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Proceedings of the Regional Advisory Meeting for the Assessment of 2J+3KL Capelin

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Foreword

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

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SUMMARY

The Regional Peer Review Process on the status of Capelin was held March 9-12, 2021 via Microsoft Teams. The purpose was to assess the stock status of Capelin (*Mallotus villosus*) in Northwest Atlantic Fisheries Organization (NAFO) Subarea 2 and Divisions 3KL.

These Proceedings include an abstract and summary of discussion for each presentation, as well as 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 a comprehensive Research Document, to be available online on the Canadian Science Advisory Secretariat (CSAS) 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 has established a National Initiative aimed at implementing an Ecosystem Approach to Fisheries Management (EAFM) in Canada that will integrate environmental variables (i.e., climate, oceanographic, and ecological factors) into single-species stock assessments in order to improve fisheries management decisions. The current iteration of this long-term initiative, which will be completed by 2023, it is intended to serve as steppingstone 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 EAFM. Within this framework, 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 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., CSAS stock-assessments, Precautionary

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

No discussion.

OCEAN CLIMATE IN NEWFOUNDLAND AND LABRADOR WATERS

Presenter: F. Cyr

Abstract

The Newfoundland and Labrador (NL) 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 1951, 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 NL 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

A participant asked if the index had changed as a result of using baseline data from 1991 to 2020, as opposed to 1981 to 2010. It was discussed that while shifting the time series forward 10 years resulted in the definition of extremely cold years and extremely warm years to be more cold and less warm, respectively, the overall trend observed from the index remains the same.

Preliminary comparisons between trends in the climate and Capelin indices were presented and discussion occurred over whether age data used in the acoustic biomass index should be lagged. Given that the research being presented was preliminary, there was some uncertainty about this, and it was suggested that the mechanisms of the acoustic biomass index and how they are correlated to the climate index be looked into further. Furthermore, it was also suggested that relationships between Capelin recruitment and the climate index be considered for a research recommendation.

Discussion pertained to how changes in ocean circulation might impact Capelin. A participant commented that anecdotally, trends in the productivity of Capelin in NL seemed to mirror those of the Icelandic Capelin stock just a few years prior. While this comment was acknowledged, it was noted that the trends in ocean climate which were presented were observed over a longer, decadal time scale. It was also noted that given the relatively short time series of available oceanographic data, it was difficult to quantify any kind of relationship between ocean circulation and Capelin productivity using cyclical trends of ocean climate taking place over a long time period. In light of these limitations, it was suggested that further research be conducted on the mechanisms between oceanographic circulation, bottom up processes, and how they relate to Capelin productivity.

OVERVIEW OF THE CHEMICAL AND BIOLOGICAL 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

A participant asked whether or not 2021 satellite imagery had been looked at with regards to sea ice retreat and the spring phytoplankton bloom. It was discussed that the cleaned and calibrated 2021 satellite data were not yet available. Therefore, it was not possible during this meeting to project what impact the timing of this year's sea ice retreat and subsequent phytoplankton bloom might have had on Capelin.

A participant asked what data were used to calculate the mean seasonal zooplankton biomass anomalies. Mean anomalies were calculated using averaged data from Seal Island, Flemish Cap, Bonavista, Station 27, and any other available data from 2J3KL. Associations between the increasing abundance of amphipods in the zooplankton community and in Atlantic cod stomachs observed over the past few years were discussed.

A participant requested clarification with regards to the seasonal biomass anomalies, which resulted in a discussion on the timing of increased zooplankton biomass versus Capelin development. It was suggested that although increasing abundances of *Pseudocalanus* copepods were observed in recent years, peak biomass may have occurred too late in the year to benefit Capelin development. It was then discussed that a peak of zooplankton biomass happening later in the year would not get captured by the Capelin diet research conducted by DFO in Trinity Bay, where sampling occurs earlier in the season.

A participant, wondering if chaetognaths were a predator or prey for juvenile Capelin, asked whether any size range data were available for chaetognaths. It was discussed that due to human resource limitations, the research being presented focused on the taxonomic resolution of copepod species. However, it was noted that based on field observations the chaetognaths captured in the zooplankton samples range anywhere from a few millimeters to 10 centimeters.

A participant asked if any size spectra analysis work had been done on the different communities of zooplankton and phytoplankton blooms, as such information could help indicate the potential capacity of the plankton communities to support Capelin throughout different times of year. With respect to zooplankton, it was discussed that there had been some preliminary work done, the results of which were not conclusive and should be looked into further. With respect to phytoplankton, it was discussed that samples had been collected over the years, but had not been analyzed due to limited human resources. Analysis of the phytoplankton samples was also suggested as a research recommendation.

A participant asked for insight on how the timing, duration, and biomass of seasonal phytoplankton blooms might influence the different zooplankton communities. In general, over the past 10 years an increase in primary productivity was observed as a result of earlier, longer, and more productive blooms. However, the relative influence of the spring versus fall phytoplankton blooms and the respective spring and fall zooplankton communities remains poorly understood. Currently, work is being done to integrate fall phytoplankton bloom indices in the AZMP. Interest was expressed in the fall bloom information and a recommendation was made to research how it might influence Capelin productivity.

AN ECOSYSTEM PERSPECTIVE FOR CAPELIN: ECOSYSTEM CONTEXT, FUNCTIONAL CONNECTIONS WITH PREDATORS, AND PREDATION IMPACTS. PART I: ECOSYSTEM CONTEXT

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

Presenter: M. Koen-Alonso

Abstract

The ecosystem structure of the NL bioregion can be divided into four Ecosystem Production Units (EPUs): the Labrador Shelf (NAFO Div. 2GH), the Newfoundland Shelf (Div. 2J3K), the Grand Bank (Div. 3LNO), and southern Newfoundland (Subdiv. 3Ps). These EPUs coarsely represent functional ecosystems, and are used as geographic boundaries for the estimation of fisheries production potential (FPP) using ecosystem production potential models. Estimated FPP distributions, together with proxies for the current productivity state of the EPU, have been used to provide guidance on upper limits of total catches total catch index (TCI) of fish functional guilds, within the 2J3K and 3LNO EPUs. These functional guilds are higher level aggregations than the fish functional groups used to describe ecosystem status and trends; for example, the benthivore guild includes all benthivore fish functional groups (small, medium, and large) plus the shellfish functional group (i.e., shrimp and Snow Crab). The analysis of FPP indicated that the historical catches for planktivores were near or above the TCI in the 1960s and 1970s, but in recent decades catches have been constantly below TCI. In both EPUs the historical catches for piscivores were substantially above the TCIs, more recently these catches have been much closer to the TCI. However, catches of benthivores and piscivores have been above TCIs during the 1995–2020 period and catches of suspension Feeding Benthos in the 3LNO EPU have also been above TCI. 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 has become 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. While the absence of an acoustic survey in 2020 represents a challenge for the evaluation of Capelin, the general consistency observed in Capelin trends between the 1 year lagged 2J3KL RV bottom trawl survey and the Div. 3L Spring acoustic survey indicate that Capelin would be expected to remain at a relatively low level in 2020. Modelling of Capelin acoustic biomass as a function of Capelin occurrence in the stomachs of cod and Turbot indicate that predator diets are useful trackers of Capelin availability, and also indicate low Capelin levels for 2020.

