

NEXEN ENERGY ULC

Eastern Newfoundland Offshore Geophysical, Geochemical, Environmental and Geotechnical Program (2018 – 2023)

Environmental Assessment Addendum (Revised)

FINAL REPORT #3

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1 INTRODUCTION

Nexen Energy ULC (Nexen) is proposing to undertake an offshore petroleum exploration program in the Canada - Newfoundland and Labrador Offshore Area, which will include planned geophysical, geochemical, environmental and geotechnical survey activities in this region between 2018 and 2027 (hereinafter referred to as the Project). The Project requires authorizations from the Canada - Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB, or the Board), pursuant to Section 138(1)(b) of the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Act* and Section 134(1)(b) of the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act (Accord Acts)*.

As part of the required regulatory review and approval processes for the Project, Nexen filed an Environmental Assessment Report (EA Report) in relation to this proposed marine exploration program in June 2017. The EA Report was planned, prepared and submitted in compliance with the associated EA requirements and processes of the C-NLOPB, including the C-NLOPB's Project-specific EA Scoping Document issued on March 13, 2017. Nexen's EA Report for the Project (*Eastern Newfoundland Offshore Geophysical, Geochemical, Environmental and Geotechnical Program (2018 – 2027) Environmental Assessment*, prepared by Amec Foster Wheeler, June 2017) was submitted to the C-NLOPB on June 19, 2017. The C-NLOPB subsequently invited government agencies and the public to review and provide comments on the EA Report. On October 12, 2017 the C-NLOPB provided Nexen with the consolidated comments received during that review. The C-NLOPB stated in its letter of transmittal that:

“The Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB), in consultation with the Board’s fishery and environmental review agencies, have reviewed the above referenced environmental assessment (EA) report.

The EA report does not satisfy all of the information requirements outlined in the Scoping Document provided to Nexen Energy ULC on March 13, 2017. In order to satisfy the requirements of the Canada-Newfoundland and Labrador Atlantic Accord Implementation Act and the Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act and to complete a report on the C-NLOPB’s determination at the conclusion of the assessment, the attached comments should be addressed”.

In March 2018, Nexen submitted an EA Addendum for the Project (EA Addendum), which was provided as a supplement to the original EA Report of June 2017. That document provided responses to the various questions and associated requests for information and clarification that were submitted by government departments and agencies and other organizations as part of the EA review, as consolidated and provided to Nexen by the C-NLOPB in October 2017.

In May 2018, Nexen submitted a revised EA Addendum for the Project (EA Addendum Revised Final Report #2), which as a cumulative document, provided additional responses supplemental to the original EA Report of June 2017 and the EA Addendum of March 2018. That document provided responses to the additional questions and requests for information and clarification that were submitted by government departments and agencies and other organizations as part of the ongoing EA review, as consolidated and provided to Nexen by the C-NLOPB in April 2018.

In October 2018, Nexen submitted a further revised EA Addendum for the Project (EA Addendum Revised Final Report #3), which as a cumulative document, provided responses to two additional comments resulting from the ongoing review of the EA Report and the EA Addendum Revised Final Report #2, as consolidated and provided to Nexen by the C-NLOPB on September 19, 2018. The EA Addendum Revised Final Report #3 (October 2018) included responses to two additional “General Comments” in two new subsections (see Sections 2.1.2.3 and 2.1.3.3 for new responses) that follow the previous general comments.

Nexen submitted its Environmental Assessment (EA) (Nexen Energy ULC Eastern Newfoundland Offshore Geophysical, Geochemical, Environmental and Geotechnical Program (2018-2027) and supporting Addendums to the C-NLOPB with an expected 10-year temporal scope (2018–2027). The C-NLOPB recently reviewed the temporal and spatial scopes of the Accord Acts, and in June 2018 made the decision to reduce the temporal scope of geophysical/geological EAs to six years to better align with Period I of an exploration licence. Therefore, the C-NLOPB’s determination on the significance of adverse environmental effects of the proposed “Nexen Energy ULC Eastern Newfoundland Offshore Geophysical, Geochemical, Environmental and Geotechnical Program (2018 – 2027)” EA will reflect this temporal decision. In following, the title of this Addendum #3 document (December 2018 version) has been revised to be Nexen Energy ULC Eastern Newfoundland Offshore Geophysical, Geochemical, Environmental and Geotechnical Program (2018-2023) to reflect this C-NLOPB decision.

In order to help optimize utility and readability, and in keeping with other such documents prepared for recent projects and their assessments, the EA Addendum is presented in a “question and answer” format, organized according to the particular departments, agencies and organizations that provided the various questions and comments (provided in ***bold italics***) that are being responded to herein.

2 RESPONSES TO REVIEW COMMENTS ON EA REPORT AND EA ADDENDUM

2.1 General Comments

2.1.1 Environment and Climate Change Canada (ECCC)

Please note that in addition to our earlier comments on the Scoping Document and Project Description are still applicable.

Nexen Response: Reviewer commentary to C-NLOPB, no additional information or response required or requested from Nexen. The EA Report was completed in accordance with the EA Scoping Document prepared and issued by the C-NLOPB with the input of various agencies and organizations. Please note, however, that Nexen and the EA Study Team did review the initial comments on the Project Description and the Scoping Document, as posted by the C-NLOPB, and these were considered and addressed where appropriate in planning and completing the EA.

2.1.2 Groundfish Enterprise Allocation Council-Canadian Association of Prawn Producers (GEAC-CAPP)

2.1.2.1 Original General Comments (EA Addendum Final Report) (March 2018)

To begin, this project is situated in a highly productive region of the Northwest Atlantic. The boundaries of the study area encompass very important Groundfish harvesting areas for a wide variety of species. Although this is acknowledged in the Environmental Assessment document, we are concerned that the potential impacts of invasive surveying techniques such as seismic exploration are not adequately assessed, nor is the long term risk truly considered.

Nexen Response: As noted by the reviewer, the EA Report recognizes the important and diverse fishing activity that occurs in the EA Study Area, and provides a detailed description of the fishery and other key aspects of the existing biophysical and socioeconomic environments. It also provides a comprehensive and balanced assessment of the potential environmental effects of the Project and associated identification of mitigation, which incorporates and is fully informed by existing scientific knowledge regarding the effects of these types of offshore activities as reported in the scientific literature and other available sources. We would therefore maintain that the potential effects of the Project are fully and adequately assessed in the EA Report.

As we have indicated in past submissions on seismic exploration, the relationship between seismic activity and the behavior of shrimp and Groundfish is poorly understood. We have experienced substantial changes in catch rates and resource distribution associated with nearby seismic activity and feel that this EA does not adequately consider those risks. The study area encompasses many different marine environments and fisheries, but the assessment is narrowly focused and returns with the assessment of 'negligible to low' risk on

fish species, fisheries and their habitats. This is clearly an over-extension of assessment given the paucity of scientific knowledge on the impacts of such intrusive activities.

As we have noted in other EAs, the document suggest that no fisher will be required to relocate based on the exploration activities. We question this conclusion, especially given that we have observed substantial reduction in catch rates of both shrimp and Groundfish as a result of seismic testing within the general vicinity. This means that although a seismic survey vessel may not force us to immediately relocate to avoid the survey vessel, the resultant impacts of fish distribution from the seismic pulses will cause us to significantly alter our fishing plans – even leading us to abandon some areas for several months.

Nexen Response: As noted in the preceding response, the EA Report provides a complete and balanced assessment of the potential environmental effects of the Project, including the various survey types (2D, 3D and 4D seismic, and associated geochemical, environmental, geotechnical and wellsite survey activities) and their potential characteristics (e.g., possible equipment types, sound source levels, etc.) that may occur as part of the Project. This has included reviewing available information and existing scientific knowledge related to the potential effects of seismic survey activities overall on species such as shrimp and groundfish, and assessing and evaluating the potential effects of the Project on these and other species and associated fishing activities in the area. As presented in the EA Report (e.g., Sections 5.4 and 5.9) past studies from the available scientific literature regarding possible behavioural effects on marine fish (finfish and invertebrates) as a result of active seismic survey operations, and any associated effects on catch rates, also indicate that these are of a temporary and localized nature (see EA Report, Table 5.2 for details regarding effect durations and extents, and associated references).

Based on this review and analysis, it is considered unlikely that the localized and short term presence of seismic sound energy in the marine environment as a result of this Project, and any associated implications for individual fish behaviours, would have a negative effect on the overall nature, intensity or value of fishing activity in the Study Area. In particular, it is unlikely that any such behavioural effects would result in any “detectable reduction in the overall economic returns generated from fisheries and/or other marine activities undertaken within the Study Area over one or more years” (Section 5.9.1).

We again request that the EA include some parameters on the avoidance of activity, to be determined through direct discussion with ourselves and member companies. This avoidance should include both a spatial and temporal element to allow our harvesting activities to continue without reductions in catch rates.

Nexen Response: Nexen is committed to on-going communications and cooperation throughout the life of the Project in order to help identify potential interactions between its planned activities and the fishing industry, and to seek to avoid any such issues and potential effects through planning, coordination and cooperation. Nexen’s planned measures for doing so are outlined in detail throughout the EA Report (in particular, in Sections 5.3.2 and 5.9).

Section 5.9.3.1 of the EA Report reiterates these commitments as part of the environmental effects assessment, and states that:

“..[T]his involves planned communications and coordination procedures involving the Operator/Contractor and relevant regulatory authorities, stakeholders and key ocean users throughout the operational life of the Project, including:

- On-going information gathering on key fishing areas and times and continued monitoring of fishing and fish survey activity;
- The presence, active participation and advice of the FLO on board the seismic ship, and a shore-based SPOC;
- The issuance of Notices to Mariners/Shipping and other notifications and direct industry communications throughout the periods of Project operations, and regular communication of planned survey activities with key industry representatives;
- The use of a standby or guard vessel to scout for hazards and for communicating with active fishers in the area (if any); and
- Establishment and implementation of a Fishing Gear Damage or Loss Compensation Program.

As noted in Section 5.3, the proposed survey activities will also be planned and implemented to avoid negative interactions with fisheries research surveys in the Study Area, through active and on-going communication and coordination with DFO and industry representatives.”

We suggest that there is not sufficient information in this document to adequately assess the impacts of seismic exploration on shrimp and Groundfish behavior and distribution (and thus the catch rates experienced by our operators). Without this information, we must proceed in a precautionary manner that respects existing ocean users while maintaining a path to allow exploration and resource development. We submit these comments based on our past experience with seismic exploration near our harvesting grounds. This experience has generally not been positive and we seek to improve our relationships with the oil and gas exploration industry such that the benefits of our oceans can benefit all sectors.

Nexen Response: The EA Report provides details on Nexen's planned offshore exploration activities, the existing biophysical and socioeconomic environments of the Study Area, the substantial scientific literature that exists regarding the potential effects of such surveys, and the potential effects of the Project on the marine fish and fish habitat and fisheries VECs. It also outlines Nexen's planned approaches and measures to avoid adverse effects upon the environment. Most of these measures (see EA Report, Sections 5.3.2 and 5.9) represent proactive, planning approaches to avoiding possible adverse environmental interactions and resulting effects. Nexen therefore submits that a precautionary approach has been a fundamental part of Project planning to date, and will continue to guide the Project throughout its implementation. As noted in the preceding response, Nexen is committed to on-going communications and cooperation throughout the life of the Project in order to help identify

potential interactions between its planned activities and the fishing industry, and to seek to avoid potential effects through on-going planning, coordination and cooperation.

2.1.2.2 Additional General Comments (EA Addendum Revised Final Report #2) (May 2018)

Nexen Note: While these additional comments comprise general commentary by the reviewer(s) and do not raise specific questions or issues nor request or provide additional information or analysis regarding the content and findings of the EA, the Proponent has provided the following general responses as part of this Revised EA Addendum.

We were disappointed by the tone of their response, which does little to promote a "common interest" relationship between our respective industries involved in offshore waters off Newfoundland and Labrador.

Nexen Response: The EA Report and this EA Addendum recognize and make clear reference to the importance of the fishing industry, and the need for both industries to work together through relevant processes and forums to seek to avoid interactions and any associated disturbances and potential effects. In our response to the original, general comments provided by the reviewer (Section 2.1.2.1), Nexen reiterated that it is “committed to on-going communications and cooperation throughout the life of the Project in order to help identify potential interactions between its planned activities and the fishing industry, and to seek to avoid any such issues and potential effects through planning, coordination and cooperation”, as well as reiterating the specific mitigation and communications / cooperative measures through which it plans to do so throughout the life of the Project.

Each of the potential environmental interactions that may be associated with the Project can be mitigated through the use of good planning and proven operational procedures, supported by standard mitigations that are well established as industry best practices and outlined in relevant regulatory procedures and guidelines (such as those referenced above, which have been identified and committed to by Nexen as part of the EA). These mitigations have been successfully applied to similar marine exploration programs off Eastern Newfoundland and elsewhere in recent years.

The spatial extent of the program precludes the broadly stated impact assessment presented by the EA and this addendum. We suspect that if we were to identify a specific point within the study area, Nexen would be unable to provide any precision on the actual 'values' contained therein (ranging from phytoplankton to larval fish and extending to top predators), because of the paucity of information that is available on a local scale. With such limited information, "likelihoods" cannot be legitimately claimed.

Nexen Response: The geographic extent and the multi-year nature of the proposed Project is recognized and acknowledged throughout the EA Report, although it should be reiterated that Project-related seismic survey activities in any given year would take place in specific parts of the Project Area (e.g., Section 2.3 of the EA Report notes that each 2D survey would involve approximately 1,000–3,000 line-kilometers of seismic data, and would be approximately 10-30 days in duration). Also, and in particular, any associated environmental disturbance resulting

from the survey activities would be localized and short-term in duration during the overall seismic program.

In terms of the nature and “resolution” of the environmental baseline data presented and used in the EA, we would note that in any assessment for any project (even those with defined and spatially focussed study areas, such as an on-land mine site for example) one rarely if ever has access to environmental datasets that allow for an exact, complete knowledge of all environmental parameters and “values” at every specific location within the project area. Rather - and especially for projects such as this, which are regional in scope but involve localized and short-term activities at particular areas and times that have yet to be determined - the objective is to develop a sound understanding of the existing environment at both a regional scale as well in the identification of any key environmental sensitivities within that region. To that end, we would maintain that the type and level of information available and used in the EA Report is adequate and appropriate for EA purposes.

In many cases, the EA’s environmental analysis, including the effects predictions and the planned application of mitigation, are quite conservative and therefore precautionary in nature. They inherently assume, for example, that an environmental component is present in the area and within the Project’s environmental zone of influence, and therefore, is “available” for a Project-VEC interaction. In reality, in many cases the abundance and spatial and temporal distributions and movements of the VECs limits the potential for interactions and effects with the Project’s relatively short-term activities and localized disturbances at any one location and time. Similarly, and in keeping with the spirit of the precautionary principle as defined above, many of the mitigation measures identified in the EA are committed to and will be implemented even where it is not certain that a Project-related interaction and resulting effect will occur.

We would therefore again note that the type and levels of environmental information available to, and presented and used in, this EA are in keeping with that typically used in such assessments and are adequate and appropriate for EA purposes - including for the prediction and evaluation of potential effects and the associated development and proposal of mitigation.

Given that knowledge about seismic impacts is also very limited, we suggest there is insufficient information to be able to legitimately claim “no likely impact”. One only has to conduct a quick literature scan to realize that localized impacts to the food web can be extremely significant. Multiply this potential effect across the entire study area and more questions than answers emerge.

Nexen Response: As noted previously, Nexen’s EA Report provides a comprehensive and balanced assessment of the potential environmental effects of the Project and associated identification of mitigation, which incorporates and is fully informed by existing knowledge regarding the effects of these types of offshore activities as reported in the scientific literature and other available sources. This has included reviewing the substantial available information and existing scientific knowledge related to the potential effects of seismic survey activities on marine biota, and assessing and evaluating the potential effects of the Project on these and other species and associated fishing activities in the area. As presented in the EA Report (e.g., Sections 5.4 and 5.9) past studies from the available scientific literature regarding possible

behavioural effects on marine fish (finfish and invertebrates) as a result of active seismic survey operations also indicate that these are of a temporary and localized nature.

As outlined in the preceding response, Project-related seismic survey activities in any given year would take place in a specific part of the Project Area, and in particular, any associated environmental disturbance would be localized and short-term in duration at any one location and time. It should therefore be clarified that any environmental disturbances and potential effects resulting from the presence and operation of the seismic survey are not “multiplicative” across the entire study area, but again represent localized and short-term disturbances at any one time and location.

As noted in our response in Section 2.2.1 below, although the specific location, extent and duration of any individual survey activity carried out as part of the Project cannot currently be defined, any concurrent or consecutive surveys would take place in different parts of the (approximately 147,200 km²) Project Area. This spatial and/or temporal separation, along with the localized and short term nature of any associated environmental disturbances, means that there is little or no potential for adverse interaction between the environmental zones of influence of each survey activity, and thus, for associated combined (accumulated or interactive) environmental effects upon any VEC.

We must take issue with the following statement in the addendum: "In particular, it is unlikely that any such behavioural effects would result in any "detectable reduction in the overall economic returns generated from fisheries and/or other marine activities undertaken within the Study Area over one or more years" (Section 5.9.1)". In the experience of our member companies, seismic activity has indeed forced the displacement of vessels from otherwise productive fishing grounds, for weeks if not months at a time, severely reducing their economic performance. Nexen's decision to make such a statement erodes faith that the overall assessment is complete, and suggests that further refinement is necessary prior to permitting any activity.

Nexen Response: The EA Report describes and assesses the potential environmental (biophysical) effects of the Project on marine fish and fish habitat, as well as any potential (socioeconomic) effects of the Project on marine fisheries and other activities that may result from such behavioural effects or from direct interactions with and disturbance of commercial fishing activity in the area.

In terms of biophysical (behavioural) effects, while there may be some effect on individual fish behaviours and their associated distributions as a result of marine seismic sound, a key consideration in this regard is whether and to what degree this localized and temporary disturbance would translate into a detectable, material effect on commercial fishing activity in the area. The EA Study Team does not consider, for example, that the presence of seismic sound energy in the marine environment as a result of this Project and any associated (localized and short term) implications for individual fish behaviours (avoidance) is likely to have a detectable effect upon the overall fishing industry in the Study Area. In particular, it is not likely that this will result in effects on the fishing industry's overall economic returns over one or more years, as the statement specifically states.

This is in keeping with the findings of other EA reviews and associated EA decisions for comparable exploration programs in the region. Moreover, we are not aware of available, documented sources that show the noted types and levels of effect for such projects, especially where the various mitigations committed to by Nexen in this EA have been completely and effectively implemented..

