Fisheries and Oceans Canada | Pêches et Océans Canada
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Canadian Science Advisory Secretariat (CSAS)

Proceedings Series 2024/020

Newfoundland and Labrador Region

Proceedings of the Regional Advisory Meeting for the Stock Assessment of Northern Cod (Divisions 2J3KL)

Meeting dates: March 23–26, 2021
Location: Virtual Meeting

Chairperson: D. Mullowney
Editor: S. Zabihi-Seissan

Science Branch
Fisheries and Oceans Canada
PO Box 5667
St. John’s, NL A1C 5X1

April 2024

Canada

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.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1701-1280
ISBN 978-0-660-71106-5 Cat. No. Fs70-4/2024-020E-PDF

Correct citation for this publication:

DFO. 2024. Proceedings of the Regional Advisory Meeting for the Stock Assessment of Northern Cod (Divisions 2J3KL); March 23–26, 2021. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2024/020.

Aussi disponible en français :

MPO. 2024. Compte rendu de la réunion sur les avis scientifiques régionale sur l'évaluation du stock de morue du Nord (divisions 2J3KL), du 23 au 26 mars 2021. Secr. can. des avis sci. du MPO. Compte rendu 2024/020.

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SUMMARY

A Regional Advisory Meeting for the assessment of Northern cod in Northwest Atlantic Fisheries Organization (NAFO) Divisions 2J3KL was held virtually on March 23–26, 2021. The purpose of the process was to assess the status of Northern cod in NAFO Divisions 2J3KL in order to inform management decisions for the 2021 fishing season.

These Proceedings include an abstract and summary of discussion for each presentation, reviewer reports, and a list of research recommendations. The meeting terms of reference, agenda, and list of participants are appended.

In addition to these Proceedings, publications to be produced from the meeting include a Science Advisory Report and comprehensive Research Documents, to be available online on the Canadian Science Advisory Secretariat website.

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., UNCLOS, UNFSA, Revised Fisheries Act, DFO Fisheries Sustainable 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 USA).

As part of this progression, DFO 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 is organized through a National EAFM Working Group (WG) and a series of Regional EAFM WGs, and its main goal is to develop a national framework to operationalize an EAFM. Within this framework, an EAFM will 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, those 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 is unclear how these components are considered in stock/fisheries management actions. Roughly one quarter of DFO assessments provide advice that incorporates 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 focus on: Northern cod, Capelin, Northern shrimp, Snow Crab, and harp seal. The species included in these case studies not only support important and iconic fisheries in the NL bioregion; they also represent core components of its food web. Trophic interactions among these species and environmental signals are emerging as important drivers in the dynamics of the individual stocks as well as the overall ecosystem, making all of these case studies particularly relevant for the development and implementation of ecosystem approaches.

Each DFO Region has 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 are intended as learning tools, and depending on the case, they may cover all or part of the elements required for EAFM. As part of their development, and whenever appropriate, results and emerging ideas will be presented at already established

science and/or management venues (e.g., Canadian Science Advisory Secretariat [CSAS] stock assessments, Precautionary Approach Frameworks, Rebuilding Plans or other Working Groups, advisory and/or consultation meetings) for discussion, consideration for application, and/or gathering feedback from participants (i.e., scientists, managers, and stakeholders). When taken together, these case studies and the experiences collected through their implementation, will inform the National EAFM WG conversation, contributing to create an approach that aims to be nationally consistent and regionally appropriate, and guiding the development of the National EAFM framework.

Discussion

A participant noted that it was great that we were moving away from a single species management approach and moving towards an ecosystem approach. However, there was still work needed to better incorporate precautionary approaches (PAs), since the various stocks that are fished (e.g., Northern cod, Northern shrimp) affect one another. Another participant raised the suggestion that there should be more targeted meetings with industry to further discuss and inform the industry sector about the ecosystem approach because participants come to stock assessment meetings thinking a lot about the targeted stock and lose focus on the ecosystem aspect. It is difficult to focus on the ecosystem approach while also attempting to assess the stock. DFO scientists mentioned that they were open to having targeted meetings about the ecosystem approach, however it is also important to retain discussions about the ecosystem and precautionary approaches in these practical CSAS meetings, to give necessary context to the assessments. Another participant mentioned that it would be great if these proposed meetings could be standardized nationally.

A participant mentioned that this was a work in progress, that we are focusing on the ecosystem approach and how the various species affect each other. The plan is to move towards ecosystem-based fishery management in the future. The current challenge at the national level is that each Region and system is different. The NL system has a lot of interacting parts, which proves to be a challenge when trying to integrate various fished stocks that affect one another. Those developing the limit reference points (LRPs) know this and are trying to consider the effects various species have on the LRPs and PAs. Later, Bill C-68 was raised and a participant responded that there will be efforts in the future to attempt to show the link between this work and Bill C-68.

OCEAN CLIMATE VARIABILITY ON THE NL SHELF

Presenter: F. Cyr

Abstract

The Newfoundland and Labrador climate experiences important fluctuations at decadal time scales, with potential impacts on ecosystem productivity. The mid-1960s was the warmest period since records began in 1950, and the early-1990s, when the Capelin stock collapsed, was the coldest, and has been linked to a regime shift in the ecosystem. The warmer than average 2000s corresponded to a modest build-up of Capelin, but it was followed by another colder period (2014–17), where declines in Capelin and other fish stocks were observed. These cold and less productive conditions on the Newfoundland and Labrador Shelf are associated with positive phases of the North Atlantic Oscillation (NAO) and changes in large-scale ocean circulation (e.g., increased Labrador Current transport).

Discussion

After the presentation, a participant wanted clarification on the processes at play. When looking at the NAO plots which indicated very cold periods in the 1990s and around 2015, the bottom temperature plots did not show a similar cold period in 2015 compared to the 1990s. The presenter clarified that the NAO is an index, and although the trends were similar, the early-1990s were a lot colder than in 2015. This can be seen by comparing the size of the cold intermediate layer (CIL). There were multiple consecutive years of very cold water which led to a very cold CIL in the early-1990s. The cooling seen in 2015 was the coldest period observed since the 1990s, but was not nearly as cold since it was shorter and less intense. A short period of cooling within a relatively warm period of time would not switch the index towards colder temperatures.

Another participant noted that it seemed like the fluctuations of the CIL at Station-27 were showing less consistent changes in recent years, with more fluctuations on a shorter time scale. The participant also wondered if any work had been done to look at the correlation between these fluctuations and the Capelin stock. The presenter confirmed that it seems that we are moving from decadal towards more rapid changes. Instead of looking at correlation between Capelin and climate fluctuation, the presenter explained that the work being done is fitting a linear regression between climate anomalies and Capelin abundance. It was observed that the CIL anomalies tended to be more negative than positive. The presenter elaborated that we may be seeing this since the anomalies shift every 10 years to account for a new baseline and that the reference period needs to be kept in mind when interpreting these results.

In terms of inter-annual variability, it was asked if the range of values of bottom and surface temperatures were lost when looking at yearly averages. The response was that the time series were separated into monthly anomalies. Annual anomalies were then calculated from these monthly anomalies, which in a way would remove the range of values effect. Although true, the presenter reminded us that the presentation showed yearly differences between summer and winter, and that having a single yearly value is useful for analyses. It was suggested that in addition to showing the yearly mean, the variance should also be presented to indicate the variability within the year.

BIOGEOCHEMICAL OCEANOGRAPHIC CONDITIONS ON THE NL SHELF

Presenter: D. Bélanger

Abstract

Biogeochemical oceanographic conditions in NAFO Divisions 2J3KL are presented and interpreted against long-term (1999–2020) mean conditions in the region. Satellite ocean colour data indicated near-normal timing and duration along with increased productivity of the spring phytoplankton blooms over the past 3–4 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 the mid-2010s after several years of below-normal levels in the early-2010s. Total copepod abundance decreased from above-normal in the mid-2015s to near-normal in 2018–19, while the abundance of non-copepod zooplankton has consistently remained above normal since 2015 with the five highest anomalies of the past two decades. Zooplankton biomass has 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, less energy-rich copepods (i.e., *Pseudocalanus* spp., *T.*

longicornis, *Oithona* spp.). The abundance of other zooplankton groups including hyperiid amphipods, appendicularians, and pteropods has markedly increased since 2010. Additionally, there has been a change in zooplankton seasonality since 2016 characterized by a weaker spring and stronger summer and fall signals.

Discussion

The first part of the discussion revolved around phytoplankton and chlorophyll. A participant began by asking for clarification around magnitude not equating production. The presenter explained that magnitude is the temporally integrated production. It was pointed out that in some figures, the bloom took place and then died off; however, production continues. Someone asked what would be the cut off threshold for blooms if production continued. The presenter explained that they do not calculate those levels, it is calculated by a remote sensing team. Usually, the cut-off for blooms is when the chlorophyll levels return to normal, ensuring that it ends before the beginning of the fall blooms. This is usually done in consultation with the remote sensing team and can vary depending on the location (north versus south). A comment was made that a lot of the variables shown during the presentation could be correlated and it would therefore be interesting to see correlation matrices between them (e.g., chlorophyll concentration, nitrate concentration, bloom duration, bloom start date). Seeing these in scatter plots or a Pearson's correlation matrix may demonstrate that we only need to look at one or two of these variables to understand the present trends. The presenter responded that correlation matrices are shown in the research document and that multiple potentially correlated variables are presented because sometimes these variables are in fact not correlated (e.g., bloom on surface versus more distributed throughout the column).

During the section of the presentation on zooplankton, someone highlighted the importance of looking closer at this secondary production in relation to Northern cod. This should be done either by looking at secondary production in terms of biomass or kilojoule (energy content). Knowing what zooplankton species/sizes are eaten by the different sizes of cod, it would be possible to develop crude available food indices for each of these cod life stages. With these in place, it could be possible to see the limiting factors for cod in terms of food availability based on time, location and life stages. In the future, it would be helpful to show what food is available for cod in key feeding areas for various life stages. The presenter agreed and mentioned that these goals are being addressed by research projects looking at food availability for various cod life stages. Other participants agreed with the importance of further research on this topic. It was mentioned that very little is known about the energy requirement of young age-0 cod. What is known is that these young fish actively move through prey sizes and shift towards a benthic regime. They are more affected by near shore coastal dynamics compared to offshore changes.

Specific discussion arose around *Appendicularia,* where a participant mentioned that these copepods can feed on smaller phytoplankton which are not available to other species. It might therefore be a good idea to differentiate between nano- and micro-phytoplankton, since different species feed on these two groups. The fact that we are seeing a big increase in a particular zooplankton group could mean that there is a shift in the underlying phytoplankton community. Determining how well certain zooplanktons feed on nano-phytoplankton may be a good indicator for phytoplankton shifts without the need for specialized equipment used to analyze phytoplankton. The presenter explained that there is a small oceanography team and there are not enough resources to process all the phytoplankton samples that are on the shelves. It was asked if it would be possible to scale the numbers presented to pre-collapse levels, possibly comparing with numbers present in the literature. The presenter replied that it could be possible using the Continuous Plankton Recorder (CPR) data that go back as far as the 1950s, with gaps in the 1980s. However, there are some instances where the two datasets do not agree, but a comparison could be possible.

A participant asked if the points shown in figures related to plankton tows corresponded to individual tows. It was clarified that each point was in fact one plankton tow, resulting in no visible uncertainty on the figure. More suggestions were given about future work on the topic. Taking a more energetics focused perspective may be beneficial rather than current abundance results. Possibly integrating a microbial component to the project could give a more complete picture of the dynamics described during this presentation. The presenter elaborated that looking at the microbial life could be beneficial, especially seeing that most organic matter is recycled in the water column on the shelf, especially in deeper waters.

AN ECOSYSTEM PERSPECTIVE FOR NORTHERN COD: ECOSYSTEM STRUCTURE, TRENDS, AND ECOLOGICAL INTERACTIONS IN THE NEWFOUNDLAND SHELF AND NORTHERN GRAND BANK (NAFO DIVS. 2J3KL). PART I: ECOSYSTEM SUMMARY

Koen-Alonso, M., H. Munro, A. Cuff, and J. Mercer

Presenter: M. Koen-Alonso

Abstract

The ecosystem structure of the Newfoundland and Labrador bioregion can be divided into four Ecosystem Production Units (EPUs): the Labrador Shelf (NAFO Divs. 2GH), the Newfoundland Shelf (2J3K), the Grand Bank (3LNO), and southern Newfoundland (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 using the total catch index (TCI) by 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). Historical catches for piscivores were substantially above their TCIs. In 2J3K, catches for planktivores were near or above TCIs in the 1960s and 1970s. Catches of piscivores and benthivores have been above TCIs during the 1995–2020 period. Catches of suspension feeding benthos (surf clams) in 3LNO EPU have also been above TCI in recent years. These results indicate that during 1995–2020 period these ecosystems have experienced fishing levels that have the potential to erode ecosystem functionality.