Capelin and shrimp are important prey items for cod, Turbot, American Plaice, and redfish. The dominance of shrimp in the diets has generally declined as the shrimp stock declined; these declines are often associated with increases of Capelin in the diet. The reduced availability of both shrimp and Capelin in recent years has also translated into more diversified diets. In northern areas (2HJ), Arctic cod and redfish are becoming more important prey items. Overall, Capelin remains low in the diets of key predators in 2J3KL in 2020, but some increases in cod and Turbot diets were observed, mostly driven by predation in Div. 3K. Average stomach content weights for cod and Turbot have also declined since the mid-2010s and track well with 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 bioregion. Current results suggest that Newfoundland Labrador ecosystems continue in low overall productivity conditions.

In summary, ecosystem units in the bioregion are currently experiencing low productivity conditions, impacting the rebuilding processes of groundfishes, and leading to important declines in total biomass. Since the mid- to 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 and Labrador ecosystems still remain in low overall productivity conditions. Considering the uncertainties around stock status, the key forage role of Capelin, that fishing does not respond to Capelin availability in the same way as predation does, and that the potential impact of fishing on the stock is augmented when Capelin level is low, high risk aversion would be advisable for the management of Capelin in 2021.

Discussion

Referencing calculations used to determine the Fishery Production Potential, a participant asked how the baseline for normal productivity was determined. It was noted that with any type of ecological modeling determining what the normal baseline is can be difficult. To mitigate the issue of a shifting baseline the data included in the model being presented went back only as far as when sampling was conducted in the same comprehensive manner that it is today (i.e., the 1980s). Thus, based on the available data, the most reliable assumption for the biomass levels of a fully functioning ecosystem was determined to be that of the 1980s.

A participant asked if the composition of prey observed in predator stomachs could be influenced by changes in the size distribution of the predator stock. It was discussed that since stomachs were sampled from predators of multiple size classes, unless there was a drastic change in the size structure of the predator stock, the overall signal of prey composition should remain the same.

A participant questioned the significance of the small increase of Capelin observed in Atlantic cod and Greenland halibut stomachs from 2019 to 2020 in Div. 3K. It was reasoned that since the Capelin forecast model projected there to be a low level of Capelin in 2020, an increase in Capelin observed in predator stomachs was not expected. Furthermore, although Capelin still made up a relatively small amount of the prey composition for these predators it was noted that no Capelin were observed in Div. 3K Atlantic cod stomachs in 2019. However, it was agreed that these results not be read into too much, as the small increase was only observed for one year.

A participant asked if any correlations had been made between predator condition and the composition of prey in their stomachs with respect to Capelin. It was discussed that work done in the past has shown that cod condition appears to respond to changes in capelin availability, so there are some evidentiary basis for exploring the use of cod condition to derive some indicator of Capelin availability.

Discussion occurred in relation to the predation of Capelin by seals. It was noted that although there was diet data for seals captured nearshore and that more research currently was underway, there was a lack of stomach content data from seals captured offshore.

AN ECOSYSTEM PERSPECTIVE FOR CAPELIN: ECOSYSTEM CONTEXT, FUNCTIONAL CONNECTIONS WITH PREDATORS, AND PREDATION IMPACTS. PART II. FUNCTIONAL CONNECTIONS BETWEEN CAPELIN AND PREDATORS

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

Presenter: M. Koen-Alonso

Abstract

Linkages can be made between predators and Capelin availability. Occurrence of Capelin in the diet of key fish predators can be used to track Capelin status and complement research vessel (RV) surveys, while Capelin availability can be used to explain and model cod population dynamics.

The probability of Capelin derived from the occurrence of Capelin in stomachs from cod and Turbot can be used to help evaluate the status of Capelin in 2J3KL. These signals are consistent with a rapid collapse of Capelin availability in the early-1990s, modest improvements in the late-2000s and early-2010s, and declining levels in recent years. The Capelin signal for 2020 is consistent with the forecast from the Capelin model, indicating that Capelin remains at a low level.

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 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 to 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 M. Ongoing work on NCAM includes the use of cod condition to drive cod M, which can be linked to prey availability.

Discussion

No discussion.

SEABIRD POPULATION TRENDS AND DIET

Presenter: W. Montevecchi

Abstract

No abstract provided.

Discussion

A participant asked if there was a relationship between the timing and spatial extent of where Murres are seeking Capelin and the Capelin fishery. The presenter was not available for comment.

FISHERY LANDINGS AND BIOLOGICAL DATA (CATCH)

Presenter: F. Mowbray

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 Div. 3L acoustic survey was not conducted in 2020 due to COVID-19, but data from previous years were 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, the spring acoustic survey abundance index declined by an order of magnitude. The size-at-age of younger Capelin (ages 1–2) increased while the age-at-maturity decreased from largely age-3 Capelin to a higher composition of age-2s. 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 asked if how much of the Total Allowable Catch (TAC) for Capelin was landed or not was due to the degree in which the fishery overlapped with spawning time. It was discussed that when the quota was not fully caught, it could be hard to discern if it was due to a low abundance of Capelin or the fishery happening while Capelin were not in the area. It was noted that from a harvesters' perspective, there did not appear to be a great abundance of Capelin in

3KL in 2020, quotas were met without issue because unlike years prior, many bays were open at the same time and there was a good spread of vessels across the two regions.

Since the spring acoustic survey picks up mostly age-2 Capelin, a participant asked if it was known what proportion of the total Capelin biomass was made up of age-2 Capelin. It was discussed that although there had been work done on this in the past, it remained unclear if there was a reliable way to determine such information. It was recommended that this be looked into further as a research recommendation.