We must also make mention of the FLO offered by Nexen. Our concern is not with a seismic vessel 'meeting' or 'sighting' our vessels, but that our actual fishing results may be disrupted by seismic operations in the general vicinity. This understanding appears to have been lost, and we would suggest that Nexen has either not considered our concerns or has simply deflected them. Either is most troubling. We suggest that a standardized impact avoidance protocol be negotiated between Nexen and fishing companies who will be operating in the same vicinity.

Nexen Response: The EA Report or EA Addendum do not state or suggest that the role of the FLO is merely to help facilitate the “sighting” of fishing vessels, but rather it is stated that this position will be the “primary at-sea liaison between the commercial fishing industry and the seismic survey program”. Nexen has also made associated commitments regarding on-going communication and cooperation throughout the EA Report, including the role of the FLO in same. For example (see EA Report, Section 5.3.2):

- Communications and coordination procedures with regulatory authorities, stakeholders and key ocean users will be used throughout the operational life of the Project. This will include:
 - On-going information gathering on key fishing areas and times and continued monitoring of fishing activity (through the presence of a Fisheries Liaison Officer (FLO) on the acquisition vessel and review of DFO VMS data and other sources) and associated survey and logistical planning to minimize interference with fishing activities;
 - The presence, active participation and advice of the FLO on board the seismic ship, and a shore-based Single Point of Contact (SPOC), which will be communicated to relevant agencies and organizations once identified. The FLO will be a FFAW – Unifor member, and will be responsible for communicating with fishing vessels at sea and relaying information to shore as needed. FLOs will serve as the primary at-sea liaison between the commercial fishing industry and the seismic survey program.
 - The issuance of Notices to Mariners/Notices to Shipping and other notifications and direct industry communications (e.g., CBC Fisheries Broadcast) throughout the periods of Project operations
 - Regular communication of planned survey activities with key industry representatives, and on-going liaison with FFAW-Unifor/One Ocean contacts.

In terms of the reviewer's reference to a "standardized impact avoidance protocol", Section 5.9.3.1 of the EA Report also states that:

On-going coordination and effective and timely communication between offshore oil and gas operators and the fishing industry and other marine interests, through the various processes and forums described above and as outlined in the *One Ocean Protocol for Seismic Survey Programs in Newfoundland and Labrador*, have been and remain the best means for ensuring that such activities are carried out in a safe and environmentally responsible manner.

We reiterate our belief that the precautionary approach is not being followed here, and that significant work must be done to gain the trust of the year-round harvesting sector, prior to seismic activity being undertaken in areas that have provided valuable and sustainable economic contributions to this sector of the fishing industry.

Nexen Response: As noted in our original responses (see Section 2.1.2.1) and the additional responses provided above, Nexen again submits that a precautionary approach has been a fundamental part of Project planning to date, including in the completion of the EA, and will continue to guide the Project throughout its implementation. As reiterated in the preceding responses, Nexen is committed to on-going communications and cooperation throughout the life of the Project in order to help identify potential interactions between its planned activities and the fishing industry, and to seek to avoid potential effects through on-going planning, coordination and cooperation.

2.1.2.3 Additional General Comments (EA Addendum Revised Final Report #3) (October 2018)

It is unfortunate that the addendum did not provide any novel information to help put our members' concerns at ease. The response again points to the original assessment which we have already suggested was inadequate in content to be able to appropriately and rigorously assess the potential impacts of the exploration activity. Furthermore, we suggest that the assessment of 'effects' was not balanced. Peer-reviewed research has made it abundantly clear that the levels of energy generated by marine seismic exploration can have profound impacts on the behaviour and survival of many components of the marine ecosystem. We contend that insufficient effort has been expended to say with confidence that the effects are truly 'short-term' and 'localized'. The experience of our members has demonstrated otherwise.

Our concerns continue to be marginalized as described by the following response from Nexen 'The EA Study Team does not consider, for example, that the presence of seismic sound energy in the marine environment as a result of this Project and any associated (localized and short term) implications for individual fish behaviours (avoidance) is likely to have a detectable effect upon the overall fishing industry in the Study Area.' It is clear that Nexen has no real intention to consider our concerns given they believe, without the benefit of evidence or experience, that our position is without merit.

Nexen Response: The extensive review and balanced discussion of the literature presented in the EA Report and follow-on discussions in the EA Addenda demonstrate Nexen's consideration of the scientific evidence about potential effects on fish and fisheries. Nexen's

presentation and discussions of concerns raised by the industry during this EA process and in previous strategic and project-specific assessments, as well as the mitigation commitments to respond to them, demonstrate Nexen's consideration of these concerns. Throughout its filings, Nexen has indicated that it recognizes the importance of fisheries resources and respects the diversity of ocean users. As described by the GEAC-CAPP, experienced fishers on the Grand Banks have noted declines in catch rates in response to previous seismic activities (One Ocean 2016). Fish and invertebrates have a variety of species specific responses to seismic activities based on detection, avoidance behavior, and priorities (i.e. foraging opportunities). As such, fish catch rates surrounding seismic activities have been observed to decrease, increase, or have no apparent behavioural effect (e.g., Hassel et al. 2004; Løkkeborg et al. 2012; Carroll et al. 2017; Bruce et al. 2018; Morris et al. 2018). As no single study is completely applicable to the described activity and environment in the EA Study Area, our conclusions are informed by the comprehensive review of available information and existing scientific knowledge on the potential effects of seismic survey activities. The information gathered was used to assess and evaluate the potential effects of the Project on shrimp, groundfish, and other species and associated fishing activities in the area.

As presented in the EA Report (e.g., Sections 5.4 and 5.9) past studies from the available scientific literature regarding possible behavioural effects on marine fish (finfish and invertebrates) as a result of active seismic survey operations, and any associated effects on catch rates, indicate that these are of a temporary and localized nature. The nature of these underwater disturbances at any one location and time during the seismic program and the typically wide spacing of the seismic acquisition lines considerably reduces the potential for adverse effects through either injury or disturbance/avoidance. With the seismic ship moving continuously, the vessel and associated survey equipment will be tens of kilometers away from any particular location within a few hours. In the case of a 2D survey location, the vessel will not return to that site except for grid crossing points although any Project presence at those locations will be separated by days, weeks or even longer. Similarly, in the case of 3D/4D activity and for any required wellsite surveys using 2D seismic, with the survey vessel moving continuously, the re-occurrence interval of firing the seismic source within proximity to a particular survey point will be at least several hours. This minimizes the potential for localized and repeated environmental disturbances at any particular location, and affecting a particular environmental receptor. We have acknowledged that further research is warranted regarding the effects of seismic activities on fish and invertebrate catchability and understand that effects of seismic activities is a research priority for local funding bodies including Petroleum Research Newfoundland & Labrador (PRNL) and Environmental Studies Research Fund (ESRF). As a lease-holder in this region, Nexen contributes to the ESRF. Nexen also provides input through various CAPP committees related to identifying research that is funded through PRNL and ESRF.

As noted in the EA report, it is not possible at this stage to identify and specify particular locations and times that Project activities may need to be modified to avoid or reduce the potential for interactions with fisheries – or science surveys – since this will require current information about locations and timing (e.g. open/closed management areas and fleet/sector timing in relation to planned geophysical activities). Any current-year program planning will therefore be based on a variety of sources, including fishing industry and DFO communications, information and advice. In particular, this includes advance logistical

planning in consultation with key fishing industry stakeholders in order to minimize the potential for interference throughout the survey, as stated in the EA Report. Other commitments to this purpose include continuing and regular communications with key stakeholders during operations, the active participation and advice of the on-board FLO, daily monitoring of fishing activity (e.g. via VMS access), communication with the shore-based Single Point of Contact (SPOC), issuance of Notices to Mariners / Notices to Shipping, and regular reporting of on-going activities and locations.

2.1.3 Fish, Food and Allied Workers (FFAW-Unifor)

2.1.3.1 Original General Comments (EA Addendum Final Report) (March 2018)

The overall study area for this EA is quite large as is the temporal scale of the project (2018-2027). While current fisheries data has been examined in the document it needs to be recognized that the fishery could change dramatically over the span of this ten year project. Our fisheries science work is likely to change as well. It is critical that effective and regular communication ensue with the fishing industry, as committed in the EA, throughout the EA lifespan so that the proponent is kept apprised of ongoing developments with fisheries in the project area.

Nexen Response: The varied and dynamic nature of the fishery off Eastern Newfoundland, including potential future changes to the fishery over the temporal scope of this Project, is reflected in various sections of the EA Report, including in the subsection entitled “Potential Future Domestic Fisheries” (Section 4.3.1.6). In that same section, the EA Report also states that:

“If, however, a new fishery, or a currently closed fishery, should become active within the Study Area during the ten-year temporal scope of this Project and its EA, it will be identified in the fishery information and analysis required in the annual EA Updates that the proponent will file in any Project year.”

The multi-year nature and overall duration of the Project is also recognized and acknowledged throughout the EA Report. As referenced and requested in the above review comment, Nexen has also made associated commitments regarding on-going communication and cooperation throughout the EA Report. For example:

“Communications and coordination procedures with regulatory authorities, stakeholders and key ocean users will be used throughout the operational life of the Project [including]...On-going information gathering on key fishing areas and times and continued monitoring of fishing activity (through the presence of a Fisheries Liaison Officer (FLO) on the acquisition vessel and review of DFO VMS data and other sources) and associated survey and logistical planning to minimize interference with fishing activities [and] Regular communication of planned survey activities with key industry representatives, and on-going liaison with FFAW-Unifor/One Ocean contacts;” (Section 5.3.2);

“Nexen will submit annual updates in relation to this multi-year program. These will describe the previous year’s activities, recent and on-going stakeholder consultations, current-year science survey plans, outline the proposed survey work for the coming year and evaluate the continued applicability and validity of the EA predictions and associated mitigations.” (Section 5.9.3.1).

The nature and timing of these future communications and engagements will be determined in consultation and cooperation with the relevant group(s), including the FFAW-Unifor, with a view to optimizing their utility and effectiveness for all involved.

A common mitigation measure noted in many Environmental Assessments is that seismic vessels avoid areas that are actively being fished. This requires planning prior to seismic activity being conducted (pages 318-319) as well as regular communication with the fishing industry throughout the fishing season. It is therefore critical that effective and regular communication ensue with the fishing industry throughout the EA lifespan so that the seismic company is kept apprised of ongoing developments with fisheries in the project area.

Nexen Response: Nexen's planned measures for seeking to avoid interactions with, and any negative effects upon, fishing activity in the Project and Study Areas, particularly through on-going communications and cooperation between the Proponent and fishing industry representatives, are outlined throughout the EA Report (in particular, in Sections 5.3.2 and 5.9). As noted in the preceding responses, Nexen is committed to on-going communications and cooperation throughout the life of the Project in order to help identify potential interactions between its planned activities and the fishing industry, and to seek to avoid any such issues and potential effects through planning, coordination and cooperation.

As a mitigation, it is also important to clarify that the Fisheries Liaison Officer (FLO) onboard the seismic vessel be the one to communicate with fish harvesters on the water, not the crew of the standby/guard vessel (pages 13, 262, 320).

Nexen Response: Understood and acknowledged, and reflected in the associated wording in Section 5.3.2 of the EA Report, which states that:

"The FLO will be a FFAW – Unifor member, and will be responsible for communicating with fishing vessels at sea and relaying information to shore as needed. FLOs will serve as the primary at-sea liaison between the commercial fishing industry and the seismic survey program".

2.1.3.2 Additional General Comments (EA Addendum Revised Final Report #2) (May 2018)

While the proponent addressed a communication concern regarding the role of the Fisheries Liaison Officer (FLO) on page 7 of the addendum, they suggested "the use of a standby or guard vessel to scout for hazards and for communicating with active fishers in the area" as a planned mitigation measure on page 34. The FLO is best placed on the seismic survey vessel as the primary at-sea liaison between the commercial fishing industry and the seismic survey program.

Nexen Response: Understood. As stated in the EA Report, Section 2.5 "***the seismic vessel*** will also have a Fisheries Liaison Officer (FLO)", while Section 5.3.2 likewise references "the presence, active participation and advice of the FLO ***on board the seismic ship***" (emphasis added).

As referenced in the preceding response, the EA Report also states that "The FLO will be a FFAW – Unifor member, and will be responsible for communicating with fishing vessels at sea

and relaying information to shore as needed. FLOs will serve as the primary at-sea liaison between the commercial fishing industry and the seismic survey program” (Section 5.3.2).

We strongly disagree with the proponent’s assessment that “the presence of seismic sound energy...is (not) likely to have a detectable (economic) effect upon the fishing industry in the Study Area” (page 35). There have been numerous reports from fish harvesters to the contrary.

It has been documented in the peer reviewed literature that seismic survey activity may result in behavioural changes among fish species. While these changes have been reported to be temporary, avoidance, startle responses and changes in swimming speed and direction can all have an impact on commercial fishing activities taking place at finite times (i.e. seasons) in finite spaces (i.e. fishing areas). The fishing industry has already witnessed catch rates drop immediately after a seismic vessel has entered an area where fishing is taking place, directly impacting economic return.

We therefore take exception to the proponent’s definitive statement that it is unlikely behavioural effects would result in any “detectable reduction in the overall economic returns generated from fisheries...over one or more years” (pages 4 and 35).

Nexen Response: Please refer to above responses to similar comments provided in Section 2.1.2.2.

The fishing industry continues to advocate for more research on impacts of seismic activity on important commercial species including shrimp, crab, turbot and Atlantic cod. These studies need to include commercial catchability in order to substantiate concerns from harvesters in Newfoundland and Labrador.

Nexen Response: The EA Report summarizes the existing and available scientific literature regarding the potential effects of seismic surveys on marine fish and fish habitat and fisheries, and the effects assessment has been fully informed by this existing scientific knowledge.

As noted in our responses below (see Section 2.2.3), however, the EA Report does acknowledge that, for example, “overall knowledge and understanding of the effects of seismic and other anthropogenic noise on marine fish and invertebrates remain incomplete in some areas”, which is also reflected in the literature reviews provided in Tables 5.2 and 5.8.

Nexen therefore concurs that additional research on the effects of seismic activity on key species and their commercial catchability would inevitably be useful to better understand (rather than “substantiate”) these concerns and potential issues. Nexen also notes that there are existing forums and funding programs through which such studies could be conducted, such as the Environmental Studies Research Fund (ESRF) program.

2.1.3.3 Additional General Comments (EA Addendum Revised Final Report #3) (October 2018)

We maintain our position that seismic activity impacts catch rates and has a resultant/detectable effect upon the economics of the fishing industry. Any change in fishing pattern/activity is a realized economic impact to harvesters. Research in this area has been extremely challenging to initiate. Whether this specific project will impact the industry will be highly dependent on commercial fishing activities taking place at finite times (i.e. seasons) in finite spaces (i.e. fishing areas) and the specific areas of interest to Nexen Energy in any given year (2018-2027).

For this reason it is critical that Nexen commit to planning with the fishing industry several months prior to the start of any seismic work in any given year of planned activities in NL waters. Our experience with new proponents to NL waters is that this “planning ahead” step is skipped and there is a heavy reliance on the FLO for planning, as this document suggests. The FLO will not be engaged in the process until the exploration activity begins on the water, that is, through actual marine activity. This is too late to change work plans.

As a minor point, although it was noted in other sections of the document, the FLO should be the primary individual to communicate with active fish harvesters, not the standby or guard vessel (Page 6, fourth point).

We look forward to further direct communication with the proponent as this EA approval/authorization process evolves.

Nexen Response: The reader is referred to the response to additional comments (see Section 2.1.2.3) of this revised EA Addendum Final Report #3 (October 2018) for further discussion on recent and ongoing research of potential effects.

As previously noted in the EA Report and the EA Addenda, Nexen Energy ULC (Nexen) recognizes the importance of the fishing industry and identifies the need for both industries to work together through relevant processes and forums to seek to avoid interactions and any associated disturbances and potential effects. Nexen has stated that it is committed to ongoing communications and cooperation throughout the life of the Project in order to help identify potential interactions and to seek to avoid potential effects through planning, ongoing coordination and cooperation. Nexen will commit to working with the fishing industry several months in advance of the start of any seismic work in any given year of planned activities in NL waters.

Regarding the comment about the FLO, Nexen agrees that the FLO will be the primary contact with the fishing industry and will be based on the seismic vessel.

2.2 Specific Comments

2.2.1 Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB)

Section 1.3 Regulatory Context and Environmental Assessment Requirements, pg 3 – The Geophysical, Geological, Environmental and Geotechnical Program Guidelines were updated in September 2017.

Nexen Response: Acknowledged. Nexen will comply with all applicable regulations and guidelines, as amended from time to time, throughout the life of the Project.

Section 2.3 Seismic Surveys, pg 11 – It is stated that “up to an estimated 15” streamers may be used for 3D programs. For clarity, is this the maximum that is considered in the assessment of potential effects?

Nexen Response: The various characteristics and parameters associated with the Project which are indicated in the EA Report reflect the most accurate and current details that are available as of the timing of EA writing and submission. As with any such proposed activity - especially given the relatively early stage of project planning and design at which EA review is carried out, and the multi-year nature of this proposed exploration program – these parameters are subject to on-going definition and evolution as Project planning and design continue to progress. As an example, Section 2.3 of the EA Report states that, for an individual survey, “Where multiple streamers are planned to be used (such as for 3D survey activity), their specific numbers (**up to an estimated 15**), tow depths, and separation distances will be determined according to survey data collection objectives and other parameters and technical considerations” (emphasis added).

It is currently anticipated that the number of streamers required and used will not exceed the 15 noted above, and it is this Project scope for which EA approval is currently being sought. Should, however, technical (e.g., the particular seismic vessel or other contractor equipment used, or other survey requirements) or other factors require that the number of streamers increase to beyond the estimated 15 streamers noted above, Nexen will report this to the C-NLOPB through future EA Updates and/or address this Project change through other appropriate means with the regulator (such as an EA Amendment).

C-NLOPB Comment on Nexen Response: Section 2.3 Seismic Surveys, pg 11 and page 8 of Addendum – For clarity, if “...the number of streamers increase to beyond the estimated 15 streamers noted above...” Nexen will be required to discuss this with the C-NLOPB prior to submitting an amendment.

Future EA Updates outline the proposed activities, confirm that the proposed program activities fall within the scope of the previously assessed program, and indicate if, with this information, the EA predictions remain valid. In addition, EA Updates also provide information regarding the adaptive management of requirements of the Species at Risk Act (SARA) into program activities (e.g., introduction of new species or critical habitat to Schedule 1; additional mitigations; implementation of recovery strategies and/or monitoring plans).

Nexen Response: This requirement is understood by Nexen, as is the required content of future EA Updates for the Project.

Section 2.3 Seismic Surveys, pg 11 – The statement “Where multiple streamers are planned ...and other parameters and technical considerations.” For the purpose of assessment, details on the 3D streamers (e.g. tow depths, length, separation distance) must be provided.

