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Proceedings of the Regional Peer Review on Coral and Sponge Mitigations in Relation to Exploratory Drilling Programs in the Newfoundland and Labrador Region

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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

The Fish and Fish Habitat Protection Program (FFHPP) of the Ecosystems Management Branch (EMB) of the Department of Fisheries and Oceans, Canada (DFO) ensures compliance with relevant provisions under the *Fisheries Act* and the *Species at Risk Act*. The FFHPP reviews proposed works, undertakings and activities that may impact fish and fish habitat. This science peer review meeting was held to review the potential impacts of exploratory drilling programs on corals and sponges and to provide science advice on techniques and methods for the avoidance and mitigation of these impacts. Participation in this meeting included representatives from Fisheries and Oceans Canada (DFO-Ecosystems Management and Aquatic Resources Branches), Impact Assessment Agency of Canada (IAAC), Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB), CAPP (Canadian Association of Petroleum Producers), the Newfoundland and Labrador Provincial Department of Fisheries and Land Resources, Fish Food and Allied Workers (FFAW), and invited experts from academia and the non-governmental organization (NGO) sector.

This Proceedings Report includes abstracts of presentations and summaries of meeting discussions, as well as a list of research recommendations. The meeting's Terms of Reference, agenda, and list of participants are appended. A Science Advisory Report and a Research Document were also produced from this process.

PRESENTATIONS

OPENING REMARKS

Presented by J. Kelly

Abstract

Ecosystems Management, specifically the Fish and Fish Habitat Protection Program (FFHPP) reviews proposed works, undertakings, and activities in or around water and provides advice and guidance to proponents to enable them to avoid and mitigate impacts to fish and fish habitat. In situations where a project cannot avoid harm to fish or fish habitat, the FFHPP may issue an Authorization for impacts, which prescribes measures for minimizing and offsetting that harm.

The FFHPP also provides expert advice to the Impact Assessment Agency of Canada (IAAC) as per responsibilities under the Impact Assessment Act (IAA) and as per the Memorandum of Understanding Concerning Participation of Federal Authorities in Impact Assessments under the Impact Assessment Act between the Impact Assessment Agency of Canada (IAAC) and Fisheries and Oceans Canada (DFO), as well as to the Canada-Newfoundland Offshore Petroleum Board (C-NLOPB) as per the Memorandum of Understanding between C-NLOPB and DFO during the review of oil and gas activities.

Ecosystems Management is developing regionally specific guidance to minimize impacts on corals and sponges from offshore exploratory drilling activities and is seeking scientific advice to assist in its development. In addition to Science advice, the guidance will also take into consideration other information such as existing marine protection standards and policies, international best management practices and socio-economic factors.

Discussion

By definition, mitigation efforts seek to minimize, but cannot completely eliminate, adverse impacts of human activity. Meeting participants sought guidance from FFHPP on the limit of residual impacts that may be acceptable with mitigation measures, and serious impacts that would either prohibit activity or require special authorization. FFHPP representatives clarified that spatial extent and temporal persistence are important factors in risk assessment. FFHPP staff currently assess anticipated impacts of proposed activities to determine if the residual impacts, following implementation of mitigation measures, are harmful to fish and fish habitat. There were participants present that felt the ultimate mitigation is not to proceed with an activity, however limited the potential impact. Several participants also argued that evaluating effects of exploratory drilling in isolation is inappropriate to the goal of the process. The goal of exploratory drilling is to achieve production, and production effects are anticipated to be much larger than those of exploratory drilling.

CORAL AND SPONGE SPECIES IN NEWFOUNDLAND AND LABRADOR

Presented by V. Wareham-Hayes

Abstract

Fisheries and Oceans Canada (DFO) in the Newfoundland and Labrador (NL) Region has been conducting research on cold water coral and sponge species from 2005-present (DFO 2010, DFO 2011, DFO 2017), aiming to identify key areas for conservation and protection, assess

vulnerability to anthropogenic activities, and investigate ecosystem functions provided by these key benthic taxa (e.g., carbon cycling, food-web linkages, habitat provision). Corals and sponges are sessile benthic animals living on or within the sea floor. Data are collected from DFO Multispecies Trawl Surveys (2005–19) and partnership surveys that are standardized and stratified. Supplementary data collected using smaller trawls and Remotely Operated Vehicles (ROVs) are also used. Spatial coverage extends from Baffin Bay to the Grand Banks of Newfoundland and Labrador with additional information from adjacent regions. To date, there are ~78 coral species and ~100 species of deep-sea sponges documented in the NL Region. Species are divided into functional groups based on general morphologies, habitat preferences, and/or life history traits. They include gorgonians, soft corals, sea pens, black-wire corals (black corals), stony cup corals, hydrocorals, and sponges. Based on supplementary data, corals and sponges can form large scale habitats (m's to km's), with some communities in existence for thousands of years. Corals are slow growing, long lived (i.e., decades to centuries) and sensitive to changes in pH due to their calcium carbonate structures. Far less is known about sponges. Even with the advances accomplished to date, significant knowledge gaps remain with respect to diversity, abundance, densities, connectivity, associations, reproduction, recovery, recruitment, and climate change induced impacts.

Discussion

Participants were interested in the data sources described by this presentation, and specifically whether data derived from ROV surveys associated with exploratory drilling surveys have been incorporated into regional records of corals and sponges. Coral and sponge data from oil and gas surveys had not been shared with DFO Science in the past, despite multiple requests. However over the last six months, FFHPP has requested access to the ROV footage, and has received video for three projects. Although at the time of the plenary meeting, these data had not yet been made available to Science.

Questions were also raised about trends in abundance, density, and distribution over time. The collection of distribution records and identification of coral and sponge species by the DFO Research Vessel (RV) Survey in Newfoundland and Labrador waters were inconsistent until the mid-2000s. As a result, the available time-series of coral and sponge data in this region represents remnants of populations that have been severely impacted by a long history of trawl fisheries.

There are, however, some historical records that offer a comparison to current conditions. Reports from the 1960s (DFO, unpublished data) indicate that the abundance and distribution of gorgonians was much greater, particularly in shallow depth ranges where these species are no longer found on the Grand Banks and Flemish Cap. The remaining high-density coral and sponge habitats identified by scientific surveys over the past 15 years do not overlap with the commercial fishing footprint, with the exception of Northern waters where emerging fisheries are encountering relatively intact coral and sponge habitats. This suggests that we are now surveying a greatly reduced distribution. The DFO RV Survey, which provides the majority of benthic data for this region, including corals and sponges, was designed to sample commercial groundfish, although in 1995–96 the trawl type was changed to a shrimp trawl to enable more inclusive sampling. The RV survey is restricted by depth (<1500 m) and limited to trawlable habitat, and therefore does not capture corals and sponges in deep water, on high slopes, or on hard bottom. ROV video surveys, like those associated with oil and gas activities, have been identified as a more appropriate, non-destructive survey method for these species (Gilkinson and Edinger 2009; Chimienti et al. 2018). Several participants emphasized the importance of sharing industry data with DFO Science in order to better understand coral and sponge distribution, ecology, and to improve science advice on the conservation of these species.

EXISTING SPECIAL AREAS

Presented by N. Wells

Abstract

Several areas have been identified in the NL Region based on significant concentrations of corals and sponges. Some have been protected using various forms of legislation such as the *Fisheries Act* and the *Oceans Act*. In most cases, these areas are protected from bottom contact fishing, but other forms of protective measures have also been implemented. For example, Laurentian Channel Marine Protected Area regulations prohibit oil and gas exploratory drilling, submarine cable installation, and anchoring. This presentation discussed special areas for corals and sponges including Vulnerable Marine Ecosystem (VME) habitats and closures, Significant Benthic Areas (SiBAs), Ecologically and Biologically Significant Areas (EBSAs), and those areas protected through legislation including Marine Refuges (MRs), and Marine Protected Areas (MPAs).

In 2009, the Food and Agriculture Organization (FAO) defined concentrations of coral and/or sponge species as VMEs (FAO 2009), leading to the eventual delineation of 30 VME habitats (9 large gorgonian VMEs, 14 sponge VMEs, and 7 sea pen VMEs) and the subsequent closure of 20 areas to bottom-contact fishing gear in international Northwest Atlantic Fisheries Organization (NAFO) Regulatory Area (NRA) waters.

