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Proceedings of the National Peer Review Meeting on the Review of the Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment

Meeting dates: May 28-30, 2019

Location: Halifax, NS

Chairperson: Gilles Olivier

Editor: Emma Cooke

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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

These proceedings summarize the relevant presentations and discussions of the national science advisory meeting held on May 28-30, 2019 at the Sheraton Four Points in Halifax, NS. The conclusions and advice resulting from this meeting will be provided in the form of a Science Advisory Report that will be made publicly available on the CSAS website. Meeting participants included experts from various sectors and regions of Fisheries and Oceans Canada, as well as external participants from industry, academic, offshore petroleum boards, and other government departments. The purpose of this meeting was to review the Statement of Canadian Practice (SOCP) with respect to the mitigation of seismic sound in the marine environment. One working paper was distributed to the participants and reviewers, and was reviewed at the meeting for publication as a Research Document. The paper provided a literature review (2004–present) and analysis of recent published scientific information (including guidelines, protocols, and science advice) applicable to the development of mitigation measures in the SOCP. There is sufficient new science and technical information to support an update to the SOCP, and the client (DFO Oceans Management) will review the CSAS documents and other pertinent information and begin to initiate discussions and work planning with partners and stakeholders towards an update of the SOCP.

INTRODUCTION

Gilles Olivier (Chair) opened the meeting by welcoming the participants (Appendix 1) and provided a brief overview of the Canadian Science Advisory Secretariat (CSAS) peer-review process. The Chair reviewed the Terms of Reference (Appendix 2), agenda (Appendix 3), and discussed deadlines for the expected publications which includes the Science Advisory Report (SAR), Proceedings, and the Research Document upon approval of the group. Participants were asked to keep meeting discussions confidential until the SAR is published.

PRESENTATIONS

STATEMENT OF CANADIAN PRACTICE AND REQUEST FOR SCIENCE ADVICE

Presented by: Jonathan R. Hill

SYNOPSIS OF PRESENTATION

The Minister of Fisheries and Oceans has authority under the *Oceans Act* to establish marine environmental quality guidelines, objectives and/or regulations. The Marine Environmental Quality (MEQ) program in Oceans Management, Fisheries and Oceans Canada (DFO) works in collaboration with partners to develop integrated and evidenced-based tools and strategies to better manage and maintain healthy and sustainable marine, coastal or estuarine ecosystems. These approaches can help to provide direction, transparency and predictability.

The MEQ program is the client for the request for science advice on the Review of the Statement of Canadian Practice (SOCP) with respect to the Mitigation of Seismic Sound in the Marine Environment. The SOCP sets out minimum standard mitigation requirements for seismic survey operations in Canada in an effort to mitigate potential negative population-level impacts on marine wildlife and negative impacts to individual marine species listed as endangered or threatened in Canadian legislation. Science advice was requested by MEQ on the review of existing mitigation measures in the SOCP and potential new measures and considerations because underwater ocean noise has been identified as an important ecosystem stressor in the marine environment and the SOCP is intended to be reviewed regularly, and to be updated as additional scientific information and improved mitigation technologies and practices became available. Oceans Management had a major role in the development of the original SOCP and DFO provides advice on the application of the Statement and has relevant responsibilities pursuant to multiple pieces of legislation, including the *Oceans Act*, *Fisheries Act*, and the *Species at Risk Act*. Advice and recommendations will be used to inform discussions and work planning with partners and stakeholders regarding a potential update of the SOCP.

DISCUSSION

DFO Oceans Management clarified that this meeting is not meant to update the SOCP. Although DFO Oceans Management will lead any subsequent updates, any potential update will involve many regulatory partners and stakeholders, and will incorporate the science advice and recommendations provided at this meeting as well as from future working groups.

STATEMENT OF CANADIAN PRACTICE WITH RESPECT TO SEISMIC SOUND IN THE MARINE ENVIRONMENT REGULATORY OVERVIEW

Presented by M. Wambolt and J. Diamond

SYNOPSIS OF PRESENTATION

Ecosystem Management-Fish and Fish Habitat Program, Regulatory Review (FFHPP) staff presented an overview of offshore oil and gas seismic activity in the Newfoundland and Maritimes Regions and the regulatory environment that Seismic activities are subject to including the Memorandum of Understanding (MOU) between DFO and the Canada Newfoundland and Canada Nova Scotia Offshore Petroleum Boards (the Boards). FFHPP representatives outlined the environmental assessment process led by the offshore boards and outlined how the mitigations in the Statement of Canadian Practice with Respect to Seismic Sound in the Marine Environment are incorporated into regulatory requirements through Environmental Assessments and other regulatory processes.

The Environmental Assessment process is the mechanism through which additional mitigation may be proposed by operators and other government departments. For example mitigations related to Species at Risk Listed species and their Critical Habitats can be identified through the EA processes or developed through MOU's with the Boards and DFO. DFO and the Boards take an active role in monitoring offshore seismic activity to ensure that all required mitigation measures and reporting requirements are being implemented.

DISCUSSION

DFO FFHPP explained that the SOCP is focused on all marine life – with specific mitigation measures for species listed on Schedule 1. The presenter also discussed operational activities and funding for monitoring and mitigation measures.

