REVIEW OF THE ENVIRONMENTAL IMPACT STATEMENTS FOR THE FLEMISH PASS EXPLORATION DRILLING PROJECT AND THE EASTERN NEWFOUNDLAND OFFSHORE EXPLORATION DRILLING PROJECT

Context

Statoil Canada Ltd. (Statoil), in association with its partners is proposing to undertake an exploration / delineation / appraisal drilling program and associated activities in the eastern portion of the Canada-Newfoundland and Labrador Offshore Area between 2018 and 2027.

ExxonMobil Canada Ltd. (ExxonMobil) and its co-venturers are planning to conduct a program of petroleum exploration / delineation / appraisal drilling program and associated activities (in the eastern portion of the Canada-Newfoundland and Labrador Offshore Area over the period 2018 to 2029.

Both Projects require review and approval pursuant to the requirements of the Canadian Environmental Assessment Act (CEAA 2012) as it has been determined that the drilling of a well constitutes a "designated project" under Section 10 of the Regulations Designating Physical Activities. In addition, the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) requires a project-specific environmental assessment (EA) be completed for offshore oil and gas activities, pursuant to the Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act and the Canada-Newfoundland Atlantic Accord Implementation Act (the Accord Acts). It is intended that the EA review process for the Projects will satisfy the requirements of CEAA 2012 and the C-NLOPB's Accord Acts EA processes. Environmental Impact Statements (EIS) have been prepared in accordance with requirements of CEAA 2012, the project-specific Guidelines for the Preparation of an Environmental Impact Statement (EIS Guidelines [CEA Agency 2016]) issued by the Canadian Environmental Assessment Agency (the Agency), and other generic EA guidance documents issued by the Agency as referenced throughout.

On January 9, 2018, the Fisheries Protection Program of the Ecosystems Management Branch in the Newfoundland and Labrador Region requested that DFO Science undertake a review of the specific sections of the Environmental Impact Statements for the Flemish Pass Exploration Drilling Project, and the Eastern Newfoundland Offshore Exploration Drilling Project. While these projects are subject to separate environmental assessments, the proponents have collaborated in the preparation of their EIS Reports and Summaries. As such, the documents share content where relevant. Science Branch undertook a Science Response Process (SRP) for this review. The information from this scientific review will be provided to Ecosystems Management to help form part of the Department's response to the overall adequacy of the EIS Reports.

The objective of this review was to evaluate:

- The sufficiency of baseline data and appropriateness of methodologies to predict effects;

- The mitigation measures proposed by the proponent;
- The level of certainty in the conclusions reached by the proponent on the effects;
- The manner in which significance of the environmental effects, as they pertain to DFO's mandate, have been determined (i.e. the scientific merit of the information presented and the validity of the proponent's methodologies and conclusions);
- The follow-up program proposed by the proponent; and
- Whether additional information is required from the proponent to complete the technical review.

The information required for this review can be found in a number of sections throughout the EIS reports, and associated appendices. The EIS Reports are available on the Agency's website at the following links:

- http://www.ceaa-acee.gc.ca/050/document-eng.cfm?document=121309 (Flemish Pass Exploratory Drilling Project); and
- http://www.ceaa-acee.gc.ca/050/document-eng.cfm?document=121311 (Eastern Newfoundland Offshore Drilling Project).

This Science Response Report results from the Science Response Process of February 28, 2018 on the Review of the Environmental Impact Statements for the Flemish Pass Exploration Drilling Project and the Eastern Newfoundland Offshore Exploration Drilling Project.

Analysis and Response

The comments provided by DFO Science, NL Region are related to the following Sections of the EIS Reports:

- **Section 2.0 – Project Description**
  - Section 2.5.2.1 – Wellsite Surveys Drill Planning
- **Section 5.0 – Existing Physical Environment**
  - Section 5.5 – Oceanography
  - Section 5.7 – Ice conditions
  - Section 5.8 – Climate change
  - Section 5.8.2 – Oceanographic Changes
  - Section 5.8.3 – Ice Conditions
- **Section 6.0 – Existing Biological Environment**
  - Section 6.1.6.5 - Corals and Sponges
  - Section 6.1.7.4 - Migratory Atlantic salmon (*Salmo salar*)
- **Section 8.0 – Marine Fish and Fish Habitat: Environmental Effects Assessment**
  - Section 8.3.3.3 – Interaction with Benthic Environment (Corals / Sponges)
  - Section 8.3.4 – Drilling and Associated Marine Discharges
  - Section 8.4.4 – Atlantic salmon and American eel (review of information related to Atlantic salmon only)
  - Section 8.5 – Significance of Residual Environmental Effects (review of information related to Corals / Sponges)

  - Section 8.6 – Environmental Monitoring and Follow-up (review of information related to Corals/Sponges)

- **Section 12.0 - Indigenous Communities and Activities: Environmental Effects Assessment**
  - Section 12.3.2.2.3 - Atlantic salmon
- **Section 15.0 - Accidental Events**
  - Section 15.4 - Fate and Behaviour of Potential Spills
  - Section 15.5 – Environmental Effects Assessment: Sections titled "Deep Sea Corals and Sponges" and "Fish Species Used by Indigenous Groups" (i.e. Atlantic salmon).
- **Appendix E – Trajectory Modelling (RPS 2017)**
- **Appendix G – Drill Cuttings Modelling (Amec Foster Wheeler 2017)**

General Comments

Overall, the report covers the main aspects of much of what is currently known regarding salmon at sea. More recent papers, like the origin of salmon at the Faroe Islands where they seem to have more North American fish present than previously thought, or the origin of salmon at west Greenland, Labrador coast and south coast of Newfoundland, as well as on the trophic (feeding) ecology of salmon could have been noted, but this would not likely change the basic conclusions in the reports.

Statements that note salmon likely do not overwinter in the Flemish Pass area (citing Reddin and Friedland) may be true, but given the limited surveys for salmon in the area, this may also be wrong, or could differ from one year to another. Overall, it is known that salmon spend one to several years in the North Atlantic before returning to their natal river. They are not stationary and hence likely use a variety of areas at different times. Salmon could be in the some of the project areas at certain times but based on what is known (versus what is still unknown), interactions may be limited.

The current criteria for identifying and avoiding corals and sponges should be reviewed and adjusted in order to accommodate important habitats generated by smaller (<30 cm in height) species of corals and sponges, known to be present in the general area.

There are problems with the numerical simulations of both the oil spill and the drill cuttings scenarios that need to be addressed and corrected.

Statements containing the qualifier *"in the unlikely event that an accidental event occurs…*" are found frequently in the reports. Unless the report actually quantifies how likely it is that an accidental event would occur, such opinion should not be found in an objective scientific report.

Section 2.5.2.1

The reports state that pre-drill surveys will be conducted using multi-beam echosounder (MBES) and sidescan sonar (SSS) at a resolution of 0.5 m x 0.5 m. This scale is not fine enough to detect coral and sponge community types found in this region that are acoustically invisible using these methods.

NOROG (the Norwegian Oil and Gas Authority) Guidelines or best practices approach for industry (2013) are not entirely relevant for the benthic communities found in this region. These guidelines were developed in Norway, to mitigate impacts on *Lophelia*, the largest known Cold Water Coral reef systems in the world.

