Newfoundland Orphan Basin Exploration Drilling Program

Responses to Round 2 Information Requests

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1.0 INFORMATION REQUIREMENT: IR-08-02

Reference to EIS:

Section 2.8.1; Section 5.3.3

Context and Rationale:

In IR-08, the Agency required the proponent to provide details on the assumed composition being flared and volumes. Environment and Climate Change Canada noted that, based on the response, it is unclear the amount of gas that is expected to be flared and it appears that flaring of associated gas has not been considered. Natural Resources Canada noted that other proponents have estimated a much larger volume of flared hydrocarbons in their estimates (up to six times the amount estimated in IR-08) and commented that it appears that gas was not considered in the flaring estimate.

Natural Resources Canada also requested clarification on the units used in Table 3 as they questioned if the units were intended to be tonnes per day rather than tonnes per year. If the units were to be tonnes per day then it should be clarified as to how many days per year it is assumed that flaring would occur.

Specific Question of Information Requirement:

Confirm whether gas was included in the flaring estimate and, if not, update the flaring estimate to include gas or provide a rationale for not including it in the estimate. Provide the rationale for using the upper limit of 10,000 barrels of oil flared during a well test or revise the assumptions to be consistent with other assessments or base the assumptions on representative field data, if available.

Response:

As indicated in the EIS, it is not currently anticipated that well testing will be carried out on the wells drilled in the initial phase of the Project (i.e., one to two wells). Since an initial well has not yet been planned, representative field data was not available, and a well test program has not been developed, the actual composition and quantity of reservoir fluids to be flared is not known. At the time of EIS preparation, a nominal value 10,000 bbl of total oil was assumed to be flared, based on information previously presented by BP in the Scotian Basin Exploration Drilling Project Environmental Impact Statement (BP 2016).

With a progression in project planning and reservoir characterization, a representative well testing scenario for an initial well has been developed. It is estimated that approximately 20,000 bbls of oil (heating value of 967,687 BTU/ft^3 (US Department of Energy 2011)) and 15 mmscf of total gas (heating value of 1050 BTU/ft^3 (US EPA 1995)) would be flared for a single zone well test. Table 3 from IR-08 (Round 1) has been updated and presented as Table 1 below to show anticipated greenhouse gas emissions from well test flaring (on a single zone per well test basis).

Table 1 GHG Emissions from Well Flow Test Flaring (tonnes per well test)

Source	CO_2 (t)	CH_4 (t)[a]	N_2O (t)[b]	CO_2e (t)
Flaring during Well Flow Testing	7,137	21.5	0.071	7,697
a Global Warming Potential, 25 b Global Warming Potential, 298 t- tonnes				

Assuming that up to two wells could be tested in any year, it is estimated that up to 15,394 tonnes of CO_{2e} could be released from non-routine flaring during well flow testing per year. This represents approximately 0.15% of Newfoundland and Labrador's annual CO_2e emissions as reported for 2017 (Government of Newfoundland and Labrador 2019).

References:

Government of Newfoundland and Labrador. 2019. Historical GHG Emissions Summary, Newfoundland and Labrador, 1990-2017. Available at: https://www.exec.gov.nl.ca/exec/occ/greenhouse-gas-data/Historical_GHG_Emissions_Summary_Newfoundland_and%20Labrador_(1990-2017).pdf

2.0 INFORMATION REQUIREMENT: IR-48-02

Reference to EIS:

Section 6.4; Figure 6.30

Context and Rationale:

The Agency required that the proponent update Table 6.24 with the distance from each identified special area (Marine Refuges, Ecologically and Biologically Significant Areas, Important Bird and Biodiversity Areas, Newfoundland and Labrador Shelves Bioregion Significant Benthic Areas, United Nations Convention on Biological Diversity Ecologically and Biologically Significant Areas, and Vulnerable Marine Ecosystems (NAFO Fisheries Closure Areas and NAFO Seamount Closures) to the nearest exploration licence and where there is the potential for platform supply vessels to intersect with the special area. However, the proponent provided the distance to the project area and did not identify the special areas where there is the potential for vessel traffic to overlap.

Provide a description for any special areas which were not included in the original response, such as Important Bird and Biodiversity Areas (e.g., Quidi Vidi Lake, Cape St. Francis and Witless Bay Islands) and Newfoundland and Labrador Shelves Bioregion Significant Benthic Areas (e.g. Large Gorgonian Corals).

In addition, the Agency required the proponent to update Figure 6.30 with all special areas. This figure does not illustrate the location of Important Bird Areas and Newfoundland and Labrador Shelves Bioregion Significant Benthic Areas. In addition, the revised Ecologically and Biologically Significant Areas are illustrated on a separate figure. A revised Figure 6.30 illustrating all special areas is required for the EA report.

Specific Question of Information Requirement:

Provide the distance from each identified special area to the nearest exploration licence and where there is the potential for platform supply vessels to intersect with the special area. Update Figure 6.30 to include all special areas on one figure. With respect to special areas that have not been included in the EIS or IR-48, provide a description of the ecosystem and conduct an assessment of potential effects on the additional special areas. Identify proposed mitigation and follow-up, for routine activities and potential accidental events, as applicable.

Response:

In total, there are 81 Individual Special Areas within the Regional Assessment Area. Each Special Area is identified in Table 1 (update of EIS Table 6.24), indicating the nearest distance from the Special Area to the Project Area, each Project Exploration Licence (EL) (1145, 1146, 1148, and 1149), and the potential vessel transit routes. Each of the Special Areas is also identified on Figure 1 (update of EIS Figure 6.30). In total there are 13 Special Areas that intersect with the potential vessel transit routes and 10 that intersect with the Project Area. There are three Special Areas that intersect EL 1145 and EL 1148, and two that intersect with EL 1146. There are no Special Areas that intersect with EL 1149. In total, there are 16 Special Areas that intersect with the Project Area, Project ELs and the potential vessel transit routes.

There are several descriptions of Special Areas that could be added to those included in the EIS and the response to IR-48. These Special Areas include three Important Bird Areas (IBAs) and Significant Benthic Areas (SBAs) for corals and sea pens. Descriptions for these areas are included below. As indicated below, effects have been evaluated and mitigation proposed as applicable in the EIS and subsequent IRs to help protect species and/or habitat associated with these Special Areas. The effects assessment for routine and accidental events, including mitigation, follow-up, and effects significance determination for Special Areas as presented in the EIS remains unchanged.

Important Bird Areas (IBAs)

Cape St. Francis

Cape St. Francis is a continentally significant IBA, located at the northern tip of the most easterly peninsula of insular Newfoundland. Surrounding waters and small offshore rocks are used by wintering eiders (with flocks as large as 5,000 birds, approximately 1.7% of the northern [borealis] population) and purple sandpipers forage along the shoreline (BirdLife International 2019). This IBA is approximately 294 km from the Project Area but approximately 14 km from potential platform supply vessel routes for the Project. Routine Project activities, including supply and servicing activities are not predicted to affect the Cape St. Francis IBA.

