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Proceedings of the Zonal Peer Review on the Assessment of Redfish in Northwest Atlantic Fisheries Organization (NAFO) Subarea 0, and Subarea 2 + Division 3K

Meeting dates: May 4–7, 2021
Location: Virtual

Chairperson: Christina Bourne
Editor: Kayla Gagliardi

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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

A Canadian Science Advisory Secretariat (CSAS) Zonal Peer Review Process on the Assessment of Redfish in Northwest Atlantic Fisheries Organization (NAFO) Subarea (SA) 0, and SA 2 + Division (Div.) 3K was held virtually May 4–7th, 2021. The purpose was to provide scientific advice on the status of redfish stocks for NAFO SA 0, and SA 2 + 3K, specifically to provide: 1) consideration of ecosystem status where the assessed redfish stock occurs based on an overview including relevant summaries of oceanographic conditions, biological community structure and trends, and pertinent knowledge of ecological interactions (e.g., predator, prey) and stressors (e.g., anthropogenic impacts); 2) a description of the biology of redfish and its distribution; 3) a description of redfish landings as bycatch in other fisheries; 4) an update of redfish abundance and biomass indices, including size structure and geographic distribution of catch for each assessment area using the relevant survey data (e.g., Northern Shrimp Research Foundation (NSRF), Fisheries and Oceans Canada (DFO) research vessel (RV) survey); 5) an examination of the trend in relative year-class strength of redfish; 6) a description of recent redfish bycatch harvest levels and stock status relative to survey indices; and, 7) a discussion of the current knowledge gaps, research, and information needs to be collected through the assessment area surveys and/or redfish bycatch within commercial fisheries to help future assessments and aid the evaluation/establishment of species-specific reference points in the future.

Both Newfoundland and Labrador (NL), and Arctic Region Resource Management Divisions requested the current assessments to provide detailed advice on the status of redfish stocks. The advice from this assessment may be used to inform management decisions for the 2021 fishing season.

This Proceedings report summarizes the relevant discussions and presents key conclusions reached during the meeting. Additional publications from this process will be posted on the DFO Canadian Science Advisory Secretariat website as they become available.

INTRODUCTION

Three species of redfish are present in the Northwest Atlantic; Deepwater redfish (*Sebastes mentella*), Acadian redfish (*S. fasciatus*) and Golden redfish (*S. norvegicus, formally S. marinus*). Deepwater and Acadian redfish are practically impossible to distinguish by their external appearance and therefore are combined with Golden redfish and managed as a stock complex.

The status of Northwest Atlantic Fisheries Organization (NAFO) Subarea (SA) 0 and SA 2 + Division (Div.) 3K redfish was last fully assessed on October 19–21, 2016 (DFO 2020). In April 2010, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the Deepwater redfish/Acadian redfish complex in Canada (COSEWIC 2010). During the assessment, Deepwater redfish were divided into two Designatable Units (DUs): Northern population and Gulf of St. Lawrence-Laurentian Channel population. The Northern population is distributed from Baffin Bay south to Grand Banks and corresponds to NAFO SA 0+2 and Divs. 3KLNO. COSEWIC designated the Northern DU as Threatened. Acadian redfish, which is found from the Gulf of Maine to the Labrador Sea, was considered as two DUs: Atlantic population (Threatened) and Bonne Bay population (Special Concern) (COSEWIC 2010).

There is currently no defined Limit Reference Point (LRP) for these stocks. In 2016, the previously established LRP (DFO 2012) and additional LRP options were examined (DFO 2020), however, none were considered applicable. In the absence of an LRP it was not possible to identify what zone of the Precautionary Approach (PA) framework this stock was within, and adaptive and cautious management was advised for any reopened fishery. Episodic recruitment, species separation, and other data and model limitations were identified as barriers to LRP development for this stock.

Both Newfoundland and Labrador, and Arctic Region Resource Management Divisions requested the current assessments to provide detailed advice on the status of redfish stocks, and inform management decisions for the 2021 fishing season.

PRESENTATIONS

WELCOME/OPENING/TOR

Presenter: C. Bourne (Chair)

Summary

The chair provided an overview of CSAS and the peer review process as well as the role of participants, guidelines for the meeting, and the expected meeting products. Since the objective of the meeting was to provide sound, objective, and impartial science advice and the issue of resource allocation is strictly a Resource Management consideration, it would not be part of the discussion in the CSAS peer review process. The Terms of Reference (Appendix 1) were reviewed and the meeting Agenda (Appendix 2) was presented. Participants from the meeting included affiliates from Fisheries and Oceans Canada (DFO) (Science and Fisheries Management Branches from Newfoundland and Labrador [NL], Ontario and Prairie [O&P], Arctic, and National Capital Regions), provincial government representatives, fishing industry, academia, aboriginal communities/organizations, and non-governmental organizations (Appendix 3). For clarity, the former Central and Arctic region was recently split into two new regions (O&P and Arctic). As such, Science activities for both Regions are currently being conducted out of the O&P region until such time that the Scientific program is established in the Arctic Region.

AN ECOSYSTEM APPROACH TO FISHERIES MANAGEMENT AT DFO

Presenter: M. Koen-Alonso

Summary

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

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

A National EAFM Working Group (WG) and Regional EAFM WGs have been established, with the goal 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, roughly one quarter of DFO assessments provide advice that incorporates climate, oceanographic, or ecological considerations in the recommendations, however it is often unclear how these components are considered in stock/fisheries management actions.

To move forward on the development of the National EAFM Framework, the Regional and National EAFM WGs have identified case studies to explore tangible ways of how to incorporate EAFM principles. In the Newfoundland and Labrador (NL) region, 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 may cover all or part of the elements required for an 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 an approach that aims to be nationally consistent and regionally appropriate, and guiding the development of the National EAFM framework.

Discussion

There was no discussion regarding this presentation.

OCEAN CLIMATE VARIABILITY ON THE NEWFOUNDLAND AND LABRADOR SHELF

Presenter: F. Cyr

Summary

An overview of ocean climate variability on the NL Shelf was presented. The Atlantic Zone Monitoring Program (AZMP) was created in 1998 and monitoring is done in NL three times a year in different hydrographic sections to measure physical and biogeophysical parameters. The sea level pressure (SLP) above the northwest Atlantic patterns change on multi-annual time scales. The North Atlantic Oscillation (NAO) is an atmospheric index that explains a large portion of climate variability in North America.

