Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans
Maritimes Region
Canadian Science Advisory Secretariat
Science Response 2015/019

REVIEW OF THE NET ENVIRONMENTAL BENEFIT ANALYSIS SUPPORT FOR THE SHELBURNE BASIN VENTURE EXPLORATION DRILLING PROJECT

Context

On January 14, 2015, the Ecosystem Management Branch, Fisheries and Oceans Canada (DFO) in the Maritimes Region requested that DFO Maritimes Science review a draft document entitled "Net Environmental Benefit Analysis (NEBA) Support of the Shelburne Basin Venture Exploration Drilling Project (Draft 4b Report)" and associated supplementary material entitled "Trajectory Modelling in Support of the Shelburne Basin Exploratory Drilling Program: Analysis of Dispersant Application". Ecosystem Management requested DFO Science advice related to the following questions:

1. Does the document and associated supplementary material accurately describe and consider the marine ecosystem components that would be at risk from an oil spill incident?
2. Is the spill modelling used for the analysis consistent with DFO's knowledge and understanding of bio-physical dynamics of the study area?
3. Does the document and associated supplementary material present its analysis, concluding results, and recommendations in a manner that is logical and consistent with DFO's understanding of oil spill risks, including those associated with the implementation of various spill response measures?

Results of the review will be provided to the Canada–Nova Scotia Offshore Petroleum Board (CNSOPB), which is the independent joint agency of the Government of Canada and Province of Nova Scotia responsible for the regulation of petroleum activities in the Nova Scotia Offshore Area (see: www.cnsopb.ns.ca). It was requested that DFO Science provide a response by January 28, 2015. To achieve this deadline, sections of the document and associated supplementary material were assigned to DFO Science experts based on subject matter areas of expertise. A limitation of the review was the short turnaround period of two weeks, which constrained the depth, nature, and level of DFO Science review of the NEBA document and associated supplementary material. Within the two week turnaround period, DFO Science reviewers only had 7 days to review and provide comments.

Given the short timeframe for review a DFO's Science Response Process (SRP) was used. This Science Response Report results from the Science Response Process of January 23, 2015, on the "Review of the Net Environmental Benefit Analysis Support for the Shelburne Basin Venture Exploration Drilling Project" document and associated supplementary material. Last, results of the SRP were presented at an Environment Canada Science Table meeting held on January 29, 2015, which was scheduled to discuss the NEBA document and its associated supplementary material.

Background

The NEBA document and associated supplementary material evaluates risks and response measures to a theoretical oil spill at potential offshore drilling sites of the Shelburne Basin Venture Exploration Drilling Project (for more project details see: www.cnsopb.ns.ca). The NEBA document presents the relative benefits and limitations of several oil spill response tools, including the use of sub-sea and surface chemical dispersants in context of offshore (slope), nearshore (shelf) and shoreline zones, as well as in relation to a suite of marine ecosystem components (e.g., fish, birds, plankton, marine mammals, commercial fisheries, etc.).

Analysis and Response

General Comments

The analysis described in the NEBA document provides for a well-organized review of the various response options available if an oil spill incident were to occur during the Shelburne Basin Venture Exploration drilling project. The document clearly outlines the theory and steps used to conduct the NEBA, and then apply the process to five response options that were identified. The conclusion of the report that subsurface injection of dispersants would result in the lowest environmental impact appears to be supported by the best science available at this time.

There are some general deficiencies with the NEBA document, such as the inclusion of several subjective statements regarding the efficacy of various response options; for example, use of terminology such as “typically” or ”may”, etc., should be qualified with additional descriptive text. Where available, more definitive analysis should be included, citing previously reported results. Similarly, toxicity information presented in the NEBA document is comprised of high-level summaries, whereas a more comprehensive analysis of existing laboratory and field study information, including lessons-learned from previous oil spills in the marine environment, is warranted in this case.