Nexen Response: Some additional details on these aspects of the Project, reflecting the current stage of the planning and design of any associated 3D surveys, are provided below:

Project Parameter	Planned Characteristics
Record Length	10 seconds
Shot Point Interval	25 m (50 m / source array)
Source Volume	Approx 3,000 – 4,500 cubic inches (cuin.)
Number of Sources	1-2
Source Separation	25-50 meters
Streamer Separation	100 to 150 meters (incl. fanning of streamers)
Number of Streamers	10 to 14
Traces / Streamer	Minimum of 560
Streamer Length	Approx. 8,000 to 10,000 meters
Streamer Depth / Profile	15 – 25 meters

Section 2.6 Project Schedule, 4th line, pg 13 – The statement “Project activity will generally occur within the April to November period...”. For the purpose of assessment, the actual months in which the project activities are proposed must be identified for the purpose of assessment.

Nexen Response: As noted in EA Report Section 2.6 (Project Schedule):

“It is currently anticipated that in-field Project work will commence in 2018. Project activity will generally occur within the April to November period for each and all years of the proposed exploration program, which will include survey activity in one or more years within the 2018 to 2027 timeframe”.

The term “generally” has been used here to indicate that while these are the overall temporal boundaries for Project activities annually, these will not necessarily occur for this full duration (eight months) every year.

Section 2.7.3.1 Liquid and Organic Discharges, pg 16 – Please clarify the “... and possible others.”

Nexen Response: This sentence in Section 2.7.3.1 is modified to remove this wording, as follows:

“The main liquid waste materials that will be generated during the Project include grey water (wastewater from washing, bathing, laundry and food preparation), black water (human wastes), bilge water and deck drainage”.

These Project-related wastes will be managed in accordance with applicable regulatory requirements.

Section 3.4.7 Cumulative Environmental Effects, Table 3.6, pg 35 – Information on the “Hebron Oilfield” should be updated.

Nexen Response: The relevant row of Table 3.6 is updated to reflect the current status of that project, as below:

Hebron Oilfield	<ul style="list-style-type: none"> • First discovered in 1980, this oilfield is estimated to contain more than 700 million barrels of recoverable resources. • The Hebron Platform was towed to field in June 2017. The Project is designed for an oil production rate of 150,000 barrels of oil per day. • First oil from the Hebron Project occurred in late November 2017
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Section 4.2.2.6 Key Areas and Times for Marine/Migratory Birds, 1st sentence, pg 141 - EBSAs are in the Newfoundland and Labrador Shelves Bioregion not the PBGB LOMA.

Nexen Response: Acknowledged. This sentence in Section 4.2.2.6 is modified as follows:

“A number of EBSAs have also been identified within the Newfoundland and Labrador Shelves Bioregion.”

Section 5.3 Environmental Planning, Management and Mitigation, pg 297 – Appendix A Table of Concordance states that the review and evaluation of best mitigation practices is contained in Section 5.3 and Section 6.0. Please provide details on this review and on any new and/or existing techniques that have been considered for the program.

Nexen Response: As noted throughout the EA Report (see Section 5.3, for example), each of the potential environmental issues and interactions that may be associated with the Project can be avoided or otherwise mitigated through the use of good planning and sound operational practices and procedures, supported by standard mitigations that are well established and outlined in relevant regulatory procedures and guidelines (see Section 1.3 and associated mitigation listed in Section 5.3.2). These mitigations have been successfully applied to similar marine exploration programs off Eastern Newfoundland and elsewhere in recent years. These planning and management measures, in combination with Nexen’s own environmental policies, plans and procedures, are designed to help avoid or reduce potential adverse environmental effects. These measures are considered integrally in the environmental effects assessments that are presented in the EA Report (Chapter 5).

As also illustrated in the EA Report (Chapter 2) the Project does not require or propose the use of new or “non-routine” equipment, methods or other technologies during its planned

activities. Rather, it uses standard exploration components and methods, for which potential environmental issues are recognized and can be managed through existing and accepted mitigation measures, as outlined above. A detailed list of the planned mitigation measures that will be implemented during the Project to avoid or reduce adverse environmental effects is provided in Section 5.3.2 of the EA Report.

In conducting the EA, Nexen reviewed and considered the mitigations that were available and likely to be required to address the potential environmental effects identified. That analysis resulted in the identification and proposal of the various mitigations outlined and committed to in the EA Report, as summarized in Section 5.3.2. These mitigations are in keeping with those implemented by other operators for similar projects, which have been accepted by the C-NLOPB and other regulators as part of these previous EA reviews and approvals. No additional or modified mitigation is currently considered to be required in relation to this Project.

Section 5.1 Project Components, Activities and Key Environmental Considerations, pg 254 – What types of multiple surveys may be conducted concurrently by Nexen in any given year? Please clarify if more than one seismic program may be executed concurrently in any given year, and if so have they been included in the assessment of activities.

Nexen Response: Chapter 2 (Project Description) of the EA Report provides a description of the various types of survey activities that comprise the overall scope of the Project (i.e., 2D, 3D and possibly 4D seismic surveys, and associated geochemical, environmental, geotechnical and site survey activities). Section 2.6 (Project Schedule) states that “Nexen may concurrently conduct multiple surveys in any given year of the program”, as does the above referenced Section 5.1 of the EA Report. The potential for multiple seismic programs to occur concurrently in any given year is part of the scope of the Project and has been addressed in the associated environmental effects assessment.

This may include, for example, the completion of a “regional-scale” 2D seismic survey in one part of the Project Area at the same time as more narrowly spaced (high resolution) 2D or 3D seismic survey work is being undertaken at another particular location. In the event that multiple surveys were to be completed concurrently within the Project Area, the nature and scope of each individual survey would be in keeping with that described and assessed in the EA Report for all VECs. This includes the particular characteristics of the seismic vessels and their overall survey methods and equipment, including the seismic energy source used (type and maximum level), streamer length and composition and other factors, all of which would be within the scope of those described and considered in the EA Report. In addition, each of the mitigation measures outlined in the EA Report (including the associated ramp-up, shut down, waste management, spill prevention and response, and other measures) would be applicable to and implemented for both surveys.

Although the specific location, extent and duration of any individual survey (and thus, any concurrent surveys) carried out as part of the Project cannot currently be defined, any concurrent surveys would be operating in different parts of the (approximately 147,200 km²) Project Area. Moreover, an adequate distance (at least tens of kilometers) would be maintained between them for technical (data quality), safety (e.g., gear deployment and use,

and vessel manoeuvrability) and environmental reasons. This spatial and temporal separation, along with the localized and short term nature of any associated environmental disturbances, means that there is little or no potential for adverse interaction between the environmental zones of influence of each seismic vessel and its effects, and thus, for associated combined (“within Project” cumulative) environmental effects upon any VEC.

As a result, there would be no change in the nature, magnitude, extent or duration of any predicted environmental effects that may occur as a result of the “multiple, concurrent survey scenario” as opposed to a single survey being conducted at any one time during the Project.

C-NLOPB Comment on Nexen Response: Section 5.1 Project Components, Activities and Key Environmental Considerations, pg 254 and pages 10 and 11 of Addendum – The response to the original comment describes two concurrent seismic surveys, a “regional-scale” 2D seismic survey and a narrowly spaced (high resolution) 2D or 3D seismic survey. Please confirm that this “example” is the maximum number and type of seismic surveys assessed and contemplated.

Nexen Response: As noted by the reviewer, the two survey “example” provided in the original response involved “a “regional-scale 2D seismic survey and a narrowly spaced (high resolution) 2D or 3D seismic survey” occurring concurrently in the Project Area. This scenario was identified in order to base this analysis on a combination of both a spatially extensive (2D) and spatially intensive (3D) survey occurring simultaneously as part of the project. Alternatively, this could also involve two concurrent 2D surveys operating in different parts of the Project Area, in which case an adequate distance (at least tens of kilometers) would continue to be maintained between them for technical (data quality), safety (e.g., gear deployment and use, and vessel manoeuvrability) and environmental reasons.

As noted in the original response above, this spatial and/or temporal separation, along with the localized and short term nature of any associated environmental disturbances, would again mean that there is little or no potential for adverse interaction between the environmental zones of influence of each seismic vessel and its effects, and thus, for associated combined (“within Project” cumulative) environmental effects upon any VEC.

It should be noted, however, that while Nexen has conservatively included the potential simultaneous conduct of two surveys in the EA, the most likely scenario would involve only one seismic survey being undertaken at any one time during the Project. In any event, it is not planned or anticipated that any more than two seismic surveys would be operating concurrently as part of this Project.

Section 5.1 Project Components, Activities and Key Environmental Considerations, pg 255 – Please provide more details on gravity and magnetic data activities to support the statement that “these activities are not likely to interact with or otherwise adversely affect the VECs”.

Nexen Response: As referenced in Section 2.3 (Seismic Surveys) of the EA Report, “The seismic survey vessel would also passively collect and record gravity and magnetic data at the same time, and have an echosounder for depth soundings.”

Gravity and magnetic data will be obtained passively as part of the proposed survey program through the installation of the recording equipment on the seismic vessel(s). The planned use of this apparatus does not have environmental emissions or interactions associated with it, and therefore, these data collection devices were not given separate treatment in the environmental effects assessments for each VEC (Chapter 5). They were therefore also not listed as separate Project components and activities in the environmental interactions or effects summary tables included in each VEC, although they are inherently included as part of the “Seabed and Environmental Sampling Activities” rows in the interactions and Residual Environmental Effects Assessment Summary Tables for each VEC.

Section 5.3.2 Required and Planned Mitigation Measures, 6th bullet, pg 260 – The Operational Monitoring Program Design should be made available to both the C-NLOPB and DFO.

Nexen Response: The Operational Monitoring Program Design will be made available to both the C-NLOPB and DFO.

Section 5.3.2 Required and Planned Mitigation Measures, pg 262 – Please confirm if a standby or guard vessel will continuously accompany the seismic vessel.

Nexen Response: The standby or guard vessel will continuously accompany the seismic vessel during active seismic survey activity and would be in the vicinity during activities such as crew changes.

Section 5.4.2 Potential Environmental Issues, Interactions and Existing Knowledge, Table 5.1, pg 265 – Table 5.1 shows no interaction between the presence and use of vessels/aircraft and equipment and feeding (availability and quality) yet in Table 5.2 this interaction is discussed. Please clarify.

Nexen Response: The only reference to “feeding” related considerations in Table 5.2 (under “Vessel Traffic/Other Equipment Use and Their Potential Environmental Emissions”, the first row) is as follows:

“Lighting emissions have the potential to attract phototactic plankton and foraging fish and may support foraging opportunities and increase predator-prey interactions (Keenan et al 2007; Cordes et al 2016). However, these potential effects would be limited for a transitory vessel.”

In this context, the adverse effect being referred to is the potential for direct mortality due to increased predation, which is covered under “Health – Individuals or Populations”.

Section 5.5.5 Environmental Monitoring and Follow-up, pg 291 – Please define what is meant by “A qualified and Experienced Environmental Observer...” For clarity, such reports are due six months after the completing of any survey.

Nexen Response: The Environmental Observer involved in the marine bird operational monitoring program will have an appropriate knowledge of the various marine avifauna likely to be found in the area and associated bird identification techniques, and will preferably have conducted such offshore bird observational programs previously.

The bird monitoring program will be designed and implemented in accordance with the C-NLOPB's *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (updated September 2017) which states that "Operators are expected to implement a seabird and marine mammal observation program throughout all C-NLOPB authorized program activities. Such a program should involve a designated observer **trained in marine mammal and seabird observations.**" (emphasis added).

The operational monitoring program for marine birds and mammals referenced above and in the EA Report will be designed, conducted and reported upon in accordance with this guidance documentation and any such requirements, including the provision of the associated reporting within the requested timeframes.

Section 5.6.5 Environmental Monitoring and Follow-up, pg 302 – Two separate people should be observing marine mammals and marine birds to ensure accurate counts and the employment of all mitigations. For example, if a check is being made for stranded birds, it is possible that marine mammals, and potentially SARA listed species may enter the 500 metre zone.

Nexen Response: As noted in the preceding response, the seabird and marine mammal monitoring program will be designed and implemented in accordance with the C-NLOPB's *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (updated September 2017), which states that "Operators are expected to implement a seabird and marine mammal observation program throughout all C-NLOPB authorized program activities. Such a program should involve **a designated observer** trained in **marine mammal and seabird** observations." (emphasis added).

The planning and design of the seabird and marine mammal monitoring program will ensure that there are adequate personnel to allow for the presence and focussed participation of a marine mammal observer at all times when such observations are required as per the Guidelines (i.e., when seismic survey operations are in progress). Checks for stranded birds and/or other bird observations will be scheduled and conducted accordingly. Other crew or Project team members can also be involved in checking for stranded birds when the designated observer is conducting such monitoring activities.

2.2.2 Fisheries and Oceans Canada (DFO)

Section 3.4.7 Cumulative Environmental Effects, pg 35 – Regarding “...concrete GBS which is being constructed at Bull Arm...” should be updated.

Nexen Response: As noted in a previous response, the relevant row of Table 3.6 is updated to reflect the current status of that project, as below:

<i>Hebron Oilfield</i>	<ul style="list-style-type: none"> • First discovered in 1980, this oilfield is estimated to contain more than 700 million barrels of recoverable resources. • The Hebron Platform was towed to field in June 2017. The Project is designed for an oil production rate of 150,000 barrels of oil per day. • First oil from the Hebron Project occurred in late November 2017
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Section 4.2.4 Special Areas, pgs 157-171 – The report mentions areas protected under “agreements” due to their ecological characteristics or importance – voluntary fisheries closures should be included in this section.

Nexen Response: A number of marine and coastal areas in Newfoundland and Labrador have been designated as protected under provincial, federal and/or other legislation or agreements due to their ecological, historical or socio-cultural characteristics or importance. Other areas have been formally identified as being special or sensitive through other relevant processes and initiatives. These special areas include voluntary fisheries closures under the *Fisheries Act* such as those presented in Section 4.2.4.1 of the EA Report. Additional *Fisheries Act* closures are described in the response that follows.

Section 4.2.4.1 Canadian (Federally) Identified and Designated Areas, Fisheries Closure Areas within Canada’s Exclusive Economic Zone, pg 158 – Additional Fisheries Act Closures that should be listed include:

- ***The Hawke Channel;***
- ***Lobster closures established to protect lobster habitat that are located on the Eastern side of Newfoundland (i.e., Gander Bay, Glovers Harbour, Gooseberry Island, Moose Island);***
- ***Crab closures and conservation areas closed to protect crab habitat on the Eastern side of Newfoundland (i.e., Bonavista Bay Exclusion Zone A, Bonavista Bay Exclusion Zone B, Crab Trinity Bay Exclusion Zone A, Crab Trinity Bay Exclusion Zone B, Crab Nearshore Conservation Exclusion Zone, Crab Conception Bay Exclusion Zone, Crab Eastern Avalon Exclusion Zone, Crab Southern Avalon Exclusion Zone, Crab Area 8Bx Conservation Zone, Crab Area 9a Exclusion Zone);***
- ***Proposed Fisheries Act closures (Hopedale Saddle and Tobin’s Point). Fisheries and Oceans Canada are currently consulting with stakeholders on these areas, which are proposed for the end of 2017.***

Nexen Response: Under the *Fisheries Act*, a number of areas off Newfoundland and Labrador have been closed to particular types of fishing to help conserve sensitive and productive fish and shellfish habitat for commercially important species such as lobster,

shrimp, crab and cod. Various fisheries closure areas are located in coastal and nearshore areas of Eastern Newfoundland. *Fisheries Act* closure areas are described in Section 4.2.4.1 of the EA Report.

Details on the additional special areas referenced by the reviewers and documented above are provided in Table 2.1 and Figures 2.1 and 2.2, below. In December 2017, the Northeast Newfoundland Slope (formerly known as Tobin's Point), Hawke Channel, Funk Island Deep and Hopedale Saddle Closures were designated as Marine Refuges by DFO. Hopedale Saddle is off the coast of Labrador (DFO 2007; 2011; 2017; 2018). The Project Area intersects with the Northeast Newfoundland Slope Closure Marine Refuge and 8B Crab Fishing Area, of which a portion is closed to crab fishing.

