are recognized. The first is found off Greenland, Newfoundland, Nova Scotia, and the Gulf of Saint Lawrence. The second, more easterly group is spotted from the Azores in spring to Iceland in July and August; it is presumed the whales follow the Mid-Atlantic Ridge between the two volcanic islands. The winter distribution of this species is poorly known, but it appears that blue whales have been widely distributed in the southern half of the North Atlantic in winter (Reeves et al., 2004).

Fin whales (*Balaenoptera physalus*) occur worldwide, mainly in offshore waters. They are rare in the tropics, except in certain cool-water areas. In the North Atlantic, the range of this species extends as far as Svalbard (Norway) in the northeast, to the Davis Strait and Baffin Bay in the northwest, to the Canary Islands (Spain) in the southeast, and to the Antilles in the southwest. While there may be some seasonal, north-south migration, it may not involve the entire population, and some individuals or groups of North Atlantic fin whales may occur to some extent throughout the year in all of their range.

Sperm whales (*Physeter macrocephalus*) have a large geographic range (Rice, 1998). They may be seen in nearly all marine regions, from the equator to high latitudes, but are generally found in continental slope or deeper water depths. However, in some areas, particularly in the western North Atlantic, sperm whales (especially males) can occur in shallower waters. Females and young are usually restricted to waters at latitudes lower than about 40° to 50° and to areas where sea surface temperatures are greater than about 15°C. Sperm whales are generally more numerous in areas of relatively high primary productivity (Jaquet et al., 1998), although there are some exceptions.

Table G-16. Summary of Marine Senegal Marine Important Bird and Biodiversity Areas (IBAs) within the Core Study Area.

IBA	Site Description	Key Biodiversity Summary
Cap Vert (Cape Verde) – SN017	This marine site consists of the coastline of the peninsula known as Cap Vert, running from les Mammelles and Pointe des Almadies north to Cambérène (c.19 km in length), together with the offshore islands and reefs and the narrow strip of sea between the islands and the mainland (up to about 2 km offshore). The two islands in question are the Ile de Yof (also known as Ile de Tenguène) and the Ile de Ngor. The coast and islands consist of rocky outcrops and some sandy beaches, and there is a string of reefs off the Pointe des Almadies, known as the "Chaussée des Almadies". The reefs and islands form a degree of natural protection from the Atlantic Ocean for the narrow sea channel (less than 1 km) between them and the mainland. Many migrating seabirds pass through this marine "bottleneck", and large numbers also pass on the seaward side of the two islands. The site is of considerable importance for seabirds and waterbirds, particularly as a migration route along which move very large numbers of spring (northward)- and autumn (southward)-passage shearwaters, petrels, skuas, gulls, and terns. Resident terns also use the site, perching on rocks all along the coast and foraging behind fishing boats at sea. Data on numbers of species are from seawatching counts made by a number of observers, particularly since 1990 (see Marr et al., 1998 for references and sources). Most of the observations were made either from the mainland (Pointe des Almadies) or from Ile de Ngor, together with a few pelagic counts made by observers from boats within 25 km of the shore. Observations are a mixture of birds moving overland or through the narrow sea channel between the islands and the mainland, and also some farther out to sea (and not strictly within this IBA). No comprehensive count covering a whole season of passage has been undertaken.	Key species: *Larus audouinii* (LC) is frequent to common off the Pointe des Almadies during January to March—numbers in the hundreds have been recorded flying south in October (counts of 132 in 1995 and 280 in 1996, each count consisting of several hours observation over several days, with a maximum single-day total of 77 on 10 October 1996). Particularly significant numbers of terns and shearwaters have been recorded. For *Sterna sandvicensis* (LC), 13,000 individuals have been recorded wintering along the coast from Cayar to the Cap Vert peninsula (this area includes parts of two other IBAs—sites SN009 and SN010—but it seems safe to assume that a number in excess of the threshold for this species occur within the Cap Vert IBA boundary). There is also a passage count for *S. sandvicensis* of 1,206 birds during 48 hours observation over a period of 8 days in October/November 1997. For *Chlidonias niger* (LC), a total of 23,923 birds were observed during 78 hours of observation over 11 days in October 1996, with a single day maximum total of 12,645 on 12 October. Other species on passage include *S. maxima* (*Thalasseus maximus* [LC]; 421 over a period of 8 days in April 1992) and *S. hirundo* (1,580 over a period of 8 days in April 1992 and 6,454 over a period of 8 days in October/November 1997); these numbers are also close to IBA thresholds for these species. For *Calonectris diomedea* (LC), 4,585 individuals were counted during a total of 64 hours observation over 8 days during October and November 1997. Non-bird biodiversity: The dolphin *Tursiops truncatus* (DD) is regularly seen, and it is likely that other dolphins, including *Steno bredanensis* (DD) and *Stenella coeruleoalba* (LC/cd), and the sea turtle *Caretta caretta* (EN), recorded from the Parc National des Iles de la Madeleine (site SN010), will also be present in this site.

IBA	Site Description	Key Biodiversity Summary
Guembeul Avifaunal Reserve and Saint-Louis lagoons – SN005	This marine/estuarine site lies approximately 12 km south of Saint-Louis and about 60 km southwest of Djoudj wetlands (site SN001). The reserve consists of an extensive lagoon of variable salinity in a shallow depression, with a relict mangrove along the shores. The lagoon is replenished both by seasonal rainfall and by inflow of salt water from the Senegal River mouth and water-levels can be controlled artificially by means of a sluice gate. In addition to the official reserve, a number of brackish lagoons around the town of Saint-Louis, all linked to the river estuary, are included in the IBA. These vary significantly in size, depending on the water-level in the Senegal River and the rainfall. The vegetation around the lagoons is Sahelian thorn-bush savanna dominated by *Acacia* spp. The lagoons are highly productive and those outside the reserve support important local fishing economies. The surrounding areas are used for livestock-grazing, agriculture and fuelwood-collection, all of which (together with fishing) are prohibited in the reserve itself.	The site harbors a wide variety of Palearctic migrant ducks and waders, and important numbers of gull and tern species. *Larus audouinii* is recorded regularly in small numbers along the river and lagoons (maximum 17 birds recorded from Saint-Louis lagoons and Parc National de la Langue de Barbarie [site SN006], combined, in 1994). In addition to key trigger species, large numbers of *Anas clypeata*, *Limosa limosa*, *Calidris minuta* and *C. ferruginea* have been recorded and *Egretta gularis* occurs regularly along the lagoon edges. *Pelecanus onocrotalus* occurs in winter numbers close to the IBA thresholds (e.g., 650 at Guembeul, 525 at Saint-Louis lagoons in the late 1980s and 1990s), and *Sterna sandvicensis* and *S. albifrons* are recorded wintering in numbers which exceed IBA thresholds, but these records cover the whole coastline from Saint-Louis to Cayar (i.e., also including Parc National de la Langue de Barbarie [site SN006]). There is a record from 1988 of 4,000 *Larus genei*, but subsequent numbers have never exceeded the hundreds (still regularly over the IBA threshold for the species). *Sterna nilotica* and *S. albifrons* are recorded breeding at Guembeul. There is considerable interchange of birds between this site and site SN006, which lies to the south, farther out to sea along the extensive Senegal River mouth. In addition, five species of the Sahel biome have been recorded. Non-bird biodiversity: A project to reintroduce mammals and reptiles which were previously common in the Sahel region is based at Guembeul Avifaunal Reserve, where there is a captive-breeding enclosure for *Gazella dama* (EN), *Oryx dammah* (EN) and the tortoise *Geochelone sulcata* (VU). The plan is for reintroductions to be made in the northern Ferlo region (site SN007).
Parc National de la Langue de Barbarie – SN006	The Langue de Barbarie National Park lies south-west of the Guembeul Avifaunal Reserve (part of site SN005), about 25 km from Saint-Louis. It consists of a 20-km length of intertidal flats and sand dunes on a spit formed across the mouth of the Senegal River. It includes both marine and riverine (brackish) waters. The terrestrial part of the park is formed by three main islands, the Ile de Gandiole (2 ha) being the largest. The vegetation on the infertile sandy soils is Sahelian in composition and includes the species *Ipomoea pescaprae*, *Alternanthera maritima*, *Sporobolus spicatus,* and *Sesuvium portulacastrum*. There are no trees.	The site is particularly important for the large numbers of breeding and wintering gulls and terns, including breeding *Sterna nilotica* at the southern limit of its breeding range. *Larus audouinii* (LR/cd) is recorded regularly in small numbers along the river and lagoons (maximum 17 birds recorded from the Langue de Barbarie and Saint-Louis lagoons [part of site SN005] combined in 1994). *Sterna sandvicensis* and *S. albifrons* are also recorded wintering in numbers which exceed IBA thresholds, but these records cover the whole coastline from Saint-Louis to Cayar (i.e., also including site SN005, Guembeul Avifaunal Reserve and Saint-Louis lagoons). The site is frequently used by wintering *Phoenicopterus ruber*; which move between this and all the other sites in the delta area of the Senegal River (i.e., sites SN001 to SN005 inclusive) and south-western Mauritania. Wintering *Pandion haliaetus* are common. *Egretta gularis* is recorded breeding (126 pairs in 1998). There is considerable interchange of birds of several species between this site and site SN005, which lies to the north, farther upstream along the extensive Senegal River mouth. Non-bird biodiversity: The marine fauna includes the turtles *Chelonia mydas* (EN), *Dermochelys coriacea* (EN), *Eretmochelys imbricata* (CE) and *Caretta caretta* (EN).

IBA	Site Description	Key Biodiversity Summary
Parc National des Iles de la Madeleine – SN010	The park consists of three rocky, volcanic islands lying about 4 km west of the Senegal coast, off the southern end of the Cap Vert peninsula on which Dakar lies, and the areas of sea between the islands. The largest, the “Iles aux serpents”, is about 15 ha. The islands are covered in steppe-grassland. Trees include baobabs *Adansonia*, jujubas *Ziziphus*, prickly-pear *Opuntia* and tamarinds *Tamarindus*.	The 30 or more pairs of *Phaethon aethereus* are the only breeding birds of this species known from a mainland African country. The islands harbor a varied avifauna, including a breeding colony (400 nests) of *Phalacrocorax carbo* (introduced in the 1980s from the Parc National des Oiseaux du Djoudj, part of site SN001) and breeding *Corvus albus*, *Milvus migrans*, *Galerida cristata*, and *Euplectes orix. Sterna anaethetus* breeds on the islands, and there are records of *Sula leucogaster*, *Morus bassanus*, *Larus cachinnans*, *L. cirrocephalus*, and *L. fuscus*. *Alaemon alaudipes*, restricted to the Sahara–Sindian (A02) biome, has been recorded from the site. Non-bird biodiversity: The sea turtle *Caretta caretta* (EN) has nested on a small beach, and the dolphins *Steno bredanensis* (DD) and *Stenella coeruleoalba* (LR/cd) have been recorded within the park. The tortoise *Geochelone sulcata* (VU) has been introduced to the islands.

From: BirdLife International, 2015

Table G-17. List of Important (Key) Bird Species for Marine Important Bird and Biodiversity Areas (IBAs) in the Senegal Portion of the Core Study Area.

	Season	Period[1]	Population Estimate (Number of Individuals)[3]	IBA Criteria[2]	IUCN Category
Cap Vert (Cape Verde) – SN017					
Audouin's Gull (*Larus audouinii*)	winter	1996	280	A1	Near Threatened
Sandwich Tern (*Thalasseus sandvicensis*)	winter	1997	13,000	A4i	Least Concern
Black Tern (*Chlidonias niger*)	passage	1996	23,923	A4i	Least Concern
Guembeul Avifaunal Reserve and Saint-Louis Lagoons – SN005					
Greater Flamingo (*Phoenicopterus roseus*)	winter	1996	4,500	A4i	Least Concern
Eurasian Spoonbill (*Platalea leucorodia*)	winter	1997	477	A4i	Least Concern
Pied Avocet (*Recurvirostra avosetta*)	winter	1988	7,000	A4i	Least Concern
Grey-headed Gull (*Larus cirrocephalus*)	winter	1997	1,050	A4i	Least Concern
Slender-billed Gull (*Larus genei*)	winter	1995	678	A4i	Least Concern
Parc National de la Langue de Barbarie – SN006					
Gull-billed tern (*Sterna nilotica*)	breeding	1984	200 (breeding pairs)	A4i	Not Recognized
Grey-headed Gull (*Larus cirrocephalus*)	winter	1997	1,838	A4i	Least Concern
Grey-headed Gull (*Larus cirrocephalus*)	breeding	1998	3,000 (breeding pairs)	A4i	Least Concern
Slender-billed Gull (*Larus genei*)	winter	1988	1,000	A4i	Least Concern
Slender-billed Gull (*Larus genei*)	breeding	1991	2,850 (breeding pairs)	A4i	Least Concern
Caspian Tern (*Hydroprogne caspia*)	winter	1997	424	A4i	Least Concern
Caspian Tern (*Hydroprogne caspia*)	breeding	1991	150 (breeding pairs)	A4i	Least Concern
Royal Tern (*Thalasseus maximus*)	breeding	1991	2,650 (breeding pairs)	A4i	Least Concern
Little Tern (*Sternula albifrons*)	breeding	1998	35 (breeding pairs)	A4i	Least Concern
Parc National des Iles de la Madeleine – SN010					
Red-billed Tropicbird (*Phaethon aethereus*)	breeding	-	30 (breeding pairs)	A4ii	Least Concern

[1] Period - Data on numbers of species and individuals are from counts made by a number of observers during the year indicated.
[2] IBA criteria A4 - Congregations. Criteria: A site may qualify on any one or more of the following four criteria:
A4i: Site known or thought to hold, on a regular basis, >1% of a biogeographic population of a congregatory waterbird species.
A4ii: Site known or thought to hold, on a regular basis, >1% of the global population of a congregatory seabird or terrestrial species.
A4iii: Site known or thought to hold, on a regular basis, > 20,000 waterbirds or >10,000 pairs of seabirds of one or more species.
A4iv: Site known or thought to exceed thresholds set for migratory species at bottleneck sites.
[3] From International Union for the Conservation of Nature (2012).
From: BirdLife International, 2015

Atlantic humpback dolphins (*Sousa teuszii*) are endemic to the eastern tropical Atlantic, where they are limited to coastal and inshore waters (Ross, 2002; Van Waerebeek et al., 2004). They occur in nearshore waters off tropical to subtropical West Africa, from Western Sahara south to at least southern Angola (Notarbartolo di Sciara et al., 1998; Van Waerebeek et al., 2004). Six contemporary management stocks are provisionally identified: Dakhla Bay (Western Sahara), Banc d'Arguin (Mauritania), Saloum-Niumi (Senegal), Canal do Gêba-Bijagos (Guinea-Bissau), South Guinea, and Angola; two stocks are now extirpated: Cameroon and Gabon Estuary. Signs of a probable north-south migration, and potential exchange of individuals between known population or subpopulation distribution centers include (from north to south): Dakhla Bay (Western Sahara), Banc d'Arguin (Mauritania), Langue de Barbarie (Senegal), Sine Saloum delta (Senegal), the northwest bank of the Gambia River outer estuary (The Gambia), and Guinea-Bissau archipelago.

Pinnipeds

The Mediterranean monk seal (*Monachus monachus*) is the only pinniped present in West African waters. Populations of Mediterranean monk seal have declined drastically over the past 50 years and, according to the International Union for Conservation of Nature (IUCN), it is now listed as an Endangered species, with an estimated world population between 350 and 450 individuals (IUCN, 2017). Approximately 130 monk seals currently inhabit the Cap Blanc area (Western Sahara-Mauritania). Historically, *Monachus monachus* occupied a wide geographical range, with colonies found throughout the Mediterranean, Marmara, and Black Seas. The species also frequented the Atlantic coast of Africa, as far south as Mauritania, Senegal, and The Gambia, as well as the Atlantic islands of Cape Verde, Madeira, the Canary Islands, and the Azores (Johnson and Lavigne, 1999; Johnson, 2004). Monk seals have been observed along the Senegal coast (Langue-de-Barbarie National Park), although no known population resides in the region. Monk seals are found mostly on the sandy and rocky beaches of the Mauritanian coast, between Cap Blanc and Cap Barbas. They are usually found in remote and quiet areas with caves in which they can breed from October to December. Females give birth during the months of September to October. Weaning takes between 4 and 6 weeks. Mediterranean monk seals take a wide variety of prey primarily from shallow water habitats (Sergeant et al., 1978; Kenyon, 1981).

Sirenians

The African manatee (*Trichechus senegalensis*) occurs in most of the coastal marine waters, brackish estuaries, and adjacent rivers along the coast of West Africa from southern Mauritania to Angola (Powell, 1990). While found in rivers and estuaries within its range, this species may be found along the coast and may venture offshore and into the Bijagos Archipelago of Guinea-Bissau as well as Casamance (Senegal). While African manatees prefer rivers and estuaries, it may occur in coastal waters (Powell and Kouadio, 2008).

Mauritania Marine Mammals

Marine mammal species of Mauritania are outlined in Table G-18.

Table G-18. Marine Mammal Species of Mauritania, Including their Habitat and Range, and Protected Status.

Common and Scientific Name	Description of Habitat and Range	Protected Status[1,2]
North Atlantic minke whale (*Balaenoptera a. acutorostrata*)	Northern hemisphere subspecies of the common minke whale, which is a cosmopolitan species found in all oceans and in virtually all latitudes, from 65° S to 80° N. In parts of its range it is very abundant, in other parts much less so. Its migration patterns are poorly known. Prominent in the North Atlantic, minke whales also occur south of this range in the southeastern North Atlantic, but with no obvious seasonality, and are not common, with the exception of the Canary Islands, where they appear to be frequent year round. There have been occasional sightings and strandings off Spain and Portugal, Western Sahara, Mauritania, and Senegal. Minke whales are rare in the Azores and not recorded from Madeira.	CMS: Not listed CITES: Appendix I and II IUCN: Least Concern
Northern sei whale *(Balaenoptera b. borealis)*	Northern hemisphere subspecies with a mainly offshore distribution, occurring in the North Atlantic and North Pacific; occasional visitor to the Mediterranean. Sei whales migrate between tropical and subtropical latitudes in December to March and temperate and subpolar latitudes in June to September, staying mainly in water temperatures of 8°C to 18°C, and tend not to penetrate to such high latitudes as other balaenopterid whales. Their December to March distribution seems to be widely dispersed and is not fully mapped. Sei whales have been recorded in December to March as far south as the Caribbean Sea and Cape Blanc, Mauritania.	CMS: Appendix I and II CITES: Appendix I IUCN: Endangered
Offshore Bryde's whale (*Balaenoptera edeni brydei*)	Subspecies that occurs in the Pacific, Indian, and Atlantic Oceans between about 40° N and 40° S or in waters warmer than 16.3°C. Migration to equatorial waters in December to March is documented for the southeast Atlantic population and for the northwest Pacific population. Migration patterns of other populations are poorly known. In the South Atlantic, there is a population that summers off the western coast of southern Africa and migrates to West African equatorial waters in December to March. Elsewhere in the Atlantic, the distribution of Bryde's whales is not well known.	CMS: Appendix II CITES: Appendix I IUCN: Data Deficient
Northern blue whale (*Balaenoptera m. musculus*)	Northern hemisphere subspecies. In the North Atlantic, the June to September distribution of blue whales extends in the west from the Scotian Shelf to the Davis Strait. The December to March distribution is poorly known but it appears that in the past blue whales were widely distributed in the southern half of the North Atlantic in December to March. Blue whales have been observed in Mauritanian waters; an eastern Atlantic population has also been recorded as wintering at the Cape Verde Islands.	CMS: Appendix I CITES: Appendix I IUCN: Endangered
Northern fin whale (*Balaenoptera p. physalus*)	Northern hemisphere subspecies. In the North Atlantic whose range extends as far as Svalbard (Norway) in the northeast, to the Davis Strait and Baffin Bay (Canada), and Denmark/Greenland in the northwest, to the Canary Islands (Spain) in the southeast, and to the Antilles in the southwest, but it is rare in the Caribbean and Gulf of Mexico.	CMS: Appendix I and II CITES: Appendix I IUCN: Endangered
North Atlantic humpback whale (*Megaptera n. novaeangliae*)	North Atlantic subspecies which ranges in June to September from the Gulf of Maine in the west and Ireland in the east; the northern extent of the humpback's range includes the Barents Sea, Greenland Sea, and Davis Strait. They occur mainly in specific feeding areas. In the December to March, the great majority of whales migrate to wintering grounds in the West Indies, and an apparently small number use breeding areas around the Cape Verde Islands. Most humpback whales migrate between mating and calving grounds in tropical waters, usually near continental coastlines or island groups, and productive colder waters in temperate and high latitudes.	CMS: Appendix I CITES: Appendix I IUCN: Least Concern
Harbor porpoise (*Phocoena phocoena*)	Harbor porpoises are found in cold temperate to subpolar waters of the Northern Hemisphere. They are usually found in continental shelf waters, although they occasionally travel over deeper offshore waters. In the North Atlantic, they are found from the southeastern U.S. to southern Baffin Island in the west, and from Senegal to Novaya Zemlya in the east.	CMS: Appendix II CITES: Appendix II IUCN: Least Concern

Common and Scientific Name	Description of Habitat and Range	Protected Status[1,2]
Sperm whale (*Physeter macrocephalus*)	Cosmopolitan geographic range. It can be seen in nearly all marine regions, from the equator to high latitudes, but is generally found in continental slope or deeper water; distribution also extends to many enclosed or partially enclosed seas.	CMS: Appendix I and II CITES: Appendix I IUCN: Vulnerable
Pygmy sperm whale (*Kogia breviceps*)	Known from deep waters (outer continental shelf and beyond) in tropical to warm temperate zones of all oceans. The range is poorly known, though a lack of records of live animals may be more due to inconspicuous behavior rather than rarity. Most information stems from strandings (especially females with calves), which may give an inaccurate picture of the actual distribution at sea.	CMS: Not listed CITES: Appendix II IUCN: Data Deficient
Dwarf sperm whale (*Kogia sima*)	Distributed widely in offshore waters of tropical and warm temperate zones, though apparently preferring warmer waters than *K. breviceps*, and offshore waters.	CMS: Not listed CITES: Appendix II IUCN: Data Deficient
Blainville's beaked whale (*Mesoplodon densirostris*)	Occurs in temperate and tropical waters of all oceans. This species has the most extensive distribution of any other beaked whale of the genus *Mesoplodon* and is also the most tropical of the genus. They are generally found in deep water environments. They also occur in many enclosed seas.	CMS: Not listed CITES: Appendix II IUCN: Data Deficient
Gervais' beaked whale (*Mesoplodon europaeus*)	Probably continuously distributed in deep waters across the tropical and temperate Atlantic Ocean, both north and south of the equator. Most records are from the east and Gulf coasts of North America, from New York to Texas, but Gervais' beaked whales are also known from several of the Caribbean islands. This is the most commonly stranded beaked whale in the southeastern U.S. In the eastern Atlantic, they are known from Ireland to Guinea-Bissau in West Africa.	CMS: Not listed CITES: Appendix II IUCN: Data Deficient
Cuvier's beaked whale (*Ziphius cavirostris*)	Most extensive range of any beaked whale species. They are widely distributed in offshore waters of all oceans, from the tropics to the polar regions in both hemispheres. Their range covers most marine waters of the world, with the exception of shallow water areas, and very high-latitude polar regions. They are also found in many enclosed seas.	CMS: Not listed CITES: Appendix I and II IUCN: Least Concern
Killer whale (*Orcinus orca*)	Most cosmopolitan of all cetaceans. Killer whales can be seen in virtually any marine region, from the equator to polar waters. Although they are generally more common in nearshore areas and in higher-productivity areas and/or higher latitudes, there appear to be no restrictions of water temperature or depth on their range.	CMS: Appendix II CITES: Appendix II IUCN: Data Deficient
Pygmy killer whale (*Feresa attenuata*)	Tropical/subtropical species that inhabits oceanic waters around the globe generally between 40° N and 35° S. It does not generally approach close to shore, except in some areas where deep, clear waters are very close to the coast.	CMS: Not listed CITES: Appendix II IUCN: Data Deficient
False killer whale (*Pseudorca crassidens*)	Found in tropical to warm temperate zones, generally in relatively deep, offshore waters of all three major oceans. They do not generally range into latitudes higher than 50° in either hemisphere. However, some animals occasionally move into higher-latitude waters. They are also found in many semi-enclosed seas and bays.	CMS: Not listed CITES: Appendix II IUCN: Data Deficient

Common and Scientific Name	Description of Habitat and Range	Protected Status[1,2]
Common dolphin (*Delphinus d. delphis*)	Oceanic species that is widely distributed in tropical to cool temperate waters of the Atlantic and Pacific Oceans, from nearshore waters to thousands of kilometers offshore. They regularly occur in some enclosed seas.	CMS: Appendix I and II CITES: Appendix II IUCN: Least Concern
Fraser's dolphin (*Lagenodelphis hosei*)	Pantropical distribution, largely between 30° N and 30° S in all three major oceans. Strandings in temperate areas may represent extralimital forays connected with temporary oceanographic anomalies.	CMS: Appendix II CITES: Appendix II IUCN: Least Concern
Atlantic humpback dolphin (*Sousa teuszii*)	Ranges along the West Africa coast from Dakhla Bay (23°54' N) in Morocco/Western Sahara south to Tombua (15°47' S), southern Angola. Six contemporary management stocks are provisionally discerned: Dakhla Bay (Morocco/Western Sahara), Banc d'Arguin (Mauritania), Saloum-Niumi (Senegal), Canal do Gêba-Bijagos (Guinea-Bissau), South Guinea, and Angola; two stocks now extirpated: Cameroon and Gabon Estuary. Signs of a probable north-south migration, and potential exchange of individuals between known population or subpopulation distribution centers (from north to south): Dakhla Bay (Western Sahara), Banc d'Arguin (Mauritania), Langue de Barbarie (Senegal), Sine Saloum delta (Senegal), NW bank of the Gambia River outer estuary (The Gambia), and Guinea-Bissau archipelago.	CMS: Appendix I and II CITES: Appendix I IUCN: Vulnerable
Pantropical spotted dolphin (*Stenella attenuata*)	Pantropical distribution, found in all oceans between about 40° N and 40° S, although it is much more abundant in the lower-latitude portions of its range. The range extends to some enclosed seas.	CMS: Appendix II CITES: Appendix II IUCN: Least Concern
Clymene dolphin (*Stenella clymene*)	Found only in the tropical and subtropical Atlantic Ocean, including the Caribbean Sea and Gulf of Mexico. This species has a notable warm-water preference, although there are records as far north as New Jersey on the U.S. east coast and as far south as southern Brazil. The limits on the West African coast are not well known, but extend from at least the equator north to Mauritania.	CMS: Appendix II CITES: Appendix II IUCN: Data Deficient
Striped dolphin (*Stenella coeruleoalba*)	Widely distributed species, found in tropical and warm-temperate waters of the Atlantic, Pacific, and Indian oceans, as well as many adjacent seas, including the Mediterranean. Northern and southern range limits are about 50° N and 40° S, although there are extralimital records.	CMS: Appendix II CITES: Appendix II IUCN: Least Concern
Atlantic spotted dolphin (*Stenella frontalis*)	Found only in the Atlantic Ocean, from southern Brazil to the U.S. (New England region) in the west, and to the coast of Africa in the east; the exact limits off West Africa are not well known. A discontinuity in the range of the species exists in the western South Atlantic Ocean.	CMS: Not listed CITES: Appendix II IUCN: Data Deficient
Spinner dolphin (*Stenella longirostris*)	Ranges through tropical and subtropical zones in both hemispheres. Limits are near 40° N and 40° S. *Stenella longirostris* occurs mainly around oceanic islands in the tropical Atlantic, Indian, and western and central Pacific east to about 145° W. However, the distribution in the Atlantic is not well known, especially in South American and African waters.	CMS: Appendix II CITES: Appendix II IUCN: Data Deficient

Common and Scientific Name	Description of Habitat and Range	Protected Status[1,2]
Rough-toothed dolphin (*Steno bredanensis*)	Tropical to subtropical species, which generally inhabits deep, oceanic waters of all three major oceans, rarely ranging north of 40° N or south of 35° S. However, in some areas (such as off the coast of Brazil and West Africa), rough-toothed dolphins may occur in more shallow coastal waters. They are found in many semi-enclosed bodies of water.	CMS: Not listed CITES: Appendix II IUCN: Least Concern
Common bottlenose dolphin (*Tursiops truncatus*)	Distributed worldwide through tropical and temperate inshore, coastal, shelf, and oceanic waters. Bottlenose dolphins generally do not range pole-ward of 45°, except in northern Europe and to southern New Zealand.	CMS: Appendix I and II CITES: Appendix II IUCN: Least Concern
Short-finned pilot whale (*Globicephala macrorhynchus*)	Found in warm temperate to tropical waters of the world, generally in offshore deep areas; they do not usually range north of 50° N or south of 40° S.	CMS: Not listed CITES: Appendix II IUCN: Data Deficient
Long-finned pilot whale (*Globicephala melas*)	Long-finned pilot whales found in the North Atlantic are wide-ranging and have been observed off the coast of the eastern U.S. and Canada, across the Atlantic in places such as the Azores and the Faroe Islands, as well as down the western coast of Europe to the Strait of Gibraltar, and northwest Africa.	CMS: Not listed CITES: Appendix II IUCN: Data Deficient
Risso's dolphin (*Grampus griseus*)	Widely distributed species, inhabiting primarily deep waters of the continental slope and outer shelf (especially with steep bottom topography), from the tropics through the temperate regions in both hemispheres; it also occurs in some oceanic areas, beyond the continental slope.	CMS: Appendix II CITES: Appendix II IUCN: Least Concern
Melon-headed whale (*Peponocephala electra*)	Pantropical distribution; distribution coincides almost exactly with that of the pygmy killer whale in tropical/subtropical oceanic waters between about 40° N and 35° S. A few high-latitude strandings are thought to be extralimital records, and are generally associated with incursions of warm water.	CMS: Not listed CITES: Appendix II IUCN: Least Concern
African manatee (*Trichechus senegalensis*)	Occurs in most of the coastal marine waters, brackish estuaries, and adjacent rivers along the coast of West Africa from southern Mauritania (16° N) to Angola (18° S); they ascend most major rivers within their range until cataracts or shallow water prevents their progress. Manatees can be found 75 km offshore among the shallow coastal flats and mangrove creeks (with abundant seagrasses and calm water) of the Bijagós Archipelago of Guinea-Bissau as well as Casamance (Senegal). They occur along the entire length of the Gambia River, penetrating into Senegal where there are records as far upstream as Niokola Koba National Park. Centers of population appear to be Guinea-Bissau; the lagoons of Ivory Coast; the lower reaches of the Niger River, Nigeria; Sanaga River, Cameroon; coastal lagoons of Gabon; and the lower reaches of the Congo River.	CMS: Appendix I and II CITES: Appendix I IUCN: Vulnerable

Common and Scientific Name	Description of Habitat and Range	Protected Status[1,2]
Mediterranean monk seal (*Monachus monachus*)	Mediterranean monk seals were once widely and continuously distributed in the Mediterranean, Black, and adjacent seas, and in the North Atlantic waters from Morocco to Cape Blanc, including the Canary Islands, Madeira Islands, and the Azores. A few individuals, possibly vagrants, have been recorded in Senegal, The Gambia, and the Cape Verde Islands in the south end of the distribution range as well as in Portugal and Atlantic France in the northern end. Today the distribution is widespread, but fragmented into an unknown but probably relatively large number of very small breeding subpopulations. The two surviving colonies in the south-eastern North Atlantic are at Cabo Blanco (also known as Cape Blanc or Ras Nouadhibou) on the border of Mauritania and Western Sahara, and the small colony at the Desertas Islands in the Madeira Islands group. Monk seals have also been reported along the Langue de Barbarie coast in northern Senegal.	CMS: Appendix I and II CITES: Appendix I IUCN: Endangered

1 CMS Appendices (CMS, 2015) - Appendix I lists migratory species which are endangered. Appendix II lists migratory species which have an unfavorable conservation status and which require international agreements for their conservation and management, as well as those which have a conservation status which would significantly benefit from the international co-operation that could be achieved by an international agreement.
2 CITES Appendices (CITES, 2017) - Appendix I lists species that are the most endangered among CITES-listed animals and plants (see Article II, paragraph 1 of the Convention). Appendix II lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled. Appendix III is a list of species included at the request of a Party that already regulates trade in the species and that needs the cooperation of other countries to prevent unsustainable or illegal exploitation.
From: Convention on International Trade in Endangered Species of Fauna and Flora [CITES], 2017; Convention on the Conservation of Migratory Species of Wild Animals [CMS], 2015, 2017; IUCN, 2017; Jefferson et al., 2015

In 2004, a survey of shelf waters was conducted by Tulp and Leopold (2004) in an effort to investigate the suitability of the combination of a survey of marine mammals and seabirds with an acoustic survey that is carried out twice per year to assess pelagic fish stocks. The survey area was conducted between 20 and 500 m water depth and between the border with Western Sahara at 20°40’ N and the border with Senegal at latitude 16°10’ N. A total of 28 transects positioned east-west at distances of 10 nm apart were surveyed. Cetaceans were only rarely encountered during the survey. In total, 10 groups or singletons were observed during 91.5 hours of counts. The sightings included two mysticete whales (fin whale and humpback whale), three species of small odontocete whales (killer whale, unidentified pilot whale and unidentified beaked whale), and two species of dolphin (common dolphin and bottlenose dolphin).

Between early February 2002 and late July 2002, a large three-dimensional (3D) marine seismic survey was conducted over an extensive area of the offshore waters off Mauritania (Burton, 2003). The survey comprised three discrete areas; one along the Mauritanian shelf and upper slope, and two along the slope. Eleven species of cetaceans were identified during the survey, including three dolphins (Atlantic spotted, bottlenose, and common), two pilot whales (short- and long-finned), one killer whale, and five mysticete whales (blue, humpback, sei, fin and minke). Dolphins accounted for over 90% of total numbers observed throughout the survey period; whereas baleen whales accounted for only 0.3%. The remaining 8.2% was composed of the larger odontocetes, predominantly pilot whales. Temporally, the sightings of all species increased in June and July, and all baleen whales were sighted in May. Spatially, the distribution of all sightings by depth showed a definite peak along the continental slope between the 500 and 1300 m contours.

Senegal Marine Mammals

Marine mammal species of Senegal are outlined in Table G-19.

Table G-19. Marine Mammals of Senegal, their Habitat and Range, and Protected Status.

Common and Scientific Name	Description of Habitat and Range	Protected Status[1,2]
Common minke whale (*Balaenoptera acutorostrata*)	Cosmopolitan species found in all oceans and in virtually all latitudes, from 65°S to 80°N. In parts of its range it is very abundant, in other parts much less so. Its migration patterns are poorly known. It occurs in the North Atlantic, the North Pacific, and the Southern Hemisphere. Prominent in the North Atlantic, minke whales also occur south of this range in the southeastern North Atlantic, but with no obvious seasonality, and are not common, with the exception of the Canary Islands, where they appear to be frequent year round. There have been occasional sightings and strandings off Spain and Portugal, Western Sahara, Mauritania and Senegal. Minke whales are rare in the Azores and not recorded from Madeira.	CMS: Not listed CITES: Appendix I and II IUCN: Least Concern
Sei whale *(Balaenoptera borealis)*	Cosmopolitan species, with a mainly offshore distribution, occurring in the North Atlantic, North Pacific, and Southern Hemisphere; occasional visitor to the Mediterranean. Sei whales migrate between tropical and subtropical latitudes in winter and temperate and subpolar latitudes in summer, staying mainly in water temperatures of 8°C to 18°C, and tend not to penetrate to such high latitudes as other rorquals. Their winter distribution seems to be widely dispersed and is not fully mapped. Sei whales have been recorded in winter as far south as the Caribbean Sea and Cap Blanc, Mauritania.	CMS: Appendix I and II CITES: Appendix I IUCN: Endangered
Bryde's whale (*Balaenoptera edeni*)	Occurs in the Pacific, Indian, and Atlantic Oceans between about 40°N and 40°S or in waters warmer than 16.3°C. Migration to equatorial waters in winter is documented for the southeast Atlantic population and for the northwest Pacific population. Migration patterns of other populations are poorly known. In the South Atlantic, there is a population that summers off the western coast of southern Africa and migrates to West African equatorial waters in winter. Elsewhere in the Atlantic, the distribution of Bryde's whales is not well known.	CMS: Appendix II CITES: Appendix I IUCN: Data Deficient
Blue whale (*Balaenoptera musculus*)	Cosmopolitan species, found in all oceans except the Arctic, but absent from some regional seas such as the Mediterranean, Okhotsk, and Bering Seas. In the North Atlantic, the summer distribution of blue whales extends in the west from the Scotian Shelf to the Davis Strait. The winter distribution is poorly known but it appears that in the past blue whales were widely distributed in the southern half of the North Atlantic in winter. Blue whales have been observed in Mauritanian waters; an eastern Atlantic population has also been recorded as wintering at the Cape Verde Islands.	CMS: Appendix I CITES: Appendix I IUCN: Endangered
Fin whale (*Balaenoptera physalus*)	Occur worldwide, mainly, but not exclusively, in offshore waters; rare in the tropics, except in certain cool-water areas (e.g., Peru). In the North Atlantic, range extends as far as Svalbard (Norway) in the northeast, to the Davis Strait and Baffin Bay (Canada) and Denmark/Greenland in the northwest, to the Canary Islands (Spain) in the southeast, and to the Antilles in the southwest, but it is rare in the Caribbean and Gulf of Mexico.	CMS: Appendix I and II CITES: Appendix I IUCN: Endangered
Humpback whale (*Megaptera novaeangliae*)	Cosmopolitan species found in all the major ocean basins, and all but one of the subpopulations (that of the Arabian Sea) migrate between mating and calving grounds in tropical waters, usually near continental coastlines or island groups, and productive colder waters in temperate and high latitudes. Humpbacks in the North Atlantic range in summer from the Gulf of Maine in the west and Ireland in the east; the northern extent of the humpback's range includes the Barents Sea, Greenland Sea, and Davis Strait. They occur mainly in specific feeding areas. In the winter, the great majority of whales migrate to wintering grounds in the West Indies, and an apparently small number use breeding areas around the Cape Verde Islands. Humpbacks have recently been sighted during 2011-2012 winter surveys between Conkary, Guinea and Dakar, Senegal (van Waerebeek et al., 2013), but were not observed between Dakar and Agadir, Morocco.	CMS: Appendix I CITES: Appendix I IUCN: Least Concern
Harbor porpoise (*Phocoena phocoena*)	Harbor porpoises are found in cold temperate to subpolar waters of the Northern Hemisphere. They are usually found in continental shelf waters, although they occasionally travel over deeper offshore waters. In the North Atlantic, they are found from the southeastern United States to southern Baffin Island in the west, and from Senegal to Novaya Zemlya in the east.	CMS: Appendix II CITES: Appendix II IUCN: Least Concern

Common and Scientific Name	Description of Habitat and Range	Protected Status[1,2]
Sperm whale (*Physeter macrocephalus*)	Large geographic range. It can be seen in nearly all marine regions, from the equator to high latitudes, but is generally found in continental slope or deeper water; distribution also extends to many enclosed or partially enclosed seas.	CMS: Appendix I and II CITES: Appendix I IUCN: Vulnerable
Pygmy sperm whale (*Kogia breviceps*)	Known from deep waters (outer continental shelf and beyond) in tropical to warm temperate zones of all oceans. The range of *Kogia breviceps* is poorly known, though a lack of records of live animals may be more due to inconspicuous behavior rather than rarity. Most information stems from strandings (especially females with calves), which may give an inaccurate picture of the actual distribution at sea.	CMS: Not listed CITES: Appendix II IUCN: Data Deficient
Dwarf sperm whale (*Kogia sima*)	Distributed widely in offshore waters of tropical and warm temperate zones, apparently preferring warmer waters, and perhaps more offshore waters.	CMS: Not listed CITES: Appendix II IUCN: Data Deficient
Blainville's beaked whale (*Mesoplodon densirostris*)	Occurs in temperate and tropical waters of all oceans. This species has the most extensive distribution of any species of the genus *Mesoplodon* and is also the most tropical of the genus. Sightings are common around some oceanic archipelagos, like the Hawaiian (USA) and Society Islands (French Polynesia). They also occur in many enclosed seas.	CMS: Not listed CITES: Appendix II IUCN: Data Deficient
Gervais' beaked whale (*Mesoplodon europaeus*)	Probably continuously distributed in deep waters across the tropical and temperate Atlantic Ocean, both north and south of the equator. Most records are from the east and Gulf coasts of North America, from New York to Texas, but Gervais' beaked whales are also known from several of the Caribbean islands. This is the most commonly stranded beaked whale in the southeastern United States. In the eastern Atlantic, they are known from Ireland to Guinea-Bissau in West Africa.	CMS: Not listed CITES: Appendix II IUCN: Data Deficient
Cuvier's beaked whale (*Ziphius cavirostris*)	Most extensive range of any beaked whale species. They are widely distributed in offshore waters of all oceans, from the tropics to the polar regions in both hemispheres. Their range covers most marine waters of the world, with the exception of shallow water areas, and very high-latitude polar regions. They are also found in many enclosed seas.	CMS: Not listed CITES: Appendix I and II IUCN: Least Concern
Killer whale (*Orcinus orca*)	Most cosmopolitan of all cetaceans. Killer whales can be seen in virtually any marine region, from the equator to polar waters. Although they are generally more common in nearshore areas and in higher-productivity areas and/or higher latitudes, there appear to be no restrictions of water temperature or depth on their range. The distribution extends to many enclosed or partially enclosed seas.	CMS: Appendix II CITES: Appendix II IUCN: Data Deficient
Pygmy killer whale (*Feresa attenuata*)	Tropical/subtropical species that inhabits oceanic waters around the globe generally between 40°N and 35°S. It does not generally approach close to shore, except in some areas where deep, clear waters are very close to the coast.	CMS: Not listed CITES: Appendix II IUCN: Data Deficient
False killer whale (*Pseudorca crassidens*)	Found in tropical to warm temperate zones, generally in relatively deep, offshore waters of all three major oceans. They do not generally range into latitudes higher than 50° in either hemisphere. However, some animals occasionally move into higher-latitude waters. They are also found in many semi-enclosed seas and bays.	CMS: Not listed CITES: Appendix II IUCN: Data Deficient
Short-beaked common dolphin (*Delphinus delphis*)	Oceanic species that is widely distributed in tropical to cool temperate waters of the Atlantic and Pacific Oceans, from nearshore waters to thousands of kilometers offshore. They regularly occur in some enclosed seas.	CMS: Appendix I and II CITES: Appendix II IUCN: Least Concern

Common and Scientific Name	Description of Habitat and Range	Protected Status[1,2]
Fraser's dolphin (*Lagenodelphis hosei*)	Pantropical distribution, largely between 30°N and 30°S in all three major oceans. Strandings in temperate areas may represent extralimital forays connected with temporary oceanographic anomalies.	CMS: Appendix II CITES: Appendix II IUCN: Least Concern
Atlantic humpback dolphin (*Sousa teuszii*)	Ranges along the West Africa coast from Dakhla Bay (23°54'N) in Morocco/Western Sahara south to Tombua (15°47'S), southern Angola. Six contemporary management stocks are provisionally discerned: Dakhla Bay (Morocco/Western Sahara), Banc d'Arguin (Mauritania), Saloum-Niumi (Senegal), Canal do Gêba-Bijagos (Guinea-Bissau), South Guinea and Angola; two stocks now extirpated: Cameroon and Gabon Estuary. Signs of a probable north-south migration, and potential exchange of individuals between known population or subpopulation distribution centers (from north to south): Dakhla Bay (Western Sahara), Banc d'Arguin (Mauritania), Langue de Barbarie (Senegal), Sine Saloum delta (Senegal), NW bank of the Gambia River outer estuary (The Gambia) and Guinea-Bissau archipelago.	CMS: Appendix I and II CITES: Appendix I IUCN: Vulnerable
Pantropical spotted dolphin (*Stenella attenuata*)	Pantropical distribution, found in all oceans between about 40°N and 40°S, although it is much more abundant in the lower-latitude portions of its range. The range extends to some enclosed seas.	CMS: Appendix II CITES: Appendix II IUCN: Least Concern
Clymene dolphin (*Stenella clymene*)	Found only in the tropical and subtropical Atlantic Ocean, including the Caribbean Sea and Gulf of Mexico. This species has a notable warm-water preference, although there are records as far north as New Jersey on the U.S. east coast and as far south as southern Brazil. The limits on the West African coast are not well known, but extend from at least the equator north to Mauritania.	CMS: Appendix II CITES: Appendix II IUCN: Data Deficient
Striped dolphin (*Stenella coeruleoalba*)	Widely distributed species, found in tropical and warm-temperate waters of the Atlantic, Pacific, and Indian oceans, as well as many adjacent seas, including the Mediterranean. Northern and southern range limits are about 50°N and 40°S, although there are extralimital records.	CMS: Appendix II CITES: Appendix II IUCN: Least Concern
Atlantic spotted dolphin (*Stenella frontalis*)	Found only in the Atlantic Ocean, from southern Brazil to the United States (New England) in the west, and to the coast of Africa in the east; the exact limits off West Africa are not well known. A discontinuity in the range of the species exists in the western South Atlantic Ocean.	CMS: Not listed CITES: Appendix II IUCN: Data Deficient
Spinner dolphin (*Stenella longirostris*)	Ranges through *tropical and subtropical zones in both hemispheres. Limits are near 40°N and 40°S. Stenella longirostris* occurs mainly around oceanic islands in the tropical Atlantic, Indian, and western and central Pacific east to about 145°W. However, the distribution in the Atlantic is not well known, especially in South American and African waters.	CMS: Appendix II CITES: Appendix II IUCN: Data Deficient
Rough-toothed dolphin (*Steno bredanensis*)	Tropical to subtropical species, which generally inhabits deep, oceanic waters of all three major oceans, rarely ranging north of 40°N or south of 35°S. However, in some areas (such as off the coast of Brazil and West Africa), rough-toothed dolphins may occur in more shallow coastal waters. They are found in many semi-enclosed bodies of water.	CMS: Not listed CITES: Appendix II IUCN: Least Concern
Common bottlenose dolphin (*Tursiops truncatus*)	Distributed worldwide through tropical and temperate inshore, coastal, shelf, and oceanic waters. Bottlenose dolphins generally do not range pole-ward of 45°, except in northern Europe and to southern New Zealand.	CMS: Appendix I and II CITES: Appendix II IUCN: Least Concern

Common and Scientific Name	Description of Habitat and Range	Protected Status[1,2]
Short-finned pilot whale (*Globicephala macrorhynchus*)	Found in warm temperate to tropical waters of the world, generally in offshore deep areas; they do not usually range north of 50°N or south of 40°S.	CMS: Not listed CITES: Appendix II IUCN: Data Deficient
Risso's dolphin (*Grampus griseus*)	Widely distributed species, inhabiting primarily deep waters of the continental slope and outer shelf (especially with steep bottom topography), from the tropics through the temperate regions in both hemispheres; it also occurs in some oceanic areas, beyond the continental slope.	CMS: Appendix II CITES: Appendix II IUCN: Least Concern
Melon-headed whale (*Peponocephala electra*)	Pantropical distribution; distribution coincides almost exactly with that of the pygmy killer whale in tropical/subtropical oceanic waters between about 40°N and 35°S. A few high-latitude strandings are thought to be extralimital records, and are generally associated with incursions of warm water.	CMS: Not listed CITES: Appendix II IUCN: Least Concern
African manatee (*Trichechus senegalensis*)	Occurs in most of the coastal marine waters, brackish estuaries, and adjacent rivers along the coast of West Africa from southern Mauritania (16°N) to Angola (18°S); they ascend most major rivers within their range until cataracts or shallow water prevents their progress. Manatees can be found 75 km offshore among the shallow coastal flats and mangrove creeks (with abundant seagrasses and calm water) of the Bijagos Archipelago of Guinea-Bissau as well as Casamance (Senegal). They occur along the entire length of the Gambia River, penetrating into Senegal where there are records as far upstream as Niokola Koba National Park. Centers of population appear to be Guinea-Bissau; the lagoons of Ivory Coast; the lower reaches of the Niger River, Nigeria; Sanaga River, Cameroon; coastal lagoons of Gabon and the lower reaches of the Congo River.	CMS: Appendix I and II CITES: Appendix I IUCN: Vulnerable
Mediterranean monk seal (*Monachus monachus*)	Mediterranean monk seals were once widely and continuously distributed in the Mediterranean, Black, and adjacent seas, and in the North Atlantic waters from Morocco to Cap Blanc, including the Canary Islands, Madeira Islands, and the Azores. A few individuals, possibly vagrants, have been recorded in Senegal, The Gambia, and the Cape Verde Islands in the south end of the distribution range as well as in Portugal and Atlantic France in the northern end. Today the distribution is widespread, but fragmented into an unknown but probably relatively large number of very small breeding subpopulations. The two surviving colonies in the south-eastern North Atlantic are at Cabo Blanco (also known as Cap Blanc or Ras Nouadhibou) on the border of Mauritania and Western Sahara, and the small colony at the Desertas Islands in the Madeira Islands group. This species has been observed along the coastline of the Langue-de-Barbarie National Park.	CMS: Appendix I and II CITES: Appendix I IUCN: Endangered

[1] CMS Appendices (CMS, 2015) - Appendix I lists migratory species which are endangered. Appendix II lists migratory species which have an unfavorable conservation status and which require international agreements for their conservation and management, as well as those which have a conservation status which would significantly benefit from the international co-operation that could be achieved by an international agreement

[2] CITES Appendices (CITES, 2017) - Appendix I lists species that are the most endangered among CITES-listed animals and plants (see Article II, paragraph 1 of the Convention). Appendix II lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled. Appendix III is a list of species included at the request of a Party that already regulates trade in the species and that needs the cooperation of other countries to prevent unsustainable or illegal exploitation.

From: Convention on International Trade in Endangered Species of Fauna and Flora [CITES], 2017; Convention on the Conservation of Migratory Species of Wild Animals [CMS], 2015, 2017; International Union for Conservation of Nature [IUCN], 2017

Regional Observations of Marine Mammals

The ESIA baseline chapter (Chapter 4) presents the most recent and relevant marine mammal observation data for the project area. Other regional surveys have been conducted; the following synopsis summarizes relevant regional research and/or survey results to support details presented in ESIA Chapter 4.

Ndao (2006) identified prior marine mammal survey efforts in the region, noting the observations acquired during a survey in northwest African waters in December 2002, surveying offshore Guinea, Senegal, The Gambia, and Guinea-Bissau. During this period, 3,538 individuals were counted. Eight taxa were observed, including bottlenose dolphin, Atlantic spotted dolphin, pantropical spotted dolphin, common dolphin, unidentified dolphins, tropical pilot whales, sperm whales, and Bryde’s whales. The three main dominant species in coastal waters of Senegal were reported to be the common dolphin (71%), pilot whales (12%), and unidentified dolphins (10%). Sperm whales and Bryde's whales are poorly recorded.

In Guinea-Bissau, there are several species of dolphins, including bottlenose dolphin (*Tursiops truncatus*) and the Atlantic humpback dolphin (*Souza teuszii*). Species of whales and dolphins encountered in the Cape Verde Islands include several baleen whale species (blue whale, *Balaenoptera musculus*; humpback whale, *Megaptera novaeangliae*) and multiple toothed whales species (bottlenose dolphin, *Tursiops truncatus*; spotted dolphin, *Stenella frontalis*; pantropical spotted dolphin, *Stenella attenuata*; common dolphin, *Delphinus delphis*; long-finned pilot whale, *Globicephala melas*; killer whale, *Orcinus orca*; short-finned pilot whale, *Globicephala macrorhynchus*; Blainville's beaked whale, *Mesoplodon densirostris*).

Djiba et al. (2015) have summarized the results of regional fisheries research surveys conducted between 2011 and 2013 within waters of the continental shelf and, to a limited extent, contiguous slope waters. The surveys covered waters off Guinea, Guinea-Bissau, Mauritania, Morocco, Senegal, The Gambia, and Western Sahara. A total of 270 primary sightings were noted comprising 14 different species, including 10 odontocete taxa and four mysticete species. Sightings were dominated by short-beaked common dolphins (>71% of total sightings), followed by several other odontocete species: common bottlenose dolphin, pilot whale, killer whale, Risso's dolphin, Atlantic spotted dolphin, Pantropical spotted dolphin, Clymene dolphin, striped dolphin, and beaked whales (Ziphiidae). Among the mysticetes, sightings were dominated by humpback whales, followed by Bryde's whales, sei whales, and blue whales.

G.7 Sea Turtles

Loggerhead turtle (Caretta caretta)

The loggerhead turtle is the most common species in the region. It is a large cheloniid sea turtle species, with adults reaching up to 1.1 m in carapace length and a weight of 181 kg (Márquez, 1990). Loggerheads are found in tropical and subtropical coastal waters. Adults feed on a wide variety of benthic fauna such as mollusks, crabs, sea urchins, sponges, and fish. Hatchling turtles feed on jellyfish, *Sargassum*, gastropods, and crustaceans (Márquez, 1990). The migration path of loggerhead turtles within West Africa is not well understood. Satellite tracking studies found that adult loggerhead females, and possibly also males (Cejudo et al., 2008), may travel close to the West African coast between Mauritania and Sierra Leone between nesting seasons (Hawkes et al., 2006). Loggerhead turtles nest during the months of July to October, mainly on continental coastlines.

Leatherback turtle (Dermochelys coriacea)

The leatherback turtle (*Dermochelys coriacea*) is the largest sea turtle and one of the largest reptiles; adults reach up to 1.8 m in carapace length and can weigh as much as 907 kg. They are easily distinguished from all other sea turtle species by their large spindle-shaped, leathery, and unscaled carapaces that possess a series of parallel dorsal ridges, or keels (Márquez, 1990). The leatherback turtle is a cosmopolitan species that is found in the Mediterranean Sea and Indian, Pacific, and Atlantic Oceans. It is a highly pelagic species that approaches coastal waters during the breeding periods, although individuals have been reported in coastal waters in search of prey items. Leatherback turtles feed mainly on jellyfish, tunicates, and other epipelagic soft-bodied invertebrates. Little is known about the route that leatherback turtles follow during their migration, but it is known that this species moves erratically in search of food. Some nesting of leatherback turtles was reported in Mauritania and Senegal (Maigret, 1978, 1983; Dupuy, 1986), but whether nesting is regular in these countries remains to be confirmed (Fretley et al., 2007).

Green turtle (Chelonia mydas)

The green turtle is the largest cheloniid sea turtle. Adults can reach 0.91 m in carapace length and range between 136 and 159 kg (Márquez, 1990). The green turtle is a circumglobal species found in the Mediterranean Sea and the Pacific, Indian, and Atlantic Oceans between 30° N and 30° S latitude, and, to a lesser extent, in temperate waters (Márquez, 1990). Satellite tagging data indicate that, similar to other sea turtles, green turtles display highly migratory behavior, making vast seasonal coastal and annual transoceanic migrations (Godley et al., 2003, 2008, 2010). Adult and juvenile green turtles occur along most of the West African coastline between Morocco and Namibia, including substantial nesting and feeding populations in Mauritania, Guinea Bissau, Equatorial Guinea, Sao Tome, and Gabon. The significant areas of seagrass beds within the Banc d'Arguin National Park [PNBA] is considered to have the most important feeding grounds for green turtles in West Africa (Formia and Bruford, 2008). Nesting occurs from January to March and July to October.

Hawksbill turtle (Eretmochelys imbricata)

The hawksbill turtle is a medium-size cheloniid sea turtle. The hawksbill turtle is a circumglobal species found in the Pacific, Indian, and Atlantic Oceans between latitudes 30° N and 30° S (Márquez, 1990). Hawksbill turtles display highly migratory behavior, with satellite tagging data demonstrating that these turtles undergo short and long migrations from nesting to foraging grounds (Blumenthal et al., 2009). Hawksbill turtles nest on the beaches of Guinea and Mauritania.

Olive ridley turtle (Lepidochelys olivacea)

The olive ridley is one of the smallest species of sea turtle (Márquez, 1990). The olive ridley is a pantropical species that lives mainly in the northern hemisphere. It usually migrates along continental shelves and feeds in shallow waters of the inner shelf and within embayments (Márquez, 1990). This species is sometimes seen in the region but its visits there are believed to be rare.

Kemp's ridley turtle (Lepidochelys kempii)

The Kemp's ridley is the smallest species of sea turtle (Márquez, 1990). Its range includes the Gulf of Mexico and western North Atlantic (Márquez, 1990). Stranded individuals of this species have been recorded along the shores of Mauritania; however, its presence in the region is considered extralimital or accidental.

G.8 Shoreline Characterization

CSA Ocean Sciences Inc. conducted a review of ESRI base map imagery in conjunction with application of the National Oceanic and Atmospheric Administration's (NOAA) shoreline characterization methodology and Environmental Sensitivity Index (ESI), to determine the shoreline characteristics of the core study area. The ESI methodology delineates 10 primary shoreline types (e.g., rocky shore; sandy beach, etc.) and a total of 27 different shoreline characterizations (NOAA, 2013).

The shoreline delineation was interpreted manually using high-resolution ESRI base map imagery. Imagery was digitized at varying scales depending on the intricacy of the different shoreline types. This approach streamlined the digitization process without jeopardizing accuracy. The scale of each line that was digitized was logged within the attributes to ensure that the accuracy of the shoreline was documented. Google Earth was also utilized to assist in ground truthing the shoreline, leveraging the geo-located photos within the application to inspect the shoreline at ground level (where applicable), and provide a clearer picture of the shoreline when the ESRI imagery was impeded (e.g., due to cloud cover, Saharan dust, etc.). Not evaluated in this imagery review was the extensive estuarine environment of the Senegal River.

A total of six pre-determined shoreline types were utilized in the shoreline characterization:

- Exposed Rocky Cliff with Boulder Talus Base (ESI category 1A)
- Exposed Rocky Shore (ESI category 1C)
- Sandy Beach (ESI category 4)
- Man-made Riprap and Seawall (Boulders, Cobbles, Bulkheads) (ESI category 6B)
- Sheltered, Rocky Shore (ESI category 8)
- Wetlands (ESI category 10)

The shoreline types were pre-determined and consolidated due to the fact that there was no conclusive ground truth effort.

The shoreline of the core study area, extending from Nouadhibou, Mauritania to Dakar, Senegal, is comprised of six shoreline types, as defined by ESI categories (NOAA, 2013). The predominant shoreline type is this area is sandy beach, with varying but limited amounts of exposed rocky shore, exposed rocky cliff with boulder talus base, man-made riprap and seawall, sheltered rocky shore, and wetlands. Shoreline types, their linear measurement, and their percentage of total shoreline length within the core study area of both Mauritania and Senegal are summarized in Table G-20.

Table G-20. Summary of shoreline types present along the coastline of the core study area.

Shoreline Type	Description	Senegal		Mauritania	
		Length (km)	Percentage of Shoreline	Length (km)	Percentage of Shoreline
1A	Exposed Rocky Shore	19.41	7.69	27.93	2.21
1C	Exposed Rocky Cliff with Boulder Talus Base	11.43	4.53	9.24	0.73
4	Sandy Beach	199.66	79.08	1,181.67	93.48
6B	Man-made Riprap and Seawall (boulders, cobbles, bulkheads)	21.37	8.47	6.53	0.52
8	Sheltered, Rocky Shore	0.61	0.24	0.00	0.00
10	Wetlands	0.00	0.00	38.71	3.06
	**Total Shoreline Length*	*252.47*		*1,264.08*	

Notes: Calculations performed using coordinate system: WGS 1984 UTM Zone 28N; Unit(s): meters; Shoreline type per NOAA (2013).

Figures G-7 and G-8 depict the ESI shoreline types and their distribution along the Mauritania and Senegal portions of the core study area, respectively.

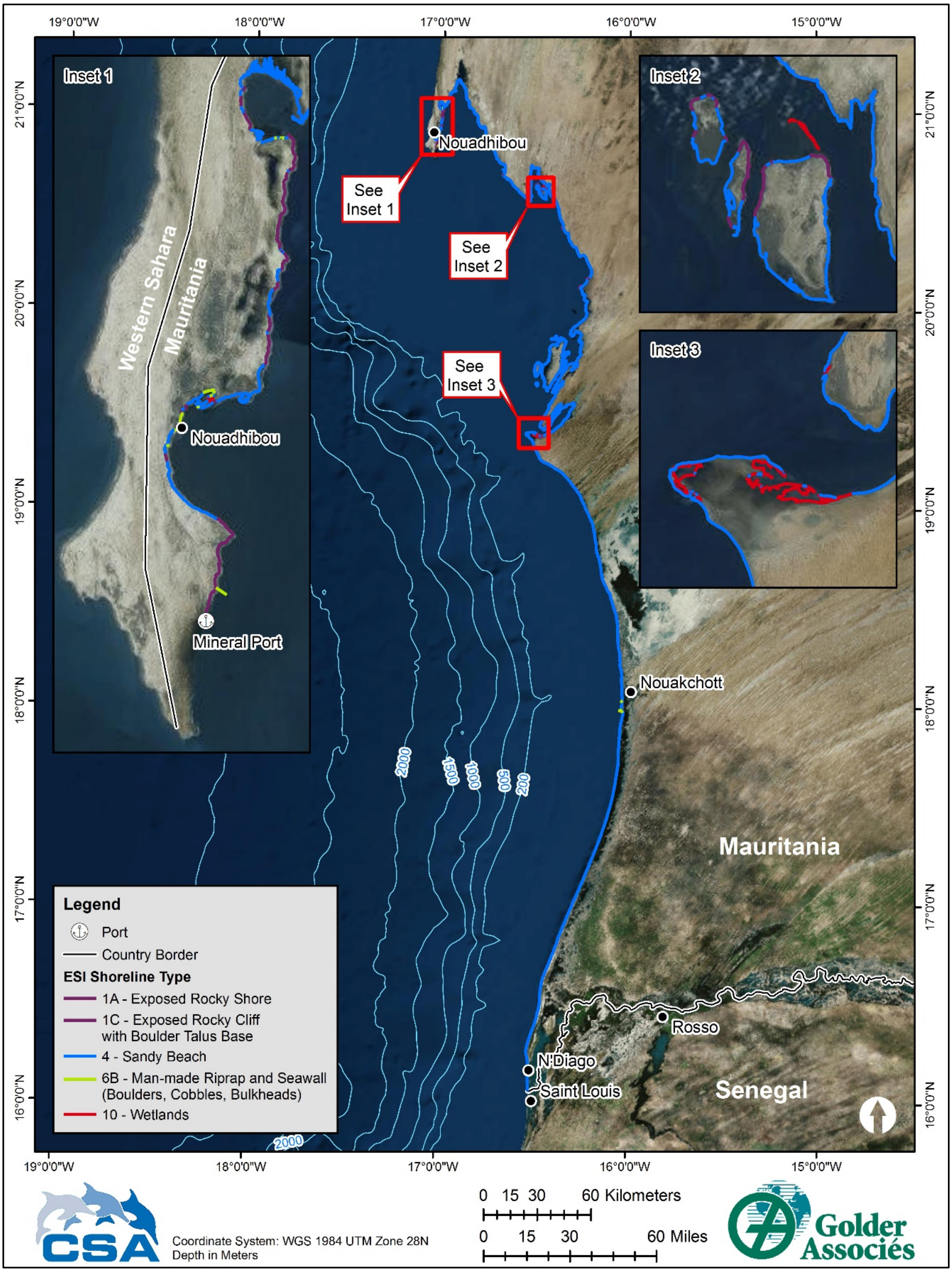


Figure G-7. Shoreline Characterization along the Mauritania Portion of the Core Study Area.

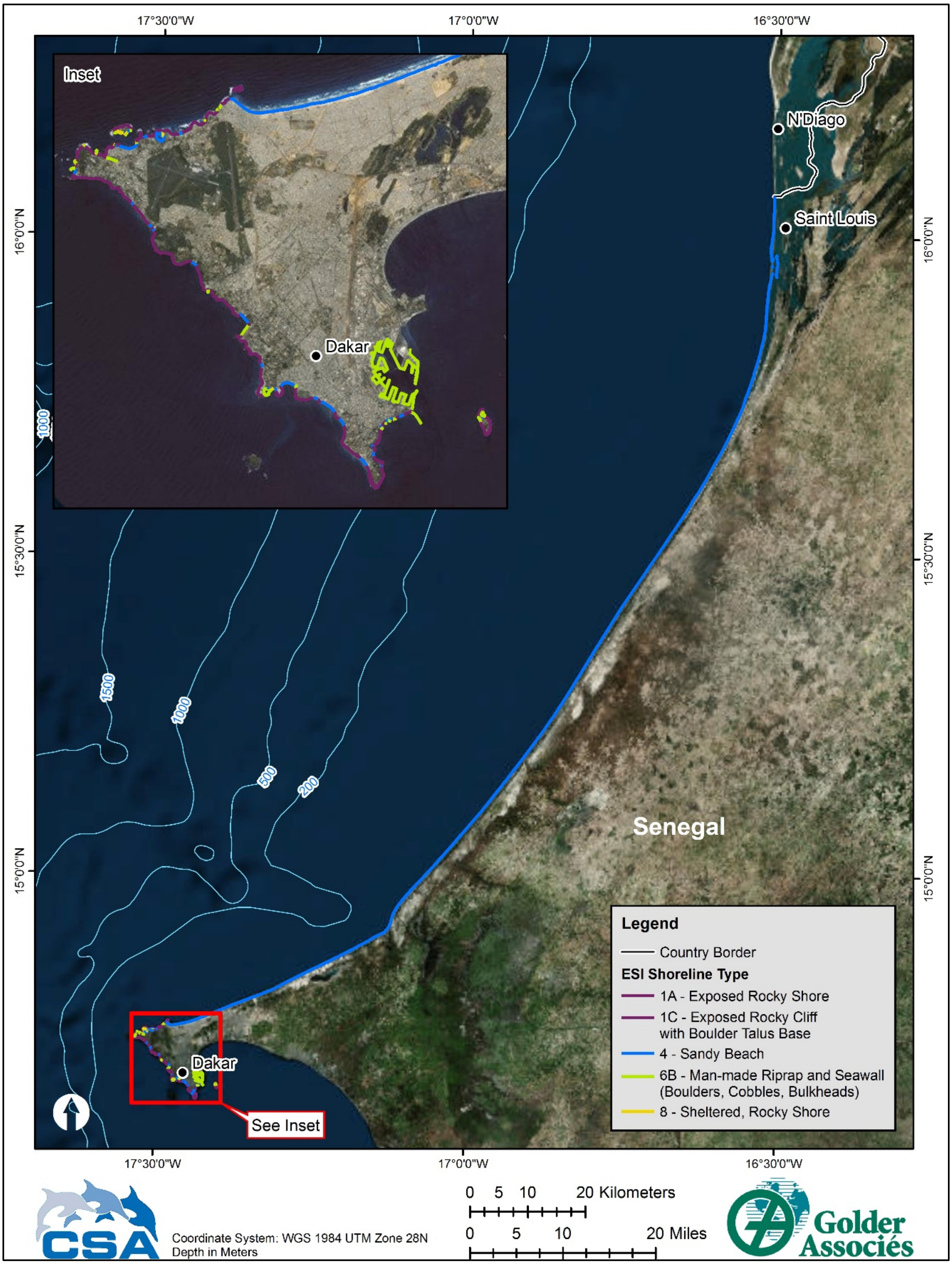


Figure G-8. Shoreline Characterization along the Senegal Portion of the Core Study Area.

G.9 Marine Mammals and Sea Turtles and Anthropogenic Sound

Background on Marine Mammals and Anthropogenic Sound

Natural or anthropogenic sounds can adversely affect marine mammals. Four zones of influence from anthropogenic sounds were proposed by Richardson et al. (1995):

- Zone of audibility – the area within which anthropogenic sounds are above the animal's hearing threshold and detectable above background sound levels;
- Zone of masking – the area within which anthropogenic sounds may mask biologically significant sounds;
- Zone of responsiveness – the area within which behavioral responses to anthropogenic sounds occur; and
- Zone of hearing loss, discomfort, or injury – the area within which the anthropogenic sound level is sufficient to cause threshold shifts or hearing damage.

These zones of influence can be used to broadly describe the nature of potential response and impact from acoustic exposure.

Southall (2014) identified at least seven levels of response for marine mammals exposed to anthropogenic sounds (by increasing severity with decreasing likelihood): no observable response, increased alertness, minor behavioral responses (e.g., vocal modifications associated with masking), cessation of feeding or social interaction, temporary avoidance behavior, modification of group structure or activity state, and habitat abandonment (see *Stress, Disturbance, and Behavioral Responses* and Table G-22). If a marine mammal reacts to an underwater sound by changing its behavior or moving to avoid a sound source, the impacts of that change may not be important to the individual, the stock, or the species. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and the population could be important.

Mortality and Non-Auditory Physiological Effects

Direct physical injury, which may result in mortality, might occur at close range to a sound source due to exposure to acoustic events characterized by a rapid rise time with a high amplitude such as in-water explosions, air guns, or pile driving (e.g., Ketten, 1995; Landsberg, 2000). However, it should be noted that no mortality or mortal injury from exposure to sound from air gun sources has been documented in any marine mammal. An animal would have to be very close to the source array for a prolonged period of time to experience a single-pulse sound exposure level (SEL_{ss}) that that might result in injury or mortality impacts. Considering the potential mitigation measures that may be implemented, it is highly unlikely that any marine mammal would be exposed to levels sufficient to cause mortality.

Auditory Effects – Hearing Threshold Shift

The minimum sound level an animal can hear at a specific frequency is called the hearing threshold. Too much exposure at a certain amplitude and at a specific frequency might cause a shift in the animal's hearing threshold. Threshold shifts can be reversible (i.e., temporary threshold shift [TTS]) or irreversible (i.e., permanent threshold shift [PTS]) and are defined as follows (Finneran et al., 2005; Southall et al., 2007):

PTS – permanent elevation in hearing threshold; no data are currently available regarding sound levels that might induce PTS in marine mammals. PTS is attributed to sounds that are characterized by high peak pressures and short rise times, or to prolonged or repeated exposures to levels of sound strong enough to elicit an extreme magnitude of TTS and ultimately a measure of auditory hair cell death.

TTS – a milder form of hearing impairment; exposure to high amplitude sound results in a non-permanent (reversible) elevation in hearing threshold, making it more difficult to hear sounds for a period of time. TTS can last from minutes or hours to days; the magnitude of the TTS depends on the level and duration of the sound exposure, among other considerations.

Several important factors relate to the type and magnitude of hearing loss, including exposure level, accumulation of acoustic energy, frequency content, duration, and temporal pattern of exposure. A range of mechanical effects and metabolic processes within the auditory system underlie TTS and PTS. Mechanical effects can result in stress or damage to supporting cell structure and fatigue, and metabolic processes include inner ear hair cell metabolism such as energy production, protein synthesis, and ion transport. The minimum peak sound pressure level (L_{pk}) or SEL that would elicit PTS is higher than the levels that induce TTS, although there are insufficient data to determine the precise differential.

Southall et al. (2007) summarized sound exposure results and offered a series of approaches to sound impact determinations applying different duel acoustic metrics (i.e., peak SPL and SEL) for marine mammals that have been adopted and further updated by the National Oceanic and Atmospheric Administration (NOAA, 2016) acoustic guidance. Table G-21 shows marine mammals sorted into specific hearing groups and species within each group that are expected around the proposed activities.

Table G-21. Marine Mammal Hearing Groups, Associated Auditory Bandwidths, and Marine Mammal Species Present in the Project Area (From: National Oceanic and Atmospheric Administration, 2016).

Marine Mammal Hearing Group	Estimated Auditory Bandwidth	Marine Mammal Species Potentially Present in the Project Area
Low-frequency cetaceans	7 Hz to 35 kHz	Mysticete whales
Mid-frequency cetaceans	150 Hz to 160 kHz	Sperm whale, beaked whales, *Stenella* dolphins, bottlenose dolphin, killer whale, pygmy killer whale, false killer whale, Risso's dolphin, short-finned pilot whale, melon-headed whale, Fraser's dolphin, rough-toothed dolphin
High-frequency cetaceans	275 Hz to 160 kHz	Pygmy and dwarf sperm whales
Pinnipeds in water	75 Hz to 75 kHz	Mediterranean monk seal
Pinnipeds in air	75 Hz to 30 kHz	

Hz = hertz; kHz = kilohertz.

Sound sources are generally categorized based on their acoustic signal characteristics and temporal properties. Two sound types are handled in this assessment: impulsive (air guns) and continuous (vessels). The review indicated that the lowest received SEL of impulsive sounds that might elicit slight TTS was an SEL of 198 decibels relative to 1 micropascal squared second (dB re 1 $\mu Pa^2 \cdot s$) in cetaceans. Odontocetes exposed to impulsive sounds developed TTS with SEL at 183 dB re 1 $\mu Pa^2 \cdot s$. Southall et al. (2007) concluded that receipt of an instantaneous unweighted L_{pk} exceeding 230 dB re 1 μPa for cetaceans might lead to auditory injury, even if the aforementioned SEL criterion was not exceeded.

Data indicate that TTS onset in marine mammals is more closely correlated with the cumulative SEL (SEL_{cum}) and should be considered a primary measure of potential impact, not just the single strongest pulse (L_{pk}) (National Science Foundation [NSF] and U.S. Geological Survey [USGS], 2011). PTS onset acoustic thresholds for marine mammals have not been directly measured and must be extrapolated from available TTS onset measurements and assumptions on the relationship of TTS growth from non-marine mammal studies (NOAA, 2016) The use of dual metrics (i.e., L_{pk} and SEL_{cum}), as proposed by Southall et al. (2007) was the foundation for the initial issuance of draft proposed acoustic threshold levels by NOAA (2013), primarily as they relate to PTS but also for TTS exposure limits, and subsequent updates and revisions (NOAA, 2015, 2016). For the purposes of this analysis, the 2016 NOAA criteria are discussed. These criteria include the most up to date acoustic thresholds for onset of permanent threshold shift (PTS) and temporary threshold shifts (TTS) in marine mammal hearing for all sound sources. It is intended to be used by NOAA analysts and managers, other federal agencies, and other relevant user groups/stakeholders to better predict how a marine mammal's hearing will respond to sound exposure. However, due to the complexity and variability of marine mammal behavioral responses, NOAA will continue to work over the next years on developing additional guidance regarding the effects of anthropogenic sound on marine mammal behavior.

The SEL_{cum} metric integrates the total received sound energy over time; it represents the accumulation of acoustic energy. SEL is defined as time-integrated squared SPL, where the time duration needs to be defined (ISO18405:2017). The use of an SEL metric is advantageous because it accounts for cumulative sound exposure, sounds of differing duration, and different sound signal types. It also allows for comparison between different sound exposures based on total energy. This approach assumes no recovery of hearing between repeated exposures; however, current criteria consider sound exposure over 24-hour periods (NOAA, 2016).

Auditory Masking

Auditory masking occurs when the perception of one sound (signal) is affected by the presence of another sound (masking sound or noise). Sound can affect hearing and partially or completely reduce an individual's ability to effectively communicate; detect important predator, prey, and/or conspecific signals; and detect important environmental features associated with spatial orientation (Clark et al., 2009). Spectral, temporal, and spatial overlap between a masking sound and a signal to be detected by the sender/receiver determines the extent of interference; the greater the spectral and temporal overlap, the greater the potential for masking.

As noted by Wood et al. (2012), research results that demonstrate the masking effects of anthropogenic sound on marine mammals typically characterize masking-related impacts through the identification of diverse compensation strategies (i.e., mechanisms by which marine mammals overcome the masking effects of sounds other than those of interest to the marine mammal). Examples of these compensation strategies include increasing call duration (e.g., by humpback whales [Miller et al., 2000]), altering call pitch or frequency (e.g., by North Atlantic and South Atlantic right whales (*Eubalaena glacialis* and *E. australis*, respectively) [Parks et al., 2007]; by common bottlenose dolphins [Heiler et al., 2016]), altering how frequently calls are made (e.g., by blue whales [Di Lorio and Clark, 2010]; by gray whales (*Eschrichtius robustus*) [Dahlheim and Castellote, 2016]; by Guiana dolphins (*Sotalia guianensis*) [Bittencourt et al., 2017]), and increasing call amplitude or intensity (e.g., by killer whales [Holt et al., 2009]). Although masking effects have been documented in a number of species, it is difficult to quantify the survival or reproductive consequences of masking on an individual or on the population (Wood et al., 2012). Generally, a lack of observed response does not imply absence of fitness costs, such as physiological stress and reduced reproduction, survival or feeding success (e.g., Wright et al., 2007, 2011; Aguilar de Soto and Kight, 2016).

Naturally occurring ambient sounds are produced from various sources, including wind, waves, rain, other animals, and (at frequencies greater than 30 kilohertz [kHz]) thermal sounds resulting from molecular agitation (Richardson et al., 1995). Background sound can also include sounds from distant human activities (e.g., shipping), particularly in areas where heavy levels of shipping traffic are located. Ambient sound can produce masking, effectively interfering with the ability of an animal to detect a sound signal that it otherwise would hear. Masking prevents a portion or all of a sound signal from being heard. Further masking of natural sounds can result when human activities produce high levels of background sounds. Ambient sound is highly variable on continental shelves (Desharnais et al., 1999), resulting in a high degree of variability in the range at which marine mammals can detect anthropogenic sounds.

Sound sources used during the proposed VSP survey(s) could mask marine mammal communication and monitoring of the environment around them if an individual is present in the area and their hearing sensitivity coincides with the frequency and intermittent nature of the sound source being used. Assuming the relatively short duration of this activity and the intermittent nature of the sound source during the VSP survey, masking is unlikely and therefore not considered to be a significant issue for marine mammals during the project. In addition, available mitigation measures may be used to decrease the risk for any marine mammal to be within the exclusion zone of the operating seismic array, thereby reducing the potential for masking within 500 m of the sound source.

Stress, Disturbance, and Behavioral Responses

Stress in marine mammals from exposure to sound typically involves the sympathetic nervous system. Romano et al. (2004) noted that no quantitative approach to estimating changes in mortality or fecundity because of stress has been identified, and that qualitative effects may include increased susceptibility to disease and early termination of pregnancy.

Wright and Kuczaj (2007) note that there are large data gaps regarding specific physiological effects that chronic, repetitive, or even acute exposure to anthropogenic sound may have on cetaceans and other marine mammals, referencing prior efforts conducted to summarize stress-related studies (e.g., Fair and Becker, 2000; Nowacek et al., 2007).

Rolland et al. (2012) determined that low-frequency sound from ships might be associated with chronic stress (i.e., elevated levels of stress-related hormones and associated metabolites) in North Atlantic right whales, with implications for all mysticetes in heavy ship-traffic areas.

Disturbance is one of the main concerns of the potential impacts of anthropogenic sound on marine mammals. Behavioral responses of marine mammals to anthropogenic sound exposure have been reviewed on several occasions over the past decade (e.g., Nowacek et al., 2007; Southall et al., 2007; NSF and USGS, 2011; Gomez et al., 2016). Southall et al. (2007) ranked behavioral response severity to delineate behaviors that are relatively minor or brief and those with higher potential to affect these animals (Table G-22).

One determination common to these reviews is that behavioral responses, even within a species, vary greatly as a function of biological and environmental parameters. Wartzok et al. (2003) categorized these biological and environmental parameters into 1) internal, animal-specific factors that affect an individual's response to anthropogenic sounds; and 2) external factors related to the context of exposure that mediate the probability of different types of behavioral responses. As summarized by Wood et al. (2012), internal factors include the following:

- Individual hearing capability, activity pattern, and motivational and behavioral states at the time of exposure;
- Past exposure of the animal to the anthropogenic sound, which may have led to habituation or sensitization;
- Individual tolerance of sound exposure; and
- Demographic factors (e.g., age, sex, and presence of dependent offspring).

External factors include the following:

- Non-acoustic characteristics of the sound source (e.g., source stationary or moving);
- Environmental factors that influence sound transmission;
- Habitat characteristics (e.g., exposure within a confined location); and
- Location (e.g., proximity of the animal to a shoreline).

These internal and external factors support the determination of separate thresholds for behavioral disturbance for cetaceans and pinnipeds. Ellison et al. (2011) argued that multiple factors (e.g., environmental, biological, operational influences) might affect both the perception of received sounds and the complex behavioral responses that may result. Such an approach deviates from the current U.S. threshold-based acoustic exposure criteria for behavioral disruption of SPL_{rms} 160 dB re 1 μPa for impulsive sounds (NOAA, 2018). TTS onset and behavioral responses are considered to be negative but non-injurious impacts. There is no consensus on the appropriate sound exposure metric or threshold level criteria for assessing behavioral reactions (Southall et al., 2007). Though behavioral threshold criteria are available, given the variability of response to sound, their use can be used to as a means to inform an assessment rather than being considered an absolute indication that impacts will occur.

Table G-22. Severity scale for ranking observed behavioral responses of free-ranging marine mammals to various types of anthropogenic sound (From: Southall et al., 2007).

Response Score	Corresponding Behaviors
0	No observable response
1	Brief orientation response (investigation/visual orientation)
2	Moderate or multiple orientation behaviors Brief or minor cessation/modification of vocal behavior Brief or minor change in respiration rates
3	Prolonged orientation behavior Individual alert behavior Minor changes in locomotion speed, direction, and/or dive profile but no avoidance of sound source Moderate change in respiration rate Minor cessation or modification of vocal behavior (duration < duration of source operation), including the Lombard Effect
4	Moderate changes in locomotion speed, direction, and/or dive profile but no avoidance of sound source Brief, minor shift in group distribution Moderate cessation or modification of vocal behavior (duration~ duration of source operation)
5	Extensive or prolonged changes in locomotion speed, direction, and/or dive profile but no avoidance of sound source Moderate shift in group distribution Change in inter-animal distance and/or group size (aggregation or separation) Prolonged cessation or modification of vocal behavior (duration > duration of source operation)
6	Minor or moderate individual and/or group avoidance of sound source Brief or minor separation of females and dependent offspring Aggressive behavior related to noise exposure (e.g., tail/flipper slapping, fluke display, jaw clapping/gnashing teeth, abrupt directed movement, bubble clouds) Extended cessation or modification of vocal behavior Visible startle response Brief cessation of reproductive behavior
7	Extensive or prolonged aggressive behavior Moderate separation of females and dependent offspring Clear anti-predator response Severe and/or sustained avoidance of sound source Moderate cessation of reproductive behavior
8	Obvious aversion and/or progressive sensitization Prolonged or significant separation of females and dependent offspring with disruption of acoustic reunion mechanisms Long-term avoidance of area (> source operation) Prolonged cessation of reproductive behavior
9	Outright panic, flight, stampede, attack of conspecifics, or stranding events Avoidance behavior related to predator detection

Ellison et al. (2011) noted that the "…focus exclusively on the amplitude of the received sound ignores a diverse suite of environmental, biological, and operational factors (i.e., context) that may affect both the perception of received sounds and complex behavioral responses that they may invoke." They further cite evidence that a variety of factors can "…determine the form, probability, and extent of an animal's response to sound."

There is a considerable amount of literature available on the effects of sound from anthropogenic activity on marine mammals. A caveat to the literature cited below is that the specific SPL metric was not defined, for example rms, peak to peak, zero to peak, or peak rms. Unfortunately the SPL units in the following context, when the information was provided it is included could not be clarified. Therefore any comparison between values and with threshold values is limited to informing discussion rather absolute indication of impact occurring.

While a prediction of behavioral responses resulting from received SPLs is difficult due to the inconsistency of the data, Richardson et al. (1995) noted that most small and medium-sized odontocetes exposed to prolonged or repeated underwater sounds are unlikely to be displaced unless the overall received SPL is at least 140 dB re 1 µPa. Bain and Dahlheim (1994) observed behavioral changes in a captive killer whale exposed to an SPL of 135 dB re 1 µPa (below 5 kHz), and Bain (1995) effectively used a signal with a received SPL of approximately 135 dB re 1 µPa (at 300 Hz) as a deterrent. Williams et al. (2002a,b, 2009) found that killer whales exhibited behavioral changes in the presence of a single vessel producing a received SPL of approximately 105 to 110 dB re 1 µPa. Holt et al. (2009) demonstrated that killer whales increased their call amplitude by 1 dB for every 1-dB increase in background sound levels.

Olesiuk et al. (2002) found harbor porpoises avoided sound from acoustic harassment devices with an SPL source level of 195 dB re 1 µPa m out to 3 km, a distance at which received SPLs were estimated to be approximately 135 dB re 1 µPa. Porpoises avoid pingers with SPL source levels of approximately 130 dB re 1 µPa m out to distances of 100 to 1,000 m, depending on experience and environmental context (Gearin et al., 1996, 2000; Kraus et al., 1997; Laake et al., 1997, 1998; Barlow and Cameron, 1999; Cameron, 1999; Cox et al., 2001; Bain, 2002).

Sperm whales exposed to low-frequency active sonar (1 to 2 kHz) have shown a shift to a non-feeding, non-resting state at received SPLs of 131 to 165 dB re 1 µPa (Isojunno et al., 2016). Evidence from Miller et al. (2009) suggested that sperm whales did not exhibit avoidance reactions following the ramp-up of air guns at distances of 7 to 13 km (4.3 to 8 miles), or full array exposures at 1 to 13 km (0.6 to 8 miles), although they could have been affected in other ways, such as delay or avoidance of foraging behavior (deep diving) in response to high sound levels under a nearby air gun array. Limited available data indicate that sperm whales are sometimes more responsive to anthropogenic sound than other odontocetes (Miller et al., 2009).

Changes in harbor porpoise (*Phocoena phocoena*) echolocation click patterns were noted by Pirotta et al. (2014) following exposure to sound from a seismic source. They found a 15% reduction in the occurrence of "buzz" clicks during the active survey. Additionally, cessation of foraging clicks was noted in northern bottlenose whales (*Hyperoodon ampullatus*) during exposure to naval sonar signals (Miller et al., 2015). Cuvier's beaked whales responded to mid-frequency active sonar received SPLs of 89 to 127 dB re 1 µPa by ceasing normal fluking and echolocation, swimming rapidly and silently away, and extending dive duration and subsequent non-foraging interval (DeRuiter et al., 2013). No responses were elicited from distant sonar sources (received SPL of 78 to 106 dB re 1 µPa), suggesting that context may moderate reactions.

Existing data suggest that mysticetes have better hearing sensitivities than odontocetes at lower frequencies, and several studies suggest potential avoidance of a source at received SPLs of approximately 120 dB re 1 µPa during migration (e.g., a 0.5 probability of avoidance by gray whales of a continuous sound source was observed by Malme et al. [1988]). Goldbogen et al. (2013) demonstrated that mid-frequency sonars (1 to 10 kHz) significantly affected blue whale feeding behaviors, despite using source levels that were orders of magnitude below some military operation systems. When behavioral responses occurred, they included cessation of feeding activity, increased swimming speed, and directed travel away from the sound source. North Atlantic right whales exhibited changes in diving behavior when exposed to SPLs below 135 dB re 1 µPa (Nowacek et al., 2004). Similar results were shown for bowhead whales. Robertson et al. (2013) indicated that changes in bowhead whale (*Balaena mysticetus*) diving behavior in the presence of seismic operations occurred but were context dependent (e.g., activity of the whale). In this study, the distance of the seismic sources from whales ranged from 6 to 99 km.

Traveling blue whales and fin whales exposed to impulsive sounds from seismic surveys have been reported to stop emitting redundant songs (McDonald et al., 1995; Clark and Gagnon, 2004). By contrast, Di Lorio and Clark (2010) found increased production of transient calls during seismic sparker operations, suggesting that blue whales respond to acoustic interference according to the context and the signal produced. North Atlantic right whales exposed to high sound levels from shipping increased call frequency (Parks et al., 2007), and some humpback whales responded to low-frequency active sonar playbacks by increasing song length (Miller et al., 2000; Fristrup et al., 2003). Gray whales changed their calling rates in the presence of large and small vessels (Dahlheim and Castellote, 2016).

Acoustic responses of cetaceans to seismic surveys include reduced vocalization rates (Goold, 1996) or cessation of singing (McDonald et al., 1995). Other short-term vocal adjustments observed across taxa exposed to elevated ambient sound levels include shifting call frequency, increasing call amplitude or duration, and ceasing to call (Nowacek et al., 2007).

Background on Sea Turtles and Anthropogenic Sound

Few studies have examined the role acoustic cues play in the ecology of sea turtles (Mrosovsky, 1972; Samuel et al., 2005; Nunny et al., 2008). There is evidence that sea turtles may use sound to communicate, but the few vocalizations described for sea turtles are restricted to the “grunts” of nesting females (Mrosovsky, 1972). These sounds are low frequency and relatively loud, thus leading to speculation that nesting females use sounds to communicate with conspecifics (Mrosovsky, 1972). Very little is known about the extent to which sea turtles use their auditory environment. The acoustic environment for sea turtles changes with each ontogenetic habitat shift. In the inshore environment where juvenile and adult sea turtles generally reside, the ambient sound levels are typically higher than the open ocean environment of the hatchlings; this inshore environment is dominated by low frequency sound (Hawkins and Myrberg, 1983) and, in highly trafficked areas, virtually constant low frequency sounds from shipping and recreational boating (Hildebrand, 2009).

Much of the research on the hearing capacity of sea turtles is limited to gross morphological dissections (Wever, 1978; Lenhardt et al., 1985). Based on the functional morphology of the ear, it appears that sea turtles receive sound through the standard vertebrate tympanic middle ear path. The sea turtle ear appears to be a poor receptor for aerial sounds but is well adapted to detect underwater sound. The dense layer of fat under the tympanum acts as a low-impedance channel for underwater sound. Furthermore, the retention of air in the middle ear of these sea turtles suggests that they are able to detect sound pressures.

Electrophysiological studies on hearing have been conducted on juvenile green turtles (Ridgway et al., 1969; Bartol and Ketten, 2006), juvenile Kemp’s ridley turtles (Bartol and Ketten, 2006), and juvenile loggerhead turtles (Bartol et al., 1999; Lavender et al., 2010, 2012). Electrophysiological responses, specifically auditory evoked potentials (AEPs), are the most widely accepted technique for measuring hearing in situations in which normal behavioral testing is impractical. Most AEP research has concentrated on responses occurring within the first 10 millisecond (ms) following presentation of a click or brief tone, which has been termed the auditory brainstem response (ABR).

Ridgway et al. (1969) measured AEPs of green turtles using both aerial and vibrational stimuli. Green turtles detect a limited frequency range (200-700 Hz) with best sensitivity at the low tone region of about 400 Hz. Though this investigation examined two separate modes of sound reception (i.e., air and bone conduction), sensitivity curves were relatively similar, suggesting that the inner ear is the main structure for determining frequency sensitivity. To measure electrophysiological responses to sound stimuli, Bartol et al. (1999) collected ABRs from juvenile loggerhead turtles. Thresholds were recorded for both tonal and click stimuli. Best sensitivity was found in the low frequency region of 250-1,000 Hz. The decline in sensitivity was rapid above 1,000 Hz, and the most sensitive threshold tested was at 250 Hz. More recently, Bartol and Ketten (2006) collected underwater ABRs from hatchling and juvenile loggerhead and juvenile green turtles using speakers suspended in air while the turtle’s tympanum remained submerged. All turtles tested responded to sounds in the low frequency range, from at least 100 Hz (lowest frequency tested) to no greater than 900 Hz. The smallest turtles tested, hatchling loggerheads, had the greatest range of hearing (100-900 Hz), while the larger juveniles responded to a much narrower range (100-400 Hz). Hearing sensitivity of green turtles also varied with size; smaller greens had a broader range of hearing (100-800 Hz) than that detected in larger subjects (100-500 Hz). Using underwater speakers as a sound source, Lavender et al. (2010, 2012) measured underwater AEPs in loggerhead turtles ranging from yearlings to subadults and detected responses to frequencies between 50 and 1,000 Hz.

Auditory Effects – Hearing Threshold Shift

Based on existing information, it is assumed that auditory impacts such as TTS or PTS could occur in sea turtles. However, unlike marine mammals, criteria specific for sea turtles have not been developed for these effects, mainly because of the few data that exist on sea turtles hearing Criteria from other aquatic resources, such as fishes, have been used for sea turtles (Popper et al., 2014). The TTS, by definition, is a temporary and recoverable damage to hearing structures (sensory hair cells) and can vary in intensity and duration. For individuals experiencing TTS, normal hearing abilities would return over time; however, animals may lack the ability to detect prey and predators and assess their environment during the recovery period. In contrast, PTS results in the permanent though variable loss of hearing through the loss of sensory hair cells (Clark, 1991). Few studies have looked at hair cell damage in reptiles, and studies do not indicate precisely if sea turtles are able to regenerate injured sensory hair cells (Warchol, 2011).

As mentioned above, there are no hearing criteria for sea turtles, and NMFS typically applies the criteria for low frequency marine mammals to evaluate the potential for similar impacts. The current NMFS criterion for PTS onset for low frequency cetaceans is a cumulative received sound exposure level (SEL_{cum}) of 183 dB for impulsive sounds. The current criterion for behavioural response/TTS onset for low frequency cetaceans is a received sound pressure level (SPL) of 160 dB_{rms}. Popper et al. (2014) provided acoustic threshold s for mortality and potential mortal injury to sea turtles from impulsive sounds (pile driving [210 dB SEL_{cum} or >207 dB_{peak}] and seismic air guns [210 dB SEL_{cum} or >207 dB_{peak}]). Auditory impairment (recoverable injury, TTS, masking, and behavioral response) thresholds were not provided.

Auditory Masking

Sound levels below the TTS and PTS onset levels may have the potential to mask relevant sounds in the environment or induce simple behavioral changes in sea turtles such as evasive maneuvers (e.g., diving or changes in swimming direction and/or speed). Masking sounds can interfere with the acquisition of prey or mates, the avoidance of predators and, in the case of sea turtles the identification of an appropriate nesting site (Nunny et al., 2008). These maskers could have diverse origins, ranging from natural to anthropogenic sounds (Hildebrand, 2009). Because sea turtles appear to be low frequency specialists, the potential masking sounds would fall mainly within the range of 50-1,000 Hz. There are no quantitative data demonstrating masking effects for sea turtles. Behavioral changes that may occur from masking sounds may have ecological consequences for sea turtles, although there are no quantitative data demonstrating these effects.

Behavioral Responses

Limited data exist on sound levels that may induce behavioral changes in sea turtles. Avoidance reactions to seismic signals have been observed at levels between 166 and 179 dB re 1 µPa rms (Moein et al., 1995; McCauley et al., 2000a); however, both of these studies were done in a caged environment, so the extent of avoidance could not be monitored. In studies attempting to use air guns to repel turtles from dredging operations, Moein et al. (1995) observed a habituation effect to sound from air guns; the animals stopped responding to the signal after three presentations. From these results, it was not clear whether this lack of behavioral response was a result of behavioral habituation, or physical effects from TTS or PTS.

G.10 Sampling Parameters for Seawater and Sediments

The scope of sampling and analysis for the seawater quality and sediment quality are presented in the Environmental Baseline Survey (EBS) in Appendix D.

Table G-23 below lists the parameters analyzed during the EBS of the project and the rationale for their selection.

Table G-23. Rationale for Seawater and Sediment Sampling Parameters.