Quidi Vidi Lake

Quidi Vidi Lake is a lake located in St. John’s, Newfoundland, fed by Virgina River and Rennies River. The eastern end of the lake empties to the ocean at the Quidi Vidi Gut. This IBA is globally significant for congreqatory species (gulls) and nationally significant for colonial waterbird/seabird concentrations. Large numbers of gulls use Quidi Vidi Lake as a daytime resting site in the late fall, winter, and early spring when there is ice on the lake. At least five species occur in substantial numbers (i.e., greater than 1% of their estimated North American populations) including herring gull (10,000 or as much as 2.8% of the estimated North American population); great black-backed gull (8,000 or as much as 6% of the estimated North American population); Iceland gull (2,000 or as much as 6.6% of the estimated North American population); glaucous gull (750 or approximately 1% of the estimated North American population); and common black-headed gull (75; the largest wintering concentration in North America) (BirdLife International 2019). Quidi Vidi Lake is approximately 311 km from the Project Area, although platform supply vessel routes may overlap with the designated IBA boundaries where the eastern end of the lake empties to the ocean via the Quidi Vidi Gut. Atmospheric sound from supply and servicing activities (i.e., platform supply vessels transit) may be audible to bird species overwintering in this IBA, although temporal overlap of activities and wintering congregations are unlikely given BP’s preference to conduct drilling between May and October. Also, birds congregating in this area would already be subject to atmospheric sound from existing marine traffic travelling in and out of St. John’s harbour and are expected to be fairly tolerant of marine traffic. No additional mitigation or follow-up is proposed for this Special Area.

Witless Bay Islands

The Witless Bay Islands consist of four small islands approximately 4 km off the east coast of the Avalon Peninsula. This IBA supports a globally important colony of breeding seabirds. Great Island supports the largest colony of Atlantic puffin in eastern North America (approximately 3.6% of the global population and possibly as much as 57% of the eastern North America population) (BirdLife International 2019).

Leach's storm-petrel, common murre, black-legged kittiwake and herring gull are also present in large numbers (more than 5-10% of eastern North American breeding populations for these birds). Other species of seabirds nesting on these islands include great black-backed gull, black guillemot, thick-billed murre, razorbill, and northern fulmar. The marine areas surrounding the islands are also important for migrating sea ducks such as white-winged and surf scoter, oldsquaw, and common eider (BirdLife International 2019).

Witless Bay Islands IBA is located approximately 341 km from the Project Area but approximately 4 km from potential platform supply vessel (PSV) routes, depending on the supply base location. As indicated in the response to IR-40 (Round 1), if Bay Bulls is selected as a supply base port, PSVs entering and exiting Bay Bulls will approach the Witless Bay Ecological Reserve no closer than 2 km. this commitment would also help protect the Witless Bay IBA as a Special Area.

Significant Benthic Areas (SBAs)

SBAs are defined in Fisheries and Oceans Canada's (DFO) Ecological Risk Assessment Framework (DFO 2013) as "significant areas of cold-water corals and sponge dominated communities", where significance is determined "through guidance provided by DFO-lead processes based on current knowledge of such species, communities and ecosystems" (Kenchington et al. 2016). SBAs were determined using a kernel density estimation, a quantitative analyses technique applied to research vessel data to identify sponge, coral and sea pen catches (Kenchington et al. 2016). The taxa used in the analysis are those identified by the North Atlantic Fisheries Organization as indicator species for Vulnerable Marine Ecosystems and include large gorgonians, small gorgonians, sea pens, and sponges. As shown on Figure 1, SBAs for small gorgonian corals and sea pens overlap with the Project Area and an SBA for large gorgonian corals is in relatively close proximity (approximately 11 km) to the Project Area. The EIS assessed potential effects of Project activities (routine and accidental) on marine fish and fish habitat including corals and sponges (refer also to IRs 49-02 and 51-02 for a discussion of effects on benthic habitat).

Table 1 Special Areas within the Regional Assessment Area (Update of EIS Table 6.24)

Special Area Name	Type	Nearest Distance (km)					
		Project Area	EL 1145	EL 1146	EL 1148	EL 1149	Potential Platform Supply Vessel Routes
Slopes of the Flemish Cap and Grand Bank	Convention on Biological Diversity (CBD) Ecologically and Biologically Significant Area (EBSA)	Intersects	128	114	54	16	Intersects
Seabird Foraging Zone in the Southern Labrador Sea	CBD EBSA	Intersects	87	39	29	16	118
Orphan Knoll	CBD EBSA	21	170	128	104	66	159
Southeast Shoal and Adjacent Areas on the Tail of the Grand Bank	CBD EBSA	456	608	613	559	481	376
Spotted Wolffish Critical Habitat	Critical Habitat	Intersects	30	70	39	113	Intersects
Northern Wolffish Critical Habitat	Critical Habitat	Intersects	16	56	28	133	Intersects
Orphan Spur	EBSA	Intersects	Intersects	6	Intersects	159	Intersects
Northeast Slope	EBSA	41	113	123	69	88	Intersects
Notre Dame Channel	EBSA	145	166	207	209	379	119
Labrador Slope	EBSA	188	223	235	304	454	299
Fogo Shelf	EBSA	191	215	263	250	415	127
Baccalieu Island	EBSA	216	247	285	245	358	Intersects
Bonavista Bay	EBSA	220	246	294	272	431	101
Grey Islands	EBSA	268	288	329	332	503	234
Labrador Marginal Trough	EBSA	271	306	327	393	549	371
Smith Sound	EBSA	280	308	350	314	442	79
Eastern Avalon	EBSA	286	328	361	314	392	Intersects
Virgin Rocks	EBSA	295	380	393	339	331	112