There is analysis upon which the NEBA document is supported by way of reference to accompanying documentation, although the two week turnaround period of DFO Science’s review did not allow the reviewers sufficient time to consult these associated referenced source documents in detail. For example, the trajectory modelling presented in the NEBA document and associated supplementary material is dependent upon the suitability of underlying circulation model outputs, as well as details of the trajectory model itself (oil behaviour, decay, weathering etc), yet no detailed information is provided on the circulation modelling within the documents reviewed by DFO Science. Again, the two week turnaround period of DFO Science’s review did not allow the reviewers sufficient time to consult the associated referenced source documents in detail. As such, the NEBA document and associated supplementary material would benefit from inclusion of an Executive Summary of key elements of the circulation modeling approach and outputs used in the analysis, as it is otherwise not possible to adequately assess usefulness or validity of the trajectory outputs as presently described within.

The global HYCOM model at 1/12-deg resolution, with data assimilation, used as input to the spill trajectory modelling, is considered state-of-the-art for deep-ocean and shelf slope regions. The model, however, does not include tides, which are significant on the Scotian Shelf. Further, surface waves are important for surface mixing and transport, but they are also not included in the trajectory modelling. The scenario simulation presented is for the summer season only and does not include extreme weather events (e.g. Tropical Storms and/or Winter Storms). This limitation of the trajectory modelling should be acknowledge as a source of uncertainty and could be considered in context of the risk analysis. In addition, grid resolution of the global HYCOM model does not capture finer flow details near the coast and proximal to geomorphic features such as the Gully, and again this limitation could be acknowledge and considered in context of the risk analysis; albeit the Gully is beyond the outer trajectory range of the projected spill scenarios presented in the NEBA document.

Over the past five years, a significant amount of scientific research has been undertaken on long-term impacts of spills, and use of chemical dispersants, on the marine environment of the Gulf of Mexico following the Macondo Prospect oil spill in 2010. The NEBA document would benefit by incorporating findings of these scientific studies directly. Specifically, topics such as oil accumulation on sediments (see: Mason et al. 2014, Passow et al. 2012, Schrope et al. 2013); transport and fate of underwater dispersed oil plumes (see: Camilli et al. 2010); and hypoxia caused by increased respiration (see: Kessler et al. 2011, Hazen et al. 2010) should be addressed more thoroughly, as these are issues that are likely to be raised if a subsurface injection program were to be implemented at the Shelburne Basin site in the event of an oil spill.

Last, it would be useful if the NEBA document included a section on the socioeconomic impacts of an oil spill (see: Morris et al. 2013). The Macondo Prospect oil spill had significant impacts on the U.S. economy in the northern Gulf of Mexico; mainly fisheries and tourism. The impact this had on residents and local economies of the region is only now becoming fully understood. As such, the NEBA document should make reference to the potential impacts of an oil spill on fisheries, which would likely be closed in the event of an oil spill at Shelburne Basin. Such analysis could also be expanded to discuss how various spill response strategies would impact residents, livelihoods, economies, and communities of the region.

Section Specific Comments

The following are comments on specific sections of the NEBA document and associated supplementary material.

Executive Summary

- The statement *"This report describes four distinct steps in the NEBA process"* is incorrect, as the report does not describe the four steps in detail. Rather, the report focusses largely on Step 4. Steps 1 and 2 are given minimal attention in the document.

Objective (Section 1.3)

- Consider utilizing an enhanced NEBA that includes well documented economic variables (e.g. commercial fisheries, aboriginal resources, etc.), known as a Net Environment and Economic Benefit Analysis (NEEBA). With a NEEBA, decision makers will have additional information that shows the monetary cost and social implications of 'NOT' applying dispersants to an oil spill; thus, resulting in the possible damage of sensitive sites.
- Identify potential products (e.g. light crude oil; Federated crude with API of 39, etc.) that could possibly be spilled, which would threaten resources in the vicinity of drilling operations. Included in this evaluation are the predicted spread, thickness, and oil movement and deposition, including weathering and chemical composition (this is outlined under spill modelling, pp. 26-36 of the NEBA document, so this statement should be placed under the numerical list).
- Under Bullet # 3 on p. 12 "Seek to identify the response option(s) that provide the best overall outcome to a spill (Stevens and Aurand 2007)", the following strategies should be included:
  - Monitor spills that do not pose human or ecological threats (natural attenuation)
  - Containment and recovery by mechanical means
  - Recovery by hand (for example, rakes, and shovels on a beach)
  - Chemical dispersants
  - In-Situ burning
- It is recommended an objective be included to establish monitoring protocols to evaluate the effectiveness of response option(s).

