Spill Impact Mitigation Assessment (SIMA)

Newfoundland Orphan Basin Exploration Drilling Program

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Operating Management System (OMS) – Sub Elements and Group Essentials

Sub Element	Sub Element Title	Group Essentials
4.6-0001	Crisis & Continuity Management	
4.6-0002	Crisis & Continuity Management - Oil Spill Preparedness and Response	

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Acronyms and Abbreviations

ADDS	Airborne Dispersant Delivery System
API	American Petroleum Institute
CBD	Convention on Biological Diversity
C-NLOPB	Canada-Newfoundland and Labrador Offshore Petroleum Board
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DOR	Dispersant-to-Oil Ratio
DU	Designatable Unit
EBSA	Ecologically and Biologically Significant Area
ECRC	Eastern Canada Response Corporation
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
EL	Exploration Licence
ESA	*Endangered Species Act*
ESRF	Environmental Studies Research Fund
EU	Environmental Unit
FCA	Fishery Closure Area
FSC	Food, Social, and Ceremonial
GB	Grand Banks
IBA	Important Bird Area
ICOADS	International Comprehensive Ocean-Atmosphere Data Set
ICS	Incident Command System
IMT	Incident Management Team
IOGP	International Association of Oil & Gas Producers
IPIECA	International Petroleum Industry Environmental Conservation Association
ISB	In-situ Burning
MBS	Migratory Bird Sanctuary
NACES	North Atlantic Current and Evlanov Sea
NAFO	Northwest Atlantic Fisheries Organization
NCC	NunatuKavut Community Council

NEB	National Energy Board
NEBA	Net Environment Benefit Analysis
NEEC	National Environment Emergencies Centre
NL	Newfoundland and Labrador
NMCA	National Marine Conservation Area
OA	Operations Authorization
OSCAR	Oil Spill Contingency and Response
OSRL	Oil Spill Response Limited
OSRP	Oil Spill Response Plan
PAH	Polycyclic Aromatic Hydrocarbon
PPE	Personal Protective Equipment
RAA	Regional Assessment Area
RMA	Representative Marine Area
ROC	Resource of Concern
ROV	Remotely Operated Vehicle
RV	Research Vessel
SARA	*Species at Risk Act*
SBA	Significant Benthic Area
SIMA	Spill Impact Mitigation Assessment
SMART	Special Monitoring of Applied Response Technologies
SSDI	Subsea Dispersant Injection
SST	Sea Surface Temperature
THC	Total Hydrocarbon Content
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States of America
VME	Vulnerable Marine Ecosystem
VOC	Volatile Organic Compound
WCCD	Worst-Credible Case Discharge

Foreword

This is the first issue of the Spill Impact Mitigation Assessment. This document is newly created and is not based on existing documents. This document supports Group Defined Practice 4.6-0001, Crisis and Continuity Management, and Group Defined Practice 4.6-0002, Crisis & Continuity Management - Oil Spill Preparedness & Response.

1 Background, Overview, and Use of SIMA

This Spill Impact Mitigation Assessment (SIMA) was prepared for the bp Canada Energy Group ULC (bp) Newfoundland Orphan Basin Exploration Drilling Program (2017-2026) (the Program). The SIMA is an integral component of contingency planning for exploration drilling and is part of the Operations Authorization (OA) process with the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB). More specifically, the SIMA process is a support tool for making optimal spill response decisions to minimize potential impacts from an oil spill and foster sound environmental recovery. To this effect, the SIMA process:

- Directs spill response development;
- Helps managing spill responders determine residual environmental effects;
- Facilitates stakeholder participation during a spill; and
- Enhances the decision-making process during spill response design (i.e., contingency planning) and a real-time spill.

A SIMA is not a recreation of an Environmental Impact Statement (EIS) or Environmental Assessment (EA) nor is it meant to be a standalone document. Relevant documentation (e.g., the Program's EIS [Stantec 2018]) is readily available to bp's response management team in the event of a spill. A SIMA is also not a comprehensive review of Resources of Concern (ROCs), response options, or oil spill modelling. Rather, a SIMA provides a summary of these topics mainly using information derived from the Program's EIS (Stantec 2018) and Program-specific spill modelling reports, such as the modelling report prepared for the Program's first well, Ephesus (Stantec 2022). During a spill event, a SIMA must be quickly conducted using the most readily available ecological and anthropological data. As such, this SIMA is a guide for conducting an expedited (incident specific) SIMA in real-time and includes a risk matrix that is meant to be quickly modified to account for real-life spill conditions. For an actual spill response, an expedited SIMA can be completed by:

1) Reviewing the contingency planning within this SIMA;
2) Updating relevant information for the spill location;
3) Identifying viable response options based on real-time physical conditions (e.g., location and weather; see Section 2.0), ROCs (see Section 3.0), and the fate and trajectory of the spill (see Section 4.0); and
4) Modifying the comparative risk matrix (see Section 5.0) to support the selection of the optimal response option(s).

During the spill response selection process, the expedited SIMA would take into account advice received from the National Environment Emergencies Centre (NEEC) Environmental Emergencies Science Table (a process organized by the NEEC for the provision of technical and scientific information during an oil spill) and from spill response experts (e.g., Eastern Canada Response Corporation [ECRC]).

1.1 BP SIMA Project Background

This SIMA was prepared for the bp Program as part of the contingency planning process for exploration drilling in Exploration Licences (ELs) 1145, 1146, and 1148 in the Orphan Basin. It should be noted that on 9 January 2023, EL 1145 and EL 1146 were consolidated to EL 1168. Pending regulatory approval, the Ephesus Well (in the original EL 1145) will be the first well of the Program and is planned to be drilled and abandoned in Quarters 2 and 3 of 2023, respectively (Stantec 2022). Oil spill modelling was initially conducted (in support of the EIS) for a hypothetical drilling location in the West Orphan Basin (BP 2018). Updated modelling specific for the Ephesus Well was conducted in 2022 (Stantec 2022). While there were similarities in the modelling results for the West Orphan Basin and Ephesus Well (see Section 3.0 in Stantec 2022), the Ephesus Well modelling was used as the basis for this SIMA as it is directly relevant to planned drilling activities. The Ephesus Well modelling utilized a worst-credible case discharge (WCCD), which consisted of a subsea blowout during the summer season (May-October). Under these conditions, oil spill trajectory and fate modelling were conducted for unmitigated relief well and capping stack scenarios using the SINTEF Oil Spill Contingency and Response (OSCAR) model (see Section 4.2). The modelled parameters of the unmitigated relief well scenario had a greater footprint within the Regional Assessment Area (RAA) than the capping stack scenario and deterministic modelling was only provided for the relief well scenario in Stantec (2022). Therefore, as the “worst” of the WCCD, the summer subsea blowout relief well scenario at the Ephesus Well was used for this SIMA (see Sections 4.0 and 5.0).

1.2 Overview of the SIMA

During 2016, the SIMA process replaced the previously used Net Environment Benefit Analysis (NEBA) to serve as a streamlined tool to direct the selection of an optimal response to minimize the effects of an oil spill on the environment and stakeholders while maintaining responder health and safety (IPIECA, API, and IOGP 2017). Environmental, socio-economic, cultural, and personnel safety factors are incorporated into SIMA and this newer term removes perceptions associated with the “Benefit” portion of the NEBA term (Sponson 2020). The 2017 *Guidelines on Implementing Spill Impact Mitigation Assessment* by the International Petroleum Industry Environmental Conservation Association (IPIECA), American Petroleum Institute (API), and International Association of Oil & Gas Producers (IOGP) (IPIECA, API, and IOGP 2017) provided a summary of SIMA methodology (Figure 1.1) and IPIECA and IOGP (2015a) outlined the SIMA process for both spill response planning and selecting real time response options (Figure 1.2). Although the best response options would ultimately depend on the characteristics of a particular oil spill, the most effective approach typically involves employing multiple response options simultaneously and maintaining flexibility and adaptability in the response strategy. The type, location, and circumstances of a spill incident dictate the required complexity of an expedited SIMA, with larger-volume, continuous, offshore spills requiring a more detailed SIMA that includes inshore and offshore response considerations and constraints compared to smaller-volume, single instance, inshore releases.

Regardless of which response options are selected, the SIMA process does recognize that there will at least some environmental impact due to an oil spill incident.

1.3 Using the SIMA for Contingency Planning

The SIMA process is useful for preparedness and response activities as components of contingency planning for an oil spill. IPIECA and IOGP (2015a) outline the general contingency planning process (see Figure 1.3 below). Contingency planning for an oil spill includes identifying spill scenarios and appropriate response options (e.g., this SIMA), stakeholder participation, practice drills for the creation of an expedited SIMA, and training an Incident Management Team (IMT) in choosing and combining optimal response options.

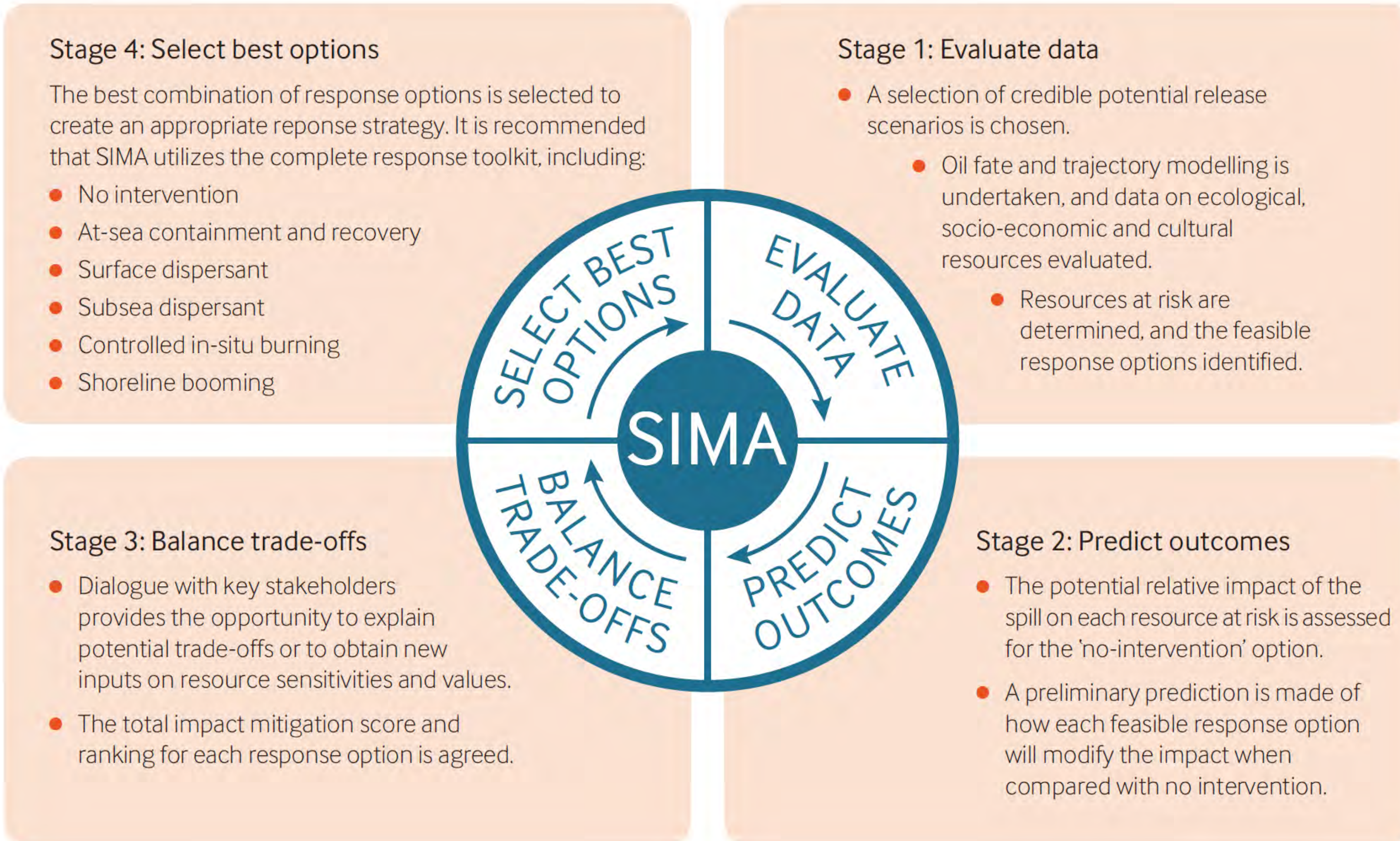


Figure 1.1. Summary of SIMA methodology (Source: Figure 1 in IPIECA, API, and IOGP 2017).

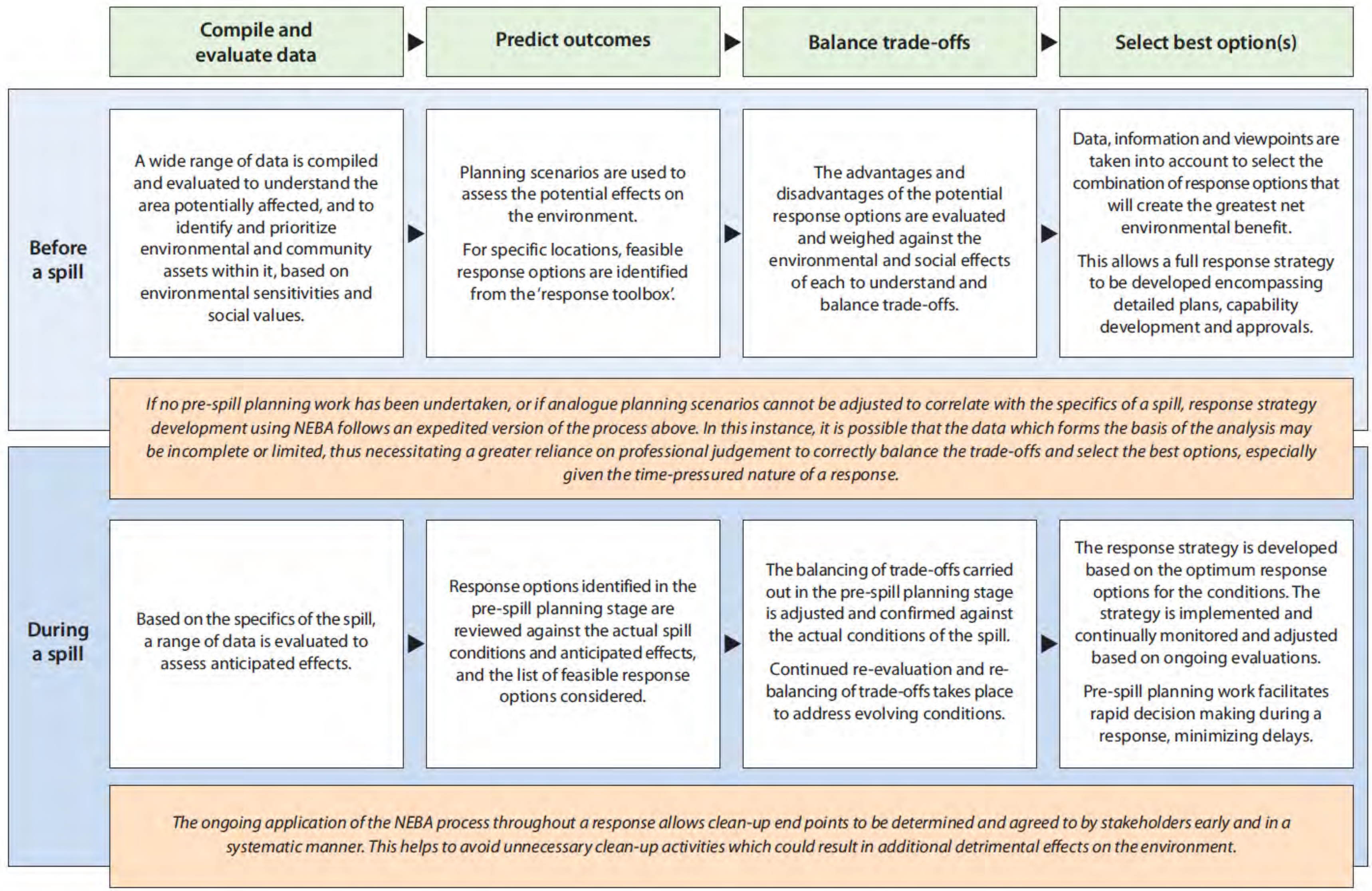


Figure 1.2. Summary of the SIMA response strategy (Note: this figure features the formerly used "NEBA" – this term is replaced with "SIMA" for the purposes of this document; Source: Figure 1 in IPIECA and IOGP 2015a).

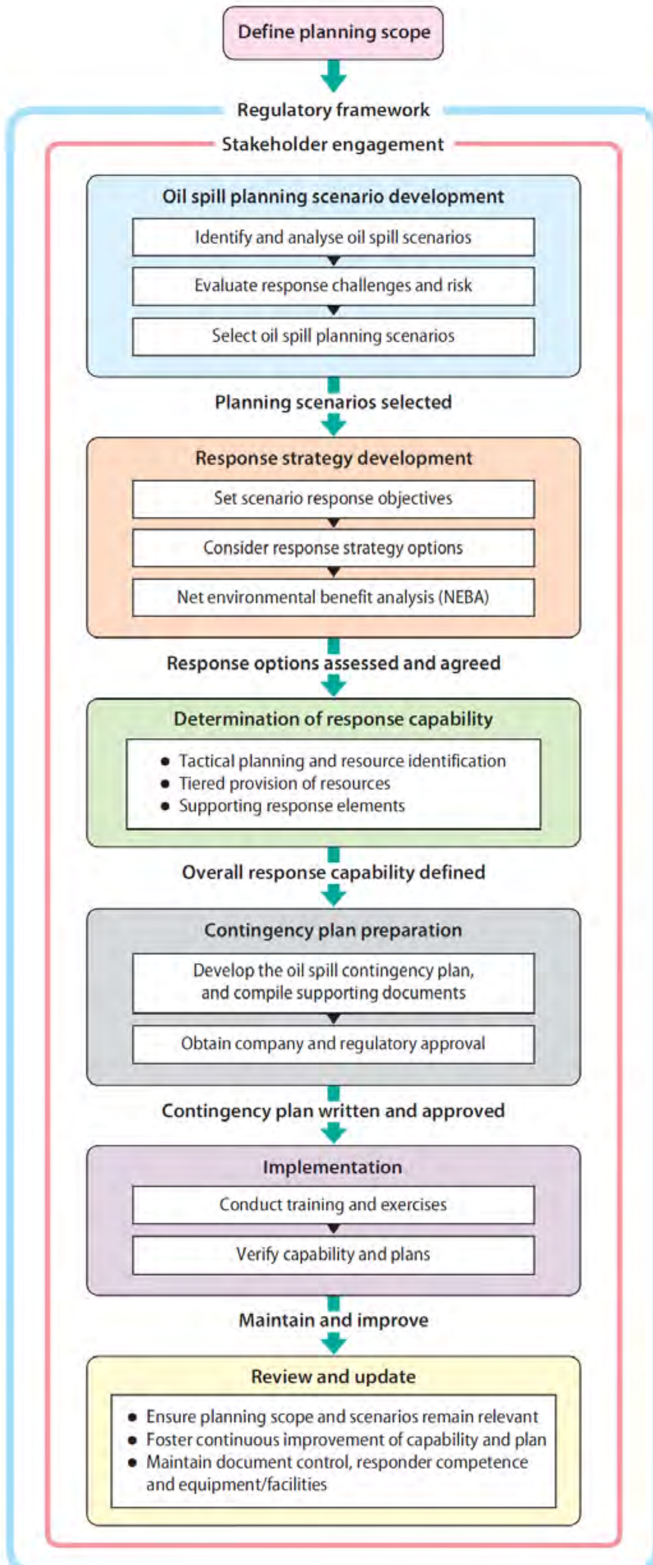


Figure 1.3. Summary of the oil spill contingency planning process (Note: this figure features the formerly used "NEBA" – this term is replaced with "SIMA" for the purposes of this document; Source: Figure 7 in IPIECA and IOGP 2015a).

Using SIMA during contingency planning can help guide and augment spill response efficiency for an actual oil spill event.

1.4 Using the SIMA for Spill Incidents

Efficiency is vital for the implementation of an effective oil spill response. An expedited SIMA, including trade-off analysis, must occur quickly within the first several hours following an oil spill. The creation and implementation of the expedited SIMA and selection of optimal response options relies heavily upon available information and input from subject matter/local experts. If a spill is continuous over the long-term, new data collection for physical parameters and ROCs may be possible to assist with ongoing spill management decisions; otherwise, spill response options must be selected based on the most recently available data for the RAA, such as those presented in the EIS (Stantec 2018) and this SIMA (e.g., see Sections 2.0 and 3.0). Utilizing these data, this SIMA will be the base model for assessing and adaptively managing a real-life oil spill. As indicated in Section 1.0 and Figure 1.2 above, this SIMA would be modified for an actual oil spill as follows:

1) **Compile and evaluate data:** Update Sections 2.0 and 3.0 of this SIMA using real-time data.
2) **Predict outcomes:** Predict the spill trajectory (via modelling and/or aerial surveys) and update Section 4.0 of this SIMA.
3) **Balance trade-offs:** Re-evaluate the advantages and disadvantages of possible response options identified during contingency planning (Section 5.0 of this SIMA) based on available data, advice from local experts/resource users, and spill modelling and confirm which options would best reduce environmental and socio-economic impacts while maintaining responder health and safety.
4) **Select best option(s):** Modify the comparative risk matrix (Table 5.4 in Section 5.0) and develop and implement the response strategy. Monitor conditions and adapt the strategy as needed for the duration of the oil spill response.

In Canada, spill response activities are managed via the Incident Command System (ICS) (ICS 2022). The ICS is "a standardized on-site management system designed to enable effective, efficient incident management by integrating a combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure" (ICS 2022). bp's Environmental Unit (EU) of the ICS would be responsible for enacting the above activities to create an expedited SIMA.

The SIMA process must be documented to demonstrate due diligence for an oil spill response, demonstrating that the appropriate steps and stakeholder input occurred. The submission of an expedited SIMA may be required for an application authorization request for certain response options, such as dispersant use. A summary of past SIMA usage in Canadian and United States of America (US) waters is provided in Appendix A of Slaughter et al. (2017) and Section 1.4.3 of Sponson (2020).

2 Project Location and Response Options

A geographical and physical summary of the RAA and/or Orphan Basin region is provided in this section, along with an overview of available response options. The geographical and physical information presented was mainly derived from the EIS (Stantec 2018), with minor updates provided where applicable (e.g., current year daylength). The summaries provided in this SIMA focus on factors relevant to oil spill response considerations. The reader is otherwise referred to the EIS for detailed descriptions of geographical and physical parameters within the RAA (see Section 5.0 in Stantec 2018).

2.1 Geographic Area of Interest

The geographical area of interest, including exclusion areas and seabed hazards (e.g., subsea cables), is described in Section 2.2 in Stantec (2018). The RAA encompasses most of the offshore area of eastern Newfoundland and includes portions of the Island of Newfoundland that could potentially be impacted by an oil spill The Project Area is approximately 44,695 km^2 located in the Orphan Basin and contains the Program's four ELs (Figure 2.1; modified from Figure 2.1 in Stantec 2018). It should be noted that when the EIS was written (2018) and the figures for this SIMA were created (late-2022), ELs 1145 and 1146 were separate. ELs 1145 and 1146 were consolidated to EL 1168 in January 2023 but, in order to align with material presented in the EIS, the original ELs are referred to in the remainder of this document and presented in the figures. Any appearance of either EL 1145 or EL 1146 in this document can be considered by the reader to represent EL 1168. ELs 1145 and 1146 (now consolidated into EL 1168) and 1148 are in West Orphan Basin. Bounding coordinates for the Project Area and ELs are provided in Table 2.1 in Stantec (2018). The Ephesus Well, the Program's first well, is located within the original EL 1145, approximately 340 km northeast of St. John's, Newfoundland and Labrador (NL), and has a water depth of 1339 m (Stantec 2022) (Figure 2.2; from Figure 1.1 in Stantec 2018). A hypothetical subsea blowout at the Ephesus Well is the focus of risk-based assessment and response options for this SIMA (see Section 5.0).

2.2 Physical Environment

Physical environmental factors that are relevant to selecting optimal oil spill response options include the shoreline type, day length, visibility, wind and waves, bathymetry, ocean currents, ice conditions, and air and water temperature. These physical environment components are summarized below for the RAA and described in further detail in Section 5.0 in Stantec (2018). See also Section 5.0 in Stantec (2018) for descriptions of air quality, precipitation, tropical storms and storm surges, lightning, climate change, geology, and seismicity within the RAA.

2.2.1 Shoreline

The island of Newfoundland has a varied coastline with numerous shoreline habitat types. Habitat classification of the shoreline within the boundaries of the RAA is provided in Figure 2.3. Much of the Newfoundland coastline is rocky, characterized as pebble, cobble, boulder beach, or bedrock, including many areas of bedrock cliff. The closest point of the coast of Newfoundland is about 270 km southwest of the Orphan Basin.

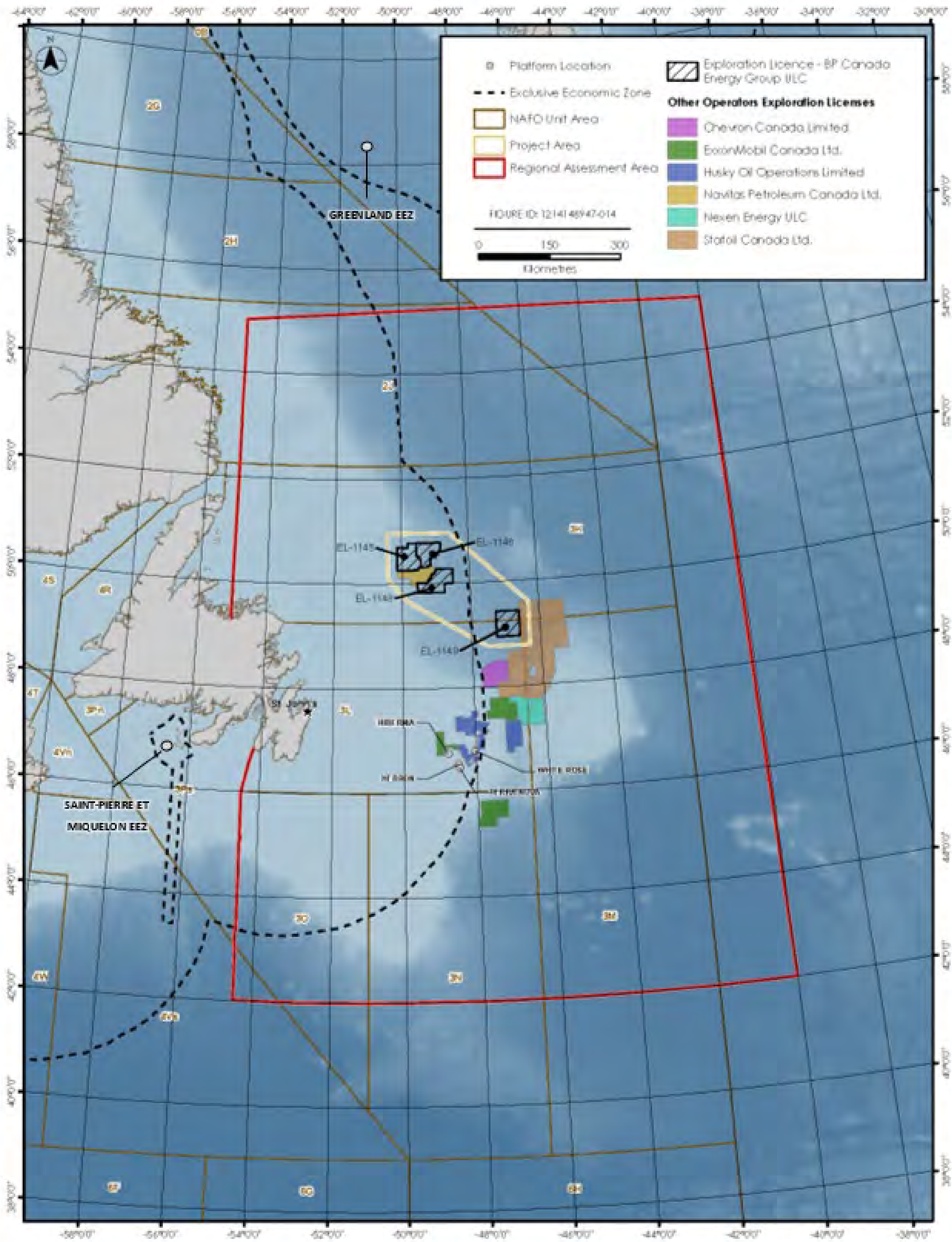


Figure 2.1. BP RAA and Project Area.

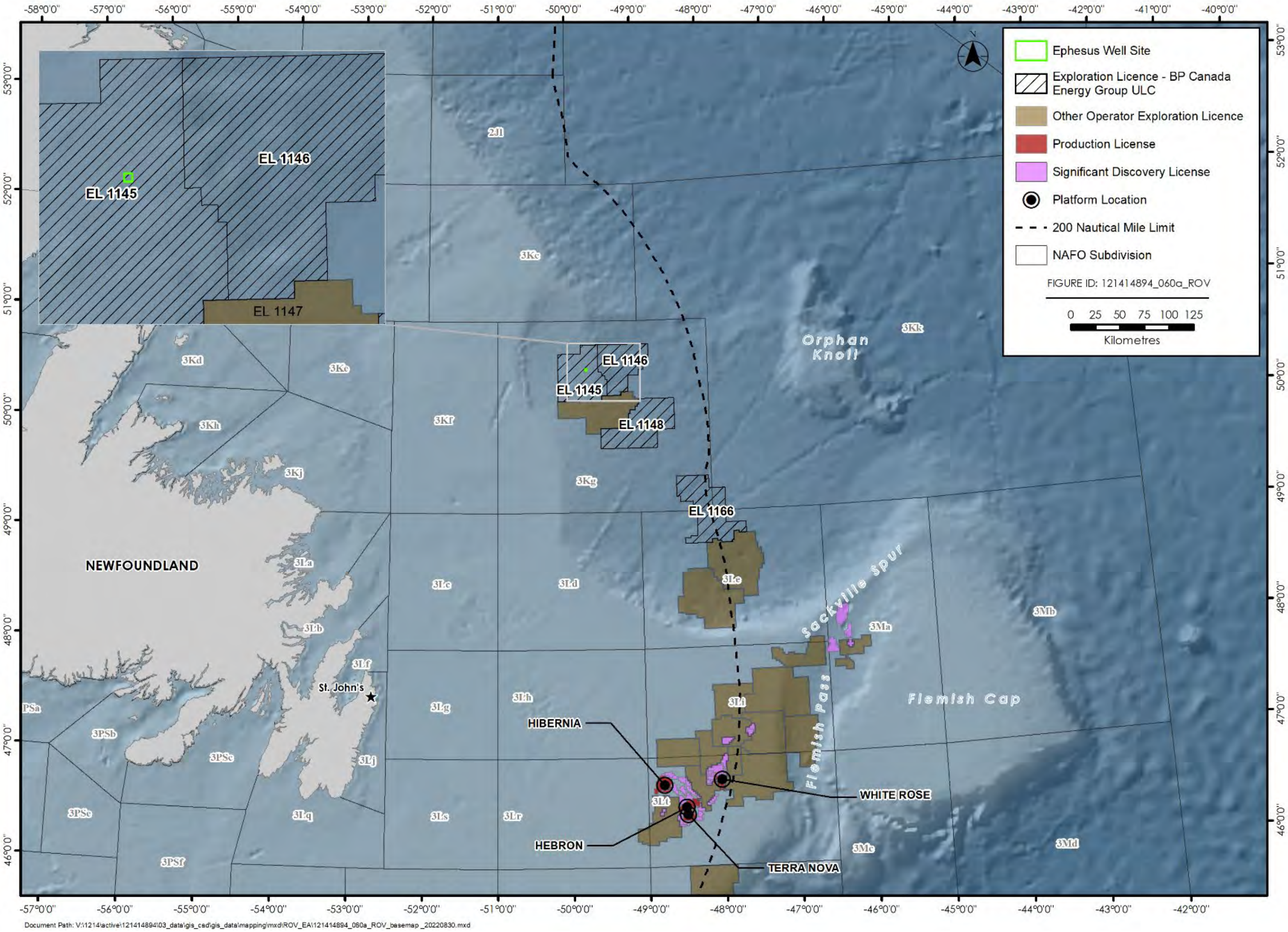


Figure 2.2. Location of the Ephesus Well in EL 1145.

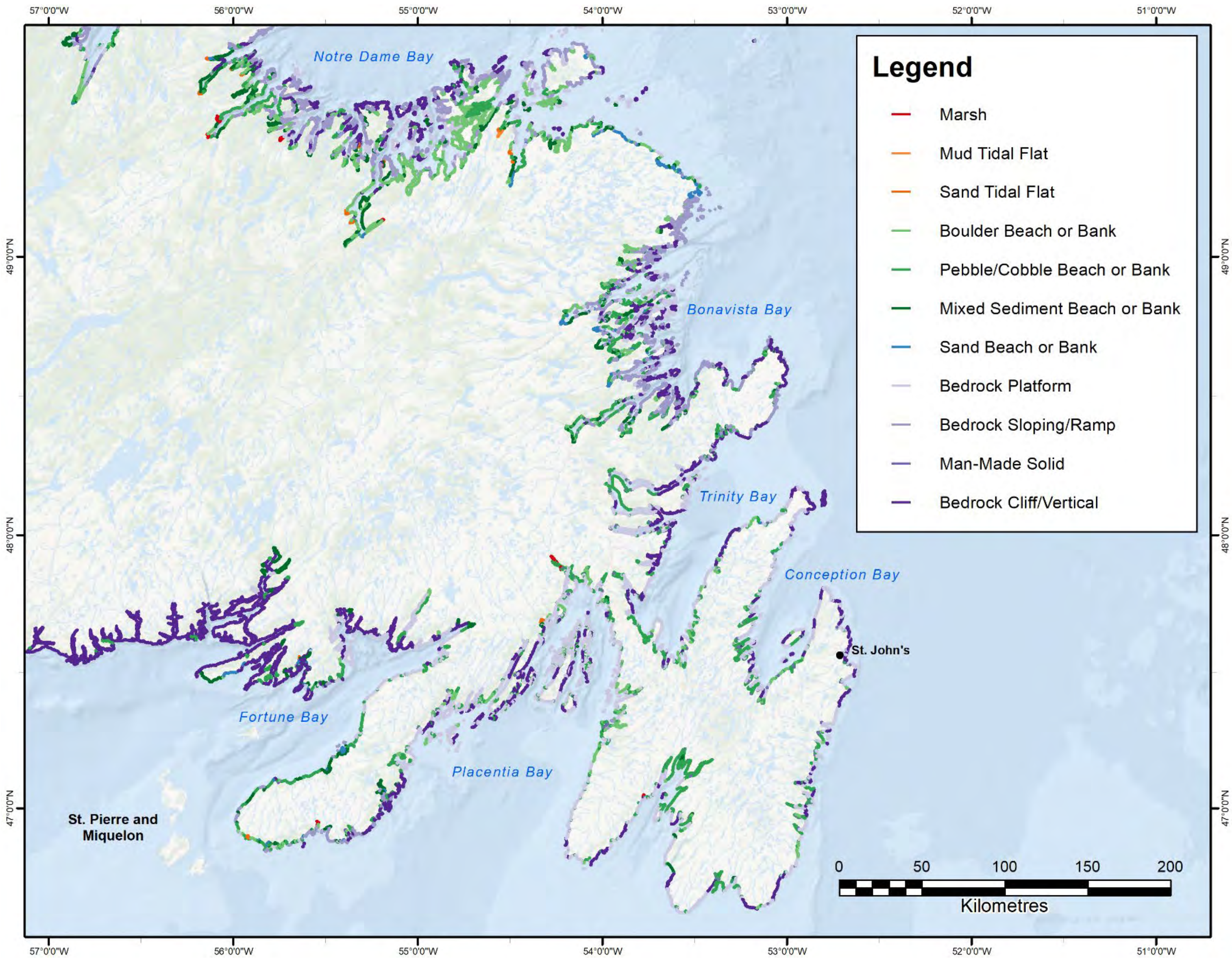


Figure 2.3. Shoreline classification for coastal Newfoundland (Source: Government of Canada 2017).

2.2.2 Day Length

The duration of usable daylight imparts an upper limit to the number of hours a surface vessel or aircraft can operate safely and efficiently during oil spill mitigation operations. Civil twilight is included in the calculation of day length (i.e., usable daylight) and, for the purposes of this SIMA, is the period after the sun sets during which enough natural daylight remains to enable marine operations to safely occur without depending on artificial light. Usable daylight available for safe operations in St. John's, NL as of the first day of each month during 2022 is provided in Table 2.1. Several subsea operations are not dependent on daylight hours and can continue operations regardless of day length, including using remotely operated vehicles (ROVs) that have onboard artificial light sources and sonar. Subsea dispersal injection can also occur 24 hours per day as its continuous operation is not dependent on daylight.

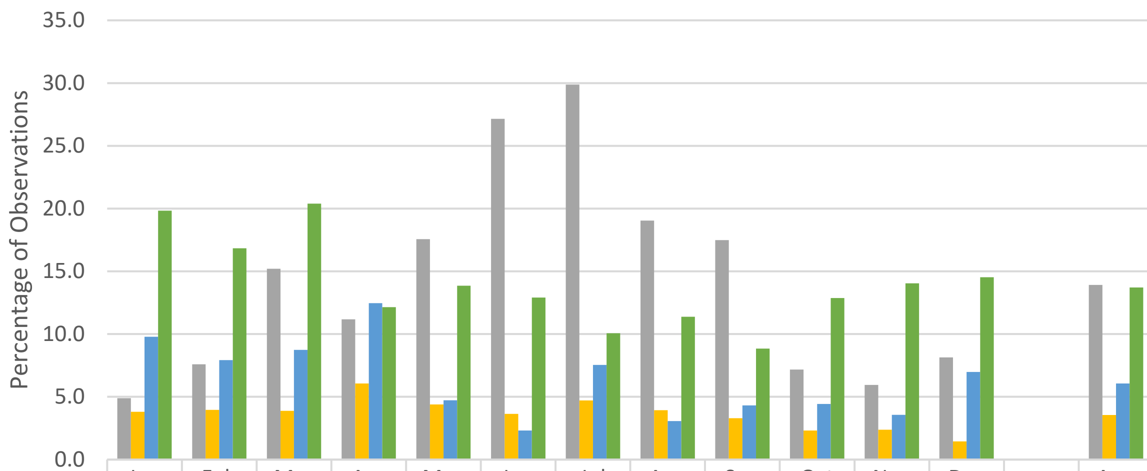
Table 2.1. Daily usable daylight in St. John's, NL by month during 2022 (Source: Time and Date 2022).

Day and Month (2022)	Daylight Start and End Time [a]	Daily Duration of Usable Daylight
1 January	07:13 – 16:55	9 h 42 min
1 February	06:54 – 17:35	10 h 41 min
1 March	06:10 – 18:16	12 h 6 min
1 April	06:08 – 20:01	13 h 53 min
1 May	05:09 – 20:47	15 h 38 min
1 June	04:28 – 21:29	17 h 1 min
1 July	04:27 – 21:42	17 h 15 min
1 August	05:02 – 21:02	16 h 0 min
1 September	05:50 – 20:08	14 h 18 min
1 October	06:29 – 19:10	12 h 41 min
1 November	07:12 – 18:15	11 h 3 min
1 December	06:52 – 16:46	9 h 54 min

[a] Includes civil twilight.

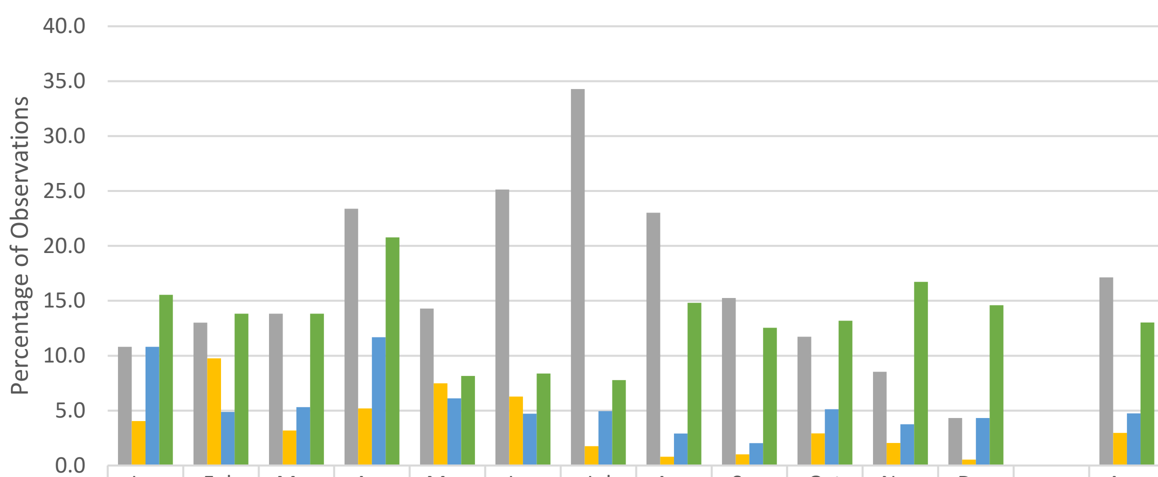
2.2.3 Visibility

Operational safety can be affected by limited visibility during daylight periods. Apart from useable day length, visibility limitations depend on weather and atmospheric conditions, such as precipitation (e.g., rain, snow) and fog, which vary throughout the year. Within the RAA, July is the worst month in terms of reduced visibility, mainly due to thick fog. The mean monthly and annual frequency of limited visibility conditions (<1 km to <10 km) for the eastern and western portions of the Orphan Basin are provided in Figures 2.4 and 2.5, respectively.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		Ann
<1	4.9	7.6	15.2	11.2	17.6	27.2	29.9	19.0	17.5	7.2	6.0	8.1		13.9
<2.0	3.8	4.0	3.9	6.1	4.4	3.6	4.7	3.9	3.3	2.3	2.4	1.5		3.6
<4.0	9.8	7.9	8.7	12.5	4.7	2.3	7.5	3.1	4.3	4.4	3.6	7.0		6.1
<10.0	19.8	16.8	20.4	12.1	13.9	12.9	10.1	11.4	8.8	12.9	14.0	14.5		13.7

Figure 2.4. Mean monthly and annual frequency of limited visibility (<10 km) within the eastern Orphan Basin (Source: Figure 5.15 in Stantec 2018 [ICOADS Database, 1986-2015]).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		Ann
<1	10.8	13.0	13.8	23.4	14.3	25.1	34.3	23.0	15.3	11.7	8.5	4.3		17.1
<2.0	4.1	9.8	3.2	5.2	7.5	6.3	1.8	0.8	1.0	2.9	2.0	0.5		3.0
<4.0	10.8	4.9	5.3	11.7	6.1	4.7	4.9	2.9	2.0	5.1	3.8	4.3		4.7
<10.0	15.5	13.8	13.8	20.8	8.2	8.4	7.8	14.8	12.5	13.2	16.7	14.6		13.0

Figure 2.5. Mean monthly and annual frequency of limited visibility (<10 km) within the western Orphan Basin (Source: Figure 5.16 in Stantec 2018 [ICOADS Database, 1986-2015]).

2.2.4 Wind and Waves

A high frequency of low-pressure systems moving over the NL region during the winter months results in higher wind speeds during the winter relative to the remainder of the year within the Orphan Basin (Tables 2.2-2.3). The most common wind directions during winter are west to northwest; in the spring, wind directions start to slowly change such that by summer the prevailing winds are from the southwest (Figure 2.6). In the fall, tropical storms originating in the south often transform into extratropical cyclones as they pass insular Newfoundland, typically producing large waves and occasionally resulting in hurricane-force winds (see Section 5.3.4 and Figures 5.7-5.10 in Stantec 2018).

Prevalent combined significant wave height direction within the RAA is westerly during the winter months, changing to southwesterly during the spring and summer (see Section 5.4.3.1 in Stantec 2018). Most significant wave heights on the Orphan Basin are between 1-3 m high, with a low occurrence frequency of significant wave heights >8 m (see Figures 5.29-5.32 and Section 5.4.3.2 in Stantec 2018; Table 2.4; Figure 2.7).

Table 2.2. Mean monthly, seasonal, and annual wind speeds (m/s) in the eastern and western portions of the Orphan Basin (Source: Table 5.4 in Stantec 2018 [MSC50 database; ICOADS dataset]).

Month/Season	Mean Wind Speed (m/s)					
	East Orphan Basin		West Orphan Basin			
	MSC50 Grid Point 15340	ICOADS	MSC50 Grid Point 16684	MSC50 Grid Point 17322	MSC50 Grid Point 17427	ICOADS
January	12.71	14.52	12.62	12.55	12.76	12.16
February	12.13	12.67	11.94	11.75	12.05	11.9
March	11.1	11.77	10.83	10.65	10.95	11.63
April	9.28	11.17	9.26	9.2	9.45	9.72
May	7.88	8.23	7.77	7.67	7.9	8.37
June	7.22	8.64	6.92	6.76	6.99	7.76
July	6.68	7.16	6.47	6.28	6.47	5.91
August	6.93	8.32	6.84	6.74	6.89	6.39
September	8.44	9.04	8.33	8.31	8.47	7.9
October	9.74	10.99	9.53	9.49	9.65	8.43
November	11.19	12.25	11.18	11.15	11.36	10.8
December	11.86	12.66	11.86	11.88	12.05	11.65
Winter	12.24	13.32	12.15	12.07	12.29	11.86
Spring	9.42	10.25	9.28	9.17	9.43	9.69
Summer	6.94	8.06	6.74	6.59	6.78	6.59
Fall	9.79	10.66	9.68	9.65	9.82	9.18
Annual	9.58	10.35	9.45	9.36	9.57	9.04

Table 2.3. Maximum monthly, seasonal, and annual wind speeds (m/s) in the eastern and western portions of the Orphan Basin (Source: Table 5.5 in Stantec 2018 [MSC50 database; ICOADS dataset]).

Month/Season	Maximum Wind Speed (m/s)					
	East Orphan Basin		West Orphan Basin			
	MSC50 Grid Point 15340	ICOADS	MSC50 Grid Point 16684	MSC50 Grid Point 17322	MSC50 Grid Point 17427	ICOADS
January	32.4	39.6	31.1	31.4	32.8	28.8
February	30.6	38.1	30.8	28.5	29.5	30.9
March	31.2	30.9	29.9	28.3	29.4	23.7
April	26.8	29.0	26.7	27.6	26.6	26.8
May	23.0	24.2	22.0	20.1	21.2	25.7
June	21.6	24.2	22.5	21.4	22.2	22.6
July	18.7	25.2	21.1	16.9	17.9	22.6
August	23.7	22.6	20.6	18.8	19.5	19.0
September	30.4	24.2	29.2	27.9	33.1	24.7
October	28.2	32.0	27.1	28.0	27.5	22.6
November	27.2	30.9	29.2	27.9	28.6	30.0
December	31.4	30.9	31.1	29.7	30.8	26.2
Winter	32.4	39.6	31.1	31.4	32.8	30.9
Spring	31.2	30.9	29.9	28.3	29.4	26.8
Summer	23.7	25.2	22.5	21.4	22.2	22.6
Fall	30.4	32.0	29.2	28.0	33.1	30.0
Annual	32.4	39.6	31.1	31.4	33.1	30.9

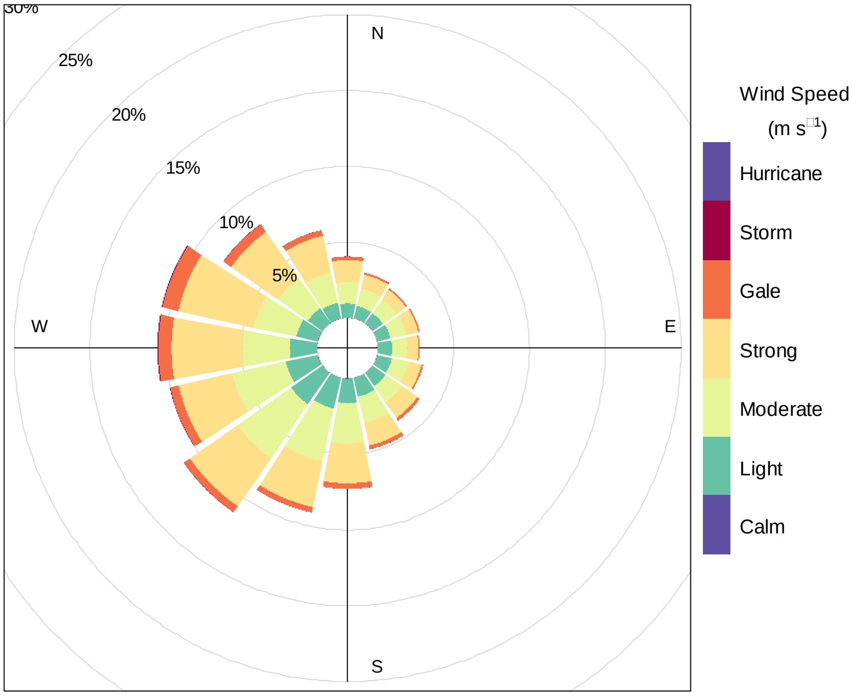


Figure 2.6. Annual wind rose for MSC50 Grid Point 16684 (West Orphan Basin), 1986-2015 (Source: Figure 5.8 in Stantec 2018).

