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Proceedings of the Regional Peer Review of the 2HJ, 3KLNOP, and 4R Snow Crab Assessment

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Editor: Nick Gullage

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Foreword

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

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SUMMARY

The Regional Peer Review process to assess Snow Crab (*Chionoecetes opilio)* in 2HJ3KLNOP4R was held February 16-18, 2021 virtually via Microsoft Teams. This Proceedings Report includes abstracts and discussion summaries of all presentations at the meeting, as well as a list of research recommendations.

In addition to these Proceedings, additional publications to be produced from this meeting include a Science Advisory Report and a comprehensive Research Document. All publications will be made available online by the Canadian Science Advisory Secretariat (CSAS).

PRESENTATIONS

AN ECOSYSTEM APPROACH TO FISHERIES MANAGEMENT AT DFO

Presenter: M. Koen-Alonso

Abstract

Fisheries and Oceans Canada (DFO) is committed to the implementation of ecosystem approaches for the management of aquatic living resources. This process aims at improving fisheries management decisions, and it is driven by Canada's international commitments and national legal obligations (e.g., United Nations Convention on the Law of the Sea [UNCLOS], UN Fish Stocks Agreement [UNFSA], Revised Fisheries Act, DFO Sustainable Fisheries Framework), but also by a global shift in fisheries management paradigms and market forces that increasingly demand certifications of sustainability for fisheries products. Many international jurisdictions are already embracing ecosystem approaches in fisheries (e.g., Australia, New Zealand, and the United States).

As part of this progression, DFO has established a National Initiative aimed at implementing an Ecosystem Approach to Fisheries Management (EAFM) in Canada that will integrate environmental variables (i.e., climate, oceanographic, and ecological factors) into single-species stock assessments in order to improve fisheries management decisions. The current iteration of this long-term initiative, which will be completed by 2023, is intended to serve as a stepping stone and learning ground for the more integrative Ecosystem-based Fisheries Management approaches that will be needed in the future.

The National Initiative was organized through a National EAFM Working Group (WG) and a series of Regional EAFM WGs, and its main goal was to develop a national framework to operationalize an EAFM. Within this framework, EAFM would retain primarily an individual stock and fishery focus, while incorporating ecosystem variables in science advice to better inform stock and individual fishery-focused decisions. DFO has already made progress towards an EAFM in some stocks/fisheries; for example, cases where oceanographic or prey considerations have been included in stock assessments and, less often, science advice. With respect to the fisheries management decision-making process, it was unclear how these components were considered in stock/fisheries management actions. Roughly one quarter of DFO assessments provided advice that incorporated climate, oceanographic, or ecological considerations in the recommendations.

To move forward on the development of the National EAFM Framework, the Regional and National EAFM WGs have identified regional case studies to explore tangible ways of how to incorporate EAFM principles. In the NL region, the case studies focused on: Northern cod, Capelin, Northern shrimp, Snow Crab, and Harp Seal. The species included in these case studies not only supported important and iconic fisheries in the NL bioregion, but also represented core components of its food web. Trophic interactions among these species and environmental signals emerged as important drivers in the dynamics of the individual stocks as well as the overall ecosystem, which made all of these case studies particularly relevant for the development and implementation of ecosystem approaches.

Each DFO region identified their own case studies. These case studies were selected for their regional relevance, but also to cover a diversity of stock characteristics (e.g., biological traits and life histories, data quality and quantity, ecosystem context, management considerations, etc.). Case studies were intended as learning tools, and depending on the case, may have covered all or part of the elements required for an EAFM. As part of their development, and

whenever appropriate, results and emerging ideas were planned to be presented at already established science and/or management venues (e.g., CSAS stock-assessments, Precautionary Frameworks, Rebuilding Plans or other Working Groups, and advisory and/or consultation meetings) for discussion, consideration for application, and/or to gather feedback from participants (i.e., scientists, managers, and stakeholders). When taken together, these case studies and the experiences collected through their implementation, would inform the National EAFM WG conversation, contributing to create an approach with an aim to be nationally consistent and regionally appropriate, and guide the development of the National EAFM framework.

Discussion

One participant asked if the presenter was comfortable with the ecosystem production units (EPUs) that were defined. The presenter remarked that they were comfortable with them, and that EPUs were derived from older work but were imperfect. It was added that the EPUs were more or less open, general concentrations of production within the ecosystem, and were in no way definitive, especially considering that there was interconnectivity between EPUs. This was proceeded by a discussion regarding the design of the model itself, noting that the model was still designed for a single species, and that much of the work in Canada on ecosystem models was behind the work being done here. Nonetheless this model was a step toward a fuller ecosystems-based fisheries model.

OCEAN CLIMATE VARIABILITY IN NEWFOUNDLAND AND LABRADOR WATERS

Presenter: F. Cyr

Abstract

An overview of physical oceanographic conditions in the Newfoundland and Labrador Region during 2020 was presented. The winter North Atlantic Oscillation (NAO) index, a key indicator of the direction and intensity of the winter wind field patterns over the Northwest Atlantic was positive for a 7th consecutive year (since 2012, only 2013 was negative). While this positive NAO phase led to colder than normal conditions for a short period (2014-17), most ocean parameters were back to above normal. Sea Surface Temperatures (SST) were above normal and sea-ice was below normal for the first time since 2014 and 2013, respectively. Observations from the summer Atlantic Zone Monitoring Program (AZMP) oceanographic survey indicated that the volume of the cold intermediate layer (CIL, <0°C) was below normal in the 2018-20 period. Bottom temperatures were warmer than normal in Northwest Atlantic Fisheries Organization (NAFO) Divisions 2HJ3KLNO.

Discussion

A participant inquired if there was more value in keeping the older timeframe for the model rather than updating it to rely on more recent years in the time-series. It was explained that the model could be changed to exclude colder years in the 1980s, but that doing so may exacerbate existing heating trends. However, there was uncertainty regarding results that would come from the inclusion of only newer dates.

There was a question regarding the quality of older data in the time-series compared to newer data, and if this had an effect on the calculation of the climate index. The presenter stated that all data came from the same time-series which started in the 1980s, and temperature values from prior years were derived from other data. It was then asked if the model would change if it

only included values for the time-series after the 1980s, but it was assured that this would not change the indices.

Another participant asked if the NAO trends would affect Snow Crab trends based on the correlation between the NAO and crab biomass, and if this assumption of a correlation would hold in the future. The presenter responded by noting that climate change caused instability in predictions, but the NAO trend may hold true because it primarily relied on winter temperatures. They also noted that the NAO trend would only change if warm winters were recurrent.