A participant asked how the composition of different ages of Capelin being captured by the fishery should be interpreted: is such the result of changes in the age of maturity or in the age of mortality? It was discussed that changes in the age of maturity and mortality are one in the same – if fish mature and thus spawn at an earlier age, they will also likely die at an earlier age due to the high rate of post spawning mortality. However, the shift in the age composition of the spawning stock is thought to be driven by changes in the age of maturity.

A participant asked if there was any information regarding discard and bycatch from the fishery. It was discussed that the way in which the fishery operates facilitates minimal discard and bycatch. Sampling prior to the fishery opening to determine when the fish are suitable (i.e., predominately roe-bearing females) to be harvested greatly reduces the likelihood of discard. Furthermore, catches are allowed to be shared amongst harvesters, should one harvester catch more than their quota allows.

CAPELIN EMERGENT LARVAL INDEX

Presenters: H. Murphy

Abstract

Year-class strength and recruitment of Capelin is related to survival of the early life stages. The Bellevue beach larval index is collected each summer from the start to the end of larval emergence. The larval index is used in the Capelin forecast model as recruitment is positively related to the Bellevue larval abundance index. In 2020, the larval index was the lowest in the data series (2001–20), suggesting 2020 would be a small year class. This was the seventh year in a row of below average larval productivity at Bellevue Beach.

Discussion

There were several questions with regards to rotting Capelin eggs observed at the demersal spawning sites being monitored in Trinity Bay. A participant asked if the mortality of Capelin eggs at these sites was being tracked or the observations made of rotting eggs over the years were just field observations. It was discussed that observations of rotting eggs were made in the field by the smell of the eggs and by looking at samples through a microscope to verify that the eggs were not viable. A participant then asked if rotting eggs at these demersal spawning sites is something that is seen often and if it was something that is typically seen on the beach as well. It was discussed that near the end of the spawning season rotting eggs are often seen at both the demersal sites and coming off the beach. This was contradicted by another participant who noted that in their monitoring of demersal spawning sites in Notre Dame Bay over the past 20 years they had only seen rotten eggs once. It was discussed that that egg quality decreases the longer fish hold onto the eggs, and thus the occurrence of rotting eggs could be a result of Capelin holding onto the eggs longer before spawning. It was noted that a camera is periodically put down at the demersal spawning sites in Trinity Bay to see if the fish are actually spawning or just at the site. It was recommended that this be monitored more closely to try and determine how long it takes for spawning to occur at the demersal sites. It was also suggested that the occurrence of rotting eggs could be the result of a combination of unfavorable environmental conditions for larval development with respect to temperature, sediment type, salinity, and oxygen levels. A participant suggested that the common occurrence of rotting eggs observed at the demersal spawning sites in Trinity Bay versus the lack thereof in Notre Dame Bay might suggest that the localized oceanographic conditions might not be as suitable for demersal spawning at the Trinity Bay sites as they are at the Notre Dame Bay sites. It was noted that for the last two spawning seasons, MicroCATs were put down to monitor some of these environmental conditions, as well as larval traps to monitor larval emergence at the demersal sites in Trinity Bay. However, this research is preliminary and thus no results were available at the time of the meeting. It was suggested that this research be continued and expanded to include a more quantitative approach to monitoring egg condition on the beach at the Trinity Bay site as well.

A participant asked if there had been a change in Capelin spawning locations and/or habitats since the stock collapsed in the 1990's. It was discussed that researchers have found that broadly, since around the time of the collapse, fewer beaches have been utilized for spawning, while demersal spawning has become more apparent. It was suggested that this change was likely a result of beach temperatures increasing and spawning occurring later in the season. It was also noted that potential changes in the distribution of spawning activity on a more localized level have not been looked at as closely, presumably because of a lack of data. It was suggested that, if possible, this be looked into further as a research recommendation.

On a related note, a participant suggested that the beach versus demersal spawners might be two different stocks of Capelin. It was discussed that genetic work determined that there was little genetic difference between beach and demersal spawners, and that their spawning preferences were likely due to phenotypic plasticity.

A participant noted that this past summer they had observed large amounts of seaweed covered in Capelin eggs ashore at one of the beach monitoring sites in Notre Dame Bay. From speaking with harvesters, who observed a large mass of Capelin close to the beach around the time the egg-covered seaweed was seen, and due to the fact that the beaches in the area were relatively warm this past summer, it was speculated that the beach site was unsuitable for the spawning Capelin and thus they found a demersal site to spawn at instead. The viability of the eggs attached to the seaweed washed ashore was questioned. It was discussed that the overall mortality rate was likely very high, with varying degrees of viability dependent on where the eggs were (i.e., rotting eggs at the bottom of the seaweed pile and viable eggs attached to seaweed floating in the wave impact zone). However, due to COVID-19 restrictions, no larval samples were able to be collected to get an estimate of the survival rate.

A participant asked if drift modelling had been done to look at larval survival. It was discussed that drift modeling could be done with data from the long term beach monitoring site in Trinity Bay. This was something that was being examined to help better understand the relationships between inter-annual variability of growth and survival through the early life stages of Capelin. Furthermore, there was also work being done to see if otolith cores from age-2 Capelin could be used to determine whether a fish came from a beach or off-beach spawning site. Preliminary results found differences in the otoliths of larvae hatched at beach and off-beach sites. If a similar otolith tag was found in adult Capelin, we would be able to have a more comprehensive understanding of the connectivity of the stock, whether or not there were differences in the survival rates of off-beach versus beach spawning, and if such a rate changed annually.

ATLANTIC HERRING PREDATION ON CAPELIN EGGS AND LARVAE

Presenter: H. Murphy

Abstract

Atlantic herring (*Clupea harengus*) is a forage fish that transfers energy from lower to higher trophic levels and sustains high volume fisheries in the North Atlantic. This study aims to improve our understanding of the ecology of Newfoundland herring and its vulnerability to climate change by identifying key prey items and describing adult herring feeding strategies. We compared plankton assemblages to stomach content and stable isotope analyses from herring collected in Trinity Bay, Newfoundland, in late summer and autumn 2017–19. Six distinct zooplankton communities were identified across all years, with a shift in community structure in September 2018. This shift coincided with a change from fresher, warmer waters (12–17°C) to more saline, cooler waters (10.5°C). Fish eggs, larvae, and juveniles, primarily identified as Capelin, were observed in stomach contents in all years. Fish contributed most to diets in 2017, which corresponded with the peak year for larval densities in Trinity Bay, suggesting that piscivory may increase at higher larval densities. Herring were primarily opportunistic feeders, although some individuals exhibited selective feeding on copepods, amphipods, euphausiids, and the early life stages of fishes. Stable isotope analyses supported the finding that herring piscivory is prevalent in eastern Newfoundland. Given its adaptive feeding strategy and wide range of consumed prey, we conclude that adult Newfoundland herring is resilient to bottom-up changes observed in the environment.

