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Proceedings of the National Peer Review Meeting on the Assessment of the Effectiveness of Mitigation Measures in Reducing the Potential Impacts of Oil and Gas Exploration and Production on Areas with Defined Benthic Conservation Objectives

Meeting Dates: June 26-28, 2018
Location: St. John's, Newfoundland

Chairperson: Mike Chadwick
Editor: Caroline Longtin

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Ottawa, ON, K1A 0E6

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

A National Science Advisory process was held June 26-28, 2018 in St. John's, Newfoundland. The purpose of the meeting was to assess the effectiveness of mitigation measures in reducing the potential impacts of oil and gas exploration and production on areas with defined benthic conservation objectives to assist Oceans Management in policy development related to oil and gas activities in areas with defined benthic conservation objectives.

The advisory process was informed by a working paper and six presentations. Presentations were given by Oceans Management, the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB), and the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB), the Canadian Association of Petroleum Producers (CAPP), and the author of the working paper. A total of 38 participants from academia, industry, the regulatory boards, non-governmental organizations, other federal departments, and employees from five of the Department of Fisheries and Oceans' (DFO) administrative Regions participated in this advisory process.

These Proceedings summarize the discussions held at the meeting. The conclusions and advice from this meeting will be posted on the DFO Science Advisory Schedule as they become available.

PRESENTATIONS AND DISCUSSION

REVIEW OF TERMS OF REFERENCE

The objectives of this science peer review meeting were to provide advice on the potential impacts of oil and gas exploration and production on areas with defined benthic conservation objectives and to assess the effectiveness of potential mitigation measures in the Canadian context. Accidental events (i.e., spills and blowouts) were beyond the scope of this review, which focused on planned routine activities and discharges associated with offshore exploration and production.

Participants were concerned about the exclusion of oil spills from the scope of this review as oil spills may have major impacts on areas with defined benthic conservation objectives. It was suggested that a future meeting be considered to combine both the impacts from oil spills and routine activities on areas with defined benthic conservation objectives.

The terminology used for the meeting differed from that of the Terms of Reference because terminology is not consistent across regions and there was concern from participants about the use of the term “valued benthic components” as this could be misconstrued to imply an economic value as opposed to a conservation value. There are also differences in the meanings of sensitive and significant benthic areas between sectors; therefore, the term “areas with defined benthic conservation objectives” was used to encompass all areas discussed. For the purpose of this meeting “areas with defined benthic conservation objectives” refer to area-based management measures (such as marine protected areas (MPAs) and other effective area-based conservation measures (OEABCMs)) applied to protect benthic components defined in conservation objectives. Defined benthic conservation objectives can include the protection of: benthic species (fish and invertebrates); benthic habitats including benthic spawning, nursery or feeding grounds; and Significant Benthic Areas, which include communities dominated by corals and/or sponges and hydrothermal vents, or locations likely to contain them such as canyons, seamounts, etc.

Participants discussed but did not come to a conclusion on whether the entire area with defined benthic conservation objectives should be avoided or only the area(s) where the species or habitats defined in benthic conservation objectives are present (i.e., avoid the entire MPA or(OEABCM or avoid only the areas with corals and sponges present).

In addition, on the first day of the meeting, participants from NRCan tabled a 2018 report on the environmental effects of exploratory drilling in offshore Atlantic Canada that concluded that "overall, the environmental effects of routine offshore exploratory drilling activities in the Canada-NS and Canada-NL offshore areas are not likely to be significant." Participants were uncomfortable with the word significant and noted that this paper cited few papers from a Canadian perspective.

PRESENTATION 1: CONTEXT SETTING

Presented by Jessica Mitchell

The Government of Canada is committed to increasing the protected coastal and marine areas of Canada to 10% by 2020, as agreed to through international Aichi Biodiversity Target 11 and domestic Biodiversity Target 1. To achieve this goal, MPAs and OEABCMs are being established. Many MPAs and OEABCMs protect areas with defined benthic conservation objectives which can include: benthic species (fish and invertebrates); benthic habitats including benthic spawning, nursery and feeding grounds; significant benthic areas and sensitive benthic

areas including corals, sponges, canyons and other benthic features where corals or sponges are likely, seamounts, and hydrothermal vents. For example, seven of the 11 established MPAs and approximately 30 of the 51 established OEABCMs have defined benthic conservation objectives. Oil and gas exploration leases are currently excluded from counting towards Canada's Marine Conservation Targets (MCTs).

For offshore oil and gas related environmental assessments DFO provides expert advice on benthic characterisation, effects assessment, mitigation measures and follow-up programs related to potential impacts on sensitive benthic habitats (e.g., corals, sponges). Advice from this Canadian Science Advisory Secretariat (CSAS) process will help to ensure that these existing sites, and future sites, provide lasting protections to their valued benthic components, and contribute to biodiversity conservation within Canada.

The Minister of Fisheries, Oceans and the Canadian Coast Guard recently announced the formation of a National Advisory Panel on Marine Protected Area Standards, which will gather perspectives and offer recommendations to the Minister on categories and associated protection standards for federal MPAs, using the International Union for the Conservation of Nature (IUCN) guidance as a baseline. The degree to which oil and gas activities are compatible with MPAs is expected to be a topic of interest to the panel. The scientific advice from this meeting will be provided to the Panel prior to providing their recommendations to the Minister in a final report by September 15, 2018.

