Spill Impact Mitigation Assessment (SIMA) for ExxonMobil Canada Ltd.'s Eastern Newfoundland Offshore Drilling Project, 2018-2030 – Update 2023

Prepared by

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Prepared for

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Table of Contents

Page

List of Figures

Page

List of Tables

Page

Acronyms and Abbreviations

ADDS	Airborne Dispersant Delivery System
API	American Petroleum Institute
bbl	Billion Barrels of [Petroleum] Liquid
bpd	Barrels per Day
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
CBD	Convention on Biological Diversity
CEWAF	Chemically Enhanced Water Accommodated Fraction
CFS	Climate Forecast System
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
cP	Centipoises
CWS	Canadian Wildlife Service
DFO	Fisheries and Oceans Canada
DOR	Dispersant-to-Oil Ratio
DWH	Deepwater Horizon
EA	Environmental Assessment
EBSA	Ecologically and Biologically Significant Area
ECCC	Environment and Climate Change Canada
ECRC	Eastern Canada Response Corporation
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
EPS	Extracellular Polymeric Substances
ESA	*Endangered Species Act*
ESRF	Environmental Studies Research Fund
EU	Environmental Unit
ExxonMobil	ExxonMobil Canada Ltd.
FAO	Food and Agriculture Organization
FSC	Food, Social, and Ceremonial
GB	Grand Bank
GDS	Global Dispersant Stockpile
HYCOM	Hybrid Coordinate Ocean Model
IBA	Important Bird Area
ICS	Incident Command System
IMP	Incident Management Team
IOGP	International Association of Oil & Gas Producers
IPIECA	International Petroleum Industry Environmental Conservation Association
ISB	In-situ Burning
LGL	LGL Limited
MBS	Migratory Bird Sanctuary
MPA	Marine Protected Area
MOSSFA	Marine Oil Snow Sedimentation and Flocculent Accumulation

NACES	North Atlantic Current and Evlanov Sea
NAFO	Northwest Atlantic Fisheries Organization
NCC	NunatuKavut Community Council
NCC	(Section 3.1.1, Special Areas) Nature Conservancy of Canada
NE	Northeast
NEB	National Energy Board
NEBA	Net Environmental Benefit Analysis
NEEC	National Environmental Emergencies Centre
NL	Newfoundland and Labrador
NMCA	National Marine Conservation Area
OSRL	Oil Spill Response Limited
OSRP	Oil Spill Response Plan
PAH	Polycyclic Aromatic Hydrocarbon
ppb	Parts Per Billion
PPE	Personal Protective Equipment
ppm	Parts Per Million
RMA	Representative Marine Area
RSA	Regional Study Area
ROC	Resource of Concern
ROV	Remotely Operated Vehicle
RV	Research Vessel
RWS	Region Without Studies
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
STB	Stock Tank Barrel
TPH	Total Petroleum Hydrocarbon
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States
VME	Vulnerable Marine Ecosystem
VOC	Volatile Organic Compound
WAF	Water Accommodated Fraction
WHS	World Heritage Site

1.0 Background, Overview, and Use of SIMA

This Spill Impact Mitigation Assessment (SIMA) update was prepared for the ExxonMobil Canada Ltd. (ExxonMobil) Eastern Newfoundland Offshore Drilling Project (2018-2030) (the Program) as part of the contingency planning process for exploration drilling in the northern Flemish Pass area in the Newfoundland and Labrador (NL) offshore. The SIMA process is a reference tool to support and guide optimal oil spill response decision making to diminish possible spill impacts and promote environmental recovery. To meet these objectives, the SIMA process:

- Directs spill response development;
- Helps spill response managers 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 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 2018a; see also ExxonMobil 2017]) would be on hand and accessible to ExxonMobil'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 basic summary of these topics mainly utilizing information included in a Program's EIS and Program-specific spill modelling reports. Although basic information was updated for this SIMA relative to the EIS, during a spill, an expedited SIMA would be completed using the most up-to-date environmental and socio-economic data that are readily available. This updated SIMA serves as an example and guide for conducting an expedited (incident specific) SIMA in real-time and includes a risk matrix that is meant to be modified as needed over the course of an entire spill response to account for ongoing real-time spill conditions and location. During a spill response, an expedited SIMA can be completed by:

1) Reviewing the contingency planning within this SIMA;
2) Updating relevant information specific for the spill location (e.g., currents, water depth and temperature);
3) Identifying viable response options based on real-time physical conditions (e.g., weather; see Section 2.0), ROCs (including anthropological activities, such as fisheries; 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 inform the selection of the optimal response option(s).

While selecting optimal spill response(s), the expedited SIMA would account for advice received from the National Environmental 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 ExxonMobil SIMA Update Project Background

During 2018/2019, a SIMA was prepared for ExxonMobil for exploratory drilling which focused on EL 1134 and EL 1135 (LGL 2019). ExxonMobil is currently planning to drill an exploratory well (Gale N-66) in EL 1167 commencing in June 2023. An EIS (Stantec 2018a) was completed for the Program and an EA for EL 1151 (IAAC 2020), which has since been consolidated with EL 1163 to become EL 1167. During 2019, RPS completed oil spill modelling for EL 1151 (RPS 2019). These documents, along with updated Program-specific information where available, serve as the basis for this updated SIMA for EL 1167. The Regional Study Area (RSA) and Project Area boundaries used in this updated SIMA are unchanged from the previous SIMA (LGL 2019). The 2019 EL 1151 oil spill modelling considered two unmitigated subsurface blowout continuous release scenarios (short release [21 days] and long release [116 days]) of Terra Nova crude oil in ~170-m water depth in the Flemish Pass during two seasons, summer (May-October) and winter (i.e., periods with ice cover; November-April). Under these circumstances, oil spill dynamics, trajectory, and fate modelling were conducted using the OILMAPDeep near-field model and SIMAP model (see Section 4.2). Deterministic analyses were provided for the "worst-case" trajectories for short and long release durations in RPS (2019), which were used for this updated SIMA (see Sections 4.0 and 5.0).

1.2 Overview of SIMA

During 2016, the SIMA process replaced the previously used Net Environmental Benefit Analysis (NEBA) process 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) provide a summary of SIMA methodology (Figure 1.1), and IPIECA and IOGP (2015a) outline 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 be at least some environmental impact due to an oil spill incident.

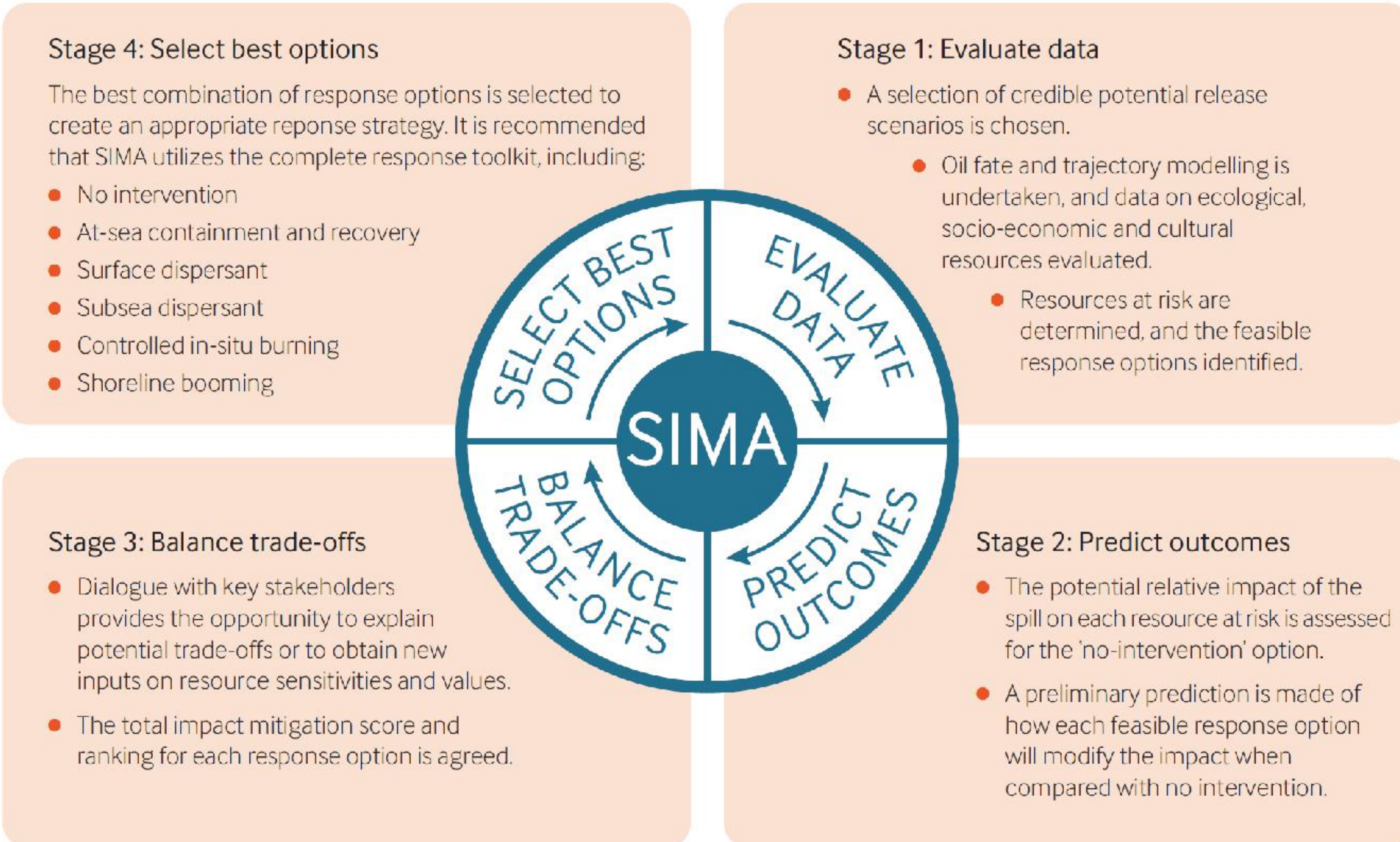


Figure 1.1. Summary of SIMA methodology (Source: Figure 1 in IPIECA, API, and IOGP 2017).

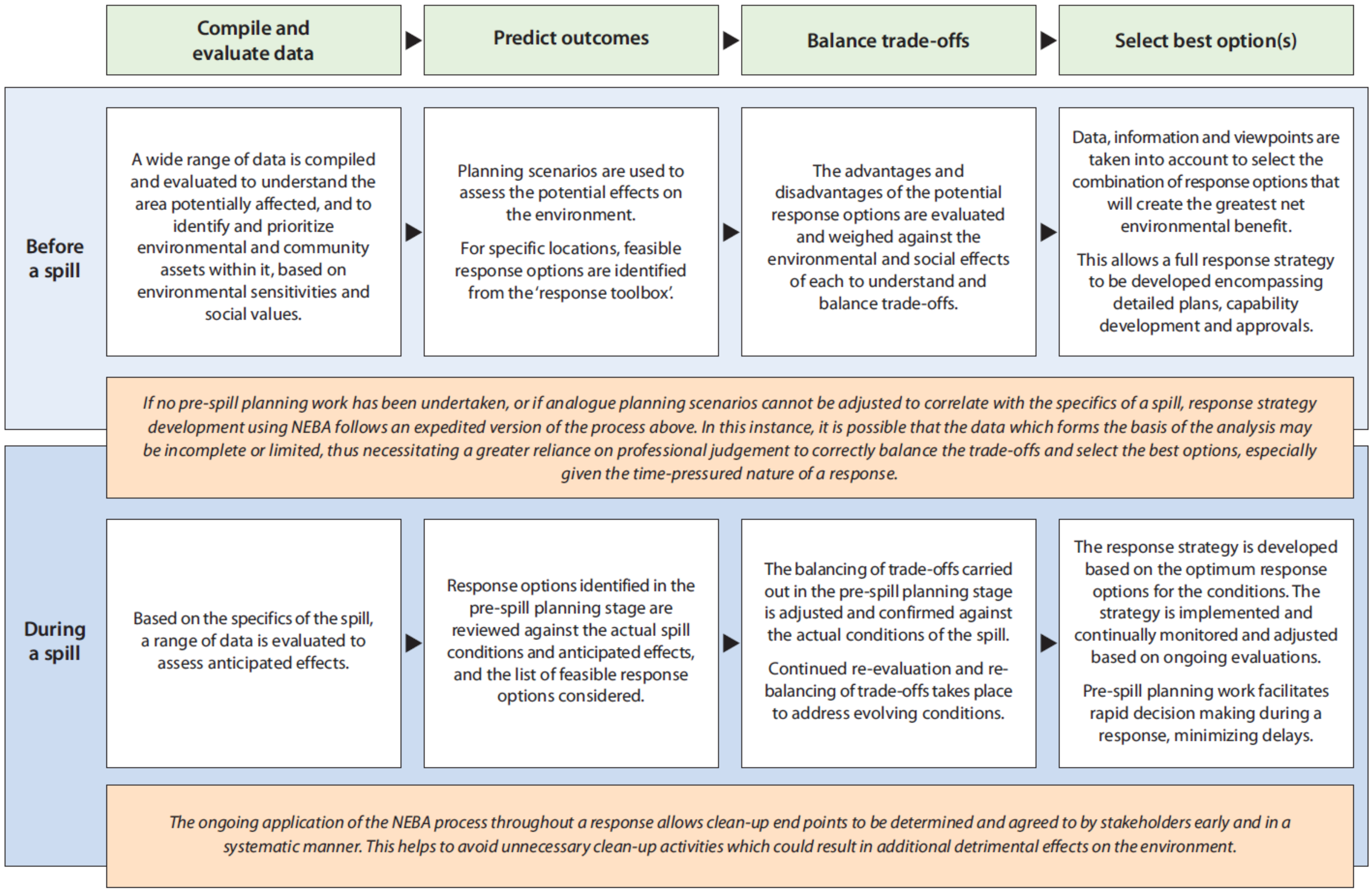


Figure 1.2. Summary of the SIMA response strategy (Note: this figure features the formerly used "NEBA" – this term can be replaced with "SIMA" for the purposes of this document; Source: Figure 1 in IPIECA and IOGP 2015a).

1.3 Using 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 updated SIMA), stakeholder participation (e.g., commercial fishers via the One Ocean Committee and Indigenous groups), practice drills for the creation of an expedited SIMA, and training an Incident Management Team (IMT) in selecting and combining optimal response options. Using SIMA during contingency planning can help guide and augment spill response efficiency for an actual oil spill event.

1.4 Using 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 RSA, such as those presented in the EIS (Stantec 2018a) and this updated SIMA (e.g., see Sections 2.0 and 3.0). Utilizing these data, this updated SIMA will be the base model for assessing and adaptively managing a real-time oil spill. As indicated in Section 1.0 and Figure 1.2 above, this updated 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 updated 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 updated SIMA.
3) Balance trade-offs: Re-evaluate the advantages and disadvantages of possible response options identified during contingency planning (Section 5.0 of this updated 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.

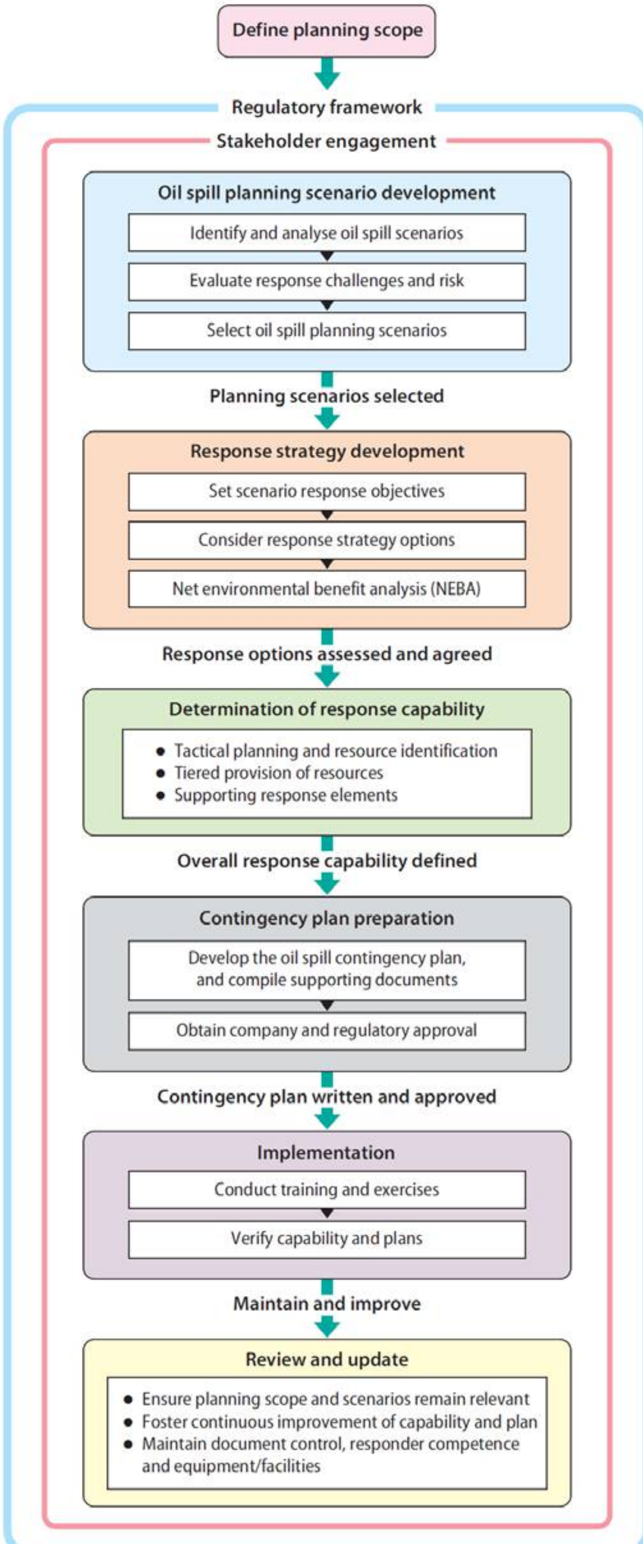


Figure 1.3. Summary of the oil spill contingency planning process (Note: this figure features the formerly used "NEBA" – this term can be replaced with "SIMA" for the purposes of this document; Source: Figure 7 in IPIECA and IOGP 2015a).

In Canada, spill response activities are managed via the Incident Command System (ICS) (ICS 2023). 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 2023). ExxonMobil'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 demonstrated due diligence for an oil spill response, showing that the appropriate steps and stakeholder input (including from commercial fishers [via the One Ocean Committee] and Indigenous groups) 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 (US) waters is provided in Appendix A of Slaughter et al. (2017) and Section 1.4.3 of Sponson (2020).

2.0 Project Location and Response Options

A geographical and physical summary of the RSA and/or Project Area 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 2018a), with some updates provided where applicable. The summaries provided in this updated 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 RSA (see Section 4.1 in Stantec 2018a; see also Sections 4.3.1 and 5.0 in ExxonMobil 2017).

2.1 Geographic Area of Interest

The geographical area of interest is described in Sections 2.3 and 4.1.1 in Stantec (2018a) (see also Section 4.3.1 in ExxonMobil 2017). The RSA 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 (i.e., from the western side of Placentia Bay to just west of Cape Freels on the northeast coast) (Figure 2.1). It extends approximately 1000 km east-west and 1500 km north-south. The Project Area, which is delineated into a Northern Section and Southern Section, includes the Flemish Pass and contains the various ELs offshore eastern Newfoundland where exploration drilling activities may be conducted as part of the Program. The Gale N-66 Well is located in EL 1167, in ~165 m water depth (at 47°5′50.52″N, 47°54′46.94″W) (Figure 2.2). A hypothetical subsea blowout at the Gale N-66 Well is the focus of risk-based assessment and response options for this updated SIMA (see Section 5.0).

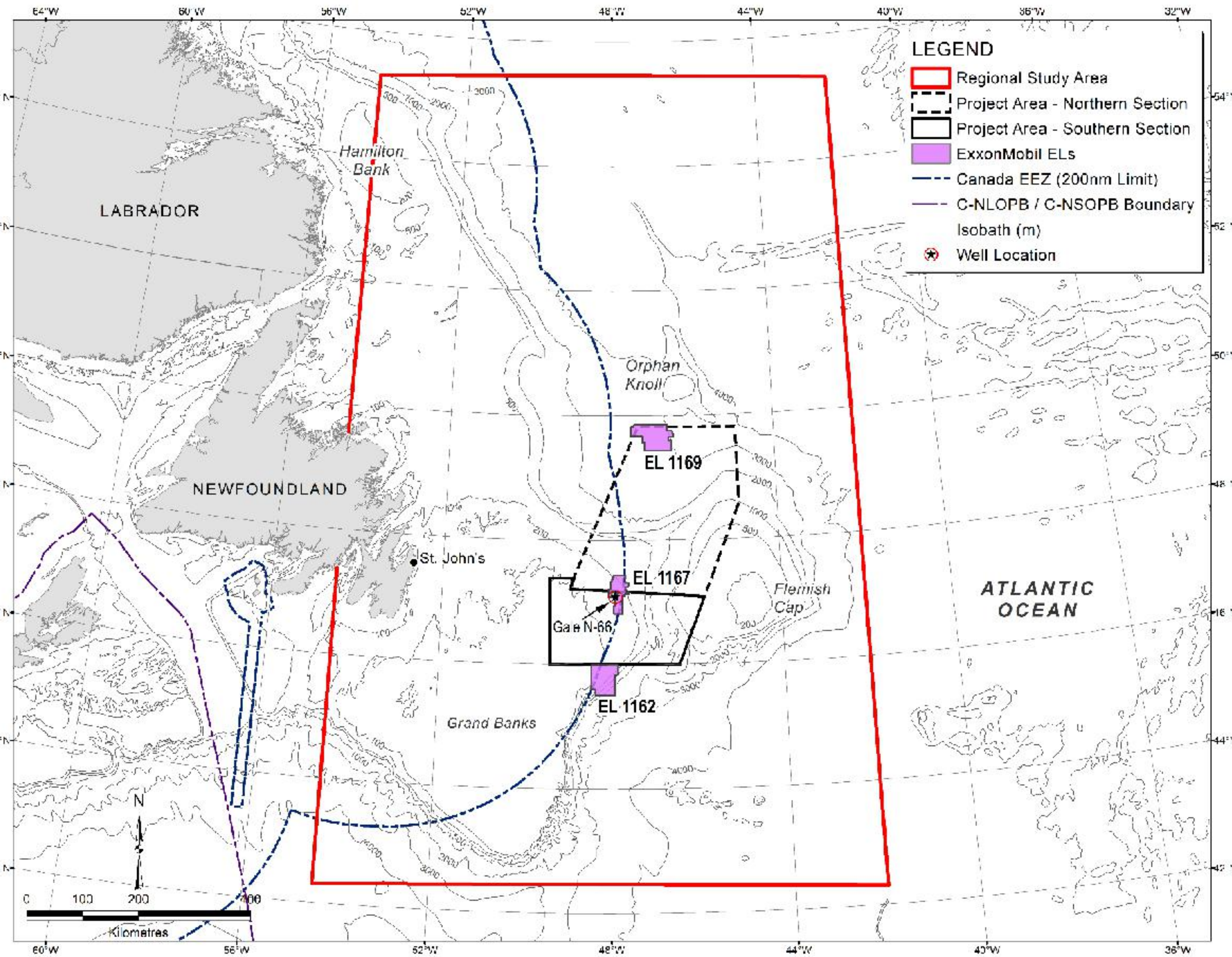


Figure 2.1. ExxonMobil RSA and Project Area.

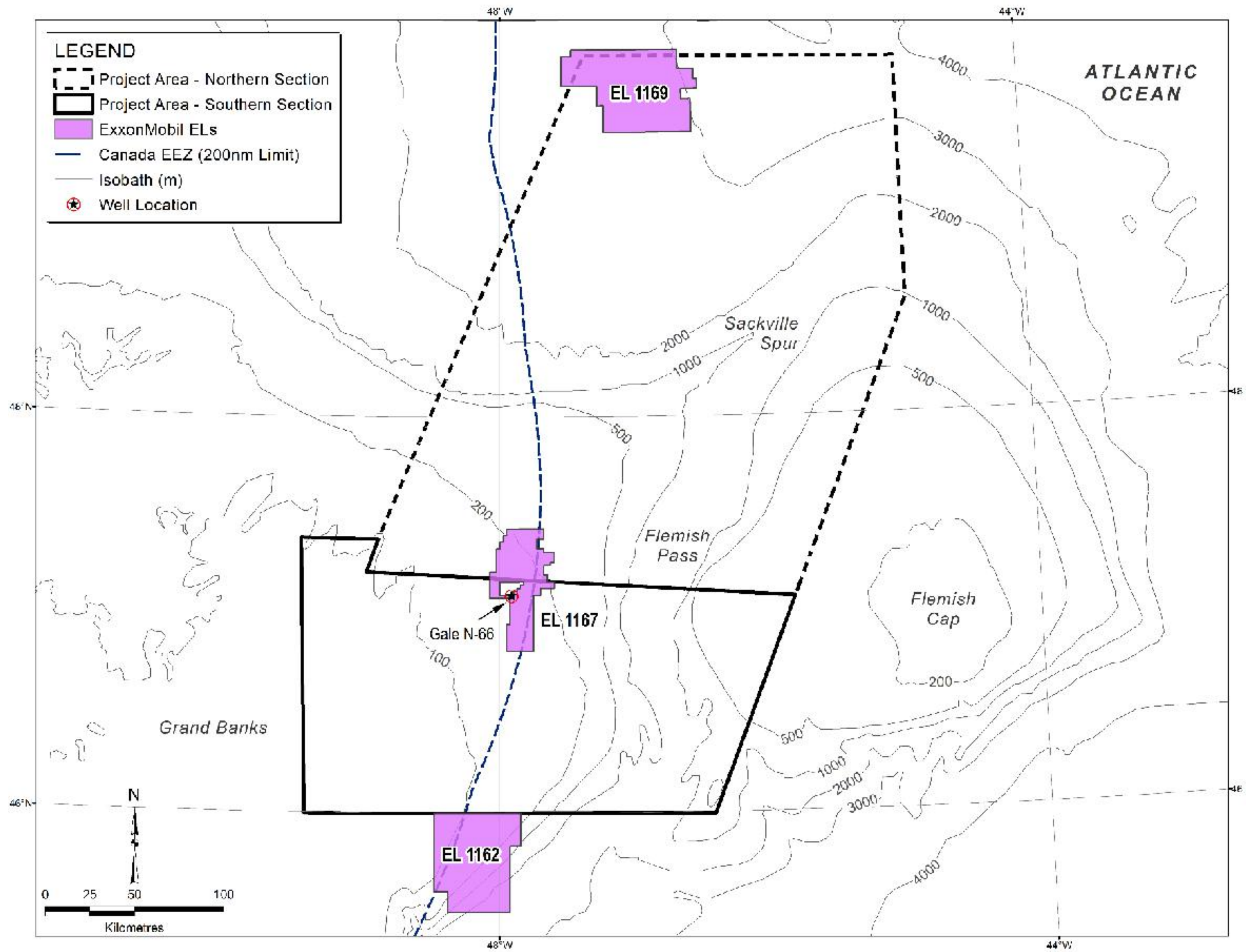


Figure 2.2. Location of the Gale N-66 Well in EL 1167.

2.2 Physical Environment

Physical environment factors that are relevant to selecting optimal oil spill response options include the shoreline type, day length, visibility, bathymetry, wind, waves, ocean currents, air and water temperature, and ice conditions. These physical environment components are summarized below for the RSA and described in detail in Section 4.1 in Stantec (2018a; see also Section 5.0 in ExxonMobil 2017). See also Section 4.1 in Stantec (2018a) for descriptions of geology, precipitation, lightning, tropical systems, tides, extreme waves and winds, water mass structure, water salinity and pH, ambient noise, and climate change within the RSA.

2.2.1 Shoreline

The island of Newfoundland has a heterogenous coastline with various shoreline habitat types. Habitat classification of the shoreline within the boundaries of the RSA 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 360 km west of the Flemish Pass.

2.2.2 Day Length

The duration of usable daylight delineates an upper limit to the number of hours a surface vessel or aircraft can safely and efficiently operate 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 updated SIMA, is the period after the sun sets during which enough natural light 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 2023 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 2023 (Source: Time and Date 2023).

Day and Month (2023)	Daylight Start and End Time [a]	Daily Duration of Usable Daylight
1 January	7:13 – 16:55	9 h 42 min
1 February	6:54 – 17:34	10 h 40 min
1 March	6:10 – 18:16	12 h 6 min
1 April	6:08 – 20:01	13 h 53 min
1 May	5:10 – 20:47	15 h 37 min
1 June	4:28 – 21:29	17 h 1 min
1 July	4:26 – 21:42	17 h 16 min
1 August	5:02 – 21:11	16 h 9 min
1 September	5:47 – 20:13	14 h 26 min
1 October	6:28 – 19:11	12 h 43 min
1 November	7:12 – 18:15	11 h 3 min
1 December	6:52 – 16:46	9 h 54 min

[a] Includes civil twilight.

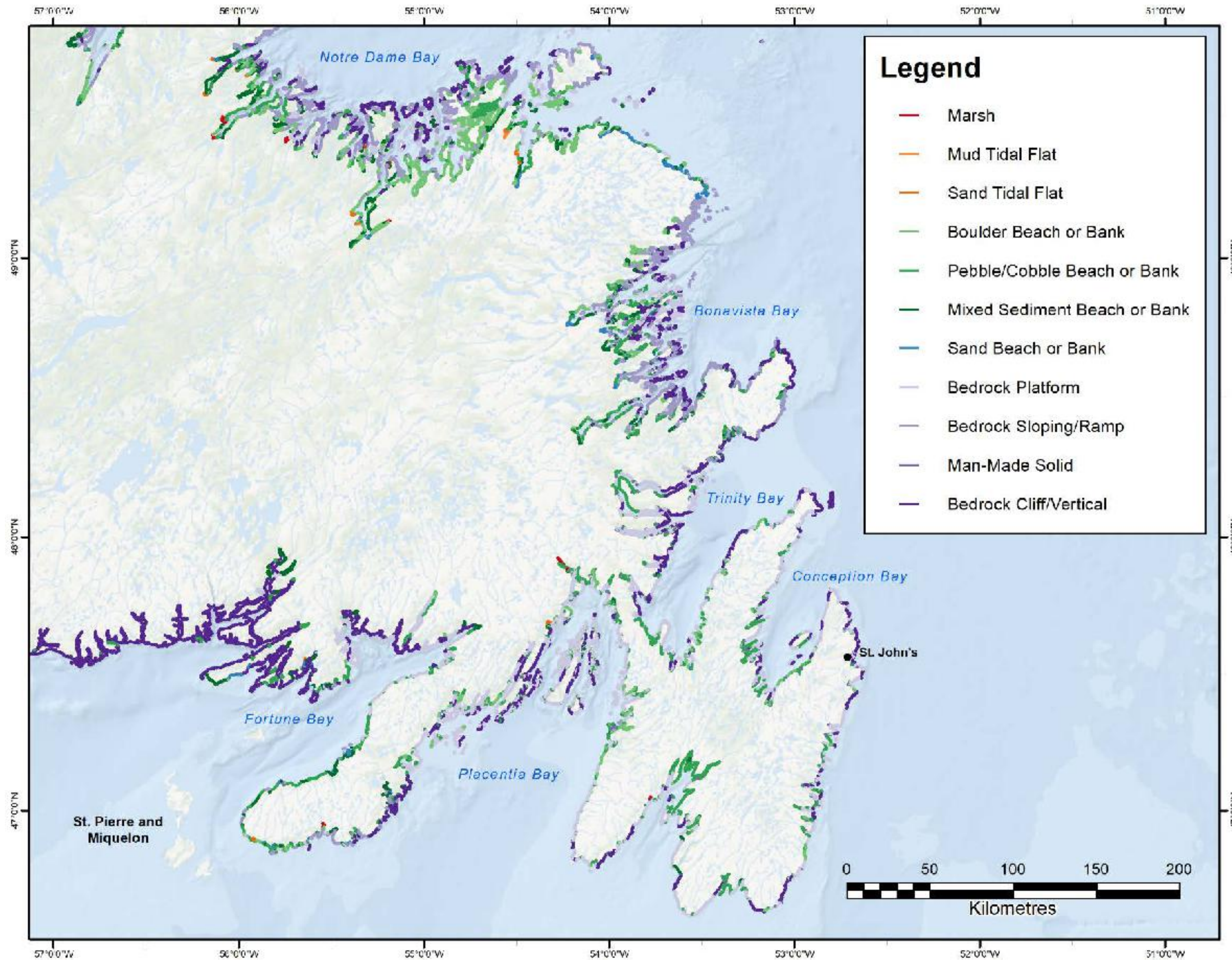


Figure 2.3. Shoreline classification for coastal Newfoundland (Source: Government of Canada 2017).

2.2.3 Visibility

During daylight periods, limited visibility can impact operational safety. 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 RSA, July is the worst month in terms of visibility, mainly due to fog (see Section 4.1.2.5 in Stantec 2018a). The mean monthly and annual frequency of limited visibility conditions (<1 km to <10 km) for the Northern Project Area are provided in Figure 2.4 and Table 2.2 and the Southern Project Area in Figure 2.5 and Table 2.3.

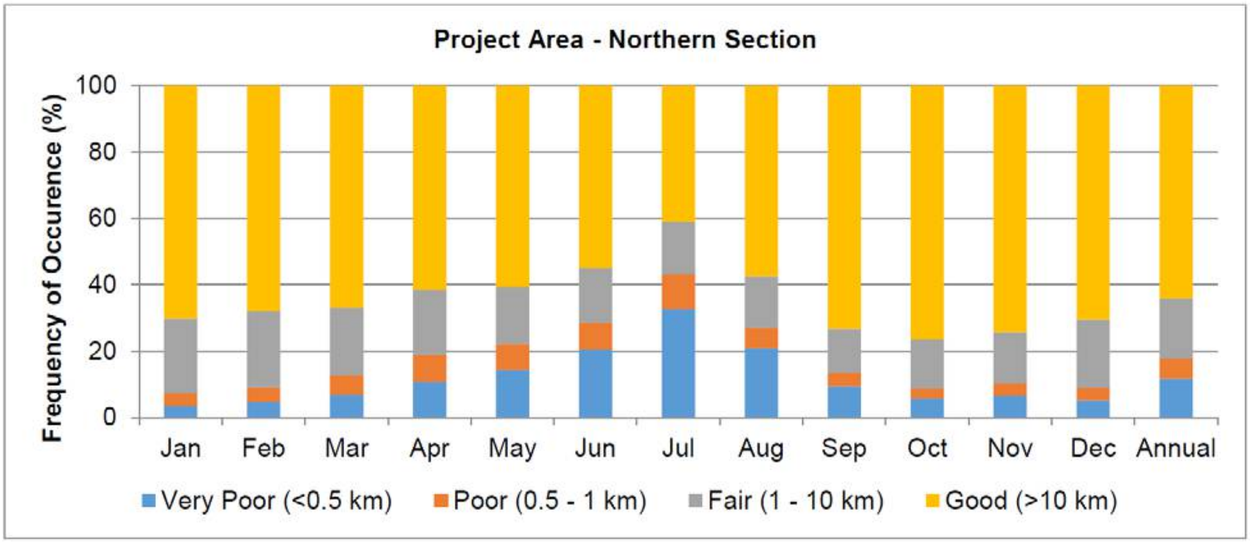


Figure 2.4. Frequency of occurrence of visibility within the Northern Project Area (Source: Figure 5-21 in ExxonMobil 2017 [ICOADS Database, 1960-2017]).

Table 2.2. Monthly and annual frequencies (%) of occurrence of visibility in the Northern Project Area (Source: Table 5.11 in ExxonMobil 2017 [ICOADS Database, 1960-2017]).

Month	Very Poor (<0.5 km)	Poor (0.5-1 km)	Fair (1-10 km)	Good (>10 km)
Jan	3.5	3.8	22.4	70.3
Feb	4.7	4.5	23.1	67.8
Mar	6.7	6.0	20.5	66.7
Apr	10.8	8.1	19.7	61.4
May	14.3	7.9	17.2	60.6
Jun	20.6	7.9	16.7	54.9
Jul	32.6	10.6	15.8	41.0
Aug	20.9	6.1	15.5	57.5
Sep	9.5	4.0	13.3	73.3
Oct	5.7	3.1	14.8	76.4
Nov	6.6	3.8	15.5	74.2
Dec	5.0	4.0	20.4	70.5
Annual	11.7	6.0	18.1	64.1

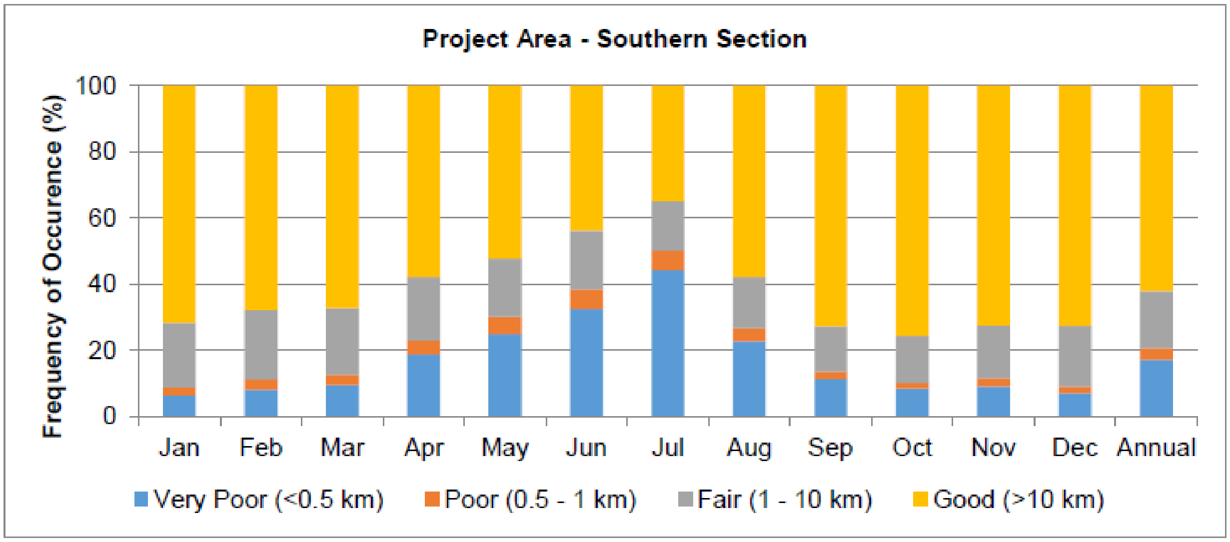


Figure 2.5. Frequency of occurrence of visibility within the Southern Project Area (Source: Figure 5-21 in ExxonMobil 2017 [ICOADS Database, 1960-2017]).

Table 2.3. Monthly and annual frequencies (%) of occurrence of visibility in the Southern Project Area (Source: Table 5.11 in ExxonMobil 2017 [ICOADS Database, 1960-2017]).

Month	Very Poor (<0.5 km)	Poor (0.5-1 km)	Fair (1-10 km)	Good (>10 km)
Jan	6.5	2.5	19.3	71.7
Feb	8.3	3.1	20.8	67.8
Mar	9.6	3.2	20.1	67.1
Apr	18.9	4.3	19.0	57.9
May	25.1	5.3	17.4	52.3
Jun	32.6	6.0	17.6	43.9
Jul	44.3	6.0	14.7	35.0
Aug	22.9	3.9	15.4	57.8
Sep	11.4	2.3	13.7	72.6
Oct	8.6	1.8	14.1	75.5
Nov	9.3	2.4	16.1	72.3
Dec	7.2	2.0	18.4	72.5
Annual	17.2	3.6	17.2	62.0

2.2.4 Bathymetry

The RSA includes the Jeanne d'Arc Basin, Flemish Pass, Flemish Cap, Orphan Basin, and a portion of the island of Newfoundland, where depths range from ~100-3800 m (see Section 5.2 in ExxonMobil 2017). Bathymetric features within the RSA are shown in Figure 2.6 (see also Section 4.1.3.1 in Stantec 2018a).

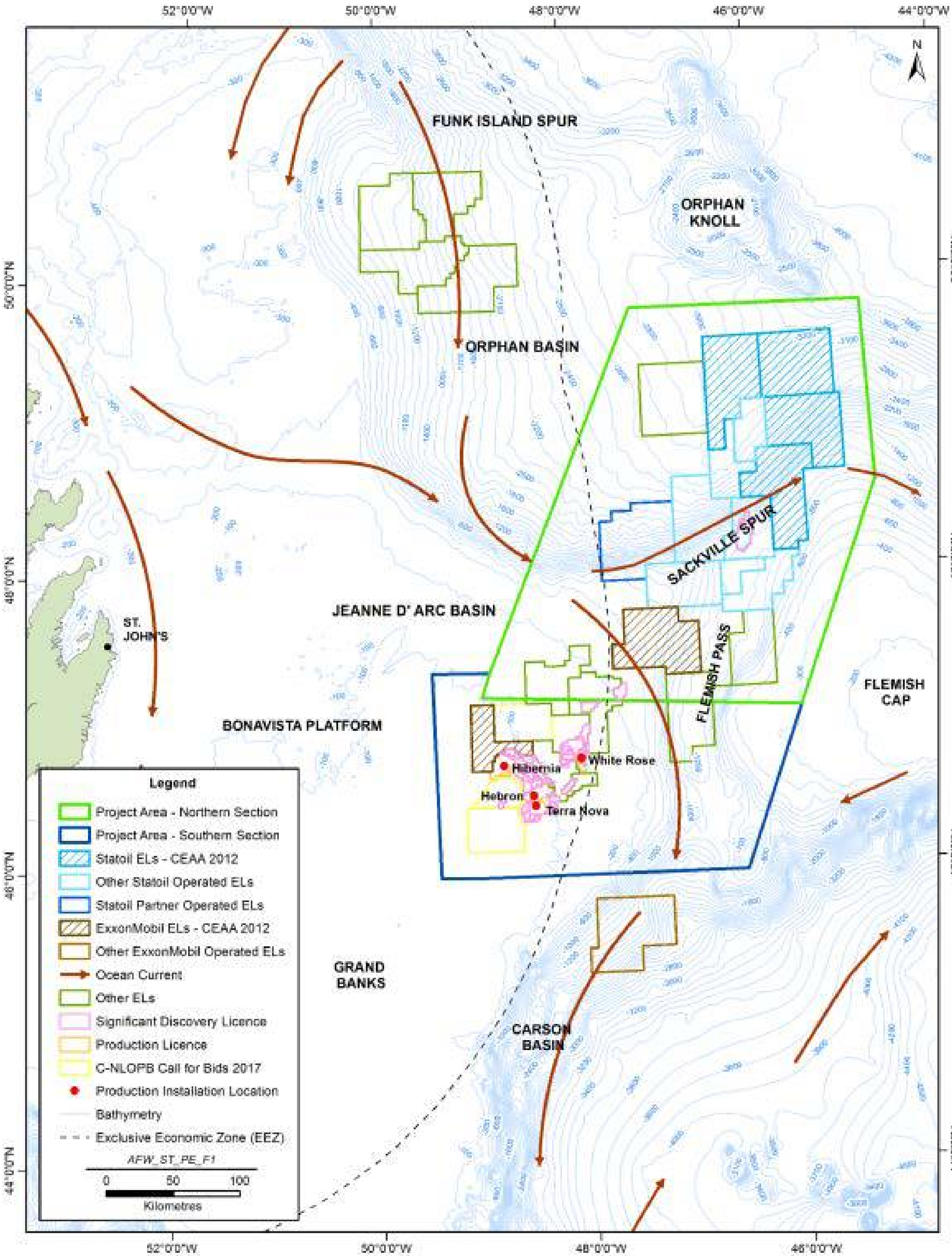


Figure 2.6. General bathymetry and ocean circulation within the RSA (Source: Figure 5-6 in ExxonMobil 2017 [ICOADS Database, 1960-2017).

2.2.5 Wind

Winds within the RSA are highly variable depending on the season, although the Project Area mainly experiences winds from the southwest to west (see Section 4.1.2.1 in Stantec 2018a). During the winter, the region experiences many high-frequency, low-pressure systems that result in high wind speeds. Tropical storms frequently transform into extratropical cyclones in the fall, causing hurricane-force winds (see Section 4.1.2.7 in Stantec 2018a). Wind speeds are greatest in the fall and winter months, mainly originating from westerly to northwesterly directions (Table 2.4; Stantec 2018a). During spring and summer, the wind shifts direction counter-clockwise to mainly originate from the southwest and wind speeds decrease. Predominant annual and monthly wind directions and speeds for the Project Area are provided in Figures 2.7-2.8.

Table 2.4. Mean and maximum monthly and annual wind speeds (m/s) and most frequent wind directions for the Project Area (Source: Table 5.2 in ExxonMobil 2017 [ICOADS Database, 1960-2017]).

MSC50 NODE	Month												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Mean Wind Speed (m/s)													
M3012443	12.1	11.7	10.6	9.0	7.9	7.2	6.7	7.0	8.4	9.7	10.5	11.5	9.3
M6013912	12.0	11.7	10.5	8.7	7.6	7.0	6.4	6.8	8.1	9.6	10.3	11.4	9.2
M6013091	11.6	11.4	10.2	8.5	7.3	6.8	6.3	6.6	7.8	9.2	9.9	11.1	8.9
M6011605	11.1	11.0	9.9	8.3	7.1	6.7	6.3	6.6	7.7	8.9	9.7	10.7	8.6
M6010089	11.3	11.2	10.0	8.4	7.1	6.7	6.0	6.4	7.6	9.0	9.6	10.9	8.7
Most Frequent Direction (from)													
M3012443	W	W	W	SW	SW	SW	SW	SW	SW	W	W	W	SW
M6013912	W	W	W	W	SW	SW	SW	SW	SW	W	W	W	W
M6013091	W	W	W	SW	SW	SW	SW	SW	SW	W	W	W	SW
M6011605	W	W	W	SW	SW	SW	SW	SW	SW	W	W	W	SW
M6010089	W	W	W	W	SW	SW	SW	SW	W	W	W	W	W
Maximum Wind Speed (m/s)													
M3012443	29.8	30.4	29.2	24.8	24.2	20.8	17.2	28.9	26.6	26.8	26.2	30.4	30.4
M6013912	29.6	31.1	30.7	25.7	25.4	23.1	19.9	28.4	28.7	27.8	27.0	31.0	31.1
M6013091	28.9	31.2	28.8	25.1	24.8	23.5	18.1	29.8	28.6	26.9	26.6	29.5	31.2
M6011605	29.2	32.4	27.8	25.2	22.3	23.5	19.1	27.0	29.0	31.6	27.4	28.3	32.4
M6010089	31.2	30.3	29.0	27.4	23.3	23.2	21.3	28.2	25.1	26.8	29.1	30.1	31.2
Direction of Maximum Wind Speed (from)													
M3012443	W	W	W	N	NW	NW	W	S	SE	SE	SW	NW	NW
M6013912	W	S	W	S	NW	NW	S	S	SE	NW	W	NW	S
M6013091	W	SW	W	S	NW	NW	S	S	SW	NW	NW	SW	SW
M6011605	W	NW	W	N	NW	NW	SW	S	SW	S	NW	SW	NW
M6010089	W	W	W	NW	NW	W	SW	S	S	W	W	SW	W

Grid Point Nodes: Northern Project Area = M3012443, M6013912, M6013091; Southern Project Area = M6011605, M6010089.

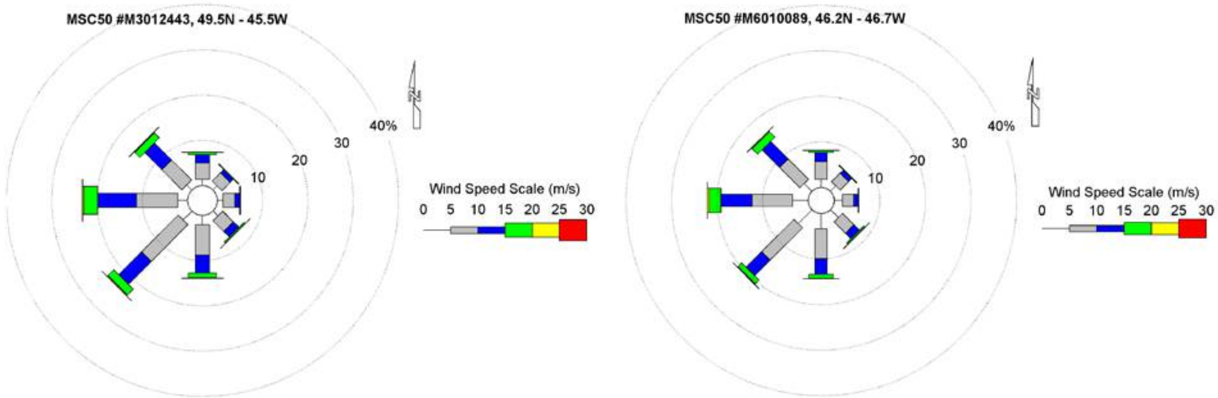


Figure 2.7. Annual wind rose for MSC50 Node M3012443 for the Northern Project Area (left) and Node M6010089 for the Southern Project Area (right), 1962-2015 (Source: Figures 5-9 and 5-13 in ExxonMobil 2017 [ICOADS Database, 1960-2017]).

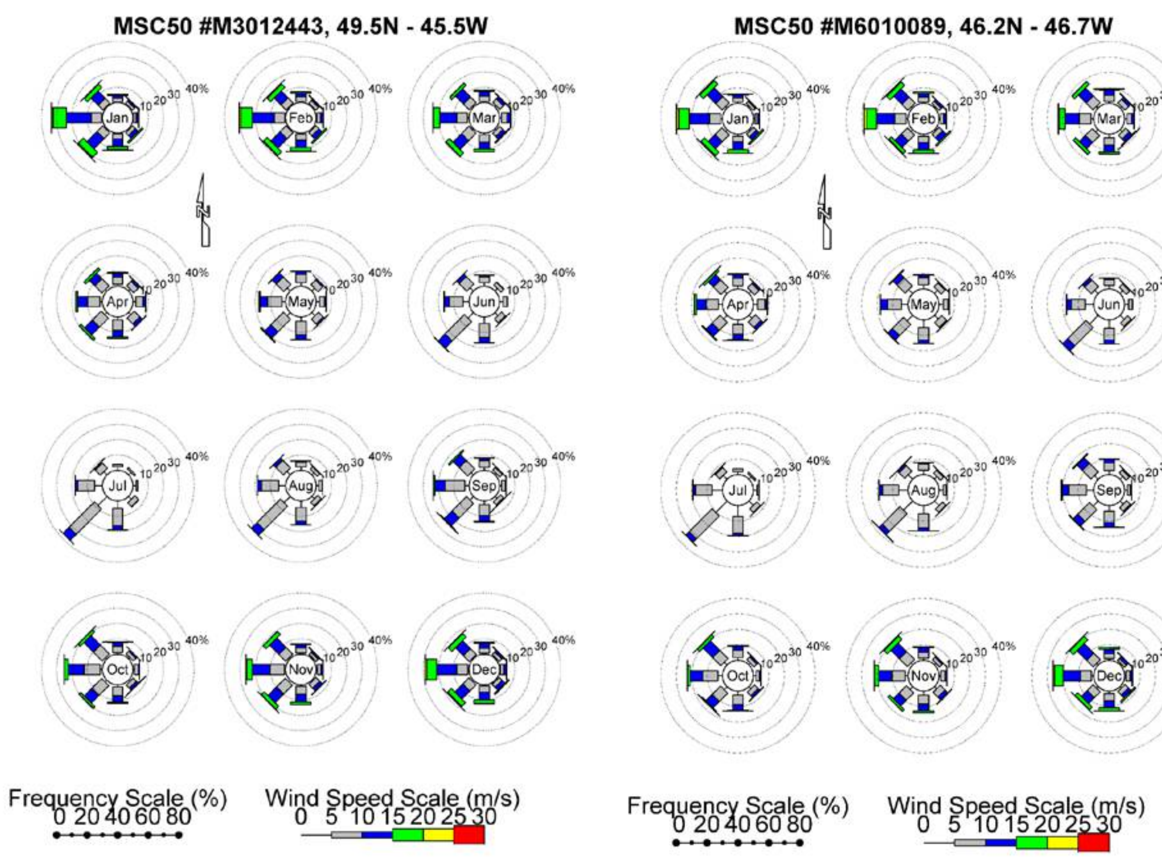


Figure 2.8. Monthly wind roses for MSC50 Node M3012443 for the Northern Project Area (left) and Node M6010089 for the Southern Project Area (right), 1962-2015 (Source: Figures 5-8 and 5-12 in ExxonMobil 2017 [ICOADS Database, 1960-2017]).

2.2.6 Waves

A region's wave climate is described in terms of peak wave spectral period and significant wave height. The wave climate in the RSA is strongly influenced by extra-tropical storms, particularly during October-March (see Section 4.1.3.4 in Stantec 2018a). The RSA's wave climate, as characterized by the MSC50 wind and wave dataset at node M3012443, is most severe during December and January, when maximum significant wave heights reach up to 13.8 m and originate from the west and northwest (Table 2.5). Maximum significant wave heights are the lowest in July (6 m), when they originate from the southwest. Annual and monthly wave roses for the Project Area are provided in Figures 2.9-2.10.

Table 2.5. Mean and maximum significant wave height (Hs) and peak wave spectral period (Tp) and most frequent wave directions for the Project Area (Source: Table 5.17 in ExxonMobil 2017 [ICOADS Database, 1960-2017]).