Table 2.1 Additional Special Areas off Eastern Newfoundland

Special Area	Rationale for Identification/Designation
Fisheries Act Closures	
Hawke Box	In 2002, at the request of local fishers, DFO closed a portion of the Hawke Channel to trawling and gillnetting (under the <i>Fisheries Act</i>) and expanded the area in 2003. The area remained open to seasonal snow crab pot fishing. Closure was a precautionary measure primarily to sustain the crab fishery and secondarily to conserve cod known to aggregate there. Also designated in 2017 as the Hawke Channel Closure Marine Refuge.
Penguin Islands	Lobster fishing has been prohibited in 7 areas around coastal Newfoundland to protect lobster spawning habitat and increase egg production. Five of these Lobster Area Closures are located in Eastern Newfoundland.
Gooseberry Island	
Glover’s Harbour	
Mouse Island	
Gander Bay	
Crab Fishing Area 5A (2 Zones)	Snow crab fishing is prohibited in various Stewardship Exclusion Zones including portions of Bonavista Bay, Trinity Bay, Conception Bay, the Avalon Peninsula and St. Mary’s Bay as well as near and mid shore fishing areas.
Crab Fishing Area 6A (2 Zones)	
Crab Fishing Area 6B	
Crab Fishing Area 6C	
Crab Fishing Area 8A	
Crab Fishing Area 8BX	
Crab Fishing Area 9A (2 Zones)	
Near Shore (2 Zones)	
Marine Refuges	
Northeast Newfoundland Slope Closure (formerly known as	Marine refuges were designated to contribute to long-term conservation of biodiversity by protecting coral and sponge

Special Area	Rationale for Identification/Designation
Tobin's Point)	habitat. Dense aggregations of large, structure-forming cold-water corals provide niche space for other organisms. Prohibitions for all bottom contact fishing activities.
Hawke Channel Closure	Conserves a portion of the Hawke Channel seafloor, which is important habitat for groundfish including commercial species such as Greenland halibut. Also protects habitat of depleted species such as Atlantic wolffish. Bottom trawl, gillnet and longline fishing activities are prohibited.
Funk Island Deep Closure	Conserves seafloor habitat important to Atlantic cod. Bottom trawl, gillnet and longline fishing activities are prohibited.
Source: DFO (2007, 2011, 2017, 2018)	

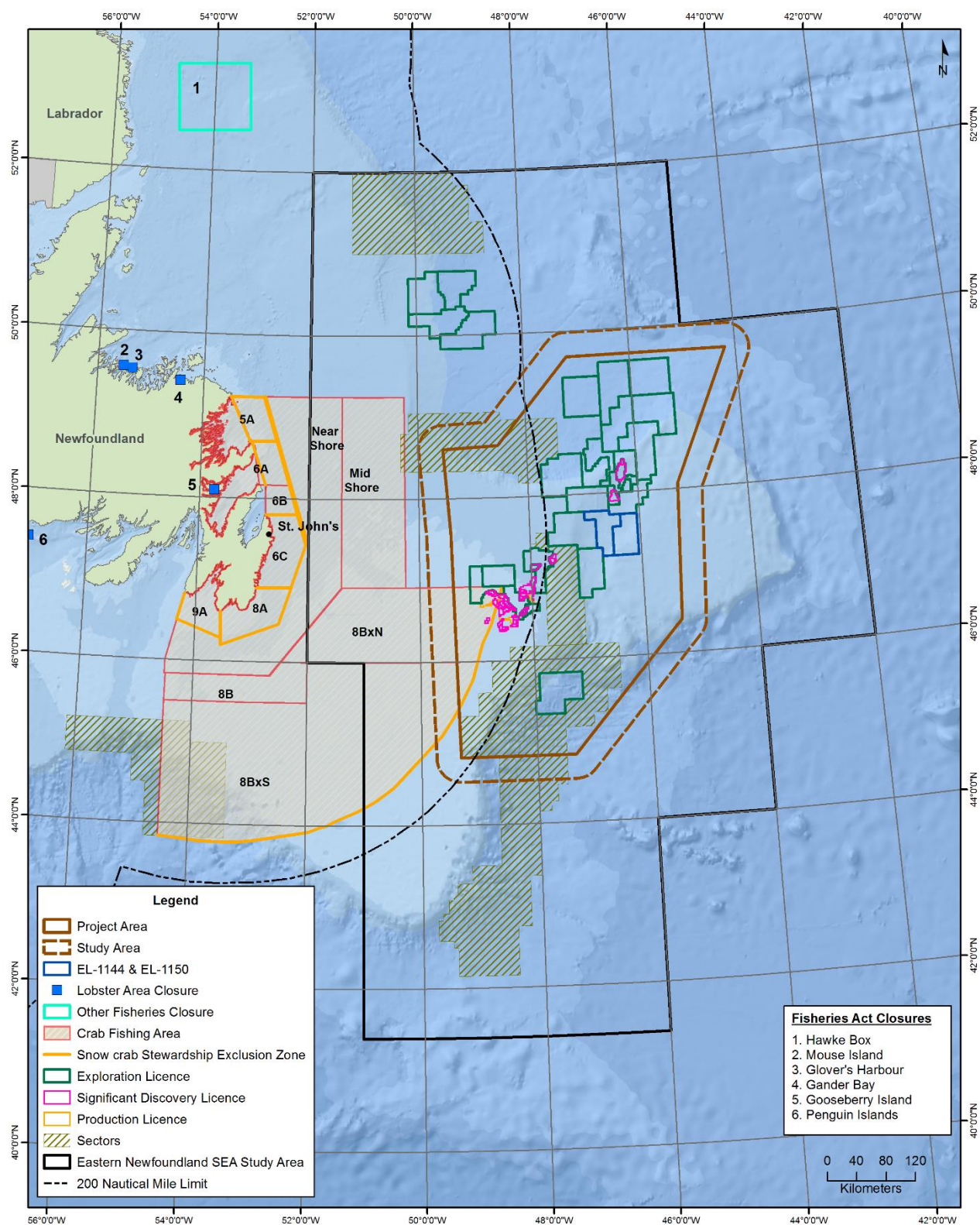
Figure 2.1 Fisheries Act Closure Areas

Figure 2.2 Marine Refuges

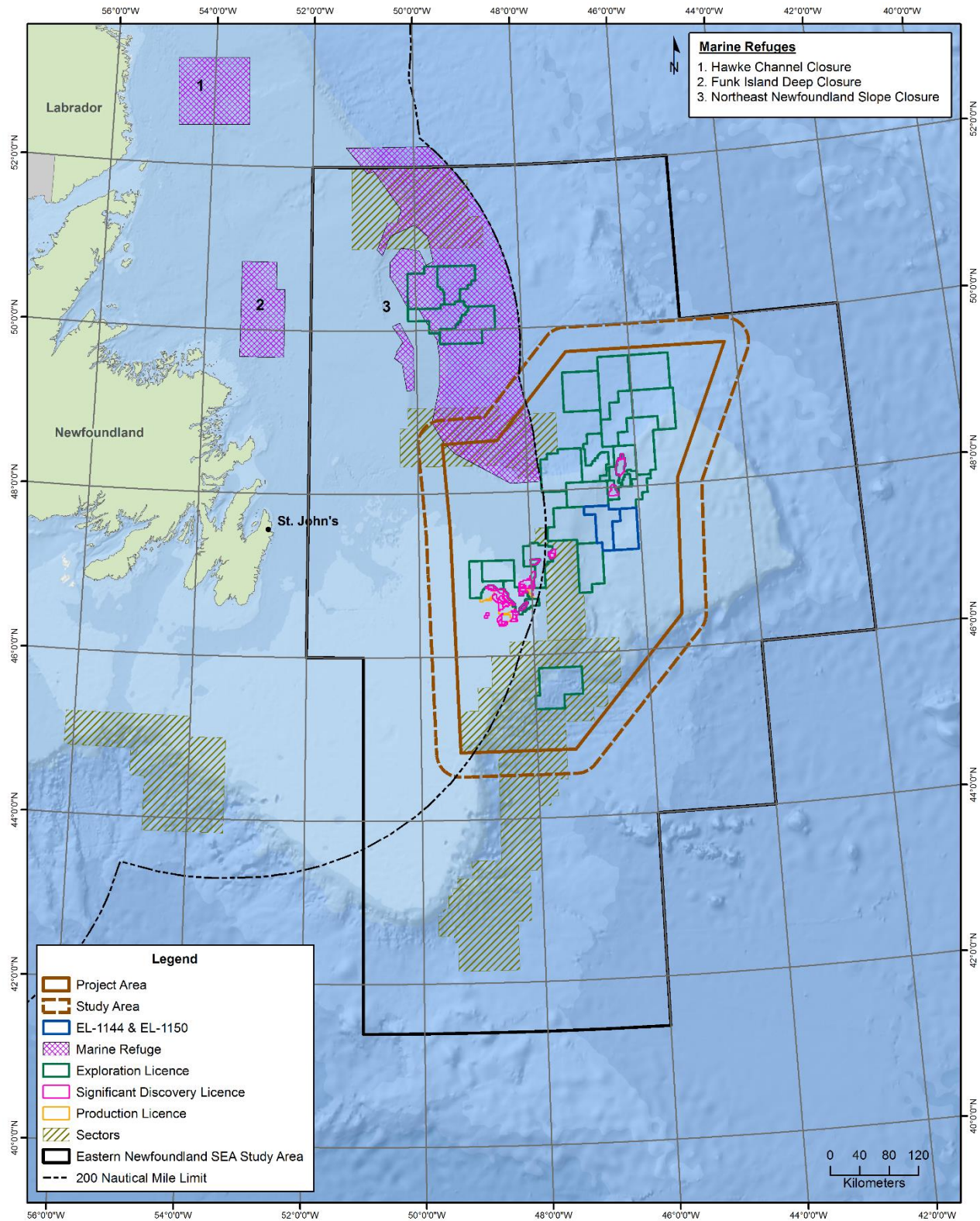


Table 2.2 below is an addition to Table 5.14 of the EA Report (Special Areas: Summary of Distances from the Project Area and Study Area), and provides similar information for each of the additional special areas referenced above.

Table 2.2 Additional Special Areas: Summary of Distances from the Project Area and Study Area

Special Area	Minimum Distance From	
	Study Area (km)	Project Area (km)
Fisheries Act Closures for Crab Fishing		
Crab Fishing Area 5A (2 Zones)	194	226
Crab Fishing Area 6A (2 Zones)	180	213
Crab Fishing Area 6B	174	207
Crab Fishing Area 6C	164	197
Crab Fishing Area 8A	188	220
Crab Fishing Area 8BX	Overlaps	Overlaps
Crab Fishing Area 9A (2 Zones)	287	320
Near Shore (2 Zones)	162	195
Marine Refuges		
Northeast Newfoundland Slope Closure Marine Refuge (formerly known as Tobin's Point)	Overlaps	Overlaps
Hawke Channel Closure Marine Refuge	475	508
Funk Island Deep Closure Marine Refuge	213	246

With the addition of this information, there are no associated changes in the overall results of the environmental effects assessment for Special Areas.

DFO Comment on Nexen Response: Section 4.2.4.1 Canadian (Federally) Identified and Designated Areas, Fisheries Closure Areas within Canada's Exclusive Economic Zone, pg 158 and pages 14-18 of Addendum - Crab Fishing Area 8A (Southern Avalon Exclusion Zone) and the Nearshore Exclusion Zone should also be listed in Tables 2.1 and 2.2. For consistency it should be noted that there are two exclusion zones for Crab Fishing Area 9A.

Nexen Response: The information provided in the original EA Addendum responses (above) was based on the various information sources available to the Study Team as of the time of writing, and we appreciate this additional information and clarification from DFO on these fisheries closure areas.

The information updates provided by DFO are now reflected in the tables provided in the original response above, with these changes being highlighted through grey shading in each of the relevant cells of the tables.

Section 4.3.1.7 Aboriginal Fisheries, bullet d, pg 233 – This document should include swordfish for Miawpukek First Nation.

Nexen Response: Acknowledged. The relevant text (bullet) is revised as follows:

“d) *Miawpukek First Nation*: Multiple enterprises and licences that give access to 3KL; tuna licences in 3LN; a seal licence for Seal Fishing Areas 4-33; a swordfish licence that includes 3KLMNO.”

Section 5.3.2 Required and Planned Mitigation Measures, pg 261 – Regarding “Should such organisms be observed on-site during conduct of the field program, the relevant technical crew and Nexen representatives will discuss to determine the appropriate mitigation approach.”, will the technical crew and Nexen representatives be trained in identification of sensitive benthic species?

Nexen Response: The technical crew during such survey activities may include a marine scientist that is qualified with specialty knowledge of cold water benthic habitat, and who will be responsible to identify any coral structures within the planned seabottom survey area. Alternatively, an onshore benthic expert contracted by Nexen will receive and review the video footage acquired during the seabed investigation noted above, and will provide “real time” information and advice to the offshore survey team on the presence of any such species and associated mitigations.

In any cases where sampling activities are planned to occur within identified high potential areas for the occurrence of such species, Nexen will discuss this with relevant DFO representatives in advance of the survey mobilization to discuss and consider potential mitigation approaches in the event that such species are observed at planned sampling locations in the field.

DFO Comment on Nexen Response: Section 5.3.2 Required and Planned Mitigation Measures, page 261 and pages 18-19 of Addendum - Representatives should be trained in identification of sensitive benthic species (i.e. coral and sponge species) and not limited to “...any coral structures...”

Nexen Response: Acknowledged. This part of the previous response is modified as follows:

The technical crew during such survey activities may include a marine scientist that is qualified with specialty knowledge of cold water benthic habitat, and who will be responsible to identify any sensitive benthic species (i.e. coral and sponge species) within the planned seabottom survey area....

Section 5.4.2 Potential Environmental Issues, Interactions and Existing Knowledge, pg 265 – Regarding “Studies indicate that plankton, eggs or larval mortality (if it occurs) would be limited to within a few metres of a seismic array.” should have a reference. There is also evidence for mortality of plankton, eggs or larvae at distances further than a few meters – this should be mentioned.

Nexen Response: This text is revised as noted below:

- “Studies indicate that plankton, eggs or larval mortality (if it occurs) would mainly be limited to within a few metres of a seismic array (Dalen and Knutsen 1987, Sætre and Ona 1996, Østby et al 2003 in Boertmann and Mosbech 2011, Payne et al 2009) with some studies observing mortality up to 1.2 km away from the air gun array (153 re 1 uPa2s-1 sound exposure level) (McCauley et al 2017). The authors suggest that the potential ‘shaking’ of sensitive mechanosensory systems of zooplankton by seismic exposure may lead to sensory hair tissue damage (McCauley et al 2017). There is little indication or evidence that direct physical damage to fish occurs at distances greater than several meters from the source, particularly due to the avoidance behaviour exhibited by mobile marine organisms (Sætre and Ona 1996).”

Section 5.4.2 Potential Environmental Issues, Interactions and Existing Knowledge, pg 266, Table 5.2 –In the “Summary of Existing Knowledge” and throughout, the method used to describe the amplitude of the sound pressure level should be included, e.g. root-mean-square (RMS), peak to peak, or peak. Also, in selected examples of studies where damage to fish from seismic sound has been noted (page 272) - the distance from the sound source should be included in these examples.

Nexen Response: Details have been added to the relevant rows of Table 5.2 from the original EA Report (reproduced below) to characterize the sound pressure levels and distances of experimental organisms to the sound source, where this information was provided through the referenced source material.

Table 5.2 Potential Environmental Effects on Marine Fish and Fish Habitat: Summary of Existing Knowledge

Potential Issue / Interaction	Overview of Relevant Studies
Seismic Noise: Potential Fish Mortality or Injury	<p>A variety of studies have investigated potential injury to fish as a result of seismic air source arrays, such as damage to hearing structures (e.g. Popper et al 2005; Popper and Hastings 2009; Popper and Fay 2011; Carroll et al 2017) and/or mortality of fish, fish eggs or larvae (e.g. Parry and Gason 2006).</p> <p>Most studies have found that stationary fish affected by seismic surveys had to be located very close to the seismic array (usually caged close to the source and subjected to multiple passes of the array) to be affected (see McCauley et al 2003 and Turnpenny and Nedwell 1994 for a review). Studies using caged fish have also noted that the response of the fish is usually a strong attempt to move away from the sound (e.g. McCauley et al 2003).</p> <p>Due to the spectrum of hearing capabilities of fish (see below), seismic noise activities may have varying effects (Popper and Hastings 2009; Popper and Fay 2011). In some species, seismic activities have been shown to cause a temporary threshold shift (TTS) in hearing sensitivity (Popper et al 2005; Popper and Hastings 2009; Carroll et al 2017) which may result in reduced abilities for communications, predator or prey detection, and assessing the environment (Carroll et al 2017). There is little information on permanent threshold shifts (PTS) in fish hearing. In one experiment,</p>

Potential Issue / Interaction	Overview of Relevant Studies
	<p>airgun emissions damaged hearing sensory structures in pink snapper with no recovery 58 days after exposure (McCauley et al 2003). However, this type of seismic air gun injury to fish has not been observed in other species (Popper et al 2005; Song et al 2008). The effects of seismic surveys on marine phytoplankton, zooplankton and the planktonic life stages of various marine fish species have also been investigated (see, for example, Dalen et al 2007 for a review). Mortality of fish, fish eggs, and larvae has been observed only within a few metres of seismic air source arrays (Kostyuchenko 1973; Dalen and Knutsen 1987; Matishov 1992; Kosheleva 1992; Holiday et al in Turnpenny and Nedwell 1994; Parry and Gason 2006) and immediate mortality is unlikely (Worcester 2006). Some species may also become habituated to underwater noise levels (Popper and Hastings 2009, Carroll et al 2017). High intensity seismic noise can have lethal or sublethal effects on plankton at short range (less than 5 m; Østby et al 2003, in Boertmann and Mosbech 2011). Davis et al (1998) estimated that up to one percent of the ichthyoplankton in the top 50 m of the water column within close proximity to the sound source could be killed during 3D seismic surveys off Nova Scotia. Kenchington (1999) also estimated a plankton mortality rate of six percent if they were concentrated in the upper 10 m in close proximity to the sound source. In Norway, it was estimated that 0.45 percent of planktonic organisms in the top 10 m of water could be killed by high intensity seismic noise (Sætre and Ona 1996). Mortality of fish eggs, caused by exposure to seismic array noise, was very low compared to natural mortality and was considered not significant to fish recruitment (Sætre and Ona 1996).</p> <p>Payne et al (2008) indicated that there was no evidence for delayed mortality or egg loss in snow crab exposed under the conditions of an actual seismic program (227 peak-to-peak, average peak energy density of 187 dB re 1 $\mu\text{Pa}^2/\text{Hz}$) in deep waters off Cape Breton. In snow crab, over a period of days to several months, there were no observed effects of delayed mortality or damage to mechano-sensory systems associated with animal equilibrium and posture. There was also no evidence of leg loss or other appendages, but potential sublethal effects in relation to feeding and serum biochemistry (Payne et al 2008).</p> <p>A snow crab test group exposed to seismic sound showed elevated bruising of the hepatopancreas, bruising of ovaries, and dilated oocytes with detached chorions (DFO 2004a). The timing and location of seismic activity and proximity to the array is a key factor in the likelihood and potential degree of the effect. Christian et al (2003, 2004) also did not observe any acute or chronic mortality in adult snow crab experimentally exposed to variable seismic sound levels (197 to 237 dB re 1 μPa peak SPL), although a higher proportion of less developed eggs was noted for experimentally exposed egg masses in comparison to unexposed egg masses. Seismic air source arrays operating in areas and times of strong seasonal stratifications</p>

Potential Issue / Interaction	Overview of Relevant Studies
	<p>or upwelling may affect more planktonic material because of their high densities (Boudreau et al 2001). Although it is recognized that marine invertebrates (including juvenile stages) can be quite sensitive to sound (Williams et al 2015; Edmonds et al 2016; Kunc et al 2016; Nedelec et al 2014), recent field-based studies on adult populations revealed no evidence of increased mortality due to airgun exposure in scallops up to ten months after exposure, clams after two days after exposure, or lobsters up to eight months after exposure (Carroll et al 2017).</p> <p>The literature suggests that although it is evident that fish often respond to sounds emitted from seismic air source arrays (see below), little direct physical damage to fish occurs at distances greater than a few meters from the source. For example, due to the avoidance behaviour by free-swimming fish, they typically do not suffer physical damage from seismic surveys (Gausland 1993). Indeed, there are no documented cases of fish mortality under exposure to seismic sound under field operating conditions (DFO 2004a; Payne 2004; Popper et al 2014; Carroll et al 2017), nor have FLOs or other seismic ship personnel reported observing dead fish around survey operations. Overall, exposure to seismic sound is considered unlikely to result in direct fish mortality (DFO 2004a).</p> <p>It has been noted, however, that non-injurious (behavioural) effects can still be of concern if they accumulate to have population-level implications (Williams et al 2015).</p>
<p><i>Seismic Noise: Behavioural Responses</i></p>	<p>When exposed to an operating seismic array, mobile marine fish may exhibit a variety of responses, including alarm responses and temporary avoidance of the area (e.g., McCauley et al 2000a, 2000b). When exposed to operating seismic air source arrays, mobile marine fish may swim deeper, mill in compact schools or become more active (e.g., Slotte et al 2004).</p> <p>Indeed, behavioural reactions to exposure to seismic noise have been widely documented in marine organisms (Popper and Hastings 2009; Slabbekoorn et al 2010; Hawkins et al 2015; Carroll et al 2017). There are well documented observations of fish and invertebrates exhibiting behaviours that appeared to be in response to exposure to active seismic air source array noise levels. These include startle responses, changes in swimming direction and speed, or changes in vertical distribution (Blaxter et al 1981; Schwartz and Greer 1984; Pearson et al 1992; McCauley et al 2000a, 2000b; Wardle et al 2001; Hassel et al 2003; Samson et al 2014; Solan et al 2016). Gadoids, for example, have been shown to leave the area during seismic surveys (Skalski et al 1992, L��kkeborg and Soldal 1993, Eng��s et al 1996, Slotte et al 2004, Parry and Gason 2006). Species such as cod, herring, rockfish and whiting have been reported to change depth in response to seismic noise (Skalski et al 1992; Pearson et al 1992; Wardle et al 2001; Slotte et al 2004).</p> <p>Other studies have found that many species of fish dive to avoid</p>