Discussion

A participant questioned the relevance of Atlantic herring predation on Capelin eggs and larvae. The research being presented did not find strong isotopic signatures for Capelin eggs, nor a high amount of Capelin larvae in the diets of adult Atlantic herring. Comparisons were made between these results and research conducted in the Barents Sea, where Capelin is known to be an important prey species of Atlantic herring. It was suggested that Atlantic herring may not be as important a predator of Capelin in NL as it is in the Barents Sea. It was suggested that if Capelin stocks were low, there might not be a strong signal of predation, but even a relatively small amount of predation of Capelin eggs and larvae by Atlantic herring could have a big impact on the stock. Overall, it was agreed upon that although the predation pressure of Atlantic herring on Capelin might not be as strong in NL waters as it is in the Barents Sea, this research still provides a valuable insight into the predator-prey dynamics within the pelagic ecosystem. It was also noted that there is a current initiative to expand this research to include juvenile Atlantic herring and to help understand if herring is a growth selective predator of Capelin.

A participant asked if there was any research on the predation of Capelin by Atlantic mackerel. It was noted that Atlantic mackerel was not assessed by the NL Region of DFO. However, it was discussed that Atlantic mackerel has been bycaught with Atlantic herring, and when the stomachs of the mackerel were analyzed, they were found to contain mostly juvenile herring. In general, it was agreed that compared to the offshore stocks, there was relatively little data on the inshore stocks of pelagic fish and that more research is needed to be conducted to investigate the predator-prey dynamics of pelagic species in the inshore waters of NL.

CITIZEN SCIENCE: BEACH SPAWNING DIARIES

Presenter: H. Murphy

Abstract

Capelin beach spawning abruptly and persistently changed in 1991, with spawning on average 4 weeks later compared to 1978–90. A Capelin spawning diary network along the southern and northeastern coasts of the island of Newfoundland was developed by DFO in 1991. On average,

18 beaches are monitored each year by paid citizen scientists. In 2020, 14 beaches were monitored and four of these beaches had no evidence of spawning. In 2020, peak beach spawning was July 22 in Div. 3K, July 15 in Div. 3L, and June 29 in Subdiv. 3Ps. These dates are later than the 1991–2019 average (July 11).

Discussion

There was a discussion surrounding citizen scientists, spawning duration, size of spawning Capelin, and demersal spawning.

A participant asked if citizen scientists just record when spawning events occur or collect samples of the spawning Capelin as well. It was discussed that while samples are collected from some beaches, the majority do not have samples collected from them. A participant asked if citizen scientists are required to go down to the beach and confirm that what looks like Capelin eggs is indeed Capelin eggs, noting that from a distance biological material such as broken shells can be easily mistaken for Capelin eggs. It was noted that the citizen scientists are advised to do a close-up visual confirmation of the spawning activity.

A participant asked if there were any hypotheses regarding the general decrease in spawning duration observed from the 1940s to more recent times. It was discussed that historically spawning appeared to happen in waves, with larger fish coming into spawn, then after a week or so of no spawning activity, smaller fish coming inshore to spawn, and so-forth. In more recent years this gap between spawning waves has narrowed and thus the spawning period is occurring over a shorter period of time. It was noted that this observed decrease in spawning duration in recent years is likely indicative of changes in the age structure of the spawning stock.

A participant asked if the relationship between the size of Capelin and when they show up at the beach to spawn has been looked at in recent years. Anecdotally, some participants noted that in the past few years they have seen larger males come into the beaches without spawning for a period of time before the females showed up and spawning occurs. As previously discussed, it was mentioned that the duration between spawning waves and number of year classes coming into spawn has decreased over the years. Thus, ascertaining a relationship between size of Capelin and spawning time might be difficult to identify. However, it was recommended that this be investigated further.

A participant noted that since the 1990s there have been more observations of demersal spawning and suggested that more emphasis be placed on monitoring demersal spawning. It was discussed that although there have been more observations of off-beach spawning occurring over the years, it was still important to continue the long term monitoring of beaches for spawning activity because it is thought that beach spawning is better for egg development and larval survival compared to deep water spawning.

IDENTIFYING THE DRIVERS OF THE ABRUPT AND PERSISTENT DELAY IN CAPELIN SPAWNING TIMING FOLLOWING THE 1991 STOCK COLLAPSE

Presenter: H. Murphy

Abstract

Spawning timing in fish is generally cyclical in temperate regions in order to increase the probability of matching larval occurrence with ideal environmental conditions. The Capelin stock in NAFO Divisions 2J3KL collapsed in 1990–91 and has not recovered. This collapse was concomitant with collapses in groundfish stocks and cold oceanographic conditions. Using

citizen science data, newspaper archives, gray and primary literature, and monitoring data, a century of Capelin beach spawning times were compiled. Capelin beach spawning has been persistently 3 weeks later since the stock collapse. To identify the drivers of Capelin spawning timing, a step-wise multiple regression model was used with environmental and biological variables and a period term (pre-collapse and post-collapse). A decrease in mean length of the spawning population was the most important driver of delayed spawning. Decreases in the summer (June-August) NAO and NL climate indices were related to delayed spawning. Using a longer time series of spawning data and environmental variables (1951–2019), spawning was later when the NL climate index decreased. A repercussion of delayed Capelin spawning is the production of weak year-classes, suggesting that late spawning is severely inhibiting the recovery of the stock.

Discussion

A participant asked if there was any research into how the timing of phytoplankton blooms could impact other planktivores in the ecosystem. The example of Atlantic herring was brought up. It was discussed that the timing of the blooms could impact the dynamic between the food availability for Atlantic herring and Capelin as well as their predator-prey relationship. It was also noted that more information on how the timing of the blooms impacts Atlantic herring could be used as an indicator for Capelin, and vice versa. Data were lacking in the NL regions, and it was suggested that these dynamics be further investigated.