REVIEW AND ANALYSIS: STATEMENT OF CANADIAN PRACTICE WITH RESPECT TO THE MITIGATION OF SEISMIC SOUND IN THE MARINE ENVIRONMENT

Presented by: Andre d'Entremont

SYNOPSIS OF PRESENTATION

The presenter gave a presentation on the results of the working paper. The objective of the working paper was to provide a literature overview and an analysis of the recent science (since the 2004 peer-reviewed report), related Canadian Science Advisory Secretariat (CSAS) processes, regional Canadian mitigation and monitoring practices, and relevant international guidelines and protocols to determine if the 2008 SOCP requires updates to protect marine species. Based on the analysis of this information, the authors provided 29 recommendations for changes to the 2008 SOCP, which addressed all components of the SOCP.

DISCUSSION

Participants asked how the offshore petroleum boards are involved with permits from academia and government. The boards are only involved with oil and gas operators, and not academia and government. However, DFO does apply the SOCP to academia and relevant research activities.

Participants were concerned about how the impact of seismic on fisheries (i.e., fishermen and fishing gear) was not covered in the working paper. The author clarified that although the impact

of seismic sound on fisheries was not covered because it is not the focus of the SOCP, the impact on fish was covered.

There was a discussion on needing clarification on whether a mitigation measure was created based on scientific information or other operational factors. For example, the standard distance between seismic operations is likely based on safety and legal considerations, and has little scientific basis.

A participant asked whether there has been any consideration in the working paper for seismic surveys in ice-covered waters. Seismic exploration has been recently occurring in ice-covered waters in areas where the ice is broken. In these areas, whales can get caught in the ice during their migration, leading to death. The author explained that the SOCP currently does not apply to ice-covered waters but this can be a point of discussion.

Participants agreed that the working paper presented here should be published as a Research Document and suggested revisions to the working paper to be incorporated when the Research Document is developed.

FISH BIOACOUSTICS AND ANTHROPOGENIC SOUND

Presented by: Arthur Popper

SYNOPSIS OF PRESENTATION

The presenter gave an overview of bioacoustics and the potential effects of anthropogenic sound on fishes. He pointed out that sound is very important for fishes, not only for communication, but also to learn about their environment from its “soundscape.” Any interference with detection of the soundscape has the potential to alter fish behavior.

The difference between particle motion and sound pressure was explained. Unlike sound pressure, particle motion is directional and can be used by fishes to detect sound position around an animal. Particle motion is an important factor in water relative to air. Sound can also travel through substrate for great distances from activities such as seismic and pile driving.

Fish ears are similar to other vertebrates, and fishes can detect and discriminate between different frequencies and intensities, and determine sound source direction. They are also able to detect biologically important sounds in the presence of other sounds, known as maskers. A major issue is that anthropogenic sounds may serve as maskers, and therefore interfere with a fish hearing sounds that are important to it.

Very little is known about the effects of anthropogenic sound on fishes due to a lack of realistic (non-caged) studies and experiments. Some studies have shown ear damage and temporary hearing loss, while others have shown no impact on hearing and tissue; the results are highly variable among species and sound sources. The most important potential effect of anthropogenic sound on fishes, however, is how it may alter behavior such as migration, reproductive behavior, etc.

Sound exposure guidelines for fishes and sea turtles (Popper et al., 2014) were developed based on the best available data, and remain relevant in 2019 (Popper, Hawkins, and Halvorsen, 2019). However, future guidelines should be developed in terms of particle motion, and should also be developed for invertebrates.

DISCUSSION

A participant asked whether seismic surveys generate a great deal of particle motion and whether this propagates long distances. The presenter responded that seismic surveys do generate particle motion in the immediate vicinity of the array, and can also travel through substrate over great ranges. The distance that particle motion propagates is largely unknown but would likely be detected by nearby fish. More research is required to determine the impact of particle motion on fish.

A participant noted that using chemical explosives has resulted in similar injuries to research on seismic (e.g., exploded swim bladder) and even more severe injuries.

THE EFFECTS OF SEISMIC EXPOSURE ON SNOW CRAB

Presented by: Bruce Martin

SYNOPSIS OF PRESENTATION

The presenter gave an overview of a four-year Environmental Studies Research Fund (ESRF) funded project, investigating the impact of seismic exploration surveys on snow crab in Atlantic Canada. The project ran from 2015-2018 and used a before-after-control-impact (BACI) and during/after (D/A) study designs to examine the impact of seismic sound (from both 2D and 3D seismic surveys) on catch rates, animal movement, physiological responses, and genomics of snow crab. The two study sites were located on the eastern edge of the Grand Banks off of Newfoundland. The study found:

- There was no statistically significant difference in catchability before and after 2D surveys. There was a difference in catchability for 3D surveys, however the trends differed between years.
- There were no obvious effects of seismic exposure on behaviour, movement patterns or on the continuous responses in velocity of crabs. There was high variation observed within and among snow crab.
- There were no significant differences found in the physiology (blood, liver, tissue) of crabs during 2D surveys. There were differences in physiology during 3D surveys in 2017, however this result was not seen in 2018.
- A tank study found no significant differences in food consumption and hair cell counts when exposed to seismic via a speaker.
- A seismic operation 40 km from a recording location is quieter than a fishing vessel operating in the area (< 1 km) of a recorder in the study area.
- Less noisy periods exist between seismic pulses. The ability of an animal to listen to the environment between these pulses depends on the hearing ability of the animal. Animals with sensitive low-frequency hearing (e.g. cod) may have their listening range reduced by 90% for the entire inter-pulse period even at ranges of 50 km from the source.

DISCUSSION

There was a discussion on the importance of future research focusing on particle motion and substrate vibration in addition to sound pressure. The author explained that there were some particle motion measurements taken in 2016 and 2017, and that future analyses will work on

these data. Substrate vibration was measured, however there were no interface waves. Substrate velocity is dominating, however further work is required to interpret these results.