The cold intermediate layer (CIL; defined as water below 0℃) is a key feature of the NL ecosystem. The volume of the CIL experiences large changes from one decade to the other. While the CIL is generally located mid-water column, it also interacts with the sea floor on a large part of the shelf. A thicker CIL will generally lead to more contact area with the sea floor, and thus colder bottom conditions, and vice-versa. Previous studies have shown high mortality in redfish larvae in years when the CIL is thicker. In 1990, most of the water column was occupied by the CIL compared to barely any in 1965. The thicker CIL in the early 1990s also corresponded to the time period that saw a collapse of most of the major groundfish fisheries stocks on the NL shelf. In recent years, after a warmer mid-2000’s and a cooler 2014–2017 period driven by a NAO+ phase, a warming trend is emerging (2018–2020) at bottom and CIL depths despite continued NAO+.

Discussion

It was asked whether it might be possible that larval production/flow is being fed by the West Greenland Current into the Labrador Current and if there have been any unique features in these currents that may have contributed to the recruitment anomalies in 2014 and 2018–2019. The presenter explained that it is not exactly known where this pulse is coming from, but transport along these currents is plausible especially since they are driven by the subpolar gyre. How the subpolar gyre spins and is driven by atmospheric conditions might influence the pathway and strength/speed of the currents. It was asked if there are any metrics available for the strength of the subpolar gyre to test for correlation and whether the current is sufficient to prevent larvae from going back up the slope. There are existing metrics for the strength of the subpolar gyre although the index only started in the early 90s (Berx and Payne 2017).

A participant noted there is another publication available (Le Corre et al. 2019) on how larval drift can connect to some of these areas, although the study looked at shrimp larvae which move differently. Larval drift may be a possibility for a redfish connection between stock areas, however synchrony in good recruitment signals among stocks may also be linked to overall favorable environmental conditions for recruitment across regions. It was noted that there was also good recruitment of redfish in west Greenland in recent years.

BIOGEOCHEMICAL OCEANOGRAPHIC CONDITIONS ON THE NEWFOUNDLAND AND LABRADOR SHELF

Presenter: D. Belanger

Summary

Biogeochemical oceanographic conditions on the NL Shelf were presented and interpreted against climatological (1999–2020) mean conditions in the region. Satellite ocean colour data indicated an intense spring phytoplankton bloom in the slope waters of NAFO SA 2 + Div. 3K and in the Labrador Sea in 2020. In-situ data from the AZMP seasonal surveys showed an increase in 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. Zooplankton abundance has remained mostly above normal since ~ 2015. Zooplankton biomass has increased to slightly above normal 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 (*Calanus* spp.), and more small copepods (*Pseudocalanus* spp., *Oithona* spp.). Additionally, there has been a change in zooplankton seasonality since 2016 characterized by weaker spring and stronger summer and fall biomass signals.

Discussion

It was discussed that although there is not a lot of information available on juvenile redfish diet, it is assumed that they likely switch from a diet of eggs and nauplii to a diet of smaller to larger stage copepodites as they grow. It was confirmed that redfish also continue to eat zooplankton and amphipods after the larval stage.

It was asked whether the understanding that most redfish in the area are *S. mentella* is true. It was explained that this was the assumption, although it was based on the timing of sampling of larvae and juveniles and no genetic analysis was done to support the distinction between species. Since it is difficult to distinguish between redfish species, speciation is typically only done for larger individuals (with only *S. norvegicus* being separated from *S. mentella* and *S. fasciatus*) and juveniles are often lumped together, therefore it was noted to be cautious with trying to distinguish between species at this stage if genetics are not involved in the identification process.

SA 0 (DIVS. 0A AND 0B) ECOSYSTEM INFORMATION

Presenter: M. Treble

Summary

An overview of the physical and biological oceanographic environment and ecosystem in SA 0 was presented, based on previously published information. In terms of the physical oceanographic environment, much of the area is covered by sea ice from December to June and there is an area of mixing on the southeast Baffin Shelf where the cold southward flowing Arctic currents meet a branch of the warmer West Greenland current. Mean bottom temperatures in Div. 0A (south of 72 °C) ranged from -0.2 to 1.7 °C and declined with depth. Mean bottom temperatures in Div. 0B were warmer, 2.1 to 4.1 °C, with the warmest temperatures at depths 800 to 1000 m. Conductivity, temperature, depth, and fluorescence (measure of chlorophyll as an indicator of phytoplankton productivity) were measured at pre-established stations along cross-shelf transects during 2004 and 2006. These results illustrated the latitudinal and temporal differences in surface and sub-surface temperature and productivity. An ocean climate index derived for SA 1 was considered informative for conditions in Div. 0B, given the index included sea surface temperature from the Labrador Sea and Hudson Strait, and air temperature from Iqaluit. In 2019 the index was at its highest since the record-high of 2010, and the third-highest since the beginning of the time series in 1985.

In terms of the biological oceanographic environment, in 2019 the initiation of the spring bloom was delayed for a second consecutive year, compared to the 1998–2015 average and the total spring bloom production (magnitude) was below normal.

Deepwater redfish (*S. mentella*) was identified as an indicator species, along with American Plaice and Roughhead Grenadier in a fish assemblage occupying shallow, warm water of the south Baffin shelf. Species abundance in the SA 0 multispecies survey is greater in Div. 0B (73 species) than in Div. 0A (45 species). Within the ten most abundant species only Greenland halibut, Deepwater redfish, Threebeard rockling, and Glacier lanternfish were common to both divisions. In Div. 0B, redfish (*Sebastes* spp.) were found to comprise approximately 10% of Greenland halibut diet. Portions of the south Baffin and northern Labrador shelf habitat have been closed to fishing in order to protect *Geodia* spp. sponge and large gorgonian coral aggregations.

Discussion

The presenter noted that some of the temperatures presented occurred beyond the depths of Redfish, which are typically found only to around 700–800 m deep. However it was also noted that there are Redfish seen in some deeper strata, especially in Division 2J in 2017–2018.

A participant commented that there appears to be a relatively contiguous habitat distribution between Greenland and Baffin Island and how it would be interesting to see how this relates to Redfish biomass and where the biomass is coming from. The participant also asked if this means that there is suitable Redfish habitat/constant distribution of Redfish across the area. The presenter confirmed that there is suitable habitat on both the Canadian and Greenland sides, however, it is not clear if it is continuous since they are unsure about the abundance in the deep waters between these areas and if mobility or currents are driving the pulses.

A participant provided observations from the commercial shrimp fishery in 2020 confirming that small Redfish were caught as bycatch and that the temperature was 2–4°C in the area fished. Highest small Redfish bycatch occurred in Davis Strait West towards Resolution Island, and a sample was taken to confirm species identification. It was noted that currents can vary quite a bit from year to year, which suggests that there does not necessarily need to be a big recruitment pulse in Eastern Greenland if there is a change in the currents that could bring additional larvae into Canadian waters. However, the contribution of larval drift to recruitment remains unknown.

The bycatch problem in *P. borealis* shrimp fisheries was identified by industry as being greatest in Divs. 0B and 2G, and moderate in 2H. There was little to no problem in 2J3K. It was noted that smaller Redfish in fishery bycatch were found further north/upstream, further from the adults. Given this observation it was suggested that there may be significant interplay between oceanography and recruitment.

