REVIEW OF THE ENVIRONMENTAL IMPACT STATEMENT FOR THE NEXEN ENERGY FLEMISH PASS EXPLORATION DRILLING PROJECT (2018-2028)

Context

Nexen Energy ULC (Nexen), is planning to conduct a program of petroleum exploration drilling and associated activities in the eastern portion of the Canada-Newfoundland and Labrador Offshore Area over the period 2018 to 2028. The Project Area includes two Exploration Licences (ELs 1144 and 1150) in the Flemish Pass region, as well as a 20 km buffer area surrounding those licences to accommodate the location and extent of ancillary activities that may be carried out in support of such drilling activities. The Project will include exploration drilling within these ELs, possible appraisal (delineation) drilling in the event of a hydrocarbon discovery, vertical seismic profiling (VSP), well testing, eventual well abandonment or suspension activities, and associated supply and service activities.

The Project requires review and approval pursuant to the requirements of the Canadian Environmental Assessment Act, 2012 (CEAA 2012) as it has been determined to constitute a “designated project” under the associated Regulations Designating Physical Activities. The Canadian Environmental Assessment Agency (the Agency) determined that a federal environmental assessment (EA) was required for the Project. The Environmental Impact Statement (EIS) for the Project has been planned, prepared and submitted by Nexen in accordance with the requirements of CEAA 2012 as well as the Project-specific EIS Guidelines and other generic EA guidance documents issued by the Agency. It has also been designed and completed to address the EA requirements of the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) under the Canada-Newfoundland and Labrador Atlantic Accord Implementation Act and the Canada- Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act (the Accord Acts).

On April 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 specific sections of the Environmental Impact Statement for the Nexen Energy Flemish Pass Exploration Drilling Project. 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 report, and associated appendices. The EIS and EIS Summary are available on the Agency's website at the following links:

Environmental Impact Statement; and Environmental Impact Statement Summary.

This Science Response Report results from the Science Response Process (SRP) of May 9, 2018 on the Review of the Environmental Impact Statement for the Nexen Energy Flemish Pass 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 5 – Existing Physical Environment
  - Section 5.2 – Bathymetry
  - Section 5.5 – Oceanography
  - Section 5.6 – Ice conditions
  - Section 5.7 – Climate change
    - Section 5.7.2 – Oceanographic Changes
    - Section 5.7.3 – Ice Conditions
- Section 6 – Existing Biological Environment
  - Section 6.1.6 – Benthic Invertebrates (Information relevant to corals and sponges)
- Section 8 – Marine Fish and Fish Habitat: Environmental Effects Assessment
  - Section 8.3 – Environmental Effects Assessment and Mitigation (Information on corals and sponges)
  - Section 8.5 – Environmental Effects Evaluation (Information on corals and sponges)
  - Section 8.6 – Environmental Monitoring and Follow-up (Information on corals and sponges)
- Section 16 - Accidental Events
  - Section 16.4 – Fate and Behaviour of Potential Oil Spills
- Appendix D – Drill Cuttings Modelling (Amec Foster Wheeler 2017)
- Appendix E – Underwater Sound Propagation Assessment (JASCO 2017)
- Appendix G – Oil Spill Modelling (RPS 2017)

General Comments

The sound component of the proposed project appears reasonable; the work is not unlike other larger-scale seismic programs ongoing in the Newfoundland and Labrador offshore. The exact sound source and source volume are not known or provided by the proponent but the assumptions made in the Underwater Sound Propagation Assessment (Appendix E) are likely representative.

Current understanding of the potential effects of industrial-scale noise production on marine life is limited, with the exception perhaps of marine mammals. Identifying data gaps with respect to other marine life and industries that rely on it, remains important.

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.

Much of the discussion of effects and mitigations refers to corals and not sponges which are a dominant benthic biomass in Flemish Pass (Fig. 1).