Participants asked whether crabs had been previously exposed to seismic, and whether this had an impact on the catchability study. There is some evidence that when crabs are habituated to noise exposure they are less susceptible to predation. The authors explained that they worked with the Canada-Newfoundland and Labrador Offshore Petroleum Board to limit seismic operations in the study area for four weeks prior to the experiments. This allowed the project to be more realistic. However, the life history of the crabs was not considered.

There were questions regarding other sources of noise that may have impacts the experiment (e.g., weather or ships). The author explained that there may have been other noise, however none would have met the peak sound pressure level of seismic.

The presenter addressed a question about tag loss via moulting, explaining that the crabs in this experiment were terminal moult so this did not occur. Only six tags were lost during the experiment which is a very small percentage.

AN INTERNATIONAL LOOK AT MITIGATIONS USED DURING SEISMIC SURVEYS

Presented by: Erica Staaterman

SYNOPSIS OF PRESENTATION

Marine seismic surveys have been widely used across the world's oceans to monitor and explore for oil and gas deposits over the last 50 years. Multiple regulatory jurisdictions and a variety of regulatory approaches have been applied across different coastal nations.

This presentation provides information about existing acoustic impact mitigation measures that are used across various jurisdictions. While the same general suite of mitigation tools are typically employed (e.g., ramp-up, exclusion zones, time-area closures), the specific ways in which they are implemented vary. This presentation highlights similarities and differences among jurisdictions. It also describes several scientific approaches for testing the efficacy of such mitigation measures, and highlights the need to develop additional, innovative and collaborative research into the effectiveness of acoustic mitigations.

DISCUSSION

An important study was emphasized in this presentation on the response of humpback whales to seismic surveys and mitigation measures (ramp-up). Participants highlighted that results showed that only mother and calves slowed speed (i.e., not males) and there was no difference in behaviour towards seismic vessels operating arrays and non-seismic vessels with gear exposed but no emission of sound.

DEVELOPMENT OF ADVICE

Prior to the meeting, a working paper was produced that provided a literature review (2004–present) and analysis of recent published scientific information (including guidelines, protocols, and science advice) applicable to the development of mitigation measures in the SOCP (Moulton et al., unpublished). This literature review, gap identification, and analysis was intended to build upon previous DFO science advice (e.g., DFO 2004, DFO 2010, DFO 2015), and other domestic and international best practices. Based on the analysis, 29 recommendations for modifying the SOCP were provided to DFO for consideration and discussion at the meeting.

Participants used the information and analysis provided in the working paper, information presented at the meeting, as well as their own expertise to evaluate the 29 recommendations on updating the SOCP for the mitigation of seismic sound on marine mammals, fish, invertebrates, and sea turtles. The recommendations and rationale from the working paper, as well as a summary of the support, modifications, and knowledge gaps associated with the 29 recommendations is available in Appendix 1 and Table 1 of the Science Advisory Report (DFO, 2020).

The working paper author clarified that these recommendations are not meant to replace the existing SOCP, but to suggest further modifications.

PLANNING A SEISMIC SURVEY

When discussing planning a seismic survey, it was noted:

- The offshore petroleum boards (i.e., CNLOPB and CNSOPB) may already include certain planning requirements in their approval process that are suggested by the working paper. For example, to receive approval, seismic operations are prohibited from conducting airgun tests outside of the project area. However, regardless of current board requirements these guidelines should be made clear in the SOCP.
- In the Arctic the National Energy Board, Inuvialuit Environmental Impact Screening Committee, Inuvialuit Environmental Review Board and the Nunavut Impact Review Board have jurisdiction.
- Currently, operators must abide by the SOCP for the EA and if the application is approved then it is legally binding.

When discussing the protection of critical habitat in the SOCP, it was noted:

- Critical habitat is only delineated for species listed on Schedule 1 of the Species at Risk Act (SARA) (i.e., endangered, threatened, or extirpated). Therefore, participants suggested that critical habitat and/or other important habitat (e.g., feeding, mating, breeding), including acoustic habitat of species not included on Schedule 1 (e.g., special concern) should be avoided. A comprehensive definition of important habitat is lacking.
- Wording such as “spatial and temporal avoidance”, “peak use” and “to the extent possible” is ambiguous, and a quantitative metric should be explored.
- There is scientific evidence to support the inclusion of acoustic habitat in critical habitat of marine mammals.
- A buffer zone should be included to consider propagation of sound beyond immediate survey area, and these buffer zones should be created using acoustic propagation modelling.
- Critical habitat is already protected under SARA, and the Environmental Assessment (EA) process may identify case-specific protections that are necessary.
- There is a lack of data and knowledge of species distribution that is required to determine avoidance of important habitat. The term “avoidance” is not quantified or defined.
- There is limited information on the critical habitat of animals other than marine mammals, such as sea turtles. There has been evidence to suggest impacts on sea turtles including behavioral impacts, displacement, hearing threshold shifts; however, more research is required to determine to what extent turtle habitat should be protected in the SOCP.

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- Critical habitat of some species (e.g., leatherback turtles) can be extensive and avoidance of these areas may not be feasible or scientifically justified considering the limited scientific information available on the impacts of noise.
 - Spatial and/or temporal avoidance of animals and their habitat is the most precautionary and effective mitigation measure.
 - Whether seismic surveys will result in destruction of critical habitat remains unclear.