Special Area Name	Type	Nearest Distance (km)					
		Project Area	EL 1145	EL 1146	EL 1148	EL 1149	Potential Platform Supply Vessel Routes
Lilly Canyon-Carson Canyon	EBSA	362	521	525	470	386	303
Placentia Bay	EBSA	362	391	433	396	513	75
St. Mary's Bay	EBSA	384	420	456	412	499	49
Southeast Shoal	EBSA	479	607	616	562	505	330
Haddock Channel Sponges	EBSA	511	555	587	539	598	173
Southwest Slope	EBSA	595	638	671	623	643	256
Funk Island Ecological Reserve	Ecological Reserve	199	223	270	260	427	161
Baccalieu Island Ecological Reserve	Ecological Reserve	271	302	341	301	416	38
Witless Bay Ecological Reserve	Ecological Reserve	342	384	416	370	449	5
Cape St. Mary's Ecological Reserve	Ecological Reserve	449	483	520	477	565	115
Funk Island	Important Bird Area (IBA)	194	218	265	255	422	156
Cape Freels Coastline and Cabot Island	IBA	232	258	306	284	444	139
Wadham Islands and adjacent Marine Area	IBA	242	267	314	301	467	184
Baccalieu Island	IBA	270	301	340	300	415	36
Grates Point	IBA	273	303	342	303	419	43
Terra Nova National Park	IBA	284	312	357	327	470	121
Cape St. Francis	IBA	294	329	365	322	422	14
Quidi Vidi Lake	IBA	311	350	384	339	428	Intersects
Witless Bay Islands	IBA	341	383	416	369	448	4
Placentia Bay	IBA	398	430	468	426	523	78
Mistaken Point	IBA	413	458	489	441	506	78
The Cape Pine and St. Shotts Barren	IBA	433	474	507	461	533	92
Cape St. Mary's	IBA	442	476	513	471	560	110
Gander Bay	Lobster Closure	301	326	374	359	521	216

Special Area Name	Type	Nearest Distance (km)					
		Project Area	EL 1145	EL 1146	EL 1148	EL 1149	Potential Platform Supply Vessel Routes
Gooseberry Island	Lobster Closure	327	356	398	361	484	92
Northeast Newfoundland Slope - Tobin's Point 1	Marine Refuge	Intersects	Intersects	Intersects	Intersects	47	Intersects
Northeast Newfoundland Slope - Tobin's Point 2	Marine Refuge	Intersects	25	66	37	201	Intersects
Funk Island Deep	Marine Refuge	147	167	207	211	379	116
Hawke Channel	Marine Refuge	263	298	323	382	545	357
Division 3O Coral	Marine Refuge	640	687	718	670	681	305
Terra Nova	Migratory Bird Sanctuary (MBS)	297	325	371	342	487	139
Terra Nova	MBS	303	330	376	347	489	136
Eastport	Marine Protected Area (MPA)	279	307	353	324	470	132
Eastport	MPA	297	325	371	341	482	130
Orphan Knoll	NAFO Vulnerable Marine Ecosystem (VME)	Intersects	173	130	106	64	138
Sackville Spur	NAFO VME	24	298	287	225	52	104
Northern Flemish Cap	NAFO VME	57	341	326	265	85	164
Northwest Flemish Cap	NAFO VME	67	349	335	275	95	160
Northwest Flemish Cap	NAFO VME	71	344	331	270	96	152
Northern Flemish Cap	NAFO VME	75	353	336	276	100	185
Northern Flemish Cap	NAFO VME	86	369	353	293	113	193
Northwest Flemish Cap	NAFO VME	141	381	373	310	162	184
Northeast Flemish Cap	NAFO VME	150	424	404	348	175	259
Flemish Pass / Eastern Canyon	NAFO VME	175	390	386	322	195	198
Eastern Flemish Cap	NAFO VME	201	484	469	408	228	304
Beothuk Knoll	NAFO VME	269	505	500	436	291	310

Special Area Name	Type	Nearest Distance (km)					
		Project Area	EL 1145	EL 1146	EL 1148	EL 1149	Potential Platform Supply Vessel Routes
Eastern Flemish Cap	NAFO VME	272	556	542	481	300	369
Beothuk Knoll	NAFO VME	309	532	528	464	329	340
Tail of the Bank	NAFO VME	499	659	663	608	523	429
Newfoundland Seamounts	NAFO VME	530	730	729	668	551	535
3O Coral Closure	NAFO VME	640	687	718	670	681	305
Fogo Seamounts 1	NAFO VME	796	880	898	844	823	532
Small Gorgonians	Significant Benthic Area (SBA)	Intersects	14	19	88	241	73
Sea Pens	SBA	Intersects	Intersects	Intersects	Intersects	90	Intersects
Large Gorgonians	SBA	11	31	73	88	105	12
5A Exclusion Zone	Snow Crab Exclusion Zone	197	224	271	247	392	63
6A Exclusion Zone	Snow Crab Exclusion Zone	220	249	290	255	392	42
8XExclusion Zone	Snow Crab Exclusion Zone	225	376	379	324	252	171
6B Exclusion Zone	Snow Crab Exclusion Zone	249	284	320	277	386	Intersects
6C Exclusion Zone	Snow Crab Exclusion Zone	270	312	344	298	387	Intersects
8A Exclusion Zone	Snow Crab Exclusion Zone	356	405	433	383	439	44
9A Exclusion Zone	Snow Crab Exclusion Zone	436	477	511	464	536	96