The ecosystem structure of the Newfoundland Shelf and Grand Bank changed in the 1990s with the collapse of the groundfish community, and the 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 appears earlier in 3LNO, and later in 2J3K. While some improvement is becoming apparent since the lows in 2016–17, current total biomass has not yet returned to the 2010–15 level, and these signals indicate a subtle increase in shellfish dominance in the community structure, this is hinting at a potential attenuation or reversal of the decreasing shellfish dominance trend that started in the mid-late-2000s.

Overall, it seems that the conditions that led to the start of a rebuilding of the groundfish community have eroded. This may be linked to the simultaneous reductions in Capelin and Shrimp availability, as well as other changes in ecosystem conditions. Overall, planktivores remain below the level observed since the mid-2000s. Capelin has yet to recover to pre-collapse levels. Results from a forecast model indicates that Capelin in 2020–21 is expected to fall to a level similar to the one observed around 2017.

Ecosystem level consumption of the total fish community has declined since the mid-2000s, mostly as the result of declines in shellfish. Finfish consumption increased during the 2010s, remained stable in the early-2010s, and showed signals of decline in the mid-late-2010s. While food consumption by cod increased until the mid-2010s, and remained somewhat stable since, consumption by fish predators in general was stable in 2010–15 and declined afterwards. This suggests reallocation of consumption and possible food limitations. Food consumption by medium-large fish predators is estimated to be 2–3 times larger than harp seal consumption. Harp seals are an important predator, but no more than other top predators. Capelin and shrimp are important prey items for cod, but also turbot, American plaice, and redfish. Overall, Capelin and shrimp remain low in the diets in 2020. The consumption of cod by cod (cannibalism) and turbot has shown an important increase since the mid-2010s. Average stomach content weights for cod and turbot track well the general trends observed in the finfish community. This supports the idea that declines in total biomass observed in recent years are associated with bottom-up processes, but also indicates that food availability has been an important driver of ecosystem changes in the Newfoundland-Labrador bioregion.

In summary, ecosystem units in the bioregion are currently experiencing low productivity conditions, impacting the rebuilding process of groundfishes, and leading to important declines in total biomass. Since the mid-late-2000s, ecosystem units within the NL bioregion have been shifting back to a more finfish dominated structure, but the conditions that allowed groundfish rebuilding appear to have eroded. This may be linked to the simultaneous reductions in Capelin and shrimp availability after 2014-15. The available evidence indicates that Newfoundland Labrador ecosystems still remain in low overall productivity conditions.

Discussion

A participant had a concern that the models presented were too detailed and that there were risks associated with how they are interpreted. The results should be shown on a broader scale in terms of if things are worsening or improving rather than following detailed trend lines that are increasing/decreasing at specific percentages. Another suggestion was to show uncertainties in the structural part of the models. The presenter agreed that the purpose of using these models was to give a relative idea of the impact of fishing of these stocks. These models are not precise and should not be taken literally.

Another participant alluded to a paper they had reviewed in 2017 where there was a time series of predators and forage fish. The paper had not found any relationship between predators and the relative abundance of forage fish, implying that predators had adaptations to respond to oscillations in prey populations and the participant wondered if this could be true. The presenter responded that there are several things at play, and although predators may have adaptations, we have not seen Capelin going through cycles of population abundance since the collapse. There has been some improvements in the last few years but not a boom and bust cycle. Another important point to consider is what is the critical minimum level of prey that is needed to maintain the predators. Even with their adaptations, Capelin may currently be below that critical level. Finally, in a lot of systems, there are multiple important prey species, however in our current system, Capelin is the most important one. Shrimp can partially fill that role but they are not as energy rich as Capelin. There are other species such as sandlance and Arctic cod, but these species are region specific and do not cover the entire area. Finally, it was noted that relative availability of prey is important, and that is something that was omitted in that paper.

2020 2J3KL STEWARDSHIP COD FISHERY COMPLIANCE REVIEW

Presenter: S. Lewis

Abstract

No abstract provided.

Discussion

Comments were made at the beginning of the discussion that COVID-19 impacts led to lots of planning for dockside monitoring. A participant asked if personal use was also included in total landings, to which the answer was yes. Someone else mentioned that it would make it easier for harvesters if one set of conditions was maintained for conditional licenses instead of having a new one for each new period of time. In terms of catches for personal use, a participant asked if the percentage of the catch being classified as personal use was based on the number of people spoken to or the amount caught. It was clarified that it was based on the landings. It was then asked why 3LNO seemed to have a lot more personal use compared to the other areas. The presenter explained that it was primarily due to the demographics of the different areas. More of the catch in 3L is sold to local restaurants, which counts as personal use. In contrast, Labrador is more isolated and therefore more is sold commercially.

A participant mentioned that the information pertaining to this presentation is important for the modelling as it is linked back to the Northern Cod Assessment Model (NCAM) with the idea of narrowing down the catch bounds around the stock. The participant proceeded to ask the presenter if there was anything that would indicate that the results in 2019 or 2020 were different or concerning, in either the stewardship or recreational fisheries. The presenter explained that compliancy issues were not abnormally higher. The violations in terms of licensing seemed to have increased slightly from 2019 to 2020. The fact they are conditional licenses may partially be the cause, but elaborated that they could not comment at the moment as to why there would have been an increase. It seemed like the number of violations have been up since 2016, especially around conditional licenses. Another meeting attendee commented that based on the presentation, they did not feel that unreported catches would have been a significant issue. Another participant said that the majority of the uncertainty around the catch bounds was probably due to the recreational fisheries and others agreed based on the results presented.

AN ECOSYSTEM PERSPECTIVE FOR NORTHERN COD: ECOSYSTEM STRUCTURE, TRENDS, AND ECOLOGICAL INTERACTIONS IN THE NEWFOUNDLAND SHELF AND NORTHERN GRAND BANK (NAFO DIVS. 2J3KL). PART 1: ECOSYSTEM SUMMARY CONTINUED

Koen-Alonso, M., H. Munro, A. Cuff, and J. Mercer

Presenter: M. Koen-Alonso

Abstract

See abstract above.

Discussion

Some clarification was asked around the forecast in prey availability (Capelin) since the results seemed to suggest that there would be a possible increase this year followed by a decrease. The presenter explained that this should be looked at on a longer time frame than one year, and in that case, the Capelin population is most likely not going to be going back up anytime soon. Another question was asked about the range of consumption by harp seals and hooded seals, and how many seals that would represent. The presenter responded that seal data come from a NAFO report and they could not remember the number of seals during the meeting. The numbers for harp seals date back to the 2014 harp seal assessment but the presenter was unsure about the source for the hooded seal numbers. The presenter also mentioned that they were waiting on new consumption numbers from the DFO Marine Mammal Section. A participant noted that they believe that less harp and hooded seals have been hunted in the last 25 years and that the actual population size is much larger now. They also voiced that the actual predation effect of seal species on Northern cod is probably higher than that of the fishery. The presenter clarified that the numbers shown during the presentation were the amount of food harp seals were eating per year and not the total number of seals. The presenter also explained that it is normal for the seal consumption to be higher than that of the fishery. If fishing mortality (F) was higher than that of the predators, there would not be enough biomass remaining in the system to make the ecosystem function and we would be in a very bad situation. Some participants agreed with this statement, saying that if a Capelin gets eaten by a cod, which in turn gets eaten by a larger cod, that energy is recycled in the system. If that cod is removed by fishing, the energy is removed from the system. A participant mentioned that this is why we need to look further into seal consumption, since they have such a large consumption of fish species such as Capelin. The presenter elaborated that it was not possible to directly compare numbers and percentages between predator consumption (e.g., seals) and F. If they were compared directly, this could lead to the collapse of the fishery/ecosystem. In order to be sustainable, we need to fish at levels that do not severely impact the functionality of the ecosystem.

A participant noted that it would be interesting to see the difference in the consumption of finfish being eaten by seals compared to other fish predators. The presenter responded that by only showing what fish predators and seals are eating, the hope is to isolate the consumption of finfish. Participants said they are looking forward to seeing the updated seal consumption numbers with their confidence intervals since the harp seal population has gone up around 40% since the last update. The participants would also like to see grey seal data if possible since they have been noticed in 3L. Participants requested to be included in future work on the matter.

Looking at the cod diet data, a question was asked about the consumption data prior to 1995 as it seemed like stomach content weights were declining but were not very different than the data from the 1980s. The presenter explained that the data from the 1980s were measured in proportion of diets instead of consumption, therefore the scale of the biomass became much smaller moving forward. The consumption of cod in the 1980s was most likely quite high. There had also been a change between the 1990s and 2010s, but work needs to be done to determine if it is significant. A participant noted that the results could be interpreted that there was no cod in the system for consumption in the 1990s but that there was more available starting in 2012. The presenter added that this could be due to less Capelin and shrimp being available to predators, reflecting the importance of relative availability.

A participant wondered that with relatively stable cod numbers and increased cannibalism, if the population was nearing its carrying capacity. The presenter replied that this question should be asked again during the presentations of capcod and NCAM. They also alluded that the prospects of growth were not great and the population may be facing a plateau in growth. A comment was made that cannibalism would be obviously affected by the food supply in the system and is not only related to the amount of biomass in the system, but also on the size frequency of the cod. A remark was made that intuitively, one would think that cannibalism is lagged with spawning stock biomass (SSB) since larger cod consume smaller ones. Another participant commented that in the 1970s, it was common to see cod feeding on other cod, especially the larger fish. It was highlighted that in the last 5 years in White Bay, there has been a lack in Capelin, leading to more cannibalism. While other species are available such as mackerel and herring, cod cannibalism still persists. Someone else echoed that they were seeing the same feeding patterns in Trinity Bay. This person also said that they have been seeing Capelin in cod stomachs in the fall, which seemed abnormal. They have also been seeing a lot of Capelin spawn in cod stomachs after the Capelin had moved away. During the discussion, someone noted that the data shown during the presentation mostly originated from the fall DFO multi-species survey, meaning that the story of the inshore cod diet was most likely not captured in these data. Finally, someone asked that since the diet data presented originate from the offshore, if we are able to determine if the cod are aggregated around anything specific such as a large amount of shrimp. The presenter said that they were not sure and that this was something they were working on.

KEY PREY (SUMMARY OF DIVS. 2J3KL CAPELIN STOCK ASSESSMENT)

Presenter: H. Murphy

Abstract

The assessment of the 2J3KL Capelin (*Mallotus villosus*) stock included fisheries and ecosystem data to the fall of 2020, and the sea ice data available to March 1, 2021. The spring 3L acoustic survey was not conducted in 2020 due to COVID-19, but data from previous years are considered. Data from 2020 were available for inshore larval surveys, the fall multispecies bottom trawl survey, commercial fishery catches, the ecosystem monitoring programs, piscivorous fish diets, and ecosystem consumption estimates by finfish. Following the collapse of this stock in the early-1990s (Buren et al. 2019), the spring acoustic survey abundance index declined by an order of magnitude. The size-at-age of younger Capelin (ages 1 to 2) increased while the age at maturity decreased from age-3 to age-2. There have been no strong indications of recovery of the stock since its collapse. The emergent larval index from Bellevue Beach in 2020 is one of the lowest larval productivity years in the 19 year time series. Larval production from 2016–20 included the four lowest values in the time series. A forecast model for this stock suggests a modest increase in the spring acoustic survey biomass index for 2021 over the 2020 value, but projected values remain less than 25% of the recent high in 2014 and less than 4% of historic highs observed in the late-1980s, approaching the low levels observed in the early-2000s. Environmental conditions in 2020 remained unfavorable to Capelin stock recovery, although consumption by fish predators increased slightly. These conditions along with early onset of maturation and late spawning are likely contributors to the current state of low productivity. Current stock and environmental conditions have many characteristics in common with those observed during the early-2000s, which resulted in the longest lowest sustained levels of biomass in the time series. These biomass levels may have strong negative implications on the potential availability of Capelin as prey for the ecosystem.

Discussion

A participant commented that the fall Capelin condition seems to be at its peak in the time series. This could be interpreted as reduced competition due to a reduction in biomass. However, this is difficult to agree with seeing that there was the same level of Capelin abundance in 2002–04. This could suggest that the increase in Capelin condition could be attributed to an increase in zooplankton abundance rather than less intraspecific competition.

A participant mentioned that it would be beneficial if there was a fall Capelin acoustic survey conducted in Div. 3K. The presenter agreed that a fall acoustic survey for 2J3KL would be beneficial as it would give an indication of the abundance of Capelin throughout their distribution. The spring acoustic survey was only made to survey the 3L nursery area. There is also an attempt to ground truth the Capelin data using acoustic monitoring data collected on the fall DFO multi-species surveys.

The last question was if there would be any drastic changes in Capelin in the next few years, to which the presenter responded that the population will most likely stay around average post-collapse levels.

