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Proceedings of the Zonal Advisory Meeting on the Assessment of Northern Shrimp in Shrimp Fishing Areas (SFAs) 4-6, Eastern and Western Assessment Zones (EAZ & WAZ) and of Striped Shrimp in SFA 4, EAZ & WAZ

Meeting dates: February 22-26, 2021
Location: Virtual Meeting

Chairperson: Darrell Mullowney
Editor: Kyle Lefort

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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 Zonal Peer Review for the Assessment of Northern Shrimp (*Pandalus borealis*) in Shrimp Fishing Areas (SFAs) 4-6, Eastern Assessment Zone (EAZ), and Western Assessment Zone (WAZ), and of Striped Shrimp (*Pandalus montagui*) in SFA 4, EAZ, and WAZ was held February 22-26, 2021 via Microsoft Teams. Fisheries and Oceans Canada (DFO) Resource Management requested this assessment as the basis for harvest advice for the 2021/22 fishing season. DFO Resource Management also requested that DFO Science establish a Limit Reference Point (LRP) consistent with the Precautionary Approach (PA) framework for Striped Shrimp in SFA 4. The meeting was attended by participants from DFO Science, DFO Resource Management, industry, indigenous groups, Government and academia. This Proceedings Document contains presentation abstracts, a summary of the discussion among meeting participants, research recommendations and uncertainties. The meeting's Terms of Reference, agenda, and a list of participants are appended. In addition to this Proceedings Document, two Science Advisory Reports (SARs) and two Research Documents will be published and made available 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 United States).

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 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 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 Newfoundland and Labrador (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 [PA] 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 emphasized the importance of including industry partners in stock assessments; other participants agreed. A participant asked when the case studies' findings will be incorporated into stock assessments. The presenter clarified that we should not think of this approach as having a start and end; the management of the fishery is an ongoing process. A participant asked how the case study stocks were selected. The presenter clarified that case studies were selected based on the stocks' relevance to their respective Regions, while also considering what data were already available. A participant asked if there will be opportunities for collaboration with the Ontario and Prairie Region Science sector staff (formally Central and Arctic Region), particularly as it relates to the management of Northern Shrimp whose distribution spans both Regions. The presenter noted that this approach can accommodate collaboration among Regions. The presenter emphasized that the focus will remain on the stocks, but by adopting this approach we will integrate more-detailed information on the ecosystem's status into stock assessments.

OCEAN CLIMATE IN NEWFOUNDLAND AND LABRADOR WATERS

Presenter: F. Cyr

Abstract

An overview of physical oceanographic conditions in the Newfoundland and Labrador Region during 2020 is presented; for the purposes of these analyses, normal is defined as the 1981–2010 average. The winter North Atlantic Oscillation (NAO) index, a key indicator of the direction and intensity of the winter wind field patterns over the Northwest Atlantic was positive for a 7th consecutive year (since 2012, only 2013 was negative). While this positive NAO phase led to colder than normal conditions for a short period (2014–17), most ocean parameters are now back to above normal. In 2020, sea-surface temperature (SST) were above normal and sea-ice below normal for the first time since 2014 and 2013, respectively. Observations from the summer Atlantic Zone Monitoring Program (AZMP) oceanographic survey indicate that the volume of the cold intermediate layer (CIL, <0°C) was below normal in the 2018–20 period. Bottom temperatures were warmer than normal in SFA 4-6 during 2020, but slightly below normal in the EAZ and WAZ.

Discussion

A participant asked at what resolution anomalies were calculated. The presenter clarified that anomalies are calculated at the pixel level and that the values presented here are the means across all pixels for each Region. A participant questioned the NAO's performance as an environmental index. The participant also asked if one years oceanographic conditions influence the next. The presenter clarified that the effects are cumulative (e.g., consecutive cold winters allow cold water to accumulate). Furthermore, the presenter noted that this is true even when a single warm winter is staggered between several cold winters, for example. A participant asked

the presenter to discuss longer-term trends in oceanographic conditions. The presenter speculated that cold winters will become less common. This lack of consecutive cold winters will prevent large volumes of cold water from amassing. The participant noted that this is unfavorable for shrimp. The presenter agreed but noted that temperatures were historically much warmer (e.g., the 1960s). A participant emphasized the importance of understanding the movement of water masses, particularly in the context of shrimp management, and asked what information exists on the topic in the study area. The presenter cited Le Corre et al. (2021) which details shifts in the distribution of Northern Shrimp in response to climate change (including changing ocean currents). The presenter noted inter-annual variation in the Labrador and the coastal Labrador currents but indicated that there are aspects of these currents that are not well understood and subsequently the impacts on Northern Shrimp have not been quantified.

OVERVIEW OF THE CHEMICAL AND BIOLOGICAL OCEANOGRAPHIC CONDITIONS ON THE NEWFOUNDLAND AND LABRADOR SHELF

Presenter: D. Belanger

Abstract

Biogeochemical oceanographic conditions on the Newfoundland and Labrador Shelf are presented and interpreted against mean conditions observed in the Region since the onset of the AZMP in 1999. For the purposes of these analyses, normal is defined as either the average from 2003–20 (ocean colour satellite data) or 1999–2020 (AZMP seasonal surveys). Satellite ocean colour data indicated near-normal timing and duration and productivity of the spring phytoplankton blooms in recent years after a period of late, short and low-production blooms in the mid-2010s. Integrated inventories from specific depth ranges sampled during AZMP seasonal surveys showed an increase in nitrate (50–150 m depth) and chlorophyll (0–100 m depth) concentrations since 2015 and 2016, respectively, after several years of below-normal levels in the early-2010s. Zooplankton abundance and biomass also showed overall increasing trends since ~2010 and have remained mostly above normal since 2015. Changes in the zooplankton community structure since ~2010 resulted in fewer large, energy-rich calanoids (*Calanus spp*.), and more small copepods (*Pseudocalanus spp., T. longicornis, Oithona spp*.) and other non-copepod groups including appendicularians and pteropods. Additionally, a change in zooplankton seasonality characterized by a weaker spring and stronger summer and fall signals was observed since 2016.

