Fisheries and Oceans Canada / Pêches et Océans Canada
Ecosystems and Oceans Science / Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat (CSAS)

Proceedings Series 2023/024

Newfoundland and Labrador Region

Joint Proceedings Report for the regional peer review assessment of Northwest Atlantic Fisheries Organization (NAFO) Subdivision 3Ps Atlantic Cod and the zonal peer review assessments of Redfish in NAFO Subarea 0, and Subarea 2 and Division 3K

Meeting dates: October 17-19, 2016 and October 19-21, 2016
Location: St. John's, NL

Chairperson: Darrell Mullowney
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July 2023

Foreword

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

Published by:

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

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

ISSN 1701-1280
ISBN 978-0-660-49067-0 Cat. No. Fs70-4/2023-024E-PDF

Correct citation for this publication:

DFO. 2023. Joint Proceedings Report for the regional peer review assessment of Northwest Atlantic Fisheries Organization (NAFO) Subdivision 3Ps Atlantic Cod and the zonal peer review assessments of Redfish in NAFO Subarea 0, and Subarea 2 and Division 3K; October 17-19, 2016 and October 19-21, 2016. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2023/024.

Aussi disponible en français :

MPO. 2023. Compte rendu de la réunion conjointe sur l'examen par les pair régional de l'évaluation de la morue de l'Atlantique dans la sous-division 3Ps de l'Organisation des pêches de l'Atlantique Nord-Ouest (OPANO) et l'examen par les pair zonal des évaluations du sébaste dans la sous-division 0, et dans la sous-division 2 et dans la division 3K de l'OPANO; du 17 au 19 octobre 2016 et du 19 au 21 octobre 2016. Secr. can. des avis sci. du MPO. Compte rendu 2023/024.

TABLE OF CONTENTS

SUMMARY

The joint meeting to assess the Northwest Atlantic Fisheries Organization (NAFO) 3Ps Atlantic Cod (*Gadus morhua*) stock and Redfish in NAFO Subareas 0, 2 and Division 3K was conducted October 17-21, 2016, at the North Atlantic Fisheries Centre (NAFC), St. John's, Newfoundland and Labrador. 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 NAFO Subdivision 3Ps Cod was last assessed in October 2015 (DFO 2016a). The aim of this meeting was to evaluate the status of the stock and to provide scientific advice concerning conservation outcomes related to management of the fishery. The current assessment is requested by Fisheries and Aquaculture Management to provide the Minister with detailed advice on the status of the stock in order to inform management decisions for the 2017 fishing season.

The status of NAFO Subarea 2 and Division 3K Redfish was last fully assessed in 2001 (DFO 2001, Power 2001). This meeting was requested by the Department of Fisheries and Oceans (DFO) and Aquaculture management to review the Limit Reference Points (LRPs), provide detailed advice on the status of the stocks, and inform management decisions for the 2017 fishing season. Subarea 0 has no history of commercial fishery for Redfish and has not been included in previous assessments. The meeting was asked to provide scientific advice on whether a commercial fishery in NAFO Subarea 0 would be sustainable, in support of ongoing evaluation of an emerging fisheries proposal to harvest Redfish in this area.

Participants included personnel from DFO Science, DFO Oceans, the French Research Institute for Exploitation of the Sea (IFREMER), Fish Food and Allied Workers (FFAW), Memorial University of Newfoundland, the Marine Institute's Centre for Fisheries and Ecosystem Research (CFER), the Groundfish Enterprise Allocation Council (GEAC), harvesters and processors.

REGIONAL PEER REVIEW PROCESS FOR SUBDIVISION 3PS COD

INTRODUCTION

The status of NAFO Subdivision 3Ps Cod was last assessed in October 2015 (DFO 2016a). The aim of this meeting was to evaluate the status of the stock based on the most recent data and to provide scientific advice concerning conservation fishery management. The current assessment is requested by Fisheries and Aquaculture Management to provide the Minister with detailed advice on the status of the stock in order to inform management decisions for the 2017 fishing season. Participants included personnel from DFO Science, DFO Oceans, the IFREMER, FFAW, Memorial University of Newfoundland, the Marine Institute's Centre for Fisheries and Ecosystem Research, the GEAC, harvesters, and processors.

The Terms of Reference (Appendix 1) listed several specific objectives for meeting participants:

1. Provide an ecosystem overview (e.g., environment, predators, prey) for the stock area.
2. Assess and report on the current status of the 3Ps Cod stock. In particular, assess current spawning biomass relative to baseline conservation thresholds (Blim), total (age 3+) biomass, exploitation rate, natural mortality, total mortality, and biological characteristics (including age composition, size at age, age at maturity, and distribution). Describe these variables in relation to historic observations.
3. Further to the previous assessment, analyze recent year class strength relative to previous observations, as it relates to long term growth and sustainability of the stock.
4. To the extent possible, provide information on the strengths of year-classes expected to enter the exploitable populations in the next 1–3 years.
5. Provide annual projections to 2019 based on the assessment of trends in the abundance index and other stock indicators, including associated risk analyses. Specifically, these analyses will include an assessment of the trends in the stock and in the risks compared to Blim.
6. Highlight major sources of uncertainty in the assessment of trends in the abundance index, biomass index, and other stock indicators, including associated risk analyses. Specifically, these analyses will include an assessment of the trends in the stock and in the risks compared to Blim.
7. Highlight major sources of uncertainty in the assessment, and where appropriate, consider alternative analytical formulations of the assessment.
8. Report on results of tagging and the distribution of this stock in other areas (e.g., 3L/3Pn).
9. Summarize the data collected during the spawning closure in 2016.
10. Calculate the suggested TAC as per the harvest control rules, which have been approved as part of the "3Ps Cod Conservation Plan and Rebuilding Strategy".

OCEAN CLIMATE AND INFLUENCES ON ATLANTIC COD

Presenter: E. Lee

A summary of oceanographic influences on 3Ps cod was presented, including analysis of trends in sea surface temperature (SST), water column stratification, bottom temperature, salinity, and the DFO multispecies survey. This area is more complex than most of the Newfoundland shelf due to interaction between local atmospheric climate conditions, the Labrador Current, the warm

Gulf Stream, and seafloor geomorphology. Satellite derived SST estimates, collected by the Pathfinder satellite and National Oceanic Atmospheric Administration (NOAA) satellites, show that 3Ps and St. Pierre Bank are generally warmer than most of the Newfoundland shelf (1981–2016). The annual cycle in SST ranges from approximately 0°C in the winter to 15°C in August. Positive SST anomalies were recorded throughout 2016 (January-September), with the exception of May which was cooler than average. Bottom temperature, recorded by trawl mounted CTDs during the multispecies survey, shows significant annual variability, with long periods of warm anomaly. Bottom temperature has been recorded above the time series normal from 2009–16.

NAFO Division 3Ps is considered a unique Ecosystem Production Unit (EPU) due to the complex oceanography and ecosystem structure. The warming trend recorded in 3Ps is the greatest of any EPU in the bioregion. The thermal habitat index shows an increase in warm habitat (>2°C) and a decrease in cold habitat (<1°C) since 1990. Historically, survey catches of cod were generally lower in years when relatively large incursions of cold/fresh Labrador Current Water dominated the shelf regions, indicating a thermal effect on cod distributions and their availability to the research vessel (RV) surveys. There was a positive correlation identified between temperature and cod abundance in shallow waters (<100 m); however, no significant relationship has been documented between occurrence of cod and temperature in deeper, warmer waters. These relationships are calculated through correlation between temperature and abundance in the DFO multispecies trawl survey and may also be related to changes in availability to survey gear or the distribution of sets in a given year. Cod temperature selection could be further explored by reporting the cumulative number of sets collected for each temperature profile and calculating the weighted mean of abundance by temperature.

ECOSYSTEM OVERVIEW: TRENDS IN THE FISH COMMUNITY IN 3PS

Presenter: N. Wells

Authors: M. Koen-Alonso

Abstract

There is a long history of fishing in this area, including fisheries targeting Atlantic Cod, Atlantic Herring (*Clupea harengus*), American Plaice (*Hippoglossoides platessoides*), Redfish, and Snow Crab (*Chionoecetes opilio*). In addition to fishery resources, 3Ps includes accepted significant benthic areas for large gorgonians and corals. Abundance in the DFO multispecies survey declined rapidly in the early-1990s and has remained relatively stable since that time. Overall biomass has declined; however, mainly due to smaller fish (e.g., sand lance [*Ammodytes americanus*]) making up a larger portion of the biomass. Biomass/Abundance was applied as a proxy for fish size within functional groups, indicating an overall decline in fish size across groups since the 1990s. Beyond functional groups, there are species-specific trends observed in the 3Ps survey data. Lumpfish (*Cyclopterus lumpus*), biomass has dropped significantly. Yellowtail Flounder (*Pleuronectes ferruginea*) account for the majority of the increase in the medium benthivore functional group. Thorny Skate (*Amblyraja radiata*), which are stable to increasing in 3Ps, dominate the biomass of the large benthivore functional group. Atlantic cod has historically been the dominant piscivorous (fish-eating) species in 3Ps. However, since 2010 there has been a sharp rise in the biomass of Silver Hake (*Merluccius bilinearis*), typically considered a warmer-water species. The increase in Silver Hake biomass may be linked to the warming trend in this ecosystem. Shellfish biomass is declining in 3Ps, with the notable exception of *Pandalus montagui*, considered an artic/boreal species, which is now showing the greatest increase in warming 3Ps waters.