There was a question about the correlation in the NAO index and the 6-8 year lag in crab biomass. It was explained that the lag corresponded to recruitment into the crab fishery which takes approximately 6-8 years.

OVERVIEW OF CHEMICAL & BIOLOGICAL OCEANOGRAPHIC CONDITIONS ON THE NL SHELF

Presenter: D. Bélanger

Abstract

Biogeochemical oceanographic conditions on the Newfoundland and Labrador Shelf were presented and interpreted against long-term (1999-2020) mean conditions in the region. Satellite ocean colour data indicated near-normal timing, duration, and productivity of the spring phytoplankton blooms in the past couple of years after a period of late, short, and low-production blooms in the mid-2010s. In-situ data from the Atlantic Zone Monitoring Program (AZMP) seasonal surveys showed an increase in the integrated inventories of nitrate (50-150 m) and chlorophyll (0-100 m) since 2015 and 2016, respectively, after several years of below-normal levels in the early 2010s. Total zooplankton abundance has remained at a time-series maximum since ~2015. Zooplankton biomass increased to above normal levels during the same period after several consecutive years of negative anomalies in the early 2010s. Changes in the zooplankton community structure since ~2010 resulted in fewer large, energy-rich calanoids (i.e., *Calanus* spp.), and more small copepods (e.g., *Pseudocalanus* spp., *T. longicornis, Oithona* spp.) and other non-copepod groups including appendicularians and pteropods. Additionally, there has been a change in zooplankton seasonality since 2016 characterized by a weaker spring and stronger summer and fall signals.

Discussion

A participant inquired if there was a trend between copepods or zooplankton and larval crab survival. The presenter commented that they were unsure because neither were a primary food source for young crab and there was not much research on the relationship between the zooplankton community and crab recruitment and survival. The participant added that some fish in Europe are directly affected by zooplankton structure, and the presenter confirmed that relationships sometimes exist, but that it was not obvious for NL Snow Crab.

There was a question about if there were any links between non-copepodite zooplankton and climatology on early life-stage crab. The presenter responded that research was aimed at looking for trends but nothing clearly stood out; there were trends in indices around 2010, but this was not definitive. They highlighted cold ocean temperatures and an increase in production post-collapse, a change in ocean temperatures, and a change in biomass indices, which all correlated to a drop in zooplankton abundance from 2012-2017, but the causal relationship was not clear.

STRUCTURE, TRENDS, AND ECOLOGY INTERACTIONS IN THE MARINE COMMUNITY OF THE NEWFOUNDLAND-LABRADOR BIOREGION

Presenters: M. Koen-Alonso, H. Munro

Abstract

The ecosystem structure of the Newfoundland and Labrador bioregion can be divided into four Ecosystem Production Units (EPUs): the Labrador Shelf (NAFO Div. 2GH), the Newfoundland Shelf (Div. 2J3K), the Grand Bank (Div. 3LNO), and southern Newfoundland (Subdiv. 3Ps). These EPUs coarsely represent functional ecosystems, and are used as geographic boundaries for the estimation of fisheries production potential (FPP) using ecosystem production potential models. Estimated FPP distributions, together with proxies for the current productivity state of the EPU, have been used to provide guidance on upper limits of total catches total catch index (TCI) of fish functional guilds, within the 2J3K and 3LNO EPUs. These functional guilds are higher level aggregations than the fish functional groups used to describe ecosystem status and trends. For example, the benthivore guild includes all benthivore fish functional groups (small, medium, and large) plus the shellfish functional group (i.e., shrimp and Snow Crab). The analysis of FPP indicated that benthivore guild catches, where Snow Crab is included, were consistently above the TCI in 2J3K, but mostly below it in 3LNO since the mid-1990s. However, benthivore guild catches have dropped below the TCI since 2015 in both EPUs. Piscivore guild total catches were above the TCI in 3LNO in the 1996-2004 period, and since 2015. Catches of suspension feeding benthos in the 3LNO EPU have also been above the TCI in recent years. These results indicate that during the 1995-2020 period, these ecosystems experienced fishing levels that had the potential to erode ecosystem functionality.

The ecosystem structure of the Newfoundland Shelf and Grand Bank changed in the 1990s with a collapse of the groundfish community and an increase in shellfish. Even with the increases in shellfish, total biomass never rebuilt to pre-collapse levels. Starting in the mid to late-2000s there were consistent signals of rebuilding of the groundfish community which coincided with modest improvements in Capelin, and the beginning of a decline in shellfish. The finfish biomass in the 2010s was relatively stable until 2014-15, when it started to show signals of decline. This signal appeared earlier in 3LNO, and later in 2J3K. While there are signals of improvement since the lows in 2016-17, especially in 3LNO, current total biomass has not yet returned to the 2010-15 level in either of these EPUs. The conditions that led to the initial rebuilding of the groundfish community in the mid to late-2000s appear to have eroded. This may be linked to the simultaneous reductions in Capelin and shrimp availability. Furthermore, the modest improvement in ecosystem conditions observed in 2019-20 has led to a subtle increase in dominance by shellfish in the community structure. Total fish biomass in 3Ps has remained fairly stable since the mid-1990s, with ephemeral increases mostly driven by plank-piscivores (e.g., 2007, 2019). However, the structure of the fish community has been changing. Among piscivores, Silver Hake has increased its dominance to similar levels as cod, and Spiny Dogfish was dominant in 2019.

From a shellfish perspective, shellfish biomass in 2015-20 saw its lowest level since 1995, the beginning of the Campelen series. Shrimp reached the lowest research vessel (RV) biomass in the time-series in 2019, but while still remaining low in 2020, showed a nominal increase. Positive signals were more clear in Snow Crab, especially in 3LNO, but the lack of Spring RV surveys in 2020 due to the COVID-19 pandemic prevented us from evaluating how consistent this picture was across EPUs (e.g., Snow Crab biomass declined in 3Ps in 2019).

Capelin and shrimp are important prey items for many predators, with sandlance also important in the 3LNO and 3Ps EPUs. The dominance of shrimp in diets has generally declined as the

shrimp stock declined. Snow Crab appeared as an important prey for cod and thorny skate across ecosystem units, especially in 3Ps. However, the dominance of Snow Crab in the diet of 3Ps cod has been comparatively low since 2017. Average stomach content weights for cod and Turbot had also declined since the mid-2010s, and tracked well with the general trends observed in the finfish community. This supported the idea that declines in total biomass observed in recent years were associated with bottom-up processes, but also indicated that food availability was an important driver of ecosystem changes in the bioregion. Current results suggested that Newfoundland and Labrador ecosystems continued in low overall productivity conditions, even though these conditions may benefit shellfish stocks.

