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Newfoundland and Labrador Region

Canadian Science Advisory Secretariat
Science Advisory Report 2020/021

STOCK STATUS OF REDFISH IN NAFO SA 2 + DIVS. 3K

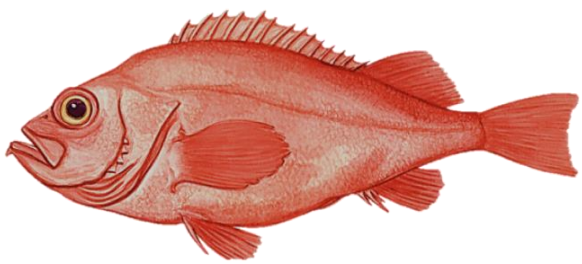

Image: Redfish

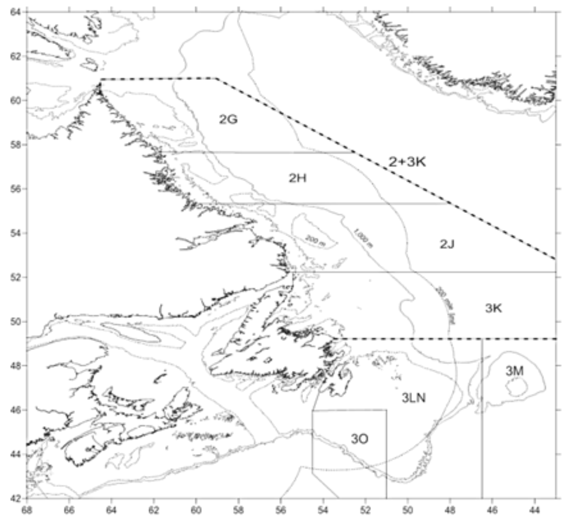

Figure 1. Map of the Northwest Atlantic indicating the SA 2 + Divs. 3K management area for Redfish.

Context:

In the Northwest Atlantic, Redfish range from Baffin Island in the north, to waters off New Jersey in the south and are managed in several discrete units. Redfish in Northwest Atlantic Fisheries Organization (NAFO) Subarea 2 (2G, 2H, and 2J) + Division 3K comprise stock complexes of two species (Sebastes mentella and S. fasciatus) recorded together in the landings because they cannot easily be distinguished visually, plus an additional less dominant species S. marinus that is visually distinct from the other species. The fishery on this stock was under Total Allowable Catch (TAC) regulation from 1974 (30,000 t) to 1996 (200 t). From 1997 to the present, the stock has been under moratorium to directed fishing. A previous assessment in 2001, of Redfish in stock status in Subarea (SA) 2 + Divs. 3K concluded that the population declined rapidly over a 10 year period from 1980-1990 and that surveys up to 2000 continue to indicate that the resource was at a low level reflecting over 25 years of recruitment failure. A Recovery Potential Assessment was conducted in a 2011 Zonal Advisory Process in which limit reference points (LRPs) were determined. During this process, stock status was updated and it was concluded that the biomass had remained stable at a low level from the mid-1990s until the mid-2000s when a period of marginal increase was evident.

This Science Advisory Report is from the October 19-21, 2016 Assessments of Redfish in Northwest Atlantic Fisheries Organization (NAFO) Subarea 0, and Subarea 2 and Division 3K. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- Biomass increased considerably from 2003 to 2010. Biomass during 2010-2015 was approximately half of the pre-collapse (1978-1990) levels.
- Recruitment (abundance of Redfish <15 cm) since 2000 was above the long term average with a time-series high in 2014.
- A fishing mortality proxy has been very low (<1%) since 2006. The fishery remains under moratorium, and average bycatch (including discards) since 2006 has been approximately 500 t.
- The meeting was neither able to validate nor invalidate existing reference points (DFO 2012) derived from production models due to substantive concerns about input data and an incomplete documentation of the rationale for model formulation.
- Other options for LRPs were considered. However, considering difficulties with respect to application of the LRP concepts for Redfish including its episodic recruitment, species separation, and other data limitations, these other LRP options were not accepted.
- No LRP examined (including DFO 2012) was considered applicable at this time.
- In the absence of a LRP, it is not possible to identify what zone of the Precautionary Approach (PA) framework this stock is currently within. It is recommended that adaptive and cautious management be applied to any reopened fishery.

INTRODUCTION

Redfish have been fished commercially in both the Atlantic and Pacific Oceans. They occur on both sides of the north Atlantic Ocean in cool waters (3 to 8°C) along the slopes of banks and deep channels generally in depths of 100-1,000 m. In the Northwest Atlantic, Redfish range from Baffin Island in the north, to waters off New Jersey in the south (Gascon 2003, Fig. 1).

Redfish found on the Northeast Newfoundland and Labrador Shelves (NAFO SA 2 + Divs. 3K) comprise a stock complex formed by three distinct species, *Sebastes mentella* (Deepwater Redfish) and *Sebastes fasciatus* (Acadian Redfish), which dominate commercial fisheries, and *Sebastes marinus* (Golden Redfish) which is much less abundant. Currently, *S. marinus* is recognized as being synonymous with *S. norvegicus* with most authorities reverting to *S. norvegicus* as the accepted binomial name. However, for consistency with previous Canadian Science Advisory Secretariat (CSAS) and Department of Fisheries and Oceans (DFO) publications, and this stock assessment, we will refer to this species as *S. marinus*. *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 (RV) surveys. *S. marinus* can be distinguished by colour, eye size and the relative size of a bony protrusion on its lower jaw. These species are not separated in the fishery and are managed together. The current assessment is based upon *S. fasciatus, S. mentella,* and *S. marinus* combined.

Along the continental shelves and slopes *S. mentella* range predominantly from the Gulf of St. Lawrence northward whereas *S. fasciatus* range predominantly from the southern Grand Banks to the Gulf of Maine. Generally, *S. mentella* is distributed deeper than *S. fasciatus* (Gascon 2003).