Statements containing the qualifier *"in the unlikely event that an accidental event occurs…"* are found throughout the report. 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 5.5 – Oceanography

5.5.2 – Ocean currents

Page 144. "*The cores of the currents are located at an average depth of 100 m. This is well-illustrated in Figures 5.19 to 5.20 below which show current transects (currents at depth approximately 45-65 m) from a recent Fisheries and Oceans Canada oceanographic program in the Sackville Spur and Flemish Pass regions in 2013-2014*". These figures do not show that the "core" is at 100 m and also, it should be emphasized that the two figures presented are snapshots in time and do not represent long-term averages.

Page 148: *"... mean current speeds range from about 2 cm/s in summer to 8 cm/s in fall, with maximum values ranging from 5 cm/s in summer to 12 cm/s in fall. At greater depths (500 m for mid-depth, 1,000 m for near- bottom), current speeds are about one half to one quarter the near-surface values. For near-bottom, mean currents range from 1 to 3 cm/s with maximum speeds of 3 to 5 cm/s ..."* This differs from what is reported in Figure 5.21 by one to two orders of magnitude (current reach ~100 cm/s in this figure). Please revisit and clarify and also correct Figures 5.22 to 5.27, if needed.

5.5.3 – Extreme events

Page 155. What is the timeframe represented by these extremes? (instantaneous? 1-minute average? hourly?). It is stated that the 100-yr return maximum is 33.8 m/s (122 km/h). It appears that the wind gusts that are important are "relatively" frequent in the area, thus the importance of specifying the averaging window.

Section 5.7 – Climate change

5.7.1.1 - Wind

Page 176. After referring to Cheng *et al* (2014), the report states: *"In a more recent study using different GCMs and emissions scenarios (Amec Foster Wheeler 2017a), the median and maximum annual sustained (hourly average) wind speeds were projected to decrease slightly or* *remain unchanged over the coming decades."* A figure from this last study is also presented to support the fact that: *"…predicted impacts of climate change on the Project Area will be similarly negligible."* The report presents 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.

Section 8 – Environmental Effects Assessment and Mitigation

Page 622. The report states "*Prior to the start of drilling activity, a seabed investigation will be undertaken with a drop camera / video system to investigate the potential presence of sensitive benthic organisms or habitats in the immediate area of the wellsite (such as corals and sponges)."* Define "immediate area" of the wellsite.

Page 623. "*A coral colony is defined as:…"* The author uses the term coral colony to refer to concentrations of corals. Depending on the taxa, these can be called fields, gardens, grounds (e.g. seapens and *Geodia* sponges, or reefs, e.g. *Lophelia*). Colony is the coral structure housing identical polyps.

With the exception of a well blow-out, most of the uncertainty associated with impacts to corals and sponges relate to the distances and depths of drill cuttings from the well head. Depending on the methods used to survey the area prior to drilling, the spatial distribution of Valued Components (VCs: e.g. corals and sponges) might be missed. For instance, it is stated that video surveys near the proposed well site will be carried out to identify presence of corals and sponges. However, given that community changes (e.g. decreased abundance and species richness) have been observed up to 1 km from the well head while infaunal communities became dominated by anoxic-resistant invertebrates (see page 631), it is important to carry out a pre-drilling survey design with multiple lengthy, video transects. A water-based mud (WBM) cuttings release model for this project shows maximum dispersal distances of 290 m. This modelling is informative for indicating cuttings dispersal directions based on different cuttings thicknesses.

Mitigations focus on *Lophelia* reefs and coral gardens. No encounters with living *Lophelia* have been documented in the region; however, data is biased by substrate with hard bottom representation limited to sporadic ROV Surveys. It is possible living colonies exist here 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, *Acanella* meadows, *Geodia* sponge grounds, and bamboo and sponge thickets. For the latter, the composition of the community may change with depth.