From a predation and impacts perspective, total food consumption by crab predators (large benthivore and piscivore fish functional groups), was estimated based on food requirements. If food availability was limited, actual consumption was expected to be lower than the calculated estimates. Results indicated that total food consumption by predators was stable in the early 2010s, but showed declines after 2013-14. These declines appeared earlier and were more evident in the southern EPUs (i.e., 3LNO, 3Ps). Total food consumption by crab predators showed increases in 2018-20, but still remained just below the level seen in the early 2010s in most ecosystems. Estimated consumption of Snow Crab increased since the late 2000s and early 2010s in 2J3K and 3LNO, and reached its highest values in 2016-18. However, the 2019-20 estimates, while still high in comparisons with the early 2010s, were down from the highest values. In contrast, consumption of Snow Crab had generally declined in 3Ps since the early 2010s. In terms of predation mortality rate, 3Ps had the highest mortality index until 2017. Predation mortality in 3Ps declined while it increased in 2J3K, putting these two ecosystems on par in terms of Snow Crab predation mortality rate. Predation mortality in 3LNO remained an order of magnitude lower than the other ecosystem units. While predation mortality rates remained among the highest in recent years, they showed important declines from the peak levels observed in the 2016-18 period.

In summary, ecosystem units in the bioregion are currently experiencing low productivity conditions, which has impacted the rebuilding process of groundfishes and led to important declines in total biomass. However, Snow Crab and other shellfish showed signals of improvement on the Newfoundland Shelf (2J3K) and Grand Bank (3LNO) in recent years. Low availability of core prey likely led to some of the increases in the fraction of Snow Crab in the diet of predators in recent years, but the mechanisms behind this response are complex. Availability of other alternative prey would have also impacted predation on Snow Crab. If environmental conditions were favorable, declines in predation pressure could improve the prospects for Snow Crab in the coming years.

Discussion

One participant commented that predation on Snow Crab in 2J was increasing, contrary to the overall trend and asked if this was a result of differences in sampling levels. It was clarified that this increase in predation was largely due to the level of crab biomass and the presence of their predators in 2J compared to 3K. The participant also inquired whether the assumption that the stock was in a low-productivity period would change if the assessment included more data for different species, particularly Harp Seals. A response emphasized the importance of seals as a component of predation, but that in general they did not overshadow other species in the ecosystem in terms of biomass or predation and analyses point toward bottom-up processes and environmental conditions as drivers of the population. This was followed by another comment with regards to the radical increase in Harp Seals since the 1990s, but it was clarified that these increases in biomass were not as large as those seen in other groups in the community.

It was questioned if diet studies were standardized throughout the day (i.e., on a 24-hour cycle) because feeding habits changed throughout the day, to which the presenter rebutted that stomach content samples were collected over the course of a day. A comment was made noting that fish were feeding less than previously, and asked if these feeding patterns at all indicated a decrease in biological condition or a decrease in fecundity. The presenter remarked that such ecosystem-scale studies did not look at condition or fecundity and expressed uncertainty in the suggestion. It was added that such indices may add confidence to results. This was furthered by a question asking why crab predation by finfish was low when biomass was high, and if this was related to issues with carapace digestion. The presenter noted that this factor had not yet been investigated. It was added that the size of crab being consumed were relatively small and were typically independent of exploitable biomass; it was also noted that smaller crabs had a thinner carapace and were comparably digestible. A concluding remark was made regarding the consumption of females, but it was assured that females were likely too big for local fish species to consume.

One participant inquired about the cause of the supposed low productivity regime, and where the energy from lower trophic levels was going if not upwards. The participant added that the model did not mention relative EPU which may impact production. The presenter clarified that the low productivity regime may partially be bottom-up limited, and energy may escape the system due to an absence of planktonic species and planktivores to carry it upwards. Furthermore, they noted that the ecosystem-scale study made it difficult to deduce how EPUs may impact overall productivity. Another participant added that the low productivity regime may be related to the timing of primary production, in that production could not travel up the food chain to achieve secondary production, or there may be inefficiencies in the food chain. The energy may also be transferred through currents and thereby sent to other regions. Further, it may also be related to oceanographic effects or climate change which could impact how energy is transferred throughout the system. A participant added that the energy in the system would not be the same every year, and if the cause of the low productivity was indeed bottom-up, then the research should look beyond primary production.

A participant asked what the average size of cod that had stomach contents of crab and Capelin was and if there were calculations of the energy contents of the prey, to which the presenter informed that cod stomach size and content was not investigated in this study but there were studies that do look into this.

It was mentioned that signals in the biomass measures did not show decreased secondary production in contrast to previous claims. It was assured that a lag in the signals within the systems was expected, such that changes in lower trophic levels that would invoke responses in upper trophic levels would take time to appear, and that biomass changes tended to show quicker responses in production but these responses were not immediate. A lack of clear cause for changes in zooplankton and the shift in production regime was discussed. Another participant responded that recent trends in plankton biomass were what indicated energy transfer throughout the system rather than where the biomass itself was.

A participant posited that Harp Seals impacted the localized EPU, particularly in 2GHJ3K, and the aggregation of data for all areas in the NL Snow Crab fishery obfuscated the trends between seals and other local species. The presenter agreed that impacts of predation between seals and other species were localized, but overall ecosystem effects may be broader. The participant inquired what the most likely cause was for the change in EPU, to which the presenter responded that production in lower trophic levels was a likely source because most production occurs there and as such could have massive effects on the food chain.

Mention of Harp Seals and their impact on the fishery, in particular in 2HJ, was a recurring talking point and issue throughout the assessment meeting. It should be noted that some participants placed much emphasis on seal abundance and predation on Snow Crab when discussions of the 2HJ fishery took place.