MSC50 NODE	Month												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Mean Hs (m)													
M3012443	4.6	4.4	3.8	3.0	2.4	2.0	1.8	1.9	2.6	3.2	3.7	4.3	3.1
M6013912	4.6	4.2	3.6	3.0	2.3	2.0	1.8	1.9	2.6	3.2	3.6	4.3	3.1
M6013091	4.4	3.8	3.0	2.8	2.3	2.0	1.8	1.9	2.5	3.1	3.5	4.2	2.9
M6011605	4.1	3.6	3.0	2.6	2.2	1.9	1.7	1.8	2.4	2.9	3.3	3.9	2.8
M6010089	4.4	4.1	3.4	2.9	2.2	2.0	1.7	1.8	2.4	3.1	3.5	4.1	3.0
Mean Tp (s)													
M3012443	10.7	10.4	10.0	9.3	8.5	8.0	7.7	7.8	8.8	9.5	9.8	10.5	9.2
M6013912	10.7	10.3	9.8	9.5	8.6	8.1	7.8	7.9	8.9	9.5	9.9	10.5	9.3
M6013091	10.5	9.4	8.6	9.0	8.6	8.1	7.8	7.9	8.9	9.5	9.9	10.5	9.1
M6011605	10.3	9.5	8.9	8.7	8.5	7.9	7.7	7.7	8.8	9.3	9.7	10.3	8.9
M6010089	10.7	10.4	9.6	9.4	8.6	8.0	7.8	7.9	8.9	9.5	9.9	10.5	9.3
Most Frequent Wave Direction (from)													
M3012443	W	W	NW	SW	SW	SW	SW	SW	SW	NW	NW	W	SW
M6013912	W	W	NW	SW	SW	SW	SW	SW	SW	NW	NW	NW	SW
M6013091	W	W	SW	SW	SW	SW	SW	SW	SW	NW	NW	NW	SW
M6011605	W	SW	SW	SW	SW	SW	SW	SW	SW	SW	NW	W	SW
M6010089	W	W	W	SW	SW	SW	SW	SW	SW	NW	NW	W	SW
Maximum Hs (m)													
M3012443	13.8	13.3	13.2	12.0	10.4	9.0	6.0	7.0	12.1	12.1	12.3	13.8	13.8
M6013912	14.2	15.3	13.1	11.0	11.7	10.5	7.1	8.2	13.3	12.5	13.2	15.3	15.3
M6013091	14.2	15.5	11.8	11.0	11.5	10.6	6.4	8.6	13.5	12.3	12.5	14.3	15.5
M6011605	12.0	14.1	10.7	10.6	9.9	9.7	6.1	8.3	12.7	11.5	11.0	12.7	14.1
M6010089	14.2	13.6	12.1	10.9	10.8	10.5	6.9	10.1	11.1	13.1	12.8	14.0	14.2
Tp of Maximum Hs (s)													
M3012443	15.9	15.2	14.7	14.3	13.3	12.2	11.0	11.6	14.4	14.8	14.4	15.7	15.7
M6013912	16.0	16.2	14.4	13.9	13.9	13.5	12.1	11.8	15.7	14.6	15.4	16.2	16.2
M6013091	14.7	16.9	13.3	13.8	14.0	13.8	11.9	11.8	15.4	14.7	14.4	15.9	16.9
M6011605	17.2	16.2	17.6	16.4	17.3	14.4	17.2	17.3	17.3	17.7	15.9	17.3	17.7
M6010089	15.7	15.8	15.3	13.0	14.2	13.7	11.8	13.5	14.2	15.0	14.4	16.0	15.7

Grid Point Nodes: Northern Project Area = M3012443, M6013912, M6013091; Southern Project Area = M6011605, M6010089.

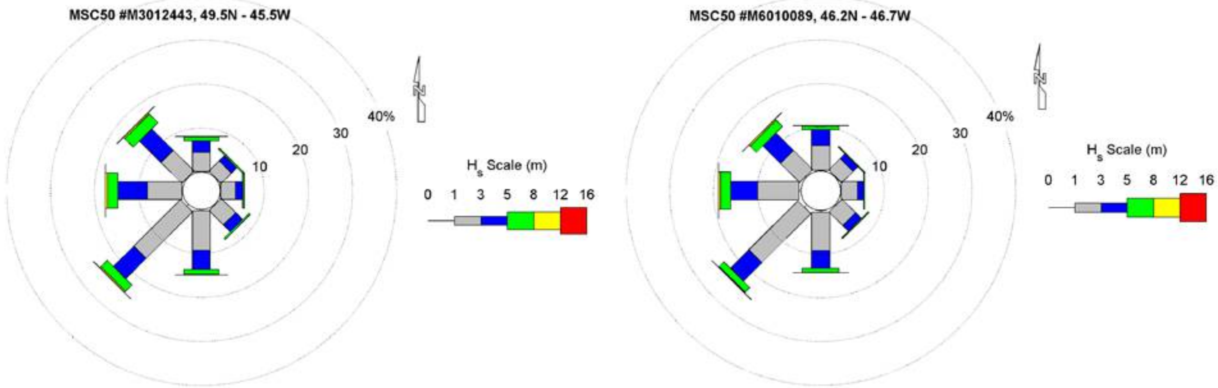


Figure 2.9. Annual wave roses for MSC50 Node M3012443 for the Northern Project Area (left) and Node M6010089 for the Southern Project Area (right), 1962-2015 (Source: Figures 5-26 and 5-29 in ExxonMobil 2017 [ICOADS Database, 1960-2017]).

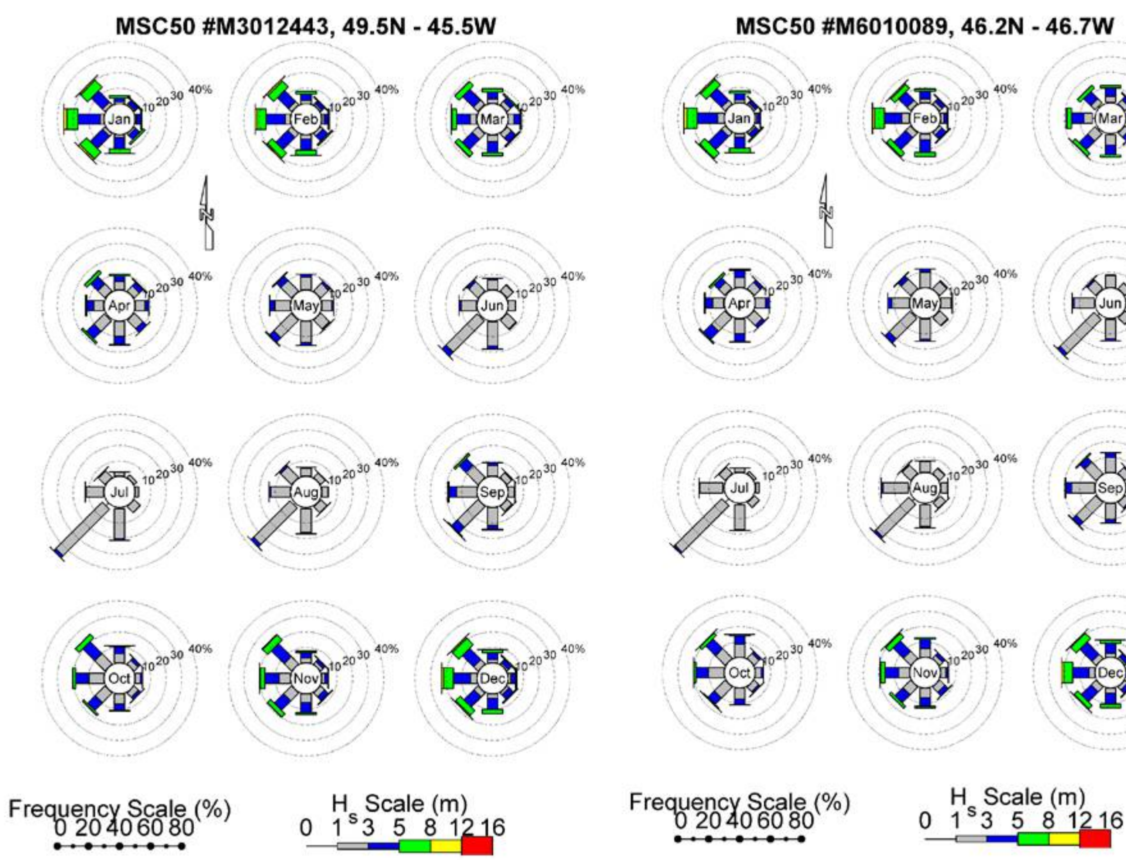


Figure 2.10. Monthly wave roses for MSC50 Node M3012443 for the Northern Project Area (left) and Node M6010089 for the Southern Project Ara (right) (Source: Figures 5-25 and 5-28 in ExxonMobil 2017 [ICOADS Database, 1960-2017]).

2.2.7 Ocean Currents

Two main ocean currents flow through the RSA, the Labrador Current and the Gulf Stream/North Atlantic Current (Figure 2.11). The Gulf Stream/North Atlantic Current flows from the south and mainly diverts eastwards around the Flemish Cap; it begins to be called the North Atlantic Current once it starts turning north at the Southeast Newfoundland Rise. The Labrador Current flows from the north and splits into two streams: an inshore branch that flows along the continental shelf, and an offshore branch that flows along the Grand Banks (see Section 4.1.3.2 in Stantec 2018a). Maximum current speeds reach upwards of 109 cm/s and minimum current speeds are 5 cm/s. Both the approximate maximum and minimum speeds have been observed in shallower waters of the RSA, including the depth range of the Gale N-66 Well (0-200m) (Figure 2.12).

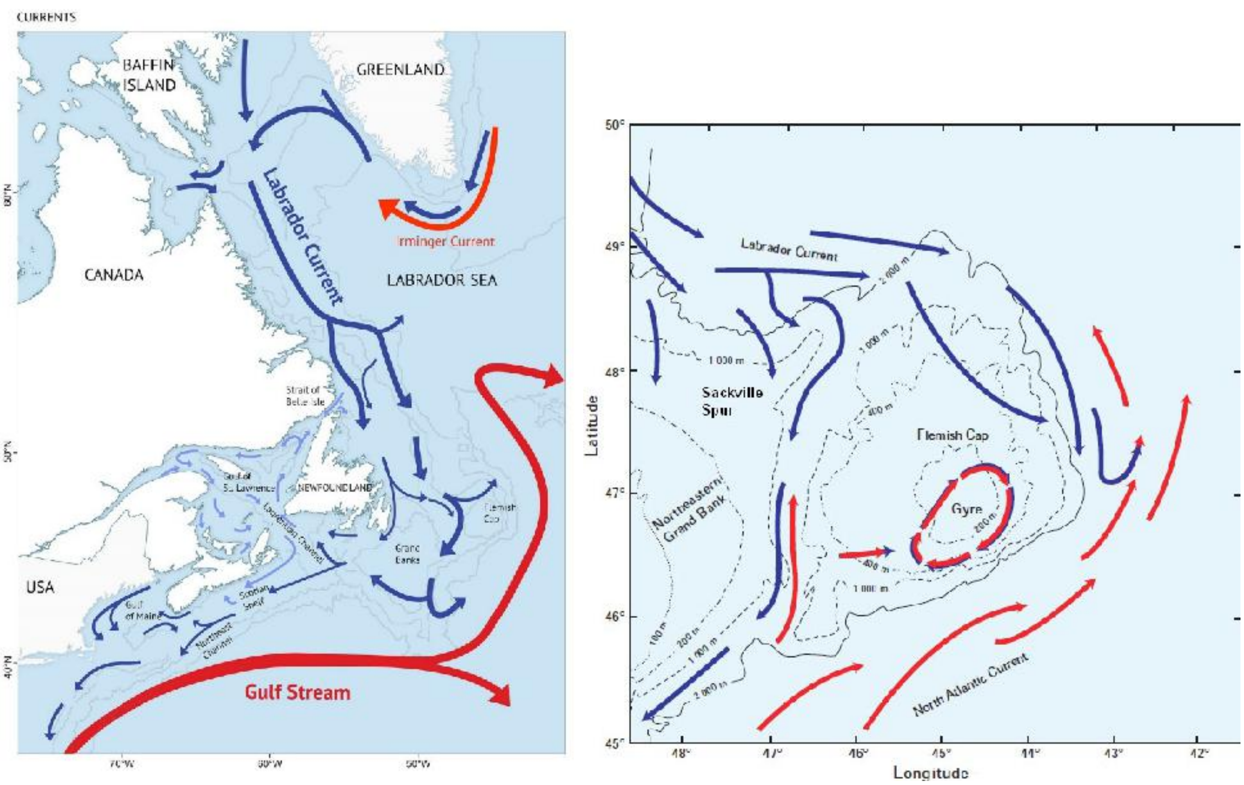


Figure 2.11. Primary currents within the RSA (left) and major circulation features around the Grand Banks, Flemish Cap, and Sackville Spur (right) (Source: Figure 2 in Bernier et al. 2018; Figure 4-12 in Stantec 2018a).

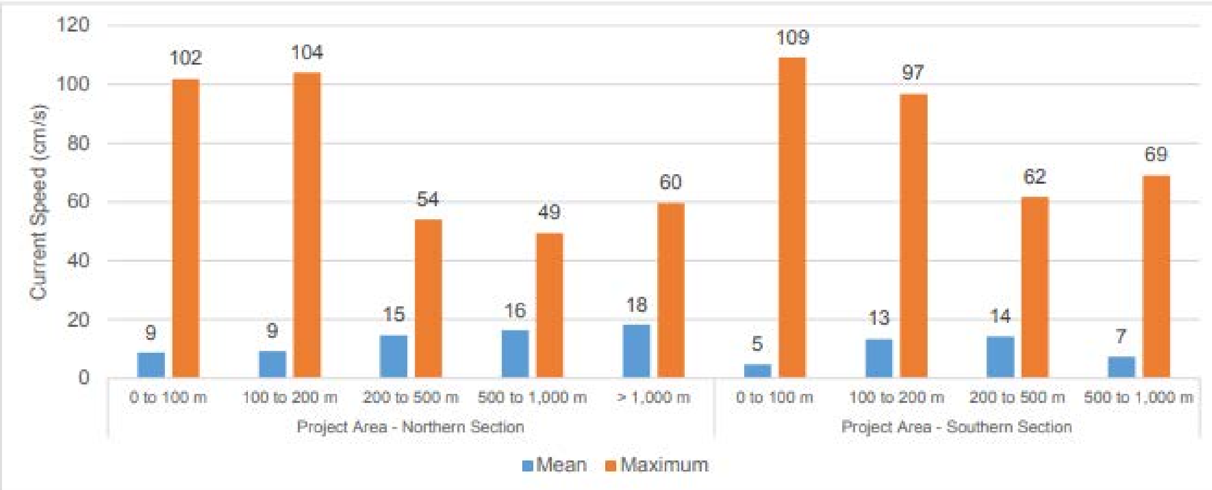


Figure 2.12. Mean and maximum ocean current speeds at different depth intervals within the Project Area (Source: Figure 5-32 in ExxonMobil 2017 [ICOADS Database, 1960-2017]).

2.2.8 Air Temperature

Within the RSA, mean air temperatures within the RSA are warmest during the month of August (~14.0ºC) and coldest in January/February (~-0.3ºC to -0.1ºC) (Tables 2.6 and 2.7; Figure 2.13; Section 4.1.2.2 in Stantec 2018a). During the winter, the maximum recorded temperature (1960-2017) was ~22°C (minimum -13.6ºC), while maximum summer temperatures reached up to 24.5°C (minimum -1.8ºC). Throughout the year, mean daily minimum and mean daily maximum temperatures typically stay within about ~3°C of the monthly mean temperature (ExxonMobil 2017).

Table 2.6. Monthly air temperature (ºC) statistics for the Northern Project Area (Source: Table 5.5 in ExxonMobil 2017 [ICOADS Database, 1960-2017]).

Month	Mean	Maximum	Minimum	SD	Mean Daily Minimum	Mean Daily Maximum
Jan	0.4	22.0	-13.0	4.0	-1.2	3.7
Feb	0.5	21.0	-13.5	4.0	-1.7	3.7
Mar	1.6	17.0	-12.0	3.7	-0.7	4.7
Apr	3.1	18.0	-6.8	3.1	0.9	6.1
May	4.9	18.7	-4.1	2.9	2.9	7.8
Jun	7.0	21.1	-1.8	3.0	5.3	9.7
Jul	10.8	23.5	1.5	3.0	9.2	13.2
Aug	13.0	24.0	3.0	2.6	11.5	14.9
Sep	11.9	24.5	1.0	2.9	10.1	14.0
Oct	8.5	22.8	-1.5	2.9	6.8	10.6
Nov	5.6	20.6	-5.8	3.4	3.8	8.0
Dec	3.2	22.0	-9.5	3.8	1.3	5.8

SD = Standard Deviation.

Table 2.7. Monthly air temperature (ºC) statistics for the Southern Project Area (Source: Table 5.7 in ExxonMobil 2017 [ICOADS Database, 1960-2017]).

Month	Mean	Maximum	Minimum	SD	Mean Daily Minimum	Mean Daily Maximum
Jan	0.4	18.0	-12.8	3.2	-1.7	3.6
Feb	-0.1	17.5	-13.6	3.2	-2.2	3.1
Mar	0.6	17.0	-11.0	3.0	-1.3	4.1
Apr	2.2	16.7	-6.5	2.6	0.5	5.2
May	4.3	18.0	-5.0	2.6	2.5	7.2
Jun	7.4	20.5	-1.2	2.7	5.7	10.2
Jul	12.0	23.5	1.2	2.7	10.0	14.2
Aug	14.4	24.0	3.0	2.3	12.4	16.4
Sep	12.9	23.5	1.0	2.6	10.8	15.0
Oct	9.2	22.5	-1.2	3.0	7.3	11.7
Nov	5.5	20.5	-5.0	3.1	3.7	8.2
Dec	2.3	19.5	-10.2	3.4	0.5	5.2

SD = Standard Deviation.

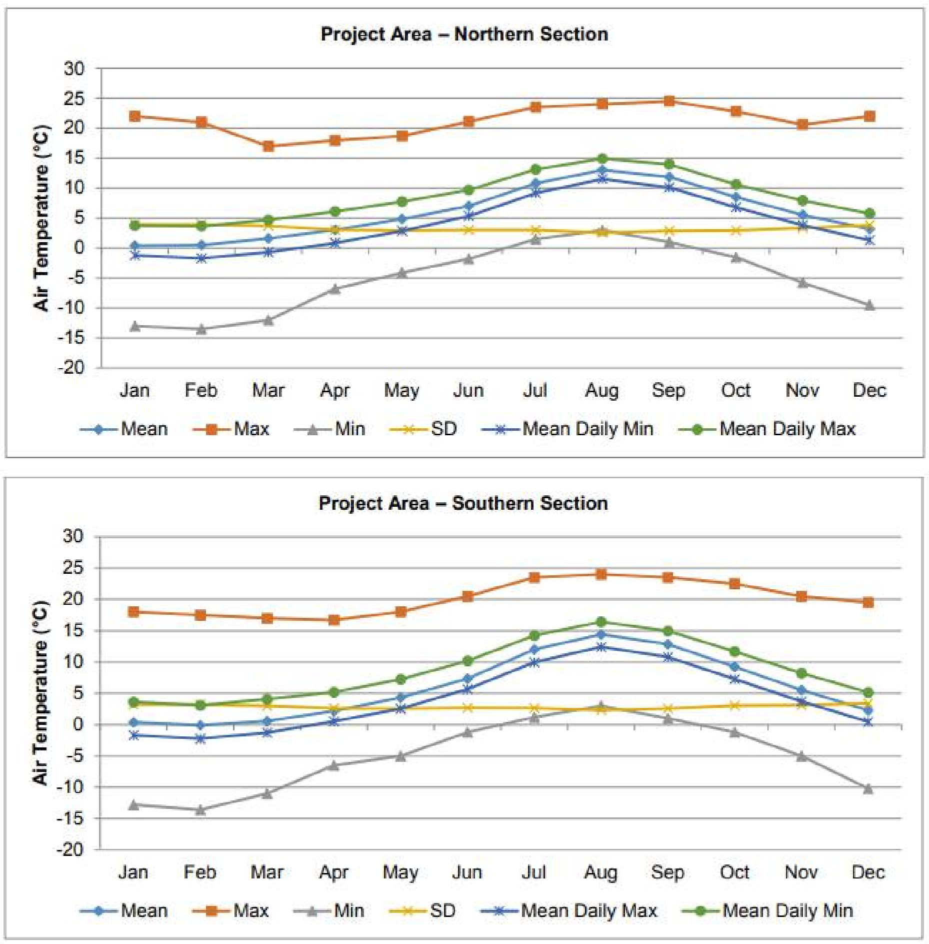


Figure 2.13. Air temperatures for the Northern (top) and Southern (bottom) Project Area sections (Source: Figures 5-14 and 5-15 in ExxonMobil 2017 [ICOADS Database, 1960-2017]).

2.2.9 Water Temperature

Water temperature can impact both oil and dispersant viscosity. As water temperature decreases, oil and dispersant resistance to flow, or viscosity, increases; therefore, oil may disperse more efficiently in warmer waters. Variation in water temperature depends mostly on depth, as the seasonal temperature cycles are observed only within the upper 250 m of the water column within the RSA (see Sections 5.5.4.1-5.5.4.2 in ExxonMobil 2017). Beyond 250-m water depth, mean temperatures exhibit minimal monthly variation (Figures 2.14-2.15). From March to August, the region's mean sea surface temperature (SST) is lower than the mean air temperature, particularly during July (see Section 4.1.2.2 in Stantec 2018a). The reverse is true during September to February. During 1960-2017, mean SSTs ranged from 5.3°C in October to 1.6°C in March for the northern portion of the Project Area, and from 10.9ºC in September to 1.6º in March for the southern portion of the Project Area. Minimum surface temperatures varied from -1.8°C in January to 1.1°C in August and September for the Northern Project Area and from -1.8ºC in February and March to 4.9ºC in September for the Southern Project Area, while maximum temperatures ranged between 11.8°C in August and 4.0°C in March and 19.6ºC in September and 5.8ºC in February for the northern and southern portions of the Project Area, respectively (ExxonMobil 2017).

2.2.10 Ice Conditions

The presence of sea ice, icebergs, or marine icing can impact oil spill mitigation operations. The RSA experiences seasonal occurrences of various ice conditions depending on the weather (Stantec 2018a). Throughout the RSA, the extent of ice conditions fluctuates throughout the year; the movement of ice is affected by cold and dry northwesterly winds, which push the ice offshore, and the northeasterly winds, which move the ice further inshore (see Section 5.7 in ExxonMobil 2017). This section provides a summary of sea ice, icebergs, and marine icing conditions within the Project Area; further details can be found in Section 4.1.4 of Stantec (2018a).

2.2.10.1 Sea Ice

Sea ice (drift or pack) in the RSA may be highly variable year to year given the temperature and wind conditions of the offshore NL region and may not necessarily occur within the Project Area on an annual basis (Stantec 2018a). The maximum sea ice extent in the region (1970-2015) is presented in Figure 2.16. The potential presence of sea ice within the RSA should be considered in any oil spill response taking place between early-December to early-August (see Section 5.5.1 in Stantec 2018b). Sea ice in the RSA occurs most frequently during early-January through mid-May and the Project Area's 30-year (1990-2020) median concentration of sea ice reaches its maximum during the week of 19 February (Figure 2.17). Overall, there is a low likelihood (0-17%) of sea ice occurrence throughout the year near the Gale N-66 Well (see Section 4.1.4.1 in Stantec 2018a; Figure 2.18).

Mean Sea Temperature (°C)

Depth (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	2.3	2.3	1.6	2.0	2.1	2.9	4.4	5.2	4.6	5.3	3.5	2.9
250	3.2	3.7	3.3	3.1	2.6	2.8	3.7	3.1	2.0	3.1	2.8	3.2
500	3.8	3.9	3.7	3.6	3.6	3.5	3.7	3.6	3.9	3.6	3.8	3.9
750	3.7	3.7	3.6	3.5	3.5	3.5	3.5	3.6	3.7	3.5	3.6	3.6
1000	3.5	3.6	3.5	3.5	3.4	3.4	3.5	3.6	3.6	3.4	3.4	3.4
1250	3.4		3.2	3.3	3.4	3.4	3.5	3.3	3.5	3.4	3.4	3.3
1500	3.4		3.3	3.3	3.3	3.4	3.3	3.4	3.4	3.4	3.5	3.2
1750	3.3			3.2	3.1				3.1		3.4	
2000	3.1			3.0	3.0		3.1		2.9		3.2	
2250				2.8	2.6						3.0	
2500				2.4	2.4						2.8	
2750				2.1	2.4						2.5	
3000				2.0	2.2						2.2	

Minimum Sea Temperature (°C)

Depth (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	-1.8	-0.7	-1.7	-1.6	-1.5	-1.4	-0.5	1.1	1.1	0.6	0.1	-0.6
250	-0.2	1.5	-0.7	-0.3	-1.3	-1.2	1.9	-0.3	-0.9	-0.5	-1.0	-0.9
500	3.4	2.6	2.8	2.6	2.7	2.7	2.9	3.2	3.4	3.3	3.2	3.3
750	3.3	3.3	3.1	3.3	3.1	2.9	3.1	3.4	3.4	3.2	3.2	3.2
1000	3.3	3.5	3.0	3.3	3.2	3.0	3.4	3.4	3.4	3.1	3.0	3.0
1250	3.3		2.9	3.2	3.1	3.2	3.4	3.3	3.4	3.1	2.9	3.0
1500	3.3		2.9	3.1	3.1	3.2	2.9	3.4	3.3	3.4	3.3	3.2
1750	3.1			3.1	3.0				3.1		3.4	
2000	3.0			2.9	2.8		3.1		2.9		3.2	
2250				2.7	2.4						3.0	
2500				2.3	2.3						2.8	
2750				2.1	2.2						2.5	
3000				2.0	2.2						2.2	

Maximum Sea Temperature (°C)

Depth (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	5.9	5.2	4.0	6.6	8.5	9.0	10.9	11.8	8.3	8.8	9.3	5.8
250	4.6	4.6	4.8	4.9	5.8	4.5	4.9	4.5	4.4	5.8	4.8	4.7
500	4.3	4.2	4.4	4.3	4.6	4.4	4.5	4.0	4.3	4.2	4.6	4.6
750	4.1	3.8	4.0	3.9	4.0	4.0	3.9	3.8	3.9	3.9	4.3	4.1
1000	3.7	3.6	3.8	3.7	3.9	3.7	3.7	3.7	3.7	3.9	3.9	3.8
1250	3.5		3.5	3.5	3.6	3.5	3.6	3.3	3.6	3.7	3.7	3.6
1500	3.4		3.5	3.5	3.5	3.5	3.5	3.4	3.5	3.6	3.6	3.2
1750	3.4			3.2	3.2				3.1		3.4	
2000	3.3			3.0	3.2		3.1		2.9		3.2	
2250				2.9	2.8						3.0	
2500				2.5	2.6						2.8	
2750				2.2	2.6						2.5	
3000				2.0	2.3						2.2	

Number of Data Months

Depth (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	10	7	10	19	38	37	22	15	12	11	24	15
250	10	8	10	19	36	35	19	16	11	11	24	14
500	9	7	9	16	27	34	18	10	4	9	23	13
750	5	5	7	11	20	27	8	7	4	9	18	8
1000	3	2	5	9	17	20	7	4	4	7	8	7
1250	2		2	5	9	4	3	1	2	4	6	7
1500	2		3	8	13	7	3	1	2	3	4	3
1750	1			2	3				1		1	
2000	1			2	4		1		1		1	
2250				2	4						1	
2500				2	4						1	
2750				2	2						1	
3000				1	2						1	

Figure 2.14. Monthly water temperature profiles for the Northern Project Area (Source: Table 5.25 in ExxonMobil 2017 [ICOADS Database, 1960-2017]).

Mean Sea Temperature (°C)

Depth (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	2.4	0.8	2.1	0.6	2.7	4.7	9.4	7.7	10.9	8.3	5.4	4.0
20	2.4	0.8	2.1	0.4	2.2	3.7	7.2	3.7	8.5	7.3	5.0	3.9
40	2.0	0.9	1.0	0.1	1.1	1.8	3.4	0.0	2.9	4.1	3.3	3.3
60	2.0	1.0	1.0	0.0	0.4	0.5	0.9	-0.9	-0.2	1.3	1.6	2.5
80	2.0	1.1	2.0	0.0	0.1	0.2	0.6	-0.6	-0.7	0.6	0.8	1.9
100	2.1	1.4	2.4	0.4	0.1	0.1	0.8	-0.6	-0.7	1.2	0.7	2.0
200	3.2	2.5	3.7	2.7	2.2	2.3	3.2	2.8	1.6	3.4	2.5	3.6
300	3.6	3.1	3.8	3.4	3.1	3.2	3.7	3.7	3.9	3.7	3.4	3.9
400	3.8	3.4	3.8	3.6	3.5	3.5	3.7	3.7	3.9	3.8	3.8	3.8
500	3.8	3.7	3.8	3.6	3.5	3.6	3.7	3.7	3.8	3.7	3.8	3.7
600	3.8	3.8	3.6	3.7	3.6	3.6	3.7	3.7		3.6	3.8	3.6
700	3.7	3.6	3.4	3.6	3.4	3.6	3.6	3.7		3.6	3.6	3.5
800	3.6	3.5	3.6	3.6	3.5	3.5	3.6	3.6		3.5	3.6	3.5
900	3.5	3.6	3.2	3.5	3.4	3.6	3.5	3.6		3.5	3.6	3.4
1000	3.5		3.4	3.5	3.5	3.5	3.4	3.5		3.4	3.4	3.3

Minimum Sea Temperature (°C)

Depth (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	-1.4	-1.8	-1.8	-1.5	-1.1	0.0	1.7	1.4	4.9	1.2	0.3	0.5
20	-1.3	-1.8	-1.8	-1.6	-1.1	-0.6	0.2	0.0	3.0	-0.7	0.5	0.5
40	-1.3	-1.8	-1.8	-1.7	-1.7	-1.5	-1.3	-1.6	-1.5	-1.3	-1.4	-0.1
60	-1.2	-1.7	-1.8	-1.8	-1.7	-1.7	-1.7	-1.7	-1.7	-1.5	-1.3	-1.2
80	-1.1	-1.7	-1.7	-1.8	-1.7	-1.7	-1.8	-1.7	-1.7	-1.6	-1.4	-1.3
100	-0.9	-1.7	-1.7	-1.8	-1.6	-1.7	-1.7	-1.7	-1.6	-1.5	-1.4	-1.3
200	-0.7	-0.8	-1.2	-0.7	-1.0	-1.0	0.0	-0.8	-0.4	0.8	-0.9	-0.8
300	1.4	1.7	2.2	0.4	0.8	0.8	2.3	1.5	3.5	1.4	0.6	1.1
400	1.6	2.1	2.5	2.3	1.8	2.0	3.0	1.9	3.5	3.1	2.2	3.4
500	3.5	2.7	3.0	3.1	2.9	3.2	3.0	3.0	3.8	3.3	3.1	3.3
600	3.5	3.3	3.4	3.2	3.1	3.2	3.1	3.1		3.2	3.2	3.2
700	3.5	3.5	3.2	3.2	3.2	3.3	3.1	3.2		3.2	3.1	3.1
800	3.4	3.3	3.0	3.3	3.2	3.2	3.1	3.3		3.1	3.3	3.2
900	3.4	3.3	3.1	3.2	3.2	3.3	3.1	3.3		3.1	3.4	3.1
1000	3.4		3.0	3.1	3.1	3.1	3.1	3.3		3.0	3.3	3.1

Maximum Sea Temperature (°C)

Depth (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	8.2	5.8	6.6	6.6	10.3	10.4	15.1	17.0	19.6	14.4	11.1	10.6
20	8.2	5.8	6.6	6.6	10.1	9.6	12.5	13.1	19.6	13.1	11.0	10.5
40	8.2	5.8	4.6	6.8	9.6	8.6	9.8	11.9	8.7	10.5	9.7	8.3
60	8.3	5.8	4.5	7.1	8.7	6.7	7.8	5.4	5.8	8.6	8.4	7.2
80	8.7	5.9	6.7	7.3	8.4	6.7	7.9	5.5	3.7	6.1	8.2	6.9
100	8.7	5.9	6.7	7.7	8.1	6.5	8.2	5.3	4.1	6.4	7.1	7.1
200	6.9	5.2	8.1	6.3	6.8	5.3	6.5	5.1	4.8	6.0	4.9	5.6
300	4.9	5.0	5.7	4.8	5.6	5.2	5.0	5.0	4.4	5.0	4.8	5.3
400	4.7	4.9	4.5	5.2	4.8	4.7	5.5	4.8	4.1	4.6	4.8	4.9
500	4.3	4.4	5.1	4.2	4.0	4.1	4.6	4.4	3.8	4.8	4.7	4.5
600	4.3	4.3	4.3	4.1	3.9	4.0	4.3	4.4		4.6	4.6	4.6
700	4.2	3.9	4.1	4.1	3.8	3.9	4.2	4.2		4.0	4.0	4.1
800	4.1	3.8	4.0	4.0	3.8	3.8	4.1	4.1		3.9	3.9	4.0
900	3.9	3.8	3.6	4.0	3.6	3.7	4.0	4.0		3.8	3.8	4.0
1000	3.8		3.7	4.0	3.6	3.7	3.9	3.9		3.7	3.5	3.8

Number of Data Months

Depth (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	119	85	114	614	537	1137	673	900	158	574	750	268
20	120	86	116	630	538	1143	674	902	159	579	752	272
40	80	77	81	611	491	1121	675	901	147	579	752	270
60	86	77	82	617	501	1125	673	694	147	579	750	272
80	87	75	115	614	490	1110	671	441	144	566	734	271
100	82	75	103	459	347	687	576	401	99	396	516	232
200	68	58	72	181	156	313	250	92	23	208	256	148
300	57	47	49	109	115	222	197	69	6	181	174	130
400	41	37	50	66	74	136	112	53	3	108	107	109
500	36	40	44	48	48	75	95	45	1	98	51	97
600	27	15	25	36	41	70	59	44		97	49	95
700	23	8	16	25	16	27	36	36		81	12	85
800	23	9	47	26	21	25	38	32		81	4	81
900	15	3	10	19	11	13	29	24		61	5	71
1000	13		18	20	11	9	18	26		52	2	56

Figure 2.15. Monthly water temperature profiles for the Southern Project Area (Source: Table 5.27 in ExxonMobil 2017 [ICOADS Database, 1960-2017]).

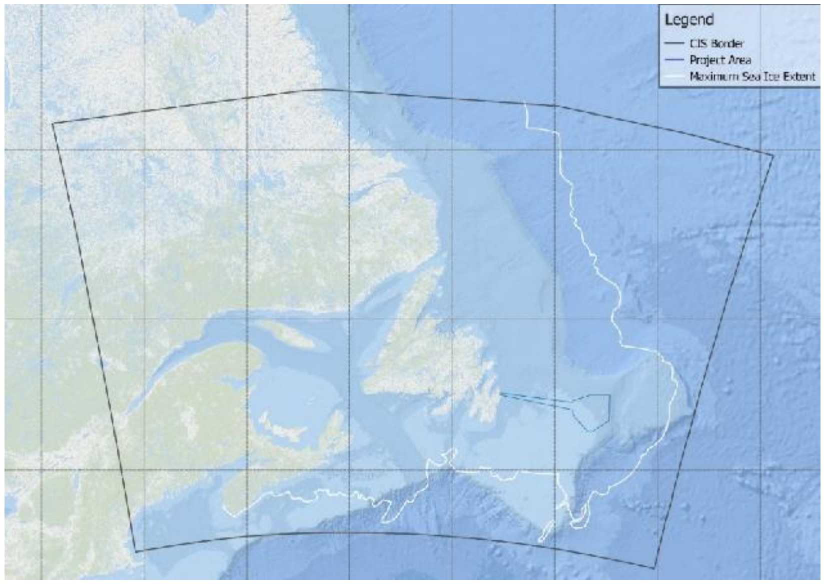


Figure 2.16 Maximum sea ice extent in the offshore Atlantic Canada region (Source: Figure 4-15 in Stantec 2018a [CIS Database 1970-2015]).

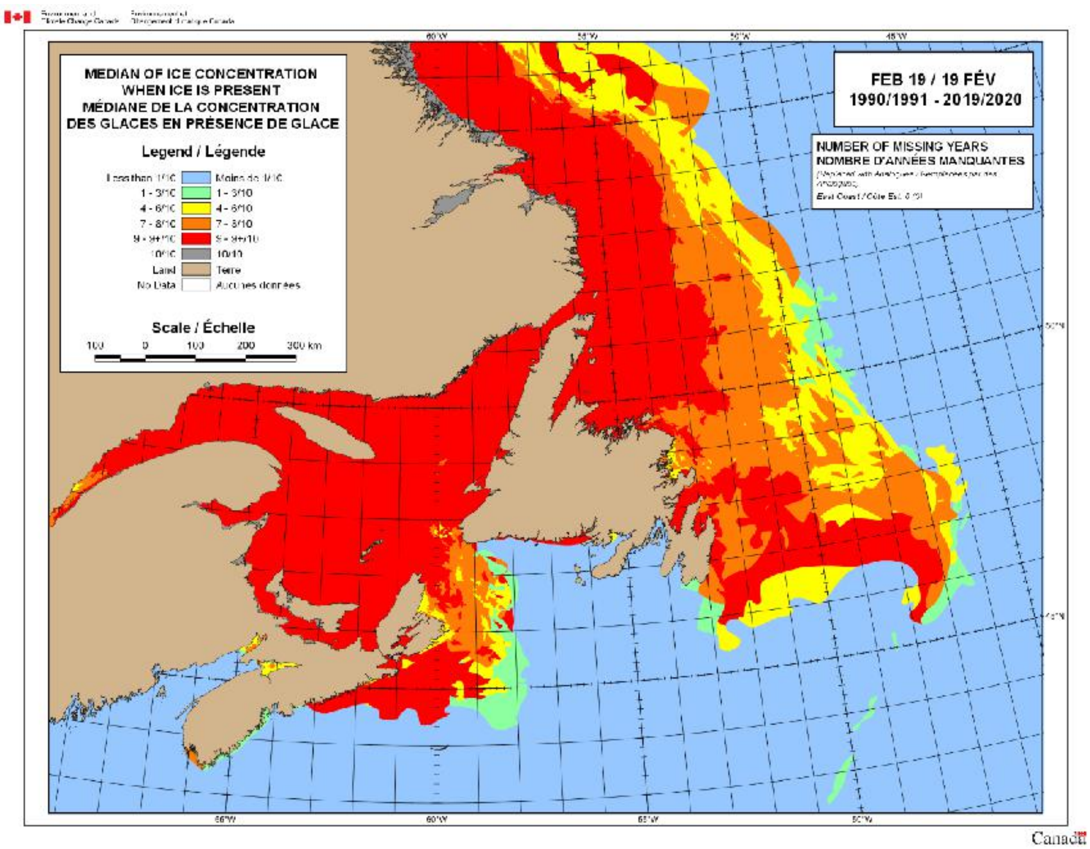


Figure 2.17 Median of ice concentration when ice is present for the week of 19 February, 1990-2020 (Source: CIS 2021; updated from Figure 4-17 in Stantec 2018a).

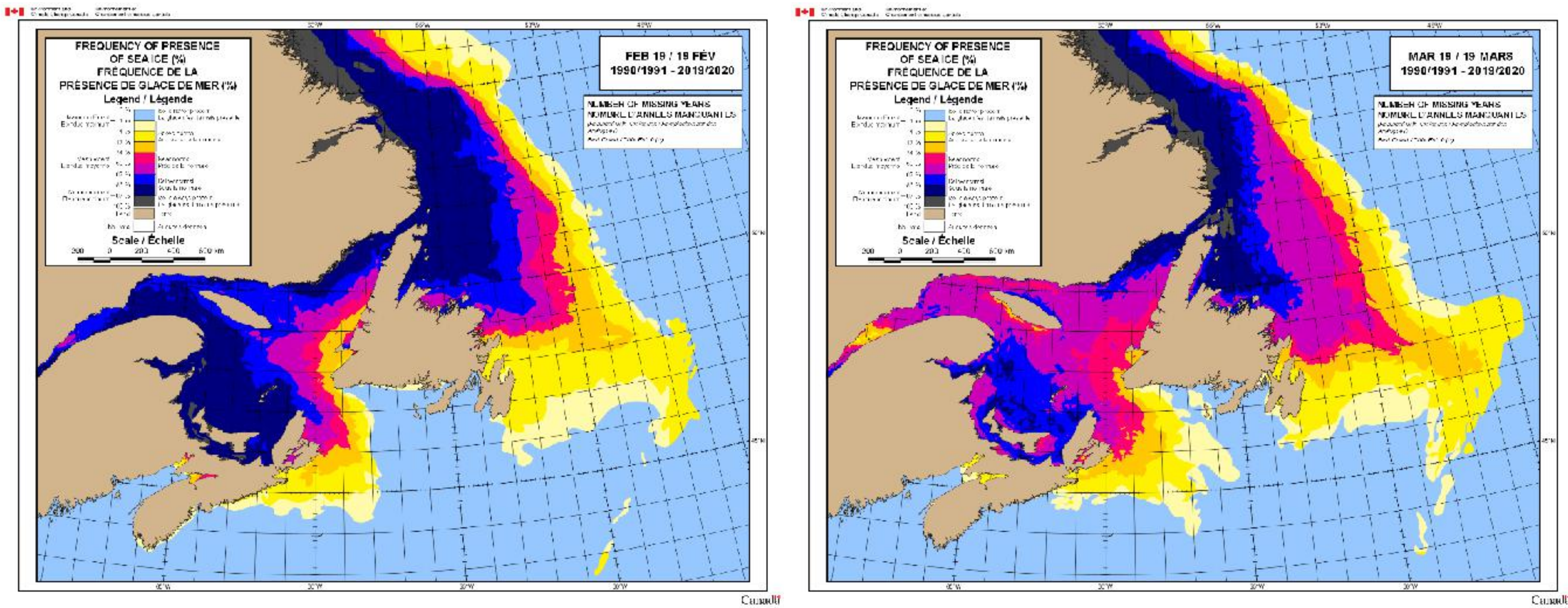


Figure 2.18 Frequency of the presence of sea ice for the week of 19 February (left) and 19 March (right), 1990-2020 (Source: CIS 2021; updated from Figure 4-16 in Stantec 2018a).

Warmer than average winter temperatures attributed 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 1.5% per year (Savard et al. 2016 in Stantec 2018b). 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 2018b).

2.2.10.2 Icebergs

The RSA may be subjected to high densities of icebergs as they travel south from Greenland (see Section 4.1.4.2 in Stantec 2018a). Iceberg movement is manipulated by both wind and ocean currents and iceberg sightings have variably occurred within the Project Area during all months of the year. From 1960-2015, the majority of and largest iceberg sightings in the region occurred from March-June (Figure 2.19). The presence of icebergs should be considered from late-winter through spring for any oil spill response plan.

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 exhibits high variability year-to-year (Stantec 2018b). No icebergs have been recorded crossing 48ºN in some years, while in other years there were over 1000 (Bigg 2015 in Stantec 2018b). 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 2018b).

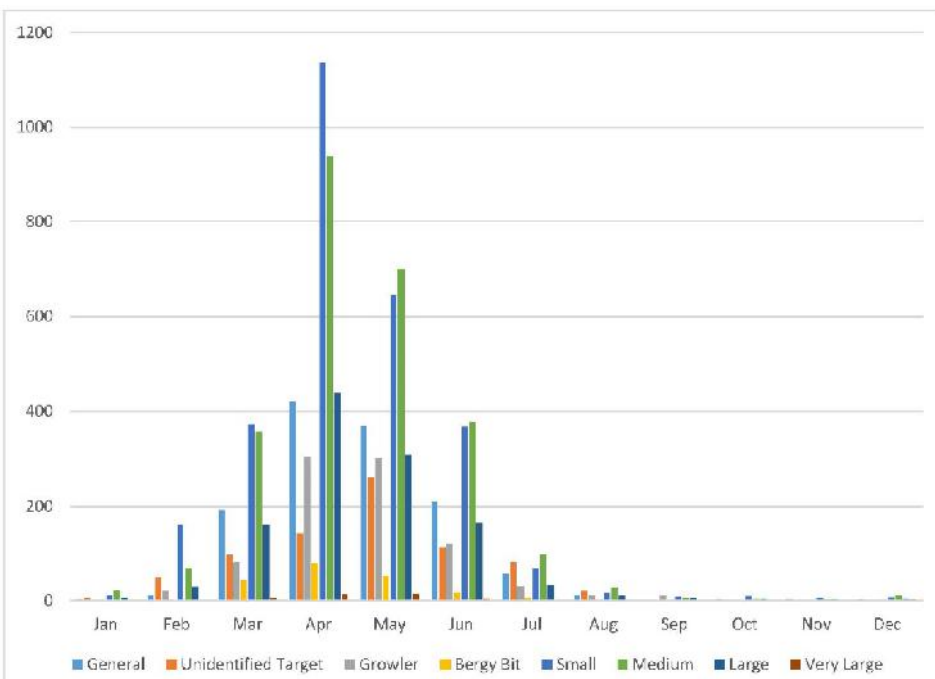


Figure 2.19. Iceberg sightings by month in the Project Area, 1985-2014 (Source: Figure 4-19 in Stantec 2018a).

2.2.10.3 *Marine Icing*

Both vessel and drilling installation activities may be negatively impacted by marine icing, often in the form of freezing spray (see Section 5.7.3 in ExxonMobil 2017). Freezing spray occurs when air temperatures drop below -2°C, which is most likely to occur throughout the winter and spring months in the Project Area (Figures 2.19 and 2.20). Marine icing should be considered for oil spill response plans, particularly from November through April (ExxonMobil 2017). Icing potential may be heavy (2-4 cm/hr) or extreme (>4 cm/hr) for vessels in the Project Area from December-March (ExxonMobil 2017).

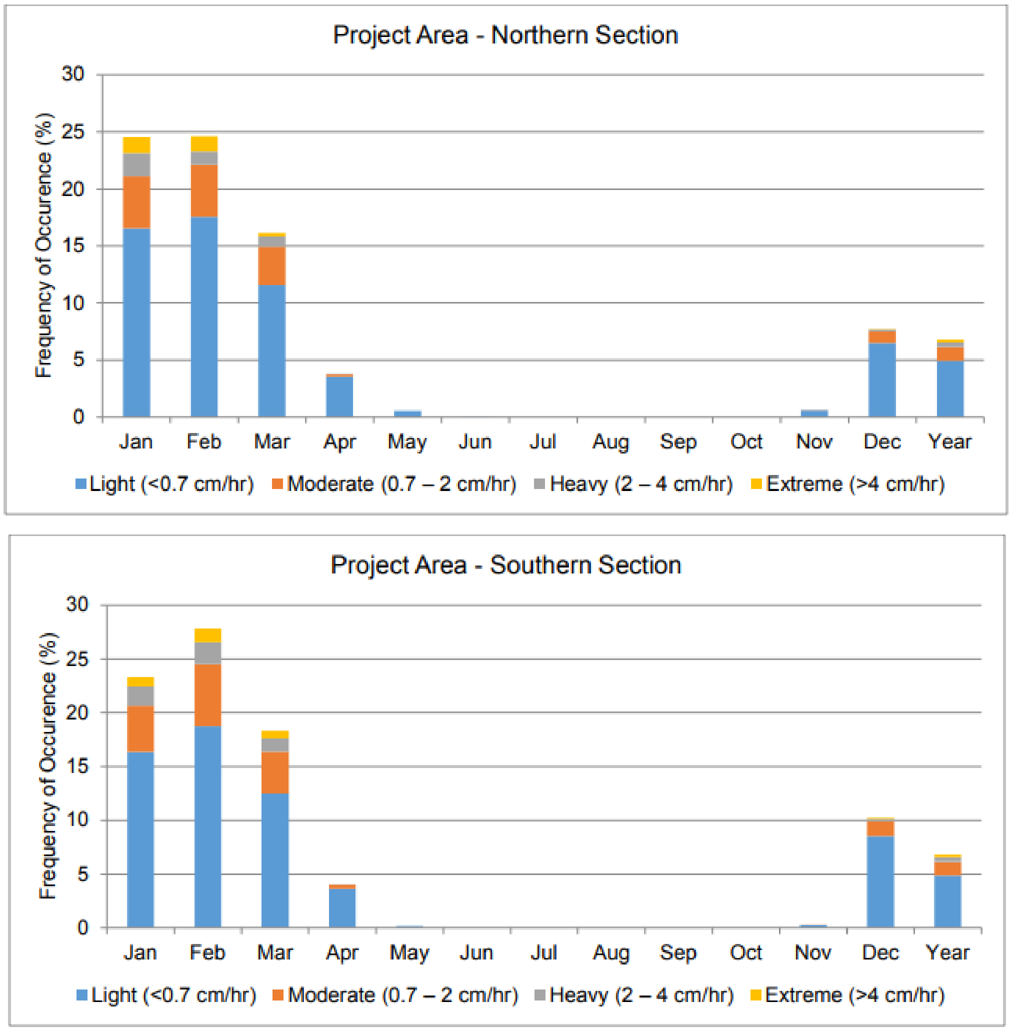


Figure 2.20. Icing potential in the Northern (top) and Southern (bottom) Project Area sections (Source: Figures 5-65 and 5-66 in ExxonMobil 2017).

2.3 Response Options

Summaries of available response options in the event of an oil spill are provided in this section (see Chapter 6 in NASEM 2020 for detailed, peer-reviewed analyses for each response option, including background information and an evaluation of the use of dispersants; see also Section 6.2 of LGL (2019) for a review of risks associated with dispersants and exposure to dispersed oil). 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 includes consideration of relevant environmental factors, such as sea state, weather, and visibility, and the time required 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 2.21). This updated 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:

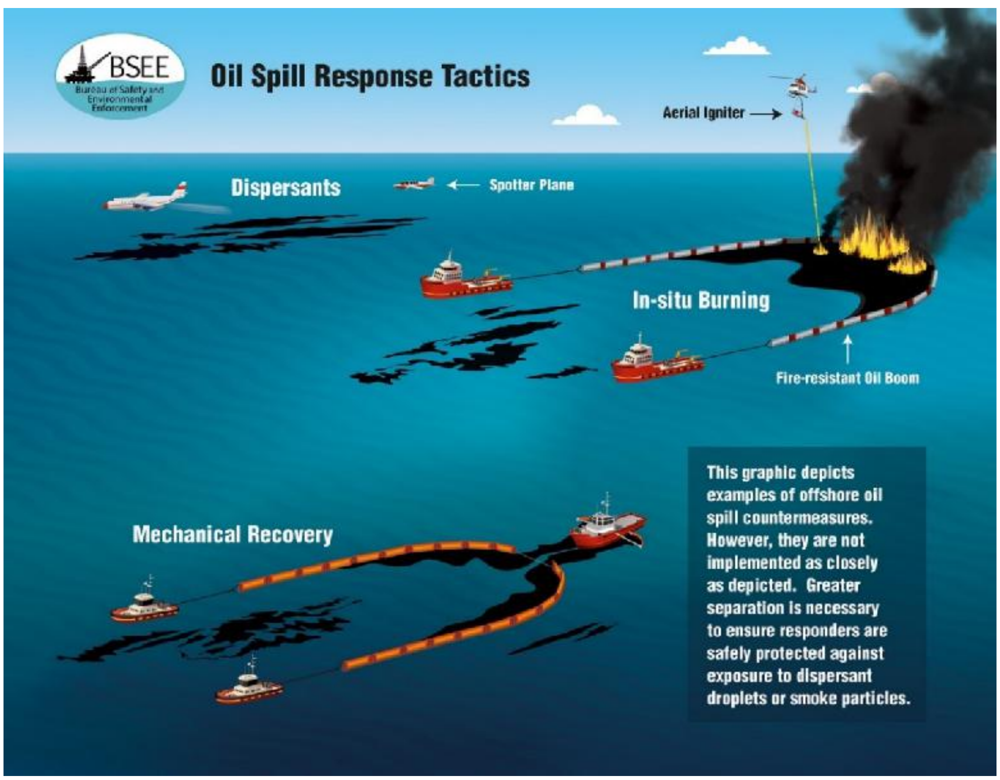


Figure 2.21. Examples of offshore oil spill response options (Source: BSEE 2023).

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).

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 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 RSA 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 RSA: Visibility is often reduced within the RSA due to the presence of thick fog, particularly during the spring and summer months (see Figures 2.4 and 2.5 above), when the Gale N-66 Well is planned to be drilled (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 relatively 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 RSA may also feature difficult terrain, such as rocky cliffs, and may also be inaccessible by land. Hurricane season within the RSA occurs from mid-August to mid-October, which coincides with planned operations at the Gale N-66 Well. Tropical storms and hurricanes have been making landfall within the RSA 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 ExxonMobil 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 (thereby reducing the potential for interaction with ROCs), 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 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 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 his 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 options 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 RSA: Much of the shoreline within the RSA 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 Gale N-66 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 typically travel at 1 knot (~1.9 km/h), although recent developments in boom/skimmer technology may allow vessel speed to increase to 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 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 safety 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 recover 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 RSA: 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 RSA often exceed this operational limitation, although they are relatively lower during the spring and summer months when activities are planned for the Gale N-66 Well (see Table 2.5 above). Visibility within the RSA can be greatly reduced by fog during the warmer months, particularly June and July (see Figures 2.4-2.5 and Tables 2.2-2.3 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 RSA, which may persist until the latter part of July or early August (see Figure 2.16 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 list of approved spill-treating agents under the *Canada Oil and Gas Operations Act* [JLW 2023]). 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 relatively 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 RSA: Due to the remote location of the Gale N-66 Well relative to shore, the potential for exposure to smoke plumes (including possibly increased concentrations of gases and airborne particles) 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 RSA often exceed these limitations, including during the spring and summer when activities are planned for the Gale N-66 Well (see Tables 2.4 and 2.5 above). Visibility within the RSA can be greatly reduced by fog during the warmer months, particularly June and July (see Figures 2.4-2.5 and Tables 2.2-2.3 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 RSA, which may persist until the latter part of July or early-August (see Figure 2.16 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 a surfactant, 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, weathering, and microbial degradation of oil components (e.g., DFO 2021). Small oil droplets that are diluted by 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. ExxonMobil has relevant information/documentation on COREXIT-9500A in house and 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 applications 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 RSA, 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 analyzed 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 recover 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 hours or days (DFO 2021) 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 2023). 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 RSA: Wave heights within the RSA are typically conducive to effective oil dispersal via surface dispersant application (see Table 2.5 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, its is anticipated that a dispersant aircraft could arrive at a spill site on the Flemish Pass 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 2023). Visibility within the RSA can be greatly reduced by fog during the warmer months, particularly June and July (see Figures 2.4-2.5 and Tables 2.2-2.3 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 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 sea water. 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; as such, it is assumed for this updated SIMA that an oil spill on the Flemish Pass would require a mobilization time of approximately one week (see also Section 3.8.1 in RPS 2019). 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 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 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 methods as a viable response option.