The NOROG Guidelines apply to *Lophelia* reefs and coral gardens. No encounters with living *Lophelia* have been documented in this region, however, data is biased by substrate with hard bottom representation limited to sporadic ROV Surveys. It is possible living colonies exist based on sub-fossilized pieces of *Lophelia* documented on the NE Flemish Cap (NEREDIA Survey 2009-2010). In addition living colonies have been recorded in adjacent regions like the Stone Fence (NS, Canada) and southern tip of Greenland. Examples of coral gardens in this region include; Sea Pen fields (Fig. 16), *Acanella* meadows (Figs. 18, 19), *Geodia* sponge grounds (Figs. 3-6), and bamboo and sponge thickets (Figs. 7, 10, 14, 15). For the latter, the composition of the community may change with depth.

The NOROG Guidelines state that experience has proven that resolution of <1 m has high accuracy. This holds true for *Lophelia* reefs in the NE Atlantic (Fig. 1) and Glass Sponge reefs (Fig. 2) in the NE Pacific but it may not be the best approach for the corals and sponges found within the project site. *Lophelia* is a reef forming coral with new animals growing on top of dead ones. Off Norway, these reefs are kilometers in length and meters in height and consequently, can be detected using MBES and SSS. Similarly, glass sponges reefs found off British Columbia form new growth on top of old. Reef complexes are 40 km in length, 15 m in height, and have been mapped using MBES technology (Conway et al. 1991; Austin et al. 2007).

Examples of habitat forming communities found in this region that cannot be detected using MBES and SSS include:

- *Geodia* sponge grounds (i.e. Boreal “Ostur” and Cold water “ostur”). These are comprised of *Geodia/Stryphnus/Stelletta* sponges with the difference being the species composition of each. These sponges are globular and/or spherical in shape, can be massive in size and weight (Figs. 5, 6). As a result, encounters are easily detected in Canadian trawl survey data and the majority have been identified at depths <1,500 m (see NAFO WGESA, 2008-17).
- Glass sponges (*Asconema* spp.) and Bamboo Coral (*Keratoisis sp. kerD2d*)Communities. These have not been well studied but have been identified in the Flemish Pass (Canadian Multispecies Survey; see Figs. 7, 12, 13), and NE Flemish Cap (ROPOS 2010 Survey; see Fig. 10). Note for the latter, community assemblages changed with depth with deeper communities dominated by bamboo corals and sponges, to a mix with *Geodia*, to a *Geodia* dominated community at shallower sites in the NE Flemish Cap.
    - *Asconema* (Class Hexactinellida) is a genus of glass sponges (Fig. 11) that are important for habitat provision and the only glass sponges identified as structure-forming (Beazley et al., 2013). *Asconema spp*. are thin-walled glass sponges with large oscula or openings where water exits. Individuals can reach 60 cm in width by 50 cm in height. Based on the current methodology, *Asconema* would not be captured due to their light weight.
    - *Keratoisis* is one genus of bamboo coral found in the region with at least two species:
        - *Keratoisis grayi* (=*K. ornata*) is a thick branched coral that requires hard substrates for attachment and found predominantly from the SW Grand Banks to Scotian Shelf (Fig. 10). Individual colonies can reach 1.5 m in height and 1 m in width (Baker et al. 2012);
        - *Keratoisis* sp. (kerD2d = *Keratoisis* cf. *flexibilus*; Saucier 2016) is a thinly branched coral that forms dense ‘thickets’ with individual colonies indistinguishable (Neves et al.

2013, Saucier 2016). Dense patches (55 m in length x 1 m in height) have been documented in Baffin Bay (Neves et al. 2013), and 2 locations in Flemish Pass with both sets mixed with *Asconema* glass sponge (Figs. 12, 13)

- Sea pens fields can be comprised of many species or dominated by 1 or 2. Sea pens fields documented in Desbarre Canyon (622 colonies in video segment) spanned several kilometers and were dominated by *Pennatula* species with adults <30 cm in height (Fig. 16; Baker et al. 2012). Based on the criteria (individuals >30 cm in height), such significant biotic habitats would not be avoided within the scope of this plan.
- Similar to sea pens, *Acanella arbuscula* can also characterise large coral fields with maximum colony height <30 cm (Fig. 15; Baker et al. 2012). *Acanella* is a bamboo coral that only inhabits soft substrates. It is very light and fragile and distributed within Flemish Pass (NAFO SCS Doc. 13/024; NAFO SCS Doc. 14/023; NAFO SCS Doc. 16/021).

Coral gardens are defined in guidelines as dense aggregations of colonies covering an area >25 m^2. However, in the EIS Reports, coral and sponge aggregations are defined as 5 or more corals larger than 30 cm in height or width. Coral garden species are non-reef builders but can form extensive sea pen fields (Figs. 16, 17), *Acanella* meadows (Figs. 18, 19), and bamboo and sponge thickets (Figs. 14, 15). *Pennatula* sea pen fields are dominated by *Pennatula* species (*P. aculata*). The maximum size of *P. aculata* is <30 cm which means such important coral habitats would not be protected based on the current criteria. Additionally, for bamboo thickets the colonies are so inter-tangled that it is extremely difficult to quantify individuals.

The multi beam echo sounder primarily collects depth data, and will reveal seabed features such as ice scouring plough marks, but can also have ***sufficient resolution*** to reveal ***potential*** coral features. DFO has used MBES and SSS to assess sites prior to ROV dives. Both can be used very well to determine abiotic sea bed features and also some biotic features (i.e. *Lophelia* and reef forming glass sponges) however, coral structures down to 1 m^2 are not detectable with MBSS or modern SSS. Possible new emerging technologies such as Synthetic Aperture Sonar are currently testing resolutions down to 3 cm scale but testing is occurring in *Lophelia* type habitats in the NE Atlantic and would require further testing on representative communities found in this region.

Based on the above, it is recommended that the current criteria be adjusted in order to accommodate important habitats generated by smaller species (<30 cm in height), known to be present in the general area. Additionally, the contact and/or impact sites should be ground-truthed using ROV. Finally, it is recommended that Canadian guidelines be developed for the offshore Oil and Gas industry, using NOROG (2013) as a starting point, in order to capture Sensitive Benthic Areas (SBAs) and/or Vulnerable Marine Ecosystems (VMEs).

Section 5.5 - Oceanography

5.5.1 - Waves

The wave model used is almost 20 years old (Swail and Cox, 2000). Recent developments in this field suggest that the ability of these models to capture extreme events amplitude (the timing of large events is well captured, however) is limited by the accuracy of wind field inputs and the model grid resolution (e.g., Pringle et al. 2015). More discussion on their limitations and also on new developments that have been made since should be provided.

The report does not provide any comparison with observations that can assess the performances of the model. Model results are *not* observations.

Recent relevant work (e.g., Li et al. 2015: "A modeling study of the impact of major storms on waves, surface and near-bed currents on the Grand Banks of Newfoundland.") is worth discussing and citing.

Representing the histogram of significant wave heights (e.g. Figs. 5-27) in % of occurrence rather than 'counts' that have little meaning, is recommended.

5.5.2 - Ocean currents

For currents over the Grand Banks, the authors cite Seaconsult Ltd. (1988) as their source. This report from 1988 is not the most accurate and updated study for ocean currents in this area. It is suggested that more recent work for circulation patterns, for example Wu et al. (2012), be explored.

Current observations from BIO's Ocean Data Inventory are presented. The authors state they have pulled “monthly current statistics records”. Such temporal smoothing (the use of monthly rather than higher resolution) completely removes tidal and higher frequency scales of motions that can be sometimes an order of magnitude greater depending on the area (e.g. Bourgault et al. 2014 illustrate this for the Gulf of St. Lawrence). For example, in the area under investigation, it appears that trapped diurnal waves traveling around the Flemish Cap are responsible for 85% of the variability on a line east of the Cap (Wright and Xu, 2004). Although likely important for the region under investigation here, such motions (diurnal) are completely eliminated when considering monthly averages.