FACTORS AFFECTING SOFT-SHELL INCIDENCE IN THE NL SNOW CRAB FISHERY

Presenter: D. Mullowney

Abstract

This presentation investigated two focal factors affecting soft-shell incidence in the NL Snow Crab fishery: seasonality and fishing. Taking advantage of large spatial contrast and different levels of harvest rate in portions of the stock range, the study compared and contrasted outcomes of the effects of the two factors at both divisional and global levels. The study showed that the two factors interacted to regulate soft-shell incidence in the fishery. June-August was a problematic period for Snow Crab in the fishery, particularly in heavily exploited areas. However, even during this problematic period, soft-shell incidence could be minimized through a management strategy of light exploitation and associated maintenance of a strong residual biomass of large hard-shelled males in the population. Finally, the study provided evidence of earlier molting periods in wild populations occupying the warmest habitats, a novel observation for NL Snow Crab.

Discussion

One participant asked if there had been a study on ocean acidification and its effect on a Snow Crab's ability to build shells when acidity was relatively high. The presenter replied that there was literature on other crab species describing abnormalities in early life-stages and other effects in highly acidic waters, but that there was nothing on Snow Crab currently.

There was a question regarding the availability of catch data to analyze the ability of pots to catch crabs, and the effect that soak time, mesh size, and bait protectors had on retention or escapement. It was revealed that current pot designs allowed crabs to crawl out at a rate of approximately 0.01 kg/hr, with maximum escapement approaching 4 days, but there were no data on how bait protectors impacted the catch rates of pots. It was added that there was work done avoiding catch of white crab in the Gulf, but it was not replicated for Snow Crab.

There was a question asking if above-normal bottom temperatures could lead to excess molting in Snow Crab. It was confirmed that it has happened in the opposite direction, whereby cold temperatures have led to less molting, and so it was possible molting could have been effected by warmer temperatures.

A comment was made that indicated recent trends in 2J aligned with what the models showed with respect to residual biomass, and even though at-sea observer coverage was low it was good to see that they lined with up the data presented.

Another participant inquired if discussions were had with harvesters to determine if management and closure strategies for soft-shell crabs were possible. The participant also asked if there were any shallow fisheries for Snow Crab and if there were any ways of managing soft-shells in these locations; and in the case when soft-shells were caught, if there was a method for returning them safely to the water. The presenter informed them that a soft-shell protocol was in place for fishery management and was established via a collaboration between fishers and management. It was added that management could direct the fishery into

soft-shell areas, and that controls like the use of different sized boats were used to reduce fishing in shallow waters. Lastly, they affirmed that careful release advice had been developed to handle discards appropriately.

A participant asked if it would make sense to fish Snow Crab earlier in northern areas where residual biomass was lower. There was a reply that fishing in Labrador in the winter could be difficult, and because residual biomass was linked to seasonality, holding back the fishery for a couple years would increase residual biomass. The participant furthered that with the decrease in ice in recent years, it may help to start the fishery earlier. Another participant commented that in the past, the fishery started at different times of the year, sometimes as early as November. It was then asked if there was a way to start fishing sooner in the year, to which another responded that the Alaskan Snow Crab fishery has started earlier and that it was possible, but December may be the earliest plausible date. Lastly, a participant asked if finished-molt cycle crab could finish earlier in the north than in the south. The response was that it could happen, but it was not definitive that this was always the case.

One participant asked when the season closed in Div. 3LNO, to which the presenter replied that it historically ran into August but recently it has closed in July. There was a note that, recently, the fishery was only open for a few weeks in the north and had a small stock size.

NUNATSIAVUT SNOW CRAB FISHERY IN 2HJ – NORTH

Presenter: A. Dale

Abstract

No abstract provided.

Discussion

There were no questions or remarks for this presentation.

AGE AND GROWTH OF SNOW CRAB. TOWARD A POPULATION MODEL FOR NL SNOW CRAB

Presenter: D. Mullowney

Abstract

Snow Crab is arguably one of the most difficult species possible to develop a population assessment model for. Sexual dimorphism, multinomial molting processes, and irregular molt frequency makes this a challenging species upon which to base demographic progression models. In NL, this difficulty is compounded by a relatively short history of dedicated biological research into Snow Crab, monitoring programs that have not always been well focused on aspects of population demographics beyond exploitable-sized males, and a large and heterogeneous stock range. This presentation overviewed both challenges and progress in research initiatives geared toward development of a population assessment model for this vital fisheries resource in NL.

Discussion

Growth

There was a question asking if the model used the indices of instars 12 & 13 from trawl surveys from 6-7 years earlier to estimate exploitable biomass. This was confirmed, and the presenter

clarified that these instar indices could be projected forward because they become part of the exploitable biomass in 6-7 years.

There was a question on the difference between instar counts and crab age, which did not seem to be consistent with the year-based exponential decay model used. There was a separate question regarding catchabilities which seemed to show increasing q-at-length given the variability in raw catch-at-age data. The presenter clarified that age was not modelled at all, that the model followed an instar-by-year pattern, and the use of instars eliminated the need for ages. It was also clarified that the catchability trend with respect to length did not exist; the dampening in catchability did not occur in Alaska, and a dampening effect did not make sense.

There was a question on how abundances were reconstructed, if this was done using trawl efficiency to reconstruct crab size distribution by year, and if this was then modelled forward by applying the constant mortality that was set. This was confirmed to be the process to derive abundances, but was only used to push signals in growth through the model. The participant asked if the abundance, and thereby growth, was delayed as indicated by the southern region's signals. This was also confirmed, and that molt probabilities had to be described in order to explain the delay in signals. The participant also asked if crab density affected growth, which was also confirmed. The participant lastly inquired if this density referred to all crabs or specifically male crabs, and if the probability of terminal molt increased for smaller sizes as density increased. The presenter responded that competition with larger crabs induced more growth and that shifts in earlier molts in southern regions resulted from the decreased density, and the spikes in abundance that were predicted would not be realized.

A participant asked if mortality changed with sizes over time, and how the RV timing played into the data. It was clarified that this model was primarily a preview to hopefully track cohorts. The participant also asked if total mortality calculations were preliminary, which was confirmed.

There was a question inquiring if there had been any investigation of the factors leading to changes in crab density and how they affected molting. The presenter remarked that the causes for molting had not yet been looked into, and that density had only been looked at as a driver of molting.

A participant asked if a decreased stock left more area for growth, and that it seemed intuitive that lower densities would lead to increased growth. It was elaborated that a low density promoted molting at smaller sizes because the lack of competition for growth led to reproduction occurring at younger ages, and therefore, at smaller sizes.

Age Composition

There was a general comment highlighting the overall importance of maintaining a good residual biomass.