In 2019, Kenchington et al. performed Kernel Density Estimation (KDE) analyses on data beyond the Canadian Exclusive Economic Zone (EEZ) to support the generation of updated VME habitats for large gorgonians, sea pens, and sponges. New VME habitats for small gorgonians and black corals were also delineated at that time. These updates have not yet been adopted by NAFO, but were made available to this meeting for comparisons with existing VME habitats.

Additional work by DFO Science has led to the identification of SiBAs for large gorgonians, small gorgonians, sea pens, and sponges, which are similar to VMEs but are located within domestic waters. SiBAs are defined in DFO's Ecological Risk Assessment Framework (O et al. 2015) as "significant areas of cold-water coral and sponge dominated communities", where significance is determined "through guidance provided by DFO-led processes based on current knowledge of such species, communities and ecosystems". SiBAs for black corals do not exist at this time within the EEZ as limited observations in the region have prevented their delineation. However, NAFO recently developed VME polygons for black corals once additional years of data allowed for the analysis to be completed (Kenchington et al. 2019).

EBSAs are areas identified through science-led processes that call attention to areas of particularly high natural value. Their identification and description are meant to facilitate the provision of a greater-than-usual degree of risk aversion in management of activities in such areas. A total of 29 EBSAs have been identified throughout the NL region based on the criteria of uniqueness, aggregation, and fitness consequences. Some of these areas were identified based on significant concentrations of coral and sponge species. EBSAs are a priority for protection as part of MPA network planning.

EBSAs have also been identified at Regional Workshops held by the Convention on Biological Diversity. There are several large EBSAs located outside the EEZ that have been identified for various reasons. For example, the Slopes of the Flemish Cap and Grand Bank EBSA contains most of the aggregations of VME indicator species in the NAFO Regulatory Area.

Twelve Marine Refuges (MRs) have been established by DFO as Other Effective Area-based Conservation Measures (OECMs) in the NL Region. Five of these MRs have conservation

objectives related to the protection of corals and sponges within the NL bioregion. Three of the areas (Northeast Newfoundland Slope, Hopedale Saddle, and Hatton Basin) were delineated based on the distribution of SiBAs, but the areas protect only a portion of the SiBA boundaries.

In 2019, the Laurentian Channel, originally identified as an EBSA, was officially designated as the third *Oceans Act* MPA in the NL Region. One of the conservation objectives is the protection of corals, particularly significant concentrations of sea pens, from harm due to human activities. At present, no additional Areas of Interest (AOIs) have been formally announced in the NL bioregion.

With the exception of the Laurentian Channel MPA, there are no locations in the NL offshore area where exploratory drilling is currently prohibited. However, because special areas contain heightened concentrations of corals and sponges, the severity of impacts resulting from anthropogenic activities are likely to be elevated in these areas.

Discussion

Meeting participants discussed the distinction between ecological boundaries defined by science and boundaries that are delineated for the purpose of marine management. SiBAs and VME habitats are identified based on the best available knowledge of high-density coral and sponge habitats. EBSAs consider many ecological factors, including coral and sponge habitat. MPAs and MRs are designated based on many factors including science advice on distribution and vulnerability of marine habitats, socioeconomic concerns, and stakeholder input. The EEZ forms an artificial boundary to seafloor habitats delineated by Canadian science and management efforts, despite the fact that corals and sponges extend beyond jurisdictional limits. In international waters, NAFO has identified VMEs, which are closely comparable to SiBAs. For these reasons, there are sometimes boundary differences between areas identified by Science (VME habitats, SiBAs, EBSAs) and the areas identified for management measures (MPAs, MRs, NAFO Fisheries Closures Areas). It was also pointed out that MRs have not been delineated based solely on sensitive benthic habitats – the boundaries were negotiated to maintain key fishing areas, or to protect other species.

NAFO is currently in the process of analyzing the adequacy of their closures and carrying out an assessment of the adverse impacts on marine habitats. The VMEs represent the remaining high concentration habitats for each group; the extent for many of these species was larger in the past, and what is seen now is what is left after a history of anthropogenic impacts.

Similar methods (e.g., KDE) have been applied to the delineation of SiBAs and VMEs, except for the Northeast Slope SiBA boundaries which were defined by species distribution models. The change in method reflects the evolution of data analysis tools available to DFO Science, as well as the analytical capacity. DFO RV survey data, and similar data from other countries, have typically been used to conduct these analyses. However, ROV and other imagery data have been used to extend the boundaries of VMEs beyond fishable habitats.

EXPLORATORY DRILLING IN NEWFOUNDLAND AND LABRADOR

Presented by L. Gullage

Abstract

Exploratory drilling in the NL region began in 1966. As of January 2019, 172 exploration wells had been drilled, and 30 active exploration licenses had been granted. To provide an understanding of the potential impacts associated with oil and gas exploration on corals and sponges, a general overview of the associated activities was described. The types of impact

were outlined for the various platform types (e.g., jack-up, semi-submersible, etc.), positioning mechanisms (e.g., dynamic positioning, anchoring), and stages of exploratory drilling (e.g., positioning, drilling, abandonment). The potential effects on coral and sponge species in the NL region were also described based on the type of impact (physical or chemical), the effects pathways, and the associated temporal and spatial impacts as described in the literature.

Discussion

For the purposes of this report, a broad literature review was conducted and all substances associated with exploratory drilling with demonstrated adverse effects on corals and/or sponges (acute or chronic) are included in the reported list of potential toxins. With the exception of *Lophelia pertusa*, there is very little research on the toxicity of drilling muds, hydrocarbons, and dispersant chemicals for corals and sponges. *L. pertusa* has not been identified in Newfoundland waters, and these findings may not be relevant to local species. One participant noted that following the Deepwater Horizon disaster, extensive research was conducted to identify exposure thresholds for Louisiana crude oil and associated dispersants for coral and sponge species, including two genera also found in the NL Region (DeLeo et al. 2015; Luter et al. 2019). Investigation of the impacts of exposure to oil and dispersants on gene expression among coral species is currently underway (Erik Cordes, Pers. Comm.). Coral and sponge experts working in the NL region agreed that this information, like studies on *Lophelia pertusa*, may offer general guidance and/or inform further research, however they represent very different conditions and should not be applied directly to Newfoundland and Labrador without validation.

Meeting participants agreed that in the absence of species-specific studies on toxicity thresholds relevant to the NL ecosystem, the precautionary approach should guide the development of recommendations on mitigating the impacts of physical and chemical exposure from drilling activities.

Industry representatives provided clarification on drill cuttings and drilling muds. Drill cuttings are made up of rock material from the drill site which has been crushed by the diamond drill bit. Much of the oil that is associated with these cuttings is removed through treatment on the drilling platform. The primary concern related to the disposal of drill cuttings is related to the potential impacts of smothering on corals and sponges.

The drilling muds used in the NL region are made up of two primary components: bentonite clay and barite (a weighting agent). A proprietary mix of other chemicals is also present in smaller quantities. Although synthetic drilled muds are more toxic than water-based mud by weight, synthetic muds are more efficient and require less volume for the same operations. Industry representatives also reported that synthetic drilling muds are under continuous development, and new formulations are becoming more and more benign. However, toxicity of these substances is currently defined by thresholds developed for shellfish and polychaetes. These definitions may not be relevant to corals and sponges. A representative from industry noted that NL Environmental Effects Monitoring (EEM) programs have been using the most sensitive toxicity testing available in the form of bacterial luminescence for sub-lethal effects and amphipod survival and have found limited toxicity (Bao et al. 2012).

Research by Cordes et al. (2016) corroborates the reports of 25 years of EEM data from industry representatives (i.e., that most significant effects are found within 200–300 m of the well), however the effects of drill cuttings are detectable much further. This study found changes in fauna biodiversity/abundance up to 3 km from the Deepwater Horizon oil spill. Sub-lethal impacts on corals and sponges are very difficult to measure and may extend much further than documented community changes. However, this review paper was not able to include findings

from the Canadian offshore oil industry due to the limited amount of information available on the impacts specific to coral and sponge species. Several participants emphasized that the research recommended by this meeting should be published in peer-reviewed literature to support robust synthesis of mitigation methods nationally and internationally in the future.

Participants noted that the presented research only considered single wells. Questions were raised about the impact of multiple nearby wells that may occur within the radius of documented impacts. Current plans represent a doubling of exploratory wells in Newfoundland and Labrador waters in the next ten years. This is a significant increase in activity in a very short period compared to the development of the industry over the last 50 years. In a single project the impacts may be deemed acceptable, however, multiple participants expressed concern that there may be overlap between the areas of influence between multiple wells. Participants involved in licensing clarified that each license covers thousands of square kilometers, and managers expect 1–2 exploratory wells per license with a low risk of spatial overlap between individual well impacts.

