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Newfoundland and Labrador Region | Science Response 2021/031

SCIENCE REVIEW OF THE LABRADOR SHELF OFFSHORE AREA STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) UPDATE

Context

The Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) is the lead authority responsible for the administration of the regulations pertaining to all oil and gas exploration and production in the Canada-Newfoundland and Labrador (NL) Offshore Area. The C-NLOPB is mandated by the Canada-Newfoundland and Labrador Atlantic Accord Implementation Act and the Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act (the Accord Acts), which govern all offshore petroleum activities in the Canada-NL Offshore Area. The C-NLOPB is responsible for issuing licenses, permits, and authorizations for exploration and development in a manner that is, among other things, consistent with environmental protection.

Under the bilateral Memorandum of Understanding (MOU) between Fisheries and Oceans Canada (DFO) and the C-NLOPB, DFO provides advice to the C-NLOPB pursuant to DFO's responsibilities under the Fisheries Act, Oceans Act, and Species at Risk Act. The bilateral MOU also sets out how DFO and the C-NLOPB collaborate in a number of areas related to offshore petroleum activities, including project-specific environmental assessments (EAs) and Strategic Environmental Assessments (SEAs).

Since 2002, the C-NLOPB has been conducting SEAs of portions of the Newfoundland and Labrador Offshore Area that may have the potential for offshore oil and gas exploration activity. A SEA is a planning tool used by decision-makers to identify the potential issues and opportunities that may be associated with a plan, program, or policy proposal. It allows for the incorporation of environmental considerations at the earliest stages of program planning; it differs from an EA or impact assessment (IA) because it does not assess a specific project and does not result in the approval of any development. A SEA involves a broader-scale (i.e., macro level) EA that considers the larger ecological setting, rather than a project-specific (i.e., micro level) EA that focuses on site-specific issues with defined boundaries. Notably, the accuracy of information in a SEA is important as it is a tool for informing for future project-specific EAs/IAs within a smaller defined study area. For a project or activity to be given approval to occur, a project-specific EA/IA must be completed and the proponent must comply with any conditions arising from the assessment. The C-NLOPB or the Impact Assessment Agency will engage DFO for expert advice and information as per existing MOUs during these project-specific assessments.

In August 2008, the C-NLOPB published the SEA for a portion of the Labrador Shelf Offshore Area. This is an area along the coast of Labrador that is known to contain oil and gas reserves but currently has no active exploration or production licenses. The original SEA provided information on the existing environment within the Labrador Shelf Offshore Area and identified key environmental features and considerations that may be associated with future oil and gas activities. In late-2017, a process to update the SEA was initiated, focusing on new information

to describe the existing environment that has become available since the original SEA report. Text from the original SEA report has been carried over into the update where information has not changed. The C-NLOPB recently requested review of the draft SEA update report by DFO NL Region. Following its detailed review of the updated SEA, the Fish and Fish Habitat Protection Program (FFHPP) of the Ecosystems Management Branch in the NL Region has requested that DFO Science undertake a review of updated sections of the report. The Science review will be utilized by FFHPP to assist in formulating a departmental response on the draft SEA update report to the C-NLOPB.

This Science Response Report results from the Regional Science Response Process of May 25, 2021 for the Science Review of the Labrador Shelf Offshore Area Strategic Environmental Assessment Update.

Objective

Ecosystems Management submitted the following sections of the updated SEA for review by DFO Science:

- 4.4 Met-Ocean Conditions
- 4.5 Oceanography
- 4.7 Climate Change
- 5.2 Plankton
- 5.3 Corals and Sponges
- 5.4 Invertebrates
- 5.5 Fish Species
- 5.6.1.1 Wolffish (Atlantic, Northern, Spotted)
- 5.6.1.2 Atlantic Salmon
- 5.6.1.3 White Shark
- 5.6.1.4 American Eel
- 5.9 Data Gaps
- 6.1 Overview
- 6.2 Mysticetes
- 6.3 Odontocetes
- 6.4 Marine Mammals and Species at Risk and Species of Conservation Concern
- 6.5 Sea turtles
- 6.6 Pinnipeds
- 6.10 Data Gaps for Marine Mammals and Sea Turtles
- 8.1.1.3 Ecologically and Biologically Significant Areas
- 8.1.1.4 Significant Benthic Areas
- 8.3 Data Gaps

- 10.4.1 Marine Research

DFO Science was asked to review the above sections of the updated draft SEA, and invited to provide advice on other sections when appropriate, with the following objectives:

- Is the information provided for the existing environment of the Labrador Shelf Offshore Area accurate at the broad-scale (i.e., macro level) and based on the most recent information available?
- Are there any key species and/or environmental features of the Labrador Shelf Offshore Area that have not been included in the report that would improve understanding of the existing environment at a strategic environmental assessment broad-scale (i.e., macro level)?

Analysis and Response

General Comments

These general comments refer to both the dimensions of this SEA Update process and the content of the SEA Update. The order of these comments does not necessarily reflect order of importance.

- **The Opportunity of a SEA Update**: SEAs provide an opportunity to update industry standards in terms of scientific methods (e.g., modelling techniques), management approaches (e.g., ecosystem-based), and evolving science-based perspectives (e.g., climate change). An update should ensure the renewed document keeps pace with continually improving best-practices and standards.
- **Complexity of the Labrador Shelf Offshore Area**: The reviewers recognize the challenge of describing the structures and processes of the Labrador Shelf Offshore Area; a system that is diverse and complex, with many data and knowledge gaps.
- **Scope of Review**: The time permitted for this science review (2 weeks) precluded a comprehensive and holistic review of a document of this complexity. For this reason, the comments provided are the results of a high level examination focused on identifying substantive shortcomings. This examination was guided by the stated purpose of the SEA in terms of "*Allows environmental issues to be identified and addressed at the earliest stages of planning, and typically focuses on "regional-scale" environmental concerns*" (Section 1.1.). As a result, an exhaustive list of issues could not be compiled, rather a representative sample of the issues that pervade the document are provided. Moreover, since reviewers were only able to review chapters specific to their area of expertise, assessing links between chapters was not fully evaluated.
- **What should be in an SEA?** The information in an SEA should be carefully selected to achieve the goals of the document-which is to provide regional ecological considerations for decision-making related to the assessed activity (Privy Council Office and the Canadian Environmental Assessment Agency 2010). In this case, what are the key ecological structures and processes in the study area and how might these be influenced by the oil and gas industry? These goals are frequently not achieved in the document. For example, less important information (e.g., the color of a particular fishes' eggs) might be identified while more relevant information (e.g., maps of its distribution in the study area) is missing. Similarly, defining linkages between the described elements is important to understanding pathways of effects from oil and gas, yet this information is largely missing.

- **Recurring Omissions and Errors from Past SEA Reviews**: Many of the substantive problems found in the Labrador Shelf Offshore Area SEA Update are not new (e.g. inadequate coverage of climate change, outdated datasets, a lack of attention to ecosystem processes, citation issues); similar issues have been identified in the original Labrador Shelf SEA Review (See Appendix 1) and in similar DFO Science peer-reviews of the Eastern Newfoundland SEA (DFO 2014a) and the Regional Assessment for exploratory drilling in eastern NL (DFO 2020a), among others. It is recommended that authors of this Update and future reports familiarize themselves with relevant past reviews to avoid deficiencies that have been previously identified.
- **Missing and Outdated Data/Citations**: Throughout the document there are issues of missing and outdated citations that result in a presented state of knowledge that is not current. The Labrador Shelf Offshore Area SEA Update states the intent to build upon prior text as indicated, for example, in Section 5.0 "*As noted previously, updated information has been provided where available, and where information has not changed, text from the original SEA Report (SEM 2008) has been carried over into this update*". However, despite the claim that updated information has been provided where available, the recurring absence of relevant references from the last 10 years in relation to focal species, ecological processes and communities, and climate change indicates that this Update lacks the necessary thoroughness that is needed in an SEA. Even broad ecosystem characterization documents generated for coastal areas (DFO 2021a) and slope and deep ocean habitats (Coté et al. 2019) of Labrador, which are of direct relevance to this document, have not been included. In other areas (e.g., Species at Risk), subject matter was described and presented based on a single, frequently outdated citation. The result is the general omission of vital information. Data series presented in this document (e.g., Physical Environment) are also dated, which is particularly problematic given the recent rapid rate of change in this region.
- **Improper Citations**: The frequent use of prior environmental assessments as valid sources of information (e.g., "*Much of this information comes from recent EAs conducted for exploration drilling projects (e.g., BP 2016, 2018; ExxonMobil 2017; Statoil 2017; Husky Energy 2018; Nexen 2018; Chevron 2019; BHP 2020)*". Section 5.5) instead of original sources (e.g., NAFO, IUCN, ICES & primary scientific journals) is not in line with scientific standards. Previous published DFO Science reviews have indicated that such a practice can result in misinterpretation of information and propagation of errors.
- **Ecological Context Missing**: In contrast to a project-specific EA, the SEA is intended to consider the larger ecological setting. Unfortunately, the document does not capture the structure of the ecosystems in the Labrador Shelf Offshore Area, both shelf and oceanic, and makes little attempt to describe ecological processes and functions. This lack of ecosystem perspective leads to a selection of Valued Ecosystem Components (VECs) that is essentially taxonomically driven, and prevents the reader from fully comprehending ecosystem links and how oil and gas impacts may affect ecosystem structure and function. For example, if oil and gas areas of interest are associated with the shelf break, they will occur in an important corridor for transport, and in the locations of complex benthic habitats. Ecological context is also critical to understand potential synergies with climate change. For example, currents and general oceanographic features play a major role in larval transport, settlement areas, and hence connectivity of ecological components; climate change effects on oceanographic features can alter these processes and affect ecosystem functioning.
- The lack of an ecosystem approach in the document also precludes identifying and describing functional ecosystems on the shelf (e.g., Ecosystem Production Units [EPUs]),

distinct from the oceanic ecosystems in the Labrador Sea. Each one of these functional ecosystems has unique characteristics, and hence the potential for distinct impacts. For example, the planktivore fish functional group is dominated by lanternfishes and black herring in NAFO Division. 2H (Labrador Shelf EPU, NAFO Divisions 2GH), but in the Newfoundland Shelf EPU (NAFO Divisions 2J3K) this functional group is dominated by Capelin, and in the Grand Bank EPU (NAFO Divisions 3LNO) it is dominated by Sand Lance and Capelin. Structural differences of this nature are overlooked in the Labrador SEA, preventing the reader from understanding that impacts on specific VECs can be dependent on the specific ecosystem unit. These kinds of functional and structural omissions limit the utility of the document to reliability assess potential impacts and/or present mitigation options.

- **Geographical Context Missing**: Areas down-current of the Labrador Shelf Offshore Area also contain important marine resources. The ocean circulation in the Update Area is dominated by a strong North-South transport driven by the Labrador Current system. In the event of an offshore incident (e.g., oil spill), the most pronounced areas of impact could occur outside and downstream from the Labrador Shelf Offshore Area addressed in this review. This includes, but is not limited to, the Gulf of St Lawrence, the Newfoundland coast, the Grand Banks, etc. It is therefore recommended that this geographical context (i.e., the strong influence of the Labrador Shelf Offshore Area on areas downstream) be emphasized in the revision of this document.
- **Temporal Variation in Labrador Shelf Offshore Area Ecosystems**: Another problem in the report relates to the lack of consideration of change in these ecosystems over time. There have been massive structural ecosystem changes in the biological communities of the entire NL bioregion, which experienced a regime shift in the late-1980s and early-1990s. The implications (e.g., resilience, cumulative effects, changing biotic communities and environmental conditions) of Labrador's dynamic marine ecosystems on potential impacts from oil and gas exploration and development are not captured in the SEA Update.
- **Superficial Consideration of Anthropogenic Climate Change**: Ecosystems in the Labrador Shelf Offshore Area are expected to change in the next 50 years due to climate change. This fundamental aspect is largely not discussed in the document beyond the use of brief caveats (e.g., *"Climate change and species-specific impacts is an evolving area of research and will have to be considered during the development of project-specific EAs. Environmental events that may be related to climate change have the potential to alter species distributions, health, and overall success, and more research and monitoring should be incorporated to monitor these effects as the climate evolves over time"* Section 5.5.3). Given the regional nature of anthropogenic climate change, these important considerations should be described in the SEA and not deferred to project-specific EAs. The information that is provided on anthropogenic climate change does not include many of the most recent studies, including some downscaling analysis that focus not just on the oceanography, but also ecological changes (e.g., the potential role of the area as a climate refuge).
- **Poor Coverage of Large Portions of the Study Area**: A large component of the Labrador Shelf Offshore Area comprises of deep ocean/oceanic areas that received insufficient attention in the document. These areas feature globally important oceanographic processes (e.g., downwelling) and unique biological communities. For example, the well-studied Labrador Deep Sea Convection Area is only briefly mentioned in the special areas section despite the significance it has in the regulation of the global climate, carbon storage, and oxygenating the deep ocean. In contrast, there are fewer deep ocean studies characterizing biological communities since DFO RV surveys cannot operate in much of this area (i.e.,

habitats >1,500 m). However, studies that do exist should be captured so key taxa (e.g., lanternfishes, Abyssal Grenadiers) and processes are identified and described, and remaining knowledge gaps indicated.

- **Selection of Focal Species**: The process/criteria used to select the focal species described is unclear. There is reference to DFO Research Vessel (RV) surveys ("The species list in Table 5.4 is primarily determined using the results from the DFO RV surveys collected between 2007 and 2018, to give an indication of species that may be present within the Labrador Shelf SEA Update Area". Section 5.5.) but based on some other statements in the document (e.g. *"The following sections provide descriptions of some benthic invertebrate species that have been noted as occurring within the Labrador Shelf SEA Update Area".* Section 5.4.), the process appears arbitrary. The invertebrates focus on commercial species and coral and sponges but other ecologically important species and/or VME taxa (e.g., crinoids, sea squirts, bryozoans) are excluded. Such data may not be published but can be made available through data requests to DFO. For fish, the selection process has resulted in some questionable inclusions such as Yellowtail Flounder (*Pleuronectes ferruginea*) and Silver Hake (*Merluccius bilinearis)* whose main habitat is outside the Labrador Shelf Offshore SEA Update study area. Furthermore, the reliance on DFO surveys (covering only portions of the shelf and shelf-break areas) to define key species also results in critical omissions (e.g. lanternfishes, which are the dominant fish taxa by abundance and biomass in northern and oceanic waters of the Labrador SEA area). Examination of more recent literature for poorly represented habitats (e.g., Coté et al. 2019, DFO 2021a) and use of other complementary international datasets (e.g., German and Greenlandic; Nogueira and Treble 2020, Fock et al. 2020) would reduce potential missteps in the selection of focal species. Where possible, population trends and distribution maps should be provided for focal species as this information will be relevant to interpreting impacts from oil and gas activities.
- **Contradictory Information**: In several places of the Update, contradictory information is presented with no explanation as to why different conclusions have been drawn. The authors should provide additional context in such situations to help the reader understand the contributing factors to these differences (e.g., study location, scales of inference, knowledge systems etc.).
- **Organization**: The organization of some sections of the document was not well suited to efficiently presenting relevant information (e.g., oceanography and protected areas sections). For example, the sensitive areas chapter would benefit from a reorganization that classifies sensitive areas based on the ecological variable(s) of interest rather than the management tool used to characterize/protect them.
- **Issues Updating Original Text**: In several areas of the document, time-sensitive text from the original SEA persists. For example, in 5.2.1 it states: "…*resulting in an increase in source water nitrate/silicate ratios over the past 12 years in the central Labrador Sea (Harrison and Li 2008)*". The "past 12 years" are linked to the time of publication of the citation and is no longer appropriate. In other areas old text remains that reflects outdated worldviews and very outdated scientific views. Specifically, the language used with respect to climate change is outdated and contrary to the vast and contemporary body of science on climate change. For example, Section 2.5.7 talks about "*potential climate change*", while Section 3.5.2. states "*Greenhouse gas (GHG) emissions are becoming a growing concern both politically and socially, and have been linked to global climate change*".

- **Presentation of SiBAs**: The presentation of Significant Benthic Areas (SiBAs; referred to as SBAs in the Update and hereafter in this scientific review to avoid confusion) in Chapter 8 is incomplete and does not characterize these areas as habitats, or identify that these SBAs can be considered equivalent to VMEs as used in international documents and agreements. This is a significant omission for several reasons:
    a. the Labrador Shelf Offshore Area includes international waters which are governed by United Nations Convention on the Law of the Sea (UNCLOS), Convention on Biological Diversity (CBD), and related international agreements/treaties;
    b. Vulnerable Marine Ecosystem (VME) protection can be afforded to areas *"likely to contain VMEs"* like canyons, sea mounts, etc., as per Food and Agriculture Organization of the United Nations (FAO) guidance;
    c. the Northwest Atlantic Fisheries Organization (NAFO) has jurisdiction on the management of fisheries in these international waters and has more than a decade of history developing and implementing tools for the protection of VMEs within its regulatory area as part of its Roadmap to an Ecosystem Approach to Fisheries. The absence of a discussion of VMEs, and the international context around them is a major shortcoming.

Detailed Comments

- General: As per DFO-Canada & international scientific standards, all words in *"Common Names"* should be capitalized (e.g., Atlantic Cod [*Gadus morhua*], American Plaice [*Hippoglossoides platessoides*], Greenland Halibut [*Reinhardtius hippoglossoides*]; throughout the document (Page et al. 2013).

4.0 Physical Environment

- The review of this chapter focused on the objectives of the Update, specifically, a *"SEA is a planning tool used by decision-makers to identify the potential issues and opportunities when considering development in a specific area"*. From the Summary of the Update, a SEA aims to:
    - Identify potential risks of development to wildlife, plants, people, and places;
    - Engage nearby communities prior to planning any projects;
    - Help define what is important to people that could be affected.

And later:

- "This SEA Update examines the potential environmental effects associated with offshore exploration and production activities".
- "Information from this SEA Update will help the C-NLOPB in deciding if exploration rights should be offered within the Labrador Shelf Offshore Area and which restrictions or mitigation measures should be applied to potential future exploration activities".
- A review of Chapter 4 indicates these goals have not been achieved. Throughout ~200 pages of text and figures, there is little that relates to the above statements. Some general comments are provided but this chapter should be revised with the above-mentioned goals of the SEA in mind.
- A more comprehensive approach both including and explaining the information that is pertinent to the Update is encouraged. For example, This chapter contains ~200 pages, among which there is:

- 4 pages about bedrock and geological aspects;
- 25 pages of wind roses and basic statistics;
- 55 pages of wave roses;
- 15 pages of extreme wave analysis;
- 20 pages of sea surface temperature, precipitation, fog and other meteorological conditions between 1985 and 2015.

The authors should be guided by the main goal of this document that is to "[*examine] the potential environmental effects associated with offshore exploration and production activities"?* Moreover, the information is structured in a way that makes it difficult for a reader to generate a holistic understanding. It would be preferable to present a distilled analysis of the key physical aspects of the region (e.g. summary maps of wind and waves could be generated) and a focus on processes that can be *impacted* by offshore exploration, and what are the specific physical aspects of this region to *take in consideration* if offshore exploration was to take place. For the latter category, for example, an important fact is that the region under consideration is located *upstream* from numerous coastal communities, important fishing grounds and shipping routes. A detailed description of the ocean circulation patterns should be a key aspect that is under-represented in this report (see next section).

- Currents: Ocean currents are arguably one of the most important physical aspects when considering potential development of offshore industries in Labrador. The section on currents is thin, inaccurate and uses outdated references. Moreover more than half of it is actually devoted to ocean conditions such as temperature, salinity, stratification and uses observations as far back as the 1930s and nothing more recent than 2010. Only two papers are cited: one from 1937 and one from 1983, which overlooks the significant progress achieved in this oceanographically important part of the world. In addition, the main Figure (4-57) excludes the Labrador coastal current, a key feature for offshore projects that are developed on the Labrador Shelf. This current could potentially carry any material (chemical, oil, fine sediment, etc.) along the Labrador Coast, inside the Gulf of St. Lawrence (via the Strait of Belle Isle), and towards Newfoundland and the Grand Banks.
- Instead of this key information, this section contains text such as: *"Prior to the 1980 Physical Oceanography Study offshore Labrador, currents were measured by various researchers. A summary of the 1980 measurements as compiled for the offshore Labrador Initial Environmental Assessments by Petro-Canada are presented in Table 4.85".*
- Then data extracted from the Ocean Data Inventory (ODI) are presented. Four Progressive vector diagrams are presented from 4 points scattered in space and for four different depths, and none from the surface (shallowest site is 157 m), which is most relevant for a buoyant substance such as oil. These progressive plots are not helpful and potentially misleading because a particle released at a certain site does not experience the conditions at the origin once it leaves the site.
- There are very powerful, high resolution and open-access 3D numerical simulations that can be used to perform detailed and useful analyses that are more in-line with the goals of this SEA. Since currents are probably the most important physical aspect to consider here, a detailed and up-to-date portrait of the situation should be developed.
- Recurring Issues:

Reading the Science Response published in 2014 for the Eastern Newfoundland SEA, it seems that the deficiencies identified were not corrected in the Update. Specifically related to the physical environment:

"The SEA is lacking a comprehensive overview on climate change in its description of the physical environment. Only a few statements regarding climate change exist throughout, with nothing substantive reported. Information taken from existing models and the most current projections should be presented for key physical indices where available." (DFO 2014a).

"The SEA contains data sets that appear to be dated (e.g., DFO fish survey data up to 2009; Sea Ice Atlas to 2010; some tropical storm data to 2000; MSC50 wave/current data to 2011; etc.) While it is understandable that some data sets may not available after a certain date; it is, however, likely that some are available in an updated format (e.g., the most recent tropical storm data). As such, if a data set is 'prematurely' truncated or not being used for some reason– it should be stated within the report and clarification provided. Also, if there are additional data expected, it should be noted when they are likely to become available." (DFO 2014a).

Similar problems with the climate change section have been repeated and the same data sets are used, but extended to 2015. These analyses do not inform the reader in relation to the previously listed primary goals of the Update.

- Section 4.7-Climate Change. Anthropogenic climate change was not covered well in this document; an issue that was pointed out in a review of a previous SEA:

"It is notable that the description of the physical environment lacks a comprehensive overview on climate change. While there are a few statements regarding climate change, nothing substantive is reported. This should be included in the SEA. In this, the document should include general information on the most current projections relative to air and sea temperatures, currents, primary productivity and changes in frequency of extreme weather based on regional climate change models. This would include consideration of which models are considered best right now for the study area in question; and data gaps and key uncertainties. These projections should be also be integrated into subsequent areas of text throughout the SEA as required (e.g. the sections on ice and icebergs as well as in the species accounts where information is available)"(DFO 2014a).

This section comprises of one page of general statements of the type *"climate change exists"*, and a few sections unrelated to how climate change could impact potential offshore projects in the Labrador Sea. These include some information about the North Atlantic Oscillation (NAO) and its correlation with air and sea temperatures. While the NAO could be important to environmental variability (a topic that should be covered elsewhere-see general comments), it is not immediately relevant to anthropogenic climate change.

"A study (Reitan 1974) found that the highest frequency of storms occurs between 40°N to 50°N, with one of the most active areas being over the Gulf Stream off the United States Eastern Seaboard (p.4-169)": This is not relevant to the climate change section. Also the inclusion of a 1974 reference is questionable given strong climate-related change.

- For sea ice and icebergs in relation to climate change, the papers cited are from 2000 and 1994, respectively (p. 4-172). Given that this field is in constant evolution, this information should be updated.
- In Section 4.7.2.7-Wind and storms in relation to climate change, the following statements are found:
    - *"According to the IPCC (2012), climate change can lead to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events, and can result in unprecedented storms.[…] Recent climate change projections suggest that substantive changes in wind speed are unlikely because of climate warming (Salon et al.*

2017). This agrees with a recent study (AMEC 2017), where wind speeds, were projected to decrease slightly or remain unchanged, and mean monthly wind directions were not expected to change significantly from present conditions".

Here the work of the IPCC (e.g. consensus among thousands of international expert scientists) is dismissed using an industry report (AMEC 2017) and a non-peer review conference abstract (Tamarin and Kaspi 2017) without suitable rationale. Furthermore, the next paragraph is also dismissive of established research using an industry report:

- *"Climate change affects storm surge, storm frequency, and intensity (Savard et al. 2016). Increased storm intensity may result in higher associated peak wave heights and more frequent occurrence of extreme wave or storm surge events; however, climate simulations for the next century show almost no change in peak significant wave heights for the western North Atlantic, consistent with recent trends in observed data (Husky Energy 2012)".*

Finally, it is important that this section addresses which aspects of the climate are expected to change and why it matters for offshore exploration.

- Missing Topics: The Labrador shelf and slope, as well as the Labrador Sea in general is a key region for the world's global ocean circulation and the Atlantic Meridional Overturning Circulation (AMOC). A large part of the freshwater fluxes in the North Atlantic also transit by the Labrador Coastal Current (refer to Florindo-López et al. 2020 for an example). Numerous national and international research programs have been designed to study these topics (e.g. OSNAP) and the state of the knowledge about the region is constantly evolving. The region is not only undergoing important changes in terms of sea ice, freshwater discharge, stratification, but also circulation (e.g. related to the AMOC, see Ceasar et al. 2021). None of this information is included and the importance of the region as a key component of the global ocean is not emphasized. These are examples, but a more complete description in the Update is recommended.

Figure presentation: Figures 4-5 and 4-6 do not represent the best available bathymetry. The figures are so pixelated that it is difficult to read the bathymetric contours (e.g. Figure 4-6).

5.0 Marine Fish and Fish Habitat

- Common names of species should include reference to the scientific name somewhere in the document. Also consistency in capitalization of common names is needed.

5.1 Macroalgal Communities

- The title of this section should reflect that it includes both macroalgae as well as other macrophytes. It is introduced in the first sentence but the section heading is misleading without the inclusion.
- Non-algal macrophytes are also not discussed in the same detail as their algal counterparts.

The importance of these species is not fully discussed. The importance of some macrophytes is mentioned in places directly relating to individual species later in the document (e.g. eelgrass in Rock Cod [*Gadus ogac*] and Atlantic Cod sections; Coté et al. [2013] provides other taxa that also use eelgrass habitats). These macrophyte species create structural habitat in the near shore (Teagle et al. 2017), an environment which is one of the most productive in the world (Smith 1981).These species are also important as primary producers and ecosystem engineers and are sensitive to disturbance.