A participant asked if it was too early to be influencing management with the population model, since a framework had not yet been finalized. The participant added that crab and their predators were not evenly distributed, and a review of the model would ask questions around how the model was able to address this. The presenter replied that predation data and the model results would nonetheless change the assessment, which could potentially change management; these developments only indicated a potential improvement, and it was not certain that this would make its way into the framework. An additional comment was made noting that an advancement of management was possible, but would be a challenge to incorporate.

A note was made that low catch rates followed low residual biomass, and that the modelling of crab could affect allowed catches, so accurate model inputs must be ensured. This was

followed by a question regarding the spike in catch rates in 3N for 2020 compared to previous years. It was explained that an increase in population density led to dispersion to marginal habitats, and that the Grand Banks population was dispersing to nearby regions, namely 3N.

A comment was made on the importance of understanding the drivers of crab populations, even if the model did not expand to a full model. A response to this highlighted that the transfer of data collection to modelling was important. A general comment was added noting that meetings helped to develop these models and allowed collaborations between different perspectives.

A participant asked if the model had to be parameterized to include substrates by area or other factors. The presenter responded with uncertainty on whether this would affect growth, but that it would affect relative abundance. The participant added that the model should recognize all parameters to be effective with respect to bottom types, to which the presenter agreed.

Another participant inquired if the aging process was done using only gastric mills, which was confirmed as it was a more accurate aging indicator. When asked for clarification on age figures, the presenter elaborated that sizes were applied to ages based on derived modal instar sizes, where the figure displayed molt frequency by instar, segregated by sex and division.

A participant expressed concern with the Labrador (2HJ) Snow Crab fishery, inquiring why DFO was not willing to change constraints on the fishery, such as the timing, and noted the potential for, but scarcity of, good data from the north that could be used for solid science. A response to this emphasized that such issues were beyond the scope of the model presented, but noted that these perspectives were important.

CLIMATE-BASED PROSPECTS FOR NL AND OTHER MAJOR GLOBAL SNOW CRAB STOCKS

Presenter: D. Mullowney

Abstract

This presentation explored correlations between stock biomasses and lags of winter phases of historic global-scale climate systems for major Snow Crab stocks. The work revealed strong linkages between the Newfoundland and Labrador and Alaskan Snow Crab stocks with both of these stocks being out of phase in biomass trends compared to the Southern Gulf of St. Lawrence stock. The burgeoning Barents Sea stock appeared to be most closely linked to the Southern Gulf of St. Lawrence stock. These patterns in stock trajectories appeared linked to spatiotemporal dynamics of climate forcing systems. The study further investigated potential global Snow Crab habitat moving forward under scenarios of greenhouse gas warming, using Arctic sea ice as a proxy for potential habitat.

Discussion

A comment was made that it was a leap to connect potential causes and responses of the stock biomass to climate effects. It was added that large-scale signals sometimes differed from local ones, which led to a question asking if an attempt was made to compare these results with other measured indices. Clarification was also requested for what the deciding factor for the model was, given that the Akaike Information Criterion (AICs) between each fitted model were very similar, and what the main differences in the best-fitting models were. The presenter replied that other indices had not been compared to signals in data, but doing so may be fruitful. The presenter also noted that the other fitted models showed very minimal overall differences such as a slight dampening in projection results. A separate comment was made suggesting that the

model should not be changed to the updated version presented, considering the small change in AIC, until further investigation into the model was done.

Another participant commented that effects from temperature led to changes in biomass, but that ice did not influence cold bottom temperatures, and suggested removing the level of cause-effect linking ice and bottom temperatures. The participant added that there were a lot of out-of-phase signals in the data with respect to currents (e.g., the Labrador current). Lastly, the participant noted that bottom temperatures less than 4°C essentially covered the entire Newfoundland Labrador shelf, so changing temperature-based conditions to this constraint did not help narrow the focus of the Snow Crab habitats. The presenter remarked that the stock was merely spread among these areas and not claiming to provide precision for crab locations based on temperature conditions.

DIVISIONS 2HJ3KLNOP4R OVERVIEW – STANDARD ASSESSMENT

Presenter: J. Pantin

Abstract

The status of the Snow Crab (*Chionoecetes opilio*) resource surrounding Newfoundland and Labrador NAFO Divs. 2HJ3KLNOP4R is assessed using a variety of metrics. The resource is assessed at larger-scale Assessment Divisions (ADs), which are comprised of combinations of NAFO Divisions. Data from multi-species bottom trawl surveys conducted during fall in ADs 2HJ, 3K, and 3LNO Offshore, and spring in ADs 3LNO Offshore and 3Ps provide information on trends in biomass, recruitment, production, and mortality over the time-series. Multi-species trawl survey indices were compared with other relevant indices to infer changes in resource status for 2021 and beyond. These other indices were derived utilizing data from harvester logbooks, at-sea observers, the dockside monitoring program, and inshore and offshore trap surveys, as well as oceanographic surveys. There was no spring multi-species trawl survey in 2020 due to the COVID-19 pandemic, therefore there was no updated trawl data for AD 3Ps. Snow Crab landings remained near 50,000 t from 2007 to 2015, but steadily declined to a 25 year low of 26,400 t in 2019. In 2020, landings increased slightly to 29,100 t. Overall effort decreased in 2020 to under 2.5 million trap hauls per year which was the lowest level in two decades. Overall Catch Per Unit Effort (CPUE) was at a time-series low in 2018, but returned to a time-series average level in 2020. There were modest increases in the trawl exploitable biomass index over the past 3-4 years and it was nearing the time-series average in 2020. Meanwhile, the trap survey exploitable biomass index declined by nearly 60% in 2017 and 2018 to a time-series low. It increased in the past two years, but remained below the time-series average. Total mortality in exploitable crab decreased in all ADs in recent years. It remained highest in AD 2HJ and lowest in AD 3LNO Offshore. There was no updated total mortality estimate for AD 3Ps in 2020, but the relatively high presence of old-shelled crab in trap survey data suggested total mortality remained low. Exploitation Rate Indices (ERIs) were near time-series lows in all surveyed ADs in 2020, except AD 2HJ where it remained high at around 50%. Elements of the Precautionary Approach Framework (PAF) presented in this assessment are tentative. Limit Reference Points (LRPs) defining the Critical Zone for the three stock status metrics have been established by a peer-reviewed Science process, but Upper Stock References (USRs) defining the Cautious and Healthy Zones and Harvest Control Rules (HCRs) remain under development. In 2021, all ADs were projected to be above the LRPs of the PAF. These projections assumed status-quo landings. There were indications that several ecosystem-related factors may encourage both short- and long-term growth of the stock, including cool bottom water temperatures in previous years and a slight decline in predation in most areas. As well, there were signals of increased abundances of pre-recruit and small sized

crab indicating a positive outlook in the next 2-7 years if fishing pressure levels allow the crab to recruit into the exploitable biomass.