C-NLOPB is responsible for assessing every well in the region. Exploratory wells are subject to an impact assessment under section 34 of the *Impact Assessment Act*, administered by the Impact Assessment Agency of Canada. For each of these exploratory drilling projects, the environmental assessment must consider cumulative effects from past, present, and future drilling and from other industrial activity and research surveys. A C-NLOPB representative reported that hundreds of sediment toxicity tests have been conducted over the past 20 years and very few have identified toxic levels. It was suggested that these data may support a study of long-term trends and/or cumulative effects. The methods and results of the C-NLOPB assessments have been published in the peer-reviewed literature (DeBlois 2014, Neff 2014, Whiteway et al. 2014). Recently, offshore oil and gas projects have also been required to conduct follow-up monitoring, in addition to pre-drill surveys. A representative from FFHPP reported that four active projects (Hibernia, Hebron, Terra Nova, and White Rose) are currently under EEM programs, which include testing toxicity of the sediment and bioaccumulation of toxins in benthic invertebrates within 300 m of the well. These invertebrates are typically polychaetes, amphipods, and Iceland scallop, not coral and sponge species. Follow-up monitoring is required for exploration drilling projects.

An industry representative noted that survey procedures have evolved and improved. For example, pipeline inspections were initially used to examine the pipeline for early signs of corrosion, but now the methods have been expanded to survey biodiversity as well. Historically, benthic community structure analysis has been conducted as part of sediment quality monitoring. In this region, polychaetes, bivalves, amphipods, and tanaids are numerically dominant. Corals and sponges have not been monitored as part of these EEM programs. However, recent benthic (visual) surveys for exploration drilling projects included coral and sponge abundance and distribution. This participant suggested that an information sharing mechanism is required to ensure that DFO Science and interested regulators have access to biodiversity data from the pre-drill and post-installation seabed ROV surveys. Many participants agreed that these surveys provide important data in often understudied areas; however, researchers present at the meeting reported that requests for ROV data from industry surveys have been denied in the past.

An external reviewer also suggested that an analysis of the distribution of exploratory drilling over time may help answer the questions raised about well density and cumulative effects. However, there remain key information gaps (i.e., level of toxicity to corals and sponges) that must be addressed before cumulative effects can be fully understood. In Newfoundland and Labrador, toxicity has only been tested for a limited number of polychaete and shellfish species.

Ecosystem and coral researchers warned that levels identified as safe by those standards should not be accepted as safe for corals and sponges without conducting validation studies.

IMPACTS OF EXPLORATORY DRILLING ON CORALS AND SPONGES

Presented by B. Neves

Abstract

Impacts of exploratory drilling activities are not well understood for most coral and sponge species in the NL Region, but studies conducted worldwide indicate that they can vary by species, ontogenetic stage, morphology, and have the potential to affect their behavior, physiology, fitness, and survival. Exploratory drilling activities can impact corals and sponges through physical contact (e.g., drills, wellheads, mooring lines, anchors), increased sedimentation, release of drilling muds, and use of cement. Physical contact can lead to damage, colony contraction and altered behavior, premature release of brooded larvae, and/or mortality. Regeneration can occur in damaged specimens, but it will depend on the taxa and their morphology, and regenerated individuals might have impaired somatic growth, reductions in sexual reproduction, decreased defensive abilities, competition, and recognition of conspecifics. Exposure to water-based muds (WBM) can lead to tissue mortality and impact survivorship and viability, and a decrease in coral coverage. There is limited research on the effects of synthetic-based muds (SBM) and oil-based muds (OBM) on corals and sponges, although exposure to SBM and OBM has been linked to changes in benthic community structure, and corals have been shown to die or experience significant polyp retraction after exposure to OBM. In sponges, excess sedimentation can influence their behavior, production of mucus, food consumption, respiration rates, and lead to pumping arrests. Effects of clean cuts are considered less damaging, as some species can make repairs in a few days. However, recovery potential varies between species, sediment size, depth, and duration of burial. Impacts are generally spatially limited, but recovery is typically prolonged. The cement used to connect sections of conductor pipes is highly alkaline and linked to reduced rates of recruitment in shallow-water corals. Although larvae can settle on alkaline surfaces, the potential benefits and trade-offs associated with the availability of cement substrate from these activities are not well understood. Some corals exposed to oil responded with mucus production, tissue disintegration, and altered gene expression. The literature also has examples of some drilling activities where no immediate effects were observed. Furthermore, intermittent exposure to drilling muds might have lower impacts in comparison to continuous exposure. Similarly, recovery rates seem to respond differently to variable exposure durations. Long-term and cumulative impacts of exploratory drilling activities on corals and sponges have not been investigated at this time.

Discussion

An industry representative noted that OBMs are no longer used in drilling activities in this region; presenters clarified that all drilling muds would be discussed in the working paper in the interest of producing a document that may be broadly relevant to other regions. Experts from the oil and gas industry and C-NLOPB noted that intermittent exposure of sponges to drilling compounds resulted in lower toxicity than continuous exposure (Edge et al. 2016). These participants suggested that the conditions of exploratory drilling (i.e., short-term and intermittent) may present a relatively low risk of harm (DFO 2019a). However, experts on corals and sponges in the Newfoundland and Labrador region stressed that these findings may not apply to all local species of corals and sponges and that DFO must follow the precautionary approach when faced with uncertainties.

Participants asked whether corals and sponges are known to colonize naturally occurring seeps on the Grand Banks. There is little information about seep habitats on the Grand Banks, but this topic has been studied in the Gulf of Mexico. Hard substrate patches are associated with seeps in that region, which form habitat for corals and sponges. This has led to strong selection for species and genotypes that are tolerant to hydrocarbons and/or associations with symbionts that process these compounds. A regional expert noted that the same adaptations are not expected to be prevalent in coral and sponges populations found in Newfoundland and Labrador waters. An ROV survey conducted on a natural seep in Baffin Bay did not observe many large coral, though soft corals and sea pens were present (Evan Edinger, Pers. Comm.). However, other factors might play a role on the presence/distribution and abundance of corals in that region.

AVOIDANCE AND MITIGATION FOR CORALS AND SPONGES

Overview

Presented by N. Wells

Existing DFO science advice recommends lower thresholds of impact and higher expectations of mitigation for activities occurring in areas with defined benthic conservation objectives. Additional recommendations indicated that mitigation of exploratory drilling activities be implemented in accordance with the widely accepted “mitigation hierarchy of: (1) avoid, (2) mitigate, (3) offset (DFO 2019b). In general, avoidance (e.g., spatial, temporal, or activity) is considered the most effective measure because it eliminates the potential for interactions, while mitigation can be used to reduce the impact that occurs when avoidance is not possible. However, offsetting impacts is not considered to be compatible with benthic conservation objectives (e.g., coral and sponge species). Based on this, various tools to avoid and mitigate impacts to coral and sponge species as a result of exploratory drilling were described.

FFHPP coordinates the departmental review of Environmental Impact Statements (EISs) submitted by proponents, and provides advice on how best to avoid and/or mitigate the impacts that exploratory drilling activities pose to coral and sponge species. Presently, if aggregations of habitat-forming corals and/or sponges are found within the location of a proposed exploratory drilling wellsite, FFHPP would request that the operator relocate the wellsite or implement other mitigation measures to avoid impacting coral and sponge aggregations. FFHPP also assesses residual impacts to determine whether a Fisheries Act Authorization would be required, which would include measures to offset residual impacts (recognizing that offsetting may not generally be compatible with benthic conservation objectives due to currents and water movement in relation to sessile organisms).

Previous DFO Science advice recommended a lower threshold of impact and a higher expectation of mitigation in areas with defined benthic conservation objectives. Avoidance of impacts to these areas is the most effective mitigation measure available because it eliminates the potential for interactions between the activity and benthic components, minimizing the likelihood of serious or irreversible harm.

Avoidance can have three components:

- spatial (move location, directional drilling),
- temporal (activity at a specific time), and
- activity (reinject or skip and ship vs. discharge)

Where avoidance is not feasible, other mitigation measures may be effective and would require consideration on a case-by-case basis.