Although data from two Statoil moorings (Section 5.5.2.1, Figs. 5-33 and Tables 5-20 and 5-21) are presented, there is no mention of the temporal average of the data.

Figures 5-34 and 5-35. These progressive vector plots are misleading. You cannot follow a particle for several months based on the currents measured at its original position; ocean trajectories do not work that way. As soon as a particle leaves it original location, it is subject to different conditions.

Section 5.5.2.2. Hibernia data: Data are averaged in monthly means, without mention of the original sampling frequency. Higher frequency motions are likely more important for dispersion. This could have provided better higher resolution estimates.

For the 'maximum' velocity, it is not clear whether it is the maximum from the raw sampling frequency or if it is the maximum monthly mean of the 2015-2016 period. The data in Tables 5-22 (especially minimum), suggests it is the maximum and minimum from the raw time-series. But in this case, the sampling frequency must be specified**,** otherwise it means very little.

The same comment applies to Figs. 5-37 to 5-39, where the sampling frequency is not specified.

Section 5.5.2.3. The statement “*…where currents are generally weak (less than 10 cm/s) and southwards and dominated by wind- induced and tidal current variability*” suggests that current variability may be dominated by higher frequency motions (tides, winds). This confirms a previous comment that monthly averages in ocean current completely miss a large part of the variability that may dominate for dispersion or advection of tracers.

5.5.3 - Extreme Events

There is no mention of the source of the data (wind and waves). Are they model results from section 5.3?

Table 5.23. The meaning of the return period of extreme events is unclear. Referencing Table 5.4 (for wind maximum), it appears that the 100-year return extreme is already exceeded in the 1962-2015 period for 7 out of 12 months. Actually, just the fact that the 100-year extreme (122 km/h) is not really extreme is confusing. The same argument may apply for wave extreme events.

5.7 - Ice conditions

Section 5.7.1.1.1. "*From mid- January through to the beginning of February the frequency of presence of sea ice is 1 to 15 percent,* ***or about as frequent as every six or seven years.***"

Section 5.7.1.2*. "Sea ice is most likely to occur over the northern portion of the Project Area – Southern Section and with a frequency of occurrence of 16 to 33 percent (**or every three to six years**)."*

Section 5.7.1.3. *"The greatest frequency of occurrence of sea ice is likely between February and early April at approximately 16 to 33 percent (**or every three to six years**)."*

The above statements on the occurrence in terms of years are incorrect and misleading as they are based on weekly statistics. If ice is found, for example 33% of the time between February and April, this means that ice is found one week out of 3 on average, and it is thus very likely to find ice every year rather than every 3 to 6 years. Please revisit and revise.

5.8 - Climate Change

Section 5.8.1.1 – Wind:*"Cheng et al. (2014) found that the frequency of high-speed hourly wind gusts in Atlantic Canada is expected to increase under both medium and high GHG emissions scenarios by the mid-21st century. Their study showed the frequency of **gusts over 25.0 m/s could double**, gusts over 19.4 m/s could increase by around 20 percent, and gusts over 11.1 m/s could increase by 15 percent."*

However, in a more recent study (Amec Foster Wheeler 2017), the median and maximum annual sustained (hourly average) wind speeds, were projected to decrease slightly or remain unchanged over the coming decades, along main transport routes, adjacent to the region of interest." The authors present two contrasting studies for the possible effect of climate change for wind increase (Cheng et al. 2014 and Amec Foster Wheeler 2017). While the former is a peer-reviewed study in a well recognized international journal (Journal of Climate), the latter is not publicly accessible and therefore cannot be reviewed and challenged. It is not appropriate to compare these two studies in this manner. Consequently, this statement is misleading for the non-specialist reader. While the impact of a **two-fold increase in the frequency of extreme wind gusts** (>25 m/s) by the mid-21st century cannot be properly evaluated, this information seems too important to be refuted using non peer-reviewed material.

Section 6.0 – Existing Biological Environment

6.1.6 – Benthic Invertebrates

An overview map showing licences, project area, Sensitive Benthic Areas, fishing closures and Vulnerable Marine Species work conducted by NAFO for the past decade would be beneficial and should be provided.

The majority of what we know is the result of trawling with sporadic ROV Surveys (i.e. ROPOS). Information is derived from Canadian Trawl Surveys with maximum depth of 1,500 m. We know very little of the deep-sea species assemblages beyond these limits.

Another model to consider is Gullage et al. 2017 which used the same data as Guijarro et al. 2016 and Kenchington et al. 2016. These results show less suitable habitat than the other models restricted to a relatively narrow band on the continental slope with no extrapolation into the deep-sea floor (see Gullage et al. 2017, Fig. 16). Of particular interest is Fig. 3 for small gorgonians (i.e. *Acanella*) and Fig. 8 habitat suitability for *Keratoisis grayi*.

Page 315. *"…EL1141 and EL1142, has the greatest coral richness within the Project Area."* This sentence is misleading. Murillo et al., 2016 states "species richness in deep water assemblages was significantly and negatively correlated with fishing intensity" meaning richness is higher in areas with low fishing effort. Please revisit and revise.

Section 15.0

15.4 - Fate and Behaviour of Potential Spills

Please note this section recalls partial results from Appendix E which is reviewed later. As most of the comments provided there also apply here, please refer to the comments regarding Appendix E. Only comments specific to Section 15.4 are provided here.

Page 1224. *"In the unlikely event that an accidental event occurs..."* This wording should not occur unless the 'likeliness' is assessed.

Page 1224. *"the mitigated scenario, which is **more realistic** than the worst-case scenario, have also been modelled and can be found in Appendix E."* Care must be taken as the mitigated scenario is not necessarily more realistic in the sense that it represents the 'best possible mitigation scenario' (that all measures would work according to the plan). Some of these measures (found in the Appendix B of the Appendix E) include a very tight schedule for instrumentation (not even found in Canada or in USA) to be transported to the drill site (located 250 nautical miles offshore) in only a few days. These measures also suppose that, for example, 100% of the discharged oil would be treated with Subsea Dispersant Injection (SSDI) or that the vessel using surface dispersant has unlimited supplies. These scenarios appear to be very optimistic. Rather, it should be stated that the worst case scenario may be *improved* by the use of mitigation strategies.

15.5.1.2.1 - Corals and Sponges

Page 1224. The last sentence "…*but follow up survey 16 months later indicated that recovery was occurring*" is misleading. It states corals are recovering but fails to mention the condition and health of the corals. Coral colonies impacted by the Deep Water Horizon (DWH) spill showed bare branches with dead tissue were recolonized with parasitic Hydroids (Fisher et al. 2014, Hsing et al. 2013).

The DWH disaster provides valuable information on the effects of oil spills on benthic ecosystems. Corals in the vicinity of the spill were already being studied prior to the accident and provide a unique opportunity. As a result, there are relevant papers that should be incorporated and further discussed in the document, including:

- Hsing et al. (2013) Evidence of lasting impact of the Deepwater Horizon oil spill on a deep Gulf of Mexico coral community. Elem Sci Anthr 1:0000012.
- Mauricio Silva, Peter J. Etnoyer and Ian R. MacDonald (2015). Coral injuries observed at mesophotic Reefs after the Deepwater Horizon oil discharge, Deep-Sea Research Part II.

