Shallow Water Absheron Peninsula 2D Seismic Survey

Environmental and Socio-Economic Impact Assessment

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Units and Abbreviations

Units

%	Percent
% w/w	Percentage by weight
$<$	Less than
$>$	Greater than
± or +/-	Plus/minus
≤	Less than or equal to
°C	Degrees Celsius
µg/g	Micrograms per gram
µg/l	Micrograms per litre
µg/m^3	Micrograms per cubic metre
µm	Micrometer
cm/year	Centimetres per year
cu in	Cubic inches
dB	Decibel
dB re 1 µPA	Decibels relative to one micropascal
Hz	Hertz
individuals/m^2	Individuals per square metre
kg	Kilogram
kg/m^3	Kilograms per cubic metre
kHz	Kilohertz
km	Kilometre
km/hr	Kilometres per hour
km^2	Square kilometre
kW	Kilowatts
L	Litre
LC_{50}	Lethal Concentration 50. The concentration of a chemical which kills 50% of a sample population.
litres/m^2	Litres per square metre
m	Metres
m/s	Metres per second
m^2	Square metre
m^3	Cubic metre
m^3/day	Cubic metres per day
mg/g	Milligrams per gram
mg/l	Milligrams per litre
mm	Millimetre
pH	-log 10 [H+] (Measure of acidity or alkalinity)
PSI	Pounds per square inch
tonnes/km	Tonnes per kilometre

Chemical Elements and Compounds

CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
N_2O	Nitrous oxide
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
PCB	Polychlorinated biphenyls
SO_x	Sulphur oxides

Abbreviations

2D	Two Dimensional
3D	Three Dimensional
4D	Four Dimensional
A	Autumn
ACG	Azeri Chirag Gunashli
ADB	Asian Development Bank
AETC	Azerbaijan Environmental and Technology Centre
AGT	Azerbaijan Georgia Turkey
ANSI	American National Standards Institute
AQAM	Air Quality Assessment and Management
ASA	Acoustical Society of America
AZE	Alliance for Zero Extinction
AzRDB	Azerbaijan Red Data Book
BAOAC	Bonn Agreement Oil Appearance Code
BOD	Biological Oxygen Demand
BOEM	Bureau of Ocean Energy Management
CARs	Corrective action requests
CE	Critically Endangered
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLR	Completion and Learning Review
COD	Chemical Oxygen Demand
CoM	Cabinet of Ministers
COP	Conference of the Parties
CWAA	Central Waste Accumulation Area
DPRAB	Department on Protection and Reproduction of Aquatic Bioresources
DS	During Survey
E	East
EA	Environmental Assessment
EBSA	Ecologically & Biologically Significant Areas
EEC	European Economic Community
EIA	Environmental Impact Assessment
EIA	U.S. Energy Information Administration
EIS	Environmental Impact Statement
EMP	Environmental Monitoring Programme
EN	Endangered
ENP	European Neighbourhood Policy
ENPI	European Neighbourhood and Partnership Instrument
ESIA	Environmental and Socio-Economic Impact Assessment
ESMP	Environmental and Socio-Economic Management Plan
ETN	Environmental Technical Note
EU	European Union
Ex.	Executive
FAO	Food and Agriculture Organization of the United Nations
FHWG	Fisheries Hydroacoustic Working Group
GHG	Greenhouse Gas
GIWA	Global International Waters Assessment
GNI	Gross National Income
GOST	Gosudarstvennye Standarty State Standard (Russian standard)
HMSO	Her Majesty's Stationery Office
HS	Hearing Specialists
HSSE	Health Safety Security and Environment
HWTP	Hovsan Wastewater Treatment Plant
IADC	International Association of Drilling Contractors
IAGC	International Association of Geophysical Contractors
IBA	Important Bird and Biodiversity Area
IDMC	Internally Displaced Monitoring Centre
IDP	Internally Displaced Persons
IMO	International Marine Organisation

IoAE	Institute of Archaeology and Ethnography
IPA	Important Plant Areas
IPIECA	International Petroleum Industry Environmental Conservation Association
ISO	International Organization for Standardization
ITOPF	International Tanker Owners Pollution Federation
IUCN	International Union for the Conservation of Nature
JNCC	Joint Nature Conservation Committee
KBA	Key Biodiversity Areas
LC	Least Concern
LTV	Lifting Transportation Vessels
LV	Low Vulnerability
MARPOL	International Convention for the Prevention of Pollution from Ships/ Vessels, 1973 as amended by the protocol, 1978
Max	Maximum
MENR	Ministry of Ecology and Natural Resources
MES	Ministry of Emergency Situations
Min	Minimum
MoT	Ministry of Tourism
MSDS	Materials Safety data Sheets
N	North
N (%)	Percentage abundance
NCRs	Non-conformance reports
NESDIS	National Environmental Satellite, Data, and Information Service
NF	Northern flank
NGDC	National Geophysical Data Center
NGO	Non-Governmental Organisation
NIP	National Indicative Programme
NMVOC	Non-methane Volatile Organic Compounds
NOAA	National Oceanic and Atmospheric Administration
NT	Near Threatened
OCS	Outer Continental Shelf
OGP	International Association of Oil and Gas Producers
OMS	Operating Management System
OSCAR	Oil Spill Contingency and Response
OSRP	Oil Spill Response Plans
PAH	Polynuclear Aromatic Hydrocarbon
PCA	Partnership and Cooperation Agreement
PDF	Potential Dangerous Facilities
PM	Pre-Mobilisation
ppb	parts per billion
ppt	parts per thousand
PS	Post Survey
PSA	Production Sharing Agreement
PTS	Permanent Threshold Shift
Q3	Quarter three (of year)
Q4	Quarter four (of year)
RDB	Red Data Book
S	Number of species observed
SB	Fish with swim bladder
SD	Shah Deniz
SD1	Shah Deniz Stage 1
SD2	Shah Deniz Stage 2
SDB	Shah Deniz Bravo
SEE	State Ecological Expertise
SEEEC	Sea Empress Environmental Evaluation Committee
SMPEP	Shipboard Marine Pollution Emergency Plan
SOCAR	State Oil Company of Azerbaijan Republic
SPL	Sound Pressure Level
STP	Standard Temperature and Pressure
SWAP	Shallow Water Absheron Peninsula

TACIS	Technical Assistance to the Commonwealth of Independent States
THC	Total Hydrocarbon Concentration
TSS	Total Suspended Solids
TSS	Total Suspended Sediments
TTS	Temporary Threshold Shift
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
US$	United States Dollar
V	Fish sometimes lacking swim bladder depending on species
VOC	Volatile Organic Compounds
VU	Vulnerable
W	Winter
WTNs	Waste Transfer Notes
WTP	Wastewater Treatment Plant

Non-Technical Summary

This Non-Technical Summary (NTS) presents a concise overview of the Environmental and Socio-Economic Impact Assessment (ESIA) prepared for the Shallow Water Absheron Peninsula (SWAP) 2D Seismic Survey to be undertaken in the SWAP Contract Area and its immediate surroundings. It is intended to provide a summary of the project activities, the issues considered in the ESIA and the main conclusions on environmental and socio-economic impacts. Detailed technical description of modelling studies, proposed mitigation measures and monitoring activities are presented in the main sections of the ESIA.

E.1 Introduction

The SWAP Contract Area covers approximately 1,900km^2 and extends from the coastline to a water depth of approximately 25m within the Azerbaijani sector of the Caspian Sea. In December 2014, BP signed a Production Sharing Agreement (PSA) with the State Oil Company of Azerbaijan Republic (SOCAR) to jointly explore and develop potential prospects in the SWAP Contract Area. The PSA was subsequently ratified in April 2015 and BP appointed as the Technical Operator.

Two seismic surveys are planned within and in the vicinity of the SWAP Contract Area:

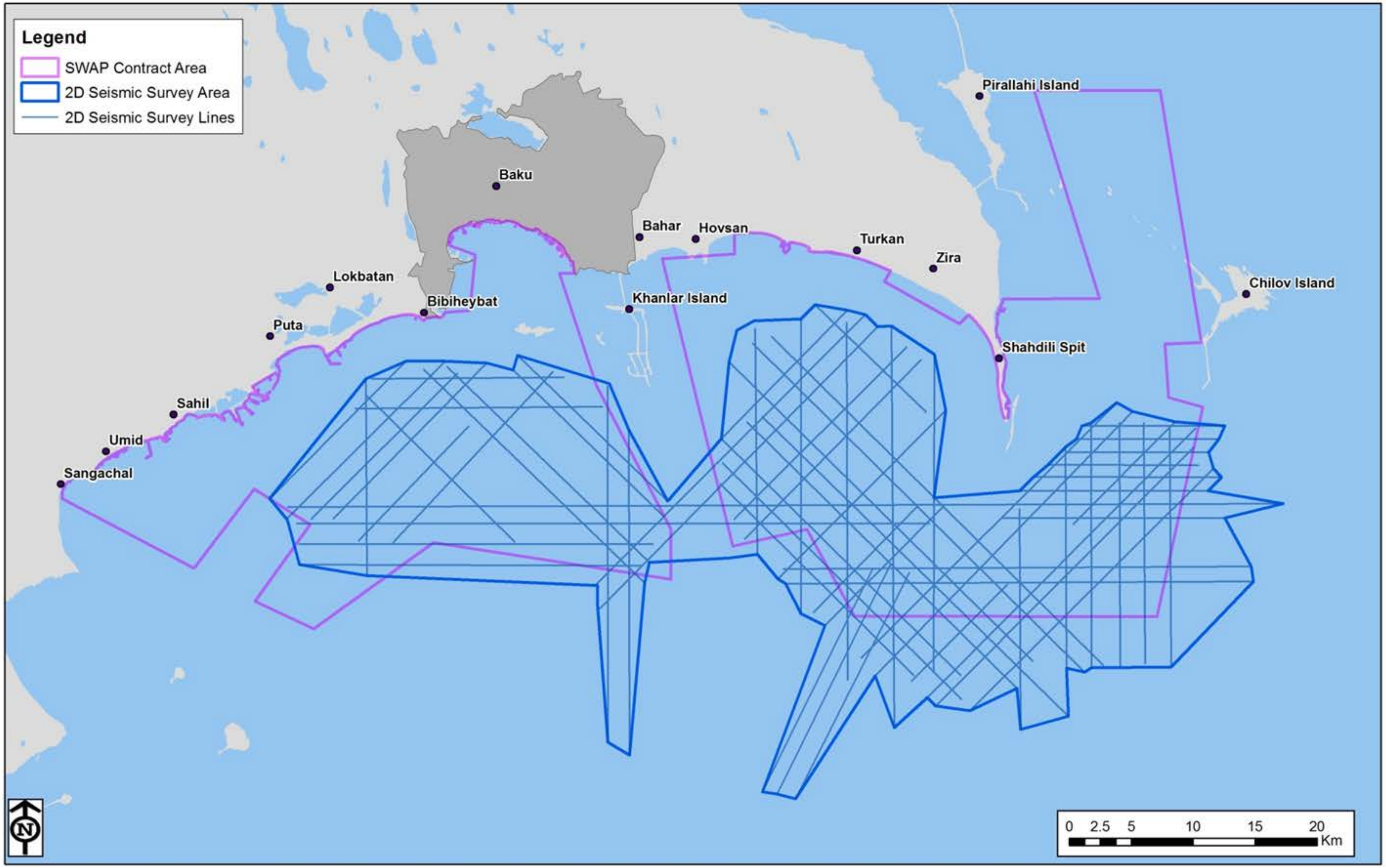
- A two dimensional (2D) seismic survey within the deeper waters of the SWAP Contract Area and the surrounding areas at water depths greater than approximately 10m; and
- A three-dimensional (3D) seismic survey within the shallower waters (less than approximately 10m water depth) of the SWAP Contract Area and the surrounding nearshore and onshore areas.

The objective of the 2D Seismic Survey is to collect geophysical data on the subsurface strata within the SWAP Contract Area. The data will be used to inform scoping and planning of exploration and development of the area. Part of the proposed Survey includes acquiring seismic data outside of the SWAP Contract Area; this data is required to gain sufficient information to allow the potential subsurface geological structures to be characterised. The 2D Seismic Survey is currently planned to commence in November 2015, lasting 2 months and covering an area of approximately 1,500m^2.

The 3D Seismic Survey is planned to be undertaken during 2016 and will be subject to a separate ESIA.

Figure E.1 shows the location of the SWAP Contract Area, the 2D Seismic Survey Area and the provisional 2D seismic survey lines.

Figure E.1: Location of the SWAP Contract Area, the 2D SWAP Seismic Survey Area and the Provisional 2D Seismic Survey Lines



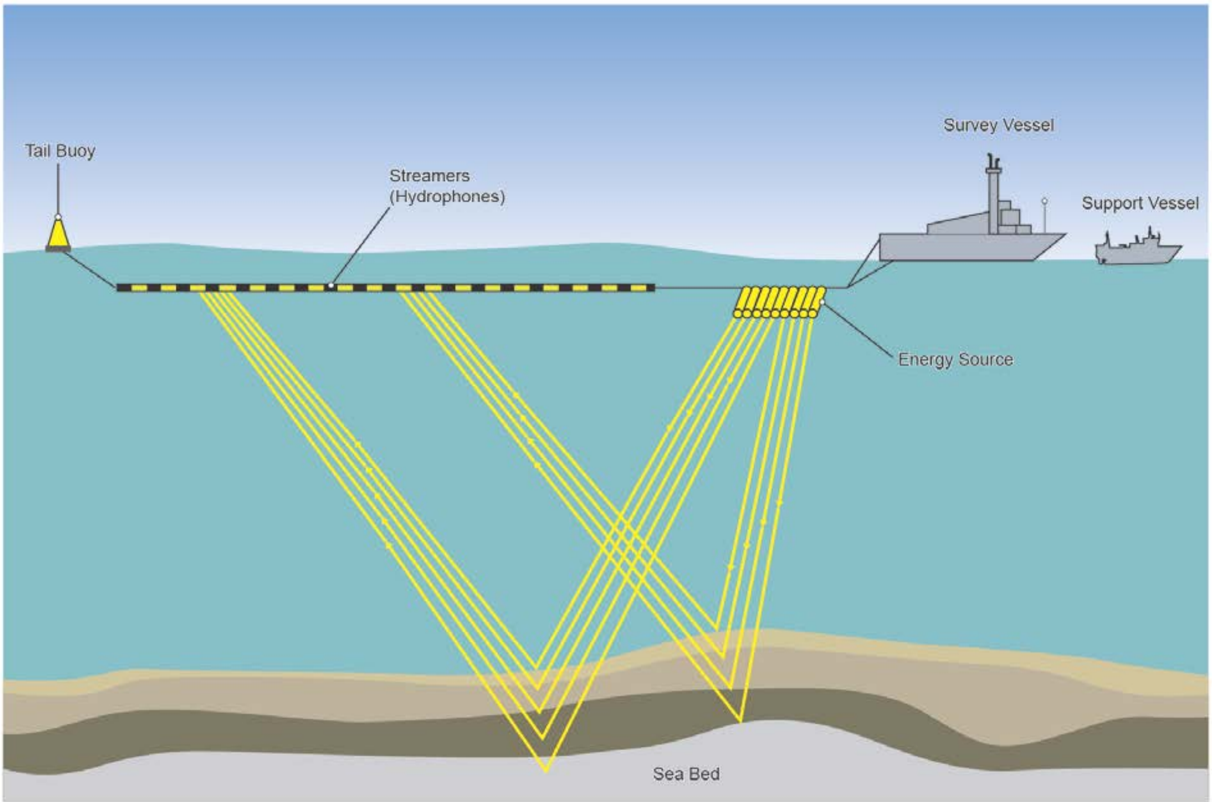
E.2 Overview of the 2D Seismic Survey and Need for an ESIA

The 2D Seismic Survey will be undertaken by a seismic survey vessel using a single streamer[1] and a single energy source, which will both be towed behind the vessel. As the survey vessel travels along pre-determined survey lines, the energy source will release a controlled burst of energy which will travel through the water column to the seabed where it will penetrate the subsurface geological layers and reflect back towards the sea surface. The reflected energy will be recorded by the receivers (termed hydrophones) which are embedded in the streamer and the data sent back to the survey vessel, where it will be stored and processed. A tail buoy will be connected to the far end of the streamer to act as a hazard warning of the submerged towed streamer and provide positional information of the location and the depth of the equipment.

During the Survey, up to two support vessels will undertake activities including transporting supplies and crew to the survey vessel, transporting waste to shore and maintaining a safety exclusion zone around the survey vessel and towed equipment. The survey and support vessels will operate on a 24-hour basis during the 2D Seismic Survey.

Figure E.2 provides an illustration of the proposed SWAP 2D Seismic Survey process.

Figure E.2 Illustration of the 2D Seismic Survey Process



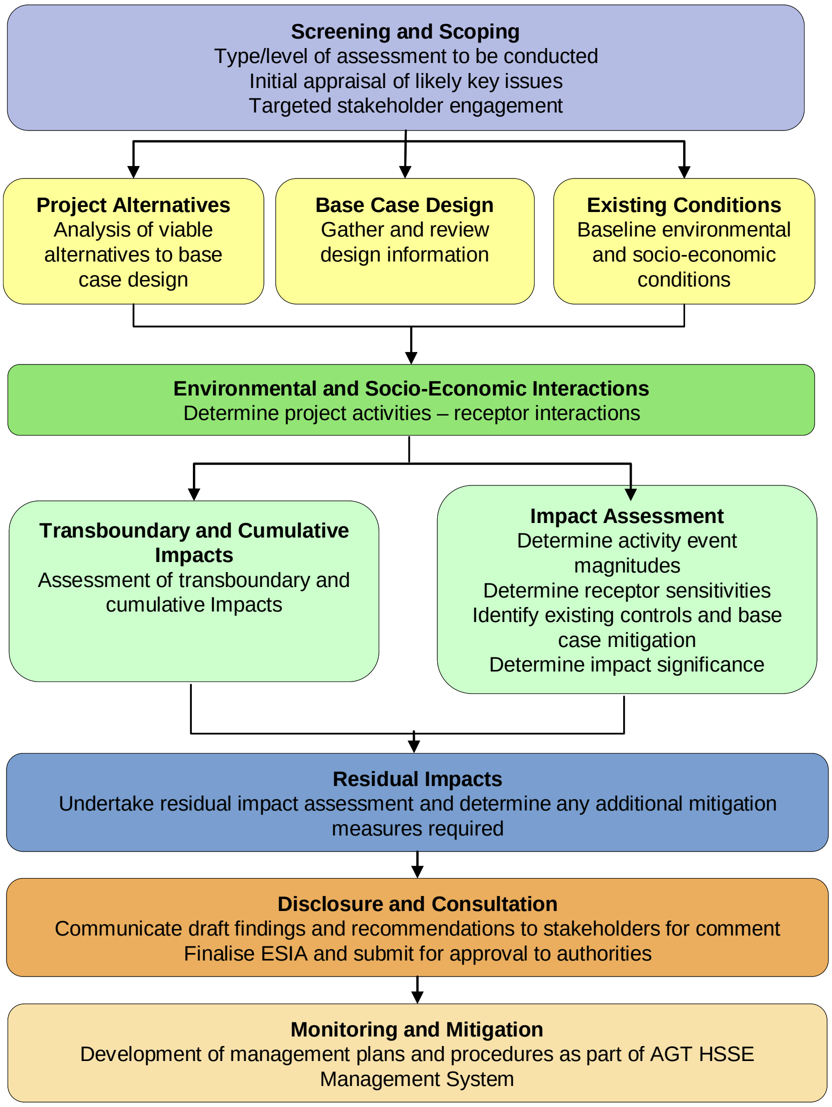
Given the location, scale and planned activities associated with the SWAP 2D Seismic Survey, BP has taken the decision to prepare an ESIA. This approach was agreed with the Ministry of Ecology and Natural Resources (MENR) and is consistent with that taken by BP for similar seismic surveys completed in the Azerbaijani sector of the Southern Caspian Sea.

[1] A streamer is an electrical cable, floating on the surface of the water, to which the seismic receivers (termed hydrophones) are connected at regular intervals and along which the signals received by each hydrophone are sent to the seismic acquisition equipment on the survey vessel.

E.3 Assessment Methodology

The ESIA process (illustrated in Figure E.3) constitutes a systematic approach to the evaluation of a project and its associated activities throughout the project lifecycle. The overall aim of the ESIA process is to identify, reduce and effectively manage potential negative environmental and socio-economic impacts arising from the SWAP 2D Seismic Survey activities.

Figure E.3: The ESIA Process



Assessment of the SWAP 2D Seismic Survey environmental and socio-economic impacts has been undertaken based on identified 2D Seismic Survey activities and events that have the potential to interact with the environment.

For routine and non-routine project activities, the ESIA process ranks impacts according to their significance determined by considering project activity event magnitude and receptor sensitivity. The expected significance of environmental impacts have been assessed taking into account:

- **Event Magnitude**: Determined based on the following parameters:
  - ***Extent*** – the size of the area across which the effect of the activity extends;
  - ***Duration*** – the length of time over which the effect of the activity occurs;
  - ***Frequency*** – how often the activity occurs; and

- – ***Intensity of the impact*** – concentration of an emission or discharge with respect to standards of acceptability that include applicable legislation and international guidance, its toxicity or potential for bioaccumulation, and its likely persistence in the environment. Degree and/or permanence of disturbance or physical impact.

- **Receptor Sensitivity**: Determined based on:
  - ***Presence*** – whether biological species present are unique, threatened, protected or not vulnerable and are present during a period of high sensitivity (e.g. breeding, spawning or nesting). For human receptors, whether they are permanently present to uncommon in the area of impact and for physical features whether those present are highly valued or of limited or no value; and
  - ***Resilience*** – how vulnerable people and/or species and/or features are to the change or disturbance associated with the environmental interaction with reference to existing baseline conditions and trends (such as trends in ecological abundance/diversity/status, ambient air quality etc.) and their capacity to absorb or adapt to the change.

Socio-economic impacts have also been assessed taking into account Event Magnitude and Receptor Sensitivity. However, a more qualitative approach has been applied, taking into account how significant the change would be on social, economic and cultural dynamics, the potential for governmental and stakeholder intervention, the value of the receptor (on a local, regional, national or international scale) and the resilience of the receptor to change or adapt to a given change.

Impact significance has been assessed taking into account existing control measures that are incorporated into the project design.

E.4 Consultation

The scope of the ESIA was agreed with the MENR at a scoping meeting held in August 2015. Key issues raised by the MENR, which have subsequently been addressed within the ESIA, include the requirement to consider impacts of the 2D Seismic Survey activities to fish and to the small scale fishing industry.

The Final Draft ESIA will be submitted for review and comment to the MENR. Comments from stakeholders, including the MENR, will be collated and the ESIA updated accordingly. The final ESIA document will then be submitted for final approval.

Public consultation and disclosure meetings are not planned for the SWAP 2D Seismic Survey Project ESIA. Given that both the 2D and 3D Seismic Surveys are for the same Contract Area and the offshore 3D Seismic Survey Areas overlap with the 2D Seismic Survey Area, it is planned to include both the 2D and 3D Seismic Surveys within the consultation undertaken during the preparation of SWAP 3D Seismic Survey ESIA, which is planned to be submitted to the MENR in 4Q 2015.

E.5 Environmental and Socio-Economic Impact

Environmental and socio-economic impacts have been assessed for the 2D Seismic Survey activities and Table E.1 summarises the outcome of the impact assessment.

Table E.1: Summary of the Residual Environmental and Socio-Economic Impacts

	Event	Event Magnitude	Receptor Sensitivity	Impact Significance
Marine Environment	Underwater sound from seismic energy source	Medium	Medium (Fish) Medium (Seals)	**Moderate Negative**
Socio-Economic	Presence of the survey vessel and seismic equipment	Low	High (International Shipping)	**Moderate Negative**

			Medium (Local/Regional Shipping)	**Minor Negative**
			Medium (Commercial Fishing)	**Minor Negative**
			High (Small Scale Fishing)	**Moderate Negative**
	Indirect effect of underwater sound on fishing	Low	Medium (Commercial Fishing)	**Minor Negative**
			High (Small Scale Fishing)	**Moderate Negative**

During the 2D Seismic Survey, the sound source will be moving and the underwater sound will occur repeatedly but intermittently, with the sound energy dissipating with distance from the source. Therefore, a given sound level will last for a very short period of time in any one location.

Since underwater sound has the potential to impact fish and Caspian seals in the marine environment, an underwater sound study was undertaken and a number of control measures (described below) have been included in the design of the 2D Seismic Survey to reduce potential impacts.

The Caspian Seal population is highly vulnerable and has an internationally protected status of 'Endangered'. Caspian seals are observed in many regions of the Caspian Sea depending on the season as they undertake annual migrations between breeding locations in the north and feeding locations in the south. Northbound autumn migration starts in October and seals are observed in the waters of Azerbaijan, particularly in the vicinity of the Absheron Peninsula and the adjacent islands to the east, from October to mid-December. Current information available on seal migration and routes has been used to identify the most sensitive areas for seals within and adjacent to the 2D Seismic Survey Area.

Existing controls will be adopted across the 2D Seismic Survey Area and have been designed to minimise the likelihood of harm to seals. These controls include the use of a soft-start procedure at the start of each survey line which means that the sound will ramp up gradually over a period of time; planning to avoid entering sensitive areas prior to mid-December and implementing a buffer zone of at least 500m from the sound source, within which trained observers on the survey vessel will undertake observations for seals prior to starting the planned soft start procedure. The Caspian seal will rapidly move away from any disturbance or sound. Additional control measures will be adopted within the identified sensitive and very sensitive areas of the 2D Seismic Survey Area where survey activities may be undertaken during the autumn migration. The operation of the sound source, even under the soft start procedure, will result in a short-term change in the behaviour of seals, which is expected to be limited to a change in swimming direction. No significant population effects are anticipated.

Monitoring and recording of Caspian seals will be undertaken by the trained vessel crew as part of the soft start procedure and at other times as far as practically possible; and a daily log will be submitted to BP as part of a final report summarising seal observations. In addition, it is recommended that BP consult with marine ecologists, both national and international, to design and set up a fit for purpose Annual Seal Survey Programme.

Endangered fish species and those highly sensitive to underwater sound are likely to be present for limited periods of time in the 2D Seismic Survey Area. It is expected that fish will move away from the sound source before sound levels are likely to cause harm; and this response is highly unlikely to result in noticeable population size changes.

Control measures to minimise potential impacts to international, regional and local shipping and commercial and small scale fishing from the physical presence of the 2D Seismic Survey, include planning the survey to minimise interference with other sea users; notifying maritime authorities and other sea users of the survey in advance; and during the survey, notifying other vessels of the survey by appropriate signals. Before undertaking the 2D Seismic Survey, a hazard survey will be undertaken to identify hazards (including any fixed fishing assets) on the seabed so that the survey team can plan to avoid them. Consultation is planned to be undertaken during the third and fourth quarter of 2015 to identify those undertaking small scale fishing activities within the 2D Seismic Survey Area.

The path of the survey vessel will fall along, across, as well as move perpendicularly to existing, identified shipping routes used by international, regional and local shipping. International shipping has limited ability to adapt to change due to restricted movement and is therefore considered to be highly sensitive. Local and regional shipping has; however, some capacity to adapt to change. Given the existing controls, it is considered unlikely that survey activities would result in concerns being raised by stakeholders or governmental bodies.

There is one commercial fishing ground within the 2D Seismic Survey Area; the Makarov Bank, where it is estimated that the survey vessel will pass within 5km for a short duration (between 5 and 6 hours) during the high fishing season. There is one licenced vessel known to fish in the vicinity of the Makarov Bank.

There is potential for the 2D Seismic Survey activities to interact with small scale fishing activities (particularly offshore from Shikhov, Bayil, Turkan and Zira) for a short duration during the high fishing season. However, it is not planned to remove fixed fishing equipment; instead, the survey team will plan to avoid it. Monitoring and reporting related to small scale fishing from the physical presence of the survey vessel and seismic equipment will be undertaken. In the unlikely event of damage to small scale fishing assets, grievances raised by the affected fishermen will be managed through the existing Azerbaijan Georgia Turkey Region Grievance Process.

It is anticipated that the indirect effect of the sound source on commercial and small scale fishing would be temporary, and unlikely to result in concerns being raised by stakeholders or governmental bodies.

The assessments within the ESIA show that impacts are minimised as far as practicable and necessary through the implementation of the existing control measures and no additional mitigation is required.

E.6 Cumulative, Transboundary and Accidental Events

Cumulative impacts, potential transboundary impacts and the impacts of accidental events associated with the SWAP 2D Seismic Survey have been assessed.

The potential for cumulative impacts arising from the combined effects of separate project-related residual impacts is insignificant; and the potential for cumulative impacts with impacts arising from SD2 Project activities is negligible.

The non-greenhouse gas (GHG), nitrogen dioxide is considered the most significant pollutant in terms of health impacts. The impact of nitrogen dioxide emissions to the atmosphere from SWAP 2D Seismic Survey activities have limited potential to result in identifiable impacts to the nearest onshore locations where people are resident. Therefore there will be no identifiable transboundary environmental impacts from non-GHG atmospheric emissions.

It is estimated that 9 kilo tonnes of GHG emissions will be released to the atmosphere as a result of the SWAP 2D Seismic Survey. Total GHG emissions for Azerbaijan in 2015 were forecast to be approximately 49,000 kilo tonnes, of which the SWAP 2D Seismic Survey is expected to contribute approximately 0.0184% of the national total.

Accidental Events are considered separately from routine and non-routine activities as they only arise as a result of a technical failure, human error or as a result of natural phenomena such as a seismic event. Studies have been undertaken to understand the impacts of the following accidental events occuring:

- Diesel spill from loss of total inventory on the 2D survey and support vessels;
- Release of chemicals from the 2D survey and support vessels; and
- Collision between survey vessel and/or equipment and Caspian Seals.

As a worst case, the loss of the entire diesel inventory stored onboard the survey vessel has been modelled. The diesel is not anticipated to be present in harmful concentrations or thickness on the sea surface for more than a few days following the release. Generally, there is a very low (less than 5%) probability of diesel reaching the shoreline, with the highest probability being 30%. The potential impacts of the 900m^3 diesel spill on fish would be insignificant; however, the impact on seals could potentially be significant, since seals are highly sensitive to hydrocarbons. The impact on commercial and small-scale fishing would be short-term and not significant. The probability of spilled diesel arriving at important bird and biodiversity areas following the release of the vessel diesel inventory is low. However, the potential impact of a diesel release on important bird and biodiversity areas (and the birds present there) could have a potentially significant impact due to the seasonal sensitives of migrating and overwintering birds in the region.

There is a very low likelihood of a mechanical failure or vessel collision resulting in the diesel inventory release to the sea. The loss of the entire diesel inventory from the survey vessel is considered particularly unlikely as diesel is stored on the survey vessel in a series of smaller tanks and it is improbable that the contents of all the tanks would be lost simultaneously.

Technical and operational control measures will be in place to minimise the potential for spills during the SWAP 2D Seismic Survey. In the event of a spill to the sea, existing plans and procedures will be followed which cover the actions to be taken in the event of a spill, including notification, response actions, follow-up actions and reporting.

A number of chemicals in small quantities will be stored and used onboard the seismic and survey vessels throughout the survey for cleaning and maintenance purposes. The potential for an accidental release of these chemicals from the survey and support vessels to the marine environment is considered to be small given the adopted control measures. No significant impacts are expected from a chemical spill which would be highly localised.

Although highly unlikely to occur (given the existing control measures), collision with a vessel or entanglement/entrapment in equipment has the potential to cause injury or death to Caspian seals. The Caspian seal will rapidly move away from any disturbance or sound and is likely to keep a distance from the survey vessel.

E.7 Environmental and Socio-Economic Management

Under the SWAP PSA, BP as Operator is responsible for the environmental and socio-economic management of the SWAP activities, to ensure that project commitments are implemented, and conforms to applicable environmental and social legal, regulatory and corporate requirements.

BP will have overall responsibility for managing the SWAP 2D Seismic Survey and for monitoring and auditing of the technical, safety, environmental and socio-economic performance of the SWAP 2D Seismic Survey Contractor. An Environmental and Social Management Plan will be developed by the Seismic Contractor and incorporated within a Project Management Plan.

The SWAP 2D Seismic Survey Contractor will be responsible for performing the 2D Seismic Survey and will ensure conformance with their Health Safety Security and Environment Management System, as well as any interface documents developed to ensure BP processes, practices and procedure requirements are met.

E.8 Conclusions

Given that underwater sound from the sound source has the potential to impact fish and Caspian seals in the marine environment, an underwater sound study was undertaken and a number of control measures have been included in the survey design. Potential impacts of the 2D Seismic Survey have been minimised as far as reasonably practical and necessary through the implementation of the existing control measures and no additional mitigation measures are required. It is recommended, however, that BP consult with marine ecologists, both national and international, to design and set up a fit for purpose annual seal survey programme.

The potential for cumulative impacts arising from the combined effects of separate project-related residual impacts is insignificant; and the potential for cumulative impacts with impacts arising from SD2 Project activities is negligible.

There will be no identifiable transboundary environmental impacts from non-GHG atmospheric emissions. For GHG emissions, the SWAP 2D Seismic Survey is expected to contribute approximately 0.0184% of the national total forecast for 2015.

Technical and operational control measures will be in place to minimise the potential for accidental events occurring during the 2D Seismic Survey.

BP will have overall responsibility for managing the SWAP 2D Seismic Survey; for monitoring and auditing the performance of the SWAP 2D Seismic Survey Contractor; and for ensuring that project commitments are implemented.

1 Introduction

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1.1 Introduction

The Shallow Water Absheron Peninsula (SWAP) Contract Area is located within the Azerbaijan sector of the Caspian Sea and extends across approximately 1,900km^2 from the coastline to a water depth of approximately 25m (refer to Figure 1.1).

In December 2014, BP signed a Production Sharing Agreement (PSA) with the State Oil Company of Azerbaijan Republic (SOCAR) to jointly explore and develop potential prospects in the SWAP Contract Area. BP Azerbaijan (Caspian Sea) Limited has been appointed as the Technical Operator for and on behalf of the PSA signatories.

Initial studies completed by the project geologists indicate that there are potential hydrocarbon reservoirs within the SWAP Contract Area at depths of 3,000-5,000m**.** To further characterise the subsurface geology and potential reservoirs within the Contract Area and in the surrounding areas two seismic surveys are planned:

- A two dimensional (2D) seismic survey within the deeper waters of the SWAP Contract Area and the surrounding areas at water depths greater than approximately 10m; and
- A three-dimensional (3D) seismic survey within the shallower waters (less than approximately 10m water depth) of the SWAP Contract Area and the surrounding nearshore and onshore areas.

This Environmental and Socio-Economic Impact Assessment (ESIA) has been prepared in support of the SWAP 2D Seismic Survey. The area the seismic survey is planned to extend across is approximately 1,500m^2 and the provisional survey lines along which the seismic data will be collected are shown in Figure 1.1.

1.1.1 Overview of 2D Seismic Survey

The 2D Seismic Survey will be undertaken by a seismic survey vessel using a single streamer[1] and a single energy source, which will both be towed behind the vessel. One or two additional vessels will undertake a number of supporting activities including transporting supplies and crew to the survey vessel, transporting waste to shore and maintaining a safety exclusion zone around the survey vessel and towed equipment. The survey will involve the survey vessel travelling along pre-determined survey lines acquiring data. During the acquisition a controlled burst of energy that travels through the water column to the seabed where it penetrates the subsurface geological layers and reflect back towards the sea surface. The reflected energy will be recorded by the receivers (termed hydrophones) which are embedded in the streamer and then transmitted to the survey vessel. The survey is currently planned to commence in November 2015 and last up to 2 months.

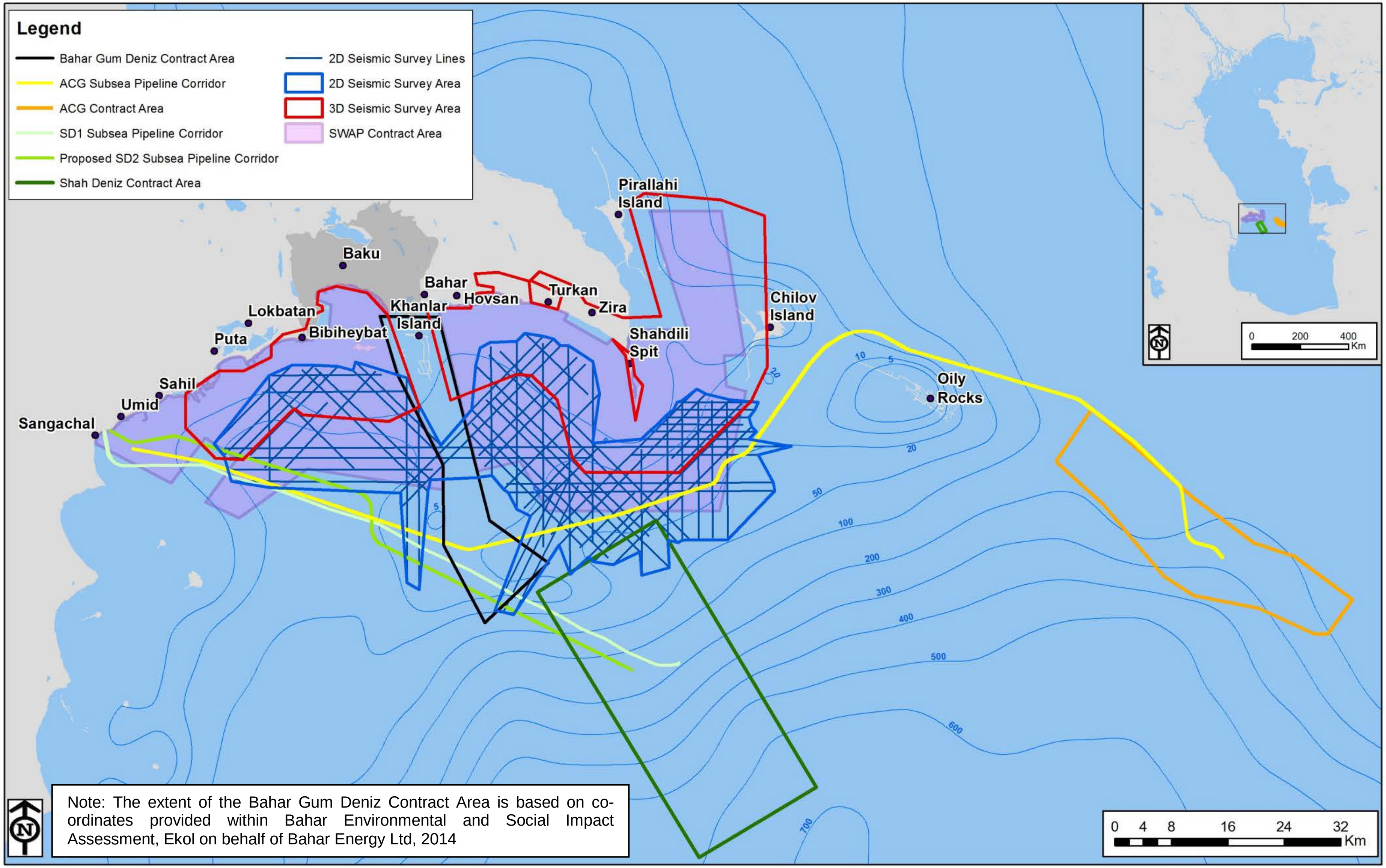
1.1.2 Other BP Exploration and Production Activities in the SWAP Contract Area Vicinity

Under the Azeri Chirag Gunashli (ACG) and Shah Deniz (SD) PSAs, signed in 1994 and 1996 respectively, BP have been undertaking exploration and production activities since 1995 including the completion of offshore seismic surveys and drilling activities and the installation and operation of onshore and offshore production and export facilities (refer to Figure 1.1). Environmental and social data have been collected throughout this period through surveys and third party data collection with the purpose of informing assessments of potential environmental and social impacts and identifying trends observed in the environment including those that may the result of BP's activities.

The location of the ACG and SD Contract Areas and the associated subsea pipeline corridors relative to the SWAP Contract Area are shown in Figure 1.1. The Bahar Gum Deniz Contract Area, which is the subject of a PSA between SOCAR and Bahar Energy Ltd, is also shown.

[1] A streamer comprises a buoyant electrical cable to which the receivers (i.e. hydrophones) are connected at regular intervals and along which the signals received by each hydrophone are sent to the seismic acquisition equipment on the survey vessel.

Figure 1.1: Location of the SWAP, ACG, Bahar Gum Deniz & SD Contract Areas, the 2D and 3D SWAP Seismic Survey Areas and the Provisional 2D Seismic Survey Lines



1.2 Scope of the 2D Seismic Survey ESIA

The overall objective of the SWAP 2D Seismic Survey ESIA process is to identify, reduce and effectively manage potential negative environmental and socio-economic impacts arising from the SWAP 2D Seismic Survey activities.

The purpose of this ESIA is to:

- Ensure that environmental and socio-economic considerations are integrated into the seismic survey design and implementation;
- Ensure that environmental and socio-economic impacts are identified, quantified and assessed and appropriate mitigation measures proposed;
- Ensure that a high standard of environmental and socio-economic performance is planned and achieved;
- Ensure that applicable legal, operator and PSA requirements and expectations are addressed;
- Consult with relevant stakeholders throughout the ESIA process; and
- Demonstrate that the seismic survey will be implemented with due regard to environmental and socio-economic considerations.

Within the impact assessment, activities and potential receptor interactions are evaluated against existing environmental and socio-economic conditions and sensitivities, and the potential impacts are ranked. The assessment of potential impacts takes account of existing and planned controls and monitoring and mitigation measures developed as part of previous seismic survey projects undertaken by BP.

1.3 ESIA Team and Structure

The details of the SWAP 2D Seismic Survey ESIA Team are provided in Table 1.1.

Table 1.1: SWAP 2D Seismic Survey ESIA Team

<table>
<tr><th>Team Member</th><th>Role</th></tr>
<tr><td rowspan="3">AECOM</td><td>ESIA Project Manager and Lead Authors</td></tr>
<tr><td>Socio-Economic Assessment</td></tr>
<tr><td rowspan="2">Marine Ecology Assessment</td></tr>
<tr><td>James McNee</td></tr>
<tr><td>Mehman M. Akhundov</td><td>Local Fish and Fisheries Specialist</td></tr>
<tr><td>Tariel Eybatov</td><td>Local Caspian Seal Specialist</td></tr>
<tr><td>Ilyas Babayev</td><td>Local Bird Specialist</td></tr>
<tr><td>Sulaco</td><td>Local Socio-Economic Specialists</td></tr>
<tr><td>Peter Ward</td><td>Underwater Sound Specialist</td></tr>
<tr><td rowspan="2">BP</td><td>SWAP Contract Area PSA Operator on behalf of SWAP PSA Partners</td></tr>
<tr><td>Spill Modelling</td></tr>
</table>

Table 1.2 provides a summary of the 2D Seismic Survey Project ESIA Report structure and content.

Table 1.2: Structure and Content of 2D Seismic Survey ESIA

Chapter	Content
Executive Summary	A summary of the ESIA.
Units and Abbreviations	A list of the units and abbreviations used in the ESIA.
Glossary	A glossary of terms.
1. Introduction	A general introduction to the 2D Seismic Survey ESIA, including objectives and ESIA structure.
2. Policy, Regulatory and Administrative Framework	A summary of applicable legislative requirements including those associated with the SWAP PSA, ratified international conventions, International Petroleum Industry Standards and Practices and applicable national legislation and guidance.
3. Impact Assessment Methodology	A description of the methodology used for the ESIA including the approach to determining impact significance and a summary of consultation undertaken during the ESIA programme.
4. Project Description	A detailed description of the SWAP 2D Seismic Survey project activities including a brief description of the options considered during the seismic survey planning relevant to the ESIA.
5. Environmental and Socio-Economic Description	A description of environmental and socio-economic baseline conditions in the vicinity of the SWAP 2D Seismic Survey area.
6. Environmental and Socio-Economic Impact Assessment, Monitoring and Mitigation	An assessment of the potential environmental and socio-economic impacts associated with the SWAP 2D Seismic Survey activities, including any necessary mitigation and monitoring.
7. Cumulative, Transboundary and Accidental Events	An assessment of the potential cumulative and transboundary impacts and accidental events associated with the SWAP 2D Seismic Survey.
8. Environmental and Socio-Economic Management	A summary of the environmental and socio-economic management system associated with the SWAP 2D Seismic Survey.
9. Residual Impacts and Conclusions	A summary of the residual impacts and conclusions arising from the ESIA process.
Appendices	Supporting technical information.

2 Policy, Regulatory and Administrative Framework

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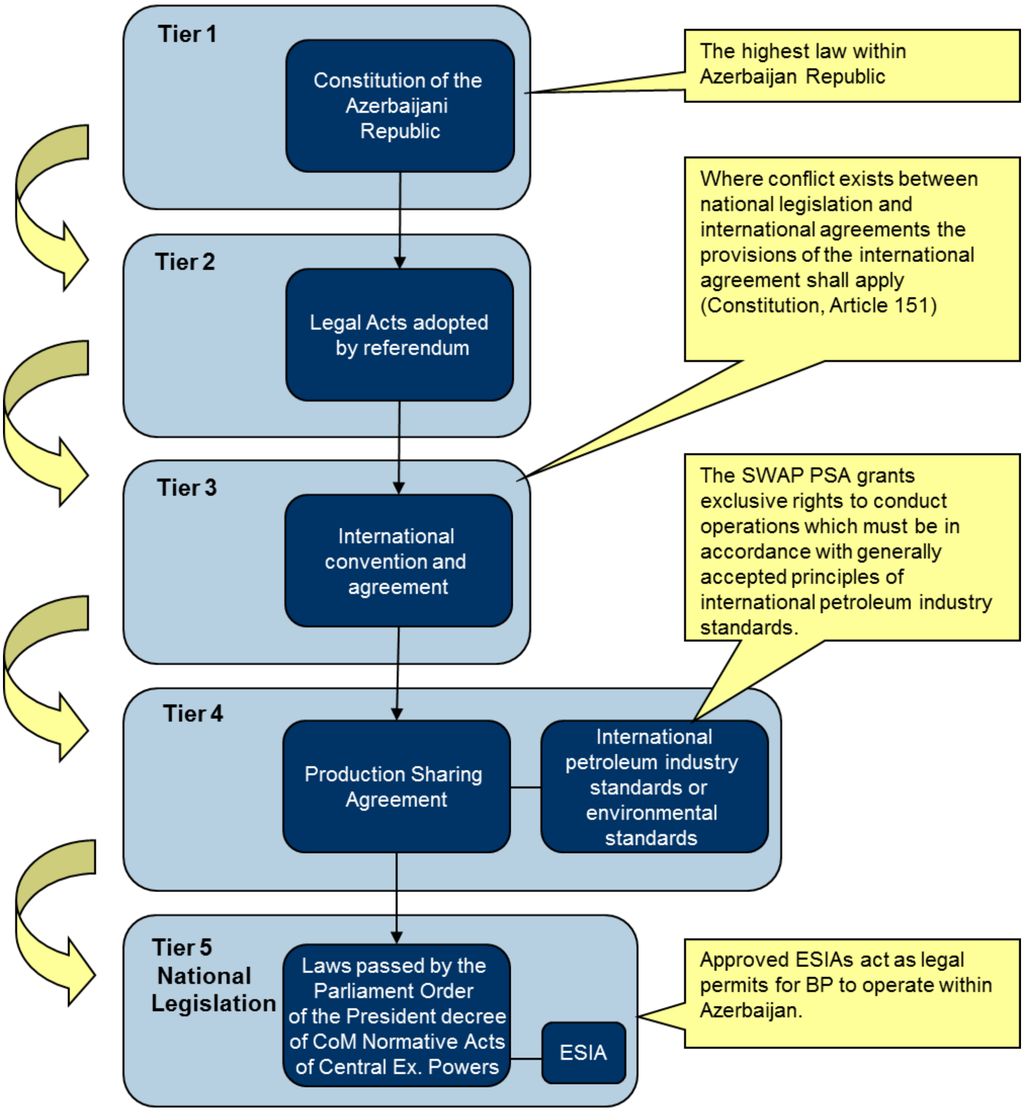
2.1 Introduction

This Chapter of the Environmental and Socio-Economic Impact Assessment (ESIA) provides an overview of the agreements, legislation, standards and guidelines which are applicable to the Shallow Water Absheron Peninsula (SWAP) 2D Seismic Survey including the following:

- SWAP Production Sharing Agreement (referred to herein as the "PSA");
- Applicable requirements of international and regional conventions ratified by the Azerbaijan government;
- Applicable national legislation and guidance;
- Regional processes; and
- International petroleum industry standards and practices.

The legal hierarchy applicable to the 2D Seismic Survey is illustrated in Figure 2.1.

Figure 2.1: Azerbaijan Legal Hierarchy



In addition to the applicable legal requirements, the 2D Seismic Survey will be undertaken in accordance with BP Group, Segment and Regional standards.

This section also sets out the responsibilities of relevant regulatory agencies in relation to environmental regulation.

2.2 Regulatory Agencies

The State Oil Company of the Republic of Azerbaijan (SOCAR) is the party to the PSA representing the Republic of Azerbaijan. Hence, the obligations that BP has undertaken in the PSA are effectively owed to SOCAR.

The Ministry of Ecology and Natural Resources (MENR) has primary responsibility for environmental regulation. The MENR's statutes were adopted by presidential decree in 2001, making this body responsible for

- Development of draft environmental legislation for submission to the Azerbaijan;
- Parliament (Milli Mejlis[1]);
- Implementation of environmental policy;
- Enforcement of standards and requirements for environmental protection;
- Suspension or termination of activities not meeting set standards;
- Advising on environmental issues;
- Expert review and approval of environmental documentation, including Environmental Impact Assessment (EIA) and Environmental and Social Impact Assessment (ESIA); and
- Implementation of the requirements set out in international conventions ratified by the Azerbaijan Republic (within its competence)

Other ministries and committees have functions that relate to environmental regulation including:

- **Ministry of Emergency Situations (MES)** - responsible for the management of natural disasters and industrial accidents and the implementation of safety rules in construction, mining and industry. MES (along with SOCAR, MENR and other appropriate Ministries) require prompt notification in the event of an emergency, or accident; MES is also responsible for licensing of "potentially hazardous facilities" and any work activities involving "potentially hazardous facilities".
- **Ministry of Health** - state institution controlling the sanitary-epidemiological situation in the country and regulation of health protection in the work place; and
- **Ministry of Fuel and Energy** - responsible for oil and gas activities, the sale of oil and gas products, and the efficient utilisation of Azerbaijan's energy resources.

2.3 The Constitution

The Constitution is the highest law in the Azerbaijan Republic and prevails over national legislation and international agreements. The following Articles help determine the applicability of national and international requirements to the 2D Seismic Survey:

- **Article 148.II** - International agreements acceded to by the Azerbaijan Republic become an integral part of the legislative system of Azerbaijan; and
- **Article 151** - If any conflicts arise between the normative-legal acts which constitute the legislative system of Azerbaijan (except for the Constitution and the acts adopted via referendum) and the international agreements acceded to by the Azerbaijan Republic, the provisions of the international agreements shall apply.

Constitution (Article 39) also stipulates the basic rights of people to live in a healthy environment, to have access to information on the state of the environment and to obtain compensation for damage suffered as the result of a violation of environmental legislation.

[1]Milli Mejlis is the name of the National Parliament of the Azerbaijan Republic.

2.4 Production Sharing Agreement

The PSA establishes the legal regime for implementation of the SWAP 2D Seismic Survey in the Azerbaijan sector of the Caspian Sea. The PSA was signed by BP as Contractor and SOCAR in Baku on 22nd December 2014. It was subsequently enacted into the law of the Republic of Azerbaijan after ratification by the Parliament of Azerbaijan Republic on 14th April 2015. The 2D Seismic Survey will be managed by BP as the Contractor under the PSA.

Article 26.1 of the PSA states:

"Contractor shall apply safety and environmental protection standards and practices that take account of the specified environmental characteristics of the Caspian Sea and draw, as appropriate, on (i) international Petroleum industry standards and experience with their implementation in exploration and production operations in other parts of the world and (ii) existing Azerbaijan safety and environmental legislation. In compilation of such standards and practices account shall be taken of such matters as environmental quality objectives, technical feasibility and economic and commercial viability".

Article 26.1 also requires that in developing relevant standards and practices, environmental quality objectives, technical feasibility and economic and commercial viability must also be taken into account and further states:

"*Subject to the first sentence of Article 26.4 the standards, which shall apply to Petroleum Operations from Effective Date shall be the standards and practices set out in Part II of Appendix 9 until substituted by new safety and environmental protection standards devised and agreed between Contractor, SOCAR and MENR. Such substitution shall take effect following the appropriate written agreement between Contractor, SOCAR and MENR on a date agreed between the Parties and MENR and from such date such agreed standards and practices shall have the force of law as if set out in full in this Agreement."*

Article 26.2 of the PSA states:

"Contractor shall conduct the Petroleum Operations in a diligent, safe and efficient manner in accordance with the Environmental Standards to minimise any potential disturbance to the general environment, including without limitation the surface, subsurface, sea, air, lakes, rivers, animal life, plant life, crops, other natural resources and property".

Article 26.4 of the PSA requires "Contractor" (BP Exploration (Azerbaijan) Limited) to: *" …comply with present and future Azerbaijani laws or regulations of general applicability with respect to public health, safety and the protection and restoration of the environment, to the extent that such laws and regulations are no more stringent than the Environmental Standards set out in Part II of Appendix 9".*

Until the protocol, on entrance into legal force of the Production Standards, has been signed by all of the parties, the standards and practices set out in part III of Appendix 9 to the PSA shall continue to apply to production activities.

2.5 International and Regional Environmental Conventions

Azerbaijan is signatory to numerous international and regional conventions that oblige the government to prevent pollution and protect specified habitats, flora and fauna. Those of relevance to the 2D Seismic Survey are listed in Tables 2.1 and 2.2.

Table 2.1: Summary of International Conventions

Convention	Purpose	Status
Bern Convention	Conservation of wild flora and fauna and their natural habitats.	In force in Azerbaijan since 2002.
Stockholm Convention on Persistent Organic Pollutants	Reduction in releases of dioxins, furans, hexachlorobenzene and PCBs with the aim of minimisation or elimination.	Azerbaijan acceded in 2004.
International Convention for the Prevention of Pollution from Ships/ Vessels (MARPOL), 1973 as amended by the protocol, 1978	The legislation giving effect to MARPOL 73/78 in Azerbaijan is the Protection of the Sea (Prevention of Pollution from Ships) Act 1983. Preventing and minimising pollution of the marine environment from ships - both accidental pollution and that from routine operations.	Azerbaijan acceded in 2004.
UN Convention on the Protection of the Ozone Layer (Vienna Convention)	Framework for directing international effort to protect the ozone layer, including legally binding requirements limiting the production and use of ozone depleting substances as defined in the Montreal Protocol to the Convention. Supported by the Montreal Protocol and amendments (see below).	Azerbaijan acceded in 1996.
Montreal Protocol on Substances that Deplete the Ozone Layer, 1987	Specific requirements for reductions in emissions of gases that deplete the ozone layer. Amended four times: London 1990, Copenhagen 1992, Montreal 1997 and Beijing 1999.	Azerbaijan acceded in 1996.
United Nations Framework Convention on Climate Change, 1992	Seeks to stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, within a sufficient time frame to allow ecosystem to adapt naturally, protect food production and enable sustainable economic development.	Azerbaijan acceded in 1992 and not formally required to meet specific targets.
Kyoto Protocol, 1997	Follow on from the Framework Convention on Climate Change.	Azerbaijan acceded in 2000.
UN Convention on Biological Diversity, 1992	Conservation of biological diversity including the sustainable use of its components and the fair and equitable sharing of benefits.	Azerbaijan became party to the Convention in 2000.
International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990	Seeks to develop further measures to prevent pollution from ships.	Azerbaijan acceded in 2004.
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Controls trade in selected species of plant and animals.	Entered into force in Azerbaijan in 1999.
Convention for the Protection of the Archaeological Heritage of Europe	Requires each state party to support archaeological research financially and promote archaeology, using public or private funding.	Azerbaijan ratified in 2000.
Basel Convention on Control of Transboundary Movements of Hazardous Wastes and their Disposals	Seeks to control and reduce transboundary movements of hazardous wastes, minimise the hazardous wastes generated, ensure environmentally sound waste management and recovery practices and assist developing countries in improving waste management systems.	Azerbaijan ratified in 2001.

Table 2.2: Summary of Regional Conventions

Convention	Purpose	Status
Aarhus Convention*	To guarantee the rights of access to information, public participation in decision-making and access to justice in environmental matters.	Azerbaijan acceded in 2000.
Espoo Convention*	To promote environmentally sound and sustainable development through the application of ESIA, especially as a preventive measure against transboundary environmental degradation.	Azerbaijan acceded in 1999 and at the time of writing, Azerbaijan had not signed a related protocol on Strategic Environmental Assessment.
Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki Convention)*	To prevent, control or reduce transboundary impact resulting from the pollution of transboundary waters by human activity.	Azerbaijan acceded in 2002.
UN Convention on Control of Transboundary Movements of Hazardous Wastes and their Disposals	Regulates the transboundary movements of hazardous wastes and provides obligations to its Parties to ensure that such wastes are managed and disposed of in an environmentally sound manner.	Azerbaijan ratified in 2001.
Protocol on Water and Health*	To protect human health and well-being by better water management and by preventing, controlling and reducing water-related diseases.	Azerbaijan acceded in 2003.
UNECE Geneva Convention on Long-range Transboundary Air Pollution*	Provides a framework for controlling and reducing transboundary air pollution.	Entered into force in Azerbaijan in 2002. Has been extended by 8 protocols, none of which at the time of writing have been ratified by Azerbaijan.
International Carriage of Dangerous Goods by Road*	Provides requirements for the packaging and labelling of dangerous goods and the construction, equipment and operations of transportation vehicles. Annexes provide detailed technical requirements.	Entered into force in Azerbaijan in 2000.
Convention on the Transboundary Effects of Industrial Accidents*	To prevent industrial accidents that may have transboundary effects and to prepare for and respond to such events.	Azerbaijan acceded in 2004.
Tehran-Caspian Framework Convention	Ratified by all five littoral states and entered into force in 2006. Requires member states to take a number of generic measures to control pollution of the Caspian Sea. Three protocols have been adopted and therefore form the basis for national legislation and regulations. One protocol, namely Environment Impact Assessment in a Transboundary Context has been drafted and was not adopted at the time of writing.	Convention is ratified and the following protocols have been adopted: • The Protocol Concerning Regional Preparedness, Response and Co-operation in Combating Oil Pollution Incidents ("Aktau Protocol") (August 2011); • The Protocol for the Protection of the Caspian Sea against Pollution from Land-based Sources and Activities ("Moscow Protocol") (December 2012); and • The Protocol for the Conservation of Biological Diversity ("Ashgabat Protocol") (May 2014).
* A UNECE agreement; Azerbaijan became a member of the UNECE in 1993. The major aim of the UNECE is to promote pan-European integration through the establishment of norms, standards and conventions.		

2.6 National Environmental Legislation

The Azerbaijan Government has committed to a process to align national environmental legislation with the principles of internationally recognised legislation, based on EU environmental legislation. As this process is on-going, the 2D Seismic Survey will comply with the intent of current national legal requirements where those requirements are consistent with the provisions of the PSA, and do not contradict, or are otherwise incompatible with, international petroleum industry standards and practice.

The framework for national environmental legislation in Azerbaijan is provided by the Law on the Protection of the Environment (1999), which addresses the following issues:

- The rights and responsibilities of the State, the citizens, public associations and local authorities;
- The use of natural resources;
- Monitoring, standardisation and certification;
- Economic regulation of environmental protection;
- State Ecological Expertise (SEE);
- Ecological requirements for economic activities;
- Education, scientific research, statistics and information;
- Ecological emergencies and ecological disaster zones;
- Control of environmental protection;
- Ecological auditing;
- Responsibility for the violation of environmental legislation; and
- International cooperation.

According to Article 54.2 of the Law on Protection of the Environment, EIAs are subject to SEE, which means that the environmental authority (MENR) is responsible for the review and approval of EIA reports submitted by developers. The Law establishes the basis for the SEE procedure, which can be seen as a “stand-alone” check of compliance of the proposed project with the relevant environmental standards (e.g. for pollution levels, discharges and noise). In addition the law determines that projects cannot be implemented without a positive SEE resolution.

The SEE approach requires state authorities to formally verify all submitted developments for their potential environmental impacts. Current internationally recognised practice emphasises a proportionate, consultative and publicly accountable approach to assessing impacts.

Table 2.3 provides a summary of the key national environmental and social laws.

Table 2.3: Key National Environmental and Social Laws[2]

Subject	Title	Date	Description / Relevance to SWAP 2D Seismic Survey ESIA
General	Law of Azerbaijan Republic on the Protection of the Environment No. 678-IQ.	08/06/1999 (last amendment 30/09/20140)	Establishes the main environmental protection principles and the rights and obligations of the State, public associations and citizens regarding environmental protection (described above).
	Law of Azerbaijan Republic on Ecological Safety No. 677-IQ.	08/06/1999 (last amendment 01/02/2013)	One of two keystone laws of the country's environmental legislation (along with the *Law on the Protection of the Environment*). Its purpose is to establish a legal basis for the protection of life and health, society, the environment, including atmospheric air, space, water bodies, mineral resources, natural landscapes, plants and animals from natural and anthropogenic dangers. The Law assigns the rights and responsibilities of the State, citizens and public associations in ecological safety, including information and liability. The Law also deals with the regulation of economic activity, territorial zoning and the alleviation of the consequences of environmental disasters.
Ecosystems	Law of the Azerbaijan Republic on Specially Protected Natural Territories and Objects No. 840-IQ.	24/03/2000 (last amendment 06/03/2015)	Determines the legal basis for protected natural areas and objects in Azerbaijan.
	Law of Azerbaijan Republic on Fauna No. 675-IQ.	04/06/1999 (last amendment 06/03/2015)	Defines the animal world, property rights over fauna and legal relationships between parties. It also describes issues of State inventory and monitoring, and economic and punitive regulations.
Water	Water Code of Azerbaijan Republic (approved by Law No. 418-IQ).	26/12/1997 (last amendment 06/03/2015)	Regulates the use of water bodies, sets property rights and covers issues of inventory and monitoring. The Code regulates the use of water bodies for drinking and service water and for medical treatment, spas, recreation and sports, agricultural needs, industrial needs and hydro energy, transport, fishing and hunting, discharge of waste water, fire protection and specially protected water bodies. It provides for zoning, maximum allowable concentrations of harmful substances and basic rules of industry conduct.

[2] This table is compiled from a variety of sources including: United Nations 2004, Environmental Performance Reviews Series No. 19 – Azerbaijan; Currie & Brown, 2008, Integrated Solid Waste Management System for the Absheron Peninsula Project, and Popov 2005, Azerbaijan Urban Environmental Profile (an ADB Publication).

Subject	Title	Date	Description / Relevance to SWAP 2D Seismic Survey ESIA
	Rules of Referral of Specially Protected Water Objects to Individual Categories, Cabinet of Ministers Decree No. 77.	01/05/2000 (last amendment 10/05/2012)	The Caspian Sea is a specially protected water body. This resolution requires special permits for disposal if there are no other options for wastewater discharge. The resolution allows for restrictions to be placed on the use of specially protected water bodies, and for further development of regulations related to these water bodies. It requires consent from MENR for activities that modify the natural conditions of specially protected water bodies, and includes provisions for permitting of any discharges to water that cannot be avoided. There are also special requirements for the protection of water bodies designated for recreational or sports use (which includes the Caspian).
	Rules for Protection of Surface Waters from Waste Water Pollution, State Committee of Ecology Decree No. 1.	04/01/1994	Under this legislation the *Permitted Norms of Harmful Impact Upon Water Bodies of Importance to Fisheries* require discharges to meet several specified standards for designated water bodies in terms of suspended solids; floating matter; colour, smell and taste; temperature; dissolved oxygen; pH; Biological Oxygen Demand (BOD) and poisonous substances. Limits are based on Soviet era standards and are to be achieved at the boundary of the facility (specific "sanitary protection zone limits") rather than "end-of-pipe" limits. End of pipe limits are defined in facility-specific "eco-passports" and are established with the intent to ensure compliance with applicable ambient standards.
Air	Law of Azerbaijan Republic on Air Protection No. 109-IIQ.	27/03/2001	Establishes the legal basis for the protection of air, thus implementing the constitutional right of the population to live in a healthy environment. It stipulates the rights and obligations of the authorities, legal and physical persons and non-governmental organisations (NGOs) in this respect, sets general requirements for air protection during economic activities, establishes norms for mitigating physical and chemical impacts to the atmosphere, establishes rules for the State inventory of harmful emissions and their sources and introduces general categories of breaches of the Law that will trigger punitive measures.
	Methodology to Define Facilities' Hazards Categories Subject to Hazardous Substance Emissions Levels and Need to Develop Projects' Maximum Permissible Emissions.	04/09/1990	Under this methodology the maximum permissible concentrations of harmful substances and their hazard classes are provided. Limits are based on Soviet era standards.
Waste	Law of Azerbaijan Republic on Industrial and Domestic Waste No. 514-IQ.	30/06/1998 (last amendment 12/06/2012)	Describes State policy in environmental protection from industrial and household waste including harmful gases, waste water and radioactive waste. It defines the rights and responsibilities of the State and other entities, sets requirements for the design and construction of waste-treatment installations, licensing of waste generating activities, and for the storage and transport of waste (including transboundary transportation). The Law also encourages the introduction of technologies for the minimisation of waste generation by industrial enterprises. There is a general description of responses to infringements. This law is specified by Resolutions of the Cabinet of Ministers on the rules of certification of hazardous wastes, state strategy on management of hazardous wastes in Azerbaijan and by Instructions on the Inventorisation Rules and Classification System of the Wastes generated by Industrial Processes and In the Field of Services approved by the MENR.
Subsurface	Law of the Azerbaijan Republic on Subsurface Resources No. 439-IQ.	13/02/1998 (last amendment 25/12/2007)	Regulates the exploitation, rational use, safety and protection of subsurface resources and the Azerbaijani sector of the Caspian Sea. The Law lays down the principal property rights and responsibilities of users. It puts certain restrictions on the use of mineral resources, based on environmental protection considerations, public health and economic interests.

Subject	Title	Date	Description / Relevance to SWAP 2D Seismic Survey ESIA
Information	Law of the Azerbaijan Republic on Access to Environmental Information No. 270-IIQ.	12/03/2002 (last amendment 20/10/2006)	Establishes the classification of environmental information. If information is not explicitly classified "for restricted use" then it is available to the public. Procedures for the application of restrictions are described. Law aims to incorporate the provisions of the Aarhus Convention into Azeri Law.
Health & Safety	Law on Sanitary-Epidemiological Services (authorised by Presidential Decree No. 371).	10/11/1992 (last amendment 30/09/2014)	Establishes sanitary and epidemiological requirements for industrial entities to be met at design, construction and operational stages, and for other economic activities. Aims to protect the health of the population. It addresses the rights of citizens to live in a safe environment and to receive full and free information on sanitary-epidemic conditions, the environment and public health.
	Law of the Azerbaijan Republic on Protection of Public Health No. 360-IQ.	26/06/1997 (last amendment 02/02/2015)	Sets out the basic principles of public health protection and the health care system. The Law assigns liability for harmful impact on public health, stipulating that damage to health that results from a polluted environment shall be compensated by the entity or person that caused the damage.
	Law of the Azerbaijan Republic on Public Radiation Safety No. 423-IQ.	30/12/1997 (last amendment 03/03/2006)	Includes requirements for ensuring radiation safety in industrial entities. The Law establishes the main principles of government policy on radiation safety, as well as environmental norms protecting the safety of employees and populations in areas potentially affected by the use of radioactive sources. The Law provides for compensation for damage to health, property and life due to accidents.
	Law of Azerbaijan on Technical Safety - 733-IQ	02/11/1999 (last amendment 30/09/2014)	The current law sets legislative, economic and social basis of PDF (Potential Dangerous Facilities) exploitation.
Liability	Law on Mandatory Insurances.	24/06/2011	Identifies requirements for the mandatory insurance of civil liability for damage caused to life, health, property and the environment resulting from accidental environmental pollution.
Permitting	A System of Standards for the Environment Protection and Improvement of Natural Resources Utilisation. Industrial Enterprise Ecological Certificate Fundamental Regulations, GOST 17.0.0.04-90.	01/07/1990	The MENR issues ecological documents on the impact on the environment of potentially polluting enterprises. The documents include maximum allowable emissions, maximum allowable discharges, and an "ecological passport." The last item is specific to countries of the Former Soviet Union and contains a broad profile of an enterprise's environmental impacts, including resource consumption, waste management, recycling, and the effectiveness of pollution treatment. Enterprises develop the draft passport themselves and submit it to MENR for approval.
Cultural heritage	Law on the Protection of Historical and Cultural Monuments.	10/04/1998	Specifies the responsibilities of state and local authorities, and lays down principles for the use, study, conservation, restoration, reconstruction, renovation and safety of monuments. The Law declares that cultural objects with national status, historical and cultural monuments, cultural goods stored in state museums, archives, libraries, as well as the territories where they are situated, are not subject to privatisation. Requires archaeological studies prior to construction works in areas with archaeological significance.

2.6.1 National EIA Guidance

Guidance on the EIA process in Azerbaijan is provided in the Handbook for the Environmental Impact Assessment Process in Azerbaijan. The Handbook introduces the main principles of the 'western'-type EIA process and details:

- The EIA process, i.e. the sequence of events and the roles and responsibilities of applicants and Government institutions;
- The purpose and scope of the EIA document;
- Public participation in the process;
- Environmental review decision (following its submission to the MENR, the ESIA document is reviewed for up to three months by an expert panel); and
- The appeal process.

A summary of the guidance provided in the Handbook is given in Table 2.4.

The approval of an EIA by the MENR establishes the compliance framework, including the environmental and social standards that an organisation should adhere to.

Table 2.4: Summary of Guidance on the EIA Process in Azerbaijan[3]

Screening	The developer is required to submit an Application (containing basic information on the proposal) to MENR to determine whether an EIA is required.
Scoping	Requirement for a Scoping Meeting to be attended by the developer, experts and concerned members of the public, and aimed at reaching a consensus on the scope of the EIA.
Project Description	Full description of technological process and analysis of what is being proposed in terms of planning, pre-feasibility, construction and operation.
Environmental Studies	Requirement to describe fully the baseline environment at the site and elsewhere, if likely to be affected by the proposal. The environment must be described in terms of its various components – physical, ecological and social.
Consideration of Alternatives	No requirement to discuss project alternatives and their potential impacts (including the so-called "do-nothing" alternative), except for the description of alternative technologies.
Impact Assessment and Mitigation	Requirement to identify all impacts (direct and indirect, onsite and offsite, acute and chronic, one-off and cumulative, transient and irreversible). Each impact must be evaluated according to its significance and severity and mitigation measures provided to avoid, reduce, or compensate for these impacts.
Public Participation	Requirement to inform the affected public about the planned activities twice: when the application is submitted to the MENR for the preliminary assessment and during the EIA process. The developer is expected to involve the affected public in discussions on the proposal.
Monitoring	The developer is responsible for continuous compliance with the conditions of the EIA approval through a monitoring programme. The MENR undertakes inspections of the implementation of activities in order to verify the accuracy and reliability of the developer's monitoring data. The developer is responsible for notifying the MENR and taking necessary measures in case the monitoring reveals inconsistencies with the conditions of the EIA approval.

[3] Source: based on a review of the Azerbaijan State Committee for Ecology, 1996. Handbook for the Environmental Impact Assessment Process in Azerbaijan and Parviz, 2005. EIA in the New Oil and Gas Projects in Azerbaijan.

2.7 Regional Processes

2.7.1 European Union

EU relations with Azerbaijan are governed primarily by the EU-Azerbaijan Partnership and Cooperation Agreement (PCA) and the European Neighbourhood Policy (ENP).

The PCA entered into force in 1999. Under Article 43:

"The Republic of Azerbaijan should endeavour to ensure that its legislation will be gradually made compatible with that of the Community".

As part of the PCA an EU assessment of Azerbaijan's environmental legislation against EU Directives identified a number of recommendations for the approximation of national legislation with EU Directives[4]. Based on this, a draft national programme was developed that emphasises a flexible approach to amending national legislation to take account of institutional capacity and cost[5].

Following the enlargement of the European Union, the EU launched the ENP and Azerbaijan became part of this policy in 2004. The current National Indicative Programme for implementing the ENP[6] includes a commitment to support legislative reform in the environmental sector, including:

- Approximation of Azerbaijan's environmental legislation and standards with the EU's;
- Strengthening management capacity through integrated environmental authorisation;
- Improved procedures and structures for environmental impact assessment; and
- Development of sectoral environmental plans (waste and water management, air pollution, etc.).

2.7.2 Environment for Europe

Environment for Europe[7] is a partnership of member states, including Azerbaijan, and other organisations within the UNECE region. Under the auspices of the Environment for Europe a series of ministerial conferences on the environment have been held that have resulted in the establishment of the UNECE conventions described in Section 2.5.

2.8 International Petroleum Industry Standards and Practices

The 2D Seismic Survey related activities are required to comply with national legislation "*to the extent that such laws and regulations are no more stringent than the Environmental Standards set out in Part II of Appendix 9*" (SWAP PSA, Art. 26.4). The safety and environmental protection standards shall be developed by the Contractor jointly with MENR and "*shall take account of the specific environmental characteristics of the Caspian Sea and draw, as appropriate, on (i) international Petroleum industry standards and experience with their implementation in exploration and production operations in other parts of the world and (ii) existing Azerbaijan safety and environmental legislation*".

Consideration of relevant international industry standards is therefore an important element in determining the applicability of national legislation or otherwise. Industry standards including those of the International Association of Oil and Gas Producers (OGP), the International Association of Geophysical Contractors (IAGC) and the International Association of Drilling Contractors (IADC) were specifically mentioned in the SWAP PSA.

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4 Mammadov, A. & Apruzzi, F. (2004) Support for the Implementation of the Partnership Cooperation Agreement between EU-Azerbaijan. Scoreboard Report on Environment and Utilisation of Natural Resources. Report prepared for TACIS.
5 SOFRECO (undated) Support for the Implementation of the PCA between EU-Azerbaijan, Draft Programme of legal Approximation.
6 European Commission, 2007. European Neighbourhood and Partnership Instrument, Azerbaijan National Indicative Programme (NIP).
7 United Nations Economic Commission for Europe UNECE (2008) Environment for Europe. Available at: http://www.unece.org/env/efe/welcome.html Accessed August 2015.

3 Impact Assessment Methodology

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3.1 Introduction

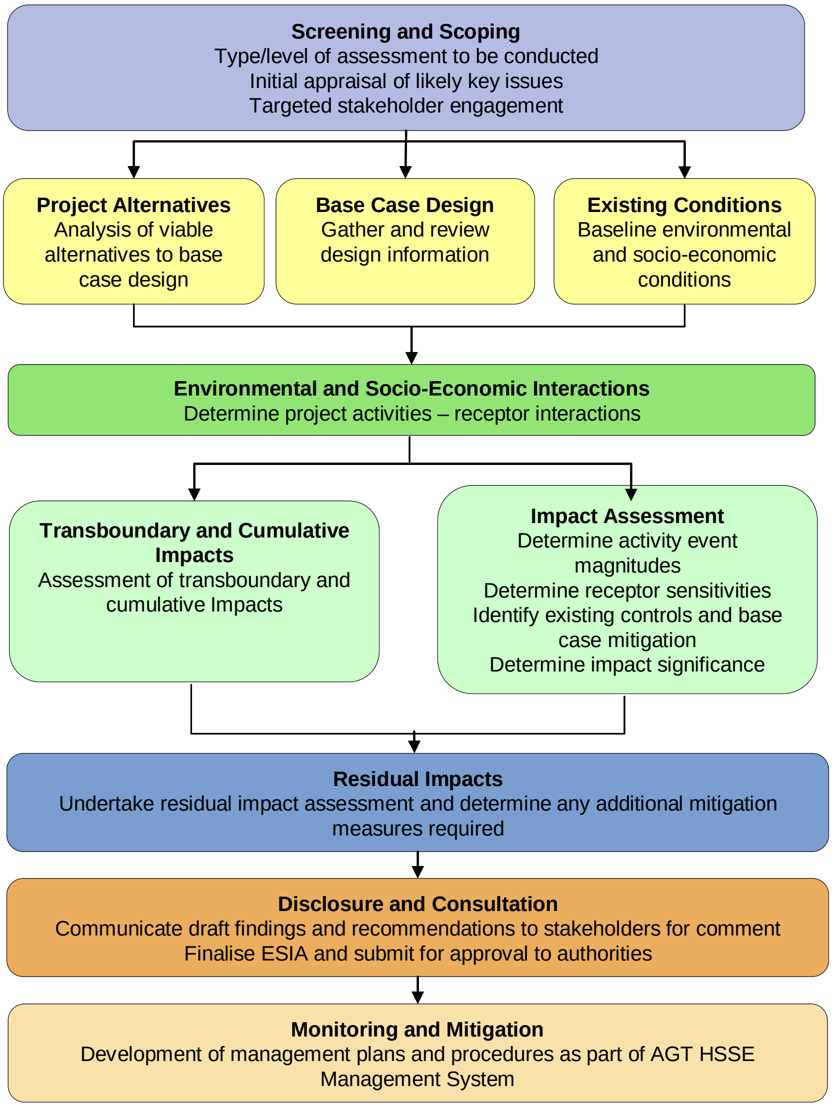
This Chapter of the Environmental and Socio-Economic Impact Assessment (ESIA) sets out the ESIA process adopted for the Shallow Water Absheron Peninsula (SWAP) 2D Seismic Survey and the methodology used to assess impact significance.

3.2 ESIA Process

The ESIA process constitutes a systematic approach to the evaluation of a project and its associated activities throughout the project lifecycle. The process (refer to Figure 3.1) includes:

- Screening and Scoping;
- Project Alternatives and Base Case Design;
- Existing Environmental and Socio-Economic Conditions;
- Impact Assessment;
- Residual Impact Identification;
- Disclosure and Stakeholder Consultation; and
- Monitoring and Mitigation.

Figure 3.1: The ESIA Process



3.2.1 Screening and Scoping

Screening is the first step in the assessment process. It confirms the need (or otherwise) for an ESIA by appraising the type of project and its associated activities throughout the project lifecycle in the context of its biophysical, socio-economic, policy and regulatory environments.

Given the location, scale and planned activities associated with the SWAP 2D Seismic Survey, BP took the decision to complete an ESIA for the SWAP 2D Seismic Survey. This is consistent with the approach taken for similar seismic surveys completed in the Azeri Chirag Gunashli (ACG), Shah Deniz (SD) and Shafag-Asiman Contract Areas, which are all operated by BP and located in the Azerbaijani sector of the Caspian Sea. This approach and the scope of the ESIA was agreed with the Ministry of Ecology and Natural Resources (MENR) at a scoping meeting held in August 2015. Key issues that were raised by the MENR and which have been addressed within this ESIA include the requirement to consider impacts of the survey activity to fish and to small scale fishing.

Scoping is a high level assessment of anticipated **interactions** between **project activities** and **environmental and socio-economic receptors**. Its purpose is to focus the assessment on key issues and eliminate certain activities from the full impact assessment process based on their limited potential to result in discernible impacts. To arrive at a conclusion to ‘scope out’ an activity/event, a mixture of expert scientific judgement based on prior experience of similar activities and events and, in some instances, scoping level quantification/numerical analysis (e.g. emission and discharge modelling) is used.

The SWAP 2D Seismic Survey Scoping process has included:

- Review of available environmental and socio-economic data and reports relevant to the area potentially affected by the SWAP 2D Seismic Survey activities; and
- Liaison with the SWAP 2D Seismic Survey Project Team to gather data and to formulate an understanding of project activities.

Based on the findings of the review and data gathering, the SWAP 2D Seismic Survey ESIA Team identified potential project related environmental and socio-economic impacts based on likely interactions between seismic survey activities and environmental/socio-economic receptors. In addition the Team identified gaps where the extent, depth and/or quality of available environmental, socio-economic and/or technical data at the scoping stage was insufficient for the SWAP 2D Seismic Survey Project ESIA process. This allowed the scope of the work required to complete the ESIA to be confirmed.

3.2.2 Impact Significance Assessment

An **impact**, as defined by the international standard ISO14001:2004 is:

“Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation’s environmental aspects”.

Where an **environmental aspect** is defined as:

“Element of an organisation’s activities or products or services that can interact with the environment”.

An impact is defined where an interaction occurs between a project activity and an environmental receptor. The ESIA process ranks impacts according to their **significance** determined by considering project activity **event magnitude** and **receptor sensitivity**. Determining event magnitude requires the identification and quantification (as far as practical) of the sources of potential environmental and socio-economic effects from routine and non-routine project activities. Determining receptor environmental sensitivity requires an understanding of the biophysical environment.

The approach to evaluating the significance of potential environmental and socio-economic impacts is set out in the sections below. It should be noted that impact significance is assessed taking into account existing control measures that are incorporated into the project design. Impacts can be positive or negative depending on whether they result in a beneficial or adverse change when compared to baseline conditions.