Redfish are longlived (up to 75 years) with a slow growth rate (Campana et. al. 1990). Estimates of size at maturity vary between and within populations with lower estimates in the range of 22-24 cm (Sévigny et al. 2007) and upper estimates of 38-39 cm for deep-sea *S. mentella* (Magnússon and Magnússon 1995). Redfish produce live young that can disperse over large distances (Valentin et. al. 2015). Recruitment is episodic and there may be decades between strong cohorts. They form aggregations throughout life and survey results for Redfish are typically dominated by one or two very large samples which has an unknown influence on survey results.

Fishery Removals

A Canadian and non-Canadian Redfish fishery has been prosecuted in SA 2 + Divs. 3K since the late 1940s. Total Allowable Catch (TAC) was established in 1974 when a 30,000 t quota was implemented (Fig. 2). The TAC was increased to 35,000 t in 1980 and remained at that amount until it was lowered to 20,000 t in 1991 (Fig. 2). The TAC decreased to 1,000 t in 1994 and was reduced to 200 t in 1995. The stock has been under moratorium since 1997 (Fig. 2).

The highest recorded removal of SA2 + 3K Redfish was 187,000 t in 1959 (Fig. 2). Removals from 1980 onwards also include discard estimates from Canadian shrimp (1980-2015) and Canadian Greenland Halibut fisheries (1995-2015) derived from fishery observer data scaled to total shrimp and Greenland Halibut landings. Reported removals fell to 56,000 t in 1961 and varied between 14,500 t and 56,000 t during the period 1962 to 1987 (Fig. 2). Removals declined after 1987 ranging from 30 t to 7,500 t up to the declaration of the moratorium in 1997 (Figs. 2 and 3). Removals from bycatch and discards have ranged between 50 t and 1,500 t since the 1997 moratorium (average of 500 t annually). From 1980 to 1996, discards ranged between 15 t to 700 t annually, averaging 200 t per year. Since the moratorium in 1997, estimates of discards ranged between 50 t and 600 t annually, averaging <300 t per year (Fig. 3). Note that Russian (2001-2008) and Lithuanian (2001-2011) catches are considered to be from the Irminger Sea and are not included in SA2 + 3K removal totals for those years.

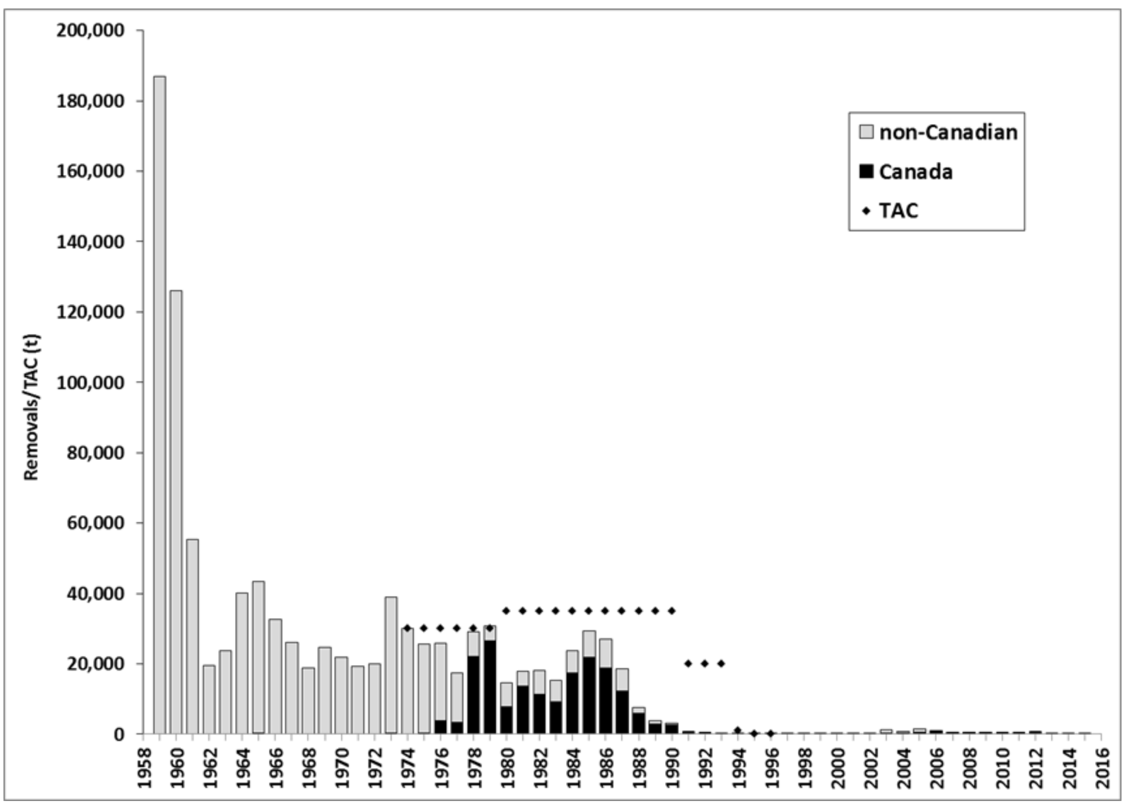

Figure 2. Redfish reported removals (t) by Canadian and non-Canadian fleets (including Canadian discard estimates from 1980-2015) and TAC in SA 2 + Divs. 3K from 1959 to 2015.