Analyte(s)	Rationale
Water Column Profiles	
Conductivity/salinity	General water mass characterization parameters
Temperature	General water mass characterization parameters
pH	General water mass characterization parameters
Dissolved Oxygen (DO)	Indicator of primary production, respiration and mineralization processes within the water column
Chlorophyll *a*	Indicator of water column relative productivity
Turbidity	Indicator of suspended solids in the water column to assess water clarity
Seawater	
Total Suspended Solids	Indicator of water quality specific to presence of particulates in the water column; is considered a conventional pollutant in the U.S. Clean Water Act
Total metals (As, Ba, Cd, Cr, Cu, Pb, Ni, V, Zn)	Analytes include some USEPA priority pollutant metals and metals typically involved in oil and gas environmental programs
Dissolved metals (As, Ba, Cd, Cr, Cu, Pb, Ni, V, Zn)	Analytes include some priority pollutant metals and metals typically involved in oil and gas environmental programs
Total Mercury (Hg)	USEPA priority pollutant
Dissolved Mercury (Hg)	USEPA priority pollutant
Total Petroleum Hydrocarbons (TPH)	Documents the presence/absence of hydrocarbons in seawater
Polycyclic Aromatic Hydrocarbons (PAHs)	Will further define the source of elevated TPH If significant elevation of TPH is observed
Sediment	
Grain size distribution by particle size analysis	Physical characteristic of sediment useful for interpreting various chemical and biological parameters
Total Organic Carbon (TOC)	Indicator of organic loading in sediment useful for interpreting various chemical and biological parameters
Total metals (Al, As, Ba, Cd, Cr, Cu, Fe, Pb, Hg, Ni, V, Zn)	Ba is an important tracer of drilling fluids. Commercial drilling mud and barites may contain elevated concentrations of several metals, including Cd, Cr, Cu, Hg, Pb, and Zn and, in addition to As and Ni, are all USEPA priority pollutants. Ni and V can be associated with crude oil. Al and Fe are useful in the interpretation of metals concentrations since they are good indicators of sediment mineral type.
TPH	Will document the presence/ absence of petroleum hydrocarbons in sediment
PAHs	Will further define the source of elevated TPH if significant elevation of TPH is observed
Macroinfauna	Baseline state of the benthic environment

Notes:
Metals: Al = aluminum; As = arsenic; Ba = barium; Cd = cadmium; Cr = chromium; Cu = copper; Fe = iron; Hg = mercury; Ni= nickel; Pb = lead; V = vanadium; Zn = zinc.
USEPA Priority PAHs: Naphthalene; 1,2-dihydroacenaphtylene; Acenaphtylene; Fluorene; Anthracene; Phenanthrene; Fluoranthene; Pyrene; Benzo[a]anthracene; Chrysene/triphenylene; Benzo[b]fluoranthene; Benzo[k,j]fluoranthene; Benzo[a]pyrene; Dibenz[a,h]anthracene; Benzo[ghi]perylene; Indeno[1,2,3-c,d]pyrene.

G.11 Literature Cited

Aguilar de Soto, N. and C. Kight. 2016. Physiological effects of noise, pp. 135-158. In: M. Solan and N. Whiteley (eds.), Stressors in the Marine Environment: Physiological and Ecological Responses and Societal Implications. Oxford University Press, Oxford.

Bain, D.E. 1995. The use of sound to guide killer whales (*Orcinus orca*) entrapped in Barnes Lake, Alaska, to open water. Poster presented at the Society for Marine Mammalogy Conference.

Bain, D.E. 2002. Acoustical properties of pingers and the San Juan Island commercial gillnet fishery. National Marine Fisheries Service Contract Report No. 40ABNF701651. 14 pp.

Bain, D.E. and M.E. Dahlheim. 1994. Effects of masking noise on detection thresholds of killer whales, pp. 243-256. In: T.R. Loughlin (ed.), Marine Mammals and the *Exxon Valdez*. Academic Press, San Diego, CA.

Barlow, J. and G.A. Cameron. 1999. Field experiments show that acoustic pingers reduce marine mammal bycatch in the California drift gillnet fishery. International Whaling Commission, Scientific Committee Document SC/51/SM2, Cambridge, UK.

Bartol, S.M. and D.R. Ketten. 2006. Turtle and tuna hearing, pp. 98-105. In: Y. Swimmer and R. Brill (eds.), Sea Turtle and Pelagic Fish Sensory Biology: Developing Techniques to Reduce Sea Turtle Bycatch in Longline Fisheries. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Technical Memorandum PIFSC-7.

Bartol. S.M., J.A. Musick, and M.L. Lenhardt. 1999. Auditory evoked potentials of the loggerhead sea turtle (*Caretta caretta*). Copeia 1999:836-840.

BirdLife International. 2015. Country profile: Senegal. Accessed at: http://www.birdlife.org/datazone/country/senegal. Accessed: 6 March 2015.

Bittencourt, L., I.M.S. Lima, L.G. Andrade, R.R. Carvalho, R.L. Bisi, J. Lailson-Brito, Jr., and A.F. Azevedo. 2017. Underwater noise in an impacted environment can affect Guiana dolphin communication. Marine Pollution Bulletin 114:1,130-1,134.

Blumenthal, J.M., F.A. Abreu-Grobois, T.J. Austin, A.C. Broderick, M.W. Bruford, M.S. Coyne, G. Ebanks-Petrie, A. Formia, P.A. Meylan, A.B. Meylan, and B.J. Godley. 2009. Turtle groups or turtle soup: dispersal patterns of hawksbill turtles in the Caribbean. Molecular Ecology 18(23):4841-4853.

Braham, C.-B. and A. Corten. 2015. Pelagic fish stocks and their response to fisheries and environmental variation in the Canary Current Large Marine Ecosystem. Chap 5. In: Valdés, L. and Déniz-González, I. (eds), Oceanographic and Biological Features in the Canary Current Large Marine Ecosystem. IOC Technical Series, No. 115. IOC-UNESCO, Paris. 383 pp.

Burton, C. 2003. Compilation and analysis of marine mammal sightings from the El Mourabitin 3D seismic survey in Mauritanian waters, by Woodside Energy, February to July 2002. A report prepared for Woodside Energy Pty Ltd. 34 pp.

Cameron, G. 1999. Report on the effect of acoustic warning devices (pingers) on cetacean and pinniped bycatch in the California drift gillnet fishery. National Marine Fisheries Service Contract Report No. 40JGNF900207.

Camphuysen, C.J. 2003. Seabirds and marine mammals off West Africa. Responses 2000 cruise report, Netherlands Institute for Sea Research, Texel, The Netherlands, January 2003.

Camphuysen, C.J., S. Kloff, and M. A. Jiyid ould Taleb. 2015. Ship-based seabird and marine mammal surveys off Mauritania, 4-14 September 2015- cruise report. Royal Netherlands Institute for Sea Research. 104 pp.

Cejudo, D., N. Varo, O. López and L.F. López Jurado. 2008. Satellite tracking of adult loggerheads (*Caretta caretta*) around waters of Cape Verde archipelago (western Africa), pp. 189. In: Proceedings of the Twenty-Fourth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-567.

Chavance, P., Y. Loktionov, and M. Mahfoud. 1991. Importance des saisons de transition hydrologique et impact des anomalies climatiques sur l'activité d'une flottille industrielle pélagique en ZEE mauritanienne, pp. 246-258. In: P. Cury et C. Roy (eds.), Pêcheries ouest-africaines: variabilité, instabilité et changement. ORSTOM, Paris.

Clark, W.W. 1991. Recent studies of temporary threshold shift (TTS) and permanent thresholds (PTS) in animals. Journal of the Acoustical Society of America 90:155-163.

Clark, C.W. and G.J. Gagnon. 2004. Low-frequency vocal behaviors of baleen whales in the North Atlantic: Insights from Integrated Undersea Surveillance System detections, locations, and tracking from 1992 to 1996. Journal of Underwater Acoustics. 48 pp.

Clark, C.W., W.T. Ellison, B.L. Southall, L. Hatch, S.M. Van Parijs, A. Frankel, and D. Ponirakis. 2009. Acoustic masking in marine ecosystems: Intuitions, analysis, and implication. Marine Ecology Progress Series 395:201-222.

Convention on International Trade in Endangered Species of Fauna and Flora (CITES). 2017. Appendices I, II and III, valid from 4 April 2017. Accessed at: http://www.cites.org/eng/app/appendices.php. Accessed: July 2017.

Convention on the Conservation of Migratory Species of Wild Animals (CMS). 2015. Appendices I and II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS), as amended by the Conference of the Parties in 1985, 1988, 1991, 1994, 1997, 1999, 2002, 2005, 2008, 2011, and 2014. Effective: 8 February 2015. 12 pp.

Convention on the Conservation of Migratory Species of Wild Animals (CMS). 2017. Whales & dolphins. Species accounts. Accessed at: http://www.cms.int/. Accessed: July 2017.

Cox, T.M., A.J. Read, A. Solow, and N. Trengenza. 2001. Will harbour porpoises (*Phocoena phocoena*) habituate to pingers? Journal of Cetacean Research and Management 3:81-86.

CSA Ocean Sciences Inc. 2017. Ahmeyim/Guembeul LNG Development, Environmental Baseline Survey Report. November 2017. Final. Prepared by CSA Ocean Sciences Inc. for Kosmos Energy LLC, Dallas, TX. 95 pp.

Dahlheim, M. and M. Castellote. 2016. Changes in the acoustic behavior of gray whales *Eschrichtius robustus* in response to noise. Endangered Species Research 31:227-242.

DeRuiter, S.L., B.L. Southall, J. Calambokidis, W.M.X. Zimmer, D. Sadykova, E.A. Falcone, A.S. Friedlaender, J.E. Joseph, D. Moretti, G.S. Schorr, L. Thomas, and P.L. Tyack. 2013. First direct measurements of behavioural responses by Cuvier's beaked whales to mid-frequency active sonar. Biology Letters 9:20130223.

Desharnais, F., A. Vanderlaan, C. Taggart, M. Hazen, and A. Hay. 1999. Preliminary results on the acoustic characterization of the northern right whale. Journal of the Acoustical Society of America 106:2163.

Di Lorio, L. and C.W. Clark. 2010. Exposure to seismic survey alters blue whale acoustic communication. Biology Letters 6:51-54.

Djiba, A., I.L. Bamy, A. Samba Ould Bilal, and K. Van Waerebeek. 2015. Biodiversity of cetaceans in coastal waters of northwest Africa: New Insights through platform-of-opportunity visual surveying in 2011-2013, pp. 283-297. In; L. Valdés, L. and I. Déniz-González (eds,), Oceanographic and Biological Features in the Canary Current Large Marine Ecosystem. IOC Technical Series, No. 115. IOC-UNESCO, Paris. 383 pp.

Dupuy, A.R. 1986. The status of marine turtles in Senegal. Marine Turtle Newsletter 39:4-7.

Ellison, W.T., B.L. Southall, C.W. Clark, and A.S. Frankel. 2011. A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. Conservation Biology, online version published December 19, 2011. doi: 10.1111/j.1523-1739.2011.01803.x.

Fair, P.A. and P.R. Becker. 2000. Reviews of stress in marine mammals. Journal of Aquatic Ecosystem Stress and Recovery 7:335-354.

Fernandez-Peralta, L. and A. Sidibe. 2015. 5.2: Demersal fish in the Canary Current Large Marine Ecosystem, pp. 215-229. In: Intergovernmental Oceanographic Commission, Technical Series 115. IOC-UNESCO, Paris. 383 pp.

Finneran, J.J., D.A. Carder, C.E. Schlundt, and S.H. Ridgway. 2005. Temporary threshold shift in common bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. Journal of the Acoustical Society of America 118:2,696-2,705.

Formia, A. and M.W. Bruford. 1988. Spatio-temporal structure in a green turtle feeding ground in the Gulf of Guinea: Searching for genetic evidence, p. 18. In: Kalb, H., A.S. Rohde, K. Gayheart, and K. Shanker (compilers), 25th Annual Symposium on Sea Turtle Biology and Conservation. Savannah, Georgia USA. NOAA Technical Memorandum NMFS-SEFSC-582.

Fretey, J., A. Billes, and M. Tiwari. 2007. Leatherback, Dermochelys coriacea, nesting along the Atlantic coast of Africa. Chelonian Conservation and Biology 6(1):126-129.

Fristrup, K.M., L.T. Hatch, and C.W. Clark. 2003. Variation in humpback whale (*Megaptera novaeangliae*) song length in relation to low-frequency sound broadcasts. Journal of the Acoustical Society of America 113(6):3,411-3,424.

Gearin, P.J., M.E. Gosho, L. Cooke, R. Delong, J. Laake, and D. Greene. 1996. Acoustic alarm experiment in the 1995 Northern Washington Marine Setnet Fishery. National Marine Mammal Laboratory and Makah Tribal Fisheries Management Division Report.

Gearin, P.J., M.E. Gosho, J.L. Laake, L. Cooke, R.L. Delong, and K.M. Hughes. 2000. Experimental testing of acoustic alarms (pingers) to reduce bycatch of harbour porpoise, *Phocoena phocoena*, in the state of Washington. Journal of Cetacean Research and Management 2:1-10.

Godley, B.J., A. Almeida, C. Barbosa, A.C. Broderick, P.X. Catry, G.C. Hays, and B. Indjai. 2003. Using satellite telemetry to determine post-nesting migratory corridors and foraging grounds of green turtles nesting at Poilao, Guinea Bissau: Report to project donors. Unpublished Report, Marine Turtle Research Group, School of Biological Sciences, University of Wales Swansea, Swansea SA2 8PP, UK. Accessed at: http://www.seaturtle.org/mtrg. Accessed: September 2016.

Godley, B.J., C. Barbosa, M. Bruford, A.C. Broderick, P. Catry, M.S. Coyne, A. Formia, G.C. Hays, and M.J. Witt. 2010. Unravelling migratory connectivity in marine turtles using multiple methods. J. Appl. Ecol. 47:769-778.

Godley, B.J., J.M. Blumenthal, A.C. Broderick, M.S. Coyne, M.H. Godfrey, L.A. Hawkes, and M.J. Witt. 2008. Satellite tracking of sea turtles: where have we been and where do we go next? Endanger Species Res 4(1-2):3-22. doi:10.3354/esr00060.

Goldbogen, J.A., B.L. Southall, S.L. DeRuiter, J. Calambokidis, A.S. Friedlaender, E.L. Hazen, E.A. Falcone, G.S. Schorr, A. Douglas, D.J. Moretti, C. Kyburg, M.F. McKenna, and P.L. Tyack. 2013. Blue whales respond to simulated mid-frequency military sonar. Proceedings of the Royal Society B: Biological Sciences 280:20130657.

Gomez, C., J.W. Lawson, A.J. Wright, A.D. Buren, D. Tollit, and V. Lesage. 2016. A systematic review on the behavioural responses of wild marine mammals to noise: the disparity between science and policy. Canadian Journal of Zoology 94:801-819.

Goold, J.C. 1996. Acoustic assessment of populations of common dolphin *Delphinus delphis* in conjunction with seismic surveying. Journal of the Marine Biological Association 76:811-820.

Hawkes, L. A., A.C. Broderick, M.S. Coyne, M.H. Godfrey, L.F. Lopez-Jurado, P. Lopez-Suarez, S.E. Merino, N.Varo-Cruz, and B.J. Godley. 2006. Phenotypically linked dichotomy in sea turtle foraging requires multiple conservation approaches. Current Biology 16:990-995.

Hawkins, A.D. and A.A. Myrberg, Jr. 1983. Hearing and sound communication under water, pp. 347-405. In: B. Lewis (ed.), Bioacoustics: A Comparative Approach. Academic Press, London, UK.

Heiler, J., S.H. Elwen, H.J. Kriesell, and T. Gridley. 2016. Changes in bottlenose dolphin whistle parameters related to vessel presence, surface behaviour and group composition. Animal Behaviour 117:167-177.

Hildebrand, J.A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Mar. Ecol. Prog. Ser. 395:5-20.

Holt, M.M., D.P. Noren, V. Veirs, C.K. Emmons, and S. Veirs. 2009. Speaking up: Killer whales (*Orcinus orca*) increase their call amplitude in response to vessel noise. Journal of the Acoustical Society of America 125(1):27-32.

Horizon Marine, Inc. (HMI). 2015. Historical Analysis of Oceanographic Conditions for Kosmos Energy Offshore Senegal. Report prepared for Kosmos Energy LLC, Dallas. 20 February 2015. 49 pp.

Horwood, J. 1987. The sei whale: Population biology, ecology & management. Croom Helm, London. 375 pp.

Horwood, J. 2002. Sei whales. In: Perrin, W.F., Würsig, B., and Thewissen, J.G.M. (eds.), Encyclopedia of Marine Mammals. Academic Press, San Diego, CA.

International Union for Conservation of Nature (IUCN). 2017. The IUCN Red List of Species. Accessed at: http://www.iucnredlist.org/ Accessed: June 2017.

Isojunno, S., C. Curé, P.H. Kvadsheim, F.P. Lam, P.L. Tyack, P.J. Wensveen, and P.J. Miller. 2016. Sperm whales reduce foraging effort during exposure to 1–2 kHz sonar and killer whale sounds. Ecological Applications 26:77-93.

Jaquet, N., S. Dawson, and E. Slooten. 1998. Diving behaviour of male sperm whales: foraging implications. International Whaling Commission, Scientific Committee Doc. SC/50/CAWS 38, 20 pp.

Jefferson, T.A., M.A. Webber, and R.L. Pitman. 2015. Marine Mammals of the World, A Comprehensive Guide to Their Identification - Second Edition. Elsevier/Academic Press. 616 pp.

Johnson, W.M., and D.M. Lavigne. 1999. Monk seals in antiquity. The Mediterranean monk seal (*Monachus monachus*) in ancient history and literature. Mededelingen 35:1-101. The Netherlands Commission for International Nature Protection, Leiden.

Johnson, W.M. 2004. Monk seals in post-classical history. The role of the Mediterranean monk seal (*Monachus monachus*) in European history and culture, from the fall of Rome to the 20th century. Mededelingen 39:1-91. The Netherlands Commission for International Nature Protection, Leiden.

Kenyon, K.W. 1981. Monk seals, pp. 203-220. In: Ridgeway, S.H., and Harrison, R.J. (eds.), Handbook of Marine Mammals. Academic Press, London.

Ketten, D.R. 1995. Estimates of blast injury and acoustic trauma zones for marine mammals from underwater explosions, pp. 391-407. In: R.A. Kastelein, J.A., Thomas, and P.E. Nachtigall (eds.), Sensory Systems of Aquatic Mammals. De Spil Publishers, Woerden, Netherlands.

Kidé, S.O., C. Manté, L. Dubroca, H. Demarcq, and B. Mérigot. 2015. Spatio-Temporal Dynamics of Exploited Groundfish Species Assemblages Faced to Environmental and Fishing Forcings: Insights from the Mauritanian Exclusive Economic Zone. Plos ONE .Accessed at: http://dx.doi.org/10.1371/journal.pone.0141566. Accessed: September 2016.

Kraus, S.D., A.J. Read, A. Solow, K. Baldwin, T. Spradlin, E. Anderson, and J. Williamson. 1997. Acoustic alarms reduce porpoise mortality. Nature 388:525.

Laake, J. L., P.J. Gearin, M.E. Gosho, and R.L. DeLong. 1997. Evaluation of effectiveness of pingers to reduce incidental entanglement of harbor porpoise in a set gillnet fishery, pp. 75-81. In: Hill, P.S. and D.P. DeMaster (eds.), Marine Mammal Protection Act and Endangered Species Act implementation program, 1996. Alaskan Fisheries Science Center Processed Report 97-10. pp. 255 National Marine Mammal Laboratory, Seattle, WA.

Laake, J., D. Rugh, and L. Baraff. 1998. Observations of harbor porpoise in the vicinity of acoustic alarms on a set gill net. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration Technical Memorandum. National Marine Fisheries Service- Alaskan Fisheries Science Center-84.

Landsberg, P.G. 2000. Underwater blast injuries. Trauma and Energy Medicine 17(2).

Lavender, A.L., S.M. Bartol, and I.K. Bartol. 2010. Hearing capabilities of loggerhead sea turtles (*Caretta caretta*) throughout ontogeny. Proceedings of the Second International Conference on the Effects of Noise on Aquatic Life, Cork, Ireland.

Lavender A.L., S.M. Bartol, and I.K. Bartol. 2012. Hearing Capabilities of Loggerhead Sea Turtles (*Caretta caretta)* Throughout Ontogeny. In: Popper A.N., Hawkins A. (eds.), The Effects of Noise on Aquatic Life. Advances in Experimental Medicine and Biology, Vol. 730. Springer, New York, NY.

Lenhardtl, M.L., R.C. Klinter, and J.A, Musick. 1985. Marine turtle middle-ear anatomy. J. Aud. Res. 25:66.

Leopold, M. F. 1993. Seabirds in the shelf edge waters bordering the Banc d'Arguin, Mauritania, in May. Hydrobiologia 258:197-210.

Machu, E., O. Ettahiri, S. Kifani, A. Benazzouz, A. Makaoui, and H. Demarcq. 2009. Environmental control of the recruitment of sardines (*Sardina pilchardus*) over the western Saharan shelf between 1995 and 2002: a coupled physical/biogeochemical modelling experiment, Fish. Oceanogr. 18:287-300.

Maigret, J. 1983. Répartition des tortues de mer sur les côtes ouest Africaines. Bulletin de la Socété Herpétologique de France 28:22-34.

Maigret, J. and B. Ly. 1986. Les poissons de mer de Mauritanie. Science Nat., Compiègne. 213 pp.

Malme, C.I., B. Würsig, J.E. Bird, and P. Tyack. 1988. Observations of feeding gray whale responses to controlled industrial noise exposure, pp. 55-73. In: W.M. Sackinger, M.O. Jefferies, J.L. Imm, and S.D. Treacy (eds.), Vol. 2. Port and Ocean Engineering under Arctic Conditions. University of Alaska, Fairbanks, AK. 111 pp.

Márquez, R. 1990. Sea Turtles of the World. An annotated and illustrated catalogue of the sea turtle species known to date. FAO Fisheries Synopsis No. 125, Vol. 11. Food and Agricultural Organization of the United Nations, Rome. 81 pp.

Marr, T. and R. Porter. 1992. Spring seabird passage off Senegal. Birding World 5:391-394.

Marr, T., R. Newell, and R. Porter. 1998. Seabirds off Senegal, West Africa. ABC (African Bird Club) Bulletin 5.1, March 1998, pp. 22-29.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.N. Jenner, J. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000. Marine seismic surveys - A study of environmental implications. Journal of the Australian Petroleum Production & Exploration Association 40:692-708.

McDonald, M.A., J.A. Hildebrand, and S.C. Webb. 1995. Blue and fin whales observed on a seafloor array in the northeast Pacific. Journal of the Acoustical Society of America 98(2):712-721.

Miller, P.J.O., N. Biassoni, A. Samuels, and P.L. Tyack. 2000. Whale songs lengthen in response to sonar. Nature 405:903.

Miller, P.J.O., M.P. Johnson, P.T. Madsen, N. Biassoni, M. Quero, and P.L. Tyack. 2009. Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. Deep-Sea Research 56:1,168-1,181.

Miller, P.J.O., P.H. Kvadsheim, F.P.A. Lam, P.L. Tyack, C. Curé, S.L. DeRuiter, L. Kleivane, L.D. Sivle, S.P. van IJsselmuide, F. Visser, P.J. Wensveen, A.M. von Benda-Beckmann, L.M. Martín López, T. Narazaki, and S.K. Hooker. 2015. First indications that northern bottlenose whales are sensitive to behavioural disturbance from anthropogenic noise. The Royal Society Open Science 2:140484.

Moein, S.E., J.A. Musick, J.A. Keinath, D.E. Barnard, M.L. Lenhardt, and R. George. 1995. Evaluation of seismic sources for repelling sea turtles from hopper dredges, pp. 90-93. In: L.Z. Hales (compiler), Sea Turtle Research Program: Summary Report. Prepared for U.S. Army Engineer Division, South Atlantic, Atlanta, GA, and U.S. Naval Submarine Base, Kings Bay, GA. Tech. Rpt. CERC-95. 145 pp.

Mrosovsky, N. 1972. Spectrographs of the sounds of leatherback turtles. Herpetologica 28(3):256-258.

National Oceanic and Atmospheric Administration (NOAA). 2013. NOAA Shoreline Assessment Manual. 4th edition. Prepared by the U.S. Department of Commerce, NOAA, Washington, DC. August 2013. 154 pp.

National Oceanic and Atmospheric Administration. 2015. National Oceanic and Atmospheric Administration Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Threshold Levels for Onset Permanent and Temporary Threshold Shifts. July 2015. NMFS Office of Protected Resources, Silver Spring, Maryland.

National Oceanic and Atmospheric Administration. 2016. Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service Technical Memorandum OPR-55. 178 pp.

National Oceanic and Atmospheric Administration. 2018. Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing: underwater acoustic thresholds for onset of permanent and temporary threshold shifts. Accessed at: https://repository.library.noaa.gov/view/noaa/15850. Accessed: April 2018.

National Science Foundation and U.S. Geological Survey. 2011. Final Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the U.S. Department of Commerce, National Science Foundation and U.S. Department of Interior, Geological Survey. 514 pp.

Ndao, I. 2006. Bio-Ecologie des Cetaces et Enjeux de Leur Conservation Pour Les Etats Cotiers Africains Comme Le Senegal. These, Docteur En Medecine Veterinaire (Diplome d'Etat), Universite Cheikh Anta Diop de Dakar (UCAD). 132 pp.

Notarbartolo-di-Sciara, G., E. Politi, A. Bayed, P-C. Beaubrun, and A. Knowlton. 1998. A winter cetacean survey off southern Morocco, with a special emphasis on right whales. Rep. Int. Whal. Commn. 48:547-551.

Nowacek, D.P., M.P. Johnson, and P.L. Tyack. 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. Proceedings of the Royal Society B: Biological Sciences 271(1536):227-231.

Nowacek, D.P., L.H. Thorne, D.W. Johnston, and P.L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. Mammal Review 37(2):81-115.

Nunny, R., E. Graham, and S. Bass. 2008. Do sea turtles use acoustic cues when nesting? National Oceanic and Atmospheric Administration, National Marine Fisheries Service Technical Memo SEFSC No. 582:83.

Olesiuk, P.F., L.M. Nichol, M.J. Sowden, and J.K.B. Ford. 2002. Effect of the sound generated by an acoustic harassment device on the relative abundance and distribution of harbor porpoises (*Phocoena phocoena*) in Retreat Passage, British Columbia. Marine Mammal Science 18:843-862.

Parks, S.E., C.W. Clark, and P.L. Tyack. 2007. Short- and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. Journal of the Acoustical Society of America 122(6):3,725-3,731.

Pirotta, E., L. New, J. Harwood, and D. Lusseau. 2014. Activities, motivations and disturbance: An agent-based model of bottlenose dolphin behavioral dynamics and interactions with tourism in Doubtful Sound, New Zealand. Ecological Modelling 282(24):44-58.

Popper, A.N., A.D. Hawkins, R.R. Fay, D. Mann, S. Bartol, T. Carlson, S. Coombs, W. Ellison, R. Gentry, M.B. Halvorsen, S. Lokkeborg, P. Rogers, B.L. Southall, D. Zeddies, and W.N. Tavolga. 2014. Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report. ASAS3/SC1.4 TR-2014 prepared by ANSI- Accredited Standards Committee S3/SC1 and registered with ANSI. Springer and ASA Press, Cham, Switzerland.

Powell, J., and A. Kouadio. 2008. *Trichechus senegalensis*. IUCN Red List of Threatened Species. Version 2011.2. International Union for Conservation of Nature. Accessed at: http://www.iucnredlist.org. Accessed: 1 April 2015.

Powell, J.A. 1990. Manatees in the Bijagos archipelago: Recommendations for conservation. A technical Report for IUCN, Wetland program.

Reeves, R.R., T.D. Smith, E.A. Josephson, P.J. Clapham, and G. Woolmer. 2004. Historical observations of humpback and blue whales in the North Atlantic Ocean: clues to migratory routes and possibly additional feeding grounds. Marine Mammal Science 20:774-786.

Rice, D.W. 1998. Marine mammals of the world: systematics and distribution. Marine Mammal Science, Special Publication 4.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. Marine mammals and noise. Academic Press, San Diego, CA. 576 pp.

Ridgway, S.H., E.G. Wever, J.G. McCormick, J. Palin and J.H. Anderson. 1969. Hearing in the giant sea turtle, *Chelonia mydas*. Proc. National Academy of Sciences 64 (3):884-890; https://doi.org/10.1073/pnas.64.3.884.

Robertson, F.C., W.R. Koski, T.A. Thomas, W.J. Richardson, B. Würsig, and A.W. Trites. 2013. Seismic operations have variable effects on dive-cycle behavior of bowhead whales in the Beaufort Sea. Endangered Species Research 21:143-160.

Rolland, R.M., S.E. Parks, K.E. Hunt, M. Castellote, P.J. Corkeron, D.P. Nowacek, S.K. Wasser, and S.D. Kraus. 2012. Evidence that ship noise increases stress in right whales. Proceedings of the Royal Society B: Biological Sciences 279(1737):2363-2368.

Romano, T.A., M.J. Keogh, C. Schlundt, D. Carder, and J. Finneran. 2004. Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound. Canadian Journal of Fisheries and Aquatic Sciences 61(7):1124-1134.

Ross, G.J.B. 2002. Humpback dolphins. In: Perrin, W.F., Würsig, B. and Thewissen, J.G.M. (eds.), Encyclopedia of Marine Mammals. Academic Press, London.

Samuel, Y., S.J. Morreale, C.H. Greene, and M.E. Richmond. 2005. Underwater, low-frequency noise in a coastal sea turtle habitat. The Journal of the Acoustical Society of America 117:1465 (2005). https://doi.org/10.1121/1.1847993.

Seabird Osteology. 2016. *Callinectris* Shearwaters. Accessed at: http://www.shearwater.nl/index.php?file=kop65.php. Accessed: September 2016.

Sergeant, D., K. Ronald, J. Boulva, and F. Berkes. 1978. The recent status of *Monachus monachus*, the Mediterranean Monk Seal. Biol. Cons. 14(4):259-287.

Southall, B.L. 2014. Marine Mammal Hearing and Sensitivity to Acoustic Impacts. Appendix H. Atlantic Outer Continental Shelf (OCS) Proposed Geological and Geophysical Activities, Mid-Atlantic and South Atlantic Planning Areas, Final Programmatic Environmental Impact Statement. OCS EIS/EA Bureau Ocean Energy Management 2014-001. February 2014. 2 vol.

Southall, B.J., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33:411-521.

Tulp, I. and M.F. Leopold. 2004. Marine mammals and seabirds in Mauritanian waters – pilot study, April 2004. Internal Report Number: 04.020. RIVO-Netherlands Institute for Fisheries Research, Animal Sciences Group, Wageningen UR. 42 pp.

Van Waerebeek, K., L. Barnett, A. Camara, A. Cham, M. Diallo, A. Djiba, A.O. Jallow, E. Ndiaye, A.O. Bilal, O. Samba, and I.L. Bamy. 2004. Distribution, status, and biology of the Atlantic Humpback Dolphin, *Sousa teuszii* (Kukenthal, 1892). Aquatic Mammals 30(1):56-83.

Van Waerebeek, K., A. Djiba, J. -O. Krakstad, A. Samba Ould Bilal, A. Almeida, and E. Mass Mbye. 2013. New evidence for a South Atlantic stock of humpback whales wintering on the Northwest African continental shelf. African Zoology 48(1):177-186.

Warchol, M.E. 2011. Sensory regeneration in the vertebrate inner ear: Differences at the levels of cells and species. Hearing Research 273:72-79.

Wartzok, D., Popper, A.N., Gordon, J. and Merrill, J., 2003. Factors affecting the responses of marine mammals to acoustic disturbance. Marine Technology Society Journal 37(4):6-15.

Western Whale Research and CSR Consultancy. 2003. Chinguetti Development Marine Fauna Survey, March 2003. Report prepared for Woodside Energy Ltd. by Western Whale Research and CSR Consultancy, December 2003.

Wever, E.G. 1978. The Reptile Ear: Its Structure and Function. Princeton University Press, Princeton, NJ.

Williams, R., A. Trites, and D.E. Bain. 2002a. Behavioural responses of killer whales (*Orcinus orca*) to whale-watching boats: Opportunistic observations and experimental approaches. Journal of Zoology (London) 256:255-270.

Williams, R., D.E. Bain, J.K.B. Ford, and A.W. Trites. 2002b. Behavioural responses of killer whales to a “leapfrogging” vessel. Journal of Cetacean Research and Management 4:305-310.

Williams, R., D.E. Bain, J.C. Smith, and D. Lusseau. 2009. Effects of vessels on behaviour patterns of individual southern resident killer whales (*Orcinus orca*). Endangered Species Research 6:199-209.

Wood, J., Southall, B. L., and Tollit, D. J. 2012. PG&E offshore 3−D Seismic Survey Project EI – Marine Mammal Technical Draft Report. Fife: SMRU Ltd.

Wright, A.J. and S. Kuczaj. 2007. Noise-related stress and marine mammals: An introduction. International Journal of Comparative Psychology 20(2-3):III-VIII.

Wright A.J., N. Aguilar de Soto, A.L. Baldwin, and M. Bateson. 2007. Do marine mammals experience stress related to anthropogenic noise? International Journal of Comparative Psychology 20:250-273.

Wright A.J., T. Deak, and E.C.M. Parsons. 2011. Size matters: management of stress responses and chronic stress in beaked whales and other marine mammals may require larger exclusion zones. Marine Pollution Bulletin 63:5-9.

Wynn, R.B. and B. Knefelkamp. 2004. Seabird distribution and oceanic upwelling off northwest Africa. British Birds 97:323-335.

APPENDIX H : SOCIAL BASELINE SUPPORT MATERIAL

Appendix H
Social Baseline Support Material

APPENDIX CONTENTS

This appendix provides supplementary information in support of Chapter 4 of the ESIA report dedicated to the description of the host environment.

Section 4.6 provides a profile of the social environment of Mauritania while Section 4.7 provides a profile of the social environment of Senegal. During the data collection process for these two sections, some of the information gathered was much too detailed for the purpose of Section 4.6 or 4.7 and with regards to consistency between the two sections. Therefore, they were not included in Chapter 4 but provided in Appendix H as support material for the social baseline.

Appendix H regroups the following series of tables and figures. Their order reflects the order in which they are called out in Sections 4.6 and 4.7.

- Table H-1: List of Villages in Diawling National Park and its Vicinity – Mauritania Portion
- Table H-2: Use of Natural Resources by Populations in Diawling National Park's Territory - Mauritania Portion
- Figure H-1: Land Use in Lévrier Bay (Nouadhibou) - Mauritania Portion
- Figure H-2: Licensed Blocks off the Mauritanian Coast in 2017
- Table H-3: Estimates of Number of Inhabitants in the Villages of the Extended Study Area – Senegal Portion
- Table H-4: School Situation in Langue de Barbarie
- Table H-5: Public Services and Amenities in the Communities of the Core Study Area and the Extended Study Area – Senegal Portion
- Figure H-3: Licensed Blocks off the Senegalese Coast in 2017

Table H-1. List of Villages in Diawling National Park and its Vicinity – Mauritania Portion.

	Name of the Site	*Moughataa*	*Commune*
1	Bneinadji	Keur Macene	M'Balal
2	Mbell villaje	Keur Macene	Keur Macene
3	Ebden	Keur Macene	N'Diago
4	Ghahra	Keur Macene	N'Diago
5	Dar Rahman	Keur Macene	N'Diago
6	Moïdina	Keur Macene	N'Diago
7	Meftah El Kheir	Keur Macene	N'Diago
8	Diemer	Keur Macene	N'Diago
9	Arafat	Keur Macene	N'Diago
10	Dar es Salam	Keur Macene	M'Balal
11	Hassi Achra	Keur Macene	N'Diago
12	Sbeikha Bariel	Keur Macene	N'Diago
13	Khaya	Keur Macene	N'Diago
14	Meimakh	Keur Macene	N'Diago
15	Berbar	Keur Macene	N'Diago
16	Voum Lebha	Keur Macene	N'Diago
17	Zire Taghridient	Keur Macene	N'Diago
18	Ziré Sbeikha	Keur Macene	N'Diago
19	Bouhajra	Keur Macene	N'Diago
20	Afdjedjir	Keur Macene	N'Diago
21	Birette	Keur Macene	N'Diago
22	Diahos2	Keur Macene	N'Diago
23	Diahos 1	Keur Macene	N'Diago
24	Gad M'Barek	Keur Macene	N'Diago
25	Lorma (Hel Daouda)	Keur Macene	N'Diago
26	M'Boyo 2	Keur Macene	N'Diago
27	M'Boyo 1	Keur Macene	N'Diago
28	Keur Macene	Keur Macene	Keur Macene
29	N'Diago	Keur Macene	N'Diago
30	Birette 2	Keur Macene	N'Diago
31	Ziré Bouhoubeini	Keur Macene	N'Diago
32	Thionk	Keur Macene	N'Diago

Source: DNP, cited by Ecodev, 2017b

Table H-2. Use of Natural Resources by Populations in Diawling National Park's Territory - Mauritania Portion.

Areas	Main Uses of the Territory
Diawling Tichilitt Basin	Area of livestock pasture and drinking and, to a lesser extent, fishing area in the dissipation basin of the Cheyal structure and in the Berbar structure.
Bell Basin	Pasture and fishing area in front of Lemer Bell 1 and 2.
N'thillakh Basin	Pasture and fishing area
Gambar Basin	Market gardening area along the basin
N'tok Lake	Shrimp fishing area depending on the year
N'ter Lake	Main shrimp fishing area
Zire Dune	Pasture area with 10 villages
Birette Dune	Pasture area but little inhabited (3 villages)
Coastal Dune	Pasture area and populated area with over 16 villages. Presence of touristic sites - Maure Bleu (Ghahara), MKH (Mouly).
Chatt Tboul	Fishing site
Aftout Es Sahli	Site with several islands, located between the coastal dune and the red dunes of Trarza

Source**:** DNP, cited by Ecodev, 2017b

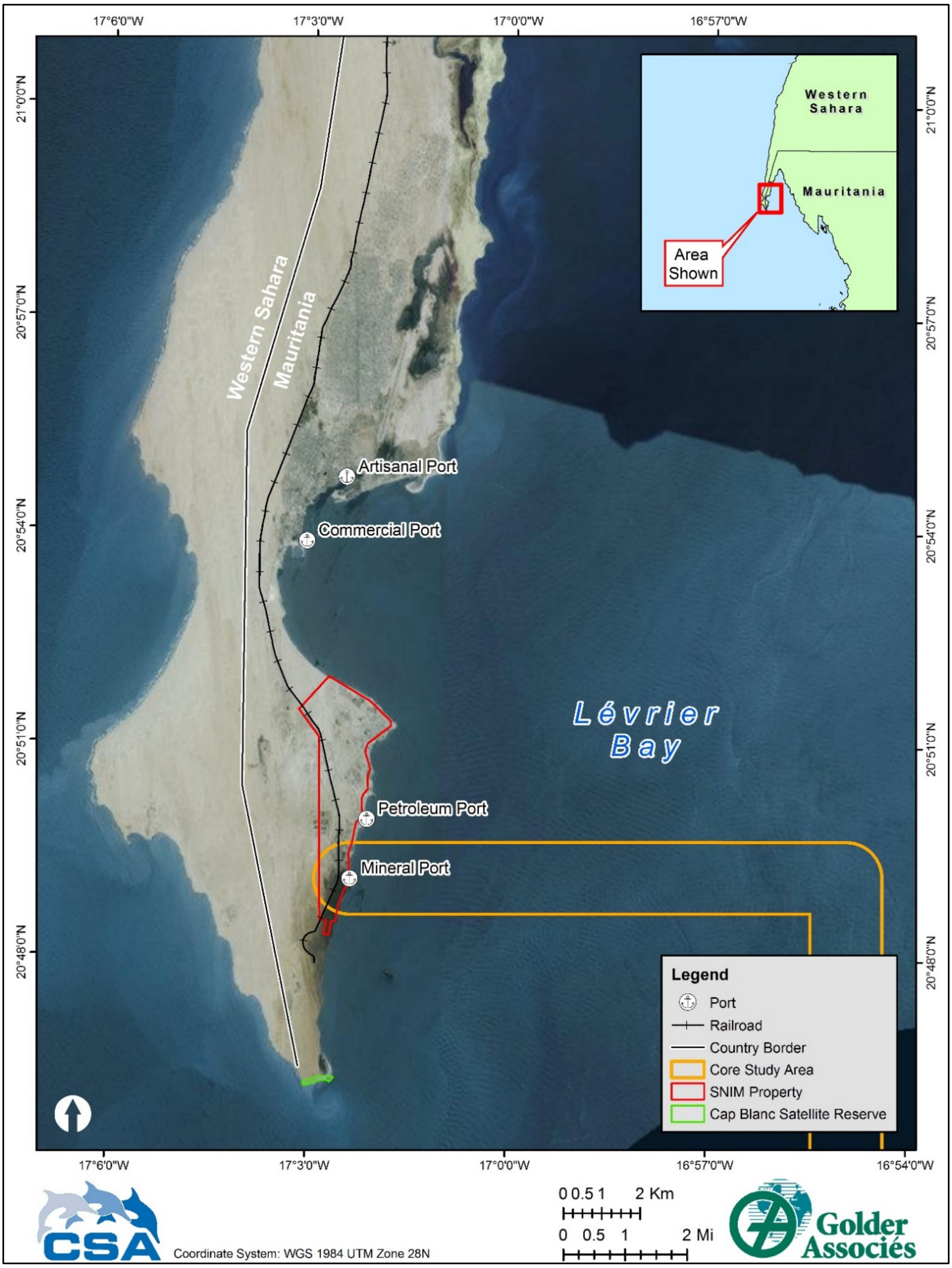
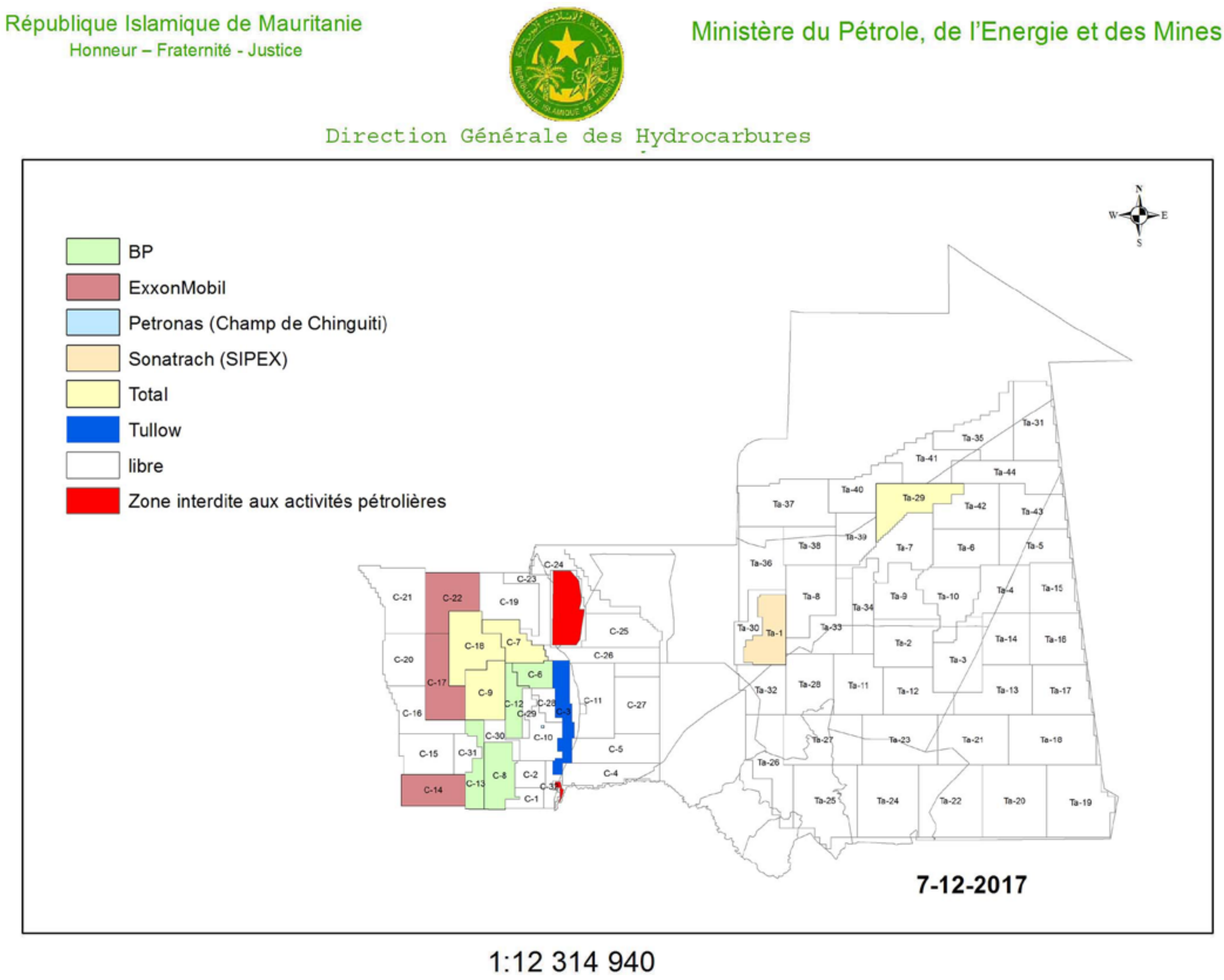


Figure H-1. Land Use in Lévrier Bay (Nouadhibou) - Mauritania Portion.



(Obtained from SMHPM)

Figure H-2. Licensed Blocks off the Mauritanian Coast in 2017.

Table H-3. Estimates of Number of Inhabitants in the Villages of the Extended Study Area – Senegal Portion.

	Cities and Villages	Population
1	Darou Mbou Baye	761
2	Mbou Mbaye	398
3	Mouit	1 786
4	Tassinère	1 032
5	Ndiébéne	2 785
6	Pilote Bare	1 060
7	Dieule Mbane	Not available
8	Doune Baba Dièye	336
9	Kalassane	270
10	Gantour	890
11	Gouye Reine	466
12	Ndoye Diagne	161
13	Ndoye Fédior	29
14	Guinguie	122
15	Bountou Ndour	Not available
16	Gueunbeug	55
17	Foté	Not available
18	Ndeugette	105
19	Pélour 1	627
20	Pélour 2	78
21	Keur Barka	492
22	Mbabara	Not available
23	Keur Bernard	26
24	Ndiol Gandiol	399
25	Deggou Niey	320
26	Lakhrar	448
27	Gnéling Mbao	233
28	Ndeugou	Not available
29	Taré Banda	Not available
30	Thignore	202
31	Ricotte	603
32	Toug Peulh	178
33	Toug Wolof	211
34	Rimbakh	347
35	Begnane	Not available
36	Bopp Thior	800
37	Diama	35 915
Tottal[1]		51 135

Source: Tropica, 2017d

[1] The populations of certain villages such as Dieule Mbane, Bountou Ndour, Fte, Mbabara, Ndeugou, Taré Banda, and Begnane are not concerned by this total because data on them could not be obtained.

Table H-4. Schools Situation in Langue de Barbarie.

School	Number of Students	Number of Classrooms	Number of Teachers
Goxxu Mbacc 2 elementary school	500	7	8
Goxxu Mbacc French-Arabic school	325	6	9
Youssou Ndiaye school of Ndar Toute	471	10	12
Elementary school of Mamour Diallo Ndar Toute	489	15 (including 3 non-functional)	15
Elementary school of Abdoulaye Mbengue KHALY Guet Ndar	635	13 (including 4 in construction)	16
Primary school of Hydrobase	500	8	10
Neighborhood school committee Samba Ndiémé SOW Ndar Toute	270	7 (and 3 administration building)	12

Source: LE PARTENARIAT NGO, June 2016, cited by Tropica, 2017d

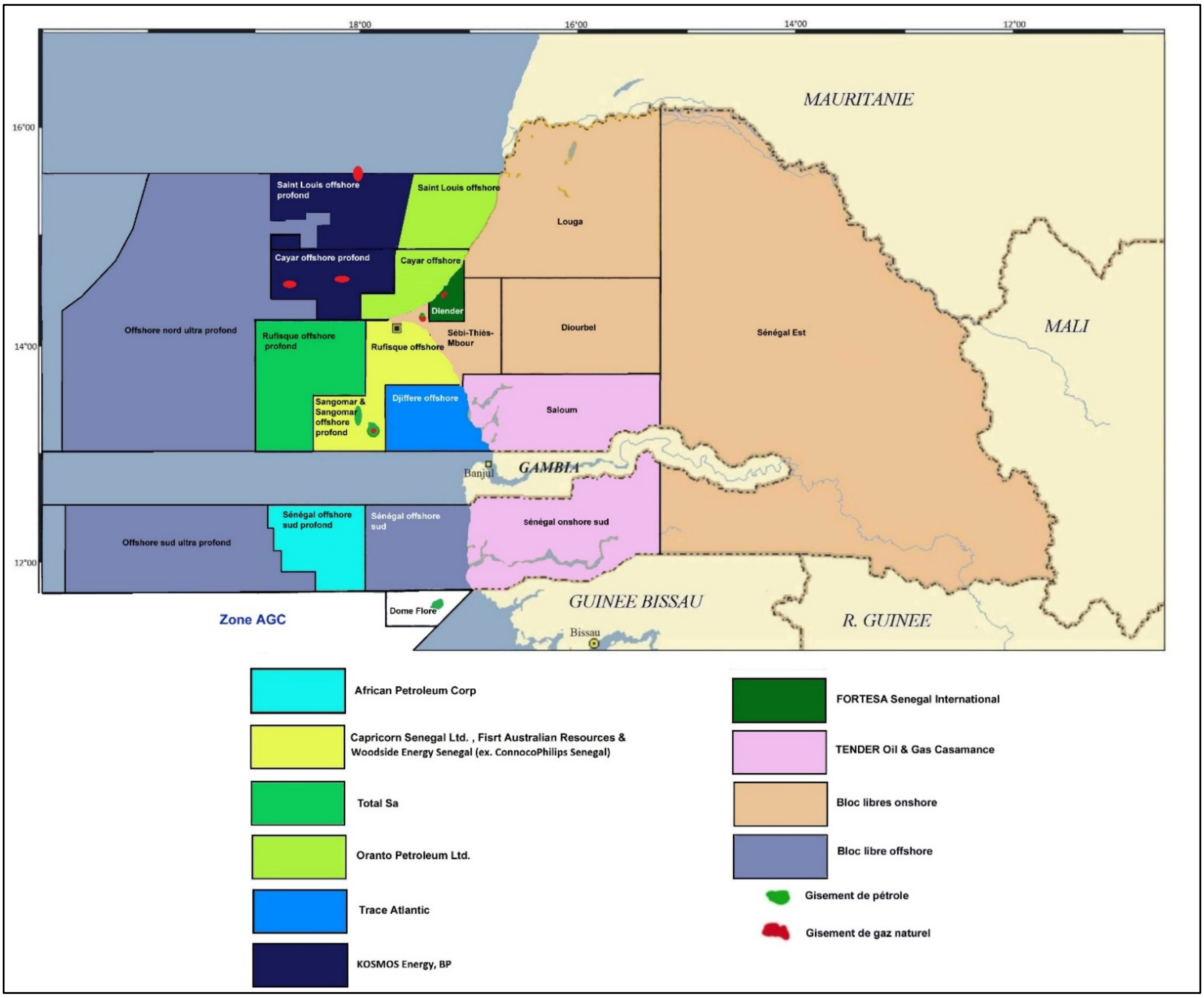
Table H-5. Public Services and Amenities in the Communities of the Core Study Area and the Extended Study Area – Senegal Portion.

Locality	Drinkable Water	Electricity	Elementary School	High School	Health Care Unit	Cell Phone Coverage	Transportation Network
Dakar	+	+	+	+	+	+	Road
Saint-Louis	+	+	+	+	+	+	Road
Niayam	-	-/+	+	+	+	+	Road and dirt road
Lompoul-sur-Mer	-	+	+	+	+	+	Road
Fass Boye	-	+	+	-	+	+	Road and tracks
Mboro Ndeundekat	-	-	+	-	-	+	Tracks
Cayar	-	+	+	+	+	+	Road
Gandiolais villages bordering the Senegal River[2]	+ for 7 villages and – for 2 villages	Data not available	+ for 7 villages and – for 2 villages	Data not available	+ for 2 villages and – for 7 villages	+	Tracks
Bopp Thior	-	-	+	-	+ (but not functional)	+	
Diama		+	+	+	+	Road	Road

+: Existing infrastructure
-: No infrastructure

Source: Tropica, 2017d

[2] Nine villages are located on the coastline: Pilote Bar, Tassinère, Mouit, Darou Mbou Baye, Mbou Baye, Deggou Niey, Lakhrar, Gneling Mbao, and Taré Banda.



(Obtained by Kosmos from PETROSEN)

Figure H-3. Licensed Blocks off the Senegalese Coast in 2017.

APPENDIX I : HYDRODYNAMIC (COASTAL EROSION) BASELINE SITUATION AND MODELING

Appendix I
Hydrodynamic (Coastal Erosion) Baseline Situation and Modeling

APPENDIX CONTENTS

This appendix provides information on the current situation regarding coastal erosion and on hydrodynamic modeling.

I-1 Regional Characterization of Coastal Processes Report

I-2 Coastline Modeling Report

I-3 Coastline Modeling – Reference Case Report

APPENDIX I-1 : REGIONAL CHARACTERIZATION OF COASTAL PROCESSES REPORT

Tortue Development Project,
Coastal Engineering Analysis,
Regional Characterization of Coastal Processes

11 December 2017

HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING AND PERMITTING
"Restoring Beaches as Natural Coastal Systems"

A/G LNG PROJECT

COASTAL ENGINEERING ANALYSIS

REGIONAL CHARACTERIZATION OF COASTAL PROCESSES

01 GENERAL

BP and Kosmos Energy are investigating the development of a natural gas field offshore of the coasts of Mauritania and Senegal. Humiston & Moore Engineers was tasked by CSA Ocean Sciences Inc. (CSA) with the evaluation of the project. The primary task includes development of a regional assessment of coastal processes present in the project area.

The purpose of this task is to provide a general description of the coastal processes in the region represented by the 250 mile (402 kilometer [km]) stretch of coastline ranging from Nouakchott, Mauritania at the North end; to Dakar, Senegal at the South end. The analysis is based on a review of available data including bathymetry, historical aerial photographs, wave record and available documentation and studies. The information is compiled and analyzed to describe wave and current climates and general regional coastline morphology changes and trends within the last three decades.

02 REGIONAL DESCRIPTION

The scope of the study area spreads across two countries: Mauritania and Senegal separated by the Senegal River on the West coast of Africa. As part of the Sahara desert, the Mauritania's shoreline is mostly sandy South of Nouakchott. The Senegal River makes its connection to the Atlantic Ocean in the vicinity of Saint-Louis in Senegal. The river delta spreads over approximately 60 miles (97 km), but the actual river inlet is located south of Saint-Louis. The shoreline between Saint-Louis and Dakar is primarily unconsolidated sediment with occasional hard rock outcrops.

Regional bathymetry was obtained from the Global Multi-Resolution Topography (GMRT) Data Synthesis. **Figure 1** shows a contour map overlaid over a satellite photograph. The contours are color coded to identify various morphologic features; with yellow to orange indicative of 0 meters (m) to -50m then brown to green representing -50m to -100m and blue indicative of deep water in excess of -500m. The figure also presents the regional shape of the continental shelf which is indicated in the zone in green shades.

The bathymetric contours show a steep drop off from the continental shelf to deep ocean, the continental shelf is narrowest near Dakar and widest near Nouakchott. Additionally, several deep water submarine canyons are present in the region near Dakar, North of Saint-Louis and in the vicinity of Nouakchott. These are typically oriented from the continental shelf out to the deep ocean and may play a role with upwelling events known to the region.

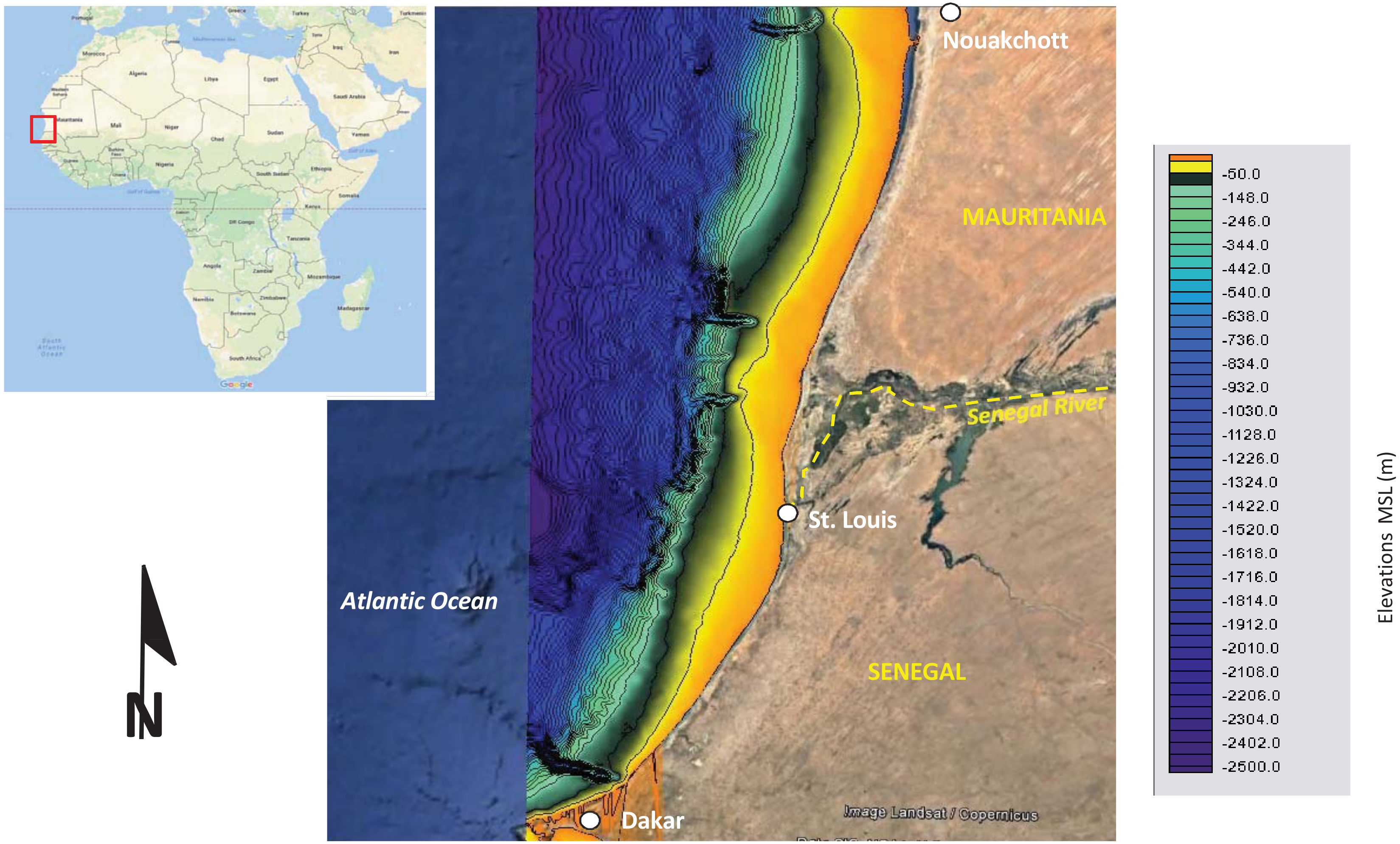


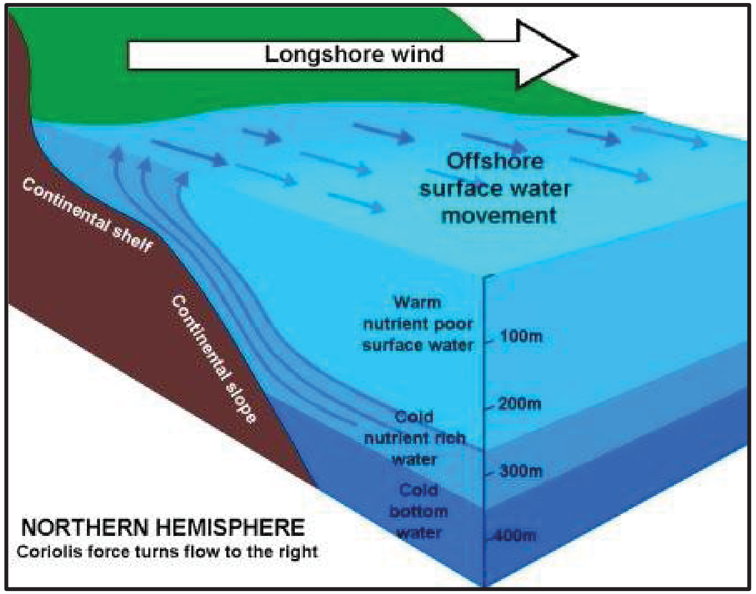
Figure 1. Study area location map and bathymetry

03 CURRENTS

The region is marked by the recurrence of upwelling events which consist of deep colder water converging near the surface along the coast and warmer surface water being pushed offshore (Figure 2). Trade winds and the Intertropical Convergence Zone (ITCZ) generate large scale divergent Ekman transports, which force in the northern hemisphere this tropical upwelling system that continuously extends from Morocco to the mouth of the Guinea Gulf, and from the African coasts to mid and west Atlantic, depending on season. Considered from a basin-scale perspective, this system forces a cyclonic gyre circulation, the Guinea Gyre, of which the Guinea Dome and the coastal West-African upwellings form the most eastern features (Figure 2). In the figure the area hatched in light gray represents the area of upwelling, dark gray arrows represent permanent currents, seasonal currents in winter-spring (green), and other seasonal currents in summer-autumn (blue). Dash lines correspond to currents not evidenced by in-situ measurements, but visible in circulation derived from altimetry.

The general schematic presented by Saliou Faye et al. in Figure 2 shows the main currents in the region in a paper “A model study of the seasonality of sea surface temperature in the North–Eastern Tropical Upwelling System” (September 2015). The schematized horizontal current circulation is further described below:

> *To the west, the North Equatorial Current (NEC) and the Canary Current (CC) forms the eastern boundary of the North Atlantic sub-tropical gyre. Near-shore, a strong wind-induced coastal upwelling is active, its extension depending on season, and a density front develops that generates the coastal jet, also named Canary upwelling Current (CanUC). However, observations are lacking and its latitudinal extension to the south is uncertain, with some model studies showing it down to the Cape Verde peninsula (see dashed green arrow in Figure 2). South of the region, the circulation is dominated by the North Equatorial Counter-Current (NECC), which has a large seasonal cycle. It is located near 5°N in winter and reaches 10°N in summer. During this season, it continues north as the Mauritania Current (MC), which flows northward until about 20°N. Offshore, the Guinea Dome (GD) is another important physical characteristic of the area, defined by a dome of the isotherms, and low hydrostatic pressure. It is centered in the southeast of the archipelago of Cape Verde, and intensifies in summer, at about 12°N, and 22–23°W. It is generated by upward Ekman pumping forced by the trade winds convergence, and belongs to the Guinea Gyre, formed by the NEC and NECC in surface. It exist a link between the GD with the Atlantic Meridional Mode (AMM) which is related to the meridional migration of the Inter tropical Convergence Zone (ITCZ).*



Source: http://www.seos-project.eu/modules/oceancurrents/oceancurrents-c04-s01-p01.html

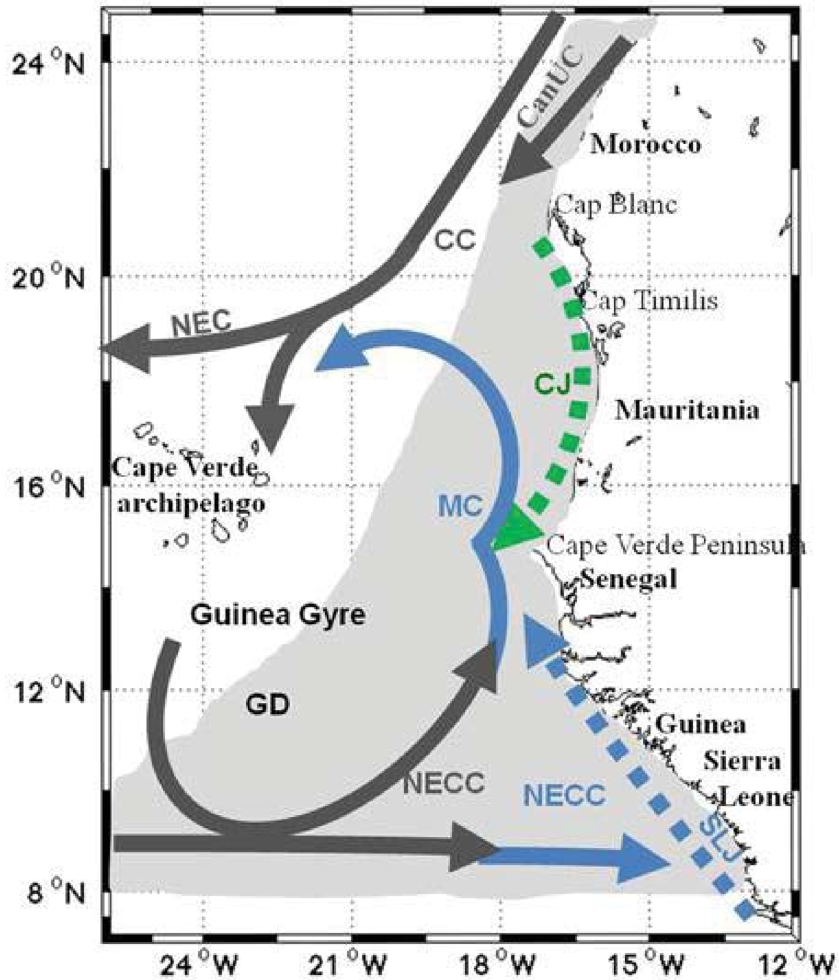


Figure 2. Map of schematic surface circulation in the Atlantic North-eastern Tropical Upwelling System (Saliou Faye et al., 2015).

The seasonal variability of surface currents and upwelling events has been described by M. Menna et al. (2016) "Upwelling features off the coast of north-western Africa in 2009-2013". The paper analyses the trajectories of drifters for a similar time period of March-April during the course of four (4) successive years: 2010 to 2013. The results are presented in **Figures 3** through **6**. Each figure represent a specific year of the study; the figures are split into quadrants each showing an 8 day mapping of sea surface temperature change along with the recorded path of several drifters for that duration. The drifters are represented as a white line with a black dot. Overall, the figures show how variable the currents can be from season to season and also from year to year. In **Figure 3** (February 2010), the drifters left Cap Vert in Dakar and made their way towards the South West; in **Figure 6**, in March 2013, the drifters initially moved from Cap Vert to the north towards Mauritania before turning around and making their way to the south. The study also noted the drifters velocities reached up to 20 and 40 cm/s (0.6 to 1 knot).

The proposed Breakwater location is under consideration at various distances offshore. The regional ocean currents might not be among the main factors influencing the nearshore morphology, however they might be worthy of future consideration in the monitoring program through the design and implementation of the proposed project. Typically, ocean water circulation and offshore currents might not initiate sediment transport in deep water. However, in areas where currents are close to the nearshore, certain storm wave events may disturb the seabed and suspend particles in the water column, once sediments are in suspension, offshore ocean currents can transport them. Once a final design is adopted for the proposed breakwater, it is recommended to establish an active monitoring program that includes acoustic Doppler current profiler (ADCP; current profiling) data and wave height measurement capabilities at the proposed project site to identify currents throughout the water column along with directional waves measurements. The data collected prior to construction should provide the baseline for post construction monitoring program and update potential impact analysis as necessary.

04 WAVES

04.01 TIME SERIES

The wave data for the region was obtained from the NOAA WAVEWATCH III (WWIII) model. The model uses the measured data from offshore buoys spread across the world and extrapolates the data to a grid through hindcast modeling. WWIII solves the random phase spectral action density balance equation for wavenumber-direction spectra. The implicit assumption of this equation is that properties of medium (water depth and current) as well as the wave field itself vary in time and space scales that are much larger than the variation scales of a single wave.

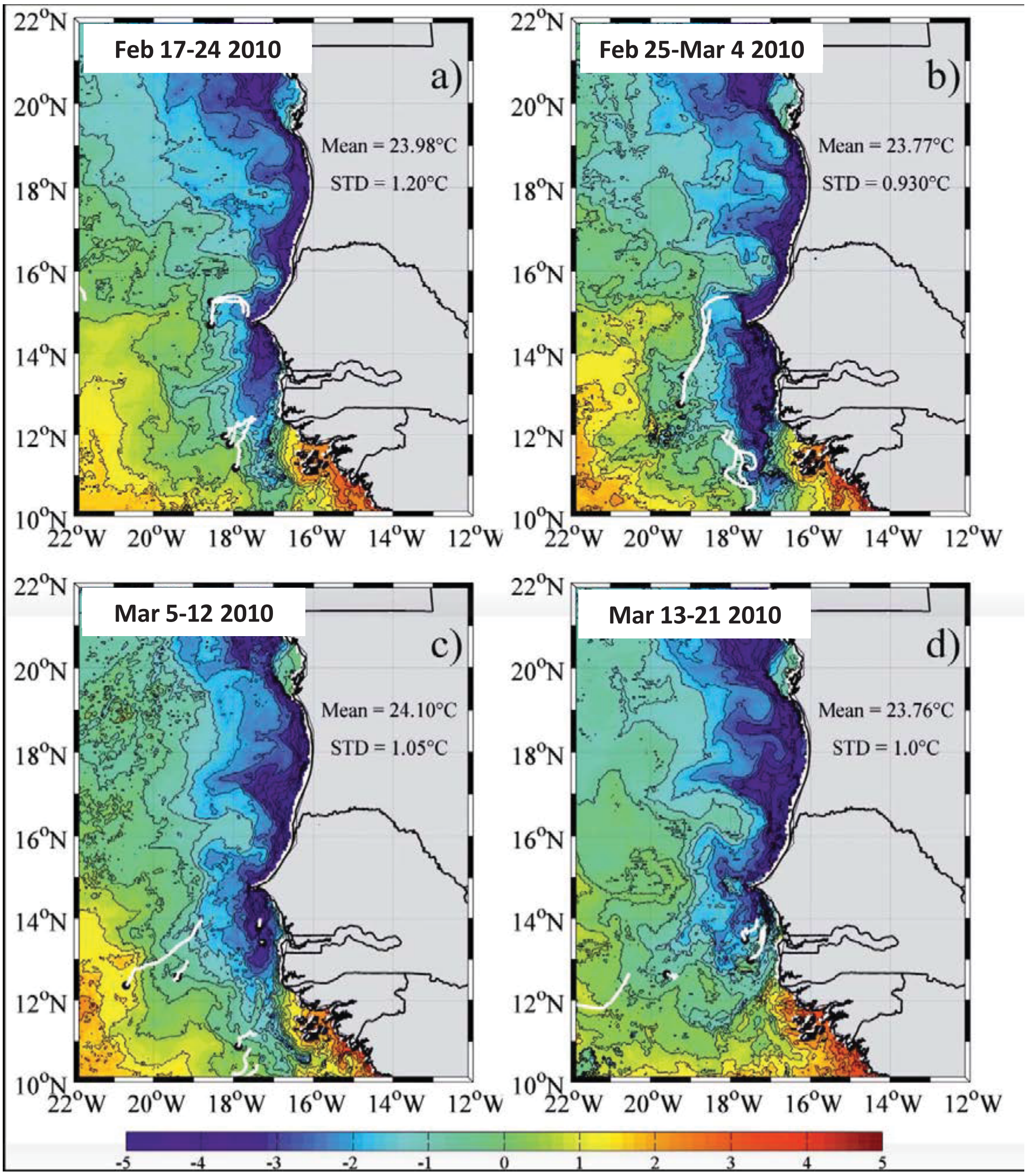
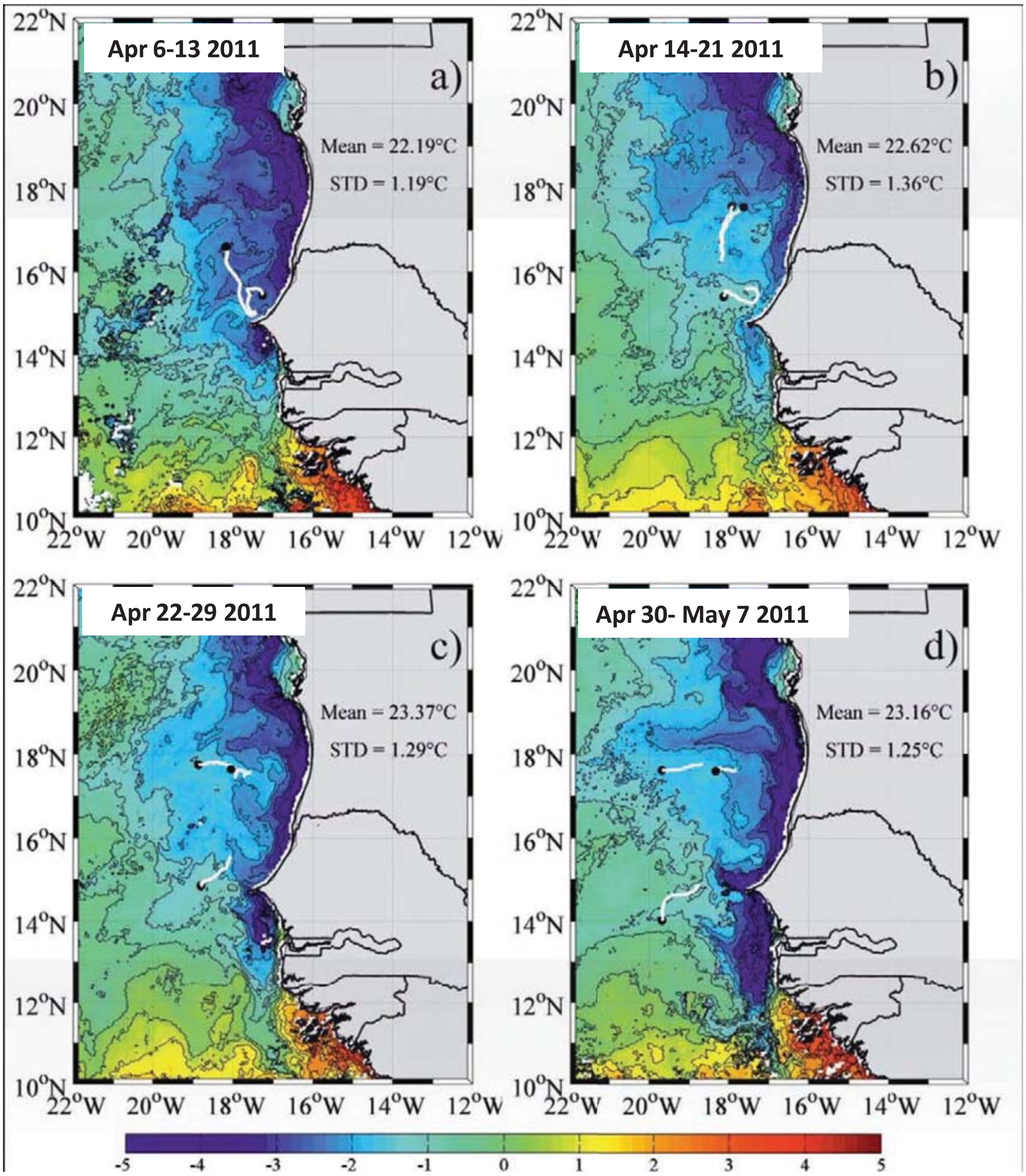


Figure 3. Normalized sea surface temperature anomaly map, 2010 (M. Menna et al., 2016)



Sea Surface temperature Change (°C)

Figure 4. Normalized sea surface temperature anomaly map, 2011 (M. Menna et al., 2016)

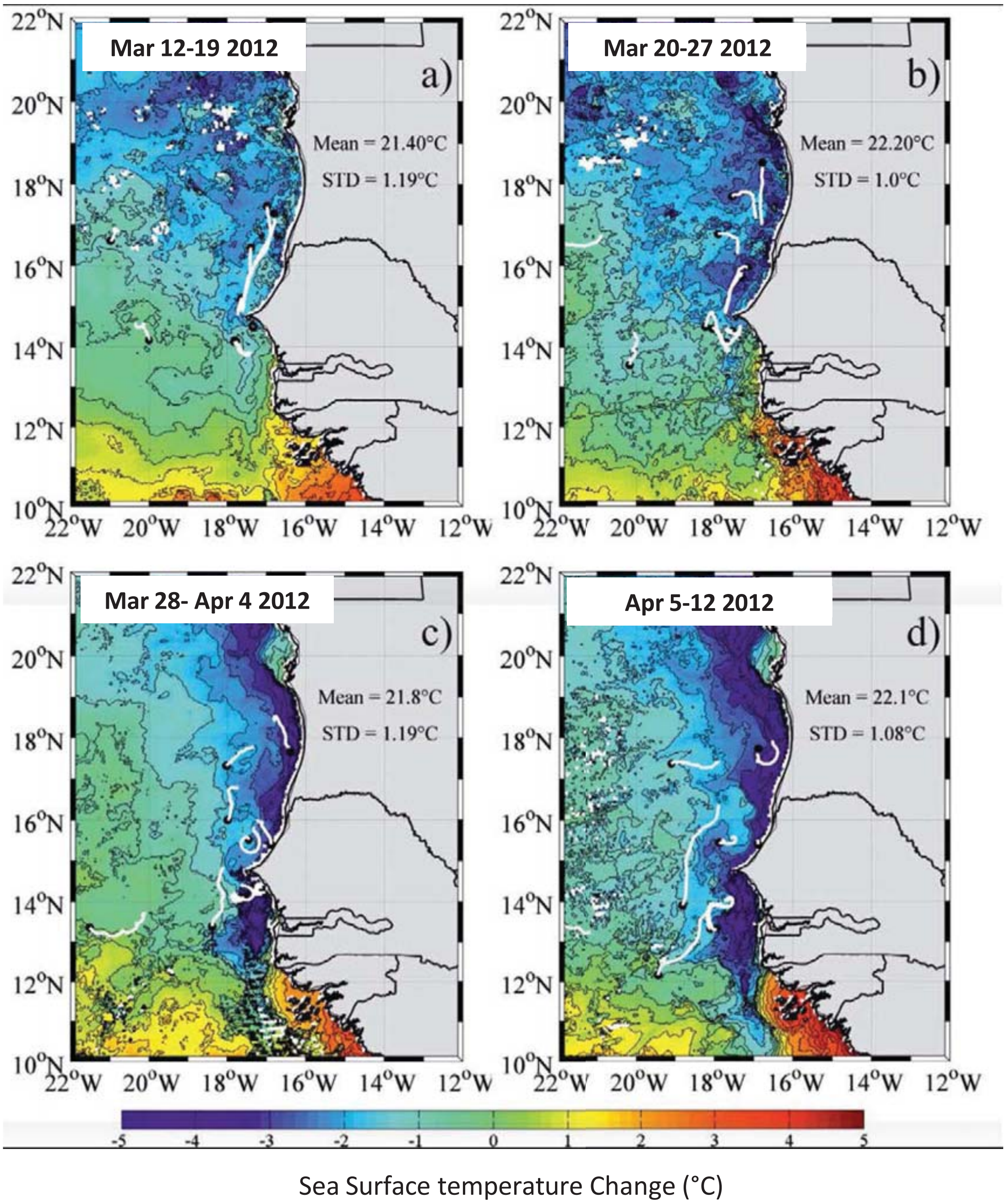
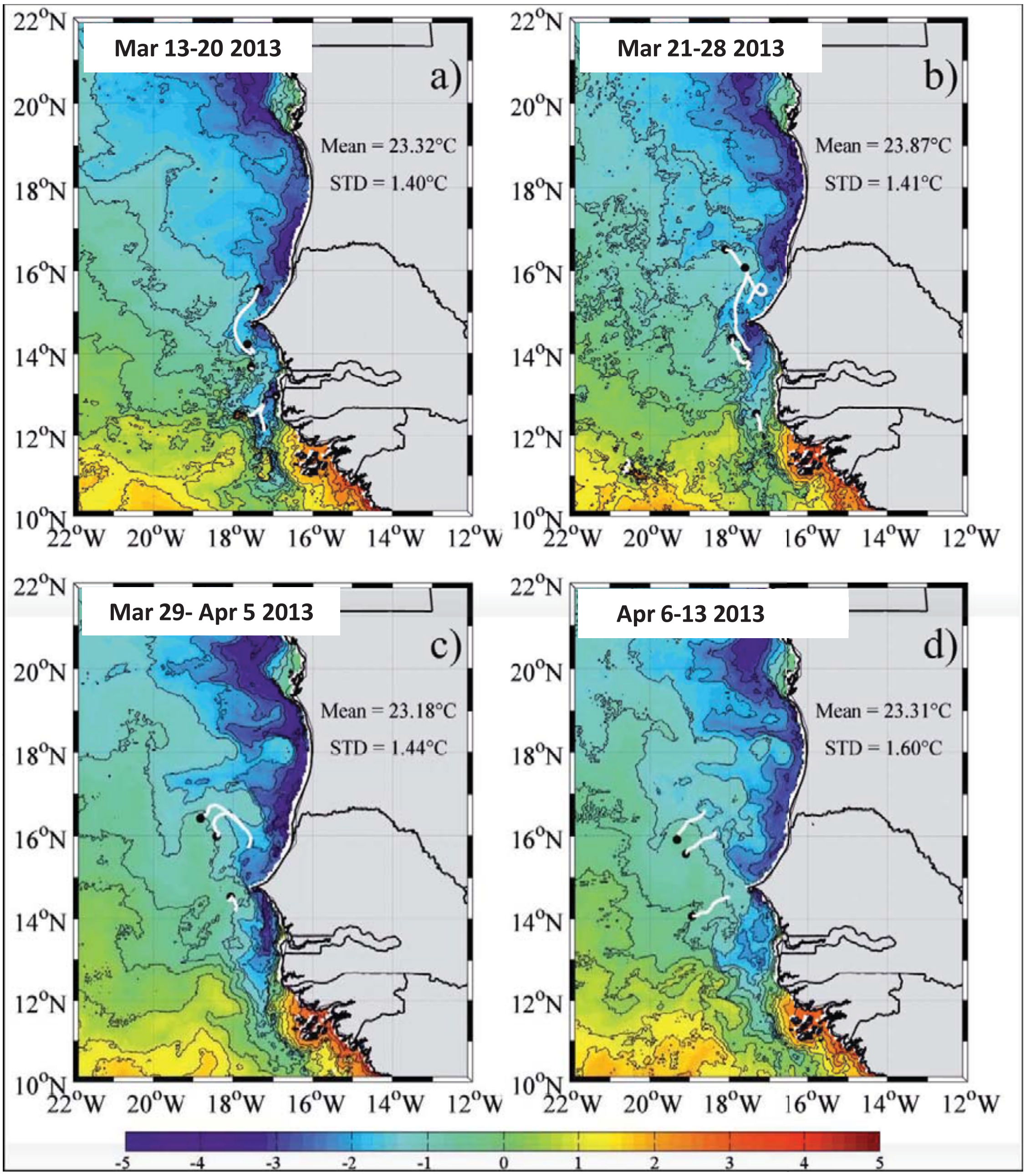


Figure 5. Normalized sea surface temperature anomaly map, 2012 (M. Menna et al., 2016)



Sea Surface temperature Change (°C)

Figure 6. Normalized sea surface temperature anomaly map, 2013 (M. Menna et al., 2016)

Wave data for the year 2016 were extracted for comparison at three locations along the region: the north end of the study area near Nouakchott (Station 1: W16.5°,N16°), in the vicinity of Saint-Louis (Station 2: 16°N, 17°W) and at the South end near Dakar (Station 3: 15°N, 18°W). The time series are presented in Figure 7, the Nouakchott station is represented in blue, the Saint-Louis station in red and the Dakar station in green. The data indicate that there are small variations between the three locations for significant wave height, peak period and peak direction. For the purpose of this task, the Saint-Louis station will be used for the remainder of the analysis. Additional wave data were extracted from the WWII model database for an eleven year record: from 2006 to 2016 at the Saint-Louis station. The annual time series are presented in Appendix A, these also include wind speed and direction time series.

Wind and wave statistics were prepared for the 11-year record using joint probabilities. The directional records were first sorted into 22.5° directional bands, then the percentage of occurrence was computed for several wind speed bins. For the wave record, each directional band was divided into 3 bins based on wave period to prepare representative wave conditions and percentage of occurrence. The joint probability wind rose is presented in Figure 8 and in Figure 9 for the waves for the whole time series (2006-2016).

Overall the data shows that the winds are predominantly from the North (25%) and that East to South West are almost inexistent. The wave data shows that more than 80% of the time waves came from the NNW and NW, 48% of the waves were over 1.8 m with a period of over 12 seconds.

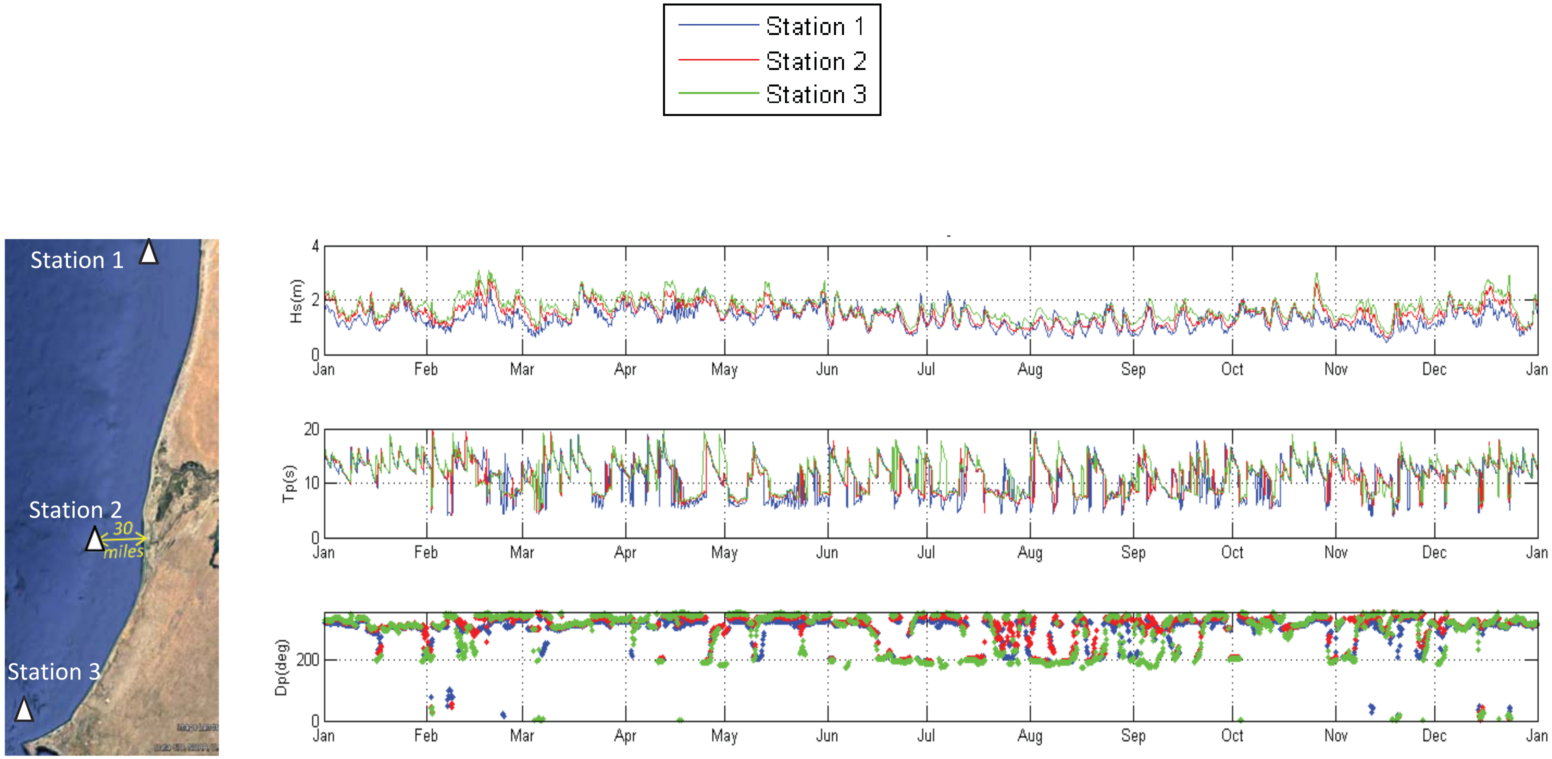


Figure 7. Wave Watch III data comparison near Nouakchott, St Louis and Dakar (2016)

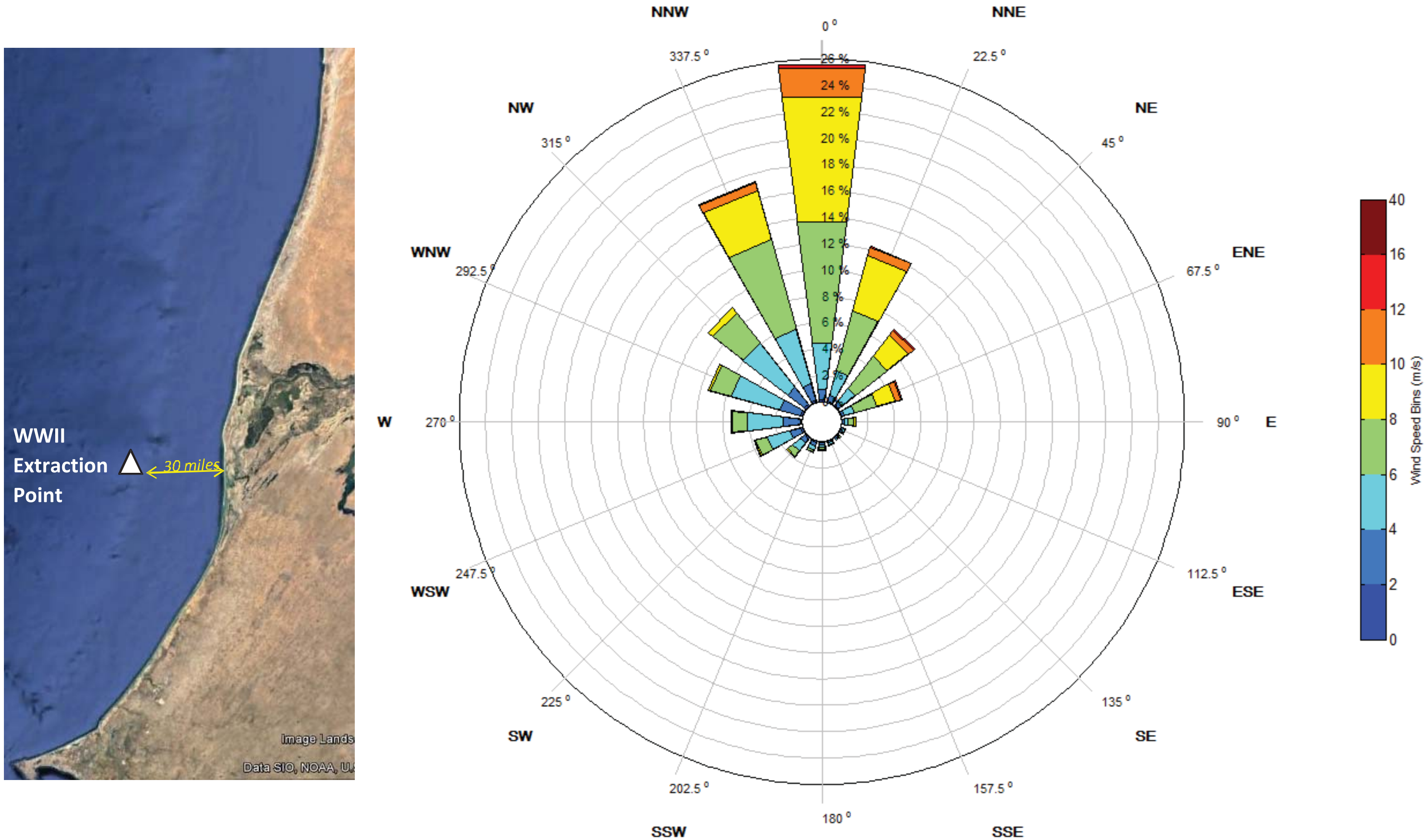


Figure 8. Wind joint probability roses (2006-2016)

Direction		Representative Wave Condition			SUM
		Period (s)	Significant Wave height (m)	Probability of Occurrence	
180	S	0.00	0.00	0.00%	0.1%
		0.00	0.00	0.00%	
		14.22	0.97	0.08%	
202.5	SSW	4.38	1.13	0.01%	4.9%
		0.00	0.00	0.00%	
		14.00	1.16	4.85%	
225	SW	4.33	1.16	0.01%	0.9%
		7.84	1.22	0.27%	
		12.90	1.15	0.64%	
247.5	WSW	5.98	1.11	0.01%	0.8%
		7.58	1.11	0.46%	
		12.79	1.22	0.36%	
270	W	4.85	1.35	0.03%	0.8%
		7.53	1.01	0.33%	
		12.43	1.28	0.46%	
292.5	WNW	4.66	1.21	0.06%	3.5%
		8.13	1.10	0.68%	
		12.43	1.54	2.79%	
315	NW	5.00	1.30	0.16%	32.0%
		9.00	1.24	4.29%	
		12.48	1.85	27.54%	
337.5	NNW	5.43	1.36	2.13%	53.9%
		7.77	1.61	30.17%	
		12.69	1.82	21.60%	
360	N	5.29	1.46	1.12%	2.8%
		6.87	1.84	0.58%	
		13.77	1.54	1.10%	

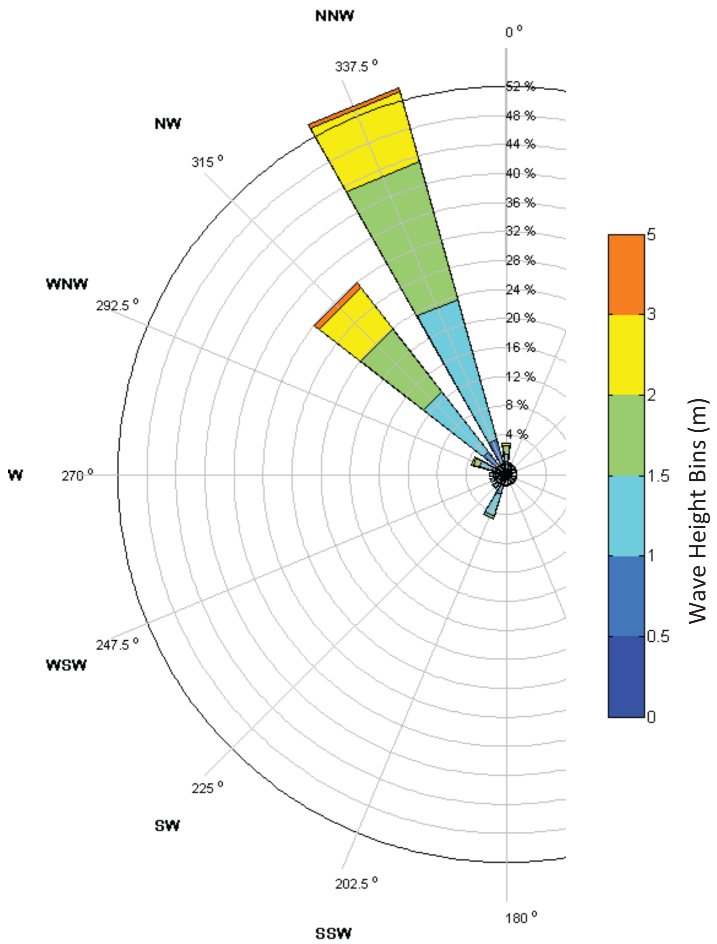


Figure 9. Wave joint probability roses (2006-2016)

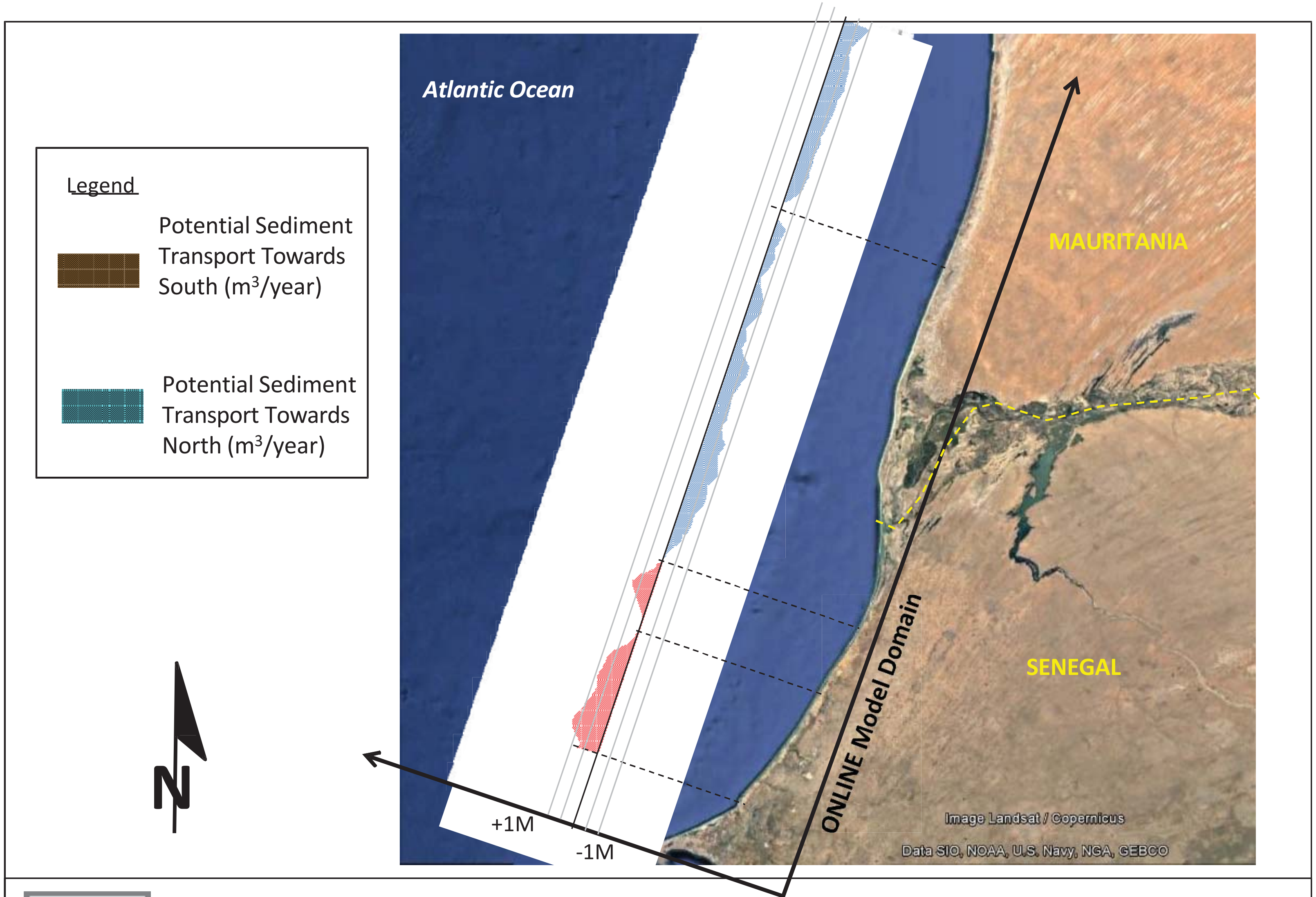


Figure 10. ONELINE model domain and annual potential sediment transport results

04.02 POTENTIAL SEDIMENT TRANSPORT

The regional potential sediment transport was evaluated using the ONELINE shoreline change model (Dabees and Kamphuis 1998). The model was used to simulate regional wave transformation to nearshore and computation of potential sediment transport along modeled region. The potential longshore sediment transport represents the potential sediment flux resulting from the action of incoming waves. The breaking wave angle of approach, period and magnitude dictate the level of sediment transport for a specific time step. Due to the large scale of the study area and limited scope of modeling, the potential longshore sediment computed herein is presented as an indication of trends in magnitude and direction and values could not be verified. These should however provide a general indication in magnitude and trends. The ONELINE model domain is presented in Figure 10, it captures the coastline from Nouakchott to Dakar with an orientation close to 93° to shore parallel, the model's origin is in the vicinity of Dakar. Annual wave records were run through the model and an average potential sediment transport computed for the domain for each year to provide potential long-term average.