Discussion

Diet and consumption estimates were also calculated, based on the survey biomass and analysis of stomach contents. Approximately 1–2 million tonnes (t) of biomass are consumed per year across all functional groups, mostly by medium and large benthivores. It is of note for this meeting, that the Silver Hake is considered a potential competitor for Atlantic Cod and have been increasing in biomass and estimated consumption in 3Ps. Atlantic Cod spring diet has been variable over the time series, made up of primarily Redfish in 1993–95, shifting to small pelagics like Capelin (*Mallotus villosus*) and sand lance in 1996–97. In recent years, crab has become a larger portion (40%), though sand lance and other invertebrates are also important prey. Silver Hake appear to have a diet composition much more similar to Redfish; however, this is based on a single year of stomach contents data so far. These differences appear to be connected to distribution; cod in 3Ps are mainly found at the North and South mouths of the channel, while Silver Hake are distributed throughout the area. The difference in diet and distribution led the author to conclude that hake are not a significant competitor for cod in 3Ps. Preliminary data indicates that crab may also be an important food source for Thorny Skate. Few other species in 3Ps prey on Snow crab. However, increases in Silver Hake biomass and occupied area have also been recorded in the Bay of Fundy with seasonal warming. Representatives from GEAC cautioned against the assumption that the distribution recorded in the spring survey would apply year-round. DFO Scientists involved in the ecosystem overview agreed that the spring snapshot is a limitation that applies to all species. There may be more significant overlap, and thus competition, between Atlantic Cod and Silver Hake later in the year.

Total consumption estimates reported as tonnes per year, are driven by biomass in the absence of a reliable estimate of total abundance. For this reason, the estimate is generated as a range from a 3-model envelop instead of a precise point-estimate. However, participants raised concern that the consumption estimate is limited by an assumption that survey Q is 1 for all species. Without a reliable estimate of Q for each species, it is impossible to make an absolute estimate of consumption. This figure can only be discussed as a relative trend. The variability of cod diet composition over time was also discussed. In general, flexibility in diet should improve the species resilience to changes in prey availability. However, in this case, cod have adapted to declines in the availability of high-value prey like Capelin by transferring to poor quality (i.e., lower nutrient/energy density) prey in many years. It was noted that observed patterns in cod diet do not appear to follow changes in biomass of the prey species. Redfish were the most important prey in the mid-nineties, while Snow Crab has become more important recently; over that time period (mid-1990s to present) crab biomass declined while Redfish appear relatively stable.

Harvesters reported significant changes in the system; compared to historic levels, harvesters are seeing very little baitfish. One harvester, describing the loss of Capelin and Atlantic Mackerel (*Scomber scombrus*), said “the bay is empty.” Both harvesters and scientists also commented on the poor condition of cod in 3Ps fisheries and survey tows. Members of both groups requested a presentation of condition data. Conditions and changes in weight-at-age indicate changes in production, which impact the stock surplus available for a sustainable fishery. Considered besides the climate and oceanographic data, the findings on ecosystem structure and condition indicate that there are changes in the 3Ps system that are not yet understood but appear to be negatively impacting the cod population.

REVIEW OF THE 2015/16 FISHING SEASON AND 2016/17 SEASON TO DATE

Presenter: D. Coffin

Abstract

The 3Ps cod fishery employs several eligible gear-types, including gillnets, hook and line, and otter trawl. Cod pots are also eligible, though not currently in use. Monitoring of this fishery includes dockside monitoring (100% coverage), at-sea observers (1% coverage), at-sea hail when vessels are landing outside Newfoundland, mandatory logbooks, and vessel monitoring systems (VMS) on the >35' fleet. Dockside monitoring is tiered by traffic; tier 3 or 4 landings can be authorized without a monitored weight. In 2014 (the most recent data available), 87% of landings were weighed by a dockside monitoring officer, down slightly from a high of 95% in 2010. Due to the quota structure, managers believe there is little incentive to misreport catch. However, it is highly likely that discards are un- or under-reported.

The 2014–15 Total Allowable Catch (TAC) was set at 13,000 t; however, only half of this quota was taken (52%). The 3Ps fishery has consistently failed to meet or even approach the TAC; the French fishery in St. Pierre and Miquelon is following the same pattern, taking 38–40% of the quota in recent years. Quota reallocation is available for active fishers; if a harvest has filled their individual quota (IQ), they may apply to expand the IQ; 92 reallocations have been approved so far, totaling 869 mt. Reallocations are not managed spatially. The season end dates vary by year. The default season for the inshore fleet is May 15 to February 28; however, the season was extended to March 31 in 2014 and to March 6 in 2015. The management for this fishery also includes size-based triggers for closure: if >15% of the catch is under 45 cm, the fishery can be closed for up to 10 years. A size-based closure has not been applied in the last five years.

Discussion

Harvesters provided comment on the issue of discards. It was not felt by participants in the meeting that discards are a significant problem in gillnets, however there was serious concern raised about small fish being discarded from otter trawl catches. In other stocks, there has been an increasing shift to handline gear, which results in fewer discards. In 3Ps; however, gillnets are still the most-used gear type.

CATCH AND SURVEY TRENDS

Presenters: R. Rideout, D. Ings, and D. Maddock Parsons

Abstract

The 3Ps cod stock was last assessed in October 2015. The DFO multispecies survey is the basis for assessment in a cohort model (survey-based assessment model [SURBA]). Based on this model, the stock remains in the cautious zone. Recruitment has improved over the last decade, with strong cohorts in 2011 and 2012. Estimated total mortality has also been increasing since 1997. Despite lower TAC, the average total mortality was estimated to be 0.65% in the years 2012–14. Recent trends in mean size, weight at age, fish condition, and age at maturity are at or near the lowest observed levels. These indicators point to decreased productivity in the stock despite the strong recruitment events recorded in 2011 and 2012.

Discussion

Catch

The 3Ps fishery has been dominated by gillnets since the moratorium. TAC is relatively consistent year to year, with an 84%/16% split between Canada and France. Recreational fishery removals are unreported. Total landings in the commercial fishery have been about half the TAC since 2008.

Although the catch data is presented in the Science Advisory Report (SAR) for this stock, they are not applied to the assessment of 3Ps cod. There has been no intersessional work to establish the quality or utility of the catch data for the purposes of a stock assessment. There is a catch data working group, that has made significant progress with the upcoming recreational fishery tag program; however, there have not been developments on commercial catch data for this area. Management has requested a framework assessment for 3Ps cod, and the use of catch data in the stock assessment would be discussed at that time. Several participants acknowledge this as a potential limitation of the stock assessment model.

RV Survey Data

The weight of catch was lower in 2016 than in 2015; however, the spatial distribution of the catch was uneven. Of 45 strata, 60% of the biomass was caught in a single stratum (309) in 2016. One or two very large fishing sets may lead to inaccuracies in the estimate. For example, a stratum with only 2 or 3 sets in which one caught 800 t and the other caught nothing would generate a very high estimate that may be far from the truth. A representative of IFREMER noted that spatial distribution of the catch, and the influence of few large catches on strata estimates are recurring issues. With so many strata, time and resource limitations mean that some strata are only sampled with one or two fishing sets in many years. Several potential solutions were suggested, including a redesign of the survey, avoiding over-stratification. In shellfish assessments, a function is applied to the biomass estimates to smooth over the survey area, instead of estimating each stratum individually. The problem could also be solved by collecting more sets in each stratum. Although 178 sets are allocated, only 130–150 are collected each year due to time or weather limitations.

Some strata were incomplete in 2016. A GEAC representative suggested that it may be helpful to address the gaps by interpolating from the results in nearby sets. Analysis of consistent areas of promise over time was also suggested and supported by many meeting participants. However, many of the suggested changes or additions to the data analysis methods are limited by available time and capacity of DFO technicians.

RV Population Age Structure

The majority of the survey catch is made up of the 2–6-year classes. Catch scaled by age-class indicates that the most recent survey catches are lower than previous years, especially in the older age classes. Split indices were reported for the Burgeo Bank, Eastern region, and inshore. Decline has been observed across all three areas in recent years. The abundance indices peaked in 2013; however, the presenter and meeting participants agreed that this peak is likely a year effect. The inshore RV catch shows relatively low biomass over the time series, and the decline in this area is less significant than the other two areas. Age composition analysis indicates that the 2016 catch on Burgeo Bank contains older fish; however, this is based on a single catch. No Atlantic Cod over 7 years old were caught anywhere in 3Ps in the 2016 survey. The origin of the Burgeo Bank fish is unclear; otolith chemistry indicates that they may be a part of the Northern Gulf of St. Lawrence stock. The distribution of the survey sets was raised again as a limitation of this data set. For example, it was noted that some areas of high catch in 2014 and 2015 were not surveyed in 2016.

The presenter of this dataset proposed that the distribution-at-age plots provide sufficient information without splitting the indices. Split indices face the potential problem of variability year to year due to the small area surveyed for each. However, because the Burgeo Bank fish may represent a different stock, participants from GEAC and the Marine Institute felt that a combined index may be misleading. For example, a strong year class in the Burgeo Bank, driven by conditions affecting a separate stock in the Northern Gulf, may lead to overestimation of the 3Ps Atlantic Cod population. For this reason, the meeting agreed to keep the split indices as presented. The meeting also recommended further research to establish the stock identity of the Burgeo Bank fish; if a significant portion of that catch is part of the 4R or 3NO stocks, the 3Ps cod may be in a much worse state than current analyses suggest.

Biological Data

All measures of biological condition show a consistent and significant decline. Average deviation from the mean length was presented as a summary of length at age trends for all ages. Among all ages of 3Ps cod, length at age shows a declining trend. The 2016 survey catch represents the lowest length at age for the entire time series. Mean weight at age shows a similar declining trend, with significant decline in the years 2012–16. Cod condition, measured by the liver index, has been below average in 2014–16. Gutted condition has also been below average since 2014, and the results of the 2016 survey are the lowest of the time series. The age at 50% maturity shows a similar pattern of long-term decline.