- This would include the development of a ‘Dispersant Decision Checklist’ (see subsequent comments below).

Geographic Area of Interest and Spill Scenarios (Section 2.1)

- The NEBA document and associated supplementary material should include a winter time spill scenario if drilling is expected to take place over the winter months. Logistics in responding to a winter time spill may be more challenging, such as deploying booming, skimming, and dispersant spraying equipment in typically more energetic sea-states. In addition, a winter time spill scenario should also include a discussion on how colder water temperatures would affect oil viscosity and dispersant efficacy, both for surface and subsurface applications.

Resources of Concern (Section 2.2)

- With regard to Table 3:
  - The depth corresponding to the surface layer should be specifically mentioned as water column (shallow) is described as less than 100 m, which includes the surface layer.
  - Indicate if juveniles or larvae could be found in the water column.
  - On the shelf (benthos) should be Invertebrates and not ”Other” invertebrates.

Response Options (Section 2.3)

- For each option, it would be beneficial to include a section on the disadvantages of the options, not just the limitations. The pros and the cons of each option are necessary to better assess them, not just the limitations.
- In this section, the document reviewed general knowledge of the response options from the natural attenuation for a small spill to dispersant application for a large spill. For each option, the document listed the methods, benefits, logistics, effectiveness, and limitations. However, the document does not point out clearly how to apply these options to the focused areas. For example, in Shoreline Protection and Recovery (Subsection 2.3.2), the document does not give the following information: 1) location of the possible shoreline 2) geological composition of the shoreline (e.g., rock, sediment, or mud); and 3) description of the option to be used for specific shoreline. It is recommended that the NEBA document include a specific geographic area for each response option listed in Table 4.

Natural Attenuation (Section 2.3.1)

- First paragraph should acknowledge the potential timeframe for persistence of stranded oil; that is, it has been shown to persist in beach sediments for up to decades (e.g. as observed following the Exxon-Valdez Oil Spill, Alaska).
- “…disperses into the water column…” The document should also mention that oil may sink depending on its physical properties, degree of weathering, and presence of particulate matter in the water column.
- With regard to efficiency: by “not applicable”, the document should clarify if this means natural attenuation may never be an efficient option. If “not applicable” specifically refers to this report than this needs to be explained why.
- Typo - “…may be experienced in offshore Nova Scotia.~~.~~

Shoreline Protection and Recovery (Section 2.3.2)

- An estimate of effectiveness including uncertainty should be included in this paragraph, even if the uncertainty is a large value.
- The discussion of effectiveness in the second paragraph is vague, and not particularly informative regarding response options: “…the shoreline recovery strategy can range from

100 percent effective (e.g. manual removal) to minimally effective initially…" The document should consider a more detailed discussion on the efficacy of each option (i.e. manual removal, debris removal, flushing, etc.) if such information is available. If this information is not available, the document should note this, so the reader knows it has been considered.

- "Additionally, once shoreline recovery begins, determination of "how clean is clean" can make decisions regarding termination difficult." Again, if more detailed information is available, it should be presented here, in order to assist response organizations in determining the endpoint for shoreline recovery efforts. This is an important aspect of the NEBA document.

On-Water In-situ Burning (Section 2.3.4)

- Typo – "Reductions in ~~area~~ air quality…"
- "... permanently removes oil from the water...". Please clarify whether this suggests that 100% of the oil will be removed or that the proportion that is removed will be removed permanently.
- The 'Benefits' section states that "*This response option permanently removes oil from the water at high rates…",* and seems to imply good efficacy, whereas in the 'Efficiency' section (and throughout the remainder of the NEBA document), in-situ burning is dismissed as a poor option. This inconsistency should be reconciled.
- The document should clarify if this option creates by-products that could be detrimental to aquatic organisms. Again, information on the potential disadvantages associated with each option would useful.
- Description of the regulations associated with on-water, in-situ burning for the area being assessed would be helpful.