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

Presenters: H. Munro

Summary

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 (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 catch via a total catch index (TCI) for each of four fish functional guilds within the 2J3K EPUs. The functional guilds are higher level aggregations of the fish functional groups used to describe ecosystem status and trends and are based on feeding habits; for example, the benthivore guild includes all benthivore fish functional groups (small, medium, and large) plus the shellfish functional group (i.e., shrimp and Snow crab). Historical catches for the piscivores, which includes Redfish, were substantially above their TCI until the early 1990s. Catches for planktivores were near or above TCIs in the 1960s and 1970s. Catches of benthivores were above their TCIs during the 1995–2020 period. These results indicate that historically that this ecosystem has experienced fishing levels with the potential to erode ecosystem functionality.

The ecosystem structure of the NL Shelf 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 2014–2015, when it started to show signals of decline. While some improvement has been observed since the lows in 2016–2017, current total biomass has not yet returned to the 2010–2015 level. 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 Div. 2H is incomplete and the signal is not entirely consistent, but it seems clear that the overall biomass has decreased during the 2015–2020 period. This overall decrease has been driven by declines in plank-piscivores (i.e., Redfish) and shellfish (i.e., shrimp), but other functional groups also show declines, including large and medium benthivores. Results from the 2020 survey suggest a potential reversal of this trend, but it is too early to advance any conclusion. Shellfish remain more dominant in the Div. 2H fish community compared to Divs. 2J3K but there are signals of change, with the predominance of shellfish declining since 2017. This change in community structure appears similar to that observed in Divs. 2J3KL in the late 2000s and early 2010s, but the pace of change appears to be more gradual. The planktivores signal shows very low biomass levels since 2015, and is dominated by oceanic species like lanternfishes and Black Herring, 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 to 2020 in comparison with previous years.

Capelin and shrimp are important prey items for Atlantic cod, Greenland halibut, American plaice, and redfish. The dominance of shrimp in predator diets has generally declined with the

shrimp stock; 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 (Divs. 2HJ), Arctic cod and redfish are becoming more important prey items. Redfish consistently appears in the diets of Atlantic cod and Greenland halibut, but is also seen in American plaice. The diets of redfish are highly variable. The diet of smaller redfish is dominated by invertebrates such as amphipods and euphausiids. While larger redfish diets have large amounts of invertebrates but also contain fish, such as myctophids, capelin, and redfish. Average stomach content weights for Atlantic cod and Greenland halibut 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 in low overall productivity conditions, even though these conditions may benefit shellfish stocks.

Ecosystem level consumption of the total fish community has declined since the mid-2000s, mostly as the result of declines in abundance of shellfish. Finfish consumption increased during the 2000s, remained stable in the early 2010s, and showed signals of decline in the mid-late 2010s. Consumption by plank-piscivores has shown a more pronounced decline since the mid-2010s, being driven by declines in biomass of plank-piscivores. Consumption estimates are based on food requirements and, if food availability is limited, actual consumption would be expected to be lower than these estimates. Food consumption by medium-large fish predators is estimated to be 2–3 times larger than harp seal consumption. Harp seals are an important predator, but no more than other top predators.

In summary, since the mid-late 2000s, ecosystem units within the NL bioregion have been shifting back to a more finfish-dominated structure, but the conditions that allowed groundfish rebuilding appear to have eroded. This may be linked to the simultaneous reductions in capelin and shrimp availability after 2014-2015. The available evidence indicates that ecosystem units in the bioregion are currently experiencing low productivity conditions, impacting the rebuilding process of groundfishes, and leading to important declines in total biomass.

Discussion

It was asked if there had been a recent shift from a finfish dominant community back to a shellfish dominant community in 2J3K. The presenter noted that shellfish were highly dominant in the early 2000s then shifted towards finfish in 2017–2018, but 2019–2020 indicated a trend that shellfish are improving slightly, although not fully returning to dominant.

A participant confirmed the point that it looks like a reversal in trend is starting to occur. There had recently been a steady increase in dominance of fish over shellfish in 2J3K (to 2017–2018) but over the last couple of years that trend has started to revert, hinting that things have started to change in favor of shellfish. A similar pattern was observed in 2H where there has been a general reduction in shellfish and increase in groundfish or finfish in the community, although it is still much more dominated by shellfish than the southern region. In 2H, there is no indication of the same magnitude of reversal as that seen in 2J3K; an explanation is that 2H is possibly following same trend as 2J3K but may be a few years behind and it will take a couple of years to see if the trend consolidates or goes back to a more fish dominated system.

It was suggested to not put focus on a single year or two of the plots presented especially when there was no uncertainty indicated and to perhaps avoid using terms like “shifting” or “reversal” of trends because what looks like a shift could really just be a plateau or levelling off of biomass.

REDFISH BIOLOGY AND DISTRIBUTION IN SA 0 AND SA 2 + DIV. 3K

Presenter: D. Ings

Summary

Redfish occur on both sides of the Atlantic Ocean. In the Western Atlantic they range from Baffin Island in the north to the Gulf of Maine in the south. Stocks are comprised of a complex of three species: *S. mentella*, *S. fasciatus,* and *S. norvegicus*. These species are visually and anatomically very similar and within the NL region they are not separated in commercial catches or in RV surveys. In the northwest Atlantic, *S. mentella* dominates in the northern range and *S. fasciatus* is the dominant species in the south. Both species overlap in the Gulf of St. Lawrence and Labrador Sea, but *S. mentella* are usually found in deeper waters than *S. fasciatus*. Redfish are slow growing, with a long life expectancy. Fertilization is internal and females bear live young. Depending on species, stock, and sex, age at maturity ranges from 8 to 15 years. Recruitment success is highly episodic. Larvae are extruded at depth, then rise to inhabit the upper 10–40 m of the water column where they feed primarily on fish and invertebrate eggs, and copepods, before settling to the bottom. The match between timing of larval extrusion and high *Calanus* abundance may be important for year-class success.

Discussion

It was asked if any information on species structure would be presented since it would be useful to know which redfish species in particular are dominating management areas. It was explained that the assessment will have to be focused on a species complex since it is difficult to differentiate the species, although in terms of genetics, it is thought that Divs. 2J3K are historically primarily dominated by *S. mentella*.

REDFISH HABITAT UTILIZATION

Presenter: B. Rogers

Summary

This presentation was focused on Divs. 2HJ+3K habitat associations since there were insufficient survey data from other areas. Habitat associations were looked at for the species complex. Preferred temperature has remained consistent around 3.5°C (SD = 3.1–4). Median available temperatures showed a considerable and sustained increase relative to the period prior in 1996–1997 (~1°C in 2H; ~0.5°C in 2J3K). Fish smaller than 15 cm exhibited different temperature preferences than larger fish: 2.3–3.9°C for small fish (< 15 cm) as opposed to 3.2–4.9°C for medium sized (15–27 cm) fish and 3.2–4.3°C for large (> 27 cm) fish.