5.1.1 Littoral Community

- *"Shorelines with a range of substrate size classes will have more diverse invertebrate communities because they provide shelter and anchorage"*: An area can have boulders of one size that provide shelter and anchorage. Diverse substrates accommodate a variety of habitat preferences.
- *"In highly exposed areas, there is little or no algal growth. Species such as the green alga Prasiola, the black alga Calothrix, and a brown filamentous species may form belts on the rock faces in areas with minimal shelter or crevices."*: Replace species with taxa. These are genre.
- *"Together they form a dense turf that appears dark green to black and is very slippery (Wilce 1959)"*: Being "slippery" is not of obvious relevance to the goals of the SEA.

5.2 Plankton

- The introductory paragraph starts by defining plankton and listing the main groups. However there is confusion about the definition of some of these groups. Zooplankton includes macroinvertebrate eggs and planktonic larval stages and is not a separate group.
- The paragraph mentions that zooplankton dominate the plankton composition but it is not clear if the authors are referring to abundance, biomass, diversity, or some other metric. Although calanoid copepods often dominate the zooplankton biomass they may not numerically dominate planktonic assemblages especially if you include phytoplankton cell counts. The abundance of other small cyclopoid copepod taxa such as Oithona, for example, frequently surpass that of calanoid copepods in the Northwest Atlantic. The statement concerning the dominance of larval redfish in the ichthyoplankton is supported by a study that took place in the Gulf of St. Lawrence, which is outside the area of interest. The mention of intertidal vegetation and benthic invertebrates also seems to be out of place in this paragraph.
- Overall, this introductory paragraph misses the opportunity to clearly define the different components of the planktonic community, to describe its role as primary source of energy for the marine ecosystem, and to explain the cascading impacts of phytoplankton and zooplankton on the entire marine community through energy transfer to upper trophic levels.

5.2.1 Phytoplankton

- Overall this subsection lacks structure and the flow of ideas could be improved. The paragraphs bounce from one topic to the other with no clear links and information is often repeated from one paragraph to another. Most references are quite dated and need to be updated as almost half of the literature cited for that subsection is from the early-2000s or older.
- The first paragraph states that predation limits phytoplankton production. Phytoplankton biomass can be limited by predation but grazing will not limit production.
- The different factors controlling phytoplankton growth and production (nutrient, irradiance, temperature, wind, etc.) are addressed in the text but the processes governed by these factors such as vertical mixing and stratification are often not clearly explained. The elements are mostly present but an improvement to increase clarity and flow of ideas is recommended. Also, there is only one sentence in the section on the fall phytoplankton bloom. Despite its lower production relative to the spring bloom, the fall bloom is ecologically relevant and requires a more lengthy discussion.

- On several occasions, inferences are made for the southern Labrador Sea based on data from the Grand Banks. Ocean circulation on the Grand Banks is quite different than that in the Labrador Sea and conditions on the shallow Grand Banks are not necessarily comparable with those in the deep offshore Labrador Sea. There are clear distinction made between the shelf and slope waters off the Labrador shelf and the deep Labrador Sea per se which creates confusion in the text. These different oceanographic domains and the different processes governing the characteristics of the physical environment should be presented in a stand-alone section on physical oceanography instead of being intertwined, and often not clearly explained, in the present subsection.
- There are statements about long-term trends supported with outdated references. For example:
    - *‘‘The long-term trend in the mixed layer depths and source water indicate that there may be a shallowing in the mixed layer depths, an increase in nitrates, and a decrease in silicates, resulting in an increase in source water nitrate/silicate ratios over the past 12 years in the central Labrador Sea (Harrison and Li 2008)”*: In this case the past 12 years is inaccurate since the cited paper was published 13 years ago. Other examples are:
        - *“This has occurred concurrently with increased surface temperatures and phytoplankton abundance and community structure changes (Li et al. 2006)”.*
        - *“Observations and modelling conducted at high-latitude environments during the last two decades suggest that the spring bloom and peak seasonal productivity are occurring progressively earlier in the year, particularly in the western subarctic (Harrison et al. 2013)”.* (Also note the western subarctic has questionable relevance to this study area.)
        - *“Bulk chlorophyll has decreased during the spring in the Labrador Sea with small phytoplankton, such as picoplankton and nanoplankton, increasing in abundance over the last decade and large phytoplankton decreasing in abundance. (Harrison and Li 2008).”*
        - “*These changes in phytoplankton assemblages over the past decade may be contributing to the observed decreases in silicate levels or it may be linked to changes in large-scale circulation patterns (Harrison and Li 2008)”.*
- The statements above should be updated as the outlined trends may no longer be true anymore. There are also some unclear and contradictory statements such as: *“In the Labrador Sea, irradiance increases from north to south, with irradiance in the northern Labrador Sea 20-40% lower than that of the central Labrador Sea (Wu et al. 2008)”* and *“It is expected that the spring bloom should occur earlier in the central Labrador Sea than that of the north Labrador Sea; however, this is not the case”.*
- *“An early ice retreat results in an early and prolonged spring phytoplankton bloom which has been shown to have effects on the overall ecosystem dynamics including exploited stocks and SAR (Wu et al. 2007)”*: The authors should describe what these effects are.
- *“The current trend in the Labrador Sea is that while the mixed layer depth may be decreasing, the overall phytoplankton biomass is also decreasing (Li et al. 2006); the ecosystem is complex, and data constraints still exist.*”. This sentence should be reworded as there are three ideas presented that do not flow together without explanation.
- There are a few places in this document where “dominate” (verb) is used instead of “dominant” (adjective).

- Overall, this subsection could be significantly streamlined by restructuring the different paragraphs to improve the flow and clarity of ideas and concepts presented while avoiding repetition and overlapping information. It would also be beneficial to see more information on the ecological importance of the main phytoplankton groups (diatoms, ciliates, flagellates) and the potential impacts of the described changes in phytoplankton community composition on marine productivity. Sources of information such as recent peer reviewed literature, and Atlantic Zone Monitoring Program (AZMP) and Atlantic Zone Offshore Monitoring Program (AZOMP) Research Documents available on the CSAS website can be used to update the recent state and ongoing trends in phytoplankton community in the region of interest.

5.2.2 Epontic Community

- Subsection 5.2.2 relies heavily on Horner et al (1992) on Sea ice Biota. The statements appear accurate. However, the lack of recent references and reliance on old reports is an issue given this field has advanced significantly since 1992. Some additional recommended references are: Poulin et al. 2011, Lovejoy et al. 2002, and Mundy et al. 2011.

5.2.3 Microflora

- The short timelines imposed for this review, precluded the involvement of a subject matter expert for this short subsection.

5.2.4 Zooplankton

- Paragraph 2 of this subsection starts by explaining that, for the purpose of this document, The Labrador Shelf SEA Update Area has been previously divided into three zones; the northern, southern, and central Labrador Sea. Explaining that partitioning of the Labrador Sea earlier in this section (5.2), while delineating the boundaries of each zone, would greatly help the following the information presented in previous subsections, especially 5.2.1, where several references are made to these three zones. The authors then compares the species richness of the northern Labrador Sea to the community that is generally encountered in tropical and temperate climates. It would be more informative to present information about the main taxa composing the zooplankton community in the area of interest as well as spatial variation in species distribution, e.g. shelf versus slope. See papers by Head and/or Pepin (Head and Pepin 2009, Pepin et al. 2011, Head et al. 2013) on that topic for the NL region.
- The entire subsection revolves mainly around *Calanus finmarchicus*. Despite the indisputable ecological importance of this copepod species in the Northwest Atlantic, the discussion should make more room for other copepod species such as *Oithona* spp. and *Pseudocalaus* spp. which often numerically dominate zooplankton assemblages and are important food source for adults and early life stages of ecologically (e.g. capelin, herring) and economically (cod, redfish, flatfish) important species. Other non-copepod zooplankton organisms such as appendicularians and pteropods play key roles in the pelago-benthic processes. Additional zooplankton taxa that are important include amphipods, euphausiids, cladocerans, cnidarians, and chaetognaths. Also the zooplankton group includes more taxa than just copepods yet these two terms are used interchangeably.
- Calanoid copepods are not limited to *C. finmarchicus*, *C. glacialis*, and *C. hyperboreus*. For example Temora, Centropages, Microcalanus, and Metridia are other calanoid copepods commonly encountered throughout the Northwest Atlantic. The ecological importance of the three large diapausing Calanus species (*finmarchicus*, *glacialis*, and *hyperboreus*) is based on the fact that they store large amount of lipids making them high-energy food source for a

variety of marine species, including adult, juvenile, and larval stages of fish, which preferentially select them over other available food items. The disproportionate ecological importance of certain copepod species with regards to fish stock productivity should be highlighted in the discussion. There is an extensive body of literature on zooplankton-fish interactions.

- There has been significant changes in the zooplankton community composition in the Northwest Atlantic over the past decades, characterized by an increase in the abundance of small copepods such as *Oithona spp*. and *Pseudocalanus spp*. along with a decline in the abundance of the large calanoid copepods. These shifts in the size structure of the copepod community are documented in annual DFO AZMP reports as well as in CSAS Research Documents for the Newfoundland Shelf and Labrador Sea regions.
- Recent studies have addressed the potentially negative impacts of seismic airgun blasting surveys on zooplankton survival. Although the authors presented mixed conclusions, these are worth mentioning in this document (see McCauley et al. 2017 – Widely used marine seismic survey air gun operations negatively impact zooplankton, and Fields et al. 2019- Airgun blast used in marine seismic surveys have limited effects on mortality and sublethal effects on behavior or gene expression, in the copepod *Calanus finmarchicus*).
- Overall, this subsection should be augmented to include a broader description of the zooplankton community and further outline the relationships between zooplankton community structure and the productivity of different ecologically and economically important fish stocks in the region. Also, a clear distinction should be made between biomass and abundance when talking about “dominant” species. For example, small *Pseudocalanus spp*. and *Oithona spp*. copepods generally dominate zooplankton abundance but only account for a fraction of the total biomass. On the other hand, the large calanoid copepods *C. finmarchicus* often account for >50% of total zooplankton biomass despite its comparatively lower abundance.

5.2.5 Significance of Oceanic Conditions Variability

- The information in this subsection should be included in a standalone section on the physical oceanography of the area of interest. Explaining the general water circulation and the relative contribution of the different water masses to the overall biogeochemical environment of the region of interest would set the table for the discussion on plankton and help structure the text and improve the flow of ideas throughout the plankton section (and most likely all sections) of this document.
- *“Plankton, including phytoplankton, zooplankton, epontic communities and microflora are the keystone to the marine ecosystem as they transfer energy up to higher trophic levels”*: Foundation is probably a more appropriate word than keystone. Keystone species exhibit a large influence on communities despite relatively low abundance. Plankton wouldn’t qualify as being relatively low abundance.

5.3 Corals and Sponges

- *“Gilkinson and Edinger (2009) identified areas of high coral diversity and abundance in the Labrador Region, including some parts of the Eastern Arctic”*. Eastern Arctic is not part of the Labrador Region. Should this read “in addition to some parts…”?
- *“As illustrated in Figure 5-5, the continental shelf remains the area where the highest concentrations of corals, sponges, and sea pens are located and is consistent with other studies that have been conducted in the area (Gilkinson and Edinger 2009; Kenchington et*

al. 2010; Edinger et al. 2011; Knudby et al. 2013)". It is worth noting that there are many areas that have had little exploration (see Coté et al. 2019).

- Corals and sponges are very long lived and the sensitivity and rebuilding time is not adequately conveyed in this section. There are no lifespan estimates referenced, and no discussion of how they produce biogenic habitat that can take decades to build. This particular information is very important in the context of oil and gas as these species are at high risk of damage from development and many are found in the offshore and in high densities in the areas typically of interest to oil and gas development.
- Bryozoans are not discussed anywhere in this document, and should be discussed in more detail along with all other VME indicator species. Though this is a designation used by NAFO and there are no assigned areas with the Labrador Shelf Offshore SEA Update area, these species do occur in this region and are important benthic species that create habitat.
- The citation of AMEC 2014 for important statements is not appropriate and is scientifically weak. The original citations should be used instead to provide credibility towards the source of references examined.
- Black corals and gorgonians are not the only vulnerable types of coral. Although the text does not directly imply it, the lack of mention of other corals such as sea pens might lead to an erroneous interpretation regarding the vulnerability of the latter.
- *"Corals are distributed along the edge of the continental shelf and slope off Nova Scotia, Newfoundland, and Labrador"* but are also found in coastal and deeper ocean areas, which are currently understudied.
- *"Coral populations are most dense in the region between Makkovik Bank and Belle Isle Bank. Scientific surveys conducted by DFO detected a peak occurrence of corals at the mouth of the Hawke Channel. While conducting RV survey trawls, at least two tows in this area had four to seven sets of gear containing corals (Edinger et al. 2007)"*: Wording is ambiguous. *"Better to say Corals are most dense in the region…".* Also, it is not clear how one can get 4-7 sets of gear containing corals from 2 tows.
- The statement that *"typically, corals are found in canyons along slope and channel in areas deeper than 200 m (Breeze et al. 1997)"* is misleading. As explained above, corals can also be found in areas shallower than 200 m.
- The statement that *"horny and stony corals (hard corals) are restricted to deep water only"* is erroneous. Furthermore, it is unclear of what the definition of deep-water is in this context.
- In the statement: *"For example, gorgonians can grow close together and form dense forest-like habitats, sea pens may occur in aggregations known as sea pen meadows, and other species (e.g., scleractinian cup corals) are solitary species"*. It sounds like the concept of a solitary coral has been misunderstood. Solitary corals can also form fields, and this sentence suggests they cannot. Forming fields has a clear importance in terms of forming significant concentrations, therefore the suggestion that solitary corals do not form fields should be rectified.
- *"Cold-water corals have been shown to play an important role in benthic ecosystems by providing habitat for other species of invertebrates and fishes (Buhl-Mortensen and Mortensen 2005; Buhl-Mortensen et al. 2010)".* This needs updated references to show that new associations are still being reported.

- The description of mapping studies in the SEA region is fine (i.e., it lists relevant studies), but it should be mentioned that all of the cited studies were based on trawl surveys, which are limited to maximum depths of ~1,500 m and do not survey coastal areas. Therefore, data limitations and gaps in terms of spatial extent of such models should be clearly stated in the text as well as in the figure legend (Figure 5-5). The studies by Coté et al. (2019) and DFO (2021a) should also contain additional information on coral presence (Note access to McCarney et al. [in press][1] can be provided-it is the more detailed Res Doc associated with DFO 2021a).
- Page 5-21:
    - *"Cold-water corals found on continental margins provide…."*, suggests only coral found on continental margins provide these functions. Remove "continental margins".
    - Names to check: *Capnella* (=*Duva*) , *Halipteris* (=*Balticina*), *P. grandis* (=*Ptilella*), *Eunephthya* (=*Gersemia*).
    - The following species are not found here and should be removed; *P. phosphorea,* and *Dasmosmilia lymani*
    - Replace *Umbellula lindahli* with *Umbellula* spp.
    - Correct spelling for *Distichophyllum gracile* (=*Distichoptilum gracile*)
    - See draft coral guide for the most up to date list of species and known ranges (will be made available to the authors).
- *"SBAs were identified using a Kernel density estimation… and sea pen catches";* remove *"…sea pen catches"* and replace with *"concentrations"*. Sea pens are corals too.
- Specific comments to Figure 5-5:
    - Survey data only shown up to 2015. More recent data are available and should be presented.
    - What does research vessel transect mean in Figure 5-5? This looks like an erroneous data interpretation.
    - The figure lacks the distribution of black corals, cup corals, and soft corals. Data pertaining to the described corals were provided by DFO.
    - Ideally this figure would also show the special areas.
- Species listed in Table 5-3 need to be checked in the WorMS database, as some of the listed species names are no longer valid (e.g. *Capnella florida*). All errors are not listed here, so please check the full list. Also, please spell full scientific names (*P. aculeata* is not appropriate in a table if not mentioned in this table before as *Pennatula aculeata*) and check scientific name spelling when doing the WoRMS checks. This check should be done for all species in the document.
- *"The most common and longest-living corals in the Labrador Shelf SEA Update Area are gorgonians, specifically the small gorgonians Acanella arbuscula and Acanthogorgia armata (Edinger et al. 2007; Wareham and Edinger 2007)." Acanella arbuscula* and *Acanthogorgia armata* are not the longest living corals in the area, species of large gorgonians are generally the longest living.

[1] McCarney, P., Coté, D., Laing, R., Wells, N., Roul, S., Novaczek, E., Colbourne, E., Maillet, G., Anderson, M.R., Denniston, M., Wareham, V., Neves, B., Murphy, A., Gullage, L., Allard, K., Janes, J., Pretty, C., Gullage, M., Lawson, J., and Stenson, G.. In press. Biophysical and ecological overview of a study area within the Labrador Inuit Settlement Area zone. DFO Can. Sci. Advis. Sec. Res. Doc.

- *"These two species are found at the average water depths of 822 m for Acanella arbuscula and 513 m for Acanthogorgia armata (Wareham and Edinger 2007)"*: In this context, depth range is more meaningful than average.
- Erroneous statement: *"Some species have a narrow distribution; for example, Primnoa resedaeformis occurs in the northern region of Labrador but is absent from the southern region." Primnoa resedaeformis* is abundant in the northern region, but the species has been documented from Davis Strait to Grand Banks. Large *Primnoa* and *Paragorgia* corals were collected by a local fisher just off Makkovick (see DFO 2021a).
- Page 5-24: *Vaughanella margaritata* statement is misleading. This species is found on rock walls and can be common when surveying with a Remotely Operated Vehicle (ROV). In the DFO trawl survey data this species is rare because DFO only surveys 'trawlable' substrates and not rock walls. Reference is outdated.
- Erroneous statement: *"Conversely, Acanthogorgia armata and Paramuricea spp. occur in the southern region only"*. Even if they have not been reported in the northern areas, which is not accurate, the statement that they are restricted to the southern region may not be true. The data that have been analyzed are mostly from DFO trawl surveys, which are not the only possible source of data.
- SEM 2008 should be replaced with a reference to the original research.
- Misleading/Erroneous statement: *"Soft corals are less fragile than those with a hard skeleton, which may attribute to its wide distribution, as populations are not destroyed by gear as often in heavily-fished areas".* Soft coral populations are also destroyed by gear. The reasons for their wider distribution have not been assessed, but include a wider bathymetric range, as *Gersemia rubiformis* can be found from depths <20 m to >1,500 m. Also brittle may be a more appropriate word than fragile.

  "*Corals are important to the benthic community. They provide structural complexity and serve as physical substrates, feeding sites, and provide shelter for fish and invertebrates, including polychaetes, amphipods, sponges, barnacles, bryozoans, ophiuroids and ichthyoplankton (Edinger et al. 2007). Areas with corals generally have high species richness and thus attract fish harvesters targeting redfish, halibut, pollock, and shrimp (Breeze et al. 1997). Coral is often damaged by bottom-fishing gear used in these fisheries (Gass 2003) and is often caught as bycatch in fisheries for bottom-dwelling fish species, such as Greenland halibut (Reinhardtius hippoglossoides), Atlantic halibut (Hippoglossus hippoglossus) and northern shrimp (Pandalus borealis). The hard skeletons of large gorgonians make them particularly sensitive to disturbance. An area of high coral species richness exists on the Labrador slope between Makkovik Bank and Belle Isle Bank (Figure 5.5). A rare species of coral, Vaughanella margaritata, was observed north of this area, near Hopedale Saddle (Wareham and Edinger 2007)":* Some of this material is duplicated in earlier text.
- Page 5-25: There are at least 150 species of sponges but not a lot of information has been published to date on species because of the time-consuming work required to identify to species level. There is a fair amount of information on sponges on community level in terms of Arctic and boreal communities.
- Sponges of the genus *Geodia*-should be changed from genus to suborder Astrophorina which includes *Geodia* spp., *Stryphnus fortis*, and *Stelletta* spp.-more reflective of sponge groups (Arctic and boreal) found on Labrador Shelf.

- This section should reference the study by Murillo et al. 2018.
- The section on data constraints should emphasize the limitations of RV surveys to depths <1,500 m and knowledge limits related to coral and sponge diversity and distribution in deep-water sites. It should emphasize that lack of corals in Figure 5.5 does not necessarily mean a true lack of corals, but rather lack of data.
- The only other invertebrates described in the document are commercially important species. Corals and sponges are not the only indicators of Vulnerable Marine Ecosystems, hence other indicators such as bryozoans and sea squirts should also be acknowledged. *"Since 2005, studies on deep-sea corals has expanded to include studies of deep-sea coral trophic relationships, reproductive ecology, and the role of deep-sea corals as fish hab*itat": References for these studies should be added.
- The document "Coral and Sponge Mitigations in Relation to Exploratory Drilling Programs in the Newfoundland and Labrador Region" (DFO in press[2]) is expected to be published in the very near future and before the final revision of the SEA is submitted for public comments, given the high relevance of this DFO Science Advice for developing mitigation strategies, it is strongly recommended that efforts are exhausted to incorporate this advice into the SEA.

5.4 Invertebrates

- Invertebrates are a broad taxonomic category that include plankton and corals-groups that are presented separately. It would be more precise to call this section Benthic Invertebrates and include corals and sponges as a subsection.
- This section could use some editing to minimize duplication.
- There is an imbalance in the amount of information devoted to coastal areas versus. deeper waters.
- More attention could be put toward highlighting aspects of biology that are relevant to oil and gas industry sensitivities and mitigation.
- Are there no data on distributions of invertebrates from RV surveys to show?
- *"Epibenthic organisms are mobile or active swimmers…"*: An animal can be mobile and an active swimmer.
- *"The spatial variability of benthic communities can be attributed to physical habitat characteristics, such as water depth, substrate type, currents, and sedimentation. The primary factors affecting the structure and function of benthic communities is water mass differences, sediment characteristics, and ice scour (Carey 1991):* Temperature and salinity should also be listed as important factors. Also the list in the second sentence wasn't the same as the first, for which no reference was provided.
- *"Upper slopes (>100 m depth) where the biomass begins to decrease".* The benthic zones describe the shelf as ending at 100 m, and simplify all areas >100 m as a single zone as "Upper slopes". This deeper area includes the shelf slope out to the abyssal plain. There is a notable diversity in habitats and taxa beyond 100 m (see references in Coté et al. 2019 for

[2] DFO. In press. Coral and Sponge Mitigations in Relation to Exploratory Drilling Programs in the Newfoundland and Labrador Region. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep.

patterns of invertebrate biomass, diversity etc. in deeper water.). It is worth spending some time breaking down habitats >100 m since most of the study area sits in these depths that are potential locations for oil and gas development. Also, the slope starts much deeper than 100 m in many areas of Labrador.

- *"Data for the northern Labrador Shelf are separated into two major groups; water depths of less than 300 m, and water depths greater than 300 m (Stewart et al. 1985)."*: Important to identify the range this study examined as it will set limits on how far the reader can extrapolate results of the >300 m category. This also contradicts the previous study where communities >100 m were the same. Context is needed.
- *"Sediment type at the station was predominantly sand and was located in a mixing zone between the Labrador Current water and deeper, warmer Atlantic intermediate water"*: This was from a single station? That should also be brought forward earlier as it reduces the generality of these results.
- *"This is discussed in Section 9.0. Mussels and clams were observed to be plentiful in the Nain district (Williamson and LIA 1997)"*: See DFO 2021a for more up to date information (DFO can provide access to the more detailed Res Doc: McCarney et al in press[1]).
- *Rhodine gracilior, Maldane sarsi, and Chaetozone setosa* are all polychaetes not echinoderms. Polycheates tend to be infaunal species, whereas echinoderms tend to be more epibenthic and represent different parts of the ecosystem. Because of their different places within the ecosystem they have different risks from oil and gas development.
- When discussing benthic invertebrates it is important to be clear which portion of the community is being discussed. It is noted that species can be infaunal, sessile, or epibenthic, but these terms should also be used when referring to which portions of the community are being discussed in relation to specific references. This is also important in the context of oil and gas as each portion of the community has different risks from oil and gas development.
- The focal species are those with commercial or potential commercial value. Though these species can account for large biomasses in trawl surveys, and great amount of information is known about these species, it is important to consider the ecosystem at a broader level and include other ecologically relevant species.
- Much of the overview of benthic invertebrates focused on smaller macrofauna including polychaetes, gastropods, and bivalves. A number of taxonomic groups are not mentioned or do not receive adequate attention (e.g., Echinoderms in general, but specifically brittle stars and sea stars which can play an important role in the deep-sea food web). Impact from oil and gas can be different for different community components. Without proper discussion of all components it is not possible to properly assess risk.
- The sensitivity of this component of the ecosystem to climate change is not covered. Though information from this geographic region may not be available, it has been noted in the northeast Pacific that deep-sea community respond to climate events (Ruhl and Smith Jr. 2004). Climate change is a huge pressure on these ecosystems and major change to benthic communities is likely to arise in the coming decades.
- *"The following sections provide descriptions of some benthic invertebrate species that have been noted as occurring within the Labrador Shelf SEA Update Area."*: What is the basis for the selected species?

5.4.1 Iceland Scallops

- Paragraph 1, last sentence: *"Found in up to 100 m in the Straits of Belle Isle"*. Use the more recent reference: DFO (2020b).
- Paragraph 2 referring to reference DFO, 2007b: Another DFO source may be more recent for the assessment of Iceland Scallop in the Straits of Belle Isle (DFO 2020b).
- Referring to reference SEM, 2008: A lot of this document is based on this one report.
- Referring to (Nunatsiavut Government 2018): Details on where this reference would be available should be provided in the reference list. The reviewer was unable to find this document.
- Paragraph 4: Domestic Harvest described in Section 9.2.6.6 should be identified in this paragraph as well.
- *"The spawning period for Iceland scallop is short, from April to August…"*: Five months seems like an extended spawning period compared to a lot of species.