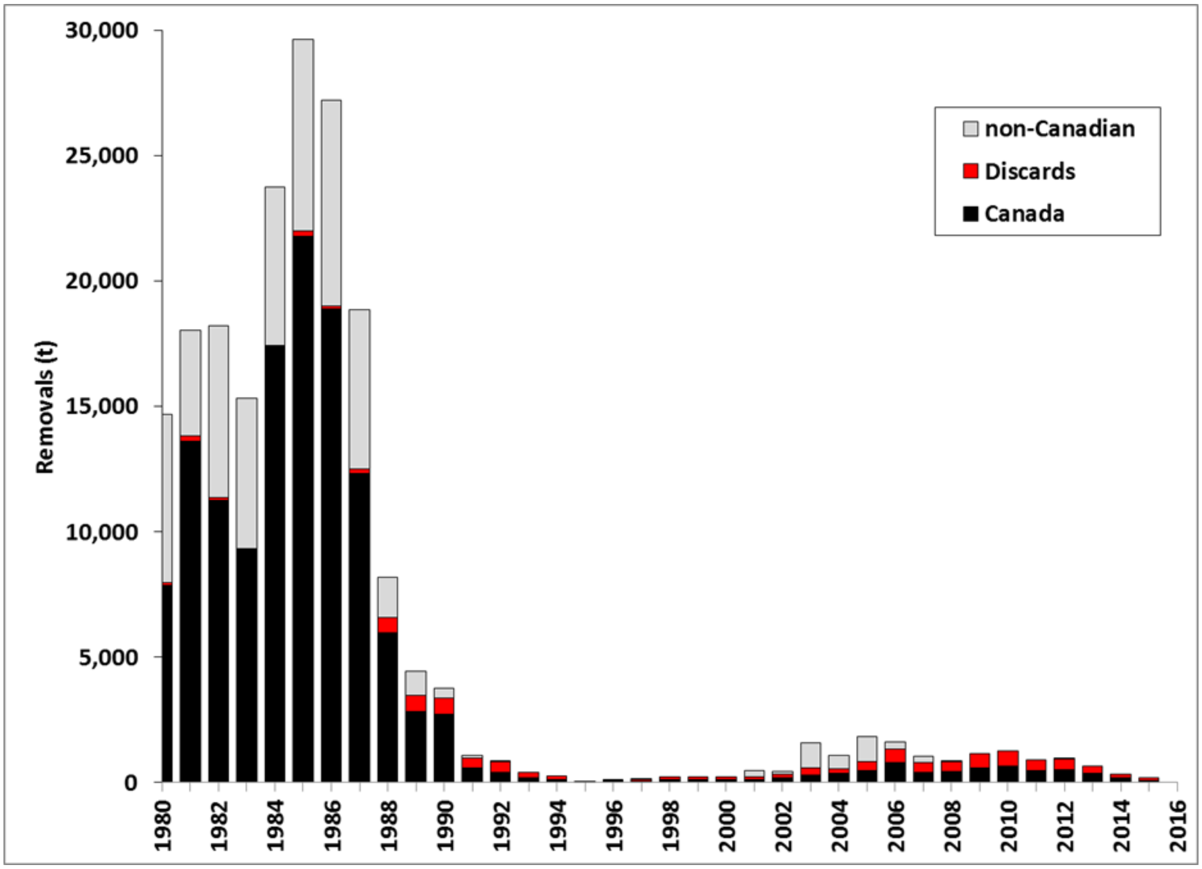

Figure 3. Redfish reported removals (t) by Canadian and non-Canadian fleets in SA 2 + Divs. 3K from 1980-2015 with Canadian discard estimates shown in red.

ASSESSMENT

This assessment considered information from landings from all countries (1959-2015) in conjunction with analyses of data from research vessel (RV) surveys conducted during autumn from 1978 to 2015.

Survey Methodology

Stratified random bottom trawl surveys were conducted in the autumn in Divs. 2J and 3K from 1977 to 1995 covering depths from 100 to 1,000 m and from 1996 to 2015 covering depths from 100 to 1,500 m. Surveys in Divs. 2G were conducted sporadically with varying spatial coverage and timing between 1978 and 1999 (the last year this Division was surveyed). Surveys were conducted sporadically in Divs. 2H between 1978 and 2010. Between 1978 and 1995 Divs. 2H surveys sampled depths from 100 to 1,000 m; in 1996 the depth range was extended to 1,500 m. Surveys have been conducted annually in Divs. 2H since 2010, although deep strata (>700 m) were not sampled in 2014 and 2015. Due to the inconsistent coverage of Divs. 2G and 2H, the primary indices for this stock are from Divs. 2J and 3K combined.