Discussion

One participant provided clarification that the fishing effort was not directly associated with catches. The participant expanded on this by noting that less than 40% of the Total Allowable Catch (TAC) was landed in 2HJ north while almost 100% of the quota was landed in 2J south (2Js). A decrease in effort explained why catch rates were low in 2J and may have been the result of inexperienced fishing enterprises in northern Labrador in 2020.

A participant confirmed that catches in 3Ps were down in 2017, but increased by 2018 and were very high in 2020 and remarked that high levels of discards in 2017 led to reduced landings.

A comment was made regarding logbooks, and that the drop in Division 4R logbook returns was a result of harvesters being unable to drop them off to offices due to COVID-19.

A participant asked if there were any correlations between Funk Island stock improvements in 3L and the marine refuge, to which the presenter remarked that it had not been looked into and so was unsure of any potential correlation.

A note was made that Division 2H had not undergone commercial fishing since 2006 due to low numbers and low recruitment which lined up with survey data, but the concern was that even though it's a good multispecies area, there is a lack of survey data.

A participant asked if any inshore stations were missed in recent years, and it was clarified that RV trawls do not cover inshore areas anymore, which is the reason for the absence of data in these areas. The participant also asked if the 2J3K inshore and offshore areas were separate due to trawl coverage like in 3L. However, it was noted that the coverage in the north was not quite the same because there was an overlap in the inshore and offshore areas.

A participant asked how biomass indices were smoothed, and it was explained that values were scaled in R and centered around and measured the deviations from zero.

A participant inquired if the ERI in 2HJ was based on the harvest rate for 2020 or the TAC. The presenter replied that the ERI was based on landings not TAC. The participant then commented that the figures projected a status quo harvest based on TAC, but that removals were not at 90-100% of TAC and landings in 2J north (2Jn) were less than the TAC. The presenter agreed that it may be helpful to include both removals and TACs in the projection figures.

Several comments were made on the importance of informing fishers to spot Bitter Crab Disease (BCD). It was added that an information form exists, and that if there was a demand for such information the forms could be circulated. A note was made that BCD was not visible in the spring survey period, but it may be visible later in the fishery season.

A participant asked if there was a figure showing if CPUE would increase with an increase in inshore fishing. The presenter commented that the figure in question showed the effect changes in ERI would have on CPUE as part of the Precautionary Approach (PA).

A remark was made regarding the absence of females, and how the status of females was concerning because they were not fished. It was added that their abundance was at the lower end of the confidence intervals (CIs), and as the abundance in 2J increased, the 3K abundance decreased greatly. This led to concern about the location of the absent females, and if their absence was a result of movement or truncation by natural mortality (e.g., predation by seals and groundfish). The presenter noted that there were high flounder, cod, and redfish numbers in 2J where there was a notable decline in female crabs. There was another comment that 2J

mortality did not correspond with other ADs, which begged the question why 2J female abundances were an exception, and that this warranted further analysis. Another comment was added that the conservation of the male population would not affect the female population.

A participant commented that there was no observed peak in small crab in 2013, and that there was a marked increase in consumption on young crab in 2J by predators. The participant added that whatever was affecting small females in AD 2HJ was affecting all small crab. There was a remark noting high female mating mortality, and the participant questioned if there was any research being done on male crabs protecting females from predators and if there was a notable increase in predation in 2HJ. The presenter responded that predation was a plausible explanation for the decrease in female crabs and also explained the shift in male size-at-maturity, but this required further investigation. However, the presenter added that tank and field research studies confirmed that male crabs can display protective behaviours around female crabs.

It was noted that cod biomass was present in 2J in 2020, and there was a presence of Atlantic wolffish in crab pots. It was speculated that a poor residual biomass in this region was keeping abundances low. This led to a question regarding how crab consumption was derived. The presenter elaborated that the total consumption of crab was calculated, then the proportion each species consumed (i.e., their diet composition) was derived and used to scale the total consumption. However, it was noted that diet data were somewhat limited, and the data were based on species that were abundant and for which data existed. The participant added that seasonality impacts predation on soft-shells and pre-terminal molts when predation spikes. The presenter responded that seasonality was important to consider, but the current results were obtained from the samples available given the timing of sampling with soft-shell abundance. A participant posited that small crab were still being caught in 2J, but in 2020 this did not include females, and that it was unlikely that predation was discriminating between males and females. It was concluded that predation seemed a likely cause for the increase in crab mortality in 2J, and more work needed to be done to determine the extent of predation.

There was a question inquiring if mature females were not choosing small males because they were not as effective at mating as larger males. The presenter replied that females may instead choose not to mature, and although females tend not to skip molt, the lack of mating opportunities may have driven females to do so. It was added that the Torngat data suggested that females were holding back from maturing, and a spike in 2J maturation indicated delayed maturation. The participant asked if these data confirmed that ovaries were building up for the future. The presenter asserted that this was not investigated at that level and that the survey trawls do not catch small crabs so it’s assumed only pubescent female crabs are caught.

A general comment highlighted the difficulty in dealing with predation, and that predation was a bigger issue in Divisions 2J and 3K with crab and shrimp. A note was added that the predation field should be expanded for a broader understanding, because a bottom-up inspection may be necessary for a better overall view of stock interactions and status, and that this is the aim of stomach content analysis. One participant also noted that predation spikes and male crab-size mating availability may be linked, and that predators eat females when they are soft-shelled and unguarded during mating.

Another participant asked if there were CIs for landings in projections, as projected values were based on status quo future landings. The participant added that it may help to include a decision table with alternative exploitation levels and their impacts, to which the presenter replied that this may be included in an appendix. The participant asked if the table would go in the Science Advisory Report (SAR), but it was confirmed that the table was only presented to management because the PAF needed to be approved before it could be included.

A participant asked if the ERI could be added for 2HJ split up by north and south and if the PA figure could be included in a larger format with just 2HJ set aside, that it would help with advisory meetings with stakeholders in that area. The presenter replied that in Science, the data is analyzed by AD, and not by smaller fishing areas because it gives more confidence in the results, but respected that those smaller scale areas do make sense to look at from a management perspective.

REVIEWER COMMENTS

Reviewer 1

The reviewer commented that the discussions in science meetings are always productive and favorable.