- Fisher, C. R., Hsing, P.-Y., Kaiser, C. L., Yoerger, D. R., Roberts, H. H., Shedd, W. W., Brooks, J. M. (2014). Footprint of Deepwater Horizon blowout impact to deep-water coral communities. Proceedings of the National Academy of Sciences. 111(32): 11744–11749.
- Baguley, J., Montagna, P., Cooksey, C., Hyland, J., Bang, H., Morrison, C., … Ricci, M. (2015). Community response of deep-sea soft-sediment metazoan meiofauna to the Deepwater Horizon blowout and oil spill. Marine Ecology Progress Series. 528: 127–140.
- Hourigan TF, Etnoyer PJ, Cairns SD (2017). The State of Deep-Sea Coral and Sponge Ecosystems of the United States. NOAA Technical Memorandum NMFS-OHC-4. Silver Spring, MD. 467 p.

Appendix E - Trajectory Modelling

Section 2.2 - Modelling Approach

Table 2-1. How is the choice of blowout depth (362 m for EL1135 and 89 m for EL1137) determinied? Is this the total depth at site?

Page 5. Processes affecting the oil fate are complex and the model considers many of them. *"Oil fate processes included in SIMAP are oil spreading (gravitational and by shearing), evaporation, transport, randomized dispersion, emulsification, entrainment (natural and facilitated by dispersant), dissolution of the soluble fraction of oil into the water column, volatilization of dissolved hydrocarbons from the surface water, adherence of oil droplets to suspended sediments, adsorption of soluble and sparingly-soluble aromatics to suspended sediments, sedimentation, and degradation."* It is not clear whether sensitivity analysis was performed on these parameters.

Section 2.2.2: *"Optimally, the minimum time window for stochastic analysis is **at least five years** so that various weather patterns from year to year are represented."* Please provide the reference or rationale for this statement.

Section 3.1 - Oil Characterization: Please provide the rationale for using of Bay du Nord and Ben Nevis for sites EL1135 and EL1137, respectively.

Section 3.2 - Ice Cover: *"Oil trapped in or under sea ice will weather more slowly than oil released in open water."* This may only be true for landfast ice. In the open ocean, the oil may disperse faster because of an increased effect of wind on the ice compared to an oil slick alone. A reference should be provided to support this statement.

-*"From 0 to ~30% coverage, the ice has no effect on the advection or weathering of surface floating oil. From approximately 30 to 80% ice coverage, oil advection is forced to the right of ice motion in the northern hemisphere, surface oil thickness generally increases due to ice-restricted spreading, and evaporation and entrainment are both reduced by damping/shielding the water surface from wind and waves. Above 80% ice coverage, surface oil moves with the ice and evaporation and entrainment cease."* Please provide references for these behaviors.

Section 3.4 - Ocean Currents

Page 25. *"The boundary where these two currents converge produces **extremely energetic and variable frontal systems and eddies on smaller scales, on the order of kilometers** (Volkov, 2005). Due to these eddies, local transport may advect parcels of water in nearly any direction."* Agreed. Do the numerical simulations have enough spatial resolution to resolve these 'extremely energetic eddies'? Do the currents used (daily average) have enough temporal resolution to resolve these eddies?

Page 25. *"HYCOM uses Mercator projections between 78°S and 47°N and a bipolar patch for regions north of 47°N to avoid computational problems associated with the convergence of the meridians at the pole."* Simulations are exactly on 47°N. Does this grid patching/merging affect the quality of the simulations at this latitude? If no, please provide a reference.

Page 25. *"The 1/12° equatorial resolution provides gridded ocean data with an average spacing of ~7 km between each point."* As the ELs are not at the Equator, what is the resolution for the region of interest?

Page 27. "While this subset of data is not the most recent five years of data, currents and winds in the study area are very similar to those from 5-10 years ago and the data used in this study would be representative of environmental conditions present today." Please provide the reference for this statement.

Page 27. *"…oil transport was defined by the **daily currents** throughout each modelled simulation."* Section 3.3 states: *"Because winds can change on time-scales of minutes to hours, it is best to acquire data at the highest temporal resolution possible (typically every six hours for large global models, or at the very least daily averages)."* What applies for the winds also applies for the currents. This is thus a major limitation of the study that should be quantified and discussed. Daily currents do not resolve high resolution motions such as inertial or tidal currents (for example trapped diurnal tide known to travel around Flemish Cap; Wright and Xu 2004). One way to deal with that would be to perform a certain number of simulations with hourly currents and then compare with the daily simulations to estimate the error in terms of spreading (more spreading will likely occur if higher resolution currents are used).

Figure 3.8: The Region covered by this figure does not encompass the region of interest.

4.1 - Stochastic analysis results

Page 33. *"results are provided for surface oil thickness >0.04 µm, dissolved hydrocarbon contamination > 1 µg/L, and shoreline contact > 1 g/m^2."* How were these thresholds defined and what do they mean?

Figures 4-1 to 4-12: In all figures, the spatial extent of the statistics are truncated by the boundaries of the numerical domain. The domain should be extended and new simulations made. The stochastic footprints of surface oil in km^2 reported in the Executive Summary (p. v) are therefore erroneous. The problem is even worse for the second site (Figs. 4-19 and further).

Shoreline contact (Figs. 4-13 to 4-18). These results are unclear. For example, Fig. 4-12 (annual probability for 113 days) suggests that there is 1% probability that oil reaches the entire southern shores of Newfoundland and Nova Scotia. However, Figs. 5-18 suggests that only Sable Island would be impacted. Is it because the [too] low grid cell resolution near the coast prevents the oil from reaching the coast? This should be further explored and explained.

Note: The above comments apply to both sets of simulations (EL1135 and EL1137).

Table 4-1: These results are erroneous as the extent of the spills is truncated by model boundaries (see previous comment).

Section 4.2 - Deterministic Analysis Results

Page 92. Typo: "*make contact with 1,560,000 km^2 of the coastline …"* Coastline should be reported in km instead of km^2.

Section 4.2.2: Unlike the coastline (Section 4.2.3) where socioeconomics and ecological thresholds are given, no such thresholds are provided here for Water Column Exposure Cases Results. They are analyzed in terms of segregation (evaporated, surface, dissolved, etc.) but not in terms of actual concentration in the water column and their effect on the ecosystem. A quick look at the literature suggests that, for example, the European Water Framework Directive (reported from Nasher et al. 2013) set the maximum admissible concentration for *individual* dissolved polycyclic aromatic hydrocarbons (PAHs) to be 2.4 µg/L. This limit is often exceeded here. What would be the social, economic and ecosystem impacts of this?

Section 4.2.4. *“Due to the small release volume and the size of the concentration gridding (1,000 m by 1,000 m), predicted concentrations of dissolved hydrocarbons were not expected at either EL 1135 and EL 1137 and thus figures have not been presented below.”* The problem here is not that concentrations are not expected but rather that the model is unable to resolve the concentration. Please revisit and revise.

Section 4.2.5. *“In all cases, nearly all the surface oil was predicted to either entrain, evaporate, or degrade by the end of the simulation (Table 4-4).”* As there is no category 'entrain' please clarify what it meant by this term. Note that if this means outside the numerical domain, it does not mean that the oil has disappeared. See for example EL1137, case for 30-day scenario, where the percentage evaporated or degraded is just below 50% (for 95th percentile case).