Table 2.4. Mean monthly, seasonal, and annual wave heights (m) in the eastern and western portions of the Orphan Basin (Source: Table 5.17 in Stantec 2018 [ICOADS dataset; MSC50 database]).

Month/Season	Mean Wave Height (m)					
	East Orphan Basin		West Orphan Basin			
	MSC50 Grid Point 15340	ICOADS	MSC50 Grid Point 16684	MSC50 Grid Point 17322	MSC50 Grid Point 17427	ICOADS
January	4.8	3.3	4.6	4.4	4.6	2.3
February	4.3	2.5	3.8	3.4	3.8	2.6
March	3.8	1.8	3.3	2.9	3.4	2.1
April	3.1	2.4	2.8	2.6	2.7	1.3
May	2.4	1.4	2.4	2.3	2.4	1.6
June	2.1	1.3	2.0	2.0	2.0	1.1
July	1.8	1.1	1.7	1.7	1.7	0.8
August	1.9	1.2	1.9	1.8	1.9	0.9
September	2.6	1.5	2.6	2.5	2.6	1.5
October	3.2	2.0	3.2	3.1	3.2	1.5
November	3.9	2.3	3.8	3.7	3.8	2.1
December	4.4	2.7	4.3	4.2	4.4	2.0
Winter	4.5	2.9	4.2	4.0	4.3	2.2
Spring	3.1	1.9	2.8	2.6	2.8	1.6

Month/Season	Mean Wave Height (m)					
	East Orphan Basin		West Orphan Basin			
	MSC50 Grid Point 15340	ICOADS	MSC50 Grid Point 16684	MSC50 Grid Point 17322	MSC50 Grid Point 17427	ICOADS
Summer	2.0	1.2	1.9	1.8	1.9	0.9
Fall	3.2	1.9	3.2	3.1	3.2	1.7
Annual	3.2	1.9	3.0	2.9	3.0	1.4

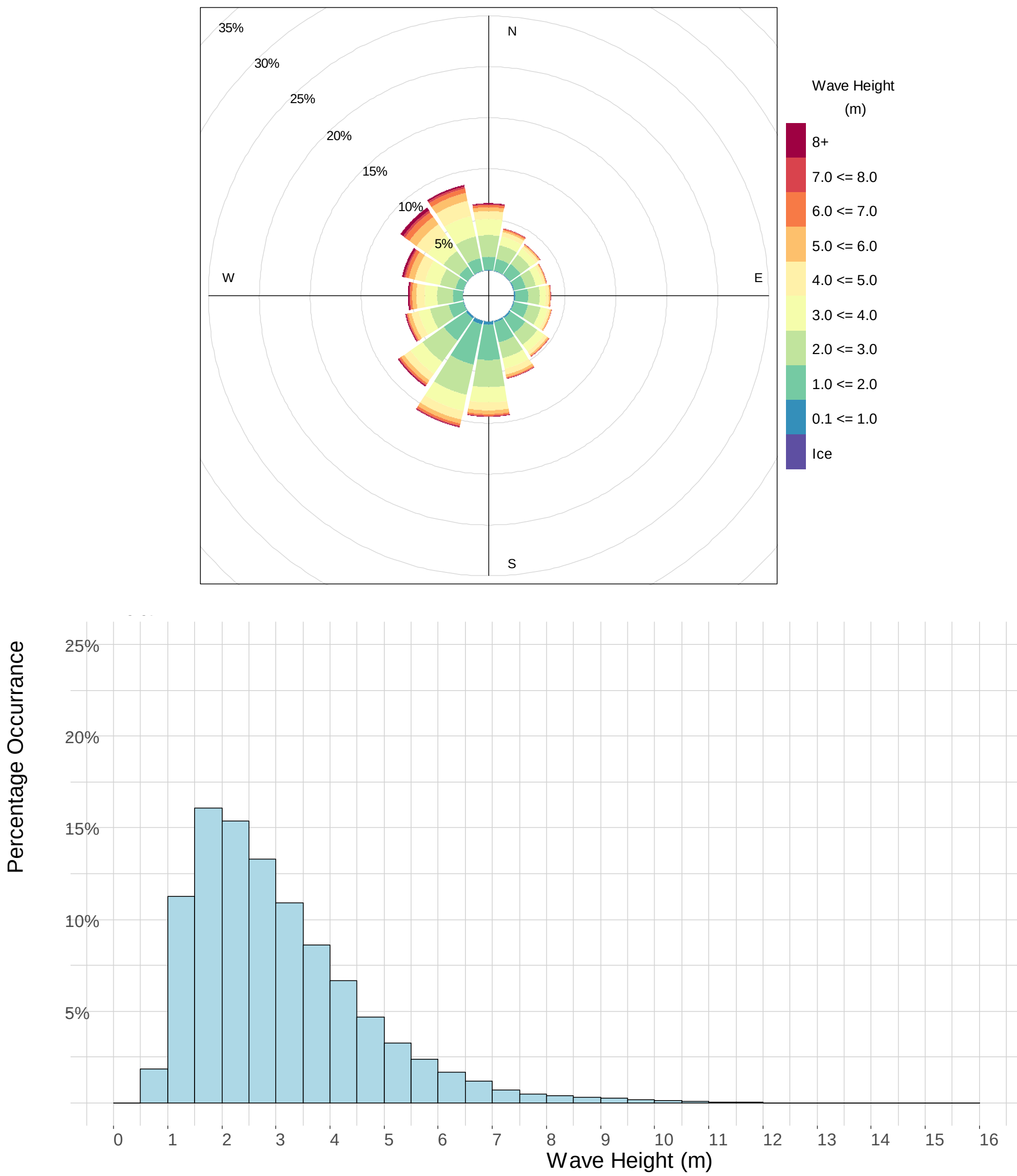


Figure 2.7. Annual wave rose (top panel) and frequency of significant wave height (lower panel) for MSC50 Grid Point 16684 (West Orphan Basin), 1986-2015 (Source: Figure 5.30 in Stantec 2018).

2.2.5 Bathymetry and Ocean Currents

Several basins form an interconnected network offshore NL. The Orphan Basin is a component of this network and the focus for the subsea blowout scenario considered in this SIMA. It is subdivided into the East and West Orphan Basin and bounded by the Orphan Knoll to the northeast, Newfoundland Shelf to the west, and Flemish Cap to the south (see Section 5.4.1 in Stantec 2018). Depths range from ~970-2400 m within ELs 1145, 1146, and 1148, with mean depths of approximately 1200 m at the shallowest site (EL 1145) and 1800 m at the deepest (ELs 1146 and 1148) (see Section 5.4.1 in Stantec 2018; Table 2.5; Figure 2.8). The mean depth of EL 1168 (designated on 9 January 2023 through the consolidation of ELs 1145 and 1146) is 1339 m and it is considered ~340 km distant from St. John’s, NL.

Two major ocean currents dominate the RAA: the Labrador Current and the Gulf Stream/North Atlantic Current. The Gulf Stream/North Atlantic Current flows from the south and largely diverts eastwards around the Flemish Cap; upon turning north at the Southeast Newfoundland Rise, the Gulf Stream begins to be called the North Atlantic Current. The Labrador Current flows down from the northwest into the Orphan Basin, then splits into two, with one part flowing through the Flemish Pass and the other diverted east around the Flemish Cap (see Section 5.4.2 in Stantec 2018; Figure 2.9).

2.2.6 Ice Conditions

The presence of sea ice or icebergs can impact oil spill mitigation operations. The potential presence of sea ice within the RAA should be considered in any oil spill response taking place between early-December to early-August (see Section 5.5.1 in Stantec 2018). Sea ice or icebergs may be found within the RAA at any time of year but occurs most frequently during late-winter through spring (see Sections 5.5.1 and 5.5.2 in Stantec 2018; Table 2.6; Figure 2.10). Warmer than average winter temperatures due to climate change have resulted in decreased ice cover and thickness and a shorter ice-covered season in the offshore NL region; during 1998-2013, mean sea ice cover in the region decreased by 1.53% per year (Savard et al. 2016 in Stantec 2018). As the presence of sea ice cover can halt wave formation, a shortened ice cover season results in storm waves having increased energy (Savard et al. 2016 in Stantec 2018). Climate change appears to be causing a general increase in the number of icebergs observed annually in the vicinity of the Grand Banks, although the number of icebergs exhibit high variability year-to-year (Stantec 2018). No icebergs have been recorded passing across 48ºN in some years, while in other years there were over 1000 (Bigg 2015 in Stantec 2018). During 2016, 687 icebergs were observed on the Northern Grand Bank (south of 48ºN), representing a 0.1 standard deviation decrease from the 1981-2010 mean of 767 bergs (Coulbourne et al. 2017 in Stantec 2018).

Table 2.5. Minimum, maximum, and mean depths (m) for ELs 1145, 1146, and 1148 within the RAA (Source: Table 5.12 in Stantec 2018).

EL	Minimum Depth (m)	Maximum Depth (m)	Mean Depth (m)
1145	970	1540	1257
1146	1360	2275	1843
1148	1250	2400	1846

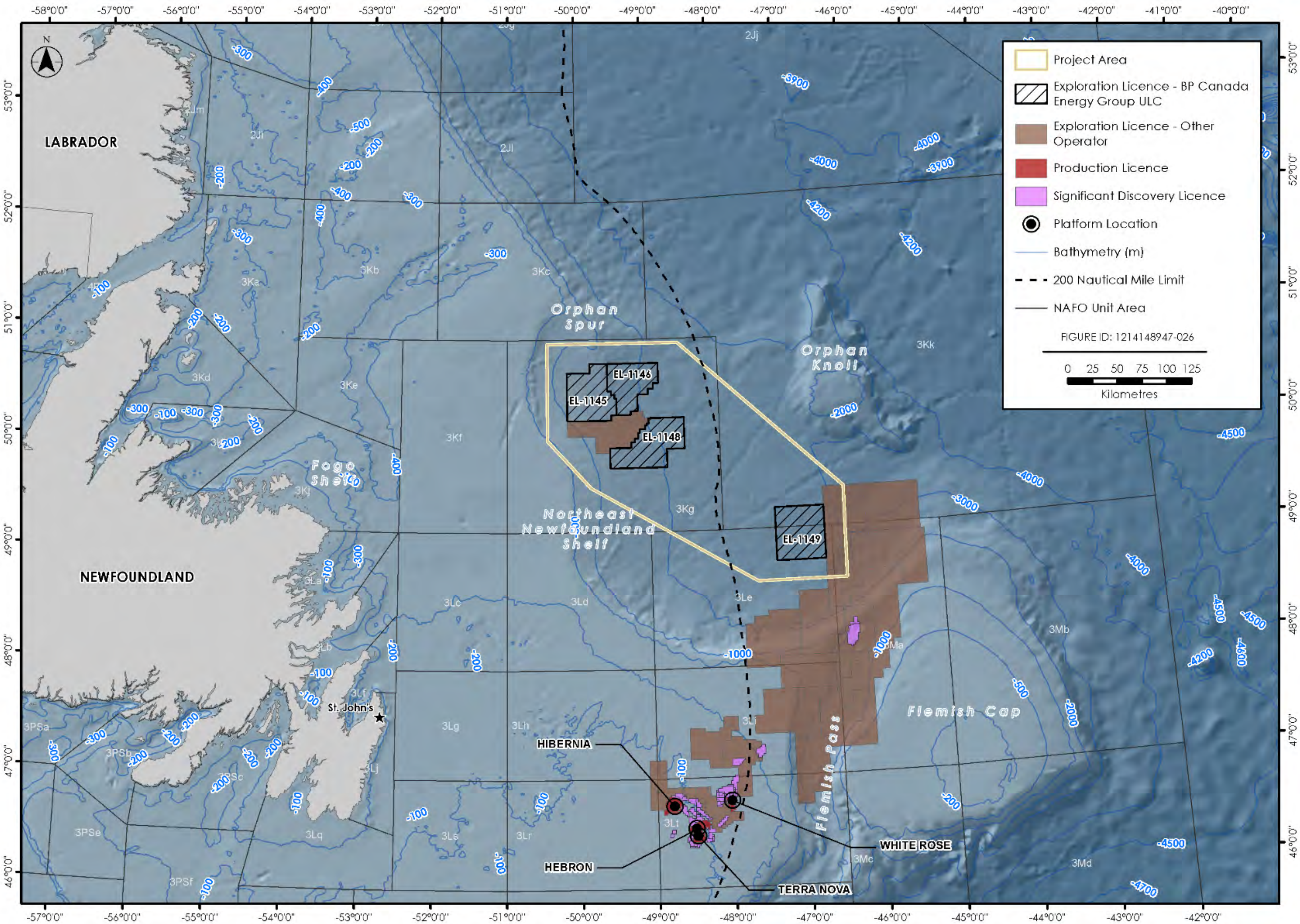


Figure 2.8. Orphan Basin bathymetry (Source: Figure 5.20 in Stantec 2018).

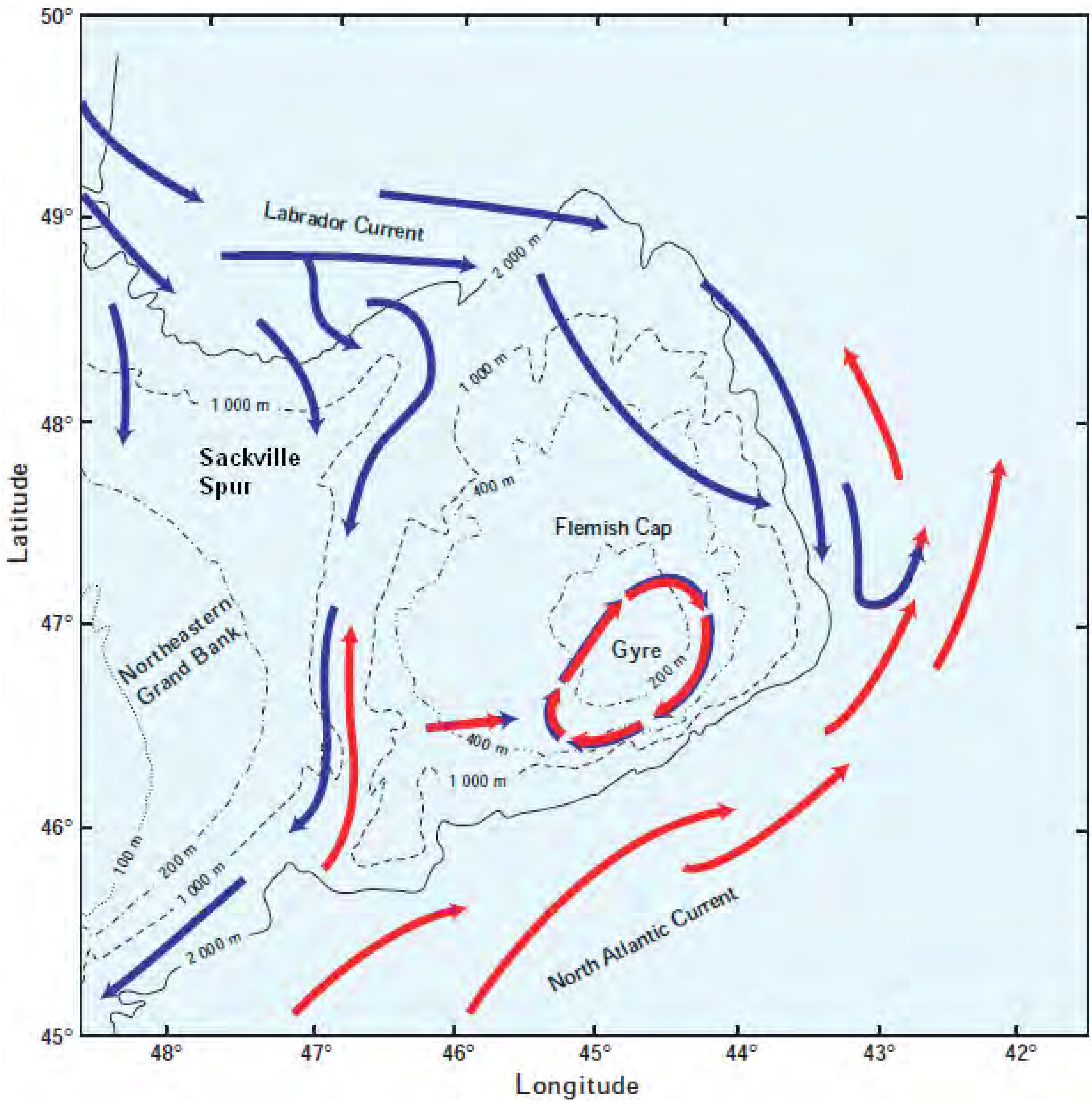


Figure 2.9. Ocean currents of the eastern Orphan Basin (Source: Figure 5.21 in Stantec 2018).

Table 2.6. Frequency of sea ice presence within the RAA, 1981-2010 (Source: excerpted from Table 5.46 in Stantec 2018).

Date	Ice Free	1-15%	16-33%	34-50%	51-66%	67-84%	85-99%	100%
Dec 04	99.98	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Dec 11	99.85	0.15	0.00	0.00	0.00	0.00	0.00	0.00
Dec 18	99.18	0.73	0.09	0.00	0.00	0.00	0.00	0.00
Dec 25	98.02	1.67	0.31	0.00	0.00	0.00	0.00	0.00
Jan 01	95.04	2.78	2.02	0.14	0.02	0.00	0.00	0.00
Jan 08	93.15	3.84	1.87	0.82	0.26	0.07	0.00	0.00
Jan 15	91.04	5.32	1.78	0.82	0.70	0.32	0.00	0.00
Jan 22	90.02	4.42	2.80	0.82	0.71	1.06	0.17	0.00
Jan 29	89.11	3.61	3.24	1.07	1.27	1.25	0.45	0.01
Feb 05	86.86	5.63	2.66	1.21	0.84	1.84	0.97	0.00
Feb 12	86.11	4.86	3.30	1.20	1.03	2.09	1.41	0.00
Feb 19	85.44	5.26	2.71	1.54	0.84	1.71	2.49	0.00
Feb 26	85.65	5.58	2.31	1.08	1.23	2.18	1.97	0.00
Mar 05	86.24	4.37	2.68	1.42	1.26	2.65	1.38	0.00
Mar 12	84.45	6.27	2.63	1.82	1.07	2.06	1.63	0.07
Mar 19	85.31	5.22	3.11	1.53	1.98	2.36	0.45	0.03
Mar 26	86.85	4.07	2.75	1.72	1.26	2.94	0.41	0.00
Apr 02	86.53	4.72	2.70	2.07	1.33	2.36	0.29	0.00
Apr 09	87.03	5.42	2.73	1.93	1.52	1.33	0.03	0.00
Apr 16	88.77	4.66	2.64	1.68	1.36	0.85	0.03	0.00
Apr 23	88.86	4.89	2.69	1.91	0.96	0.68	0.02	0.00
Apr 30	90.67	4.16	2.42	1.39	1.05	0.31	0.00	0.00
May 07	91.93	3.70	2.12	1.43	0.75	0.08	0.00	0.00
May 14	92.77	3.30	2.03	1.48	0.36	0.07	0.00	0.00
May 21	92.84	3.60	2.42	0.84	0.28	0.03	0.00	0.00
May 28	92.87	4.54	1.94	0.62	0.03	0.00	0.00	0.00
Jun 04	94.66	3.56	1.45	0.32	0.00	0.00	0.00	0.00
Jun 11	95.46	3.02	1.40	0.12	0.00	0.00	0.00	0.00
Jun 18	95.94	3.36	0.70	0.00	0.00	0.00	0.00	0.00
Jun 25	96.06	3.81	0.13	0.00	0.00	0.00	0.00	0.00
Jul 02	97.45	2.51	0.03	0.00	0.00	0.00	0.00	0.00
Jul 09	98.96	1.04	0.00	0.00	0.00	0.00	0.00	0.00
Jul 16	99.27	0.73	0.00	0.00	0.00	0.00	0.00	0.00
Jul 23	99.85	0.15	0.00	0.00	0.00	0.00	0.00	0.00
Jul 30	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug 06	99.99	0.01	0.00	0.00	0.00	0.00	0.00	0.00

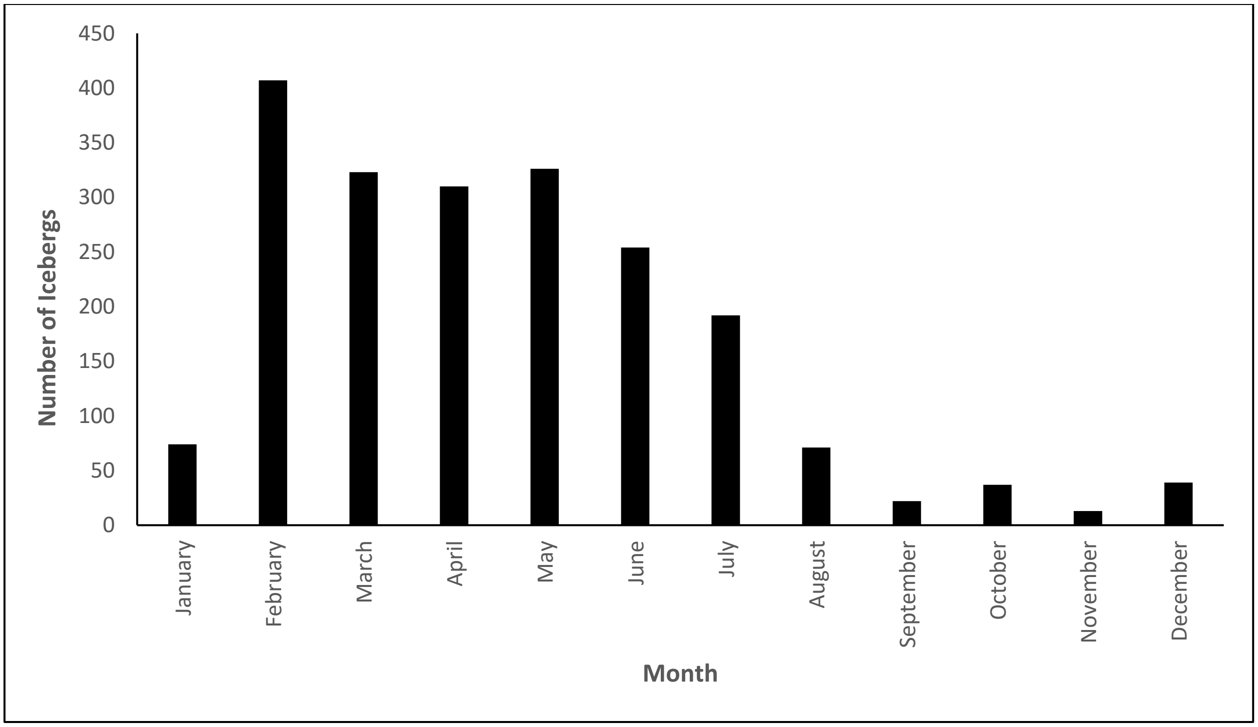


Figure 2.10. Monthly iceberg sightings within the Project Area on the Orphan Basin (Source: Figure 5.60 in Stantec 2018 [International Ice Patrol Iceberg Sightings database, 1986-2015]).

2.2.7 Air and Water Temperature

Water temperature can impact both oil and dispersant viscosity (Fingas 1991; Subhashini et al. 2006). As water temperature decreases, oil and dispersant resistance to flow, or viscosity, increases; therefore, oil may disperse more efficiently in warmer waters (Fingas 1991; Subhashini et al. 2006). Within the Orphan Basin, sea surface temperatures (SSTs) are warmest during the month of August and coldest between March and April (see Section 5.3.6 in Stantec 2018; Tables 2.7-2.8). Within the eastern portion of the Orphan Basin, the mean SST is consistently higher than the mean air temperature throughout the year, while the mean SST for the West Orphan Basin is higher than mean air temperature year-round except during the months of May and July (see Section 5.3.6 in Stantec 2018; Figures 2.11-2.12).

Table 2.7. Monthly mean air and sea surface temperature (°C) for the West Orphan Basin (Source: Table 5.8 in Stantec 2018 [ICOADS database; years not specified]).

Month	Air Temperature (°C)				Sea Surface Temperature (°C)			
	Mean	Maximum	Minimum	Standard Deviation	Mean	Maximum	Minimum	Standard Deviation
January	-1.0	10.6	-13.0	3.7	2.5	10.8	-2.0	1.1
February	-2.9	12.0	-17.0	5.5	2.1	10.0	-1.8	1.3
March	-1.2	8.7	-12.6	3.9	2.2	10.1	-1.6	1.6
April	0.8	10.5	-4.4	2.4	2.0	9.3	-2.2	1.6

Month	Air Temperature (°C)				Sea Surface Temperature (°C)			
	Mean	Maximum	Minimum	Standard Deviation	Mean	Maximum	Minimum	Standard Deviation
May	3.2	13.8	-1.0	2.0	3.0	10.0	-1.8	1.6
June	5.7	15.0	0.3	2.1	4.4	13.3	-2.2	1.7
July	8.7	18.0	0.6	2.8	8.2	18.5	0.9	2.1
August	11.6	21.0	0.9	2.4	12.6	18.2	2.0	2.0
September	10.0	18.7	0.4	2.6	10.5	17.8	2.3	1.8
October	5.8	15.5	-1.7	3.1	8.0	16.2	0.0	2.3
November	3.2	14.0	-6.0	2.9	4.8	15.0	-0.5	1.6
December	1.5	13.9	-9.3	3.7	3.5	13.0	-0.1	1.5

Table 2.8. Monthly mean air and sea surface temperature (°C) for the East Orphan Basin (Source: Table 5.7 in Stantec 2018 [ICOADS database; years not specified]).

Month	Air Temperature (°C)				Sea Surface Temperature (°C)			
	Mean	Maximum	Minimum	Standard Deviation	Mean	Maximum	Minimum	Standard Deviation
January	0.4	15.0	-11.0	3.5	4.9	11.0	-2.0	1.2
February	0.4	16.2	-10.0	4.2	4.2	13.3	-2.0	1.1
March	1.8	10.7	-10.1	3.5	3.9	12.3	-1.1	0.9
April	3.7	11.9	-2.1	2.2	4.3	11.0	0.0	0.8
May	5.2	13.9	-2.0	1.8	5.4	13.3	0.0	1.1
June	7.0	16.1	0.5	2.0	7.4	15.1	0.5	1.7
July	10.2	17.8	1.4	2.1	10.2	18.6	1.0	1.4
August	12.3	20.0	6.6	1.9	13.1	18.0	5.7	1.3
September	11.8	18.3	5.0	2.0	11.7	20.0	5.0	1.8
October	8.9	18.0	-1.8	2.2	9.9	18.0	1.0	1.5
November	5.3	15.0	-6.1	2.6	7.7	16.1	0.7	1.4
December	3.2	12.5	-5.0	3.0	6.0	15.0	0.0	1.2

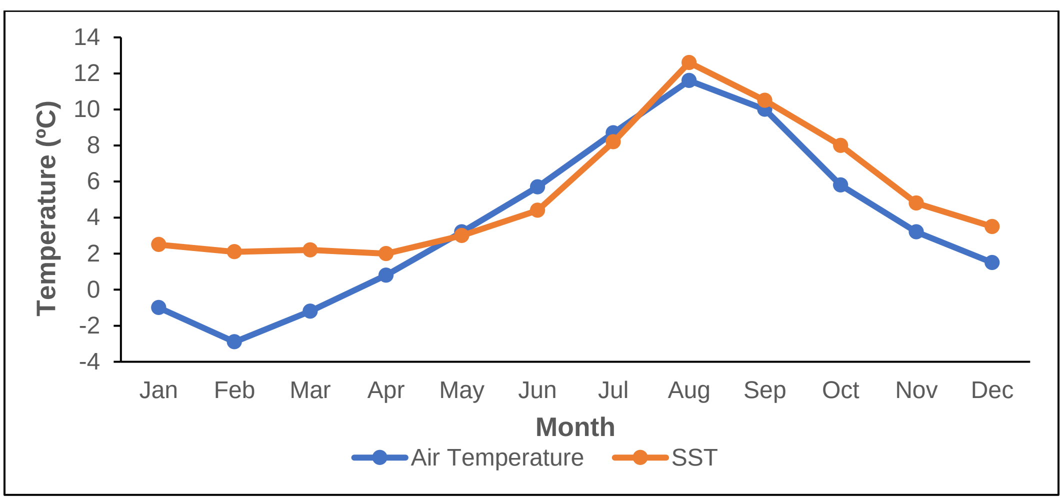


Figure 2.11. Monthly mean air and sea surface temperature (ºC) for the West Orphan Basin (Source: Figure 5.14 in Stantec 2018 [ICOADS database]).

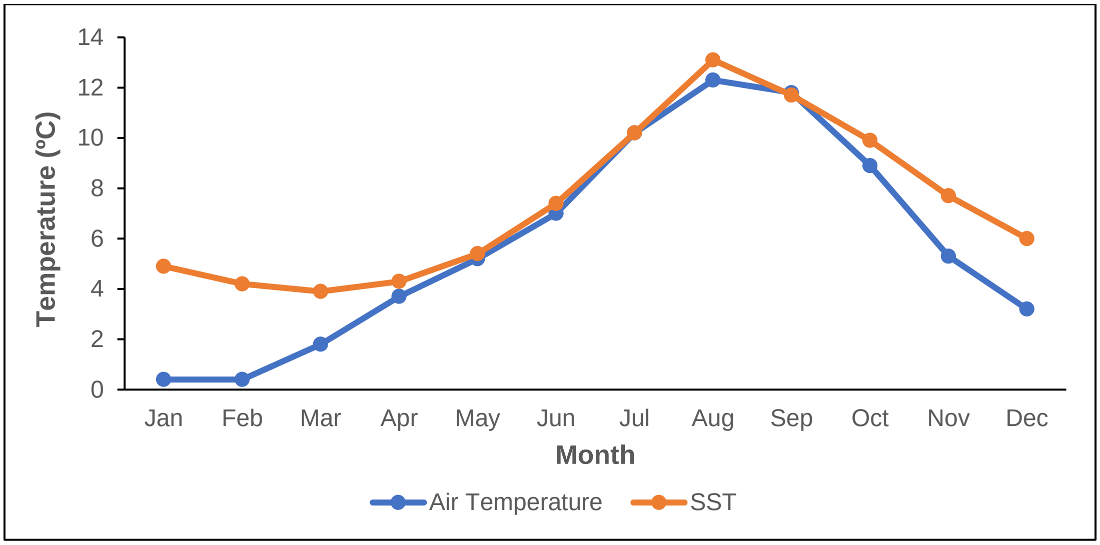


Figure 2.12. Monthly mean air and sea surface temperature (ºC) for the East Orphan Basin (Source: Figure 5.13 in Stantec 2018 [ICOADS database]).

2.3 Response Options

This section summarizes available response options in the event of an oil spill (see Chapter 6 in NASEM 2020 for detailed, peer-reviewed analyses for each response option). When selecting optimal response options during a spill, the logistical advantages and limitations of each response option must be weighed in a trade-off analysis that also includes consideration of relevant environmental factors, such as sea state, weather, visibility, and the required time to deploy specialized equipment to an offshore spill site from shore-based Canadian or international sources. Generally, the most effective solution is to employ multiple response options concurrently to best reduce surface and shoreline oiling (Caplis and Krieger 2017). However, response planning must include safe and efficient logistics to avoid issues, such as the overlap of areas of operation, that could impede the conduct of simultaneous operations or cause increased risk to human safety (Figure 2.13). This SIMA is intended to serve as an example of response option selection, including evaluating whether different response options would better protect resources and promote their recovery compared to natural attenuation (i.e., no intervention). Six possible spill response options are considered, including:

1) Natural Attenuation;
2) Shoreline Protection and Recovery;
3) On-water Mechanical Recovery;
4) On-water In-situ Burning (ISB);
5) Surface Dispersant Application; and

6) Subsea Dispersant Injection (SSDI).

Figure 2.13. Examples of offshore oil response options (Source: BSEE 2022).

2.3.1 Natural Attenuation

Natural attenuation is the no intervention response option, during which spilled oil is left to gradually and naturally weather until it evaporates, dissolves, and disperses into the water column or undergoes shoreline stranding. Stranded oil continues to undergo weathering from tidal action and will ultimately biodegrade or become buried in the sediment. The fate of the weathering and stranded oil is modelled in real-time via remote sensing and monitored at sea and on impacted shorelines.

Advantages: The only aspect of natural attenuation with direct human involvement is spill monitoring; therefore, this response option features the lowest threat to responder health and safety. Of note is the reduced/lack of threat from Volatile Organic Compound (VOC) inhalation or unfavourable sea states (e.g., storms). Natural attenuation also eliminates the risk of harm to sensitive habitats (particularly shorelines) due to the presence of humans and response equipment.

Limitations: Shorelines are not protected from oil contact should winds and currents cause spilled oil to reach the coast. ROCs could experience chronic exposure if oil is left to weather and dissipate naturally, including oil in/on the water and stranded on the shoreline. Stranded oil on the shoreline could potentially re-mobilize due to tidal/wave action, increasing total potential for interaction/exposure for ROCs. Natural attenuation may be a lengthy process in areas or during times of year that are colder, have relatively few daylight hours, and/or feature calm conditions. Sea surface oil slicks may persist for hours for lighter oils in areas with high sea states or up to months for heavier/emulsified oils in low-energy conditions (Sponson 2020). Although the risk of exposure of response personnel to VOCs is decreased throughout the RAA with this response option, it does not reduce the health and safety risk of VOC exposure at the well site itself for personnel on board vessels operating on the sea surface. There is also a risk of negative public perception towards an oil and gas producer, the response organization, and regulatory agencies should managing responders opt to utilize this non-intervention response method, as the public can be anticipated to expect the producer to actively try to eliminate spilled oil from the environment. A lack of response (other than monitoring) could result in public outcry against the producer and the Program.

Considerations Specific to the RAA: Visibility is often reduced within the RAA due to the presence of thick fog, particularly during the spring and summer months (see Figure 2.5 above), when the Ephesus Well is planned to be drilled and plugged and abandoned (per industry standards and regulatory requirements) during 2023. Because of this, monitoring of the fate of an oil spill would likely need to consist of both remote sensing (e.g., oil spill tracking buoys) and, when conditions allow, aerial observations (e.g., aircraft or satellite imagery) (Sponson 2020). The remote location of the Program's ELs would also limit available flight time for aerial surveys due to fuel consumption during lengthy transits between shore and the spill site.

2.3.2 Shoreline Protection and Recovery

Shoreline protection involves diversion and deflection booming of oil and recovery refers to active, manual oil retrieval. Shoreline protection and recovery may be employed when other response options fail to prevent oil from reaching the shoreline. Shoreline protection and recovery requires a large responder work force and specific training. Strong logistical management is needed, including personnel transportation, lodging, and coordination; the provision, maintenance, storage, and transportation of responder personal protective equipment (PPE), tools, washing equipment, and booms; and planning operations in potentially remote locations and/or during periods of poor weather conditions. Remote shoreline locations within the RAA may also feature difficult terrain, such as rocky cliffs, and may also be inaccessible by land. Hurricane season within the RAA occurs from mid-August to mid-October, which coincides with planned operations at the Ephesus Well. Due to climate change, tropical storms and hurricanes have been making landfall within the RAA at increased frequency and intensity in recent years. Depending on the location and weather, shoreline protection and recovery efforts may be thwarted by logistical and/or physical constraints.

There are several shoreline oil recovery methods that may be employed. The type(s) and intensity of the recovery option(s) used depend on the habitat type and biological sensitivity of the impacted shoreline area. Responding managers would decide which method(s) to use based on an analysis of site maps, consultation with wildlife technical specialists and regulators, and bp tactical response plans. Typical recovery methods include:

1) Manual Removal: responder personnel manually remove surface oil using means such as PPE-protected hands, rakes, shovels, buckets, scrapers, and sorbents;
2) Debris Removal: responder personnel manually and/or mechanically remove oiled and unoiled debris from the shore/sea surface as a preventative measure against further contamination;
3) Use of Mechanical Recovery Equipment: limited use within reasonably accessible areas if warranted by the level of contamination; and
4) Low-pressure Cold-water Flushing (or possibly high-pressure/elevated temperature flushing or the use of surface washing agents).

Advantages: Booming can protect small portions of the shoreline from contact with oil and can effectively safeguard sensitive habitats or areas that are important for stakeholders, including areas of importance for Indigenous persons. By taking environmental conditions into account and using real-time spill trajectory modelling, booms can be quickly and strategically deployed as an attempt to prevent oil from reaching the shoreline. Should oil reach the shoreline, employing shoreline recovery options may be more advantageous than natural attenuation as shoreline recovery reduces shoreline oiling, and, therefore, the chances of oil remobilization, involves the direct removal of oil from the ecosystem, includes the recycling or appropriate disposal of recovered oil, mitigates effects on areas of environmental, ecological, and/or cultural importance, and prevents the negative public perception associated with inaction. It should be noted that while waste handling and the disposal of recovered oil are part of the oil spill response strategy for this and other applicable response options, secondary risks associated with waste management (i.e., the fate of the waste/recovered oil) are beyond the scope of a SIMA but would occur in accordance with bp's Oil Spill Response Plans (OSRPs) regulatory requirements.

Limitations: Static oil boom systems may only be utilized during relatively low sea states and are generally restricted to swell heights below approximately 1 m (e.g., Nuka Research 2015). Strong tides and currents may be problematic for successful boom use and high winds/stormy conditions may transport oil beyond a boom or prevent its deployment entirely. The physical characteristics of the shoreline habitat, such as topography and hydrography, may also restrict boom use. Overall, shoreline recovery causes more habitat disturbance than on-water response options. While a boom may protect a shoreline from contact with oil, its use may inadvertently cause damage to the habitat during installation, maintenance, or removal activities, such as disturbance to or anchor scarring on sediments and marine flora or shoreline erosion from boom movement. However, should this damage occur, it would typically be considered insignificant relative to potential impacts from contact with oil from a spill. Similarly, sensitive shorelines can be negatively affected by the presence of humans and equipment during shoreline oil recovery. In this case, secondary impacts from recovery operations can be more damaging than the natural attenuation option, such as for soft-sediment habitats (e.g., wetlands) where pollutants may be submerged below the surficial sediment layer and interact with floral root systems or infauna. To prevent this occurrence, shoreline recovery in such habitats may be restricted to the use of sorbents deployed at the water line to absorb buoyant oil. Other than substrate type, shoreline recovery operations are restricted to daylight hours and cannot be conducted if environmental conditions (e.g., weather) would endanger responder health and safety. Depending on the volume of oil spilled and physical parameters of the shoreline (e.g., daylight intensity/duration, wave action, precipitation, geology), shoreline recovery can be a lengthy process, lasting from months to years.

Considerations Specific to the RAA: Much of the shoreline within the RAA is remote and inaccessible or difficult to access by land and features physically active seas that would prevent the safe use of small vessels to transfer responders or deploy/maintain/retrieve a boom. Coastal areas with coarse (i.e., boulder/large cobble) sediment may also impede the use of boats and the presence of bedrock platforms or cliffs may block responder access to an impacted shoreline. Likewise, many shoreline areas of Newfoundland are inaccessible by road, which may prevent or delay response. Although the Ephesus Well is planned to be drilled during the warmer months of the year, if activity during colder weather is necessary for this or future wells, impacted shoreline areas may be inaccessible/unsafe for shoreline recovery activities due to the presence of snow and ice.

2.3.3 On-Water Mechanical Recovery

On-water mechanical recovery is a water surface-based oil redirection, containment, and removal option that involves the combined use of skimming and support vessels, storage barges, spotter aircraft, booms, and skimmers. Skimmer-towing vessels generally travel at 1 knot (~1.9 km/h), although recent developments in boom/skimmer technology may allow vessel speed to increase up to 5 knots (~9.3 km/h; e.g., QualiTech 2023); these speeds result in a relatively low oil encounter rate (IPIECA and IOGP 2015b). Recovered oil is stored on specialized barges or in towable bladders. When the storage units reach capacity, they transit (barges) or are towed (bladders) to designated shore-based facilities to be offloaded and treated, recycled, or disposed of in accordance with direction from Service NL. Optimal on-water mechanical recovery conditions include calm wind and waves and long daylight hours. If necessary, night vision devices and infrared telemetry may be used to support operations during periods of darkness, but on-water mechanical recovery activities are typically restricted to daylight periods with relatively good visibility, as operational monitoring is limited to visual means (e.g., spotter aircraft or satellite imagery).

Advantages: Recovered oil is completely removed from the environment, which can garner public approval of on-water mechanical recovery as a response option and can minimize effects on ROCs. With this method, oil recovery may continue if some weathering occurs, making it a viable response option for a longer period than other on-water options. On-water mechanical recovery is usually always included as part of the chosen response plan for an oil spill, providing environmental conditions allow it to be safely conducted.

Limitations: Weather (namely fog and wind), sea ice, visibility, and sea state conditions are limiting factors for the safe conduct of on-water mechanical recovery. Vessel speed and barge/towable bladder storage capacity limitations reduce the overall efficiency of this method; even when sea states are conducive for on-water mechanical recovery operations, these techniques typically recovery no more than ~10% of the oil spilled in open ocean environments (P. Page, pers. comm., 3 Nov. 2022). Recovery vessels would be on hand to assist in immediate spill response, but these vessels are only capable of small-scale recovery operations. The mobilization and transit time required for vessels and equipment to reach the spill site that could support high-capacity recovery operations results in a delayed start to large-scale activities and reduced temporal opportunity to conduct on-water mechanical recovery before spilled oil undergoes too much weathering for recovery to continue.

Considerations Specific to the RAA: Relatively calm sea states are required for on-water mechanical recovery. Although some booms are rated for wave heights of approximately <3.5 m, which corresponds to a World Meteorological Organization sea state of ≤5 (e.g., C-NLOPB 2009), operations are generally limited to periods with wave heights of approximately <1.2-1.5 m (P. Page, pers. comm., 3 Nov. 2022). Beyond this general wave height, booms used in association with skimming operations typically lose their effectiveness. Wave heights within the RAA often exceed this operational limitation, although they are relatively lower during the spring and summer when activities are planned for the Ephesus Well (see Table 2.4 above). Visibility within the RAA can be greatly reduced by fog during the warmer months, particularly June and July (see Figures 2.4-2.5 above). Daylight periods are reduced during fall and winter (see Table 2.1 above), although cold-weather drilling operations are not planned at this time. The presence of sea ice within the RAA, which may persist until the latter part of July (see Table 2.6 above), may hamper vessel booming/skimming operations.

2.3.4 On-Water In-Situ Burning

Like on-water mechanical recovery, on-water ISB involves the use of vessels and booms to collect and concentrate oil on the sea surface; however, unlike mechanical recovery, ISB requires the use of fire-resistant booms. The effectiveness of on-water ISB is generally determined via the conduct of a test burn on spilled oil that has been collected and concentrated to a thickness (2-5 mm [IPIECA and IOGP 2016]) that will support combustion. Some oil residue is generally left on the surface following on-water ISB, but the small amount precludes collection for burning. On-water ISB produces dense, black plumes of smoke that are comprised of gases and soot particulates (e.g., CO_2, CO, SO_2, and NO_x, and up to 90% ultrafine soot particles [<1.0 μm], which can be deeply inhaled into human lungs and enter the blood stream) that disperse into the atmosphere (Faksness et al. 2022). Providing responders would not be exposed to the smoke plumes, aerial monitoring may be necessary during on-water ISB.

Advantages: On-water ISB significantly removes more oil from the sea surface than on-water mechanical recovery, although ISB does increase atmospheric oil particulate matter concentrations. Logistics for on-water ISB are simpler than on-water mechanical recovery, as there is no need to store collected oil or transfer the oil to shore for treatment.

Limitations: Regulatory approval is required before on-water ISB can occur. The effectiveness of on-water ISB is dependent on oil type and weathering, as heavy and highly weathered oils burn less readily. On-water ISB requires the use of specialized, fire-resistant booms rather than the nonspecialized booms used for on-water mechanical recovery. Otherwise, on-water ISB is limited by the same operational constraints as on-water mechanical recovery, including low vessel speed, calm weather and sea state, daylight operations, and relatively low oil encounter rate while the oil is initially collected using vessels and booms. Ice-covered waters preclude the use of on-water ISB in Canada; although herding agents may be deployed via helicopter in ice-covered waters of other countries, no herding agents have been approved for use in Canadian waters (see the list of approved spill-treating agents under the *Canada Oil and Gas Operations Act* [JLW 2022]). Unlike on-water mechanical recovery, on-water ISB does create a relatively small amount of by-product burn residues that may descend into the water column and is not recoverable. Visible smoke plumes can result in unfavourable public perception of recovery efforts for on-water ISB; however, due to the Program's remote EL locations, smoke plumes would not be visible to community residents and may only be viewed by the public via potential media coverage or by stakeholders (e.g., fishers) operating in the region.

Considerations Specific to the RAA: Due to the remote location of the Ephesus Well relative to shore, the potential for exposure to smoke plumes (including possibly increased concentrations of gases and airborne particulates) would be limited to responder personnel, as smoke plumes would be anticipated to disperse before reaching land. On-water ISB requires calmer sea states than on-water mechanical recovery, with operations typically limited to wave heights <1 m and wind speeds <10 knots (<5.14 m/s) (IPIECA and IOGP 2016). Wave heights and wind speeds within the RAA often exceed these operational limitations, including during the spring and summer when activities are planned for the Ephesus Well (see Tables 2.2-2.4 above). Visibility within the RAA can be greatly reduced by fog during the warmer months, particularly June and July (see Figures 2.4-2.5 above). Daylight periods are reduced during fall and winter (see Table 2.1 above), although cold-weather drilling operations are not planned at this time. The presence of sea ice within the RAA, which may persist until the latter part of July (see Table 2.6 above), may hamper on-water ISB operations.

2.3.5 Surface Dispersant Application

Surface dispersant application is conducted via aircraft or vessels fitted with a spray-boom that deploy commercial dispersants onto the sea surface, in conjunction with a spotter aircraft that targets surface oil slicks suitable for this response method. The purpose of the dispersants is to act as surfactants, reducing the surface tension so spilled oil is broken into smaller-sized droplets (typically 10 to >200 μm diameter) that can disperse into the water column (upper ~10 m), thereby increasing the surface area-to-volume ratio and rate of dissolution, dilution, weathering, and microbial degradation of oil components (e.g., DFO 2021). Small oil droplets that are diluted through the use of dispersants also have a reduction in droplet collisions, hindered droplet coalescence, and minimized reformation of surface slicks (DFO 2021). An overview of dispersants and dispersed oil, including how they work, toxicity, biodegradation, and other biological considerations is available in IPIECA and IOGP (2015c), Appendix A of Sponson (2020), and DFO (2021). The only dispersant approved for use in Canada is COREXIT-9500A. bp has all relevant information/documentation in house, on hand, and readily available to a spill response team for preparedness training and an actual spill event. Additionally, ECRC, the expert spill response organization that would be employed during a spill, is very familiar with this dispersant.

The dispersant-to-oil ratio (DOR) used for surface dispersant application depends on the type and degree of weathering of spilled oil and can be modified throughout oil spill response operations for optimal efficiency based on data collected via real-time monitoring. The initial DOR is generally 1:20 for this response method (DFO 2021). Dispersant released from a large aircraft (which would be necessary within the RAA, given the distance from shore) can effectively break up ≤400 m^3 of oil per trip (Sponson 2020).

In addition to targeting oil slicks, the spotter aircraft monitors the effectiveness of response operations. Monitoring should occur in accordance with international Special Monitoring of Applied Response Technologies (SMART) protocols (USGC et al. 2006; OGP 2011). SMART protocols involve tiered monitoring methodology depending on the severity of a spill, ranging from aerial surveying for smaller spills (Tier 1) up to sampling and monitoring to determine hydrocarbon concentrations in the upper water column for model validation and the creation of an expedited SIMA for larger, more complex spills (Tier 3). For Tier 3 spills, field data must be quickly collected and analysed to inform daily response operations and determine whether dispersant use should continue.

Advantages: Applying surface dispersants physically reduces oil at the sea surface, which reduces VOC levels and the potential for VOC exposure for responders. The deployment speeds and oil encounter rates are considerably greater for surface dispersant application relative to on-water mechanical recovery or on-water ISB because dispersant application occurs from faster-moving vessels or aircraft. Vessel-based dispersant spraying can be conducted from specially equipped vessels that depart from port or on-site platform support vessels; oil targeting can be more accurate when dispersants are deployed via vessel rather than aircraft, although the overall encounter rate is lower. Surface dispersant application can be conducted in higher sea states than on-water mechanical recovery or ISB; greater wave action is actually advantageous to surface dispersant application as it will accelerate the dispersal of floating oil components into the upper water column. The maximum sea state and wind conditions are effectively dictated by safe operational requirements of vessels or aircraft; generally, wave heights above ~4 m would likely lead to natural dispersion and preclude dispersant operations. Like on-water mechanical recovery or on-water ISB, there can be a limited temporal window of effectiveness for surface dispersant application before weathering/natural dispersion renders its use unproductive; this window varies based on specific oil type and spill conditions but is typically up to several days for one-time spills (C-NLOPB 2009). However, this response method can be continuously used to contain a prolonged release, such as from a subsea well blowout which is the oil spill scenario modelled for this SIMA.