Considerations Specific to the RSA: 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 Project Area tend to be below 5 m (see Table 2.5 above). Response effectiveness may be reduced in relatively shallow areas (<500 m) within the Northern or Southern Project Areas due to hydrate formation and lower oil rise times relative to deeper areas (Sponson 2020). This could be applicable to the Gale N-66 Well, which will be located in a water depth of ~165 m.

3.0 Resources of Concern

ROCs were identified for this updated SIMA based on comprehension of the marine ecosystem and anthropogenic activities within the RSA and of human safety during oil spill response operations. Marine species within the RSA that are important for commercial and Food, Social, and Ceremonial (FSC) fishing were elucidated through consultations with Indigenous individuals and communities and publicly available documents and community websites (see Section 3.0 in Stantec 2018a and Section 3.7 below).

Oil spill-related ROCs are summarized in this section based on the identification framework above using data presented in the EIS (Stantec 2018a) and EA (IAAC 2020), updated where possible (e.g., critical habitat and the status of species at risk, and DFO [Fisheries and Oceans Canada] Research Vessel [RV] and commercial fisheries data) to provide spill response decision makers the most up-to-date information readily available to best inform response planning and operations. 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 [Section 2.2.5], waves [Section 2.2.6], reproduction/migration [Sections 3.2 and 3.4-3.5]).

Using the identification framework, the ROCs identified for the Program's SIMA (LGL 2019), including the ROCs used for the Program's previous SIMA (LGL 2019), which were added to/modified for this updated SIMA, are provided in Table 3.1. To improve clarify and reflect more recent SIMAs in the region, the ROC summaries provided in this Section are considerably more streamlined relative to the descriptions provided in the Program's previous SIMA (LGL 2019) and the reader is instead directed to relevant background documents (e.g., the EIS [Stantec 2018a] and EA [IAAC 2020]) for detailed information relative to each ROC. The reader is reminded that a SIMA is not a detailed replication of an EIS or EA, but rather is best used as a reference tool to support decision making during an oil spill response.

Table 3.1. Resources of Concern (ROCs) identified for the Program's previous SIMA and those used for this updated SIMA.

ROCs used for previous SIMA [a]	ROCs used for this updated SIMA
Fish and Fish Habitat	Special Areas and Species at Risk
Migratory Birds	Marine Fish and Fish Habitat
Marine Mammals	Invertebrates and Benthic Communities
Sea Turtles	Marine and Migratory Birds
Fisheries	Marine Mammals and Sea Turtles
	Socio-Economic
	Indigenous Fisheries
	Responder Health and Safety

[a] See Section 4.0 in LGL (2019).

To highlight spill response-relevant differences between inshore and offshore regions, a summary of associated habitat types for the ROCs used in this updated SIMA is provided in Table 3.2. Socio-Economic, Indigenous Fisheries, and Responder Health and Safety encompass all habitat types within the RSA.

Table 3.2. Habitats of Resources of Concern (ROCs) within the RSA (Source: Based on Table 3 in LGL 2019).

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	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

Habitat			ROC
Category	Type	Summary	
	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 NL contain various special areas, including sanctuaries, protected areas, fisheries closures, ecological reserves, and refuges and numerous species at risk (Stantec 2018a; IAAC 2020).

3.1.1 Special Areas

Special areas were previously incorporated across multiple ROCs (see Section 4.0 in LGL 2019); for increased clarity and to better align with more recent SIMAs (e.g., Sponson 2020), "Special Areas and Species at Risk" are now a separate ROC for this updated SIMA. All special areas protected under various legislation, whether they be federal, provincial, or international, are considered here (see Section 4.2.9 in Stantec 2018a). Additionally, areas which provide ecological, historical, and socio-economic value and/or hold stakeholder/regulatory interests are acknowledged. Figures 3.1-3.4 indicate the location of all special areas within the RSA (updated from Stantec 2018a). Fisheries closure areas, Marine Protected Areas (MPAs), marine refuges, National Marine Conservation Areas (NMCAs), Migratory Bird Sanctuaries (MBSs), national parks, wildlife areas, and critical habitats are all designated under federal legislation. Ecologically and Biologically Significant Areas (EBSAs) and Significant Benthic Areas (SBAs) are designated federally but not under legislation and, therefore, are not legally protected. Provincial parks and provincial protected areas are designated under the *Provincial Parks Act and Regulations* and receive legal protection under the Government of NL. Provincial historic sites are also designated and protected by the Government of NL. Internationally, Vulnerable Marine Ecosystems (VMEs) off Canada's east coast are designated and managed and/or protected (e.g., through closures to bottom contact fishing) by the Northwest Atlantic Fisheries Organization (NAFO) in conjunction with the Food and Agriculture Organization (FAO) of the United Nations (UN). UN Educational, Scientific and Cultural Organization (UNESCO) World Heritage Sites (WHSs) are managed/protected by the provincial and/or federal governments. BirdLife International Important Bird Areas (IBAs) are identified globally and those within Canada may or may not receive legislative protection, depending on whether they occur within areas under provincial or national protection (see Figure 3.16 below).

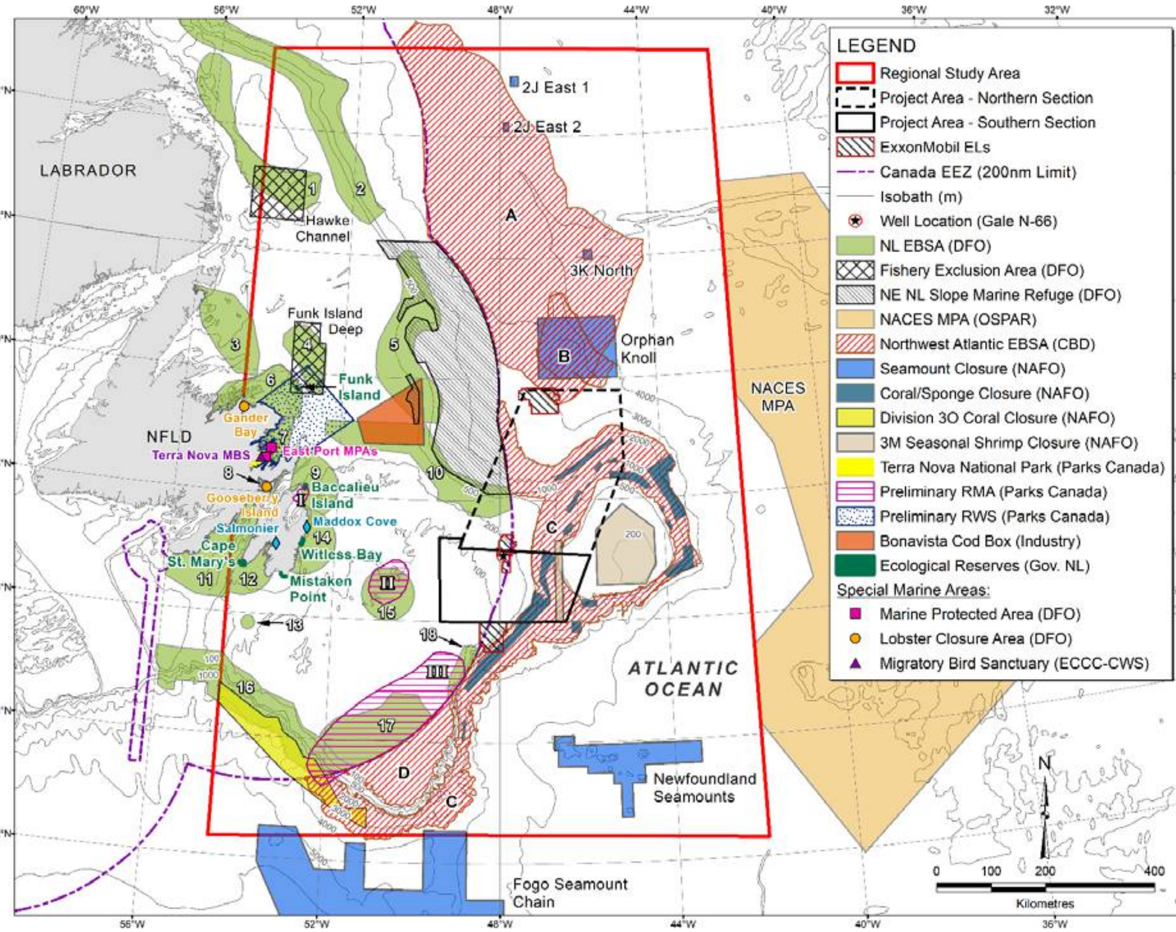
Under the *Oceans Act*, there are two MPAs within the RSA, Eastport Duck Island and Eastport Round Island; the Eastport MPAs are also designated reduced lobster fishing areas under the *Fisheries Act* (ExxonMobil 2017). There are two Lobster Closure Areas under the *Fisheries Act* within the RSA, Gooseberry Island and Gander Bay, where lobster fishing is prohibited to protect spawning habitat. Four marine refuges, including the Division 3O Coral Closure, Funk Island Deep Closure, Hawke Channel Closure, and Northeast Newfoundland Slope Closure, occur within the RSA; these areas are closed to certain fishing activities, such as bottom contact fishing and bottom trawling, to protect coral/sponge concentrations and benthic habitats that support a variety of species, including Atlantic cod (Stantec 2018a). One federal national park, Terra Nova National Park, occurs within the RSA (Stantec 2018a). There is one MBS within the RSA, the Terra Nova MBS, designated under the *Migratory Birds Convention Act* to protect numerous nesting forest and seabird species (ExxonMobil 2017). DFO has identified 18 EBSAs that occur within or overlap the RSA and are recognized as significant habitats to various marine species, including those of conservation concern (Wells et al. 2019). There are no critical habitats for marine mammals, sea turtles, or birds within the RSA. However, there are five critical habitat areas for northern and spotted wolffish that intersect with the RSA (DFO 2020). 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 RSA by Parks Canada as candidate sites for establishing new 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 RSA, and for small and large gorgonian corals in roughly the same depth range in the southwestern and northwestern portions of the RSA (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).

There are five ecological reserves under provincial regulation and the *Wilderness and Ecological Reserves Act* within the RSA, including Cape St. Mary's, Funk Island, Witless Bay, Mistaken Point, and Baccalieu Island, all of which host significant seabird breeding colonies and nesting areas (Stantec 2018a). Eight provincial parks designated under the *Provincial Parks Act* occur within the RSA, from Deadman's Bay in the north coast to Chance Cove on the southeast Avalon peninsula (TCAR 2016). There are two Coastal Nature Reserves (Salmonier and Maddox Cove) designated under the Nature Conservancy of Canada (NCC) to protect endemic lichens and important habitat for Atlantic salmon [Salmonier Nature Reserve] and coniferous forests and associated coastal regions that serve as important habitat for landbirds and seabirds (NCC 2023).

Internationally, there are 14 coral and sponge closure areas (three of which have split components [7 and 7a, 11 and 11a, and 14a and 14b]) and three seamount closure VMEs identified by NAFO that occur within or overlap the RSA (NAFO 2023). NAFO also designated a shrimp fishery closure area around the Flemish Cap. There is one UNESCO WHS (Mistaken Point Ecological Reserve), 13 IBAs, and an experimental fishery closure area designated by the fishing industry (Bonavista Cod Box) located within the RSA. 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, is adjacent to the eastern boundary of the RSA (OSPAR 2023). There are four Northwest Atlantic EBSAs designated by the Convention on Biological Diversity (CBD) within/overlapping the RSA: 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

Species at risk were previously incorporated across multiple ROCs (see Section 4.0 in LGL 2019); for increased clarity and to better align with more recent SIMAs (e.g., Sponson 2020), "Special Areas and Species at Risk" are now a separate ROC for this updated SIMA. There are various species at risk and species of conservation concern that occur in the marine habitats of the RSA. The EIS (see Section 4.2.8 in Stantec 2018a) provided in-depth descriptions and distribution maps of 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 RSA are provided in Table 3.3.



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 = Placentia Bay; 12 = St. Mary's Bay; 13 = Haddock Channel Sponges; 14 = Easter Avalon; 15 = Virgin Rocks; 16 = Southwest Slope; 17 = Southeast Shoal; 18 = 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. Special marine areas within or that overlap the RSA (Source: Wells et al. 2019; CBD 2023; MCI 2023; NAFO 2023a; OSPAR 2023; Protected Planet 2023).

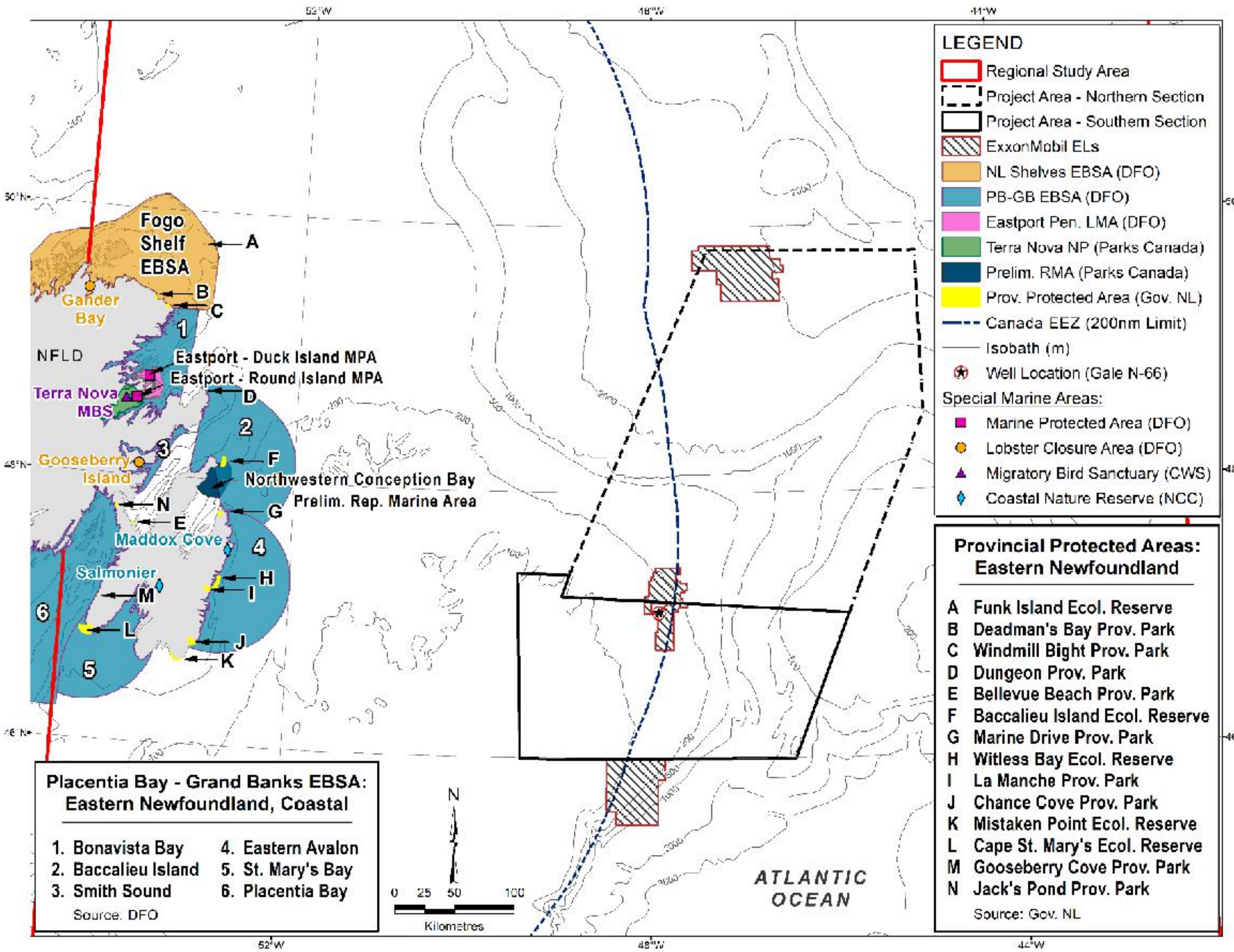


Figure 3.2. Special marine areas within coastal regions of the RSA (Source: Wells et al. 2019; MCI 2023; Protected Planet 2023).

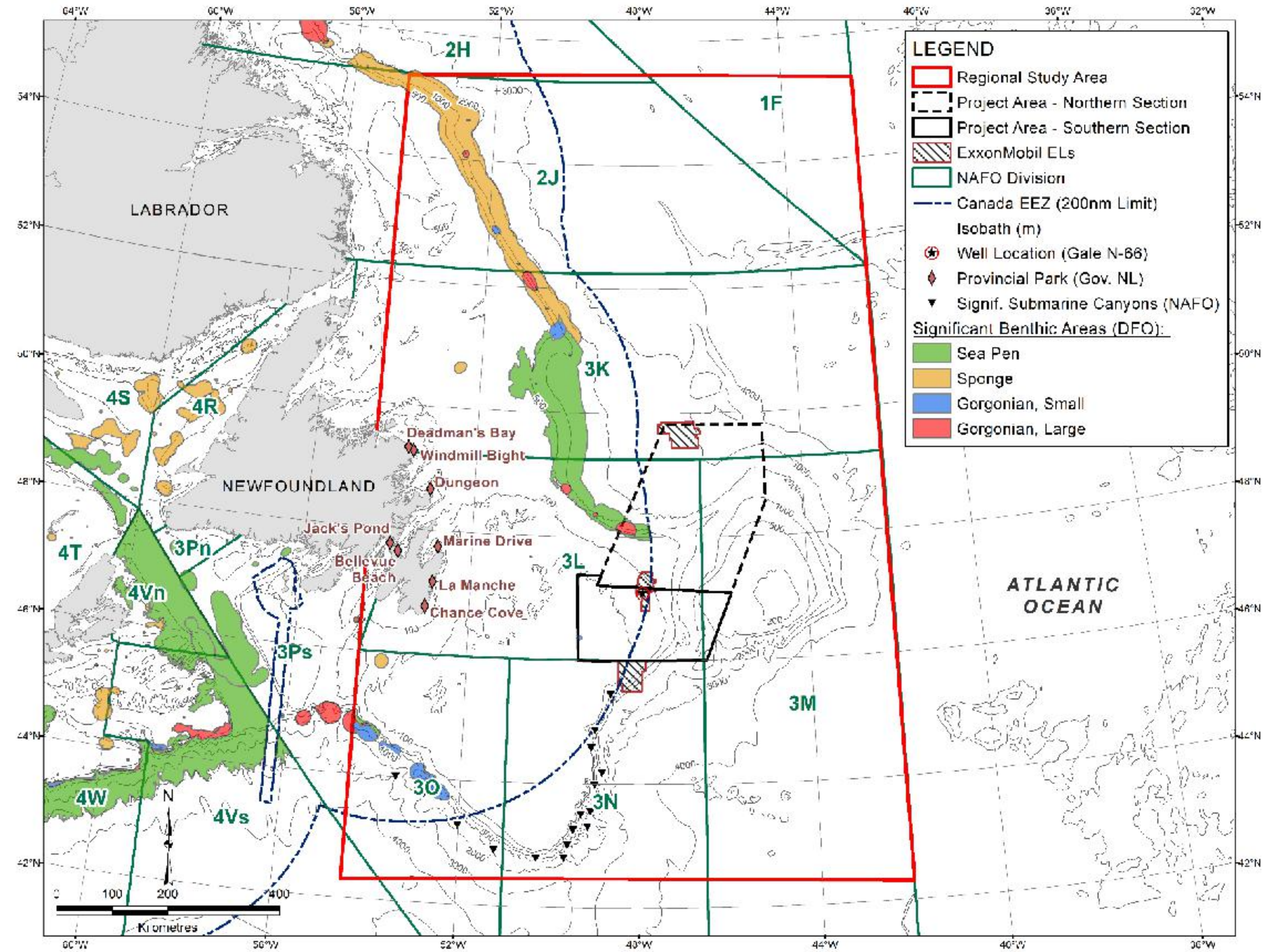


Figure 3.3. Significant benthic areas, significant submarine canyons, and provincial parks within or that overlap the RSA (Source: Kenchington et al. 2018a,b; J. Murillo-Perez, DFO, pers. comm., 2 May 2022).

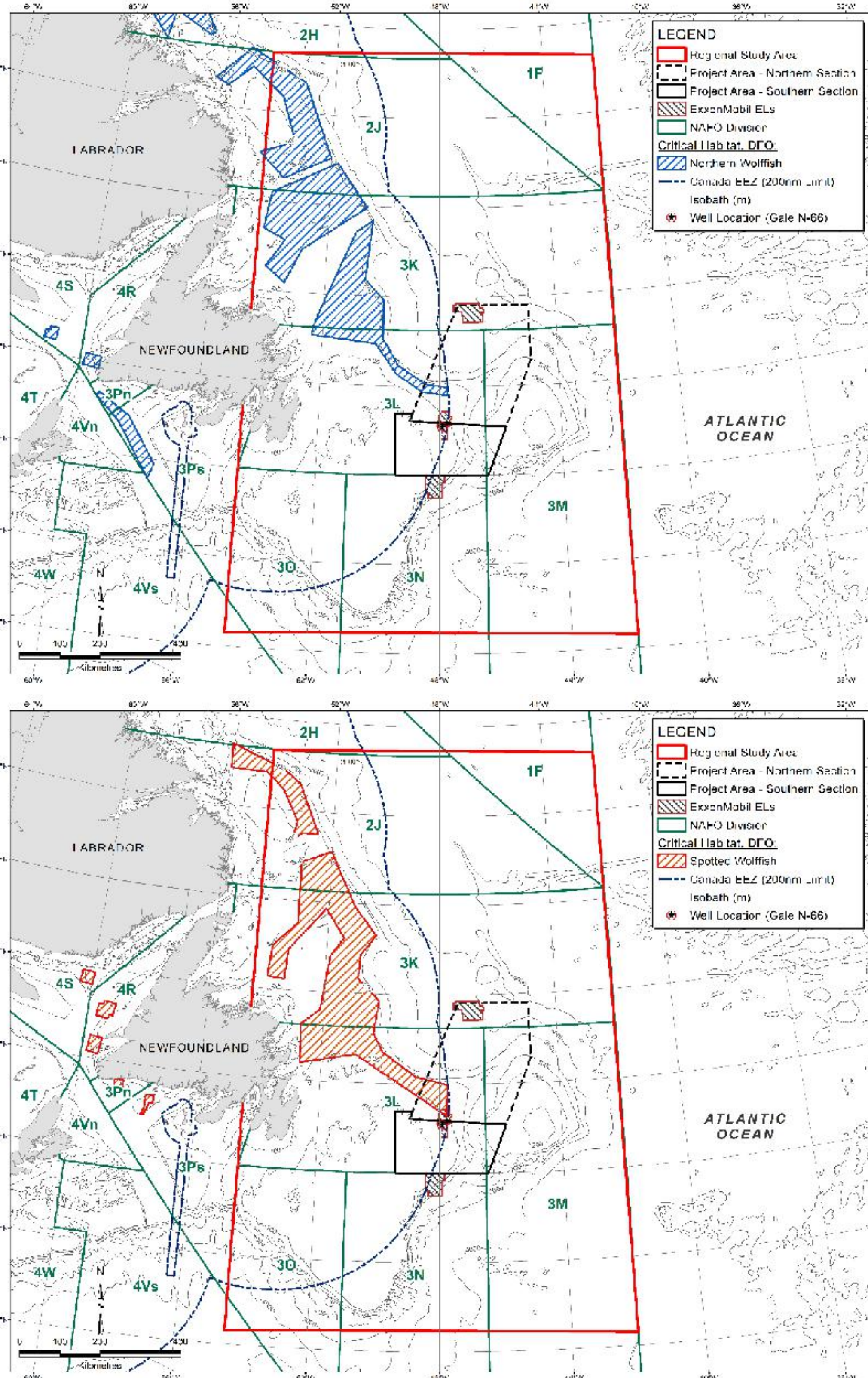


Figure 3.4. Critical habitats for northern (top) and spotted (bottom) wolffish (Source: DFO 2020).

3.2 Marine Fish and Fish Habitat

A variety of fish species and associated habitats are located within the RSA and Project Area. 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 led to their selection as a ROC.

Within the RSA, habitats in the marine environment transition from shallow shelf zones through to continental slopes and into deep abyssal regions (see Section 6.1 in IAAC 2020). These areas support high biodiversity and productivity while being essential to both fish and invertebrates that are commercially, culturally, and ecologically significant (IAAC 2020). Predominant fish species within the RSA (i.e., those contributing ≥0.1% to the total fish catch weight) recorded during the most recent five years of available spring and fall DFO RV trawl survey data (2017-2021) are provided in Table 3.4 [note: there were no spring surveys during 2020 or 2021 due to COVID-19; spring and fall surveys in 2021 were also affected by vessel issues, resulting in incomplete data]. Fish species with the highest abundance (in terms of catch weight) 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*). Of these six species, deepwater redfish (northern population), Atlantic cod (NL population), American plaice (NL population), and thorny skate have been assessed as at-risk by COSEWIC (see Table 3.3 below). These four species are also under consideration for addition to Schedule 1 of SARA (Government of Canada 2023).

Redfish, capelin, and grenadiers were identified in the EA as key fish species of commercial, recreational, or cultural importance within the RSA (IAAC 2020). The distributions of redfish, capelin, and grenadiers caught during 2017-2020 DFO RV surveys within the RSA are provided in Figures 3.5-3.7. Spawning periods and locations for the six predominant species noted above are provided in Table 3.5. Given their high probability of occurrence within the RSA and on/near the Flemish Pass, year-round presence, and wide distribution throughout the RSA, these species are at high risk for interaction with an oil spill in the area (IAAC 2020).

Table 3.3. Species at risk under SARA, COSEWIC, and the ESA that occur in the RSA (Source: updated from Appendix D in IAAC 2020).

Species Common Name (population)	SARA Status (Schedule 1) [a]	COSEWIC Assessment [b]	ESA Designation [c]
Fish			
Atlantic Wolffish	SC	SC	-
Northern Wolffish	T	T	-
Spotted Wolffish	T	T	-
American Eel	*	T	V
Basking Shark (Atlantic)	*	SC	-
Atlantic Cod (Newfoundland and Labrador)	*	E	-
Cusk	*	E	-
Lumpfish	*	T	-
Porbeagle Shark	*	E	-
Shortfin Mako (Atlantic)	*	E	-
Spiny Dogfish (Atlantic)	*	SC	-
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	-
Winter Skate (Eastern Scotian Shelf - Newfoundland population)	*	E	-
Atlantic Salmon (South 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
Hudsonian Godwit	*	T	-
Red Knot (*rufa* subspecies; Northeastern South America wintering)	*	SC	E
Red Knot (*rufa* subspecies; Southeastern USA/Gulf of Mexico/Caribbean wintering)	*	E	
Red Knot (*rufa* subspecies; Tierra del Fuego/Patagonia wintering)	E	E	

Species Common Name (population)	SARA Status (Schedule 1) [a]	COSEWIC Assessment [b]	ESA Designation [c]
Buff-breasted Sandpiper	SC	SC	-
Lesser Yellowlegs	*	T	-
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
Marine Mammals			
Blue Whale (Atlantic)	E	E	-
North Atlantic Right Whale	E	E	-
Fin Whale (Atlantic)	SC	SC	-
Sei Whale (Atlantic)	*	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	-
Ringed Seal	*	SC	-
Sea Turtles			
Leatherback Sea Turtle (Atlantic)	E	E	
Loggerhead Sea Turtle	E	E	

[a] Species listing under SARA (Government of Canada 2023).
[b] Species assessment by COSEWIC (COSEWIC 2023).
[c] Species designation by the Government of NL ESA (Government of NL 2023).
* Under consideration for addition.
** Delisted from SARA.
Note: E = Endangered; T = Threatened; SC = Special Concern; V = Vulnerable; NR = Not at Risk; "-" = No status.

Table 3.4. Predominant fish species that occur in the RSA and Flemish Pass (Source: DFO RV survey database, 2017-2021 [adapted from Tables 4.23 and 4.24 in Stantec 2018a]).

Common Name	Scientific Name	Potential for Occurrence in the RSA	Potential for Occurrence on/near the Flemish Pass	Timing of Presence on/near the Flemish Pass
Demersal				
Deepwater Redfish*	*Sebastes mentella*	High	Year-Round	High
Atlantic Cod*	*Gadus morhua*	High	Year-Round	High
American Plaice*	*Hippoglossoides platessoides*	High	Year-Round	High
Yellowtail Flounder	*Limanda ferruginea*	High	Year-Round	High
Thorny Skate*	*Amblyraja radiata*	High	Year-Round	High
Greenland Halibut	*Reinhardtius hippoglossoides*	High	Year-Round	High
Sand Lance	*Ammodytes sp.*	Moderate	Year-Round	Moderate
Roughhead Grenadier	*Macrourus berglax*	High	Year-Round	Moderate
Silver Hake	*Merluccius bilinearis*	Moderate	Year-Round	Moderate
Witch Flounder	*Glyptocepalus cynoglossus*	Moderate	Year-Round	Moderate
Atlantic Halibut	*Hippoglossus hippoglossus*	Moderate	December to March	Moderate
Northern Wolffish	*Anarhichas denticulatus*	Moderate	Year-Round	Moderate
White Hake*	*Urophycis tenuis*	Moderate	Year-Round	Moderate
Atlantic Wolffish**	*Anarhichus lupus*	Moderate	Year-Round	Low
Spotted Wolffish**	*Anarhichas minor*	Moderate	Year-Round	Low
Spinytail Skate	*Raja spinicauda*	High	Year-Round	Low
Roundnose Grenadier*	*Coryphaenoides rupestris*	Moderate	Year-Round	Low
Longfin Hake	*Urophycis chesteri*	Moderate	Year-Round	Low
Golden Redfish	*Sebastes marinus*	Moderate	Year-Round	Low
Marlin Spike	*Nezumia bairdi*	Moderate	Year-Round	Low
Spiny Dogfish Shark*	*Squalus acanthias*	Moderate	Year-Round	Low
Atlantic Haddock	*Melanogrammus aeglefinus*	Moderate	Year-Round	Low
Black Dogfish Shark	*Centroscyllium fabricii*	Moderate	Year-Round	Low
Shorthorn Sculpin	*Myoxocephalus scorpius*	Moderate	Year-Round	Low
Moustache Sculpin	*Triglops murrayi*	Moderate	Year-Round	Low
Monkfish	*Lophius americanus*	Moderate	Year-Round	Low
Blue Hake	*Antimora rostrata*	Moderate	Year-Round	Low
Arctic Cod	*Boreogadus saida*	Moderate	Year-Round	Low
Longhorn Sculpin	*Myoxocephalus octodecemspinosus*	Moderate	Year-Round	Low
Longnose Eel	*Synaphobranchus kaupi*	Moderate	Year-Round	Low
Common Lumpfish*	*Cyclopterus lumpus*	Moderate	Year-Round	Low
Sea Raven	*Hemitripterus americanus*	Moderate	Year-Round	Low
Pelagic				
Capelin	*Mallotus villosus*	High	Year-Round	Moderate
Greenland Shark	*Simniosus microcephalus*	Moderate	June to October	Low
Atlantic Herring	*Clupea harengus*	Moderate	Year-Round	Low
Atlantic Salmon***	*Salmo salar*	Migratory/Transient	Smolt: Year-Round; Post-Smolt and Adults: Winter	Migratory/Transient

* Assessed under COSEWIC.
** Listed on Schedule 1 of SARA and assessed under COSEWIC.
*** Was not caught during DFO RV surveys (2017-2021) but has multiple populations or Designatable Units (DU's) which can occur in the area, one of which has at-risk status under COSEWIC.

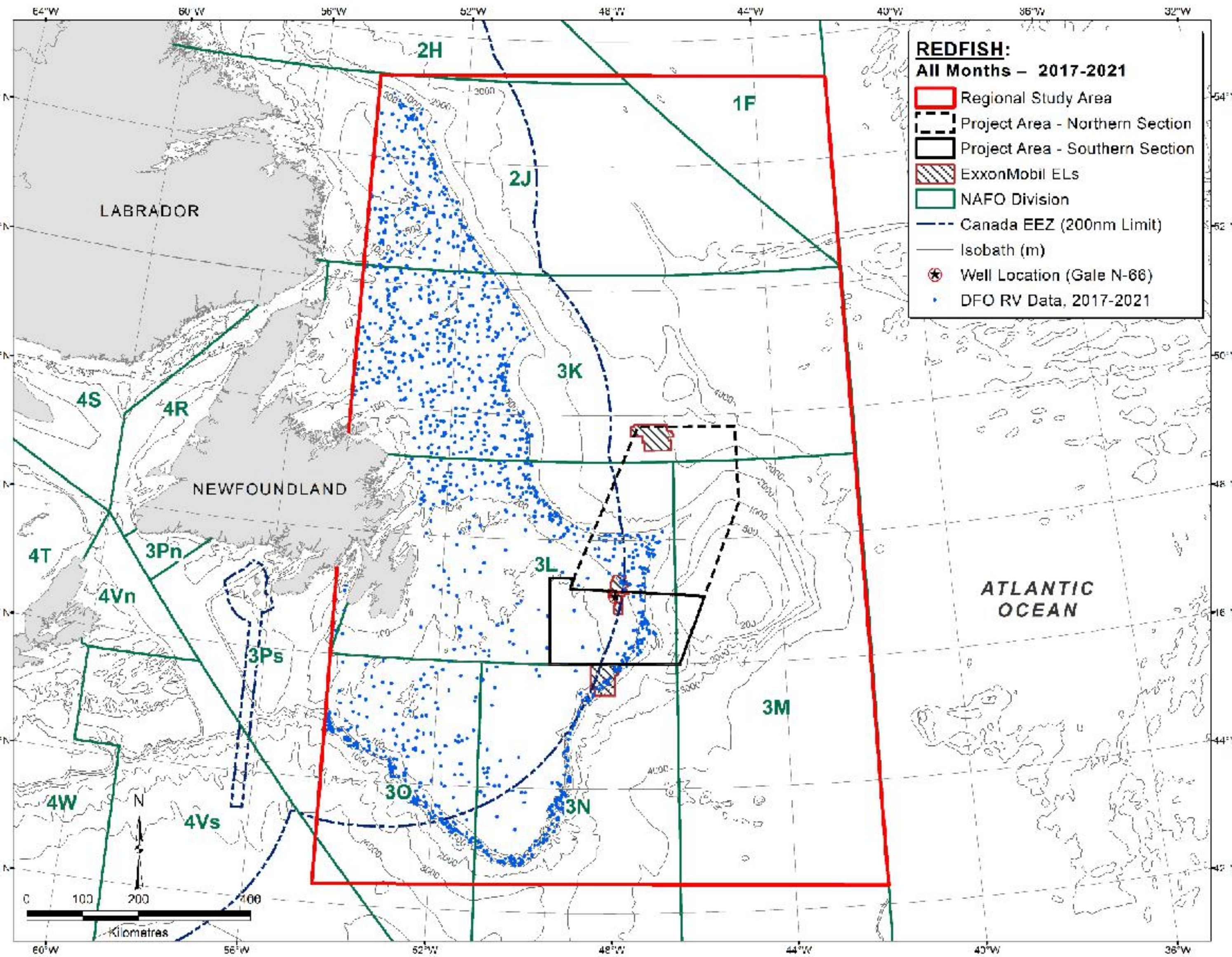


Figure 3.5. Distribution of redfish in the RSA (Source: DFO RV database, 2017-2021; each blue point represents a catch location).

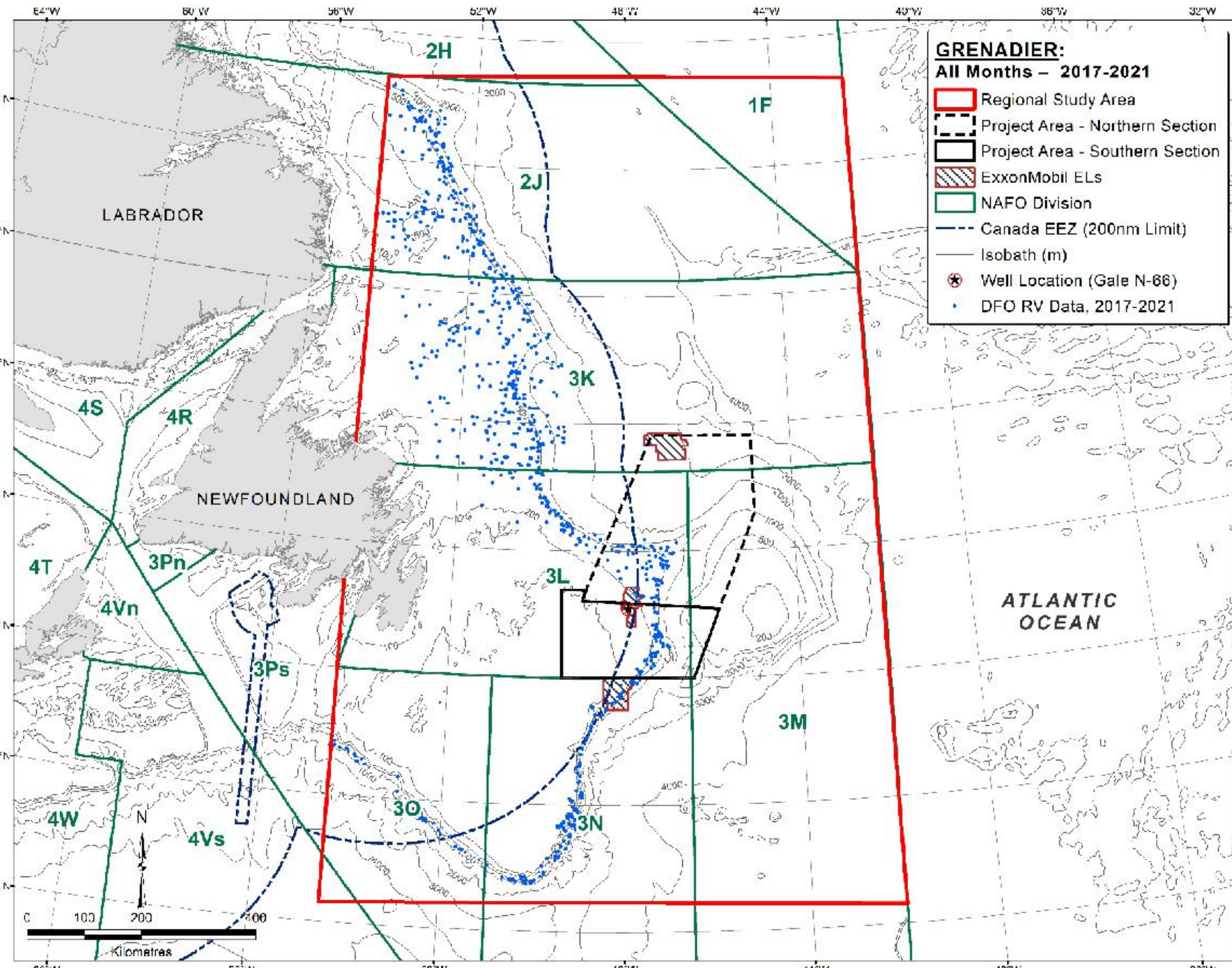


Figure 3.6. Distribution of grenadiers in the RSA (Source: DFO RV database, 2017-2021; each blue point represents a catch location).

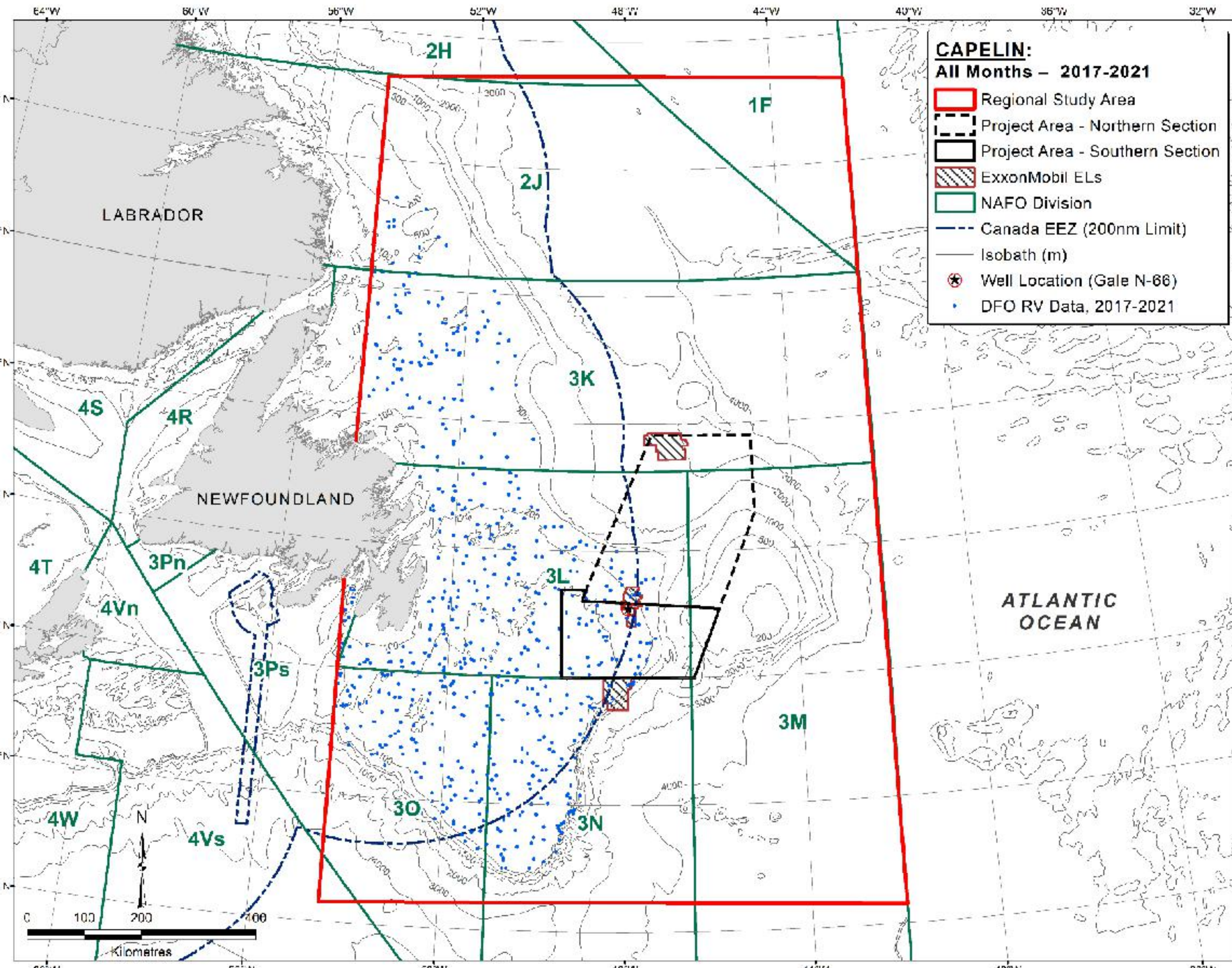


Figure 3.7. Distribution of capelin in the RSA (Source: DFO RV database, 2017-2021; each blue point represents a catch location).

Table 3.5. Timing and location of spawning events for some key fish species in the RSA (Source: adapted from Tables 4.23 and 4.24 in Stantec 2018a).

Common Name	Scientific Name	Spawning Time												Known Spawning Locations
		J	F	M	A	M	J	J	A	S	O	N	D	
Sand lance	*Ammodytes dubius*	■	■	■								■	■	Grand Bank[1]
Capelin	*Mallotus villosus*						■	■						Southeast shoal of Grand Bank[1] Coastal waters of Newfoundland[1]
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[2]
American plaice (NL population)	*Hippoglossoides platessoides*			■	■	■								Hamilton Bank, northeast Newfoundland Shelf, and over the entire Grand Bank and St. Pierre Bank[3]
Sculpin	*Triglops* sp.								■	■	■	■		No particular spawning location[1]
Lanternfish	Myctophidae				■	■	■	■						No particular spawning location[1]
Atlantic cod (NL population)	*Gadus morhua*				■	■	■	■	■	■	■			Spawning occurs in waters off Newfoundland with depths ranging from tens to hundreds of metres[4]
Greenland halibut	*Reinhardtius hippoglossoides*	■	■	■									■	Spawning is 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[5]
Blue hake	*Antimora rostrata*													Not known to spawn in Canadian waters[1]
Roughhead grenadier	*Macrourus berglax*	■	■	■	■									Southern Grand Bank[1,6]
Common grenadier	*Nezumia bairdii*	■	■	■	■									No particular spawning location[1]

Note: Shading indicates spawning periods.
Sources: [1] ExxonMobil (2017); [2] Ollerhead (2004); [3] COSEWIC (2009); [4] COSEWIC (2010); [5] Gunderson et al. (2010); [6] Stantec (2018a).

3.3 Invertebrates and Benthic Communities

Invertebrate species and benthic communities were previously incorporated into the Fish and Fish Habitat ROC (see Section 4.0 in LGL 2019); to improve clarity and better align with more recent SIMAs in the region (e.g., Sponson 2020), "Invertebrates and Benthic Communities" are now a separate ROC for this updated SIMA. Invertebrates is a catch all designation for a wide diversity of fauna, 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 blowout, their potential interaction with oil will depend on where the organism lives (including during different life stages) and how the oil disperses in the water column. For the purposes of this updated SIMA, invertebrates will be broadly divided into two groups, pelagic and benthic.

3.3.1 Pelagic Invertebrates

Pelagic invertebrates consist of animals that either live solely in the pelagic environment or swim upwards from the benthos to feed. Northern shrimp (*Pandalus borealis*) and striped shrimp (*Pandalus montagui*) were the most abundant non-gelatinous pelagic invertebrate species caught within the RSA during the most recent DFO RV surveys with available data (2017-2021). Northern shrimp was identified in the EA as a key pelagic benthic invertebrate species of commercial, recreational, or cultural importance within the RSA (IAAC 2020). Northern shrimp are mainly concentrated along the continental shelf (Figure 3.8) and have been an essential part of the region's commercial fisheries since the 1970s, particularly after the cod fishery collapse in the early 1990's (Stantec 2018a).

Cnidarians and ctenophores (comb jellies) are common gelatinous pelagic invertebrates in the RSA. In recent years, annual jellyfish abundance within the RSA has been observed to reach its peak in late-summer in response to SST changes and advective processes that foster aggregations of this species group (ExxonMobil 2017). Most jellyfish are carnivores, consuming zooplankton, larval and adult fish, and invertebrates (ExxonMobil 2017). Jellyfish and tunicates (salps and doliolids) are fundamental prey for leatherback turtles, sunfish, and bluefin tuna (ExxonMobil 2017; Stantec 2018a). Like plankton, tunicates contribute to the pelagic biological pump processes, while jellyfish may function as a catalyst to the biological pump process within the RSA (ExxonMobil 2017).

3.3.2 Benthic Community

The marine benthic community is a diverse group of taxa that live on the seafloor and serve integral roles in ocean ecosystems (see Section 4.2.2 in Stantec 2018a). Benthic invertebrates influence/enhance nutrient cycling and biochemical processes and are a critical component of the benthic food web (Stantec 2018a). Benthic species distributions are highly dependent on environmental conditions (Stantec 2018a) that are associated with varying depths (i.e., currents, temperature, and nutrition). Therefore, there are no "typical" benthic species for the Project Area, but rather assemblages of species associated with depth zones (ExxonMobil 2017). Predominant taxological groups at different depths are provided in Table 3.6, including bivalves, echinoderms, polychaetes, brachiopods, corals, and sponges. Propeller clam (*Cyrtodaria siliqua*) and snow crab (*Chionoecetes opilio*) were identified in the EA as key benthic invertebrate species of commercial, recreational, or cultural importance within the RSA (IAAC 2020). Their distribution of from 2017-2020 DFO RV surveys within the RSA is provided in Figures 3.9-3.10.

Some benthic invertebrates (i.e., corals and sponges) form structural colonies that are important habitats for other animals, including fish. The habitat formed by corals depends on how and where they grow, and different corals can provide a home for various marine animals during

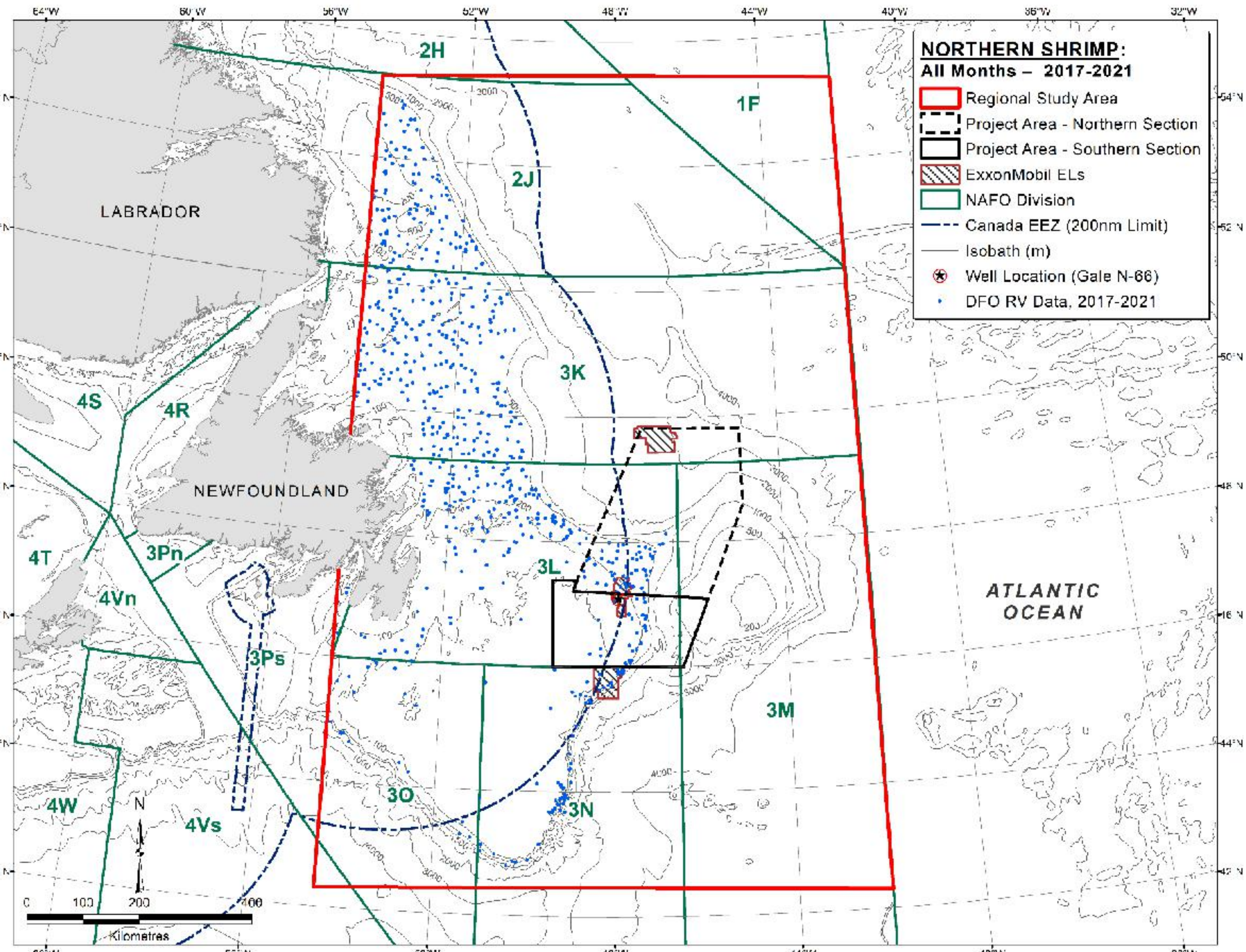


Figure 3.8. Distribution of northern shrimp in the RSA (Source: DFO RV database, 2017-2021; each blue point represents a catch location).

Table 3.6. Predominant invertebrate taxa at different depths on the Grand Bank Shelf and Flemish Pass (Source: Adapted from Tables 6.3 and Table 6.6 in ExxonMobil 2017).

Area	Common Name	Scientific Name
Grand Bank Shelf		
Shelf/Slope Edge 70-100 m	Brittlestars	Ophiuroidea (O)
	Sand dollar	*Echinarachnius parma*
	Icelandic scallop	*Chlamys islandica*
	Pale sea urchin	*Strongylocentrotus pallidus*
	Whelks	Buccinidae (F)
	Crabs	Majidae (F)
	Polychaetes	Sabellidae (F)
Shelf/Slope Edge 120-150 m	Polychaetes	Sabellidae (F)
	Amphipod	*Priscillina armata*
	Chalky macoma	*Macoma calcarea*
	Sand dollar	*Echinarachnius parma*
	Propeller clam	*Cyrtodaria siliqua*
	Brittlestar	*Ophiura sarsi*
	Pale sea urchin	*Strongylocentrotus pallidus*
	Boreal astarte	*Astarte borealis*
	Snow crab	*Chionoecetes opilio*
	Soft coral	*Gersemia* sp.
Shelf/Slope Edge 150-250 m	Sand dollar	*Echinarachnius parma*
	Green sea urchin	*Strongylocentrotus droebachiensis*
	Hydrozoan	*Sertularia fabricii*
	Hydrozoan	*Thuiaria thuja*
Flemish Pass		
Middle-Deep Slope 400-1400 m	Sponges	Porifera (P)
	Echinoderms	Echinodermata (P)
	Cnidarians	Cnidaria (P)
	Arthropods	Arthropoda (P)
	Chordates	Chordata (P)
	Annelids	Annelida (P)
	Ectoprocts	Ectoprocta (P)
	Molluscs	Mollusca (P)
	Brachiopods	Brachiopoda (P)
	Unidentified	Unidentified

Note: Taxonomic group: (P) = Phylum; (O) = Order; (F) = Family.

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 4.2.3 in Stantec 2018a for detailed descriptions of corals and sponges within the RSA). 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 RSA. They can also be found growing more spread out over a larger area, such as the northeast Grand Bank (see Figure 6-12 in ExxonMobil 2017). The distribution of corals and sponges within the RSA based on data from 2017-2021 DFO RV surveys is provided in Figure 3.11. Since corals and sponges are sessile and have a low metabolic rate, they are known to be sensitive to disturbances (Stantec 2018a). Corals and sponges that may occur on the Flemish Pass and/or northeast Grand Bank within the RSA are provided in Tables 3.7 and 3.8.