The model results are presented in Figure 10, the negative sediment transport (in blue) represents potential for sediments to travel towards the south and the positive potential sediment transport shown in red represents potential for sediments to travel towards the north. While these trends vary with seasons and storms, these offer a general indication of net annual magnitude of transport and typical direction. The results show high potential sediment transport values potentially reaching over one million m^3/year towards the south for the majority of the region with a possible sediment transport reversal towards the north in the vicinity of Dakar.

05 SHORELINE EVOLUTION

The shoreline evolution in the study area was evaluated through study of historical satellite aerial photographs from 1984 to 2016 and review of available publications. The study area can be split into three coastline regions with similar behaviors: the first is the south Mauritania region covering from Nouakchott to the north end of the Senegal River delta, the second is the Senegal River Delta including Saint-Louis and the third is the North Senegal region from the south end of the Senegal river delta to Dakar.

05.01 SOUTH MAURITANIA REGION

At the north end of this region is Nouakchott, the largest city in Mauritania. Ahmed Ould Elmoustaph et al. (2007) described the coastal region as linear, dry windy beach associated with a 5 to 10 m sand dune that bounds and protects vast low–lying salty depressions. The mild sloping beach profile reaches -9m at about 400m offshore, while the upland beach has narrow sand dunes that can be flooded during periods of high swell.

The study discusses an open coast harbor built at the south end of Nouakchott called "Port de l'Amitie" which is a major structure built in 1986, which consists in a shore perpendicular impermeable barrier. Since construction, the shoreline has experienced drastic changes due to sediments accumulating on the north end of the structure and eroding at the south end. Figure 11 shows a comparison between conditions in 1984 and 2016. In the three decade timeframe, the shoreline accreted by approximately 2,500 feet on the north side and eroded by approximately 3,000 feet (914 m) on the south side. The downdrift impacts are seen as far as 5 miles (8 km) south of the structures. These observations confirm that the predominant longshore sediment transport is from north to south in the region. This is consistent with the ONELINE model results presented above. Additionally, the study from Ahmed Ould Elmoustaph et al. (2007) quantifies the sediment transport rates in the range of approximately 1 million m^3/year which is also consistent with values computed herein.

Observations from satellite images since 1984 to present for the Mauritania region south of Port de l'Amitie indicate that the shoreline has mostly remained stable during that time period. However the historical images also show that the coastal/dune vegetation line has been consistently retreating towards the South East. This could be the result of overwashing during high swell events as described in Elmoustapha et al. (2007) or the result of aeolian sand transport. Coastal vegetation is typically a sign of a stable environment. The recession observed suggests that the shoreline in this region may not remain as stable in the future if vegetation retreat continues. Figure 12 shows an example of coastal vegetation recession; similar observations were made through the South Mauritania region.

05.02 SENEGAL RIVER DELTA REGION

The Senegal River delta spans approximately 60 miles (97 km), it is characterized by a sandy shoreline for the most part represented by a continuous vegetated sand spit. The Senegal River has one inlet to the Atlantic Ocean, it is located at the south end of the delta in the vicinity of Saint-Louis, the largest city in the region. The shoreline has overall remained fairly stable north of the inlet since 1984 with similar vegetation line recession as observed in the rest of South Mauritania, with the exception of occasional sand wave making their way along the coastline. The vegetation line retreat also follows a south to south east pattern consistent with general southward longshore transport. On the other hand, the area of the inlet's mouth and south of the inlet has experienced significant changes in the last three decades, most likely the largest changes in the study area.

This very dynamic coastal area is described in great detail in a published book by Boubou Aldiouma Sy (2015) ("Breche ouverte sur la langue de Barbarie a Saint Louis, Esquisse de bilan d'un amenagement precipite"). The publication describes the changes that occurred in the area through anthropogenic action. Figure 13 shows the regional shoreline evolution between 1984 and 2016. In 1984, the mouth of the Senegal River was located at the south end of the delta as circled in yellow in the figure. Because the delta system is natural, the mouth of the inlet is dynamic and subjected to southward migration from incoming Atlantics waves and river current forcings. The figure shows that in 1992 the inlet had migrated several miles (km) south, by 2004 it had maintained its southern migration by a few additional miles, and another opening occurred at the north end, just south of Saint-Louis. Boubou Aldiouma explains that as the inlet migrated south, the increasing pressure at the north end resulted in the local government deciding to open a small breach south of Saint-Louis to prevent flooding of the city or the formation of a natural breach to form at the north end of Saint-Louis with potentially catastrophic consequences. While the breach was initially only 3 m wide and intended to temporarily relieve the excess water in the estuary, the opening expanded rapidly and within a few years grew from the original 3 m to close to 4 miles (6.4 km) by 2016. In the process, several villages in the bay got exposed to the open ocean waves and significant local erosion forced the evacuation of these villages. This is the case of Keur Bernard and Doune Baba-Dieye which were wiped out in a few year's time. **Figure 14** shows a close-up of the breach location and surrounding villages affected in a succession of aerial photographs.

The city of Saint-Louis also experiences fluctuations along its shoreline, specifically in N'Dar Toute. **Figure 15** shows several close-ups of the shoreline between 2003 and 2016. The fluctuations appear to be the results of erosional episodes followed by episodes of recovery in the form of sand waves traveling along the coastline as evidenced in the figure in 2014. However, it seems that in the recent years the trend has been mostly erosional and locals have placed concrete blocks to help protect the upland properties. This is more evident in the 2016 aerial photograph (red arrow) where the beach is close to nonexistent in certain areas.

05.03 NORTH SENEGAL REGION

The north Senegal region spans from the south end of the Senegal River delta to Dakar. The shoreline in the region appears to be stable for the most part. In opposition with the coastal vegetation along the Mauritanian coastline, here the vegetation seems to have progressively increased and become more established. This indicates some level of stability for the coastline. **Figures 16 and 17** show a couple examples with evidence of coastal vegetation thriving since 1984. In the figures photographs from 1984 and 2016 are compared, vegetated areas are circled in yellow for comparison.

The south end of the region is marked by the presence of the Dakar canyon which is in an area of the coast with a very narrow continental shelf. **Figure 17** shows the location where the deep water canyon is the closest to the coast in Kayar. The uneven shoreline orientation at this location is an indication of possible rock substrate and would explain the stable shoreline here. Since Dakar is mostly a rock peninsula, the presence of rock substrate in Kayar would not be surprising since it is at the base of the Dakar peninsula.

Cite Keur Salam is located South West of Kayar, it is the area that has experienced the most erosion within the last three decades. The area initially eroded until early 2008 and then started to accrete again until present time (2016). These changes could be related to the development of Cite Keur Salam which happened towards the end of that period. **Figure 18** shows a succession of satellite images from 1984 to 2016 to illustrate this.

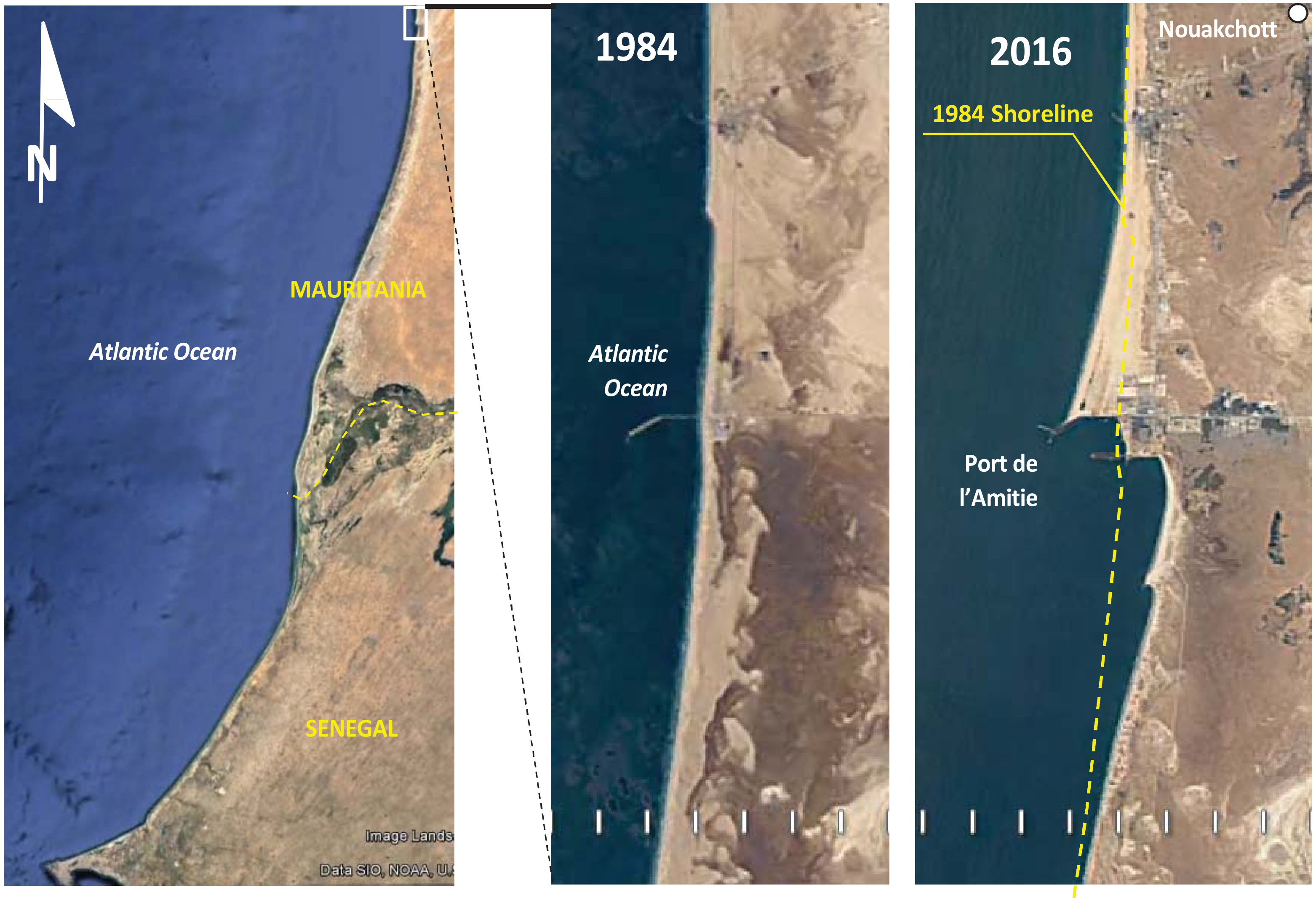


Figure 11. Nouakchott Port de l'Amitie aerial comparison (1984 & 2016)

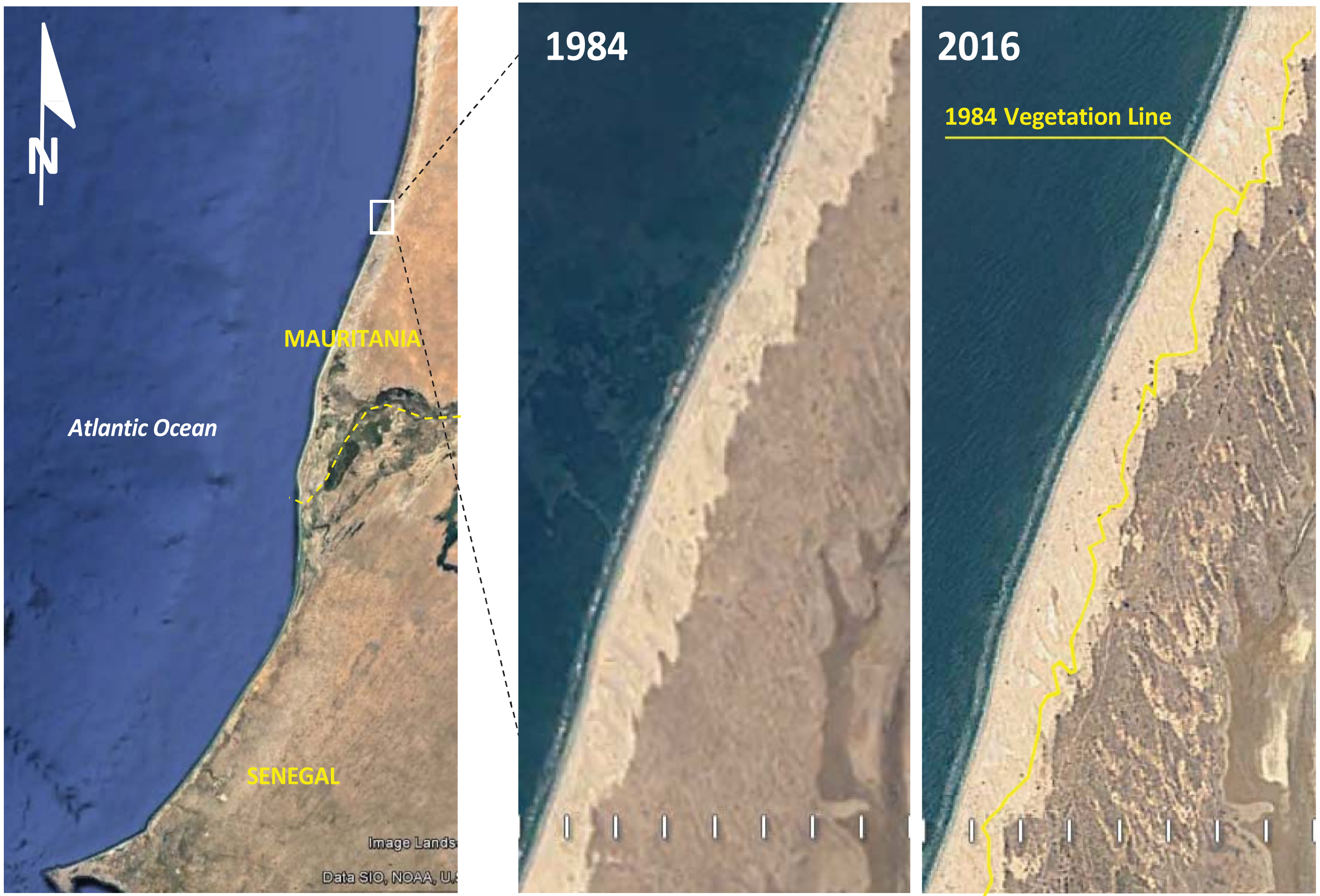


Figure 12. Typical south Mauritania Coast aerial comparison (1984-2016)

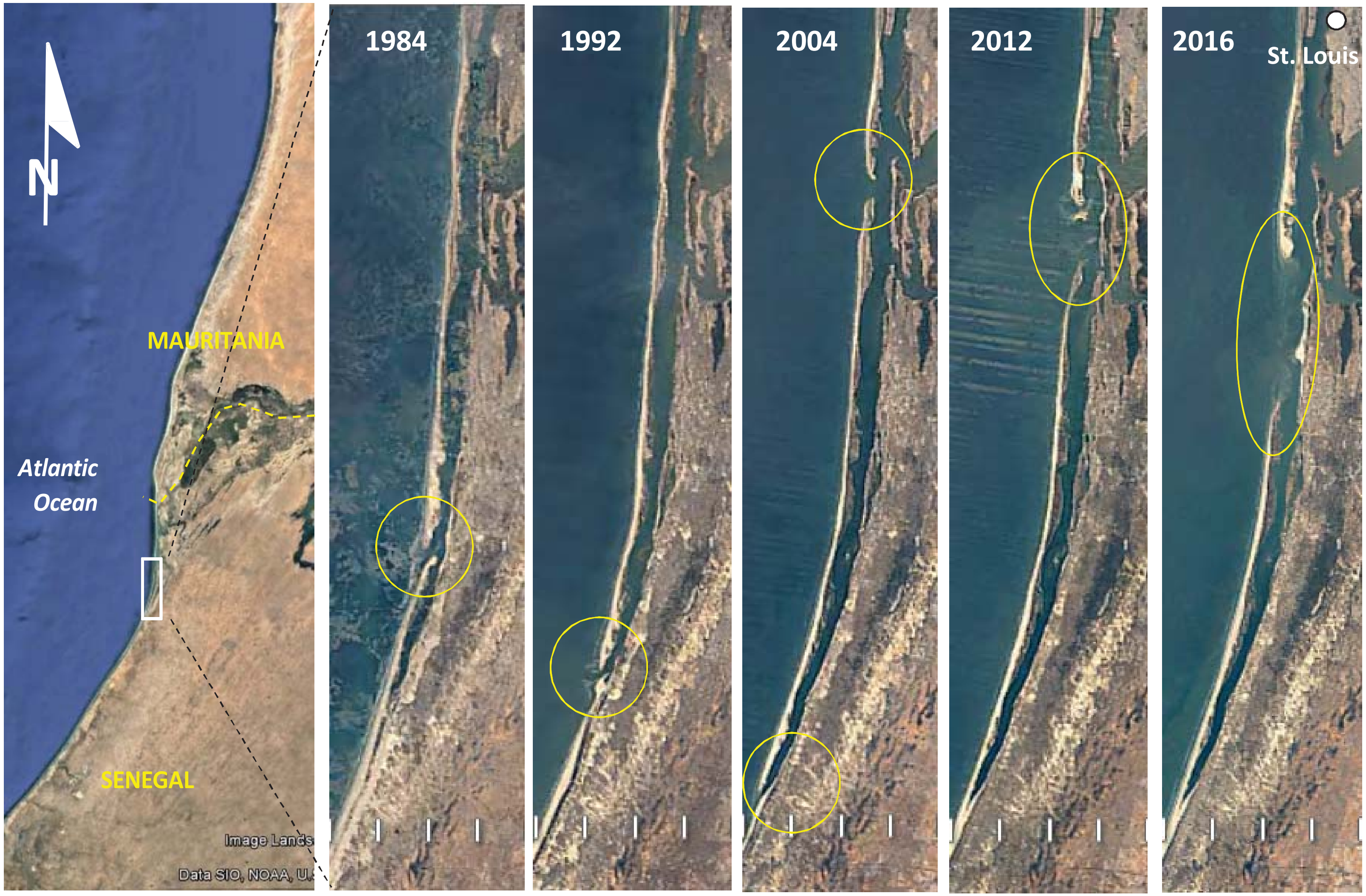


Figure 13. Senegal River inlet regional evolution (1984 – 2016)

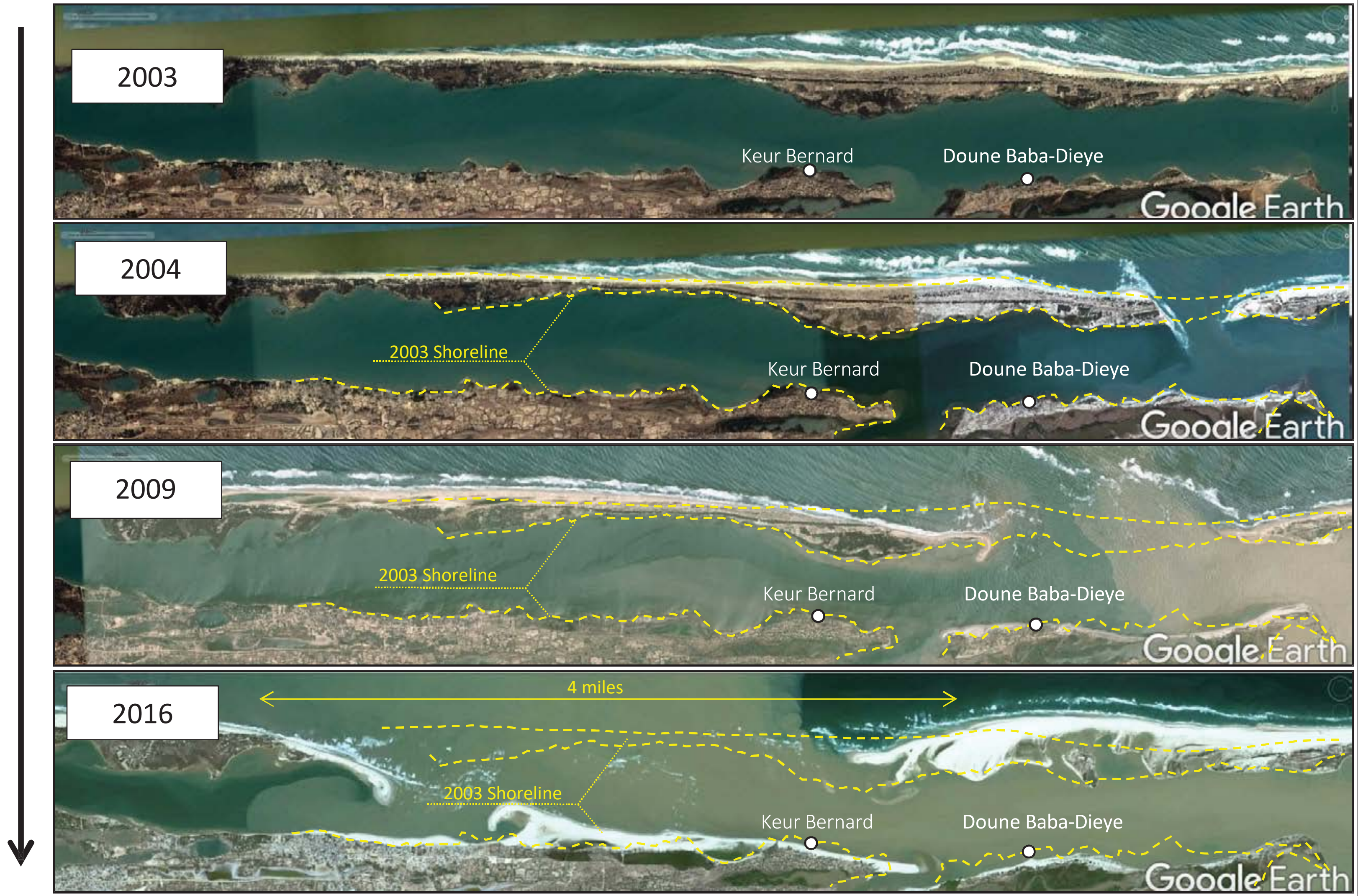


Figure 14. St Louis Senegal breach evolution (2003 – 2016)

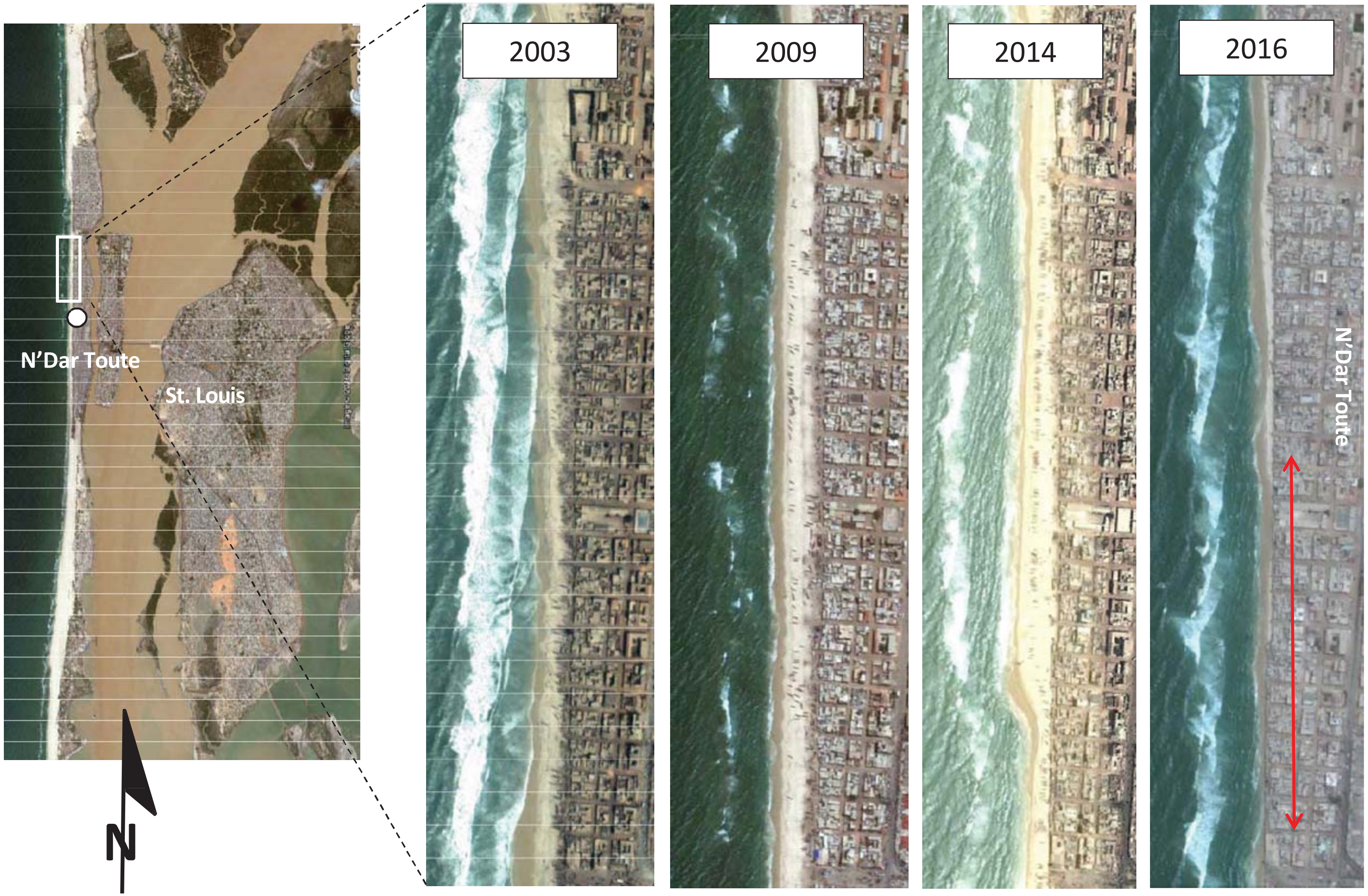


Figure 15. St Louis N'Dar Toute Senegal breach evolution (2003 – 2016)

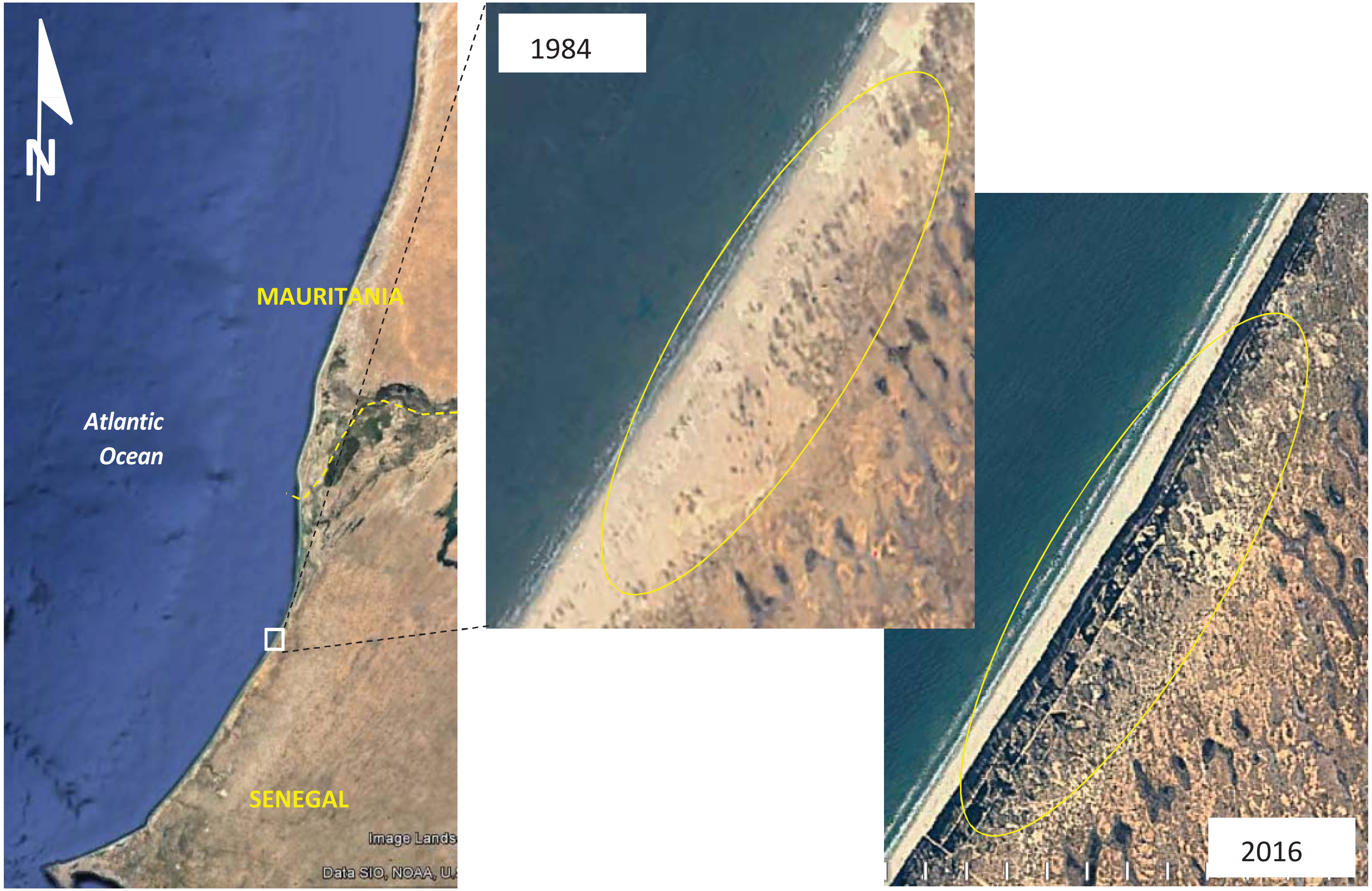


Figure 16. Typical north Senegal Coast aerial comparison (1984-2016)

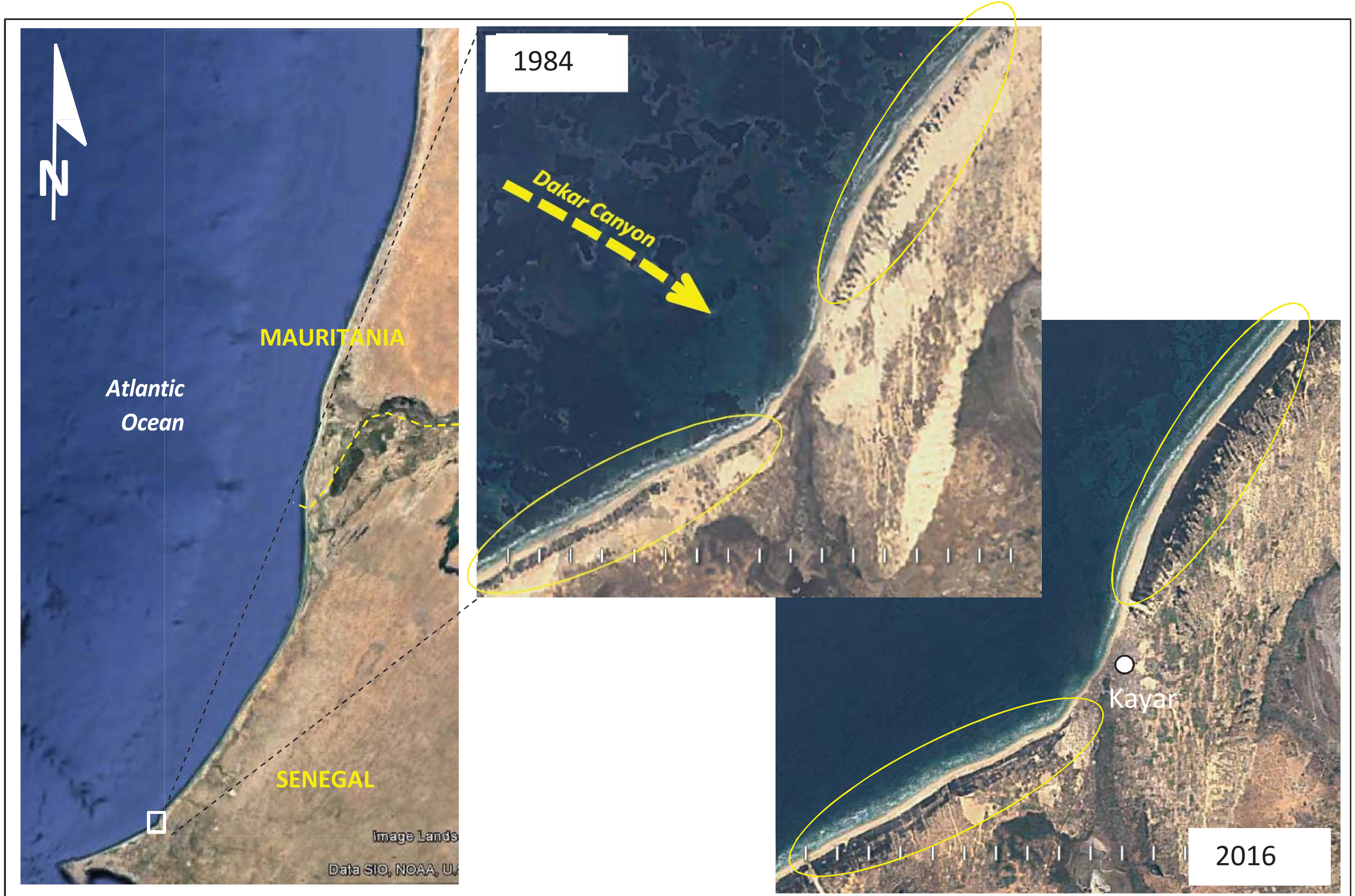


Figure 17. Satellite imagery comparison near Kayar (1984 – 2016)

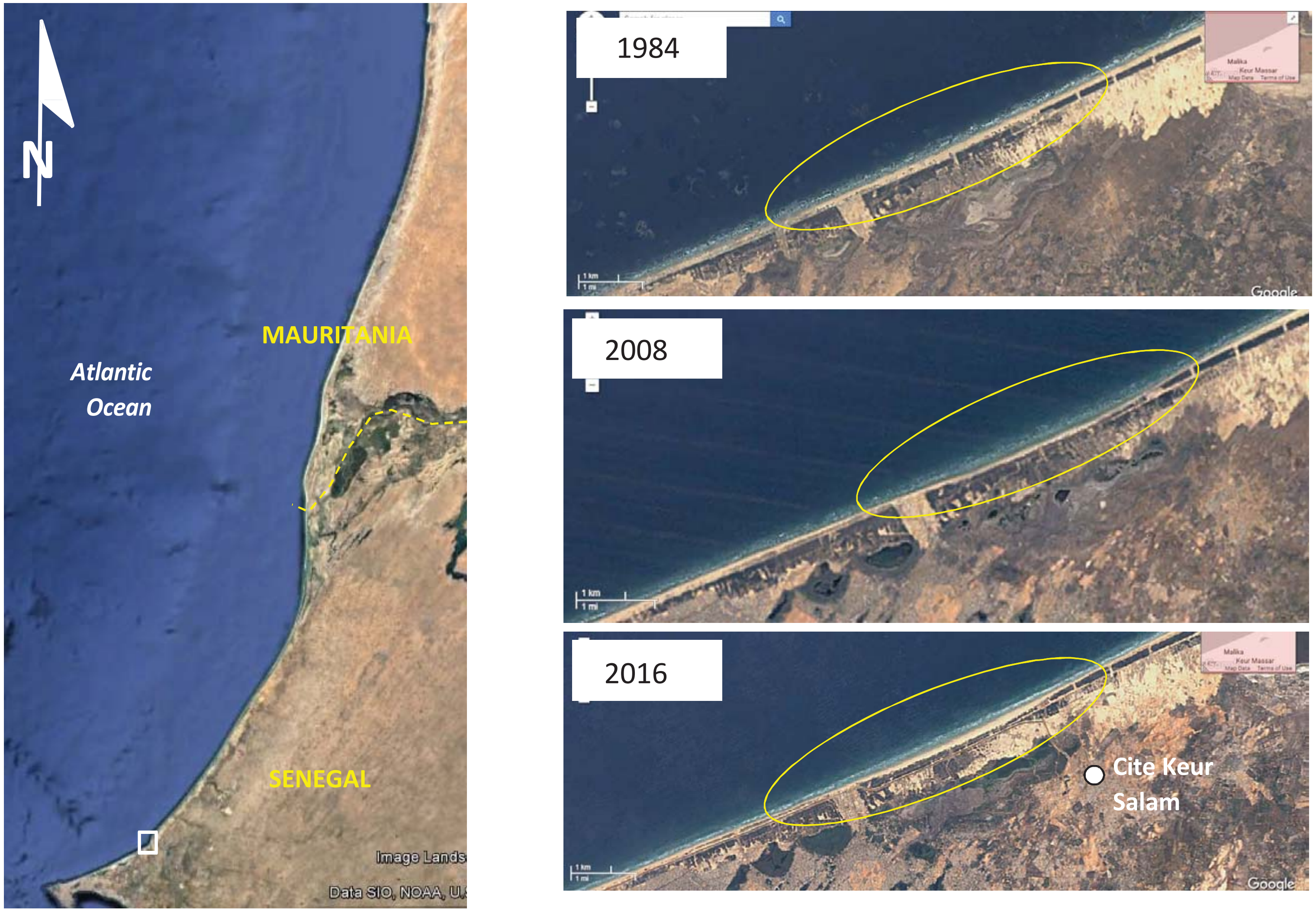


Figure 18. Satellite imagery comparison near Keur Salam (1984 – 2016)

APPENDIX A

NOAA WAVE WATCH III WAVE RECORD

WAVES EXTRACTED AT LAT:16° LONG:-17°

FROM 2006 TO 2016

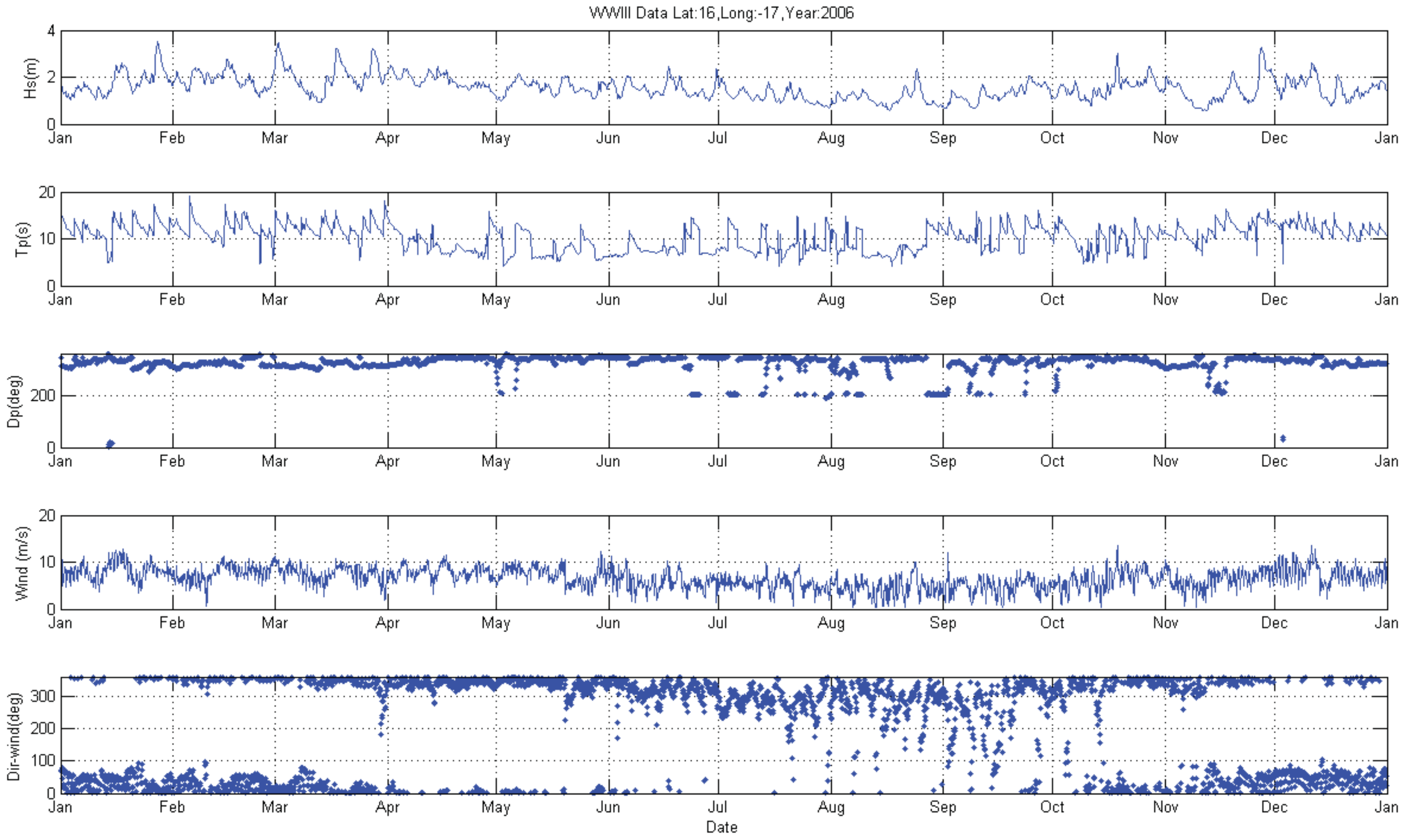


Figure A1. Wave Watch III time series 2006

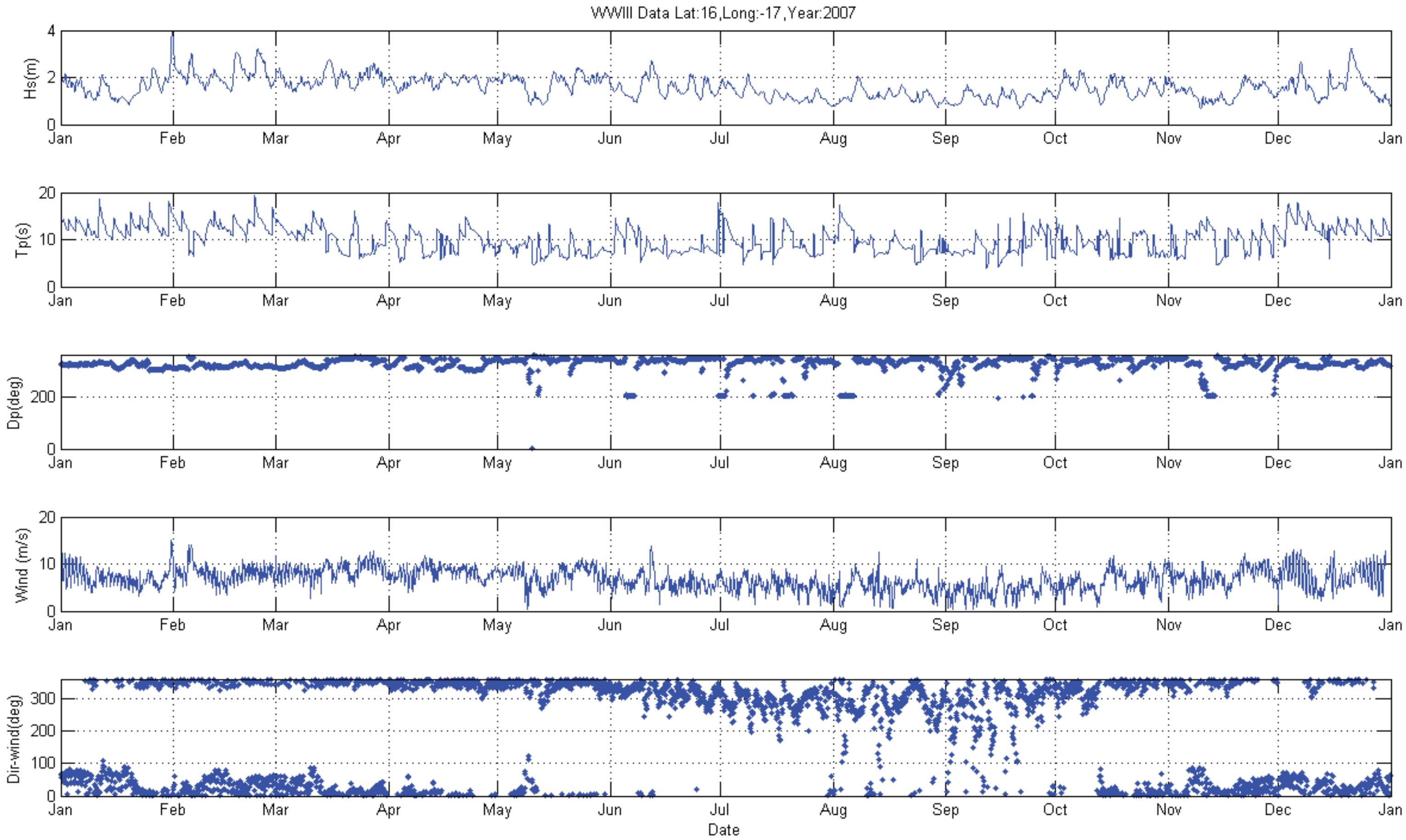


Figure A2. Wave Watch III time series 2007

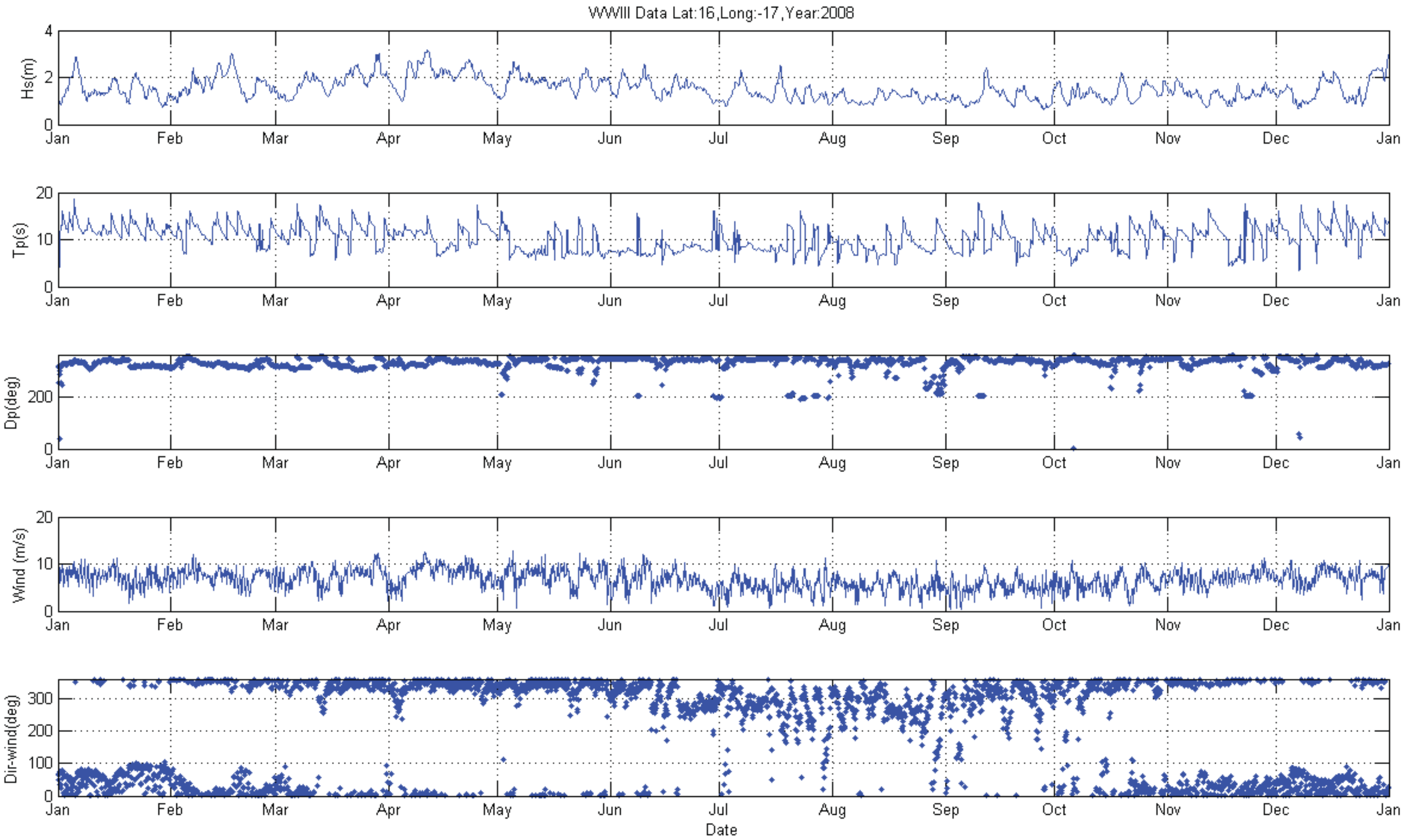


Figure A3. Wave Watch III time series 2008

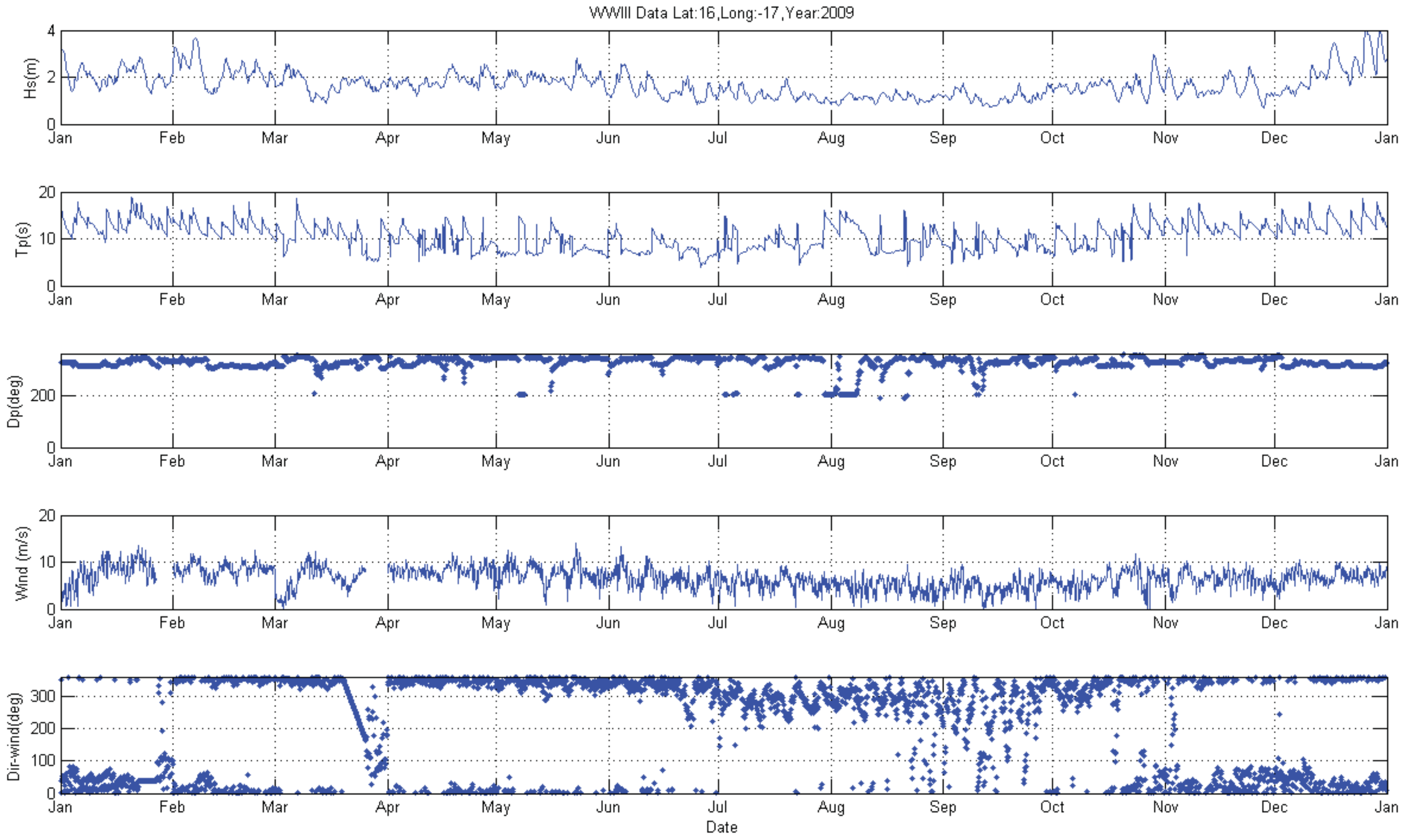


Figure A4. Wave Watch III time series 2009

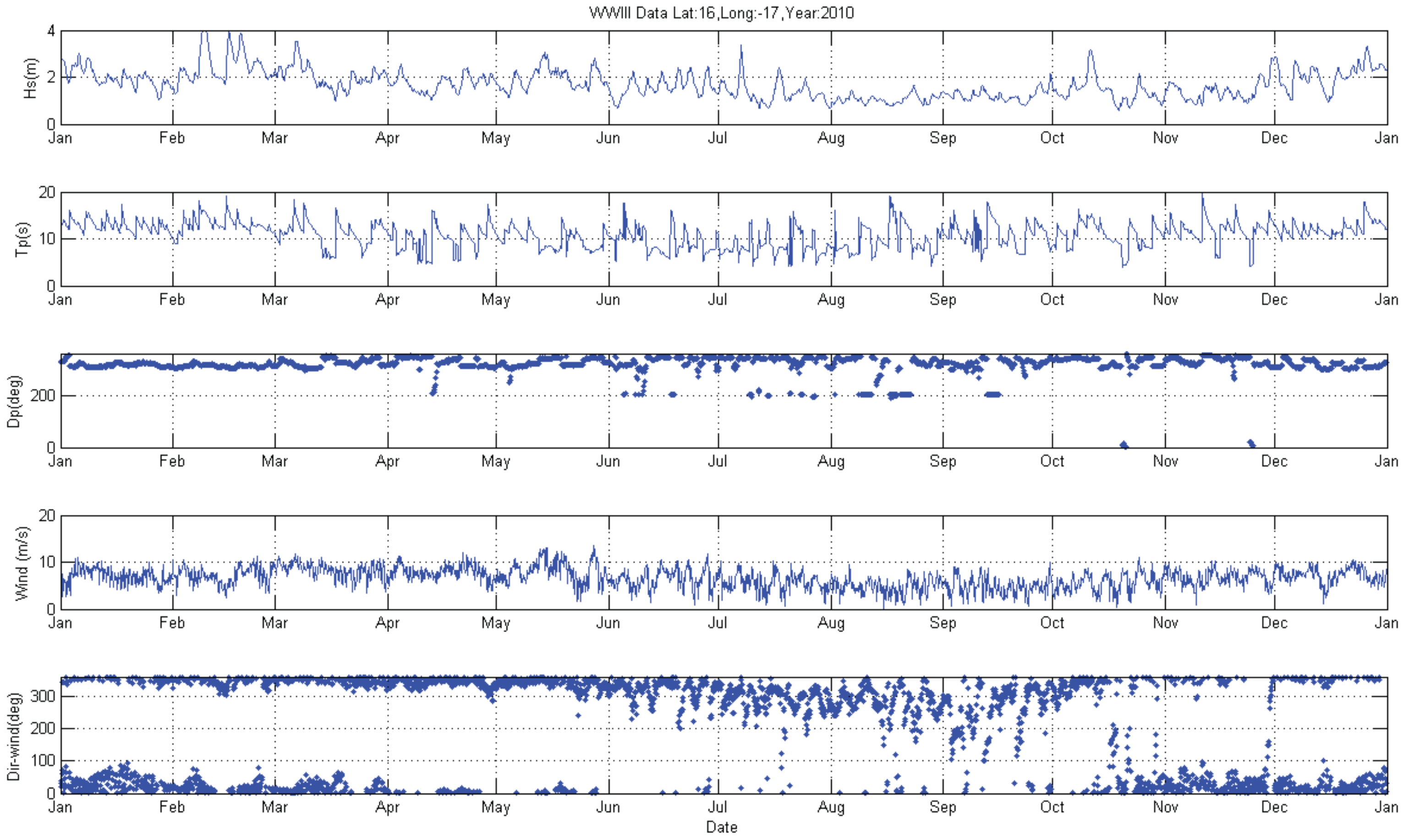


Figure A5. Wave Watch III time series 2010

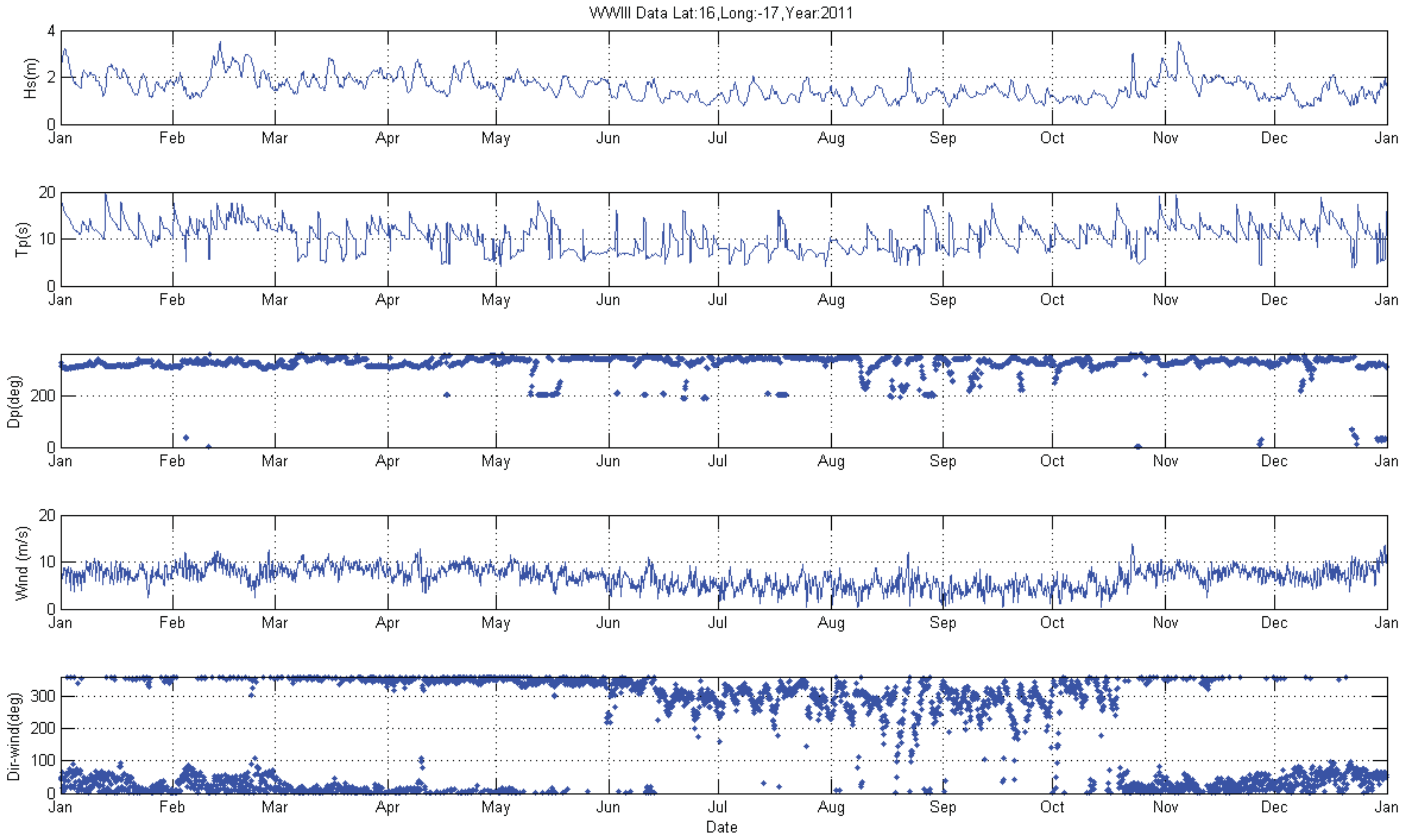


Figure A6. Wave Watch III time series 2011

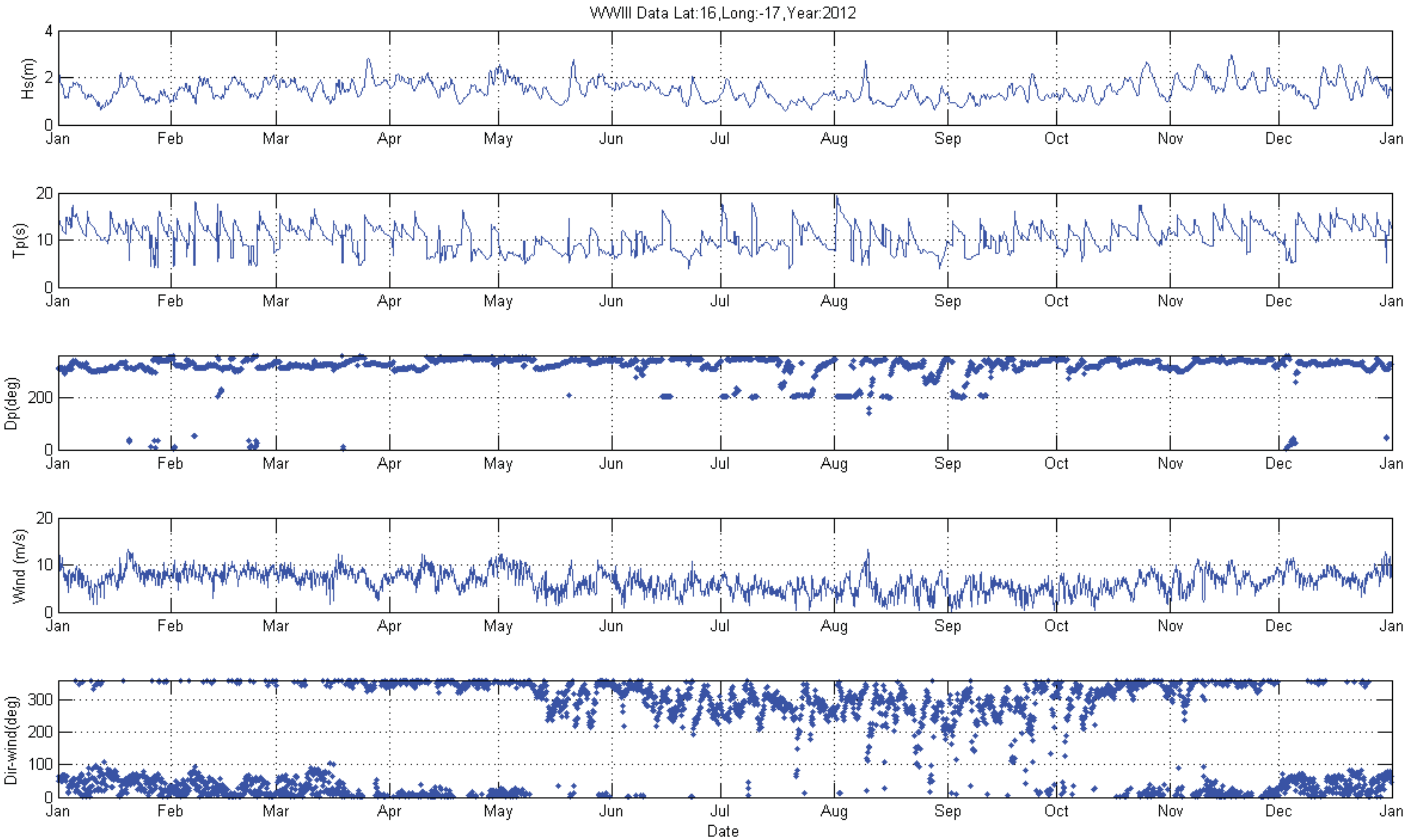


Figure A7. Wave Watch III time series 2012

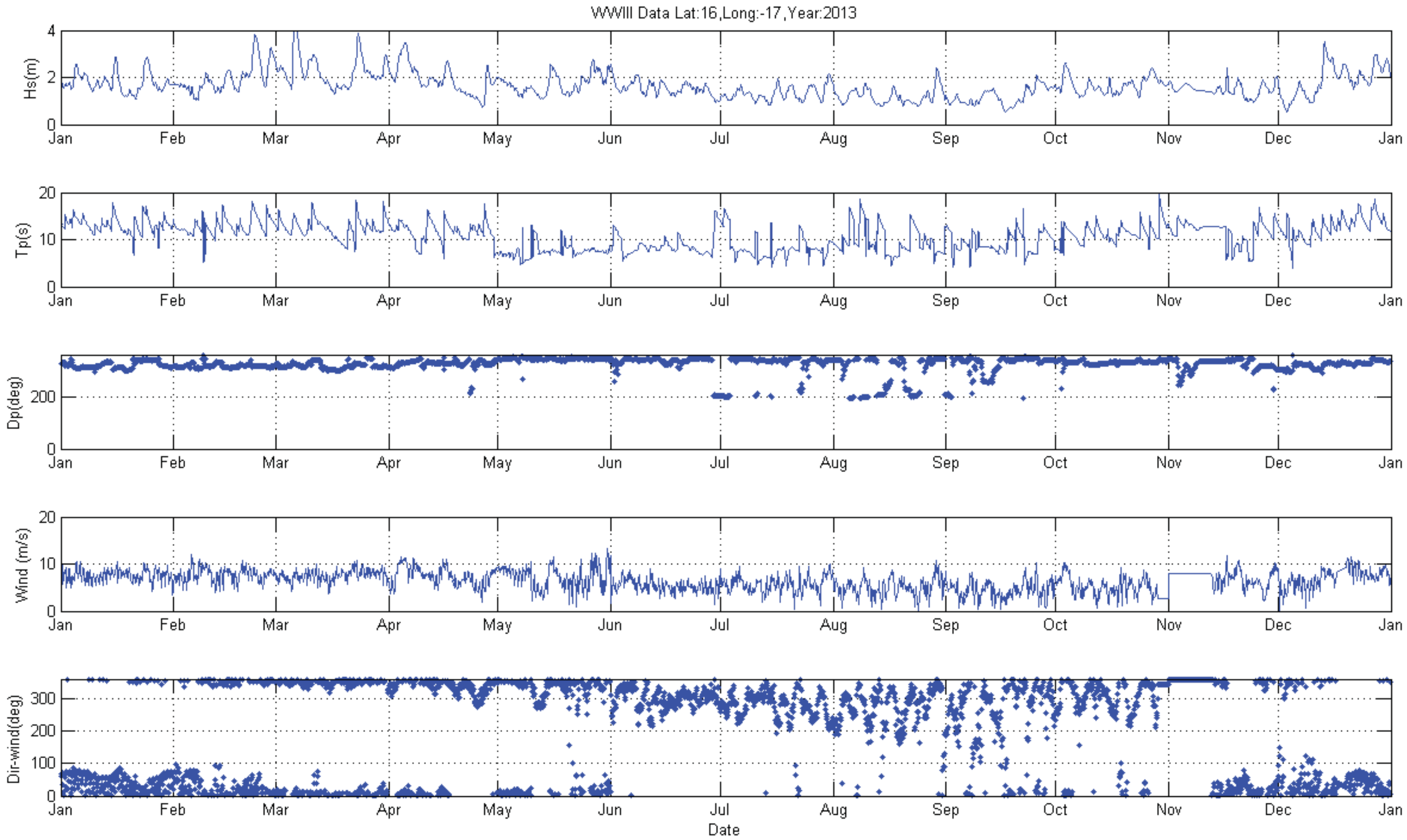


Figure A8. Wave Watch III time series 2013

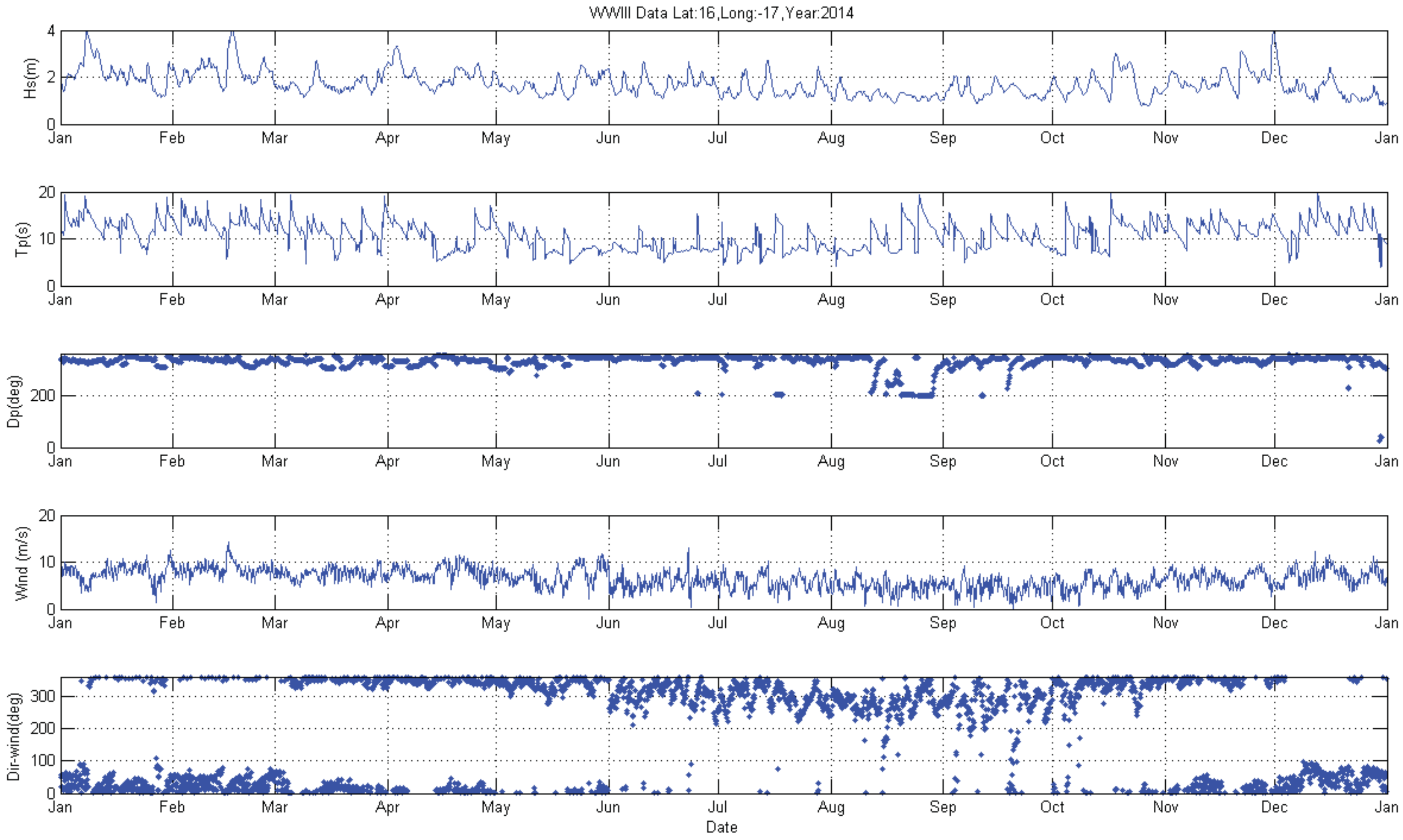


Figure A9. Wave Watch III time series 2014

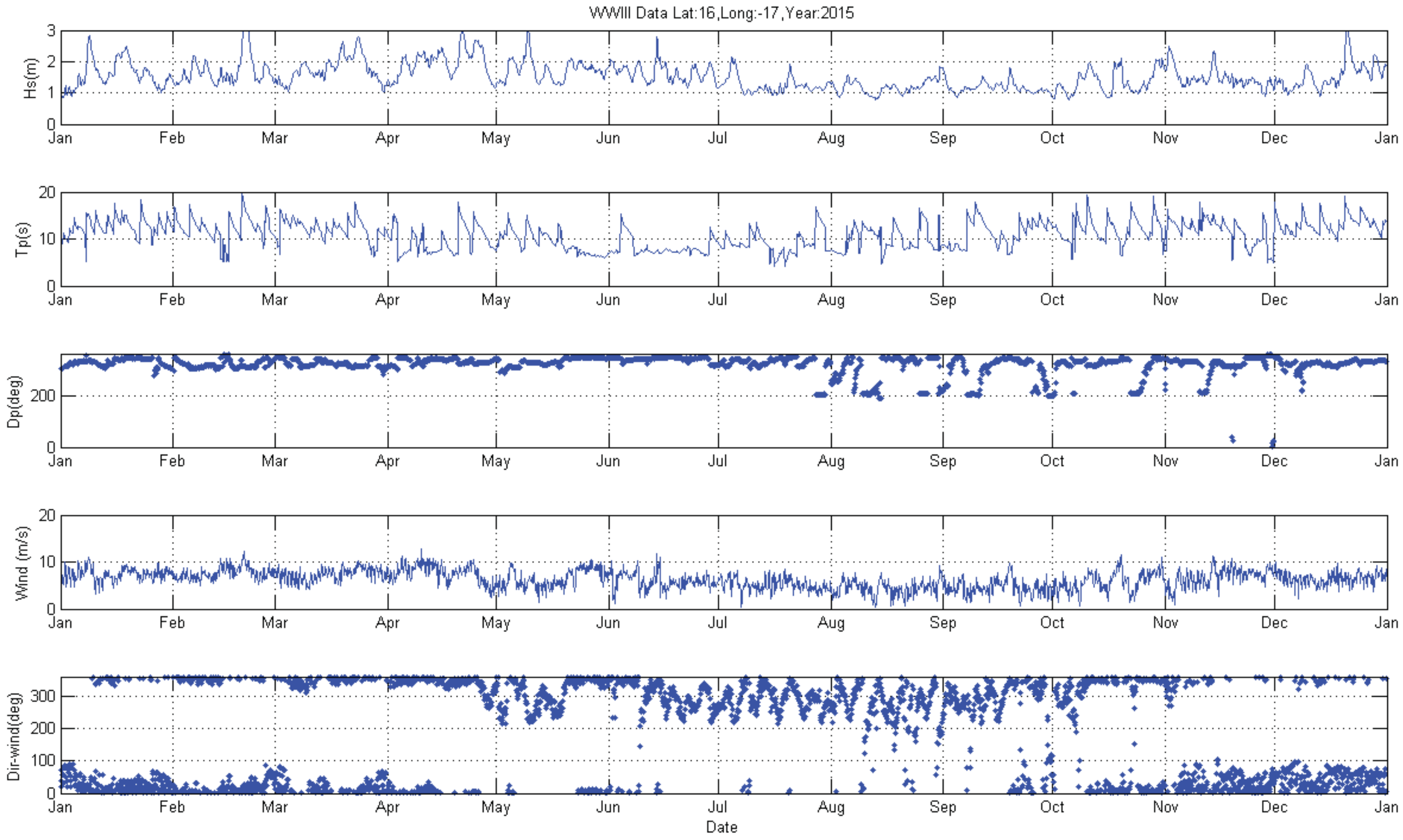


Figure A10. Wave Watch III time series 2015

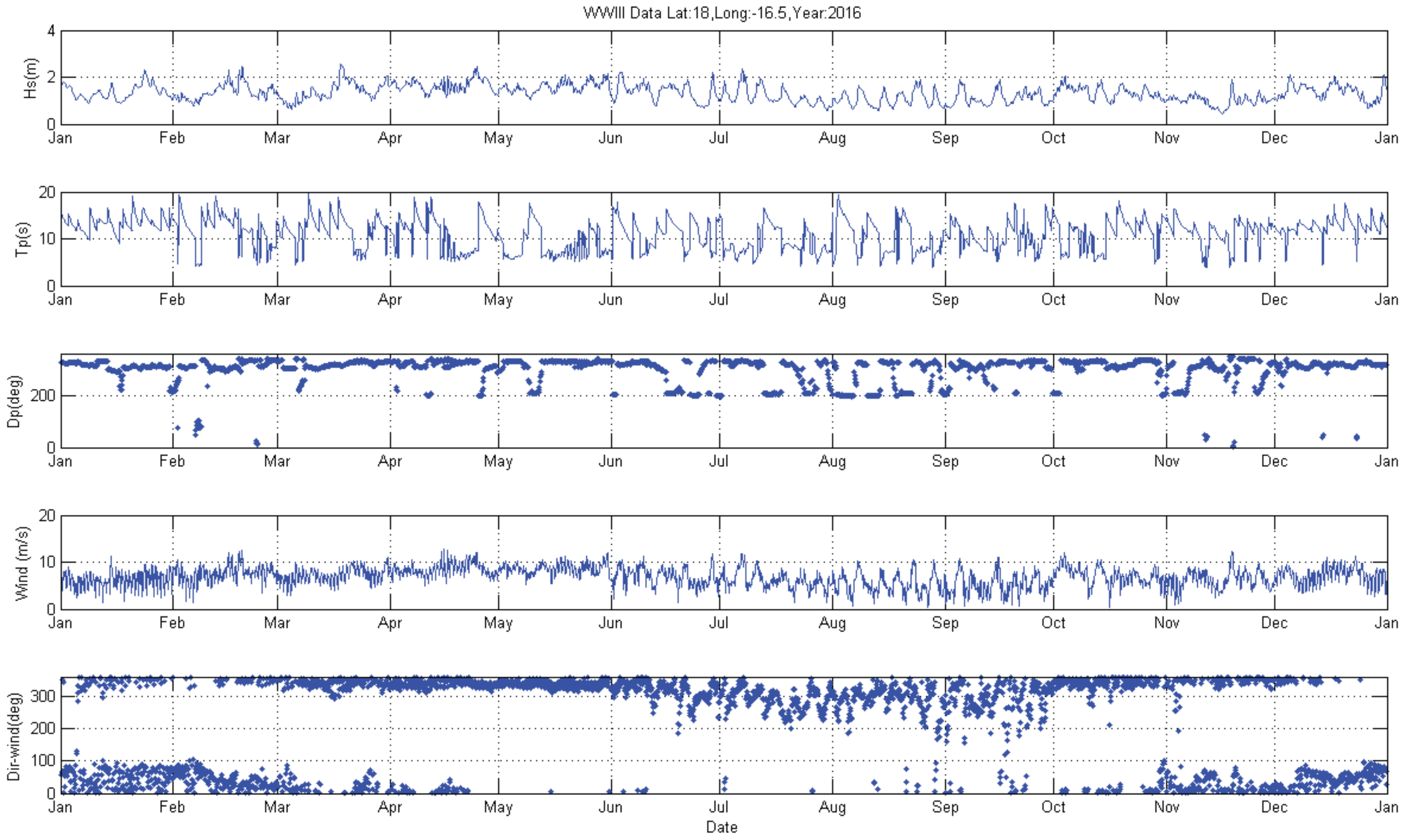


Figure A11. Wave Watch III time series 2016

APPENDIX I-2 : COASTLINE MODELING REPORT

Security Classification: General

Mauritania & Senegal Region

Tortue Phase 1

TORTUE DEVELOPMENT PROJECT

Coastline Modelling

Rev.	Reason for Issue	Date	Author	Checker	Approver	QA
						-
B02	Issued for Use	27/04/2018	K Rakha, C Stuiver & B Li	H Johnson	S Dunn	-
B01	Issued for Information	11/04/2018	K Rakha, C Stuiver & B Li	H Johnson	S Dunn	-

Refresh Cycle Code (Years):	Not Applicable

Unique Identifier:	Not Applicable	MS002-CV-STU-010-04023	Rev.
RD Type:	Not Applicable		B02

Uncontrolled when printed or stored locally

Revision History

Revision Date	Revision Number	Approver	Revision Description

* Only required for B02 revisions and beyond.

Holds

Hold Ref.	Description / Reason for Hold	Ref. Section
HOLD 1	No Holds	

Reviewers

Name	Role	Type of Review	Date Reviewed

Reference Documents

Ref.	Document Number	Document Name
1		

Abbreviations

A	Parameter used in Dean equilibrium profile
ArcGIS	Geographic Information System Software
BP	BP Group of Companies
BW	Breakwater
C_{dis}	Coefficient 1 for white capping dissipation
CE90	90% confidence interval of the positional accuracy
CMAP	Digital Maps
D_{50}	Mean Grain Size
d_c	Height of beach profile
DHI	DHI Water and Environment Institute
DSAS	Digital Shoreline Analysis System
DWD	Dominant Wave Direction
δ_{dis}	Coefficient 2 for white capping dissipation
FEED	Front End Engineering Design
FLNG	Floating Liquefied Natural Gas
FM	Flexible Mesh
FPSO	Floating Production, Storage and Offloading
h	Water depth from MLWS
H_{m0}	Zero moment (spectral significant) wave height
H_{rms}	Root Mean Square wave height
KBR	KBR Group of Companies
Kn	Roughness Height
LITDRIFT	Littoral Drift
LITLINE	Coastline Evolution
LNG	Liquefied Natural Gas
MIKE	Software by DHI
MLWS	Mean Low Water Spring
MMscfd	Million standard cubic feet per day
MSL	Mean Sea Level
MTPA	Million Tonnes Per Annum
MWD	Mean wave Direction
N	North
NNW	North-North West
OWI	OceanWeather Inc.
PWD	Peak Wave Direction
Qs	Sediment Transport Rate
S	South
S_g	Spreading coefficient for sediment size
SLR	Sea Level Rise
SW	Spectral Wave
SWAN	Spectral Wave model developed by Delft University of Technology

T_p	Peak wave period
W	West
x	Alongshore direction
x_o	Offshore distance
y	Distance of shoreline from baseline
2D	Two Dimensional

Table of Contents

APPENDICES

TABLES

FIGURES

1.0 EXECUTIVE SUMMARY

The proposed Tortue hub, on the Mauritania and Senegal maritime border, comprises a breakwater to protect marine operations, including Liquefied Natural Gas (LNG) processing and carrier loading. The proposed breakwater is located in an area exposed to significant natural coastal erosion.

A simplified calculation based on two representative waves, showed that the proposed locations for the breakwater may have varying impact on the existing coastal dynamics depending on the selected location and size of the breakwaters. The simplified calculation was used to estimate the rate of coastline change, based on longshore sediment transport calculated for the initial coastline. Next, a more accurate model, using all wave combinations in the average annual wave climate and detailed longshore sediment transport and coastline model was used.

This report provides a summary of the coastline evolution modelling performed to select the breakwater location taking into account the coastline dynamics. Several locations for the breakwater are studied by simulating 10 years of coastline evolution. These simulations are compared to a simulation for 10 years without any breakwater (do nothing) to quantify the impact of the breakwater on existing coastline changes.

The main input data to the coastline evolution model is the wave climate, the initial coastline, the beach profile and sediment properties. Offshore wave data covering a period of 38 years (obtained from OceanWeather Inc. (OWI)) was analysed to generate an offshore yearly average wave climate (maintaining monthly frequencies). The offshore yearly average wave climate was transformed to the 10 m depth contour using a 2D Spectral Wave model developed by DHI Water and Environment (MIKE 21 SW). The nearshore wave data was extracted every 30 m along a coastline stretch of about 40 km to resolve the change in wave climate induced by the proposed breakwater.

In the absence of information on sediment properties over the full active zone, beach sediment data from previous studies at the project site was used. This data is expected to be reasonable since more than one source was used. Also due to the absence of recent nearshore bathymetric data, an equilibrium beach profile shape was assumed for the active zone (from -5 m to the coast). Although no previous studies were available to confirm that the equilibrium beach profile is valid for the Tortue project site, the equilibrium beach profile concept has been shown to be a good approximation for long-term averaged beach profiles (averaged over many years) at many sites. Hence, it is a good concept to use in long term coastline evolution modelling.

The Littoral Drift (LITDRIFT) model was calibrated based on published data and data derived from the historic coastline changes (for the net sediment transport rates). The historic coastline changes were obtained by digitizing Satellite images for different dates. Some sensitivity analysis to different LITDRIFT model parameters and input data was conducted to quantify some uncertainties.

Three different breakwater locations were simulated using a Coastline Evolution (LITLINE) model together with a modified breakwater layout at the Location B. For each of these locations, the MIKE21 SW model is used to transform the offshore wave climate to the 10 m contour and the LITLINE model is then used to predict the coastline changes over 10 years.

The breakwater causes a reduction of the wave heights along part of the study area and a modification to the wave directions. This causes a reduction in the sediment transport rates along the section sheltered by the breakwater, inducing coastline changes.

For all the breakwaters simulated, a salient formed in the shadow zone and some downdrift erosion (south of the shadow zone). The model results showed that for location D (at a depth of about 33 m), part of the coastline currently experiencing erosion will start to accrete. This accretion will provide a positive impact to the houses along that section. Further south, the model results predict that erosion relative to the case without any breakwater will occur. The maximum value for this erosion is be about 15 m over 10 years. This value is lower than the natural erosion rates at some sections along the study area and is located along a stretch that does not include any infrastructure along the coast. Furthermore, this increased coastal erosion is predicted to occur only close to the tip of the spit (i.e. south of St. Louis).

As the breakwater is moved further inshore, the model results predict that the impact increases and the maximum erosion relative to the case without any breakwater reaches 71 m for Location B (at a depth of about 18 m). The erosion also increases if the breakwater length at Location B is extended due to the wider shadow zone.

Finally, some sensitivity analysis was included to assess the impact of uncertainties in the model setup, model parameters and input data on the predicted longshore sediment transport rates, and hence coastline changes. This analysis showed that the modelled impact of the breakwaters will be reduced for larger grain sizes. The ranking of the different breakwater locations alternatives however will not change.

The first revision of this report was reviewed by HR Wallingford. These comments were incorporated in this revision.

2.0 INTRODUCTION

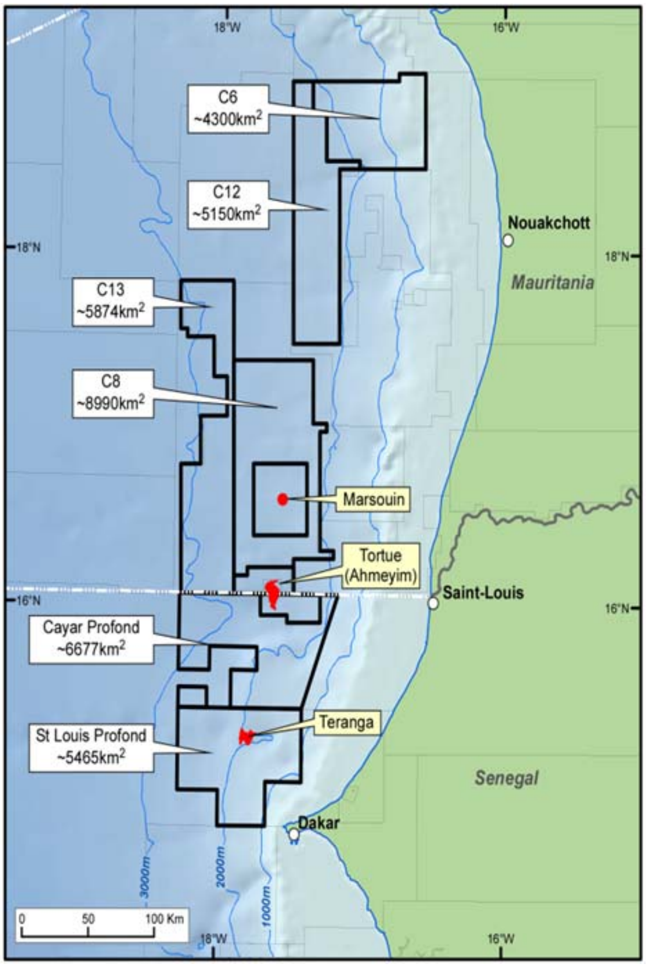
BP has requested KBR to perform pre-Front End Engineering Design (pre-FEED) and project support activities for the major elements of the Tortue project to support definition of the concept. This initial phase comprises a subsea production system tied back to a pre-treatment Floating Production, Storage and Offloading (FPSO) unit, which subsequently transfers gas to a near-shore hub for LNG production and export.

2.1 Background

Development of the field is expected to be performed in two phases. Phase 1A targets first gas production during 2021 from 5 wells across a number of drill centres, and will be incrementally developed with additional wells and drill centres. Phase 1A will provide ~480 MMscfd of sales gas production, generate ~2.5 MTPA of LNG and deliver a domestic supply of 35 MMscfd each to Mauritania and Senegal.

The Phase 1A FPSO, which is located in 100-130 m of water, will process up to 505 MMscfd of inlet gas from the subsea wells by separating condensate from the gas stream and exporting conditioned gas to a hub, where LNG processing and export will occur. The Hub, which is located in shallow water (18 m water depth) on the Mauritania and Senegal maritime border, comprises a breakwater to protect marine operations, including LNG processing and carrier loading. A single Floating LNG (FLNG) vessel will condition the gas for LNG export. Domestic gas pipeline connections will be available on the trestle riser platform. A map showing the field location is provided in Figure 2.1.

Figure 2.1 – Tortue Field Location Map



Approximately two years after first gas, the Central Tortue expansion will add additional wells and drill centres, which tie-back through a separate flowline system to a second gas processing facility, nominally located adjacent to the Phase 1A FPSO. Gas exported from the new facility will tie in to the flowline between the FPSO and the Hub. Liquids from the second facility will be routed to the FPSO for further processing. Additional FLNG processing capacity will be provided at the Hub to accommodate the Central Tortue production, at processing rates to be confirmed by BP as part of the Concept Development for Central Tortue. For the purposes of Phase 1A pre FEED, a nominal ~1275 MMscfd wet gas production from the Central Tortue expansion wells is assumed.

2.2 Purpose

This report provides a summary of the detailed coastline modelling performed to predict the impact of the breakwater on the coastline. Several locations for the breakwater are studied to assist in the decision on the preferred location.

3.0 METHODOLOGY AND DATA

3.1 Methodology

3.1.1 Simple Approach

Initially a simple approach was used to identify if the proposed breakwaters may have a negative impact on the coastline. This simple approach was based on two representative wave conditions and a bulk sediment transport formula. The one-line concept was used to estimate the initial rate of coastline changes for the cases with and without the proposed breakwater. This simple method was used for high-level screening of the breakwater locations and was deemed insufficient due to the environmental sensitivity of the results. Thus, it has been superseded by the more detailed study presented herein and is not described in this report.