Depth associations were less consistent but are generally ~ 350 m. Associations to depth are much weaker in Div. 3K (not statistically significant prior to 1995) and roughly follow what is available. Similar to temperature, fish smaller than 15 cm show different depth preferences than larger fish: 257–325 m for small fish (< 15 cm) as opposed to 333–476 m for medium sized fish (15–27 cm) and 347–570 m for large fish (> 27cm). This research is preliminary and it is difficult to draw conclusions.

Discussion

It was asked how the thermal envelope is calculated and if it is corrected for coverage. The presenter explained that this is the fishing temperature which is generally the bottom temperature and coverage was not considered. This point was noted since sets are randomly allocated across the shelf and although it will not impact the analysis, it could affect the plots.

It was asked if there were any interactions between individual redfish species at various depth associations in 2HJ3K, as this has been observed in the Gulf of St. Lawrence. The presenter agreed that there probably is but since it is mostly *S. mentella* looked at in this region and catches are not separated by species it cannot be determined at this time. There have been historical research programs where the species were split by depth in these regions but caution is warranted in trying to apply this information to present conditions as distributions and environments (e.g., temperature) can change through time. Differences in habitat association within small, medium, and large fish could be related to year-classes of particular species coming in, but this is uncertain. Species composition probably makes a difference to some extent but the patterns seen within the small, medium, and large fish have been pretty consistent over time so it probably is not a strong impact.

A participant commented how in 2020 in 2H and 2G it seemed like redfish were the same size as shrimp, which caused vessels to not be able to screen them (a big problem in Shrimp Fishing Area [SFA] 5) and asked if there was a theory as to the cause of this recruitment pulse. It was explained that generally the recruitment dynamics are poorly understood and relating them to stock size in previous years or temperature is difficult and would require some experimental fishing.

A participant suggested looking back to different species structure work that has been done, such as from Ni (1982). However, there were comments to be careful using this older species composition data to comment on current species composition, and the participant agreed it should not be used for precise numbers but could be used as guidance for what species are likely in the area. More information on species differentiation is expected in the next few years as a new project on redfish genomics is ongoing. There have been different methodologies used to try to separate the species over the years but they were either inaccurate or changes in distribution occurred. A participant recommended checking available Spanish survey data to determine depths associated with *S. mentella* and *S. fasciatus*. It was suggested to consider incorporating more recent publications available (from 2018) on contemporary patterns of gene flow into the final assessment document to show that more work needs to be done.

It was pointed out how the prior redfish biology presentation said that there is a latitudinal cline associated with growth, however, in this presentation the temperature associations with small, medium, and large fish implied that fish of similar size are of different ages. The presenter clarified that the age of fish would likely not impact these associations in a meaningful way. Generally, fish are a certain size at age and their thermal tolerance would change as they grow and they can become more resistant to temperature changes. Larger fish may be better able to regulate and there is also a relationship between size and the likelihood of being predated on; so growth rates should not impact this association.

REDFISH CATCH IN SA2 + DIV. 3K

Presenter: D. Ings

Summary

The catch time-series for SA2 + Div. 3K redfish extends back to 1959. Prior to 1976, the fishery was prosecuted primarily by non-Canadian countries. From 1978 to present, redfish removals were comprised of reported catch and bycatch landings by Canada, non-Canadian fleets, and discards by all countries. The highest recorded landings were 187,000 t in 1959. Reported landings fell to 55,000 t in 1961 and varied between 15,000 t and 56,000 t during the period from 1962 to 1987. From 1988 to 1996, landings averaged 2,000 t up to the establishment of a moratorium in 1997. Landings from bycatch in other directed fisheries have ranged between about 56 t and 1,500 t since 1997.

Discards in the shrimp fishery, which emerged in the 1980s, and in Greenland halibut fisheries were estimated from catch rates derived from fishery observer data scaled to the total shrimp and Greenland halibut landings. From 1980 to 2014, discards averaged 265 t annually. During the period 2014 to 2019, discards averaged 50 t annually. The estimated weight of redfish discards in SA2 + 3K during 2020 was 232 t, primarily from the shrimp fishery in NAFO Div. 2G. Most redfish discarded by the shrimp fishery during 2020 were between 7 and 10 cm.

Discussion

It was asked what observer coverage is like for these fisheries that are giving the discard information and if it was impacted in 2020 by Covid-19 restrictions. The presenter explained that generally the coverage is quite good and catches are estimated by scaling up from the observed coverage to the recorded landings. This is done by division so in 2020 it ranged from 50% scale up to approximately less than 20%, but this varies every year between divisions. The presenter clarified that scaling up occurs whether observers are on board or not as observers are not present for every set even when they are on board. Data are scaled from the weight of fish caught in observed sets to the total catch of the shrimp fishery based on proportion of shrimp landings, but there are a lot of uncertainties with scaling up and therefore in resulting discard estimates. The presenter confirmed that the discards in Div. 2G are mainly juveniles.

IMPROVING ABUNDANCE INDICES FOR NAFO SA 2 + DIV. 3K REDFISH VIA A SPATIO-TEMPORAL MODEL

Presenter: N. Fuller

Summary

The presenter summarized the objectives of their MSc study which are to fill in survey coverage gaps with better abundance indices, detect hotspots in distribution, and to look at juvenile abundance/distribution. This study looks at a Vector Autoregressive Spatio-Temporal (VAST) model instead of the conventional design-based method for survey index estimation, since there are cons associated with the latter, such as ignoring the observational error, only using the area that are consistently sampled, extrapolating to the entire area, and using spatially aggregated data. The VAST model generates random sample locations and spatial covariates, uses piecewise function, and difference structure for temporal, spatial, and spatio-temporal effects. Results presented were preliminary.

The VAST model used here has been good at predicting tow estimates. There has been potential bias in VAST at the division level such as systematically underestimating compared to design estimates. However, this could be because of omitting low density strata in design-based estimates due to lack of sampling as VAST is using all strata regardless of sampling. In strata that are consistently sampled, the different estimates of VAST are more likely to be influenced by the estimates of adjacent areas since the current version does not include depth as an environmental covariate. Potential bias will be examined in simulation testing. Future steps for the study include adding environmental covariates (e.g., depth), running simulation testing, and for juveniles: getting the true SFA 4 polygon, true length-weight relationship, and possibly adding data from surveys in 2G and 2H (since these divisions have not been regularly surveyed so they are lacking in data).