5.4.2 Snow Crab

- Paragraph 3: *"There is little information on offshore crab migrations"*: See Mullowney et al. 2018. This study describes the dynamics of ontogenetic movements and seasonal migrations in snow crab along the Newfoundland and Labrador continental shelves. This study also provides some information on distances moved by male and female snow crab from a tagging study as well as references to other tagging studies. This may provide some additional information to the statement regarding crab being stationary fish in paragraph 6.
- The discussion surrounding the timing of mating and moulting should be more general (seasons instead of specific months). The timing may be a bit different in different areas depending on such factors as the bottom temperature/depth, so focusing on specific months may not capture the full range of timing. Mullowney et al. (2018) describes many of the complexities of the mating and molting system of this species.
- Paragraph 4: *"It takes 5-10 years for male snow crab to grow to legal size …"*. See Baker et al. 2021. This report has some more refined information on age to recruit to the fishery and maximum life span (page 1 paragraph 2).
- Last paragraph: *"For instance, the crab in Cartwright Channel were only just starting to recover in 2008"*: Clarification is requested on what recovery this is referring to and recovery from what? Is this a general reference to the trends in snow crab biomass based on DFO stock assessment? If so, this is incorrect. Both the latest snow crab Science Advisory Report (DFO 2021b) and Research Document (Baker et al. 2021) do not indicate any improvements in snow crab exploitable biomass in Assessment Division 2HJ (the assessment division which includes the area of interest). Alternatively, if it is based on local knowledge, it should be specified.
- *"Crab are stationary fish…"*: Confirm that this is cited correctly (comment also applies to Toad Crab and Porcupine Crab).

5.4.3 Whelk

- "*The suggestion that whelks are scavengers is based on their infrequent feeding, high mobility, and capacity to detect and locate dead animals on the seabed*". Although they are highly mobile, their dispersal potential is quite limited compared to other commercially fished

invertebrate species (i.e., Snow Crab [*Chionoecetes opilio*] and shrimp) due to internal fertilization and the lack of planktonic larvae (Pálsson et al. 2014, Lapointe and Sainte-Marie 1992, Hancock 1963, Himmelman and Hamel 1993). This is an important aspect of the species that needs to be taken into account. Although widespread, whelk have a lot of variation between populations due to this lack of dispersal ability.

- *"…gastropod mollusk characterized by a spiral shell and large foot mussel"*: A mussel is a different type of mollusk (that also has a foot). Perhaps, change mussel to "used for locomotion".

5.4.4 Toad Crab

- Crustaceans are sensitive to disturbance during molting. A stock status report from Cape Breton states that molting occurs May-September in Newfoundland (DFO 1996).
- Paragraph 2: This information seems to be taken from a DFA document. The text should reference that rather than the last SEA.
- Paragraph 3: *"For instance, the crab in Cartwright Channel were only just starting to recover"*: This exact sentence is in the Snow Crab section. Since there is no Toad Crab stock assessment conducted by DFO and since these sentences have been repeated several times, it seems likely this information is derived from local knowledge holders. If the species is not known, perhaps a section on "Coastal Crab" would capture these observations.

5.4.5 Porcupine Crab

- *"Nunatisiavut Government observed in 2007 that crab are stationary fish that live on the bottom of the ocean and drilling on their beds would negatively affect the stock. For instance, the crab in Cartwright Channel were only just starting to recover. An accidental release there would have serious consequences. The tides and the wind would bring released oil to traditional fishing grounds (SEM 2008)"*: Since there is no Porcupine Crab stock assessment conducted by DFO and since these sentences have been repeated several times, it seems likely this information is derived from local knowledge holders. If the species isn't known, perhaps a section on "Coastal Crab" would capture these observations.

5.4.6 Shrimp

- "*Shrimp undergo a diel vertical migration, moving off the bottom into the water column at night to feed on small pelagic crustaceans and then returning to the bottom during the day"*. Suggest changing wording to "…feeds on small crustaceans and other planktonic organisms…".
- *"Spawning by some invertebrate species occurs in the Labrador Shelf Offshore SEA Update Area, but limited research has been conducted on the passive movements of planktonic invertebrate eggs and larvae in this area"*. The authors should be aware of research in this area by LeCorre et al. (2019).

5.4.7 Data Constraints Associated with benthic Invertebrate Communities

- Paragraph 3: *"The overall lack of knowledge outside of commercially-important benthic invertebrates represent a data constraint"*. A more accurate statement is "The lack of published/publically available data outside commercially-important benthic invertebrates represent a data constraint". Data is collected during DFO RV trawl surveys of all species caught in the trawl (including non-commercial benthic invertebrates); however only data on commercially-important species is published in stock assessment documents. But there is

some relevant information that is not cited (see recent characterizations of the Labrador Coast and Labrador Sea Deep Ocean; DFO 2021a, [more detail available on request from McCarney et al. in press[1]], Coté et al. 2019).

- Paragraph 4: *"Spawning by some invertebrate species …"*. See Le Corre et al. (2019). This study investigates connectivity processes during the pelagic larval phase of Northern shrimp using biophysical modelling. Results indicate source and sink roles for northern and southern populations, respectively, and the results could possibly apply to other species with similar pelagic larval phases.

5.5 Fish Species

- *"During their northern migrations, these migratory species typically remain in the warmer waters of the Gulf Stream"*: Capelin and salmon should be noted as exceptions as they migrate into the colder waters of the Labrador Shelf Offshore SEA Update Area.
- The DFO RV survey for the dates described (2007-18) did not use a bottom otter trawl, it used a Campelen 1800 shrimp trawl (Rideout and Ings 2020).
- *"…results from the DFO RV surveys collected between 2007 and 2018, to give an indication of species that may be present within the Labrador Shelf SEA Update Area"*: Should specify *"in surveyed parts of…"*.
- *"For fish in general, Nunatisiavut Government have noted larger and more plentiful fish since DFO made the mesh size for nets bigger about 10 to 15 years ago (Nunatisiavut Government 2018)"*: Should specify what nets. Char gill nets or trawls? Also note that Nunatsiavut is misspelled in many places throughout the document.
- Table 5.4: *"Includes species at risk (SAR) and species of conservation concern (SOCC)"*: If adding other non ROV species, it would be worth noting key species found in deep ocean areas in Coté et al. (2019). Also there is inconsistent capitalization of species names.

5.5.1 Demersal Species

- How were focal species selected? There are some suprising species on this list (Haddock, Yellowtail Flounder) at the expense of other important species that were omitted (e.g. Abyssal Grenadier). The same applies for pelagic species which is missing lanternfish, in particular *Benthosema glaciale*; probably the most abundant fish in the SEA area (See Pepin 2013).
- Though some species have more details than others, most lack the detailed information about role within the ecosystem. This includes prey and predators for a given species. These details are important for placing species in context and allows the reader to understand how impacts on a particular species could affect the ecosystem at a larger scale.
- Species distribution from DFO RV surveys is alluded to but are not presented. Average relative density layers (i.e., persistent areas of relatively high/low biomass) for fish functional groups and many key species have been published (Wells et al. 2021). The distribution of species provides information on which species are at the greatest risk due to overlap with oil and gas activity, but also understanding of the diversity in species composition across the region.
- Population trends are referenced for a number of fish species as it relates to traditional knowledge, but recent stock assessments which provide complementary information is not

included. General population trends are very important as many of these species have seen major changes over the last several decades and therefore may have elevated sensitivity to additional pressures.

- The fish section takes a species-specific approach and in doing so misses many components of the ecosystem. In '5.5.2.6 Other fish' the authors have opportunity to reference species not covered but they only discuss two species observed through local knowledge. This section could include further discussion about the other species groups where the amount of information may be lacking, but we do know that species exist and that they play important roles with in the ecosystem (e.g. deep ocean species). For example, Myctophids are a species rich group of oceanic fish that are important prey in the more diets of many fish.
- Throughout the document, populations are referred to that do not directly overlap the Labrador Shelf Offshore SEA Update area. This is not a problem as long as it is clear why these populations are included in the discussion. Valid reasons to include such populations are: neighboring populations known to intermix, edges of the population overlap with the Update area, populations that migrate through the area of interest, or are expected to expand into the Update area with changing environmental conditions. This is stated for some species and populations, but should be clearly stated for all. It makes it unclear which populations and species are at the greatest risk of impacts of development in the region and which are not currently in the region and represent a much lower risk.
- References should be updated to reflect more recent information. NAFO Scientific Council Reports and DFO Research Documents and Science Advisory Reports are suggested resources for these updates. Effort should also be put in to ensure that references are reflective of the study area wherever possible (e.g. current references in the Witch Flounder section largely focus on Subdiv. 3Ps, when information is available from the Labrador Sea Area through the 2J3KL Stock.).
- *"Emerging continental slope fisheries for grenadiers, Greenland halibut and redfish are resulting in additional pressures for other continental slope species"*. The Greenland halibut fishery is established, and the redfish fishery is under moratorium.

5.5.1.4 Sand Lance

- *"Sand lance (Ammodytes spp.) is a small fish found on sandy seabeds and is known to be an important forage species for other species of groundfish and pelagic fish and marine mammals"*: Cite Dempson et al. 2002 for importance of sand lance and capelin to Arctic Char diets.

5.5.1.5 Hake

- This area extends beyond the northern extent range of Silver Hake. This species could be removed from the report. If included, the Update should include research results from Reed et al. 2018.
- The Update should include research results for Longfin Hake from Beacham (1983).
- The Update should include research on Blue Hake from:
  - Kulka et al. (2003)
  - Vedishcheva et al. (2019)
  - Orlov et al. (2019)

- Note that some data on depth use in Labrador Sea are available in Coté et al. (2019). This document also suggests that the study area may be a spawning ground for this species.

5.5.1.6 Witch Flounder

- *"Witch flounder (Glyptocephalus cynoglossus) are a deep-water flatfish, also known as grey sole, that occur in the Northwest Atlantic from Hamilton Inlet in Labrador (northern limit for this species)"*: More northern records exist in Greenland.

5.5.1.7 Black Dogfish

- This subsection is greatly lacking in basic life history facts [e.g., length-weight relationships; maturity-at-age; fecundity; reproduction; sex-based changes over time], distribution/biomass, and unacceptably cites only one 14-year-old publication for species information. SEA should include research results from:
    - Hedeholm et al. (2019)
    - Román-Marcote et al. (2020)
    - Qvist (2017)

5.5.1.9 Arctic Cod

- This species would be more appropriate under pelagic fishes.

5.5.1.10 Rock Cod

- See DFO (2021a) or request access to McCarney et al. (in press)[1] for more detailed information on Rock Cod on the Labrador Coast.

5.5.1.11 Roughhead Grenadier

- Latin/scientific name is *missing*.
- SEA unacceptably cites only one 13-year-old publication for species information.
- SEA should include research results from:
    - COSEWIC (2018)
    - González-Troncoso et al. (2020)
    - Orlov et al. (2018)
    - Simpson et al. (2017)
- Data on depth distribution in Labrador Sea are available in Coté et al. (2019).

5.5.2.1 Atlantic Herring

- *"Atlantic herring (Clupea harengus) are a pelagic, schooling fish that usually occur in shallow inshore waters. In the northwest Atlantic, they are found from Labrador to Cape Hatteras (DFO 2015g, in BP 2016)"*: Knowing where in Labrador would be important given the size of the area.

5.5.2.2 Arctic Char

- References needed in this section. See Arctic Char related papers by Dempson for the coast of Labrador (Dempson and Green 1985, Dempson and Kristofferson 1987, Dempson 1995, Dempson et al. 2002, Dempson et al. 2004, Dempson et al. 2008).

- *"Ocean migrations are also spatially limited, with few Arctic char moving less than 100 km from home rivers"*. Authors can cite Layton et al. (2020) and Coté et al. (in press)[3].
- Paragraph 4: Relevance is not clear.
- *"A change in char movement has been observed in the summer over the last 5-6 years, with char staying in the bay, as opposed to moving through the bay and out to sea (Nunatsiavut Government 2018)."*: Note, Coté et al. (in press)[3] links this to availability of capelin (fish stay in bays if capelin are abundant).
- *"Arctic char are opportunistic predators while at sea, with diet varying over spatial areas. Within the Labrador Shelf SEA Update Area, sand lance, sculpins and hyeriid amphipods are the four main prey sources for Arctic char (DFO 2001)"*. Is capelin missing off this list? Only three species are listed.
- *"NCC, in 2009 reported char fishing in Lake Melville, Rabbit Island, Bob's Brook, Traverspine River, Mud Lake, Metchin River, Muskrat Falls and Gull Island (Minaskuat 2009 as cited in Nalcor Energy 2010). NCC observed that depending on the region, Char populations have been higher in past years but declined recently, remained stable or even rebounded a bit at some locations (NCC 2019)"*. Nunatukavut Community Council (NCC) did not fish in Lake Melville under FSC until 2013.
- Nunatsiavut Government should be replaced with NG as it is abbreviated earlier in the document.
- *"Arctic Char populations fluctuate for many reasons including overfishing, change in migration patterns, and industrial activities (Clément 1998)"*: Regime shifts and prey availability should be added to this list (see Layton et al. 2020; Dempson et al. 2002).

5.5.2.3 Capelin

- *"Spawning typically occurs in late June and early July, although it was somewhat later in the 1990s (Carscadden et al. 1997, 2001)"*: These references are out of date. Several recent papers are available on this subject by H. Murphy.
- *"Capelin eggs are red in colour…"*: This is an example of information whose inclusion is not relevant to interpreting oil and gas effects and mitigations.
- Capelin assessment referenced is the 2005 and for Divisions 4RST. This is not a regionally appropriate assessment and it is also outdated.
- From the document, *"The primary cause of capelin mortality is predation, and as such, variations in capelin abundance are directly linked to natural causes (DFO 2006c)"*. The source does not support this statement and is a misuse of this reference.
- *"Capelin are major components in marine ecosystem dynamics as they facilitate the transfer of energy between trophic levels, principally between primary and secondary producers to higher trophic levels (DFO 2006c)"*: Also move energy across regions-bringing important resources to coastal areas of Labrador to species such as Arctic Char.
- *"Predators to capelin include most major fish species including Atlantic cod, haddock, herring, flatfish species, dogfish, and others"*: Given the region, Arctic Char should be highlighted on this list. See Dempson et al. (2002).

[3] Cote, D., Dempson, J.B., Piersiak, M., Layton, K., Roul, S., Laing, R., Angnatok, J., and Bradbury, I. In press. Using movement, diet and genetic analysis to understand Arctic charr responses to ecosystem change. Marine Ecology Progress Series.

- Paragraph 6: The information on temporal shifts is a useful addition and encouraged for inclusion in other species descriptions. Note there is more recent information on capelin in Carscadden et al. (2013).

5.5.2.4 Greenland Shark

- *"In the North Atlantic, Greenland sharks are found from Baffin Island south"*. Range extends north of Baffin Island (See Devine et al 2018). *"Greenland shark are scavengers that feed on marine mammals, fishes, and invertebrates (Coad and Reist 2004)"*. They are a mixture of scavenging and predation. "Greenland shark has not been studied extensively with little information on its life history and current behaviour as a species." There has been significant progress in research on Greenland shark biology and distribution. See research results from:
    - Bryk et al. (2018)
    - Campana et al. (2015a)
    - Gallant et al. (2016)
    - González-Costas and Ramilo (2019)
    - Hedeholm et al. (2018)
    - Hendrickson (2018)
    - Hendrickson et al. (2018)
    - Lydersen et al. (2016)
    - Nielsen et al. (2013)
    - Nielsen et al. (2020)
    - Simpson et al. (2018)
    - Ste-Marie et al. (2020)
    - Wheeland and Devine (2018)
    - Wheeland et al. (2019)
    - Edwards et al. (2019)

5.5.2.5 Blue Shark

- The Update cites only one 14-year-old publication for species information.
- The Update should note that they are very common in inshore NL waters in summer.
- The Update should include research results from:
    - Campana et al. (2011)
    - Campana et al. (2015b)
    - da Silva et al. (2021)
    - Howey et al. (2017)
    - Vandeperre et al. (2014)
    - Vedor et al. (2021)

5.5.2.6 Other Fish

- *"NCC observed fewer smelt in recent years in some locations throughout southern Labrador (NCC 2019)"*: Lamprey and Striped Bass have also been observed in increased numbers in recent years in southern Labrador. The NCC have contributed data to the aforementioned publication and may be willing to confirm these observations.
- *"…observed a reduction in trout and smelt abundance in the past three years in areas surrounding Snook's Cove and in ponds near Rigolet (Nunatsiavut Government 2018)"*: Past

three years from a report in 2018 is not the past three years for a report in preparation in 2021.

5.5.3 Data Constraints for Marine Fish

- There are several good points made in this section. It should be added that two major areas not well studied are deep ocean areas (see Coté et al. 2019) and coastal areas inside of DFO RV surveys and beyond the coastal areas frequented by local people (DFO 2021a).

5.6 Species at Risk and Species of Conservation Concern

General Comments:

This section is lacking significant information, generally is outdated and should avoid citing other Environmental Assessments or Environmental Impact Statements as sources of species information (e.g., BP 2016). Instead, a comprehensive literature search is needed for each SEA topic/species, in order to find and include the most current scientific information and species SAR designations. Many SAR species were described and presented based on only one reference, with the majority of those single-citations being outdated. In some cases the references were cited erroneously. This resulted in missed critical information on every species that was reviewed. The citations used are also too narrow in scope, with reputable sources like NAFO, IUCN, ICES & primary scientific journals remaining unused. The authors are directed to a sample of recent online publications provided in the sources of information to update the references and to use that content in the species descriptions.

5.6.1.1 Wolffish (Atlantic, Northern, Spotted)

- The Update should include research results from:
  - Collins et al. (2015)
  - Simpson et al. (2012a)
  - Simpson et al. (2013a)
  - Simpson et al. (2013b)
  - Simpson et al. (2014)

Atlantic Wolffish:

- *"DFO annual spring (1971-2019) and fall (1977-2019) surveys…"*. New information is available from these surveys up to and including year 2019.
- *"…due to similarities between species, it can be assumed that Atlantic Wolffish would likely occupy similar areas* as *both northern and Spotted Wolfish"*. This is an invalid assumption. When not in spawning season, maturing and adult Northern Wolffish are often pelagic hunters of jelly-like invertebrates (e.g., comb jellies like *Beroe*). Change to: *"…due to similarities between species, it can be assumed that Atlantic Wolffish would likely occupy similar areas* as *Spotted Wolfish"*.
- Add the following after last sentence of second-to-last Atlantic Wolffish paragraph: "IUCN Red List of Atlantic Wolffish classified as "Data Deficient" in 2015 (Collette et al. 2015a).
- The Update should include research results from:
  - Bianucci et al. (2016)
  - Fairchild et al. (2015)
  - Gunnarsson et al. (2019)
  - Novaczek et al. (2017)

Northern Wolffish:

- *"DFO annual spring (1971-2012) and fall (1977-2011) surveys…"*. New information is available from these surveys up to and including year 2019.
- Add: *"feeding on pelagic jelly-like invertebrates (e.g., comb jellies like Beroe) [DELETE: ~~benthic crustaceans and~~ invertebrates…"*. Although extremely difficult to find during stomach content analyses, pelagic jelly-like invertebrates [e.g., comb jellies like *Beroe*] are a major food source for adult Northern Wolffish; hence why their tooth structure is significantly different from both Atlantic and Spotted Wolffish (C.Miri, DFO-NL, pers. comm.).
- Add the following after last sentence of second-to-last Northern Wolffish paragraph: "IUCN Red List of Northern Wolffish classified as "Endangered" in 2015 (Collette et al. 2015b)".
- The Update should include research results from:
    - Bayse and Grant (2020)
    - DFO (2015)
    - Gunnarsson et al. (2014)
    - Sandrini-Neto et al. (2016)

Spotted Wolffish:

- *"DFO annual spring (1971-2012) and fall (1977-2011) surveys…"*. New information is available from these surveys up to and including year 2019.
- Add the following after last sentence of second-to-last Spotted Wolffish paragraph: "IUCN Red List of Spotted Wolffish classified as "Near Threatened" in 2015 (Collette et al. 2015c)".
- The Update should include research results from:
    - Dutil et al. (2013)
    - Le Francois et al. (2013)
    - Nygaard (2017)
    - Nygaard and Nogueira (2020a)
    - Nygaard and Nogueira (2020b)

5.6.1.2 Atlantic Salmon

- *"Atlantic salmon (Salmo salar) is an anadromous fish that lives in freshwater rivers for the first two years of its life before migrating to the sea"*. Juvenile Atlantic Salmon remain in freshwater habitats for two to five years in Newfoundland and three to seven years in Labrador prior to undergoing smoltification and migrating to sea as smolts – taken directly from the last Science Advisory Report (DFO 2018).
- *"If fish eggs are not eaten by predators (e.g., speckled trout and Arctic char), the small salmon migrate to the sea in October (Clément 1998)"*: Fry would not normally migrate to sea in their first year and typically migration to sea would occur in the spring after several years in the river.
- Paragraph 5: Missing recent references which document movements in the Labrador Sea of different stocks.
    - Bradbury et al. (2015)
    - Bradbury et al. (2021)

- *"Other salmon populations in Atlantic Canada have been shown to migrate up the coast of Labrador to Greenland or the Labrador Sea to overwinter (e.g., Lacroix 2013)"*. Should also reference recent report from ICES (2021) working group on North Atlantic salmon.
- *"While still in rivers, post-smolts mainly eat aquatic insect larvae"*: Does this statement refer to parr? Post smolts enter that lifestage at sea.
- *"In 1997, Nunatsiavut Government shared that char were speared as they migrated up the rivers"*.: Arctic Char information would be best presented in the Arctic Char section.
- *"…but it is known that they are prey for seals, sharks, pollock, and tuna (Scott and Scott 1988)"*: Seabirds too. See paper by Montevecchi et al. (2009)
- *"Nunatsiavut Government conducts salmon surveys and noted that in 2007, 200 salmon were caught, measured, weighed, and tagged within six weeks".* This study was conducted in 2013 and 2014.
- *"…80% of rivers have experienced a decline in salmon abundance in the summer of 2019…"*. There is only one fence in SFA 1 (English River) that is operated by the NG, so it is unclear where a value of 80% of rivers comes from.
- Population trends from the Labrador salmon fences would be useful.
- *"NCC, in 2009 reported char fishing in Lake Melville, Rabbit Island, Bob's Brook, Traverspine River, Mud Lake, Metchin River, Muskrat Falls and Gull Island (Minaskuat 2009 as cited in Nalcor Energy 2010)"*. The NCC was not able to fish for char in Lake Melville until 2013 under their negotiated Food, Social, and Ceremonial (FSC) licence. Table 5.5, Inner Bay of Fundy Population-This population has yet to be detected in the Labrador Sea.

5.6.1.3 White Shark

- *"The white shark is rare in the Northwest Atlantic (32 records in 132 years), as it is the northern edge of their range. However, they do have the potential to occur within the area.", and "the species is relatively rare"*. Recent, published USA tagging results indicate that Nova Scotian waters contain a "hotspot" for this species, which has also been found annually around the island of Newfoundland in Summer and Autumn. In addition the number of records is outdated.
- *"there currently are no existing recovery strategies, action plans"*. The authors should contact Dr. Heather Bowlby for an update: A White Shark Recovery Strategy for Atlantic Canadian waters" has been proposed in 2020, while an "Action Plan" is being formulated in 2021.
- SEA unacceptably cites only one 14-year-old publication for species information.
- SEA should include research results from:
    - Curtis et al. (2014)
    - OCEARCH (2020)
    - Skomal et al. (2017)
    - State of Maine (2021)

5.6.2.1 Atlantic Cod

- *"The NL population of Atlantic cod contained 75% to 80% of cod found in Canadian waters in the 1960s, and since then there has been a three-generation ratio of decline of 97% to*

99% (COSEWIC 2010b)". Update on more recent population trends with available stock assessment reports (e.g., DFO 2019).

5.6.2.2 Atlantic Bluefin Tuna

- SEA should include research results from:
  - Block et al. (2019)
  - ICCAT (2017)
  - Restrepo et al. (2010)
  - Richardson et al. (2016)
  - Rodriguez-Marin et al. (2015)
  - Secor et al. (2011)

5.6.2.4 Basking Shark

- SEA should include research results from:
  - Austin et al. (2019)
  - Bizzarro et al. (2017)
  - Crowe et al. (2018)
  - Johnston et al. (2019)
  - Lieber et al. (2020)
  - Pirotta et al. (2019)
  - Siders et al. (2013)

5.6.2.5 Cusk

- The Update should include research results from:
  - Chen and Runnebaums (2014)
  - DFO (2014b)
  - DFO (2017a)
  - DFO (2020c)
  - Hare et al. (2012)
  - Harris et al. (2018)
  - Zhang and Chen (2015)

5.6.2.6 Lumpfish

- The reference for 'Marine Institute (2007a)' is not appropriate. It is a website with a broken link.
- The Update should include research results from:
  - COSEWIC (2017)
  - Eliasen et al. (2020)
  - Kennedy et al. (2018)
  - Nygaard and Nogueira (2020b)
  - Rusyaev and Orlov (2014)

5.6.2.7 Porbeagle Shark

- The Update is missing vital information on this species. It should include research results from:
  - Campana et al. (2015c)
  - Campana et al. (2016)

- Cortés and Semba (2020)
- ICCAT (2020)
- Natanson et al. (2019)
- Simpson and Miri (2014)

5.6.2.8 Redfish

- The reference for 'Marine Institute (2007a)' is not appropriate. It is a website with a broken link.
- In addition to eating zooplankton, adult redfish are also known to consume other fish.