A participant questioned the use of the same level of variance for all the variables tested in the sensitivity analyses. Since a 10% change in one variable may not have the same magnitude of impact as a 10% change in another variable, it was suggested that the variance for each variable be normalized in such a way that their relative impacts were more comparable. It was discussed that although ultimately altering how the sensitivity analyses were done in this regard would not be expected to have any repercussions on the results presented, this was something that should be examined.

A participant asked how sea ice severity, which includes the duration and area of sea ice cover, impacted Capelin with respect to their overwintering activities. It was discussed that while there was some work done in the 1980s which had shown that Capelin feed further north in Div. 3K and 2J during the winter months, little was known about their activity during this time due to an inability to sample them in ice-covered conditions. Second, a participant asked whether a milder winter and low sea ice could lead to an earlier or more intense phytoplankton bloom which could benefit Capelin in 2021. It was discussed that although these conditions could lead to an earlier spawning time and more productive year for Capelin, these are not the only factors to consider, and it is still too early to predict with any degree of certainty how the spawning season might play out this year.

A participant asked if the lack of data for Div. 2J from the newspaper analysis in recent years was a result of no spawning occurring or a lack of observations. It was discussed that the lack of data for Div. 2J was likely a result of both and that there had been both a reduction of beach spawning in the region and a lack of media coverage of when spawning had occurred.

MONITORING SURVEY RESULTS AND BIOLOGICAL CHARACTERISTICS

Presenter: F. Mowbray

Abstract

No abstract provided.

Discussion

A participant asked why the spring acoustic survey happens before Capelin come inshore to spawn. It was discussed that when the timing of the survey was being decided the objective was to derive an estimate of the immature stock to project the spawning stock biomass the following year. Given the widespread distribution of where spawning occurs across NL it would be difficult to get an accurate estimate of the spawning stock biomass directly.

A participant asked if adding acoustics to the fall bottom trawl survey had been considered. It was discussed that acoustic data had been collected during the fall bottom trawl surveys since 2008, but there had been difficulties in analyzing the data in the past due to a lack of quality data and the inability to distinguish between species which have similar acoustic signals (e.g., Capelin vs. Arctic cod). However, it was noted that these limitations were currently being addressed with the addition of new personnel and ongoing research initiatives.

Data were presented on the ages of Capelin from the fishery by NAFO Division. A participant asked if these data could be broken down by bay, as based on their observations they would have expected to see differences in the age composition of the landings between each bay. This breakdown was not available for this meeting, but could be calculated and used to examine differences in the age composition of the catch by bay.

Data were presented on the locations of Capelin aggregations across years. A participant noted that the center of Capelin concentration seemed to move a lot year-to-year. Referencing one of the previous presentations on Capelin consumption, they asked if the lack of Capelin in the diets of Atlantic cod might have been a result of their distributions no longer overlapping. It was discussed that when the Capelin stock first collapsed there was research looking at site-specific ingestion of Capelin and the distribution of Capelin versus cod. However, little research has been done in this regard recently and it was agreed upon that this should be revisited.

There was confusion regarding data presented which indicated that the mean length-at-age had increased over time, while the mean length of Capelin had decreased over time. It was discussed that in the 1970s and 1980s the mean length of spawning Capelin was greater because the spawning stock was dominated by age-3 Capelin, whereas more recently the spawning stock has been dominated by age-2 Capelin. Thus, although the mean length-at-age increased, because the spawning stock has become increasingly dominated by age-2 Capelin and because age-2 Capelin are inherently smaller than age-3 Capelin, the mean length of spawning Capelin has decreased. Additionally, because Capelin have been maturing at an earlier age over time, and given the high rate of post-spawning mortality, there are less older, and thus larger, Capelin in the stock than there were historically, which in turn reduces the average length of Capelin in the spawning stock.

A participant noted that while they agreed that there has been an increased prevalence of age-2 spawners, a driver for this age structure change in the spawning stock has not yet been identified. It was asked whether such changes might be the result of a fisheries induced evolution due to the timing of the fishery and suggested that this be looked into as a research recommendation.

There was hesitancy with regards to how the signal between seasonal Capelin diet and condition should be interpreted. It was noted that between 2014 and 2015 a reduction in the frequency of occurrence of copepods was observed and followed by a shift in the dominance of larger copepods to smaller copepods in Capelin stomachs, and that this finding seemed to correlate well with a poor spring condition of Capelin. It was also noted that during this time the fall diets of Capelin contained more larger prey items such as euphausiids and hyperiids compared to copepods, which seemed to correlate with a good fall condition of Capelin. It was questioned whether good fall feeding conditions could make up for poor spring feeding conditions with regards to the overall condition of Capelin. It was noted that diet changes with size and was cautioned that what constitutes as good versus poor feeding conditions is subjective to the size of Capelin. Furthermore, because complementary data were lacking on the abundances and composition of prey species present during spring feeding no inferences could be made with regard to prey selectivity. It was noted that plankton samples have been taken simultaneously with spring feeding since 2004, but due limited human resources have not been analyzed. It was recommended that more research into the relationships between Capelin diet and condition with respect to their size and prey availability be undertaken.

DEMERSAL SPAWNING IN LABRADOR

Presenter: M. Geoffroy

Abstract

Demersal spawning of Capelin generally occurs after beach spawning, when sea surface temperatures (SST) reach >12˚C. Demersal spawning has rarely been reported in northern Labrador, where beach spawning events occur less frequently since the past decades. We surveyed Makkovik Bay in August 2018 to document the spawning behaviour of Capelin in northern Labrador (55˚N). No beach spawning was reported in the Bay in 2018, but using a hull-mounted multi-frequency echosounder and environmental DNA analyses, we detected 28 demersal schools of Capelin over 3 days (6–8 August) in bottom depths ranging from 6–22 m. Capelin eggs were sampled at one of the schooling sites, on a flat rock slab, confirming that at least some of these schools were spawning aggregations. Sea surface temperatures where demersal schools were detected varied from 8.18 to 14.2˚C, and bottom temperatures ranged from -0.7˚C to 4.9˚C. At the confirmed spawning location, SST was 11.9˚C and bottom temperature 2.4–4.9˚C. Density in the confirmed spawning school was >43 fish per m^3. The absence of beach spawning in Makkovik Bay in 2018, despite favourable conditions and the occurrence of demersal spawning, suggests that only documenting beach spawning events might result in false negatives when monitoring Capelin occurrence and spawning at high latitudes.