Overall, the biological data presents an alarming picture for the future of the stock. Participants questioned how to best apply this information to the biomass-based assessment and harvest control rule. It was generally agreed that under an ideal management strategy, additional risk aversion would not be necessary based on the biological data presented. However, for this stock, the current harvest control rule is not functioning as intended, demonstrated in part by the fact that only half of the TAC has been taken in recent years.

Survey data indicates that 3Ps cod are maturing earlier, which may contribute to higher production. However, the high mortality rate and loss of older fish seem to negate any increase in productivity. In short, recruitment indices appear to be positive, however the fish are not surviving long enough to reproduce. It was also suggested that poor body condition may simply signal a prioritization of gonadal growth. Liver condition represents short-term storage of energy that is used to build gonads; depending on when sampling occurs relative to spawning, this index may deliver different results. Measures of growth and gutted condition represent long term storage of energy. In this case, the two indices agree; condition is declining beyond a reallocation of energy to gonadal growth. In seven of the last ten years condition has been below average for both liver and gutted condition indices. Growth is also substantially below average; almost all of the 3–9 age classes have been recorded at lower-than-average length in the past three years. Harvesters agreed with these findings. Participants at the meeting reported that recent fishing seasons have been marked by very poor condition. One harvester described recent catch as “big-headed fish with long, skinny bodies.” When these fish are gutted, harvesters typically find crab and smaller cod in their stomachs. Notably, harvesters report that Capelin are missing from the cod stomachs. Members of the processing industry were also concerned about “slinky, starved-looking fish” in the catch, and reported that conditions appear to be getting worse in the most recent fishing seasons.

The full implications of observed early maturation, high mortality, and poor condition are unknown, however, these circumstances point to low productivity in the stock. Poor condition may also indicate that the high mortality observed in this stock is the result of bottom-up processes (i.e., starvation). Meeting participants agreed that these findings are a cause for serious concern among scientists, managers, and industry.

Sentinel Survey

The 5’ gillnet and line trawl sentinel survey has undergone a decrease in effort and catch rate since 2003. The 3.25’ gillnet net sentinel survey catch rates have varied without trend over the same time period. Catch rates in 2015 are below the series mean for all gear types.

The RV survey results indicated a strong 2011 cohort, but this signal is not picked up by the sentinel survey. No strong cohorts have been tracked in the standardized sentinel datasets since the mid-1990s. Condition data for the sentinel survey in 2015 was not yet available at the time of the meeting, however, in previous years conditions trends observed in the RV survey have matched well sentinel survey findings.

POPULATION DYNAMICS OF 3PS COD

Presenter: B. Healey

Abstract

No abstract provided.

Discussion

The SURBA results are based on a survey model of total mortality with log-normal fitting and inter-annual smoothing. This model remains relatively unchanged over the past decade.

The age structure of 3Ps SSB and mortality rates were discussed as causes for concern. Total mortality (Z) appears to be increasing over the time series, with a more rapid increase in the past three years. Among ages 5–10, Z was at its highest recorded value in 2015. Overall Z was reported at 0.7 (47% annual survival for 2015). Positive recruitment was recorded throughout 2005–11, with a series high in recruitment in 2011. However, recent year classes are at or below recruitment average. When mortality and recruitment are examined together, it appears that the strong 2011 cohort is dying out, and current recruitment rates cannot match that loss. The composition of the Spawning Stock Biomass (SSB) in 2016 is very young; 46% is made up of 4 and 5-year-old fish. The median age of SSB is in strong decline.

Very high biomass values were recorded by the RV survey in 2013, which has impacted model predictions to date. This spike is likely an artefact of the survey (i.e., year effect). Retrospective analyses indicate that SSB was overestimated in the years following 2013. The 2014 SSB was determined to be in the healthy zone during the last assessment; however, retrospectives presented at this meeting have reduced the survey biomass estimate by 22%. Due to the nature of the Precautionary Approach (PA) framework, small changes in the estimate can have large impacts on management for a stock that is close to threshold levels. The persistent overestimation of SSB revealed in the retrospectives led participants to request additional model runs, employing higher and lower shrinkage parameters. These tests did not yield significantly different model predictions. The overestimation of SSB appears to be related to the high 2013 survey results. As additional years are added to the model time-series, the 2013 and subsequent year class estimates have been lowered. It was suggested that the results of the 2013 survey should be underweighted or adjusted to reduce bias in the model predictions; however, it was not possible within the meeting scope to identify a defensible, quantitative way to correct the 2013 estimate, or to generate a smoothing factor applicable to the entire time series.

The weight at age results for 2015 were not available at the time of the meeting. The weight keys from 2012–14 were applied to the most recent catch. However, the biological trends indicate that weight at age is declining, and this may lead to overestimation of the stock.

Further, meeting participants pointed out that the Harvest Control Rule (HCR) does not account for declining weights; as individual weights decrease, the same TAC will cause additional mortality. The meeting was asked to use the SURBA to estimate stock status and calculate TAC based on the HCR; however, following a lengthy discussion of survey trends and SURBA results, many participants expressed serious concern about whether the existing process provides sound scientific advice for this stock. Similar concerns were raised in the previous SAR (DFO 2016a), however, the TAC calculation was completed and applied by managers at that time.

The 3Ps cod stock is currently in the Cautious Zone as defined by the DFO PA framework. There were strong concerns related to the decline of SSB since 2012 and updated estimates place the stock at only 18% above the lower limit reference point (LRP; $B_{recovery}$=SSB1994) in 2016. Due to the associated uncertainty in stock size estimates, there is a high (n=0.22) probability that the stock could actually be in the Critical Zone (i.e., below the LRP). The fishery has achieved about half of the TAC in recent years, which participants view as a sign that the current assessment model and HCR do not deliver appropriate management advice for this stock. Several members of the meeting advised against calculating the 2016–17 HCR catch allowance. Once the TAC is provided, meeting participants believed that it would be applied, as it has in previous years, despite significant limitations. Other participants felt that, as the TAC was requested in the Terms of Agreement, it should be provided. Some argued that it is more logical to provide the TAC calculation in order to demonstrate that it is not appropriate, considering the condition of the 3Ps cod stock. Following an extensive debate on how to proceed under these circumstances, participants agreed that uncertainty was too high to support projections and that the TAC calculations would be inappropriate based on the history of the stock and recent data on age composition, mortality, and biological condition.

Projections were generated for this stock based on the recruitment geometric mean for 2013–15, the weights-at-age from 2012–14 and the maturity at age generated from the cohort estimation model. The 3Ps cod stock is projected to increase until 2017 due to growth in the strong 2011-year class. However, the stock projections decline rapidly after 2017, due to high mortality in the older age classes. If mortality rate remains at the current level, the stock is projected to be approximately B_{lim} (1.07) within three years. It was noted that even these estimates may be optimistic; the only growth expected in the stock is related to a single year class. if the 2011 cohort does not perform as well as expected, the stock may decline even more rapidly.

UPDATE ON TAGGING IN 3PS

Presenter: J. Brattey

Abstract

The recent time-series of tag data begins in 2007, with limited spatial coverage. The recreational fishery makes up a small portion of the tag return in that time (up to 10%). High-low tag rewards are used to estimate reporting rate. There is a slight decline in the inshore reporting rate (mean of 0.77 for the time-series, 0.68 in 2015). There is no trend in the offshore reporting rate (mean of 0.66 for the time-series, 0.66 in 2015). The exploitation rate is calculated based on initial tagging mortality, Kirkwood's model of tag loss, tag reporting rates, and fixed natural mortality.

Based on an M=0.2 scenario, if the full TAC was taken in the fishery, the harvest rate would be 25–32%. Results were similar under M=0.4. However, the portion of the TAC that is taken ranges from 42–54% in recent years. Exploitation of the stock outside of 3Ps appears to be

minimal; 2.3% of tag returns have been captures in 3KL since 2011. Participants agreed that the biological indicators presented at this meeting suggest that mortality rate is higher than 0.2. While harvest rate appears to be relatively low, the fishery combined with high natural mortality may be detrimental to the future of the stock.

SPAWNING CLOSURES

Presenter: R. Rideout

Abstract

Gillnets and trawls have been shown to disrupt cod spawning behaviour (Morgan et al. 1997). A seasonal closure of the 3Ps stock area was announced in 2000 which excludes the fishery from March to mid-May of each year. In general, closures are enacted as an intuitive measure to protect spawners and improve stock production. However, there is a lack of empirical evidence that the closures improve recruitment.

Cod collected by observers on commercial vessels in March of 2015 were examined for reproductive status. Females classified at-sea as “spent” were found in the lab to be skipped-spawners, rather than recently spent. No spent fish were identified in the March samples, indicating that spawning had not started at that time in the season. Measurements of developing oocytes indicate that very few fish were near spawning and histological analysis of the largest eggs indicated that none of the ripening fish had begun spawning. Survey maturities from April were also considered; few fish were found to be spawning at that time. There was no segregation observed between spawning and non-spawning individuals of the same size.

Discussion

Based on these results, spawning appears to occur in April-June for 3Ps cod, with the spawning ground behaviour beginning earlier in March. The March 1 closure date likely protects early or pre-spawning behaviour; however, the mid-May closure end date is not sufficient. A closure end-date of June 30 was proposed to provide protection throughout the spawning period. Concern was raised by harvesters that variability in the timing of pre-spawning behaviour may lead to increased vulnerability, as pre-spawning aggregations have been reported as early as January and February in some years.