Potential Issue / Interaction	Overview of Relevant Studies
	<p>intense sound (Protasov 1966; Schwartz and Greer 1984; Knudsen et al 1992). McCauley et al (2000a, 2000b) describes a more intense “generic” fish alarm startle response of seeking shelter in tight schools and moving near the bottom. Anthropogenic noise appears to have a more pronounced effect on larger fish (Engås et al 1996) and invertebrates (Wale et al 2013a, 2013b) than smaller individuals. In contrast, other studies indicate that fish do not change behaviour when exposed to an active seismic air source array (e.g., Pickett et al 1994; Wardle et al 2001; Andriguetto-Filho et al 2005). Wardle et al (2001), for example, report that neither finfish nor invertebrates showed signs of moving away from a reef on the west coast of Scotland after four days of seismic air source array firing. Similarly, Peña et al (2013) indicated that feeding herring were undeterred by seismic activity as they approached to within two kilometers of seismic survey operations. Marine benthic invertebrates exposed to seismic sounds have been observed to respond to seismic noise with startle or stress behaviours (Solan et al 2016), but often do not necessarily undergo avoidance behaviours (Carroll et al 2017, Morris et al 2018). Snow crab located 50 m from a seismic source did not exhibit alarm responses, changes in physiology (Christian et al 2004). Field experiments with tagged snow crabs exposed to seismic noise (229 dB re 1 $\mu\text{Pa}^2\text{s}$ source sound exposure level) have also indicated that seismic explorations did not affect commercial catch rates of snow crab over days or weeks (Morris et al 2018). There was no evidence of effects on snow crab egg hatch time although the proportion of less developed eggs were higher in exposed egg masses (Christian et al 2003, 2004; Payne et al 2008). Hawkins and Popper (2014) illustrate that seemingly similar species respond differently to the same anthropogenic noise source. They also indicate that the response can differ within a species depending on the time of day and other factors.</p> <p>Some studies indicate that any behavioural changes that do occur are very temporary while others imply that marine animals might not resume pre-seismic behaviours or distributions for several days (Engås et al 1996; Løkkeborg 1991; Skalski et al 1992; Hassel et al 2004; Solan et al 2016). Most available literature (Blaxter et al 1981; Dalen and Raknes 1985; Pearson et al 1992; Davis et al 1998; McCauley et al 2000a, 2000b) indicates that the effects of noise on fish are brief and if the effects are short-lived and outside a critical period, they are expected not to translate into biological or physical effects. However, Slabbekoorn et al (2010) and Hawkins et al (2015) emphasize that the understanding of anthropogenic noise effects on fish remains incomplete.</p> <p>Radford et al (2014) recently reviewed the effects of anthropogenic noise on fish communication. They highlight that communication plays an important role in the ecology of many fish (e.g. territorial disputes, mating, predatory attacks, aggregating for spawning) and masking these sounds could affect survival and reproductive</p>

Potential Issue / Interaction	Overview of Relevant Studies
	<p>success. Furthermore, non-masking sounds have the potential to stress fish and/or reduce performance of many activities. These authors and others (e.g., Hawkins et al 2015) emphasize that there remains relatively little empirical data regarding seismic effects on fish, particularly given the vast number of species involved and that such effects vary across fish taxa, based on their physiology, ecology and adaptation (Radford et al 2014; Carroll et al 2017).</p>
<p><i>Seismic Noise: Observed Effects on Fish Presence (and Fishing Activity)</i></p>	<p>A number of studies have documented changes in fishing success rates during and following nearby seismic survey activity.</p> <p>Skalski et al (1992), for example, cite seismic activity as a contributing factor for decreased redfish abundance, and Løkkeborg (1991) observed reduced catches in fish for days following 2D/3D seismic survey exposure as a result of changes in fish behaviour. Similarly, reduced catches of haddock and Atlantic cod within several kilometres of seismic activity continued for days after seismic activity stopped (Engås et al 1996; Engås and Løkkeborg 2002). Catches for some species/gear types (such as gillnet catches of orange rockfish and halibut) have actually increased during seismic activity, whereas others (such as longline catches of haddock) have been observed to decrease. At larger scales, regions with seismic survey activity had decreased catches for only a few species for certain gear types (e.g., saithe and haddock with gill nets; Vold et al 2009). There also has been evidence of increased catch rates of fish 30-50 km away from seismic activities indicating avoidance by migrating fish (Popper and Hastings 2009). Seismic noise effects have not been demonstrated on catch rates of Australian rock lobster, snow crab, lobster, shrimp and some reef invertebrates (Carroll et al 2017).</p> <p>A desktop study of four species (gummy shark, tiger flathead, silver warehou, school whiting) in Bass Strait, Australia, found no consistent relationships between catch rates and seismic survey activity in the area, although the large historical window of the seismic data may have masked immediate or short-term effects which cannot therefore be excluded (Thomson et al 2014). A subsequent desktop study targeting a single seismic survey found that of the 15 commercial species examined, six species showed higher catch following the survey, three species showed reduced catch, and five species showed no change (Przeslawski et al 2015). In Newfoundland waters, anecdotal information from fishers indicated reduced catch rates of snow crab were observed after a pass by seismic survey vessels (Christian and Bocking 2013). Fishers also observed temporary avoidance to deeper waters by a school of shrimp in response to a seismic sound source (Christian and Bocking 2013).</p> <p>The potential effects of seismic survey activity on fish catch rates therefore appear to vary by species and gear type (Hirst and Rodhouse 2000; Løkkeborg et al 2012; Worcester 2006; Vold et al 2012). More locally, fishers that utilize the EA Study Area have also</p>

Potential Issue / Interaction	Overview of Relevant Studies
	expressed concern that seismic survey activity may affect catch rates and the results of research surveys (Amec 2014).
<p><i>Seismic Noise: Sound Levels that may Affect Fish and Invertebrates (Physical or Behavioural)</i></p>	<p>Studies of fish reactions to anthropogenic noise in the marine environment have produced a range of results across different sound levels and between species. For context, container shipping and oil platform production can reach levels of 184 - 195 dB re 1 µPa peak SPL (Hildebrand 2009). Subtle behavioural changes of rockfish exposed to seismic sounds, for example, commenced at 161 dB re 1 µPa peak SPL and alarm response became significant at 180 dB re 1 µPa peak SPL (Pearson et al 1992). Eastern striped grunter displayed persistent C-turn startle responses at 182 – 195 dB re 1 µPa mean-peak (McCauley et al 2000a, 2000b), and various fish showed startle responses to noises at approximately 195 dB re 1 µPa peak SPL (Wardle et al 2001). The onset of ‘alarm’ behaviours typically begin at 156 – 161 dB re 1 µPa root-mean-square (RMS) (McCauley et al 2000a, 2000b). Skalski et al (1992) estimated that avoidance behaviour in fish occurs between 180 and 191 dB re 1 µPa peak SPL. Løkkeborg and Soldal (1993) estimated that avoidance behaviour in fish occurs between 160 and 171 dB re 1 µPa (Moriyasu et al 2004). Engås et al (1996) noted that mild behavioural effects can extend to tens of kilometres from the seismic source (253 dB re 1 µPa at 1 m peak SPL). This is supported by DNV Energy (2007, in Hurley 2009) which states that scare effects have been demonstrated in a radius of more than 30 km from the seismic sound source.</p> <p>As with fish, some invertebrates may become habituated to sound, with squid showing fewer alarm responses with subsequent exposure to noise from airguns, cuttlefish habituating to repeated 200 Hz tone pips (Samson et al 2014), and squid showing decreased responses over sound exposure trials (Mooney et al 2016). There is also some indication of habituation in crabs to vibrations (Roberts et al 2016).</p> <p>Some select examples of studies which have investigated physical and physiological damage to fish as a result of exposure to different levels of seismic sound are provided below. It is noteworthy that many of these studies were conducted in the laboratory and therefore may not always reflect effects experienced by free ranging organisms in the wild.</p> <ul style="list-style-type: none"> • In comparison to controls, there were no mortalities one to four days post exposure to seismic airguns in monkfish larvae (205 dB re 1 µPa peak to peak) and capelin eggs (199 dB re 1 µPa peak to peak) 0.5 m away from the seismic airguns (Payne et al 2009). • Cod eggs exposed to seismic shots (202 – 220 dB re 1 µPa) showed no signs of injury (Dalen and Knutsen 1987). • Cod larvae (220 dB re 1 µPa) and fry (234 dB re 1 µPa) were shown to experience immediate mortality, but eggs showed

Potential Issue / Interaction	Overview of Relevant Studies
	<p>no signs of injury (Dalen and Knutsen 1987)</p> <ul style="list-style-type: none"> • No injury to red mullet eggs occurred at 210 dB but eight percent were injured at 230 dB (Kostyuchenko 1973). • Kostyuchenko (1973) reported more than 75 percent survival of fish eggs at 0.5 m from the source (233 dB re 1 μPa at 1 m) and more than 90 percent survival at 10 m from the source. • Pollock eggs (242 dB) have been observed to show delayed mortality (Booman et al 1996). • Swimbladders of anchovy larvae were ruptured at 238 dB (Holiday et al, in Turnpenny and Nedwell 1994). • Matishov (1992) showed that five day old cod experienced delimitation of retina at 250 dB. • Caged freshwater pallid sturgeon and paddlefish that were exposed to a single pulse from a small seismic airgun array (10,160 cm³) 6 m above the cage showed no mortality or mortal injury either immediately or within seven days of exposure (231 dB re 1 μPa peak SPL) (Popper et al 2016, Carroll et al 2017). • European seabass exposed to playbacks of pile-driving or seismic noise for 12 weeks no longer responded with an elevated ventilation rate to the same noise type, and showed no differences in stress, growth or mortality compared to those reared with exposure to ambient-noise playback (Radford et al 2016). • Popper et al (2005) reported exposure to seismic airguns (205-207 dB re 1 μPa peak SPL) 13-17 m away from cages resulted hearing TTS in freshwater lake chub and northern pike with recovery within 18-24 hours. In the same study, no effects were observed on broad whitefish, another freshwater species. • Hastings (1990) reported that lethal threshold for fish occurs at 229 dB and a stunning effect in the 192 to 198 dB range. • Caged pink snapper (5-15 m away from source) had extensive sensory hair damage with no recovery or repair 58 days after exposure in response seismic source sound levels of 222.6 dB re 1 μPa peak to peak, (McCauley et al 2003). • Kosheleva (1992) reported no obvious physiological effects of fish beyond 1 m from a source of 220 to 240 dB re 1 μPa at distances of greater than 0.5 m.

Potential Issue / Interaction	Overview of Relevant Studies
	<ul style="list-style-type: none"> • Brown shrimp exposed to a source level of 190 dB re 1 μPa at 1 m showed no injury (Webb and Kempf 1998). • There were no acute or chronic mortalities 12 weeks after exposure in captive adult snow crab 4-170 m away associated with variable seismic noise (sound peak levels (SPL) 191-221 dB re 1 μPa_{0-p}, and sound energy levels (SEL) <130-187 dB re 1μPa²s) (Christian et al 2003, 2004). • At 217 dB re 1 μPa sound exposure level at 2 m away from source, Matishov (1992) observed shell damage in caged Iceland scallops while caged sea urchins lost 15 percent of their spines. • No detectable differences were observed in mussels, crustaceans or periwinkles within 30 days after exposure to 220-240 dB re 1 μPa seismic arrays greater than 0.5 m away from test organisms (Kosheleva 1992; Moriyasu et al 2004). • Dungeness crab larvae molt times and long term survival were not affected with exposure to seismic levels 231 dB re 1 μPa mean peak SPL approximately 1-10 m away (Pearson et al 1994). <p>In recent research, Hawkins et al (2014) studied the response of mackerel and sprat schools to repeated impulsive sounds. Incidence of response increased with sound levels but responses were different across species (mackerel changed depth while sprat dispersed). The sound level where 50 percent of fish schools responded was 163.2 and 163.3 dB re 1mPa² (peak to peak) and 135 and 142 dB re 1mPa² for single strike for sprat and mackerel, respectively.</p> <p>Popper et al (2014) established sound exposure guidelines for seismic activities for fishes with and without swim bladders. It was estimated that potential hearing TSS would occur at 186 dB re 1 μPa accumulated SEL and recoverable injuries would occur at 203-216 dB re 1 μPa accumulated SEL or 207-213 dB re 1 μPa peak SPL. Mortality or potential mortal injury sound exposure guidelines ranged from 207-219 dB re 1 μPa SEL and 207-213 dB re 1 μPa peak SPL.</p>
<p><i>Seismic Noise: Detection Ability of Fish and Invertebrates</i></p>	<p>Many fish species and invertebrates are capable of emitting noise that share frequencies with those of seismic noise (Myrberg 1980; Turnpenny and Nedwell 1994; Engen and Folstad 1999; Hawkins and Amarin 2000; Slabbekoorn et al 2010). Some species use acoustic communication during reproduction and predator interactions (Slabbekoorn et al 2010). Some fish are also able to distinguish and interpret competing sounds (MMS 2004).</p> <p>Fish can be categorized based on their hearing capability and method of transmission for particle motion and sound pressure detection</p>

Potential Issue / Interaction	Overview of Relevant Studies
	<p>(Popper et al 2014). Fish with no swim bladder including sharks and flatfish hear through direct sound transmission to the otolith and sensory hairs, restricting detection to the particle motion component of sound. The swim bladder is a gas filled structure that may contract or expand relative to the rest of the fish in a sound field (Christian and Bocking 2013). Fish with swim bladders not associated with hearing including Atlantic cod and Atlantic salmon, also detect the particle motion component of sound but may be susceptible to barotrauma (Carroll et al 2017). Fishes with connections between the inner ear and the swim bladder include squirrel fish, mormyrids and herring. These fish have increased hearing sensitivity and may be more susceptible to sound pressure (Christian and Bocking 2013; Carroll et al 2017).</p> <p>Marine invertebrates typically lack organs that detect pressure waves but some species (e.g. marine crabs, squid, and echinoderms) have statocysts that are capable of sound detection through particle motion (Popper et al 2001; Morley et al 2014). Cephalopods and decapod crustaceans have sensory hairs that also aid in particle motion detection (Carroll et al 2017). Organisms that rely exclusively on particle motion (as in most invertebrates) to detect sound are more resilient to anthropogenic noise exposure (Morley et al 2014). Laboratory studies show that some crustaceans (e.g., Norway lobster) will respond to sounds that are within the frequency range of that used in seismic surveys (Goodall et al 1990).</p> <p>Hearing sensitivities of finfish are reviewed by Popper and Carlson (1998) and Popper et al (2003). Cod, salmon, America plaice and herring have hearing sensitivity between 80 and 200 Hz, with a sensitivity threshold at 80 to 100 dB re 1µPa (Mitson 1995). Deep water species and those lacking swim bladders may be less vulnerable to effects from seismic survey activities (Boertmann and Mosbech 2011). Larger fish are also potentially more susceptible to injury than smaller fish resulting from differences in swim bladder resonance (Carroll et al 2017).</p>

Section 5.4.3 Environmental Effects Assessment, Table 5.3 page 278; Table 5.9 pg 300; Table 5.17 pg 321 – Regarding the “Certainty” rating of “H”, for “Seismic Sound”, given the knowledge gaps associated with effects of seismic sound - recommend changing the rating from “H” to “M to H” for Fish and Fish Habitat and Marine Fisheries VECs and changing to “M” for Marine Mammals and Sea Turtles VEC.

Nexen Response: It should be noted that the EA Report does acknowledge that, for example, “overall knowledge and understanding of the effects of seismic and other anthropogenic noise on marine fish and invertebrates remain incomplete in some areas”, which is also reflected in the literature reviews provided in Tables 5.2 and 5.8. While Nexen remains of the view that with the implementation of the mitigation measures committed to in the EA Report any such effects are manageable and predicted to be not significant, we accept the proposed change to

the certainty ratings noted by the reviewer to reflect the inherently conservative nature of the effects analysis.

Excerpts from the referenced Tables in the original EA Report are provided below to illustrate these accepted changes.

Table 5.3 Marine Fish and Fish Habitat: Residual Environmental Effects Assessment Summary

Project Activity and Potential Effect(s)	Environmental Effect Descriptors						
	Nature	Magnitude	Extent	Duration	Frequency	Reversibility	Certainty
<i>Seismic Sound</i> • Potential injury • Disturbance	A	L	2-3	1	1	R	M-H

Table 5.9 Marine Mammals and Sea Turtles: Residual Environmental Effects Assessment Summary

Project Activity and Potential Effect(s)	Environmental Effect Descriptors						
	Nature	Magnitude	Extent	Duration	Frequency	Reversibility	Certainty
<i>Seismic Sound</i> • Disturbance	A	L	3	2	1	R	M

Table 5.17 Marine Fisheries and Other Activities: Residual Environmental Effects Assessment Summary

Project Activity and Potential Effect(s)	Environmental Effect Descriptors						
	Nature	Magnitude	Extent	Duration	Frequency	Reversibility	Certainty
<i>Seismic Sound</i> • Disturbance	A	N	2	1	1	R	M-H

Section 5.8.3 Environmental Effects Assessment, pgs 311-315:

- ***This section focuses on how the activities proposed for the Project will not interact with the seabed and benthic animals, but does not address impacts to pelagic organisms. Please describe potential effects on pelagic species;***

Nexen Response: Please note that the section of the EA Report referenced by the reviewer (Section 5.8.3) provides the environmental effects assessment for Special Areas. The Marine Fish and Fish Habitat VEC is addressed in Section 5.4, which includes a focus on both benthic and pelagic species.