Based on the above, it is recommended that the seabed habitat extending out from the location of the well head should be ground truthed using ROV. Additionally, there should be increased collaboration with DFO to identify VMEs using ROV technologies. 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. It is also recommended to exercise caution when identifying species from HD imagery (i.e.: report Genus only if no voucher specimen, or species with voucher specimen).

Please revisit and change all in-text references (and Literature Cited) from Gilkinson and Edinger 2009 to Gilkinson and Edinger (Eds.) 2009.

Section 16.4 – Fate and Behaviour of Potential Spills

See comments re: Appendix G below and update accordingly.

Appendix D - Drill Cuttings Modelling

General Comments

The drift study uses CECOM and Webtide for the wind driven parts of ocean current (CECOM) and Webtide for the tides. The Flemish Pass has more flow components than just tidal and wind driven flow due to large scale oceanic and atmospheric changes over time. The momentum equation in CECOM is governed by wind driven flow as well as mean flow given by climatology.

There are much better current descriptions now available for the area then CECOM that include assimilation of sea level, SST and in-situ ARGO data to provide the best possible representation of ocean circulation throughout the water column.

- The GOC CONCEPTS systems: see transect Hovmöller plot for Flemish Pass at surface and bottom (Figs. 2 and 3)
- HYCOM (US Navy/NOAA)
- FOAM (UK Metoffice)
- Altimetry derived currents; Provide depth averaged 2D currents since 1992 in the area (i.e., AVISO data base).

As seen from the GOC CONCEPTS RIOPS prediction system as well as Atlantic Zone Monitoring Program (AZMP) Acoustic Doppler Current Profile (ADCP) transects in the area, there is strong variability of current in the Flemish Pass (see Hovmöller plots Figs. 2 and 3) and currents as observed by ADCP may be higher than mean spring currents (see tel886 Flemish Cap line (Fig. 4).

3.2.1 - Scenarios, Well Sequences, Well Types

Page 18.: *"...63 days for the EL-1144 Deepwater Jurassic Example Well and 53 days for the EL-1150 Shallow Water Cretaceous Example Well. These are estimates only: actual wells to be drilled may have longer or shorter drill times.*" Two series of modelling within a range of possible timeframes would be helpful here.

Page 21. Equations 4 and 5 are dimensionally inconsistent (unless constants have units that are not specified). Moreover, the reference to Sleath (1984) is misreported in the bibliography (states 1939).

3.2.2 - Cuttings Particle Characterization

Page 22. "*A 'base case' of 0.001 m/s values for the two smallest particle types as reported in Table 3-4, were deemed the most reasonable and selected for the model runs. These values, somewhat smaller than a faster 0.005 m/s settling, provide a somewhat more conservative estimate in terms of how far horizontally the cuttings may disperse.*" This is not necessarily conservative since the slowing down of settling velocities due to benthic boundary layer (BBL) stress are not taken into account. The effect of that is even mentioned in the report: "*slowing to 0.0001 m/s (for floc breakup when the bottom stress exceeds a threshold)*". By neglecting this parametrization, the model neglects re-settling/re-suspension mechanisms that would create a plume/cloud near the bottom that may be critical for benthic biology (e.g., Cranford and Gordon, 1992). Such assessment has been conducted for previous other EISs.

3.2.3 – Ocean Currents

Page 23. “Therefore currents for input to the drill cuttings model were derived from seasonal average currents at near-surface, mid-depth and near-bottom depths through the water column…” This is not sufficient. Bourgault et al. (2014) shows that seasonal average currents may not be appropriate to model dispersion as it remove all energetic high frequency motions (eddies, tides, storms, etc.). Even this EIS states that such energetic motions are important in this region (see Appendix G), and this is confirmed with drifter observations (see comment above stating that current of ~100 cm/s are observed). In the oil spill modeling scenario, higher resolution HYCOM currents are used. A similar approach should be used here.