Survey Indices

Abundance and Biomass

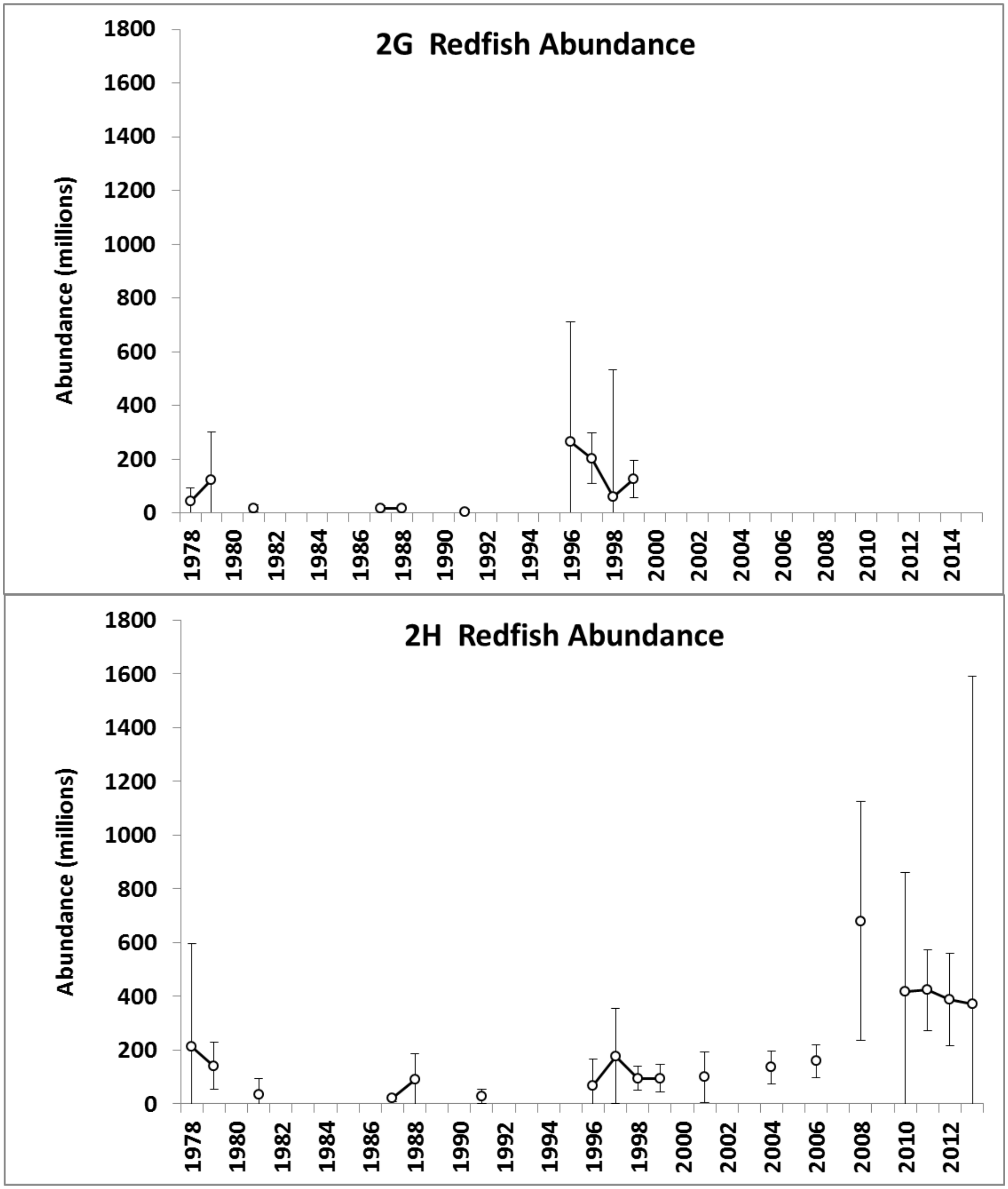

Figure 4. Abundance indices (millions) for Redfish in NAFO Divisions 2G and 2H from 1978 to 2013 (vertical lines represent 95% confidence intervals). Note that deep strata (>700 m) were not sampled in 2H in 2014 and 2015 (gaps represent years when the Division was not sampled).