Discussion

A participant suggested looking into using the Tweedie distribution since it is able to handle zeros without treating them as a special case and recent papers have noted that mixed model approaches might introduce some biases. Using this distribution would allow for a direct comparison between the estimate within strata that are sampled and included in the design-based assessment and provide a direct comparison excluding the low sampling zones. The presenter confirmed a future step would be to add depth to the indices. A participant suggested trying raw Campelen and Engel indices instead of converted indices to estimate catchability difference between surveys. The participant also suggested using the mean length-weight relationships observed in the area or a local length-weight relationship if available as it would be more representative than what was available from FishBase.

NAFO SA 2 + DIV. 3K REDFISH ASSESSMENT (WORKING PAPER)

Presenter: R. Kumar

Summary

Information available to evaluate the status of redfish in SA 2 + Div. 3K included commercial catch (1959–2020) and Canadian RV bottom trawl data from fall surveys (1978 to 2020). Biomass and abundance indices for the management unit of SA 2 + Div. 3K were based primarily upon survey indices from Divs. 2J + 3K only, due to inconsistent sampling in 2G and 2H.

The 2J3K recruitment index (abundance of redfish < 15 cm length) in 2020 was substantially higher than any value observed previously in the time-series (1978–2020). Signals indicate that recruitment was also high in 2H in 2020. Long-term recruitment trends need to be interpreted with caution as data prior to 1995 are Engel trawl data in Campelen-equivalent units, and may under represent recruitment. Redfish recruitment is episodic, and conditions that produce strong recruitment are not understood, including the potential for recruits to originate from neighboring areas.

The 2J3K abundance index generally declined from 2011–2017, followed by a sharp increase in 2020, to the third highest value in the time-series (1978–2020). Converted time-series may still not accurately reflect abundance of small fish, however. Abundance indices from surveys conducted in 2H (1978–2020) were at time-series highs in 2020. Biomass indices across all survey areas showed similar trends as abundance, with the exception of recent abundance increases as these are driven by very small fish that do not yet contribute significantly to biomass.

There is currently no accepted population model for this stock and projections could not be performed. Redfish are a very slow growing species and strong recruitment pulses do not always persist. Therefore it is unknown whether the 2020 pulse will make a significant contribution to the stock biomass or any potential fishery. While there is no defined PA framework for this stock, current total survey biomass remains low; therefore, it is advised that management measures focus on encouraging stock growth.

Discussion

It was clarified that typically redfish caught in the RV survey are more than 5–6 cm, and fish that are less than 15 cm are used as a proxy for recruitment.

It was asked why the fishery does not use a stock assessment model and explained that various models have been attempted for this redfish stock in the past with no success. In an assessment model, the instantaneous rate of mortality is estimated from the declining slope of the cohort and since redfish are slow growing and difficult to age, it is difficult to track cohorts. Modelling efforts are continuing but it was noted that given the slow growth and sporadic recruitment, redfish can be particularly challenging to model.

A catch:biomass ration was discussed as a potential proxy for fishing mortality (F). However, this index was not accepted by the meeting as an indicator of relative harvest rate as the catch and survey biomass are generally not from the same area.

Discussion on inclusion of Divs. 2H and 2G in summary bullets

There was discussion as to whether Divs. 2H and 2G should be included in the abundance summary bullets instead of just 2J3K to be more representative of the area. Other than in 2020 the average contribution to total abundance in 2H was 12.5%, but in 2020 it was 32%. A participant commented that even though a lot of the biomass of 2H might have been missed in 2020 given survey coverage deficiencies, the overall contribution of biomass from 2H is still relatively low, so the perspective in terms of stock biomass will not change. Participants agreed that 2H should still be mentioned in the summary bullets. Caution should be used with discussing the number of recruits as these are an index not an absolute estimate, and since the relation to spawning stock biomass (SSB) is not known yet. It was agreed that there was no point in excluding the 2019 survey from the index, since the mean total contribution to total biomass of all the missed strata in 2J3K was less than 10%. Since this is not a modelled stock it will not change any trends or cause any residuals. It was suggested to note in the sources of uncertainty that some relatively significant areas were missed though, so it may be an under-estimate.

There were concerns about 2G not being discussed as much compared to 2H, but it was noted that this division had not been surveyed in the DFO trawl survey since 1999, so it was not possible to identify long-term biomass trends.

Discussion on recruitment

The pattern of wide-spread increasing recruitment was discussed. Favorable environmental conditions discussed in earlier presentations included the warming trend from 2018–2020 that could be favorable for juvenile redfish survival as well as the overall increasing trend in nutrient inventories and primary production since the mid-2010’s with above normal production in recent years. Those favourable conditions along with having the mature fish here could possibly justify that those recruitments have originated within the stock area, although since redfish are sporadic it is difficult to comment on this. Since the mid-2000s there have been more frequent increasing peaks in recruitment compared to before and to what was expected for redfish based on the pre-conceived idea that recruitment is very sporadic, so this is where something might be changing. It is important to consider the Engel issue in the earlier part of the time series since these sorts of patterns may have been occurring but may not have been seen since the Engels weren’t picking up small fish.

It was asked if higher recruitment is occurring due to improved environmental conditions or if it is plausible that recruitment is coming from elsewhere (such as the Irminger sea stock) and if DNA analysis could be used to get a more definitive answer as to whether recruitment is within or external to Canadian waters. The presenter noted that this is currently unknown. Genetic work might be able to help answer this question. It was noted that this is not the first time there has been high recruitment pulses associated with a low biomass of redfish and that this is a typical occurrence for redfish.

Further discussion occurred around the question of whether the current recruitment pulse originated from within the stock area and/or was imported via currents from an adjacent stock. Larval period, current strengths, and environmental drivers were discussed. Previous work on shrimp larval transport (LeCorre et al. 2019) was also discussed as to whether this work could be directly translated for redfish. Concerns were noted in making conclusions for redfish based on this work including the different ecology and life history and distribution of shrimp vs. redfish, and the exclusion of smaller inshore currents and eddies. Participants noted that synchronous recruitment across stock areas often results from large-scale patterns in the environment that can lead to favourable recruitment conditions across broad areas. It was agreed to reflect the discussion of the uncertain origin of recruitment in the SAR.

A participant commented that patience is required since redfish are slow growing and 2H is not currently driving biomass since it has been low for a while. The pulse in 2020 was widespread over 2H and into 2G, but that pulse is not going to drive biomass next year since it will be at least 5 years before it contributes significantly to biomass.