3.2.3 Environmental Impacts

3.2.3.1 Method for Determining Event Magnitude

Event magnitude is determined based on the following parameters, which are equally weighted and are each assigned a rating of 1, 2, or 3:

- **Extent / Scale**: Events range from those where the effect extends across an area:

  1 – Near to the source (in the range tens to hundreds of metres); to

  2 – At intermediate distance from the source (in the range hundreds to thousands of metres); to

  3 – At far distance from the source (in the range thousands of metres and above).

- **Frequency**: Events range from those occurring:

  1 – Once or twice; to

  2 - Repeatedly but intermittently; to

  3 – Frequently and persistently.

- **Duration**: Events range from those where effects occur over: :

  1 – Instantaneous/short term (i.e. hours to days); to

  2 - Medium term (weeks to 3 months); to

  3 - Long term (more than 3 months to permanent).

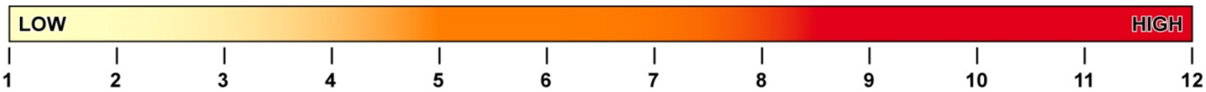
- **Intensity**: Concentration[1] of an emission or discharge with respect to standards of acceptability that include applicable legislation and international guidance, its toxicity or potential for bioaccumulation, and its likely persistence in the environment. Degree/permanence of disturbance or physical impact. Ranges from:

  1 - A low intensity event; to

  2 - A moderate intensity event; to

  3 - A high intensity event.

Overall, event magnitude is scored from low (1) to high (12) by adding the individual parameter scores:



Resulting individual ratings are summed to give the overall event magnitude ranking. Table 3.1 presents the score ranges for magnitude rankings of Low, Medium and High.

[1] In the case of underwater sound this parameter relates to peak sound pressure level or sound energy level depending on the criteria selected

Table 3.1: Event Magnitude Rankings

Event Magnitude	Score (Summed Parameter Rankings)
Low	4
Medium	5-8
High	9-12

3.2.3.2 Method for Determining Receptor Sensitivity

Receptor sensitivity considers the type of receptor (namely, biological/ecological, human and physical receptor/feature); and is determined based on the following parameters, which are equally weighted and are each assigned a rating of 1, 2, or 3:

- Biological/Ecological Receptors:

  Presence ranges from:

  3 - Internationally threatened species[2] within the area impacted by the project activity/activities during period of high sensitivity (e.g. during breeding, spawning or nesting) and during peak presence; to

  2 - Internationally threatened species[2] within the area impacted by the project activity/activities outside of period of high sensitivity or during peak presence.

  Internationally near threatened[3] species within the area impacted by the project activity/activities during period of high sensitivity (e.g. during breeding, spawning or nesting) and/or during peak presence.

  Nationally protected species and/or species which are of importance to the local and regional ecosystem within the area impacted by the project activity/activities.

  1 - Presence of species which is none of the above.

  Resilience (to the identified stressor) ranges from:

  3 - Species and/or population which has little or no capacity to absorb or adapt to change (i.e. little or no capacity to move away from or adapt to the project impact), leading to potential for substantial change of character and/or loss of ecological functionality.

  2 - Species and/or population which has moderate capacity to absorb or adapt to change (i.e. has capacity to move away from or adapt to the project impact), leading to potential temporary but sustainable effect which does not substantially alter character or result in significant loss of ecological functionality.

  1 - Species and/or population unaffected or marginally affected.

- Human Receptors[4]:

  Presence ranges from:

---

[2] IUCN Red List Classification of Critically Endangered, Endangered or Vulnerable
[3] IUCN Red List Classification of Near Threatened
[4] For the SWAP 2D Seismic Survey , the geographical area is offshore and hence there are no permanently present human receptors resident. The exception is potential impacts to onshore human receptors associated with emissions due to the survey activities.

3 - People being permanently present (e.g. residential property) in the geographical area of anticipated impact; to

2 - People being present some of the time (e.g. commercial property); to

1 - People being uncommon in the geographical area of anticipated impact.

Resilience (to the identified stressor) ranges from:

1 - People being least vulnerable to change or disturbance (i.e. ambient conditions such as air quality are well below applicable legislation and international guidance); to

2 - People being vulnerable to change or disturbance (i.e. ambient conditions such as air quality are below adopted standards); to

3 - Most vulnerable groups (i.e. ambient conditions such as air quality are at or above adopted standards).

- Physical Receptors/Features[5]:

Presence (to the identified stressor) ranges from:

3 - Presence of feature which has, in reverse order, national or international value (e.g. state protected monument); to

2 – Feature with local or regional value and is sensitive to disturbance; to

1 - Feature which is none of the above.

Resilience (to the identified stressor) ranges from:

1 – Feature/receptor is unaffected or marginally affected (i.e. resilient to change);

2 – Undergoes moderate but sustainable change which stabilises under constant presence of impact source, with physical integrity maintained; and

3 – Highly vulnerable (i.e. potential for substantial damage or loss of physical integrity).

Overall, receptor sensitivity is then scored on a spectrum from low (1) to high (6) by adding the individual parameter scores:

Table 3.2 presents the score ranges for sensitivity rankings of Low, Medium and High.

Table 3.2: Receptor Sensitivity Rankings

Receptor Sensitivity	Score (Summed Parameter Rankings)
Low	2
Medium	3-4
High	5-6

[5] For the SWAP 2D Seismic Survey, the geographical area is offshore and hence cultural heritage features potentially impacted are limited to potential subsea features and artefacts with the Survey Area.

3.2.4 Socio- Economic Impacts

The socio-economic impact assessment will use a semi-qualitative assessment approach to describe and evaluate potential impacts based on the event magnitude and receptor sensitivity rankings set out in Tables 3.3 and 3.4 respectively. Indirect socio-economic impacts (i.e. induced effects) will also be assessed using the same approach.

Table 3.3: Event Magnitude Rankings

Magnitude	Criteria
Low	Changes in social, economic or cultural dynamics with slight and temporary effect on any given sector performance and/ or population wellbeing. Unlikely to result in concerns being raised by governmental bodies or stakeholders.
Medium	Changes in social, economic or cultural dynamics with moderate and noticeable adverse effect on any given sector performance and/or population wellbeing. Such impact may result in concerns being raised by governmental bodies or stakeholders.
High	Changes in social, economic or cultural dynamics with major adverse effect on any given sector performance and/or population wellbeing. Such impacts may result in immediate intervention by governmental bodies and stakeholders.

Table 3.4: Receptor Sensitivity Ranking

Sensitivity	Criteria
Low	Moderate to high resilience: A receptor with capacity and means to adapt to a given change and maintain / improve quality of life. or Local Socio-economic value: A socio-economic activity or element of local importance.
Medium	Low resilience: A receptor with limited capacity and means to adapt to a given change and maintain / improve quality of life. or National / Regional Socio-economic value: A socio-economic activity or element which is recognised as being of national or regional importance.
High	Very low resilience: A vulnerable receptor with little capacity and means to adapt to a given change and maintain / improve quality of life (e.g. homeless people, Internally Displaced Persons community in temporary accommodation, people with low access to recourse (e.g. no land titles), people with no or low representation (e.g. migrants, seasonal herders with no permanent assets in the area.) or International Socio-economic value: A socio-economic activity or element which is recognised as being of international importance.

3.2.5 Environmental and Socio-Economic Impact Significance

For both Environmental and Socio-Economic Impacts, impact significance, as a function of event magnitude and receptor sensitivity, is ranked as **Negligible**, **Minor**, **Moderate** or **Major** as presented in Table 3.5.

Table 3.5: Impact Significance

		Receptor Sensitivity		
		Low	**Medium**	**High**
Event Magnitude	**Low**	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	High	Moderate	Major	Major

Any impact classified as **Major** is considered to be significant and, where the impact is **negative**, requires additional mitigation. Impacts of **Negligible**, **Minor** or **Moderate** significance are considered as being mitigated as far as practicable and necessary, and therefore, do not require further mitigation.

3.3 Transboundary and Cumulative Impacts

Transboundary impacts are impacts that occur outside the jurisdictional borders of a project's host country. The potential transboundary impacts associated with the SWAP 2D Seismic Survey Project activities are anticipated to be limited to greenhouse gas (GHG) and non GHG emissions to air.

Cumulative impacts arise from:

- Interactions between separate project-related residual impacts; and
- Interactions between project-related residual impacts in combination with impacts from other projects and their associated activities.

These can be either additive or synergistic effects, which result in a larger (in terms of extent or duration) or different (dependent on impact interaction) impacts when compared to project-related residual impacts alone.

The cumulative assessment presented in Chapter 7: Cumulative and Transboundary Impacts and Accidental Events, initially considers the potential for impact interaction and accumulation in terms of the following:

- **Temporal Overlap** – the impacts are so close in time that the effect of one is not dissipated before the next one occurs; and
- **Spatial Overlap** – the impacts are so close in space that their effects overlap.

During the scoping stage of the SWAP 2D Seismic Survey Project ESIA, new projects which are proposed and those under construction in the vicinity of the SWAP study area and have the potential to result in impacts which overlap with the SWAP Seismic Surveys (either spatially or temporally) were identified in liaison with BP and the MENR.

Where there is potential for impact interaction, and the project is sufficiently defined and sufficient data is available, a quantitative assessment will be undertaken. Where insufficient data is available, a qualitative assessment is presented (refer to Chapter 7).

3.4 Mitigation and Monitoring

The iterative and integrated nature of the ESIA and project planning processes means that the majority of proposed additional mitigation measures and strategies have been incorporated into the project Base Case (as provided within Chapter 4: Project Description) and integrated into the design of the 2D Seismic Survey. These measures / strategies have included mitigation measures and ongoing commitments as previously adopted by other projects (including similar seismic surveys) in the AGT Region.

The ESIA will be submitted for review and comment to the MENR who will have an opportunity to make comments on the findings, including suggestions for additional mitigation measures to those already committed to in this ESIA associated with project activities. If deemed appropriate, such mitigation measures will be added to the 2D seismic survey design and/or management programme.

3.5 ESIA Disclosure and Finalisation

Comments from stakeholders, including formal responses from MENR will be collated and the ESIA updated accordingly. The final ESIA document will then be submitted for final approval.

Public consultation and disclosure meetings are not planned for the SWAP 2D Seismic Survey Project ESIA, Given that both the 2D and 3D Seismic Surveys are for the same Contract Area and the offshore 3D Seismic Survey Areas overlap with the 2D Seismic Survey Area, it is planned to include both the 2D and 3D Seismic Surveys within the consultation undertaken during the preparation of SWAP 3D Seismic Survey ESIA, which is planned to be submitted to the MENR in Q4 2015.

4 Project Description

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4.1 Introduction

This Chapter of the Environmental and Socio-Economic Impact Assessment (ESIA) describes the activities associated with the proposed Shallow Water Absheron Peninsula (SWAP) two-dimensional (2D) Seismic Survey including:

- An overview of the survey methodology and survey activities; and
- A description of the planned survey vessels and equipment to be used.

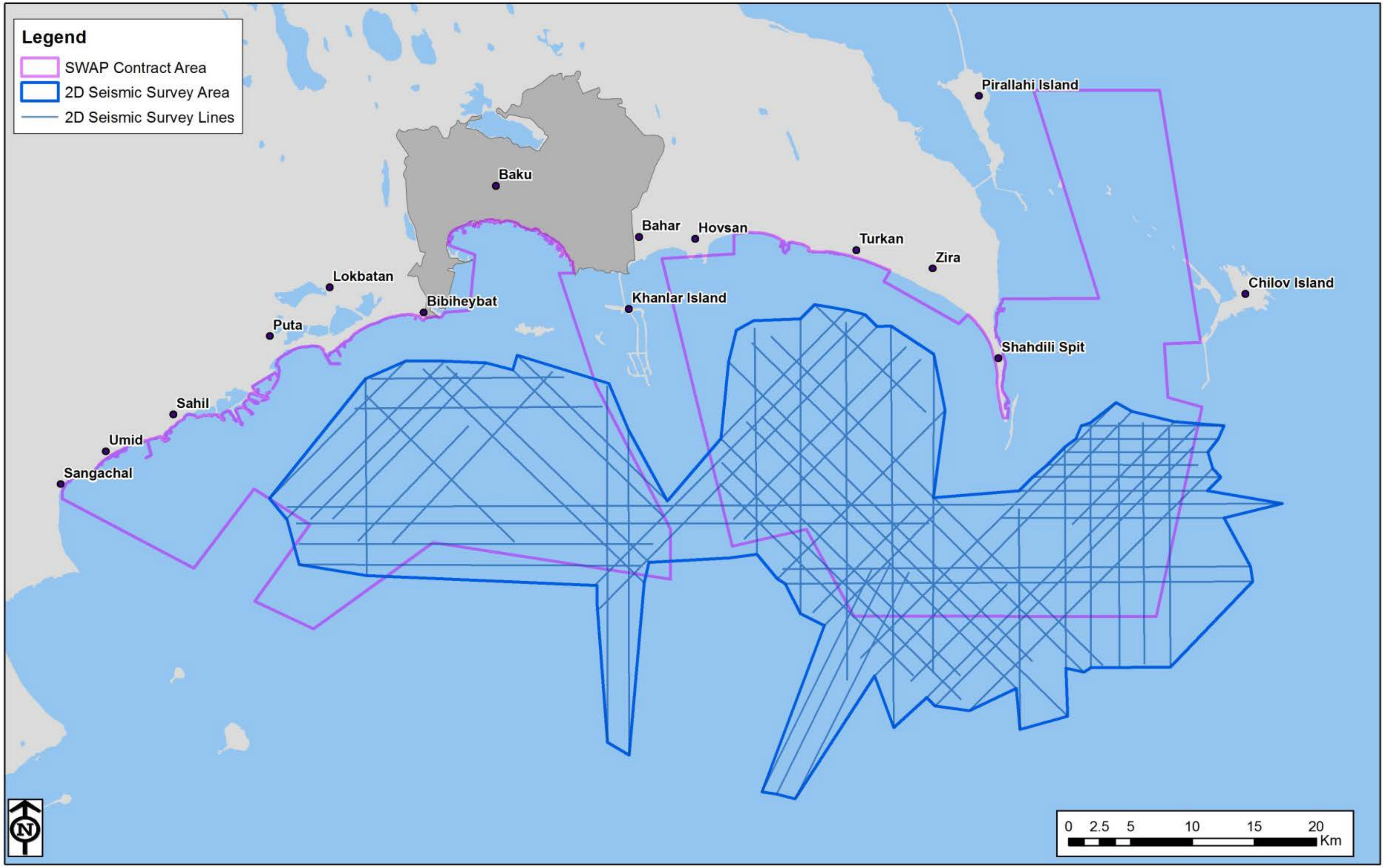
The information presented in this Chapter provides the basis for assessment of impacts undertaken in Chapter 6. This ESIA has been prepared during the planning stage of the Survey.

Estimated emissions, discharges and wastes associated with the Survey are presented within Section 4.5.

The objective of the 2D Seismic Survey is to collect geophysical data on the subsurface hydrocarbon reservoirs within the SWAP Contract Area (Figure 4.1). The data will be used to inform further exploration and development of the area. Part of the proposed Survey includes acquiring seismic data outside of the SWAP Contract Area; this data is required to gain sufficient information to allow the subsurface target to be characterised.

The Survey is anticipated to commence in November 2015 and will last up to two months.

Figure 4.1: SWAP Contract Area, 2D Seismic Survey Area and Provisional Seismic Lines



Note: The vessel will travel outside of the 2D Seismic Survey Area in order to turn at the end of each line

4.2 Overview of Seismic Survey Methods

4.2.1 Introduction

Seismic surveys are geophysical survey methods based on discharging directionally focused energy pulses into the subsurface by a seismic energy source. These acoustic waves propagate into the subsurface and are refracted/reflected to the surface where they are detected by seismic receivers (hydrophones in the offshore environment). There are two main types of seismic surveys - refraction and reflection:

- **Refraction** – This method is based on the analysis of refracted waves, where a proportion of the seismic energy will travel along the surface of the geological formation as a direct wave. When this wave encounters a boundary between two different soil or rock layers a portion of the energy is refracted and the remainder will propagate through the layer boundary at an angle. The refracted energy is recorded by a seismic receiver and interpreted by the seismic acquisition system.
- **Reflection** – This method is based on the analysis of reflected waves. When a wave reaches a boundary between two different soil or rock layer the wave is reflected back to the surface. This information is recorded by a seismic receiver and interpreted by the seismic acquisition system.

The most common geophysical method used in marine surveys is reflection. The technique involves discharging directionally focused energy pulses into the water column. To reach the desired depths below the seabed, seismic surveys use low frequency sound energy that can penetrate more than 6,000m below the seafloor.

The energy reflection is recorded by hydrophones which are either towed behind the survey vessel (towed streamer[1] survey) or placed on the seafloor (ocean bottom seismic survey):

- **Towed Streamer Survey** – The most common seismic survey method where hydrophones, in the form of streamers, are towed behind the vessel to detect the reflected energy; and
- **Ocean Bottom Seismic (OBS) Survey** - Hydrophones streamers or nodes are placed on the seafloor. This method is generally applied in areas not open to conventional streamer operations (of restricted manoeuvrability for example) or in which towed streamer data does not image the subsurface appropriately due to environmental conditions.

Analysis of the characteristics of these seismic reflections provides a profile of the underlying rock strata and identification of any formations which could be favourable to hydrocarbon accumulations.

A 2D towed streamer reflection seismic survey has been selected for the SWAP 2D Seismic Survey. This methodology provides fast acquisition and data processing turnaround for larger areas; it can be undertaken in shallow water areas and is less expensive than 3D surveys. Additionally, the level of detail expected will be sufficient to infill the existing 2D grid of data in the region.

4.2.2 Overview of the Proposed SWAP 2D Seismic Survey

A 2D towed streamer seismic survey will be undertaken as follows:

- A single energy source array will be towed directly behind the survey vessel and release a controlled pulse of sound energy at a pre-determined frequency and sound pressure level. A seismic airgun is the most common energy source used in towed streamer seismic surveys with multiple airguns typically arranged within a single source array or multiple source arrays (refer to Section 4.4.2 below for details of the proposed energy source for the 2D Seismic Survey).
- The seismic energy (sound) will travel through the water column to the seabed where it will travel through the geological layers below the seafloor and reflect back from the geological

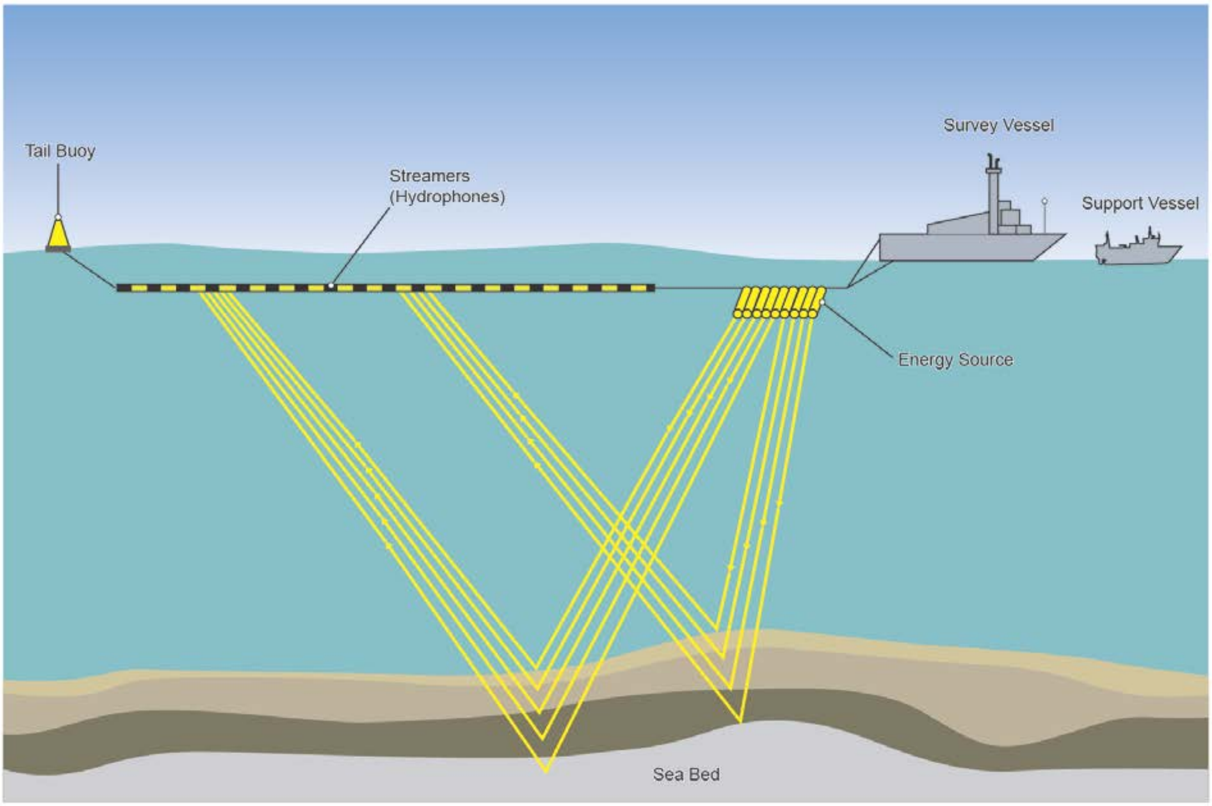
[1] A marine cable, usually a buoyant assembly of electrical wires approximately 5m below the sea surface that connects hydrophones and relays seismic data to the recording survey vessel.

formation towards the sea surface. The geological formations below the seafloor exhibit a difference in acoustic impedance, defined as the product of seismic wave velocity and density;

- The reflected energy will be detected by the hydrophones, which are towed behind the survey vessel embedded in the streamer. A tail buoy will be connected to the far end of the streamer to act as a hazard warning of the submerged towed streamer and provide positional information of the location and the depth of the equipment; and
- The reflected energy will be recorded by the hydrophones and the data sent back to the survey vessel, where it will be stored and processed. The depths and spatial extent of the strata are calculated and mapped, based upon the difference between the time of the energy being generated and subsequently recorded by the receivers.

Figure 4.2 provides a schematic representation of the proposed SWAP 2D Seismic Survey.

Figure 4.2: Illustration of 2D Seismic Data Acquisition Process using Towed Streamer



The survey vessel will travel along pre-determined survey lines defined by the survey team for the period of the Survey. The final location of the survey lines have not been defined, however their anticipated location is shown in Figure 4.1. There is potential for the survey lines to be adjusted by up to 100m before the commencement of the Survey; this will be based on the results of a hazard survey scheduled for Q3 2015.

Survey vessels have restricted manoeuvrability and, under maritime regulations, are given priority over vessels that are not similarly restricted. The survey vessel will therefore be accompanied by up to two support vessels which will:

- Ensure operational safety and maintaining an safety exclusion zone around the survey vessel and the streamer;
- Monitor the towed equipment;
- Warn maritime traffic of the ongoing surveying to ensure that other vessels do not cross the survey vessel right of way;
- Check for obstructions, uncharted shallow water and fishing equipment (which may need to be removed from the path of the vessel to avoid interference with towed equipment);

- Resupply consumables and diesel to the survey vessel and ship to shore solid and liquid waste for treatment and disposal;
- Provide support in emergency situations, including spills; and
- Crew changes.

The survey and support vessels will operate on a 24-hour basis during the 2D Seismic Survey[2]. The operational crew will be permanently stationed on both the survey and support vessels. It is expected that the crew will mobilise from the shore and crew changes will be completed by support vessels returning to shore or by helicopter approximately every 2.5 weeks. The frequency of crew change will vary depending on the contractor’s requirements.

4.3 Survey Activities

The 2D Seismic Survey will comprise of the following key activities:

- Mobilisation to the 2D Seismic Survey Area after the completion of pre-mobilisation checks in the port, including equipment upgrades where required. The survey vessel will be inspected and approved by the Marine BP Team prior to mobilisation;
- Deployment of survey equipment (streamer and energy source);
- Data acquisition - The energy source will be activated once the vessel is in position on the first pre-determined survey line (in the event of adverse weather conditions or mechanical problems it may be necessary to temporarily postpone the survey); and
- Demobilisation - On completion of the survey, towed equipment will be retrieved and vessels either return to port or move to another survey elsewhere.

It is planned to commence acquiring data along the survey lines in the 2D Seismic Survey Area (Figure 4.1) in November 2015 starting to the west of the Survey Area. Acquisition will commence at the start of each line with the activation of the energy source and recording system. Data will be recorded at regularly spaced intervals as defined by the end-user of the data. At the end of each line, all systems (including the airgun array) will be deactivated as the vessel moves to the next survey line.

Across the whole 2D Seismic Survey Area the following measures, which are designed to reduce potential impacts on marine mammals, will be adopted for the duration of the Survey:

- Vessel crew will be trained to undertake marine mammal observations;
- Trained vessel crew will conduct ongoing ad-hoc visual observations of Caspian seal (*Phoca Caspica*) in the vicinity of the survey vessel. All observations will be logged including location of sighting and number of individuals seen;
- Survey vessels will not intentionally approach seals for the purposes of casual marine mammal viewing;
- Airguns will not be operational during line changes;
- A soft start procedure will be used at the start of each survey line;
- Prior to the seismic source being activated using the soft-start procedure, marine mammal monitoring will be conducted by the trained vessel crew for a 30 minute period to observe whether there are any Caspian seals within 500m of the sound source (buffer zone). If Caspian seals are sighted, the soft-start procedure will be delayed for at least 20 minutes following which the trained crew will confirm no Caspian seals are within the buffer zone and the soft start procedure can start. The soft start procedure cannot start until no Caspian seals are observed within the buffer zone for a 20 minute period.

The following additional control measures will be implemented with respect to sensitive and very sensitive areas of the 2D Seismic Survey Area. These areas are defined within Chapter 5, Section 5.5.4.3:

[2] The operation of the energy source will not be continuous during this period (refer to Section 4.3).

    - Prior to mid-December 2D Seismic Survey activities will not be conducted in a very sensitive area.
    - The 2D Seismic Survey will be planned to avoid entering a sensitive area prior to mid December as far as possible. If it does become necessary to enter a sensitive area prior to mid December the following additional controls will be implemented:
- Prior to the seismic source being activated using a soft-start procedure, marine mammal monitoring will be conducted by the trained vessel crew for a 50 minute period to observe whether there are any Caspian seals within the buffer zone. If Caspian seals are sighted, the soft-start procedure will be delayed for at least 30 minutes following which the trained crew will confirm no Caspian seals are within the buffer zone and the soft start procedure can start. The soft start procedure cannot start until no Caspian seals are observed within the buffer zone for a 30 minute period; and
- When operations occur in hours of darkness, exterior vessel lighting will be limited to that necessary for ensuring safe operations.

The Survey will be planned to minimise interference with other sea users. Relevant maritime authorities and other sea users will be notified of the survey prior to commencement in accordance with BP's existing marine operations and geophysical survey pre-mobilisation procedures. Clear lines of communication and operational procedures will also be established between the survey vessel and support vessels before the start of surveying.

Throughout the survey, other vessels will be notified by appropriate signals in accordance with International Maritime Law; these will include communications via radio, including regular security broadcasts, lights and flags. Support vessels will be used to notify other vessels that are not contactable or are unaware of the International Maritime signal system**.**

The survey and support vessels will carry appropriate navigation lights for operating during night-time and periods of poor visibility. The level of lighting will be in compliance with safety regulations at sea to ensure operational safety needs.

4.4 Vessels and Equipment

4.4.1 Vessels

The M/V Gilavar vessel will be deployed for the Survey, which is a dedicated seismic research vessel used in previous surveys within the Azerbaijani sector of the Caspian Sea (Figure 4.3). The specifications of the survey and support vessels currently planned to be used to undertake the Survey are provided in Table 4.1.

Figure 4.3: Survey Vessel

Table 4.1: Survey and Support Vessel Specifications

Parameter	Unit	Specifications			
		Survey Vessel	Support Vessel 1	Support Vessel 2	Support Vessel 3
Name	-	***M/V Gilavar***	***Triumph***	***Svetlomor-2***	***Sanmar***
Owner	-	SOCAR	Topaz-Marine	CBARS	Topaz-Marine
Vessel length	m	84.9	67.4	61.0	33.1
Draft (mean)	m	5.9	4.8	4.5	4.6
Tonnage (gross)	tonnes	3779	2148	1695	354
Engine Size	kW	2400+1500 Thruster	5369	2600	2028
Cruising Speed	km/hr	20.3	22.2	18.5	16.7
Acquisition Speed	km/hr	7.4 - 9.3	7.4 - 9.3	7.4 – 9.3	7.4 – 9.3
Maximum Number of Berths	-	50	42	34	8
Fuel Tank Size	m^3	885	600	230	85
Fuel Consumption per day (normal working)	m^3/day	20	13	10	4
Fuel Consumption per day (steaming full speed)	m^3/day	20	18	12	3
Endurance	days	42	28	28	20
Lubricating Oil Capacity	m^3	22	44	10	+/- 2
Notes: It is planned to use two of the support vessels presented in this table during the survey. The selection of which vessels will be used will be decided at the time of the survey depending on availability.					

The hull of the M/V Gilavar is double skinned and there are multiple fuel tanks, which are double bottomed.

It is anticipated that the survey and support vessels will mobilise from Baku or one of the ports nearby. The support vessels will be re-fuelled in port and the survey vessel will either refuel at port every 2.5 weeks or be refuelled offshore by the support vessel.

4.4.2 Energy Source

The energy source will comprise a single array of airguns, arranged in two sub arrays. Airguns are underwater pneumatic devices that expel a bubble of air under pressure into the water. Once in the water, the bubble collapses and may oscillate several times. The acoustic signal thus produced consists of a sequence of positive and negative pulses that are proportional to the rate of change of volume of the air bubbles.

The energy source specifications for the 2D Seismic Survey are summarised in Table 4.2.

Table 4.2: Energy Source Specifications

Parameter	Unit	Specification
Total array volume	cu in	2098
Gun types	-	Bolt
Number of arrays	-	1
Number of sub arrays	-	2
Number of airguns per array	-	8
Nominal operating pressure	psi	2000
Array length	m	9
Array width	m	15
Tow depth	m	5 (+/- 1)
Distance from stern	m	TBC

Parameter	Unit	Specification
Peak-to-peak Sound pressure level (SPL)	dB re 1 µPA @ 1m	~241
Frequency of firing	m	25

The airgun array will produce short, sharp sound pulses (impulsive sound) with peak levels of short duration (less than 30 microseconds). The sound pressure level (SPL) for the proposed 2D Seismic Survey is estimated as 241 dB re 1 µPa @ 1 m [3].

The primary output of a seismic source has most of the energy in the frequency bandwidth between 10 and 300 Hz, which is the frequency bandwidth of most interest in seismic surveying, However, array pulses also contain high frequency energy (up to 500 - 1000 Hz). Although this high frequency components are weak compared to the low-frequency components, they may be above the ambient sound level.

In open, non-stratified waters, the amplitude of sound waves declines proportionately with distance from the source due to attenuation of the water column and the seabed. This weakening of the signal with distance is frequency dependent, with stronger attenuation at higher frequencies.

Seismic sound attenuation also depends on the energy radiation pattern. Figure 4.4 provides an example of the sound pressure distribution from a seismic source array (parallel and perpendicularly to the boat axis). The pressure is released in all directions, but not in a symmetrical and uniform way. The source array is designed so that the energy is predominantly directed vertically downwards towards the seabed (source directivity) and sound levels are highest below the array. SPLs could be approximately 10 to 30 dB less off-axis in the horizontal directions due to directivity of the source and existing interference (including sea surface reflections).

4.4.3 Streamer

The seismic streamer detects the very low level of reflection energy that travels from the seismic source, through the water downwards into subsurface and back, using pressure sensitive devices called hydrophones. The hydrophones convert the reflected pressure signals into electrical energy that is digitised and transmitted along the seismic streamer to the recording system on board the survey vessel, where the data is recorded on a suitable medium such as magnetic tape.

The proposed specifications for the streamer to be used in the Survey are provided in Table 4.3.

Table 4.3: Streamer Specifications

Parameter	Unit	Specification
Length	m	4500
Tow depth	m	6 (+/- 1)
Type	-	Q-Marine solid

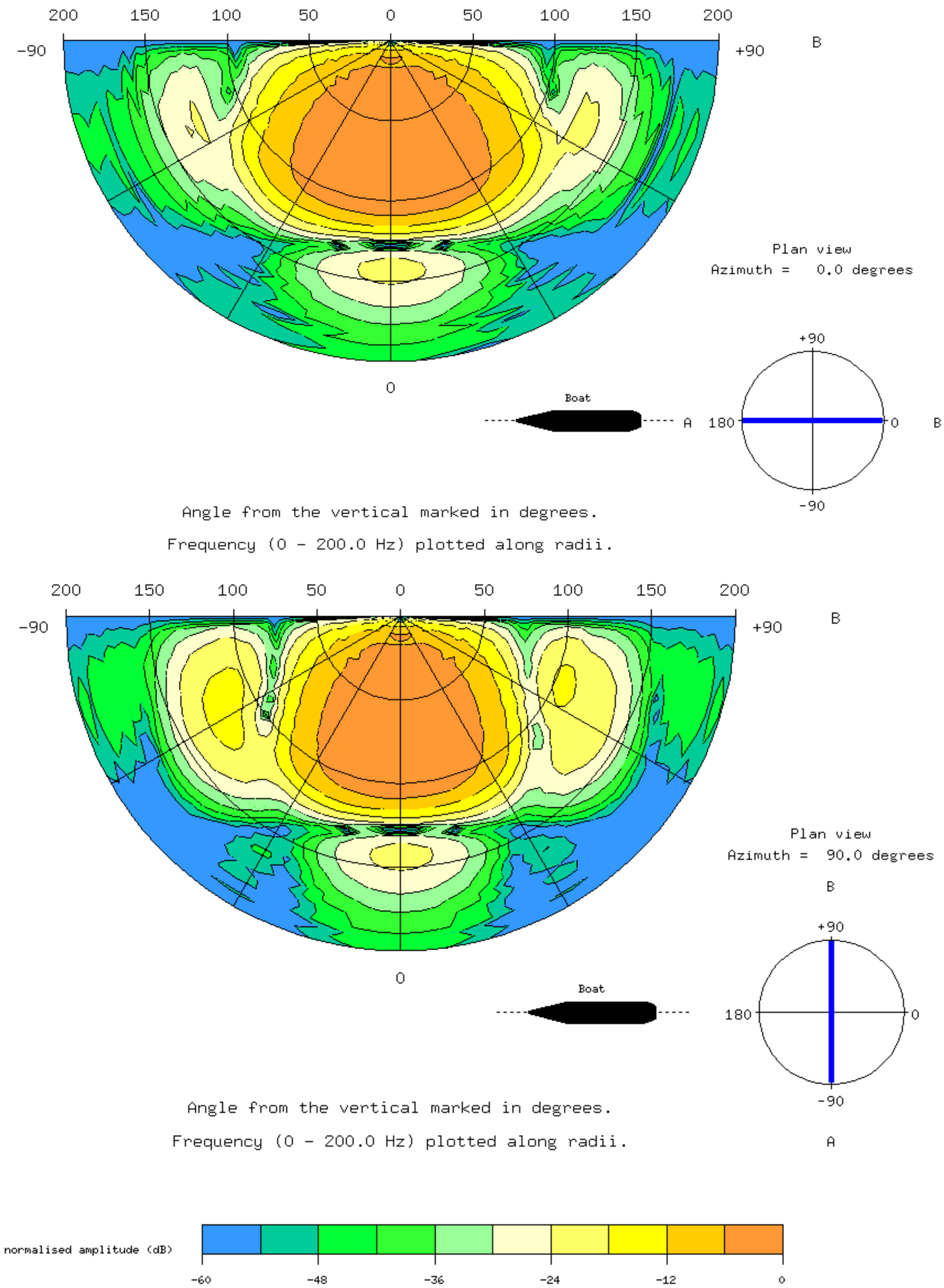
The solid type streamer to be used in the Survey is proven to provide superior sound performance, greater dynamic towing stability, and higher resistance to physical damage compared to fluid-filled streamers. It provides the capability of extending operations into marginal weather windows, allows stable towing at shallower depths to optimise high-frequency acquisition where required, and is environmentally benign, making it the streamer of choice in environmentally sensitive areas.

The streamer will be towed behind the survey vessel at a fixed depth. External devices which will be attached to the streamer will include acoustic positioning units, depth control units (often referred as

[3] It is important to note that source level is used as a measure of the strength of an energy source at a nominal 1m distance from the source, whereby for a distributed source such as an airgun array, a pressure level is either modelled or measured at some distance from the source array (far-field), where energy from individual elements is assumed to add constructively and is corrected back to a theoretical 1 metre distance from the source. In reality the sound level close to a distributed source such as airgun array (near field) is lower than this (17dB) due to the interaction between source elements and energy from individual elements not adding constructively. The calculated near field and far field characteristics of the 2D seismic survey array are presented within Appendix 6A: Underwater Sound Study of this ESIA.

"birds") and a tail buoy. Power to these systems will be provided both through the streamer itself and by batteries in each external device.

Figure 4.4: Source Directivity Plot, on a 4135 cu.in Source Array



N.B. Colours indicate relative pressure levels: orange the highest and blue the lowest[4]

4.5 Emissions, Discharges and Waste

4.5.1 Emissions to Atmosphere

The main source of atmospheric emissions during the 2D Seismic Survey will be from burning of fuel to power the engines, compressors and electrical generators onboard the survey and support vessels. Other minor emissions will result from incineration of combustible waste materials onboard the survey vessel. Gases emitted from the fuel combustion processes comprise:

- Carbon dioxide (CO_2);
- Nitrogen oxides (NO_x, N_2O);
- Sulphur oxides (SO_x);
- Methane (CH_4);
- Volatile organic compounds (VOC);
- Carbon monoxide (CO), and
- Particulate matter.

All shipboard emissions will be in compliance with MARPOL 73/78 Regulations for the prevention of air pollution from ships (Annex VI), aiming to reduce global emissions of SO_x, NO_x and particulate matter.

Table 4.4 summarises the greenhouse gases (GHG: i.e. CO_2 and CH_4 [5]) and non GHG emissions predicted for the proposed Survey due to operation of the survey and support vessel engines.

Table 4.4: Estimated GHG and Non GHG Emissions Associated with Survey Activities

Emissions	Estimated Volume (tonnes)
CO_2	**9,088**
CO	**23**
NO_x	**168**
SO_x	**23**
CH_4	**1**
NMVOC	**7**
GHG	**9,231**

Notes:
1. Emission Factors were taken from the E&P Forum Report (No. 2.59/197);
2. One survey vessel (M/V Gilavar - engine size 2400kw plus 1500kW thruster) and 2 support vessels will be used for the 2D Seismic Survey. As a worst case it is assumed the two larger support vessels will be used: Triumph - engine size 536kW and Svetlomor2 - engine size 2600kW;
3. It is assumed that all vessels will operate at normal working speed during the Survey and will travel at full speed to shore for refuelling and supplies;
4. The duration of Survey is up to 2 months (60 days);
5. During the Survey, the survey vessel will travel to shore at full speed twice (4 days in total).Support vessels will each travel to shore at full speed 3 times (6 days in total).
6. Fuel consumption rates for each vessel and for full and normal working speeds are presented in Table 4.1.

4.5.2 Hazardous and Non Hazardous Waste Streams

Survey and support vessels generally produce a relatively small range of waste streams. The types of wastes produced during a typical seismic survey are listed in Table 4.5, along with their constituents and proposed disposal routes.

Hazardous materials handled during the 2D Seismic Survey will include fuel (typically diesel), hydraulic and other utility oils, paints and solvents, batteries, refrigerants and cleaning chemicals (Table 4.5). Strict handling procedures will be in place for all of hazardous materials on board the

[4] International Association of Oil & Gas Producers (OGP) and International Association of Geophysical Contractors (IAGC), 2011. An overview of marine seismic operations. Report No. 448, April 2011.
[5] To convert to CO_2 equivalent the predicted volume of CH_4 is multiplied by a global warming potential of 21.

survey and support vessels and the vessel crews will be trained in chemical handling and spill response.

In addition to the compliance with the MARPOL 73/78 requirements, BP's AGT Region Waste Manual will be adhered to, to ensure that all wastes will also be managed in compliance with BP's standards.

Table 4.5: Types of Waste Streams Produced During a Typical Seismic Survey[6]

Waste Category	Main Constituents	Handling and Disposal Route
Non Hazardous Waste		
Garbage (non-combustible)	Plastic, glass, domestic waste	Segregated and compacted waste is stored onboard for disposal at suitable facilities onshore.
Garbage (combustible)	Paper, packaging, wood	Incinerated using MARPOL compliant onboard incineration facilities (most garbage is amenable to incineration with the exception of metal and glass; special rules on incineration may apply under domestic law in some ports; the incineration of plastic is subject to specific regulations).
Food Waste	Organic nutrients	Incinerated using MARPOL compliant onboard incineration facilities; the resulting ashes will be transferred to shore for disposal at licensed facilities.
Bilge water[7]	Residual hydrocarbons and inorganic substances	Stored on board and transferred onshore for treatment and disposal at licensed waste facilities.
Sludge	Residual hydrocarbons and organic and inorganic substances	Either incinerated onboard using an International Marine Organisation (IMO) approved incinerator or stored onboard and transferred onshore for treatment and disposal at licensed waste facilities.
Hazardous Waste		
Clinical waste	Pathogenic organisms, plastic, glass, medicines, needles	Segregated and stored separately for disposal/ incineration at authorised onshore medical facilities.
Acids	Acids refer to substances and mixtures with a pH less than 7	Segregated and stored separately to be transferred to shore for safe disposal at licensed hazardous waste management facilities. All hazardous waste streams will be managed in compliance with the requirements of BP's AGT Regional Waste Manual.
Solvents, degreasers and thinners	Organic solvents used as industrial cleaning solutions (degreasers) and paint thinner	
Paints and coatings	Water-based liquid paints and oil/solvent based liquid epoxy resin paints, lacquers and varnishes.	
Contaminated materials	Various materials that are lightly contaminated with oils, chemicals, etc.	
Adhesives, resins and sealants	Solvent based adhesives	
Waste oil /fuel	Used refined petroleum distillates incl. engine lubrication oil, motor oil, transmission oil and hydraulic fluid. Diesel from generators etc. that cannot be reused	
Batteries	General purpose batteries	

[6] Waste streams listed in the table have been categorised based on MARPOL's waste categories and BP AGT Region Waste Manual waste streams. Refer to Appendix 5A for a comparison between these categories.
[7] Bilge water is water generated in the bilge of the ship's machinery spaces and therefore may be contaminated with oil and other substances, some of which may be harmful if discharged directly to the marine environment.

The following waste management criteria and protocols will be implemented throughout the 2D Seismic Survey:

- In accordance with MARPOL 73/78 requirements, survey and support vessels will maintain an Oil Record Book. The book will be used to record how, when and where waste oil, bilge water, oily material, sludge etc., are disposed of. Recognised waste disposal authorities or contractors will undertake disposal of any waste generated onboard. Disposal details will be recorded in the vessel's Oil Record Book;
- Survey vessel and support vessels will maintain a Garbage Management Plan and Garbage Record Book to record how waste items, other than mentioned above, are managed and disposed of. The Garbage Management Plan will classify waste types according to MARPOL specification and BP's AGT Region Waste Manual and lists item type , quantity stored on-board, waste delivered ashore, and how much waste has been generated (e.g. food waste, incinerator ash); and
- All wastes will be will be shipped to shore for disposal in accordance with the existing AGT waste management plans and procedures.

4.5.3 Discharges to Sea

Aqueous discharges to sea associated with the 2D Seismic Survey and support vessels will comprise:

- Grey water;
- Treated black (sewage) water;
- Deck drainage; and
- Ballast water[8].

Aqueous discharges from the vessels will comply with the standards set out by[9]:

- National authorities (i.e. the MENR) within the Framework Convention for the Protection of the Marine Environment of the Caspian Sea; and
- The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78 *(as amended)),* more specifically Annexes I and IV.

It is expected that survey and support vessels will produce an estimated daily average of 5 and 200 litres of treated black (sewage) water and grey water per man, respectively. Grey water and black water will be discharged to sea in accordance with MARPOL 73/78 Annex IV: Prevention of Pollution by Sewage from Ships standards and the SWAP Production Sharing Agreement (PSA) requirements i.e. no floating solids will be observed on water surface. If treatment is not possible (e.g. due to unavailability of the treatment unit) sewage will be stored and shipped to shore for treatment and disposal.

In accordance with the PSA, deck drainage and wash water will be discharged as long as no visible sheen is observable. Oily and clean drainage or wash water will be segregated; clean water will be discharged to sea and oily water transported to an appropriate onshore disposal facility.

[8] Ballast water is essential for safe operating conditions of vessels in the marine environment, and fulfil a number of functions: (i) reduces stress on the hull; (ii) provides transverse stability; (iii) improves propulsion and manoeuvrability; (iv) compensates for weight lost due to fuel and water consumption. Ballast water can contain multitude of marine species including bacteria, microbes, small invertebrates, eggs, cysts and larvae of various species.

[9] The SWAP PSA states that black and grey water may be discharged into the sea from a certified bio-treatment unit following treatment in accordance with the requirements of the EU Council Directive 91/271/EEC. This directive relates to urban waste water treatment and is not considered applicable to vessels. MARPOL 73/78 Annex IV standards are considered international best practice with regard to vessel discharges and have been adopted for vessel discharges across the Azerbaijan sector of the Caspian Sea.

5 Environmental and Socio-Economic Description

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5.1 Introduction

This Chapter describes the environmental and socio-economic baseline conditions relevant to the Shallow Water Absheron Peninsula (SWAP) 2D Seismic Survey. The purpose of the chapter is to provide sufficient information to allow the potential impacts of the SWAP 2D Seismic Survey activities to be assessed in accordance with the assessment methodology as set out in Chapter 3 of this Environmental and Socio-economic Impact Assessment (ESIA). The scope and content of this Chapter has therefore been determined based on the anticipated environmental and socio-economic interactions identified during the SWAP 2D Seismic Survey scoping process.

This Chapter provides relevant information on the following relating to environmental baseline conditions:

- Physical setting including a summary of seismicity, geology, meteorology and climatic conditions relevant to Caspian region as a whole (i.e. the entire geographic area in which the Caspian Sea is located) and to the 2D Seismic Survey Area;
- Marine setting including an overview of bathymetry and oceanography within the Southern basin of the Caspian Sea in which the 2D Seismic Survey Area is located and within the 2D Seismic Survey Area itself;
- Seabed and water column environment including the physical, chemical and biological/ecological conditions within the 2D Seismic Survey Area and in the surrounding area including routes known to be used by migrating fish and seals; and
- Characteristics of locations and routes used by overwintering, migrating and nesting birds along the Azerbaijani coastline, specifically within the Absheron region.

With regard to socio-economic baseline conditions, information is provided relating to:

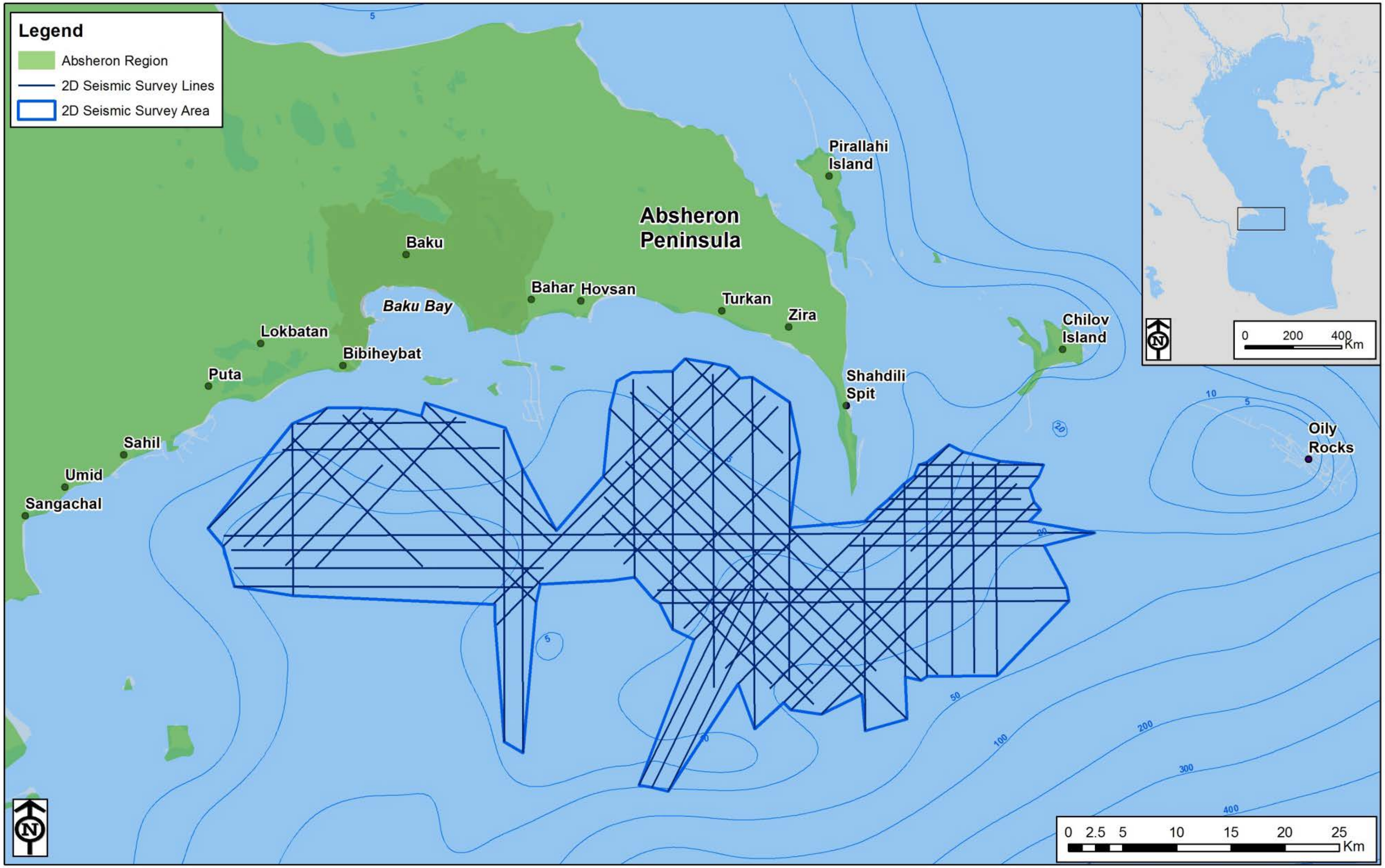
- Commercial fishing within the Azerbaijani sector of the Caspian Sea and within the 2D Seismic Survey Area;
- Small scale and recreational fishing undertaken along the coastline of the Absheron region;
- Recreational activities undertaken within the vicinity of the 2D Seismic Survey Area and along the coastline of the Absheron region; and
- Aspects associated with commercial shipping and fishing including shipping routes, ports and existing offshore infrastructure within the vicinity of the 2D Seismic Survey Area and along the coastline of the Absheron region.

In addition, a brief summary of potential marine cultural heritage sites located within and in the vicinity of the 2D Seismic Survey Area is provided.

The geographic scope of the data presented has been determined based on the anticipated nature and scale of the potential impacts with regional and national information provided where relevant.

Figure 5.1 shows the location of the SWAP 2D Seismic Survey Area relative to the Absheron Peninsula and the Absheron region, the city of Baku, the man made Oily Rocks industrial settlement and other key coastal locations including the towns of Sangachal, Umid, Sahil Puta, Lokbatan, Bibiheybat, Bahar, Hovsan, Turkan, Zira and Chilov and Pirallahi Islands.

Figure 5.1: SWAP 2D Seismic Survey Area in the Context of the Absheron Region



5.2 Data Sources

This Chapter has been prepared based on the following:

- Review of other available BP and third party ESIAs completed for projects in the Azerbaijan sector of the Caspian Sea and specifically within or in close proximity to the SWAP 2D Seismic Survey Area, including:

    - Azeri Chirag Guneshli (ACG) ESIAs and Environmental Technical Notes (ETNs). The ACG Contract Area is located 35km west from the SWAP 2D Seismic Survey Area. The ACG subsea export pipelines connect five production platforms in the ACG Contract Area to the onshore Sangachal Terminal. The ACG pipeline corridor passes from the east of the 2D Seismic Survey Area, through the south east corner and along the southern boundary into Sangachal Bay. ACG ESIAs and ETNs reviewed include:
        - ACG Regional Seismic EIA, 2015[1]
        - East Azeri 4D Seismic Survey ETN, 2011[2]
        - Chirag Oil Project ESIA, 2010[3]
        - ACG Phase 1-3 ESIAs, 2002 - 2004[4,5,6]
    - Shah Deniz (SD) ESIAs. The SD Contract Area is located south east of the SWAP 2D Seismic Survey Area with the northwest corner overlapping with the Survey Area. Currently one operational platform is present in the SD Contract Area, exporting hydrocarbon products to the Sangachal Terminal via the SD1 subsea export pipelines. An additional offshore platform complex, export pipelines and an associated expansion of the Terminal is planned as part of the SD Stage 2 Project. SD ESIAs reviewed include:
        - SD Stage 1 and Stage 2 ESIAs, 2002 & 2013[7,8]
    - Bahar Gum Deniz ESIA[9]. The Bahar Gum Deniz Contract Area is located between the east and west sections of the SWAP Contract Area. An ESIA was prepared to obtain permission to undertake explorative activities (e.g. seismic survey, drilling of an exploration well and geotechnical investigations) and included primary data gathering.
    - Hovsan Wastewater Treatment Plant (WTP) Sea Outfall Construction[10]. Located 5 km to the north of the 2D Seismic Survey Area. In 2009 an EIA was prepared associated with the construction of a treated sewage outfall pipeline approximately 9km in length. As part of the EIA a survey was undertaken along the proposed pipeline route extending to 8km offshore to characterise sediment and water quality.

- Primary data held by BP associated with the studies and surveys undertaken to support the BP ESIAs listed above and ongoing operational monitoring data collected as part of the Environmental Monitoring Programme (EMP). The EMP provides a consistent, long-term set of data in the vicinity of BP's operations in Azerbaijan and includes regular monitoring of physical, chemical and ecological characteristics in the marine environment at established sample stations.

[1] AECOM, 2015, ACG Regional Seismic Environmental Impact Assessment (EIA)
[2] Azerbaijan Environmental and Technology Centre (AETC), 2011. East Azeri 4D Seismic Survey EIA
[3] URS, 2010, Chirag Oil Project Environmental and Socio-Economic Impact Assessment (ESIA)
[4] URS, 2002. Azeri, Chirag & Gunashli Full Field Development Phase 1 ESIA.
[5] RSK, 2002. Azeri, Chirag and Gunashli Full Field Development Phase 2 ESIA.
[6] URS, 2004, Azeri, Chirag & Gunashli Full Field Development Phase 3 ESIA.
[7] URS, 2002, Shah Deniz Stage 1 Project ESIA.
[8] URS, 2013. Shah Deniz Stage 2 Project ESIA.
[9] Ekol on behalf of Bahar Energy Ltd, 2012, Bahar Gum-Deniz Project EIA.
[10] Seureca-ASPI, 2009. Environmental Impact Assessment Study for Hovsan Wastewater Treatment Plant Sea Outfall Construction.

- Primary data gathered as part of the Baku Dredge Spoil Site Project[11]. A survey of 10 sample stations undertaken in 2004. The site is located east of Baku Bay, approximately 1.7km north of the 2D Seismic Survey Area.

- Primary data collected during earlier coastal sensitivity mapping exercises completed in 2003 and 2014.

- Secondary data collected through consultation with local organisations including:
    - Institute of Zoology;
    - Natural History Museum;
    - Caspian Shipping Company;
    - The Ministry of Environment and Natural Resources (MENR);
    - Institute of Botany;
    - Institute of Archaeology and Ethnography (IoAE);
    - The Ministry of Tourism (MoT);
    - Azerbaijan Committee of Urban Planning and Architecture;
    - The State Oil Company of Azerbaijan Republic (SOCAR); and
    - Temiz Sheher.

- Secondary data and literature publically available on the internet including reports published by International Union for Conservation of Nature (IUCN); United Nations Environment Programme Global International Waters Assessment (UNEP / GIWA), the World Bank and the Internally Displaced Monitoring Centre (IDMC).

Baseline data collection is ongoing for the SWAP Contract Area; however, the primary focus of this data collection is to inform the 3D Seismic Survey Area ESIA. The SWAP 3D Seismic Survey Area covers both onshore and offshore environments and it is anticipated that the ESIA will be submitted in Q4 2015.

5.3 Physical Setting

5.3.1 Geology and Seismicity

The Caspian Basin represents one of the largest continental lake systems in the world. The recent geological sequence is characterised by Fluvial Deltaic sandstones and Lacustrine Shales. Sedimentation rates were rapid with 8km of sediment deposited over six to ten million years. Pliocene deposition in a low gradient, lacustrine basin formed regionally extensive sandstone sheets. Fluctuations in lake level, driven primarily by climate change, allowed rapid large scale avulsion of the Volga Delta and the deposition of laterally continuous lacustrine Shales.

Geological data obtained from surveys undertaken in 2002[4,5] indicated that the area south of Baku Bay is likely to comprise the Akchagyl and Absheron formations, which are primarily claystones with layers of siltstones and sandstones. Below these deposits are Pliocene hydrocarbon-producing deposits of the Surakhany (anhydrites), Sabunchi, Balakhany and Pereriv formations.

The dominant geological structures of the Caspian region were formed during the period of tectonic movement between the Arabian and Indian continental plates that resulted in the formation of the Caucasus Mountains and the associated basin and plateau structures that form the Caspian and adjacent onshore regions. Subsequent periods of tectonic compression (mainly during the Late Pliocene period) resulted in the production of a number of folded structures within the region, forming a number of anticlines (upward thrusting folds)[5].

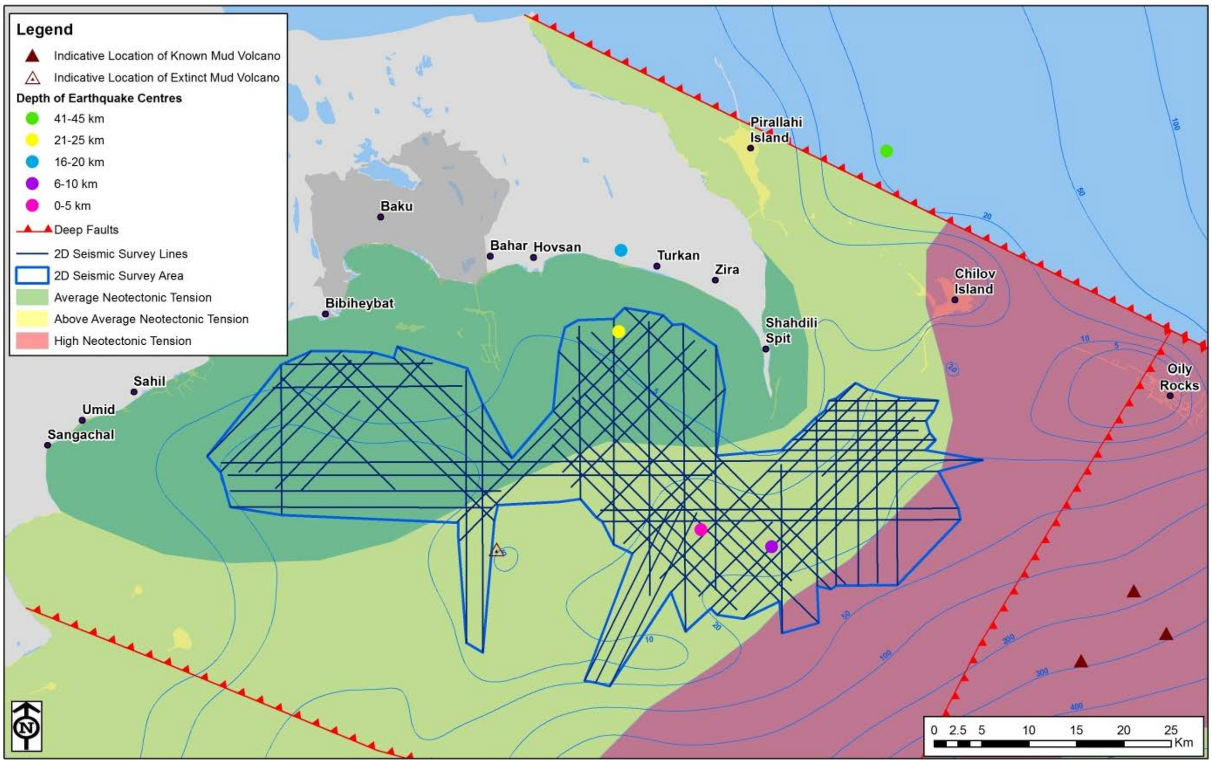
The convergent plate boundary between the Arabian and Indian continental plates in the Caspian region, which is part of the Eurasian continental plate, results in the region being subject to relatively high levels of seismic activity, typically accompanied by earthquakes and volcanism. The Southern Caspian (in which the 2D Seismic Survey Area is located - refer to Figure 5.2 below) is located in an

[11] BP, 2004, Dredged Sediment Disposal Site Assessment Report

area where a number of regional microplates and smaller plates meet and, as such, is characterised by a considerable amount of both low and high intensity earthquake activity. Current neotectonic (more recent) processes are leading to convergent movements of these plates of 1.8cm/year in the Caspian region[12]. Figure 5.2 shows the SWAP 2D Seismic Survey Area is located partially in areas classified as subject to average and above average neotectonic tension with a small portion of the 2D Seismic Survey Area in an area classified as subject to high neotectonic tension. Figure 5.2 also shows the location and depth of recorded earthquakes within the area.[1] Five earthquakes with a magnitude greater than 6.0 on the Richter scale have occurred in Azerbaijan since 1842 with the most recent, measuring 6.5, on 25th November 2000 with an epicentre 30km east-north east of Baku.

While further studies are planned for Q3 2015 to identify seabed features including potential mud volcanos across the 2D Seismic Survey Area, the indicative locations of known mud volcanoes at the time of writing located within and in the vicinity of the 2D Seismic Survey Area are also shown in Figure 5.2 (including the Makarov Bank which is understood to be an extinct mud volcano). It is estimated that there are more than 170 mud volcanoes located across the Caspian Sea[2]. These phenomena are formed as a result of overpressurising of muds and are found most commonly in areas where there are thick, rapidly deposited young sediments. In addition to the basic mud medium, rock fragments, water, gas and oil often erupt from the volcanoes, depositing sediments highly distinguishable from the well sorted clays, silts and sand deposits of the surrounding seabed.

Figure 5.2: Seismic Characteristics in the Vicinity of the 2D Seismic Survey Area, including the Locations of Mud Volcanoes and Earthquake Centres



5.3.2 Meteorology and Climate

5.3.2.1 Temperature

The climate along the coastline of the Absheron region is classified as being warm and semi-arid. Based on meteorological data collected at Baku and Puta the annual mean air temperature is approximately 14 degrees Celsius (°C). Summers are warm with typical maximum air temperatures in the order 35-40°C. January is the coldest month with an average of 0°C. Temperature extremes of –16°C and 41°C have been recorded historically in January and July, respectively[8].

[12] Karabanov, Institute of Geology, *pers comm*.

Offshore air temperatures exhibit a wide degree of variation. The average air temperatures above the Caspian Sea typically peak at 25.5°C during the summer, and may drop to 0°C for some periods in the winter[13].

5.3.2.2 Precipitation

Based on the rainfall data collected from the meteorological station at Baku, mean annual rainfall from 1992 to 2006 was 263mm. The maximum monthly rainfall from 2002 to 2006 was 184mm in December 2002. October to February were wet months receiving an average of 41 to 79mm rain/month, with drier months occurring from July to August receiving an average of 1 to 5mm rain/month[8].

5.3.2.3 Wind

In regional terms, the wind conditions are influenced by the north-south orientation of the Caspian Sea as well as the physical and geographical conditions of the coastline. Based on data collected during 2007 at Baku Airport[14] the predominant wind direction in the vicinity of Baku is north, occurring approximately 15% of the year. North-north-westerly and north-north-easterly winds account for approximately 10-12% of other winds. Wind speeds typically range from 0.5m/s to 12m/s with approximately 30% of winds being greater than 8m/s. Strong winds and storms can arise at any time of the year but are more frequent during the winter months with the largest number of days with storm winds of more than 15 m/s occurring on the Absheron Peninsula[8].

5.3.2.4 Visibility

Moisture saturated air converges in the south-west Caspian giving rise to foggy conditions during the winter months. Such conditions are expected to occur for around 10% of the year, mainly between October and May[13].

5.4 Marine Setting

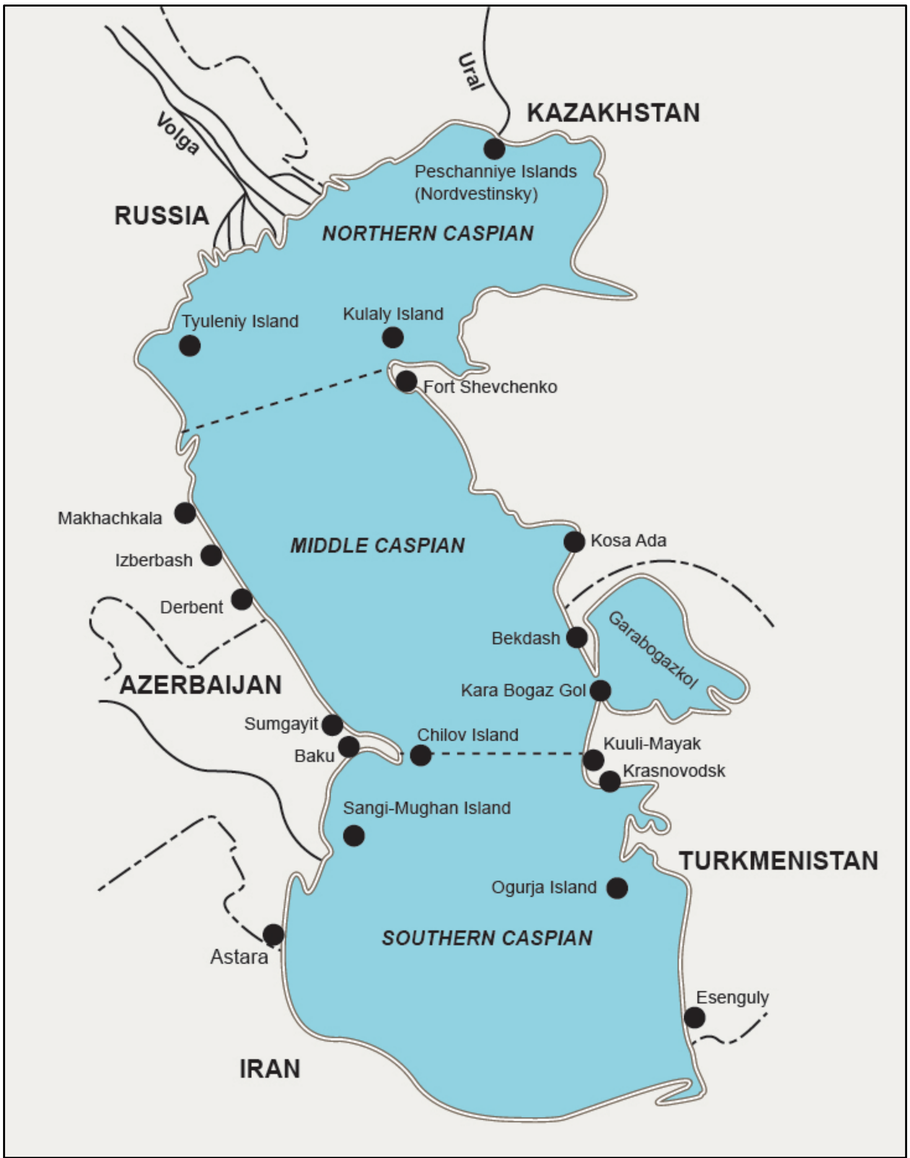
5.4.1 Bathymetry and Oceanography

The Caspian Sea is the largest landlocked water body on earth with a surface area of approximately 371,000km^2. It is fed by numerous rivers; the largest of which is the Volga to the north. The Sea is made up of three basins: the Northern, Central and Southern Basins (Figure 5.3). The Northern Basin is the smallest (about 25% of the total surface area), but is very shallow. The Central and Southern Basins have similar surface areas, but the Southern Basin is deeper and contains almost twice the volume of water as the Central Basin. The deepest recorded depth is in the Southern Basin at just over 1,000m.

The Absheron Ridge, which separates the Central and Southern Basins, is a narrow section of relatively shallow water (between 50 to 300m deep) which extends from Absheron Peninsula to the Khazar Peninsula on the east coast of Turkmenistan. The SWAP 2D Seismic Survey Area is located within the Southern Basin. The SWAP 2D Seismic Survey Area is located within a shallow subsea plateau that gently slopes offshore from the coast to a distance of approximately 20 to 35 km offshore and includes a small section of the Absheron Ridge. As shown in Figure 5.1, depths across the SWAP 2D Seismic Survey Area vary from less than 5m nearest to the coastline to up to 50m towards the east and south.

[13] Kosarev, A.N. and Yablonskaya, E.A., 1994. The Caspian Sea. SPB Academic Publishing, The Hague.
[14] The anemometer is located 10m above ground level.

Figure 5.3: Location of the Northern, Central and Southern Basins of the Caspian Sea[15]



5.4.1.1 Sea Level

The Caspian Sea experiences significant short term and long term water level fluctuations and is one of the few water bodies in the world where the water level is lower than that of the world's oceans. While sea levels were observed to fall between the 1930s and 1970s, in 1978 they had increased before falling again up to 1996. More recent measurements between 2002 and 2006[16] showed that the Caspian Sea level is again rising at a mean rate of +7.5 cm/year. The continued rise in sea levels has resulted in the inundation of low-lying areas, the formation of lagoons, and the development of islands. The current water level is approximately 27-28m below sea level.

5.4.1.2 Wave and Current Regime

Wind induced waves in the 2D Seismic Survey Area are a predominant feature of the Southern Caspian. Storms in the Caspian region blow along a north-westerly/northerly axis, although the Absheron Peninsula shelters the 2D Seismic Survey Area from the most severe of these storms. A large gradient in extremes of waves also exists across the region. A maximum wave height of 14m in

[15] Aladin , N. and Plotnikov I., 2004. The Caspian Sea. Lake Basin Management Initiative, Thematic Paper.
[16] Lebedev S. and Kostianoy A., 2006. Satellite Altimetry of the Caspian Sea.

the Southern Caspian Basin has been recorded[17]. During normal wind conditions wave heights are generally less than 1m[8].

The Caspian is effectively a non-tidal water body, and any currents are primarily wind generated. Currents of the region are complicated and are affected by season with lower current speeds measured during summer as compared to winter. The severity of winter also affects current speeds and currents may be strong at both the surface and near the sea bed.

The predominant direction of the strong currents is from the north east. The currents may act from surface to seabed, or surface flows may differ from the deepwater flows whereby strong currents may act in either layer. The currents may be driven directly by local weather events or by distant forcing mechanisms. In the latter case the currents may occur during periods of unremarkable local weather[8].

The mechanism that drives the current can be traced back to the Northern Caspian Basin. Here, very cold winter air temperatures, shallow waters and large fluvial inputs from rivers, lead to rapid ice development and the formation of a reservoir of cold, dense water on the boundary with the Central Caspian Basin. The cold water is transported along the western Central Caspian Basin under the influence of cyclonic winds associated with the winter low pressure trough. A component sinks and flushes the bottom waters of the Central Caspian Basin, but in normal years a large volume finds its way over the western section of the Absheron sill and into the Southern Caspian Basin where it appears to mix and sink. A counter flow of relatively warm Southern Caspian Basin water along the eastern section of the Absheron sill balances the cold water inflow[8].

The irregular depth of the Absheron shelf complicates the winter seasonal flow further. The shelf is deeper on the western side (with a maximum depth of over 200m), than on the eastern side (where depths are usually less than 150m). Therefore, the cold water inflow penetrates beneath the level of the warm water outflow. This is thought to cause currents along the continental slope of the eastern shelf to flow towards the west[8].

The overall circulation pattern within the 2D Seismic Survey Area is in a clockwise direction, while prevailing currents in the south west of the SWAP 2D Seismic Survey Area are southward along the coast[12]. This can lead to higher turbidity in the area[18].

5.4.1.3 Storm Surges and Waves

Storm surges occur in the Caspian Sea causing temporary rises or falls in sea level. Significant sea level changes occur in the Central Caspian Basin. These events are associated with persistent strong winds, particularly the strong prevailing regional winds that blow along the axis of the Caspian Sea, from north and north west or from the south and south east. Strong winds from the north are more frequent and more severe than strong winds from the south. Waves in the Caspian Sea are wind driven and subsequently the windiest months also exhibit the greatest wave action.

Wave height data recorded at Oily Rocks indicates that the months of July, August and September have the strongest winds and storms, with a greater frequency of wave heights in excess of 2m recorded. The period of October to February, however, shows the greatest number of wave heights between 1 and 2m, reflecting the steady occurrence of strong winds during this period[8].

South of the Absheron Peninsula, northerly winds create a fall in sea level while southerly winds result in a rise. In Baku Bay this change can be ±70-80cm. The typical time period for a storm surge is estimated to be 6-24 hours[8].

The area of greatest wave development extends from the western portion of the Central Caspian Basin, down and across the central section of the Absheron Ridge.

[17] Marine Annual Reference Books, cited in Woodward-Clyde International, 1996
[18] Wei Shi and Menghua Wang, 2010. ‘Characterization of global ocean turbidity from Moderate Resolution Imaging Spectroradiometer Ocean Color Observations’.

5.5 Marine Environment

To establish the anticipated physical, chemical and biological characteristics of the seabed environment and the water column within the SWAP 2D Seismic Survey Area, the data sources as listed within Section 5.2 were reviewed. This included survey data collected between 2004 and 2014 from surveys conducted in and adjacent to Sangachal Bay, along the ACG offshore pipeline corridor and as part of the ACG Regional water column survey, to the east of Baku Bay at a Dredge Spoil Site, along the route of a proposed outfall from the Hovsan WTP, within the Bahar Gum Deniz Contract Area and to the north of the SD Contract Area.

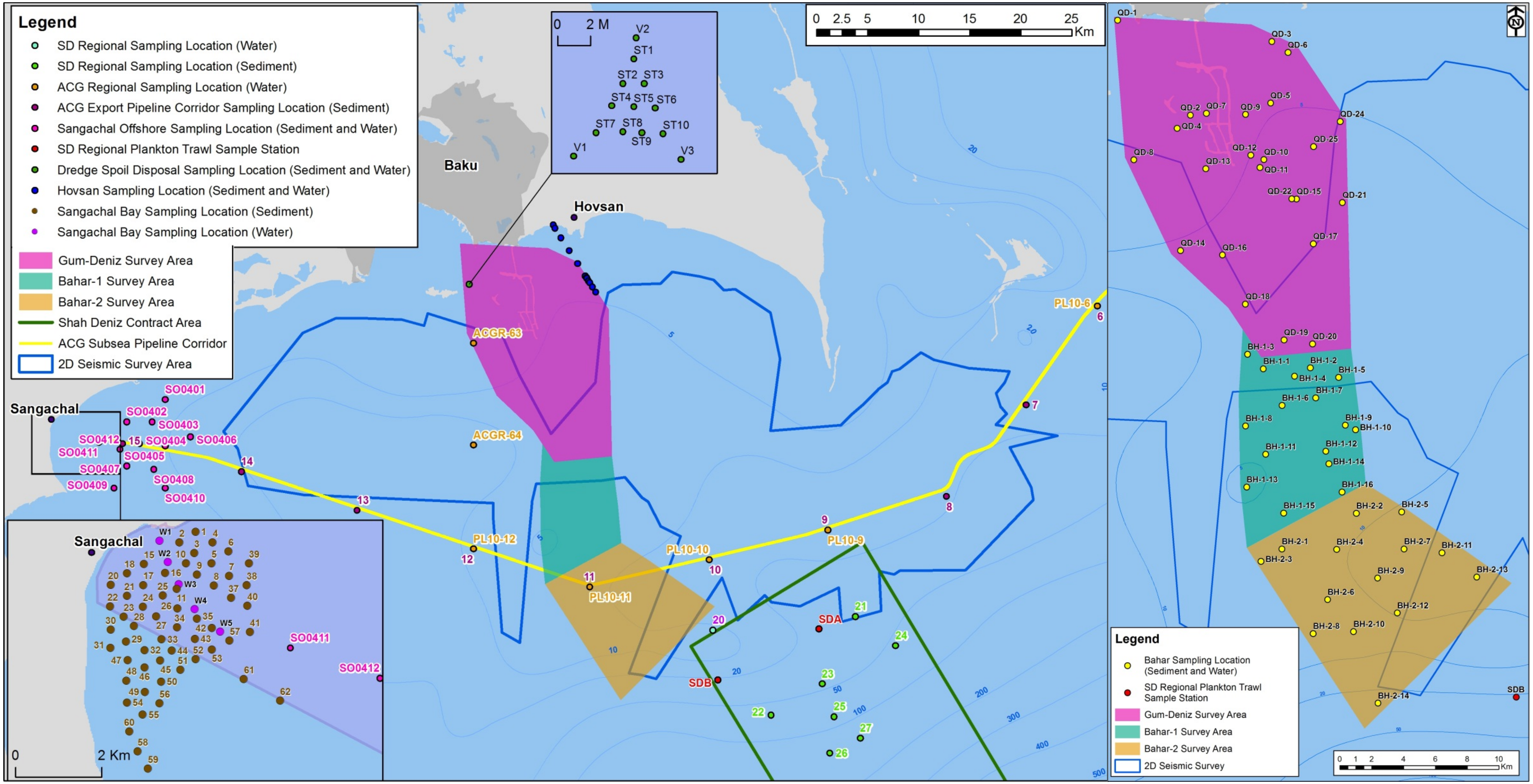
Figure 5.4 shows the locations of the sampling stations associated with these surveys that are considered to be particularly relevant to the SWAP 2D Seismic Survey Area. A summary of the relevant stations per type of sample is presented within Table 5.1.

Table 5.1: Type and Number of Monitoring Stations Relevant to the SWAP 2D Seismic Survey Area

Survey Area	Date	Relevant Monitoring Locations	Approximate Water Depth at Stations (m)	Number of Stations Relevant to the 2D Seismic Survey Area per Sample Type	
				Seabed	Water Column
Sangachal Bay Offshore	2004	All	9-15	12	12
Dredge Spoil Site	2004	All	5	10	n/a
Hovsan WTP	2009	All	0-8	12[2]	12[2]
Bahar Gum Deniz[1]	2011	All	5-50	55	55
ACG Pipeline Corridor (Seabed)	2012	6-15	13-25	10	n/a
ACG Regional (Water Column)	2012	PL6, PL9, PL10, PL11, PL12, ACGR63, ACGR64[4]	5-20	n/a	7
Sangachal Bay	2013	All	3-10	62[3]	5
SD Regional	2013	20-27, SDA, SDB	25-100	8	3[5]

Notes:
1.Comprises three survey areas – Gum Deniz, Bahar 1 and Bahar 2 as shown in Figure 5.4
2. Physical sediment characteristics not reported. Samples collected for biological analysis at 3 of the 12 stations.
3. Reported results are provided for 57 of the 62 sample locations.
4. Biological analysis reported for locations PL6, PL9 and PL12 only.
5. Physical and chemical analysis undertaken only at station 20. SDA and SDB are plankton trawl stations.

Figure 5.4: Location of the Bahar Gum Deniz, Dredge Spoil, ACG Export Pipeline Corridor, ACG and SD Regional, Hovsan WTP and Sangachal Bay Sampling Stations Relevant to the 2D Seismic Survey Area



The limitations around the data obtained from these surveys are as follows:

- Baku Bay – both sediments and the water column within Baku Bay are known to be very highly contaminated with hydrocarbons and heavy metals, and have an exceptionally high organic content (likely to reflect a combination of sewage and industrial discharges from onshore sources into an area with very limited circulation and flushing). As such, the data collected in the vicinity of Baku Bay i.e. from the Dredge Spoil and within the Gum Deniz area of the Bahar Gum Deniz Survey is not necessarily representative of the general sediment properties across the SWAP 2D Seismic Survey Area. The data therefore provides a "worst case" in terms of expected conditions and represent a situation close to the upper limit of tolerance for benthic and plankton organisms.
- Hovsan – Hovsan WTP is an operational facility and prior to the survey was routinely discharging waste water into the coastal environment at Hovsan from an existing outfall. It would therefore be expected that nutrient levels would be high in the vicinity of the coastal outfall. However, this would not be representative of the conditions in the SWAP 2D Seismic Survey Area which is located more than 5km from the existing Hovsan outfall.
- Sangachal Bay – a rocky sill at the outer margins of Sangachal Bay is thought to partially isolate the Bay from coastal contamination, with the result that sediments within the Bay are much less contaminated than areas to the north and support a greater biological diversity, than sediments immediately outside the Bay. Comparison between successive surveys in Sangachal Bay between 2003 and 2013, as part of BP's EMP, has shown some evidence that more contaminated sediment is periodically transported into the outer margins of the Bay, presumably by storm activity. Sangachal Bay also receives drainage from three local terrestrial catchments, and the deposition of terrestrially derived material transported by this run-off results in the presence of substantially siltier sediments compared to the north and further offshore to the east.