3.1.2 Detailed Approach

A coastline evolution model is used to determine the potential impact of the proposed breakwater on the coastline. Figure 3.1 provides a flow chart for the methodology used in this study where three models are used:

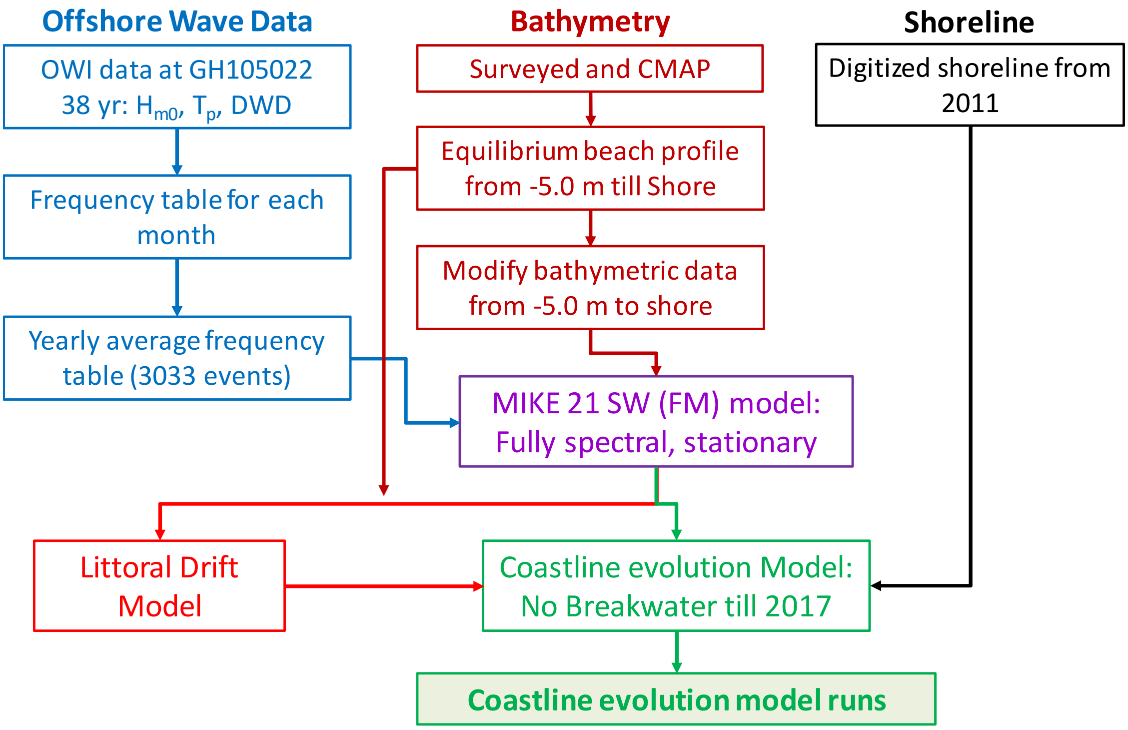
- MIKE 21 Spectral Wave (SW) Flexible Mesh (FM); and
- MIKE 21 Littoral Processes FM:
  - Littoral Drift
  - Coastline Evolution

The MIKE 21 SW model is used to provide the wave climate at the offshore limit of the beach profiles. This offshore limit is taken as the 10 m depth contour which will be inshore of the breakwaters for all the simulated locations. Although it would be possible to include the offshore breakwaters as structures in the coastline evolution model. Such an approach would be based on a simple wave model for the wave climate in the shadow area behind the breakwater. Thus, a more accurate Two-Dimensional (2D) model (MIKE 21 SW) is used to simulate the wave climate behind the proposed breakwater. The output of the 2D model is then used as input to the coastline evolution model. The offshore boundary used in the MIKE 21 SW model, is based on monthly frequency tables as discussed later.

The LITDRIFT model is used for sediment budget calculations where the sediment transport model is calibrated. The calibration is based on predicting the net sediment transport rates reported in previous studies and estimated from historical coastline changes. The main calibration factor is bed friction (specified as roughness height). The LITDRIFT model is also used to determine the suitable spacing required to resolve the sediment transport distribution over the beach profile.

Finally, the LITLINE model is used to simulate the coastline changes over 10 years for the case without any breakwater (existing) and for the different breakwater locations and layouts. The main input to the LITLINE model is initial coastline, the wave climate and sediment transport tables. The initial shoreline is taken as the shoreline predicted from LITLINE for a warm up period of six years. This warm-up simulation uses the 2011 coastline for the case without any breakwater resulting in a baseline 2017 shoreline. The wave climate is obtained from the MIKE 21 SW model along the 10 m contour with a spacing of 30 m. The sediment transport tables are generated using the parameters determined from the calibrated LITDRIFT model.

Figure 3.1 – Flow Chart for Methodology Used in Study



3.2 Data

The main data required for the SW model is the bathymetry and the offshore wave conditions. The wave conditions along the 10 m depth contour are extracted from the output of the SW model and used as input to the Littoral processes models as explained above. The beach profile, the coastline and the sediment properties are also required for the littoral models.

3.2.1 Bathymetric Data

The bathymetric data available at the project site included surveyed data and data extracted from digital sea charts from Digital Maps (CMAP) (Figure 3.2). The survey data had a horizontal resolution of 2 to 10 m and was acquired in 2017. The CMAP data was mainly of Grade C that has a compilation scale of 1:336,000. The area south of the project site included some Grade C data with a compilation scale of 1:60,000. All the CMAP data are based on data from 2004. All bathymetric data was converted to Mean Sea Level (MSL).

Due to the lack of bathymetric data in the nearshore (from shore to depths of 5 m), an equilibrium beach profile was assumed in that zone. The equilibrium profile is based on the Dean profile (Dean, 1977) expressed as:

$$h = Ax_o^{2/3} \qquad 3\text{-}1$$

Where h is the depth below Mean Low Water Spring (MLWS), x_o is the distance offshore from the MLWS coastline and A is a parameter for the equilibrium profile determined from the fall velocity according to (Dean, 2002). Figure 3.3 shows the equilibrium beach profile based on a mean grain size of D_{50} = 0.2 mm. A similar profile was generated for a value of D_{50} = 0.3 mm. The equilibrium profile was applied normal to the coastline throughout the model area.

The equilibrium beach profile concept has been shown to be a good approximation for long-term averaged beach profiles (averaged over many years) at many sites. Hence, it is a good concept to use in long term coastline evolution modelling. However, this concept has not been validated for this site.

Figure 3.2 – Bed Level Contours and Sources of Bathymetric Data

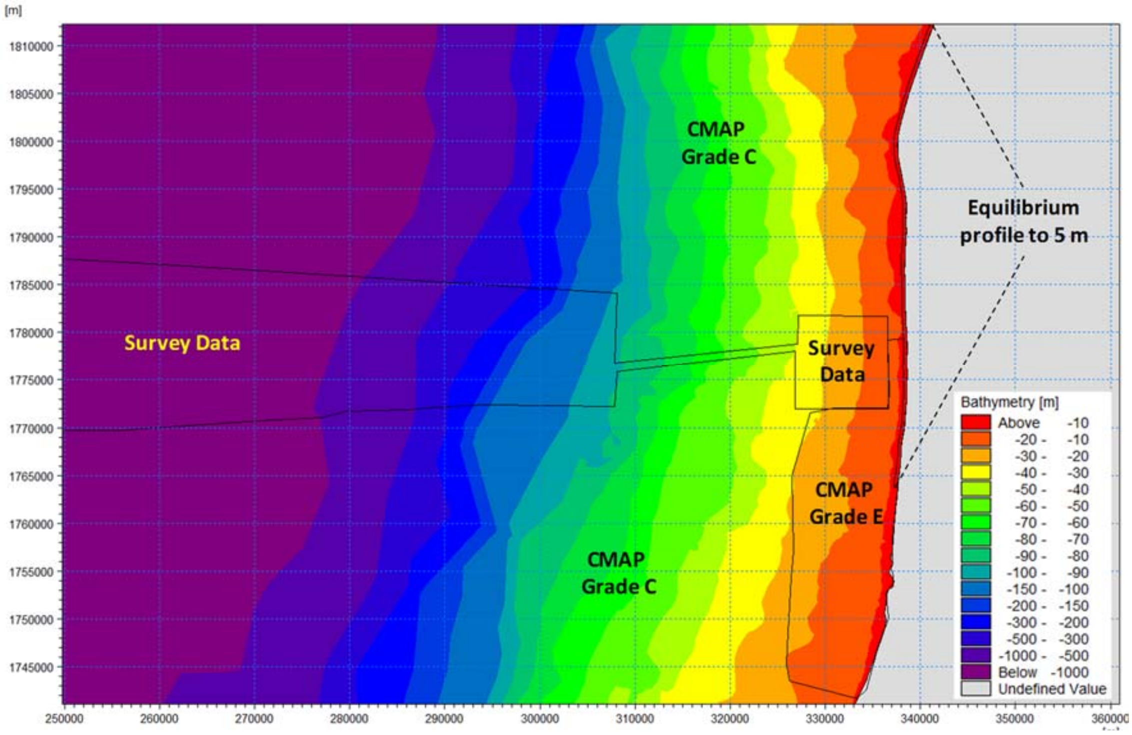
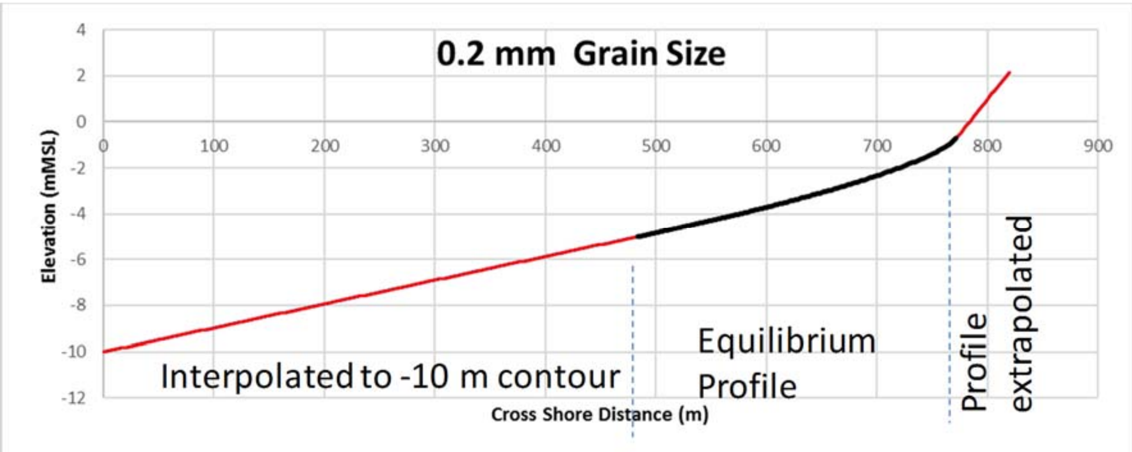


Figure 3.3 – Equilibrium Beach Profile for D_{50} = 0.2 mm



3.2.2 Offshore Waves

Offshore wave data at GH105022 (Figure 3.4) was obtained from OWI. The data covers a period of 38 years starting from Jan. 1979. Figure 3.5 provides a wave height rose plot for the 38 years of data using both the Dominant Wave Direction (DWD) and the Mean Wave Direction (MWD). This shows that the predominant direction is from North (N) for the rose plotted based on the DWD, and from North-North West (NNW) for the MWD rose. As shown in Figure 3.5, the MWD rose is significantly different from the DWD rose due to the bimodal nature of the wave spectra at the project site. In this study the DWD was used to capture the direction where most of the energy is coming from rather than using the MWD which may not represent any direction containing energy. For example, in the case with significant energy from the N and the South (S), the MWD will be from the West (W). In such a case neither of the dominant directions are captured. Whereas, using the DWD ensures that at least the dominant direction is captured.

Figure 3.4 – Location of Offshore Wave Data

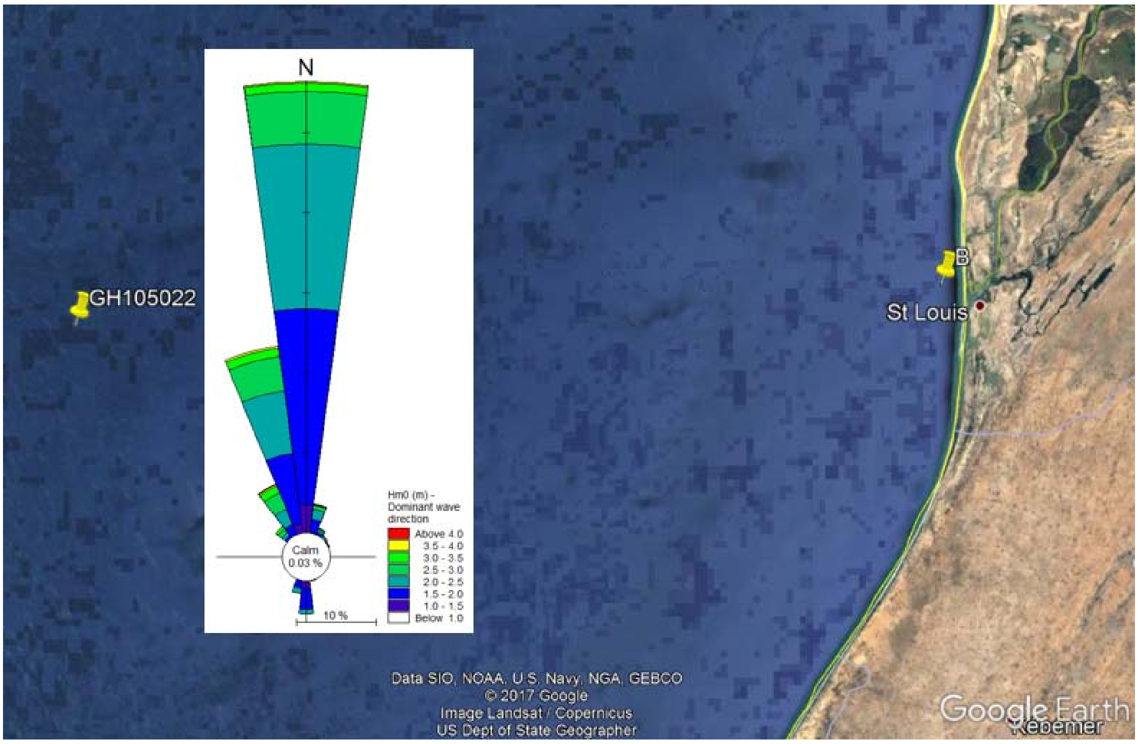


Figure 3.5 – Offshore Wave Rose Based on MWD and DWD

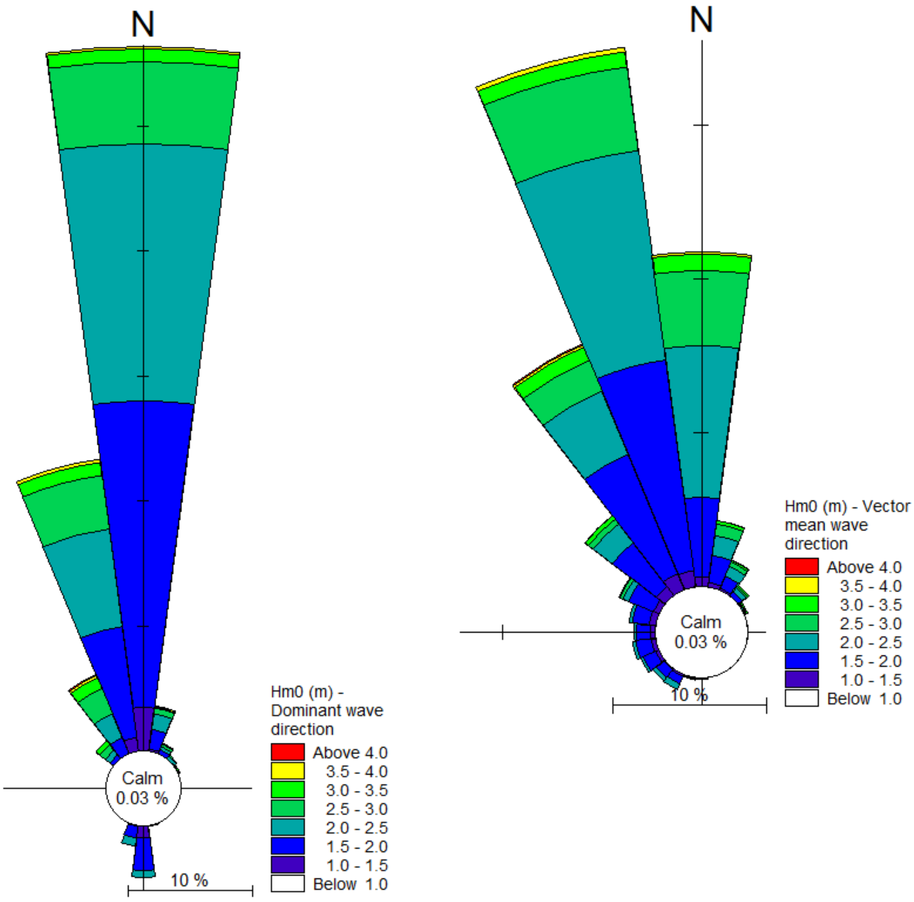
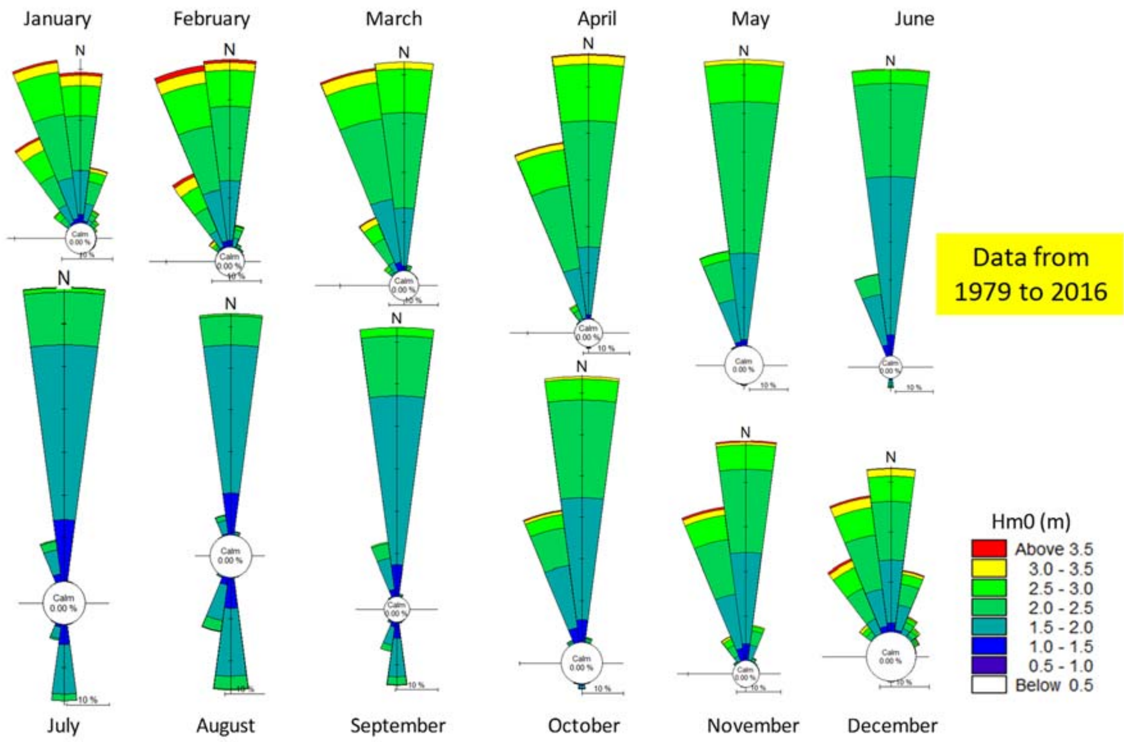


Figure 3.6 shows that the wave roses vary in different seasons of the year. To include such seasonal effects, a monthly average wave climate was generated for each month and then used to produce a yearly average climate. More details on the method used to generate the yearly average climate file are provided below.

Figure 3.6 – Offshore Wave Roses for Different Months



Our approach in this study is to determine the yearly average wave climate and repeat this climate 10 times to simulate 10 years of shoreline evolution. The steps used to generate a yearly average wave climate are as follows:

- Select suitable bin sizes and number of bins to cover the range of values in the offshore wave data (0.5 m for H_{m0}, 1 sec for T_p and 10 degree for DWD);
- Generate 12 files for the 38 years of hourly wave data with each file only including data from a specific month;
- Use the MIKE 21 scatter analysis tool to determine the valid events for each file generated in the previous step and get the frequency of occurrence for each event (3,023 events);
- Remove all the repeated events between different months (678 unique events);
- Apply these 678 events at the open boundaries of the SW model and determine the wave climate along the 10 m depth contour every 30 m for the modelled reach;
- Re-establish the 3,023 events to maintain the monthly variations in wave climate (by repeating certain events);
- Split up each event with percentage of occurrence greater than 0.8% in the year (about 72 hours in the year) into two. For example, if an event has percent of occurrence of 1.0%, this is split into two smaller events each with 0.5% annual occurrence. This process increased the number of events to 3,033; and
- Re-arrange events within a month to have a semi-random climate within the month.

This approach is appropriate for predicting coastline response due to average yearly wave climate, it does not take into consideration the year to year variability in the wave climate.

Figure 3.7 provides a plot for the resulting wave climate used in the coastline evolution simulations. For a ten year simulation, this wave climate is repeated 10 times. Figure 3.8 provides a sample for January of this yearly average climate.

Figure 3.7 – Yearly Average Wave Climate for Different Months

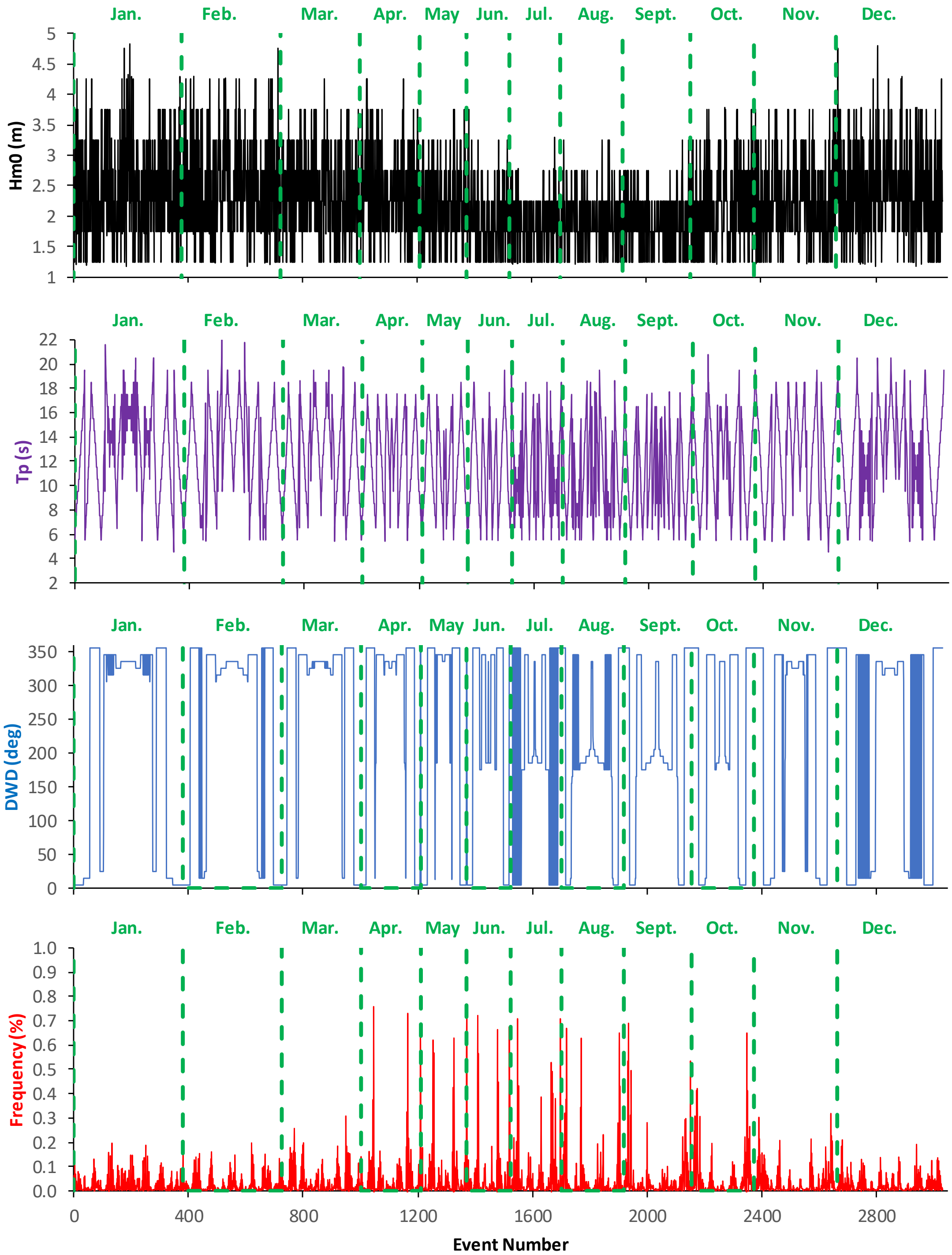
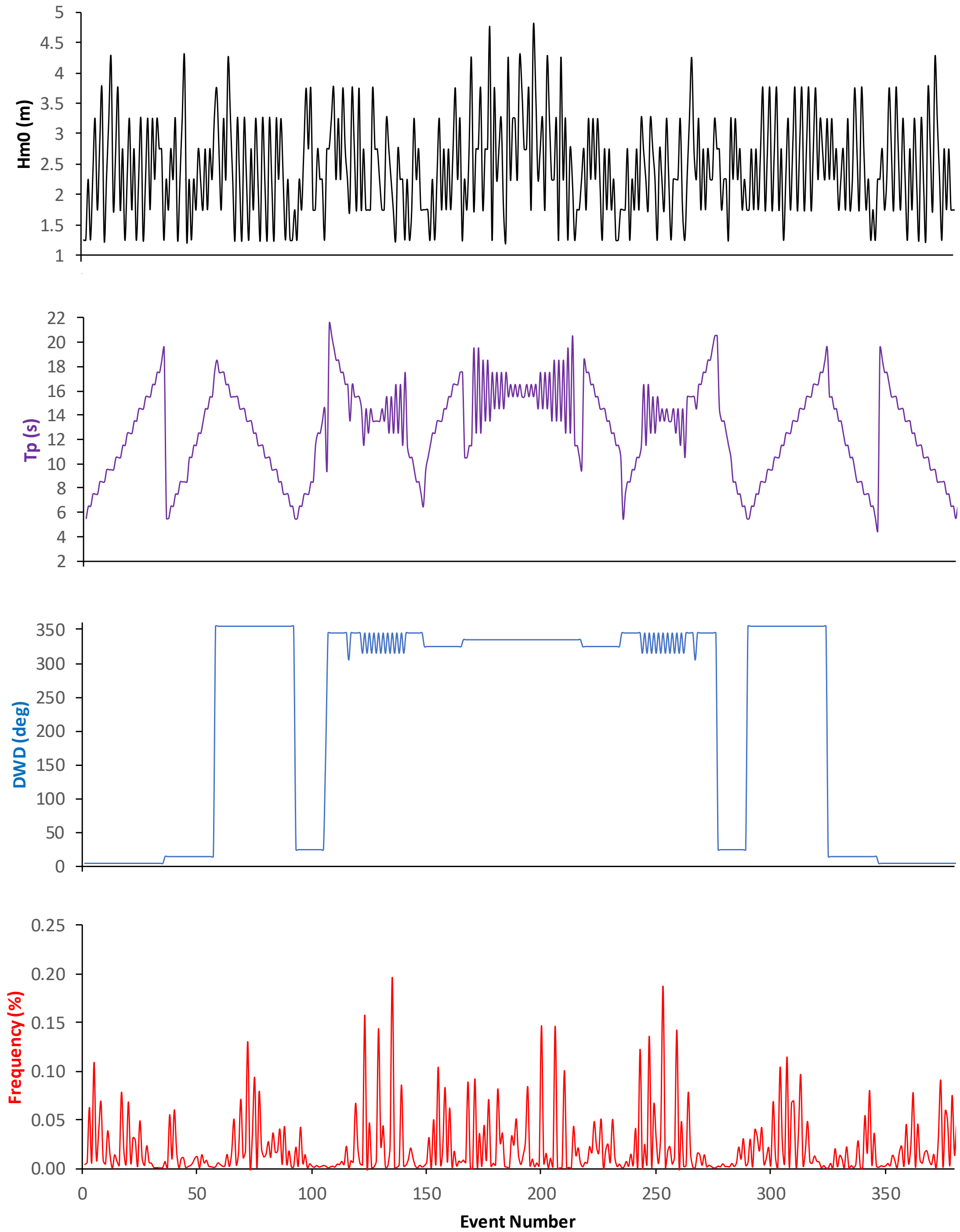


Figure 3.8 – Wave Data for January of Yearly Average Wave Climate



3.3 Sediment Properties & Sediment Transport

No field data was collected as part of this study for the sediment size along the coastline and at different depths over a beach profile. Values from previous studies were used. The study by (ARCADIS, 2011) used a Median Grain Size (D_{50}) of 0.2 mm to estimate the sediment transport rates at the location of the 2003 breach. They mentioned that this value was based on their field work. They estimated the net sediment transport rates to be 175,000 m^3/year towards the south. This value however was based on calculations that neglected the waves in the direction bin -15 ˚N to +15 ˚N. The wave rose presented in Figure 3.5 shows that most of the waves are from that direction sector and thus must be included in the calculations. They also performed sensitivity tests using a D_{50} of 0.3 mm.

In another study [AlDioma et al. 2013], the data presented showed a value for D_{50} ranging from 0.2 mm to 0.33 mm. The spreading ($Sg = \sqrt{D_{84}/D_{16}}$) ranged from about 1.2 to 1.6. Thus, for this study a conservative value for D_{50} of 0.2 mm is used with the corresponding spreading of 1.2. A sensitivity check is done with D_{50} = 0.3 mm and S_g = 1.6. (AlDioma et al. 2013) also reported that the sediment transport rates (including Aeolian transport) based on previous studies ranged from 365,000 m^3/yr to 1,500,000 m^3/yr.

In a recent study (Sadio et al. 2017), the longshore sediment transport rate induced by swell waves was estimated to be 669,000 m^3/year (from north to south). They mentioned that the swell waves contribution is about 89% of the total longshore sediment transport rates.

3.4 Satellite Images

Satellite images were provided by Digital Global for dates between 2007 and 2017. Several images were selected to maximise area covered on a single date and to ensure a good spread of dates. The coverage for each date is shown in Appendix I. Data from Airbus for 2002 and 2006 was also provided. The data is summarised in Table 3.1. CE90 is the 90% confidence interval of the positional accuracy for the image.

Table 3.1 – Summary of Satellite Imagery

Data Source	Years	Resolution (m)	CE90 (m)
Digital Global	26/01/2007	0.6	-
	13/09/2008	0.5	8.4
	06/06/2009	0.6	-
	08/03/2009	0.6	-
	25/10/2010	0.5	8.4
	21/01/2011	0.5	8.4
	05/04/2014	0.5	8.4
	10/02/2015	0.5	8.4
	01/06/2016	0.5	8.4
	22/11/2016	0.5	8.4
	11/03/2017	0.3	8.4
AirBus	October 2002	2.5	-
	December 2006	2.5	-

The coastline position, defined as the boundary from wet to dry sand, for the selected dates was digitised. It was assumed that the boundary between wet and dry sand represents the highest tide in the previous 24 hours. Variations in the high tide level can cause a shift in the recorded coastline position. These shifts can be corrected using the beach slope. There is no data available for beach slope so the extrapolated section of the equilibrium profile shown in Figure 3.3 was used, i.e. 1 in 17. Predicted tides were used to determine the high tide levels for each coastline. The range in high tide levels was 0.39 m, assuming a beach slope of 1 in 17, this equated to a range in the coastline position of 6.6 m. This is within the range of positional accuracy shown in Table 3.1, therefore no correction to the coastline position was made. The data will be used for the historical coastline analysis (Section 4.0). The coastline location on the satellite image recorded on the 11 Mar 2017 is ambiguous at a number of locations due to sand bars on the beach. After sensitivity tests a decision was made to remove the 2017 coastline from the analysis, see Appendix I for more details.

3.5 Breakwater Layout

Three breakwater locations were tested together with the case without any breakwater (Figure 3.9). These included the Breakwater at Location B, D and between B&D (B-D). The breakwater layout at the three locations is the same as that illustrated for breakwater B in Figure 3.10. An additional layout was tested at Location B with an extended breakwater (B-Ext) as shown in Figure 3.10.

Figure 3.9 – Location of Breakwater B and D Tested in Coastline Evolution Model

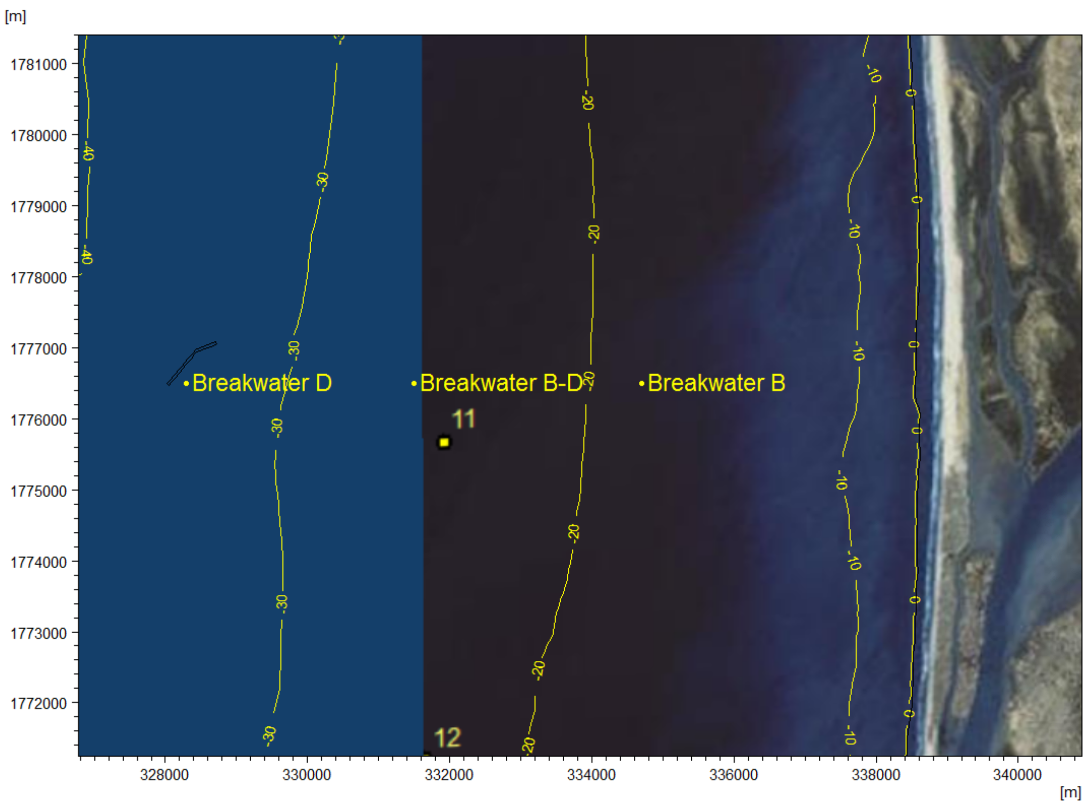
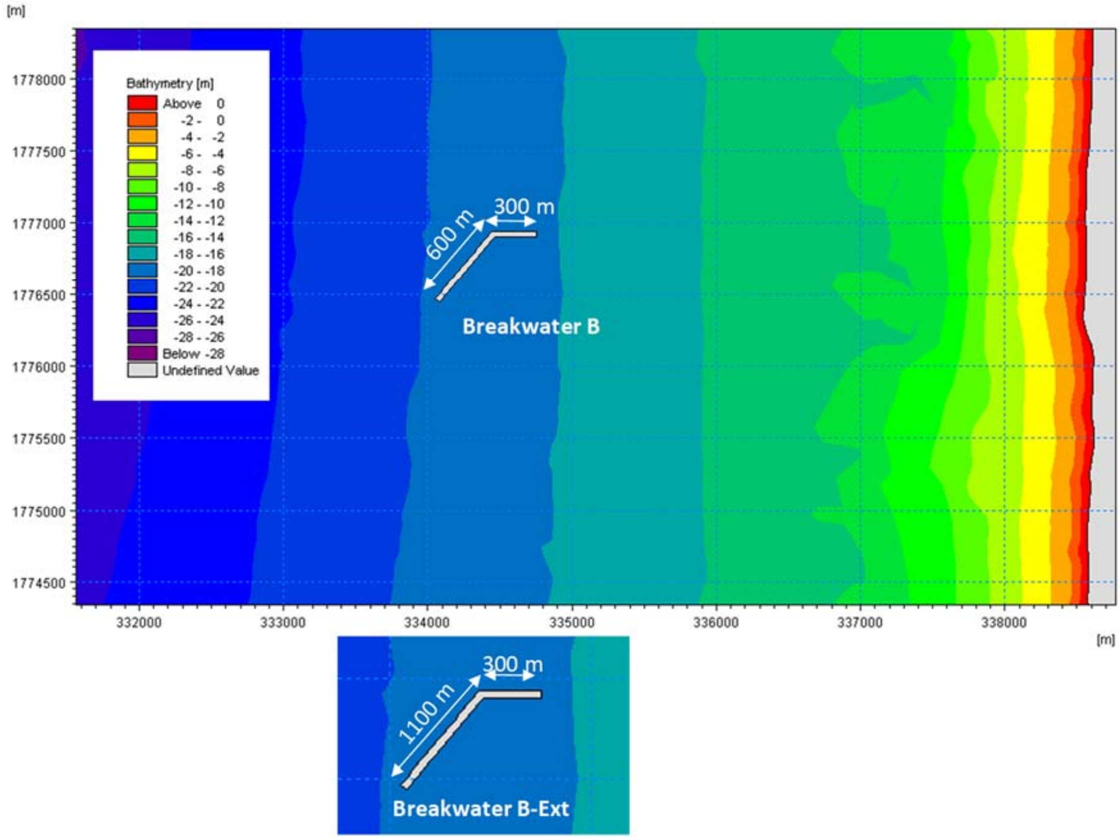


Figure 3.10 – Breakwater Layouts Tested in Coastline Evolution Model



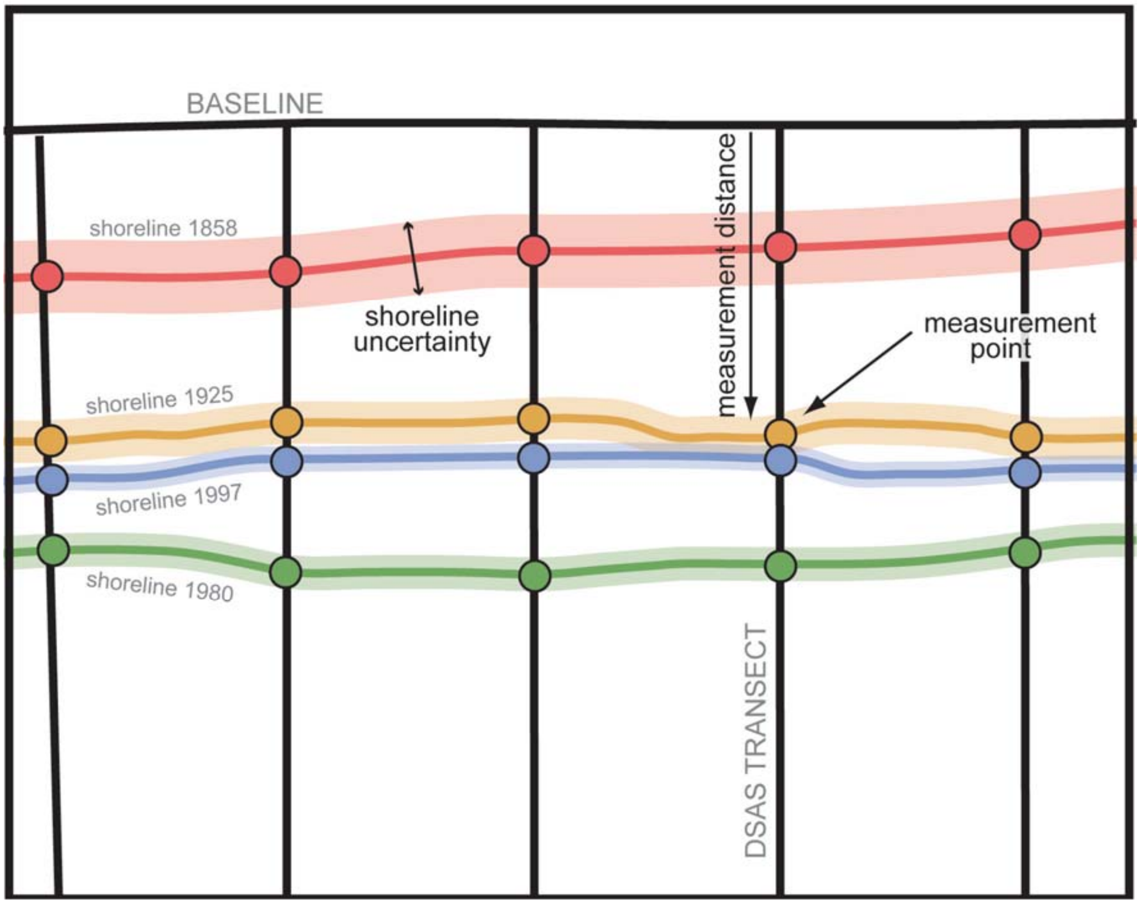
4.0 HISTORICAL COASTLINE ANALYSIS

Analysis of the historical coastline change is required to determine the baseline conditions in the area influenced by the breakwater and to provide some validation of the model. The analysis was carried out using DSASv4.4 (Digital Shoreline Analysis System) (Thieler et al. 2017) with coastline digitised from satellite imagery.

4.1 Coastline Change Calculation

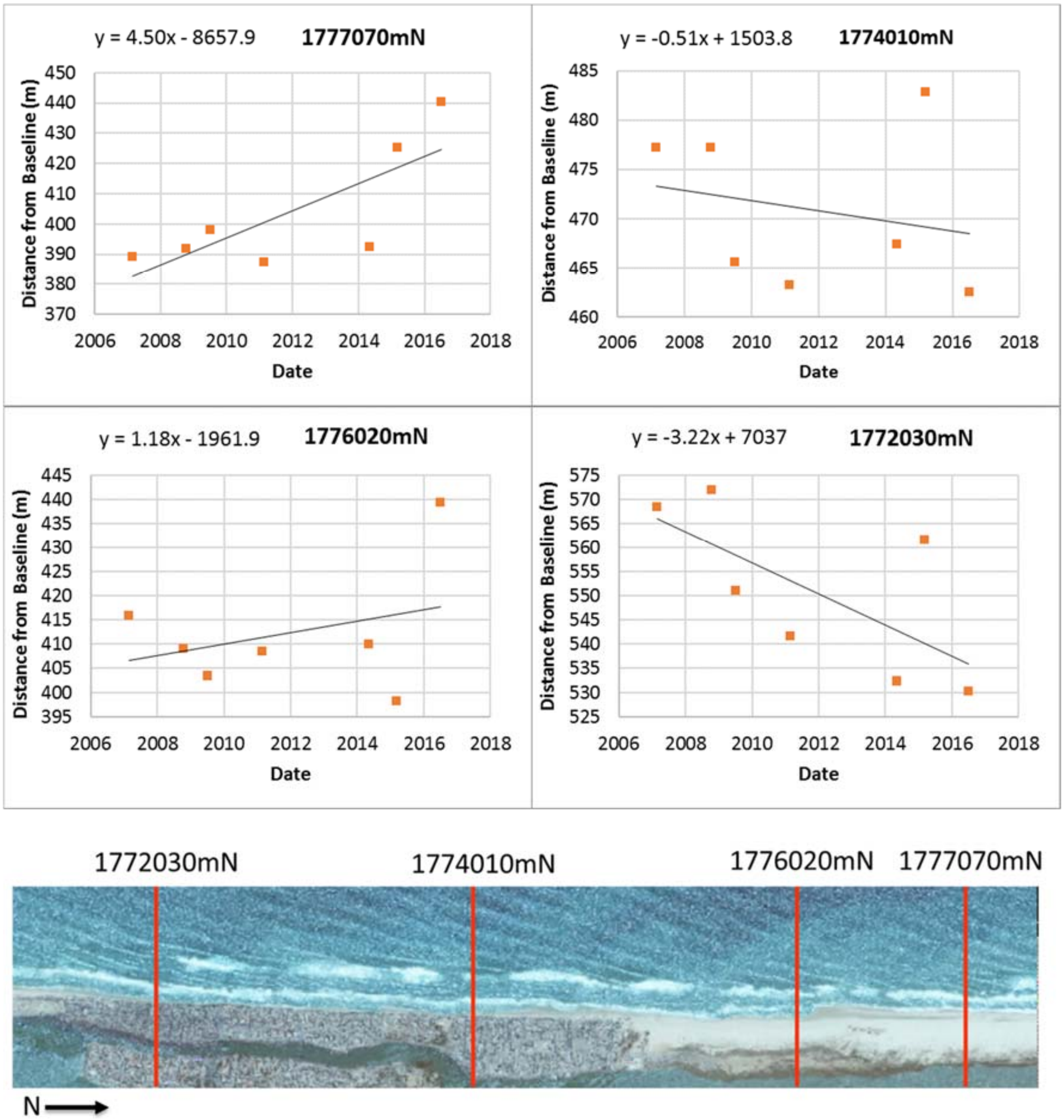
DSAS measures the distance from the baseline along a series of transects to the coastline. The measurement distance is used with the corresponding coastline date to calculate the rate of change statistics (Figure 4.1).

Figure 4.1 – Example of DSAS Setup (Source: (Thieler et al. 2017))



A base line was set up along a constant easting from 1,763,000 mN to 1,803,110 mN. The same baseline is used in the coastal evolution model (Figure 7.2). Transects were cast every 30 m along the baseline. The linear regression rate of change statistics is calculated by fitting a least-squares regression line for all coastline points from a transect. Examples of this fitting for selected location along the coastline are presented in Figure 4.2.

Figure 4.2 – Calculation of Linear Regression Rate of Change at Selected Location



4.2 Coastline Change Results

The average annual rates of coastline change are presented in Figure 4.3. The solid blue line is the least square estimate (based on data from 2007 to 2016). The dashed blue lines represent the corresponding 95% confidence level of the rates. Since the first issuing of this document additional satellite images from Airbus for 2002 and 2006 have been made available (green solid line includes Airbus data). The confidence limits in the areas around the project site, from around 1,768,000 mN to 1,785,000 mN, are narrower than in the area to the north. This is due to the number of coastlines available for the analysis. The high rates of accretion, up to 45 m/year, seen in the southern limit of the analysis is related to spit growth (Figure 4.4 where the red line is 2016 shoreline while green line is 2007 shoreline). The green line on Figure 4.3 and Figure 4.5 represent the updated linear regression rates calculated with the additional shorelines. The variations in calculated recession rates are large in some areas in the north where previously limited data was available, however in the area of interest the additional data did not have a significant impact on the calculated recession rates.

Coastline change rates in the area of interest are presented in Figure 4.5. North of the developed area, accretion of up to 5 m/year is seen. The rates of accretion reduce southwards switching to erosion around 1,774,500 mN. Erosion rates increase to a maximum of around 4 m/year between 1,769,500 and 1,770,000 mN.

Figure 4.3 – Average Annual Coastline Change Rates

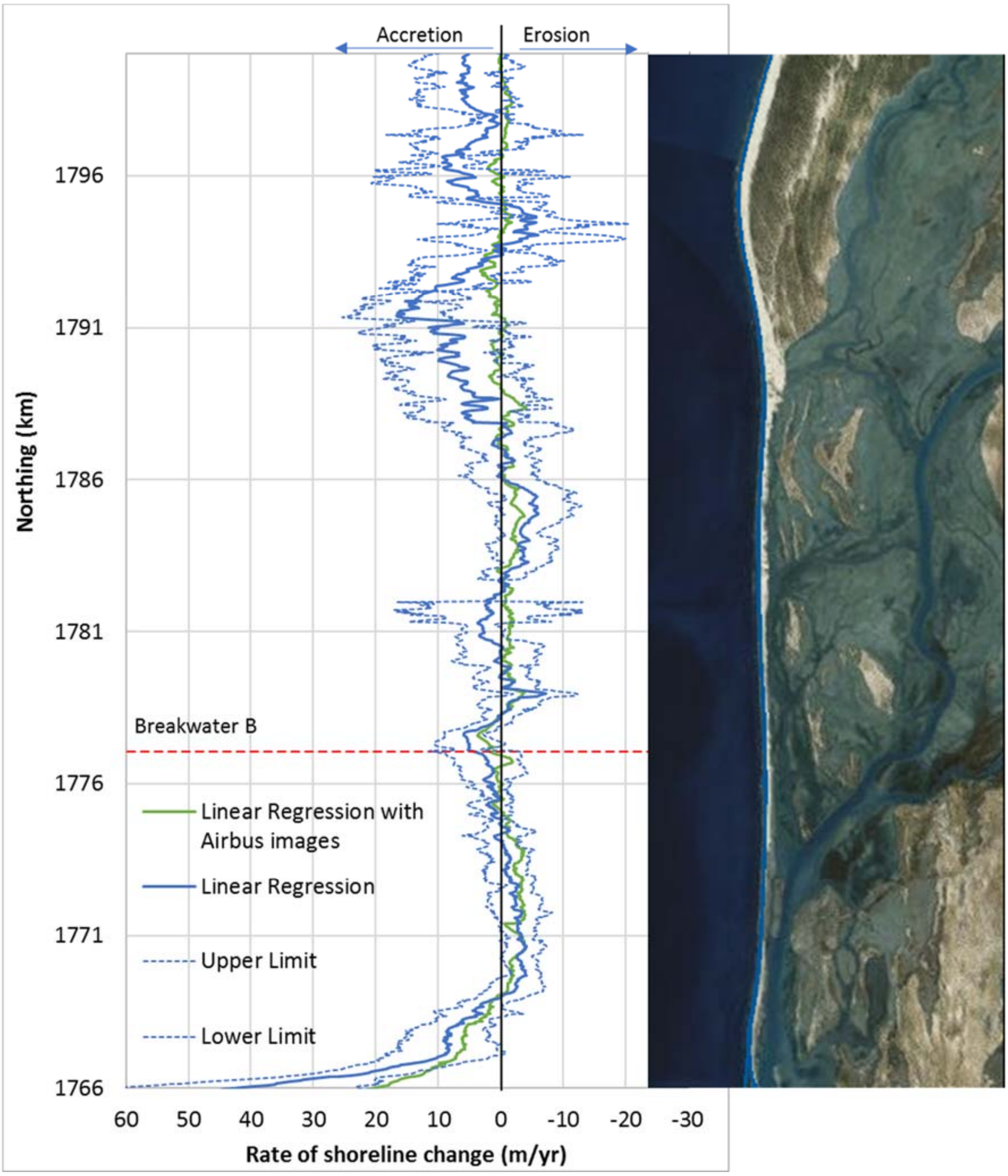


Figure 4.4 – Influence of Spit Growth on Measured Coastline Change

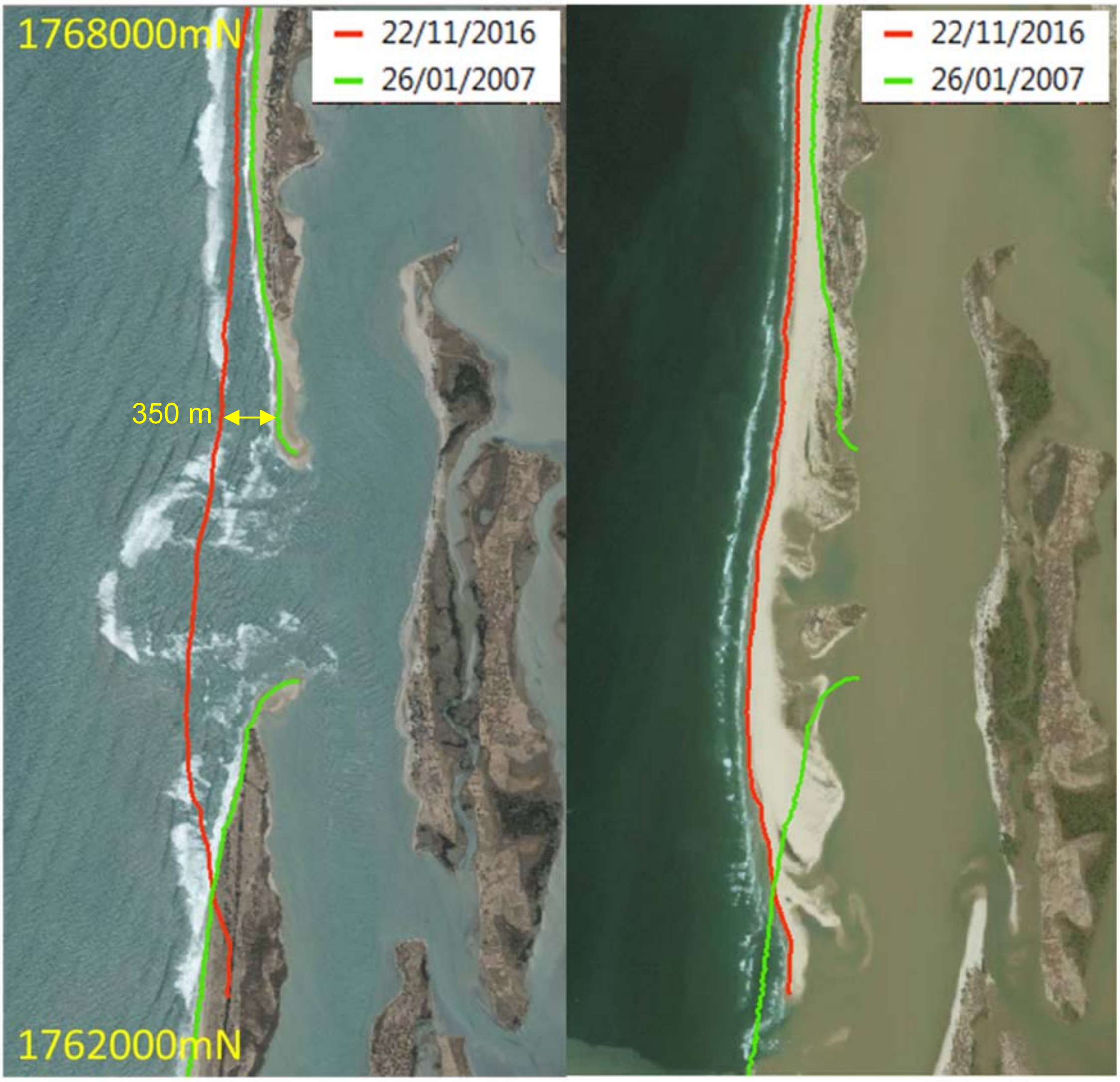
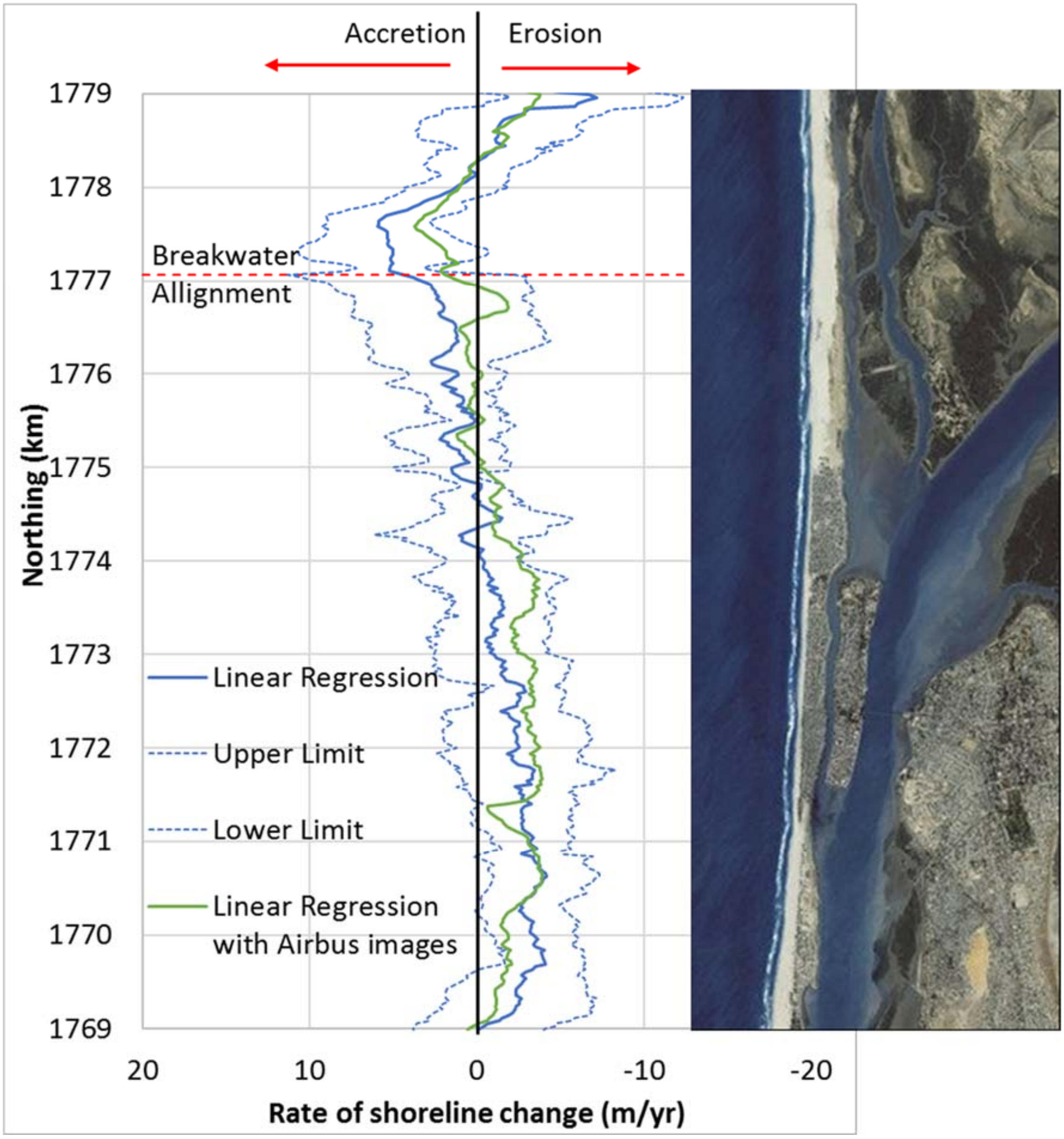


Figure 4.5 – Average Annual Coastline Change Rates at Project Site

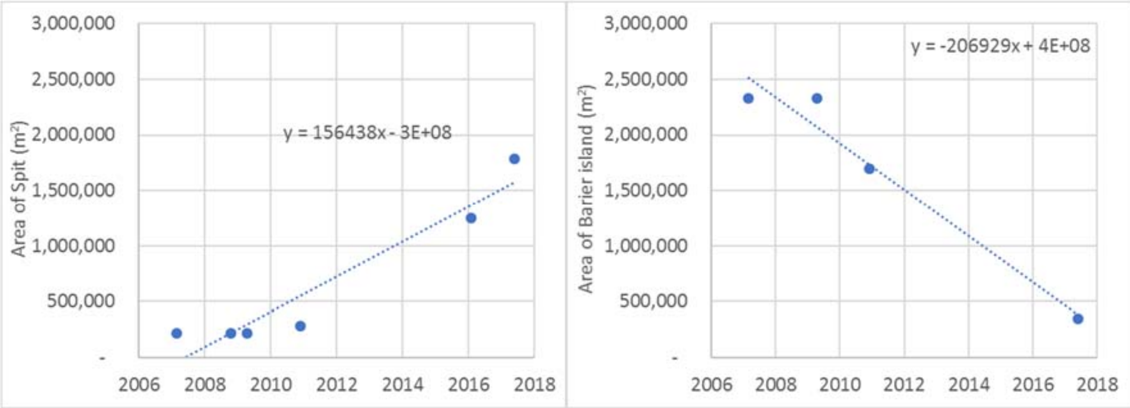


4.3 Estimation of Transport Rates

Estimation of sediment transport rates can be made by considering the growth of the spit and the erosion of the barrier island to the south of the breach. The area of the spit and the barrier island were calculated in the Geographic Information System software (ArcGIS). The change in the spit and barrier island area over time was plotted and linear regression analysis carried out (Figure 4.6).

Assuming an average thickness for the spit of 4 m (thickness assumed to vary from about 5.5 m on the seaward side to about 2.5 m on the landward side), results in an accretion rate of approximately 626,000 m^3/year for the spit and an erosion rate of approximately 828,000 m^3/year for the barrier island to the south of the breach. Thus, the estimated transport rate is between 626,000 and 828,000 m^3/year. More accurate predictions can be obtained if bathymetric data at different dates is available in the vicinity of the spit.

Figure 4.6 – Change in Spit and Barrier Island Area Over Time



5.0 NEARSHORE WAVE MODEL

Wave data at the toe of the beach profile is required as input to the sediment transport calculations. Thus, a nearshore wave model capable of transforming the offshore wave climate to the toe of the beach profile is required.

5.1 Modelling Software

The wave transformation modelling is conducted using the state-of-the-art MIKE 21 SW FM module of DHI software (version 2017). MIKE 21 SW FM is a third-generation spectral wind-wave module that uses unstructured meshes and simulates the growth, decay, and transformation of wind-generated waves and swell in the offshore and coastal areas. The model accounts for the following physical phenomena over large areas of open water:

- Wave growth by action of winds;
- Non-linear wave-wave interaction;
- Wave dissipation due to white-capping, bottom friction, and depth-induced wave breaking;
- Wave refraction and shoaling due to depth variations;
- Wave diffraction;
- Wave-current interaction; and
- Effect of time-varying water depths, including flooding and drying of low-lying land surfaces.

MIKE 21 SW can be run using the fully spectral formulation where the directional-frequency wave action spectrum is the dependent variable. This formulation is based on the wave action conservation equation, as described in (Komen et al. 1994 & Young, 1999). The fully spectral formulation was chosen for this study.

Diffraction is included using the phase-decoupled refraction-diffraction approximation proposed by (Holthuijsen et al. 2003). The approximation is based on the mild-slope equation for refraction and diffraction, omitting phase information.

In a study (Enet et al. 2006) using the Spectral Wave model developed by Delft University of Technology (SWAN) that implements the same method for diffraction, they performed tests for a semi-infinite breakwater. Those tests revealed that the diffraction approximation works quite well. They also mentioned that, the effect of directional spreading is to smooth out the typical spatial variation due to diffraction, since local variations of different spectral component cancel each other. In cases with large directional spreading, it is not needed to turn diffraction on.

5.2 Model Setup

The mesh for the SW model is shown in Figure 5.1 and Figure 5.2. The mesh size varied from about 9 km at the offshore to 20 m around the breakwater. The bathymetric data described earlier was used to interpolate the bed levels at the nodes of the mesh (Figure 5.2).

At the time of this study, no data was available for model calibration, hence conservative values were used for the different parameters. The SW model was setup with the parameters and options provided in Table 5.1. The model will be calibrated later based on the ongoing field measurements that started in the summer of 2017. This model calibration will be described in another report.

Figure 5.1 – Flexible Mesh Used in SW Model

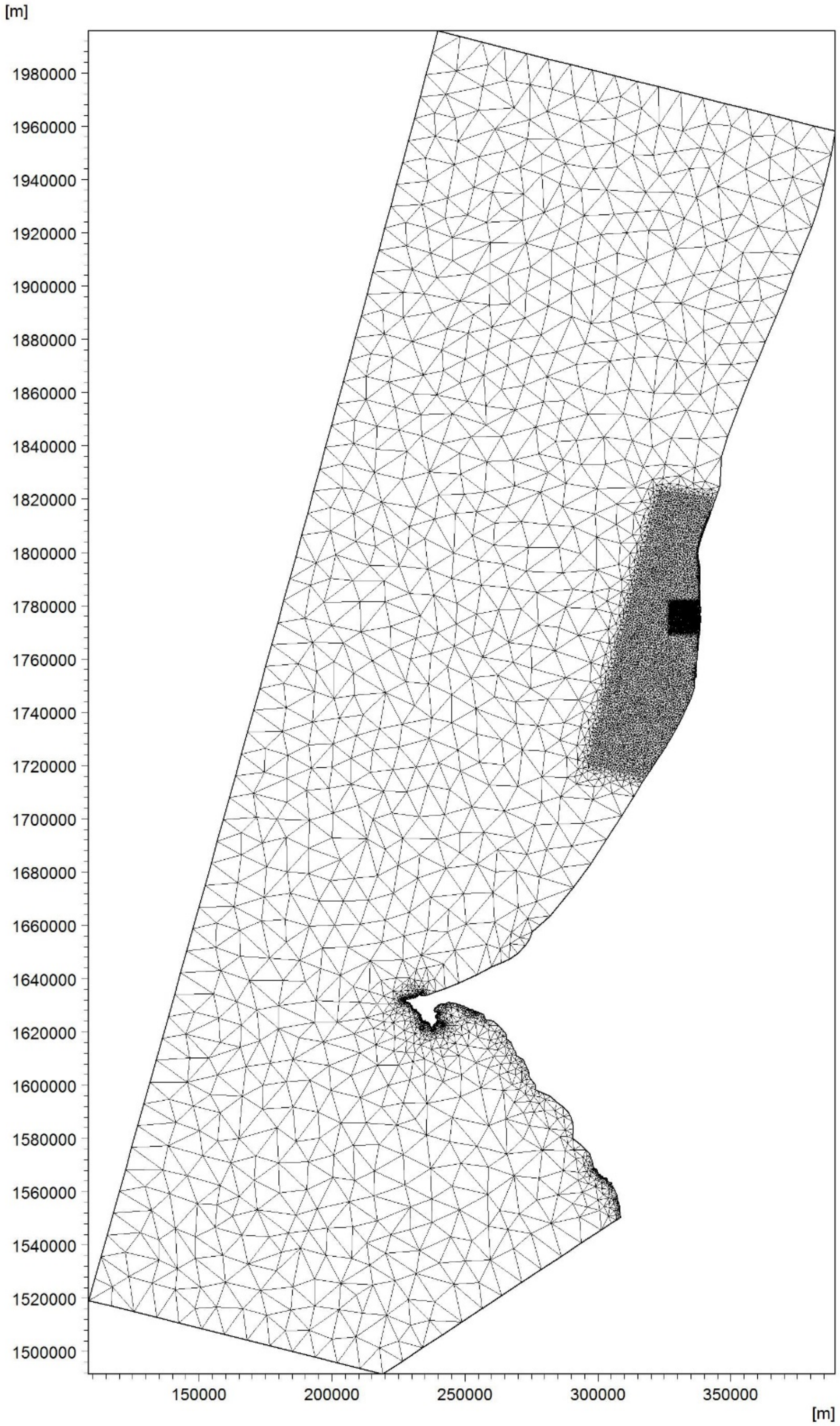


Figure 5.2 – Flexible Mesh in Vicinity of Breakwater With Bed Level Contours

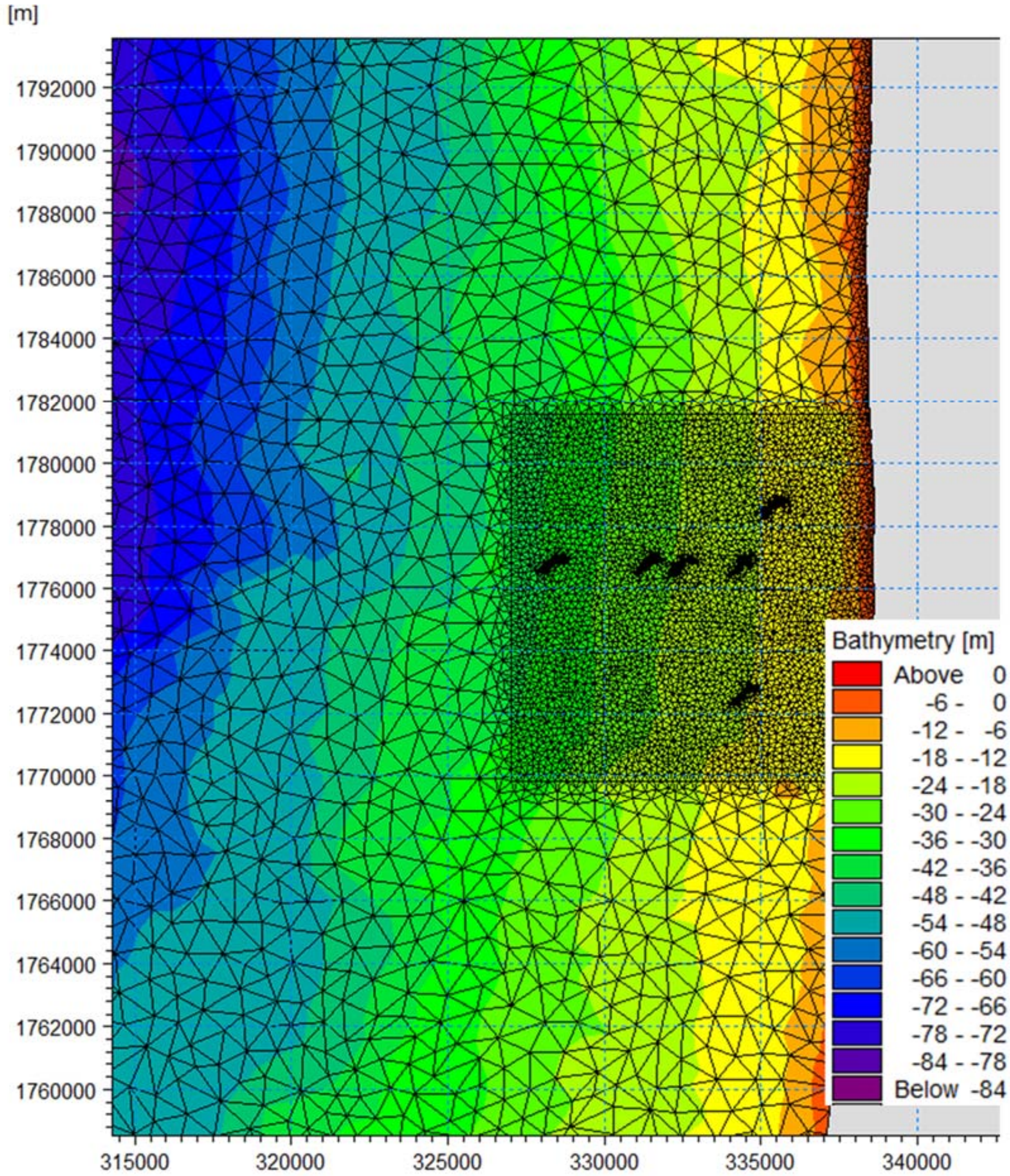


Table 5.1 – Setup and Parameters Used in SW Model

Parameter	Setting
Basic Equations	Spectral: Fully Spectral Time: Quasi-stationary
Spectral Discretisation	Number of Frequencies: 28 Minimum Frequency: 0.028 Hz Frequency Factor: 1.1 Number of Directions: 24
Solution Technique	Low order, fast algorithm
Water Level Condition	MSL
Current Conditions	No Currents
Wind Forcing	No wind
Diffraction	Included
Energy Transfer	Quadruplet-wave interactions included

Parameter	Setting
Wave Breaking	Gamma (constant): 0.8 Alpha: 1
Bottom Friction	Nikuradse roughness (constant) kn: 0.001 m
White Capping	Dissipation coefficient 1, C_{dis} (constant): 4.5 Dissipation coefficient 2, δ_{dis} (constant): 0.5
Boundary Conditions	H_{m0}, T_p and DWD specified along all open boundaries

5.3 Model Results

Figure 5.3 provides a sample of the model results for one run from the 678 runs completed. The shadow effect from the breakwater is evident with this wave condition. It can also be seen that extending the length of the breakwater, results in a wider shadow zone. A sample transect along the 10 m contour is also presented in Appendix II where the effect of the breakwater on the wave heights and directions are evident.

A wave rose at a station along the 10 m contour (E = 337,586 m and N = 1,775,700 m) is provided in Figure 5.4 (case without breakwater). This wave rose is plotted based on the Peak Wave Direction (PWD) for the annual wave climate at this location. It can be seen that, at the 10 m contour the wave directions changed significantly (see Figure 3.6 for offshore waves). It is clear from Figure 5.4, that the predominate waves will transport sediment from north to south.

Figure 5.3 – Sample Result for SW Model

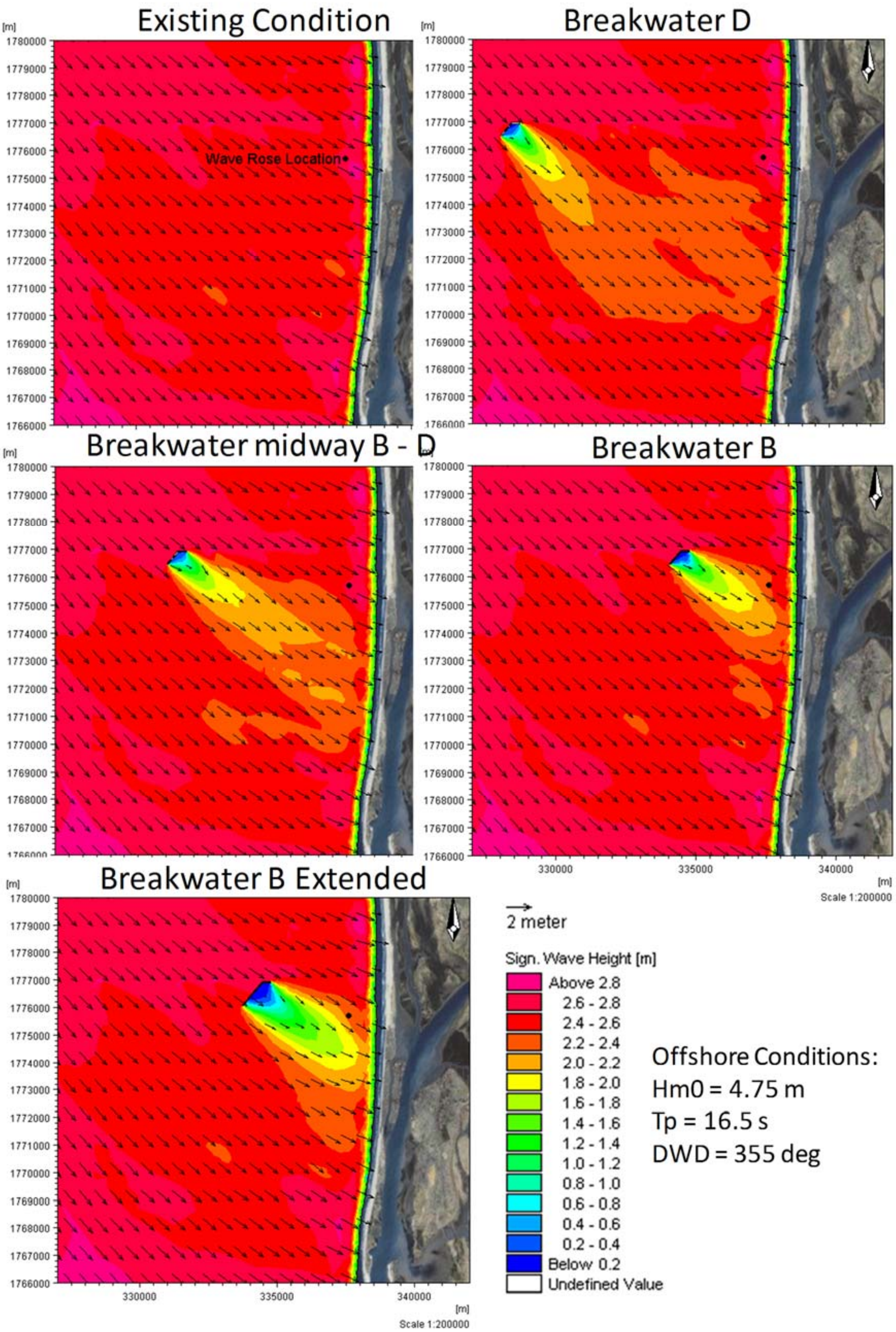
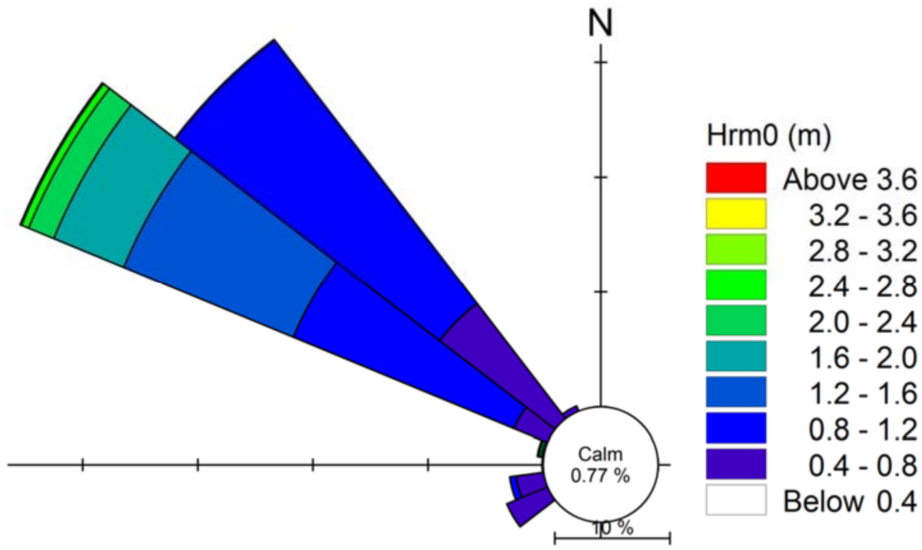


Figure 5.4 – Sample of Annual Wave Rose at Location along 10 m Contour



6.0 LONGSHORE SEDIMENT TRANSPORT

The longshore sediment transport rates provide insight on the dynamics of the nearshore area with respect to sediment movement.

6.1 Modelling Software

The Littoral Processes FM model developed by DHI Water and Environment is utilized. The Littoral Processes model is an integrated modelling system that simulates non-cohesive transport in points, along a beach profile and models coastline evolution. The LITDRIFT module calculates the cross-shore distribution of wave height and direction, the related wave driven currents and littoral drift for one or several individual cross-shore profiles based on wave conditions at the toe of the profile. LITDRIFT is used to determine the annual net and gross alongshore sediment transport rates along the project coastline.

6.2 LITDRIFT Model Setup

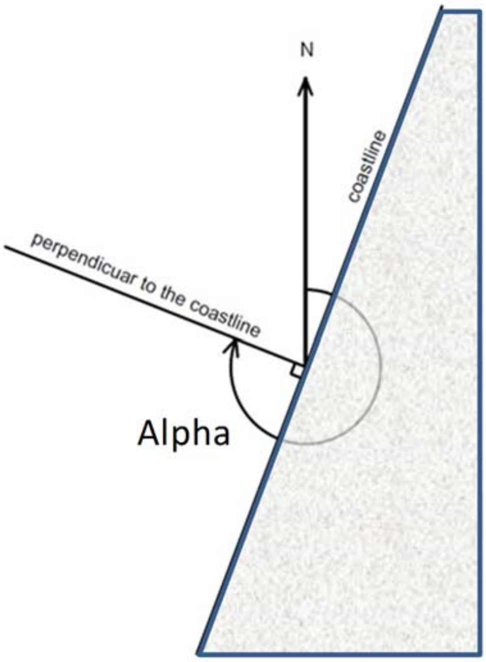
The beach profile shown in Figure 3.3 was used as input to the LITDRIFT model. The beach profile makes an angle of 270 with the North (angle of normal to shore with north in clockwise direction as shown in Figure 6.1). A spacing of 2 m (over the profile) was used in the calculations after testing a 4 m resolution with slightly different results (10% difference in sediment transport rates).

The H_{m0} values were converted into H_{rms} wave heights assuming a Rayleigh distribution for waves (H_{rms} used with the Battjes and Jansen wave breaking model). The bed roughness height can be used as a calibration factor if accurate measured data is available for the sediment budget. A value of Kn = 0.01 m was found to produce a net Sediment Transport Rate (Qs) close to the estimate based on historic coastline changes and published data. This value was selected as discussed below. The other options used in the LITDRIFT model are provided in Table 6.1.

Table 6.1 – Setup and Parameters used in LITDRIFT

Parameter	Setting
Water level	MSL
Current	No currents
Bed resistance	Roughness height Kn = 0.01 m (after calibration)
Wave model used	Battjes and Jansen (gamma = 0.8)
Wind Forcing	No wind
Sediment properties	Graded sand
Bed parameters	Ripples included
Wave theory	Linear waves
Bed concentration method	Deterministic

Figure 6.1 – Schematic for Coastline Orientation



6.3 LITDRIFT Results

Several test results were conducted and indicated that the main calibration parameter was the bed roughness height. The coastline orientation is an important parameter since the coastline evolution model will use the predicted coastline which evolves during the simulation.

6.3.1 Sensitivity to Bed Roughness

The effect of Kn on Qs was tested using three values for Kn applied based on wave data at the 10 m contour for a location where the coastline orientation was 270 deg (N = 1,784,400). These results are summarized in Figure 6.2. It can be seen that Kn = 0.01 m results in a net Qs close to 600,000 m^3/yr (i.e. close to estimate from historic coastline changes and previous studies).

6.3.2 Sensitivity to Coast Orientation

The above calculations were conducted using a coast orientation (Alpha) of 270 degree. The actual coastline changes its orientation along the study area and the coastline orientation will also change with time if coastline changes take place. It is thus useful to study how Qs varies with Alpha (Q-Alpha relation).

Figure 6.3 provides a Q-Alpha relation where it can be seen that Qs changes considerably for a change in coastline orientation within 10 degrees. Figure 6.3 also shows that the equilibrium coast orientation (coast orientation for net Qs = 0.0) is about 295 degree. The equilibrium coast orientation is the orientation the coastline will reach just updrift a long groin (where no sand by-passing occurs).

A value of Alpha = 290 degree can be observed just north of a long breakwater 220 km north of the project site (see Appendix III). The coast orientation for different times at the tip of the southern end of the breach also has an Alpha = 295 degree (see Appendix III). At this location, it is expected that no sediment by-passes the breach from the north since the breach width is quite wide for the dates used.

Figure 6.2 – Variation of Qs with Kn

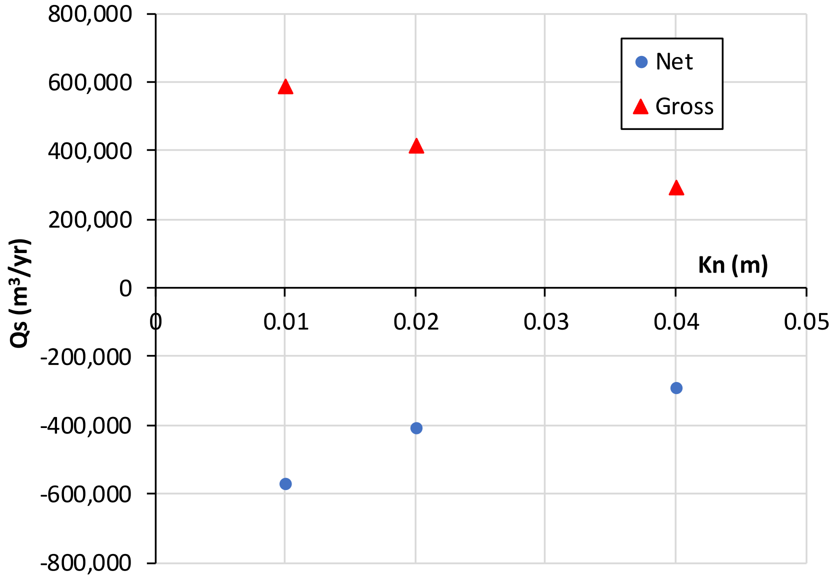
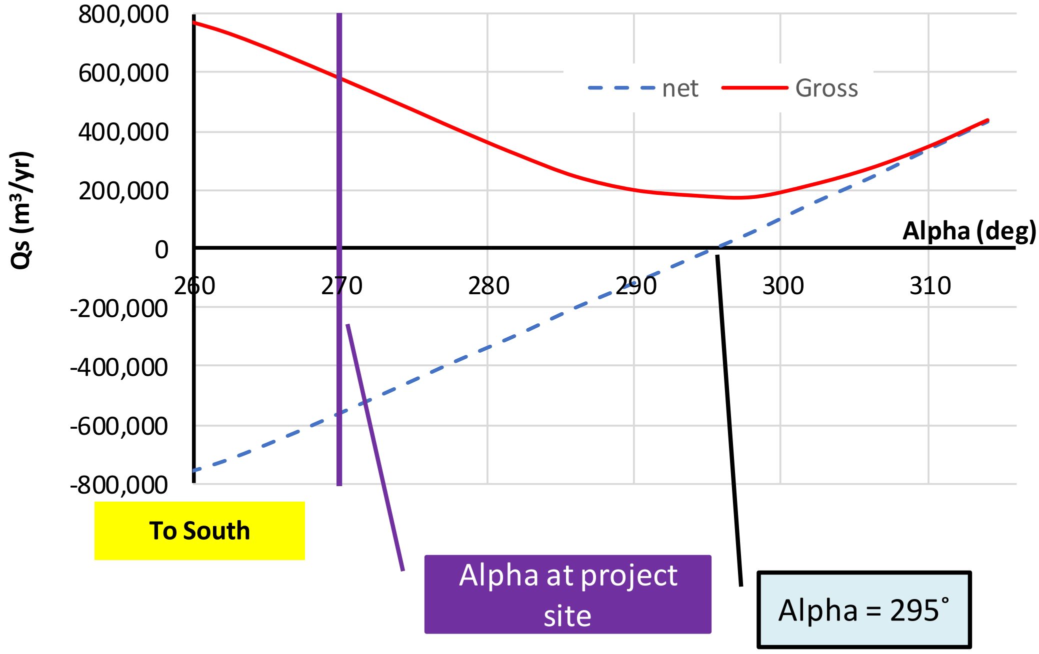


Figure 6.3 – Q-Alpha Relation

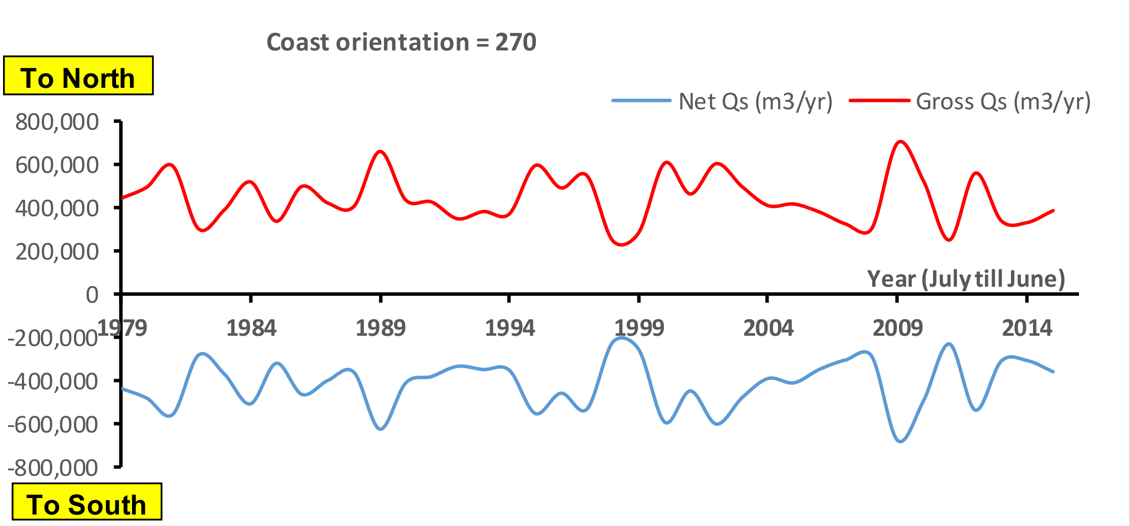


6.3.3 Sensitivity to Frequency Discretization

The adequacy of the frequency table bin widths is investigated by comparing the sediment transport results using the hourly OWI offshore wave data, with results using the frequency table for the offshore wave data.

Figure 6.4 provides the yearly variation in Qs calculated using the hourly OWI offshore wave data. The wave transformation is calculated assuming straight and parallel bed contours. It can be seen that the variability from year to year (year is taken from July till June of the next year) can be significant. The average net Qs for the 37 years simulated was 416,200 m^3/year to the south. This simulation was repeated using the frequency table at the offshore and the net Qs was 430,000 m^3/year to the south. Thus, the resolution of the frequency table is suitable for sediment transport calculations.

Figure 6.4 – Variation of Qs over Years (Using OWI Data at Offshore)



Additional sensitivity tests were carried out and the results are provided in Appendix III.

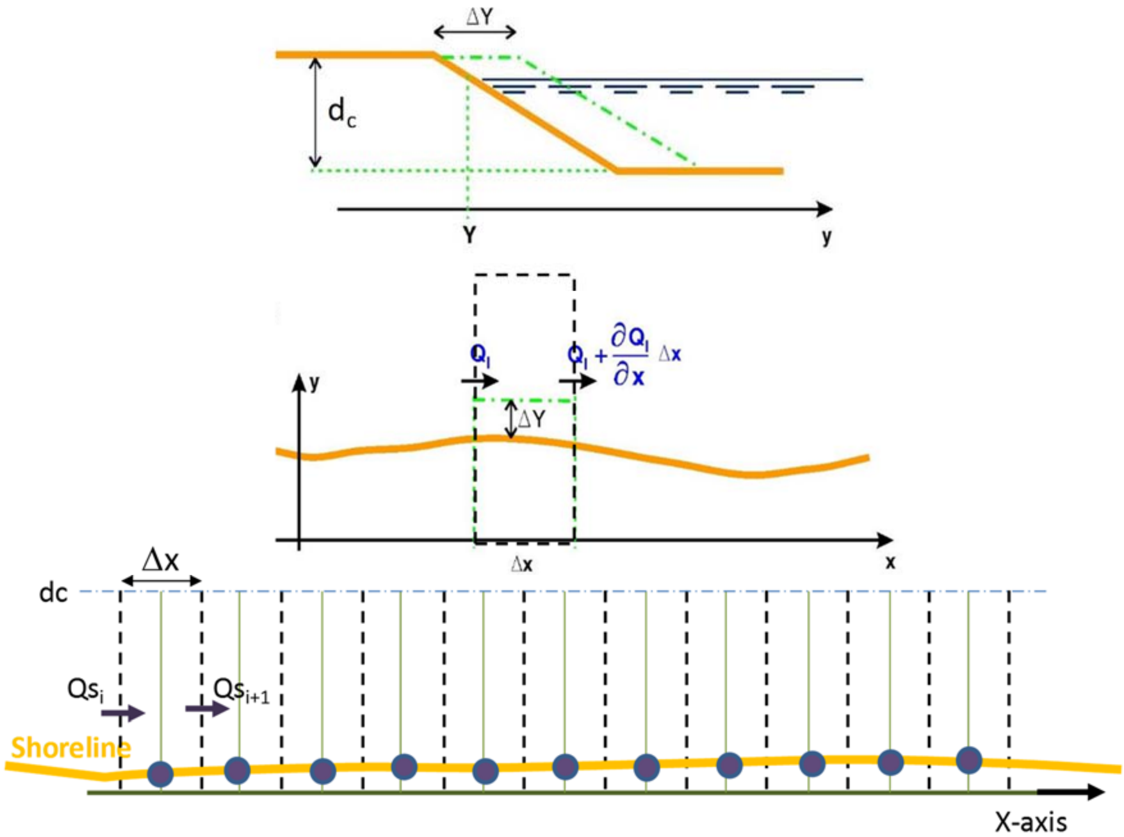
7.0 COASTLINE EVOLUTION MODEL

To study the impact of the proposed breakwater on the coastline, morphological calculations are required. 2D morphological modelling will require extensive computer time. Furthermore, due to the absence of recent bathymetric surveys in the nearshore, such 2D modelling is not suitable at this stage. Thus, a coastline evolution model based on the one-line concept is used to test the impact of different breakwater layouts and locations.

7.1 Modelling Software

The coastline evolution module of the Littoral Processes FM model developed by DHI Water and Environment is utilized. The LITLINE module calculates the coastline evolution for a coastline with one or several representative cross-shore profiles. The LITLINE model is based on the one-line approximation (Figure 7.1) that assumes the beach profile does not change over the simulation period. Thus, any gradient in the longshore sediment transport rate along the coastline will cause coastline changes. The height of the beach profile d_c is the sum of the closure depth and the berm height.

Figure 7.1 – Schematic of One-line Concept



7.2 LITLINE Model Setup

A coastline stretch extending over 40 km from the northern end of the breach (2011 location) was modelled using the LITLINE model. The baseline of the model was taken to be aligned with the South North direction as shown in Figure 7.2. The coastline location is measured relative to the baseline (y) with a spacing of 30 m along the alongshore (x) direction. The beach profile used in the LITDRIFT calculations was also used in this model. This profile was assumed to be constant over the 40 km simulated. The sediment properties were also assumed to be constant along the simulated reach.

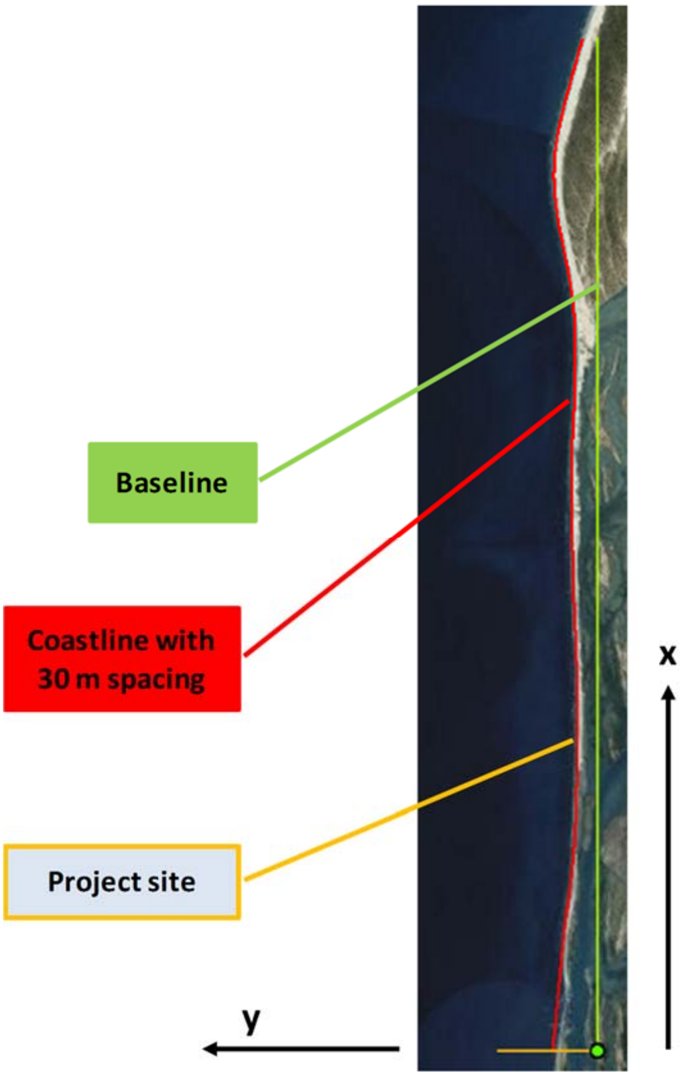
Prior to the coastline evolution simulation, transport tables were generated to be used for the sediment transport calculations. These tables were generated using the beach profile shown in Figure 3.3 and the same calibrated parameters determined for LITDRIFT.