Discussion

A participant asked why seemingly normal chlorophyll levels (i.e., within the normal range) in recent years are resulting in more-productive blooms. The presenter explained that while these blooms are more productive than those in the early-2010s, they are within the normal range. The presenter also noted two potential sources of error: ship-based measurements do not occur at the same time every year and satellite-derived measurements describe only the ocean's surface. A participant asked why nitrate levels fluctuate on the Newfoundland shelf. The presenter suggested that these fluctuations are a function of different water masses flowing over the shelf. For example, the presenter suggested that recent increases in nitrates were caused by greater volumes of nutrient-rich Arctic water. A participant noted data-poor regions, particularly along the northern Labrador coast. The presenter explained that these are ice-covered regions where satellite-derived data could not be obtained. A participant asked if seismic activity had occurred in the same area as data collection. The presenter referred to McCauley et al. (2017) and explained that this question is in response to an article that shows

that seismic activity kills zooplankton. The presenter explained that in McCauley et al. (2017), the effects were limited to within ~1 km of the seismic source; thus, this would not disturb our surveys as there are no vessels within this range. The presenter also noted that the study's methods have been questioned and that there are plans to repeat the experiment. A participant noted that areas where seismic activity has occurred are avoided during the multi-species surveys. A participant asked if copepod community composition is correlated with temperature. The presenter explained that there are no clear correlations with temperature; however, the presenter suggested that earlier and more-productive blooms may disproportionately favor the more-competitive larger-bodied calanoid copepods. One participant emphasized that studying how bloom timing influences shrimp recruitment is a priority. A participant asked how the sinking rates of fecal pellets compare to the sinking rates of the copepods. The presenter clarified that the take-away message is that fecal pellets are often overlooked, yet they are a mechanism by which organic material can be concentrated on the seafloor. A participant asked what proportion of primary productivity sinks to the bottom, noting that biomass from the ocean's surface only benefits those living on the seafloor if it sinks to the bottom. The participant suggested sediment traps as a means of answering this question. The presenter agreed but noted that there are no sediment traps installed on moorings at present. In the context of the availability of prey, participants discussed shrimp diet, noting that information on the topic is scarce. A participant asked if shrimp consume cod eggs or larvae. Another participant speculated that shrimp will eat whatever is available (and while shrimp may not specifically target cod eggs or larvae, they will eat them). Shrimp's preferred prey; however, remains unknown. Another participant referred to Pedersen and Storm (2002), noting that larval *P. borealis* and *P. montagui* are omnivorous. Others mentioned unpublished data that may elucidate shrimp's diet. A participant suggested that survey timing be considered in the analyses, noting that in the Gulf of St Lawrence survey timing influenced results. A participant asked if within-transect variation in indices is considered. The presenter explained that the purpose of this presentation is to show indices representative of the area as a whole; thus, within-transect variation is not considered. A participant emphasized that increasing survey effort in northern areas, an area for which we have limited data, is a priority. The presenter agreed but noted that unfortunately, the AZMP does not have the capacity to expand into the Arctic. The presenter suggested tasking harvesters with data collection in northern regions as one means of resolving this data deficiency.

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

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

Presenter: M. Koen-Alonso

Abstract

The ecosystem structure of the Newfoundland and Labrador (NL) bioregion can be divided into four Ecosystem Production Units (EPUs): the Labrador Shelf (NAFO Div. 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 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 [*Chionoecetes opilio*]). The

analysis of FPP indicated that benthivore guild catches, where shrimp is included, were consistently above the TCI in 2J3K, but mostly below it in 3LNO since the mid-1990s. However, benthivore guild catches have dropped below the TCI since 2015 in both EPUs. Piscivore guild total catches have been above the TCI in 3LNO in the 1996–2004 period, and since 2015. Catches of suspension feeding benthos in the 3LNO EPU have also been above the TCI in recent years. These results indicate that during the 1995–2020 period these ecosystems experienced fishing levels that 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 (*Mallotus villosus)*, and the beginning of a decline in shellfish. The finfish biomass in the 2010s was relatively stable until 2014–15, when it started to show signals of decline. This signal appeared earlier in 3LNO, and later in 2J3K. While some improvement is becoming apparent since the lows in 2016–17, current total biomass has not yet returned to the 2010–15 level. From a shellfish perspective, improvements are being observed in Snow Crab, but shrimp reached the lowest biomass in the time series (starting in 1995) in 2019 with only nominal increase in 2020. 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.

The time series for the Research Vessel (RV) survey in 2H is incomplete and the signal is not entirely consistent, but it seems clear that the overall biomass has decreased in 2015–20. This overall decrease has been driven by declines in plank-piscivores (i.e., Redfish [*Sebastes fasciatus*]) and shellfish (i.e., shrimp), but other functional groups also show declines, including large and medium benthivores. The 2020 survey suggests a potential reversal of this trend, but it is too early to advance any conclusion. Shellfish still remain more dominant in 2H than 2J3KL within the fish community, but there are signals of change. The dominance of shellfish has decreased since 2017. This change in community structure appears similar to those observed in 2J3KL in the late-2000s and early-2010s but the pace of change appears to be more gradual. The planktivore signal shows very low biomass levels since 2015 and is dominated by oceanic species like lanternfishes (*myctophids*) and Black Herring (*Bathytroctes* sp.), hinting at potential pelagic connections between the shelf and the nearby Labrador Sea ecosystem. Within the context of a rather noisy time series, shrimp clearly shows lower levels in 2018–20 in comparison with previous years.

Capelin and shrimp are important prey items for Atlantic Cod (*Gadus morhua)*, Turbot (*Scophthalmus maximus*), American Plaice (*Hippoglossoides platessoides)*, 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 (*Boreogadus saida)* and Redfish are becoming more important prey items. 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 NL ecosystems continue to experience low overall productivity conditions, even though these conditions may benefit shellfish stocks.

From a predation and impacts perspective, total food consumption by predators (medium and large benthivores, piscivores, and plank-piscivores fish functional groups) in 2J3KL was estimated based on food requirements. If food availability is limited, actual consumption would be expected to be lower than the calculated estimates. Results indicate that total food consumption by predators was stable between 2011–15 but has declined somewhat since. Consumption of shrimp by these predators increased until 2011 in 2J3KL and 2013 in 2H, and while generally decreased afterwards, some recent years have seen small increases in shrimp consumption in 2018 and 2019, but low levels in 2020. In 2J3KL, predation mortality increased between 2008 and 2011, decreased afterwards, but increased again in 2018 and 2019, with some of the highest levels of predation mortality since the start of the time series in 1995. This was the result of modest increases in consumption paired with clear declines in shrimp biomass. The 2020 predation mortality has declined to levels comparable to 2008. Predation mortality in 2H has been highly variable, but consistently lower than the levels estimated for 2J3KL. The potential relative impact of fishing with respect to predation has been variable in the 1995–2019 period, with a median value around 20%, a peak around 40% in 2002–04, and recent values around 5 to 10%. The gap between the estimated shrimp availability and shrimp utilization in the ecosystem (i.e., predation and fishing) in 2020 hints that under current conditions further shrimp declines may be less likely. While this is a positive signal for shrimp, it is critical not to over interpret this observation.