5.5.1 Physical and Chemical Environment - Seabed

5.5.1.1 Physical Properties of Sediment

Table 5.2 presents the physical sediment characteristics reported within the sediment surveys listed within Table 5.1 (with the exception of the Bahar Gum Deniz Survey for which no numerical data was reported).

In most locations surveyed, sediments were found to comprise silt, clay and sand with gravel present in locations across the Bahar Gum Deniz Contract Area (comprising shell fragments and sand) and across most of the Hovsan WTP Survey locations. Sediments across the Bahar Gum Deniz Contract Area were found to be homogeneous, and no significant variations in sediment type of size were observed across different monitoring locations and water depths sampled.

Across the Dredge Spoil Site (to the north west of the SWAP 2D Seismic Survey Area), sediments generally ranged from medium silt (20μm mean particle diameter) to very coarse sand (1019μm mean particle diameter). Organic content ranged from 1.16% to 13.54%; the highest organic content recorded across all the surveys analysed. Significantly lower organic content was measured within the samples associated with Hovsan WTP Survey, which varied between 0.8 and 6.9%.

Towards the south of the SWAP 2D Seismic Survey Area, results from the ACG Pipeline Corridor indicated that, in general, sediments were found to become coarser moving towards Sangachal Bay, as water depth becomes shallower. The exception was at location 6 where a mean particle diameter of 1414μm was recorded as a result of consistently coarse sediments known to be present in this location. In general, carbonate and organic content was found to be generally consistent across the survey locations with higher levels of carbonate and lower organic content recorded in areas of coarser sediments.

Table 5.2: Physical Sediment Properties Recorded in Sediment Surveys in the Vicinity of the SWAP 2D Seismic Survey Area

	Locations Relevant to the West of the Survey Area						Locations Relevant to the North of the Survey Area						Locations Relevant to the South West of the Survey Area			Locations Relevant to the South East of the Survey Area		
	Sangachal Offshore Survey, 2004			Sangachal Bay Survey, 2013			Dredge Spoil Disposal Site Survey, 2004			HWTP, 2009			ACG Export Pipeline Corridor (Seabed) Survey, 2012			SD Contract Area Survey, 2013		
Parameter	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**
Mean diameter (µm)	15.58	167.39	50.2	4	1281	263	20	1019	-	80	>10000	-	6	1414	145	5	360	59
Sampling Station	SO0405	SO0401	-	24	34	-	-	-	-	-	-	-	7; 10	6	-	24	26	-
Carbonate (% w/w)	41	64	54	17	92	57	-	-	-	10	45	-	6	90	30	20	69	35
Sampling Station	SO0405	SO0402	-	17	51	-	4	8	-	7800m	-	-	11	6	-	25	26	-
Organic (% w/w)	3.0	5.1	4.2	0.93	6.94	3.21	1.16	13.54	-	0.80	6.9	-	1.2	7.79	5.1	2.2	7.2	5.3
Sampling Station	SO0401	SO0408	-	55	24	-	-	-	-	7800m	-	-	6	11	-	26	25	-
Silt/Clay (% w/w)	34	81	65	3	100	48	-	-	-	-	-	-	0.2	100	82	28	100	84
Sampling Station	SO0401	SO0404	-	45	17	-	-	-	-	-	-	-	6	10	-	26	22; 24	-
Silt (% w/w)	14.1	35.0	26.1	0	70	19	-	-	-	-	-	-	0	58	41	10	46	35
Sampling Station	SO0401	SO0405	-	45	23	-	-	-	-	-	-	-	6	13	-	26	20	-
Clay (% w/w)	19.9	46.9	38.6	2	78	29	-	-	-	-	-	-	0	53	41	18	62	49
Sampling Station	SO0401	SO0404	-	45	24	-	-	-	-	-	-	-	6	11	-	26	24	-

Within the Sangachal Bay Offshore Survey undertaken in 2004, to the south west of the SWAP 2D Seismic Survey Area, mean particle diameter varied between 15.58 and 167.39µm with the coarsest particle size measured at location SO0401 at the shallowest water depth included in the survey (9m). Carbonate and organic content were found to be similar to those recorded within the other surveys detailed within Table 5.2.

Within Sangachal Bay itself sediments were found to be poorly sorted mixtures of fine and coarse particles with mean particle size varying between 4 and 1281µm. An area in the centre of the Bay, as in previous Sangachal Bay surveys, was characterised by very coarse sediments high in carbonate but very low in silt/clay and organic matter.

Mean particle sizes across locations 20-27 of the SD Regional Survey undertaken in 2013 varied between 5µm and 360µm with coarser sediment identified at locations 26 and 27. As for the ACG Pipeline Corridor Survey (2012), higher levels of carbonate and lower organic content were recorded in the areas where coarser sediments were identified.

5.5.1.2 Chemical Properties of Sediment

Hydrocarbon Concentrations

All the sediment samples listed within Table 5.1 and shown in Figure 5.4 were analysed to determine hydrocarbon concentrations with all surveys reporting Total Hydrocarbon Concentrations (THC) except for the Bahar Gum Deniz Survey which reported "hydrocarbon concentrations". A summary of the results obtained are presented in Table 5.3.

Table 5.3: Minimum, Maximum and Mean Total Hydrocarbon Concentrations in the Vicinity of the SWAP 2D Seismic Survey Area

		Total Hydrocarbon Concentration mg/g		
		Min	Mean	Max
Locations in the vicinity of the west of the Survey Area	Sangachal Offshore Survey, 2004	387	705	839
	At Sampling Station	SO0401	-	SO0405
	Sangachal Bay Survey, 2013	7	64	517
	At Sampling Station	51	-	62
Locations in the vicinity of the north of the Survey Area	Dredge Spoil Disposal Site Survey, 2004	1208	4309	14257
	Sampling Station	4	-	8
	Bahar Gum Deniz Survey, 2011 – Gum Deniz Area[2]	210	626	41950
	At Sampling Station	QD-11	-	QD-6
	Hovsan WTP, 2009	<100	-[1]	6200
	At Sampling Station	8000m from shore	-	400-4500m from shore
Locations in the vicinity of the centre of the Survey Area	Bahar Gum Deniz Survey, 2011 – Bahar 1 Area[2]	180	1080	3360
	At Sampling Station	B1-9	-	B1-10
	Bahar Gum Deniz Survey, 2011 – Bahar 2 Area[2]	300	1581	3120
	At Sampling Station	B2-5	-	B2-2
Locations in the vicinity of the south west of the Survey Area	ACG Export Pipeline Corridor (Seabed) Survey, 2012	1.5	223	563
	At Sampling Station	6	-	15
Locations in the vicinity of the south east of the Survey Area	SD Contract Area Survey, 2013	23	160.5	325
	At Sampling Station	26	-	22

Notes:
1. Full data set not provided within the source document.
2. Reported as "Hydrocarbon concentration".

Table 5.3 shows that THCs in sediment samples vary significantly across the surveys reviewed, with the highest mean concentration recorded at the Dredge Spoil Disposal Site Survey, which is located to the east of Baku Bay (known to be contaminated), and lowest mean concentration recorded in Sangachal Bay (largely sheltered from contamination in the local area).

The highest concentration recorded across all the surveys reviewed (reported as hydrocarbons) was 41950 mg/g at the QD-6 Bahar Gum Deniz Survey station which is located approximately 6km offshore from Hovsan adjacent to the Hovsan WTP Survey stations. Similar results were also obtained at stations QD3 (located immediately next to QD-6) and QD1 located at the far edge of Baku Bay to the east. The maximum concentration of 6200mg/g from the earlier Hovsan WTP Survey undertaken in 2009 suggests that this area was subject to worsening hydrocarbon contamination between 2009 and 2011.

To the south and south east of the SWAP 2D Seismic Survey Area, the results from the ACG Export Pipeline Corridor and the SD Contract Area Surveys undertaken in 2012 and 2013, respectively indicate low levels of hydrocarbon contamination with THCs an order of magnitude less than those reported in the Bahar 1 and 2 Areas of the Bahar Gum Deniz Survey. Similar but slightly higher THC were recorded during the Sangachal Bay Offshore Survey. Comparing these results with the more recent ACG Export Pipeline Corridor Survey results for locations 11-15 suggests that sediment hydrocarbon contamination in this area has reduced over time either due to the works associated with installation of pipelines between 2002 and 2009 within the ACG pipeline corridor, due to natural degradation processes or a combination of both.

In general THCs are expected to be generally moderate to low across the SWAP 2D Seismic Survey Area; higher towards the north and west of the SWAP 2D Seismic Survey Area and lower towards the south east. While data is not available for the north west section of the SWAP 2D Seismic Survey Area it is likely that there may be locations where THC concentrations are high given the industrial nature of the coastline between Bibiheybat and Sahil and the known contamination in this area and in Baku Bay. In addition, there may be localised areas of high hydrocarbon contamination across the SWAP 2D Seismic Survey Area as a whole from historic oil and gas activities as well as natural hydrocarbons from seeps and mud volcanoes.

Heavy Metal Concentrations

With regard to heavy metals concentrations, sediment samples for the surveys listed in Table 5.1 were analysed for concentrations of Arsenic, Barium, Cadmium, Chromium, Copper, Iron, Mercury, Lead and Zinc except for samples associated with the Hovsan WTP Survey (analysed for arsenic, cadmium and copper only). Tables 5.4 and 5.5 present the maximum, minimum and mean average concentrations reported for each survey.

Table 5.4: Minimum, Maximum and Mean Heavy Metal Concentrations Recorded in Sediment Surveys in the Vicinity of the SWAP 2D Seismic Survey Area (West and North) (µg/g)

Parameter		Locations Relevant to the West of the Survey Area				Locations Relevant to the North of the Survey Area			
		Sangachal Offshore Survey, 2004	Sampling Station	Sangachal Bay Survey, 2013	Sampling Station	Dredge Spoil Disposal Site Survey, 2004	Sampling Station	HWTP, 2009	Sampling Station
Arsenic	Min	7.3	SO0404	8.51	62	4.1	4	<1	1-6 and 11-12
	Max	14.5	SO0411	36.1	44	13.2	6	11.2	8
	Mean	10	-	17.4	-	5.7	-	-	-
Barium	Min	122	SO0406	85	34	185	4	-	-
	Max	660	SO0410	1140	62	629	2	-	-
	Mean	301	-	354	-	411	-		-
Cadmium	Min	0.16	SO0403	0.196	22	0.11	4	<0.4	All
	Max	0.30	SO0409	0.429	29	0.49	8	<0.4	All
	Mean	0.22	-	0.277	-	0.25	-	-	-
Chromium	Min	26.30	SO0401	6.8	51	9.5	4	2.7	8
	Max	101.80	SO0409	80.9	24	94	8	41.4	5
	Mean	68.30	-	42.3	-	44.6	-	-	-
Copper	Min	13.90	SO0401	8.6	42	7.7	4	4.3	7
	Max	33	SO0405	50	24	47	8	910.6	3
	Mean	28	-	27	-	23	-		-
Iron	Min	16770	SO0401	8261	42	6661	4	-	-
	Max	23153	SO0405	43110	24	26373	8	-	-
	Mean	20556	-	26155	-	16331	-		-
Mercury	Min	0.15	SO0401	0.023	46	0.34	8	<0.1	7,8,9,10
	Max	0.26	SO0405	0.117	62	0.07	6	1.2	5
	Mean	0.21	-	0.039	-	0.18	-	-	-
Lead	Min	28.80	SO0401	9.3	43	4.9	4	3.8	10
	Max	49.90	SO0406	20.2	61	31.1	8	15.8	5
	Mean	38.80	-	14.9	-	19.5	-	-	-
Zinc	Min	63.90	SO0401	20.6	34	19.4	4	-	-
	Max	100.80	SO0409	99	24	104.1	8	-	-
	Mean	86.60	-	59.3	-	62.6	-	-	-

Table 5.5: Minimum, Maximum and Mean Heavy Metal Concentrations Recorded in Sediment Surveys in the Vicinity of the SWAP 2D Seismic Survey Area (Centre and South) (µg/g)

Parameter		Locations Relevant to the Centre of the Survey Area						Locations relevant to the South west and South East of the Survey Area			
		Bahar Contract Area Survey - Gum-Deniz Section, 2011	Sampling Station	Bahar Contract Area Survey - Bahar1 Section, 2011	Sampling Station	Bahar Contract Area Survey - Bahar2 Section, 2011	Sampling Station	ACG Export Pipeline Corridor (Seabed) Survey, 2012	Sampling Station	SD Contract Area Survey, 2013)	Sampling Station
Arsenic	Min	3	QD-9	2	B1-6	0.7	B2-12	6.9	15	7.5	26
	Max	14	QD-24	9	B1-11	80	B2-8	17	6	12.5	22
	Mean	7	-	5.56	-	12.69	-	13	-	9.7	-
Barium	Min	43	QD-22	279	B1-3	225	B2-10	177	6	305	20
	Max	896	QD-15	1422	B1-11	569	B2-1	1925	15	790	25
	Mean	382	-	753	-	336.07	-	966	-	435	-
Cadmium	Min	0.10	QD-5; QD-6; QD-7; QD-8; QD-10; QD-11; QD-13; QD-21; QD-22; QD-25;	<0.01	-	0.1	B2-2; B2-10	0.12	7	0.108	27
	Max	0.70	QD-3	<0.01	-	0.4	B2-7;B2-11	0.23	15	0.154	20
	Mean	0.26	-	<0.01	-	0.24	-	0.16	-	0.134	-
Chromium	Min	18	QD-9	42	B1-2	53	B2-10	5	6	41.5	26
	Max	111	QD-1	75	B1-11	78	B2-1	65	11	66.8	22
	Mean	48	-	57.25	-	64.43	-	52	-	59.6	-
Copper	Min	1	QD-9	7	B1-5;B1-7;B1-14	22	B2-10	7	6	20.1	26
	Max	45	QD-1	12	B1-16	30	B2-12	29	7	28	25
	Mean	17	-	8.75	-	26.57	-	23	-	25	-
Iron	Min	11774	QD-5	23923	B1-3	31494	B2-10	6194	6	21218	26
	Max	27949	QD-1	34071	B1-11	38635	B2-7	35361	8	34704	22
	Mean	19453	-	29575	-	36088	-	28665	-	30690	-
Mercury	Min	1	QD-9; QD-12;	2	B1-1	3	B2-9; B2-11	0.03	6	0.022	27
	Max	7	QD-1	11	B1-11	8	B2-1	0.26	14	0.151	20
	Mean	3	-	5.5	-	4.93	-	0.13	-	0.097	-
Lead	Min	1	QD-9	15	B1-1	18	B2-10	12	6	12.3	26
	Max	28	QD-1	28	B1-11	28	B2-6	29	15	21.9	22
	Mean	11	-	19.94	-	22	-	19	-	19.2	-
Zinc	Min	107	QD-12	21	B1-1	72	B2-10	11	6	53.3	26
	Max	237	QD-13	43	B1-11	104	B2-5	89	15	89.9	21
	Mean	162	-	33.06	-	86	-	69	-	79.1	-

Tables 5.4 and 5.5 show that arsenic concentrations vary little across the surveys reviewed with the maximum concentration of 36µg/g recorded in Sangachal Bay in 2013 and minimum concentrations of less than 1µg/g at locations associated with the Hovsan WTP and Bahar 2 surveys. While barium concentrations across all surveys were found to generally vary between approximately 300 - 400µg/g, maximum concentrations of 1925µg/g at ACG Pipeline Corridor station 15 and at 1140µg/g at station 62 of the Sangachal Bay 2013 Survey were recorded. Both locations are within Sangachal Bay. A maximum barium concentration of 1422µg/g was also recorded at location of B1-11 within the Bahar 1 Survey area.

Cadmium levels were found to vary little across all surveys except within the Bahar 1 Survey area where very low concentrations (<0.01µg/g) were reported. The reason for this is not known. With regard to chromium, while maximum concentrations of 111µg/g and 102µg/g were recorded at locations within the Gum Deniz Survey area and the Sangachal Bay Offshore Survey respectively, concentrations were found to generally vary between 40-70µg/g across all the surveys analysed.

Copper concentrations across all surveys analysed were found to generally vary between 20-30µg/g with a very high maximum concentration of 910µg/g recorded at location 3 of the Hovsan WTP survey. Similar high concentrations were also recorded at 2 other Hovsan WTP survey stations, located 6km apart. The reason for the high concentrations could not be explained.

With regard to iron, mean concentrations across the surveys were found to vary between 16331µg/g (Dredge Soil Site) and 36088µg/g (Bahar 2 survey area) indicating no significant trends. The largest variation in iron concentrations were within Sangachal Bay with the lowest concentrations recorded in areas of coarser sediments.

Mercury concentrations were found to be high (up to 11µg/g) across the whole of the Bahar Gum Deniz Survey area (as compared to mean concentrations of approximately 0.1 to 0.2µg/g across the majority of the other surveys considered). The reason for these high concentrations is not known. Lead concentrations, however, were found to vary little across surveys with mean concentrations across all surveys of between approximately 10-40µg/g.

Zinc concentrations were found to vary between a minimum of 11µg/g (at station 6 of the ACG Pipeline Corridor 2012) and a maximum of 237µg/g (at station QD13 of the Gum-Deniz Survey). Consistently higher concentrations were recorded at all stations across the Gum-Deniz Survey, however they were not significantly higher than those recorded across the other surveys considered.

In general heavy metal concentrations in sediments were found vary little across survey areas except in localised areas where higher concentrations were recorded and for mercury, where consistently higher concentrations were recorded across the whole Bahar Gum Deniz Survey area.

5.5.2 Biological Environment – Seabed

The biological benthic environment comprises marine flora (seagrass and algae) and benthic invertebrates.

5.5.2.1 Marine Flora

Reviews of historical data (comprising species lists from the 1960s and 1970s)[19] indicates seagrass beds were present along much of the coastline between Baku and Sangachal as well as in shallow waters surrounding the Shahdili Spit and the lagoons adjacent to Sahil. Recent data to confirm the presence and density of seagrass in these areas is not available. The presence and density of seagrass within Sangachal Bay, however, has been established through surveys between 2001 and 2014[20] indicating that the seagrass present comprises a single species, *Zostera noltii* and is found in waters depths less than 5m[21].

Surveys completed prior to and after ACG pipeline installation works indicate that seagrass does not appear to be sensitive to physical disturbance and recovery is rapid following disturbance[22] but it is likely to be indirectly affected by coastal eutrophication, as this will tend to encourage the growth of green algae, which can take up nutrients directly from seawater and which are likely to outcompete and suppress seagrass, especially in turbid water.

The species lists available from the 1960s and 1970s and earlier surveys undertaken in Sangachal Bay in 2002 and 2003 suggest a number of red and green marine algae species were known to be present in the SWAP 2D Seismic Survey Area. However, the increase in discharges of wastewater to sea associated with increasing urbanisation of coastal areas, particularly in Baku, and the associated increases in nutrient levels and pollution, may have significantly affected the diversity, abundance, and distribution of floral species. Thus, the current diversity of flora in the SWAP 2D Seismic Survey Area is unknown.

Marine flora is typically sensitive to changes in nutrient levels and turbidity, both of which can affect primary productivity for some species. For example, within the samples collected in the vicinity of the Hovsan WTP outfall[10], only the nutrient tolerant green alga, *Enteromorpha* sp. was observed.

The distribution of marine flora, including the presence of algae and seagrass, in the SWAP 2D Seismic Survey Area is largely unknown.

5.5.2.2 Benthic Invertebrates

The surveys completed within or in the vicinity of the SWAP 2D Seismic Survey Area where seabed (benthic) samples were taken and analysed are summarised in Table 5.1 above.

Whilst these surveys took place across a nine year period and at different times of the year, and there may be some minor seasonal pattern in the abundance of invertebrates, the data does show the general characteristics of the benthic communities observed in each of the surveys.

In areas where surveys have been carried out, the distribution and abundance of benthic fauna has been found to be very patchy. However, high spatial and temporal heterogeneity is fairly common in benthic habitats where settlement of larvae depends on a number of stochastic (chance) events and conditions.

The data from the surveys listed in Table 5.1 show that many species, particularly those found in low abundance such as amphipods and gastropods, are particularly patchy in distribution. Many are only occasionally sampled resulting in highly variable species composition both between samples in a

[19] Karayeva, Dr N., 2003. Literature review conducted by Dr Ninel Karayeva of the Institute of Botany, Azerbaijan National Academy of Sciences.
[20] There is no known available marine flora data from 1970 to 2001 for this area.
[21] Envision Mapping Ltd., 2014. SD2-SB-Drop Down Video Survey, Sangachal Bay, Azerbaijan.
[22] Azerbaijan-Georgia-Turkey Region, 2009. Integrated Environmental Monitoring Programme Annual Report.

single survey and between different surveys. Thus, a useful indicator of community composition and health is the number of species representing each of the major taxonomic groups. The major groups of benthic invertebrates observed in the surveys listed in Table 5.1 are:

- Polychaetes;
- Oligochaetes;
- Cirripedia (barnacles);
- Cumacea (hooded shrimp);
- Amphipoda (small crustaceans);
- Decapods (crabs, prawns and lobsters);
- Bivalve molluscs (shellfish such as mussels); and
- Gastropoda (snails and slugs).

Table 5.6 presents a summary of the number of invertebrate species by major faunal group and percentage of total abundance reported within the surveys relevant to the SWAP 2D Seismic Survey Area.

Table 5.6 shows the number of samples taken for each survey as sampling effort (the number of grab samples taken) can affect the number of species observed. This is because the distribution of benthic invertebrates in marine systems is usually highly variable across an area with some species present in small, sometimes high density patches. Thus each individual grab sample will only capture a proportion of the species present in an area. With each additional grab there is a chance of finding a species that was not captured in one of the previous grabs. Thus, a 20 sample survey would be expected to capture more species than a survey of only 10 samples in the same area. Comparisons of community composition should always take into consideration the number of samples taken.

Table 5.6: Summary of Number of Invertebrate Species (S) and Percentage (%) of Total Abundance Recorded in Benthic Surveys Relevant to the 2D Seismic Survey Area

Taxon Group	Sangachal Bay Offshore 2004		Dredge Spoil Disposal Site, 2004		Bahar Gum Deniz[1]2011		ACG Pipeline Corridor 2012		Sangachal Bay 2013		SD Regional 2013	
	S	N (%)	S	N (%)	S	N (%)	S	N (%)	S	N (%)	S	N (%)
Polychaete	4	91.2	5	53.1	4	57.6	7	44.3	5	64.7	3	0.6
Oligochaete	3	0.4	2	0.7	0	7.0	4	6.0	4	15.8	3	47.0
Cumacea	0	0.0	0	0.0	0	0.0	2	0.2	2	<0.1	5	4.7
Cirripedia	1	4.6	1	16.3	1	20.6	1	6.0	1	<0.1	1	<0.1
Amphipoda	0	0.0	0	0.0	0	0.0	17	22.7	9	0.2	25	39.8
Decapod	1	0.2	1	0.1	1	1.0	1	0.1	1	<0.1	1	<0.1
Bivalve	3	3.6	4	29.8	4	13.8	4	20.5	3	16.3	3	0.5
Gastropoda	0	0.0	0	0.0	0	0.0	0	0.0	4	3.1	0	0.0
No. of species per sample	5-12		7-10		0-10		5-28		2-16		4-32	
No. of stations	12		10		54		10		57		8	
Total species per survey	12		13		10		36		29		42	
Average abundance/m^2		1024		27517		1795		1327		6653		862

Notes: S = number of species observed; N (%) = percentage abundance.
1. Average of all three survey areas (Gum Deniz, Bahar 1 and Bahar 2) (Figure 5.5).

Table 5.6 shows that considerably higher diversity of invertebrate species was observed (i.e. higher number of species recorded) in the ACG Pipeline Corridor 2012, Sangachal Bay 2013 and Shah Deniz 2013 Regional Surveys compared to those undertaken in the vicinity of Baku (i.e. the Dredge Spoil Disposal Site and the Bahar Gum Deniz surveys) and the 2004 Sangachal Bay Offshore survey.

However, the high diversities observed in the ACG Pipeline Corridor 2012 and the SD Regional 2013 surveys were due to a high number of species being recorded at Station 6 of the ACG Pipeline Corridor survey (28 species as compared to 5 to 13 species at the other stations) and Stations 26 and 27 of the SD Regional Survey (30 and 32 species respectively as compared to 4 and 9 species at stations 20-25).

In each of the locations where the higher diversity was recorded, the presence of a large number of different amphipods was observed. This indicates that the distribution of amphipods is therefore extremely variable and probably reflects local conditions (sediment type for example) and the fact that most amphipods brood their young so local populations persist. Thus, while diversity appears to be higher in regions away from the shallow Baku Bay area, the distribution of species is highly heterogeneous and surveys including a low number of survey locations may not sample areas showing the highest diversity.

As noted in Section 5.5 above, the rocky sill around Sangachal Bay is thought to protect the bay from contamination and contribute to higher biological diversity. This is supported by the 2013 Sangachal Bay survey where there were between 2 and 16 species collected per grab sample, and 29 species in the survey as a whole. While the higher diversity may be a reflection of the survey effort (a total 57 stations were sampled), the results do include many amphipod species, absent from the surveys in the vicinity of Baku Bay and in the centre of SWAP 2D Seismic Survey Area (i.e. the Bahar Gun Deniz Survey area). This indicates diversity is higher but that species are not evenly distributed through Sangachal Bay.

The diversity observed at the Dredge Spoil Disposal Site and across the Bahar Gum Deniz Survey area ranged from 0 and 10 species per sample (13 and 10 species, respectively over the whole survey) indicating impoverished communities in areas close to Baku but also areas further offshore (only 10 species were also observed at Bahar 1 and Bahar 2). Based on the summary data available the three samples taken for the Hovsan WTP survey in 2009 also had low diversity with a total of eight species, mostly polychaetes and bivalves[10].

Of particular note in the Dredge Spoil Disposal Site and Bahar Gum Deniz surveys is the absence of amphipod species. The Bahar Gum Deniz survey sampled 54 stations across all three of the survey areas (Gum Deniz, Bahar 1 and Bahar 2) so this absence probably cannot be explained by survey effort. Amphipods are known to be generally sensitive to organic pollution[23] and hydrocarbons[24] so local environmental conditions, close to a densely populated area where nutrient levels are known to be higher, may be an explanation for their absence.

Numerically, benthic communities from most of the locations investigated were dominated by polychaete worms and bivalves, animals typical of muddy and sandy sediments. At stations with a high diversity of amphipods, there was generally also high abundance.

The high percentage abundance of amphipods in the 2012 ACG Pipeline Corridor samples comes from a single sample, (the very diverse Station 6) where over 3000 individuals/m^2 were sampled. Amphipods were either absent or in very low abundance (maximum of seven individuals/m^2) in the remaining nine samples. In the absence of amphipods, polychaetes, bivalves and oligochaetes were the most important component of the benthic community.

Some samples had a high abundance of cirripedia (barnacles), particularly at the Baku Dredge Spoil Disposal Site and across the Bahar Gum Deniz Survey area. This is expected to be due to the presence of larger particles such as stones, gravel and pebbles which provide a substratum for *Balanus improvisus*, an invasive barnacle in the Caspian Sea, to attach.

Table 5.6 shows that average abundance across the surveys ranged from just over 1000 individuals to 27517 individuals per m^2. The particularly high abundance figures are from samples taken from the Dredge Spoil Disposal Site where there were especially high densities of polychaetes, barnacles and bivalves. Most of the polychaetes were the native species *Hypaniola kowalewski* which is reported to have a preference for sediments with a mixture of sand and silts. The high number of barnacles reflects the presence of larger sediment sizes. Thus, the high abundances at this site may be a reflection of the particular sediment characteristics of the dredged spoil.

The average abundance of fauna observed during the Bahar Gum Deniz surveys was 1795 individuals per m^2 but there appears to be a trend of decreasing abundance with distance away from coast. The average abundance for each of the three sections of this survey (Gum Deniz, Bahar 1 and

[23] de-la-Ossa-Carretero, J.A., Del-Pilar-Ruso, Y. Giménez-Casalduero, F. Sánchez-Lizaso, J.L. & Dauvin, J.C., 2012. Sensitivity of amphipods to sewage pollution, Estuarine, Coastal and Shelf Science, 96, 129-138.
[24] Sea Empress Environmental Evaluation Committee (SEEEC), 1998. The environmental impact of the Sea Empress oil spill. Final Report of the Sea Empress Environmental Evaluation Committee, 135 pp., London: HMSO.

Bahar 2) were 2600, 1598 and 584 individuals per m^2 respectively whilst species composition remained very similar.

Table 5.7 presents the species that were found in each of the benthic surveys reviewed and shows that many of the same species were found in all the surveys, regardless of location. Most of these are invasive species that have become well established in the Caspian Sea: the polychaete worm *Nereis diversicolor,* the barnacle *Balanus improvisus*, the crab *Rhithropanopeus harrisii* and the bivalves *Abra, Mytilaster, and Cerastoderma*. The native polychaete *Hypaniola kowalewski* was also found in high abundance.

Table 5.7: Species Presence in Surveys Conducted within and in the Vicinity of the 2D Seismic Survey Area

Species	Sangachal Bay Offshore, 2004	Dredge Spoil Disposal Site, 2004	Bahar Gum Deniz' 2011	ACG Pipeline Corridor, 2012	Sangachal Bay, 2013	SD Regional, 2013
Oligochaetes						
Isohaetides michaelseni		✓	✓		✓	✓
Psammoryctides deserticola		✓			✓	✓
Stylodrilus cernosvitovi	✓		✓	✓	✓	✓
Stylodrilus parvus	✓	✓			✓	
Tubificidae spp.	✓			✓		
Polychaetes						
Ampharetidae spp.				✓		
Nereis diversicolor	✓	✓	✓	✓	✓	✓
Nereis succinea				✓	✓	✓
Fabricia sabella	✓	✓		✓	✓	
Hypaniola kowalewskii	✓	✓	✓	✓	✓	✓
Manayunkia caspica	✓	✓		✓	✓	✓
Sabellidae spp.				✓		
Crustaceans						
Pterocuma pectinata					✓	
Pterocuma rostrata						✓
Schizorhynchus eudorelloides				✓		✓
Stenocuma diastyloides						
Stenocuma gracilis					✓	
Stenocuma graciloides				✓		✓
Balanus improvisus	✓	✓	✓	✓	✓	✓
Amathillina pusilla				✓	✓	✓
Amathillina spinosa						✓
Caspicola knipovitschi						✓
Corophium chelicorne				✓		✓
Corophium curvispinum				✓	✓	✓
Corophium monodon				✓	✓	✓
Corophium mucronatum				✓	✓	✓
Corophium nobile				✓		✓
Corophium robustum				✓		✓
Corophium spinulosum				✓		✓
Corophium volutator				✓	✓	✓
Dikerogammarus aralensis						✓
Dikerogammarus haemobaphes				✓	✓	✓
Dikerogammarus oskari						✓
Gammarus ischnus				✓		✓
Gammarus pauxillus				✓	✓	✓
Gammarus warpachowskyi						✓
Gmelina brachyura				✓		✓
Gmelina costata						✓

Species	Sangachal Bay Offshore, 2004	Dredge Spoil Disposal Site, 2004	Bahar Gum Deniz' 2011	ACG Pipeline Corridor, 2012	Sangachal Bay, 2013	SD Regional, 2013
Gmelinopsis aurita						✓
Iphigenella andrussovi				✓		
Niphargoides caspius						✓
Niphargoides deminutus						✓
Niphargoides derzhavini				✓		
Niphargoides grimmi						✓
Niphargoides paradoxus						✓
Jaera sars caspica						
Saduria entomon caspia						✓
Rhithropanopeus harrisii	✓	✓	✓	✓	✓	✓
Molluscs						
Caspia gmelini					✓	
Caspiohydrobia curta					✓	
Caspiohydrobia cylindrica					✓	
Caspiohydrobia gemmata					✓	
Abra ovata	✓	✓	✓	✓	✓	✓
Cerastoderma lamarcki	✓	✓	✓	✓	✓	✓
Didacna profundicola				✓		
Dreissena caspia		✓				
Dreissena rostriformis grimmi						✓
Dreissena rostriformus distincta			✓			✓
Mytilaster lineatus	✓	✓	✓	✓	✓	

The overall conclusion is that the available data indicates that the SWAP 2D Seismic Survey Area is likely to be populated by benthic communities of low diversity and that several invasive species are likely to be well established throughout the SWAP 2D Seismic Survey Area. In particular, it appears that key native species are largely absent from benthic communities in areas close to Baku Bay. Based on the limited data available, it is possible that diversity may be higher with distance from Baku Bay. Nonetheless, it is considered unlikely that the SWAP 2D Seismic Survey Area will contain any benthic communities significantly different to those described above or support benthic species of local or regional conservation significance or vulnerability.

5.5.3 Physical and Chemical Environment – Water Column

5.5.3.1 Water Temperature and Salinity

Differential climatic conditions between the Caspian Basins cause large latitudinal variations in sea surface temperature. During the winter, the Northern Caspian Basin freezes while temperatures in the Central and Southern Caspian Basins remain well above freezing (10 to 11°C), although some ice may form during severe winters[13].

During summer, the temperature of the waters in the Southern Caspian Basin becomes stratified and a strong thermocline develops that inhibits vertical mixing at depths of 20 to 50m. Surface water temperatures can reach a maximum of 28ºC in August[25]. Temperatures at depth remain approximately 6ºC all year round[8Error! Bookmark not defined.].

During summer and autumn the thermocline moves deeper reflecting the increase in solar energy warming the surface water and forcing denser cold water to sink. As the thermocline deepens, the temperature stratification becomes less significant until the thermocline eventually breaks down during late autumn and winter months[2].

[25] OceanMetrix, 2009. Shah Deniz Wind, Wave, Surge and Current Criteria V3.1a. Report developed for BP Exploration Operating Company Ltd.

Surface salinity levels vary with water temperature (due to evaporation rates), distance to fresh water sources and the riverine input. Salinity in the Southern Caspian basin increases from west to east due to the lack of freshwater inputs along the east Caspian coast. The salinity of near seabed and in the central water column is more stable in comparison with surface water salinity. The salinity of the surface water in the vicinity of the SWAP 2D Seismic Survey Area is considered to be relatively constant all year round at approximately 13 parts per thousand (ppt). To the south of the SWAP 2D Seismic Survey Area where there is increasing freshwater input due to the influence of the Kura Delta, salinity is typically in the range 12.7-12.8 ppt.

5.5.3.2 Oxygen Regime

The deep water areas of the Southern Caspian Basin are characterised by lower dissolved oxygen levels compared to the Northern and Central Caspian Basins. This is caused among other factors, by poor penetration of sunlight and reduced photosynthesis activity, the deficiency of large river inflows and the stratification of the water column during the thermocline. Dissolved oxygen levels in the Southern Caspian Basin decrease with depth and saturation can reach levels as low as 10% at 600m depth[26].

Oxygen levels in the Southern Caspian Basin are also highly influenced by anthropogenic pressures and marine contamination. In the nearshore waters of Azerbaijan, the oxygen regime and concentration are understood to be greatly influenced by anthropogenic factors, particularly by wastewater and sewage discharges. While oxygen levels across the Northern Caspian Basin are known to vary between 4.9 and 10.6 mg/l, oxygen levels recorded in Baku Bay vary between 3-5 mg/l[27]. During the water column surveys listed in Table 5.1 dissolved oxygen levels of between 6-9 mg/l have been recorded.

Throughout the year the surface waters of the Southern Caspian Basin are characterised by high oxygenation with high saturation levels occurring in the spring due to phytoplankton activity. During summer, the water column becomes stratified resulting in decreased oxygen levels below the thermocline[28].

5.5.3.3 Water Quality

Water column surveys during which samples were taken to analyse physical, chemical and biological parameters are listed in Table 5.1 above. While the parameters analysed across surveys varied, the following were generally measured with the exception of the Hovsan WTP and Bahar Gum Deniz surveys where a reduced set of parameters were considered:

- Heavy metals concentrations including barium, lead, zinc, copper, iron, chromium, cadmium, arsenic and mercury;
- THC, polynuclear aromatic hydrocarbon (PAH) and phenol; and
- Water quality and nutrient indicators including total suspended solids (TSS), total nitrogen, total phosphorus, nitrate, nitrite, ammonia, phosphate, silicate, Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD).

Table 5.8 summarises the minimum, maximum and average heavy metal concentrations recorded across the surveys.

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[26] Jamshidi S., Bakar N. B. A., 2011. Variability of Dissolved Oxygen and active reaction in deep waters of Southern Caspian Sea, near the Iranian Coast. Available at: http://www.pjoes.com/pdf/20.5/Pol.J.Environ.Stud.Vol.20.No.5.1167-1180.pdf Accessed in August 2015.
[27] GIWA and UNEP, 2006. Regional Assessment Report 23 – the Caspian Sea. Global International Waters Assessment Program, UNEP.
[28] RSK, 2005. SDX-4 Drilling Programme Environmental Technical Note - Addendum to Shah Deniz Exploration Drilling EIA.

Table 5.8: Minimum, Maximum and Mean Heavy Metal Concentrations Recorded in Water Column Surveys in the Vicinity of the SWAP 2D Seismic Survey Area (µg/l)

Parameter		Locations relevant to the west of the Survey Area				Locations relevant to the north of the Survey Area		Locations relevant to the east of the Survey Area		Locations relevant to the south east of the Survey Area		Locations relevant to the centre of the Survey Area	
		Sangachal Offshore 2004	Sampling Station	Sangachal Bay 2013	Sampling Station	HWTP, 2009	Sampling Station	ACG Contract Area 2012	Sampling Station	SD Contract Area 2013	Sampling Station	Bahar Gum Deniz 2011	Sampling Station
Arsenic	Min	<5	All	-	-	<0.01	All	-	-	-	-	<2	All
	Max	<5	All	-	-	<0.01	All	-	-	-	-	<2	All
	Mean	-	-	-	-	-	-	-	-	-	-	<2	-
Barium	Min	9.4	SO0401;SO0402;SO0403;SO0411	-	-	<0.01	All	-	-	-	-	8.0	QD-19; B1-9
	Max	15.4	SO0404;SO0405;SO0406;SO0412	-	-	<0.01	All	-	-	-	-	57.0	QD-9
	Mean	-	-	-	-	-	-	-	-	-	-	24.2	-
Cadmium	Min	0.016	SO0407;SO0408;SO0409;SO0410	<0.01	W3, W5	-	-	<0.01	PL9	-	-	<0.1	All
	Max	0.018	SO0404;SO0405;SO0406;SO0412	0.018	W4	0.016	One location (location not provided)	0.028	PL6	0.011	20	<0.1	All
	Mean	-	-	-	-	-	-	-	-	-	-	<0.1	-
Chromium	Min	<2	All	-	-	<0.01	All	-	-	-	-	<0.1	All
	Max	<2	All	-	-	<0.01	All	-	-	-	-	<0.1	All
	Mean	-	-	-	-	-	-	-	-	-	-	<0.1	-
Copper	Min	0.579	SO0401;SO0402;SO0403;SO0411	1.02	W4	<0.01	All	0.77	PL6	-	-	0.9000	QD-17; QD-20
	Max	0.695	SO0407;SO0408;SO0409;SO0410	1.56	W1	<0.01	All	4.12	PL9	0.98	20	6.6	B2-13
	Mean	-	-	-	-	-	-	-	-	-	-	3.2	-
Iron	Min	<10	All	13	W5	<0.01	All	8.21	ACGR64	-	-	10.0	QD-20
	Max	<10	All	161	W1	<0.01	All	12.8	ACGR63	2.72	20	84	B2-9
	Mean	-	-	-	-	-	-	-	-	-	-	43.2	-
Mercury	Min	<0.01	All	-	-	<0.01	All	-	-	-	-	<0.1	All
	Max	<0.01	All	-	-	<0.01	All	-	-	-	-	<0.1	All
	Mean	-	-	-	-	-	-	-	-	-	-	<0.1	-
Lead	Min	0.034	SO0404;SO0405;SO0406;SO0412	0.095	W4	<0.01	All	0.09	ACGR64	-	-	0.10	70% of all samples
	Max	0.054	SO0407;SO0408;SO0409;SO0410	0.257	W1	<0.01	All	0.383	PL9	0.037	20	0.6	B1-8
	Mean	-	-	-	-	-	-	-	-	-	-	0.2	-
Zinc	Min	0.751	SO0401;SO0402;SO0403;SO0411	2.15	W4	<0.01	All	1.14	ACGR63	-	-	3.7	QD-23
	Max	1.017	SO0407;SO0408;SO0409;SO0410	5.87	W5	<0.01	All	4.71	PL6	6.7	20	30.5	B1-3
	Mean	-	-	-	-	-	-	-	-	-	-	14.3	-

In general concentrations of arsenic, mercury, cadmium, lead and chromium were consistently low across all surveys. Barium levels varied between 8 and 57µg/l with the lowest concentrations recorded in Sangachal Bay Offshore Survey and the highest concentrations recorded at location QD-9 of the Bahar Gum Deniz Survey. Copper levels were generally consistent varying between 0.579µg/l at four locations associated with the Sangachal Bay Offshore Survey to 6.6µg/l at location B2-13 of the Bahar Gum Deniz Survey.

Iron concentrations were generally low varying between <0.01µg/l and 161µg/l with the highest levels recorded in Sangachal Bay 2013 Survey. Conversely the lowest zinc levels were associated with the Hovsan WTP Survey and the Sangachal Bay Offshore Survey.

In general all heavy metals concentrations were low and, with very few exceptions, were well below the maximum allowable concentrations for good fisheries water quality (Azerbaijan MAC Fisheries Waters). In addition, hydrocarbon concentrations were also found to vary little across the surveys relevant to the SWAP 2D Seismic Survey Area, with levels of between 17 and 91µg/l recorded. For both heavy metals and hydrocarbons, there was no clear trend across the surveys analysed, and based on the data available, there is no evidence of widespread or persistent contamination associated with heavy metals or hydrocarbons within the water column in the vicinity of the SWAP 2D Seismic Survey Area.

A summary of the nutrient levels recorded during the water column surveys listed in Table 5.1 above is presented in Table 5.9. The table shows in general, TSS vary between 5-9mg/l across all the surveys considered except across the Bahar Gun Deniz Survey area where TSS concentrations of up to 81mg/l were recorded. This is understood to be due to the entrainment of sediment within samples taken at depth. BOD-5 concentrations were found to vary little across all surveys except the Sangachal Bay 2013 survey where higher levels were recorded. It was noted that these levels were significantly higher than in the previous survey completed in 2011 however, as dissolved oxygen levels were similar, oxygen available to biota was considered to be unaffected.

COD concentrations were found to be similar across the surveys completed within or adjacent to Sangachal Bay with lower concentrations (<4µg/l) recorded across the relevant ACG and SD Contract Areas survey locations. Nitrite and nitrate concentrations were found to be consistent across all survey locations except within the Bahar Gum Deniz survey area where high concentrations up to 1040 µg/l (nitrite) and 910µg/l (nitrate) were recorded. No explanation for these high levels was provided.

With regard to ammonium concentrations these were general found to be low across the surveys considered except for the Hovsan TWP locations where a very high level of 853µg/l was recorded. The station where this concentration was measured was located in the immediate vicinity of the existing discharge outfall from the Hovsan WTP and the high level was considered to be due to the biological load present in the discharge.

Total nitrogen concentrations across all surveys were found to be consistently low as were phosphate and total phosphorus concentrations except for very high maximum concentrations recorded during the Hovsan WTP survey (900 and 1500µg/l respectively). This maximum was found to occur at one station approximately 400m from the existing outfall and was thought to occur due to mineralisation of the phosphorus in the wastewater discharge. At locations further from the outfall the concentrations were found to fall to approximately 10µg/l.

There was no discernible trend in silicate concentrations across the surveys, which were consistently low.

It should be noted, however, that the surveys are generally conducted over short periods generally during the summer and therefore it cannot be inferred that contamination is low at all times of the year. Nevertheless, the results do indicate no evidence of persistent contamination. Furthermore, it should be noted that there is no data currently available for the area to the immediate south of Baku Bay and in the offshore area between Bibiheybat and Sahil. Given the known pollution present in Baku Bay and the known industrial and wastewater discharges both within Baku Bay and along the coastline, there is potential for water quality in this area to be poorer than in areas further offshore.

Table 5.9: Minimum, Maximum and Mean Nutrient Levels Recorded in Water Column Surveys in the Vicinity of the SWAP 2D Seismic Survey Area (µg/l)

Parameter		Locations relevant to the west of the Survey Area				Locations relevant to the north of the Survey Area		Locations relevant to the east of the Survey Area		Locations relevant to the south east of the Survey Area		Locations relevant to the centre of the Survey Area	
		Sangachal Offshore 2004	Sampling Station	Sangachal Bay 2013	Sampling Station	HWTP 2009	Sampling Station	ACG Contract Area 2012	Sampling Station	SD Contract Area 2013	Sampling Station	Bahar Gum Deniz 2011	Sampling Station
TSS (in mg/l)	Min	<2	SO0401-SO0403,SO04011	3	W5	1.8	8	<2	All	<2	20	13.4	QD-20
	Mean	4.85	-	9		5	-	<2	-	-	-	28.8	-
	Max	6.35	4,5,6,12	17	W1	8.8	1	<2	All	2	20	81	QD-12
BOD-5	Min	<0.5	SO0401-SO0403, SO04011,SO0407-SO04010	11	W5	-	-	<0.5	All	<0.5	20	-	-
	Mean	0.433	-	14		-	-	<0.5	-	<0.5	-	-	-
	Max	0.5	4.5.6.12	17	W1	-	-	<0.5	All	<0.5	20	-	-
COD	Min	28.4	SO0407-SO04010	29	W5	-	-	<4	All	<4	20	-	-
	Mean	34	-	35		-	-	<4	-	<4	-	-	-
	Max	44.7	4,5,6,12	45	W1	-	-	<4	All	<4	20	-	-
Nitrites NO_2–N	Min	<0.2	All	<0.2	W2	<10	All	<0.2	PL9	<0.2	20	15	QD-18
	Mean	<0.2	-	0.4		<10	-	0.42	-	<0.2	-	53	-
	Max	<0.2	All	0.5	W3	30	11	0.63	ACGR63	<0.2	20	1040	B1-11
Nitrates NO_{2+3} –N	Min	27	SO0401,SO0402,SO0403, SO04011	<10	All	50	10,11	<10	ACGR63 & R64; PL6; PL11; PL12	<10	20	70	B2-6
	Mean	44	-	<10		55	-	15	-	-	-	621	-
	Max	54	4,5,6,12	<10	All	330	4	43	PL9	10	20	910	QD-13
Ammonium NH_4-N	Min	<10	All	<10	All	60	12	<10	All	<10	20	14	QD-7
	Mean	<10	-	<10		167	-	<10	-	<10	-	41	-
	Max	<10	All	<10	All	853	1	<10	All	<10	20	76	B2-13
Total N,	Min	120	SO0401-SO0403,SO04011	384	W4	-	-	420	ACGR64	500	20	-	-
	Mean	237	-	398	-	-	-	562	-	-	-	-	-
	Max	370	7,8,9,10	417	W3	-	-	653	PL11	480	20	-	-
Phosphates, PO_4 –P	Min	<5	All	<1.6	W2,W3, W4,W5	<10	6,8,9,10, 11,12	<1.6	ACGR63; ACGR64	<1.6	20	-	-
	Mean	<5	-	1.5	-	94	-	2.3	-	-	-	-	-
	Max	<5	All	1.9	W1	900	2	3.2	PL12	2	20	-	-
Total P	Min	<2	All	4.7	W4	<100	8,9,12	5.6	ACGR64	6.8	20	-	-
	Mean	<2	-	15	-	1089	-	8.8	-	-	-	-	-
	Max	<2	All	43	W1	1500	1,2	11.9	PL12	7	20	-	-
Silicates SiO2-Si	Min	480	SO0401-SO0403,SO04011	27	W4	-	-	169	PL6	57	20	-	-
	Mean	633	-	40	-	-	-	230	-	-	-	-	-
	Max	730	7,8,9,10	57	W1	-	-	256	ACGR64	112	20	-	-

5.5.4 Biological Environment – Water Column

5.5.4.1 Plankton

The water column surveys relevant to the SWAP 2D Seismic Survey Area where biological analysis was completed (i.e. plankton) are detailed in Table 5.1 above.

Phytoplankton

The phytoplankton of the southern Caspian Sea is comprised of marine, euryhaline, and brackish water forms. Species diversity decreases southwards as the input of freshwater, and consequently the number of freshwater species is lower. A total of 71 species were recorded in the Southern Caspian in the period 1962 to 1974[13] (but more recently over 100 species have been identified[1]).

The most numerous phytoplankton of the Southern Caspian, in terms of both numbers and taxa are diatoms, followed by dinoflagellates and cyanophytes (blue-green algae). Of the diatoms, the invasive species *Rhizosolenia calvaris* is often the most abundant and is now found to be generally present throughout the year. This species has an exceptionally large cell size, and combined with its abundance, it can be responsible for up to 90% of the total phytoplankton biomass[2].

On the whole the number of species observed in the surveys listed in Table 5.1 is low with between 13 and 24 species observed per survey. As shown in Table 5.10, the phytoplankton community is composed of diatoms, dinoflagellates, chlorophyta (green algae) and cyanophyta (blue-green algae). The most diverse and numerous phytoplankton were diatoms with up to 11 different species observed in a single survey (ACG Pipeline Corridor, 2012).

Table 5.10: Summary of Phytoplankton Community Composition for Surveys Relevant to the SWAP 2D Seismic Survey Area

Taxon Group	HWTP, 2009		Bahar Gum Deniz, 2011		ACG Pipeline Corridor 2012		Sangachal Bay, 2013	
	S	N (%)	S	N (%)	S	N (%)	S	N (%)
Diatoms	5	29.5	10	58.4	11	84.9	10	83.1
Dinoflagellates	2	23.1	5	21.4	8	6.8	6	2.8
Green algae	3	18.7	2	8.4	1	0.8	0	0
Blue-green algae	3	28.7	4	11.8	4	7.4	4	14.1
Total species observed	13		21		24		20	

Table 5.11 presents the species that were found in each of the plankton surveys reviewed and shows that diatom species of the genera *Chaetoceros* and *Coscinodiscus*, were observed in most surveys but there was no one diatom species seen in all surveys which is likely to reflect seasonal changes in community composition. Dinoflagellates were the next most diverse group with species of the genus *Prorocentrum* widely present. In particular, the species *Prorocentrum cordatum* was sampled in all four surveys (Table 5.11). The remaining groups of phytoplankton are chlorophyta (green algae) and cyanophyta (blue-green algae). Chlorophyta are generally dominated by *Pediastrum duplex*, a worldwide spread colonial green algae, which is frequently cited in the literature as a usual inhabitant of the Caspian Sea. The most common blue-green algae is *Microcystis pulverea*, a brackish-fresh-water cosmopolitan species.

Table 5.11: Species of Phytoplankton Observed in Surveys Relevant to the SWAP 2D Seismic Survey Area

Species	HWTP, 2009	Bahar Gum Deniz, 2001	ACG Pipeline Corridor, 2012	Sangachal Bay, 2013
Diatoms				
Actinocyclus ehrenbergii			✓	
Actinocyclus paradoxus			✓	
Chaetoceros rigidus				✓
Chaetoceros subtilis				✓
Chaetoceros mirabilis		✓		
Chaetoceros sosialis		✓		
Chaetoceros wighamii	✓			✓
Coscinodiscus gigas			✓	
Coscinodiscus granii		✓	✓	✓
Coscinodiscus jonesianus		✓	✓	✓
Coscinodiscus radiatus			✓	
Cyclotella caspia		✓		
Diploneis bombus			✓	
Gyrosigma balticum			✓	
Nitzschia closterium			✓	✓
Rhizosolenia calcar avis	✓	✓	✓	
Rhizosolenia fragilissima		✓	✓	
Sceletonema costatum	✓	✓		
Synedra tabulata				✓
Thalassionema nitzschioides			✓	✓
Thalassiosira variabilis			✓	
Thallasionema nitzschioides	✓	✓		
Thallassiosira decipiens	✓	✓		
Dinoflagellates				
Exuviaella marina		✓		
Glenodinium danicum				✓
Glenodinium lenticula			✓	
Goniaulax polyedra		✓		✓
Goniaulax digitale	✓	✓		✓
Goniaulax polyedra			✓	
Peridinium achromaticum			✓	
Peridinium crassipes			✓	
Prorocentrum cordatum	✓	✓	✓	✓
Prorocentrum marinum			✓	
Prorocentrum micans			✓	
Prorocentrum obtusum			✓	
Prorocentrum scutellum		✓	✓	✓
Cholorophytes				
Binuclearia lauterbornii	✓	✓	✓	
Oocystis lacustrix	✓			
Pediastrum duplex	✓	✓		
Cyanophytes				
Gloecapsa minuta	✓			
Gloeocapsa turgida			✓	
Gamphosphaeria aponima		✓	✓	
Gamphosphaeria lacustris		✓		
Lyngbya limnetica	✓			✓
Microcystis pulverea	✓	✓	✓	✓
Microcystis grevillei		✓		
Oscillatoria geminata				✓
Oscillatoria redekei				✓

In addition to the surveys discussed above, as part of the 2013 SD Regional survey BP undertook a plankton trawl survey. 10 stations were sampled, of which 2 (SDA and SDB) were located within close proximity of the 2D Seismic Survey Area. At these stations samples were taken using nets towed horizontally between the water surface and 20m below the water surface for a distance of approximately 200m. Analysis of the samples collected confirmed 18 species of phytoplankton present in the SDA samples and 13 species in the SDB samples. No additional species were recorded in these samples as compared to those listed in Table 5.11.

Phytoplankton growth follows a seasonal cycle with two 'blooms' of peak biomass in the Caspian Sea - a large bloom in the autumn and a smaller bloom in the spring. The seasonal cycle of production reflects seasonal changes in sunlight and water temperature and the availability of nutrients. During the winter phytoplankton production is low due to low water temperatures, low light levels and a mixed water column. Changes in light and temperature in the spring, and the resulting stratification of the water column trapping nutrients in the upper layers, results in a dramatic increase in growth, particularly by diatoms such as *Rhizosolenia calcaravis*.

Growth remains high during the summer but there is a successional shift from diatoms to dinoflagellates, typical of phytoplankton cycles in marine systems. Through the autumn the warm waters continue to be productive, often with a second peak in production levels, before phytoplankton biomass decreases again in winter[29].

Thus, the timing of phytoplankton surveys can be a strong determinant of the phytoplankton community observed; high abundance with many diatoms in the spring compared to more dinoflagellates and lower abundance overall in the summer. These seasonal changes are typical of marine environments at northern latitudes.

There are some broad spatial patterns in productivity evident in the Caspian Sea with higher levels of production (as measured by chlorophyll concentration) observed in some shallow water areas compared to open ocean, particularly where nutrient levels are high near urban coastal areas. For example, in the waters around Hovsan Bay, there were high levels of primary production in comparison to values measured off-shore and the sampled sea water was considered to be eutrophic or mesotrophic[10].

Zooplankton

The southern region of the Southern Caspian Basin has been reported to support around 180 species of zooplankton comprising protists, rotifers, copepods, cladocera and pelagic crustaceans such as mysids and the larvae of a range of invertebrate organisms[30]. The three main types of zooplankton are:

- **Copepods** - small, shrimp-like animals often no more than 1mm long, some native to the Caspian Sea and some introduced from other areas;
- **Cladocerans** - 'water fleas', often larger than copepods (1 - 5mm long), predominantly native to the Caspian; and
- **Ctenophore** - 'comb jelly' - one species, which is not native to the Caspian Sea and was first recorded in the Caspian Sea in 1999. This species may have been transported into the Caspian Sea from the Black Sea.

Prior to 2000, the zooplankton was largely dominated by naturalised and endemic species of cladocera and copepods. Since 2003, however, native and endemic taxa have been rare or absent in BP-sponsored surveys, whilst the predatory invasive ctenophore *Mnemiopsis leidyi* has become progressively more abundant and common. This species seems to have established itself as a permanent member of the zooplankton community in the Central Caspian Basin.

A number of zooplankton surveys, as listed in Table 5.1, show a similar zooplankton community structure in the SWAP 2D Seismic Survey Area. Table 5.12 shows that zooplankton communities in all surveys were dominated by copepods, cladocerans and benthic invertebrate larvae. The invasive copepod *Arcartia tonsa* is widespread and is often the dominant copepod present. The invasive ctenophore, *Mnemiopsis leidyi*, was the only species observed in all the surveys investigated. Seasonal abundance of zooplankton is closely related to that of phytoplankton with peaks in spring and autumn (approximately one month later). Thus, there are large temporal changes in both the abundance and presence of zooplankton species and so surveys conducted at different times of the year cannot be directly compared.

[29] BP, 2000. Inam Exploration Drilling Environmental Impact Assessment (ERT).
[30] Kasimov, A.G., 1994. The Ecology of the Caspian Sea. Azerbaijan Publishing House, Baku.

Table 5.12: Species of Zooplankton Observed in Surveys Relevant to the SWAP 2D Seismic Survey Area

Species	HWTP, 2009	Bahar Gum Deniz, 2011	ACG Pipeline Corridor, 2012	Sangachal Bay, 2013
Cladocera				
Evadne anonus prolongata		✓		
Evadne anonus typica		✓		
Podonevadne trigona		✓		
Podonevadne trigona typica		✓		
Cercopagis pengoi	✓	✓		
Polyphemus exiguus		✓		
Copepoda				
Calanipeda aguae dulcis		✓		
Eurytemora grimmi		✓	✓	
Eurytemora minor		✓	✓	
Acartia tonsa		✓	✓	✓
Helicyclops sarsi		✓		
Heterocope caspia		✓		
Ctenophora				
Mnemiopsis leidyi	✓	✓	✓	✓
Larvae				
Larvae Mollusca		✓		✓
Larvae *Balanus*		✓		✓
Larvae Copepoda		✓		✓
Larvae Polychaete				✓

5.5.4.2 Fish

In general, the main distribution of fish species in the Southern Caspian Sea is within the shallow water shelf areas. Maximum concentrations of fish are typically found at depths of up to 50m for the majority of the year, with only seasonal migrations into deeper water[13].

It is understood that the area to the south of the Absheron Peninsula is an important as a nursery area for almost all commercial fish species. This area is particularly sensitive in early spring, summer and autumn, when resident species are spawning. In addition, migration of sturgeon, roach, grey mullet and other species take place through the SWAP 2D Seismic Survey Area. This occurs from the south to north in the spring and north to south in the autumn.

Fish commonly found in the Southern Caspian Sea can be categorised into the three following types:

- **Migratory species**: this includes sturgeon and shad species whose spawning grounds are the river Kura and other rivers of the south-western and southern Caspian. These species will only be present in the SWAP 2D Seismic Survey Area as individuals passing through; **Other species (semi migratory)**: this includes kilka (herring family), the most abundant fish in Caspian fisheries and mullet. Kilka have a wide distribution in the Caspian with important areas in the Southern and the Central Caspian Sea, which is likely to include some parts of the SWAP 2D Seismic Survey Area and have been observed out at depth (SD Contract Area) in the winter. Kilka are also important prey for other species such as sturgeon, salmon and the Caspian seal. Mullet were introduced from the Black Sea in the 1930s and normally overwinter in the southern Caspian. They migrate in the spring to feeding grounds in the Central and Northern Caspian. Spawning takes place in deep waters between June and September. Mullet are not likely to be in the SWAP 2D Seismic Survey Area in any great numbers; and
- **Resident species**: several non-commercial species such as gobies are found in all regions of the Caspian Sea, predominantly in shallower areas (up to 30-70m in spring and summer, migrating to greater depths in winter). Gobies are second only to herring in the number of species in the Caspian Sea.

The migration routes and spawning areas of fish species passing through the SWAP 2D Seismic Survey Area are shown in Figure 5.5 and the depths where fish are likely to be present are shown in Table 5.13[8].

Figure 5.5: Migration Routes for Herring/Shad, Mullet, Sturgeon, Kilka and Beluga

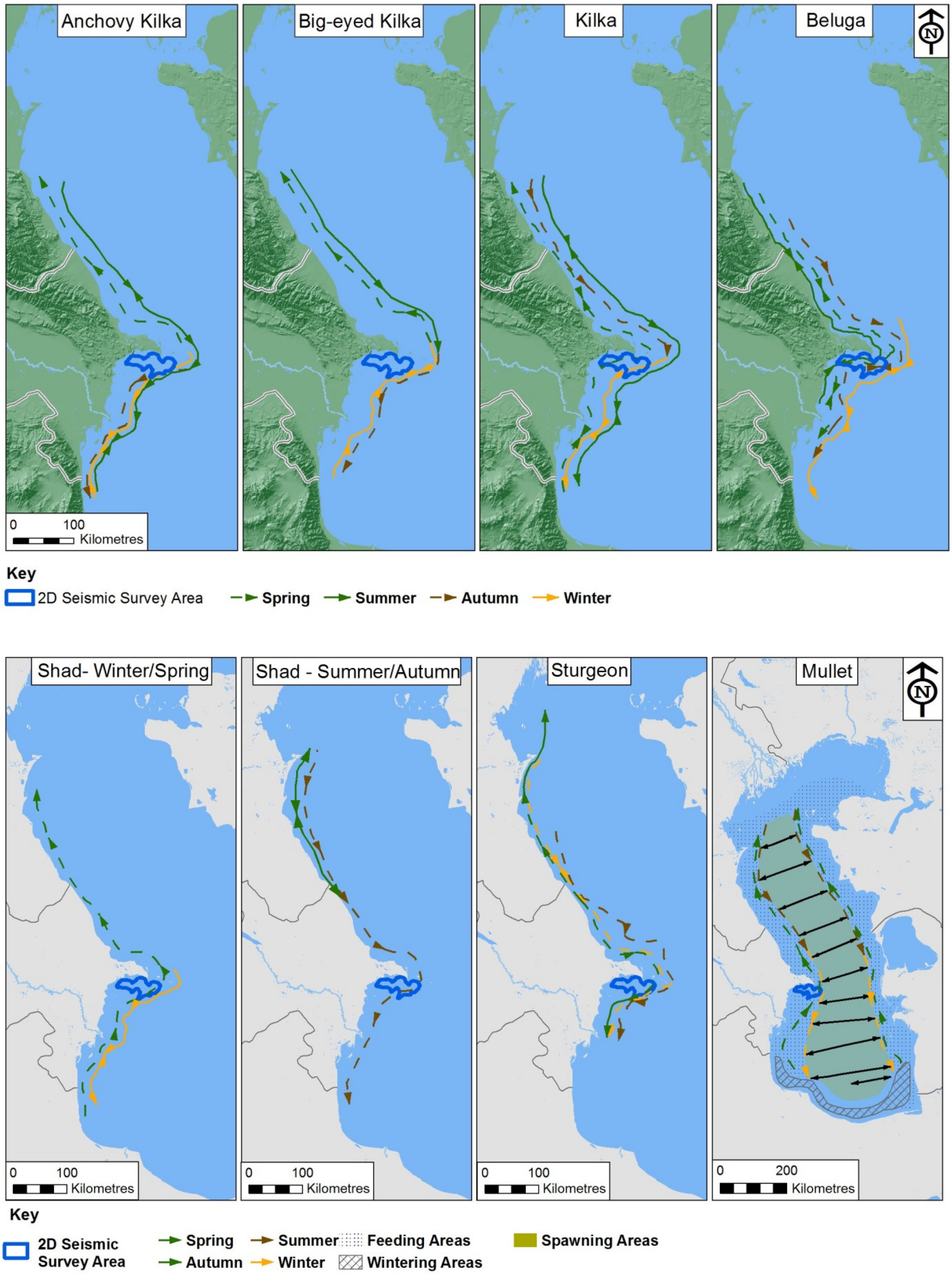


Table 5.13: Summary of the Fish Species Expected to Present in the Southern Caspian Sea

Name of Species	Common name	Hearing group	IUCN Red List Status	Seasonal presence in Southern Caspian Sea	Spring/ Summer Depth (m)	Autumn/ Winter Depth (m)
STURGEON (Family Acipenseridae)						
Huso huso	Beluga	SB	EN	Spring and autumn migration	Up to 70	80-100
Acipenser guldenstadti	Russian sturgeon	SB	EN			
Acipenser güldenstädtii persicus natio cyrensis	Kura (Persian) sturgeon	SB	EN			
Acipenser nudiventris	Kura barbel sturgeon	SB	EN			
Asipenser stellatus stellatus natio cyrensis	Kura (South-Caspian) stellate sturgeon	SB	EN		Up to 50	75-100
KILKA (genus *Clupeonella*, family Clupeidae – herring)						
Clupeonella engrauliformis	Anchovy kilka	SB/HS	LV	Migrating along coastline in spring/ summer and winter	Up to 40	A: ≤ 60-80 W: ≤ 100-130
Clupeonella grimmi	Big-eyed kilka	SB/HS	LV		Up to 80	A: up to 80-100 W: up to 130-450
Clupeonella delicatula caspia	Caspian common kilka	SB/HS	LV		Up to 40	
SHAD (genus *Alosa* Cuvier, family Clupeidae – herring)						
Alosa caspia caspia	Caspian shad	SB/HS	LC	Spring and autumn/ winter migration route	Up to 40	A: up to 30-40 W: deeper but depth not known
Alosa brashnikovi autumnalis	Big-eyed shad	SB/HS	LC			
Alosa kessleri volgensis	Volga shad	SB/HS	LC		Depth not known	A: depth unknown W: > 100
Alosa kessleri kessleri	Black-backed shad	SB	LC			
CARP (family Cyprinidae)						
Rutilus frisii kutum	Kutum/Black Sea Roach	SB	LC	Feeding summer/ autumn	Up to 20-50	
Rutilus rutilus caspicus	Roach	SB	LC	Year round migration	Not known	
Alburnus chalcoides	Danubian bleak	SB	LC	Southwest migrations in coastal waters	Not known	
Vimba vimba	Bream	SB	LC	North-south migrations	Not known	
Cyprinus carpio	Common carp	SB	VU	North-south migrations	Not known	
MULLET (family Mugilidae)						
Lisa auratus	Golden mullet	SB	LC	Summer feeding and spawning	Up to 400-500	
Lisa saliens	Leaping mullet	SB	LC		Up to 200-300	
OTHERS						
*Atherina mochon pontica nation caspia**	Big-scale sandsmelt	Not known	-	Migrations in sea	Up to 50	
Gasterosteus aculeatus	Three-spined stickleback	Not known	LC	Migrations in sea	Not known	
Salmo trutta caspius	Caspian trout	SB	LC	Feeding migrations during the year	Western coastal areas of middle and southern Caspian at depths up to 40-50 m.	
Syngnathus nigrolineatus caspius	Pipefish	No SB	LC	Migrations in sea	Not known	
Sander marinus	Estuarine perch	Not known	LC	Migrations in sea	Not known	

Name of Species	Common name	Hearing group	IUCN Red List Status	Seasonal presence in Southern Caspian Sea	Spring/ Summer Depth (m)	Autumn/ Winter Depth (m)
CARP (family Cyprinidae)						
Rutilus frisii kutum	Kutum	SB	LC	Feeding summer/ autumn	Up to 20-50	
MULLET (family Mugilidae)						
Lisa auratus	Golden mullet	SB	LC	Summer feeding and spawning	Up to 400-500	
Lisa saliens	Leaping mullet	SB	LC		Up to 200-300	
GOBY (family Gobiidae)						
Neogobius caspius	Caspian goby	V	LC	Resident species predominant in shallow water but also found offshore in winter	Up to 70	> 70 up to 500
Neogobius melanostomus affinis	Round goby		LC			
Neogobius syrman eurystomus	Caspian syrman goby		LC			
Neogobius fluviatilis	Monkey goby		LC			
Knipowitschia longicaudata	Knipovich long-tailed goby		LC			
Neogobius kessleri gorlap	Caspian big-headed goby		LC			
Benthophilus grimmi	Grimm big-headed goby		LC			
Neogobius bathybius	Deepwater goby		LC			
Knipowitschia Iljini	-		LC			
Mesogobius nonultimus	-		LC			
Anatrirostrum profundorum			LC			
Benthophilus ctenolepidus	Persian Goby		LC			

Key:
Hearing Type: SB – fish with swim bladder; V – sometimes lacking swim bladder depending on species; HS – hearing specialists with wide frequency hearing range
IUCN Red list: EN – endangered; LV – low vulnerability, LC – least concern
Seasons: A – autumn, W – winter
* Also known as *Atherina boyeri caspia*.

The timing of species most likely to be present in the shallow waters of the 2D Seismic Survey Area (between approximately 10 and 25 m) are:

- Sturgeon – spring and autumn migration route passes through shallow coastal waters;
- Kilka – most likely to be in shallow waters during spring and summer migrations;
- Shad – spring (northwards) and autumn (southwards) migration in shallow waters;
- Mullet – spawning in the summer months on east and west coastal areas; and
- Gobies – widely distributed in shallow waters all year round, breeding between April and July.

The only data immediately available on nearshore fish populations is contained in a series of reports of studies conducted for BP in Sangachal Bay between 2000 and 2014. The majority of these studies have focused on physical and physiological measurements on resident fish populations of gobies and sandsmelt, and have not attempted to make overall assessments of fish community composition and abundance.

During recent years distribution and abundances of kilka has altered in response to a number of factors including overfishing, and the presence of the invasive ctenophore (*Mnemiopsis leidyi*). Data from Department on Protection and Reproduction of Aquatic Bioresources (DPRAB) indicates that the total quantity of kilka (traditionally the most important species for the fishing industry) landed in the Azerbaijan Sector of the Caspian Sea has consistently reduced by 96% from 2002 (10,950 tonnes) to 2011 (485 tonnes)[8].

As well as a reduction in catch size the proportional share of species in catches has changed, from being dominated by anchovy kilka (*Clupeonella engrauliformis*) to ordinary Caspian kilka (*Clupeonella cultriventris)* being the dominant species in fish catches. In addition major aggregations of kilka have been observed in nearshore locations in less than 50 m of water, such as at Oily Rocks rather than in deeper waters at the traditional fishing banks[8].

Most of the fish species, including sturgeon which are IUCN classified[31] 'endangered' possess a swim-bladder, a gas-filled sac found in most bony fishes of the class Osteichthyes which provides buoyancy and can act as a sound-producing organ. The swim-bladder can enhance the hearing capability of the fish species through the amplification of underwater sound. Fish with swim-bladders therefore tend to be more sensitive to sound than those that do not possess such an organ. Subsequently, there is potential for such species of fish to be more susceptible to underwater sound than fish with no swim-bladder.

Fish of the herring family and its relatives (Clupeiformes) are regarded as hearing specialists because their hearing below 1,000 Hz is generally similar to other fish but their hearing range extends to at least 4,000 Hz and some species (e.g. American shad) are able to detect sounds to over 180 kHz[32].

Hearing specialist fish, in particular kilka, are likely to be found in the 2D Seismic Survey Area year round although in smaller numbers in winter, outside the main spawning and migration periods.

5.5.4.3 Caspian Seals

The Caspian seal (*Pusa caspica*) is the only marine mammal present in the Caspian Sea. The species is endemic to the Caspian Sea and has been listed on the IUCN Red List of Threatened Species[31] as 'Endangered' since October 2008. The Caspian seal population has decreased by more than 90% since the start of the 20th century and continues to decline, considered to be due to a combination of commercial hunting, habitat degradation (through introduction of invasive species), disease, industrial development, pollution and fishing operations using nets. The population is now thought to be around 100,000 individuals though this estimate is disputed by Russian scientists[33].

Caspian seals are observed in many regions of the Caspian Sea depending on the season as they undertake annual migrations between breeding locations in the north and feeding locations in the south[34] (Figure 5.6). In the winter, seals are found in the north of the Caspian Sea where pupping and mating occurs before migrating in the spring to the summer feeding grounds in the south of the Caspian Sea.

Pupping occurs between the end of January and the beginning of February although this can vary by up to a month depending on weather. About a month after giving birth, females finish nursing the pups and once lactation has finished seals mate on the sea ice.

When the sea ice melts the seals begin their southern migration in two directions - most travel along the east coast of the Caspian Sea while the remainder travel south along the west coast (Figure 5.6). The western migration route passes between Pirallahi Island, Chilov Island and Oily Rocks. Historically, seals have appeared in the waters of Azerbaijan from late April to early May with peak numbers of seals observed in the vicinity of the Absheron Peninsula and the adjacent islands to the east between late April and May. However, since 2009, seals have been observed in the waters of Azerbaijan from late March. These earlier observations, from aerial data collected by helicopter pilots and seal tracking[35], are thought to be the result of earlier melting of the sea ice and the need for seals to feed in the south for longer due to lower stocks of fish in general, and kilka in particular.

In early or mid-May most seals move from the islands of Absheron Peninsula and oil rocks and head east and southeast towards the central part of the Caspian Sea[36]. However, around a third remain to

[31] IUCN, 2015. IUCN Red List of Threatened Species. Available at: http://www.iucnredlist.org/ Accessed August 2015.
[32] Popper, A.N. 2012. Fish Hearing and Sensitivity to Acoustic Impacts. Appendix J. Atlantic OCS proposed Geological and Geophysical Activities, Mid-Atlantic and South Atlantic Planning Areas, Draft Programmatic Environmental Impact Statement. OCS EIS/EA BOEM 2012-005. March 2012. 2 vols. Available from http://www.cbd.int.
[33] Eybatov, T. M., 2015. Caspian Seal Status Report for Seismic Project SWAP. Zardabi Natural History Museum.
[34] Eybatov, T. M., 2015. Long term observations of seal population numbers and migration patterns by the seal research team at the Zardabi Natural History Museum.
[35] Liliya Dmitrieva, Per Comms, 2015
[36] Tariel Eybatov, August 2015, *Per.comms.*

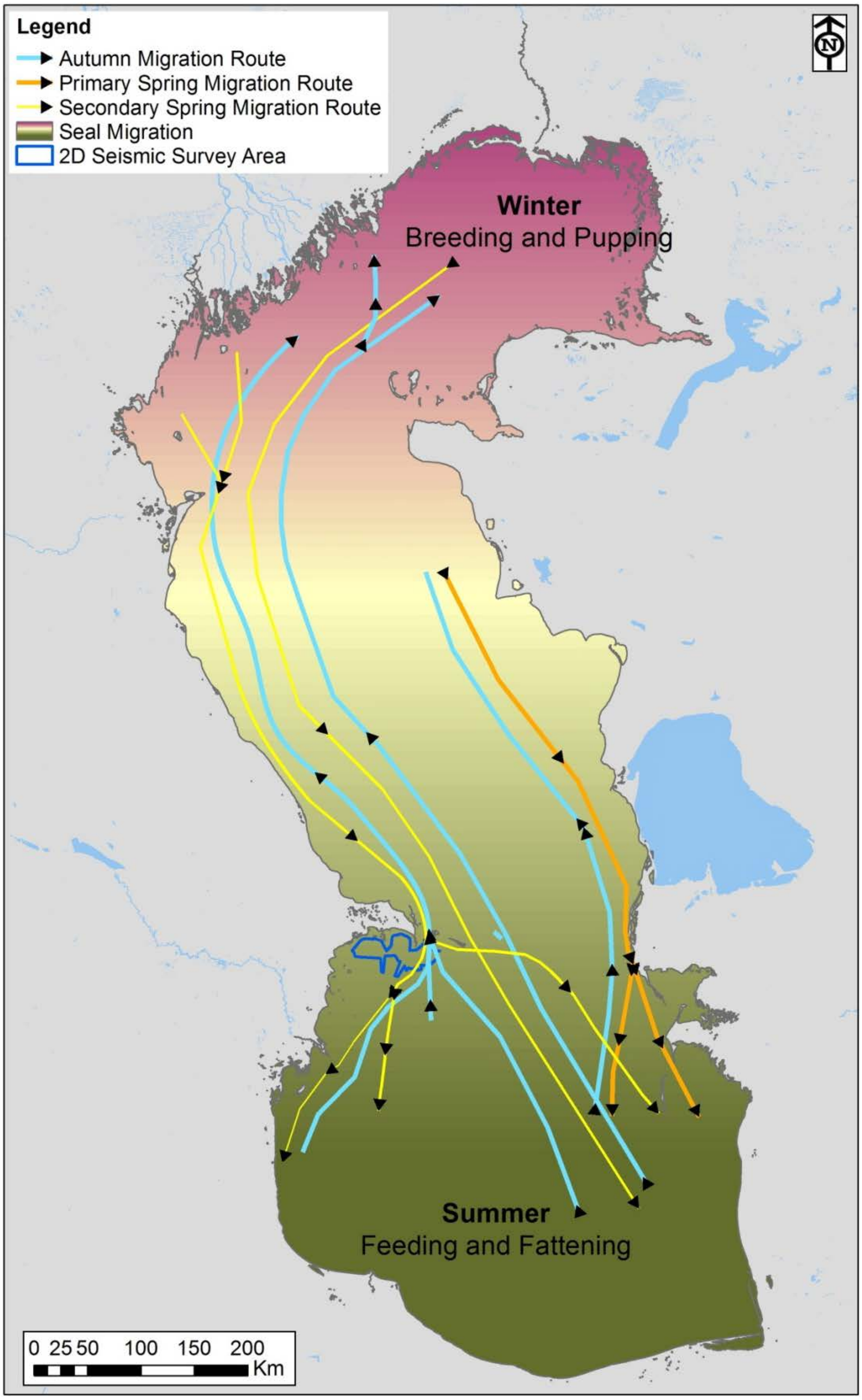
the north of the Absheron Peninsula during the summer time. They usually keep a distance of 1-2 km away from the coastline but can be observed anywhere between the coast and the central part of the Caspian Sea. The maximum concentration is usually between 2 km and 8 km from the coastline.

From the area to the east of the Absheron Peninsula, seals have been observed to migrate south in two directions. The main route taken is directly south to the Southern Caspian where seals feed on anchovy kilka and herring. A secondary route is taken by fewer seals towards the Kura River delta where they feed on roach or towards the fishing nets installed near Shirvan National Park.

It is understood that seals generally avoid the coastal waters south of the Absheron Peninsula due to high turbidity in the area generated by currents and the relatively shallow water. Their migration routes are closely linked with the migration and distribution of kilka, which is the main source of food for seals. The spring migration is considered to be the most sensitive period for seals in the vicinity of the Absheron Peninsula as they are more vulnerable as they have depleted fat reserves following the winter pupping and mating season.

The winter migration northwards starts in October, following similar routes in the opposite direction. Thus, seals are again observed in the waters of Azerbaijan, particularly in the vicinity of the Absheron Peninsula and the adjacent islands to the east from October to mid-December, with peak numbers generally observed in November. However, in recent years the northwards migration has been delayed and it is now expected that significant numbers of seals will be still present in Azerbaijani sector of Caspian Sea during the first half of December. In contrast to the spring migration the autumn migration is not characterised by high speed movement of seals and therefore the islands of the Absheron archipelago are usually not massively crowded during the autumn migration months.

Figure 5.6: Spring and Autumn Migration of the Caspian Seal



Recent seal observation data, from 2010 to 2015, in the area around the Absheron Peninsula have been collected by helicopter pilots and compiled by the Zardabi Natural History Museum[33]. These observations give an indication of the presence of seals in areas in and adjacent to the 2D Seismic Survey Area. The records of these observations are provided within Table 5.14 with the approximate areas where seals were observed shown on Figure 5.7. It should be noted this data from aerial observations can only provide indicative information with regard to areas known to be used by seals as the observations are not systematic.

Table 5.14: Location of Caspian Seal Seasonal Sightings from Aerial Observations in the Period Spring 2010 to Spring 2015

Season	Location	Observations Made
Spring	Pirallahi Island Kichik Tava Island Boyuk Tava Island Tava Alti Island Dardanella Chilov Island Oily Rocks Shahdili Spit Gugushu Garabatdag Island Urunos Island	Early migrations (observations seals at the beginning of April) in 2011 and 2014. Seals observed in small to large (200-400 individuals) groups, particularly in the islands south of Pirahilli Island. Large numbers observed in 2011 and 2013 in particular.
Summer	Yalama to Lankaran Oily Rocks South of Shahdili Spit Between Chilov Island and Oily Rocks	Smalls groups of seals observed offshore. Occasional observations of seals following supply boats and small groups at night around ships with bright lights.
Autumn	Pirallahi Island Chilov Island Around the Absheron Peninsula and Shahdili Spit Gizilagach resort Shirvan resort	Observations in the autumn range from small to very large groups (consisting of several hundred seals) seen around the Absheron peninsula and islands in late October and November.
Winter	Chilov Island including southern spit Tava Alti Island Urunos Island Garabatdag Island Dardanelli Kichik Tava Island	Seals either absent or seen only as individuals or very small groups during winter.

The data currently available, supplemented with local specialist knowledge, indicates that that the area to the south east and east of the Absheron Peninsula including Pirallahi and Chilov Islands and the other islands in this area is the most sensitive with regard to Caspian Seals. Seals are known to be present in these locations, sometimes in large groups, from early April to the end of May and from October to mid-December. The peak months with regard to sensitivity, are April, May and November with the spring months of higher sensitivity due to the vulnerability of the seals during these months in particular. The area to the south of the Absheron Peninsula is not considered sensitive except the area immediately the south west of Shahdili Spit which lies on the secondary migration route described above.