The Special Areas VEC includes Fisheries Closure Areas, Vulnerable Marine Ecosystems (VMEs) and other special areas, many of which were established to protect benthic areas or species; hence the focus on benthic environments in, for example, the first paragraph on page 313 of the EA Report. The environmental effects assessment for the Special Areas VEC does, however, consider all types of special areas (see Table 5.14 for example), including EBSAs and other designations that involve marine biota and features beyond the benthic environment, including pelagic organisms.

The environmental effects assessment for fish and invertebrates including pelagic organisms is addressed in detail in Section 5.4 (Marine Fish and Fish Habitat: Environmental Effects Assessment). Some additional information and analysis related to pelagic species is provided below, as an addition to Sections 5.4.2 and 5.4.3 of the EA Report (with no associated changes in the overall results of the environmental effects assessment).

The effects of seismic activities on pelagic fish and invertebrates have been documented in numerous studies in laboratory and field experiments. In general, due to the spectrum of hearing capabilities, seismic noise activities may have varying effects including avoidance, startle responses, and changes in swimming speed and direction. Cod species have been shown to leave the area of seismic activity and cod, herring, rockfish and whiting have been reported to change depth in response to seismic noise (Skalski et al 1992, Pearson et al 1992, Løkkeborg and Soldal 1993, Engås et al 1996, Wardle et al 2001, Slotte et al 2004, Parry and Gason 2006). Penned European sea bass have been shown to increase swimming speed and depth and swam away from the seismic source upon exposure (163-169 dB re 1 μ Pa, 5.8 m away from the pen) (Neo et al 2016). Squid have also been shown to exhibit alarm responses and firing of ink sacs in response to seismic noise exposure, but not when there was a ramp-up in sound levels (McCauley and Fewtrell 2008). Conversely, feeding herring were undeterred by seismic activity when approaching within 2 km of seismic survey operations (Peña et al 2013). Studies have shown that behavioural changes are largely temporary, however some species may not resume pre-seismic behavior or distributions for several days (Engås et al 1996; Løkkeborg 1991; Skalski et al 1992; Hassel et al 2004; Solan et al 2016). Most available literature indicates that the effects of noise on fish are brief and if the effects are outside a critical period they are expected not to translate into biological or physical effects (Blaxter et al 1981; Dalen and Raknes 1985; Pearson et al 1992; Davis et al 1998; McCauley et al 2000a, 2000b).

The effects of seismic surveys on marine phytoplankton, zooplankton and the planktonic life stages of various marine fish species have also been investigated (see, for example, Dalen et al 2007 for a review). Mortality of fish, fish eggs, and larvae has primarily been observed experimentally within a few metres of seismic air source arrays (Kostyuchenko 1973; Dalen and Knutsen 1987; Matishov 1992; Kosheleva 1992; Holiday et al in Turnpenny and Nedwell 1994; Parry and Gason 2006) with immediate mortality is unlikely (Worcester 2006). However, McCauley et al (2017) observed decreased zooplankton abundance, and increases in larval and adult zooplankton mortality up to 1.2 km (153 re 1 μ Pa²s⁻¹ sound exposure level) away from the seismic array. Kenchington (1999) has estimated a plankton mortality rate of six percent if they were concentrated in the upper 10 m in close proximity to the sound source. Mortality of fish eggs, caused by exposure to seismic array noise, has been suggested to be low in comparison to natural mortality and thus not considered significant to fish recruitment (Sætre and Ona 1996). Payne et al (2009) observed no mortalities compared to controls, one to four days post exposure to seismic airguns in monkfish larvae (205 dB re 1 μ Pa peak to peak) and capelin eggs (199 dB re 1 μ Pa peak to peak) 0.5 m away from the seismic airguns (Payne et al 2009).

- ***This section addresses the ‘short duration’ of contact which will occur with the seafloor but does not discuss potential impacts to fragile, long lived, slow growing sponges and***

corals or the recovery time for these organisms. Please describe potential impacts to corals and sponges, including recovery time, and any significant adverse effects;

Nexen Response: As noted in the preceding response, Section 5.8.3 of the EA Report is part of the environmental effects assessment for the Special Areas VEC, which includes consideration of a number of special area designations that pertain to the known or potential presence of corals and sponges in these areas.

Some additional information related to the potential effects of these Project activities on sensitive corals and sponges is provided below, as an addition to Sections 5.4.2 and 5.4.3 of the EA Report (with no associated changes in the overall results of the environmental effects assessment).

Deep-sea corals and sponges increase biodiversity and habitat heterogeneity in the deep sea system (WGEAFM 2008; Buhl-Mortensen et al 2010; Beazley et al 2013) by creating vertical structure that is used as refuge and foraging habitat (Watanabe et al 2009; WGEAFM 2008) for a variety of species that include those of commercial importance (Gilkinson and Edinger 2009; Baillon et al 2012). The presence and distribution of corals and sponges in the Study Area are detailed in Section 4.2.1.6 of the EA Report (Corals, Sea Pens and Sponges), and the environmental effects assessment for Marine Fish and Fish Habitat (including benthic invertebrates, such as corals and sponges) is provided in Section 5.4.

The effect of seismic activity on adult corals have been suggested to be even less than those on other fish and invertebrates as they lack statocysts, gas filled chambers and other sensory structures that are often the pathways for sound responses (Heyward et al 2018). Hastings (2008, cited in Heyward et al 2018) has indicated that hydroacoustic forces at unrealistically high levels (260-270 dB re 1 μ Pa peak to peak) could potentially cause skeletal and tissue damage in corals. However, tropical Scleractinian corals exposed to a three dimensional seismic survey (226 dB re 1 μ Pa peak SPL in waters primarily 40-60 m deep) showed no evidence of skeletal or tissue damage or immediate physiological damage including mucous streaming, polyp withdrawal or flaccidity in soft corals (IOAA 2014; Heyward et al 2018). Planktonic early life history stages of corals in close proximity to seismic arrays may result in injury and mortality based on responses of other plankton to seismic activities (Sætre and Ona 1996, Kenchington 1999, Dalen et al 2007; McCauley et al 2017). Acoustic cues of reefs have been shown to influence the settling of larval stages of some tropical reef building coral species (Vermeij et al 2010, Lillis et al 2016). Exposure to seismic activities may mask the acoustic cues and potentially affect coral settlement. However, acoustic cues have not been demonstrated to be a main determinant for larval settlement in deep sea cold water corals.

Other offshore survey activities that may have contact with the sea floor include seabed coring, grabs and seabed sampling, towed video surveys, and water sampling., although these will have a very small footprint (ranging from approximately 0.10 – 6 m in radius). Potential effects to corals and sponges from these activities may include mortality or injury from sampling equipment and sedimentation resulting from seabed disturbances. The fragile nature and slow growth of corals and sponges mean that disturbance to bottom habitats (such as trawling, infrastructure placement) can have important and long-lasting effects (Campbell and Simms 2009, Watanabe et al 2009; Barrio-Froján et al 2012; Bell et al 2015, Clark et al 2016). Black corals as well as large and small gorgonian corals, which have carbonate skeletons, are

considered to be amongst the most sensitive to disturbance because they can be permanently dislodged from substrate (Gilkinson and Edinger 2009). Corals and sponges are also particularly sensitive to sedimentation and burial in the marine environment (Larsson and Purser 2011; Allers et al 2013; Bell et al 2015; Purser 2015; Liefmann 2016; Järnegren et al 2016; Ragnarsson et al 2017), as they are sessile, suspension feeding and slow growing. However, adult corals are often able to tolerate short term exposure to certain amounts of sedimentation without any visible detrimental short-term effects or mortality due to their efficient sediment clearing mechanisms (Brooke et al 2009; Allers et al 2013; Larsson et al 2013; Purser 2015).

Chronic or high level sedimentation exposure may lead to sublethal effects including reduced growth rates and smaller egg size (Larsson et al 2013; Baussant et al 2014), however field observations have not shown degradation of *L. pertusa* coral reefs exposed to sedimentation (e.g., drill cuttings) over time (Purser 2015). Studies with suspended mine tailings on the soft coral *Duva florida*, and a gorgonian coral *Primnoa resedaeformis*, species found in the Northwest Atlantic, indicated that small sharp sediment particles were more harmful than smooth edged particles to corals and resulted in changes in feeding behaviour and increased mortality (Liefmann 2016). Sponge tolerance for suspended and settled sediments vary with habitat, with species adapted to soft bottom habitats having a higher tolerance for re-suspended sediments (Bell et al 2015; Kutti et al 2015). *Geodia barretti*, a habitat forming sponge distributed on the slopes of the Flemish Cap and in the Flemish Pass (Knudby et al 2013), is adapted to cope with sedimentation events by reducing filter feeding and thus decreasing their intake of sediment particles (Tjensvoll et al 2013; Kutti et al 2015). However, introduction of sediment sizes atypical from natural conditions may reduce organism condition (Kutti et al 2015). Larval sponges are more sensitive to sedimentation, resulting in higher larval mortality and decreased settlement (Maldonado et al 2008; Bell et al 2015). Therefore, corals and sponges are often adapted to tolerate short term exposure to sedimentation with potential effects on adults related to chronic exposure or high sedimentation and burial unlikely to occur seabed grabs and coring. Although early life stages also show sensitivity to suspended sediments and sedimentation, overall sedimentation from seabed interactions would be low.

Cold water coral and sponge communities are characterized as having slow growth and high longevities with recruitment considered slow and episodic suggesting that recovery from physical disturbance can be prolonged (Cordes et al 2016). Surveys of a marine protected area indicated little recovery in deep-sea cold-water corals after eight years of fisheries closure (Huvenne et al 2016).

Specific to the reviewer's comment regarding the duration and overall magnitude of any such effects, it is acknowledged that the primary consideration related to the potential effects of Project activities on these sensitive benthic species (and thus, on any special areas that are linked to them) is related less to the "duration" of the interaction, but rather to the fact that (as stated in Section 5.8.3 of the EA Report):

"Most of the offshore survey activities that are planned to be undertaken as part of this Project will not result in any direct contact with the seabed, and will therefore not physically disturb benthic animals or their habitats. Seabed core, grab and seabed samples may also be acquired to determine seabed sediment characteristics, as well

as other geochemical and environmental data acquisition using a towed seabed camera/video system, gravity or piston core, box corer, vibro-corer or water sampler ... and those which involve contact with the seabed will have a very small footprint. As referenced earlier, Nexen will undertake representative seabed reconnaissance prior to core drilling or other intrusive seabed sampling work in areas that have been identified as having a high probability of occurrence of sensitive corals and sponges”

DFO Comment on Nexen Response: Section 5.8.3 Environmental Effects Assessment. pages 311-315, regarding corals and sponges, and last sentence, paragraph 1, page 31 of Addendum - The comment was addressed; however, a reference should be provided.

Nexen Response: The intent of the above referenced sentence that “acoustic cues have not been demonstrated to be a main determinant for larval settlement in deep sea cold water corals” was to illustrate that, to our knowledge, no previous studies have demonstrated that sound is an important factor in settlement of cold water corals (i.e., to indicate the lack of references showing this). Specifically, all of the known research has focussed on tropical corals that have been attracted to the sounds of the reef itself.

For further clarification, this sentence is revised as follows:

However, biological, physical, and chemical cues, rather than acoustic cues, have been observed to be the key factors influencing settlement in deep sea cold water corals (e.g., Sun et al 2010; Watling et al 2011; Larsson et al 2014; Liefmann et al. 2018).

- **The report does not acknowledge the known impacts of seismic testing on zooplankton, krill and other small marine crustaceans such as copepods (Day et al., 2010 and Neo et al., 2015), which are important food sources for many marine fish, marine mammals and seabirds. Please describe potential impacts to these species and any significant adverse effects.**

Nexen Response: The distribution and composition of plankton in the Study Area is described in Section 4.2.1.3 of the EA Report (Plankton). The environmental effects assessment for fish and invertebrates (including plankton) is addressed in Section 5.4 of the EA Report (Marine Fish and Fish Habitat: Environmental Effects Assessment) and is summarized below with supplemental information related to plankton added where relevant and available. This information is provided as an addition to Sections 5.4.2 and 5.4.3 of the EA Report, with no associated changes in the overall results of the environmental effects assessment.

The plankton community is comprised of small free-floating microscopic marine plants (phytoplankton), invertebrates (zooplankton), vertebrate and invertebrate eggs and larvae, bacteria, fungi and viruses (Legendre and Rassoulzadegan 1995; Suttle 2005). Plankton comprise the most diverse and abundant group in the ocean and form the foundation of marine food webs through primary (phytoplankton) and secondary (zooplankton) production. Many commercially important finfish and invertebrate species occur as plankton early in their

life cycle. Their early life cycles may also depend on other plankton for food.

A variety of studies have investigated potential injury to plankton as a result of seismic sound source arrays (e.g. Payne 2004, Parry and Gason 2006, Day et al 2016, Edmonds et al 2016, Carroll et al 2017, McCauley et al 2017). Mortality of eggs and larvae have primarily been observed only within a few metres of seismic air source arrays (Payne 2004, Østby et al 2003 in Boertmann and Mosbech 2011, Parry and Gason 2006). Payne et al (2009) observed no mortalities in comparison to controls, one to four days post exposure to seismic sound sources in monkfish larvae (205 dB re 1 μ Pa peak to peak) and capelin eggs (199 dB re 1 μ Pa peak to peak) 0.5 m away from the seismic sound sources. Dungeness crab larvae molt times and long term survival were not affected with exposure to seismic levels 231 dB re 1 μ Pa mean peak SPL approximately 1-10 m away from the seismic array (Pearson et al 1994). Development of spiny lobster larvae was also not affected by seismic exposure (185 dB re 1 μ Pa²s sound exposure level) with no differences in the quantity or quality of hatched larvae (Day et al 2016). Seismic experiments with snow crab have shown variations in effects from some retardation in egg development to no differences from controls in hatch rate, survival and swimming behavior of larvae (DFO 2004b, Payne 2004). Scallop veliger larvae exposed to seismic noise (160-164 dB re 1 μ Pa RMS) was shown to result in abnormal growth and delayed development (Aguilar de Soto 2013). In field experiments, there were no obvious mortalities of shrimp or evidence of reduced catches in brown shrimp that were exposed to seismic activity (190 dB re 1 μ Pa at 1 m source level) (Webb and Kempf 1998). However, McCauley et al (2017) observed decreased zooplankton abundance, and increases in larval and adult zooplankton mortality up to 1.2 km (153 re 1 μ Pa²s⁻¹ sound exposure level) away from the seismic array. The authors suggest that the potential 'shaking' of sensitive mechanosensory systems of zooplankton by seismic exposure may lead to sensory hair tissue and damage (McCauley et al 2017). Similar to fish species, zooplankton have varying capabilities in sensory sensitivity and may account for differing responses to seismic noise among species (McCauley et al 2017). Seismic activities may also have effects on larval settlement as acoustic cues have been shown to play a role in settlement of tropical coral larvae (Vermeij et al 2010, Lillis et al 2016).

Overall estimates for effects of seismic activity on plankton have been assessed based on potential mortality near the seismic array. Davis et al (1998) estimated that up to one percent of the ichthyoplankton in the top 40-60 m of the water column within close proximity to the sound source could be killed during 3D seismic surveys off Nova Scotia. Kenchington (1999) also estimated a plankton mortality rate of six percent if they were concentrated in the upper 10 m in close proximity to the sound source. In Norway, it was estimated that 0.45 percent of planktonic organisms in the top 10 m of water could be killed by high intensity seismic noise (Sætre and Ona 1996). Mortality of fish eggs, caused by exposure to seismic array noise, was very low compared to natural mortality and was considered not significant to fish recruitment (Sætre and Ona 1996). Furthermore, extensive seismic surveys have been carried out in the North Sea without any measurable effects on commercial fish populations (Payne 2004).

As noted in the EA Report, due to the transient and short term nature of the planned seismic activities and with the implementation of the proposed mitigation measures, it is unlikely that plankton, fish and invertebrates will be affected by the Project in a manner that causes negative and detectable effects to fish at a population or regional level (Section 5.4.3.2).

2.2.3 Fish, Food and Allied Workers (FFAW-Unifor)

Section 5.1 Project Components, Activities and Key Environmental Considerations, pg 255, 7th bullet AND Section 5.9.2 Potential Environmental Issues, Interactions and Existing Knowledge, pg 317, 2nd bullet - “Reduced access to preferred fishing...areas during survey activities in certain locations, with possible decreases in activity success, efficiency, value or enjoyment” was mentioned as an environmental consideration in this assessment. It is not clear what mitigation measures will be employed to mitigate these potential effects. We request clarification in this instance.

Nexen Response: All of the “Required and Planned Mitigation Measures” outlined in Section 5.3.2 of the EA Report are intended to help avoid or reduce these potential issues and effects, particularly those which are linked directly and specific to the Marine Fisheries and Other Activities VEC, as outlined in Section 5.9.3 and reiterated below:

“[T]his involves planned communications and coordination procedures involving the Operator/Contractor and relevant regulatory authorities, stakeholders and key ocean users throughout the operational life of the Project, including:

- On-going information gathering on key fishing areas and times and continued monitoring of fishing and fish survey activity;
- The presence, active participation and advice of the FLO on board the seismic ship, and a shore-based SPOC;
- The issuance of Notices to Mariners/Shipping and other notifications and direct industry communications throughout the periods of Project operations, and regular communication of planned survey activities with key industry representatives;
- The use of a standby or guard vessel to scout for hazards and for communicating with active fishers in the area (if any); and
- Establishment and implementation of a Fishing Gear Damage or Loss Compensation Program.

As noted in Section 5.3, the proposed survey activities will also be planned and implemented to avoid negative interactions with fisheries research surveys in the Study Area, through active and on-going communication and coordination with DFO and industry representatives. “

Section 5.9.3.2 Seismic Sound and Other Potential Emissions (Routine or Accidental), Table 5.17, pg 321 - The unknown long term effects of seismic activities continue to concern fish harvesters. While the research has not determined any direct mortality of fish or shellfish attributable to seismic activity there may be behavioural changes that could affect migration and/or reproductive and spawning activities as well as movement of the exploitable biomass in an area. This, in turn, can impact catch rates in the current fishing season and/or for years to

come. There is need for further research on impacts of seismic activity on important commercial species including shrimp, crab, turbot and Atlantic cod to address data gaps. As such, we would challenge the magnitude of the effect on seismic sound on marine fisheries to be “Low”, not “Negligible” as reported in Table 5.17.

Nexen Response: The EA Report does acknowledge that, for example, “overall knowledge and understanding of the effects of seismic and other anthropogenic noise on marine fish and invertebrates remain incomplete in some areas”, which is also reflected in the literature reviews provided in, for example, Tables 5.2.

In the EA Report, Table 5.3 summarizes the potential environmental (biophysical) effects of the Project on marine fish and fish habitat. Table 5.17 summarizes the potential environmental (socioeconomic) effects of the Project on marine fisheries and other activities. While there may indeed be some effect on individual fish behaviours and their associated distributions as a result of marine seismic sound, a key consideration in this regard is whether and to what degree this localized and temporary disturbance would translate into a detectable, material effect on commercial fishing activity in the area.