Limitations: Regulatory approval is required before dispersant application can occur. The dispersant must be listed as an approved spill-treating agent in a regulation by the Minister of the Environment under the *Canada Oil and Gas Operations Act* (JLW 2022). The use of the dispersant would be evaluated by the Chief Conservation Officer of the C-NLOPB and/or National Energy Board (NEB) to determine whether it would meaningfully contribute to oil spill response activities for a particular oil spill by reducing effects on the environment and promoting ROC recovery. If the Officer(s) approved the use of the dispersant, the C-NLOPB/NEB would issue a permit of authorization stipulating the conditions of its use (Government of Canada 2016). Depending on the location of an oil slick, operational health and safety regulations may limit the use of surface dispersant application. Aerial-based operations would be prohibited within the aerial exclusion (i.e., no fly) zone around source control, the diameter of which would be determined by the Program's safety group. The temporal window within which surface dispersant application may be optimally employed could be reduced if there is a lengthy transit between port and the oil spill site; fuel and allowable pilot flight time could be particularly limiting for aircraft dispersal. Dispersants lose their effectiveness once spilled oil is no longer fresh and begins to undergo weathering. The necessity to visually target oil slicks and monitor response operations limits surface dispersant application to daylight hours with good visibility. Unlike on-water mechanical recovery or on-water ISB, surface dispersant application requires a minimum sea state to maintain effectiveness, typically including wave heights of at least ~0.2 m (IPIECA and IOGP 2015c). Dispersant use may carry some risks to marine birds, as they might experience direct physical or toxicological effects from exposure to dispersant chemicals or dispersed oil or indirect effects due to exposure impacts on their prey or habitat, either of which could potentially result in reduced fitness or mortality for marine birds that spend time in the upper water column (Fiorello et al. 2016; Whitmer et al. 2018; Osborne et al. 2022). Monitoring following the Deepwater Horizon spill revealed the first implication that oil may be transported to the seafloor as marine snow following the use of dispersants, and recent findings indicated that the application of COREXIT increased polycyclic aromatic hydrocarbon (PAH) incorporation into sinking aggregates (Brakstad et al. 2018; Bacosa et al. 2020).

Considerations Specific to the RAA: Wave heights within the RAA are typically conducive to effective oil dispersal via surface dispersant application (see Table 2.4 above). Due to the remote well site location relative to shore, the onset of surface dispersant application would experience a delay due to necessary vessel transit time from port, and the daily duration of aerial operations would be limited. Upon activation, it is anticipated that a dispersant aircraft could arrive at a spill site on the Orphan Basin within 24 h and be operational by the spill's second day. Lengthy transit time out of the St. John's airport would restrict aerial options to large aircraft, such as a C-130 equipped with a 20-m^3 Airborne Dispersant Delivery System ("ADDS Pack") or one of Oil Spill Response Limited's (OSRL's) purposely modified Boeing 727-2S2F (RE) aircrafts fitted with internal tanks, pumps, and a spray boom (Sponson 2020; OSR 2022). Visibility within the RAA can be greatly reduced by fog during the warmer months, particularly June and July (see Figures 2.4-2.5 above). Daylight periods are reduced during fall and winter (see Table 2.1 above), although cold-weather drilling operations are not planned at this time.

2.3.6 Subsea Dispersant Injection

Instead of releasing dispersant onto the sea surface as with surface dispersant application, SSDI involves the injection of dispersant into the flow of spilling subsea oil from a fixed point, such as a well head opening on the seabed. SSDI is vessel-based and utilizes a vessel that features dispersant storage, pumps, and coiled tubing for dispersant delivery. Dedicated ROVs are used to deploy the injection equipment and monitor operational efficiency using underwater video and an oil particle size detector. Monitoring should be conducted in accordance with a subsea dispersant monitoring plan that should be enacted as soon as possible upon the commencement of response operations and include measurements of concentrations of deep-water hydrocarbon and dissolved oxygen. Visual monitoring should also occur via aircraft surveys or satellite imagery, and at/near sea surface monitoring for potential toxins (e.g., VOCs) should be performed.

Because the dispersant is in direct contact with oil being released from the seabed, the initial DOR for SSDI is generally 1:100. Like surface dispersant application, the subsequent DOR can be modified as necessary to optimize results.

Advantages: If SSDI is functioning optimally, it should result in reduced soluble/semi-soluble hydrocarbons (e.g., PAHs) and VOC emissions into the atmosphere – and, therefore, increased responder health and safety and operational effectiveness – at the sea surface in the vicinity of source control activities (i.e., within the area where activities pursuant to stopping/controlling hydrocarbon release due to containment loss are occurring) (Crowley et al. 2018; French-McCay et al. 2018). SSDI also decreases the size and thickness of surface oil slicks and can reduce the amount of oil that may reach the shoreline (Bock et al. 2018; French-McCay et al. 2018). In addition to improved conditions at the sea surface, the overall risk to responder health and safety through exposure to oil, dispersants, or dispersed oil is generally lowest for SSDI relative to the other active response methods, as most operations are conducted via ROV. Unlike the other active response options summarized above, SSDI operations are more robust in the face of adverse weather conditions and are not limited to daylight hours. Rather, SSDI activities may be conducted continuously, 24 h/day. Like surface dispersant application, SSDI has a high oil encounter rate, considerably greater than that of on-water mechanical recovery or on-water ISB. A lower volume of dispersant is required for SSDI compared to surface dispersant application (typical DORs of 1:100 versus 1:20 for SSDI and surface dispersant application, respectively). Compared to surface dispersant application, where dispersed oil dilutes vertically into the upper several metres of the water column, oil dispersed at the seafloor via SSDI dilutes in all directions throughout a considerably greater volume of seawater. Further, this rapid and widespread dilution results in lower dispersed oil concentrations for SSDI relative to surface dispersant application.

Limitations: Like surface dispersant application, SSDI requires regulatory approval before operations may commence. Mobilization activities to prepare a vessel to conduct SSDI is a longer process than the other active response methods and can take up to several days or weeks to mobilize and arrive on site. Sponson (2020) estimated a mobilization time of one to two weeks for a spill on the Orphan Basin. Once the necessary equipment is deployed on location (which also requires more time than other active response methods), support vessels are still required to resupply dispersant and for pumping. Two ROVs are required, both for equipment deployment and monitoring activities. If a real-life spill situation demands its necessity (e.g., due to the fate and transport of oil plumes), a dedicated monitoring vessel may also be required. Depending on real-life spill conditions it is possible that microbial degradation processes associated with SSDI operations could result in the depletion of deep-water oxygen concentrations within dispersed oil plumes, leading to hypoxia (e.g., NOAA 2012). For the duration of a spill response, conditions must be carefully monitored in real-time and the viability of continuing SSDI operations if oxygen concentrations decrease must be considered when planning daily response operations as part of the SIMA process. Although oil can be effectively dispersed utilizing SSDI, public misconception regarding the fate and transport of dispersed oil often results in negative perceptions of this method as a viable response option.

Considerations Specific to the RAA: Although SSDI subsea operations are largely independent of sea state and weather conditions, these factors could influence sea surface logistics (e.g., dispersant resupply) which may not be safely conducted in poor conditions (e.g., wave heights >5 m; Sponson 2020). However, mean wave heights within the Orphan Basin region of the RAA tend to be below 5 m (see Table 2.4 above). Potential reductions in response effectiveness associated with shallow areas (<500 m) are not applicable to the Program's ELs within the RAA, where the minimum depth is 970 m in EL1145, the EL within which the Ephesus Well will be located (see Table 2.5 above).

3 Resources of Concern

ROCs were identified for this SIMA based on comprehension of the marine ecosystem and anthropogenic activities within the RAA and of human safety during oil spill response operations. Marine species within the RAA that are important for commercial communal and Food, Social, and Ceremonial (FSC) fishing were elucidated through ongoing engagement and consultations with Indigenous communities (see Sections 3.2 and 7.4 in Stantec 2018 and Section 3.7 below). The fate and behaviour of a hypothetical, worst-case scenario oil spill for the Ephesus Well (Stantec 2022) were also assessed to identify vulnerable resources that could be impacted by an oil spill due to variables such as habitat location, species type, life stage, and sensitivity to oil.

Oil spill-related ROCs are summarized in this section based on the identification framework above using data presented in the EIS (Stantec 2018). Critical habitat and the status of species at risk, along with DFO Research Vessel (RV) and commercial fisheries data, were updated in this SIMA relative to data supplied in the EIS to provide spill response decision makers the most up-to-date information available to best inform response planning and operations (see Sections 3.1-3.3 and 3.6). Response priorities would be anticipated to vary in accordance with spill-specific conditions, including Indigenous and other stakeholder concerns and factors associated with seasonality (e.g., visibility [Section 2.2.3], wind and waves [Section 2.2.4], reproduction/migration [Sections 3.2 and 3.4-3.5]), regulatory changes in the status of species at risk, and the real-time occurrence of anthropogenic activity (e.g., fishing [Sections 3.6-3.7]).

Using the identification framework, the following ROCs were identified for this SIMA:

1) Special Areas and Species at Risk;
2) Marine Fish and Fish Habitat;
3) Invertebrates and Benthic Communities;
4) Marine and Migratory Birds;
5) Marine Mammals and Sea Turtles;
6) Socio-Economic;
7) Indigenous Fisheries; and
8) Responder Health and Safety.

To highlight spill response-relevant differences between inshore and offshore regions, a summary of associated habitat types for these ROCs within the RAA is provided in Table 3.1. Socio-Economic, Indigenous Fisheries, and Responder Health and Safety encompass all habitat types within the RAA.

Table 3.1. Habitats of Resources of Concern (ROCs) within the RAA (Source: based on Table 4-1 in LGL 2020).

Habitat			ROC
Category	**Type**	**Summary**	
Shoreline	Intertidal	Marine intertidal zone is defined as the area of the foreshore and seabed that is exposed during low tide and submerged during high tide	Special Areas and Species at Risk Marine Fish and Fish Habitat Invertebrates and Benthic Communities Marine and Migratory Birds Marine Mammals and Sea Turtles
Continental Shelf (subtidal zone to shelf break)	Sea Surface	Top 1 mm of the ocean surface; boundary layer where exchanges occur between the atmosphere and the ocean surface	Marine Fish and Fish Habitat [eggs / larvae] Marine and Migratory Birds Marine Mammals and Sea Turtles
	Upper Water Column (≤20 m)	Oceanic mixed layer pelagic environment	Special Areas and Species at Risk Marine Fish and Fish Habitat Invertebrates and Benthic Communities Marine and Migratory Birds Marine Mammals and Sea Turtles
	Lower Water Column (>20 m)	Marine pelagic environment between mixed layer and seabed	Special Areas and Species at Risk Marine Fish and Fish Habitat Invertebrates and Benthic Communities Marine and Migratory Birds Marine Mammals and Sea Turtles
	Seabed	Surficial sediment (surface and sub-surface)	Special Areas and Species at Risk Marine Fish and Fish Habitat Invertebrates and Benthic Communities
Continental Slope (shelf break to offshore)	Sea Surface	Top 1 mm of the ocean surface; boundary layer where exchanges occur between the atmosphere and the ocean surface	Marine Fish and Fish Habitat [eggs / larvae] Marine and Migratory Birds Marine Mammals and Sea Turtles
	Upper Water Column (≤20 m)	Oceanic mixed layer pelagic environment	Special Areas and Species at Risk Marine Fish and Fish Habitat Invertebrates and Benthic Communities Marine and Migratory Birds Marine Mammals and Sea Turtles
	Lower Water Column (>20 m)	Marine pelagic environment between mixed layer and seabed	Special Areas and Species at Risk Marine Fish and Fish Habitat Invertebrates and Benthic Communities Marine and Migratory Birds Marine Mammals and Sea Turtles
	Seabed	Surficial sediment (surface and sub-surface)	Special Areas and Species at Risk Marine Fish and Fish Habitat Invertebrates and Benthic Communities
Socio-Economic			Commercial Fisheries Other Anthropogenic Marine Activity
Indigenous Peoples and Communities			Indigenous Fisheries
Air			Responder Health and Safety

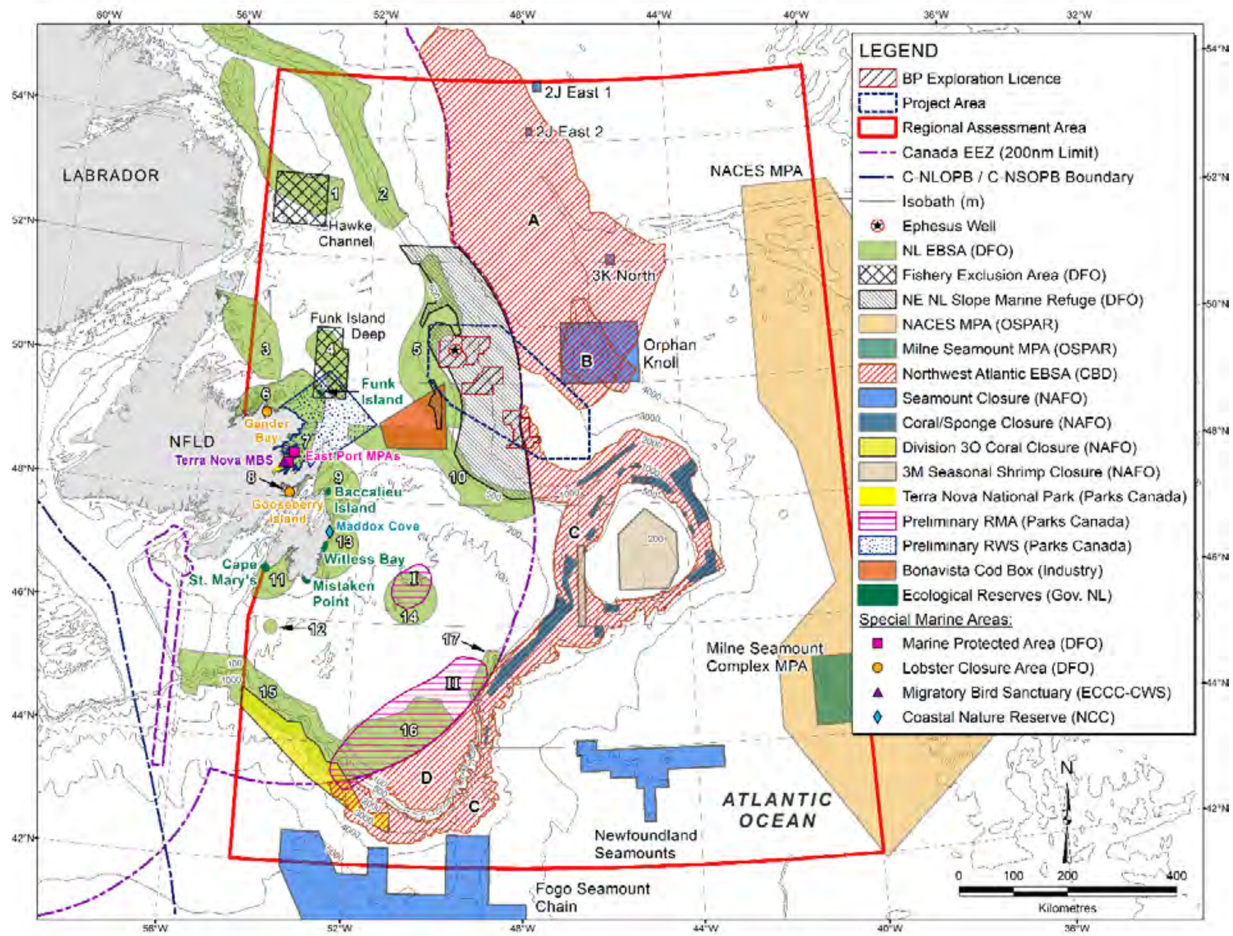
3.1 Special Areas and Species at Risk

The marine areas of coastal and offshore Newfoundland and Labrador contain various special areas, including sanctuaries, protected areas, fisheries closures, ecological reserves, and refuges and numerous species considered at risk (Stantec 2018).

3.1.1 Special Areas

All special areas protected under legislations, whether they be federal, provincial, or international, are considered here (Stantec 2018). Additionally, areas which provide ecological, historical (including cultural or archaeological), or socio-economic significance are acknowledged (Stantec 2018). Figure 3.1a,b indicates the location of all special areas within the RAA (updated from Stantec 2018). Fisheries closure areas, marine protected areas and refuges, migratory bird sanctuaries, national parks, wildlife areas, and critical habitats are all designated under federal legislation (Stantec 2018). Ecologically and Biologically Significant Areas (EBSAs) and Significant Benthic Areas (SBAs) are designated federally but not under legislation and therefore not legally protected (Stantec 2018).

Under the *Oceans Act*, there are two Marine Protected Areas (MPAs) in the region; however, only one is within the RAA: Eastport (which is also a designated reduced lobster fishery area under the *Fisheries Act*) (Stantec 2018). Additionally, there are two Lobster Closure Areas within the RAA, in which lobster fishing is prohibited to protect spawning habitat: Gander Bay and Gooseberry Island (Stantec 2018). Four marine refuges, including Division 3O Coral, Northeast Newfoundland Slope, Funk Island Deep, and Hawks Channel, fall within the RAA (Stantec 2018). These areas are closed to certain fishing activities, such as bottom contact fishing and bottom trawling, in order to protect habitats that support a variety of species, including Atlantic wolffish, Atlantic cod, and leatherback sea turtles (Stantec 2018). One federal national park, Terra Nova National Park, occurs within the RAA (Stantec 2018). There is one Migratory Bird Sanctuary (MBS) located in the RAA, as designated under the *Migratory Birds Act* (Stantec 2018). The Terra Nova bird sanctuary is important for up to 30 shorebird, seabird, and waterfowl species (Stantec 2018). DFO has identified 17 EBSAs which fall within the RAA and are recognized as significant habitats to various marine species, including those of conservation concern (Stantec 2018; Wells et al. 2019). There are no critical habitats for marine mammals, sea turtles, or birds within the RAA. However, there are five critical habitat areas for northern and spotted wolffish that intersect with the RAA (DFO 2020; Figures 3.2-3.3 below). Three preliminary Representative Marine Areas (RMAs; Northwestern Conception Bay, Virgin Rocks, and South Grand Bank Area) and one preliminary Region Without Studies (RWS; Unknown 17) have been identified within the RAA by Parks Canada as candidate sites for establishing new National Marine Conservation Areas (NMCAs) (Parks Canada 2023). SBAs identified by DFO for sea pens and sponges occur in water depths between ~500-2000 m in the northwestern portion of the RAA, and for small and large gorgonian corals in roughly the same depth range in the southwestern and northwestern portions of the RAA (Kenchington et al. 2018a,b). Numerous significant submarine canyons identified by NAFO occur along the slopes of the southern Grand Banks (J. Murillo-Perez, DFO, pers. comm., 2 May 2022).



NL [Bioregion] Ecologically and Biologically Significant Area (EBSA): 1 = Labrador Marginal Trough; 2 = Labrador Slope; 3 = Grey Islands; 4 = Notre Dame Channel; 5 = Orphan Spur; 6 = Fogo Shelf; 7 = Bonavista Bay; 8 = Smith Sound; 9 = Baccalieu Island; 10 = Northeast Slope; 11 = St. Mary's Bay; 12 = Haddock Channel Sponges; 13 = Eastern Avalon; 14 = Virgin Rocks; 15 = Southwest Slope; 16 = Southeast Shoal; 17 = Lilly Canyon-Carson Canyon.

Convention on Biological Diversity (CBD) Northwest Atlantic EBSA: A = Seabird Foraging Zone in the Southern Labrador Sea; B = Orphan Knoll; C = Slopes of the Flemish Cap and Grand Bank; D = Southeast Shoal and Adjacent Areas on the Tail of the Grand Bank.

Parks Canada Preliminary Representative Marine Areas (RMAs): I = Northwestern Conception Bay; II = Virgin Rocks; III = South Grand Bank Area. Parks Canada Region Without Studies (RWS): Unknown 17.

Figure 3.1.a Special marine areas within or that overlap the RAA (Source: Wells et al. 2019; CBD 2023; MCI 2023; NAFO 2023; OSPAR 2023; Protected Planet 2023).

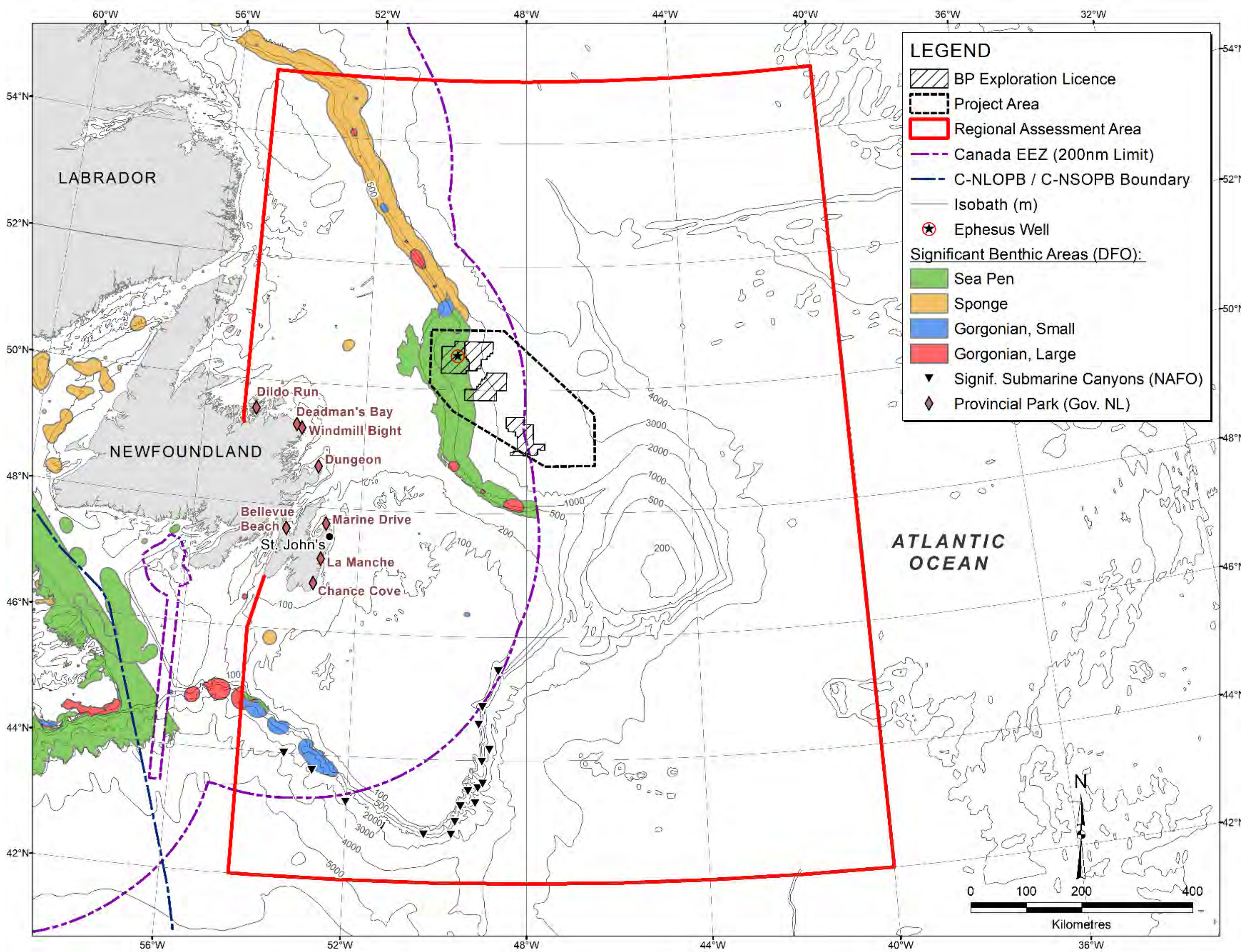


Figure 3.2.b Significant benthic areas, significant submarine canyons, and provincial parks within or that overlap the RAA (Source: TCAR 2016; Kenchington et al. 2018a,b; J. Murillo-Perez, DFO, pers. comm., 2 May 2022).

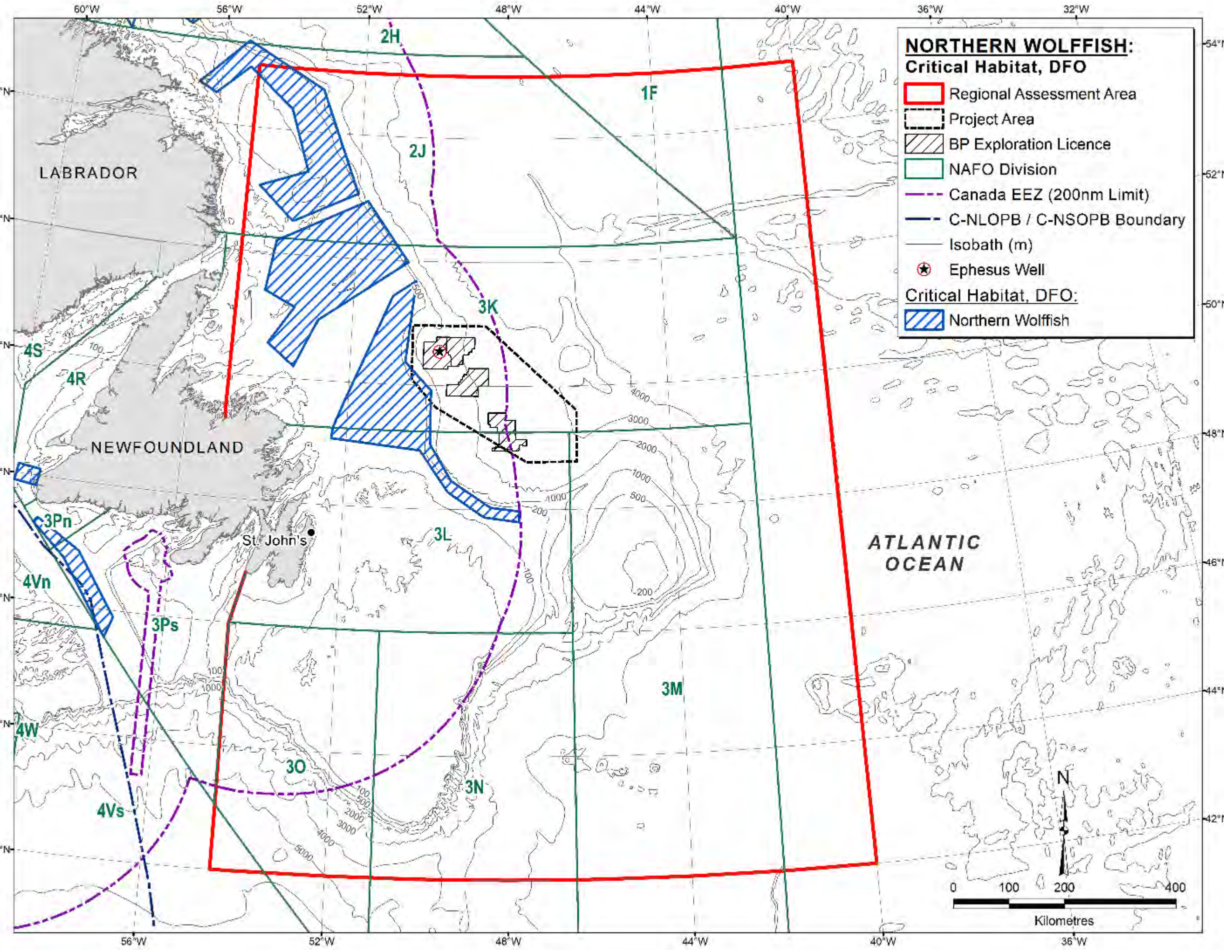


Figure 3.3. Critical habitat for northern wolffish (Source: DFO 2020).

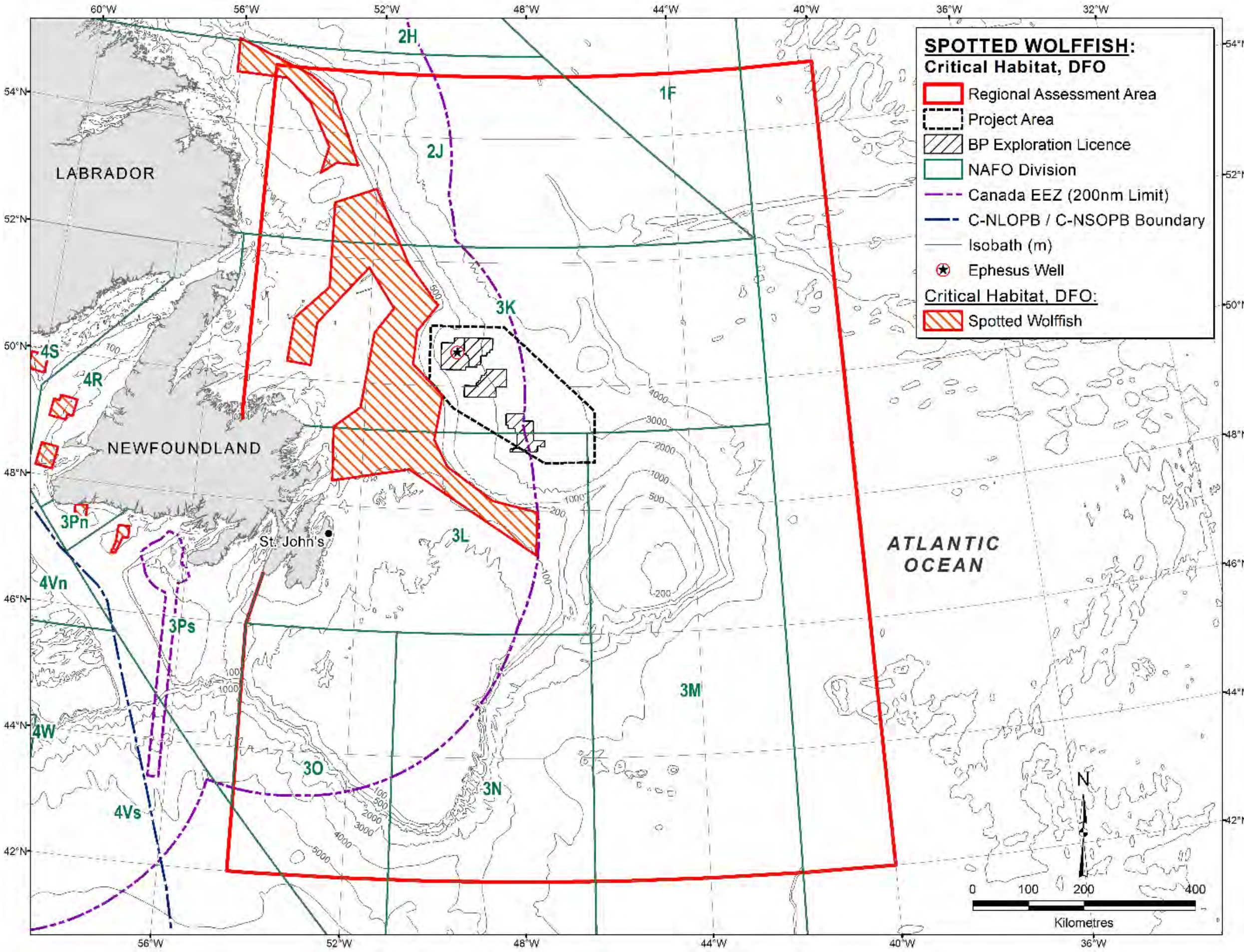


Figure 3.4. Critical habitat for spotted wolffish (Source: DFO 2020).

There are four ecological reserves under provincial designation within the RAA (Stantec 2018). The ecological reserves include Funk Island, Baccalieu Island, Witless Bay, and Cape St. Mary's; all contain significant seabird breeding colonies and nesting areas (Stantec 2018). Eight provincial parks occur within the RAA, from Dildo Run on the north coast to Chance Cove on the southeast Avalon peninsula (TCAR 2016).

Internationally, portions of Vulnerable Marine Ecosystems (VMEs) identified by the Northwest Atlantic Fisheries Organization (NAFO) intersect with the RAA. These are either coral, sponge, and sea pen closures or seamount closures; there are 15 of the former and five of the latter present in the RAA. Additionally, there is one United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage site, 12 Important Bird Areas (IBAs), and an experimental closure area called the Bonavista Cod Box located within the RAA (see Figure 3.15 below for IBAs). The North Atlantic Current and Evlanov Sea (NACES) basin MPA, designated by the OSPAR Commission in 2021 to protect important feeding/foraging habitat for coastal Northeast Atlantic and migrating seabird populations, overlaps most of the eastern border of the RAA (OSPAR 2023). The OSPAR Commissions Milne Seamount Complex MPA overlaps the southeastern portion of the RAA; this MPA protects near pristine oceanic seamount ecosystems (OSPAR 2010). There are four Northwest Atlantic EBSAs designated by the Convention on Biological Diversity (CBD) within/overlapping the RAA, including Southeast Shoal and Adjacent Areas on the Tail of the Grand Bank, Slopes of the Flemish Cap and Grand Bank, Orphan Knoll, and Seabird Foraging Zone in the Southern Labrador Sea (CBD 2023).

3.1.2 Species at Risk

There are various species at risk and species of conservation concern that occur in the marine habitats of the RAA. The EIS (Stantec 2018) provides in-depth descriptions of multiple biological groups, or resources of concern, as well as species at risk and/or conservation concern. Marine and marine-associated species at risk may be listed under Schedule 1 of the federal *Species at Risk Act* (SARA) as either special concern, threatened, or endangered; assessed under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as extirpated, endangered, threatened, or special concern; or designated under the Government of NL's *Endangered Species Act* (ESA) as endangered, threatened, or vulnerable. Species at risk and their status under SARA/COSEWIC/ESA that occur in the RAA are provided in Table 3.2.

Table 3.2. Species at risk under SARA and COSEWIC that occur in the RAA (Source: updated from Table 8 in Stantec 2018).

Species Common Name (Population)	SARA Status (Schedule 1) [a]	COSEWIC Designation [b]	ESA Designation [c]
Fish			
Atlantic Wolffish	SC	SC	-
Northern Wolffish	T	T	-

Species Common Name (Population)	SARA Status (Schedule 1) [a]	COSEWIC Designation [b]	ESA Designation [c]
Spotted Wolffish	T	T	-
American Eel	*	T	V
Basking Shark (Atlantic)	*	SC	-
Atlantic Cod (Newfoundland and Labrador)	*	E	-
Porbeagle Shark	*	E	-
Shortfin Mako (Atlantic)	*	E	-
White Shark (Atlantic)	E	E	-
Roundnose Grenadier	*	E	-
White Hake (Atlantic and Northern Gulf of St. Lawrence)	*	T	-
American Plaice (Newfoundland and Labrador)	*	T	-
Smooth Skate (Funk Island Deep)	*	E	-
Thorny Skate	*	SC	-
Atlantic Salmon (Southern Newfoundland)	*	T	-
Atlantic Bluefin Tuna	-	E	-
Acadian Redfish (Atlantic)	*	T	-
Deepwater Redfish (Northern)	*	T	-
Birds			
Harlequin Duck (Eastern)	SC	SC	V
Barrow's Goldeneye (Eastern)	SC	SC	V
Piping Plover (*melodus* subspecies)	E	E	E
Red Knot (*rufa* subspecies; Northeastern South America wintering)	*	SC	
Red Knot (*rufa* subspecies; Southeastern USA/Gulf of Mexico/Caribbean wintering)	*	E	E
Red Knot (*rufa* subspecies; Tierra del Fuego/Patagonia wintering)	E	E	
Buff-breasted Sandpiper	SC	SC	-
Red-necked Phalarope	SC	SC	-
Ivory Gull	E	E	E
Ross's Gull	T **	E	-
Leach's Storm-Petrel (Atlantic)	*	T	-
Peregrine Falcon (*anatum/tundrius* subspecies)		NR	V
Short-eared Owl	SC **	T	V
Marine Mammals			
Blue Whale (Atlantic)	E	E	-
Fin Whale (Atlantic)	SC	SC	-
Sei Whale (Atlantic)	*	E	-
North Atlantic Right Whale	E	E	-
Bowhead Whale (Eastern Canada-West Greenland)	*	E	-
Northern Bottlenose Whale (Scotian Shelf)	E	E	-
Northern Bottlenose Whale (Davis Strait-Baffin Bay-Labrador Sea)	*	SC	-
Sowerby's Beaked Whale	SC	SC	-
Killer Whale (Northwest Atlantic/Eastern Arctic)	*	SC	-
Harbour Porpoise (Northwest Atlantic)	-	SC	-

Species Common Name (Population)	SARA Status (Schedule 1) [a]	COSEWIC Designation [b]	ESA Designation [c]
Ringed Seal	*	SC	-
Sea Turtles			
Leatherback Sea Turtle (Atlantic)	E	E	-
Loggerhead Sea Turtle	E	E	-

[a] Species listing under the *Species at Risk Act* (Government of Canada 2022).

[b] Species assessment by COSEWIC (COSEWIC 2022).

[c] Species designation by the Government of NL ESA (Government of NL 2023).

* Under consideration for addition.

** Under consideration for status change.

Note: E = Endangered; T = Threatened; SC = Special Concern; NR = Not at Risk; V = Vulnerable; "-" = No status.

3.2 Marine Fish and Fish Habitat

A variety of fish species and associated habitats are located within the RAA and Orphan Basin. Marine fish and fish habitat are valuable components of the marine ecosystem and drive socio-economically significant fisheries. This, along with the potential for interactions between fish, their habitats, and hypothetical oil spill scenarios have led to their selection as a ROC.

The marine environment within the RAA is highly productive with habitats ranging from the Newfoundland slope to deep water (Stantec 2018). This gradient of habitats supports many marine fish species and assemblages, including demersal groundfish and pelagic bony and cartilaginous fishes (DFO 2016a in Stantec 2018). Fish species with the highest abundance (in terms of catch weight) from spring and fall DFO RV trawl surveys within the RAA (2017-2020 [note: there were no spring surveys during 2020 due to COVID-19]) included deepwater redfish (*Sebastes mentella*), Atlantic cod (*Gadus morhua*), American plaice (*Hippoglossoides platessoides*), yellowtail flounder (*Limanda ferruginea*), thorny skate (*Raja radiata*), and Greenland halibut (*Reinhardtius hippoglossoides*). Predominant fish species (i.e., those that contributed ≥0.01% to the total fish catch weight) recorded during the DFO RV surveys are provided in Table 3.3. Of the six most predominant species, deepwater redfish (northern population), Atlantic cod (NL population), American plaice (NL population), and thorny skate have been assessed under COSEWIC, and deepwater redfish, Atlantic cod, American plaice, and thorny skate are currently under consideration for addition to Schedule 1 of SARA (Government of Canada 2022) (see Section 3.1.2 and Table 3.2 above for all listed species within the RAA). The distribution of the predominant six species noted above during 2017-2020 DFO RV surveys are provided in Figures 3.4-3.9.

Various spawning strategies are used by fish species within the RAA, whether they stay in the area to spawn or migrate elsewhere. The spawning periods and locations for the six predominant fish species noted above for the RAA are provided in Table 3.4. Owing to their abundance, these species have the highest potential for interaction with an oil spill within the RAA and Orphan Basin area (Stantec 2018).

Many fish species found in the RAA are of value to commercial, recreational, or Indigenous fisheries (see Sections 3.6-3.7 below). Within the Canadian Exclusive Economic Zone (EEZ), fisheries resources and their associated habitats are managed by the Canadian federal *Fisheries Act*. Beyond the Canadian EEZ, species are managed by NAFO. Under the *Fisheries Act* and NAFO, there are designated fishery closure areas (FCAs) in the region; however, there are no FCAs within the RAA (Stantec 2018). Critical habitats for northern and spotted wolffish were finalized in a 2020 amendment to the SARA Recovery Strategy for these species (DFO 2020), of which five overlap the RAA (see Figures 3.2-3.3 above). Further information on fisheries and protected areas can be found in Sections 3.6-3.7 and 3.1.1, respectively.

Table 3.3. Predominant fish species that occur in the RAA and Orphan Basin (Source: DFO RV survey database, 2017-2020 [updated from Table 6.4 in Stantec 2018; modified to indicate species with at risk status under SARA and/or COSEWIC]).

Common Name	Scientific Name	Potential for Occurrence in the RAA	Potential for Occurrence on/near the Orphan Basin	Timing of Presence on / near the Orphan Basin
Demersal				
Deepwater Redfish*	*Sebastes mentella*	High	High	Year-Round
Atlantic Cod*	*Gadus morhua*	High	Moderate	Year-Round
American Plaice*	*Hippoglossoides platessoides*	High	Low	Year-Round
Yellowtail Flounder	*Limanda ferruginea*	High	Low	Year-Round
Thorny Skate*	*Amblyraja radiata*	High	Moderate	Year-Round
Greenland Halibut	*Reinhardtius hippoglossoides*	High	High	Year-Round
Sand Lance	*Ammodytes sp.*	Moderate	Low	Year-Round
Roughhead Grenadier	*Macrourus berglax*	High	High	Year-Round
Silver Hake	*Merluccius bilinearis*	Moderate	Low	Year-Round
Witch Flounder	*Glyptocepalus cynoglossus*	Moderate	High	Year-Round
Northern Wolffish**	*Anarhichas denticulatus*	Moderate	High	Year-Round
Atlantic Halibut†	*Hippoglossus hippoglossus*	Moderate	Moderate	December to March
White Hake*	*Urophycis tenuis*	Moderate	Low	Year-Round
Atlantic Wolffish**	*Anarhichus lupus*	Moderate	Low	Year-Round
Spotted Wolffish**	*Anarhichas minor*	Moderate	Moderate	Year-Round
Spinytail Skate	*Raja spinicauda*	High	Moderate	Year-Round
Roundnose Grenadier*	*Coryphaenoides rupestris*	Moderate	High	Year-Round
Longfin Hake	*Urophycis chesteri*	Moderate	Low	Year-Round
Golden Redfish	*Sebastes marinus*	Moderate	Low	Year-Round
Marlin Spike	*Nezumia bairdi*	Moderate	Moderate	Year-Round
Spiny Dogfish Shark*	*Squalus acanthias*	Moderate	Low	Year-Round

Common Name	Scientific Name	Potential for Occurrence in the RAA	Potential for Occurrence on/near the Orphan Basin	Timing of Presence on / near the Orphan Basin
Atlantic Haddock	*Melanogrammus aeglefinus*	Moderate	Low	Year-Round
Black Dogfish Shark	*Centroscyllium fabricii*	Moderate	Low	Year-Round
Shorthorn Sculpin	*Myoxocephalus scorpius*	Moderate	Low	Year-Round
Moustache Sculpin	*Triglops murrayi*	Moderate	Low	Year-Round
Monkfish	*Lophius americanus*	Moderate	Low	Year-Round
Blue Hake	*Antimora rostrata*	Moderate	Moderate	Year-Round
Common Lumpfish*	*Cyclopterus lumpus*	Moderate	Low	Year-Round
Arctic Cod	*Boreogadus saida*	Moderate	Low	Year-Round
Longhorn Sculpin	*Myoxocephalus octodecemspinosus*	Moderate	Low	Year-Round
Longnose Eel	*Synaphobranchus kaupi*	Moderate	Low	Year-Round
Sea Raven	*Hemitripterus americanus*	Moderate	Low	Year-Round
Pelagic				
Capelin	*Mallotus villosus*	High	Low	Year-round
Greenland Shark	*Simniosus microcephalus*	Moderate	Low	June to October
Atlantic Herring	*Clupea harengus*	Moderate	Low	Year-Round
Atlantic Salmon***	*Salmo salar*	Migratory/Transient	Migratory/Transient	

* Assessed under COSEWIC.

** Listed on Schedule 1 of SARA and assessed under COSEWIC.

*** Was not caught during DFO RV surveys (2017-2020) but has multiple populations or Designatable Units (DU's) which can occur in the area, all of which are assessed under COSEWIC.

† This species is listed under the IUCN Red List of Threatened Species but not under COSEWIC. The IUCN assessment did not include the entire Canadian distribution of the species and is outdated (1996), so may not be relevant to the species' current distribution within the RAA (COSEWIC 2011).

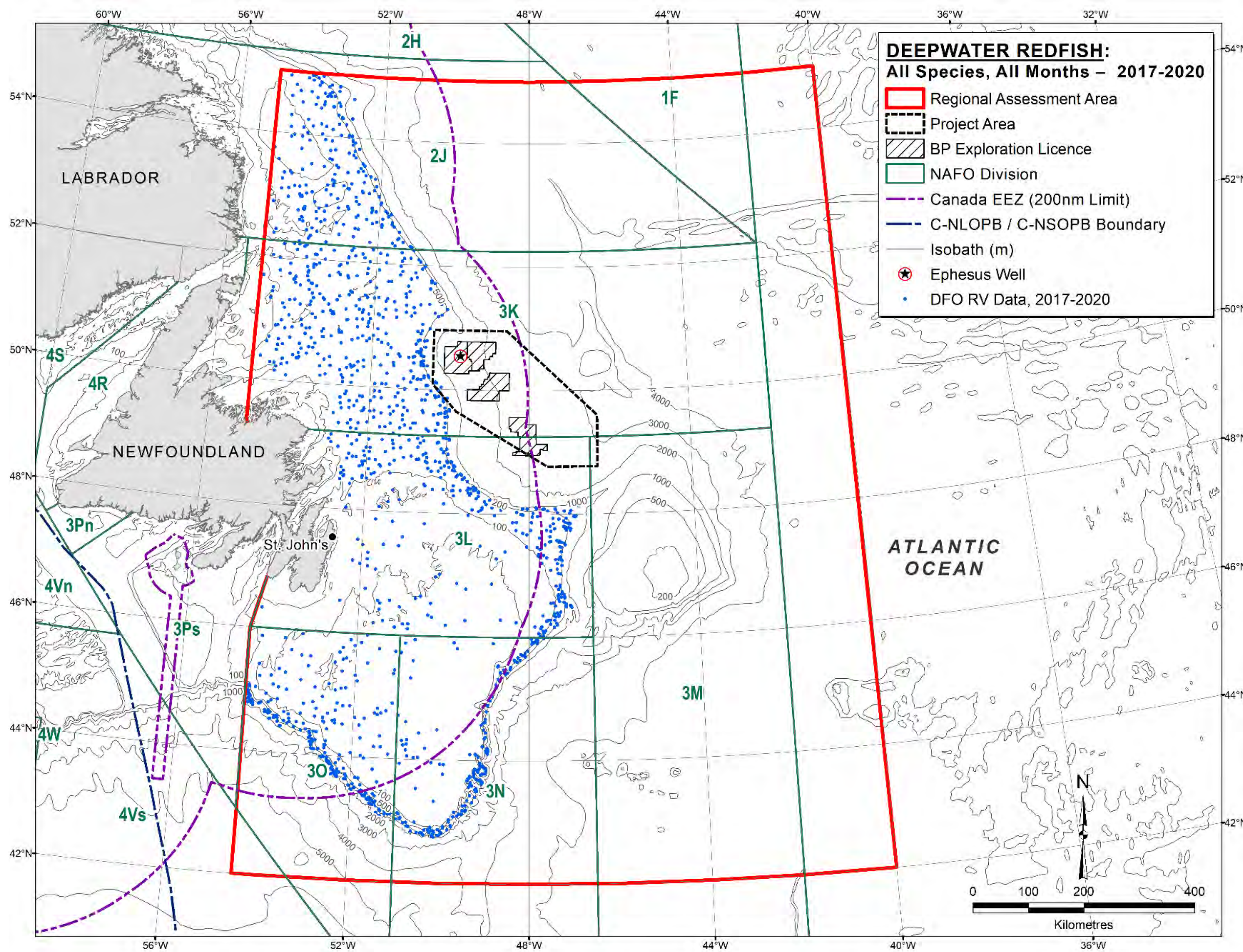


Figure 3.5. Distribution of deepwater redfish in the RAA (Source: DFO RV database, 2017-2020; each blue point represents a catch location).

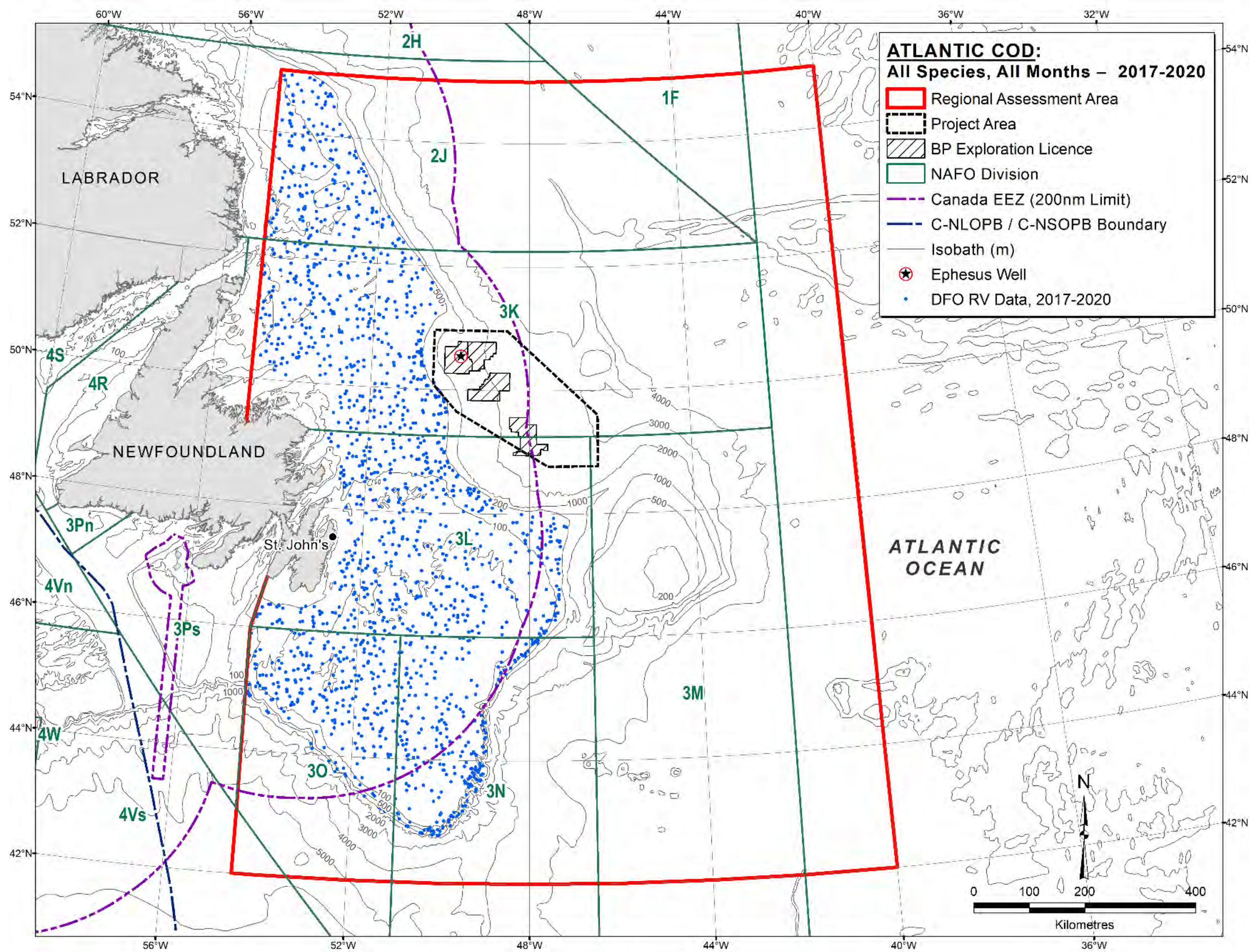


Figure 3.6. Distribution of Atlantic cod in the RAA (Source: DFO RV database, 2017-2020; each blue point represents a catch location).