When discussing the protection of habitat important for Indigenous subsistence harvesting, it was noted:

- There is scientific evidence that seismic surveys may impact animals (e.g., belugas) and this can have implications for Indigenous harvesting.
- Seismic activity before or during harvesting should be avoided, regardless of peak time. Consultation with user groups is the best way to determine when or if seismic activities should be conducted.
- Indigenous subsistence harvesting is a constitutional right and should be protected.
- Any wording regarding this recommendation requires policy and legal review.
- The recommendation does not meet the requirements for all regions (e.g., Arctic vs. eastern Canada); regional differences need to be identified.
- There are limited studies on the effects of noise on animals other than marine mammals (e.g., marine fish) that may be important to subsistence harvesting, and further research is required to include them in the SOCP.

When discussing wording in the SOCP, it was noted:

- “Significant adverse effects” should be removed completely from the SOCP since SARA-listed species are already protected via legislation. “Prohibited effects” may be an appropriate alternative wording as this would be consistent with SARA and the Fisheries Act.
- The SOCP references population-level effects, which is not currently covered in legislation and may not be able to be defined.
- If terminology is not clear in the SOCP, proponents may believe they avoid significant adverse effects if they follow SOCP guidelines.
- Terminology in the SOCP needs to be clear and defined and should go under policy and legal review to avoid confusion with existing legislation.

When discussing a monitoring and mitigation plan, it was noted:

- A comprehensive list of Marine Mammal Observer (MMO) and Passive Acoustic Monitoring (PAM) Operator requirements should be included, and specific requirements should also be outlined in the SOCP. For example, the minimum number of staff, MMO perch height, and shift length should all be specified to ensure standardization.
- During any update of the SOCP, it will be important to have technical working groups involving regulators, industry, MMOs and PAM Operators to develop specific and feasible minimum requirements.
- Ultimately these metrics should be prescriptive in the SOCP and should not be left up to the operator.

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- Some measures and monitoring plan items are agreed upon in the EA process. Therefore, anything additional from the EA process (e.g., expected sightings) should be included as necessary.
 - Region specific items may also need to be added ad hoc such as environmental conditions that trigger a shutdown. For example, providing a Beaufort Scale cut-off for effective visual observation; at a Beaufort 5, the safety zone may be visible but whales will not be visible in large swell. Participants stressed that “low visibility” be clarified.

When discussing MMO and PAM Operator qualifications and experience, it was noted:

- The definitions for “acceptable qualifications and experience level” should be included in an appendix of the SOCP.
- Some offshore boards already require a CV from MMOs and PAM Operators.
- Field experience in addition to knowledge should be required because depending on the situation, types of experience may be more valuable than others.

When discussing pre-seismic survey research, it was noted:

- Requiring pre-survey research may be similar to EA Guidelines, however not all seismic operations go through the EA process so the SOCP should include this to cover all situations as a precaution.
- Currently, seismic surveys will proceed even if there are knowledge gaps, and that the wording needs to not assume that data exists and pre-survey research is not required.
- Operators should be required to have additional research if there is insufficient data available.
- Research should also be conducted if there is insufficient data on species not listed under SARA (Schedule 1), specifically those identified in the EA process.
- Pre-survey research will fill data gaps in areas where there is not sufficient information to evaluate importance.
- Pre-survey research could be either field or desktop research. However, field research may not be feasible due to time and costs. There is no agreement on who should be leading or funding the research (e.g., operator vs. regulator).

SAFETY ZONE AND START-UP

When discussing the size of the safety zone, it was noted:

- The recommendations imply that a SZ of 500 m covers PTS and TTS of marine mammals, when this is not the case.
- It is not scientifically justifiable to have a set SZ distance because of differences in sound propagation. Based on the environment and sound pressure level, SZ distance has been modelled anywhere from 500 m in deep clear water to 2500 m in shallower nearshore areas. In some cases, a SZ of 500 m may be sufficient, but it is best to use the most conservative value of either 500 m or a distance determined by sound propagation modelling. Ideally the SZ should be based on an acoustic threshold. This is consistent with previous advice from DFO (2015).
- The size of SZ will likely vary by region and differ based on outcomes of the EA process.

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- Modeling may need to be weighted for hearing groups of marine mammals. Internationally, a generic SZ is used to encompass avoidance of injury for more than one hearing group and protection against more severe reactions which would occur at closer ranges.
 - Even though thresholds have been developed Internationally (e.g., NOAA in the United States), the applicability in Canadian waters is unknown due to differences in environmental context and types and distributions of marine species.
 - Establishment of acoustic thresholds are a major knowledge gap for many species.
 - Modelling a minimum SZ radius will not be meaningful without an established acoustic threshold.
 - Whether the SZ is measured from the centre of the perimeter of the airgun array is trivial because is it a matter of metres. However, the point of measurement should be specified for practical purposes. It should also be array-based and not MMO-based.
 - Modelling results can be inaccurate or have high variation, especially in non-homogenous environments. As a result, sound propagation should be verified in the field and adjusted if necessary.
 - Methods for validating modelling results in the field were not specified. Discussions between operators and technical experts need to occur to determine restrictions.
 - The requirements for modelling and in-field verification may depend on several factors including the size of the array, area of operation, and number of times the array has been used in previous surveys.
 - The SOCP should specify the goal of the SZ. For example, is the goal to avoid PTS, TTS, Harm, Harassment etc. It is unclear how TTS and PTS fit into definitions such as Harm, Harassment, and Disturbance, in current legislation.