In terms of shrimp productivity in 2J3KL, shrimp per capita net production has declined since the mid-1990s. Consistent with previous results, fishing has detectable indirect impacts on shrimp net production with lags of two to four years, predation has impacts with lags of one to three, and climate conditions have impacts with a lag of three years. Results also indicated that the fishing level in 2GH was correlated with shrimp net production in 2J3KL. Based on the current results, and the observed trends in the identified drivers, shrimp per capita net production would be expected to remain around current values or slightly improve in the coming one to three years.

The historical build-up of shrimp was driven by a combination of favorable environmental conditions and reduced predation. Shrimp is an important forage species, and the trend in predation mortality in the near future is highly associated with the availability of alternative prey like Capelin. Current predation mortality on shrimp in 2J3KL has declined to a level comparable to 2008. Under current ecosystem conditions (i.e., low shrimp biomass, high predation pressure), fishing is unlikely to be a dominant driver for shrimp in 2J3KL, but it could now be more influential on stock declines than it was in the past. Considering the decline in predation pressure, the current levels of fishing utilization, and the somewhat positive outlook for the shrimp per capita net production in 2J3KL suggest that shrimp could remain stable or show some signs of improvement in the coming years.

Discussion

A participant asked for an example of an “indirect effect of fishing”. The presenter clarified that the removal of egg-bearing females, for example, is an indirect effect of fishing. A participant asked if the model was derived from the presenter's data or published sources. The presenter clarified that the model was derived from published sources. The presenter also noted that with minor modifications, the model could represent any marine ecosystem. A participant asked where Markov Chain Monte Carlo simulations were implemented. The presenter clarified that Markov Chain Monte Carlo simulations were implemented in computing the transfer efficiency among model nodes. A participant questioned the model’s exploitation rate, noting that 20% is not specific to this system or a single species. The presenter clarified that 20% is an average across many ecosystem-level studies. The presenter emphasized that this is a broad-scale

analysis to complement what we already know about shrimp. Participants discussed the relationship between the TCI and a functional group's biomass growth rate. The presenter noted that when the TCI is high, growth rates are generally negative, while when the TCI is low, growth rates vary considerably. A participant asked how estimated integrated availability was calculated. The presenter explained that estimated integrated availability is the sum of the standing stock biomass and the product of standing stock biomass and the production/biomass ratio. The standing stock biomass is the total biomass in the system and the product of standing stock biomass, and the production/biomass ratio is the biomass that the standing stock will produce. A participant noted that most of this data is collected during the fall survey and that seasonality in predator diet could bias predation estimates. The presenter agreed but noted that on the Grand Banks, where surveys occur during both the spring and fall, predator diet remains similar across seasons. A participant noted that Arctic Cod consume shrimp in 4VN, yet they are not included in this analysis. The presenter agreed that Arctic Cod is a predator of shrimp but indicated that the program cannot sample additional predators. A participant noted positive anomalies in the shellfish functional group's biomass/abundance ratio between 2017 and 2020. The presenter indicated that the biomass/abundance ratio is a proxy for an individual's size. In this case, positive anomalies are an artifact of the functional group's dominant organism shifting from shrimp (small-bodied) to crab (large-bodied). A participant asked how harp seals' (*Pagophilus groenlandicus*) estimated consumption was calculated. The presenter clarified that the estimate is based on the most recent abundance estimate, the population's age-class structure, an individual's age-specific energetic requirements, and the population's diet. A participant suggested accounting for the consumptive effects of whales and seabirds in the model. The presenter agreed but noted that in the case of whales, we do not have consistent estimates of abundance from which an energetics model could be derived. However, coarse estimates suggest whales consume 2 Mt/year. In the case of seabirds, we must consider that colony-nesting seabirds forage near the colony; thus, their effect is limited by their range. Furthermore, many seabirds overwinter elsewhere, introducing a spatiotemporal component to their consumptive effects. These factors make including whales and seabirds a challenge.

PREDATION RESULTS FROM THE NSRF SURVEY

Presenter: W. Walkusz

Abstract

The stomach contents of American Plaice, Atlantic Cod, Greenland Halibut (*Reinhardtius hippoglossoides*), Redfish (*Sebastes sp*.), Roughhead Grenadier (*Macrourus berglax*), and skates (*Rajidae*) sampled during the 2018 and 2019 Northern Shrimp Research Foundation (NSRF) and DFO summer shrimp survey in the EAZ, WAZ, and SFA 4 were analyzed. This work was done to help determine the potential predation pressure of these predators on the Regions' populations of Northern Shrimp and Striped Shrimp in the context of stock assessment for the commercial Northern Shrimp fishery. A total of 1,014 and 1,039 stomachs were dissected in 2018 and 2019, respectively. Shrimp were found to be important diet items in Atlantic Cod, Greenland Halibut and Roughhead Grenadiers; however, shrimp were found in all fish species analyzed.

Discussion

A participant asked why some stomach contents were only identified to the genus level. The presenter indicated that species-level identification is not always possible for stomach contents. A participant asked if the trawl was equipped with a bycatch-limiting grate. The presenter indicated that to allow for a detailed analysis of predators, no bycatch-limiting grate was used. A

participant emphasized that these findings represent diet at a single point in time and questioned whether longer-term diet proxies, such as stable isotope or fatty acid analyses, would corroborate these findings. The presenter agreed that such proxies should be explored, noting that Greenland Halibut often consume shrimp in the trawl, skewing our perception of their natural diet. A participant noted that no shrimp were documented in Redfish stomachs in 2018. The presenter reiterated that this was unexpected but suggested that shrimp-consuming Redfish may have had their stomachs inverted upon capture (and their stomach contents lost). Another participant noted that there was a high proportion of unidentified crustaceans in Redfish stomachs in 2018. A participant asked what would be required to complete a north-south comparison of predator diet. The presenter suggested simultaneously occurring surveys in each area but recognized that this would be a costly endeavor. A participant asked if this study will continue. The presenter indicated that at-sea sampling did not occur in 2020. However, whole fish were collected and are being processed for stomach contents and stable isotope analysis. A participant asked if Arctic Cod were caught as bycatch. The presenter indicated that Arctic Cod were caught, but that their diets were not considered in this study. A participant asked if certain predators targeted larger shrimp. The presenter indicated that this would be a challenging question to answer due to varying degrees of prey digestion. A participant suggested that there may be food limitation (i.e., predators competing for shrimp) in some southern areas and asked if there was evidence for this in the north. The presenter indicated that there is no evidence of food limitation in the north.