5.6.2.9 Roundnose Grenadier

- The Update cites only two outdated publications (one 10 years old and one 12 years old) for species information.
- The Update should also include research results from:
  - Bergstad et al. (2013)
  - Delaval et al. (2017)
  - Gaither et al. (2018)
  - ICES (2019)
  - Knutsen et al. (2012)
  - Lemaire et al. (2010)
  - Simpson et al. (2011)

5.6.2.10 Shortfin Mako

- Add: *"…have decreased by up to 50-79% in the past 15 to 30 years…"* to: "…have decreased by 50-79% in the past 30 years…".
- The Update cites only one 14 year old publication for species information.
- Authors should add after last sentence of last Mako paragraph: IUCN Red List of Shortfin Mako classified as globally "Endangered" in 2019 (Rigby et al. 2019).
- The Update should also include research results from:
  - Byrne et al. (2017)
  - Francis et al. (2019)
  - Gibson et al. (2021)
  - ICCAT (2019)
  - Nasby-Lucas et al. (2019)
  - Natanson et al. (2020)
  - Queiroz et al. (2019)
  - Showell et al. (2017)

5.6.2.11 Smooth Skate

- *"Mark-recapture studies of skates (primarily other species) show average movements of about 100 km…"*: Delete this sentence from the Update if the authors didn't find such research specifically on Smooth Skate. Scientific information should not be extrapolated.
- The Update should also include research results from:
  - DFO (2017b)
  - Purtle (2011)

- Simpson et al. (2012b)
- Simpson et al. (2013c)
- Sosebee (2020)
- Swain et al. (2012)

5.6.2.12 Spiny Dogfish

- The citation Kulka (2006) is not in the Update References section. Please double check all references.
- Add the following after last sentence of last Spiny Dogfish paragraph: “IUCN Red List of Spiny Dogfish classified as globally “Vulnerable” in 2016 (Fordham et al. 2016)”.
- The Update should also include research results from:
  - Bangley (2011)
  - Bangley and Rulifson (2014)
  - Dell’Apa et al. (2014)
  - DFO (2014c)
  - DFO (2016a)
  - ICES (2020)
  - Sosebee (2020)
  - Sulikowski et al. (2013)
  - Thorburn et al. (2015)

5.6.2.13 Thorny Skate

- The text citation Kulka (1996) is not in the References section.
- Add the following after the last sentence of last Thorny Skate paragraph: “IUCN Red List of Thorny Skate classified as globally “Vulnerable” in 2020 (Kulka, et al. 2020)”.
- The Update should include research results from:
  - Curtis (2017)
  - DFO (2017b)
  - Grieve et al. (2020)
  - Kneebone et al. (2020)
  - Knotek et al. (2019)
  - Pennino et al. (2019)
  - Schwieterman et al. (2019)
  - Simpson and Miri (2020)

5.6.2.14 White Hake

- The Update should include research results from:
  - DFO (2016b)
  - Marancik et al. (2020)
  - Simpson et al. (2016)
  - Simpson et al. (2019)

5.6.2.15 Winter Skate

- First sentence**:** Delete the text *“…and ~~southern Newfoundland~~ south to”* and add *“and Labrador south to…(Scott and Scott 1988; COSEWIC 2015; IUCN 2020)”*. Note that the IUCN distribution map has the most recent data on the distribution of this species. It might

be worth mentioning that egg cases and juveniles are regularly being found by citizen scientists in nearshore areas and on shorelines around the Island of Newfoundland and a few from southern Labrador (can cite C. Miri, DFO, NL).

- The Update cites only one 5 year old publication for species information.
- Add the following after last sentence of last Winter Skate paragraph: “IUCN Red List of Winter Skate classified as globally “Endangered” in 2020 (Kulka et al. 2020)”.
- SEA should also include research results from:
  - Coté et al. (2019)
  - DFO (2017c)
  - DFO (2017d)
  - Frisk et al. (2019)
  - O’Connell et al. (2019)
  - Raposo (2021)
  - Sosebee (2019)
  - Sosebee (2020)

5.7 Sensitive Biological Periods for Fish and Invertebrates

- Table 5.6: What are references for these entries? Are they all based on data from the Labrador Sea?

5.8 Effects Assessment-Fish and Fish Habitat

5.8.1 Potential Pathways

- *“Potential interactions with routine project activities most closely relate to concerns with the changes to the existing quality and use of natural habitats within these sensitive areas”*. This statement is not exclusive to quality and use of habitats. Potential interactions also include a direct impact on coral, sponges, and other organisms in the surrounding area. Statements such as: *“Reduction of water and sediment quality from discharge of drill muds and cuttings from exploration drilling and production operations”* do not fully capture the impacts at the organism level. The problem is not the reduction of water and sediment quality per se, but the consequences of these changes to the ecosystem.
- **Overview of Effects** (8.2.2) and **Mitigation Measures** (8.2.3) should be revised in light of the publication by Cordes et al. (2016): Environmental Impacts of the Deep-Water Oil and Gas Industry: A Review to Guide Management Strategies.
- There could be more. See Cordes et al. (2016) paper (Note a DFO paper on coral and sponge mitigations SAR is on the verge of being published and can be made available to the authors).
- This document should also include: Hurley and Ellis (2004).

5.8.2 Overview of Effects

- *“…seismic surveys, will have a shorter period of interaction with fish species and their associated habitats”*: But a much larger area of effect.
- Table 5.8: See papers on seismic by Morris et al. (2018), Morris et al. (2020) and Coté et al. (2020) for effects of seismic on snow crab and general information from other more recent papers.

5.8.4.2 Important Areas and Times for Fish and Fish Habitat

- Gilbert Bay cod should be noted in the Atlantic cod section too.
- *"The continental shelf areas within the Labrador Shelf Offshore SEA Update Area are also important for fish and fish habitat, as these areas are typically the most productive for the marine environment, due primarily to upwelling that occurs along the shelf and the abundance of nutrients during times of the year. Spring and summer is typically when plankton blooms reach their peak, and most species are present along the shelf edge"*: There are no maps or references provided to support this conclusion.

5.9 Data Gaps

- *"While studies have been conducted on fish species regarding effects from oil and gas operations, it only represents a small sample size of the various fish species that exist in the marine environment"*: While true, there is a much better understanding of seismic effects on fish than there is of effects on invertebrates. Invertebrates are much more taxonomically diverse than fish yet less studied.
- *"While DFO surveys are an indicator of presence of fish species, they are only indicative of species present during a set timeframe and within a defined survey area. As a result, it may not be a total representation of species presence within the Labrador Shelf SEA Update Area"*: This is an important point but it should also be accompanied by information on what areas have poor coverage (coastal areas and offshore areas).
- *"…have the potential to affect fish and fish habitat and may alter species distributions and/or habitat use"*: Not "may", but "will" affect fish and fish habitat, and already has. Factors such as disease and invasive species should be included here too.

6.0 Marine Mammals and Sea Turtles

6.1 Overview

- In general, the references used within this section are very limited in number and relevancy, and often are dated. Within the pinnipeds section, the majority of references are from before the year 2000. Although the information given is generally (although not always) accurate considering what was known in 2000, advancements and new knowledge from the past 20 years are generally not included.
- A good reference to use for this update is the IUCN red list. They have descriptions of each species that are updated every few years.
- Maps: Some of the colours and symbols used on the maps are very difficult to distinguish from the background and each other. For example in Figure 6-2: traditional knowledge porpoise and unknown whale. Using red and other easily distinguishable colours would greatly improve the readability of the maps. The same colour can be used on different maps to indicate different species-currently since e.g., yellow is used to show Atlantic white-sided dolphins on Figure 6-2, it's not used on the other figures.
- Maps: Some of the text in the maps is very difficult to read because text size is too small. The same comment applies to the size used for points in many maps.
- The authors could use old whaling data (some of which they seem to present in the (opportunistic sightings maps) to improve information on distributions of lesser known whale species. This could give an idea on at least past distributions and potential present/future distributions-with the caveat that it might not represent current conditions.

- It seems as if when new information was added in this Update, it was entered as a new paragraph without attempting to fit it in with what was already there. There are many examples within sections of logical contradictions, needless repetitions, multiple abundance estimates from different surveys cited as the “current” estimate, etc.
- The formatting of the references is inconsistent in many sections and could do with some editing. Also, the authors cite previous industry reports to support some statements-it would be more credible and proper, to cite original research.

6.2 Mysticetes

6.2.1 Humpback Whale

- There is no date associated with the original population estimate for Humpback Whales from the original 2008 SEA Report. In addition, the 2011 “updated” estimate is a decade old. The most up-to-date information should be included.
- As in most of the marine mammal sections, there is too much detailed information for species distribution and life history outside the study area (such as the Gulf of Mexico or Caribbean breeding grounds of humpbacks). This does not need to be listed unless it has a direct bearing on the animals in the Study Area.
- As for seasonality, it is important to note that Humpback Whales have been recorded singing at stations in the middle of the Labrador Shelf throughout much of the winter (Lawson et al. 2017).
- There’s inconsistency in distribution information. In the first paragraph, it says Humpback Whales occur from the Gulf of Mexico to southeastern Labrador. In the third paragraph, it says humpbacks have primary feeding areas concentrated along the shoreline from Hudson Strait to southern Newfoundland. Hudson Strait is not located in south eastern Labrador.

6.2.2 Minke Whale

- Paragraph 1: states Minke Whales are commonly referred to as “grampas”. In the last paragraph it says this is primarily a name used in Labrador and it’s spelled “grumpus”. This Labrador information should be entered in the first paragraph and the same spelling should be used in both places.
- The statement *“There are currently no overall population estimates for minke whales in the Northwest Atlantic”* is incorrect, as there are corrected estimates for the NL region based on the 2007 Trans North Atlantic Sightings Survey (TNASS) survey of 13,008 whales (CV = 45.9%), plus estimates for the Gulf and Scotian Shelf (Lawson and Gosselin 2018). There are also annual estimates for the NE United Sates produced by National Oceanic and Atmospheric Adminstration (NOAA) as well as surveys off Greenland.
- The statement *“The presence of baleen whales is temporally and spatially variable due to variations in the abundance and distribution of prey species (AMEC 2014)”*. This is likely true in many cases, but whales on the Labrador Shelf may be migrating through an area, or be present for reproductive activities, independent of prey availability.
- The statement *“Figure 6-1 shows opportunistic sightings of non-SAR mysticetes in the Labrador Shelf SEA Update Area created using the DFO sightings database”* must include the caveats that these data represent multiple years, seasons, sightings platforms, and observers (with variation in identification effort and skills). It is risky to conflate these opportunistic data into a single map given that we know there have been changes in whale

abundance and distribution at different spatial and temporal scales-some of which are significant. Also, these data are not weighted for effort-it is possible that for multiple species, the preponderance of opportunistic sightings towards southern Labrador is as much a function of the greater observer effort compared to the northern portion of the Labrador Shelf.

6.3 Odontocetes

6.3.2 Common Dolphin

- The *"Abundance estimates for the Newfoundland region, based on the same surveys, suggest a population of 576 individuals"* is an underestimate based on more recent analyses. In the Newfoundland region alone the common dolphins likely number almost 50,000 (e.g., Lawson and Gosselin 2018).
- While their numbers have declined since the demise of the squid fishery, there are likely close to 30,000 pilot whales in Newfoundland and Labrador (e.g., Lawson and Gosselin 2018).

6.3.5 Sperm Whale

- It should be noted that in recent years Sperm Whales have learned to depredate longlines and seek trawl discards; they are often sighted near fishing vessels. This is a source of injury and mortality for these whales.

6.4 Marine Mammal Species at Risk and Conservation Concern

- Figure 6-3: It is recommended the authors break this up into multiple figures. There are 11 species on this map and it is very difficult to distinguish them. The common species (i.e., Fin Whale) also makes it more difficult to see the remaining, less-common species. This map should ideally be turned into 2 or 3 separate maps.

6.4.2 Blue Whale

- Paragraph 5: states that a certain number of whales have been photographed over the past 21 years and then cites a 2002 study. This sentence needs to be rewritten-something like "photographed during the 1980s and 1990s" or find a newer reference.

6.4.3 Bowhead Whale

- In recent years these whales have been sighted occasionally around Newfoundland, and one adult is a regular visitor to waters as far south as the Gulf of Maine.

6.4.4 Fin Whale

- There are likely closer to 2,200 fin whales in Newfoundland and Labrador (e.g., Lawson and Gosselin 2018).

6.4.5 Harbour Porpoise

- While it is true that the 2007 DFO aerial survey did not detect harbour porpoise on the Labrador Shelf, they were detected in a follow-on aerial survey there in 2016, as well as during vessel-based studies on the southern Labrador Shelf.

6.4.6 Narwhal

- There are newer population estimates than the ones cited from 1984 and 2000, including surveys done in 2011 and 2018, which should be included here.

6.4.7 Killer Whales

- As is symptomatic in many of the marine mammal sections, more relevant and recent publications and reports exist to address the species' biology-and yet are not cited. For example, it is worth noting that Killer Whales are increasingly being sighted in northern areas in relation to climate-driven sea-ice declines.
    - Ferguson et al. (2010)
    - Higdon and Ferguson (2009)
    - Jourdain et al. (2019)
    - Lawson and Stevens (2014)
    - Lawson et al. (2007)
    - Lefort et al. (2020)

6.4.7 Northern Right Whales

- Paragraph 2: this section needs to be updated in accordance with the large increase in the presence of this species in the Gulf of St. Lawrence, NL since 2017-this section currently states that "smaller numbers observed".
- In addition to the 2015 sighting in Labrador, there was also a male seen on the north coast of Newfoundland in the early Fall of 2019-after travelling from previous sighting locations in Iceland and western France.

6.4.8 Northern Bottlenose Whales

- Population estimate of Scotian Shelf population – there is a newer estimate available in from O'Brien and Whitehead (2013).
- As with the sperm whale, in recent years northern bottlenose whales have learned to depredate longlines and deep-set gillnets in mid- and northern Labrador where they are often sighted near fishing vessels. This is a source of injury and mortality for these whales.

6.5 Sea Turtles

- There are a few paragraphs describing bycatch of loggerhead sea turtles, but only a sentence for such mortality for Leatherback Sea Turtles. The bycatch section for leatherbacks needs to be expanded-especially as this is the *"main threat in Atlantic Canada waters"*. There are multiple references that can be of use here (e.g., Hamelin et al. 2016).

6.6 Pinnipeds

6.6.1 Walrus

- *"The walrus has a discontinuous circumpolar Arctic and sub-Arctic distribution with distinct Atlantic and Pacific subspecies (Fay 1985; Cronin et al. 1994). There are considered to be two populations in the Arctic, one east of Greenland, and one in western Greenland and Canada (Stewart 2002)"*. The second sentence (which is presumed to only be based on Atlantic walrus and should be specified) is incorrect. This may have been the view in 2002 but genetic studies since then have proven that this is not the case – nine stocks of Atlantic walruses are now recognized.
- *"The Nova Scotia-Newfoundland-Gulf of St. Lawrence population of Atlantic walrus is considered extinct (COSEWIC 2017). The Northwest Atlantic population is currently listed as Extirpated on Schedule 1 of SARA and recovery of this species is not considered biologically or technically feasible (DFO 2008)"*. These sentences about the same former

population are contradictory. The second sentence is more correct. The authors then repeat this in the next paragraph which is unneeded repetition.

- Another important climate change impact on walruses is the disappearance of sea ice in the summer so it can no longer be used as a haul-out platform over benthic foraging areas. This leads to increased use of terrestrial haul-outs (and deaths due to trampling events) and increased distances to travel to reach foraging sites. This has mostly been observed in the Pacific to date but could also become a problem for Atlantic walruses (e.g., Udevitz et al. 2017; MacCracken 2012)
- Recently, single walruses have been sighted in northern and eastern Newfoundland across multiple summers, along with sightings as far south as Cape Breton and Sable Island, Nova Scotia. Whether these animals represent vagrants or recolonization of former walrus habitat is unknown.

6.6.2 Bearded Seal

- Is called “square flipper”, not “square flippered”.
- Paragraph 2: *“feed in waters of less than 130 m”*: this is very specific, especially for a population which we don’t know much about. It is suggested to edit this to: “generally feed in waters of less than 150 m” to bring this more in line to what’s known from better studied regions.
- There are many newer references the authors should be using in this section regarding diet, movement, etc.
- Paragraph 3: *“…weigh approximately 340 kg in winter and 215 to 239 kg in summer”*: this is again very specific and is from the Svalbard population. It is suggested the authors at least compare this to studies in the Bering-Chukchi-Beaufort region to see if these weight ranges are true for other Arctic regions.
- The authors should say when in the year moulting occurs and how long nursing lasts.
- The authors cannot say that abundance is increasing in the Nain district using the Williamson and LIA (1997) reference – this is 24 years old. The authors can say that abundance increased in the 1990s but recent trends are unknown.

6.6.3 Grey Seal

- The authors should use the newest references available when talking about population size. The reference for the 2016 pup counts is: den Heyer et al. 2020.
- It is inaccurate to say that grey seals are *“now more commonly observed”* using the Williamson and LIA (1997) reference – this is 24 years old. The authors can say that abundance increased in the 1990’s but current trends are unknown.

6.6.4 Harbour Seal

- The 2012 survey the authors reference took place in coastal Maine – this can hardly be used as an estimate for the entire Northwest Atlantic.
- Also, the NOAA document the authors reference includes only southern Nova Scotia as the northernmost part of their range-information from that report thus might not be applicable for harbour seals in Newfoundland and Labrador. There are also reports on the NOAA website up to 2019 – the Update should use the newest available literature.

- The authors cannot say that abundance is both increasing and decreasing in the Nain district using the Williamson and LIA (1997) reference – this is 24 years old. The authors can say that this occurred in the 1990s but current trends are unknown.
- It is inaccurate to state that the east coast population of harbour seals in Canada is increasing using a 2001 reference that is now 20 years old. The authors can say that abundance increased in the 1990s but current trends are unknown.
- Other things to include in limiting factors from anthropogenic sources: fisheries bycatch.

6.6.5 Harp Seal

- This section is contradictory. In one paragraph the authors say the population size is increasing, the next paragraph the authors cite a population estimate from a 2012 reference, the paragraph after that the authors cite a different population estimate from a 2005 reference and say the population is stable.
- The authors should use more recent population estimates (DFO 2020d; Hammill et al. 2021) and update their description of the population trend.
- There is also newer diet information for this species which the authors should be using.

6.6.6 Hooded Seal

- The authors cite two different population estimates for hooded seals in the Northwest Atlantic-one in the first paragraph and a different one in the last paragraph. They should either only present the most recent population estimate, or combine both population estimates in the same paragraph and comment on the trend.

6.6.7 Ringed Seal

- Paragraph 1: There is no need to state they occur in the Atlantic Ocean – leave it at they have a circumpolar distribution and are found in the assessment area.
- Paragraph 2: Ringed seals pups also need snow lairs for thermal protection.
- The movement papers the authors cite (Teilmann et al. 1999, Born et al. 2004) are some of the earliest tags deployed on this species. Since this time, there have been hundreds of tags deployed throughout their range – including in Saglek Bay and throughout the Canadian Arctic. The authors need to update this section and especially include the seals tagged in Canada and in this assessment area.
- The authors cannot say that abundance is increasing using the Williamson and LIA (1997) reference – this is 24 years old. The authors can say that abundance increased in the 1990s but current trends are unknown.
- What is the source for the population estimate of 1.3 million seals from Area 1 from? If the authors are taking this from the NAMMCO paper, the authors need to acknowledge that this is an estimate and is from 1997. This number is also no longer supported by NAMMCO. On their website, the population size for the Canadian Arctic Archipelago is listed as NA.
- If NAMMCO's subdivision into 3 stock area is mentioned, the authors need to specify that this is only in the North Atlantic.

6.8 Seasonality

- When the authors mention that generally pinnipeds are most common during the winter and spring when there is sea ice-they should also state that this is especially the case for Harp

Seals and Hooded Seals that pup and nurse on drifting sea ice in late winter/early spring in the assessment area. Ringed and Bearded Seals also pup in the early spring in the assessment area.

- Table 6.2: For some species the authors talk about NL waters and for others the authors talk about the Labrador assessment area. The authors need to be consistent in what is done for each species.
- Table 6.2: The seasonal movements of Bearded Seals in the Canadian Arctic (including Labrador region) are unknown. In the Bering-Chukchi-Beaufort region they have large seasonal movements following the advance and retreat of sea ice. In Svalbard they have very limited seasonal movements and stay coastal throughout the year. The scale of their seasonal movements is unknown in Labrador but they're likely present in this area throughout the year.
- Table 6.2 Harp seal: The authors should mention that a large portion of the Northwest Atlantic population whelps in the Labrador assessment area, similar to what the authors say for Hooded Seals.
- Page 6-38: While citing the Lawson ESRF 2013/2014 surveys is suggestive of seasonality for cetacean presence in Labrador, these were only a pair of small-scale aerial surveys. In addition, there was the confounding effect of a seismic survey occurring in the area-which had apparently displaced cetaceans. In a subsequent replicate aerial survey in 2016-which was conducted only two weeks later than the 2007 survey, far more cetaceans were sighted.
- Table 6.2: Singing humpbacks whales were heard at recording stations under and near pack ice in winter months off mid Labrador.
- Table 6.2: There is evidence of north-south migration of killer whales – at least one whale that was tagged in the Arctic swam towards the Azores (Matthews et al. 2011); there is also photo-identification evidence of killer whale movements between southern Newfoundland and the Gulf, to southern Labrador waters (e.g., Lawson and Stevens 2014; Lawson, et al. 2007).

6.9 Effects Assessment-Marine Mammals and Sea Turtles

6.9.1 Potential Pathways

- Add potential for injury and mortality if ships, especially those with ice-breaking capabilities, traverse the pupping, nursing and moulting habitats of ice associated seals.
- Add potential pathway for impacts on prey quality (through displacement or changes in the food web) or toxicology risks (through tainting prey with petrochemical products or dispersants entering the food chain).

6.9.2 Overview of Effects

- Add Heide-Jørgensen et al. (2013) – seismic exploration likely increasing risks of ice entrapments by delaying migration timing.
- Add to vessel movement: Wilson et al. (2017) risks to ice breeding seals of ice breaks transiting through their pupping and nursing areas.
- Add to movement of supply vessels and aircraft: low flying aircrafts and helicopters have led to mass abandonments of haul outs by seals and walrus.

- When discussing the temporal scope of impacts the authors should also include a section on seasonal timing – e.g., is most activity happening during the winter, summer or constant throughout the year? Seasonal aspects will also affect how many and what species of marine mammals and turtles are impacted.
- Many of the geophysical impacts described haphazardly in Table 6.4, are also summarised in relevant review articles such as Gomez et al. (2016).
- Page 6-47: *"a seismic survey program, which can last just weeks to complete a survey"*. In most cases, in this region exploratory or 4D seismic survey last multiple months, with underwater noise fields overlapping with concurrent surveys in the region, and over multiple years.

6.9.3 Mitigation Measures for Marine Mammals and Sea Turtles

- Table 6.5 and accompanying text: A number of the "Standard" mitigation measures will likely be changed in the current update process for the Canadian Statement of Best Practices.

6.9.4.2 Important Areas and Timing for Marine Mammals and Sea Turtles

- When discussing timing for seals, be sure to mention that pupping, nursing, and moulting also happen in the late winter and early spring for the ice-associated seals. These are very important time periods and need to be mentioned explicitly.
- Further, it must be acknowledged that ice coverage and timing are being impacted by climate change in the Study Area. For example, the range and seasonal occupancy of a number of cetacean species is likely affected by such changes in sea ice cover-as evidenced by surveys and traditional knowledge. Such changes in species' distributions could change the possible exposure to anthropogenic stressors and resultant impacts.

6.10 Data Gaps for Marine Mammals and Sea Turtles

- There are many more recent references the authors can use in this section when talking about data gaps, especially when talking about climate change impacts. This section seems to select only a few random examples to discuss data gaps for this species assemblage.

8.0 Sensitive Areas

- The organization of some sections was not well suited to efficiently presenting relevant information. For example, this chapter would benefit from a reorganization that classifies sensitive areas based on the ecological variable(s) of interest rather than the management tool used to characterize/protect them. The existing organization results in confusion between the type of ecological feature associated with a particular location, and the management tool used to afford protection to some of those locations. For example, the Laurentian Channel MPA (outside the Labrador Shelf Offshore Area, and hence not featured in this report) and the Northeast Newfoundland slope Marine Refuge both have the protection of sea pens as a key conservation objective, but the management tool used to provide protection is different (MPA versus Fisheries Closure). Furthermore, the choice of management tool is more a function of the management context (when it was defined, legislation/policies at the time, stakeholder concerns/involvement, etc.) than the type of ecological feature. However, a proper assessment of oil and gas impacts needs to focus on the type of ecological/biological features being impacted, not the management tool used to protect them. Deep-water corals will be equally impacted irrespective of their sensitive area designation (e.g., MPAs, Marine Refuges versus no legal protection). By confounding ecological features with management measures, the Update adds unnecessary complexity

to what locations in the Labrador Shelf Offshore Area contain ecological/biological features which are particularly important and/or vulnerable to oil and gas activities.

- Figure 8-1: presents some biological/ecologically relevant areas (DFO EBSAs, CBD EBSAs) and some of the spatial management tools which are in place. However, it does not include the SBAs, which are areas of particular significance in the context of oil and gas impacts because these correspond to habitats with high concentrations of corals and sponges. Their absence in this figure is problematic because these areas are presented in Chapter 5 as part of the description of corals and sponges, and there is no explanation provided as to why they were considered not relevant to display in this figure. Instead the authors state that this information is provided earlier in the report and miss an opportunity to provide an integrative and complete picture of sensitive areas. Also, the provincial protected areas are not indicated on this map.
- The definition of a “sensitive area” is confusing and lacks a reference or explanation of from where it originates. The list of conditions to be considered for a sensitive area should include an “or” as any single element of the list makes an area sensitive. Without proper explanation on the definition and origin the term “sensitive area” is not clear.
- The coral protection zone (voluntary fishing closure) depicted in the Hatton Basin Marine Refuge is no longer relevant since the area became a marine refuge (Figure 8-1).
- Section 8.1.1.1. Header says: “Marine Protected Areas and Areas of Interest”, but only the Gilbert Bay MPA is mentioned. Since the Nunatsiavut Government and DFO has shown interest in the Labrador Coastal area as a potential AOI (DFO 2021a), that should also be described here.
- “The SBAs were determined using a kernel density estimation, a quantitative analyses technique applied to RV data to identify sponge, coral, and sea pen catches”: This technique does not identify coral and sponge catches. It identifies significant concentrations of these organisms. Sea pens are corals too.

8.1 Regulatory Framework

8.1.1 Federally Designated Sensitive Areas

- The definition of a bioregion within this section is out of place. This is a critical piece of information when describing the ecosystem and would be better placed in a section where the ecosystem structure is described.
- EBSAs and SBAs are not defined or introduced in this section. They are mentioned previously but the concepts are important in the following sections. These two designations of sensitive habitat are different but also critical to understand. They play important role in informing which areas should be protected. They also help explain the types of activities that will be the most detrimental to the species within these habitats.
- This section is organized with the closures presented before the biologically important areas. This does not flow logically. SBAs and EBSAs should be presented first as they help to explain some of the reasons why these areas have been selected for protection.
- This section does not mention VME habitats which is a designation defined by Food and Agriculture Organization (FAO) and used by NAFO for vulnerable marine ecosystems. This designation is important as it plays an important role as SBAs and a portion of the SEA Update area is outside of Canada’s Exclusive Economic Zone (EEZ) and subject to NAFO designations.