In a review of the IAACs Regional Assessment, DFO Science recommended that special mitigations be applied in areas that are deemed special (e.g., VMEs, SiBAs, EBSAs) but are not currently protected by other management measures. It was recommended that mitigation measures be considered at the scale of the actual special areas (e.g. SiBAs, not at the scale of the protected portions (e.g. MRs).

Discussion

Several participants noted that the existing guidance on mitigation of harm to coral and sponge species is vague. Mitigation measures are triggered by the presence of aggregations of “habitat forming” corals or coral species that support fish; both of these terms are difficult to define and many participants felt that interpretation of these terms was highly subjective. The following discussion also highlighted the fact that most existing research on coral and sponge density in this region is based on the results of trawl surveys, which are not directly comparable to ROV data.

Pre-Drill Surveys

Presented by B. Neves

Abstract

In the NL Region, proponents typically conduct pre-drill seabed surveys at least three months and up to a year prior to the initiation of exploration drilling. These surveys aim to characterize the area surrounding the proposed well-site and identify whether aggregations of habitat-forming corals are present. Results of the surveys are used to determine whether avoidance and/or mitigation measures are required. Present methodologies for pre-drill surveys in the NL region are partly based on Norwegian Oil and Gas Authority (NOROG) guidelines, which are focused on attributes (e.g., size and concentration) specific to *Lophelia pertusa* reef systems, which have not been reported in the NL region. These systems are not comprised of many sea pens, small gorgonians, or sponges. Pre-drill survey activities include bathymetric and video surveys and sediment dispersion modelling. Bathymetric surveys take place during the first phase of the pre-drill survey. They allow data collection using sonar technologies including side scan sonar (SSS) and multibeam echosounders (MBES) to aid in the identification of potential coral structures and suitable substrate. The collection of high-resolution bathymetry data can allow for the detection of certain structures that could indicate the presence of corals and sponges in the NL region. However, on their own, bathymetric data do not allow for the detection of taxa found in this region. Visual surveys are therefore conducted at sites identified during bathymetric surveys or other sites of interest that are likely to contain corals. In the NL region, visual surveys extend from the proposed wellsite to a predefined distance along eight transects arranged at 45 degree intervals in a radial pattern. Visual surveys should also consider positioning uncertainty from the extent of each anchor and the area where the mooring line will be in contact with the seafloor. An alternative survey design based on the literature was discussed. Visual data are collected using an ROV equipped with a camera, which maintains a consistent altitude and speed to maximize field of view and resolution, which can be time consuming. Autonomous underwater vehicles (AUVs) equipped with cameras may prove to be a suitable alternative to ROVs if the latter are not available. However, AUVs might not provide imagery at a sufficient resolution to enable taxa identification or measurements due to their higher survey altitude. Finally, dispersion models provide estimates of sediment dispersal, and how the thickness of sediments change within the dispersed area. The probable no-effects

threshold (PNET) is the sediment thickness threshold above which species exhibit adverse effects as a result of burial. The current threshold has been set at 6.5 mm based on the assessment of sensitivity for bivalves and crustaceans. A more conservative 1.5 mm threshold is often suggested to account for potentially more sensitive species such as corals and sponges. A series of recommendations regarding pre-drill survey methods/design and coral and sponge density thresholds and avoidance following the results of pre-drill surveys were discussed at the meeting.

Discussion

Under current guidelines and regulations, the operator is responsible for designing pre-drill survey plans and follow-up monitoring plans, which are subsequently reviewed by the C-NLOPB and FFHPP. However, the survey design is not reviewed by DFO Science – a gap in the system that many participants identified as a serious weakness. Once the information is collected and analyzed, either by an in-house biologist or a consultant, the operator provides DFO with a report indicating whether the well site meets the coral or sponge aggregation criteria and if it does, an alternate site is proposed. FFHPP representatives reported that, to date, one proponent has voluntarily moved an exploratory drilling proposal to an alternate site after preliminary surveys identified high densities of corals and sponges. There have not been any instances of a proponent refusing to move a wellsite, which would require further mitigation measures. Under this system, the ROV footage, raw data, or even data summaries are not always provided to DFO, however FFHPP representatives clarified that some video footage had been shared recently, although it had not been made available to DFO Science staff or species experts at the time of the plenary meeting.

Participants noted that coral and sponge species identification can be extremely difficult and asked whether industry uses any mechanisms for data quality assessment or standardized training for technical staff tasked with video analysis. To date, there is no independent review of data quality or species identification accuracy. Assessment of the survey design and review of the reports are completed by FFHPP, based on whether the environmental assessment (EA) conditions pertaining to pre-drill benthic surveys outlined in decision statements for EA release have been met. These conditions have to be met by the proponent in order to obtain an Operations Authorization from the C-NLOPB to proceed with exploratory drilling. Currently, this is completed without consultation with DFO Science to review methodology or results. Several participants identified this disconnect between FFHPP and DFO Science as a weakness in the current procedure. However, a representative from FFHPP added that some survey methodology has been reviewed by DFO Science as part of a technical review of the proponents' EIS reports.

Pre-drill surveys include collection of bathymetric data and the topography of the seafloor. These data can be used to identify potential coral and sponge habitat, guiding ROV survey design. A regional expert on corals and sponges asked industry representatives whether this type of data analysis and targeted ROV survey design is currently conducted. Several scientists in the meeting with experience on this type of survey noted that a standard radial survey is likely to miss coral and sponges due to the patchy nature of these habitats and agreed that using bathymetry, backscatter, or side scan data to target potential hotspots would greatly increase detection probability. Industry representatives reported that bathymetric survey data are not currently used in the ROV survey design.

Exploratory Drilling Activities

Presented by L. Gullage

Abstract

At present, there are various mechanisms which allow for the avoidance and mitigation of coral and sponge species during exploratory drilling activities. Avoidance of impacts to corals and sponges is the primary goal and can be achieved through changes in the location, timing, and/or type of activity being performed. However, in cases where avoidance may not be possible, mitigation of impacts associated with positioning, drilling, and abandonment are also recommended. Techniques used to mitigate drilling impacts were described in detail and their potential suitability for the NL region assessed. In general, avoidance and mitigation recommendations were made to avoid/limit the distribution of sediment near the exploration site and minimize the potential for physical contact with coral and sponge species when they are present.

Discussion

The meeting quickly reached consensus that the role of this meeting was not to review and recommend specific engineering solutions, but to identify the goals of mitigation (i.e., minimize resuspension and disposal of sediments, reduce the footprint of the drilling platform and anchoring equipment, etc.). These objectives should then be met by the safest, most appropriate methods available to the operators.

Several meeting participants emphasized that spatial avoidance should be prioritized over any of the available mitigation measures.

MONITORING AND FOLLOW-UP

Presented by L. Gullage

Abstract

If drilling has been approved, monitoring tools are used to confirm the zone of influence, test chemical and biological effects, and determine whether proposed mitigations during exploration were effective. Monitoring measures can be applied to assess changes to the drilling site through visual (e.g., ROV surveys), chemical (e.g., sediment, invertebrate, and vertebrate samples), and/or physical (e.g., current and turbidity measurements) means. In most cases, collecting baseline information is suggested prior to the start of drilling to provide clear conditions for comparison. To account for this, recommendations were presented with respect to the timeline and design of monitoring surveys, and methods were suggested to enhance the information gathered specific to changes in coral and sponge health. In general, methodologies were categorized based on their advantages and drawbacks, and a list of recommendations were developed based on this information.

Discussion

Sedimentation, and subsequent smothering of coral and sponges, was identified as one of the impacts of exploratory drilling. An external reviewer recommended the use of sediment traps to measure deposition. This type of monitoring would provide in situ data to validate the sediment dispersal models prepared by proponents in the pre-drill surveys and to assess the success of mitigation measures.

Pre-drill surveys currently rely on existing environmental data; current metres are not installed at well sites until the active drilling phase of development and are exclusively used to enhance safety of the operation. *In situ* current data are not included in EEM programs. This has been identified by DFO scientists as a weakness in EIS in the past. For example, one expert reported

reviewing an impact statement wherein proponents had used acoustic Doppler current profiler (ADCP) data over a short period (one year) in a single site to estimate the sediment plume associated with drilling. This was identified as a significant weakness in the review; however, the project was ultimately approved without making the recommended changes. Oceanography experts in the meeting repeated that single point, short-term current estimates are insufficient for this purpose. Robust sediment plume estimates require 3D reanalysis of current data from a scientifically accepted current model, and the results of this type of analysis would be much more useful to industry than observations from a single point.