When discussing the pre-clearance zone, it was noted:

- A pre-clearance zone larger than the SZ should be established as a precautionary measure to increase the probability of detection for approaching animals. However, there is currently no scientific basis for a pre-clearance zone larger than the SZ or for a standardized zone radius.
- In certain regions like Newfoundland, observers are not even able to see 500 m due to fog, so a pre-clearance zone of 1000 m is likely excessive and not realistic.
- If a pre-clearance zone is required, the radius should be determined by propagation modeling, similar to determining the radius of the SZ.
- There may be environmental factors that could create a guide for operators to determine pre-clearance distance, such as water depth, water temperature, and other parameters.
- MMOs should be surveying ahead of the vessel to monitor where the array will be situated when ramp-up procedures begin.

When discussing ramp-up, it was noted:

- Sharks were added to the pre-clearance list because of the White Shark (SARA-listed) which can be detected at the surface and has been shown to be sensitive to particle motion. However, overall there is limited expertise at the meeting to determine whether sharks should be included on the pre-clearance list.

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- The EA process is the appropriate level at which to make the specific species determination. It is logical to include SARA-listed species at a national level, but regional offices should be given oversight during the EA process to allow flexibility.
 - All marine mammals (i.e., not only cetaceans) should be included because of the difficulty of identifying marine mammals at the species level.
 - A ramp-up delay of 60 minutes should be extended to all deep diving species. Deep diving species can dive longer than 60 minutes and this will improve probability of detection over one dive cycle. However for species that can dive longer than 60 minutes a ramp-up may not be appropriate since, an animal that is observed during pre-clearance may not remain in the SZ for the duration of its dive considering the movement of both the vessel and the animal.
 - Traditional knowledge needs to be considered in addition to science when developing pre-clearance and ramp-up species lists and procedures.
 - Additional species other than those listed in the SOCP could be added during the EA process. The list should remain flexible.
 - There are regional differences in species and their behaviour which may impact ramp-up procedures. For example, in the Arctic certain species have been known to follow ships which may impede a ramp-up.
 - The SOCP should not preclude starting a survey if you cannot see the pre-ramp up clearance zone. This would make it difficult in regions like Newfoundland where there is often low visibility, and prohibiting seismic depending only on monitoring the safety zone would have economic consequences.
 - There should be concurrent PAM and visual monitoring since in PAM will be more effective at detecting certain species, which visual monitoring may be more effective for others. For example, certain species in the Arctic cannot be detected using PAM and as a result surveys only occur during the day.
 - There is little research conducted on the efficacy of PAM and more studies are required. Future research should focus on the efficacy and practicality of other detection technologies such as active acoustics and infrared cameras.
 - Ramp-up may be considered 'harassment' under SARA, considering that the goal of ramp-up is to displace animals from a specific area. Further consultation with DFO is required to discuss this issue.
 - Factors such as the number of seismic vessels and size of the array should be considered when determining the ramp-up duration.
 - There should be a time bound for the duration of a period of inactivity before a ramp-up is required, but there is no science to shorten the duration of the existing SOCP.
 - The ship will be moving during a period of inactivity, likely into areas that were not exposed to sound. Therefore, the SZ must be maintained visually during all shut-down periods.
 - The purpose of the single compressed air source is to prevent ramping up again. Therefore, there should not be a requirement to ramp up after using a single air source.
 - The purpose of a single air source is to prevent animals entering the area, that were not previously exposed. Ramp-up from a single air source should be required to alert any

animals that did not respond to a single air source since the response to a single air source is unknown.

SHUT-DOWN OF AIR SOURCE ARRAY(S)

During discussions about shut-downs of air source array(s) it was noted:

- The current list of species that triggers a shut-down should include other species that are potentially impacted (e.g., beluga, walrus, narwhal). These species may be identified during an EA process or other regulatory processes. This list should remain flexible for project-specific scenarios, but should remain prescriptive.
- There is very little support for including polar bears and sharks on a shut-down list. Polar bears in water are at the surface, usually with their head out of the water, and likely only experience only very low sound levels. The impact of sharks with respect to particle motion is unknown.
- The lists of animals for ramp-up and shut-down are not necessarily going to be the same. The lists will depend on the sensitivities and responses of each species.
- The SOCP should require a shut-down for species “within or entering” the SZ to protect approaching animals and to avoid subjectivity by the MMO(s).

LINE CHANGES AND MAINTENANCE SHUT-DOWNS

During discussions about line changes and maintenance shut-downs it was noted:

- Internationally, the risk of ramp-up after line changes and maintenance shut-downs has been accepted when the SZ cannot be fully monitored.
- The SOCP should not prohibit a complete shut-down during line changes if the SZ is not visible. Line changes can take a long time (>20 hours) and the intent should be to reduce sound input into the environment.
- Ramp-up procedures should be clearly outlined in the SOCP.
- The effectiveness of using ramp-up as a mitigation measure to displace animals is unclear and requires further research and testing.
- If a single airgun is active, a time period should be defined in the SOCP for when ramp-up is required; however, a specific time period was not agreed upon.
- Many factors need to be taken into account when determining ramp-up requirements after a certain period of inactivity including: cetacean speed, vessel speed, and sound levels.

OPERATIONS IN LOW VISIBILITY

During discussions about operations in low visibility it was noted that:

- PAM should be employed throughout the seismic survey in addition to visual monitoring regardless of visibility to enhance probability of detection. Some whales (e.g., beaked whales) are better detected via PAM than visual monitoring.
- The SOCP should not preclude a complete shut-down if only using PAM and not visual monitoring during periods of low visibility.