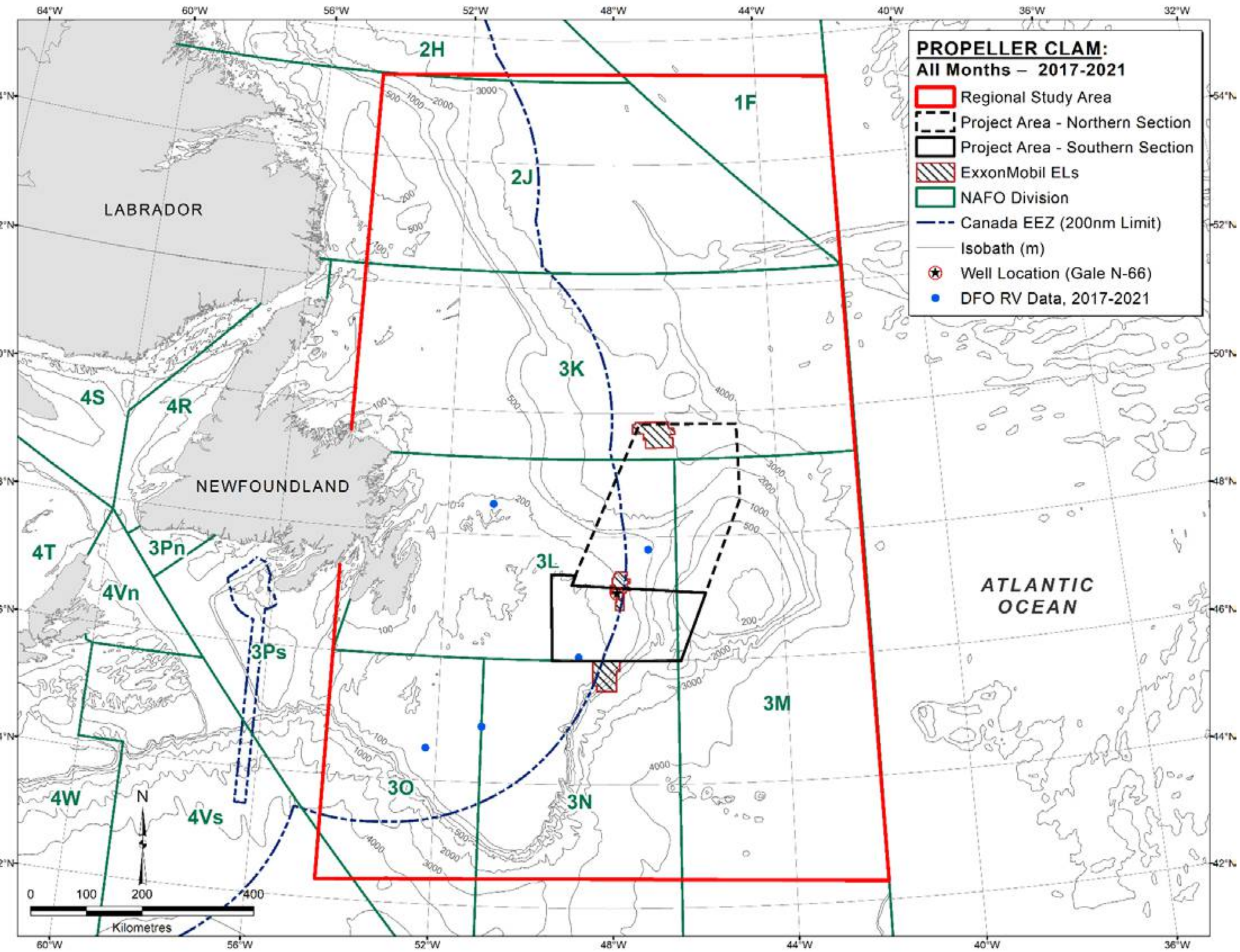


Figure 3.9. Distribution of propeller clam in the RSA (Source: DFO RV database, 2017-2021; each blue point represents a catch location [note: DFO RV surveys do not include dredges as survey gear, so while this species is important for the commercial fisheries, there are few catches during DFO RV surveys; blue points enlarged for improved visibility]).

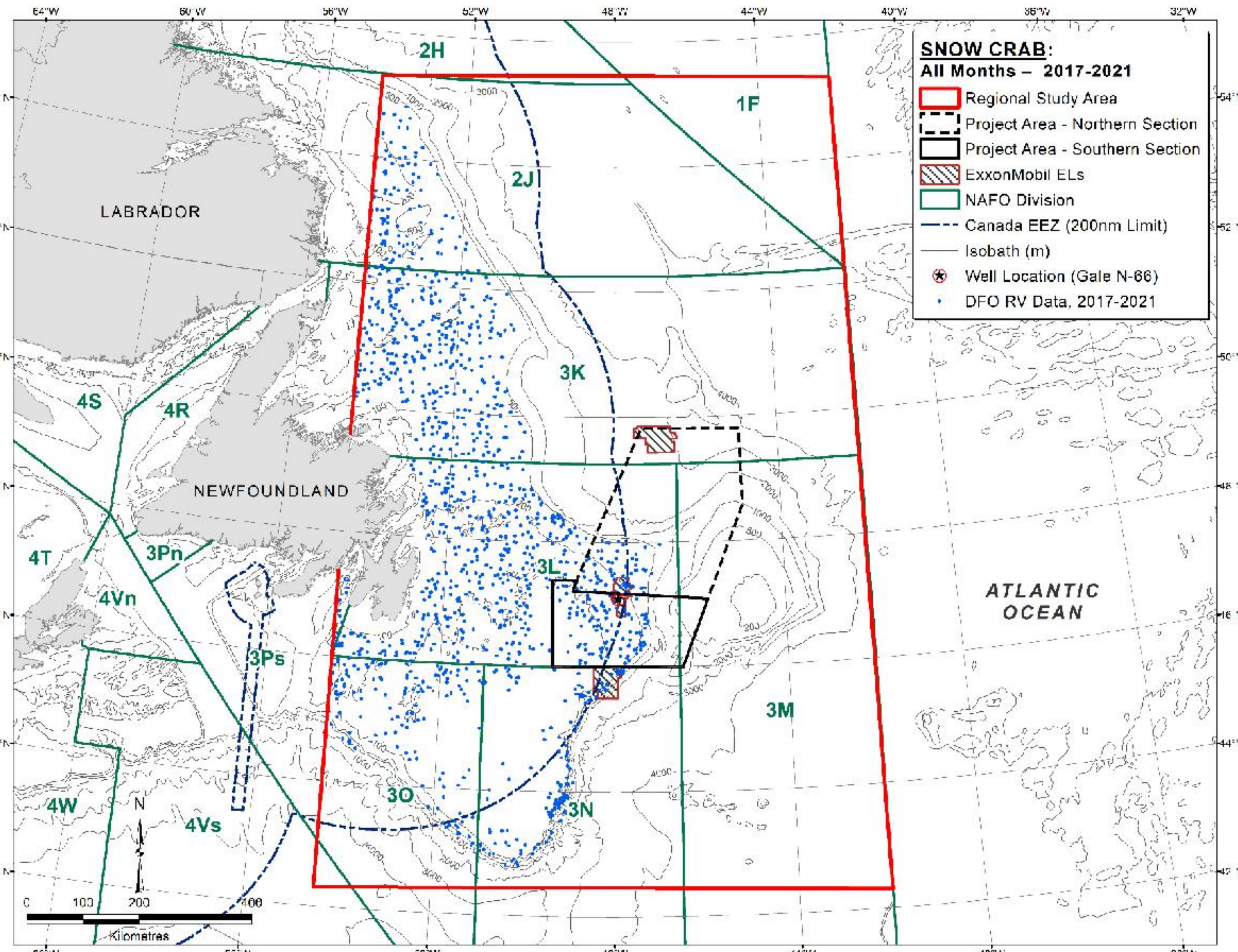


Figure 3.10. Distribution of snow crab in the RSA (Source: DFO RV database, 2017-2021; each blue point represents a catch location)

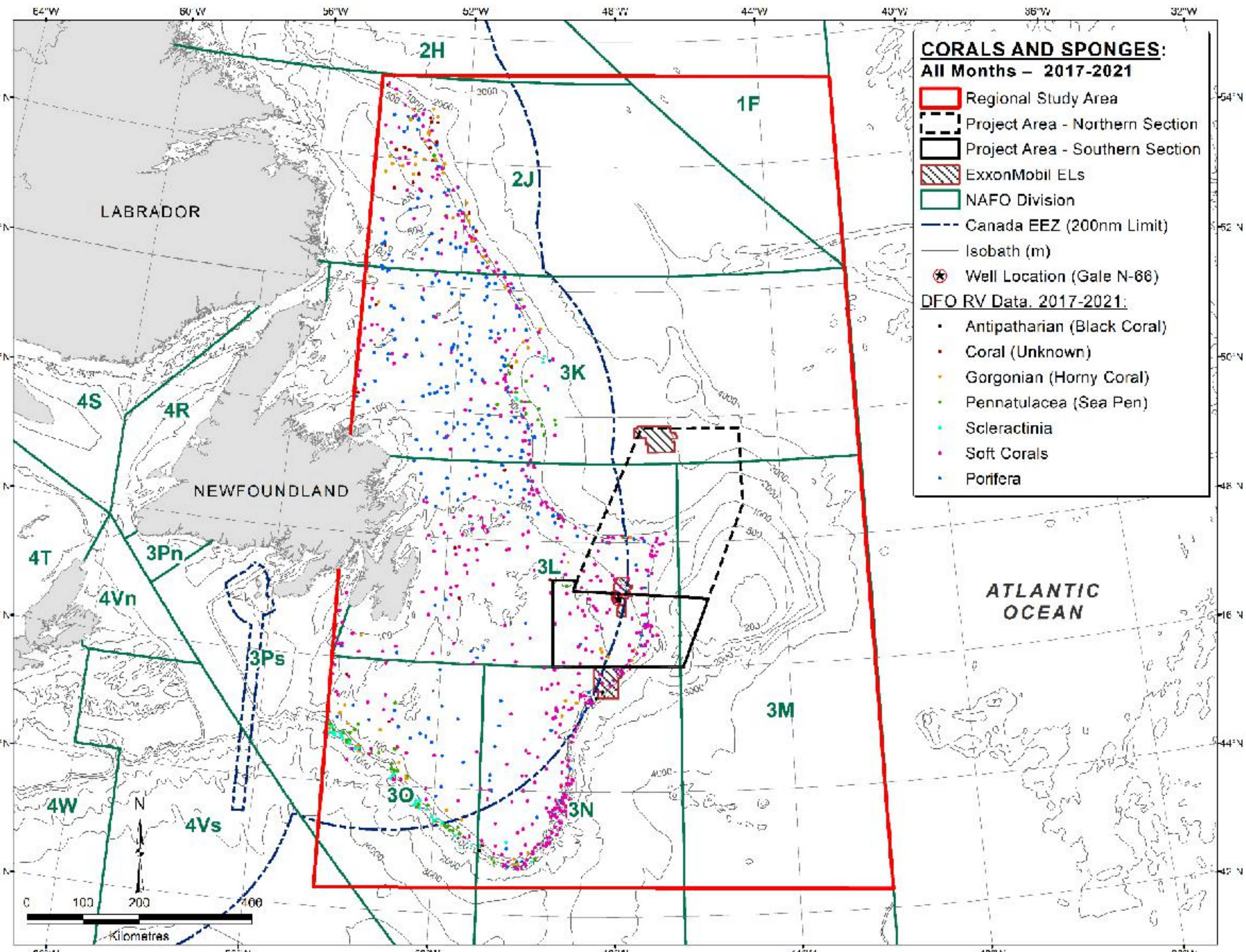


Figure 3.11. Distribution of corals and sponges in the RSA (Source: DFO RV database, 2017-2021; each point represents a catch location).

Table 3.7. Corals that may occur on the Flemish Pass and northeast (NE) Grand Bank (Source: Adapted from Table 6.8 in ExxonMobil 2017).

Order	**Group**	**Species Name**	**Depth Range (m)**	**Flemish Pass**	**NE Grand Bank**
Antipatharia	Black-wire corals	*Bathypathes* spp		■	
		Leiopathes sp.		■	
		Stauropathes artica	480-970	■	■
		Stauropathes magna		■	
Alcyonacea	Large gorgonians	*Acanella arbuscula*	480-1442	■	■
		Keratoisis ornata		■	
		Keratoisis sp.		■	
		Paragorgia arborea	250-750	■	■
		Paramuricea spp.	335-1351	■	■
		Primnoa resedaeformis	527		■
	Small gorgonians	*Acanthogorgia* sp.		■	
		Acanthogorgia armata	494-1351	■	
		Anthothela grandiflora	707-1351	■	
		Radicipes gracilis	416-1370	■	
	Soft corals	*Anthomastus grandiflorus*	612	■	
		Anthomastus sp.	-	■	
		Anthomastus spp.	1095-1370	■	
		Duva florida	56-1374	■	■
		Gersemia rubiformis	46-246	■	■
		Heteropolypus cf. insolitus	-	■	
		Nephtheidae indet.	-	■	■
Schleractinia	Solitary stony corals	*Flabellum alabastrum*	359-1189	■	■
		Flabellum angulare	-	■	
		Desmophylllum dianthus	-	■	
Pennatulacea	Sea pens	*Anthoptilum* sp.	-	■	
		Anthoptilum grandiflorum	200-1370	■	■
		Distichoptilum gracile	727-1020	■	
		Funiculina quadrangularis	476-1258	■	
		Halipteris sp.	-	■	
		Halipteris finmarchica	320-1370	■	■
		Kophobelemnon sp.	-	■	
		Pennatula sp.	-	■	
		Pennatula aculeata	302-1189	■	■
		Pennatula grandis	324-1246	■	■
		Pennatula phosphorea	-	■	
		Umbellula lindahli	402-1370	■	
		Unidentified Sea Pens	-	■	

Note: Shaded cell indicates presence.

Table 3.8. Sponges that may occur on the Flemish Pass (Source: Adapted from Table 6.9 in ExxonMobil 2017).

Group	Species Name	Depth Range (m)
Hexactinellida	*Asconema foliata*	138-1374
Demospongiae	*Demospongiae* indet.	144-163
Spirophorida	*Craniella* spp.	-
Astrophorida	*Geodia barretti*	979-1374
Hadromerida	*Rhizaniella sp.*	452-1351
	Stylocordyla borealis	335-866

3.4 Marine and Migratory Birds

The NL 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 RSA 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 4.2.7 in Stantec 2018a).

The RSA 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 2018a). The seasonal presence and relative abundance of seabirds and other marine-associated birds found in the RSA are provided in Table 3.9.

Table 3.9. Marine-associated avian species presence and relative abundance throughout the year within the RSA (Source: Adapted from Figure 6-64 in ExxonMobil 2017).

Common Name	Presence and Relative Abundance											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cormorants												
Great and Double-crested Cormorants	S	S	S	C	C	C	C	C	C	C	S	S
Gannets												
Northern Gannet	P	P	C	C	C	C	C	C	C	C	C	P
Phalaropes												
Phalaropes *					S	S	P	S	S	S		
Gulls and Terns												
Large Gulls	C	C	C	C	C	C	C	C	C	C	C	C
Ivory Gull *	S	S	S	S	S						S	S
Ross's Gull *	S	S	S	S	S					S	S	S
Black-legged Kittiwake	C	C	C	C	C	C	C	C	C	C	C	C
Terns					C	C	C	C	C	S		
Auks, Murres, Puffins, and Guillemots												
Dovekie	C	C	C	C	P	P	P	P	P	P	C	C
Atlantic Puffin	P	P	P	C	C	C	C	C	F	F	P	P
Black Guillemot	C	C	C	C	C	C	C	C	F	F	C	C
Common Murre	C	C	C	C	C	C	C	C	F	F	C	C
Thick-billed Murre	C	C	C	C	C	C	C	C	F	F	C	C
Razorbill	P	P	P	P	P	P	P	P	F	F	P	P
Jaegers and Skuas												
Jaegers and Skuas	P	P	P	P	S	P	P	S	S	S	P	P

Common Name	Presence and Relative Abundance											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fulmarine Petrels, Shearwaters, and Gadfly Petrels												
Fulmars and Shearwaters	C	C	C	C	C	C	C	C	C	C	C	C
Storm-Petrels												
Storm-Petrels *	P	P	P	C	C	C	C	C	C	C	P	P
Ducks, Geese, and Swans												
Waterfowl (including loons and grebes)	C	C	C	C	C	S	S	S	S	S	C	C *
Migratory Landbirds and Shorebirds												
Migratory Landbirds and Shorebirds *		P	P	P	S	S	P	S	S	S	S	

* Species with at-risk designation (see Table 3.3 in Section 3.1.2).
Relative Abundance: C = Common; P = Present; S = Scarce; F = Flightless birds (dependent young and/or moulting adults) at sea, potentially in RSA; 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 2018a). 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 RSA 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 3.12-3.17). It should be noted that the previous SIMA for the Program (LGL 2019) included density maps for 2006-2016; the most recent dataset (2006-2020) was used to create the figures for this updated SIMA [note: incremental time ranges, such as the most recent five years, are not possible with the Environment and Climate Change Canada-Canadian Wildlife Service (ECCC-CWS) database].

Analysis of a ten-year dataset (ECSAS database, 2006-2016) of seabird densities in eastern Canada indicated that Northern Fulmar has the highest recorded density in the region, 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 were the Lesser Black-backed Gull (*Larus fuscus*) and the South Polar Skua (*Stercorarius maccormicki*) at 38 and 39 individuals, respectively (Bolduc et al. 2018).

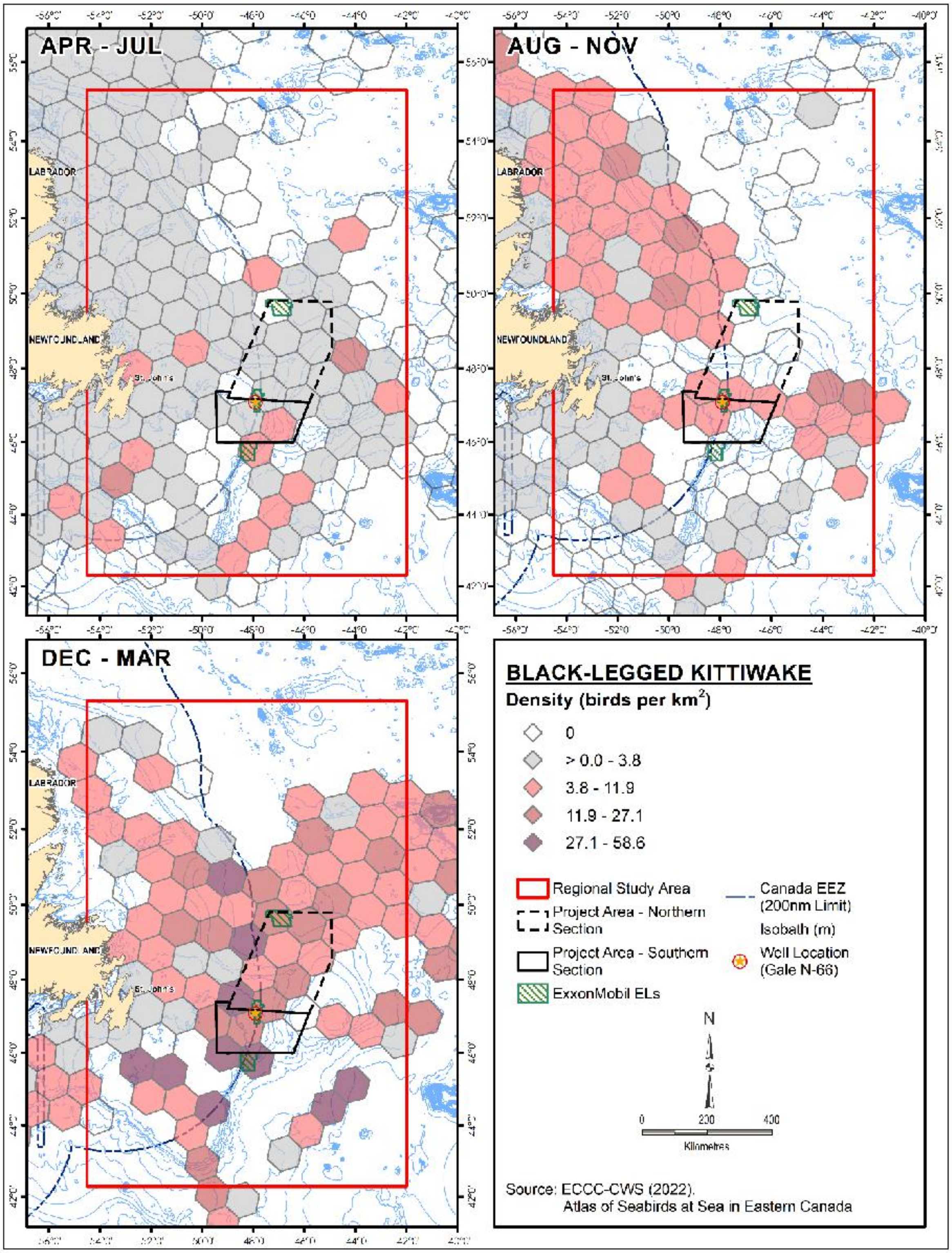


Figure 3.12. Black-legged Kittiwake seasonal distribution and densities within the RSA, 2006-2020 (Source: ECCC-CWS 2022).

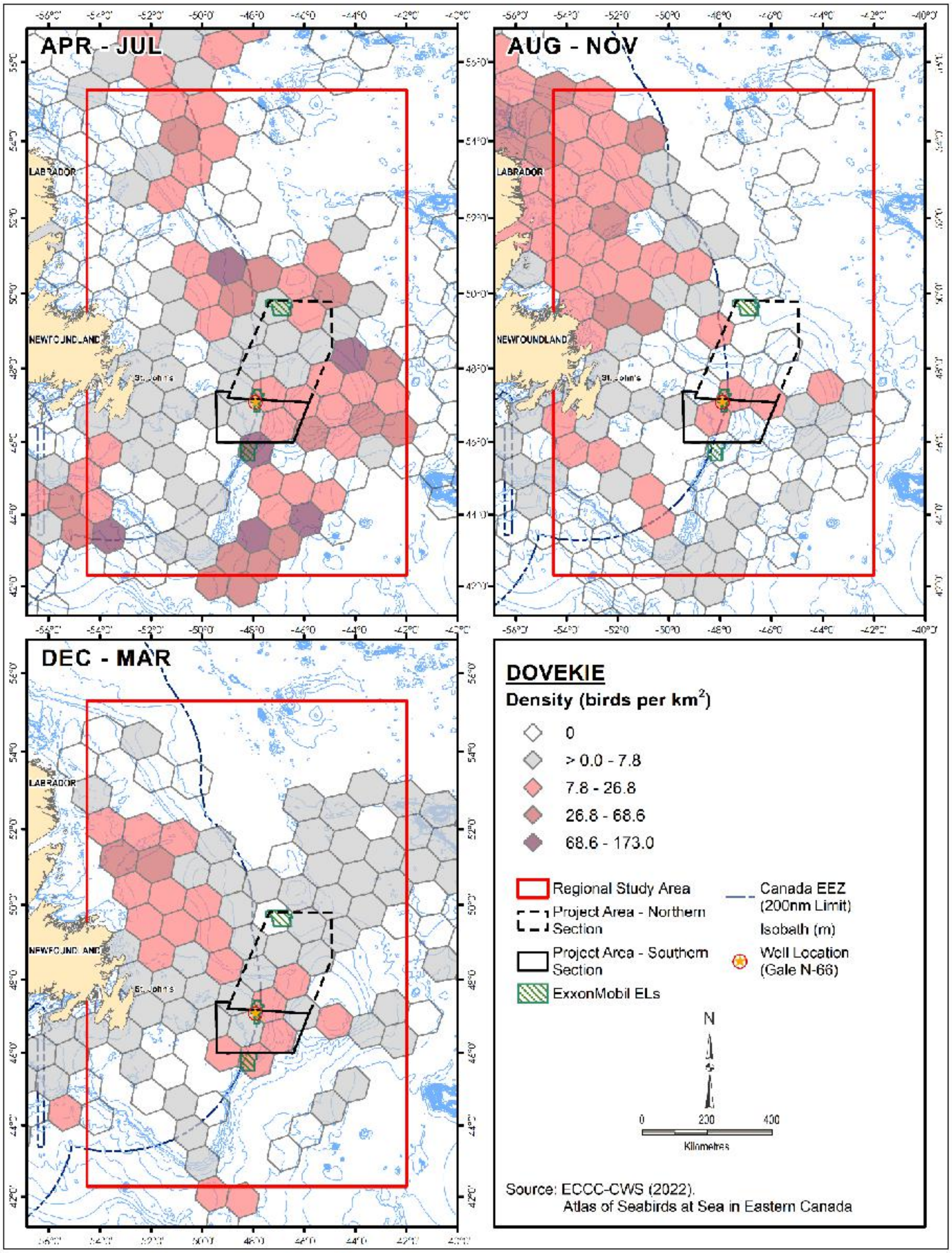


Figure 3.13. Dovekie seasonal distribution and densities within the RSA, 2006-2020 (Source: ECCC-CWS 2022).

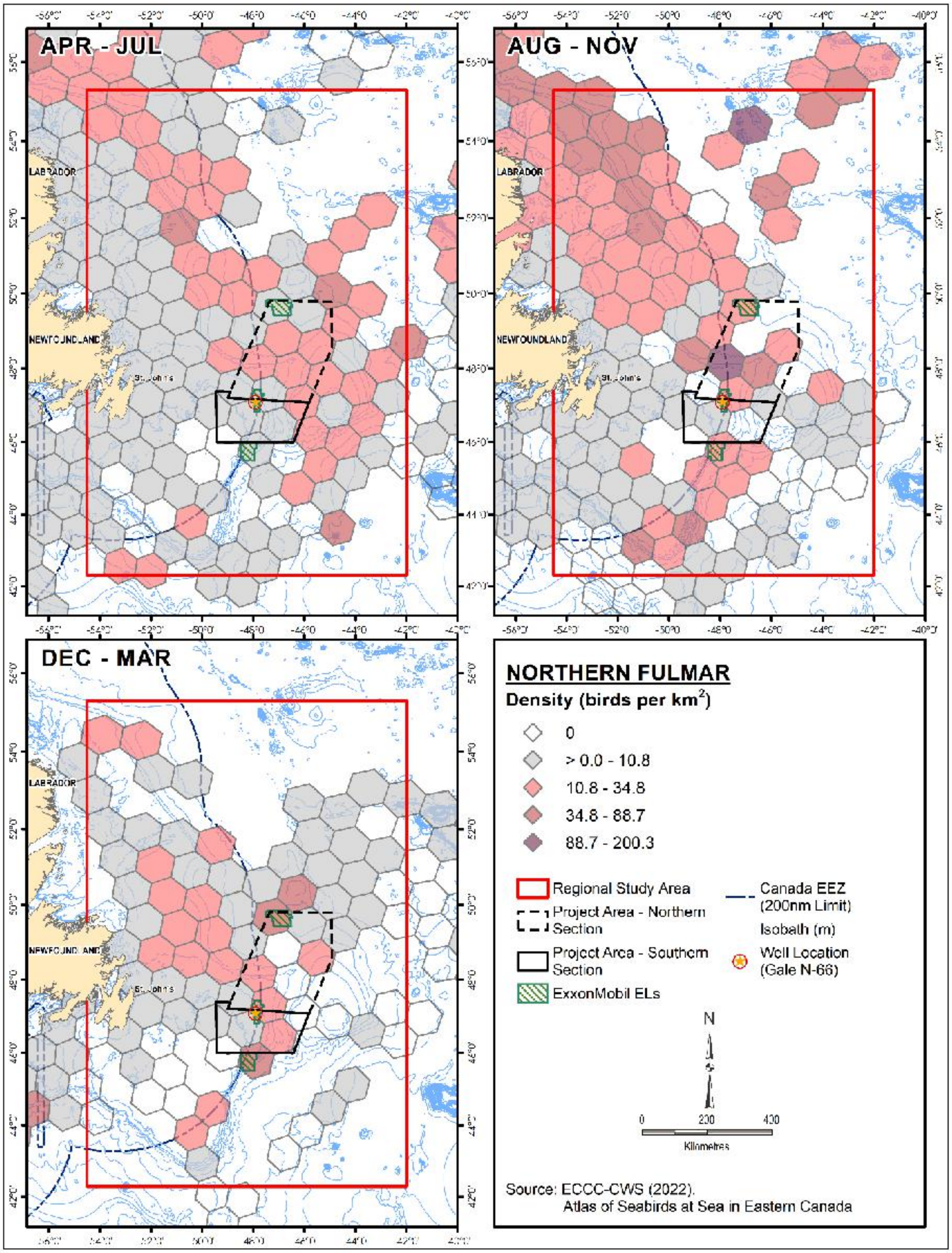


Figure 3.14. Northern Fulmar seasonal distribution and densities within the RSA, 2006-2020 (Source: ECCC-CWS 2022).

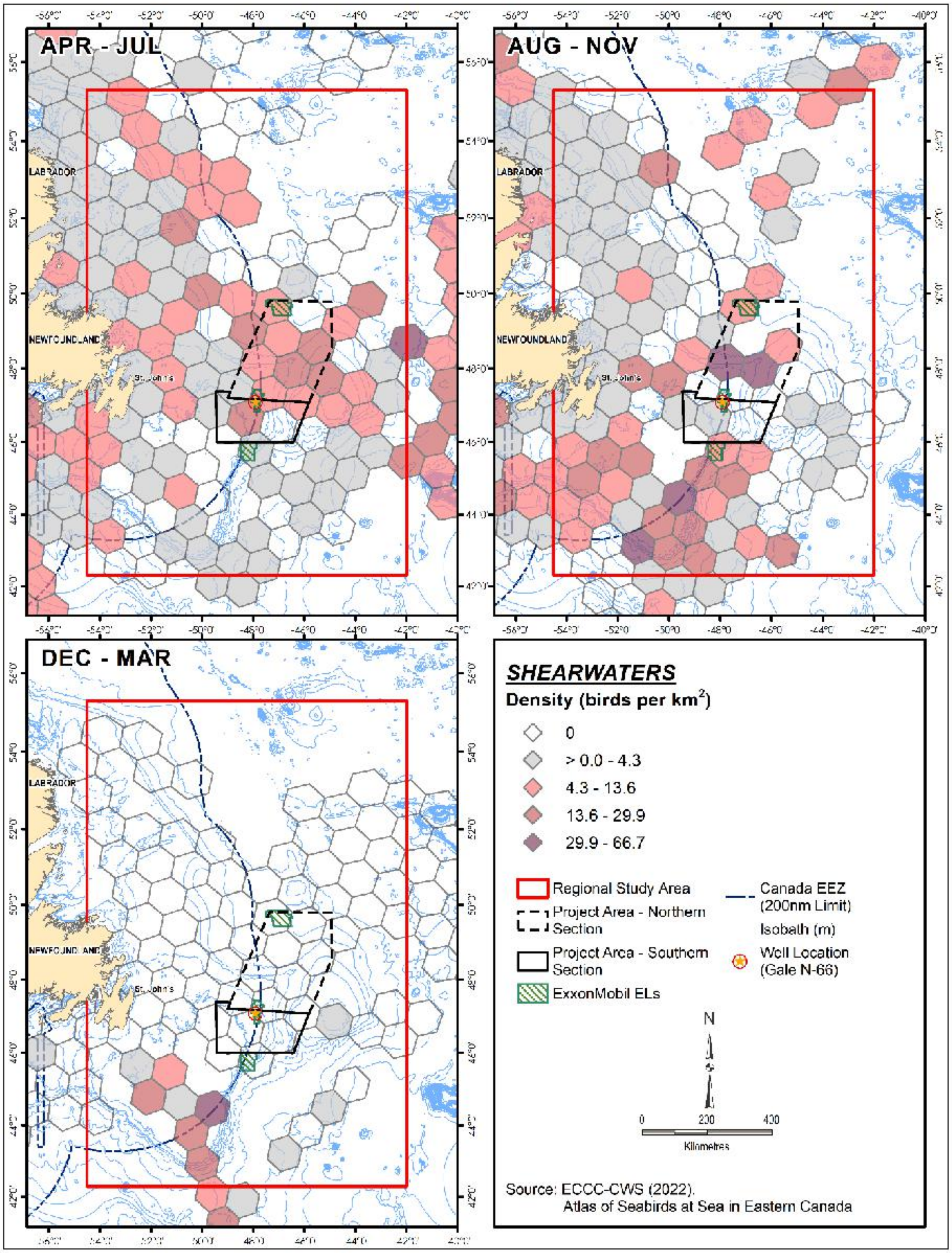


Figure 3.15. Shearwater seasonal distribution and densities within the RSA, 2006-2020 (Source: ECCC-CWS 2022).

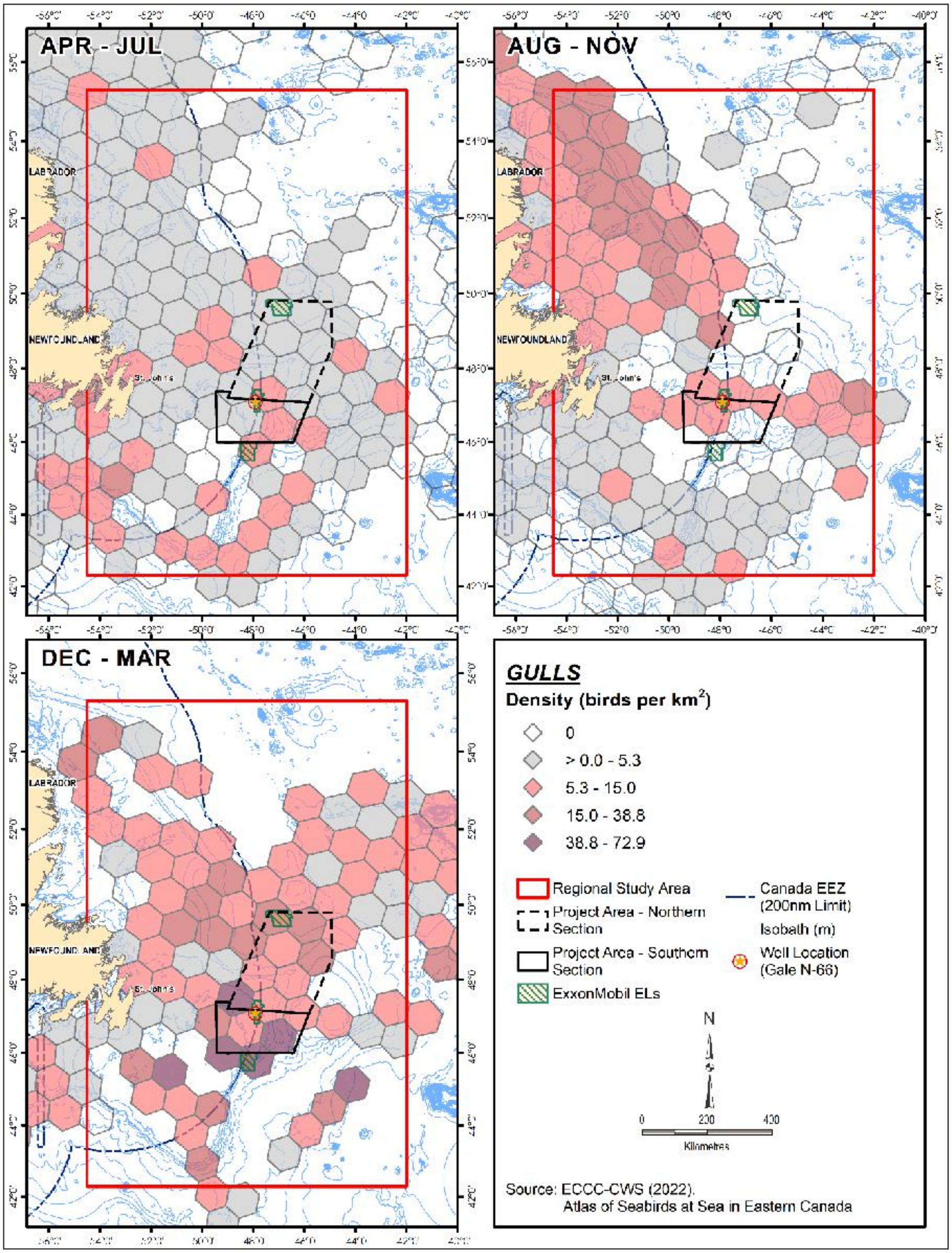


Figure 3.16. Gull seasonal distribution and densities within the RSA, 2006-2020 (Source: ECCC-CWS 2022).

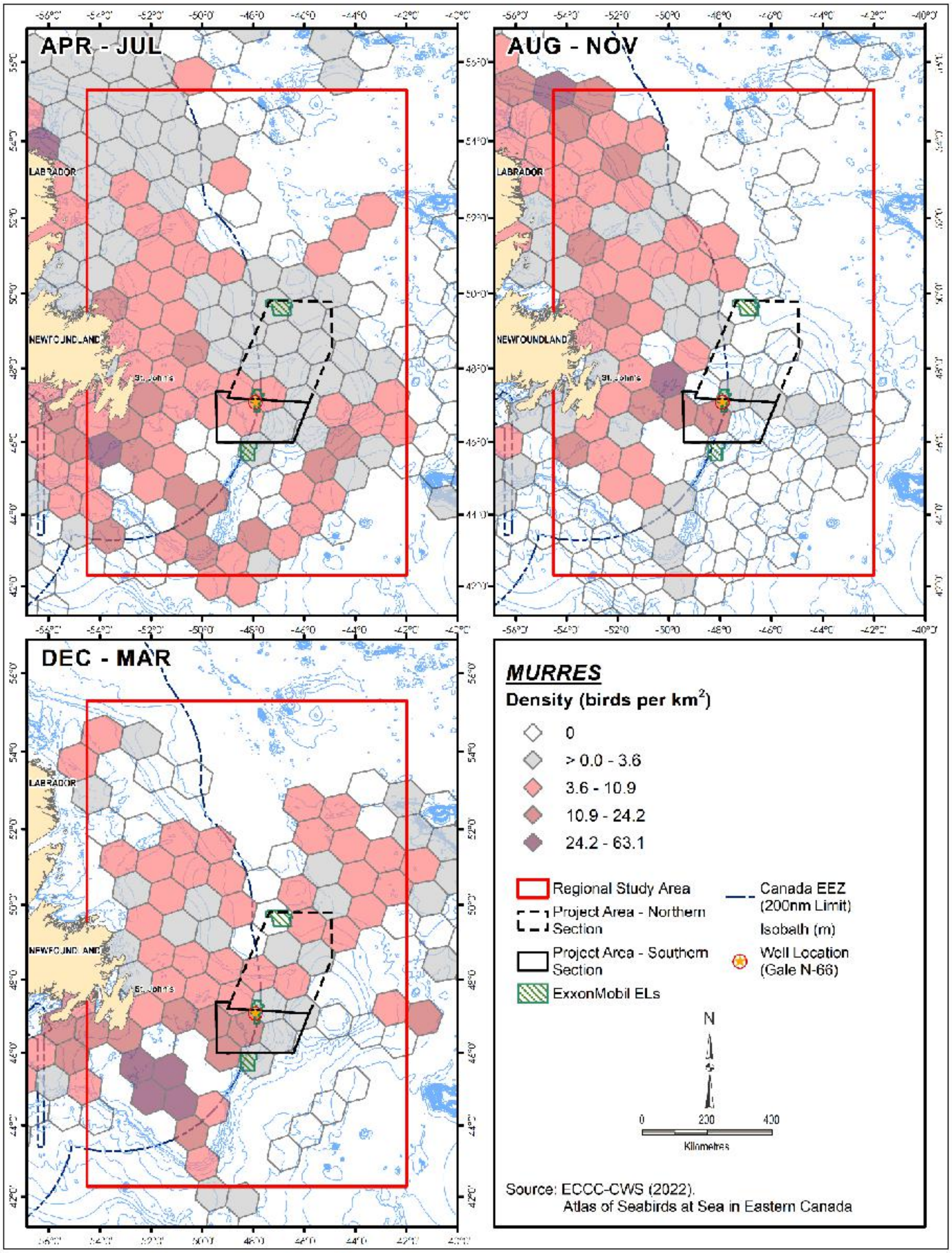


Figure 3.17. Murre seasonal distribution and densities within the RSA, 2006-2020 (Source: ECCC-CWS 2022).

Many seabirds nest in Newfoundland in the spring and summer at the >300 breeding colonies along the island's coasts (Warkentin et al. 2009). Four major breeding colonies/ecological reserves are located within the RSA, including Funk Island, Baccalieu Island, Witless Bay Islands, 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 assessed as *threatened* under COSEWIC and under consideration for addition to Schedule 1 of SARA [COSEWIC 2023; Government of Canada 2023]), and Black-legged Kittiwake (CPAWS 2014). There are also several IBAs within the RSA (Bird Studies Canada 2015; see Figure 3.18 below and Table 4.32 and Figure 4-33 in Stantec 2018a). Seabirds typically forage throughout the Grand Banks and surrounding areas during and following the breeding season (Stantec 2018a; Bolduc et al. 2018). Various non-breeding seabirds also forage within the RSA during the nesting season, with their presence varying from spring to fall depending on the species (BirdLife International 2018 in LGL 2019; Bolduc et al. 2018). Several species/groups, such as large gulls, Northern Gannet, Black-legged Kittiwake, Dovekie, Atlantic Puffin, Common and Thick-billed Murres, Razorbill, jaegers and skuas, fulmars and shearwaters, and storm-petrels, occur within the RSA year-round (see Table 3.9 above). 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) and 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 RSA include Ross's Gull (*Rhodostethia rosea*; *threatened* under SARA and *endangered* under COSEWIC) and Ivory Gull (*Pagophila eburnea*; *endangered* under SARA and COSEWIC) (COSEWIC 2023; Government of Canada 2023). The Red-necked Phalarope (*Phalaropus lobatus*; *special concern* under SARA and COSEWIC [COSEWIC 2023; Government of Canada 2023]) may be present in the area during spring and fall migrations. Overall, there are 12 bird species at risk that may occur in the RSA (see Table 3.3 and Section 3.1.2 above).

Migratory birds, including many landbird, waterfowl, and shorebird species, occur within the RSA (see Sections 4.2.7.3.1-4.2.7.3.8 in Stantec 2018a). Landbirds (e.g., passerines and raptors) that associate with coastal areas (e.g., for nesting), migrate through the region, and/or prey upon migrants typically occur within the RSA from May to June and from July to November, except Mourning Dove (*Zenaida macroura*) which has been observed during February and May, and Gyrfalcon (*Falco rusticolus*) and Snowy Owl (*Bubo scandiacus*) which have been observed when pack ice is nearby in late-winter (ExxonMobil 2017; Statoil 2015a,b in ExxonMobil 2017; Mactavish and Lang 2019). Nocturnal migrants (e.g., passerines) may be attracted to artificial light sources of vessels/platforms at sea, particularly during foggy conditions in summer and fall (Stantec 2018a) and any migrating landbird may be blown off course into the RSA during storms or periods of high winds; such birds may seek refuge on at-sea vessels/platforms. Raptors, such as Peregrine Falcon (*Falco peregrinus*), migrate along the Newfoundland coast and are also encountered well offshore in small numbers, often landing on vessels or oil/gas platforms

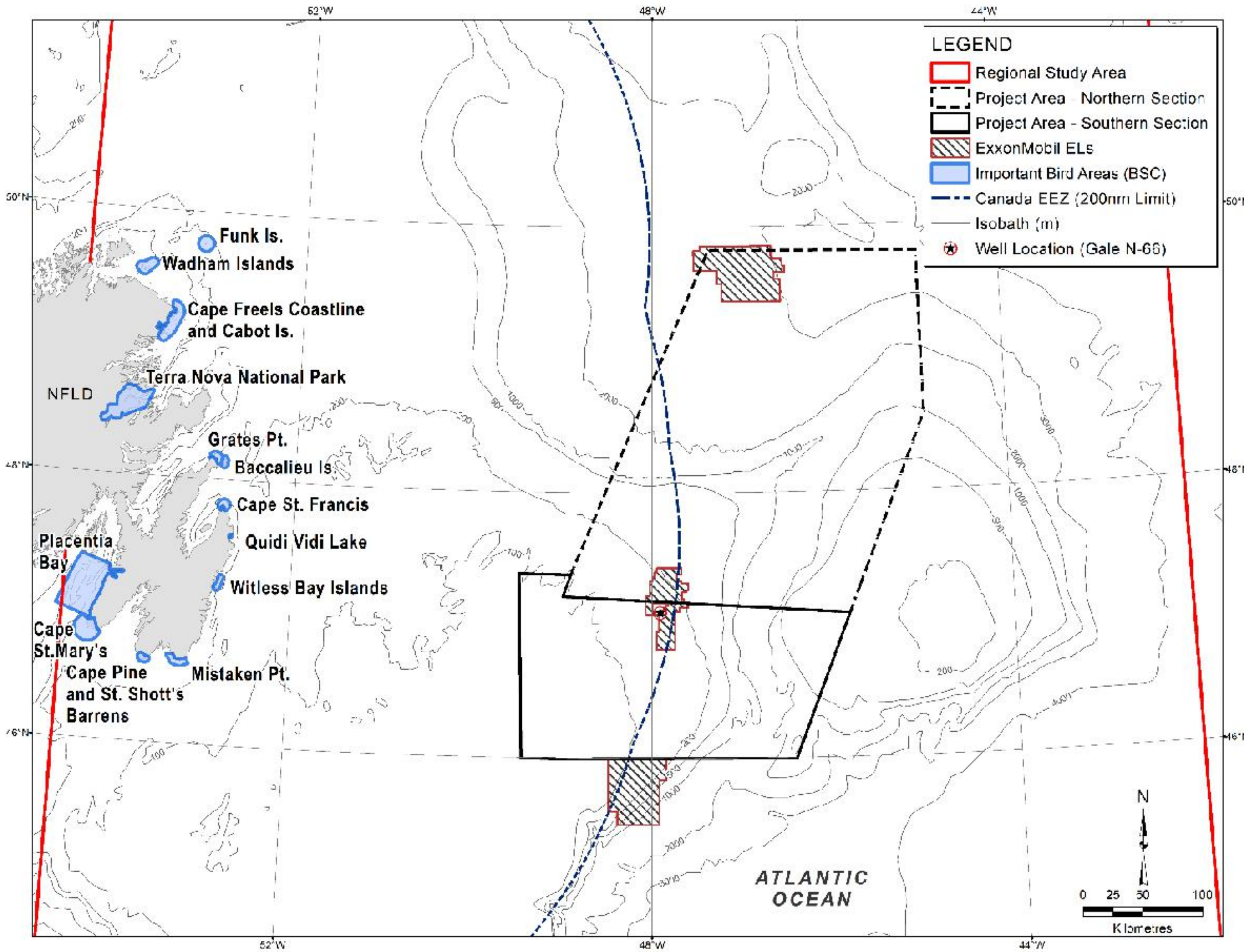


Figure 3.18. Important Bird Areas (IBAs) within the RSA (Source: Bird Studies Canada 2015).

(e.g., Mactavish and Penney-Belbin 2018). They prey on migrating waterfowl and shorebirds, particularly during the fall (see Table 6.34 in ExxonMobil 2017).

Waterfowl (and divers, i.e., loons and grebes) spend a great deal of their time on the water's surface, typically within coastal areas of marine waters (Stantec 2018a) although there have been observations within offshore portions of the RSA, including the Northern Project Area (see Figure 3.19 below). Approximately 24 waterfowl/diver species occur in the RSA during at least a portion of the year (see Table 4.30 in Stantec 2018a), including two at-risk species, Barrow's Goldeneye (*Bucephala islandica*, eastern population) and Harlequin Duck (*Histrionicus histrionicus*, eastern population), both of which are considered *special concern* under SARA and COSEWIC (COSEWIC 2023; Government of Canada 2023). Common Eider (*Somateria mollissima*) is the most common duck species in the region and although few eiders currently nest in coastal Newfoundland waters, this species winters in these waters in significant numbers (Lock et al. 1994 in Stantec 2018a).

Almost 30 shorebird species occur in the region for at least a portion of the year (see Table 4.30 in Stantec 2018a). Some, such as Least and Spotted Sandpipers (*Calidris minutilla* and *Actitis macularius*), Greater Yellowlegs (*Tringa melanoleuca*), Piping and Semipalmated Plovers (*Charadrius melodus* and *C. semipalmatus*), and Killdeer (*Charadrius vociferus*) nest in Newfoundland, while others, such as Purple Sandpiper (*Calidris maritima*) and Ruddy Turnstone (*Arenaria interpres*), overwinter along rocky shorelines and offshore ledges/islands, and various others occur within the RSA while migrating (Warkentin et al. 2009), particularly during the fall migration period (Stantec 2018a). Several stopover sites occur within eastern Newfoundland (see Section 6.2.3.2 in ExxonMobil 2017). Shorebirds occur offshore during fall migration as trans-oceanic migrants. Although they typically do not land on the sea surface, small numbers regularly land on vessels and offshore oil/gas platforms within the RSA (e.g., MacTavish and Lang 2015; Mactavish and Penney-Belbin 2018).

3.5 Marine Mammals and Sea Turtles

Many species of marine mammals and two species of sea turtles regularly occur in the RSA. Marine mammals and sea turtles were separate ROCs in the Program's previous SIMA (LGL 2019) but, in keeping with more recent SIMA methodologies, were combined into a single ROC for this updated SIMA.

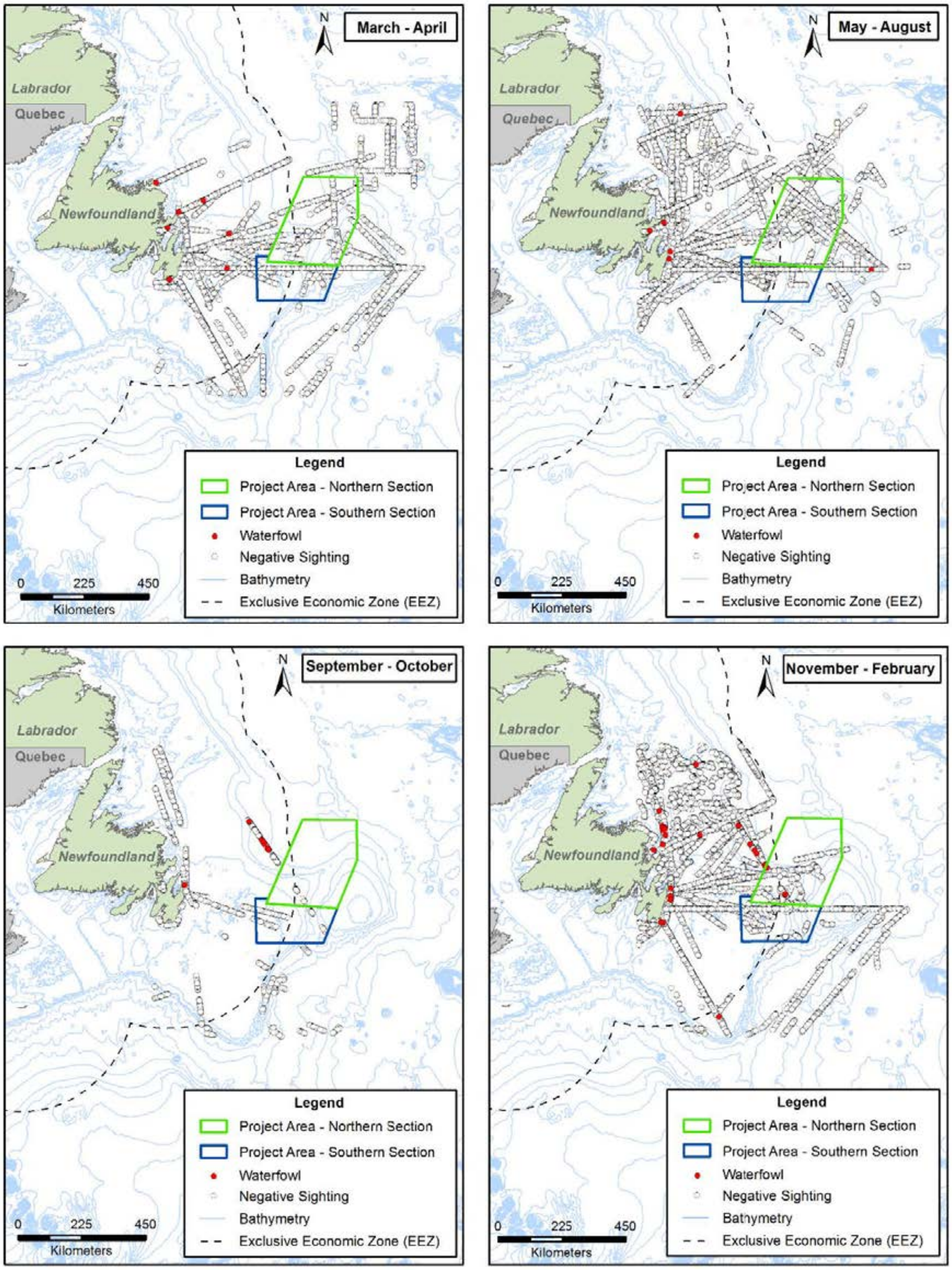


Figure 3.19. Waterfowl seasonal distribution in the waters off Eastern Newfoundland, 2001-2016 (Source: Figure 6-63 in ExxonMobil 2017 [note: the Atlas of Seabirds at Sea in Eastern Canada 2006-2020 dataset (ECCC-CWS 2022) does not allow for the creation of distribution and density maps for waterfowl like Figures 3.12-3.17 above]).