SA 0 REDFISH ASSESSMENT (WORKING PAPER)

Presenter: T. Loewen

Summary

Redfish species (*Sebastes mentella, S. norvegicus* and *S. fasciatus*) were assessed as a species complex for SA 0 to provide information on commercial bycatch and science surveys. Information was also provided for the northern portion of Div. 2G. There are no commercial fisheries for redfish in Baffin Bay and Davis Strait. However, redfish are captured as bycatch in Greenland halibut and shrimp fisheries. Annual total bycatch of redfish peaked in 2005 at 229 t and has since declined. Annual mean catch per unit effort (CPUE) (kg redfish/hour) was examined by trawl fishery and fishing area. Mean CPUE has varied without trend in the Divs. 0A and 0B shrimp fisheries and the Div. 0B Greenland halibut fishery. Div. 0A Greenland halibut fishery shows an increase in mean CPUE between 2001 and 2019, increasing from nearly 0 to 150 kg per 60 min. However, CPUE is used with caution in stock assessments given the effects of targeted fishing on catch rates and consequent risk of hyperstability in the data.

DFO multispecies and Northern Shrimp Research Foundation (NSRF) surveys were analyzed for stock metrics. The largest catches in the DFO survey occurred between 400–800 m and the lowest in 800–1500 m. For the NSRF survey highest catches were between 200–750 m. Geographic distribution of catches were presented. Higher catches were generally observed in Divs. 0B and 2G with higher concentrations along the north of the Baffin Island Shelf break and along the perimeter of the Hatton Basin Conservation Area.

Length-frequency distribution from the DFO multispecies survey in Div. 0A showed several pulses of redfish recruitment between 1999 and 2019 with fork length increasing from 22 cm in 2016 to above 22 cm in 2019. Length-frequency distribution for Div. 0B (most current year being 2016) showed wider distributions with more pronounced multiple peaks within each year suggesting the ongoing presence of several year-classes. Length-frequency distributions were available for two NSRF survey areas, Resolution Island Shrimp Area (RISA) and SFA 1 and they showed stable ranges across years. With spatial overlap between the surveys in Baffin Bay (Div. 0A and SFAs 0 and 1) and Davis Strait (Div. 0B and RISA, SFA 2), it appears that redfish smaller than 20 cm fork length are captured by the NSRF survey, which uses a shrimp trawl, while redfish larger than 20 cm fork length are captured more consistently in the DFO multispecies survey, which uses an Alfredo groundfish trawl that has a larger mesh and included deeper depths. Provisional age-at- length data were presented for redfish collected during the DFO survey in 2016.

Divs. 0A and 0B abundance and biomass indices peaked in 2012, and 2011, respectively, and subsequently declined to- 2019 and 2016, respectively. The NSRF survey Div. 2G biomass index was relatively high during 2010–2014 and then increased substantially in both abundance and biomass in 2020. High abundance was observed throughout all the NSRF survey areas in 2020 (RISA, SFA 2 and 3).

The catch of small redfish, (fork length < = 15 cm) was examined as a potential index of recruitment. However, the development of this index is hindered due to the fact that length measurements are not available from most of the NSRF surveys. Small redfish are consistently observed in Div. 0B and several SFAs. The mean number of small redfish showed considerable inter-annual variation in both Div. 0B and SFAs. High biomass of small redfish in the SFAs (RISA, SFA 2 and 3) in 2007 preceded higher abundance and biomass index values in 2010. However, more recent high catches of small redfish in 0B were not followed by elevated abundance or biomass indices. Knowledge gaps include lack of species discrimination in the commercial bycatch and lack of understanding for connectivity with adjacent stocks, stock productivity, growth rates, maturity, and genetic stock structure.

Discussion

It was asked if there was any information for Ungava Bay with regards to commercial bycatch and noted that there is bycatch data for SFA 3 included in Div. 0B.

The presenter noted that the DFO surveys described in the presentation were using a groundfish type gear that only covers depths of 400 m or deeper, missing the shallow strata (200–400 m) that may contain redfish. The NSRF redfish surveys that are using a shrimp type trawl that may have better catchability for redfish take place on shallower banks but may miss adult redfish located beyond 800 m. There are plans to expand that DFO survey into shallower depth areas in Div. 0B to try to enhance these assessments in the future.

Discussion on bycatch

By-catch data for 2020 were not presented since it was not available at the time of this meeting, but a participant involved in the commercial fishery informed the meeting that there had been a large amount of small redfish bycatch in Davis Strait West based on sampling data by sea observers. This was not apparent in 2019 but became a concern for harvesters in 2020 where an estimated 50% of the tows were above the allowable bycatch limit after they had started surveying the information, which led to a an adjustment in the allowable limit on a temporary basis. The same significant redfish bycatch issue occurred in SFA4 North and SFA4 South, two major fishing zones within Div. 2G. Some bycatch problems have been occurring in the northern part of 2H but have not yet become apparent in the southern portion of 2H and in 2J3K it was negligible. Therefore the prevalence of bycatch were higher encounters when moving further north, almost on a gradient.

A participant commented that the decline in annual total bycatch after peaking in 2005 may be due to the fact that the fish had grown and were not being caught in the shrimp fishery. From industry experience it is known that in deep areas like Davis Strait East (Div. 0B) there will likely be larger redfish, but for the last 10–15 years because of the lack of shrimp in that area, boats have not been going there. Captains today are trying to find the optimal spot to avoid small redfish in 2H, but they are finding more small redfish in traditional shrimp grounds now, which raises the possibility that there has been a recent surge of small redfish. It was asked if the presenter was considering the eastern side of SFA3 since it looks like the problem there is more on the eastern side of Ungava Bay. This suggests that things are originating up north/north east and not flowing out from Ungava Bay. The presenter will take a closer look at the data to be able to look into the eastern/western aspect of redfish distribution.

Discussion on recruitment

A participant commented how since there have been important recruitment signals in all surveys in 2020 it is important to understand how and why the signal is occurring. Since it looks like a fairly widespread signal it might be based on favorable environmental conditions as opposed to good recruitment in just one specific area and then dispersal from there. This discussion and the origin of recruitment could be noted as a research recommendation in the SAR.

A limitation of the surveys presented was that the time frame was fairly short. A longer period of time will be needed to tease out this question but it will be considered further as more widespread recruitment has been occurring in these areas. Since widespread recruitment signals have been seen all the way from 2G to 3K in a relatively short time frame (a few months), it is hard to imagine that dispersal from 2G could occur in this time, suggesting that good widespread recruitment is occurring instead of recruitment drifting southward with the currents.

Discussion on larval drift

A participant asked about the relationship to adjacent redfish stocks on the Greenland side and if there is any inference on what is happening there or any relationship with the geographic distribution seen in the North. According to NAFO reports there is no directed fishery in West Greenland as the *S. mentella* stock is depleted. There has been no recruitment in either *S. mentella* or *S. norvegicus* stocks since 2010–2011. There has been some variability in Golden redfish stocks but not so much in Deepwater redfish and not to the extent that would point to signals of expansion or contributing to movement over to Canadian waters.