They noted that the low exploitable biomass and high exploitation rate are interesting results, and it was interesting to see the new trends in female crabs and overall predation. They also noted that the outcomes from the assessment were similar to last year.

Reviewer 2

The reviewer started by commenting that it is useful to understand how the climate impacts the region and the crab stock therein. They also emphasized the importance of the warming period and that it should be integrated into the assessment, expounding that understanding past trends may help us understand future trends.

They mentioned that the composition of zooplankton and the change in energy in the system is important, and that it may be critical to understand how this impacts upper trophic levels. They also noted that it may help to investigate changes in biomass as a result of energy in the system, and how energy in Labrador regions may move outside of those regions.

They commented that the assessment involved some good analyses in the time-series, like recruitment and indices of instar stages, and the work thus far shows interesting progress.

They mentioned that 2HJ predation should be taken into consideration in the future. As well, many factors affect crab populations and it is important to relay this information to harvesters.

DISCUSSION ON SUMMARY BULLETS

ENVIRONMENT

A participant expressed uncertainty with the effect of bottom temperature on crab stocks and how this could be reflected in the bullet. It was mentioned that the correlation between the stock and bottom temperatures was degrading, but it would still be important to note the warming trend without associating it to crab.

A comment noted the recent warming bottom and CIL temperatures, and changes in other parameters like sea ice. This prompted further discussion on whether or not to include a qualifier for temperature conditions and their association with Snow Crab.

A comment was made suggesting that the relative value of EPUs and how 2J may be a bellwether for the rest of the stock. A participant responded that while some signals begin in the north, others begin in the south.

There were further comments that the issue regarding female crabs in 2J was not settled and that the cause of the signal in the data was not clear. However, this was rebutted by the claim

that there was lack of science necessary to come to such conclusions, and that this information was only reported by harvesters.

OVERALL

There was much discussion on the significance of COVID-19 and its impact on data collection for 2020 and the assessment. It was debated whether or not to include a general bullet or statement detailing these impacts. Some concern was raised about such a bullet detracting from the significance of the results of the assessment. There was agreement when one participant said that the pandemic hadn't affected the assessment due to modifications made by Science.

A participant asked why it was stated that ERI was about 50% rather than the exact value. It was clarified that obtaining precise catch biomass is difficult so approximations for ERI values were more appropriate.

A note was made to consider all the exceptions that relate to 2HJ and the fishers in these regions. A separate comment noted that the Cautious Zone indicates to the managers that a decline in fishing is recommended. Some participants were hesitant to refer to the Critical Zone and would instead prefer referencing the Healthy or Cautious Zones. It was clarified that this could not be done because the USRs for the Healthy and Cautious Zones, and therefore the zones themselves, were not yet defined by the working group. There was concern that not all participants were equally informed on the PAF, and it was suggested that instead of stating that all populations were above the Critical Zone, it could be that they were all in the Healthy or Cautious Zones. Another participant suggested to simply state that the stock was above the LRP, and that it was too early to mention zones other than the Critical. Some participants claimed that the bullet should be excluded because reference points were not defined and this was causing issues. However, another participant remarked that LRPs were defined and it was important to state whether or not the stock was in the Critical Zone.

2HJ

There was a comment clarifying that trap surveys were only inconsistent for 2Js but not 2Jn, and that over the last 3 years no data were presented because coverage was poor. It was suggested that the bullet should generally state that trap surveys were inconsistent for 2HJ and not over-specify the details, but not all participants agreed. It was furthered that poor signals in 2HJ were compounded by data deficiencies across a number of sources due to changes in the Collaborative Post-Season (CPS) survey coverage and systemic issues with observer training and coverage. Predation was also raised as a fundamental concern of harvesters. It was concluded that, overall, such a bullet would be difficult to include because of the range of data deficiencies in 2HJ.

One participant commented that there was a recognition by the 2J fleet that the crab status in this area is poor, and that it is important to include this information, alongside the predation issue.

One participant noted the unique challenge in the 2HJ data, and that the goal of the Science branch should be to point out gaps in the data. There was a comment explaining that better data quality was requested from all parts of 2HJ. A participant expressed their concern for the stock regarding the accumulation of issues for 2J, and suggested that it should be decided whether to generalize or emphasize this matter. There was also a comment noting that incomplete trap surveys in recent years have made it hard to compare data trends with previous years.

There was a suggestion to mention finfish predation on crab, and also to include that seals must be feeding on crab and that despite the lack of data for this claim, the fishers were seeing it.

Another participant explained that a low biomass would remain low due to predation, and the abundance of seals in 2HJ which constituted high predation would result in a long recovery time. It was emphasized that predation needed to be addressed somehow, but it was explained that there was not much to be done about the predation issue other than gathering more information to explain biomass reductions and to possibly provide predictions for other stocks experiencing biomass declines in the presence of a great number and diversity of predators. Another participant suggested that this issue may be amplified if there was selective feeding on berried or pre-primiparous female crabs, potentially in the soft-shelled phases, but there was no evidence for this.

3K

A participant commented that trawl indices were up a bit in recent years while trap indices were quite low, and that the model was moderating between the low and high measures to an intermediate level. The survey signals were somewhat conflicting between exploitable biomass while the fishery CPUE remained the same in 2020. A participant noted the one to two year lag between trap and trawl surveys. It was added that an increase in trap survey indices was expected due to trends in the trawl survey indices in previous years, but exploitable biomass did not increase as much as expected.

One participant noted that the natural mortality for size-at-terminal molt was within the realm of normalcy, but was dropping. It was not as low as in 2HJ but still lower than previous years. There was also concern expressed about bullets only mentioning exploitable biomass and molt size. It was assured that the general bullets are intended to provide a takeaway message while these division-specific bullets aim to provide further detail for each AD.

A note was made regarding the positive prospects of recruitment and that recruitment was increasing, while the exploitation rate was at a historic low.

3L INSHORE

It was explained that the inshore fishery noticed an increase in crab abundance in areas they were not seen last year, and abundances stayed the same in areas where they had increased the previous year.

4R3PN

It was clarified that ongoing data deficiencies affected the outcomes and accuracy of the assessment, not the model itself.

A comment was made noting recent improvements in biomass and recruitment in major areas in the past two years. It was added that several measures were down recently, but were still higher than past values.

One participant commented that this division will soon be the only division in Atlantic Canada not under a PA for Snow Crab because of deficiencies affecting the application of one.