Section 5 - Discussion and Conclusion

In regards to the statement: *“... the results of this modelling study suggest that if oil were to be released in the Project Area, it has the highest likelihood of moving away from shore to the east.”* How was this quantified?

Appendix B (of Appendix E) - Mitigation Response Modelling

These scenarios seem very optimistic. For example:

- The Subsea Dispersant Injection (SSDI) would begin on Day-5 after blowout while the equipment is located in Fort Lauderdale (USA) or Southampton (UK) and that the transit time to Flemish Cap is about 1 day steaming at 10 knots.
- The modelling assumes that 100% of the discharged oil would be treated with SSDI. Is 100% really an achievable target?;
- Vessel surface dispersant application was assumed to arrive on scene on Day 2 (while the transit time is likely over 24 hours from St. John's). Is there such a vessel in St. John's?
- Vessel surface dispersant has unlimited supplies. Is this statement correct?

Appendix G - Drill Cuttings Modelling

Page 16. “*For example, the four well hole section discharges for a Jeanne d’Arc Basin well are simulated to take place at days 1, 6, 15, and 26 (of 35) and last 2, 2, 8, and 10 days respectively, a very conservative approach*.”. Conservative in what sense? It is stipulated that the drilling schedule is not determined. It is recommended to do both 35 days and 65 days scenarios to have the full range of concentrations.

Page 16. Unlike oil spill scenarios, no stochastic analysis is made (only 4 simulations argued to be representative of each season). This is a large limitation to this study. Current computer capabilities allow stochastic studies that should be used here to assess the impacts. Moreover, very good high resolution reanalysis exist today (e.g. Mercator GLORYS or HYCOM that was used for oil spill scenarios). These should have been used to force the model over several months/years. Using such products would avoid uncertainty related to the use of incomplete or non-homogeneous forcing from site to site. This was done nicely by RPS for the oil spill simulation. This large discrepancy from the two modelling parts is odd for the same report.

Page 16. The time average of current used to force the model is not clear. Are they monthly currents? If the case, this seems too low resolution to account for energetic and important meso- and sub-mesoscale dynamics in the area.

Table 3-3: Using equation 5 for fine silt clays results in a settling velocity of 3e-6 m/s (not 0.001 m/s, as in the table). At this settling velocity, clay would stay in the water column for 10 years if the depth is 1000 m. There appears to be a problem. It is noted that 3e-6m/s is reported later in the text (p.19).

Page 17. In the discussion regarding changes in the settling velocity as the particles encounter “bottom stress” (including breaking up of the flocs and resettling), it is not clear which mechanisms are taken into account. Are the processes at the benthic boundary layer (BBL) been considered? If not, it should not be called a “conservative estimate”. By neglecting this parameterization, the model neglects re-settling/re-suspension mechanisms that would create a plume/cloud near the bottom. The presence of a mud plume/cloud near the bottom must be addressed as it is critical for benthic biology (e.g., Cranford and Gordon 1992). Please revisit and clarify.

Page 17. “*The temporal coverage of the current data record allows application of the drilling well sequences and provides some statistical reliability of conclusions drawn from analysis of the current data.*” Given that only 4 seasons are considered (see previous comments re: no stochastic analyses) it cannot be stated that the study provides “*statistical reliability of conclusions.*”

Page 20. It appears that current measurements used to force the model are very scarce. For example, multiple different sources are used. The authors state they have used a short time-series (25th July 1986 15:00:00 to 31st October 1986 17:00:00) which they “*replicated to fill the periods with no data for near-surface, mid-depth and near-bottom depth levels*”. Does this mean that, for example, winter data are filled with data from other seasons? If this is not the case, please clarify. If it is indeed the case, how can filling this gap with non-existing data be justified? Again, the use of homogeneous datasets such as global hindcasts (see previous comment on the use of GLORYS or HYCOM) would solve the problem.

Page 24. Model Application “*It is assumed that the currents are generally representative of conditions at the drilling locations and are uniform over the deposition grids modelled”.* This assumption does not hold far from the release point: currents vary in time and space, thus the need for time-varying and space-varying current input. This assumption may hold over a very small distance, but it is stipulated further (Section 4.0) that some cuttings travelled as far as 20-200 km. This is especially true for the fine fraction (silts and clays which are by far the largest fraction in the release; see Table 3-2) that remains in the water column for a longer period.

Section 3.2.5. Model Algorithm. Advective-Diffusive equations are very standard and simple modeling procedure equations. Such modelling should be used here. There are different problems with the turbulent diffusion term (Rx,Ry,Rz in [-1,1]):

a) x', y', z' are not defined;
b) Unsure why vertical (Rz) and horizontal (Rx,Ry) “diffusivity” coefficients are the same order of magnitude. Is there any scientific justification for this?;
c) This scheme appears to be totally dependent on the model horizontal and vertical grid resolution (which has the advantage of reducing the problem raised in b);

d) What is the scientific rationale for imposing the range [-1,1]? If interpreted correctly, the equation means that the particle can move at most by one grid cell per time step.

Section 4.1. Northern Project Area site: "*As reported above, few of the SBM cuttings settle within the model domain.*" What does this mean for the fine fraction plume? There is an effect on the water column that is not being quantified with this model.

There are results that cannot be interpreted. For example, Figures 4-1 and 4-3: How can the cuttings from a single source form numerous little patches? It is expected that the number of patches would match the number of different cutting size classes (6 at most). The results seem physically unrealistic and illustrate that there may be a problem with the numerical domain, the discretization, or the forcing.

Appendix A1: Current roses for some stations (e.g. Figure p. 114) display surprisingly steady and slow currents. Could this be an effect of the reconstruction method used? Moreover, why would they represent the year 2017 (report was submitted even before the end of that year)?

Conclusions

The objective of this review was to evaluate:

The sufficiency of baseline data and appropriateness of methodologies to predict effects;

- A lot of out-dated and non peer-reviewed material (reports, previous environmental assessments, etc.) is cited whereas more recent and peer-reviewed material exists. Also, some inaccurate and misleading statements are found in the reports.
- The pre-drill surveys using MBES and SSS will be conducted at a resolution that is not fine enough to detect some of the coral and sponge community types found in this region that are acoustically invisible using these methods.
- There are problems with the numerical simulations of oil spill scenarios that need to be addressed and corrected, namely the use of daily instead of hourly currents (see comments for Appendix E); and the model domain is too small to account for the scenarios
- The drill cuttings simulations are much weaker than oil spill scenarios. They have several problems including: unusual advection-diffusion scheme; use of spatially homogeneous currents; "re-constructed" current time-series to fill sequence with no data; no stochastic analysis.

The mitigation measures proposed by the proponent;

- The mitigation measures proposed for the oil spill scenarios appear to be optimistic.
- The NOROG (2013) Guidelines or best practices approach for industry are not entirely relevant for the benthic (corals and sponges) communities found in this region.

The level of certainty in the conclusions reached by the proponent on the effects;

- Numerical simulations (spills and cuttings) suffer from limitations that are discussed in this review. The impacts of these limitations were not discussed.

The manner in which significance of the environmental effects, as they pertain to DFO's mandate, have been determined (i.e. the scientific merit of the information presented and the validity of the proponent's methodologies and conclusions);

- The reporting of environmental conditions suffers from some contradictions (e.g. stating that energetic eddies are important, but are not considered in the analysis). Additionally, the comparison of peer-reviewed material with not publicly accessible grey literature in the context of having the same scientific value is not considered appropriate.
- The strategy/ framework adopted for oil spills scenarios seems appropriate, but the model suffers from discretization problems (forcing and domain size).
- The strategy used to model drill cuttings is not considered appropriate in regards to the current state of scientific knowledge.