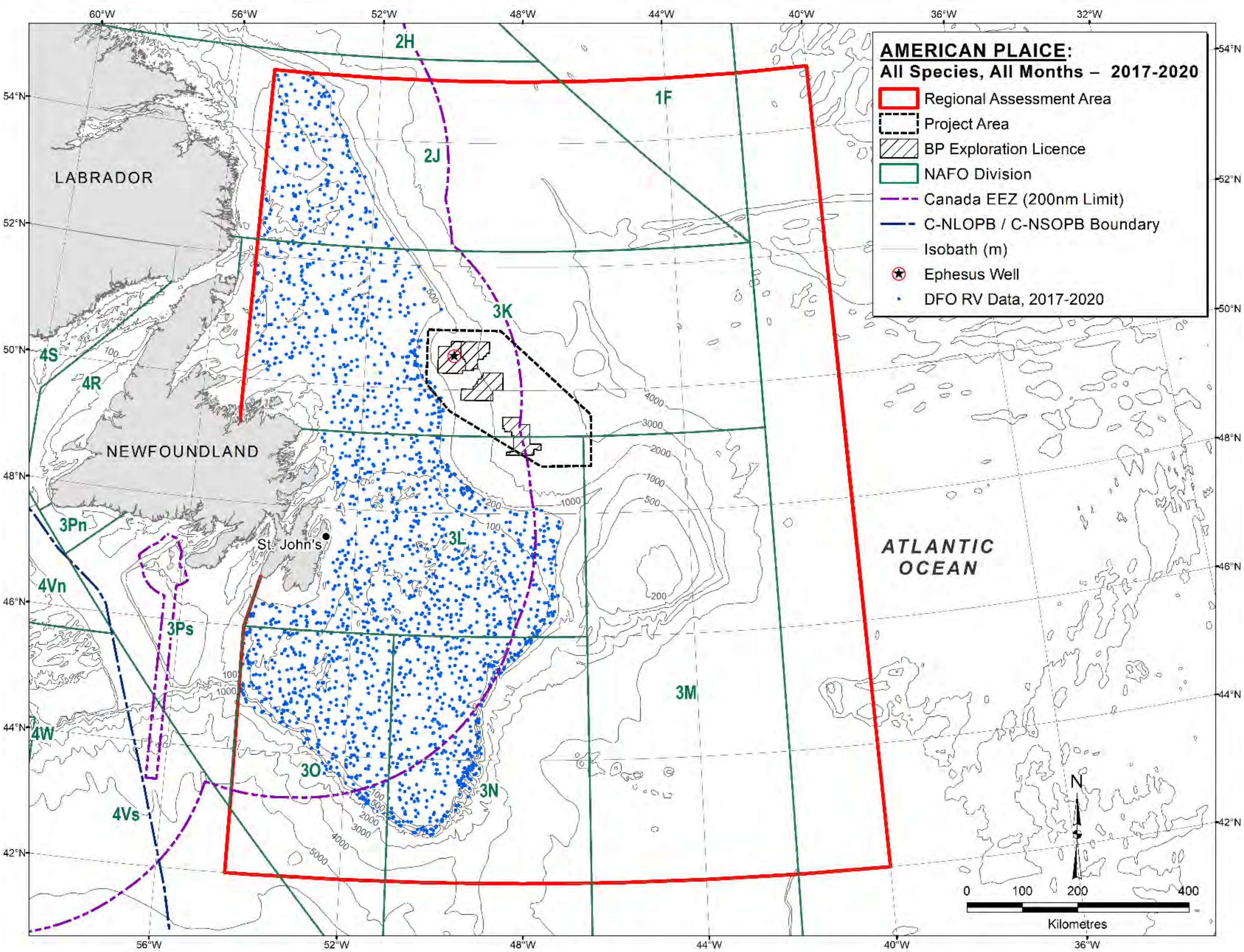


Figure 3.7. Distribution of American plaice in the RAA (Source: DFO RV database, 2017-2020; each blue point represents a catch location).

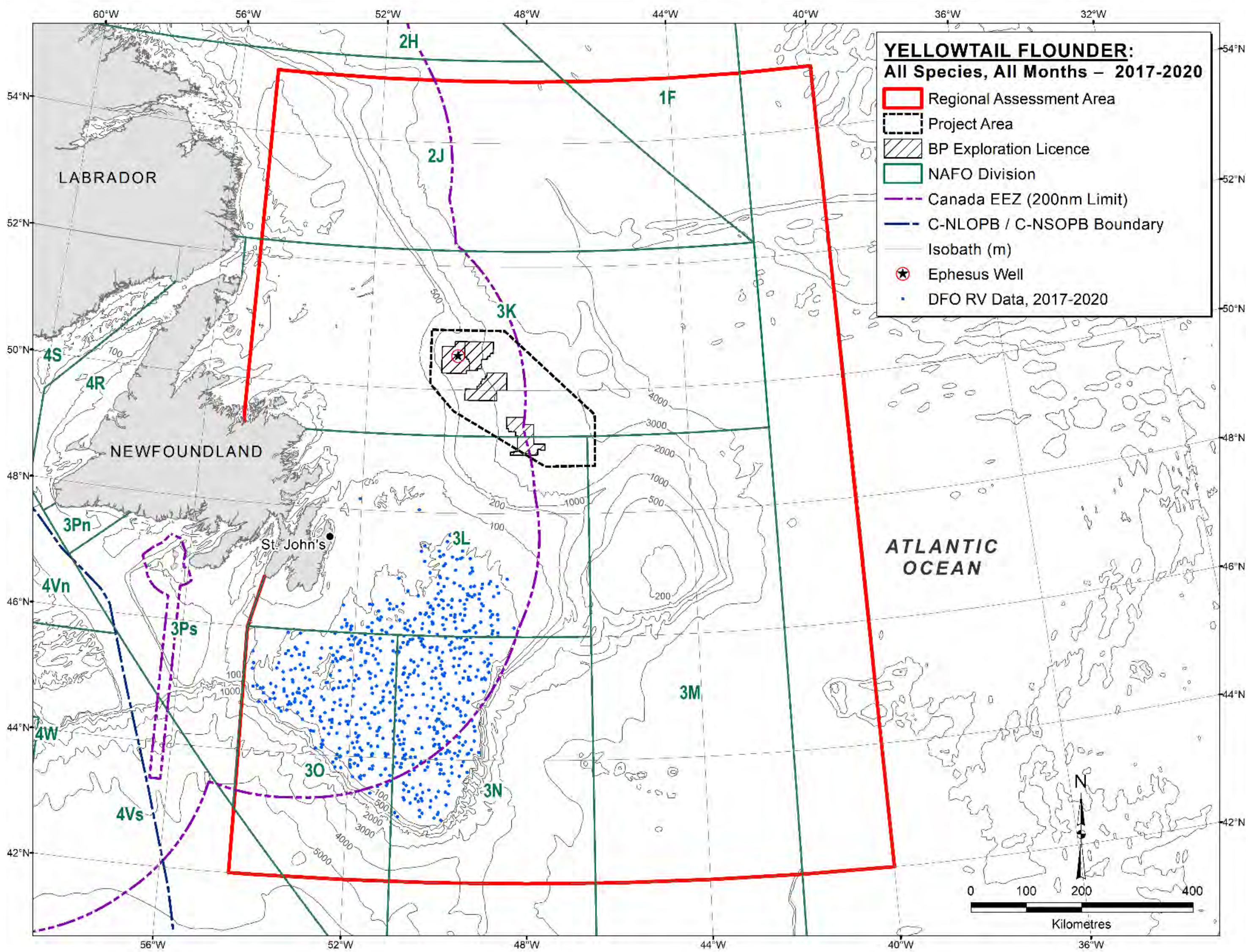


Figure 3.8. Distribution of yellowtail flounder in the RAA (Source: DFO RV database, 2017-2020; each blue point represents a catch location).

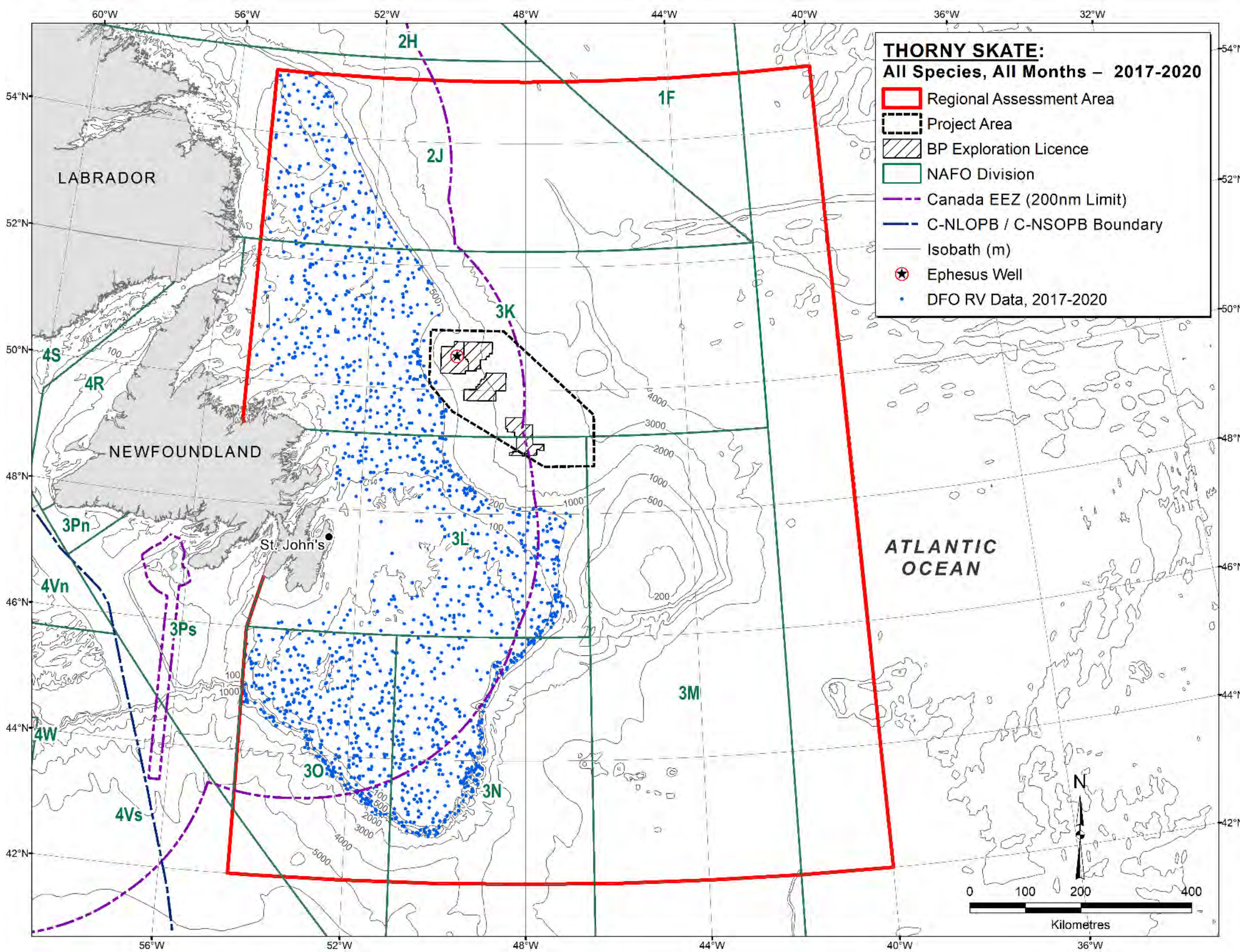


Figure 3.9. Distribution of thorny skate in the RAA (Source: DFO RV database, 2017-2020; each blue point represents a catch location).

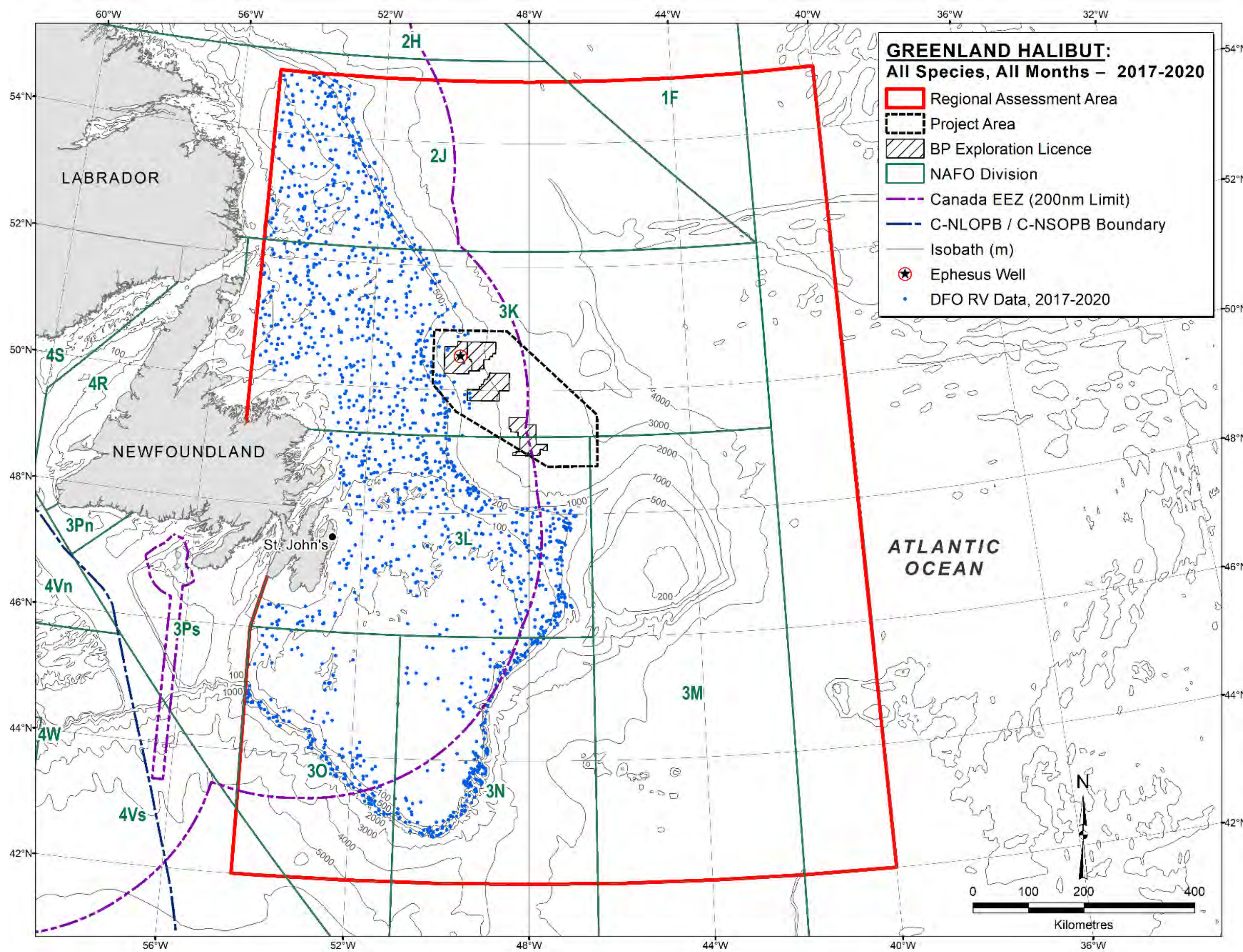


Figure 3.10. Distribution of Greenland halibut in the RAA (Source: DFO RV database, 2017-2020; each blue point represents a catch location).

Table 3.4. Timing and locations of spawning events for the most abundant fish species in the RAA (Source: updated from Table 6.5 in Stantec 2018 to reflect predominant species in DFO RV surveys, 2017-2020).

Common Name	Scientific Name	Spawning Time												Known Spawning Locations
		J	F	M	A	M	J	J	A	S	O	N	D	
Deepwater Redfish	*Sebastes mentella*			■	■	■	■							March-July: Southern Newfoundland shelf and Grand Banks (GB); May: mainly along the edge of the GB; June: mainly eastern GB near Flemish Pass[1]
Atlantic Cod (NL population)	*Gadus morhua*				■	■	■	■	■	■	■			Spawning occurs in waters off Newfoundland with depths ranging from tens to hundreds of metres[2]
American Plaice (NL population)	*Hippoglossoides platessoides*			■	■	■								Hamilton Bank, northeast Newfoundland Shelf, and over the entire Grand Bank and St. Pierre Bank[3]
Yellowtail Flounder	*Limanda ferruginea*						■	■	■					Widespread throughout southern Grand Bank[4]
Thorny Skate	*Amblyraja radiata*	■	■	■	■	■	■	■	■	■	■	■	■	Year-round spawning in waters off Atlantic Canada, including northeast Newfoundland Shelf and Grand Banks; peak spawning in fall and winter[5]
Greenland Halibut	*Reinhardtius hippoglossoides*	■	■	■									■	Spawning thought to occur in the deep waters of the Davis Strait to south of the Flemish Pass. No clear seasonality for Flemish Pass but peaks in winter for Davis Strait[6]

Note: Shading indicates spawning periods.

Sources: [1] Ollerhead (2004); [2] COSEWIC (2010); [3] COSEWIC (2009); [4] Walsh and Morgan (2004); [5] COSEWIC (2012); [6] Gunderson et al. (2010).

3.3 Invertebrates and Benthic Communities

Invertebrates is a catch all designation for a wide diversity of animals, such as crustaceans, echinoderms, and jellyfish, that share the basic trait of the absence of a spinal column. They collectively occupy a plethora of ecological niches, from active hunters to stationary filter feeders. Some serve as the building blocks that make up important habitat for other species. Some invertebrates are important commercial species while others are food for vertebrates, such as fish and whales. In the event of a subsea blow out, their potential interaction with oil will depend on where the organism lives and how the oil spill disperses in the water column. For the purposes of this report, invertebrates will be broadly divided into two groups, pelagic and benthic.

Crustaceans, such as copepods and shrimp, make up a sizeable proportion of the pelagic invertebrates found in the RAA (see Section 6.1.5 in Stantec 2018). Pelagic crustaceans are important prey items for predators such as fish, birds, and whales (Christensen et al. 1992; Mehlum and Gabrielsen 1993; Ignatyev 1996). Surveys completed by DFO found several species of shrimp in Newfoundland waters. Northern shrimp is the most common shrimp species inside the RAA, mostly concentrated along the continental shelf. They have been fished commercially since the 1970's, and they have been one of the most important economically after the cod collapse of the early 1990s (DFO 2016a in Stantec 2018; see Sections 6.1.5 and 7.2.7.1 in Stantec 2018). Soft bodied, gelatinous pelagic invertebrates, such as tunicates (salps and doliolids) and jellyfish, are important prey items for leatherback turtles, bluefin tunas, and sunfish (Hays et al. 2009; Heaslip et al. 2012; Section 6.1.5 in Stantec 2018). Short-finned squids are active pelagic hunters that in Newfoundland waters, and eat fish such as young cod, sand lance, and adult capelin (Dawe et al. 1997).

Typical members of the benthic community found during a 1977 survey on the Orphan Basin included polychaetes, bivalves, echinoderms (e.g., sea urchins and brittlestars), sponges, bryozoans, and brachiopods. Predominant taxological groups at different depths on the Orphan Basin are provided in Table 3.5. One benthic species, snow crab, has become one of the most important commercial species for the fisheries operating out of Newfoundland and Labrador (see Section 7.2.7.2 in Stantec 2018). Some benthic invertebrates form structural colonies that are themselves important habitat for other animals, including invertebrates and fish. On the Orphan Basin, this includes sponges and several types of corals (see Section 6.1.6.1 in Stantec 2018). Corals and sponges that can potentially be found in the RAA are provided in Table 3.6.

The habitat formed by corals depends on how and where they grow, and different corals can provide a home for various marine animals during several life stages. Cup corals are a type of solitary stony coral (scleractinians), while sea pens (pennatulaceans) can grow individually or in assemblages. Sea pens can typically be found growing on muddy sediment. Colonial black corals (antipatharians) and gorgonians and other soft corals (alcyonaceans) often anchor themselves to solid substrate, such as gravel and bedrock. Gorgonians can grow in dense formations, creating something like a forest (see Section 6.1.6.1 in Stantec 2018). Dense formations of *Geodia* spp. (i.e., sponge grounds) form important habitats and are likely present along the edge of the continental slope within the RAA. They can also be found growing more spread out over a larger area (see Section 6.1.6.1 in Stantec 2018). The distribution of corals and sponges within the RAA based on data from 2017-2020 DFO RV surveys is provided in Figure 3.10.

Table 3.5. Predominant invertebrate taxa at different depths on the Orphan Basin based on photographic surveys (Source: Table 6.2 in Stantec 2018).

Area	Common Name	Scientific Name
Shallow Slope 300-700 m	Polychaetes	Polychaeta (C)
	Marine bivalves	*Nuculana* sp., *Cuspidaria* sp., and *Dentalium* sp.
	Sand dollars / sea urchins	Echinoidea (C)
	Brittlestar	Ophiuroidea (C)

Area	Common Name	Scientific Name
	Sponges	Porifera (P)
	Bryozoans	Bryozoa (P)
	Brachiopods	Brachiopoda (P)
Middle Slope 700-2000 m	Sea anemone	*Cerianthus* sp.
	Polychaete	Polychaeta (C)
	Marine Bivalves	*Nucula* sp., *Nuculana* sp., *Thyasira* sp., *Cylichna* sp., and *Dentalium* sp.
	Gastropods	Gastropoda (C)
	Brittlestars	Ophiuroidea (C).
	Tusk shell	*Dentalium* sp.
	Sand dollars / sea urchins	Echinoidea (C)
Deep Slope 2000-2500 m	Polychaetes	Polychaeta (C)
	Marine bivalve	*Nucula* sp.
	Brittlestar	Ophiuroidea (C).
	Sponges	Porifera (P)
	Brachiopods	Brachiopoda (P)
Deep Slope >2500	Polychaetes	Polychaeta (C)
	Marine bivalve	*Cuspidaria* sp.
	Brittlestars	Ophiuroidea (C).
Note: Taxonomic group: (P) = Phylum; (C) = Class; (O) = Order.		

Table 3.6. Corals and sponges that may occur in the RAA (Source: Table 6.3 in Stantec 2018).

Exploration Licence	Known Presence and Distribution Based on Existing Information	Summary of Known or Potential Presence and Distribution
EL1144 EL1145 EL1148	**Corals** Soft Corals *Acanella arbuscular* *Paragorgia arborea* *Paramuricea* spp. *Capnella florida* Neptheidae Sea Pens *Anthoptilum grandiflorum* *Distichoptilum gracile* Stony Corals *Flabellum alabastrum* *Antipatharian* spp. **Sponges** Demosponges *Geodia* sp.	Depth and minimum bottom salinity are key predictors for *Geodia* sp. presence (Knudby et al. 2013). High density aggregations of sponges are unlikely based on distribution modelling (Knudby et al. 2013). Around EL 1144 and EL 1145, corals were concentrated on the shelf edge and slope with soft corals on the bank tops. *Acanella arbuscula* and soft corals were the most abundant species, along with *A. grandiflorum* (Wareham and Edinger 2007). The coral species around EL1148 were dominated by *C. florida*, sea pens, and antipatharians (Wareham and Edinger 2007).
Data Sources: DFO RV Data (2014a, 2015, 2016a), Knudby et al. (2013), and Wareham and Edinger (2007) in Stantec (2018).		

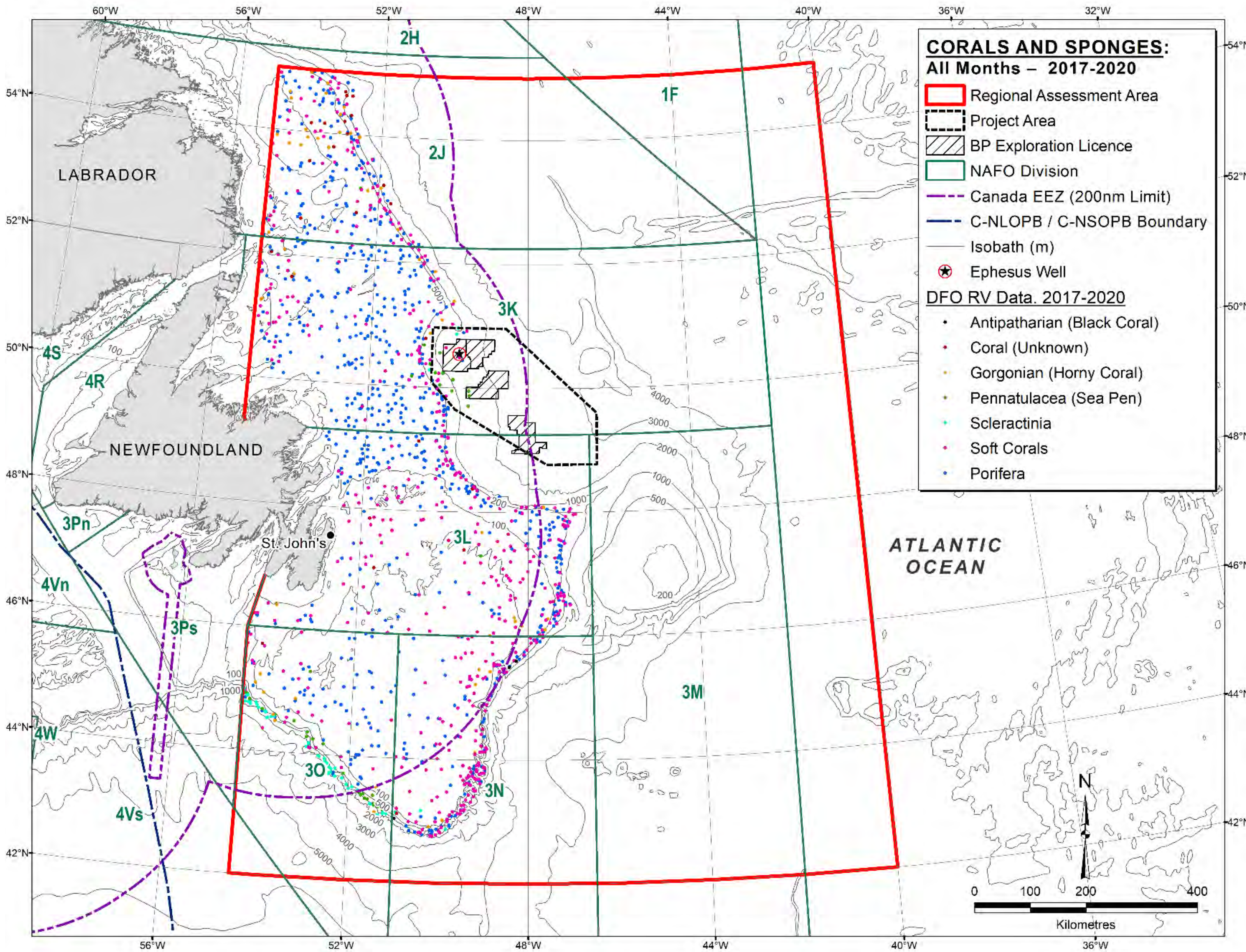


Figure 3.11. Distribution of corals and sponges in the RAA (Source: DFO RV database, 2017-2020; each point represents a catch location).

3.4 Marine and Migratory Birds

The Newfoundland and Labrador region hosts important breeding colonies and vast numbers of marine and migratory birds every year (Warkentin et al. 2009; CPAWS 2018). The significance of the marine environment within the RAA to all life cycles of avian species across all seasons, along with the potential for their interactions with hypothetical oil spill scenarios, makes them a ROC (see Section 6.2 in Stantec 2018).

The RAA includes highly productive marine and coastal ecosystems which provide significant feeding and nesting habitat for marine birds, as well as an important stopover point for migratory birds (CPAWS 2018; Stantec 2018). The seasonal presence and relative abundance of seabirds and other marine-associated birds found in the Orphan Basin region of the RAA are provided in Table 3.7.

Table 3.7. Marine-associated avian species presence and relative abundance throughout the year within the Orphan Basin region of the RAA (Source: modified from Table 6.13 in Stantec 2018).

	Presence and Relative Abundance											
Common Name	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Ducks, Geese, and Swans												
Waterfowl (passage migrants)			VS	VS					VS	VS		
Plovers and Sandpipers												
Shorebirds (passage migrants)							S	S	S	S		
Phalaropes												
Red-necked Phalarope*					S	S	S	S	S			
Red Phalarope					S	S	S	S	S	S		
Gulls and Terns												
Black-legged Kittiwake	C	C	C	S	S	S	S	S	S	C	C	C
Ivory Gull*	VS	VS	VS	VS								
Sabine's Gull					VS	VS		VS	VS			
Ross's Gull*	VS	VS	VS	VS	VS					VS	VS	VS
Herring Gull	U	U	U	U	U	S	S	S	S	S	S	S
Iceland Gull	S	S	S	S						S	S	S
Lesser Black-backed Gull					VS	VS	VS	VS	VS	VS	VS	VS
Glaucous Gull	S	S	S	S						S	S	S
Great Black-backed Gull	U	U	U	U	U	S	S	U	C	C	U	U
Arctic Tern					S	S	VS	S	S			
Skuas and Jaegers												
Great Skua					S	VS	VS	S	S	S		
South Polar Skua					S	S	S	S	S	S		
Pomarine Jaeger				S	S	VS	VS	S	S	S		
Parasitic Jaeger					VS	VS	VS	VS	VS	VS		
Long-tailed Jaeger					S	S	S	S	S			
Auks, Murres, Puffins, and Guillemots												
Dovekie	C	C	C	C	U	VS	VS	VS	S	C	C	C
Common Murre	S-U	S-U	S-U	C	C	S	S	U	U	U	U	U

	Presence and Relative Abundance											
Common Name	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Thick-billed Murre	C	C	C	C	C	S-U	S-U	S-U	U-C	C	C	C
Razorbill				S	S	S	S	S	S	S	S	
Atlantic Puffin				S	S	S	S	S	U	U	U	U
Fulmarine Petrels, Shearwaters, and Gadfly Petrels												
Northern Fulmar	C	C	C	C	C	C	C	C	C	C	C	C
Great Shearwater	VS	VS	VS	VS	VS	C	C	C	C	VS	VS	VS
Sooty Shearwater					S	S-U	S-U	S-U	S-U	S-U	S	
Manx Shearwater					S	S	S	S	S	S		
Cory's Shearwater							VS	VS	VS			
Bermuda Petrel*		VS	VS	VS	VS							
Zino's Petrel				VS	VS	VS	VS	VS	VS	VS		
Desertas Petrel	VS	VS	VS								VS	VS
Storm-Petrels												
Leach's Storm-Petrel*					U-C	C	C	C	C	C	S	
Band-rumped Storm-Petrel					VS	VS	VS	VS				
Wilson's Storm-Petrel							S	S	S	S		
Gannets												
Northern Gannet				S	S	S	S	S	S	S		
Cormorants												
Great and Double-crested Cormorants				VS	VS				VS	VS		
Landbirds												
Landbirds (vagrant migrants)				VS	VS			VS	VS	VS		

* Species with conservation designation.

Relative Abundance: C = Common, present daily in moderate to high numbers; U = Uncommon, present daily in small numbers; S = Scarce, present, regular in very small numbers; VS = Very Scarce, very few individuals or absent; blank space = not expected to occur in that month.

Seabird species are abundant in the offshore waters of NL throughout the year, with different species most abundant either during migration, the breeding season, or winter (Bolduc et al. 2018; Stantec 2018). The Grand Banks region was determined to be the most important to seabirds out of those examined in the 2009 Environmental Studies Research Fund (ESRF) Offshore Seabird Monitoring Program, particularly during the non-breeding season (fall to spring) (Fifield et al. 2009). Other offshore 'hotspots' listed by the study that fall within the RAA include the Flemish Cap and Pass, Orphan Basin, Sackville Spur, Northeast Newfoundland Shelf, and Labrador Shelf/Sea (Fifield et al. 2009). Overall, dominant species present in the 'hotspots' included Black-legged Kittiwake (*Rissa tridactyla*), Dovekie (*Alle alle*), Northern Fulmar (*Fulmarus glacialis*), shearwaters (*Ardenna*, *Puffinus, Calonectris*), gulls (Laridae), and murres (*Uria* sp.) (Fifield et al. 2009; Figures 3.11-3.14).

Analysis of a ten-year dataset (2006-2016) of seabird densities in eastern Canada indicated that Northern Fulmar have the highest recorded density in the region, with 31,424 individuals, followed by Dovekie and Black-legged Kittiwake (Bolduc et al. 2018). Great Shearwater (*Ardenna gravis*) and Thick-billed Murre (*Uria* *lomvia*) also had relatively high densities, while terns (Sternidae), skuas and jaegers (*Stercorarius* spp.), and phalaropes (*Phalaropus* spp.) had much lower counts (Bolduc et al. 2018). The least abundant species recorded was the Lesser Black-backed Gull (*Larus fuscus*), at 38 individuals, followed by the South Polar Skua (*Stercorarius maccormicki*) at 39 individuals (Bolduc et al. 2018).

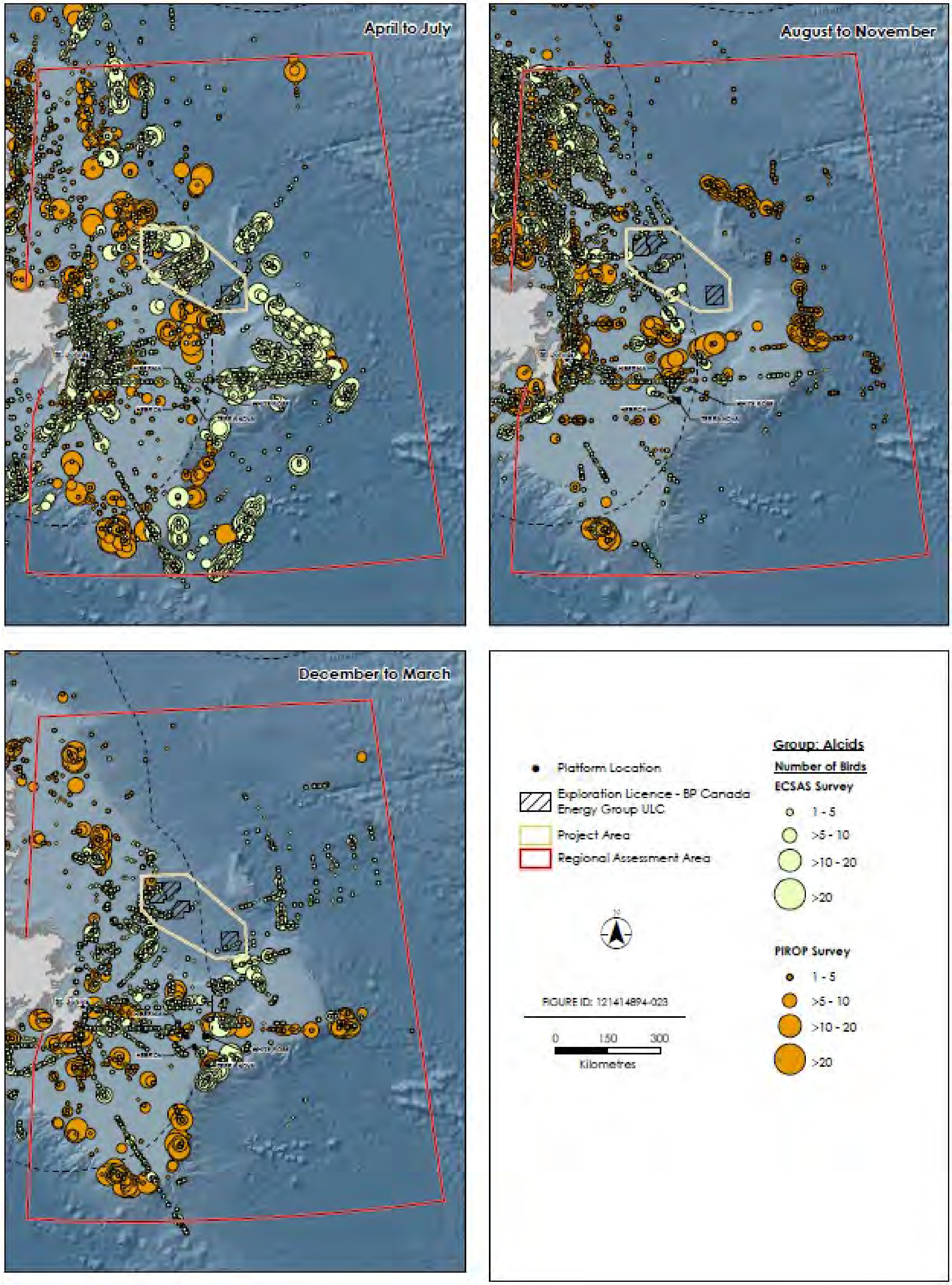


Figure 3.12. Seasonal distribution of alcids (Dovekie, Razorbill, and Black Guillemot) in the RAA, 2001-2016 (Source: Figure 6.19 in Stantec 2018).

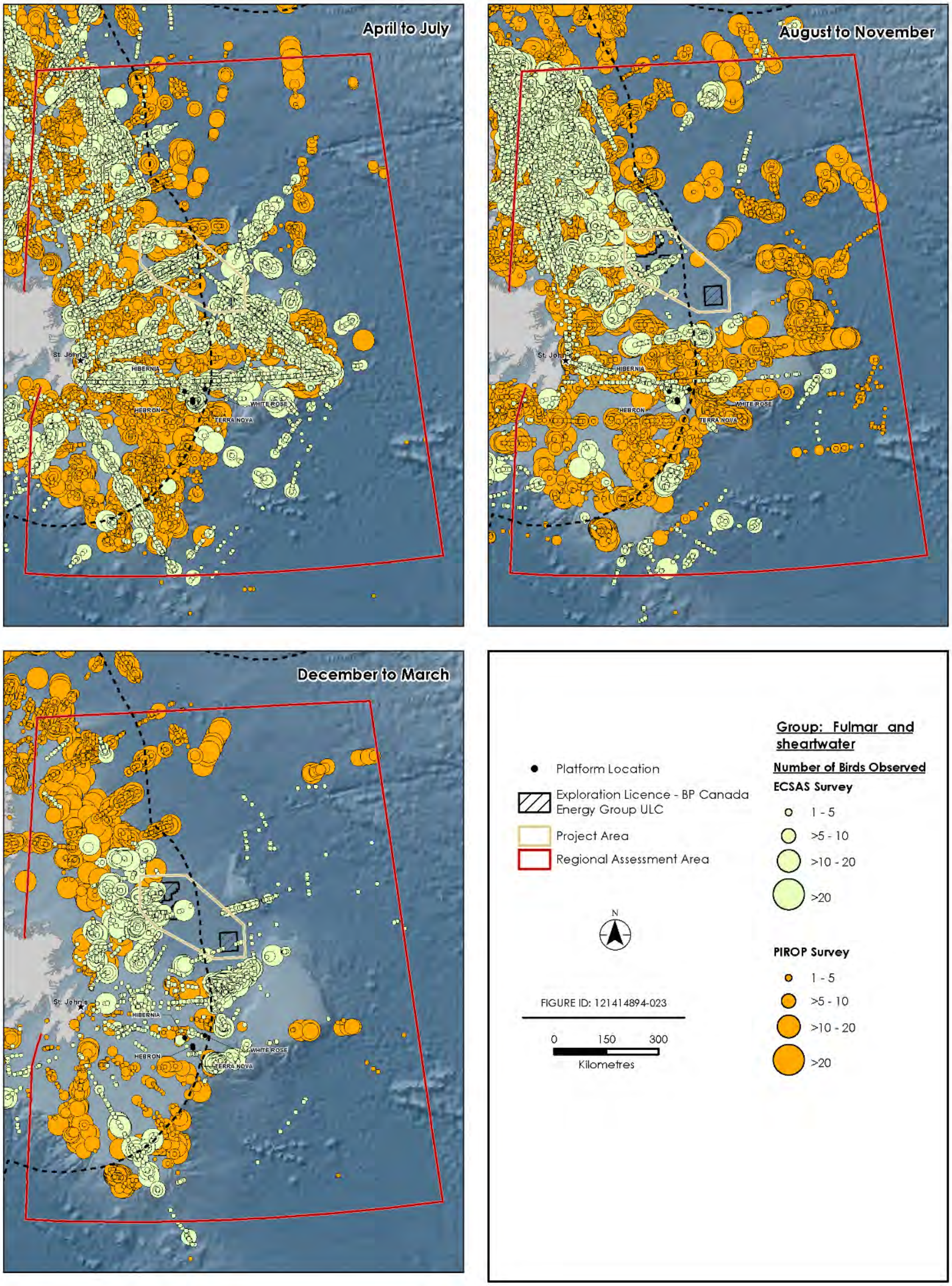


Figure 3.13. Seasonal distribution of Fulmar and shearwaters in the RAA, 2001-2016 (Source: Figure 6.21 in Stantec 2018).

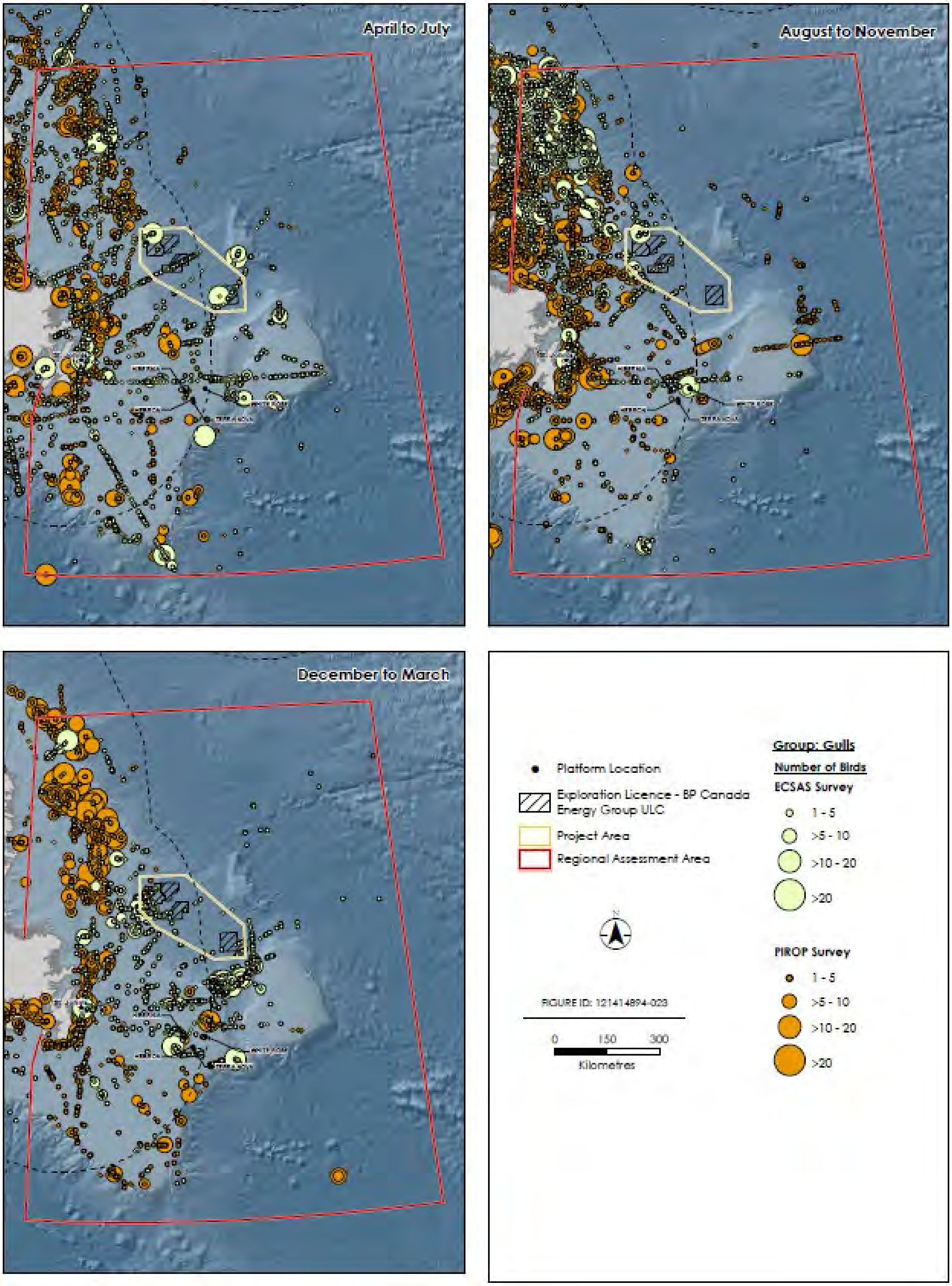


Figure 3.14. Seasonal distribution of gulls in the RAA, 2001-2016 (Source: Figure 6.16 in Stantec 2018).

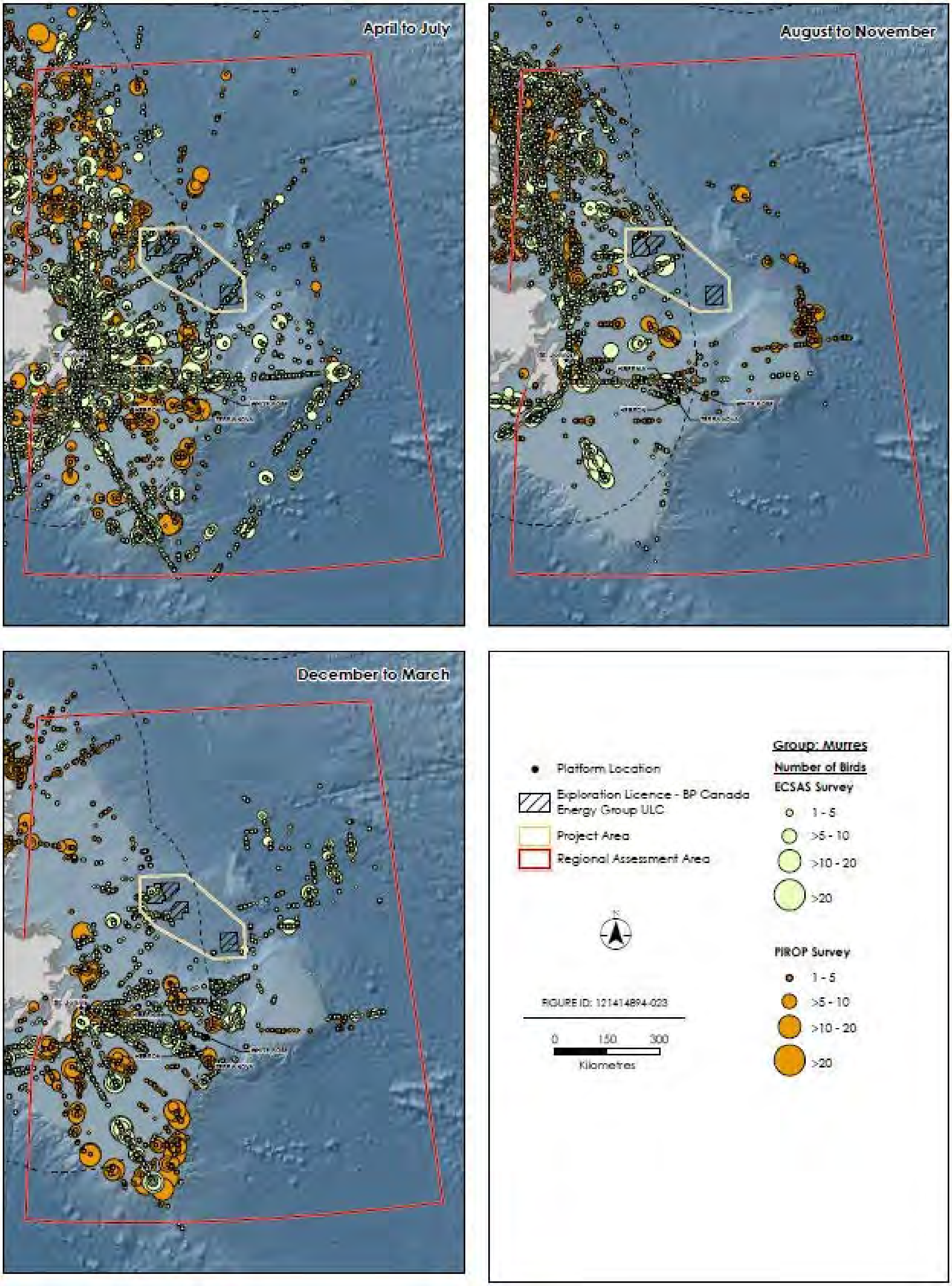


Figure 3.15. Seasonal distribution of murres in the RAA, 2001-2016 (Source: Figure 6.20 in Stantec 2018).