Discussion

What factors might lead to differences in spawning behaviour of Capelin in Labrador versus Newfoundland waters were discussed. Current data showed that trends in water temperature at beach versus demersal spawning sites seem to be comparable for Labrador and Newfoundland; however, it was suggested that pulses of cold water could impact spawning behaviour on a localized basis. It was noted that both regions have exhibited an overall shift in spawning time over the years from June to August. Currently, research is underway to determine whether or not there are genetically different populations of Capelin in Newfoundland versus Labrador, and thus different populations of Capelin with different adaptations to their environments.

The discussion surrounding observations of changes in Capelin spawning behaviour over time in Labrador focused on three main topics: beach versus demersal spawning, presumably untraditional types of spawning habitats, and northward expansion of Capelin.

It was discussed that in recent years there have been fewer observations of beach spawning and more attention has been paid towards demersal spawning. Speculations were made as to whether demersal spawning was a relatively new phenomenon or if due to decreased beach spawning we are now mostly only seeing demersal spawning. It was noted that although demersal spawning seemed to be more prevalent in the Makkovik Region, there was still beach spawning happening in Northern Labrador.

In recent years there have been observations in both Labrador and Nunavut of spawning activity in presumably untraditional spawning habitats such as flat slate rocks, bedrock, vertical cliffsides, and seaweed. It was speculated as to whether these spawning behaviours had been previously overlooked or if they were indeed a new phenomenon. It was suggested that these spawning behaviours might be a reflection of water conditions such as temperature and oxygen levels less often being suitable for spawning in traditionally-known habitats. Concerns were raised about the viability of spawn in such locations. It was raised that seaweed might serve as a good spawning environment, as attached eggs would be well oxygenated due to the movement of seaweed with wave action, and was highlighted as being an area of interest for future research.

It was discussed that the observations in recent years of increased demersal spawning, decreased beach spawning, and spawning in seemingly untraditional habitats could be the result of the northward expansion of Capelin due to climate change. It was suggested that if there was expansion, it would be less likely to happen along the Labrador Coast where cold water currents move south, and instead could occur up the Greenland Coast and into Baffin Bay where warm water currents come up from the south. However, it was noted that changes in the distribution and behaviour of similar forage fish species (e.g., sandlance, Arctic cod) and their interactions with Capelin should be considered as a research recommendation, as this information could provide valuable insights on the response of Capelin to climate change.

It was discussed that the diets of Northern cod in Div. 2J showed a notable amount of Capelin in stomachs up until the 1980s, whereas in recent years there was little presence of Capelin in the stomachs of their fish predators. It was noted that these findings coincide with observations from long-time residents of Northern and Southern Labrador who are no longer seeing Capelin in the stomachs of Arctic char and Northern cod, and instead are seeing more cannibalism.

A participant asked whether there was a current abundance estimate for Capelin in the area of Makkovik, Labrador. It was discussed that while the final estimate of abundance is not yet completed, preliminary calculations suggest that the area does not have a very high abundance of Capelin.

UPDATE ON CAPELIN FORECAST MODEL

Presenter: A. Adamack

Abstract

The Capelin forecast model was introduced at the 2018 Assessment of Capelin in 2J3KL and uses a Bayesian predictive modeling approach (Lewis et al. 2019). The objective of the forecast model is to predict the biomass index for the spring acoustic survey of the current year and provide a forecast of the biomass index for the following year. The data used in the forecast model included various combinations of the emergent larval abundance index and *Pseudocalanus* density from two years prior, the relative condition of age-1 and age-2 Capelin from the preceding fall, and the timing of sea ice retreat in the current year. The forecast model could not be updated in 2021 because the 2020 spring acoustic survey was cancelled due to the COVID-19 pandemic. To investigate how the forecast model performs when we are unable to refit the model, we used subsets of the existing data (e.g., limited the data used to fit the models to what would have been available for the respective assessment years) to fit the forecast model as of the 2018, 2019, and 2020 Capelin Assessments and used those models to generate forecasts of the Capelin biomass index to 2021. Those forecasts were compared

across assessment years and where possible to the observed biomass indices. We found that missing a few (1–3) spring acoustic surveys had a limited effect on model forecasts, but cautioned against going an extended amount of time without adding new data as ecological relationships can shift over time. Given the limited effect of a missed survey on model forecasts, we proceeded with running the forecast model for this assessment. The model was fit with data collected through to the completion of the 2019 spring acoustic survey and projected forward using available data collected through March 1, 2021 (e.g., the timing of sea ice retreat for 2021 was not fully known). The median biomass index forecast for 2021 is 233 kt (80% prediction interval 94 to 576 kt) while the partial forecast for 2022 is 145 kt (80% prediction interval 57 to 362 kt). The biomass index forecast for 2021 suggests that the probability that the biomass index will be approximately the same as the 2020 biomass index is 0.64 while the probability of a decrease is 0.03 and the probability of an increase is 0.33. We note that Capelin biomass index remains low compared to both their pre-collapse biomass and the more recent peak in the biomass index between 2012 and 2014. As the timing of sea ice retreat for 2021 was not fully known at the time the model was run, a sensitivity analysis was run to determine how the forecast would be affected if the timing of sea ice retreat occurred after March 1. Later timings of sea ice retreat were expected to result in increases in the forecast biomass index through March 15, before beginning to trend back towards the forecast biomass index through April 5.

Discussion

There was a short discussion surrounding how the different variables used in the Capelin forecast model would influence its projection.

A participant asked how this year's unusual sea ice conditions might have influenced the Capelin forecast model. It was noted that the model had performed well during sensitivity analyses of the sea ice data. Furthermore, it was also noted that the model performed well in the past during years of abnormal sea ice conditions (e.g., 2010). Ultimately, participants agreed that although there may be an increased uncertainty this year due to the unusual ice conditions, the model should be robust enough to project a reliable forecast. Following this conversation, a participant asked what data regarding sea ice were included in the forecast model. It was clarified that the model was fed a timing of sea ice retreat value, which was essentially the date of the region's most southerly extent of sea ice. It was questioned why factors such as sea ice density and thickness were not included in the model, as such conditions can vary greatly year-to-year. It was discussed these factors had been looked at in the past but the only variable with respect to sea ice which seemed to influence the forecast model was the day of ice retreat. However, it was noted that a more comprehensive inclusion of sea ice data in the forecast model would be worth looking into.