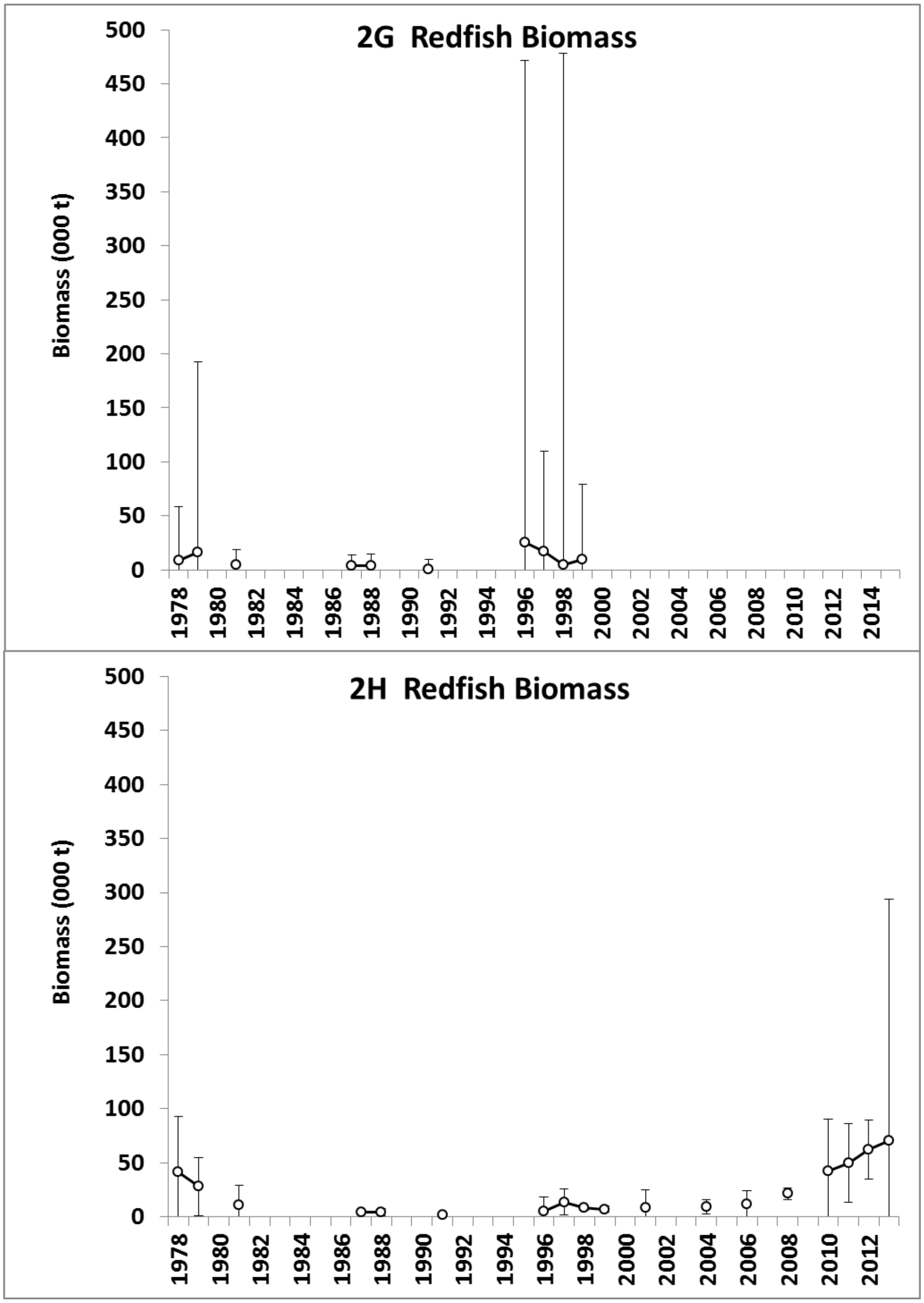

Figure 5. Biomass indices (000 t) for Redfish in NAFO Divisions 2G and 2H from 1978 to 2013 (vertical lines represent 95% confidence intervals). Note that deep strata (>700 m) were not sampled in 2H in 2014 and 2015 (gaps represent years when the Division was not sampled).

Abundance indices were relatively stable in Divs. 2H from 2010 to 2013 (Fig. 4). During this period, biomass values increased (Fig. 5) due to fish growth. In 2014 and 2015 the survey was incomplete as important areas for Redfish (depths >700 m) were not covered. Overall, both 2G and 2H represent a relatively small portion of the Redfish abundance and biomass within Divs. SA 2 + Divs. 3K.

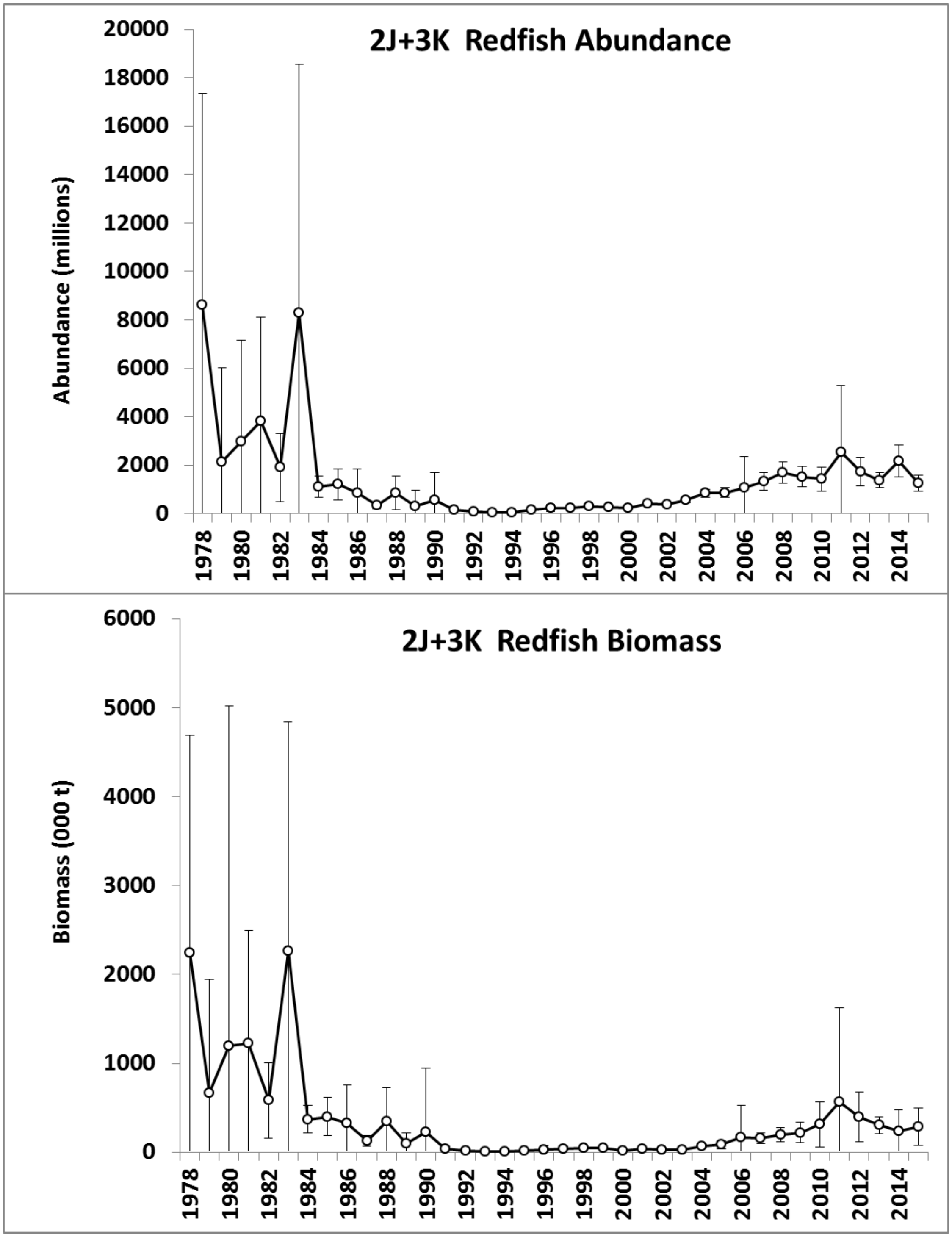

Figure 6. Abundance (millions) and biomass (000 t) indices for Divs2J3K Redfish from 1978 to 2015 (vertical lines represent 95% confidence intervals).

Abundance and biomass (Fig. 6) indices for Divs. 2J3K) were relatively high from 1978 to 1983, compared to the 1991 to 2003 collapse period. The biomass index increased by approximately a factor of 10 from 2003 to 2011. Biomass from 2011 to 2015 declined marginally but was relatively stable at approximately half of the pre-collapse (1978-1990) levels. Abundance values from 2011 to 2015 were also relatively stable at approximately 70% of pre-collapse levels. Generally, patterns were consistent between the abundance and biomass indices.