Under the current conditions of EA approval, production sites, not exploration sites, are surveyed before drilling and every two years for the lifetime of the project; measured parameters include sediment chemistry, benthic community richness and diversity, Microtox® using luminescent bacteria, and benthic animal bio-burden (muscle and liver tissue from American plaice, Snow crab, and scallop are tested for total hydrocarbons and the presence of 32 metals). For example, the White Rose project includes 54 monitoring stations in a radial design; two samples are collected at each station. Approximately twelve of these stations are analyzed each year. An expert on benthic ecology in the Newfoundland and Labrador region pointed out that this protocol does not constitute before-after, control-impact (BACI) experimental design. Furthermore, this participant suggested drill site monitoring may be better served by a study that samples three locations: up-current from the anticipated impacts, within the anticipated zone of impact, and down-current. A representative from industry added that the EEM is a gradient design using 5 statistical tools to measure project-induced effects. Four control sites are sampled to measure natural variability. In 2016, a total of 243 taxa, from 80 families, were identified from 106 samples collected from 53 stations (Husky Energy 2019).

EEM and follow-up monitoring activities were also clarified for the meeting. EEMs are not linked to the Canadian Environmental Assessment Act (CEAA) and are required for production projects, but not required for exploratory wells. Follow-up monitoring is used for exploration drilling projects. The decision statements issued for exploratory drilling do not prescribe specific follow-up monitoring procedures; instead, the proponent is required to implement a survey in consultation with DFO and the board. An industry representative added that there are 27 conditions related to protection of Fish and Fish Habitat in each project's Decision Statement. The meeting was encouraged to provide suggestions for the requirements described by decision statements that would support effective mitigation and accurate impact predictions. Some DFO scientists present at the meeting reported that they had never been consulted on follow-up monitoring for exploratory drilling, while others said they had been involved. However, this is a relatively new requirement and management representatives expect consultation on upcoming projects. Follow-up monitoring, based on CEAA 2012, requires seabed investigation surveys with a similar requirement for consultation with DFO on the appropriate methods/survey design. The legislation is not specific on whether DFO Science or FFHPP should be consulted on these matters and it does appear that there is latitude for DFO to determine who is most appropriate to review follow-up monitoring design.

Participants expressed concern that the standard monitoring methods have been designed for amphipods, polychaetes, and other short-lived animals. However, the sampling method and levels of acceptable toxicity are expected to be very different for sensitive, rare, and long-lived taxa like the corals and sponges found in the NL region. For example, LD50 (the amount of a material, given all at once, which is lethal to half of a group of test organisms) would not be an acceptable threshold for corals. These methods, however, are in reference to production projects, and not exploratory projects. The oil and gas industry in this region has adopted the conservative 1.5 mm probable no effect threshold (PNET) for deposition of drill cuttings to define the footprint of the dispersion model for estimating impacts from drilling. This threshold

was introduced specifically to mitigate impacts on species vulnerable to burial impacts, like corals and sponges. The previous industry standard of 6.5 mm PNET is still in use as a threshold above which benthic species exhibit adverse effects as a result of burial, with the 1.5 mm PNET considered a conservative threshold for more sensitive benthic species. Industry representatives asked the researchers in the room whether it is possible to detect 1.5 mm sediment deposition from the ROV video, in order to validate the model. Several experts indicated that this would not be possible from visual ROV data; instead, sediment traps or carefully planned sediment push core sample surveys would be required to validate deposition predictions.

REVIEWER COMMENTS

Reviewed by Dr. Susanna Fuller (Oceans North) and Dr. Evan Edinger (Memorial University of Newfoundland)

Discussion

Both reviewers agreed that the working paper was very thorough and provided critical information to the meeting and to managers. There was some discussion around how the conclusions of this meeting will feed into the Regional Assessment of Offshore Oil and Gas Exploratory Drilling East of Newfoundland and Labrador. The Regional Assessment document will take the place of project-specific assessments, if the conditions of the Regulation are met. This also means that decision statements will not be issued; instead, ministerial regulations are being developed that will apply to the entire regional assessment boundary. The Regional Assessment is meant to be an evergreen document that evolves as new information becomes available including, for example, new mitigation measures recommended by this meeting. However, it is not yet clear how often updates to the Regional Assessment and related guidelines will be considered, or what that process will entail. The current recommendation is that all guidance from the most recent decision statements will be adopted into regulation, including the current guidance to proponents to develop a pre-drill survey in consultation with C-NLOPB and DFO. The meeting was instructed to provide high level recommendations about the avoidance of important areas for corals and sponges. Several participants who have been involved in the Regional Assessment process expressed concern over the vague information available on how the conclusions of this meeting will be incorporated. Participants further noted that there has not been sufficient transparency on how recommendations from DFO Science regarding Regional Assessment guidelines have been considered, and when/why some recommendations are rejected. Industry did not agree with this concern.

Both reviewers agreed that it is important to focus on special areas defined by Science (i.e., SiBAs and VMEs) when developing recommendations, and that in these areas exploratory drilling should be prohibited or severely restricted to mitigate damage to corals and sponges. It was further recommended that efforts to measure the impacts of drilling activities focus on the longest living coral and sponge species, noting that the frequently cited research on trawl impacts only considered *Gersemia,* a very common, robust, and short-lived species. It would be extremely risky to apply impact thresholds developed for this kind of species to the more vulnerable corals and sponges found in the NL region. Experts warned that studies on *Cliona* sponges are similarly inappropriate sources upon which to base broad mitigation guidelines. *Cliona* is a rock-boring sponge with a unique life-history that is not comparable to the species under consideration by this meeting.

Reviewers emphasized the importance of following the published scientific findings. Cordes et al. (2016) identified 2 km as the distance threshold for measurable impacts from drilling activities based on produced water, rather than drill cuttings. At the scale of the NL shelf

bioregion, 2 km is very small and reviewers did not consider this to be an onerous requirement for industry. The meeting was strongly cautioned against considering any spatial avoidance measure less than 2 km. An industry representative did consider this recommendation much more onerous than international best practice and noted that a 2 km offset from 1–6 corals or sponges per 100 sq. m potentially eliminates vast areas of the offshore.

Coral and ecosystem experts expressed frustration that the Terms of Reference of this meeting didn't include discussion of risks associated with potential oil spills, calling it "disingenuous" to attempt to mitigate impacts from exploratory drilling without considering further development, and specifically, spills. By compartmentalizing risk in this way, several meeting participants warned that managers risk underestimating impacts and the resulting decisions may introduce higher levels of cumulative environmental risk than would be acceptable if these projects were assessed holistically.

CONCLUSIONS

Recommended Best Practices

Presented by N. Wells

Recommended best practices documented within the working paper, as well as others that had come up throughout the meeting, were summarized by Nadine Wells and reviewed/updated by all meeting participants.

Discussion

Spatial Avoidance

The meeting agreed that spatial avoidance is the first, and most effective management measure for reducing harm to corals and sponges. It was recommended that exploratory drilling not be permitted within special areas that have been identified and closed to bottom contact gear; these closures are based on significant densities of corals or sponges. For significant densities of corals identified outside of SiBAs and VME habitats, the meeting recommended a minimum avoidance distance of 2 km (based on Cordes et al. 2016). It was noted by experts in the room that in deep water and/or strong current conditions, the measurable biological impacts of drilling (e.g., concentrations of barite) may reach much further than 2 km. The meeting recommended that 2 km be treated as a minimum avoidance distance, and that the drill mud dispersion model should be used to determine if a larger avoidance distance is necessary based on the unique conditions of the drill site in question. Participants further clarified that the zone of impact should not overlap with SiBAs or VMEs. There was some concern over the uncertainty associated with these estimates, as they are often based on single current measurements. This discussion highlighted the critical needs for robust, three-dimensional current models to support mitigation measures.

There were some objections to the 2 km avoidance recommendation by industry representatives who suggested that the Cordes et al. (2016) findings (i.e., that under generalized conditions, drilling impacts of produced water reach 1–2 km and drill cuttings reach 100–500 m) were based on production drilling, and were not applicable to exploratory drilling and cited DFO 2019a in support of this statement. The lead author of this paper was present and clarified that the 2 km value is based on exposure vectors under normal operation and incidental discharges, and the findings are applicable to all stages of drilling activity. Furthermore, meeting participants were advised to be precautious in the development of mitigation recommendations, as little is known about the sub-lethal impacts that may not be visible from ROV survey imagery, but may still compromise sponge and coral communities.