A participant asked if there was any insight into what variables observed in 2020 might be causing the model to project a small chance of an increase in the amount of Capelin available in 2021. It was discussed that the poor larval abundance would bring the projection down, while the early sea ice retreat, which might correlate to better feeding conditions for Capelin, would bring the projection up.

AN ECOSYSTEM PERSPECTIVE FOR CAPELIN: ECOSYSTEM CONTEXT, FUNCTIONAL CONNECTIONS WITH PREDATORS, AND PREDATION IMPACTS. PART III: ECOSYSTEM-LEVEL FOOD CONSUMPTION AND PREDATION ON CAPELIN

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

Presenter: M. Koen-Alonso

Abstract

Ecosystem-level consumption of the total fish community was estimated using an array of allometric models and daily ration calculations. This approach rendered an order of magnitude envelope for food consumption by the entire fish community. These estimations, along with information on diet composition, were then used to estimate the envelope of annual predation on Capelin. Total food availability has recently declined after being relatively stable between 2011 and 2015. Consumption on Capelin showed an increasing trend since the mid-late 2000s until 2015 and has decreased since, while consumption of shrimp peaked in 2011. Consumption of Capelin has been generally larger than consumption of shrimp since 2013. Predation mortality on Capelin peaked in 2010, and declined afterwards despite the increasing consumption in between 2010 and 2015. Predation mortality and consumption declined between 2017 and 2019, but 2020 showed an increase. Estimates of predation mortality in 2020 need to be taken with caution because they rely on the forecasted Capelin level given the absence of the 2020 spring acoustic survey. Fishing impacts on Capelin relative to predation were estimated to be around 10–20% of predation between 1996 and 2008 period, declined to roughly 2% by 2015, then increased until 2019 where it peaked at roughly 15%. The estimated level for 2020 declined to roughly 6%. This decline would imply a lessening of the conditions where fishing could influence stock status, but given the uncertainty around current Capelin level, caution is warranted.

Overall, results indicated that the order of magnitude of the estimated Capelin consumption and availability were fairly consistent, indicating that the Div. 3L acoustic survey effectively measured a sizable fraction of the 2J3KL Capelin biomass. Fishing represented a comparatively small component of Capelin use relative to use within the ecosystem. However, when Capelin biomass was low, the potential impact of fishing on the stock was augmented.

Discussion

There was a discussion surrounding removals of Capelin by predation versus the fishery, Capelin predation by harp seals, and Capelin availability versus ecosystem demand.

A participant questioned the usefulness of comparing the relative nominal impact of removals via the fishery versus removals via predation on the stock. Comparing removal sources using nominal values does not explicitly take into account the loss of Capelin production, which is a consequence of a spawning-targeted fishery. It was discussed that in the absence of a model to look at the direct impact of fishing on the Capelin stock, this comparison was made to give an approximation of the overall biomass being removed by the fishery relative to the biomass being removed by predators. Since Capelin is a forage species it is expected that removals from the stock will be much greater from predators than they are from the fishery. Additionally, it was discussed that further inferences could be made using nominal catch data in conjunction with biological data from the fishery which could help provide insight into the loss of Capelin productivity as a result of the fishery.

The population of harp seals in the Northwest Atlantic increased by a third since the 1990s (DFO 2020). With this in mind, a participant questioned data presented which did not show a similar increase in the impact of predation by harp seals on Capelin during this time. It was explained that the amount of food a harp seal eats is proportional to its body weight. On an individual level, a harp seal consumes more Capelin by weight than a fish would. However, on a relative scale, the biomass of harp seals has not increased enough to overshadow the biomass of Capelin consumed by fish, which is several orders of magnitude higher. A participant then questioned the lack of current harp seal diet composition data. It was discussed that although the diet composition of harp seals may have changed over the years, since the signals of available Capelin biomass and consumption by predators tracked well, it was not anticipated that there has been a significant change in harp seal diets which could be detrimental to the Capelin stock.

Participants questioned what should be inferred from a graph which showed integrated Capelin availability to shift from being above ecosystem demand (i.e., predation) in 2019 to below ecosystem demand in 2020. In particular participants questioned what these results meant with regard to the growth potential for predator stocks. It was stated that these results suggested that Capelin were potentially being “fully utilized” by the ecosystem, which could generally be expected for a forage species. It was noted that an estimate of stock productivity was derived from literature values and the integrated Capelin availability presented here was calculated from the acoustic biomass index, which was derived from the spring acoustic survey. How the acoustic index translates to total biomass (i.e., catchability) remains unclear. Participants noted that since the biomass portion of this availability estimate did not contain any correction for catchability it underestimates the biomass available to predators. As a consequence of these discussions, while the usefulness of this graph to provide insight with respect to Capelin availability and consumption was agreed upon, there was a lack of plenary agreement around the concept of the Capelin stock being fully utilized in the ecosystem due to data coarseness. A participant also noted that the concept of Capelin being fully utilized by the ecosystem and ecosystem demand being fulfilled were not equivalent. Further concerns were raised when this integrated availability index was contrasted with the estimate of total ecosystem demand (predation), with particular emphasis on how this should be interpreted for years such as 2020 when ecosystem demand exceed Capelin availability. It was then suggested that the relationship between Capelin predation and predator condition be looked at and taken into consideration when determining Capelin availability, as low availability and consumption of Capelin would likely lead to poorer predator condition.

RESEARCH RECOMMENDATIONS

- Investigate kelp as a potential spawning environment for Capelin.
- Analyze data with respect to site specific predation of Capelin - i.e., distribution of Capelin versus distribution of predator species (e.g., Atlantic cod).
- Look into potential correlations between changes in Capelin diet with respect to size and age.
- Expand current research on phytoplankton blooms with respect to characteristics such as species composition, size, etc. and their potential influence on Capelin growth, condition, and abundance.
- Look further into and analyze data with respect to the timing and location of phytoplankton blooms versus planktivore (i.e., Capelin) activity.
- Quantitatively analyze the relationship between fish length and the timing of when they show up to beach to spawn.
- Investigate decaying eggs at demersal spawning sites through enhanced monitoring of environmental conditions (e.g., dissolved oxygen, water temperature).
- Investigate how pelagic predators operate in inshore waters (current research focused on offshore; pelagic species in NL Region relatively inshore).
- Further investigate historical records for qualitative data on deep water spawning activities.