Mortality

A proxy for fishing mortality was calculated as the ratio of total landings (including discard estimates) in a given year to the RV survey biomass index from the previous year. This proxy was variable from the 1980s to the mid-2000s but since 2006, has been low (<1%) (Fig. 7).

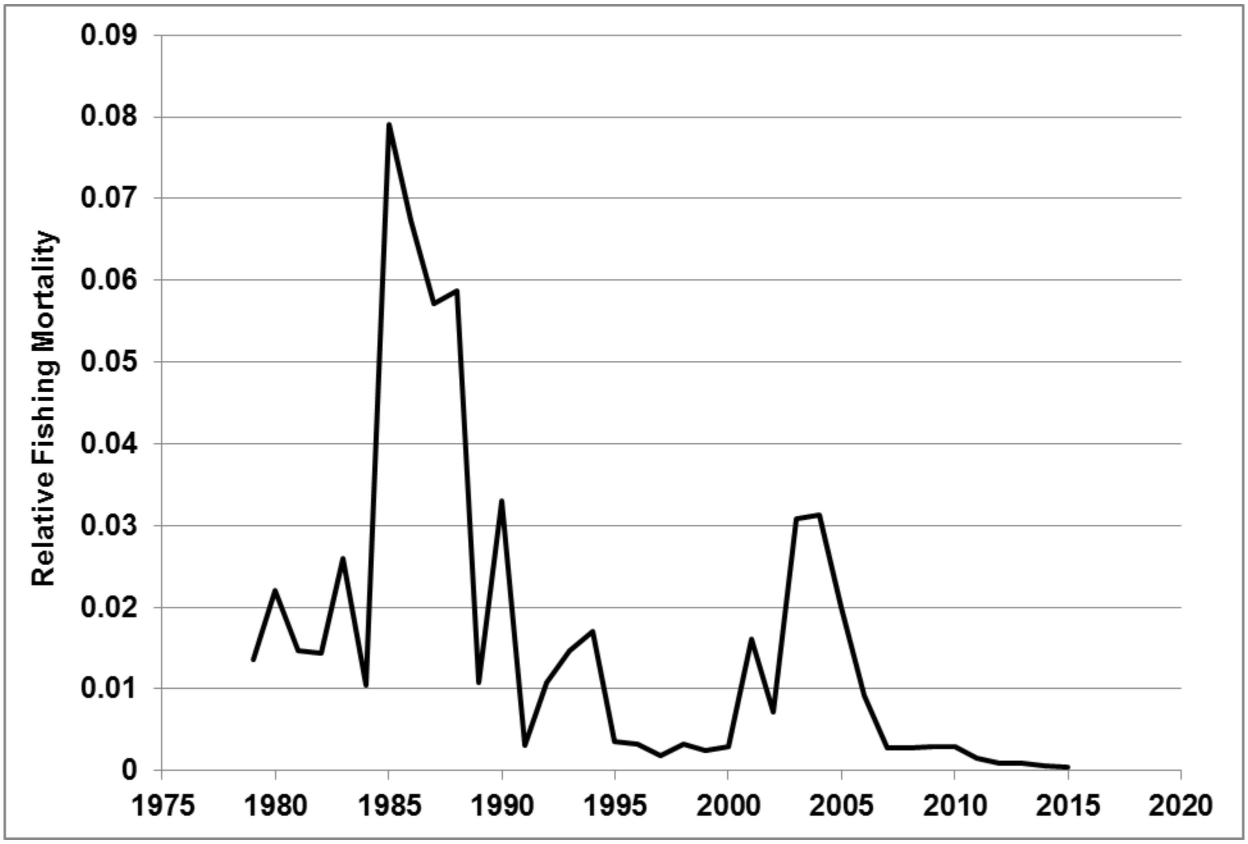

Figure 7. Proxy for Redfish fishing mortality from 1978 to 2015 in SA 2 + Divs. 3K calculated as the ratio of total landings in a given year to the survey biomass index in the previous year.

Recruitment

Length Composition

Although the Campelen trawl (1995 onward) samples small (<20 cm) Redfish more effectively than the Engel trawl, relatively few small Redfish were collected in annual sampling before 2001. From 2002 onward, one or multiple length modes were apparent in the length frequency distributions within Divs. 2H, 2J, and 3K. These modes persisted over time and some can be tracked over several years. However, few fish larger than 30 cm were sampled recently relative to the 1978 to 1983 period.

A strong length mode that first appeared in Divs. 3K during 2014 at 6 cm was apparent in both Divs. 2J and 3K at approximately 10 cm during 2015. Presently, it is unclear how these young fish will contribute to future fisheries. Previously, similar events have been observed in survey results, but modes were not tracked consistently over time.

Recruitment Index

A recruitment index, calculated as the abundance of Redfish less than 15 cm, was relatively low from 1979 to 2000 (Fig. 8). Since then, the recruitment index has generally been near or above the long term average with a time series high in 2014 (Fig. 8). As Redfish grow quite slowly, sequential index values are not independent and annual index values are comprised of multiple cohorts.