Several participants were interested in the implications of the presence of skipped spawners, and the possible connection to declining condition among fish sampled in recent years. Previous research into skip spawning in 2J3KLNO was linked to condition (Rideout et al. 2006). Efforts were made to improve the SSB estimate by accounting for the occurrence of skip spawners, however in that case the revised SSB estimate was not found to improve the modeled stock/recruit relationship. A key limitation to research on this topic is the availability of skip spawner data, which cannot be readily collected at sea. It is not possible to identify skip spawners without histology, which is rarely collected. Establishing a relationship between condition and skip spawning is further complicated by survey timing; a poor-condition fish may a skipped-spawner, but two months later these skipped-spawners may be in better condition than the fish who did invest limited energy into egg production. Harvesters present at the meeting reported that this phenomenon is not new in 3Ps. Previous research also suggests that 3Ps has always had a relatively high rate of skip spawning (Rideout et al. 2006).

HARVESTER QUESTIONNAIRE

Presenter: E. Carruthers

Abstract

No abstract provided.

Discussion

A telephone survey of 3Ps inshore license holders is conducted annually by the FFAW. In 2015, the survey returned 87 responses from harvesters aged 35–77, with an average of 36 years' experience in the fishery. The majority of respondents were from the <35' fleet, primarily fishing with gillnets. No significant changes in soak times or distance from shore were reported (usually 24–36 hour soak times). Some respondents also reported use of handlines and longlines. Many expressed concerns about baitfish; reports throughout the area for Capelin and squid abundance were extremely low. Herring, mackerel, and sand lance appear to be more abundant, although most herring present were reported to be very small individuals. Cod stomach contents reported by harvesters were dominated by shrimp, crab (including Rock Crab [*Cancer productus*], Toad Crab [*Hyas araneus*], and Snow Crab), stones, and worms. Reported seal abundance and seal bycatch increased in 2015. Harvesters present at the meeting also reported increase abundance and bycatch of Blue Sharks (*Prionace glauca*).

Tag returns were lower than expected-only 50% of harvesters who caught tags reported that they were returned. However, the small sample size of the survey may not be comparable to the large-scale calculation of tag reporting rates based on the high-low tag system.

Most harvesters reported that cod were in good body condition, which is inconsistent with the survey results from 2015. Researchers noted that this discrepancy may be due to differences in survey and fishery timing. Condition reported by the fishery in the fall may not be comparable to spring condition. Harvesters present at the meeting and industry representatives reported poor condition among fish catches and among fish reaching the processing plants.

UPDATE ON THE HARVEST CONTROL RULE FOR 3PS COD

Presenter: P. Shelton

Abstract

No abstract provided.

Discussion

The objective of the HCR is to maintain SSB in the healthy zone at or near SSB_{MSY}. There is no timeframe or probability given by the HCR for this recovery goal. The Integrated Fisheries Management Plans (IMFP) framework requires measurable objectives (DFO 2016b). At the time of this meeting, measurable objectives were not provided for Atlantic Cod in 3Ps. The IMFP for 3Ps includes a sustainability checklist updated in 2015, which may support future assessments. The time and scope of this meeting did not permit a detailed examination of this checklist.

The 3Ps cod SSB index recovered rapidly after 1994, which suggests that the stock level at that time was sufficient to support recruitment and recovery. The limit reference points identified by the HCR for 3Ps cod are based on the 1994 SURBA estimate. The lower reference is equal to the 1994 SSB point estimate, and the upper reference is double that figure. The cautious zone rules are clearly defined and simple to calculate; critical zone rules are more subjective and difficult to identify clearly. Fundamentally, F should not exceed F_{MSY}; however, F_{MSY} remains unknown.

Simulations were used to test 3Ps cod management strategy, specifically the concern that the initial TAC was too high to form the basis for an appropriate HCR. Simulated management scenarios began with a population in the middle of the identified Cautious Zone, under the assumption that an equilibrium TAC would maintain biomass at that level. Simulations indicate that if the TAC was scaled up, SSB rebuilding continues up to 1.4x current TAC. However, at 1.6x current TAC, the fishery collapses. In general, the simulations indicate that the HCR in its current form can lead to rebuilding in the simplified simulation scenarios. However, catch is currently below estimated Maximum Sustainable Yield (MSY) for the stock, which indicates that the fishery cannot rebuild under current conditions due to some unmeasured phenomena. The presenter emphasized that fisheries management should aim to provide long term benefits for all Canadians. In the case of 3Ps cod, the rebuilding rate is very slow and should be incorporated into management efforts. The challenge remains that Q and absolute SSB remain unknown for this stock.

CONCLUSIONS

The key messages presented at this meeting were that the older fish in the 3Ps cod population are experiencing very low growth and high mortality. Analysis of diet suggested that food quality and availability are insufficient, leaving cod in poor condition and at high risk of early mortality following spawning events. Although meal sizes are in the lower range documented in the time series, poor condition appears to be more connected to food quality. The proportion of crab, a low energy-density prey, in 3Ps cod diet is increasing over previous staples, including Capelin, Redfish, and sand lance.

Several participants expressed that the 3Ps stock assessment is subject to exceptional circumstances. Current SSB is driven by two young adult year classes that are facing extremely high mortality rate; these fish are likely to disappear in the next 3 years and there are no following year classes to replace them in the fishable biomass. The standard stock assessment tools, SURBA and the HCR, do not account for the skewed SSB year-class composition and high mortality which brings significant doubt into any resulting advice for management. Concerns related to SURBA include the persistent SSB overestimation in the retrospectives, the lack of updated weights for 2015, and the high probability (0.22) that the stock may already be in the critical zone. In addition, the biological parameters show worrying decline in the stock. Results presented at this meeting strongly indicate that unless something radically changes in this environment, the remaining cohorts will continue dying at young ages. No clear diagnostic was presented to validate or invalidate SURBA results, however meeting participants were unanimous that if a SURBA-based TAC similar to previous years (approximately 13,000 tons) was fully taken in the next season, it would be a disaster for the 3Ps cod stock. The stock indices are approaching the critical zone. In 2015, calculations indicated that the stock was at 1.4x B_{lim}; updated analysis in 2016 shows that it was only 1.1x B_{lim}. The meeting reached general agreement that uncertainties were too great for the SURBA model results to be used to generate reliable projections, or to be applied to the HCR and TAC calculation.

RECOMMENDATIONS

Several participants expressed frustration and concern that the meeting was lacking key data updates and model diagnostics. A framework meeting was recommended to evaluate the data and methods used to assess this stock. Regarding the inputs to the assessment, specific recommendations included analysis to test the inclusion of survey weight-at-age, instead of commercial weight-at-age, or weigh-at-age based on a cohort growth model.

Recommendations were made to update or replace the SURBA model:

- Evaluation of SURBA sensitivity to year-effect through simulation testing.
- Investigate SURBA parameter changes (ex. shrinkage) to address the retrospective overestimation bias.
- Review of alternate methods for analysis of survey data (e.g., generation of bootstrapped confidence intervals, geospatial analysis).
- Exploration of alternative models that incorporate catch age composition and treats catch as uncertain.

Directions for new research were also suggested; several participants recommended development of research projects to investigate 3Ps cod stock structure and stock identity. In particular, questions were made regarding potential stock identity issues with Burgeo Bank and Halibut Channel fish. Investigation of stock identity may include otolith analysis, strategic spatial distribution of survey efforts, and/or further tagging studies.

ZONAL PEER REVIEW PROCESS FOR NAFO SUBAREA 0, AND SUBAREA 2 & DIVISION 3K REDFISH

INTRODUCTION

Three species of Redfish are present in the Northwest Atlantic; Deepwater Redfish (*Sebastes mentella*), Acadian Redfish (*S. fasciatus*), and Golden Redfish (*S. marinus*). These three species are currently managed as a species complex. The status of NAFO Subarea 2 and Division 3K was last fully assessed in 2001 (DFO 2001, Power 2001). This meeting was requested by DFO Fisheries and Aquaculture management to review the LRPs, provide detailed advice on the status of the stock, and inform management decisions for the 2017 fishing season in Subarea 2 and Division 3K. Subarea 0 has no history of commercial fishery for Redfish, and has not been included in previous assessments. The meeting was asked to scientific advice on whether the population can support a commercial harvest in NAFO Subarea 0, to support ongoing evaluation of a proposed fisheries for Redfish in this area. Participants included personnel from DFO Science, DFO Oceans, FFAW, Memorial University of Newfoundland, the Marine Institute Centre for Fisheries and Ecosystem Research, and representatives from the fishing industry, including the GEAC.

The Terms of Reference (Appendix I) lists several specific objectives for Subarea 2 and Division 3K, and Subarea 0.

Objectives for Subarea 0:

1. Provide an ecosystem overview (e.g., physical oceanography) for NAFO Subarea 0 and an overview of the biology of Redfish.
2. Assess trends in catch-effort and biological data (e.g., distribution, abundance, length-frequency) collected up to 2015.
3. Provide advice on allowable harm, including bycatch for each species within NAFO Subarea 0, and identify associated uncertainties; and,
4. Discuss current knowledge gaps and research needs.

Objectives for Subarea 2 and Division 3K:

1. An ecosystem overview (e.g., physical and biological oceanographic environment, predators, prey) for NAFO Subarea 2+Division 3K.
2. A description of the biology of Redfish and their distribution.
3. A description of Redfish landing as by-catch in other fisheries.
4. And update of abundance and biomass indices derived from the DFO RV survey, including size structure and geographic distribution of catch.
5. Analyses of relative year class strength of Redfish as it relates to long-term growth potential.
6. Assessment of the impact on biomass trajectory of allowing relative harvest rates of up to 3% of survey biomass, using a 3–5-year average survey biomass to monitor change, and calculate TAC.
7. Evaluate the current LRPs for this stock (DFO 2012). If they are still considered valid, determine stock status relative to the LRPs. However, if they are found to be invalid, determine an appropriate proxy; and,

8. Identity information that could be collected through the DFO RV survey and/or commercial fishery to help future assessments and aid the evaluation/establishment of species-specific reference points in the future.