ECOLOGY OF STRIPED SHRIMP IN SFA 4, EAZ AND WAZ

K. Baker and K. Skanes

Presenter: K. Baker

Abstract

Data collected in SFA 4, EAZ, and WAZ from 2005–20 during the Northern Shrimp Research Foundation survey were used to investigate trends in Striped Shrimp sizes, stages of maturity, sex ratio, size at transition, and prevalence of parasites and pathogens. We also investigated ecological drivers of the presence of parasites and size of transition. We found Striped Shrimp were substantially larger than previously known, and although the size of transition varied with time, it was a function of both large-scale and local processes (e.g., average size of females and the amount of preferred habitat in the previous year over the entire study area). The probabilities of Striped Shrimp being observed with black gill, black shell, a bopyrid isopod parasite, or microsporidia were generally related to sex, depth, temperature, salinity, latitude, and density. The large sizes observed in the study area and the plasticity of the population to environmental changes indicate that this species should be closely monitored in the future in relation to exploitation pressure and climate change.

Discussion

A participant asked if the model's period coefficient was categorical or continuous. The presenter clarified that the variable is categorical. A participant emphasized that studying how long an individual remains in the male phase before transitioning into a female, and how this is influenced by warming waters, is a priority. A participant asked for clarification on how night catches were corrected. The presenter explained that male night catches were corrected by a factor of 1.52 (male catch was 1.52x greater during the day). The presenter clarified that this correction was applied only to Striped Shrimp. A participant noted that the proportion of the male population that complete this nocturnal vertical migration is unknown. A participant asked if fishing only during the day was an option. The presenter explained that the vessel must fish

non-stop to complete the survey; thus, fishing only during the day is not an option. Participants discussed combining data from the three assessment zones for analyses and whether this would change our perspective. The presenter indicated that any analysis would be limited to the six years for which we have data from each of the three zones. A participant noted that most view SFA 4, WAZ, and EAZ as a single stock. Others agreed but clarified that these zones are management units and that there is no reason shrimp cannot move among them. However, the presenter emphasized that differences in size-at-transition observed among zones are noteworthy. A participant emphasized that studying microsporidium is a priority. A participant asked if *Dichelopandalus leptocerus* were caught in northern areas. A participant indicated that *D. leptocerus* are occasionally caught in 3Ps and 3LNO in water <300 m but are not observed further north. The participant also noted that many of the specimens have black gill.

LIMIT REFERENCE POINT AND ASSESSMENT OF STRIPED SHRIMP IN SFA 4

K. Skanes, K. Baker, D. Sullivan, S. Zabihi Seissan, and E. Coughlan

Presenter: K. Skanes

Abstract

A limit reference point is required for SFA 4 Striped Shrimp under DFO Decision-Making Framework, incorporating the PA. Development of a limit reference point also supports legal requirements under the *Fisheries Act* to promote sustainability, by preventing stocks from reaching limit reference points, for stocks prescribed in regulation.

To develop a limit reference point, survey trawl data was examined over the relatively short survey time series (2005–20). The trends of available indices (shrimp biomass, predator catch, predator biomass, and habitat indices based on bottom temperature and salinity) were considered when deriving a reference point for this resource.

In order to protect current and upcoming spawning stock, and to avoid potential harm, a limit reference point was based on the fishable biomass index of the SFA 4 Striped Shrimp stock. The limit reference point was established at 13,900 t of fishable biomass and represents the lowest estimate of fishable biomass from which the fishable biomass was able to recover to above the time-series average three years later.

A combination of survey and commercial data was considered in the assessment of the SFA 4 Striped Shrimp stock; however, interpretation of commercial data for Striped Shrimp is complicated due the nature of some commercial catch being directed, while some is bycatch; the proportion of directed to bycatch catch varies annually. The stock status of Striped Shrimp in SFA 4 is not concerning. The by-catch limit of 4,033 t has not been taken in the past eight years, with the commercial catch ranging between 1,113 t and 3,035 t. Over 2005 to 2020 the fishable biomass index averaged 28,800 t. It was 25,500 t in 2020, a 35% decrease from 2019. Over 2005 to 2020 the female biomass index averaged 22,100 t. It was 18,700 t in 2020, a 43% decrease from 2019. The exploitation rate index was 9.7% in 2020/21. If the by-catch limit had been taken, the exploitation rate index would have been 15.8% in 2020/21.

Discussion

A participant asked if shifts in Striped Shrimp's distribution have been documented. The presenter indicated that there is no evidence of distributional shifts. A participant asked why different methods to estimate biomass are used in adjacent areas. The presenter indicated that different methods are accepted for use in fisheries biomass estimations but that a detailed comparison between the two methods is necessary. A participant asked if model-estimated

bottom temperatures were ground-truthed. The presenter indicated that yes, and that the model performed well. The participant recommended that the model be ground-truthed in an area where it is being applied. Some participants questioned the rationale for using the $B_{Recovery}$ method to establish the LRP, while others agreed it was appropriate. Participants noted that in the $B_{Recovery}$ method, the LRP is the lowest estimate of fishable biomass from which the fishable biomass was able to recover to above the time-series average within three years: biomass was low in 2011 but recovered despite high exploitation rates in 2011 and 2012. A participant questioned the rationale for using different methods (e.g., B_{MSY} vs. $B_{Recovery}$) to establish LRPs in adjacent areas (WAZ, EAZ, SFA 4). It was stressed that B_{MSY} is unknown for any of these stocks at this time.

Participants discussed the use of fishable biomass (FB) vs. female SSB as the index for establishing the LRP. A participant noted that males in the FB transition to female SSB within a year or two and, for that reason, suggested that FB be used as the index. Participants questioned why different approaches were being proposed for adjacent areas (i.e., LRP based on SSB in EAZ and WAZ; and based on FB in SFA 4). Others emphasized that using an approach in one area does not justify its use in an adjacent area. A participant asked if the proportion of males in the SFA 4 FB is different than stocks in adjacent areas. Otherwise, the participant believed that the method should be consistent with adjacent stocks. A participant indicated that there appears to be a higher proportion of males in SFA 4 *P. montagui* catches when compared to *P. borealis* fisheries in other areas, but also noted that the sex ratio changes inter-annually. A participant noted that both methods will generate comparable results.