3.5.1 Marine Mammals

Marine mammals are regulated by the *Fisheries Act* and have ecological importance to the marine environment and economic, cultural, and recreational importance to Indigenous communities, stakeholders, and government regulators (see Section 4.2.5 in Stantec 2018a). 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 marine mammal species can be expected to occur within or near the RSA (see Table 4.27 in Stantec 2018a; Table 3.10), including six mysticetes (baleen whales), 13 odontocetes (toothed whales), and six phocids (seals [note: ringed seal *Pusa hispida* was not included in Table 4.27 of the EIS but may occur within the northernmost portion of the RSA, and bearded seal *Erignathus barbatus* was similarly not included in Table 4.27 but the northwestern portion of the RSA is within their normal distribution range; NOAA 2022; Government of Canada 2023]). The most recent five years (2012-2016) of sighting locations of baleen and toothed whales and dolphins and porpoises in the RSA are provided in Figures 3.20-3.22. Three baleen whale species (fin [*Balaenoptera physalus*], blue [*B. musculus*], and North Atlantic right [*Eubalaena glacialis*] whales) and two toothed whale species (Sowerby's beaked [*Mesoplodon bidens*] and northern bottlenose [*Hyperoodon ampullatus*] whales) are listed under SARA and seven whale species, one porpoise, and one seal species have at-risk status under COSEWIC (COSEWIC 2023; Government of Canada 2023; Tables 3.3 and 3.10).

Marine mammals can be found in the region any time of year, but there are seasonal differences. Some seal species, such as ringed, harp (*Pagophilus groenlandicus*), and hooded (*Cystophora cristata*) seals, are influenced by the seasonal shift in sea ice and are mostly found within the RSA during winter and spring. In contrast, bearded 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 late-spring through early-fall (e.g., humpback whale [*Megaptera novaeangliae*]) (see Table 4.27 in Stantec 2018a). As a result, there are more whale sightings from June to September than at other times of year (see Sections 4.2.5-4.2.5.4 in Stantec 2018a). Work is currently underway to designate critical habitat for blue whales which may potentially occur within or near the RSA (DFO 2016).

Table 3.10. Marine mammals that may occur within or near the RSA, including frequency and seasonality of occurrence, habitat type, and status under SARA and COSEWIC (Source: adapted from Tables 4.27 and 4.28 in Stantec 2018a).

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
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

Species	Population	Occurrence	Season	Habitat	SARA (Schedule 1) [a]	COSEWIC [b]
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	Atlantic and Eastern Arctic subspecies	Common	Year-round	Coastal & shallow water	No Status	Not at risk

[a] Species listing under SARA (Government of Canada 2023).
[b] Species assessment by COSEWIC (COSEWIC 2023).

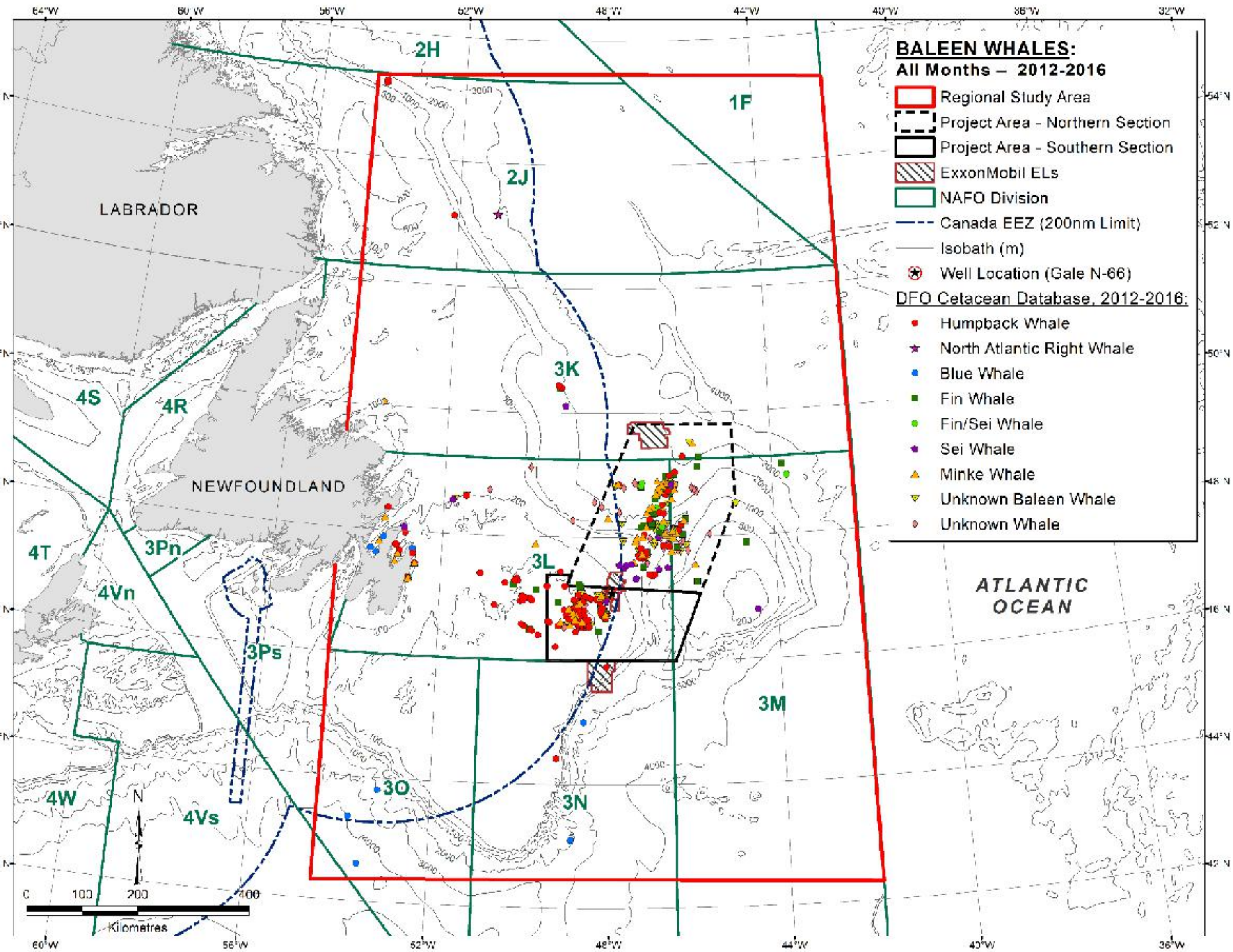


Figure 3.20. Baleen whale sightings in the RSA (Source: DFO Sightings Database, 2012-2016).

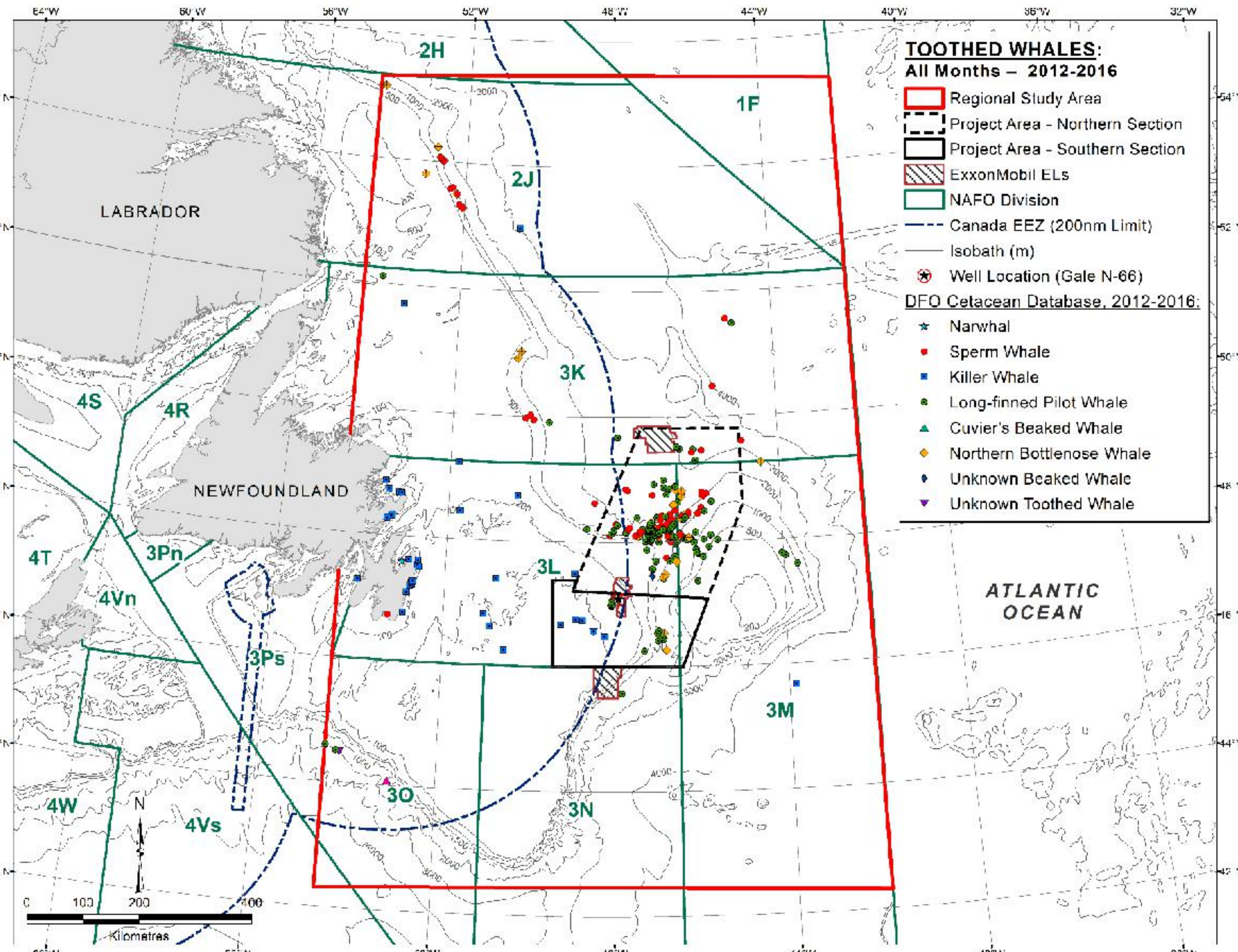


Figure 3.21. Toothed whale sightings in the RSA (Source: DFO Sightings Database, 2012-2016).

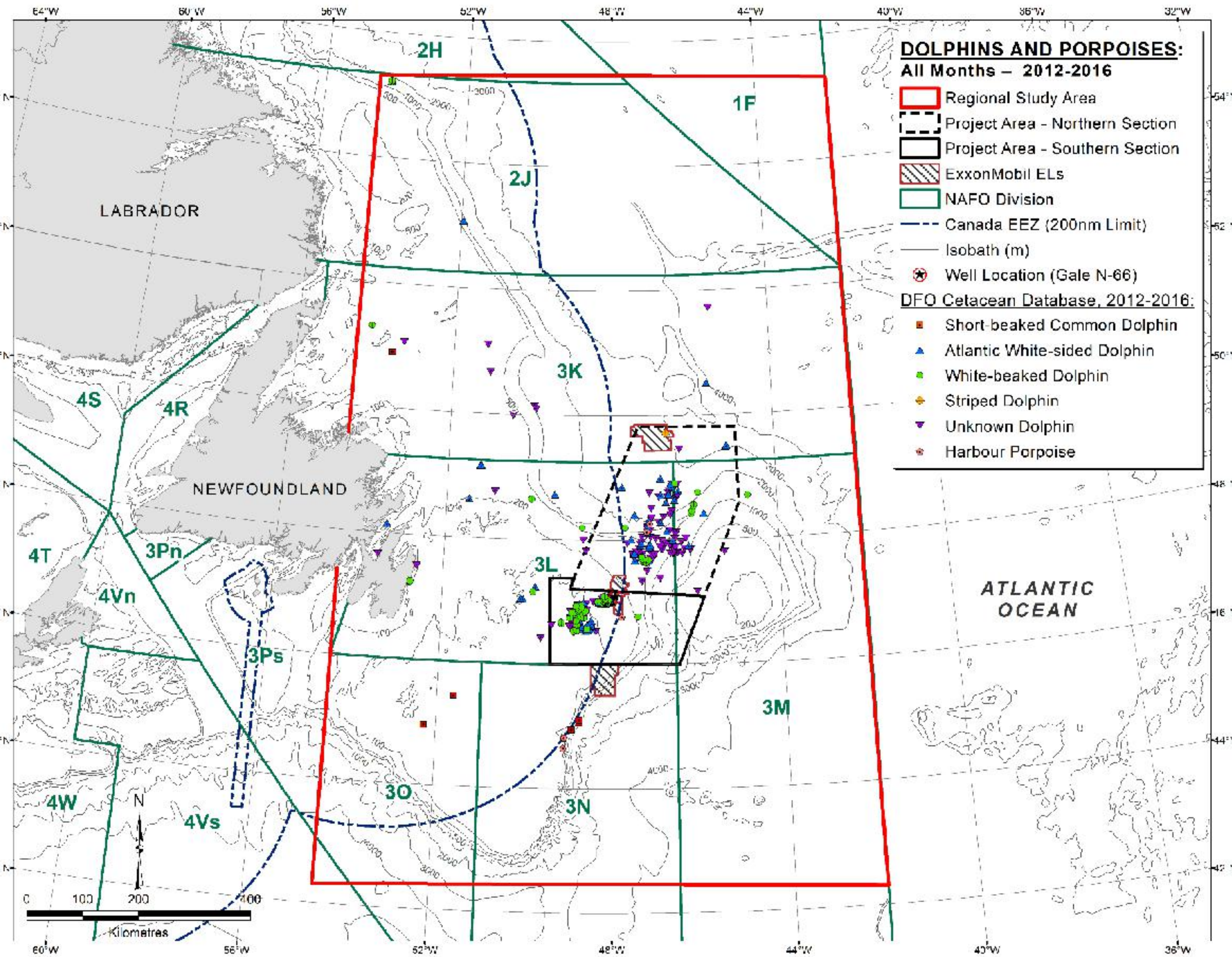


Figure 3.22. Dolphin and porpoise sightings in the RSA (Source: DFO Sightings Database, 2012-2016).

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 (*Dermochelys coriacea*) and loggerhead (*Caretta caretta*), are expected to occur within the RSA (Table 3.11). Leatherback (Atlantic population) and loggerhead sea turtles are *endangered* under both SARA and COSEWIC (COSEWIC 2023; Government of Canada 2023). Green sea turtles (*Chelonia mydas*) are expected to be rare within the RSA. A fourth species, Kemp's ridley sea turtle (*Lepidochelys kempii*; low-priority candidate species under COSEWIC [COSEWIC 2023]), has been reported from Newfoundland but is likely exceedingly rare in the RSA and was excluded from the remainder of this section (see Section 4.2.6 in Stantec 2018a). The most recent five years (2012-2016) of sighting locations of sea turtles within the RSA are provided in Figure 3.23.

Table 3.11. Sea turtles expected to occur within or near the RSA, including frequency and seasonality of occurrence, habitat types, and status under SARA and COSEWIC (Source: adapted from Table 4.29 in Stantec 2018a).

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 listing under SARA (Government of Canada 2023).
[b] Species assessment by COSEWIC (COSEWIC 2023).

Leatherback sea turtles occur in waters off Newfoundland from April-December (see Section 3.2 in Appendix D of Stantec 2018a). Loggerheads are found in the region during the summer and fall (see Section 3.3 in Appendix D of Stantec 2018a), while green sea turtles are only seen (rarely) in the summer through early-fall (see Table 6.44 in ExxonMobil 2017). Currently, critical habitat has not been established for sea turtles in Canada.

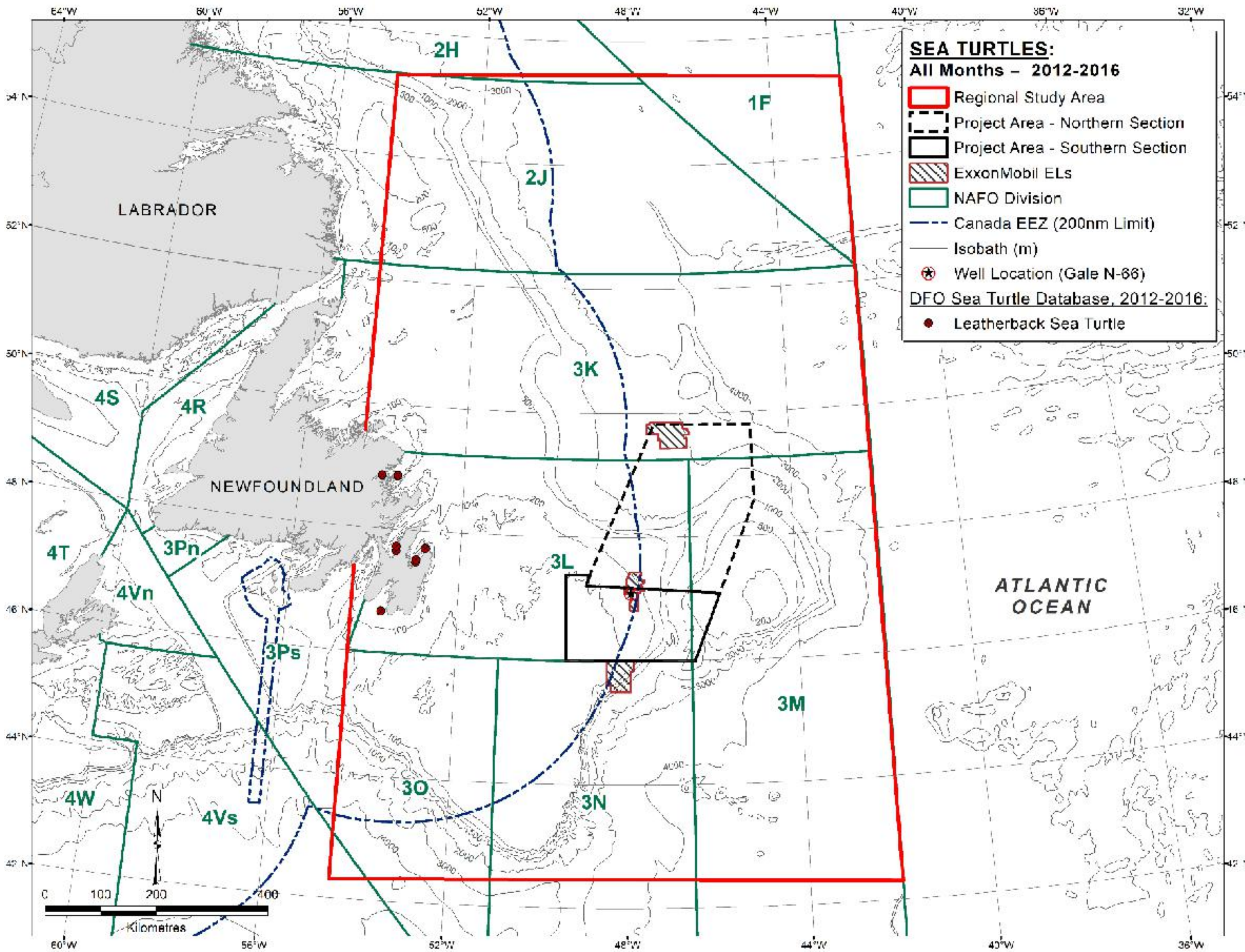


Figure 3.23. Sea turtle sightings in the RSA (Source: DFO Sightings Database, 2012-2016).

3.6 Socio-Economic

The Program's previous SIMA (LGL 2019) featured a Fisheries ROC that included commercial fisheries, Indigenous fisheries, and aquaculture. In keeping with more recent SIMAs in the region, a Socio-Economic ROC was identified for this updated SIMA which includes commercial fisheries, aquaculture, and other anthropogenic marine activity (shipping, oil and gas, tourism, and aquaculture). Indigenous Fisheries are now their own ROC for this updated SIMA (see Section 3.7). The fisheries are a vital part of the province's financial and socio-economic setting; they and other socio-economic activities that occur in the RSA are summarized below.

3.6.1 Commercial Fisheries

Early European settlement of Newfoundland was intimately linked and driven by the development of commercial fishing for groundfish, predominantly Atlantic cod. The cod fisheries were an important economic resource until the stock collapsed and a moratorium was established in the early 1990s (see Section 4.3.1 in Stantec 2018a). 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, largely replacing cod and other groundfish as valuable target species (Lear 1998; see Section 4.3.1.2 and Figure 4-36 in Stantec 2018a). In the event of a subsea blowout, fisheries can be expected to interact with the oil spill in two 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. It should be noted that negative perceptions of food safety and quality could also occur due to dispersant use/dispersed oil.

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 key NAFO Divisions associated with the RSA include 2J and 3KLMNO. 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 (2011-2015) were generated by DFO and provided specifically for the EIS (see Figures 4-37 and 4-38 and Tables 4.38 and 4.39 in Stantec 2018a). 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 fulfill. There was insufficient time for such a request to be fulfilled for the completion of this updated SIMA and it is unlikely that such data would be readily available for the creation of an expedited SIMA. Therefore, this updated SIMA utilizes the latest five years of DFO commercial fisheries quartile range data available for the RSA (2017-2021) 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 RSA include snow crab, Atlantic cod, northern shrimp, and Greenland halibut (see Table 4.38 in Stantec 2018a; Tables 3.12-3.16). Within the RSA, most commercial fishing activity occurs on the continental shelf, including the Grand Banks, Labrador Shelf, and slopes along the Orphan Basin (Figure 3.24). Spring and summer (~April to September) are typically the busiest seasons for commercial fisheries in the region (see Section 4.3.1.4 and Figures 4-40 and 4-41 in Stantec 2018a; Figure 3.25). Most of the harvest within international waters of the RSA (i.e., beyond Canada's Exclusive Economic Zone [EEZ]) is landed by Canadian vessels (Figure 3.26). The seasonal distribution of fishing effort in areas outside the Canadian EEZ largely mirrors that of the effort inside the EEZ (see Section 4.3.1.1 and Figure 4-58 in Stantec 2018a).

A variety of fishing gear is used in commercial fisheries within the RSA. 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 their target species. For example, the pelagic fisheries use a combination of nets, longlines, and seines (see Section 4.3.1.5 in Stantec 2018a).

Table 3.12. Annual commercial catch weights and values in the RSA, 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	1086	1483	1249	326	737	1170	1361	876	771	1148	1979	199	47	-	4144
Northern Shrimp	272	340	240	136	369	301	208	110	-	13	472	54	-	449	988
Atlantic Cod	250	285	266	101	440	327	117	18	59	398	217	12	-	216	902
Atlantic Halibut	146	202	190	113	204	249	162	36	-	90	77	73	-	411	651
Greenland Halibut	90	220	242	83	122	234	221	58	2	89	278	45	-	221	635
Redfish	55	108	121	68	105	127	94	26	1	14	70	17	-	250	352
American Plaice	39	109	114	81	118	123	82	20	7	23	14	2	-	297	343
Yellowtail Flounder	57	118	92	65	151	104	66	11	-	-	1	-	-	331	332
Witch Flounder	32	87	88	55	76	83	74	29	-	-	27	12	-	223	262
White Hake	72	74	45	12	91	84	25	3	-	70	41	48	-	44	203
Capelin	-	5	41	106	32	43	49	28	42	61	49	-	-	-	152
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
Atlantic Herring	-	6	11	52	15	39	14	1	9	37	23	-	-	-	69
Stimpson’s Surf Clam	1	8	17	42	6	13	16	33	-	-	-	-	-	68	68
Swordfish	28	18	20	-	20	21	25	-	-	19	17	30	-	-	66
Striped Shrimp	11	17	17	9	10	18	15	11	-	-	-	-	-	54	54
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.	14	7	-	1	12	8	2	-	-	9	13	-	-	-	22
Pollock	-	1	14	-	-	11	4	-	-	5	9	-	-	1	15

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’**	
Albacore Tuna	4	4	3	-	3	4	4	-	-	1	8	2	-	-	11
Sea Scallop	10	-	-	-	10	-	-	-	9	1	-	-	-	-	10
Pink Glass Shrimp	3	5	2	-	7	3	-	-	-	9	1	-	-	-	10
Whelk	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
Winter Flounder	2	3	-	2	4	3	-	-	-	7	-	-	-	-	7
Atlantic Wolffish	4	1	-	-	1	4	-	-	-	-	5	-	-	-	5
Dolphinfish	-	-	3	-	-	-	3	-	-	2	-	1	-	-	3
Mackerel	-	-	2	-	-	2	-	-	2	-	-	-	-	-	2
Pelagic sp.	1	-	-	-	1	-	-	-	-	-	-	1	-	-	1
Total	**2253**	**3226**	**2893**	**1311**	**2650**	**3107**	**2628**	**1298**	**907**	**2070**	**3381**	**557**	**47**	**2721**	**9683**

[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 3.13. Annual commercial catch weights and values in the RSA, 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	1134	1438	1117	210	678	1141	1369	711	843	1216	1637	182	21	-	3899
Atlantic Cod	205	286	213	94	429	250	107	12	60	337	120	16	-	265	798
Northern Shrimp	235	201	178	117	259	194	187	91	-	8	448	76	-	199	731
Greenland Halibut	119	244	266	96	167	272	229	57	3	104	326	46	-	246	725
Atlantic Halibut	142	182	192	134	202	245	158	45	-	53	62	88	-	447	650
American Plaice	25	98	152	90	94	156	97	18	3	18	-	-	-	344	365
Yellowtail Flounder	38	123	132	70	137	149	70	7	-	1	-	-	-	362	363
Redfish	31	81	108	74	62	106	95	31	2	10	32	21	-	229	294
Witch Flounder	28	64	103	89	63	89	92	40	-	-	1	15	-	268	284
White Hake	46	53	29	13	55	59	26	1	-	40	33	34	-	34	141
Capelin	-	2	32	88	20	38	42	22	33	51	38	-	-	-	122
Atlantic Haddock	28	24	28	12	40	31	20	1	-	10	13	17	-	52	92
Swordfish	55	28	8	-	16	53	19	3	-	20	42	29	-	-	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
Atlantic Herring	-	1	12	20	11	15	6	1	2	20	11	-	-	-	33
Dolphinfish	11	14	6	-	-	17	12	2	-	10	11	10	-	-	31
Albacore Tuna	15	11	4	-	3	17	9	1	-	5	10	15	-	-	30
Bluefin Tuna	9	6	5	-	8	9	3	-	8	1	9	2	-	-	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’	
Bigeye Tuna	8	7	4	-	3	7	7	2	-	2	6	11	-	-	19
Pollock	6	5	6	1	9	6	3	-	-	4		14	-	-	18
White Marlin	4	8	2	-	2	4	7	1	-	2	9	3	-	-	14
Striped Shrimp	5	2	3	1	4	3	3	1	-	-	-	-	-	11	11
Winter Flounder	1	5	4	-	6	4	-	-	-	10	-	-	-	-	10
Skate sp.	4	5	1	-	5	4	1	-	-	1	3	6	-	-	10
Sea Scallop	7	-	-	1	7	-	1	-	8	-	-	-	-	-	8
Silver Hake	3	3	-	-	6	-	-	-	-	-	-	-	-	6	6
Roughhead Grenadier	-	1	1	3	-	1	1	3	-	2	1	-	-	2	5
Roundnose Grenadier	3	1	-	-	2	2	-	-	-	-	-	4	-	-	4
Iceland Scallop	2	1	1	-	3	1	-	-	1	1	2	-	-	-	4
Atlantic Wolffish	1	2	-	-	1	2	-	-	-	-	3	-	-	-	3
Mackerel	-	-	2	1	1	2	-	-	-	-	3	-	-	-	3
Quahaug Clam	-	1	2	-	-	3	-	-	-	-	-	-	-	3	3
Shortfin Squid	-	-	2	-	1	1	-	-	-	2	-	-	-	-	2
Whelk	1	-	-	-	1	-	-	-	-	-	1	-	-	-	1
Porbeagle Shark	-	1	-	-	1	-	-	-	-	1	-	-	-	-	1
Total	**2228**	**2974**	**2709**	**1252**	**2355**	**3010**	**2642**	**1156**	**963**	**1966**	**2884**	**635**	**21**	**2694**	**9163**

[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 3.14. Annual commercial catch weights and values in the RSA, 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	703	1042	984	222	432	780	1039	700	636	825	1292	179	19	-	2951
Atlantic Cod	201	244	196	115	384	225	122	25	45	354	156	14	-	187	756
Northern Shrimp	178	170	171	133	222	170	146	114	-	7	425	59	-	161	652
Greenland Halibut	90	208	215	82	151	213	180	51	2	124	306	25	-	138	595
Atlantic Halibut	97	179	159	149	182	193	152	57	-	66	77	35	-	406	584
Yellowtail Flounder	58	99	99	99	129	116	83	27	-	-	-	-	-	355	355
American Plaice	14	82	114	112	70	124	96	32	5	21	8	-	-	288	322
Redfish	39	84	73	57	96	82	59	16	2	9	55	7	-	180	253
Witch Flounder	9	37	52	58	31	42	46	37	-	-	6	-	-	150	156
White Hake	44	59	34	16	56	71	23	3	-	46	46	33	-	28	153
Stimpson’s Surf Clam	-	5	22	63	-	23	22	45	-	-	-	-	-	90	90
Cockle	-	3	22	62	-	21	21	45	-	-	-	-	-	87	87
Capelin	-	7	21	53	15	35	23	8	16	40	25	-	-	-	81
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	15	20	16	13	21	17	3	-	-	21	7	-	26	54
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
Atlantic Herring	2	3	6	17	8	9	8	3	3	19	6	-	-	-	28
Mako Shark	9	11	6	-	5	8	10	3	-	1	8	17	-	-	26
Albacore Tuna	3	10	7	-	-	5	12	3	-	-	6	14	-	-	20
Winter Flounder	3	8	1	3	11	1	3	-	1	14	-	-	-	-	15

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’	
Silver Hake	9	3	1	2	10	3	2	-	-	-	2	-	-	13	15
Roughhead Grenadier	-	3	4	3	2	2	4	2	-	1	9	-	-	-	10
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
Sea Scallop	2	-	-	-	2	-	-	-	2	-	-	-	-	-	2
Skate Sp.	1	1	-	-	1	1	-	-	-	2	-	-	-	-	2
Pollock	1	1	-	-	2	-	-	-	-	1	-	1	-	-	2
Shortfin Squid	1	-	-	-	1	-	-	-	-	1	-	-	-	-	1
Whelk	1	-	-	-	1	-	-	-	-	1	-	-	-	-	1
Striped Shrimp	-	-	-	1	-	-	-	1	-	-	-	-	-	1	1
Mackerel	-	1	-	-	1	-	-	-	-	-	1	-	-	-	1
Total	**1523**	**2354**	**2272**	**1330**	**1882**	**2237**	**2139**	**1221**	**727**	**1585**	**2484**	**450**	**19**	**2214**	**7479**

[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 3.15. Annual commercial catch weights and values in the RSA, 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	503	893	988	270	305	737	992	620	501	731	1228	178	16	-	2654
Atlantic Cod	236	262	255	145	398	311	139	50	63	335	218	21	-	261	898
Greenland Halibut	105	302	200	41	138	310	162	38	6	97	346	33	-	166	648
Atlantic Halibut	111	186	174	155	150	240	166	70	1	55	87	41	-	442	626
Northern Shrimp	142	142	139	88	175	158	101	77	-	-	305	66	-	140	511
Yellowtail Flounder	64	109	146	137	132	152	126	46	-	1	-	-	-	455	456
American Plaice	30	92	152	135	83	148	131	47	5	19	-	-	-	385	409
Witch Flounder	10	50	62	76	21	55	78	44	-	-	-	-	-	198	198
Redfish	29	76	53	26	46	80	40	18	-	4	14	25	-	141	184
Capelin	1	4	34	138	12	59	35	71	43	77	54	3	-	-	177
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
Monkfish	4	14	11	16	9	18	8	10	-	-	10	14	-	21	45
Swordfish	16	13	15	-	25	16	3	-	-	14	1	29	-	-	44
Cusk	5	25	7	6	8	22	10	3	-	12	28	3	-	-	43
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	-	-	8	17	4	10	11	-	1	10	14	-	-	-	25
Albacore Tuna	8	4	6	-	10	7	1	-	-	2	-	16	-	-	18
Roughhead Grenadier	2	12	3	-	3	11	3	-	-	-	8	9	-	-	17
Bigeye Tuna	1	5	10	-	3	11	2	-	-	4	-	12	-	-	16

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’	
Roundnose Grenadier	4	5	1	-	3	6	1	-	-	-	10	-	-	-	10
Pollock	-	3	1	3	-	4	2	1	-	1	6	-	-	-	7
Sea Scallop	6	-	-	-	6	-	-	-	6	-	-	-	-	-	6
Dolphinfish	3	-	1	-	3	1	-	-	-	4	-	-	-	-	4
Mackerel	-	1	2	-	1	2	-	-	2	-	1	-	-	-	3
Whelk	2	-	-	-	2	-	-	-	-	2	-	-	-	-	2
White Marlin	2	-	-	-	2	-	-	-	-	1	-	1	-	-	2
Winter Flounder	-	1	1	-	-	2	-	-	-	2	-	-	-	-	2
Shortfin Squid	-	-	2	-	-	2	-	-	1	1	-	-	-	-	2
Mako Shark	-	-	-	1	-	-	-	1	-	1	-	-	-	-	1
Total	**1327**	**2282**	**2374**	**1428**	**1595**	**2488**	**2089**	**1239**	**644**	**1394**	**2378**	**482**	**16**	**2497**	**7411**

[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.

Table 3.16. Annual commercial catch weights and values in the RSA, 2021 (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, 2021).

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	491	1033	1226	344	158	578	1247	1111	537	850	1420	263	24	-	3094
Atlantic Cod	192	268	231	150	371	285	149	36	27	306	175	57	-	276	841
Atlantic Halibut	128	208	214	147	175	264	204	54	-	117	107	70	-	403	697
Northern Shrimp	115	173	158	131	198	166	146	67	-	-	359	80	-	138	577
Greenland Halibut	48	240	171	44	123	234	119	27	2	61	278	25	-	137	503
Yellowtail Flounder	44	117	131	126	131	157	99	31	-	-	-	-	-	418	418
American Plaice	31	89	138	139	94	144	118	41	2	2	-	-	-	393	397
Redfish	36	59	70	31	71	66	44	15	-	1	42	12	-	141	196
Witch Flounder	9	35	68	48	22	39	68	31	-	-	-	-	-	160	160
White Hake	44	54	41	10	50	69	27	3	-	31	43	52	-	23	149
Capelin	-	4	40	79	18	45	38	22	37	57	26	3	-	-	123
Stimpson’s Surf Clam	1	3	27	54	3	25	20	37	-	-	-	-	-	85	85
Cockle	-	1	26	53	-	24	19	37	-	-	-	-	-	80	80
Propellor Clam	-	2	22	48	1	22	16	33	-	-	-	-	-	72	72
Atlantic Haddock	24	23	13	9	22	26	17	4	-	16	13	17	-	23	69
Swordfish	34	22	3	-	25	24	10	-	-	25	-	34	-	-	59
Monkfish	5	14	14	8	15	18	7	1	-	-	10	10	-	21	41
Cusk	12	14	11	1	13	19	6	-	-	2	15	21	-	-	38
Bluefin Tuna	11	3	17	1	11	14	7	-	18	5	9	-	-	-	32
Sea Scallop	30	-	-	-	30	-	-	-	25	5	-	-	-	-	30
Atlantic Herring	9	4	7	5	11	5	7	2	1	3	5	16	-	-	25
Roughhead Grenadier	2	17	4	-	11	9	3	-	-	1	22	-	-	-	23
Mackerel	9	7	7	-	9	7	7	-	-	-	-	23	-	-	23

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’	
Bigeye Tuna	6	10	3	-	5	7	7	-	-	6	-	13	-	-	19
Albacore Tuna	7	6	-	-	6	6	1	-	-	8	-	5	-	-	13
Atlantic Wolffish	4	5	2	-	2	8	1	-	-	-	11	-	-	-	11
Dolphinfish	6	1	-	-	4	2	1	-	-	4	-	3	-	-	7
Squid sp.	2	3	2	-	2	3	2	-	-		-	7	-	-	7
Yellowfin Tuna	2	2	-	-	2	2	-	-	-	4	-	-	-	-	4
Winter Flounder	-	-	2	-	-	2	-	-	1	1	-	-	-	-	2
Skate sp.	-	1	1	-	2	-	-	-	-	2	-	-	-	-	2
Iceland Scallop	-	1	-	-	-	1	-	-	-	-	1	-	-	-	1
Roundnose Grenadier	-	1	-	-	-	1	-	-	-	-	1	-	-	-	1
Atlantic Rock Crab	1	-	-	-	1	-	-	-	-	1	-	-	-	-	1
Striped Shrimp	-	-	1	-	-	1	-	-	-	-	-	-	-	1	1
Silver Hake	-	-	-	1	-	-	1	-	-	-	-	-	-	1	1
Pelagic sp.	-	-	1	-	-	-	1	-	-	-	-	1	-	-	1
Total	**1303**	**2420**	**2651**	**1429**	**1586**	**2273**	**2392**	**1552**	**650**	**1508**	**2537**	**712**	**24**	**2372**	**7803**

[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 (2021): 1 = 0–2025 kg; 2 = 2026–8783 kg; 3 = 8784–35,210 kg; 4 = ≥35,211 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 (2021): 1 = \$0–\$11,497; 2 = \$11,498–\$53,379; 3 = \$53,380–\$227,707; 4 = ≥\$227,708.
[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.

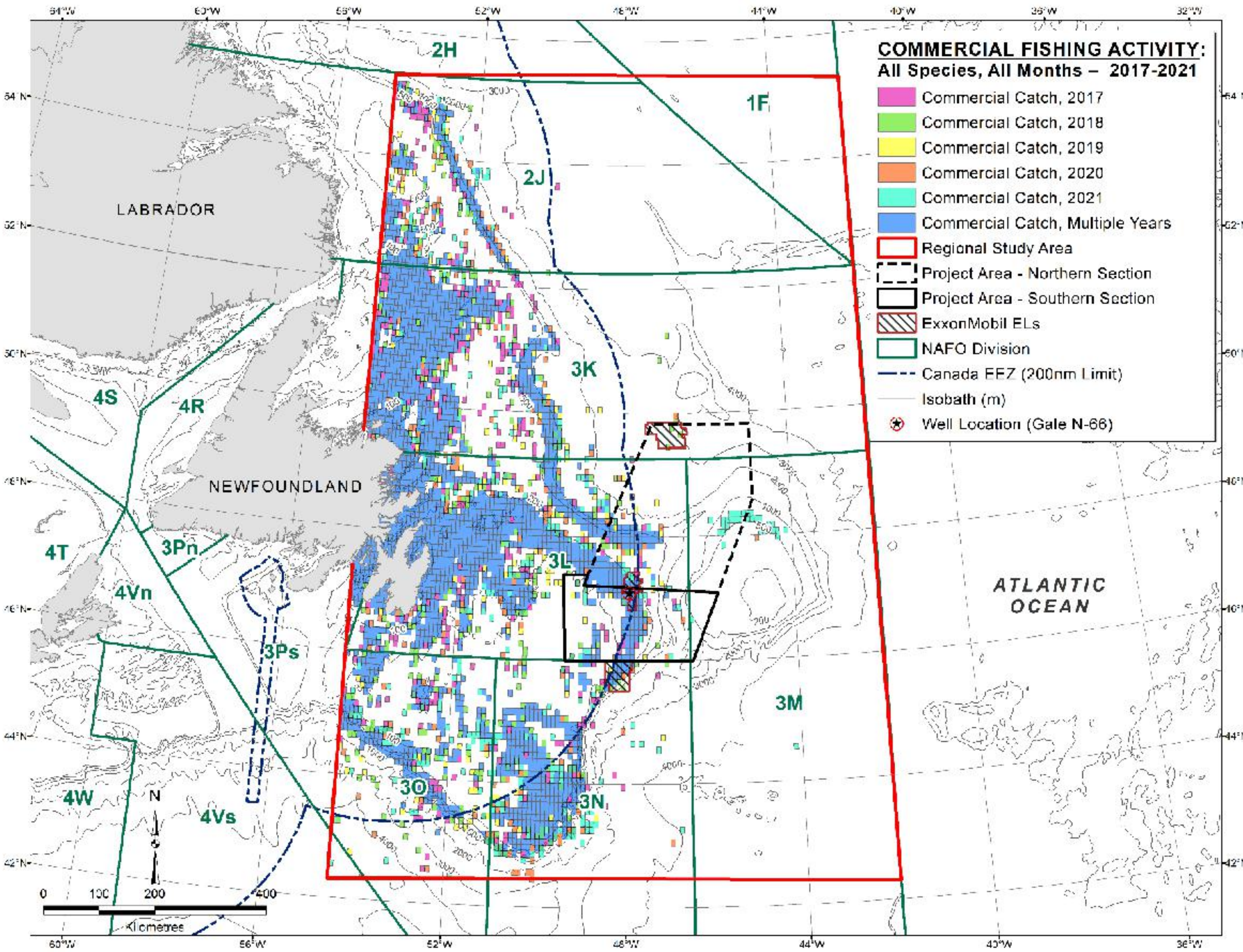


Figure 3.24. Domestic harvest locations in the RSA, 2017-2021 (Source: DFO Commercial Landings database, 2017-2021).

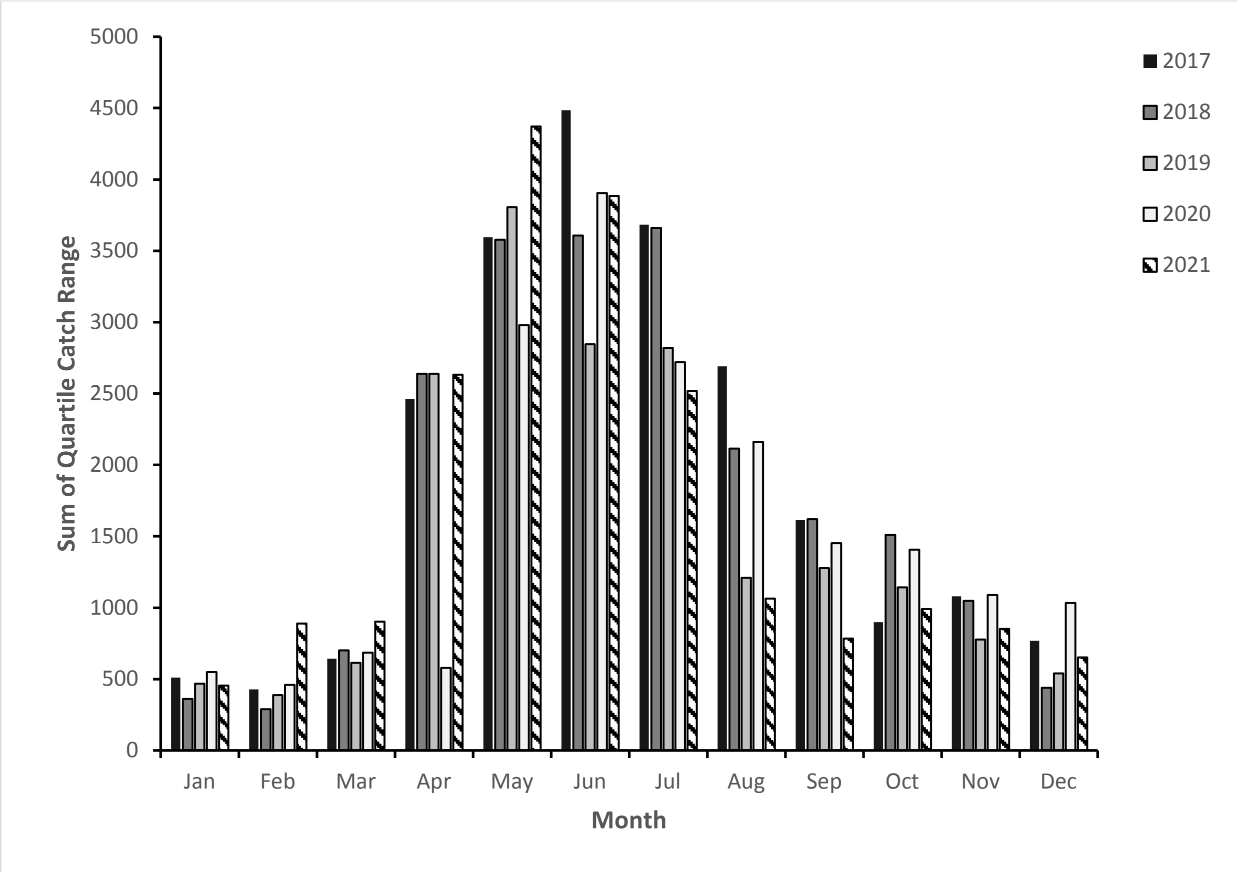


Figure 3.25. Offshore domestic harvest seasonality in the RSA, all species 2017-2021 (Source: DFO Commercial Landings database, 2017-2021).

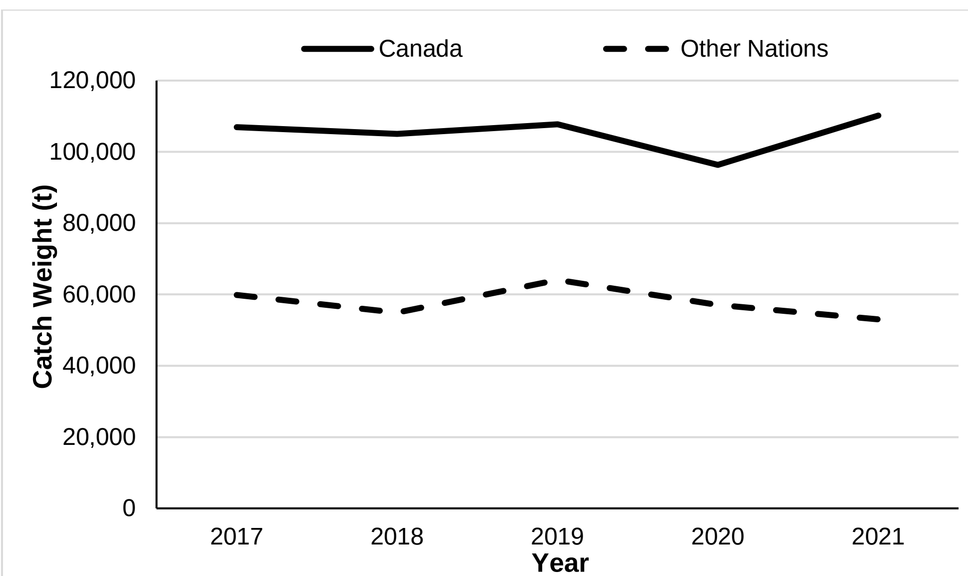


Figure 3.26. Annual Canadian and international total catch weights (t) of NAFO-managed commercial fisheries in NAFO Divisions 3KLMNO (Source: NAFO STATLANT21A database [NAFO 2023b]).

3.6.2 Aquaculture

Aquaculture is an important growing industry in the region, but most of the sites are found outside the RSA. As of July 2022, within the RSA, there are coastal-based production facilities for Atlantic salmon (*Salmo salar*), Atlantic cod, tilapia (*Oreochromis* spp.), green sea urchin, blue mussel (*Mytilus edulis*), and American oyster (*Crassostrea virginica*) (see Section 7.1.9 in ExxonMobil 2017; FFA 2022; Figure 3.27).

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 (see Sections 4.3.4-4.3.5 in Stantec 2018a). A total of 1344 vessels visited St. John's Harbour during 2017, a 6.8% decrease from 2016 (SJPA 2023). 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 (TI 2023) and federal governments (Marine Atlantic 2023; SPM Ferries 2023). These include local routes and federal routes between Newfoundland and Nova Scotia and Newfoundland and St. Pierre and Miquelon (Figure 3.28). Tourism is another important driver of marine activity, both along the coastline and involving larger, ocean-going vessels, such as cruise ships. During 2018, there were a total of 87 port calls to 21 different ports made by 30 cruise ships throughout the province, including 25 port calls in St. John's; these port calls brought a total of 47,565 visitors to NL, including 19,151 visitors to St. John's (TCII 2019). Local tour companies operate along the coast of Newfoundland, offering experiences such as whale, seabird, and iceberg safaris (TNL 2023). 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 4.3.6 in Stantec 2018a).

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 licences are issued to Indigenous communities, Commercial Communal Fishing and FSC Fishing. Both types of licences are held by Indigenous communities rather than individual community members (see Section 4.3.2 in Stantec 2018a). There are several Indigenous communities in NL, including Labrador Inuit (Nunatsiavut Government), Labrador Innu (Innu Nation), NunatuKavut Community Council (NCC), Qalipu Mi'kmaq First Nation, and Miawpukek First Nation (see Section 4.3.2.2 of Stantec 2018a for community profiles). Indigenous communities in NL are shown in Figures 3.29 and 3.30.

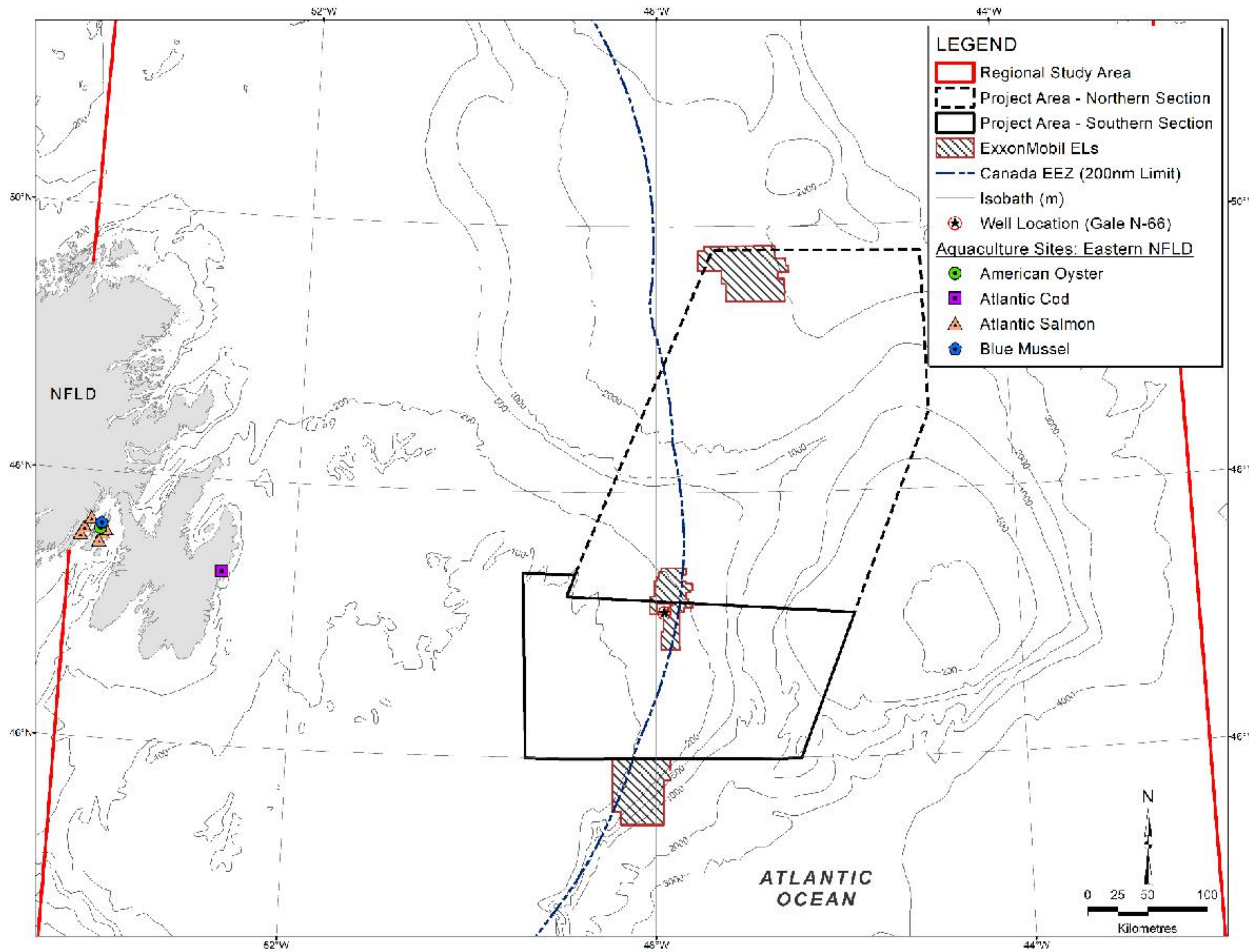


Figure 3.27. Aquaculture sites in the RSA as of July 2022 (Source: FFA 2022).

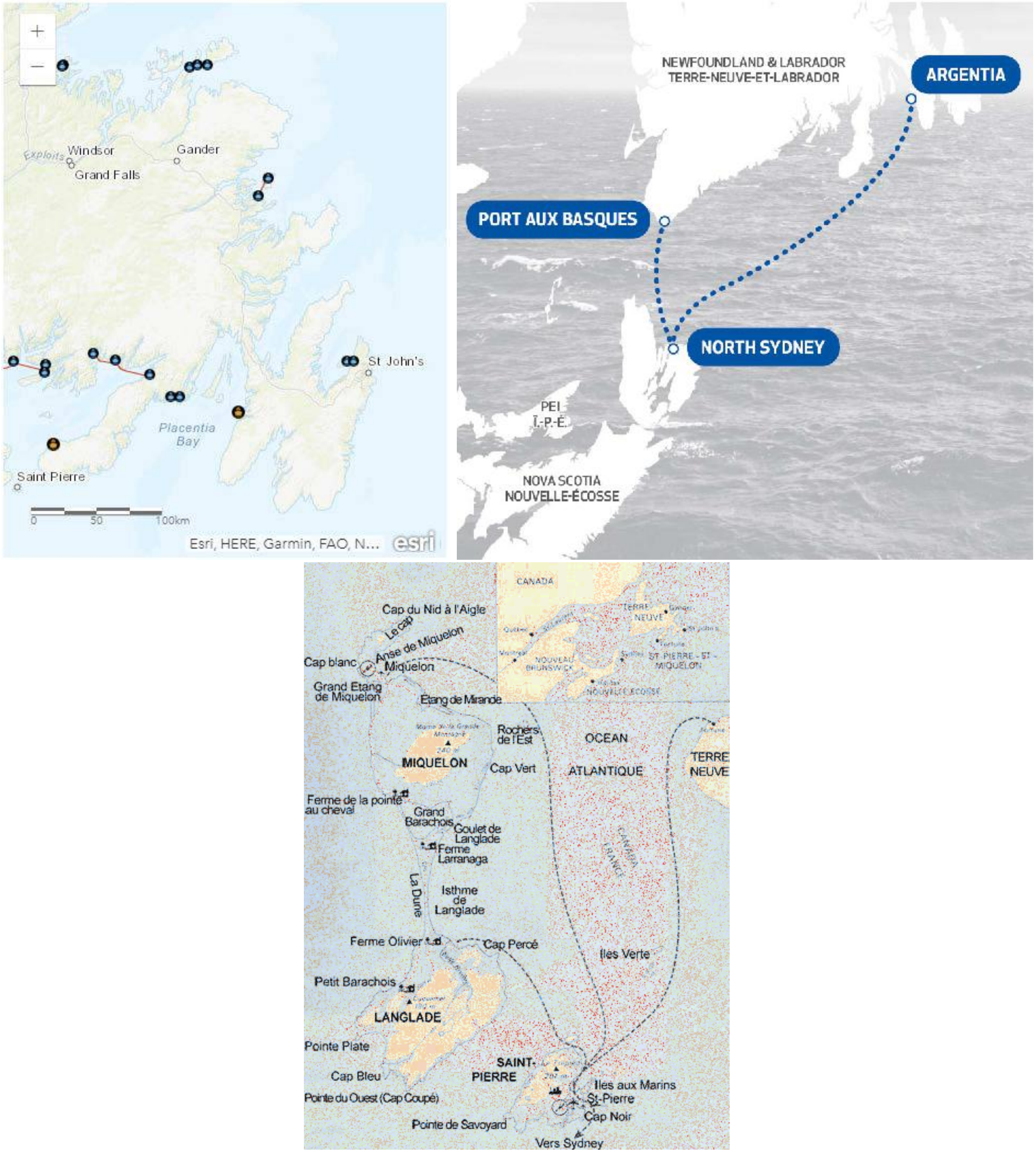


Figure 3.28. Local/provincial (top left) and federal ferry routes that overlap or occur near the RSA (top right: Marine Atlantic routes; bottom: St. Pierre and Miquelon routes; blue dotted lines represent ferry routes) (Source: Atlas Words n.d.; Marine Atlantic 2023; SPM Ferries 2023; TI 2023).