PHYSICAL AND BIOLOGICAL OCEANOGRAPHIC UPDATE

Presenter: E. Colbourne

Abstract

The North Atlantic Oscillation (NAO) is currently in a positive phase, which is expected to produce cold anomalies in the Labrador Sea, the Newfoundland Shelf, and extending to the Northern Scotia Shelf. However, current conditions are warmer than normal within the 1981–2010 reference period. In 2016, March-April sea ice was more extensive than normal; however overall, 2016 ice cover (January-June) was below the long-term mean. The Atlantic Multi-decadal oscillation (AMO) is in above normal conditions, with a dramatic temperature increase in recent years. Based on this pattern, it is reasonable to expect that warm conditions will continue for the next two decades. Over the past 30 years, mean air temperature has increased approximately 2 degrees. Similarly, average water column temperature has increased one degree since 1990, coinciding with fresher conditions. Salinity is approximately half a standard deviation below normal for the last five years.

The Atlantic Zone Monitoring Program (AZMP) collects hydrographic and meteorological data off the coast of Newfoundland. Results of the 2014–15 surveys showed an above average Cold Intermediate Layer (CIL); however, CIL was below normal in 2016. Warm conditions on the Hamilton Bank persisted through the summer of 2016. In general, temperature has increased from below average in 2014–15 to near average in 2016, with fresher than normal salinity. The Atlantic Zone Off-shelf Monitoring Program (AZOMP), led by the Bedford Institute of Oceanography (BIO) provides an offshore complement for the AZMP. Temperature cross sections from Labrador to the West Greenland shelf provide a comparison between 1994, when conditions were very cold, to record warm anomalies in 2011 which extend to depths of 3,000 m. There has been some decrease in water column temperature in 2014 and 2015. Weather station data also provides water column temperature in the Labrador Sea since the early-1950s. Warm conditions in the 1960s and 70s extended through the water column to bottom. Conditions cooled significantly throughout the 1990s, followed by the recent warm period. A composite climate index for the area is derived from 27 meteorological, ice, and ocean temperature, and salinity time series. The index has varied in recent decades from the time-series low (i.e., cold conditions) in 1991 to the highest levels on record in 2006 and returning to very low levels in 2015. Results from 2016 show the system recovering to series mean.

Discussion

No discussion occurred.

ECOSYSTEM OVERVIEW

Presenter: N. Wells

Abstract

Ecosystem trends and fish community structure are analyzed at the scale of Ecosystem Production Units. The core data for ecosystem analysis are collected by the DFO RV Fall Survey for NAFO Divs 2J3K. Shellfish biomass is available only from 1995 onward, following the

shift to the Campelen trawl gear. Diet composition of key predators is derived from stomach contents collected during the 2008–15 DFO RV Surveys in 2J3K and 2H.

Groundfish biomass and individual fish size declined drastically in the late-1980s and early-1990s. There are consistent signals of rebuilding since the mid to late-2000s. Moderate changes in the relative proportions of functional groups within the community has been accompanied by increases in mean fish size. Redfish are part of the plankton-piscivore functional group, defined as species that begin their life-history eating plankton, and shift to eat smaller fish as they grow. During the groundfish rebuilding period, shellfish biomass has declined and plank-piscivore biomass has increased. Redfish account for the majority of the increasing trend in their functional group. Analysis of Redfish stomach composition showed diverse and variable diet, dominated by amphipods, copepods, and Capelin.

Analysis of diet composition among other functional groups indicates that there is low to moderate predation on Redfish. Turbot appear to be the most significant predator of Redfish (up to 30% of diet composition). Atlantic Cod and American Plaice are also minor predators.

Discussion

No discussion occurred.

REDFISH BIOLOGY AND DISTRIBUTION

Presenter: E. Lee

Abstract

Redfish found on the northeast Newfoundland and Labrador Shelves (NAFO Subarea 2+Div.3K) include three distinct species, *Sebastes mentella* and *Sebastes fasciatus*, which dominate commercial fisheries, and *Sebastes marinus* which is much less abundant. *S. mentella* and *S. fasciatus* are visually and anatomically very similar, and historically they have not been separated in commercial catches or in research vessel surveys. *S. marinus* can be distinguished by color, eye size and the relative size of a bony protrusion on its lower jaw. The three species are not separated in the fishery and are managed together as a species complex.

Redfish are found in cold, deep water. Although the three species of Redfish overlap in much of their distribution, the two more common species *S. mentella* and *S. fasciatus* show some separation in depth and latitude. *S. fasciatus* are more abundant in slightly shallower water (150–300 m) than *S. mentella*, which are most abundant between 350–500 m. A geographical distribution cline has been observed in the Northwest Atlantic with *S. mentella* dominating biomass in the northern range (Davis Strait) while *S. fasciatus* is the dominant species in the southerly range (Gulf of Maine and Scotian Shelf). The two species overlap in roughly equal abundance in the Gulf of St. Lawrence and Labrador Sea. Redfish spend most of their time near-bottom, however they have been recorded participating in diel migrations into the water column following prey.

Redfish have very long lifespans; they frequently reach 40 years of age, and individuals may live up to 75–80 years. Males of *S. mentella* reach maximum lengths of 40–45 cm; females reach 45–60 cm. The maximum length for both sexes of *S. fasciatus* is approximately 45 cm. Growth rates are slightly higher among *S. mentella* than *S. fasciatus*. A latitudinal cline is also observed in Redfish growth rate, with fish in the southern areas growing faster than fish from the northern areas.

The estimated age at maturity for SA2+3K *S. mentella* is approximately 15 years for females and 13–14 years for males. The estimated age at maturity for *S. fasciatus* is approximately 10 years for females and 8–9 years for males. Redfish fertilization is internal, and Redfish bear live young. Breeding occurs in the fall to early winter (September-December) and larvae are released the following spring to early summer (April-July). Redfish dispersal is believed to occur mainly in the larval stage; however, large scale adult movements are possible due to the long life span of the species. Juveniles usually settle to the bottom by the fall of their first year.

Recruitment success is inconsistent and episodic, with significant year classes in healthy populations occurring at 5–12-year intervals or more. In some cases, Redfish may go much longer between recruitment events, up to 25 years. Although Redfish live long, grow slowly and mature late, they are not true K-strategists. When recruitment is successful, they may produce millions of larvae at a time.

Discussion

No discussion occurred.

REDFISH GROWTH CURVES

Presenter: N. Cadigan

Abstract

Previous efforts to establish Redfish growth parameters have been limited by the difficulty distinguishing species, identifying annual increments at different ages, or due to the use of whole otoliths or scales, which may introduce age underestimation bias. For this study, growth curves were estimated through a hierarchical population growth model based on a validated age dataset of >900 otoliths from *S. mentella* and *S. fasciatus* (Campana et al. 2016).

Overall, *S. mentella* grow to larger sizes than *S. fasciatus*, with one exception: in 3LN, the two species were found to have very similar growth rates. In all areas, females of both species grow to larger sizes than their male counterparts. Of all the areas sampled and modeled for growth rate, 3O showed the lowest growth rates and smallest sizes at age. The author of this work suggested that the methods and findings presented may contribute to a length-based assessment. However, this type of work requires a good understanding of species structure which is not available throughout the time-series. Species identification is further complicated by evidence of hybridization between *Sebastes* species (Roques et al. 2001). Back-casting will be difficult, and relative species composition of the biomass may change dramatically over time due to asynchronous episodic recruitment among Redfish species. The slow growth rates demonstrated for *Sebastes* spp also limit year class tracking; it is very difficult to distinguish fast-growing young fish and small older fish.

Discussion

Meeting participants also noted that establishing LRPs for Redfish will be a significant challenge, largely due to episodic recruitment. In the Gulf, Redfish were driven down to their lowest recorded level, yet experienced record recruitment in 2011. That may suggest that the biological B_{lim} for these species is very low.

ASSESSMENT OF REDFISH IN NAFO SUBAREA 0

REDFISH SURVEY TRENDS, DISTRIBUTION AND BYCATCH

Presenter: M. Treble

Abstract

The survey time-series is relatively recent; data collection on Redfish in Subarea 0 began in 1999. DFO RV surveys employ Campelen bottom trawls, usually deployed in September or October. Deep strata, where Redfish are primarily found, have very limited coverage in the DFO RV survey. Survey data is also collected in collaboration with the Greenland Institute of Natural Resources, on the RV Paamiut. This deepwater survey (400–1,500 m) employs an Alfredo III trawl with 30 mm mesh liner in the cod end). *Sebastes mentella* dominate catches in Div. 0B (>99.9% of speciated catch).

Recent biomass estimates from the DFO Central and Arctic RV survey in SA 0B have fluctuated between 20,000 and 43,000 t since the year 2000; however, these estimates are limited by incomplete survey coverage. Abundance estimates for the short time-series peaked in 2011 at 400 million fish. This may be a survey artefact, as the 2011 survey was defined by 6 very large sets (>2,000 fish). In a typical year, the largest sets contain approximately 1,000 fish. Recently (2013–15), estimated Redfish abundance has ranged from 110–119 million. Changes in recorded distribution of individual lengths have also been observed throughout the survey. The survey catch includes Redfish from 2–48 cm. In 2001, a single mode fell at 6–7 cm. However, by 2011–13, the survey catch shifted to a bi-modal pattern, with peaks at 17–21, and 24 cm. The proportion of the catch under 20 cm has increased from 40% in 2000–01 to >80% in 2013–15.

The Northern Shrimp Research Foundation (NSRF) has also conducted Campelen surveys within SA 0B, including SFA2Ex, RISA (2005-present) and SFA3 (2014-present) at depths of 100–800 m. Shrimp are the focus of these surveys, so only counts and weights are recorded for fish species. Estimates from the NSRF for 2005–12 indicate stable or slightly increasing biomass in the stock.