Participants discussed the use of the B_{MSY} approach vs. the $B_{Recovery}$ approach to establish the LRP. A participant questioned the $B_{Recovery}$ approach, indicating that B_{MSY} was more appropriate. The participant questioned whether there was sufficient evidence for a sustained recovery since the so-called low point in 2011. Instead, the participant suggested that the observed trend was either growth of virgin biomass or fluctuation in biomass without trend; thus, does not meet the criteria for $B_{Recovery}$. The participant further noted that notable catches in the SFA 4 Striped shrimp fishery only began in 2005 (the same year the NSRF survey started); thus, there is no evidence that biomass had historically been any higher than the so-called low point in 2005. Likewise, there is no evidence that the so-called low point in 2011 is a point from which there has been a recovery. Others disagreed, emphasizing that the 2011 biomass was being considered as it is the lowest biomass from which we have observed a recovery, based on the available data. Participants emphasized that there is no biomass-predicting model for SFA 4 and that we do not know how the stock will respond to fishing pressure at biomass below the 2011 biomass. A participant noted that the B_{MSY} approach is designed to be used during periods of high productivity; thus, it is not appropriate here. One participant noted two low points, one in 2005 and a second in 2011, from which the stock recovered. The participant noted that this gives us additional confidence in being able to recover from this biomass. The participant in favor of the B_{MSY} approach questioned why in the adjacent EAZ and WAZ, where Northern Shrimp stocks are exhibiting similar trends, the B_{MSY} approach is used. Others reiterated that the fact that B_{MSY} is used for Northern Shrimp in SFA 4-6 is not sufficient rationale for using it for Striped Shrimp in SFA 4. Participants noted that every stock is different, and in this case, we have limited stock-specific information. The participant in favor of the B_{MSY} approach stated that the relatively short time series for Striped Shrimp in SFA 4 provides additional justification for using B_{MSY} (thereby using all of the available data). Other participants agreed, noting that a LRP would be more robust if based on more than a single year. A participant indicated that this is a bycatch fishery and that the risk of elevated fishing mortality is low. Another participant noted that exploitation rates were ~20% in some years and that the fact that this is a bycatch fishery does not mean the exploitation rates are dismissible. A participant questioned why a LRP is being established for a bycatch fishery. Another participant clarified that this is a requirement for

Marine Stewardship Council certification. Furthermore, the participant indicated that the fact that this is a bycatch fishery should not deter us from establishing a LRP. Several participants emphasized that a $B_{Recovery}$ is an interim measure that will be revisited. The $B_{Recovery}$ method is a conservative first step that establishes a baseline from which we can build as additional stock-specific information becomes available.

After considerable discussion, no consensus was reached concerning the establishment of a LRP for Striped Shrimp in SFA 4.

ASSESSMENT OF NORTHERN AND STRIPED SHRIMP IN THE EAZ/WAZ

W. Walkusz, S. Atchison, and C. Lumb

Presenter: W. Walkusz

Abstract

The assessment includes 2019 and 2020 surveys' biomass indices, fishery data, and fishery exploitation rate indices for Northern Shrimp and Striped Shrimp from the Eastern and Western Assessment Zones (EAZ and WAZ). Distribution of the stocks is presented in relation to the environmental factors, including depth and bottom temperatures. The stock biomass data are presented in conjunction with the newly established Limit Reference Points and proposed Upper Stock Reference points. *Pandalus borealis* stock in the EAZ is currently well above the established LRP. Although there is currently no established Upper Stock Reference (USR), the stock is considered in a healthy state. *Pandalus montagui* stock in the EAZ is currently well above the established LRP. Although there is currently no established USR and the stock biomass index is subject to considerable interannual variability, the stock is considered in a healthy state. *Pandalus borealis* stock in the WAZ is currently well above the established LRP. Although there is currently no established USR, the stock is considered in a healthy state. Although there is currently no established USR for *Pandalus montagui* stock in the WAZ, the stock is above the established LRP relevant to a PA framework.

Discussion

Participants noted that Striped Shrimp migrate across the EAZ-WAZ border. Participants emphasized that this causes big problems for industry. Several participants discussed the relocation of the EAZ-WAZ boundary line. One participant suggested that this be added as a research recommendation. Other participants agreed but emphasized that the purpose of this meeting is stock assessment and not the demarcation of fishing area boundaries. Participants discussed whether it would be beneficial to include a SAR bullet describing stock status where the EAZ and WAZ are considered as a single stock. One participant noted that while the division of a population into management units is challenging, this will only lead to more questions. Another participant suggested that this be added as a research recommendation. Participants discussed the Davis Strait Closure and whether biomass estimates pre-closure should be corrected retrospectively. The presenter indicated that the difference would be negligible. Others agreed.

ASSESSMENT OF NORTHERN SHRIMP IN SFA 4

K. Skanes, K. Baker, D. Sullivan, S. Zabihi Seissan, and E. Coughlan

Presenter: K. Skanes

Abstract

A combination of survey and commercial data was considered in the assessment of the SFA 4 Northern Shrimp stock. Spatial surplus production model results were also presented; however, these are not yet approved for use in management decisions as some refinements and testing of the model are required. The stock indices have changed little from 2020.

TAC was reduced from 15,725 t in 2018/19 to 10,845 t in 2019/20 and further reduced by 20%, to 8,658 t, in 2020/21. Large-vessel standardized commercial catch per unit effort (CPUE) varied without trend near the long-term mean (1989–2019/20). Over 2005 to 2020 the fishable biomass index averaged 97,200 t. It was 58,900 t in 2020, a 9% increase from 2019 and the third lowest level in the time series. Over 2005 to 2020 the female Spawning Stock Biomass (SSB) index averaged 60,900 t. It was 43,100 t in 2020, a 9% increase from 2019 and amongst the lowest levels in the time series. The exploitation rate index ranged between 7% and 37.3% from 2005/06 to 2019/20 and was 12.8% in 2020/21. If the TAC had been taken, the exploitation rate index would have been 14.7%. Female SSB index in 2020 was in the Cautious Zone within the Integrated Fisheries Management Plan (IFMP) PA Framework, for the third consecutive year, with a 6% probability of having been in the Critical Zone and a 36% probability of having been in the Healthy Zone.