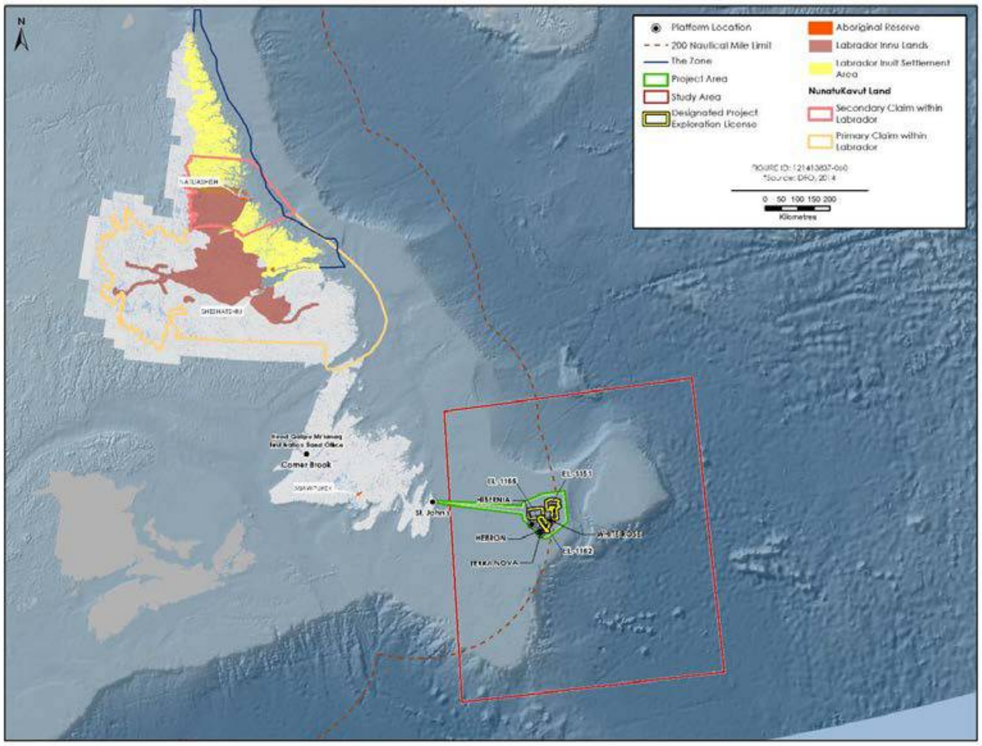


Figure 3.29. Indigenous communities and lands in NL (Source: Figure 4-61 in Stantec 2018a).

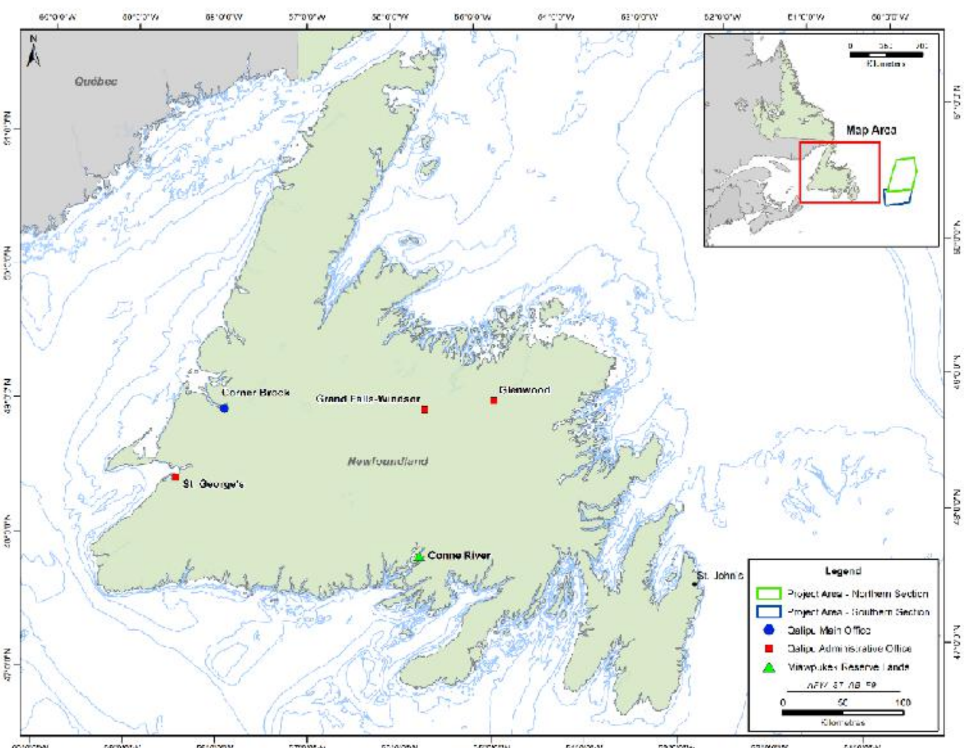


Figure 3.30. Indigenous communities and lands in Newfoundland (Source: Figure 7-36 in ExxonMobil 2017).

Several Commercial Communal licences are held by Indigenous communities in NL. The Nunatsiavut Government holds Commercial Communal licences for snow crab, shrimp, Arctic char, scallop, seal, Greenland halibut, and groundfish. The Innu Nation holds Commercial Communal licences for mackerel, capelin, halibut, groundfish, and shrimp. The Qalipu Mi'kmaq First Nation holds Commercial Communal licences for snow crab, toad crab, scallops, shrimp, groundfish, capelin, herring, and seal. The Miawpukek First Nation holds Commercial Communal licences for mackerel, herring, swordfish, caplin, groundfish, tuna (including bluefin tuna), squid, snow crab, and seal. The NunatuKavut Community holds Commercial Communal licences for snow crab, toad crab, shrimp, scallops, groundfish, capelin, herring, and seal. The region's Indigenous communities also hold several licences for FSC fishing. For example, several Indigenous communities hold licences for the harvest of salmon and Arctic char. An overview of the Indigenous communities of NL and their traditional harvest of marine resources is provided in Table 4.47 in Stantec 2018).

3.8 Responder Health and Safety

Responder health and safety was not included as a ROC in the Program's previous SIMA (LGL 2019). In accordance with more recent SIMA methodology, it has been included as a dedicated ROC here.

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 heath 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 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) 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 oil 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 contaminants 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. Dedicated safety officers should also be present during response operations.

4.0 Oil Spill Scenario

4.1 Oil Characteristics

Terra Nova oil was used for the EL 1151 modelling (see Section 3.1 in RPS 2019). The reader is reminded that after the modelling was conducted in 2019 (RPS 2019), EL 1151 was consolidated with EL 1163 to become EL 1167, the focus of this updated SIMA. Nonetheless, the hypothetical release location used in RPS (2019) is for a similar water depth as the planned Gale N-66 Well (170 m and ~165 m, respectively) and the sites are in close proximity (~0.5 km apart; model: 47º5′59.8617″N, 47º55′6.5331″W; Gale N-66: 47°5′50.52″N, 47°54′46.94″W); therefore, the EL 1151 modelling is considered applicable for this updated SIMA and EL 1167. Terra Nova is a light crude oil with low viscosity and high volatile and soluble content. During a spill, approximately 10% of constituents of Terra Nova oil could dissolve into the water column, which is relatively high compared to oils that have lower soluble content (RPS 2019). Because Terra Nova oil is volatile, a relatively large portion of the oil could possibly discharge into the atmosphere as vapors during a spill (RPS 2019). The physical properties of Terra Nova oil are provided in Table 4.1 (see also Table 3-2 in RPS 2019 for fractions of the whole oil at different distillation cuts).

Table 4.1. Physical properties of the Terra Nova oil product used in the modelling (Source: Table 3-1 in RPS 2019).

Physical Property	Terra Nova Oil
Density (g/cm^3)	0.854 @16°C
Viscosity (cP)	22 @ 15°C
API Gravity	34.2
Pour Point (ºC)	-10.6
Interface Tension (dyne/cm)	28.8
Emulsion Maximum Water Content (%)	10%

Note: cP = centipoises.

4.2 Oil Spill Model and Response Parameters

4.2.1 Oil Spill Model

Oil spill modelling for this updated SIMA was conducted using the OILMAPDeep near-field blowout model and SIMAP oil trajectory, fate, and effects model (RPS 2019). The near-field dynamics of the subsurface blowout plume were defined using OILMAPDeep and these findings were used to conduct the far-field modelling using SIMAP. Near-field dynamics include the subsurface oil and gas plume's mass, location, geometry, centerline velocity, and concentrations until the plume reaches the surface or a "trap height" (i.e., where "the oil jet and buoyant oil and gas plume are 'trapped' and form an intrusion" [see Section 2.2.1 in RPS 2019]), and droplet size distribution at the trap height. Trap height varies depending on environmental conditions, oil properties, and release parameters (RPS 2019) but typically occurs within several hundred metres above the release depth (Socolofsky et al. 2015 in RPS 2019). The OILMAPDeep model also accounts for increased hydrostatic pressure in water depths >200 m. The SIMAP model estimates the fate of spilled oil, including on the water surface and shorelines and in the water column and sediments. See Section 2.2.1 and Appendix A in RPS (2019) for further details on the OILMAPDeep and SIMAP model methodologies. Model uncertainties and validation are provided in Section 2.4 of RPS (2019).

4.2.2 Rationale for Scenario Selection for SIMA Assessment

Stochastic analyses indicated probable spill trajectories based on different environmental conditions and deterministic analyses were conducted to determine spill spatial and temporal movements and behaviour, along with oil thicknesses, concentrations, and masses for the sea surface, water column, seabed, and shoreline environmental compartments (see Section 2.2. in RPS 2019). The modelling assessed 345 simulations and determined that the credible "worst-case" scenarios (i.e., "95th percentile 'worst-case' for surface oil, subsurface contamination, and shoreline oiling" [see Sections 2.2 and 2.24 and Table 2-1 in RPS 2019]) consisted of untreated (i.e., natural attenuation response option) subsea blowouts with short (21 days) and long (116 days) release durations during winter and summer (see Section 2.2 in RPS 2019). The short duration release represented a capping stack response scenario, and the long duration release represented the length of time required to mobilize a drilling platform and drill a relief well (see Section 4.1.3 in RPS 2019). These worst-case scenarios were used for this updated SIMA.

It should be noted that modelling was also conducted for a 21-day release duration for a spill commencing in May that undergoes mitigation response treatment, including SSDI, surface dispersant application, in-situ burning, and the installation of a capping stack (see Sections 3.8 and 4.3 in RPS 2019). However, as modelling of a treated subsea blowout determined this would not be the worst-case scenario for the modelled spill site relative to untreated scenarios, it was not used as the basis for this updated SIMA.

4.2.3 Model and Response Parameters and Stochastic Scenario Information

The model release location, parameters, and stochastic scenario information for a subsurface blowout in [the former] EL 1151 are provided in Table 4.2 and the deterministic worst-case scenario parameters are in Table 4.3. The modelling domain, which encompasses the RSA and areas beyond its bounds, is provided in Figure 4.1.

Table 4.2. Modelled subsurface release location, parameters, and stochastic scenario information (Source: Table 2-4 in RPS 2019).

Scenario Parameter	**Value**	
Block/Release Location	EL 1151	
Latitude	47° 05’ 59.8617” N	
Longitude	47° 55’ 6.5331”	
Water Depth of Release	170 m	
Released Product	Terra Nova	
Gas to Oil Ratio	700 scf/STB	
Pipe Diameter	29.7 cm (11.7 in.)	
Oil Discharge Temperature	181°F (82.3ºC)	
Release Duration	21 d	116 d
Release Rate	191,930 bpd	
Total Released Volume	4,030,530 bbl	22,263,880 bbl
Model Duration	45 d	160 d
Number of Simulations within Stochastic Analysis*	172 annual (92 winter & 80 summer)	173 annual (90 winter & 83 summer)

* A total of 345 individual subsurface releases were modelled within the stochastic analyses.
Note: STB = Stock Tank Barrel; bpd = Barrels per Day; bbl = Billion Barrels of [Petroleum] Liquid; for duration, d = days.

Table 4.3. Representative deterministic worst-case scenario parameters (Source: Table 2-5 in RPS 2019).

Parameter	**Value**					
	21-day Subsurface Release			**116-day Subsurface Release**		
Representative Scenario	Surface Oil Exposure Area	Water Column Oil Mass	Shoreline Contact Length	Surface Oil Exposure Area	Water Column Oil Mass	Shoreline Contact Length
Block / Release Site	EL 1151					
Release Type	Subsurface Blowout					
Water Depth of Release	170 m					
Released Product	Terra Nova					
Release Duration (days)	21			116		
Release Rate	191,930 bpd					
Total Released Volume	4,030,530 bbl			22,263,880 bbl		
Model Duration (days)	45			160		
Modelled Start Date and Season	13 May 2009 Summer	25 Jan 2008 Winter	25 Nov 2010 Winter	14 Sep 2010 Winter	18 May 2012 Summer	21 Aug 2010 Winter

Note: bpd = Barrels per Day; bbl = Billion Barrels of [Petroleum] Liquid.

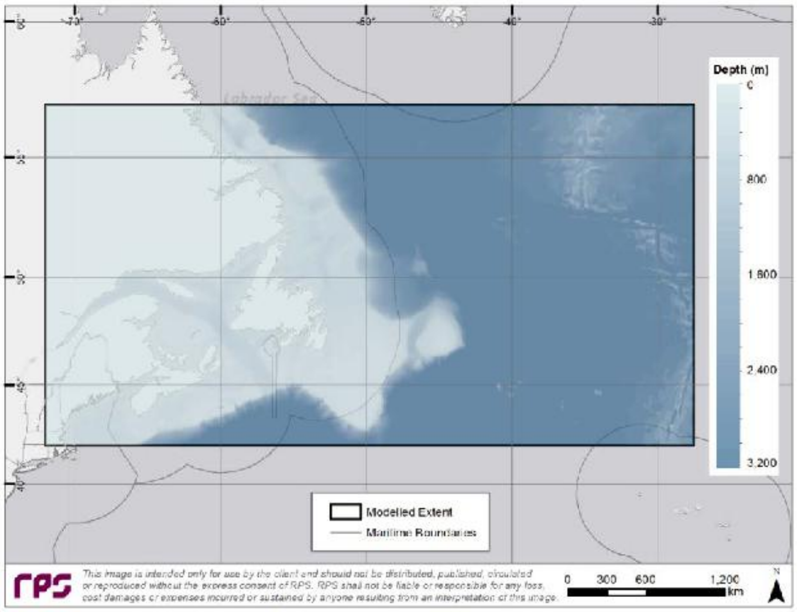


Figure 4.1. Modelled domain for EL 1151 (Source: Figure 3-1 in RPS 2019).

4.2.3.1 *Environmental Inputs*

Environmental inputs applied to the oil spill modelling included geographic and habitat data (i.e., bottom/shoreline type, vegetation), and ice cover, wind, current, and water temperature and salinity data (see Sections 3.2-3.6 of RPS 2019; Figures 4.2-4.9).

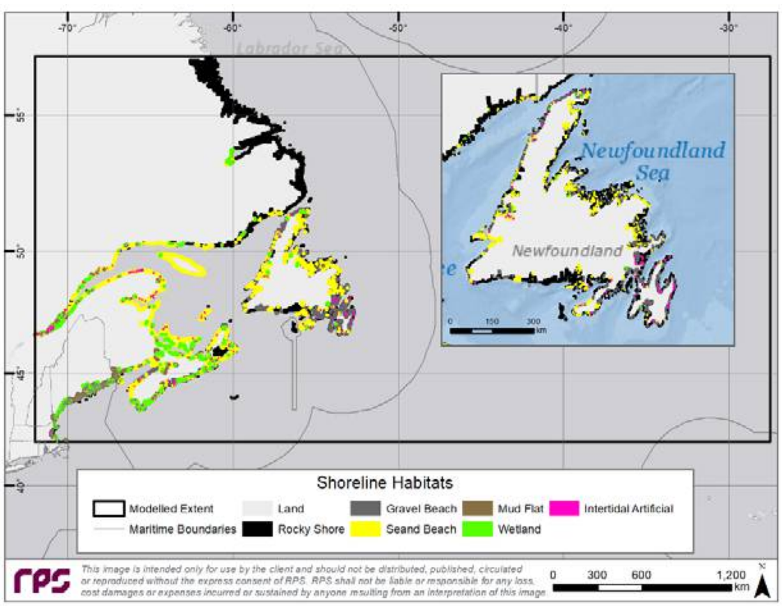


Figure 4.2. Shoreline habitat data used for EL 1151 oil spill modelling (Source: Figure 3-1 in RPS 2019).

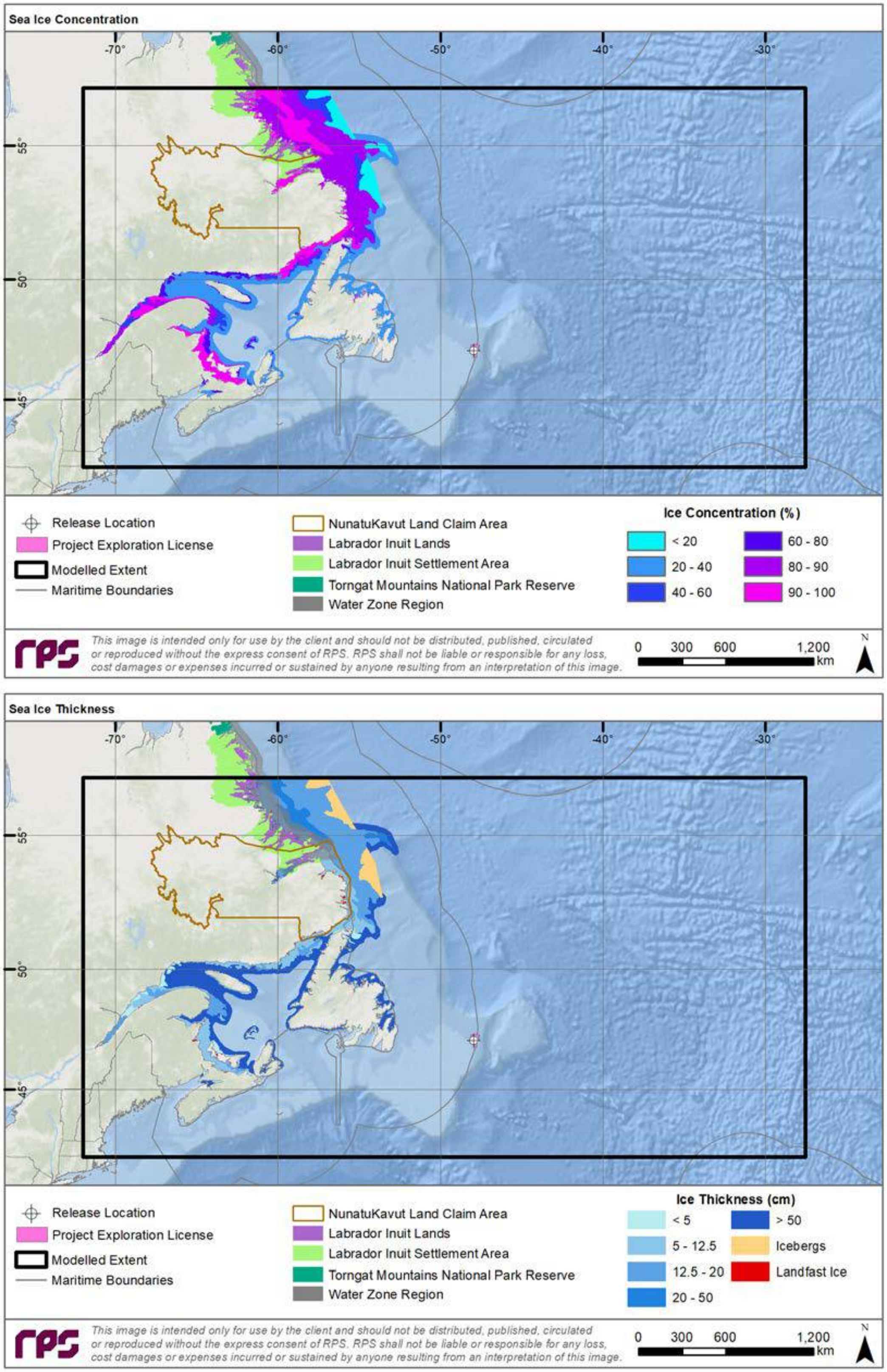


Figure 4.3. Representative percentage sea-ice coverage (top) and corresponding thickness (bottom) for the first week of February 2008 (Source: Figure 3-3 in RPS 2019).

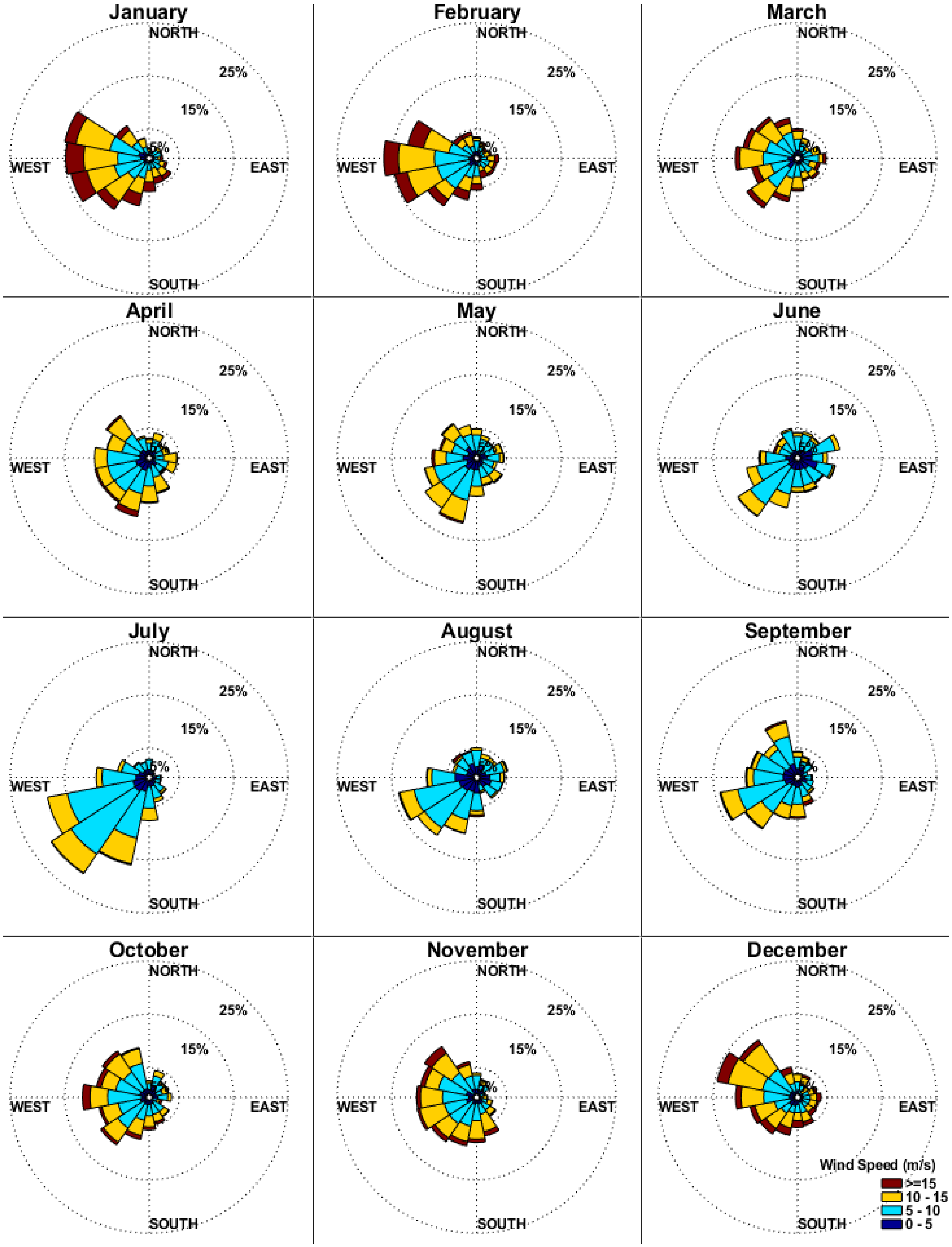


Figure 4.4. Monthly CFS wind roses near the modelled spill site (wind speeds in m/s, using meteorological convention [i.e., direction wind is coming from]; Source: Figure 3-5 in RPS 2019).

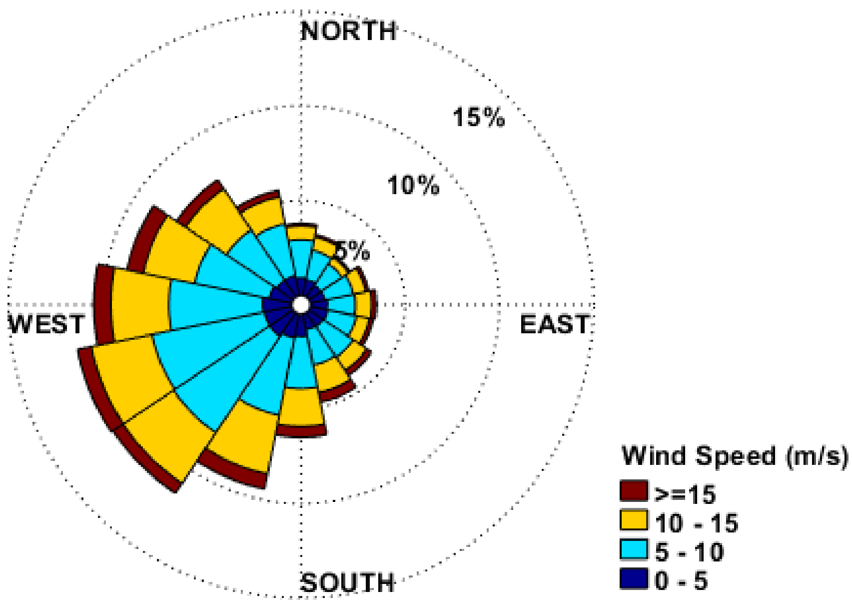


Figure 4.5. Annual Climate Forecast System (CFS) wind rose near the modelled spill site (wind speeds in m/s, using meteorological convention [i.e., direction wind is coming from]; Source: Figure 3-4 in RPS 2019).

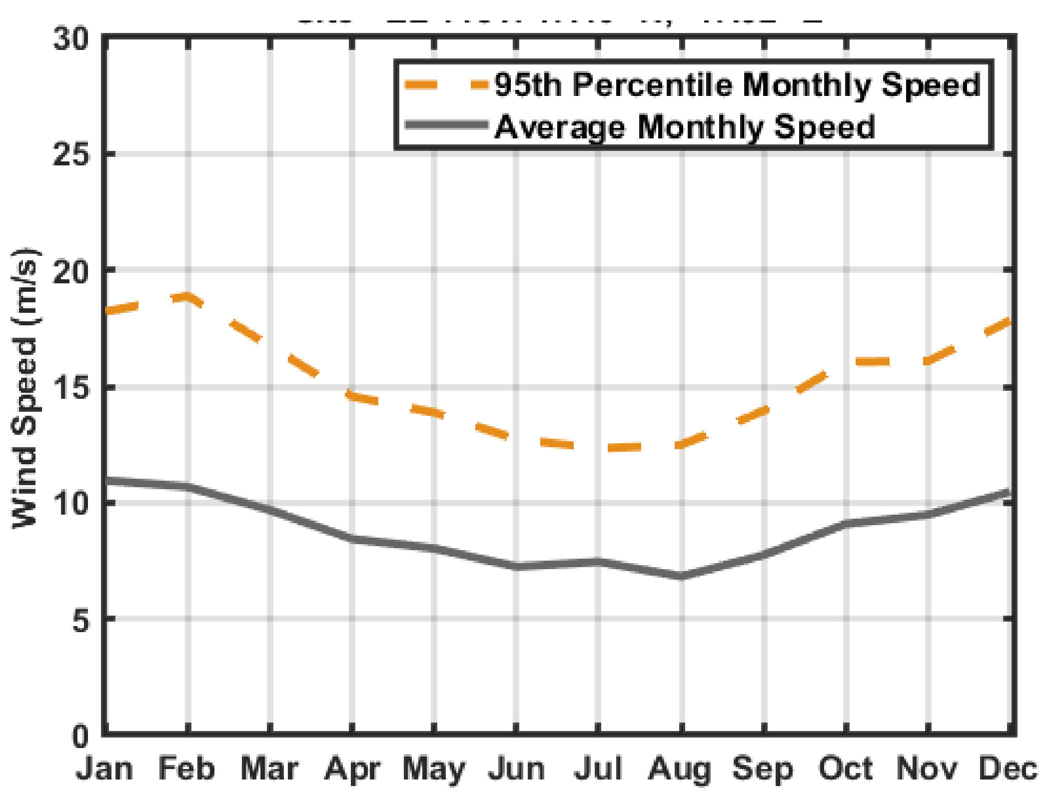


Figure 4.6. Average and 95th percentile monthly wind speeds near the modelled spill site (Source: Figure 3-6 in RPS 2019).

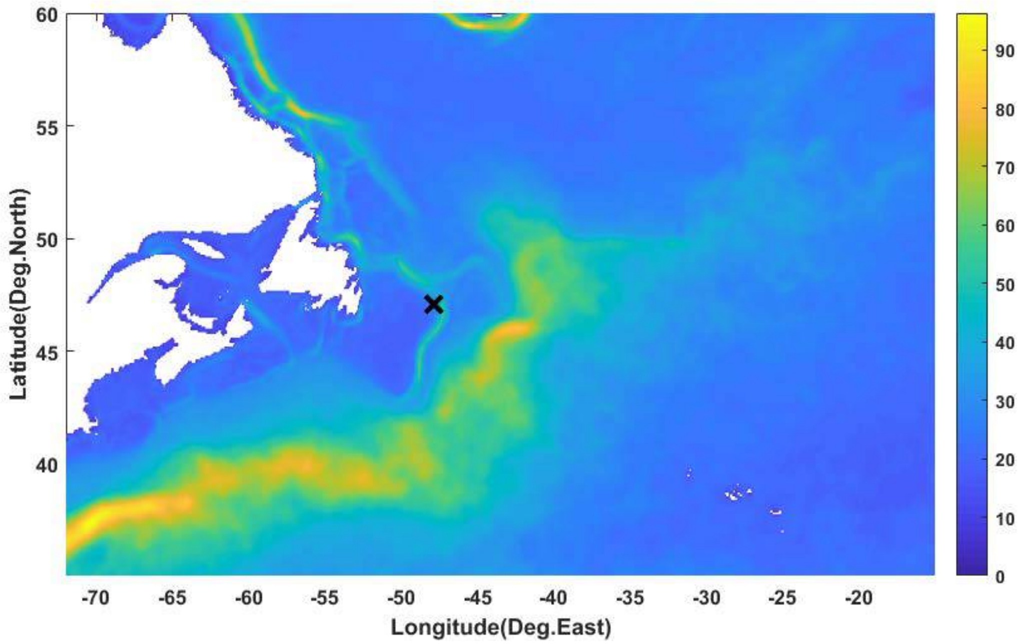


Figure 4.7. Average Hybrid Coordinate Ocean Model (HYCOM) surface current speeds (cm/s) offshore Newfoundland (2006-2012; black ‘x’ = modelled well location; Source: Figure 3-8 in RPS 2019).

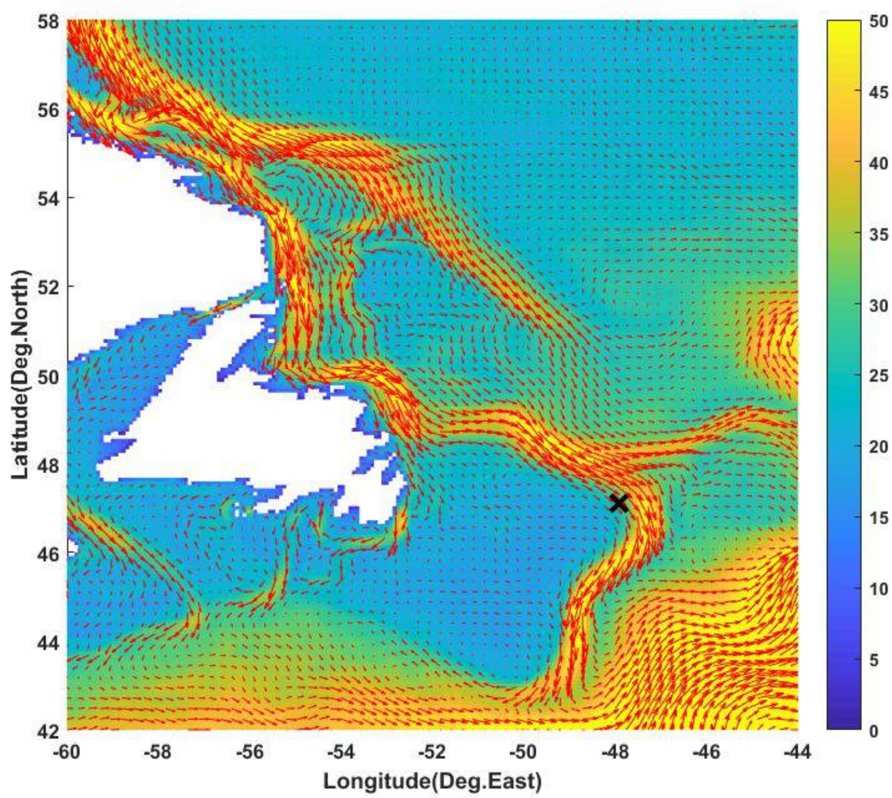


Figure 4.8. Averaged HYCOM surface current speed (cm/s) and direction around the coasts of NL (2006-2012; black ‘x’ = modelled well location; Source: Figure 3-9 in RPS 2019).

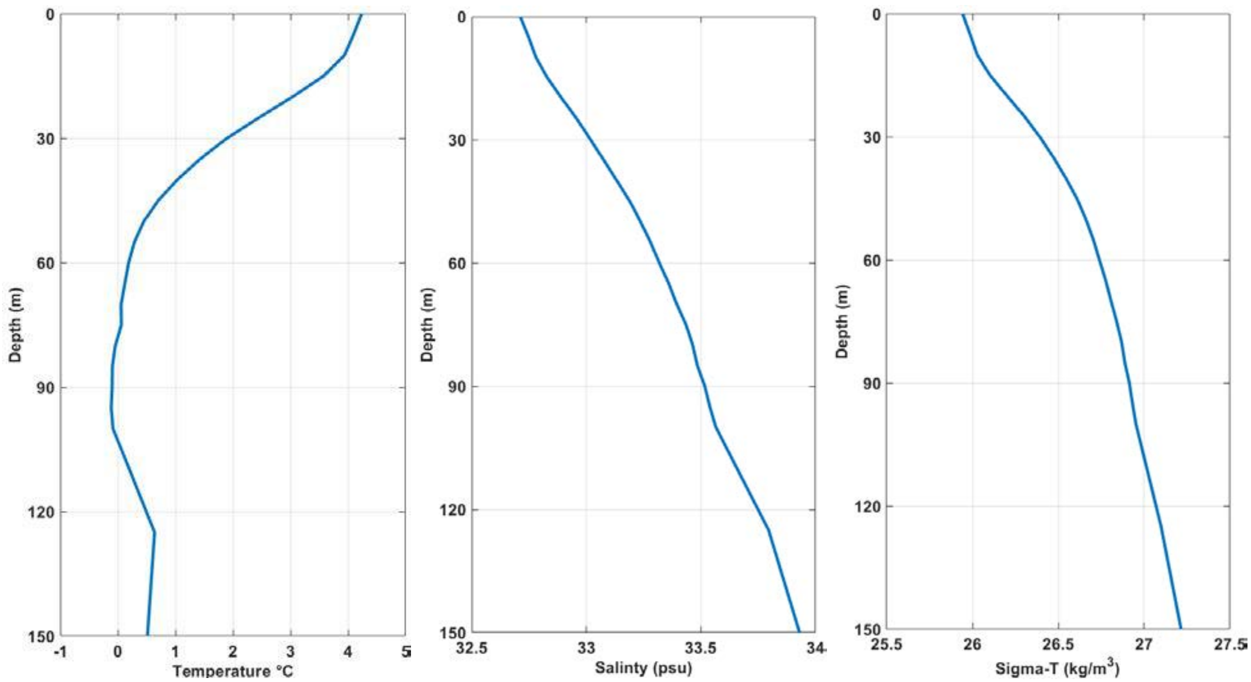


Figure 4.9. Annual water column temperature (left), salinity (middle), and calculated density (right) profiles near the modelled well location (Source: Figure 3-10 in RPS 2019).

4.2.3.2 Impact Assessment Thresholds

Impact assessment thresholds are specific, conservative values for surface oil thickness, oil on shorelines and sediments, and in-water oil concentrations above which there is a potential for negative effects to occur for relevant ROCs. These thresholds are required for stochastic modelling to determine the probability/likelihood of potential exposure (see Section 2.2.3 in RPS 2019). The thresholds used for modelling and their rationales and appearance are provided in Table 4.4. See Table 2-3 and Figure 2-3 in RPS (2019) for further descriptions and examples of oil appearances based on surface oil thickness and product type.

Table 4.4. Impact threshold values, rationales, and appearance used for the modelled subsea blowout scenarios (Source: Table 2-2 in RPS 2019).

Threshold Type	Threshold Value [a]	Rationale	Visual Appearance
Oil Floating on Water Surface (thickness of oil on the water surface)	0.04 g/m^2 (0.04 µm on average over grid cell)	Socio-economic: A conservative threshold used in several risk assessments to determine effects on socio-economic resources (e.g., fishing may be prohibited when sheens are visible on the sea surface). Socio-economic resources and uses that would be affected by floating oil include commercial, recreational, and subsistence fishing; aquaculture; recreational boating; port concerns, such as shipping, recreation, transportation, and military uses; energy production (e.g., power plant	Fresh oil at this minimum threshold corresponds to a slick being barely visible or scattered sheen (colorless or silvery/grey), scattered tar balls, or widely scattered patches of thicker oil.

Threshold Type	Threshold Value [a]	Rationale	Visual Appearance
		intakes, wind farms, offshore oil and gas); water supply intakes; and aesthetics.	
	10 g/m^2 (10 µm on average over grid cell)	Ecological: Mortality of birds on water has been observed at and above this threshold. Sublethal effects on marine mammals, sea turtles, and floating *Sargassum* (seaweed) communities are of concern.	Fresh oil at this threshold corresponds to a slick being a dark brown or metallic sheen.
Shoreline Oil (volume of oil reaching the shoreline)	1.0 g/m^2 (1 µm on average over grid cell)	Socio-economic/Response: A conservative threshold used in several risk assessments. This is a threshold for potential effects on socio-economic resource uses, as this amount of oil may trigger the need for shoreline cleanup on amenity beaches and affect shoreline recreation and tourism. Socio-economic resources and uses that would be affected by shoreline oil include recreational beach and shore use, wildlife viewing, nearshore recreational boating, tribal lands and subsistence uses, public parks and protected areas, tourism, coastal dependent businesses, and aesthetics.	May appear as a coat, patches or scattered tar balls, stain.
	100 g/m^2 (100 µm on average over grid cell)	Ecological: This is a screening threshold for potential ecological effects on shoreline flora and fauna, based upon a synthesis of the literature showing that shoreline life has been affected by this degree of oiling. Sublethal effects on epifaunal intertidal invertebrates on hard substrates and on sediments have been observed where oiling exceeds this threshold. Assumed lethal effects threshold for birds on the shoreline.	May appear as black opaque oil.
In-water Concentration (total hydrocarbons)	1.0 ppb (µg/L) of dissolved PAHs (corresponds to ~100 ppb [µg/L] of whole oil [THC] in the water column [soluble PAHs are ~1% of the total mass of fresh oil])	Water column effects for both ecological and socio-economic (e.g., seafood) resources may occur at concentrations exceeding 1 ppb dissolved PAH or 100 ppb whole oil; this threshold is typically used as a screening threshold for potential effects on sensitive organisms.	N/A

[a] Thresholds used in supporting stochastic results figures.

4.3 Oil Spill Fate and Trajectory

This section provides a summary of the modelled fate and trajectory of oil for the modelled worst-case untreated, 21-day and 116-day, winter and summer subsea blowout spill scenarios for the modelled spill site in [former] EL 1151 (now EL 1167). The information provided in this section is the type 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. Although modelling results for a treated spill were not the base of this SIMA (see Section 4.2.2 above), they were referred to where appropriate as rationale for risk scores in Section 5.3 below; such modelling would be included as part of real-time analyses to inform the creation of expedited SIMAs and response decisions for the duration of response operations.

4.3.1 Results of Stochastic Analyses

The predicted spatial extents and minimum time footprints (i.e., shortest amount of time required from the initial release to exceed thresholds) of surface floating oil, water column contamination, and shoreline contact above impact assessment thresholds (see Section 4.2.3.2 above) for unmitigated summer and winter subsea blowouts of 21-day and 116-day release durations are provided in Figures 4.10-4.15. For both release durations, areas to the south and east of the release site had the greatest potential (>90% likelihood) to exceed impact assessment thresholds (see Section 4.1.3 in RPS 2019). The area of 90% likelihood for threshold exceedance for surface and in-water oil extended >300 km to the south for the 21-day release and ~610 km and 1470 km to the south and east, respectively, for the 116-day release. Modelling estimated release volumes of 4,030,530 bbl and 22,263,880 bbl for the 21-day and 116-day simulation, respectively, and predicted larger footprints for water column contamination than surface oil (Tables 4.3 and 4.5).

The 116-day release scenario had the highest probability of Canadian shoreline oiling (mean: ~7%; maximum: 19%) (Table 4.6). The minimum time for shoreline exposure to exceed impact threshold was ~28-55 days for Newfoundland's Avalon peninsula and southeastern coast and 50-100+ days for Sable Island and the Atlantic shores of Nova Scotia. Both release durations indicated higher probabilities and shorter minimum time for threshold exceedance for shoreline oiling for winter (~3-7%; ~28 days) versus summer (~1-3%; ~38-55 days) blowouts.

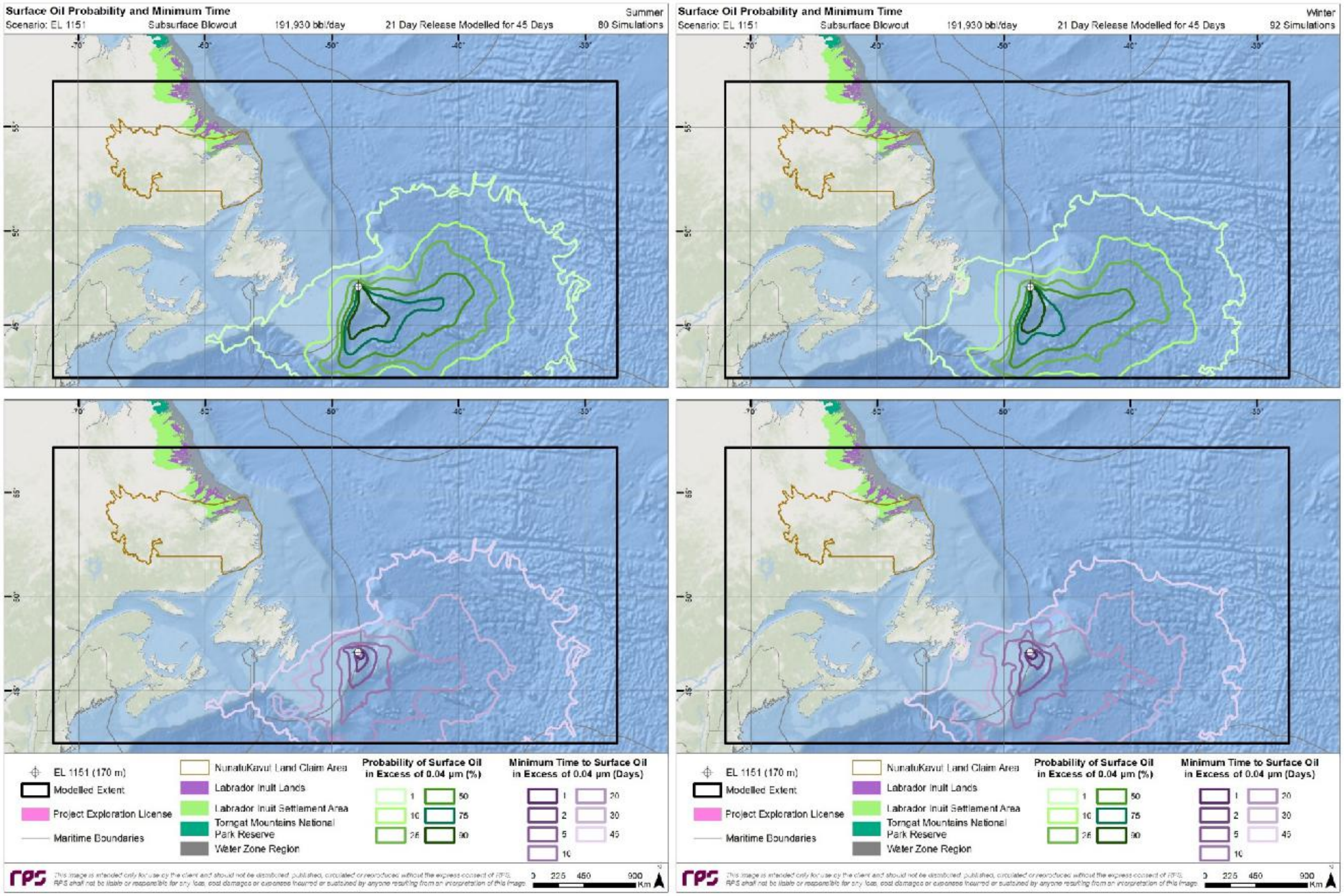


Figure 4.10. Predicted summer (left) and winter (right) probability of surface oil thickness >0.04 µm (top panels) and minimum time to threshold exceedance (bottom panels) resulting from a 21-day subsurface blowout at [former] EL1151 (Source: Figures 4-2 and 4-3 in RPS 2019).

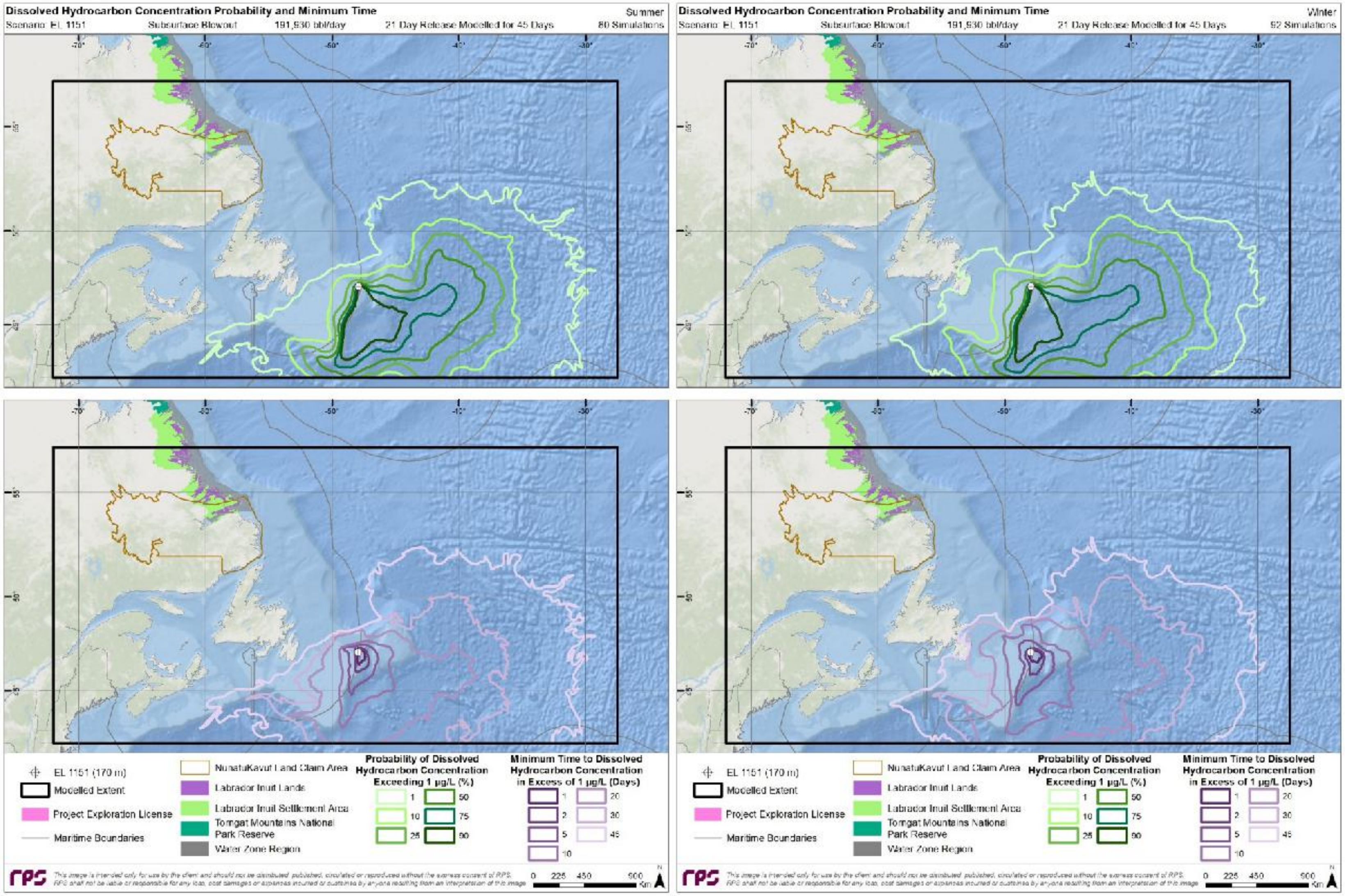


Figure 4.11. Predicted summer (left) and winter (right) probability of dissolved hydrocarbon concentrations >1 µg/L in the water column (top panels) and minimum time to threshold exceedance (bottom panels) resulting from a 21-day subsurface blowout at [former] EL 1151 (Source: Figures 4-5 and 4-6 in RPS 2019).

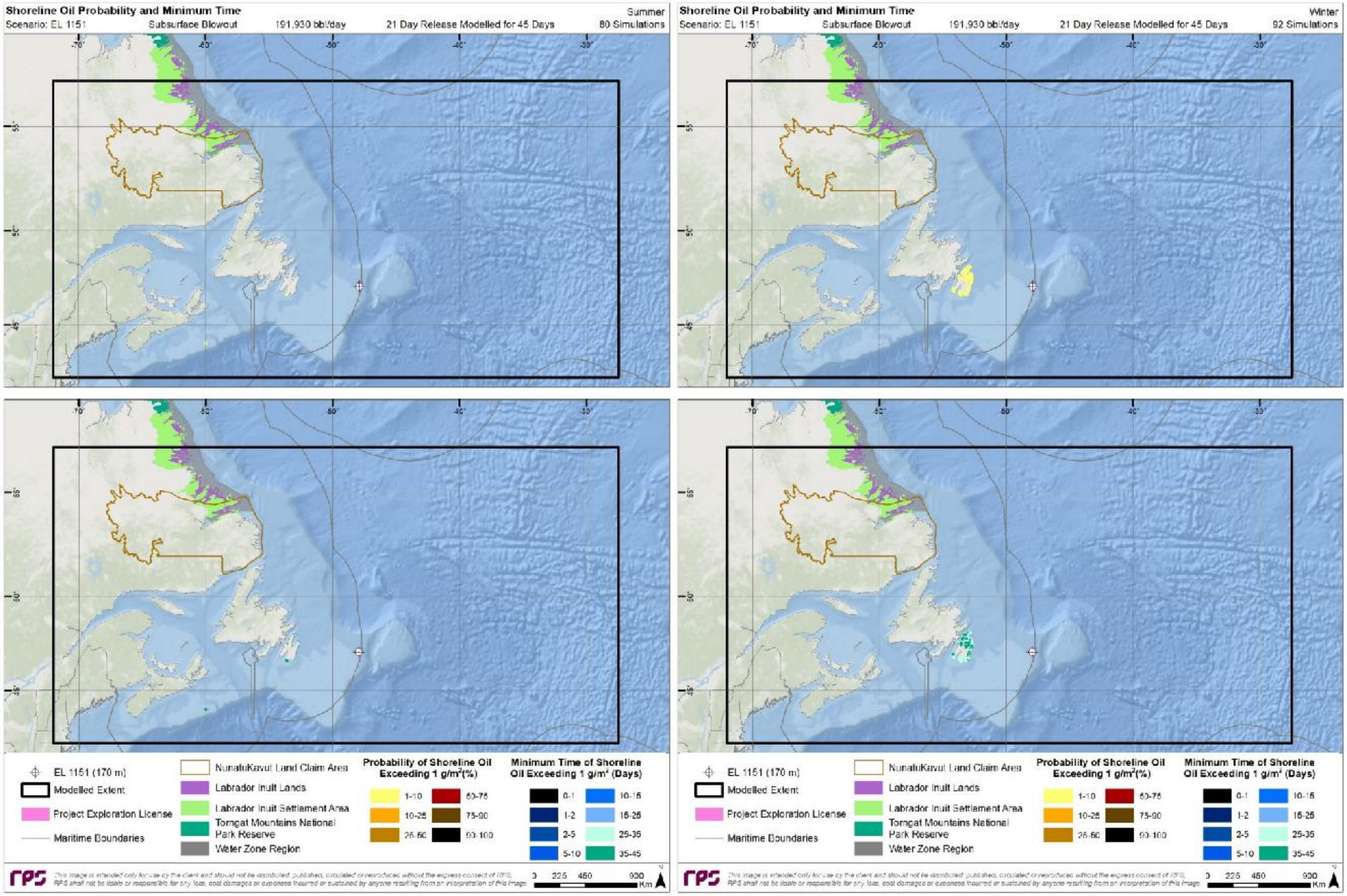


Figure 4.12. Predicted summer (left) and winter (right) probability of shoreline contact >1 gm/^{2} (top panels) and minimum time to threshold exceedance (bottom panels) resulting from a 21-day subsurface blowout at [former] EL 1151 (Source: Figures 4-8 and 4-9 in RPS 2019).