The follow-up program proposed by the proponent;

No comments.

Whether additional information is required from the proponent to complete the technical review.

- The oil spill numerical simulations should be re-done with hourly currents and with a larger numerical domain, otherwise clearly state the impacts of these limitations.
- At the moment, drill cutting scenarios cannot be considered reliable. It is recommended to re-run these simulations using more up-to-date tools/ modelling.
- It is recommended that the current criteria (NOROG Guidelines) be adjusted in order to accommodate important habitats generated by smaller (<30 cm in height) species of corals and sponges, known to be present in the general area.

Contributors

Name	Affiliation
James Meade (Chair)	DFO Science (CSAS)
Frederic Cyr	DFO Science
Vonda Wareham	DFO Science
Brian Dempson	DFO Science

Approved by

B. R. McCallum
Regional Director Science, NL Region
Fisheries and Oceans Canada
February 28, 2018

Sources of information

Amec Foster Wheeler. 2017. ARP Pilot Area 4 Climatological Report: Port Hawkesbury and the Strait of Canso. Environment and Climate Change Canada.

Austin, W.C., Conway, K.W., Barrie, J.V. and Krautter, M. 2007. Growth and morphology of a reef-forming glass sponge, *Aphrocallistes vastus* (Hexactinellida), and implications for recovery from widespread trawl damage. Porifera Research: Biodiversity, Innovation and Sustainability 2007:139–145.

Baker, K. D., Wareham, V. E., Snelgrove, P. V. R., Haedrich, R. L., Fifield, D. A., Edinger, E. N., and Gilkinson, K. D. 2012. Distributional patterns of deep-sea coral assemblages in three submarine canyons off Newfoundland, Canada. Marine Ecology Progress Series. 445: 235–249.

Beazley, L. I., Kenchington, E. L., Murillo, F. J., and Sacau, M. 2013. of epibenthic megafauna in the Northwest Atlantic. ICES Journal of Marine Science. 70: 1471–1490.

Bourgault, D., Cyr, F., Dumont, D., and Carter, A. 2014. Numerical simulations of the spread of floating passive tracer released at the Old Harry prospect. Environmental Research Letters. 9(5): 054001.

Cheng, C.S., Lopes, E., Fu, C. and Huang, Z. 2014. Possible Impacts of Climate Change on Wind Gusts under Downscaled Future Climate Conditions: Updated for Canada. Journal of Climate. 27: 1255-1270.

Conway, K.W., Barrie, J.V., Austin, W.C. and Luternauer, J.L. 1991. Holocene sponge bioherms on the western Canadian Contintal shelf. Continental Shelf Research. 11: 771-790.

Cranford, P. J., and Gordon, D. C. 1992. The influence of dilute clay suspensions on sea scallop (*Placopecten magellanicus)* feeding activity and tissue growth. Netherlands Journal of Sea Research. 30: 107-120.

Guijarro, J., Beazley, L., Lirette, C., Kenchington, E., Wareham, V., Gilkinson, K. and Koen-Alonso, M.F.J. 2016. Species Distribution Modelling of Corals and Sponges from Research Vessel Survey Data in the Newfoundland and Labrador Region for Use in the Identification of Significant Benthic Areas. Can. Tech. Rep. Fish. Aquat. Sci. 3171: vi + 125p.

Gullage, L., Devillers, R., & Edinger, E. (2017). Predictive distribution modelling of cold-water corals in the Newfoundland and Labrador region. Marine Ecology Progress Series. 582: 57–77.

Kenchington, E., Lirette, C., Murillo, F. J., Beazley, L., Guijarro, J., Wareham, V., Gilkinson, K., Koen Alonso, M., Benoît, H., Bourdages, H., Sainte-Marie, B., Treble, M., and Siferd, T. 2016. Kernel Density Analyses of Coral and Sponge Catches from Research Vessel Survey Data for Use in Identification of Significant Benthic Areas Ocean and Ecosystem Sciences Division Fisheries and Oceans Canada. Can. Tech. Rep. Fish. Aquat. Sci. 3161: viii + 207p.

Li, M., LiYongsheng, W., Han, G., Prescott, R., and Tang, C. 2015. A modeling study of the impact of major storms on waves, surface and near-bed currents on the Grand Banks of Newfoundland."Journal of Geophysical Research: Oceans 120. 8: 5358-5386.

Ma, Z., Han, G., and Chassé, J. 2016. Simulation of circulation and ice over the Newfoundland and Labrador Shelves: The mean and seasonal cycle. Atmosphere-Ocean. 54(3): 248-263.

Murillo, F.J., Kenchington, E., Beazley, L., Lirette, C., Knudby, A., Guijarro, J., Benoît, H. Bourdages, H. and Sainte-Marie, B. 2016. Distribution Modelling of Sea Pens, Sponges, Stalked Tunicates and Soft Corals from Research Vessel Survey Data in the Gulf of St. Lawrence for Use in the Identification of Significant Benthic Areas. Can. Tech. Rep. Fish. Aquat. Sci. 3170: vi + 132 p.

NAFO. 2013. SC Working Group on Ecosystem Science and Assessment: November 2013. 13/024.

NAFO. 2014. SC Working Group on Ecosystem Science and Assessment: November 2014. SCS Doc. 14/023.

NAFO. 2016. SC Working Group on Ecosystem Science and Assessment: November 2016. SCS Doc. 16/021

NAFO. 2018. Working Group on Ecosystem Science and Assessment (WGESA): 2008-2017. Accessed March, 2018.

Nasher, E., Heng, L. Y., Zakaria, Z. and Surif S. 2013. Concentrations and sources of Polycyclic Aromatic Hydrocarbons in the seawater around Langkawi Island, Malaysia. Journal of Chemistry: 975781.

Neves, B. D. M., Edinger, E., Hillaire-Marcel, C., Heestand, E., France, S. C., and Treble, A. 2013. Deep-water bamboo coral forests in a muddy Arctic environment. Marine Biodiversity, 45: 867-871.

Pringle, J., Stretch, D. and Bárdossy, A. 2015. On linking atmospheric circulation patterns to extreme wave events for coastal vulnerability assessments. Natural Hazards. 79(1): 45-59.

Saucier, E.H. 2016. Phylogenetic studies of the deep-sea bamboo corals (Octocorallia: Isididae: Keratoisidinae). Doctor of Philosophy Dissertation presented to the Graduate Faculty of the University of Louisiana at Lafayette. ProQuest Number: 10163340

Swail, V.R., and Cox, A.T. 2000. On the use of NCEP/NCAR reanalysis surface marine wind fields for a long term North Atlantic wave hindcast. Journal of Atmospheric and Ocean Technology.17: 532-545.

Wright, D. G., and Xu, Z. 2004. Double Kelvin waves over the Newfoundland shelf-break. Atmosphere-Ocean. 42(2): 101-111.

Wu, Y., Tang, C., and Hannah, C. 2012. The circulation of eastern Canadian seas. Progress in Oceanography. 106: 28-48.