STEWARDSHIP COD (2J3KL) 2020 MANAGEMENT MEASUREMENT OVERVIEW

Presenter: E. Careen

Abstract

A stewardship fishery for cod and a recreational fishery for groundfish have been permitted in the inshore since 2006. Since 2016, commercial fishery removals have been regulated by weekly limits (lbs/week) by Division and time of year. Reported landings in 2021 were 10,879 tonnes (t), including 10,822 t in the stewardship fishery, 57 t in the sentinel surveys, and 6 t taken as by-catch.

Discussion

After the presentation, a participant suggested that sets of conditions should be standardized to one set rather than having two or three different sets. They explained that the crab fishing areas get crowded due to the fall cod fishery, where more boats come into the area to fish. They explained that it feels like there is a lack of consultation since it leads to crab grounds and crab gear being damaged or destroyed. There are very few crab harvesters taking advantage of the fall cod fishery. The presenter noted the point made about the different conditions. With regards to the crowded fishing grounds, a proposal will get tabled and will be taken into consideration.

Someone asked if the landings by NAFO division were based on where the fish were caught, landed, or the home port of the harvester. The presenter explained that it was based on the home port of the harvester.

CITIZEN SCIENCE (DOCKSIDE OUTREACH OF RECREATIONAL FISHERY)

Presenter: H. Rockwood

Abstract

In recent years, removals by the recreational groundfish fishery in Newfoundland and Labrador were identified as a knowledge gap at the Northern cod stock assessment. To help rectify this, a citizen science pilot project employing high school students from coastal communities in Newfoundland was developed in 2017 to help improve understanding of these removals. The project was renewed for 2018–20 and in 2020, Fisheries and Oceans Canada (DFO) Science hired 36 grade 10, 11, and 12 students with an interest in biology to work in pairs sampling at 19 wharves and landing sites. An online survey was also developed for the public to self-report their catch in areas where and at times when samplers were not present. The Avalon Peninsula had the highest data collection rates because this region had the largest number of student

applicants, the most centralized floating wharf systems, and the most fishers landing round or gutted catch which were easily measured. The mean lengths landed in different communities were not significantly different and the catch rates among communities were not significantly different. The average length of fish landed and the level of fishing activity generally decreased over the course of the season. When analyzing 2017–18 data using a Poisson regression model, wind strength was found to have a significant impact on fishing activity, and this model had good predictive power using weather, community population, eCapelin reporting, commercial landings, day of week, and time in season as parameters. The project is set to continue in 2021 to collect more data to help fill a knowledge gap with regards to removals by recreational fishers, engage communities and future scientists, and inform future efforts to quantify recreational removals.

Discussion

A participant noted that there is a similar need for this type of program in other parts of Canada. Someone asked about clarification around what fish they are allowed to keep, and commented that it would be great to move from descriptive statistics to a model based approach which could be interpolated for the whole province. The presenter explained that the regulations stipulate that the first five fish caught are to be kept. They further elaborated on factors that could be explored using a model, such as where the larger fish are, are certain communities catching more fish than others, etc. A question was asked as to why weights are not taken during the dock side sampling. The presenter explained that weighing fish would take longer and less people may be inclined to participate. A length/weight ratio from the inshore fishery and DFO multi-species surveys were used to get a good weight estimate based on the lengths recorded. In terms of modelling, the presenter also explained that work was being done on creating a strong model to predict numbers and sizes of fish caught in communities that were not sampled.

A participant mentioned that the coastal cod in Norway is in a similar predicament. There is always uncertainty with recreational inshore cod and it would be good to formalize the methods and standardize the protocols. Some participants voiced support for further studies on the matter. A participant from Northern Labrador said that although they were interested in the study, it may be difficult for them to participate seeing that there are very few cod in their area. It was mentioned based on that comment, that there is a self-reporting survey that is available for places where students involved in the Citizen Cod survey are not present. The knowledge of this self-reporting survey is not widespread. There is ongoing work to establish digital data collection for various recreational fisheries.

Someone asked if they are hoping to gain catch per unit of effort (CPUE) data from this program or simply the number of fish per person. The presenter responded that this was the first year where students were asking about the amount of time out fishing. There will be an emphasis on this question moving forward, as well as possibly asking survey respondents the depth they were fishing. Someone pointed out that most people continue to fish until they have caught their daily limit, possibly increasing the chances of high-grading, which could be looked at in a model. Another factor that was raised during the presentation was that not everyone fishes where they live, meaning that looking at population size of the communities with a large amount of commuters may be an issue (e.g., Petty Harbour or tourist hubs). The presenter clarified that the current analyses are looking at results at a much larger scale (e.g., greater St. John’s area), but it could still problematic and something that should be accounted for. It is worth noting that in the online survey, respondents are asked where they fished and what community they are from. Someone inquired about the times of day the students were out surveying, since if they are not there early enough, they may miss the more serious fishers. The presenter responded that initially, some students would start at 5 or 6 am although they standardized the start time to

7 am. Anecdotally, no significant difference was noticed between people who were serious about fishing and the others in terms of size of fish caught. Someone commented that if no difference is detected, that is an interesting result in itself.

RECREATIONAL COD FISHERY UPDATE

Presenter: R. Holub

Abstract

No abstract provided.

Discussion

To begin, a participant asked the presenter what they thought was the best way forward. The presenter replied that it is difficult to say. The next step may be to look at all the information collected and see what works. A point was made that the biggest issue with the recreational fishery estimate is the sampling frame since it is unknown. The results show that the estimates are within a few thousand tons but that they are on par with the results shown by the cod tagging program. Since the tagging estimates are used quite a bit, if enough tags get put out, it may be possible to calculate the scale of the recreational fishery. Someone asked if it would be possible to have hailing done on daily catches, similar to what is done for seal hailing, and if that could give an official estimate of how many fish are being taken from the water during the recreational fisheries. Others echoed that tackling the situation with multiple approaches is a good idea, hopefully leading to accurate numbers. In the fishery monitoring process, there are tools that can be used to help, however these are dependent on the type of data available. Someone said that the presentation on the matter was encouraging. If DFO Science, Conservation and Protection (C&P), and Citizen Cod students all work together, a good estimate for the recreational fishery would be attainable. The tagging estimates show a lot of inter-annual variation, and it would be preferable to have a more stable estimate, possibly based on the type of work shown during the presentation.

The issue of shore-based recreational fishery participants was brought up. Some participants were wondering if there was a way to account for these individuals, who do not participate in the survey since they do not meet the students at docks. A participant mentioned that some of the effect of shore-based fishers would be accounted for through the tagging program.

The discussion turned towards the use of phone surveys to collect information on the recreational groundfish fishery. Someone mentioned that the data collected by C&P may not be as science oriented. It could be beneficial for C&P to have a discussion with DFO Science in order to refine survey questions to be more useful in terms of data analyses. C&P collects a lot of detailed data, but DFO Science also needs data to account for uncertainty. It could also be beneficial to bring in a statistician. A comment was made that the key important aspect of a survey designed is the ability to determine and track changes of the effect of the recreational fishery.

Finally, someone asked if there was a way to increase logbook returns for tour boat operators. A participant responded that the reporting requirement for licensing is there. If the logbooks are not coming in, this would have to be looked into further.

2J3KL COD CATCH AND CATCH-AT-AGE

Presenter: B. Rogers

Abstract

Landings of Atlantic cod in NAFO Divs. 2J3KL were reported from the Stewardship fishery, Sentinel survey, and as bycatch both inside and outside the Canadian Exclusive Economic Zone (EEZ). Recreational fishery landings are not reported. In 2020, the Stewardship fishery landings increased from 9991 t to 10078 t, whereas Sentinel landings decreased from 122 t to 70 t. Bycatch levels outside Canadian EEZ remain low (38 t). The amount of unsampled landings from all gears has been increasing, with 99.9% and 100% of linetrawl and ottertrawl landings being unsampled in 2020, respectively. Overall, 34% of landings were unsampled in 2020, up from 27.5% in 2019. The reduction in sampling was likely driven by the COVID-19 pandemic. In 2020, distributions of catch across ages remains broadly similar to previous years, with the 2009 cohort still present in the catch and the 2011–12 cohorts dominating the catch. Weight-at-age of cod aged 3–6 and 8–10 have shown a small increase whereas weight of cod aged 11–12 show a continued downward trend.

Discussion

The first question asked was what the total otoliths shown in the presentation represented. The presenter explained that there were inconsistencies related to some of the results shown in the tables. One table only showed otoliths from the sentinel survey while the other table showed otoliths from the sentinel survey and stewardship fishery. In some years, more than 50% of the otoliths were from the sentinel survey. Someone noted that the cod age composition from the sentinel survey was not independent from the commercial fishery if most of the otoliths were coming from the sentinel survey. The presenter clarified that sentinel otoliths are not generally used to age commercial catches, but used to age sentinel catches. The two sources of otoliths (commercial and sentinel) are usually kept separate. There are some instances of borrowing otolith data from the other source when there is a lack of otoliths or the age structures are skewed. Someone commented that the lack of otoliths could be due to the seasonality of the sampling and a result of the difficulties associated with sampling during the COVID-19 pandemic. The presenter elaborated that sometimes age/length keys are used. The age/length keys tend to be skewed towards smaller fish for the DFO multi-species survey due to the gear used (shrimp trawl). Therefore the otoliths from the DFO multi-species surveys are generally not used for catch-at-age but are sometimes included for good measure.

Someone asked about the software/modelling approach used to calculate the catch-at-age, highlighting the importance of explaining how it is calculated, seeing that it is important for the stock assessment. The presenter explained that it is a bit of an *ad hoc* process which uses a program developed by a consultant company. The inner workings of the program are notoriously difficult. The program uses R as an engine but has a separate graphical interface. A suggestion was given that we should move away from these “black box” type programs towards more open source R programming starting on a clean slate. Replicating what was done before has however been challenging.

A participant asked for clarification around what is included in the stewardship landing and if using shrimp trawls could have a big impact on catching a large amount of small fish. The presenter explained that it would seem like there is a small amount of bycatch, primarily from the turbot fishery. The data would include every cod caught (in directed fishery or bycatch). As for the shrimp trawl, it is difficult to get a handle on what the actual impact would be since there are no catch values associated with the length frequencies recorded since the cod are simply discarded. The number of cod caught in the shrimp trawls seems high, but it is important to remember that this is across the large shrimp fishery. The results suggest that shrimp trawls would have a low or moderate impact, depending on how the data are analyzed. The annual impact seems to vary. For example, in 2019 there was a larger impact than this year. The level of impact is highly affected by the way the data are analyzed. The presenter finished by saying they are open to suggestions on the way this should be analyzed.

Some suggestions were given by participants. One suggested that time series bar plots of catch-at-length and catch-at-age should be shown. The same data should also be shown as proportions. This would help detect anomalies in the time series. The anomalies could then be scrutinized to determine if they are due to sampling issues or actual changes in the ecosystem.

A participant asked if any relationship was noticed between length-at-age and weight-at-age. The presenter responded that they had not seen if length-at-age decreased with weight-at-age. Someone else supported the idea of looking further into this relationship as it is a common trend throughout different cod stocks. Part of the trend seems to be that weights at younger ages are stable but that weight-at-age tends to decrease proportionally with age. The presenter replied that the same pattern should be seen in length-at-age since a standard length/weight ratio is used. Another participant asked if these analyses are conducted at the strata level, and at what point in the analyses is the length/weight relationship applied. The presenter explained that the weight/length relationship is applied when the length frequencies are matched with the age-at-length key.

Some were disappointed that soak time data were not shown during the presentation, wondering if it would be possible to show this in future presentations. The response was that the data may not be accurate since the majority of the data simply state 24 hour soak times. These values may represent arbitrary inputs that could be inaccurate or misleading. DFO Science was not comfortable conducting analyses on these data due to those reasons. Someone mentioned that 3Ps may have potentially had accurate soak time data but that conversation could be had outside the meeting. Another participant mentioned that they believed having soak time in the analyses is very important, giving anecdotal evidence that harvesters back in the 1970–80s would catch 100 lbs of cod in three days compared to now catching between 500 and 2000 lbs in less than 10 hours of soak time. The individual was confused as to how the figures in the presentation were showing a decrease in catches even with this apparent increase in catches with shorter soak times. The response was that the data are not shown monthly but rather for the whole year. This can cause the data to seem like they are decreasing. One final comment was made that it felt like more fish were being caught in the last 5 years using hand lines and longlines compared to the 1980s. Some participants were confused as they believed the cod population was higher than what is shown in the results of the presentation.

NORTHERN COD (NAFO DIVS. 2J3KL) RV SURVEY 2020

Presenter: K. Dwyer

Abstract

The full time series of fall DFO research vessel survey index values begins in 1983 and shows that the abundance and biomass indices have been low since the start of the moratorium in 1992. Both abundance and biomass indices increased from a low level since 2011. Most of the abundance and biomass (>80%) is located in the northern portion of the stock area (Divs. 2J and 3K). In recent years there are increased numbers of small cod (≤age-4) observed in the surveys. The three-year averages (2018–20) for the abundance and biomass indices are approximately 30% of the average during the 1980s. Mean catch per tow at age was generally high (mostly 50–200 fish per tow) in all three divisions in the 1980s, but declined rapidly to generally <10 fish per tow during 1990–93. The age structure also contracted during the collapse period, with few old cod (>age-6) in the survey catches by the early-1990s. The catch rates-at-age remained low for more than a decade, but catch rates have been increasing (less

so in 3L) since about 2010. Generally since 2012, age structure had been expanding, with cod spawned in the early-2000s onwards surviving through to older ages in recent surveys. Overall catch rates averaged ~40 cod per tow in surveys since 2012.