Many seabirds nest in Newfoundland in the spring at the >300 breeding colonies along the island's coasts (Warkentin et al. 2009). Four major breeding colonies/ecological reserves are located within the RAA, including Funk Island, Baccalieu Island, Witless Bay, and Cape St. Mary's. These ecological reserves are particularly important for Northern Gannet (*Morus bassanus*), Common Murre (*Uria aalge*), Thick-billed Murre, Razorbill (*Alca torda*), Atlantic Puffin (*Fratercula arctica*), Leach's Storm-Petrel (*Hydrobates leucorhous*) (Atlantic population threatened under COSEWIC and under consideration for addition to Schedule 1 of SARA [COSEWIC 2022; Government of Canada 2022]), and Black-legged Kittiwake (CPAWS 2014). There are also several IBAs within the RAA (Bird Studies Canada 2015; see Figure 3.15 below and Table 6.14 and Figure 6.25 in Stantec 2018). Seabirds typically forage throughout the Grand Banks and surrounding areas during and following the breeding season (Stantec 2018). Various non-breeding seabirds also forage within the RAA throughout the summer months (Stantec 2018). Several alcids, including Dovekie, Common Murre, Thick-billed Murre, Northern Fulmar, and Black-legged Kittiwake, are commonly present in the RAA year-round along with (Bolduc et al. 2018; Stantec 2018). During the winter, the RSA supports globally important populations of kittiwakes (Frederiksen et al. 2012), murres (Hedd et al. 2011; McFarlane Tranquilla et al. 2013; Frederiksen et al. 2016), and Dovekie (Fort et al. 2013). During the summer, the RSA supports globally important concentrations of shearwaters (Hedd et al. 2012) and storm-petrels (Hedd et al. 2018); the summer foraging ranges of breeding seabirds can extend hundreds of kilometres from coastal colonies in the region (Ronconi et al. 2022). At-risk seabirds that overwinter within the RAA include Ross's Gull (*Rhodostethia rosea*; threatened under SARA and currently under consideration for status change and endangered under COSEWIC) and Ivory Gull (*Pagophila eburnea*; endangered under SARA and COSEWIC) (COSEWIC 2022; Government of Canada 2022). The Red-necked Phalarope (*Phalaropus lobatus*; special concern under SARA and COSEWIC [COSEWIC 2022; Government of Canada 2022]) may be present in the area during the summer months. Overall, there are 11 bird species at risk that may occur in the RAA (see Table 3.2 and Section 3.1.2 above).

Migratory birds, including many landbird, waterfowl, and shorebird species, occur within the RAA (see Section 6.2 in Stantec 2018). Landbirds, such as songbirds and raptors, migrate through the area and are most common during the autumnal months (Stantec 2018). They may also be blown off course into the area by large storms and strong winds, during which time they may seek refuge on vessels or platforms (Stantec 2018). Additionally, nocturnal species can be disorientated by and attracted to the artificial lights of vessels/platforms (Stantec 2018). Raptors, including Peregrine Falcon (*Falco peregrinus*; vulnerable under the ESA but not at risk under SARA or COSEWIC; Government of Canada 2022; Government of NL 2023), migrate along the coast of the island while hunting migrating ducks and shorebirds (Stantec 2018). Shorebirds make use of the coastlines throughout their fall migration, having several stopover sites within the RAA (Stantec 2018). Long-distance, trans-oceanic migration routes will likely be at high altitudes and in the western region of the RAA, so it is unlikely that large numbers of shorebirds will be encountered at sea

(Stantec 2018). Wintering waterfowl species, including eiders, scoters, and ducks, are also mainly concentrated in coastal regions (Stantec 2018; Figure 3.16). Harlequin Duck (*Histrionicus histrionicus*) and Barrow's Goldeneye (*Bucephala islandica*) (both special concern [eastern populations] under Schedule 1 of SARA) move to coastal marine waters for the winter to moult and males move there for the summer to moult but are not commonly encountered offshore (Stantec 2018).

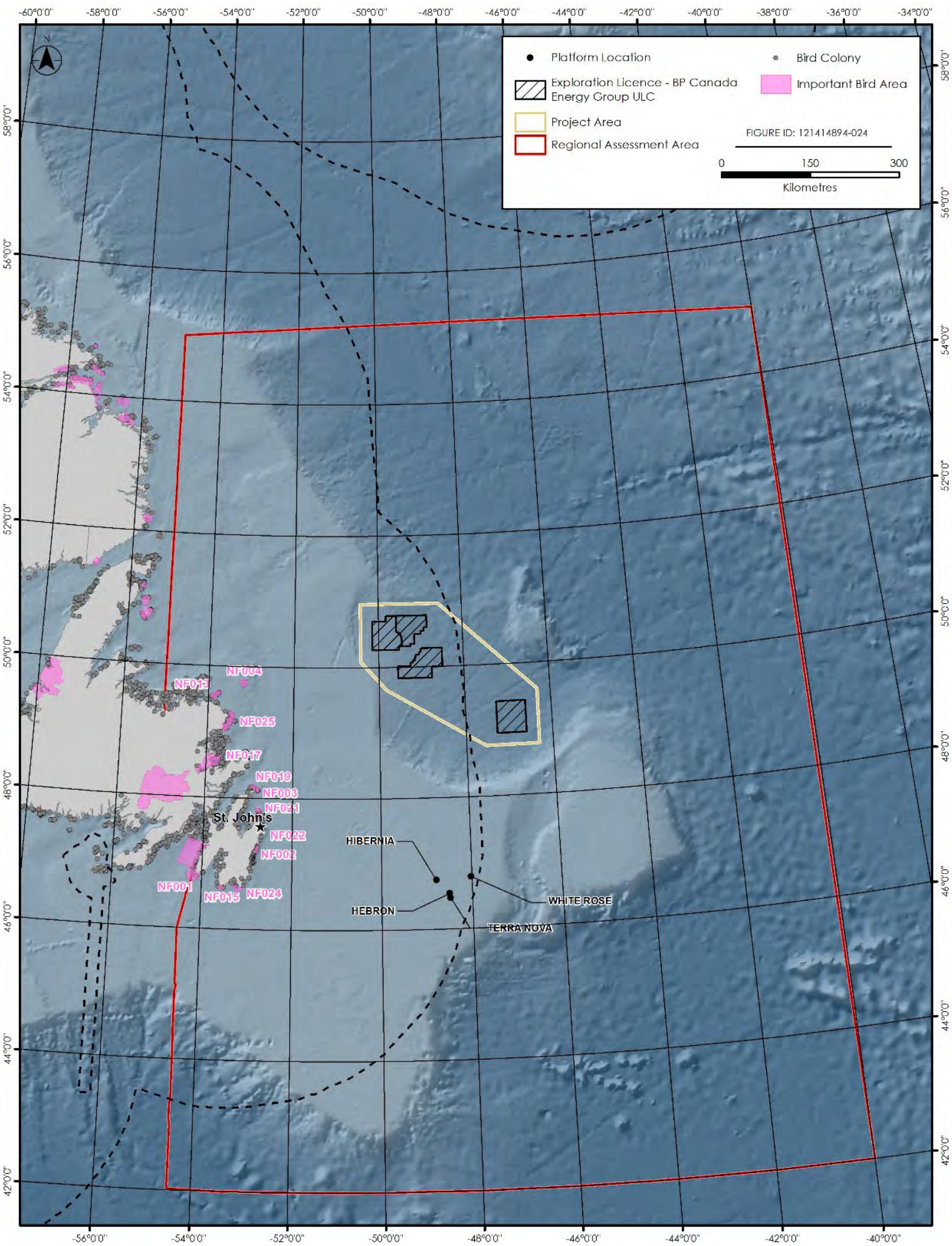


Figure 3.16. Important Bird Areas and marine bird nesting colony locations within the RAA (Source: Figure 6.25 in Stantec 2018).

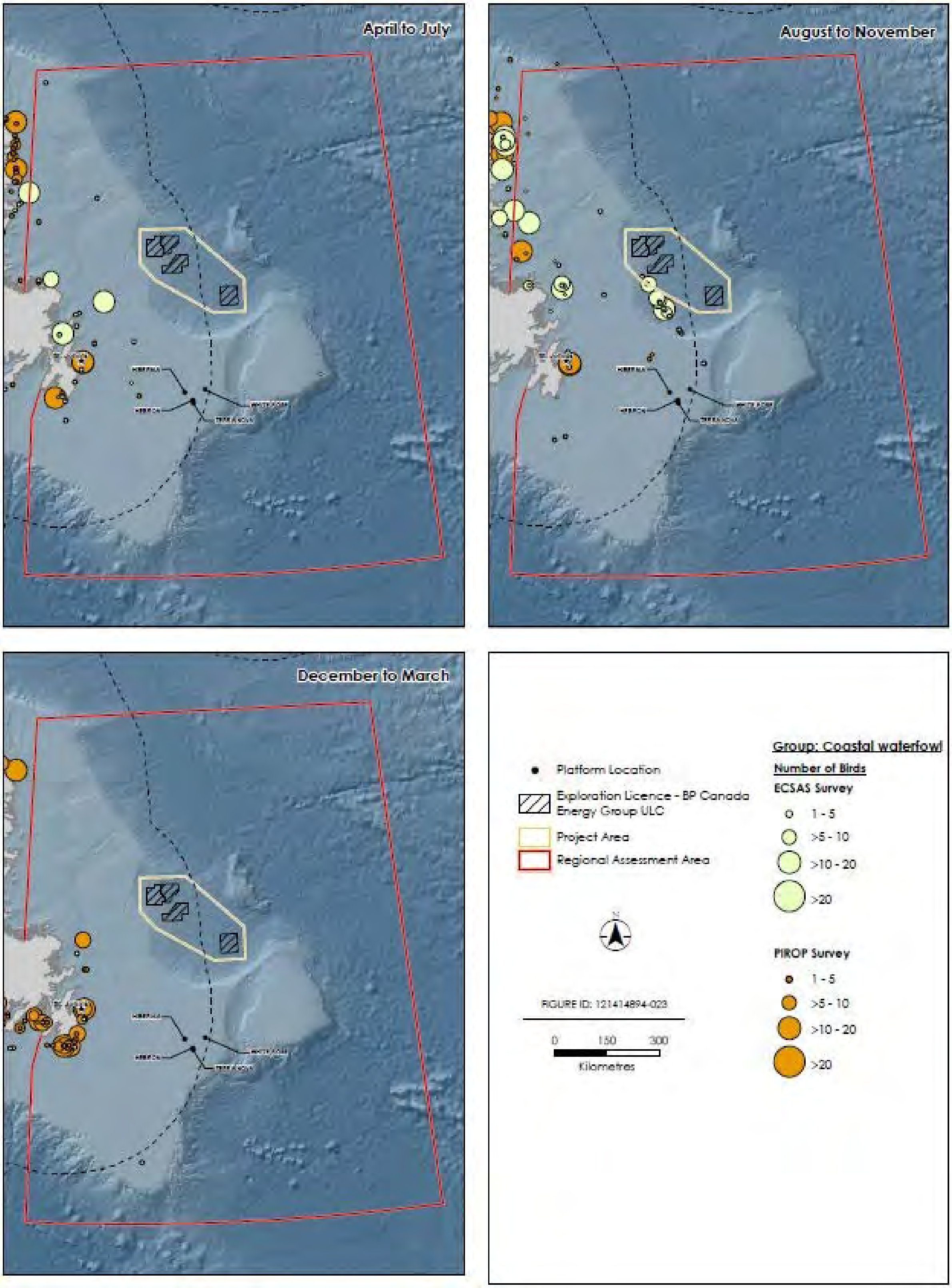


Figure 3.17. Seasonal distribution of waterfowl in the RAA, 2001-2016 (Source: Figure 6.24 in Stantec 2018).

3.5 Marine Mammals and Sea Turtles

Many species of marine mammals and two species of sea turtles occur in the RAA.

3.5.1 Marine Mammals

Marine mammals are an ecologically important group regulated by the *Fisheries Act*. Several marine mammal species are listed under SARA and COSEWIC and some are harvested by Indigenous groups (see Sections 6.3 to 6.3.8 in Stantec 2018). In the event of a subsea blowout, they can be expected to interact with oil spills both on the surface and in the water column, through the ingestion of oiled prey, or during haul-out along the shore or on sea ice (LGL 2020).

A total of 25 species of marine mammals can be expected to occur within or near the RAA (see Table 6.16 in Stantec 2018; Table 3.8), including six mysticetes (baleen whales), 13 odontocetes (toothed whales), and six phocids (seals). An additional four whale species (Cuvier's beaked whale, beluga, narwhal, and false killer whale)) have been sighted in the RAA, but these sightings have been so rare that they were excluded from any further consideration (see Table 6.17 in Stantec 2018; Figures 3.17-3.19). Bowhead whale was included in Table 6.17 in Stantec (2018); however, the distribution range for this species does not include waters offshore NL so it was not included in this SIMA. Three baleen whale species (fin whale, blue whale, and north Atlantic right whale) and two toothed whale species (Sowerby's beaked whale and northern bottlenose whale) are listed under SARA. Nine whale species and one seal species have at-risk status under COSEWIC (COSEWIC 2022; Government of Canada 2022; Table 3.8).

Marine mammals can be found in the region any time of year, but there are seasonal differences. Some seal species, such as ringed, harp, and hooded seals, are affected by the seasonal shift in sea ice and are mostly found within the RAA during winter and spring. In contrast, bearded seals and harbour seals are equally common year-round while grey seals are more common during summer. Some whales, such as northern bottlenose and blue whales, can be sighted in the area year-round, while several species are much more commonly found during summer. As a result, there are more whale sightings from June to September than at other times of the year (see Sections 6.3 to 6.3.5 in Stantec 2018). Work is currently underway to designate critical habitat for blue whales which may potentially occur within or near the RAA (DFO 2016).

Table 3.8. Marine mammals expected to occur within or near the RAA, including frequency and seasonality of occurrence, habitat type, and status under SARA and COSEWIC (Source: updated from Table 6.16 in Stantec 2018).

Species	Population	Occurrence	Season	Habitat	SARA (Schedule 1) [a]	COSEWIC [b]
Baleen Whales (Mysticetes)						
Blue Whale	Atlantic	Uncommon	Year-round	Coastal & pelagic	Endangered	Endangered
North Atlantic Right Whale	-	Rare	Summer	Coastal, shelf & pelagic	Endangered	Endangered
Fin Whale	Atlantic	Common	Year-round, but mostly summer	Shelf breaks, banks & pelagic	Special Concern	Special Concern
Sei Whale	Atlantic	Uncommon	May–Nov	Pelagic	Under consideration for addition	Endangered
Humpback Whale	Western North Atlantic	Common	Year-round, but mostly May-Sept	Coastal & banks	No status	Not at Risk
Minke Whale	North Atlantic subspecies	Common	Year-round, but mostly May-Oct	Coastal, shelf, & banks	No status	Not at Risk
Toothed Whales (Odontocetes)						
Sperm Whale	-	Common	Year-round, but mostly summer	Slope, canyons & pelagic	No Status	Mid-priority Candidate
Northern Bottlenose Whale	Davis Strait-Baffin Bay-Labrador Sea	Uncommon	Year-round	Slope, canyons & pelagic	Under consideration for addition	Special Concern
	Scotian Shelf				Endangered	Endangered
Sowerby's Beaked Whale	-	Rare	Year-round	Slope, canyons & pelagic	Special Concern	Special Concern
Striped Dolphin	-	Rare	Summer	Shelf & pelagic	No Status	Not at Risk
Atlantic Spotted Dolphin	-	Rare	Summer	Shelf, slope & pelagic	No Status	Not at Risk
Short-beaked Common Dolphin	-	Common	Summer	Shelf & pelagic	No Status	Not at Risk
White-beaked Dolphin	-	Common	Year-round, but mostly June-Sept	Shelf & pelagic	No Status	Not at Risk
Atlantic White-sided Dolphin	-	Common	Year-round, but mostly summer-fall	Coastal & shelf	No Status	Not at Risk

Species	Population	Occurrence	Season	Habitat	SARA (Schedule 1) [a]	COSEWIC [b]
Common Bottlenose Dolphin	-	Rare	Summer	Coastal & pelagic	No Status	Not at Risk
Risso's Dolphin	-	Rare	Year-round	Continental slope	No Status	Not at Risk
Killer Whale	Northwest Atlantic / Eastern Arctic	Uncommon	Year-round	Coastal & pelagic	Under consideration for addition	Special Concern
Long-finned Pilot Whale	-	Common	Year-round, but mostly spring-fall	Shelf break, pelagic & slope	No Status	Not at Risk
Harbour Porpoise	Northwest Atlantic	Uncommon	Year-round, but mostly spring-fall	Coastal, shelf & pelagic	No Status	Special Concern
True Seals (Phocids)						
Harp Seal	-	Common	Year-round, but mostly winter-spring	Pack ice & pelagic	No Status	Low-priority Candidate
Hooded Seal	-	Common	Year-round, but mostly winter-spring	Pack ice & pelagic	No Status	Mid-priority Candidate
Grey Seal	-	Uncommon	Year-round, but mostly summer	Coastal & shelf	No Status	Not at Risk
Ringed Seal	-	Uncommon	Winter-spring	Landfast ice with snow cover	Under consideration for addition	Special Concern
Bearded Seal	-	Uncommon	Year-round	Coastal, shallow & ice edge	No Status	Mid-priority Candidate
Harbour Seal [c]	Atlantic and Eastern Arctic subspecies	Common [c]	Year-round [c]	Coastal & shallow water [c]	No Status	Not at risk

[a] Species listing under the *Species at Risk Act* (Government of Canada 2022).

[b] Species assessment by COSEWIC (COSEWIC 2022).

[c] Source: COSEWIC (2007); Anderson and Olsen (2010).

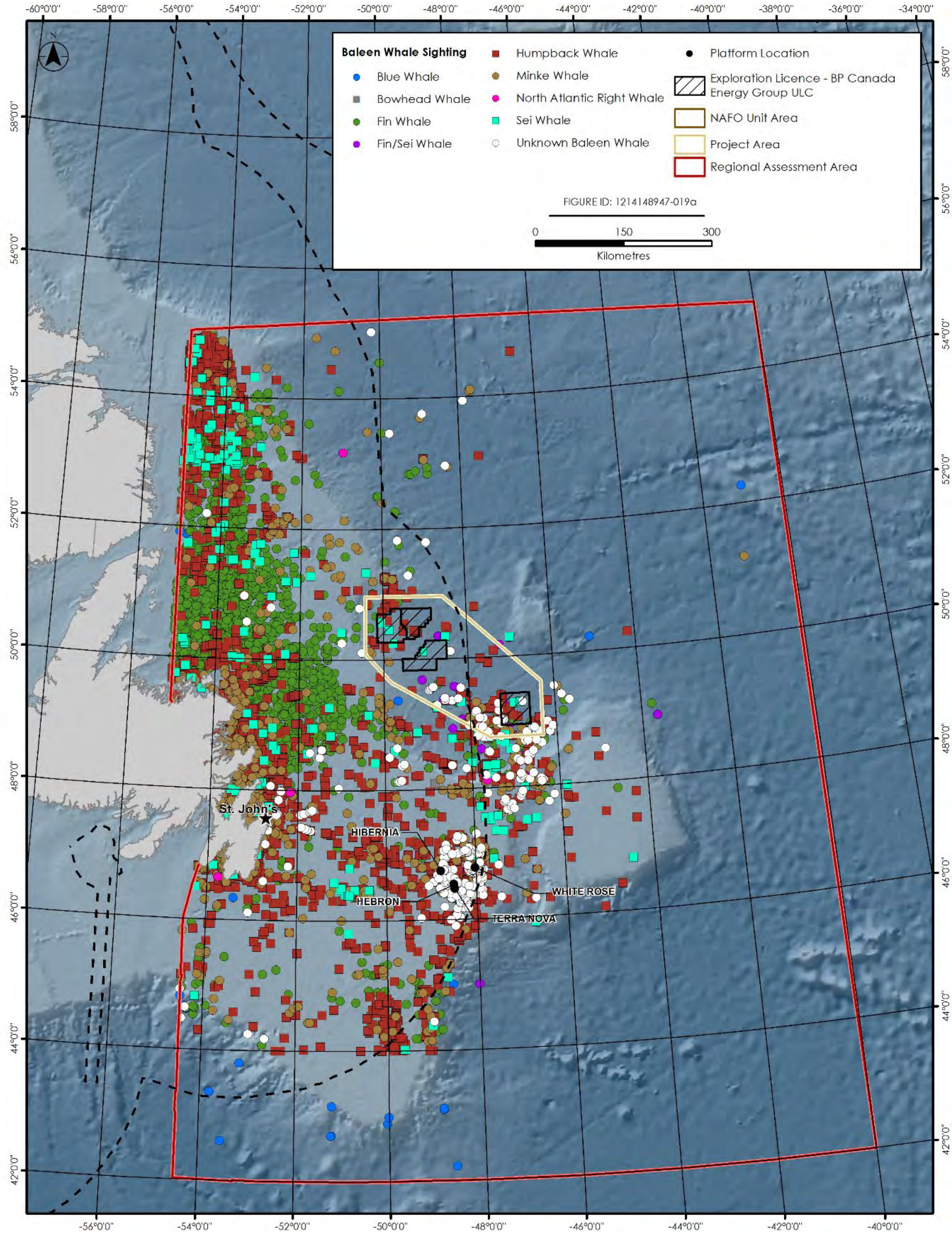


Figure 3.18. Baleen whale sightings in the RAA (Source: Figure 6.26 in Stantec 2018 [DFO Sightings Database, 1947-2015]).

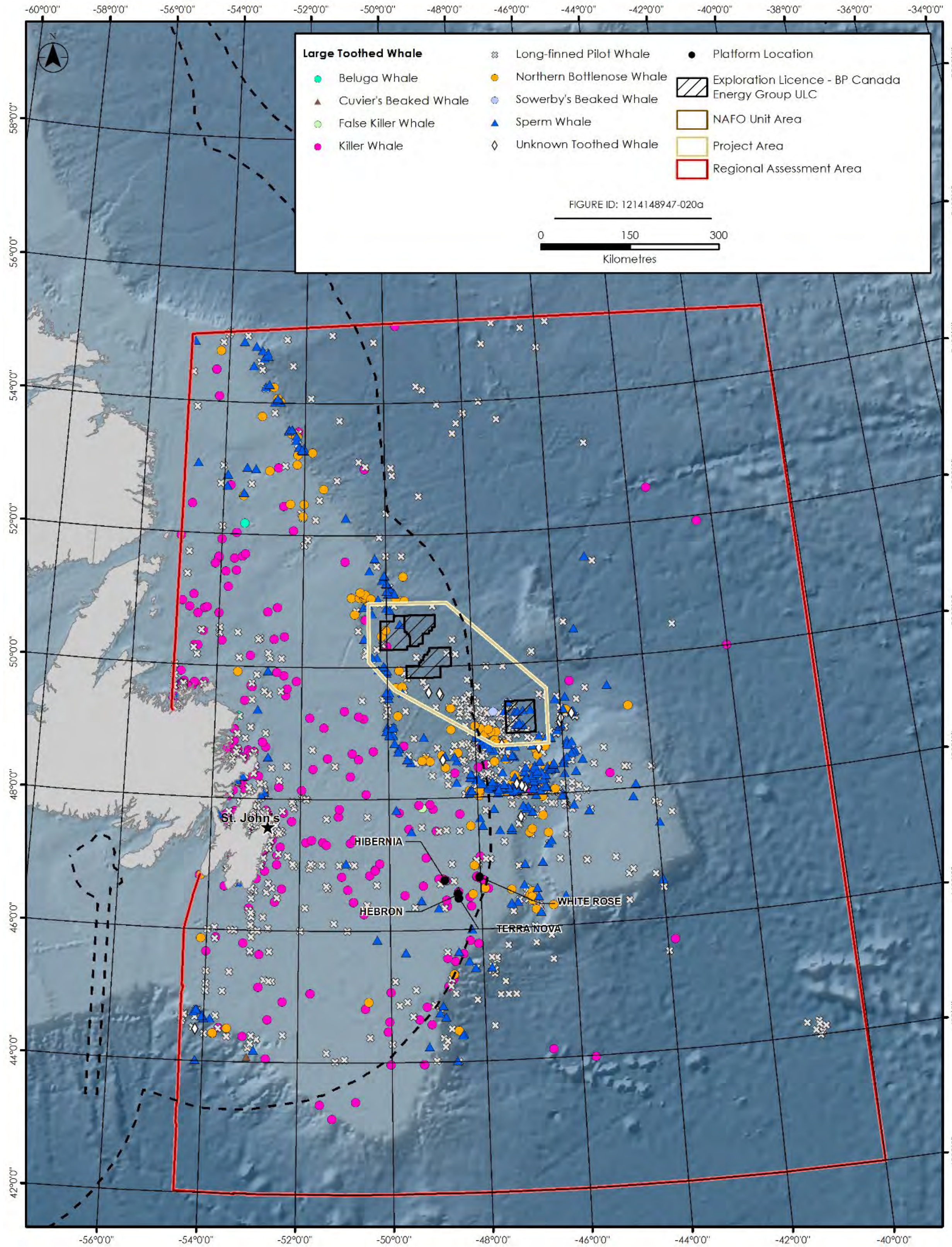


Figure 3.19. Toothed whale sightings in the RAA (Source: Figure 6.27 in Stantec 2018 [DFO Sightings Database, 1947-2015]).

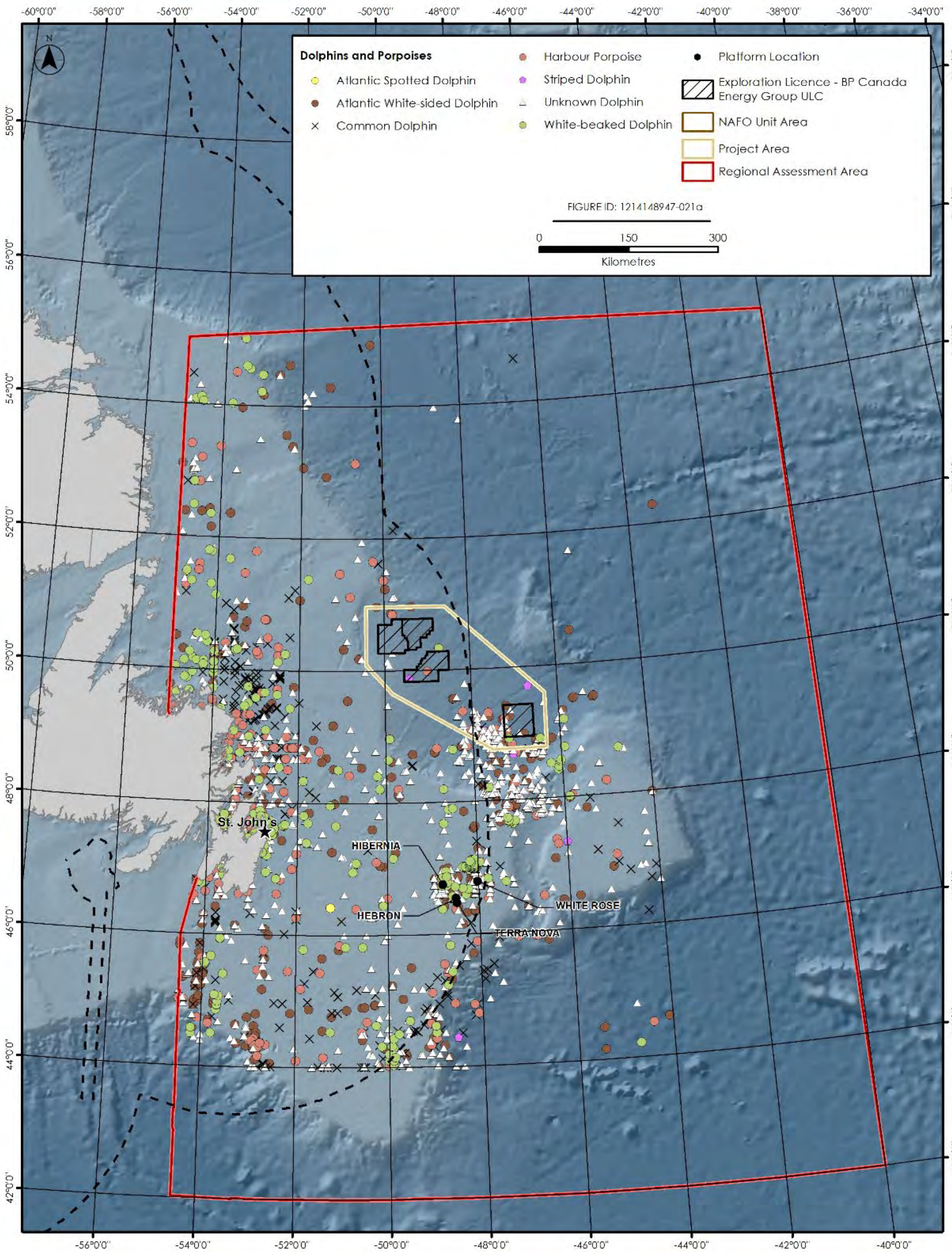


Figure 3.20. Dolphin and porpoise sightings in the RAA (Source: Figure 6.28 in Stantec 2018 [DFO Sightings Database, 1947-2015]).

3.5.2 Sea Turtles

In the event of a subsea blowout, sea turtles, if present, can be expected to interact with oil spills both on the surface and in the water column and through the ingestion of oil while feeding (LGL 2020). Two sea turtle species, leatherback and loggerhead, are expected to occur within the RAA (Table 3.9; Figure 3.20). Leatherback and loggerhead sea turtles are endangered under both SARA and COSEWIC (COSEWIC 2022; Government of Canada 2022). Green sea turtles are expected to be rare within the RAA. A fourth species, Kemp's ridley sea turtle, has been reported from Newfoundland but is likely exceedingly rare in the RAA (see Section 6.3.6 in Stantec 2018; COSEWIC 2022; Government of Canada 2022).

Table 3.9. Sea turtles expected to occur within or near the RAA, including frequency and seasonality of occurrence, habitat types, and status under SARA and COSEWIC (Source: modified from Table 6.18 in Stantec 2018).

Species	Population	Occurrence	Season	Habitat	SARA (Schedule 1) [a]	COSEWIC [b]
Leatherback Sea Turtle	Atlantic	Uncommon	April to December	Shelf & pelagic	Endangered	Endangered
Loggerhead Sea Turtle	-	Uncommon	Summer and fall	Pelagic	Endangered	Endangered
Green Sea Turtle	-	Rare	Summer	Pelagic	No Status	Low-priority Candidate

[a] Species designation under the *Species at Risk Act* (Government of Canada 2022)
[b] Species designation by COSEWIC (COSEWIC 2022)

Leatherback sea turtles are observed in the waters off Newfoundland from April to December. Loggerheads are found in the region during the summer and fall, while green sea turtles are only seen (rarely) in the summer (see Table 6.18 in Stantec 2018). Currently, critical habitat has not been established for sea turtles in Canada.

3.6 Socio-Economic

The fisheries are a vital part of the province's financial and socio-economic setting. Other socio-economic activities, including shipping, oil and gas, tourism, and aquaculture, occur in the RAA.

3.6.1 Commercial Fisheries

Early European settlement of Newfoundland was intimately linked and driven by the development of commercial fishing for groundfish, predominantly cod. The cod fisheries were an important economic resource until the stock collapsed and a moratorium was established in the early 1990s. Even so, fishing has remained an important part of the culture and local economy. The commercial fishing industry has shifted its primary focus, with shellfish, such as northern shrimp and snow crab, replacing cod as valuable target species (Lear 1998; see Section 7.2.2 in Stantec 2018). In the event of a subsea blowout, fisheries can be expected to interact with the oil spill in two main ways. First, commercial fishers might suffer direct economic damage through the hindrance of day-to-day operations and there is the potential for reduction in the quantity or actual/perceived quality of key commercial stocks. Secondly, they could suffer reputational and economic harm from any perceived impact to the quality of the product they sell, even if no objectively measurable reduction in quality has occurred (Stantec 2018). It should be noted that negative perceptions of food safety and quality could also occur due to dispersant use/dispersed oil.

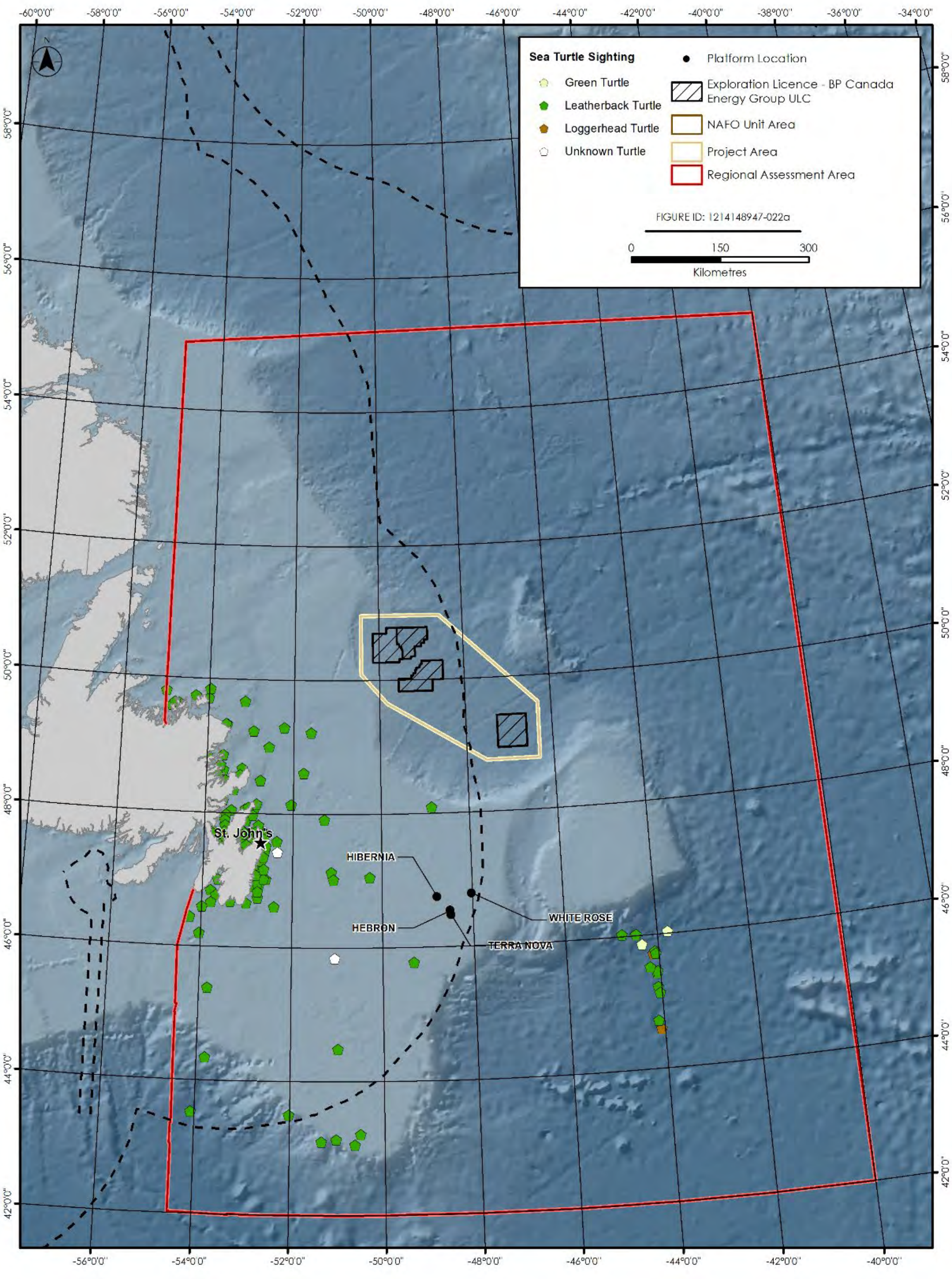


Figure 3.21. Sea turtle sightings in the RAA (Source: Figure 6.29 in Stantec 2018 [DFO Sightings Database, 1947-2015]).

The regulation, monitoring, and management of commercial fishing activity that falls under Canadian jurisdiction is handled by DFO. Management of resources is divided into NAFO Divisions, and the RAA overlaps with NAFO Divisions 2J + 3KLMNO (see Section 7.2.1 in Stantec 2018). As of 2011, to increase fisher privacy, DFO changed the format in which they provide commercial fisheries data. Prior to 2011, actual catch weights and values were provided as single point catch data, whereas from 2011 onward, data were provided as annual catch weight and value quartile ranges within 6 minute x 6 minute (latitude x longitude) cells. Actual annual catch weights and values (2012-2016) were generated by DFO and provided specifically for the EIS (see Tables 7.4-7.5 in Stantec 2018). However, due to data request backlogs (particularly following the delays induced by COVID-19 lockdowns/restrictions during 2020-2021), such specific requests typically require lengthy turnaround times for DFO to be able to fulfill. There was insufficient time for such a request to be fulfilled for the completion of this SIMA and it is unlikely such data would be readily available for the creation of an expedited SIMA. Therefore, this SIMA utilizes the latest DFO commercial fisheries quartile range data available for the RAA (2017-2020) and serves as an example of how commercial fisheries data could be quickly updated as part of an expedited SIMA for a real spill event.

Predominant commercial fishery species within the RAA include snow crab, Atlantic cod, northern shrimp, and Greenland halibut (Tables 3.10-3.13). Within the RAA, most activity from commercial fishing occurs on the continental shelf, including the Grand Banks, Labrador shelf, and slopes along the Orphan Basin (Figure 3.21). Spring and summer (~April to September) are typically the busiest seasons for commercial fisheries in the region (see Section 7.2.4 and Figure 7.6 in Stantec 2018; Figure 3.22). Most of the harvest within international waters of the RAA (i.e., beyond Canada’s EEZ) is landed by Canadian vessels (Figure 3.23). The seasonal distribution of fishing effort in areas outside the Canadian EEZ largely mirrors that of the effort inside the EEZ (see Section 7.2.6 in Stantec 2018).

Table 3.10. Annual commercial catch weights and values in the RAA, 2017 (values indicate the frequency of catch weight quartile codes [i.e., 1-4] or vessel length classes attributed to each species; derived from DFO commercial landings database, 2017).

Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Counts [b]				Vessel Length Class Total Quartile Code Counts [c]						Total Counts [d]
	1	2	3	4	1	2	3	4	1-34.9′	35-44.9′	45-64.9′	65-99.9′	100-124.9′	≥125′	
Snow Crab	1125	1549	1291	328	778	1206	1421	888	819	1206	2019	202	47	-	4293
Northern Shrimp	273	348	243	142	370	309	211	116	-	13	473	54	-	466	1006
Atlantic Cod	222	272	242	95	401	298	114	18	53	338	212	12	-	216	831
Atlantic Halibut	146	202	190	113	204	249	162	36	-	90	77	73	-	411	651
Greenland Halibut	90	216	242	83	120	233	220	58	2	90	272	45	-	222	631
Redfish	53	103	120	68	99	125	94	26	-	8	69	17	-	250	344
Yellowtail Flounder	57	118	92	65	151	104	66	11	-	-	1	-	-	331	332
American Plaice	37	96	104	79	107	107	82	20	-	5	12	2	-	297	316
Witch Flounder	32	87	88	55	76	83	74	29	-	-	27	12	-	223	262
White Hake	71	74	45	12	90	84	25	3	-	69	41	48	-	44	202
Capelin	-	5	42	107	33	44	49	28	43	63	48	-	-	-	154
Atlantic Haddock	24	41	30	12	40	41	23	3	-	25	15	14	-	53	107
Monkfish	5	34	24	7	26	32	11	1	-	10	20	-	-	40	70
Stimpson's Surf Clam	1	8	17	42	6	13	16	33	-	-	-	-	-	68	68
Striped Shrimp	12	22	18	15	11	23	16	17	-	-	-	-	-	67	67
Swordfish	28	18	20	-	20	21	25	-	-	19	17	30	-	-	66
Atlantic Herring	-	6	12	48	16	33	16	1	9	40	17	-	-	-	66
Cockle	1	6	14	32	6	11	7	29	-	-	-	-	-	53	53
Cusk	15	20	15	3	21	23	9	-	-	24	22	7	-	-	53
Mako Shark	15	12	15	-	11	12	19	-	-	11	10	21	-	-	42
Bluefin Tuna	12	4	9	-	9	9	7	-	5		8	12	-	-	25
Skate sp.	13	6	-	1	10	8	2	-	-	7	13	-	-	-	20

Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Counts [b]				Vessel Length Class Total Quartile Code Counts [c]						Total Counts [d]
	1	2	3	4	1	2	3	4	1-34.9’	35-44.9’	45-64.9’	65-99.9’	100-124.9’	≥125’	
Pollock	-	1	14	-	-	11	4	-	-	5	9	-	-	1	15
Mackerel	-	1	5	8	3	5	6	-	2	10	2	-	-	-	14
Albacore Tuna	4	4	3	-	3	4	4	-	-	1	8	2	-	-	11
Whelk	3	5	2	-	7	3	-	-	-	9	1	-	-	-	10
Pink Glass Shrimp	1	2	4	3	1	2	4	3	-	-	-	-	-	10	10
Bigeye Tuna	2	3	3	-	1	2	5	-	-	1	4	3	-	-	8
Roughhead Grenadier	1	3	2	2	1	4	1	2	-	3	1	4	-	-	8
Atlantic Wolffish	4	1	-	-	1	4	-	-	-	-	5	-	-	-	5
Winter Flounder	1	2	-	1	2	2	-	-	-	4	-	-	-	-	4
Dolphinfish	-	-	3	-	-	-	3	-	-	2	-	1	-	-	3
Pelagic sp.	1	-	-	-	1	-	-	-	-	-	-	1	-	-	1
Total	**2249**	**3269**	**2909**	**1321**	**2625**	**3105**	**2696**	**1322**	**933**	**2053**	**3403**	**560**	**47**	**2752**	**9748**

[a] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch weights in a given year, all species combined). Quartile weight ranges (2017): 1 = 0–1912 kg; 2 = 1913–8828 kg; 3 = 8829–35,206 kg; 4 = ≥35,207 kg.

[b] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch value in a given year, all species combined). Quartile value ranges (2017): 1 = $0–$9811; 2 = $9812–$43,514; 3 = $43,515–$166,502; 4 = ≥$166,503.

[c] Includes the total quartile code count for ranges 1-4 combined; total counts for catch weight and catch value are equal.

[d] Total counts of the number of catch records per species; the total quartile range counts for catch weight and catch value are equal.

Table 3.11. Annual commercial catch weights and values in the RAA, 2018 (values indicate the frequency of catch weight quartile codes [i.e., 1-4] or vessel length classes attributed to each species; derived from DFO commercial landings database, 2018).

Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Counts [b]				Vessel Length Class Total Quartile Code Counts [c]						Total Counts [d]
	1	2	3	4	1	2	3	4	1-34.9’	35-44.9’	45-64.9’	65-99.9’	100-124.9’	≥125’	
Snow Crab	1171	1467	1161	215	694	1173	1411	736	873	1280	1657	183	21	-	4014
Atlantic Cod	186	274	199	98	403	234	105	15	53	289	134	16	-	265	757

Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Counts [b]				Vessel Length Class Total Quartile Code Counts [c]						Total Counts [d]
	1	2	3	4	1	2	3	4	1-34.9’	35-44.9’	45-64.9’	65-99.9’	100-124.9’	≥125’	
Northern Shrimp	236	203	181	117	260	197	189	91	-	8	448	76	-	205	737
Greenland Halibut	119	241	264	96	166	270	227	57	3	103	322	46	-	246	720
Atlantic Halibut	143	181	192	134	202	245	158	45	-	52	62	89	-	447	650
Yellowtail Flounder	38	123	132	70	137	149	70	7	-	1	-	-	-	362	363
American Plaice	22	92	148	89	88	150	95	18	3	4	-	-	-	344	351
Redfish	31	80	107	73	61	105	94	31	2	7	32	21	-	229	291
Witch Flounder	28	64	103	89	63	89	92	40	-	-	1	15	-	268	284
Capelin	-	3	40	106	26	43	49	31	38	68	43	-	-	-	149
White Hake	46	53	29	13	55	59	26	1	-	40	33	34	-	34	141
Swordfish	55	28	8	-	16	53	19	3	-	20	42	29	-	-	91
Atlantic Haddock	28	23	28	12	39	31	20	1	-	9	13	17	-	52	91
Stimpson’s Surf Clam	1	7	25	45	5	16	18	39	-	-	-	-	-	78	78
Monkfish	15	20	18	13	28	23	14	1	-	1	15	16	-	34	66
Mako Shark	37	20	6	-	10	37	14	2	-	11	32	20	-	-	63
Cockle	-	5	13	42	3	11	9	37	-	-	-	-	-	60	60
Propellor Clam	1	4	17	32	3	12	12	27	-	-	-	-	-	54	54
Cusk	8	20	17	6	10	30	11	-	-	25	16	10	-	-	51
Dolphinfish	11	14	6	-	-	17	12	2	-	10	11	10	-	-	31
Albacore Tuna	15	11	4	-	3	17	9	1	-	5	10	15	-	-	30
Atlantic Herring	-	1	12	15	11	16	1	-	1	20	7	-	-	-	28
Bluefin Tuna	9	6	5	-	8	9	3	-	8	1	9	2	-	-	20
Bigeye Tuna	8	7	4	-	3	7	7	2	-	2	6	11	-	-	19
Pollock	6	3	5	1	8	4	3	-	-	1	-	14	-	-	15
White Marlin	4	8	2	-	2	4	7	1	-	2	9	3	-	-	14
Striped Shrimp	6	3	4	1	5	4	4	1	-	-	-	-	-	14	14

Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Counts [b]				Vessel Length Class Total Quartile Code Counts [c]						Total Counts [d]
	1	2	3	4	1	2	3	4	1-34.9’	35-44.9’	45-64.9’	65-99.9’	100-124.9’	≥125’	
Skate sp.	4	5	1	-	5	4	1	-	-	1	3	6	-	-	10
Winter Flounder	-	5	2	-	5	2	-	-	-	7	-	-	-	-	7
Silver Hake	3	3	-	-	6	-	-	-	-	-	-	-	-	6	6
Mackerel	-	-	4	1	3	2	-	-	-	2	3	-	-	-	5
Roughhead Grenadier	-	1	1	3	-	1	1	3	-	2	1	-	-	2	5
Roundnose Grenadier	3	1	-	-	2	2	-	-	-	-	-	4	-	-	4
Atlantic Wolffish	1	2	-	-	1	2	-	-	-	-	3	-	-	-	3
Quahaug Clam	-	1	2	-	-	3	-	-	-	-	-	-	-	3	3
Shortfin Squid	-	-	2	-	1	1	-	-	-	2	-	-	-	-	2
Iceland Scallop	2	-	-	-	2	-	-	-	1	1	-	-	-	-	2
Porbeagle Shark	-	1	-	-	1	-	-	-	-	1	-	-	-	-	1
Whelk	1	-	-	-	1	-	-	-	-	-	1	-	-	-	1
Total	**2238**	**2980**	**2742**	**1271**	**2336**	**3022**	**2681**	**1192**	**982**	**1975**	**2913**	**637**	**21**	**2703**	**9231**

[a] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch weights in a given year, all species combined). Quartile weight ranges (2018): 1 = 0–2045 kg; 2 = 2046–8549 kg; 3 = 8550–33,818 kg; 4 = ≥33,819 kg.

[b] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch value in a given year, all species combined). Quartile value ranges (2018): 1 = $0–$10,353; 2 = $10,354–$45,610; 3 = $45,611–$166,300; 4 = ≥$166,301.

[c] Includes the total quartile code count for ranges 1-4 combined; total counts for catch weight and catch value are equal.

[d] Total counts of the number of catch records per species; the total quartile range counts for catch weight and catch value are equal.

Table 3.12. Annual commercial catch weights and values in the RAA, 2019 (values indicate the frequency of catch weight quartile codes [i.e., 1-4] or vessel length classes attributed to each species; derived from DFO commercial landings database, 2019).

Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Counts [b]				Vessel Length Class Total Quartile Code Counts [c]						Total Counts [d]
	1	2	3	4	1	2	3	4	1-34.9’	35-44.9’	45-64.9’	65-99.9’	100-124.9’	≥125’	
Snow Crab	756	1098	1030	228	478	807	1101	726	677	905	1327	184	19	-	3112

Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Counts [b]				Vessel Length Class Total Quartile Code Counts [c]						Total Counts [d]
	1	2	3	4	1	2	3	4	1-34.9’	35-44.9’	45-64.9’	65-99.9’	100-124.9’	≥125’	
Atlantic Cod	194	228	186	112	368	211	116	25	49	309	161	14	-	187	720
Northern Shrimp	180	171	171	133	224	171	146	114	-	7	425	59	-	164	655
Greenland Halibut	88	209	217	82	150	215	180	51	3	125	305	25	-	138	596
Atlantic Halibut	97	177	156	149	180	190	152	57	-	62	76	35	-	406	579
Yellowtail Flounder	58	99	99	99	129	116	83	27	-	-	-	-	-	355	355
American Plaice	14	76	105	111	64	116	94	32	5	5	8	-	-	288	306
Redfish	39	82	70	57	94	79	59	16	2	5	54	7	-	180	248
Witch Flounder	9	37	52	58	31	42	46	37	-	-	6	-	-	150	156
White Hake	44	58	34	16	55	71	23	3	-	46	45	33	-	28	152
Stimpson’s Surf Clam	-	5	22	63	-	23	22	45	-	-	-	-	-	90	90
Cockle	-	3	22	62	-	21	21	45	-	-	-	-	-	87	87
Capelin	-	8	23	53	18	35	23	8	16	43	25	-	-	-	84
Propellor Clam	-	3	20	44	-	19	14	34	-	-	-	-	-	67	67
Atlantic Haddock	11	21	12	10	16	20	15	3	-	8	1	12	-	33	54
Monkfish	3	14	20	16	12	21	17	3	-	-	20	7	-	26	53
Cusk	11	19	13	5	17	23	8	-	-	34	11	3	-	-	48
Swordfish	16	21	9	-	8	14	19	5	-	9	10	27	-	-	46
Bluefin Tuna	11	6	7	4	13	9	5	1	15	-	9	4	-	-	28
Mako Shark	9	11	6	-	5	8	10	3	-	1	8	17	-	-	26
Atlantic Herring	-	2	8	15	6	9	7	3	3	19	3	-	-	-	25
Albacore Tuna	3	10	7	-	-	5	12	3	-	-	6	14	-	-	20
Silver Hake	9	3	1	2	10	3	2	-	-	-	2	-	-	13	15
Winter Flounder	3	6	1	2	9	1	2	-	1	11	-	-	-	-	12
Roughhead Grenadier	-	3	4	3	2	2	4	2	-	1	9	-	-	-	10

Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Counts [b]				Vessel Length Class Total Quartile Code Counts [c]						Total Counts [d]
	1	2	3	4	1	2	3	4	1-34.9’	35-44.9’	45-64.9’	65-99.9’	100-124.9’	≥125’	
Blue Shark	3	3	1	-	1	3	3	-	-	-	-	7	-	-	7
Dolphinfish	-	4	2	-	-	-	4	2	-	-	3	3	-	-	6
Bigeye Tuna	3	2	1	-	2	2	2	-	-	2	1	3	-	-	6
Ocean Quahaug	-	-	-	4	-	2	1	1	-	-	-	-	-	4	4
Mackerel	-	1	1	-	1	1	-	-	-	1	1	-	-	-	2
Skate sp.	1	1	-	-	1	1	-	-	-	2	-	-	-	-	2
Striped Shrimp	-	-	-	1	-	-	-	1	-	-	-	-	-	1	1
Shortfin Squid	1	-	-	-	1	-	-	-	-	1	-	-	-	-	1
Pollock	1	-	-	-	1	-	-	-	-	-	-	1	-	-	1
Whelk	1	-	-	-	1	-	-	-	-	1	-	-	-	-	1
Total	**1565**	**2381**	**2300**	**1329**	**1897**	**2240**	**2191**	**1247**	**771**	**1597**	**2516**	**455**	**19**	**2217**	**7575**

[a] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch weights in a given year, all species combined). Quartile weight ranges (2019): 1 = 0–1938 kg; 2 = 1939–8218 kg; 3 = 8219–33,113 kg; 4 = ≥33,114 kg.

[b] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch value in a given year, all species combined). Quartile value ranges (2019): 1 = $0–$11,209; 2 = $11,210–$46,951; 3 = $46,952–$176,461; 4 = ≥$176,462.

[c] Includes the total quartile code count for ranges 1-4 combined; total counts for catch weight and catch value are equal.

[d] Total counts of the number of catch records per species; the total quartile range counts for catch weight and catch value are equal.

Table 3.13. Annual commercial catch weights and values in the RAA, 2020 (values indicate the frequency of catch weight quartile codes [i.e., 1-4] or vessel length classes attributed to each species; derived from DFO commercial landings database, 2020).

Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Counts [b]				Vessel Length Class Total Quartile Code Counts [c]						Total Counts [d]
	1	2	3	4	1	2	3	4	1-34.9’	35-44.9’	45-64.9’	65-99.9’	100-124.9’	≥125’	
Snow Crab	568	944	1035	267	359	778	1053	624	542	811	1266	179	16	-	2814
Atlantic Cod	214	250	243	138	365	299	131	50	64	275	224	21	-	261	845
Greenland Halibut	105	306	205	41	140	318	161	38	8	99	351	33	-	166	657
Atlantic Halibut	112	186	173	155	151	240	165	70	2	52	89	41	-	442	626

Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Counts [b]				Vessel Length Class Total Quartile Code Counts [c]						Total Counts [d]
	1	2	3	4	1	2	3	4	1-34.9'	35-44.9'	45-64.9'	65-99.9'	100-124.9'	≥125'	
Northern Shrimp	142	145	139	88	178	158	101	77	-	-	307	66	-	141	514
Yellowtail Flounder	64	109	146	137	132	152	126	46	-	1	-	-	-	455	456
American Plaice	27	87	146	133	76	142	128	47	4	4	-	-	-	385	393
Witch Flounder	11	51	63	76	23	56	78	44	2	1	-	-	-	198	201
Redfish	28	75	53	26	45	79	40	18	-	2	14	25	-	141	182
Capelin	1	5	35	138	13	60	35	71	44	78	54	3	-	-	179
Stimpson's Surf Clam	1	12	31	68	4	24	27	57	-	-	-	-	-	112	112
White Hake	21	46	19	14	29	47	16	8	-	16	33	27	-	24	100
Cockle	-	10	26	62	2	20	22	54	-	-	-	-	-	98	98
Cusk	5	27	7	6	8	24	10	3	-	12	30	3	-	-	45
Monkfish	4	14	11	16	9	18	8	10	-	-	10	14	-	21	45
Swordfish	16	13	15	-	25	16	3	-	-	14	1	29	-	-	44
Propellor Clam	-	1	11	25	-	8	6	23	-	-	-	-	-	37	37
Bluefin Tuna	10	6	9	4	10	15	4	-	15	1	12	1	-	-	29
Atlantic Haddock	11	8	7	1	11	12	3	1	-	4	3	3	-	17	27
Atlantic Herring	-	1	9	17	6	12	9	-	1	12	14	-	-	-	27
Roughhead Grenadier	2	13	3	-	3	12	3	-	-	-	9	9	-	-	18
Albacore Tuna	8	4	6	-	10	7	1	-	-	2	-	16	-	-	18
Bigeye Tuna	1	5	10	-	3	11	2	-	-	4	-	12	-	-	16
Roundnose Grenadier	4	5	1	-	3	6	1	-	-	-	10	-	-	-	10
Mackerel	-	1	3	3	1	4	2	-	2	3	2	-	-	-	7
Pollock	-	2	1	3	-	3	2	1	-	-	6	-	-	-	6
Dolphinfish	3	-	1	-	3	1	-	-	-	4	-	-	-	-	4
White Marlin	2	-	-	-	2	-	-	-	-	1	-	1	-	-	2

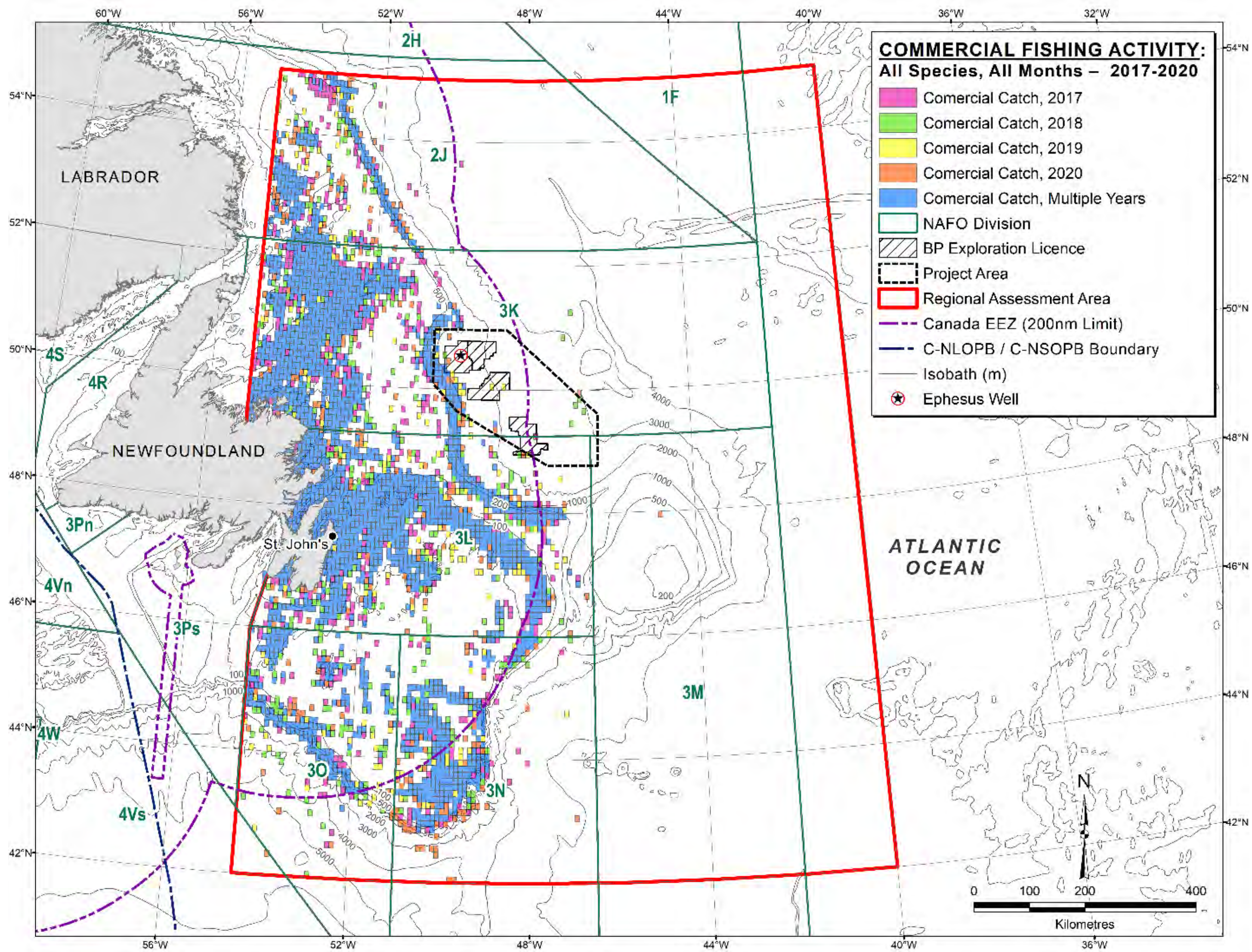
Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Counts [b]				Vessel Length Class Total Quartile Code Counts [c]						Total Counts [d]
	1	2	3	4	1	2	3	4	1-34.9’	35-44.9’	45-64.9’	65-99.9’	100-124.9’	≥125’	
Whelk	2	-	-	-	2	-	-	-	-	2	-	-	-	-	2
Shortfin Squid	-	-	2	-	-	2	-	-	1	1	-	-	-	-	2
Mako Shark	-	-	-	1	-	-	-	1	-	1	-	-	-	-	1
Winter Flounder	-	-	1	-	-	1	-	-	-	1	-	-	-	-	1
Total	**1362**	**2326**	**2411**	**1419**	**1613**	**2525**	**2137**	**1243**	**685**	**1401**	**2435**	**483**	**16**	**2498**	**7518**

[a] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch weights in a given year, all species combined). Quartile weight ranges (2020): 1 = 0–1989 kg; 2 = 1990–8248 kg; 3 = 8249–34,645 kg; 4 = ≥34,646 kg.

[b] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch value in a given year, all species combined). Quartile value ranges (2020): 1 = \$0–\$8664; 2 = \$8665–\$38,347; 3 = \$38,348–\$144,765; 4 = ≥\$144,766.

[c] Includes the total quartile code count for ranges 1-4 combined; total counts for catch weight and catch value are equal.

[d] Total counts of the number of catch records per species; the total quartile range counts for catch weight and catch value are equal.



Note: "Commercial Catch: Multiple Years" = Catches occurred within this cell during two or more years. Cells with catch locations that only occurred during a single year are specifically indicated in the legend for that year.

Figure 3.22. Domestic harvest locations in the RAA, 2017-2020 (Source: DFO commercial landings database, 2017-2020).

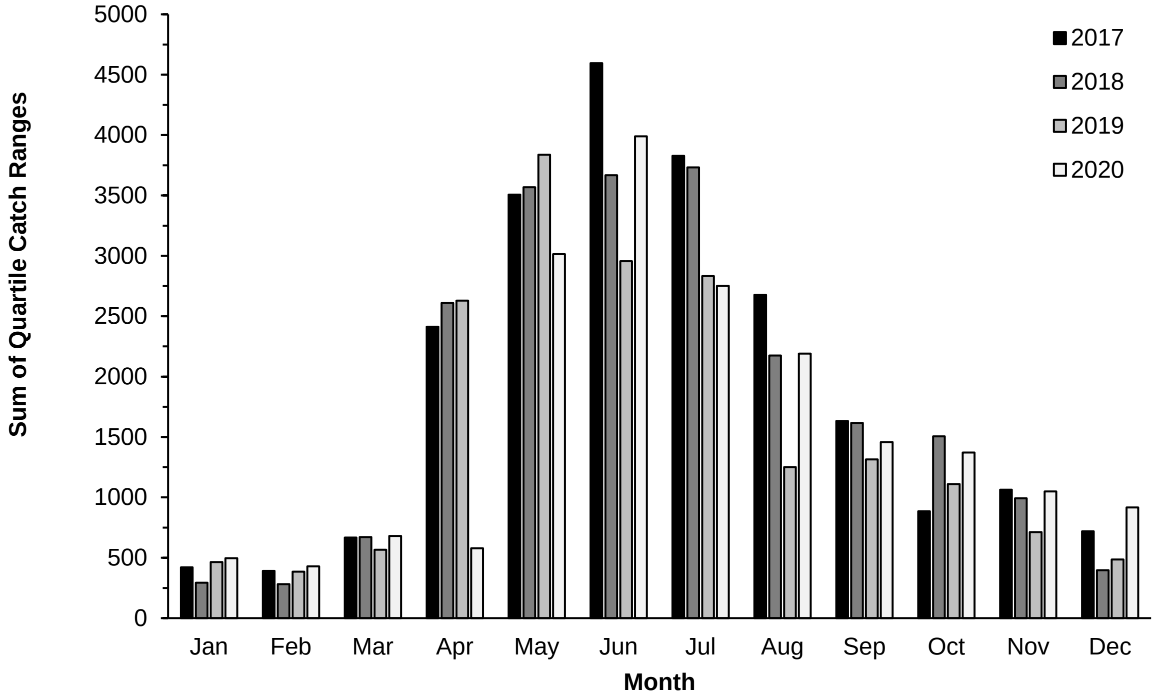


Figure 3.23. Offshore domestic harvest seasonality in the RAA, all species 2017-2020 (Source: DFO commercial landings database, 2017-2020).

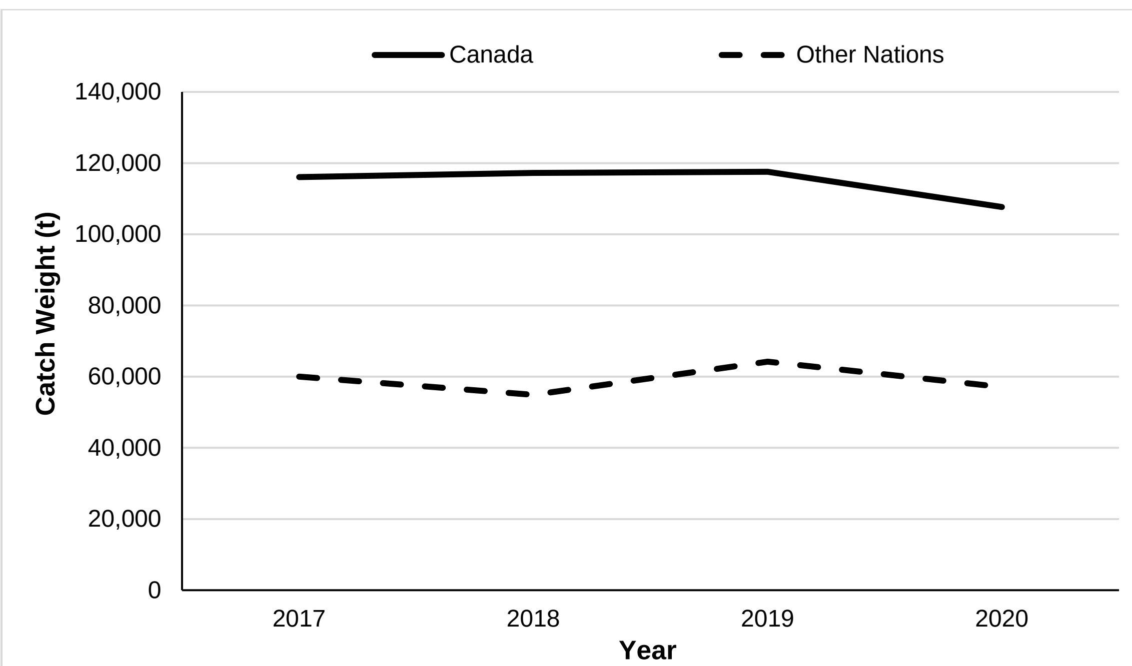


Figure 3.24. Annual Canadian and international total catch weights (t) of NAFO-managed commercial fisheries stocks in NAFO Divisions 2J+3KLMNO, 2017-2020 (Source: NAFO STATLANT21A database [NAFO 2022]).

A variety of fishing gear is used in commercial fisheries within the RAA. For example, shrimp fisheries use trawls while snow crabs are harvested using pots that sink to the sea floor. Other gear types, such as nets, seines, gillnets, dredgers, longlines, and stern trawls, are used in accordance with the target species. For example, the pelagic fisheries use a combination of nets, longlines, and seines (see Section 7.2.5 in Stantec 2018).

3.6.2 Aquaculture

Aquaculture is another important and growing industry in the region, but most of the sites are found outside the RAA. Within the RAA, there are coastal-based production facilities for blue mussels, Atlantic cod, rainbow trout, oyster, and tilapia (see Section 7.2.9 in Stantec 2018; Figure 3.24).

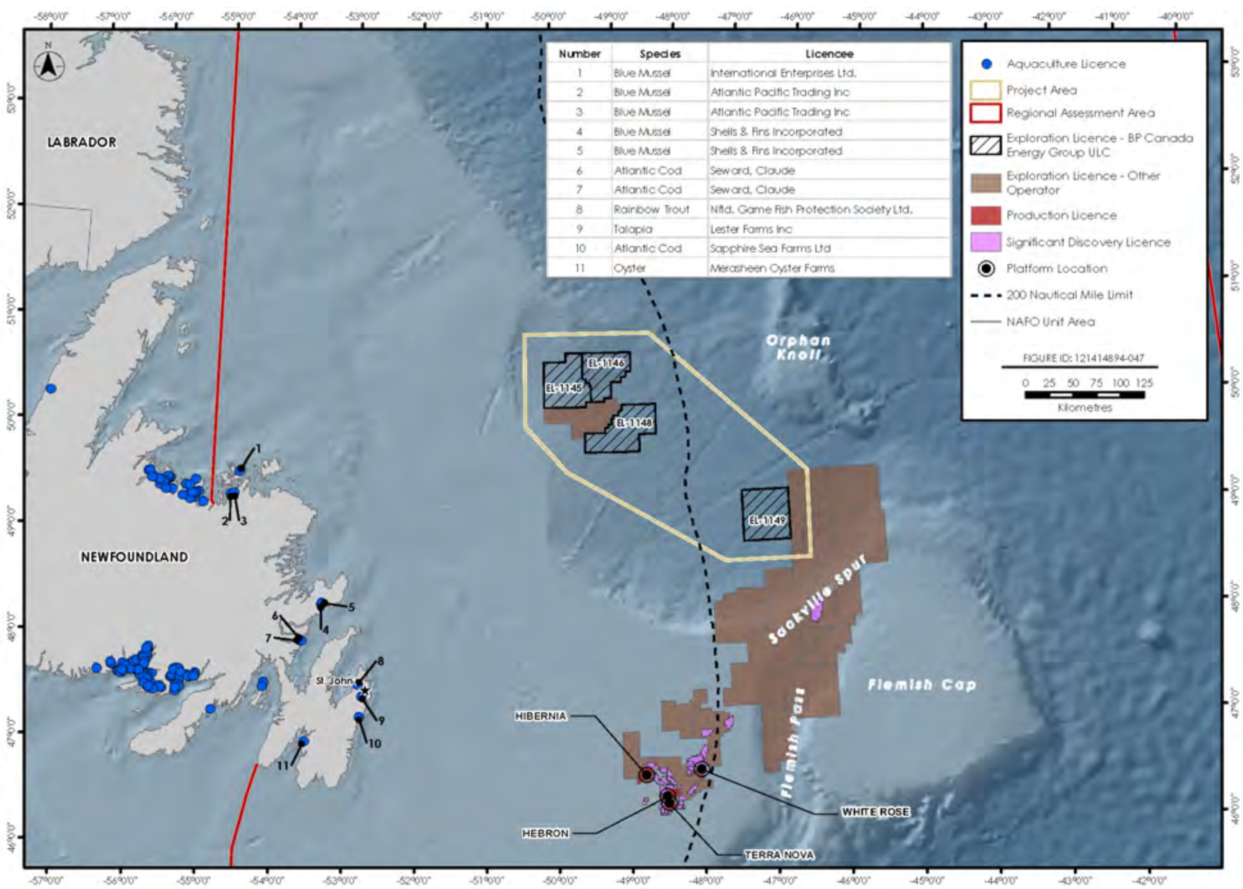


Figure 3.25. Aquaculture sites in the RAA as of 2018 (Source: Figure 7.35 in Stantec 2018).

3.6.3 Other Anthropogenic Marine Activity

St. John's Harbour supports and services commercial marine activity, including international shipping and offshore oil and gas. A total of 1344 vessels visited St. John's harbour in 2017, a 28% increase since 2007 but a 16% decrease from the peak in 2013 (see Figure 7.39 and Section 7.3.2.1 in Stantec 2018). Offshore oil and gas exploration vessels and their support vessels also operate out of Bay

Bulls. In addition, there are several ferry routes run by the provincial government. These include local routes and ferry traffic between the province and Nova Scotia and St. Pierre and Miquelon (see Section 7.3.2.3 in Stantec 2018). Tourism is another important driver of marine activity, both along the coastline and involving larger, ocean-going vessels, such as cruise ships. A total of 31 cruise ships visited 20 ports within the RAA in 2017, bringing a combined total of 38,321 visitors to Newfoundland. Local tour companies operate along the coast of Newfoundland, offering experiences such as whale, seabird, and iceberg safaris (see Section 7.3.2.2 in Stantec 2018). In addition to civilian activity, both the Royal Canadian Navy and Air Force operate in the area. Military activity can include surveillance and training exercises using both aircraft and vessels operated by the navy (see Section 7.3.4 in Stantec 2018).

3.7 Indigenous Fisheries

Indigenous communities have long utilized marine resources for trade and personal, cultural, and spiritual use. Indigenous communities maintain rights for commercial harvest and traditional uses. Two types of licenses are issued to Indigenous communities, Commercial Communal Fishing and FSC Fishing. Both types of licenses are held by Indigenous communities rather than individual community members (see Section 7.4 in Stantec 2018). Several Indigenous communities call the province of Newfoundland and Labrador home, including Labrador Inuit (Nunatsiavut Government), Labrador Innu (Innu Nation), NunatuKavut Community Council (NCC), Qalipu Mi’kmaq First Nation, and Miawpukek First Nation. Indigenous communities in Newfoundland and Labrador are shown in Figure 3.25.

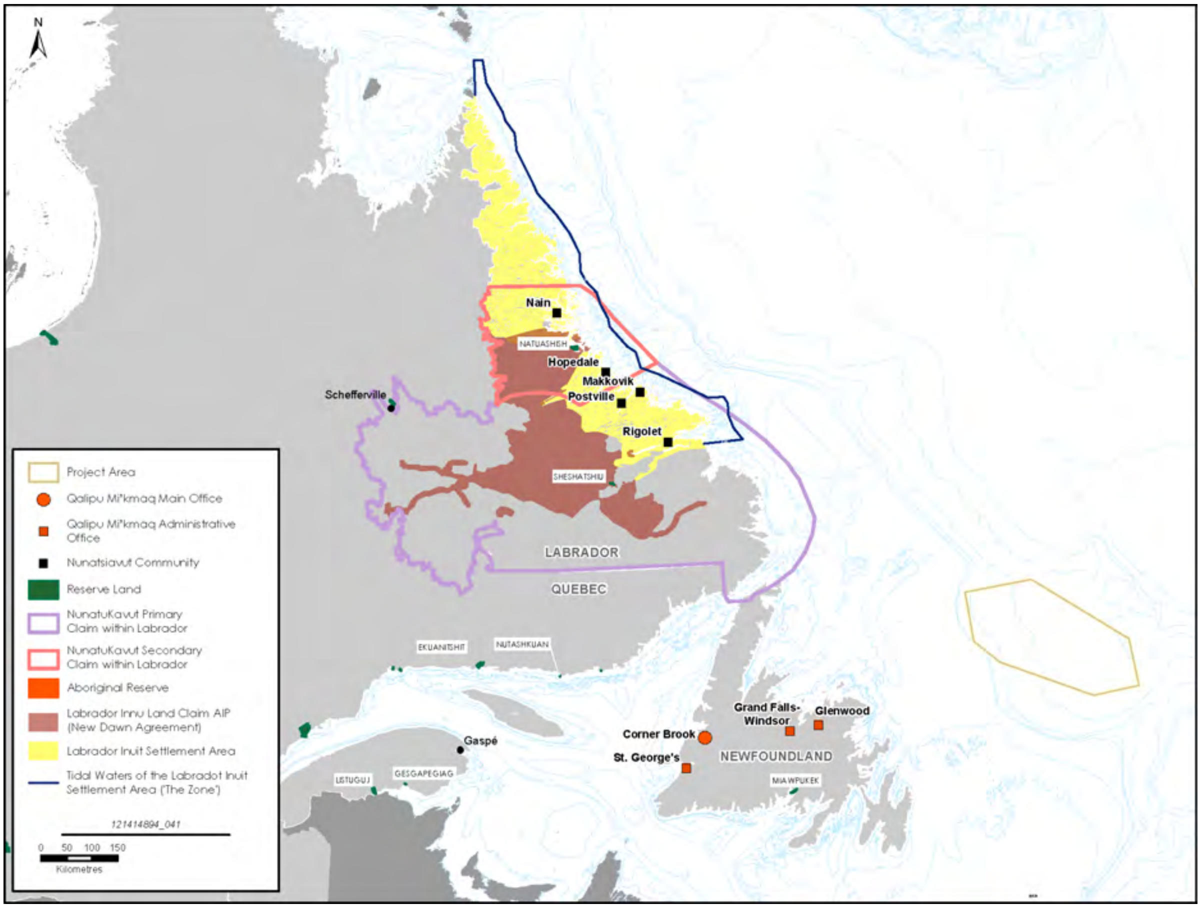


Figure 3.26. Indigenous communities in Newfoundland and Labrador and Quebec (Source: Figure 7.45 in Stantec 2018).

Several Commercial Communal licences are held by Indigenous communities in Newfoundland and Labrador. The Nunatsiavut Government holds Commercial Communal licenses for snow crab, shrimp, Arctic char, scallop, seal, Greenland halibut, and groundfish. The Innu Nation holds Commercial Communal licenses for mackerel, capelin, halibut, groundfish, and shrimp. The Qalipu Mi'kmaq First Nation holds Commercial Communal licenses for snow crab, toad crab, scallops, shrimp, groundfish, capelin, herring, and seal. The Miawpukek First Nation holds Commercial Communal licenses for mackerel, herring, swordfish, capelin, groundfish, tuna (including bluefin tuna), squid, snow crab, and seal. The NunatuKavut Community Council holds Commercial Communal licenses for snow crab, toad crab, shrimp, scallops, groundfish, capelin, herring, and seal. The region's Indigenous communities also hold several licenses for FSC fishing. For example, several Indigenous communities hold licenses for the harvest of salmon and Arctic char (see Section 7.4.2 in Stantec 2018). An overview of the Indigenous communities of Newfoundland and Labrador and their traditional harvest of marine resources is provided in Table 7.15 in Stantec (2018).

3.8 Responder Health and Safety

The health and safety of responders is paramount during all oil spill response activities. The IMT is responsible for establishing response/responder health and safety parameters in accordance with applicable legislation for the area. The most concerning factor for health and safety relating to a spill involves exposure to the carcinogenic components of crude oil, particularly including PAHs (cause human lung, bladder, and skin cancers) and benzene (VOC constituent of fresh oil; causes human hematological cancer) (NASEM 2020). Other toxic VOC oil components of concern for responder health and safety include toluene, ethylbenzene, and xylene (NASEM 2020). Potential health hazards other than cancer associated with exposure to oil spill components include acute/subacute dermal toxicity and acute central nervous system effects (NASEM 2020). Primary potential responder health and safety issues related to dispersant use may include irritation of the skin, eye, and respiratory tract (NASEM 2020). Inhalation of gases and soot particulates (e.g., CO_2, CO, SO_2, and Nox, and up to 90% ultrafine soot particles [<1.0 µm], which can be deeply inhaled into human lungs and enter the blood stream) from smoke produced during on-water ISB is also possible (Faksness et al. 2022). Responders may also be at risk due to the inherent flammability and explosive properties of oil that reaches the surface.

During oil spill response activities, responders may be exposed to VOC components of oils, dispersants, or dispersed oil via inhalation or dermal exposure. Inhalation exposure may occur primarily at the site of an oil spill or secondarily via the aerial transport of VOCs downwind from an oil spill that causes secondary air pollutants to form, such as ozone (NASEM 2020). VOC exposure may also occur due to the aerosolization of oil-containing particles (NASEM 2020). Responders may be exposed to PAHs or dispersant components via ingestion if contaminated food is consumed during or after a spill, such as consuming seafood that was exposed to spill/dispersant components or food that was subject to cross-contamination during ongoing response activities (e.g., improper personal washing between conducting a response action, such as cleaning oiled equipment, and preparing/consuming food) (NASEM 2020). It is imperative that responders receive proper training to avoid exposure/cross-contamination and use air quality monitoring devices and appropriate PPE during oil spill response activities.

4 Oil Spill Scenario

4.1 Oil Characteristics

The light, low-viscosity crude oil YME (IKU) was used as an oil analogue for the Ephesus Well modelling (note: it was also used for the original West Orphan Basin modelling for the EIS) (BP 2018; Stantec 2018, 2022). The fluid properties of YME (IKU) are provided in Table 4.1.

Given that the wells to be drilled for this project are exploratory, the exact nature of the well hydrocarbon fluids that may be encountered is unknown. The crude oil characteristics were selected to align with the expected reservoir characteristics using a bottom up petroleum system analysis approach. Specific properties of the petroleum fluid will depend on the richness, quality and thermal maturity of the source rocks. Where available, top down observations on petroleum fluid analogues from offset wells or nearby areas were used to further constrain expected fluid properties.

Table 4.1. Fluid properties of YME (IKU), the oil analogue used for the Ephesus Well oil spill modelling (Source: Table 3.2 in Stantec 2022).

Fluid Property	YME (IKU)
API Gravity	38.4
Specific Gravity	0.833
Pour Point (ºC)	6
Wax Content (wt%)	6
Asphaltene Content (wt%)	0.3
Dead Oil viscosity at Reference Temperature (cP)	4
Reference Temperature (ºC)	13

Note: 'wt%' = Percent Weight; cP = centipoises.

4.2 Oil Spill Model and Response Parameters

4.2.1 Oil Spill Model

Oil spill modelling for this SIMA was conducted using the SINTEF OSCAR model (Stantec 2022). The SINTEF OSCAR model calculates the three-dimensional distribution (i.e., mass and concentration) of contaminants for the water surface, shorelines, water column, and seabed sediments; allows for the input of several, specific release sites and release start/end dates; and takes into account oil and gas buoyancy, ambient stratification, and cross flow of the plume's dilution and rise time (Stantec 2022).

4.2.2 Rationale for Scenario Selection for SIMA Assessment

As noted in Section 1.1 above, oil spill modelling was originally conducted for a hypothetical drilling location in the West Orphan Basin (BP 2018); however, updated modelling specific for the Program's first planned well, Ephesus, was conducted in 2022 (Stantec 2022). While there were similarities in the modelling results for the West Orphan Basin and Ephesus Well (see Section 3.0 in Stantec 2022), the Ephesus Well modelling was used as the basis for the oil spill scenario for this SIMA as it is directly relevant to planned drilling activities. The Ephesus Well modelling utilized a WCCD, which consisted of a subsea blowout during the summer season (May-October). Under these conditions, oil spill trajectory and fate modelling were conducted for a relief well scenario and capping stack scenario using the SINTEF OSCAR model. The modelled parameters of the relief well scenario had a greater surface footprint within the RAA than the capping stack scenario and deterministic modelling was only provided for the relief well scenario in Stantec (2022). Therefore, as the "worst" of the WCCD, the summer subsea blowout relief well scenario at the Ephesus Well was used for the oil spill scenario for this SIMA.

4.2.3 Model and Response Parameters

The model and response parameters for the relief well scenario of a subsea blowout during the summer at the Ephesus Well are provided in Table 4.2. The modelling domain for the Ephesus Well scenario was the same as that used for the original West Orphan Basin modelling (Figure 4.1; see Section 5.4 in BP 2018).

The 3-D current dataset used in OSCAR modelling to drive oil dispersion and transport was comprised of 3 hourly HYCOM current speeds with Bedford Institute Tides linearly superimposed. The HYCOM currents are from the Navy Research Laboratory experiment 19.1 (HYCOM GLBu0.08) for the period 1st January 2006 to 31st December 2010. The spatial resolution is 1/12.5 degrees and the results were extracted onto a domain that spans: longitude 30 to 70 degrees West and latitude 35 to 65 degrees North. The HYCOM currents were provided on forty depth levels, from the surface to 5,000m. (see EIS Appendix D, Stantec 2018)

Table 4.2. Model and response parameters for the modelled Ephesus Well summer subsea blowout relief well scenario (Source: Table 3.1 in Stantec 2022).

Parameter	Value
Well Location	50°33’17.856” N 49°44’31.742” W
Water Depth (m)	1339
“Pipe” ID Diameter (blowout preventor or casing or tubing) at the Seabed Release Point for WCCD (m / in.)	0.314 / 12.375
Temperature of Release as it Leaves the Wellbore (°C)	94.3
Salinity of Release as it Leaves the Wellbore (ppt)	30.0
Release Duration – Relief Well (P90 time; days)	120
Initial Oil Volume Release Rate (m^3/d / bpd)	33.228 / 209,000
Initial Water Volume Release Rate (m^3/d / bpd)	0 / 0
Gas-Oil Ratio (sm^3/m^3 / sfc/bbl)	125 / 700
Gas-Liquid Ratio (sm^3/m^3 / sfc/bbl)	125 / 700
Gas Density (kg/sm^3)	1.100
Calculated Gas Value Release Rate (MMsm^3/d / MMsfc/d)	4.14 / 146.30
Calculated Mass Flow Rate of Gas Released (kg/s)	52.75

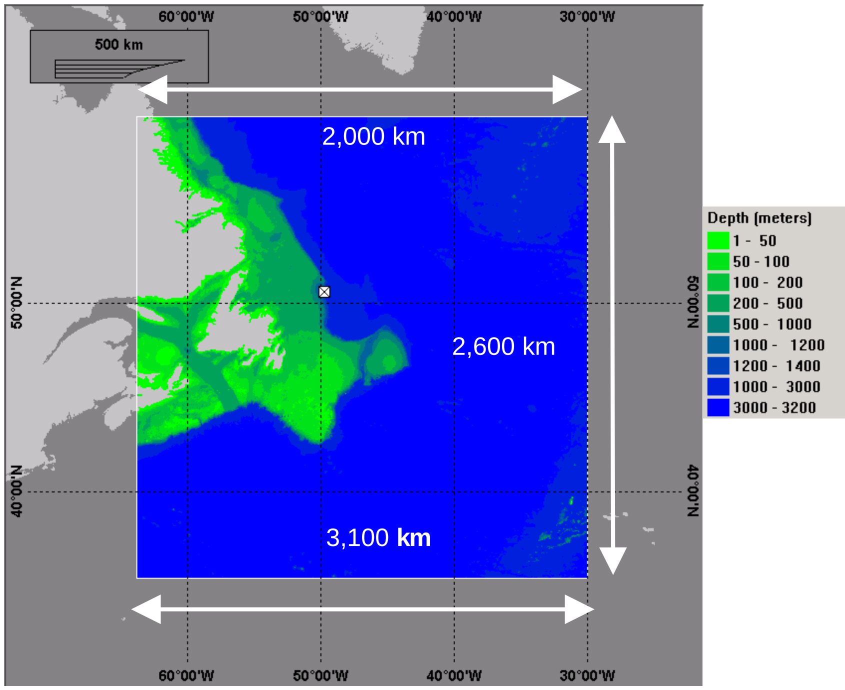


Figure 4.1. Modelling domain for the Ephesus Well oil spill scenario (Source: Figure 5.1 in Stantec 2022).

4.2.3.1 Environmental Inputs

Environmental inputs applied to the Ephesus Well oil spill modelling were the same as those used for the West Orphan Basin modelling (see Section 5.3 in BP 2018), including wind field, surface currents, and sea ice extent (Figures 4.2-4.4).

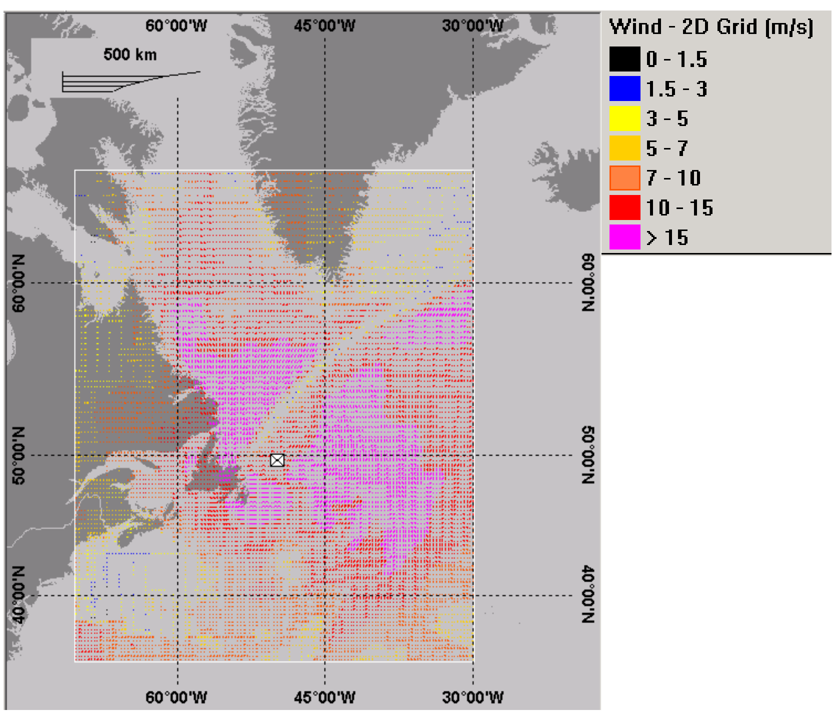


Figure 4.2. Wind field input applied to modelling for the Ephesus Well oil spill scenario (Source: Figure 5.2 in Stantec 2022 [National Centers for Environmental Prediction Climate Forecast System Reanalysis Data {1/3 deg grid spacing}; 1 Jan 2006 to 31 Dec 2010; time resolution of surface winds = 3 h]).

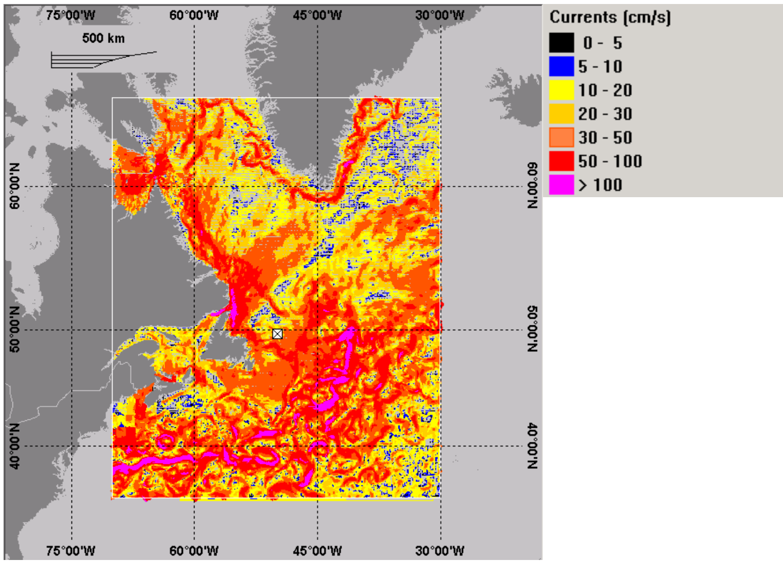


Figure 4.3. Surface current input applied to modelling for the Ephesus Well oil spill scenario (Source: Figure 5.3 in Stantec 2022 [1/2 deg grid spacing; 1 Jan 2006 to 31 Dec 2010; vertical resolution = 40 levels {0−5000 m water depth}; time resolution = 3 h]).

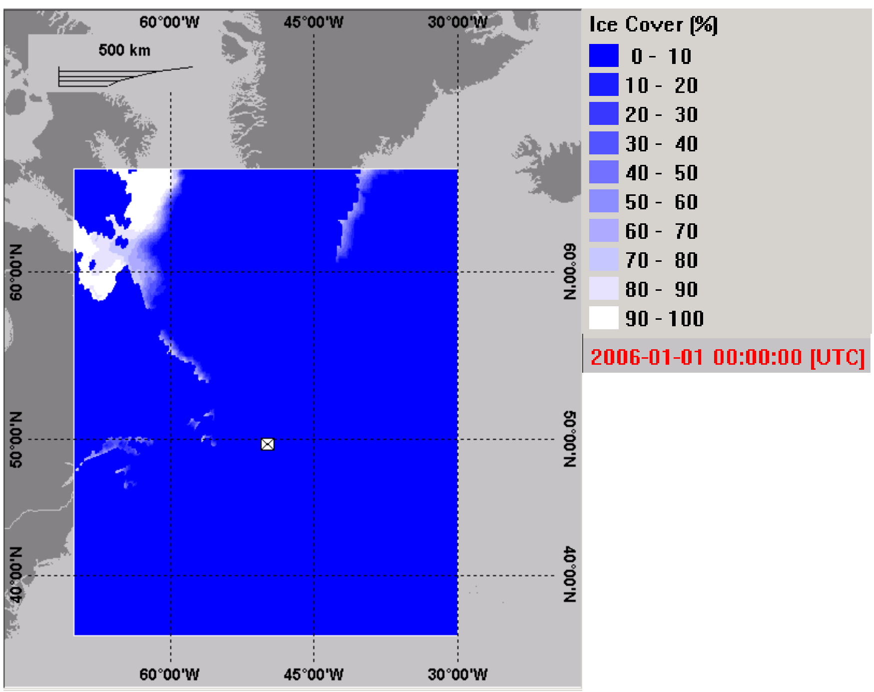


Figure 4.4. Sea ice extent input applied to modelling for the Ephesus Well oil spill scenario (Source: Figure 5.4 in Stantec 2022 [spatial resolution = 25 km x 25 km; 1 Jan 2006 to 31 Dec 2010; time resolution = 24 h]).

4.2.3.2 Impact Assessment Thresholds and Stochastic Model Outputs / Simulations

The same impact threshold values were applied to the Ephesus Well modelling as for the West Orphan Basin modelling (see Section 7.1 in BP 2018). Impact threshold values and rationales are provided in Table 4.3. Similarly, the same stochastic model outputs were generated for the Ephesus Well and West Orphan Basin modelling for the sea surface, water column, and shoreline areas of impact (Table 4.4; see also Section 7.1 in BP 2018). Stochastic modeling simulations for the WCCD Ephesus Well oil spill scenario is provided in Table 4.5; simulations for both the relief well and capping stack scenarios are provided for comparative purposes.

The OSCAR model uses 25 pseudo-oil compound groups, based on boiling points (Reed et al., 2000), and representing saturates and aromatic hydrocarbons.. These "OSCAR groups" represent compounds within the boiling point range of temperatures, T, 0°C < T < 500°C, which include 80% of light oils. Biodegradation data in OSCAR are represented by degradation rates in normal seawater for each of the 25 pseudo-oil compound groups, based on first-order rate kinetics (Reed et al., 2000; Brakstad and Faksness, 2000). The rates described in OSCAR represent biotransformation (primary biodegradation), i.e. the first biochemical conversion to metabolic products. The data are based on experimental studies in natural non-amended seawater, determining the depletion of oil compounds by chemical analyses (GC-FID and GC-MS analyses).

The biotransformation rates are determined by first-order rate calculations for three compartments, water-soluble oil compounds, dispersed oil, and sedimented oil (Brakstad and Faksness, 2000; Reed et al., 2000). The complete

Mineralization (ultimate biodegradation) of the oil compound groups to CO2 are therefore not described in the model. The OSCAR model uses a Q10-approach, based on the Arrhenius curve for temperature compensation between laboratory and in situ conditions

Table 4.3. Impact threshold values and rationales for the modelled Ephesus Well oil spill scenario (Source: Table 5.1 in Stantec 2022).

Impact Threshold	Threshold Value	Rationale
Surface Oil Thickness (thickness of oil on the water surface)	0.04 µm	Visible sheen on surface (Bonn Agreement Oil Appearance Code) and therefore potential threshold for fisheries closure; 10 µm often used as wildlife effects threshold (French-McCay 2009 in Stantec 2022)
Shoreline Mass (volume of oil reaching the shoreline)	1.0 g/m^2	Threshold to trigger shoreline cleanup; based on 2011 ITPOF Technical Information Paper No. 6 “Recognition of Oil on Shorelines”
In-Water Concentration (Total Hydrocarbons) (concentration of oil in the water column)	58 ppb	Threshold for “no observed effect concentration” for acute exposure to total hydrocarbons based on Norwegian Oil Industry Association (OLF) guideline for risk assessment of effects on fish from acute oil pollution

Table 4.4. Stochastic model outputs for the Ephesus Well oil spill scenario (Source: Table 5.2 in Stantec 2022).

Impacted Area	Significance Threshold	Model Output
Sea Surface	0.04 µm	Probability of Surface Oiling Minimum Travel Time of Surface Emulsified Oil Maximum Exposure Time of Surface Emulsified Oil Maximum Emulsified Oil Thickness Average of Time-Averaged Emulsified Oil Thickness
Water Column	58 ppb	Probability of Water Column Contamination Minimum Travel Time of Oil in the Water Column Maximum Exposure Time of Oil in the Water Column Maximum Time Averaged THC Concentration in the Water Column Maximum Time Averaged Dissolved Oil Concentration in the Water Column
Shoreline	1.0 g/m^2	Probability of Shoreline Oiling Minimum Arrival Time of Shoreline Oiling Degree of Shoreline Oiling

Table 4.5. Stochastic modelling simulations for WCCD Ephesus Well oil spill modelling (Source: Table 5.3 in Stantec 2022).

Oil Spill Scenario [a]	Well Site Location	Release Rate		Gas-Oil Ratio (scf/bbl)	Release Duration (days)	No. of Simulations	Simulation Duration (days)
		Oil (bpd)	Water (bpd)				
Well Blowout: Relief Well	Ephesus	Initial rate: 209,000 Day 120: 103,000	Initial rate: 0 Day 120: 10,000	700	120	>100	160
Well Blowout: Capping Stack	Ephesus	Initial rate: 209,000 Day 30: 174,000	Initial rate: 0 Day 30: 6000	700	30	>100	90

[a] Scenarios modelled for the summer season (May-October).

bp's justification for release duration times for well blowout relief well or capping stack were decided using information as described in the EIS, specifically Chapter 15 "For modelling purposes, conservative estimates of 120 days (to simulate a relief well scenario) and 30 days (to simulate a capping stack response scenario) are used; however, as indicated in Section 15.3.3, anticipated response time is significantly less." The EIS is a public document available on ECCC website.

4.3 Oil Spill Fate and Trajectory

This section provides a summary of the modelled fate and trajectory of oil for the Ephesus Well relief well summer spill scenario, including discharge rates, release volumes, deterministic simulation, sea surface footprints, shoreline contacts, and water column concentrations. This is the type of information that would be updated for an actual spill based on real-time modelling and used to conduct trade-off analyses for ROCs and create an expedited SIMA.

4.3.1 Estimated Discharge Rates and Release Volumes

Discharge rates of oil and water separately and oil and water combined ("liquid") were estimated for the WCCD Ephesus Well subsea blowout oil spill modelling (Figures 4.5-4.6). The estimated rates were generally similar to those previously modelled for the West Orphan Basin, although the estimated oil discharge rates were greater for the Ephesus modelling.