Dispersant Application at Water Surface (Section 2.3.5)

- It is stated at the end of the first paragraph that: "Within 2-4 hours, concentrations typically decrease to below 10 ppm, which is approaching the threshold limit below which adverse ecological effects are not anticipated, even to sensitive species." and in the 'Benefits' section: "It reduces the potential smothering of or oil ingestion by wildlife that use surface waters in or near a spill." With regard to the potential effects on biota, it should be more clearly stated how this information was derived, as this is a very brief treatment of dispersed oil toxicity issues. If this information is based on a comprehensive analysis of existing laboratory/field/spill studies, it should be clarified here. Smothering and ingestion should also be treated separately.
- First paragraph, sentence # 6 on dispersed oil droplet size distribution, note, from research studies by Li et al. (2009a,b,c), that oil droplets sizes <70 µm in diameter are a positive indication of oil dispersion effectiveness.
- The NEBA document states that dispersed oil droplets are generally less than 0.01-0.02 mm in diameter. It is generally accepted that chemically-dispersed oil is usually less than 70 µm in diameter (Lunel 1995), although the droplet size depends on the type of oil, degree of weathering, dispersant efficacy, and amount of mixing energy provided by waves.
- Under Benefits: Not only are small (<70 µm diameter) oil droplets more susceptible (e.g. ideal surface area for microbial interaction) to biodegradation, their suspension in the water column permits interactions with suspended sediments to form oil-sediment-aggregates (OSAs). OSAs will remain suspended until their density exceeds that of water, where they will most likely sink. The NEBA document should mention that dispersed oil droplets may interact with suspended particulate material in the water column to form Oil-Particulate Aggregates (OPA) or Oil-Mineral Aggregates (OMA).
- Please define calm waters (e.g. non-breaking waves, no waves, etc.).

- Under Efficiency: the efficiency of the natural dispersion of oil (e.g. light crude) should be described. It is important to include this information, so it can be compared to the benefits of using chemical dispersant to enhance the natural dispersion of oil.
- Under Efficiency: that the statement “Dispersant effectiveness can approach 100% when…” is vague, and should be better described.
- “The droplets of dispersed oil are more susceptible to biodegradation.” The NEBA document could mention that by using chemical dispersants to break the oil slick into small droplets, the surface area-to-volume ratio is increased, which helps to promote biodegradation by providing more surface area for bacteria to interact.
- Table 4: Some information on the length of time for ecosystem recovery is required. For example, describe whether the response option(s) improve natural oil weathering; thus, reducing the time for a contaminated ecosystem to recover.
- A NEBA is a tool that indicates whether the use of dispersant is a feasible response option for a specific area or location and is conducted as part of the pre-planning process. A “Dispersant Decision Checklist” is a tool that is completed when a spill incident occurs to help in the final decision making process regarding the use of dispersants. If done correctly, the checklist should cover all the issues facing oil spill responders and give a solid “Yes” or “No” as to whether or not it is feasible and appropriate to use dispersants. Please refer to the paper by Stevens et al. (2001), as an example or select your own example), which provides a flowchart of dispersant use guidelines. It would be appropriate if a dispersant checklist could be developed, agreed upon by all parties, and incorporated into the NEBA document for the proposed Shelburne Basin Venture Project.
- “…due to natural mixing processes.” The NEBA document should state what these mixing processes are. Wave energy provides the greatest amount of mixing energy, although turbulence created by rain and surface currents may also provide some mixing energy.
- Under limitations, it should be stated that aerial dispersant spraying would not be used close to shorelines or areas where the dispersed oil could interact with sediments.

Subsea Dispersant Injection (Section 2.3.6)