Discussion

Although there are areas with defined benthic conservation objectives that overlap with current oil and gas interests, there is potential for more overlap to occur as Canada increases the number of conserved or protected areas and the oil and gas industry explores new locations; therefore this meeting does not exclusively address the areas that currently overlap as these areas will change over time.

PRESENTATION 2: OVERVIEW OF THE CANADA-NEWFOUNDLAND AND LABRADOR OFFSHORE PETROLEUM BOARD (C-NLOPB), AND THE CANADA-NOVA SCOTIA OFFSHORE PETROLEUM BOARD (CNSOPB)

Presented by Janice Ray and Elizabeth Young

Canada has three offshore petroleum regulators: the National Energy Board (NEB); the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB); and, the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB). The role of the C-NLOPB and CNSOPB is to regulate the exploration for, and development and production of, petroleum resources in their respective offshore areas. The offshore boards are responsible for issuing the following licences: exploration licence (9 year term, but if no work has occurred within 6 years the licence is forfeited); significant discovery licence (indefinite term); and, production licence (25 year term, but can be renewed if production is ongoing).

The offshore boards lead strategic environmental assessments (SEAs), which are used as a planning tool to inform the board on the environmental or socio-economic sensitivity of an offshore area. SEAs are completed in support of the land tenure process and occur prior to the issuing of an exploration licence. Project specific environmental assessments (EAs) are required prior to the authorization of any project. EAs can be led under the *Accord Act* by the respective board or under the *Canadian Environmental Assessment Act,* 2012, by the Canadian Environmental Assessment Agency (CEAA). The EA report is required to describe all mitigation measures that the proponent will implement.

For over ten years, a specific condition has been applied to authorizations of drilling activities in areas where cold-water corals may be present. Operators accomplish compliance by means of a Remotely-Operated Vehicle (ROV) survey of the area of a planned well site prior to conducting operations. Proponents of drilling programs also model the settling and subsequent seafloor deposition of well mud/cuttings; pre and post drilling ROV surveys are used to verify modelling results, but it was noted that they do not observe functionality of habitats.

The offshore boards conduct environmental effects monitoring (EEM) for development and production activities. DFO, CEAA, and Environment and Climate Change Canada (ECCC) are involved in EEM program design and/or reporting.

PRESENTATION 3: OFFSHORE OIL AND GAS OVERVIEW

Presented by Steve Bettles

The Canadian Association of Petroleum Producers (CAPP) is the voice of Canada's upstream (taking resources out of the ground) oil and gas industry and represents the companies that explore for, develop and produce natural gas and crude oil throughout Canada. There are currently two producing gas projects in Nova Scotia (Sable Offshore Energy Project and Deep Panuke), four producing oil projects in Newfoundland (Hibernia, Terra Nova, White Rose and Hebron), and ongoing exploration in both Newfoundland and Nova Scotia.

The lifecycle of an oil and gas field follows the following path: exploration (seismic, exploration drilling, delineation drilling); development (drilling wells, engineering, fabrication/construction); production (recovering the resource, transportation to market); and, decommissioning/abandonment (completion of project, removal of installation).

The potential environmental effects of oil and gas exploration and production are monitored through scientific programs in collaboration with regulators; however, most programs are focused on production projects as opposed to short term exploration wells. Studies have indicated that the benthic footprint of oil and gas exploration and production can be relatively small and reversible.

PRESENTATION 4: ENVIRONMENTAL EFFECTS MONITORING

Presented by Elisabeth DeBlois

The EEM program for the Terra Nova Field located on the Newfoundland Grand Banks was presented to meeting participants.

The main discharges from oil and gas activities include drill muds and cuttings from drilling operations, and produced water from production operations.

Given project discharges and other project activities, Suncor made a commitment in its development application to conduct an EEM program that would assess project effects on fish and fish habitat. The EEM program design was informed by the Terra Nova Environmental Impact Statement, modelling results for drill cuttings and produced water, and input from DFO, ECCC, academia, consultants and the public. There are three components to the Terra Nova EEM program: sediment (particle size, composition, concentration); commercial fish (Iceland Scallop and American Plaice chemical body burden, Iceland Scallop and American Plaice taint, and American Plaice health indicators); and, water (physical characteristics, chlorophyll, and chemical characteristics).

Elevated levels of drill mud constituents ($>C_{10}$-C_{21} hydrocarbons and barium) were observed in sediments with the highest levels of barium and hydrocarbons occurring within 1 to 2 km from drill centres. Hydrocarbon and barium levels were observed to decrease over time

corresponding with a decrease in drilling activity. Hydrocarbons and barium occurred in scallop viscera, while hydrocarbons occurred only in muscle tissue in some years. There was little evidence of drill mud constituents in plaice tissue.