Patterns of distribution in the most recent four years (2017–20) indicate that both number and weight per tow are generally spread widely throughout Div. 2J, 3K, and northern 3L. In some years, there are large tows of fish on the edge of the continental shelf. This may be related to aggregations depending on timing of the survey. In 2020, there are some large tows of cod (>500 fish per tow) in Div. 2J. Plots of biomass estimates by stratum area indicate a number of ‘hot spots’ in the survey for Northern cod. Consistently the survey indicates that Belle Isle Bank, near Hawke Channel is an important area for cod in the fall. Age-1 fish are distributed mainly nearshore off the tip of the Northern Peninsula in the fall survey. Younger fish move out onto the shelf and show a northward and southward expansion (to south of the 3L divider) as they get older.

Annual variation in mean weight-at-age for Div. 2J3KL combined was examined over ages 3–7 by analyzing deviation from the average as a proportion over the time series for each age. The average mean weight-at-age from 1981 to 2018 was calculated for each age. Deviation was calculated for each age in each year by subtracting the mean for the age for the time series from the annual observation for that age and then dividing this by the mean for that age. Mean weight-at-age decreased from the beginning of the time series to the early-1990s. It increased to well above average by 1997. From 1997 to 2015 mean weight-at-age fluctuated but remained at or above average. Mean weights-at-age from 2011–13 were among the highest in the time series, but this was followed by a steady decline to well below average since then.

Cod caught in the spring survey of 3L tend to be in the poorest condition. The most pronounced decline in mean relative condition was observed during spring in 3L in the early-1990s. Condition appears to have improved slightly relative to 2016, especially in the fall; however, spring and summer condition remains at relatively low levels.

The estimated age at 50% maturity (A50) is used as a metric for monitoring changes in age at maturity. A50 was generally between 6.0 and 7.0 among cohorts produced in the late-1950s and around 6.0 among those produced during the late-1960s to the early-1980s, but declined thereafter. Age at maturity has remained low but variable (4.8–5.7) for the 1990–2016 cohorts, with no clear trend.

Discussion

It was clarified during the presentation that the relative condition for cod was calculated using gutted weight. After the presentation, a participant commented that at a glance, there does not seem to be a trend in the last 20 years except for spikes that then drifted back down. The participant wanted to know if these large spikes were associated with large age classes followed by smaller age groups coming through, signaling a lack of food availability.

Another participant asked how missing strata in some years are accounted for. The presenter explained that models have been looked at to account for missing values and to conduct extrapolations. Luckily, the missing strata are usually not crucial ones. Someone mentioned that a Hurdle model using presence/absence could be used to account for the missing values. Distribution indices could also be computed using the sum of the strata area as a baseline within a weighted model. This suggestion could compliment the biomass and abundance indices and one could look at the correlation between the two. Since certain strata are more statistically important than others (high cod abundance), density dependent habitat models could be used in conjunction with other layers to help determine strata that don’t fluctuate as much as others. Someone mentioned that they would caution against eliminating strata from the analysis, as there will always be one or two very large tows every year. The probability of getting large tows is probably related to the survey effort. The presenter was asked if they think large tows may be missed due to reduced sampling in some years. The presenter replied that it could be the case, as well as missing zero catches. In response to discussions around omitting large catches, the presenter explained that 2020 was a good year for index strata despite COVID-19 with one large catch being present (normally happens with Northern cod). There was no reason for excluding that large catch.

It was mentioned that reviewers had asked for design-weighted area of occupancy (DWAO, presence/absence) to determine areas where most cod are aggregated. The population collapse caused the occupied area to shrink, but it has since started to increase again. In comparison, the surveyed area has not really changed through the time series. These trends were corroborated with a paper from the 1990s, which found that as the stock declined, the fish concentrated rather than disappearing uniformly across their range. A note was made that even if the cod stock reached its original spatial coverage, that would not necessarily mean the biomass would also be at pre-collapse levels. It's important to point out that cod seem to be expanding into areas where cod historically were not found. There seems to be lots of focus on a stratum that had very little cod historically. Participants said that it would be interesting to look further into this to determine if it is problematic or concerning. Some said that it looked like an anomaly and could possibly not be representative of the actual population. The presenter agreed that the stratum was not very important historically. They cautioned that we cannot conclude that cod are being seen in areas where they were not seen before due to one large catch during the surveys. It is important to note in the SAR that very large catches in tows can sway the results. Others said that hot spots of cod abundance are important as they can be related to anecdotal statements about areas of high catch rates in the past.

Another participant mentioned that the DFO fall survey has not had constant catchability (q) for Northern cod for a number of years. On several occasions, a good amount of the stock was found outside of the range of the DFO multi-species survey. Almost half of the SSB was in a small area outside of the range of the survey. Someone concluded by saying that there most likely was more of a contraction during the collapse since the DFO multi-species survey wouldn't have covered the actual whole range of the Northern cod stock in the first place. Participants agreed that it is difficult to discuss areas outside of the survey range. It is difficult to say and we must be cautious around assumptions that cod have never been in an area prior to the collapse as literature suggests that may have been a possibility.

In response to the discussion about the large catch outliers, a participant asked if more survey sets would help reduce the variability and uncertainty. The participant also asked about the use of inshore survey data. The presenter responded that more survey sets is always better. Inshore strata have not been surveyed in many years. The idea now is to use the sentinel survey instead as a source of inshore data. A participant clarified that the goal of the inshore survey was to determine where the cod stock was and if they were moving away from the offshore.

Someone asked what portion of the cod data were included in the DWAO analysis. The presenter explained that all cod were included in the analysis, to which the participant said that it would be interesting to split the analysis between adult and juvenile cod to see the difference. Another suggestion was made to look at each assessment division separately, which had not been done before. Next steps that would bolster the analytics would be to look at the correlation between biomass and distribution, and to create density dependent habitat selection models.

Looking at some of the figures from the presentation, a participant noted that there may be a carrying capacity issue in the population since there seemed to be a trailing off after strong year classes. It could also be due to age reading issues. The presenter responded that they did not think there was an age reading issue but that it was something to look into.

STRENGTH OF 2018–20 COHORTS, FROM NEARSHORE SURVEYS OF DEMERSAL AGE 0–1 ATLANTIC COD IN NEWMAN SOUND, BONAVISTA BAY

Presenter: B. Gregory

Abstract

We qualitatively assessed the relative strength of three cohorts (2018–20) of Atlantic cod (*Gadus morhua*) based on abundance of demersal age-0 and 1 juveniles in Newman Sound, Bonavista Bay in summer and autumn of two years (2019–20) at nearshore sites (<10 m deep) using a demersal beach seine net. Our assessment was based on comparisons with abundance of Atlantic cod sampled at 6–12 sites, every 2 weeks from July until November, from 1995–2020. Analysis of annual length frequency and abundance data indicated that age-0 Atlantic cod settled in the nearshore in several distinct pulses, a typical pattern along the Newfoundland coast. In 2019 and 2020, the first pulse of age-0 individuals settled in late-July; subsequent pulses followed more than two months later and were numerically weak. Abundances at age-0 and age-1 in Newman Sound in 2019 and 2020 suggest that 2018 will be the strongest of the three we presented here. However, all three cohorts (2018–20) appear to be weak relative to others in the 25-year Newman Sound time series, especially among those of the past decade. Mortality rate remains below the long-term average, but it has increased in the past two years. Evidence that settlement pulse structure of Atlantic cod in Newman Sound, Bonavista Bay is typical of broad patterns by age-0 juvenile cod along the northeast Newfoundland coast. The Newman Sound age-0 and age-1 abundances (1998–2017 cohorts) are significantly correlated with age-2 and 3 estimates, using the Northern Cod Assessment Model (NCAM) results – especially between Newman Sound age-0 and NCAM age-2. The relative interannual change of age-0 across adjacent cohorts was significantly correlated with NCAM results for age-2 and 3 in 75% of years of the Newman Sound time series.

Discussion

At the end of the presentation, a participant asked if the sampling was lethal to the fish and if they attempted to recapture the fish. The presenter replied that they released all fish and almost all of them survive (a subset of the catch is sampled). Mark/recaptured studies are common.

Looking at the presentation figures, a participant asked if the line used to separate cohorts changed year to year and if it could be estimated using data. The presenter replied that the growth rates differ year to year. For example, on some occasions there is a 2 cm difference between consecutive winters. Someone suggested that these data could be used in a length-based model. Different factors could be integrated to see how changes occur and different sites could be used as replicates. The individual finished by asking if a standard methodology is used to identify pulses in the population. The presenter responded that to assign pulse structure, they fit a finite mixture distribution model. This is done for each survey trip and is lined up across the entire season. A gamma distribution is used as it fits better than a normal distribution.

Clarification was asked about the deviance explained as a function of year. The participant was confused by how the deviance was increasing. The presenter explained that the median window year is used (5 years on either side). This leads to correlation over a period of time and the amount of deviance explained varies depending on the year.

Some participants noticed that the older cod are decreasing in size on average. Someone asked if the younger cod do better when the overall conditions are deteriorating or are they remaining stable. A few more questions were asked, such as if the presenter looked at changes in growth rates or if growth rates are better when cohorts are weak. The presenter replied that these are all important things to look into but that is a work in progress. A participant commented that it is possible that there is growth selective mortality, where the slower growing individuals are dying while the faster growing ones are surviving. The presenter agreed that this may be a possibility, but more work is needed to confirm what is happening in the system.

FLEMING SURVEY REBOOT: DEMERSAL JUVENILE COD IN COASTAL AREAS OF EASTERN NEWFOUNDLAND

Presenter: R. Lewis

Abstract

A survey of demersal juvenile Atlantic cod (*Gadus morhua*) was conducted along the Northeast Coast of Newfoundland in nearshore waters (<10 m deep) from 1959–64 by Government of Canada Departments (now represented by DFO). This survey (which became known as the Fleming survey, after originator Alistair Fleming) aimed to characterize the distribution and abundance of juvenile Atlantic cod and was based upon Norway's Flødevigen sampling program which has been conducted continuously since 1919. A 25 m seine was used to sample juvenile cod nursery locations on the Avalon Peninsula and Northeast Coast of Newfoundland in September and October. The survey was discontinued in 1964 but was reinstated by Memorial University of Newfoundland from 1992–97. Multiple tows were conducted at a subset of the original 55 Fleming sites located in St. Mary's Bay, Trepassey Bay, the Southern Shore, Conception Bay, Trinity Bay, Bonavista Bay, Gander Bay, New World Island, Fortune Harbour, Badger Bay, Halls Bay, and Green Bay. A full version of the survey (40 sites) was executed in 2001 and select sites were surveyed in 2017 and 2018.

The Fleming survey program was reestablished by DFO in 2020. A total of 42 of the modern subset of 45 sites were visited resulting in 40 sites being sampled successfully in 2020. Direct comparison of cod catch (count, lengths, and rate) is possible across the time series because of consistency with survey methods. The primary objective was to collect data to determine abundance of age-0-, 1-, and 2-group cod to compare with previous surveys and reestablish a network of inshore harvesters (active and retired) to participate in the survey.

A total of 665 juvenile cod (615 0-group; 47 1-group, 3 2-group) were collected at 40 sites between St. Mary's Bay and western Notre Dame Bay. The catch of 0-group cod dominates the overall catch (mean=15.38 cod/tow). In general, the mean juvenile cod catch for each group is similar to the mean catches from the 1990s and latter part of the 1959–64 time series. During the 2020 survey, only one tow was made per site to measure juvenile cod density due to logistical constraints. In earlier Fleming survey programs, multiple tows were conducted (minimum two) at a survey site in an attempt to develop a density index. In 2020, the average catch rate for age-0-, 1-, and 2-groups was 15.38, 1.18, and 0.08 cod per haul, respectively. These rates were generally consistent with the average cod per tow (first tow only) reported from the Fleming survey in the post-collapse era (1992–97 and 2001): 13.35, 5.90, and 0.56 cod per tow for 0-, 1-, and 2-groups. Densities of juvenile cod have not recovered since the stock collapse in the early-1990s, despite some improvements in the adult population size.

Discussion

Participants were excited to see old surveys being brought back. This work will be complimentary to the work in Newman Sound, and both projects will help better understand juvenile cod. One participant expressed concerns regarding the comparability of the results presented with those of previous Fleming surveys, because different deployment gear was used (e.g., row boats versus motorized). The presenter noted that effort has been made to ensure consistency across the time series (same seine dimension and same fishing techniques), and also noted that there is published research that indicates that 'powered engine' vs 'rowed' does not influence the catch. The historic surveys between 1959–60 also had fewer sets, which was visible in the confidence intervals. It was confirmed that only one tow was completed per site due to operational constraints in 2020; however, the presenter also noted that the data from 2020 is comparable to the first tow data across all survey years.