Discussion

A participant asked if at-sea observers collected data in 2020. The presenter indicated that the program went ahead despite COVID-related delays. A participant noted that the assessment index was in the cautious zone for the third consecutive year and asked if there is a protocol where if the index remains in the cautious zone for a certain number of years it justifies the implementation of a rebuilding plan. Other participants clarified that rebuilding plans are only required as per DFO Policy when the index moves into the critical zone. A participant suggested considering the difference between a priori model-estimated biomass and OGMAP-estimated biomass to explore other factors that might be influencing biomass, allowing us to more accurately forecast biomass. A participant suggested that the model appears to be overestimating mortality. A participant noted that predation is accounted for, but that shifts in predator diet are not. A participant noted that this appears to be a population of older females and asked if old-age mortality could influence stock biomass, nothing that the last time the population was per capita this old (the early-2000s) the stock was much larger. The presenter indicated that this will be monitored. Another participant noted that the population was per capita much older in the 1990s.

ASSESSMENT OF NORTHERN SHRIMP IN SFA 5

K. Skanes, K. Baker, D. Sullivan, S. Zabihi Seissan, and E. Coughlan

Presenter: K. Skanes

Abstract

A combination of survey and commercial data was considered in the assessment of the SFA 5 Northern Shrimp stock. Model results were also presented; however, these are not yet approved for use in management decisions as some refinements and testing of the model are required. The stock indices have changed little from 2020.

TAC was reduced from 25,630 t in 2018/19 to 22,100 t in 2019/20 and further reduced, by 35%, to 14,450 t in 2020/21. Standardized large-vessel CPUE had varied without trend at relatively high levels for more than a decade before falling below the long term mean beginning in

2017/18. Commercial catch rates may have been partly influenced by ice coverage. The number of stations sampled by the DFO multi-species survey in 2020 was reduced due to several factors. Retrospective time-series simulations suggest that the biomass estimates may slightly underestimate the stock status in SFA 5 in 2020. Over 1996 to 2020 the fishable biomass index averaged 127,000 t. It was 80,400 t in 2020, an increase from 2019, but still near the lowest levels in the survey time series. Over 1996 to 2020 the female SSB index averaged 63,000 t. It was 51,300 t in 2020, an increase from 2019, but still near the lowest levels in the survey time series. The exploitation rate index varied without trend with a median value of 15% from 1997–2020/21 and was 16.4% in 2020/21. If the TAC is fully taken in 2020/21 then the exploitation rate index will be 22.4%. Female SSB index is in the Healthy Zone within the IFMP PA Framework with 19% probability of being in the cautious zone. If the 14,500 t TAC is maintained and taken in 2021/22, then the exploitation rate index will be 18%.

Discussion

A participant questioned why reduced survey effort resulted in low estimated biomass, noting that we might expect reduced confidence but not systemic decreases. Participants suggested that this may be a coding error. A participant proposed that the underestimates are an artifact of the species' *patchy* distribution. By reducing effort, we are less likely to catch these *patches*, and more likely to generate smaller estimates. A participant noted that the SAR should reflect that the OGMAP appears to generate underestimates when survey coverage was similar to that of 2020. The group agreed. Participants expressed concern about reduced survey effort, noting that reduced effort influences how the resource is managed. Participants asked how decisions concerning reductions in the number of sets are made, and whether these reductions are permanent. A participant explained that in 2020, the number of sets was reduced to accommodate the comparative fishing program, which was ultimately canceled due to vessel repairs and COVID-related delays. The participant noted that such reductions in the number of sets will likely occur until comparative fishing is complete; thus, likely for the next few years.

ASSESSMENT OF NORTHERN SHRIMP IN SFA 6

K. Skanes, K. Baker, D. Sullivan, S. Zabihi Seissan, and E. Coughlan

Presenter: K. Skanes

Abstract

A combination of survey and commercial data was considered in the assessment of the SFA 6 Northern Shrimp stock. Model results were also presented; however, these are not yet approved for use in management decisions as some refinements and testing of the model are required. The stock indices have changed little from 2020.

Total allowable catch (TAC) was increased from 8,730 t in 2018/19 to 8,960 t in 2019/20 and reduced, by 8%, to 8,290 t in 2020/21. The annual CPUE declined considerably between 2015/16 and 2017/18 to the lowest levels in two decades and has remained low since. Over 1996 to 2020 the fishable biomass index averaged 370,000 t. It was 118,000 t in 2020, an increase from 2019, but still near the lowest levels in the survey time series. Over 1996 to 2020 the female SSB index averaged 232,000 t. It was 74,800 t in 2020, an increase from 2019, but still near the lowest levels in the survey time series. The exploitation rate index ranged between 5.5% and 21.5% from 1997 to 2020/21 and was 5.6% in 2020/21. If the TAC is fully taken in 2020/21 then the exploitation rate index will be 10%. The female SSB index is currently in the Critical Zone of the IFMP PA framework with a 35% probability of being in the cautious zone. The rebuilding plan states a maximum exploitation rate of 10% while the female SSB index is in

the Critical Zone. If the 2020/21 TAC of 8,290 t is maintained and taken in 2021/22, the exploitation rate index would be 7%.

Discussion

A participant asked if the 2021 projection is based on the 2020 OGMAP-generated biomass estimate or the 2020 model-estimated projection. The presenter clarified that the 2021 projection is based on the 2020 OGMAP-generated biomass estimate.

DRAFTING OF SCIENCE ADVISORY REPORT BULLETS

EASTERN AND WESTERN ASSESSMENT ZONES SUMMARY BULLETS

Participants agreed to include a summary bullet for each species. Several participants reiterated that the movement of adult shrimp across the EAZ-WAZ boundary is a major concern. Participants agreed and this was included as a summary bullet. A participant cited Le Corre et al. (2021) and noted that we do have information on the movement of shrimp across management areas, albeit not adults. Participants agreed to remove the bullet outlining what data was used in the assessment.

EASTERN ASSESSMENT ZONE STRIPED SHRIMP

Participants discussed the migration of adult shrimp across the EAZ-WAZ border and proposed reiterating this concern in the stock-specific bullets. A participant emphasized that inter-annual fluctuations in biomass are expected but that the goal of this assessment is to assess stock status relative to the long-term mean. Instead, participants added a broader statement noting that inter-annual fluctuations in estimated biomass in a given assessment zone can be influenced by resource distribution. While some participants noted that there is no scientific support for this statement, others maintained that it is factual. This modification was also made to other stocks, where applicable, for consistency. A participant proposed including the change in biomass since the previous year for all stocks. Others disagreed, stating that this can be misleading.