Page 23. *“Wu et al (2012) conducted an extensive comparison of the CECOM model results and 11 years of observational data.”* Although seasonal averages by Wu et al. and CECOM data are in agreement, this is not a justification for the use of seasonal currents for the reasons stated above.

Page 24. “*In the model algorithm, as each calendar day of drilling and possible discharge is followed, the corresponding day of current data is input from the representative year time series file and is used to advect the particles*.” The meaning of this statement is not clear. There cannot be a “corresponding day” as seasonal averages are used as forcing.

Page 24. “*It is assumed that the currents are representative of the two locations and are uniform over the deposition grids (domain) modelled*.” If uniform currents are used, then the model is not a real 3D model as stated in the introduction. Moreover, Figures 3-1 to 3-8 clearly show that velocities are not uniform over the domain. This simplification/ shortcut is not acceptable, especially as the selected location for the currents are from the lowest advection velocities. These figures suggest that as the particles move away from the release site, they should be entrained by stronger velocities.

- Unlike in the oil spill scenarios, no stochastic analysis is made (only 4 simulations said to be representative of each season). This is a rather large limitation to this study. Modern computer capabilities allow stochastic studies that should be used here to assess the impacts.

- Additionally, very good high resolution reanalysis exists (e.g. Mercator GLORYS or HYCOM that was used for oil spill scenarios) and 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 well for the oil spill simulation. This large discrepancy between the two modelling exercises for the same report is odd.

3.2.4 – Model Geometry

Page 31. “*The model assumes uniform depth, with values set equal to the water depth at each modelling location...” The assumption of a flat bathymetry is borne out as a reasonable approximation given the distances and directions that the cuttings drift.”* The “reasonable” approximation is based on other questionable approximations: the use of constant, uniform and seasonal currents, as well as the neglecting of BBL processes. The bathymetry approximation may not hold if more realistic currents were used.

3.2.5 Model Algorithm

Page 31. There are a few issues regarding the turbulent diffusion term (Rx, Ry, Rz in [-1,1]) that require explanation/ clarification:

A) x', y', z' are not defined;

B) What is the scientific reasoning for the vertical (Rz) and horizontal (Rx, Ry) “diffusivity” coefficients being the same order of magnitude?

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?

Appendix E - Underwater Sound Propagation Assessment

The assessment is reasonable, given what is currently known, and the existing mitigation measures used in Canada regarding the effects of industrial scale seismic surveying in the waters offshore Newfoundland and Labrador. However, the sound propagation report in terms of biological effects and thresholds is focused on marine mammals. Is this a scoping issue or simply that the current regulations and mitigation measures related to sound are linked to marine mammals? Unfortunately, little information is available in scientific literature describing impacts on species other than marine mammals. This is considered an important information gap.

Although little information is available to confirm, a somewhat stationary source might lead to an increased potential for effects on relatively stationary marine life, given the seismic source will be operating within a small area. This is another information gap for which the distance and duration of effect is not known for many species, however, the area impacted would likely be small and perhaps short lived.

Appendix G - Oil Spill Modelling

The use of OILMAP DEEP and SIMAP are basically the industry standard tools currently available. Until further research and tools are available for drift prediction of oil in and on the ocean, the approach taken by the proponent is acceptable.

It would be a good exercise to test other input data for currents than HYCOM, as there tend to be differences between the various top 6 global ocean forecasting systems. Having additional results from another ocean forecast system for comparison purposes would help to ensure the conclusions about the fate of spilled oil are reasonable.

Section 2.2 – Modelling Approach

Page 5. Processes affecting the oil fate are complex and a lot are taken into account in the model. A list of processes is even provided: “*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.*” However, it is not clear whether sensitivity analysis was performed on these parameters.

Page 6. "*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 a reference or rationale for this statement.

Section 2.4 - Model Uncertainty and Validation

Page 15. *"In the unlikely event of an actual release of oil [...]"* The word 'unlikely' alone is not part of a scientific statement and should be remove if the likelihood is not assessed.