Some larger fish may have escaped but the study is more interested in the smaller fish (juvenile cod). Someone asked if all of the samples were collected during the day. The presenter replied that they were. The historic survey data were not specific in terms of time of day. Due to the nature of the work, it was not logistically feasible to sample at night. Newman Sound in comparison did do night sampling. The catchability was different in that larger fish moved closer to shore at night. This movement is related to possible predation effects (more visible during the day).

It was mentioned that based on the histogram of sampled juvenile cod in 2020, it is possible to see some recruitment pulses. Interestingly, this is seen in multiple datasets. Someone mentioned that it will be great to have a more holistic approach in the future to look at cod recruitment using different sources of data.

SENTINEL SURVEYS 1995–2020 – CATCH RATES AND BIOLOGICAL INFORMATION ON ATLANTIC COD (*GADUS MORHUA*) IN NAFO DIVISIONS 2J3KL

Presenter: L. Mello

Abstract

Catch rates and biological information of Atlantic cod (*Gadus morhua*) from the Sentinel gillnet and linetrawl surveys in Northwest Atlantic Fisheries Organization (NAFO) Divisions (Divs.) 2J3KL are updated for 2020. Catch rates for all gears were considerably variable among communities. Catch rates were relatively low and stable in most communities from the north stratum prior to 2005. In contrast, catch rates from the communities located in the south stratum were higher at the beginning of the time-series, and then declined by ten-fold in the mid-2000s. In the central stratum, catch rates for most communities remained relatively high throughout the time-series. Catch rates increased steadily in communities from the north stratum since the mid-2000s and were relatively high thereafter but remained stable at low levels in the communities from the south stratum during the same period. Similar patterns were observed in catch rates from the small mesh gillnet (all strata) and linetrawl (central and south strata) surveys.

Standardized age-disaggregated catch rates for large mesh gillnet were higher at the beginning of the time-series, peaking in 1998 and dominated by 5–8 year-old fish. Catch rates declined rapidly to the lowest estimate in 2002, then increased during most of the 2003–14 period, before declining once more in the following years. In the case of small mesh gillnet (experimental sites), catch rates declined from 1996 to 2001, then fluctuated during 2002–16, before declining by 50% or more in 2017–20. Most fish caught were 3–7 year-olds until 2015, but the contribution of younger year-classes, notably 3 and 4 year-old fish, was reduced thereafter.

Large mesh gillnet and linetrawl surveys captured larger fish from specific size ranges, whereas the small mesh gillnet survey retained small and large fish from multiple length-classes. Indices of physiological condition for both male and female cod (Fulton's condition factor, Hepatosomatic Index, and Gonadosomatic Index) varied seasonally and annually.

Total removals (control plus experimental sites, all gears combined) of Atlantic cod caught in Divs. 2J3KL Sentinel surveys (1995–2020) peaked at 388 t in 1998, declined to 92 t in 2003, reached 270 t annually over 2012–15, and then declined thereafter, reaching 71 t in 2020. Several fish species were recorded as Sentinel bycatch in 2005–20. American Plaice and Winter Flounder were the most common species in the large mesh gillnet survey.

Discussion

First, it was clarified that the only index from this presentation that is used in NCAM is the combined large gillnet age-disaggregated catch rates. A participant was concerned about the dip in sample size in 2020 as well as the overall downward trend of sample sizes. They asked the presenter if this could in part be due to saturation of gillnets by by-catch species and if there is ongoing work to look at catchability. The presenter replied that the data are difficult to interpret since it is all pooled together regardless of gear type. They finished by saying that this will definitely be looked at in the future. A participant asked if the difference in configuration of the 3.5 gillnets (bi-modal) versus 5.5 gillnets (uni-modal) could contribute to a difference in catchability. The presenter replied that the difference is simply due to the difference in mesh size between the two types of gillnets.

A participant commented that it was positive to see catches in the north (i.e., White Bay, northern shore) as these were not historically areas of high importance for the cod fishery. The participant also gave some insight into the decline in sample size. They attributed it to fewer harvesters (retirement, etc.). The decline in participation can be attributed to newer participants having difficulty participating for 10 weeks and then going on the sentinel survey for 3 weeks. A requirement of the sentinel fishery is that no cod is wasted. Therefore if there are no local buyers, some harvesters end up giving their catch to senior citizens in the community. Someone else mentioned that it is troubling that there is a decrease in sample size with a proportional increase in the number of zero catches in the data.

A reviewer pointed out a potential confounding effect when looking at the Gonadosomatic Index. If year after year more older fish are caught, that would contribute to an increase of the Gonadosomatic Index. If in addition to this, there is an increase of zeros in the data, the Poisson model could become over-dispersed. A potential solution to this would be to use a negative binomial distribution. The presenter agreed that the situation described could lead to over-dispersion in the model.

Someone asked for clarification as to why other species caught in the survey were classified as "by-catch" if it is in fact a randomized survey. The presenter explained that it is a targeted survey for cod, and there are regular survey locations (fixed) and then harvesters pick other areas to sample based on their knowledge and expertise. The sampling protocol is detailed for cod but not for other species.

A participant noted that it did not seem like the cod were moving out of the area, which is concerning. Some were wondering if this would complicate the usability of the data in NCAM. Another participant asked for some clarification on how NCAM determines catchability. The presenter replied that they could not comment on that at this time. Later, a participant mentioned that they believe saturation may be playing a part in the catchability of cod. There may be a contraction of the range of cod and the survey simultaneously. This could explain why NCAM is displaying the patterns that it is.

2021 TAGGING AND TELEMETRY UPDATE 2J3KL COD

Presenter: E. Novaczek

Abstract

An update was provided on recent mark-recapture tagging for 2018 (n=2525 Northern cod tagged), 2019 (n=2614), and 2020 (n=1045). Most Northern cod tagging in recent years has taken place in Petty Harbour and between Bonavista and LaScie. In 2019, tagging also extended to St. Anthony and southern Labrador. The vast majority of tags returned were recaptured in the NAFO division in which they were released.

Estimates of recreational catch of Northern cod based on tag returns were also updated for recent years: 1,606 t in 2018, 607 t in 2018, and 2,959 t in 2020. The recreational catch estimate for 2020 is the third highest in the time series, following 2017 (3,027 t) and 2014 (4,123 t).

Tagging data are used in NCAM to inform on mortality and exploitation rates. These calculations rely on an estimate of reporting rate, which is calculated based on the relative proportion of high and low reward tags that are returned (see Konrad et al. 2016 for details). The commercial reporting rate for Northern cod tags has declined steadily from a high of 0.84 in 2001 to 0.43 in 2020. The recreational reporting rate is estimated to be a constant 0.47 throughout the time series (Konrad et al. 2016). It would be beneficial to the tagging program to revisit the reward values, which have not changed since this program began in the 1990s.

An update was also provided on the ongoing acoustic telemetry program for Northern cod. An inshore acoustic array of 79 receivers is maintained by the DFO-NL Groundfish section, and 75 offshore receivers were also deployed in 2020 as part of the Northern Cod Acoustic Telemetry (NCAT) project, a partnership between DFO, industry, and academia. Over 1,000 Atlantic cod have been implanted with acoustic transmitters by the DFO-NL Groundfish section since 2005. Based on estimates of battery life, over 500 are expected to remain active and at-liberty, including 401 that were deployed in 2019. Inshore receiver data are retrieved annually by DFO-NL Groundfish staff and analysis of the telemetry dataset is ongoing. Offshore NCAT receiver data will be retrieved annually by gliders operated by the Ocean Tracking Network. Due to fieldwork restrictions imposed by COVID-19, no transmitters were deployed in 2020, however this work is expected to resume with inshore and offshore transmitter deployments in 2021, including over 1,000 transmitters associated with the NCAT project.

A small pilot study (n=100) on the use of predation-detection tags in small cod (30–35 cm) is also planned for 2021–22. These transmitters include a bio-enamel switch and change their signal when the tagged fish is ingested by a predator. These tags also record and report temperature, allowing researchers to distinguish between warm and cold-bodied predators.

Discussion

Participants noted that although reporting rates are declining, the main issue is the total number of tags being returned. Some participants voiced their opinion that the tag return price should be increased. A solution for the low number of tags returned could be to increase the total number of tags deployed. It was noted that the ratio estimators used were not new, however they now also incorporated variance. The estimate is very sensitive to the number of tags reported. One additional tag can change the estimate by a large amount. One important thing to note is that the magnitude of the estimate matches with other methods used to attempt to measure the recreational cod fishery catches. A question was asked about how the cod are aged during the tagging process. The presenter responded that it is done by weight indicators rather than by length. The smallest cod tagged is 100 g as the tags need to at most correspond to 2% of the weight of an individual fish.

Someone asked if there would be other ways to increase the rate of tag returns other than increasing the reward price, such as having a public relations campaign or simply increasing the number of tags that are put out each year. Others agreed a public relations campaign could be helpful for increasing returns as it seems like the commercial harvesters are more aware of the tags than the recreational harvesters. It was suggested that it would be a good to pair public outreach with an increase in tag reward prices. One suggestion was given to incorporate tagging outreach into the Citizen Cod program to increase visibility. A reviewer was skeptical that the rate of returns was assumed at 100%. The presenter agreed that it was most likely not 100% but rather in the high 90%. The time required to get tags returned can take up to a year since most harvesters wait until they have a good amount before sending them all in at once. The use of tags cannot replace the surveys, but they allow us to see what the fish are doing between the various surveys. A question was asked about the rate of mortality from handling and overall tagging. The presenter replied that the rate of mortality during the handling process is quite low. Tagging mortality post-handling was calculated using data from 1997–2001 (Brattey and Cadigan 2004). The effect is incorporated into NCAM in order to account for possible tags lost due to mortality.

A participant asked for clarification on if tagging data are used to determine movement of cod (where they were tagged versus where they were caught). The presenter replied that it had been done using the tags in the past, and the results were published (Brattey et al. 2002). There was no information on this in the presentation as the presenter wanted to limit the content to what is used in the stock assessment. Another participant asked if the tagging data suggest that the Northern cod stock is a closed stock. The presenter responded that there are no tagging data for the northern edge of the stock range, however, there are signs that some fish move into 3Ps. They concluded that it is something worth looking into but probably does not play an important role in the stock dynamics. Other participants showed interest in seeing further work done to look at the connectivity of sub-populations within the stock using telemetry data. Some participants said they are interested in tagging data as they can give an indication of the value of fishing mortality (F). In contrast, there is a significant source of uncertainty for natural mortality (M) of cod during the inshore-offshore migration in the fall. Telemetry data can give good information on the inter-annual variability of that migration.

Some participants noted that it seemed like there was low fishing activity in 2019 but a substantial high in 2020 compared to other years. There may have been more people out participating in the recreational fishery due to COVID-19 encouraging people to do activities outside and socially distant. Some participants also corroborated that there seemed to have been more recreational boats on the water this year during the recreational fishery. With the overall decrease in the number of tags, a participant asked if it would be possible to conduct simulations of the relationship between the number of tags deployed and the overall catch as well as tags returned. The presenter agreed that this would be an interesting exercise, which has yet to be done.

One of the reviewers asked for clarification around the analysis of the telemetry data. They wanted to know what the goals of the analysis were and what methods were included. The presenter replied that part of the work was to compliment the inshore arrays with offshore arrays to determine if there was movement of cod from inshore to the offshore and vice versa. Some preliminary results have shown that up to 90% of fish tagged inshore are found again inshore. Comparatively, the detection rate of fish tagged offshore was only 30%. It is important to keep in mind that factors such as location of the array, seasonality, substrate type, ice cover, storm events, etc. can play a role on the detectability of the fish. There is also some modelling work being done to determine the detectability range based on seasonality and site. There are still a few more years of offshore data coming in as well as predation data based on temperature changes in the receivers. Some participants showed enthusiasm and support for this project. A participant voiced their opinion that this project is a good investment as it will fill knowledge gaps on the distribution of cod between the offshore and inshore areas. They commented that there is a good distribution of arrays in both the inshore and offshore, but there is a lack of coverage in between the two areas. Another important note on the distribution of the arrays is that some offshore arrays are out of reach of the coverage of the multi-species survey. Therefore, those arrays cannot be used to account for fish that may be potentially sampled by the offshore DFO surveys. We are only getting part of the picture as there is limited array coverage in the mid-shore areas. The arrays could at least give an indication of larger patterns of migration. Others mentioned that arrays are being put out for other species such as witch flounder and that collaboration between different groups could allow for better coverage. The participant alluded to work they had done where their tagged cod had moved from Newman Sound to Bonavista and were detected by receivers from another research group.