Appendix: Figures

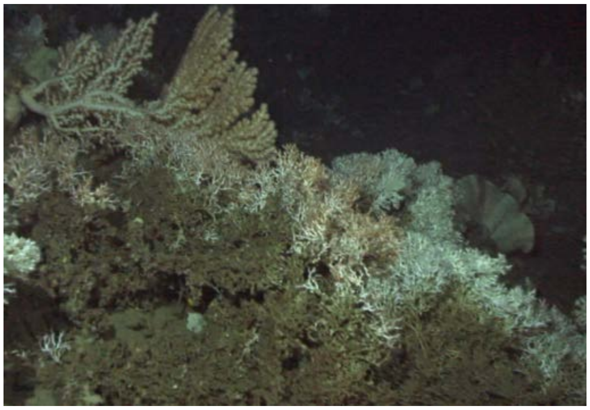

Figure 1. Lophelia reefs: Norway.

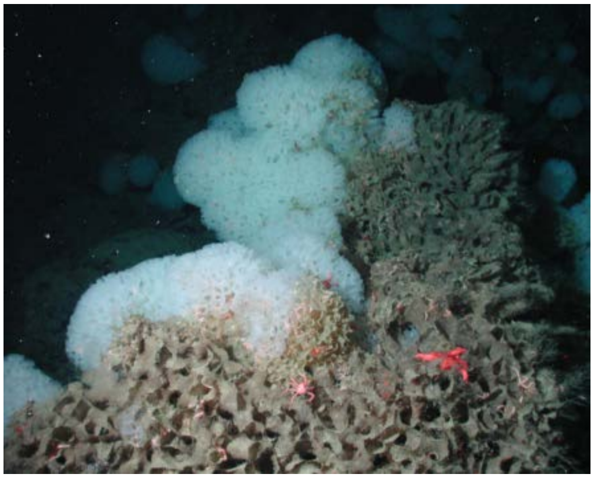

Figure 2. Glass sponge reefs: British Columbia, Canada.

Figure 3. Sponge bycatch (dominated by Geodia spp.), Flemish Pass.

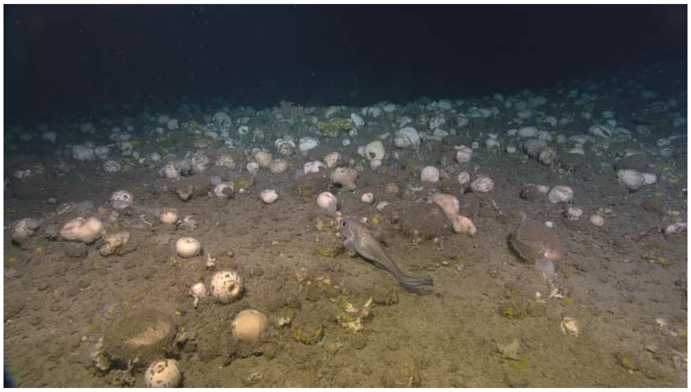

Figure 4. Geodia sponge grounds in situ: NE Flemish Cap.

Figure 5. Geodia sponge ground encounter: Flemish Pass (~500 kg).

Figure 6. Geodia sponge (2.4 kg): Orphan Basin.

Figure 7. Sponge and coral bycatch from S Flemish Cap. Catch dominated by glass sponge (Asconema) and bamboo coral (Keratoisis sp.)

Figure 8. Asconema bycatch: Flemish Pass

Figure 9. Relatively intact Asconema samples: Flemish Pass (~0.720 kg).

Figure 10. Keratoisis thickets: SW Grand Banks of Newfoundland.

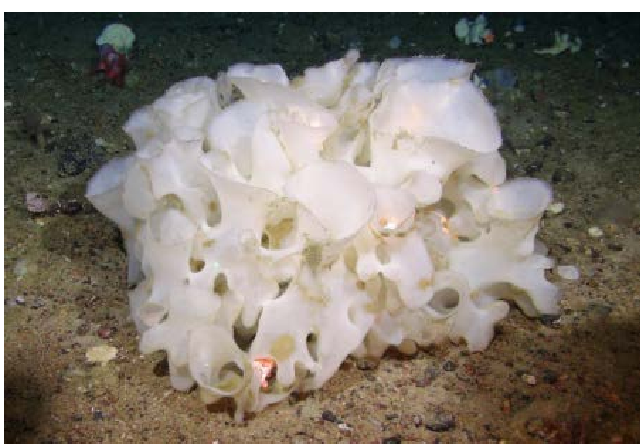

Figure 11. In situ Asconema glass sponge (60 cm x 50 cm).

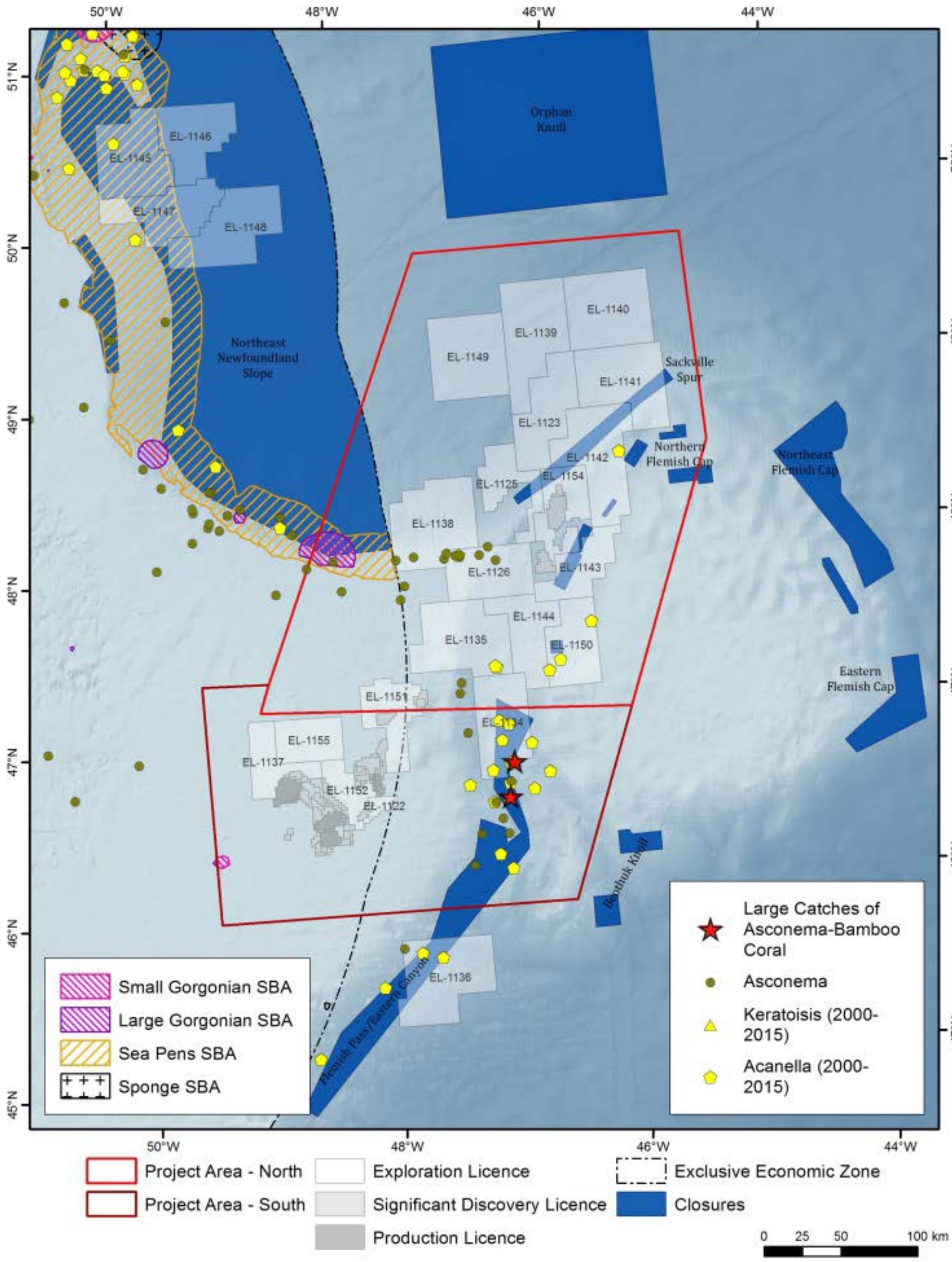

Figure 12. Bamboo corals (Keratoisis spp. and Acanella arbuscula) and Asconema sponge catches in the Flemish Pass.