- “The same general chemical dispersion principles that were discussed in Section 2.3.5 apply here as well, except for a few key distinctions.” The unique aspects of subsea injection should be outlined more clearly here.
- The NEBA document states that subsea dispersant operations can operate with little to no impact from weather. During the Macondo Prospect oil spill response, subsurface dispersant injection operations were ceased when a tropical storm passed through the region, so there are certain wave and wind conditions where the Remotely Operated Vehicle cannot operate. Such limitations should be noted here.
- The limitations of subsurface dispersant injection need to be expanded upon. Again, during the Macondo Prospect oil spill response, there were concerns over the possible formation of anoxic conditions caused by increased respiration, as bacteria consumed the dispersed crude oil in the water column. In addition, following the spill it was found that oil was present in the sediment in the vicinity of the wellhead. Finally, the formation and long distance transport of underwater “plumes” of dispersed oil were a concern during the Macondo Prospect oil spill response. A large scale water quality monitoring program would need to be established during and after the spill to assess these effects.
- “For the purposes of this scenario and NEBA, subsea dispersant efficiency was assumed at 80% for a modeling assumption.” It is believed that the NEBA document means to state that subsea dispersant application efficiency, since the following sentence states that “…the remaining dispersant treats the oil with 100% efficiency.”
- Besides logistical reasons, monitoring the droplet size distribution just above the dispersant injection point may not be feasible since most instrumentation would not be able to measure

droplet sizes in such a high concentration plume. A wider scale water quality monitoring program would be more appropriate to delineate the size and properties of a plume.
- Dispersant application should include a monitoring protocol. The purpose of a monitoring protocol is to assist in determining the effectiveness of the dispersant applications and to record potential impacts to ecosystem resources from its use.
- Monitoring protocols should include visual assessment, remote sensing, and water column monitoring (e.g. collection of water samples for analyses or in-situ equipment to track and monitor oil dispersion effectiveness).

Spill Modelling (Section 2.4)

- There is some inconsistency in use of citations for Horn and French McCay (2014a,b), and Horn and McCay (2014a). These citations are not found in the NEBA document reference list.
- Spill modelling results critically depend on, in addition to the trajectory and weathering components, inputs from the hydrodynamic model. Information is needed in the NEBA document on the source of the input field, spatial and temporal resolution, whether data assimilation is included, and how the model results compared with observations. This should be possible by including a brief description and key references.
- Since the detailed information of the spill model has been described in other reports, a very brief description of the model is given in this report, however:
  - Weathering model results are extremely sensitive to the model parameters, which are related to oil types, ocean, and atmospheric situations. The parameters in oil spilling models are usually derived from limited laboratory tests. It is suggested that the NEBA document include discussion on the uncertainty of model results.
  - The physical environments, especially the current fields, in the study area are complicated, especially in the shelf break area. As such, the NEBA document should add a brief description about the physical model development and the related validation.
  - Since the aim of the document is to show the potential impacts due to spills, it is suggested that results from extreme weather situations (e.g. tropical storms) be included.

- There may be merit in presenting a more generic model that includes the transport, dispersal, and interaction of oil and dispersant that generates the highlighted trends, but does not focus on the specifics of the area of interest (rather is generally representative).

The Risks Associated with Oil Exposure (Section 3.1)

- The NEBA document states that there are few toxicological tests “using short-term exposure durations that focus on anything but lethal endpoints.” This is a rapidly growing field, and since the Macondo Prospect oil spill response there have been many scientific studies that assess short term exposures and non-lethal endpoints.
- Please provide more details related to how “any of the spill scenarios in which dispersant application would be considered as a response option already represent some degree of marine toxicity risk”.
- It should be noted in the NEBA document that sensitive early life stages of fish (i.e. embryos and larvae) are not self- mobile, rather they are essentially planktonic and may move with an oil slick, resulting in greater exposure relative to more self-mobile organisms.
- The NEBA document appears to contradict itself on p. 39 regarding tests using short-term exposure durations (“very useful” vs “not particularly reliable”). While it is important to acknowledge the limitations of the available data, it should also be incorporated into the analysis. Sub-lethal impacts after short-term exposure could be relevant.

- It is unclear how the Species Sensitivity Distribution curves are incorporated into the NEBA process outlined in the NEBA document.
- The toxicity information seems to be based on species not necessarily found in the area of interest. Although the NEBA document acknowledges this, it claims the information is relevant, although this is not supported by the literature.
- Where there are references to the toxicity of unmitigated oil and oil that has been dispersed (i.e. smaller droplets, lower concentrations, etc., but a bigger exposure area and duration), there isn't any reference to the toxicity of the dispersant itself in this section.