The symbol “N” in Table 5.17 refers to either “no effect” or a “negligible effect” (see key in last row of the table). As described in the EA Approach and Methods Chapter (and Section 3.4.6, Table 3.4 in particular), environment effect magnitude for this VEC is defined as follows:

For the Fisheries and other Marine Activities VEC:

Negligible: Although there is potential for a Project-VEC interaction, there would be no detectable effect

Low: A detectable change that is within the range of natural variability, with no associated adverse effect on the overall nature, intensity or value of the affected component or activity.

Medium: A detectable change that is beyond the range of natural variability, but with no associated adverse effect on the overall nature, intensity or value of the affected component or activity.

High: A detectable change that is beyond the range of natural variability, with an adverse effect on the overall nature, intensity or value of the affected component or activity.

The EA Study Team does not consider, for example, that the presence of seismic sound energy in the marine environment as a result of this Project and any associated (localized and short term) implications for individual fish behaviours (avoidance) is likely to have a detectable effect upon the fishing industry in the Study Area. In particular, it is not likely that it will result in a significant effect on marine fisheries, which was defined in the EA as “a detectable reduction in the overall economic returns generated from fisheries and/or other marine activities undertaken within the Study Area over one or more years.” (Section 5.9.1).

2.2.4 Environment and Climate Change Canada (ECCC)

Section 4.2.2.5 Species at Risk and of Conservation, Table 4.18, pg 129, Barrow's Goldeneye - Change "does not breed" to "occurs in and may breed" in Newfoundland.

Nexen Response: The text in the relevant row of Table 4.18 is revised as follows:

Species	Provincial Status	Federal Status		Habitat and Distribution in Newfoundland	Potential Presence in Study Area
		SARA Schedule 1 Listing	COSEWIC Assessment		
Barrow's Goldeneye (Eastern pop.)	Vulnerable	Special Concern	Special Concern	<ul style="list-style-type: none"> Occurs in and may breed in Newfoundland. Moults and winters in small numbers off the coast of Eastern Canada, often in groups with Common Goldeneye. Small numbers have been reported wintering at Port Blandford and Newman Sound in Terra Nova National Park, as well as Traytown Bay, St. Mary's Bay, and Spaniard's Bay (Schmelzer 2006). Known to congregate in relatively small geographic areas in important shipping corridors, therefore considered to be particularly vulnerable to being affected by accidental spills (Schmelzer 2006). 	Unlikely, due to their affinity for coastal habitats.

Section 5.5.3.2 Seismic Sound Energy, pgs 286-290 - Though there is little evidence that marine birds are adversely affected by marine geophysical surveys, the reverse is also true; there is little evidence that marine birds are not adversely affected by marine geophysical surveys. Further research is required to support either position. ECCC-CWS recommends revising this section to remove speculation.

Nexen Response: The literature review provided in this section related to the potential effects of seismic sound on this VEC, and the associated environmental effects assessment that it

informs, presents a balanced and “nonspeculative” analysis of these potential interactions and effects.

While the assessment indicates that the available literature does not suggest adverse effects on marine avifauna as a result of such surveys, it does clearly acknowledge that, for example “There have been no known studies that have tested the levels of sound that cause injury to marine birds” and “Deep-diving birds (such as the alcids - murres, dovekies, puffins) and other bird species that spend considerable amount of time underwater, swimming or plunge diving for food may be at somewhat higher risk of injury or disruption due to exposure to underwater noise during seismic exploration” (see Table 5.5).

In addition, the associated effects assessment states for example that “It is possible that birds on the water at close range would be startled by the sound, although the presence of the vessel and associated gear dragging in the water should have already warned the bird of unnatural visual and auditory stimuli. Any such disturbances, if they occur at all, would be intermittent and very short-term at any one location”.

3 SUMMARY AND CONCLUSION

This EA Addendum has been provided as a supplement to Nexen's original EA Report for the Project, and provides responses that address the various questions and associated requests for information and clarification that were submitted by government departments and agencies and other organizations as part of the EA review, as consolidated and provided to Nexen by the C-NLOPB.

As noted in the original EA Report, each of the potential environmental interactions and effects that may be associated with the Project can be avoided or otherwise mitigated through the use of good planning and proven operational practices and procedures, supported by standard mitigations that are well established and outlined in relevant regulatory procedures and guidelines, and which have been identified by Nexen as part of the EA. Overall, the Project will entail a localized, short-term and transient disturbance in the marine environment throughout the operational life of the exploration program.

The additional information and clarifications provided through this EA Addendum do not result in any changes in the original environmental effects predictions, required mitigation or associated determinations related to environmental effects significance for any component of the environment. The Project is not likely to result in significant adverse environmental effects.

4 REFERENCES

- Aguilar De Soto, N., Delorme, N., Atkins, J., Howard, S., Williams, J., and M. Johnson (2013). Anthropogenic noise causes body malformations and delays development in marine larvae. *Scientific reports*, 3, 2831.
- Allers, E., Abed, R.M.M., Wehrmann, L.M., Wang, T., Larsson, A.I., Purser, A. and D. de Beer (2013). Resistance of *Lophelia pertusa* to coverage by sediment and petroleum drill cuttings. *Marine Pollution Bulletin*, 74(2013): 132-140.
- Amec (Amec Environment & Infrastructure) (2014). Eastern Newfoundland and Labrador Offshore Area Strategic Environmental Assessment Update. Report prepared for the Canada-Newfoundland and Labrador Offshore Petroleum Board, St. John's, NL.
- Andriguetto-Filho, J. M., Ostrenskya, A., Pie, M. R., Silva, U.A., and W.A. Boeger (2005). Evaluating the impact of seismic prospecting on artisanal shrimp fisheries. *Continental Shelf Research*. 25(2005):1720–1727.
- Baillon, S., Hamel, J.-F., Wareham, V.E., and A. Mercier (2012). Deep cold-water corals as nurseries for fish larvae. *Frontiers in Ecology and the Environment*. 10:351-356.
- Barrio-Froján, C.R.S., MacIsaac, K.G., McMillan, A.K., del Mar Sacau Cuadrado, M., Large, P.A., Kenny, A.J., Kenchington, E. and E. de Cárdenas González (2012). An evaluation of benthic community structure in and around the Sackville Spur closed area (Northwest Atlantic) in relation to the protection of vulnerable marine ecosystems. *ICES Journal of Marine Science: Journal du Conseil*, 69(2), 213-222.
- Baussant, T., Nilsen, M., Westerlund, S., Ramanand, S., Ravagnan, E., Zetsche, E.-M., Gerla, D. and D. van Oevelen (2014). Study of *Lophelia pertusa* coral under different food conditions and varying drill cutting exposure concentrations. International Research Institute of Stavanger. Project No. 7911886. 2014/075: 21 p.
- Beazley, L.I., Kenchington, E.L., Murillo, F.J., and M. del Mar Sacau (2013). Deep-sea sponge grounds enhance diversity and abundance of epibenthic megafauna in the Northwest Atlantic. *ICES Journal of Marine Science: Journal du Conseil*, 70(7), 1471-1490.
- Bell, J. J., McGrath, E., Biggerstaff, A., Bates, T., Bennett, H., Marlow, J., and M. Shaffer (2015). Sediment impacts on marine sponges. *Marine Pollution Bulletin*, 94(1), 5-13.
- Blaxter, J.H.S., Gray, J.A.B., and E.J. Denton (1981). Sound and startle responses in herring shoals. *Journal of the Marine Biological Association of the United Kingdom* 61: 851-869.
- Boertmann, D. and A. Mosbech (eds.) (2011). The western Greenland Sea, a strategic environmental impact assessment of hydrocarbon activities. Aarhus University, DCE – Danish Centre for Environment and Energy, 268 pp. - Scientific Report from DCE – Danish Centre For Environment and Energy no. 22.

- Booman, C., Dalen, J., Leivestad, H., Levsen, A., van der Meeren T., and K. Toklum (1996). Effekter av luftkanonskyting på egg, larver og yngel. Fisker og Havet 1996(3): v+83p. [In Norwegian with English summary.]
- Boudreau, P.R., Harding, G.C., Lee, K., and P.D. Keizer (2001). The Possible Environmental Impacts of Petroleum Activities in the Southern Gulf of St. Lawrence and Sydney Bight Ecosystems. Canadian Science Advisory Secretariat Research Document 2001/112.
- Brooke, S.D., Holmes, M.W. and C.M. Young (2009). Sediment tolerance of two different morphotypes of the deep-sea coral *Lophelia pertusa* from the Gulf of Mexico. Marine Ecology Progress Series. 390: 137–144.
- Bruce, B., Bradford, R., Foster, S., Lee, K., Lansdell, M., Cooper, S., & Przeslawski, R. (2018). Quantifying fish behaviour and commercial catch rates in relation to a marine seismic survey. Marine environmental research.
- Buhl-Mortensen, L., Vanreussel, A., Gooday, A.J., Levin, L., Priede, I.J., Buhl-Mortensen, P., and M. Raes (2010). Biological structure as a source of habitat heterogeneity and biodiversity on the deep ocean margins. Marine Ecology Progress Series 31: 21-50.
- Campbell, J.S., and J.M. Simms (2009). Status Report on Coral and Sponge Conservation in Canada. St. John's, NL: Fisheries and Oceans Canada.
- Carroll, A. G., Przeslawski, R., Duncan, A., Gunning, M., and B. Bruce (2017). A critical review of the potential impacts of marine seismic surveys on fish & invertebrates. Marine pollution bulletin, 114(1), 9-24.
- Christian, J.R. and R.C. Bocking (2013). Appendix F: Review of Potential Effects of Airgun Sounds on Fishes. In Environmental Assessment of BP Exploration (Canada) Limited's Tangier 3-D Seismic Survey. Report prepared by LGL Limited.
- Christian, J.R., Mathieu, A., Thompson, D.H., White, D., and R.A. Buchanan (2003). Effect of Seismic Energy on Snow Crab (*Chionoecetes Opilio*). Environmental Research Funds Report No. 144. Calgary. (106p).
- Christian, J.R., Mathieu, A., R.A. Buchanan (2004). Chronic Effects of Seismic Energy on Snow Crab (*Chionoecetes Opilio*). Environmental Research Funds Report No. 158. Calgary. (25pp).
- Clark, M.R., Althaus, F., Schlacher, T.A., Williams, A., Bowden, D.A. and A.A. Rowden (2016). The impacts of deep-sea fisheries on benthic communities: a review. ICES Journal of Marine Science 73 (Supplement 1): i51– i69.
- Cordes, E.E., Jones, D.O., Schlacher, T.A., Amon, D.J., Bernardino, A.F., Brooke, S., Carney, R., DeLeo, D.M., Dunlop, K.M., Escobar-Briones, E.G., Gates, A.R., Génio, L., Gobin, J., Henry, L.A., Herrera, S., Hoyt, S., Joye, N., Kark, S., Mestre, N.C., Metaxas, A., Pfeifer, S., Sink, K., Sweetman, A.K. and U. Witte (2016). Environmental impacts of the deep-water oil and gas industry: a review to guide management strategies. Frontiers in Environmental Science. 4, 58.

- Dalen, J. and A. Raknes (1985). Scaring effects on fish from 3D seismic surveys. Institute of Marine Research Report, No. P.O. 8504, Bergen, Norway.
- Dalen, J. And G.M. Knutsen (1987). Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic explorations. S. 93-102 i MERKLINGER, H.M. red. Progress in Underwater Acoustics. Plenum Publishing Corporation.
- Dalen, J., Dragsund, E., Næss, A. and O. Sand (2007). Effects of seismic surveys on fish, fish catches and sea mammals. Report for the Cooperation group – Fishery Industry and Petroleum Industry. Report no.: 2007-0512. Det Norske Veritas AS, 24.04.07. Høvik. 29p.
- Davis, R.A., Thomson, D. H., and C.I. Malme (1998). Environmental Assessment of Seismic Exploration on the Scotian Shelf. Prepared for Mobil Oil Canada Properties Ltd., Shell Canada Ltd. and Imperial Oil Ltd. Submitted to the Canada - Nova Scotia Offshore Petroleum Board, Halifax, NS.
- Day, R.D., McCauley, R.D., Fitzgibbon, Q.P., and Semmens, J.M. (2016). Seismic air gun exposure during early-stage embryonic development does not negatively affect spiny lobster *Jasus edwardsii* larvae (Decapoda: Palinuridae). Scientific reports, 6, 22723.
- DFO (Fisheries and Oceans Canada) (2004a). Review of Scientific Information on Impacts of Seismic Sound on Fish, Invertebrates, Marine Turtles and Marine Mammals. DFO Can. Sci. Advis. Sec. Habitat Status Report 2004/002.
- DFO (Fisheries and Oceans Canada) (2004b). Potential Impacts of Seismic Energy on Snow Crab. DFO Can. Sci. Advis. Sec. Habitat Status Report 2004/003.
- DFO (Fisheries and Oceans Canada). (2007). Northern Shrimp (SFAs) 0-7 and the Flemish Cap: Resource Management Operations – Fisheries and Oceans Canada. Retrieved October 26, 2016 from <http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries>.
- DFO (Fisheries and Oceans Canada). (2011). Snow Crab (*Chionoecetes opilio*) - Newfoundland and Labrador - 2009-2011. Retrieved January 17, 2018 from <http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries>.
- DFO (Fisheries and Oceans Canada). (2017). Lobster Area Closures (Trout River, Shoal Point, Penguin Islands, Gooseberry Island, Glovers Harbour, Mouse Island, Gander Bay). Retrieved January 17, 2018 from <http://www.dfo-mpo.gc.ca/oceans>.
- DFO (Fisheries and Oceans Canada). (2018). New Marine Refuges off the Coasts of Nunavut and Newfoundland and Labrador. News Release December 21, 2017. Retrieved January 15, 2018 from <https://www.canada.ca/en/fisheries-oceans/news/2017/12>.
- Edmonds, N.J., Firmin, C.J., Goldsmith, D., Faulkner, R.C., and D.T. Wood (2016). A review of crustacean sensitivity to high amplitude underwater noise: Data needs for effective risk assessment in relation to UK commercial species. Marine Pollution Bulletin. 108: 5-11.

- Engås, A.S. and S Løkkeborg (2002). Effects of seismic shooting and vessel-generated noise on fish behaviour and catch rates. *Bioacoustics*, 12(2-3), 313-316.
- Engås, A.S. Løkkeborg, E.O., and A.V. Soldal (1996). Effects of seismic shooting on local abundance and catch rates of cod (*G. morhua*) and haddock (*M. aeglefinus*). *Canadian Journal of Fisheries and Aquatic Sciences*. 53(10):2238-2249.
- Engen, F., and I. Folstad (1999). Cod courtship song: a song at the expense of dance? *Canadian Journal of Zoology* 77: 542-550.
- Gausland, L. (1993). Impact of offshore seismic on marine life. 55th Meeting of the European Association of Exploration Geophysicists, Stavanger.
- Gilkinson, K. and E. Edinger (2009). The ecology of deep-Sea corals of Newfoundland and Labrador waters: biogeography, life history, biogeochemistry, and relation to fishes. *Canadian Technical Report of Fisheries and Aquatic Sciences* 2830.
- Goodall, C, Chapman, C., and D. Neil (1990). The acoustic response threshold of the Norway lobster, *Nephrops norvegicus* (L.) in a free sound field. In *Frontiers in Crustacean Neurobiology* (ed. K. Wiese, W.-D. Krenz, J. Tautz, H. Reichert and B. Mulloney), pp. 106–113. Basel, Boston, Berlin: Birkhäuser Verlag.
- Hassel, A., Knutsen, T., Dalen, J., Løkkeborg, S., Skaar, K., Østensen, Ø. Haugland, E.K., Fonn, M., Høines, Å., and M.A. Misund (2003). Reaction of sandeel to seismic shooting: A field experiment and fishery statistics study. Institute of Marine Research, Bergen, Norway.
- Hassel, A., Knutsen, T., Dalen, J., Skaar, K., Løkkeborg, S., Misund, O.A., Østensen, Ø., Fonn, M. and E.K. Haugland (2004). Influence of seismic shooting on the lesser sandeel (*Ammodytes marinus*). *ICES Journal of Marine Science: Journal du Conseil*, 61(7), pp.1165-1173.
- Hastings, M.C. (1990). Effects of Underwater Sound on Fish. Document No. 46254-900206-01IM, Project No. 401775-1600, AT and T Bell Laboratories.
- Hawkins A.D., Roberts L., and S. Cheesman (2014). Responses of free living coastal pelagic fish to impulsive sounds. *Journal of the Acoustic Society of America*. 135:3101–3116. doi:10.1121/1.4870697.
- Hawkins, A.D. and A.N. Popper (2014). Assessing the impacts of underwater sounds on fishes and other forms of marine life. *Acoustics Today* 10:30–41.
- Hawkins, A.D. and M.C. Amorin (2000). Spawning sounds of the male haddock, *Melanogrammus aeglefinus*. *Environmental Biology of Fishes*, 59: 29-41.
- Hawkins, A.D., Pembroke, A.E., and Popper, A.N. (2015). Information gaps in understanding the effects of noise on fishes and invertebrates. *Reviews in Fish Biology and Fisheries*, 25(1), 39-64.