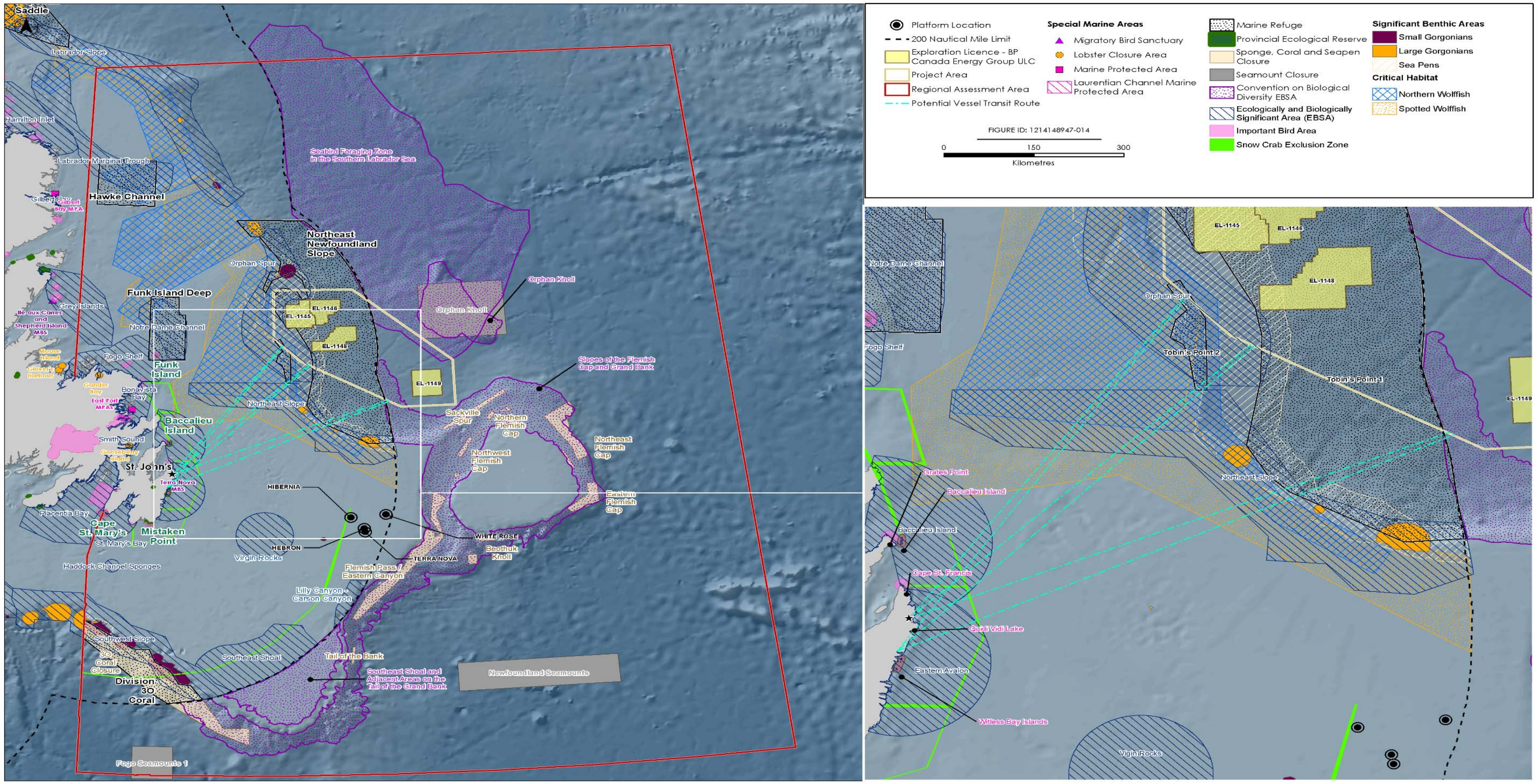

Figure 1 Special Areas within the RAA

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References:

BirdLife International. 2019. Important Bird Areas Factsheet: Witless Bay Islands, Cape St. Francis and Quidi Vidi. Downloaded from http://www.birdlife.org on 02/08/2019.

Kenchington, E., L. Beazley, C. Lirette, F.J. Murillo, J. Guijarro, V. Wareham, M. Koen Alonso, H. Benoît, H. Bourdages, B. Sainte-Marie, M. Treble and T. Siferd. 2016. Delineation of Coral and Sponge Significant Benthic Areas in Eastern Canada Using Kernel Density Analyses and Species Distribution Models. DFO Can. Sci. Advis. Sec. Res. Doc., 2016/093: vi + 178 pp.

DFO (Fisheries and Oceans Canada). 2013. Ecological Risk Assessment Framework (ERAF) for Coldwater Corals and Sponge Dominated Communities. Sustainable Fisheries Framework (SFF): Policy to Manage the Impacts of Fishing on Sensitive Benthic Areas. 18 pp. Available at: http://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/risk-ecolo-risque-eng.htm

3.0 INFORMATION REQUIREMENT: IR-49-02

Reference to EIS:

Section 6.4.1.4; Section 11.1.3; Section 11.1.4.2; Section 11.3; Section 11.3.3.1

Context and Rationale:

In IR-49-02, the Agency requested the proponent provide information on the potential effects of Project activities on the Northeast Newfoundland Slope Closure marine refuge. The proponent provided information on the Northeast Newfoundland Slope Closure marine refuge and zones of influence from project activities which have the potential to cause effects. The KMKNO noted, in the proponent's assessment of effects on the Project on water quality and valued components was limited as the proponent did not discuss potential effects of water-based muds, synthetic-based muds and barite on marine species. With respect to the one literature reference provided (Trannum et al. 2011), KMKNO noted additional publications are available which have shown that:

- barite may result in toxicity in deep-water sponges (Edge et al. 2016);
- metals and organic compounds in water-based muds may accumulate in tissues reducing growth and reproduction even at relatively low concentrations, (Lee et al, 2011);
- microbial degeneration of synthetic-based muds may result in hypoxia (Tait et al., 2016); and
- sediment reworking activity in water-based drill cuttings found a significant reduction in downward transportation of sediment particles and in maximum mixing depth (Trannum, 2017).

The Agency notes the R95% distance estimate is less conservative than the Rmax estimate for the distance over which sound above the behavioural threshold could be expected. The Rmax estimate has been used on other exploration projects in the Newfoundland Offshore.

References:

Edge, K. J., Johnston, E. L., Dafforn, K. A., Simpson, S. L., Kutti, T., and Bannister, R. J. (2016) Sub-lethal effects of water-based drilling muds on the deep-water sponge Geodia barretti. Environ. Pollut. 212: 525–534. doi: 10.1016/j.envpol.2016.02.047

Lee, K., Armsworthy, S.L., Cobanli, S.E., Cochrane, N.A., Cranford, P.J., Drozdowski, A., Hamoutene, D., Hannah, C.G., Kennedy, E., King, T., Niu,H., Law, B.A., Li, Z., Milligan, T.G., Neff, J., Payne, J.F., Robinson, B.J., Romero, M., and Worcester, T. (2011) Consideration of the Potential Impacts on the Marine Environment Associated with Offshore Petroleum Exploration and Development Activities. DFO. Can. Sci. Advis. Sec. Res.Doc. 2011/060: xii + 134 p. Available online at: http://waves-vagues.dfo-mpo.gc.ca/Library/343863.pdf

Tait, R.D., Maxon, C.L., Parr, T.D., and Newton, F.C. (2016) Benthos response following petroleum exploration in the southern Caspian Sea: Relating effects of nonaqueous drilling fluid, water depth, and dissolved oxygen. Marine Pollution Bulletin, 110(1): 520-527. ISSN 0025-326X,doi.org/10.1016/j.marpolbul.2016.02.079

Trannum, H.C. (2017) Drilling discharges reduce sediment reworking of two benthic species. Marine Pollution Bulletin, 124(1): 266-269. ISSN 0025-326X, doi.org/10.1016/j.marpolbul.2017.07.044

Specific Question of Information Requirement:

Provide an assessment of the potential effect of project activities that result in a release of barite, water-based muds, synthetic-based muds, and drill cuttings on valued components located in the Northeast Newfoundland Slope Closure Marine Refuge (e.g., deep-water sponges)

Discuss the how the potential effects described in the references could affect the Northeast Newfoundland Slope Closure Marine Refuge or provide a rationale for not assessing these potential impacts.

Revise the effects analysis to use the more conservative Rmax estimate for the distance over which sound above the behavioural threshold could be expected (i.e. 61 km). Revise the figures provided in IR-48, to illustrate the Rmax distance of potential effects from sound. Alternatively provide a sound rationale as to why the values were chosen.