The Ranking Process (Section 3.2)

- It is unclear how the qualitative 'levels of concern' (i.e. 1A to 4D) were assigned in the risk ranking matrix; this is a fundamental step in determining relative risk. For instance, was it left to the discretion of the NEBA document authors (i.e. did they make qualitative judgements to assign '*time to recovery*' (category 1 to 4) and '*% of resource at risk*' (category A to D))? While the use of threshold values is described, it is not clear how this was translated to recovery time ranges and % of resource at risk for the various species/populations. Last, it should be clarified if the approach taken is a typical approach used in other NEBA processes.

Risk Analysis Results (Section 3.3)

- With regard to Figure 16 in the NEBA document, if only the early life stage of a single fish species is at very high risk, it should be clarified how this is reflected in the results for the whole "fish" category.

Natural Attenuation (Section 3.3.1)

- Fisheries closures are the responsibility of Fisheries and Oceans Canada and food safety falls under the authority of Canadian Food Inspection Agency, not Health Canada.
- It is incorrect to consider that United States and Canadian fishery closures would be similar. The sentence should be revised removing, "it is appropriate to consider that closures would be lifted within one year." Simply state that, in the case of the Macondo Prospect oil spill, fisheries closures were lifted after a year.

Dispersant Application at Water Surface (Section 3.3.5)

- Dispersant application should include having a monitoring protocol. The purpose of a monitoring protocol is to assist in determining the effectiveness of the dispersant applications and to record any impacts to ecosystem resources from its use.
- Monitoring protocols should include visual assessment, remote sensing, and water column monitoring (e.g. collecting water samples for analyses or *in situ* equipment to track and monitor oil dispersion effectiveness).

Subsea Dispersant Injection (Section 3.3.6)

- The NEBA document lists the risks of subsea dispersant injection to water column resources and shoreline habitats. The risks of oil collecting on the bottom sediments should also be discussed.
- Dispersant application should include having a monitoring protocol. The purpose of a monitoring protocol is to assist in determining the effectiveness of the dispersant applications and to record any impacts to ecosystem resources from its use.
- Monitoring protocols should include visual assessment, remote sensing, and water column monitoring (e.g. collecting water samples for analyses or *in situ* equipment to track and monitor oil dispersion effectiveness).

Key Findings Related to Ecological Impacts (Section 4.2)

- It is not clear that potential sub-lethal impacts to fish are accounted for under Bullet # 3. Early life stages of fish may be particularly sensitive to sub-lethal impacts.
- The statement that "*Subsea dispersant injection increases hydrocarbon concentrations of oil in deep waters, but the affected areas are small relative to the reference area and do not represent a risk to sensitive biological resources"* should be more clearly substantiated in the NEBA document.

Recommendations Concerning Response Options (Section 4.3)

- It should be clarified if there are other response option(s) to consider or whether the options listed in this section are the primary ones that the Area Response Organization (e.g. Eastern Canada Response Organization) is equipped to execute during a spill. If there are no others response option(s) then indicate that the response options recommended are those that the Area Response Organization is equipped to execute in the event of an oil spill.
- If the spill happens during a reproduction period of a commercial fishery resource, the whole ecosystem may not be affected in the long-term, but there would be an effect on this species regarding fish reaching the adult age. This type of scenario should be mentioned in this section.

An Overview of Dispersants (Appendix A)

- On p. 57 of the NEBA document, it is stated that "*Chemical dispersants are surfactants specifically designed for use in marine environment".* Not all dispersants are formulated for marine environments. Some are formulated to be used in fresh and brackish waters. This point should be clearly stated.
- On p. 58 of the NEBA document, the last sentence should be revised as follows; a DOR of 1:20 is recommended for light and medium crudes. For Heavy crudes a DOR of 1:10 is usually recommended if research studies support its application.
- The following questions need to be addressed in Appendix A:
  - What dispersants are being considered or is there a list of ones approved for use in the offshore of Nova Scotia in the event of an oil spill? The aim of developing a list of approved dispersants is to show that the most effective low toxicity dispersants are available at the time of a spill.
  - If there is a catastrophic spill, such as Macondo Prospect oil spill in the Gulf of Mexico in 2010, will the supplier(s) of chemical dispersants be able to keep up with demand along with proper application equipment?
  - Will other dispersants (e.g. Finasol OSR52, and Dasic slickgone) besides Corexit 9500 be considered if a catastrophic spill does occur at the Shelburne Basin site?