7.2.1 Model Boundaries

The southern boundary of the model is at a very complex location where the sand spit moves to the south. This boundary was assumed to be open since most of the transport is from North to South and sand exiting will deposit south of the boundary (at the river mouth). The mechanisms in the vicinity of the river mouth are very complex, and depends on the interplay between tidal flow, river flow and breaking waves induced longshore sediment transport. The model however, cannot predict the coastline changes accurately in this complex area. A 2D model would be required to model the dynamics of such a complex spit. Some sensitivity tests were conducted to test the influence of this boundary on the study area as discussed later.

The Northern boundary was also assumed to be open and this boundary was taken at a section where the coastline was relatively straight and far away from the area of interest. Thus, it is expected that this boundary will have no influence on the model results in the study area.

Figure 7.2 – Setup of Coastline Evolution Model



7.2.2 Other Setup Parameters

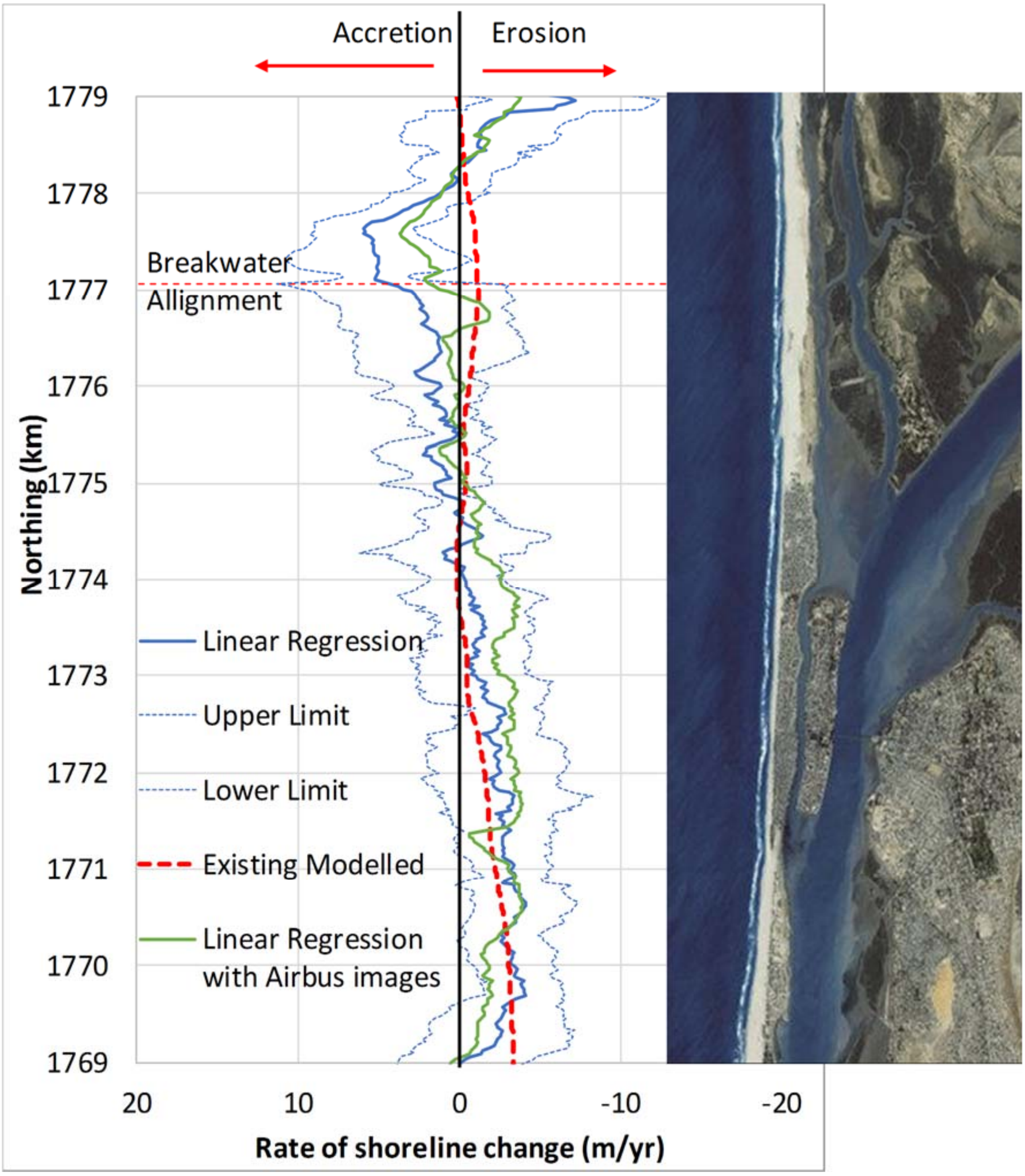
The LITLINE model was run for 6 years using the 2011 coastline as the initial coastline. The resulting coastline was then used as the initial 2017 coastline for all the cases studied. This model warmup was required to remove any coastline oscillations instead of smoothing the initial coastline.

The wave conditions (H_{rms}, T_p, DWD and Frequency) were provided along the 10 m depth contour with a spacing of 30 m. As discussed in Section 3.2.2, 3033 wave events are used to represent the yearly average wave climate. The yearly average wave conditions were repeated 10 times to simulate a period of 10 years.

7.3 Model Validation

The results from the LITLINE model were used to validate the trends predicted by the model. The LITLINE model was run for a period of 10 years and the yearly rates of coastline changes were estimated. Figure 7.3 shows that within the study area, the model predicts the observed coastline trends (from coastline change analysis) reasonably well. These results are satisfactory given the limited data available.

Figure 7.3 – Comparison of Measured and Modelled Coastline Change Rates



7.4 Model Results

Figure 7.4 and Figure 7.5 provide results from the 10 year simulations for the different locations of the breakwater. As expected, the modelled impact on the coastline is reduced as the breakwater is moved offshore. These conclusions are also evident by comparing the volume changes and the maximum erosion and accretion provided in Table 7.1 and Table 7.2. The volume changes are calculated for the section shown in Figure 7.6 and a sketch for the different volumes for Breakwater (BW) B are provided in Figure 7.7. The reduction in erosion relative to the existing conditions represents a positive impact for each alternative relative to the do nothing alternative.

For Location D, modelling results predict that the eroded section of the coastline is close to the tip of the spit as shown in Figure 7.6. The maximum change in erosion (as compared to the case without a breakwater) for this case is 15 m over 10 years as shown in Table 7.2. This increase in erosion rate is relatively small compared to the observed natural variations in the coastline that can reach 5 m/yr (see Figure 7.3 and Section 4.0). As mentioned earlier, LITLINE model cannot predict the coastline changes well in the vicinity of the river entrance. A 2D sediment transport model would be required to simulate this area.

Figure 7.4 – LITLINE 10 Year Coastline along Study Area

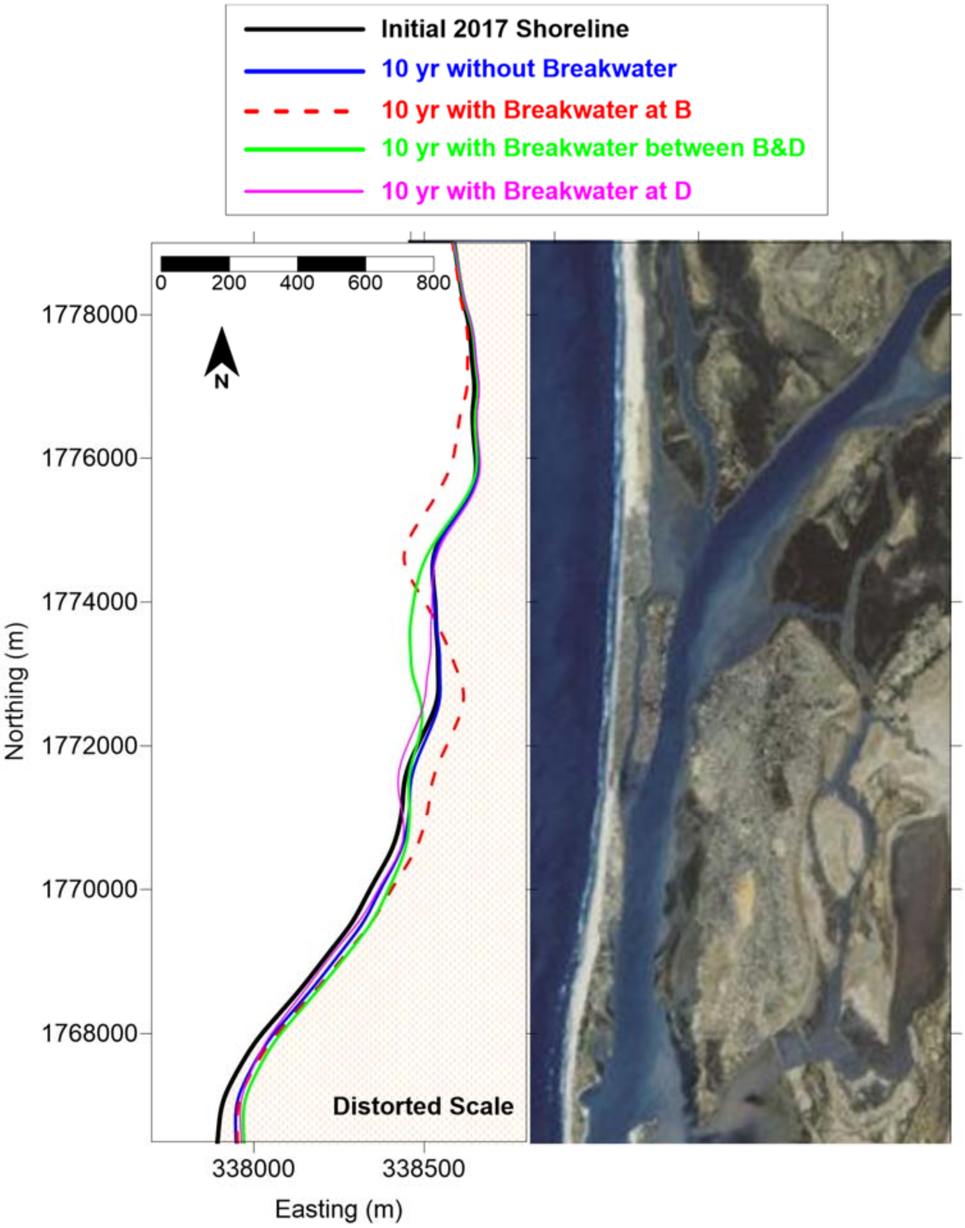


Figure 7.5 – Net Qs along Study Area for Different Simulations

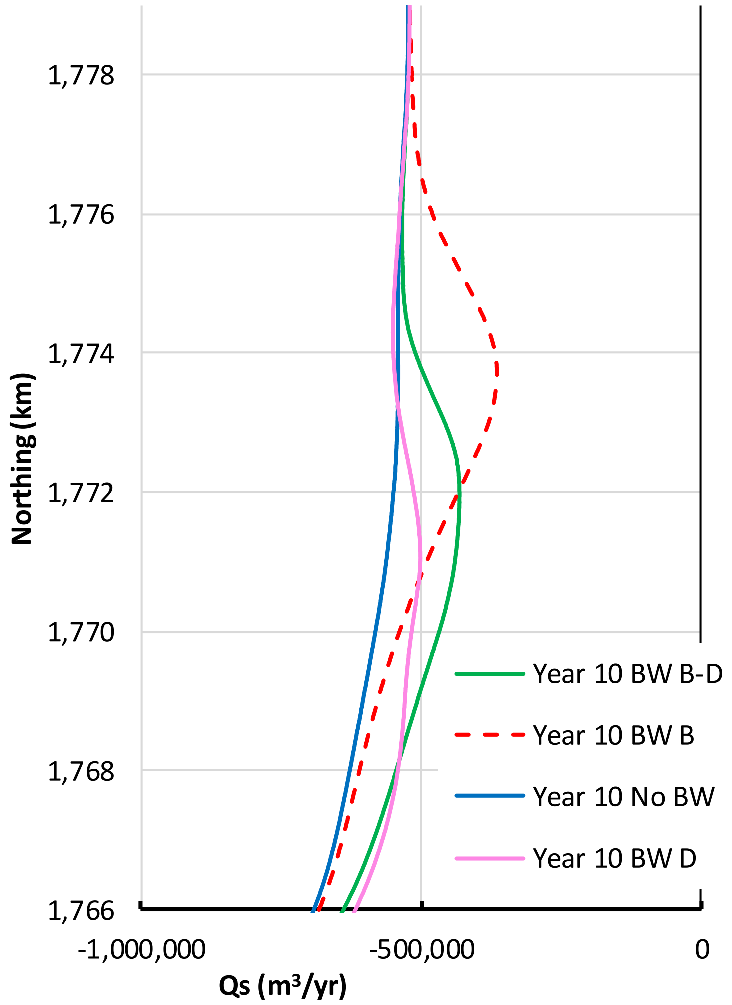


Figure 7.6 also shows that extending the breakwater by 500 m at Location B will increase the impact of the structure on the coastline (also see Table 7.2). The general shape of the coastline change is similar with a slightly longer accreted section along the shore.

There was an interest in understanding the impact of extending the breakwater by 500 m at Location D. Our analysis for Location B shows that the shadow zone will extend further south. Consequently a similar extension at Location D is expected to shift the eroded section further south with a smaller impact compared to Location B.

Figure 7.6 – Coastline Changes after 10 Years Relative to Case Without Breakwater

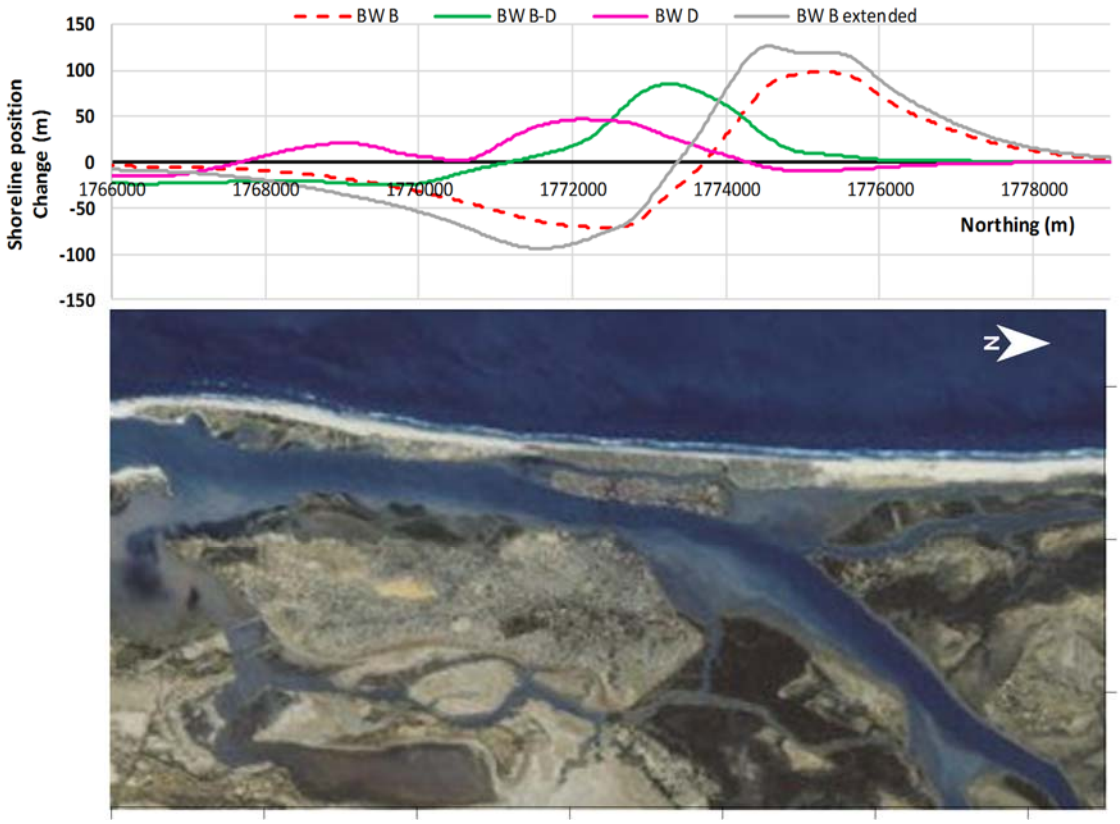


Figure 7.7 – Schematic for Different Erosion Volumes

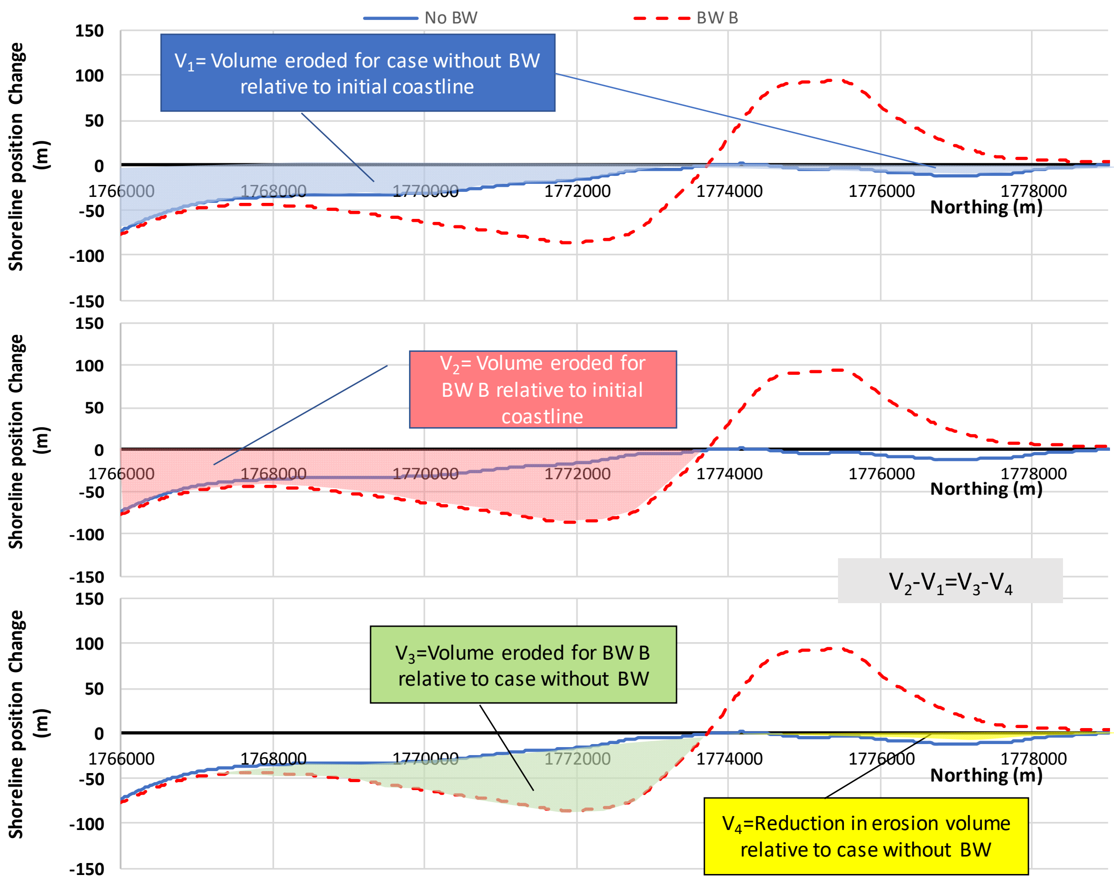


Table 7.1 – Summary of Volume Changes in Study Area

Values in m^3 after 10 Years	No Breakwater	Breakwater B	Breakwater B-D	Breakwater D	Breakwater B Ext.
Eroded volume relative to initial coastline (V_1 & V_2)	3,852,000 (V_1)	5,409,000 (V_2)	4,698,000 (V_2)	3,869,000 (V_2)	6,088,000 (V_2)
Accreted volume relative initial coastline	28,000	1,601,000	1,059,000	520,000	2,312,000
Eroded volume relative to the existing conditions (i.e. no breakwater) (V_3)	n/a	1,742,000	1,035,000	491,000	2,426,000
Accreted volume relative the existing conditions	n/a	1,759,000	1,220,000	967,000	2,475,000
Reduction in erosion volume relative to existing conditions (V_4)	n/a	185,000	189,000	474,000	190,000

Table 7.2 – Summary of Maximum Coastline Erosion and Accretion for Study Area

Parameter after 10 Years	Breakwater B	Breakwater B-D	Breakwater D	Breakwater B Ext.
D_{50} = 0.2 mm				
Maximum coastline erosion compared to existing (m)	71	25	15	93
Maximum coastline accretion compared to existing (m)	98	85	47	126
Maximum reduction in Net Qs compared to existing (m^3/yr)	174,700	122,300	85,800	245,700
D_{50} = 0.3 mm				
Maximum coastline erosion compared to existing (m)	50	17	11	-
Maximum coastline accretion compared to existing (m)	72	59	30	-
Maximum reduction in Net Qs compared to existing (m^3/yr)	117,500	78,500	55,600	-

7.4.1 Sensitivity Analysis

Due to the uncertainties in some of the input data, sensitivity tests were conducted.

The first parameter investigated for the sensitivity tests is the median grain size. A value of D_{50} = 0.3 mm was used for the three breakwater locations. The results for these cases are provided in Appendix IV and Table 7.2.

The effect of Sg on the impact of the breakwaters was also found to be very small although the net Qs changed. That is due to the fact that the coastline changes are driven by the gradient in Qs and not the actual values.

Due to the uncertainty in representing the southern boundary, different boundary conditions were tested, namely:

- Pinned boundary by assuming a short groin;
- Closed boundary by assuming a very long groin; and
- Extending domain by 6 km to the south assuming pre-breach conditions.

The results of these different tests showed that at the study area, the relative results for the cases with and without breakwaters are not sensitive to the boundary condition imposed. Appendix IV provides some plots for the results for the domain extended 6 km south. The maximum erosion for the case with the breakwater at B is 71 m (as compared to 71 m for the default value). For the breakwater at D, the maximum erosion is 14 m with the extended shore (as compared to 15 m for the default value).

8.0 CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

8.1 Summary

The potential impact of a proposed breakwater on the coastline stability, is studied using a coastline evolution model. The offshore yearly average wave climate (maintaining monthly frequencies) was transformed to the 10 m depth contour using MIKE 21 SW. This wave data was extracted every 30 m along the coastline to resolve the change in wave climate induced by the proposed breakwater.

The sediment transport model was calibrated based on published data and data derived from the historic coastline changes (for the net sediment transport rates).

Three different breakwater locations were simulated using LITLINE model together with a modified breakwater layout at the Location B. The results from these simulations were compared to the results for simulations without any breakwater (do nothing) to determine the impact of different alternatives.

8.2 Conclusions

The model results showed that for location D (at a depth of about 33 m), part of the coastline currently experiencing erosion will start to accrete. This accretion will provide a positive impact to the houses along that section. Further south, the model predicts that erosion relative to the case without any breakwater will occur. The maximum calculated value for this erosion is about 15 m over 10 years. This value is lower than the natural erosion rates at some sections along the study area and is located along a stretch that does not include any infrastructure along the coast. Furthermore, this increased coastal erosion is predicted to occur only close to the tip of the spit (i.e. south of St. Louis).

As the breakwater is moved further inshore, the model predicts that the impact increases and the maximum erosion relative to the case without any breakwater reaches 71 m for Location B (at a depth of about 18 m). The erosion also increases if the breakwater length at Location B is extended due to the wider shadow zone.

8.3 Uncertainties & Limitations

This study has been based on the best available data to provide an assessment of the impact of the proposed breakwater on the coastline. However, there are some uncertainties and limitations. Some of these limitations and uncertainties were addressed by sensitivity testing as described in Table 8.1. Other uncertainties will require further field data collection / studies to be carried out.

Table 8.1 – Summary of Model Limitations and Uncertainties

Item	Uncertainty / Limitation	Mitigations Taken	Studies Recommended
Data			
Beach profile data	Lack of any measured beach profile data along study area.	Two equilibrium beach profiles assumed depending on gran size.	Beach profiles should be surveyed along the study area to account for any variation along the coast.
Bathymetric data	Limited surveyed data especially in the nearshore.	Two equilibrium beach profiles assumed depending on gran size.	Bathymetric surveys required.
Sediment properties	Limited measured data along the beach and along the beach profile.	Sensitivity testing conducted.	Field data should be collected.

Item	Uncertainty / Limitation	Mitigations Taken	Studies Recommended
Wave Model			
Calibration of wave model	No wave data was available for the calibration of the wave model.	Conservative parameters were used.	Model could be calibrated based on data from ongoing field measurements.
Bimodal nature of offshore wave data.	The bimodal nature of the waves was not included in the transformation of the frequency table.	DWD used instead of MWD, At study area, the energy from the south is not significant.	Data could be extracted from long term simulations using spectral data at boundaries with wind input.
Coastline Evolution Model			
Inter-annual variability	Inter-annual variation in sediment transport and associated coastline changes is not included.	-	Further modelling could be carried out using time varying wave conditions in the historical sequence
Sequence of wave conditions	Chronological sequence of wave conditions can affect the predicted coastline response	Preserved the sequence of averaged monthly wave conditions in the averaged yearly wave data.	Further modelling could be carried out using time varying wave conditions in the historical sequence.
Active depth	No information on historical beach profiles is available for estimating active depth	Estimated using LITDRIFT results (depth shoreward of which 95% of the longshore sediment transport takes place)	Other estimates can be obtained, and sensitivity tests carried out
Cross-shore sediment transport	Not included although breakwater is expected to modify it.	-	Given that the breakwater reduces incident wave conditions in a section of the coast, it is not expected that the breakwater will have a negative impact on erosion due to cross-shore processes.
Sea Level Rise (SLR)	Impact of erosion due to sea level rise is not included.	-	An estimate of erosion due to SLR can be added to estimated coastline changes. However, it is not expected that the breakwater will have a negative impact on erosion due to SLR.

9.0 REFERENCES

AlDioma B., I. A. Bilbao, A. Abou, I. S. Perez and S. R. Valido (2013). Résultats du suivi 2010-2012 de l'évolution de la brèche ouverte sur la Langue de Barbarie au Sénégal et de ses consequence. Physio-Géo Géographie physique et environnement, Volume 7.

ARCADIS (2011). Some Considerations on Water and Climate Change Impacts - St. Louis, Senegal. Final Report.

Dean, R.G. (1977). Equilibrium beach profiles: U.S. Atlantic and Gulf coasts. Department of Civil Engineering, Ocean Engineering Report No. 12, University of Delaware, Newark, DE.

Dean, R.G. (2002). Beach Nourishment Theory and Practice. Advanced Series on Ocean Engineering: Volume 18. World Scientific.

Enet F., A. Nahon, G. van Vledder, and D. Hurdle (2006). Evaluation of diffraction behind a semi-infinite breakwater in the SWAN wave model. 9th International Workshop on Wave Hindcasting and Forecasting.

Holthuijsen L.H., A. Herman & N. Booij (2003). Phase-decoupled refraction–diffraction for spectral wave models. Coastal Eng. Volume 49, Issue 4, pp. 291-305.

Komen, G.J., Cavaleri, L., Doneland, M., Hasselmann, K., Hasselmann S. and Janssen, P.A.E.M. (1994) Dynamics and modelling of ocean waves. Cambrigde University Press, UK, 560p.

Sadio M., E. J. Anthony, A. T. Diaw, P. Dussouillez, J. T. Fleury, A. Kane, R. Almar and E. Kestenare (2017). Shoreline Changes on the Wave-Influenced Senegal River Delta,West Africa: The Roles of Natural Processes and Human Interventions. Water, 9, 357.

Thieler, E.R., Himmelstoss, E.A., Zichichi, J.L., and Ergul, Ayhan, 2017. Digital Shoreline Analysis System (DSAS) version 4.0 — An ArcGIS extension for calculating shoreline change (ver.4.4, July 2017): U.S. / 2017 Geological Survey Open-File Report 2008-1278 https://pubs.er.usgs.gov/publication/ofr20081278/.

Young, I.R. (1999), Wind generated ocean waves, in Elsevier Ocean Engineering Book Series, Volume 2, Eds. R. Bhattacharyya and M.E. McCormick, Elsevier.

Appendix I
Additional Discussion on Coastline Position

The coverage of the Airbus and Digital Global satellite images is presented in Figure AI.1 and Figure AI.2. The highlighted blue line indicates the coverage. Note that the best temporal coverage is around the project site.

Figure AI.1 – Coverage of Airbus Satellite Images (Highlighted Blue Line Indicates the Coverage)

October 2002	December 2006
	

Figure AI.2– Coverage of Digital Global Satellite Images (Highlighted Blue Line Indicates the Coverage)

6/01/2007	13/09/2008	06/06/2009	08/03/2009	23/02/2010	25/10/2010	21/01/2011	05/04/2014	10/02/2015	01/06/2016	22/11/2016

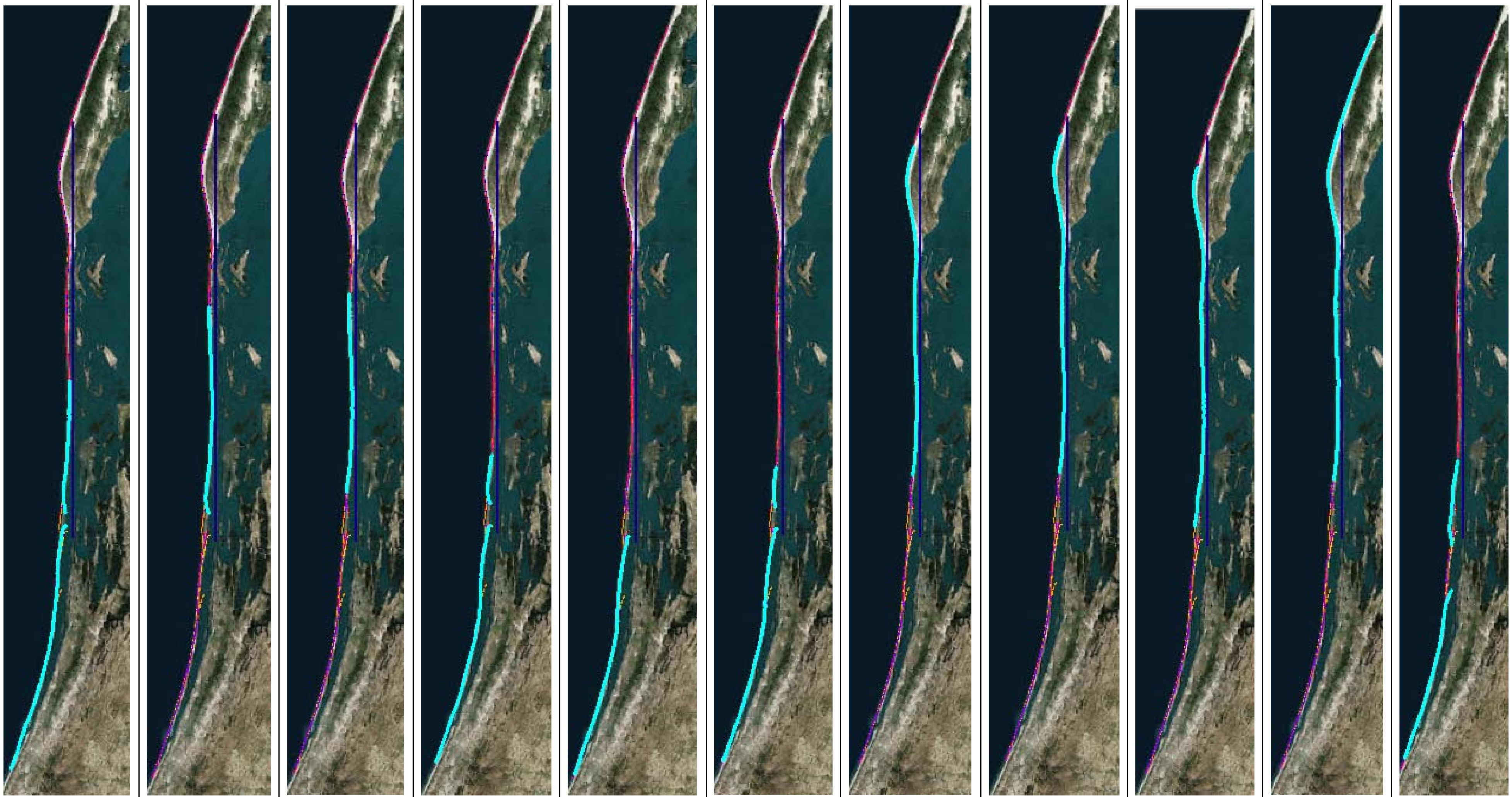
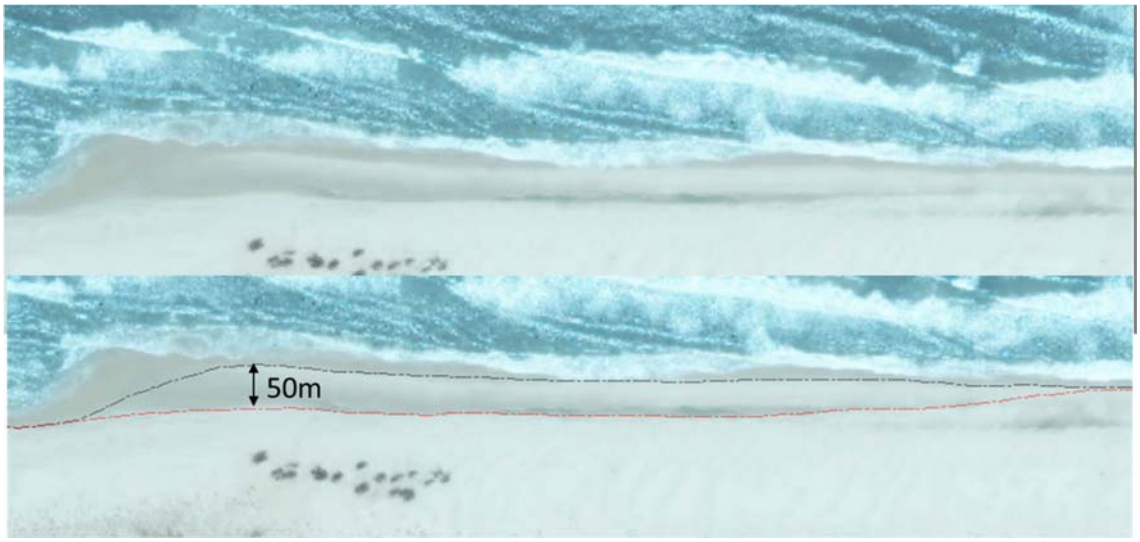
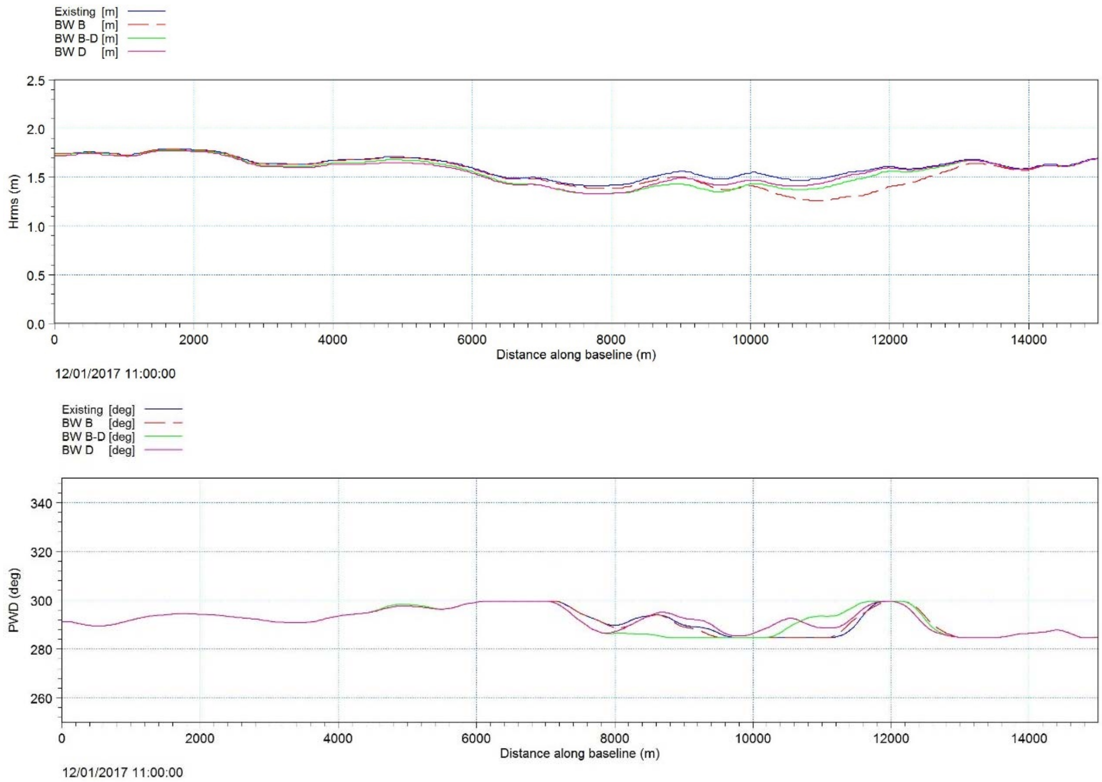


Figure AI.3 – Example of Ambiguity in the 2017 Coastline



Appendix II
Additional Nearshore Wave Modelling Results

Figure AII.1 – Sample for Wave Climate Variation along 10 m Contour



Appendix III
Additional LITDRIFT Model Results

Figure AIII.1 and Figure AIII.2 provide the coastline orientation at sections where the shore orientation is expected to be close to the equilibrium shore orientation.

Figure AIII.1 – Coastline Orientation Updrift a Breakwater 220 km North the Project Site

Figure AIII.2 – Coastline Orientation for Southern End of Breach

AIII 1.1 Other Sensitivity Tests

The sensitivity of the LITDRIFT model to several parameters was tested and the results are summarized in the table below.

Table AIII.1 – Additional Sensitivity Tests for LITDRIFT

Case	Net Qs (m^3/yr)	Gross Qs (m^3/yr)
Default: First order wave theory, D_{50} = 0.2 mm, S_g = 1.2	-570,700	587,700
Fifth order stokes theory, D_{50} = 0.2 mm, S_g = 1.2	-516,000	532,900
First order wave theory, D_{50} = 0.3 mm, S_g = 1.2	-425,500	443,200
First order wave theory, D_{50} = 0.3 mm, S_g = 1.6	-505,600	527,600

Appendix IV
Additional LITLINE Results

Figure AIV.1 – LITLINE 10 Year Coastline along Study Area (D_{50} = 0.3 mm)

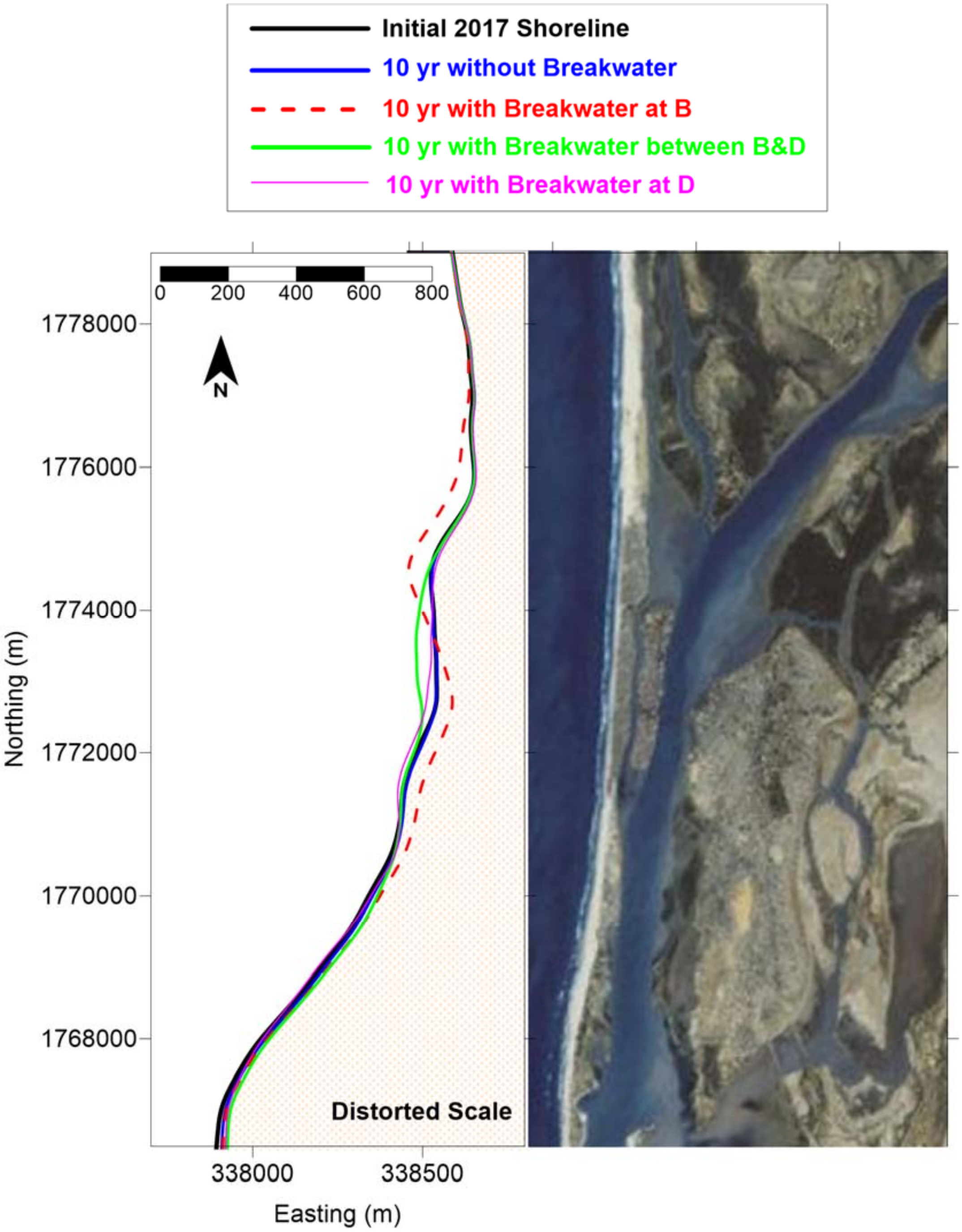


Figure AIV.2 – Net Qs along Study Area for Different Simulations (D_{50} = 0.3 mm)

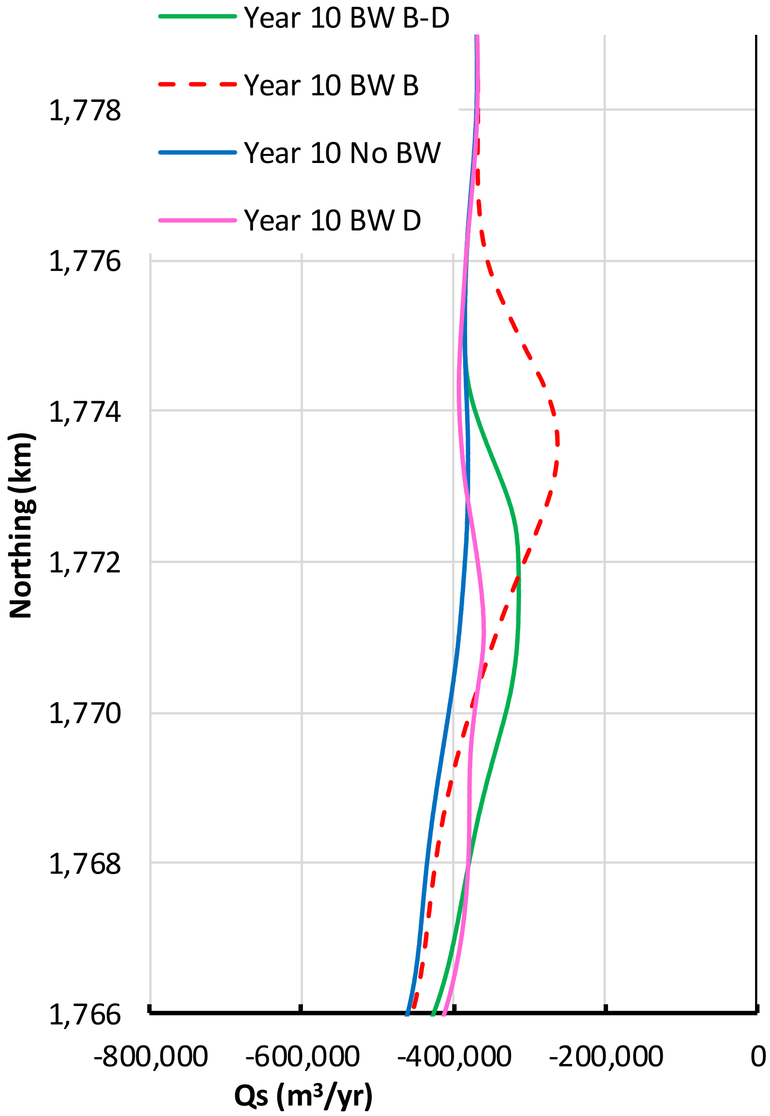


Figure AIV.3 – Coastline Changes after 10 Years Relative to Case Without Breakwater (D_{50} = 0.3 mm)

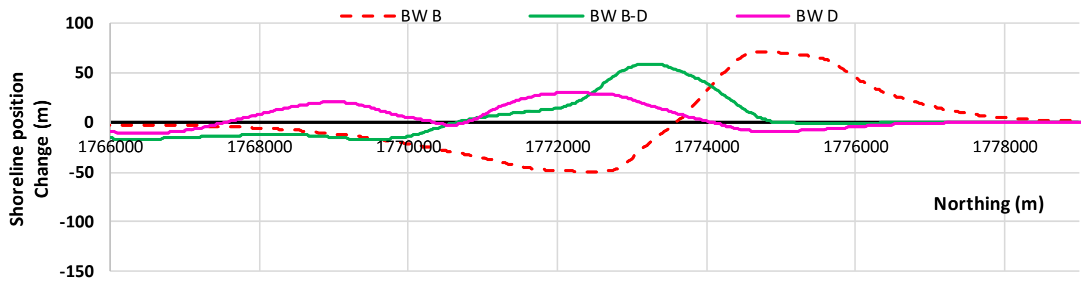


Figure AIV.4 – Effect of Sg on Coastline Changes with Breakwater B (D_{50} = 0.3 mm)

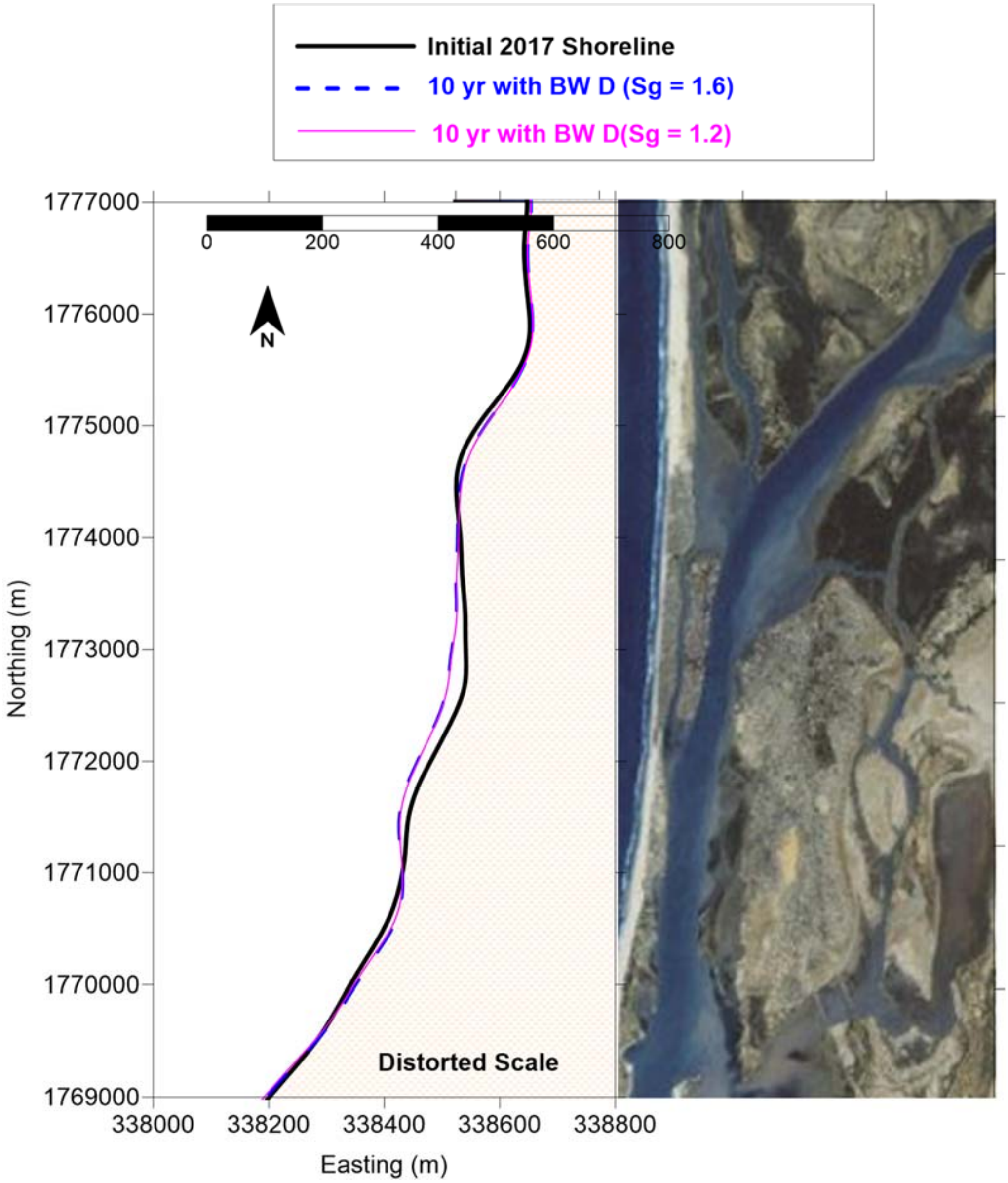


Figure AIV.5 – Effect of Sg on Qs with Breakwater B (D_{50} = 0.3 mm)

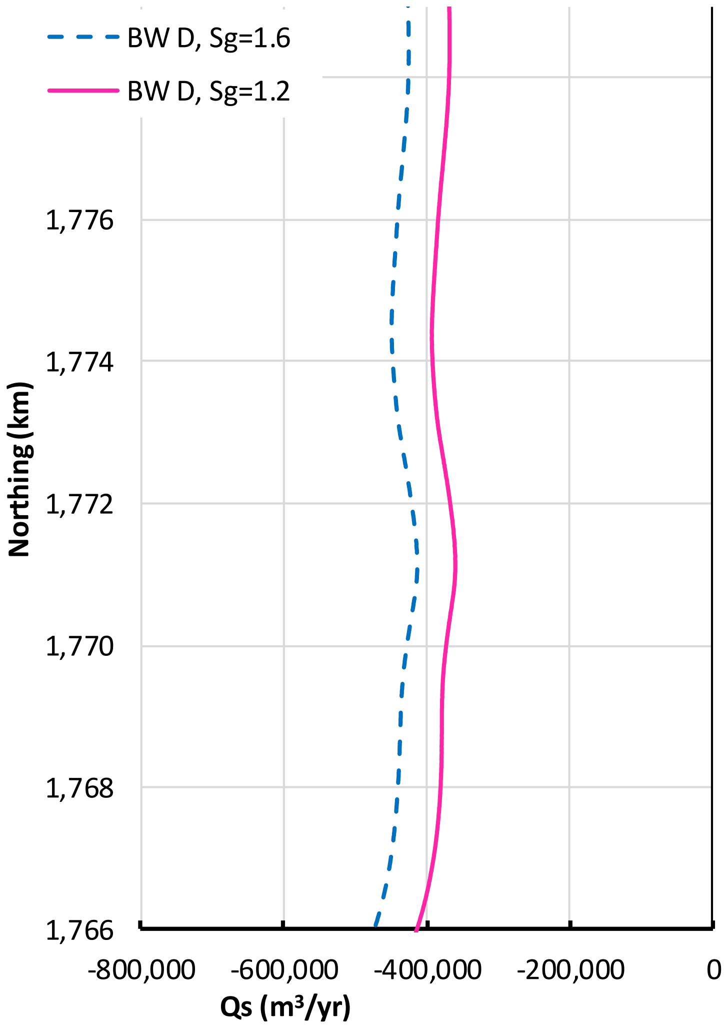


Figure AIV.6 – Effect of Southern Boundary on Qs

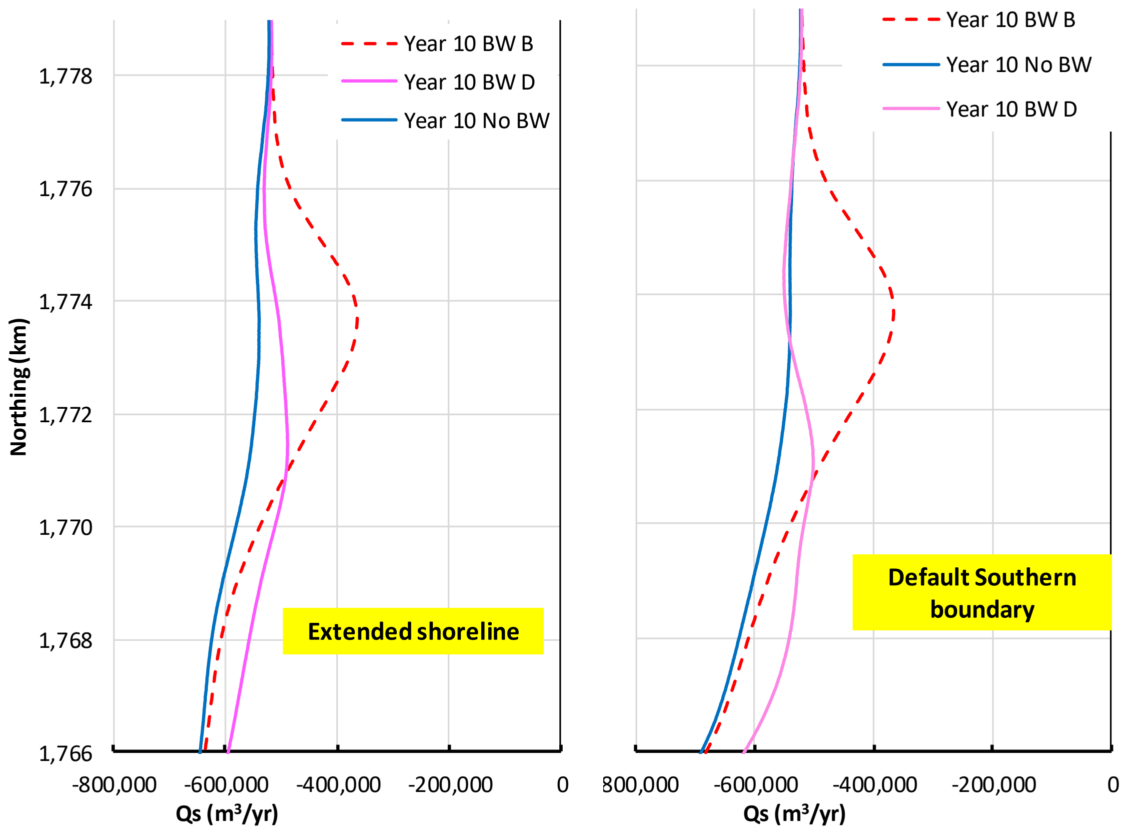
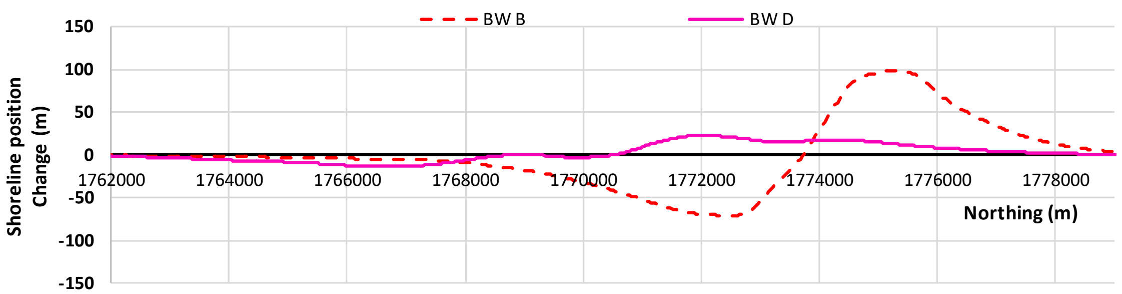


Figure AIV.7 – Coastline Changes for Case with Extended Shore to the South



APPENDIX I-3 : COASTLINE MODELING – REFERENCE CASE REPORT

Security Classification: General

Mauritania & Senegal Region

Tortue Phase 1

TORTUE DEVELOPMENT PROJECT

Coastline Modelling – Reference Case

			K.A. Rakha	HJohnson	[signature]	-
B01	Issued for Information	11/04/2018	K Rakha	H Johnson	S Dunn	-
Rev.	Reason for Issue	Date	Author	Checker	Approver	QA

Refresh Cycle Code (Years):	Not Applicable

Unique Identifier:	Not Applicable	MS002-CV-STU-010-04024	Rev.
RD Type:	Not Applicable		B01

Uncontrolled when printed or stored locally

Revision History

Revision Date	Revision Number	Approver	Revision Description

* Only required for B02 revisions and beyond.

Holds

Hold Ref.	Description / Reason for Hold	Ref. Section
HOLD 1	No Holds	

Reviewers

Name	Role	Type of Review	Date Reviewed

Reference Documents

Ref.	Document Number	Document Name
1	MS002-CV-STU-010-04012	Coastline Impact Assessment
2	MS002-CV-STU-010-04010	Inshore Metocean Study: Nearshore Wave Modelling / B02/ Mar 2018

Abbreviations

A	Parameter used in Dean equilibrium profile
ArcGIS	Geographic Information System Software
BP	BP Group of Companies
BW	Breakwater
C_{dis}	Coefficient 1 for white capping dissipation
CE90	90% confidence interval of the positional accuracy
CMAP	Digital Maps
D_{50}	Mean Grain Size
d_c	Height of beach profile
DHI	DHI Water and Environment Institute
DSAS	Digital Shoreline Analysis System
DWD	Dominant Wave Direction
δ_{dis}	Coefficient 2 for white capping dissipation
FEED	Front End Engineering Design
FLNG	Floating Liquefied Natural Gas
FM	Flexible Mesh
FPSO	Floating Production, Storage and Offloading
h	Water depth from MLWS
H_{m0}	Zero moment (spectral significant) wave height
H_{rms}	Root Mean Square wave height
KBR	KBR Group of Companies
Kn	Roughness Height
LITDRIFT	Littoral Drift
LITLINE	Coastline Evolution
LNG	Liquefied Natural Gas
MIKE	Software by DHI
MLWS	Mean Low Water Spring
MMscfd	Million standard cubic feet per day
MSL	Mean Sea Level
MTPA	Million Tonnes Per Annum
MWD	Mean wave Direction
N	North
NNW	North-North West
OWI	OceanWeather Inc.
PWD	Peak Wave Direction
Qs	Sediment Transport Rate
S	South
S_g	Spreading coefficient for sediment size
SLR	Sea Level Rise
SW	Spectral Wave
SWAN	Spectral Wave model developed by Delft University of Technology

T_p	Peak wave period
W	West
x	Alongshore direction
x_o	Offshore distance
y	Distance of shoreline from baseline
z	Bed Level
2D	Two Dimensional

Table of Contents

APPENDICES

TABLES

FIGURES

1.0 EXECUTIVE SUMMARY

The proposed Tortue hub, on the Mauritania and Senegal maritime border, comprises a breakwater to protect marine operations, including Liquefied Natural Gas (LNG) processing and carrier loading. The proposed breakwater is located in an area exposed to significant natural coastal erosion.

During pre-FEED, a coastal impact assessment was conducted to select a suitable location for the proposed breakwater. The pre-FEED study (site selection study) used transformed wave parameters based on the offshore average annual wave climate. The offshore yearly average wave climate was transformed to the 10 m depth contour using a 2D Spectral Wave model developed by DHI Water and Environment (MIKE 21 SW). Three different breakwater locations were simulated using a Coastline Evolution (LITLINE) model. The site selection study concluded that Location D (at 33 m depth) is a suitable location for the proposed breakwater. This location was selected as the reference case.

The present study provides additional coastline evolution modelling for the selected location (reference case). It also addresses three of the uncertainties identified in the site selection study. The first uncertainty addressed is associated with transformation of wave parameters rather than the wave spectra from deep water to the nearshore. Several wave modes could be identified in the offshore wave data. Thus, the transformation of the average wave parameters based on the Dominant Wave Direction (DWD) as used previously will not capture the multi-modal wave spectra. In this study, two-Dimensional (2D) wave spectra are imposed at the offshore boundary of the nearshore wave model. The MIKE 21 SW model is run in fully spectral mode for 10 years with and without the breakwater. The second uncertainty addressed is associated with the lack of beach profile data (and use of empirical equilibrium beach profile). Published data on beach profiles is used in this study.

The third uncertainty addressed is the beach sediment data. In this study an additional data set (in addition to the studies used in the site selection study) from a previous study at the project site was used.

This report provides a summary of the coastline evolution modelling performed to predict the impact of the proposed breakwater on the dynamic coastline.

The Littoral Drift (LITDRIFT) model is setup based on published data and some sensitivity analysis to different model parameters and input data is conducted to quantify some uncertainties.

Ten years of coastline evolution are simulated for the case with and without any breakwater (do nothing) to quantify the impact of the breakwater on existing coastline changes.

The breakwater causes a reduction of the wave heights along part of the study area and a modification to the wave directions. This causes a reduction in the sediment transport rates along the section sheltered by the breakwater, inducing coastline changes.

The use of more accurate wave data as compared to the previous site selection study had a moderate influence on the model results (about 25 % reduction in net sediment transport rates). The impact of the breakwater on the coastline is slightly reduced as compared to the previous study.

The model results showed that reference case, the coastline sections with inland development will accrete relative to the case without the breakwater. This accretion will provide a positive impact to the densely populated residential area along that section. Further south, the model results show that erosion relative to the case without any breakwater would occur. The maximum value calculated for this erosion is lower than the natural erosion rates at some sections along the study area and is located along a stretch that is less densely populated along the coast.

2.0 INTRODUCTION

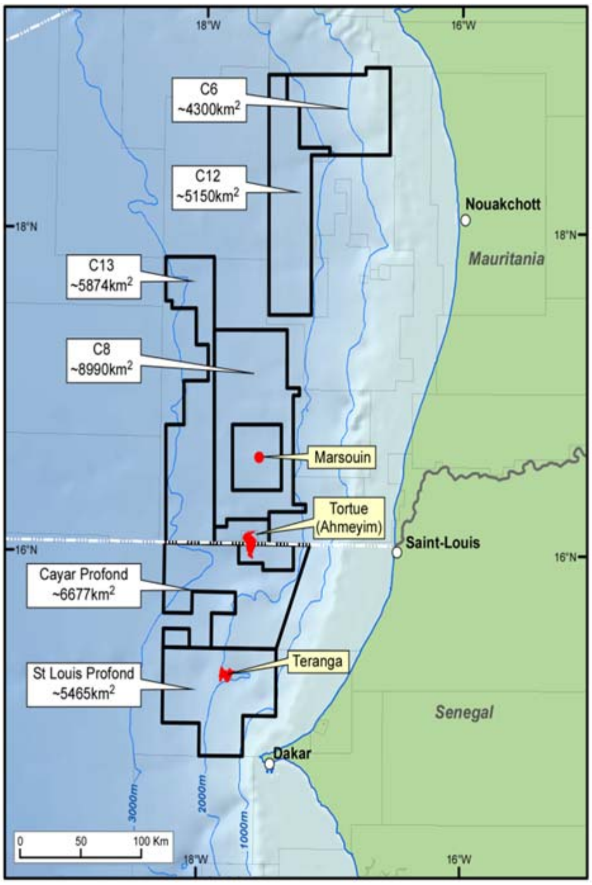
The BP Tortue Development comprises a subsea production system tied back to a pre-treatment Floating Production, Storage and Offloading (FPSO) unit, which subsequently transfers gas to a near-shore hub for Liquefied Natural Gas (LNG) production and export, and is envisaged to be developed in stages.

2.1 Background

Phase 1A will provide sales gas production, domestic supply and generate ~2.5 MTPA of LNG to Mauritania and Senegal.

The Phase 1A FPSO, which is located in 100-130 m of water, will process inlet gas from the subsea wells located across a number of drill centres by separating condensate from the gas stream and exporting conditioned gas to a hub, where LNG processing and export will occur. The Hub, which is located in shallow water on the Mauritania and Senegal maritime border, comprises a breakwater to protect marine operations, including LNG processing and carrier loading. A single Floating LNG (FLNG) vessel will condition the gas for LNG export. A map showing the field location is provided in Figure 2.1.

Figure 2.1 – Tortue Field Location Map



Central Tortue will add additional wells and drill centres, which tie-back through a separate flowline system to a second gas processing facility, nominally located adjacent to the Phase 1A FPSO. Gas exported from the new facility will tie in to the flowline between the FPSO and the Hub. Liquids from the second facility will be routed to the FPSO for further processing. Additional LNG processing capacity will be provided to accommodate the Central Tortue production.

2.2 Purpose

This report provides details on the coastline evolution modelling performed to predict the impact of the proposed breakwater on the dynamic coastline.

3.0 METHODOLOGY AND DATA

3.1 Methodology

3.1.1 Previous Site Selection Study

As explained in [Ref. 1], a coastline impact assessment was conducted to select a suitable location for the proposed breakwater. The suitable location for the breakwater was selected based on the modelled impact on the coastline. In that study three models were used:

- MIKE 21 Spectral Wave (SW) Flexible Mesh (FM); and
- MIKE 21 Littoral Processes FM:
  - Littoral Drift
  - Coastline Evolution

The MIKE 21 SW model was used to provide the wave climate (monthly frequency tables) at the offshore limit of the beach profile. This offshore limit was taken as the 10 m depth with the breakwater included in the SW model domain. The offshore boundary used in that MIKE 21 SW model, was based on monthly frequency tables obtained from 38 years of OceanWeather Inc. (OWI) data.

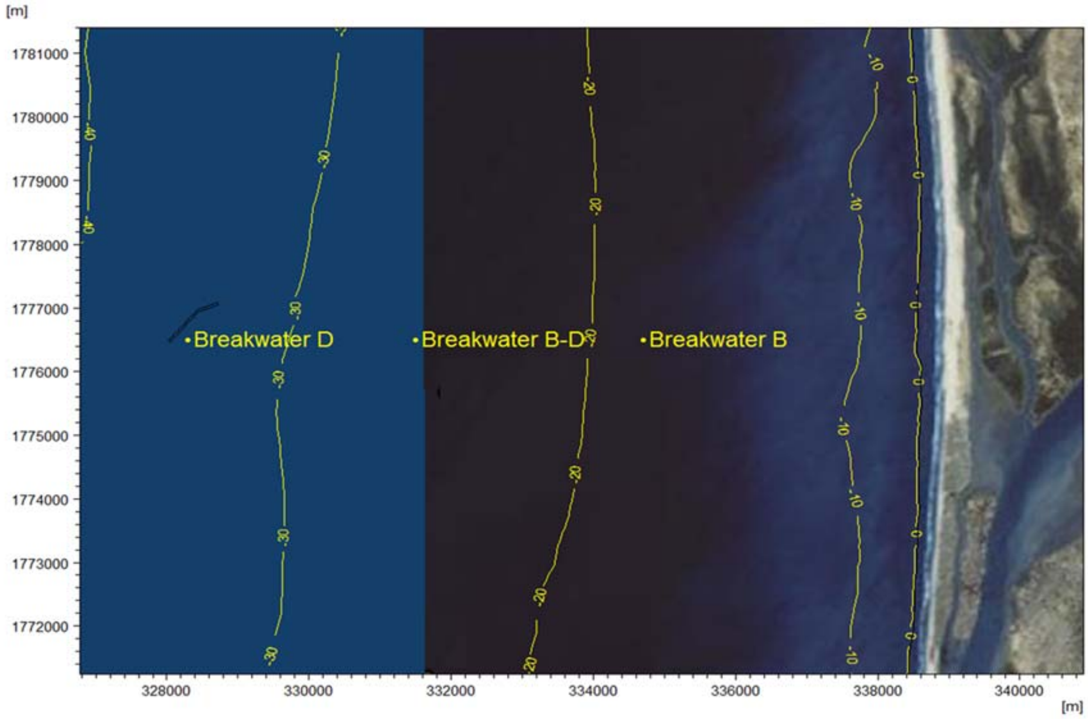
The LITDRIFT model was used for sediment budget calculations. Equilibrium beach profiles were used due to the absence of bathymetric data in the area from the shore till the 10 m depth. The model was calibrated using the net sediment transport rates reported in previous studies and estimated from historical coastline changes.

Finally, the LITLINE model was used to simulate the coastline changes over 10 years for the case without any breakwater (existing) and for the different breakwater locations (see Figure 3.1) and layouts. The main input to the LITLINE model was the initial coastline, the wave climate and sediment transport tables. The initial coastline was taken as the shoreline predicted from LITLINE after a warm up period of six years starting with the 2011 coastline. This warm-up simulation used the 2011 coastline and applied six years of wave climate for the case without any breakwater resulting in an initial 2017 coastline. The wave climate was obtained from the MIKE 21 SW model along the 10 m contour with a spacing of 30 m. The sediment transport tables were generated using the parameters determined from the calibrated LITDRIFT model.

The previous site selection study showed that for location D (at a depth of about 33 m), part of the coastline currently experiencing erosion will start to accrete. This accretion would provide a positive impact to the densely populated residential area along that section. Further south, erosion relative to the case without any breakwater was predicted by the model. The maximum value for this erosion was estimated to be about 15 m over 10 years. This increased coastal erosion was predicted to occur only close to the tip of the spit (i.e. south of St. Louis). As the breakwater was moved further inshore, the impact increased and the erosion also increased for the case with the breakwater length at Location B extended.

Location D was selected in the site selection study and this study provides further detailed modelling for this location including more accurate data to address some of the uncertainties identified in [Ref. 1].

Figure 3.1 – Location of Breakwaters Tested in Previous Site Selection Coastline Evolution Model



3.1.2 Present Study for Reference Case

The present study addresses three of the uncertainties identified in the site selection study mentioned above. The following uncertainties in the site selection study are addressed:

1. Uncertainty associated with the transformation of wave parameters rather than wave spectra;
2. Uncertainty with the use of empirical beach profiles due to lack of beach profile data;
3. Uncertainty due to limited data on sediment characteristics.

The first uncertainty addressed was the transformation of wave parameters rather than the wave spectra from deep water to the nearshore. As demonstrated in [Ref. 1 & 2], several wave modes could be identified in the offshore wave data. The transformation of the average wave parameters based on the Dominant Wave Direction (DWD) as used previously will not capture the multi-modal wave spectra.

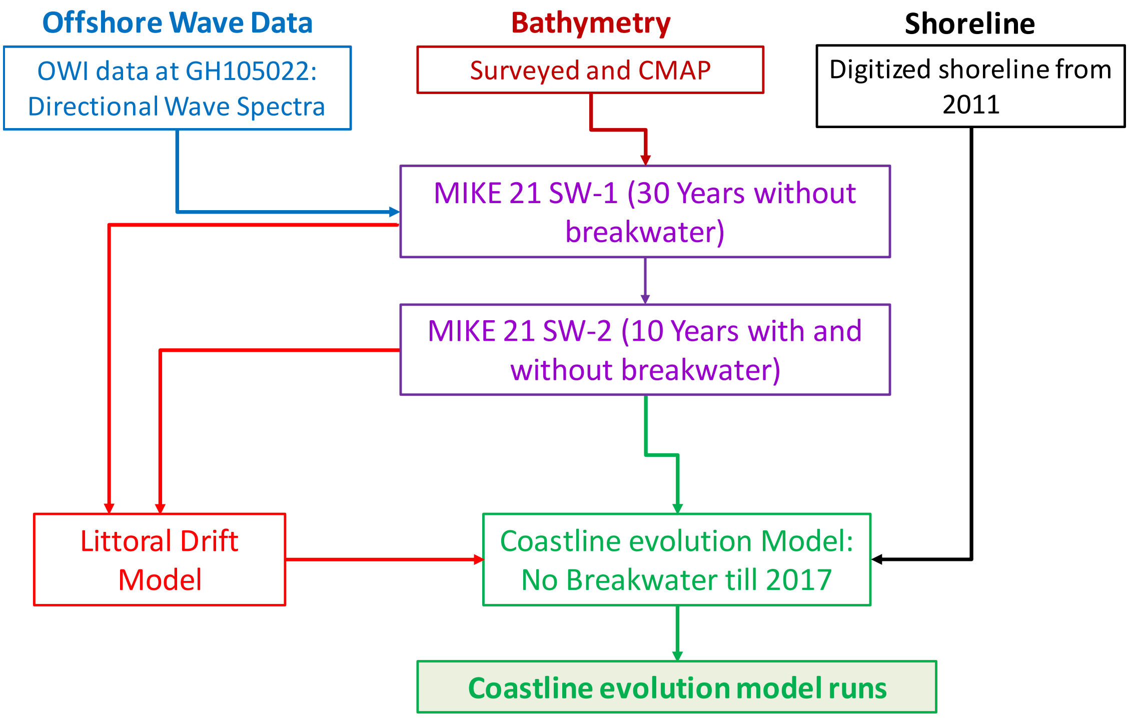
A block flow diagram of the methodology used in this study is shown in Figure 3.2. Wave data at the offshore boundary of the local SW (SW-2) model used in this study (at a depth of about 40 m) is obtained from the MIKE 21 Spectral Wave (SW) model (termed SW-1) explained in [Ref. 2]. The SW-1 model was run for 30 years to generate long term wave data for the existing conditions (without any breakwater). The 30 years were based on offshore wave spectra from the OWI offshore data. Ten years of nearshore wave spectra generated by the SW-1 model is used as offshore boundary for the SW-2 model to simulate the waves along the coastline for the case with and without the proposed breakwater. Details of the model domain for the local SW-2 model is provided later in Section 4.2.

Furthermore, the MIKE 21 SW model used in the present study was calibrated as explained in [Ref. 2].

The other uncertainties addressed in this study are the absence of surveyed beach profiles and sediment samples covering the active sediment zone. Although no recent surveys were available, some additional data from previous studies are used as explained below.

The wave data at a selected location along the coast was used as input to the LITDRIFT model to test the model sensitivity to different input parameters and data. The sensitivity of the LITDRIFT model results to the 10 years selected is studied using data from the SW-1 model. Based on this analysis, certain data and parameters were selected to be used in the LITLINE model.

Figure 3.2 – Flow Chart for Methodology Used in Present Study



3.2 Data

The main data required for the SW model is the bathymetry and the offshore wave conditions. The beach profile, the coastline and the sediment properties are also required for the littoral models.

3.2.1 Bathymetric Data

The bathymetric data used in the MIKE 21 SW model is the same as that used in the previous site selection study [Ref. 1]. For the LITDRIFT and the LITLINE models, the site selection study used an equilibrium beach profile over the surf zone (from shore to depths of 5 m). The equilibrium profile was based on the Dean profile (Dean, 1977) expressed as:

$$h = Ax_o^{2/3} \quad (3\text{-}1)$$

Where h is the depth below Mean Low Water Spring (MLWS), x_o is the distance offshore from the MLWS coastline and A is a parameter for the equilibrium profile determined from the fall velocity according to (Dean, 2002).

Barusseau et al. (1998) provided plots for several beach profiles surveyed every 6 months from June 1989 till Nov. 1991 (as provided in Figure 3.3). The profiles extended over a stretch of about 6.5 km with the southern profile about 2.5 km north of the sand spit location in 1986. Although the surveyed profiles will currently be located at the breach area, the data can provide a guide on the expected beach profile for the study area.

Figure 3.3 – Beach Profiles Provided in Barusseau et al. (1998)

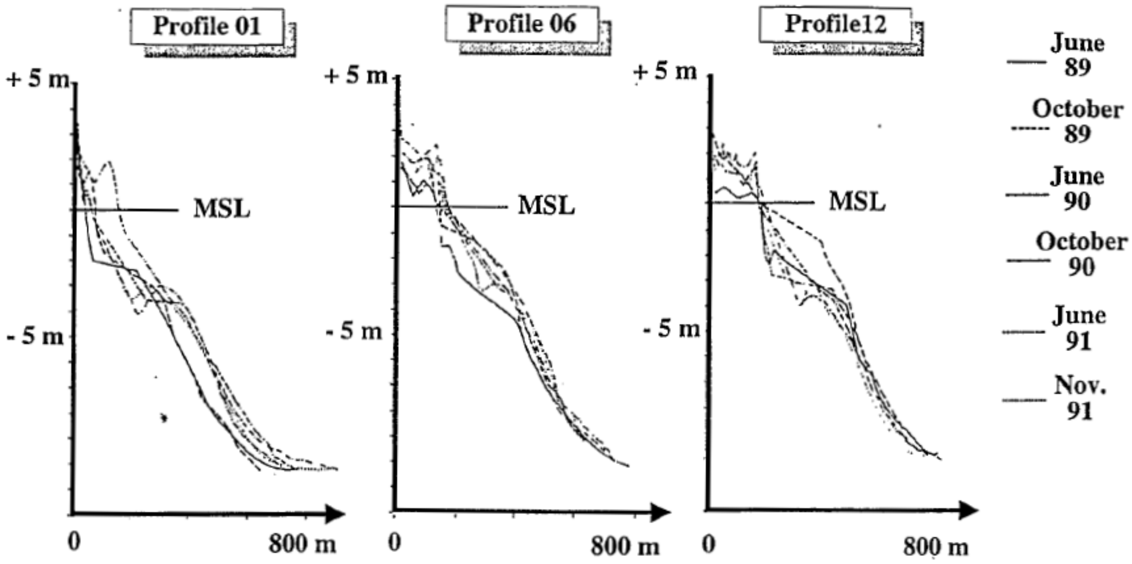


Figure 3.4 provides a comparison of the beach profiles taken in June 1989 at three locations where the cross-shore distance was adjusted to have overlapping profiles at the deeper part of the profiles. It can be seen that in general the beach profiles are composed of three main sections. The first section is the foreshore that is quite steep and the second section extends from a depth of about 1 m to a depth of about 5 m. The last section is from the 5 m till the 10 m depths with a slope steeper than the middle section. An offshore bar was observed at some instances as shown in Figure 3.3.

Figure 3.4 –Beach Profiles Surveyed in June 1989 as Provided in Barusseau et al. (1998)

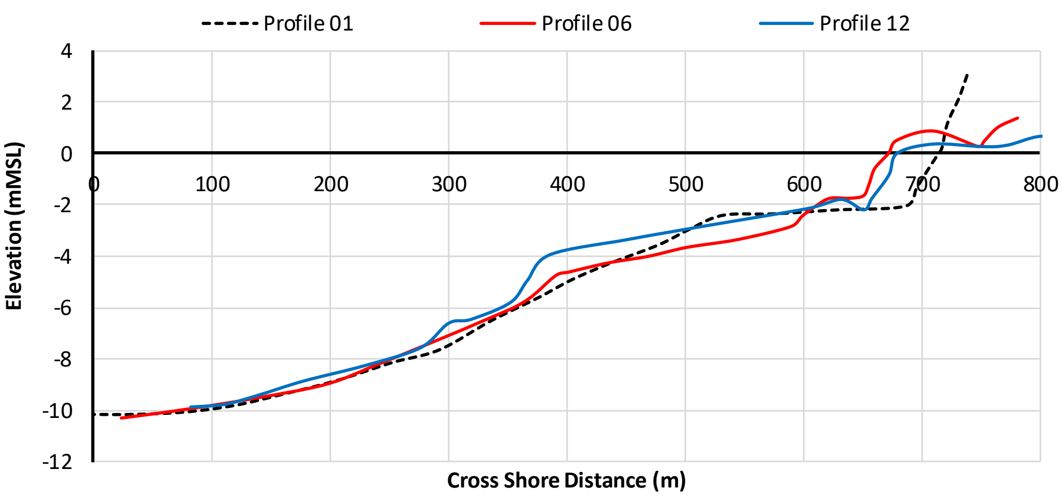


Figure 3.5 provides a plot for several of the profiles shown in Figure 3.3 together with the equilibrium beach profile used in the previous site selection study (based on a mean grain size of D_{50} = 0.2 mm). The equilibrium profile follows some of the measured profiles for the central zone (from depth of 1 to 5 m).

Based on the analysis of the beach profiles, a default beach profile was created by using the equilibrium beach profile till a depth of 5 m and a measured beach profile till a depth of 10 m. This profile is plotted in Figure 3.6 together with one measured beach profile.

The barred beach profile P01_3 shown in Figure 3.5 is also tested in this study.

Figure 3.5 – Equilibrium Profile Previously used and Beach Profiles Provided by Barusseau et al. (1998)

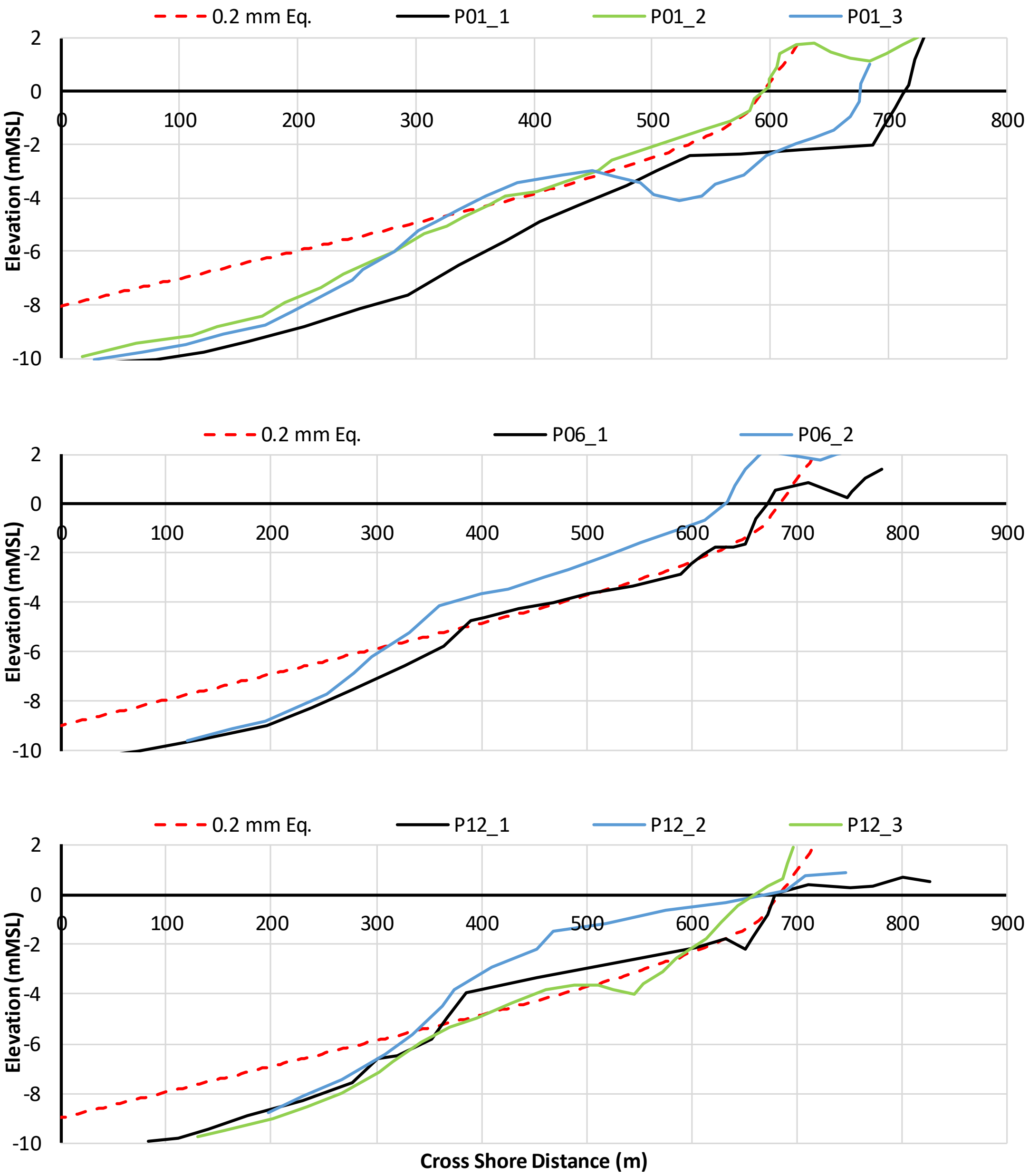
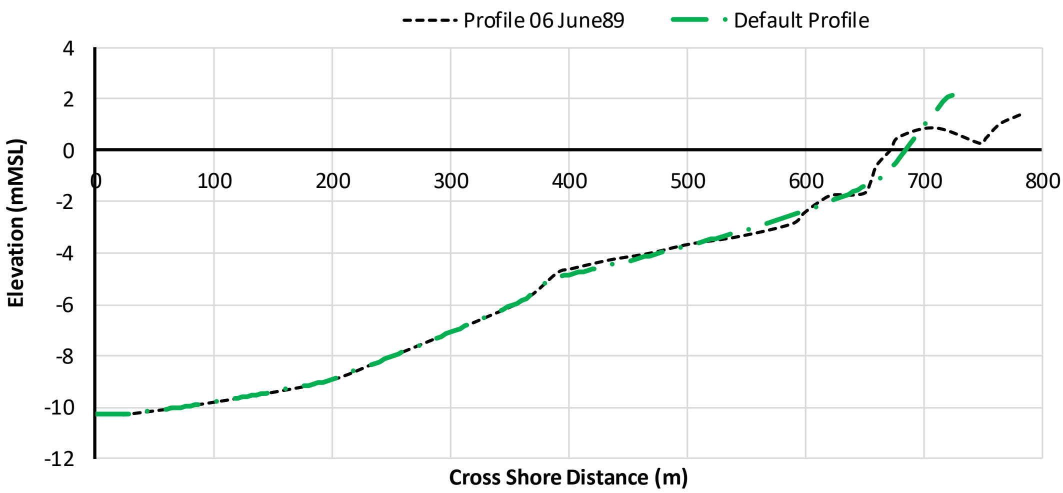


Figure 3.6 – Default Profile Used in Present Study



3.2.2 Offshore Waves

As mentioned earlier, offshore spectral wave data at GH105022 was obtained from OWI. The data covers a period of 38 years starting from Jan. 1979. Thirty years (1987 till 2016) of this data was transformed to the nearshore using a spectral wave model (SW-1). The last 10 years from the wave spectra were extracted at the boundary of the SW-2 model. The SW-2 model was then used to determine the wave conditions along the 10 m depth contour for the case with and without the breakwater at Location D (33 m depth). Details on the offshore wave data and the spectral wave model SW-1 used can be found in [Ref. 2].

3.2.3 Wind Data

Wind data extracted from the Climate Forecast System Reanalysis (CFSR) by the National Centres for Environmental Prediction (NCEP) is used. This data is 2D hourly data for the wind velocity (components in E and N directions) 10 m above the sea surface available from 1979.

3.2.4 Sediment Properties & Sediment Transport

Values from previous studies are used for the sediment size along the coastline and at different depths over a beach profile. The study by (ARCADIS, 2011) used a Median Grain Size (D_{50}) of 0.2 mm to estimate the sediment transport rates at the location of the 2003 breach. They mentioned that this value was based on their field work. They estimated the net sediment transport rates to be 175,000 m^3/year towards the south. This value however was based on calculations that neglected the waves in the direction bin -15 ˚N to +15 ˚N. They also performed sensitivity tests using a D_{50} of 0.3 mm.

In another study [AlDioma et al. 2013], the data presented showed a value for D_{50} ranging from 0.2 mm to 0.33 mm. The spreading ($Sg = \sqrt{D_{84}/D_{16}}$) ranged from about 1.2 to 1.6. Thus, for the site selection study, a conservative value for D_{50} of 0.2 mm was used with a corresponding spreading of 1.2. A sensitivity check was done with D_{50} = 0.3 mm and S_g = 1.6. AlDioma et al. (2013) also reported that the sediment transport rates (including Aeolian transport) based on previous studies ranged from 365,000 m^3/yr to 1,500,000 m^3/yr.

In a recent study (Sadio et al. 2017), the longshore sediment transport rate induced by swell waves was estimated to be 669,000 m^3/year (from north to south). They mentioned that the swell waves contribution is about 89% of the total longshore sediment transport rates.

In the previous site selection study [Ref. 2], using satellite images the estimated net transport rate was found to be between 626,000 to 828,000 m^3/year (towards south).

Barusseau et al. (1998) provided data on sediment properties that covered several of the beach profiles described earlier in Section 3.2.1. The D_{50} and S_g for the data provided in their paper are plotted in Figure 3.7 and Figure 3.8. The data shows that in general for the June 1990 data, D_{50} decreases as bed level decreases. A similar trend for S_g can be observed but with more scatter in the data. The values of D_{50} at the shore are mainly between 0.2 and 0.3 mm similar to other studies.

Figure 3.7 – Sediment Properties for all Results Provided by Barusseau et al. (1998)

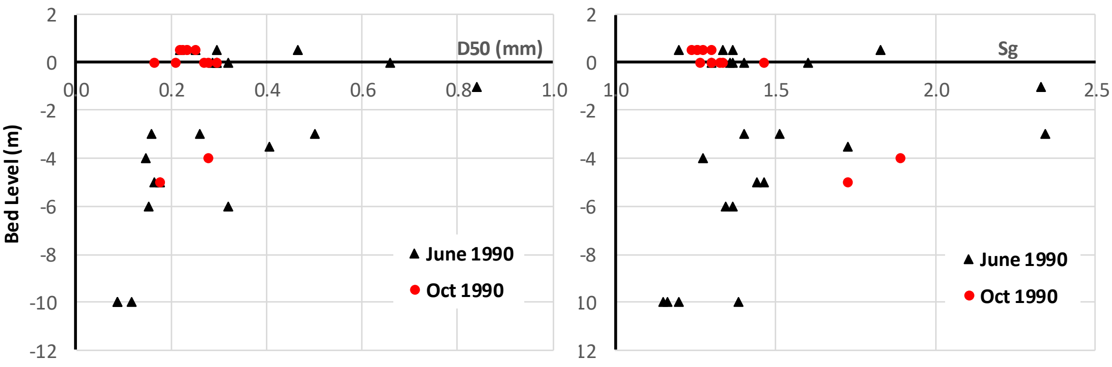
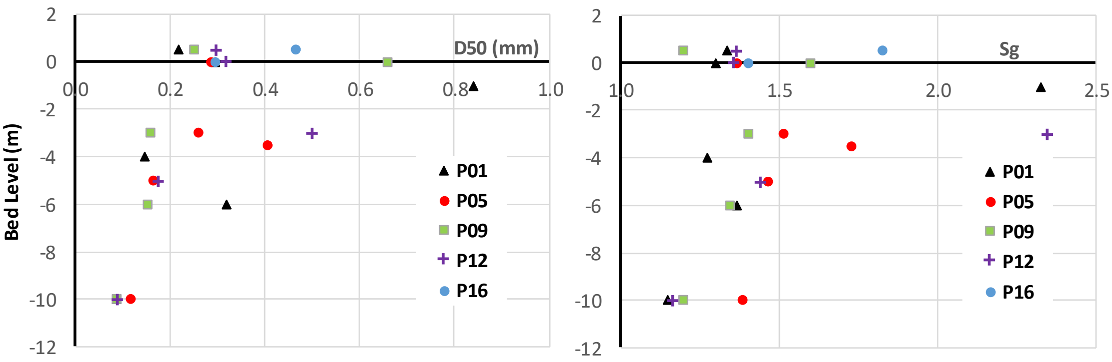


Figure 3.8 – Sediment Properties for all Results Divided According to Profile Provided by Barusseau et al. (1998)

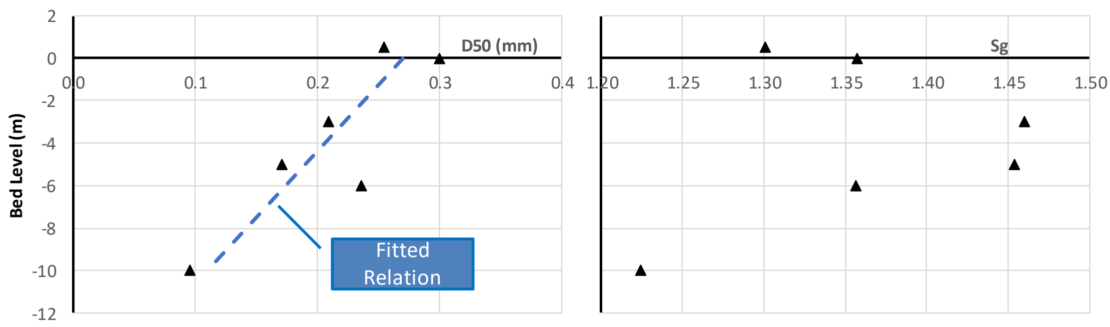


The June 1990 data provided in Figure 3.7 was analysed by first excluding the bed levels where only one sample was available and excluding the extreme samples (with D_{50} > 0.45 mm). Secondly average values for D_{50} and S_g were calculated and the results are provided in Figure 3.9. It can be seen that, the D_{50} decreases with the decrease in bed level. A linear relation was fit resulting in the following:

D_{50}(mm) = 0.016z+0.27, where z is the bed level in m.

For S_g an average value of about 1.4 can be used due to the large scatter in the data.

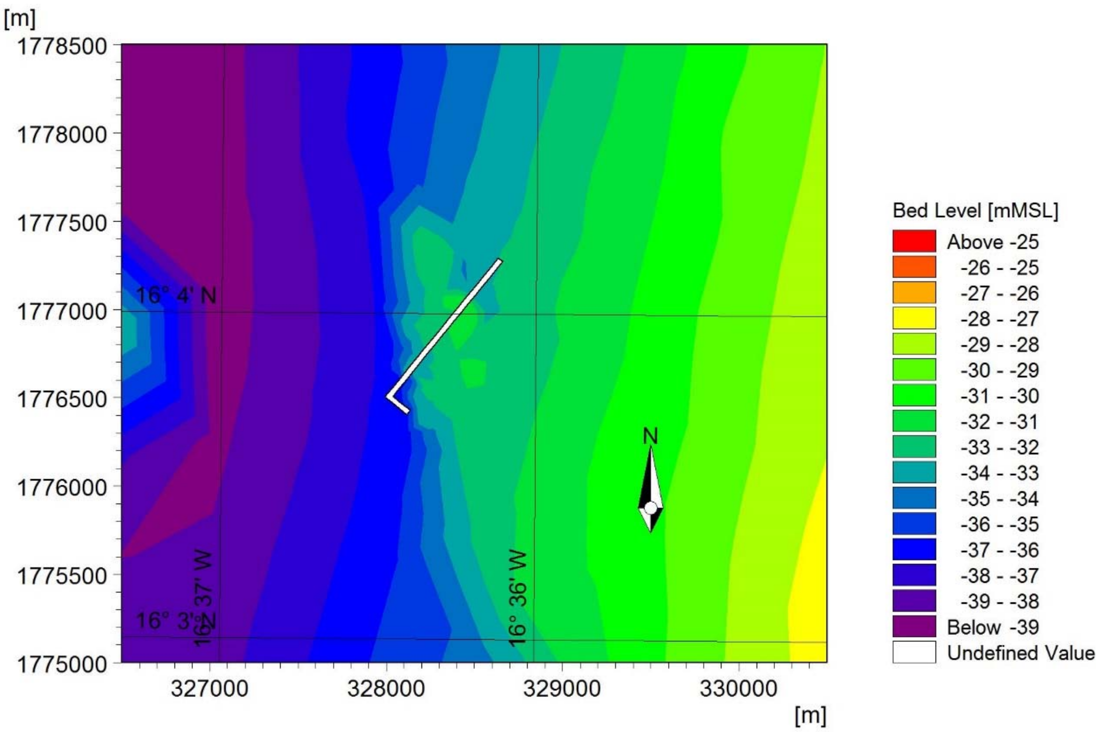
Figure 3.9 – Trend in Sediment Properties Provided by Barusseau et al. (1998)



3.2.5 Breakwater Layout

In this study, the reference breakwater layout shown in Figure 3.10 is used. This breakwater is at the Location D provided in Figure 3.1.