Response:

The Northeast Newfoundland Slope Closure marine refuge extends from a depth of approximately 400 to 2,000 m and is the only marine refuge that overlaps with the Project Area with approximately 24,460 km² of co-occurrence, equivalent to 44% of the total area of the marine refuge. The Northeast Newfoundland Slope Closure marine refuge includes a Significant Benthic Area for sea pens and a portion of critical habitat for wolfish. The marine refuge is high in species diversity and contains corals, fish, marine mammals, and seabirds. Several rare or endangered fish species (spotted, northern and Atlantic wolffish, skates, and roundnose grenadier) are found throughout the marine refuge. Demosponges and *Geodia* sp. are likely present in the marine refuge, although high density aggregations are unlikely based on distribution modelling (Knudby et al. 2013).

Exploration drilling may result in changes to benthic habitat as a result of drilling mud and cuttings discharges, with components of these discharges causing physical or chemical changes in the water column and/or sediment. These changes in habitat may also result in mortality or physical injury to benthic organisms. Sections 8.3 and 11.3 of the EIS assessed residual environmental effects of Project activities on the marine benthos including corals and sponges and species which may rely on these organisms for habitat in the Northeast Newfoundland Slope Closure marine refuge.

Barium sulphate (barite) is added to water-based muds (WBMs) and synthetic-based muds (SBMs) to control mud density and thus help balance formation pressures within the well. Edge et al. (2016) assessed biological responses to barite and bentonite (another common component in WBM and SBM) using lysosomal membrane stability (LMS) a biomarker for cellular toxicity. Test sponges *Geodia barretti*, collected from the marine environment were exposed to environmentally realistic concentrations of suspended barite, bentonite and reference sediments of 0, 10, 30 and 50 mg/L. *G. barretti* exhibited adverse effects from barite at suspended solid concentrations above 10 mg/L, whereas exposure to suspended reference sediment and bentonite at similar concentrations resulted in no observed effects. Continuous chronic exposures over the 14-day test resulted in higher toxicity than intermittent chronic exposures when sponges were provided with the opportunity to recover every 12 hours. With the intermittent exposure the long-term effect on sponges was reduced.

It is possible that drilling muds and associated cuttings may release metals and organic compounds which may then accumulate in benthic organisms. Metal concentrations found in barite and bentonite did not readily bioaccumulate in *G. barrette* (Edge et al. 2016), although studies have shown that scallops exposed to drilling muds in laboratory settings have the potential to concentrate barium and chromium as well as clay particles in their digestive tract (Cranford and Gordon 1992, Cranford et al. 1999 in Lee 2011). It has been found during production drilling that drill cuttings may affect biomarkers in filter feeding bivalves and cause elevated sediment oxygen consumption and mortality in benthic fauna up to approximately 0.5 km to 1 km of the discharge point (Bakke et al. 2013). Modern drilling fluids are prepared with high quality barite with much lower trace metal content than historical sources, with most metals of concern being at concentrations similar to those of fine-grained marine sediments (IOGP 2016). The trace metals in the barite are in the form of insoluble sulfides and hydroxides, which renders the metals largely unavailable to exposed marine organisms (IOGP 2016). When considering the bioaccumulation of chemicals from drill cuttings in marine organisms, several bioaccumulation bioassays using WBM cuttings found that metal concentration in the tissues of exposed animals were very similar to those in the tissues of unexposed animals (IOGP 2016).

Results from multiple environmental effects monitoring (EEM) programs conducted for offshore drilling and production programs on the east coast of Canada have concluded that there have been negligible effects on benthic species such as American plaice, Icelandic scallop and snow crab (Buchanan et al. 2003; Hurley and Ellis 2004; DeBlois et al. 2014). The most recent results from the White Rose EEM show that there continues to be no significant body burden (chemical) differences in plaice fillets or crab tissue collected in the White Rose field and reference areas (Husky 2017).

SBMs developed to be rapidly biodegradable will tend to deplete oxygen more quickly than slower degrading materials. Rapid biodegradation, however, reduces the exposure period of aquatic organisms to materials that may bioaccumulate or have toxic effects. Tait et al. (2016) assessed recovery adjacent to a drill centre over time and identified a decrease in species diversity and density in the short-term and indicated hypoxia as the most likely cause of the decrease in benthic organism diversity. Hypoxia-tolerant polychaetes and mobile ostracods were observed in greater numbers after drilling; this resulted in a decrease in diversity but no significant decrease in abundance. Hypoxia, along with potential SBM toxicity and changes in sediment grain size, were identified to be potential causes of reduced bioturbation or sediment reworking by a species of brittlestar (*Amphiura filiformis*) and bivalve (*Abra segmentum*).

Recolonization of the benthic habitat surrounding the drill site approached baseline conditions within two years after drilling at distances 200 to 600 m from the well site with conditions within the study area returning to baseline conditions at 33 months post drilling (Tait et al. 2016). The area with the longest duration of effects covered a relatively uniform area less than 0.12 km^2 or approximately 200 m from the wellsite (Tait et al. 2016).

Section 8.3.3 of the EIS discusses the effects of barium on benthic habitat as a result of offshore drilling operations using the results of Husky's EEM programs for White Rose and Suncor's EEM for Terra Nova. The spatial extent of contamination measured in the 2014 White Rose EEM was found to be within environmental assessment predictions (barium contamination extended up to 1 km from source) (Husky 2017). Note that these are based on 38 wells being drilled since 2004. These results are similar to those reported in the Terra Nova EEM, which indicated the highest levels of barium contamination extended to 1 to 2 km from source (DeBlois et al. 2014). Of the 53 samples taken during this program, all but two samples were determined to be non-toxic to amphipod survival. The spatial extent of effects on benthic invertebrates at White Rose is generally consistent with the Terra Nova EEM and literature on effects of contamination from offshore oil developments with elevated barium concentrations extending out to 1 to 2 km (3 to 12 km^2). In comparison the area of the Northeast Newfoundland Slope Closure is approximately 55,353 km^2. This represents 0.005 to 0.022% of the Northeast Newfoundland Slope Closure Area.

As discussed in Section 8.3.3.1 of the EIS, benthic mortality rates as a result of drilling discharges are not predicted to result in irreversible changes to local populations. To reduce potential adverse effects from drilling muds, cuttings and their components on sensitive benthic flora such as corals and sponges, BP has proposed an imagery-based seabed survey prior to drilling each well which will encompass an area within a 500 m radius from the wellsite. If environmental (or anthropogenic) sensitivities are identified during the survey, BP will notify the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) immediately to discuss an appropriate course of action. This may involve further investigation and/or moving the wellsite if it is feasible to do so. Criteria for environmental sensitivities and an appropriate setback distance or any additional mitigation will be established in consultation with Fisheries and Oceans Canada (DFO) and the C-NLOPB.