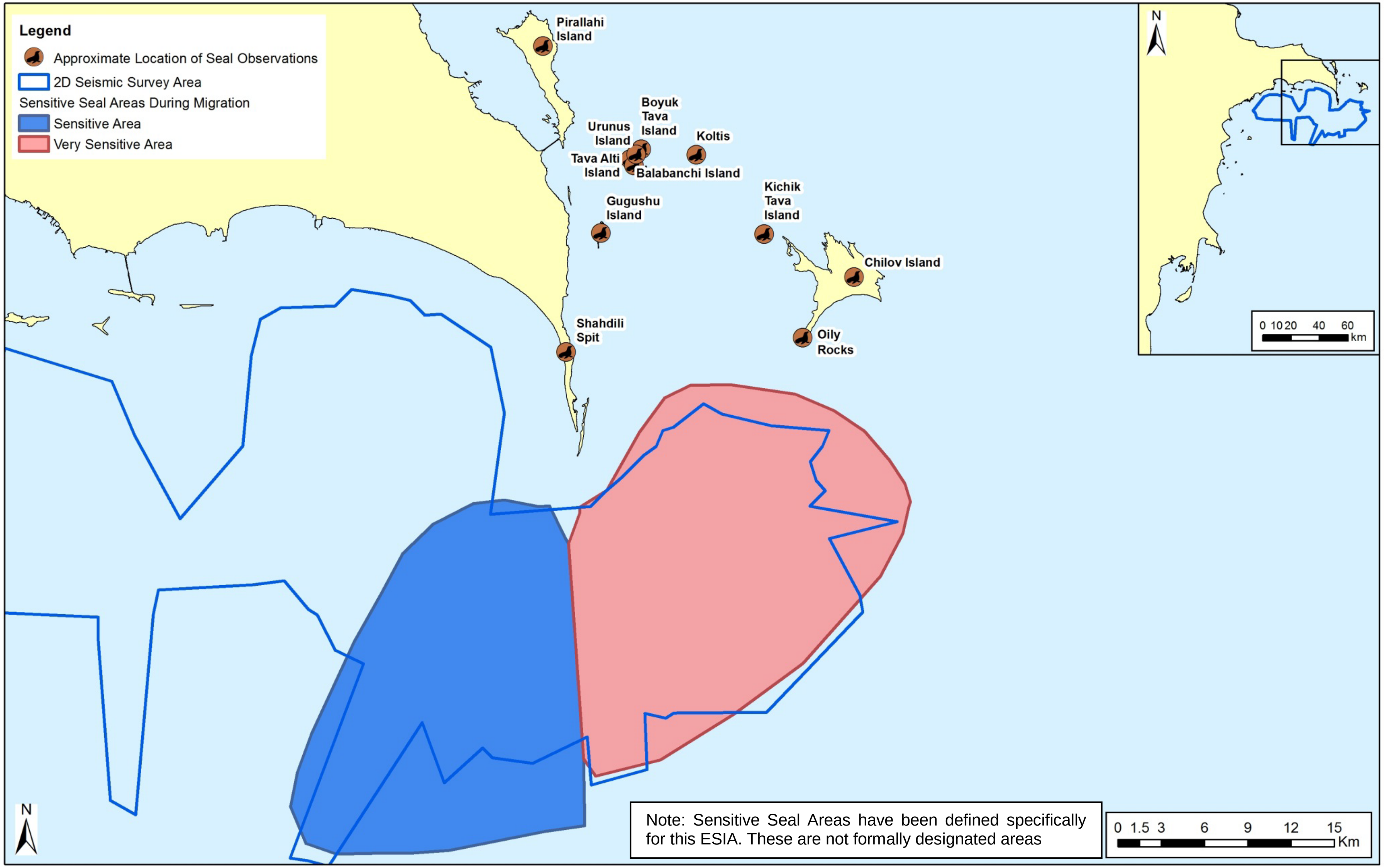
In liaison with local specialist, Tariel Eybatov, two indicative areas (denoted Sensitive and Highly Sensitive) have been determined relative to the 2D Seismic Survey Area in which seals are considered particularly sensitive during the spring and autumn migration periods and specifically during April, May and November. These areas are shown in Figure 5.7.

In general the hearing of all seal species is restricted to the 10Hz - 100kHz frequency range, therefore they are highly sensitive to low frequency sound of the type generated by seismic surveys with effects ranging from potential auditory injury to an avoidance response depending on source sound level and the distance from the source[37].

It should be noted that no systematic scientific Caspian seal surveys have been undertaken in Azerbaijani waters for 20 years. As such there is a high level of uncertainty around the data presented in this section which is based on available information and expert advice at the time of writing.

[37] Southall, B. L., A. E. Bowles, William T. Ellison, J. J., J. J. Finneran, R. L. Gentry, C. R. G. Jr., D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A. Thomas, and P. L. Tyack. 2008. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals 33:1-521.

Figure 5.7: Approximate Locations of 2010-2015 Observations of the Caspian Seal and Location of Sensitive and Very Sensitive Seal Areas in the Vicinity of the SWAP 2D Seismic Survey Area



5.6 Overwintering, Migrating and Nesting Birds

The Caspian region has a high diversity of bird species, with a large number of endemic species present. Migrating and overwintering birds tend to move widely along the Caspian coast. Consequently, at a regional level, the coastal zone of the Caspian Sea has been identified as an area of ornithological importance, supporting both internationally and nationally significant numbers of migrating and overwintering birds. Given Azerbaijan's location within the bird migrating circuit of Europe, Asia and the Middle East a large number of bird species have been recorded, with onshore and offshore areas providing habitats for 347 avifauna species, including 31 species of seabirds[38].

The Absheron to Gobustan coastline of the Caspian Sea is an area of international and regional importance providing habitat for breeding, nesting, migratory and overwintering birds. An estimated 128 species of waterfowl and coastal birds have been recorded in this region. Many species of conservation importance, including globally threatened species, species included in Annex I of the EU Birds Directive (2009/147/EC) and birds listed in the Red Book of Azerbaijan, can be found in this coastal area at some point. Approximately 21 of these species are included in the Azerbaijan Red Data Book (AzRDB) and the IUCN Red List of Threatened Species[31].

The waters and coastline within the vicinity of the SWAP 2D Seismic Survey Area provide an abundant food source, including small fish (preyed on by grebes, herons, cormorants, gulls, terns and egrets), plants and invertebrates (fed on by grebes, swans, geese, ducks, coot and stints) and large fish and other birds (preyed on by harriers and white-tailed eagles). A total of around 130,000 waterfowl are found in the coastal waters of the Absheron to Gobustan region[39].

The ornithological importance of this coastline is reflected in the designation of six Important Bird and Biodiversity Areas (IBAs) in vicinity of the SWAP 2D Seismic Survey Area, listed in Table 5.15 and shown in Figure 5.8. The SWAP 2D Seismic Survey Area is immediately adjacent to the Absheron National Park and between approximately 5km of the Red Lake and Sahil Settlement IBAs.

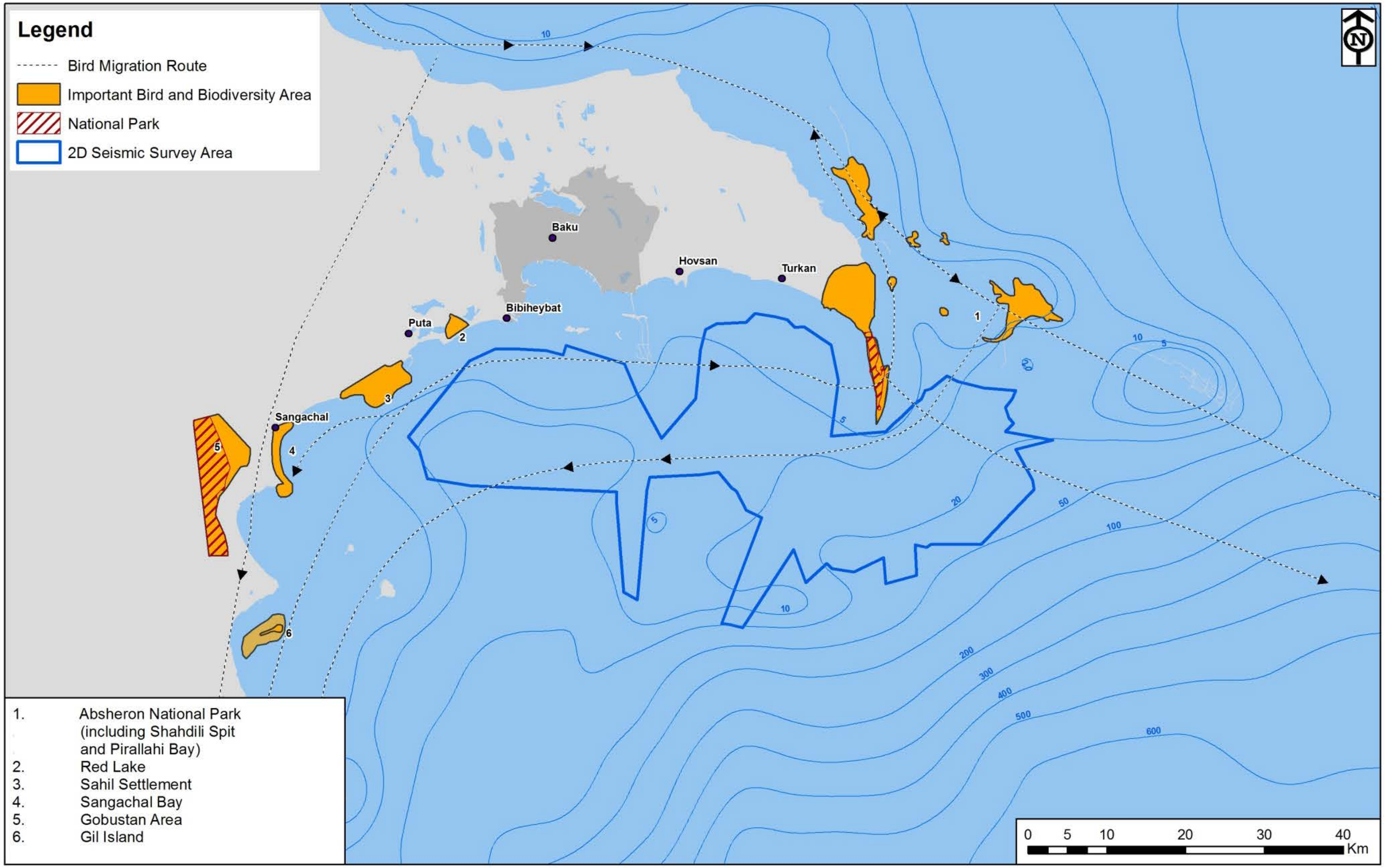
Table 5.15: Azerbaijani Sites of Ornithological Importance In the Vicinity of the 2D Seismic Survey Area

Sites of Ornithological Importance		Designation	Reasons for Designation
1	Absheron National Park (including Shahdili spit and Pirallahi Island)	KBA[1]/IBA[2] IUCN not reported[3] IUCN II[4]	KBA/IBA - The area is important for overwintering and migrating bird species. IUCN not reported – Absheron National Park 46 RDB species occur within and in the surroundings of the national park.
2	Red Lake	KBA/IBA	Significant populations of globally threatened bird species are known to occur here. The area is important for breeding bird species.
3	Sahil Settlement	KBA/IBA	Significant populations of globally threatened bird species are known to occur here. The area is important for overwintering and migrating bird species.
4	Sangachal Bay	KBA/IBA	The area is important for overwintering and migrating bird species.
5	Gobustan Area	KBA/IBA IUCN not reported	KBA/IBA - Populations of globally threatened bird species are known to occur here. The area is important for breeding bird species. IUCN not reported – Gobustan State Nature Reserve.
6	Gil Island	KBA/IBA IUCN IV	KBA/IBA - The area is important for breeding bird species. IUCN IV – two RDB species occur in the area.

Notes:[1] Nationally identified sites of global significance that address biodiversity conservation at a local scale (individual protected areas, concessions and land management units). Key Biodiversity Areas (KBAs) comprise an 'umbrella' which includes globally important sites (e.g. Important Bird Areas (IBAs), Important Plant Areas (IPA), Important Sites for Freshwater Biodiversity, Ecologically & Biologically Significant Areas (EBSAs) in the High Seas, Alliance for Zero Extinction (AZE) sites).
[2] Key sites for the conservation of bird species, identified by BirdLife International. These sites are small enough to be conserved in their entirety, and are different in character or habitat or ornithological importance from the surrounding area.
[3] A nationally protected area as listed by the World database on protected areas, but with an unknown IUCN category, e.g. Gobustan State Nature Reserve.
[4] The main objective of a national park (IUCN Category II) is to protect functioning ecosystems, rather than focussing on protecting a particular species or habitats through management of the reserves thus prioritising these species or habitats which would come under IUCN category IV

[38] BirdLife International, 2014. Country profile: Azerbaijan. Available from: http://www.birdlife.org/datazone/country/azerbaijan, Accessed in August 2015.
[39] Babayev. I.R.. 2015. Summary of References on the Birds of Absheron-Gobustan Coastline of The Caspian Sea In South-Western Absheron Contract Area.

Figure 5.8: Important Ornithological Sites Located on the Southwest Caspian Coast and Migration Routes



The distribution and abundance of birds in the vicinity of the SWAP 2D Seismic Survey Area is subject to significant seasonal changes particularly during the spring and autumn migration periods as birds move between feeding, breeding and overwintering grounds.

The species composition changes sharply during migration periods, leading to the area being highly sensitive during periods of overwintering and migration, (although Shahdili Spit is considered to be sensitive all year around). Birds use these routes primarily for migrating to the southern coast of the Caspian Sea, the Kur-Araz lowland, Turkmenistan, south west Asia and Africa for the winter and then fly north along the same route during spring.

In the autumn, birds nesting in western Russia, Siberia and northwest Kazakhstan migrate south to overwinter in the southern Caspian, south west Asia and Africa. The most active migration period occurs from mid-August until mid-December though this may extend into January depending on the weather. The most active period of migration, when most migrating birds are likely to be travelling through the 2D Seismic Survey Area, is November. The number of birds is directly influenced by the weather conditions, with colder winters bringing greater numbers and species to the region. Following the autumn migration, birds are widespread along the coastline, both on land and at sea.

The spring migration starts in the second half of February and finishes in April with March being the most active period[40,41]. During the autumn migration, 51.43% of birds fly along the Caspian Sea coast to the south, 36.64% fly to the south west, while 11.93% of the birds fly from the Pirallahi-Shahdili coastline to the south east. In spring, 39.76% of the birds fly to the north, 26.32% to the northwest and 25.50% to the north east[42]. The migration routes in the surroundings of the SWAP 2D Seismic Survey Area are shown in Figure 5.8.

Limited information is available regarding the offshore distribution and abundance of birds in the Southern Caspian Sea. However, a literature review undertaken in January 2010 focused on the number and species of birds observed in surveys between 2002 and 2006 along the coastlines of the Shahdili Spit and Pirallahi Island[8]. This review highlighted that the breeding season of birds in the area begins at the end of April/beginning May and continues until mid-July. At the end of July and beginning of August, the birds leave their nesting places and disperse. During the breeding season, 18 species were recorded along the Pirallahi coastline and 16 species along the Shahdili coastline.

5.6.1 Overwintering Birds

Around 50 species of bird are reported to overwinter along the Absheron to Gobustan coastline. The majority are ducks (of the genera *Anas, Netta* and *Aythya*) and coot (*Fulica atra*) but migrating herring, common, black-headed and great black-headed gulls (all of the genus *Larus*) also overwinter in this area. The most sensitive areas for overwintering birds are largely defined by the designated IBAs[43] although the coastline near Turkan and Puta (Figure 5.8) is also reported to be important[44].

The Absheron Peninsula coastlines support particularly high numbers of overwintering birds. During the winter bird surveys between 2002 and 2006, an average of 24873 waterfowl and 181 coastal birds, and 20004 waterfowl and 198 coastal birds were recorded along the Pirallahi coastline and Shahdili coastline, respectively. Table 5.16 presents overwintering birds of importance recorded between 2002 and 2006 along the Pirallahi and Shahdili coastlines. Four species recorded along both coastlines exceeded the 1% limit[45] for the provision of Ramsar status though none of these is considered to be endangered (Table 5.16). Four rare and endangered bird species listed in the AzRDB and the IUCN Red List of Threatened Species were also recorded.

[40] Mustafayev G. T., Sadigova N. A., 2005. Azerbaijan Birds (defining monograph) Baku, "Çaşoğlu" publishing house.
[41] Tugayev D. G., 2000. Catalogue of Azerbaijan birds. Elm, Baku..
[42] Karabanova N. I., 1991. Migrations of birds in the northeast part of Azerbaijan. Abstract of a thesis for a degree of C. and. S. {Biology} Kishinyov.
[43] BirdLife International, 2015. Important Bird and Biodiversity Areas (IBAs). Available at: http://www.birdlife.org/worldwide/programmes/important-bird-and-biodiversity-areas-ibas Accessed August 2015
[44] Babayev, I. R., 2015. Shallow Water Absheron Peninsula Bird Report.
[45] Criterion 6 of the Ramsar Convention states that a wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

Table 5.16: Overwintering Birds of Importance Recorded between 2002 and 2006 in Pirallahi and Shahdili Coastlines

Bird Species		Pirallahi Coastline	Shahdili coastline	Exceeds limit for the provision of Ramsar Status	Red Book of Azerbaijan	IUCN Red List Status
Species name	Common name					
Aythya ferina	Common Pochard	✓	✓	✓		
Aythya fuligula	Tufted duck	✓	✓	✓		
Cygnus cygnus	Whooper Swan	✓	✓			
Cygnus olor	Mute Swan	✓	✓		✓	
Falica atra	Coot	✓	✓	✓		
Numenius arquata	Eurasian Curlew	✓				✓ (NT)
Pelecanus crispus	Dalmatian Pelican		✓		✓	✓ (VU)
Podiceps cristatus	Great Crested Grebe	✓	✓	✓		
Porphyrio porphyrio	Purple Swamphen		✓		✓	

A number of overwintering species, particularly ducks, will dive in shallow waters to feed on small fish and benthic invertebrates on or near the seabed. Wading birds also feed in coastal waters but, with the exception of the beak, remain above the water during feeding.

There are no duck or gull species of conservation concern thought to be overwintering in or in the vicinity of the 2D Seismic Survey Area although the ferruginous duck, *Aythya nyroca*, is listed as Near Threatened (NT) on the IUCN Red List of Threatened Species[31].

5.6.2 Migrating Birds

Survey work completed between 2002 and 2006 during the spring migration identified 19 and 29 bird species in the coastal waters of Pirallahi Island and the Shahdili coastline, respectively. In total, nine species recorded between 2002 and 2006 exceeded the 1% limit established for the provision of Ramsar status. During the same period, five endangered species were also recorded (Table 5.17).

Table 5.17: Migrating Birds of Importance Recorded between 2002 and 2006 in Pirallahi and Shahdili Coastlines

Bird Species		Pirallahi Coastline	Shahdili coastline	Exceeds limit for the provision of Ramsar Status	Red Book of Azerbaijan	IUCN Red List Status
Species name	Common name					
Aythya ferina	Common Pochard	✓	✓	✓		
Aythya fuligula	Tufted duck		✓	✓		
Aythya nyroca	Ferruginous Duck		✓			✓ (NT)
Cygnus cygnus	Whooper Swan		✓	✓		
Cygnus columbianus	Tundra Swan		✓	✓	✓	
Cygnus olor	Mute Swan	✓	✓	✓	✓	
Netta rufina	Red-crested pochard		✓	✓		
Pelecanus crispus	Dalmatian Pelican	✓	✓		✓	✓ (VU)
Podiceps cristatus	Great Crested Grebe	✓	✓	✓		
Phoenicopterus roseus	Greater Flamingo		✓		✓	

5.6.3 Nesting Birds

The coastal area of the Absheron region is also important for nesting migratory seabirds, in particular the Mediterranean gull (*Larus melanocephalus)* and the slender-billed gull *(Larus genei)* and a number of tern species (of the genera *Sterna*, *Chlidonius* and *Hydroprogne*). During the nesting period the key areas for these breeding birds are the Shahdili Spit, including Pirallahi and other nearby islands, and a number of small islands near Puta Bay and Bibiheybat (refer to Figure 5.8). Birds can be found nesting, between May and July, in a wide range of habitats including areas of open dry land, wet sand, rocky, gravelly places, piled shells and old offshore platforms.

Some species, particularly terns (of the genus *Sterna*), are specialist plunge divers taking fast moving prey by diving into the water from height. Non-specialist feeders like the gulls may also dive to feed but do so with less skill and from lower height. Most gulls are more reliant on surface feeding catching krill or small fish that have been concentrated by marine currents. Thus, there may be diving birds feeding in waters within or close to the SWAP 2D Seismic Survey Area during the nesting season.

None of the species of nesting birds is recorded as being of international conservation concern.

5.6.4 Species of Conservation Importance

Table 5.18 list the 20 species of bird of conservation importance (included on the IUCN Red List or listed in the AzRDB) known to be present along the Absheron to Gobustan coastline[44].

Table 5.18: Bird Species of Conservation Concern Observed on the Absheron to Gobustan Coastline

Species	Common name	Red Book of Azerbaijan[46]	IUCN Red List of Threatened Species[31]
Anser erythropus	Lesser White-fronted	✓	✓ (VU)
Aythya nyroca	Ferruginous Duck	✓	✓ (NT)
Branta ruficollis	Red-breasted Goose	✓	✓ (EN)
Chetusia gregaria (or Vanellus gregarious)	Sociable Lapwing	✓	✓(CE)
Crex crex	Corn Crake	✓	
Cygnus olor	Mute Swan	✓	
Gallinago media	Great Snipe	✓	✓ (NT)
Glareola nordmanni	Black-winged Pratincole	✓	✓ (NT)
Leucogeranus leucogeranus (or Grus leucogeranus	Siberian Crane		✓(CE)
Limosa limosa	Black-tailed Godwit		✓ (NT)
Marmaronetta angustirostris	Marbled Teal	✓	✓ (VU)
Melanitta fusca	Velvet Scoter	✓	✓(EN)
Numenius arquata	Eurasian Curlew		✓ (NT)
Numenius tenuirostris	Slender-billed Curlew		✓ (CE)
Oxyura leucocephala	White-headed Duck	✓	✓ (EN)
Pelecanus crispus	Dalmatian Pelican	✓	✓ (VU)
Pelecanus onocrotalus	Great White Pelican	✓	
Phoenicopterus ruber	Greater Flamingo	✓	
Porphyrio porphyrio	Purple Gallinule or Purple Swamphen	✓	
Vanellochetusia leucura (or Vanellus leucurus)	White-tailed Lapwing	✓	
IUCN: CE - critically endangered; E – endangered; VU – vulnerable; NT – near threatened.			

5.6.5 Summary

A large number of overwintering, migrating or nesting birds will be present in the 2D Seismic Survey Area throughout the year. There are, however, some key periods and areas of higher sensitivity. Ducks and coots are overwintering from December to February and the presence of migrating species peaks in March and November. The IBAs are the key areas for these groups of birds. Nesting birds, including those that plunge dive to feed, will be present between May to July with the Shahdili Spit and nearby islands of the Absheron Peninsula the most sensitive area.

[46] Azerbaijan Ornithological Society, 2015. Threatened Bird Species in Azerbaijan. Available at: http://www.aos.az/en/2013-01-10-09-21-19/threatened-bird-species-in-azerbaijan Accessed August 2015

5.7 Socio-Economic Environment

5.7.1 National Context

Azerbaijan comprises 77 administrative districts including 11 city districts. Most of Azerbaijan's major settlements are coastal, with 22%[47] of the population resident in the Azerbaijani capital, Baku. Other major cities along the coast include Ganja and Sumgait, located approximately 290km west and 30km north west of Baku, respectively.

Azerbaijan's economy is heavily dependent on its energy exports, with more than 90% of total exports accounted for by oil and gas[48]. This reliance resulted in increased pressure from falling oil prices, which led to the recent devaluation of the currency by a third (34%) in February 2015. The devaluation was imposed by the Azerbaijan Government in order to protect country exports and to support the diversification of the economy.

After oil and gas, the economy is dominated by the agricultural sector, with the majority of those engaged in agriculture being self-employed and living in rural areas, and to a lesser extent, the manufacturing (mainly mining and hydrocarbon) and services (tourism, financial and telecommunications) sectors. The contribution of the fisheries industry to the Azerbaijani economy as a whole is low, with a reported 1,400 people employed nationally in the fisheries industry in 2008[49]. The overall contribution of fisheries to national food security and poverty reduction is also therefore low; however there are local areas where fisheries are important for the rural economy and the livelihoods of coastal communities[50].

5.7.2 Regional Context

The SWAP 2D Seismic Survey Area is wholly located in the marine environment to the east and south east of the Absheron Peninsula. The six coastal districts considered along the coastline nearest to the SWAP 2D Seismic Survey Area include Baku City, Garadagh, Khazar, Sabayel Surakhany Pirallahi and Goya. The main settlements located within these districts include Sangachal, Umid, Sahil, Puta, Lokbatan, Bibiheybat, Baku, Hovsan, Turkan, Zira, Shahdili Spit, and the islands of Pirallahi and Chilov. The majority of these settlements are located within the Garadagh District, which was reported to have a total population of 118,500 people in 2015[51]. Economic activity in the Garadagh District is dominated by the industrial sector, primarily oil and gas.

5.7.3 Population, Demographic Structure and Ethnicity

In 2015, the population of Azerbaijan was 9,593,000 with a gender distribution of 49.8% male and 50.2% female. The proportion of the population resident in urban areas has remained relatively constant at around 50% over the past 20 years[47]. There are some indications, however, that the population of urban areas may be under-recorded as many people who move to Baku for employment on a temporary or permanent basis may retain their registration in their place of origin.

Azerbaijan is characterised by a relatively high birth rate, a population structure dominated by young people and active (external and internal) migration flows. In 2015 71% of the population were aged between 16 to 64 years old and potentially economically active[52]. In 2015, the dependency ratio[53] was

[47]The State Statistical Committee of the Republic of Azerbaijan. Available at: http://www.stat.gov.az/source/demoqraphy/indexen.php Accessed August 2015.
[48] US Energy Information Administration (EIA), 2014. Country Analysis Briefs: Azerbaijan. Available at: http://www.eia.gov/countries/cab.cfm?fips=AJ Accessed in August 2015.
[49] These numbers do not include employees in the processing industry, which are privately owned.
[50] Salmanov, Z., Qasimov, A., Fersoy, H. & van Anrooy, R., 2013. Fisheries and Aquaculture in the Republic of Azerbaijan: a review. FAO Fisheries and Aquaculture Circular No. 1030/4. Ankara, FAO. 42 pp. Available at: http://www.fao.org/docrep/017/i3113e/i3113e00.htm Accessed August 2015
[51] State Statistical Committee of the Republic of Azerbaijan, 2014 Territories, number and density of population by economic and administrative regions of the Republic of Azerbaijan. Available at: http://www.stat.gov.az/source/demoqraphy/en/1_15en.xls Accessed August 2015
[52] World Bank, 2015. Population ages 15-64 (% of total). Available at: http://data.worldbank.org/indicator/SP.POP.1564.TO.ZS Accessed in August 2015.

28%. Data from 2009 showed a dependency ratio slightly higher in rural areas (24%) than in urban areas (21%)[47].

Azerbaijan has shown a natural increase in population; the scale of increase was 12.2 per 1000 people in 2014. Life expectancy in 2011 was 73.6 years (70.9 years for men and 76.2 years for women) which reflected a significant, positive change since 1990 when average life expectancy was 71.1 years (67.0 for men and 74.8 years for women). Migration patterns have changed from a 20-year period of net outward migration between 1970 and 2007, to a net increase in immigration, which in 2011 was 1,700 persons[47].

Based on the 2009 census[47] (which provides the latest data), the majority of the national population (91.6%) was ethnically 'Azerbaijani', with the remaining 8% made up of a range of ethnic groups. Main ethnicities are Lezgis, Armenians, Russians and Talyshs, representing the 2%, 1%, 1%, and 1%, respectively[47]. The religious distribution in Azerbaijan is relatively homogenous, with the majority of the population defined as Muslim. Other religions include Orthodox Christianity, Judaism, Catholicism and Protestantism.

Azerbaijan has a large population of Internally Displaced Persons (IDP) as a result of the conflict between Armenia and Azerbaijan in the early 1990s, over the Nagorno–Karabakh region, nationally approximately 568892 people are classed as IDPs[54]. Within the Garadagh District in 2010 IDPs represented approximately 10% of the population; the same trend was observed in other districts in Azerbaijan[8].

5.7.4 Regional Economy

Within the Absheron region, as across the country as a whole, the economy is dominated by the industrial sector, primarily oil and gas. As Table 5.19 shows in 2013 the highest number of small enterprises registered in the country were in the trade sector (including oil and gas) which accounted for 45% of small enterprises within the Absheron region[47]. Agriculture, forestry and fisheries businesses are shown to account for approximately 5% of small enterprises within the Absheron region, which is less half the national average (11.5%). Industry accounts for a large percentage of the small enterprises registered in the Absheron region (20%) compared to the national level (12%). In other sectors such as construction and real estate the Absheron region figures recorded were similar to Baku City and national levels.

Based on reported data, overall the number of enterprises in Baku City and in the Absheron region has remained relatively constant for the period of 2005 to 2013.

[53] The dependency ratio relates the number of children (0-14 years old) and older persons (65 years or over) to the working-age population (15-64 years old)
[54] Internally Displaced Monitoring Centre (IDMC), 2014. Available at: http://www.nrc.ch/europe-the-caucasus-and-central-asia/azerbaijan/ Accessed August 2015.

Table 5.19 Number of Small Enterprises Registered Nationally, within Baku City and the Absheron Region by Economic Activity, 2013

Sector	National Total		Baku City		Absheron Region	
	Number of Enterprises	%	Number of Enterprises	%	Number of Enterprises	%
Agriculture, forestry and fishing	1,663	11.50	56	0.71	38	4.87
Industry	1,804	12.47	934	11.77	160	20.49
Construction	1,012	7.00	5,75	7.25	62	7.94
Trade (including oil and gas)	6,405	44.29	3,761	47.41	355	45.45
Transportation and Storage	286	1.98	177	2.23	1	0.13
Real Estate Activities	226	1.56	187	2.36	10	1.28
Other Sectors	3,065	21.19	2,243	28.27	155	19.85

5.7.5 Poverty

In recent years, a significant reduction in poverty in Azerbaijan has occurred[55], accompanied by a rise in gross national income (GNI) per capita by 91% between 2001 and 2013 moving from 660US$ to 7,350US$[56]. This rapid growth is due to the expansion of the oil and gas sector, high levels of public expenditure and substantial reforms supporting a market-based economy[56]. However, growth slowed in 2014 due mostly to falling oil prices and a decline in oil production.

Improvements to health and education have also been achieved across many parts of the country. However basic infrastructure such as accessible roads and sanitation systems are lacking in rural communities and utility services such as electricity and water are not universally reliable.

Nationally, the level of inequality is high, particularly between rural and urban areas. Agricultural is a key component of the non-oil economy. The majority of those engaged in agriculture are known to be self-employed and live in rural areas. In 2011, agricultural lands comprised approximately 4.8 million hectares, including both pasturelands and sown areas[57], which equates to approximately 55% of the total area of Azerbaijan.

Inequality is also high in urban areas with reported data showing significant disparities between the rich and the poor with regard to access to services[57]. As in other transition countries economic growth has not had a significant impact on employment, with youth employment is comparatively low at 14 % (2008), having fallen from 42% in 1999[57]. This is because the growth has not generated a comparatively significant number of jobs nationally, partly as it has not been based on a diversified economy.

[55] World Bank, 2015. Azerbaijan Partnership Program Snapshot.
[56] World Bank, 2015 World Development Indicators. Available at: http://data.worldbank.org/country/azerbaijan Accessed August 2015.
[57] RSK, 2014. SCP Expansion Project, Azerbaijan, Environmental and Social Impact Assessment. Available at: http://www.bp.com/content/dam/bp-country/en_az/pdf/ESIAs/SCPXESIA/Overall_Project_Assessment.pdf. Accessed August 2015 Accessed August 2015.

5.7.6 Fisheries

5.7.6.1 Commercial Fishing

Commercial fishing is undertaken across the Azerbaijan sector of the Southern Caspian Sea by a number of legal entities and individual companies. Currently 93 vessels registered in Azerbaijan and an associated 298 fishermen hold appropriate permits to fish the waters of the Southern Caspian[58]. The DPRAB which forms part of the MENR is responsible for issuing commercial fishing permits and specifying quotas per fish species and per vessel.

Table 5.13 above presents a summary of fish species known to be present within the SWAP 2D Sesimic Survey Area, migration patterns and depth of expected occurrance. Of those fish listed, the following are known to be of importance for commerical fishing[58]:

- Sprat (i.e. kilka) – *Clupeonella delicatula caspia Svetovidov;*
- Sprat anchovy (i.e. anchovy kilka)– *Clupeonella engrauliformis* (Borodin);
- Caspian shad – *Alosa caspia caspia* (Eichwald);
- Brazhnikov's shad – *Alosa brashnikovi* (Borodin);
- Blackback shad – *Alosa kessleri kessleri* (Grimm);
- Roach – *Rutilus rutilus caspicus* Berg;
- Black sea roach – *Rutilus frisii kutum* (Kamensky);
- Danubian bleak – *Chalkarburnus chalcoides* (Guldenstadt);
- Zahrte or bream – *Vimba vimba persa* (Pallas);
- Common carp – *Cyprinus carpio Linne; and*
- Golden grey mullet – *Liza auratus Risso.*

All individuals (vessel owners, crew and owners of companies) involved in commercial fishing within the Azerbaijan sector of the Caspian Sea must be Azerbaijani nationals. At the end of each month, the individual holding the commercial fishing permit is required to submit a report to DPRAB that indicates the results of their fishing effort (number of vessels and time spent at sea) and total weight caught.

Commercial fishing methods include:

- ***Seine Boats:*** There are medium and large seine boats sized 8-10m and 14-18m in length, respectively. This method involves releasing two cone-shaped nets into the water at a depth of approximately 20m, which are then lifted onto the boat. Nets are normally equipped with electric lighting to attract kilka.
- ***Lifting Transportation Vessels:*** Lifting transportation vessels (LTV) are similar to seine boats, equipped with cone-shaped nets and in some cases with freezer, ice and processing facilities, so fish can be processed on board. LVT are normally 14 to 18 m length.

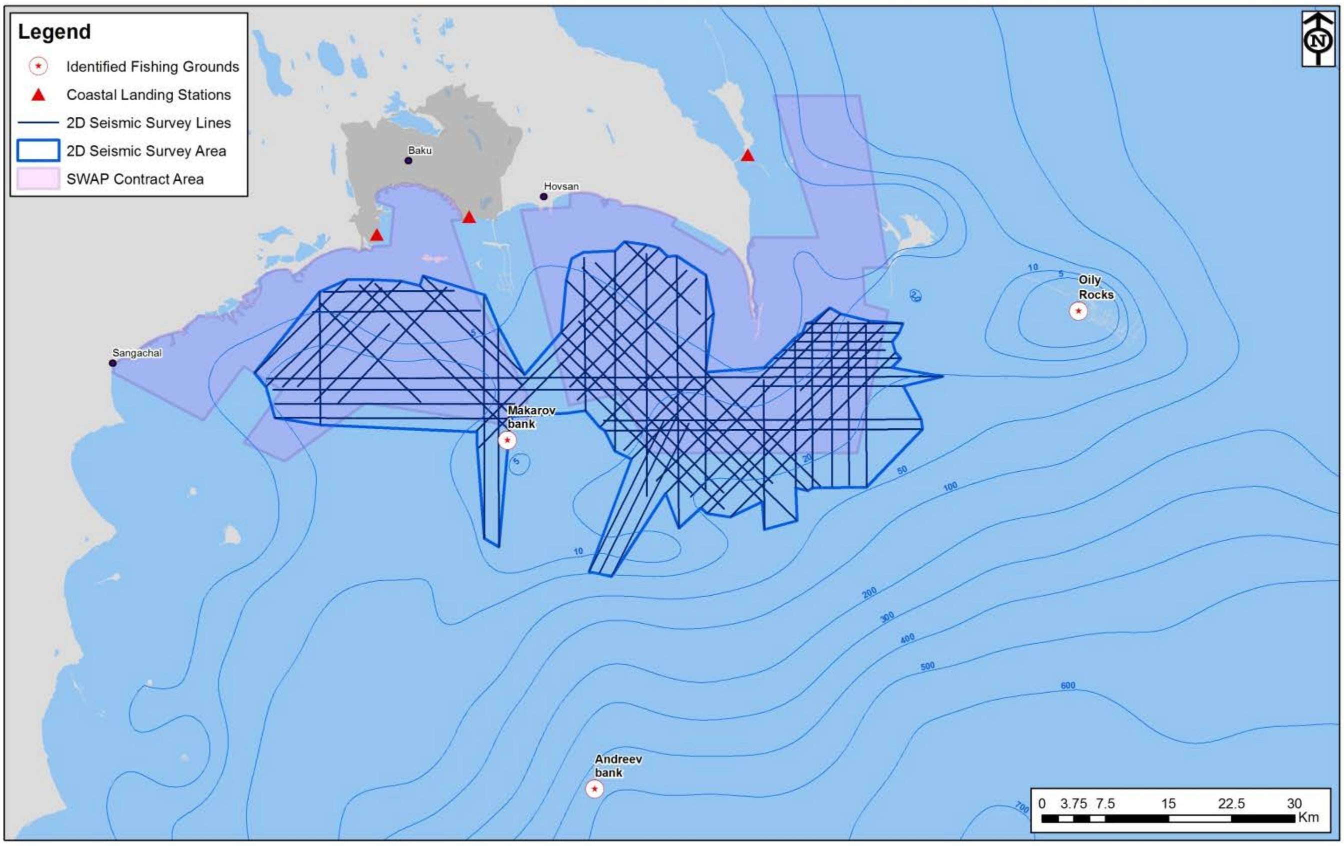
Figure 5.9 below shows the location of the key commercial fishing grounds in the vicinity of the SWAP 2D Seismic Survey Area[8]. The fishing ground Makarov Bank is located within the SWAP 2D Seismic Survey Area, while Andreev Bank and Oily Rocks are the other closest favoured fishing grounds to the SWAP 2D Seismic Survey Area, located approximately 24 km south and 23 km east, respectively.

The seasonal variation in commercial fishing activity within the Azerbaijan sector of the Caspian Sea is summarised below:

[58] MENR Letter, 3 July 2015. Response to a Request for Information from BP. Ref. 4/1009-6.

- **December to February** – mid to low season due to unfavourable winter weather conditions. Typically fishing undertaken by 50% of the commercial fishing fleet or less;
- **March to April** - **September to November** – high season with fishing particularly favourable during dull, cloudy weather conditions when electric lighting to attract fish is particularly effective;
- **May to June** – low season when kilka species are spawning and migrate to the Northern and Central Caspian Sea; and
- **July to August** – mid - low season, due to clear and cloudless weather.

Figure 5.9: Locations of Favoured Fishing Grounds and Locations of Landing Ports and Harbours



All licensed owners of fishing vessels and accompanying crew are of Azerbaijan nationality, male, and typically recruited from the coastal regions. Fishing crews are comprised of four to five crew members; the crew leader is named in the fishing licence. In addition, indirect jobs are created including industry support workers including fish processing, fishing equipment supplies and transportation. Crew members typically work without any formal written contract and are paid either in cash, or a mixture of cash and fish for household consumption. During the low season fishermen typically seek alternative sources of income in other sectors such as such as construction, agriculture and retail. The average salary of a crew member is not known.

Stocks of the key fish species important to the fishing industry has gradually declined over the years resulting in a significant reduction in catch. In a number of cases, as species have become less abundant, they have been given protection status (i.e. listed in the AzRDB) and catching them has been prohibited. Data from DPRAB indicates that the total quantity of kilka (traditionally the most important species for the fishing industry) landed in the Azerbaijan Sector of the Caspian Sea has consistently reduced by 96% from 2002 (10950 tonnes) to 2011 (485 tonnes)[8]

The Makarov Bank, shown in Figure 5.9, is a kilka fishing ground. There are five commercial vessels currently operating in the Azerbaijan sector of the Caspian Sea which fish for kilka. Four of these vessels are based and depart from Lenkoran port (in the south of Azerbaijan) and mostly operate closer to the border waters with Iran (primarily within the KurKamen, Borisov and Karagedova banks). It is not financially viable for these vessels to travel further i.e. to the north of Azerbaijani sector of the

Caspian Sea. The remaining vessel (LTRV-50 "Shahriyar") owned by the Caspian Fish Company is based and departs from Pirallahi Island. Between November and March this vessel is operated approximately twice a month for periods of up to one week (limited by the fuel capacity of the vessel). Fishing is carried out only at night time using cone nets and electric lighting[59].

5.7.6.2 Small-Scale Fishing

Small-scale fishing is known to occur along the coast of the Absheron region and is undertaken primarily for local consumption (i.e. subsistence) and sale within the local communities e.g. to local companies and enterprises, and also for recreational purposes.

Based on a survey focused on the small-scale fishing undertaken within Sangachal Bay for the purpose of the SD2 Project[60] it is understood that small-scale fishing is typically undertaken using fixed nets (including gill nets), fish traps, fishing rods, seine nets and small boats equipped with outboard motors. Fishing equipment, including boats, is normally shared among fishermen who work in the same fishing crew. Licences are granted for individual vessels and impose certain limitations in relation to fishing areas, species that can be caught and the number of crew members to which each licence applies. On the basis of the licence terms it is understood the small-scale fishing is typically undertaken within 2-3 nautical miles (i.e. up to 5.5km) of the coast.

Small-scale fishing was reported to be undertaken year round with high season occurring between September and May, while the low fishing season occurs between June and August.

The main species caught by small-scale fishermen in Sangachal Bay in 2014 were reported to be kutum (*Rutilus frisii*), carp (*Cyrpinus carpio*) and mullet (*Liza auratus*). Bream (*Abramis brama*) and vobla (*Rutilus caspicus*) were caught in lower quantities. A relatively small quantity of beluga, or European sturgeon (*Huso huso*), is also caught.

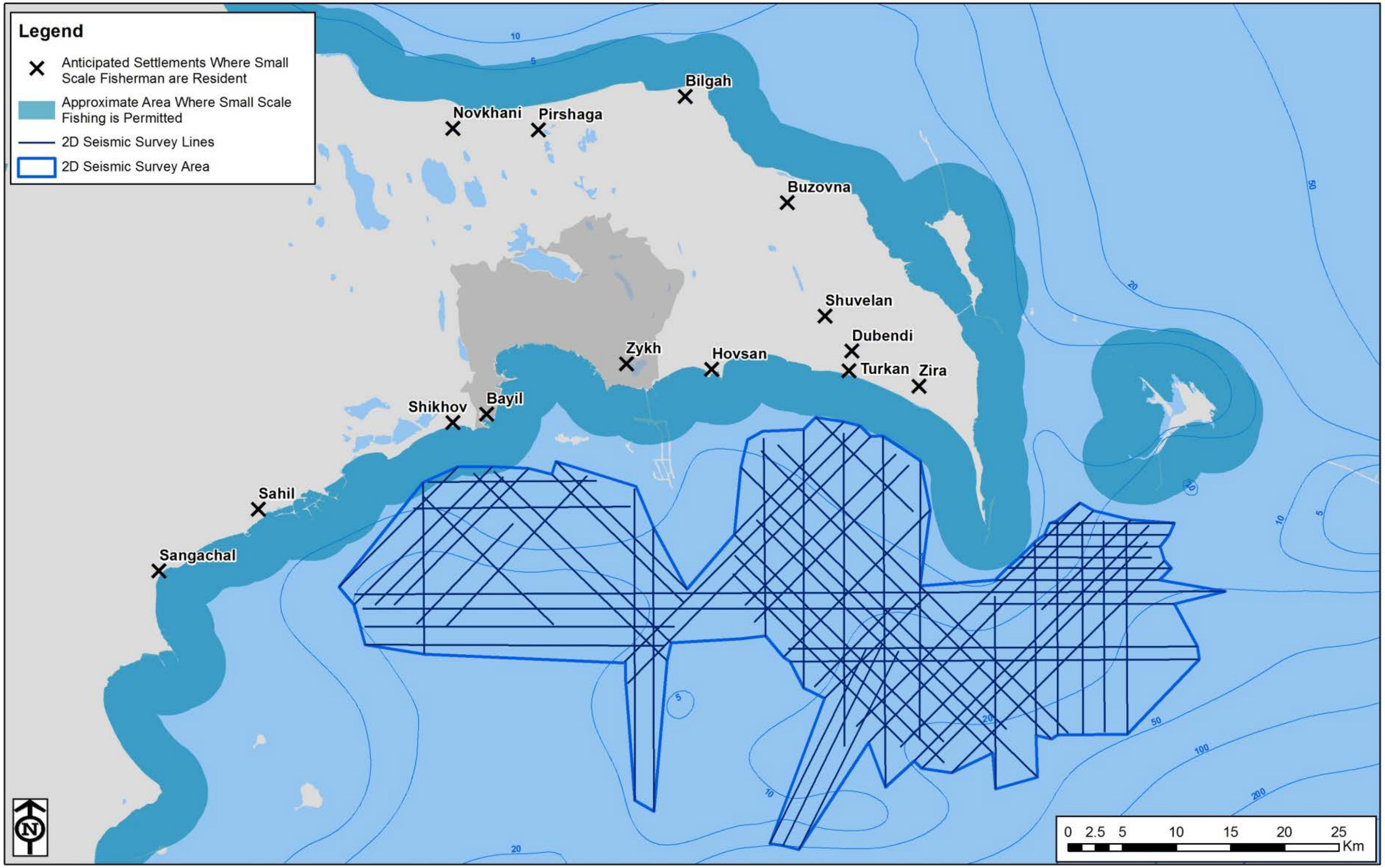
Based on 2011 population data, the number of people from Sangachal who rely on small-scale fishing for income represents 3% of the population. More than 50% of the fishermen involved in fishing in Sangachal Bay belong to households where this was reported to be the main source of income.

In addition to Sangachal Bay, small-scale fishing is known to be undertaken from a number of locations along the Absheron coastline including Sahil, Shikhov, Bayil, Zikh, Hovsan, Turkan and Zira (Figure 5.10)[61]. The number of fishermen involved, the extent to which they rely on fishing for their income and the communities they come from is not known.

Recreational fishing in Azerbaijan can be undertaken without a permit except within national reserves, fish hatcheries and fish farms. Approximately 20000 recreational fishermen are understood to be registered at the regional and national branches of the Society of Hunters and Fishers[50].

[59] Mehman Akhundov, 2015, *Per.comms.*
[60] AECOM, 2015, SD2 Livelihood Baseline Study of Small-Scale Fishing Activities.
[61] Sulaco, 2015, *Per.comms.*

Figure 5.10: Approximate Locations Where Small Scale Fishermen Are Resident and Approximate Area Where Small Scale Fishing is Understood to be Permitted



5.7.6.3 Unlicensed Fishing Activity

Unlicensed fishing activity relates to both fish catch exceeding the quota and species authorised by the regulatory authorities, as well as fishing without any license, i.e. unlicensed vessels or unlicensed fishermen. From previous studies undertaken in the Azerbaijan sector of the Caspian Sea there is evidence of fishing crews being composed of more crew members than those authorised in the fishing licence.

Illegal fishing in the Absheron Peninsula is considered to be substantial, with evidence of violations to fishery protection legislation every year as well as instances of fishing equipment and catch being confiscated. In 2009 for example, there were 103 violations of fish protection legislation, and 114 people were prosecuted (94 were charged with criminal offences). Confiscated fish that year included 3,224kg of ordinary fish and 2649kg of sturgeon[8].

5.7.7 Recreational Activities

There are a number of locations along the coast of the Absheron Region that are used for recreational activities and water sports including diving, sailing and kite surfing. The majority of the beach locations used by the public for recreation are located along the northern coast of the Absheron Peninsula, however there are also a number of beaches along the southern coastline between Hovsan and the Shahdili Spit (refer to Figure 5.11).

While diving for recreation is not known to be a significant activity in the Azerbaijan sector of the Caspian Sea, three diving clubs are understood to be located within the Absheron Region who are known to undertake diving in the locations shown within Figure 5.11. The location nearest to the 2D Seismic Survey Area is Boyuk Zira Island (just south of Baku Bay), approximately 2km from the Survey Area. This location is understood to be visited less frequently than the sites to the east of the Absheron Peninsula and is generally used by experienced divers, who travel to the island by boat. Diving is known to take place year round although is less popular during winter months and is not undertaken during windy or stormy weather.

5.7.8 Shipping, Ports and Existing Offshore Infrastructure

The primary commercial ports of Azerbaijan are situated on the Absheron Peninsula and in the vicinity of Baku. Shipping activities in the waters of the Central and Southern Caspian Sea include commercial trade, passenger, scientific and supply vessel operations to the offshore oil and gas industry. The main shipping routes, ports and obstructions (e.g. operational and abandoned oil and gas related structures) are illustrated in Figure 5.12. There are three shipping routes that pass through the SWAP 2D Seismic Survey Area, including the Baku-Turkmenbashy and the Baku-Cheleken shipping routes, which pass through the centre of the SWAP 2D Seismic Survey Area.

Figure 5.11: Recreational Activities in the Surroundings of the SWAP 2D Seismic Survey Area

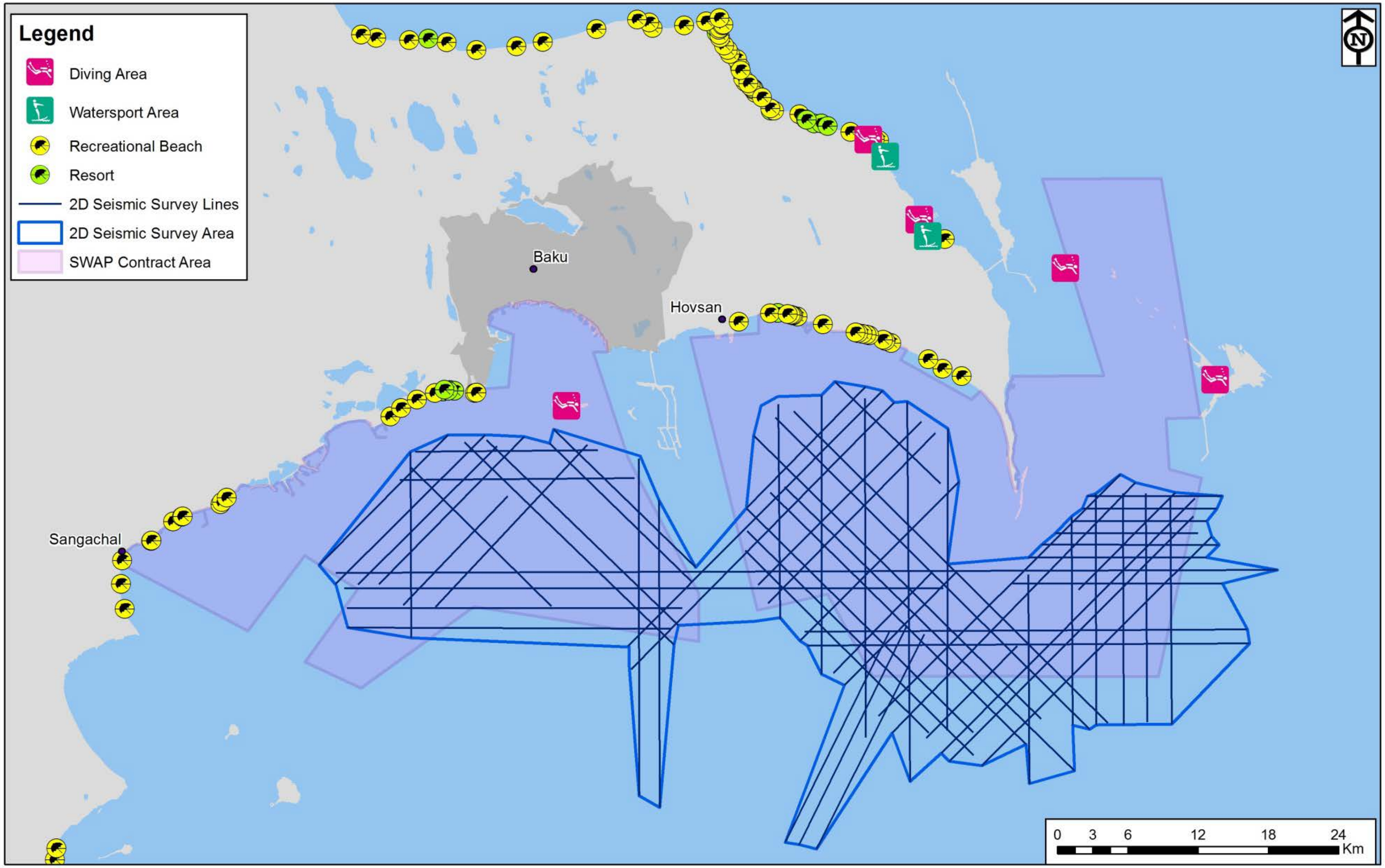
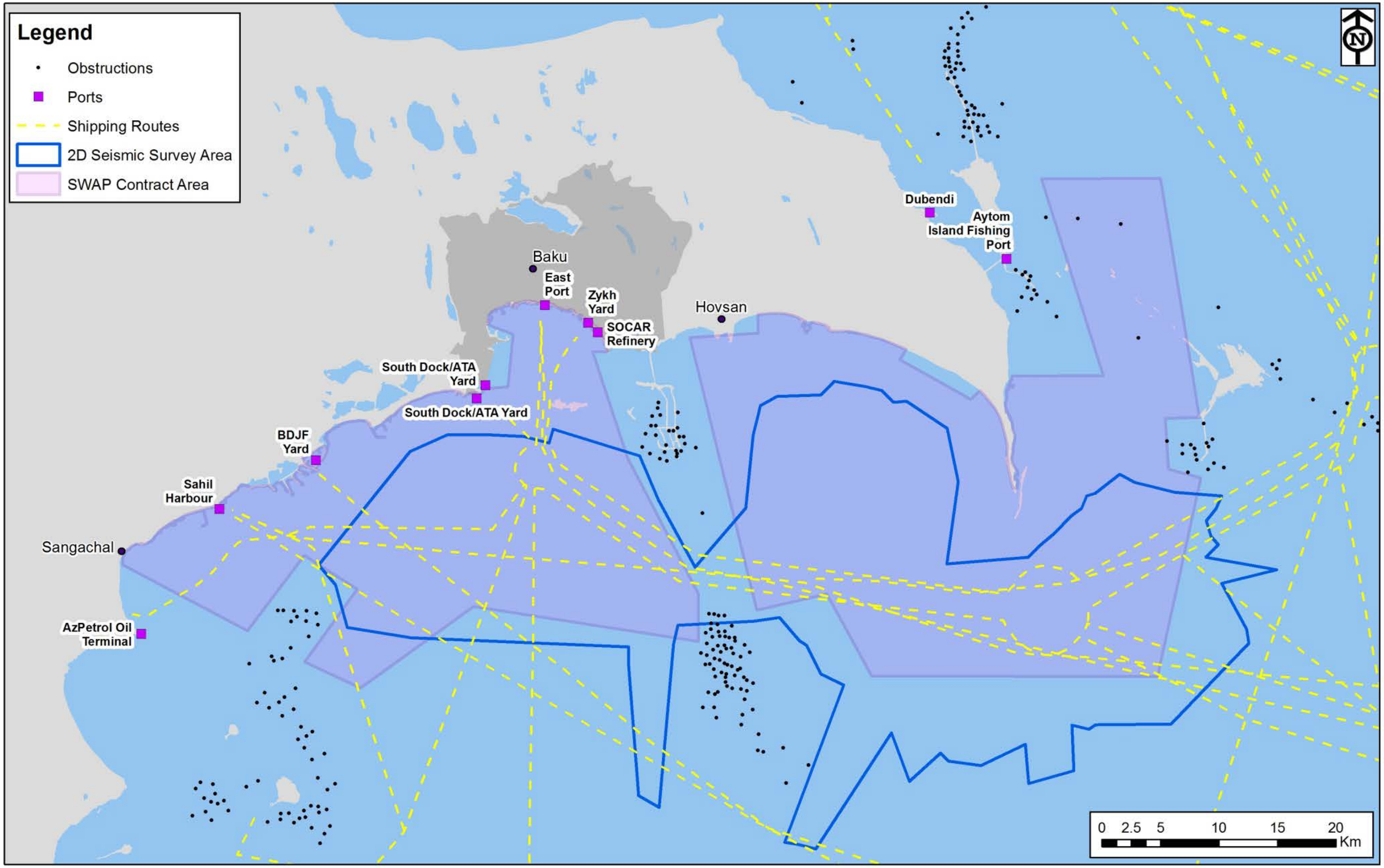


Figure 5.12: Shipping Routes, Ports and Obstructions in the Vicinity of the SWAP 2D Seismic Survey Area



5.8 Marine Cultural Heritage

The ancient Paratethys Sea was a large shallow sea that stretched from the region north of the Alps in Europe to Central Asia. From the start of the Pliocene period (approximately five million years ago), the Paratethys Sea became progressively shallower; the Caspian Sea is a remnant of this. The Caspian has been subject to extensive fluctuation in sea levels, with recorded sequences of succession and regression[62]. As a result a number of ancient settlements and fortifications have been claimed by rising sea levels, resulting in submerged archaeological landscapes.

Baku and the Absheron Peninsula have a rich cultural heritage dating back to the late Stone Age. The coastal plains were vulnerable to attack from the sea and consequently a number of fortifications were built along the coastline primarily during the 13th to 15th centuries. As the sea level of the Caspian Sea has fluctuated over time a number of the cultural heritage assets have been become inundated by the sea. There has been little marine archaeological research in Azerbaijan since the end of the Soviet era[63]. No recent survey has been undertaken to identify potential marine cultural heritage, however two confirmed marine archaeological sites[64] in the vicinity of the SWAP Contract Area (refer to Figure 5.13) are known:

- **Bayil Castle**[64] – located approximately 350m from the shoreline, the castle was built on the Bayil Hills in the 13th century by Shirvanshah Fariburz III. As a result of an earthquake in 1306, the castle collapsed and subsequent sea level rises caused the complete submergence of the castle. Since 1306 the Caspian Sea level has fluctuated and in the 18th century the castle ruins were visible again due to a fall in the sea level. However, recent sea level rises have completely submerged the castle again. The site was investigated by the Institute of History, Academy of Science, between 1939 and 1969; and
- **Ancient fortress**[64] ('Zira Fortress') - this site is located on the shelf of the eastern boundary of the Absheron Peninsula. The structure appears to have been significantly altered by the action of silt and/or sand drift. The site is not known to have been subject to archaeological investigation.

In addition, there is a high potential for submerged marine archaeology, including shipwrecks and possibly buried former land surfaces across the SWAP 2D Seismic Survey Area. There is a high probability that the approaches to Baku and Hovsan contain archaeological shipwrecks. A number of medieval and early post-medieval shipwrecks in the vicinity of Absheron Peninsula were investigated by the History Museum of Azerbaijan between the 1960s and 1980s[65].

It is understood the MENR have recently undertaken a study to identify and remove and/or salvage the shipwrecks of modern vessels around the Absheron Peninsula to clear navigational and environmental hazards[66]. In total it is understood that 99 modern shipwrecks were identified in areas just outside of Baku Bay, offshore of Sahil and Bibheybat. To date it is understood that 20 shipwrecks have been removed. Data identifying the locations of the modern wrecks is not currently available.

Figure 5.13 shows the indicative location of Bayil Castle and the ancient fortress.

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[62] Kvachidze, V.A., and Veliyev, S.S., 1997. "Periodichnost izmeneniya urovnya Kaspiyskogo morya v istoricheskoye vremya" (Periodicity of change in the level of the Caspian Sea in history). Reports of the Academy of Sciences of Azerbaijan, 1997, No. 1 [In Russian]; Karpychev, Y.A., 2001. "Variations in the Caspian Sea Level in the Historic Epoch," Water Resources 28/1,5

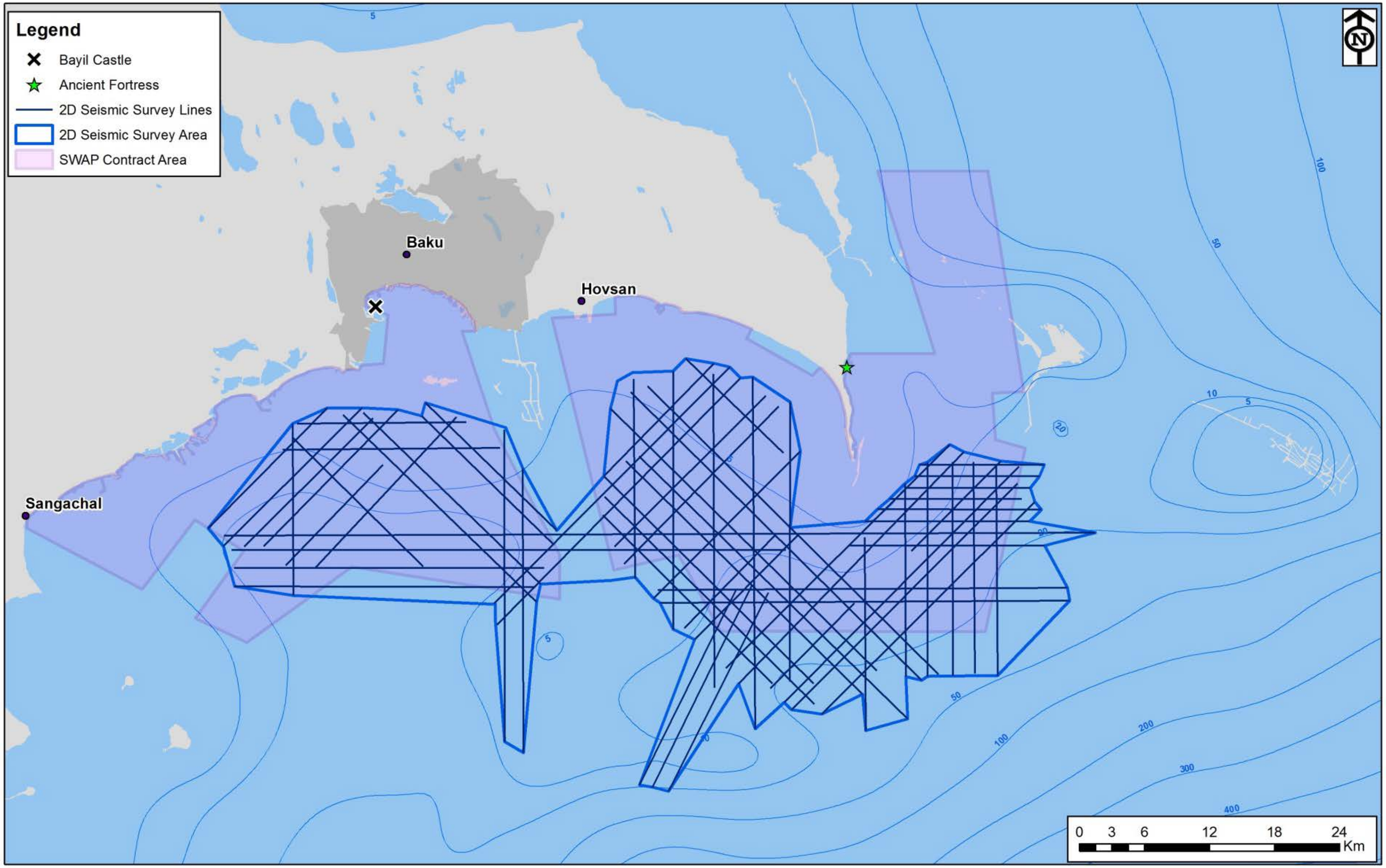
[63] Kvachidze, V.A., 2001. "Podvodnyye arkheologicheskiye issledovaniya Muzeya Istorii Azerbaydzhana – k 30-letiyu nachala rabot" (Underwater archaeological studies of the History Museum of Azerbaijan – on the 30th anniversary of the start of work). History Museum of Azerbaijan – 80. Baku, 2001 [In Russian]

[64] Khalilova T. Sh., and Khalilov, E.N, 2011. Traces of an Ancient Civilization at the bottom of the Caspian Sea. Page 94- 99. Proceedings of the International Congress "Natural Cataclysms and Global Problems of the Modern Civilization". Istanbul, 19-21 September, 2011. Available at: *https://ascendingstarseed.files.wordpress.com/2012/11/international-committee-on-geochange2.pdf* Accessed August 2015.

[65] Ibrahimov, K., 2014. "Shipwrecks and Ceramics- Archaeology off the Absheron coast". Visions of Azerbaijan. Available at: http://www.visions.az/art,547/ Accessed August 2015.

[66] Trend News Agency, 2007. 99 Shipwrecks in Azerbaijani Part of the Caspian Sea. Available at: http://az.trend.az/azerbaijan/society/928448.html [In Azeri] Accessed August 2015.

Figure 5.13: Known Marine Cultural Heritage Sites



6 Environmental & Socio-Economic Impact Assessment, Mitigation and Management

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6.1 Introduction

The activities and events associated with the SWAP 2D Seismic Survey have been determined based on the activities described within Chapter 4: Project Description; and the potential for Interactions with the environment identified. In accordance with the impact assessment methodology (see Chapter 3), ESIA Scoping has been undertaken to identify survey activities that may be "scoped out" from the full impact assessment process based on Event Magnitude and the likely receptor Interaction. In addition, existing controls and mitigation have been identified which include routine procedures and design measures that will be used to ensure that activities are consistent with environmental expectations.

Those activities that have not been scoped out have been assessed on the basis of Event Magnitude and Receptor Sensitivity, taking into account the existing controls and mitigation, and impact significance determined. Monitoring and reporting activities undertaken to confirm that these controls are implemented and effective, as well as additional mitigation and monitoring to further minimise impacts, are provided.

Assessments of cumulative and transboundary impacts and accidental events have also been undertaken and are provided in Chapter 7.

6.2 Scoping

The SWAP 2D Seismic Survey Activities and associated Events that have been scoped out due to their limited potential to result in discernible environmental and socio-economic impacts are presented in Table 6.1. The scoping process has used professional judgement based on prior experience of similar Activities and Events for similar projects in Azerbaijan and across the world. In some instances, scoping level quantification/numerical analysis has been used to justify the decision. Reference is made to relevant quantification, analysis, survey and/or monitoring reports in these instances.

Table 6.1: "Scoped Out" SWAP 2D Seismic Survey Activities

ID	Activity / Event	Ch. 4 Project Description Reference	Justification for "Scoping Out"
Environmental			
2D_E-R1	Crew change/ refuelling operations	4.2.2	• Crew changes will be made approximately every 2.5 weeks over the 2 month survey duration either using helicopters or support vessels. • The low volume of emissions released will be dispersed across the entire flight path/vessel route and the wider area. Increases in pollutant concentrations will be very small and indistinguishable from existing background concentrations. • Helicopter flights will originate from Zabrat heliport. A portion of the flight path will be over residential receptors but at height (>500m). Noise disturbance will be temporary, of short duration and low intensity. **Conclusion:** Emissions and noise from crew change operations is expected to result in no discernible impact to human receptors.
2D_E-R2	Waste Management	4.5	• Waste generated during the 2D Seismic Survey will be consistent with the type and quantity that have been routinely generated during previous seismic surveys managed by BP within the Azerbaijan sector of the Caspian Sea. • In accordance with MARPOL 73/78 requirements, survey and support vessels will maintain an Oil Record Book. The book will be used to record how, when and where waste oil, bilge water, oily material, sludge etc., are disposed of. Recognised waste disposal authorities or contractors will undertake disposal of any waste generated onboard. Disposal details will be recorded in the vessel's Oil Record Book. • Survey vessel and support vessels will maintain a Garbage Management Plan and Garbage Record Book to record how waste items, other than mentioned above, are managed and disposed of. The Garbage Management Plan will classify waste types according to MARPOL specification and BP's AGT Region

ID	Activity / Event	Ch. 4 Project Description Reference	Justification for "Scoping Out"
			Waste Manual and lists item type, quantity stored on-board, waste delivered ashore, and how much waste has been generated (e.g. food waste, incinerator ash). • All wastes will be shipped to shore for disposal in accordance with the existing AGT waste management plans and procedures. • An outline of the applicable waste management principles are described in Chapter 8: Environmental and Socio-Economic Management. **Conclusion:** Waste will be managed as described within Chapter 8: Environmental and Socio-Economic Management. No discernible impact to the terrestrial or marine environment expected.
2D_E-R3	Emissions to atmosphere (non GHG) from vessels[1]	Table 4.4	• Emissions of non greenhouse gases (GHG) to atmosphere will arise from the operation of the survey and support vessel engines. • Estimated volumes of non GHG emissions (NOx, CO, SOx and non-methane volatile organic hydrocarbons) are 168, 23, 23 and 7 tonnes respectively over the survey duration (refer to Table 4.4 of Chapter 4). • NO_X (comprising nitrogen oxide (NO) and nitrogen dioxide (NO_2)) is the main atmospheric pollutant of concern, based on the larger predicted emission volumes as compared to other pollutants (sulphur oxides or SOx, CO and non-methane hydrocarbons) and the potential to impact human health and the environment. • Air quality along the coastline of the Absheron region is variable with background NO_2 concentrations varying between 12µg/m^3 in the vicinity of Sangachal[2], and 38µg/m^3 in the vicinity of Bibiheybat [3] in 2013, just below the annual EU standard for NO_2 of 40µg/m^3. Significantly higher NO_2 concentrations (up to 120 µg/m^3)[3] have been recorded within Baku itself. • The SD2 ESIA[2] considered the impact of NOx emissions associated with mobile drilling rig engines while drilling one well in the north flank of SD Contract Area approximately 70km offshore and within approximately 10km of the SWAP 2D Seismic Survey Area. The volume of NOx emissions was estimated as 157 tonnes. • The air quality modelling undertaken to assess the air quality impact to onshore receptors confirmed that annual average NOx concentrations would increase by up to 1.5µg/m^3 within 1km and by up to 1µg/m^3 within 10km of the rig location. • Given the NOx emissions released during the 2D Seismic Survey are estimated to be of a similar magnitude and in a similar location, it is anticipated increases in annual average concentrations with distance from the source will be similar. • Given there are no onshore receptors within 5km of the SWAP 2D survey activities it is anticipated that there will be no discernible impact to air quality at onshore receptors. • The low volume of emissions released will be dispersed across the entire survey area and the wider area. Increases in pollutant concentrations will be very small and indistinguishable from existing background concentrations. • Vessels will be well maintained and use good quality, and low sulphur fuel (typically <0.05% weight). • The volume of fuel used by the vessels over the duration of the survey will be recorded and reported to the MENR at the end of the survey for each vessel. **Conclusion**: Based on efficient operation, regular maintenance and planned use of low sulphur fuel there is deemed to be no discernible impact to onshore receptors.

[1] Greenhouse gas (GHG) emissions are discussed within Chapter 7: Cumulative, Transboundary and Accidental Events.
[2] URS, 2013. Shah Deniz Stage 2 Project ESIA.
[3] MWH, 2014, Air Quality Governance in the ENPI East Countries National Pilot Project – Azerbaijan "Improvement of Legislation on Assessment and Management of Ambient Air" - Draft National Strategy on AQAM, report funded by the European Union.

ID	Activity / Event	Ch. 4 Project Description Reference	Justification for "Scoping Out"
2D_E-R4	Underwater sound from survey and support vessel engines	4.4.1	• The survey and support vessels will be operating 24 hours a day throughout the survey period (up to 2 months commencing in November). • The vessels are similar in terms of engine size to those typically used to support drilling activities within the Azerbaijan sector of the Caspian Sea. • Assessment of underwater sound generated by support vessel engines in water depths of between 66 and 480m undertaken for the SD2 ESIA[2] indicated that, during winter, fish and seal injury thresholds (refer to Section 6.3.1.2 below for further details) were not reached at any distance from the source. Mild avoidance reactions in seal and fish were limited to distance of no more 72m from the source. • The SWAP 2D Seismic Survey Area is located within a busy shipping area, through which international and regional shipping passes regularly in addition to numerous smaller vessels that provide offshore support to the oil and gas industry. Hence vessel engine noise will contribute to background underwater sound levels throughout the year and the sound from the 2D Seismic Survey and support vessels is unlikely to be distinguishable. **Conclusion:** Underwater sound from vessel engines is unlikely to be distinguishable from existing background underwater noise levels. Modelling for similar vessels has shown there is a limited potential for impacts to fish and seals from vessel engine noise.
2D_E-R5	Discharges to sea from vessels	4.5.2	• Discharges from vessels will comprise ballast water, grey water, treated black water, deck drainage and wash water. • Under routine conditions grey water and treated black water will be discharged to sea in accordance with MARPOL 73/78 Annex IV: Prevention of Pollution by Sewage from Ships standards and the SWAP Production Sharing Agreement (PSA) requirement i.e. no floating solids will be observed on water surface. If treatment is not possible (e.g. due to unavailability of the treatment unit) sewage will be stored and shipped to shore for treatment and disposal. • The volume of grey water and treated black water discharged is estimated at approximately 0.6m^3 and 25m^3 per day respectively based on maximum vessel berths and estimated rates as stated within Table 4.1 and Section 4.5.3 of Chapter 4. • In accordance with the PSA, deck drainage and wash water will be discharged as long as no visible sheen is observable. Oily and clean drainage or wash water will be segregated; clean water will be discharged to sea and oily water transported to an appropriate onshore disposal facility. • There will be no discharge of food waste or garbage. Food waste and combustible garbage will be incinerated on the vessel using MARPOL compliant onboard incineration facilities. Non-combustible garbage and incinerator ashes will be contained and shipped to shore for disposal in accordance with AGT waste management plans and procedures. • Daily visual checks will be undertaken when discharging grey water and treated black water to confirm no floating solids are observable. • Summary of vessel sewage sampling analysis results, recorded floating solids observations and estimated volumes of treated black water and grey water discharged daily (based on a generation rate of 5 litres/person/day and 200 litres/person/day respectively will be reported to the MENR at the end of the survey for each vessel**.** **Conclusion:** The low volume and rate of these discharges in accordance with the relevant standards over the short duration of the survey period is not anticipated to result in any discernible impact to the marine environment.

ID	Activity / Event	Ch. 4 Project Description Reference	Justification for "Scoping Out"
2D_E-R6	Seabed disturbance/ disturbance to marine cultural heritage	4.4.2 & 4.4.3	• The survey will be undertaken over a period of up to 2 months 24 hours a day. • There is no planned anchoring associated with the survey • When deployed the sound source will be approximately 5m and 6m below sea surface; a minimum of at least 2.5 – 3.5m above the seabed and the streamer will be at least 2.5m above the seabed for the duration of the survey. • Prior to the seismic survey being undertaken a hazard survey will be undertaken (planned for Q3 2015) to confirm the location of seabed hazards prior to the seismic survey to allow the survey team to plan to avoid these. **Conclusion:** Potential for physical interaction between the survey activities and the seabed including marine cultural heritage present considered to be very small.
2D_E-R8	Disturbance due to use of lighting on the vessels		• The survey and support vessels will carry appropriate navigation lights for operating during night-time and periods of poor visibility. The level of lighting will be in compliance with safety regulations at sea to ensure operational safety needs. • Light has the potential to affect fish and seals within the marine environment if they are present in the area, attracting seals and fish to the light source. However given the adoption of the existing controls including the soft start it is considered unlikely that seals and fish will be present in the vicinity of the seismic vessel during operations. The underwater sound from the support vessel engines will also likely dissuade fish and seals from approaching these vessels. • Furthermore if it does become necessary to enter a sensitive area (as defined within Chapter 5 Figure 5.7) prior to mid December, when operations occur in hours of darkness, exterior vessel lighting will be limited to that necessary for ensuring safe operations. **Conclusion:** Potential for disturbance to receptors in the marine environment due to use of lighting on the vessels considered to be very small.
Socio-Economic			
2D-S-R2	Physical presence of survey and support vessels on recreational users, businesses and tourism	4.3	• There are a number of beaches, resorts and hotels located along coast of the Absheron Region between Hovsan and the Shahdili Spit in addition to a number of locations where watersports are known to occur within close proximity to the coastline (refer to Chapter 5 Section 5.7.4). • During November and December air temperatures in the Absheron region are typically between 7-11°C and the sea temperature generally between 9 and 14°C. The sea is subject to strong currents and winds through October to February. • As such peak season for tourism and recreational businesses is generally during the summer when weather conditions are more favourable. While the hotels and resorts may operate during the winter, income derived from offshore water based activities during this period would be insignificant. • Local residents and visitors may use the coastline for recreation (e.g. walking and to observe wildlife during the winter months). • As the survey will be located a minimum of 4km from the shore within an area where there is routine existing shipping and vessel traffic there is expected to be an indiscernible impact on recreational users onshore. **Conclusion:** Potential for impacts to recreational users, businesses and tourism due to the physical presence of the survey considered to be insignificant.
2D-S-R4	Underwater sound on divers	4.4.2	• The seismic source will only operate as the survey vessel travels along the survey lines. • Within the underwater sound study (Appendix 6A) an assessment was undertaken to establish the distance from the survey sound source at which thresholds relating to potential auditory injury to divers are reached. As a worst case a distance of 255m was estimated. • Recreational diving is not widely undertaken within the Azerbaijan

ID	Activity / Event	Ch. 4 Project Description Reference	Justification for "Scoping Out"
			sector of the Caspian sea, however a number of sites have been identified where diving in known to occur. • These sites are predominantly around the Pirallahi and Chilov Islands (more than 7km) from the 2D Seismic Survey Area. The nearest known dive site to the Survey Area is located adjacent to Boyuk Zira Island, approximately 2km from the 2D Seismic Survey Area. • On the basis of the distance between the nearest dive site and the underwater sound modelling the impact of the survey sound source on divers is expected to be indiscernible as compared to existing background sound levels. **Conclusion:** Potential for impacts to divers associated with underwater sound from the sound source is considered to be insignificant.
2D-S-R3	Employment	4.4.1	• The survey will be undertaken by an experienced seismic contractor and offer the opportunity for continued employment over the seismic survey duration for the existing survey and support vessel crews and their families. • Based on the total number of berths a total of up to 126 persons will be stationed on the survey and support vessels at any one time (refer to Chapter 4 Table 4.1) during the survey with crew changes occurring approximately every 2.5 weeks. **Conclusion:** Employment over the survey duration, while beneficial, will result in an insignificant impact on national or regional employment levels.

The SWAP 2D Seismic Survey routine and non-routine activities and their associated events assessed in accordance with the full impact assessment process are presented in Table 6.2.

Table 6.2: "Assessed" SWAP 2D Seismic Survey Activities

ID	Activity / Event	Ch. 5 Project Description Reference	Event	Receptor
Environmental				
2D-E-R7	Operation of survey sound source	4.4.2 Table 4.2	Underwater sound	Marine Environment (Fish and Seals)
Socio-Economic				
2D-S-R1	Seismic survey activities	4.3	Physical survey presence	Commercial Fishing Small scale Fishing Shipping
2D-S-R5	Operation of survey sound source	4.4.2 Table 4.2	Indirect effect of underwater sound on fish	Commercial Fishing Small scale Fishing

The sections below present an assessment of these Activities in accordance with the impact assessment methodology and significance criteria as presented within Chapter 3 of this ESIA. Environmental and socio-economic impacts are assessed using separate criteria with the socio-economic criteria more qualitative based on the nature of the anticipated impacts.

6.3 Environmental Impacts

6.3.1 Underwater Sound from Energy Source

Underwater sound, resulting from the discharging of seismic sources, as described in Section 4.4 of Chapter 4, has the potential to impact biological/ecological receptors (specifically seals and fish) in the marine environment.

6.3.1.1 Mitigation

To minimise potential impacts from underwater sound a number of control measures have been included in the project design. These include the following:

- Across the whole 2D Seismic Survey Area the following measures, which are designed to reduce potential impacts on marine mammals, will be adopted for the duration of the Survey:
  - Vessel crew will be trained to undertake marine mammal observations;
  - Trained vessel crew will conduct ongoing ad-hoc visual observations of Caspian seal (*Phoca Caspica*) in the vicinity of the survey vessel. All observations will be logged including location of sighting and number of individuals seen;
  - Survey vessels will not intentionally approach seals for the purposes of casual marine mammal viewing;
  - Airguns will not be operational during line changes;
  - A soft-start procedure will be used at the start of each survey line;
  - Prior to the seismic source being activated using the soft-start procedure, marine mammal monitoring will be conducted by the trained vessel crew for a 30 minute period to observe whether there are any Caspian seals within 500m of the sound source (buffer zone). If Caspian seals are sighted, the soft-start procedure will be delayed for at least 20 minutes following which the trained crew will confirm no Caspian seals are within the buffer zone and the soft-start procedure can start. The soft start procedure cannot start until no Caspian seals have been observed within the buffer zone for a 20 minute period.

- The following additional control measures will be implemented with respect to sensitive and very sensitive areas of the 2D Seismic Survey Area. These areas are defined within Chapter 5, Section 5.5.4.3:
  - Prior to mid December 2D Seismic Survey activities will not be conducted in a very sensitive area;
  - The 2D Seismic Survey will be planned to avoid entering a sensitive area prior to mid December as far as possible. If it does become necessary to enter a sensitive area prior to mid December the following additional controls will be implemented:
    - Prior to the seismic source being activated using a soft-start procedure, marine mammal monitoring will be conducted by the trained vessel crew for a 50 minute period to observe whether there are any Caspian seals within the buffer zone. If Caspian seals are sighted, the soft-start procedure will be delayed for at least 30 minutes following which the trained crew will confirm no Caspian seals are within the buffer zone and the soft start procedure can start. The soft start procedure cannot start until no Caspian seals have been observed within the buffer zone for a 30 minute period.