Figure 3.10 – Reference Breakwater Layout used in Present Study



4.0 NEARSHORE WAVE MODEL

Wave data at the toe of the beach profile is required as input to the sediment transport calculations. Thus, a nearshore wave model capable of transforming the offshore wave climate to the toe of the beach profile is required.

4.1 Modelling Software

The wave transformation modelling is conducted using the state-of-the-art MIKE 21 SW FM module of DHI software (version 2017). MIKE 21 SW FM is a third-generation spectral wind-wave module that uses unstructured meshes. The SW model simulates the growth, decay, and transformation of wind-generated waves and swell in offshore and coastal areas. The model accounts for the following physical phenomena:

- Wave growth by action of winds;
- Non-linear wave-wave interaction;
- Wave dissipation due to white-capping, bottom friction, and depth-induced wave breaking;
- Wave refraction and shoaling due to depth variations;
- Wave diffraction;
- Wave-current interaction; and
- Effect of time-varying water depths, including flooding and drying of low-lying land surfaces.

The fully spectral formulation in MIKE 21 SW is used in this study where the directional-frequency wave action spectrum is the dependent variable. This formulation is based on the wave action conservation equation, as described in (Komen et al. 1994 & Young, 1999).

Diffraction is included using the phase-decoupled refraction-diffraction approximation proposed by (Holthuijsen et al. 2003). The approximation is based on the mild-slope equation for refraction and diffraction, omitting phase information.

In a study by Enet et al. (2006), using the Spectral Wave model developed by Delft University of Technology (SWAN) that implements the same method for diffraction, they performed tests for a semi-infinite breakwater. Those tests revealed that the diffraction approximation is adequate for this type of study.

4.2 Model Setup

As mentioned in Section 3.1.2, the SW-1 model was used to generate 30 years of spectral wave data at the boundary of the SW-2 model. The spectral data at a station along the boundary west of the breakwater (E = 325,380 m & N = 1,776,800 m) was applied along the open boundaries.

The mesh for the SW-2 model is shown in Figure 4.1 and Figure 4.2. The mesh size varied from about 1.2 km at the offshore to 30 m around the breakwater. The bathymetric data described earlier was used to interpolate the bed levels at the nodes of the mesh (Figure 4.2).

The SW model was setup with the parameters and options provided in Table 4.1. These parameters are based on the model calibration as explained in [Ref. 2].

Figure 4.1 – Flexible Mesh Used in SW-2 Model

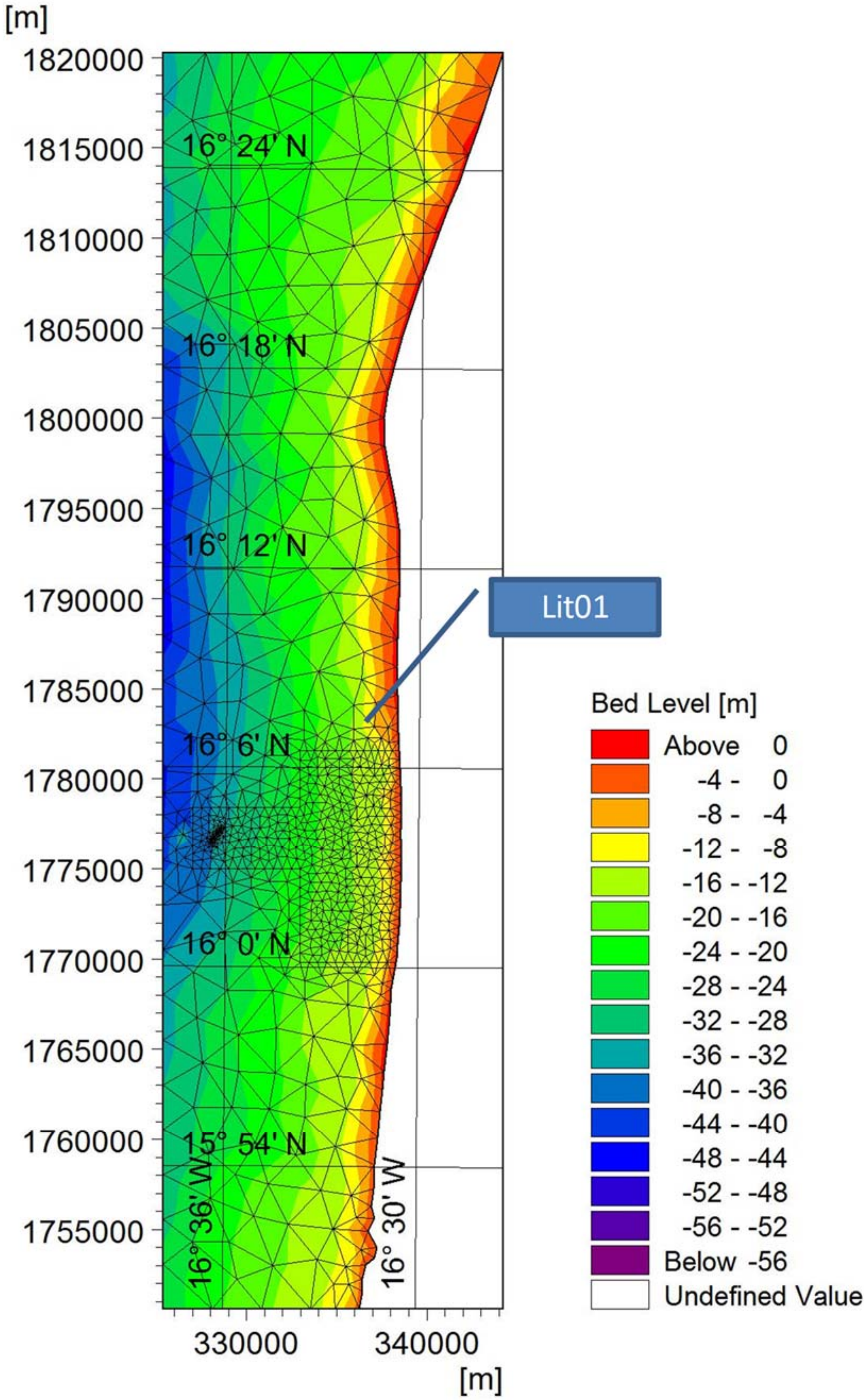


Figure 4.2 – Flexible Mesh in Vicinity of Breakwater

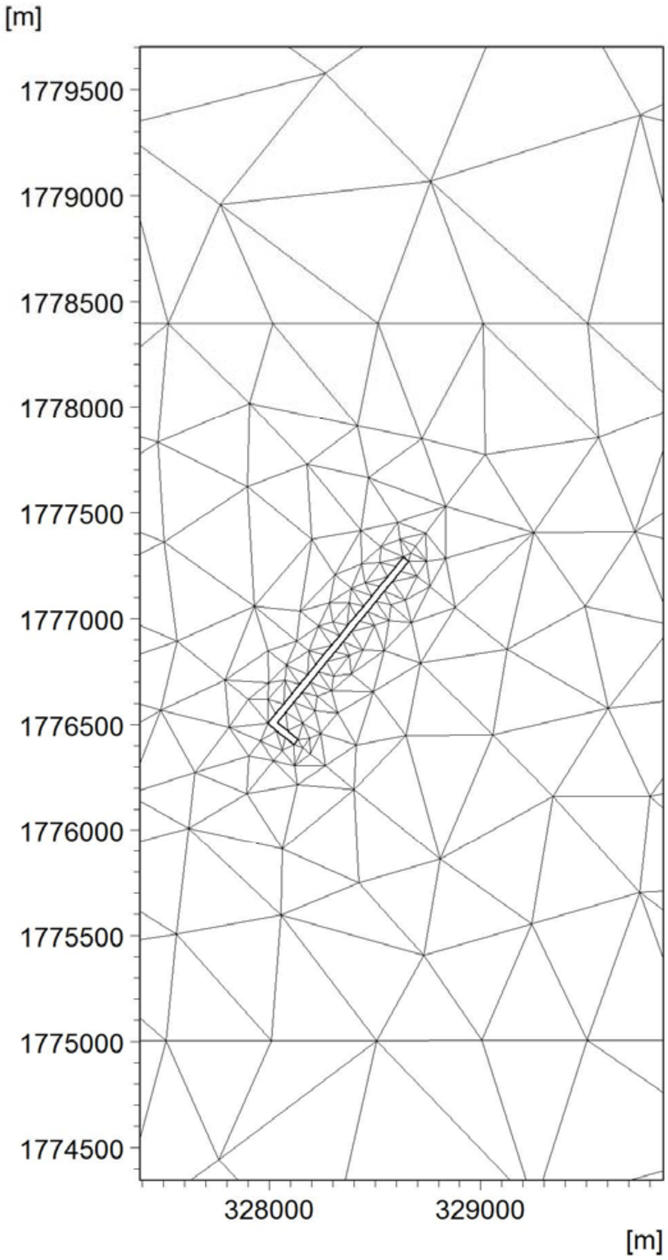


Table 4.1 – Setup and Parameters Used in SW Model

Parameter	Setting
Basic Equations	Spectral: Fully Spectral Time: in-stationary
Spectral Discretisation	Number of Frequencies: 28 Minimum Frequency: 0.028 Hz Frequency Factor: 1.1 Number of Directions: 24
Solution Technique	Low order, fast algorithm
Water Level Condition	MSL
Current Conditions	No Currents
Wind Forcing	2D CFSR wind

Parameter	Setting
Diffraction	Included
Energy Transfer	Quadruplet-wave interactions included
Wave Breaking	Gamma (constant): 0.8 Alpha: 1
Bottom Friction	Nikuradse roughness (constant) kn: 0.001 m
White Capping	Dissipation coefficient 1, C_{dis} (constant): 4.5 Dissipation coefficient 2, δ_{dis} (constant): 0.5
Boundary Conditions	2D wave spectra specified along all open boundaries

4.3 Model Results

Figure 4.3 provides a sample of the model results during a storm event where the sheltering from the breakwater is clear. This sheltering is further elaborated by plotting different wave parameters along the 10 m contour as provided in Figure 4.4.

A wave rose at a station (Lit01 shown in Figure 4.1) along the 10 m contour (E = 336,790 m and N = 1,784,400 m) is provided in Figure 4.5 (case without breakwater). It can be seen that the wave rose is similar when the Peak Wave Direction (PWD) or the Mean Wave Direction (MWD) is used at this location. It is clear from Figure 4.5, that the predominant waves will transport sediment from north to south. The wave rose at Lit01 from the previous site selection study (based on transformation of wave parameters) is shown in Figure 4.6. It can be seen that the wave rose based on the transformation of wave parameters using the PWD provided results close to those from the fully spectral model with 2D wave spectra imposed at the offshore boundary. The following differences can be observed:

- The percentage of waves from 315˚ N is less for the present study compared to the site selection study. This is likely to result in reduced longshore sediment transport rates with the present study, and
- The percentage of waves from the South West quadrant is smaller for the present study.

Figure 4.3 – Sample Result for SW-2 Model

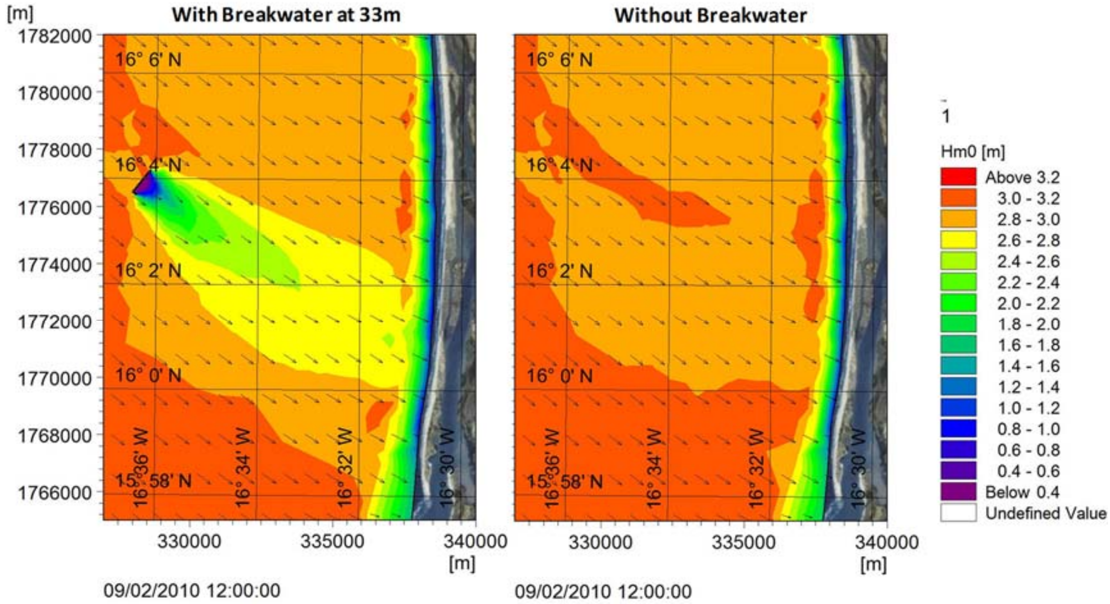


Figure 4.4 – Variation of Wave Parameters along Area of Interest With and Without Breakwater (during storm event with: H_{m0} = 3 m, T_p = 17 s at SW-2 boundary)

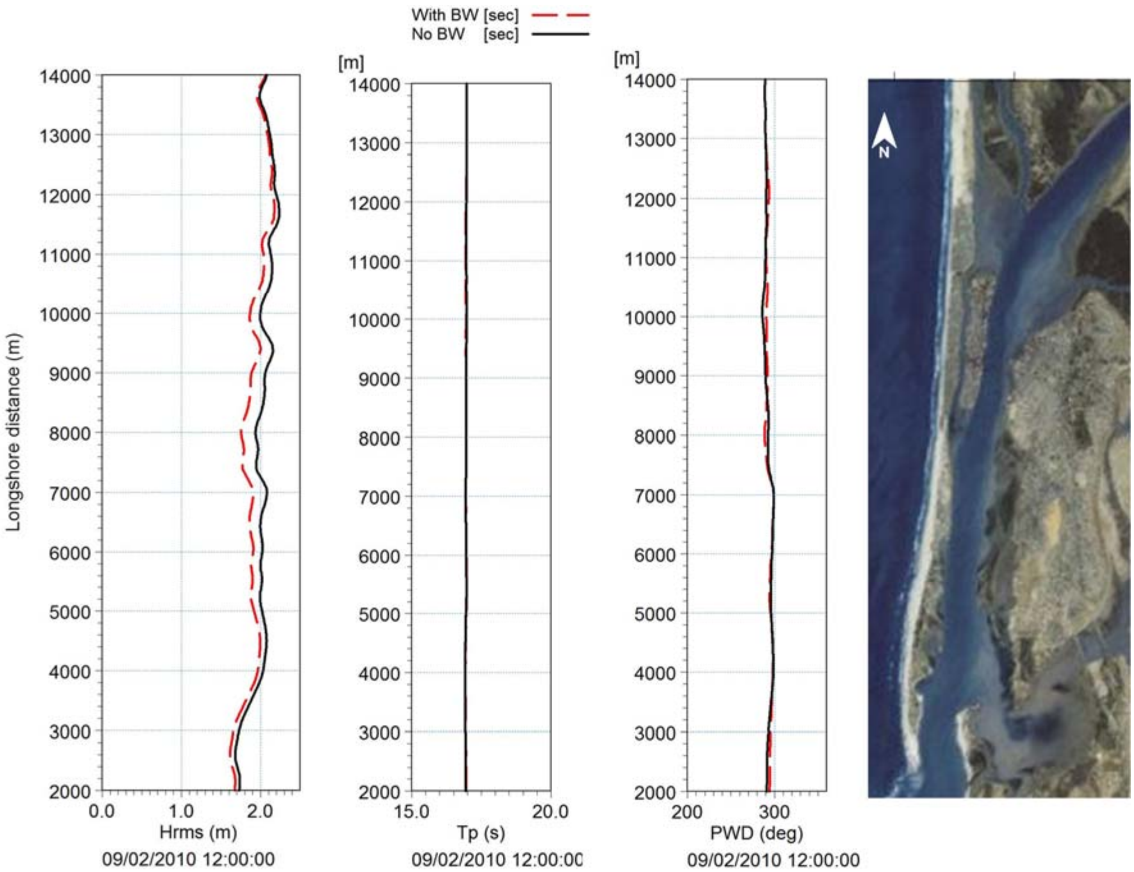
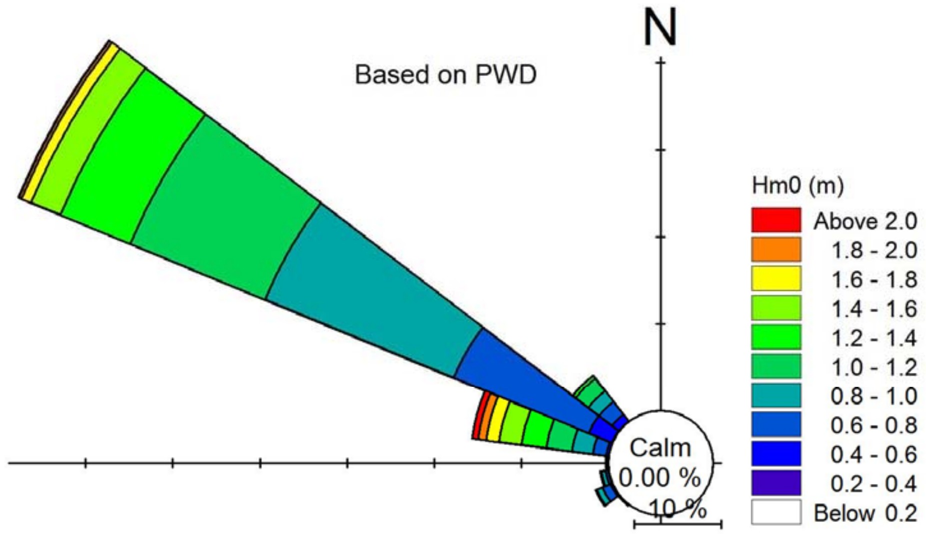


Figure 4.5 – Sample of Wave Rose at Location Lit01 along 10 m Contour



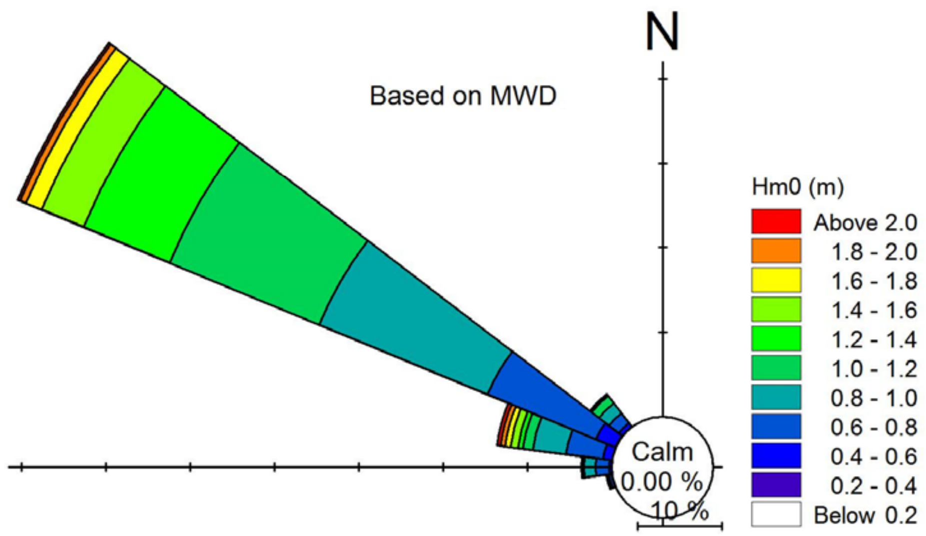
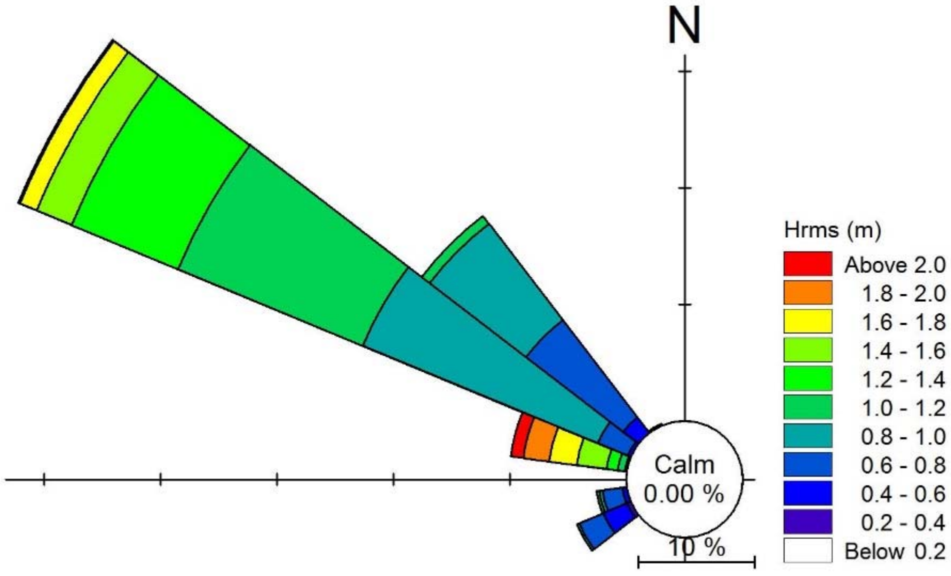


Figure 4.6 – Wave Rose from Previous Site Selection Study at Location Lit01 along 10 m Contour



Notes:

1. Based on PWD

5.0 LONGSHORE SEDIMENT TRANSPORT

The longshore sediment transport rates provide insight on the dynamics of the nearshore area with respect to sediment movement.

5.1 Modelling Software

The Littoral Processes FM model developed by DHI Water and Environment is utilized. The Littoral Processes model is an integrated modelling system that simulates non-cohesive transport and coastline evolution. The LITDRIFT module calculates the cross-shore distribution of wave height and direction, the related wave driven currents and littoral drift for one or several individual cross-shore profiles based on wave conditions at the toe of the profile. LITDRIFT is used to determine the annual net and gross alongshore sediment transport rates along the project coastline.

5.2 LITDRIFT Model Setup

5.2.1 Beach Profile

The default beach profile used in this study is the profile shown in Figure 3.6. The beach profile is assumed to make an angle of 270 with the North (angle of normal to shore with north in clockwise direction). In some of the LITDRIFT model runs, the equilibrium beach profile used in the previous site selection study and shown in Figure 3.5 was used (to compare values with previous study). Other beach profiles as the barred profile P01_3 shown in Figure 3.5 were also used for the sensitivity tests.

5.2.2 Wave Input

The H_{m0} values were converted into H_{rms} wave heights assuming a Rayleigh distribution for waves (H_{rms} used with the Battjes and Jansen wave breaking model in LITDRIFT).

5.2.3 Additional Parameters

The bed roughness height can be used as a calibration factor if accurate measured data is available for the sediment budget. In the previous site selection study [Ref. 1], value of Kn = 0.01 m was found to produce a net Sediment Transport Rate (Qs) close to the estimate based on historic coastline changes and published data. This value together with other options previously used are maintained in this study as provided in Table 5.1.

Table 5.1 – Setup and Parameters used in LITDRIFT

Parameter	Setting
Water level	MSL
Current	No currents
Bed resistance	Roughness height Kn = 0.01 m
Wave model used	Battjes and Jansen (gamma = 0.8)
Wind Forcing	No wind
Sediment properties	Graded sand
Bed parameters	Ripples included
Wave theory	Linear waves
Bed concentration method	Deterministic

5.3 LITDRIFT Results

The sensitivity of the sediment transport rates to different parameters are studied to quantify the impact of using more accurate wave data and to identify the most suitable input to be used in the LITLINE model. The following is tested:

- Sensitivity to the wave data where different periods of 10 year are tested and a comparison with the previous site selection study,
- Sensitivity to coast orientation, and
- Sensitivity to beach profile and grain size.

5.3.1 Sensitivity to Wave Data

The effect of the wave data on the sediment transport rates (Qs) is tested using wave data at the 10 m contour for a location where the coastline orientation was 270 deg (at Location Lit01). The bed sediment parameters are specified as D_{50} = 0.2 mm and S_g = 1.2 in these simulations to be consistent with the site selection study. Similarly, the same 0.2 mm equilibrium profile (Figure 3.5) is used as in the site selection study. The sediment transport results are summarized in Table 5.2.

To study the variability in the sediment transport rates over different 10 year intervals, the data from the SW-1 model is used (SW-2 covered only 10 years). The choice of the 10 year period (within the 30 years simulated) only changes the model results by a maximum difference of 6% of the results obtained using the full 30 years (see Table 5.2). The last 10 years provide results for Qs close to those predicted for the full 30 years (within 3%). These 10 years are used in the LITLINE model. It should be noted that the results from the SW-1 model and the SW-2 model produced close results at Location Lit01(difference of 10% in net Qs).

The results provided in Table 5.2 show that the use of the more accurate wave data (as compared to that used in the site selection study) resulted in lower Qs values. Thus, it would be expected that the site selection study results would be slightly more conservative.

Table 5.2 – Summary of Impact of Wave Data used on Net and Gross Qs

Wave Data	Net Qs (m^3/yr)	Gross Qs (m^3/yr)
Wave data from previous site selection study	-570,700	587,700
SW-1 Model: 1987 till 1996	-452,100	466,700
SW-1 Model: 1997 till 2006	-415,100	424,000
SW-1 Model: 2007 till 2016	-418,100	427,400
SW-1 Model: 1987 till 2016	-428,400	439,400

Notes: -ve value for Net Qs is from North to South

5.3.2 Sensitivity to Coast Orientation

The above calculations were conducted using a coast orientation (Alpha) of 270 degree. The actual coastline changes its orientation along the study area and the coastline orientation will also change with time if coastline changes take place. It is thus useful to study the variation in Qs for different Alpha values (Q-Alpha relation).

Figure 5.1 provides a Q-Alpha relation where it can be seen that Qs changes considerably for a change in coastline orientation within 10 degrees. Figure 5.1 also shows that the equilibrium coast orientation (coast orientation for net Qs = 0.0) is about 294 degree. The equilibrium coast orientation is the orientation the coastline will reach just updrift a long groin (where no sand by-passing occurs).

The sediment transport rates are lower than those estimated in the site selection study as shown in Figure 5.2. The equilibrium coast orientation however, is nearly the same (294 instead of 295 degree) as shown in Figure 5.2.

Figure 5.1 – Q-Alpha Relation

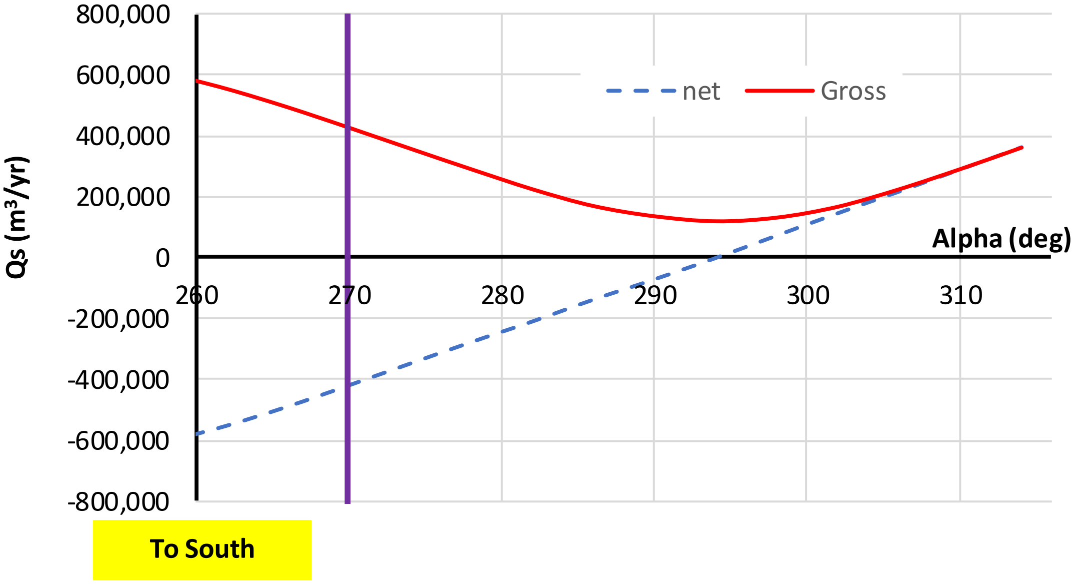
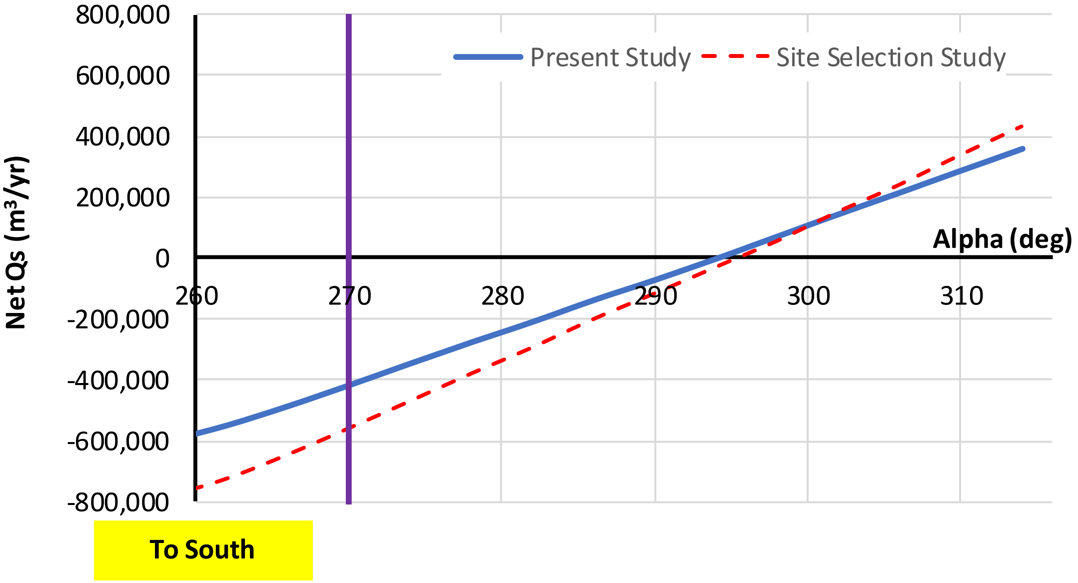


Figure 5.2 – Comparison of Q-Alpha Relation for Present Study with that from Site Selection Study



5.3.3 Sensitivity to Beach Profile and Sediment Properties

The sensitivity of the LITDRIFT model to the beach profile and the sediment properties was tested. The wave data at Lit01 for the years 2007 till 2016 are used. The following settings for the beach profile and sediment properties were tested:

- Default beach profile (Figure 3.6) with D_{50} = 0.2 mm and S_g=1.4
- Barred Beach Profile with D_{50} = 0.2 mm and S_g=1.4
- Default Profile with Varying D_{50} and S_g = 1.4
- Barred Beach Profile with Varying D_{50} and S_g = 1.4

The sediment transport results are shown in Table 5.3. The barred beach profile (P01_3 shown in Figure 3.5) results in a significant reduction in Qs. Such a barred beach profile would develop under storm conditions and would reduce the longshore drift during such seasons. A variation in the beach profile along the study area will result in changes in Qs affecting the shoreline changes. This conclusion emphasizes the importance of long term monitoring of the beach profiles along the study area.

Introducing a variation in the values of D_{50} over the beach profile as explained in Section 3.2.4 (and using S_g = 1.4), results in a further reduction in Qs.

For the LITLINE model, a constant D_{50} of 0.2 mm is used with a value of S_g=1.4. The default beach profile shown in Figure 3.6 is also used.

Table 5.3 – Sensitivity of LITDRIFT to Beach Profile and Sediment Properties

Case	Net Qs (m^3/yr)	Gross Qs (m^3/yr)
Default	-416,000	425,200
Barred Beach Profile	-241,200	246,300
Default Profile with Varying D_{50} and S_g = 1.4	-336,000	345,500
Barred Beach Profile with Varying D_{50} and S_g = 1.4	-207,700	213,000

6.0 COASTLINE EVOLUTION MODEL

A coastline evolution model based on the one-line concept was used in the site selection study. The breakwater location D was selected based on the predicted impact on the coastline. This model is used to study the potential impact of the breakwater at location D using more accurate wave data as described earlier.

6.1 Modelling Software

The coastline evolution module of the Littoral Processes FM model developed by DHI Water and Environment is utilized. The LITLINE module calculates the coastline evolution for a coastline with one or several representative cross-shore profiles. The LITLINE model is based on the one-line approximation that assumes the beach profile does not change over the simulation period. Thus, any gradient in the longshore sediment transport rate along the coastline will cause coastline changes. The height of the beach profile d_c is the sum of the closure depth and the berm height. The model results will not include any shoreline changes due to cross-shore sediment transport. Given that any proposed breakwater would reduce the incident wave conditions in the shadow of the breakwater, it is not expected that the breakwater would have a negative impact on erosion due to cross-shore processes.

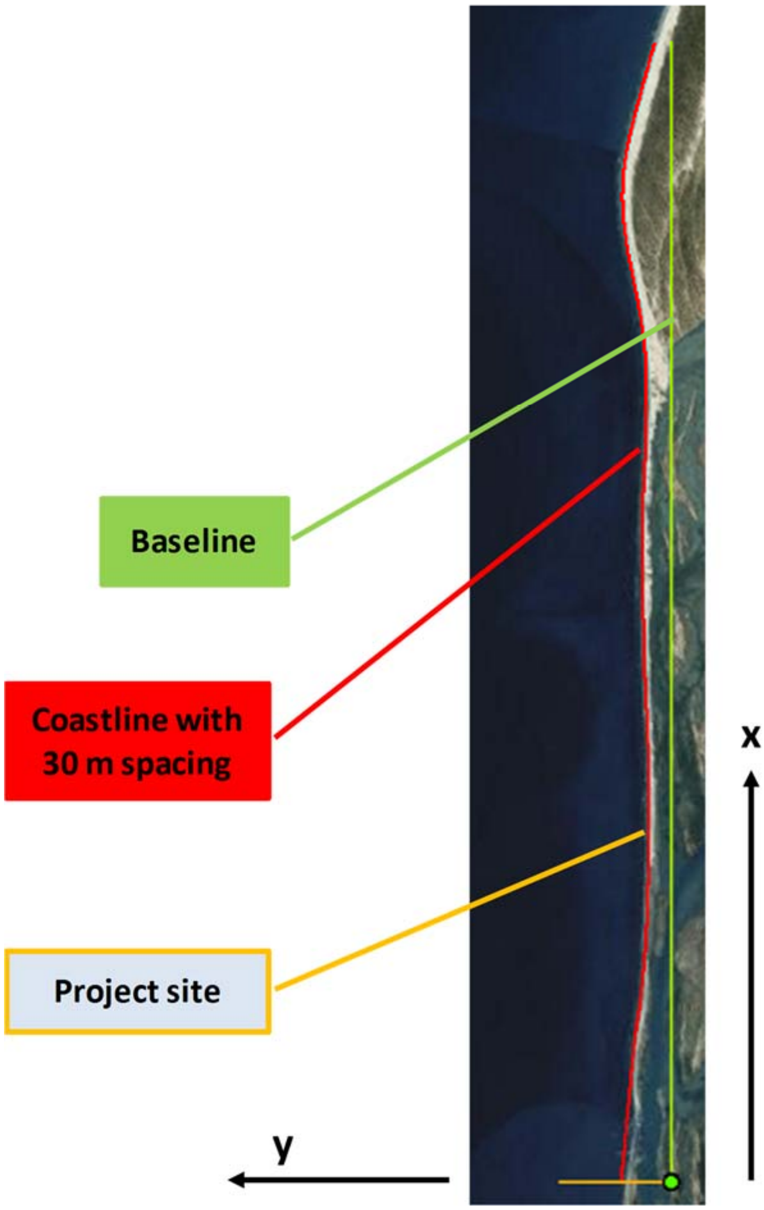
The impact of Sea Level Rise (SLR) on coastline erosion is not included since the impact of a proposed breakwater relative to the do nothing option is studied. SLR would increase the erosion for the case with and without the breakwater.

6.2 LITLINE Model Setup

The same 40 km coastline stretch used in the site selection study is used. The baseline of the model was taken to be aligned with the South North direction. The coastline location is measured relative to the baseline (y) with a spacing of 30 m along the alongshore (x) direction. The beach profiles used in the LITDRIFT calculations were also used in this model. The default setup uses the same beach profile and sediment properties over the 40 km simulated (due to the absence of data).

Prior to the coastline evolution simulation, transport tables were generated to be used for the sediment transport calculations. These tables were generated using the same parameters used in the LITDRIFT model.

Figure 6.1 – Setup of Coastline Evolution Model



6.2.1 Model Boundaries

The southern boundary of the model is at a very complex location where the sand spit moves to the south. This boundary was assumed to be open since most of the transport is from North to South and sand exiting will deposit south of the boundary (at the river mouth). The mechanisms in the vicinity of the river mouth are very complex, and depends on the interplay between tidal flow, river flow and breaking waves induced longshore sediment transport. The model however, cannot predict the coastline changes accurately in this complex area. A 2D model would be required to model the dynamics of such a complex spit. Some sensitivity tests for different downdrift boundaries were conducted in the site selection study [Ref. 1]. These tests showed that, the downdrift boundary used has a minor impact on the model results in the study area.

No sediment supply is assumed at the river mouth since most sediment discharged at the river mouth would be expected to move towards the south. Furthermore, any sediment supply should reduce any possible coastline erosion of the beaches and thus the present setup would be more conservative.

The northern boundary was also assumed to be open and this boundary was taken at a section where the coastline was relatively straight and far away from the area of interest. Thus, it is expected that this boundary will have no influence on the model results in the study area.

6.2.2 Other Setup Parameters

The LITLINE model was run for 6 years using the 2011 coastline as the initial coastline. The resulting coastline was then used as the initial 2017 coastline for all the cases studied. This model warmup was required to remove any coastline oscillations instead of smoothing the initial coastline.

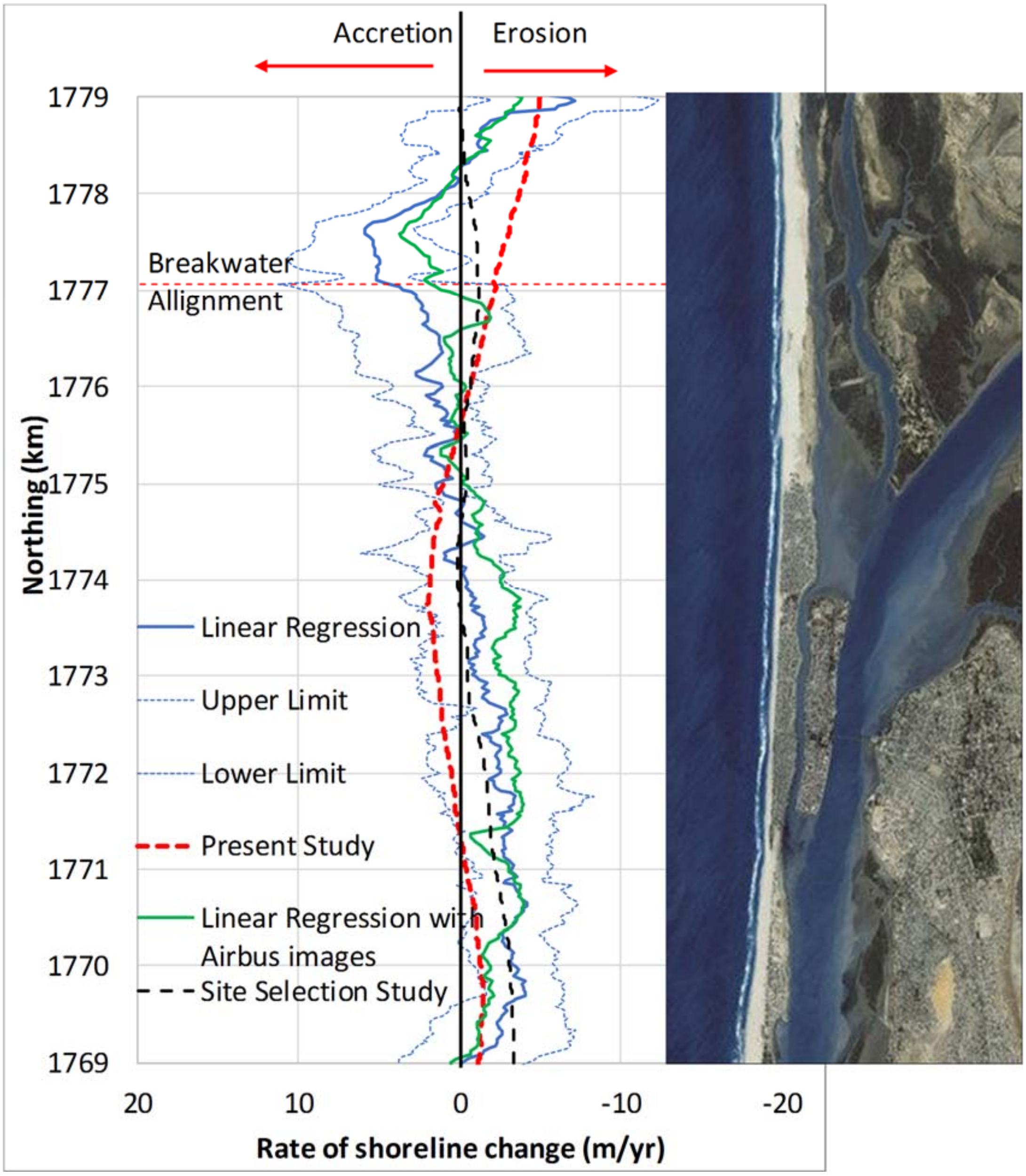
The wave conditions (H_{rms}, T_p and DWD) were provided along the 10 m depth contour with a spacing of 30 m.

6.3 Model Validation

The results from the LITLINE model were used to validate the trends predicted by the model. The LITLINE model was run for a period of 10 years and the yearly rates of coastline changes were estimated. Figure 6.2 shows that within the study area, the model predicts the observed coastline trends (from coastline change analysis) reasonably well along some sections. These results are satisfactory given the data available along the study area. No improvement was obtained by using the more accurate wave data as compared to the site selection study (also shown in Figure 6.2). Thus, the simpler wave model used in the site selection study was reasonable.

The discrepancies between the present model and the observed coastline trends could be due to spatial variation of the beach profile and sediment properties along the modelled area - but no data is available to assess this variation. The sediment transport rates were shown earlier to be sensitive to the beach profile. Sensitivity analysis to the effect of varying the beach profile or the sediment properties along the modelled reach is provided in Section 6.4.1.

Figure 6.2 – Comparison of Measured and Modelled Coastline Change Rates



6.4 Model Results

Figure 6.3 provides the shoreline changes predicted over 10 years for the case with and without the reference breakwater. It can be seen that the potential impact of the breakwater as compared to the case without the breakwater is small (< 1 m/year). A positive impact (accretion) is predicted along most of the developed coastline. The impact from the breakwater is due to the reduction in the sediment transport rates caused by the breakwater as shown in Figure 6.4.

The maximum change in the 10 year coastline as compared to the case without a breakwater is shown in Figure 6.5. The model results show that, most of the impacted area will experience accretion and the changes are lower than those predicted in the site selection study.

Figure 6.3 – LITLINE 10 Year Coastline along Study Area for Case with and without Breakwater

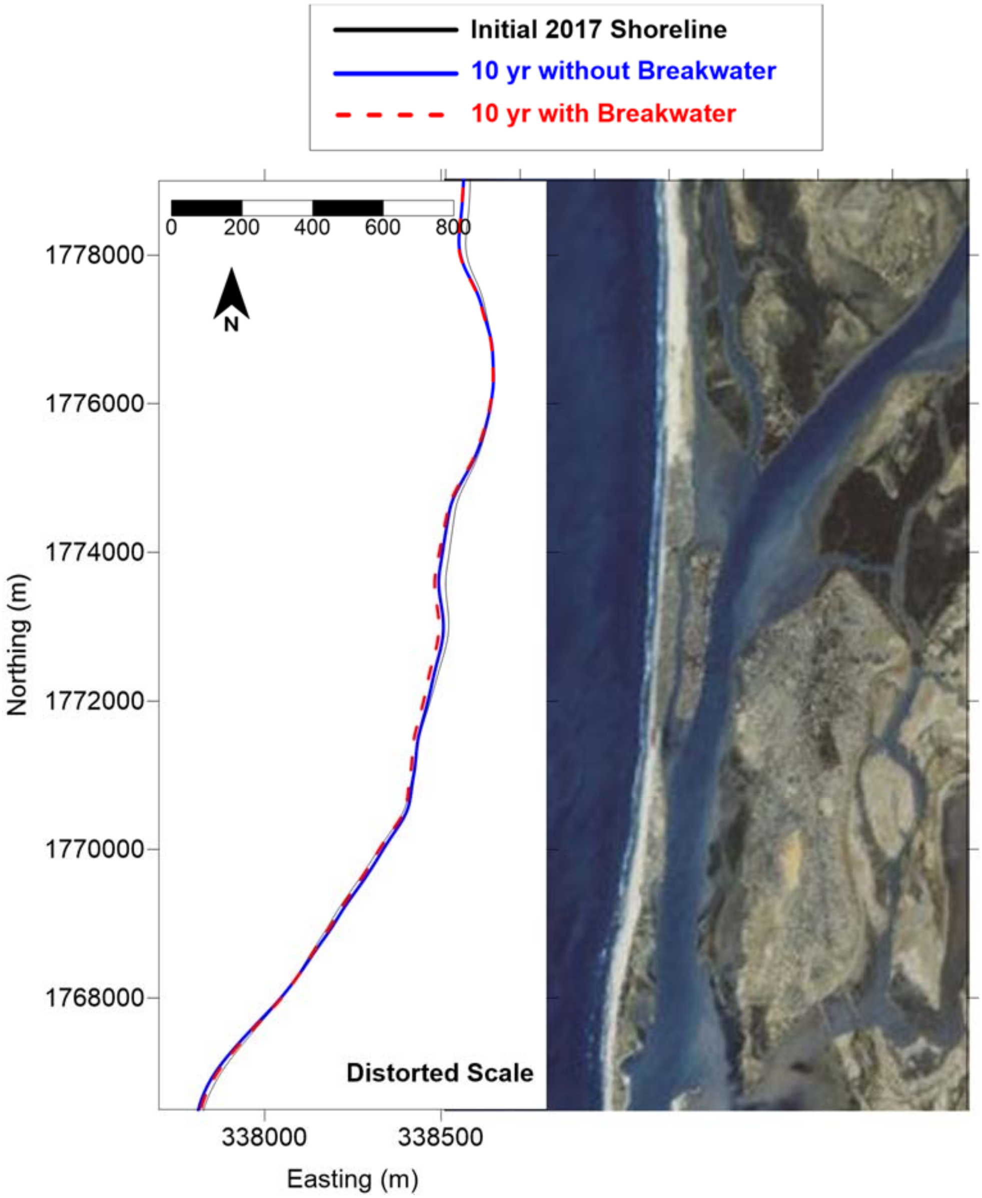


Figure 6.4 – Net Qs along Study Area for Case with and without Breakwater

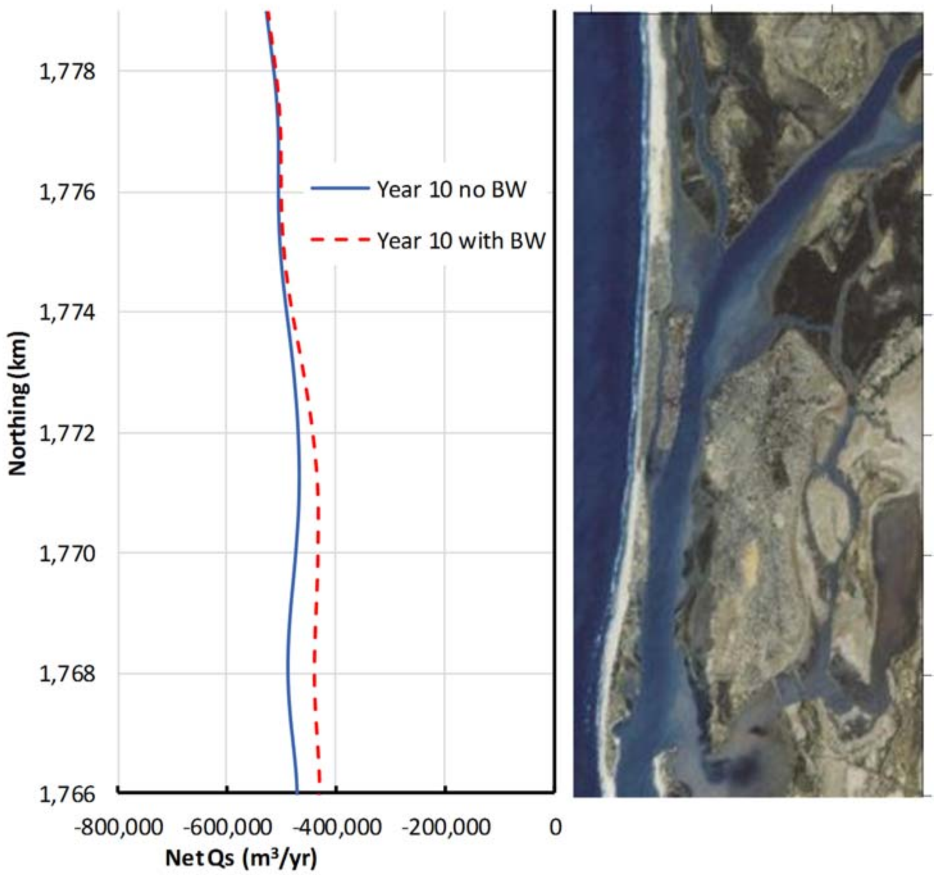
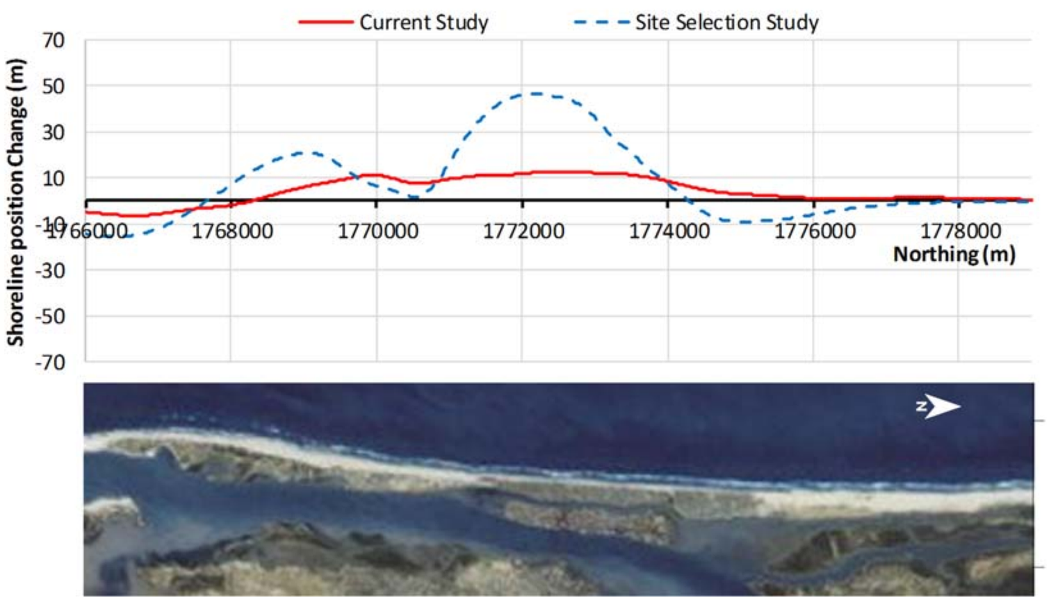


Figure 6.5 – 10 Year Change in Shoreline Position Relative to Case Without Breakwater



The maximum change in erosion (as compared to the case without a breakwater) for this case is predicted to be 6 m over 10 years. This increase in erosion rate is small compared to the observed natural variations in the coastline that can reach 5 m/yr (see Figure 6.2). Furthermore, this increase in erosion is close to the breach as shown in Figure 6.5.

6.4.1 Sensitivity Analysis

Due to the lack of data on the spatial variation in D_{50} and the beach profile over the modelled domain, sensitivity tests were conducted. Two cases were simulated:

- Case 1: The value of D_{50} was taken as 0.3 mm for the reach north of N=1774400 and 0.2 mm for the rest of the model domain.
- Case 2: The barred beach profile (P01_3 shown in Figure 3.5) is used for the reach north of N=1774400 and the default profile for the rest of the model domain.

It can be seen from Figure 6.6 and Figure 6.7, that the model results are quite sensitive to a variation in D_{50} or the beach profile along the coastline (compare results to Figure 6.2).

Figure 6.6 – Comparison of Measured and Modelled Coastline Change Rates with Variation in D_{50} Over Coastline (Case 1)

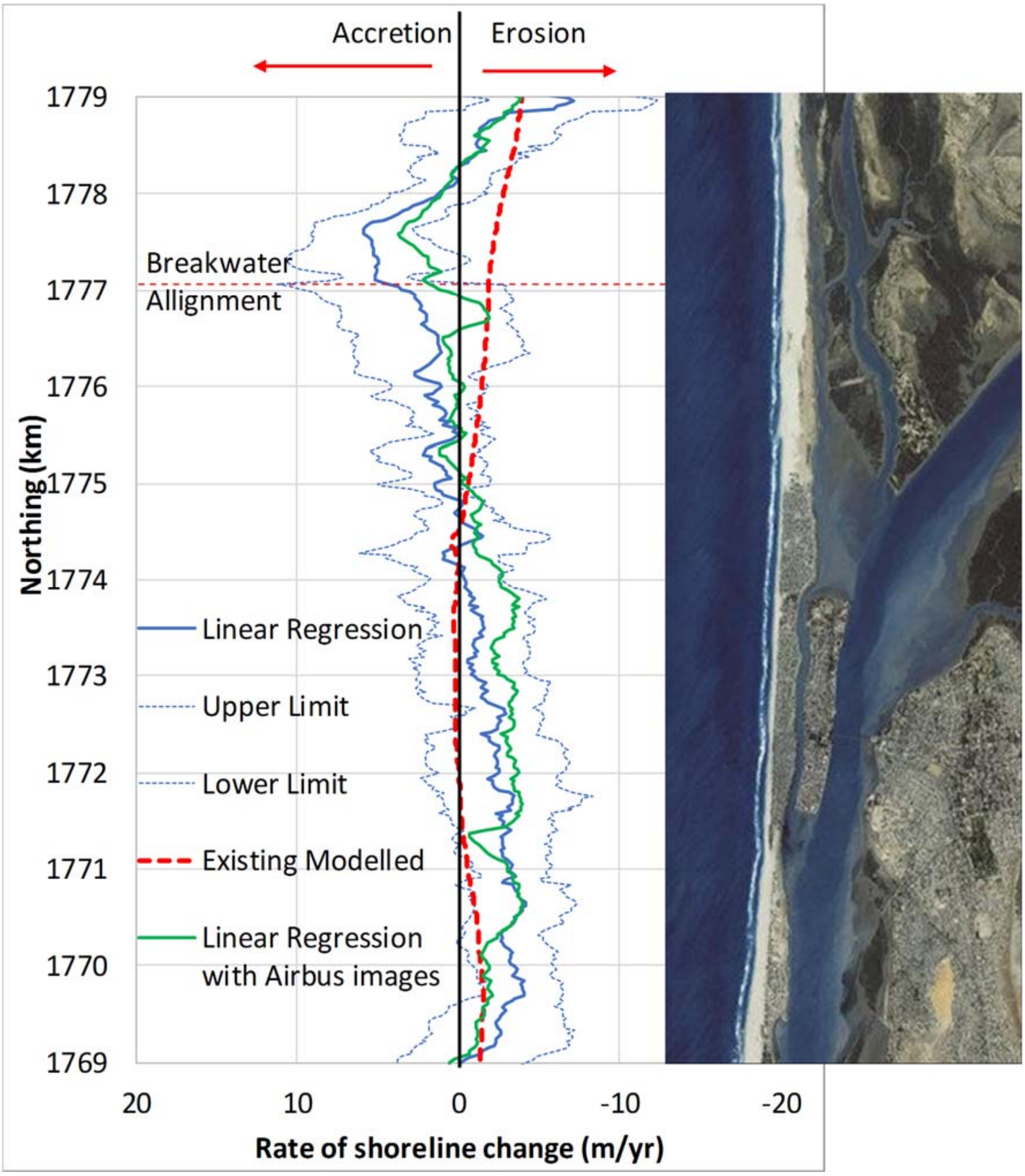
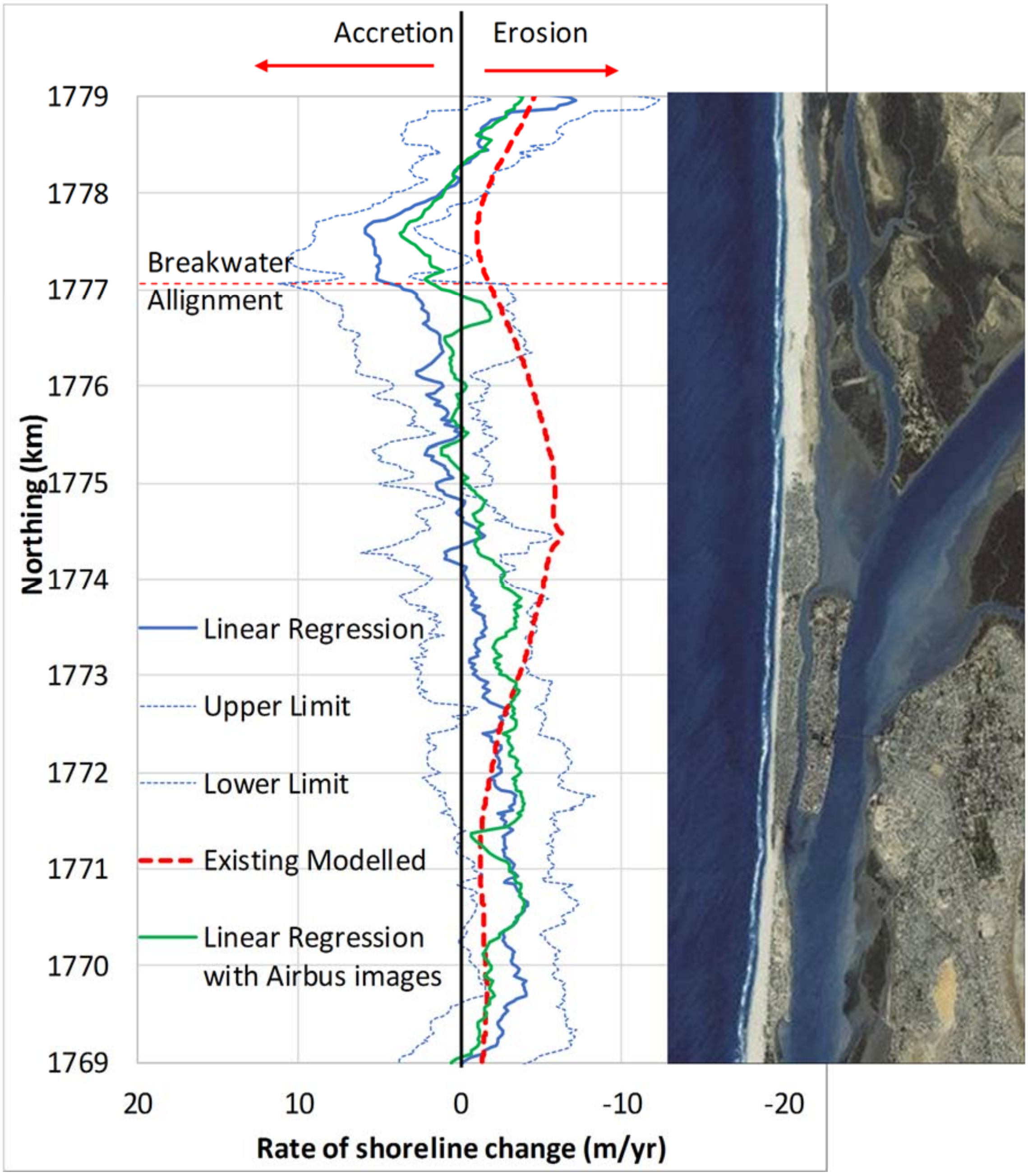
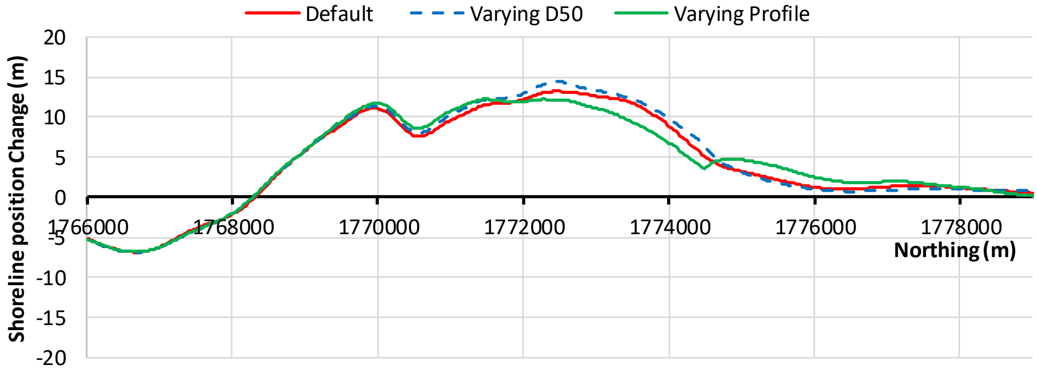


Figure 6.7 – Comparison of Measured and Modelled Coastline Change Rates with Varying Profile Over Coastline (Case 2)



Although the shoreline changes for these different cases are significant, the relative effect of including the breakwater is not that sensitive as shown in Figure 6.8. In Figure 6.8, the case with a breakwater is compared to the corresponding case without a breakwater (run with and without breakwater with the same variation in D_{50} or beach profile). This conclusion will provide confidence in the conclusion that the proposed breakwater is not expected to have any negative impact on the coastline at the project site.

Figure 6.8 – Sensitivity of Change in Shoreline Position Relative to Case Without Breakwater (10 Year Simulation)



7.0 CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

7.1 Summary

The potential impact of the reference breakwater on the coastline stability, is studied using a coastline evolution model. Ten years of offshore spectral data was transformed to the 10 m depth contour using the MIKE 21 SW model. This wave data was extracted every 30 m along the coastline to resolve the change in wave climate induced by the proposed breakwater.

The sediment transport rates were estimated using the LITDRIFT model and sensitivity analysis to different parameters was conducted.

The coastline changes were modelled using LITLINE model for the case with the breakwater. The results from these simulations were compared to the results for simulations without any breakwater (do nothing) to determine the impact of the proposed breakwater.

Some sensitivity analysis for the LITLINE model is conducted to account for the lack of data on the variation of the beach profile and sediment properties along the modelled reach.

7.2 Conclusions

The LITDRIFT results showed that using the more accurate wave data resulted in a reduction in the net sediment transport rates by about 25 % as compared to the site selection study. The more accurate wave data did not result in an improvement in the LITLINE model validation. The potential impact of the proposed breakwater is slightly lower as compared to the previous site selection study.

The LITLINE model results showed that for the case with the breakwater, part of the coastline currently experiencing erosion will start to accrete. This accretion will provide a positive impact to the densely populated residential area along that section. Further south, the model results show that erosion relative to the case without any breakwater would occur. This modelled erosion is located along a stretch that is less densely populated (close to the tip of the spit i.e. south of St. Louis).

7.3 Uncertainties & Limitations

This study has been based on the best available data to provide an assessment of the potential impact of the proposed breakwater on the coastline. Although some of the uncertainties on the site selection study were addressed, there are still some remaining uncertainties and limitations. Some of these limitations and uncertainties were addressed by sensitivity testing as described in Table 7.1. Other uncertainties will require further field data collection / studies to be carried out.

Table 7.1 – Summary of Model Limitations and Uncertainties

Item	Uncertainty / Limitation	Mitigations Taken	Studies Recommended
Data			
Beach profile data	Lack of any measured beach profile data along study area.	Beach profiles from a published paper were used.	Beach profiles should be surveyed along the study area to account for any variation along the coast.
Bathymetric data	Limited surveyed data especially in the nearshore.	Sensitivity testing conducted.	Bathymetric data required.
Sediment properties	Limited measured data along the beach and along the beach profile.	Sensitivity testing conducted.	Field data should be collected.

Item	Uncertainty / Limitation	Mitigations Taken	Studies Recommended
Sediment transport rates	Lack of accurate field estimates for longshore sediment transport rates.	Analysed historical coastlines. Collected data from previous studies.	Bathymetric data for the spit growth over a few years.
Coastline Evolution Model			
Southern Boundaries	Not possible to accurately represent the spit in a one-line model.	Sensitivity testing conducted.	A 2D model could be set up in future studies to improve understanding of the coastal dynamics at the river mouth and any potential impact on the breach area.

8.0 REFERENCES

AlDioma B., I. A. Bilbao, A. Abou, I. S. Perez and S. R. Valido (2013). Résultats du suivi 2010-2012 de l'évolution de la brèche ouverte sur la Langue de Barbarie au Sénégal et de ses consequence. Physio-Géo Géographie physique et environnement, Volume 7.

ARCADIS (2011). Some Considerations on Water and Climate Change Impacts - St. Louis, Senegal. Final Report.

Barusseau J.P., M. Ba, C. Descamps, E.S. Diop, B. Diouf, A. Kane, J.L. Saos and A. Soumare (1998). Morphological and sedimentological changes in the Senegal River estuary after the construction of the Diama dam. Journal of African Earth Sciences, Vol. 26, No. 2, pp. 317-326.

Dean, R.G. (1977). Equilibrium beach profiles: U.S. Atlantic and Gulf coasts. Department of Civil Engineering, Ocean Engineering Report No. 12, University of Delaware, Newark, DE.

Dean, R.G. (2002). Beach Nourishment Theory and Practice. Advanced Series on Ocean Engineering: Volume 18. World Scientific.

Enet F., A. Nahon, G. van Vledder, and D. Hurdle (2006). Evaluation of diffraction behind a semi-infinite breakwater in the SWAN wave model. 9th International Workshop on Wave Hindcasting and Forecasting.

Holthuijsen L.H., A. Herman & N. Booij (2003). Phase-decoupled refraction–diffraction for spectral wave models. Coastal Eng. Volume 49, Issue 4, pp. 291-305.

Komen, G.J., Cavaleri, L., Doneland, M., Hasselmann, K., Hasselmann S. and Janssen, P.A.E.M. (1994) Dynamics and modelling of ocean waves. Cambrigde University Press, UK, 560p.

Sadio M., E. J. Anthony, A. T. Diaw, P. Dussouillez, J. T. Fleury, A. Kane, R. Almar and E. Kestenare (2017). Shoreline Changes on the Wave-Influenced Senegal River Delta,West Africa: The Roles of Natural Processes and Human Interventions. Water, 9, 357.

Young, I.R. (1999), Wind generated ocean waves, in Elsevier Ocean Engineering Book Series, Volume 2, Eds. R. Bhattacharyya and M.E. McCormick, Elsevier.

APPENDIX J : AIR EMISSIONS MODELING REPORT

AIR EMISSIONS & MODELING ANALYSIS REPORT

Tortue Phase 1A

Prepared By:

TRINITY CONSULTANTS
919 Lake Baldwin Lane
Suite B
Orlando, FL 32814
(407) 982-2891

May 2, 2018

Environmental solutions delivered uncommonly well

TABLE OF CONTENTS

Acronym List

API	American Petroleum Institute
BP	BP group of companies
CH_4	Methane
CO_2e	Carbon Dioxide equivalent
CO	Carbon Monoxide
EEZ	Exclusive Economic Zone
EPA	Environmental Protection Agency
FEED	Front End Engineering Design
FGC	Flash Gas Compression
FGR	Flare Gas Recovery
FLNG	Floating Liquefied Natural Gas
FPSO	Floating Production, Storage and Offloading
GHG	Greenhouse Gas
GJ	Giga Joule
GT	Gas Turbine
GWP	Global Warming Potential
HAP	Hazardous Air Pollutant
HHV	Higher Heating Value
HIPPS	High Integrity Pressure Protection System
IPCC	Intergovernmental Panel on Climate Change
KBR	KBR group of companies
kW	kilowatt
LHV	Lower Heating Value
LNG	Liquefied Natural Gas
LNGC	Liquefied Natural Gas Carrier
LP	Low Pressure
MARPOL	International Convention for the Prevention of Pollution from Ships
MEG	Monoethylene Glycol
MJ/kg	Mega Joules per kilogram
MMscfd	Million standard cubic feet per day
MW_e	Megawatt electrical
MW_{th}	Megawatt thermal
NO_X	Nitrogen Oxides
NO_2	Nitrogen Dioxide
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter less than 2.5 microns in diameter
PM_{10}	Particulate Matter less than 10 microns in diameter
RICE	Reciprocating Internal Combustion Engines
SO_2	Sulfur Dioxide
T_epy	Tonnes per year
WHR	Waste Heat Recovery
WHO	World Health Organization
BOEM	Bureau of Ocean Energy Management

EXECUTIVE SUMMARY

On behalf of BP, this report summarizes Trinity Consultants' (Trinity's) screening dispersion modeling assessment of air quality impacts on the shoreline of the Senegalese and Mauritanian maritime boundary from the Tortue Project activities. Throughout this document, this analysis is referred to as a screening/preliminary analysis due to the various conservative assumptions and precautionary principles applied to the modeling analysis and emissions estimates outlined in this report. Section 1 includes additional details on the project description. This executive summary focuses on:

- Emissions Quantification from the Pipeline Area and Nearshore Hub/Terminal
- Dispersion Modeling Summary for the Tortue Project

As mentioned above, the primary purpose of this dispersion modeling analysis is to assess the screening modeling impacts from the Tortue project's activities on the shoreline of the Senegalese and Mauritanian maritime boundary. This analysis assesses the air emissions impact from activities categorized under the Tortue Project Pipeline Area, as well as the Near Hub/Terminal Area. The dispersion modeling analysis has been performed using the CALPUFF dispersion model, further discussed in Section 3.

MODELING THRESHOLDS

The emission rates modeled in this report have been compared to the modeling thresholds for averaging periods shown in Table A. Upon complying with the stringent thresholds in Table A, Trinity assumes that compliance is also demonstrated with the corresponding Senegalese air quality guidelines that have higher thresholds than the table below.

Table A. Applicable Guidance Values (μg/m^3)

Pollutant	WHO Guideline Values for various Averaging Periods (μg/m^3)[1]		
	1-hour	24-hour	Annual
NO_2	200	-	40
SO_2	-	20	-
PM_{10}	-	50	20
$PM_{2.5}$	-	25	10

MODELED EMISSIONS

Table B includes the various sources and activities that have been included in the dispersion modeling effort along with the emissions quantified for each activity, and the modeled stack parameters. Since averaging periods for the modeling thresholds vary in duration (1-hour period, 24-hour period, annual period), Trinity has utilized the grams/second (g/s) short-term emission rate for all averaging periods as a conservative estimate[2]. Detailed emissions are included in Appendix Jb. Assumptions for the emissions quantification are included in this executive summary.

[1] Trinity assumes that the "form" of the standard can be incorporated from the current ambient air quality guidelines promulgated by EPA.

[2] The g/s emission rate is conservative since all sources may not operate continuously for the entire year. Therefore, the annual tonnes per year emissions are, at best, going to be equal to or lower than the g/s emission rates.

Table B. Emissions Sources Included in the Air Impact Assessment

Source Designation	Source Description	NO_X (g/s)	SO_2 (g/s)	PM (g/s)	Stack Height (m)	Stack Exit Diameter (m)	Exit Temperature (°C)[3, 4]	Exit Velocity (m/s)
FPSO	Gas Turbines	1.31	-	0.33	80	2.00	555	25.09
	Emergency Generator	5.17	1.64	0.15	60	0.30	380	30.70
	FW Pumps	15.40	4.89	0.49	60	0.25	380	32.90
	Essential Service Generator	9.79	3.11	0.30	10	0.20	--	--
	Flare Pilots	7.53	-	2.69	125	0.80	40	347.63
	Assist Tug	20.16	2.03	1.08	7	0.45	573	34.00
	Supply Boat	12.89	1.28	0.70	14	0.30	573	40.00
	Guard/Security	4.48	0.44	0.24	2	0.30	573	40.00
	Crew Boat	19.90	1.96	1.09	2	0.30	573	40.00
FLNG	Gas Turbines	13.17	0.28	0.93	75	3.00	515	32.60
	Gas Generators	7.76	0.28	0.95	75	1.00	380	26.80
	Flare Igniters	6.25	0.28	0.47	125	0.80	-60	347.63
HUB	Assist Tug	20.16	2.03	1.08	7	0.45	573	34.00
	Service Tug	20.16	2.03	1.08	7	0.45	573	34.00
	Mooring Line	20.16	2.03	1.08	7	0.45	573	34.00
	Guard/Security	4.48	0.44	0.24	2	0.30	573	40.00
	Crew Boat	19.90	1.96	1.09	2	0.30	573	40.00
	Flare Igniters	0.23	-	0.02	60	0.25	-90	44.45
	Gas Generators	10.56	-	0.34	15	0.40	380	33.50
	Emergency Generator	0.10	0.33	0.09	15	0.15	380	26.80
	FW Pumps	7.93	2.52	0.37	60	0.25	380	32.90

Given the limited amount of information available at the time of model set up, all the sources listed in Table B were modeled at these emission rates and were assumed to operate simultaneously in this iteration of preliminary air dispersion modeling analysis.

[3] Support Vessel stack temperature based on exit temperature for similar vessels previously modeled by Trinity.
[4] Flare exit temperatures assumed to be for a "cold" flare.

EMISSIONS AND MODELING ASSUMPTIONS

Several assumptions have been made by BP and Trinity to quantify emissions for this screening modeling analysis. The key assumptions are listed in this executive summary, and assumptions that lead to the "worst-case" modeling scenario are noted as such. Detailed assumptions are included in the emissions discussion in Appendix Ja.

- Emissions from FPSO, FLNG and the Hub Terminal, as well as support vessel activities in each area have been included in the dispersion model.
- Emissions from the Offshore Area consisting of the reservoirs and subsea production system (approximately 125 km from the shoreline) have not been included in this modeling analysis.
- **Conservative Assumption -** As mentioned in the previous section, each modeled averaging period includes the short-term the g/s emission rate since all sources may not operate continuously for the entire year. Therefore, the annual tonnes per year emissions are, at best, going to be equal to or lower than the g/s emission rates.
  - Although the appendices to this report include tonnes per year emissions, the potential annual emissions are only included in this modeling report for completeness. This modeling analysis solely focuses on the short-term emission rate for each emissions source. The short-term emission rates are the largest in magnitude, and as a result, contribute to the worst-case modeled emissions scenario
  - As a point of emphasis, these short term emissions rates represent the worst case operation as these are conceivably the highest rates of pollutant emissions from the vessel engines and associated emissions sources when operated at 100%; however, this is not a realistic representation of their mode of operation for the entire year or while all on station at the FPSO/Hub
- Flaring emissions have not been included in the modeling analysis since flaring will only occur during emergency/upset conditions. However, flare pilot emissions have been included to account for normal operation.
- **Conservative Assumption -** Although emergency equipment such as firewater pumps, emergency generators, and essential generators are also designated for use primarily for emergency situations, Trinity understands that these sources will require annual maintenance and testing during normal operation. Therefore, these sources have been included in the dispersion model to account for hypothetical scenarios where maintenance and testing on these sources is done in tandem with normal operation, as a conservative measure.
  - FPSO emergency generator and essential generator are limited to 216 hours and 438 hours per year, respectively, based on BP data.
  - Hub emergency generator, and the Hub and FPSO firewater pumps are limited to 100 hours per year (each) based on estimated operational data.
- **Conservative Assumption** - As with other types of emissions sources, the preliminary project design assumes varying hours of operation for each type of support vessel[5]. To account for the worst-case modeled scenario for the support vessels, Trinity has modeled the short-term emission rate for each support vessel (kg/hr or g/s emission rate) instead of modeling the annual tonnes per year. It is also assumed that that support vessels are operating at 100% load for the purpose of the model even when on standby-mode.

[5] As an example, the three FPSO Assist Tugs are projected to operate 216 hours, annually, and the three FLNG/Hub Assist Tugs are projected to operate 1,752 hours, annually.

- Emissions for diesel fuel combustion are only included for documentation purposes. The screening modeling analysis does not include diesel emissions from gas turbines.
- **Conservative Assumption** - For support vessels for which data was not sufficiently available, Trinity has made suitable assumptions on the short-term emission rates by utilizing emissions of other similar support vessels. This is a conservative assumption since these support vessels are unlikely to operate at such high emission rates once the support vessel selection and schedule is finalized. The assumptions are stated below:
  - Trinity assumed that the FLNG/Hub service tug and mooring lines would have the same normal operation as the FLNG/Hub assist tugs.
  - Trinity assumed that the FLNG/Hub security boat would have the same normal operation as the FPSO security boat.
  - The support vessel emission shown in the table above include total emissions from each vessel type
- In this screening analysis, all sources have been modeled as point sources for simplicity. Note that some of the modeled sources are in fact mobile sources that are assumed to be stationary for the purpose of this modeling analysis.
- **Conservative Assumption -** It was assumed that all modeled sources listed in Table B will be operating simultaneously. By assuming simultaneous operation, this analysis accounts for the cumulative impact from project-wide emissions.
- The modeling analysis was not performed for CO pollutant as WHO do not have an ambient air quality standard to comply with.
- Also, the O_3 8-hour and SO_2 10-minute models were not included as a part of this modeling analysis. Additional discussion for exclusions included in Section 2.
- **Conservative Assumption -** The current air emission estimates are more conservative than the MARPOL regulations, which leads to conservative modeling impacts[6]. As an example, MARRPOL regulations include limits on NO_X emissions from marine diesel engines with a power output of more than 130 kW. The standards apply to both main propulsion and auxiliary engines and require the engines to be operated in conformance with the MARPOL NO_X emission limits. Upon finalization of equipment design, the project sources will comply with the relevant MARPOL regulations, and likely result in lower modeling concentrations.
- **Conservative Assumption -** The Flare pilot stack parameters information were provided to Trinity by BP based on preliminary estimates. These stack parameters are currently considered extremely conservative and may be subject to change upon additional design finalization. However, the flare pilots contribute a negligible amount to the worst-case model results.
- **Conservative Assumption** - Stack parameters for each facility, and the support marine vessels were provided by BP, KBR, or Golar. If data was unavailable at the time of the screening modeling analysis, Trinity made assumptions based on modeling experience for similar emissions sources.
  - Trinity assumed that the Hub Terminal assist tug and service tug stack parameters would be equivalent to the stack parameters for the FPSO assist tug.
  - Similarly, it was assumed that the stack parameters for the Hub Terminal security and crew boats would be equivalent to the security and crew boats at the FPSO facility.
  - Since stack information for the Hub Terminal firewater pumps were not available at the time of the screening modeling, the corresponding stack parameters for the FPSO firewater pumps were used as a conservative estimate.
- Several U.S. Federal and State agencies allow for the either the exclusion of intermittent sources or emergency equipment in typical modeling analyses, or the annualization of emissions from such

[6] https://www.epa.gov/enforcement/marpol-annex-vi

emissions with hours of operation that are much less than 8,760 hours per year[7, 8]. In the absence of similar guidance from WHO, Trinity has applied this available U.S. guidance for intermittent sources as part of this analysis.

- A total of 124 receptors were modeled by Trinity on the Senegalese and Mauritanian maritime boundary. The receptors were as close as 10 km, and as far as 40 km from the FLNG/Hub Terminal area. Therefore, it is assumed that the modeling domain sufficiently captures the impact from the Tortue Project on the shoreline of this maritime boundary.
- **Conservative Assumption –** WHO has a modeling threshold value for NO_2 (200 µg/m³), but does not have a corresponding threshold for NO_X. Although NO_X released during combustion of fuels typically undergoes a chemical reactions with ambient ozone to form NO_2 resulting in only a portion of NO_X converting into NO_2 released into the atmosphere, this modeling analysis assumes that all NO_X is converted into NO_2. Therefore, the calculated NO_X emissions are modeled for comparison to the more stringent WHO NO_2 threshold.

MODELING RESULTS SUMMARY

Table C presents the summarized results of the modeled pollutants at various averaging periods and compares against their respective guidance levels provided by WHO.

Table C. Screening Air Dispersion Modeling Results (µg/m³)

Pollutant - Averaging Period	WHO Guideline Levels (µg/m³)	Predicted Modeled Concentrations for 2014-2016 year			Does Model Pass?
		2014 (µg/m³)	2015 (µg/m³)	2016 (µg/m³)	
NO_2 - 1 hour (H1H)[1]	200	252.33	312.05	254.00	Yes[2]
NO_2 - 1 hour (H8H)[1]	200[9]	180.48	196.19	181.29	
NO_2 - Annual	40	3.67	3.72	3.88	Yes
SO_2 - 24 hour	20	6.06	6.67	11.26	Yes
PM_{10} - 24 hour	50	2.85	3.22	5.51	Yes
PM_{10} - Annual	20	0.23	0.24	0.24	Yes
$PM_{2.5}$ - 24 hour	25	2.46	2.78	4.77	Yes
$PM_{2.5}$ - Annual	10	0.20	0.20	0.21	Yes

[1] H1H = Highest first high, H8H = Highest eight high.
2 NO_2 1-hr results discussion pass when using the EPA methodology to evaluate NO_2 1-hr results.

A review of the results modeled for this project using meteorological data from 2014 through 2016 indicates that the proposed operations do not exceed the applicable guidance levels for SO_2, PM_{10}, and $PM_{2.5}$, and the annual averaging period for NO_2. In addition, since the WHO does not promulgate a form of its modeling

[7] U.S. EPA Memo - https://www3.epa.gov/scram001/guidance/clarification/Additional_Clarifications_AppendixW_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf
[8] Page 100 of https://www.tceq.texas.gov/assets/public/permitting/air/Modeling/guidance/airquality-mod-guidelines6232.pdf
[9] The results for NO_2 are included for the 3-year average value of the 98th percentile, consistent with the current form of the standard used by U.S.EPA.

standard, Trinity has utilized the form of the modeling standard utilized by EPA since the modeling thresholds for the NO_2 1-hour averaging period for EPA (**188 µg/m³**) and WHO (**200 µg/m³**) are similar in magnitude. Therefore, the NO_2 1-hour results for the H8H value (98th percentile averaged over 3 years of modeled data) indicates that the modeled concentration for NO_2 1-hour (along with all other averaging periods) is under the WHO and EPA modeling thresholds for NO_2. Based on the modeled concentrations, the air quality impact of Tortue Project is not expected to violate WHO air quality standards.

REPORT CONTENTS

The rest of this modeling report includes the following information:

- Section 1 includes a brief project description of the Tortue Project
- Section 2 includes additional modeling methodology discussion.
- Section 3 includes detailed modeling results discussion including visual representation and select source contribution analysis for the worst-case NO_2 modeled concentration
- Appendix Ja includes a discussion on the emissions quantification methodologies.
- Appendix Jb includes the detailed emissions calculations.

1. PROJECT DESCRIPTION

BP is proposing development of a natural gas field located ~125 km offshore, along the Mauritania-Senegal maritime boundary, and associated infrastructure to transport, process, and compress natural gas. Termed the Tortue Project, BP proposes the following three primary components:

- **Offshore Area**: located about 125 km from the coast and containing the areal extent of the Lower Cenomanian and Albian reservoirs to be developed. These reservoirs will be developed via a subsea production system, including development wells at two manifold centers, production manifolds, and in field flowlines. All of the equipment in the Offshore Area will be located in approximately 2,700 m to 2,800 m water depth, on the continental slope and within the bounds of the Mauritania and Senegal Exclusive Economic Zones (EEZs).

- **Pipeline Area**: a 3 km-wide corridor connecting the Offshore Area with the Nearshore Hub/Terminal Area. Infrastructure within the offshore portion of the Pipeline Area will include: two 16-inch (outer diameter, OD) production flowlines to carry produced gas from the offshore wells to the floating production, storage, and offloading (FPSO) vessel; an umbilical which controls the electric, hydraulic, and production chemicals required for the wells within the Offshore Area; a 10-inch OD delivery line carrying monoethylene glycol (MEG) to ensure that produced gas is properly treated to prevent the formation of hydrates; and the FPSO. The production flowline will be trenched up to an estimated 800m from the FPSO to the Offshore Area. Between the FPSO and Nearshore Hub/Terminal Area, a 30-inch OD export pipeline will deliver processed gas to the nearshore facility. The Pipeline Area extends from the continental slope across the continental shelf, all of which are within the bounds of the Mauritania and Senegal EEZ.

- **Nearshore Hub/Terminal Area**: a constructed area of approximately 0.165km^2 (excluding safety zone) containing a breakwater, associated berthing facilities for tugs, a single floating liquid natural gas (FLNG) vessel and berthing space for visiting LNG carriers. The Nearshore Hub/Terminal Area will be located about 10 to 11 km from the coast, in water depth of about 33 m, on the continental shelf and within the bounds of the Mauritania and Senegal EEZ. LNG processing aboard the FLNG will cool the gas to temperatures below -160° C in order to bring it to a liquid state, thus enabling storage and long-distance transportation. The FLNG will liquefy and store the gas for export, the latter of which will occur via periodic visits from an LNGC.

The project also comprises an on-land component called the Support Operations Areas. It includes a supply base in the Port of Dakar, a supply base in the Port of Nouakchott and facilities in the airports of Dakar and Nouakchott.

1.1. FACILITY DESCRIPTION

The Tortue Project will consist of three facilities: the Floating Product, Storage and Offloading (FPSO) facility, the Floating Liquefied Natural Gas (FLNG) facility, and the Hub facility. The FLNG and Hub facilities will both be located in the Nearshore Hub/Terminal Area. Both the FPSO and FLNG/Hub will also have supporting marine vessels primarily used for personnel and product transportation.

1.2. PROCESS DESCRIPTION

Gas, condensate, and produced water are received on the FPSO facility via a multiphase pipeline and are separated on the FPSO facility. The condensate is then stabilized, treated and stored aboard the FPSO for routine transport via condensate carrier. Treated gas is subsequently transported via pipeline to the FLNG, where it is compressed and liquefied, enabling the LNG to be transported via LNGC. The Hub facility will mainly consist of a breakwater approximately 1,000 m long and living quarters to support the personnel at the facility.

2. AIR DISPERSION MODELNG METHODOLOGY

This section of the report describes the modeling procedures and data resources that were utilized in the air dispersion modeling analysis. The modeling analysis was performed based on the latest emission estimates and the stack parameters, as shown in Table B of this report. For air dispersion modeling analyses, the latest available three year (2014-2016) meteorological data was selected, and the modeled concentrations ($\mu g/m^3$) corresponding to three meteorological years were compared against the applicable air quality standards. This modeling analysis was performed in order to access the air quality impacts of the proposed activity on the Mauritania and Senegal shoreline areas.

2.1. MODEL SELECTION

Dispersion models predict downwind pollutant concentrations by simulating the evolution of the pollutant plume over time and space given data inputs. These data inputs include the quantity of emissions and the initial conditions of the stack exhaust to the atmosphere. The extent to which a specific air quality model is suitable for the evaluation of source impacts depends on

- The meteorological and topographical complexities of the area;
- The level of detail and accuracy needed in the analysis;
- The technical competence of those undertaking such simulation modeling;
- The resources available; and
- The accuracy of the database (i.e., emissions inventory, meteorological, and air quality data).

One of the preferred model for analyzing long-range pollutant transport (i.e., distances greater than 50 km) is the CALPUFF modeling system. The latest version (Version 6.42) of the CALPUFF model was used to determine the possible impacts of the proposed project. CALPUFF 6.42 is the latest version of BREEZE, a division of Trinity Consultants. Features that were added to SRC CALPUFF 7.2.1 version (next version to 6.42) were not required for this preliminary modeling analysis (For e.g. - new source types including roadways, new pre-processor SUFRGEN which can process sub-hourly ASOS data and the post-processors CALRANK, CALAVE and CALMAX). Therefore, the Breeze CALPUFF modeling software was utilized for modeling purposes, consistent with analyses submitted for similar projects recently to other regulatory agencies by Trinity. The post-processing of the CALPUFF data was performed using the latest version of the CALPOST (Version 6.292). The meteorological data that was processed by using CALMET (Version 5.8.5) was also compatible with latest versions of CALPUFF and CALPOST. CALPUFF is a multi-layer, multi-species, non-steady-state Lagrangian puff model, which can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation, and removal. For this refined analysis, meteorological fields generated by CALMET were used as inputs to the CALPUFF model to ensure that the effects of terrain and spatially varying surface characteristics on meteorology are considered.

In addition to meteorological data, the CALPUFF model uses several other input files to specify source and receptor parameters. The selection and control of CALPUFF options are determined by user-specific inputs contained in the control file. This file contains all of the necessary information to define a model run (e.g., starting date, run length, grid specifications, technical options, output options).

2.2. APPLICABLE AIR QUALITY STANDARDS

Senegal air regulations include some basic guidance on air quality thresholds that has been considered in this analysis by Trinity. Upon preliminary review, Trinity has determined that the Senegalese modeling thresholds are not as stringent as the WHO standards (except for NO_2, where each regulatory body has equal threshold values). Moreover, Trinity did not find consolidated ambient air quality modeling thresholds for Mauritania as part of this air quality regulatory review for modeling consideration. However, the "WHO air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide" Global update 2005, Summary of risk assessment (referred to as "The Guidelines") offer global guidance on thresholds and limits for key air pollutants that pose health risks[10]. The Guidelines apply worldwide and are based on expert evaluation of current scientific evidence for (PM, ozone (O_3), NO_2, and SO_2, in all WHO regions. These thresholds have been utilizes to perform this modeling analysis. Table 2-1 summarizes these standards for key pollutants and their different averaging periods, and has also been included in the executive summary.

Table 2-1. Applicable Guidance Values (µg/m³)

Pollutant	Organizations[11], [12]	Guideline Values for various Averaging Periods (µg/m³)		
		1-hour	24-hour	Annual
NO_2	WHO	200	-	40
	Senegal's Air Pollution Discharge Standards	200[a]	-	40[b]
SO_2	WHO	-	20	-
	Senegal's Air Pollution Discharge Standards	-	125[c]	50[d]
PM_{10}	WHO	-	50	20
	Senegal's Air Pollution Discharge Standards	-	260[e]	80[f]
$PM_{2.5}$	WHO	-	25	10
	Senegal's Air Pollution Discharge Standards	-	-	-

[a] Average Hourly
[b] Annual average (arithmetic average)
[c] Daily average
[d] Annual average (arithmetic average)
[e] Daily average; shall in no case be exceeded more than once per year
[f] Annual average (arithmetic average)

The modeling results have been compared with the WHO thresholds shown in Table 2-1. These standards are more stringent that the current Senegalese air quality guidelines as shown above.

In this air dispersion modeling analysis, the most conservative screening level approach was utilized, where all NO_X emitted is modeled as NO_2, i.e., total conversion of NO (the primary chemical form of NO_X) to NO_2 is assumed. If the impacts predicted using this approach result in exceedances of the standards, a more refined technique could be used.

Given the stringency of the 1-hour NO_2 standard relative to the annual standard, the assumption of ($NO_X = NO_2$) made in this preliminary modeling analyses might be considered extremely conservative. Typically, this method

[10] http://apps.who.int/iris/bitstream/10665/69477/1/WHO_SDE_PHE_OEH_06.02_eng.pdf
[11] Trinity assumes that the "form" of the WHO standard can be incorporated from the current ambient air quality guidelines promulgated by EPA.
[12] Senegalese Air Pollution – Emissions Standard NS 05-062, October 2003
http://extwprlegs1.fao.org/docs/pdf/sen54266.pdf

is adopted when the project is still in earlier stages of planning where the facility does not have enough information on the in-stack ratios (i.e. NO_2/NO_X conversion factor is not available from stack testing data), or lack of ambient monitoring data, and/or lack of background ozone data. The majority of the oxides of nitrogen (NO_X) emissions from air emission sources are in the form of nitric oxide (NO), whereas EPA has established a National Ambient Air Quality Standard (NAAQS) for nitrogen dioxide (NO_2).

As per the latest BOEM air dispersion modeling guidance (dated January 2018) [13] which is used for similar off-shore air dispersions modeling analysis in the Gulf of Mexico (GOM), if the modeled results do not pass using the assumption of $NO_X = NO_2$, one can apply a NO_2/NO_X conversion ratio of 0.8 for 1-hour and 0.75 for annual averaging periods NO_X modeling results.

Also, based on Section 4.2.3.4 Models for Nitrogen Dioxide of the latest EPA Guideline[14], this full-conversion approach is referred to as first-tier approach. The second tier approach allows the model to assume ambient equilibrium between NO and NO_2. Under US EPA jurisdiction, this is referred to as Ambient Ratio Method 2 (ARM2) which provides estimates of representative equilibrium ratios of NO_2/NO_X value based on ambient levels of NO_2 and NO_X derived from national data from the EPA's Air Quality System (AQS). The national default for ARM2 includes a minimum ambient NO_2/NO_X ratio of 0.5 and a maximum ambient ratio of 0.9. Although, there is not enough information on the ambient air quality data around this project location, Trinity believes that a NO_2/NO_X conversion ratio of 0.9 could be utilized if modeling results indicate significant impacts to the ambient air quality.