- Appendix A contains oil-specific dispersion data and further to it, it should be considered that Corexit 9500 has been shown to be one of the more effective dispersants over a wide range of oil types and environmental conditions that have been tested in a flow-through wave tank. As such, the NEBA document should include the following research on dispersant effectiveness testing and fate and behavior of spilled oil covered in Li et al. (2008), Li et al. (2009a), Li et al. (2009b), Li et al. (2009c), and Li et al. (2010).
- The NEBA document should include research on toxicity of dispersants and dispersed oil (e.g. related to Atlantic fish species) found in McIntosh et al. (2010), Wu et al. (2012), Greer et al. (2012), and Adams et al. (2013).

Conclusions

The NEBA document and its associated supplementary material is generally sufficient, with the analysis making a reasonable assertion that subsea dispersant injection is likely to be the preferred response option in the event of a large subsea blow-out oil spill (relative to natural attenuation) at the proposed drilling site, based on available environmental information and modelling outputs. Some aspects of the NEBA document and associated supplementary material, however, require clarification and more detailed scientific analyses, including but not limited to:

- lack of supporting information in some sections, such as the trajectory modelling and method used to determine "level of concern";
- reliance on information derived from different environments, including references to non-indigenous species for the biological effects discussion;
- lack of discussion on monitoring protocols, such as water quality monitoring or biological effects monitoring; and
- an overall lack of knowledge about slope area (e.g., species use, sensitivities, and dynamics) to verify the assessment finding that little harm will occur in deeper water close to the wellhead itself.

Last, it is again noted that the two week time line provided to DFO Science for this review did not allow for a thorough review of the NEBA document, the associated supplementary material, or other applicable references. Within the two week turnaround period that was provided to DFO Science, science reviewers only had 7 days to review and provide comments. As such, the time limitation constrained the depth, nature, and level of the DFO Science review of the NEBA document and associated supplementary material.

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Sources of Information

Adams, J., Sweezey, M., and Hodson, P. 2013. Oil and Oil Dispersant do not Cause Synergistic Toxicity to Fish Embryos. Environ. Toxicol. Chem. 33(1): 107-114.

Camilli, R., Reddy, C.M., Yoerger, D.R., Van Mooy, B.A.S., Jakuba, M.V., Kinsey, J.C., McIntyre, C.P., and Maloney, J.V. 2010. Tracking Hydrocarbon Plume Transport and Biodegradation at Deepwater Horizon. Science 330: 201-204.

Greer, C., Hodson, P., Li, Z., King, T., and Lee, K. 2012. Toxicity of Crude Oil Chemically Dispersed in a Wave Tank to Atlantic Herring (*Clupea Hargenus*) Embryos. Environ. Toxicol. Chem. 31: 1-10.

Hazen, T.C., Dubinsky, E.A., DeSantis, T.Z., Andersen, G.L., Piceno, Y.M., Singh, N., Jansson, J.K., Probst, A., Borglin, S.E., Fortney, J.L., Stringfellow, W.T., Bill, M., Conrad, M.E., Tom, L.M., Chavarria, K.L., Alusi, T.R., Lamendella, R., Joyner, D.C., Spier, C., Baelum, J., Auer, M., Zemla, M.L., Chakraborty, R., Sonnenthal, E.L., D'haeseleer, P., Holman, H.-Y.N., Osman, S., Lu, Z., Van Nostrand, J.D., Deng, Y., Zhou, J., and Mason, O.U. 2010. Deep-Sea Oil Plume Enriches Indigenous Oil-Degrading Bacteria. Science 330: 204-208.

Kessler, J.D., Valentine, D.L., Redmond, M.C., Du, M., Chan, E.W., Mendes, S.D., Quiroz, E.W., Villanueva, C.J., Shusta, S.S., Werra, L.M., Yvon-Lewis, S.A., and Weber, T.C. 2011. A Persistent Oxygen Anomaly Reveals the Fate of Spilled Methane in the Deep Gulf of Mexico. Science 331: 312-315.