- o When operations occur in hours of darkness, exterior vessel lighting will be limited to that necessary for ensuring safe operations.

6.3.1.2 Event Magnitude

To evaluate the magnitude of the impact of underwater sound to the biological receptors in the marine environment (seals and fish) an underwater sound study was undertaken (refer to Appendix 6A). The sound modelling study investigated the sound output from the proposed seismic source array and resultant sound propagation based on physical environmental conditions representative of the survey area. The outcomes of which were compared to available sound threshold criteria to assess potential injury and behaviour impacts for Caspian seals and fish.

Sound Threshold Criteria

Responses of marine mammals and fish to underwater sound have been studied and reported within scientific literature over many years with thresholds developed for a number of species and groups of species. Thresholds are usually proposed for different levels of impact from physiological damage to behavioural responses.

Thresholds for physiological damage consider potential permanent and temporary effects on hearing where animals exposed to sufficiently intense sound exhibit an increased hearing threshold (i.e. poorer sensitivity) for some period of time following exposure. This is called a sound-induced threshold shift and the amount of shift is determined by the species activity at the time of hearing the sound, the distance between a sound and species in combination with the amplitude, duration, frequency content, temporal pattern, and energy distribution of sound exposure relative to the hearing sensitivity of the species and background sound levels. Hearing threshold shifts may be permanent (PTS) or temporary (TTS) and thus physiological impacts are generally considered at these two levels:

- **Permanent threshold shift (PTS)** is a permanent, irreversible increase in the threshold of audibility at a specified frequency or portion of an individual's hearing range above a previously established reference level. This is considered to be auditory injury. Available data from humans and other terrestrial mammals indicate that a 40 dB threshold shift approximates PTS onset[4]. Permanent threshold shift (PTS) is considered to be auditory injury.

  Due to the absence of data on permanent injury in marine taxa PTS thresholds have been extrapolated from observed TTS responses combined with scientific studies on terrestrial mammals, where exposure levels resulting in a shift from TTS to PTS have been observed[4]. There are therefore, very high levels of uncertainty in the currently available threshold criteria for PTS in marine receptors.

- **Temporary threshold shift (TTS)** is a temporary, reversible increase in the threshold of audibility at a specified frequency or portion of an individual's hearing range above a previously established reference level. Based on data from cetacean TTS studies[4], a TTS of 6 dB is considered the minimum threshold shift clearly larger than any natural variation in an animal's normal hearing.

Thus, for each case, there are necessarily limitations associated with the thresholds given because of the limited species and number of individuals that have been studied. Nevertheless, current thresholds are based on the best currently available evidence, as described in more detail below.

[4] Southall, B.L., Bowles, A.E., Ellison W.T., Finneran J.J., Gentry, R.J., Greene Jr, C.R., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, J.W., Thomas, J.A, and Tyack P.L. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammals, Vol 33, 411–522.

Thresholds for Seals

Thresholds have been developed for both the onset of PTS and TTS in seals (based on data for the northern elephant seal and harbour seal)[4]. A recent study[5] based on the underwater hearing ability of two captive spotted seals suggested that their hearing ability was similar to harbour seals, and lower than other Arctic species tested (i.e., harp and ringed seals). This suggests that harbour seals are an appropriate proxy for other ice seals, such as the Caspian seal for which no specific thresholds exist.

With regard to behavioural reactions, indicative thresholds have been developed for seals based on a very small number of studies of ringed, spotted and bearded seals. The thresholds relate to the onset of avoidance behaviour, limited disturbance and low level disturbance in seals due to impulsive sound[4].

Thresholds for Fish

There is no data on the impact of seismic sound sources in fish and so current injury guidelines for fish are based on predictions derived from the effects of impulsive sounds[6,7].

The PTS thresholds for fish have been developed based on the following fish hearing categories[6]:

- High hearing sensitivity fish, particularly herring and related species (Clupeidae), use the swim bladder in hearing;
- Medium sensitivity fish including sturgeon have a swim bladder but it is not used in hearing; and
- Low sensitivity fish, particularly sharks and rays, do not have any gas filled organs.

Temporary shifts (TTS) have been demonstrated in some fish but there are high levels of variability in the duration and magnitude of the shift depending on many factors, including the intensity and duration of sound exposure, the species and life stage of fish[6]. TTS thresholds for all fish (regardless of hearing ability) are based on a number of studies including the exposure of several riverine species to a seismic airgun array[6].

There are no reliable thresholds for fish behavioural changes but TTS can be used as an estimate of the point at which a significant behavioural response would be expected[4].

There are no thresholds for benthic invertebrates and plankton because they are not considered to be sensitive to seismic sound. The thresholds adopted for the underwater sound study are presented in full within Appendix 6A.

Underwater Sound Modelling

In order to determine a more accurate estimate of sound source level for the proposed seismic source array that is used for propagation modelling of underwater sound in the marine environment sound source levels were calculated close to the array based on sound output of individual source elements. The sound propagation computer models BELLHOP and RAM were then used to model sound propagation from the source array. The bathymetry of the seabed in the 2D Seismic Survey Area was constructed using bathymetry data contained in the ETOPO1 database[8] and temperature and salinity data for the months of November and December taken from the World Ocean Atlas. Once the results had been calculated for a stationary source and receptor a summation method was used to take into account the moving energy source and moving receptor in determining the threshold distances.

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[5] Sills, J.M., Southall, B.L. and Reichmuth, C. 2014. Amphibious hearing in ringed seals (Pusa hispida): underwater audiograms, aerial audiograms and critical ratio measurements. The Journal of Experimental Biology. Vol 217, 726-734.

[6] Popper, A.N., Hawkins, A.D., Fay, R.R., Mann, D., Bartol, S., Carlson, T., Coombs, S., Ellison, W.T., Gentry, R., Halvorsen, M.B., Løkkeborg, S., Rogers, P., Southall, B.L., Zeddies, D. and Tavolga, W.N. 2014. ASA S3/SC1.4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. Springer and ASA Press, Cham, Switzerland.

[7] Fisheries Hydroacoustic Working Group (FHWG), 2008. US National Marine Fisheries Service interim criteria for pile driving.

[8] Amante, C. and Eakins, B. W. 2009. ETOPO1 1 Arc-Minute Global Relief Model: Procedures, Data Sources and Analysis. NOAA Technical Memorandum NESDIS NGDC-24,19.

The purpose of the modelling was to estimate the distance from the seismic source at which sound levels would decrease to below each of the relevant thresholds discussed above and hence the distance within which the potential acoustic effects to fish and seals may occur if they were present within this distance. The sound source level, based on far field assumptions only, was estimated to be 240.7 dB re 1 µPa @ 1m. However this method does not consider the near field interaction effects between individual source elements and can lead to an estimate of source level which can be in excess of the actual level by up to 20 dB. Taking into account the near-field interaction effects a more reliable estimate of the sound source was calculated to be 224.8 dB re 1 µPa@1m.

The distances at which the sound levels would be below the thresholds were modelled and are shown in Tables 6.3 and 6.4 below. Detailed results of the modelling are presented in Appendix 6A.

Table 6.3: Distance from Source Array Where Sound Levels Are Predicted to be Below Relevant Thresholds (Fish)

Fish Hearing Group	Potential Mortal Injury Threshold (m)	Onset of Recoverable Injury (m)	Onset of TTS (m)
High hearing sensitivity	79	79	989 (Nov) 1029 (Dec)
Medium hearing sensitivity	49	79	
Low hearing sensitivity	<1	<1	
Note: The distance is determined by whichever of the dual criteria thresholds (the SPL or SEL threshold) is met first			

Table 6.4: Distance from Source Array Where Sound Levels Are Predicted to be Below Relevant Thresholds (Caspian Seals)

Onset of PTS (m)	Onset of TTS (m)
349 (Nov) 379 (Dec)	1729 (Nov & Dec)
Note: The distance is determined by whichever of the dual criteria thresholds (the SPL or SEL threshold) is met first	

The results within Table 6.3 show that for all fish species, regardless of hearing sensitivity, sound levels decrease to below thresholds associated with potential mortal injury and recoverable injury beyond 79m of the source array. Sound levels decrease to below thresholds associated with the onset of TTS beyond approximately 1km from the source in November with a slightly greater distance predicted during December.

With regard to seals (Table 6.4), the results show sound levels decrease to below the threshold for the onset of PTS beyond 379m and the threshold for the onset of TTS beyond 1729m. These distances are estimated based on operation of the source array at full power i.e. not taking into account the soft start procedure.

Definition of Buffer Zone

Based on the thresholds described above and the results of the underwater sound study a buffer zone can be determined for the purpose of the 2D Seismic Survey, designed to minimise the risk of potential impacts to Caspian seal. The buffer zone comprises an area centred on the seismic source in which trained observers will undertake observations for seals prior to commencing the planned soft start procedure. Table 6.4 shows that the distance at which a permanent auditory shift (PTS) could be induced in Caspian seals due to the operation of the source array is 379m. For operational purposes, the radius of the mitigation buffer zone that will be established around the sound source will be at least 500m from the source.

Magnitude of Impact

Taking into account the results of the underwater sound study, the existing controls described above and the impact significance criteria set out in Chapter 3 of the ESIA, the event magnitude associated with the operation of survey sound source is presented within Tables 6.5 and 6.6 below.

Table 6.5: Event Magnitude (Fish)

Parameter	Explanation	Rating
Extent / Scale	The onset of permanent or recoverable injury in all fish hearing groups is predicted to occur at 79m from the energy source.	1
Frequency	Underwater sound emissions occur repeatedly but intermittently.	2
Duration	Sound energy dissipates with distance from the source and the sound source is moving, therefore a given sound level in any one location will last for a very short period of time, with the resulting potential impact lasting probably in the order of one or a few hours.	1
Intensity	The onset of permanent or recoverable injury would be a high intensity event. However the combination of a moving sound source and existing controls such as a soft-start procedure suggests fish will move away from the energy source. As such the impact from underwater sound, taking into account existing controls, is anticipated to be of low intensity.	1
Total		**5**

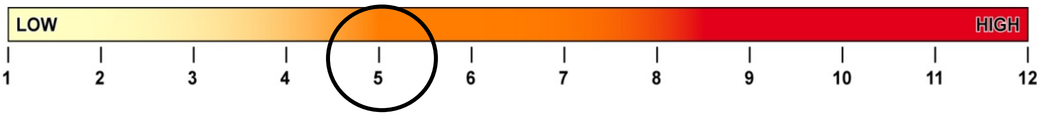
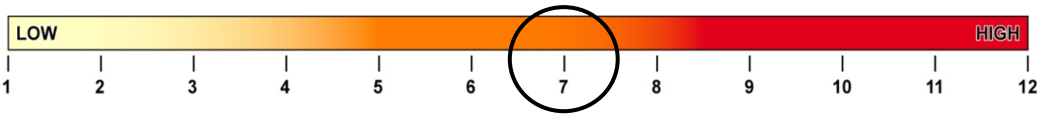


Table 6.6: Event Magnitude (Caspian Seals)

Parameter	Explanation	Rating
Extent / Scale	The distance at which sound levels reduce below those that may cause permanent auditory shift (PTS) in Caspian seals due to the operation of the source array was predicted to be beyond 379m from the source array. Trained observers on the seismic vessel will monitor a buffer zone of at least a 500m radius from the sound source prior to starting the soft start procedure.	2
Frequency	Underwater sound emissions occur repeatedly but intermittently.	2
Duration	Sound will last for a very short period of time, with the resulting impact lasting probably in the order of one or a few hours.	1
Intensity	The onset of permanent auditory shift (defined as PTS) would be a high intensity event. The combination of a moving sound source and the existing controls such as a soft-start, designed to allow underwater sound to increase slowly, reduce this intensity as seals are expected to move away from the sound source before sound levels reach the level where permanent auditory shift can occur. During this period there is a possibility that seals may experience temporary auditory shift. This would be reversible and the seals would recover within hours to days. As such the event is rated as a medium intensity.	2
Total		7



6.3.1.3 Receptor Sensitivity

The marine receptors within and in the vicinity of the 2D SWAP Seismic Survey Area are plankton, benthic invertebrates, fish and seals. No widely recognised underwater sound thresholds exist for plankton and benthic invertebrates which are generally considered to be unaffected by underwater sound[9].

Fish

Fish species known to be present within the 2D Seismic Survey Area include a number of endangered species and species with moderate of high sensitivity to underwater sound. The species present (including seasonal activity, hearing sensitivity, depth of occurrence and protection status) are summarised within Table 5.13 of Chapter 5.

[9] Spiga, I., Cheesman, S., Hawkins, A., Perez-Dominguez, R., Roberts, L., Hughes, D., Elliott, M., Nedwell, J. and Bentley, M. 2012. Understanding the Scale and Impacts of Anthropogenic Noise upon Fish and Invertebrates in the Marine Environment. SoundWaves Consortium Technical Review (ME5205).

With regard to endangered species, a number of sturgeon species are known to migrate through the 2D Seismic Survey Area in March and April and again in September to November. Thus, there may be some individuals present in the survey area in November. However, these fish are not common and do not use the area in which the survey takes place exclusively as they are only passing through on their passage from spawning grounds in freshwater rivers of the south and southwest and feeding grounds in the north. Also, in November and December sturgeon are more likely to be found away from the coast in deeper water (refer to Chapter 5 Section 5.5.4.2). Sturgeon species have medium or moderate hearing sensitivity; they do have a swim bladder but it is not specifically used in hearing.

Fish species likely to be present in the 2D Seismic Survey Area that are highly sensitive to underwater sound include shad and kilka. These species have structures that mechanically couples the inner ear to the swim bladder increasing the hearing ability compared to other fish. Several of these species, particularly shad, are known to migrate through the 2D Seismic Survey Area in the autumn and winter. However, they do not use this area exclusively and as they are passing through will only be present for a short time, probably only hours.

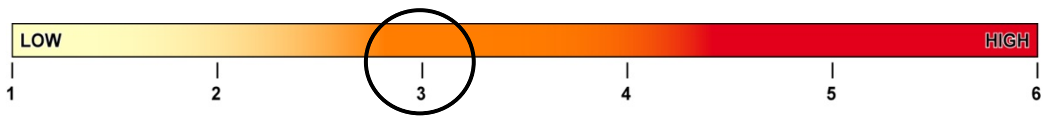
There are not likely to be any resident fish, such as gobies, spawning in significant numbers in November and December. Most species will spawn earlier in the year and so fish and larvae at particularly sensitive life stages are not expected to be present in the 2D Seismic Survey Area.

With regard to the current status of fish populations, as summarised within Chapter 5 Section 5.5.4.2, catch size of the most important commercial fish (kilka) has significantly reduced over the years with a reduction of 96% recorded between 2002 and 2011. This is due in part to overfishing but also to the presence of the invasive ctenophore (*Mnemiopsis leidyi*) which is known to predate on fish eggs and larvae and zooplankton. Fish populations are therefore considered to reasonably vulnerable.

Existing controls associated with the survey include use of a soft start procedure at the start of each survey line, where the sound is ramped up gradually over a period of time. Local sound levels will also increase and decrease slowly as the vessel is moving. This allows any fish in the vicinity of the sound source to move away before sound levels become injurious. Such behavioural responses are highly unlikely to result in any detectable population size changes because sensitive life stages (e.g. spawning) are not present and changes in swimming direction are a natural behaviour during migration periods as fish respond to prey and predator abundance and changes in underwater topography. Receptor Sensitivity is shown in Table 6.7.

Table 6.7: Receptor Sensitivity (Fish)

Parameter	Explanation	Rating
Resilience	Endangered fish species and hearing specialist fish are likely to be present for limited periods of time in the 2D Seismic Survey Area. However, these species are widely distributed and do not use the Seismic Survey Area exclusively. Also, there will be no fish species at the sensitive spawning stage likely to be present.	2
Presence	Fish species are able to move away from underwater sound before permanent or temporary injury impacts are likely. There will be a change in behaviour but this is expected to be limited to a change in swimming direction and will be short-term and ecological functionality will be maintained.	1
Total		**3**



Seals

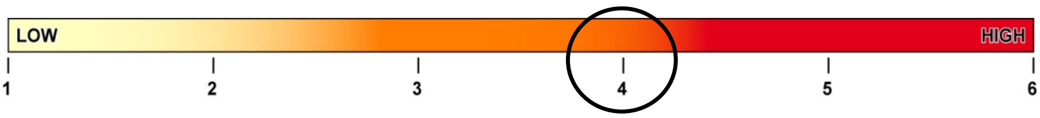
The endemic Caspian seal, *Phoca caspia*, a threatened species with an IUCN Red List ‘Endangered’ status, will be present in the 2D Seismic Survey Area during the spring and autumn migration periods. Seals are most likely to be seen around the Absheron Peninsula and associated islands from April to May and October to mid-December. The most sensitive months, when the highest numbers of seals are likely to be present are April, May and November.

As stated within Chapter 5 Section 5.5.4.3 the Caspian seal population has significantly declined over the 20th Century (by more than 90% since the start of the century) and continues to decline due to a combination of factors including commercial hunting, habitat degradation (through introduction of invasive species), disease, industrial development, pollution and fishing operations. The seal population is therefore highly vulnerable as reflected by its "Endangered" status.

The Caspian seal is highly intelligent animal and will rapidly move away from any disturbance or sound. Current information available on seal migration timing and routes are described within Chapter 5, Section 5.5.4.3, which also describes the most sensitive areas within and adjacent to the 2D Seismic Survey Area with regard to seals. The existing controls provided within Section 6.3.1.1 above describe the measures to be adopted across the Survey Area as a whole where seals are expected to be present in small numbers throughout the year with additional measures to be adopted within the sensitive and very sensitive areas of the 2D Seismic Survey Area where survey activities may be undertaken during the autumn migration, which begins in October, lasts until mid December and peaks during November.

Table 6.8: Receptor Sensitivity (Seals)

Parameter	Explanation	Rating
Resilience	Internationally protected Caspian seals are likely to be present in the 2D Seismic Survey Area as they will be undertaking northward migrations through the area. However, the seals are passing through on migration routes and will be present for a short time only. The survey period does not overlap with the most sensitive periods in the seals' lifecycle i.e. breeding (which occurs in the Northern Caspian) and spring migration when seals are travelling south to replenish depleted fat reserves following breeding and pupping.	2
Presence	Seals have the capacity to move away from the seismic sound. Existing control measures are designed to minimise the chance that individual seals could be injured by providing the opportunity for them to move away and avoid the sound before it reaches injurious levels. The operation of the sound source, even under the soft start procedure, will result in a change in the behaviour of seals present but this is expected to be limited to a change in swimming direction and will be short-term. No significant population effects are anticipated and ecological functionality will be maintained.	2
Total		**4**



6.3.1.4 Impact Significance

Table 6.9 summarises impacts to fish and seals associated with operation of the energy source.

Table 6.9: Impact Significance

Event	Event Magnitude	Receptor Sensitivity	Impact Significance
Underwater sound from energy source	Medium	Medium (Fish)	Moderate Negative
		Medium (Seals)	

The following monitoring and reporting related to impacts to seals from underwater sound from the sound source will be undertaken:

- In addition to the monitoring and recording Caspian seals as part of the soft start procedure, the trained vessel crew will endeavour to record Caspian seal sightings at other times as far as practically possible;
- Daily logs of Caspian Seal sightings will be completed by the trained vessel crew using the relevant JNCC marine mammal forms[10]; and

[10] Joint Nature Conservation Committee (JNCC), 2010. JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys, Aberdeen.

- A final report summarising the Caspian seal observations over the duration of the survey and including all the daily log forms will be completed by the trained vessel crew and submitted to BP within eight weeks of completion of the survey.

It is considered that potential impacts are minimised are far as practicable and necessary through the implementation of the existing mitigation measures and no additional controls are required.

6.4 Socio Economic Impacts

6.4.1 Physical Survey Presence

The 2D Seismic Survey will be undertaken in an area used by international, regional and local shipping (refer to Chapter 5 Section 5.7.5) and commercial and small scale fishing (refer to Chapter 5 Section 5.7.3). As such there is potential for impacts to shipping and commercial and small scale fishing due to the physical presence of the survey.

6.4.1.1 Mitigation

To minimise potential impacts from the physical survey presence a number of control measures have been included in the project design. These include the following:

- The survey will be planned to minimise interference with other sea users;
- Relevant maritime authorities and other sea users will be notified of the survey prior to commencement in accordance with BP’s existing marine operations and geophysical survey procedures; and
- Throughout the survey, other vessels will be notified by appropriate signals in accordance with International Maritime Law; these will include communications via radio, including regular security broadcasts, lights and flags. Support vessels will be used to notify other vessels that are not contactable or are unaware of the International Maritime signal system.

In addition, prior to the seismic survey being undertaken a hazard survey will be undertaken (planned for Q3 2015) to confirm the location of seabed hazards prior to the seismic survey to allow the survey team to plan to avoid these. These hazards will include any fixed fishing assets.

To further understand small scale fishing activities in the vicinity of the SWAP Contract Area consultation is planned to be undertaken during Q3 and Q4 2015 to identify those engaged in this activity and characterise the small scale fishing undertaken in this area. This consultation will be primarily be used to inform SWAP 3D Seismic Survey ESIA (refer To Chapter 1). In the unlikely event of any damage to small scale fishing assets during the 2D Seismic Survey any grievances raised by the affected fishermen will be managed through the existing AGT Region Grievance Process which sets out the mechanisms through which complaints are received, resolved and documented. The process is designed such that complaints received are managed appropriately, and that corrective actions to resolve complaints are implemented effectively and in a timely manner.

6.4.1.2 Event Magnitude

As described within Chapter 4 Section 4.3 the 2D Seismic Survey is planned to commence in November and last up to 2 months. It is planned to commence in the west of the Survey Area and move towards the east, travelling along pre-determined lines (as shown within Figure 4.1 Chapter 4 Project Description) at an approximate speed of 7.4 – 9.3 km/hr on a 24-hour basis. The survey vessel will be equipped with a streamer (approximately 4.5km length) which will towed behind the vessel and will be accompanied by up to two support vessels. The vessels will undertake a number of activities including enforcing a safety exclusion zone around the survey vessel and the streamer. Due to its restricted manoeuvrability, the survey vessel will be given priority over vessels that are not similarly restricted under maritime regulations.

Shipping

The path of the survey vessel will travel along, cross, as well as move perpendicularly to existing, identified shipping routes (as shown in Chapter 5 Figure 5.12). These routes include the international Baku-Turkmenbashy and the Baku-Cheleken shipping routes, which are used by large cargo vessels, tankers and other international shipping as well as routes used by regional and local shipping, including vessels that supply the offshore oil and gas industry.

Taking into account the survey activities, the existing controls described above and the impact significance criteria set out in Chapter 3 of the ESIA, the event magnitude associated with the physical presence of the survey with respect to shipping is presented within Table 6.10 below.

Table 6.10: Event Magnitude (Shipping)

Event	Explanation	Event Magnitude
Presence of the survey vessel and seismic equipment	The survey vessel and streamer will be continuously moving and not present in an area for any significant period. Design controls are designed to communicate the survey activities to all shipping and vessels prior to commencement and during the survey. It is therefore anticipated that the effect of the survey on shipping would be slight and temporary. It is considered unlikely that survey activities would result in concerns being raised by stakeholders or governmental bodies. This is therefore considered an event of Low magnitude.	**Low**

Fishing

As shown within Chapter 5 Figure 5.9 there are two favoured fishing grounds frequented by commercial fishing vessels within 20 to 30 km of the 2D Seismic Survey Area and one fishing ground, Makarov Bank, which is located just within the Survey Area. While the provisional survey lines do not cross the Makarov Bank they do pass immediately adjacent to the area. As the survey is planned to commence in November, there will be an overlap with the high fishing season (March to April and September to November). December is considered to be mid to low season due to unfavourable weather conditions. Based on the speed of the survey vessel and the provisional survey lines it is estimated that the survey vessel pass within 5km of Makarov Bank for a total period of between 5 and 6 hours (in 1 - 2 hours periods likely to be on different days).

With regard to small scale fishing it is understood that this is undertaken up to 2-3 nautical miles (up to approximately 5.5km) from shore. As shown within Chapter 5 Figure 5.10 there are a number of locations along the Absheron coastline where individuals known to take part in small scale fishing reside. The extent of small scale fishing and location of any fixed equipment is not currently understood however there is potential for the survey activities to interact with the small scale fishing activities particularly offshore from Shikhov, Bayil, Turkan and Zira.

Taking into account the survey activities, the existing controls described above and the impact significance criteria set out in Chapter 3 of the ESIA, the event magnitude associated with the physical presence of the survey with respect to fishing is presented within Table 6.11 below.

Table 6.11: Event Magnitude (Commercial and Small Scale Fishing)

Event	Explanation	Event Magnitude
Presence of the survey vessel and seismic equipment	The survey vessel and streamer will be continuously moving and will not be present in an area for any significant period. Control measures are designed to communicate the survey activities to all commercial fishing vessels and small scale fishing vessels prior to commencement and during the survey. While the survey will be undertaken adjacent to the Makarov Bank commercial fishing ground during high season the survey will be present for a short period (5-6 hours). Presence within the area potentially used by small scale fishermen is also expected to be short duration. It is not planned to remove fixed fishing equipment, which it is expected will be identified during the planned hazard survey and the survey team will plan to avoid. It is therefore anticipated that the effect of the survey on commercial and small scale would be slight and temporary. This is therefore considered an event of Low magnitude.	**Low**

6.4.1.3 Receptor Sensitivity

With regard to international shipping, vessels using the international shipping routes are typically large with restricted manoeuvrability and of limited ability to adapt to change. These vessels typically ship goods and materials to and from Azerbaijan to other Caspian nations and further afield via the Don-Volga or Baltic-Volga canal and river systems (although these routes are not open during winter). Local and regional shipping typically comprises vessels with increased manoeuvrability. Larger vessels are restricted to using recognised shipping lanes however there are numerous routes across the 2D Seismic Survey Area. Smaller vessels are less restricted in their movement.

With regard to commercial fishing, as discussed within Section 5.7.3.1 Chapter 5 a significant decline in kilka catch (the main commercial species caught) of 96% was recorded over the period 2001 to 2011, indicating that the commercial fishing industry is under pressure. Illegal fishing undertaken by unlicensed fishermen further increases this pressure. The period in which the survey is planned is includes November which is within the high fishing season for commercial fishermen. Commercial fishing is undertaken using seine boats and lifting transportation vessels (LTV). These methods do not use fixed equipment and the vessels are manoeuvrable. Furthermore as stated in Chapter 5 Section 5.7.6.1 it is understood that fishing within the Makarov Bank is undertaken by one vessel only, which operates approximately twice a month for periods of up to one week and at night time only.

Based on information collected with regard to small scale fishing undertaken within Sangachal Bay it is anticipated that the majority of small scale fishing undertaken in the vicinity of the 2D Seismic Survey Area provides the associated households with their main source of income. These households are therefore vulnerable to any change. Small scale fishing is undertaken year round with the low season between June and August and the equipment used includes fixed nets (including gill nets), fish traps, fishing rods and seine net.

The sensitivity of shipping and commercial and small scale fishing receptors to the physical presence of the seismic survey is summarised within Table 6.11.

Table 6.12: Receptor Sensitivity

Receptors	Explanation	Receptor Sensitivity
International Shipping	International shipping is considered to be of international importance and has limited ability to adapt to change due to restricted movement. International shipping is therefore considered to be highly sensitive.	**High**
Local/Regional Shipping	Local and regional shipping provides local and regional services and have capacity to adapt to change. Local/regional shipping is considered to be of medium sensitivity.	**Medium**

Commercial Fishing	The commercial fishing industry is known to be under pressure. The survey is planned to be undertaken in the vicinity of a favourable fishing ground during the high fishing season. However the survey will only be within the area for a short duration and may potentially affect one fishing vessel. This vessel represents one fifth of the national Azerbaijan fleet that fish for kilka. Commercial fishing is therefore considered to be of medium sensitivity.	**Medium**
Small Scale Fishing	Small scale fishing is understood to be undertaken by fishermen whose main household income is derived from sale of their catch. The high season for small scale fishing is between September and May. The survey will likely be present within areas used for small scale fishing for a short duration however as the fishermen are reliant on the activity for their household income and predominantly used fixed nets they are highly vulnerable to change.	**High**

6.4.1.4 Impact Significance

Table 6.13 summarises impacts to International and Local/Regional Shipping Operators, commercial and small scale fishing due to the physical presence of the survey vessel and seismic equipment.

Table 6.13: Impact Significance

Event	Receptor	Event Magnitude	Receptor Sensitivity	Impact Significance
Presence of the survey vessel and seismic equipment	International Shipping Operators	Low	High	**Moderate Negative**
	Local/Regional Shipping Operators	Low	Medium	**Minor Negative**
	Commercial Fishing	Low	Medium	**Minor Negative**
	Small Scale Fishing	Low	High	**Moderate Negative**

The following monitoring and reporting related to small scale fishing from the physical presence of the survey vessel and seismic equipment will be undertaken:

- Any existing equipment which is removed or damaged as a result of the survey, which the vessel crew cannot confirm is associated with small scale fishing will be logged by the vessel crew. The log will include a description of the equipment, the date it was removed or damaged and the location encountered. The log along with the equipment (where it has been removed) should be submitted to BP on completion of the survey.
- BP will be responsible for receiving, resolving and documenting any grievances raised by affected parties associated with the 2D Seismic Survey activities. The Seismic Contractor will be responsible for assisting in resolving grievances where requested including providing operational logs and records completed during the survey where relevant.

It is considered that potential impacts are minimised as far as practicable through the implementation of the existing control measures and therefore no additional mitigation is required.

6.4.2 Indirect Effect of Underwater Sound on Fishing

The operation of the sound source as the survey vessel moves along each survey line has the potential to impact fish within the water column, having an effect on fish behaviour. This could potentially affect both commercial and small scale fish catch. Section 6.3.1.2 above summarises the results of the underwater sound study (Appendix 6A) undertaken to quantify the effect of the seismic source on marine animals with regard to potential reversible and irreversible injury or behavioural effects based on recognised thresholds. The threshold study suggests that, at full power, sound from the seismic source has the potential to injure fish (both mortal and recoverable injury) if they are present within 79m of the source. Temporary auditory shift (TTS) may occur in fish (regardless of hearing ability) up to 989m in November and 1029m in December.

6.4.2.1 Mitigation

As described within Section 6.3.1.1 above a number of existing control measures will be adopted throughout the survey designed to minimise impacts from underwater sound on biological/ecological receptors (specifically seals and fish) in the marine environment. These controls include use of a soft start procedure, whereby the source level is increased slowly.

6.4.2.2 Event Magnitude

During the soft start procedure and while the seismic source is operational fish will move away from the source. Once the energy source has moved away from the area the fish are likely to return although the time taken is unknown. In some studies on the impact of seismic survey on fish catch rates were reduced for up to 5 days after the seismic survey[11].

[11] Engås, A., Løkkeborg, S., Ona, E, and Soldal, A.V. 1996. Effects of seismic shooting on local abundance and catch rates of cod (Gadus morhua) and haddock (Melanogrammus aeglefinus). Canadian Journal of Fisheries and Aquatic Sciences. Vol 53, 2238–2249.

As described within Section 6.4.1.2 above, the survey is expected to pass within 5km of the Makarov Bank, a favoured commercial fishing ground, for a total period of between 5 and 6 hours (in 1 - 2 hours periods likely to be on different days. For safety reasons the commercial fishing vessel that fishes in this area will likely need to avoid this area while the survey passes. Once the vessel returns to the fishing grounds when the survey has passed fishing activities can continue. It is anticipated that the effect of the underwater sound will have a very short duration, temporary and reversible impact on fish presence, resulting in no discernible change in fish catch.

Similarly with regard to small scale fishing (refer to Section 6.4.1.2 above) the effect of underwater sound on fish will be of very short duration, short duration, temporary and reversible and there will be no discernible change in fish catch.

Taking into account the survey activities, the results of the underwater sound study, the existing controls described above and the impact significance criteria set out in Chapter 3 of the ESIA, the event magnitude associated with the indirect effect of underwater sound on fishing is presented within Table 6.14 below.

Table 6.14: Event Magnitude

Event	Explanation	Event Magnitude
Indirect Effect of Underwater Sound on Fishing	The survey vessel and streamer will be continuously moving and not present in an area for any significant period. Control measures are designed to minimise the effect of underwater sound on biological/ecological receptors (including fish and seals) in the marine environment. While the survey will be undertaken adjacent to the Makarov Bank commercial fishing ground during high season the survey will be present for a short period (5-6 hours). Presence within the area potentially used by small scale fishermen is also expected to be short duration. Fish within these areas will move away from seismic source as it passes but will return quickly after the underwater sound levels are below injury and temporary effect thresholds It is therefore anticipated that the indirect effect of the survey on commercial and small scale fishing would be slight and temporary. It is considered unlikely that survey activities would result in concerns being raised by stakeholders or governmental bodies. This is therefore considered an event of Low magnitude.	**Low**

6.4.2.3 Receptor Sensitivity

Commercial fishing activities, described in Section 6.4.1.2 above, are known to be undertaken in the vicinity of Makarov Bank focused on kilka. With regard to small scale fishing, as described within Chapter 5 Section 5.7.3.2, this is understood to be undertaken within approximately 5.5km of the coastline. Based on data for Sangachal Bay fish species typically caught include kutum, carp, mullet, bream and vobla. These species are all known to have swimbladders and therefore have medium or high hearing sensitivity. All would react quickly to the commencement of the soft start procedure, swimming away from the sound source and returning once the source had passed.

The fish stocks available for commercial and small scale fishing are known to have decreased with significant decreases in the main commercial species kilka. The reason for this decrease is not known but is thought to be associated with continued pollution of the Caspian Sea over many years from industrial and agricultural industries, spread of invasive species (the jellyfish (ctenophore) species Mnemiopsis) and unregulated fishing in addition to increasing human influence in sensitive areas and climate change[12].

[12] Salmanov, Z., Qasimov, A., Fersoy, H. & van Anrooy, R., 2013. Fisheries and Aquaculture in the Republic of Azerbaijan: a review. FAO Fisheries and Aquaculture Circular No. 1030/4. Ankara, FAO. Available at: http://www.fao.org/docrep/017/i3113e/i3113e00.htm Accessed August 2015

Table 6.15: Receptor Sensitivity (Commercial Fishing and Small Scale Fishing)

Receptor	Explanation	Receptor Sensitivity
Commercial Fishing	It is considered that commercial fishing vessels have some capacity to adapt to the temporary reductions on fish catch due to fish behaviour reactions to noise. Considering that fishing activities in the Caspian Sea are currently under pressure, that survey activities will be undertaken in high fishing season and are expected to affect a preferred local fishing ground albeit for a temporary duration, this receptor is considered to be of medium sensitivity.	**Medium**
Small-Scale Fishing	It is considered that small-scale fishermen are a vulnerable receptor with little capacity and means to adapt to change. Considering that fishing activities in the Caspian Sea are currently under pressure, that survey activities will be undertaken in high fishing season and the likely high level of reliance on fishing income to support livelihoods and maintain food security of small-scale fishing, this receptor is considered highly sensitive.	**High**

6.4.2.4 Impact Significance

Table 6.16 summarises impacts to commercial and small scale fishing due to the effect of underwater sound on fish during the seismic survey.

Table 6.16: Impact Significance

Event	Receptor	Event Magnitude	Receptor Sensitivity	Impact Significance
Indirect Effect of Underwater Sound on Fishing	Commercial Fishing	Low	Medium	**Minor Negative**
	Small Scale Fishing	Low	High	**Moderate Negative**

It is considered that potential impacts are minimised as far as practicable through the implementation of the existing control measures and therefore no additional mitigation is required.

6.5 Summary of Residual Environmental and Socio-Economic Impacts

The assessments presented within the Chapter show that that potential impacts are minimised as far as practicable and necessary through the implementation of the existing control measures and no additional mitigation is required.

Tables 6.17 and 6.18 summarises the residual environmental and socio economic impacts associated with the routine and non routine SWAP 2D Seismic Survey activities.

Table 6.17: Summary of SWAP 2D Seismic Survey Environmental Impacts

Event	Event Magnitude	Receptor Sensitivity	Impact Significance
Underwater sound from energy source	Medium	Medium (Fish)	**Moderate Negative**
		Medium (Seals)	

Table 6.18: Summary of SWAP 2D Seismic Survey Socio-Economic Impacts

Event	Event Magnitude	Receptor Sensitivity	Impact Significance
Presence of the survey vessel and seismic equipment	Low	High (International Shipping)	**Moderate Negative**
		Medium (Local/Regional Shipping)	**Minor Negative**
		Medium (Commercial Fishing)	**Minor Negative**
		High (Small Scale Fishing)	**Moderate Negative**
Indirect Effect of Underwater Sound on Fishing	Low	Medium (Commercial Fishing)	**Minor Negative**
		High (Small Scale Fishing)	**Moderate Negative**

6.6 Additional Recommendations

As stated within Chapter 5 Section 5.5.4.3 recent data relating to seal migration and numbers within Azerbaijani waters and seals observed at haul out sites within Azerbaijan is not comprehensive and uncertain. Scientific surveys have tended to focus on the winter ice fields in the Northern Caspian with annual surveys undertaken between 2005 and 2012 by the Caspian International Seal Survey in liaison with the Darwin Caspian Seal Project and the Caspian Seal Conservation Network (CSCN)[2].

The most recent data collected within Azerbaijan has been focused on observed usage of known haul out sites, counting of dead seals found on the Azerbaijan coastline and ad hoc observations from vessels and helicopters. No recent systematic surveys have been completed. To improve the understanding of seal movements within Azerbaijan waters (particularly in the vicinity of the SWAP Contract Area) including migration routes used, timing of migration, numbers using each migration route and location and numbers using haul out sites within Azerbaijan it is recommended that BP consult with marine ecologists, both national and international, to design and set up a fit for purpose Annual Seal monitoring programme.

7 Cumulative, Transboundary and Accidental Events

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7.1 Introduction

This Chapter of the SWAP 2D Seismic Survey Environmental and Socio-economic Impact Assessment (ESIA) discusses:

- Cumulative and Transboundary Impacts; and
- Accidental Events that could potentially occur during the SWAP 2D Seismic Survey and the control, mitigation and response measures designed to minimise event likelihood and impacts.

7.2 Cumulative and Transboundary Impacts

As discussed within Chapter 3, cumulative impacts arise from:

- Interactions between separate project-related residual impacts; and
- Interactions between project-related residual impacts in combination with impacts from other projects and their associated activities.

The potential for cumulative impacts with other projects has been determined, based on a review of available information relating to projects in the vicinity of the SWAP 2D Seismic Survey Area, which are of a scale that has the potential to result in cumulative impacts.

7.2.1 Cumulative Impact Between Separate Project Impacts

As discussed in Chapter 6, the majority of the environmental interactions associated with the 2D Seismic Survey have been scoped out of the full assessment on the basis that impacts to the environment would be indiscernible as compared to background levels. Underwater sound, resulting from the operation of seismic sound source, was considered to have the potential to impact biological/ecological receptors (specifically seals and fish) and consequently an assessment was undertaken based on an underwater sound study and taking into account existing controls. The assessment concluded the underwater sound had the potential for a moderate negative impact to seals and fish and no additional mitigation was required. The sound will be experienced within the water column following the operation of sound source along each survey line but will quickly dissipate. As this was the only potential environmental impact of any significance identified, the potential for cumulative impact between project environmental impacts is considered insignificant. With regard to socio-economic impacts these were limited to the impact of the physical survey presence on shipping and fishing and the indirect effect of underwater sound on fishing. The potential for cumulative impacts between these aspects is considered to be insignificant.

7.2.2 Cumulative Impacts with Other Projects

With regard to other projects within the vicinity of the SWAP 2D Seismic Survey, known projects include the Shah Deniz Stage 2 (SD2) Project[1], Hovsan Wastewater Treatment Plant (WTP) Sea Outfall Construction[2] and the activities within the Bahar Gum Deniz Contract Area[3]. The ESIAs that describe these projects are referenced within Chapter 6 of this ESIA.

In addition, it is understood that BP are planning to undertaken seismic surveys in the north-eastern section of the SD Contract Area in October 2015 and the Azeri-Chirag-Guneshi (ACG) Contract Area from January to February 2016. However, given that the timings of the surveys do not overlap with the 2D seismic survey (scheduled November to December 2015), the potential for cumulative impacts is considered insignificant.

While the SWAP 3D Seismic Survey, outlined in Chapter 1, is planned to be completed in a similar area to the 2D Seismic Survey, it is not planned to commence the 3D Seismic Survey until March 2016, several months after the 2D Survey is due to be completed. Therefore, the potential for

[1] URS, 2013. Shah Deniz Stage 2 Project ESIA.
[2] Seureca-ASPI, 2009. Environmental Impact Assessment Study for Hovsan Wastewater Treatment Plant Sea Outfall Construction.
[3] Ekol on behalf of Bahar Energy Ltd, 2012, Bahar Gum-Deniz Project EIA.

cumulative impacts of the 2D survey relative to the later 3D survey is considered insignificant. The potential cumulative impacts of the 3D survey relative to the 2D survey will be assessed in the ESIA for the 3D seismic survey.

With regard to the Hovsan WTP ESIA the planned activities associated with the project primarily involved the installation of a new offshore outfall for the Hovsan WTP. At the time of writing it is understood, however that this project has been either temporarily or permanently abandoned[4].

The Bahar Gum Deniz ESIA[3] was prepared in 2011 to obtain permission to undertake explorative activities within the Bahar Gum Deniz Contract Area (which is located between the east and west sections of the SWAP Contract Area – refer to Figure 7.1 below) including seismic surveys, drilling of an exploration well and geotechnical investigations. It is understood that the planned seismic surveys were completed in March 2015 and interpretation of data is ongoing, however drilling of new wells within the Contract Area is currently suspended, with new drilling not forecast to resume until Q3 2016[5].

As such the potential for cumulative impacts with other projects is limited to potential interactions with impacts arising for SD2 Project activities, where drilling, construction and offshore installation activities are known to be ongoing.

7.2.2.1 Shah Deniz Stage 2

The second stage of development of the Shah Deniz (SD) Contract Area comprises construction and installation of the fixed Shah Deniz Bravo (SDB) platform complex, drilling and completion of 26 wells, installation of subsea infrastructure tied back to the SDB platform and the installation of subsea export pipelines to the Sangachal Terminal[1]. The wells associated with the SD2 Project are planned to be located in five clusters around the SD Contract Area and will all be drilled using a mobile drilling rig. The wells will then be tied into a manifold which will, in turn, be tied in the SDB platform complex using flowlines.

It is understood that in Q4 2015 SD2 Project activities are likely to include drilling and completion of a number of wells, installation of subsea infrastructure within the SD Contract Area (including manifolds and flowlines) and installation of the subsea export pipelines between the SD Contract Area and Sangachal Terminal.

As shown on Figure 7.1, the northern flank (NF) well cluster is the closest to the SWAP 2D Seismic Survey Area; located approximately 10km to the south. Based on the impact assessment presented within the SD2 Project ESIA, SD2 activities in this location, likely to comprise drilling and completion of wells and installation and subsea infrastructure installation, are only predicted to result in minor and localised impacts to the seabed (e.g. associated with the discharge of water based mud and cuttings to the seabed). Given the distance between the NF location and the SWAP 2D Seismic Survey Area, no cumulative impacts are expected to arise between SWAP 2D Seismic Survey activities and the SD2 activities in this location.

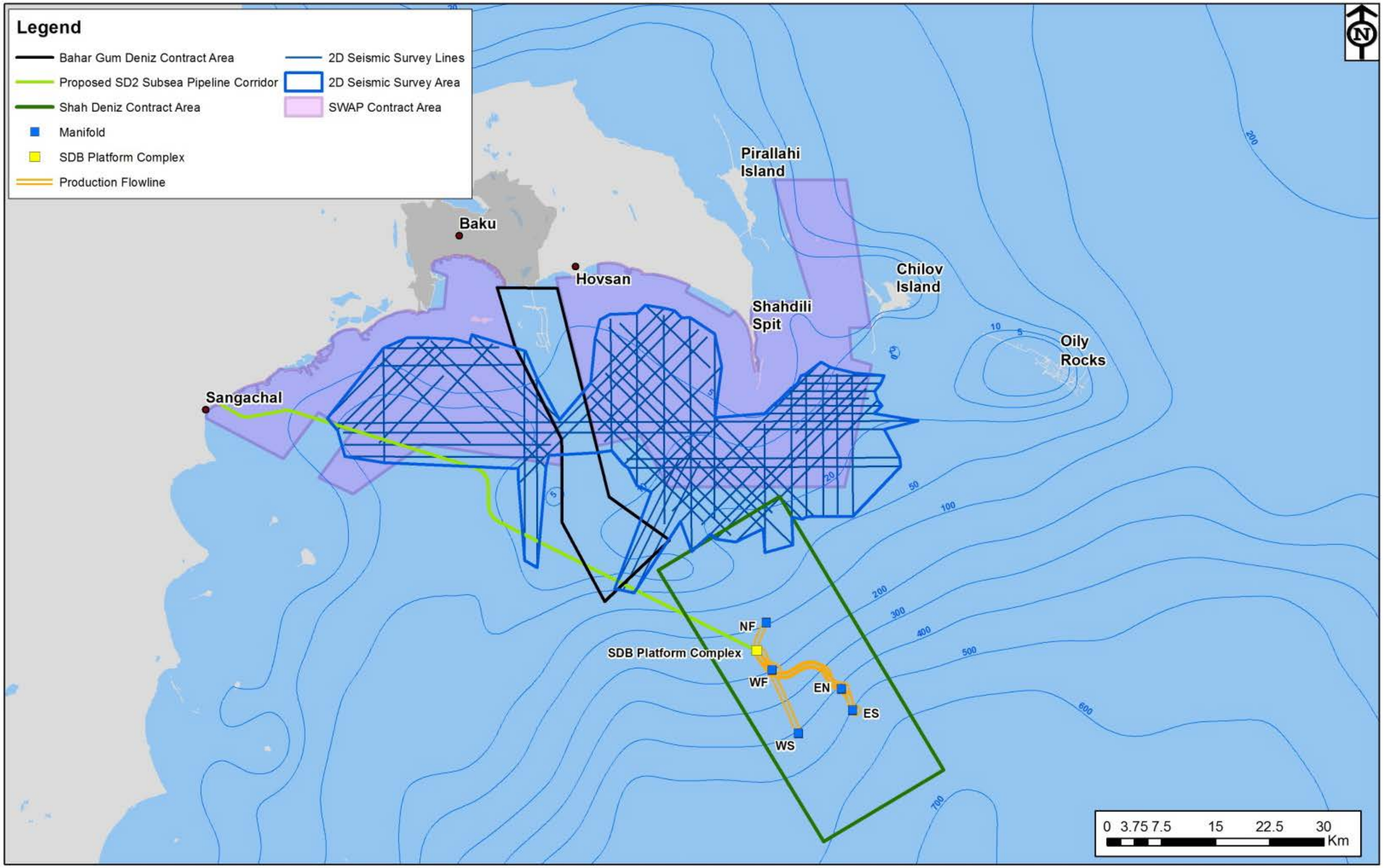
With regard to the installation of the SD2 subsea export pipelines, the SD2 pipeline corridor route crosses the SWAP 2D Seismic Survey Area in three locations (ref to Figure 7.1). Based on the SD2 Project schedule as presented within the SD2 Project ESIA, there is potential that pipelay activities may take place at the same time as the SWAP 2D Seismic Survey activities. The pipelay activities involve use of a pipelay vessel and support vessels to lay the SD2 pipelines directly on the seabed. Impacts to the seabed are considered to be very limited and localised. Underwater sound associated with the pipelay and support vessel engines was also considered to be of minor significance with no significant impacts to fish and seals predicted. Vessels will discharge only treated black water, grey water, drainage and ballast water resulting in no discernible impacts to the water column. The SD2 pipelay works and the SWAP 2D Seismic Survey, both of which are managed by BP as the SD and SWAP Technical Operator, will be planned in such a way that the seismic survey activities are not

[4] Independent Evaluation Group Azerbaijan CLR Review on behalf of the World Bank, 2015
[5] Greenfields Petroleum Corporation. Investor Update - Annual General Meeting, August 11, 2015, Houston, Texas. Available at: http://www.greenfields-petroleum.com/uploads/pdfs/investor_presentations/GNF%20AGM%202015.pdf?bcsi_scan_ab11caa0e2721250=0&bcsi_scan_filename=GNF%20AGM%202015.pdf Accessed August 2015

undertaken in the vicinity of the SD2 pipeline corridor during pipelay works. Furthermore both the SD2 pipelay works and the SWAP 2D Seismic Survey will be required to notify relevant maritime authorities and other sea users prior to the start of activities in addition to notifying other vessels by appropriate signals in accordance with International Maritime Law.

Given the design controls to be employed for both projects and through planning to avoid undertaking seismic survey activities in close vicinity to the SD2 pipelay works, the potential for cumulative impacts is considered negligible.

Figure 7.1: Location of Other Proposed Projects in the Vicinity of the SWAP 2D Seismic Survey Area



7.3 Transboundary Impacts

7.3.1 Non-Greenhouse Gas Atmospheric Emissions

The potential for transboundary impacts associated with non-greenhouse (GHG) emissions are dependent on the environmental / health effects associated with the pollutant, residence time (i.e. atmospheric lifetime) and the expected dispersion characteristics of the pollutant in the atmosphere in addition to the location of potential receptors. The most significant pollutant in terms of health impacts is nitrogen dioxide ($NO_{2)}$.

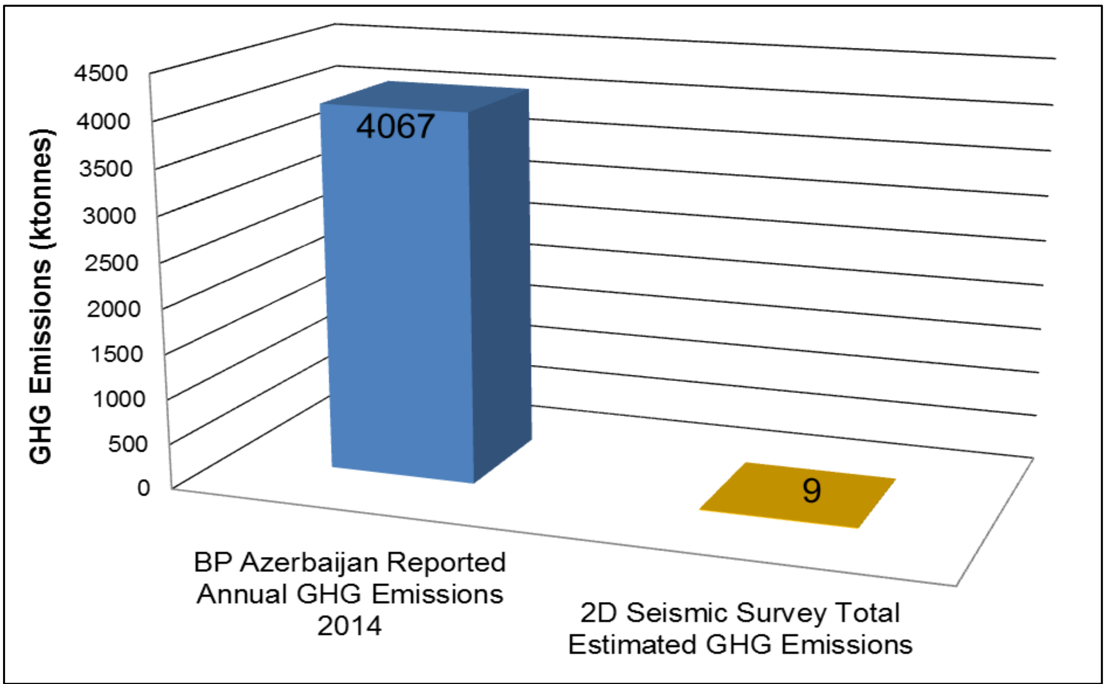
As stated in Chapter 6 Table 6.1 the impact of NO_2 emissions to atmosphere from SWAP 2D Seismic Survey activities have been scoped out due to their limited potential to result in discernible impacts to the nearest onshore receptors (i.e. locations where people are resident). This assessment was based on the anticipated volume of non GHG emissions released to the atmosphere (set out in Chapter 4 Section 4.5.1) and a previous study completed for a release with similar characteristics in the nearby SD Contract Area, As stated within Chapter 6 the low volume of emissions released will be dispersed across the entire survey area and the wider area and any increases in pollutant concentrations will be indistinguishable from existing background concentrations. Therefore, there will be no discernible transboundary environmental impacts from non-GHG atmospheric emissions.

7.3.2 Greenhouse Gas Atmospheric Emissions

The estimated volume of GHG emissions generated by the SWAP 2D Seismic Survey activities (including carbon dioxide and methane) are presented in Chapter 4 Section 4.5.1 of this ESIA.

Figure 7.2 presents the estimated volume of SWAP 2D Seismic Survey total GHG emissions compared with the annual 2014 GHG emission volumes reported for BP's Azerbaijan operations in the AGT Region[6].

Figure 7.2 Estimated SWAP 2D Seismic Survey Total GHG Emissions Compared to Reported 2014 BP Azerbaijan Annual GHG Emissions



[6] BP Exploration (Caspian Sea) Limited, 2014, BP in Azerbaijan Sustainability Report 2014

Figure 7.2 demonstrates that the estimated SWAP 2D Seismic Survey GHG emissions represent approximately 0.22% of the annual operational GHG emissions from BP's upstream activities in Azerbaijan in 2014.

The most recently published GHG emissions data for Azerbaijan estimated a total of 48,209 kilotonnes of GHG emissions were emitted in 2010[7]; 76% of which was estimated to be generated by the energy sector. Total GHG emissions for 2015 were forecast to be approximately 49,000 kilotonnes. As a proportion, the estimated GHG emissions for the SWAP 2D Seismic Survey are expected to contribute approximately 0.0184% to the 2015 national total.

7.4 Accidental Events

Accidental Events are considered separately from routine and non-routine activities as they only arise as a result of a technical failure, human error or as a result of natural phenomena such as a seismic event. Potential accidental events that may result in potentially significant environmental impacts during the SWAP 2D Seismic Survey have been identified and include:

- Spill of marine diesel from the 2D seismic survey and support vessels, including a worst case scenario of a full diesel inventory loss;
- Release of chemicals from the 2D seismic survey and support vessels; and
- Collision between survey vessel and/or equipment and Caspian Seals.

The likelihood of these events occurring, the consequences, the mitigation and the control, mitigation and response measures designed to minimise event likelihood and impacts are described in the sections below.

7.4.1 Vessel Marine Diesel Spill

As described within Chapter 4 the 2D Seismic Survey will be undertaken by a seismic survey vessel and up to two support vessels that will travel along the predetermined survey lines within the 2D Seismic Survey Area. While considered unlikely it is possible due to mechanical failure or due to a collision the diesel inventory of the fuel tanks onboard one or more of the vessels may be released to sea. Analysis of water transport accident statistics by the International Association of Oil & Gas Producers[8] shows that ship to ship collisions represent only 12% of total ship losses and that the likelihood of this occurring is extremely low.

As a worst case it was assumed that the largest inventory is spilled (900m^3 onboard the seismic survey vessel). In reality this is considered unlikely as diesel is stored on the seismic vessel in a series of smaller tanks which are double bottomed and connected by valves and it is unlikely that contents of all the tanks would be lost simultaneously. Furthermore, the hull of the Survey vessel is double skinned. However, as a worst case this scenario has been considered.

7.4.1.1 Properties of Marine Diesel

Marine diesel fuel is classified as a non-persistent oil that does not contain a considerable proportion of heavy fractions; it would be expected to evaporate and disperse very quickly. It is a refined petroleum product with a relatively narrow boiling range, which means when spilled on water, most of the diesel fuel will evaporate or naturally disperse within a few days or less, even in cold water.

The key processes that govern the dispersion of diesel are shown in Figure 7.3. When oil is released into the marine environment it undergoes a number of physical and chemical changes as a result of evaporation, dissolution, dispersion, emulsification, sedimentation, photooxidation and bio-

[7] UN Framework Convention on Climate Change (UNFCCC), 2014. The First Biennial Updated Report of the Republic of Azerbaijan to the UN Framework Convention on Climate Change. Submitted in accordance with the UN Framework Convention on Climate Change Conference of the Parties (COP) Decision 1/CP.16. Baku. Available at: http://unfccc.int/resource/docs/natc/aze_bur1_eng.pdf?bcsi_scan_e956bcbe8adbc89f=0&bcsi_scan_filename=aze_bur1_eng.pdf Accessed August 2015

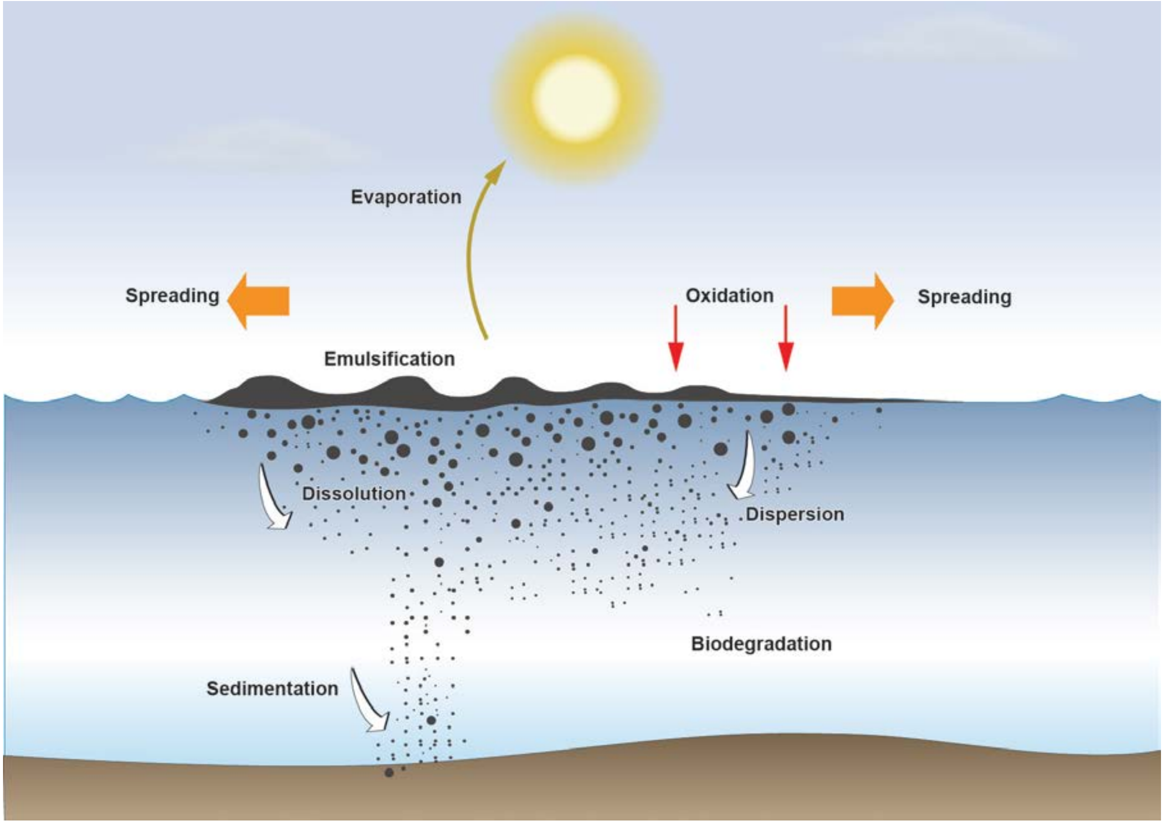
[8] International Association of Oil & Gas Producers (OGP), 2010. Water Transport Accident Statistics, Risk Assessment Data Directory, Report No. 434 – 10.

degradation processes, collectively known as weathering. These changes are dependent upon the type and volume of oil spilt, and the prevailing weather and sea conditions.

Evaporation and dispersion are the two main mechanisms that act to remove oil from the sea surface, whilst oxidation, sedimentation and biodegradation transform hydrocarbons into basic elements at later stages.

Marine diesel has a very low viscosity and is readily dispersed into the water column when wind speeds reach 5 to 7 knots or the sea state is approximately Force 2 Beaufort scale or higher. It is much lighter than water with a specific gravity of 0.843, compared to 1.03 for seawater. Therefore, it is not possible for the diesel to sink and accumulate on the seabed as pooled or free oil. However, it is possible for the diesel to be physically mixed into the water column by wave action, forming small droplets that are carried and kept in suspension by the currents.

Figure 7.3: Processes Acting on Spilled Oil



Marine diesel dispersed in the water column can adhere to fine-grained suspended sediments, which then settle out and are deposited on the seabed. This process is more likely to occur near the mouths of rivers and estuaries where fine-grained sediments are carried downstream. It is less likely to occur in open marine settings.

Compared to unrefined crude oils, marine diesel is not very sticky or viscous. When spills of marine diesel do strand on the shoreline, the diesel tends to penetrate porous sediments quickly and degrade over time, but also to be quickly washed off hard surfaces by waves. Thus, shoreline clean-up may not be needed. In these situations, marine diesel is readily and completely degraded by naturally occurring microbes within one to two months.

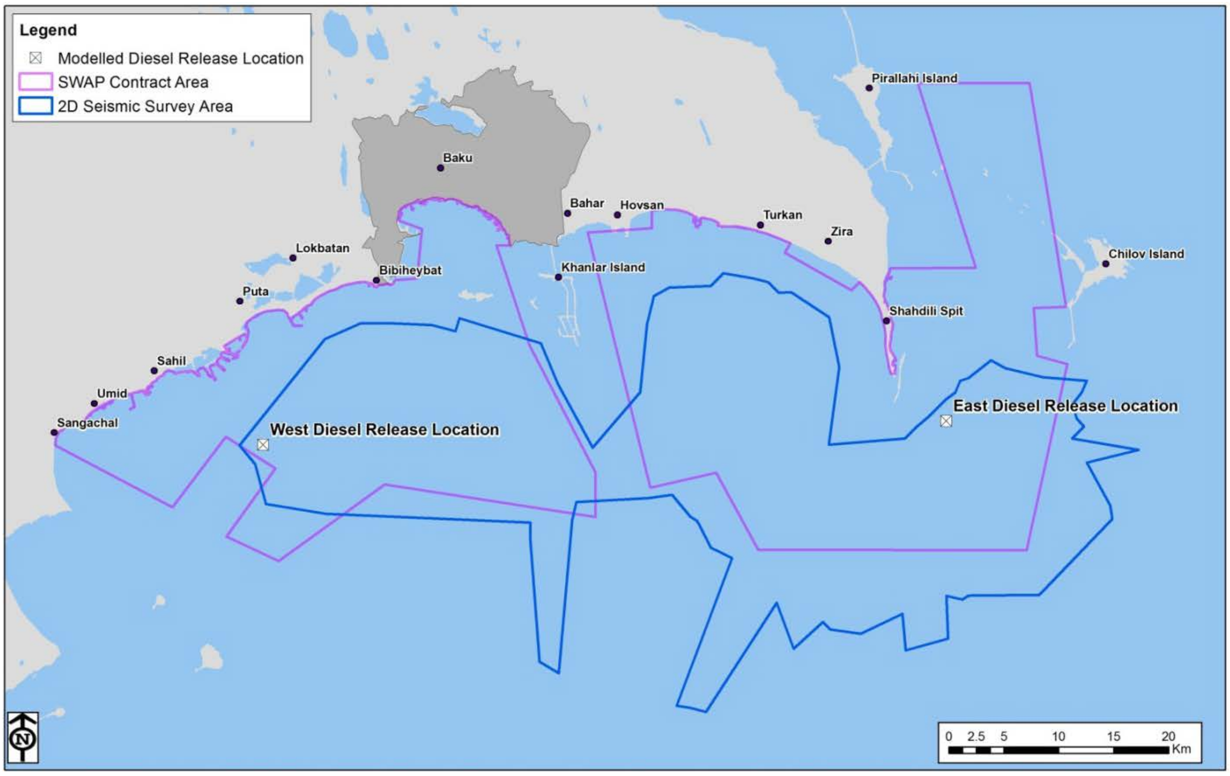
7.4.1.2 Vessel Marine Diesel Spill Modelling

To assess the potential impact of the loss of the complete inventory of the seismic survey vessel spill modelling was undertaken using the OSCAR modelling software (see Appendix 7A for a description of the model). Two potential release locations were selected within the west and east of the 2D Seismic Survey Area as shown in Figure 7.4. While the Survey is planned to be undertaken during November and December modelling was undertaken for both summer and winter conditions to provide a complete set of modelling results. Table 7.1 provides a summary of the model inputs.

Table 7.1: 2D Seismic Survey Diesel Inventory Loss Scenarios – Input Data

Scenario	Release Coordinates	Release Depth	Release Volume	Release Duration	Air Temperature	Oil Type
West (Winter)	49°41'4.310" E 40°10'14.500" N	Surface	900 m^3	1 hour	8 °C	Marine Diesel
West (Summer)					25 °C	
East (Winter)	50°25'29.950" E 40°11'46.290" N				8 °C	
East (Summer)					25 °C	

Figure 7.4: Vessel Marine Diesel Spill Modelling Release Locations



7.4.1.3 Modelling Results

Modelling of the spill scenarios was undertaken using both stochastic (multiple scenario) and deterministic (single scenario) modelling where stochastic modelling was used to identify the appropriate period (winter or summer) under which the deterministic modelling should be run over to obtain under worst case results[9]. The worst and least worst deterministic spill modelling scenarios identified from the stochastic modelling (in terms of the volume of diesel that would beach on the shore) assumed a release from the West release location in summer and from the East release location in winter respectively.

The sections below present the following:

- West Release Location - results of the stochastic spill modelling (winter conditions) and deterministic modelling (worst case - summer conditions); and

[9] Deterministic modelling predicts the movement of an oil spill based on specific scenario and met-ocean conditions over time whereas stochastic modelling demonstrates the probability of where an oil spill may impact for defined time periods by running a series of trajectories under various wind conditions from historic records.

- East Release Location - results of the stochastic spill modelling (winter conditions) and deterministic modelling (least worst case - winter conditions).

West Release Location – Stochastic Modelling Results

Thickness and Persistence of Diesel on the Sea Surface[10]

The modelling predicted that following the spill the marine diesel would rapidly spread out to form a thin sheen on the sea surface and will move in southerly direction along the Azerbaijan coastline towards Iran. It was predicted that there is a more than 5% probability of surface diesel (i.e. greater than 0.04µm thick) crossing into Iranian waters for a minimum of 14 days after the spill. As shown in Figure 7.5 surface diesel thicknesses[11] are predicted to be greater than 50µm thick in the area immediately adjacent to the release, reducing to less than 5 µm thick at greater distance from the spill location. Localised areas of surface diesel of thickness between 0.3 and 5µm (described as “rainbow”) can also be observed at significant distance from the spill location in Iranian waters. The modelling confirms that the diesel does not persist in any one location on the sea surface for more than 3 days and generally less than 2 days, due in part to the fact it is a single bulk release that is transported away from the release site by currents and winds.

Amounts of Diesel Coming Ashore, Time to Come Ashore and Probable Locations

Figure 7.6 shows the predicted probability of shoreline oiling above the emulsion mass threshold of 0.169 tonnes/km[12] (which equates to a diesel thickness of 1mm on the shoreline) following the release of diesel at the west release location during winter. The figure indicates that the predicted probability of shoreline oiling above the emulsion mass threshold is less than 30% for all areas and generally less than 5% for most areas of coastline.

Probabilistic modelling results show that diesel will start washing ashore within a day of the release, with the first diesel reaching land after 0.2 days. This is generally in locations nearest the release location along the coastline between Baku and Sangachal. Diesel is anticipated to come ashore in the vicinity of Shirvan National Park approximately 10 days after the release and after 15-30 days further south towards the Gizilaghaj State Nature Reserve. The modelling indicated that the worst case quantity of diesel that could beach following the spill in the west location in winter is approximately 535 tonnes.

Concentrations of Hydrocarbons in the Water Column

Figure 7.7 shows the predicted duration that the total diesel in water (dissolved and dispersed) concentration is anticipated to exceed the threshold level of 58 ppb[13], where the probability of the water column diesel concentrations being greater than 58 ppb is greater than 1%. The figure shows that the total diesel concentration is shown to persist for less than 3 days, and in many areas for less than 1 day above the 58 ppb threshold. It is also shown that the extent of the area where the total diesel concentration is anticipated to exceed the 58 ppb threshold is a relatively constrained area that extends from Baku towards Gizilaghaj State Nature Reserve.

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[10] Thicknesses are presented as groups accounting to the Bonn Agreement Oil Appearance Code (BAOAC). The five codes of the BAOAC are based on experimental evidence that has linked visual appearance to known oil thicknesses. Each of the codes, apart from Code 5 (Continuous True Oil Colour), has a minimum and a maximum oil layer thickness.

[11] No probability threshold is applied due to limited functionality in OSCAR. Results represent surface oil probabilities >1%.

[12] A minimum threshold for shoreline emulsion mass of 0.169 tonnes/km was used within the stochastic simulations. These values are the lower limit of the “Light Oiling” threshold used by The International Tanker Owners Pollution Federation Ltd (ITOPF, 2014). The threshold of 0.169 tonnes/km for condensate releases was calculated based on: a) the length of the hypotenuse of each surface grid (1060 m); b) a mean shoreline width of 2m; c) minimum Light Oiling threshold of 0.1litres/m^2 and d) emulsion density of 846kg/m^3 @STP (based on 2% water uptake).

[13] Research completed by Statoil (2006) and Det Norsk Veritas (2008) resulted in the development of species sensitivity dose-response curves to assess the impact to organisms from different water column hydrocarbon concentrations. A 5th percentile LC_{50} for total hydrocarbon concentrations was found to be 58 ppb. This value of 58 ppb has been used within this modelling as the lower threshold for potential acute toxicological responses. This is a conservative value as 58 ppb is below the LC_{50} for 95% of species.

Figure 7.5 Time-Averaged Thickness of Diesel on the Sea Surface (Winter), West Release Location

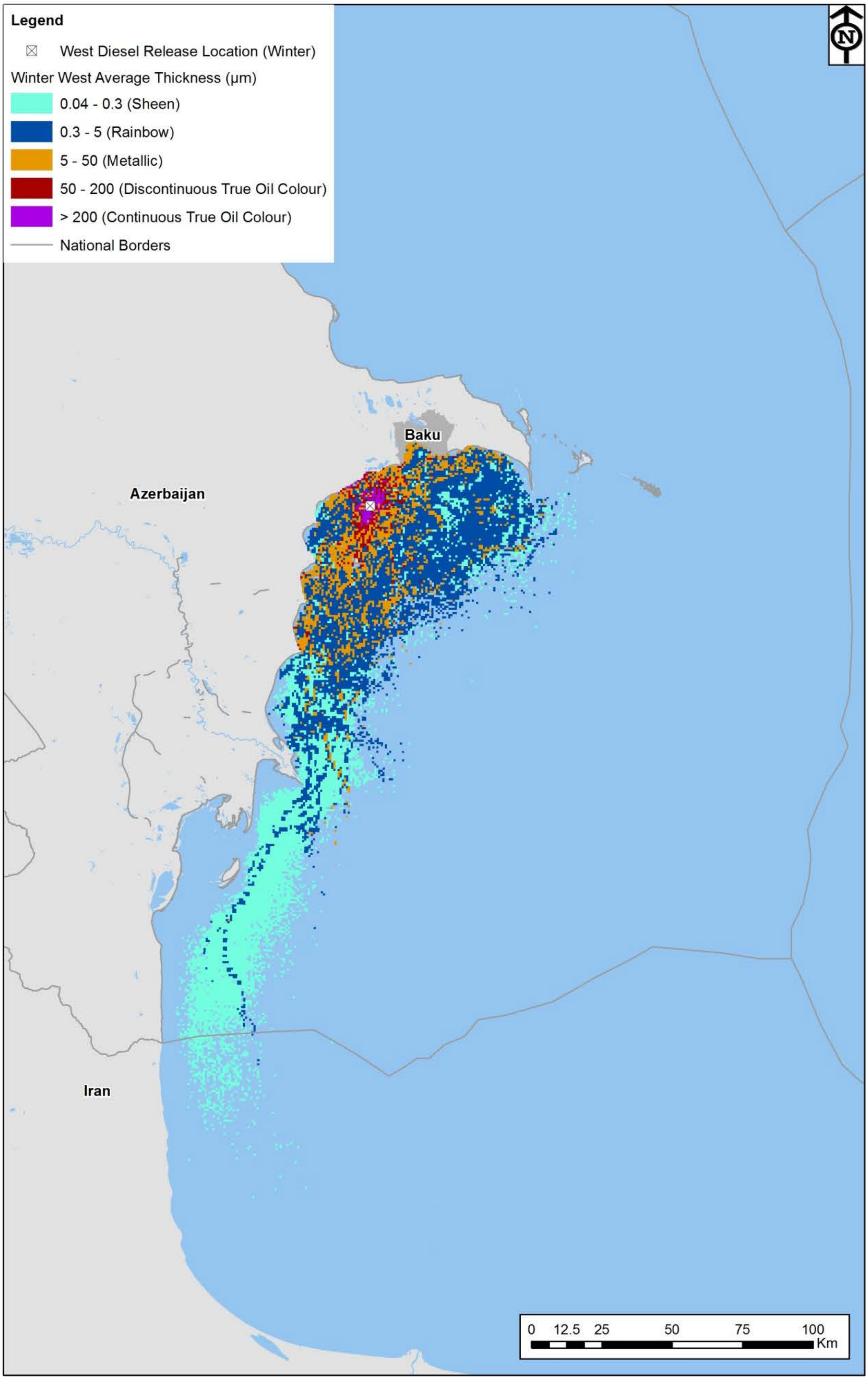


Figure 7.6 Probability of Shoreline Oiling Above the Emulsion Mass Threshold of 0.169 tonnes/km (Winter), West Release Location

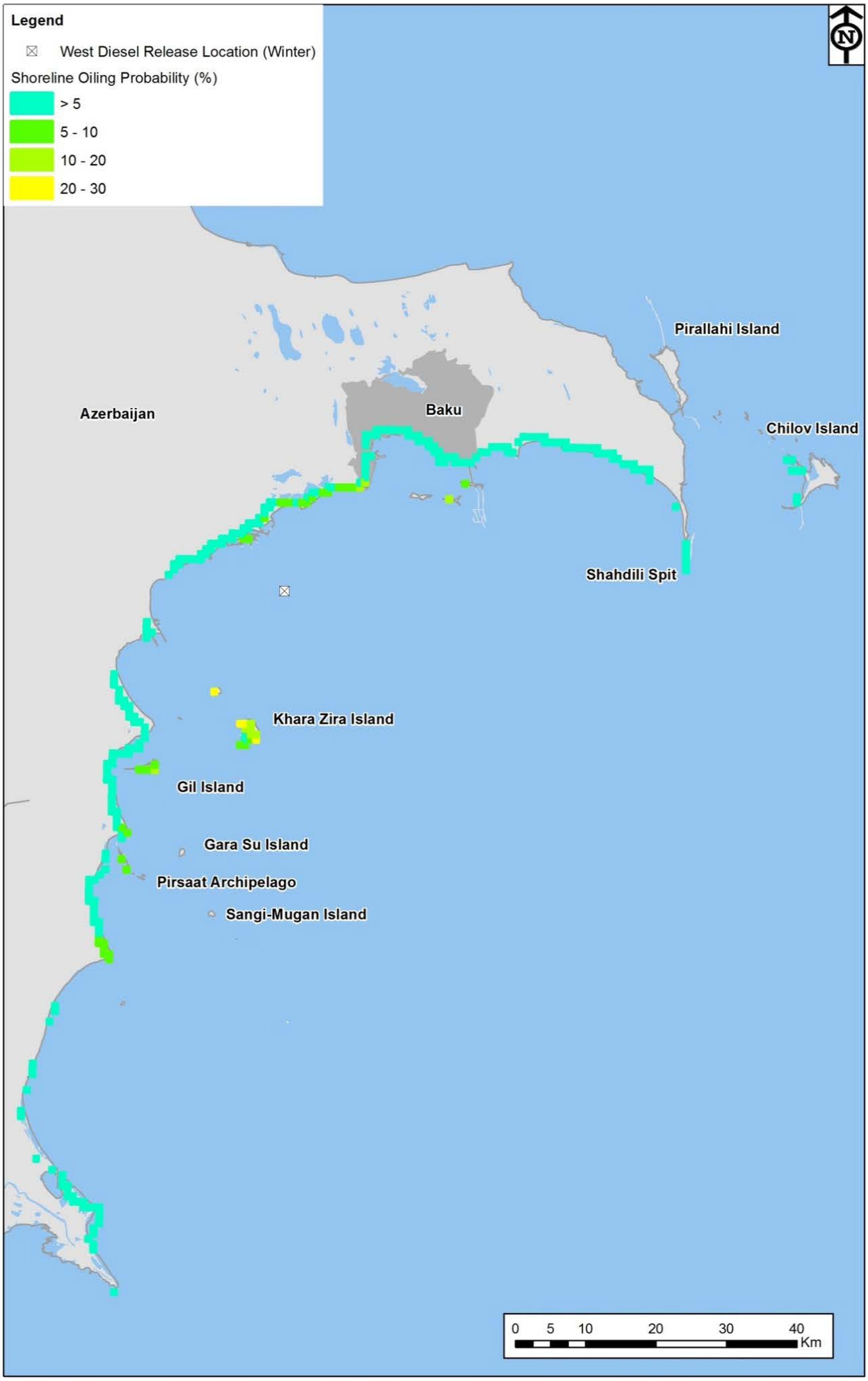
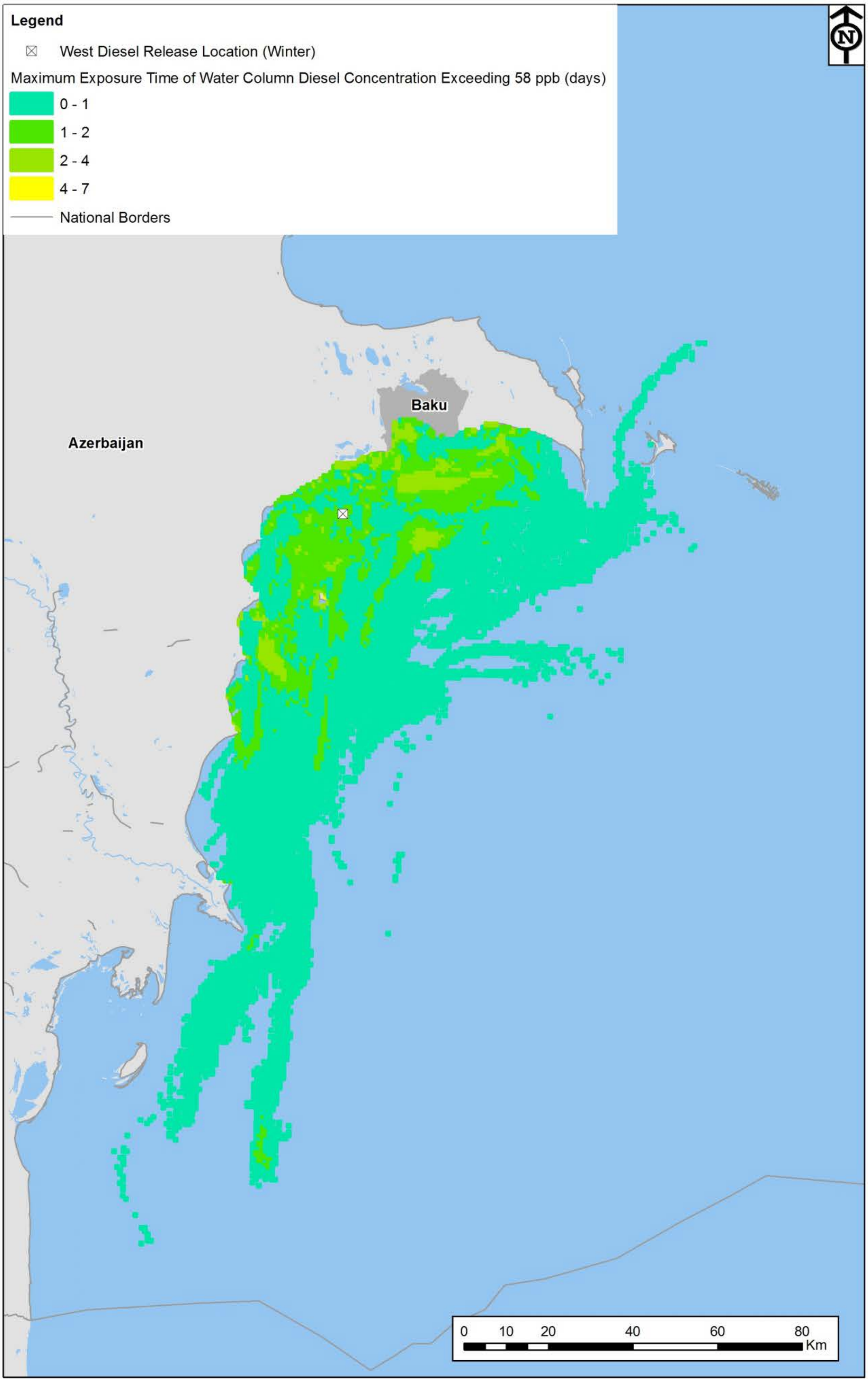


Figure 7.7 Maximum Exposure Time Above Dispersed Diesel in Water Column Concentration Threshold of 58 ppb (Winter), West Release Location

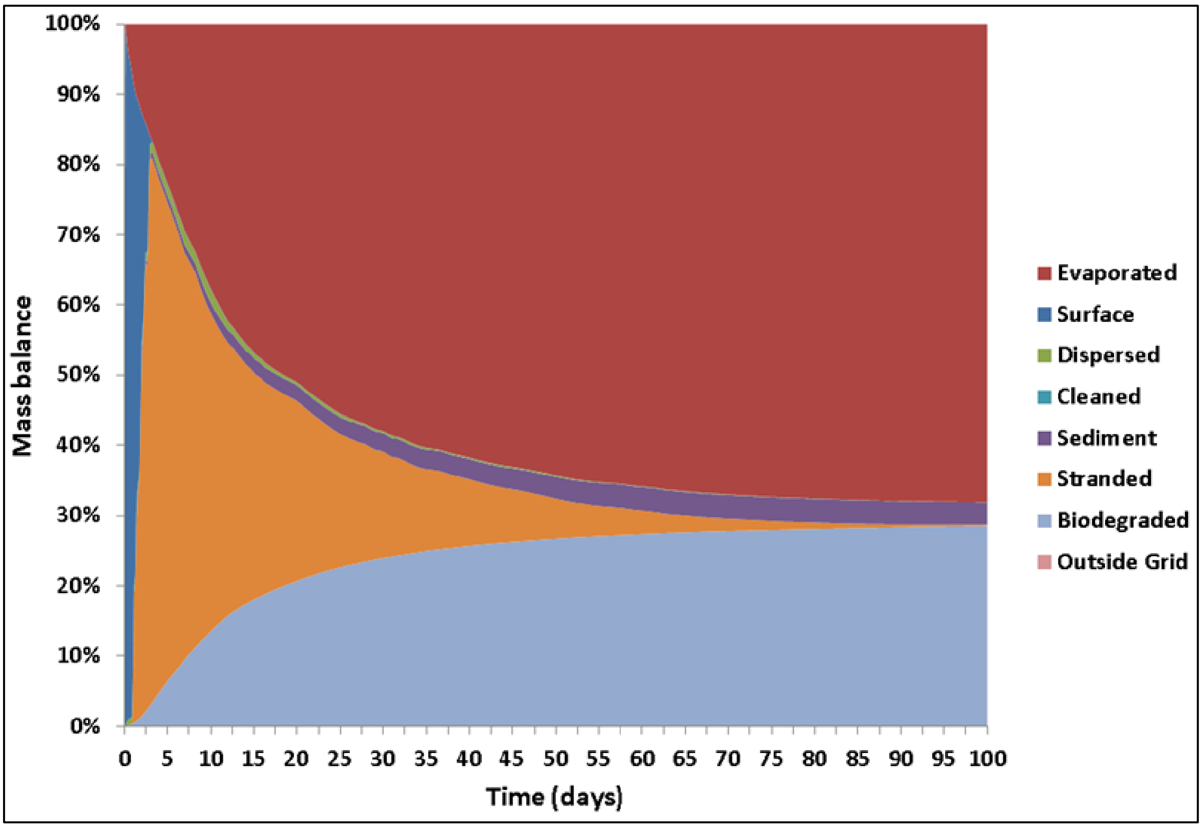


West Release Location – Deterministic Modelling Results

From the stochastic simulations the most shoreline oiling in any single of the 100 scenarios modelled is 554 tonnes, which was from a release in summer conditions. This worst case shoreline oiling scenario was re-run as a single deterministic simulation so the evolution of this spill and the fate of the diesel could be analysed.