EASTERN ASSESSMENT ZONE NORTHERN SHRIMP

Participants discussed how to accurately describe stock status relative to the LRP and USR. Participants noted that while the stock is expected to be in the Healthy Zone, the USR has not been established; thus, any statement would be speculative. Others noted that whether the USR is 70% or 80% of the SSB (which are thought to be the most likely scenarios based on what has been proposed) the stock will be in the Healthy Zone and suggested that this be reflected in the bullet. Participants discussed the implications of using 70% or 80% of the SSB. Others noted that if a USR is included, we must clearly state that this is a proposed USR. Participants agreed on indicating that the stock is in a healthy state, which does not explicitly state that the stock is in the Healthy Zone, but does imply that the stock is healthy. Discussion on the stock likely being in the Healthy Zone was moved to the body of the document. This modification was also made to other stocks, where applicable, for consistency.

SHRIMP FISHING AREA 4 STRIPED SHRIMP

Given that there was no consensus on establishment of a LRP for this stock, bullets could not be constructed in the context of a PA status.

SHRIMP FISHING AREA 4 NORTHERN SHRIMP

A participant questioned the rationale for including the probability of the index being in the critical zone or the healthy zone. Participants agreed that the probability is informative if the probability of being in an adjacent zone is high. Participants agreed to keep the probabilities in the bullets.

SHRIMP FISHING AREA 5 NORTHERN SHRIMP

Participants discussed the data simulation exercise used to consider the effect of reduced survey effort on biomass estimates. The associated bullet was revised to reflect that these are retrospective time-series simulations. Participants expressed concerns about omitting the 25% increase in fishable biomass between 2019–20 from the bullets. Others indicated that this statement implies positivity which is not accurate. The statement was removed.

SHRIMP FISHING AREA 6 NORTHERN SHRIMP

Participants expressed concerns about omitting the 42% increase in fishable biomass from the bullets. Others emphasized that our role is to provide impartial science advice. This 42% increase is from one of the lowest points in the time series; thus, while the statement is accurate, it could easily be misinterpreted. Another participant noted that while year-to-year increases are encouraging, our role is to consider long-term trends. One participant noted that exploitation rates should not exceed 10%, yet the bullet considers a scenario where the exploitation rate is 15%. The exploitation rate was modified to reflect a scenario where the TAC remained constant and was fully taken.

RESEARCH RECOMMENDATIONS

- Investigate the movement of shrimp between the EAZ, WAZ, and SFA 4.
- In the EAZ, WAZ, and SFA 4, investigate the difference between Striped Shrimp biomass estimates (and confidence intervals) when we assume the stocks are discrete units vs. when we assume a hypothetical single stock.
- Inter-regional stock level integration of the *P. borealis* biomass data (North->South integration).
- Further investigate predator-prey dynamics in the north: continue data collection in 2021, process existing samples (from 2020), analyze existing data (from 2019), and publish analyzed data (from 2018).
- Investigate the use of different methods (i.e., BMSY vs. BRecovery; fishable biomass vs. female standing stock biomass) to calculate the LRP for Striped Shrimp in SFA 4.
- Continue collecting ancillary environmental data.
- Investigate the difference between OGMAP- and STRAP-generated biomass estimates.

SOURCES OF UNCERTAINTY

- The lack of information in the north is a major uncertainty. Participants noted that this often results in more-conservative approaches in northern areas.
- The influence of tidal cycles on survey results.
- The influence on of the trawl’s catchability on survey results.

- The influence of each ship's catchability on survey results, particularly given differences in spatial coverage among vessels.
- The movement of shrimp across management boundaries and how this influences how the stocks are managed.
- The vertical movement of shrimp and how this influences survey results.
- Inter-annual differences in survey coverage and how this influences survey results (e.g., 2019 and 2020).

REFERENCES CITED

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McCauley, R.D., Day, R.D., Swadling, K.M., Fitzgibbon, Q.P., Watson, R.A., and Semmens, J.M. 2017. Widely used marine seismic survey air gun operations negatively impact zooplankton. Nat. Ecol. Evol. 1(1095): 1–8.

Pedersen, S.A., and Storm, L. 2002. Northern Shrimp (*Pandalus borealis*) Recruitment in West Greenland Waters Part II. Lipid Classes and Fatty Acids in *Pandalus* Shrimp Larvae: Implications for Survival Expectations and Trophic Relationships. J. Northw. Atl. Fish. Sci. 30: 47–60.

APPENDIX I: TERMS OF REFERENCE

Assessment of Northern Shrimp in SFAs 4-6, EAZ & WAZ and of Striped Shrimp in SFA 4, EAZ & WAZ

Zonal Advisory Meeting - Newfoundland & Labrador Region and Ontario & Prairies Region

February 22-26, 2021
Virtual Meeting

Chairperson: Darrell Mullowney

Context

The status of Northern Shrimp (*Pandalus borealis*) in Shrimp Fishing Areas (SFAs) 4-6 has been assessed annually since 2015. Northern Shrimp in the Eastern and Western Assessment Zones (EAZ and WAZ, respectively), and Striped Shrimp (*Pandalus montagui*) in SFA 4, EAZ and WAZ, is assessed on a biennial basis. In Interim years, stock status updates are conducted.

The status of Northern Shrimp in SFAs 4-6 was last assessed in February 2020 (DFO 2021). A stock status update for shrimp in the EAZ and WAZ and for Striped Shrimp in SFA 4 was held in January 2020 (DFO 2020a, 2020b).

Fisheries and Oceans Canada Resource Management has requested Fisheries and Oceans Canada Science establish a Limit Reference Point (LRP) consistent with the Precautionary Approach (PA) framework for Striped Shrimp in SFA 4.

Fisheries Resource Management has requested the current assessment as the basis for harvest advice for the 2021/2022 fishing season.

Objectives

- Review Striped Shrimp data and establish a LRP for Striped Shrimp in SFA 4;
- Assess the status of the stock based on available indicators for Northern Shrimp in SFAs 4 to 6 (Northwest Atlantic Fisheries Organization [NAFO] Divisions 2G to 3K);
- Assess the status of the stock based on available indicators for Striped Shrimp in SFA 4;
- Assess the status of the stock based on available indicators for Northern and Striped Shrimp in the EAZ and WAZ;
- Consider ecosystem status where the assessed stocks occur based on an overview including relevant summaries of oceanographic conditions, biological community structure and trends, and pertinent knowledge of ecological interactions (e.g., predator, prey) and stressors (e.g., anthropogenic impacts).