- *"A number of sills created during the spring run-off separate Gilbert Bay…"*: Presumably sills were created by glaciers and become a factor during spring run off?
- *"Fishing activities in areas outside the MPA boundaries is the greatest potential threat to Gilbert Bay cod (DFO 2013a)"*: While this is correct it seems contradictory to the statement two paragraphs above which states: "*Tagging and tracking of the Gilbert Bay cod have confirmed they remain in the bay year-round (DFO 2005b)"*. Some Gilbert Bay cod do leave the MPA and are caught in areas where they mix with offshore stocks.

8.1.1.2 Marine Refuge Areas

- The descriptions of the Marine Refuge Areas that overlap with the SEA Update area are all very short and cursory. It is important to describe not only the biological features that make up these areas, but also the physical area. Important details about their history and rationale for designation are also missing. This information is important as some of these areas were designated to protect species that have higher risk to oil and gas. These areas also have different protections in place depending on the conservation objectives.
- An improved description of what EBSAs are and how they are defined should be incorporated. A reference is included, but a description is needed in the text. These areas are important because of their ecology and sensitivity. This information is critical to the process of designating Marine Refuges and the areas do not always coincide.
- Hatton Basin is known for significant concentrations of large gorgonians and sponges, not so much for small gorgonians.

8.1.1.3 EBSAs

- While the first sentence of this section is correct, it leaves out the context of the second part of the bullet on which it was referenced (DFO 2005) about EBSA identification *"facilitat[ing] provision of a greater-than-usual degree of risk aversion in management of activities in such areas"*. This context is important to include given the statement in Section 8.0 that says *"the description of an area as a sensitive area … does not automatically imply that this area will require the application of non-typical mitigations or restrictions on activities".*
- There are 29 EBSAs within the Newfoundland and Labrador Shelves Bioregion (Wells et al. 2017; Wells et al. 2019), not 25.
- There are actually 13 EBSAs in the Update Area; Southern Pack Ice (Wells et al. 2017) has been omitted from this section. Additionally, the Straight of Belle Isle EBSA was identified through a different process for the Estuary and Gulf of St. Lawrence Bioregion. This point should be clarified in the text.
- Information on the scientific process behind how these EBSAs were identified and their importance to the broader ecosystem should be included. This will require referencing processes from two different bioregions (NL Shelves and Estuary and Gulf of St. Lawrence [Straight of Belle Isle EBSA]).A reference to Figure 8-1 is missing in this section.
- Table 8.2 has generally identified the key biological features; however, it should be double-checked for omissions (e.g. unique land fast ice habitat missing from Nain Area EBSA) and other important attributes as described in Wells et al. (2017). Additionally, more information could be given on the physical features, including whether the EBSA is coastal/offshore/both and emphasis on the physical habitat (e.g., underwater features; see Figure 6 in Wells et al. 2017).

- What about sensitive areas down current from the LSSUA? They could be impacted from oil and gas operations.

8.1.1.4 SBAs

- The SBAs section is short and does not convey the importance of these areas. These habitats are significant as, along with being composed of long-lived species, they create habitat for many other species.
- The sentence regarding SBAs identifying *"key marine species distribution"* and *"indicate areas of future restoration activities"* was incorrectly interpreted from a paragraph in Kenchington et al. (2016) recommending further analyses of anthropogenic pressures in SDMs and is not related to SBAs themselves.
- DFO (2013b) is not the correct reference for the ERAF definition of SBAs.
- In the document they state *"The SBAs identified within the Labrador Shelf SEA Update Area are primarily related to aggregations of small and large gorgonian corals"*. This is not correct, the largest SBAs are aggregations of sponges followed by large gorgonian corals. This is important as these species are sensitive to oil and gas development.

8.1.1.5 National Parks and Historic Sites

- *"Many species have low populations…"*: Ambiguous terminology. Presumably low population abundance is intended?
- *"Common marine life includes whales, seals, Arctic char, and Atlantic salmon (Nature Canada 2007)"*: Where are Atlantic salmon common in the Torngats?
- *"The upper portion of the Eagle River in the Mealy Mountains is a productive salmon river (Parks Canada 1976)"*: Given this is a marine focused document, it would be worth mentioning whether there are other diadromous species of fish in these rivers (e.g., brook trout, eels, smelt etc.).

8.1.3.3 Internationally Identified EBSAs

- *"This area is located in offshore waters of the Labrador Shelf, extending northward from the Labrador Sea towards the mouth of Baffin Bay (CBD 2018)"*: It's worth noting that the western boundary is defined by Canada's EEZ and not necessarily the limits of the important deepwater convection processes.

8.2 Effects Assessment-Sensitive Areas

- Page 8-12: there are relevant/recent publications that could be used for this section (e.g., Cordes et al. 2016).

8.2.4 Environmental Planning Considerations for Sensitive Areas

- Page 8-15: it should be explicitly mentioned that majority of data/knowledge on corals and sponges is from DFO trawl surveys and only represents information from *"trawlable substrates"*.
- There are large knowledge gaps on other habitat types and species from these habitats.
- Coastal areas are not surveyed by DFO.
- DFO does not survey northern Labrador; only NSRF survey, and this survey does not have the same rigor as DFO multispecies surveys (e.g., training, staff, mandate, etc.).

- DFO surveys do cover southern Labrador but historically less frequent; due to distance, weather and vessel availability.

8.3 Data Gaps

- There is no reference to aquatic invasive species in any of the reviewed sections of the document. This is of particular importance when discussing the risk associated with the movement of equipment to and from oil and gas sites. The introduction of aquatic invasive species can have wide spread and detrimental impact to the ecosystem, and proper mitigation techniques must be considered. It is also an important issue to consider early in development because the risk of introduction can be high in the early stages of development and once species are introduced rectification is difficult and often impossible.

9.0 Commercial, Recreational, and Indigenous Fisheries

9.2 Commercial Fishing

9.2.9 Sealing

- The text says that harp and hooded seals are the seals most frequently harvested, but then the table includes only numbers of harp and grey seals. Is it possible to add hooded seal harvest data as well?
- The document states that commercial harvesting takes place between November and June. This is incorrect-the harvesting is closed during the pupping and nursing period.
- Page 9-4: The report states *"shellfish species like Northern Shrimp and Snow Crab became, and still are the primary species harvested in offshore NL".* This is not supported by the figure presented (Figure 9-2) where in 2019 'Shrimp and Snow Crab' are at a similar level to 'Other Species'.
- Page 9-7: It is not clear what the units are for Table 9.1.
- Page 9-8 and 9-9, in Table 9.2 and Table 9.3: Is the information for Icelandic Scallop being withheld between 2013 and 2017? If so, the total should not be the sum, and thus left blank.
- Page 9-7 to 9, in Table 9.1 to 9.3: It would be valuable to list all fisheries even if data is not available for all of them.
- The projection of the maps presenting the spatial and temporal distribution changes part way through the section. This makes it difficult to compare maps in different parts of the section.
- In Figure 9-33 and Figure 9-34: Redfish, is that recorded by-catch that is being presented? It is mentioned that this fishery is under moratorium so it should be clear what is being presented in the maps. This misrepresents the data making it appear that there is an active fishery on Redfish.

10.0 Human Use

10.2 Traditional and Cultural Activities

10.2.1.3 Current Activities

- Are there any newer studies to update the information and compare with the results from the 1997 references – e.g., has use of the land, traditional hunting of specific species, etc. increased, decreased or remained stable over the last decades?

- Figure 10-1 and other figures: the authors should add a locator map into this figure to show where in Labrador this primary map is situated.
- Figure 10-1 and other figures: the size of map objects (font size in legends, point size) should be increased and the resolution of the map is poor.

10.2.1.4 and 10.2.2.4 Marine Mammal Harvesting

- There are six species of seals in Labrador-which of these species does this *"seal hunting"* refer to?

10.2.3.4 Marine Mammal Harvesting

- The authors use multiple names for the same species. In one sentence of this section the name *"jar seals"* is used and in the next sentence Ringed Seals. Names should be as consistent as possible within this document (and at least within a section). This section is also the first-time rangers and uppers are mentioned. The authors need to define which species these are.

10.4.1 Marine Research

- This section is short and is missing key details on regular marine research that is occurring. It also does not reference the single mission, or short term research trips that also occur based out of DFO and in partnership with other organizations. For example, multi-year research programs on the coast of Labrador (ISICLE-Integrated Studies In Coastal Labrador Ecosystems) and in deep ocean areas of the Labrador Sea (ISECOLD-Integrated Studies and Ecosystem Characterization of the Labrador Deep Sea) are ongoing in partnership with the Nunatsiavut Government.
- The DFO RV survey is not directly mentioned in the text (there is a figure with transects). Key information that is missing is the scope, timing, targets, and general utilization of the data. The data from this survey does more than inform stock assessments, it has been integral in the designation of EBSAs and SBAs, used in ecosystem-based research, and used by researchers around the world. Excluding this information makes it appear that less research is occurring in the area.
- There is no reference to coastal marine research programs. DFO has a range of these programs along with others. These programs are important to our ecological understanding of the region.
- There's nothing at all in this section regarding cetaceans, pinnipeds, or sea turtles.
- For pinnipeds-there is winter seal sampling every year and also collectors in some of the northern communities.
- In addition to ongoing aerial surveys and acoustic recording by DFO Science, there is opportunistic genetic sampling of cetaceans by hunters and Fisheries Officers in Labrador.

11.0 Cumulative Environmental Effects

11.2 Cumulative Environmental Effects Interactions

- The review of literature and applicable methodologies to assess cumulative impacts for marine mammals, or any species really, is limited in scope and relevance. DFO, other Canadian federal agencies, and international researchers have done much in the last few years to develop approaches to assess net impacts from multiple anthropogenic stressors.

These should be better cited in this section and better addressed in activity-specific EAs. To list a small number:

- Donovan et al.(2017)
- Hawkins et al. (2017)
- Hegmann et al. (1999)
- Lesage et al. (in press)[4]
- MacDonald (2000)
- Moore et al. (2012)
- Murray et al. (2020)

- Table 11.1: *"change in habitat quality"* is listed as a potential cumulative impact for fish and fish habitat-but not for marine mammals and sea turtles and marine birds. This important point needs to be added to the latter two groups.
- Table 11.1*: "…may cause a change in habitat quality…"* is already listed as a residual impact. This point also needs to be added to the last column.

Conclusions

- A SEA serves as a critical document that will assist the C-NLOPB in determining whether exploration rights should be offered in whole or in part within the Labrador Shelf Offshore Area and may identify general restrictive or mitigation measures that should be considered for application to exploration activities. Consequently, it is important that such a document is of high quality to provide sufficient information and context to inform evidence-based decision making, and establish appropriate guide posts (criteria, standards, guidelines) for subsequent project-specific Environmental Assessments.
- A SEA Update provides a shared opportunity to not only update existing technical content, but also learn from previous SEA and EA documents, incorporate modern scientific approaches and standards, and improve the quality in order to ensure science-based decision making and mitigation is of the highest quality for this industry.
- The Labrador Shelf Offshore Area is oceanographically and biologically complex and its structure and function are a challenge to capture. Notwithstanding, the scope and attention to detail in the revision have not adequately advanced the Update over the original 2008 SEA document, nor corrected shortcomings and deficiencies already identified by DFO Science in its review of the original 2008 SEA document.
- In response to Objective 1: Is the information provided for the existing environment of the Labrador Shelf Offshore Area accurate at the broad-scale (i.e., macro level) and based on the most recent information available? The Labrador Shelf Offshore Area SEA Update does not provide the most recent information in many areas of the document and in some cases the information provided is not accurate.
- In response to Objective 2: Are there any key species and/or environmental features of the Labrador Shelf Offshore Area that have not been included in the report that would improve understanding of the existing environment at a strategic environmental assessment broad-

[4] Lesage, V., Lawson, J.W., and Gomez, C. In Prep. Cumulative Ecological Risk Assessment Framework (CERAF) to quantify impacts from marine development projects on marine mammals and sea turtles. Department of Fisheries and Oceans. DFO Can. Sci. Advis. Sec. Res. Doc.

scale (i.e., macro level)? The Labrador Shelf Offshore Area SEA Update is missing key taxa, and lacks information on important areas and critical physical and ecological processes.

- Only with substantial corrections, additions to content, and editing, will this document have the potential to serve the intended purpose as a planning tool for decision-makers to identify the potential issues and opportunities that may be associated with a plan, program, or policy proposal, and positively affect the quality of subsequent project-specific EAs.

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Sources of Information

AMEC Foster Wheeler. 2017. ARP Pilot Area 4 Climatological Report: Port Hawkesbury and the Strait of Canso. Environment and Climate Change Canada.

Austin, R.A., Hawkes, L.A., Doherty, P.D., Henderson, S.M., Inger, R., Johnson, L., Pikesley, S.K., Solandt, J.-L., Speedie, C., and Witt, M.J. 2019. Predicting habitat suitability for basking sharks (*Cetorhinus maximus*) in UK waters using ensemble ecological niche modelling. J. of Sea Res. 153:101767.

Baker, K., Mullowney, D., Pedersen, E., Coffey, W., Cyr, F. and Belanger, D. 2021 An Assessment of Newfoundland and Labrador Snow Crab (*Chionoecetes opilio*) in 2018. DFO Can. Sci. Advis. Sec. Res. Doc. 2021/028. viii + 180 p.

Bangley, C., and Rulifson, R. 2014. Observations on spiny dogfish (*Squalus acanthias*) captured in late spring in a North Carolina estuary [version 2; peer review: 2 approved]. F1000Research 3:189.

Bangley, C.W. 2011. Food and feeding habits of the spiny dogfish *Squalus acanthias* overwintering off the coast of North Carolina and the effects on the marine community. Masters Thesis. East Carolina University.

Bayse, S.M., and Grant, S.M. 2020. Effect of baiting gillnets in the Canadian Greenland halibut fishery. Fish. Manag. Eco. 27(5):523-530.

Beacham, T. 1983. Variability in size or age at sexual maturity of white hake, pollock, longfin hake, and silver hake in the Canadian Maritimes area of the Northwest Atlantic Ocean. Can. Tech. Rep. Fish. Aquat. Sci. 1157.

Bergstad, O.A., Hansen, H.Ø., and Jørgensen, T. 2013. Intermittent recruitment and exploitation pulse underlying temporal variability in a demersal deep-water fish population. ICES J. Mar. Sci. 71(8):2088-2100.

Bianucci, L., Fennel, K., Chabot, D., Shackell, N., and Lavoie, D. 2016. Ocean biogeochemical models as management tools: a case study for Atlantic wolffish and declining oxygen. ICES J. Mar. Sci. 73(2):263-274.

Bizzarro, J.J., Carlisle, A.B., Smith, W.D., and Cortés, E. 2017. Chapter Four – Diet Composition and Trophic Ecology of Northeast Pacific Ocean Sharks. Adv. Mar. Bio. 77:111-148.

Block, B.A., Whitlock, R., Schallert, R., Wilson, S., Stokesbury, M.J.W., Castleton, M., and Boustany, A. 2019. Estimating Natural Mortality of Atlantic Bluefin Tuna Using Acoustic Telemetry. Scientific Reports 9:4917.

Bradbury, I.R., Hamilton, L.C., Rafferty, S., Meerburg, D., Poole, R., Dempson, J.B., Robertson, M.J., Reddin, D.G., Bourret, V., Dionne, M., Chaput, G., Sheehan, T.F., King, T.L., Candy, J.R., and Bernatchez, L. 2015. Genetic evidence of local exploitation of Atlantic salmon in a coastal subsistence fishery in the Northwest Atlantic. Can. J. Fish. Aquat. Sci. 72:83-95.

Bradbury, I.R., Lehnert, S.J., Messmer, A., Duffy, S.J., Verspoor, E., Kess, T., Gilbey, J., Wennevik, V., Robertson, M., Chaput, G., Sheehan, T., Bentzen, P., Dempson, J.B., and Reddin, D. 2021. Range-wide genetic assignment confirms long-distance oceanic migration in Atlantic salmon over half a century. ICES J. Mar. Sci. fsaa152.

Bryk, J.L., Hedges, K.J., and Treble, M.A. 2018. Summary of Greenland Shark (*Somniosus microcephalus*) catch in Greenland Halibut (*Reinhardtius hippoglossoides*) fisheries and scientific surveys conducted in NAFO Subarea 0. NAFO SCR Doc. 18/041.

Byrne, M.E., Cortés, E., Vaudo, J.J., Harvey, G.C.M.N., Sampson, M., Wetherbee, B.M., Shivji, M. 2017. Satellite telemetry reveals higher fishing mortality rates than previously estimated, suggesting overfishing of an apex marine predator. Pro. R. Soc. B. 284:20170658.

Caesar, L., McCarthy, G.D., Thornalley, D.J.R., Cahill, N., and Rahmstorf, S. 2021. Current Atlantic Meridional Overturning Circulation weakest in last millennium. Nat. Geosci. 14:118-120.

Campana, S.E., Dorey, A., Fowler, M., Joyce, W., Wang, Z., Wright, D., and Yashayaev, I. 2011. Migration Pathways, Behavioural Thermoregulation and Overwintering Grounds of Blue Sharks in the Northwest Atlantic. PLoS ONE 6(2): e16854.

Campana, S.E., Fisk, A.T., and Klimley, A.P. 2015a. Movements of Arctic and northwest Atlantic Greenland sharks (*Somniosus microcephalus*) monitored with archival satellite pop-up tags suggest long-range migrations. Deep Sea Research Part II. 115:109-115.

Campana, S.E., Fowler, M., Houlihan, D., Joyce, W., Showell, M., Miri, C., and Simpson, M. 2015b. Current Status and Threats to the North Atlantic Blue Shark (*Prionace glauca*) Population in Atlantic Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/026. v + 44 p.

Campana, S.E., Fowler, M., Houlihan, D., Joyce, W., Showell, M., Simpson, M., Miri, C., and Eagles, M. 2015c. Recovery Potential Assessment for Porbeagle (*Lamna nasus*) in Atlantic Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/041. iv + 45 p.

Campana, S.E., Joyce, W., Fowler, M., and Showell, M. 2016. Discards, hooking, and post-release mortality of porbeagle (*Lamna nasus*), shortfin mako (*Isurus oxyrinchus*), and blue shark (*Prionace glauca*) in the Canadian pelagic longline fishery. ICES J. Mar. Sci. 73(2):520-528.

Carscadden, J.E., Gjøsæter, H., Vilhjálmsson, H. 2013. A comparison of recent changes in distribution of capelin (*Mallotus villosus*) in the Barents Sea, around Iceland and in the Northwest Atlantic. Progr. Oceanogr. 114:64–83

Chen, Y., and Runnebaums, J. 2014. A preliminary study for Improving survivability of cusk bycatch in the Gulf of Maine lobster trap. University of Maine. Nat. Mar. Fish. Ser.

Collette, B., Fernandes, P., and Heessen, H. 2015a. Atlantic Wolffish–*Anarhichas lupus*. The IUCN Red List of Threatened Species: e.T18155993A44739312

Collette, B. Fernandes, P., and Heessen, H. 2015b. Northern Wolffish–*Anarhichas denticulatus*. The IUCN Red List of Threatened Species: .e.T18155990A44739291

Collette, B., Fernandes, P., and Heessen, H. 2015c. Spotted Wolffish–*Anarhichas minor*. The IUCN Red List of Threatened Species: e.T18263655A44739959

Collins, R.K., Simpson, M.R., Miri, C.M., Mello, L.G.S., Chabot, D., Hedges, K., Benoît, H., and McIntyre, T.M. 2015. Assessment of Northern Wolffish, Spotted Wolffish, and Atlantic Wolffish in the Atlantic and Arctic Oceans. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/034. iv + 86 p.

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., Gates, A.R., Génio, L., Gobin, J., Henry, L.-A., Herrera, S., Hoyt, S., Joye, M., Kark, S., Mestre, N.C., Metaxas, A., Pfeifer, S., Sink, K., Sweetman, A.K., and Witte, U. 2016. Environmental Impacts of the Deep-Water Oil and Gas Industry: A Review to Guide Management Strategies. Front. Environ. Sci. 4:58

Cortés, E., and Semba, Y. 2020. Estimates of vital rates and population dynamics parameters of interest for porbeagle shark in the Western North Atlantic and South Atlantic oceans. Collect. Vol. Sci. Pap. ICCAT, 77(6): 118-131

COSEWIC. 2017. COSEWIC assessment and status report on the Lumpfish *Cyclopterus lumpus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 78 pp.

COSEWIC. 2018. COSEWIC assessment and status report on the Roughhead Grenadier *Macrourus berglax* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 38 pp

Coté, D., Gregory, R.S., Morris, C.J., Newton, B.H., and Schneider, D.C. 2013. Elevated habitat quality reduces variance in fish community composition. J. Experi. Mar. Bio. Eco., 440: 22-28

Coté, D., Heggland, K., Roul, S., Robertson, G., Fifield, D., Wareham, V., Colbourne, E., Maillet, G., Devine, B., Pilgrim, L., Pretty, C., Le Corre, N., Lawson, J.W., Fuentes-Yaco, C. and Mercier, A. 2019. Overview of the biophysical and ecological components of the Labrador Sea Frontier Area. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/067. v + 59 p.

Cote, D., Morris, C.J., Regular, P.M., and Piersiak, M.G. 2020. Effects of 2D Seismic on Snow Crab movement behavior. Fisheries Research 230:105661

Crowe, L.M., O'Brien, O., Curtis, T.H., Leiter, S.M., Kenney, R.D., Duley, P., and Kraus, S.D. 2018. Characterization of large basking shark *Cetorhinus maximus* aggregations in the western North Atlantic Ocean. J. Fish Bio. 92(5): 1371-1384

Curtis, T.H. 2017. Status Review Report: Thorny Skate (*Amblyraja radiata*). Final Report to National Marine Fisheries Service, Office of Protected Resources. February 2017. 60 pp.

Curtis, T., McCandless, C.T., Carlson, J.K., Skomal, G.B., Kohler, N.E., Natanson, L.J., Burgess, G.H., Hoey, J.J., and Pratt Jr., H.L. 2014. Seasonal Distribution and Historic Trends in Abundance of White Sharks in the Western North Atlantic Ocean. PLoS ONE 9(6): e99240

da Silva, T.E.F., Lessa, R., and Santana, F.M. 2021. Current knowledge on biology, fishing and conservation of the blue shark (*Prionace glauca*). Neotropical Biology and Conservation 16(1):71-88

Delaval, A., Dahle, G., Knutsen, H., Devine, J., Gro Vea Salvanes, A. 2017. Norwegian fjords contain sub-populations of roundnose grenadier *Coryphaenoides rupestris*, a deep-water fish. MEPS, 586: 181-192

Dell'Apa, A., Cudney, J., Kimmel, D., and Rulifson, R. A. 2014. Sexual Segregation of Spiny Dogfish in Fishery-Dependent Surveys in Cape Cod, Massachusetts: Potential Management Benefits. Transactions of the American Fisheries Society.143(4)

Dempson, J.B. 1995. Trends in population characteristics of an exploited anadromous Arctic charr, *Salvelinus alpinus*, stock in northern Labrador. Nordic. J. Freshw. Res. 71: 197-216

Dempson, J.B., and Green, J.M. 1985. Life history of anadromous Arctic charr, *Salvelinus alpinus*, in the Fraser River, northern Labrador. Can. .J Zool. 63:315-324

Dempson, J.B., and Kristofferson, A.H. 1987. Spatial and temporal aspects of the ocean migration of anadromous Arctic char. Am. Fish. Soc. Symp. 1: 340-357

Dempson, J.B., Shears, M., and Bloom, M. 2002. Spatial and temporal variability in the diet of anadromous Arctic charr, *Salvelinus alpinus*, in northern Labrador. Environ. Biol. Fish. 64: 49-62

Dempson, J.B., Shears, M., Furey, G., and Bloom, M. 2004. Review and status of north Labrador Arctic charr, *Salvelinus alpinus*. DFO Can. Sci. Advis. Sec. Res Doc 2004/070.

Dempson, J.B., Shears, M., Furey, G., and Bloom, M. 2008. Resilience and stability of north Labrador Arctic charr, *Salvelinus alpinus*, subject to exploitation and environmental variability. Environ. Biol. Fish. 82: 57-67

den Heyer, C.E., Don Bowen, W., Dale, J., Gosselin, J-F., Hammill, M.O., Johnston, D.W., Lang, S.L.C., Murray, K.T., Stenson, G.B., and Wood, S.A. 2020. Contrasting trends in gray seal (*Halichoerus grypus*) pup production throughout the increasing northwest Atlantic metapopulation.

DFO. 1996. Eastern Cape Breton Toad Crab. DFO Can. Sci. Stock. Stat. Rep. 1996/038

DFO, 2004. Identification of Ecologically and Biologically Significant Areas. DFO Can. Sci. Advis. Sec. Ecosystem Status Rep. 2004/006.

DFO. 2014a. Science Review of the Eastern Newfoundland Strategic Environmental Assessment (SEA). DFO Can. Sci. Advis. Sec. Sci. Resp. 2014/035.

DFO. 2014b. Update to the Recovery Potential for Cusk in Canadian Waters. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/048.

DFO. 2014c. Assessment of Spiny Dogfish in the Northwest Atlantic. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/055.

DFO. 2015. Wolffish in the Atlantic and Arctic regions. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/022.

DFO. 2016a. Northwest Atlantic Spiny Dogfish Stock Status Update Report. DFO Can. Sci. Advis. Sec. Sci. Resp. 2016/019.

DFO. 2016b. Recovery Potential Assessment for White Hake (*Urophycis tenuis*): Population of the Atlantic and Northern Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/035.

DFO. 2017a. Status of Cusk (*Brosme brosme*) in North Atlantic Fisheries Organization (NAFO) Divisions 4VWX5Z Under the Precautionary Approach Framework. DFO Can. Sci. Advis. Sec. Sci. Resp. 2017/005.

DFO. 2017b. Status Updates for Thorny Skate in the Canadian Atlantic and Arctic Oceans and Smooth Skate (Laurentian-Scotian and Funk Island Deep Designatable Units). DFO Can. Sci. Advis. Sec. Sci. Resp. 2017/011.

DFO. 2017c. Recovery Potential Assessment for Winter Skate (*Leucoraja ocellata*): Eastern Scotian Shelf and Newfoundland Population. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2017/014.

DFO. 2017d. Recovery Potential Assessment of Winter Skate (*Leucoraja ocellata*): Gulf of St. Lawrence population. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/059.