Figure 7.8 presents the predicted fate of the relative proportions of the diesel for a release from the west location for the worst case shoreline oiling scenario. As Figure 7.8 shows, the majority of the volume of the released diesel is expected to be rapidly accumulate on the shoreline between day 1 and 4 after the release. This is due to easterly winds blowing the diesel directly towards the nearest shoreline. Evaporation and biodegradation rates are high during the first 25 days of the release and act to remove and remediate the diesel mass initially washed ashore Shoreline oiling is predicted to occur less than a day after the release and peak after around 4 days. From days 5-25 rapid degradation of diesel on the shoreline occurs as a result of biodegradation and evaporation. From days 25-60 these process continue to dominate, albeit at a gradually reducing rate as the diesel weathers. After the first 5 days some diesel still exists on the sea surface and some is also remobilised to the sea surface due to wave action along the shoreline. This small mass of diesel is shown to be transported southwards where it comes ashore to the North of the Shirvan National Park after around 30 days. It is shown to persist for <10 days on the shoreline. By day 60 around 25 tonnes of emulsified diesel is predicted to remain on the shoreline and a similar mass is bound to seabed sediments, but the majority has either evaporated or biodegraded. After 100 days <2 tonnes of diesel remains on the shoreline and 25 tonnes remains bound to seabed sediments.

Figure 7.8 Fate of Diesel Released (Winter) West Release Location



East Release Location – Stochastic Modelling Results

Thickness and Persistence of Diesel on the Sea Surface

The modelling predicted that following the spill the marine diesel would rapidly spread out to form a thin sheen on the sea surface. Figure 7.9 shows the diesel is predicted to drift in a predominantly south-westerly direction from the release location. Surface diesel thicknesses are predicted to be greater than 50µm thick in the area immediately adjacent to the release while further away the thickness of surface diesel is predicted to be less than 5 µm thick. The modelling predicts that the diesel will not persist for longer than 3 days on the surface, and generally for less than 2 days.

Amounts of Diesel Coming Ashore, Time to Come Ashore and Probable Locations

Figure 7.10 shows the predicted probability of shoreline oiling above the emulsion mass threshold of 0.169 tonnes/km[12] (which equates to diesel thickness of 1mm on the shoreline) following a release of diesel at the east release location in the winter. The figure indicates that the predicted probability is less than 20% for all areas and generally less than 5% for most areas of coastline.

Predicted shoreline oiling is shown to occur mainly around the Shahdilli Spit and Chilov Island with oiling predicted to occur within the first 2 days of spill at Shahdilli Spit and Chilov Island and after 5-15 days further south from Baku towards Shirvan National Park. The modelling indicated that the worst case quantity of diesel that could beach following the spill in the east location in winter is approximately 442 tonnes.

Concentrations of Hydrocarbons in the Water Column

Figure 7.11 shows the duration that the dispersed diesel in water concentration is anticipated to exceed the threshold level of 58 ppb[13]. The figure indicates that the diesel concentration is shown to persist for less than 3 days in most areas and in many areas for less than 1 day above the 58 ppb threshold.

It can also be seen that the extent of the area where the total diesel concentration is anticipated to exceed the 58 ppb threshold (where the probability of the water column diesel concentrations being greater than 58 ppb is greater than 1%) occurs over a relatively large area in all directions from the east release location.

Figure 7.9 Average of Time-Averaged Thickness of Diesel on the Sea Surface (Winter), East Release Location

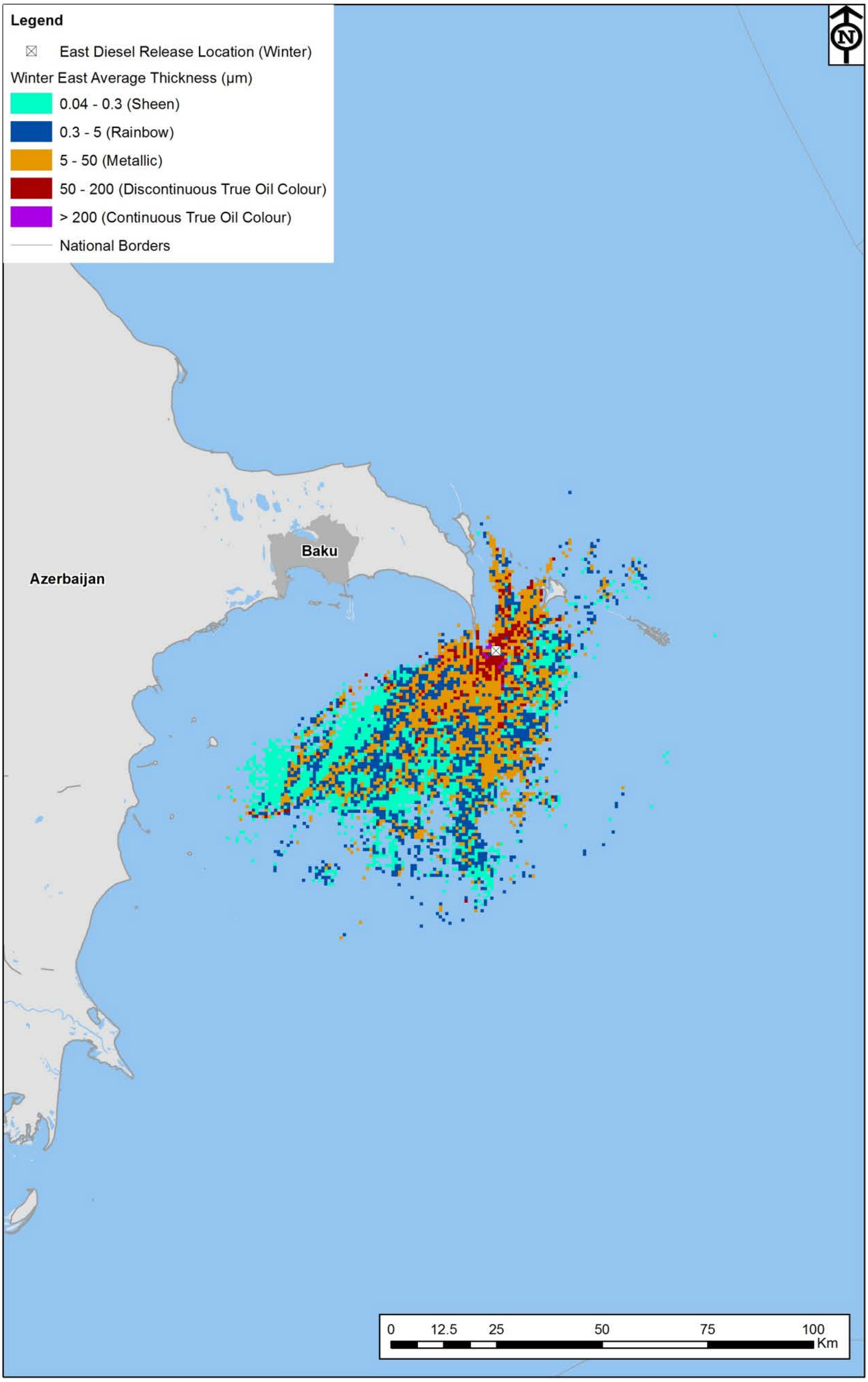


Figure 7.10 Probability of Shoreline Oiling Above the Emulsion Mass Threshold of 0.169 tonnes/km (Winter) East Release Location

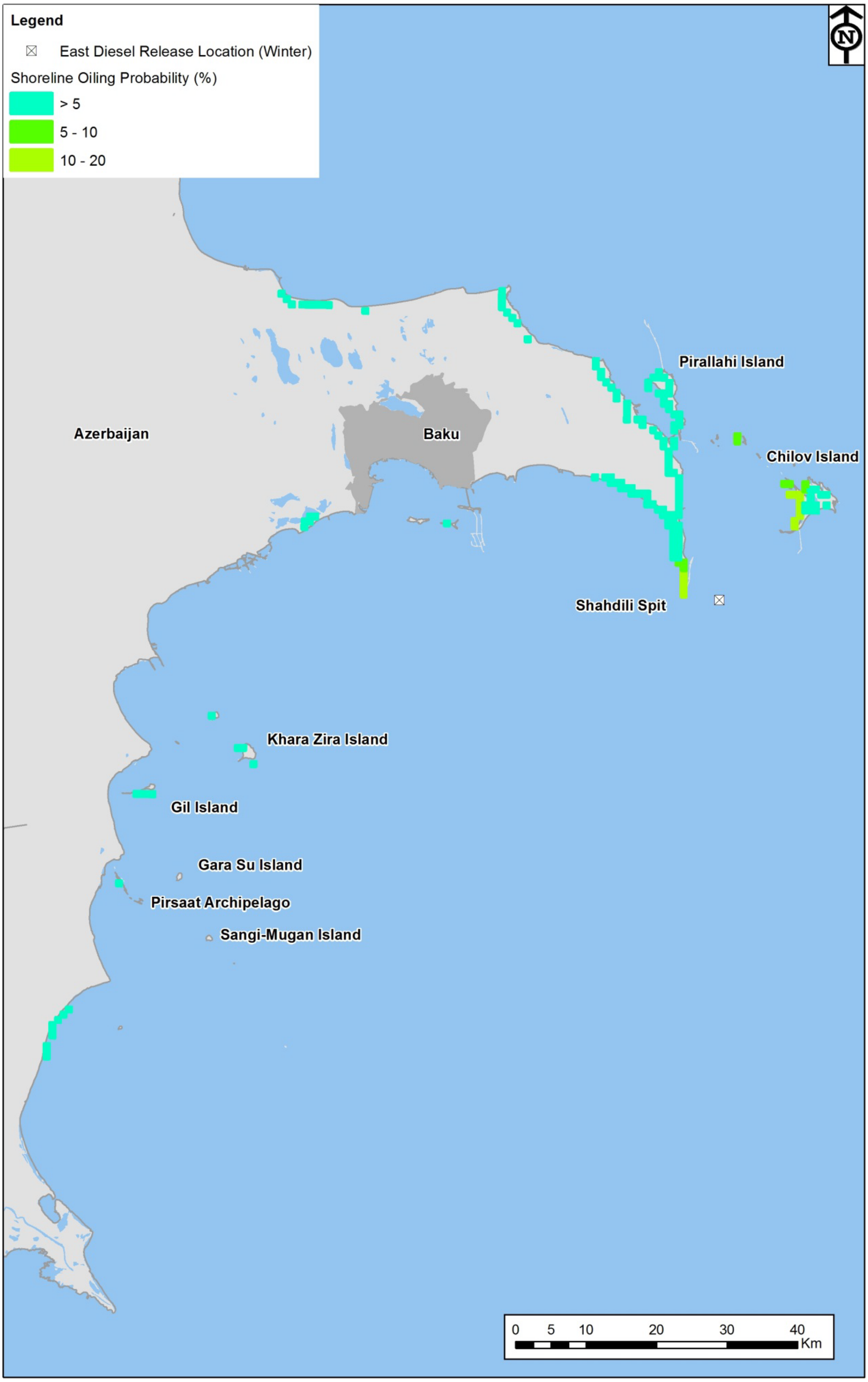
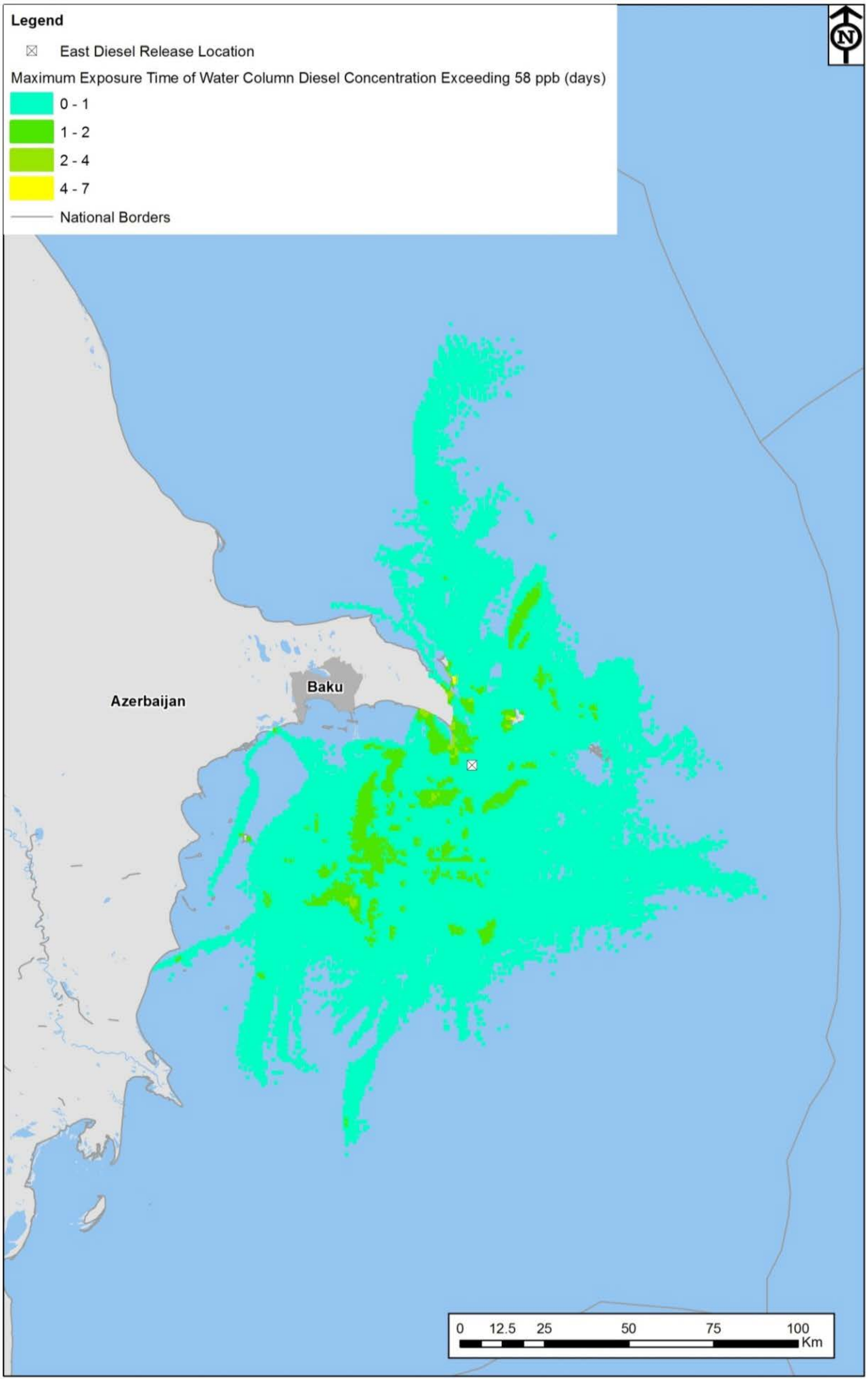


Figure 7.11 Maximum Exposure Time Above Dispersed Diesel in Water Column Concentration Threshold of 58 ppb (Winter) East Release Location

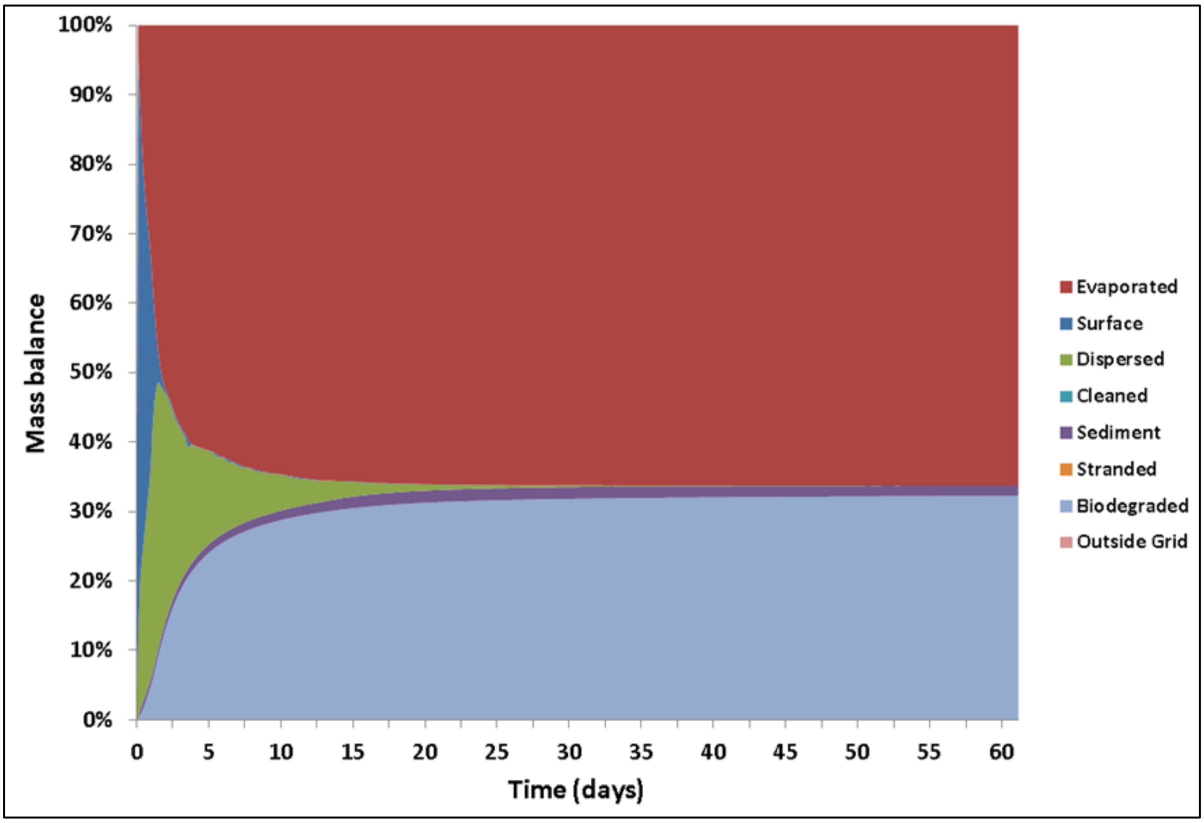


East Release Location – Deterministic Modelling Results

As for the west release location, 100 stochastic simulations were completed in this case to identify the least worst shoreline oiling scenario. The scenario identified was under winter conditions where approximately 30kg of diesel was predicted to beach on the shoreline. This scenario was re-run as a single deterministic simulation so the evolution of this spill and the fate of the diesel could be analysed.

Figure 7.12 presents the predicted fate of the relative proportions of the diesel for a release for a release from the east release location for the least worst case shoreline oiling scenario. As Figure 7.12 shows, the majority of the volume of the released diesel is expected to be rapidly lost to the air by evaporation within 2.5 days of release. Biodegradation is also expected to occur at a rapid pace for the first 5 days following the release and significant amounts of diesel are also predicted to be dispersed in the water column within the first 2 days (~300 tonnes). This mass is predicted to reduce significantly over the next 18 days as the remaining diesel gradually biodegrades and evaporates.

Figure 7.12 Fate of Diesel Released (Winter) West 2D Seismic Survey Area Release Location



7.4.1.4 Impact of Diesel Release

Hydrocarbons have the potential to cause detrimental effects on water and sediment quality, marine and coastal flora and fauna, including plankton, benthic invertebrates, fish, seabirds, and marine mammals that may come into contact with an area of a spill and may have an indirect impact on fisheries. The vulnerability of these receptors to hydrocarbon spills is summarised within Table 7.2.

Table 7.2 Vulnerability of Receptors (Marine and Coastal Flora and Fauna and Fisheries) to Hydrocarbon Spills[14,15,16,17]

Receptor	Vulnerability to Hydrocarbons
Plankton	• Abundance of phytoplankton may increase after an hydrocarbon spill due to increased nutrient availability, while zooplankton, fish larvae and eggs may suffer increased mortality due to toxicity in the water column, and therefore can affect the food chain of other fish species. • Although localised mortality is likely, the overall effect on plankton communities is not statistically significant and generally short-term. Following a spill plankton biomass may fall, however, after a few weeks, population often returns to baseline levels as a as a result of high reproductive rates and redistribution of species from outside the affected area.
Benthic Invertebrates	• Effects on the benthos include acute toxicity and organic enrichment. Offshore impacts are typically minimal, and influenced by water depth and local hydrography. Sub-tidal regions generally have lower hydrocarbon concentrations after a spill than inter-tidal regions as often the hydrocarbon is carried and spread at the sea surface. Recovery times are variable, and for light hydrocarbons are generally in the region of a few months to a few years. • Impacts can include rapid mortality of sensitive species such as crustaceans and amphipods; a period of reduced species population and abundance; a period of altered community structure with increased abundance of opportunistic species.
Fish	• Evidence suggests that fish are able to detect and avoid hydrocarbon-contaminated waters. This avoidance may cause disruption to migration or spawning patterns. • Hydrocarbon exposure in fish can lead to mortality or sub-lethal impacts on growth, physiology, behaviour and lowered disease resistance. • Fish populations are more sensitive to hydrocarbon pollution in shallow waters than in deep waters, with hydrocarbon concentrations being typically higher in the upper column. • Fish may ingest large amounts of hydrocarbons through their gills. Fish that have been exposed to hydrocarbons may suffer from changes in heart and respiratory rate, enlarged livers, reduced growth, fin erosion and a variety of effects at biochemical and cellular levels. Hydrocarbons toxicity can also affect reproductive capacity negatively and/or result in deformed fry. • Fish eggs and larvae are more vulnerable to hydrocarbon pollution than adults. In many fish species, these stages float to the surface where contact with spilt hydrocarbons is more likely. However, as most fish species have extensive spawning grounds and produce large numbers of eggs, there is unlikely to be any effect on numbers in the adult populations. Stocks may be at risk from a spill if it is large and coincides with spawning periods. • Longer term impacts of a hydrocarbon spill have shown genetic damage, physical deformities, reduced abundance and growth, and compromised survival of some life stages.
Birds	• The spilled hydrocarbon can penetrate into the plumage of sea birds, reducing its insulating ability, and making them more vulnerable to temperature fluctuations and much less buoyant in the water. This can lead to death from hypothermia or drowning. • In their efforts to clean themselves from hydrocarbon, the birds may inhale or ingest the hydrocarbon. As hydrocarbons are toxic, this may result in serious injuries/health effects such as pneumonia, congested lungs, intestinal or lung haemorrhage, liver and kidney damage. • Hydrocarbons may also affect the reproductive success of the birds as hydrocarbons from feathers of a bird that is laying on eggs may pass through the pores in the eggshells and either kill the embryos or lead to malformations.
Seals	• Seals are very vulnerable to hydrocarbon pollution because they spend much of their time on or near the surface of the water. They need to surface to breathe, and regularly haul out onto beaches. During the course of a hydrocarbon pollution incident, they are at risk both when surfacing and when hauling out. • Seals may be damaged through the ingestion of food contaminated by hydrocarbons or the inhalation of hydrocarbon droplets and vapours. Oil, especially light oils and hydrocarbon vapours, will attack exposed sensitive tissues. These include mucous membranes that surround the eyes and line the oral cavity, respiratory surfaces, anal and urogenital orifices. This can cause corneal abrasions, conjunctivitis and ulcers. Consumption of contaminated prey can lead to the accumulation of hydrocarbons in tissues and organs.
Fisheries	• Fish exposed to hydrocarbons may become tainted, defined as giving the product a petroleum taste or smell. Commercial fish species rarely become tainted in open water, as they are able to avoid the affected area. However, major spills can result in loss of fishing days and exclusion zones and bans on certain species lasting for a whole season may be enforced.

[14] U.S. National Oceanic and Atmospheric Administration (NOAA) Office of Response and Restoration (http://response.restoration.noaa.gov).
[15] Petroleum Industry Environmental Conservation Association (IPIECA), 1997. Guidelines on Biological Impacts of Oil Pollution. Volume 8: Biological Impacts of Oil Pollution: Fisheries. International.
[16] Effects of Oil Pollution on the Marine Environment, 2011. Technical Information Paper 13. International Tanker Owners Pollution Federation Limited (ITOPF)..
[17] The Ireland Department of Communications, Energy and Natural Resources, Petroleum Affairs Division, 2011. Rules and Procedures for Offshore Petroleum Exploration and Appraisal Operations.

Based on the results of the diesel spill modelling presented in Section 7.4.1.3, and the existing environmental and socio-economic conditions described in Chapter 5, an assessment of the potential impacts on key marine and coastal receptors from a release of diesel in the east and west parts of the SWAP 2D Seismic Survey Area has been undertaken and is presented below.

Plankton

For both east and west release locations the total diesel in water concentrations above the 58 ppb threshold are shown to persist for less than 3 days, and in many cases less than 1 day, as the majority of the diesel evaporates or biodegrades. Therefore, the exposure of plankton to toxic levels of hydrocarbons is expected to be localised to the area of the spill and will be short term. In addition, as the SWAP 2D Seismic Survey is being undertaken in winter months this will avoid the potential for a spill during the peak period of plankton production (spring and autumn) and consequently there is unlikely to be a significant impact on plankton communities.

Benthic Invertebrates

As described in Chapter 5 Section 5.5.2.2 it is considered unlikely that the SWAP 2D Seismic Survey Area will support benthic species of local or regional conservation significance or vulnerability. The results of the diesel spill modelling suggest that impacts on benthic communities and sediments are considered to be low due to the majority of the diesel being subject to evaporation, biodegradation and dispersion. However, for both locations modelled, a small percentage of the diesel released will end up bound to seabed sediments. Although diesel in sediments persists longer and evaporates and biodegrades at a slower rate than when diesel remains on the sea surface it is unlikely to remain entrained in sediments for any significant duration of time. Impacts are therefore not considered to be significant. It should be noted that bivalves and crustaceans located in shallower water are particularly vulnerable to contamination from some of the lighter, more aromatic, compounds in hydrocarbons.

Fish

As discussed in Chapter 5 Section 5.5.4.2, the most sensitive period for fish (spawning) occurs during early spring, summer and autumn. While a diesel spill associated with the 2D Seismic Survey is not expected to impact fish during the most sensitive period, there will be a number of fish species present that are permanently resident, overwintering or migrating along the coast from the northern and central Caspian to the southern Caspian that may be affected by a spill of diesel from the survey vessel.

Fish have the ability to detect waters contaminated with hydrocarbons through olfactory (smell) or gustatory (taste) systems and therefore avoid them. They would thertefore have the ability to avoid a spill. However, this may disrupt migration routes for some fish species. In particular, the modelling of the diesel release in the west part of the SWAP 2D Seismic Survey Area shows that the diesel will travel in a southerly direction along the Azerbaijan coastline towards Iran. This has the potential to impact the migration of species of sturgeon and shad and semi-migratory species such kilka and mullet. A spill from the east release location is most likely to impact the migration route of large shoals of shad migrating south past Chilov Island. Juveniles and larvae are more susceptible to oil spills as they lack the ability to move away from the spill.

Section 7.4.1.3 shows that although the area of sea surface covered by diesel following a spill appears to be large, the modelling indicates that, apart from areas close to the release location most areas of the sea will only be affected by a very thin layer (0.04-0.3μm and 0.3-5μm) and the diesel does not persist for longer than 2-3 days on the sea surface. Furthermore, the total diesel in water concentration above the 58 ppb threshold is shown to persist for less than 3 days, and in many area less than 1 day.

As the potential impacts of a diesel spill will be outside the most sensitive period (spawning), the ability of fish to detect and avoid hydrocarbons and the fact that the diesel will not persist in harmful concentrations for more than a few days, no significant impacts to fish are anticipated.

Seals

As described in Table 7.2, Caspian seals could be affected by hydrocarbon spills through coating, inhalation and ingestion of the spilled hydrocarbon if they happen to be within the area of a spill or if the spill affects their haul out sites. Chapter 5 Section 5.5.4.3 describes the Caspian seal winter migration within Azerbaijani waters (from the south Caspian to the North) is understood to start in October and continue until mid-December with peak numbers of migrating seals present in November. As shown in Chapter 5 Figure 5.6, the seals migrate in two directions - most travel along the east coast of the Caspian Sea while the remainder travel north along the west coast following similar routes used during the spring migration south. Seals are observed in the waters of Azerbaijan, particularly in the vicinity of the Absheron Peninsula and the adjacent islands to the east from October to mid-December. On the basis of the seal migration routes which pass through the SWAP 2D Seismic Survey Area, Chapter 5 Figure 5.7 shows the location of the sensitive and very sensitive seal areas defined for the purpose of the SWAP 2D Seismic Survey, where the very sensitive area represents an area activities are not permitted until after the seal autumn migration period has ended and the sensitive area is where specific mitigation has been defined required to minimise impacts of the survey to seals.

The east release location included within the diesel spill modelling is located within the very sensitive seal area which lies in the autumn seal migration route. As a result, if there is an accidental release at this location it is likely that seals will come into contact with the diesel either at sea or potentially at nearby temporary haul out sites. Given seals' high sensitivity to hydrocarbons, the impact of this is considered potentially significant. The modelling confirmed that surface diesel thickness will be greatest nearest the spill location but it will quickly start to disperse and thin out, meaning seals nearest the spill are most likely to suffer being coated in diesel. It should be noted that the spill modelling indicates that the duration of diesel on the sea surface in most areas will not exceed 4 days, the probability of shoreline oiling in areas such as the Absheron Peninsula and the adjacent islands which are known to be used by seals for haul out is low (less than 20%) and exposure to total diesel in water concentrations above the 58 ppb threshold is generally less than 4 days in the sensitive and very sensitive seal areas. As such, the duration of time that seals will be exposed to spilled diesel will be limited.

The west release location modelled included within the diesel spill modelling is not located within in an area identified as sensitive or very sensitive for seals, however the modelling predicts the spill will drift south along the coast of Azerbaijan and may impact on seals migrating north from Iranian sector of the Caspian Sea. Numbers of seals potentially affected by the spill are anticipated to be lower than seal numbers in the vicinity of the Absheron Peninsula and the adjacent islands to the east as generally there will only be small groups of seals migrating through this area. Compared to a release of diesel at the east release location, a release at the west location is predicted to result in a greater area where total diesel in water concentrations are above the 58 ppb threshold for up to 4 days. In some areas the concentration above the threshold is predicted to last up to 7 days. The west release location is also predicted to result in a larger area being affected by surface oiling[18] and shoreline oiling[19] compared to the east release location. Therefore, despite the lower numbers of seals anticipated to be impacted by a spill in the west release location, it is possible that the duration of their exposure to the spilled diesel may be greater compared to a spill in the east release location. However, the potential exposure time is still limited to a few days.

Fisheries

As discussed within in Chapter 5 Sections 5.7.6.1 and 5.7.6.2 there are a number of important commercial fishing grounds (Oily Rocks, Andreev Bank and Makarov Bank) located within or in the vicinity of the SWAP 2D Seismic Survey Area and small scale fishing areas located along the coastline of the Absheron region. It is understood that the high season for commercial fishing is during March to April and September to November whereas the peak fishing period for small-scale fishing occurs between September and May.

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[18] Where surface oil is thicker than 0.04µm in areas with a probability of more than 5%.
[19] Where shoreline oil mass exceeds 0.169 tonnes/km in areas where there is a shoreline oiling probability of greater than 1%.

Table 7.2 describes how hydrocarbon spills have the potential to affect fishery resources in a number of ways. Despite the susceptibility of juvenile stages of fish to relatively low concentrations of hydrocarbons in the water column, adult free swimming fish and wild stocks of commercially important species will tend to swim away after detecting hydrocarbons in the water column and thus it is unlikely that a spill will cause serious mortalities in any wild stocks. Following a spillage, the reproductive success of unaffected fish, as well as the influx of eggs, juveniles and adults from unaffected areas leads the recovery of stock numbers. Given that many marine species produce vast numbers of eggs and larvae that are widely distributed by sea currents means that species can recover from any mortality events as a result of short-term unfavourable conditions. Thus, the depletion of adult stocks is very rarely recorded following spillages as marine organisms can generally adapt to high mortalities though production of large numbers of eggs and replacement from outside the affected area.

Fish can become tainted by hydrocarbon spills and such tainting can affect the marketability of the product. In the event of an hydrocarbon spill, if there are signs of fish oil tainting or contamination, any resultant imposed authority restrictions on fishing activities could result in detrimental impacts upon local fisheries.The spill modelling presented in Section 7.4.1.3 has established that the majority of the diesel will evaporate, disperse or biodegrade within a few days of release and the maximum exposure time of the water column total diesel concentration exceeding the 58 ppb thresold is generally less than two days in most areas.

Based on the spill modelling, there is a low probability (less than 20%) that the diesel may drift to the Makarov Bank fishing ground from an accidental release from the west release location and to Oily Rocks, Andreev and Makarov banks from an accidental release from the east release location. Additionally, there is 10% probability that a release of diesel from the west release location could travel as far as the fishing grounds of Borisov and Karagedova banks in the south of Azerbaijan. Due to the low probability of a diesel spill reaching the fishing grounds and the minimal time that fish stocks in these areas may be exposed to concentrations of diesel in the water column exceeding 58 ppb, the impacts to the commercial fishing industry are considered to be low, with negligible impacts to stocks or fish quality anticipated.

Impacts to small scale fishermen are also anticipated to be low due to the low probability (less than 10%) of diesel concentrations in the water column of 58 ppb being exceeded in the coastal areas where small scale fishing is undertsood to take place. In addition, in the unlikely event that the water column total diesel concentration exceeded the 58 ppb thresold in the coastal areas, the modelling indicates that the maximum exposure time would not exceed 3-4 days for the west release location and 2-3 days for the eastern release location. Therefore, the potential that fish will move away from known fishing areas or to be contaminated or tainted is low and will be short term meaning there is unlikely to be a significant impact to small scale fishing.

Birds and Important Bird and Biodiversity Areas

Chapter 5 Section 5.6 describes that the Caspian region supports a high diversity of bird species, with a large number of endemic species present. As such, the coastal zone of the Caspian Sea has been identified as an area of ornithological importance, supporting both internationally and nationally significant numbers of migrating and overwintering birds, which is reflected in the designation of a number of important bird and biodiversity areas.

Species composition changes sharply during migration periods, leading to the area being highly sensitive during periods of overwintering and migration. A large number of overwintering and migrating birds will be present in the vicinity of the 2D Seismic Survey Area throughout the year. There are, however, some key periods and areas of higher sensitivity. Ducks and coots are overwintering from December to February and the presence of migrating species peaks in March and November. The important bird and biodiversity areas are the key areas for these groups of birds. Limited information is available regarding the offshore distribution and abundance of birds in the Southern Caspian Sea, however there will be a number of birds that plunge dive to feed and species that spend the majority of their time on the sea surface present throughout the year. The SWAP 2D Seismic Survey will be undertaken outside the sensitive bird nesting season, which begins at the end of April/beginning May and continues until mid-July.

As the important bird and biodiversity areas are the key habitats for birds, the potential impacts of an accidental release of diesel focuses on these areas. The potential impact to birds in these areas is described in Table 7.2. Figure 7.13 shows the location of important bird and biodiversity areas along the Azerbaijan coastline and the probability of shoreline oiling at these sites following an accidental release from the east and west release locations, respectively.

Figure 7.13 shows that the modelling indicates there is potential for shoreline oiling following a release of diesel from the west release location in each important bird and biodiversity area between Absheron National Park in the north and Kura Delta in the south, although the oiling is mostly predicted to be concentrated in areas southwest of the release location. However, the probability of this oiling is predicted to be very low (less than 5%) for most areas with the highest probability (30%) is only predicted near the Pirsaat Archipelago.

Figure 7.14 shows that the modelling indicates there is potential for shoreline oiling following the release of diesel from the east release location in the majority of important bird and biodiversity areas between Absheron National Park in the north and Gizilaghaj in the south. The probability of this occurring is, however, predicted to be very low (less than 5%) for almost all areas with the exception of the Absheron National Park (including Shahdili Spit and Pirallahi), where a 10-20% probability of shoreline oiling was predicted.

Although the modelling indicates some of the important bird and biodiversity areas may be exposed to elevated hydrocarbon concentrations as a result of surface or dispersed / dissolved diesel beaching on the shoreline, the extent of and persistence of such pollution is likely to be spatially and temporally limited. However, it should be noted that, once onshore, the diesel biodegrades and evaporates more slowly that when on the sea surface and that stranded diesel can become remobilised by wave action, which can result in isolated and sporadic sheens on the sea surface a number of weeks after the release. Therefore, although the probability of diesel arriving at important bird and biodiversity areas is low, it is considered that the potential impact of a diesel release on the important bird and biodiversity areas (and the birds present there) could have a potentially significant impact due to the spill potentially occurring during the most sensitive time of year for migrating and overwintering birds in the region.

7.4.1.5 Summary of Vessel Marine Diesel Spill Oil Impacts

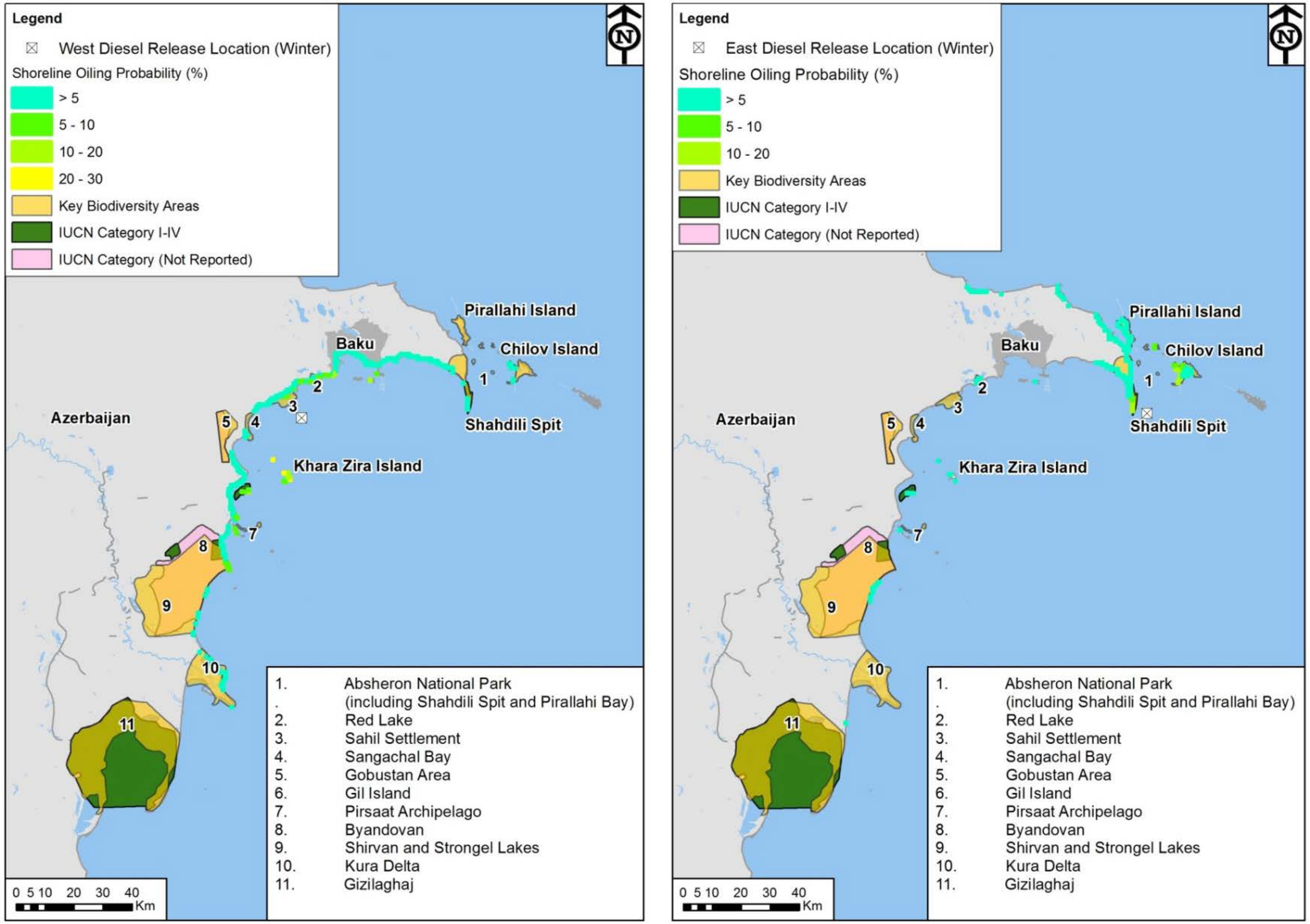
The loss of the entire diesel inventory stored onboard the seismic survey vessel has been modelled and the resulting impacts to marine receptors has been assessed. As Section 7.4.1.3 shows in general the diesel is not anticipated to persist in the environment in harmful concentrations or thickness on the sea surface for more than a few days following the release. Furthermore, the probability of the diesel reaching the shoreline from the release location is predicted to be very low (less than 5%) for most directions with the highest probability being 30%.

The potential impacts of the 900m^3 diesel spill on plankton, benthic invertebrates and fish was considered to be insignificant. However, given that the survey will be undertaken during the peak winter migration period for the Caspian seals (an IUCN Endangered species), and they are likely to be present in the vicinity of the SWAP 2D Seismic Survey Area, it is considered that the impact of the 900m^3 diesel release on seals could potentially be significant, particularly given their high sensitivity to hydrocarbons. The potential exposure time, however, will be limited to a few days only.

While the seismic survey will be undertaken towards the end of the high season for commercial fishing and during the high season for small-scale fishing, it is anticipated the impact on commercial and small-scale fishing would be short-term and not significant. The modelling shows that the probability of spilled diesel arriving at important bird and biodiversity areas following the release of the vessel diesel inventory is low. However, it is considered that the potential impact of a diesel release on important bird and biodiversity areas (and the birds present there) could have a potentially significant impact as the release would occur during the most sensitive time of year for migrating and overwintering birds in the region.

The likelihood of a mechanical failure or vessel collision resulting in the diesel inventory of the vessel fuel tanks being released to sea is considered to be very low. With regard to the seismic vessel the loss of the entire diesel inventory is considered particularly unlikely as diesel is stored on the seismic vessel, which is double skinned, in a series of smaller double-bottomed tanks which are connected by valves and it is improbable that the contents of all the tanks would be lost simultaneously. The technical and operations control measures to minimise the risk of any diesel or hazardous material spill and the response measures to be implemented in the unlikely event a spill occurs are described in Section 7.4.3 below.

Figure 7.13 Probability of Diesel Beaching at Important Bird and Biodiversity Areas West and East 2D Seismic Survey Area Release Locations



7.4.2 Release of Chemicals

A number of chemicals in small quantities will be stored and used onboard the seismic and survey vessels throughout the survey for cleaning and maintenance purposes e.g. cleaning fluids, paints etc. The potential for an accidental release of these chemicals to the marine environment is considered to be small given the measures as set out in Section 7.4.3 below. Any effect of any chemical spill would be highly localised due to volumes of chemicals onboard and no significant impacts are expected.

7.4.3 Spill Prevention and Response Planning

Spill Prevention

The specific technical and operational control measures in place to minimise the potential for spills during the SWAP 2D Seismic Survey include:

- Audits of the seismic survey and support vessels by BP Marine Operations to ensure vessels meet relevant BP standards (e.g. condition of the vessel, competence of crew and examination of the vessel Shipboard Marine Pollution Emergency Plan (SMPEP);
- Establish and ensure compliance with poor weather operational restrictions for vessels in line with BP's existing marine operations and geophysical survey procedures;
- Regular maintenance and inspection of equipment and high risk spill points (in particular bunkering hoses, bunds, storage tank valves etc.);
- Chemical selection procedures to minimise chemical use;
- Strict refuelling procedures to be followed and bunkering operations supervised at all times for both the seismic and support vessels;
- Non-return valves installed on fuel transfer hoses;
- Regular preventative maintenance to prevent leaks by repairing or replacing equipment such as hoses and tanks;
- Staff training in in hazardous materials management, refuelling and waste management roles, as applicable to their roles;
- Implementation of appropriate handling and storage procedures and storage of all hazardous substances within designated areas and in fit for purpose containers (i.e. sealed/hermetic drums) to minimise the risk of leaks and spillage;
- Availability of Materials Safety data Sheets (MSDS) for all chemicals stored on board to facilitate efficient spill response;
- Reporting of all minor spills to detect underlying trends, and task risk assessments; and
- Provision of appropriate spill response and containment equipment at specific locations based on risk assessment. This will allow rapid response should a spill occur.

Response Planning

BP has developed and maintains a range of Oil Spill Response Plans (OSRP) for its offshore operations in Azerbaijan. These plans establish the notification, response and follow-up actions that must be implemented should an accidental spill occur. Under MARPOL regulations the seismic survey and support vessels are required to develop and maintain a SMPEP. This document specifies the control and response measures specific to the vessel, focused on the actions to be taken to stop or minimise the spill and to mitigate the effects. The plan also includes responsibilities and lines of communication with regard to notification and reporting. The seismic contractor and BP will be responsible for ensuring the SMPEP for each vessel is aligned with the relevant AGT Region OSRPs and spill response procedures prior to the survey mobilisation.

Under the AGT spill procedures, spill incidents are categorised according to the level of resource required to mitigate them. BP has adopted the internationally recognised tiered response concept to oil spill response as shown in Table 7.3.

Table 7.3 Oil Spill Response Tiers

Tier 1	Tier 1 spills are defined as small operational spills that can be can be handled immediately by on-site personnel. In most cases, the response would be to clean up using on site resources.
Tier 2	Tier 2 spills are defined as spills that require additional local (in-country) resources and manpower that are not available on the site that the spill occurs. The site response team would carry out cleanup, aided by the dedicated Tier 2 oil spill contractor.
Tier 3	Tier 3 spills are very large, possibly ongoing spills, which will require additional resources from outside the country of spill origin. Such spills are very rare and would only occur through events such as a well blowout or full diameter pipe rupture. All available spill contractors (from within and outside Azerbaijan) would carry out the physical response, with extensive support from the BP Incident Management Team and the Business Support Team.

Reporting

Under the AGT spill reporting procedures, all non-approved releases (liquids, gases or solids) including releases exceeding approved limits or specified conditions during the SWAP 2D Seismic Survey will be internally reported and investigated. Existing external notification requirements agreed with the MENR will be adopted during the SWAP 2D Seismic Survey are:

- For liquid releases to the environment exceeding a volume of 50L, notification will be made to the MENR within 24 hours after the incident verbally and within 72 hours in the written form; and
- If the release to the environment is less than 50L, then information about the release will be included into the BP AGT Region Report on Unplanned Releases and sent to the MENR on a monthly basis.

A Protocol “On Agreeing the Main Principles of Cooperation for Regulation of Unplanned Material Releases” signed between BP and MENR in December 2012 defines an approved release as “a release that is permitted by applicable PSA, MENR permitted and/or approved documents including ESIA, EIA, Technical Note, Technical Letter, individual discharge request letters to MENR or any other written agreement with the MENR”. Unapproved releases are those that do not fall into this definition.

7.4.4 Collision with Caspian Seals

Although highly unlikely to occur, the potential for collision with a vessel or entanglement/entrapment of individual seals in equipment cannot be completely excluded. Collison with a vessel or entanglement/entrapment in equipment has the potential to cause injury or death to seals. The Caspian seal is a highly intelligent animal and will rapidly move away from any disturbance or sound and is likely to keep a distance from the survey vessel, which will operate at slow speed, and associated equipment (i.e. streamers).

The control measures in place to minimise the potential for impacts to Caspian Seals, which includes not intentionally approaching seals, use of trained observers and adoption of a soft start procedure are described in Chapter 6 Section 6.3.1.

8 Environmental and Socio-Economic Management

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8.1 Introduction

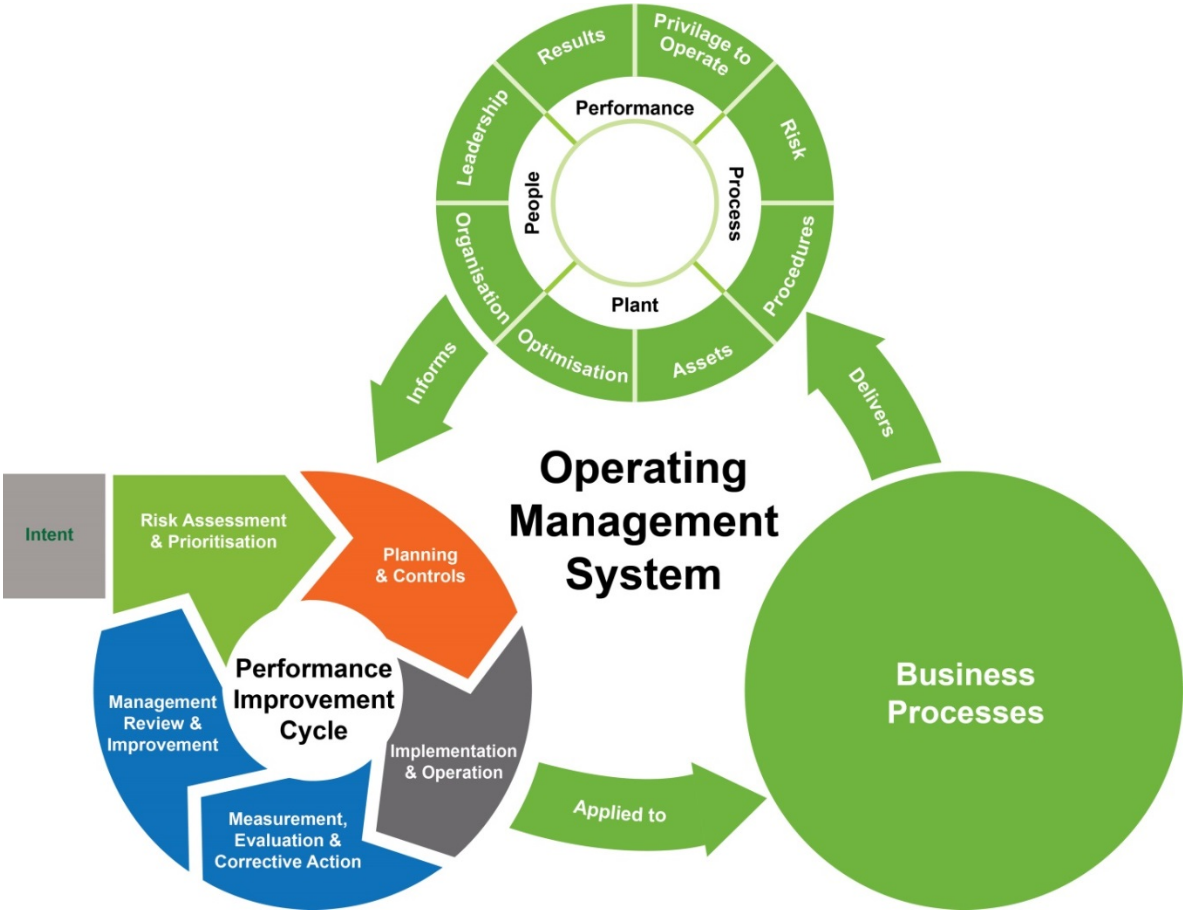
Under the Shallow Water Absheron Peninsula (SWAP) Production Sharing Agreement (PSA), BP as Operator is responsible for the environmental and socio-economic management of the SWAP activities, to ensure that project commitments are implemented, and conforms to applicable environmental and social legal, regulatory and corporate requirements. This Chapter provides an overview of the system that will be used to manage the environmental and socio-economic issues associated with the SWAP 2D Seismic Survey.

8.1.1 Overview of AGT Region Operating Management System

The Azerbaijan Georgia Turkey (AGT) Region manages BP's operations in Azerbaijan and have an established Operating Management System (OMS). The OMS is a structured set of processes designed to keep operations safe, compliant and reliable. This system forms the structured framework to the Health, Safety, Security and Environment (HSSE) performance of the organisation for which there are six key stages as set out in Figure 8.1:

- Intent;
- Risk Assessment & Prioritisation;
- Planning & Controls;
- Implementation & Operation;
- Measurement, Evaluation & Corrective Action; and
- Management Review & Improvement.

Figure 8.1: AGT Region Operating Management System Framework



8.2 SWAP 2D Seismic Survey Roles and Responsibilities

BP will have overall responsibility for managing the SWAP 2D Seismic Survey and for monitoring and auditing of the technical, safety, environmental and socio-economic performance of the SWAP 2D Seismic Survey Contractor.

It is a BP requirement that the SWAP 2D Seismic Survey Contractor used to undertake the SWAP 2D Seismic Survey have their own HSSE Management System and ensure conformance against this system. Where required, additional documentation will be developed to interface between the SWAP 2D Seismic Survey Contractor's HSSE System and BP's processes, practices and procedures.

The SWAP 2D Seismic Survey Contractor will be responsible for performing the 2D Seismic Survey and is expected to conform fully to the relevant aspects of any interface documents developed to ensure BP's processes, practices and procedures requirements are met.

8.3 BP SWAP 2D Seismic Survey Environmental and Socio-Economic Management Plan

The management process described in this Chapter will be used to set out detailed procedures in the Environmental and Social Management Plan (ESMP) which will be developed by the Seismic Contractor and incorporated within a Project Management Plan.

The main topics within the ESMP will comprise:

- Environmental Management;
- Spill Prevention, Response, Notification and Close Out Actions; and
- Waste Management and Minimisation.

The ESMP will identify key criteria (e.g. waste volumes, spills, marine mammal monitoring etc.) that will be used to measure environmental and socio-economic performance.

Inspections will be undertaken to ensure BP procedures and mitigation outlined in this ESIA are implemented. The inspection process will be documented with non-conformance reports (NCRs) and corrective action requests (CARs). Both BP and the SWAP 2D Seismic Survey Contractor will develop and maintain action-tracking systems to monitor the effectiveness of actions taken in response to NCRs and CARs.

BP will track the implementation of corrective actions and will update the SWAP 2D Seismic Survey Project Manager daily on non-conformances that require follow-up actions. The SWAP 2D Seismic Survey Contractor will be responsible for the management of their staff.

8.4 Briefings, Planning and Training

The SWAP 2D Seismic Survey activities will be of relatively short duration, so establishing key environmental and socio-economic requirements at the outset is important to the provision of effective briefings, planning and training. The main briefing, planning and training elements required are:

- Management briefings to ensure that BP's 2D Seismic Survey Management Team and senior personnel from the 2D Seismic Survey Contractor have a common understanding of the roles, responsibilities and applicable standards set out in the SWAP 2D Seismic Survey ESMP;
- Environmental and socio-economic induction training for key SWAP 2D Seismic Survey staff to explain the key requirements (e.g. marine mammal observation training described in Section 8.4.1); and
- Daily planning meetings held by the vessel's Master or deputy to plan forthcoming activities to be attended by a senior staff member from each discipline on board.

8.4.1 Marine Mammal Observation Training

As described in Chapter 4 Section 4.3 vessel crews will be trained to undertake marine mammal observations. Training will be provided to vessel crews by a specialist Contractor appointed by BP prior to the survey commencing. All training material will be reviewed and agreed with BP.

The training will involve presentations and distribution of guidance documents to vessel crews that will include, but will not be limited to:

- Caspian seal identification;
- Observation methods and techniques;
- Communication protocols between trained vessel crew and vessel Master;
- Actions to take in the event of observing a seal during the seismic survey; and
- Recording and reporting requirements.

8.5 Waste Management

Waste generated during the SWAP 2D Seismic Survey will be managed in accordance with MARPOL 73/78 requirements, relevant national legislation and existing BP AGT Region management plans and procedures. All wastes generated as part of the SWAP 2D Seismic Survey will be identified and managed using the management criteria and protocols set out in Section 4.5.2 of this ESIA.

8.5.1 Waste Segregation and Transfer

Waste streams will be segregated at source to permit reuse/recycling and to avoid contact between incompatible materials. The segregation requirements will be clearly indicated by the use of containers with clear signage denoting the waste types that are suitable for the containers provided.

All waste transfers will be accompanied individual carbon copy Waste Transfer Notes (WTNs), confirming the waste type, quantity, waste generator, consignee, consignor (if different from the generator) and in the case of hazardous wastes, Material Safety Data Sheet (MSDS) and Waste Passports, where required. A final visual inspection of all waste consignments will be made prior to transfer note sign-off and uplift. Coloured copies of the waste transfer documentation together with other relevant information e.g. MSDS, Waste Passports, will be retained by the waste generator. All parties involved in transporting wastes will retain a carbon copy of the WTN.

Hazardous Waste Passports are required for the transportation of hazardous wastes from BP operated facilities to non-BP operated Waste Disposal Contractor facilities within Azerbaijan.

Depending upon the nature of the waste and the approved method of recycling/disposal, wastes may be routed via the Central Waste Accumulation Area (CWAA), waste transfer station or similar facility, or alternatively may be routed directly to their final approved destination.

8.6 Summary of SWAP 2D Seismic Survey ESIA Design Controls, Mitigation Measures, Monitoring and Reporting Requirements

The specific design control, mitigation, monitoring and reporting requirements designed to avoid and/or minimise impacts to the environment and socio-economics, and confirm the effectiveness of these measures as detailed within this ESIA are summarised in Table 8.1. The specific actions required to address the requirements; assigned responsibilities and target close out dates will be developed and included within the SWAP 2D Seismic Survey ESMP as described in Section 8.3.

Table 8.1: SWAP 2D Seismic Survey ESIA Design Controls, Mitigation Measures, Monitoring and Reporting Requirements

Topic	Reference	Detailed Requirement Text	Implementation Stage: Pre-Mobilisation (PM) During Survey (DS) Post Survey (PS)
Environmental Management	Chapter 4, Section 4.3 Survey Activities Chapter 6, Section 6.3.1 Underwater Sound from Energy Source	Across the whole 2D Seismic Survey Area the following measures, which are designed to reduce potential impacts on marine mammals, will be adopted for the duration of the Survey:	
		• Vessel crew will be trained to undertake marine mammal observations;	PM
		• Trained vessel crew will conduct ongoing ad-hoc visual observations of Caspian seal (*Phoca Caspica*) in the vicinity of the survey vessel. All observations will be logged including location of sighting and number of individuals seen; • Survey vessels will not intentionally approach seals for the purposes of casual marine mammal viewing; • Airguns will not be operational during line changes; • A soft start procedure will be used at the start of each survey line; • Prior to the seismic source being activated using the soft-start procedure, marine mammal monitoring will be conducted by the trained vessel crew for a 30 minute period to observe whether there are any Caspian seals within 500m of the sound source (buffer zone). If Caspian seals are sighted, the soft-start procedure will be delayed for at least 20 minutes following which the trained crew will confirm no Caspian seals are within the buffer zone and the soft start procedure can start. The soft start procedure cannot start until no Caspian seals are observed within the buffer zone for a 20 minute period. •	DS
	Chapter 4, Section 4.3 Survey Activities	The following additional control measures will be implemented with respect to sensitive and very sensitive areas of the 2D Seismic Survey Area. These areas are defined within Chapter 5, Section 5.5.4.3:	

Topic	Reference	Detailed Requirement Text	Implementation Stage: Pre-Mobilisation (PM) During Survey (DS) Post Survey (PS)
	Chapter 6, Section 6.3.1 Underwater Sound from Energy Source	Prior to mid-December 2D Seismic Survey activities will not be conducted in a very sensitive area; • The 2D Seismic Survey will be planned to avoid entering a sensitive area prior to mid-December as far as possible. If it does become necessary to enter a sensitive area prior to mid-December the following additional controls will be implemented: ▪ Prior to the seismic source being activated using a soft-start procedure, marine mammal monitoring will be conducted by the trained vessel crew for a 50 minute period to observe whether there are any Caspian seals within the buffer zone. If Caspian seals are sighted, the soft-start procedure will be delayed for at least 30 minutes following which the trained crew will confirm no Caspian seals are within the buffer zone and the soft start procedure can resume. The soft start procedure cannot resume until no Caspian seals are observed within the buffer zone. ; and ▪ When operations occur in hours of darkness, exterior vessel lighting will be limited to that necessary for ensuring safe operations.	DS
	Chapter 6, Section 6.3.1 Underwater Sound from Energy Source	Table 6.4 shows that the distance at which a permanent auditory shift (PTS) could be induced in Caspian seals due to the operation of the source array is 379m. For operational purposes, the radius of the mitigation buffer zone that will be established around the sound source will be at least 500m from the source.	DS
	Chapter 4, Section 4.5.1 Emissions to Atmosphere	All shipboard emissions will be in compliance with MARPOL 73/78 Regulations for the prevention of air pollution from ships (Annex VI), aiming to reduce global emissions of SO_x, NO_x and particulate matter.	DS

Topic	Reference	Detailed Requirement Text	**Implementation Stage:** Pre-Mobilisation (PM) During Survey (DS) Post Survey (PS)
	Chapter 4, Section 4.5.3 Discharges to Sea	Aqueous discharges from the vessels will comply with the standards set out by[1]: • National authorities (i.e. the MENR) within the Framework Convention for the Protection of the Marine Environment of the Caspian Sea; and • The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78 *(as amended)),* more specifically Annexes I and IV.	DS
	Chapter 4, Section 4.5.3 Discharges to Sea	Grey water and black water will be discharged to sea in accordance with MARPOL 73/78 Annex IV: Prevention of Pollution by Sewage from Ships standards and the SWAP Production Sharing Agreement (PSA) requirements i.e. no floating solids will be observed on water surface. If treatment is not possible (e.g. due to unavailability of the treatment unit) sewage will be stored and shipped to shore for treatment and disposal.	DS
	Chapter 4, Section 4.5.3 Discharges to Sea/ Chapter 6.2 Scoping	In accordance with the PSA, deck drainage and wash water will be discharged as long as no visible sheen is observable. Oily and clean drainage or wash water will be segregated; clean water will be discharged to sea and oily water transported to an appropriate onshore disposal facility.	DS
	Chapter 6, Section 6.2 Scoping	Vessels will be well maintained and use good quality, and low sulphur fuel (typically <0.05% weight).	DS
	Chapter 6, Section 6.2 Scoping	The volume of fuel used by the vessels over the duration of the survey will be recorded and reported to the MENR at the end of the survey for each vessel.	DS
	Chapter 6, Section 6.2 Scoping	Under routine conditions grey water and treated black water will be discharged to sea in accordance with MARPOL 73/78 Annex IV: Prevention of Pollution by Sewage from Ships standards and the SWAP Production Sharing Agreement (PSA) requirement i.e. no floating solids will be observed on water surface. If treatment is not possible (e.g. due to unavailability of the treatment unit) sewage will be stored and shipped to shore for treatment and disposal.	DS
	Chapter 6, Section 6.2 Scoping	There will be no discharge of food waste or garbage. Food waste and combustible garbage will be incinerated on the vessel using MARPOL compliant onboard incineration facilities. Non- combustible garbage and incinerator ashes will be contained and shipped to shore for disposal in accordance with AGT waste management plans and procedures.	DS
	Chapter 6, Section 6.2 Scoping	Daily visual checks will be undertaken when discharging grey water and treated black water to confirm no floating solids are observable.	DS

[1] The SWAP PSA states that black and grey water may be discharged into the sea from a certified bio-treatment unit following treatment in accordance with the requirements of the EU Council Directive 91/271/EEC. This directive relates to urban waste water treatment and is not considered applicable to vessels. MARPOL 73/78 Annex IV standards are considered international best practice with regard to vessel discharges and have been adopted for vessel discharges across the Azerbaijan sector of the Caspian Sea.

Topic	Reference	Detailed Requirement Text	Implementation Stage: Pre-Mobilisation (PM) During Survey (DS) Post Survey (PS)
	Chapter 6, Section 6.3.1 Underwater Sound from Energy Source	The following monitoring and reporting related to impacts to seals from underwater sound from the sound source will be undertaken: • In addition to the monitoring and recording Caspian seals as part of the soft start procedure, the trained vessel crew will endeavour to record Caspian seal sightings at other times as far as practically possible; • Daily logs of Caspian Seal sightings will be completed by the trained vessel crew using the relevant JNCC marine mammal forms[2]; and • A final report summarising the Caspian seal observations over the duration of the survey and including all the daily log forms will be completed by the trained vessel crew and submitted to BP within eight weeks of completion of the survey.	DS
	Chapter 6, Section 6.4.1 Physical Survey Presence	The following monitoring and reporting related to small scale fishing from the physical presence of the survey vessel and seismic equipment will be undertaken: • Any existing equipment which is removed or damaged as a result of the survey, which the vessel crew cannot confirm is associated with small scale fishing will be logged by the vessel crew. The log will include a description of the equipment, the date it was removed or damaged and the location encountered. The log along with the equipment (where it has been removed) should be submitted to BP on completion of the survey. • BP will be responsible for receiving, resolving and documenting any grievances raised by affected parties associated with the 2D Seismic Survey activities. The Seismic Contractor will be responsible for assisting in resolving grievances where requested including providing operational logs and records completed during the survey where relevant.	DS
Communication	Chapter 4.3 Survey Activities	The Survey will be planned to minimise interference with other sea users. Relevant maritime authorities and other sea users will be notified of the survey prior to commencement in accordance with BP's existing marine operations and geophysical survey pre-mobilisation procedures. Clear lines of communication and operational procedures will also be established between the survey vessel and support vessels before the start of surveying.	PM
	Chapter 4.3 Survey Activities	Throughout the survey, other vessels will be notified by appropriate signals in accordance with International Maritime Law; these will include communications via radio, including regular security broadcasts, lights and flags. Support vessels will be used to notify other vessels that are not contactable or are unaware of the International Maritime signal system	DS

[2] Joint Nature Conservation Committee (JNCC), 2010. JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys, Aberdeen.

Topic	Reference	Detailed Requirement Text	Implementation Stage: Pre-Mobilisation (PM) During Survey (DS) Post Survey (PS)
Spill Prevention, Response, Notification and Close Out Actions	Chapter 7, Section 7.4.3 Spill Prevention and Response Planning	The specific technical and operational control measures in place to minimise the potential for spills during the SWAP 2D Seismic Survey include:	
		• Audits of the seismic survey and support vessels by BP Marine Operations to ensure vessels meet relevant BP standards (e.g. condition of the vessel, competence of crew and examination of the vessel Shipboard Marine Pollution Emergency Plan (SMPEP); • Establish and ensure compliance with poor weather operational restrictions for vessels in line with BP's existing marine operations and geophysical survey procedures;	PM
		• Regular maintenance and inspection of equipment and high risk spill points (in particular bunkering hoses, bunds, storage tank valves etc.);	DS
		• Chemical selection procedures to minimise chemical use;	PM
		• Strict refuelling procedures to be followed and bunkering operations supervised at all times for both the seismic and support vessels;	DS
		• Non-return valves installed on fuel transfer hoses;	PM
		• Regular preventative maintenance to prevent leaks by repairing or replacing equipment such as hoses and tanks;	DS
		• Staff training in in hazardous materials management, refuelling and waste management roles, as applicable to their roles;	PM
		• Implementation of appropriate handling and storage procedures and storage of all hazardous substances within designated areas and in fit for purpose containers (i.e. sealed/hermetic drums) to minimise the risk of leaks and spillage; • Availability of Materials Safety data Sheets (MSDS) for all chemicals stored on board to facilitate efficient spill response; • Reporting of all minor spills to detect underlying trends, and task risk assessments; and • Provision of appropriate spill response and containment equipment at specific locations based on risk assessment. This will allow rapid response should a spill occur.	DS

Topic	Reference	Detailed Requirement Text	Implementation Stage: Pre-Mobilisation (PM) During Survey (DS) Post Survey (PS)
	Chapter 7, Section 7.4.3 Spill Prevention and Response Planning	The seismic contractor and BP will be responsible for ensuring the SMPEP for each vessel is aligned with the relevant AGT Region OSRPs and spill response procedures prior to the survey mobilisation.	PM
	Chapter 7, Section 7.4.3 Spill Prevention and Response Planning	Under the AGT spill reporting procedures, all non-approved releases (liquids, gases or solids) including releases exceeding approved limits or specified conditions during the SWAP 2D Seismic Survey will be internally reported and investigated. Existing external notification requirements agreed with the MENR will be adopted during the SWAP 2D Seismic Survey are: • For liquid releases to the environment exceeding a volume of 50L, notification will be made to the MENR within 24 hours after the incident verbally and within 72 hours in the written form; and • If the release to the environment is less than 50L, then information about the release will be included into the BP AGT Region Report on Unplanned Releases and sent to the MENR on a monthly basis	DS
Waste Management and Minimisation	Chapter 4, Section 4.5.2 Hazardous and Non Hazardous Waste Streams	Strict handling procedures will be in place for all of hazardous materials on board the survey and support vessels and the vessel crews will be trained in chemical handling and spill response.	PM
	Chapter 4, Section 4.5.2 Hazardous and Non Hazardous Waste Streams	In addition to the compliance with the MARPOL 73/78 requirements, BP's AGT Region Waste Manual will be adhered too, to ensure that all wastes will also be managed in compliance with BP's standards.	DS

Topic	Reference	Detailed Requirement Text	Implementation Stage: Pre-Mobilisation (PM) During Survey (DS) Post Survey (PS)
	Chapter 4, Section 4.5.2 Hazardous and Non Hazardous Waste Streams/ Chapter 6.2 Scoping	The following waste management criteria and protocols will be implemented throughout the 2D Seismic Survey: • In accordance with MARPOL 73/78 requirements, survey and support vessels will maintain an Oil Record Book. The book will be used to record how, when and where waste oil, bilge water, oily material, sludge etc., are disposed of. Recognised waste disposal authorities or contractors will undertake disposal of any waste generated onboard. Disposal details will be recorded in the vessel's Oil Record Book; • Survey vessel and support vessels will maintain a Garbage Management Plan and Garbage Record Book to record how waste items, other than mentioned above, are managed and disposed of. The Garbage Management Plan will classify waste types according to MARPOL specification and BP's AGT Region Waste Manual and lists item type , quantity stored on-board, waste delivered ashore, and how much waste has been generated (e.g. food waste, incinerator ash); and • All wastes will be will be shipped to shore for disposal in accordance with the existing AGT waste management plans and procedures.	DS
	Chapter 8, Section 8.5 Waste Management	Waste generated during the SWAP 2D Seismic Survey will be managed in accordance with MARPOL 73/78 requirements, relevant national legislation, the SWAP 2D Seismic Survey ESMP and existing BP AGT Region management plans and procedures.	DS
	Chapter 8, Section 8.5 Waste Management	All wastes generated as part of the SWAP 2D Seismic Survey will be identified and managed using the management criteria and protocols set out in Section 4.5.2 of this ESIA.	DS
	Chapter 8, Section 8.5.1 Waste Segregation and Transfer	Waste streams will be segregated at source to permit reuse/recycling and to avoid contact between incompatible materials.	DS
	Chapter 8, Section 8.5.1 Waste Segregation and Transfer	The segregation requirements will be clearly indicated by the use of containers with clear signage denoting the waste types that are suitable for the containers provided.	DS
	Chapter 8, Section 8.5.1 Waste Segregation and Transfer	All waste transfers will be accompanied individual carbon copy Waste Transfer Notes (WTNs), confirming the waste type, quantity, waste generator, consignee, consignor (if different from the generator) and in the case of hazardous wastes, Material Safety Data Sheet (MSDS) and Waste Passports, if required.	DS

Topic	Reference	Detailed Requirement Text	Implementation Stage: Pre-Mobilisation (PM) During Survey (DS) Post Survey (PS)
	Chapter 8, Section 8.5.1 Waste Segregation and Transfer	A final visual inspection of all waste consignments will be made prior to transfer note sign-off and uplift.	DS
	Chapter 8, Section 8.5.1 Waste Segregation and Transfer	Coloured copies of the waste transfer documentation together with other relevant information e.g. MSDS, Waste Passports, will be retained by the waste generator. All parties involved in transporting wastes will retain a carbon copy of the Waste Transfer Note.	DS

9 Residual Impacts and Conclusion

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9.1 Introduction

This Chapter of the Environmental and Socio-Economic Impact Assessment (ESIA) summarises the residual impacts and conclusions of the SWAP 2D Seismic Survey ESIA.

9.2 Environmental and Socio-Economic Impacts

Environmental and socio-economic impacts have been assessed for the 2D Seismic Survey activities. The assessments within the ESIA show that impacts are minimised as far as practicable and necessary through the implementation of the existing control measures and no additional mitigation is required.

Tables 9.1 and 9.2 summarises the residual environmental and socio economic impacts associated with the routine and non routine SWAP 2D Seismic Survey activities.

Table 9.1: Summary of SWAP 2D Seismic Survey Environmental Impacts

Event	Event Magnitude	Receptor Sensitivity	Impact Significance
Underwater sound from energy source	Medium	Medium (Fish)	**Moderate Negative**
		Medium (Seals)	

Table 9.2: Summary of SWAP 2D Seismic Survey Socio-Economic Impacts

Event	Event Magnitude	Receptor Sensitivity	Impact Significance
Presence of the survey vessel and seismic equipment	Low	High (International Shipping)	**Moderate Negative**
		Medium (Local/Regional Shipping)	**Minor Negative**
		Medium (Commercial Fishing)	**Minor Negative**
		High (Small Scale Fishing)	**Moderate Negative**
Indirect Effect of Underwater Sound on Fishing	Low	Medium (Commercial Fishing)	**Minor Negative**
		High (Small Scale Fishing)	**Moderate Negative**

Environmental Residual Impacts

Underwater sound emissions will occur repeatedly but intermittently during the 2D Seismic Survey, and the sound energy will dissipate with distance from the source. The sound source will be moving during the survey; therefore a given sound level will last for a very short period of time in any one location, with the resulting potential impact lasting probably in the order of one or a few hours.

Plankton and benthic invertebrates are generally considered to be unaffected by underwater sound resulting from the discharge of the sound source. Underwater sound has, however, the potential to impact fish and Caspian seals (*Phoca Caspica*) in the marine environment. As a result, a number of control measures have been designed and will be adopted for the duration of the 2D Seismic Survey to reduce potential impacts on marine mammals. These measures are discussed in the following sections.

Fish

Endangered fish species and hearing specialist fish are likely to be present for limited periods of time in the 2D Seismic Survey Area. A number of endangered sturgeon species are known to migrate through the 2D Seismic Survey Area during November, when the survey is proposed to commence; however, these fish are not common and are more likely to be found away from the coast in deeper water (approximately 75 to 100m water depth) during November and December. Kilka and shad are considered to be highly sensitive to underwater sound and are known to migrate through the 2D Seismic Survey Area, however, they are expected be present for a short time, probably only hours.

Fish species at the sensitive spawning stage, are not likely to be present within the 2D Seismic Survey Area in significant numbers during November and December.

Based on the results of the underwater sound modelling study, the onset of permanent or recoverable injury in all fish species is predicted to occur at 79m from the energy source. Control measures will be implemented to reduce any potential impacts and includes adoption of a soft-start procedure at the start of each survey line is designed to ramp up sound gradually over a period of time; and local sound levels will increase and decrease slowly as the vessel is moving. As such, it is expected that fish will move away from the sound source before sound levels become injurious. These behavioural responses are highly unlikely to result in detectable population size changes because sensitive life stages (e.g. spawning) are not present; and changes in swimming direction are a natural behaviour during migration periods as fish respond to prey and predator abundance and changes in underwater topography.

Seals

The Caspian Seal population is highly vulnerable, having declined by more than 90% since the start of the century, with the population continuing to decline. Hence, the endemic Caspian seal has an internationally protected status. Caspian seals are observed in many regions of the Caspian Sea depending on the season as they undertake annual migrations between breeding locations in the north and feeding locations in the south.

Northbound autumn migration starts in October and seals are observed in the waters of Azerbaijan, particularly in the vicinity of the Absheron Peninsula and the adjacent islands to the east from October to mid-December, with peak numbers generally observed in November. Migrating seals are likely to be present in the 2D Seismic Survey Area at the time of the survey for a short time only. It is also understood that a small number of seals have been observed in the area throughout the year.

Underwater sound modelling predicts that the distance at which a permanent auditory shift (PTS) could be induced in Caspian seals due to the operation of the source array is 379m. For operational purposes, the radius of the mitigation buffer zone that will be established around the sound source will be at least 500m from the source. Trained observers on the survey vessel will undertake observations for seals within this buffer zone prior to commencing the planned soft start procedure.

The Caspian seal will rapidly move away from any disturbance or sound. Current information available on seal migration and routes has been used to identify the most sensitive areas for seals within and adjacent to the 2D Seismic Survey Area (Chapter 5, Section 5.5.4.3). Existing controls include undertaking marine mammal observations within the buffer zone, implementing a soft-start procedure at the beginning of each survey line, and planning to avoid entering sensitive areas prior to mid-December (as set out in Chapter 6, Section 6.3.1.1). These controls are designed to minimise the chance that individual seals could be injured by providing the opportunity for them to move away and avoid the sound before it reaches injurious levels. The existing controls will be adopted across the 2D Seismic Survey Area where seals are expected to be present in small numbers throughout the year, with additional measures to be adopted within the sensitive and very sensitive areas of the 2D Seismic Survey Area where survey activities may be undertaken during the autumn migration. The operation of the sound source, even under the soft start procedure, will result in a change in the behaviour of seals present but this is expected to be limited to a change in swimming direction and will be short-term. No significant population effects are anticipated and ecological functionality will be maintained.

Monitoring and recording of Caspian seals will be undertaken by the trained vessel crew as part of the soft start procedure and at other times as far as practically possible; and daily log forms will be submitted to BP as part of a final report summarising seal observations. In addition, it is recommended that BP consult with marine ecologists, both national and international, to design and set up a fit for purpose Annual Seal Survey Programme.

Socio-Economic Residual Impacts

Control measures (embedded into the project design) to minimise potential impacts to international, regional and local shipping and commercial and small scale fishing from the physical presence of the 2D Seismic Survey, include planning the survey to minimise interference with other sea users; notifying maritime authorities and other sea users of the survey prior to commencement; and during the survey, notifying other vessels of the survey by appropriate signals in accordance with International Maritime Law and through the use of support vessels. In addition, a hazard survey will be undertaken (planned for Q3 2015) prior to commencing the 2D Seismic Survey to confirm the location of seabed hazards (including any fixed fishing assets) to allow the survey team to plan to avoid these hazards. Consultation is planned to be undertaken during Q3 and Q4 2015 to identify those engaged in small scale fishing activities within the 2D Seismic Survey Area.