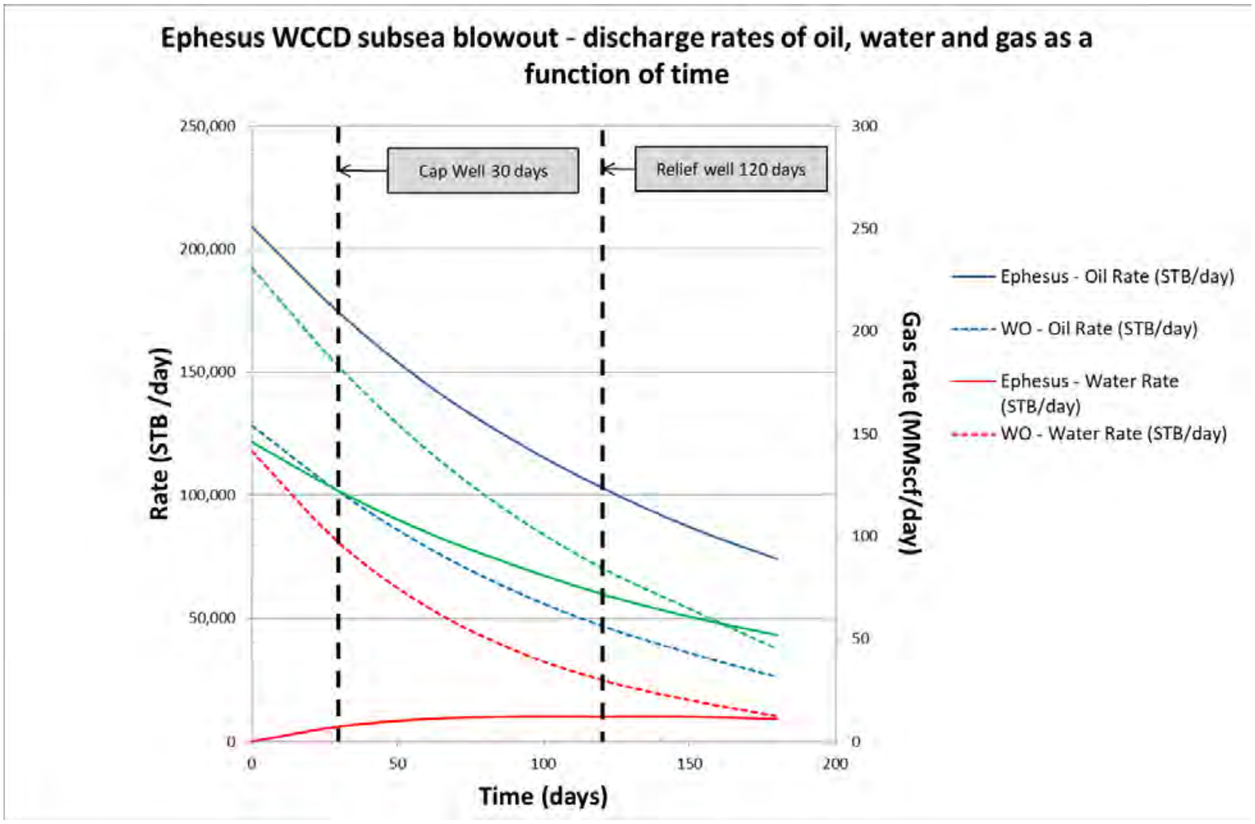


Figure 4.5. Estimated discharge rates of oil, water, and gas over time for the WCCD Ephesus Well oil spill modelling (Source: Figure 4.1 in Stantec 2022).

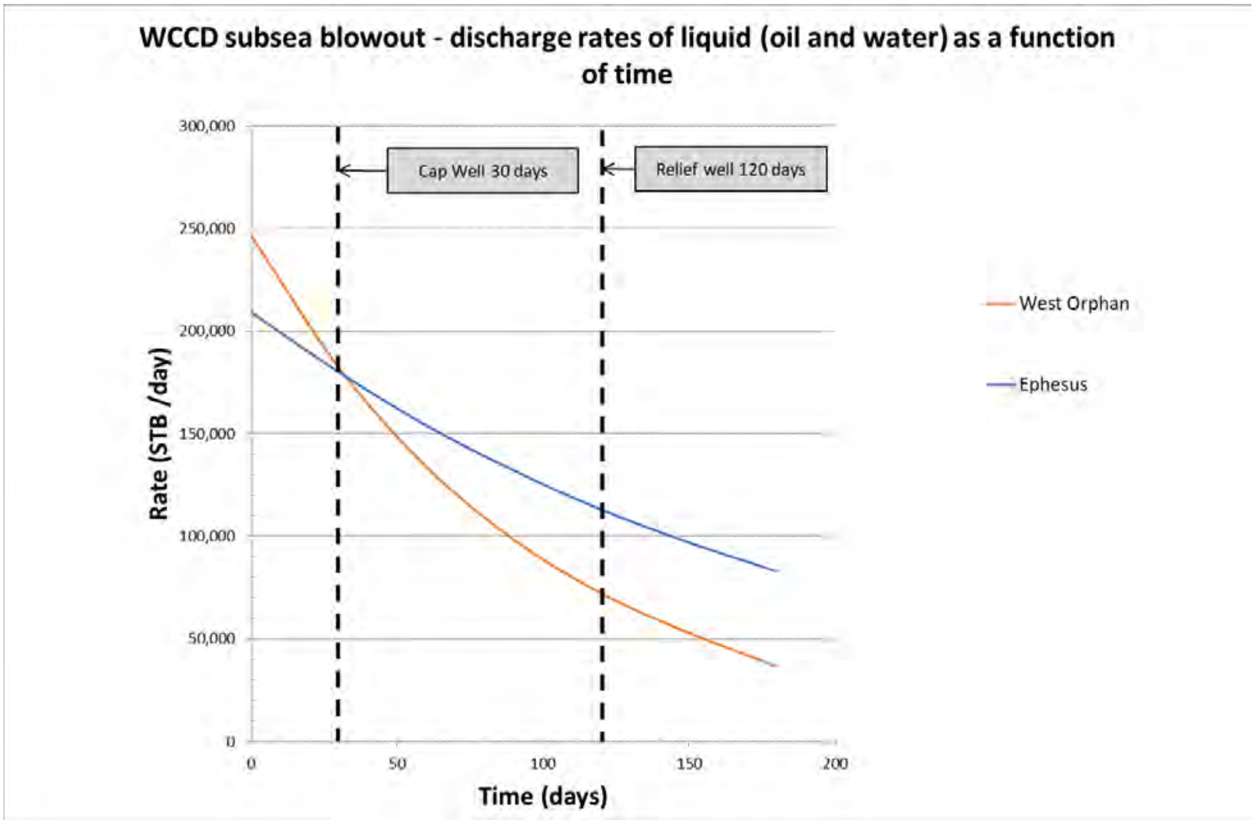


Figure 4.6. Estimated discharge rates of liquid (oil and water) over time for the WCCD Ephesus Well oil spill modelling (Source: Figure 4.2 in Stantec 2022).

Cumulative release rates of produced oil and water were estimated for the WCCD Ephesus Well oil spill modelling (Figure 4.7).

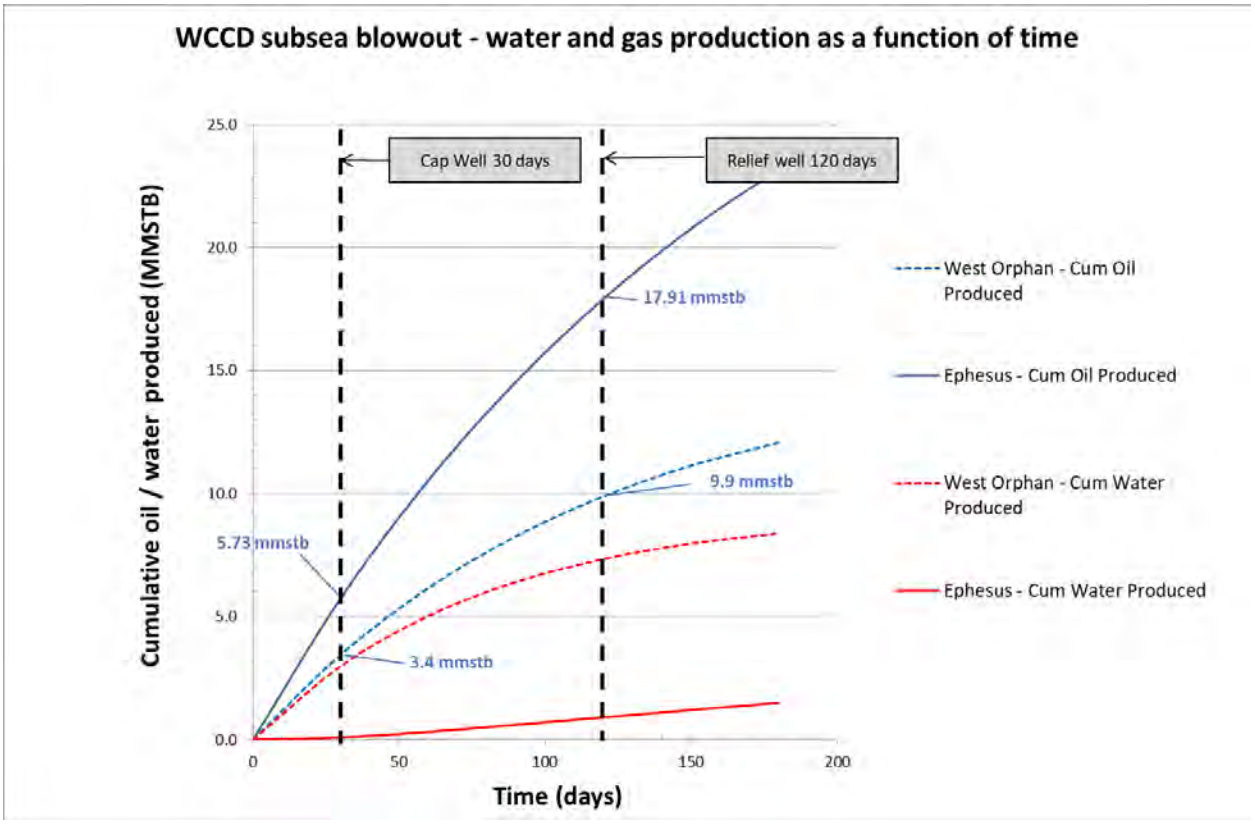


Figure 4.7. Estimated cumulative oil and water release rates over time for the WCCD Ephesus Well oil spill modelling (Source: Figure 4.3 in Stantec 2022).

4.3.2 Deterministic Simulation

Deterministic modelling for the Ephesus Well summer oil spill relief well scenario with a release duration of 120 days (simulation duration of 160 days) and initial release rate of 209,000 bbl/day estimated a total release of 2,431,102 tonnes of oil (Stantec 2022). The full deterministic simulation results are provided in Table 4.6. The percentage of total oil released at the end of the simulation would be greatest in the biodegraded (34.5%), water column (dispersed and dissolved; 32.4%), and atmosphere (31.0%) model compartments and negligible or nil in the remaining model compartments (Table 4.7). The mass balance distribution of oil over time is provided in Figure 4.8.

Table 4.6. Deterministic modelling simulations for the Ephesus Well oil spill scenario (Source: Table 7.1 in Stantec 2022).

Oil Type	Simulation End Point	Result
Stranded Oil	First shore hit (days)	131.0
	Maximum mass on shoreline (tonnes)	108
	Ashore time (maximum mass) (days)	137
	Length of coastline impacted (at maximum mass ashore) (km)	8
	Maximum length of coastline impacted (km)	8

Oil Type	Simulation End Point	Result
	Ashore time (maximum length) (days)	137
Surface Oil	Maximum mass of oil on sea surface (tonnes)	435,100
	Time of occurrence (maximum surface mass) (days)	108
	Average mass of oil on sea surface (tonnes)	119,721
	Maximum area coverage of emulsified oil (>0.04 µm) on the sea surface (km²)	275,900
	Time of occurrence for maximum area coverage of emulsified oil (>0.04 µm thickness) on the sea surface) (days)	108
	Average area coverage of emulsified oil (>0.04 µm) on the sea surface (km²)	39,157
	Maximum area coverage of thick emulsified oil (>100 µm) on the sea surface (km²)	1,791
	Time of occurrence for maximum area coverage of thick emulsified oil (>100 µm thickness) on the sea surface) (days)	46
	Average area coverage of thick emulsified oil (>100 µm) on the sea surface (km²)	568
	Max water content of surface oil (%)	80
	Average Mean Viscosity of Surface Oil (cP)	18,653
	Maximum Max Viscosity of Surface Oil (cP)	40,620

Table 4.7. Percentage of total oil released by model compartment at the end of simulation for the Ephesus Well oil spill scenario (Source: Table 7.2 in Stantec 2022).

Model Compartment	Percentage (%) of Total Oil Released at end of Simulation
Surface	0.0185
Atmosphere	31.0
Water Column (Dispersed and Dissolved)	32.4
Shoreline	0.0041
Biodegraded	34.5
Outside Model Domain and In the Sediment	2.0
Total	**100.0**

4.3.3 Spill Trajectories

This section summarizes the modelled sea surface and shoreline oil footprints and water column hydrocarbon concentrations for the unmitigated Ephesus Well oil spill scenario. This information serves as a guide upon which to base anticipated oil spill trajectories and direct optimal responses in the event of an actual spill, including accounting for the potential available temporal window(s) within which necessary response equipment could be sourced and transported to appropriate response locations.

The oil mass balance shown in Figure 4.8 is a mass balance of the mass of “oil” in each compartment. However, processes such as emulsification and changing oil viscosity are considered through algorithms incorporated within the model and can be exported as time series charts and maps

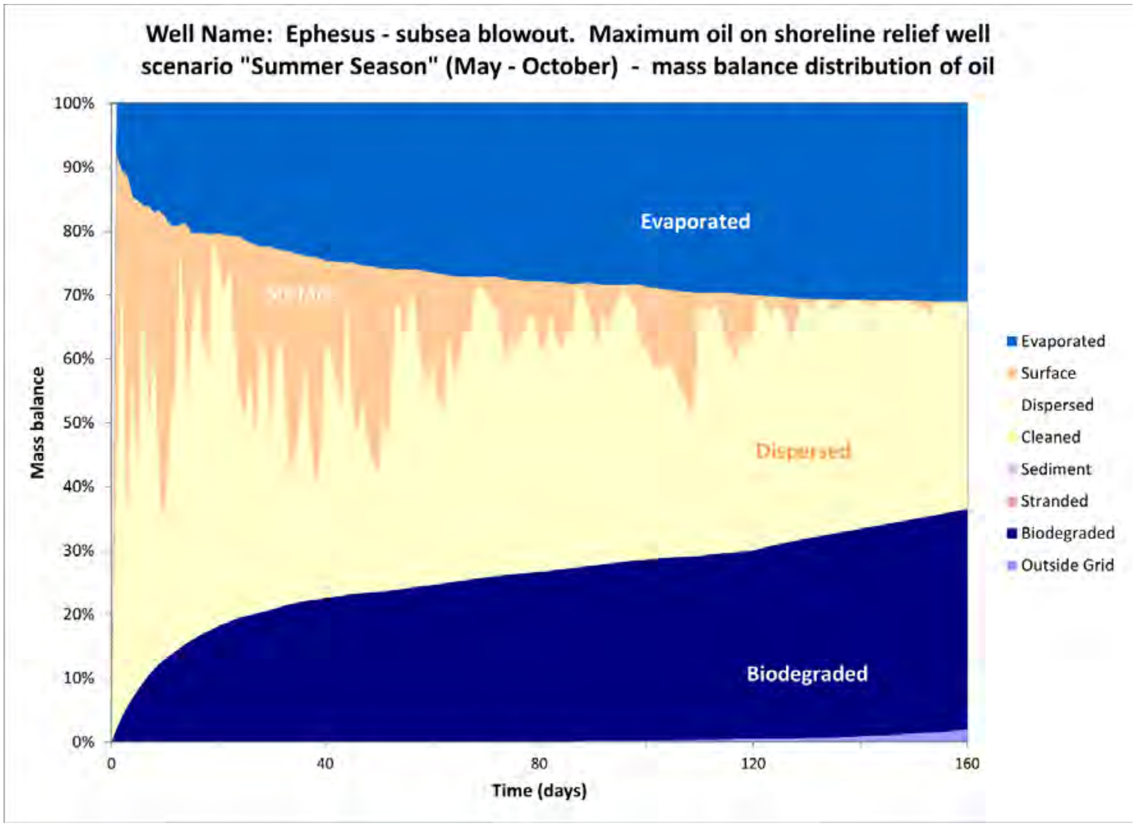
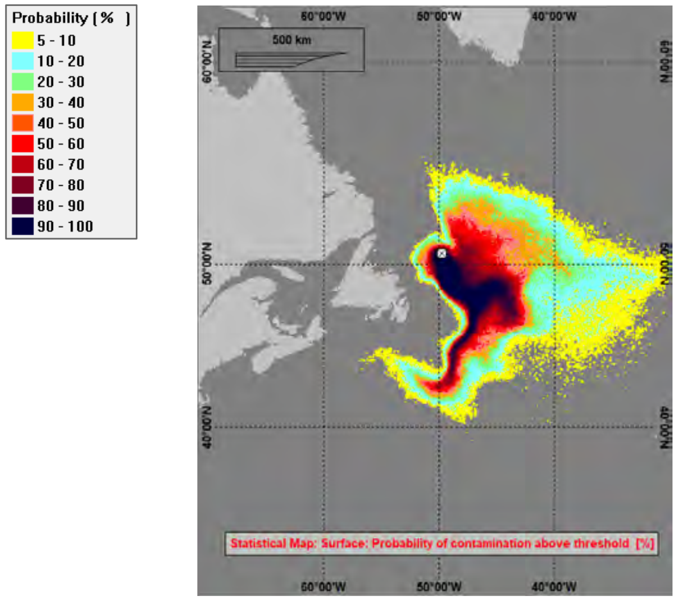


Figure 4.8. Mass balance distribution of oil over time for the Ephesus Well oil spill scenario (Source: Figure 7.1 in Stantec 2022).

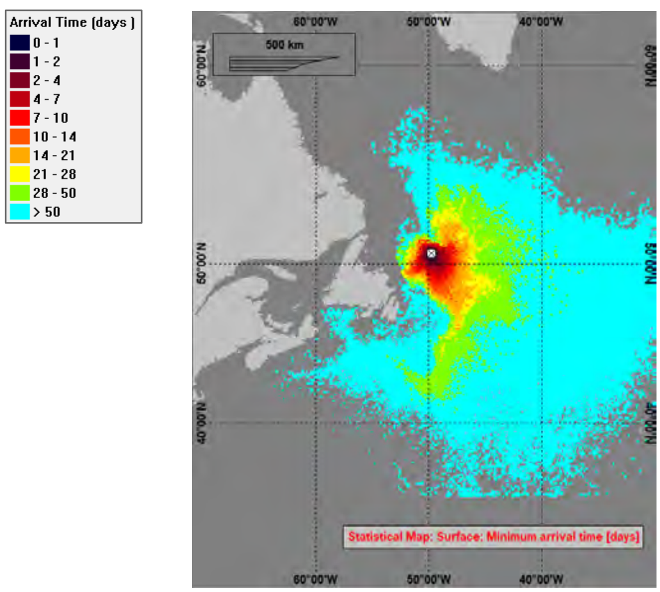
4.3.3.1 Socioeconomic Thresholds – Sea Surface Footprints

The spill trajectory for sea surface emulsified oil thicknesses exceeding the 0.04 µm threshold was predicted to mainly extend south and southeast of the Ephesus Well site and, to a lesser extent, northeast and east of the spill location (Figure 4.9). It was anticipated that it would take at least 2–7 days for oil exceeding this threshold to reach the surrounding area beyond the immediate vicinity of the Ephesus Well and over 50 days to spread throughout the larger RAA (Figure 4.10). Surface oil exceeding the threshold thickness would be expected to occur at and east/southeast of the Ephesus Well site for over one month, with maximum exposure time otherwise decreasing with increasing distance from the spill site (Figure 4.11). Surface emulsion thickness would likely exceed 200 µm at the immediate spill site and range from 50-200 µm in the surrounding area; surface emulsions would otherwise range from “metallic” (5-50 µm) to “sheen” (0.04–0.3 µm) throughout most of the probable affected areas within the RAA (Figure 4.12).



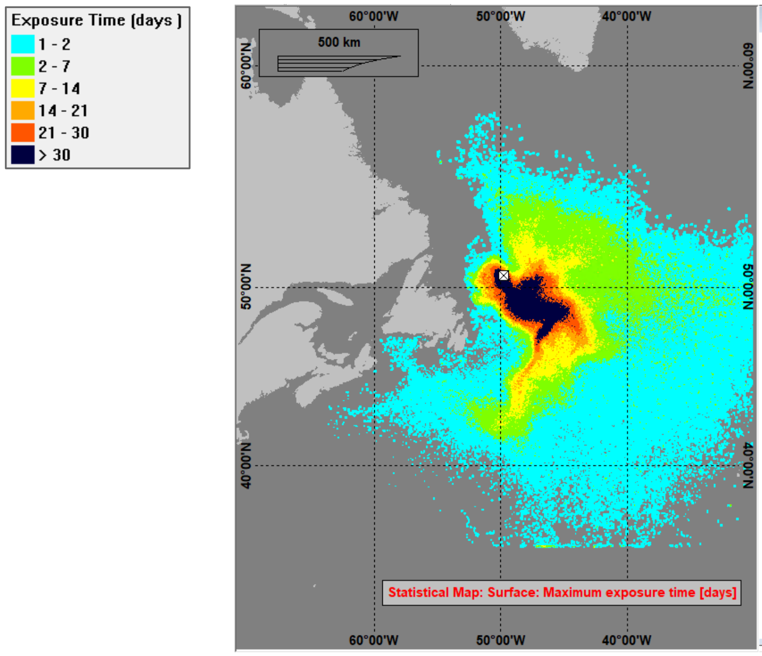
Note: Maps show the probability of sea surface emulsified oil thicknesses exceeding the 0.04 µm thickness threshold (Appearance: BAOAC "Sheen") for probabilities >1%.

Figure 4.9. Surface footprint for the probability (%) of contamination above threshold (0.04 µm thickness) for the Ephesus Well oil spill scenario (Source: Figure 6.1 in Stantec 2022).



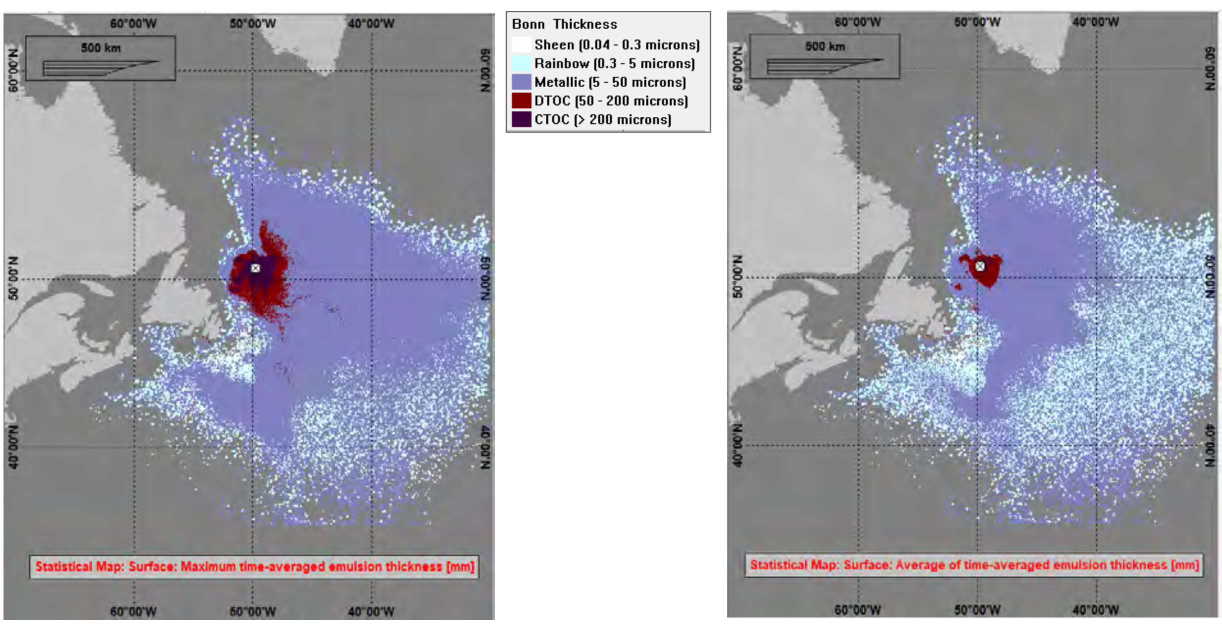
Note: Minimum travel time before emulsified oil thicknesses on the sea surface exceed the 0.04 µm thickness threshold (Appearance: BAOAC "Sheen"). No probability threshold was applied due to limitations with the OSCAR model.

Figure 4.10. Surface footprint for the minimum arrival time (days) for the Ephesus Well oil spill scenario (Source: Figure 6.2 in Stantec 2022).



Note: Maximum exposure time for emulsified oil thicknesses on the sea surface to exceed the 0.04 µm thickness threshold (Appearance: BAOAC "Sheen"). No probability threshold applied due to limitations with the OSCAR model.

Figure 4.11. Surface footprint for the maximum exposure time (days) for the Ephesus Well oil spill scenario (Source: Figure 6.3 in Stantec 2022).

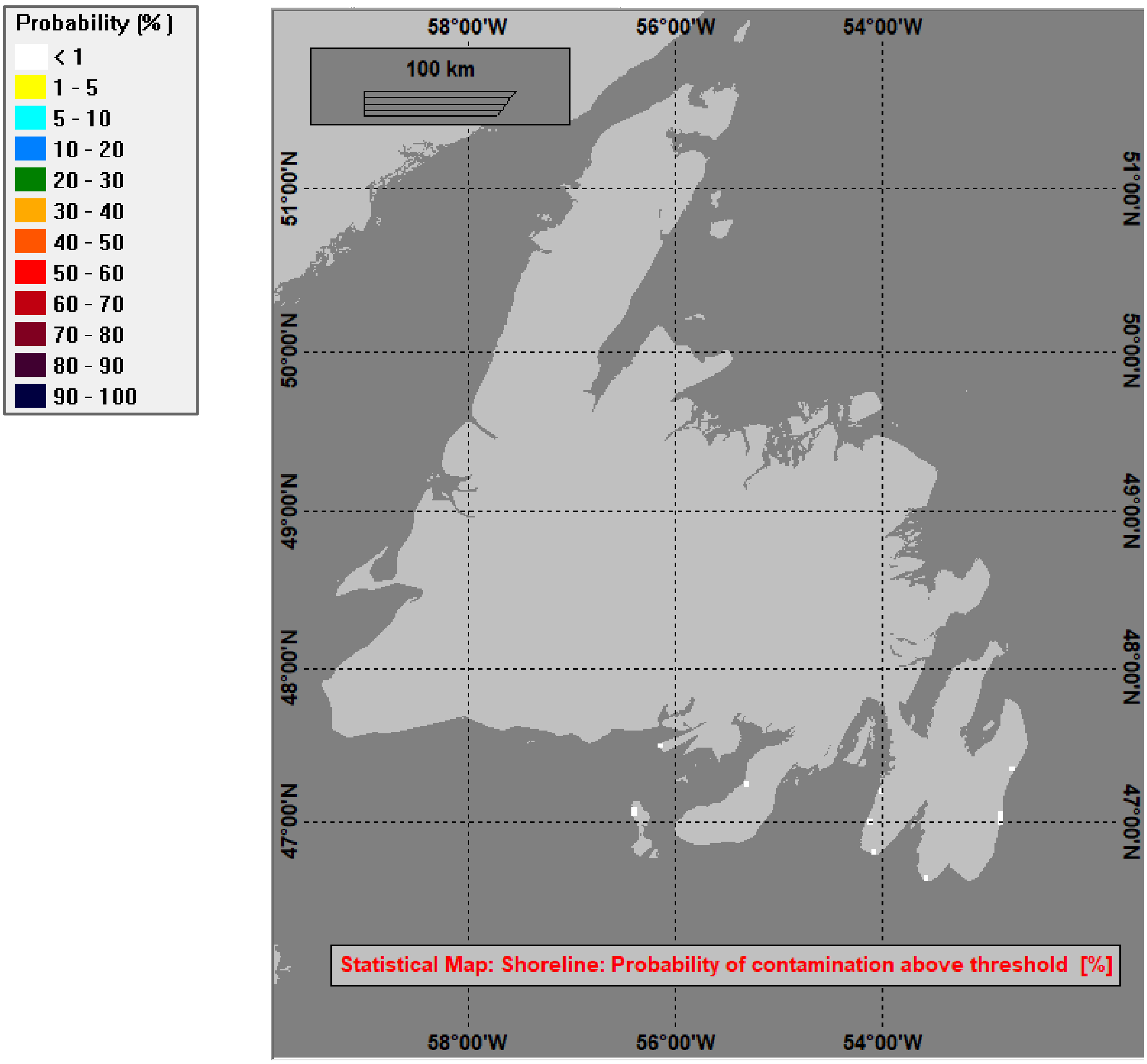


Note: 0.04 µm thickness threshold applied (Appearance: BAOAC "Sheen"). No probability threshold applied due to limitations with the OSCAR model.

Figure 4.12. Surface footprint for the maximum (left) and average (right) time-averaged emulsion thickness (µm) for the Ephesus Well oil spill scenario (Source: Figures 6.4-6.5 in Stantec 2022).

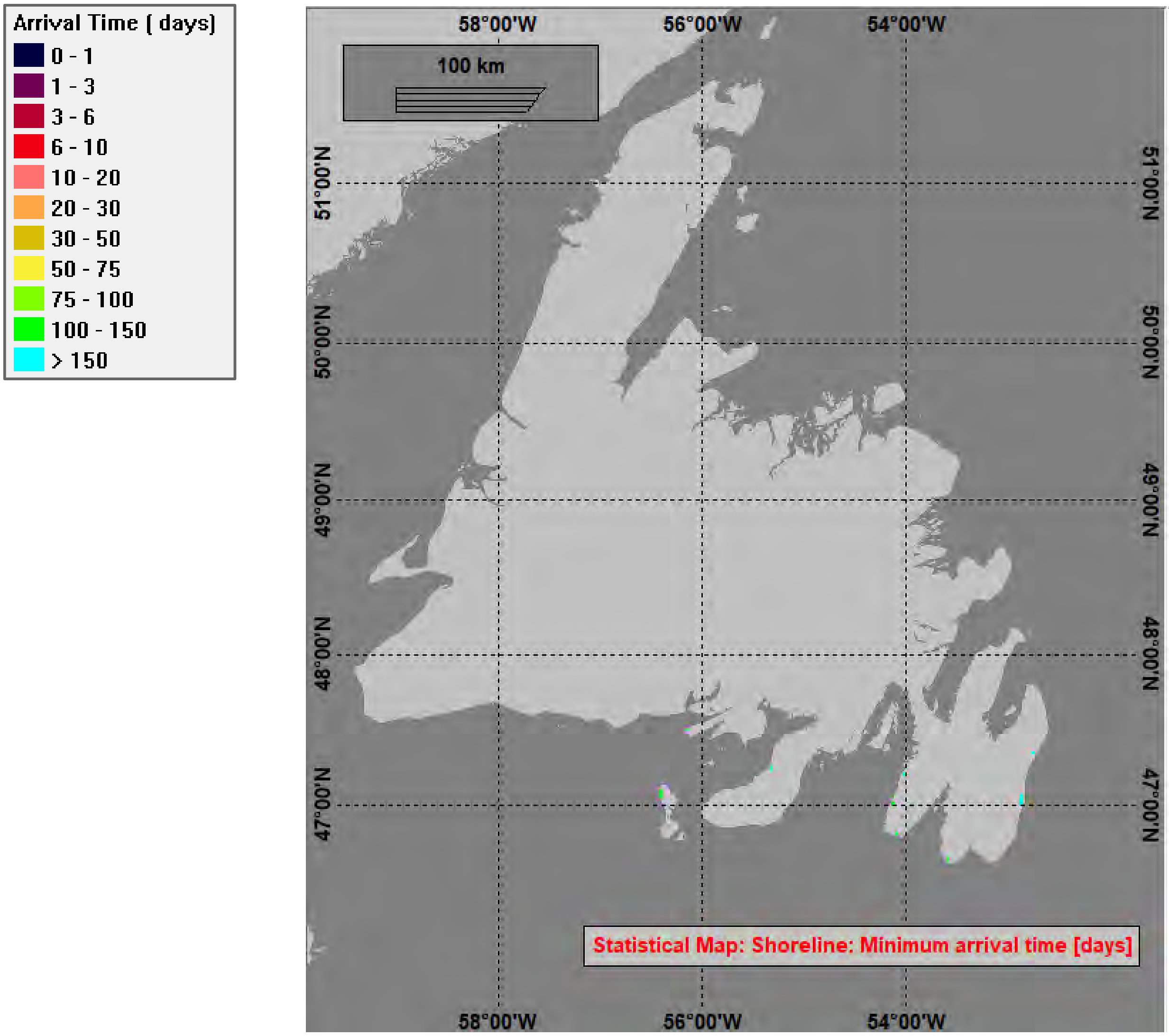
4.3.3.2 Socioeconomic Thresholds – Shoreline Contacts

Modelling indicated there would be minimal shoreline contact from a worst-case scenario oil spill at the Ephesus Well and a low probability (<1%) that the contact would exceed the 0.0019 tonnes/km minimum threshold for "film/sheen" (0.001-0.01 mm) oiling (Figure 4.13). The earliest probable arrival time of oil to reach the shore within the RAA would be 112 days (see Figure 4.14 below) and the maximum accumulated emulsion thickness would be expected to range from "film/sheen" to "heavy oiling" (>10 mm); most shore contact sites should they occur would likely have a maximum accumulated thickness of "moderate oiling" (1–10 mm) (Figure 4.15).



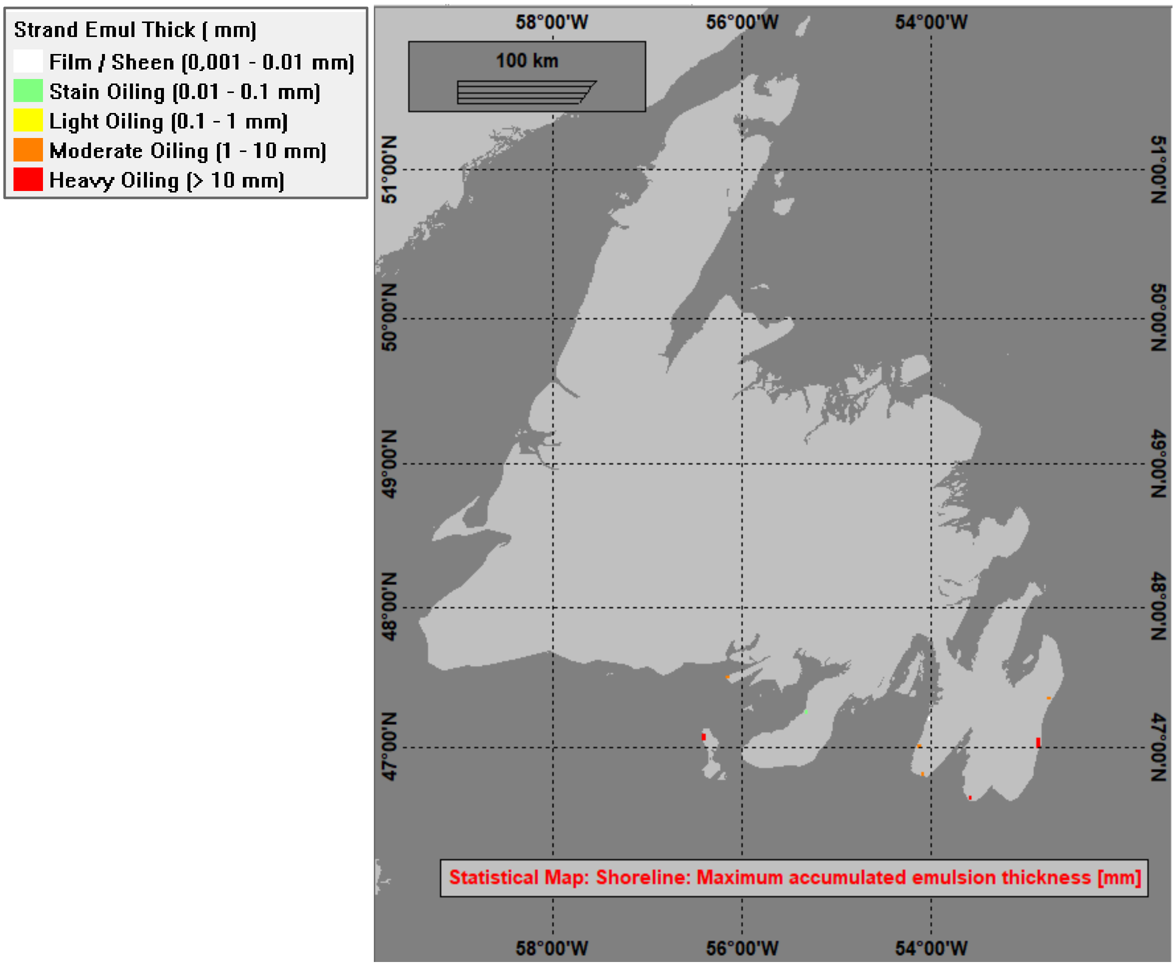
Note: Probability for shoreline emulsion mass exceeding the 0.0019 tonnes/km (or 0.001 L/m^2 = 1 µm) minimum threshold for "Film/Sheen" oiling.

Figure 4.13. Shoreline footprint for the probability (%) of contamination above threshold (for film/sheen) for the Ephesus Well oil spill scenario (Source: Figure 6.6 in Stantec 2022).



Note: Minimum arrival time for shoreline emulsion mass exceeding the 0.0019 tonnes/km minimum threshold for “Film/Sheen” oiling.

Figure 4.14. Shoreline footprint for the minimum arrival time (days) for the Ephesus Well oil spill scenario (Source: Figure 6.7 in Stantec 2022).



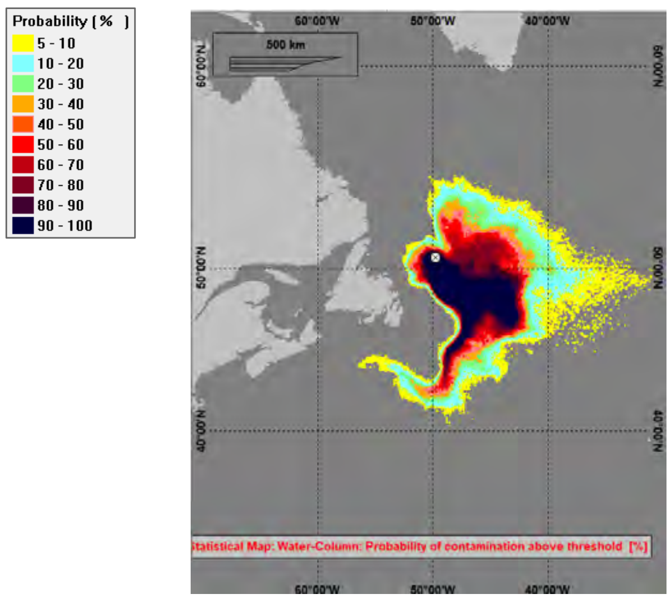
Note: Maximum time-averaged thickness of emulsified oil on the shoreline exceeding the 0.0019 tonnes/km minimum threshold for "Film/Sheen" oiling.

Figure 4.15. Shoreline footprint for the maximum accumulated emulsion thickness (mm) for the Ephesus Well oil spill scenario (Source: Figure 6.8 in Stantec 2022).

4.3.3.3 Water Column Concentrations – Environmental (Sublethal) Thresholds

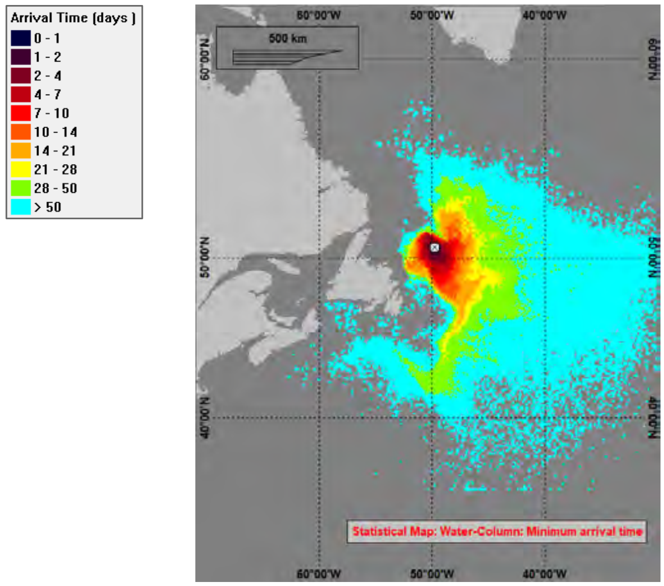
Oil in the water column (dispersed and dissolved) exceeding the 58-ppb threshold would be expected to follow the same trajectory as sea surface emulsified oil (i.e., mainly south and southeast from the Ephesus Well with a lower probability of extending northeast and east) (Figure 4.16). Water column concentrations above the threshold were also anticipated to exhibit the same general minimum arrival times (i.e., 2–7 days to reach the surrounding area and up to >50 days to potentially reach affected locations farther from the well site) (Figure 4.17) and maximum exposure times (i.e., >30 days within the regions most likely to be exposed to above-threshold concentrations, decreasing to 1-2 days with increasing distance from the Ephesus Well location) (Figure 4.18). The maximum time-averaged total and dissolved concentrations in the water column would likely range from 1-10 ppm nearest the spill site to 0.058-0.1 ppm (total) and 0.01-0.1 ppm (dissolved) farther from the Ephesus Well; however, the areal footprint for the dissolved concentration would be expected to be considerably more restricted to the Ephesus Well location compared to the total concentration (Figures 4.19-4.20).

Concentrations of dissolved and total hydrocarbons are predicted to be highest around the release site and dissipate as the oil moves away and disperses within the water column. While the highest concentrations of THC are predicted near the release site at the plume trap height the majority of the predicted THC concentrations are within tens of meters of the surface. This is due to the majority of the predicted THC being the result of entrained oil from wind-induced surface breaking waves. Vertical cross sections through the water column at the WO release site showed that the subsea probability of oil exceeding the 58 ppb THC threshold is limited to a maximum radius from the wellsite of circa 70 km for probabilities > 1%. (see EIS Appendix D, Stantec 2018).



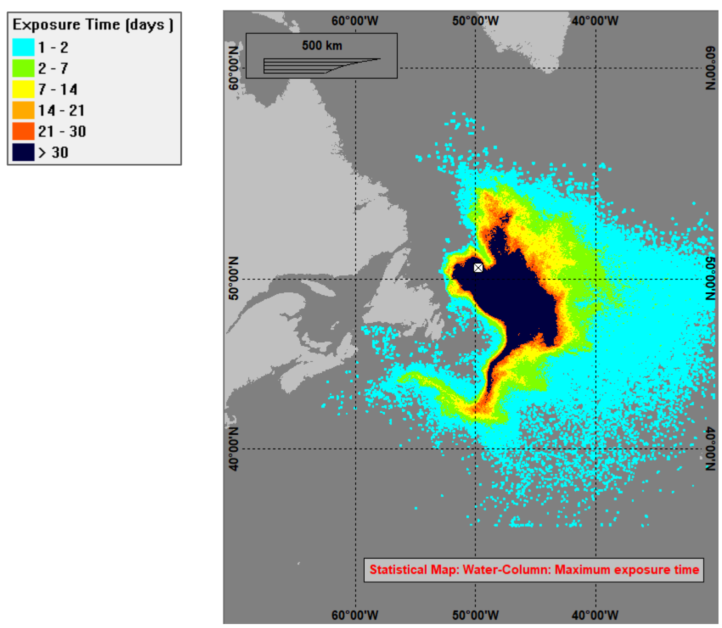
Note: Probability of the maximum time-averaged total oil concentration in the water column (dispersed and dissolved oil) exceeding the 58 ppb threshold for probabilities >1%.

Figure 4.16. Water column footprint for the probability (%) of contamination above threshold (58 ppb) for the Ephesus Well oil spill scenario (Source: Figure 6.12 in Stantec 2022).



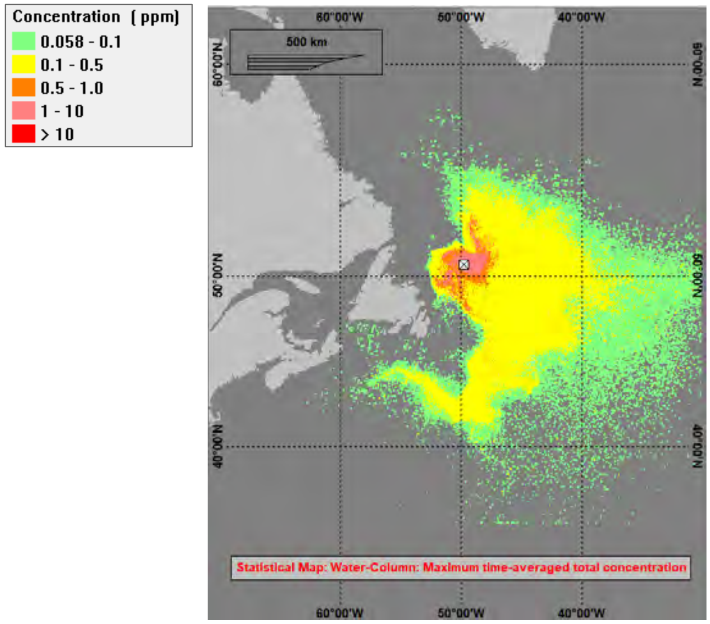
Note: Minimum travel time before maximum time-averaged total oil concentrations in the water column exceed the 58 ppb (dispersed and dissolved oil) concentration threshold. No probability threshold applied due to limitations with the OSCAR model.

Figure 4.17. Water column minimal arrival time for the Ephesus Well oil spill scenario (Source: Figure 6.13 in Stantec 2022).



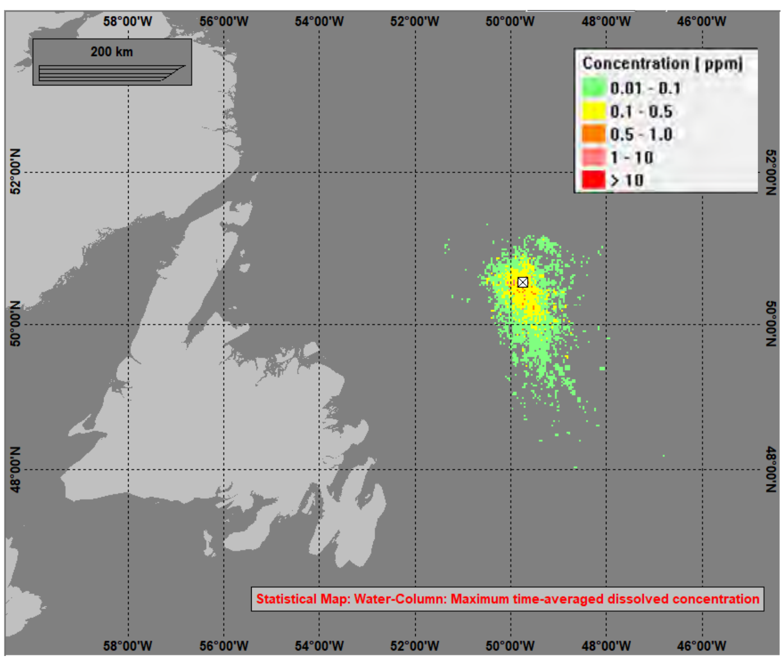
Note: Maximum exposure time for time-averaged total oil concentrations in the water column which exceed the 58 ppb (dispersed and dissolved oil) concentration threshold. No probability threshold applied due to limitations with the OSCAR model.

Figure 4.18. Water column maximum exposure time for the Ephesus Well oil spill scenario (Source: Figure 6.14 in Stantec 2022).



Note: Maximum time-averaged total oil concentrations in the water column which exceed the 58 ppb (dispersed and dissolved oil) concentration threshold. No probability threshold applied due to limitations with the OSCAR model.

Figure 4.19. Water column maximum time-averaged total concentration for the Ephesus Well oil spill scenario (Source: Figure 6.15 in Stantec 2022).



Note: Maximum time-averaged dissolved oil concentrations in the water column in excess of 10 ppb (58 ppb total hydrocarbon content [THC] for dispersed and dissolved oil threshold applied). No probability threshold applied due to limitations with the OSCAR model.

Figure 4.20. Water column maximum time-averaged dissolved concentration for the Ephesus Well oil spill scenario (Source: Figure 6.16 in Stantec 2022).

5 Risk-Based Assessment of Response Options

5.1 Risk Assessment Framework

Unlike the previous NEBA process, which required the creation of several risk matrices for a spill event, the newer SIMA process uses a single comparative risk matrix (Table 5.1 below), making it more user-friendly and easier to adapt to actual data during a real spill response. Response options are scored for each ROC category by evaluating the following elements (which are summarized in Section 5.1.1 below and detailed in IPIECA, API, and IOGP [2017]):

1) Potential Relative Impact Assessment;
2) Impact Modification Factor;
3) Relative Impact Mitigation Score; and
4) Total Impact Mitigation Score.

Using this scoring method, a qualitative predictive comparison for the mitigative potential of each response option compared to natural attenuation is possible and used to inform the decision-making process.