Biological effects from discharges were limited. There was no evidence of effects on Microtox (bacterial luminescence) and evidence of effects on laboratory amphipods was limited to one station in some EEM years. Evidence of the effects on total benthic abundance, biomass and richness was weak or absent (depending on the year) beyond 140 m from drill centres; however, there was stronger evidence of effects on some individual benthic invertebrates. Scallop muscles and plaice fillets were not tainted and fish health was similar between Terra Nova and the Reference Area.

Overall the EEM program has determined that development drilling at Terra Nova has resulted in limited biological effects, which are highly localized, and all effects have been within predictions made in the Environmental Assessment.

Discussion

Participants commented that the EEM program at Terra Nova doesn't monitor dynamic parts of the environment very well, especially for the measurement of produced water and the movement of fine particles. For example, participants mentioned that the observed decrease in $>C_{10}$-C_{21} hydrocarbons and barium may be due to redistribution through sediment shifting rather than degradation.

OBJECTIVE 1: POTENTIAL IMPACTS OF OIL AND GAS EXPLORATION AND PRODUCTION ON AREAS WITH DEFINED BENTHIC CONSERVATION OBJECTIVES

Presentation

Presented by Tara Oak

The potential impacts on areas with defined benthic conservation objectives from the following oil and gas exploration and production activities were assessed:

- Seismic and electromagnetic surveys;
- Seabed surveys (geohazard, geotechnical and environmental sampling); and,
- Exploration/delineation/development drilling and production including the placement, retrieval and presence of structures, underwater noise, and drilling discharges (drill muds, cuttings, and produced water).

The potential impacts from underwater noise (e.g., seismic surveys, well drilling, pile-driving, piling the conductor, and vessel traffic) are death (immediate or delayed), tissue and/or physiological damage, hearing impairment, masking, behavioural response changes, and habitat changes from altered sediment reworking. Studies show evidence of physical, physiological and behaviour effects; however, there is conflicting evidence for noise-related physical trauma in fish and invertebrates. Significant data gaps exist for the impacts of noise on fish and invertebrates including but not limited to noise thresholds, physical impacts, and whether masking occurs in invertebrates.

Direct seabed disturbance can occur through physical seabed surveys, the placement and retrieval of seabed infrastructure, and drill muds and cuttings piles. Potential impacts from seabed disturbance include crushing, burial, fragmentation, smothering, and excessive particle loading which can obstruct feeding and gas exchange structures.

The potential impacts from discharges (drill muds, cuttings, and produced water) include smothering, excessive particle loading (obstruction of feeding and gas exchange structures), chemical toxicity (direct and/or sub-lethal), enrichment effects (oxygen deprivation), and sediment reworking (habitat alteration).

The introduction of hard substratum (on seabed) and hardscape (in water column) can result in colonisation by sessile epifauna and associates (including invasive species), habitat alteration, increased habitat connectivity, and altered species distribution.

Discussion

Potential impacts

Participants discussed potential impacts from the routine planned activities associated with oil and gas exploration and production which included: seismic surveys; controlled source electromagnetic surveys; geotechnical/geohazard surveys that may involve the physical collection of bottom samples (e.g., cores, grab samples); exploration and/or delineation drilling, including the placement of structures on the seabed and authorized discharges (e.g., drill muds, drill cuttings and cement); and development drilling and production including placement of structures on the seabed and authorized discharges (e.g., produced water, drill muds, and drill cuttings).

Although different activities are expected to have different potential impacts on areas with defined benthic conservation objectives it is also important to consider the difference between the spatial and temporal scale of the activities (e.g., for exploration vs. production activities). It is also important to note that there may be a difference between the activity footprint (e.g., infrastructure) versus the footprint of the impact area, which may be larger geographically and persist for a longer duration.

When considering impacts on areas with defined benthic conservation objectives the full range of biodiversity/ecosystem impacts must be considered as opposed to focusing only on the impacts to single species. Ecosystem functionality in areas with defined benthic components is largely unknown; however, the spatial extent of the habitat has been deemed important as well as the ecosystem services provided by the species and habitat. It's also important to consider not only strong impacts, but the potential for low level, more chronic impacts to these ecosystems.

Very few studies have been conducted on coral and sponge species in Canadian waters and little is known about coral and sponge reproductive biology; therefore, it is difficult to assess how they will respond to oil and gas activities. Potential impacts on areas with defined benthic conservation objectives could include everything from direct mortality to sub-lethal effects (e.g., tissue and/or physiological damage); the most likely effects are those that may elicit a behavioural response (e.g., displacement from preferred habitats, changes in movement patterns, delay or prevention of migration to spawning or feeding grounds; prevention of recruitment or settlement in preferred habitats; altered sediment reworking resulting in habitat changes).

Noise

There is great uncertainty around the potential impacts from underwater noise (e.g., seismic surveys, drilling activities, pile driving, dynamic positioning rigs, etc.) on areas with defined benthic conservation objectives including impacts on the benthic species, juveniles, and habitat functionality. Seismic surveys encompass a wide range of noise levels, frequencies, and sound pressures which makes the prediction of impacts difficult. 2D, 3D, 4D, and Vertical Seismic

Profiling (VSP) are different seismic techniques and may have different impacts on the benthic components

The following uncertainties about the potential impacts of noise were discussed:

- There are few field studies on the sensitivity of different species of marine benthos to sound; most of these studies are at the individual or population level and little is known about the community level and the potential for cumulative effects.
- Fish and invertebrates all have primary hearing below 500 Hz, which overlaps with the frequencies used for seismic exploration. It is important to note that although fish and invertebrates can hear below 500 Hz the potential impacts of the sound on these organisms are unknown.
- There is evidence that the ambient underwater noise baseline is increasing, which leads to greater uncertainty as to how animals may adapt and use sound as the baseline changes.