THE NORTHERN COD ASSESSMENT MODEL (NCAM): OVERVIEW AND UPDATE

Presenter: P. Regular

Abstract

The Northern cod assessment is based on a state-space population dynamics model (Northern Cod Assessment Model, NCAM) that integrates much of the existing information about the productivity of the stock. The model integrates information from DFO RV fall trawl surveys (1983–2018), Sentinel fishery surveys (1995–2018), inshore acoustic surveys (1995–2009), fishery catch-at-age compositions (1983–2018), partial fishery landings (1983–2018), and tagging (1983–2017).

The abundance of Northern cod remained low for more than a decade after the collapse and moratorium in 1992, but has increased in recent time. The latest assessment indicated that stock abundance (ages-2+) has increased from 233 million cod in 2005 to 954 million cod (95% CI, 564–1,614) in 2019. Recruitment (age-2) increased from lowest estimated levels of 36 million fish in 1995 to an average of 302 million in 2014–18. This recent average is 23% of the pre-collapse period of the 1980s. Total biomass (ages-2+) shows a similar trend to abundance and increased from 87 Kt in 2005 to 588 Kt (95% CI, 457–756 Kt) in 2019.

SSB declined rapidly in the late-1980s and early-1990s and has remained low, but showed an increasing trend in the last decade. SSB increased from 26 Kt in 2005 to 398 Kt (95% CI, 306-518 Kt) in 2019. SSB has been well into the critical zone of the Precautionary Approach (PA) Framework since the stock collapse; the stock is currently 48% of B_{lim} in 2019 (95% CI, 37–63%). A one-year projection with catch ranging from zero to 1.3 times the model estimated catch for 2018 (14 Kt) indicated that the probability that SSB will reach the LRP by 2022 ranges between 6–9% for all catch scenarios. The probability of the stock in 2022 being greater than 2019 ranged from 63–73%.

Discussion

A participant asked the presenter if the value of natural mortality (M) was fixed at a specific level when large amounts of fish had died. The presenter replied that the value of M was imposed on the model at the mean value, but that it is consistent with values estimated by the model in the past. The model also has some flexibility to deal with the values imposed into it. The rationale behind this change was that there was a high level of process error was required to account for the increase and the resultant heightened process error variance estimate could introduce too much variation in later time periods. It was opted instead to fix the value of M to limit the process error. Following this, a participant asked why the value of M of age-2 cod was low and then starts to increase after that. The presenter responded that the data and baseline model outputs suggest that the rate of M was much higher for older groups of cod but not age-2 cod. It was mentioned that the lower M value of the younger cod should not affect the M value of older cod in the model. This was confirmed by the presenter, giving an example that if the M in the baseline was set at 0.2, the model output would predict a similar value. Further research is needed on M for juvenile cod as there is limited tagging data for that age group. The small amounts of data already collected are somewhat contradictory to DFO multi-species data. Someone asked at what age do 50% of the cod enter the fishery. The presenter replied at about 5 years of age. Another participant asked if there was somewhere else in the model where fish could be lost other than the setting of the value of M. The presenter responded that the other way would be by including it into the fishing effect. This response raised concern about if this would affect the tag return component of the model. The presenter explained that the tag reporting numbers can be dubious at times, and that the model attempts to account for this using catch bounds. The model is told that the catch should be between pre-specified bounds and, balancing this with catch-at-age information and tagging data, it attempts to account for the disappearance of fish accordingly.

Someone asked why the baseline model presented should be considered as such, seeing that there are other trajectories of stock collapse. Another participant responded that a lot of fish died during the 1990s collapse, not just cod. This included species that were not heavily fished. Therefore, it makes sense to attribute the loss to M rather than to an effect of fishing mortality (F). This could be considered a justification for setting M *a priori*, however a participant asked what would be the purpose of doing this. The presenter explained that the benefit of setting M *a priori* is that by shifting the intercept, it also reduces the process error. The one downside of this method is that it essentially rules out the possibility that it ever happens again in the future model outputs. Originally, the model did not have an imposed fixed M value but the model would on its own tend to create a spike in M. The justification behind the assumption that this spike in M would not happen again is that we are now monitoring the factors that could lead to another M. Therefore, it was opted to set M and reduce the processing error. A participant asked how knife edge collapses in the population be justified. Another participant responded that knife edge collapses happen in model predictions due to process variance. If you increase the process variance to allow the spike to happen, it would also allow the model to have very large and unrealistic fluctuations in M. That would lead to unrealistic population predictions into the future. That is why M has to be included into the model differently (fixed) to account for an abnormally high mortality event (i.e., the collapse). In other words, the fish population collapse in the early-1990s was an extremely rare event. This is also highlighted by population shifts in Capelin during those years which had not been seen in 100 years. A participant noted that harvesters were sounding the alarm back in the 1980s and that this spike in mortality most likely did not happen overnight and may not all be linked to M. Other participants mentioned that it also most likely included F. The compounding effects of fishing on a declining stock already affected by M can be substantial, especially if the fishing pressure is above what is sustainable for the ecosystem. There were some concerns around what is included in M and how it interacts with the model. A participant noted that gaining a better understanding of the bottom-up factors that affect M will be important. Others noted that they are seeing similar results from capcod, which suggests that we need to look into the split between M and F.

A participant asked if a much higher M compared to F (during 1991) would cause an underestimation of the impact of fishing in the projections. The presenter responded that this question is difficult to answer. Based on their exploration of NCAM, they concluded that the key important factors are how the baseline M and catch bounds are parameterized. The partitioning of F and M does not seem to drastically affect recruitment (R) or the current values of F and M. The biggest effect is on the process error. This is seen when the uncertainty around the future projections grows drastically larger if an arbitrary M value is not set for the collapse. A flat-lined M value would lead to high process error. Someone pointed out that the catch bounds only have an effect on the projections if they are close to the bounds, meaning that either the bounds have no effect or the projections are stuck to the bounds. The presenter agreed that this is something interesting to look into further. Looking at certain years where the estimates were spiking up and down, a participant asked if that is really what is happening or if it would be better if the estimate was smoothed somewhat over the spikes. The presenter responded that those years correspond to years with recreational fishery catches estimates. An equation was included to adjust the upper bound accordingly. It was suggested to further elaborate on the upper bound to adjust it based on tag landings. Some participants showed interest in seeing a better evaluation of the catch bounds and how they are driving some of the results. Some of the criticism of NCAM could be resolved by fine tuning the catch bounds and how they fit into NCAM. A participant pointed out that although this may be the case, catch bounds were set at a peer review process with 40–50 participants (DFO 2018). There were a lot of discussions during that process about the potential range of misreporting and the fraction the recreational fishery contributes to this. There would have to be a similar process once again if changing the catch bounds was considered. Someone reminded the meeting that this topic had been addressed at one of the previous CSAS meetings on the stock, and the general consensus was that the catch bounds chosen must be relatively accurate for the time being. Another participant reviewed the proceedings from previous CSAS stock assessment meetings for Northern cod and mentioned that there did not seem to be any mention of lower catch bounds in the proceedings, although they remember the discussion did take place. Someone replied that the catch bounds had been agreed upon for up to 2013. There had not been much discussion about the catch bounds changing drastically after that. One of the reviewers finished by saying that before discussing changes to the catch bounds, it would be important to determine how they are affecting the model estimates. They asked if the model was at one year time steps, to which the presenter responded yes.

A reviewer wanted to know how the tagging data would constrain the model outputs, and if they would specifically constrain M or F. The presenter responded that they did not think the tagging data would constrain either type of mortality as the tagging data are not providing any information on the magnitude of the population. The reviewer agreed but cautioned that there may be some effects when looking at the interplay between the various components of the model as a whole. Some participants voiced their concerns that it seemed like there was a lot of uncertainty in the recreational catches in the results shown and including a smoother may help account for this uncertainty. One question was raised about if there is a significant difference in the differential mortality between recreational and commercial fishing. That is something that may need to be addressed in the future.

Looking at the bubble plots associated with the sentinel survey, some participants were concerned that there was either an overestimation of small cod and underestimation of large cod or vice versa due to a linear shift throughout the years. The offshore data also seemed to have a year effect but not linear like was the case with the sentinel survey data. The presenter explained that they attempted a version of the model where catchability varied with year and age, which seemed to resolve the apparent issue. Alternatively, it may be that younger aged cod are staying offshore longer. There is an overall concern based on the sentinel survey bubble plots that the sentinel data may be over-fitted. One possible explanation could be that there is selectivity going on due to gear or other factors. The gear selectivity may also have been shifting through the years, causing the results observed in the sentinel survey data. As for the DFO research vessel bubble plots, a reviewer suggested they be formatted so that bubbles represent noise in the data rather than noise in the data by year. The main difference between the sentinel and DFO RV surveys is that the latter is seeing younger fish while the sentinel survey is not. Some participants gave modification suggestions to the model based on discussions from 2019 such as removing the sentinel data from the model or adding weights to the research vessel or sentinel survey data. Another suggestion given was to possibly include selectivity as a function of fish length. The presenter reminded participants that simply removing data may not be the solution. NCAM already inherently self-weighs datasets by applying reasonable amounts of trust to the different datasets included. Reviewers agreed that artificial weights should not be used in NCAM. It may be a good idea to include the proportion of offshore/inshore data (or even north/south). One challenge with this approach is that it is not clear how much of the stock is available to the sentinel survey, as it is important to know in order to weigh the surveys properly.

Some participants thought that these discussions around the implementation of the sentinel survey in NCAM may be beyond the scope of this meeting and may warrant the triggering of a new framework meeting since NCAM is 5 years old and there are knowledge gaps that the model is failing to address. Others suggested more thought be put into possible changes to the sentinel survey design. The fact that the input data seem to be changing (i.e., size-at-age) suggests that more thought needs to be put into the sentinel survey design rather than modifications to NCAM. The participants came to the conclusion that the issues around the sentinel survey data are not causing substantial trouble to hamper the group’s ability to give science advice for the time being. One suggestion was given to look at length-based catchability rather than age-based, since gillnets select by size rather than by age directly. This is especially worth looking at if length-at-age has been changing. Most agreed that the meeting could go ahead with the presented model for this year. The presenter finished by stating that when projections were done without the sentinel data in 2019, the data had not changed significantly. The same pattern and trends were seen this year as well, which is reassuring. The residual patterns are not great, but the model still seems to perform well. A participant mentioned that the group should still report on the potential bias when giving the science advice.

When the presenter showed various model projections based on small changes, someone asked about the catch bound results shown and if they correspond to the total NCAM negative log likelihood (nll). The presenter responded that no, the results shown correspond to a snapshot of every year. Every year had a catch bound and the presenter used the catch bounds to illustrate the profile of where the negative log likelihood lands in that year. Essentially, it determines if the result lands in or out of the soft bounds. Looking at these results, someone asked how often do the results come close to the “kick up” point. Another participant responded that looking at a broad scale, almost all the catches in the past were close to the bounds. The mid-1990s seemed to have a high level of variation which can be worrisome. One of the reviewers concluded based on the results that the catch bounds may be having a stronger influence on the model outputs than initially thought. This would suggest that the model should possibly be up for re-examination. It was pointed out that the time periods with large variations were during periods of low catches such as the collapse. This was also seen in the drop off of tags during the collapse period. Others agreed, the model seems to accurately determine what is happening on average but is unable to get accurate numbers year by year. It would seem that the concern is more pronounced in the past due to a lack of data compared to more recent years. It may be difficult to get very accurate results from the 1990s due to the lack of large amounts of data. On the same topic, the presenter mentioned that they attempted to run the model without the nll contribution from the catch bounds, which resulted in the model recovering the lost magnitude without the bounds. The consensus was that looking at the big picture, the model trends are acting properly as expected. The issues tend to show themselves when looking at the catch bounds and confidence intervals which seem slightly too narrow.

Someone asked a question about the difference in the predicted and observed output lines. The presenter replied that it was deliberately that the predicted be slightly higher than the observed to attempt to account for the recreational fishery catches. The conversation turned again to the impact of the sentinel survey index on the NCAM model outputs. There was a bit of division of perspectives between participants on the matter. Some participants were concerned by the patterns in the sentinel survey index and thought the model runs in the 2019 assessment (DFO 2019a) with and without the sentinel data made no significant changes to the terminal SSB over B_{lim}. Other participants thought that the 2019 assessment attempts at running NCAM with and without the sentinel data determined that there was a small change. It was finally agreed upon that there was a small change but that the difference was not statistically significant.

This brought the group to discuss the number of years of projections that should be used in the assessment. Due to the potential issues around the catch bounds and sentinel survey data, participants were leaning towards shorter-term projections to avoid too much uncertainty associated with projections made further forward in time. Although participants were favouring 1–3 year projections, some participants noted that longer-term projections (5 years) were also important for the stock rebuilding plan. Those favouring shorter-term projections brought up the argument that assessments are currently done on an annual basis and that there are some longer-term Capelin data that can be used to infer what may happen beyond that. In the same vein, a participant noted that based on the current trajectory of prey species, it is very unlikely that there will be an increase in the stock as forecasted in the longer-term projections. The long-term projections feel somewhat misleading since the level of uncertainty is not shown. A suggestion was given to have figures show a fan plot of the probabilities of landing at different stock outcomes. The consensus was that the short-term projections should be used, but that in order to build a recovery plan, work needs to be done to have accurate long-term projections. The current long-term projections could still be included, but with the caveat that they are not very accurate. There was once again a call for a framework review. It was suggested that a dotted line be included in the plots to separate observed data and projections.