DFO. 2018. Stock Assessment of Newfoundland and Labrador Atlantic Salmon – 2017. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2018/034. (Erratum: September 2018)

DFO. 2019. Stock assessment of Northern cod (NAFO Divisions 2J3KL) in 2019. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2019/050.

DFO. 2020a. Review of the Impact Assessment Agency's Draft Regional Assessment of Offshore Oil and Gas Exploratory Drilling East of Newfoundland and Labrador. DFO Can. Sci. Advis. Sec. Sci. Resp. 2020/033.

DFO. 2020b. An Assessment of Iceland Scallop (*Chlamys islandica*) in the Strait of Belle Isle. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/009.

DFO. 2020c. Update of the Status of Cusk (*Brosme brosme*) in NAFO Divisions 4VWX5Z for 2019. DFO Can. Sci. Advis. Sec. Sci. Resp. 2020/020.

DFO. 2020d. 2019 Status of Northwest Atlantic Harp Seals, *Pagophilus groenlandicus*. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/020.

DFO. 2021a. Biophysical and Ecological Overview of a Study Area within the Labrador Inuit Settlement Area Zone. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2021/003.

DFO. 2021b. Assessment of Newfoundland and Labrador (Divisions 2HJ3KLNOP4R) Snow Crab. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2021/009.

Donovan, C.R., Harris, C.M., Milazzo, L., Harwood, J., Marshall, L., and Williams, R. 2017. A simulation approach to assessing environmental risk of sound exposure to marine mammals. Ecology and Evolution. 7(7): 2101-2111

Dutil, J.-D., Proulx, S., Chouinard, P.M., Borcard, D., and Larocqu, R. 2013. Distribution and environmental relationships of three species of wolffish (*Anarhichas spp.*) in the Gulf of St. Lawrence. Aquatic Conservation: Marine and Freshwater Ecosystems 24(3):351-368

Edwards, J.E., Hiltz, E., Broell, F., Bushnell, P.G., Campana, S.E., Christiansen, J.S., Devine, B.M., Gallant, J.J., Hedges, K.J., MacNeil, M.A., McMeans, B.C., Nielsen, J., Præbel, K., Skomal, G.B., Steffensen, J.F., Walter, R.P., Watanabe, Y.Y., VanderZwaag, D.L., and Hussey, N.E. 2019. Advancing Research for the Management of Long-Lived Species: A Case Study on the Greenland Shark. Front. Mar. Sci. 6(87)

Eliasen, K., Patursson, E.J., McAdam, B.J., Pino, E., Morro, B., Betancor, M., Baily, J., and Rey, S. 2020. Liver colour scoring index, carotenoids and lipid content assessment as a proxy for lumpfsh (*Cyclopterus lumpus* L.) health and welfare condition. Sci. Rep. 10:8927

Fairchild, E. A., Tallack, S., Elzey, S.P., and Armstrong, M.P. 2015. Spring feeding of Atlantic wolffish on Stellwagen Bank, Massachusetts. NAOO, 113 (2): 191-201 pp.

Ferguson, S.H., Higdon, J.W., and Chmelnitsky, E.G. 2010. The Rise of Killer Whales as a Major Arctic Predator. A Little Less Arctic. Springer, Dordrecht: 117-136 pp.

Fields, D.M., Handegard, N.O., Dalen, J., Eichner, C., Malde, K., Karlsen, Ø., Skiftesvik, A.B., Durif, C.M.F., and Browman, H.I. 2019. Airgun blasts used in marine seismic surveys have limited effects on mortality, and no sublethal effects on behaviour or gene expression, in the copepod *Calanus finmarchicus*. ICES J. of Mar. Sci. 76(7):2033–2044

Florindo-López, C., Bacon, S., Aksenov, Y., Chafik, L., Colbourne, E., and Holliday. N.P. 2020. Arctic Ocean and Hudson Bay Freshwater Exports: New Estimates from Seven Decades of Hydrographic Surveys on the Labrador Shelf, J. Climate. 33(20): 8849-8868

Fock, H., Werner, K.-M., and Stransky, C. 2020. Survey results of the German bottom trawl survey 1982-2019 with special reference to years 2016-2019. NAFO SCR Doc. 20/052

Fordham, S., Fowler, S.L., Coelho, R.O., Goldman, K., and Francis, K. 2016. *Squalus acanthias*, Spiny Dogfish. The IUCN Red List of Threatened Species 2016: e.T91209505A2898271

Francis, M.P., Shivji, M.S., Duffy, A.J., Rogers, P.J., Byrne, M.E., Wetherbee, B.M., Tindale, S.C., Lyon, W.S., and Meyers, M.M. 2019. Oceanic nomad or coastal resident? Behavioural switching in the shortfin mako shark (*Isurus oxyrinchus*). Marine Biology. 166(5).

Frisk, M.G., Martinez, C.M., McKown, K.A., Zacharias, J.P., and Dunton, K.J. 2019. First Observations of Long-Distance Migration in a Large Skate Species, the Winter Skate: Implications for Population Connectivity, Ecosystem Dynamics, and Management. Mari. Coast. Fish: Dyan. Man. Eco. Sci. 11: 202-212

Gaither, M.R., Gkafas, G.A., de Jong, M., Sarigol, F., Neat, F., Regnier, T., Moore, D., Gröcke, D. R., Hall, N., Liu, X., Kenny, J., Lucaci, A., Hughes, M., Haldenby, S., and Rus Hoelzel, A. 2018. Genomics of habitat choice and adaptive evolution in a deep-sea fish. Nat. Ecol. Evol. 2. 160-687

Gallant, J.J., Rodriguez, M.A., Stokesbury, M.J.W., and Harvey-Clarke, C. 2016. Influence of environmental variables on the diel movements of the Greenland Shark in the St. Lawrence Estuary. Can. Field. Nat. 130(1)

Gibson, K.J., Streich, M.K., Topping, T. S., and Stunz, G. W. 2021. New Insights Into the Seasonal Movement Patterns of Shortfin Mako Sharks in the Gulf of Mexico. J Front. Mar Sci. 8: 5pp.

Gomez, C., Lawson, J.W., Buren, A., Wright, A.J., Tollit, D., and Lesage, V. 2016. A systematic review and meta-analysis on the behavioural responses of wild marine mammals to man-made sounds: synthesis and recommendations for the future. *In* 4th International Marine Conservation Congress, St. John's, NL.

González-Costas, F., and Ramilo, G. 2019. Greenland sharks (*Somniosus microcephalus*) Spanish data (Surveys and Fishery) in NAFO Regulatory Area. NAFO SCR Doc. 19/030

González-Troncoso, D., Garrido, I., and Gago, A. 2020. Biomass and length distribution for roughhead grenadier, thorny skate, white hake, squid and capelin from the surveys conducted by Spain in NAFO 3NO. NAFO SCR Doc. 20/010

Grieve, B.D., Hare, J.A., and McElroy, W.D. 2020. Modeling the impacts of climate change on thorny skate on the Northeast US shelf using trawl and longline surveys. J. Fish. Ocean. 30(3): 300-314

Gunnarsson, A., Pampoulie, C., Skírnisdóttir, S., Daníelsdóttir. A,K., and Þorsteinsson, V. 2014. Genetic diversity, growth, maturity and migration of the Atlantic wolffish (*Anarhichas lupus*). Matis 9-13:6011-1991

Gunnarsson, A., Sólmundsson, J., Björnsson, H., Sigurðsson, G., and Pampoulie, C. 2019. Migration pattern and evidence of homing in Atlantic wolfish (*Anarhichas lupus*). J. Fish. Res. 215: 69-75

Hamelin, K.M., James, M.C., Ledwell, W., Huntington, J. and Martin, K. 2016. Incidental capture of leatherback sea turtles in fixed fishing gear off Atlantic Canada. J. Aquatic. Con. 27(3):631-642

Hammill, M.O., Stenson, G.B., Mosnier, A. and Doniol-Valcroze, T. 2021. Trends in abundance of harp seals, *Pagophilus groenlandicus*, in the Northwest Atlantic, 1952-2019. DFO Can. Sci. Advis. Sec. Res. Doc. 2021/006. iv + 30 p.

Hancock, D.A. 1963. Marking experiments with the commercial whelk (*Buccinum undatum*). Int. Comm. Northwest Atl. Fish. Spec. Publ. ICNAF 4:176-187.

Hare, J.A., Manderson, J.P., Nye, J.A., Alexander, M.A., Auster, P.J., Borggaard, D.L., Capotondi, A.M., Damon-Randall, K.B., Heupel, E., Mateo, I., O'Brien, L., Richardson, D.E., Stock, C.A., and Biegel, S.T. 2012. Cusk (*Brosme brosme*) and climate change: assessing the threat to a candidate marine fish species under the US Endangered Species Act. ICES. J. Mar. Sci. 69(10): 1753-1768

Harris, L.E., Greenlaw, M., McCurdy, Q., and MacDonald, D. 2018. Information on the Potential for Recovery of Cusk (Brosme brosme) in Canadian Waters. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/002. vi + 62 p.

Hawkins, E.R., Harcourt, R., Bejder, L., Brooks, L.O., Grech, A., Christiansen, F., Marsh, H., and Harrison, P.L. 2017. Best Practice Framework and Principles for Monitoring the Effect of Coastal Development on Marine Mammals. Front. Mar. Sci. 4(59)

Head, E., and Pepin, P. 2009. Long-term variability in phytoplankton and zooplankton abundance in the Northwest Atlantic in Continuous Plankton Recorder (CPR) samples. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/063. Vi +29 p.

Head, E.J.H., Melle, W., Pepin, P., Bagøien, E., and Broms, C. 2013. On the ecology of *Calanus finmarchicus* in the subarctic North Atlantic: A comparison of population dynamics and environmental conditions in areas of the Labrador Sea-Labrador/Newfoundland Shelf and Norwegian Sea Atlantic and coastal waters. Progr. Oceanogr. 114:46-63

Hedeholm, R., Nygaard, R., and Nogueira, A. 2018. Greenland shark in Greenland waters in NAFO Subarea 1 and ICES XIV. NAFO SCR Doc. 18/037

Hedeholm, R., Qvist, T., Nielsen, J., and Grønkjær, P. 2019. Temporal changes in size-at-maturity of black dogfish *Centroscyllium fabricii*. J. Fish. Bio. 95(3)

Hegmann, G., Cocklin, C., Creasey, R., Dupuis, S., Kennedy, A., Kingsley, L., Ross, W., Spaling, H., and Stalker, D. 1999. Cumulative Effects Assessment Practitioners guideline. Canadian Environmental Assessment Agency. xii + 71 + Appendices p.

Heide-Jørgensen, M.P., Hansena, R.G., Westdal, K., Reeves, R.R., and Mosbechd, A. 2013, Narwhals and seismic exploration: Is seismic noise increasing the risk of ice entrapments?. J. Bio. Con. 158: 50-54

Hendrickson, L. 2018. Greenland shark (*Somniosus microcephalus*) catches off the U.S. East Coast based on data from data from research surveys, fishery observer programs, logbooks and tagging programs conducted by the U.S. National Marine Fisheries Service. NAFO SCR Doc. 18/016

Hendrickson, L., Aker, J., Glindtvad, S., and Blasdale, T. 2018. Greenland shark (*Somniosus microcephalus*) catches in fisheries conducted in the Northwest Atlantic Fisheries Organization Regulatory Area. NAFO SCR Doc. 18/020REV2

Higdon, J.W., and Ferguson, S.H. 2009. Loss of Arctic sea ice causing punctuated change in sightings of killer whales (*Orcinus orca*) over the past century. Ecol. Appl. 19(5):1365-1375

Himmelman, J.H., and Hamel, J.R. 1993. Diet, behaviour and reproduction of the whelk *Buccinum undatum* in the northern Gulf of St. Lawrence, eastern Canada. Mar. Bio. 116(3):423-430.

Howey, L.A., Wetherbee, B.M., Tolentino, E.R., and Shivji, M.S. 2017. Biogeophysical and physiological processes drive movement patterns in a marine predator. Mov. Ecol. 5 (16)

ICCAT. 2017. Report of the 2017 ICCAT bluefin (western atlantic) stock assessment meeting. Stock Assess. Exec. Sum.

ICCAT. 2019. Report of the 2019 Shortfin Mako Shark stock assessment update meeting. ICCAT. Sci. Pap. 76:1-77

ICCAT. 2020. Report of the 2020 Porbeagle Shark stock assessment meeting. ICCAT. Sci. Pap. 77:1-88

ICES. 2019. Roundnose grenadier (*Coryphaenoides rupestris*) in subareas 1, 2, 4, 8, and 9, Division 14.a, and in subdivisions 14.b.2 and 5.a.2 (Northeast Atlantic and Arctic Ocean). ICES. Advis.

ICES. 2020. Spurdog (*Squalus acanthias*) in subareas 1–10, 12, and 14 (the Northeast Atlantic and adjacent waters). ICES. Advis.

ICES. 2021. Working Group on North Atlantic Salmon. ICES Sci. Rep. 3(29). 407 pp.

Johnston, E.M., Mayo, P.A., Mensink, P.J., Savetsky, E., and Houghton, J.D.R. 2019. Serendipitous re-sighting of a basking shark *Cetorhinus maximus* reveals inter-annual connectivity between American and European coastal hotspots. J. Fish. Bio. 95:1530-1534

Jourdain, E., Ugarte, F., Víkingsson, G., Samarra, F., Ferguson, S.H., Lawson, J.W., Vongraven, D., Prewitt, J., and Desportes, G. 2019. North Atlantic killer whale *Orcinus orca* populations: a review of current knowledge and threats to conservation. Mammal Rev. 49:384-400

Kenchington, E., Beazley, L., Lirette, C., Murillo, F.J., Guijarro, J., Wareham, V., Gilkinson, K., Koen Alonso, M., Benoît, H., Bourdages, H., Sainte-Marie, B., Treble, M., and Siferd, T. 2016. Delineation of Coral and Sponge Significant Benthic Areas in Eastern Canada Using Kernel Density Analyses and Species Distribution Models. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/093: vi + 178 pp.

Kennedy, J., Durif, C.M.F., Florin, A.-B., Fréchet, A., Gauthier, J., Hüssy, K., Þór Jónsson, S., Ólafsson, H.G., Post, S., and Hedeholm, R.B. 2018. A brief history of lumpfishing, assessment, and management across the North Atlantic. ICES. J. Mar. Sci. 76(1):181-191

Kneebone, J., Sulikowski, J., Knotek, R., McElroy, W.D., Gervelis, B., Curtis, T., Jurek, J., and Mandelman, J. 2020. Using conventional and pop-up satellite transmitting tags to assess the horizontal movements and habitat use of thorny skate in the Gulf of Maine. ICES. J. Mar. Sci. 77(7-8):2790-2803

Knotek, R., Kneebone, J., Sulikowski, J., Curtis, T., Jurek, J., and Mandelman, J. 2019. Utilization of pop-up satellite archival transmitting tags to evaluate thorny skate (*Amblyraja radiata*) discard mortality in the Gulf of Maine groundfish bottom trawl fishery. ICES. J. Mar. Sci. 77(1):256-266

Knutsen, H., Jorde, P.E., Berfstad, O.A., and Skogen, M. 2012. Population genetic structure in a deepwater fish *Coryphaenoides rupestris*: patterns and processes. Mar Ecol Prog Ser. 460:233-246

Kulka, D.W., Anderson, B., Cotton, C.F., Derrick, D., Pacoureau, N., and Dulvy, N.K. 2020. Winter Skate—*Leucoraja ocellata*: The IUCN Red List of Threatened Species. e.T161631A124518400

Kulka, D.W., Ellis, J., Anderson, B., Cotton, C.F., Derrick, D., Pacoureau, N., and Dulvuy, N.K. 2020. Thorny Skate—*Amblyraja radiata*: The IUCN Red List of Threatened Species: e.T161542A124503504

Kulka, D.W., Simpson, M.R., and Inkpen, T.D. 2003. Distribution and Biology of Blue Hake (*Antimora rostrata* Gunther 1878) in the Northwest Atlantic with Comparison to Adjacent Areas. J. NW. Atl. Fish. Sci. 31:299-318

Lapointe, V., and Sainte-Marie, B. 1992. Currents, predators, and the aggregation of the gastropod Buccinum undatum around bait. Mar. Ecol. Prog. Ser. 85:245-257.

Lawson, J.W., and Stevens, T. 2014. Historic and current distribution patterns, and minimum abundance, of killer whales (*Orcinus orca*) in the northwest Atlantic. J. Mar. Biol. Assoc. U.K. 6(94):1253-1265

Lawson, J.W., and Gosselin, J.-F. 2018. Estimates of cetacean abundance from the 2016 NAISS aerial surveys of eastern Canadian waters, with a comparison to estimates from the 2007 TNASS. NAMMCO Secretariat. SC/25/AE/09 for the NAMMCO Scientific Committee. 40 p

Lawson, J.W., Stevens, T., and Snow, D. 2007. Killer whales of Atlantic Canada, with particular reference to the Newfoundland and Labrador Region. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/062

Lawson, J.W., Gomez, C., Sheppard, G.L., Buren, A.D., Kouwenberg, A.-L., Renaud, G.A.M., and Moors-Murphy, H.B. 2017. Final Report : DFO Mid-Labrador Marine Megafauna Visual and Acoustic Study. Environmental Studies Research Fund. 142 p.

Layton, K.K.S, Dempson, B., Snelgrove, P.V.R., Duffy, S.J., Messmer, A.M., Paterson, I.G., Jeffery, N.W., Kess, T., Horne, J.B., Salisbury, S.J., Ruzzante, D.E., Bentzen, P., Coté, D., Nugent, C.M., Ferguson, M.M., Leong, J.S., Koop, B.F., and Bradbury, I.R. 2020. Resolving fine-scale population structure and fishery exploitation using sequenced microsatellites in a northern fish. Evol Appl 13(5):1055-1068

Le Corre, N., Pepin, P., Han, G., Ma, Z., and Snelgrove, P.V.R. 2019. Assessing connectivity patterns among management units of the Newfoundland and Labrador shrimp population Fisheries Oceanography. 28:183-202

Le Francois, N.R., Tremblay-Bourgeois, S., Cyr, B.A.D., Savoie, A., Roy, R.L., Imsland, A.K., and Benfey, T.J. 2013. Cortisol and Behavioral Response to Handling (Acute) and Confinement (Chronic) Stressors in Juvenile Spotted Wolffish, *Anarhichas minor*. J. App. Sci. 25(3):248-264

Lefort, K.J., Matthews, C.J.D., Higdon, J.W., Petersen, S.D., Westdal, K.H., Garroway, C.J., and Ferguson, S.H. 2020. A review of Canadian Arctic killer whale (*Orcinus orca*) ecology. Can. J. Zool. 98(4):245–253

Lemaire, B., Priede, I.G., Collins, M.A., Bailey, D.M., Schtickzelle, N., Thomé, J.-P., and Rees, J.-F. 2010. Effects of organochlorines on cytochrome P450 activity and antioxidant enzymes in liver of roundnose grenadier *Coryphaenoides rupestris*. Aquat. Biol. 8:161-168

Lieber, L., Graham, H., Hall, J., Berrow, S., Johnston, E., Gubili, C., Sarginson, J., Francis, M., Duffy, C., Wintner, S.P., Doherty, P.D., Godley, B.J., Hawkes, L.A., Witt, M.J., Henderson, S.M., de Sabata, E., Shivji, M.S., Dawson, D.A., Sims, D.W., Jones, C.S., and Noble, L.R. 2020. Spatio-temporal genetic tagging of a cosmopolitan planktivorous shark provides insight to gene flow, temporal variation and site-specific re-encounters. Sci. Rep. 10:1661

Lovejoy, C., Legendre, L., Martineau, M.-J., Bâcle, J., and von Quillfeldt, C. 2002. Distribution of phytoplankton and other protists in the North Water. Deep-Sea Res. II 49(22): 5027-5047

Lydersen, C., Fisk, A.T., and Kovacs, K.M. 2016. A review of Greenland shark (*Somniosus microcephalus*) studies in the Kongsfjorden area, Svalbard Norway. Polar Biology 39:2169-2178

MacCracken, J.G. 2012. Pacific Walrus and climate change: observations and predictions. Ecology and Evolution 2(9): 2072-2090

MacDonald, L.H. 2000. Evaluating and Managing Cumulative Effects: Process and Constraints. Environ. Manage. 26(3):299-315

Marancik, K.E., Richardson, D.E., and Konieczna, M. 2020. Updated Morphological Descriptions of the Larval Stage of Urophycis (Family: Phycidae) from the Northeast United States Continental Shelf. Copeia 108(1):83-90

Matthews, C.J.D., Luque, S.P., Petersen, S.D., Andrews, R.D., and Ferguson, S. 2011. Satellite tracking of a killer whale (*Orcinus orca*) in the eastern Canadian Arctic documents ice avoidance and rapid, long-distance movement into the North Atlantic. Polar Biol. 34(7):1091-1096

McCauley, R.D., Day, R.D., Swadling, K.M., Fitzgibbon, Q.P., Watson, R.A., and Semmens, J.M. 2017. Widely used marine seismic survey air gun operations negatively impact zooplankton. Nat. Eco. Evo. 1:0195

Montevecchi, W.A., Benvenuti, S., Garthe, S., Davoren, G.K., and Fifield, D. 2009. Flexible foraging tactics by a large opportunistic seabird preying on forage- and large pelagic fishes. MEPS 385:295-306

Moore, S.E., Reeves, R.R., Southall, B.L., Ragen, T.J., Suydam, R.S., and Clark, C.W. 2012. A New Framework for Assessing the Effects of Anthropogenic Sound on Marine Mammals in a Rapidly Changing Arctic. BioSci. 62(3):289-295

Morris, C.J., Coté, D., Martin, B., and Kehler, D. 2018. Effects of 2D seismic on the Snow Crab fishery. Fisheries Research 197:67-77

Morris, C.J., Cote, D., Martin, B., and Mullowney, D. 2020. Effects of 3D seismic surveying on the Snow Crab fishery. Fisheries Research 232:105719

Mullowney, D., Morris, C., Dawe, E., Zagorsky, I.O., and Goryanina, S. 2018. Dynamics of snow crab (*Chionoecetes opilio*) movement and migration along the Newfoundland and Labrador and Eastern Barents Sea continental shelves. Reviews in Fish Biology and Fisheries 28:435-459

Mundy, C.J., Gosselin, M., Ehn, J.K., Belzile, C., Poulin, M., Alou, E., Roy, S., Hop, H., Lessard, S., Papakyriakou, T.N., Barber, D.G., and Stewart, J. 2011. Characteristics of two distinct high-light acclimated algal communities during advanced stages of sea ice melt. Polar Biol. 34: 1869-1886

Murillo, F.,J., Kenchington, E., Tompkins, G., Beazley, L., Baker, E., Knudby, A., and Walkusz, W. 2018. Sponge assemblages and predicted archetypes inthe eastern Canadian Arctic. Mar. Ecol. Prog. Ser. 597:115-135

Murray, C., Hannah, L., and Locke, A. 2020. A Review of Cumulative Effects Research and Assessment in Fisheries and Oceans Canada. Can. Tech. Rep. Fish. Aquat. Sci. 3357 vii + 51 p.

Nasby-Lucas, N., Dewar, H., Sosa-Nishizaki, O., Wilson, C., Hyde, J. R., Vetter, R. D., Wraith, J., Block, B. A., Kinney, M. J., Sippel, T., Holts, D. B., and Kohin, S. 2019. Movements of electronically tagged shortfin mako sharks (*Isurus oxyrinchus*) in the eastern North Pacific Ocean. Anim. Biotelemetry. 7(12)

Natanson, L.J., Deacy, B.M., Joyce, W., and Sulikowski, J. 2019. Presence of a resting population of female porbeagles (*Lamna nasus*), indicating a biennial reproductive cycle, in the western North Atlantic Ocean. NOAA Nat. Mar. Fish. Ser. 117:70-77

Natanson, L.J., Winton, M., Bowlby, H., Joyce, W., Deacy, B., Coelho, R., and Rosa, D. 2020. Updated reproductive parameters for the shortfin mako (*Isurus oxyrinchus*) in the North Atlantic Ocean with inferences of distribution by sex and reproductive stage. NAFO. 118(1):21-36

Nielsen, J., Hedeholm, R. B., Lynghammar, A., McClusky, L. M., Berland, B., Steffensen, J. F., Jørgen S. Christiansen, J. S. 2020. Assessing the reproductive biology of the Greenland shark (*Somniosus microcephalus*). PLoS ONE.15(10): e0238986

Nielsen, J., Hedeholm, R. B., Simon, M., and Steffensen, J. F. 2013. Distribution and feeding ecology of the Greenland shark (*Somniosus microcephalus*) in Greenland waters. Polar Biol. 37:37-46

Nogueira, A., and Treble, M. 2020. Comparison of vessels used and survey timing for the 1CD and 0A-South deep-water surveys and the 1A-F west Greenland shelf surveys. NAFO. SCR Doc. 20/015. N7060

Novaczek, E., Devillers, R., Edinger, E., and Mello, L. 2017. High-resolution seafloor mapping to describe coastal denning habitat of a Canadian species at risk: Atlantic wolffish (*Anarhichas lupus*). J. Fish. Aqua. Sci. 74(12):2073-2084

Nygaard, R. 2017. Assessment of wolffish in NAFO subarea 1. NAFO SCR Doc. 17-036

Nygaard, R., and Nogueira, A. 2020a. Biomass and Abundance of Demersal Fish Stocks off West and East Greenland estimated from the Greenland Institute of Natural resources (GINR) Shrimp and Fish Survey (SFW), 1990-2019. NAFO SCR Doc. 20/006

Nygaard, R., and Nogueira, A. 2020b. Denmark/Greenland Research Report for 2019. NAFO SCS Doc. 20/12 (REV. 2)

O'Brien, K., and Whitehead, H. 2013. Population analysis of Endangered northern bottlenose whales on the Scotian Shelf seven years after the establishment of a Marine Protected Area. Endang. Species. Res. 21:273-284

OCEARCH. 2020. OCEARCH Brings Advanced White Shark Research Expedition Back to Nova Scotia. Press Release. Accessed May 7, 2021.