Captains in shrimp fleets were encountering the problem of too many small redfish in Davis Strait West last summer and it evolved through the year. There were no reports of bycatch concerns in a specific area until recently (in April 2021), where reports showed that increased levels of small redfish were being caught in northern 2H. The concerning levels of small redfish bycatch have been following a north to south trend with 2J3K being largely unaffected as of this time.

Further discussion was held on the origin of the high recruitment observed in 2020. It was reiterated that this recruitment signal was widespread and that favorable environmental conditions and/or north-south current transport may have contributed to this. The origin of the recruitment cannot be definitively determined at this time.

DISCUSSION AND DRAFTING OF SCIENCE ADVISORY REPORT BULLETS FOR SA 0, AND SA 2 + DIV. 3K

Participants reviewed and discussed summary bullets and agreed on the following.

OVERARCHING BULLET

It was agreed to specify that *S. mentella* has been the historically dominant species. It was agreed to not include another overarching bullet about the high recruitment in 2020 and how it can have important rebuilding potential since this will be described in more detail in the later bullets.

ENVIRONMENTAL AND ECOSYSTEM INFORMATION BULLETS

After discussion it was agreed to include a sentence in the first bullet to acknowledge and make the connection between environmental conditions and redfish stock productivity. It was agreed to use more general terms like "warmed" instead of specific temperatures since they are only a snapshot from surveys. It was also agreed to not specifically link temperature to redfish abundance since this link has not been looked at yet. This point about habitat associations and redfish abundance was instead included in the research recommendations section.

Participants debated whether a point about groundfish biomass should be included since the relevance to redfish was unclear and not enough is known about the links to redfish diet. It was suggested to describe this more in the body of the SAR where diet is discussed instead, but a participant disagreed that this is an important ecological point to keep in the bullets to connect the data to the bottom-up signal. There is strong evidence that bottom-up processes (e.g., food availability) are regulating the productivity of the stocks. Redfish share resources with other groundfish species, and when piscivores increased, plankpiscivores decreased, while the overall biomass of medium-large groundfishes remained relatively stable. These are the kind of concepts/patterns that can help managers to integrate things. Like with climate, there is a risk of missing the signals because the evidence available is not as robust. If these issues are not included in the bullets, there is a chance of assuming that they pose no risk. From this discussion it was agreed to include a sentence in the third bullet about increases in medium-large predatory groundfish from 2010–2015 to include the link to bottom-up processes.

It was noted that a fundamental issue in past documents has been defining the population of redfish being discussed, especially when considering larval drift. It was suggested to flag this in the sources of uncertainty or research recommendations section. Another suggestion was to reference the COSEWIC report that acknowledges linkages between northern populations in Canada and Greenland, however drift can also go farther into Iceland. This point about larval transport and currents far up north was not explored enough in the meeting aside from the Irminger sea, so it was suggested to remove this from the bullets and move it to the research recommendations.

A participant questioned why no specific values have been included in the summary bullets (for both areas), such as how many tons the stock has declined by. A participant explained that since only time-series averages are available as indices, actual estimates should not be used.

SA 2 AND DIV. 3K REDFISH ASSESSMENT BULLETS

It was agreed to add a sentence about how redfish recruitment is episodic and conditions that produce strong recruitment are not understood, including the potential for recruits to originate from neighboring areas.

For the second bullet it was agreed to specify that the recent abundance increases were driven by very small fish.

For the third bullet it was agreed that since specific numbers have not yet been calculated they should not be included in the bullets, such as the percentage that the redfish discards represent. It was noted that people are going to want to know the number of fish relative to the area as fundamental advice from DFO Science and that effort should be put into calculating these numbers for future work on bycatch.

SA 0 REDFISH ASSESSMENT BULLETS

It was agreed to add a sentence to the last bullet advising that a cautionary approach should be taken for managing the 2019–2020 cohort until it achieves exploitable size.

RESEARCH RECOMMENDATIONS

After discussion it was agreed to include a bullet about species identification since development of a consistent practice could be highly useful for stock management. If better able to distinguish between species in the stock complex, it could be possible to target specific species based on their preferred depth for example, or target a species if their abundance is increasing (and better protect less abundant species that may be co-occurring).

It was agreed to make a general list of research recommendations for the SAR and then use a subset of the list in each of the research documents, depending on what is applicable to each stock. It was agreed to include a separate research recommendation specific for developing LRPs since they can be developed outside of quantitative stock assessment models.

The participants discussed and agreed on the following research recommendations to be included in the SAR:

- Update/investigate methods of species and stock identification and linkages, including genetics.
- Further explore redfish stock habitat associations (e.g., temperature, depth).
- Develop quantitative stock assessment models and modelling efforts to improve indices for inconsistently sampled areas.
- Develop LRPs for stocks, if possible.
- Investigate the potential for larval/population flow and connectivity among stock and other areas (i.e., Greenland).
- Examine how the timing of different surveys may impact the interpretation of the recruitment signal.
- Look for linkages between environmental drivers and recruitment (e.g., physical and biological oceanographic conditions).
- Conduct research on redfish diet at all life stages.
- Hold a peer review meeting focused on impacts of bycatch in other fisheries.
- Collect length-frequency data in Div. 0B to address data gaps.
- Aging methodology needs to be further investigated to determine age composition, growth rates, and maturity patterns in each stock.
- Increase collection and analysis of environmental/ecosystem data in northern divisions (2GH and 0AB), including the impacts of climate change.

SOURCES OF UNCERTAINTY

The participants discussed and agreed on sources of uncertainty in the assessment of these stocks to be included in the science advisory report.

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APPENDIX 1. TERMS OF REFERENCE

Assessment of Redfish in Northwest Atlantic Fisheries Organization (NAFO) Subarea 0, and Subarea 2 + Division 3K

Zonal Advisory Meeting – Newfoundland and Labrador (NL), and Ontario and Prairie and Arctic (O&P/Arctic) Regions

May 4–7, 2021
Virtual Meeting

Chairperson: Christina Bourne

Context

Three species of Redfish are present in the Northwest Atlantic; Deepwater Redfish (*Sebastes mentella*), Acadian Redfish (*Sebastes fasciatus*) and Golden Redfish (*Sebastes marinus*). Deepwater and Acadian Redfish are practically impossible to distinguish by their external appearance and therefore are combined with Golden Redfish and managed as a stock complex.

The status of Northwest Atlantic Fisheries Organization (NAFO) Subarea 0 and Subarea 2 + Division 3K Redfish was last fully assessed on October 19-21, 2016 (DFO 2020). In April 2010, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the Deepwater Redfish/Acadian Redfish complex in Canada (COSEWIC 2010). During the assessment, Deepwater Redfish were divided into two Designatable Units (DUs): Northern population and Gulf of St. Lawrence-Laurentian Channel population. The Northern population is distributed from Baffin Bay south to Grand Banks and corresponds to NAFO Subareas 0+2 and Divisions 3KLNO. COSEWIC designated the Northern DU as Threatened. Acadian Redfish, which is found from the Gulf of Maine to the Labrador Sea, was considered as two DUs: Atlantic population (Threatened) and Bonne Bay population (Special Concern) (COSEWIC 2010).