Looking at the plots of initial deviation, participants were concerned that there are trends around the collapse where the F deviations are all positive. There should have been a lot of tagging activity during that time meaning that there should not have been any time patterns in the F deviations. Someone noted that the scale of the recaptures does not matter, only the reduction in time (minus the first year returns). The early tagging data are therefore not very informative. The presenter explained that the theta and the first year F deviations could be removing a lot of the explanation. The initial F deviation values could be due to high tagging mortality during the tagging experiments (not published but can be found in some research documents). The theta is a composite parameter that accounts for initial tagging mortality, but also the reporting rates. Reporting rates were assumed constant but experiment-specific. At the end of this section of the discussion, some participants once again called for a new framework meeting where all the components of the model be re-assessed.

Looking at the results of the retroactive analyses, participants noted that the same issues are seen when the model is run with and without the sentinel survey data. The presenter noted that in 2017, the DFO multi-species data were quite influential, causing the oldest age groups to fall off the map. When that is the terminal data point, it highly influences the results and increases mortality. A participant asked if the idea of looking at pre-recruits would entail using the existing Newman Sound and Fleming survey data as priors. The presenter replied that it is still being discussed. One option could be to include the indices of ages-0 and 1 as it could provide additional information on younger age groups. This would not be treated as a prior, but it would integrate it directly into the model. It would require some work since it would disrupt current age structures in the model. B_{lim} is calculated using average of the early-1980s as it is considered the last time the stock had a good level of productivity.

Some participants mentioned that it may have been a good idea to start with NCAM during this CSAS process in order to have a better full discussion, especially seeing that it is the basis for the science advice given. Participants noted that they enjoyed the dashboards used to present the various components of NCAM as they allowed for engaged participation from all members present.

AN ECOSYSTEM PERSPECTIVE FOR NORTHERN COD: ECOSYSTEM STRUCTURE, TRENDS, AND ECOLOGICAL INTERACTIONS IN THE NEWFOUNDLAND SHELF AND NORTHERN GRAND BANK (NAFO DIVS. 2J3KL). PART II: FUNCTIONAL CONNECTION BETWEEN CAPELIN AND COD: CAPCOD

Koen-Alonso, M., H. Munro, A. Cuff, and J. Mercer

Presenter: M. Koen-Alonso

Abstract

Capelin is a key forage species in the ecosystem at large, and a key driver of the Northern cod dynamics in particular. The per capita net biomass productivity of Northern cod is linked to capelin availability. The capcod model provides a simple bioenergetics platform to connect cod dynamics with Capelin and fishing as drivers. It has shown good performance for both Northern cod and Barents Sea cod. In both cases Capelin and fisheries appear as a key drivers. While the capcod model does not explicitly estimate cod natural mortality (M), a proxy for cod M can be derived from it. The changes over time in this proxy M show a similar pattern than the one observed in the estimated cod M from the Northern cod assessment model (NCAM), indicating that availability of Capelin is an important driver of cod natural mortality. The results from the capcod model indicate that the relative impact of capelin on cod productivity is accentuated at low capelin levels. Forecasted levels of capelin are more consistent with maintenance of cod at the current level, than rebuilding. Rebuilding of cod to pre-collapse levels requires average capelin levels which are higher than the observed average since the collapse. However, these capelin levels have indeed been observed since the collapse, but they have not been sustained long enough. Under the forecasted levels of capelin for 2020–22, the capcod model indicates that Northern cod is expected to remain stable or decline under all catch levels considered, but modest improvements in the level of capelin from the forecasted values can affect this outcome. The prospect of the stock rebuilding to pre-collapse levels in the next 1–5 years is poor. Under these conditions, fishing pressure on cod needs to be kept as low as possible to maximize the odds of stock growth. Overall, these results show that Capelin level is an important consideration for the management of Northern cod; rebuilding capelin appears as a necessary condition for the rebuilding of Northern cod.

Discussion

The discussion started by a participant mentioning that it is encouraging to see that Capelin are currently the limiting factor for Northern cod but that it will not stay a linear relationship forever. The participant asked why assessment outputs were used instead of survey data for the analysis. The presenter replied that they would have preferred to use survey data if possible but that the assessment outputs are generated using models. There may be some issues around using models outputs from one model into another. A reviewer was concerned about the use of reported catches as total catches in the analysis. That could underestimate the actual catch numbers. They suggested checking if M biases are high. A participant responded that the NCAM catches and reported catches used aren't very different so it may not be as big of an issue for capcod. Someone else asked how many years of projections from the Capelin model would be available to capcod. The presenter replied 3 years, although the quality of the data for each year is not identical. Participants were comforted seeing that the short-term projections for capcod were similar to those from the NCAM model. The presenter reminded the group that capcod is not intended to replace NCAM, but rather is there to compliment NCAM and gives the ability to bring into the analyses processes that are known to impact cod stocks (food availability).

With regards to predator-prey interactions, a participant commented that Capelin numbers need to increase to support growth of the cod stock. If cod stocks increase, that would lead to high predation pressure on Capelin, which in return would negatively impact the cod once again. The presenter explained that the solution to that problem is that there needs to be a bottom-up increase in productivity so that Capelin numbers can increase. As it stands, Capelin are controlled by food availability. Some participants were curious if achieving that level of bottom-up growth would not be possible in the current state of the ecosystem. The presenter replied that based on their results, they think it is still feasible. One participant looked through the last Capelin assessment (DFO 2019b) and concluded that the majority of the Capelin mortality was associated with predators rather than fishing. The presenter replied that when we are talking about biomass levels at the scale of Capelin, the majority of the mortality will be due to predators. For there to be a top-down control on the Capelin population, the predators would need to be actively limiting the growth of the Capelin population, which is not the case.

Suggestions for future work included that seals also be included in the analysis. Participants voiced their concern that the relationship between cod and Capelin is important and could not be properly discussed in a short amount of time at the end of an assessment meeting.

REVIEWER REPORTS

Reviewer 1

The stock assessment of northern cod (NAFO Division 2J3KL) relies on advanced analytical methods that use up-to-date and exhaustive information collected throughout the range of the stock. The meeting agenda was optimistic and some parts of the assessment were not presented as part of the meeting. The assessment followed the policies and guidelines set forth by DFO, the jurisdiction in charge of its management. A whole-ecosystem view to understanding the status and projected trajectories of the stock implied presentations of the physical and biological oceanographic conditions, which were very useful to put the stock assessment in context. The population model used (NCAM) was updated to include data to 2020 in order to provide science advice on the Total allowable catch (TAC) for 2021. While the model performance was defensible, some patterns were evident in the residuals of certain data sources, especially in the sentinel gillnet survey. It would be timely to review the population model through a framework assessment process in the coming years. The stock assessment scientists also pointed out the possibility of using length frequency data directly in the model to complement the ageing data, which is an avenue worth exploring. The presentation of the assessment model results and the availability of the diagnostic information in the form of a “dashboard” was greatly appreciated. It made the discussions during the meeting very productive and allowed the reviewers and the assessment scientists to have meaningful discussions on the perceived and real issues facing the population model.

Reviewer 2

The 2020 workshop on the Northern cod assessment provided a wide-ranging overview of the different data sources around the entire life history of the stock, including datasets from well before the collapse as well as more recent information on early life stages.

In “International Council for the Exploration of the Sea (ICES) speak” the meeting combined an annual update stock assessment with an “integrated ecosystem assessment” meeting, with the addition of having invited external reviewers (and hence moving somewhat towards an ICES benchmark). I can see that presenting everything each year has advantages, but I would also worry that this results in a high degree of repetition between years and resulted in a high workload for the meeting, with rather limited time for examining the actual model results and a number of key presentations being dropped due to time constraints. More tightly focusing the ecosystem presentation on cod-related factors would help, and setting and enforcing time limits for presentations and discussions would help with meeting planning regardless of any other measures that might be taken (such as extending the meeting).

The “cod collapse” in the early-1990s is clearly not a “cod-specific collapse”, but rather impacted a wider range of species. The estimated cod mortalities for the collapse period could fairly be described as “eye opening”.

The NCAM model performance appears to be reasonable, and the overall perception of the stock status appears robust. However, there are features in the model which would bear closer examination (somewhat worrying performance of the catch estimation, patterns in survey residuals, method of imposing a high M in the collapse). This, combined with the length of time the model has been in existence, suggests that a more thorough “framework” review of the model design may be in order. Beyond internal model settings, such a review should examine the potential of including environmental drivers (especially Capelin) directly into the model dynamics and/or forecast.

Finally, the diagnostic tool for the NCAM model is to be highly commended in terms of making the complex model diagnostics accessible and comprehensible.

At times it was not clear to me if the ecosystem component is supposed to be an “ecosystem overview for its own sake”, or the “ecosystem background for the cod assessment”. I suspect it is not always clear to the presenters either. Having ecosystem information in the cod assessment meeting is advantageous and potentially useful. However, given that this is a cod review, in some cases it could be preferable to focus the work more directly on the relevant issues for the “cod in the ecosystem” rather than the “ecosystem as a whole”. For example, presenting plankton biomass rather than abundance would fit more directly into an understanding of food available for the cod. Such focus would both increase the utility for understanding the cod dynamics and would help constrain the meeting time.

For the plankton information, this potentially gives valuable information on the food available for the early life stages, but at present it is not being presented in a form to facilitate this. Presenting abundance of different species would be best done in biomass rather than abundance given the large difference in size between the different species. In addition, it could be valuable to create rough indices of available food (in kJ if possible, in kg if not) for each cod life stage, preferably in the place where the different life stages are. It’s not going to be precise, but even rough estimates would be useful given that the stock is in a period of below expected recruitment. Even kg would be a lot better than abundance, but rough estimates of kJ might also be possible if time allows. It is unfortunate that the plankton surveys don’t start earlier, but it’s generally the case that monitoring is only put in place after a major change.

For the Total Catch Index (TCI), a dedicated review of the specific model should be conducted before results are used to influence management. The details of the model structure, and the justification of the sustainable levels, both need detailed review which is not possible at this meeting. In particular a number of the underlying parameters (such as "ecotrophic efficiency" in an EwE setting) are critical to the energy flow through the system and are not readily constrained by data. As such, the absolute values coming out of the modelling should treated with extreme care. However, the model does have utility when used in a relative manner – for example identifying periods of very high overfishing levels compared to more reasonable fishing regimes probably does show a signal through the (unquantifiable) noise. The proposed use of the model to identify fisheries situations which might require more detailed scrutiny rather than as a direct input to management actions goes a long way to address the concerns around using this kind of model.

The overall ecosystem perspective of different species in the surveys is very useful. Firstly, it shows clearly that the collapse affected a large range of species, not just cod. Secondly, that the partial recovery has occurred in several groundfish species. Finally, it highlights the trade-offs between the different species (for instance that shrimp has been declining in recent years in the presence of more cod).

The compliance section and stewardship cod landings management information are not something I have seen in a review previously. This summary clearly feeds into the estimation of the catch ranges, but beyond that would be a valuable part of any stock review as it could identify early on if compliance issues are arising.

The predation and diet section is clearly a work in progress, and is a challenging thing to attempt. The information presented gives an important overview of the mid- and high-trophic level functioning of the key drivers of the ecosystem. Even though the absolute estimates are uncertain, the trends are informative and worth examining. The only review comment here is that this work should continue to be supported and developed, both for general ecosystem understanding and to give context to the cod assessment. More specifically for cod, the lack of either shrimp or Capelin can be seen to have led to higher predation on cod (by cod and turbot) and cod switching to other foods (crabs and amphipods) which are likely to be less valuable for the cod.

The Capelin assessment results are clear of great relevance to outcome for the cod stock, given Capelin's key role as a forage fish and the lack of the shrimp as an alternate prey. They may not go directly into the cod stock assessment, but do give an important indication of the likely food availability for the future development of the cod stock.

In the context of recreational cod catches, if the estimate of 1–2 kt of catch are reasonable, the uncertainty within that range is less than 10% of the current overall catch, which is not terrible. Improving the estimate within the range would be good, but work aimed at validating the overall range is probably more important. The estimates should also be aimed at picking up any changes which might be occurring in the recreational catches. The Citizen Cod program is useful, not just for any trends it identifies but also in verifying which things are not variable (in space or time). Knowing that assumptions of stability underlying the assessment model are validated is extremely useful even if it may be less obviously "interesting" than identifying trends.