Expected Publications

- Regional Science Advisory Reports (2)
- Meeting Proceedings
- Regional Research Documents on Stock Status (2)
- NL Research Document on LRP

Expected Participation

- DFO - Science and Resource Management Branches

- Government of Newfoundland and Labrador - Department of Fisheries and Land Resources
- Government of Nunatsiavut
- Government of Nunavut
- Indigenous groups
- Fishing Industry
- Academia
- Other invited experts

References

DFO. 2020a. Update of stock status indicators for Northern Shrimp, *Pandalus borealis*, and Striped Shrimp, *Pandalus montagui*, in the Western and Eastern Assessment Zones, January 2020. DFO Can. Sci. Advis. Sec. Sci. Resp. 2020/014. (Erratum: February 2020).

DFO. 2020b. Stock status update of striped shrimp (*Pandalus montagui*) in SFA 4. DFO Can. Sci. Advis. Sec. Sci. Resp. 2020/016.

DFO. 2021. An Assessment of Northern Shrimp (*Pandalus borealis*) in Shrimp Fishing Areas 4-6 in 2019. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2021/010.

APPENDIX II: MEETING AGENDA

Monday, February 22, 2021

Time	Activity	Presenter
10:00	Welcome/Opening/ToR	D. Mullowney (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 Newfoundland and Labrador Shelf	D. Belanger
-	*Presentation*: Structure, Trends, and Ecological Interactions in the Marine Community of the Newfoundland and Labrador Bioregion	M. Koen Alonso/H. Munro
-	*Presentation*: Predation Results from the NSRF Survey	W. Walkusz

Tuesday, February 23, 2021

Time	Activity	Presenter
10:00	*Presentation*: Ecology of Striped Shrimp in SFA 4, EAZ and WAZ	K. Baker
-	*Presentation*: Limit Reference Point for Striped Shrimp in SFA 4	K. Skanes
-	*Presentation*: Assessment of Striped Shrimp in SFA 4	K. Skanes
-	Drafting of SAR Bullets for Striped Shrimp in SFA 4	All
-	*Presentation*: Assessment of Northern and Striped Shrimp in the EAZ/WAZ	W. Walkusz

Wednesday, February 24, 2021

Time	Activity	Presenter
10:00	*Continuation of Presentation*: Assessment of Northern and Striped Shrimp in the EAZ/WAZ	W. Walkusz

Time	Activity	Presenter
-	Drafting of SAR Bullets for EAZ/WAZ	All
-	*Presentation*: Assessment of Northern Shrimp in SFA 4	K. Skanes
-	Drafting of SAR Bullets for SFA 4	All
-	*Presentation*: Assessment of Northern Shrimp in SFA 5	K. Skanes
-	Drafting of SAR Bullets for SFA 5	All

Thursday, February 25, 2021

Time	Activity	Presenter
10:00	Drafting of SAR Bullets for SFA 5 (continued)	All
-	*Presentation*: Assessment of Northern Shrimp in SFA 6	K. Skanes
-	Drafting of SAR Bullets for SFA 6	All
-	Research Recommendations	All
-	Upgrading of SARs/Working Papers	All
-	Adjourn	D. Mullowney

Friday, February 26, 2021

A fifth day (February 26) has been added to the schedule in the event extra time is required for presentations or discussions.

Notes:

- Agenda remains fluid-breaks to be determined as meeting progresses.
- This agenda may change prior to or during the meeting.

APPENDIX III: LIST OF PARTICIPANTS

Name	Organization/Affiliation
Darrell Mullowney (Chair)	DFO-NL – Science
Eugene Lee (Meeting Coordinator)	DFO-NL – Centre for Science Advice
Katherine Skanes (Stock Lead)	DFO-NL – Science
Wojciech Walkusz (Stock Lead)	DFO-O&P – Science
Brian Healey	DFO-NL – Science
Brittany Beauchamp	DFO-NCR – Science
Brittany Pye	DFO-NL – Science
Christina Schaefer	DFO-NL – Science
Darren Sullivan	DFO-NL – Science
David Belanger	DFO-NL – Science
Derek Osborne	DFO-NL – Science
Elizabeth Coughlan	DFO-NL – Science
Frédéric Cyr	DFO-NL – Science
Hannah Munro	DFO-NL – Science
Julia Pantin	DFO-NL – Science
Kelly Dooley	DFO-NL – Science
Krista Baker	DFO-NL – Science
Kyle Lefort	DFO-NL – Science
Manon Cassista-De Ros	DFO-Maritimes – Science
Mariano Koen-Alonso	DFO-NL – Science
Nicholas LeCorre	DFO-PQ – Science
Roanne Collins	DFO-NL – Science
Sanaollah Zabihi-Seisson	DFO-NL – Science

Name	Organization/Affiliation
Sheila Atchison	DFO-O&P – Science
William Coffey	DFO-NL – Science
Jennifer Duff	DFO-NL – Communications
Christie Friesen	DFO-Arctic – Resource Management
Courtney D'Aoust	DFO-NCR – Resource Management
Martin Henri	DFO-NL – Resource Management
Robyn Morris	DFO-NL – Resource Management
Abe Solberg	MUN – Marine Institute
Arnault LeBris	MUN – Marine Institute
Raquel Ruiz	MUN – Marine Institute
Tyler Eddy	MUN – Marine Institute
Adam Mugeridge	Government of Nova Scotia
Claude Pelletier	Government of New Brunswick
Joanne Bowers	Government of Prince Edward Island
Nicole Rowsell	Government of Newfoundland and Labrador
Zoya Martin	Government of Nunavut
Alastair O'Reilly	Northern Coalition
Brian Burke	Nunavut Fisheries Association
Craig Taylor	Torngat Wildlife, Plants & Fisheries Secretariat
Derrick Dalley	Innu Nation, Newfoundland and Labrador
Frankie Jean-Gagnon	Nunavik Marine Wildlife Board
Lisa Matchim	Torngat Secretariat
Rob Coombs	NunatuKavut Community Council
Todd Broomfield	Nunatsiavut Government

Name	Organization/Affiliation
Tony Wright	Makivik Corporation
Brian McNamara	Newfoundland Resources Ltd.
Bruce Chapman	Canadian Association of Prawn Producers
Allister Russell	Fish, Food and Allied Workers Union
Bobby Noble	Fish, Food and Allied Workers Union
Dwan Street	Fish, Food and Allied Workers Union
Erin Carruthers	Fish, Food and Allied Workers Union
Nelson Bussey	Fish, Food and Allied Workers Union
Derek Butler	Association of Seafood Producers
Keith Watts	Torngat Fish Cooperation (NC)
Susanne Fuller	Oceans North