RESEARCH RECOMMENDATIONS

1. Further investigations of predation and environmental drivers on Snow Crab.
2. Monitor for potential impacts of ocean acidification on Snow Crab.
3. Continue investigations of discard mortality.

APPENDIX I – TERMS OF REFERENCE – SNOW CRAB

2HJ, 3KLNOP, and 4R Snow Crab Assessment

Regional Peer Review Process - Newfoundland and Labrador Region

February 16-18, 2021
Virtual Meeting

Co-Chairs: Travis Van Leeuwen and Kristin Loughlin, DFO Science

Context

The status of Divisions 2HJ3KLNO, Subdivision 3Ps and Division 4R Snow Crab was assessed in 2020.The current assessment was requested by Fisheries Management to provide current information on the status of the resource and to provide the science advice that will be used in the 2021 Snow Crab Management Plan.

Objectives

- To assess the status of Snow Crab in Divisions 2HJ3KLNOP4R;
- To determine the impacts of various harvest levels on stock status; and
- Consider ecosystem status where the assessed stock occur based on an overview including relevant summaries of oceanographic conditions, biological community structure and trends, and pertinent knowledge of ecological interactions (e.g., predator, prey) and stressors (e.g., anthropogenic impacts).

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Participation

- Fisheries and Oceans Canada (DFO) Science and Fisheries Management
- Province of Newfoundland and Labrador - Department of Fisheries, Forestry, and Agriculture
- Government of Nunatsiavut
- Indigenous Groups
- Fishing Industry
- Academia
- Other invited experts

References

No references provided.

APPENDIX II – AGENDA

Regional Peer Review Process: 2HJ3KLNOP4R Snow Crab Assessment
February 16-18, 2021

Chairpersons: Travis Van Leeuwen and Kristin Loughlin

Tuesday, February 16

Time	Activity	Presenter
10:00 am NL Time	Opening, Terms of Reference and Introductions	Co-Chairs
-	Presentation: Ocean climate in Newfoundland and Labrador waters	F. Cyr
-	Presentation: Overview of the chemical and biological oceanographic conditions on the NL shelf	D. Bélanger
-	Presentation: An Ecosystem Approach to Fisheries Management at DFO	M. Koen-Alonso
-	Presentation: Structure, trends and ecological interactions in the marine community of the Newfoundland-Labrador bioregion	M. Koen-Alonso/ H. Munro
-	Presentation: Factors affecting soft-shell incidence in the NL snow crab fishery	D. Mullowney
-	Presentation: Ago and growth of Snow Crab. Toward a population for NL Snow Crab	D. Mullowney
-	Presentation: Climate-based prospects for NL and other major global Snow Crab stocks	D. Mullowney

Wednesday, February 17

Time	Activity	Presenter
10:00 am NL Time	Presentation: Nunatsiavut Snow Crab Fishery in 2HJ - North	A. Dale
-	Presentation: Divisions 2HJ3KLNOP4R Overview – Standard Assessment	J. Pantin
-	Reviewer Conclusions	S. Boudreau and M. Laurans
-	Science Advisory Report Bullets – Continued	ALL

Thursday, February 18

Time	Activity	Presenter
10:00 am NL Time	Science Advisory Report Bullets – Continued	ALL
-	Research Recommendations	ALL

Time	Activity	Presenter
-	Upgrading of working paper to research document	ALL
-	ADJOURN	Co-Chairs

Notes:

- The agenda remains fluid and exact timing of breaks to be determined as meeting progresses.
- The meeting will aim to adjourn each day by 4:00 p.m.
- Lunch will typically occur 12:00-1:00 p.m. (Newfoundland Standard Time)
- Long distance charges may apply for the teleconference line. DFo is unable to reimburse long distance charges.

APPENDIX III – LIST OF PARTICIPANTS

Name	Affiliation
Erika Parrill	DFO-NL – Centre for Science Advice
Kristin Loughlin	DFO-NL – Science
Travis Van Leeuwen	DFO-NL – Science
David Small	DFO-NL – Resource Management
Jodi Riggs-Power	DFO-NL – Resource Management
Laurie Hawkins	DFO-NL – Resource Management
Mark Simms	DFO-NL – Resource Management
Martin Henri	DFO-NL – Resource Management
Robyn Morris	DFO-NL – Resource Management
Jennifer Duff	DFO-NL – Communications
Brian Healey	DFO-NL – Science
Brittany Pye	DFO-NL – Science
Darrell Mullowney	DFO-NL – Science
Darren Sullivan	DFO-NL – Science
David Belanger	DFO-NL – Science
Derek Osborne	DFO-NL – Science
Elizabeth Coughlan	DFO-NL – Science
Frederic Cyr	DFO-NL – Science
Hannah Munro	DFO-NL – Science
Julia Pantin	DFO-NL – Science
Katherine Skanes	DFO-NL – Science
Krista Baker	DFO-NL – Science
Mariano Koen-Alonso	DFO-NL – Science
Mark Simpson	DFO-NL – Science
Nick Gullage	DFO-NL – Science
Sanaollah Zabihi-Seissan	DFO-NL – Science
Will Coffey	DFO-NL – Science
Stephanie Boudreau	DFO-Gulf – Science
Brittany Beauchamp	DFO-NCR – Science
Bobbi Rees	Fisheries, Forestry and Agriculture NL
Brian Careen	Fish, Food and Allied Workers Union
Dwight Russell	Fish, Food and Allied Workers Union
Erin Carruthers	Fish, Food and Allied Workers Union
Miranda McGrath	Fish, Food and Allied Workers Union
Nelson Bussey	Fish, Food and Allied Workers Union
Tony Doyle	Fish, Food and Allied Workers Union
Trevor Jones	Fish, Food and Allied Workers Union
Derek Butler	Association of Seafood Producers
Lisa Matchim	Nunatsiavut Government
Todd Broomfield	Nunatsiavut Government

Name	Affiliation
Rob Coombs	Nunatukavut Community Council
Aaron Dale	Torngat Secretariat
Craig Taylor	Torngat Secretariat
Ron Johnson	Torngat Fish Co-op
Martial Laurans	French Research Institute for Exploitation of the Sea
Abe Solberg	Memorial University - Marine Institute
Paul Winger	Memorial University - Marine Institute
Raquel Ruiz-Diaz	Memorial University - Marine Institute
Scott Grant	Memorial University - Marine Institute
Shannon Bayse	Memorial University - Marine Institute
Tyler Eddy	Memorial University - Marine Institute