Discussion

No discussion occurred.

ALLOWABLE HARM, KNOWLEDGE GAPS AND RESEARCH NEEDS OF SA 0

Presenter: K. Hedges

Abstract

There is no history of directed fishery for deepwater Redfish in NAFO Subarea (SA) 0; however, there is a current request issued for the development of an exploratory Redfish fishery. Redfish are subject to by-catch pressure in SA 0, primarily in the Northern shrimp, Striped shrimp, and Greenland halibut fisheries. Total by-catch of Redfish across all commercial fisheries in SA 0 has ranged from 17–236 t between 1997–2012. The survey biomass index is stable, indicating that by-catch levels over the recent 10-year period are not harming the productivity of the stock. The full relationship between biomass and bycatch is not clear; in recent years bycatch has declined; however, there has not been a corresponding increase in biomass. SA 0 lacks historic data needed to evaluate long-term trends in abundance or biomass. No estimates of Redfish

abundance or biomass are available for this area prior to 2000, and there is no estimate for biomass levels before exploitation of the stock.

The time-series available (2007-present) represents a period much shorter than individual Redfish lifespans. Current indices are further limited by the gear types and survey methods; the bottom trawl gear is not designed to target Redfish. As a result, the current biomass index for SA 0 is based mostly on immature fish and is limited by spatial representation. While the current DFO RV survey cannot be tailored to Redfish without compromising other research programs, it was noted that the NSRF survey may be adapted to collect Redfish data. More research on population structure and connectivity with adjacent stocks is needed. To date, SA 0 also lacks Redfish demographic data that may improve scientific understanding of the impact that by-catch, or an exploratory fishery may have on the stock in the long term. These are significant knowledge gaps; maximum size and growth rate will be important factors to a potential fishery. In more southern Redfish fisheries, 25 cm has been identified as the minimum size for financial viability. Under colder, slow growth conditions, Redfish may take decades to reach this size in SA 0.

Discussion

No discussion occurred.

CONCLUSIONS

Based on the limited available data, it appears that the current level of by-catch is sustainable and a carefully executed exploratory fishery for NAFO SA 0 is reasonable. An exploratory fishery in this area should emphasize the collection of demographic data by at-sea observers (i.e., sex, maturity, length, weight, otoliths). Due to the unique life history of Redfish regarding stock productivity and connectivity, the author of this work recommended that any increases in fishing mortality be carefully considered and monitored closely.

ASSESSMENT OF REDFISH IN NAFO SUBAREA 2 AND DIVISION 3K

CATCH AND SURVEY TRENDS FOR 2+3K REDFISH

Presenter: D. Ings on behalf of E. Lee

Abstract

The last full assessment of this stock was carried out in 2001. At that time DFO survey indices indicated that the resource was at very low levels, with poor recruitment over the last 25 years. Since 1990, Redfish has been a primarily by-catch fishery. Russian and Lithuanian catches assigned to 2J since 2001 are from outside the 200-mile limit and are assumed to originate from the Irminger Sea pelagic stock. This catch is not included in 2+3K totals.

Biological data (length and weight measurements) and catch rate estimates of Redfish (no. fish/tow, kg/tow) are obtained from the DFO multi-species stratified random groundfish bottom trawl surveys. Surveys generally covered strata to depths of 1,000 m but were extended to deeper waters (1,500 m) in 1996. The abundance of Redfish drops off sharply beyond 800 m in the slope area. Annual surveys have been conducted in NAFO Divs 2J3K since 1978; in 2H, sporadic survey data is available between 1978–2009, with annual surveys since 2010; and in 2G, surveys were conducted sporadically from 1978–79. Survey indices for this stock are primarily calculated from 2J3K, where consistent data are available. Abundance peaked in the

late-1970s and early-80s. Between 1984 and 1990, abundance declined significantly to reach the lowest values in the time-series.

Discussion

Biomass has followed similar trends. The highest biomass levels on record occur early in the survey, from 1978–83. Biomass declined significantly from 1984–94, the lowest recorded level. Modest increase in biomass indices was observed in the 1995–2011 period; however, in recent years (2012–15), Redfish biomass has been stable or slightly declining. Exploitation rate is calculated as the ratio between catch biomass to survey total biomass estimates. Current exploitation rate appears to be very low on this stock (1–3%). Meeting participants pointed out that differences in fishery and survey selectivity may lead to mis-estimation of relative exploitation rates. It was suggested that a more relevant figure would be exploitation rate based on exploitable survey biomass, as so much of the biomass is made up of fish below the exploitation size ranges.

Data collected with the Engels tow gear (1978–94) has been converted to Campelen equivalent units to compare to the current time period. However, the Engels gear is well known to underestimate juvenile fish, due to size. Participants suggested that, even after conversion, the early data may miss the small biomass. A more accurate way to examine relative biomass through the two time periods may be to exclude small fish (<10 cm) throughout and compare only the relative adult biomass. Apparent discrepancies between survey gear types may also be related to episodic recruitment. Early surveys may have sampled older stock components: individuals that were barely growing and not recruiting for years at a time. Assessment of biological parameters has also revealed adult-sized fish with immature gonads, indicating that size-based definitions of maturity may not apply to this stock.

Cohort tracking is limited due to slow growth and episodic recruitment. Dominant cohorts, based on length-frequency distributions, were recorded in 2J3K in 1978–91 (25–33 cm) and in 2004–14 (10–27 cm). Divisions 2H, 2J, and 3K all display signs of recent recruitment events from 2008–14.

SPECIES SPLITTING OF COMMERCIAL AND SURVEY CATCHES AND LRPS

Presenter: K. Vascotto, based on a Working Paper by B. Atkinson

There are many challenges to the generation of a model and limit reference points for this stock. However, biomass indices are now near levels recorded in the 1980s, a period that supported a strong fishery. The way in which species proportions are estimated has a large impact on stock productivity estimates and alters how reference points are calculated for stock management.

In the 2004 SAR, survey-based indices for *S. mentella* and *S. fasciatus* were split following an approach developed by Ni (1982). This method is based on depth partitioning and meristic characteristics applied to split species in multiple years of data. It was originally intended to be a preliminary assessment method; however, these calculations have been carried forward into subsequent status reports. However, the Ni method does not incorporate temporal or geographic variation. Genetic studies have shown that meristic characteristics are not as reliable as previously thought. For example, the most commonly used characteristic is the number of anal fin rays (AFR); however, *S. fasciatus* and *S. mentella* have some overlap. An anal fin ray count of eight or fewer is *S. fasciatus,* eight or above is *S. mentella*. An individual with eight anal fin rays could be either species. Valentin (2006) speciated catches in 2+3K genetically, finding higher levels of *S. mentella* (~86% of catch) than predicted by Ni (~60%). Valentin also highlighted spatial differences in species structure across the range. Similarly, an AFR assessment of survey and commercial catch in 2015 did not match Ni predictions; in this case *S. fasciatus* were much more prevalent than expected, especially beyond depths of 300 m. Despite limitations of anal fin ray counts, the exploratory fishery catch is being speciated by this meristic, under the assumption that individuals in the overlap (i.e., with eight anal fin rays) belong to the species that dominates the tow. Members of DFO cautioned against relying on a single meristic; many characteristics overlap in occurrence between the two species, but in combination, they can be useful.

The current survey-based assessment methods face several data limitations. Length at maturity is based on empirical results from Unit 2; however, it is known that L_{mat} increases in more northern populations. This may lead to overestimation of the spawning stock biomass if the L50 applied is less than the real L50. The catch totals are derived from DFO reported landings, based on catch area reporting. To obtain annual landing estimate by species, the catch species split is estimated based on species proportion determined for the RV surveys, and in years when survey information is not available, the mean proportion is applied. However, the catch species structure may not match survey results. Catch is not likely to accurately represent mature biomass due to market preferences for colour (i.e., preference for *S. mentella*) and size.

Models were developed through external contract to explore LRPs for Redfish based on survey mature biomass (MacAllister and Duplisea 2011); however, in the absence of the report author at this meeting, it was unclear how the species split was applied to the survey data. In the model built for *S. mentella,* NAFO Divs 2J3KLNO were treated as a single, continuous population. For management purposes, 2+3K were parsed out, according to the proportion of occupied area; however, it is not clear if this partitioning is consistent with distribution of biomass or how it was calculated. The model built for *S. fasciatus* was specific to 2J3K. In both models, survey Q was allowed to vary across time blocks informed by Bayesian posteriors. Q shifts were incorporated to improve model fit and were not based on gear changes. The documentation of the model presented at this meeting was not sufficient to address questions on how time blocks were generated, or how they would be applied to any data updates. At present, there is no capacity within DFO to update or refine these models. In the absence of accurate species composition estimates, species-specific models are inappropriate.

Index-based LRPs were proposed as a possible alternative, following the methods of Duplisea et al. (2012). The Campelen equivalent units of the 1979–82 survey results were proposed as unfished B_{MSY}. In this case, 80% of B_{MSY} would be the upper limit, and 40% of B_{MSY} would be the lower reference point. Participants also raised questioned the description of the 1979–82 period as unfished biomass. Records prior to this period show that annual catches exceeded 20,000 t. It was also noted that the level of catch exerted in the 1979–82 period, combined with environmental factors, contributed to the stock collapse of the early-1990s. Concerns were also raised equating a period to an MSY, which may not refer to MSY directly, but refer to a period that seemed to sustain a certain catch under ecological conditions and fishing effort (i.e., targeted or bycatch) that may or may not apply to the current period.