There is currently no defined Limit Reference Point (LRP) for these stocks. In 2016, the previously established LRP (DFO 2012) and additional LRP options were examined (DFO 2020), however none were considered applicable. In the absence of an LRP it was not possible to identify what zone of the Precautionary Approach (PA) framework this stock was within, and adaptive and cautious management was advised for any reopened fishery. Episodic recruitment, species separation, and other data and model limitations were identified as barriers to LRP development for this stock.

Both Newfoundland and Labrador, and Arctic Region Resource Management Divisions requested the current assessments to provide detailed advice on the status of Redfish stocks, and inform management decisions for the 2021 fishing season.

Objectives

To provide scientific advice on the status of Redfish stocks for NAFO Subareas 0, 2, and Division 3K. Specifically to provide:

1. Consideration of ecosystem status where the assessed Redfish stock occurs based on an overview including relevant summaries of oceanographic conditions, biological community structure and trends, and pertinent knowledge of ecological interactions (e.g. predator, prey) and stressors (e.g. anthropogenic impacts);
2. A description of the biology of Redfish and its distribution;
3. A description of Redfish landings as by-catch in other fisheries;

4. An update of Redfish abundance and biomass indices, including size structure and geographic distribution of catch for each assessment area using the relevant survey data (e.g., Northern Shrimp Research Foundation (NSRF), DFO research vessel (RV) survey);
5. An examination of the trend in relative year-class strength of Redfish ;
6. A description of recent Redfish by-catch harvest levels and stock status relative to survey indices; and,
7. A discussion of the current knowledge gaps, research, and information needs to be collected through the assessment area surveys and/or Redfish by-catch within commercial fisheries to help future assessments and aid the evaluation/establishment of species-specific reference points in the future.

Expected Publications

- Science Advisory Report
- Proceedings
- Two Research Documents

Expected Participation

- Fisheries and Oceans Canada (DFO) (Science and Fisheries Management Branches, NL Region and O&P/Arctic Regions)
- Provincial Government Representatives
- Fishing Industry
- Academia
- Aboriginal Communities/Organizations
- Non-Governmental Organizations

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APPENDIX 2. LIST OF MEETING PARTICIPANTS

Name	Organization/Affiliation
Christina Bourne (Chair)	DFO – Science, Newfoundland and Labrador Region
Rajeev Kumar	DFO – Science, Newfoundland and Labrador Region
Tracey Loewen	DFO – Science, Ontario and Prairie Region
Eugene Lee (CSA Office)	DFO – Science, Newfoundland and Labrador Region
Kayla Gagliardi (Rapporteur)	DFO – Science, Ontario and Prairie Region
Ellen Careen	DFO – Resource Management, Newfoundland and Labrador Region
Hannah Munro	DFO – Science, Newfoundland and Labrador Region
Brian Healey	DFO – Science, Newfoundland and Labrador Region
Frédéric Cyr	DFO – Science, Newfoundland and Labrador Region
David Bélanger	DFO – Science, Newfoundland and Labrador Region
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Karen Dwyer	DFO – Science, Newfoundland and Labrador Region
Divya Varkey	DFO – Science, Newfoundland and Labrador Region
Rick Rideout	DFO – Science, Newfoundland and Labrador Region
Megan Kennedy	DFO – Science, Newfoundland and Labrador Region
Noah Parsons	DFO – Science, Newfoundland and Labrador Region
Lauren Bottke	DFO – Science, National Capital Region
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Aimee Finley	DFO – Resource Management, Arctic Region
Nicole Rowsell	Province of Newfoundland
Anna Tilley	Province of Newfoundland
Rob Coombs	Nunavut Community Council, NL
Todd Broomfield	Nunatsiavut Government
Aaron Dale	Torngat Secretariat, Wildlife, Plants & Fisheries
Bruce Chapman	Canadian Association of Prawn Producers
Brian McNamara	Newfoundland Resources Ltd.
Alastair O'Rielly	Northern Coalition
Kris Vascotto	Atlantic Groundfish Council
Erin Carruthers	Fish, Food and Allied Workers Union
Jason Spingle	Fish, Food and Allied Workers Union
Brian Burke	Nunavut Fisheries Association
Lisa Matchim	Torngat Secretariat

Name	Organization/Affiliation
Rick Lambe	Baffin Fisheries Coalition
Tyler Eddy	Memorial University of Newfoundland
Abe Solberg	Memorial University of Newfoundland
Jin Gao	Memorial University of Newfoundland
Hoag Nguyenthe	Memorial University of Newfoundland
Natalie Fuller	Memorial University of Newfoundland
Allesandra Gentile	Memorial University of Newfoundland

APPENDIX 3. AGENDA

Zonal Peer Review

Assessment of Redfish in Northwest Atlantic Fisheries Organization (NAFO) Subarea 0, and Subarea 2 + Division 3K

Chair: Christina Bourne, Science Branch, DFO

May 04-07, 2021

Virtual Meeting – MS Teams Platform

Tuesday, May 04, 2021

Time	Activity	Presenter
10:00 am NL Time	Welcome/Opening/ToR	C. Bourne (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	D. Belanger
-	*Presentation*: Structure, Trends, and Ecological Interactions in the Marine Community	M. Koen-Alonso/ H. Munro
-	*Presentation*: Redfish Biology	D. Ings
-	*Presentation:* Redfish Habitat Utilization	B. Rogers
-	*Presentation:* Redfish catch in 2+3K	D. Ings
5:00 pm NL Time	End of plenary	-

Wednesday, May 05, 2021

Time	Activity	Presenter
10:00 am NL Time	*Presentation*: Improving Abundance Indices for NAFO Subarea 2 + Division 3K Redfish via a Spatio-temporal model	N. Fuller
-	*Presentation*: Subarea 2 + 3K Redfish Assessment	R. Kumar
-	*Presentation*: Subarea 0 Redfish Assessment	T. Loewen
-	Drafting of SAR Bullets Subarea 0, and for 2 + 3K	All
5:00 pm NL Time	End of plenary	-

Thursday, May 06, 2021

Time	Activity	Presenter
10:00 am NL Time	Continuation of SAR Bullet Drafting: Subarea 0 + 2 + 3K	All
-	Research Recommendations	All
-	Deliverable Summary	All
5:00 pm NL Time	End of plenary	-

A fourth day (Friday, May 07, 2021) has been added to the schedule in the event extra time is required for presentations or discussions.

Time	Activity	Presenter
10:00 am NL Time	TBD	-
5:00 pm NL Time	End of plenary	-

Notes:

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