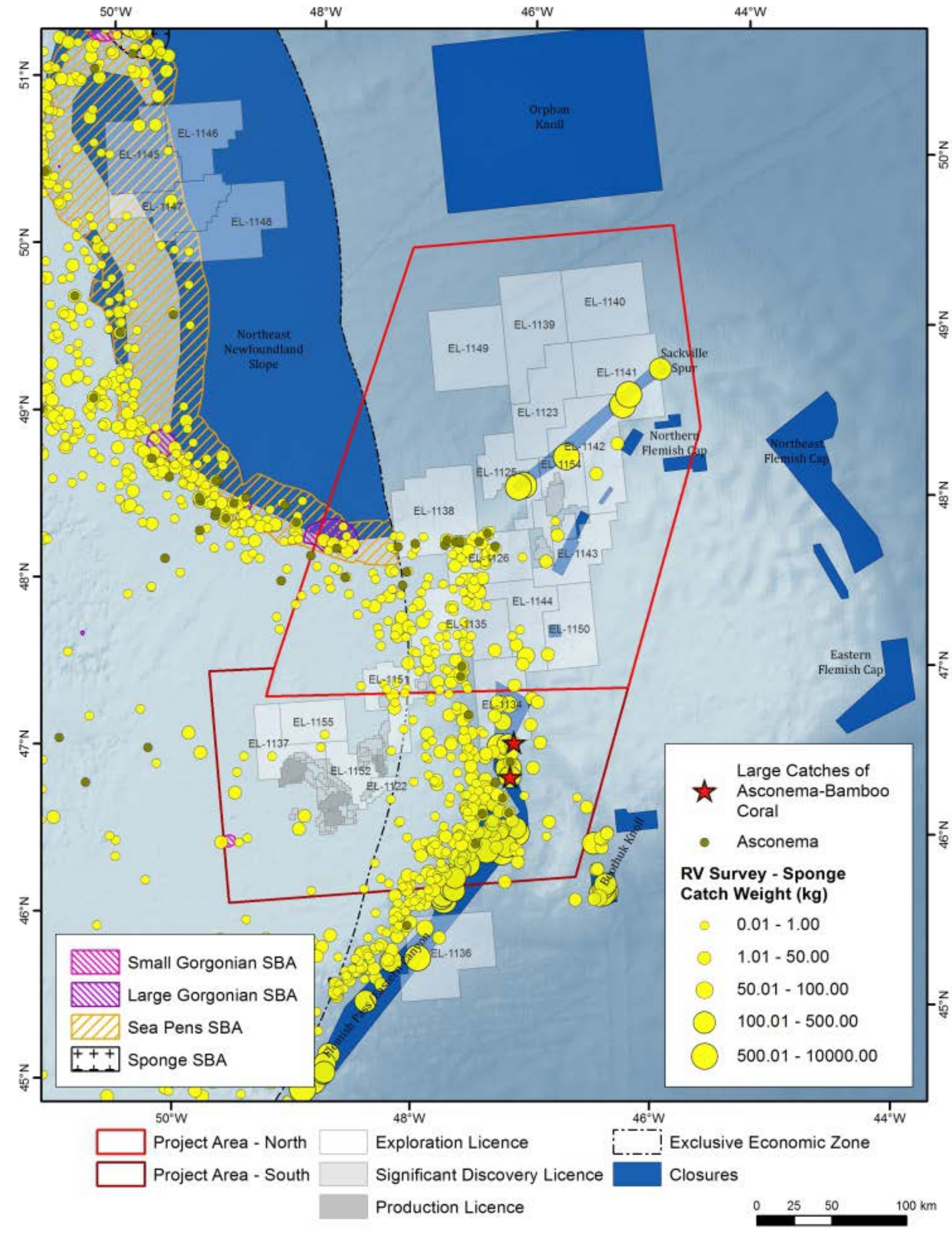

Figure 13. Sponge bycatch by weight with Asconema and unique Asconema-bamboo coral communities highlighted (red stars).

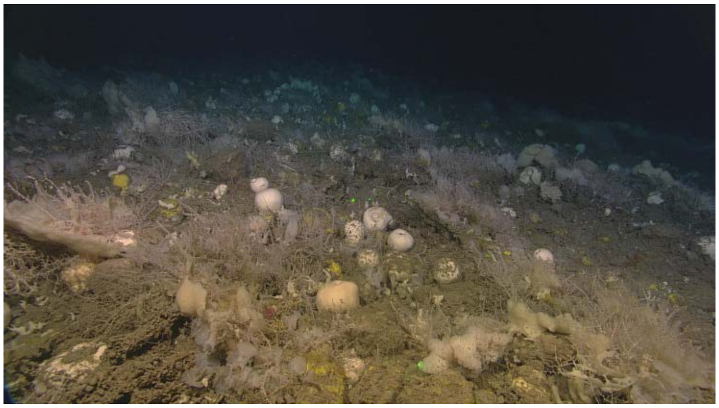

Figure 14. In situ coral (bamboo coral) and sponge grounds, NE Flemish Cap. Note community assemblages, hence diversity, changed with depth.

Figure 15. In situ bamboo coral forest in soft muds: Disko Fan. Initial observations suggest community diversity is low but within the forest many smaller species are using the bamboo coral as substrate.

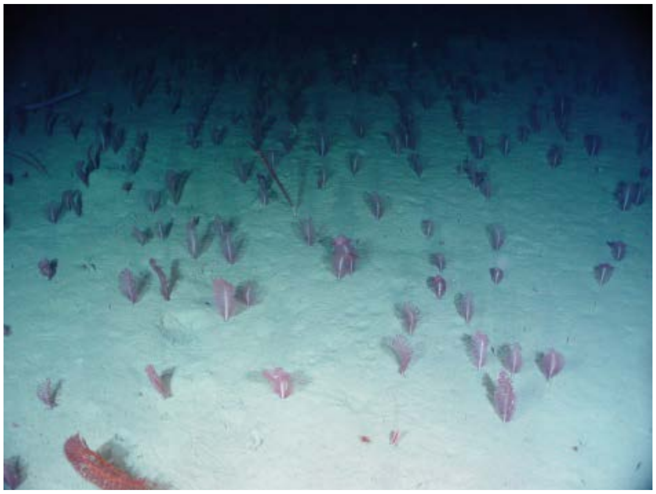

Figure 16. In situ sea pen field dominated by Pennatula aculeata: SW Grand Banks.

Figure 17. In situ sea pen field dominated Halipteris finmarchia, Scotia Shelf.

Figure 18. Acanella arbuscula in situ.

Figure 19. Acanella arbuscula bycatch from gillnet set. Average weight of individual Acanella ~0.0126 kg.

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Telephone: 709-772-3332
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