- Look at interactions between other forage fish species (e.g., sand lance) as potential proxy for Capelin response to climate change.
- Expand on the use of sea ice in the capelin forecast model (i.e., not just day of ice-retreat, but thickness, etc.).
- Expand current research on predator (e.g., Atlantic cod) condition as an indicator of Capelin availability.
- Determine the capture rate of age-1 Capelin during DFO multispecies bottom trawl surveys.
- Further investigate potential drivers for age structure changes in the spawning stock.
- Implement a fall Capelin acoustic survey.
- Look into the logistics of a collaboration between DFO and 2J3KL Capelin harvesters for the acquisition of acoustics data.

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Lewis, K.P., Buren, A.D., Regular, P.M., Mowbray, F.K., and Murphy, H.M. 2019. Forecasting capelin *Mallotus villosus* biomass on the Newfoundland shelf. Mar. Ecol. Prog. Ser. 616: 171–183.

APPENDIX I: TERMS OF REFRENCE

Assessment of Divisions 2J+3KL Capelin

Regional Advisory Meeting - Newfoundland and Labrador Region

March 9-12, 2021
St. John's NL

Chairperson: Laura Wheeland

Context

Divisions 2J+3KL Capelin was last assessed in 2020 (DFO 2021).

The current assessment is requested by Fisheries Management to inform the development of management measures for the stock for the upcoming fishing season.

Objectives

Provide advice on the sustainability of the stock. The following items will be reviewed:

- Consider ecosystem status where the assessed stock occur based on an overview including relevant summaries of oceanographic conditions, biological community structure and trends, and pertinent knowledge of ecological interactions (e.g., predator, prey) and stressors (e.g., anthropogenic impacts).
- Review information on historical catches up to and including the 2020 fishery.
- Assess the relative status of abundance, recruitment and biomass, and update indices of biological/behavioural characteristics of the stock.
- Review impact of single year data loss on spring acoustic survey biomass forecast model and provide model estimate for 2021.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Participation

- Fisheries and Oceans Canada (DFO) Science and Fisheries Management
- Newfoundland and Labrador Department of Fisheries, Forestry and Agriculture
- Nunatsiavut Government
- Indigenous groups
- Fishing Industry
- Academia
- Non-governmental organizations

References

DFO. 2021. Assessment of 2J3KL Capelin in 2019[1]. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2021/045. (Erratum: November 2021)

APPENDIX II: AGENDA

CSAS Regional Peer Review Process:

Assessment of 2J+3KL Capelin

Chair: Laura Wheeland

March 9-12, 2021

Tuesday, March 9, 2021

Time	Topic	Presenter
10:00	Opening remarks, Terms of Reference, and agenda	Chair
-	Presentation: An ecosystem approach to fisheries management at DFO	M. Koen Alonso
-	Presentation: Ocean climate in Newfoundland and Labrador waters	F. Cyr
-	Presentation: Overview of the chemical and biological oceanographic conditions on the NL Shelf	D. Belanger
-	Presentation: An ecosystem perspective for Capelin: Ecosystem context, functional connections with predators, and predation impacts. Part I: Ecosystem context	M. Koen-Alonso
-	Presentation: An ecosystem perspective for Capelin: Ecosystem context, functional connections with predators, and predation impacts. Part II: Functional connections with predators	M. Koen-Alonso
-	Presentation: Seabird population trends and diet	W. Montevecchi
-	Presentation: Fishery • Landings • Biological data (catch)	F. Mowbray

Wednesday, March 10, 2021

Time	Topic	Presenter
10:00	Presentation: Capelin emergent larval index	H. Murphy
-	Presentation: Atlantic herring predation on Capelin eggs and larvae	H. Murphy
-	Presentation: Citizen science: beach spawning diaries	H. Murphy

Time	Topic	Presenter
-	Presentation: Identifying the drivers of the abrupt and persistent delay in Capelin spawning timing following the 1991 stock collapse	H. Murphy
-	Presentation: Monitoring survey results and biological characteristics	F. Mowbray
-	Presentation: Demersal spawning in Labrador	M. Geoffroy
-	Presentation: Update on Capelin forecast model	A. Adamack
-	Presentation: An ecosystem perspective for Capelin: Ecosystem context, functional connections with predators, and predation impacts. Part III: Ecosystem-level food consumption and predation on capelin	M. Koen-Alonso
-	Reviewer Reports	B. Bárðarson and G. Davorean

Thursday, March 11, 2021

Time	Topic	Presenter
10:00	Summary and Conclusions	Chair
-	Presentation: Next Steps - LRP development	K. Lewis
-	Drafting of Science Advisory Report (SAR) Summary Bullets	ALL
-	Drafting of Research Recommendations	ALL
-	Upgrading of working paper to Research Document and next steps	E. Parrill
-	Adjourn	

APPENDIX III: LIST OF MEETING PARTICIPANTS

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Erika Parrill	DFO-NL – Centre for Science Advice
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Erin Dunne	DFO-NL – Resource Management
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Brandi O’Keefe	DFO-NL – Science
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David Bélanger	DFO-NL – Science
Fran Mowbray	DFO-NL – Science
Frédéric Cyr	DFO-NL – Science
Hannah Munro	DFO-NL – Science
Hannah Murphy	DFO-NL – Science
Hannah Polaczek	DFO-NL – Science
Karen Cogliati	DFO-NCR – Science
Karen Dwyer	DFO-NL – Science
Keith Lewis	DFO-NL – Science
Marc Legresley	DFO-NL – Science
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Eldred Woodford	Fish, Food and Allied Workers Union
Erin Carruthers	Fish, Food and Allied Workers Union
Robbie Green	Fish, Food and Allied Workers Union
Steven Miller	Fish, Food and Allied Workers Union
Colin Webb	Nunatsiavut Government
Bill Montevecchi	Memorial University
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Abe Solberg	Memorial University - Marine Institute
Chelsea Boaler	Memorial University - Marine Institute
Jin Gao	Memorial University - Marine Institute
Matthew Robertson	Memorial University - Marine Institute
Maxime Geoffroy	Memorial University - Marine Institute
Raquel Ruiz-Diaz	Memorial University - Marine Institute
Tyler Eddy	Memorial University - Marine Institute
Ashley Tripp	University of Manitoba
Gail Davoren	University of Manitoba
Scott Morrison	University of Manitoba
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Reba McIver	Oceana
Victoria Neville	World Wildlife Fund Canada