Please note that the O_3 8-hour and SO_2 10-minute models are not included as a part this modeling analysis. Also, please note that from air emissions standpoint, it is important to estimate air emissions for all criteria pollutants. Therefore, the air emissions for CO pollutant are included, CO being one of these six pollutants which have health effects at varying concentration levels , even though WHO does not have CO air quality standards. Short-term SO_2 modeling has been performed for the 24-hour averaging period. Consistent with the requirements for similar modeling analyses for projects under jurisdiction of the U.S. EPA, pollutant modeling over a short-term averaging period is limited to 60 minutes (1 hour) as the shortest term for modeling against ambient air quality standards. Ozone modeling[15] is typically performed in areas that are not in attainment of the ambient air quality standard. NO_2 and VOC are precursors to ozone formation. However, currently there are no background monitors for NO_2 and VOC in the vicinity of the project. Therefore, a determination on the attainment status of ozone cannot be made at this time.

2.3. TERRAIN PROCESSING AND BUILDING DOWNWASH

Because the coastal area of concern is situated at sea level, terrain features have not been considered (i.e., simple terrain only). It is assumed that there are no buildings or structures influencing downwash on the emission sources.

2.4. BACKGROUND OZONE AND AMMONIA CONCENTRATIONS

The CALPUFF model is capable of simulating linear chemical transformation effects by using pseudo-first-order chemical reaction mechanisms for the conversions of SO_2 to SO_4, and NO_X, which consists of nitric oxide (NO) and nitrogen dioxide (NO_2), to NO_3 and HNO_3. In this analysis, chemical transformations involving five species

[13] https://www.boem.gov/Dispersion-Modeling-Guidelines/
[14] U.S. EPA: Guideline on Air Quality Models, 40 CFR Part 51 – Appendix W (Revised January 17, 2017), referred here as "EPA Guideline"
[15] CALPUFF is not used for ozone modeling. Chemical transport models such as CMAQ and CAMx are considered for ozone modeling for attainment demonstration.

(SO_2, SO_4, NO_X, HNO_3, and NO_3) were modeled using the MESOPUFF II chemical transformation scheme, in accordance with the Interagency Workgroup on Air Quality Modeling (IWAQM) guidance. In addition, two user-selected input parameters are available that affect the MESOPUFF II chemical transformation: ammonia concentrations and ozone concentrations. The selection of each parameter is discussed separately.

Ambient ozone concentrations can be input to the model as a background level or using hourly, spatially varying observations. Similarly, the spatially constant background ammonia concentrations can be used to participate in the MESOPUFF II chemical transformation mechanism. In the absence of an extensive monitoring network for ozone and ammonia and because of the limitation of CALPUFF to simulate only a single, domain-average background ozone and ammonia level for each month of analysis, a single value was used from similar offshore regions near the U.S. Therefore, the ozone and ammonia background level for the analysis was set at 80 ppb and 3 ppb respectively. These background values have been utilized in several CALPUFF air dispersion modeling analyses performed in Gulf of Mexico region under U.S. EPA jurisdiction. Therefore, for conservatism, these background levels are assumed to be representative for this project location.

2.5. CALMET METEOROLOGICAL PROCESSING

The NCEP FNL (Final) Operational Global Analysis data (1-degree by 1-degree grids prepared operationally every six hours; GRIB2 format)[16], the NCEP ADP Global Upper Air Observational Weather Data[17], the NCEP ADP Global Surface Observational Weather Data[18], the daily real time global sea surface temperature data[19], and the geographical input data[20] for the years of 2014 to 2016 were used as inputs to the Weather Research and Forecasting (WRF) [21] model system.

The two-way nesting method was utilized when executing WRF. The parent domain was centered at 328,504 m Easting, 1,776,823 m Northing, UTM zone 28Q, covering a 612 km by 612 km region. The parent domain has a resolution of 12 km, resulting in 52 by 52 grid points with the (1, 1) grid point at the south-west corner. The nest starts from the parent grid point of (18, 18), with a center the same as the parent domain center, covering a 204 km by 204 km region (17 grid cells of the parent domain). The nest has a resolution of 4 km, resulting in 52 by 52 fine grid points.

The WRF model system includes: WRF Preprocessing System (WPS: GEOGRID, UNGRIB, and METGRID), Objective Analysis (OBSGRID), and WRF. During the execution of WPS, the GEOGRID creates terrestrial data from the geographical inputs; the UNGRIB unpacks the NCEP FNL operational Global Analysis data and the daily real time sea surface temperature data and packs them into an intermediate file format; and METGRID then horizontally interpolates the meteorological data onto the parent and nest domains. OBSGRID is an objective analysis program to improve meteorological analyses on the mesoscale grid by incorporating information from observations. It takes WPS outputs along with the NCEP ADP Global Surface and Upper Air Observational Weather Data as inputs. Finally, WRF uses outputs from OBSGRID to generate numerical weather predictions. The FNL data from 2014 to May 12, 2016 has 27 vertical layers, and after May 12, 2016, the data has 32 vertical layers. All vertical layers were used when WRF was executed as part of this processing task.

The geophysical and 3-D meteorological output fields from WRF and observational surface data from Global Weather station (616000 GOSS station, latitude 16.051°, longitude -16.463°) were then processed by CALMET to

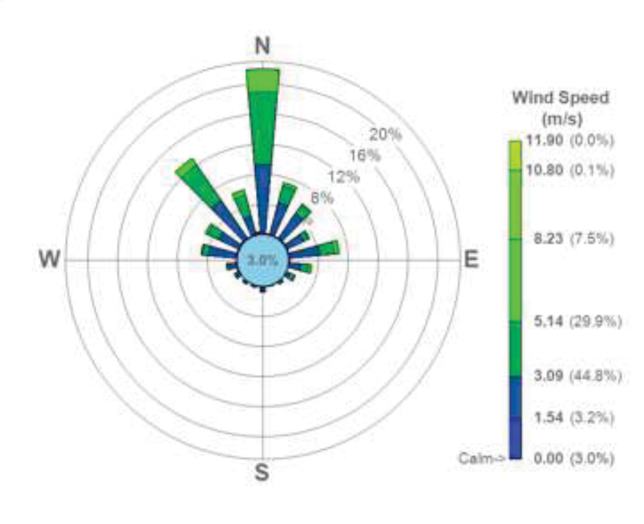
---

[16] https://rda.ucar.edu/datasets/ds083.2/
[17] https://rda.ucar.edu/datasets/ds351.0/
[18] https://rda.ucar.edu/datasets/ds461.0/
[19] ftp://polar.ncep.noaa.gov/pub/history/sst/rtg_high_res/
[20] http://www2.mmm.ucar.edu/wrf/users/download/get_sources.html
[21] https://www.mmm.ucar.edu/weather-research-and-forecasting-model

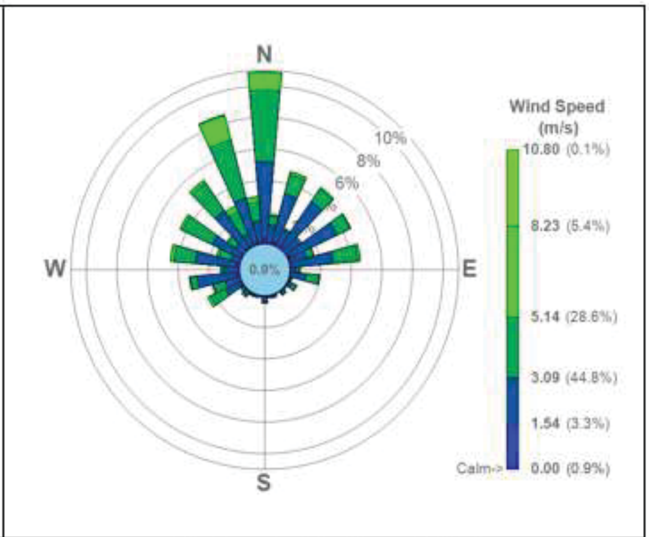
generate 3-D CALPUFF ready meteorological data. CALMET was executed using U.S. EPA recommended options (11 vertical layers ranging from 0 m to 4000 m)[22]. The 150 km by 150 km CALMET domain has a center at 328504 m Easting, 1776823 m Northing, UTM zone 28Q, with a resolution of 1 km, resulting in 151 by 151 horizontal grid points. Figure 2-1 shows the three-year wind roses at the GOSS Global Weather station. The GOSS station located in St. Louis, Senegal, is the only meteorological station that is within the modeling domain and therefore, has been utilized in combination with WRF data, as it closely represents the climatological characteristics of the modeled region.

[22] https://www3.epa.gov/scram001/guidance/clarification/CALMET%20CLARIFICATION.pdf

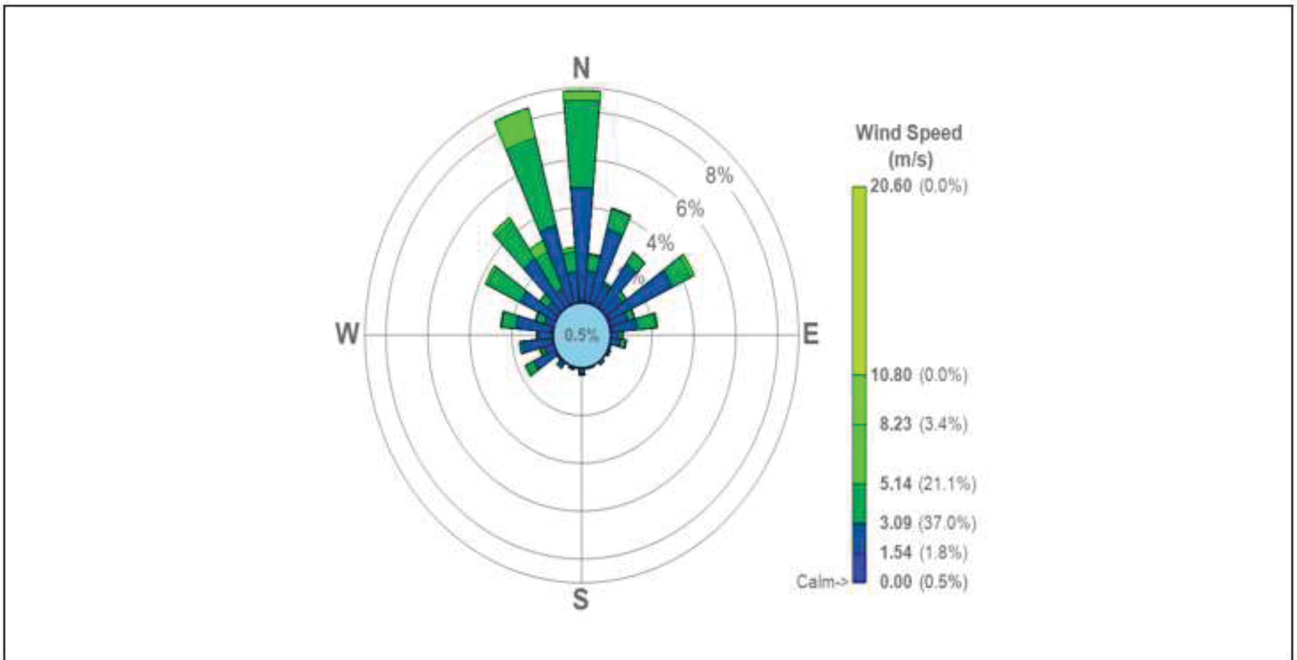
Figure 2-1. Wind Rose Diagrams at GOSS Meteorological station (2014-2016)



Meteorological Year 2014



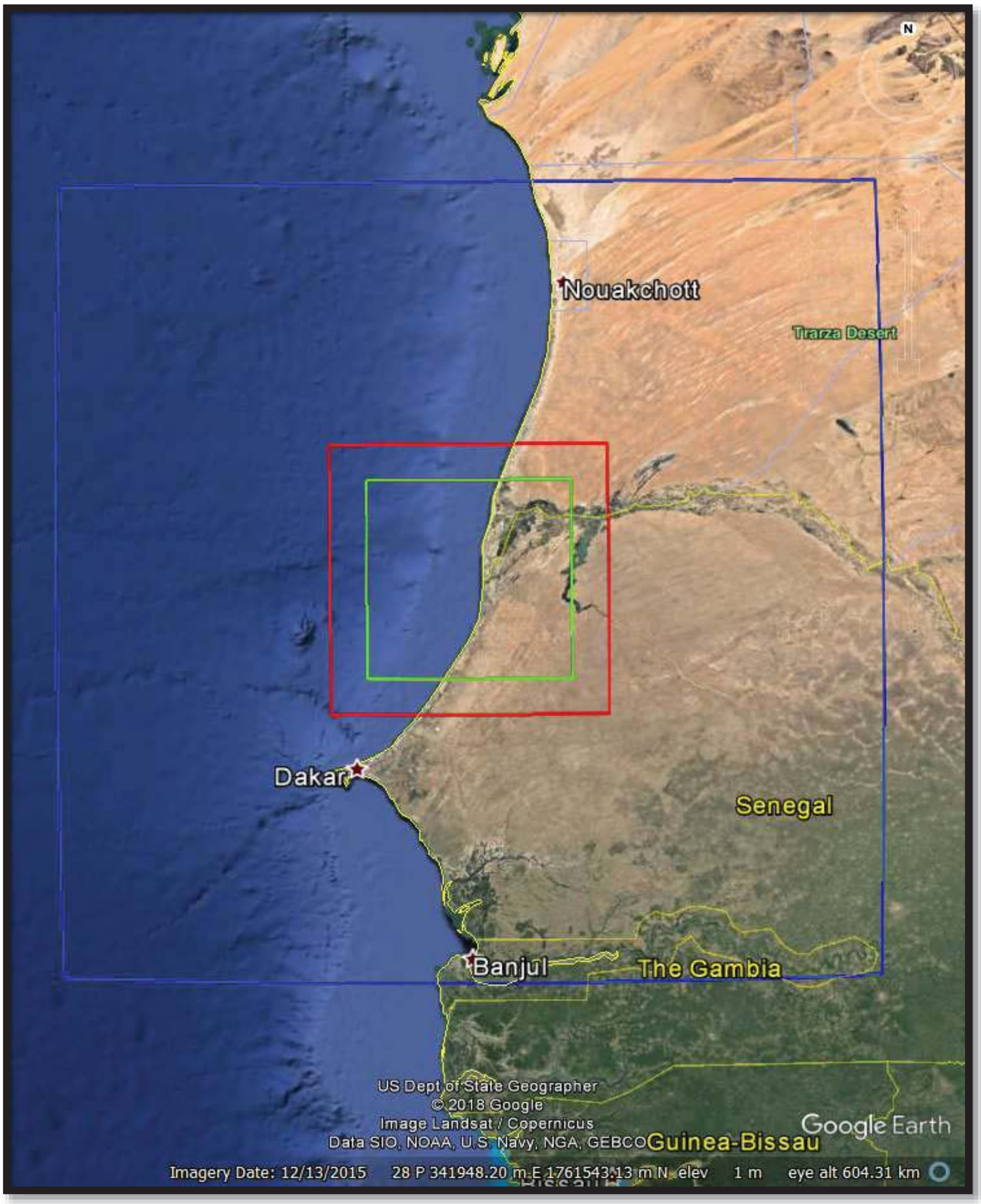
Meteorological Year 2015



Meteorological Year 2016

Figure 2-2 shows the CALMET domain, the WRF nest domain, and the WRF parent domain.

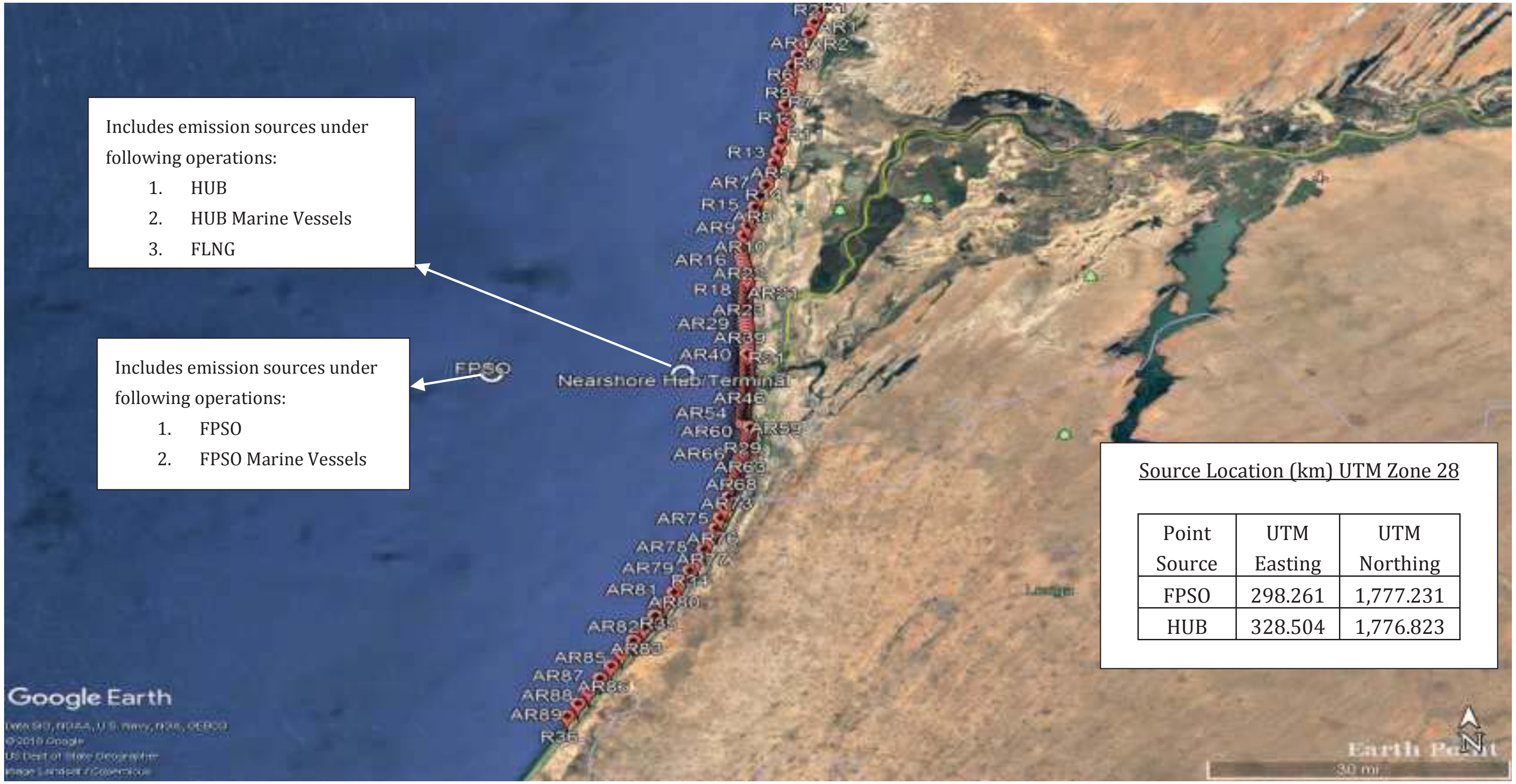
Figure 2-2. CALMET Domain (Green), WRF Nest Domain (Red), and WRF Parent Domain (Blue)



2.6. RECEPTOR LOCATIONS AND INLAND IMPACTS

In this air dispersions modeling analysis, a receptor is a selected physical location where the public could be exposed to an air contaminant in the ambient air. The receptors utilized in this analysis were a function of the computational domain selected for the project. Since the offshore locations of the project vary in distance from land, Trinity considered a computational domain of 150 km x 150km. As a part of the modeling analysis, a series of discrete receptors (Receptor IDs: “R”) spaced 3 to 5 kilometers (km) apart have been placed along the Mauritania and Senegal shoreline as shown in Figure 2-3. Additional fine grid receptors (Receptor IDs: “AR”) at 1 or 2 km spacing were also modeled between discrete receptors, especially near the shoreline closer to the proposed activity. For conservatism, the impacts at the fine grid receptors will also be utilized to assess the impacts at the nearest protected wildlife areas (i.e. Class I area) located potentially further inland. As a general rule of thumb, these impacts will gradually decrease as the distance between the modeled sources and the impacted areas increases. Therefore, no separate on-shore receptor grid was generated during this modeling analysis.

Figure 2-3. Receptor and Source Locations



Point Source	UTM Easting	UTM Northing
FPSO	298.261	1,777.231
HUB	328.504	1,776.823

Figure 2-3. Receptor and Source Locations	Trinity Consultants	**Tortue Phase 1A Mauritania and Senegal Region**
R - Discrete Receptors, AR - Fine Grid Receptors		**Modeled Sources**

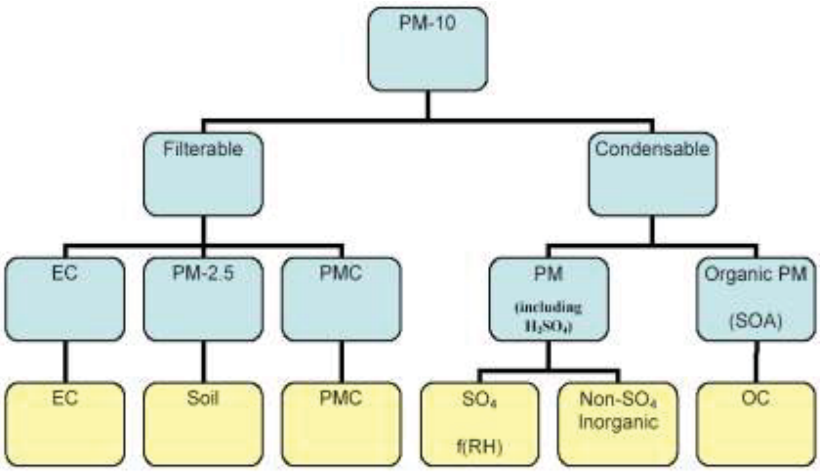
Figure 2-3. Receptor and Source Locations (Continued)

Figure 2-3. Receptor and Source Locations	Trinity Consultants	Tortue Phase 1A Mauritania and Senegal Region
R - Discrete Receptors, AR - Fine Grid Receptors		Modeled Sources

2.7. PM EMISSIONS SPECIATION

Although, Class I area visibility analysis is not a part of the scope of work, Trinity speciated the PM emissions as a proactive measure for future potential Class I analysis. Modeling of visibility impairment due to PM emissions requires that the components of the exhaust stream be speciated because different sizes and phases of particulate matter affect visibility to varying extents. The amount by which a mass of a certain species scatters or absorbs light is termed the *extinction efficiency* or *extinction coefficient*, and varies considerably from coarse particulate matter to elemental carbon. Fine particulate matter and organic aerosols scatter light with intermediate efficiencies, and ammonium sulfate and ammonium nitrate (that form from precursor SO_2 and NO_X emissions in the presence of ambient ammonia) are hygroscopic species that scatter light efficiently in the presence of ambient water vapor. Figure depicts the speciation of visibility-affecting pollutant emissions as represented in the *VISTAS BART Modeling Protocol*[23]

Figure 2-4. Particulate Matter Speciation



Trinity estimated speciated PM emissions associated with the proposed operations based on the AP-42 emission factors, manufacturer provided data, and conservative engineering estimates.

Total PM_{10} (TPM_{10}) emissions from each modeled facility were calculated as the summation of TPM_{10} emissions from all emission sources on the facility. TPM_{10} emissions for the individual emission sources on the facility were calculated as the sum of filterable PM_{10} (FPM_{10}) emissions and condensable particulate emissions (CPM). It was assumed that the large diesel-fired sources will contribute a vast majority of the emissions from the proposed operations. Therefore, Trinity used the particle size-specific emission factors for large diesel fired engines from AP-42 to speciate TPM_{10} into FPM_{10} and CPM.[24] Filterable particulate less than 3 μm was used as a surrogate for filterable $PM_{2.5}$ (PMF). No representative data or emission factors were available for determining inorganic (sulfates (SO_4) and nitrates (NO_3)) condensable emissions. Therefore, inorganic condensable emissions from the facility were assumed to be zero. Based on guidance provided in the *Procedure for Speciation*

[23] VISTAS; Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technologies (BART), Revision 3.2 (August 31, 2006), Figure 4-3. http://www.vistas-sesarm.org/documents/BARTModelingProtocol_rev3.2_31Aug06.pdf

[24] AP-42, Table 3.4-2, Particulate and Particle-sizing Emission Factors for Large Uncontrolled Stationary Diesel Engines (October 1996).

of Emissions for VISTAS BART Modeling, 100% of non-H_2SO_4 condensable particulate mass was assumed to be organic condensable (OC).[25] The percentage of coarse filterable particulate matter (PMC) in TPM_{10} was calculated as the difference between the percentages of FPM_{10} and filterable $PM_{2.5}$ (PMF). Consistent with the previous modeling reports submitted to EPA Region 4 for similar projects, an elemental carbon was assumed to be 0% due to lack of representative data or emission factors. Table 2-2 summarizes the particulate speciation breakdown as a percent of total PM_{10} emissions.

Table 2-2 PM Speciation Summary

Emissions Speciation*	Percentage (% of Total PM_{10})
Total PM_{10} (TPM_{10})	100%
Condensable portion of TPM_{10} (CPM)	13.4%
Organic portion of CPM (SOA)	13.4%
Inorganic portion of CPM	0.0%
Filterable portion of TPM_{10} (FPM_{10})	86.6%
Coarse Filterable (PMC)	3.0%
Fine Filterable (PMF)	83.6%
Elemental Carbon (EC)	0.0%

*Values in *italics* are not modeled in CALPUFF directly, but instead are shown for informative purposes.

The average particle diameter for each non-default speciated particulate (PM) category (PMF, PMC) was taken as the geometric mass mean diameter for that category.[26] Geometric standard deviation was assumed to be zero for both PMC and PMF. Default CALPUFF values for geometric mass mean diameter and geometric standard deviation were used for SOA particles. A summary of the geometric mass mean diameter and geometric standard deviation is presented in Table 2-3.

Table 2-3. Geometric Dimensions for PM Species

Species	Geometric Mass Mean Diameter (microns)	Geometric Standard Deviation (microns)
Filterable Coarse Particles - PMC (PM_3 to PM_{10})	6.5	0.0
Filterable Fine Particles - PMF ($PM_{0.5}$ to PM_3)	1.75	0.0
Organic Condensable PM - SOA	0.48	2.0

[25] Procedure for Speciation of Emissions for VISTAS BART Modeling, July 18, 2006.
[26] Methodology used is in accordance with the methodology presented in Example Screening BART Simulation using the VISTAS Regional Domain, Earth Tech, Inc., Concord, Massachusetts, June 9, 2006, available online at - http://www.src.com/datasets/VISTAS_Files/ExampleBARTSimulation_Guide_R.pdf

2.8. MODEL INPUT EMISSION RATES

A detailed summary of emission estimates are presented Appendix Ja and Jb of this report. These air emissions were utilized to perform the air dispersion modeling analysis for different pollutants and averaging period. For conservatism, both short-term (i.e. 1 hour, 3 hour, 8 hour and 24 hour averaging periods) and long-term models (annual averaging period) was performed using the hourly emissions (tonne/hr) as estimated in the Appendix Jb. For modeling purposes, these hourly emissions were converted to pounds per hour (lb/hr) units by multiplying the metric tonne hourly emissions (tonne/hr) with 2,200 conversion rate (i.e. 1 tonne = 2,200 lbs). For reference purposes, the same modeled emission rates have been summarized in Table 1-2 in g/s.

<u>Sample Calculation for Source ID FPSOGT:</u>

NO_X emissions = 4.730E-03 tonne/hr * 2,200 (lb/tonne) * 453.592 (g/lb) * (1 hr/3,600 s)
= 10.41 lb/hr * 0.126 = 1.312E+00 g/s

2.9. CALPOST POSTPROCESSING ANALYSIS

The CALPOST postprocessor (Version 6.221) was used to compute the ambient concentrations of PM_{10}, $PM_{2.5}$, and NO_2 at the shoreline areas for assessment against the applicable standards. For PM_{10} assessment against the standards, POSTUTIL was first used to combine the speciated PM (PMC, PMF, and SOA) to calculate total PM_{10} concentration. The PM_{10} concentration was then processed using CALPOST and compared to the appropriate standards.

For estimating the extent of nitrogen and sulfur deposition, POSTUTIL was first used to combine the appropriate wet and dry fluxes of nitrogen- and sulfur-bearing species deposited as particles and gases. These combined fluxes were then processed using CALPOST to obtain the nitrogen and sulfur deposition values.

2.10. OZONE IMPACT ANALYSIS

Ozone is a toxic air pollutant that is formed on warm, sunny days when its precursors NOx and VOC react in the presence of sunlight. Ozone is of particular interest when evaluating its impact on protected lands and wilderness preserves (sometimes referred to as Class I areas). Because ozone is a regional pollutant, precursor sources both near and far from Class I areas can contribute to ozone formation. However, due to the complex photochemical reactions that are involved in the formation of ozone, it is difficult to quantify specific relationships between precursor emissions and ambient ozone concentrations at this area, and also to quantify the specific relationship between ambient ozone at a protected wildlife area and the vegetation in the vicinity.

Based on review of available dispersion models, it has been found that there are currently no publicly available dispersion models that can relate emissions from a single source to changes in ozone concentrations at particular receptor locations. Demonstrating compliance with the deposition thresholds shall provide an indication of whether the proposed project operations NO_X emissions are likely to cause an adverse impact on soils, and/or surface waters, however, there are no deposition thresholds defined for protected areas in this region. Assuming all Class I areas are NO_X-limited for formation of ozone, it can be deduced that there are no ozone impacts on the vegetation.

3. DISPERSION MODELING RESULTS

The following section details the results of the air dispersion modeling analysis. Table 3-1presents the summarized results of the modeled pollutants at various averaging periods and compares against their respective guidance levels.

Table 3-1 CALPUFF Air Dispersion Modeling Results (µg/m³)

Pollutant - Averaging Period	WHO Guideline Levels[1] (µg/m³)	Predicted Modeled Concentrations for 2014-2016 year			Maximally Impacted Receptor ID		
		2014 (µg/m³)	2015 (µg/m³)	2016 (µg/m³)	2014	2015	2016
NO_2 - 1 hour (H1H)[1]	200	252.33	312.05	254.00	AR37	AR42	AR43
NO_2 - 1 hour (H8H)[2]	200[27]	180.48	196.19	181.29	AR43	AR42	R21
NO_2 - Annual	40	3.67	3.72	3.88	AR48	AR43	AR43
SO_2 - 24 hour	20	6.06	6.67	11.26	AR44	AR39	AR43
PM_{10} - 24 hour	50	2.85	3.22	5.51	AR44	AR39	AR43
PM_{10} - Annual	20	0.23	0.24	0.24	AR48	AR43	AR43
$PM_{2.5}$ - 24 hour	25	2.46	2.78	4.77	AR44	AR39	AR43
$PM_{2.5}$ - Annual	10	0.20	0.20	0.21	AR48	AR43	AR43

[1] Based on "WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide" Global update 2005, Summary of risk assessment.
[2] H1H = Highest first high, H8H = Highest eight high.

As stated earlier in the report, the NO_X emissions were modeled and with an assumption that all $NO_X = NO_2$, which therefore allows us to compare the modeling results to the NO_2 threshold in a conservative manner. The modeled concentrations (µg/m³) represents the maximum highest high 1-hour average concentration corresponding to the meteorological year for short-term (1-hr, 24 hr) averaging periods and highest annual concentration for the annual averaging period respectively. A review of the results indicates that the proposed operations do not exceed the applicable guidance levels for SO_2, PM_{10}, and $PM_{2.5}$, and the annual averaging period for NO_2. Trinity noted that the maximum modeled concentrations (H1H) for the 1-hour averaging period for NO_2 is at 156% of the guidance level (i.e. 312.05 µg/m³) if comparing each year separately. Note that the WHO standards referenced in Section 2.2 do not have a "form" of the standard similar to the NAAQS promulgated by EPA. Although this modeling analysis adopts the "form" of the EPA standard, the modeling analysis only compares the predicted modeled concentrations to the EPA threshold values for completeness, since the project is required to meet WHO guidelines, and not necessarily EPA thresholds. However, as noted throughout this report, this modeling analysis includes multiple conservative assumptions, and as such these data are not likely to result in practical ambient air quality threshold exceedances. Particularly when considering NO_2, the assumption that 100% of the NO_X has been converted to NO_2 at the receptors is extremely conservative/ unrealistic.

[27] The results for NO_2 are included for the 3-year average value of the 98th percentile, consistent with the current form of the standard used by U.S.EPA.

Per U.S. EPA's *Guideline on Air Quality Models* (the "EPA Guideline")[28], the NAAQS are limits defined as the total allowable concentration of a pollutant in the atmosphere. The NAAQS analysis demonstrates that the proposed project should not cause or contribute to a violation of federal ambient air concentration thresholds. The NAAQS Analysis uses the sum of the dispersion model and an ambient monitoring concentration to demonstrate compliance. In the absence of an extensive monitoring network for NO_2, no nearest representative NO_2 monitor concentrations was available to add to the modeled results as background concentration. The NO_2 annual-average impacts predicted in the NAAQS Analysis are reported as the H1H modeled concentration. The design value of the 1-hour NO_2 NAAQS is "the three-year average of the 98th percentile of the annual distribution of daily maximum 1-hour average concentrations." In a recent guidance document, the U.S. EPA confirmed the design concentration for modeled impacts should match the form of the 1-hour NO_2 NAAQS and be established based on the highest of the five-year average 8th-highest (98th-percentile) daily maximum 1-hour concentrations across all receptors.[29]

This methodology of applying percentiles to emissions standards is a common approach in regulation of air quality (e.g. USEPA; UKBEIS). It is used to accommodate the highly variable nature of atmospheric emissions in the environment as a result of fluctuations in source (e.g. loads, fuels etc.), environmental factors influencing dispersion (e.g. prevailing or extreme meteorological conditions) and time averaging periods (e.g. short term extremes vs long term averages). The percentile approach allows for some of these extremes in variability by providing a demonstration of a more probabilistic expression of emissions against air quality standards. In other words, exceedances of the 98-percentile can be seen to have a 2% probability of occurrence. Thus, this form of the standard allows for extreme or less representative / likely conditions giving rise to concentrations of pollutants in ambient air.

If the expected ambient concentration is less than the applicable NAAQS, the proposed project does not cause or contribute to an exceedance of the NAAQS and, therefore, no further analysis is required. If the expected ambient concentration is greater than or equal to the NAAQS, a culpability analysis is performed to determine if the contribution from the significant impact analysis is significant at the same time and location of the modeled exceedance.

In the absence of an available form of the WHO standard, when the modeling analysis utilizes the form of the corresponding EPA NAAQS 1-hour averaging period, the 98th percentile of the daily maximum concentration of NO_2 results (i.e. H8H results) averaged over 3 years (i.e. average of NO_2 - 1 hour (H8H) values of 180.48, 196.18, and 181.29, which equals 185.98 μg/m^3) is at **92.9%** of the WHO guidance level, and **98.9%** of the EPA NAAQS threshold for the 1-hour averaging period for NO_2. In the absence of an extensive monitoring network for NO_2, no nearest representative NO_2 monitor concentrations was available to add to the modeled concentration. **Therefore, based on these preliminary results the proposed project will potentially cause minimal to no significant impacts on the shoreline as well as the surrounding inland Class I areas of Mauritania and Senegal**.

3.1. SOURCE CONTRIBUTION ANALYSIS FOR NO_2 1-HOUR MODEL

Trinity performed a source contribution analysis to identify the highest contributor to the total maximum impacts from NO_2 1-hour model. Please note that this analysis is performed for NO_2 1-hour model only, and no other pollutants and/or averaging periods were analyzed. Also, this analysis is performed only for one year as the results for 2015 year represent the worst-case impacts as shown in Table 3-1. It is assumed that the source

[28] U.S. EPA: Guideline on Air Quality Models, 40 CFR Part 51 – Appendix W (Revised January 17, 2017), referred here as "EPA Guideline".

[29] U.S. EPA Technology Transfer Network, Support Center for Regulatory Atmospheric Modeling (SCRAM), Notice Regarding Modeling New Hourly NO2 NAAQS – Updated, February 25, 2010.

contribution will remain similar for other two meteorological years as well. The results are summarized as shown in Table 3-2.

The source contribution analysis was performed by selecting the maximally impacted receptor (Receptor ID: AR42) and for worst meteorological hour (i.e. 10^{th} hour of May 1, 2015) from the NO_2 1-hour model. As shown in Table 3-2 Source Contribution Analysis for NO_2 1-hour H1H Modeling Impacts, the crew boats at the Hub Terminal (Source ID: HUBCB) were the highest contributor (~ 23%) to the total NO_2 1-hour impacts for year 2015 (NO_2 total impacts = 312.05 $\mu g/m^3$).

Please note that the CALPUFF model is a non-steady Lagrangian Gaussian puff model containing modules for overwater transport, coastal interaction effects and simple chemical transformation.[30] The model advects "puffs" of material emitted from modeled sources, simulating dispersions and transformation processes along the way. This model represent a continuous plume as a number of discrete packets of pollutant material and the total concentration at a receptor is the sum of the contributions of all nearby puffs averaged for all sampling steps within the basic time step. In other words, the puffs that are generated during prior hours may also contribute to this concentration depending on whether the puff travels within the computational domain. Therefore, the meteorological conditions for the hour with worst-case impacts in any given year may not be the only meteorological conditions that contribute to the concentrations reported at any given hour.

[30] A User's Guide for the CALPUFF Dispersion Model (Version 5), January 2000; http://www.src.com/calpuff/download/CALPUFF_UsersGuide.pdf

Table 3-2. Source Contribution Analysis for NO_2 1-hour H1H Modeling Impacts (µg/m³)

Operations	Source ID	Source Description	Stack Height MSL (m)	Stack Inside Diameter (m)	Stack Gas Temperature at tip (°C)	Stack Gas Exit Effective Velocity (m/sec)	Modeled NOx Emissions (lb/hr)	Modeled NOx Emissions (g/s)	% Source Contribution to Total NO_2 impacts
FPSO	FPSOGT	Gas Turbines	80.00	2.00	555.00	25.09	10.41	1.311E+00	-
	FPSOEGEN	Emergency Generator	60.00	0.30	380.00	30.70	41.03	5.169E+00	-
	FPSOFWP	FW Pumps	60.00	0.25	380.00	32.90	122.19	1.540E+01	-
	FPSOESG	Essential Service Generator	10.00	0.20	0.00	0.001	77.69	9.788E+00	-
	FPSOFI	Flare Igniters	125.00	0.80	40.00	347.63	59.77	7.531E+00	-
FPSO Marine Vessels	FPSOAT	Assist Tug	7.00	0.45	573.00	34.00	159.99	2.016E+01	-
	FPSOSB	Supply Boat	14.00	0.30	573.00	40.00	102.29	1.289E+01	-
	FPSOGS	Guard/Security	2.00	0.30	573.00	40.00	35.54	4.479E+00	-
	FPSOCB	Crew Boat	2.00	0.30	573.00	40.00	157.98	1.990E+01	-
HUB Marine Vessels	HUBAT	Assist Tug	7.00	0.45	573.00	34.00	159.99	2.016E+01	19.36%
	HUBST	Service Tug	7.00	0.45	573.00	34.00	159.99	2.016E+01	19.36%
	HUBML	Mooring Line	7.00	0.45	573.00	34.00	159.99	2.016E+01	19.36%
	HUBGS	Guard/Security	2.00	0.30	573.00	40.00	35.54	4.479E+00	4.49%
	HUBCB	Crew Boat	2.00	0.30	573.00	40.00	157.98	1.990E+01	23.35%
FLNG	FLNGGT	Gas Turbines	75.00	3.00	515.00	32.60	104.54	1.317E+01	-
	FLNGGG	Gas Generators	75.00	1.00	380.00	26.80	61.60	7.761E+00	-
	FLNGFI	Flare Igniters	125.00	0.80	-60.00	347.63	49.58	6.247E+00	-
HUB	HUBFI	Flare Igniters	60.00	0.25	-90.00	44.45	1.80	2.271E-01	0.07%
	HUBGG	Gas Generators	15.00	0.40	380.00	33.50	83.83	1.056E+01	9.34%
	HUBEG	Emergency Generator	15.00	0.15	380.00	26.80	0.82	1.038E-01	0.05%
	HUBFWP	FW Pumps	60.00	0.25	380.00	32.90	62.91	7.927E+00	4.63%
						TOTAL ->	***1,805.45***	***2.275E+02***	***100.00%***

Based on the source contribution analysis represented in Table 3-2, the marine vessels at the Hub Terminal are the highest contributors to the H1H modeling impacts (crew boat being the highest contributor). Please note that the exact marine vessels at the Hub Terminal are not identified per the current engineering and design estimates. Therefore, for screening modeling purposes, the representative FPSO assist tug stack input parameters as well as model input emission rates have been utilized for the Hub Terminal - assist tug, service tug, and mooring line sources respectively. Based on follow-up discussions with the project team, Trinity believes there is conservatism built into the stack parameters as well as the modeled emission rates for these Hub marine vessels, which is demonstrated by % source contribution to Total NO_2 impacts column in Table 3-2. Also, these marine vessels have been modeled as stationary point sources, instead of considering their mobility around the Hub and/or FPSO operations which leads to additional conservatism within the model. There is additional conservatism in the modeling of marine vessels as they are assumed to be running at 100% load at all times, even while stationed at the Hub and FPSO. Realistically, the engine loads (and consequently the emission rates) will be lower when not in transit.

Additionally, as further discussed in Appendix Ja of this report, only the emissions associated with normal operations have been taken into account while estimating the air emissions. That includes maintenance and readiness testing emissions from the generators, pilot emissions from flares assuming they all occur at the same time (i.e. under normal operation). Thus, with preliminary understanding of the different operating scenarios (emergency vs normal vs other additional scenarios) at the time of model set up, it has been assumed that the air emissions from all the sources listed in Table 3-2 will be emitted simultaneously. Also, please note that the source contribution analysis was performed at a single hour of worst-case meteorological year and it truly represents the source contributions at that given hour.

The FLNG sources are expected to have higher emisisons controls than the marine vessels modeled sources. Also, since FLNG sources have taller stacks compared to the marine vessels, they have negligible to zero contribution to the total worst-case impacts as shown in Table 3-2. Also, since the FPSO sources (both FPSO marine vessels and main FPSO combustion sources) are located further away from the shoreline receptors as compared to the Hub/FLNG, they have zero to minimal contribution to the total maximum impact.

For visual representation, the contour plots for NO_2 1-hour modeled concentrations (H1H) are shown in Figure 3-1 through Figure 3-4. For illustration purposes, the shoreline receptors are removed from that area in Figure 3-1 and Figure 3-3, however, they are shown as a part of Figure 3-2 and 3-4 respectively. Since the receptor grid is somewhat linear, i.e. follows the coastal boundary and does not follow a rectangular grid format, the contour plots might need additional data points in order to interpolate the results and create high resolution plots around the emission sources. Since addition of receptors around the emission source is not required (i.e. not required to assess impacts overwater as it does not qualify as ambient air), Trinity did not include these data points in the screening models. However, if a refined modeling analysis is deemed necessary to generate higher resolution contour plots that also cover the impacts over water, a more comprehensive modeling setup and an additional modeling iteration would be required to suffice the visual representation requirements of this analysis. Please note that Figure 3-2 and Figure 3-4 are zoomed in version of Figure 3-1 and Figure 3-3 respectively.

Figure 3-1. Contour Plots for NO_2 1-hour Modeled Concentrations (H1H) for 2015 Year

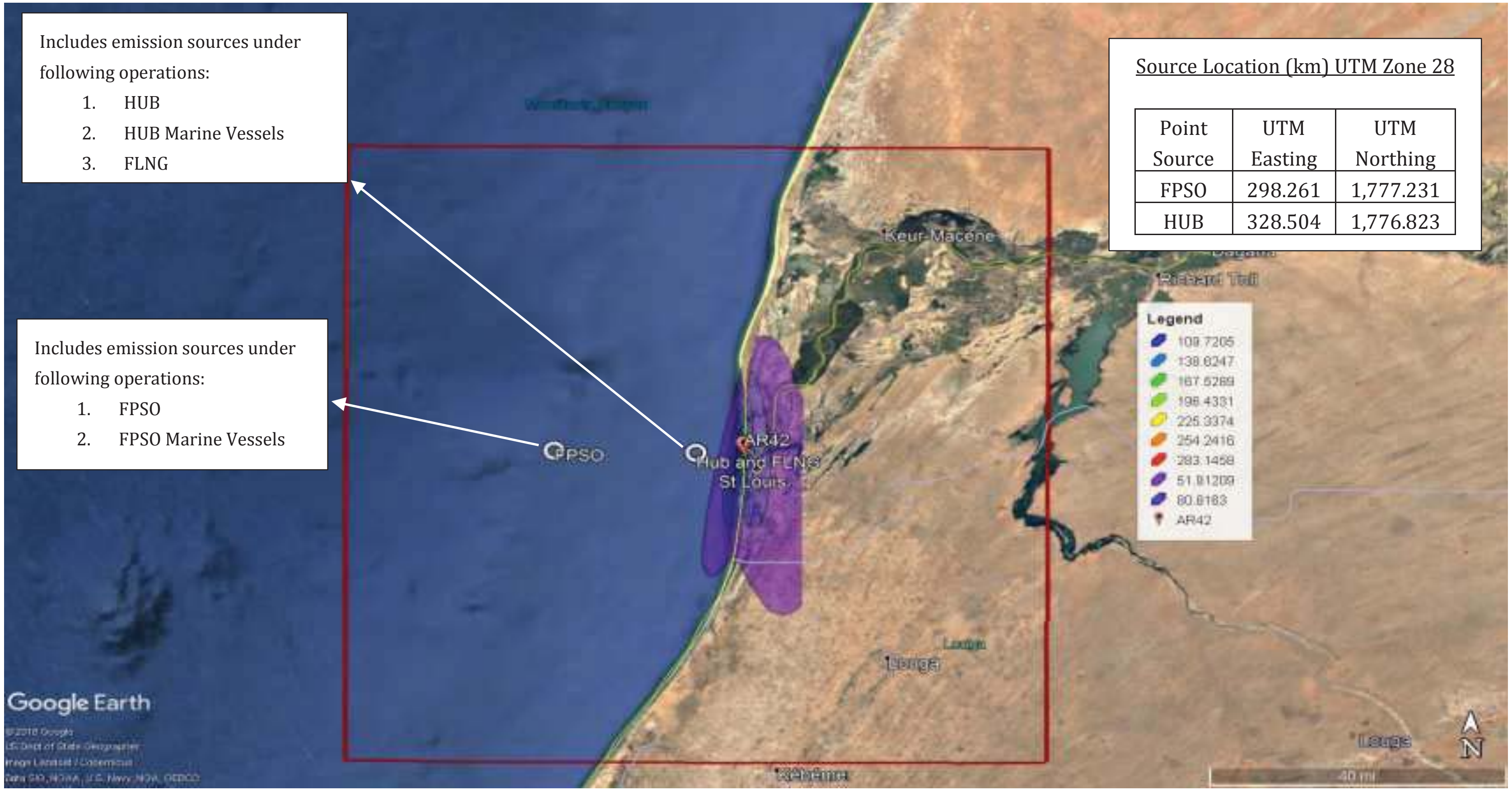


Figure 3-1. Receptor and Source Locations	Trinity Consultants	**Tortue Phase 1A Mauritania and Senegal Region**
R - Discrete Receptors, AR - Fine Grid Receptors		**Modeled Sources**

Figure 3-2. Contour Plots for NO_2 1-hour Modeled Concentrations (H1H) Worst Case for 2015 Year

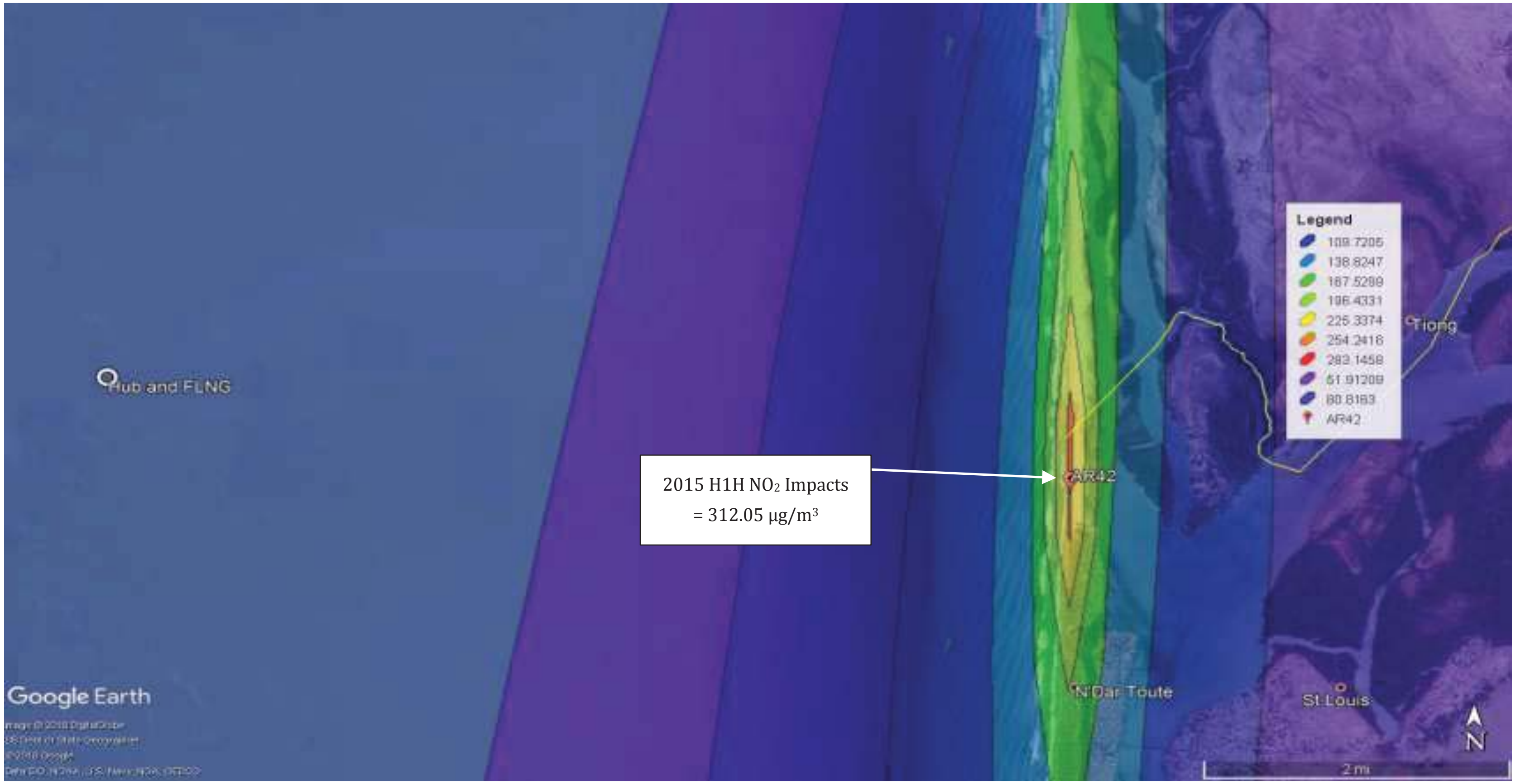


Figure 3-2. Receptor and Source Locations	Trinity Consultants	Tortue Phase 1A Mauritania and Senegal Region

R - Discrete Receptors, **AR - Fine Grid Receptors** **Receptor ID-AR42: Worst-Case Receptor with Highest NO_2 1-hour impacts**	**Modeled Sources**

Figure 3-3. Contour Plots for NO_2 1-hour Modeled Concentrations (H8H) for 2015 Year

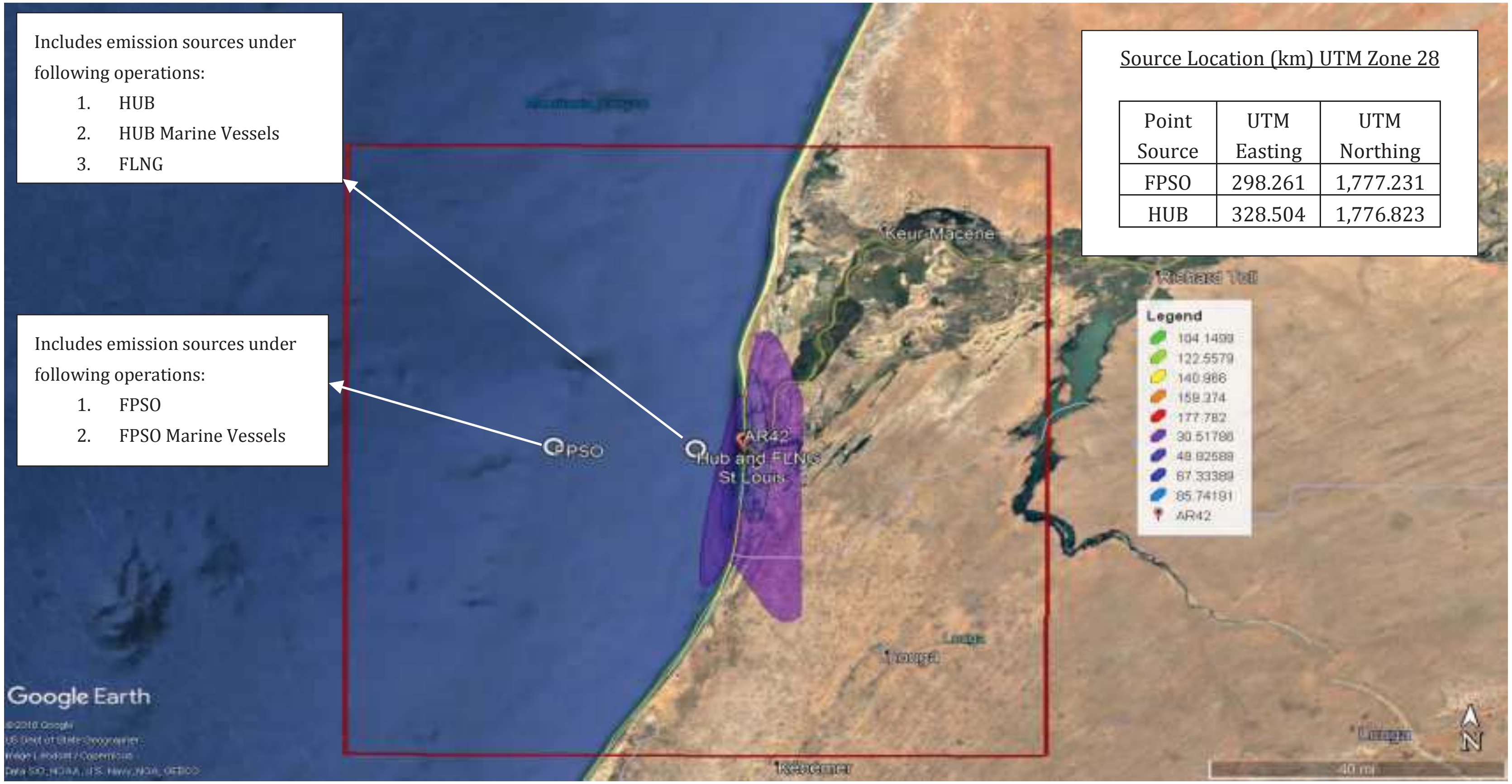


Figure 3-3. Receptor and Source Locations

Tortue Phase 1A
Mauritania and Senegal Region

R - Discrete Receptors,
AR - Fine Grid Receptors

Modeled Sources

Figure 3-4. Contour Plots for NO_2 1-hour Modeled Concentrations (H8H) Worst Case for 2015 Year

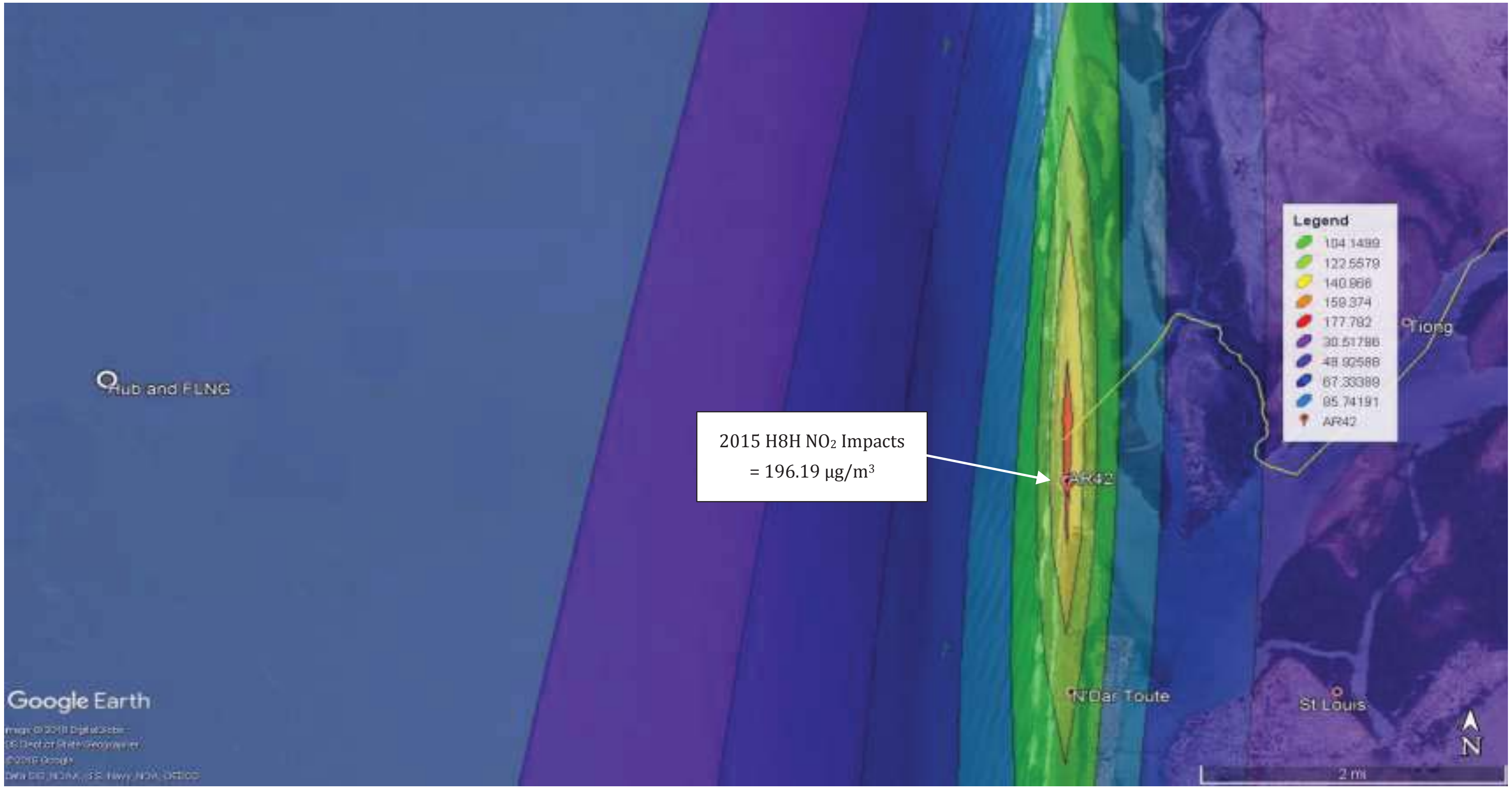


Figure 3-4. Receptor and Source Locations	Trinity Consultants	Tortue Phase 1A Mauritania and Senegal Region

R - Discrete Receptors,
AR - Fine Grid Receptors
Receptor ID-AR42: Worst-Case Receptor with Highest NO_2 1-hour impacts

Modeled Sources

3.2. MODELING RESULTS CONCLUSION

With the aforementioned assumptions and modeling results interpretation of this screening/preliminary study, it is interpreted that the air dispersion modeling impacts are below the WHO guideline values (*using the three year average value of the NO_2 1-hour H8H modeling results per US EPA guidelines*), and subsequently below the Senegalese air quality guidelines as well. Therefore, under the current design and operating assumptions for the modeled parameters, the Tortue Phase 1A project will not have any significant air quality impacts along the shoreline, as well as to the surrounding inland Class I areas of Mauritania and Senegal. The below table demonstrates that the modeling passes each individual modeling threshold.

Table 3-3 Model Summary

Pollutant - Averaging Period	WHO Guideline Levels (µg/m³)	Does Modeling Pass?
NO_2 - 1 hour (H1H)	200	Yes
NO_2 - 1 hour (H8H)		
NO_2 - Annual	40	Yes
SO_2 - 24 hour	20	Yes
PM_{10} - 24 hour	50	Yes
PM_{10} - Annual	20	Yes
$PM_{2.5}$ - 24 hour	25	Yes
$PM_{2.5}$ - Annual	10	Yes

* *Note that the WHO standards referenced in Section 2.2 do not have a "form" of the standard similar to the National Ambient Air Quality Standards (NAAQS) promulgated by EPA. Please refer to page 3-1 and 3-2 of the report.*

Trinity included the interpretation of NO_2 1-hour modeling impacts and its comparison with WHO, as well as U.S. EPA standards only for reference purposes. The primary reason to do so was to show that NO_2 1-hour modeling concentrations are not an exceedance of WHO standards and the EPA NO_2 threshold, since the WHO standard does not include details on promulgation of the standard (i.e. no form of standard). Trinity included the source contribution analysis to demonstrate that the worst-case results seen in 2015 for NO_2 are as a result of meteorological conditions, as well as high NO_X emissions from marine support vessels. The emissions are high from these vessels based on the high engine capacity on these vessels, the speciation of marine vessel fuel, MDO, as well as the conservative emission factors utilized per the current reference - *Commercial Marine Vessels are sourced from ICF International Report for US EPA, Current Methodologies in Preparing Mobile Source Port-related Emissions Inventories, April 2009*. In addition, although the emissions from flares included in the model only include flare pilot emissions, the conservatively high emission factors based on API data for the flare pilots (incorporated per the current design for the Tortue project) are one of the lower contributors to the overall modeling results.

APPENDIX JA: EMISSIONS QUANTIFICATION DISCUSSION

The Tortue Project will operate a number of air emissions sources at each of the facilities described in this modeling report. The following sections provide a brief description of each source at each Tortue Project facility, the methods used to estimate emissions associated with each type of source, and the amount of nitrogen oxides (NO_x), carbon monoxide (CO), volatile organic compounds (VOC), particulate matter (PM), sulfur dioxide (SO_2), hazardous air pollutants (HAP), and greenhouse gases (GHG) emitted by each source. For the emission calculations, PM was conservatively assumed to equal PM with an aerodynamic diameter of less than 10 microns (PM_{10}) and PM with an aerodynamic diameter of less than 2.5 microns ($PM_{2.5}$). NO_x, CO, VOC, PM_{10}, $PM_{2.5}$, and SO_2 are known as criteria pollutants. Appendix Jb provides a summary of the Tortue Project's emissions for criteria pollutants, GHGs, and HAPs in metric tons per year. For the purposes of this report, only the normal operating scenario has been evaluated for emissions estimation and dispersion modeling analyses.

SUMMARY OF THE NORMAL OPERATING SCENARIO (INCLUDED IN DISPERSION MODELING)

The development of a normal operating scenario for the Tortue project relied on data provided by BP, Golar LNG (Golar), and KBR, Inc. (KBR)[1]. When specific operational data was not provided, Trinity Consultants, Inc. (Trinity) presented a conservative assumption to estimate the normal operations of the emission unit, based either on similar emission units or regulations observed by specific regulating agencies (such as the U.S. Environmental Protection Agency {EPA}, World Health Organization {WHO}, etc.) Below is a summary of the normal operating scenarios of each facility and the assumptions made for each emission source.

FPSO Facility Sources and Assumptions

The FPSO facility will primarily consist of two (2) gas turbines, an emergency generator, four (4) firewater pumps, an essential service generator, and two (2) emergency flares.

The following assumptions were made for the normal operating scenario of the emission units at the FPSO facility:

- Each gas turbine will be rated at 7.6 megawatts (MWe) with a combined rating of 15.3 MWe, according to the November 2017 Tortue Report[2];
- The two (2) gas turbines will have a 95% annual availability of normal operation, based on preliminary engineering estimates. Trinity assumed 500 hours of diesel fuel combustion and the remaining hours as natural gas combustion, as a conservative estimate attributable to the dual fuel capabilities of the turbines;
- The emergency generator will be rated at 1.25 MWe, based on preliminary engineering estimates provided by BP;
- The potential hours of annual operation of the emergency generator is projected to be 216 hours, based on information provided by BP on November 20, 2017. Normal operation of the generator will only include maintenance and readiness testing, and does not include operation during an emergency situation;
- The four (4) firewater pumps will be rated at 1.00 MWe, based on engineering estimates provided by BP;
- Since an estimate on the annual non-emergency operation was not finalized at the time of this assessment, Trinity estimated the potential hours of annual operation of the firewater pumps to be 100 hours[3], which includes maintenance and readiness testing of the units.

---

[1] Latest set of data provided by BP on December 13, 2017.

[2] The Tortue Development Project "Energy Usage and Air Emissions Forecast", November 2017.

[3] The U.S. EPA Federal Regulations for stationary reciprocating internal combustion engines (RICE) limit the maximum hours of annual operation for emergency engines to 100 hours per year. However, since this project is not under U.S. EPA jurisdiction, it is assumed that the non-emergency operation for the emergency generators (216

- The essential service generator will be rated at 2.5 MWe, based on engineering estimates provided by BP;
- The potential hours of annual operation of the essential service generator is estimated to be 438 hours, based on information provided by BP;
- Based on preliminary design information, it was assumed that the FPSO facility contained two (2) emergency flares, however, because only one (1) set of stack and emissions data was provided for the FPSO pilot flare operations in the latest design details, the emissions from each flare were assumed to be equivalent; and
- Normal operations of the two (2) emergency flares consist only of the pilot flares, which are projected to operate continuously. Normal operations of the flares do not model emergency and upset flaring conditions. Natural gas consumption of the pilot flares was provided by BP.

Detailed emissions calculations are provided in Appendix Jb of this report.

FLNG Facility Sources and Assumptions

The FLNG facility primarily consists of four (4) gas turbines, two (2) gas generators, and three (3) emergency flares.

The following assumptions were made for the normal operating scenario of the emission units at the FLNG facility based on engineering estimates provided by BP:

- Each of the four (4) gas turbines will be rated at 33.7 megawatts (MWe;
- The four (4) gas turbines will have a 97% annual availability of normal operation;
- The two (2) gas generators will be rated at 9.00 MWe;
- Trinity conservatively estimated the potential annual operation of the gas generators to be equivalent to the gas turbines hours, i.e., 97% annual utilization;
- Based on preliminary design information provided by BP, it was assumed the FLNG facility contained three (3) emergency flares, however, because only one (1) set of stack and emissions data was provided for the FLNG pilot flare operations in the latest design details from BP, the emissions from each flare were assumed to be equivalent; and
- Normal operations of the emergency flare consists only of the pilot flare, which is projected to operate continuously. Normal operations of the flare does not model emergency and upset flaring conditions. The natural gas consumption of the pilot flares were provided by BP. The total natural gas consumption rate for each flare was combined together to provide the total emissions for the FLNG pilot flare operations.

Detailed emissions calculations are provided in Appendix Jb of this report.

Hub Facility Sources and Assumptions

The Hub facility primarily consists of two (2) gas generators, an emergency generator, two (2) firewater pumps, and an emergency flare.

The following assumptions were made for the normal operating scenario of the emission units at the Hub facility based on engineering estimates provided by BP:

---

hours), and essential services generator (438 hours) as part of the FPSO will be approved by the regulatory agencies involved in authorizing this project.

- The two (2) gas generators will be rated at 2.50 MWe;
- The two (2) gas generators will have a 95% annual availability of normal operation;
- The emergency generator will be rated at 0.25 MWe;
- Trinity estimated the potential hours of annual operation of the emergency generator to be 100 hours[4], which includes maintenance and readiness testing of the unit.
- The two (2) firewater pumps will be rated at 1.00 MWe, based on guidance provided by CSA;
- Trinity estimated the potential hours of annual operation of the firewater pumps to be 100 hours[5], which includes maintenance and readiness testing of the units;
- Based on preliminary design information provided by BP, it was assumed that the Hub facility contains a single emergency flare; and
- Normal operations of the emergency flare consists only of the pilot flare, which is projected to operate continuously. Normal operations of the flare does not model emergency and upset flaring conditions. Natural gas consumption of the pilot flare was provided by BP.

Detailed emissions calculations are provided in Appendix Jb of this report.

Marine Support Vessels and Assumptions

The marine support vessels for the FPSO facility consist of three (3) assist tugs, a supply boat, a security boat, and a crew boat. The assist tugs are predicted to offload condensate from the facility every 67 days, on average. The supply boat will be used to provide the facility with needed materials, and load/offload rich/lean MEG used for dehydration. The security boat will operate continuously in the region of the FPSO facility. The crew boat will be used to transfer crew between the shore and the FPSO facility.

The marine support vessels for the Hub/FLNG facility consists of three (3) assists tugs, a service tug, a security boat, three (3) mooring lines, and a crew boat. Information for the service tug and security boat were not finalized as part of the preliminary design information report provided by BP on November 20, 2017. Therefore, for a conservative estimate of emissions, it was assumed the service tug and mooring lines emissions would be equivalent to the three (3) assist tugs for the Hub/FLNG facility and that the security boat would be equivalent to the security boat at the FPSO facility.

The following assumptions were made for the normal operating scenario for the Marine Support Vessels[6]:

- Emissions for the vessels main engines and all category auxiliary engines are from Tables 2-9, 2-13, and 2-16 from the ICF International Report (2007).
- The three (3) FPSO Assist Tugs are projected to operate 216 hours, annually;
- The FPSO Supply Tug is projected to operation 288 hours, annually;
- The FPSO and FLNG/Hub Security boat is conservatively projected to operate continuously;
- The FPSO Crew boat is projected to operate 1,248 hours, annually;
- The three (3) FLNG/Hub Assist Tugs are projected to operate 1,752 hours, annually;
- Trinity conservatively assumed that the FLNG/Hub Service Tug and mooring lines would have the same normal operation scenario as the FLNG/Hub Assist Tugs, 1,752 hours of annual operation;
- Trinity conservatively assumed that the FLNG/Hub Security boat would have the same normal operation scenario as the FPSO Security boat, and operate continuously; and

[4] The U.S. EPA Federal Regulations stationary RICE limit the maximum hours of annual operation for emergency engines to 100 hours per year.
[5] Ibid.
[6] The operational and emission details of the Marine Support Vessels were provided by BP on November 20, 2017.

- The FLNG/Hub Crew boat is projected to operate 4,380 hours, annually.

EMISSIONS CALCULATION DETAILS – NORMAL OPERATING SCENARIO

As mentioned previously, the development of a normal operating scenario potential emissions for the Tortue project relied on data provided by BP, Golar, and KBR. When specific emissions data was not provided, Trinity presented a conservative assumption to estimate the normal operations of the emission unit, based either on similar emission units or regulations observed by specific regulating agencies (such as the U.S. EPA, WHO, etc.)

Below describes the process used for calculating potential emissions based on provided data:

- Potential emissions are provided where possible based on emissions data provide by BP, Golar, or KBR to Trinity via its subcontract through Golder, CSA on December 13, 2017;
- If emissions data from BP, Golar, or KBR were not available to calculate potential emissions, emissions based on API emission factors provided by BP or KBR on November 20, 2017[37] were utilized;
- If API emission factors were not provided for an emissions source or certain pollutant, AP-42 emission factors were used for the corresponding source and fuel type.

The following subsection below describe the development of the normal operating scenario potential emissions of each facility and the assumptions made for each emission unit.

Gas Turbines

FPSO Facility

The two (2) gas turbines (GT) on the FPSO facility will be used to generate power for the facility. The total energy required for the facility according to the CSA Tortue Report[38] will be 15.3 MWe for Phase 1A production. Therefore, each turbine's capacity was estimated to be 7.6 MWe, which equates to a combined capacity of 15.3 MWe.

The FPSO GTs will combust natural gas as a primary fuel and diesel fuel as a secondary fuel in the event natural gas is not available. Potential emissions used the estimation that the GTs have a 95% annual availability, with 500 hours of operation assumed to be on diesel fuel as a conservative estimate.

Natural Gas Combustion

Emissions for the combustion of natural gas were calculated with the following assumptions:

The heat content of the natural gas (in British thermal units per kilowatt-hour [Btu/kW-hr]) as a lower heating value (LHV) combusted in the GTs and the fuel consumption rate (tonnes of fuel/hr) of each turbine was provided by BP and used to estimate emissions from the annual operation of each turbine. The LHV of natural gas provided by BP was converted to a higher heating value (HHV) by increasing the LHV by 11%. Emissions from NO_X, CO, PM, and SO_2 were provided by BP based on preliminary engineering estimates in grams per second (g/s). VOC emissions were estimated using the API emission factor provided by BP based on the latest

[37] API emission factors were provided for a number of emission sources by BP in response to a data request from Trinity Consultants on November 20, 2017. These emission factors were deemed as more accurate to represent the emissions versus AP-42 factors, where available.
[38] The Tortue Development Project "Energy Usage and Air Emissions Forecast", November 2017.

design data. Hazardous Air Pollutants (HAP) emissions were calculated using AP-42 Section 3.1-3 emission factors the combustion of natural gas (in pounds per million British thermal units [lb/MMBtu]), which utilize the higher heating value (HHV) of natural gas. GHG emissions for natural gas combustion were based off of API emission factors provided by BP on November 20, 2017. Carbon dioxide equivalent (CO_2e) emissions were calculated using the Global Warming Potentials (GWP) from the United States Code of Federal Regulations (CFR), Title 40, Part 98, Table A-1, and are 1 for CO_2, 25 for CH_4, and 298 for N_2O.

Diesel Fuel Combustion

Emissions for diesel fuel combustion are only included for documentation purposes. The screening modeling analysis does not include diesel emissions from gas turbines. Emissions for the combustion of diesel fuel were calculated with the following assumptions:

The heat content of diesel fuel (MMBtu/ 1,000 gallons) was based on the AP-42 reference for the HHV of distillate oil. The fuel consumption rate was assumed to be equivalent to that of natural gas, which was provided by BP to conservatively estimate diesel combustion emissions. Emissions for each criteria pollutant and HAP were based on AP-42 Section 3.1-1 emission factors for uncontrolled distillate oil combustion. GHG emissions were based off of 40 CFR Part 98 emission factors for distillate oil combustion. CO_2e emissions were calculated using the GWP from Part 98, Table A-1 and are 1 for CO_2, 25 for CH_4, and 298 for N_2O.

FLNG Facility

The four (4) GTs on the FLNG facility are used to drive the refrigerant compressors, with waste heat recovery (WHR) used to supply heat for the steam power generation. Each turbine's capacity was estimated to be 33.7 MWe, which equates to a combined capacity of 134.8 MWe. The FLNG GTs will only combust natural gas.

Natural Gas Combustion

Emissions for the combustion of natural gas calculated with the following assumptions:

Potential emissions used the conservative assumption that the GTs will have a 97% availability during the calendar year. The heat content of the natural gas (Btu/kW-hr) as a LHV combusted in the GTs and the fuel consumption rate (MMBtu/hr) of each turbine were provided by BP on November 20, 2017 and used to estimate emissions from the annual operation of each turbine. The LHV of natural gas provided by BP was converted to a HHV by increasing the LHV by 11%. Emissions from NO_X, CO, PM, and SO_2 were provided by BP based on the latest design data (in g/s). VOC emissions were estimated using the AP-42 Section 3.1-2a for natural gas combustion in stationary combustion turbines. HAP emissions were calculated using AP-42 Section3.1-3 emission factors the combustion of natural gas (in lb/MMBtu), which utilize the HHV of natural gas. GHG emissions for natural gas combustion were based off of emissions factors for natural gas combustion provided in 40 CFR Part 98. CO_2e emissions were calculated using the GWP from 40 CFR Part 98, Table A-1 and are 1 for CO_2, 25 for CH_4, and 298 for N_2O.

Gas Generators

FLNG Facility

The two (2) gas generators at the FLNG facility are used for power generation when the WHR on the gas turbines are not sufficient to meet the electrical power demand. Each generator was estimated at 9 MWe.

The gas generators will only combust natural gas. Potential emissions conservatively used the estimation that the generators will also have 97% annual availability, the same as the GTs. The heat content of the natural gas

(Btu/kW-hr) as a lower heating value (LHV) used in the GTs was provided by BP and assumed to be equivalent to the GTs because they will be operating in the same facility and likely using the same fuel. The LHV of natural gas provided by BP was converted to a HHV by increasing the LHV by 11%. Emissions from NO_X, CO, VOC[39], and SO_2 were provided by Golar (in tonne/hr). PM emissions were based off of the maximum AP-42 Section 3.2, PM emission factor for natural gas fired reciprocating engines[40]. HAP emissions were calculated using AP-42 Section 3.2-1 emission factors the combustion of natural gas for uncontrolled 2-stroke lean burn engines (in lb/MMBtu), which utilize the HHV of natural gas. GHG emissions for natural gas combustion were based off of the CO_2 emission factor provided by Golar, and the 40 CFR Part 98 emission factor for CH_4 and N_2O. CO_2e emissions were calculated using the GWP from 40 CFR Part 98, Table A-1 and are 1 for CO_2, 25 for CH_4, and 298 for N_2O.

Hub Facility

The two (2) gas generators at the Hub facility are used for power generation. Each generator was estimated at 2.5 MW_e.

The gas generators will combust natural gas (fuel gas). Potential emissions conservatively used the estimation that the generators will have 95% annual availability. The heat content of the natural gas (Btu/kW-hr) as a lower heating value (LHV) used in the gas generators was provided by BP, and is assumed to be equivalent to the heat content of the fuel used at the FLNG facility because the Hub and FLNG will be located together and likely use the same fuel. The LHV of natural gas provided by BP was converted to a HHV by increasing the LHV by 11%. Emissions from NO_X, CO, and SO_2 were provided by BP (in g/s). PM and VOC emissions were based off of the maximum AP-42 Section 3.2, PM and VOC emission factors for natural gas fired reciprocating engines[41]. HAP emissions were calculated using AP-42 Section 3.2-1 emission factors the combustion of natural gas for uncontrolled 2-stroke lean burn engines (in lb/MMBtu), which utilize the HHV of natural gas.

GHG emissions for natural gas combustion were based off of the 40 CFR Part 98 emission factor for CO_2, CH_4 and N_2O. CO_2e emissions were calculated using the GWP from 40 CFR Part 98, Table A-1 and are 1 for CO_2, 25 for CH_4, and 298 for N_2O.

Diesel Driven Auxiliary Equipment

FPSO Facility

The FPSO will have a number of emergency and back-up equipment that is powered by diesel fuel. The emergency generator and four (4) firewater pumps will both be used in emergency situations. If main power is not available, the emergency generator will be used to provide energy to the FPSO facility. The four (4) firewater pumps will be used to ensure adequate coverage in the event of a fire. The emergency generator is rated a 1.25 MWe, and each firewater pump is rated at 1 MWe. The essential service generator will be used as a back-up for the GT's to ensure that proper power is provided to the facility at all times. The essential service generator is rated at 2.5 MWe. The generator, firewater pumps, and essential service generator will all be driven by diesel fuel.

The projected annual operations of the emergency generator was provided by BP, and was estimated to be 216 hours, which includes shutdown and maintenance activities on the unit. Because a projected estimate of the annual operations of the firewater pumps was not finalized prior to the calculation of emissions and modeling

[39] The total non-methane hydrocarbon (NMHC) emission rate was conservatively assumed to be all VOC emissions.
[40] The maximum PM emission factor for AP-42 Section 3.2 is for an uncontrolled 2-stroke lean burn engine.
[41] The maximum PM and VOC emission factors for AP-42 Section 3.2 are for an uncontrolled 2-stroke lean burn engine.

analyses, it was estimated to be 100 hours per year, which is a conservative estimate of emergency and maintenance activities performed on the pumps. The projected annual operations of the essential service generator was provided by BP, and was estimated to be 438 hours, which equates to a conservative estimation of 18.25 days of annual operation.

Potential emission rates for NO_X, CO, and SO_2 of both the emergency generator, and the firewater pumps were provided by BP. Emissions of NO_X, CO, and SO_2 for the essential service generator were not finalized at this time, and therefore, emissions from NO_X and CO were estimated using API emission factors previously provided by BP, and SO_2 emission for the essential service generator were estimated by conservatory assuming that the sulfur content in the diesel fuel was 1.0%.

Emissions from PM for all the engines were estimated using AP-42 Section 3.3-1 emission factors for diesel fuel combustion. Emissions from VOC for all the engines were calculated based on API emission factors provided by BP.

HAP emissions for all the diesel driven equipment was calculated based on the approximate fuel consumption of each diesel engine at full load[42] (in gal/hr), and the approximate HHV of diesel fuel provided by the AP-42 reference for the HHV of distillate fuel oil (MMBtu/gal), and the potential annual operation of each engine.

GHG emissions for diesel fuel combustion were based off of API emission factors for CO_2, CH_4, and N_2O provided by BP. CO_2e emissions were calculated using the GWP from 40 CFR Part 98, Table A-1 and are 1 for CO_2, 25 for CH_4, and 298 for N_2O.

Hub Facility

The emergency generator at the Hub facility will be used in the event of a power outage. The generator will be rated at 0.25 MWe. The two (2) firewater pumps at the Hub facility will be used to ensure adequate coverage in the event of a fire. Each firewater pump will be rated at 1 MWe. Both the emergency generator and the firewater pumps will only combust diesel fuel.

Because a projected estimate of the annual operations of the emergency generator and the firewater pumps were not finalized at the time of this assessment, they were conservatively estimated to be 100 hours each, which includes emergency, shutdown, and maintenance activities on the unit.

Emissions of NO_X, CO, and SO_2 for the emergency generator were provided by BP. Emissions of NO_X, CO, and SO_2 for the firewater pumps were not finalized at the time of this assessment, and therefore, emissions from NO_X and CO were estimated using API emission factors previously provided by BP, and SO_2 emission for the firewater pumps were estimated by conservatively assuming the sulfur content in the diesel fuel was 1.0%.

Emissions from PM for all the engines were estimated using AP-42 Section 3.3-1 emission factors for diesel fuel combustion. Emissions from VOC for all the engines were calculated based on API emission factor provided by BP for the FPSO emergency generator, firewater pumps, and essential service generator.

---

[42] The approximate fuel consumption of a diesel engine at full load based on information provided at http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx

HAP emissions for all the diesel driven equipment was calculated based on the approximate fuel consumption of each diesel engine at full load[43] (in gal/hr), and the approximate HHV of diesel fuel provided by the AP-42 reference for the HHV of distillate fuel oil (MMBtu/gal), and the potential annual operation of each engine.

GHG emissions for diesel fuel combustion were based off of API emission factors provided by BP[44]. CO_2e emissions were calculated using the GWP from Part 98, Table A-1 and are 1 for CO_2, 25 for CH_4, and 298 for N_2O.

Flaring Operations

It is important to note that the potential emissions for the flares only include operation of the pilot flares. Emergency flaring operations are not included in the modeling scenario, as these sources are intermittent and not reflective of normal operations.

FPSO Facility

Flaring operations at the FPSO facility will consist of a nitrogen purge with a flare gas recovery (FGR) process during normal operations.

Annual pilot flare potential emissions of NO_X, CO, PM, and SO_2 are calculated based on the exhaust emissions provided by BP. The estimated fuel consumption of the flare pilots during normal operation is based on information provided by BP (in million standard cubic feet per day [MMscf/d]). Trinity conservatively assumed both flares pilots at the facility will possess equivalent fuel consumption rates. The potential emission calculations do not assume an FGR is used and assumes that the flare pilots are operated continuously (i.e. 8,760 hours per year).

HAP emissions were calculated using AP-42 Section 1.4-3, “Emission Factors for Speciated Organic Compounds from Natural Gas Combustion”.

GHG emissions for natural gas combustion were based off of API emissions factors provided by BP. CO_2e emissions were calculated using the GWP from Part 98, Table A-1 and are 1 for CO_2, 25 for CH_4, and 298 for N_2O.

It should be noted that with the FGR, the emission from the flare operations will be negligible.

FLNG Facility

Flaring operations at the FLNG facility will recover minor operational flows of low pressure gas routed from sources that cannot be recovered, due to either low pressure or recovery inefficiency. The flare will consist of a pilot, which is assumed to be permanently lit (i.e. 8,760 hours per year).

Annual pilot flare potential emissions of NO_X, CO, PM, and SO_2 are calculated based on the exhaust emissions provided by BP. The hourly natural gas fuel consumption rate for normal operations was provided by BP for three (3) separate flares (assumed to be a total 11.6 kg/hr for all three (3) flares).

HAP emissions were calculated using AP-42 Section 1.4-3, “Emission Factors for Speciated Organic Compounds from Natural Gas Combustion”.

---

[43] The approximate fuel consumption of a diesel engine at full load based on information provided at http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx
[44] The same emission factors for the FPSO diesel fired Essential Service Generator were used for the diesel fired emergency equipment at the Hub facility as a conservative estimate of potential emissions.

GHG emissions for natural gas combustion were based off of API emissions factors provided by BP for the FPSO flare pilots. Because the flare pilots would combust similar fuels to those at the FPSO facility, the emission factors were used for the FLNG flare as well. CO_2e emissions were calculated using the GWP from Part 98, Table A-1 and are 1 for CO_2, 25 for CH_4, and 298 for N_2O.

It should be noted that with the FGR, the emission from the flare operations will be negligible.

Hub Facility

Flaring operations at the Hub facility will be a nitrogen purge, and will be a source of emissions during maintenance and upset conditions. The flare will consist of a pilot, which is assumed to be permanently lit (i.e. 8,760 hours per year).

Annual potential emissions of NO_X, CO, PM, and SO_2 are calculated based on the exhaust emissions provided by BP. The projected hourly fuel consumption rate of the flare during normal operations was provided by the facility (based on the relationship between the emission factors and potential emissions of each pollutant provided).

HAP emissions are based on AP-42 Section 1.4-4, Emission factors for Speciated Organic Compounds from Natural Gas Combustion, the hourly fuel consumption rate of the flare during normal operations, and the projected continuous operation of the flare.

GHG emissions were calculated based on API emission factors provided by BP for natural gas flaring operations. CO_2e emissions were calculated using the GWP from Part 98, Table A-1 and are 1 for CO2, 25 for CH4, and 298 for N_2O.

It should be noted that maintenance and upset conditions will not occur continuously, therefore the potential emission from the flare operations are a conservative estimate of annual pilot flare emissions.

Marine Support Vessels

FPSO

The marine support vessels for the FPSO facility consist of three (3) assist tugs, a supply boat, a security boat, and a crew boat. The assist tugs are predicted to offload condensate from the facility every 67 days. The supply boat will be used to provide the facility with needed materials, and load/offload rich/lean MEG used for dehydration. The security boat will operate continuously in the region of the FPSO facility. The crew boat will be used to transfer crew between the shore and the FPSO facility.

FLNG/Hub

The marine support vessels for the Hub/FLNG facility consists of three (3) assists tugs, a service tug, a security boat, three (3) mooring lines, and a crew boat. Information for the service tug and security boat were not provided by BP. Therefore, for a conservative estimate of emissions, it was assumed the service tug and mooring lines would be equivalent to the three (3) assist tugs for the Hub/FLNG facility and that the security boat would be equivalent to the security boat at the FPSO facility. All the marine vessels at both the FPSO and Hub/FLNG facility combust diesel fuel.

Details on the number of engines for each vessel, the rating of each engine, the operating hours, and emission factors for NO_X, CO, PM_{10}, $PM_{2.5}$, SO_2, VOC, CO_2, CH_4, and N_2O were provided by BP on November 20, 2017[45]. However, the following conservative assumptions have been made to estimate emissions from the support marine vessels:

- Annual PM emissions were estimated to be equivalent to PM_{10} emissions to conservatively quantify PM emissions; and
- The sulfur content in the fuel was conservatively assumed to be 1.5 weight percent (1.5 w%), although this value will be lowered per MARPOL guidance.

HAP emissions for each marine vessel were calculated based on sum of each criteria pollutant multiplied by the HAP pollutant speciation fraction of each criteria pollutant[46]. Carbon dioxide equivalent (CO_2e) emissions were calculated using the GWP from 40 CFR Part 98, Table A-1 and are 1 for CO_2, 25 for CH_4, and 298 for N_2O.

[45] Criteria pollutant emission factors for all ocean going vessels main engines and all category auxiliary engines are from Tables 2-9, 2-13, and 2-16 from the ICF International Report (2007). http://www.nao.usace.army.mil/Portals/31/docs/regulatory/publicnotices/2014/July/NAO-2013-0418_Appendix_I_Air_Emissions.pdf?ver=2014-07-17-160106-627

[46] The speciation fraction of each HAP pollutant is based off of Report for TCEQ, "2014 Texas Statewide Commercial Marine Vessel Emissions Inventory and 2008 through 2040 Trend Inventories", August 2015, Table 4-6, pg 4-7. https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/582155149301FY15-20150826-erg-commercial_marine_vessel_2014aerr_inventory_trends_2008to2040.pdf

APPENDIX JB: DETAILED EMISSIONS CALCULATION

Short Term Natural Gas Fuel Maximum Emission Rate (per Gas Turbine)

Proposed Capacity (MW)[1]	Number of Units[2]	HHV of Natural Gas (Btu/kW-hr)[3]	Fuel Consumption Rate (tonne/hr)[4]	Annual Hours of Operation (hrs)[5]
7.6	2.0	12,171	2.5	7,822

1. Provided by CSA via Email (January 10, 2017).
2. Provided by BP on November 20, 2017.
3. Provided by BP as a LHV. HHV calculated as HHV = LHV*1.11
4. Provided by BP on November 20, 2017.
5. Assumed to be available 95% of the time (Tortue Report 09/11/2017), (assumes 500 hours on diesel fuel).

Pollutant	Emission Factor	Units	Short Term Emissions (tonne/hr)	Long Term Emissions (tonne/yr)	Reference
NOx	0.657	g/s	4.73E-03	37.00	1
CO	0.418	g/s	3.01E-03	23.54	1
PM	1.66E-01	g/s	1.20E-03	9.35	1,2
VOC	4.40E-05	tonne/tonne fuel	1.10E-04	0.86	3
SO2	0.00E+00	g/s	0.00E+00	0.00	1
SAM	5.0	%	0.00E+00	0.00	4
HAPS					
Acetaldehyde	4.0E-05	(lb/MMBtu)	3.36E-06	2.63E-02	5
Acrolein	6.4E-06	(lb/MMBtu)	5.37E-07	4.20E-03	5
Benzene	1.2E-05	(lb/MMBtu)	1.01E-06	7.88E-03	5
1,3-Butadiene	4.3E-07	(lb/MMBtu)	3.61E-08	2.82E-04	5
Ethylbenzene	3.2E-05	(lb/MMBtu)	2.69E-06	2.10E-02	5
Formaldehyde	7.1E-04	(lb/MMBtu)	5.96E-05	4.66E-01	5
Naphthalene	1.3E-06	(lb/MMBtu)	1.09E-07	8.53E-04	5
Propylene Oxide	2.9E-05	(lb/MMBtu)	2.43E-06	1.90E-02	5
Toluene	1.3E-04	(lb/MMBtu)	1.09E-05	8.53E-02	5
o-Xylene	6.4E-05	(lb/MMBtu)	5.37E-06	4.20E-02	5
Total HAP				0.67	

* Potential emission calculations based on maximum heat input at HHV
1. Provided by CSA via email (13/12/2017)
2. Assumed PM = PM10 = PM2.5
3. API Emission factors provided by BP on November 20, 2017.
4. Assumed SAM comprised of 5% of SO2 emissions.
5. AP-42 Table 3.1-3 for natural gas combustion.

Short Term Natural Gas Fuel Maximum Emission Rate (per Gas Turbine)

Proposed Capacity (MW)[1]	Number of Units[2]	HHV of Natural Gas (Btu/kW-hr)[3]	Fuel Consumption Rate (tonne/hr)[4]	Annual Hours of Operation (hrs)[5]
7.6	2.0	12,171	2.5	7,822

1. Provided by BP on November 20, 2017.
2. Provided by BP on November 20, 2017.
3. Provided by BP as a LHV. HHV calculated as HHV = LHV*1.11
4. Provided by BP on November 20, 2017.
5. Assumed to be available 95% of the time (Tortue Report 09/11/2017).

Pollutant	Emission Factor	Units	Short Term Emissions (tonne/hr)	Long Term Emissions (tonne/yr)	Reference
CO2	2.8	tonne/tonne fuel	14.0	109,508	1
CH4	2.90E-04	tonne/tonne fuel	1.45E-03	11.34	1
N2O	7.30E-05	tonne/tonne fuel	3.65E-04	2.86	1
CO2e	4.40E-05	tonne/tonne fuel	14.1	110,642	2

* Potential emission calculations based on maximum heat input at HHV
1. API Emission factors provided by BP on November 20, 2017.
2. Table C-1 and C-2 from 40 CFR part 98 for natural gas combustion. Global warming potentials from Part 98, Table A-1 and are 1 for CO2, 25 for CH4 and 298 for N2O

Short Term Diesel Fuel Maximum Emission Rate (per Gas Turbine)

Proposed Capacity (MW)[1]	Number of Units[2]	HHV of Diesel Fuel (MMBtu/ 10^3 gal)[3]	Fuel Consumption Rate (tonne/hr)[4]	Annual Hours of Operation (hrs)[5]
7.6	2.0	139	2.5	500

1. Provided by BP on November 20, 2017.
2. Provided by BP on November 20, 2017.
3. Trinity assumed the AP-42 estimate for the HHV of distillate oil for conservative emissions
4. Provided by BP on November 20, 2017.
5. Trinity assumed to operate 500 hrs a year based for conservative PTE

Pollutant	Emission Factor	Units	Short Term Emissions (tonne/hr)	Long Term Emissions (tonne/yr)	Reference
NOx	8.80E-01	lb/MMBtu	8.69E-02	43.46	1
CO	3.30E-03	lb/MMBtu	3.26E-04	0.16	1
PM	4.30E-03	lb/MMBtu	4.25E-04	0.21	1,2
VOC	4.10E-04	lb/MMBtu	4.05E-05	0.02	1
SO2	3.40E-03	lb/MMBtu	3.36E-04	0.17	1
SAM	5.0	%	1.68E-05	0.01	3
HAPS					
Benzene	5.5E-05	(lb/MMBtu)	5.43E-06	2.72E-03	4
1,3-Butadiene	1.6E-05	(lb/MMBtu)	1.58E-06	7.90E-04	4
Formaldehyde	2.8E-04	(lb/MMBtu)	2.77E-05	1.38E-02	4
Naphthalene	3.5E-05	(lb/MMBtu)	3.46E-06	1.73E-03	4
PAH	4.0E-05	(lb/MMBtu)	3.95E-06	1.98E-03	4
Total HAP				2.10E-02	

* Potential emission calculations based on maximum heat input at HHV
1. Emission factor based on output based AP-42 Table 3.1-1 for distillate oil combustion
2. Assumed PM = PM10 = PM2.5
3. Assumed SAM comprised of 5% of SO2 emissions.
4. AP-42 Table 3.1-4 for uncontrolled diesel fuel combustion.

Short Term Diesel Fuel Maximum Emission Rate (per Gas Turbine)

Proposed Capacity (MW)[1]	Number of Units[2]	HHV of Diesel Fuel (MMBtu/ 10^3 gal)[3]	Fuel Consumption Rate (tonne/hr)[4]	Annual Hours of Operation (hrs)[5]
7.6	2.0	139	2.5	500

1. Provided by BP on November 20, 2017.
2. Provided by BP on November 20, 2017.
3. Assumed the AP-42 estimate for the HHV of distillate oil for conservative emissions
4. Provided by BP on November 20, 2017.
5. Assumed to operate 500 hrs a year based for conservative PTE.