Residual effects associated with discharges on fish and fish habitat (including the Northeast Newfoundland Slope Closure marine refuge) are predicted to be potentially adverse, low in magnitude, restricted to the Project Area, medium term to long term in duration, occur more than once at irregular intervals (corresponding with well drilling programs) and be reversible. Residual environmental effects on marine fish and fish habitat (including the Northeast Newfoundland Slope Closure marine refuge) are predicted to be not significant. Refer also to the revised response to IR-49 (May 2019) for an assessment of Project effects on the Northeast Newfoundland Slope Closure marine refuge.

With respect to the IR query on the underwater sound assessment, the assessment of underwater sound as presented in the EIS and discussed in IR-49 used $R_{95\%}$ values since it was considered to be most statistically representative of the 'real world' aerial extent of sound levels (associated with the activity) being above a given threshold level and therefore is considered more appropriate to use for assessing potential impacts of a marine species being exposed to sound levels above the given threshold value. The R_{max} metric is likely to represent localized outlying distance values or locations which are less representative of the aerial extent of the sound field.

As explained in Zykov (2016), underwater sound fields predicted by the propagation models are sampled so that the received sound level at each point in the horizontal plane are taken to be the maximum value over all modelled depths for that point. The predicted distances to specific levels are then computed from the maximum-over-depth sound fields. Two distances relative to the source are reported for each sound level: (1) R_{max}, the maximum range at which the given sound level was encountered in the modelled maximum-over-depth sound field and (2) $R_{95\%}$, the maximum range at which the given sound level was encountered after the 5% farthest such points are excluded (see Figure 1 below). The $R_{95\%}$ is commonly used because the maximum-over-depth sound field footprint might not be circular and, along a few azimuths, could extend far beyond the main ensonification zone. Regardless of the geometric shape of the maximum-over-depth footprint, $R_{95\%}$ is the predicted range encompassing at least 95% of the area (in the horizontal plane) that would be exposed to sound at or above that level. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the heterogeneity of the acoustic environment. The $R_{95\%}$ excludes ends of protruding areas or small isolated acoustic foci not representative of the nominal ensonification zone.

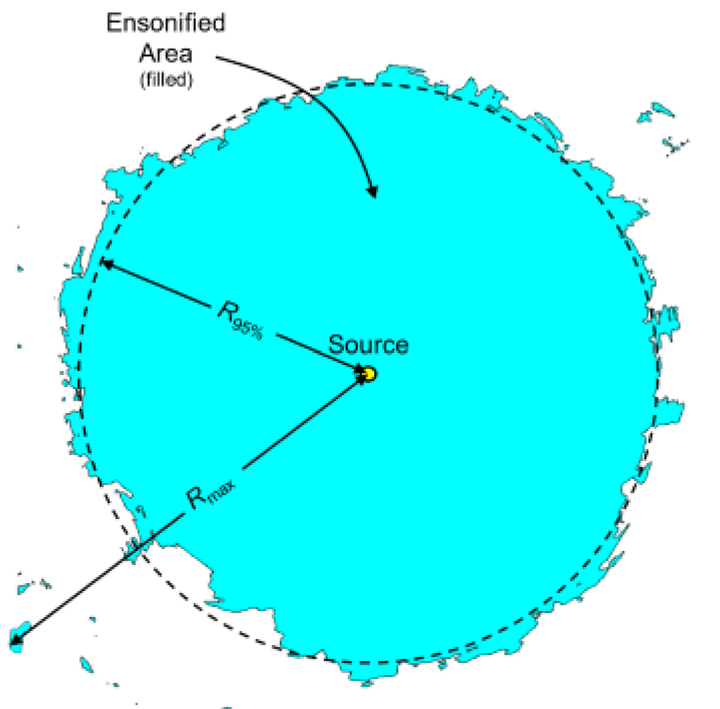

Figure 1. Example of an area ensonified to an arbitrary sound level showing R_{Max} and $R_{95\%}$ radii (Figure 8 from Zykov 2016)

Matthews et al. (2018) predicted that distances to sound level isopleths for the Orphan Basin Exploration Drilling Project would be in the range of those predicted for May in Flemish Pass (Matthews et al. 2017) and for August in Scotian Basin (Zykov 2016). Table 1 below presents the $R_{95\%}$ and R_{Max} values from MODU operations (semi-submersible platforms) to rms SPL Sound Level Isopleths for Flemish Pass in May and the Scotian Basin in August and February.

Table 1 Predicted Distances from MODU Operations (Semi-submersible Platforms) to rms SPL Sound Level Isopleths for Flemish Pass in May and the Scotian Basin in August and February

rms SPL (dB re 1 µPa)	Maximum Horizontal Distance (R_{Max}) Predicted in May in Flemish Pass[1] (km)	95% Horizontal Distance ($R_{95\%}$) Predicted in May in Flemish Pass[1] (km)	Maximum Horizontal Distance (R_{Max}) for MODU Predicted in August in the Scotian Basin[2] (km)	95% Horizontal Distance ($R_{95\%}$) for MODU Predicted in August in the Scotian Basin[2] (km)	Maximum Horizontal Distance (R_{Max}) for MODU Predicted in February in the Scotian Basin[2] (km)	95% Horizontal Distance ($R_{95\%}$) for MODU Predicted in February in the Scotian Basin[2] (km)
120	47.61 (Site A) 56.78 (Site B)	38.07 (Site A) 40.58 (Site B)	51.3 (Site A) 60.8 (Site B)	24.0 (Site A) 26.7 (Site B)	>150 (Sites A & B)	>150 (Sites A & B)

1 Refer to Table 13 in Matthews et al. (2017)
2 Refer to Tables 14 and 15 in Zykov (2016)

If the R_{Max} value is used to calculate a zone of influence for behavioural effects on marine mammals from underwater sound related to exploration drilling, the radius increases from 40 km (as presented in IR-49) to 61 km. However, given the explanation of the two values provided above, BP maintains that the $R_{95\%}$ value used to delineate a probable zone of influence of effects from underwater sound is more appropriate for effects assessment and therefore the figures presented in IR-48 remain unchanged.

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(*Hippoglossoides platessoides*) near the Terra Nova offshore oil development over ten years of drilling on the Grand Banks of Newfoundland, Canada. Deep Sea Research II, 110: 65-83.

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Trannum, H.C. 2017. Drilling discharges reduce sediment reworking of two benthic species. Marine Pollution Bulletin, 124(1): 266-269. ISSN 0025-326X, doi.org/10.1016/j.marpolbul.2017.07.044

4.0 INFORMATION REQUIREMENT: IR-51-02

Reference to EIS:

Section 8.3.3.2

Context and Rationale:

The Agency required that sea pen habitat be described with respect to ecological processes that govern their presence and that potential effects from Project discharges and emissions be described in terms of a change to habitat quality. The proponent responded by describing the habitat of three species of sea pens studied by Greathead et al. (2015) and identifying two species of coral known to be present in waters off Newfoundland and Labrador. The Greathead et al. (2015) study is related to sea pens found in Scottish waters and it is unclear how this study relates to the project area. The proponent stated that no other life history information was available for the species found within the project area; however, information is available (see below).