Regardless of which stage of drilling activity would have the most impact, several participants felt that it would be counterintuitive to allow exploratory drilling at a site where the impacts of production would not be acceptable.

Industry also suggested that the meeting's conclusion that drilling should not be permitted within SiBAs and VMEs was unnecessary. This participant suggested that coral and sponge distribution is not continuous within these areas and that the 2 km avoidance of significant concentrations should be sufficient regardless of SiBA or VME designation. This suggestion was met with strong disagreement from many experts. The distribution of corals and sponges within VMEs and SiBAs is not expected to be continuous, but the entire habitat complex contributes to ecosystem function; the risk of harm within these areas is high.

Furthermore, it was clarified by an external reviewer that the restriction to exploratory drilling recommended by this meeting is not extreme. SiBA and VME habitats are mostly found on the slope, where filter feeding is supported. These areas are generally inappropriate for drilling, and the overlap is limited. In the rare event that relocation of the well is prohibited for safety reasons, managers will be able to consider the risk specific to a particular well site and issue an authorization if appropriate. Ultimately, the meeting reached consensus on the above recommendations to prohibit drilling within SiBAs and VMEs, and to require a minimum 2 km spatial avoidance from high density coral and sponge habitat beyond designated boundaries.

Sediment Dispersion Models

A participant with experience reviewing dispersion models from EISs for exploratory drilling noted that the quality of these models varies widely from project to project. Based on the importance of these models to estimating the zone of impact, the meeting agreed that recommendations on model development are important. Large sediment components (i.e., cobbles, gravel, pebbles) will sink near the well. However, mud and silt, which represent up to 40 % of the removed sediment by weight, can travel great distances and many of the reviewed models lose track of these small components very quickly.

Oceanography experts emphasized that sediment dispersion models for these projects should use the best available current data (i.e., 3-dimensional and time variable data), estimate dispersion of sediment classes that are representative of the site, and incorporate benthic boundary layer processes. It was also recommended that sensitivity analyses on model parameters be performed and presented to reviewers. Furthermore, the meeting agreed that all models be validated with observations in follow-up monitoring, and when available the validation results of previous dispersion models from nearby or similar sites should be used to inform model configuration for subsequent projects.

Benthic Surveys

Participants agreed that, for clarity in the development of recommendations around survey methods, the pre-drill surveys must have a clearly stated purpose. The primary purpose is to ensure drilling safety and the secondary purpose is to provide a benthic survey as part of the environmental impact assessment. Coral experts cautioned that it would be dangerous to assume complete detection of corals and sponges by either randomly distributed or clover-leaf pattern ROV surveys. With that in mind, a hybrid design was suggested that works toward both goals; a clover leaf ROV survey pattern (designed to detect soft bottom species or unexpected habitats), and targeted ROV deployments on hard bottom patches identified by classification of high resolution bathymetry, multibeam backscatter, sidescan sonar, or seismic data (designed to detect coral and sponge species on suitable habitat patches). This combined targeting approach would address some concerns raised by participants about the probability of detection of species that are restricted to patchy hard bottom habitats. Industry representatives reiterated

that the extent of benthic surveys is based on the results of the deposition model. Participants agreed that if the requirements of a robust deposition model can be satisfied and the predicted footprint can be surveyed with 100 % coverage, that is ideal. However, depending on water depth and current dynamics, this may not be feasible at all sites and the meeting agreed that there should be further guidance provided.

Multibeam and/or side-scan sonar data are collected during pre-drill surveys, however these data are generally collected simultaneously with ROV video footage, and have not been used to target ROV survey coverage of hard-substrate habitat patches. An external reviewer recommended conducting an ROV flight 20 m above bottom to collect multibeam backscatter, followed by a low-altitude flight using the backscatter data to target hard substrate. This procedure would require minimal processing and interpretation of the backscatter, and could be completed in the field. This approach would allow targeted ROV video to be conducted within the same survey trip, though it would require more ROV dives.

Questions were raised about the justification for restricting benthic surveys to the wellsite footprint defined by the deposition model, rather than extending ROV video coverage out to the anchors (up to a 1.5 km radius). Industry representatives clarified that the anchor lines are not in continuous contact with the seabed from the wellsite to the anchor. Benthic surveys currently include ROV video of each anchor site and a 50 m radius of the surrounding area.

One industry representative reported that well site ROV surveys often find coral and sponge colonies that have been previously damaged or killed by bottom-contact fishing gear, and compared the impact of trawl fisheries to clearcutting benthic communities. Several scientists were very concerned at the implication that the oil and gas sector could avoid mitigation measures in previously fished areas. Many participants strongly emphasized the importance of conserving the remaining coral and sponge populations, especially in an ecosystem under many forms of anthropogenic pressure, including fishing, offshore drilling, and climate change. A representative from the fishing industry also clarified that over time, approaches to marine conservation and management have changed. In Newfoundland and Labrador, which has a long history of fishing, there has been significant evolution in the way corals and sponges are studied, understood, and preserved. It is now well established that fishing has had and still has an impact on these vulnerable species, and as a result, there are now many fishing closures in the region designed to protect benthic habitats. The meeting strongly agreed that the fact that previous damage has occurred should not, in any circumstance, be used as justification for avoiding responsible management or scientifically supported mitigation measures.

Several participants, including managers and former benthic survey technicians for exploratory drilling projects reported that video transects are not fully analyzed. Detectability of these species remains unknown, and many participants raised concerns that subsetting the video footage increases the rate of false negative detections, and ultimately results in more harm than is acceptable to coral and sponge habitats. It was noted that if the full video transects are shared with DFO Science, it may be possible to develop a scientifically supported basis for subsetting video to reduce the time and cost of this work without compromising the data. However, in the absence of a scientifically supported and independently reviewed method, the meeting agreed that it is critical that all video footage be analyzed. Experts in ROV surveys explained that the survey path must be consistent in order to produce reliable and comparable data; rapid changes in speed and altitude severely compromise data quality. It was also noted that training and resources provided to the technicians responsible for video analysis is inconsistent. Many participants emphasized the need for a photo ID guide created by regional experts, and encouraged managers to recommend standardized training.

Density Thresholds

EIS reports currently define coral and sponge aggregations as 5 or more colonial organisms larger than 30 cm in height or width. Based on the recommendation for spatial avoidance of significant densities of corals and sponges, the meeting agreed that thresholds more appropriate for the NL Region were needed. Preliminary density thresholds were presented at the meeting, based on SiBA and VME published biomass thresholds and trawl abundance data, for the detection of significant concentrations of corals and sponges during seabed video surveys.

There was also discussion of the visual surveys: whether species level identification is possible from ROV videos, whether there is sufficient training available for technicians conducting these surveys, and whether there is a mechanism for species identification to be confirmed by independent experts and DFO scientists. Participants with experience conducting video analysis for pre-drill surveys reported that training is minimal, however video quality is typically sufficient to distinguish most functional groups (ex. sea pens, sponges, and large gorgonians). There can be confusion between some species of small gorgonian and black corals. One participant also reported that calculating coral density in the field can be extremely challenging, and recommended that the meeting consider guidelines that are easier to operationalize. In the past, video analysis was conducted in the same season as site development, so analysis was often conducted in the field with immediate turn-around to managers, leaving limited time for analysis. However, industry and management representatives reported that the structure of pre-drill surveys has changed so that this analysis is conducted the season before the onset of exploration drilling, allowing technicians to conduct video analysis in the lab and allowing more time and access to data processing tools to easily calculate coral and sponge density.

Although many participants agreed that the advice on mitigation measures should provide simple, easily operational instructions, there was concern raised about over-simplification of the ecosystem, particularly regarding the setting of occurrence thresholds for corals and sponges. For example, experts agreed that a threshold of 5 individuals per 100 m^2 would be too high for the rare and solitary black corals, and experts cautioned strongly against treating all species the same for this reason. Extensive research has established VMEs and SiBAs as important habitats for these species; the meeting agreed to use the presented estimated density of corals and sponges within SiBA/VME boundaries as guidance for thresholds set for each functional group.