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- The knowledge and use of PAM has improved substantially since publication of the original SOCP; however, there are still knowledge gaps regarding PAM efficacy and specifications of PAM systems.
 - The SOCP should refer to PAM directly instead of “cetacean detection technology” in general. Other cetacean detection technologies (e.g., infra-red cameras, active acoustics) still require further development and testing.
 - Even with excellent experience and equipment, it is difficult to localize an animal. However, while accurate localization is not typically possible, an experienced PAM Operator can know whether the detected animal is within a certain distance of the vessel (i.e., within the safety zone). The original SOCP encourages better use of PAM systems and more qualified MMOs. PAM information should continue to be used to implement a ramp-up delay or shut-down. If a marine mammal cannot be localized with a reasonable degree of accuracy using PAM (which may often be the case), the marine mammal should be assumed to be within or entering the SZ, and a ramp-up delay or shut-down must be implemented.
 - For some species, detection distance using PAM is unknown. Also, some whales vocalize at the same frequency as seismic.
 - Information on PAM specifications should be delivered to the appropriate regulatory agency, not only DFO.
 - The SOCP should refer to an ISO standard for PAM systems, if it exists.

ADDITIONAL MITIGATION MEASURES AND MODIFICATIONS

When discussing cumulative effects of seismic surveys it was noted:

- Current separation distance between seismic operations used internationally are largely for safety concerns or as a result of litigation, and it not scientifically based. There is no scientific evidence to implement separation distances greater than those already implemented by the industry for safety purposes.
- Acoustic modeling should inform separation distances of seismic surveys both spatially and temporally.
- Cumulative effects can occur when surveys are concurrent and/or consecutive (e.g., different companies or one company requiring additional data in the same area).
- It is unknown whether seismic surveys should be closer or further apart, both spatially and temporally. Both frequency and sound level (dB) need to be considered in the context of a marine species.
- It may be worse for a small area to be exposed to high noise levels, not a large region overall. Quiet periods are important.
- The impacts as well as how to measure and assess cumulative effects from multiple seismic surveys is a large knowledge gap. There is limited scientific literature on cumulative effects of sound.
- More guidance is required for regulators and operators on how to address cumulative effects.
- When there is little knowledge on the presence and/or impacts of cumulative effects, seismic surveys should not occur.

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- The best mitigation measure for cumulative effects is prevention; surveys should be planned so they are not in proximity to one another or occurring consecutively or concurrently in the same area.
 - There is uncertainty around cumulative effects between seismic sound and other stressors (e.g., bycatch, fisheries, climate change etc.).

OTHER

During the discussions about data collection throughout seismic surveys it was noted that:

- The SOCP should include a standardized approach for MMOs and PAM Operators to collect and report on data. For example, the Canadian Wildlife Service provides a standard bird database to operators. However, it was acknowledged that collecting data is not the primary task of MMOs and PAM Operators so this should be limited to necessary data.
- Any data collected during seismic operations could be used to inform efficacy of mitigation measures and help address data gaps on the impacts of seismic surveys on marine animals.
- The data and reports should be submitted and approved by the appropriate regulatory agency (which may include DFO, offshore petroleum boards, etc.).
- The type of data and metadata to be collected and reported should be defined in the SOCP. Some data is proprietary and should not have a sharing requirement.
- Protocols for archiving and managing data should be developed. However, legal protection of data may be an issue for any publically available database.

Additional Discussions

Other points made by participants include:

- The effectiveness of the application of the measures outlined in the SOCP may vary depending on specifications of the seismic survey. For example, the extent of in-field verification of safety zone size, or specific ramp-up procedures may depend on the size of the airgun array, area of seismic operation, number of vessels, and frequency of array use in previous surveys. For example, using a small airgun array may not warrant sound propagation modeling compared to a survey using a large airgun array.
- Prevention is the greatest form of mitigation. There is the most scientific evidence that spatio-temporal avoidance of marine species reduces potential impacts of seismic surveys; taking a precautionary approach was recommended.
- Many of the measures in the SOCP should undergo legal review.

ADDITIONAL MITIGATION MEASURES

Due to time constraints additional mitigation measures not addressed in the existing SOCP or by the recommended modifications and additions were not discussed or peer-reviewed at the meeting. Participants were asked to submit suggestions for additional mitigation measures (based on scientific rationale) to DFO Science, where they were compiled and submitted to DFO Oceans Management to potentially be considered during a future SOCP update.

RISKS TO MARINE SPECIES NOT ADDRESSED IN THE SOCP

Participants discussed the potential risks to marine species that are not addressed by the existing SOCP, nor by any recommended modifications. These risks include far-field and sub-lethal impacts, potential impacts on animals other than marine mammals, impacts from surveys in ice-covered waters, and impacts from other sound sources. Participants highlighted that there are many studies in the literature on fish and invertebrates, yet this meeting did not discuss the impacts or mitigation of seismic sound on fish and invertebrates in depth. The complete list of potential risks are outlined in the Science Advisory Report.

REFERENCES CITED

- DFO. 2004. [Review of Scientific Information of Impacts of Seismic Sound on Fish, Invertebrates, Marine Turtles and Marine Mammals](#). DFO Can. Sci. Advis. Sec. Habitat Status Report 2004/002.
- DFO. 2010. [Guidance Related to the Efficacy of Measures Used to Mitigate Potential Impacts of Seismic Sound of Marine Mammals](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/043.
- DFO. 2015. [Review of Mitigation and Monitoring Measures for Seismic Survey Activities in and near the Habitat of Cetacean Species at Risk](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/005.
- DFO. 2020. [Review of the Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/005.
- Popper, A. N., Hawkins, A. D., Fay, R. R., Mann, D. A., Bartol, S., Carlson, T. J., Coombs, S., Ellison, W. T., Gentry, R. L., Halvorsen, M. B., Lokkeborg, S., Rogers, P. H., Southall, B., Zeddies, D., and Tavolga, W. A. (2014). ASA S3/SC1. 4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI (Springer, New York)
- Popper, A. N., A.D. Hawkins, and M. C. Halvorsen. 2019. [Anthropogenic sound and fishes](#). A Report Prepared for the Washington State Department of Transportation, Olympia, WA.