Studies on the impact of seismic surveys on invertebrates have not been conclusive: a recent study showed mortality of juvenile krill within 1.2 km from the airgun signal (McCauley et al. 2017), while the previously assumed impact range was only 10 m; another study did not detect a measurable impact of 2D seismic surveying on snow crab catch rates (Morris et al. 2018). Participants disputed the methodology and findings of the McCauley et al. (2017) paper as it has been highly criticized by experts in the field for a number of substantial experimental errors.

Ground-roll (low-frequency, low-velocity interface waves) has been suggested to impact organisms far from the source of the seismic noise; however, attempts to measure ground-roll have been unsuccessful, suggesting that the effects may not be as large as originally thought.

In general for most cases in the marine environment the effects of seismic surveys are behavioural (e.g., displacement from preferred habitats, changes in movement patterns, delay or prevention of migration to spawning or feeding grounds; prevention of recruitment or settlement in preferred habitats; altered sediment reworking resulting in habitat changes) or sub-lethal (e.g., tissue and/or physiological damage) as opposed to direct mortality.

Discharges

This review focused primarily on drilling muds and cuttings, and produced water (only produced during production phase) discharges and their potential impacts on areas with defined benthic conservation objectives. Activity footprint size and impact area differ between exploration and development wells, as the number of wells drilled increases from the exploration to development phase.

Drill muds and cuttings

Drill muds and cuttings are present in the exploration and production phase of oil and gas activities. The areal extent of drilling mud deposition is similar between exploration and development drilling activities on a per well basis; however, the time scale, volume of drilling waste, number of well sites and size and depth of deposition areas increases significantly from exploration to development drilling activities. It is also important to note the difference between the spatial scale of the activity footprint and the impact area (e.g., the downstream effects, including fine particulate transport). Deposition areas represent the coarser drilling mud materials; the fine materials may be transported further afield. It is difficult to measure the movement of fine particles in the field; therefore, modelling is required to predict their dispersion.

It was difficult to assess the impacts of drill muds and cuttings on areas with defined benthic conservation objectives as most of the literature available is based on laboratory studies or

studies in shallow waters, whereas these specific benthic habitats are found in deep water environments. Little is known of the reproductive biology of sponges and corals (approx. 70 species)

Produced water

Produced water only occurs during the production phase and typically comprises the largest volume of waste from offshore oil and gas production with tens of thousands of barrels treated and discharged daily at sea in accordance with the Offshore Waste Treatment Guidelines.

Produced water has undesirable properties (e.g., highly saline, anoxic, contaminants, naturally radioactive material, and high nutrient levels) and the composition of materials varies depending on the reservoir. The excess nutrients (nitrogen and phosphorous) associated with produced water may have impacts on benthic-pelagic coupling due to changes in primary productivity which could increase sedimentation and alter the delivery of material to the seafloor. It was also suggested that the delivery of contaminants can affect a large area and be extended beyond the cuttings pile.

The behaviour of produced water is difficult to assess in the field and to model because it flocculates and effects may change over time as it disperses. The eventual fate of produced water contaminants remains unknown.

Infrastructure

Oil and gas exploration and development activities are associated with different types of infrastructure placed on the bottom, which may include anchors, transmitters, pipelines, flowlines, and wellheads/blowout preventers and anti-fouling paints. The scale of infrastructure can range from small with exploration drilling (e.g., one wellhead benthic footprint of $1m^2$) to large during the development phase. The impacts of infrastructure are dependent on the type of facility used and the activity phase. Infrastructure introduces vertical hardscape and hard substratum that can be colonized by sessile organisms; however, the placement of the infrastructure can disturb sediments and possibly crush organisms. Some corals and sponges need to be perfectly upright or they cannot feed, which means that even a slight disturbance can result in mortality. Other potential impacts to areas with defined benthic conservation objectives include habitat fragmentation (i.e., some organisms will not cross pipelines), introduction of aquatic invasive species, and suspension feeding arrest and/or metabolic arrest due to disturbance.

There is also a need to consider impacts from dredging for iceberg protection in areas such as Newfoundland, which can create a large seabed footprint and piling of dredge spoils.

Cumulative impacts

Although not assessed at this meeting, participants agreed that cumulative assessments are necessary to consider all impacts from all activities over time (e.g., impacts from oil and gas, fishing, shipping, etc.) in areas with defined benthic conservation objectives.

Cumulative effects must be considered as a result of one operation (exploration, development, production, number of wells at the site) over time and in terms of other activities that may cumulatively affect the valued benthic components in the area.