Li, Z., Lee, K., King, T., Boufadel, M. C., and Venosa, A. D. 2008. Assessment of Chemical Dispersant Effectiveness in a Wave Tank Under Regular Non-breaking and Breaking Wave Conditions. Mar. Pollut. Bull. 56(5): 903-912.

Li, Z., Lee, K., King, T., Boufadel, M.C., and Venosa, A. D. 2009a. Evaluating Crude Oil Chemical Dispersion efficacy in a Flow-through Wave Tank Under Regular Non-breaking Wave and Breaking Wave Conditions. Mar. Pollut. Bull. 58(5): 735-744.

Li, Z., Lee, K., King, T., Kepkay, P., Boufadel, M., and Venosa, A. 2009b. Evaluating Chemically Dispersant Efficacy in a Wave Tank: 1- Dispersant Effectiveness as a Function of Energy Ddissipation Rate. Environ. Eng. Sci. 26(6): 1139-1148.

Li, Z., Lee, K., King, T., Boufadel, M., and Venosa, A. 2009c. Evaluating Chemically Dispersant Efficacy in a Wave Tank: 2- Significant Factors Determine *in situ O*il Droplet Size Distribution. Environ. Eng. Sci. 26(9): 1407-1418.

Li, Z., Lee, K., King, T., Boufadel, M.C., and Venosa, A.D., 2010. Effects of Temperature and Wave Conditions on Chemical Dispersion Efficacy of Heavy Fuel Oil in an Experimental Flow-through Wave Tank. Mar. Pollut. Bull*.* 60(9): 1550-1559.

Lunel, T. 1995. Dispersant Effectiveness at Sea. International Oil Spill Conference Proceedings: February-March 1995, Vol. 1995(1): 147-155.

Mason, O.U., Scott, N.M., Gonzalez, A., Robbins-Pianka, A., Bælum, J., Kimbrel, J., Bouskill, N.J., Prestat, E., Borglin, S., Joyner, D.C., Fortney, J.L., Jurelevicius, D.W., Stringfellow, T., Alvarez-Cohen, L., Hazen, T.C., Knight, R., Gilbert, J.A., Jansson, J.K. 2014. Metagenomics Reveals Sediment Microbial Community Response to Deepwater Horizon Oil Spill. ISME J. (2014) 8: 1464−1475.

McIntosh, S., King, T., Wu, D., and Hodson, P. 2010.Toxicity of Dispersed Weathered Crude Oil to the Early Life Stages of Atlantic Herring (*Clupea harengus*). Environ. Toxicol. Chem. 29(5): 1160-1167.

Morris, J.G. Jr., Grattan, L.M., Mayer, B.M., and Blackburn, J.K. 2013. Psychological Responses and Resilience of People and Communities Impacted by The Deepwater Horizon Oil Spill. Trans. Am. Clin. Climatol. Assoc (2013) 124: 191-201.

Passow, U., Ziervogel, K., Asper, V., and Diercks, A. 2012. Marine Snow Formation in the Aftermath of the Deepwater Horizon Oil Spill in the Gulf of Mexico. Environ. Res. Lett. 7: 1-11.

Schrope, M. 2013. Dirty Blizzard Buried Deepwater Horizon Oil. Nature News doi:10.1038/nature.2013.12304.

Stantec. 2014. Shelburne Basin Venture Exploration Drilling Project: Environmental Impact Statement. Prepared for Shell Canada Limited: 83 pp.

Stevens, L., and Aurand, D. 2007. Criteria for Evaluating Oil Spill Planning and Response Operations. A Report to IUCN, The World Conservation Union. Ecosystem Management & Associates, Inc., Lusby, MD. 20657. Technical Report 07-02 (Revised June 2008): 55p.

Stevens, L., Roosen, J., and Irving, P. 2001. Guidelines on Dispersant Use in New Zealand, pp. 1185-1194. In: 2001 International Oil Spill Conference Volume 2. International Oil Spill Conference Proceedings: March 2001, Vol. 2001.

Wu, D., Wang, Z., Hollebone, B., McIntosh, S., King, T. and Hodson, P.V. 2012. Comparative Toxicity of Four Crude Oils to Rainbow Trout Embryos. Environ. Toxicol. Chem. 31(4): 754-765.

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