Identification of a $B_{recovery}$ of F_{MSY} for Redfish is further complicated by their life history. A stock may have high biomass and yield little or no recruitment. Conversely, low biomass conditions have been shown to produce high recruitment at times. The biomass/recruitment relationship cannot be described for these species. Participants pointed out that this logic may lead managers to treat F_{max} as F_{MSY}, since recruitment does not appear dependent on biomass. If the gap between F_{MSY} and F_{crash} (the exploitation level that drives the stock to collapse) is narrow, this approach may be very dangerous. Furthermore, although Redfish populations have demonstrated capacity to produce strong recruitment from low biomass, the gap between these recruitment events may last decades. The capacity for the stock to recover from low biomass may not support a sustainable socio-economic fishery on that time scale.

ALTERNATIVE METHOD FOR ESTABLISHING REDFISH LRPS

Presenter: L. Mello

As a potential alternative, an index-based assessment model currently in use for several data-poor stocks in the USA was explored for Redfish of SA 2+3K. The objectives of this work were to fit the relationship between the fall RV survey biomass index and commercial removals (ZIF and NAFO STATLANT-21A) in Divs. 2J and 3K, and to estimate the level of relative F at which the population is likely to be stable in response to steady harvest (i.e., a proxy for F_{MSY}). Data was insufficient to apply the model to 2G and 2H. Survey data indicate that the distribution of Redfish in 3K is dense; there is more data available for this area and the best model fit was achieved.

A four (Div. 2J) and two-year (Div. 3K) centered average of the biomass index provided the best fit for the index method (AIM) model estimates and was used as the measure of average stock size. The AIM model is predicated on four assumptions:

1. Population biomass at time (t) can be written as a linear combination of historical population biomasses;
2. Recruitment is proportional to population biomass;
3. F is proportional to catch divided by an index of population size (i.e., Relative F); and
4. The rate of change in population biomass is a monotonically decreasing function of Relative F.

The model outputs include a proxy for F_{MSY}, representing the F associated with a sustained stock, wherein the replacement ratio is equal to one. This proxy value is estimated graphically through comparison of relative F and replacement ratio. In this analysis, the median commercial removal during the period when the stock indices were stable or increasing according to the AIM model was assumed to be a proxy for MSY. In Div. 2J, median removals during 1993–2015 (0.66 t) was identified as the MSY proxy. In Div. 3K, MSY proxy was identified as median removals in the 1995–2015 period (15.05 t). Biomass at MSY (B_{MSY}) was calculated as the ratio of MSY proxy to the F_{MSY} proxy. Based on the results of the AIM model, fishing has exceeded sustainable levels in both divisions since 1978 (i.e., relative $F>F_{MSY}$) but Redfish was not overfished until the early-1990s (i.e., RV $B_{index}< B_{MSY\ proxy}$). Biological production has increased considerably during the last 10–12 years coinciding with a period when Relative F was consistently below or near F_{MSY} levels. The author noted that the estimates of MSY proxy may reflect a regime characterized by a period of stock depletion and low productivity under commercial moratorium (i.e., fishery pressure through by-catch only). It was suggested that biological reference points be re-assessed as the stock becomes more productive.

Significant limitations of this approach include the aggregation of the three Redfish species, the geographic division of a stock considered continuous throughout a larger region, and the assumption of a constant linear relationship between relative F and relative biomass under a widely varying fishing regime. The overall biological understanding is that recruitment is very sporadic for Redfish. Statistically the AIM model is defensible, and the output of the model is generally consistent observations. However, it is by-necessity a very simplistic model that cannot incorporate the full scope of variation in the system. The results presented at this meeting indicate that the current level of removals is not detrimental to the stock, and projections could generate more detailed catch advice.

The iteration of the AIM model presented at this meeting applied the removals during a moratorium period as F_{MSY}. However, targeted commercial catch and by-catch pressure are very different, and that conflation may introduce bias into the model results. Overall, meeting participants felt that the assumptions of the AIM model were not acceptable for Redfish in these stocks. In particular, the relationship between recruitment and biomass cannot be demonstrated for these species.

PROPOSAL: ALTERNATIVE REFERENCE POINTS FOR 2+3K REDFISH

Presenter: K. Vascotto

Abstract

Fisheries scientists and managers have been unable to assign species-specific LRPs due to issues associated with species splitting of survey and commercial catches. Redfish life history includes strong, episodic recruitment pulses that can occur with very low levels of spawning stock biomass. Based on the uncertainties of species splitting and the unique life history of Redfish, the use of $B_{recover}$ (biomass level at which point the stock is capable of rebuilding) may be applicable to 2+3K. The proposed approach would select a period that gave rise to strong recruitment and biomass growth to define $B_{recover}$. The management goal would be to maintain biomass above $B_{recover}$. The years 1995–99 were proposed as a period of relatively low biomass that produced strong growth beginning in 2003. The mean survey biomass index (i.e., proposed $B_{recovery}$) during this period was 33 479 mt, with a mean 95% upper confidence interval of 58 735 mt. The author proposed a lower limit reference point (B_{lim}) of twice $B_{recovery}$: 117,471 mt. Under this proposal, harvest would be scaled according to the relative distance from B_{lim}, based on the year mean index to minimize year effects. The author proposed a relative harvest rate (1%) when the stock was at the identified B_{lim}. With stock growth, harvest rate would be scaled up linearly to a limit of 3% exploitation of a stock biomass 3x the identified B_{lim}.

Discussion

Although proposed alternatives for LRPs and assessment of this stock were discussed at length, participants felt that the data limitations were too great, and the time provided was too brief to adequately examine and validate any proposal.

CONCLUSIONS

A published assessment model is available for Redfish (MacAllister and Duplisea 2011), but was not presented at this meeting. The MacAllister production model provides stock estimates up to 2010. Many participants felt that it was incomplete to hold this meeting without having a model update extending to 2015. This model was designed to investigate reference points but has not been applied directly to 2+3K stock assessments, nor has it been formally accepted for this purpose. Participants noted that assessments for Unit 1 and Unit 2 Redfish have discarded the production model. Previously identified reference points were also questioned. At the time these LRPs were developed (Duplisea et al. 2012), there was pressure to identify reference points for Redfish within a limited timeline. The use of archival data from the 1960s to calculate the species split has not aged well. The archival records are still the best available dataset for meristics; however, these characteristics are no longer considered the best method for speciation. The large and unexplained variation in Q throughout the time-series of the 2012 Redfish stock assessment model was a major point of concern, and this uncertainty led many participants to conclude that the previous model was inappropriate for assessment of 2+3K Redfish.

Members of the fishing industry have reported that there is a lost fishing opportunity, based on increases in Redfish stocks observed in 2J3K. The survey biomass appears to be similar to that recorded in the 1980s, which supported a 20–25,000 t fishery. However, the last evaluation of

LRPs (DFO 2012) placed both species in the critical zone. Without updated results from an accepted assessment model, the meeting was unable to evaluate LRPs for this stock, as requested in the Terms of Reference. Participants expressed frustration and concern that this meeting did not represent a complete assessment of the stock. Many felt that a framework meeting is urgently required to determine appropriate methods for stock assessment and evaluation of limit reference points.

The unique life history of Redfish (long-lived, episodic recruitment) makes this stock very difficult to manage. The stock/recruit relationship is poorly defined for finfish in general, yet most stock assessments are built around this assumption. For Redfish, in particular, the recruitment mechanism is unknown. This may be considered a reason to set a low B_{lim} to maximize fishery of a stock that has the capacity to recover from very low biomass. However, it was also argued that the lack of a well understood stock/recruit relationship, and without an accurate estimate of Q, there is cause for managers to proceed with additional caution. Management of this stock may adopt methods that look beyond the stock/recruit relationship. In other fisheries (e.g., Snow Crab), the B_{lim} also considers maintenance of populations with sufficient biomass to support economically efficient harvest.

The prospects of the stock vary dramatically depending on the LRP approach that is applied. Furthermore, all presented methods are species-aggregated, which was cited as a central limitation to the existing production model. Ultimately, the meeting could not validate the existing stock assessment model LRPs, or any of the proposed alternatives due to difficulties with the application of conventional approaches to Redfish life history. In the absence of agreed-upon LRPs, the meeting was further unable to establish current stock status or to offer harvest advice.

RECOMMENDATIONS

Investigation of the Redfish species-complex composition was strongly recommended. There is potential to use historic otolith collections to identify species through shape and genetic analysis. Improved estimates of the species composition will also contribute to analysis of the stock relationships and a better understanding of the role of rescue effect. Better mechanisms for species identification within the commercial and survey catch, coupled with species-level data on growth rates and recruitment may also improve understanding of the stock-recruit relationship and facilitate stock assessment. Participants were unanimous that a framework meeting should be set for this stock as soon as possible, to critically investigate data sources, assessment models, and limit reference points.

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APPENDIX I: TERMS OF REFERENCE

Assessment of Northwest Atlantic Fisheries Organization (NAFO) Subdivision 3Ps Atlantic Cod

Regional Peer Review-Newfoundland and Labrador Region

October 17-21, 2016

St. John's, NL

Chairperson: Darrell Mullowney

Context

The status of Northwest Atlantic Fisheries Organization (NAFO) Subdivision 3Ps Cod was last assess in October 2015 (DFO 2016). The main objectives were to evaluate the status of the stock and to provide scientific advice concerning conservation outcomes related to various fishery management options. The current assessment is requested by Fisheries and Aquaculture Management to provide the Minister with detailed advice on the status of the stock in order to inform management decisions for the 2017 fishing season.