Monitoring

Environmental effects monitoring (EEM) surveys have been conducted at least biennially at producing fields in Nova Scotia and Newfoundland for the life of the field starting in the first year of production. EEM surveys include measurements of sediment (e.g., particle size, infauna, physical and chemical characteristics), water (physical and chemical characteristics), and biota

(including toxicity, benthos, fish body burden, histopathology). It is important to note that there is no formal EEM structure for exploratory wells and current EEM programs do not explicitly monitor areas with defined benthic conservation objectives as current projects do not operate in these areas.

OBJECTIVES 2 AND 3: THE EFFECTIVENESS OF EXISTING MITIGATION MEASURES FOR ACTIVITIES ASSOCIATED WITH OIL AND GAS EXPLORATION AND PRODUCTION IN RELATION TO THE IDENTIFIED IMPACTS ON AREAS WITH DEFINED BENTHIC CONSERVATION OBJECTIVES

Presentation

Presented by Tara Oak

It was difficult to assess the effectiveness of mitigation measures as there was insufficient scientific literature available on the topic. Instead a list of possible mitigation measures was provided for discussion.

Mitigation measures are ideally identified and implemented in accordance with the widely-accepted mitigation hierarchy of: avoid; minimize/reduce; and, offset/compensate. In order to avoid and minimize potential impacts on significant benthic areas participants agreed that these areas must be identified and mapped. Then risk management strategies and mitigation measures should be applied.

Mitigations for seismic surveys include: reducing the amount of energy used; restricting survey boundaries to only include essential areas; modifying the timing and/or duration (e.g., to avoid spawning periods); and avoid multiple surveys in one area.

Seabed imagery can be used to identify, map and quantify areas with defined benthic conservation objectives. In order to confirm the presence or absence of significant benthic areas drop camera/video system transects can be used.

Setbacks can be applied to planned well and infrastructure locations to avoid areas with defined benthic conservation objectives. Minimum proposed setbacks for areas with defined conservation objectives are 200 m from seafloor infrastructure with no expected discharges, and 2 km from any discharge points and/or surface (i.e. floating) infrastructure. A cuttings transport system could also be used to transfer drill muds and cuttings to a discharge location with sufficient setback from an area with a defined benthic conservation objective.

Available mitigation measures for drill muds and cuttings focus on methods and technologies that reduce the volume of drilling fluids required and the amount of drill cuttings generated. A mud recovery system could be used during riserless (top-hole) drilling to return drill mud and cuttings to the rig for alternate use or disposal. The reinjection of cuttings could be considered for production platforms. Cluster and/or directional drilling may be considered as a way to concentrate discharges in one location and/or access reservoirs under areas with defined benthic conservation objectives.

Mitigations for produced water focus on generating less produced water by modifying processes, adapting technologies, or substituting products. Produced water can be recycled/reused by reinjecting it to enhance oil production and/or maximize oil recovery. Innovative treatment methods also exist for produced water, such as membrane technology, evaporation, and ion exchange.

Pipeline mitigations include conducting an ROV survey of the proposed route to determine the presence of sensitive species and/or habitats. If sensitive species and/or habitats are found then

the pipeline route should be adjusted using an applicable setback distance (e.g., 50 m from corals and other sensitive benthic species and habitats (DNV 2013), 200 m from seafloor infrastructure with no expected discharges (Cordes et al. 2016)).

Discussion

The major challenge to identifying effective mitigations is the lack of information on impacts from oil and gas exploration and production activities.

Participants compared the benefits and limitations of different types of imaging gear and technologies used to identify and characterize benthic habitats:

- ROVs can provide non-destructive habitat imaging, but they can't travel long distances due to tethering.
- Acoustic imaging technology is only useful in areas with dense aggregations of corals and sponges.

Currently, operations in Canadian waters avoid colonies of corals when placing infrastructure on the seabed. This decision is based on ROV surveys (e.g., approx. 500 m long transects, 10 m apart) at exploration sites. The trigger to avoid an area is based on the presence of an iconic species of coral (*Lophelia*) more than 30 cm above the substrate. Because this species is rare in Canadian waters and native corals and other benthos can extend <30 cm above the seabed, better indicator species are required.

Participants agreed that with minimal literature available on the impacts of oil and gas exploration and production on areas with defined benthic conservation objectives and the effectiveness of mitigation measures for those impacts, that activities in these areas should be managed with greater risk aversion than activities in areas without these features.

Available mitigation measures for noise were developed for marine mammals and may not be effective in areas with defined benthic conservation objectives. It is also difficult to apply mitigation measures for noise as the impacts of noise on areas with defined benthic conservation objectives are unknown.

Utility of the following mitigation measures was discussed at the meeting:

- Buffer zones or "setbacks" could be used as a tool to restrict exploration and production activities in areas with defined benthic conservation objectives. Setback distances should be determined through a combination of predictive dispersion modelling, species and habitat distribution modelling and imaging from ROV surveys to determine the appropriate buffer zone. For example, the predictive dispersion model and the habitat suitability model could be overlaid and then ROV surveys could be applied to the areas of overlap to identify whether there is a risk of potential impacts. If dispersion models are unavailable then a minimum 2 km setback distance from discharging infrastructure should be applied.
- Directional drilling could be used to access resources beneath an area with defined benthic conservation objectives by accessing the resources from outside the proposed buffer zone.
- Reinjection techniques for drill cuttings currently used in Canada at Hebron and Hibernia may be useful for minimizing discharge from drilling activity.