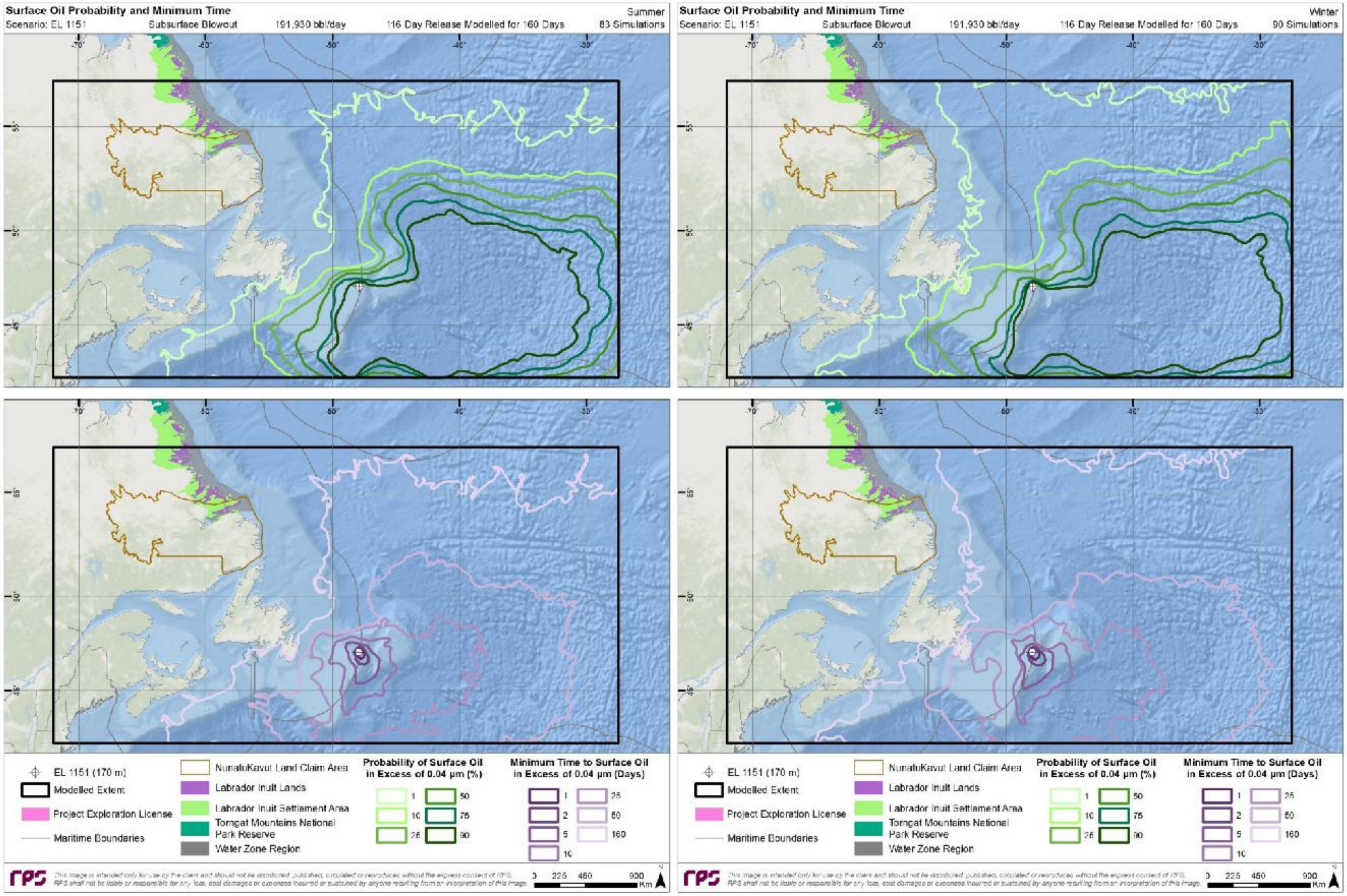


Figure 4.13. Predicted summer (left) and winter (right) probability of surface oil thickness >0.04 µm (top panels) and minimum time to threshold exceedance (bottom panels) resulting from a 116-day subsurface blowout at [former] EL1151 (Source: Figures 4-11 and 4-12 in RPS 2019).

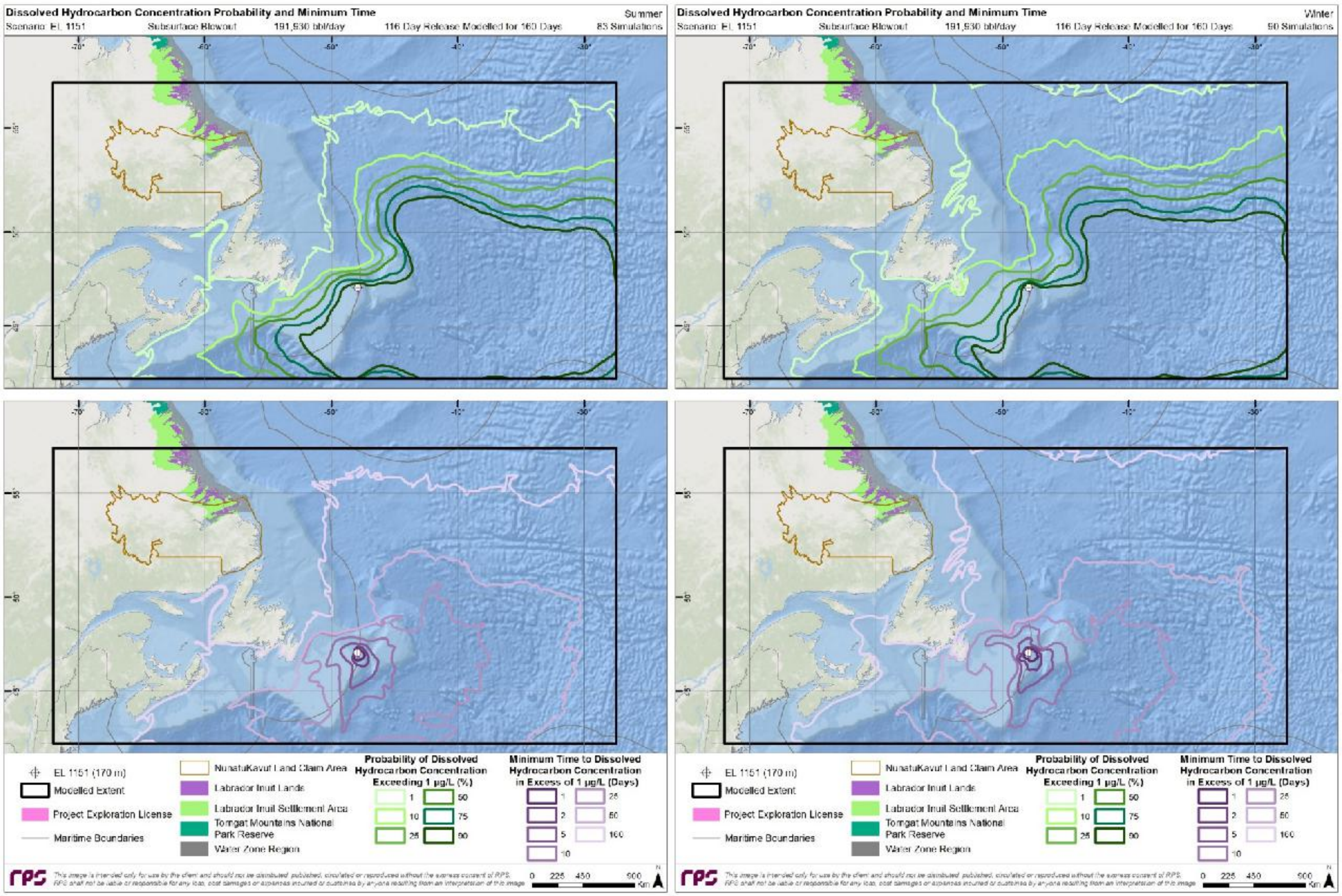


Figure 4.14. Predicted summer (left) and winter (right) probability of dissolved hydrocarbon concentrations >1 µg/L in the water column (top panels) and minimum time to threshold exceedance (bottom panels) resulting from a 116-day subsurface blowout at [former] EL 1151 (Source: Figures 4-14 and 4-15 in RPS 2019).

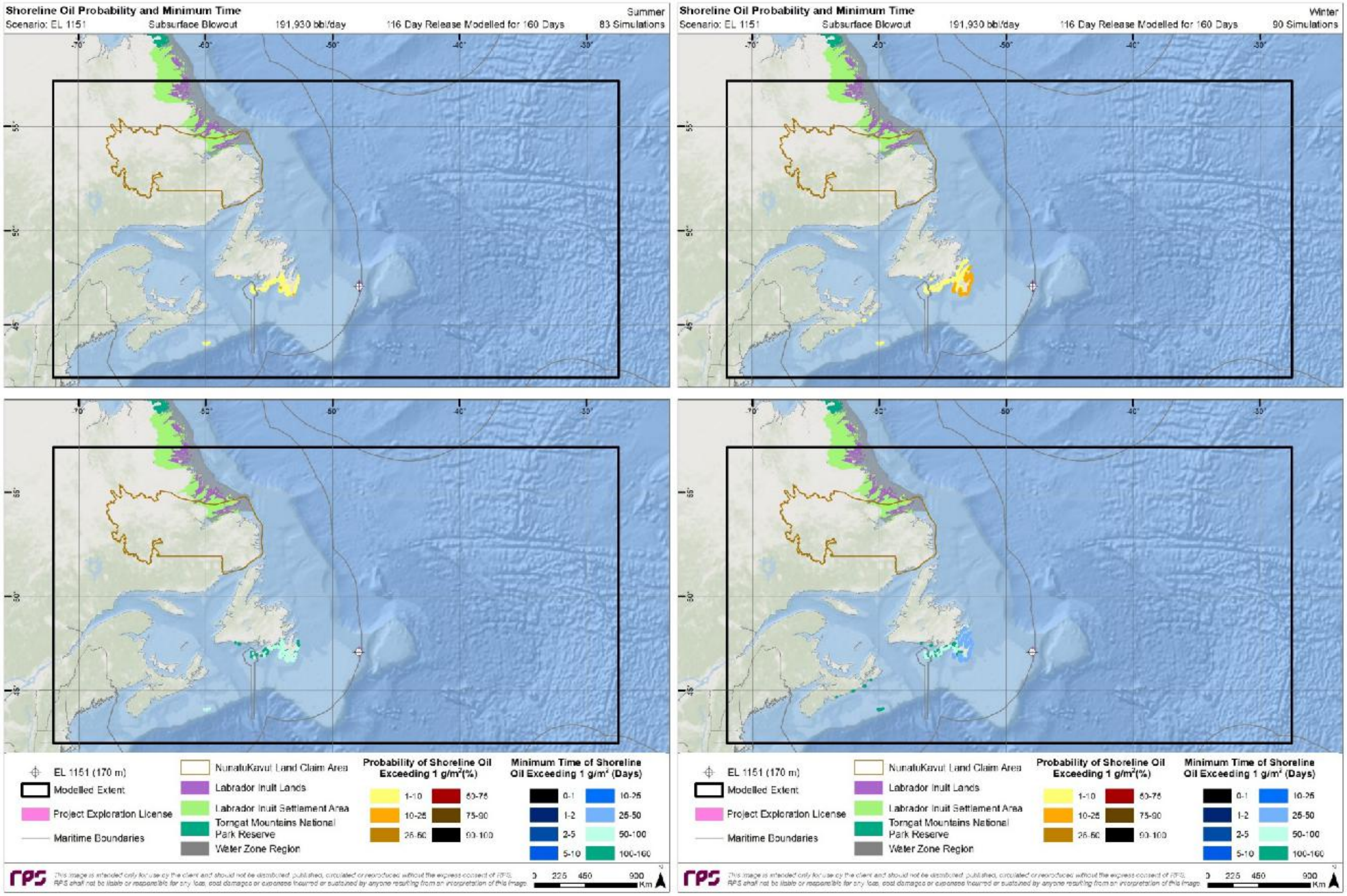


Figure 4.15. Predicted summer (left) and winter (right) probability of shoreline contact >1 gm/² (top panels) and minimum time to threshold exceedance (bottom panels) resulting from a 116-day subsurface blowout at [former] EL 1151 (Source: Figures 4-17 and 4-18 in RPS 2019).

Table 4.5. Summary of impact assessment threshold exceedance information for predicted surface, water column, and shoreline oil exposure for winter and summer subsea blowouts (Source: Table 4-1 in RPS 2019).

Stochastic Scenario Parameters			Areas Exceeding Threshold (km^2)	
Component (Threshold)	**Scenario**	**Probability Contour or Bin [a]**	**Winter (Ice cover)**	**Summer (ice-free)**
Surface Oil (>0.04 µm, on average)	21-day release	1%	1,688,000	1,783,000
		10%	801,100	786,500
		90%	21,960	38,400
	116-day release	1%	3,379,000	2,969,000
		10%	2,294,000	2,133,000
		90%	1,090,000	1,059,000
Water Column Dissolved Hydrocarbons (>1 µg/L at some depth within the water column)	21-day release	1%	1,817,000	1,770,000
		10%	1,053,000	795,100
		90%	73,820	24,630
	116-day release	1%	3,485,000	3,040,000
		10%	2,466,000	2,295,000
		90%	1,435,000	1,495,000
			Lengths Exceeding Threshold (km)	
Shoreline Oil (>1 gm^2, on average)	21-day release	1-5%	261	4
		5-15%	15	0
		15-30%	0	0
		All Probabilities	276	4
	116-day release	1-5%	581	476
		5-15%	530	124
		15-30%	66	0
		All Probabilities	1,177	600

[a] Bins are based on stochastic probabilities; for example, 24,630 km^2 of the ocean surface is predicted to exceed the 0.04 µm surface oil threshold in 90% of the 172 modelled simulations from the 21-day release over the entire modelled duration.

Table 4.6. Mean and maximum probabilities of shoreline oil contamination exceeding the 1 g/m^2 impact assessment threshold for winter and summer subsea blowouts (Source: Table 4-2 in RPS 2019).

Scenario	**Scenario Timeframe**	**Probability of Shoreline Oil Contamination (%)**		**Time to Shore (days)**	
		Mean	**Maximum**	**Minimum**	**Maximum**
21-day release	Winter	3.1	6.0	27.8	44.0
	Summer	1.0	1.0	37.9	44.8
116-day release	Winter	6.8	19.0	27.6	158.5
	Summer	3.2	11.0	54.5	159.9

4.3.2 Results of Deterministic Analyses

The affected areas, lengths, and volumes for representative deterministic cases that exceeded impact assessment thresholds for worst-case (i.e., 95% percentile) surface, water column, and shoreline contact trajectories are provided in Table 4.7. Cases for all three contact types indicated greater surface areas exceeding both socio-economic and ecologic thickness thresholds for the long release scenarios (116 days) than the short release duration scenarios (21 days). No shore lengths were expected to exceed mass per unit area socio-economic or ecologic thresholds for the worst-case surface oil exposure or water column cases for the 21-day release duration, or the water column case for the 116-day release. Where shore lengths in exceedance of thresholds were anticipated to occur, the lengths were approximately double for a long release (116 days) relative to a short release (21 days). Surface volumes exceeding the total hydrocarbon concentration socio-economic threshold were ~16-40% greater for a long release blowout.

Approximately 30% and 50% of the released oil was predicted to degrade by natural processes for the 21-day and 116-day scenarios, respectively, and about 30% would be anticipated to evaporate for both release durations (Table 4.8; see also Section 4.2.4 in RPS 2019). Of the remaining released oil, more would likely remain in the water column and on the surface due to a short release (21 days) than a long one (116 days), and <0.1% of the oil would be anticipated to reach the shoreline or settled onto sediments for both release durations.

Table 4.7. Representative deterministic cases and associated outputs exceeding impact assessment thresholds for 95th percentile surface, water column, and shoreline contact trajectories (Source: Table 4-3 in RPS 2019).

95th Percentile Scenario Case	Released Oil Volume	Approx. Surface Area Exceeding Thickness Thresholds (km^2)		Approx. Shore Length Exceeding Mass Per Unit Area Thresholds (km)		Approx. Subsurface Volume Exceeding Total Hydrocarbon Concentration Threshold (km^3)
		Socio-economic (0.04 µm)	Ecologic (10 µm)	Socio-economic (1 g/m^2)	Ecologic (100 g/m^2)	Socio-economic (1 µg/L) [a]
21 Days						
Surface oil exposure	4,030,530 bbl (191,930 bpd)	570,500	285,900	-	-	36,010
Water column		485,300	199,900	-	-	39,420
Shoreline contact		327,800	165,200	333	333	24,450
116 Days						
Surface oil exposure	22,263,880 bbl (191,930 bpd)	2,510,000	1,096,000	732	732	151,300
Water column		1,679,962	893,165	-	-	105,900
Shoreline contact		2,405,000	1,120,000	786	786	148,700

[a] Calculated by multiplying the area by the depth of the grid cell.

Table 4.8. Mass balance for representative deterministic cases (values represent a percentage of the total amount of released oil at the end of the representative [95th percentile] deterministic scenarios; Source: Table 4-4 in RPS 2019).

95th Percentile Scenario Case	Percent of Total Released Oil (%)						
	Surface	Evaporated	Water Column	Sediment	Ashore	Degraded	Outside Grid
21 Days							
Surface oil exposure	14.13	33.47	18.35	0.02	0.00	30.85	3.19
Water column	1.11	30.43	32.99	0.02	0.00	34.35	1.12
Shoreline contact	10.28	29.79	25.16	0.02	0.09	34.64	0.02
116 Days							
Surface oil exposure	1.46	32.76	10.24	0.02	0.06	47.54	7.91
Water column	0.53	36.18	10.97	0.02	0.00	45.83	6.48
Shoreline contact	1.76	33.91	11.15	0.02	0.07	46.36	6.74

High variability in windy and calm conditions affected all worst-case scenarios. During calmer, more quiescent periods, it was predicted that oil would rise to the surface and form slicks. During windier conditions, the formation of surface breaking waves resulted in surface oil becoming entrained into the water column.

Modelled surface oil, water column, and shoreline exposure are summarized in Sections 4.3.2.1-4.3.2.3.

4.3.2.1 Surface Oil Exposure

Cumulative maximum surface oil thickness and associated cumulative maximum dissolved/total hydrocarbon concentrations in the water column and total hydrocarbon concentration on the shore and sediment for the worst-case (i.e., 95th percentile; see Section 4.2.2 above) surface oil thickness cases for the modelled 21-day and 116-day blowouts are provided in Figures 4.16-4.19. The mass balance distribution of oil over time is provided in Figure 4.20.

Due to higher release volume, the long duration (116-day) release was predicted to result in a larger surface area (2,510,000 km^2) with oil thickness ranging from 0.01-0.1 mm (appearance of dark brown sheens) at some point over the release scenario than the short duration (21-day) release (570,500 km^2) (Table 4.7 above). Due to the chemical properties of Terra Nova crude oil (light, low density, low viscosity), no heavy black oil (>1 mm) was expected for either release duration.

For the worst-case surface oil thickness cases, water column dissolved hydrocarbon concentrations were anticipated to have similar distributions for both the long and short release durations, but the long release would likely result in higher concentrations and more zonal dispersion. Both dissolved and total hydrocarbon concentrations were predicted to exhibit strong southern transport through the West Flemish Pass for both release durations. The majority of in-water elevated dissolved hydrocarbon concentrations (i.e., >500 μ/L) was expected to occur within 276-520 km of the release site, particularly to the south and, to a lesser extent, north. Due to subsurface currents circulating around the Flemish Cap and southwest along the shelf break, elevated dissolved hydrocarbon concentrations at depth would not likely cross into shallower shelf waters for either release duration.

The worst-case surface oil thickness cases were not expected to result in shoreline oiling for the 21-day release. For the 116-day release, shoreline oiling >100 g/m^2 could potentially occur along ~732 km of shoreline along southeastern Newfoundland (Table 4.7 above), mostly on the Avalon Peninsula. For the short release duration, sediment contamination ranging from <0.1 to 0.5 g/m^2 was predicted to occur along the continental shelf break, ~800 km to the southwest of the release location with some patches on the western edge of the Flemish Cap. For the long release duration, the same trajectory was predicted along with an additional westward expansion.

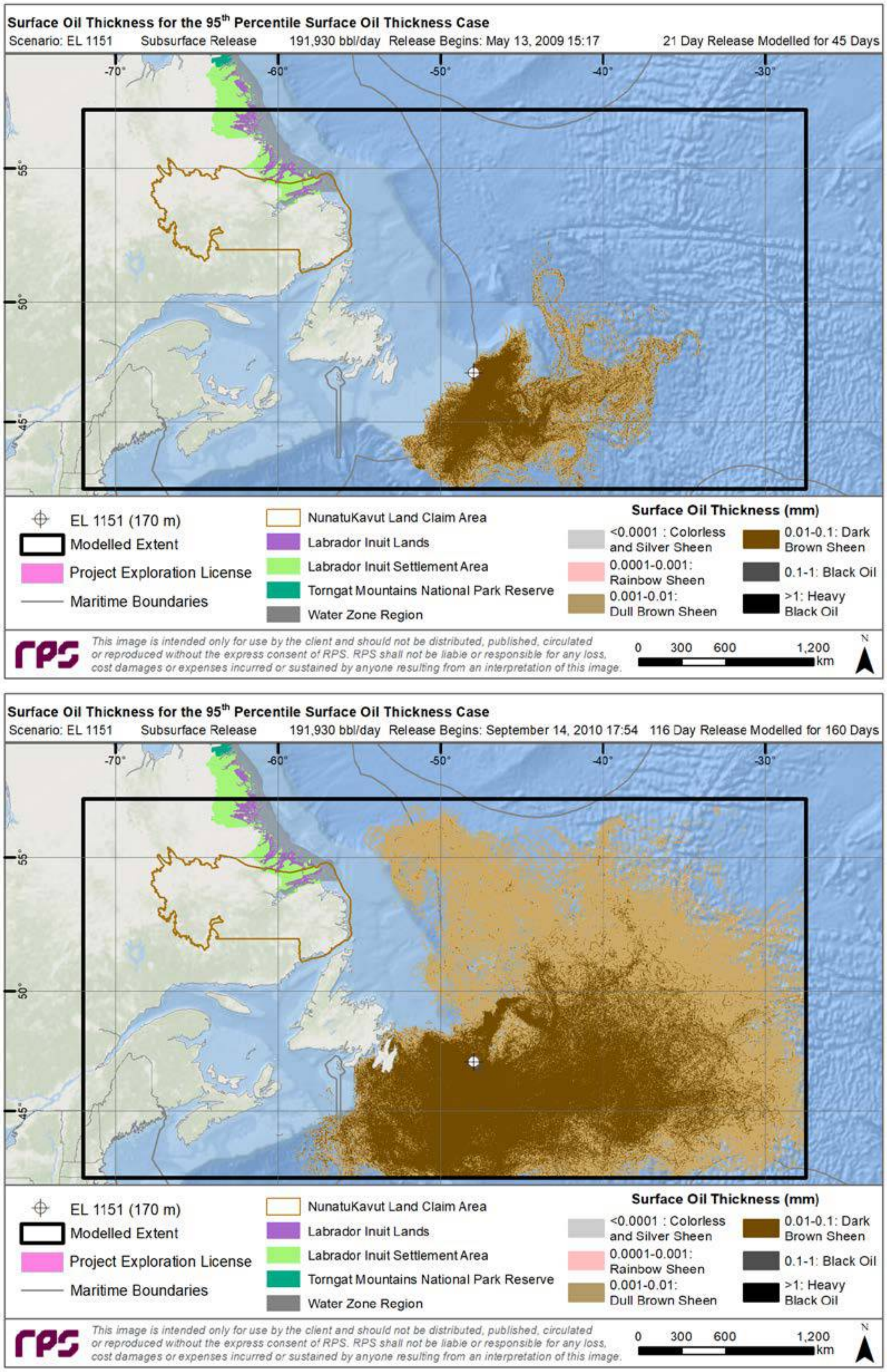


Figure 4.16. Cumulative maximum surface oil thickness predicted for the 95th percentile surface oil thickness cases resulting from modelled 21-day (top) and 116-day (bottom) blowouts (Source: Figure 4-21 in RPS 2019).

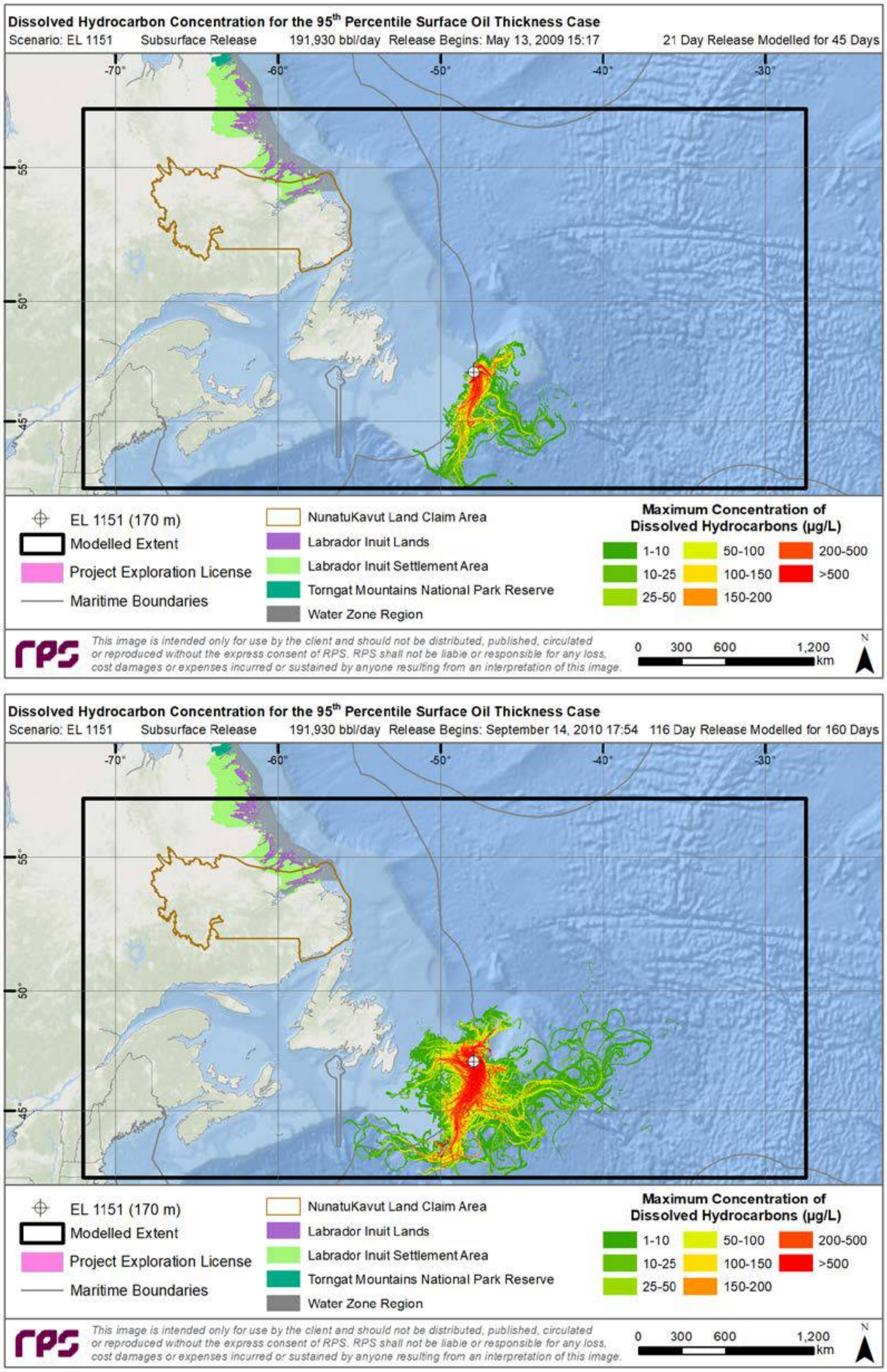


Figure 4.17. Cumulative maximum dissolved hydrocarbon concentration predicted at any depth in the water column for the 95th percentile surface oil thickness cases resulting from modelled 21-day (top) and 116-day (bottom) blowouts (Source: Figure 4-22 in RPS 2019).

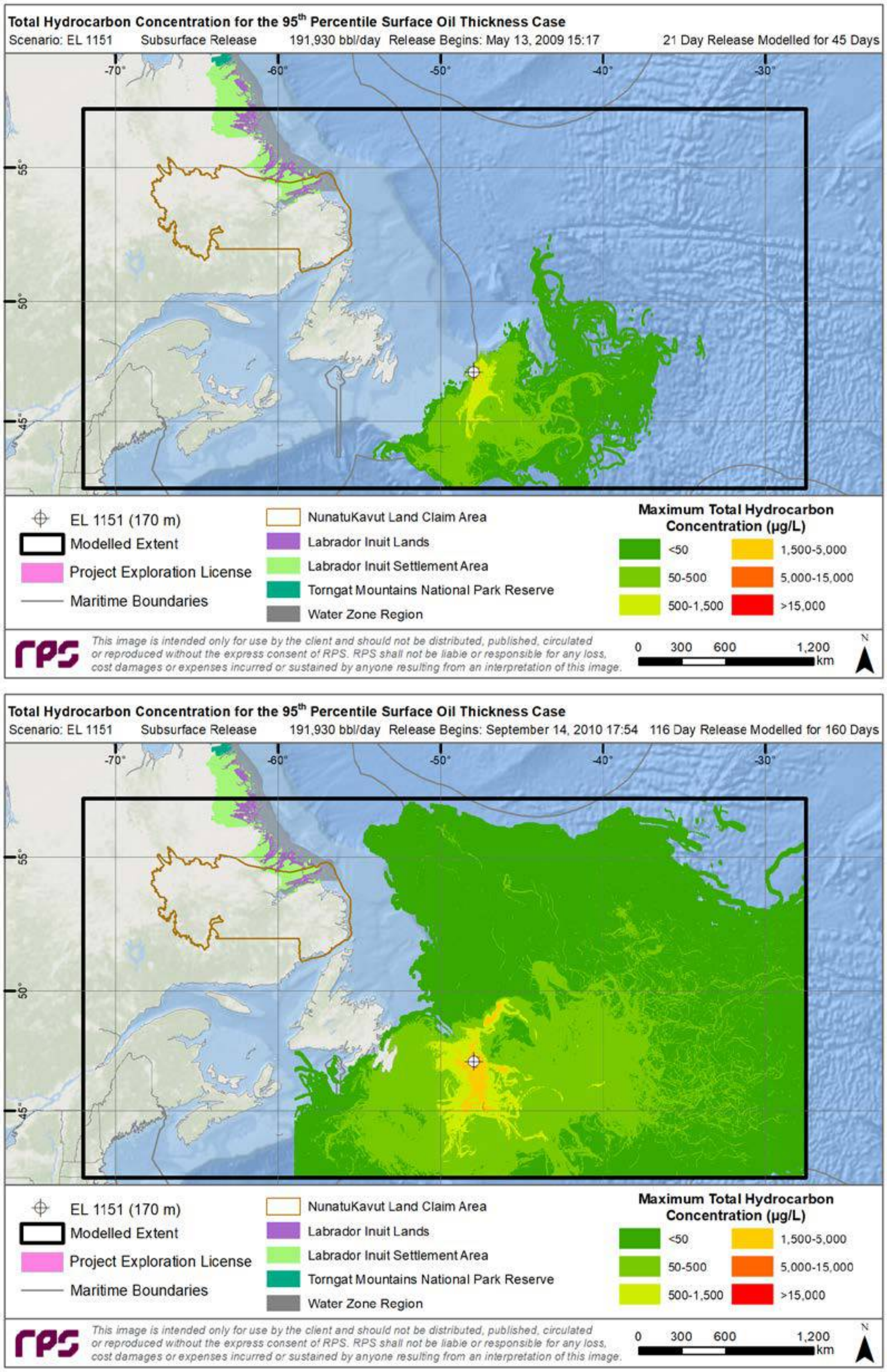


Figure 4.18. Cumulative maximum total hydrocarbon concentration at any depth in the water column for the 95th percentile surface oil thickness cases resulting from modelled 21-day (top) and 116-day (bottom) blowouts (Source: Figure 4-23 in RPS 2019).

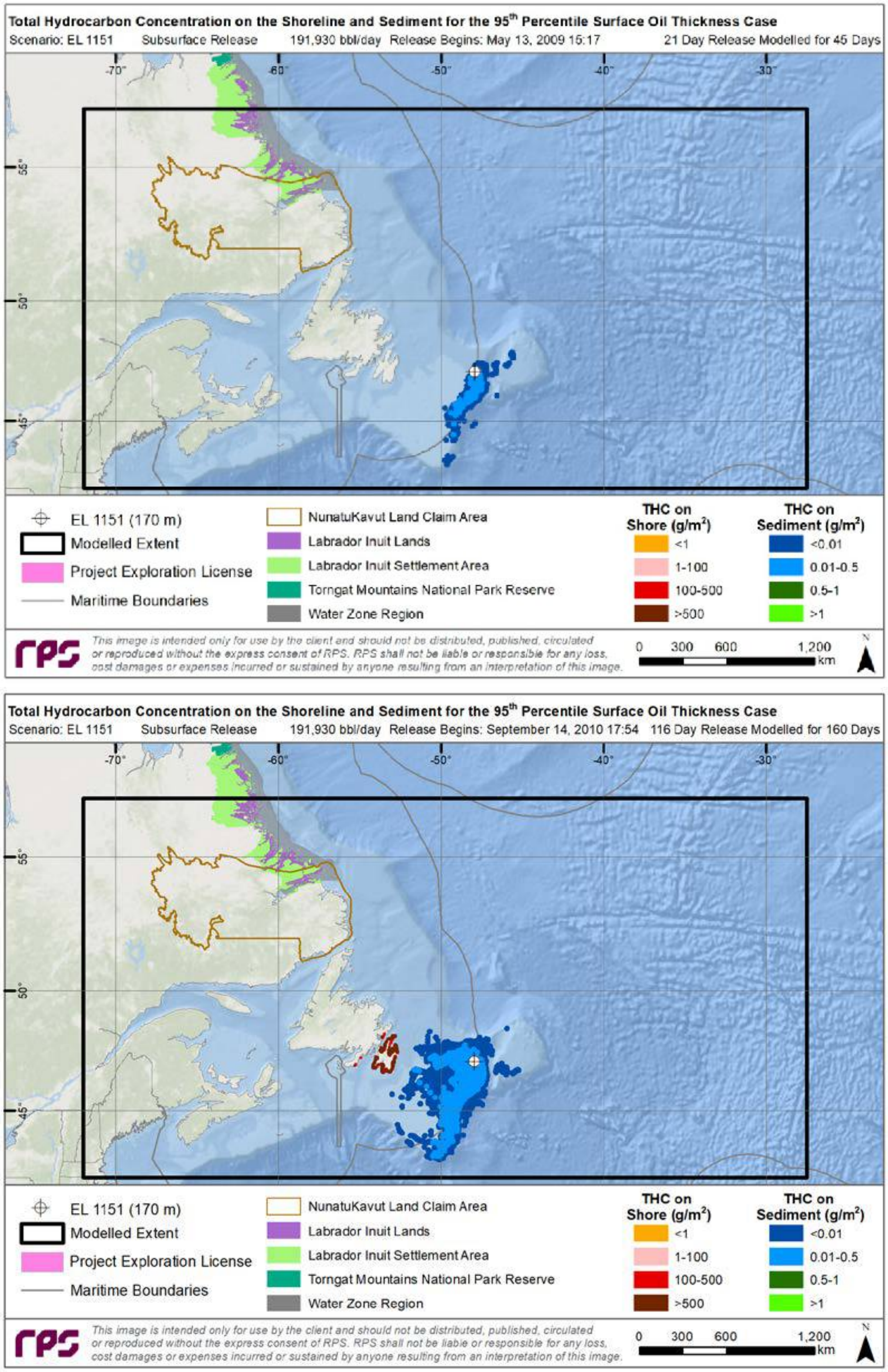


Figure 4.19. Cumulative maximum total hydrocarbon concentration on the shore and sediment predicted for the 95th percentile surface oil thickness cases resulting from modelled 21-day (top) and 116-day (bottom) blowouts (Source: Figure 4-24 in RPS 2019).

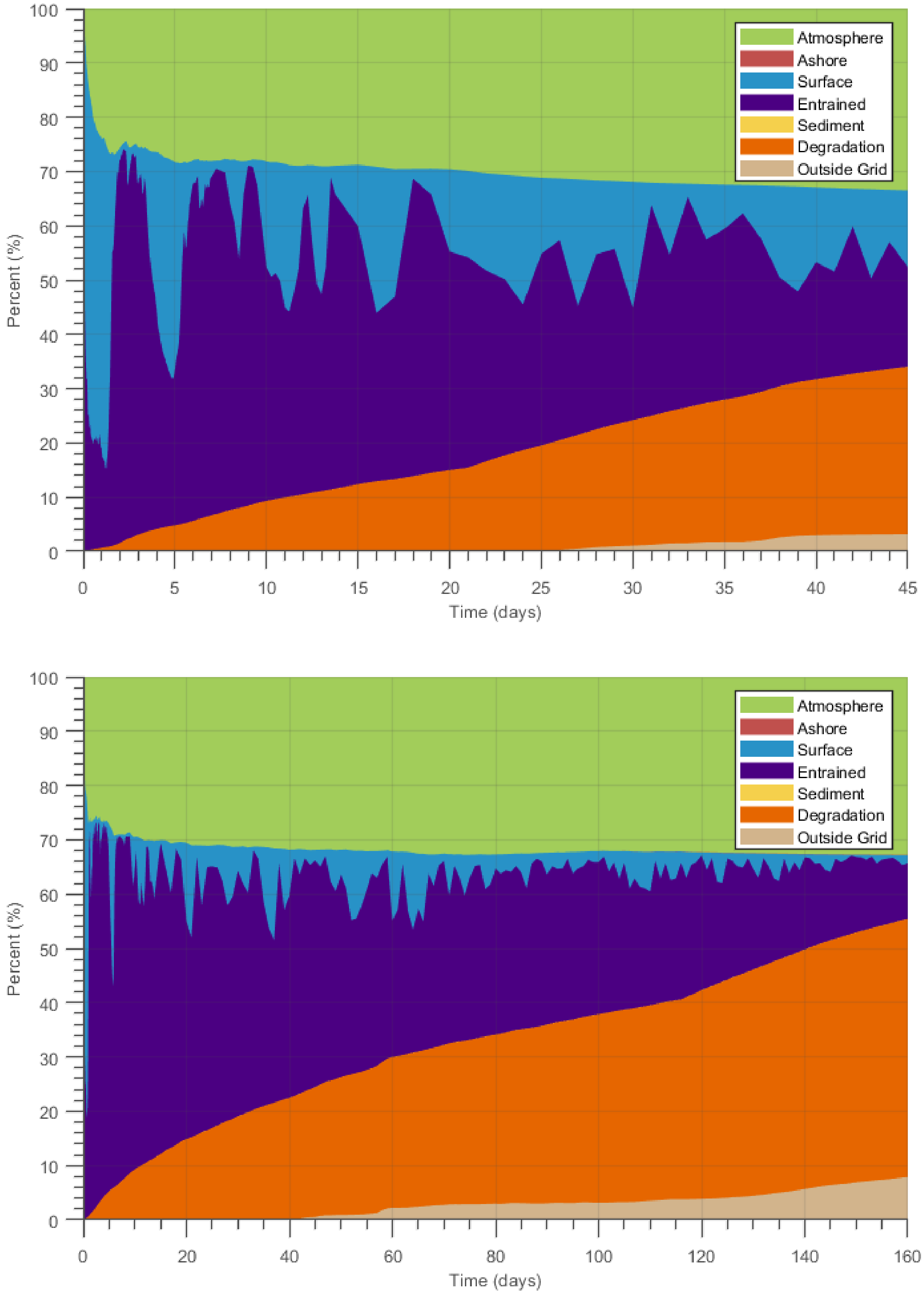


Figure 4.20. Mass balance plots of the 95th percentile surface oil thickness cases predicted for the modelled 21-day (top) and 116-day (bottom) blowouts (Source: Figure 4-25 in RPS 2019).

By the end of the worst-case scenarios for surface oil thickness, much of the oil was predicted to have evaporated and degraded for both the short release (evaporation: 33%; degradation: 31%; total: 64%) and long release (evaporation: 33%; degradation: 48%; total: 81%) durations (Table 4.8 above). A total of ~18% and 10% of oil was predicted to remain in the water column for the short and long release durations, respectively. A minimal proportion (0.02%) of oil was expected to settle on sediments for either release duration. No proportion of the oil was predicted to be present on shorelines for the short release duration, while 0.06% may be present for the long release.

4.3.2.2 Water Column Exposure

Cumulative maximum surface oil thickness and associated cumulative maximum dissolved/total hydrocarbon concentrations in the water column and total hydrocarbon concentration on the shore and sediment for the worst-case (i.e., 95th percentile; see Section 4.2.2 above) water column cases for the modelled 21-day and 116-day blowouts are provided in Figures 4.21-4.24. The mass balance distribution of oil over time is provided in Figure 4.25.

The worst-case water column exposure cases predicted a considerably larger surface area exposed to oil thickness >0.001 mm (appearance of dull brown sheens to heavy black oil) for the long release duration than the short release. Both durations resulted in surface oil footprints that mainly extended to the south and east of the release location. Heavy black oil (>1 mm thickness) was not noticeably present for either release scenario (see Section 4.2.2 in RPS 2019).

High wind speeds in the region result in the formation of surface breaking waves that were predicted to cause the entrainment of surface oil into the water column. Modelling predicted the formation of persistent emulsions with low water content, which would increase the likelihood that oil would transition back and forth between the surface mixed layer and the water surface. For both release durations, the expected total hydrocarbon concentration footprints were larger than those for dissolved hydrocarbon concentration, particularly for the long release scenario since the dissolved portion was predicted to disperse, degrade, and volatize/evaporate (see Section 4.2.2 in RPS 219). The highest total and dissolved hydrocarbon concentrations were anticipated to be transported south through the Flemish Pass, and bifurcate westward along the shelf break and eastward along the southern Flemish Cap.

The worst-case water column exposure cases were not expected to result in shoreline oil contamination. However, there is potential for some of the spilled oil (0.02%) to contaminate the sediment at levels <0.1 g/m^2 for both release durations (Table 4.8 above).

By the end of the modelled scenarios for the worst-case water column cases, a large portion of the spilled oil was predicted to have degraded and evaporated for both the long release (evaporation: 30%; degradation: 34%; total: 64%) and short release (evaporation: 36%; degradation: 46%; total: 82%) durations (Table 4.8 above). Modelling resulted in 33% and 11% of spilled oil remaining in the water column for the short and long release durations, respectively.

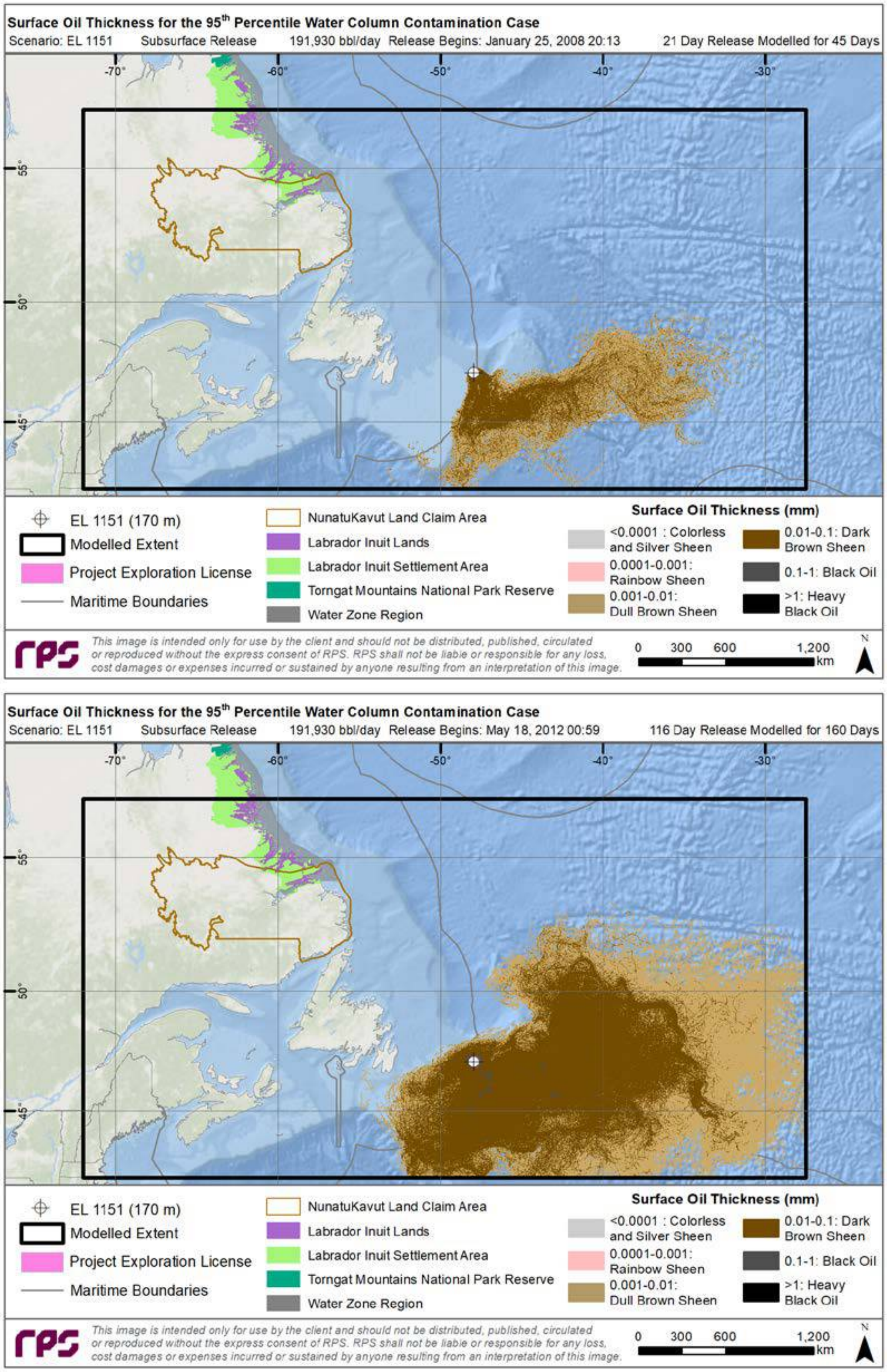
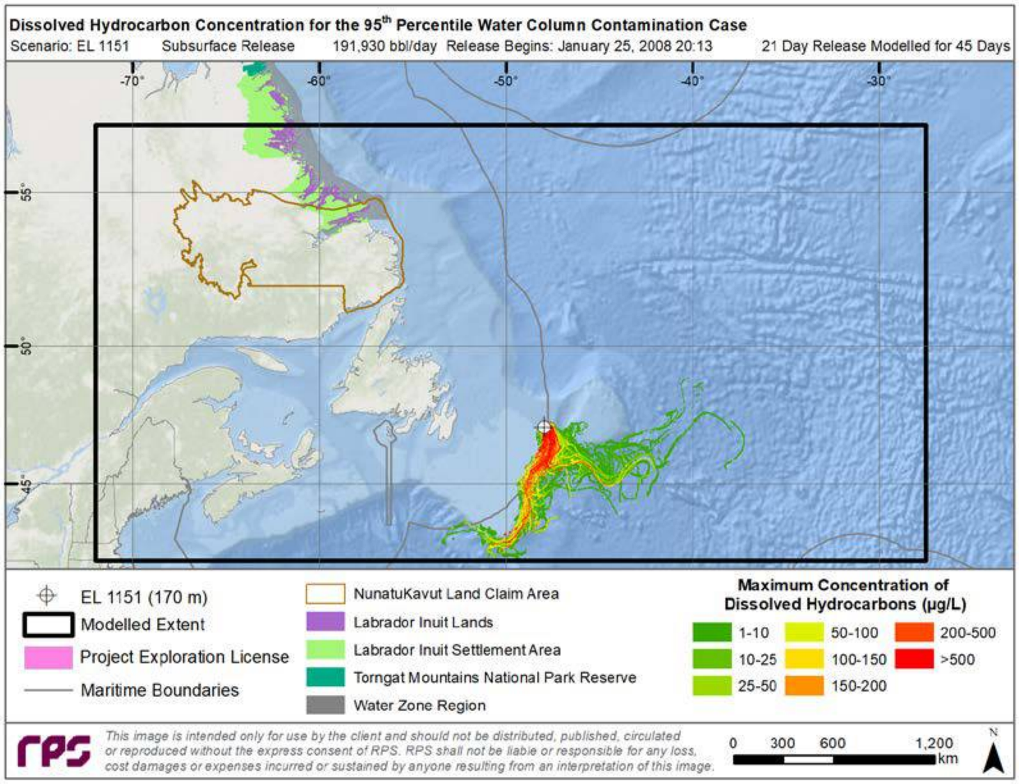


Figure 4.21. Cumulative maximum surface oil thickness predicted for the 95th percentile water column cases resulting from modelled 21-day (top) and 116-day (bottom) blowouts (Source: Figure 4-26 in RPS 2019).



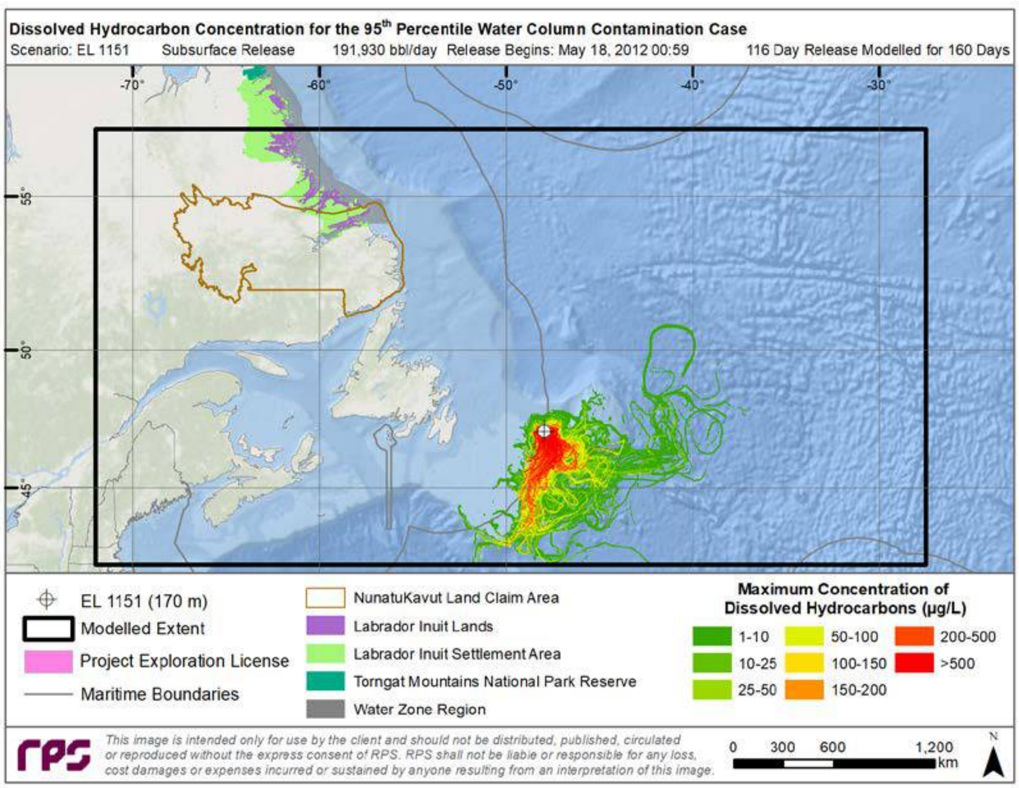


Figure 4.22. Cumulative maximum dissolved hydrocarbon concentration predicted at any depth in the water column for the 95th percentile water column cases resulting from modelled 21-day (top) and 116-day (bottom) blowouts (Source: Figure 4-27 in RPS 2019).