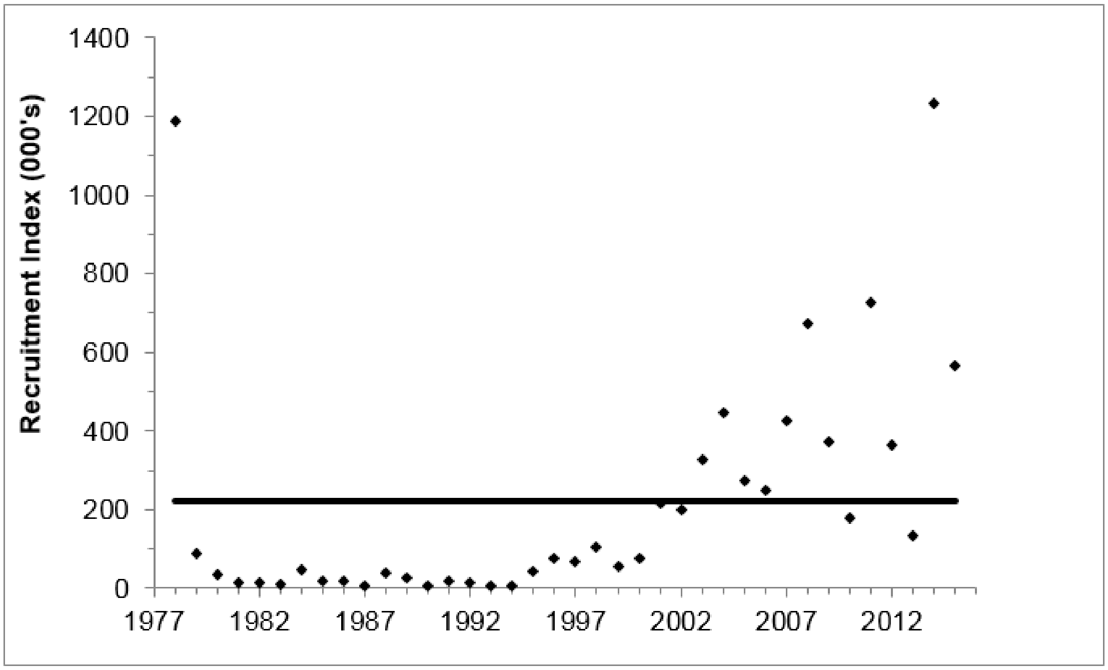

Figure 8. Recruitment index for Redfish in SA 2 + Divs. 3K based on total abundance estimates of Redfish less than 15 cm. The solid line indicates the time series average.

Reference Points

Models were developed through an external contract to explore LRPs for Redfish based on survey mature biomass (MacAllister and Duplisea 2011). Reference points for several Redfish stocks in the Northwest Atlantic were adopted by DFO based upon Bayesian production model results and various empirical methodologies (DFO 2012). This model was designed to investigate reference points but has not been applied directly to SA 2 + Divs. 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. Prior to the current assessment of SA 2 + Divs. 3K Redfish, DFO received a critique of the existing production model and limit reference points for the stock from a former DFO Redfish biologist (GEAC [Atkinson, D.B. 2016] in Lee et al. in prep, Appendix 1[1]).

During the assessment plenary session it was agreed that there were substantive concerns about the input data and incomplete documentation of the rationale for model formulation.

[1] Lee, E., Ings, D. Mello, L., and R. Rideout. In prep. Stock status of Redfish (*Sebastes sp.*) in NAFO SA 2 + Div. 3K. Appendix 1 – GEAC (Atkinson D. B. 2016) An investigation of inputs to the analytical model used to determine stock status and limit reference points (LRP's) for Redfish (*Sebastes sp.*) in NAFO Subarea 2 + Division 3K. CSAS Res. Doc.

Specifically, the meeting recognized issues with separating the species in the survey and commercial catch data based on preliminary results from studies in the 1980s.

The assessment model for *S. mentella* was developed for the designatable unit spanning SA 2 + Divs. 3KLNO rather than just the SA 2 + Divs. 3K stock complex. This required apportioning biomass between Divs. 2J3K and Divs. 3LNO based on area of occupancy for the determination of LRPs. The meeting identified concerns with the validity of using this approach to delineate the critical/cautious and healthy zones for the SA 2 + Divs. 3K Redfish complex. 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 need to sub-divide the survey series into multiple time periods to produce acceptable model fit caused concern as there is no *a priori* justification to support these groupings.

Length at maturity was based on empirical results from Unit 2 (Gulf of St. Lawrence/Southeastern NL). However, it is known that L_{max} increases in more northern populations; this may lead to overestimation of the spawning stock biomass if the L_{50} applied is less than the real L_{50}. Further, index-based LRPs using both $B_{Recovery}$ and B_{MSY} concepts were also presented to the meeting but were not accepted due to difficulties with respect to applying LRP concepts to Redfish, including its episodic recruitment, species separation and other data limitations.

Due to the incomplete documentation of model formulations, resource and data limitations, the existing model was not updated during the meeting nor were the previously calculated reference points accepted. Therefore, no LRP, including the previously established values (DFO 2012), was considered applicable at this time. In the absence of a LRP, it was not possible to identify which zone of the Precautionary Approach framework the stock is currently within.

Ecosystem

Physical Oceanographic Environment

The SA 2 + Divs. 3K region extends off northern Labrador to the eastern Newfoundland Shelf with bottom topography consisting of relatively shallow banks, deep cross-shelf channels and steep continental slopes. The ocean circulation is dominated by the southward-flowing Labrador Current which transports colder relatively fresh water from the north, as well as warmer saltier Labrador Sea water along the continental slope regions. Hydrographic conditions are determined in part by these and other factors, such as local winds and air temperatures. The main features of an analysis of historical climate data show mostly above average temperature conditions during the 1960s, a brief cold period during the early 1970s and again in the mid-1980s. Temperature conditions then declined to the coldest on record in the early 1990s and remained below normal until the mid-1990s. Since then there has been a significant warming trend with temperature values reaching record highs in the late 2000s. The most recent years, notably 2014 and 2015, experienced a short term decline but data available to date in 2016 indicates a return to a warming trend.