Objectives

- Provide an ecosystem overview (e.g., environment, predators, prey) for the stock area.
- Assess and report on the current status of the 3Ps cod stock. In particular, assess current spawning biomass relative to baseline conservation thresholds (B_{lim}), total (age 3+) biomass, exploitation rate, natural mortality, total mortality, and biological characteristics (including age composition, size at age, age at maturity, and distribution). Describe these variables in relation to historic observations.
- Further to the previous assessment, analyze recent year class strength relative to previous observations, as it relates to long term growth and sustainability of the stock.
- To the extent possible, provide information on the strengths of year-classes expected to enter the exploitable populations in the next 1–3 years.
- Provide annual projections to 2019 based on the assessment of trends in the abundance index and other stock indicators, including associated risk analyses. Specifically, these analyses will include an assessment of the trends in the stock and in the risks compared to B_{lim}.
- Highlight major sources of uncertainty in the assessment of trends in the abundance index, biomass index, and other stock indicators, including associated risk analyses. Specifically, these analyses will include an assessment of the trends in the stock and in the risks compared to B_{lim}.
- Highlight major sources of uncertainty in the assessment, and where appropriate, consider alternative analytical formulations of the assessment.
- Report on results of tagging and the distribution of this stock in other areas (e.g., 3L/3Pn).
- Summarize the data collected during the spawning closure in 2016.
- Calculate the suggested TAC as per the harvest control rules, which have been approved as part of the "3Ps Cod Conservation Plan and Rebuilding Strategy".

Expected Publications

- Science Advisory Report

- Proceedings[1]
- Research Document(s)

Expected Participation

- Fisheries and Oceans Canada (DF), Science and Fisheries Management Branches
- French Research Institute for Exploration of the Sea (IFREMER)
- Provincial Department of Fisheries, Forestry and Agrifoods
- Fishing Industry
- Academia
- Aboriginal organizations
- Non-governmental organizations

References

DFO. 2016. Stock Assessment of NAFO Subdivision 3Ps cod. DFO. Can. Sci. Advis. Sec. Rep. 2016/005.

[1] Joint Proceeding with October 17-21, 2016 Assessments of Redfish in NAFO Subarea 0, and Subarea 2 and Div. 3K

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

Zonal Peer Review-Newfoundland and Labrador, and Central and Arctic Regions

October 19-21, 2016

St. John's, NL

Chairperson: Darrell Mullowney

Context

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

The status of Northwest Atlantic Fisheries Organization (NAFO) Subarea 2+Division 3K Redfish was last fully assessed in 2001 (DFO 2001, Power 2001), while Subarea 0 has never been included in past assessments because there is no history of commercial Redfish fishing in this area. In April 2010, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the Deepwater Redfish/Acadian Redfish Complex in Canada. During the assessment, Deepwater Redfish were divided into two Designable 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 designated units: Atlantic population (Threatened) and Bonne Bay population (Special Concern) (COSEWIC 2010). Redfish is currently going through the *Species at Risk Act* (SARA) listing decision process.

In 2010, Limit Reference Points (LRPs) were developed for the population-based on data for Redfish from NAO Subarea 2+Div 3K using a Bayesian surplus production model (DFO 2012). During this meeting, it was determined that the two Redfish species that comprise the stock were in the critical zone of DFO's precautionary approach framework (DFO 2012).

DFO Fisheries and Aquaculture Management requested the current assessments to review the LRPs, provide detailed advice on the status of the stocks, and inform management decisions for the 2017 fishing season. The assessment will also determine if this population can support a commercial harvest in NAFO Subarea 0, thus allowing DFO to better evaluate an existing emerging fisheries proposal to harvest Redfish in this area.

Objectives: Subarea 0 Redfish

Provide advice on the status of the Deepwater Redfish/Acadian Redfish complex in NAFO Subarea 0 (i.e., Baffin Bay, Davis Strait, and Hudson Strait). Specifically, the meeting will address the following objectives to the extent possible:

1. Provide an ecosystem overview (e.g., physical oceanography) for NAFO Subarea 0 and an overview of the biology of Redfish.
2. Assess trends in catch-effort and biological data (e.g., distribution, abundance, length-frequency) collected up to 2015.
3. Provide advice on allowable harm, including bycatch for each species within NAFO Subarea 0, and identify associated uncertainties; and,
4. Discuss current knowledge gaps and research needs.

Objectives: Subarea 2+Division 3K Redfish

Provide scientific advice on the stock status of 2 + 3K Redfish. This advice shall include:

1. An ecosystem overview (e.g., physical and biological oceanographic environment, predators, prey) for NAFO Subarea 2+Division 3K.
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 abundance and biomass indices derived from the DFO research vessel (RV) survey, including size structure and geography distribution of catch.
5. Analyses of relative year class strength of Redfish as it relates to long-term growth potential.
6. Assessment of the impact on biomass trajectory of allowing relative harvest rates of up to 3% of survey biomass, using a 3–5-year average survey biomass to monitor change, and calculate Total Allowable Catch (TAC);
7. Evaluate the current LRPs for this stock (DFO 2012). If they are still considered valid, determine stock status relative to the LRPs. However, if they are found to be invalid, determine an appropriate proxy; and,
8. Identify information collected through the DFO RV survey and/or commercial fishery to help future assessments and aid the evaluation/establishment of species-specific reference points in the future.

Expected Publications

- Science Advisory Reports
- Proceedings[2]
- Research Document(s)

Expected Participation

- Fisheries and Oceans Canada (DFO), Science and Fisheries Management Branches
- Provincial Representatives (Newfoundland and Labrador, Nunavut, and Quebec)
- Fishing Industry
- Academia
- Aboriginal communities/organizations
- Non-governmental organizations

References

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[2] Joint Proceedings with October 17-21, 2016 Assessment of NAFO Subdivision 3Ps Cod.

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APPENDIX II: AGENDA

Regional Peer Review Process for Subdivision 3Ps Cod

Memorial Meeting Room

NAFC, St. John's

October 17-19, 2016

Chairperson: Darrell Mullowney

Monday, October 17

Time	Topic	Presenter
09:00	Opening/Chair Remarks	D. Mullowney
-	Introductions/ToR	D. Mullowney
-	Presentation: Physical Oceanographic Update	E. Colbourne
-	Presentation: Ecosystem Overview	N. Wells
-	Presentation: Review of 2015/16 Fishing Season and 2016/17 Season to Date	D. Coffin
-	Presentation: Catch and Survey Trends for 3Ps Cod • Catch ○ Total Landings	R. Rideout/D. Ings

-	Presentation: Catch and Survey Trends for 3Ps Cod
	• Survey
	  ○ Biomass/Abundance Updates
	  ○ SSB
	  ○ Age Composition, Size at Age (Length, Weight and Condition), Age at Maturity
	  ○ Distribution
		R. Rideout

-	Presentation: Catch and Survey Trends for 3Ps Cod • Sentinel Program ○ Data Overview & Standardized Index	D. Maddock Parsons
-	Presentation: Tagging Update	J. Brattey
-	Presentation: Population Dynamics • SURBA-Survey Based Analysis • Short Term Projections	B. Healey
-	Presentation: Spawning Time in Relation to the 3Ps Spawning Closure	R. Rideout

Tuesday, October 18

Time	Topic	Presenter
09:00	Presentation: Cod Assessment (Continued)	R. Rideout/B. Healey

Time	Topic	Presenter
-	Presentation: Further analysis of the 3Ps Cod HCR • Scaling the Base TAC to the Size of the Stock	P. Shelton
-	Industry Perspective (SPM)	E. Carruthers
-	FFAW Questionnaire Update	E. Carruthers
-	Drafting of Cod SAR/Summary Bullets	All

Wednesday, October 19

Time	Topic	Presenter
09:00	Drafting of Cod SAR/Summary Bullets (continued)	All

Zonal Peer Review Process: Subarea 0, and Subarea 2 & Division 3k Redfish

Memorial Meeting Room

NAFC, St. John's

October 19-21, 2016

Chairperson: Darrell Mullowney

Wednesday, October 19

Time	Topic	Presenter
13:00	Opening/Chair Remarks	D. Mullowney
-	Introductions/ToR	D. Mullowney
-	Presentation: Physical and Biological Oceanographic Update	E. Colbourne
-	Presentation: Ecosystem Overview	N. Wells
-	Presentation: Redfish Biology and Distribution	E. Lee
-	Presentation: Assessment of Redfish in NAFO Subarea 0 • Redfish Survey Trends, Distribution and Bycatch	M. Treble
-	Presentation: Assessment of Redfish in NAFO Subarea 0 • Allowable Harm, Knowledge Gaps and Research Needs	K. Hedges
-	Presentation: Assessment of Redfish in NAFO Subarea 0 • Drafting of SA 0 Redfish SAR/Summary Bullets	All

Thursday, October 20

Time	Topic	Presenter
09:00	Drafting of SA 0 Redfish SAR/Summary Bullets (Continued)	All
-	Presentation: Assessment of Redfish in NAFO Subarea 3 and Division 3K • Redfish Growth Curves	N. Cadigan
-	Presentation: Assessment of Redfish in NAFO Subarea 3 and Division 3K • Catch and Survey Trends for 2 + 3K Redfish o Commercial Catch/Bycatch	E. Lee
-	Presentation: Assessment of Redfish in NAFO Subarea 3 and Division 3K • Catch and Survey Trends for 2 + 3K Redfish o Survey	E. Lee

Time	Topic	Presenter
	▪ Biomass/Abundance Updates ▪ Distribution ▪ Length Distributions	
-	Presentation: Species Splitting of Commercial and Survey Catches and LRPs	K. Vascotto
-	Drafting of 2+3K Redfish SAR/Summary Bullets	ALL

Friday, October 21

Time	Topic	Presenter
09:00	An Index Method-SA2+3K Redfish	L. Mello
-	Drafting of 2+3K Redfish SAR/Summary Bullets (Continued)	ALL

APPENDIX III: PARTICIPANT LIST

Name	Affiliation
Darrell Mullowney (Chair)	DFO Science, NL Region
Jim Meade (CSA Office)	DFO Science, NL Region
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