References:

Baillon S, Hamel J-F, Mercier A (2014) Diversity, Distribution and Nature of Faunal Associations with Deep-Sea Pennatulacean Corals in the Northwest Atlantic. PLoS ONE 9(11): e111519. https://doi.org/10.1371/journal.pone.0111519

Baker, K., Wareham, V., Snelgrove, P., Haedrich, R., Fifield, D., Edinger, E., & Gilkinson, K. (2012). Distributional patterns of deep-sea coral assemblages in three submarine canyons off Newfoundland, Canada. Marine Ecology Progress Series, 445, 235-249. Retrieved from http://www.jstor.org/stable/24875404

Specific Question of Information Requirement:

Provide clarification on the applicability of Greathead et al. (2015) to the sea pens in the project area and update the sea pen habitat description and analysis to include relevant information in Baillon et al. (2014) and Baker et al. (2012) with respect to ecological processes for *Anthoptilum grandiflorum* and *Distichoptilum gracile.* Discuss how potential effects from project discharges and emissions could cause changes to the habitat quality or use by sea pens or species dependent upon them.

Response:

Greathead et al. (2015) indicated that four habitat variables (mud, minimum salinity, depth, and gravel) have been found to be important in predicting the presence of the three sea pen species in their study. While those species were not found in the Project Area, the habitat variables that influence presence and distribution of sea pens species remain valid, as discussed in Baker et al. (2012). Roberts et al. (2009, *in* Baker et al. 2012) indicated that temperature, salinity, substrate, currents, and slope are important factors that contribute to distribution and abundance of deep-sea corals. Baker et al. (2012) found that many of the sea pen species observed in their study were not restricted to certain depths, but instead were found over a wide range of depths. In their study they observed that *Distichoptilum gracile* was found primarily in areas with soft sediments; they did not discuss *Anthoptilum grandiflorum*, though they were observed in the study.

Baillon et al. (2014) studied two deep-sea coral species found in areas with soft substrate in the offshore Newfoundland area of the Northwest Atlantic. The focus of their study was the use of deep-sea corals as microhabitats for other species. *Anthoptilum grandiflorum* was one of the two species studied as they are common, widespread, and found over a wide range of depths (100 to <2,000 m). A total of 14 species were found living in close association with *Anthoptilum grandiflorum*. These included fish larvae, shrimp larvae, amphipods, copepods (parasitic and free-living), nematodes, fish eggs, sea anemones, and hydrozoans. Analysis showed that of the variety of organisms found, copepods are most closely associated with sea pens. Data also indicated that species richness decreased with increasing latitude. Depth, region, and season did not appear to affect measures of biodiversity.

Section 8.3.3.1 of the EIS states that the accumulation of drill solids on the seafloor can cause stress and disturbance to benthic fauna through direct toxicity from drilling muds and cuttings, burial (smothering), changes due to sediment grain size, nutrient enrichment, and oxygen depletion (Neff et al. 2004; Neff 2010; Smit et al. 2006). The effects of smothering can include mortality, reduced growth rates, reduced larval settlement, and a change in fauna composition (Neff et al. 2004). It is possible that some species may die from the mass of the discharges crushing them, while others may die because they cannot penetrate through the deposited layer that is burying them. This includes potential effects to sea pens. Additionally, any effects to sea pens could therefore result in effects to species that are dependent on them for their life cycle. Refer to IR-18 for general effects of change in habitat quality or use and IR-12 for proposed mitigation.

References

Baillon S, J.-F. Hamel and A. Mercier. 2014. Diversity, Distribution and Nature of Faunal Associations with Deep-Sea Pennatulacean Corals in the Northwest Atlantic. PLoS ONE 9(11): e111519. https://doi.org/10.1371/journal.pone.0111519

Baker, K., V. Wareham, P. Snelgrove, R. Haedrich, D. Fifield, E. Edinger and K. Gilkinson. 2012. Distributional patterns of deep-sea coral assemblages in three submarine canyons off Newfoundland, Canada. Marine Ecology Progress Series, 445, 235-249. Available at: http://www.jstor.org/stable/24875404.

Greathead, C., J.M. González-Irusta, J. Clarke, P. Boulcott, L. Blackadder, A. Weetman and P. J. Wright. 2015. Environmental requirements for three sea pen species: Relevance to distribution and conservation. ICES Journal of Marine Science, 72: 576-586.

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Smit, M.G.D., J.E. Tamis, R.G. Jak, C.C Harman, C. Kjelilen, H. Trannum and J. Neff. 2006. Threshold levels and risk functions for non-toxic sediment stressors: burial, grain size changes and hypoxia. Summary, Environmental Risk Management System, Report 9, THO 2006-BH0046/A Open, 2006.

5.0 INFORMATION REQUIREMENT: IR-67-02

Reference to EIS:

Section 15.5.1.3

Context and Rationale:

The Agency required the proponent to describe the applicability of synthetic-based mud spill modelling conducted for CNOOC International's (formerly Nexen Energy) Flemish Pass Exploration Project to the current Project given the differences in oceanographic conditions; and to discuss the potential environmental effects of the specific oceanographic conditions in the Project Area on the modelled results. The proponent provided an explanation for the west Orphan Basin exploration licences (1145,1146, 1148) but did not provide a similar assessment for the east Orphan Basin exploration licence (1149).

Specific Question of Information Requirement:

Describe the applicability of CNOOC International's Flemish Pass Exploration Project synthetic-based mud spill modelling for the current Project given the differences in oceanographic conditions in the east Orphan Basin. Discuss the potential environmental effects that the oceanographic conditions in the east Orphan Basin may have on the synthetic based mud spill modelling.

Response:

The monthly and daily current statistics for modelled surface and bottom currents at East Orphan Basin well location are shown in Tables 1 and 2.