Invertebrate and fish community

The structure of the ecosystem within NAFO Divs. 2J and 3K has undergone significant changes since the mid-1990s. The entire fish community collapsed in the late 1980s and early 1990s, with average fish size also declining during this period. After the collapse, the system became highly dominated by shellfish, with peak dominance in 2003 when more than 60% of the estimated Fall RV biomass was shellfish. Consistent signals of rebuilding of the fish community appeared in the mid-to-late 2000s; this signal was also associated with an increase in average fish size. In the 2010s the overall biomass has remained relatively stable, but the dominance of groundfish has increased, while shellfish has decreased. Redfish is the dominant fish among plank-piscivores, having a three-fold increase in biomass between the mid-1990s and the 2010s.

Studies of diet composition of key groundfish species in Divs. 2J and 3K since 2008 indicate that Redfish is a frequent food item for Atlantic Cod and Greenland Halibut, and an occasional one for American Plaice. Despite its regular occurrence, Redfish does not appear as a dominant prey for these predators. However, long term diet data for Greenland Halibut indicate that Redfish represented up to 20% of its diet in the late 1980s, while available data from Divs. 2H shows up to a maximum of 30% of Redfish in the Greenland Halibut diet in 2010. Major diet changes in recent years involve the shift from shrimp to capelin as key prey item among fish top predators. As a predator, Redfish shows a variable diet composition between years, but amphipods, shrimp, myctophids, and euphausiids appear as consistently important prey items.

Sources of Uncertainty

Russian (2001-2015) and Lithuanian (2001-2015) catches assigned to Divs. 2J in the NAFO Statlant 21 database are fished outside the 200 mile limit and likely originate from the Irminger Sea pelagic stock (Power 2001). Subsequently, these values are omitted from the catch totals for SA 2 + Divs. 3K (2J + 3K) for the years 2001 to 2015. Prior to 2001, Russian and Lithuanian (and non-Canadian) catch are assumed to be primarily within the 200 mile limit and are included in the catch total. It is possible that a larger portion of non-Canadian catch currently assigned to SA 2 + Divs. 3K also originates within the Irminger Sea.

Redfish in SA 2 + Divs. 3K are composed of a mixture consisting primarily of *S. mentella*, lesser amounts of *S. fasciatus*, and sporadic occurrences of *S. marinus. S. mentella* and *S. fasciatus* are similar in appearance and are not separated in either the commercial or research survey catch. Despite their physical similarities the species have different depth and temperature preferences; changes in environmental conditions will not affect the three species equally, increasing the difficulty in interpreting survey indices changes in the stock complex.

Atlantic *Sebastes spp.* are known as episodically recruiting species where large year-classes may occur only once a decade or less frequently even in healthy populations.

Redfish survey catchability can vary significantly due to biological (formation of dense aggregations) or environmental (water temperature effects or depth range) reasons. This can result in inconsistent catch results within surveys, leading to high inter-annual variation at times. This is exacerbated by the combination of three species into a stock complex since the catchability of individual species can change independently in response to environmental changes.

Incomplete observer coverage of certain gear types, such as <50% coverage of trawl effort or <10% of gillnet effort, can introduce bias and/or uncertainty into analyses to determine Redfish bycatch and/or discards within commercial fisheries.

Lack of age information precludes certain types of analyses such as weight at age and cohort-based population modelling.

CONCLUSIONS AND ADVICE

Redfish biomass increased considerably from 2003-2010 with biomass during 2010-2015 reaching approximately half of the pre-collapse (1978-1990) levels. Recruitment (abundance of Redfish <15 cm) since 2000 was above the long term average with a time-series high in 2014. The fishery remains under moratorium, and average bycatch (including discards) since 2006 has been approximately 500 t. The meeting was neither able to validate nor invalidate existing reference points (DFO 2012) derived from production models due to substantive concerns about input data and an incomplete documentation of the rationale for model formulation.

In the absence of a LRP, it is not possible to identify what zone of the PA framework this stock is currently within. It is recommended that adaptive and cautious management be applied to any reopened fishery.

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SOURCES OF INFORMATION

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DFO 2011. Recovery potential assessment of Redfish (*Sebastes fasciatus* and *S. mentella*) in the Northwest Atlantic. DFO Can Sci. Advis. Sec. Advis. Rep. 2011/044.

DFO 2012. Reference points for Redfish (*Sebastes fasciatus*, *S. mentella*) in the Northwest Atlantic. DFO Can Sci. Advis. Sec. Advis. Rep. 2012/004.

Campana, S.E., Zwanenburg, K.C.T., and J.N. Smith. 1990. $^{210}Pb/^{226}Ra$ determination of longevity in Redfish. Can. J. Fish. Aquat. Sci. 47:163-165.

Gascon, D. (Editor). 2003. Redfish Multidisciplinary Research Zonal Program (1995-1998): Final Report. Can. Tech. Rep. Fish. Aquat. Sci. No. 2462. 155 p.

MacAllister, M., and D.E Duplisea. 2011. Production model fitting and projection for Atlantic Redfish (*Sebastes fasciatus* and *Sebastes mentella*) to assess recovery potential and allowable hard. DFO. Can. Sci. Advis. Sec. Advis. Rep. 2011/057.

Magnússon, J., and J.M. Magnússon. 1995. Oceanic Redfish (*Sebastes mentella*) in the Irminger Sea and adjacent waters. Scientia Marina 59: 241-254.

Power, D. 2001. The status of Redfish in SA 2 + Divs. 3K. DFO Can. Sci. Advis. Sec. Res. Doc. 2001/102.

Sévigny, J.-M., Methot, R., Bourdages, H., Power, D.J., and P.A. Comeau. 2007. Review of the structure, the abundance and distribution of *Sebastes mentella* and *S. fasciatus* in Atlantic Canada in a species-at-risk context: an update. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/085

Valentin, A., Power, D., and J.-M. Sévigny. 2015. Understanding recruitment patterns of historically strong juvenile year classes in Redfish (*Sebastes* spp.): the importance of species identity, population structure, and juvenile migration. Can. J. Fish. Aquat. Sci. 72: 774-784.

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