Mitigation measures should ideally be identified and implemented in accordance with the DFO Fisheries Protection Policy Statement (2013) "mitigation hierarchy" of: (1) avoid; (2) mitigate; and (3) offset (recognizing that offsetting will not generally be compatible with benthic conservation objectives). Offsetting is not effective for areas with defined benthic conservation objectives as there is no way to offset these unique, structurally complex habitats. The optimal

mitigation measure avoids the impact entirely by eliminating the possibility of interaction between the activity and the area with the defined benthic conservation objective, thereby removing all potential pathways of effects.

Mitigation measures should be continually assessed for effectiveness as technology continues to improve and new, more effective mitigations may become available.

OBJECTIVE 4: RECOMMENDATIONS ABOUT WHICH MITIGATION MEASURES ARE MOST EFFECTIVE IN AREAS WITH DEFINED BENTHIC CONSERVATION OBJECTIVES AND THE DEGREE TO WHICH THEY ARE CONSISTENT WITH THE ACHIEVEMENT OF BENTHIC CONSERVATION OBJECTIVES IN THE CANADIAN CONTEXT

An attempt was made to address Objective 4 as a group discussion at the meeting due to the lack of peer reviewed literature on the effectiveness of mitigation measures in areas with defined benthic conservation objectives; however, due to the lack of peer reviewed literature participants did not feel that they could adequately assess the effectiveness of potential mitigation measures.

Participants agreed that mitigation measures should be identified and implemented in accordance with the “mitigation hierarchy” of: (1) avoid; (2) mitigate; and (3) offset (recognizing that offsetting will not generally be compatible with benthic conservation objectives). Therefore, the optimal mitigation measure is avoidance of the area with defined benthic conservation objectives. All other mitigations should be assessed on a case-by-case basis.

MAIN CONCLUSIONS AND RECOMMENDATIONS

The activities and geographic scales differ between the oil and gas exploration and production phases; therefore, the level of impact and required mitigation measures may also differ.

The main potential impacts to benthic species and habitats from exploration and delineation drilling are associated with placing infrastructure on the seabed, and depositing drill muds and cuttings at the seafloor and/or in the water column. Compared to exploration drilling, development drilling and production are generally considered to have increased risks of impacts to benthic species and habitats, with additional activities, greater seabed footprints and longer timeframes.

Most studies on the impacts of oil and gas activities have been conducted in the lab or on the continental shelf and may not be reflective of impacts in deep waters as the scale and magnitude of impacts may differ. Ecosystem-based studies are required to characterize the ecological processes and functions of benthic features associated with benthic conservation objectives, and to determine how functional roles, features and/or habitats protected through benthic conservation objectives, including community/food web dynamics, can be impacted by oil and gas related activities.

This review was unable to assess the general effectiveness of mitigation measures in reducing the impacts from oil and gas exploration and production on areas with defined benthic conservation objectives due to the limited number of scientific studies available. However, avoidance (spatial, temporal, and/or activity) was identified as the most effective means of protecting areas with defined benthic conservation objectives.

This review highlights the need for the development of a regionally appropriate species list and criteria for setback distances to support determination of what level of coral and/or sponge occurrences/densities (or associated features and species) are consistent with significant

concentrations in Canadian waters. There is also a need for consistent descriptions and definitions relating to areas with defined benthic conservation objectives within and across agencies.

This review focused on offshore activities with most examples from the Atlantic offshore, and did not explicitly address the fact that impacts and mitigation measures may differ between offshore and nearshore/estuarine environments, and in Arctic environments.

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APPENDIX A: TERMS OF REFERENCE

Assessment of the Effectiveness of Mitigation Measures in Reducing the Potential Impacts of Oil and Gas Exploration and Production on Areas with Defined Benthic Conservation Objectives

National Peer Review – National Capital Region

Date: June 26-28, 2018
Location: St. John's, Newfoundland

Chairperson: Mike Chadwick

Context

The Government of Canada is committed to increasing the protected coastal and marine areas of Canada to 10% by 2020, as agreed to through international Aichi Biodiversity Target 11 and domestic Biodiversity Target 1. To achieve this goal, marine protected areas (MPAs) and other effective area-based conservation measures (OEABCMs) are being established. Many MPAs and OEABCMs have valued benthic components with defined conservation objectives. Valued benthic components defined in conservation objectives can include: benthic species (fish and invertebrates); benthic habitats including benthic spawning, nursery and feeding grounds; and Sensitive Benthic Areas (SBAs) including corals, sponges, canyons and other benthic features where corals or sponges are likely, seamounts, and hydrothermal vents.