The limitations of detectability were also raised again in the context of threshold setting; corals may be off the ROV track simply by chance, sea pens may withdraw into the sediment, and/or species identification may not be perfect. For all these reasons, experts on corals and sponges emphasized the need to exercise caution around the definition of thresholds for “significant” densities. Concerns were also raised about the comparability of trawl data (which informed the boundaries of VMEs and SiBAs) to ROV data, which will likely be used to conduct the visual surveys that will use these thresholds. For this reason, density was calculated and presented by gear efficiency (i.e., 1 %, 5 %, 10 %, 100 %) within these areas and careful consideration of the potential uncertainties associated with detectability of these species guided the meeting consensus on recommended thresholds (Table 1). Gear efficiency (Campelen trawl) estimates for sponges and sea pens were provided by Kenchington et al. (2011). There are no estimates of gear efficiency available for small gorgonians, large gorgonians, or black corals. Assuming a gear efficiency of 1 % for large gorgonians and black corals results in a threshold below 1. Therefore 5 % was not considered. In contrast, both 1 % and 5 % gear efficiencies (comparable to sponges and sea pens) were considered for small gorgonians, followed by a discussion amongst meeting participants leading to the selection of a suitable significant density threshold.

Based on the best available data, the meeting agreed on a density threshold of 6 large sponges per 100 m^2. In this context, a “large” sponge is defined as any sponge that is 5 cm or greater in either height or width. A density threshold of 4 sea pens per 100 m^2 was agreed upon. The meeting also agreed on thresholds of 2 small gorgonians per 100 m^2 and 1 large gorgonian per 100 m^2. In this case, “large” and “small” refer to the name of the functional groups, not to specific size criteria. The proposed threshold for black corals is 1 per 100 m^2. If the average density within the survey area (recorded via video) meets any one of these density thresholds, that site will be subject to mitigation measures (e.g., offset by a minimum of 2 km).

Thresholds were not identified for non-VME species (e.g., soft corals, stony cup corals), however these species may be added to the mitigation guidance as new information on their ecological role, vulnerabilities, and distribution become available. There is insufficient information for a threshold to be developed for extremely rare or new species (e.g., hydrocorals), however the meeting agreed that any record of a rare or new species in the pre-drill surveys should be shared with DFO Science.

Table 1. Proposed density thresholds for sponges and coral functional groups that would trigger mitigation measures.

Functional Group	**Rationale**		**Proposed density threshold**
	Gear efficiency	Density within SiBAs/VMEs	
Sponges	1 %	6–10 large sponges per 100 m^2	6 large sponges per 100 m^2
Sea pens	5 %	4–10 colonies per 100 m^2	4 sea pens per 100 m^2
Small Gorgonians	1 %*	5–8 colonies per 100 m^2	2 small gorgonians per 100 m^2
	5 %*	1–2 colonies per 100 m^2	
Large Gorgonians	1 %*	1 colony per 100 m^2	1 large gorgonian per 100 m^2
Black Corals	1 %*	1 colony per 100 m^2	1 black coral per 100 m^2

* There are no available data on gear efficiency for gorgonians or black corals. These figures are based on the figures available for other species (Kenchington et al. 2011).

Participants asked managers how the current guidelines have impacted drilling; i.e., if any well sites have been relocated because the benthic survey identified significant densities of corals or sponges. To date, there has not been an instance where an operator was required to move a well site. However, managers described one case where, in the course of doing the benthic survey, an operator identified high densities of corals at one proposed site, and voluntarily shifted to an alternate site before reaching the review stage. Operators have also been required to repeat surveys in cases where anchors were missed. Overall, it appeared to this meeting that current mitigation measures are far from onerous on the industry, and in fact rarely impact project development at all. It was noted that licenses have previously been granted in areas where significant densities of corals and sponges were not expected; the current expansion of offshore exploratory licenses will enter different habitats and these projects are more likely to overlap with coral and sponge distributions, and the mitigation measures proposed by this meeting will become more important as exploration expands.

Other measures

If complete spatial avoidance of high density corals and sponge habitat is not possible, the meeting agreed that follow-up monitoring should be enhanced and alternate mitigation measures should be enacted. This mirrors the approach taken by Fisheries and Oceans managers; closures in ecologically important areas, and encounter protocols enacted outside those boundaries. In areas where high densities of corals or sponges are identified outside VMEs and SiBAs and cannot be spatially avoided, all feasible options should be taken to reduce the benthic footprint of exploratory drilling activities. These include, but should not be limited to, use of anchor patterns with the smallest benthic footprint or dynamic positioning, selection of the least toxic drilling mud available, and removal of drill cuttings. If corals are present at a proposed site, but fall below the significant density threshold, the meeting agreed that enhanced follow-up monitoring should still be required to better understand the impacts of exploratory drilling on these species and habitats.

RESEARCH RECOMMENDATIONS

Discussion

Meeting participants agreed that there are still many gaps in our understanding of the risks associated with the exposure of corals and sponges to exploratory drilling activities. The conclusions and recommendations put forward by this meeting should be updated and/or reviewed as new information becomes available. The meeting discussed important areas of research to support mitigation of harm to corals and sponges and emphasized that the research recommended by this meeting should be published in peer-reviewed literature, in order to support robust synthesis of mitigation methods nationally and internationally in the future.

Spatial distribution and density

Several participants noted throughout the meeting that more information is needed on coral and sponge distribution throughout the region. In particular, coral and sponge surveys are needed beyond the footprint of existing RV trawl surveys (e.g., >1500 m). Benthic surveys associated with exploratory drilling provide a valuable source of information on coral and sponge distribution, and these data should feed back into DFO Science research on coral and sponge habitats. As new information becomes available on the density and distribution of these species, the avoidance and mitigation thresholds and SiBA boundaries should be reviewed and updated as necessary. The meeting also recommended that SiBAs need to be identified for all remaining coral functional groups (e.g., soft corals, black corals, cup corals).

Toxicity and exposure thresholds

Further research is needed to identify how exposure to drilling muds, cuttings, and other compounds associated with drilling activities impact coral and sponge species in the NL region. Toxicity levels currently applied to management of drilling impacts were developed for benthic polychaete and shellfish species; experts agreed that it is very unlikely that these thresholds are relevant to corals and sponges. The literature review conducted in preparation for this meeting identified very little available research on the toxicity of drilling muds, hydrocarbons, and dispersant chemicals for corals and sponges, with the notable exception of *L. pertusa*, a species that has not been identified in Newfoundland waters, and there is no evidence that these findings are transferable to the Newfoundland and Labrador region. Further research is required to better understand the impacts of these compounds and to establish toxicity thresholds relevant to the coral and sponge species of Newfoundland and Labrador. Similarly, further research is required to develop an appropriate sediment deposition PNET for coral and sponge species in Newfoundland and Labrador. Participants emphasized that research on PNET and

toxicity thresholds for coral and sponges must also consider sub-lethal impacts. This is challenging to measure for corals and sponges; investigation into underwater hyperspectral imaging for monitoring coral and sponge health is recommended for local species (see Letnes et al. 2019).

The lack of information on cumulative effects was brought up by several participants throughout the meeting. Several participants raised concerns about cumulative impacts of multiple nearby wells, citing research showing that deposition of drilling material from routine activities can extend several kilometres from the well site and that surface oil from accidental discharges reaches seafloor in the form of oiled marine snow altering the benthic environment up to 45 km from the wellsite (Cordes et al. 2016). With the history of drilling in the Newfoundland and Labrador offshore, there is also an important opportunity and a need to better understand cumulative impacts of drilling over time. A representative from the C-NLOPB suggested that a review and synthesis of records from the last 20 years of the EEM program, including hundreds of toxicity tests, may inform a better understanding of cumulative effects.

Coral and sponge ecology

Mitigation efforts are supported by understanding of the biology and ecology of the species in question. It was noted multiple times throughout the meeting that there are information gaps on the functional ecological roles and life histories of coral and sponge species in Newfoundland and Labrador waters. Specifically, meeting participants recommended research on the reproductive patterns, larval dispersion, and habitat connectivity of coral and sponge species in the NL region to ensure drilling impacts can be avoided/minimized. One reviewer further recommended that functional groups need to be developed for sponges, as they are for coral species in the region.

Information sharing

Throughout the meeting, participants stressed the need for more transparency and accessibility regarding the information collected during pre-drill surveys and follow-up monitoring programs. These surveys are extremely valuable data sources that should be used to fill gaps in existing science.

In order to facilitate consistency across ROV video analysis by different consultants, proponents, or for different projects, it was recommended that DFO Science and expert collaborators develop a photo ID guide for Newfoundland and Labrador corals and sponges.