APPENDIX 1: LIST OF PARTICIPANTS

Name	Affiliation
Gilles Olivier	Chair
Emma Cooke	Rapporteur, DFO Science, National Headquarters
Mike Stoneman	DFO Science, National Headquarters
David Cote	DFO Science, Newfoundland and Labrador
Andrew Wright	DFO Science, Maritimes
Jim Theriault	DFO Science, Maritimes
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Hilary Moors-Murphy	DFO Science, Maritimes
Michael Wambolt	DFO Fisheries Protection Program, Maritimes
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Jonathan Hill	DFO Oceans Management, National Headquarters
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Heather Breeze	DFO Oceans Management, Maritimes
Bob Courtney	Natural Resources Canada, Geological Survey of Canada
Lindy Weilgart	Dalhousie University
Ashley Krakowka	Government of Newfoundland and Labrador
Elizabeth MacDonald	Canada-Nova Scotia Offshore Petroleum Board
Eric Theriault	Canada-Nova Scotia Offshore Petroleum Board
Melissa Moss	Canada-Newfoundland and Labrador Offshore Petroleum Board
Geoff Hurley	Hurley Environment Ltd.
Bruce Martin	JASCO Applied Science
David Livingstone	Joint Secretariat - Environmental Impact Screening Committee
Miguel Chenier	Nunavut Tunngavik Inc.
Arthur Popper	University of Maryland
Andre d'Entremont	LGL Ltd.
Benjamin Laws	National Oceanic and Atmospheric Administration
Rob Pitt	GX Technology
Gary Isaken	ExxonMobil
Jill Lewandowski	Bureau of Ocean Energy Management
Erica Staaterman	Bureau of Ocean Energy Management
Alexandria Rivard	International Association of Geophysical Contractors
Robyn Lee	Fish, Food and Allied Workers
Emily Gregus	Canadian Environmental Assessment Agency

APPENDIX 2: TERMS OF REFERENCE

Review of the Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment

National Peer Review – National Capital Region

May 28 – 30, 2019
Halifax, NS

Chairperson: Gilles Olivier

Context

Interest in offshore oil and gas exploration and development in Canadian waters from the Offshore Petroleum Industry continues. Concurrently, the interest and pressure to mitigate the impacts of seismic exploration activities on marine wildlife has been growing. Sound produced from airgun arrays used in these surveys can potentially have negative impacts on marine species including a variety of physiological (e.g., temporary threshold shifts, permanent threshold shifts, increased stress levels), behavioural (e.g., disturbance, harassment, displacement) and environmental (e.g., masking) impacts.

The [2007 Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment](#) (SOCP) sets out minimum standard mitigation requirements for seismic survey operations in Canada in an effort to mitigate potential negative population-level impacts on marine wildlife (DFO 2008). The mitigations in the SOCP were based on documents produced at a 2003 DFO workshop that reviewed the impacts of seismic survey sound on fish, invertebrates, marine turtles, and marine mammals (e.g., DFO 2004a,b). When it was created, it was recommended that the SOCP be reviewed annually, and to be updated as additional scientific information and improved mitigation technologies and practices became available. However, the SOCP has not been formally reviewed or updated since its original publication.

Since 2007, there have been advances in the knowledge of the impacts of underwater noise on marine species, and a number of related Science Advisory Reports (SAR) and associated Research Documents have been generated (e.g., DFO 2010, DFO 2015). Although these SARs provide input relevant to the guidance in the SOCP, the advice has often been focused on the mitigation of impacts on SARA-listed species and marine mammals. Furthermore, these past SARs were intended to supplement but not replace the current SOCP. In light of new scientific information that forms the basis of the SOCP, the SOCP may benefit from a directed and comprehensive review to its effectiveness in protecting exposed marine species.

Prior to the meeting, a working paper will be produced that provides a literature review (2004–present) and analysis of recent published scientific information (including guidelines, protocols, and science advice) applicable to the development of mitigation measures in the SOCP. This literature review, gap identification, and analysis is intended to build upon previous DFO science advice, and other domestic and international best practices.

The intent of this process is to develop science advice that is applicable at the national level to be used to review and potentially update the mitigation measures in the SOCP. This meeting will address the potential impacts of seismic sound in general on all marine life, and particularly on marine mammals, fish, invertebrates and sea turtles, and will consider domestic and international best practices.

Objectives

Participants will conduct a peer-review of the working paper and, based on information contained in the working paper and participant expertise, will assess the recommendations with respect to the measures within the 2007 SOCP. More specifically, participants are asked to address the following questions with respect to the impacts of seismic surveys (using air source arrays) in Canada, on marine mammals, fish, invertebrates, and sea turtles, and mitigation of these impacts:

1. Which of the existing mitigation measures for seismic exploration activities listed in the SOCP should be updated? If revisions to an existing mitigation measure are required, what changes are recommended?
2. Are there other technically feasible mitigation measures that should be added to the SOCP? If additional mitigation measures are required, what additions are recommended?
3. If updates or additions are recommended but not possible at this time due to knowledge gaps, what are the knowledge gaps that need to be addressed and can meeting participants make recommendations as to how can they be addressed?
4. Are there potential risks to marine species from sounds produced during seismic exploration activities that are not currently addressed in the SOCP, or by the recommended revisions or additions to the SOCP?