Section 3.3 – Ice Cover

Page 20. "*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.

Page 20. "*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 3.5 – Currents

Page 27. "*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) resolve these eddies?

Page 28. "*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 current forcing at this latitude?

Page 29. "*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 a reference for this statement.

Page 30. "…*oil transport was defined by the daily currents throughout each modelled simulation."* This is 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 & Xu, 2004). This is especially strange given that it is stated just before that "*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*". Do the daily currents take these extremely energetic frontal system into account?

Figure 3.10: The region covered by this figure does not actually encompass the region of interest for the proposed project.

4.1 – Stochastic analysis results

Page 36. "*Figures depicting stochastic results are provided for surface oil thickness >0.04 µm, dissolved hydrocarbon contamination > 1 µg/L, and shoreline contact > 1 g/m²*." How are these thresholds defined and what do they mean?

Figures 4-1 to 4-18. In nearly all scenarios, the spatial extent of the statistics is truncated by the boundaries of the numerical domain. The domain should be extended and new simulations carried out. The stochastic footprint of surface oil in km², as reported in the Executive Summary (p. vi) is therefore erroneous.

- In regards to shoreline contact, the results suggest that only Sable Island would be affected by a potential release. However, the simulations are stopped when the patch is dangerously approaching the coasts (e.g. Figures 4-4). The report should point out that continuing the simulations after the release stops may lead to oil being in contact with the shore (it appears that simulations are stopped very early while most of the oil is still close to the release site).

Table 4-1 presents erroneous results as the extent of the spills are truncated by model boundaries.

Conclusions

The objective of this review was to evaluate:

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

- There are 2 issues with the numerical simulations of oil spill scenarios that need to be addressed, if not corrected:
  - the use of daily instead of hourly currents (see comments re: Appendix G);
  - model domain is too small to account for the scenarios (extent of spills in km² are erroneous).
- Drill cuttings simulations are much weaker than oil spill scenarios. They have several problems (see comments re: Appendix D):
  - Non-traditional turbulent diffusion scheme;
  - Use of spatially homogeneous currents;
  - Use of seasonnal currents;
  - No boundary layer processes;
  - Use of a flat bottom;
  - No stochastic analysis.

The mitigation measures proposed by the proponent;

- The mitigations or best practices 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 (especially cuttings, but also oil spill scenarios) 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.

- New simulations for drill cuttings dispersion are needed to properly estimate their fate.

Contributors

Name	Affiliation
James Meade (Chair)	DFO Science (CSAS)
Frederic Cyr	DFO Science
Fraser Davidson	DFO Science
Kent Gilkinson	DFO Science
Corey Morris	DFO Science