Table 1 East Orphan Basin Representative Well Location, Monthly Current Statistics

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Water Depth (0m BSL)	Min (cm/s)	10	7	6	5	6	6	6	7	8	9	10	7
	Mean (cm/s)	30	26	20	19	20	23	21	31	30	36	33	31
	Max (cm/s)	58	64	52	51	42	62	56	86	113	81	68	64
Water Depth (-25 m BSL)	Min (cm/s)	2	3	3	3	3	3	3	7	6	5	2	4
	Mean (cm/s)	20	15	12	11	13	18	14	23	24	31	27	22
	Max (cm/s)	40	44	33	22	32	52	36	68	85	76	57	47
Water Depth (-100 m BSL	Min (cm/s)	4	3	2	2	1	1	1	2	2	2	2	2
	Mean (cm/s)	19	13	10	7	7	7	9	11	9	8	11	13
	Max (cm/s)	38	37	35	17	24	20	19	23	24	33	39	38
Water Depth (-1,300 m B	Min (cm/s)	1.7	2.1	1.2	1.0	1.4	1.3	1.9	1.1	0.9	1.8	1.5	1.2
	Mean (cm/s)	6	6	5	6	7	7	7	6	6	7	6	7
	Max (cm/s)	13	14	10	13	20	15	11	15	14	15	15	15

Table 2 Summary of HYCOM daily current speeds at East Orphan Representative Well Location (cm/s) (2006 - 2010)

Depth (m)	Mean	Std Dev	Min	25%	50% (Median)	75%	Max
0	27	13	5.3	17	24	33	113
25	19	12	2.5	11	16	25	85
50	15	10	1.7	8.2	13	20	73
100	10	6.7	0.9	5.4	8.4	13	39
2,700	6.3	3.0	0.9	4.0	5.8	8.1	20

The Nexen Energy EL 1144 wellsite is located at a water depth of 1,137 m, which is shallower than the water depth at the East Orphan Basin wellsite (2,240 m). The, mean surface / near-surface current velocities at the East Orphan location are approximately two to five times stronger than those at the EL 1144, with mean near-bottom currents two to three times stronger.

As discussed in the original response to IR-67 (Round 1), the transport and dispersion of particles (especially smaller particles like silts and clays) will tend to be enhanced with increased current speeds and water depth and with greater variation in current direction over time and depth. Larger particles (sand) tend to settle quickly, forming a pile that aligns with the predominant current axis and are not affected as much by ambient current speeds. This would be the situation following a synthetic-based mud (SBM) release as drill solids contained in SBM are "sticky" and tend to agglomerate (Delvigne 1996) forming larger "clumps" consisting of the synthetic base fluid, cuttings and barite with increased sinking velocities (SwRI 2007) (typically > 10 cm/s). Hence, SBM clumps would sink down to the sea floor relatively fast, so dispersion would be less sensitive to variations in ambient current velocities and depth.

The implication for the East Orphan Basin is that the SBM would be transported over a greater distance before settling on the seabed, resulting in a thinner layer of drill solids spread over a larger area, compared to those discharged at the EL 1144 wellsite. Hence, as was demonstrated in the Drill Cuttings Modeling Report (EIS Appendix B), higher ambient currents are likely to reduce the maximum distance from the wellsite location where benthic burial affects occur.

If an unplanned SBM release was to occur at the wellhead, then the SBM drill solids deposition would be localized around the wellhead, resulting in thicker sediments spread over a smaller area than if a SBM release was to occur at the surface.

References:

Delvigne, G.A.L. 1996. Laboratory investigations on the fate and physiochemical properties of drill cuttings after discharge to the sea. Pages 16 – 24 in The Physical and Biological Effects of Processed Oily Drill Cuttings (Summary Report). E & P Forum, London, 1996.

SwRI (Southwest Research Institute). 2007. Fall Velocity of Synthetic-Based Drilling Fluids in Seawater. Final Report, prepared for Minerals Management Service.

6.0 INFORMATION REQUIREMENT: IR-68-02

Reference to EIS:

Appendix D

Context and Rationale:

The Agency required the proponent to discuss the implications of the pour point being above the deep-water temperature on the modelled results. Based on the response provided, Natural Resources Canada advised that the proponent's calculations of viscosity appear to assume that the oil remains a liquid because pour point is not a variable under consideration (viscosity would increase sharply upon solidification) as stated within the response to IR-68: "Within OSCAR a module has been developed that determines the average temperature during droplet size formation using a regression model that depends on the variables of outlet velocity, volume flux, oil temperature, water temperature and orifice diameter. This temperature (rather than the ambient temperature) is then used to estimate the oil's viscosity during droplet formation.

The temperature adjusted viscosity allows for a better prediction of the oil droplet size distribution." The discussion of pour point calculated as a function of evaporation at the water surface given is not relevant to the mechanisms that would be at play in deep water such as solidification of oil droplets or separation of solid oil components of the oil like wax particles from more fluid parts of the oil (dewaxed oil). These mechanisms would occur before the oil arrived at the surface so no evaporation could have occurred yet.

Specific Question of Information Requirement:

Discuss the implication on the modelled results given that the discussion of the pour point given, calculated as a function of evaporation at the water surface is not relevant to the mechanisms that would be at play in deep water (solidification of oil droplets, separation of solid oil components of the oil (e.g. wax particles from more fluid parts of the oil (dewaxed oil)), etc.). These mechanisms would occur before the oil arrived at the surface so no evaporation could occur.

Response:

SINTEF is an independent research organization that has led the industry in developing and refining a systematic, step-wise procedure to characterize the weathering of oils, thereby isolating the influence of different weathering processes (i.e. evaporative loss, photolysis and water/oil-emulsification). These laboratory methods have been described by Daling et. al (1990, 1997). Weathered oil samples are prepared from the fresh crude and each sample is then subjected to physico-chemical analysis to measure oil properties like specific gravity, flash point, pour point and viscosity as well as maximum water uptake, water/oil-emulsification studies and chemical dispersibility tests. In the case of oils with high pour points, physical properties are measured on fresh and weathered oil at different reference temperatures to establish formulas which describe parameters like viscosity and pour point as a function of temperature. These algorithms are incorporated into the Oil Spill Contingency and Response (OSCAR) model to simulate weathering processes including dispersion. For example, the analogue oil Varg 2004, used in the modelling study, has a pour point of 9°C. Its fresh oil viscosity at 13°C is 36 cP. However, the measured fresh oil viscosity increases to 485 cP at 5°C, which is 4 degrees below its pour point. These viscosity changes as a function of temperature and the influence on oil dispersion and spreading are accounted for during OSCAR simulations. In addition, the sea temperature typically needs to be sustained at 10-15 degrees below the pour point of an oil before the oil would solidify.

Once the oil starts to weather, the pour point is described in OSCAR by the equation:

$$\text{Pour point (°C): } P = e^{(a+bf)} - 273$$

where f is the fraction evaporated, or dissolved (%), and the a's and b's are regression factors derived from laboratory weathering studies on the oil. As oil droplets arrive at the surface within a day, (see EIS Appendix D, Section 7.2) composition change from dissolution on the rise should be minimal compared to the evaporation on the surface, so it is expected that changes in pour point in the water column would be minor.

References:

Daling, P. S., P. J. Brandvik, D. Mackay and Ø. Johansen, 1990: Characterization of Crude Oils for Environmental Purposes. Oil and Chemical Pollution, Vol. 7, pp. 199 – 224.

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