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document(s)

Expected Participation

- Fisheries and Oceans Canada (DFO)
- Academic experts
- Offshore Petroleum Boards
- Natural Resources Canada
- Other invited experts

References

- DFO. 2004a. [Potential Impacts of Seismic Energy on Snow Crab](#). DFO Can. Sci. Advis. Sec. Habitat Status Report 2004/003.
- DFO. 2004b. [Review of Scientific Information of Impacts of Seismic Sound on Fish, Invertebrates, Marine Turtles and Marine Mammals](#). DFO Can. Sci. Advis. Sec. Habitat Status Report 2004/002.
- DFO. 2010. [Guidance Related to the Efficacy of Measures Used to Mitigate Potential Impacts of Seismic Sound of Marine Mammals](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/043.
- DFO. 2015. [Review of Mitigation and Monitoring Measures for Seismic Survey Activities in and near the Habitat of Cetacean Species at Risk](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/005.

APPENDIX 3: AGENDA

DAY 1 – Tuesday, May 28

Time	Subject	Presenter
09:00	Welcome and Introductions Review Agenda and Housekeeping CSAS Overview and Procedures	Chair
09:15	Review Terms of Reference	Chair
09:30	Context Setting: Statement of Canadian Practice (SoCP) and Request for Science Advice	DFO - Oceans Management
09:50	Context Setting: Application of the SoCP in the regulatory environment	DFO – Fish and Fish Habitat Protection Program
10:15	HEALTH BREAK	
10:30	Presentation of Working Paper: Part #1 (Sections 1.0 – 5.0) <ul style="list-style-type: none"> • Overview of the SoCP • Science Advice and Supplemental Guidance and Approaches Used in Canada • Review of Key Scientific Findings since 2004 • International Practices and Guidelines 	Working paper authors
11:00	Formal Review of Working Paper Provided by Designated Reviewers: Part #1 (Sections 1.0 – 5.0)	Formal reviewers
11:30	Group Discussion of Working Paper: Part #1 (Sections 1.0 – 5.0)	All participants
12:00	LUNCH BREAK (not provided)	
13:00	Presentation of Working Paper: Part #2 (Sections 6.0 – 7.0) <ul style="list-style-type: none"> • Review and Analysis of SoCP • Recommendations for Consideration 	Working paper authors
13:45	Formal Review of Working Paper from Designated Reviewers: Part #2 (Sections 6.0 – 7.0)	Formal reviewers
14:15	Group Discussion of Working Paper: Part #2 (Sections 6.0 – 7.0)	All participants
15:00	HEALTH BREAK	
15:15	Presentation on the Impacts of Noise on Fish	Arthur Popper (University of Maryland)
15:45	Group Discussion	All participants
16:00	Presentation on the Impacts of Noise on Invertebrates (Snow Crab)	Bruce Martin (JASCO)
16:30	Group Discussion	All participants
16:45	Wrap-up Day 1	Chair
17:00	Adjournment Day 1	

DAY 2 – Wednesday, May 29

Time	Subject	Presenter
09:00	Review of day 1 and proposed approach for day 2	Chair
09:15	Presentation on existing international mitigation measures for seismic airgun surveys	Erica Staaterman (BOEM)
09:45	Group Discussion	All participants
10:00	Discussion on each of the SoCP measures and recommendations against the four objectives outlined in Terms of Reference (see Appendix 1): <u>Planning Seismic Surveys Measures</u> <ul style="list-style-type: none"> ○ SoCP measures #3-5 ○ Working paper recommendations #1-8 	All participants
11:00	HEALTH BREAK	
11:15	Discussion on each of the SoCP measures and recommendations against the four objectives outlined in Terms of Reference (see Appendix 1): <u>Safety Zone and Start-up Measures</u> <ul style="list-style-type: none"> ○ SoCP measures #6-7 ○ Working Paper Recommendations #9-17 	All participants
12:45	LUNCH BREAK (not provided)	
13:45	Discussion on each of the SoCP measures and recommendations against the four objectives outlined in Terms of Reference (see Appendix 1): <u>Shut-down of Air Source Arrays and Line Changes and Maintenance Shut-downs Measures</u> <ul style="list-style-type: none"> ○ SoCP measures #8-10 ○ Working Paper recommendations #18-20 	All participants
15:15	HEALTH BREAK	
15:30	Discussion on each of the SoCP measures and recommendations against the four objectives outlined in Terms of Reference (see Appendix 1): <u>Operations in Low Visibility and Additional Mitigative Measures and Modifications Measures</u> <ul style="list-style-type: none"> ○ SoCP measures #11-15 ○ Working Paper recommendations #21-29 	All participants
16:45	Wrap-up day 1	Chair
17:00	Adjournment day 2	

DAY 3 – Thursday, May 30

Time	Subject	Presenter
09:00	Review of day 2 and proposed approach for day 3	Chair
09:15	Continuation of any outstanding points from day 2 to be discussed	All participants
10:30	HEALTH BREAK	
10:45	Development of science advice, including consensus on: <ul style="list-style-type: none">• Summary bullets• Sources of uncertainty• Results and conclusions	All participants
12:00	LUNCH BREAK (not provided)	
13:00	Development of science advice (continued...)	All participants
14:45	HEALTH BREAK (not provided)	
15:00	Development of science advice (continued...)	All participants
16:30	Next Steps: <ul style="list-style-type: none">• Science Advisory Report (SAR) review/approval process and timelines• Research document & proceedings timelines Other follow-up or commitments (<i>as necessary</i>)	Chair
17:00	Adjournment of Meeting	