Approved by

B. R. McCallum
Regional Director Science, NL Region
Fisheries and Oceans Canada
May 10, 2018

Sources of information

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

Appendix: Figures

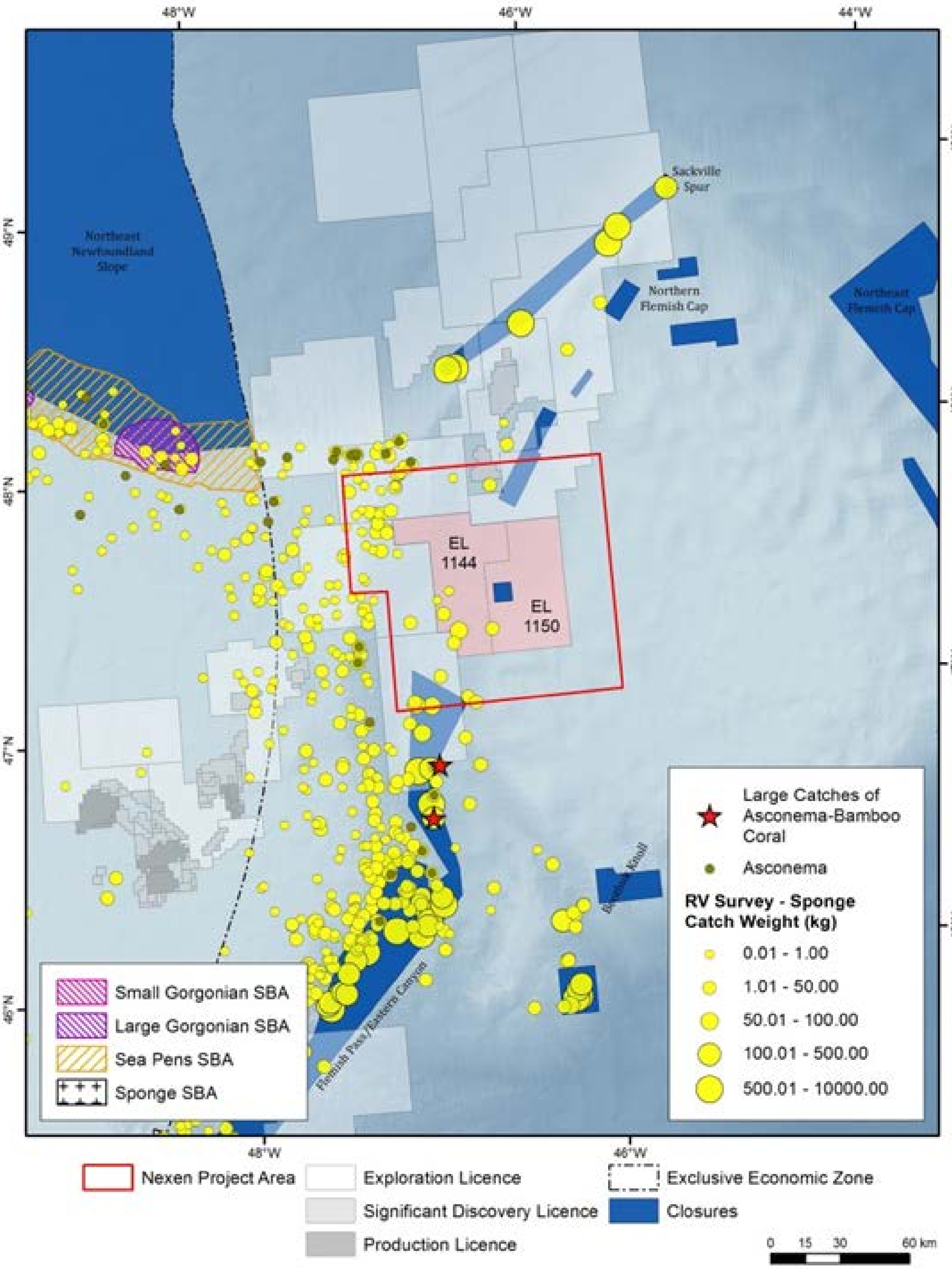

Figure 1. Sponge bycatch by weight with Asconema and unique Asconema-bamboo coral communities highlighted (red stars).