Shipping

The path of the survey vessel will travel along, across, as well as move perpendicularly to existing, identified shipping routes used by international, regional and local shipping. International shipping has limited ability to adapt to change due to restricted movement and is therefore considered to be highly sensitive; whereas local and regional shipping has some capacity to adapt to change. Given that the survey vessel and streamer will be continuously moving; and that the survey activities will be communicated to all shipping and vessels prior to commencement and during the survey; it is anticipated that the effect of the survey on shipping would be slight and temporary. It is considered unlikely that survey activities would result in concerns being raised by stakeholders or governmental bodies.

Fishing

The commercial fishing industry is known to be under pressure. There is only one commercial fishing ground within the 2D Survey Area; the Makarov Bank, which is a kilka fishing area. It is estimated that the survey vessel will pass within 5km of Makarov Bank for a short duration (total of between 5 and 6 hours) during the high fishing season. There are five Azerbaijani fishing vessel licenced to fish for kilka; of which only one of these vessels fishes in the vicinity of the Makarov Bank.

Small scale fishing is understood to be undertaken within waters approximately 5.5km from the coastline. The location of fixed equipment is not currently understood. There is potential for the survey activities to interact with small scale fishing activities (particularly offshore from Shikhov, Bayil, Turkan and Zira) for a short duration during the high fishing season. As the fishermen are reliant on the activity for their household income and predominantly used fixed nets, they are highly vulnerable to change. It is not planned to remove fixed fishing equipment, which it is expected will be identified during the planned hazard survey and the survey team will plan to avoid. Monitoring and reporting related to small scale fishing from the physical presence of the survey vessel and seismic equipment will be undertaken. In the unlikely event of damage to small scale fishing assets, any grievances raised by the affected fishermen will be managed through the existing Azerbaijan Georgia Turkey (AGT) Region Grievance Process.

Indirect Effect of Underwater Sound on Fisheries

While the 2D Seismic Survey will be undertaken adjacent to the Makarov Bank commercial fishing ground during high season, survey activities will be present for a short period (5-6 hours). Survey presence within the area potentially used by small scale fishermen is also expected to be of short duration. Fish within these areas will move away from seismic source as it passes but will return quickly after the underwater sound levels are below injury and temporary effect thresholds.

Commercial fishing vessels have some capacity to adapt to temporary reductions on fish catch due to fish behaviour reactions to noise. Considering that fishing activities in the Caspian Sea are currently under pressure, that survey activities will be undertaken in high fishing season and are expected to affect a preferred local fishing ground albeit for a temporary duration, commercial fishing is considered to be of medium sensitivity.

Small-scale fishermen are vulnerable in that they have little capacity and means to adapt to change. Since that are likely to have a high level of reliance on fishing income to support their livelihoods and maintain food security, small scale fishermen are considered highly sensitive.

It is anticipated that the indirect effect of the survey on commercial and small scale fishing would be slight and temporary. It is considered unlikely that survey activities would result in concerns being raised by stakeholders or governmental bodies.

9.3 Cumulative, Transboundary and Accidental Events

Cumulative impacts, potential transboundary impacts and the impacts of accidental events associated with the SWAP 2D Seismic Survey have been assessed.

The potential for cumulative impacts arising from interactions between separate project-related residual impacts is considered to be insignificant.

The potential for cumulative impacts with other projects is limited to potential interactions with impacts arising from SD2 Project activities, where drilling, construction and offshore installation activities are known to be ongoing.

SD2 Project activities associated with the northern flank well cluster are predicted to result in minor and localised impacts to the seabed (e.g. associated with the discharge of water based mud and cuttings to the seabed). Given that approximately 10km separates the northern flank location and the SWAP 2D Seismic Survey Area, no cumulative impacts are expected to arise between SWAP 2D Seismic Survey activities and the SD2 activities in this location. The SD2 Project pipeline corridor route crosses the SWAP 2D Seismic Survey Area in three locations, and there is potential that pipelay activities may take place at the same time as the SWAP 2D Seismic Survey activities. Given the design controls to be employed for both projects and through planning to avoid undertaking seismic survey activities in close vicinity to the SD2 Project pipelay works, the potential for cumulative impacts is considered negligible.

The non-greenhouse gas (GHG), nitrogen dioxide ($NO_{2)}$, is considered the most significant pollutant in terms of health impacts. The impact of NO_2 emissions to the atmosphere from SWAP 2D Seismic Survey activities have limited potential to result in discernible impacts to the nearest onshore locations where people are resident. There will be no discernible transboundary environmental impacts from non-GHG atmospheric emissions.

It is estimated that 9 ktonnes of GHG emissions will be released to the atmosphere as a result of the SWAP 2D Seismic Survey, which represents approximately 0.22% of the annual operational GHG emissions from BP's upstream activities in Azerbaijan in 2014. Total GHG emissions for Azerbaijan in 2015 were forecast to be approximately 49,000 ktonnes, of which the SWAP 2D Seismic Survey is expected to contribute approximately 0.0184% of the national total.

Accidental Events are considered separately from routine and non-routine activities as they only arise as a result of a technical failure, human error or as a result of natural phenomena such as a seismic event. The accidental event scenarios assessed include:

- Spill of marine diesel from the 2D survey and support vessels;
- Release of chemicals from the 2D survey and support vessels; and
- Collision between survey vessel and/or equipment and Caspian Seals.

As a worst case, the loss of the entire diesel inventory stored onboard the survey vessel has been modelled. The diesel is not anticipated to be present in harmful concentrations or thickness on the sea surface for more than a few days following the release. Generally, there is a very low (less than 5%) probability of diesel reaching the shoreline, with the highest probability being 30%.

The potential impacts of the 900m^3 diesel spill on plankton, benthic invertebrates and fish was considered to be insignificant. However, the impact of the 900m^3 diesel release on seals would be limited to an exposure time of a few days, and could potentially be significant, since seals are highly sensitive to hydrocarbons. The impact on commercial and small-scale fishing would be short-term and not significant. The probability of spilled diesel arriving at important bird and biodiversity areas following the release of the vessel diesel inventory is low. However, the potential impact of a diesel release on important bird and biodiversity areas (and the birds present there) could have a potentially significant impact due to the seasonal sensitives of migrating and overwintering birds in the region.

There is a very low likelihood of a mechanical failure or vessel collision resulting in the diesel inventory release to the sea. The loss of the entire diesel inventory from the survey vessel is considered particularly unlikely as diesel is stored on the survey vessel in a series of smaller tanks which are connected by valves and it is improbable that the contents of all the tanks would be lost simultaneously.

Technical and operational control measures will be in place to minimise the potential for spills during the SWAP 2D Seismic Survey. In the event of a spill to the sea, existing plans and procedures will be followed which cover the actions to be taken in the event of a spill, including notification, response actions, follow-up actions and reporting.

The potential for an accidental release of cleaning and maintenance chemicals from the survey and support vessels to the marine environment is considered to be small given the adopted control measures. No significant impacts are expected from a chemical spill which would be highly localised.

Although highly unlikely to occur, collision with a vessel or entanglement/entrapment in equipment has the potential to cause injury or death to Caspian seals. The Caspian seal will rapidly move away from any disturbance or sound and is likely to keep a distance from the survey vessel, which will operate at slow speed, and associated equipment (i.e. streamers). There will be control measures in place to minimise potential for impacts to Caspian seals, which includes not intentionally approaching seals, use of trained observers and adoption of a soft start procedure.

9.4 Environmental and Social Management

Under the SWAP PSA, BP as Operator is responsible for the environmental and socio-economic management of the SWAP activities, to ensure that project commitments are implemented, and conforms to applicable environmental and social legal, regulatory and corporate requirements.

The AGT Region manages BP's operations in Azerbaijan and have an established Operating Management System (OMS). The OMS is a structured set of processes designed to keep operations safe, compliant and reliable.

BP will have overall responsibility for managing the SWAP 2D Seismic Survey and for monitoring and auditing of the technical, safety, environmental and socio-economic performance of the SWAP 2D Seismic Survey Contractor. An Environmental and Social Management Plan will be developed by the Seismic Contractor and incorporated within a Project Management Plan.

The SWAP 2D Seismic Survey Contractor will be responsible for performing the 2D Seismic Survey and will ensure conformance with their Health Safety Security and Environment Management System, as well as any interface documents developed to ensure BP processes, practices and procedure requirements are met.

9.5 Conclusions

Given that underwater sound, resulting from the discharging of seismic sources, has the potential to impact biological/ecological receptors (specifically seals and fish) in the marine environment, a number of control measures have been included in the project design. It is considered that potential impacts are minimised are far as practicable and necessary through the implementation of the existing control measures and no additional mitigation measures are required. In addition, it is recommended that BP consult with marine ecologists, both national and international, to design and set up a fit for purpose Annual Seal survey programme.

The potential for cumulative impacts arising from interactions between separate project-related residual impacts is considered to be insignificant; and the potential for cumulative impacts with impacts arising from SD2 Project activities is considered negligible.

There will be no discernible transboundary environmental impacts from non-GHG atmospheric emissions. For GHG emissions the SWAP 2D Seismic Survey is expected to contribute approximately 0.0184% of the national total forecast for 2015.

Technical and operational control measures will be in place to minimise the potential for accidental events occurring during the 2D Seismic Survey.

The SWAP 2D Seismic Survey Contractor will be responsible for preparing an Environmental and Social Management Plan which aligns with BPs expectations; and for undertaking the 2D Seismic Survey in accordance with the Plan. BP will have overall responsibility for managing the SWAP 2D Seismic Survey; for monitoring and auditing the performance of the Contractor; and for ensuring that project commitments are implemented.

APPENDIX 5A

Waste Categories

Waste Category (MARPOL)	Main Constituents	Waste Category (AGT)	Handling and Disposal Route
Non Hazardous Waste			
Garbage (non-combustible)	Plastic, glass, domestic waste, cooking oil and incinerator ash	• Domestic/office wastes • Plastics - recyclable (HDPE) • Oils - cooking oil • Incinerator ash	Segregated and compacted waste is stored onboard for disposal at suitable facilities onshore.
Garbage (combustible)	Non-recyclable paper, packaging, wood and food waste	• Incinerator ash (following incineration)	Incinerated using MARPOL compliant onboard incineration facilities (most garbage is amenable to incineration with the exception of metal and glass; special rules on incineration may apply under domestic law in some ports; the incineration of plastic is subject to specific regulations). The resulting ash will be transferred to shore for disposal at licensed facilities.
Bilge water	Residual hydrocarbons and inorganic substances	• Water - oily	Stored on board and transferred onshore for treatment and disposal at licensed waste facilities.
Sludge	Residual hydrocarbons and organic and inorganic substances	• Sewage sludge • Tank bottom sludge (if not incinerated)	Either incinerated onboard using an International Marine Organisation (IMO) approved incinerator or stored onboard and transferred onshore for treatment and disposal at licensed waste facilities.
Hazardous Waste			
Clinical waste	Pathogenic organisms, plastic, glass, medicines and needles	• Clinical waste	Segregated and stored separately for disposal/ incineration at authorised onshore medical facilities.
Acids	Acids refer to substances and mixtures with a pH less than 7	• Acids	Segregated and stored separately to be transferred to shore for safe disposal at licensed hazardous waste management facilities. All hazardous waste streams will be managed in compliance with the requirements of BP's AGT Regional Waste Manual.
Solvents, degreasers and thinners	Organic solvents used as industrial cleaning solutions (degreasers) and paint thinner	• Solvents, degreasers and thinners	
Paints and coatings	Water-based liquid paints and oil/solvent based liquid epoxy resin paints, lacquers and varnishes.	• Paints and coatings	
Contaminated materials	Various materials that are lightly contaminated with oils, chemicals, etc.	• Contaminated materials	
Adhesives, resins and sealants	Solvent based adhesives	• Adhesives, resins and sealants	
Waste oil /fuel	Used refined petroleum distillates incl. engine lubrication oil, motor oil, transmission oil and hydraulic fluid. Diesel from generators etc. that cannot be reused	• Oils – fuel	
Batteries	General purpose batteries	• Batteries - dry cell • Batteries - wet cell	

APPENDIX 6A

SWAP 2D Seismic Survey Underwater Sound Study

SWAP 2D Seismic Survey - Underwater Sound Study

P D Ward

PDW/2015-03-0002-V3

11 September 2015

Administration Page

Customer Information	
Customer reference number	N/A
Project title	SWAP 2D Seismic Survey - Underwater Sound Study
Customer Organisation	AECOM St Georges House, 5 St Georges Road, Wimbledon, London, SW19 4DR
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Contract number	PDW/2015-03-0002-V2
Date due	20 August 2015

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Record of changes		
Issue	Date	Detail of Changes
1	August 2015	Initial draft for review
2	September 2015	Incorporated reviewers comments
3	September 2015	Incorporated diver impact modelling

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EXECUTIVE SUMMARY

The Shallow Water Absheron Peninsular (SWAP) Contract Area is located within the Azerbaijan sector of the Caspian Sea and extends across approximately 1,900km^2 from the coastline to a mean water depth of approximately 25m. A two dimensional (2D) seismic survey is planned to undertaken within the deeper waters of the SWAP Contract Area and the surrounding areas at water depths greater than approximately 10m during November and December 2015. Underwater sound generated by the seismic airgun array has the potential to impact biological/ecological receptors (specifically seals and fish) in the marine environment. A study has therefore been conducted to determine the potential distances from the seismic sound source at which sound from the seismic source decreases to below available thresholds for potential injury and behavioural impacts.

Marine fauna known to be present within and in the vicinity of the 2D SWAP Seismic Area includes Caspian seals (a critically endangered species) and various species of fish including sturgeon (also critically endangered), kilka, shad, carp and mullet species. The international published literature was reviewed in order to determine the most up-to-date advice on acoustic impact criteria relating to pinnipeds and fish being exposed to seismic airgun sound. Subsequently, thresholds were established using both peak sound pressure level (SPL), root-mean-square (RMS) SPL, and sound exposure (energy) level (SEL) metrics. For fish, dual exposure criteria for Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) were based on those developed by Popper *et al*.[1] and given in terms of sound pressure level (SPL) and sound exposure level (SEL). The audiological sensitivities for different species of fish were accounted for by having a range of thresholds at which each impact was met. For pinnipeds, dual exposure criteria for permanent and temporary hearing damage were based largely on the work undertaken by Southall *et al*.[2] Where appropriate, M-weighting functions relating to the auditory sensitivity of pinnipeds were used.

Seismic airgun source levels are usually modelled by back-propagating measurements of sound pressure level made in the far-field back to a reference distance of 1 m. The underlying assumption is that in the far-field, SPLs from individual airguns add constructively and that this representation of sound level can be corrected or back-propagated to represent source sound level. However, this process over-estimates source levels in close proximity to the source array (in the near-field). Sound propagation models require a single number for the source level and basing this on the back-propagated value does not give a realistic representation of sound levels within close proximity of the source. To address this, a simple model of a distributed acoustic source representing the individual airguns in the array was developed in order to provide a more accurate estimate of the near-field acoustic source level for the array.

[1] Popper, A. N., Hawkins, A. D., Fay, R. R., Mann, D., Bartol, S., Carlson, T., Coombs, S., Ellison, W. T., Gentry, R., Halvorsen, M. B., Løkkeborg, S., Rogers, P., Southall, B. L., Zeddies, D., and Tavolga, W. N. (2014). "Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report," ASA S3/SC1.4 TR-2014 prepared by ANSI Accredited Standards Committee S3/SC1 and registered with ANSI. Springer and ASA Press, Cham, Switzerland.

[2] Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene Jr., C.R., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A., Tyack, P.L., 2007. "Marine mammal noise exposure criteria: initial scientific recommendations". Aquatic Mammals 33, 411–521.

An analysis of the propagation of underwater sound from the seismic airgun array was undertaken in order to estimate distances at which sound levels are predicted to decrease below threshold levels.

Ranges for potential impacts based on peak and RMS level metrics are given in Tables ES.1 and ES.2 for fish and pinnipeds respectively. It will be seen that SPLs fall below the level at which potential mortality may occur in fish at a distance of 88 m from the airgun array while the threshold SPL for recoverable injury is reached at 92 m. Using the same metrics, the analysis showed that peak levels fall below the level at which PTS may occur in pinnipeds at 20 m from the array while the distance over which peak levels remain above that which may cause TTS extends to 45 m

Limited behavioural disturbance thresholds are given using RMS metrics. The underlying evidence for behavioural impacts is scarce[2] but SPLs around 190 dB are likely to cause avoidance behaviour reactions and these could at distances up to 75 m from the array. SPLs in the range 150-180 dB re 1 μPa (RMS) have limited potential cause behavioural reactions. The impact modelling indicates that RMS levels fall to these thresholds at distances ranging from 165 m to 2.0 km.

The distances over which the airgun sound becomes inaudible to the pinniped relative to background sound levels. A range of background levels are given from 100 dB re 1 μPa (RMS) to 120 dB re 1 μPa (RMS). Accordingly, limiting distances vary between 4.3 km when background levels are high to 51 km when levels are low. It is noted that longer limiting ranges tend to occur during December.

Impact	Threshold dB re 1 μPa	Distance m
Potential mortal injury in fish with low hearing sensitivity exposed to impulse sound Recoverable injury in fish with low hearing sensitivity exposed to impulse sound	213 dB peak	40 m
Potential mortal injury in fish with medium hearing sensitivity exposed to impulse sound Potential mortal injury in fish with high hearing sensitivity exposed to impulse sound Potential mortal injury in fish eggs and larvae exposed to impulse sound Recoverable injury in fish with medium hearing sensitivity exposed to impulse sound	207 dB peak	88 m
Recoverable injury in fish with high hearing sensitivity exposed to impulse sound	203 dB peak	92 m

Table ES.1: Summary of impact ranges for fish species exposed to seismic airgun array sound using peak level metrics

Potential Impact	Threshold dB re 1 μPa	Distance m	
		Nov	Dec
Permanent Threshold Shift (PTS) onset	218 dB peak	20 m*	20 m*
Temporary Threshold Shift (TTS) onset	212 dB peak	45 m*	45 m*
Avoidance Behaviour	190 dB RMS[1]	75 m	75 m
Avoidance Behaviour	190 dB RMS[2]	115 m	105 m
Limited disturbance	180 dB RMS[1]	165 m	165 m
Limited disturbance	180 dB RMS[2]	255 m	285 m
Limited disturbance	150 dB RMS[1]	1.53 km	1.54 km
Limited disturbance	150 dB RMS[2]	2.0 km	2.0 km
Background level	120 dB RMS[1]	4.3 km	9.4 km
Background level	120 dB RMS[2]	5.1 km	17 km
Background level	110 dB RMS[1]	5.5 km	31 km
Background level	110 dB RMS[2]	6.2 km	51 km
Background level	100 dB RMS[1]	7.3 km	51 km
Background level	100 dB RMS[2]	7.9 km	51 km

Table ES.2: Summary of impact ranges for pinnipeds exposed to seismic airgun sound based on peak level and RMS metrics (* - maximum range derived from near-field source level model; [1] – based on Peak level – 15 dB; [2] - based on Peak level – 10 dB)

In order to assess potential impacts using energy-level metrics (SEL), a moving animal/source scenario is modelled. This considers an animal moving away from the sound source and consequently experiencing sound levels which vary over time. As the SEL accumulates over time, eventually it may exceed a threshold level corresponding to the onset of PTS or TTS. The results, given in Table ES.3 show that, for the movement scenario considered, the modelling results suggest cumulative sound levels would be below the SEL PTS and TTS threshold for pinnipeds beyond a distance of379 m and 1.7 km from the source array respectively. Similarly for fish, cumulative sound levels would be below the SEL thresholds for potential mortal injury and recoverable injury beyond a distance of 92 m from the array and below the SEL thresholds for the onset of TTS beyond a distance of 1029 m from the array.

It is noted that, for the longer distance sound propagation, there is some seasonal variation with longer ranges occurring during the month of December.

Species	Impact	SEL Threshold dB re 1 μPa^2.s	Impact ranges	
			Nov	Dec
Pinnipeds	Onset of PTS	186	349 m	379 m
	Onset of TTS	171	1759 m	1729 m
Fish	Potential mortal injury in fish with low hearing sensitivity	219	<1 m	<1 m
	Potential mortal injury in fish with medium hearing sensitivity; and in eggs & larvae	210	49 m	49 m
	Potential mortal injury in fish with high hearing sensitivity	207	59 m	79 m
	Recoverable injury in fish with low hearing sensitivity	216	<1 m	<1 m
	Recoverable injury in fish with medium and high hearing sensitivity	207	59 m	79 m
	TTS in all fish	186	989 m	1029 m

Table ES.3: Summary of cumulative acoustic impacts for pinnipeds and fish exposed to SWAP airgun array

1. INTRODUCTION

The Shallow Water Absheron Peninsular (SWAP) Contract Area is located within the Azerbaijan sector of the Caspian Sea and extends across approximately 1,900km^2 from the coastline to a water depth of approximately 25m. A two dimensional (2D) seismic survey is planned to undertaken within the deeper waters of the SWAP Contract Area and the surrounding areas at water depths greater than approximately 10m during November and December 2015.

This report has been prepared by Peter Ward on behalf of AECOM Infrastructure & Environment UK Ltd in order to establish distances at which underwater sound associated with the SWAP 2D Seismic Survey met relevant underwater sound thresholds developed for the protection of marine fauna are met.

Seismic surveys involve the generation and propagation of underwater sound, which may have potential to impact species of marine fauna in the vicinity of the survey.

This study comprises the following:

- Discussion on the source parameters relating to the seismic airgun array proposed for the survey including a comparison of the derived near-field and back-propagated (based on far-field assumptions) source level.
- Summary of relevant acoustic impact thresholds based on international published literature on studies of animal audiology, injury and behaviour, taking into account known marine fauna within the SWAP 2D Seismic Survey area.
- Description of the sound propagation modelling undertaken using the derived far-field source level for the seismic array to determine the maximum distances over which each threshold is met; and
- Discussion of the results obtained.

2. DESCRIPTION OF UNDERWATER SOUND AND ASSESSMENT METRICS

2.1. Introduction

This section provides a brief review of the metrics used to measure and assess the impact of underwater sound in the marine environment. It is noted that a number of these definitions and parameters draw on the advice given in American National Standards Institute (ANSI) S12.7-1986[1].

Sound may be defined as the periodic change in pressure from some equilibrium value. The unit of pressure is given in Pascals (Pa) or Newton per square metre (N/m^2). Levels of sound however cover a very wide range of pressure values, typically from 1×10^{-3} Pa for the hearing threshold value of a human diver at 1 kHz to 1×10^{7} Pa for the sound of a lightening strike on the sea surface. For convenience therefore, sound levels are expressed on a logarithmic scale given by decibels (dB) relative to a fixed reference pressure commonly 1 μPa for measurements made underwater.

2.2. Peak Sound Level

For transient pressure pulses such as an impulse generated by a seismic airgun, the peak sound level is the maximum absolute value of the instantaneous sound pressure recorded over a given time interval. Hence:

$$\text{Peak Level (zero-to-peak)} = 20 \times \log_{10} (P_{peak}/P_{ref}) \qquad \text{eqn. 2-1}$$

When the pulse has approximately equal positive and negative parts to the waveform, the peak-to-peak level is often quoted and this is equal to twice the peak level or 6 dB higher.

2.3. RMS Sound Pressure Level

The Root-Mean-Square (RMS) Sound Pressure Level (SPL) is used to quantify sound of a continuous nature such as shipping, sonar transmissions, drilling or cutting operations, or even background sea sound; and also for impulsive sounds such as that from seismic surveys. In each case, the RMS SPL is the mean square pressure level measured over a given time interval (t), and hence represents a measure of the average SPL over that time. It is expressed as:

$$\text{RMS Sound Pressure Level} = 20 \times \log_{10} (P_{RMS}/P_{ref}) \qquad \text{eqn. 2-2}$$

When the sound is continuous, as in the examples given above, the time period over which measurements are taken is not relevant as the measurement will give the same result regardless of the period over which the measurements are averaged. For impulsive sounds, the time period over which the measurements are averaged must be quoted as the RMS value will vary with the averaging time period.

[1] ANSI S12.7-1986, "Methods for measurement of impulse noise", Issued by the American National Standards Institute, 20 February 1986

2.4. Sound Exposure Level

The previous section notes that it is important to define the time period over which the SPL is averaged hence the longer the averaging period, the greater the RMS SPL. Alternatively, the transient pressure wave may be described in terms of the Sound Exposure Level (SEL) where the SEL is the time integral of the square pressure over a time window long enough to include the entire pressure-time history. The SEL is therefore the sum of the acoustic energy over a measurement period, and effectively takes account of both the level of the sound, and the duration over which the sound is present in the acoustic environment. Sound Exposure (SE) is defined by the equation:

$$SE = \int_0^T p^2(t)dt \qquad \text{eqn. 2-3}$$

where *p* is the acoustic pressure in Pascals, *T* is the duration of the sound in seconds and *t* is time. The Sound Exposure is a measure of the acoustic energy and therefore has units of Pascal squared seconds (Pa^2-s).

To express the Sound Exposure as a logarithmic decibel, it is compared with a reference acoustic energy level of 1 μPa^2.s. The SEL is then defined by:

$$\mathrm{SEL} = 10\log_{10}\int_0^T \frac{p^2(t)dt}{\mathrm{P}_{ref}{}^2} \qquad \text{eqn. 2-4}$$

For continuous sources, the RMS SPL and the SEL of 1 second duration are equal. Where a sound time period is less than a second the RMS SPL will be greater than the SEL. For signals of greater than 1 second, the SEL will be greater than the RMS SPL where:

$$\mathrm{SEL} = \mathrm{SPL} + 10\log_{10}\mathrm{T} \qquad \text{eqn. 2-5}$$

2.5. Cumulative Sound Exposure Level

Where multiple transient pressure wave events occur, the total or cumulative SEL from multiple events can be calculated by summing the SEL from a number of individual events. The events themselves may be separated in time or space or both. For instance, the events could be consecutive from seismic airgun surveys moving from site to site or else concurrent where seismic surveys take place at the same time on neighbouring sites.

2.6. Source Level

The source level (SL) is the apparent strength of a sound source at a reference distance, usually 1 m, from the source. For example, a source may be quoted as having a source SPL of 180 dB re.1µPa at 1 m. In practise the parameters of the source are rarely measured at such a close range, and the source level is inferred by back-propagating the sound from a number of far field measurements

2.7. Received Level

The Received level (RL) is the strength of the acoustic field at a given depth and range relative to the source. As the sound varies with range, it is important to state the range at which the measurement has been taken or the estimate has been made.

2.8. Transmission Loss

The transmission loss (TL) represents the loss in intensity or pressure of the acoustic field strength as the sound propagates from source to receptor. In general terms the transmission loss is given by:

$$TL = N \log(r) + \alpha r \qquad \text{eqn. 2-6}$$

where r is the range from the source, N is a factor for attenuation due to geometric spreading, and α (in $dB.km^{-1}$) is a factor for the absorption of sound in water. Hence, the received sound level at a range r from a source is given by:

$$RL = SL - TL \qquad \text{eqn. 2-7}$$

which can be written in the form :

$$RL = SL - N \log(r) - \alpha r \qquad \text{eqn. 2-8}$$

A more rigorous discussion of transmission loss is given in Section 6 where the acoustic propagation modelling for the SWAP 2D Seismic Survey is presented.

It is noted that the terms transmission loss and propagation loss (PL) are synonymous.

3. SOUND SOURCE CHARACTERISTICS

3.1. Introduction

Seismic surveys are an essential part of an oil and gas exploration programme. During a survey, high intensity, low frequency sound emitted from a seismic source array is used to image the subsea rock formations so as to identify potential hydrocarbon traps and reservoirs. For offshore surveys the reflections from the rock structures are recorded using hydrophones streamed behind the survey vessel. The signals are then transmitted to the on-board processing equipment and analysed.

The sound sources themselves are airguns. These are underwater pneumatic devices that expel a bubble of compressed air into the water. Once in the water, the compressed air is released to form a bubble, the bubble collapses in on itself and may oscillate several times. The acoustic signal thus produced consists of a sequence of positive and negative pulses that are proportional to the rate of change of volume of the air bubbles.

A single airgun produces an acoustic signal that is both non-directional and largely lacking sufficient power to penetrate far into the seabed. To achieve the right degree of directionality and signal strength, an array of multiple airguns, often 10 to 30 or more, are used to form a source array which is distributed over a spatial area of up to 15m x 50m. Consequently, a highly directional, downward pointing acoustic signal is produced and this has the potential to penetrate the subsea geology to a depth of several kilometres. Airgun seismic source arrays currently provide the most efficient and safe sound source that is commercially available for conducting seismic surveys.

The performance of a seismic source array may be modelled through the use of a number of industry-standard packages[2,3]. The modelling programs require a number of input parameters including airgun types, pressure, spatial geometry and depth and from these, it is possible to determine the response of the array in terms of beam directivity and source frequency spectrum.

From an acoustic modelling perspective the data thus derived require additional analysis and interpretation in order to correctly represent the signature of the array. The sections below describe the steps required such that the array is correctly characterised.

3.2. Source Level

The source level of a seismic source array may be estimated by either modelling or measuring underwater SPL at a number of distances from the array itself. The measurements are often made over distances ranging from a few 10's of metres to 100's of metres. To allow for comparisons to be made between various source arrays, it is necessary to propagate the data back to a reference distance of 1 m from the array. The main assumption is that in the far-field, SPLs from individual airguns add constructively and that this simple representation of the acoustic sound level can be corrected by back-

[2] http://www.pgs.com/upload/Nucleus.pdf
[3] https://www.gundalf.com/

propagating to represent source sound level. However, this process leads to an estimate of source level which can be in excess of the actual level by up to 20 dB as it does not consider the near field interaction effects between individual source elements. Acoustic propagation modelling tools typically use a single source level number as input data. Consequently there is a need to derive a more realistic near-field source level based on inputs from individual source elements as well as using the single far-field derived source level that can be input to the propagation modelling tools.

The underlying assumption while back-propagating the data, is that the source is ultimately a point source and that it radiates sound equally in all directions. When an array consists of a number of source elements positioned over a finite sized area, this simple description is no longer valid. In acoustic terms, the array is now a distributed source, that is, it consists of a number of individual acoustic point sources each with its own acoustic intensity and which all contribute to the overall acoustic field. Close to the array, the sound output from individual elements no longer add constructively as sound energy no longer arrives at a location at the same time due to the distributed nature of the array. In order to estimate a more appropriate source level for use at distances close to the array, an alternative approach is sought.

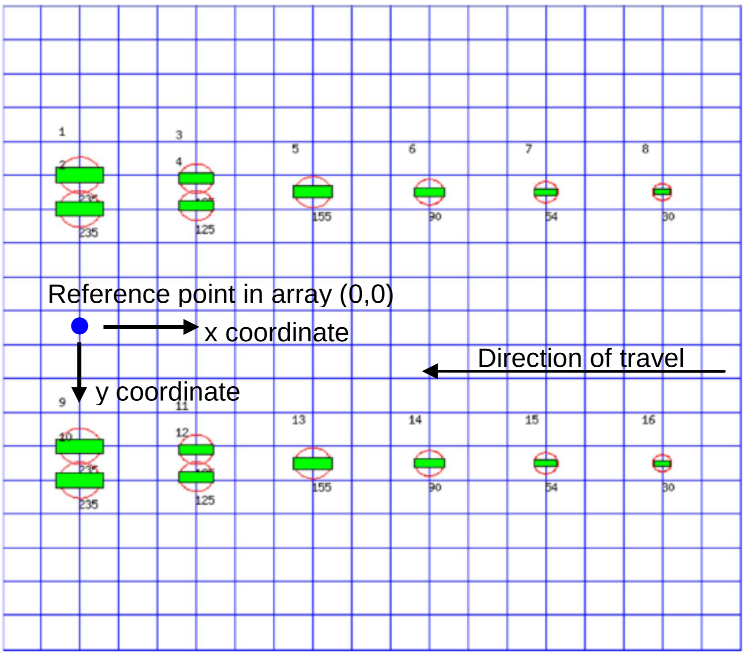


Figure 3.1: Schematic of airgun array configuration

Provisional details on the source array to be used in the SWAP 2D seismic survey have been provided by BP based on the GUNDALF report[4]. Figure 3.1 shows the intended configuration of the SWAP 2D survey airgun array. It is noted that there are a total of 16 airguns arranged in 2 sub-arrays. The GUNDALF report also provided data on individual airgun geometry, capacity and energy level. This data is summarised in Table 3.1. The

[4] "GUNDALF array modelling suite – SWAP 2D array" (2015). BP– Pers. Comm.

entries in red (guns 1, 2, 9 and 10) indicate that these airguns are absorbing energy and do not directly contribute to the acoustic field. Energy-absorbing airguns arise through the complex interactions of individual airguns in an array[5]. The outcome of the process is that the overall energy efficiency of the array is increased.

It is noted that the source levels for the airguns are given in energy units of Joules. Source levels in dB units for individual airguns may be estimated through converting energy to power by dividing by a representative time t. Subsequently, the source level in dB units is given by[6]:

$$SL = 170 + 10 \log_{10}(Pw) \qquad \text{eqn. 3-1}$$

where Pw is the power in Watts.

In order to complete the calculation, it is necessary to assign a suitable value to time t. Hatton[7] notes that energy flux occurs from the moment of array discharge through to the end of a series of bubble pulses and this may last approximately 0.5 seconds. Consequently, this value is taken forward for use in the analysis. Airgun acoustic source levels are included in Table 3.1.

Gun	Airgun volume	Location in array relative to reference point (see Figure 3.1)			Acoustic energy	Source level
No.	Cubic inch	x m	y m	z m	Joules	dB re 1 μPa at 1 m
1	235	0	-4.5	5	-6202.2	210.9
2	235	0	-3.5	5	-12805.5	214.1
3	125	3	-4.4	5	18316.5	215.6
4	125	3	-3.6	5	17563.1	215.5
5	155	6	-4	5	17746.3	215.5
6	90	9	-4	5	10798.5	213.3
7	54	12	-4	5	8635.5	212.4
8	30	15	-4	5	5250.6	210.2
9	235	0	3.5	5	-12968.6	214.1
10	235	0	4.5	5	-6032.2	210.8
11	125	3	3.6	5	17472.7	215.4
12	125	3	4.4	5	18409.6	215.7
13	155	6	4	5	17749.8	215.5
14	90	9	4	5	10799.9	213.3
15	54	12	4	5	8634.8	212.4
16	30	15	4	5	5248.3	210.2

Table 3.1: Airgun array configuration details

[5] Laws R., G. Parkes, L Hatton, (1988), "Energy-Interaction: The Long-Range Interaction Of Seismic Sources", *Geophysical Prospecting*, Volume 36, Issue 4, pages 333–348.
[6] Erbe C., *Underwater Acoustics: Noise and the Effects on Marine Mammals - A Pocket Handbook,* 3rd Edition, JASCO Applied Sciences. Accessed at http:// oalib.hlsresearch.com.
[7] Hatton L., (2008), "The Acoustic Field Of Marine Seismic Airguns And Their Potential Impact On Marine Animals", *Proceedings of the Institute of Acoustics: Underwater Noise 2008,* Vol 30 Pt 5.

To assist in the calculation of the source level of the airgun array, the concept of near-field and far-field is used. Near-field refers to locations within and close to the airgun array while far-field refers to distances beyond this. The distance over which each term is valid is discussed further below.

To calculate the maximum distributed near-field source level, it is assumed that each airgun emits sound as a point source. The total acoustic field for the whole array at a given field location is determined by summing the pressure contributions in Pascals from individual airguns while also taking into account the propagation loss over the distance between the airgun and the field location.

Accordingly, Figure 3.2 shows the near-field representation of the acoustic field within and close to the confines of the airgun array based on the source level presented in Table 3.1. The blue lines represent acoustic propagation from the 12 individual airguns emitting sound and acting in isolation – noting that airguns 1, 2, 9 and 10 are absorbing energy meaning that the other airguns in the array therefore act more efficiently. For the four airguns absorbing energy, the source level has been set to zero. The red line represents the summation of the pressures from the individual airguns along the centre-line of the array from the point of origin at (0, 0) (see Figure 3.1) out to a distance of 100 m and in the same plane as the airgun array i.e. at a depth of 5 m below surface. Within the confines of the array, i.e. from 1 m to 15 m as shown in Figure 3.2, the modelled near-field source level is seen to lie in the range 222 - 224.8 dB re 1 μPa at 1 m.

In order to determine the distance at which the sound level derived from the addition of individual airgun outputs transitions from the near-field to the far-field, the difference between the slope of the modelled near-field data and the slope of the sound field that is back projected from the far-field characteristic was calculated. When the difference became negligible, in this instance at a range of approximately 30 m, this indicated the end of the near-field. A trendline using data from 30 m to 100 m was extended back to 1 m distance from the source (indicated by the green line in Figure 3.2) and this led to a nominal source level of approximately 241 dB re 1 μPa at 1 m. This value represents the back-propagated source level based on the distributed nature of the source array elements, which is used as input for acoustic propagation modelling in the far-field.

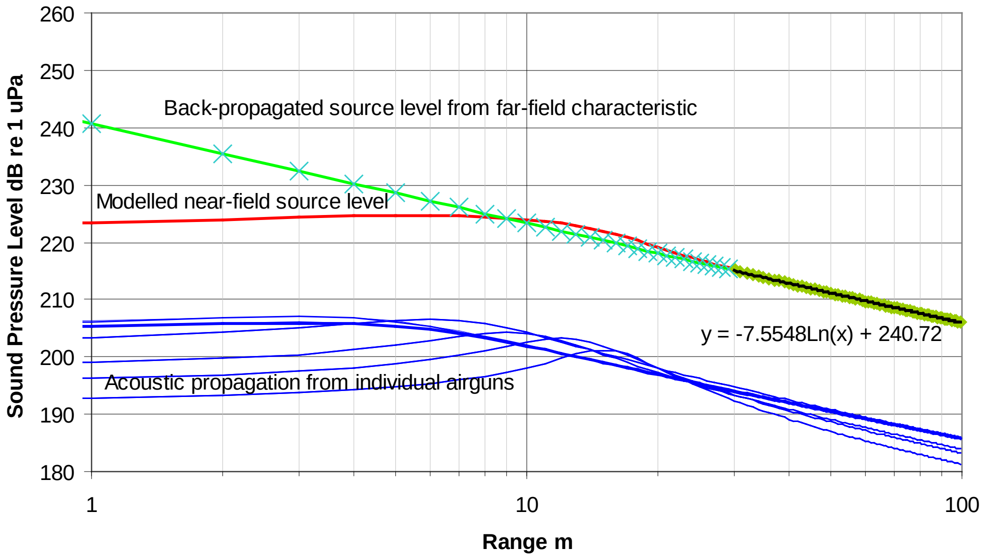


Figure 3.2: Near-field and partial far-field representation of the airgun array source

3.3. Source Spectrum

The primary output of a seismic array source typically has most of the energy in the frequency bandwidth between 10 and 200 Hz, which is the frequency bandwidth of most interest in seismic surveying. Source frequency spectral data derived from airgun source modelling are currently limited to 1000Hz frequency range or less, whereas source data is required for higher frequencies that extend across the auditory hearing range of the fish and marine mammal species of concern to the Project (see Section 4) in order to enable an assessment of potential effects of sound from the seismic source on these species. However, few seismic source measurement datasets are currently available which include analysis of spectral levels at frequencies above 1kHz. Breitzke *et al.*[8] analysed data up to a frequency of 80 kHz, which suggested that sound levels beyond 1 kHz in frequency was dominated by sound from the vessel operating the seismic source. Tashmukhambetov *et al.*[9] studied a 3D seismic airgun array. This was an array consisting of 21 airguns in 3 sub-arrays and having a total volume capacity of 3590 cubic inches (cu in). Measurements of SPL were made at a distance of 736 m from the hydrophone and from these data, the frequency spectrum was determined up to a frequency of 1000 Hz. For the purposes of calibration, the data was compared with those from the source modelling software packages Nucleus[2] and GUNDALF[3]. It was found that at frequencies up to 230 Hz, the modelled data was in close agreement with those derived from the experimental measurements. At higher frequencies, the roll-off of spectral levels as modelled by the software generally followed the measured data, although individual spectral levels from the modelled data were up to 12 dB higher than the measured data.

[8] Breitzke M., Boelbel O., El Naggar S., Jokat W., Werner B., (2008), “Broad-band calibration of marine seismic sources used by *R/V Polarstern* for academic research in polar regions”, *Geophys. J. Int*. (2008) **174**, 505–524.
[9] Tashmukhambetov, A.R., G.E. Ioup, J.W. Ioup, N.A. Sidorovskaia, J.J. Newcomb, (2008), “Three-dimensional seismic array characterization study: Experiment and modeling”, *J. Acoust. Soc. Am*. **123(**6).

For the purpose of modelling the SWAP airgun array, the modelled source frequency spectrum was extended up to a frequency of 160 kHz by applying a best-fit line on a logarithmic scale to the data at frequencies from 200 Hz to 1000 Hz then extrapolating the resulting trendline up to the requisite frequency. Following this, the spectral levels were adjusted by adding a spherical spreading term to account for the propagation over the distance from 736 m to 1 m so as to arrive at the same far-field source level as the SWAP array viz. 240.7 dB re 1 μPa. (Note that the spectrum is adjusted to give a source level of 240.7dB re 1 μPa rather than the lower near-field source level of 224.8 dB re 1 μPa as the higher figure is used for sound propagation beyond the near-field of the source array's acoustic field *i.e*. beyond a range of 30 m – see Figure 3.2.) Data from the Tashmukhambetov *et al*. study[9] and the proposed SWAP array frequency spectrum in 1/3rd octave bands are given in Figure 3.3.

The figure shows that over the frequency range 50 Hz to 80 Hz, band levels are around 220 - 224 dB re 1 μPa. This is followed by a notch at 150 Hz where subsequently there is a general roll-off in spectral levels at higher frequencies.

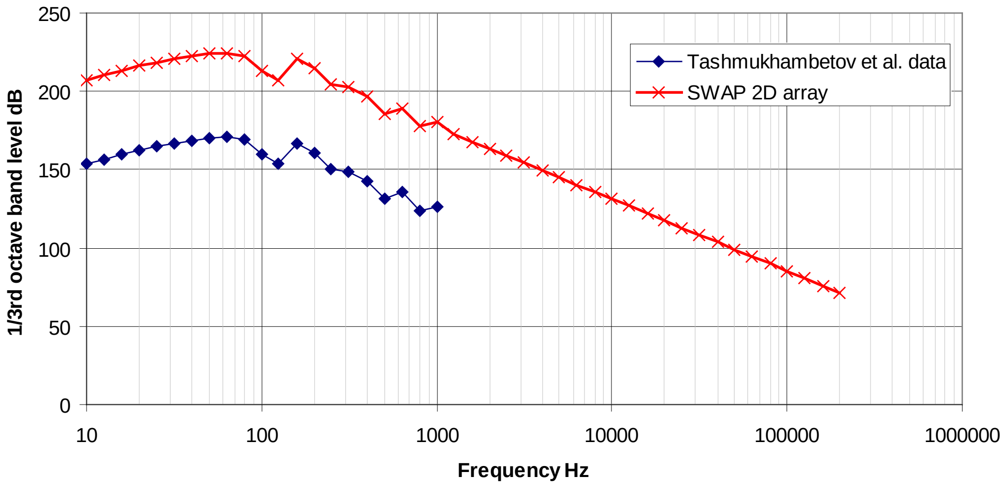


Figure 3.3: Indicative frequency spectrum for the SWAP 2D seismic source array and the spectrum from the Tashmukhambetov et al. study

3.4. Summary of 2D Source Characteristics

Using the available source data and developing a simple model to account for the contributions of individual airguns and the acoustic energy lost as sound propagates from each, an appropriate value for the acoustic near-field source level of the SWAP airgun array has been determined. In addition, based on data from the international published literature, it is possible to estimate a representative frequency spectrum for the output signal of the source array.

Based on Sections 3.2 and 3.3 above the SWAP 2D source characteristics have been estimated as follows:

- Near field or distributed source level - 224.8 dB re 1 μPa;
- Far field source level - 240.7dB re 1 μPa;
- Frequency spectrum (refer to Figure 3.3).

4. SENSITIVITY OF MARINE FAUNA IN THE SWAP 2D SEISMIC SURVEY TO UNDERWATER SOUND

4.1. Introduction

Previous studies have identified a number of species of fish and one species of marine mammal that are expected to be present in the Azerbaijan Sector of the Caspian Sea and more specifically within the SWAP 2D Seismic Survey Area. This section provides an overview of the susceptibility of the species to underwater sound. It is also noted that the survey area lies close to a number of sites at which recreational divers may be present. Further details on the species present are provided within Chapter 5 of the SWAP 2D Seismic Survey Environmental and Socio Economic Impact Assessment (ESIA).

4.2. Fish

The sensitivity of fish to underwater sound is largely dependent on their internal physiology. This has been discussed extensively in the published literature and has been reviewed most recently by Fay and Popper[10] and Popper and Fay[11]. Some fish species do not have a swimbladder (e.g. dab, plaice) and as a consequence they have poor sensitivity to sound and thus relatively poor hearing. By contrast, a number of fish species have a swimbladder. This gas-filled sac performs several different functions such as acting as a float which gives the fish buoyancy; as a lung; and as a sound-producing organ. In addition, the swim bladder can enhance the hearing capability of the fish species through the amplification of underwater sound although this alone, would not necessarily make such a fish highly sensitive to sound. These fish would be deemed to have a medium level of auditory sensitivity. For some species (e.g. members of the herring family) there is a connection between the inner ear and the swim bladder and it is this feature which results in them being the most sensitive to underwater sound. Subsequently, there is the potential for such species to be more susceptible to acoustic impacts than fish with low or medium hearing sensitivity.

The literature suggests that the terms high-, medium- and low-sensitivity appear somewhat subjective. Auditory data[12] shows that, in general, fish hearing covers the frequency range 10 Hz to 1000 Hz. Hearing threshold data varies considerably from species to species. The data shows that the fish with the least sensitive hearing have thresholds greater than 90-110 dB re 1 μPa while those species that have the most sensitive hearing have thresholds as low as 50-60 dB re 1 μPa. Clearly, for those species that are classed as having neither low- nor high-sensitivity hearing, an intermediate class is more appropriate.

[10] Fay R.R. & Popper A.N. (eds) (1999) *Comparative Hearing: Fish and Amphibians*. New York: Springer-Verlag.
[11] Popper A. N. & R. .R. Fay (2009). “Rethinking sound detection by fishes”. Hearing Research.
[12] Nedwell J R, Edwards B., Turnpenny A W H , Gordon J., (2004) “Fish and Marine Mammal Audiograms: A summary of available information”, Subacoustech Report ref: 534R0214.

4.3. Mammals

The only mammal known to be present in the Caspian Sea (including the SWAP 2D Seismic Survey Area) is the Caspian seal; listed as critically endangered on the IUCN Red List of Threatened Species.

Although seals are classed as marine mammals they spend considerable periods of time on land. As a consequence, seals are known to hear very well in-air as well as underwater. When diving or swimming, they may be susceptible to impacts arising from high levels of underwater sound.

A number of species of seal have been auditory tested – principally harbour, ringed, harp and monk seals as well as Californian sea lions and northern fur seals (reviewed in Richardson *et al*.[13]) but not, it is noted, the Caspian seal. Auditory data is thus generally available over the frequency range 100 Hz to 200 kHz. Thresholds are as low as 60-70 dB re 1 μPa over the frequency range 4 kHz to 30 kHz. For the purpose of the analysis undertaken in the current study, it is assumed that the hearing sensitivity of the Caspian seal is broadly in line with the pinniped species for which data exists.

[13] Richardson, W.J., Green Jr, C.R., Malme, C.I. & Thomson, D.H. (1995). *Marine Mammals and Noise*. Academic Press, New York.

5. POTENTIAL IMPACTS AND ACOUSTIC THRESHOLDS

5.1. Introduction

The extent to which a given species might be affected by man-made underwater sound depends on the hearing ability of the species, the activity/behaviour of the individuals during exposure, and the level, frequency and duration of the sound.

This section of the report provides a discussion of the thresholds proposed within literature relevant to the SWAP 2D Seismic Survey, specifically associated with fish and seals and confirms which are adopted for the purpose of the underwater acoustic propagation modelling presented in Section 6.

5.2. Limitations

All acoustic impact criteria considered in this study have been developed in accordance with best scientific practice and have been discussed extensively in the international peer-reviewed literature. It should be noted however; in many cases the criteria have had little or no validation under open water conditions. For marine mammals, TTS and PTS studies have been limited to just a few species. However, the results derived from such work have been extrapolated to other species based on best knowledge of marine mammal physiology and comparisons with data from terrestrial mammals. Observations of behavioural avoidance with concurrent acoustic measurements are sparse, and hence the behavioural avoidance criteria are limited and informed by scientific studies such as those reviewed by Southall *et al*[14]. With regards to fish, only a few of the 30,000 plus species have been auditory tested. Of those however, the sample sizes have been such that the results may be considered statistically significant. The qualitative threshold assessment methodology subsequently developed offers an indication of potential impact on an individual basis, and, by taking note of the precautionary principle, enables the significance or likelihood of impact to be assessed relative to the overall population.

5.3. Marine Mammals

5.3.1. Mortality

Very high levels of underwater sound can be potentially lethal to marine life. Yelverton *et al.*[15] carried out a number of studies on the impact of explosive blasts on various species of fish and terrestrial animals and demonstrated that mortality rates were related to body mass of the subject and the magnitude of the impulsive wave. It was noted that mortality or direct physical injury from the sound generated by the blast was associated with very high peak pressure levels – in excess of 240 dB re 1 μPa. The effects associated with sound from explosives are assumed to be also associated with sound from a seismic airgun array due to the similar impulsive characteristics of the source output signal. It is

[14] Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene Jr., C.R., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A., Tyack, P.L., 2007. “Marine mammal noise exposure criteria: initial scientific recommendations”. Aquatic Mammals 33, 411–521.

[15] Yelverton, J. T., Richmond, D. R., Hicks, W., Saunders, K., and Fletcher, E. R. (1975). "The Relationship Between Fish Size and Their Response to Underwater Blast." Report DNA 3677T, Director, Defense Nuclear Agency, Washington, DC.

observed however that the studies by Yelverton *et al*[15]. concerned predominantly terrestrial animals hence it is unclear whether the conclusions arising could readily be applied to marine animals and sound from airgun sources. In addition, a literature search has indicated that there are no known studies concerning lethality in marine mammals when exposed to seismic airgun sound. As a result, this impact threshold is not used further in the current study.

5.3.2. Auditory Impairment

Permanent and temporary hearing loss may occur when marine animals are exposed to sound levels lower than those which are commonly associated with potential lethality and physical injury. Permanent hearing loss in mammals results from non-recoverable damage to the sensory hair cells of the inner ear. This gives rise to a permanent increase in threshold sensitivity over the affected frequencies and is known as Permanent Threshold Shift (PTS). It is noted that PTS has not been measured in marine mammals following exposure to loud sounds. Thresholds for PTS are based on Temporary Threshold Shift (TTS) thresholds with an extrapolation based on the difference between PTS and TTS that has been observed in studies[14]. Therefore exceeding PTS thresholds does not necessarily mean that permanent hearing damage will occur.

Temporary Threshold Shift (TTS) is a temporary hearing impairment and is not considered an injury. While experiencing TTS, the hearing threshold rises and a sound must get louder in order to be heard. For sound exposures at or somewhat above the TTS threshold, hearing sensitivity in both terrestrial and marine mammals recovers after exposure to the sound ends. The recovery period can last from minutes or hours to (in cases of strong TTS) days. A number of studies on TTS have been reviewed in some detail by Southall *et al*.[14] and additional work on sound levels and durations necessary to elicit TTS has been provided by Finneran and Schlundt[16], Lucke *et al*.[17], and Kastelein *et al*.[18].

Southall *et al.*[14] grouped marine mammals according to the frequency response of their hearing. Southall *et al*. suggest that SEL thresholds for injury (and behavioural responses) should be examined separately by applying an M-weighting function for five functional hearing groups: low-frequency cetaceans (mysticetes, for which the functional hearing range is concluded to be 7 Hz to 22 kHz) and denoted M_{lf}; mid-frequency cetaceans (the majority of odontocetes, 150 Hz to 160 kHz), denoted M_{mf}; high-frequency cetaceans (remaining odontocetes, 200 Hz to 180 kHz), denoted M_{hf}; pinnipeds in water (75 Hz to 75 kHz), denoted M_{pw}; and pinnipeds in air (75 Hz to 30 kHz), denoted M_{pa}.

Studies reviewed by Southall *et al.*[14] indicated that hearing damage could occur following a single exposure to a loud sound or to multiple exposures of lower level sound. In the

[16] Finneran J.J., Schlundt C.E., (2013), "Effects of fatiguing tone frequency on temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*)", *J Acoust Soc Am*. **133**(3):1819-26.
[17] Lucke K., Siebert U., Lepper P.A., Blanchet M.A., (2009), "Temporary shift in masked hearing thresholds in a harbor porpoise (Phocoena phocoena) after exposure to seismic airgun stimuli", *J Acoust Soc Am*. **125**(6):4060-70. doi: 10.1121/1.3117443.
[18] Kastelein R.A., Gransier R., Hoek L., (2013), "Comparative temporary threshold shifts in a harbor porpoise and harbor seal, and severe shift in a seal.", *J Acoust Soc Am*. **134**(1):13-6.

first case, the threshold is given by the peak SPL while in the second case; the threshold is given by the SEL indicating a build-up of energy over a period of time.

Assessment criteria were also based on the type of sound e.g. single and multiple pulse such as those arising from seismic airgun discharges; and non-pulse or continuous sound such as that arising from shipping. Consequently, using the peak level metrics, for pinnipeds exposed to single or multiple pulses, for PTS a threshold level of 218 dB re 1 µPa Peak SPL is proposed, while the corresponding threshold using the energy based metric is 186 dB re 1μPa^2 s SEL M-Weighted. For TTS; threshold levels of 212 dB re 1 µPa (Peak SPL) and 171 dB re 1μPa^2 s SEL M-Weighted are suggested.

5.3.3. Behavioural Reactions

At still lower sound levels, it has been observed that animals may exhibit changes in their normal behaviour. These changes range from a startle reaction to the sound, a cessation of their current activities (e.g. feeding, nursing, breeding) or the animals may move away from the sound source for a period of time. Often the behavioural effects are context-dependent and very subtle. Painstaking experimental procedures and much analysis are required to determine whether the observed results are statistically significant.

Southall *et al*[14]. reviewed a number of studies on behavioural disturbances in marine mammals including seals exposed to multiple pulses such as those emitted by seismic airguns. From the limited data available, it was found that there was “limited potential to induce avoidance behaviour” at received sound levels in the range 150-180 dB re 1 μPa (RMS) while received levels at 190 dB re 1 μPa (RMS) and above were likely to elicit avoidance responses, at least in the species observed which was predominantly ringed seals. The review also noted that the threshold levels representing behavioural disturbance from single pulses are the same as those indicating the onset of TTS following exposure to multiple pulses and as discussed above.

5.3.4. Summary of Thresholds Relevant to Marine Mammals

The thresholds for pinnipeds exposed to seismic array sound that have been selected for the current study are summarised in Table 5.1.

Threshold level	Effect	Study
218 dB re 1 μPa Peak OR 186 dB re.1μPa^{2}s SEL M-Weighted	Onset of Permanent Threshold Shift (PTS)	Southall *et al.* (2007) Dual criteria – applicable for multiple pulses
212 dB re 1 μPa Peak OR 171 dB re.1μPa^{2}s SEL M-Weighted	Onset of Temporary Threshold Shift (TTS) also indicating significant behavioural disturbance.	Southall *et al.* (2007) For TTS, dual criteria – applicable for multiple pulses For disturbance, dual criteria – applicable for single pulses
190 dB re 1 μPa RMS	Avoidance behaviour in pinnipeds exposed to impulsive sounds	Southall *et al*. (2007)
150-180 dB re 1 μPa RMS	Limited disturbance expected in pinnipeds exposed to impulsive sounds	Southall *et al*. (2007)

Table 5.1: Summary of acoustic impact threshold criteria for pinnipeds

5.4. Fish

5.4.1. Mortality

Until very recently, acoustic impact criteria for fish were somewhat less well developed compared with those for marine mammals. In order to address this, Popper *et al.*[19] conducted a similar process for fish as Southall et al. had done for marine mammals. Reviewing a number of studies and was subsequently used to define various impact thresholds that were a function of the hearing sensitivity of fish species. The hearing function groupings, labelled as “High sensitivity”; “Medium sensitivity”; and “Low sensitivity”; refer back to studies either of the internal physiology of the fish or else to their auditory sensitivity (see Section 4).

As with the Southall *et al*.[14] work, the potential impact thresholds use a dual criteria in recognition of the fact that an impact may arise either through exposure to a single loud sound or from exposure at a lower level but over a long period of time. Accordingly, potential mortality injury in fish with low hearing sensitivity was found to occur at 213 dB re 1 μPa (Peak SPL) or 219 dB re 1 μPa^2.s (SEL). For fish with medium hearing sensitivity and for fish eggs and larvae, the corresponding thresholds are 207 dB re 1 μPa (peak) and 210 dB re 1 μPa^2.s (SEL) while for fish with high hearing sensitivity, the thresholds are set at 207 dB re 1 μPa (peak) and 207 dB re 1 μPa^2.s (SEL).

It is noted that the thresholds all make use of unweighted SPLs and SELS; there is no correction for hearing sensitivity across different species of fish using a methodology similar to the M-weighting criteria presented by Southall *et al.*[14].

[19] Popper, A. N., Hawkins, A. D., Fay, R. R., Mann, D., Bartol, S., Carlson, T., Coombs, S., Ellison, W. T., Gentry, R., Halvorsen, M. B., Løkkeborg, S., Rogers, P., Southall, B. L., Zeddies, D., and Tavolga, W. N. (2014). “Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report,” ASA S3/SC1.4 TR-2014 prepared by ANSI Accredited Standards Committee S3/SC1 and registered with ANSI. Springer and ASA Press, Cham, Switzerland.

5.4.2. Auditory Impairment

Popper *et al.*[19] also proposed thresholds for potential recoverable hearing damage for fish. Again, this was found to vary with the auditory sensitivity of fish. The thresholds for recoverable injury in fish with low hearing sensitivity are 213 dB re 1 μPa (Peak SPL) and 216 dB re 1 μPa^2.s (SEL) while for fish with medium and high hearing sensitivity, the corresponding thresholds are 203 dB re 1 μPa (Peak SPL) and 207 dB re 1 μPa^2.s (SEL). The same study also defined a threshold for temporary hearing damage, indicated by TTS, in fish of all hearing sensitivities, of 186 dB re 1 μPa^2.s (SEL).

5.4.3. Behavioural Reactions

Behavioural reactions have been observed in fish when exposed to man-made underwater sound such as that from pile driving, seismic airgun surveys, and operational sonar and the studies arising have been subject to extensive review[20]. It is acknowledged that the most useful work on behavioural reactions takes place when fish can be observed before, during and after exposure to a given sound. This condition was met when in work undertaken by Wardle *et al.*[21]. Fish were exposed to seismic airgun sound and were seen to exhibit a "C-start" reaction where their bodies curled up then straightened out over a period of about 1 second. Other studies include observations of free-roaming fish that have been shown to move temporarily away from an airgun source[22],[23] Similarly, captive fish have been seen to move away from airgun emissions and to show modified behaviour patterns[24].

The logistical difficulties of carrying out statistically meaningful experiments on fish in open-water conditions means that currently, no data is available on threshold levels of sound relating to acoustic impacts.

5.4.4. Summary of Thresholds Relevant to Fish

The thresholds for fish exposed to seismic array sound that have been selected for the current study are summarised in Table 5.2.

[20] Popper A. N., Hastings M. C., "The effects of human-generated sound on fish", *Integrative Zoology* 2009; 4: 43-52.
[21] Wardle CS, Carter TJ, Urquhart G.G. (2001). "Effects of seismic air guns on marine fish", *Continental Shelf Research* 21, 1005–27.
[22] Løkkeborg, S. (1991). "Effects of a geophysical survey on catching success in longline fishing". ICES (CM) B:40.
[23] Engås A., Løkkeborg S., (2002). "Effects Of Seismic Shooting And Vessel-Generated Noise On Fish Behaviour And Catch Rates", Bioacoustics: The International Journal of Animal Sound and its Recording Volume 12, Issue 2-3.
[24] Fewtrell J.L., McCauley R.D., (2012), "Impact of air gun noise on the behaviour of marine fish and squid", Mar Pollut Bull. **64**(5):984-93.

Exposure limit	**Effect**	**Study**
213 dB re 1 µPa Peak OR 219 dB re 1 μPa^2 s SEL	Potential mortal injury in fish with low hearing sensitivity exposed to seismic sound	Popper *et al.* (2014)
207 dB re 1 µPa Peak OR 210 dB re 1 μPa^2 s SEL	Potential mortal injury in fish with medium hearing sensitivity exposed to seismic sound & Potential mortal injury in fish eggs and larvae exposed to seismic sound	Popper *et al.* (2014)
207 dB re 1 µPa Peak OR 207 dB re 1 μPa^2 s SEL	Potential mortal injury in fish with high hearing sensitivity exposed to seismic sound	Popper *et al.* (2014)
213 dB re 1 µPa Peak OR 216 dB re 1 μPa^2 s SEL	Recoverable injury in fish with low hearing sensitivity exposed to seismic sound	Popper *et al.* (2014)
203 dB re 1 µPa Peak OR 207 dB re 1 μPa^2 s SEL	Recoverable injury in fish with high or medium hearing sensitivity exposed to seismic sound	Popper *et al.* (2014)
186 dB re 1 μPa^2 s SEL	TTS in all fish exposed to seismic sound	Popper *et al.* (2014)

Table 5.2: Summary of acoustic impact threshold criteria for fish

6. UNDERWATER ACOUSTIC PROPAGATION MODELLING

6.1. Introduction

The sections below describe the propagation modelling undertaken in order to estimate sound levels in the far field, specifically the acoustic models used and the geo-acoustic and oceanographic data required as input parameters for the models.

6.2. Description of the Models and limitations

Numerous computer models are available to predict acoustic propagation in the marine environment. Each model has its own strengths and weaknesses in terms of input requirements and calculation methods, but all include some form of description of various environmental parameters, such as the water column sound speed profile (SSP) and sediment acoustic properties.

Reviews of a number of acoustic propagation computer programs are given by Buckingham[25], Jensen *et al.*[26] and Etter[27]. A number of these have been coded up and are included in the Acoustics Toolbox[28]. The computer programs are based on ray-trace, normal mode, parabolic equation and fast field techniques. The models of relevance to the analysis undertaken in this report are BELLHOP – based on the ray-trace method; and RAM – based on the parabolic equation. Both programs carry out a 2D analysis for a given sound speed profile in an ocean waveguide overlying a range-dependent, acoustically absorbent seabed sediment. Both programs provide a solution that is valid over a limited frequency, water depth and range regime: the parabolic equation technique covers low frequencies (~<1 kHz) while the ray-trace is appropriate at high frequencies (~>1 kHz). The sound source associated with the SWAP 2D Seismic Survey (see Section 3) covers a wide range of frequencies hence it is considered acceptable to use both the BELLHOP and RAM models such that the whole frequency range of interest is covered.

The quality of the output data is highly dependent on obtaining site-specific oceanographic and geo-acoustic data. The sources of data used as inputs to the propagation modelling process are discussed below.

6.3. Transect Bathymetry

Water depth data was taken from the bathymetry database ETOP01[29]. This is a database of water depths having global coverage and a resolution of 1 min of arc (corresponding to a spatial separation of around 1.8 km in the vicinity of the 2D Seismic Survey Area).

A representative location for acoustic propagation modelling was taken at 40°15.83'N 050°13.58'E. This lies 15 km off the Absheron Peninsula in 32 m water depth. A total of

[25] Buckingham M.J., "Ocean-acoustic propagation models". Journal d'Acoustique: 223-287 June 1992.
[26] Finn Jensen, William Kuperman, Michael Porter, and Henrik Schmidt, *Computational Ocean Acoustics*, Springer-Verlag (2000).
[27] Etter Paul C., *Underwater Acoustic Modeling and Simulation* , 3rd edition, Spon Press, New York, 2003, ISBN 0-419-26220-2
[28] An online repository funded by the US Office of Naval Research and containing a number of underwater acoustic propagation loss computer programmes. Found at http://oalib.hlsresearch.com/Modes/AcousticsToolbox/
[29] Amante, C. and B. W. Eakins, (2009), ETOPO1 1 Arc-Minute Global Relief Model: Procedures, Data Sources and Analysis. NOAA Technical Memorandum NESDIS NGDC-24, 19 pp, March 2009.

12 equally spaced transects radiating from the nominal centre were selected for modelling. The bathymetric data indicates that over the selected transects, the water depths vary generally between 20 m and 40 m although as the coastline is approached on the northerly and westerly transects, the depths decrease rapidly to zero while further offshore along the southerly and easterly directions, depths exceed 100 m. The transects vary in length from 15km to 50 km depending on the proximity of the coastline to the modelling centre location.

6.4. Oceanographic Data

Oceanographic data was obtained through the World Ocean Atlas (WOA 2009[30]). This consists of gridded monthly samples of temperature, salinity and depth and from which, sound speed profiles in the vicinity of the 2D Seismic Survey Area may be reconstructed with the Chen-Millero[31] relationship. Sound speed profiles for the months of November and December are illustrated in Figure 6.1.

Over the course of a year, temperature changes in the topmost layers of water have a significant effect on the nature of the sound speed profile. Below about 50m, the seasonal heating has little effect as water temperatures remain little changed over the course of the year. During November the top 50 m of the water column retain some residual heat from the summer months with the result that there is a general decrease in sound speed with increasing depth. Consequently, the sound speed profile tends to be slightly downward refracting and this ensures that the sound from a shallow source is directed towards the seabed. By December, the surface cooling is advanced and this has given rise to a sound speed that is strongly upwardly refracting over the top 20 m. The nature of the profile is such that for a shallow sound source, the sound tends to become trapped in a surface channel and subsequently may propagate to considerable distances.

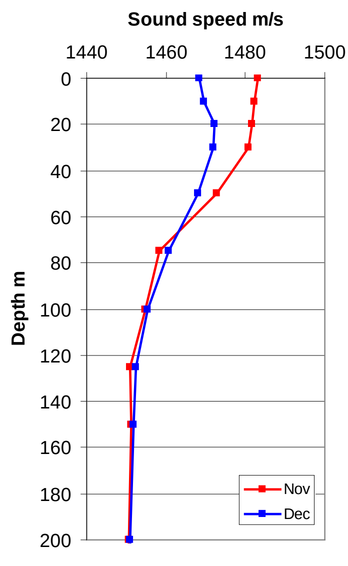


Figure 6.1: Monthly sound speed profiles for the vicinity of the 2D Seismic Survey Area

[30] WOA (2009), World Ocean Atlas dataset available for download at www.nodc.noaa.gov/OC5/WOA09/pr_woa09.html
[31] C-T. Chen and F. J. Millero, (1977), "Speed of Sound in Seawater at High Pressures". J. Acoust Soc Am, 32(10), p 1357

6.5. Seabed Geoacoustics

Seabed mapping surveys in areas adjacent to the 2D Seismic Survey Area [32,33] indicate a range of different sediment types from consolidated material through to soft, silty muds. In inshore regions, the sediments tend to consist of a poorly sorted mixture of silt, clay, sand and shell fragments while further offshore coarse sands and gravel predominate.

From an acoustic perspective, the seabed may be modelled as a layer of soft clay with a thickness of 500 m. Due to its thickness and the acoustic losses inherent in the clay, the nature of the basement rock is of lesser importance. Hamilton[34,35,36] provides guidance on determining seabed sediment parameters and from this, the sound speed and attenuation data was obtained. These are summarised in Table 6.1. It is noted that the classic 3-layer acoustic model as represented in both BELLHOP and RAM assumes a basement that is semi-infinite in thickness.

Layer	Compressional wave velocity Vp m/s	Density kg/m^3	Attenuation dB/m/kHz	Thickness m
Terrigenous mud	1451	1652	0.468	500
Sandstone basement	5548	2745	0.094	-∞

Table 6.1: Seabed sediment properties for the vicinity of the 2D Seismic Survey Area

6.6. Background Sound

Background sound levels in shallow water are very variable being dependent on shipping activity and marine industrial activity as well as wind speed and rainfall (Urick[37]). Typically, at frequencies around 100 Hz, background sound levels are around 70-80 dB re 1 μPa per Hz.

No data of underwater background sound in the Caspian Sea have been found. However, comparisons may be made with other shallow water sites in which similar hydrocarbon related activity takes place.

The North Sea contains a number of oil fields that are being both developed and commissioned or else are in full operation. Measurements of background sound in the coastal fringe of the North Sea by Nedwell *et al.*[38], indicate a background sound level range of 100-135 dB re 1 μPa with a modal value of 120 dB re 1 μPa. (The report fails to

[32] Shafag Asiman Offshore Block 3d Seismic Exploration Survey Environmental Impact Assessment, Reference No. P140167, Prepared for BP Azerbaijan, 23 August 2011. Accessed:http://www.bp.com/content/dam/bp-country/en_az/pdf/ESIAs/Shafag-Asiman/Shafag-Asiman-3D-seismic-survey-EIA.pdf
[33] Chirag Oil Project, Environmental & Socio-economic Impact Assessment - Volume 1, AIOC Reference Number: BP BFZZZZ, February 2010. Accessed:http://www.bp.com/content/dam/bp-country/en_az/pdf/ESIAs/ACG/COP-ESIA.pdf
[34] E.L. Hamilton (1963), "Sediment Sound Velocity Measurements made In Situ from Bathyscaph TRIESTE", Journal of Geophysical Research 68, pp. 5991-5998.
[35] E.L. Hamilton, (1970), "Sound velocity and related properties of marine sediments, North Pacific", Journal of Geophysical Research 75, pp. 4423-4446.
[36] E.L. Hamilton, (1972), "Compressional-wave attenuation in marine sediments", Geophysics 37, pp. 620-646.
[37] Urick, Robert J. (1983), Principles of Underwater Sound, 3rd Edition. New York. McGraw-Hill.
[38] Nedwell J R, Parvin S J, Edwards B, Workman R, Brooker A G, Kynoch J E, (2008), "Measurement and interpretation of underwater noise during construction and operation of offshore windfarms in UK waters", COWRIE NOISE-03-2003.

explain whether the SPL data are given using RMS or peak values. As it is common practice to present background sound levels in RMS units, it is assumed that the data provided in the report follow this convention.) It is proposed that background sound levels in the vicinity of the 2D Seismic Survey Area are considered in the range of 100-120 dB re 1 μPa (RMS). It must be emphasised that the North Sea data is the best estimate available but nevertheless may not be wholly representative of sound levels in the coastal Caspian Sea.

6.7. Source Modelling Parameters

Sound emitted by a seismic airgun array may be characterised by a pulse of finite duration and covering a wide range of frequencies (see Section 3). For this, a broadband, time-domain propagation model ideally should be used to represent the source and underwater acoustic environment. However, these tend to be difficult to use, and have a considerable time overhead associated with them[26].

An alternative approach is to divide the source frequency bandwidth into 1/3rd octave bands[39] where each band has a given spectral level, centre frequency and bandwidth; and then to use a frequency-domain type program (such as BELLHOP and RAM discussed above) for subsequent propagation modelling. The 1/3rd octave centre frequencies thus selected cover the frequency range of interest for the seismic airgun array and are listed in Table 6.2 while the 1/3rd octave band levels are given in Figure 3.3.

Parameter	
Frequency Hz	**10, 12.5, 16, 20, 25, 31, 40, 50, 63, 80, 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1k, 1.25k, 1.6k, 2k, 2.5k, 3.15k, 4k, 5k, 6.3k, 8k, 10k, 12.5k, 16k, 20k, 25k, 31.5k, 63k, 80k, 100k, 125k, 160k**

Table 6.2: Acoustic modelling frequencies

6.8. Sound Propagation Modelling Scenarios

Using the bathymetric and geo-acoustic data given in the preceding sections, propagation loss data was generated along each of the 12 transects using sound speed profile data for the months of November and December.

The propagation loss data was subtracted from the source level data (equation 2-7) for the seismic airgun array (given in Figure 3.3) in order to arrive at SPL data. A discussion of the results generated by this stage is given in Section 7.

Further calculations are then undertaken as described in Section 8 to allow comparison with relevant impact thresholds as discussed in Section 5.

[39] Kinsler, L.E., Frey, A.R., Coppens, A.B. & Sanders, J.V. (1999) *Fundamentals of Acoustics*, 4th edn.Wiley,NJ.

7. ACOUSTIC PROPAGATION MODELLING RESULTS

For the SWAP airgun array, seismic sound was modelled as a function of range from the source and depth along each of 12 transects using oceanographic conditions for the months of November and December and a source depth of 5 m.

The modelling results indicate that SPLs generally fall with increasing distance from the seismic airgun array. Both bathymetry and the nature of the sound speed profile (SSP), which varies considerably over the months of November and December, can have a significant effect on the SPL at a given location. The bathymetry may give rise to shadow zones into which the seismic airgun sound cannot propagate while the SSP may direct the sound either towards the sea surface where it has the potential to propagate over relatively long distances or else towards the seabed into which it is absorbed and hence propagates over much shorter distances. Each of these features are discussed in further detail below.

A typical result is given in Figure 7.1 which shows the modelled SPL for the month of November along the transect having a bearing of 0° where the water depth decreases from 32 m to zero over a distance of 15 km.

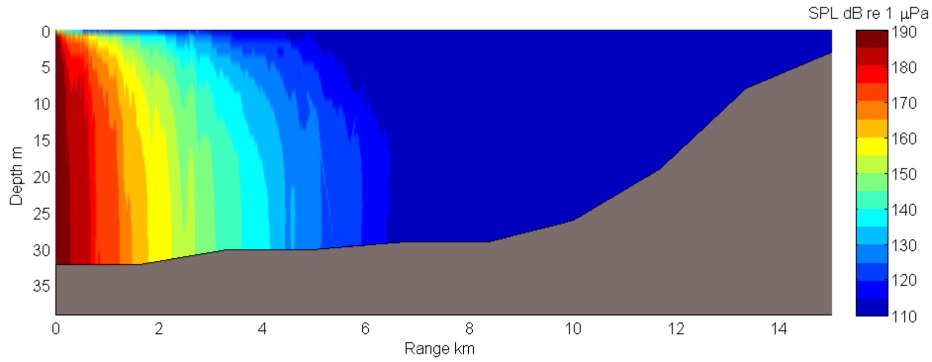


Figure 7.1: Contour plot of seismic sound from the SWAP airgun array as a function of range and depth along the 0° transect for the month of November (note the part coloured grey indicates the seabed)

It will be seen that over most of the water column, the SPL falls from 240.7 dB re 1 μPa to 110 dB re 1 μPa within a distance of 6.5 km from the source. At very shallow depths, the SPLs are much lower compared with those at the same range but greater depth. This arises due to the presence of the downwardly refracting sound speed profile (see Section 5) where in this case, the sound is directed away from the sea surface. In addition, the dissipative nature of the soft clay sediment means that acoustic energy is readily absorbed into the seabed and relatively low levels of sound are subsequently reflected back into the water column.

Figure 7.2 shows SPLs in range and depth over the 90° transect for the month of November. As with the 0° transect, the SPLs are seen to fall rapidly to 110 dB within a distance of 6.5 km from the source.

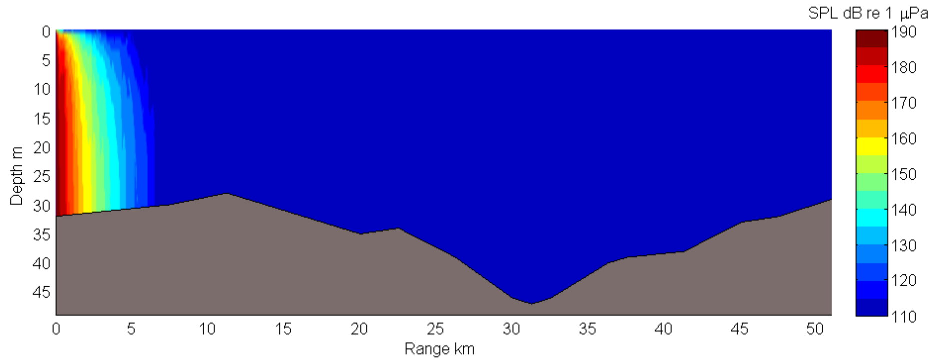


Figure 7.2: Contour plot of seismic sound from the SWAP airgun array as a function of range and depth along the 90° transect for the month of November

Figure 7.3 shows SPL as a function of range and depth over the 0° transect using oceanographic conditions for the month of December. It will be seen that although SPLs fall with increasing range, SPLs at a given depth and range are 20-25 dB higher than those modelled using November oceanographic data. This is attributed to the upwardly refracting nature of the sound speed profile (see Section 5) where sound is directed towards the sea surface.

Figure 7.4 shows SPL modelled over the 30° transect. As with the previous example, it will be seen that SPLs are relatively high at mid-water column locations compared with those modelled using November oceanography. Along this transect however it will be seen that the bathymetry further influences SPL where an intervening subsea ridge creates a shadow zone further down-range. Beyond a distance of 15 km, the seismic sound tends to propagate in a surface duct where at a range of 40-45 km, SPLs are around 120 dB re 1 μPa in the topmost 10 m of the water column and down to 110 dB re 1 μPa below the surface duct.

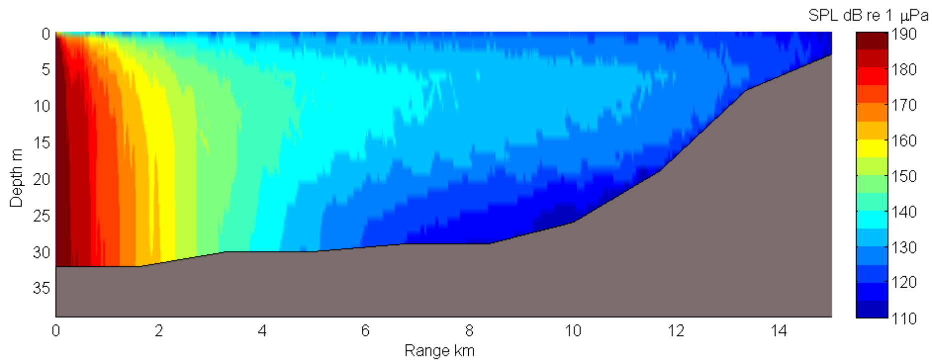


Figure 7.3: Contour plot of seismic sound from the SWAP airgun array as a function of range and depth along the 0° transect for the month of December

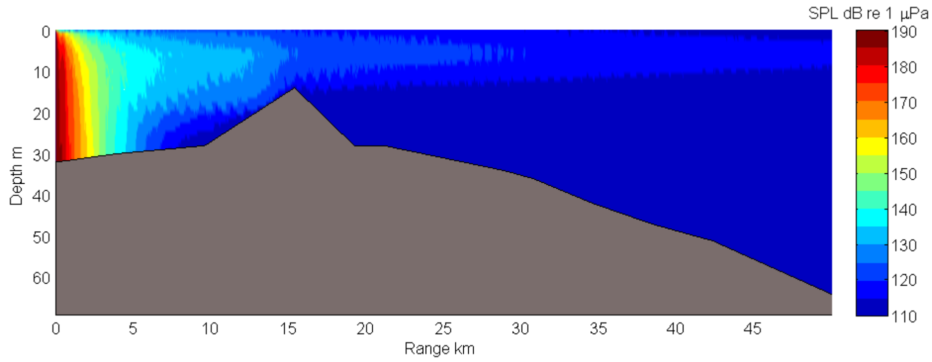


Figure 7.4: Contour plot of seismic sound from the SWAP airgun array as a function of range and depth along the 30° transect for the month of December

Figures showing SPLs as a function of range and depth computed along each transect for the months using November and December oceanographic data are given in Annex A.

8. COMPARISON WITH RELEVANT THRESHOLDS

8.1. Introduction

The previous section discussed the propagation of sound from the seismic source array through the marine environment. This section determines the ranges at which sound levels decrease to below the potential impact thresholds introduced in Section 5.

The assessment of potential acoustic impacts are informed in terms of both peak and RMS sound pressure level (SPL) as well as sound exposure level (SEL) metrics. When using peak SPL metrics, the impact range is determined by comparing a given impact threshold with the sound propagation modelling results shown in Section 7.

The results discussed in Section 7 show that sound propagation potentially varies slightly along each transect and this is attributed to differences in bathymetry. Accordingly, the range to a given threshold also varies slightly along each transect. The range at which each acoustic impact criterion is met and as discussed below is given by the longest of the impact ranges as determined over each of the transects.

Potential impacts based on SEL metrics require the sound exposure of a receptor to be calculated over a period of time and this is subsequently compared with the SEL-based thresholds. The calculations are based on unweighted SELs for fish and M-weighted SELs for pinnipeds (see Section 5). These processes are discussed further and the ranges at which predicted sound levels decrease to below the each acoustic threshold are discussed below. Ranges at which each impact criterion is met along each transect are given in Annex B.

8.2. Single Exposure – Peak and RMS SPL metrics

Using the peak or RMS SPL metrics, distances within which potential impacts may occur are determined by finding the maximum range at any depth in the water column at which the peak SPL is greater than or equal to a given threshold level. This procedure is repeated along each transect and the greatest of all the maximum ranges is taken as the overall distance at which a particular impact criterion is met.