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APPENDIX 1 – TERMS OF REFERENCE

Coral and Sponge Mitigations in Relation to Exploratory Drilling Programs in the Newfoundland and Labrador Region

Regional Peer Review – Newfoundland and Labrador Region

January 28–30, 2020

St. John's, NL

Co-Chairs: Robyn Jamieson and Sara Lewis

Context

The Fish and Fish Habitat Protection Program (FFHPP) of the Ecosystems Management Branch (EMB) of the Department Fisheries and Oceans, Canada (DFO) evaluates proposed works, undertakings and activities (WUA) that may affect fish and fish habitat and provides advice to proponents to enable them to avoid and mitigate the impacts of WUAs (DFO 2019). FFHPP provides expert advice to the Impact Assessment Agency of Canada (IA Agency) under section 20 of the *Impact Assessment Act* (IAA)2, as well as the Canada-Newfoundland Offshore Petroleum Board (C-NLOPB) Memorandum of Understanding between C-NLOPB and DFO during the review of oil and gas activities. Exploratory drilling programs including the drilling, testing, and abandonment of offshore exploratory wells have the potential to affect corals and sponges through certain activities, including drilling of the well(s) and the release of discharges such as drill cuttings and muds. For such activities, DFO provides advice pertaining to benthic characterization, effects assessment, mitigation measures and follow-up monitoring requirements.

FFHPP is seeking scientific advice on the mitigation of harmful impacts on corals and sponges during exploratory drilling programs in offshore Newfoundland and Labrador. The advice generated from this Regional Peer Review Process will be used in the development of Newfoundland and Labrador best management practices to support these reviews. Information gathered will also identify gaps where further research is required.

Objective

The objectives of the science peer review meeting are to characterize potential impacts of exploratory drilling programs, including the drilling, testing and abandonment of offshore exploratory wells on corals and sponges in offshore Newfoundland and Labrador, and techniques/methods to avoid or mitigate potential impacts. More specifically, the objectives are:

1. Provide a summary of coral and sponge species that are currently known to be present in offshore NL, including but not limited to: species list, distribution and biomass, habitat requirements, and sensitivities.
2. Provide descriptions of exploratory drilling activities, including the drilling, testing and abandonment of offshore exploratory wells, with the potential to impact corals and sponges (e.g., anchors, discharges),. Descriptions should include classification of types (e.g., burial) and severity (e.g., temporal and spatial scales) of potential impacts associated with each activity.
3. Provide a summary of the potential impacts of exploratory drilling activities (e.g., direct physical contact of any sub-sea infrastructure, sedimentation etc.) on corals and sponges (e.g., growth, injury, mortality) around NL and the world. If information at the species level does not exist for NL or worldwide, the impacts on other species of similar structure should be used as proxies. Such gaps and generalizations must be acknowledged.

4. Recommend methods/techniques for pre-drill surveys (e.g., DNV 2013) to characterize corals and sponges in the vicinity of exploratory drilling activities (e.g., baseline information, technologies, survey designs, impact thresholds) based on knowledge of species/taxa known in NL waters. Describe relevance of methods/techniques to the NL offshore environment. For relevant methods/techniques, develop pros and cons and compare and contrast various options. Describe effectiveness and lessons learned from the application of methods/techniques in the NL offshore and elsewhere.
5. Recommend measures to avoid and mitigate impacts to corals and sponges from exploratory drilling programs (e.g., DNV 2013). Describe relevance of measures to the NL offshore environment.
6. Recommend methods/techniques for monitoring and follow-up regarding impacts on corals and sponges from exploratory drilling programs (e.g., DNV 2013). Describe relevance of methods/techniques to the NL offshore environment. For relevant methods/techniques, develop pros and cons and compare and contrast various options.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Expected Participation

- Fisheries and Oceans Canada (DFO-Ecosystems Management and Aquatic Resources Branches)
- Impact Assessment Agency of Canada (IA Agency)
- CNLOPB (Canada-Newfoundland and Labrador Offshore Petroleum Board)
- CAPP (Canadian Association of Petroleum Producers)
- Provincial Department of Fisheries and Land Resources
- Academia
- Non-government organizations

References

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APPENDIX 2 – AGENDA

CORAL AND SPONGE MITIGATIONS IN RELATION TO EXPLORATORY DRILLING PROGRAMS IN THE NEWFOUNDLAND AND LABRADOR REGION

Co-Chairperson: Robyn Jamieson

Co-Chairperson: Sara Lewis

Editor: Emilie Novaczek

January 28-30, 2020

Memorial Room - Northwest Atlantic Fisheries Centre
80 East White Hills Road, St. John's

Tuesday, January 28, 2020

Time	Topic	Presenter
09:00	Welcome - Overview of Regional CSAS Peer Review Process	*Co-Chairperson*
9:30	Introduction – Opening Remarks (FFHPP)	*J. Kelly*
10:15	Health Break	-
10:30	Coral And Sponge Species in Newfoundland and Labrador	*V. Wareham Hayes*
11:15	Existing Special Areas	*N. Wells*
12:00	Lunch	-
1:00	Exploratory Drilling in Newfoundland and Labrador	*L. Gullage*
1:30	Impacts of Exploratory Drilling on Corals and Sponges	*B. Neves*
2:30	Health Break	-
3:00	Avoidance and Mitigation for Corals and Sponges - • Introduction • Pre-Drill Surveys • Exploratory Drilling Activities	• *N. Wells* • *B. Neves* • *L. Gullage*

Wednesday, January 29, 2020

Time	Topic	Presenter
9:00	Monitoring and Follow-Up	*L. Gullage*
9:30	External Reviewers Comments	*S. Fuller* *E. Edinger*
10:30	Health Break	-
11:00	Review of Recommended Best Practices	*N. Wells*
12:00	Lunch	-
1:00	Drafting of Coral and Sponge SAR Summary Bullets	*All*
2:30	Health Break	-
3:00	Drafting of Research Recommendations	*All*

Thursday, January 30, 2020

Time	Topic	Presenter
09:00	Drafting/Final Review of Coral and Sponge SAR Summary Bullets	*All*
-	Drafting/Final Review of Coral and Sponge Research Recommendations	*All*
-	Discussion of Coral and Sponge Res Doc and SAR Document Outputs.	*All*

Notes:

- Health breaks will occur at approximately 10:30 a.m. and 2:30 p.m. Coffee and tea can be purchased from the cafeteria.
- Lunch (not provided) will normally occur approximately 12:00-1:00 p.m.
- Agenda remains fluid – breaks to be determined as meeting progresses.
- This agenda may change.

APPENDIX 3 – LIST OF PARTICIPANTS

NAME	AFFILIATION
Ann M. White	DFO-NL – FFHPP
Annie Mercier	Memorial University
Bárbara de Moura Neves	DFO-NL – Science
Bobbi Rees	Provincial Government – Fisheries and Land Resources
Bret Pilgrim	DFO-NL – FFHPP
Christina Pretty	DFO-NL – Science
Dale Richards	DFO-NL – Centre for Science Advice
David Pinsent	Canadian Association of Petroleum Producers (CAPP)
Elizabeth Young	Canada – NL Offshore Petroleum Board (C-NLOPB)
Emilie Novaczek	DFO-NL – Science
Eric Cordes	Temple University
Eugene Lee	DFO-NL – Centre for Science Advice
Evan Edinger	Memorial University
Frédéric Cyr	DFO-NL – Science
Geoff Hurley	CAPP and Hurley Environmental Ltd.
Hannah Munro	DFO-NL – Science
Jason Kelly	DFO-NL – FFHPP
Javier Murillo	DFO-Maritimes – Science
Jennifer Janes	DFO-NL – Marine Planning and Conservation
Jill Adams	Impact Assessment Agency of Canada
Johan Joensen	Fish, Food and Allied Workers Union
Kimberley Keats	DFO-NL – FFHPP
Krista Baker	DFO-NL – Science
Lauren Gullage	DFO-NL – Science
Lisa Setterington	DFO-NCR – Science
Margaret Warren	DFO-NL – Science
Mariano Koen-Alonso	DFO-NL – Science
Michelle Roberge	DFO-NL – FFHPP
Nadine Wells	DFO-NL – Science
Robyn Jamieson	DFO-NL – Science
Sara Lewis	DFO-NL – Science
Shelley Decker	DFO-NL – FFHPP
Susanna Fuller	Oceans North
Vonda Wareham Hayes	DFO-NL – Science