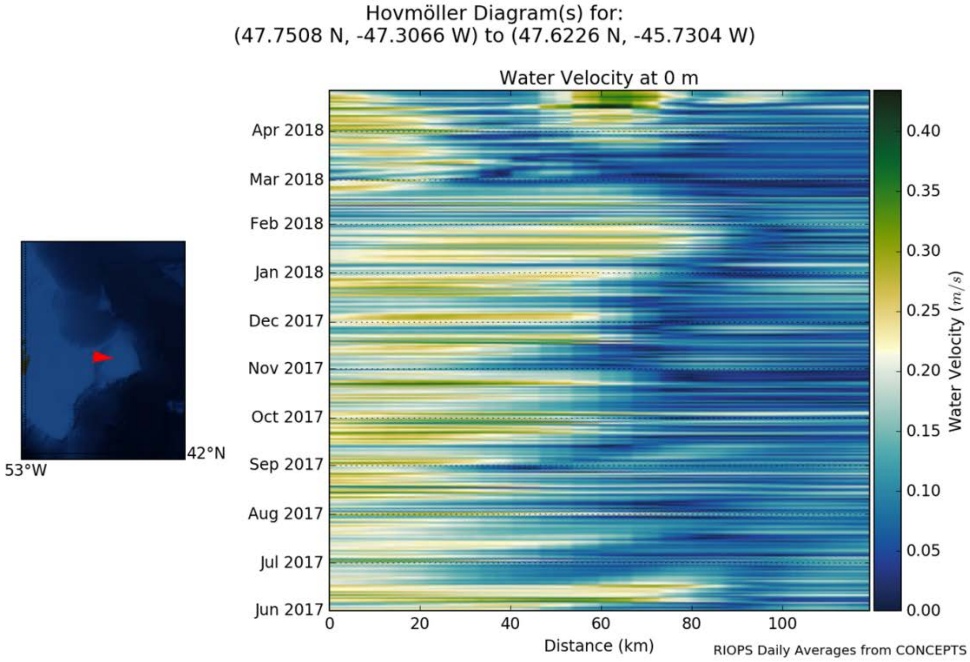

Figure 2. Hovmöller plot for Flemish Pass water velocity at surface.

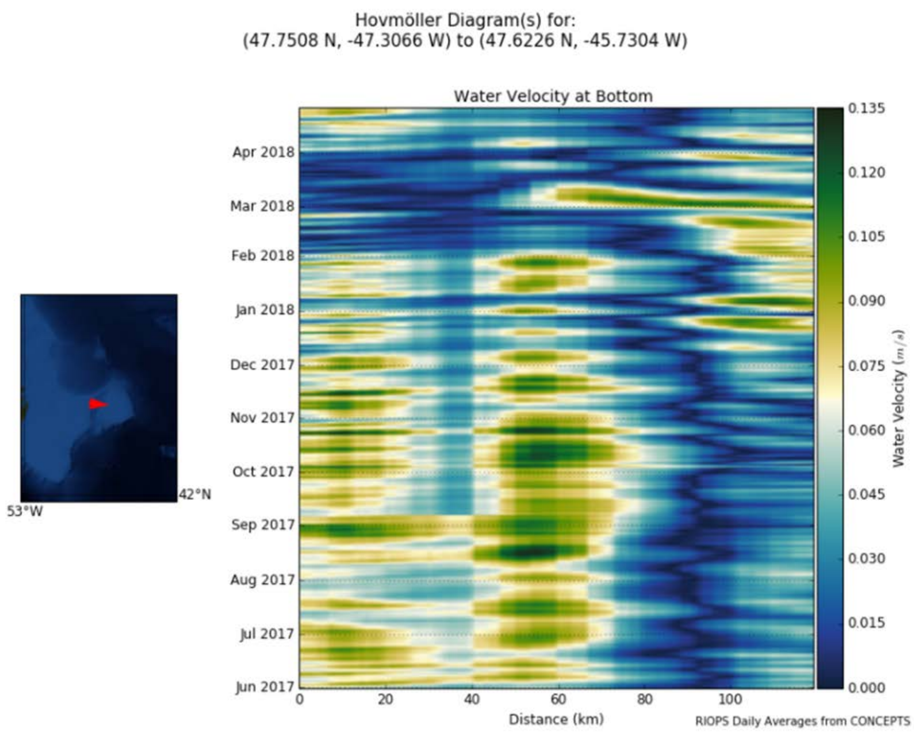

Figure 3. Hovmöller plot for Flemish Pass water velocity at bottom.