The survey presentations ranged wider than the tuning data for the model. This provided a wider background than is typically the case, giving both a much longer perspective and a detailed dataset on the nursery areas. This wider picture is valuable in providing broad life-cycle understanding. It also potentially serves as validating datasets to flag up issues in the main tuning series as they might arise. In terms of the direct model inputs, the consistency in trends in the sentinel survey and the RV survey on the stewardship fishery is an encouraging sign to validate these indices. Given the consistency between different datasets, the overall trends seem well determined for this stock.

The correspondence between the 0-group in inshore survey and the 2- and 3-year olds in the model is especially notable given the generic difficulty in identifying details of 0-group dynamics which relate to subsequent recruitment to the population and fishery. Further development of this work, with a view to potentially incorporating this into the model projections is recommended.

The presentation and review of the model was rather brief, and therefore this could not be said to be a full review of the model functioning (and nor was this the intent). In many ways the model is similar to other statistical-catch-at-age state-space models such as SS3 (USA) or SAM (ICES). This section will therefore focus on the “nonstandard” features of this model.

One key “non-standard” feature of the NCAM model over other state-space model formulations, is the high rate of mortality in the time of the crash. It is clear that total mortality (Z) was high at that time, and given that the crash also affected non- or lightly- fished groundfish at the same time, placing this primarily as a M driver rather than F seems reasonable. This is not to say that there was not also an F competent to the increase in Z, especially given that F was high at the time and the difficulty in reducing F early and fast enough during periods when the stock is (naturally) declining.

It is clear that allowing a high enough process variance throughout time to be able to account for the high M in the collapse period is likely to lead to unrealistic model behavior in other years. Adding an increase in the base M is one method of achieving the higher M over a short period. However, an alternate method might be to allow a higher level of process variance in the relevant period, thus allowing the model to internally estimate a realistic M during the crash without resulting in too high a process variance (and hence over-fitting and over-variable M) in the other years and without requiring an input spike of M values. It is therefore recommended that the option of replacing the M forcing with a period of different process variance.

The other “non-standard” feature is the treatment of catch, specifically the use the bounds on the estimate of overall removal. This is not done in a Bayesean fashion, rather the bounds either have almost no effect at all on the estimation (if the value if not near a bound) or else catches will be constrained to be near the bound. In practice the model is often constraining the estimated catch to lie on the prescribed bounds, which is likely not what these bounds were intended to do. It can be seen that in some model periods (1990s especially) the catch estimates bounce between the two bounds, suggesting a potential lack of information to determine the annual catch. In a couple of years the estimate exceeds the bounds – depending on how strongly the likelihood is being penalized this may indicate an extremely strong push for the model to be exceeding the imposed bounds. In general, a revision of the catch estimation procedure is strongly recommended.

In terms of the model fit, the key issue is the patterns in the residuals in the sentinel survey fits. This is imposing a misfit in recent years in the fit to the RV survey, but otherwise the RV survey has less problems with patterns in the residuals. The recommendation here is to investigate a trend in the selectivity of the sentinel survey over time.

Overall, a model revision is to be recommended in the not-too-distant future. Potential issues for any future model revision include:

- Potential for integrating Capelin effects into the cod model (historical and/or projection)
- Revisit the catch bounds and catch estimation methodology
- Examine the assumption of same selectivity in recreational catch and commercial catch

- Time shift in selectivity (maybe catchability overall, but definitely age selectivity) of the sentinel survey
- Think about length selectivity
- Investigate the choice of base M=0.4
- Year to year flexibility in M – is there too much flexibility here and hence too much vulnerability to problems in the terminal year survey?
- Investigate replacing the imposed spike in M with a period of higher process variance
- Check the way tagging is used in the model estimation
- Investigate ways of incorporating wider ecosystem information (especially Capelin), either in the assessment model formulation or else in terms of constraining forecast scenarios

RESEARCH RECOMMENDATIONS

- Relationships between long-term changes in ocean climate, plankton community structure, seasonality, and cod recruitment/mortality.
- Build on the model already developed for Citizen Cod work (advanced modelling). If possible, get a handle on unrecorded catches in the recreational fishery.
- Further develop recreational fishery surveys (possibly account for shore-based fishing).
- Look further into incorporating DWAO index in future assessments.
- Determine Sentinel catchability issues with by-catch.
- Look at age and length composition data from recreational fish and how they compare to the stewardship fishery.
- Look into NCAM model or sentinel survey re-assessment. Potential for a framework meeting. Possibly address length-based catchability.
- Developing tighter errors around BNAM model projections.

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APPENDIX I – TERMS OF REFERENCE

Stock Assessment of Northern Cod (Divs. 2J3KL)

Regional Advisory Meeting - Newfoundland and Labrador Region

March 23-26, 2021

Virtual Meeting

Chairperson: Darrell Mullowney, DFO Science

Context

The last full stock assessment for Northern cod was completed in March 2019 (Fisheries and Oceans Canada [DFO] 2019b). A stock status update science response was completed in April 2020 (DFO 2021). In January 2019, a Regional Peer Review Process was held to evaluate the Limit Reference Point (LRP) for Northern cod (DFO 2019a). The peer review meeting reached a consensus that the method for determining the LRP and the reference point itself remained valid.

Detailed advice on the status of the stock was requested by the Resource Management Branch to inform recommendations to the Minister for management decisions for the 2021 fishing season.

Objectives

- Consider ecosystem status where the assessed stock occurs 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).
- Assess the current spawning stock biomass (SSB) relative to the LRP (Blim), total biomass, recruitment, fishing and natural mortality, distribution, and other relevant biological characteristics.
- Determine the output calculation of the Harvest Decision Rule (HDR) and a determination by Science that the HDR still applies. Will also need confirmation that none of the exceptional circumstances in the Rebuilding Plan (RP) have been triggered.
- Identify the major sources of uncertainty, where applicable.
- To assist in the development of the management measures for 2021, conduct three year projections of Spawning Biomass relative to the limit reference point (with 95% CIs) assuming total removals are (0.7, 0.85, 1.0, 1.15, and 1.3) times the 2020 value.
- DFO's Precautionary Approach (PA) Framework indicates there is zero tolerance for preventable decline. Identify the level of removals that provide a high probability (>95%) of continued stock growth over the medium to long-term (5-10 years). If possible, provide the levels of removals that provide a 0.95 probability of 0, 25, 50 and 75% growth from the 2019 estimate of spawner biomass.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Documents

Participation

- Fisheries and Oceans Canada (DFO) Science and Fisheries Management
- Newfoundland and Labrador Department of Fisheries and Land Resources
- Industry
- Academia
- Indigenous Groups
- Non-Governmental Organizations
- Other invited experts

References

DFO. 2019a. Evaluation of the Limit Reference Point for Northern Cod (NAFO Divisions 2J3KL). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2019/058.

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DFO. 2021. 2020 Stock Status Update for Northern Cod. DFO Can. Sci. Advis. Sec. Sci. Resp. 2021/004.

APPENDIX II – AGENDA

CSAS Regional Peer Review Process:

Stock Assessment of Northern Cod (Divs. 2J3KL)

March 23-26, 2021

Chairperson: Darrell Mullowney

Tuesday, March 23 (0930-1530)

Activity	Presenter
Opening, Terms of Reference and Introductions	Chair
An Ecosystem Approach To Fisheries Management At DFO	M. Koen-Alonso
Ocean Climate Variability On The NL Shelf	F. Cyr
Biogeochemical Oceanographic Conditions On The Nl Shelf	D. Bélanger
An Ecosystem Perspective for Northern Cod: Ecosystem Structure, Trends, and Ecological Interactions in the Newfoundland Shelf and Northern Grand Bank (NAFO Divs. 2J3KL). Part I: Ecosystem Summary	M. Koen-Alonso

Wednesday, March 24 (0900-1545)

Activity	Presenter
2020 2J3KL Stewardship Cod Fishery Compliance Review	S. Lewis
An Ecosystem Perspective for Northern Cod: Ecosystem Structure, Trends, and Ecological Interactions in the Newfoundland Shelf and Northern Grand Bank (NAFO Divs. 2J3KL). Part I: Ecosystem Summary Continued	M. Koen-Alonso
Key Prey (Summary of Divs. 2J3KL Capelin Stock Assessment)	H. Murphy
Stewardship Cod (2J3KL) 2020 Management Measurement Overview	E. Careen
Citizen Science (dockside outreach of Recreational Fishery)	H. Rockwood
Recreational Cod Fishery Update	R. Holub
2J3KL Cod Catch and Catch-At-Age	B. Rogers
Northern cod (NAFO Divs. 2J3KL) RV Survey 2020	K. Dwyer

Thursday, March 25 (0930-1600)

Activity	Presenter
Strength of 2018-20 Cohorts, from Nearshore Surveys of Demersal Age 0-1 Atlantic cod in Newman Sound, Bonavista Bay	B. Gregory
Fleming survey reboot: Demersal Juvenile Cod in Coastal Areas of Eastern Newfoundland	R. Lewis
Sentinel Surveys 1995-2020 – Catch Rates and Biological Information on Atlantic Cod (*Gadus morhua*) in NAFO Divisions 2J3KL	L. Mello
2021 Tagging and Telemetry Update 2J3KL Cod	E. Novaczek
The Northern Cod Assessment Model (NCAM): Overview	P. Regular

Friday, March 26 (0900-1600)

Activity	Presenter
The Northern Cod Assessment Model (NCAM): Update	P. Regular
An Ecosystem Perspective for Northern Cod: Ecosystem Structure, Trends, and Ecological Interactions in the Newfoundland Shelf and Northern Grand Bank (NAFO Divs. 2J3KL). Part II: Functional Connection Between Capelin And Cod: Capcod	M. Koen-Alonso
Science Advisory Report Bullets	ALL
Reviewer Reports	D. Howell/D. Ricard
Research Recommendations	ALL
Upgrading of working papers to research documents	H. Rockwood/E. Parrill
Next Steps	H. Rockwood
ADJOURN	Chair

APPENDIX III – LIST OF PARTICIPANTS

Name	Affiliation
Darrell Mullowney	DFO-NL – Science
Dale Richards	DFO-NL – Centre for Science Advice
Erika Parrill	DFO-NL – Centre for Science Advice
Hilary Rockwood	DFO-NL – Centre for Science Advice
Jenn Duff	DFO-NL – Communications
Sky Ann Lewis	DFO-NL – C&P
Ellen Careen	DFO-NL – Resource Management
Julia Sparkes	DFO-NL – Resource Management
Robyn Morris	DFO-NL – Resource Management
Aaron Adamack	DFO-NL – Science
Bob Gregory	DFO-NL – Science
Bob Rogers	DFO-NL – Science
Corey Morris	DFO-NL – Science
Daniel Ricard	DFO-Gulf – Science
David Bélanger	DFO-NL – Science
Divya Varkey	DFO-NL – Science
Dwayne Pittman	DFO-NL – Science
Emilie Geissinger	DFO-NL – Science
Emilie Novaczek	DFO-NL – Science
Fran Mobray	DFO-NL – Science
Fred Tulk	DFO-NL – Science
Frédéric Cyr	DFO-NL – Science
Hannah Munro	DFO-NL – Science

Name	Affiliation
Hannah Murphy	DFO-NL – Science
Jennica Seiden	DFO-NL – Science
Karen Dwyer	DFO-NL – Science
Keith Lewis	DFO-NL – Science
Laura Wheeland	DFO-NL – Science
Luiz Mello	DFO-NL – Science
Mariano Koen-Alonso	DFO-NL – Science
Martha Krohn	DFO-NCR – Science
Nick Gullage	DFO-NL – Science
Paul Regular	DFO-NL – Science
Rachel Holub	DFO-NL – Science
Rajeev Kumar	DFO-NL – Science
Rick Rideout	DFO-NL – Science
Ron Lewis	DFO-NL – Science
Ryan Chlebak	DFO-NCR – Science
Sana Zabini- Seissan	DFO-NL – Science
Greg Robertson	ECCC
Anna Tilley	Government of NL – Fisheries, Forestry and Agriculture
Kris Vascotto	Atlantic Groundfish Council
Albert Wells	Fish, Food and Allied Workers Union
Chad Strugnell	Fish, Food and Allied Workers Union
Erin Carruthers	Fish, Food and Allied Workers Union
Harrison Campbell	Fish, Food and Allied Workers Union
Keith Smith	Fish, Food and Allied Workers Union

Name	Affiliation
Jim Baird	NLGIDC
Derrick Dalley	Innu Nation
Rob Coombs	NunatuKavut Community Council
Todd Broomfield	Nunatsiavut Government
Daniel Howell	Institute of Marine Research
Abe Solberg	MUN – Marine Institute
Matthew Robertson	MUN – Marine Institute
Noel Cadigan	MUN – Marine Institute
Raquel Ruiz	MUN – Marine Institute
Sherrylynn Rowe	MUN – Marine Institute
Tyler Eddy	MUN – Marine Institute
Devan Archibald	Oceana Canada
Chelsey Karbowski	Oceans North
Victoria Neville	World Wildlife Fund Canada