Peak SPLs may be converted to equivalent RMS following consideration of the nature of the signal. For a sinusoidal signal, the relationship between peak level signal and the RMS equivalent is given by peak level – 3dB. Seismic airgun signals are not sinusoidal in shape so this conversion is not valid. Furthermore, during propagation the outgoing airgun signal stretches out in time (see e.g. Urick 1983) and this is attributed to the sound travelling along multiple paths and each arriving at a given location at a slightly different time. As a result, the difference between peak level and RMS varies with distance. Various studies[40,41,42] suggest a range of values between 2 dB and 20 dB. The lower the

[40] Madsen P.T., (2005), “Marine mammals and noise: Problems with root mean square sound pressure levels for transients”, J. Acoust. Soc. Am. 117(6), 2005).

[41] Greene Jnr C.R.,“Physical acoustics measurements”. In: W.J. Richardson (ed.) Northstar Marine Mammal Monitoring Program 1996: Marine Mammal and Acoustical Monitoring of a Seismic Program in the Alaskan Beaufort Sea. LGL Rep 2121-2, LGL Ltd, Canada and Greeneridge Sciences Inc. USA for BP (Alaska) Inc. and Nat. Mar. Fish Serv. Alaska. 245 pp.

conversion factor, the greater the overestimation of RMS SPL. For the purpose of the analysis undertaken in the current study, it is suggested that both 10 dB and 15 dB be used for the conversion thus giving a range of distances to each of the behavioural thresholds.

8.2.1. Fish

The results of the analysis for fish are shown in Table 8.1.

Impact	Threshold dB re 1 μPa	Distance m
Potential mortal injury in fish with low hearing sensitivity exposed to impulse sound Recoverable injury in fish with low hearing sensitivity exposed to impulse sound	213 dB peak	40 m
Potential mortal injury in fish with medium hearing sensitivity exposed to impulse sound Potential mortal injury in fish with high hearing sensitivity exposed to impulse sound Potential mortal injury in fish eggs and larvae exposed to impulse sound Recoverable injury in fish with medium hearing sensitivity exposed to impulse sound	207 dB peak	88 m
Recoverable injury in fish with high hearing sensitivity exposed to impulse sound	203 dB peak	92 m

Table 8.1: Summary of impact ranges for fish species exposed to seismic airgun array sound using peak level metrics

As Table 8.1 shows the distances at which the sound level decreases to below the various threshold criteria for both potential mortal injury and recoverable injury for all fish groupings. All distances are short-range and are thus unaffected by seasonal changes in the sound speed profile. In addition, they are all close to the near-field region of the source array.

For fish with low hearing sensitivity, peak sound levels decrease to below the threshold for potential mortal injury and recoverable injury (both represented by the 213 dB re 1 μPa peak threshold) beyond a distance of 40 m from the source array. For those species having medium and high hearing sensitivity, as well as for fish eggs and larvae, peak sound levels decrease to below the threshold for potential mortal injury (represented by the 207 dB re 1 μPa peak threshold) beyond a distance of 88 m from the source array. Similarly, the range at which recoverable injury in fish with high hearing sensitivity (as represented by the 203 dB re 1 μPa threshold) peak sound levels decrease to below the threshold beyond a distance of 92 m from the source array.

8.2.2. Pinnipeds

The results of the analysis for pinnipeds are shown in Table 8.2.

[42] McCauley, R.D., Fewtrell, J., Duncan, A.J., Jenner, C., Jenner, M.N., Penrose, J.D., Prince, R.I.T., Adhitya, A., Murdoch, J. and McCabe, K. (2000). Marine seismic surveys – a study of environmental implications. APPEA Journal 2000:692-708.

Potential Impact	Threshold dB re 1 μPa	Distance m	
		Nov	Dec
Permanent Threshold Shift (PTS) onset	218 dB peak	20 m*	20 m*
Temporary Threshold Shift (TTS) onset	212 dB peak	45 m*	45 m*
Avoidance Behaviour	190 dB RMS[1]	75 m	75 m
Avoidance Behaviour	190 dB RMS[2]	115 m	105 m
Limited disturbance	180 dB RMS[1]	165 m	165 m
Limited disturbance	180 dB RMS[2]	255 m	285 m
Limited disturbance	150 dB RMS[1]	1.53 km	1.54 km
Limited disturbance	150 dB RMS[2]	2.0 km	2.0 km
Background level	120 dB RMS[1]	4.3 km	9.4 km
Background level	120 dB RMS[2]	5.1 km	17 km
Background level	110 dB RMS[1]	5.5 km	31 km
Background level	110 dB RMS[2]	6.2 km	51 km
Background level	100 dB RMS[1]	7.3 km	51 km
Background level	100 dB RMS[2]	7.9 km	51 km

Table 8.2: Summary of impact ranges for pinnipeds exposed to seismic airgun sound based on peak level and RMS metrics (* - maximum range derived from near-field source level model; [1] – based on Peak level – 15 dB; [2] - based on Peak level – 10 dB)

It will be seen that the sound levels generated by the SWAP 2D seismic airgun array decrease to below the threshold for both PTS and TTS (represented by the 218 dB re 1 μPa peak and 212 dB re 1 μPa peak thresholds respectively) beyond distances of 20m and 45m respectively, both of which are within or close to the near-field of the array itself.

When RMS SPLs are around 190 dB re 1 μPa, avoidance behaviour reactions may occur in pinnipeds and these are likely to occur out to a distance of 75 m from the array. At lower RMS SPLs, in the range 150-180 dB re 1μPa, limited disturbance reactions may be evident over distances varying from 165 m to 2.0 km. Thus far, the short distances considered are seen not to vary significantly over the times of year for which the seismic survey is planned: the distances are relatively insensitive to the influence that the environment has on acoustic propagation.

The distances over which the airgun sound may become inaudible to a pinniped depends on background sound levels. A range of values are given from 100 dB re 1 μPa (RMS) to 120 dB re 1 μPa (RMS). Accordingly, limiting distances vary between 4.3 km when background levels are high to 51 km when levels are low. It is noted that longer limiting ranges tend to occur during December.

8.3. Cumulative Exposure – SEL Metrics

8.3.1. Introduction

The cumulative build-up of sound for a receptor is estimated using a moving animal and source model[43] where the animal moves away from the source and through the sound field, starting at various distances from the sound source and over a period of time. For each sound source – animal separation, the corresponding SPL is determined using data from the 90° transect[44]. The SEL is calculated using eqn 2-4 in Section 2 and the cumulative SEL is determined by summing the SEL over a given time. The SEL as a function of time is compared with threshold levels given in Tables 5.1 and 5.2 in order to determine the range at which the threshold is met. .For fish, the SEL is unweighted while for pinnipeds, the M-weighting function is applied to the SEL (see Section 5.3.2).

8.3.2. Moving Animal/Source Scenario

The cumulative dose for an animal is dependent not only on its hearing sensitivity to the sound but also on its proximity and duration of exposure to a sound source. Any result arising from a given sound - animal scenario therefore is unique to that specific model scenario only. Nevertheless the results from modelling several scenarios provide some boundary conditions for real-world source-receiver movement scenarios to inform an assessment using a cumulative SEL threshold criterion.

For the animal – sound source scenarios considered, it is assumed that the seismic survey airgun array is transiting at a speed of 2.3 m/s (corresponding to a typical survey vessel tow speed of 4.5 knots[45]) and at a bearing of 270° from a nominal point of origin. It is further assumed that an animal swims from a given start location relative to the seismic airgun array on a constant bearing of 180° and at a constant speed of 0.2 m/s for the fish[46] and typically 2.6 m/s for the seal[47].

As the animal moves through the acoustic field, it experiences a sound level that can be represented as either an instantaneous SPL or a SEL both of which vary over time as the animal moves. The relative locations and velocities of the source and animal are indicated in Figure 8.1 where it will be seen that the distance between the two at time t_n is denoted by $r(t_n)$. For each separation range, the SPL and SEL are calculated. For pinnipeds, the SEL has the M-weighting applied to it whilst for fish, the SEL is unweighted. The movement of the animal is modelled over three different paths (path a, b and c) with each having a different closest point of approach (CPA). The SPL and SEL as a function of time is shown in Figure 8.2 for each of three typical paths a, b, and c over which the animal may travel for a total exposure duration of 600 seconds. The three

[43] Theobald P., Lepper P., Robinson S., Hazelwood D., (2009), "Cumulative Noise Exposure Assessment For Marine Mammals Using Sound Exposure Level As A Metric", UAM Conference Proceedings 2009.
[44] The 90° transect has a mean depth of 35 m. Acoustic propagation along this transect is deemed representative of propagation over all the transects.
[45] "An overview of marine seismic operations", (2011), OGP IAGC Report No. 448. Accessed http://www.ogp.org.uk/pubs/448.pdf
[46] Based on a sustained swim speed for a sturgeon - http://www.fsl.orst.edu/geowater/FX3/help/FX3_Help.html#9_Fish_Performance/Fish_Length_and_Swim_Speeds.htm
[47] Gallon, S. L., Sparling, C. E., Georges, J-Y., Fedak, M. A., Biuw, M., & Thompson, D. (2007). How fast does a seal swim? Variations in swimming behaviour under differing foraging conditions. The Journal of Experimental Biology, **210**, 3285-3294.

paths each represent a different start location with Path a being the furthest from the sound source and Path c being the nearest. On Path c, due to its relative proximity to the sound source, it will be seen that the SEL builds up quicker than it does on Paths b and a.

This process was repeated a total of 2000 times, each time with a different location along each of the paths a, b or c, for each animal grouping categorised by hearing sensitivity, and using SPLs computed using oceanographic conditions for the months of November and December. Subsequently, the maximum SEL generated during each run is presented as a function of its corresponding start location. The results are shown in Figures 8.3 and 8.4 for pinnipeds and fish respectively.

8.3.3. Cumulative Exposure Modelling Results

The results of the cumulative sound modelling undertaken using the SEL metric are presented within Table 8.3.

The SELs given as a function of start distance illustrated in Figures 8.3 and 8.4 can be compared with the M-weighted SEL thresholds for pinnipeds given in Table 5.1 and the unweighted SEL thresholds for fish given in Table 5.2.

The modelling results suggest cumulative sound level would be below the SEL PTS and TTS threshold for pinnipeds beyond a distance of 349 m (November) or 379 m (December) and 1.7 km (November & December) from the airgun source array respectively. Similar criteria may be used to assess the impact of seismic airgun array sound on fish. Mortal injury and recoverable injury are not likely beyond between <1 m and 79 m depending on fish auditory sensitivity and season. For fish having low, medium and high auditory sensitivities, temporary hearing damage indicated by the TTS impact criterion, may occur at a maximum range of 1029 m.

In general, for the longer range impacts it is noted that there is some seasonal variation with the longer ranges occurring during the month of December.

Species	Impact	SEL Threshold dB re 1 μPa^2.s	Impact ranges	
			Nov	Dec
Pinnipeds	Onset of PTS	186 dB	349 m	379 m
	Onset of TTS	171 dB	1759 m	1729 m
Fish	Potential mortal injury in fish with low hearing sensitivity	219 dB	<1 m	<1 m
	Potential mortal injury in fish with medium hearing sensitivity; and in eggs & larvae	210 dB	49 m	49 m
	Potential mortal injury in fish with high hearing sensitivity	207 dB	59 m	79 m
	Recoverable injury in fish with low hearing sensitivity	216 dB	<1 m	<1 m
	Recoverable injury in fish with medium and high hearing sensitivity	207 dB	59 m	79 m
	TTS in all fish	186 dB	989 m	1029 m

Table 8.3: Summary of cumulative acoustic impacts for pinnipeds and fish exposed to SWAP airgun array

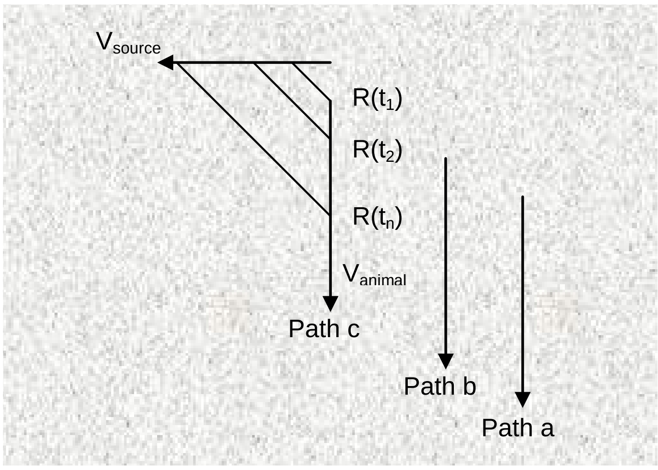


Figure 8.1: Schematic showing relative locations and velocities of source and receptor for three different paths (paths shown horizontally separated for clarity)

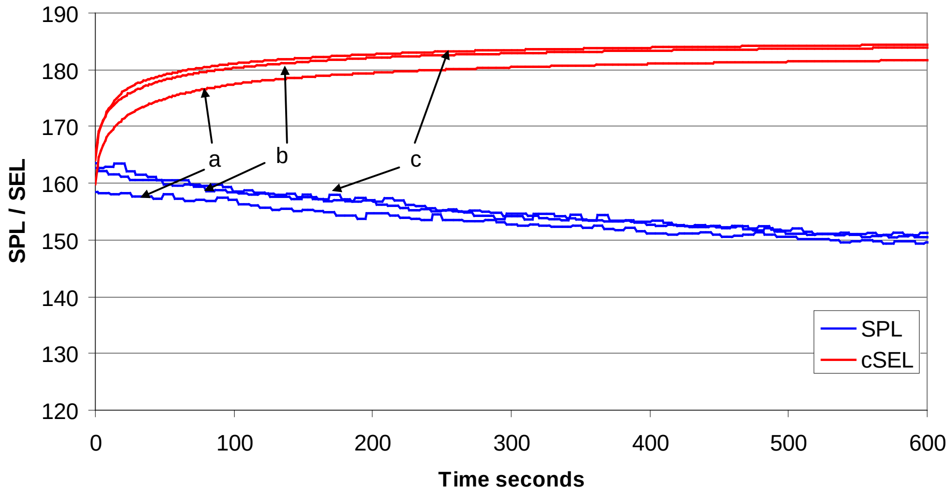


Figure 8.2: Typical instantaneous SPL and cumulative SEL on an animal for a 600 second exposure duration

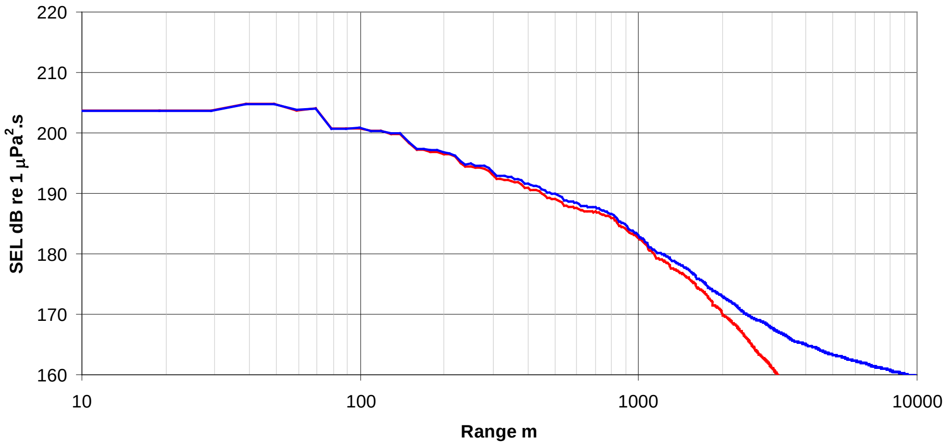


Figure 8.3: SEL as a function of starting range for a pinniped moving in the seismic array sound field

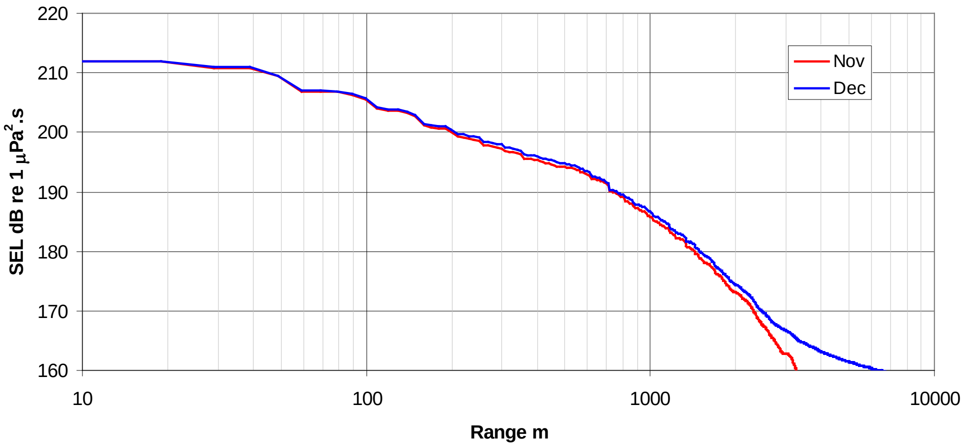


Figure 8.4: SEL as a function of starting range for a fish moving in the seismic array sound field

9. SUMMARY AND CONCLUSIONS

Man-made underwater sound will be generated during the proposed SWAP seismic airgun survey planned for the Caspian Sea. The sound thus produced has the potential to impact on biological receptors in the marine environment.

A simple model was developed in order to estimate the near-field acoustic source level for the seismic airgun array. This resulted in a source level of 224.8 dB re 1 μPa compared with a level approximately 16 dB higher which would have been derived from far-field modelling assumptions. The improved accuracy of the source modelling helps to ensure that source sound levels are not over-estimated within the near-field of the seismic airgun array.

A number of marine species have been identified as being of specific concern to the SWAP survey. These are the Caspian seal and species of fish including members of the sturgeon, lamprey and shad families. The published literature was accessed to determine threshold values relating to potential acoustic impacts on marine life. The potential impacts considered were mortality; auditory impairment (Permanent and Temporary Threshold Shift) and behavioural reactions, which were assessed based on peak SPL and cumulative SEL metrics derived from studies by Southall *et al*.[14] and Popper *et al*.[19].

Underwater acoustic propagation modelling was undertaken using site- and time- specific environmental data relating to the SWAP Contract Area and the results were applied to the source data for the SWAP 2D seismic airgun array.

Ranges for impacts based on peak SPL metrics are given in Tables 9.1 and 9.2 for fish, and pinnipeds respectively. The analysis showed that sound levels generated by the SWAP seismic airgun array fall below the level relating to potential mortality in fish at distances of 40 – 88 m from the array depending on the hearing sensitivity of the species considered. Recoverable injury in fish is found to arise over largely the same distances.

When using the same metrics, the analysis showed that sound pressure levels fall below that which may cause PTS and TTS in pinnipeds at distances of 23 m and 45 m respectively from the array. It is noted that these ranges are within or close to the acoustic near-field of the seismic array. Based on RMS metrics, sound levels fall to thresholds corresponding to the occurrence of avoidance behavioural responses at distances up to 75 m from the array while threshold levels denoting limited behavioural reactions occur at ranges from 165 m to 2.0 km depending on the time of year considered.

In order to determine the sensitivity of pinnipeds and fish to airgun array sound using energy-level metrics, a moving animal/source model was constructed and the results are given in Table 9.4. The results showed that for pinnipeds, the threshold for PTS may be exceeded if they approach the airgun array closer than 379 m while the onset of TTS may be avoided by remaining further than 1.7 km. For fish, potential mortal injury and recoverable injury may occur if the animal approaches within 79 m of the array. The onset of TTS will be avoided provided the fish approaches no closer than 1029 m from the array.

In general, for the longer range impacts it is noted that there is some seasonal variation with the longer ranges occurring during the month of December.

Impact	Threshold dB re 1 μPa	Distance m
Potential mortal injury in fish with low hearing sensitivity exposed to impulse sound Recoverable injury in fish with low hearing sensitivity exposed to impulse sound	213 dB peak	40 m
Potential mortal injury in fish with medium hearing sensitivity exposed to impulse sound Potential mortal injury in fish with high hearing sensitivity exposed to impulse sound Potential mortal injury in fish eggs and larvae exposed to impulse sound Recoverable injury in fish with medium hearing sensitivity exposed to impulse sound	207 dB peak	88 m
Recoverable injury in fish with high hearing sensitivity exposed to impulse sound	203 dB peak	92 m

Table 9.1: Summary of impact ranges for fish species exposed to seismic airgun array sound using peak level metrics

Potential Impact	Threshold dB re 1 μPa	Distance m	
		Nov	Dec
Permanent Threshold Shift (PTS) onset	218 dB peak	20 m*	20 m*
Temporary Threshold Shift (TTS) onset	212 dB peak	45 m*	45 m*
Avoidance Behaviour	190 dB RMS[1]	75 m	75 m
Avoidance Behaviour	190 dB RMS[2]	115 m	105 m
Limited disturbance	180 dB RMS[1]	165 m	165 m
Limited disturbance	180 dB RMS[2]	255 m	285 m
Limited disturbance	150 dB RMS[1]	1.53 km	1.54 km
Limited disturbance	150 dB RMS[2]	2.0 km	2.0 km
Background level	120 dB RMS[1]	4.3 km	9.4 km
Background level	120 dB RMS[2]	5.1 km	17 km
Background level	110 dB RMS[1]	5.5 km	31 km
Background level	110 dB RMS[2]	6.2 km	51 km
Background level	100 dB RMS[1]	7.3 km	51 km
Background level	100 dB RMS[2]	7.9 km	51 km

Table 9.2: Summary of impact ranges for pinnipeds exposed to seismic airgun sound based on peak level and RMS metrics (* - maximum range derived from near-field source level model; [1] – based on Peak level – 15 dB; [2] - based on Peak level – 10 dB)

Species	Impact	SEL Threshold dB re 1 μPa^2.s	Impact ranges	
			Nov	Dec
Pinnipeds	Onset of PTS	186	349 m	379 m
	Onset of TTS	171	1759 m	1729 m
Fish	Potential mortal injury in fish with low hearing sensitivity	219	<1 m	<1 m
	Potential mortal injury in fish with medium hearing sensitivity; and in eggs & larvae	210	49 m	49 m
	Potential mortal injury in fish with high hearing sensitivity	207	59 m	79 m
	Recoverable injury in fish with low hearing sensitivity	216	<1 m	<1 m
	Recoverable injury in fish with medium and high hearing sensitivity	207	59 m	79 m
	TTS in all fish	186	989 m	1029 m

Table 9.3: Summary of cumulative acoustic impacts for pinnipeds and fish exposed to SWAP airgun array

Annex A

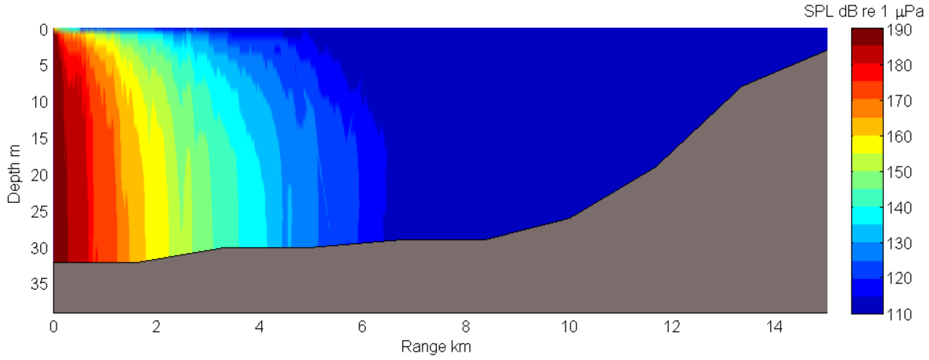


Figure A.1: Contour plot of SPL as a function of range and depth along the 0° transect during the month of November

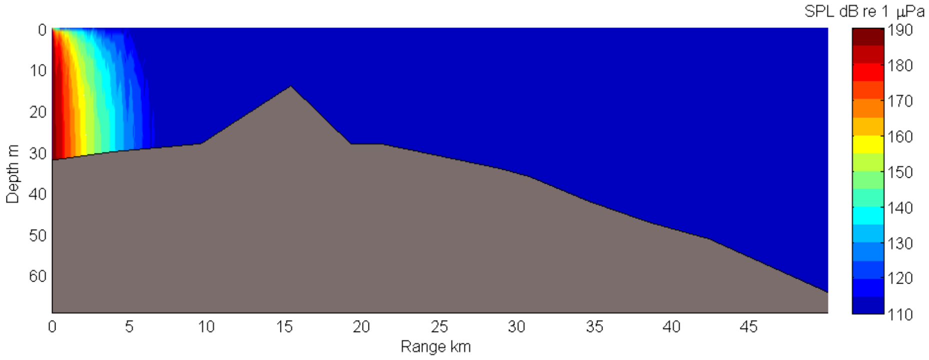


Figure A.2: Contour plot of SPL as a function of range and depth along the 30° transect during the month of November

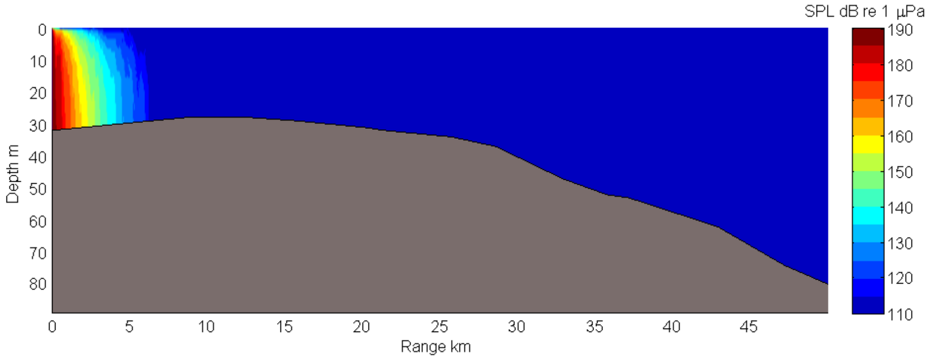


Figure A.3: Contour plot of SPL as a function of range and depth along the 60° transect during the month of November

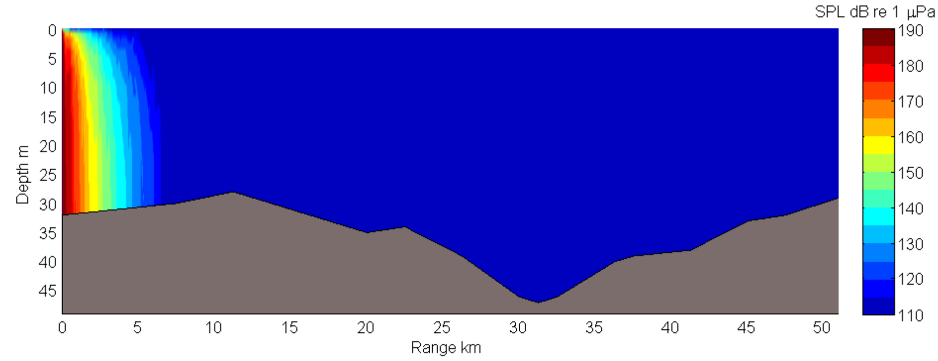


Figure A.4: Contour plot of SPL as a function of range and depth along the 90° transect during the month of November

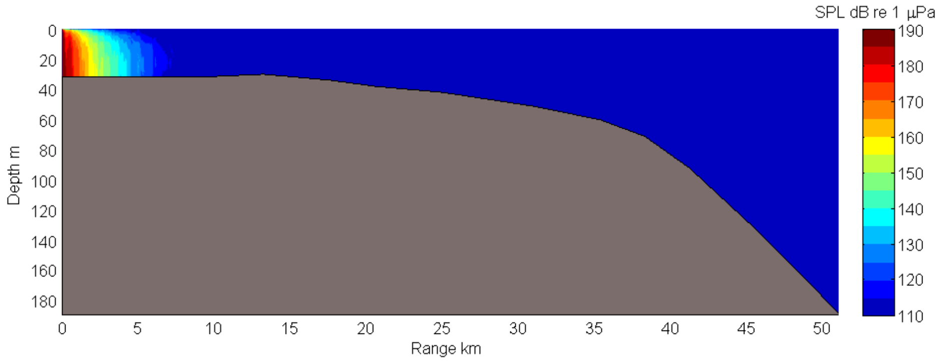


Figure A.5: Contour plot of SPL as a function of range and depth along the 120° transect during the month of November

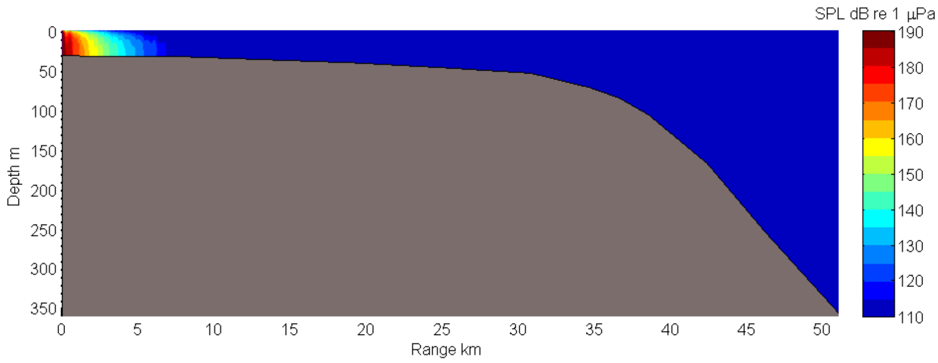


Figure A.6: Contour plot of SPL as a function of range and depth along the 150° transect during the month of November

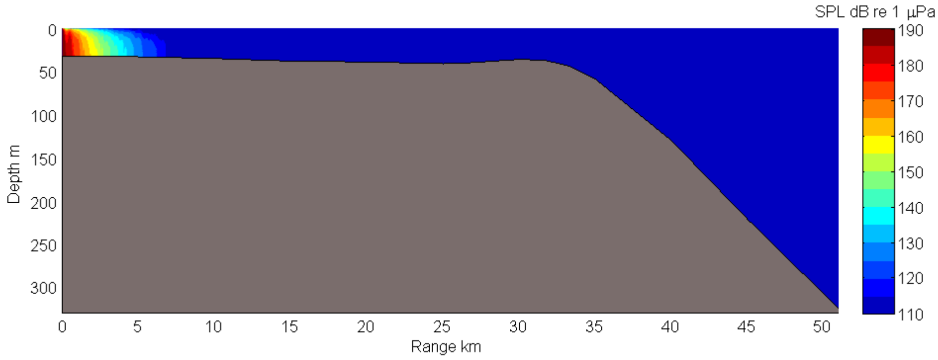


Figure A.7: Contour plot of SPL as a function of range and depth along the 180° transect during the month of November

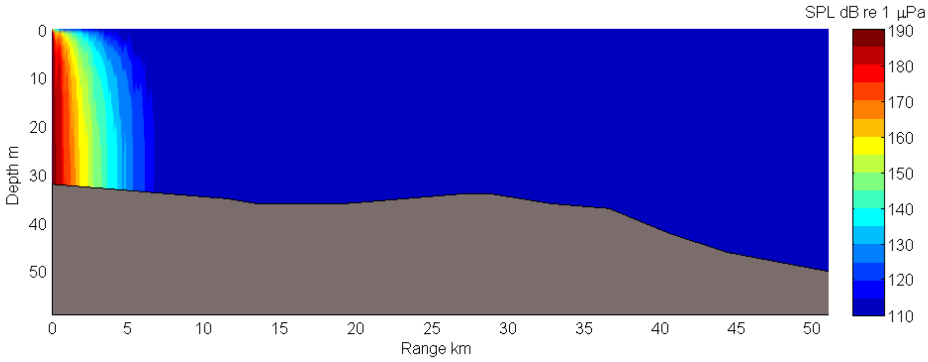


Figure A.8: Contour plot of SPL as a function of range and depth along the 210° transect during the month of November

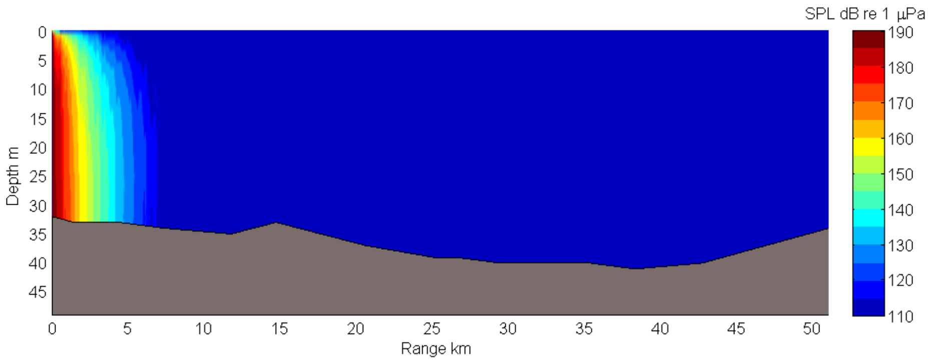


Figure A.9: Contour plot of SPL as a function of range and depth along the 240° transect during the month of November

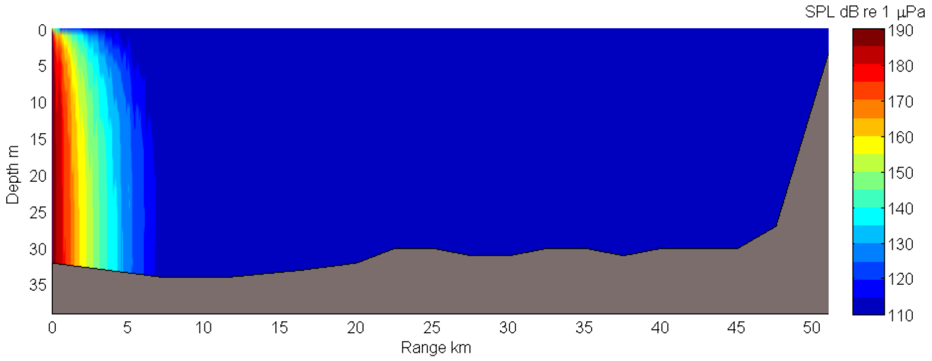


Figure A.10: Contour plot of SPL as a function of range and depth along the 270° transect during the month of November

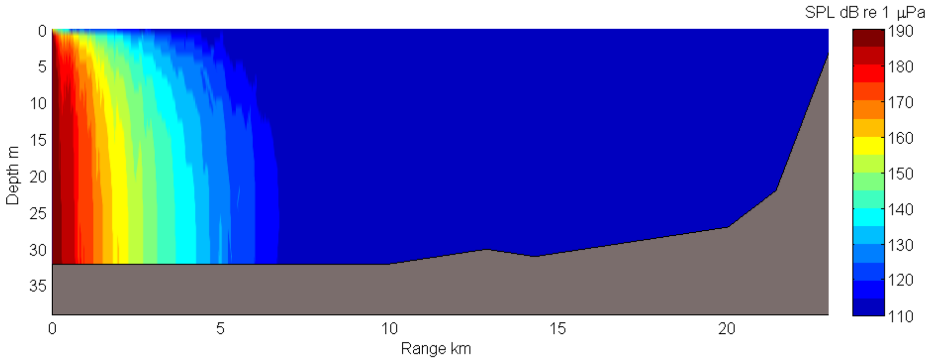


Figure A.11: Contour plot of SPL as a function of range and depth along the 300° transect during the month of November

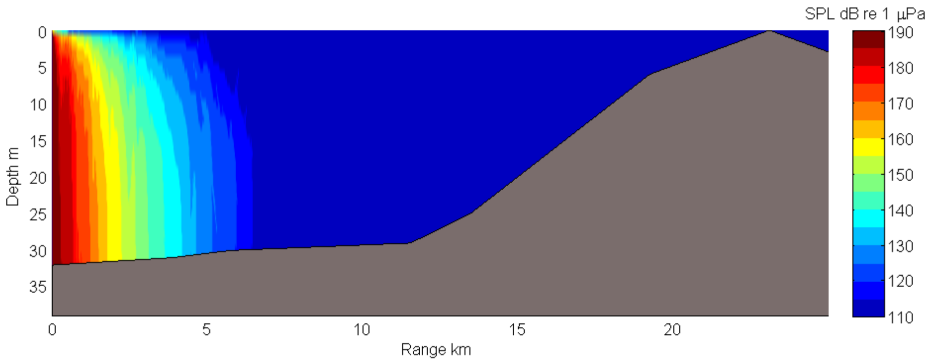


Figure A.12: Contour plot of SPL as a function of range and depth along the 330° transect during the month of November

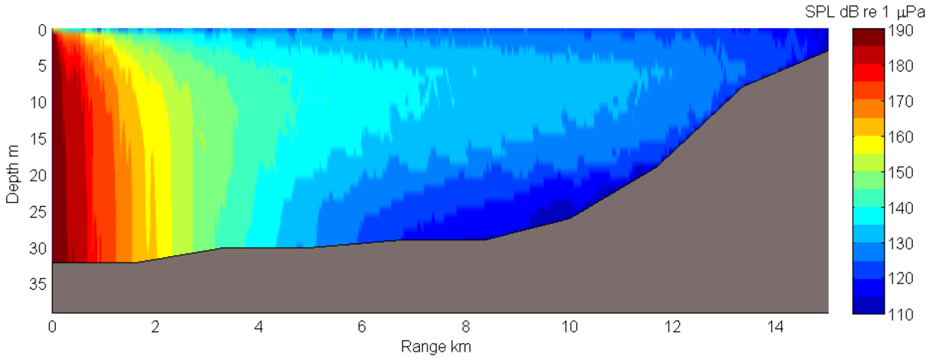


Figure A.13: Contour plot of SPL as a function of range and depth along the 0° transect during the month of December

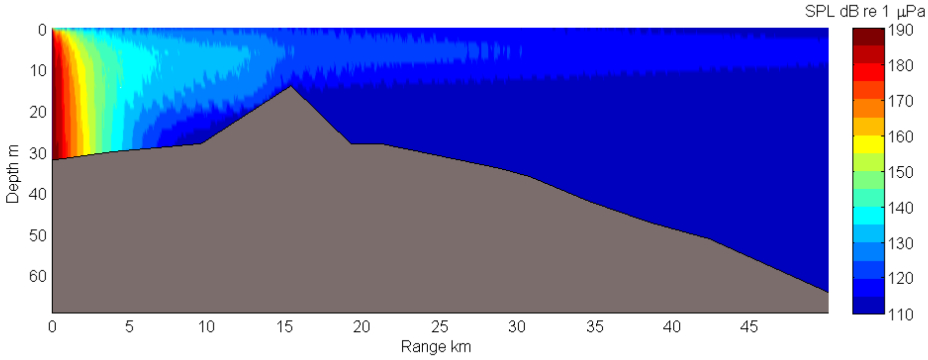


Figure A.14: Contour plot of SPL as a function of range and depth along the 30° transect during the month of December

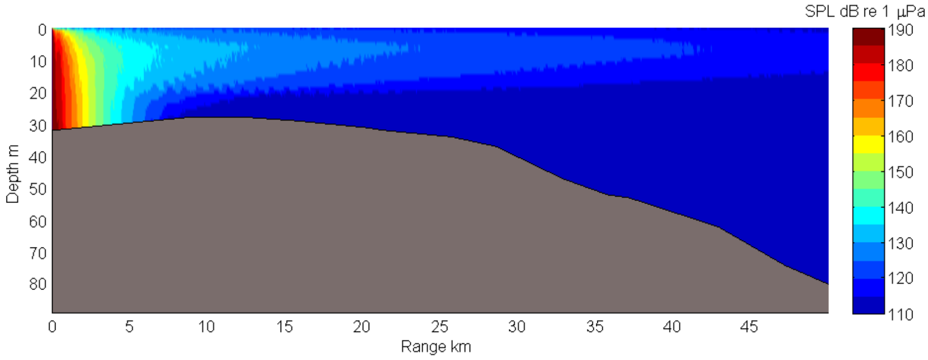


Figure A.15: Contour plot of SPL as a function of range and depth along the 60° transect during the month of December

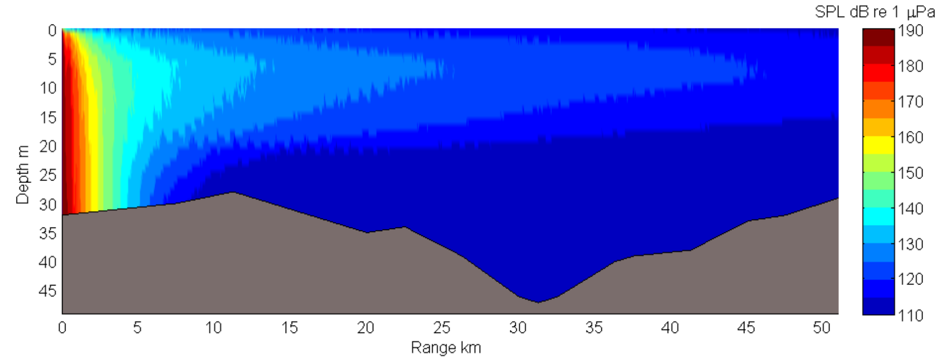


Figure A.16: Contour plot of SPL as a function of range and depth along the 90° transect during the month of December

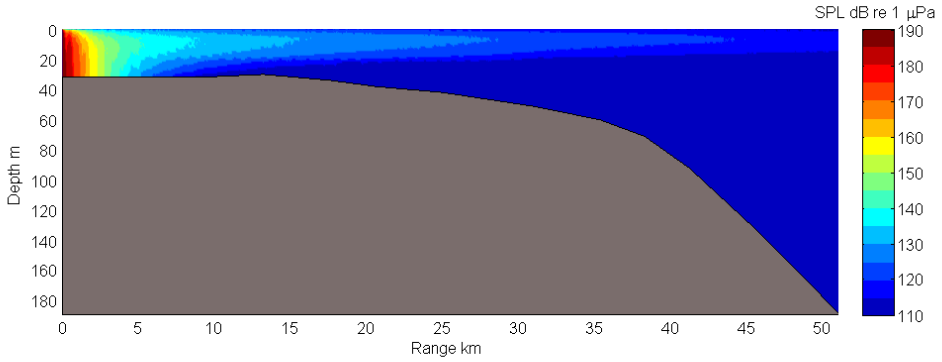


Figure A.17: Contour plot of SPL as a function of range and depth along the 120° transect during the month of December

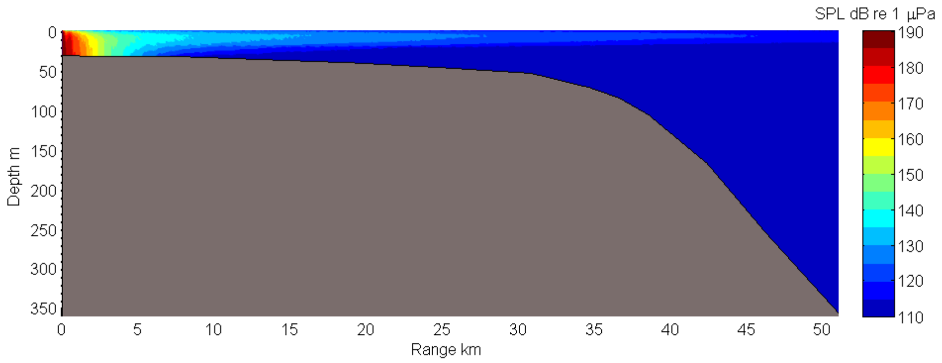


Figure A.18: Contour plot of SPL as a function of range and depth along the 150° transect during the month of December

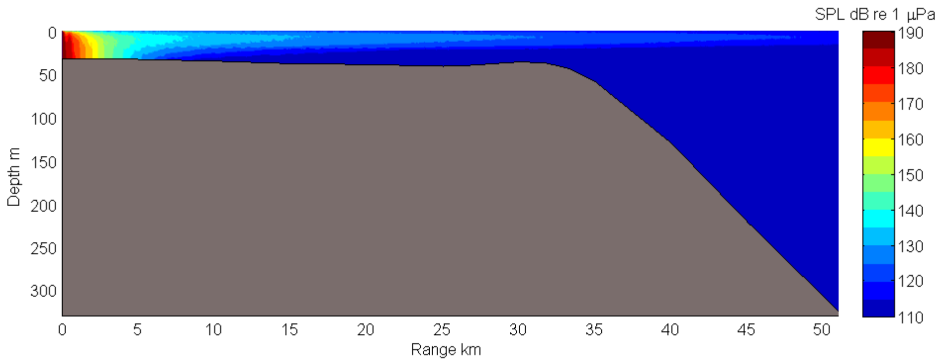


Figure A.19: Contour plot of SPL as a function of range and depth along the 180° transect during the month of December

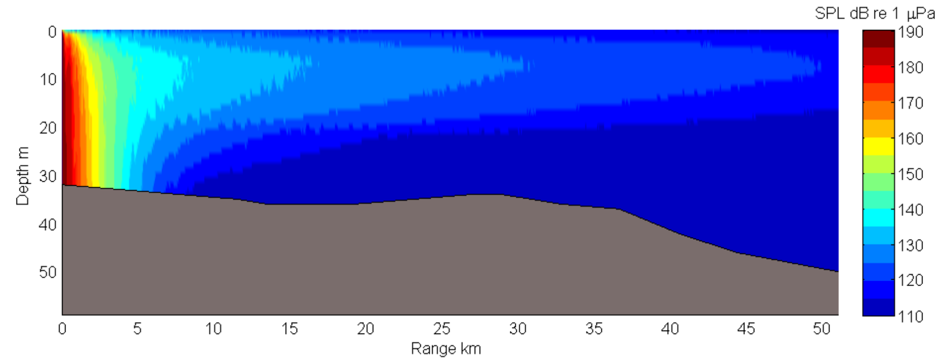


Figure A.20: Contour plot of SPL as a function of range and depth along the 210° transect during the month of December

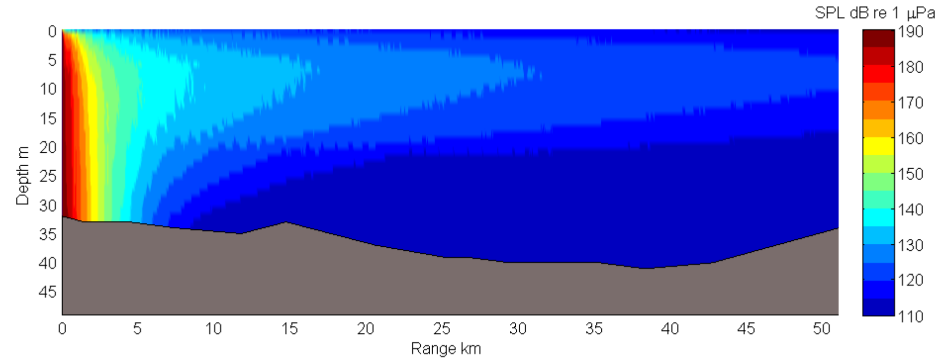


Figure A.21: Contour plot of SPL as a function of range and depth along the 240° transect during the month of December

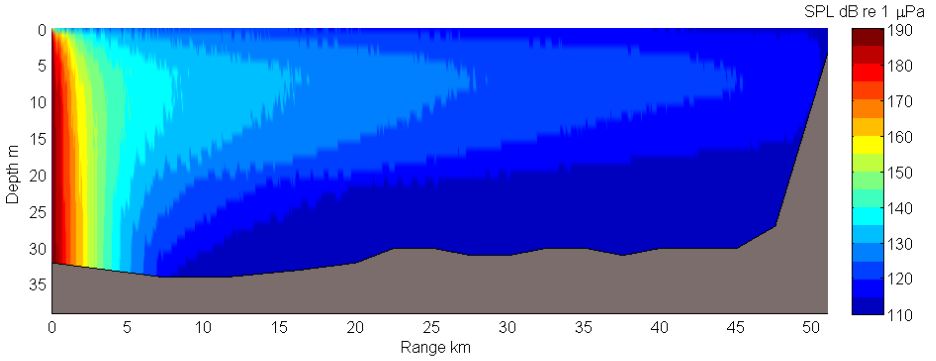


Figure A.22: Contour plot of SPL as a function of range and depth along the 270° transect during the month of December

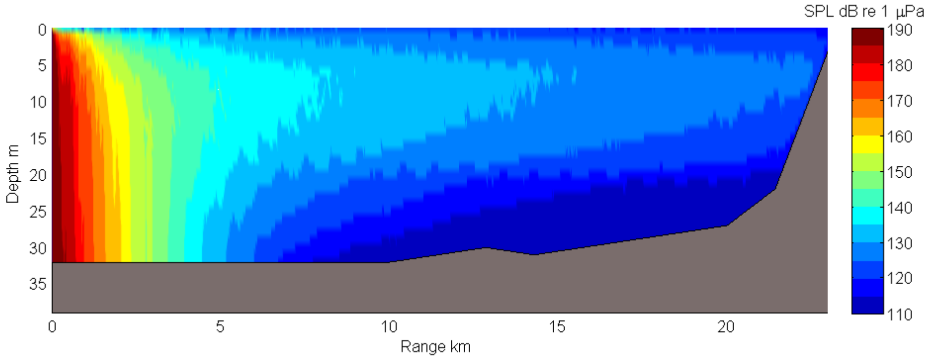


Figure A.23: Contour plot of SPL as a function of range and depth along the 300° transect during the month of December

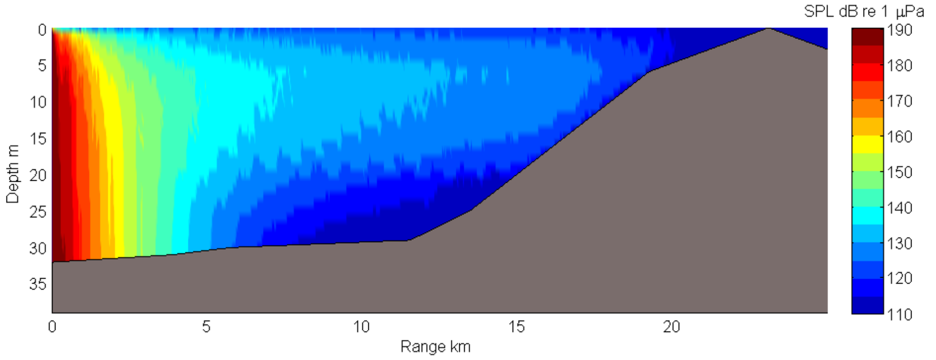


Figure A.24: Contour plot of SPL as a function of range and depth along the 330° transect during the month of December

Annex B

Impact	Threshold dB re 1 μPa	Transect bearing (degrees)												Max range m
		0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°	
Potential mortal injury in fish with low hearing sensitivity exposed to impulse noise Recoverable injury in fish with low hearing sensitivity exposed to impulse noise	213 dB peak	15	0	0	0	0	0	0	0	0	0	23	25	40*
Potential mortal injury in fish with medium hearing sensitivity exposed to impulse noise Potential mortal injury in fish with high hearing sensitivity exposed to impulse noise Potential mortal injury in fish eggs and larvae exposed to impulse noise Recoverable injury in fish with medium hearing sensitivity exposed to impulse noise	207 dB peak	60	50	50	51	51	51	51	51	51	51	46	50	60
Recoverable injury in fish with high or medium hearing sensitivity exposed to seismic sound	203 dB peak	90	50	50	51	51	51	51	51	51	51	92	75	92

Table B.1: Ranges in metres at which SPL has fallen to threshold level along individual transects for fish during the month of November (* - maximum range derived from near-field source level model)

Impact	Threshold dB re 1 μPa	Transect bearing (degrees)												Max range m
		0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°	
Potential mortal injury in fish with low hearing sensitivity exposed to impulse noise Recoverable injury in fish with low hearing sensitivity exposed to impulse noise	213 dB peak	15	0	0	0	0	0	0	0	0	0	23	25	40*
Potential mortal injury in fish with medium hearing sensitivity exposed to impulse noise Potential mortal injury in fish with high hearing sensitivity exposed to impulse noise Potential mortal injury in fish eggs and larvae exposed to impulse noise Recoverable injury in fish with medium hearing sensitivity exposed to impulse noise	207 dB peak	60	50	50	51	51	51	51	51	51	51	46	50	60
Recoverable injury in fish with high or medium hearing sensitivity exposed to seismic sound	203 dB peak	90	50	50	51	51	51	51	51	51	51	92	75	92

Table B.2: Ranges in metres at which SPL has fallen to threshold level along individual transects for fish during the month of December (* - maximum range derived from near-field source level model)

Impact	Threshold dB re 1 μPa	Transect bearing (degrees)												Max range m
		0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°	
Auditory injury (PTS) onset in pinnipeds	218 dB peak	15	0	0	0	0	0	0	0	0	0	0	0	20*
Temporary deafness (TTS) onset in pinnipeds	212 dB peak	30	0	0	0	0	0	0	0	0	0	23	25	45*
Limited disturbance in pinnipeds exposed to impulsive sounds	190 dB (RMS)[1]	75	50	50	51	51	51	51	51	51	51	69	75	75
Limited disturbance in pinnipeds exposed to impulsive sounds	190 dB (RMS)[2]	105	100	100	102	102	102	102	102	102	102	115	100	115
Limited disturbance in pinnipeds exposed to impulsive sounds	180 dB (RMS)[1]	165	150	150	153	153	153	153	153	153	153	161	150	165
Limited disturbance in pinnipeds exposed to impulsive sounds	180 dB (RMS)[2]	240	250	250	255	255	255	255	255	255	204	230	225	255
Limited disturbance in pinnipeds exposed to impulsive sounds	150 dB (RMS)[1]	1485	1500	1500	1479	1479	1530	1530	1530	1479	1479	1518	1500	1530
Limited disturbance in pinnipeds exposed to impulsive sounds	150 dB (RMS)[2]	1800	1900	1900	1836	1836	1887	1887	1938	1836	1989	2001	1975	2001

Table B.3: Ranges in metres at which SPL has fallen to threshold level along individual transects for pinnipeds during the month of November (* - maximum range derived from near-field source level model; [1] – based on Peak level – 15 dB; [2] - based on Peak level – 10 dB)

Impact	Threshold dB re 1 μPa	Transect bearing (degrees)												Max range m
		0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°	
Auditory injury (PTS) onset in pinnipeds	218 dB peak	15	0	0	0	0	0	0	0	0	0	0	0	20*
Temporary deafness (TTS) onset in pinnipeds	212 dB peak	30	0	0	0	0	0	0	0	0	0	23	25	45*
Moderate level disturbance in pinnipeds exposed to impulsive sounds	190 dB (RMS)[1]	75	50	50	51	51	51	51	51	51	51	69	75	75
Moderate level disturbance in pinnipeds exposed to impulsive sounds	190 dB (RMS)[2]	105	100	100	102	102	102	102	102	102	102	115	100	105
Moderate level disturbance in pinnipeds exposed to impulsive sounds	180 dB (RMS)[1]	165	150	150	153	153	153	153	153	153	153	161	150	165
Moderate level disturbance in pinnipeds exposed to impulsive sounds	180 dB (RMS)[2]	285	250	250	255	255	255	255	255	255	204	276	275	285
Low level disturbance in pinnipeds exposed to impulsive sounds	150 dB (RMS)[1]	1545	1600	1650	1581	1581	1632	1632	1632	1632	1581	1587	1575	1545
Low level disturbance in pinnipeds exposed to impulsive sounds	150 dB (RMS)[2]	2025	2050	1950	1887	1836	1989	2040	1989	1938	2040	2047	2050	2025

Table B.4: Ranges in metres at which SPL has fallen to threshold level along individual transects for pinnipeds during the month of December (* - maximum range derived from near-field source level model; [1] – based on Peak level – 15 dB; [2] - based on Peak level – 10 dB)

Threshold	Threshold dB re 1 μPa	Transect bearing (degrees)												Max range m
		0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°	
Background noise level	120 dB (RMS)[1]	4185	4100	4100	4233	4233	4182	4284	4284	4182	4284	4278	4200	4284
	120 dB (RMS)[2]	4620	4600	4700	4590	5100	4794	4692	4845	4794	5100	5037	4650	5100
	110 dB (RMS)[1]	5340	5350	5300	5355	5406	5355	5304	5355	5406	5304	5543	5300	5543
	110 dB (RMS)[2]	5925	5850	6000	6018	6171	6222	6222	6069	6171	6069	6003	5950	6222
	100 dB (RMS)[1]	6465	6700	6900	6477	7293	7344	6885	6681	6987	6783	6716	6475	7344
	100 dB (RMS)[2]	7680	7800	7650	7905	7905	7803	7650	7701	7803	7752	7751	7675	7905

Table B.5: Ranges in metres at which SPL has fallen to background noise levels along individual transects during November
([1] – based on Peak level – 15 dB; [2] - based on Peak level – 10 dB)

Threshold	Threshold dB re 1 μPa	Transect bearing (degrees)												Max range m
		0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°	
Background noise level	120 dB (RMS)[1]	8175	8150	8150	8160	9384	8976	8976	8976	9384	8976	8970	8175	9384
	120 dB (RMS)[2]	11955	13300	13300	13923	16320	16320	16830	16830	16881	16881	15525	14700	16881
	110 dB (RMS)[1]	13380	15550	23650	25704	28611	27846	31518	30957	31467	28560	22517	17700	31518
	110 dB (RMS)[2]	14565	30200	42400	46155	44829	45594	48450	49776	50949	45339	22931	19350	50949
	100 dB (RMS)[1]	14910	49950	49950	50949	50949	50949	50949	50949	50949	50388	22977	20050	50949
	100 dB (RMS)[2]	14985	49950	49950	50949	50949	50949	50949	50949	50949	50847	22977	20525	50949

Table B.6: Ranges in metres at which SPL has fallen to background noise levels along individual transects during December
([1] – based on Peak level – 15 dB; [2] - based on Peak level – 10 dB)

Annex C

Sensitivity of Humans

A number of recreational dive sites are known to be in the vicinity of the proposed seismic survey site. Therefore potential impacts of underwater sound on humans is considered here.

Although the impact of underwater sound on humans has been studied for several decades, there is very little published data on human hearing in water. From the available data, reviewed by Ainslie[1], it is seen that humans are sensitive to underwater sound over the frequency range 25 Hz to 15 kHz. The most sensitive region of the human audiogram lies in the frequency range 200 Hz to 2 kHz where thresholds are as low as 70 dB re 1 μPa.

Potential Impacts and acoustic thresholds – Humans

A review of the published literature revealed that there is relatively little guidance on determining threshold levels of sound that might give rise to potential impacts on human divers following exposure specifically to seismic airgun sound.

A review document, produced by Ainslie[1], pertains to divers exposed to operational sonar. A sonar signal tends to be narrowband in frequency while by contrast, seismic airguns emit sound over a much broader range of frequencies. It is uncertain whether impact guidance for divers subject to seismic sound should be based on threshold data obtained from sonar-based experiments. Two studies are referenced. Fothergill *et al*.[2] reported on US Navy tests on recreational divers. The tests were designed to find the maximum acceptable SPL over the frequency range 600 -- 2500 Hz that did not cause changes in heart rate or breathing frequency in the test subjects. The limiting threshold was found to be 154 dB re 1 μPa. No tests were performed on recreational divers at higher frequencies. Parvin *et al*.[3] carried out a broadly similar set of tests over the frequency range 500 Hz to 2500 Hz and recommend a limiting threshold of 155 dB re 1 μPa.

A later report issued by the UK Health and Safety Executive[4] provides a technique for estimating safe limits for divers when exposed to high levels of sound in the course of their work. The “Control of Noise at Work Regulations (2005)” (CoNaWR2005) define exposure values at which employees must take action to reduce noise hazard on their employees. For sound transmitted through air, the dB(A) scale is used to represent sounds having equal loudness as perceived by the human ear. The A-weighting function takes into account the difference in audiological sensitivity across the frequency range over which human hearing

[1] Ainslie M.A., (2008), “Review of published safety thresholds for human divers exposed to underwater sound”, TNO-DV 2007 A598.
[2] Fothergill D.M., D. Schwaller, S.E. Forsythe, E.A. Cudahy, (2002), “Recreational Diver Responses To 600–2500 Hz Waterborne Sound”, NSMRL Technical Report No. 1223.
[3] Parvin S. J., E.A Cudahy, D.M Fothergill, (2002), “Guidance for diver exposure to underwater sound in the frequency range 500 to 2500 Hz”, *Proceedings of Underwater Defence Technology*.
[4] Anthony T.G., N A Wright & M A Evans, (2009), "Review of diver noise exposure”, Health and Safety Executive Research Report RR735,

responds. The CoNaWR2005 legislation is based on the average daily noise dose of the A-weighted noise energy normalised to an 8-hour working day. Exposure action levels are set at 80 dB(A) and 85 dB(A). It is noted that for every halving of the exposure duration, the exposure thresholds are increased by 3 dB(A).

When divers do not wear helmets, the ear canal fills with water and the water makes contact with the ear drum. The ensuing “wet ear” condition results in human hearing being less sensitive to sound than if the ear was dry. As a result, underwater sound levels must be adjusted through the application of an underwater (UW) weighting function such that the decreased sensitivity is adequately represented. The apparent loudness of a sound source as perceived by a human underwater with “wet ears” may subsequently be compared with the dB(A) exposure action levels. The current study follows this process in order to determine the potential impact arising on humans when exposed to seismic airgun sound.

Comparison with relevant thresholds - Human Divers

The results of the potential impact analysis for human divers exposed to seismic airgun sound are given in Table C.2.

The diver impact criterion, given by thresholds of 85 dB(A) and 80 dB(A) indicate sound energy levels that may be endured over a period of 8 hours without giving rise to hearing damage.. The results show that the sound energy decreases to the threshold levels at distances of 153 m and 255 m respectively. These are relatively short range and thus unaffected by temporal changes in acoustic propagation.

Impact	Threshold dB(A)	Impact ranges	
		Nov	Dec
Diver impact	85	153 m	153 m
Diver impact	80	255 m	255 m

Table C.2: Summary of impact ranges for human divers exposed to seismic airgun sound based on dB(A) metrics

Appendix 7A

SWAP 2D Seismic Survey Oil Spill Contingency and Response (OSCAR) Modelling

1.1 Overview

Spill modelling for the SWAP 2D Seismic Survey was undertaken by BP[1] to examine the potential impacts of an accidental diesel release from a seismic survey vessel. The spill modelling was undertaken using The Foundation for Scientific and Industrial Research (SINTEF) Oil Spill Contingency And Response model (OSCAR).

1.2 Background to the OSCAR Model

The SINTEF OSCAR model is the Segment preferred oil spill fate and trajectory model for Upstream Deep-water operations. OSCAR is a state of the art model and simulation tool for predicting the fates and effects of oil released during an accidental release of oil, either from a platform or a vessel. OSCAR provides insight in the behaviour of oil during an accident and captures the effects of contingency and response, allowing for contingency analysis and planning as well as hind- and forecasting.

OSCAR is a 3-dimensional model that calculates and records the distribution (as mass and concentrations) of contaminants on the water surface, on shorelines, in the water column, and in sediments. The model allows multiple release sites, each with a specified beginning and end to the release. This allows time-variable releases at a given location, as well as throughout the study area. For subsurface releases (e.g. blowouts or pipeline leakages), the near field part of the simulation is conducted with a multi-component integral plume model that is embedded in the OSCAR model. The near field model accounts for buoyancy effects of oil and gas, as well as effects of ambient stratification and cross flow on the dilution and rise time of the plume.

The model output is recorded in three physical dimensions plus time. The model databases supply values for water depth, sediment type, ecological habitat, and shoreline type. The system has an oil physical-chemical database that supplies physical and chemical parameters required by the model.

The model computes surface spreading, slick transport, entrainment into the water column, evaporation, emulsification and shoreline interactions to determine oil drift and fate at the surface. In the water column, horizontal and vertical transport by currents, dissolution, adsorption, settling and degradation are simulated. The varying solubility, volatility, and aquatic toxicity of oil components are accounted by representing the oil in terms of a number of pseudo-components. By modelling the fate of individual pseudo-components, changes in the oil composition due to evaporation and degradation may be accounted for in the toxicity of the dissolved oil fraction.

OSCAR may compute oil weathering from crude assay data, although results that are more reliable are produced if the target oil has been through a standardized set of laboratory weathering procedures established by the SINTEF laboratories. Alternatively, the model may use oil weathering properties from oils for which data already exists, selecting the crude oil in the oil database that most closely matches the composition of the oil of concern.

1.3 Input Data to Run OSCAR

OSCAR accepts input as both 2- and 3-dimensional current data from hydrodynamic models and single point or gridded wind data from meteorological models. An Ekman model integrated into OSCAR computes a wind-driven current which transports entrained oil on the surface

The surface spreading, slick transport, entrainment into the water column, evaporation, emulsification and shoreline interactions processes that determine oil drift and fate are linked to an oil properties database. 27 key compounds within each hydrocarbon stored in the SINTEF database used within OSCAR are analysed in SINTEF laboratories. This ensures accurate representation of physical, chemical and biological behaviour of each hydrocarbon as it is released into the model.

[1] BP, 2015. Technical Report Oil Spill Modelling: SWAP 2D Seismic Survey Vessel Diesel Release. Document No: UHSE-RCE-REP-2015-0011.

1.4 Outputs from Oscar

1.4.1 Types of Output

Both single spill scenarios and stochastic scenarios with variable start times can be simulated. In the stochastic simulations, a specified number of scenarios are simulated subsequently in one run. The set of scenarios to be run may be specified either by selecting the number of scenarios to be simulated within a specified time period (single year statistics), or by specifying the number of scenarios to be run each year in a specified season (multiyear statistics). In order to provide data for computing oil drift statistics, certain oil drift parameters are accumulated for each scenario in each impacted grid cell. These results are in the end used to calculate probabilities for impact in a given cell. The impact is defined in terms of exceeding certain threshold values for oil concentration, thickness or mass. The results are presented as probabilistic maps for the different environmental compartments (sea surface, water column or shoreline).

1.4.2 Stochastic Modelling and Probabilistic Results

The following section describes some of the technical details regarding the statistical output from OSCAR.

The notion of a grid cell will be used, referring to the two-dimensional surface or shoreline grid, or the three-dimensional concentration grid. Each of these grids consists of cells, which represent the smallest area (highest spatial resolution) on which OSCAR operates when producing statistics.

OSCAR produces a set of statistics in its stochastic outputs including

- Maximum or minimum;
- Time-averaged;
- Maximum time-averaged; and
- Probability.

A map of maximum or minimum values can be produced from a stochastic simulation (for example maximum accumulated oil or minimum arrival time). This means that for all time steps and for all simulations, OSCAR has kept a record of the maximum or minimum for that particular value in each grid cell.

For example, the maximum accumulated shoreline oil map, the oil mass in every shoreline cell is checked every time step for every simulation. Whenever OSCAR detects that a shoreline cell has more oil than previously recorded, it will record this new value as the maximum. After all simulations have been performed, this maximum can then be reported for each cell.

Time-averaged statistics are used to produce an average value for a variable. For each simulation, OSCAR monitors each grid cell and records its value unless it has no impact (for example no surface oil or no total concentration). At the end of the simulation, these values are then averaged to produce the time-average. Whenever thresholds are applied pre-processing, the time-average will also exclude values below these specified thresholds.

Maximum time-averaged values can be presented as maps (such as the maximum time-averaged value total concentration). This means that for each grid cell, the value from the simulation with the largest time-average is selected and reported.

Probability maps can also be produced by the stochastic simulation. These maps indicate in the fraction or percentage of the stochastic simulations that reported the specified event (for example oil thicker than some threshold) for each cell. This can be oil on the surface, oil on the shoreline etc.

For example, the shoreline impact probability records each simulation that has some oil that hits a specific grid cell. If then three out of a total of ten simulations record oil hitting this shore cell, the probability for shoreline impact for this cell is 30%. Here there is no weighting for the frequency of oil coming ashore within each scenario.

1.5 OSCAR Set-Up for the SWAP 2D Seismic Survey Spill Modelling

Metocean data from the Imperial College London Regional Earth System (ReEMS) model[2,3,4] was used for all modelled scenarios. Data was provided in the form of 3D currents and 2D winds as set out in Table 7A.1.

Table 7A.1 ReEMS Current and Wind Data

Current and Wind	Imperial College London ReEMS
Data Coverage	01/01/2006 – 31/12/2009
Depth	32 levels, full depth
Horizontal Resolution	4 km
Temporal Resolution	3 hourly
Atmospheric Forcing	ROMS WRF (3-hour)
Vertical Diffusion	Calculated
Tide	Yes
Boundary	Volga, Ural, Samur, Sulak, Terek and Kura Rivers
Current / Wind Domain	36.5N-47.7N, 46.5E-55E

1.5.1 Surface, Shoreline, and Water Column Oil Thresholds

1.5.1.1 Sea-Surface Oil Thickness

A minimum oil thickness threshold of 0.04µm was used within the stochastic simulations. This value is the lower limit of the thinnest oil appearance classification – Sheen – within the Bonn Agreement[5]. Any oil present on the surface thinner than 0.04µm is not included in the stochastic outputs. Surface oil values below this Bonn Agreement Oil Appearance Code (BAOAC) minimum threshold were not exported from OSCAR.

1.5.1.2 Shoreline Emulsion Mass

A minimum threshold for shoreline emulsion mass of 0.169 tonnes/km was used within the stochastic simulations for condensate releases. These values are the lower limit of the "Light Oiling" threshold used by The International Tanker Owners Pollution Federation Ltd (ITOPF)[6]. Shoreline oiling values below this ITOPF minimum threshold were not exported from OSCAR.

The threshold of 0.169 tonnes/km was calculated based on:

a) The length of the hypotenuse of each surface grid (1060m);
b) A mean shoreline width of 2m;
c) Minimum Light Oiling threshold of 0.1litres/m^2; and
d) Emulsion density of 846kg/m^3 @STP (based on 2% water uptake).

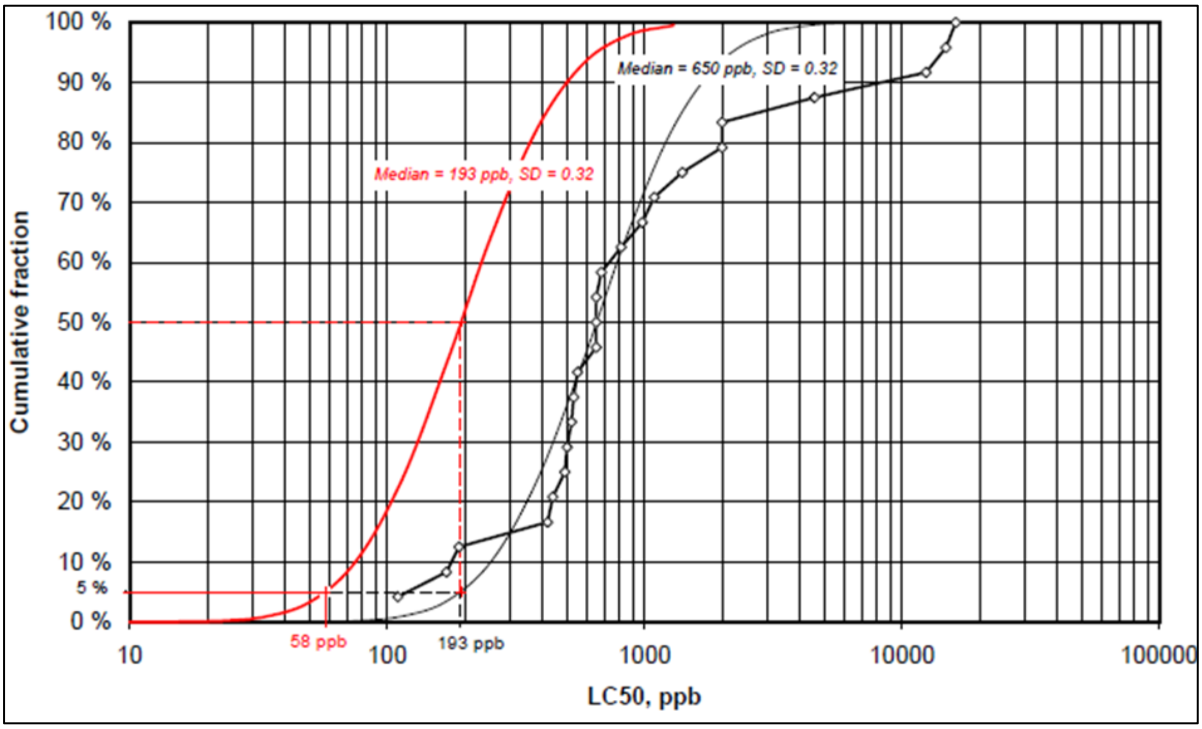
1.5.1.3 Total Diesel Concentrations of Diesel in the Water Column

Total diesel concentrations in the water column pose a risk to organisms when they exceed a certain concentration. Research completed by Statoil and Det Norsk Veritas resulted in the development of species sensitivity dose-response curves to assess the impact to organisms from different water column hydrocarbon concentrations. A 5th percentile LC_{50}[7] for total hydrocarbon concentration was

[2] White, R. H., Toumi, R., 2013. River flow and ocean temperatures: The Congo River. Journal of Geophysical Research-Oceans, 119 (4), 2501-2517.
[3] White, R. H., Toumi, R., 2013. The limitations of bias correcting regional climate model inputs. Geophysical Research Letters, 40 (12), 2907-2912.
[4] Nicholls, J. F., Toumi, R., 2013. On the lake effects of the Caspian Sea. Quarterly Journal of The Royal Meteorological Society, 140 (681), 1399-1408.
[5] Lewis, A., 2007. Current Status of the BAOAC (Bonn Agreement Oil Appearance Code): A report to the Netherlands North Sea Agency - Directie Noordzee.
[6] ITOPF. 2011. Recognition of Oil on Shorelines: Technical Information Paper (TIP) 6. ITOPF, UK. pp12
[7] LC_{50} refers to Lethal Concentration 50%. The concentration of a chemical which=h kills 50% of a sample population.

found to be 58 ppb (see Figure 7A.1). This value of 58 ppb is within this modelling as the lower threshold for potential acute toxicological responses. Concentrations below this threshold are not exported from OSCAR. This is a conservative value as 58 ppb is below the LC_{50} for 95% of species as can be seen from Figure 7A.1.

Figure 7A.1 LC_{50} Values from Toxicity Studies on Dispersed Oil on Various Aquatic Species

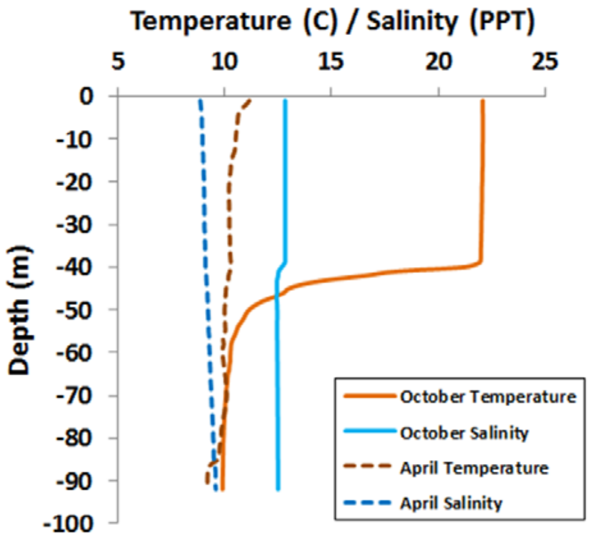


The red line shown in Figure 7A.1 is the cumulative distribution curve of interest. This sensitive species dose-response curve shows the 5 % percentile LC_{50} value and SD = 0.32. From this dose-response curve, the threshold value (5 % lethal risk) is found to be 58 ppb.

1.6 Water Column Conditions

Temperature and salinity data is used within OSCAR to calculate the trajectory and fate of released hydrocarbons. This data is exported from the ReEMS model and averaged for the summer (May - October) and winter (November - April) seasons (see Figure 7A.2). Oxygen content of 10 mg/l was used throughout for both summer and winter scenarios.

Figure 7A.2 Temperature and Salinity Depth Profiles used within the OSCAR Simulations for Summer and Winter



1.7 OSCAR Set-Up

The modelling domain used for the SWAP 2D Seismic Survey diesel releases covers an area from 47.36°E, 36.49°N – 54.33°E, 43.06°N (560km x 730km) which equals 408,800 km^2. The modelling domain with bathymetry is shown in Figure 7A.3 and other OSCAR modelling set-up parameters and release data are outlined in Table 7A.2 and Table 7A.3, respectively.

The vessel diesel spill scenarios modelled for the SWAP 2D Seismic Survey are presented in Table 7A.4.

Figure 7A.3 OSCAR Modelling Domain Used

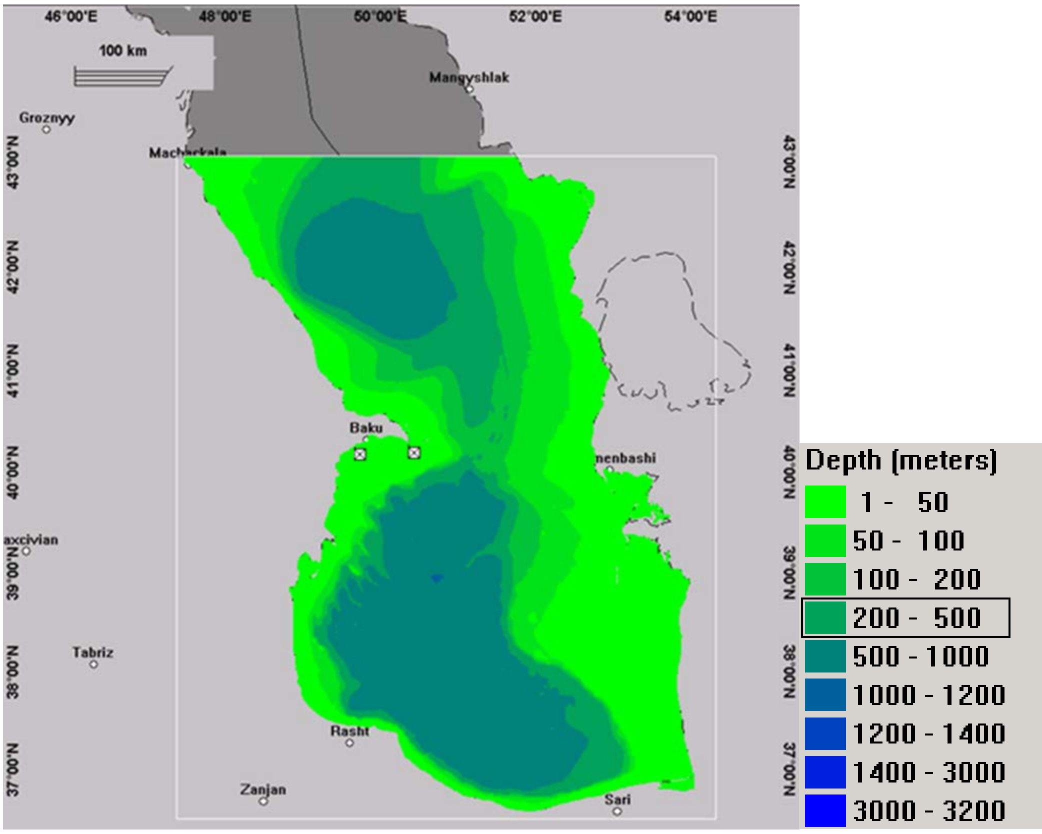


Table 7A.2 OSACR Model Set-Up Parameter for SWAP 2DSeismic Survey Vessel Diesel Release

Release Location	West Positon	Longitude	49° 41' 44.310" East	
		Latitude	40° 10' 14.500" North	
	East Position	Longitude	50° 25' 29.950" East	
		Latitude	40° 11' 46.290" North	
Number of Particles	Liquid / Solid Particles		10,000	
	Dissolved Particle		10,000	
	Gas Particles		1000	
Habitat Grid Spatial Resolution	Resolution in the x-direction (longitude)		750	m
	Resolution in the y-direction (latitude)		750	m
Shoreline Type / Width	Sandy Beach		2	m
Concentration Grid Resolution	Resolution in the x-direction (longitude)		750	m
	Resolution in the y-direction (latitude)		750	m
	Resolution in the z-direction (depth)		5	m
Surface Grid Spatial Resolution	Resolution in the x-direction (longitude)		750	m
	Resolution in the y-direction (latitude)		750	m
Concentration Grid Depth	Min:		0	m
	Max:		50	m
Lower Concentration Limit			58	ppb
Surface Film Thickness	Initial Thickness		1	mm
	Thickness Limit		0.1	mm
	Terminal Thickness		0.04	µm
Computational / Output Time-step	Time-step		3	hours
	Output Interval		20	minutes
Release Period			1	hr
Simulation Period			100	days
Air Temperature	Summer/Winter		25/8	°C

Table 7A.3 Hydrocarbon Properties Marine Diesel

Parameter	Value
Hydrocarbon Name	Marine Diesel (IKU)
Specific gravity	0.843kg/l
API gravity	36.4
Viscosity	3.9 cp @°C
Asphaltene	0%
Wax	0%
Pour point	-36°C

Table 7A.4 SWAP 2 Seismic Survey Vessel Spill Scenarios Modelled

Scenario	Fuel Type	Release Coordinates	Season	Air Temperature (°C)	Volume (m^3)	Release Depth	Release Duration	Total Simulation Time
1	Marine Diesel (UKI)	49° 41' 44.310" East	Summer	25	900	Surface	1 hour	100 days
2		40° 10' 14.500" North	Winter	8				
3		50° 25' 29.950" East	Summer	25				
4		40° 11' 46.290" North	Winter	8				