O'Connell, K.A., Di Santo, AV., Maldonado, J., Molina, E., and Fujita, M. K. 2019. A Tale of Two Skates: Comparative Phylogeography of North American Skate Species with Implications for Conservation. J. Copeia. 107(2):297-304

Orlov, A.M., Vedishcheva, E. V., Trofimova, A. O., and Orlova, S. Y. 2018. Growth and Age of the Roughhead Grenadier *Macrourus berglax* in Waters off Southwest Greenland. J. Ichthyol. 58:389-395

Orlov, A.M., Sytov, A. M., Marí, N., Figueroa, D. E., Barbini, S. A., Costa, P. A. S., Marin, Y. H., and Mincarone, M. M. 2019. Blue Hake Antimora rostrata (*Gadiformes: Moridae*) off the Atlantic Coast of South America: an Overview on Its Distribution and Biology. J. Ichthyol. 59: 174-185

Page, L.M., Espinosa-Pérez, H., Findley, L.T., Gilbert, C.R., Lea, R.N., Mandrak, N.E., Mayden, R.L., and Nelson, J.S. 2013. Common and scientific names of fishes from the United States, Canada, and Mexico. 7th Edition. American Fisheries Society, Spec. Publ. 34. Bethesda, MD. 243 pp

Pálsson, S., Magnúsdóttir, H., Reynisdóttir, S., Jónsson, Z.O., and Örnólfsdóttir, E.B. 2014. Divergence and molecular variation in common whelk *Buccinum undatum* (Gastropoda: Buccinidae) in Iceland: a trans-Atlantic comparison. Biol. J. Linn. Soc. 111(1):145-159.

Pennino, M.G., Guijarro-García, E., Vilela, R., Luis del Río, J., and Bellido, J. M. 2019. Modeling the distribution of thorny skate (*Amblyraja radiata*) in the southern Grand Banks (Newfoundland, Canada). J. Fish. Aqua. Sci. 76(11):2121-2130

Pepin, P., Colbourne, E., and Maillet, G. 2011. Seasonal patterns in zooplankton community structure on the Newfoundland and Labrador Shelf. Prog. Oceanogr. 91:273-285.

Pepin, P. 2013. Distribution and feeding of *Benthosema glaciale* in the western Labrador Sea: Fish–zooplankton interaction and the consequence to calanoid copepod populations. DeepSea Research Part I: Oceanographic Research Papers 75:119-134.

Pirotta, V., Grech, A., Jonsen, I. D., Laurance, W. F., Harcourt, R. G. 2019. Consequences of global shipping traffic for marine giants. J. Front Ecol Environ. 17(1): 39-47

Poulin, M., Daugbjerg, N., Gradinger, R., Ilyash, L., Ratkova, T., and von Quillfeldt, C. 2011. The pan-Arctic biodiversity of marine pelagic and sea-ice unicellular eukaryotes: a first-attempt assessment. Mar. Biodiv. 41:13-28

Privy Council Office and the Canadian Environmental Assessment Agency. 2010. Strategic Environmental Assessment: The Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals.

Purtle, J.R. 2011. Petition to List Four Skate Species Under the U.S. Endangered Species Act: Thorny Skate (*Amblyraja radiata*), Barndoor Skate (*Dipturus laevis*), Winter Skate (*Leucoraja ocellata*), Smooth Skate (*Malacoraja senta*).

Queiroz, N., Humphries, N.E., Couto, A. *et al*. 2019. Global spatial risk assessment of sharks under the footprint of fisheries. Nature. 572:461-466

Qvist, T. 2017. Age Estimates and Distribution of the Black dogfish (*Centroscyllium fabricii*). M.Sc. thesis, Aarhus University, Denmark.

Raposo, L. 2021. Winter & Thorny Skate Habitat Overlap With Trawl Fishing on the Nova Scotian Shelf. Accessed May 14, 2021.

Reed, D., Plourde, S., Cook, A., Pepin, P., Casault, B., Lehoux, C., and Johnson, C. 2018. Response of Scotian Shelf silver hake (*Merluccius bilinearis*) to environmental variability. Fish. Ocean. 28(3):256-272

Restrepo, V.R., Diaz, A.G., Walter, J.F., Neilson, J.D., Campana, S.E., Secor, D., and Wingate, R.L. 2010. Updated estimate of the growth curve of Western Atlantic bluefin tuna. Aquat. Living Resour. 23: 235-342.

Richardson, D.E., Marancik, K.E., Guyon, J.R., Lutcavage, M.E., Galuardi, B., Lam, C.H., Walsh, H.J., Wildes, S., Yates, D.A., and Hare, J.A. 2016. Discovery of a spawning ground reveals diverse migration strategies in Atlantic bluefin tuna (*Thunnus thynnus*). PNAS 113(12):3299-3304

Rideout, R.M., and Ings, D.W. 2020. Temporal and Spatial Coverage of Canadian (Newfoundland and Labrador Region) Spring and Autumn Multi-Species RV Bottom Trawl Surveys, With an Emphasis on Surveys Conducted in 2019. NAFO SCR Doc. 20/002. Serial No. N7041.

Rigby, C.L., Barreto, R., Carlson, J., Fernando, D., Fordham, S., Francis, M.P., Jabado, R.W., Liu, K.M., Marshall, A., Pacoureau, N., Romanov, E., Sherley, R.B., and Winker, H. 2019. Shortfin Mako – *Isurus oxyrinchus*. The IUCN Red List of Threatened Species: e.T39341A2903170

Rodriguez-Marin, E., Ortiz, M., de Urbina, J.M., Quelle, P., Walter, J., Abid, N., Addis, P., Alot, E., Andrushchenko, I., Deguara, S., Natale, A.D., Gatt, M., Golet, W., Karakulak, S., Kimoto, A., Macias, D, Saber, S., Santos, M.N. and Zarrad, R. 2015. Atlantic Bluefin Tuna (*Thunnus thynnus*) Biometrics and Condition. PLOS ONE 11(6): e0157291

Román-Marcote, E., González-Troncoso, D., and Alvarez, M. 2020. Results for the Atlantic cod, roughhead grenadier, redfish, thorny skate and black dogfish of the Spanish Survey in the NAFO Div. 3L for the period 2003-2019. NAFO SCR Doc. 20/014

Ruhl, R.A., and Smith Jr., K.L. 2004. Shifts in deep-sea community structure linked to climate and food supply. Science 305(5683): 513-515.

Rusyaev, S., and Orlov, A. 2014. Lumpfish as Main Consumer of Northern Comb Jelly and Effective Tool of its Research. ICES CM 2014/3064; conference poster

Sandrini-Neto, L., Geraudie, P., Santana, M.S., and Camus, L. 2016. Effects of dispersed oil exposure on biomarker responses and growth in juvenile wolfish *Anarhichas denticulatus*. Envir. Sci. Poll. Res. 23:21441-21450

Schwieterman, G.D., Crear, D.P., Anderson, B.N., Lavoie, D.R., Sulikowski, J.A., Bushnell, P.G., and Brill, R.W. 2019. Combined Effects of Acute Temperature Change and Elevated pCO_2 on the Metabolic Rates and Hypoxia Tolerances of Clearnose Skate (*Rostaraja eglanteria*), Summer Flounder (*Paralichthys dentatus*), and Thorny Skate (*Amblyraja radiate*). Biology 8(3):56

Secor, D.H., Gahagan, B., Rooker, J.R. 2012. Atlantic bluefin tuna population assignment based on otolith stable isotopes: the 2003 year-class within the U.S. North Carolina recreational fishery. Collect. Vol. Sci. Pap. ICCAT 68(1): 212-222

Showell, M.A., Fowler, G.M., Joyce, W., McMahon, M., Miri, C.M., and Simpson M.R. 2017. Current Status and Threats to the North Atlantic Shortfin Mako Shark (*Isurus oxyrinchus*) Population in Atlantic Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/039. v + 45 p.

Siders, Z.A., Westgate, A.J., Johnston, D.W., Murison, L.D., and Koopman, H.N. 2013. Seasonal Variation in the Spatial Distribution of Basking Sharks (*Cetorhinus maximus*) in the Lower Bay of Fundy, Canada. PLoS ONE 8(12): e82074

Simpson, M.R., and Miri, C.M. 2014. A pre-COSEWIC assessment of Porbeagle Shark (*Lamna nasus*) in Newfoundland and Labrador waters. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/088. iv + 19 p.

Simpson, M.R., and Miri, C. 2020. Assessment of Thorny Skate (*Amblyraja radiata* Donovan, 1808) in NAFO Divisions 3LNO and Subdivision 3Ps. NAFO SCR Doc. 20/41

Simpson, M.R., Miri, C.M., Mercer, J.M., Bailey, J., Power, D., Themelis, D., and Treble, M. 2011. Recovery potential assessment of Roundnose Grenadier (*Coryphaenoides rupestris* Gunnerus, 1765) in Northwest Atlantic Waters. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/077. vi + 68 p.

Simpson, M.R., Mello, L.G.S., Miri, C.M., and Treble, M. 2012a. A pre-COSEWIC assessment of three species of Wolffish (*Anarhichus denticulatus, A. minor*, and *A. lupus*) in Canadian waters of the Northwest Atlantic Ocean. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/122. iv + 69 p.

Simpson, M.R., Mello, L.G.S., Miri, C.M., Treble, M., and Siferd, T. 2012b. Distribution, abundance, and life history of smooth skate (*Malacoraja senta* Garman 1885) in Northwest Atlantic waters. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/116. iv + 40 p.

Simpson, M.R., Chabot, D., Hedges, K., Simon, J., Miri, C.M., and Mello, L.G.S. 2013a. An update on the biology, population status, distribution, and landings of wolffish (Anarhichus denticulatus, A. minor, and A. lupus) in the Canadian Atlantic and Arctic Oceans. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/089. v + 82 p.

Simpson, M.R., Sherwood, G.D., Mello, L.G.S. Miri, C.M., and Kulka, D.W. 2013b. Feeding habits and trophic niche differentiation in three species of wolffish (*Anarhichas sp.*) inhabiting Newfoundland and Labrador waters. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/056. v + 29 p.

Simpson, M.R., Miri, C.M., Mello, L.G.S., Collins, R.K., and Bailey, J.A. 2013c. Assessment of the Potential for Recovery of Smooth Skate (*Malacoraja senta* Garman 1885) in the Funk Island Deep Designatable Unit. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/098. iv + 22 p

Simpson, M.R., Mello, L.G.S., Miri, C.M., Collins, R. ,Holloway, C. and Maddigan, T. 2014. A Preliminary Analysis of Habitat Use and Movement Patterns of Wolffish (*Anarhichas spp.*) in Coastal Newfoundland Waters. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/033. v + 27 p.

Simpson, M.R., Collins, R.K., Miri, C.M., and Bailey, J.A. 2016. Evaluation of White Hake (*Urophycis tenuis*) populations in the NL Region in support of a Recovery Potential Assessment. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/051. v + 59 p

Simpson, M.R., Themelis, D.E., Treble, M., Miri, C.M., Collins, R.K., and Mello, L.G.S. 2017. A pre-COSEWIC assessment of Roughhead Grenadier (*Macrourus berglax*) in Canadian Atlantic and Arctic Waters. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/045. vi + 87 p.

Simpson, M.R., Miri, C.M., and Collins, R.K. 2018. Distribution and Analysis of Canadian Greenland Shark (*Somniosus microcephalus*) bycatch in the NAFO Regulatory Area. NAFO SCR Doc. 18/026

Simpson, M.R., Collins, R., and Miri, C. 2019. An Assessment of White Hake (*Urophycis tenuis*, Mitchill 1815) in NAFO Divisions 3N, 3O, and Subdivision 3Ps. NAFO SCR Doc. 19/022

Skomal, G.B., Braun, C.D., Chisholm, J.H., and Thorrold, S.R. 2017. Movements of the white shark *Carcharodon carcharias* in the North Atlantic Ocean. Mar. Eco. Prog. Ser. 580:1-16

Smith, S.V. 1981. Marine Macrophytes as a Global Carbon Sink. Science, 211: 838-840.

Sosebee, K. 2019. 2018 NE Skate Stock Status Update. NEFSC

Sosebee, K.A. 2020. United States Research Report for 2019. NAFO SCS Doc. 20/18

State of Maine, Dept. of Marine Resources. 2021. White Shark Research. Accessed May 7, 2021

Ste-Marie, E., Watanabe, Y.Y., Semmens, J.M., Marcoux, M., and Hussey, N.E. 2020. A first look at the metabolic rate of Greenland sharks (*Somniosus microcephalus*) in the Canadian Arctic. Scientific Reports. 10:19297

Sulikowski, J.A., Prohaska, B.K., Carlson, A.E., Cicia, A.M., Brown, C.T., and Morgan, A.C. 2013. Observations of neonate spiny dogfish, *Squalus acanthias*, in Southern New England: A first account of a potential pupping ground in the Northwestern Atlantic. Fish. Res. 137:59-62

Swain, D.P., Benoît, H.P., and Aubry, É. 2012. Smooth skate (*Malacoraja senta*) in the southern Gulf of St. Lawrence: life history, and trends from 1971-2010 in abundance, distribution and potential threats. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/033. iii + 34 p.

Tamarin, T., and Kaspi, Y. 2017. The poleward shift of storm tracks under global warming: A Lagrangian perspective. Geo. Res. Lett. 44(20):10,666-10,674

Teagle, H, Hawkins, S.J., Moore, P.J. and Smale, D.A. 2017. The role of kelp species as biogenic habitat formers in coastal marine ecosystems. Journal of Experimental Marine Biology and Ecology, 492: 81-98.

Thorburn, J., Neat, F., Bailey, D.M., Noble, L.R., and Jones, C.S. 2015. Winter residency and site association in the Critically Endangered North East Atlantic spurdog *Squalus acanthias*. Mar. Ecol. Prog. Ser. 526:113-124

Udevitz, M.S., Jay, C.V., Taylor, R.L., Fischbach, A.S., Beatty, W.S., and Noren, S.R. 2017. Forecasting consequences of changing sea ice availability for Pacific walruses. Ecosphere 8(11):e02014

Vandeperre, F., Aires-da-Silva, A., Fontes, J., Santos, M., Santos, R.S., and Afonso, P. 2014. Movements of Blue Sharks (*Prionace* glauca) across Their Life History. PLoS ONE 9(8):e103538

Vedishcheva, E.V., Korostelev, N.B., Gordeev, I.I., and Orlov, A.M. 2019. A first attempt to evaluate the age and growth of blue hake *Antimora rostrata* (Moridae, Gadiformes, Teleostei) from the Lazarev and Weddell seas (Antarctic). Cambridge University Press 55(1): 25-31 pp.

Vedor, M., Queiroz, N., Mucientes, G., Couto, A., da Costa, I., dos Santos, A., Vandeperre, F., Fontes, J., and Afonso, P. 2021. Climate-driven deoxygenation elevates fishing vulnerability for the ocean's widest ranging shark. eLife 10:e62508

Wells, N.J., Stenson, G.B., Pepin, P., and Koen-Alonso, M. 2017. Identification and Descriptions of Ecologically and Biologically Significant Areas in the Newfoundland and Labrador Shelves Bioregion. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/013. v + 87 p.

Wells, N., Tucker, K., Allard, K., Warren, M., Olson, S., Gullage, L., Pretty, C., Sutton-Pande, V., and Clarke, K. 2019. Re-evaluation of the Placentia Bay-Grand Banks Area of the Newfoundland and Labrador Shelves Bioregion to Identify and Describe Ecologically and Biologically Significant Areas. DFO Can. Sci. Advis. Sec. Res. Doc. 2019/049. viii + 151 p.

Wells, N.J., Pretty, C., Warren, M., Novaczek, E. and Koen-Alonso, M. 2021. Average Relative Density of Fish Species and Functional Groups in the Newfoundland and Labrador Shelves Bioregion from 1981-2017. Can. Tech. Rep. Fish. Aquat. Sci. 3427: viii + 76 p

Wheeland, L., and Devine, B. 2018. Bycatch of Greenland Shark (*Somniosus microcephalus*) from inshore exploratory fisheries adjacent to NAFO Division 0. NAFO SCR Doc. 18/044.

Wheeland, L., Treble, M., and Nogueira, A. 2019. Overview of sources of uncertainty in reported catches of Greenland shark *Somniosus microcephalus* within the NAFO Convention Area. NAFO SCR Doc. 19/037

Williamson, T., and Labrador Inuit Association (LIA). 1997. From Sina to Sikujâluk: Our Footprint: Mapping Inuit Environmental Knowledge in the Nain District of Northern Labrador. Nain, Labrador: Labrador Inuit Association, 1997. Print.

Wilson, S.C., Trukhanova, I., Dmitrieva, L., Dolgova, E., Crawford, I., Baimukanov, M., Baimukanov, T., Ismagambetov, B., Pazylbekov, M., Jüssi, M., and Goodman, S.J. 2017. Assessment of impacts and potential mitigation for icebreaking vessels transiting pupping areas of an ice-breeding seal. Bio. Conser. 214:213-222

Zhang, C., and Chen, Y. 2015. Development of Abundance Indices for Atlantic Cod and Cusk in the Coastal Gulf of Maine from their Bycatch in the Lobster Fishery. North American Journal of Fisheries Management 35:708–719

Appendix I: Past Review of the Original SEA

Subject: Labrador Shelf Strategic Environmental Assessment-Review of Draft Two Report

Fisheries and Oceans Canada (DFO) has conducted a review of the document entitled, *"Draft Two Report: Strategic Environmental Assessment, Labrador Shelf Offshore Area"* and offers the following comments for your review and consideration.

General Comments

The description of the existing biological environment appears to be deficient. In particular, Section 4.3, which should contain the general biological framework of the ecosystem is lacking in rigor and documentation. The description of the lower food web demonstrates a lack of understanding regarding the fundamental processes and ecological dynamics supporting primary and secondary production on the Labrador Shelf. The sections on plankton are poorly written as well as generally deficient. The microbial web is omitted completely. Contributions to primary production by ice algae, macroalgae and seagrasses are also missing.

In a number of places throughout the document, the authors note that information is lacking about the biology and ecology of the Labrador Shelf Area. While much remains to be learned, there is a long history of biological studies in the region. It should be noted that a lot of this information has not been referenced in this document. The authors failed to carry out an adequate literature review and have omitted reference to most of the relevant literature. Much of this literature was reviewed in the "Offshore Labrador Initial Environmental Assessment" (Petro Canada 1982) and in the detailed studies of the Offshore Labrador Biological Studies (OLABS) Program. An update of this material since that time should be included in this document.

In the case of marine mammal species where specific Strategic Environmental Assessments (SEA) regional data (and in many cases, any data at all) are lacking, general biological information from other parts of their range as well as 'global' or 'northern hemisphere' abundance information is provided. This information is important, but should not overshadow or deflect attention away from the fact that little is known about the species in the SEA region. A lot of the marine mammal species descriptions are taken from COSEWIC documents, which are somewhat general by nature; hence some of the information does not reflect the biology, migratory behavior and social behavior of the species in Newfoundland and Labrador waters. When available, key original references and regionally specific information should be presented. To reiterate, when there is a paucity of data, it should be more clearly noted, rather than adding information that is not really relevant to the area.

Ice as a habitat is not mentioned in the document. The ice algae community is not discussed and its contribution to primary production is ignored. Ice as habitat for marine mammals is not discussed either. As a result, the consequences of an oil spill in ice are not addressed in this context. The document also down plays the risk associated with an oil spill in ice. Current clean-up methods are not sufficient when ice cover is >30%. While oil spill response is highlighted as an important requirement for exploration and production in the Labrador Shelf Area, the lack of adequate technology for this purpose is not addressed.

Assessment of the risks associated with oil and gas exploration and production in the Labrador Shelf Area are based on the assumption that accident and spill data from temperate regions around the world adequately reflect the level of risk of such developments on the Labrador Shelf. While the regulatory regime and technologies may be similar, this is not the case for environmental conditions. More appropriate comparison groups would be the Grand Banks,

Beaufort Sea or Sakhalin Island where ice conditions and severe weather might be assumed to be similar as a first basis for comparison. The importance of failing to meet this basic assumption in selection of a comparison group is clear when the oil spill statistics for the Grand Banks are compared with those from the US Outer Continental Shelf (OSC) or the North Sea when calculating associated risks. According to the data presented in Section 2.6.5, spills are orders of magnitude more frequent on the Grand Banks than elsewhere. This is a concern. Arctic environmental conditions should be taken into consideration in these calculations. Indeed the US federal government has projected an 11-24 % chance of a major oil spill from a single oil field (Northstar) currently operating in the Beaufort Sea.

For future reference and clarification, Transport Canada is the Lead Agency for ship safety, Response Organizations (Eastern Canada Response Corporation [ECRC] in NL), the 60 Oil Handling Facilities (Oil Pollution Emergency Plans [OPEP]), and the Shipboard Oil Pollution Emergency Plans (SOPEPs) for tankers over 150 t and all ships over 400 t. After an oil pollution incident has occurred or is about to occur, then the Canadian Coast Guard-Environmental Response becomes the Lead Agency responsible for ensuring an adequate response.

There is no acknowledgement or recognition of the importance of climate variability and climate change on both the environment and the ecosystem of the Labrador Shelf. The document should include a section on anticipated changes, potential effects on exploration and production of oil and gas on the Labrador Shelf as well as the changes in risk scenarios that may result (due to changes in ice conditions or severe weather event frequency or magnitude, for example). There are regional models becoming available which provide our first ‘look’ forward at what conditions may be like over the next 25-50 years. This is relevant information that should be taken into consideration throughout the SEA document.

There is no mention of the large scale ecosystem changes that have occurred in the Northwest Atlantic since the mid-1980s. In the historical overview section, the graphics clearly show how the industry has radically changed and yet there is no ecological framework provided. These large scale changes should be appropriately indicated for all the species that are discussed, particularly the ones that are considered ‘keystone’ such as capelin and Arctic cod (which are not even included in the document). This concern has been raised previously and should be addressed in this document.

The primary focus on commercial fish species somewhat compromises the intent of a SEA, since some ecologically important species may not have been included. This is particularly evident with the omission of Arctic cod, which is a ‘keystone’ species that should be included.

Specific Comments

Pg. 26, Emergency Response. It is important to understand how the Canadian Oil Spill Response Regime is set up. There are Response Organizations in place in Canada, but their main focus is on land-based Oil Handling Facilities (OHF) and ships of a specified size. Although Response Organizations (more specifically ECRC in NL) have had, and continue to have, arrangements/contracts with offshore operators, they are not required by any legislation to enter into these contracts.

Through its Environmental Response program, the Canadian Coast Guard (CCG-ER) is responsible for ensuring the cleanup of ship-sourced spills of oil and other pollutants into Canadian waters. This includes: monitoring clean-up efforts by polluters; and managing cleanup efforts when polluters are unknown, unwilling or unable to respond to a marine pollution incident. The objectives of the Environmental Response (ER) program of the Canadian Coast Guard are: to minimize the environmental, economic and public safety impacts of marine

pollution incidents; and provide humanitarian aid to natural or manmade disasters. The Canadian Coast Guard maintains a level of its own preparedness capacity, monitors and investigates all reports of marine pollution incidents and ensures an appropriate response to all marine pollution incidents in waters under Canadian jurisdiction.

Transport Canada is the lead federal regulatory agency responsible for Canada's Marine Oil Spill Preparedness and Response Regime, which was established in 1995 and is built on a partnership between government and industry. Within the framework of the regime, Transport Canada sets the guidelines and regulatory structure for the preparedness and response to marine oil spills. Transport Canada ensures that the appropriate level of preparedness is available to respond to marine oil pollution incidents in Canada of up to 10,000 t within prescribed time standards and operating environments. The Regime is built on the principle of cascading resources, which means that in the event of a spill, the resources of a specific area can be supplemented with those from other regions (geographic areas) or from international partners, as needed.

Pg. 28, Para. 3: The following statement "*A study by the US Naval Research Laboratory done in 1972 showed that ambient noise levels in the sea were 87 dB... Studies of ambient noise worldwide have shown a 3 dB rise in levels per decade that would bring the levels to approximately 96 dB"* needs to be clarified. What studies? Where was the recorded level equal to 87 dB, and under what conditions? It should be noted that this may not necessarily relate to levels in the Labrador SEA area.

Pg. 29, Table 2.3: Cetacean species as listed are fine; however, pinnipeds also communicate acoustically and can be masked by industrial noise. This is particularly the case for bearded seals and, to a lesser degree, ringed seals. Cases could also be made for hooded and harp seals at certain times of the year.

- Bearded and ringed should also be listed in the table (and generally considered/included in all subsequent sections of related text).

Pg. 31, Para. 2:*"A relatively strong infrasonic component approximately 1.5 Hz, corresponding to the rotation rate of the drilling turntable, was measured by Hall and Francine …; however, such low frequencies would attenuate rapidly in water shallower than a few tens of metres and are not transmitted into the water by all caisson rigs"*. Please explain how this applies to offshore rigs in Labrador or in deep water.

Pg. 42, Produced Water: The first sentence is incorrect. It implies that produced water is only seawater.

- Radioactivity of produced water is a significant concern for certain formations. For example, produced water is now the largest source of radioisotopes to the North Sea; however, there is considerable uncertainty about the exact numbers as most countries do not require reporting on discharges of radioactivity (Betti et al., 2004). Inorganic and organic nutrient enrichment from produced waters can be considerable and may have significant consequences on the marine foodweb (Rivkin et al. 2001). Both Radioisotopes and nutrient enrichment should be included in the discussion.

Pg. 46, Accidental Events: Throughout this section various worldwide statistics are referenced and compared to operations on the East coast where there hasn't been any large scale spills. CCG-ER believes that exploration/production operations should be fully self-sufficient in responding to the small scale releases, which make up the majority of the releases. The entire Canadian Oil Spill Response regime could be used for any large scale releases, which are very rare. This would ensure a response to the smaller spills, which sometimes get ignored when

industry compares the small impact to that of a large release worldwide. Having a large container outfitted with one very large skimmer system designed for the 1 in 100 year release isn't practical for the smaller releases, which are much more frequent.

- Time is extremely important when responding as well and CCG-ER believes that this response equipment should be on site during exploration and production.
- Accidental events due to severe weather are ignored in this section. Many serious accidents to rigs were caused by storms or other severe weather events.
- While the practices and technologies that will be used in the Labrador Sea area may be the same as elsewhere around the world, this is not the case for the environmental conditions. This very important assumption underlies the use of accident and risk statistics from other offshore oil producing regions. There are a number of oil producing regions subject to extreme weather conditions and ice. These should be used for risk analysis and comparison purposes.