- Heyward, A., Colquhoun, J., Cripps, E., McCorry, D., Stowar, M., Radford, B., ... and Battershill, C. (2018). No evidence of damage to the soft tissue or skeletal integrity of mesophotic corals exposed to a 3D marine seismic survey. *Marine Pollution Bulletin*, 129(1), 8-13.
- Hildebrand, J.A. (2009). Anthropogenic and natural sources of ambient noise in the ocean. *Marine Ecology Progress Series*, 395, 5-20.
- Hirst, A.G. and P.G. Rodhouse (2000). Impacts of geophysical seismic surveying on fishing success. *Reviews in Fish Biology and Fisheries*. 10:113-118.
- Hurley, G.V. (2009) Environmental Assessment Biophysical Data Gap Study – Petroleum Exploration Activities on the Offshore Scotian Shelf and Slope. Consultant report prepared by Hurley Environment Ltd. for the Canada-Nova Scotia Petroleum Board. March, 31 2009. 122 pp.
- Huvenne, V. A. I., Bett, B. J., Masson, D. G., Le Bas, T. P., and A.J. Wheeler (2016). Effectiveness of a deep-sea cold-water coral Marine Protected Area, following eight years of fisheries closure. *Biological Conservation*, 200, 60-69.
- Kenchington, T.J. (1999). Impacts of Seismic Surveys on Fish Behaviour and Fisheries Catch Rates on Georges Bank. Report prepared for Norigs 2000 for submission to the Georges Bank Review Panel, Halifax, Nova Scotia - 28 January 1999.
- Knudby, A., Kenchington, E. and F.J. Murillo (2013). Modeling the distribution of *Geodia* sponges and sponge grounds in the Northwest Atlantic. *PLOS One*, 8(12).
- Knudsen, F.R., Enger, P.S., and O. Sand (1992). Awareness reactions and avoidance responses to sound in juvenile Atlantic salmon. *Journal of Fisheries Biology* 40(4): 523-534.
- Kosheleva, V. (1992). The impact of air guns used in marine seismic explorations on organisms living in the Barents Sea. *Contr. Petro Piscis II '92 Conference F-5*, Bergen, 6-8 April, 1992.
- Kostyuchenko, L.P. (1973). Effects of elastic waves generated in marine seismic prospecting on fish eggs in the Black Sea. *Hydrobiologia*. 9:45-48.
- Kunc, H.P., McLaughlin, K.E., and R. Schmidt (2016). Aquatic noise pollution: implications for individuals, populations, and ecosystems. *Proc. R. Soc. B* 283: 20160839. <http://dx.doi.org/10.1098/rspb.2016.0839>
- Kutti, T., Bannister, R.J., Fosså, J.H. Krogness, C.M., Tjensvoll, I. and G. Søvik (2015). Metabolic responses of the deep-water sponge *Geodia barretti* to suspended bottom sediment, simulated mine tailings and drill cuttings. *Journal of Experimental Marine Biology and Ecology*, 473(2015): 64-72.
- Larsson, A.I. and A. Purser (2011). Sedimentation of the cold-water coral *Lophelia pertusa*: Cleaning efficiency from natural sediments and drill cuttings. *Marine Pollution Bulletin*, 62(2011): 1159-1168.

- Larsson, A.I., van Oevelen, D., Purser, A. and L. Thomsen (2013). Tolerance to long-term exposure of suspended benthic sediments and drill cuttings in the cold-water coral *Lophelia pertusa*. *Marine Pollution Bulletin*, 70(2013): 176-188.
- Larsson, A. I., Järnegren, J., Strömberg, S. M., Dahl, M. P., Lundälv, T., & Brooke, S. (2014). Embryogenesis and larval biology of the cold-water coral *Lophelia pertusa*. *PLoS One*, 9(7), e102222.
- Legendre, L., and Rassoulzadegan, F. (1995). Plankton and nutrient dynamics in marine waters. *Ophelia*, 41(1), 153-172.
- Liefmann, S. (2016). Eco-physiological responses of cold-water corals to anthropogenic sedimentation and particle shapes. MSc Thesis; Norwegian University of Science and Technology, Trondheim, Norway.
- Liefmann, S., Järnegren, J., Johnsen, G., & Murray, F. (2018). Eco-physiological responses of cold-water soft corals to anthropogenic sedimentation and particle shape. *Journal of Experimental Marine Biology and Ecology*, 504, 61-71.
- Lillis, A., Bohnenstiehl, D., Peters, J. W., and D. Eggleston (2016). Variation in habitat soundscape characteristics influences settlement of a reef-building coral. *PeerJ*, 4, e2557.
- Løkkeborg, S. (1991). Effects of geophysical survey on catching success in longline fishing. Paper presented at the International Council for the Exploration of the Sea (ICES) Annual Science Conference. ICES. 40: 1-9.
- Løkkeborg, S. and A.V. Soldal (1993). The influences of seismic exploration on cod (*Gadus morhua*) behavior and catch rates. *International Council for the Exploration of the Sea (ICES) Marine Science Symposium* 196: 62-67.
- Løkkeborg, S., Ona, E., Vold, A. and A. Salthaug (2012). Sounds from seismic air guns: gear - and species-specific effects on catch rates and fish distribution. *Canadian Journal of Fisheries and Aquatic Sciences*. 69:1278-1291.
- Maldonado, M., Giraud, K., and C. Carmona (2008). Effects of sediment on the survival of asexually produced sponge recruits. *Marine Biology*, 154(4), 631-641.
- Matishov, G.G. (1992). The reaction of bottom-fish larvae to airgun pulses in the context of the vulnerable Barents Sea ecosystem. *Fisheries and Offshore Petroleum Exploitation 2nd International Conference*, Bergen, Norway, 6-8 April 1992.
- McCauley, R. D., and J. Fewtrell (2008). Marine invertebrates, intense anthropogenic noise, and squid response to seismic survey pulses. *Bioacoustics*, 17(1-3), 315-318.
- McCauley, R.D., Day, R.D., Swadling, K.M., Fitzgibbon, Q.P., Watson, R.A., and J.M. Semmens (2017). Widely used marine seismic survey air gun operations negatively impact

zooplankton. *Nature ecology & evolution*, 1(7), 0195.

- McCauley, R.D., Fewtrell, J., Duncan, A.J., Jenner, C., Jenner, M.-N., Penrose, J.D., and K. McCabe (2000a). Marine seismic surveys: Analysis of airgun signals; and effects of air gun exposure on humpback whales, sea turtles, fishes and squid (Report prepared for Australian Petroleum Production Association, Sydney, Australia). Perth, Australia: Centre for Marine Science and Technology, Curtin University.
- McCauley, R.D., Fewtrell, J., Duncan, A.J., Jenner, M.-N., Jenner, C., Prince, R.I.T. and A.N. Popper (2003). High intensity anthropogenic sound damages fish ears. *Journal of the Acoustical Society of America*. 113(1):638-642.
- McCauley, R.D., Fewtrell, J., Duncan, A.J., Jenner, M.-N., Jenner, C., Prince, R.I.T. and J. Murdoch (2000b). Marine seismic surveys - a study of environmental implications. *APPEA (Australian Petroleum Production and Exploration Association) Journal*, 40, 692-708.
- Mitson R.B. (1995) Underwater noise of research vessels: review and recommendations. ICES Cooperative Research Report 209:61.
- MMS (Minerals Management Service) (2004). Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf: Final Programmatic Environmental Assessment. United States Department of the Interior, Gulf of Mexico Outer Continental Shelf Region.
- Mooney, T.A., Samson, J.E., Schlunk, A.D., and S. Zacarias (2016). Loudness-dependent behavioral responses and habituation to sound by the longfin squid (*Doryteuthis pealeii*). *Journal of Comparative Physiology*. 202: 489–501.
- Moriyasu, M., Allain, R., Benhalima, K., and R. Claytor (2004). Effects of seismic and marine noise on invertebrates: A literature review. Fisheries and Oceans Canada, Canadian Science Advisory Secretariat Research Document. 2004/126.
- Morley, E.L., Jones, G., and A.N. Radford (2014). The importance of invertebrates when considering the impacts of anthropogenic noise. *Proceeding of the Royal Society*. 281:20132683.
- Morris, C. J., Cote, D., Martin, B., and D. Kehler (2018). Effects of 2D seismic on the snow crab fishery. *Fisheries Research*, 197, 67-77.
- Myrberg, A.A. (1980). Hearing in damselfishes: An analysis of signal detection among closely related species. *Journal of Comparative Physiology A*, 140: 135-144.
- Nedelec, S.L., Radford, A.N., Simpson, S.D., Nedelec, B., Lecchini, D., and S.C. Mills (2014). Anthropogenic noise playback impairs embryonic development and increases mortality in a marine invertebrate. *Scientific Reports*. 4: 5891.
- Neo, Y. Y., Hubert, J., Bolle, L., Winter, H. V., Ten Cate, C., and H. Slabbekoorn (2016). Sound exposure changes European seabass behaviour in a large outdoor floating pen: effects of

temporal structure and a ramp-up procedure. *Environmental Pollution*, 214, 26-34.

One Ocean. 2017. 2016 Multi-Industry Workshop on Marine Seismic Surveying, February 8, 2016. Retrieved at <http://www.oneocean.ca/pdf/2017%20PPT%20%20IIWMSS%20sent.pdf>

Parry, G.D., and A. Gason (2006). The effect of seismic surveys on catch rates of rock lobsters in western Victoria, Australia. *Fisheries Research*. 79:272-284.

Payne, J.F. (2004). Potential effect of seismic surveys on fish eggs, larvae and zooplankton (Research Document 2004/125.). DFO Canadian Science Advisory Secretariat.

Payne, J.F., Andrews, C., Fancey, L., White, D., and J. Christian (2008). Potential effects of seismic energy on fish and shellfish: An update since 2003. Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, Research Document 2008/060.

Payne, J.F., Coady, J. and D. White (2009). Potential effects of seismic airgun discharges on monkfish eggs (*Lophius americanus*) and larvae. Environmental Studies Research Funds Report No. 170, St. John's, NL. 32p.

Pearson, W.H., Skalski, J.R., and C.I. Malme (1992). Effects of sounds from a geophysical survey device on behavior of captive rockfish (*Sebastes* spp). *Canadian Journal of Fisheries and Aquatic Sciences* 49: 1343-1356.

Pearson, W.H., Skalski, J.R., Sulkin, S.D. and C.I. Malme (1994). Effects of seismic energy releases on the survival and development of zoeal larvae of Dungeness crab (*Cancer magister*). *Marine Environmental Research* 38: 93-113.

Peña, H., Handegard, N.O., and E. Ona (2013). Feeding herring schools do not react to seismic air gun surveys. – *ICES Journal of Marine Science*, doi.10.1093/icesjms/fst079.

Pickett, G.D., Eaton, D.R.M., Seaby, R.M.H., and G.P. Arnold (1994). Results of Bass Tagging by Poole Bay During 1992. Laboratory Leaflet 74, Ministry of Agriculture, Fisheries and Food, Directorate of Fisheries Research.

Popper, A.N. and T.J. Carlson (1998). Application of sound and other stimuli to control fish behaviour. *Trans. Am. Fish. Soc.* 127(5):673-707.

Popper, A.N., Salmon, M., and K.W. Horch (2001). Acoustic detection and communication by decapod crustaceans. *Journal of Comparative Physiology* 187: 83-89.

Popper, A.N., Smith, M.E., Cott, P.A., Hanna, B.W., MacGillivray, A.O., Austin, M.E. and D.A. Mann (2005). Effects of exposure to seismic airgun use on hearing of three fish species. *Journal of the Acoustical Society of America*. 117(6):3958-3971.

Popper A.N., Fay R.R., Platt C. and O. Sand (2003). Sound detection mechanisms and capabilities of teleost fish. In Collin S.P. and Marshall N.J. (Eds.). *Sensory Processing in Aquatic Environments* (Springer-Verlag, New York) pp. 3–38 446 pp.

- Popper, A. N. and M.C. Hastings (2009). The effects of anthropogenic sources of sound on fishes. *Journal of fish biology*, 75(3): 455-489.
- Popper, A.N. and R.R. Fay (2011). Rethinking sound detection by fishes. *Hearing Research*, 273, 25–36.
- Popper, A.N., Hawkins, A.D., Fay, R.R., Mann, D., Bartol, S., Carlson, T., Coombs, S., Ellison, W.T., Gentry, R., Halvorsen, M.B., Løkkeborg, S., Rogers, P., Southall, B.L., Zeddis, D., and W.N. Tavolga (2014). *Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report*. Springer and ASA Press, Cham, Switzerland.
- Popper, A.N., Gross, J.A., Carlson, T.J., Skalski, J., Young, J.V., Hawkins, A.D., and D. Zeddis (2016). Effects of exposure to the sound from seismic airguns on pallid sturgeon and paddlefish. *PLoS One* 11, e0159486
- Protasov, V.R. (1966). *Bioacoustics of fishes*. Springfield, Vermont. NTIS, 214 pp.
- Przeslawski, R., Byrne, M., and C. Mellin (2015). A review and meta-analysis of the effects of multiple abiotic stressors on marine embryos and larvae. *Global Change Biology*. 21: 2122–2140.
- Purser, A. (2015). A time series study of *Lophelia pertusa* and reef megafauna response to drill cuttings exposure on the Norwegian margin. *PLOS One*, 10(7).
- Radford, A.N., Kerridge, E. and S.D. Simpson (2014). Acoustic communication in a noisy world: can fish compete with anthropogenic noise. *Behavioural Ecology* 25: 1022-1030.
- Radford, A.N., Lèbre, L., Lecaillon, G., Nedelec, S.L., and S.D. Simpson (2016). Repeated exposure reduces the response to impulsive noise in European seabass. *Global Change Biology* 22: 3349–3360.
- Roberts, L., Cheesman, S., Elliott, M., and T. Breithaupt (2016). Sensitivity of *Pagurus bernhardus* (L.) to substrate-borne vibration and anthropogenic noise. *Journal of Experimental Marine Biology and Ecology*. 474: 185–194.
- Sætre, R. and E. Ona (1996). Seismike undersøkelser og på fiskeegg og -larver en vurdering av mulige effekter på bestandsniva. [Seismic investigations and damages on fish eggs and larvae; an evaluation of possible effects on stock level] *Fisken og Havet* 1996:1-17, 1-8. (Norwegian, with English summary - full translation not published).
- Samson, J.E., Mooney, T.A., Gussekloo, S.W.S., and R.T. Hanlon (2014). Graded behavioral responses and habituation to sound in the common cuttlefish *Sepia officinalis*. *Journal of Experimental Biology*. 217: 4347–4355.
- Schwartz, A.L. and G.L. Greer (1984). Responses of Pacific herring, *Clupea harengus pallasii* to some under water sounds. *Canadian Journal of Fisheries and Aquatic Sciences* 41:1183-1192.
- Skalski, J.R., Pearson, W.H., and C.I. Malme (1992). Effects of sounds from a geophysical survey

- device on catch-per-unit-effort in a hook-and-line fishery for rockfish (*Sebastes* spp). Canadian Journal of Fisheries and Aquatic Sciences. 49:1357-1365.
- Slabbekoorn, H., Bouton, N., van Opzeeland, I., Coers, A., Cate, C., and A.N. Popper (2010). A noisy spring: the impact of globally rising underwater sound levels on fish. Trends Ecol. Evol. 25, 419 –427. (doi:10. 1016/j.tree.2010.04.005).
- Slotte, A., Hansen, K., Dalen, J., and E. Ona (2004). Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian coast. Fisheries Research. 67:143-150.
- Solan, M., Hauton, C., Godbold, J. A., Wood, C.L., Leighton, T.G. and P. White (2016). Anthropogenic sources of underwater sound can modify how sediment-dwelling invertebrates mediate ecosystem properties. Scientific reports, 6.
- Song, J., Mann, D.A., Cott, P.A., Hanna, B.W. and A.N. Popper (2008). The inner ears of northern Canadian freshwater fishes following exposure to seismic air gun sounds. The Journal of the Acoustical Society of America, 124(2), 1360-1366.
- Sun, Z., Hamel, J. F., & Mercier, A. (2010). Planulation periodicity, settlement preferences and growth of two deep-sea octocorals from the northwest Atlantic. Marine Ecology Progress Series, 410, 71-87.
- Suttle, C. A (2005). Viruses in the sea. Nature, 437(7057), 356-361.
- Thomson, R., Sporcic, M., Foster, S., Haddon, M., Potter, A., Carroll, A., Przeslawski, R., Knuckey, I., Koopman, M., and J. Hartog (2014). Examining Fisheries Catches and Catch Rates for Potential Effects of Bass Strait Seismic Surveys. Hobart and Canberra, CSIRO and Geoscience Australia, p. 84.
- Tjensvoll, I., Kutti, T., Fosså, J.H. and R.J. Bannister (2013). Rapid respiratory responses of the deep-water sponge *Geodia barretti* exposed to suspended solids. Aquatic Biology, 19: 65-73.
- Turnpenny, A.W.H., and J.R. Nedwell (1994). The Effects on Marine Fish, Diving Mammals and Birds of Underwater Sound Generated by Seismic Surveys. Report to the UK Offshore Operators Association, Hans Crescent, London (No. FRR 089/94). Fawley, UK: Fawley Aquatic Research Laboratories Ltd.
- Vermeij, M. J., Marhaver, K. L., Huijbers, C. M., Nagelkerken, I., and S.D. Simpson (2010). Coral larvae move toward reef sounds. PloS one, 5(5), e10660.
- Vold, A., Lokkeborg, S., Tenningen. M., and J. Saltskar (2009). Analysis of commercial catch data to study the effects of seismic surveys on the fisheries of Lofoten and Vesterålen summer of 2008. Fisker og Havet 5/2009, Havforskningsinstituttet, Bergen. (summary in English).
- Vold, A. Lokkeborg, S., and M.M. Tenningen (2012). Using catch statistics to investigate effects of

- seismic activity on fish catch rates. *Advances in Experimental Medicine and Biology*. 730:411-413.
- Watling, L., France, S. C., Pante, E., & Simpson, A. (2011). Biology of deep-water octocorals. In *Advances in Marine Biology* (Vol. 60, pp. 41-122). Academic press.
- Wale M.A., Simpson, S.D. and A.N. Radford (2013a). Noise negatively affects foraging and antipredator behaviour in shore crabs. *Animal Behaviour* 86: 111 –118. (doi:10.1016/j.anbehav.2013.05.001).
- Wale, M.A., Simpson, S.D., and A.N. Radford (2013b). Size-dependent physiological responses of shore crabs to single and repeated playback of ship noise. *Biology letters*, 9(2), 20121194.
- Wardle, C.S., Carter, T.J., Urquhart, G.G., Johnstone, A.D.F., Ziolkowski, A.M., Hampson, G., and D. Mackie (2001). Effects of seismic air guns on marine fish. *Continental Shelf Research*. 21(8-10):1005-1027.
- Watanabe, S., Metaxas, A., Sameoto, J., and P. Lawton (2009). Patterns in abundance and size of two deep-water gorgonian octocorals, in relation to depth and substrate features off Nova Scotia. *Deep-Sea Research Part I*, 56: 2235-2248.
- Webb, C.L.F. and N.J. Kempf (1998). The impact of shallow water seismic in sensitive areas. Society of Petroleum Engineers Technical Paper, SPE 46722.
- WGEAFM (Working Group on Ecosystem Approaches to Fisheries Management) (2008). Scientific council meeting – June 2008. NAFO SCS Doc. 08/10.
- Williams, R., Wright, A.J., Ashe, E., Blight, L.K., Bruintjes, R., Clark, C.W., Cullis-Suzuki, S., Dakin, D.T., Erbe, C., Hammond, P.S., Canessa, R., Merchant, N.D., O'Hara, P.D., Purser, J., Radford, A.N., Simpson, S.D., Thomas, L., and M.A. Wale (2015). Impacts of anthropogenic noise on marine life: Publication patterns, new discoveries, and future directions in research and management. *Ocean & Coastal Management*. 115: 17-24.
- Worcester, T. (2006). Effects of seismic energy on fish: a literature review. Fisheries and Oceans Canada, Canadian Science Advisory Secretariat Research Document. 2006/092.