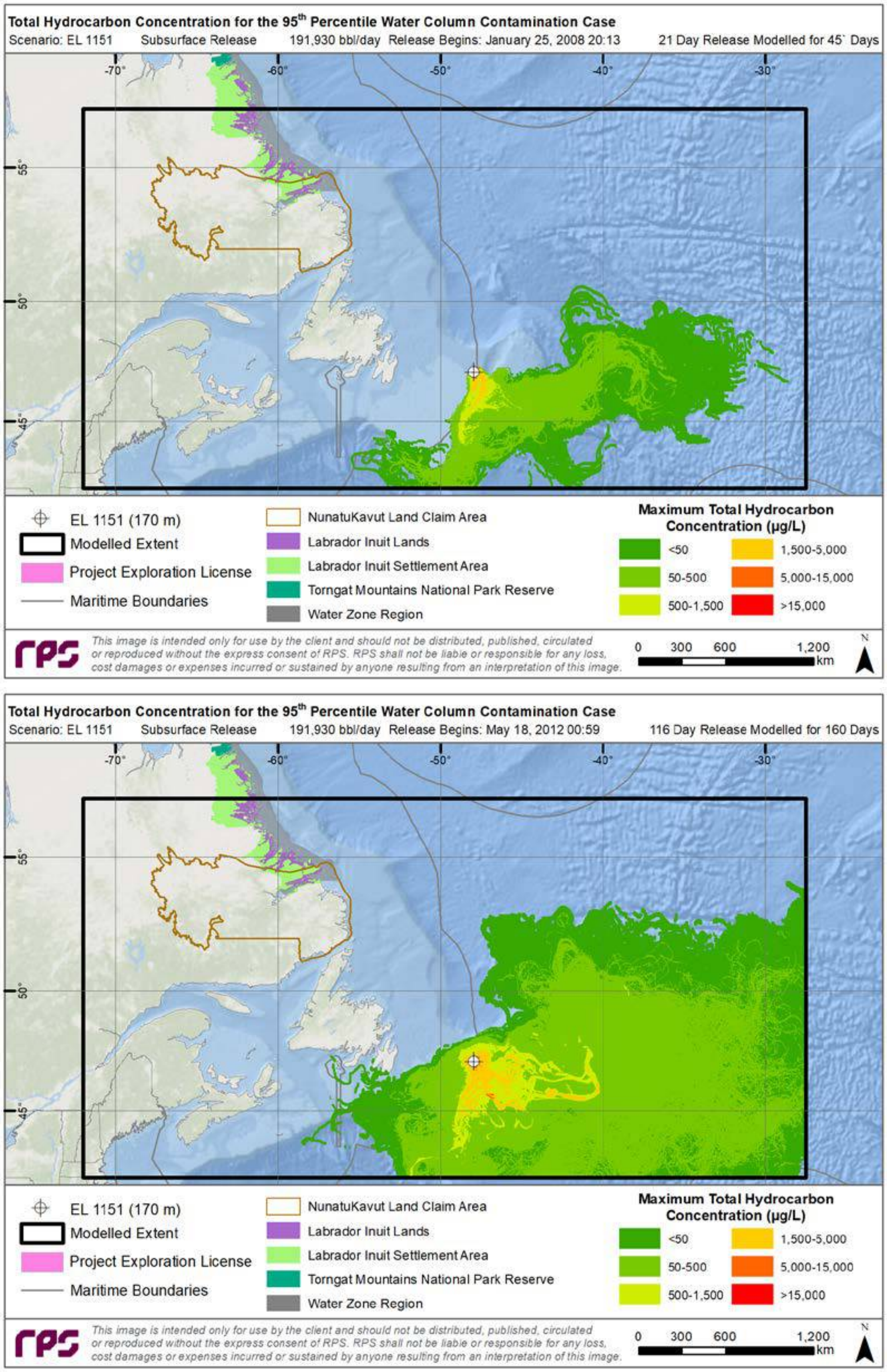
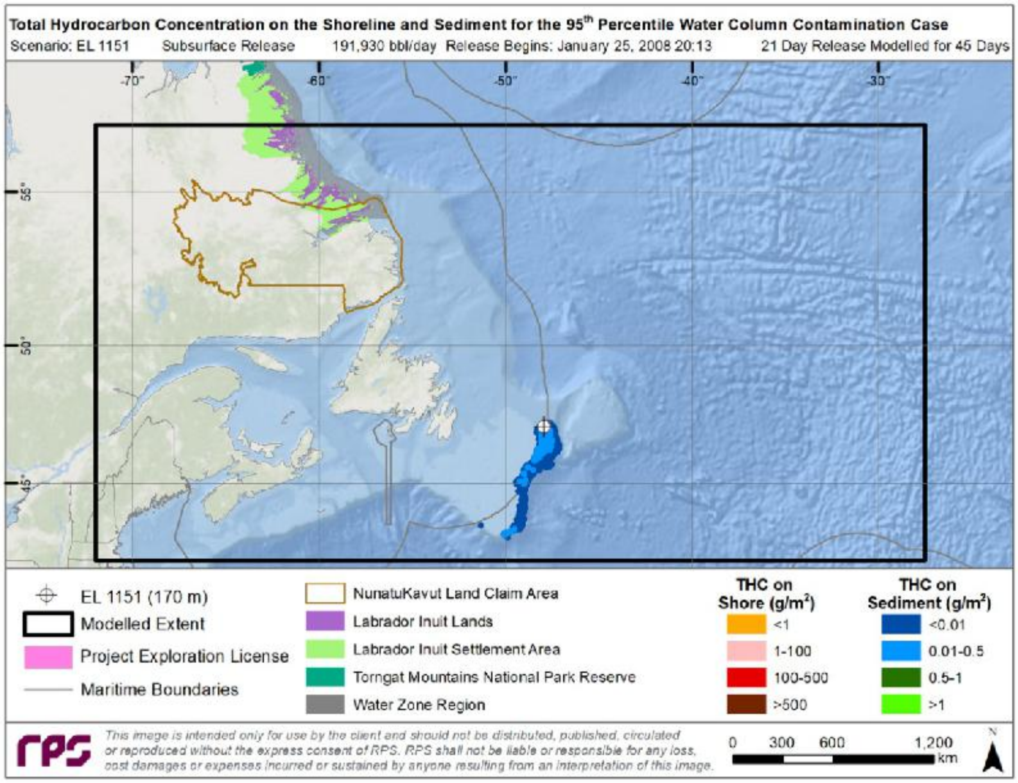


Figure 4.23. Cumulative maximum total hydrocarbon concentration at any depth in the water column for the 95th percentile water column cases resulting from modelled 21-day (top) and 116-day (bottom) blowouts (Source: Figure 4-28 in RPS 2019).



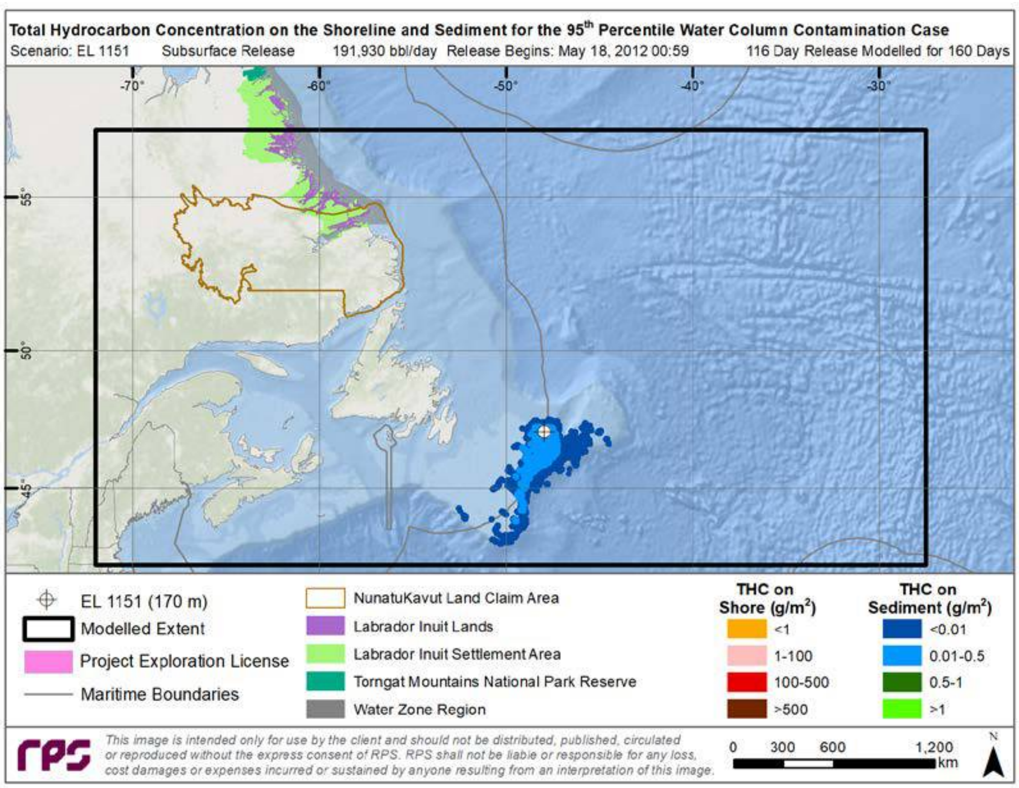
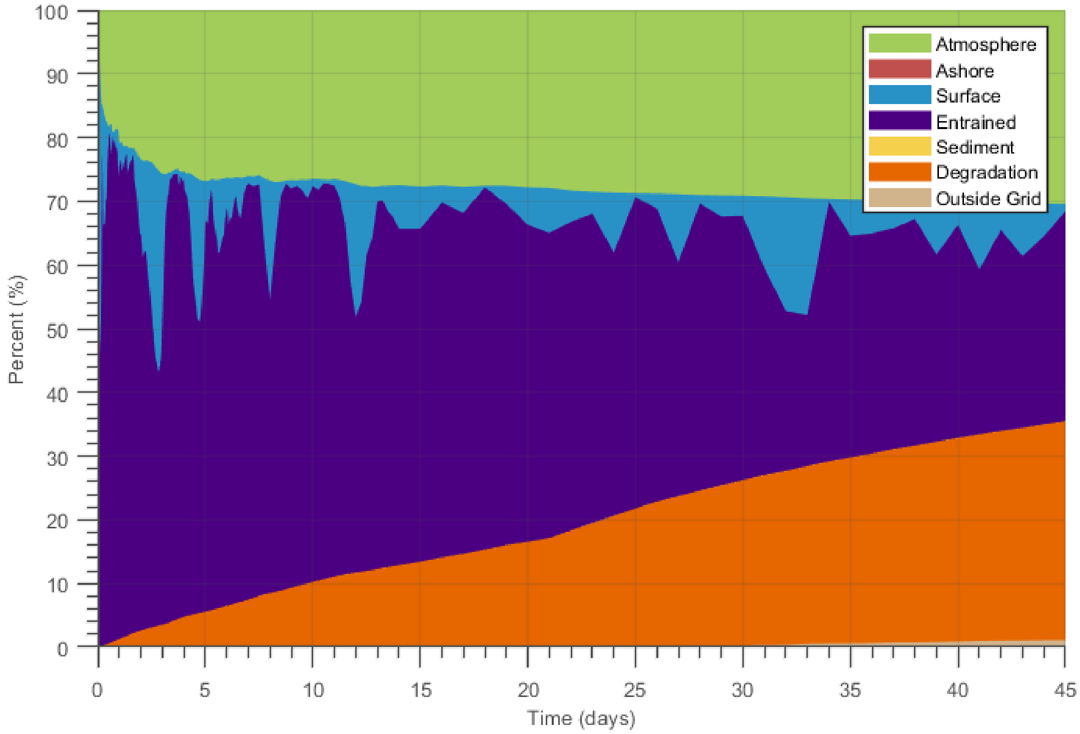


Figure 4.24. Cumulative maximum total hydrocarbon concentration on the shore and sediment predicted for the 95th percentile water column cases resulting from modelled 21-day (top) and 116-day (bottom) blowouts (Source: Figure 4-29 in RPS 2019).



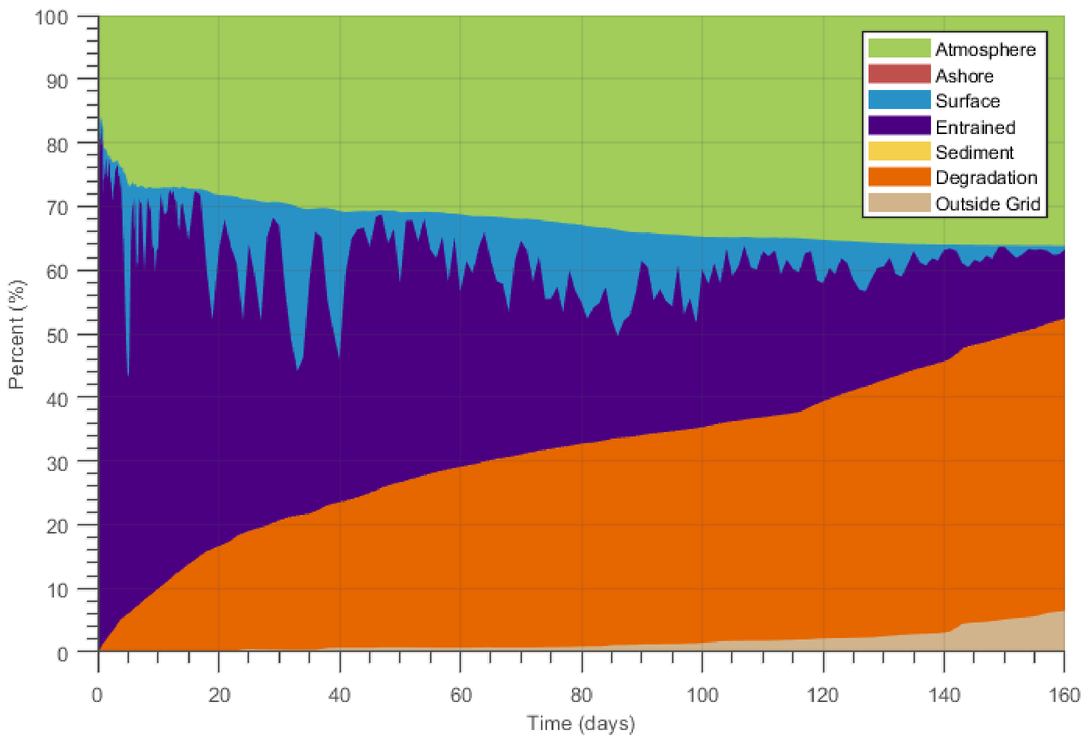


Figure 4.25. Mass balance plots of the 95th percentile water column cases predicted for the modelled 21-day (top) and 116-day (bottom) blowouts (Source: Figure 4-30 in RPS 2019).

4.3.2.3 Shoreline Exposure

Cumulative maximum surface oil thickness and associated cumulative maximum dissolved/total hydrocarbon concentrations in the water column and total hydrocarbon concentration on the shore and sediment for the worst-case (i.e., 95th percentile; see Section 4.2.2 above) shoreline scenarios for the modelled 21-day and 116-day blowouts are provided in Figures 4.26-4.29. The mass balance distribution of oil over time is provided in Figure 4.30.

The worst-case shoreline exposure scenarios resulted in larger surface areas exposed to oil >0.001 mm (appearance of dull brown sheens to heavy black oil) for the long release than the short release duration. The modelled scenarios were predicted to result in cumulative surface oil footprints that extended radially around the release site; the long release duration extended further east and north for the presence of dull brown sheens. Heavy black oil (>1 mm) was not noticeably present in the modelled scenarios.

The expected cumulative total hydrocarbon concentration footprints were larger than those for dissolved hydrocarbon concentrations, especially for the long release duration scenarios. The highest concentrations (>500 µg/mL) of total and dissolved hydrocarbon concentrations were predicted to extend south of the Flemish Pass; the cumulative total hydrocarbon concentration footprint would extend farther radially for the short release and farther to the south and east for the long release.

The worst-case shoreline exposure cases were predicted to result in shoreline oiling >100 g/m^2 over 333 km and 786 km for the short and long release durations, respectively (Table 4.7 above). Both release durations carried the potential for contamination along the same portions of the Avalon Peninsula and Southeastern Newfoundland, along with potential for contamination along St. Pierre for the long release. The long release was also predicted to be patchier and more discontinuous, resulting in lighter oiling. Due to weathering over a month or longer during transport from the spill site to shore, oil that reached the shorelines was anticipated to be highly weathered, patchy, and discontinuous. Sediment contamination (<0.1 to 0.5 g/m^2) was expected to occur along the continental shelf break for ~500 km to the southwest of the release site, with some patchy areas along the southern edge of the Flemish Cap for the short release and additional sediment contamination to the west and south for the long release.

By the end of the worst-case shoreline exposure scenarios, a large portion of the spilled oil was predicted to have evaporated and degraded for the short (evaporation: 30%; degradation: 35%; total: 65%) and long (evaporation: 34%; degradation: 46%; total: 80%) release durations (Table 4.8 above). A total of 25% and 11% of the spilled oil was expected to remain in the water column and 10% and 2% on the water surface for short and long release durations, respectively. Although these scenarios were the worst-cases for shoreline exposure, low proportions of the spilled oil were predicted to reach the shorelines (short release: 0.09%; long release: 0.07%). Only 0.02% of the spilled oil was predicted to settle on sediments for either release duration.

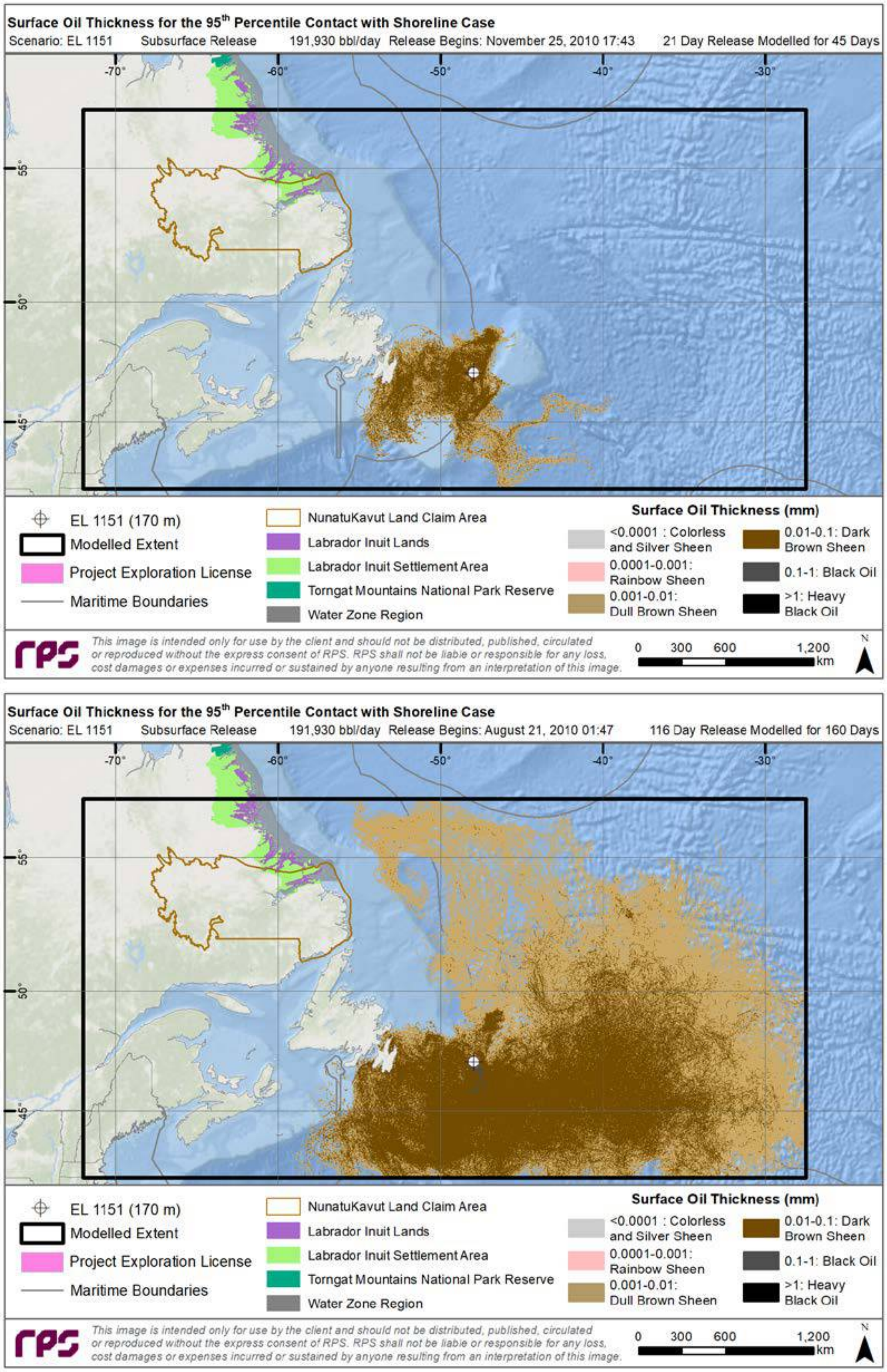


Figure 4.26. Cumulative maximum surface oil thickness predicted for the 95th percentile shoreline cases resulting from modelled 21-day (top) and 116-day (bottom) blowouts (Source: Figure 4-31 in RPS 2019).

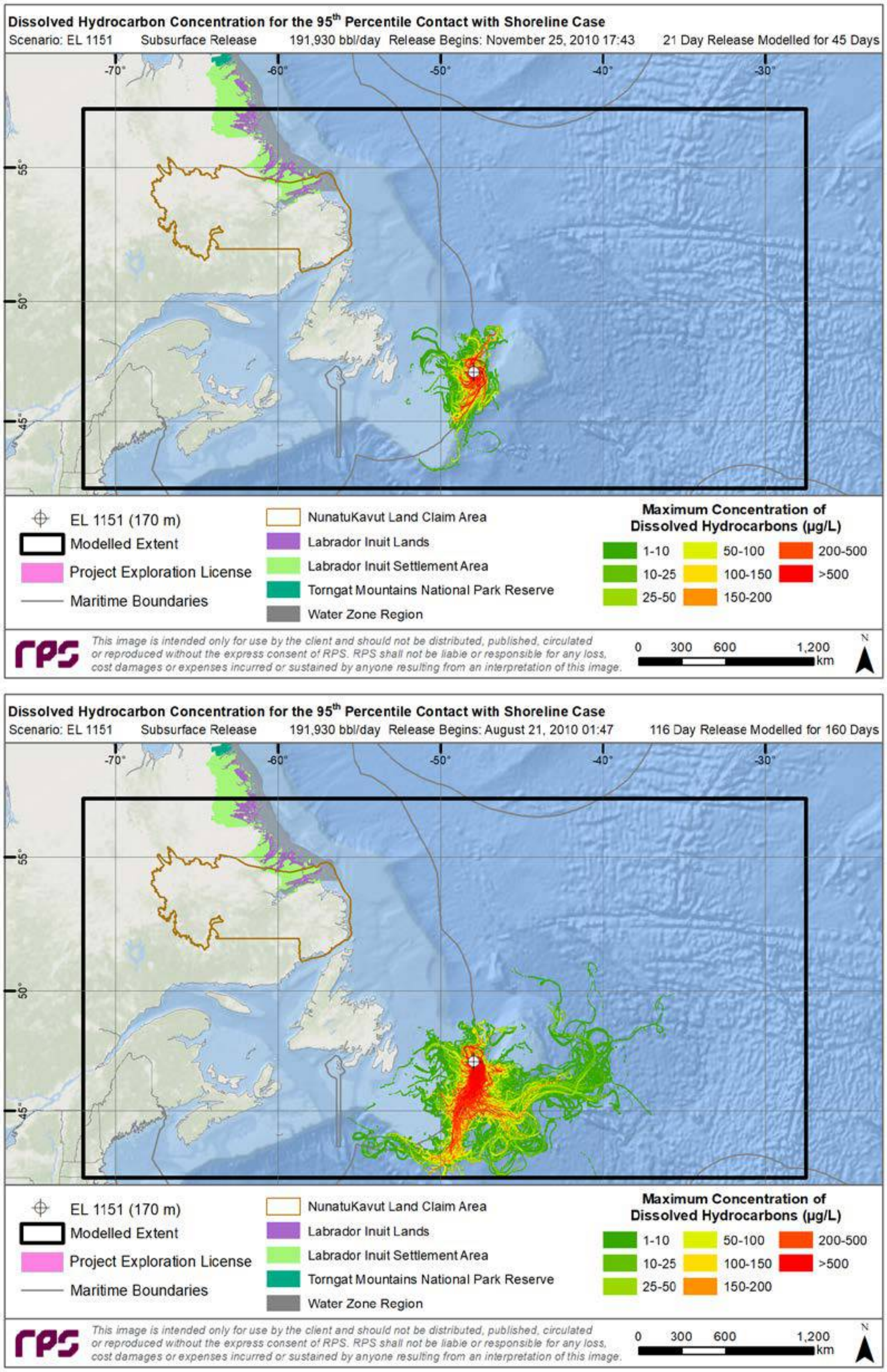


Figure 4.27. Cumulative maximum dissolved hydrocarbon concentration predicted at any depth in the water column for the 95th percentile shoreline cases resulting from modelled 21-day (top) and 116-day (bottom) blowouts (Source: Figure 4-32 in RPS 2019).

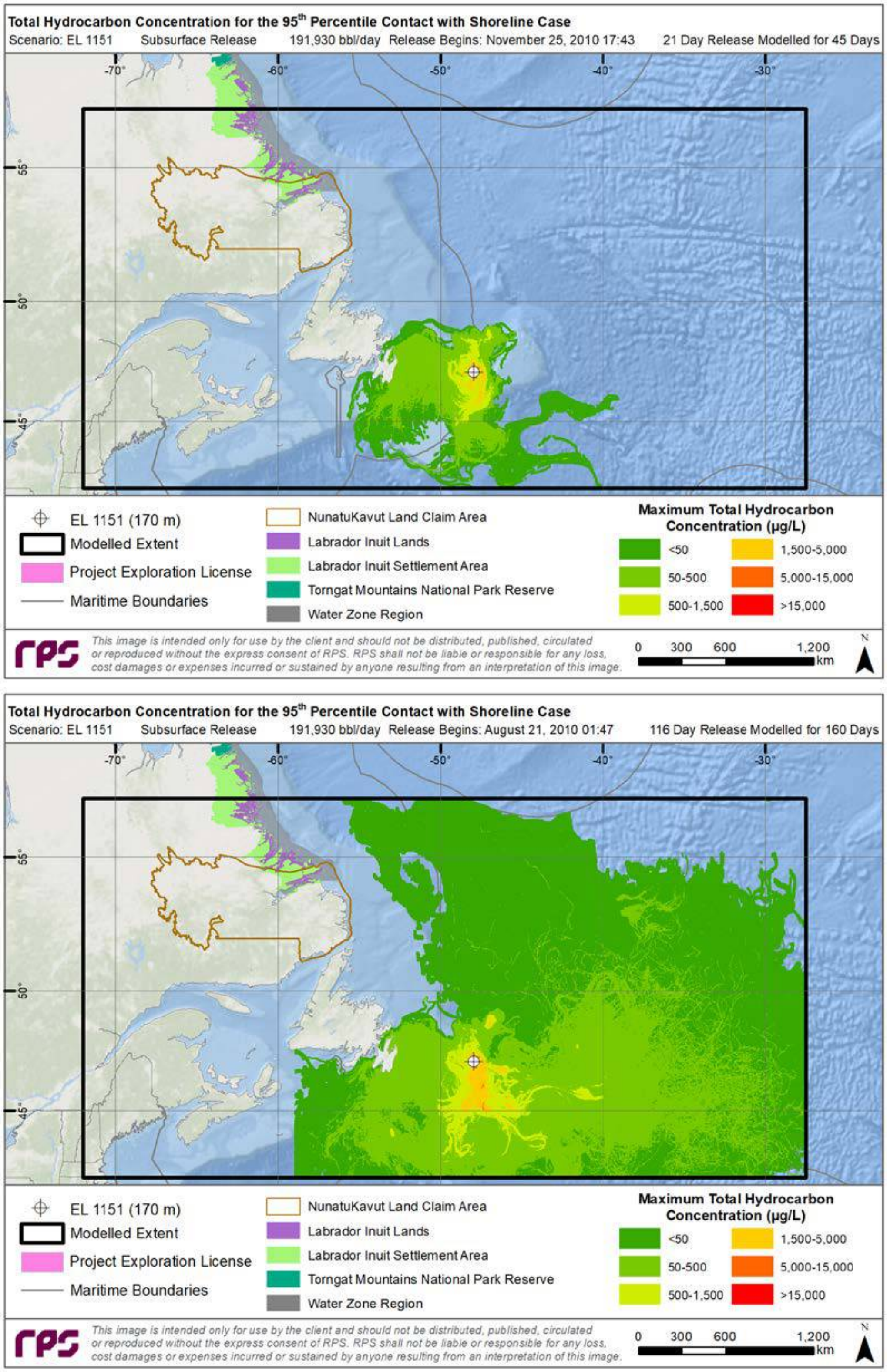
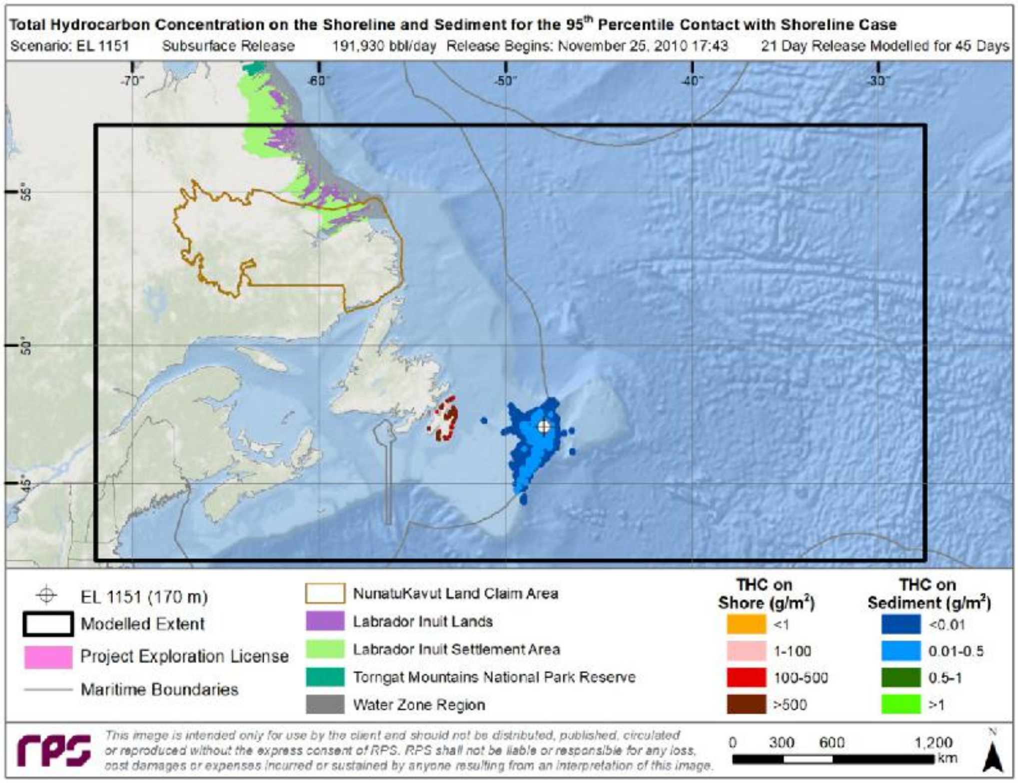


Figure 4.28. Cumulative maximum total hydrocarbon concentration at any depth in the water column for the 95th percentile shoreline cases resulting from modelled 21-day (top) and 116-day (bottom) blowouts (Source: Figure 4-33 in RPS 2019).



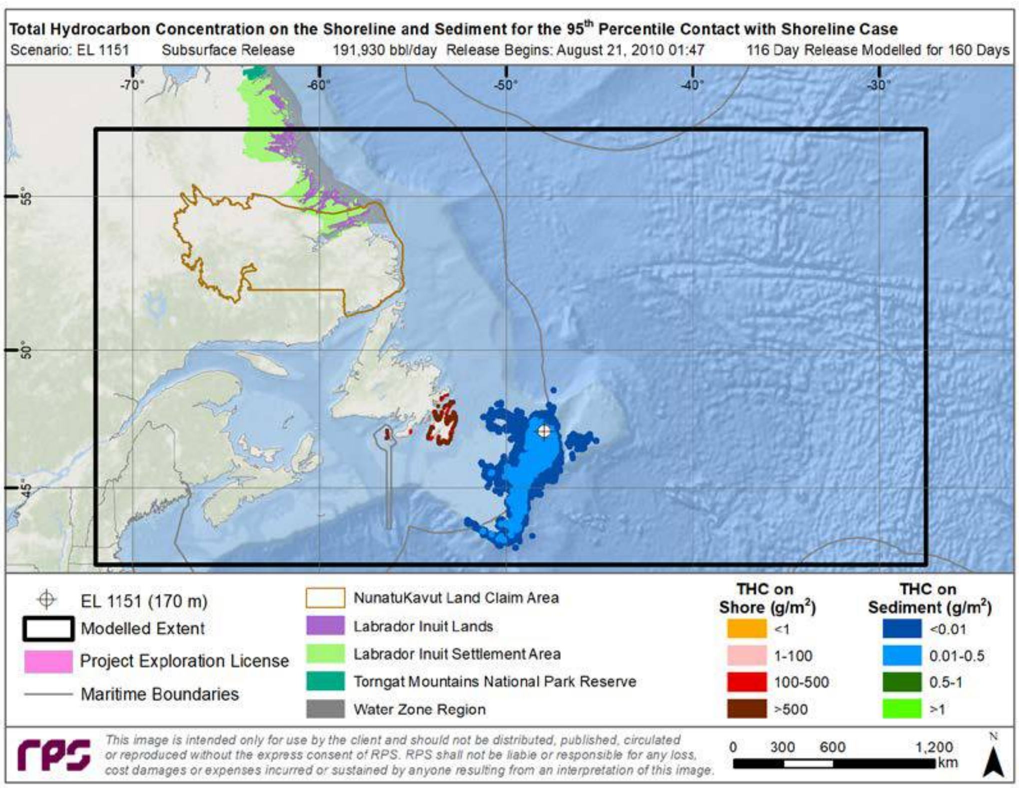
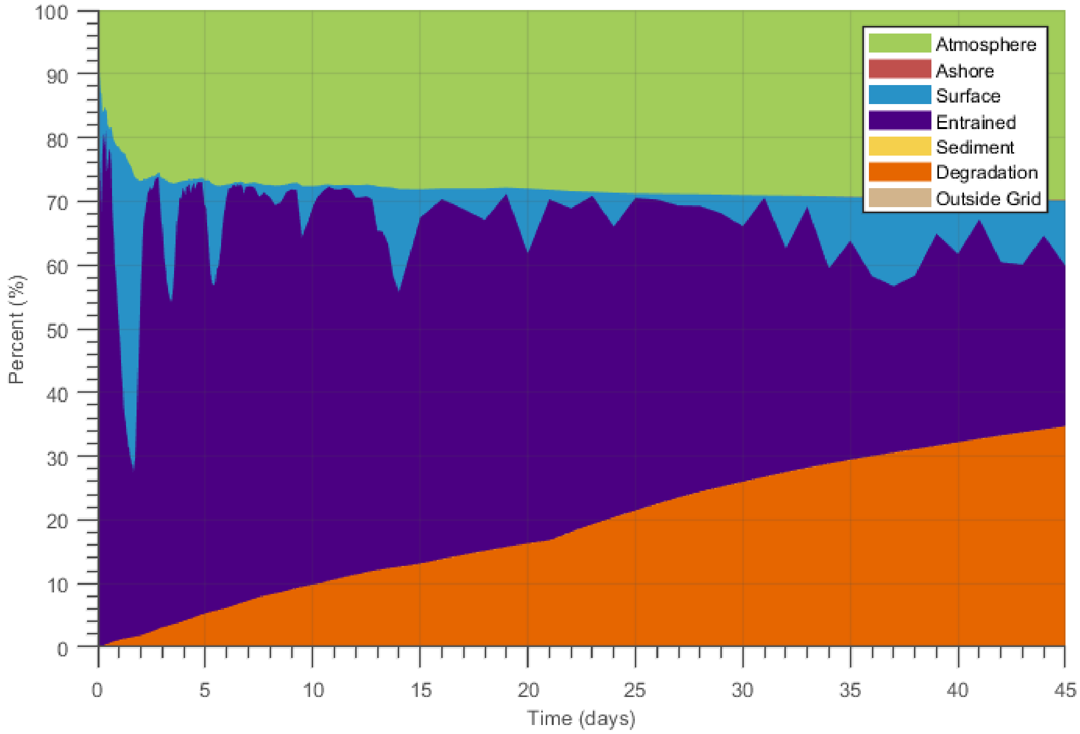


Figure 4.29. Cumulative maximum total hydrocarbon concentration on the shore and sediment predicted for the 95th percentile shoreline cases resulting from modelled 21-day (top) and 116-day (bottom) blowouts (Source: Figure 4-34 in RPS 2019).



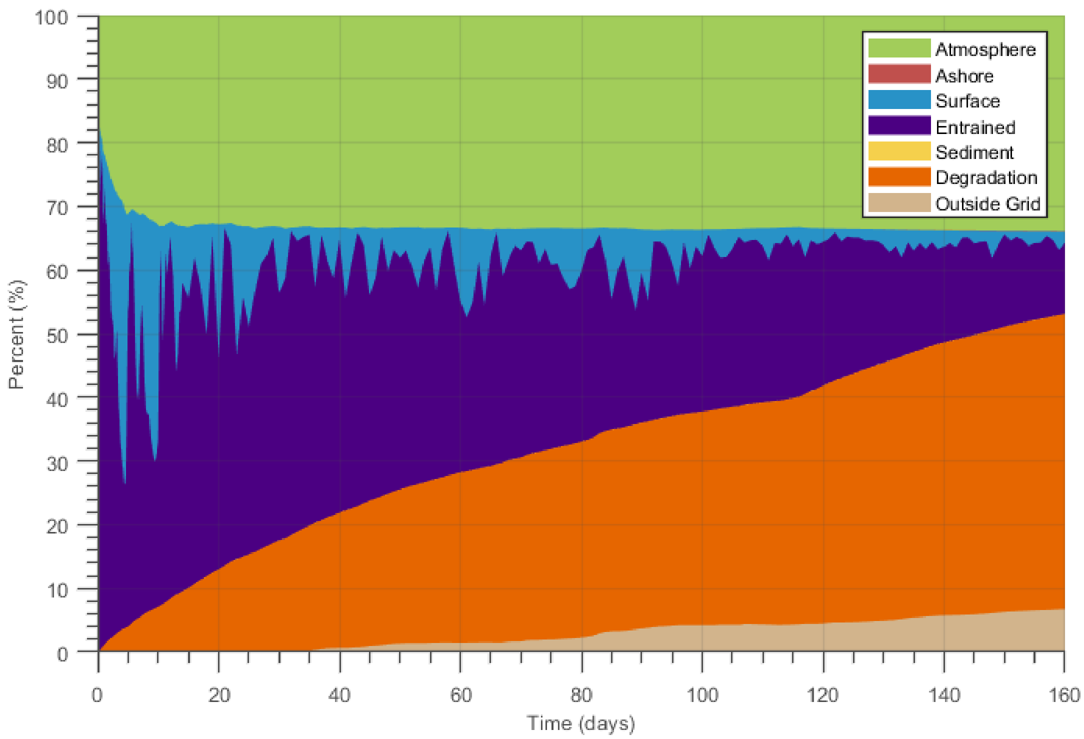


Figure 4.30. Mass balance plots of the 95th percentile shoreline cases predicted for the modelled 21-day (top) and 116-day (bottom) blowouts (Source: Figure 4-35 in RPS 2019).

5.0 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 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 an actual 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 responsive 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 an actual 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

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

ExxonMobil SIMA (17 April 2023) Gale N-66 Well EL 1167			**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													
	Water Column Compartment Average													
Seabed	*Special Areas and Species at Risk*													
	Marine Fish and Fish Habitat													
	Invertebrates and Benthic Communities													
	Seabed Compartment Average													

ExxonMobil SIMA (17 April 2023) Gale N-66 Well EL 1167			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 x B_1	B_2	A x B_2	B_3	A x B_3	B_4	A x B_4	B_5	A x B_5
Socio-Economic	*Commercial Fisheries* *Other Anthropogenic Marine Activity*													
Socio-Economic	**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., B1, B2).

Relative Impact Mitigation Score: Calculated by multiplying Potential Relative Impact by Impact Modification Factor (e.g., A x B1).

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 Table) using the most readily available data. The assigned weighting factor should serve as a reflection of the resource protection priorities as identified during the expedited SIMA process based on actual spill conditions.

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).

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 estimates 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 above), 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 5.3. 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 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 quantitative 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 relative 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 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 communities and activities, and commercial fisheries and other ocean users was completed for the EIS (see Section 6.0 in Stantec 2018a). 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 Flemish Pass 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 limited capacity for moving away from an affected area (e.g., Langangen et al. 2017; Samulesen 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 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; Frit-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 products become entrained into the sediment. Atlantic haddock embryos are highly susceptible to oil spills because they bind dispersed crude oil droplets to their eggshell (Sørhus et al. 2023). Laboratory exposure of Atlantic haddock embryos, larvae, and juveniles (which occur near the sea surface/in the upper water column in the wild) to a laboratory-simulated weathered crude oil blend from the Heidrun oil field in the Norwegian Sea at a concentration of 10 µg/L did not affect growth or survival; however, exposure to higher concentrations resulted in acute and delayed mortality for all three life stages and impaired growth of the cardiac ventricle for yolk sac larvae (Sørhus et al. 2023).

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 in 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/reaches the surface 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 RSA 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 turtle 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 hypothermia 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 that have not yet developed insulating blubber would be at risk (St. Aubin 1990; Kooyman et al. 1976 in Helm et al. 2015). If a baleen whale was 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 (Garaci 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 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 (Stacey et al. 2017; NOAA 2021). Sea turtles may also experience toxic effects form 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 RSA region to feed, not reproduce, and there are no nesting beaches within the RSA; therefore, shoreline oiling is less problematic for sea turtles in the RSA.

5.2.5 Socio-Economic and Indigenous Fisheries

Possible risks for 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. 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 and 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). The Gale N-66 Well is not located within a special area, but critical habitat for spotted wolffish occurs north of the well site and the Slopes of the Flemish Cap and Grand Bank CBD EBSA and NAFO coral/sponge closure areas occur in the Flemish Pass (see Section 3.1.1 above).

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 or mortality during response 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 aerosolized (NASEM 2020). Responders could be exposed to PAHs via ingestion if they consumed contaminated food during or after spill response activities, such as eating food 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 systems (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 (Faksness 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 Selected Scenarios

The scenarios selected for this SIMA include subsea blowouts with durations of 21- and 116-days during winter and summer near the planned Gale N-66 Well site in EL 1167 (formerly EL 1151; see Section 4.0 above). Modelling indicated there was no single "worst-case scenario" – potential spill fates and trajectories were "worse" for some scenarios related to release duration while others were due to season, with further variations observed for the 95th percentile cases for surface oil thickness and water column and shoreline exposure. As such, a combined comparative risk assessment matrix was completed for these scenarios (Table 5.4), with the factors with the highest impacts for either scenario used to inform scoring rationale. The scoring rationale for Table 5.4 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 scenarios, natural attenuation has a high (4) potential relative impact for the shoreline (except the marine mammals and sea turtles ROC), sea surface, socio-economic, Indigenous people 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 the 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 medium risk, as sea turtles do not typically go ashore within the RSA (they migrate to the area to feed) and most marine mammal species within the RSA 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. Effects from a subsea blowout would be anticipated to significantly affect socio-economic activities and Indigenous peoples and communities. 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, recreational boating, or shipping. Responders engaged in monitoring activities could be at high risk of exposure, particularly the inhalation of VOCs.

Natural attenuation was considered to have a low (2) to medium (3) potential relative impact for the water column resource category. The modelled worst-case scenarios indicated that by scenario end, while most of the oil would have evaporated or degraded, the greatest proportion of the remaining oil would occur within the water column, particularly for a short release duration (21 days) (see Table 4.8 above). However, 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, thereby lowering its relative impact from high as in the sea surface compartment to low or medium for the water column resource category. The upper water column (≤20 m) is where elements of the crude oil at surface mostly dissolve (water soluble elements) or disperse (oil droplets) into the sea water. Modelling also indicated that spilled oil would vacillate between the surface layer and upper water column due to frequently changing wind conditions in the region (see Sections 4.2.1-4.2.3 in RPS 2019). Therefore, ROCs that typically spend most of their time within the upper water column were considered most at potential risk of impact (i.e., medium [3] potential relative impact), including marine fish and fish habitat (plankton and pelagic fishes/invertebrates, especially eggs, larvae, and juveniles), diving marine and migratory birds, and species at risk [special areas and species at risk ROC]. Other ROCs that spend less time in the upper water column, are highly mobile and can avoid the upper water column by directed movement, and/or spend most or all their time near the seabed were considered at lower risk of impact (i.e., low [2] potential relative impact).

Table 5.4. Comparative risk matrix for the modelled scenarios of subsea blowouts with 21-day and 116-day release durations during winter and summer near the Gale N-66 Well in EL 1167 (former EL 1151).

ExxonMobil SIMA (17 April 2023) Gale N-66 Well EL 1167			**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	Med	3	0	0	+1	3	+1	3	-3	-9	-4	-12	
	Marine Fish and Fish Habitat	R	Med	3	0	0	+1	3	+1	3	-3	-9	-4	-12	
	Invertebrates and Benthic Communities	R	Low	2	0	0	+1	2	+1	2	-3	-6	-4	-8	
	Marine and Migratory Birds [diving]	R	Med	3	0	0	+1	3	+1	3	-3	-9	-1	-3	
	Marine Mammals and Sea Turtles	R	Low	2	0	0	+1	2	+1	2	-2	-4	-3	-6	
	Water Column Compartment Average					0		3		3		-7		-8	
Seabed	*Special Areas and Species at Risk*	L	Med	3	0	0	0	0	0	0	0	0	-3	-9	
	Marine Fish and Fish Habitat	L	Low	2	0	0	0	0	0	0	0	0	-2	-4	
	Invertebrates and Benthic Communities	L	Med	3	0	0	0	0	0	0	0	0	-3	-9	
	Seabed Compartment Average					0		0		0		0		-7	

ExxonMobil SIMA (17 April 2023) Gale N-66 Well EL 1167			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	$A \times B_5$
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	1	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		24		20		36		49
	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., B1, B2).
Relative Impact Mitigation Score: Calculated by multiplying Potential Relative Impact by Impact Modification Factor (e.g., A x B1).

Natural attenuation was also considered to have a low (2) to medium (3) potential relative impact for the seabed resource category. Untreated sinking oil is mainly associated with suspended organic particulate matter (i.e., marine snow). The low proportion of spilled oil (0.02%) that was modelled sink to/reach the seabed for the worst-case spill scenarios, along with the increased surface area-to-volume ratio and rate of dissolution, dilution, weathering, and microbial degradation of oil within the water column lowers the potential relative impact for sensitive benthic ROCs from high as for sensitive ROCs at the sea surface compartment to low or medium for the seabed resource category. Although the Gale N-66 Well does not occur within a special area, modelling indicated that oil could settle on sediments extending southwards along the Flemish Pass to the Southern Grand Bank (particularly for a long release; see Figure 4.24 above), which would overlap with special areas designated to protect corals and sponges, VME indicator taxa, such as crinoids and cerianthids (tube anemones), and benthic species at risk, such as wolffishes. Therefore, the special areas and species at risk and invertebrates and benthic communities ROCs were considered to have a medium (3) potential relative impact and the marine fish and fish habitat ROC was considered to have a low (2) potential relative impact for the seabed resource category.

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 RSA 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 or 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 safely 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 and benthic communities, marine and migratory birds, and marine mammals and sea turtles).

Given the limited scope of viable shoreline protection and recovery activities within the RSA 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 seabed 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 RSA often exceed the safe and efficient operating parameters for on-water mechanical recovery and visibility within the RSA if frequently reduced (e.g., by fog) during the summer months (particularly in June and July). Lengthy transit distance between shore and the Gale N-66 Well spill site for vessels and equipment capable of supporting high-capacity recovery operations would delay the start of large-scale recovery activities and, depending on spill conditions, could 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 proportion (0.02%) 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 seabed 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 updated SIMA, it was assumed that dispersant application would occur using both aircraft and vessel(s). Upon activation, 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 rates achievable through the combined use of aircraft and vessel(s) and the RSA'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 to the marine and migratory birds ROC for the sea surface resource category. With this response option, a large volume of oil could be quickly dispersed, thereby reducing the risks of exposure for fish eggs and larvae, marine and migratory birds, and marine mammals and sea turtles to oil 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. Additionally, treating the spilled oil would result in a smaller cumulative footprint of surface oil with a dark brown sheen (0.01-0.1 mm thickness) and a patchier total hydrocarbon concentration footprint on the sediment that does not extend as far south compared to natural attenuation, thereby reducing potential exposure areas for resources/habitats important for socio-economic and/or Indigenous use (see Figures 4-36 and 4-39 in RPS; note: these figures represent modelling results for the combined used of surface dispersant application, SSDI, in-situ burning, and the installation of a capping stack). Higher impact modification factors were not assigned for these resource categories because it is possible that the public may perceive the use of surface dispersant application as introducing toxic substances into the marine environment and thereby tainting the animals targeted in fisheries and/or for Indigenous importance.

It is anticipated that surface oil would undergo considerable weathering before reaching the shoreline. Therefore, the additional decrease 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 and the shoreline. Therefore, a negligible (+1) impact modification factor was assigned for ROCs in the shoreline resource category. As the proportion of spilled oil that may reach the seabed is anticipated to be low (0.02%), the dispersion of surface oil into the upper ~10 m of the water column was expected to have no alteration of impact on the seabed 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 increase 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 risk of ingestion 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 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 a week for the Gale N-66 Well site; see Section 3.8.1 in RPS 2019) 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 considerably decreases the volume of spilled oil from a subsea blowout reaching 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 greatly 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. In addition, treating the spilled oil would result in a smaller cumulative footprint of surface oil with a dark brown sheen (0.01-0.1 mm thickness) and a patchier total hydrocarbon concentration footprint on the sediment that does not extend as far south compared to natural attenuation, thereby reducing potential exposure areas for resources/habitats important for socio-economic and/or Indigenous use (see Figures 4-36 and 4-39 in RPS; note: these figures represent modelling results for the combined used of surface dispersant application, SSDI, in-situ burning, and the installation of a capping stack). 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. Like surface dispersant application, higher impact modification factors were not assigned for these resource categories because it is possible that the public may perceive the use of dispersants as introducing toxic substances into the marine environment and thereby tainting the animals targeted in fisheries and/or for Indigenous importance.

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 dispersant. 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 proportion of spilled oil in exceedance of the 0.001 L/m^2 threshold that could reach the shoreline within the RSA was modelled to be quite low (worst-case 0.09%), 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 Gale N-66 Well would result in the greatest increase of oil products in the water column relative to the other response options (see Section 4.3.1 in RPS 2019). All pelagic life stages of 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 more spilled oil and dispersant product compared to surface dispersant application and natural attenuation. 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 anticipated to 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 RSA are deep 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]), the diving depths of most bird species within the RSA 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/near 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 could 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). Based on worst-case scenario modelling, a relatively low proportion (0.02%) of spilled oil would be expected to sink to the seabed. However, corals/sponges and VME indicator species (e.g., crinoids and cerianthids) in the immediate vicinity of the Gale N-66 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 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 invertebrate and benthic communities and special areas and species at risk ROCs for the seabed resource category to account for potentially affected individuals or habitats of sensitive, protected corals/sponges or VME indicator species. A minor (-2) additional impact modification factor was assigned to the marine fish and fish habitat ROC for the seabed resources category, since, overall, only a small portion of this ROC may experience exposure and mobile species could leave the area.

6.0 SIMA Summary

Response priorities during an actual oil spill typically focus on the prevention or reduction of the exposure of shorelines to oil. Modelling for a spill near the Flemish Pass indicated that there is a higher probability of shoreline oil contamination exceeding the 1 g/m^2 impact assessment threshold for a long release (116 days) than a short release (21-days) duration, and a higher probability during the winter than the summer for either release duration (see Table 4.6 above and RPS 2019). Modelling indicated that the greatest proportion of spilled oil (that did not evaporate or degrade) would occur in the water column followed by the sea surface, particularly for a short release duration (see Table 4.8 above and RPS 2019). In addition to preventing or minimizing shoreline exposure, response priorities for this Program should include the removal/reduction of surface and water column oil to the extent possible, as its presence would pose the greatest risk to ROCs within the RSA, particularly those that interact with the surface and upper water column.

This SIMA was completed based on recent environmental, biological, and socio-economic (including commercial and Indigenous fisheries) data for the RSA and modelling conducted for worst-case spill scenarios near the Program's Gale N-66 Well (RPS 2019). Environmental conditions within the RSA largely preclude the effective use of several spill response options that depend on low sea states and high visibility, such as on-water mechanical recovery 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 RSA are conducive to the use of surface dispersant application and generally would not be problematic for SSDI operations, apart from a somewhat lengthy transit from shore to the Gale N-66 Well site. Sea state conditions within the RSA 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 spring/summer conditions within the RSA was reflected in the ranking scores of the risk assessment matrix (see Table 5.4), with the most optimal responses as follows: SSDI (49); surface dispersant application (36); on-water mechanical recovery (24); on-water ISB (20); and shoreline protection and recovery (16). As a reminder the scoring considers 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 updated SIMA would be optimal to reduce harm to an increase recovery for ROCs in the RSA. When conditions allow, on-water mechanical recovery and/or on-water ISB could be the first options(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 RSA. Once regulatory approvals were provided, large-scale surface dispersant application could be the next temporally effective response option (with aerial dispersant application likely able to begin operations one or two days earlier than vessel dispersant application due to shorter transit time), followed by SSDI. If environmental conditions allow, on-water recovery operations 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 one to two months (the longest minimum arrival time was for a long release duration for a summer subsea blowout; see Table 4.6); 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 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 in the water column and reducing oil at the surface, which are some of the resource categories of greatest concern for the Program, these responses options do have the potential to result in increased risk of harm to ROCs in these resource compartments, at least temporarily. Nonetheless, either of the dispersant 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 RSA. While natural attenuation is an option, lack of intervention would not likely 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 regulators and 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 RSA.

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