Pg. 47, Table 29: NRC 2002 is not in the reference list.

Pg. 54, Para. 1: The calculation of blowout frequency does not make sense. It is unclear why 4 temporally overlapping frequencies were averaged and then reduced by 50%? If blow out frequencies for older data are not relevant for today's operating conditions, then they should be omitted and only data for relevant time periods used. The rationale for the time period selected (i.e., regulatory and technological relevance) should be provided.

Pg. 64, Behaviour of Oil Spilled in Water: Some of the natural processes that effect oil when spilled act differently when the same oil is spilled in, on or around ice. Oil will remain persistent for longer periods and will resist dispersion and evaporation. There should be a better understanding of response strategies for responding to oil in ice, especially if production or exploration will occur throughout the ice season in Labrador.

- CCG-ER would like to see the most advanced response equipment designed for oil in ice to be stationed along the Labrador Coast or on the rig themselves. The regular response equipment will not be satisfactory for most of the year.

Pg. 66, Oil Spilled Within Pack or Drift Ice: Supporting documentation/references are needed for this section. For instance, is it just speculation or is data available to back up these statements?

Pg. 75, Spill Modeling and Response Planning: This section should include a discussion of the lack of capability to clean up spills in >30% ice cover and the effectiveness of cleanup capabilities in ice < 30%.

Pg. 100, Para. 1: Subsidence and bank edge slips are not considered in the section on geological hazards. Do they occur in the Labrador Shelf Area? If so where, how often and what are the potential consequences?

Pg. 104, Fig 3.18, and Pg. 105, Fig 3.19: There should be some georeferencing provided on these maps.

Pg. 106, Para.1: The description on the seasonal sea surface temperature (SST) change is confusing and should be re written.

Pg. 117, Current. The Labrador Current has significant interannual and longer-term variability in response to climate variability and change. A discussion of knowledge regarding the interannual and decadal variability of the Labrador Current should be included. See for example, Han, 2005; Hakkinen and Rhines, 2004; Han and Tang, 1999.

- In terms of the seasonal and spatial variability of the Labrador Shelf circulation, the document should include a more detailed and better illustration either based on the BIO model, or on a finite element model developed for the PERD project by DFO Newfoundland.

Pg. 117, Fig. 3.25: There is a significant onshore current south of Hamilton Bank, which is not represented in the figure.

Pg. 118, Para. 1: The description needs improvement. Readers have to guess that Fig. 3.26 is from "the previous Labrador Sea model". If the model physics is similar, how can the new model improve the result over the Labrador Shelf? By including the Scotian Shelf and the Gulf of St. Lawrence?

Pg. 120, Table 3.23: Definitions for Column 7 and 8 are not clear. Are they mean velocity magnitude and mean velocity direction, respectively?

Pg. 120, Table 3.23: What does steadiness mean? Does it need to be included?

Pg. 121, Para. 1: What about current meter data after 1980? For example, DFO collected multi-year current meter data during 1985 to 1987 (Lazier and Wright, 1993).

Pg. 122, Tides: It is impossible for the K_1 tidal currents to be "3.1 to 2.5 m/s". Please revisit and revise.

- Change "M2" to "M_2", "S2" to "S_2", "K1" to "K_1" and "O1" to "O_1".

Pg. 122, Table 3.24: Major and Minor axes have a unit of cm/s, but Inc. has a unit of degree.

Pg. 130, Fig. 3.32: The legend appears to be reversed implying that the region has very low visibility throughout the year.

Pg.130, Para. 1: The categories proposed for ceiling and visibility ratings do not make sense. Is this a typo?

Pg. 132, Bullet 1: The document should contain contour maps of the day of first presence, last presence and duration in days.

Pg. 132, Bullet 2: In the north the number of weeks of ice presence is 1 week in the offshore areas to 28 weeks near shore, not 1 to 28 weeks in the north and similarly for the southern regions. The text as written is misleading.

Pg. 132, Figs 3.34 to 3.48: These illustrations are of poor quality and almost impossible to read.

Pg. 133, Fig 3.35 and 3.36. These figures are not necessary and could give the impression that ice is present year around. The plots by month should be sufficient.

Pg. 139, Fig 3.47: According to the Environment Canada Sea-Ice atlas, sea ice is present in Lake Melville in late November.

Pg. 140, Sea Ice Drift: It would be useful to express some of the numbers in knots or nautical miles per day.

- Speed of ice movement should be presented in the same units in table and text. Please ensure consistency.

Pg. 145, Fig 3.49: Which years are included?

Pg. 147, Para.1: Typo-the number should be 1×10^{-4} km^{-2} not 1×10^{-4} $/km^{-2}$.

Pg. 147, Iceberg Drift: The beginning of this section should read: "…Contact frequency with structures is directly related to iceberg drift speed…".

Pg. 152, Ice Islands: The shallow draft of ice islands also allows them to drift into much shallower water than the larger icebergs. The areas of risk of movement and grounding on the banks of the Shelf will therefore be different for ice islands. This should be addressed in the document.

Pg. 167: The first paragraph contains several grammatical and typographical errors.

Pg. 169, Para. 4: The last sentence is internally inconsistent. Please revise for clarity.

Pg. 171, Para. 3: Explain what is meant by the phrase 'Though not as great as' in the following statement "*Though not as great as the other species, the Atlantic wolffish (or the striped wolffish) has also declined in population and distribution (see Figure 4.3).*

Pg. 172, Para. 4: There is no reference provided for the following statement "*The global blue whale population is estimated at 5,000 to 12,000 individuals; although to date, there are no reliable estimates*". Explain what is meant by the underlined part of this statement.

- As written the opening text of the section ('blue whales are found globally') does not appropriately emphasize the serious situation which blue whales of the northern hemisphere are in.
- Compared to text on the fin whale, the blue whale information is less detailed and vague; general life history information is missing.
- To complete the list of projected related stressors listed (e.g. ship collisions) in the last paragraph of the text; disturbance due to industry-related underwater noise should also be included.

Pg. 174, Para 2: All scientific names should be italicized.

Pg. 174, Para 2: Another threat to blue whales (and all marine mammals in general) is displacement of the animals due to anthropogenic noise.

Pg. 175, Para. 4: It should be stated that the lack of sightings of fin (or any other marine mammal or sea turtle) in mid- and northern Labrador waters may relate as much to the lack of observer effort as it does to actual distributional differences. The map for fin whales (Figure 4.5) should at least state this.

Pg. 183, Table 4.2 and Section 4.2.1: The correct spelling is *Gadus morhua*, not *morhue.*

Pg. 183, Table 4.2: Please delete western Hudson Bay from the range/population designation column (this population is not endangered) and correct its' status.

- Walruses should be added to the table since the Arctic population is listed as threatened and walruses observed along the Labrador coast, primarily in the pack-ice zone, are from this population. Ensure related walrus information is inserted in text.
- Given that it is not certain whether the beluga along the Labrador coast are from the eastern Hudson Bay stock, the listings of the Cumberland Sound and eastern Arctic populations should also be included in the table.

Pg. 183, Para. 1: The northern cod stock does not extend from 2G to 3L, but rather that area encompasses two stocks 2GH and northern cod (2J3KL).

Pg. 183, Para. 2: *"The extent of migration between the inshore and offshore stocks of 2J3KL is not well understood."* should probably be the 'current extent'.

Pg. 183, Para. 4: The following statement *"Tagging experiments have shown that the Northern cod stock is relatively isolated from adjacent stocks in divisions 2J3KL, 4TVn, and 3Ps."* does not make sense since 2J3KL is the northern cod stock. If this is referring to the cod stock in 2GH, then it should be called 2GH. More recent tagging by Brattey (many CSAS documents) has shown the at least the inshore portion of northern cod area has regular migrations from 3Ps.

Pg. 183, Para. 4: "*However, the stock does occasionally mix in the Northwest Gulf with 4TVn cod, and in the Strait of Belle Isle with 2J3KL cod (Yvelin et al. 2005)*". The stock referred to here is from the perspective of the Northern Gulf stock (4RS3Pn), therefore replace 2J3KL cod with "4RS3pn cod…this latter stock is referred to as the Northern Gulf cod stock".

Pg. 183, Para. 5: *"Despite its commercial and ecological importance, the spawning behavior of Atlantic cod is poorly understood. Spawning has rarely been observed in the field. Recent studies have shown that successful reproduction involved complex behaviour between the sexes"*. In fact the spawning behaviour of cod was well described in the 1960s (Brawn, 1961a,b).

Pg. 183, Section 4.2.1: For Atlantic cod, there is no discussion of juvenile ecology, despite numerous published accounts in the past 15 years-mainly from the northern cod stock described in this document-on feeding, movement, and habitat associations. Omitting this information represents a significant deficiency of this report.

Pg. 185, Beluga Whale: Please check entire document for reference to the Labrador Inuit Association (LIA) and replace with Nunatsiavut Government or other related designation.

- In the sentence referring to the stock affinities of the beluga whales observed in Labrador waters-the eastern Hudson Bay population should be included in addition to the Ungava Bay population. However, it is also possible that there are whales from the Cumberland Sound population, or even Western Hudson Bay. The sentences in question need rewording-check the most current stock status reports for beluga whales on DFO Publication web site.

Pg. 187: Typo-correct Lance to lance.

Pg. 189, Benthic Community: Highly productive kelp beds are found scattered throughout the coastal archipelago where they are sheltered from ice scour by irregular bathymetry. These make a significant contribution to primary production in the coastal areas of the Labrador Shelf. Although the sessile community has been documented qualitatively (see Petro Canada 1982), it has not been assessed quantitatively. This should be identified as a data gap.

Pg. 189, Plankton: The scientific studies cited are quite dated and the document lacks more recent data collected on behalf of Fisheries and Oceans (Atlantic Zone Monitoring Program). There is no information presented on potential environmental impacts of exploration and production activities on the lower trophic levels, but rather it focuses on the upper trophic levels such as commercial fish/invertebrate species and marine mammals, which are clearly dependent on the lower trophic levels as a prey source.

Pg. 189, Phytoplankton: This is a poor summary of the pelagic system of the Labrador shelf and demonstrates a general lack of understanding of the ecology of primary production. This section should be rewritten and adequately documented as much of the existing literature is ignored.

- Bacteria, ice algae and microzooplankton are ignored as is the role of heterotrophic production. The contribution of aquatic macrophytes and freshwater inputs of organic matter to primary production of the Shelf is ignored. There is no discussion of the influence of the many rivers draining onto the shelf.

Pg. 195, Zooplankton: This section is also poorly written. Conclusions are drawn from references pertaining to areas outside the Labrador Shelf (Breeze et al.=Scotian Shelf) and references are incomplete (Drinkwater and Harding).

Pg. 195, Benthic Invertebrates: This section is poorly written. None of the relevant literature appears to have been referenced. There are in fact quite a number of studies directly relevant to the benthos of the Labrador Shelf (e.g., Gagnon and Haedrich, 1991; Barrie et al. 1980; Carey 1991; Stewart et al. 1985).

Pg. 195, Intertidal Community. The references provided in this section are for the Gulf of St. Lawrence.

Pg. 207, Para. 5: *"Northern or pink shrimp (Pandalus borealis) distributions in the Northwest Atlantic range from the Davis…"*. If spp. is used, then the author should include all species, which would include more than just the northern or pink shrimp. Note insert borealis.

Pg. 207, Para. 5: The following statement *"They occupy shallow inshore waters to depths of 180 m…"* is not accurate. The bulk of the commercial fishery takes place in waters ranging from 200-500 m. The fishery takes place well offshore; however, females do migrate into shallower cooler water during spring.

Pg. 207, Para. 5: *"Eggs (1,700 for the average female) are laid in the summer…"*. This is probably a little low. According to FAO Fisheries Synopsis No. 144 the average female (Carapace length = 28 mm) should carry approx. 2,400 eggs.

Pg. 207, Para. 6: *"As with most crustacea, northern shrimp grow by moulting their shells. During this period, the new shell is soft, causing them to be highly vulnerable to predators such as Greenland halibut (turbot), cod (DFO 2006c), Atlantic halibut, skates, wolffish and harp seals (Phoca groventandica) (DFO 2000b)"*. The authors should note they will be vulnerable to these predators regardless of whether they have a soft shell.

Pg. 207, Para. 7: *"During collection of traditional knowledge (Nain 2007; Makkovik 2007) and at public consultations (Nain 2007; Natuashish 2007; Hopedale 2007; Happy Valley-Goose Bay 2007; Mary's Harbour 2007; Port Hope Simpson 2007) it was indicate that northern shrimp were fished within the Labrador Shelf SEA Area. The areas in which northern fish may be fished included areas between Makkovik and Hopedale (Nain 2007; Natuashish 2007; Hopedale 2007; Happy Valley-Goose Bay 2007; Mary's Harbour 2007;Port Hope Simpson 2007)"*. They are fished along the coast of Labrador and off Northeastern Newfoundland. Please see the map of the 2007 fishing areas attached.

Pg. 208, Para. 5: "*Redfish are icethotropic viviparous…"*. Please define the term icethotropic as it has not been encountered by the reviewers.

Pg. 210, Para. 4: *"Females do not reach sexual maturing until they are 11 years of age (40 to 45 cm)"*. According to Busby *et al.* 2007., current age at sexual maturity for females in the area (2+3K) is around 8 years with a length of maturity of about 30 cm.

Pg. 211, Para. 2: "*Spawning occurs in deep warm waters of the Davis Straight"*. This is a dated statement. The following is taken from Fishery Bulletin in July, 2002, by Jesper Boje: "*The spawning grounds of Greenland halibut are believed to be located southwest of Iceland (Sigurdsson1) and cover an extended area from Davis Strait, south of 67[degrees]N (Jensen, 1935; Smidt, 1969) to south of Flemish Pass off Newfoundland (Junquera and Zamarro, 1994) between 800 and 2,000 m depths"*. In addition see Morgan et al. (2001) and references therein.

Pg. 212, Para. 2: Killer whales are sighted regularly in the northwest Atlantic. A recent summary by Lawson et al. (2007) includes a preliminary abundance estimate and descriptions of distribution that includes the project SEA.

Pg. 215, Para. 3: The scientific name for Rock cod is *Gadus ogac*, not *Lotella rhacina.* The latter is in the Family Moridae as opposed to *Gadus ogac*, which is in the Family Gadidae.

- There is no discussion of juvenile rock cod ecology, despite several published accounts in the past decade on movement and habitat associations of this life stage. As it is the most habitat-restricted of the life-stages, this is a significant omission.

Pg. 219, Sei Whale: The reference for evidence of two stocks should be provided.

Pg. 219, Bowhead: The statement "*No live bowheads for a century…"* needs to be put into proper context. There have been several sightings in Newfoundland waters in more recent years, suggesting whales still occasionally use the area; these references should be included. There is a high likelihood that the species uses the northern areas of SEA region and this should also be reflected.

Pg. 223, Fig 4.25: This figure should be deleted because it is based on so little data. Furthermore, it is not representative of any of the species. In fact, it leaves the reader with an incorrect perspective of seal distribution.

Pg. 223, Harbour Seals: The last two sentences of the first paragraph should be reworded as they incorrectly leave the impression that harbour seal pups do not go into the water until after the weaning period.

Pg. 224, Harp Seals: Update population estimates and references (2004 survey information is available on DFO web site).

- Check the sentence that indicates '*Atlantic cod'* comprises 54% of the harp seal diet - it should probably be '*Arctic cod'* or there is some other mistake or missing contextual information. Regardless, the sentence is an over simplification and provides an inaccurate perception of harp seal diet given the annual, seasonal, geographic and age class variations that exist.
- Change the sentence *"…harp seals are expected to be common in the SEA region…"* to *" are common in the SEA region"*.
- It should be noted that in most years a substantial proportion of the harp seals pupping in Newfoundland and Labrador waters do so in the southern portion of the SEA region. This has implication for the impact assessment of oil spills and possibly other industry-related activities.
- There is minimal TEK information provided for this species. Brice-Bennett (1977) is sited. There needs to be more detailed information provided regarding current subsistence use and evolving commercial use. The Nunatsiavut Government has plans to become more actively involved in encouraging increased participation the harp seal commercial hunt.

Pg. 224, Hooded Seals: There are new 2004 population estimates available for this population on the DFO web site.

- As in the case with harp seals, in most years a substantial proportion of the hooded seals pupping in Newfoundland and Labrador waters do so in the southern portion of the SEA region. This information should be added to the text.

Pg. 224, Bearded Seals: All scientific names should be italicized.

- The following statement "*Seasonal movements are directly related to sea ice…*"' should be reworded. Along the Labrador coast, some bearded seals remain in coastal waters during the summer and may not follow the receding ice northward. As written the above sentence is an over simplification which gives an incorrect impression of the ecology and movement patterns of the species for the SEA region.
- Including information on weights, lengths and body condition deviates from the format used for other seal species. Similar information exists for them as well. Please revisit and add complimentary information for the other species.
- TEK information is missing.

Pg. 225, Grey Seals: Reword the sentence pertaining to grey seal distribution from *"…grey seals will likely be present…"* to "grey seals are present in the SEA region…".

Pg. 226, Ringed Seal: Reword and add additional information regarding the sentence-"*no compelling evidence that ringed seals undertake co-ordinated seasonal migrations*". The meaning of this sentence is unclear because 'co-ordinated' is not defined. Nor is it clear what comparisons are being made. More emphasis should be placed on the variable nature of the movement patterns that have been documented: some animals do not move, while others move relatively short distances (within 100-300 miles) and still others move several thousand miles. As written, the sentence and related text does not accurately reflect the movement behavior of this species in general and it does not provide information that is more specific to the coast of Labrador.

Pg. 227, Marine Mammal and Turtle Data Gaps: This section outlines the general areas where data gaps exist; however, it should be made clear that even for species that are relatively well studied in parts of their range-little is known about what occurs in Labrador waters. This point tends to get lost in the generalities.

Pg. 243, Historical Overview: The document discusses the distinction between historical fisheries along the Labrador coast as being primarily a groundfish fishery and the present fishery, which is dominated by shellfish (shrimp and crab). Although the present fishery is dominated by shellfish, any future environmental assessments (EA) documents for this area should consider appropriate mitigations for historical groundfish fisheries species, as it is possible that these fisheries could return to the Labrador coast in the near future. Some recoveries of groundfish and pelagic species have already been observed in the area. Capelin and cod, for instance are returning to the Labrador coast.

Pg. 243, Capelin: Given the importance of capelin in the SEA region, this section should be revised with more regional specific information and references. This section also needs a discussion of long term changes in the resource (i.e., effects of ecosystem change and impact of future climate change).

- Some rewording is required to ensure that the reader is not left with the impression that capelin may spawn in early June in coastal Labrador as this is not the case.

Pg. 243-245: There appears to be some inconsistencies among Figures 4.3.1 and 4.3.2 and Table 4.9. Fig. 4.3.1 seems to indicate a total of about 100,000 t of catch in the last few years (foreign+domestic), while Fig 4.3.2 indicates less than 60 000 t. Table 4.9 reports 135 000 t for the domestic harvest alone.

Pg. 243, Fig. 4.31 (NAFO catches 2GHJ, All countries+Canada Only, 1960-2005): The x-axis scale is missing, but the graph suggests there were foreign catches within the 2GHJ Divisions in the latter period in the order of 45,000-60,000 t. This is incorrect and the values in this figure

need to be checked because the only foreign effort in 2GHJ since 1994 occurred outside the 200-mile limit and the only species caught was redfish; however, the level of such catches is not in the order of 45,000-60,000 t. Although the graph illustrates that catches occurred between 1960-2005, the text notes the period as 1985-2005.

Pg. 244, Fig. 4.32: This figure shows a similar trend to Fig. 4.31 but a smoothed line is displayed even though a very different scale is used (largest catch in graph is about 120,000 t and largest in Fig. 4.3.1 is over 180,000 t). A better explanation of the differences between Fig. 4.31 and 4.32 should be provided. Also, it is not clear which source is used for Fig. 4.31, since the text indicates for Fig 4.32. "…*Catches for NAFO-regulated species by foreign and domestic harvesters, based on NAFO statistics, are shown in Figure 4.32"*.

Pg. 244, Fig. 4.33: This appears to be percent of landed weight rather than value, which underestimates the importance of snow crab in Labrador.

Pg. 253, Atlantic cod: More information is required on cod in 2GH. A good recent source is Smedbol *et al*. (2002).

Pg. 284, Para. 1: *"Eventually, the fishery moved further offshore to the sentential slopes (Brodie et al. 2007)"*. Should this read 'continental slopes'?

Pg. 284, Para 3: The following statement "*Although a TAC (Figure 4.76) is established for this resource, estimated catches have been exceeded by 27 %, 22 % and 27 %, respectively for the first three years of the rebuilding plan (Healey et al. 2007)"* should state "estimated catches have exceeded the TAC by…".

Pg. 284, Para. 4: The following statement *"The temporal coverage of Divisions 2GH has been irregular, with no surveys being conducted in 2G since 1999 (Healey 2007)"* should read the "temporal coverage of research surveys".

Pg. 290, Para. 3: "*Within the Labrador Shelf SEA Area, Arctic char have been harvested from exclusively from NAFO Unit Area2H"*. While commercial harvesting of Arctic Char occurs in 2H, Arctic Char is harvested for subsistent purposes along the entire Labrador coast. For example, there are significant harvests of Arctic char in the Sandwich Bay and Black Tickle areas.

Pg. 302, Table 5.7: Please provide references for the spawning times reported in Table 5.7 (referenced as 5.6 in the text).

Pg. 303, Witch Founder: The statement *"Age data from fishery and DFO surveys have not be collected since 1994…"* is not accurate in regard to the DFO survey as aging material (otoliths) have been collected annually since 1994, but have not been aged due to a lack of technical expertise.

Pg. 303, Greenland Halibut: The statement *"Abundance and biomass estimates carried out in both spring and autumn multi-species surveys have been sporadic, especially in Divisions 2GH"* is not correct. This should read: "…surveys have been sporadic in Divisions 2GH, especially in Division 2G".

Pg. 303, Regulatory Framework: This section lists and outlines the mandates for key Acts-e.g. the *Marine Mammal Act* and the *Fisheries Act*. However, the *Oceans Act* and *Species at Risk Act [SARA]* have not been included.

Pg. 303, Sensitive Areas and Pg. 317 Data Gaps for Sensitive Areas: There are no sensitive areas for marine mammals mentioned and this is primarily because so little is known. This point needs to be reflected and emphasized in the text. There is a significant amount of evidence that

indicates areas important for marine birds are also likely important for a variety of marine mammal species (and there are some sensitive sea bird areas identified in the text).

Pg. 308, Hawke Channel-Hamilton Bank: Although the Sensitive Areas section was updated to include a reference to Hawke Channel-Hamilton Bank area, the figures were not updated to reflect the change and still focus on the channel. The conclusion regarding sensitive areas hasn't been updated either and only lists the channel. This could lead to some confusion for the public.

- DFO notes that the authors have not explained the development/formation Hawke Channel Box adequately, as was previously requested.

Pg. 345, Para. 4: If the Offshore Waste Treatment Guidelines (OWTG 2002) are supposed to be reviewed every 5 years, this would have been due last year (2007). What is the current status of the guidelines and the review?

Pg. 345, Newfoundland Experience: What is the NL experience with drill cuttings? Why are only model results discussed? Observations of drill waste dispersion and deposition should be included in this section as well as a discussion of how well the models work.

Pg. 351 and Pg. 355. Mitigations: Why is reinjection not included as a possible mitigation?

Pg. 352, Produced Water: This section is missing several important items: impacts on primary and secondary production; radioisotopes; and changes to redox chemistry upon release and consequences for availability of contaminants.

Pg. 354, Para. 7: The density of the produced water will also depend on the salinity of the formation.

Pg. 355, Commercial Fisheries: Produced water discharges increase with the age of a well. The White Rose Environmental Effect Report referenced is too early in the production life of the project to expect impacts from produced water.

Pg. 362, Para 6: Oil spills could also indirectly effect the health of marine mammals through ingestion, ingestion of contaminated prey, or by a reduction in available prey resulting from prey mortality. For example, this may be the cause of the decline of the Alaskan killer whale population following the Exxon Valdez oil spill.

Pg. 366, Oil Spills: This section demonstrates a good knowledge of the effects that an oil spill may have on the sensitive areas along the shoreline. Obviously, prevention and preparedness are key. Having Emergency Response Plans in place with the appropriate response equipment to accompany the plan as well as the staff to operate the equipment is also critical when taking into account the remoteness of most of the area.

Pg. 367, Marine Transportation: Although Marine Communication and Traffic Services (MCTS) only tracks vessels over 500 t, the Canadian Oil Spill Response Regime captures tankers over 150 t and all vessels over 400 t that carry oil as fuel or cargo. These vessels are all required to have SOPEPs. This is regulated by Transport Canada’s Marine Safety. Each community (or OHF) that has fuel oil offloaded or loaded should have an OPEP. Included in the plan should be a list of response equipment that should be present when the transfer is taking place as well as a declaration stating that the OHF has an arrangement with a certified Response Organization.

Pg. 378, Para. 3: CCG-ER supports the idea of operators considering the value of maintaining onsite spill response equipment with locally trained responders.

Pg. 382, Table 5.7: DFO previously highlighted that a table listing spawning times had incorrect information for the *SARA* listed wolffish species. Table 4.16-The table states that wolffish spawn

from December to February, but on page 173 it notes northern wolffish spawn in late fall early winter and spotted and Atlantic wolffish spawn between July-October. The table should be updated to reflect that larger timing window for wolffish spawning, particularly as these are *SARA* species. This table is now Table 5.7 on pg.382, but it hasn't been updated.

Pg. 388, Planning Considerations: Spill response capability along the Labrador Coast needs to be upgraded to support any activities that may be undertaken in the area. The appropriate equipment with locally trained people should be in place.

Pg. 390, Bullet 7: Seismic airgun array shut downs should be applicable to marine mammals other than those identified as *SARA*-listed species.

Pg. 390, Bullet 8: The authors should provide more detail on the “Marine Mammal and Seabird Observation program”. DFO personnel (J. Lawson) has offered to train these observers in the past, and they can offer far better data collection and mitigation through training and a clear and detailed plan for their activities.

Pg. 391, Accidental Events: The Oil Spill Response Plan needs to be exercised on a regular basis. The response times and the response equipment need to be appropriate for the environment and the type of product that is being explored. Prevention equipment should be in place and ready to further mitigate any damages after a spill has occurred.

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