Oil and gas exploration and production activities considered at this meeting will include seismic surveys, controlled source electromagnetic surveys and geotechnical/geohazard surveys that may involve the placement of structures on the bottom or physical collection of bottom samples (cores/grabs), and drilling-related activities which may have direct or indirect impacts on valued benthic ecosystem components. Although there are other activities related to oil and gas exploration and production (accidental events, decommissioning, etc.) these are the subject of other CSAS reviews[1] and so we have limited the scope of this meeting to only include those activities listed above. The Minister of Fisheries, Oceans and the Canadian Coast Guard

[1] Identifying Research Requirements for the Biological Effects of Oil and Gas Industry-Related Contaminants on Aquatic Ecosystems (March 2014)

Review of the Net Environmental Benefits of Dispersant Use for Responding to Oil Spills from Oil and Gas Facilities on the Newfoundland Grand Banks (April 2014)

A framework for assessing vulnerability of aquatic ecosystems to ship-source oil spills (March 2016)

Evaluation of Pacific Region application of a National Framework to assess the vulnerability of biological components to ship-source oil spills in the marine environment (September 2016)

Vulnerability assessment of biological components of the St. Lawrence to ship-source oil spills (January 2017)

Towards the Development of Toxicity Standard Methods to Evaluate Biological Effects of Heavy Oils on Aquatic Ecosystems (January 2017)

Status Report on the Knowledge of the Fate and Behaviour of Diluted Bitumen in the Aquatic Ecosystems (April 2017)

Development of Guidelines for the Sampling of Marine Biota following the Accidental Release of Oil Products in Canada (expected July 2018)

recently announced the formation of a National Advisory Panel on Marine Protected Area Standards, which will gather perspectives and offer recommendations to the Minister on categories and associated protection standards for federal MPAs, using the International Union for the Conservation of Nature (IUCN) guidance as a baseline. The degree to which oil and gas activities are compatible with MPAs is expected to be a topic of interest to the panel.

Oceans Management is seeking national guidance and advice on the effectiveness of existing mitigation measures in reducing the impacts of oil and gas exploration and production activities in Canadian waters, including seismic surveys and drilling, on areas with defined benthic conservation objectives. The advice generated from this request will be used to refine policy related to oil and gas activities in areas with defined benthic conservation objectives (such as MPAs and OEABCMs), and will provide guidance to share with other federal departments and oil and gas industry partners. The scientific advice from this meeting will also be provided to the Panel prior to providing their recommendations to the Minister in a final report by September 15, 2018.

Objectives

The objectives of the science peer review meeting are to provide advice on the potential impacts of oil and gas exploration and production on areas with defined benthic conservation objectives and to assess the effectiveness of potential mitigation measures in the Canadian context. Specifically, the meeting will review:

1) The extent and significance of potential impacts of oil and gas exploration and production activities on valued benthic components, including benthic species (fish and invertebrates); benthic habitats such as spawning, nursery and feeding grounds; and Sensitive Benthic Areas (SBAs) including corals, sponges, seamounts, and hydrothermal vents. For the purpose of this meeting “exploration and production activities” includes:
    - seismic surveys, in particular sound energy emitted from these surveys;
    - controlled source electromagnetic surveys, (that may include placement of structures/materials on the seabed);
    - geotechnical/geohazard surveys that may involve the physical collection of bottom samples (e.g., cores, grab samples)
    - exploration and/or delineation drilling, including placement of structures on the seabed and authorized discharges (e.g. water and synthetic based muds, drill cuttings and cement) associated with the activities, and recovery/removal of wellheads and/or related structures; and
    - development drilling and production, including placement of structures on the seabed and authorized discharges associated with the activities, and recovery/removal of related structures; but excluding accidental events and decommissioning.
2) The effectiveness of existing mitigation measures for activities associated with oil and gas exploration in relation to the identified impacts to valued benthic components.
3) The effectiveness of existing mitigation measures for oil and gas production in relation to the identified impacts to the valued benthic components.

4) Recommendations about which mitigation measures are most effective in areas with valued benthic components and the degree to which they are consistent with the achievement of benthic conservation objectives in the Canadian context.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Expected Participation

- Fisheries and Oceans Canada (DFO) (Ecosystems and Oceans Science, Aquatic Ecosystems, Fisheries and Harbour Management)
- Other federal departments
- Academia
- Industry
- Invited experts

APPENDIX B: MEETING PARTICIPANTS

Name	Affiliation
Mike Chadwick	Chair
Tara Oak	Paita Environmental Consulting Inc.
Caroline Longtin	DFO Science, National Headquarters
Lesley MacDougall	DFO Science, Pacific
Lisa Setterington	DFO Science, National Headquarters
Jessica Mitchell	DFO Oceans Management, National Headquarters
Miriam O	DFO Science, Pacific
Christine Desjardins	DFO Science, Québec
Guy Cantin	DFO Science, Québec
Alice Ortmann	DFO Science, Maritimes
Michael Wambolt	DFO Fisheries Protection Program, Maritimes
Keith Clarke	DFO Science, Newfoundland and Labrador
Corey Morris	DFO Science, Newfoundland and Labrador
Stephen Snow	DFO Oceans Management, Newfoundland and Labrador
Candace Newman	Natural Resources Canada, National Headquarters
Susanna Fuller	Oceans North
Sigrid Kuehnemund	World Wildlife Fund (WWF)
Janice Ray	Canada-Nova Scotia Offshore Petroleum Board (CNSOPB)
Elizabeth Young	Canada-Newfoundland Offshore Petroleum Board (C-NLOPB)
Steve Bettles	Canadian Association of Petroleum Producers
Heather Giddens	Canadian Association of Petroleum Producers
Marina Petrovic	DFO Resource Management, National Headquarters
Jason Simms	DFO Resource Management, Newfoundland and Labrador
Evan Edinger	Memorial University
Jinshan Xu	DFO Science, Maritimes
Kent Gilkinson	DFO Science, Newfoundland and Labrador
Vonda Wareham	DFO Science, Newfoundland and Labrador
Johan Joensen	Fish, Food and Allied Workers (FFAW)
Mariano Koen-Alonso	DFO Science, Newfoundland and Labrador
M. Robin Anderson	DFO Science, Newfoundland and Labrador
Darrin Sooley	DFO Fisheries Protection Program, Newfoundland and Labrador
Nadine Templeman	DFO Science, National Headquarters
Bob Courtney	Natural Resources Canada, Geological Survey of Canada
Melissa Preston	Natural Resources Canada
Cheryl Benjamin	Canadian Environmental Assessment Agency (CEAA)
Elisabeth DeBlois	Elisabeth DeBlois Inc.
Written reviews	
Arthur Popper	University of Maryland
Kevin Hedges	DFO Science, Central and Arctic