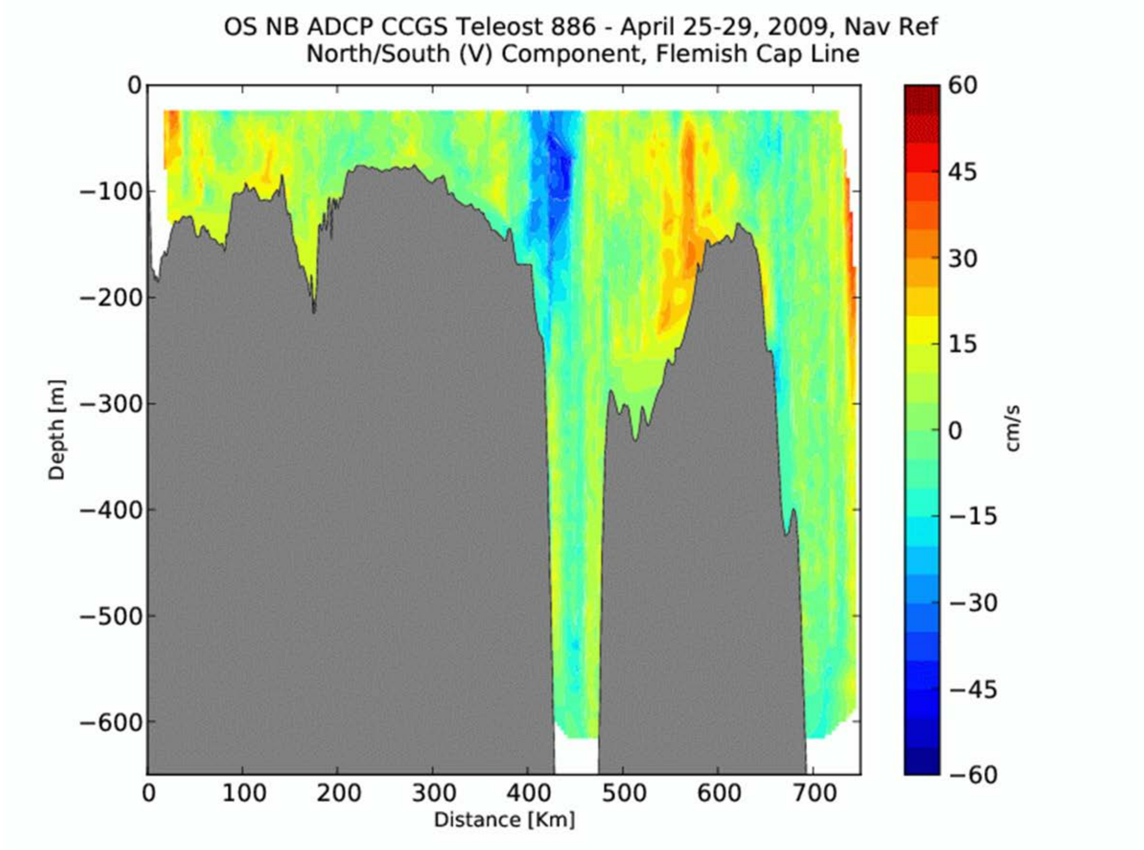

Figure 4. Example of ACDP of observed North-South Velocity along Flemish Cap Transect conducted by the DFO AZMP program between April 25 and April 29 2009.

This Report is Available from the

Center for Science Advice (CSA)
Newfoundland and Labrador Region
Fisheries and Oceans Canada
PO Box 5667
St. John's, NL, A1C 5X1

Telephone: 709-772-3332
E-Mail: DFONLCentreforScienceAdvice@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-3769

Correct Citation for this Publication:

DFO. 2018. Review of the Environmental Impact Statement for the Nexen Energy Flemish Pass Exploration Drilling Project (2018-2028). DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/039.

Aussi disponible en français :

MPO. 2018. Examen de l'énoncé des incidences environnementales du projet de forage exploratoire dans la passe Flamande de Nexen Energy (2018-2028). Secr. can. de consult. sci. du MPO, Rép. des Sci. 2018/039.