Pollutant	Emission Factor	Units	Short Term Emissions (tonne/hr)	Long Term Emissions (tonne/yr)	Reference
CO2	73.25	kg/MMBtu	15.9	7,974	1
CH4	3.00E-03	kg/MMBtu	0.0	0.33	1
N2O	6.00E-04	kg/MMBtu	0.0	0.07	1
CO2e		tonne/tonne fuel	16.0	8,002	1

* Potential emission calculations based on maximum heat input at HHV

1. Table C-1 and C-2 from 40 CFR part 98 for diesel fuel combustion. Global warming potentials from Part 98, Table A-1 and are 1 for CO2, 25 for CH4 and 298 for N2O

Emergency Generator

Proposed Allowable Criteria Pollutant Emissions

Fuel	Diesel	
Number of Engines	1	
Rated Capacity[1]	1.25	MW
Potential Hours of Operation[2]	216	hrs/yr
Approximate Fuel Consumption at full load[3]	89	gal/hr
Approximate Fuel Consumption at full load[4]	0.283	Tonne/hr
Approximate HHV of diesel fuel[5]	0.139	MMBtu/gal

Proposed Allowable Criteria Pollutant Emissions

Pollutant	Emission Factor		Emissions (tonne/hr)	Emissions (tonne/yr)	Reference
NO_x	5.180	g/s	0.019	4.03	6
CO	1.380	g/s	0.005	1.07	6
SO_2	1.64	g/s	0.006	1.28	6
PM	1.34E-03	kg/KW-hr	0.002	0.36	7
VOC	1.6E-03	tonne/tonne fuel	0.000	0.10	8

References:

1. Based on generator specific information provided by BP on November 2017.
2. 216 hours of operation (provided by BP on November 20, 2017).
3. Based on approximate fuel usage from http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx
4. Based on a conversion of 1 gal = 0.003192 metric tons of diesel fuel from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
5. Based on 1 gallon = 138,700 Btu – HHV from AP-42 estimate for the HHV of distillate oil for conservative emissions
6. Vendor specific emission factors provided by CSA via email (13/12/2017).
7. Based on AP-42, Table 3.3-1, assumed all PM = PM10 = PM2.5.
8. Based on API Emission Factors provided by BP (20/11/2017).

Emergency Generator

Proposed Allowable HAP Emissions

Fuel	Diesel	
Number of Engines	1	
Rated Capacity[2]	1.25	MMBtu/hr
Potential Hours of Operation[3]	216	hrs/yr
Approximate Fuel Consumption at full load[4]	89	gal/hr
Approximate Fuel Consumption at full load[5]	0.283	Tonne/hr
Approximate HHV of diesel fuel[6]	0.139	MMBtu/gal

Proposed allowable HAP Emissions

HAP	Emission Factor (lb/MMBtu)	Emission Factor (tonne/MMBtu)	Emissions (tonne/hr)	(tonne/yr)	Reference
Benzene	9.33E-04	4.23E-07	5.21E-06	1.13E-03	1
Toluene	4.09E-04	1.86E-07	2.28E-06	4.94E-04	1
Xylene	2.85E-04	1.29E-07	1.59E-06	3.44E-04	1
Propylene	<2.85E-03	<1.29E-06	1.59E-05	3.44E-03	1
Polycyclic Aromatic Hydrocarbon (PAH)	1.68E-04	7.62E-08	9.39E-07	2.03E-04	1
Napthalene	8.48E-05	3.85E-08	4.74E-07	1.02E-04	1
Acenaphthylene	5.06E-06	2.30E-09	2.83E-08	6.11E-06	1
Acenapthene	1.42E-06	6.44E-10	7.93E-09	1.71E-06	1
Fluorene	<2.92E-05	<1.32E-08	1.63E-07	3.52E-05	1
Phenanthrene	2.94E-05	1.33E-08	1.64E-07	3.55E-05	1
Anthracene	<1.87E-06	<8.48E-10	1.04E-08	2.26E-06	1
Fluoranthene	7.61E-06	3.45E-09	4.25E-08	9.18E-06	1
Pyrene	4.78E-06	2.17E-09	2.67E-08	5.77E-06	1
Benzo(a)anthracene	1.68E-06	7.62E-10	9.39E-09	2.03E-06	1
Chrysene	3.53E-07	1.60E-10	1.97E-09	4.26E-07	1
Benzo(b)fluoranthene	9.91E-08	4.50E-11	5.54E-10	1.20E-07	1
Benzo(k)fluoranthene	1.55E-07	7.03E-11	8.66E-10	1.87E-07	1
Benzo(a)pyrene	<1.88E-07	<8.53E-11	1.05E-09	2.27E-07	1
Indeno(1,2,3-cd)pyrene	3.75E-07	1.70E-10	2.10E-09	4.53E-07	1
Dibenzo(a,h)anthracene	5.83E-07	2.64E-10	3.26E-09	7.04E-07	1
Benzo(g,h,l)perylene	4.89E-07	2.22E-10	2.73E-09	5.90E-07	1
Total HAP				5.81E-03	

References:

1. From AP-42, Table 3.3-2, 2009.
2. Based on generator specification information provided by the BP (20/11/2017).
3. Per Rule 62-210.300(3)(a)35., F.A.C. and approximate 216 hours of operation (provided from facility)
4. Based on approximate fuel usage from http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx
5. Based on a conversion of 1 gal = 0.003192 metric tons of diesel fuel from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
6. Based on 1 gallon = 138,700 Btu – HHV AP-42 estimate for the HHV of distillate oil for conservative emissions

Emergency Generator

Proposed Allowable Criteria Pollutant Emissions

Fuel		Diesel
Number of Engines	1	
Rated Capacity[1]	1.25	MW
Potential Hours of Operation[2]	216	hrs/yr
Approximate Fuel Consumption at full load[3]	89	gal/hr
Approximate Fuel Consumption at full load[4]	0.283	Tonne/hr
Approximate HHV of diesel fuel[5]	0.139	MMBtu/gal

Proposed Allowable GHG Emissions

Pollutant	Emission Factor		Emissions (tonne/hr)	Emissions (tonne/yr)	Reference
CO_2	3.20	tonne/tonne fuel	0.91	195.92	6
CH_4	2.00E-04	tonne/tonne fuel	0.00	0.01	6
N_2O	9.40E-05	tonne/tonne fuel	0.00	0.01	6
CO_2e	--	--	0.92	197.94	7

References:

1. Based on generator specific information provided by the BP (20/11/2017).
2. 216 hours of operation (provided by BP on 20/11/2017)
3. Based on approximate fuel usage from http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx
4. Based on a conversion of 1 gal = 0.003192 metric tons of diesel fuel from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
5. Based on 1 gallon = 138,700 Btu – HHV AP-42 estimate for the HHV of distillate oil for conservative emissions
6. Based on API Emission Factors provided by BP on 11/20/2017.
7. Table C-1 and C-2 from 40 CFR part 98 for natural gas combustion. Global warming potentials from Part 98, Table A-1 and are 1 for CO2, 25 for CH4 and 298 for N2O.

FW Pumps

Proposed Allowable Criteria Pollutant Emissions

Fuel	Diesel	
Number of Engines	4	
Rated Capacity[1]	1.00	MW
Potential Hours of Operation[2]	100	hrs/yr
Approximate Fuel Consumption at full load[3]	71	gal/hr
Approximate Fuel Consumption at full load[4]	0.227	Tonne/hr
Approximate HHV of diesel fuel[5]	0.139	MMBtu/gal

Proposed Allowable Criteria Pollutant Emissions					
			Emissions		
Pollutant	**Emission Factor**		**(tonne/hr)**	**(tonne/yr)**	**Reference**
NO_x	3.857	g/s	0.056	5.55	6
CO	1.033	g/s	0.015	1.49	6
SO_2	1.22	g/s	0.018	1.76	6
PM	1.34E-03	kg/KW-hr	0.005	0.54	7
VOC	1.6E-03	tonne/tonne fuel	0.001	0.15	8

References:

1. Based on generator specific information provided by the facility on 20/11/2017.
2. Per Rule 62-210.300(3)(a)35., F.A.C.
3. Based on approximate fuel usage from http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx
4. Based on a conversion of 1 gal = 0.003192 metric tons of diesel fuel from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
5. Based on 1 gallon = 138,700 Btu – HHV AP-42 estimate for the HHV of distillate oil for conservative emissions
6. Vendor specific emission factors provided by CSA via email (13/12/2017).
7. Based on AP-42, Table 3.3-1, assumed all PM = PM10 = PM2.5.
8. Based on API Emission Factors provided by BP on 20/11/2017.

FW Pumps

Proposed Allowable HAP Emissions

Fuel		Diesel
Number of Engines	4	
Rated Capacity[2]	1.00	MMBtu/hr
Potential Hours of Operation[3]	100	hrs/yr
Approximate Fuel Consumption at full load[4]	71	gal/hr
Approximate Fuel Consumption at full load[5]	0.227	Tonne/hr
Approximate HHV of diesel fuel[6]	0.139	MMBtu/gal

Proposed allowable HAP Emissions

HAP	Emission Factor (lb/MMBtu)	Emission Factor (tonne/MMBtu)	Emissions (tonne/hr)	(tonne/yr)	Reference
Benzene	9.33E-04	4.23E-07	1.67E-05	1.67E-03	1
Toluene	4.09E-04	1.86E-07	7.32E-06	7.32E-04	1
Xylene	2.85E-04	1.29E-07	5.10E-06	5.10E-04	1
Propylene	<2.85E-03	<1.29E-06	5.10E-05	5.10E-03	1
Polycyclic Aromatic Hydrocarbon (PAH)	1.68E-04	7.62E-08	3.01E-06	3.01E-04	1
Napthalene	8.48E-05	3.85E-08	1.52E-06	1.52E-04	1
Acenaphthylene	5.06E-06	2.30E-09	9.05E-08	9.05E-06	1
Acenapthene	1.42E-06	6.44E-10	2.54E-08	2.54E-06	1
Fluorene	<2.92E-05	<1.32E-08	5.22E-07	5.22E-05	1
Phenanthrene	2.94E-05	1.33E-08	5.26E-07	5.26E-05	1
Anthracene	<1.87E-06	<8.48E-10	3.35E-08	3.35E-06	1
Fluoranthene	7.61E-06	3.45E-09	1.36E-07	1.36E-05	1
Pyrene	4.78E-06	2.17E-09	8.55E-08	8.55E-06	1
Benzo(a)anthracene	1.68E-06	7.62E-10	3.01E-08	3.01E-06	1
Chrysene	3.53E-07	1.60E-10	6.32E-09	6.32E-07	1
Benzo(b)fluoranthene	9.91E-08	4.50E-11	1.77E-09	1.77E-07	1
Benzo(k)fluoranthene	1.55E-07	7.03E-11	2.77E-09	2.77E-07	1
Benzo(a)pyrene	<1.88E-07	<8.53E-11	3.36E-09	3.36E-07	1
Indeno(1,2,3-cd)pyrene	3.75E-07	1.70E-10	6.71E-09	6.71E-07	1
Dibenzo(a,h)anthracene	5.83E-07	2.64E-10	1.04E-08	1.04E-06	1
Benzo(g,h,l)perylene	4.89E-07	2.22E-10	8.75E-09	8.75E-07	1
Total HAP				8.61E-03	

References:

1. From AP-42, Table 3.3-2, 2009.
2. Based on generator specification information provided by BP on 20/11/2017.
3. Per Rule 62-210.300(3)(a)35., F.A.C.
4. Based on approximate fuel usage from http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx
5. Based on a conversion of 1 gal = 0.003192 metric tons of diesel fuel from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
6. Based on 1 gallon = 138,700 Btu – HHV AP-42 estimate for the HHV of distillate oil for conservative emissions

FW Pumps

Proposed Allowable Criteria Pollutant Emissions

Fuel		Diesel
Number of Engines	4	
Rated Capacity[1]	1.00	MW
Potential Hours of Operation[2]	100	hrs/yr
Approximate Fuel Consumption at full load[3]	71	gal/hr
Approximate Fuel Consumption at full load[4]	0.227	Tonne/hr
Approximate HHV of diesel fuel[5]	0.139	MMBtu/gal

Proposed Allowable GHG Emissions					
			Emissions		
Pollutant	Emission Factor		(tonne/hr)	(tonne/yr)	Reference
CO_2	3.20	tonne/tonne fuel	2.90	290.50	6
CH_4	2.00E-04	tonne/tonne fuel	0.00	0.02	6
N_2O	9.40E-05	tonne/tonne fuel	0.00	0.01	6
CO_2e	--	--	2.93	293.49	7

References:

1. Based on generator specification information provided by BP on 20/11/2017.
2. Per Rule 62-210.300(3)(a)35., F.A.C.
3. Based on approximate fuel usage from http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx
4. Based on a conversion of 1 gal = 0.003192 metric tons of diesel fuel from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
5. Based on 1 gallon = 138,700 Btu – HHV AP-42 estimate for the HHV of distillate oil for conservative emissions
6. Based on API Emission Factors provided by BP on 20/11/2017.
7. Table C-1 and C-2 from 40 CFR part 98 for natural gas combustion. Global warming potentials from Part 98, Table A-1 and are 1 for CO2, 25 for CH4 and 298 for N2O.

Essential Service Generator

Proposed Allowable Criteria Pollutant Emissions

Fuel	Diesel	
Number of Engines	1	
Rated Capacity[1]	2.50	MW
Potential Hours of Operation[2]	438	hrs/yr
Approximate Fuel Consumption at full load[3]	176	gal/hr
Approximate Fuel Consumption at full load[4]	0.561	Tonne/hr
Approximate HHV of diesel fuel[5]	0.139	MMBtu/gal

Proposed Allowable Criteria Pollutant Emissions					
			Emissions		
Pollutant	Emission Factor		(tonne/hr)	(tonne/yr)	Reference
NO_x	0.063	tonne/tonne fuel	0.035	15.47	6
CO	0.017	tonne/tonne fuel	0.009	4.12	6
SO_2	1.0%	S in fuel	0.011	4.91	6
PM	1.34E-03	kg/KW-hr	0.003	1.46	7
VOC	1.6E-03	tonne/tonne fuel	0.001	0.40	6

References:

1. Based on generator specific information provided by BP provided on 20/11/2017.
2. Based on BP estimation of 18.25 operational hours per day provided on 20/11/2017.
3. Based on approximate fuel usage from http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx
4. Based on a conversion of 1 gal = 0.003192 metric tons of diesel fuel from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
5. Based on 1 gallon = 138,700 Btu – HHV AP-42 estimate for the HHV of distillate oil for conservative emissions
6. Based on API Emission Factors provided by BP on 20/11/2017.
7. Based on AP-42, Table 3.3-1, assumed all PM = PM10 = PM2.5.

Essential Service Generator

Proposed Allowable HAP Emissions

Fuel	Diesel	
Number of Engines	1	
Rated Capacity[2]	2.50	MMBtu/hr
Potential Hours of Operation[3]	438	hrs/yr
Approximate Fuel Consumption at full load[4]	176	gal/hr
Approximate Fuel Consumption at full load[5]	0.561	Tonne/hr
Approximate HHV of diesel fuel[6]	0.139	MMBtu/gal

Proposed allowable HAP Emissions

HAP	Emission Factor (lb/MMBtu)	Emission Factor (tonne/MMBtu)	Emissions (tonne/hr)	(tonne/yr)	Reference
Benzene	9.33E-04	4.23E-07	1.03E-05	4.51E-03	1
Toluene	4.09E-04	1.86E-07	4.52E-06	1.98E-03	1
Xylene	2.85E-04	1.29E-07	3.15E-06	1.38E-03	1
Propylene	<2.85E-03	<1.29E-06	3.15E-05	1.38E-02	1
Polycyclic Aromatic Hydrocarbon (PAH)	1.68E-04	7.62E-08	1.86E-06	8.13E-04	1
Napthalene	8.48E-05	3.85E-08	9.37E-07	4.10E-04	1
Acenaphthylene	5.06E-06	2.30E-09	5.59E-08	2.45E-05	1
Acenapthene	1.42E-06	6.44E-10	1.57E-08	6.87E-06	1
Fluorene	<2.92E-05	<1.32E-08	3.23E-07	1.41E-04	1
Phenanthrene	2.94E-05	1.33E-08	3.25E-07	1.42E-04	1
Anthracene	<1.87E-06	<8.48E-10	2.07E-08	9.05E-06	1
Fluoranthene	7.61E-06	3.45E-09	8.41E-08	3.68E-05	1
Pyrene	4.78E-06	2.17E-09	5.28E-08	2.31E-05	1
Benzo(a)anthracene	1.68E-06	7.62E-10	1.86E-08	8.13E-06	1
Chrysene	3.53E-07	1.60E-10	3.90E-09	1.71E-06	1
Benzo(b)fluoranthene	9.91E-08	4.50E-11	1.09E-09	4.80E-07	1
Benzo(k)fluoranthene	1.55E-07	7.03E-11	1.71E-09	7.50E-07	1
Benzo(a)pyrene	<1.88E-07	<8.53E-11	2.08E-09	9.10E-07	1
Indeno(1,2,3-cd)pyrene	3.75E-07	1.70E-10	4.14E-09	1.81E-06	1
Dibenzo(a,h)anthracene	5.83E-07	2.64E-10	6.44E-09	2.82E-06	1
Benzo(g,h,l)perylene	4.89E-07	2.22E-10	5.40E-09	2.37E-06	1
Total HAP				2.33E-02	

References:

1. From AP-42, Table 3.3-2, 2009.
2. Based on generator specification information provided by BP on 20/11/2017.
3. Based on a facility estimation of 18.25 operational hours per day provided by BP on 20/11/2017.
4. Based on approximate fuel usage from http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx
5. Based on a conversion of 1 gal = 0.003192 metric tons of diesel fuel from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
6. Based on 1 gallon = 138,700 Btu – HHV AP-42 estimate for the HHV of distillate oil for conservative emissions

Essential Service Generator

Proposed Allowable Criteria Pollutant Emissions

Fuel		Diesel
Number of Engines	1	
Rated Capacity[1]	2.50	MW
Potential Hours of Operation[2]	438	hrs/yr
Approximate Fuel Consumption at full load[3]	176	gal/hr
Approximate Fuel Consumption at full load[4]	0.561	Tonne/hr
Approximate HHV of diesel fuel[5]	0.139	MMBtu/gal

Proposed Allowable GHG Emissions

Pollutant	Emission Factor		Emissions (tonne/hr)	Emissions (tonne/yr)	Reference
CO_2	3.20	tonne/tonne fuel	1.79	785.62	6
CH_4	2.00E-04	tonne/tonne fuel	0.00	0.05	6
N_2O	9.40E-05	tonne/tonne fuel	0.00	0.02	6
CO_2e	--	--	1.81	793.72	7

References:

1. Based on generator specific information provided by BP on 20/11/2017.
2. Per Rule 62-210.300(3)(a)35., F.A.C. and approximate 216 hours of operation (provided from facility on 20/11/2017)
3. Based on approximate fuel usage from http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx
4. Based on a conversion of 1 gal = 0.003192 metric tons of diesel fuel from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
5. Based on 1 gallon = 138,700 Btu – HHV from AP-42 estimate for the HHV of distillate oil for conservative emissions
6. Based on API Emission Factors provided by BP on 20/11/2017.
7. Table C-1 and C-2 from 40 CFR part 98 for natural gas combustion. Global warming potentials from Part 98, Table A-1 and are 1 for CO2, 25 for CH4 and 298 for N2O.

Flare - Pilot Only

Proposed Potential-to-Emit Criteria Pollutant Emissions from Pilot

Pilot Fuel	Natural Gas	
Natural Gas Heating Value[1]	1,027	Btu/scf
Pilot fuel Consumption during Normal Operation[2]	0.032	MMscf/d
Tonnes of fuel during normal operations[3]	0.03	tonne/hr
Number of Pilots[4]	2	
Potential Hours of Operation[5]	8,760	hrs/yr
Destruction efficiency[6]	98%	

Flare - Pilot Only
Proposed Potential-to-Emit Criteria Pollutant Emissions

Pollutant	Emission Factor		Hourly Emission Rate (tonne/hr)	Annual Emissions (tonne/yr)	Reference
NO_x	3.77339	g/s	0.03	238.00	7
CO	20.53298	g/s	0.15	0.65	7
VOC	0	g/s	< 0.001	< 0.001	8
PM	1.346328	g/s	0.01	84.92	7
SO_2	--	g/s	< 0.001	< 0.001	7

References:

1. Based on the average value provided in https://www.extension.iastate.edu/agdm/wholefarm/html/c6 -89.html
2. Based on BP provided data on 20/11/2017.
3. Tonne/hr = (MMscf/d)*(MMBtu/MMscf)*(1 day/24 hrs)* (1 lb NG/20,551 Btu) * (0.0004 tonnes/1 lb) based on heat input data from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-89.html
4. BP provided data on 20/11/2017 (includes one HP and one LP flare tip).
5. Flare tips assumed to operate continusouly, emissions only represent normal operations and do not include startup or shutdown and no FGR
6. Based on information provided by CSA via email (13/12/2017).
7. Vendor specific emission factors provided by CSA via email (13/12/2017).
8. Assumed to be negligable based on the total HC of the fuel.

Flare - Pilot Only

Proposed Potential-to-Emit HAP Emissions from Pilot

Pilot Fuel	Natural Gas	
Natural Gas Heating Value[1]	1,027	Btu/scf
Pilot fuel Consumption during Normal Operation[2]	0.032	MMscf/d
Tonnes of fuel during normal operations[3]	0.03	tonne/hr
Number of Pilots[4]	2	
Potential Hours of Operation[5]	8,760	hrs/yr

Flare - Pilot Only
Proposed allowable HAP Emissions

HAP	Emission Factor (lb/MMscf)	Emission Factor (tonne/MMscf)	Hourly Emission Rate (tonne/hr)	Annual Emissions (tonne/yr)	Reference
Benzene	2.1E-03	9.5E-07	< 0.001	< 0.001	6
Dichlorobenzene	1.2E-03	5.4E-07	< 0.001	< 0.001	6
Formaldehyde	0.075	3.4E-05	< 0.001	< 0.001	6
n-Hexane	1.80	8.2E-04	< 0.001	< 0.001	6
Naphthalene	6.1E-04	2.8E-07	< 0.001	< 0.001	6
Toluene	3.4E-03	1.5E-06	< 0.001	< 0.001	6
Polycyclic Organic Matter	8.8E-05	4.0E-08	< 0.001	< 0.001	6, 8
Arsenic	2.0E-04	9.1E-08	< 0.001	< 0.001	7
Barium	4.4E-03	2.0E-06	< 0.001	< 0.001	7
Beryllium	<1.20E-05	5.4E-09	< 0.001	< 0.001	7
Cadmium	1.1E-03	5.0E-07	< 0.001	< 0.001	7
Chromium	1.4E-03	6.4E-07	< 0.001	< 0.001	7
Cobalt	8.4E-05	3.8E-08	< 0.001	< 0.001	7
Copper	8.5E-04	3.9E-07	< 0.001	< 0.001	7
Manganese	3.8E-04	1.7E-07	< 0.001	< 0.001	7
Mercury	2.6E-04	1.2E-07	< 0.001	< 0.001	7
Nickel	2.1E-03	9.5E-07	< 0.001	< 0.001	7
Selenium	<2.4E-05	1.1E-08	< 0.001	< 0.001	7
Total HAP				< 0.001	

References:

1. Based on the average value provided in https://www.extension.iastate.edu/agdm/wholefarm/html/c6-89.html
2. Based on BP provided data (on 20/11/2017).
3. Tonne/hr = (MMscf/d)*(MMBtu/MMscf)*(1 day/24 hrs)* (1 lb NG/20,551 Btu) * (0.0004 tonnes/1 lb) based on heat input data from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-89.html
4. BP provided data on 20/11/2017 (includes one HP and one LP flare tip).
5. Flare tips assumed to operate continusouly, emissions only represent normal operations and do not include startup or shutdown and no FGR.
6. Emission factors for organic compounds based on AP-42 Table 1.4-3, Emission Factors for Speciated Organic Compounds from Natural Gas Combustion, July 1998.
7. Emission factors for metals based on AP-42 Table 1.4-4, Emission Factors for Metals from Natural Gas Combustion, July 1998.
8. The emission factor for Polyclic Organic Matter (POM) is calculated as the sum of the emission factors per footnote c to AP-42 Chapter 1, Table 1.4-3 (July 1998).

Flare - Pilot Only

Proposed Potential-to-Emit GHG Emissions from Flare Pilot

Pilot Fuel	Natural Gas	
Natural Gas Heating Value[1]	1,027	Btu/scf
Pilot fuel Consumption during Normal Operation[2]	0.032	MMscf/d
Tonnes of fuel during normal operations[3]	0.03	tonne/hr
Number of Pilots[4]	2	
Potential Hours of Operation[5]	8,760	hrs/yr

Flare - Pilot Only
Proposed Potential-to-Emit GHG Emissions

Pollutant	Emission Factor		Hourly Emission Rate (tonne/hr)	Annual Emissions (tonne/yr)	Reference
CO_2	2.80	tonne/tonne fuel	0.169	1483	6
CH_4	1.30E-02	tonne/tonne fuel	7.858E-04	7	6
N_2O	2.20E-04	tonne/tonne fuel	1.33E-05	0	6
CO_2e	--	--	0.2	1689	**7**

References:

1. Based on the average value provided in https://www.extension.iastate.edu/agdm/wholefarm/html/c6-89.html
2. Based on BP provided data on 20/11/2017.
3. Tonne/hr = (MMscf/d)*(MMBtu/MMscf)*(1 day/24 hrs)* (1 lb NG/20,551 Btu) * (0.0004 tonnes/1 lb) based on heat input data from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-89.html
4. BP provided data on 20/11/2017 (includes one HP and one LP flare tip).
5. Flare tips assumed to operate continusouly, emissions only represent normal operations and do not include startup or shutdown.
6. Based on API emission factors provied by BP on November 20, 2017.
7. Table C-1 and C-2 from 40 CFR part 98 for natural gas combustion. Global warming potentials from Part 98, Table A-1 and are 1 for CO2, 25 for CH4 and 298 for N2O.

FUGITIVE EMISSIONS FROM FPSO

Source	Stream Composition	# Sources	OIL & GAS PROD. Average Emission Factor (kg/hr/source)	Uncontrolled Emissions (kg/hr)	Uncontrolled Emissions (MT/yr)
Valves	Gas	117	0.0045	0.527	4.612
	Light Liquid	434	0.0045	1.951	17.089
	Heavy Liquid	0	0.0045	0.000	0.000
Flanges	Gas	315	0.00039	0.123	1.076
	Light Liquid	1151	0.00039	0.449	3.931
	Heavy Liquid	0	0.00039	0.00	0.00
Pumps	Light Liquid	3	0.0024	0.01	0.06
	Heavy Liquid	0	0.0024	0.00	0.00
Compressors	Gas	3	0.0088	0.03	0.23

Speciation

Compound	wt%	Uncontrolled Emissions (kg/hr)	Uncontrolled Emissions (MT/yr)
Water	2.33	0.07	0.630
Nitrogen	0.06	0.00	0.02
CO2	0.43	0.01	0.12
H2S	0.00	0.00	0.00
Methane	22.16	0.68	5.98
Ethane	4.45	0.14	1.20
Total Non-VOCs	**29.43**	**0.91**	**7.95**
EGlycol	2.04	0.06	0.55
Propane	7.09	0.22	1.91
i-Butane	2.30	0.07	0.62
n-Butane	4.28	0.13	1.15
i-Pentane	2.06	0.06	0.56
n-Pentane	1.85	0.06	0.50
2-Mpentane	1.00	0.03	0.27
3-Mpentane	0.51	0.02	0.14
n-Hexane	1.21	0.04	0.33
Mcyclopentan	1.39	0.04	0.38
Benzene	1.64	0.05	0.44
2-Mhexane	0.29	0.01	0.08
3-Mhexane	0.42	0.01	0.11
Mcyclohexane	2.27	0.07	0.61
Toluene	0.33	0.01	0.09
E-Benzene	0.40	0.01	0.11
p-Xylene	0.11	0.00	0.03
o-Xylene	0.11	0.00	0.03
m-Xylene	1.00	0.03	0.27
C7	1.60	0.05	0.43
C8	2.44	0.08	0.66
C9+	36.24	1.12	9.79
Total VOCs	**70.57**	**2.18**	**19.06**
Total	100	3.08	27.00

Notes:
1. Oil and Gas Production Operations Average Emission Factors are from US EPA's "Protocol for Equipment Leak Emission Estimates" (Doc No.: EPA-453/R-95-017 November 1995)
2. Fugitive Emission Calculations are for the FPSO
3. The operating days for the FPSO per year is 365

Legend:
EF: Emission Factors
MB: Material Balance
EC: Engineering Calculation
NA: Not Available
MT: Metric Tonnes
MDO: Marine Diesel Oil

																Hourly Air Emissions - Per Engine Type (kg/hr)										
Operations Location	**Specific Activity**	**Marine Vessels/ Equipment Used**	**Number of Vessels**	**Engine Type**	**Number of Engines Per Vessel**	**Engine Rating (kW)**	**Engine Load Factor**	**Fuel Type**	**Annual Operating Days**	**Operating Hours (hr/day)**	**Annual Operating Hours (hr)**	**Emission Factor Lookup (See Note 1 and Table A Below)**	**Engine Category for Emission Calculations (from Table A)**	**Remarks**	**Typical Representative Vessel**	**NOx**	**CO**	**PM10**	**PM2.5**	**SO2**	**VOCs**	**CO2**	**CH4**	**N2O**	**GHG as CO2e**	**HAPs**
FPSO	Offloading of Condensate every 67 days	Assist Tug	3	Main	2	1999	0.43	MDO	9	24	216	3	1	1. Assumed engine capacity based on typical ocean going tug. 2. Tugs boats will be used to assist Condensate offloading into tankers. Condensate offloading assumed to take place once every 2 months in a year, 6 times a year, and 36 hours per offloading.	Crowley Titan Class	22.69	1.89	1.24	1.20	2.23	0.86	1186	0.155	0.034	1200	0.15
				Auxiliary	2	180	0.43	MDO	9	24	216	8	2			1.55	0.23	0.06	0.06	0.20	0.04	107	0.014	0.003	108	0.01
	Supply of Materials, Loading/ Offloading of Riach/Lean MEG, etc	Supply Boat	1	Main Engine / Generator	2	1500	0.68	MDO	12	24	288	3	3	1. Assumed engine capacity based on typical offshore supply vessel	Damen Platform Supply Vessel 3300 CD	26.93	2.24	1.47	1.42	2.65	1.02	1408	0.184	0.041	1424	0.18
				Main Engine / Generator	2	1030	0.68	MDO	12	24	288	3	3	2. Assumed Supply Boat making once a month trip to the FPSO.		18.49	1.54	1.01	0.98	1.82	0.70	967	0.126	0.028	978	0.12
				Auxiliary Power	1	250	0.43	MDO	12	24	288	7	2			1.08	0.16	0.03	0.03	0.14	0.03	74	0.010	0.002	75	0.01
	One securitry boat continually operating in region of FPSO	Guard / security boat	1	Main Engine	2	900	0.68	MDO	365	24	8760	3	2		Damen stan 2205 patrol vessel	16.16	1.35	0.88	0.85	1.59	0.61	845	0.110	0.024	854	0.11
				Generators	2	22.5	0.43	MDO	365	24	8760	NA	0													
	Transfer of Crew to and from between Shore and FPSO	Crew Boat	1	Main Engines	4	2000	0.68	MDO	104	12	1248	3	3	1. Assumed engine capacity based on typical offshore supply vessel 2. Crew boat used for two trips a week to the FPSO, with each trip duration of 12 hours.	Damen Fast Crew Supplier 5009	71.81	5.98	3.92	3.80	7.07	2.72	3754	0.490	0.109	3798	0.47
Sea Island	Assist LNGCs	Assist Tug	3	Main	2	2250	0.43	MDO	73	24	1752	3	3	1. Assumed engine capacity based on Tug boat capacity in the Utility & Diesel Storage Barge Functional Specification. 2. Two tugs will be used to assist LNGCs every 5 days and one tug boat is on ready-standby during LNGC operations. Each LNGC is expected to be berthed for a maximum of 24 hours.		25.54	2.13	1.39	1.35	2.52	0.97	1335	0.174	0.039	1351	0.17
				Auxiliary	2	180	0.43	MDO	73	24	1752	8	2			1.55	0.23	0.06	0.06	0.20	0.04	107	0.014	0.003	108	0.01
	LNGC every 1.67 days	service tug	1																							
		Mooring line	3																							
		Guard / security boat	1								8760															
	Transfer of Crew to and from between Shore and Sea Island	Crew Boat	1	Main Engines	4	2000	0.68	MDO	365	12	4380	3	3	1. Assumed engine capacity based on typical offshore supply vessel 2. Crew boat used for daily trips to the Sea Island, with each trip duration of 12 hours.	Damen Fast Crew Supplier 5009	71.81	5.98	3.92	3.80	7.07	2.72	3754	0.490	0.109	3798	0.47
Total																										

Notes and Assumptions:

1. Emissions other than HAPs are estimated for the each engine by using the following equation: Emissions per Engine (kg) = Emission Factor (EF) (g/kW) x Engine Load Factor x Engine Rating (kW) x Total Operating Hours x (kg/1000g)
   In the above spreadsheet, based on the engine type in the vessel, the equivalent EF is selected from the Table A below.
   For example, the Main Propulsion Engine for the Tug Boat is considered an Ocean Going Engine with Medium Speed Engine using Marine Diesel Oil, and assigned a lookup value of 1. The EFs for NOx, CO, PM, SO2, etc. used in the calculations are selected from the Table A below for that engine type. Similarly, if the vessel is Harbor Craft with engine type as Tier 0 and Category 2 (Power rating between 1000 - 3000 kW), then the EF lookup value will be 3.
2. The Hazardous Air Pollutant (HAP) emissions are considered a component of the VOC or PM10 or PM2.5 emissions and are estimated using speciation fractions from the EPA's National Emission Inventory (NEI) as shown in the following equation:
   $E = A \times SF$,
   Where:
   E = Annual emissions for HAP (tons)
   A = Annual emissions for speciation base (tons) - VOC or PM10 or PM2.5
   SF = Speciation factor (unitless fraction) as shown in the Table B below.
3. Emission Factors (EFs) for Commercial Marine Vessels are sourced from ICF International Report for US EPA, Current Methodologies in Preparing Mobile Source Port-related Emissions Inventories, April 2009
   See Table A below for the EFs.
4. Hazardous Air Pollutants (HAPs) emission calculation methodology is based on the ERG, Inc. Report for TCEQ, "2014 Texas Statewide Commercial Marine Vessel Emissions Inventory and 2008 through 2040 Trend Inventories", August 2015, Table 4-6, pg 4-7.
5. The type and number of marine vessels, and their operating days are sourced from the BP Tortue Concept Select Study, Cost Estimate Report, Doc. No. J7018-BP-RE-K-001 Rev.B
6. The number of operating hours per day per vessel is assumed to be 24 hours (unless otherwise stated) due to lack of details at the conceptual stage, and it also provides a conservatively higher emissions estimate
7. Engine details, such as number of engines, type of engines, nominal power rating and fuel type are based on typical vessels used in offshore construction activities
8. The engine load factors (propulsion and auxiliary engines) are from Section 2.5 (pg 2-11) and Table 2-7 for Ocean Going Vessels, and Table 3-4 for Harbor Crafts

Legend:
EF: Emission Factors
MB: Material Balance
EC: Engineering Calculation
NA: Not Available
MT: Metric Tonnes
MDO: Marine Diesel Oil

														Hourly Air Emissions Per Vessel (kg/hr)										
Operations Location	Specific Activity	Marine Vessels/ Equipment Used	Number of Vessels	Engine Type	Number of Engines Per Vessel	Engine Rating (kW)	Engine Load Factor	Fuel Type	Annual Operating Days	Operating Hours (hr/day)	Annual Operating Hours (hr)	Emission Factor Lookup (See Note 1 and Table A Below)	Engine Category for Emission Calculations (from Table A)	NOx	CO	PM10	PM2.5	SO2	VOCs	CO2	CH4	N2O	GHG as CO2e	HAPs
FPSO	Offloading of Condensate every 67 days	Assist Tug	3	Main	2	1999	0.43	MDO	9	24	216	3	1	24.2	2.1	1.3	1.3	2.4	0.9	1293	0.169	0.037	1308	0.16
				Auxiliary	2	180	0.43	MDO	9	24	216	8	2											
	Supply of Materials, Loading/ Offloading of Riach/Lean MEG, etc	Supply Boat	1	Main Engine / Generator	2	1500	0.68	MDO	12	24	288	3	3	46.5	3.9	2.5	2.4	4.6	1.7	2448	0.32	0.07	2477	0.3
				Main Engine / Generator	2	1030	0.68	MDO	12	24	288	3	3											
				Auxiliary Power	1	250	0.43	MDO	12	24	288	7	2											
	One securitry boat continually operating in region of FPSO	Guard / security boat	1	Main Engine	2	900	0.68	MDO	365	24	8760	3	2	16.16	1.3464	0.88128	0.8548416	1.5912	0.612	844.56	0.11016	0.02448	854	0.1060598
				Generators	2	22.5	0.43	MDO	365	24	8760	NA	0											
	Transfer of Crew to and from between Shore and FPSO	Crew Boat	1	Main Engines	4	2000	0.68	MDO	104	12	1248	3	3	71.8	6.0	3.9	3.8	7.1	2.7	3754	0.49	0.11	3798	0.5
Sea Island	Assist LNGCs	Assist Tug	3	Main	2	2250	0.43	MDO	73	24	1752	3	3	27.1	2.4	1.5	1.4	2.7	1.0	1442	0.19	0.04	1459	0.2
				Auxiliary	2	180	0.43	MDO	73	24	1752	8	2											
	LNGC every 1.67 days	service tug	1																					
		Mooring line	3																					
		Guard / security boat	1								8760													
	Transfer of Crew to and from between Shore and Sea Island	Crew Boat	1	Main Engines	4	2000	0.68	MDO	365	12	4380	3	3	71.8	6.0	3.9	3.8	7.1	2.7	3754	0.49	0.11	3798	0.5
Total																								

Notes and Assumptions:

1. Emissions other than HAPs are estimated for the each engine by using the following equation: Emissions per Engine (kg) = Emission Factor (EF) (g/kW) x Engine Load Factor x Engine Rating (kW) x Total Operating Hours x (kg/1000g)
   In the above spreadsheet, based on the engine type in the vessel, the equivalent EF is selected from the Table A below.
   For example, the Main Propulsion Engine for the Tug Boat is considered an Ocean Going Engine with Medium Speed Engine using Marine Diesel Oil, and assigned a lookup value of 1. The EFs for NOx, CO, PM, SO2, etc.
   used in the calculations are selected from the Table A below for that engine type. Similarly, if the vessel is Harbor Craft with engine type as Tier 0 and Category 2 (Power rating between 1000 - 3000 kW), then the EF lookup value will be 3.
2. The Hazardous Air Pollutant (HAP) emissions are considered a component of the VOC or PM10 or PM2.5 emissions and are estimated using speciation fractions from the EPA's National Emission Inventory (NEI) as shown in the following equation:
   E = A × SF,
   Where:
   E = Annual emissions for HAP (tons)
   A = Annual emissions for speciation base (tons) - VOC or PM10 or PM2.5
   SF = Speciation factor (unitless fraction) as shown in the Table B below.
3. Emission Factors (EFs) for Commercial Marine Vessels are sourced from ICF International Report for US EPA, Current Methodologies in Preparing Mobile Source Port-related Emissions Inventories, April 2009
   See Table A below for the EFs.
4. Hazardous Air Pollutants (HAPs) emission calculation methodology is based on the ERG, Inc. Report for TCEQ, "2014 Texas Statewide Commercial Marine Vessel Emissions Inventory and 2008 through 2040 Trend Inventories",
   August 2015, Table 4-6, pg 4-7.
5. The type and number of marine vessels, and their operating days are sourced from the BP Tortue Concept Select Study, Cost Estimate Report, Doc. No. J7018-BP-RE-K-001 Rev.B
6. The number of operating hours per day per vessel is assumed to be 24 hours (unless otherwise stated) due to lack of details at the conceptual stage, and it also provides a conservatively higher emissions estimate
7. Engine details, such as number of engines, type of engines, nominal power rating and fuel type are based on typical vessels used in offshore construction activities
8. The engine load factors (propulsion and auxiliary engines) are from Section 2.5 (pg 2-11) and Table 2-7 for Ocean Going Vessels, and Table 3-4 for Harbor Crafts

Legend:
EF: Emission Factors
MB: Material Balance
EC: Engineering Calculation
NA: Not Available
MT: Metric Tonnes
MDO: Marine Diesel Oil

														Total Hourly Air Emissions for a Vessel Type (kg/hr)										
Operations Location	**Specific Activity**	**Marine Vessels/ Equipment Used**	**Number of Vessels**	**Engine Type**	**Number of Engines Per Vessel**	**Engine Rating (kW)**	**Engine Load Factor**	**Fuel Type**	**Annual Operating Days**	**Operating Hours (hr/day)**	**Annual Operating Hours (hr)**	**Emission Factor Lookup (See Note 1 and Table A Below)**	**Engine Category for Emission Calculations (from Table A)**	**NOx**	**CO**	**PM10**	**PM2.5**	**SO2**	**VOCs**	**CO2**	**CH4**	**N2O**	**GHG as CO2e**	**HAPs**
FPSO	Offloading of Condensate every 67 days	Assist Tug	3	Main	2	1999	0.43	MDO	9	24	216	3	1	72.72	6.37	3.90	3.78	7.31	2.70	3879	0.506	0.112	3925	0.47
				Auxiliary	2	180	0.43	MDO	9	24	216	8	2											
	Supply of Materials, Loading/ Offloading of Riach/Lean MEG, etc	Supply Boat	1	Main Engine / Generator	2	1500	0.68	MDO	12	24	288	3	3	46.49	3.95	2.51	2.43	4.61	1.75	2448	0.319	0.071	2477	0.30
				Main Engine / Generator	2	1030	0.68	MDO	12	24	288	3	3											
				Auxiliary Power	1	250	0.43	MDO	12	24	288	7	2											
	One securitry boat continually operating in region of FPSO	Guard / security boat	1	Main Engine	2	900	0.68	MDO	365	24	8760	3	2	16.16	1.35	0.88	0.85	1.59	0.61	844.56	0.110	0.024	854	0.11
				Generators	2	22.5	0.43	MDO	365	24	8760	NA	0											
	Transfer of Crew to and from between Shore and FPSO	Crew Boat	1	Main Engines	4	2000	0.68	MDO	104	12	1248	3	3	71.81	5.98	3.92	3.80	7.07	2.72	3754	0.490	0.109	3798	0.47
Sea Island	Assist LNGCs	Assist Tug	3	Main	2	2250	0.43	MDO	73	24	1752	3	3	81.27	7.08	4.37	4.23	8.15	3.03	4326	0.564	0.125	4377	0.52
				Auxiliary	2	180	0.43	MDO	73	24	1752	8	2											
	LNGC every 1.67 days	service tug	1																					
		Mooring line	3																					
		Guard / security boat	1								8760													
	Transfer of Crew to and from between Shore and Sea Island	Crew Boat	1	Main Engines	4	2000	0.68	MDO	365	12	4380	3	3	71.81	5.98	3.92	3.80	7.07	2.72	3754	0.490	0.109	3798	0.47
Total																								

Notes and Assumptions:
1. Emissions other than HAPs are estimated for the each engine by using the following equation: Emissions per Engine (kg) = Emission Factor (EF) (g/kW) x Engine Load Factor x Engine Rating (kW) x Total Operating Hours x (kg/1000g)
   In the above spreadsheet, based on the engine type in the vessel, the equivalent EF is selected from the Table A below.
   For example, the Main Propulsion Engine for the Tug Boat is considered an Ocean Going Engine with Medium Speed Engine using Marine Diesel Oil, and assigned a lookup value of 1. The EFs for NOx, CO, PM, SO2, etc.
   used in the calculations are selected from the Table A below for that engine type. Similarly, if the vessel is Harbor Craft with engine type as Tier 0 and Category 2 (Power rating between 1000 - 3000 kW), then the EF lookup value will be 3.
2. The Hazardous Air Pollutant (HAP) emissions are considered a component of the VOC or PM10 or PM2.5 emissions and are estimated using speciation fractions from the EPA's National Emission Inventory (NEI) as shown in the following equation:
   $E = A \times SF$,
   Where:
   E = Annual emissions for HAP (tons)
   A = Annual emissions for speciation base (tons) - VOC or PM10 or PM2.5
   SF = Speciation factor (unitless fraction) as shown in the Table B below.
3. Emission Factors (EFs) for Commercial Marine Vessels are sourced from ICF International Report for US EPA, Current Methodologies in Preparing Mobile Source Port-related Emissions Inventories, April 2009
   See Table A below for the EFs.
4. Hazardous Air Pollutants (HAPs) emission calculation methodology is based on the ERG, Inc. Report for TCEQ, "2014 Texas Statewide Commercial Marine Vessel Emissions Inventory and 2008 through 2040 Trend Inventories",
   August 2015, Table 4-6, pg 4-7.
5. The type and number of marine vessels, and their operating days are sourced from the BP Tortue Concept Select Study, Cost Estimate Report, Doc. No. J7018-BP-RE-K-001 Rev.B
6. The number of operating hours per day per vessel is assumed to be 24 hours (unless otherwise stated) due to lack of details at the conceptual stage, and it also provides a conservatively higher emissions estimate
7. Engine details, such as number of engines, type of engines, nominal power rating and fuel type are based on typical vessels used in offshore construction activities
8. The engine load factors (propulsion and auxiliary engines) are from Section 2.5 (pg 2-11) and Table 2-7 for Ocean Going Vessels, and Table 3-4 for Harbor Crafts

Legend:
EF: Emission Factors
MB: Material Balance
EC: Engineering Calculation
NA: Not Available
MT: Metric Tonnes
MDO: Marine Diesel Oil

														Total Air Emissions for a Vessel Type for the Period of Operation (MT)										
Operations Location	**Specific Activity**	**Marine Vessels/ Equipment Used**	**Number of Vessels**	**Engine Type**	**Number of Engines Per Vessel**	**Engine Rating (kW)**	**Engine Load Factor**	**Fuel Type**	**Annual Operating Days**	**Operating Hours (hr/day)**	**Annual Operating Hours (hr)**	**Emission Factor Lookup (See Note 1 and Table A Below)**	**Engine Category for Emission Calculations (from Table A)**	**NOx**	**CO**	**PM10**	**PM2.5**	**SO2**	**VOCs**	**CO2**	**CH4**	**N2O**	**GHG as CO2e**	**HAPs**
FPSO	Offloading of Condensate every 67 days	Assist Tug	3	Main	2	1999	0.43	MDO	9	24	216	3	1	15.71	1.38	0.84	0.82	1.58	0.58	838	0.11	0.02	848	0.10
				Auxiliary	2	180	0.43	MDO	9	24	216	8	2											
	Supply of Materials, Loading/ Offloading of Riach/Lean MEG, etc	Supply Boat	1	Main Engine / Generator	2	1500	0.68	MDO	12	24	288	3	3	13.39	1.14	0.72	0.70	1.33	0.50	705	0.09	0.02	713	0.09
				Main Engine / Generator	2	1030	0.68	MDO	12	24	288	3	3											
				Auxiliary Power	1	250	0.43	MDO	12	24	288	7	2											
	One securitry boat continually operating in region of FPSO	Guard / security boat	1	Main Engine	2	900	0.68	MDO	365	24	8760	3	2	141.53	11.79	7.72	7.49	13.94	5.36	7398.3456	0.97	0.21	7485	0.93
				Generators	2	22.5	0.43	MDO	365	24	8760	NA	0											
	Transfer of Crew to and from between Shore and FPSO	Crew Boat	1	Main Engines	4	2000	0.68	MDO	104	12	1248	3	3	89.62	7.47	4.89	4.74	8.83	3.39	4684	0.61	0.14	4739	0.59
Sea Island	Assist LNGCs	Assist Tug	3	Main	2	2250	0.43	MDO	73	24	1752	3	3	142.39	12.41	7.65	7.42	14.28	5.30	7579	0.99	0.22	7668	0.92
				Auxiliary	2	180	0.43	MDO	73	24	1752	8	2											
	LNGC every 1.67 days	service tug	1																					
		Mooring line	3																					
		Guard / security boat	1								8760													
	Transfer of Crew to and from between Shore and Sea Island	Crew Boat	1	Main Engines	4	2000	0.68	MDO	365	12	4380	3	3	314.52	26.21	17.16	16.64	30.98	11.91	16441	2.14	0.48	16634	2.06
Total																								

Notes and Assumptions:

1. Emissions other than HAPs are estimated for the each engine by using the following equation: Emissions per Engine (kg) = Emission Factor (EF) (g/kW) x Engine Load Factor x Engine Rating (kW) x Total Operating Hours x (kg/1000g)
   In the above spreadsheet, based on the engine type in the vessel, the equivalent EF is selected from the Table A below.
   For example, the Main Propulsion Engine for the Tug Boat is considered an Ocean Going Engine with Medium Speed Engine using Marine Diesel Oil, and assigned a lookup value of 1. The EFs for NOx, CO, PM, SO2, etc. used in the calculations are selected from the Table A below for that engine type. Similarly, if the vessel is Harbor Craft with engine type as Tier 0 and Category 2 (Power rating between 1000 - 3000 kW), then the EF lookup value will be 3.
2. The Hazardous Air Pollutant (HAP) emissions are considered a component of the VOC or PM10 or PM2.5 emissions and are estimated using speciation fractions from the EPA's National Emission Inventory (NEI) as shown in the following equation:
   $E = A \times SF$,
   Where:
   E = Annual emissions for HAP (tons)
   A = Annual emissions for speciation base (tons) - VOC or PM10 or PM2.5
   SF = Speciation factor (unitless fraction) as shown in the Table B below.
3. Emission Factors (EFs) for Commercial Marine Vessels are sourced from ICF International Report for US EPA, Current Methodologies in Preparing Mobile Source Port-related Emissions Inventories, April 2009
   See Table A below for the EFs.
4. Hazardous Air Pollutants (HAPs) emission calculation methodology is based on the ERG, Inc. Report for TCEQ, "2014 Texas Statewide Commercial Marine Vessel Emissions Inventory and 2008 through 2040 Trend Inventories", August 2015, Table 4-6, pg 4-7.
5. The type and number of marine vessels, and their operating days are sourced from the BP Tortue Concept Select Study, Cost Estimate Report, Doc. No. J7018-BP-RE-K-001 Rev.B
6. The number of operating hours per day per vessel is assumed to be 24 hours (unless otherwise stated) due to lack of details at the conceptual stage, and it also provides a conservatively higher emissions estimate
7. Engine details, such as number of engines, type of engines, nominal power rating and fuel type are based on typical vessels used in offshore construction activities
8. The engine load factors (propulsion and auxiliary engines) are from Section 2.5 (pg 2-11) and Table 2-7 for Ocean Going Vessels, and Table 3-4 for Harbor Crafts

Short Term Natural Gas Fuel Maximum Emission Rate (per Gas Turbine)

Proposed Capacity (MW)[1]	Number of Units[2]	HHV of Natural Gas (Btu/kW-hr)[3]	Fuel Consumption Rate (MMBtu/hr)[4]	Annual Hours of Operation (hrs)[5]
33.7	4.0	10,889	367.0	8,497

1. Provided by BP on November 20, 2017.
2. Provided by BP on November 20, 2017.
3. Provided by BP as a LHV. HHV calculated as HHV = LHV*1.11
4. Provided by BP on November 20, 2017.
5. Estimated to be available 97% of the time (Tortue Report 09/11/2017).

Pollutant	Emission Factor	Units	Short Term Emissions (tonne/hr)	Long Term Emissions (tonne/yr)	Reference
NOx	3.3	g/s	4.75E-02	403.79	1
CO	2.656	g/s	3.82E-02	324.99	1
PM	0.234	g/s	3.37E-03	28.63	1,2
VOC	9.53E-07	tonne/MMBtu	1.40E-03	11.88	3
SO2	--	g/s	<0.001	<0.001	1
SAM	5.0	%	<0.001	<0.001	4
HAPS					
Acetaldehyde	4.0E-05	(lb/MMBtu)	2.66E-05	2.26E-01	5
Acrolein	6.4E-06	(lb/MMBtu)	4.26E-06	3.62E-02	5
Benzene	1.2E-05	(lb/MMBtu)	7.99E-06	6.79E-02	5
1,3-Butadiene	4.3E-07	(lb/MMBtu)	2.86E-07	2.43E-03	5
Ethylbenzene	3.2E-05	(lb/MMBtu)	2.13E-05	1.81E-01	5
Formaldehyde	7.1E-04	(lb/MMBtu)	4.73E-04	4.02E+00	5
Naphthalene	1.3E-06	(lb/MMBtu)	8.66E-07	7.35E-03	5
Propylene Oxide	2.9E-05	(lb/MMBtu)	1.93E-05	1.64E-01	5
Toluene	1.3E-04	(lb/MMBtu)	8.66E-05	7.35E-01	5
o-Xylene	6.4E-05	(lb/MMBtu)	4.26E-05	3.62E-01	5
Total HAP				5.80E+00	

* Potential emission calculations based on maximum heat input at HHV
1. Vendor specific emission rates provided by CSA via email (13/12/2017).
2. Assumed PM = PM10 = PM2.5
3. AP-42 Table 3.1-2a for natural gas combustion.
4. Assumed SAM comprised of 5% of SO2 emissions.
5. AP-42 Table 3.1-3 for natural gas combustion.

Short Term Natural Gas Fuel Maximum Emission Rate (per Gas Turbine)

Proposed Capacity (MW)[1]	Number of Units[2]	HHV of Natural Gas (Btu/kW-hr)[3]	Fuel Consumption Rate (MMBtu/hr)[4]	Annual Hours of Operation (hrs)[5]
33.7	4.0	10,889	367.0	8,497

1. Provided by BP on November 20, 2017.
2. Provided by BP on November 20, 2017.
3. Provided by BP as a LHV. HHV calculated as HHV = LHV*1.11
4. Provided by BP on November 20, 2017.
5. Assumed to be available 97% of the time (Tortue Report 09/11/2017).

Pollutant	Emission Factor	Units	Short Term Emissions (tonne/hr)	Long Term Emissions (tonne/yr)	Reference
CO2	53.06	kg/MMBtu	77.9	661,797.26	1
CH4	1.00E-03	kg/MMBtu	1.47E-03	12.47	1
N2O	1.00E-04	lb/MMBtu	1.47E-04	1.25	1
CO2e	4.40E-05	tonne/tonne fuel	78.0	662,480.76	1

* Potential emission calculations based on maximum heat input at HHV

1. Table C-1 and C-2 from 40 CFR part 98 for natural gas combustion. Global warming potentials from Part 98, Table A-1 and are 1 for CO2, 25 for CH4 and 298 for N2O

FLNG Gas Generator

Proposed Allowable Criteria Pollutant Emissions

Fuel	Natural Gas	
Number of Engines	2	
Rated Capacity[1]	9.00	MW
Potential Hours of Operation[2]	8,497	hrs/yr
Approximate Fuel Consumption at full load[3]	10,889	Btu/kW-hr
Approximate Fuel Consumption at full load[4]	98.002	MMBtu/hr

Proposed Allowable Criteria Pollutant Emissions					
			Emissions		
Pollutant	Emission Factor		(tonne/hr)	(tonne/yr)	Reference
NO_x	0.014	tonne/hr	0.028	237.92	5
CO	0.021	tonne/hr	0.042	356.88	5
SO_2	--	tonne/hr	<0.001	<0.001	5
PM	1.74E-02	kg/MMBtu	0.003	29.009	6
VOC	6.0E-03	tonne/hr	0.012	101.97	5

References:

1. Based on generator specific information provided by BP on November 2017.
2. Assume operational during normal operations (provided by BP on 20/11/2017).
3. Provided by BP on 20/11/2017, assumed to the be same fuel that is used in the gas turbines.
4. MMBtu/hr = (Btu/kW-hr)*(1000 kW/MW)*(MW)/(10^6 Btu/MMBtu)
5. Provided by CSA via email (13/12/2017).
6. Based on maximum PM emissions in AP-42 Section 3.2, Assumed all PM=PM10=PM2.5.

FLNG Gas Generator

Proposed Allowable HAP Emissions

Fuel	Natural Gas	
Number of Engines	2	
Rated Capacity[2]	9.00	MMBtu/hr
Potential Hours of Operation[3]	8,497	hrs/yr
Approximate Fuel Consumption at full load[4]	10,889	Btu/kW-hr
Approximate Fuel Consumption at full load[5]	98.002	MMBtu/hr

Proposed allowable HAP Emissions

HAP	Emission Factor (lb/MMBtu)	Emission Factor (tonne/MMBtu)	Emissions (tonne/hr)	Emissions (tonne/yr)	Reference
1,1,2,2-Tetrachloroethane	6.63E-05	3.01E-08	5.89E-06	5.01E-02	1
1,1,2-Trichloroethane	5.27E-05	2.39E-08	4.69E-06	3.98E-02	1
1,3-Butadiene	8.20E-04	3.72E-07	7.29E-05	6.19E-01	1
1,3-Dichloropropene	4.38E-05	<1.99E-08	3.89E-06	3.31E-02	1
2,2,4-Trimethylpentane	8.46E-04	3.84E-07	7.52E-05	6.39E-01	1
2-Methylnaphthalene	2.14E-05	9.71E-09	1.90E-06	1.62E-02	1
Acenaphthene	1.33E-06	6.03E-10	1.18E-07	1.00E-03	1
Acenaphthylene	3.17E-06	1.44E-09	2.82E-07	2.39E-03	1
Acetaldehyde	7.76E-03	<3.52E-06	6.90E-04	5.86E+00	1
Acrolein	7.78E-03	3.53E-06	6.92E-04	5.88E+00	1
Anthracene	7.18E-07	<3.26E-10	6.38E-08	5.42E-04	1
Benz(a)anthracene	3.36E-07	1.52E-10	2.99E-08	2.54E-04	1
Benzene	1.94E-03	8.80E-07	1.72E-04	1.47E+00	1
Benzo(a)pyrene	5.68E-09	2.58E-12	5.05E-10	4.29E-06	1
Benzo(b)fluoranthene	8.51E-09	3.86E-12	7.57E-10	6.43E-06	1
Benzo(e)pyrene	2.34E-08	1.06E-11	2.08E-09	1.77E-05	1
Benzo(g,h,i)perylene	2.48E-08	1.12E-11	2.20E-09	1.87E-05	1
Benzo(k)fluoranthene	4.26E-09	<1.93E-12	3.79E-10	3.22E-06	1
Biphenyl	3.95E-06	1.79E-09	3.51E-07	2.98E-03	1
Carbon Tetrachloride	6.07E-05	2.75E-08	5.40E-06	4.59E-02	1
Chlorobenzene	4.44E-05	2.01E-08	3.95E-06	3.35E-02	1
Chloroform	4.71E-05	2.14E-08	4.19E-06	3.56E-02	1
Chrysene	6.72E-07	3.05E-10	5.97E-08	5.08E-04	1
Ethylbenzene	1.08E-04	4.90E-08	9.60E-06	8.16E-02	1
Ethylene Dibromide	7.34E-05	3.33E-08	6.53E-06	5.55E-02	1
Fluoranthene	3.61E-07	1.64E-10	3.21E-08	2.73E-04	1
Fluorene	1.69E-06	7.67E-10	1.50E-07	1.28E-03	1
Formaldehyde	5.52E-02	2.50E-05	4.91E-03	4.17E+01	1
Indeno(1,2,3-c,d)pyrene	9.93E-09	4.50E-12	8.83E-10	7.50E-06	1
Methanol	2.48E-03	1.12E-06	2.20E-04	1.87E+00	1
Methylene Chloride	1.47E-04	6.67E-08	1.31E-05	1.11E-01	1
n-Hexane	4.45E-04	2.02E-07	3.96E-05	3.36E-01	1
Naphthalene	9.63E-05	4.37E-08	8.56E-06	7.27E-02	1
PAH	1.34E-04	6.08E-08	1.19E-05	1.01E-01	1
Perylene	4.97E-09	2.25E-12	4.42E-10	3.75E-06	1
Phenanthrene	3.53E-06	1.60E-09	3.14E-07	2.67E-03	1
Phenol	4.21E-05	1.91E-08	3.74E-06	3.18E-02	1
Pyrene	5.84E-07	2.65E-10	5.19E-08	4.41E-04	1
Styrene	5.48E-05	2.49E-08	4.87E-06	4.14E-02	1
Toluene	9.63E-04	4.37E-07	8.56E-05	7.27E-01	1
Vinyl Chloride	2.47E-05	1.12E-08	2.20E-06	1.87E-02	1
Xylene	2.68E-04	1.22E-07	2.38E-05	2.02E-01	1
Total HAP				60.08	

1. From AP-42, Table 3.2-1 for uncontrolled 2-stroke lean burn engines as a conservative estimate.
2. Based on generator specific information provided by the BP on November 20, 2017.
3. Assume operational during normal operations (provided by BP on 20/11/2017).
4. Provided by BP on 20/11/2017, assumed to the be same fuel that is used in the gas turbines.
5. MMBtu/hr = (Btu/kW-hr)*(1000 kW/MW)*(MW)/(10^6 Btu/MMBtu)

FLNG Gas Generator

Proposed Allowable Criteria Pollutant Emissions

Fuel	Natural Gas	
Number of Engines	2	
Rated Capacity[1]	9.00	MW
Potential Hours of Operation[2]	8,497	hrs/yr
Approximate Fuel Consumption at full load[3]	10,889	Btu/kW-hr
Approximate Fuel Consumption at full load[4]	98.002	MMBtu/hr

Proposed Allowable GHG Emissions					
			Emissions		
Pollutant	Emission Factor		(tonne/hr)	(tonne/yr)	Reference
CO_2	5.40	tonne/hr	10.80	91769.76	6
CH_4	1.00E-03	kg/MMBtu	0.00	1.67	7
N_2O	1.00E-04	kg/MMBtu	0.00	0.17	7
CO_2e	--	--	10.81	91861.03	7

References:

1. Based on generator specific information provided by BP on November 2017.
2. Assume operational during normal operations.
3. Provided by BP on 20/11/2017, assumed to the be same fuel that is used in the gas turbines.
4. MMBtu/hr = (Btu/kW-hr)*(1000 kW/MW)*(MW)/(10^6 Btu/MMBtu)
6. Based on emissions information provided by CSA via email (13/12/2017).
7. Table C-1 and C-2 from 40 CFR part 98 for natural gas combustion. Global warming potentials from Part 98, Table A-1 and are 1 for CO2, 25 for CH4 and 298 for N2O.

FLNG Flare - Pilot Only

Proposed Potential-to-Emit Criteria Pollutant Emissions from Pilot

Pilot Fuel	Natural Gas	
Natural Gas Heating Value[1]	1,027	Btu/scf
Pilot fuel Consumption during Normal Operation[2]	0.001	MMscf/hr
Tonnes of fuel during normal operations[3]	0.01	tonne/hr
Number of Pilots[4]	1	
Potential Hours of Operation[5]	8,760	hrs/yr
Destruction Efficiency[6]	98%	

Flare - Pilot Only
Proposed Potential-to-Emit Criteria Pollutant Emissions

Pollutant	Emission Factor		Hourly Emission Rate (tonne/hr)	Annual Emissions (tonne/yr)	Reference
NO_x	6.26	g/s	0.022536	197.42	7
CO	34.06	g/s	0.122616	1074.12	7
VOC	0	g/s	<0.001	<0.001	8
PM	0.466	g/s	0.0016776	14.70	7
SO_2	--	g/s	<0.001	<0.001	7

References:

1. Based on the average value provided in https://www.extension.iastate.edu/agdm/wholefarm/html/c6 -89.html
2. MMscf/hr = (tonne of NG/hr)*(MMBtu/tonne of NG)/(MMBtu/MMscf)
3. Based on vedor specific operational data provided by BP on 20/11/2017 (assumed 11.6 kg/hr).
4. BP provided data on 20/11/2017.
5. Flare tip assumed to operate continusouly, emissions only represent normal operations and do not include startup or shutdown.
6. Provided by CSA via email (13/12/2017).
7. Vendor specific emission factors provided by CSA via email (13/12/2017).
6. Based on vendor specific operational data provided by CSA via email (13/12/2017).
8. Assumed to be neglibeable based on total HC content.

FLNG Flare - Pilot Only

Proposed Potential-to-Emit HAP Emissions from Pilot

Pilot Fuel	Natural Gas
Natural Gas Heating Value[1]	1,027 Btu/scf
Pilot fuel Consumption during Normal Operation[2]	0.001 MMscf/d
Tonnes of fuel during normal operations[3]	0.01 tonne/hr
Number of Pilots[4]	1
Potential Hours of Operation[5]	8,760 hrs/yr
Destruction Efficiency[6]	98%

Flare - Pilot Only
Proposed allowable HAP Emissions

HAP	Emission Factor (lb/MMscf)	Emission Factor (tonne/MMscf)	Hourly Emission Rate (tonne/hr)	Annual Emissions (tonne/yr)	Reference
Benzene	2.1E-03	9.5E-07	< 0.001	< 0.001	6
Dichlorobenzene	1.2E-03	5.4E-07	< 0.001	< 0.001	6
Formaldehyde	0.075	3.4E-05	< 0.001	< 0.001	6
n-Hexane	1.80	8.2E-04	< 0.001	< 0.001	6
Naphthalene	6.1E-04	2.8E-07	< 0.001	< 0.001	6
Toluene	3.4E-03	1.5E-06	< 0.001	< 0.001	6
Polycyclic Organic Matter	8.8E-05	4.0E-08	< 0.001	< 0.001	6, 8
Arsenic	2.0E-04	9.1E-08	< 0.001	< 0.001	7
Barium	4.4E-03	2.0E-06	< 0.001	< 0.001	7
Beryllium	<1.20E-05	5.4E-09	< 0.001	< 0.001	7
Cadmium	1.1E-03	5.0E-07	< 0.001	< 0.001	7
Chromium	1.4E-03	6.4E-07	< 0.001	< 0.001	7
Cobalt	8.4E-05	3.8E-08	< 0.001	< 0.001	7
Copper	8.5E-04	3.9E-07	< 0.001	< 0.001	7
Manganese	3.8E-04	1.7E-07	< 0.001	< 0.001	7
Mercury	2.6E-04	1.2E-07	< 0.001	< 0.001	7
Nickel	2.1E-03	9.5E-07	< 0.001	< 0.001	7
Selenium	<2.4E-05	1.1E-08	< 0.001	< 0.001	7
Total HAP				< 0.001	

References:

1. Based on the average value provided in https://www.extension.iastate.edu/agdm/wholefarm/html/c6-89.html
2. MMscf/hr = (tonne of NG/hr)*(MMBtu/tonne of NG)/(MMBtu/MMscf)
3. Based on vedor specific operational data provided by BP on 20/11/2017.
4. BP provided data on 20/11/2017.
5. Flare tip assumed to operate continusouly, emissions only represent normal operations and do not include startup or shutdown.
6. Emission factors for organic compounds based on AP-42 Table 1.4-3, Emission Factors for Speciated Organic Compounds from Natural Gas Combustion, July 1998.
7. Emission factors for metals based on AP-42 Table 1.4-4, Emission Factors for Metals from Natural Gas Combustion, July 1998.
8. The emission factor for Polyclic Organic Matter (POM) is calculated as the sum of the emission factors per footnote c to AP-42 Chapter 1, Table 1.4-3 (July 1998).

FLNG Flare - Pilot Only

Proposed Potential-to-Emit GHG Emissions from Flare Pilot

Pilot Fuel	Natural Gas	
Natural Gas Heating Value[1]	1,027	Btu/scf
Pilot fuel Consumption during Normal Operation[2]	0.001	MMscf/d
Tonnes of fuel during normal operations[3]	0.01	tonne/hr
Number of Pilots[4]	1	
Potential Hours of Operation[5]	8,760	hrs/yr

Flare - Pilot Only Proposed Potential-to-Emit GHG Emissions					
Pollutant	Emission Factor		Hourly Emission Rate (tonne/hr)	Annual Emissions (tonne/yr)	Reference
CO_2	2.80	tonne/tonne fuel	0.032	285	6
CH_4	1.30E-02	tonne/tonne fuel	1.508E-04	1	6
N_2O	2.20E-04	tonne/tonne fuel	2.55E-06	0	6
CO_2e	--	--	0.0	324	7

References:

1. Based on the average value provided in https://www.extension.iastate.edu/agdm/wholefarm/html/c6-89.html
2. MMscf/hr = (tonne of NG/hr)*(MMBtu/tonne of NG)/(MMBtu/MMscf)
3. Based on vedor specific operational data provided by BP on 20/11/2017 (assumed to be 11.6 kg/hr).
4. BP provided data on 20/11/2017.
5. Flare tip assumed to operate continusouly, emissions only represent normal operations and do not include startup or shutdown.
6. Based on API emission factors provied by BP on November 20, 2017.
7. Table C-1 and C-2 from 40 CFR part 98 for natural gas combustion. Global warming potentials from Part 98, Table A-1 and are 1 for CO2, 25 for CH4 and 298 for N2O.

HUB Gas Generator

Proposed Allowable Criteria Pollutant Emissions

Fuel	Natural Gas	
Number of Engines	2	
Rated Capacity[1]	2.50	MW
Potential Hours of Operation[2]	8,322	hrs/yr
Approximate Fuel Consumption at full load[3]	10,889	Btu/kW-hr
Approximate Fuel Consumption at full load[4]	34.758	Tonne/hr
Approximate HHV of Natural Gas	27.223	MMBtu/hr

Proposed Allowable Criteria Pollutant Emissions					
			Emissions		
Pollutant	**Emission Factor**		**(tonne/hr)**	**(tonne/yr)**	**Reference**
NO_x	5.292	g/s	0.038	317.09	5
CO	0.092	g/s	0.001	5.51	5
SO_2	0	g/s	0.000	0.00	5
PM	1.74E-02	kg/MMBtu	0.001	10.08	6
VOC	5.4E-02	kg/MMBtu	0.004	31.49	6

References:

1. Based on generator specific information provided in the Tortue Report, November 2017 (09/11/2017).
2. Based on information provided by BP in November Tortue Report (09/11/2017).
3. Provided by BP on 20/11/2017, assumed to be the same fuel that is used in the FLNG gas turbines.
4. MMBtu/hr = (Btu/kW-hr)*(1000 kW/MW)*(MW)/(10^6 Btu/MMBtu)
5. Provided by CSA via email (13/12/2017).
6. Based on maximum PM and VOC emissions in AP-42 Section 3.2, assumed all PM = PM10 = PM2.5.

HUB Gas Generator

Proposed Allowable HAP Emissions

Fuel	Natural Gas	
Number of Engines	2	
Rated Capacity[2]	2.50	MW
Potential Hours of Operation[2]	8,322	hrs/yr
Approximate Fuel Consumption at full load[3]	10,889	Btu/kW-hr
Approximate Fuel Consumption at full load[4]	34.758	Tonne/hr
Approximate HHV of Natural Gas	27.223	MMBtu/hr

Proposed allowable HAP Emissions

HAP	Emission Factor (lb/MMBtu)	Emission Factor (tonne/MMBtu)	Emissions (tonne/hr)	Emissions (tonne/yr)	Reference
1,1,2,2-Tetrachloroethane	6.63E-05	3.01E-08	1.64E-06	1.36E-02	1
1,1,2-Trichloroethane	5.27E-05	2.39E-08	1.30E-06	1.08E-02	1
1,3-Butadiene	8.20E-04	3.72E-07	2.03E-05	1.69E-01	1
1,3-Dichloropropene	4.38E-05	<1.99E-08	1.08E-06	9.00E-03	1
2,2,4-Trimethylpentane	8.46E-04	3.84E-07	2.09E-05	1.74E-01	1
2-Methylnaphthalene	2.14E-05	9.71E-09	5.28E-07	4.40E-03	1
Acenaphthene	1.33E-06	6.03E-10	3.28E-08	2.73E-04	1
Acenaphthylene	3.17E-06	1.44E-09	7.83E-08	6.51E-04	1
Acetaldehyde	7.76E-03	<3.52E-06	1.92E-04	1.59E+00	1
Acrolein	7.78E-03	3.53E-06	1.92E-04	1.60E+00	1
Anthracene	7.18E-07	<3.26E-10	1.77E-08	1.48E-04	1
Benz(a)anthracene	3.36E-07	1.52E-10	8.30E-09	6.91E-05	1
Benzene	1.94E-03	8.80E-07	4.79E-05	3.99E-01	1
Benzo(a)pyrene	5.68E-09	2.58E-12	1.40E-10	1.17E-06	1
Benzo(b)fluoranthene	8.51E-09	3.86E-12	2.10E-10	1.75E-06	1
Benzo(e)pyrene	2.34E-08	1.06E-11	5.78E-10	4.81E-06	1
Benzo(g,h,i)perylene	2.48E-08	1.12E-11	6.12E-10	5.10E-06	1
Benzo(k)fluoranthene	4.26E-09	<1.93E-12	1.05E-10	8.76E-07	1
Biphenyl	3.95E-06	1.79E-09	9.75E-08	8.12E-04	1
Carbon Tetrachloride	6.07E-05	2.75E-08	1.50E-06	1.25E-02	1
Chlorobenzene	4.44E-05	2.01E-08	1.10E-06	9.13E-03	1
Chloroform	4.71E-05	2.14E-08	1.16E-06	9.68E-03	1
Chrysene	6.72E-07	3.05E-10	1.66E-08	1.38E-04	1
Ethylbenzene	1.08E-04	4.90E-08	2.67E-06	2.22E-02	1
Ethylene Dibromide	7.34E-05	3.33E-08	1.81E-06	1.51E-02	1
Fluoranthene	3.61E-07	1.64E-10	8.92E-09	7.42E-05	1
Fluorene	1.69E-06	7.67E-10	4.17E-08	3.47E-04	1
Formaldehyde	5.52E-02	2.50E-05	1.36E-03	1.13E+01	1
Indeno(1,2,3-c,d)pyrene	9.93E-09	4.50E-12	2.45E-10	2.04E-06	1
Methanol	2.48E-03	1.12E-06	6.12E-05	5.10E-01	1
Methylene Chloride	1.47E-04	6.67E-08	3.63E-06	3.02E-02	1
n-Hexane	4.45E-04	2.02E-07	1.10E-05	9.15E-02	1
Naphthalene	9.63E-05	4.37E-08	2.38E-06	1.98E-02	1
PAH	1.34E-04	6.08E-08	3.31E-06	2.75E-02	1
Perylene	4.97E-09	2.25E-12	1.23E-10	1.02E-06	1
Phenanthrene	3.53E-06	1.60E-09	8.72E-08	7.25E-04	1
Phenol	4.21E-05	1.91E-08	1.04E-06	8.65E-03	1
Pyrene	5.84E-07	2.65E-10	1.44E-08	1.20E-04	1
Styrene	5.48E-05	2.49E-08	1.35E-06	1.13E-02	1
Toluene	9.63E-04	4.37E-07	2.38E-05	1.98E-01	1
Vinyl Chloride	2.47E-05	1.12E-08	6.10E-07	5.08E-03	1
Xylene	2.68E-04	1.22E-07	6.62E-06	5.51E-02	1
Total HAP				1.63E+01	

1. From AP-42, Table 3.2-1for uncontrolled emissions from a 2-stroke lean burn engine as a conservative estimate.
2. Based on generator specification information provided by BP in the November Tortue Report (09/11/2017).
3. Provided by BP on 20/11/2017, assumed to be the same fuel that is used in the FLNG gas turbines.
4. MMBtu/hr = (Btu/kW-hr)*(1000 kW/MW)*(MW)/(10^6 Btu/MMBtu)

HUB Gas Generator

Proposed Allowable Criteria Pollutant Emissions

Fuel	Natural Gas	
Number of Engines	2	
Rated Capacity[1]	2.50	MW
Potential Hours of Operation[2]	8,322	hrs/yr
Approximate Fuel Consumption at full load[3]	10,889	Btu/kW-hr
Approximate Fuel Consumption at full load[4]	34.758	Tonne/hr
Approximate HHV of Natural Gas	27.223	MMBtu/hr

Proposed Allowable GHG Emissions

Pollutant	Emission Factor		Emissions (tonne/hr)	Emissions (tonne/yr)	Reference
CO_2	53.06	kg/MMBtu	2.89	24041.02	6
CH_4	1.00E-03	kg/MMBtu	0.00	0.45	6
N_2O	1.00E-04	kg/MMBtu	0.00	0.05	6
CO_2e	--	--	**2.89**	24065.85	7

References:

1. Based on generator specific information provided by BP 20/11/2017.
2. Based on information provided in the November Tortue Report (09/11/2017).
3. Based on approximate fuel usage from http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx
4. MMBtu/hr = (Btu/kW-hr)*(1000 kW/MW)*(MW)/(10^6 Btu/MMBtu)
5. Table C-1 and C-2 from 40 CFR part 98 for natural gas combustion. Global warming potentials from Part 98, Table A-1 and are 1 for CO2, 25 for CH4 and 298 for N2O.

Emergency Generator

Proposed Allowable Criteria Pollutant Emissions

Fuel	Diesel	
Number of Engines	1	
Rated Capacity[1]	0.25	MW
Potential Hours of Operation[2]	100	hrs/yr
Approximate Fuel Consumption at full load[3]	18	gal/hr
Approximate Fuel Consumption at full load[4]	0.057	Tonne/hr
Approximate HHV of diesel fuel[5]	0.139	MMBtu/gal

Proposed Allowable Criteria Pollutant Emissions					
			Emissions		
Pollutant	Emission Factor		(tonne/hr)	(tonne/yr)	Reference
NO_x	0.104	g/s	0.000	0.04	6
CO	0.280	g/s	0.001	0.10	6
SO_2	0.33	g/s	0.001	0.12	6
PM	1.34E-03	kg/KW-hr	0.000	0.03	7
VOC	1.6E-03	tonne/tonne fuel	0.000	0.01	6

References:

1. Based on generator specific information provided by the facility in the November 2017 Tortue Report (09/11/2017).
2. Per Rule 62-210.300(3)(a)35., F.A.C.
3. Based on approximate fuel usage from http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx
4. Based on a conversion of 1 gal = 0.003192 metric tons of diesel fuel from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
5. Based on 1 gallon = 138,700 Btu – HHV from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
6. Based on data provided by CSA via email (13/12/2017).
7. Based on AP-42, Table 3.3-1, assumed all PM = PM10 = PM2.5.

Emergency Generator

Proposed Allowable HAP Emissions

Fuel	Diesel	
Number of Engines	1	
Rated Capacity[2]	0.25	MMBtu/hr
Potential Hours of Operation[3]	100	hrs/yr
Approximate Fuel Consumption at full load[4]	18	gal/hr
Approximate Fuel Consumption at full load[5]	0.057	Tonne/hr
Approximate HHV of diesel fuel[6]	0.139	MMBtu/gal

Proposed allowable HAP Emissions

HAP	Emission Factor (lb/MMBtu)	Emission Factor (tonne/MMBtu)	Emissions (tonne/hr)	Emissions (tonne/yr)	Reference
Benzene	9.33E-04	4.23E-07	1.06E-06	1.06E-04	1
Toluene	4.09E-04	1.86E-07	4.63E-07	4.63E-05	1
Xylene	2.85E-04	1.29E-07	3.23E-07	3.23E-05	1
Propylene	<2.85E-03	<1.29E-06	3.23E-06	3.23E-04	1
Polycyclic Aromatic Hydrocarbon (PAH)	1.68E-04	7.62E-08	1.90E-07	1.90E-05	1
Napthalene	8.48E-05	3.85E-08	9.60E-08	9.60E-06	1
Acenaphthylene	5.06E-06	2.30E-09	5.73E-09	5.73E-07	1
Acenapthene	1.42E-06	6.44E-10	1.61E-09	1.61E-07	1
Fluorene	<2.92E-05	<1.32E-08	3.31E-08	3.31E-06	1
Phenanthrene	2.94E-05	1.33E-08	3.33E-08	3.33E-06	1
Anthracene	<1.87E-06	<8.48E-10	2.12E-09	2.12E-07	1
Fluoranthene	7.61E-06	3.45E-09	8.62E-09	8.62E-07	1
Pyrene	4.78E-06	2.17E-09	5.41E-09	5.41E-07	1
Benzo(a)anthracene	1.68E-06	7.62E-10	1.90E-09	1.90E-07	1
Chrysene	3.53E-07	1.60E-10	4.00E-10	4.00E-08	1
Benzo(b)fluoranthene	9.91E-08	4.50E-11	1.12E-10	1.12E-08	1
Benzo(k)fluoranthene	1.55E-07	7.03E-11	1.76E-10	1.76E-08	1
Benzo(a)pyrene	<1.88E-07	<8.53E-11	2.13E-10	2.13E-08	1
Indeno(1,2,3-cd)pyrene	3.75E-07	1.70E-10	4.25E-10	4.25E-08	1
Dibenzo(a,h)anthracene	5.83E-07	2.64E-10	6.60E-10	6.60E-08	1
Benzo(g,h,l)perylene	4.89E-07	2.22E-10	5.54E-10	5.54E-08	1
HAP Total				5.45E-04	

References:

1. From AP-42, Table 3.3-2, 2009.
2. Based on generator specification information provided by in November Tortue Report (09/11/2017).
3. Per Rule 62-210.300(3)(a)35., F.A.C.
4. Based on approximate fuel usage from http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx
5. Based on a conversion of 1 gal = 0.003192 metric tons of diesel fuel from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
6. Based on 1 gallon = 138,700 Btu – HHV from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html.

Emergency Generator

Proposed Allowable Criteria Pollutant Emissions

Fuel	Diesel	
Number of Engines	1	
Rated Capacity[1]	0.25	MW
Potential Hours of Operation[2]	100	hrs/yr
Approximate Fuel Consumption at full load[3]	18	gal/hr
Approximate Fuel Consumption at full load[4]	0.057	Tonne/hr
Approximate HHV of diesel fuel[5]	1.387	MMBtu/gal

Proposed Allowable GHG Emissions

Pollutant	Emission Factor		Emissions (tonne/hr)	Emissions (tonne/yr)	Reference
CO_2	3.20	tonne/tonne fuel	0.18	18.39	6
CH_4	2.00E-04	tonne/tonne fuel	0.00	0.00	6
N_2O	9.40E-05	tonne/tonne fuel	0.00	0.00	6
CO_2e	**--**	**--**	**0.19**	18.58	7

References:

1. Based on generator specific information provided by November Tortue Report (09/11/2017).
2. Per Rule 62-210.300(3)(a)35., F.A.C.
3. Based on approximate fuel usage from http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx
4. Based on a conversion of 1 gal = 0.003192 metric tons of diesel fuel from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
5. Based on 1 gallon = 138,700 Btu – HHV from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
6. Based on API Emission Factors provied by BP on 20/11/2017.
7. Table C-1 and C-2 from 40 CFR part 98 for natural gas combustion. Global warming potentials from Part 98, Table A-1 and are 1 for CO2, 25 for CH4 and 298 for N2O.

FW Pumps

Proposed Allowable Criteria Pollutant Emissions

Fuel	Diesel	
Number of Engines	2	
Rated Capacity[1]	1.00	MW
Potential Hours of Operation[2]	100	hrs/yr
Approximate Fuel Consumption at full load[3]	71	gal/hr
Approximate Fuel Consumption at full load[4]	0.227	Tonne/hr
Approximate HHV of diesel fuel[5]	0.139	MMBtu/gal

Proposed Allowable Criteria Pollutant Emissions					
			Emissions		
Pollutant	**Emission Factor**		**(tonne/hr)**	**(tonne/yr)**	**Reference**
NO_x	0.063	tonne/tonne fuel	0.029	2.86	6
CO	0.017	tonne/tonne fuel	0.008	0.76	6
SO_2	1.0%	S in fuel	0.009	0.91	6
PM	1.34E-03	kg/KW-hr	0.001	0.13	7
VOC	1.6E-03	tonne/tonne fuel	0.001	0.07	6

References:

1. Based on generator specific information provided by CSA via email (10/01/2018).
2. Per Rule 62-210.300(3)(a)35., F.A.C.
3. Based on approximate fuel usage from http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx
4. Based on a conversion of 1 gal = 0.003192 metric tons of diesel fuel from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
5. Based on 1 gallon = 138,700 Btu – HHV from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
6. Based on API Emission Factors provided by BP on 20/11/2017.
7. Based on AP-42, Table 3.3-1, assumed all PM = PM10 = PM2.5.

FW Pumps

Proposed Allowable HAP Emissions

Fuel	Diesel	
Number of Engines	2	
Rated Capacity[2]	1.00	MMBtu/hr
Potential Hours of Operation[3]	100	hrs/yr
Approximate Fuel Consumption at full load[4]	71	gal/hr
Approximate Fuel Consumption at full load[5]	0.227	Tonne/hr
Approximate HHV of diesel fuel[6]	0.139	MMBtu/gal

Proposed allowable HAP Emissions

HAP	Emission Factor (lb/MMBtu)	Emission Factor (tonne/MMBtu)	Emissions (tonne/hr)	Emissions (tonne/yr)	Reference
Benzene	9.33E-04	4.23E-07	8.35E-06	8.35E-04	1
Toluene	4.09E-04	1.86E-07	3.66E-06	3.66E-04	1
Xylene	2.85E-04	1.29E-07	2.55E-06	2.55E-04	1
Propylene	<2.85E-03	<1.29E-06	2.55E-05	2.55E-03	1
Polycyclic Aromatic Hydrocarbon (PAH)	1.68E-04	7.62E-08	1.50E-06	1.50E-04	1
Napthalene	8.48E-05	3.85E-08	7.59E-07	7.59E-05	1
Acenaphthylene	5.06E-06	2.30E-09	4.53E-08	4.53E-06	1
Acenapthene	1.42E-06	6.44E-10	1.27E-08	1.27E-06	1
Fluorene	<2.92E-05	<1.32E-08	2.61E-07	2.61E-05	1
Phenanthrene	2.94E-05	1.33E-08	2.63E-07	2.63E-05	1
Anthracene	<1.87E-06	<8.48E-10	1.67E-08	1.67E-06	1
Fluoranthene	7.61E-06	3.45E-09	6.81E-08	6.81E-06	1
Pyrene	4.78E-06	2.17E-09	4.28E-08	4.28E-06	1
Benzo(a)anthracene	1.68E-06	7.62E-10	1.50E-08	1.50E-06	1
Chrysene	3.53E-07	1.60E-10	3.16E-09	3.16E-07	1
Benzo(b)fluoranthene	9.91E-08	4.50E-11	8.87E-10	8.87E-08	1
Benzo(k)fluoranthene	1.55E-07	7.03E-11	1.39E-09	1.39E-07	1
Benzo(a)pyrene	<1.88E-07	<8.53E-11	1.68E-09	1.68E-07	1
Indeno(1,2,3-cd)pyrene	3.75E-07	1.70E-10	3.35E-09	3.35E-07	1
Dibenzo(a,h)anthracene	5.83E-07	2.64E-10	5.22E-09	5.22E-07	1
Benzo(g,h,l)perylene	4.89E-07	2.22E-10	4.37E-09	4.37E-07	1
Total HAP				4.31E-03	

References:

1. From AP-42, Table 3.3-2, 2009.
2. Based on generator specification information provided by CSA via email (10/01/2018).
3. Per Rule 62-210.300(3)(a)35., F.A.C.
4. Based on approximate fuel usage from http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx
5. Based on a conversion of 1 gal = 0.003192 metric tons of diesel fuel from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
6. Based on 1 gallon = 138,700 Btu – HHV from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html.

FW Pumps

Proposed Allowable Criteria Pollutant Emissions

Fuel		Diesel
Number of Engines	2	
Rated Capacity[1]	1.00	MW
Potential Hours of Operation[2]	100	hrs/yr
Approximate Fuel Consumption at full load[3]	71	gal/hr
Approximate Fuel Consumption at full load[4]	0.227	Tonne/hr
Approximate HHV of diesel fuel[5]	1.387	MMBtu/gal

Proposed Allowable GHG Emissions

Pollutant	Emission Factor		Emissions (tonne/hr)	Emissions (tonne/yr)	Reference
CO_2	3.20	tonne/tonne fuel	1.45	145.25	6
CH_4	2.00E-04	tonne/tonne fuel	0.00	0.01	6
N_2O	9.40E-05	tonne/tonne fuel	0.00	0.00	6
CO_2e	**--**	**--**	**1.47**	146.75	7

References:

1. Based on generator specification information provided by CSA via email (10/01/2018).
2. Per Rule 62-210.300(3)(a)35., F.A.C.
3. Based on approximate fuel usage from http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx
4. Based on a conversion of 1 gal = 0.003192 metric tons of diesel fuel from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
5. Based on 1 gallon = 138,700 Btu – HHV from https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html
6. Based on API Emission Factors provided by BP on 20/11/2017.
7. Table C-1 and C-2 from 40 CFR part 98 for natural gas combustion. Global warming potentials from Part 98, Table A-1 and are 1 for CO2, 25 for CH4 and 298 for N2O.

HUB Flare - Pilot Only

Proposed Potential-to-Emit Criteria Pollutant Emissions from Pilot

Pilot Fuel	Natural Gas	
Natural Gas Heating Value[1]	1,027	Btu/scf
Pilot fuel Consumption during Normal Operation[2]	1.322	MMscf/hr
Tonnes of fuel during normal operations[3]	29.97	tonne/hr
Number of Pilots[4]	1	
Potential Hours of Operation[5]	8,760	hrs/yr
Destruction Efficiency[6]	98%	

Flare - Pilot Only					
Proposed Potential-to-Emit Criteria Pollutant Emissions					
Pollutant	**Emission Factor**		**Hourly Emission Rate (tonne/hr)**	**Annual Emissions (tonne/yr)**	**Reference**
NO_x	0.2276	g/s	0.00081936	7.18	6
CO	1.2382	g/s	0.00445752	39.05	6
VOC	0	lb/MMBtu	< 0.001	< 0.001	7
PM	0.017	g/s	6.12E-05	0.54	6
SO_2	--	g/s	< 0.001	< 0.001	6

References:

1. Based on the average value provided in https://www.extension.iastate.edu/agdm/wholefarm/html/c6-89.html
2. MMscf/hr = (tonne of NG/hr)*(MMBtu/tonne of NG)/(MMBtu/MMscf)
3. Based on vedor specific operational data provided by BP on 20/11/2017.
4. BP provided data on 20/11/2017.
5. Flare tip assumed to operate continusouly, emissions only represent normal operations and do not include startup or shutdown.
6. Based on vendor specific operational data provided by CSA via email (13/12/2017).
7. Assumed to be neglibeable based on total HC content.

HUB Flare - Pilot Only

Proposed Potential-to-Emit HAP Emissions from Pilot

Pilot Fuel	Natural Gas	
Natural Gas Heating Value[1]	1,027	Btu/scf
Pilot fuel Consumption during Normal Operation[2]	1.322	MMscf/d
Tonnes of fuel during normal operations[3]	29.97	tonne/hr
Number of Pilots[4]	1	
Potential Hours of Operation[5]	8,760	hrs/yr
Destruction Efficiency[6]	98%	

Flare - Pilot Only
Proposed allowable HAP Emissions

HAP	Emission Factor (lb/MMscf)	Emission Factor (tonne/MMscf)	Hourly Emission Rate (tonne/hr)	Annual Emissions (tonne/yr)	Reference
Benzene	2.1E-03	9.5E-07	< 0.001	< 0.001	7
Dichlorobenzene	1.2E-03	5.4E-07	< 0.001	< 0.001	7
Formaldehyde	0.075	3.4E-05	< 0.001	0.01	7
n-Hexane	1.80	8.2E-04	< 0.001	0.19	7
Naphthalene	6.1E-04	2.8E-07	< 0.001	< 0.001	7
Toluene	3.4E-03	1.5E-06	< 0.001	< 0.001	7
Polycyclic Organic Matter	8.8E-05	4.0E-08	< 0.001	< 0.001	7,9
Arsenic	2.0E-04	9.1E-08	< 0.001	< 0.001	8
Barium	4.4E-03	2.0E-06	< 0.001	< 0.001	8
Beryllium	<1.20E-05	5.4E-09	< 0.001	< 0.001	8
Cadmium	1.1E-03	5.0E-07	< 0.001	< 0.001	8
Chromium	1.4E-03	6.4E-07	< 0.001	< 0.001	8
Cobalt	8.4E-05	3.8E-08	< 0.001	< 0.001	8
Copper	8.5E-04	3.9E-07	< 0.001	< 0.001	8
Manganese	3.8E-04	1.7E-07	< 0.001	< 0.001	8
Mercury	2.6E-04	1.2E-07	< 0.001	< 0.001	8
Nickel	2.1E-03	9.5E-07	< 0.001	< 0.001	8
Selenium	<2.4E-05	1.1E-08	< 0.001	< 0.001	8
Total HAP				0.20	

References:

1. Based on the average value provided in https://www.extension.iastate.edu/agdm/wholefarm/html/c6-89.html
2. MMscf/hr = (tonne of NG/hr)*(MMBtu/tonne of NG)/(MMBtu/MMscf)
3. Based on vedor specific operational data provided by BP on 20/11/2017.
4. BP provided data on 20/11/2017.
5. Flare tip assumed to operate continusouly, emissions only represent normal operations and do not include startup or shutdown.
6. Based on vendor specific data provided by CSA via email (13/12/2017).
7. Emission factors for organic compounds based on AP-42 Table 1.4-3, Emission Factors for Speciated Organic Compounds from Natural Gas Combustion, July 1998.
8. Emission factors for metals based on AP-42 Table 1.4-4, Emission Factors for Metals from Natural Gas Combustion, July 1998.
9. The emission factor for Polyclic Organic Matter (POM) is calculated as the sum of the emission factors per footnote c to AP-42

HUB Flare - Pilot Only

Proposed Potential-to-Emit GHG Emissions from Flare Pilot

Pilot Fuel	Natural Gas	
Natural Gas Heating Value[1]	1,027	Btu/scf
Pilot fuel Consumption during Normal Operation[2]	1.322	MMscf/d
Tonnes of fuel during normal operations[3]	29.97	tonne/hr
Number of Pilots[4]	1	
Potential Hours of Operation[5]	8,760	hrs/yr

Flare - Pilot Only					
Proposed Potential-to-Emit GHG Emissions					
Pollutant	**Emission Factor**		**Hourly Emission Rate (tonne/hr)**	**Annual Emissions (tonne/yr)**	**Reference**
CO_2	2.80	tonne/tonne fuel	83.916	735104	6
CH_4	1.30E-02	tonne/tonne fuel	3.896E-01	3413	6
N_2O	2.20E-04	tonne/tonne fuel	6.59E-03	58	6
CO_2e	--	--	95.6	837641	7

References:

1. Based on the average value provided in https://www.extension.iastate.edu/agdm/wholefarm/html/c6-89.html
2. MMscf/hr = (tonne of NG/hr)*(MMBtu/tonne of NG)/(MMBtu/MMscf)
3. Based on vedor specific operational data provided by BP on 20/11/2017.
4. BP provided data on 20/11/2017.
5. Flare tip assumed to operate continusouly, emissions only represent normal operations and do not include startup or shutdown.
6. Based on API emission factors provied by BP on November 20, 2017.
7. Table C-1 and C-2 from 40 CFR part 98 for natural gas combustion. Global warming potentials from Part 98, Table A-1 and are 1 for CO2, 25 for CH4 and 298 for N2O.

golder.com