To modify the comparative risk matrix presented in this SIMA for a real-life spill response, potentially impacted ROCs (see Section 3.0) and viable response options (see Section 2.3) based on environmental conditions (see Section 2.2) would be integrated by calculating scores for each applicable ROC within relevant habitat types (e.g., shoreline [intertidal], sea surface, water column) in accordance with Table 3.1 above. Oil slick monitoring/modelling and consultations with local resource experts would determine which ROCs may be affected; viable response options would be identified based on advice from the NEEC Environmental Emergencies Science Table and response experts (e.g., ECRC, OSRL); and the resultant risk matrix scoring would serve as the basis for an expedited SIMA and the spill response decision-making process. Updated data collected throughout a prolonged spill response would be utilized to validate or modify the SIMA process as necessary to optimize ongoing response strategies and define response termination.

5.1.1 Comparative Risk Matrix Elements

5.1.1.1 Potential Relative Impact

For a real spill scenario, each resource category would be assigned a potential relative impact and associated numerical relative impact, ranging from none to high and 1 to 4, respectively (Table 5.2). The assigned potential relative impact values would be uniquely specified based on real-life spill, ROC, and environmental conditions and may not necessarily match those provided in this SIMA. The potential relative impact is considered a weighting factor and would be used to calculate the relative impact mitigation score for each response option ('A' in the equations indicated in the comparative risk matrix [see Table 5.1 below]). To assign potential relative impact, the portion of the resource that would be affected and length of recovery time must be estimated, including consideration of the spatial scale of each resource category. For potential relative impact, the probability of oil interacting with a ROC is not considered; rather, it is assumed that contact occurs and evaluates the intensity of effect oil contact may have for a ROC within a given resource category. Depending on factors such as distribution, population dynamics, and ability to recover, each resource would be considered as either "local" or "regional". The assigned potential relative impact value is ultimately subjective and would be based on determinations made by subject matter experts (e.g., NEEC Environmental Emergencies Science Table) using the most readily available data. The assigned weighting factor should serve as a reflection of resource protection priorities as identified during the expedited SIMA process based on actual spill conditions.

5.1.1.2 Impact Modification Factor

Each viable response option would be assessed to determine the level of impact it would have on each resource category compared to natural attenuation and assigned an impact modification factor ranging from -4 to +4 (Table 5.3). Score designation would include estimations of the proportion of the resource that would be impacted and necessary recovery time. An impact modification factor is indicated as 'B' in the equations within the comparative risk matrix (see Table 5.1 below), whereby each response option receives a unique subscript indicator. For example, on-water mechanical recovery may be indicated as B_2 in the risk matrix equations, and SSDI as B_5.

Table 5.1. Comparative risk matrix template (Source: based on Table 13 in Sponson 2020).

BP SIMA (15 October 2022) Ephesus Well EL 1145			**Response Option**											
			Natural Attenuation		Shoreline Protection & Recovery		On-water Mechanical Recovery		On-water In-situ Burning		Surface Dispersant Application		Subsea Dispersant Injection	
			Potential Relative Impact	Numerical Relative Impact	Impact Modification Factor	**Relative Impact Mitigation Score**	Impact Modification Factor	**Relative Impact Mitigation Score**	Impact Modification Factor	**Relative Impact Mitigation Score**	Impact Modification Factor	**Relative Impact Mitigation Score**	Impact Modification Factor	**Relative Impact Mitigation Score**
Resource Category		**Spatial Scale [a]**	-	A	B_1	$A \times B_1$	B_2	$A \times B_2$	B_3	$A \times B_3$	B_4	$A \times B_4$	B_5	$A \times B_5$
Shoreline (Intertidal)	*Special Areas and Species at Risk*													
	Marine Fish and Fish Habitat													
	Invertebrates and Benthic Communities													
	Marine and Migratory Birds													
	Marine Mammals and Sea Turtles													
	Shoreline Compartment Average													
Sea Surface	*Marine Fish and Fish Habitat [eggs/larvae]*													
	Marine and Migratory Birds													
	Marine Mammals and Sea Turtles													
	Sea Surface Compartment Average													
Water Column	*Special Areas and Species at Risk*													
	Marine Fish and Fish Habitat													
	Invertebrates and Benthic Communities													
	Marine and Migratory Birds [diving]													
	Marine Mammals and Sea Turtles													

BP SIMA (15 October 2022) Ephesus Well EL 1145			**Response Option**											
			Natural Attenuation		Shoreline Protection & Recovery		On-water Mechanical Recovery		On-water In-situ Burning		Surface Dispersant Application		Subsea Dispersant Injection	
			Potential Relative Impact	Numerical Relative Impact	Impact Modification Factor	**Relative Impact Mitigation Score**	Impact Modification Factor	**Relative Impact Mitigation Score**	Impact Modification Factor	**Relative Impact Mitigation Score**	Impact Modification Factor	**Relative Impact Mitigation Score**	Impact Modification Factor	**Relative Impact Mitigation Score**
Resource Category		**Spatial Scale [a]**	-	A	B_1	$A \times B_1$	B_2	$A \times B_2$	B_3	$A \times B_3$	B_4	$A \times B_4$	B_5	$A \times B_5$
	Water Column Compartment Average													
Seabed	*Special Areas and Species at Risk*													
	Marine Fish and Fish Habitat													
	Invertebrates and Benthic Communities													
	Seabed Compartment Average													
Socio-Economic	*Commercial Fisheries*													
	Other Anthropogenic Marine Activity													
	Socio-Economic Compartment Average													
Indigenous Peoples and Communities	*Indigenous Fisheries*													
Air	*Responder Health and Safety*													
	Total Impact Mitigation Score													
	Ranking													

[a] Spatial Scale: L = Local; R = Regional.

Notes:

'A' = Numerical score for Potential Relative Impact.

'B' = Impact Modification Factor; each response option has a unique subscript identifier (e.g., B_1, B_2).

Relative Impact Mitigation Score: Calculated by multiplying Potential Relative Impact by Impact Modification Factor (e.g., $A \times B_1$).

Table 5.2. Potential relative impact and associated numerical relative impact.

Potential Relative Impact	Numerical Relative Impact [a]
None	1
Low	2
Medium	3
High	4

[a] Numerical Relative Impact = 'A' in the equations indicated in the comparative risk matrix (see Table 5.1 above).

Table 5.3. Impact modification factor (left), and relative impact score range and associated colour code (right).

Impact Modification Factor		Relative Impact Mitigation	
Impact Modification Factor [a]	Description	Relative Impact Score Range	Colour Code
+4	Major mitigation of impact	+13 to +16	
+3	Moderate mitigation of impact	+9 to +12	
+2	Minor mitigation of impact	+5 to +8	
+1	Negligible mitigation of impact	+1 to +4	
0	No alteration of impact	0	
-1	Negligible additional impact	-4 to -1	
-2	Minor additional impact	-8 to -5	
-3	Moderate additional impact	-12 to -9	
-4	Major additional impact	-16 to -13	

[a] Impact Modification Factor = 'B' in the equations indicated in the comparative risk matrix (see Table 5.1 above).

Note: Ranges for Impact Modification Factor and Relative Impact Score based on IPIECA, API, and IOGP (2017) and recent SIMAs for the NL Offshore and Scotian Shelf regions (LGL 2020; Sponson 2017, 2020).

5.1.1.3 Relative Impact Mitigation Score

The relative impact mitigation score quantifies the overall effect a response option would have on the impact of an oil spill on the resource categories. To calculate the relative impact mitigation score for each resource category, the numerical potential relative impact score ('A') would be multiplied by the impact modification factor ('B') for each viable response option. The resultant score would then be colour-coded in accordance with the shade indicated in Table 5.3 above to serve as a visual aid.

For resource categories with multiple ROCs (which is the case for nearly all categories), a mean relative impact mitigation score would also be calculated and inserted into the appropriate cell of the comparative risk matrix (see Table 5.1 above).

5.1.1.4 Total Impact Mitigation Score

A total impact mitigation score is the combined additive total of the mean relative impact mitigation scores for each response option and serves as a qualitative predictor of the effectiveness of each response option to reduce the effects of an oil spill on ROCs. Once calculated, total impact mitigation scores for each response option would be entered into the second-last row of the comparative risk matrix (see Table 5.1 above). A total impact mitigation score would not be calculated for natural attenuation, as impact modification factors and impact mitigation scores are assigned based on a comparison of response methods to natural attenuation and, therefore, cannot be designated for natural attenuation itself.

The total impact mitigation scores would be ranked from first to last place for each response option, with the highest score receiving first place and the lowest receiving last place. This ranking would be entered into the last row of the comparative risk matrix (see Table 5.1 above) and serve as an objective indicator of the relative capability of each response option to mitigate oil spill impacts on and enhance the recovery of ROCs following a spill. IPIECA, API, and IOGP (2017) emphasises that total impact mitigation scores are meant to be compared relatively and not directly mathematically; in other words, a score twice as high for one response option than another does not indicate that one response option would be twice as effective as the other, but rather that it would be more optimal than the other.

5.2 Potential Effects of Natural Attenuation

An effects assessment detailing the risks for mortality, harm, or habitat quality for marine fish and fish habitat (inclusive of invertebrates), marine and migratory birds, marine mammals and sea turtles, special areas, Indigenous Peoples and Community Values, and commercial fisheries and other ocean users was completed for the EIS (see Section 15.5 in Stantec 2018; see also Section 8.0 in Stantec 2022). This section summarizes potential exposure pathways, toxicity, and the effects of natural attenuation (i.e., no mitigation) for ROCs for a subsea blowout oil spill originating in the Orphan Basin area.

5.2.1 Marine Fish and Fish Habitat

Potential risks for marine fish and fish habitats from oil spill exposure may include:

- Reduction of water/sediment quality;
- Altered primary productivity (note: plankton and zooplankton are included in this section as they are integral ecosystem components of fish habitat);
- Altered food web interactions; and
- Sub-lethal to lethal effects due to acute/chronic exposure.

Increased PAH concentrations at the sea surface, in the water column, or on the seabed may cause higher rates of mortality and developmental abnormalities and increased immunotoxicity and cardiotoxicity for fish eggs, larvae, and/or juveniles that are incapable of or have a limited capacity for moving away from an affected area (e.g., Langangen et al. 2017; Samuelsen et al. 2019; Honda and Suzuki 2020). Other toxicity concerns for marine fish and fish habitat include the carcinogenicity of PAHs, along with developmental toxicity, genotoxicity, immunotoxicity, oxidative stress, and endocrine disruption (Honda and Suzuki

2020). PAHs also demonstrate bioaccumulation within tissues of marine fishes (Honda and Suzuki 2020). The water-soluble fraction of petroleum has also been linked to immunosuppression in marine fish (Rezende et al. 2016).

Exposure to spilled oil from a subsea blowout would likely result in a temporary change in phytoplankton abundance and diversity, particularly if the blowout were to occur during a bloom. Some phytoplankton species are resistant to acute and/or chronic exposure to oil spills while others are more sensitive and experience declines in abundance (e.g., Buskey et al. 2016; Brussaard et al. 2016; Fritt-Rasmussen et al. 2018; Quigg et al. 2021). Some phytoplankton species can utilize petroleum hydrocarbons as a carbon source, particularly C10 to C22 n-alkanes (AMAP 2010), and may experience a temporary increase in primary production and biomass while the hydrocarbons are available as an energy source (e.g., Linden et al. 1979; Johansson et al. 1980; Tang et al. 2019; Quigg et al. 2021). There is some indication that the presence of crude oil may alter water chemical compositions and marine food web interactions such that phytoplankton growth and biomass increases are promoted (Ozhan et al. 2014). Zooplankton abundance and community species composition could also be affected, both due to direct oil exposure and secondarily through an increase/decrease in prey (phytoplankton) abundance or bioaccumulation of oil components in their prey. However, depending on the species and life stage in question, effects on zooplankton may be minimal if they are resistant to oil exposure and/or capable of active motion to avoid continual exposure. As noted above, various life stages of fish (egg to adult) could experience lethal or sub-lethal effects, including benthic species that utilize the seabed for various life stage/nursery functions should oil spill products become entrained into the sediment.

5.2.2 Invertebrates and Benthic Communities

Possible risks for invertebrates and benthic communities, including corals and sponges, from oil spill exposure may include:

- Reduction of water/sediment quality;
- Ingestion of oil droplets;
- Smothering;
- Altered food web interactions;
- Altered energy allocation;
- Increased stress or other sub-lethal effects; and
- Mortality.

Pelagic invertebrates may be exposed to spilled oil within the water column and could ingest small oil droplets (e.g., Lee et al. 2012). Benthic invertebrates may be directly impacted through contact with spilled oil from the subsea blowout itself or from oil that enters the water column from the blowout and sinks to the seabed, or indirectly through the consumption of contaminated prey, such as algae or sunken plankton (Szczybelski et al. 2016). Depending on species, feeding and swimming/drifting/burrowing behaviour, and species-specific sensitivities to oil, the effects of a subsea blowout on invertebrates would be variable. Amphipods (*Gammarus setosus*) were observed to experience decreased cellular energy allocation and increased energy consumption upon laboratory-based exposure to water-accommodated fraction of crude oil, while no changes were observed for the bivalve *Liocyma fluctuosa* (Olsen et al. 2007). Little is known regarding the impacts of oil spills on deep-sea corals (Ragnarsson et al. 2016) or sponges; however, they are considered more susceptible to smothering from oil compounds than mobile biota (Elmgren et al. 1983; DHNRDAT 2016) and their long lifespans, slow growth rates, and potentially lengthy recovery times could render them particularly vulnerable to oil spills. Exposure to spilled oil from a blowout may cause death or induce stress in corals, which could include tissue loss, excessive mucus production, or retracted polyps (Ragnarsson et al. 2016). Some deep-sea corals have been found to demonstrate increased growth rates to compensate for damage received from an oil spill, although this may occur at the cost of energy being diverted from other essential activities, such as reproduction (Girard et al. 2019). Conversely, some deep-water coral species seem to be resistant to the effects of an oil spill and their communities remain overall unchanged (Fisher et al. 2014).

5.2.3 Marine and Migratory Birds

Potential risks to marine and migratory birds from oil exposure may include:

- Sub-lethal to lethal toxicity (via ingestion);
- Physiological impairment;
- Organ damage;
- Reduced flight efficiency;
- Reduced reproductive success;
- Hypothermia; and
- Drowning.

Oil spills have a high potential to cause negative impacts on marine and migratory birds, particularly those that spend most of their time on the water, such as Thick-billed Murres (Irons et al. 2000; Wiese and Robertson 2004; Lieske et al. 2019; Gaston and Hipfner 2020). Spilled oil may coat or otherwise contaminate the plumage of marine and migratory birds, leading to hypothermia and drowning. Adults that become contaminated through foraging may transfer hydrocarbon contamination to their eggs or young upon return to their nests, which may be fatal. Marine and migratory birds are also at high risk of the inhalation of VOCs/aerosolized oil droplets and ingestion of petroleum products during preening or feeding, which can lead to lethal or sub-lethal toxicity.

Exposure to spilled oil from a subsea blowout causes increased mortality rates, physiological impairment (e.g., anemia), and organ damage for marine and migratory birds, along with reduced flight efficiency and reproductive success (Morandin and O’Hara 2016; Bursian et al. 2017; Maggini et al. 2017a,b,c; Burger 2018; Matcott et al. 2019). High population losses coupled with decreased reproductive success could result in chronic population declines (Esler et al. 2002; Wiese and Robertson 2004; Morandin and O’Hara 2016). If surface oil were to spread over a large area, a significant number of marine and migratory birds within the RAA could encounter and be impacted by the oil, particularly if hydrocarbons from a spill were to persist in important feeding or reproductive areas (e.g., Esler et al. 2010).

5.2.4 Marine Mammals and Sea Turtles

Potential risks to marine mammals and sea turtles from oil exposure may include:

- Habitat contamination;
- Organ damage;
- Increased cell and tissue abnormalities;
- Reduced locomotion;
- Disorientation;
- Altered thermoregulation; and
- Mortality, including by drowning.

Marine mammals and sea turtles may be exposed to oil when they surface, at which time surface oil could coat their body or clog the baleen plates of whales. Marine mammals and sea turtles are also at risk for the inhalation of VOCs/aerosolized oil droplets at the surface and the ingestion of PAHs or other oil components through the consumption of contaminated prey (Lee et al. 2015; NRDA 2016; Ruberg et al. 2021).

Exposure to oil from a subsea blowout that resulted in a marine mammal’s body becoming coated in oil may affect the animal’s ability to thermoregulate, which may lead to hyperthermia and mortality. Adult seals would be largely unaffected by a coating of oil, as pinnipeds rely on a subcutaneous layer of blubber for insulation (Geraci 1990). However, seal pups and polar bears that have not yet developed insulating blubber would be at risk (St. Aubin 1990; Kooyman et al. 1976 in Helm et al. 2015). If the baleen of whales were to become coated with oil from a subsea blowout, the animal would experience reduced filtration and correspondingly reduced feeding efficiency; however, this effect is considered reversible once the oil is removed (Geraci 1990). Oil exposure may also cause damage (e.g., lesions) to the brain, kidney, or liver of marine mammals, which can alter their behaviour and impact their ability to perform normal/essential functions (Geraci and Smith 1976; Spraker et al. 1994). Harbour seals observed immediately after oiling were lethargic and disoriented, possibly attributed to lesions found in the thalamus of their brains (Spraker et al. 1994). Hydrocarbons ingested via the consumption of contaminated food may be metabolized and excreted, but some become stored in blubber and other fat deposits within a marine mammal's body (Lee et al. 2015). Absorbed oil can cause organ lesions and disfunction, along with various cell and tissue abnormalities (Spraker et al. 1994; Ruberg et al. 2021; Takeshita et al. 2021). The inhalation of VOCs or aerosolized oil droplets by marine mammals at the surface may lead to inflamed airways, respiratory tissue damage, pneumonia, or lung disease (Schwacke et al. 2014; Takeshita et al. 2017). Chronic exposure to oil from a prolonged spill or spilled oil that persists in the environment can cause swollen nictitating membranes or permanent eye damage in seals, thereby reducing their foraging ability (St. Aubin 1990; Spraker et al. 1994; Levenson and Schusterman 1997) and potentially resulting in population-wide impacts, particularly if compounded by potential long-term effects of oil exposure on the reproductive capacity of adults (Helm et al. 2015). Elevated petroleum compounds within the environment caused by a subsea blowout have been shown to cause increased mortality in dolphins, including following the Deepwater Horizon spill (e.g., Venn-Watson et al. 2015; Schwacke et al. 2021). Chronic exposure to oil from a subsea blowout may also reduce the pregnancy success rates of dolphins (Lane et al. 2015; Kellar et al. 2017), possibly due to increased concentrations of genotoxic metals in their tissues (Wise et al. 2018).

Like marine mammals, sea turtles can experience a range of effects from oil exposure. Spilled oil from a subsea blowout could coat the body of sea turtles, causing movement restriction and stress and leading to exhaustion, which in turn can subject them to suboptimal environmental temperatures (e.g., prolonged sun exposure at the surface) and increase their vulnerability to predators (Stacy et al. 2017; NOAA 2021). Sea turtles may also experience toxic effects from the ingestion of spilled oil or oil-contaminated prey/water (NOAA 2021). Sea turtles have been observed to exhibit high site fidelity for established foraging grounds, despite the presence of spilled oil and chemical dispersants from a subsea blowout (Vander Zanden et al. 2016). It was estimated that 4900-7600 large juvenile and adult sea turtles and 56,000-166,000 small juveniles died as a result of the Deepwater Horizon spill (NOAA 2021). Further estimates for the Deepwater Horizon spill indicated that the mortality of sea turtles was 100% for those that were heavily oiled (due to physical effects), and 85% for moderately oiled, 50% for lightly oiled, and 25% for minimally oiled sea turtles (due to ingestion) (Mitchelmore et al. 2017). Because sea turtles have slow maturity rates and the sea turtle species in the region are at risk, their populations are highly susceptible to negative impacts from an oil spill and could require decades of restoration efforts to recover from significant losses (NOAA 2021). Sea turtles migrate to the RAA region to feed, not reproduce, and there are no nesting beaches within the RAA; therefore, shoreline oiling is less problematic for sea turtles in the RAA.

5.2.5 Socio-Economic and Indigenous Fisheries

Possible risks for the socio-economic (i.e., commercial fisheries, other anthropogenic marine users) and Indigenous fisheries ROCs from oil exposure may include:

- Perceived or actual reduction in the value or condition of fisheries products or other important marine resources (note: perceived negative public perception could occur due to exposure to oil and/or dispersant and/or dispersed oil);
- Differences in species presence/density;
- Reduced availability of or access to species/areas important for FSC or commercial/recreational purposes;
- Damage and/or reduced access to key economic shoreline assets (e.g., beaches, docks, water intakes);
- Reduced fishing effort; and
- Damage to fishing gear.

As summarized in Sections 5.2.1-5.2.4 above, exposure to oil from a subsea blowout can have a range of impacts on species and ecosystems that are important for socio-economic activities and Indigenous fisheries. Overall, most effects tend to be negative. The presence of substantial at- or near-surface oil could cause sufficient biota loss such that the availability of important resources could be decreased for fishers or other ocean users, and access to important fishing or other ocean use areas could be prevented due to health and safety risks to humans. If fishing gear were deployed in an area impacted by a subsea blowout, it could become damaged or otherwise fouled, resulting in loss of harvest, income, and/or culturally important resources for fishers and increased cost in gear maintenance and repair. If spilled oil from a subsea blowout were to reach the shore, it could similarly affect/displace coastal fishing and cultural activities and gear, along with aquaculture activities and operations and the health/mortality of farmed species. Regulatory bodies (e.g., DFO, NAFO) may enact closures of important socio-economic or Indigenous fisheries areas until the relevant resources are tested and qualify as safe for human consumption. In the event of a spill, regardless of whether there was an actual impact on fisheries or habitat resources, the public may perceive a reduction in the safety or quality of the resources, which may result in decreased market prices, tourism, and income for relevant stakeholders.

5.2.6 Special Areas and Species at Risk

The potential pathways, toxicity, and risks for special areas and species at risk are the same as those identified for the ROCs above (see Sections 5.2.1-5.2.5).

5.2.7 Responder Health and Safety

Potential risks to responder health and safety from oil exposure may include:

- Exposure to carcinogenic components of oil and VOCs;

- Sub-lethal toxic effects; and
- Injuries during mechanical recovery activities.

During spill response activities, responders may be exposed to carcinogenic or otherwise toxic VOC components of spilled oil via inhalation or dermal exposure. Inhalation may occur directly at a spill site or downwind from a spill site via the aerial transport of VOCs and formation of secondary pollutants, such as ozone (NASEM 2020). VOC exposure may also occur if oil-containing particles become aerosolised (NASEM 2020). Responders could be exposed to PAHs via ingestion if they consumed contaminated food during or after spill response activities, such as eating seafood that was exposed to spill components or food that was cross-contaminated (e.g., due to improper personal washing after cleaning oiled equipment/habitat) (NASEM 2020). Inhalation of gases and soot particulates (e.g., CO_2, CO, SO_2, and Nox, and up to 90% ultrafine soot particles [<1.0 μm], which can be deeply inhaled into human lungs and enter the blood stream) from smoke produced during on-water ISB is also possible (Faksness et al. 2022). Responders may also be at risk due to the inherent flammability and explosive properties of oil that reaches the surface.

If responders were exposed to oil components from a subsea blowout, the most concerning factor would be the carcinogenic components of crude oil, especially PAHs (known to cause human lung, bladder, and skin cancers) and benzene (type of VOC that causes human hematological cancer) (NASEM 2020). Sub-lethal toxicity effects for responders exposed to spilled oil may include acute or subacute dermal toxicity, headaches, irritated or damaged airways, and acute impacts on the central nervous system (Zock et al. 2014; NASEM 2020). Shore-based or offshore mechanical recovery methods can require a high level of responder labour and may occur in environments with difficult terrain and/or harsh weather. Depending on the recovery location and environmental conditions, the risk of physical injury, such as bodily strain, limb crush (particularly hands and feet), and slips, trips, and falls, can be high. The inhalation of ultrafine soot particulates from smoke produced during on-water ISB operations may result in the ultrafine particulates entering the blood stream from the lungs and potentially causing organ damage, including to the respiratory and cardiovascular system (Faksness et al. 2022). Gas inhalation from on-water ISB activities is generally not considered a serious threat to human health because their concentrations within the smoke are much lower than those necessary to become harmful (Faksness et al. 2022). Although gas concentrations may be within hazardous thresholds as they immediately leave the fire, they quickly drop below these thresholds within a very short distance from the fire (Fakness et al. 2022). Responders could be at risk of physical injury or mortality due to the flammability/explosiveness of surface oil should combustion occur.

5.3 Relative Risks: Risk Assessment for the Scenario Selected for this SIMA

The scenario selected for this SIMA is a subsea blowout during summer at the Ephesus Well in EL 1145 (now EL 1168; see Section 4.0 above). A comparative risk assessment matrix was completed for this scenario (Table 5.4), the scoring rationale for which is summarized in Sections 5.3.1-5.3.6 below.

5.3.1 Natural Attenuation

Natural attenuation is summarized in Section 2.3.1 and is the baseline against which all other potential response options are weighed. For the modelled spill scenario, natural attenuation has an overall high (4) potential relative impact for the shoreline, sea surface, socio-economic, Indigenous peoples and communities, and air (i.e., responder health and safety) resource categories.

If oil were to reach the shoreline, it would pose a high risk for marine fish that use shoreline habitats for spawning, nursery grounds, feeding, or migration. Invertebrates that inhabit or otherwise utilize shoreline habitats would be at high risk for smothering or sub-lethal/lethal effects, particularly those that lack the ability to actively swim away from an oiled area, such as sessile species, eggs, or larval life stages. Marine and migratory birds would be at high risk for contamination, including foraging adults; adults and eggs/young within nests along the shore that could be exposed to oil during stormy weather that raised the water line above the normal high tide line (e.g., Spotted Sandpiper); and eggs/young in nests subject to cross-contamination from foraging adults acquiring oil on their plumage and returning to their nests. Special areas and marine species at risk that include organisms or habitat from either of the above ROCs would be similarly at high risk. Marine mammals and sea turtles were considered at medium risk, as sea turtles do not typically go ashore within the RAA (they migrate to the area to feed) and most marine mammal species within the RAA do not go ashore, with the main exception of seal species, particularly harbour seals.

Surface oil would pose a high risk for plankton and fish eggs and larvae that occupy the sea surface, and for marine and migratory birds and marine mammals and sea turtles as they interact with the surface to feed, breathe, or rest. Although modelling and the EIS suggests that residual environmental effects from a subsea blowout at the Ephesus Well would not significantly affect marine fish and fish habitat, it would be anticipated to significantly affect socio-economic activities and Indigenous peoples and communities (see Table 8.2 in Stantec 2022). Perceived or actual contamination of fisheries or FSC resources could negatively impact the relevant stakeholders and access to areas important for fisheries or other cultural reasons could be temporarily removed if regulators need to close the grounds until testing proves the resources therein are safe for human consumption/use. Access could similarly be temporarily blocked for areas used for other anthropogenic activities, such as tourism, research, or shipping. Responders engaged in monitoring activities could be at high risk of exposure, particularly the inhalation of VOCs.

Table 5.4. Comparative risk matrix for the modelled scenario of a subsea blowout during the summer at the Ephesus Well in EL 1145.

BP SIMA (21 October 2022) Ephesus Well EL 1145			Response Option											
			Natural Attenuation		Shoreline Protection & Recovery		On-water Mechanical Recovery		On-water In-situ Burning		Surface Dispersant Application		Subsea Dispersant Injection	
			Potential Relative Impact	Numerical Relative Impact	Impact Modification Factor	**Relative Impact Mitigation Score**	Impact Modification Factor	**Relative Impact Mitigation Score**	Impact Modification Factor	**Relative Impact Mitigation Score**	Impact Modification Factor	**Relative Impact Mitigation Score**	Impact Modification Factor	**Relative Impact Mitigation Score**
Resource Category		**Spatial Scale [a]**	-	A	B_1	$A \times B_1$	B_2	$A \times B_2$	B_3	$A \times B_3$	B_4	$A \times B_4$	B_5	$A \times B_5$
Shoreline (Intertidal)	*Special Areas and Species at Risk*	L	High	4	+2	8	+1	4	+1	4	+1	4	+2	8
	Marine Fish and Fish Habitat	R	High	4	+2	8	+1	4	+1	4	+1	4	+2	8
	Invertebrates and Benthic Communities	L	High	4	+2	8	+1	4	+1	4	+1	4	+2	8
	Marine and Migratory Birds	R	High	4	+2	8	+1	4	+1	4	+1	4	+2	8
	Marine Mammals and Sea Turtles	R	Med	3	+2	6	+1	3	+1	3	+1	3	+2	6
	Shoreline Compartment Average					8		4		4		4		8
Sea Surface	*Marine Fish and Fish Habitat [eggs/larvae]*	L	High	4	0	0	+1	4	+1	4	+3	12	+4	16
	Marine and Migratory Birds	R	High	4	0	0	+1	4	+1	4	+2	8	+4	16
	Marine Mammals and Sea Turtles	R	High	4	0	0	+2	8	+2	8	+3	12	+4	16
	Sea Surface Compartment Average					0		5		5		11		16
Water Column	*Special Areas and Species at Risk*	R	Low	2	0	0	+1	2	+1	2	-3	-6	-4	-8
	Marine Fish and Fish Habitat	R	Low	2	0	0	+1	2	+1	2	-3	-6	-4	-8
	Invertebrates and Benthic Communities	R	Low	2	0	0	+1	2	+1	2	-3	-6	-4	-8
	Marine and Migratory Birds [diving]	R	Low	2	0	0	+1	2	+1	2	-3	-6	-1	-2
	Marine Mammals and Sea Turtles	R	Low	2	0	0	+1	2	+1	2	-2	-4	-3	-6
	Water Column Compartment Average					**0**		**2**		**2**		**-6**		**-6**

BP SIMA (21 October 2022) Ephesus Well EL 1145			Response Option											
			Natural Attenuation		Shoreline Protection & Recovery		On-water Mechanical Recovery		On-water In-situ Burning		Surface Dispersant Application		Subsea Dispersant Injection	
			Potential Relative Impact	Numerical Relative Impact	Impact Modification Factor	**Relative Impact Mitigation Score**	Impact Modification Factor	**Relative Impact Mitigation Score**	Impact Modification Factor	**Relative Impact Mitigation Score**	Impact Modification Factor	**Relative Impact Mitigation Score**	Impact Modification Factor	**Relative Impact Mitigation Score**
Resource Category		**Spatial Scale [a]**	-	A	B_1	$A \times B_1$	B_2	$A \times B_2$	B_3	$A \times B_3$	B_4	$A \times B_4$	B_5	$A \times B_5$
Seabed	*Special Areas and Species at Risk*	L	Low	2	0	0	0	0	0	0	0	0	-2	-4
	Marine Fish and Fish Habitat	L	Low	2	0	0	0	0	0	0	0	0	-2	-4
	Invertebrates and Benthic Communities	L	Low	2	0	0	0	0	0	0	0	0	-3	-6
	Seabed Compartment Average					**0**		**0**		**0**		**0**		**-5**
Socio-Economic	*Commercial Fisheries*	R	High	4	+1	4	+1	4	+1	4	+2	8	+3	12
	Other Anthropogenic Marine Activity	R	High	4	+1	4	+1	4	+1	4	+2	8	+3	12
	Socio-Economic Compartment Average					**4**		**4**		**4**		**8**		**12**
Indigenous Peoples and Communities	*Indigenous Fisheries*	R	High	4	+1	4	+1	4	+1	4	+2	8	+3	12
Air	*Responder Health and Safety*	L	High	4	0	0	+1	4	0	0	+3	12	+4	16
	Total Impact Mitigation Score					**16**		**23**		**19**		**37**		**53**
	Ranking					**5th**		**3rd**		**4th**		**2nd**		**1st**

[a] Spatial Scale: L = Local; R = Regional.

Notes:

'A' = Numerical score for Potential Relative Impact.

'B' = Impact Modification Factor; each response option has a unique subscript identifier (e.g., B_1, B_2).

Relative Impact Mitigation Score: Calculated by multiplying Potential Relative Impact by Impact Modification Factor (e.g., $A \times B_1$).

Natural attenuation was considered to have a low (2) potential relative impact for the water column and seabed resource categories, as the concentration and volume of spilled oil that may be present in the water column or on/in the seabed substrate from a summer subsea blowout would be anticipated to be considerably lower than the other resource categories. Oil that disperses into the water column has an increased surface area-to-volume ratio and rate of dissolution, dilution, weathering, and microbial degradation relative to oil at the surface. As such, a corresponding relatively low amount of spilled oil would be likely to sink to the seabed. The seabed in the immediate vicinity of the spill site itself would have the highest probability of contacting spilled oil, with the likelihood of exposure decreasing with increasing distance from the spill source.

5.3.2 Shoreline Protection and Recovery

Shoreline protection and recovery is summarized in Section 2.3.2. Much of the Newfoundland shoreline within the RAA is remote and difficult to access by land (e.g., coarse sediment, seaside cliffs and limited road access) and features physically active seas that would prevent access by sea or the deployment and use of booms. If shoreline protection and recovery activities were necessary during the winter months, impacted shoreline areas may be inaccessible or deemed unsafe for responders due to the presence of snow and ice. However, where shoreline protection and recovery could be safety deployed, it could prevent oil from reaching the shoreline or the resuspension/entrainment of oil that did reach the shoreline (e.g., due to tides). Therefore, this response option was assigned a minor (+2) impact modification factor for ROCs within the shoreline resource category (i.e., special areas and species at risk, marine fish and fish habitat, invertebrates, marine and migratory birds, and marine mammals and sea turtles).

Given the limited scope of viable shoreline protection and recovery activities within the RAA relative to the spatial footprint of coastal areas that may be used for socio-economic activities or purposes important for Indigenous peoples and communities, it was assigned a negligible (+1) impact mitigation factor for these resource categories.

As shoreline protection and recovery only occurs in coastal areas, it would have no alteration of impact (0) for ROCs within the surface, water column, or benthos resource categories. The use of booms does not remove oil from the environment and the absorption of buoyant oil by sorbents is such a slow process that this response method would have no alteration of impact (0) for the air (i.e., responder health and safety) resource category.

5.3.3 On-Water Mechanical Recovery

On-water mechanical recovery is summarized in Section 2.3.3. Wave heights within the RAA often exceed the safe and efficient operating parameters for on-water mechanical recovery and visibility within the RAA is frequently reduced (e.g., by fog) during the summer months (particularly in June and July). Lengthy transit distance between shore and the Ephesus Well spill site for vessels and equipment capable of supporting high-capacity recovery operations would delay the start of large-scale recovery activities and reduce the temporal window for recovery before surface oil underwent too much weathering for recovery to be possible. While on-water mechanical recovery was operational, it would have a low oil encounter rate owing to the necessarily low skimmer-towing vessel speed. For these reasons along with the fact that marine fish and fish habitat (in this case, eggs and larvae at the surface) and marine and migratory birds are reasonably likely to experience negative effects from immediate, acute exposure to surface oil before it could be recovered, a negligible (+1) impact modification factor was assigned to these ROCs for the surface resource category. However, marine mammals and sea turtles were assigned a minor (+2) impact modification factor for the surface resource category, as their risks of injury from exposure while they surface to breathe, feed, or rest may more measurably decrease as a result of the permanent removal of spilled oil from the sea surface using this recovery option.

A negligible (+1) impact modification factor was assigned to ROCs within the shoreline, water column, socio-economic, Indigenous peoples and communities, and air (i.e., responder health and safety) resource categories, as even though this recovery method has a low oil encounter rate, it would nonetheless result in the permanent removal of oil from the surface, which would in turn cause a slight, albeit negligible, reduction in oil that could reach either of these resource categories.

Given the already low volume of spilled oil that would be anticipated to sink to the seabed, the relatively low volume of oil recovered from the sea surface would have no alteration of impact (0) to the benthos resource category.

5.3.4 On-water In-Situ Burning

On-water ISB was summarized in Section 2.3.4. The only method with regulatory approval in Canada for the collection of surface oil for burning is the use of fire booms. Therefore, on-water ISB is subject to the same limitations relevant to impact mitigation scoring as on-water mechanical recovery, including sea state, visibility, transit distance, and low oil encounter rate. As such, the rationale and assigned scoring are the same for on-water ISB as on-water mechanical recovery, except for the air (i.e., responder health and safety) resource category. The negligible mitigation of impact by the reduction in surface oil is offset by the slight increase in gases and airborne particulates into the air, resulting in a net impact modification factor of zero (0).

5.3.5 Surface Dispersant Application

Surface dispersant application is summarized in Section 2.3.5. For scoring purposes for this SIMA, it was assumed that dispersant application would occur using both aircraft and vessel(s). Due to lengthy transit distance between shore and the Ephesus Well spill site, it would be reasonable to expect up to one day for a dispersant aircraft to arrive on site and for it to be operational by day two post spill. Also, daily trip durations would be limited for aircraft due to fuel and allowable pilot flight time. Mobilization of dispersant application via vessel would also necessitate a delay in the start of operations. These initiation delays could reduce the temporal window within which surface dispersant application may be optimally employed before surface oil undergoes too much weathering. However, due to the high oil encounter and treatment rate achievable through the combined use of aircraft and vessel(s) and the RAA's frequent wave heights conducive to effective oil dispersal via surface dispersant application, a moderate (+3) impact mitigation factor was assigned for the marine fish and fish habitat and marine mammals and sea turtles ROCs for the sea surface resource category. Recent studies (e.g., Fiorello et al. 2016; Whitmer et al. 2018; Osborne et al. 2022) indicate that marine birds that spend most of their time at the surface and in the upper water column may experience reduced fitness or mortality, either from direct exposure to dispersant chemicals or dispersed oil or indirectly via exposure impacts on their prey or habitat quality. This potential for negative impacts on marine birds offsets the impact mitigation factor assigned to the other ROCs by one; therefore, a minor (+2) impact mitigation factor was assigned for the marine and migratory birds ROC for the sea surface resource category . With this response option, a large volume of surface oil could be quickly dispersed, thereby reducing risks of exposure for fish eggs and larvae, marine and migratory birds, and marine mammals and sea turtles at the surface. This surface dispersal should also reduce exposure risks for the air (i.e., responder health and safety) resource category by decreasing VOC concentrations and reducing the probability of exposure via inhalation, resulting in the assignation of a moderate (+3) impact mitigation factor.

The dispersion of surface oil into the upper ~10 m of the water column via the use of surface dispersants was assigned a minor (+2) impact modification factor for the socio-economic and Indigenous peoples and communities resource categories. The dispersal of surface oil should occur relatively quickly, thereby reducing the necessary duration of response activities and associated temporary closures of areas important for fishing, FSC, or other anthropogenic purposes.

It is anticipated that surface oil would undergo considerable weathering before reaching the shoreline. Therefore, the additional removal of surface oil offshore via surface dispersant application would be anticipated to result in a slight reduction of oil that could reach the shore compared to all the weathering (i.e., natural attenuation) it would be subject to between the spill site on the Orphan Basin and the shoreline. Therefore, a negligible (+1) impact modification factor was assigned for ROCs in the shoreline resource category. As the volume of oil that may reach the seabed is anticipated to be low, the dispersion of surface oil into the upper ~10 m of the water column was expected to have no alteration of impact on the benthos resource category and an impact modification factor of zero (0) was assigned. Recent literature suggests that oil transport to the seabed in the form of marine snow may increase with the application of dispersant, which may result in increased oil sedimentation (Brakstad et al. 2018; Bacosa et al. 2020). More studies are needed to evaluate this possibility (Brakstad et al.

2018) and, if applicable, accurately incorporate it into SIMA scoring and spill modelling.

Oil dispersed from the surface would be anticipated to enter the upper ~10 m of the water column, thereby increasing the risk of exposure for fish and fish habitat, invertebrates, and marine and migratory birds that inhabit or otherwise utilize (or occur within, in the case of habitat) this area, including sensitive areas and species at risk. Fishes and invertebrates would be at relatively high risk of ingestion of and exposure to dispersed oil and the dispersant itself, as would diving marine and migratory birds, which can be sensitive to even acute exposure to oil products. Therefore, a moderate (-3) additional impact modification factor was assigned to these ROCs for the water column resource category. Marine mammals and sea turtles would be similarly at risk of increased exposure; however, depending on species (e.g., deep divers, such as northern bottlenose whales), life stage (juvenile or adult), and activity (e.g., brief, intermittent surfacing to breathe), they could be anticipated to spend less time within the affected upper water column than fish or invertebrates that inhabit the area, thereby minimizing their potential for exposure. Therefore, a minor (-2) additional impact modification factor was assigned for this ROC for the water column resource category.

5.3.6 Subsea Dispersant Injection

SSDI was summarized in Section 2.3.6. This response method requires the lengthiest mobilization and deployment time (likely about two weeks for the Ephesus Well modelled spill) of all the response options and can be logistically complex, involving the use of at least two dedicated ROVs for equipment deployment and operational monitoring, a dispersant resupply vessel, possibly a dedicated monitoring vessel, and continuous, real-time monitoring of environmental conditions, particularly oxygen concentrations. However, this method effectively prevents or otherwise significantly decreases the volume of spilled oil from a subsea blowout reaching the surface (e.g., Socolofsky et al. 2022). This method also has the highest oil encounter rate of any of the response options and the greatest potential for the prevention of surface slicks. Given the considerable reduction of oil reaching the surface, a major (+4) impact modification factor was assigned for all ROCs for the surface resource category, as their risk of exposure would be significantly reduced. Similarly, a vast reduction of oil products reaching the surface (e.g., see Figure 8 in Socolofsky et al. 2022) would greatly reduce health and safety risks for responders, including decreased probability of inhalation of VOCs and other exposure pathways (e.g., dermal or respiratory irritation). Thus, a major (+4) impact mitigation factor was assigned for the air (i.e., responder health and safety) resource category.

Like surface dispersant application, the reduction of oil that reached the surface because of SSDI would be expected to decrease the necessary duration of response activities and associated temporary closures of areas important for fishing, FSC, or other anthropogenic purposes. Given the greater reduction of surface oil or surface slicks with SSDI relative to surface dispersant application, a moderate (+3) impact mitigation factor for the socio-economic and Indigenous peoples and communities resource categories was assigned.

As SSDI would have a higher oil treatment rate than surface dispersant application, it would be expected to result in a greater reduction in oil reaching the shoreline than the use of surface dispersants. However, given the long distance between the spill site and shoreline and considerable weathering oil would undergo in that distance, it would ultimately have a minor impact mitigation relative to natural attenuation. Also, as the probability of oil in exceedance of the 0.001 L/m^2 threshold reaching the shoreline within the RAA was modelled to be quite low (<1%), it is unlikely that any offshore treatment methods would result in a moderate or major mitigation of impact. Therefore, a minor (+2) impact mitigation factor was assigned to ROCs for the shoreline resource category.

Applying a dispersal method directly at the site of a subsea blowout at the Ephesus Well would result in the greatest increase of oil products in the water column relative to the other response options. All life stages of pelagic fishes and invertebrates, along with their habitat components (including special areas and species at risk) that occur in the water column would be subject to significantly more spilled oil and dispersant product compared to surface dispersant application. This would include fishes and invertebrates that regularly inhabit specific depth ranges and those that undergo diel vertical migrations between the upper and lower portions of the water column. Therefore, a major (-4) additional impact modification factor was assigned to these ROCs for the water column resource category. Marine mammals and sea turtles would be at similarly increased risk of exposure in the water column, particularly species that are deep divers (e.g., sperm whales) that could conceivably reach depths with the highest oil concentrations; however, as the concentration of oil at the surface would be considerably lower than in the water column and marine mammals and sea turtles would spend more time at the surface (e.g., surfacing to breathe) relative to pelagic fishes and invertebrates, a moderate (-3) additional impact modification factor was assigned to the marine mammal and sea turtle ROC for the water column resource category. It should be noted that although sea turtles would not dive as deeply as marine mammal species and, therefore, would not reach the areas of the water column with the highest oil/dispersant concentrations, the impact modification factor was conservatively assigned based on the capabilities of the marine mammal component of this ROC. Although some marine bird species within the RAA are deep divers, even the deepest divers (e.g., Thick-billed Murre with diving depths up to 210 m and Common Murre and Atlantic Puffin with depths up to 180 m [Warkentin et al. 2009]) would not reach the depths within the water column that would have the highest concentrations of spilled oil or dispersants. Diving depths of most bird species within the RAA are typically within approximately ≤10 m of the surface (e.g., Shirihai 2002; Warkentin et al. 2009; Ronconi et al. 2010). Although the general increase in oil within the water column would increase the risk of exposure, marine and migratory birds would nonetheless benefit from reduced oil at the surface due to SSDI. Therefore, a negligible (-1) additional impact modification factor was assigned to the marine and migratory birds ROC for the water column resource category.

Oil dispersed via SSDI would be anticipated to remain in the water column, where it would be subject to dilution in seawater and degradation via microbes, rather than sinking to the seabed (McFarlin et al. 2014, 2018 and Garneau et al. 2016 in Sponson 2020). A relatively low volume of oil products would be expected to sink to the seabed. However, corals and sponges in the immediate vicinity of the Ephesus Well blowout site would be at increased risk of exposure to dispersed oil plumes, with those species that are intolerant of oil or dispersant products more likely to experience sub-lethal to lethal effects than those located farther from the spill site. Although this increased risk would generally be expected to be limited to a relatively small area immediately around the blowout site, during the initial stage of a major subsea blowout, a mixture of dispersed oil and dispersant agent could extend beyond the immediate vicinity of the well head before response actions to stem oil flow and cease dispersant injection occur; therefore, a moderate (-3) additional impact modification factor was assigned to the invertebrates and benthic communities ROC for the seabed resource category to account for potentially affected individuals of sensitive coral and sponge. A minor (-2) additional impact modification factor was assigned to the special areas and species at risk and marine fish and fish habitat ROCs for the seabed resource category, since, overall, only a small portion of these ROCs may experience exposure and mobile species could leave the area.

6 SIMA Summary

Response priorities during an actual oil spill typically focus on the prevention or reduction of the exposure of shorelines to oil. However, modelling for a spill on the Orphan Basin indicates that there is a low probability (<1%) of oil reaching the shore within the RAA (BP 2018; Stantec 2022), owing to the far distance of the bp ELs from shore and spill trajectories. Instead, response priorities for this Program should include the removal and reduction of surface oil to the extent possible, as its presence would pose the greatest risk to ROCs within the RAA.

This SIMA was completed based on recent environmental, biological, and sociological (including commercial and Indigenous fisheries) data for the RAA and modelling specifically conducted for the worst-case spill scenario for the Program's first planned well, Ephesus (Stantec 2022). Environmental conditions within the RAA largely preclude the effective use of several spill response options that depend on low sea states and high visibility, such as on-water mechanical recover or on-water ISB. Similarly, Newfoundland shorelines can be difficult to access or pose physical hazards for responder health and safety, thereby reducing or negating the possibility of enacting some aspects of shoreline protection and recovery, depending on location and weather conditions. However, typical sea states within the RAA are conducive to the use of surface dispersant application and generally would not be problematic for SSDI operations, apart from a lengthy transit from shore to the Ephesus Well site. Sea state conditions within the RAA that exceed safe operating parameters of either dispersant method would likely result in surface oil dispersion and weathering via natural attenuation. The relative effectiveness of individual response options compared to natural attenuation during typical summer conditions within the RAA was reflected in the ranking scores of the risk assessment matrix (see Table 5.4), with the most optimal responses as follows: SSDI (54); surface dispersant application (38); on-water mechanical recovery (23); on-water ISB (19); and shoreline protection and recovery (16). As a reminder, the scoring is based on one spill scenario in one season with historical wind/wave data inputs and assumes that each spill response option could be utilized.

Ultimately, a combination of the response options considered in this SIMA would be optimal to reduce harm to and increase recovery for ROCs in the RAA. When conditions allow, on-water mechanical recovery and/or on-water ISB could be the first option(s) utilized, as they have the fastest mobilization times and result in the removal of oil from the environment. On-water mechanical recovery has a slightly higher allowable sea state for safe operations than on-water ISB, so it is the most likely viable option of the two for the RAA. Once regulatory approvals were provided, surface dispersant application could be the next temporally effective response option, followed by SSDI. If environmental conditions allow, on-water recovery options could continue while dispersant operations were underway, providing safe distances were maintained between activities. If oil were to reach the shoreline, modelling indicated the minimum arrival time would be approximately three months following the spill; therefore, where possible, the enactment of shoreline protection and recovery could be the last option to initiate. Depending on location and spill, environmental, and ROC-related conditions, a variety of response activities could occur concurrently at any given time. Response operations and their locations would be determined during daily planning sessions and would take into account updated data.

Although SSDI and surface dispersant applications would be the most effective at treating large quantities of spilled oil and reducing oil at the surface, which is the resource category of greatest concern for the Program, these response options do have the potential to result in increased risk of harm to ROCs in the water column and seabed resource categories, at least temporarily. Nonetheless, either of the dispersant response options would be more effective overall at treating an oil spill than either of the other methods and would result in oil dispersion occurring considerably faster than natural attenuation within the RAA. While natural attenuation is an option, lack of intervention will likely not be received well by the public.

Regardless of which response option or combination of response methods is/are utilized at a given moment for an actual oil spill, it is essential that effective monitoring is regularly conducted, both to aid and evaluate response effectiveness and to ensure the safety of responders. During the development of an expedited SIMA and throughout response operations, it is important to consult with and include information from spill and resource experts and account for input from stakeholders, including Indigenous peoples and communities, and utilize the latest available data for all applicable ROCs. This information would be used to modify expedited SIMAs as necessary, which in turn would support the decision-making process to ultimately reduce harm and promote recovery for ROCs in the RAA.

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