APPENDIX C: MEETING AGENDA

Canadian Science Advisory Secretariat

National Peer Review Process

AGENDA

Assessment of the Effectiveness of Mitigation Measures in Reducing the Potential Impacts of Oil and Gas Exploration and Production on Areas with Defined Benthic Conservation Objectives

June 26-28, 2018
St. John's, Newfoundland and Labrador
Chair: Michael Chadwick

Draft agenda: All times are subject to change depending on discussions

DAY 1 – Tuesday, June 26

Time	Subject	Presenter
09:00	Introductions Review Agenda and Housekeeping CSAS Overview and Procedures	Chair
09:15	Review Terms of Reference	Chair
09:30	Context Setting	Oceans Management
10:00	**HEALTH BREAK**	
10:15	Presentation and Discussion	CNSOPB/C-NLOPB All Participants
10:45	Presentation and Discussion • Activities and mitigation measures	CAPP All Participants
11:15	Presentation and Discussion • Environmental effects monitoring program	CAPP All Participants
12:00	**LUNCH BREAK**	

Time	Subject	Presenter
13:00	Presentation of Working Paper • TOR Objective 1 – potential impacts of oil and gas exploration and production on valued benthic components (benthic species (fish and invertebrates), benthic habitats, and SBAs)	Author
13:45	Discussion of TOR Objective 1 • Create a table of potential impacts separated into exploration and production activities and by benthic component type (benthic species (fish and invertebrates), benthic habitats, and SBAs) where possible to address the likelihood of impact, the level of impact, and the estimated zone of impact	All Participants
14:45	**HEALTH BREAK**	
15:00	Continue discussion and table for TOR Objective 1	All Participants
17:00	**Adjourn for Day**	

DAY 2 – Wednesday, June 27

Time	Subject	Presenter
09:00	Review of Day 1	Chair
09:15	Presentation of Working Paper • TOR Objectives 2 and 3 – effectiveness of existing mitigation measures to reduce the potential impacts of oil and gas exploration and production on valued benthic components (fish, invertebrates, benthic habitats, and SBAs)	Author

Time	Subject	Presenter
09:45	Discussion of TOR Objectives 2 and 3 • Create a table to compare the effectiveness of mitigation measures for potential impacts of oil and gas exploration and production on valued benthic components (benthic species (fish and invertebrates), benthic habitats, and SBAs) • Rank the mitigation measures in terms of effectiveness	All Participants
10:15	**HEALTH BREAK**	
10:30	Continue discussion and table for TOR Objectives 2 and 3	All Participants
12:15	**LUNCH BREAK**	
13:15	Discussion of TOR Objective 4 • Determine if any measures or combination of measures can be applied to meet benthic conservation objectives for benthic species (fish and invertebrates), benthic habitat and/or SBAs	All Participants
14:45	**HEALTH BREAK**	
15:00	Discussion – all objectives	All Participants
17:00	**Adjourn for Day**	

DAY 3 – Thursday, June 28

Time	Subject	Presenter
09:00	Review of Days 1 and 2	Chair
09:15	Science Advisory Report (SAR) Development including Consensus on: • Summary Bullets • Sources of Uncertainty • Results and Conclusions	Author
10:15	**HEALTH BREAK**	

Time	Subject	Presenter
10:30	Science Advisory Report (SAR) Development including Consensus on: • Summary Bullets • Sources of Uncertainty • Results and Conclusions	All Participants
12:00	**LUNCH BREAK**	
13:00	Science Advisory Report (SAR) Development including Consensus on: • Summary Bullets • Sources of Uncertainty • Results and Conclusions	All Participants
14:45	**HEALTH BREAK**	
15:00	Science Advisory Report (SAR) Development cont'd including Consensus on: • Summary Bullets • Sources of Uncertainty • Results and Conclusions	All Participants
16:30	Next Steps: • SAR review/approval process and timelines • Research Document & Proceedings timelines Other follow-up or commitments (*as necessary)*	Chair
17:00	**Adjourn Meeting**	