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Science Advisory Report 2023/004

STOCK STATUS OF REDFISH IN NORTHWEST ATLANTIC FISHERIES ORGANIZATION (NAFO) SUBAREA 0, AND SUBAREA 2 + DIVISION 3K

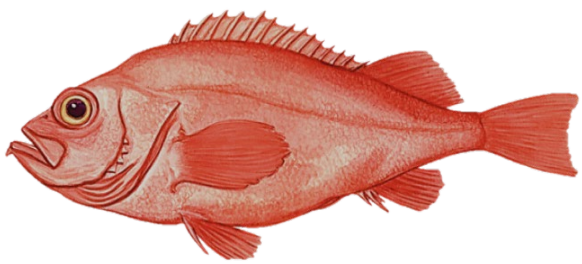

Image: Redfish, Sebastes sp.

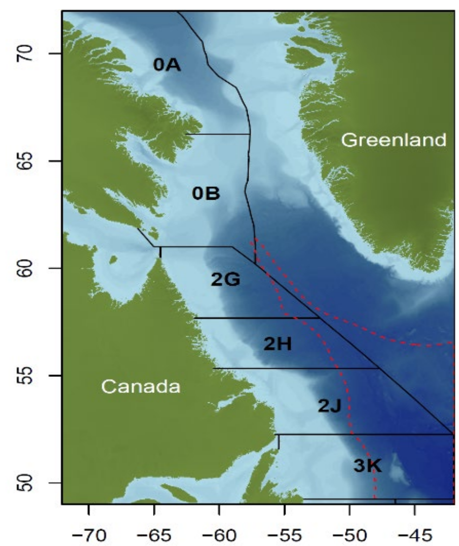

Figure 1. Map of the Northwest Atlantic indicating the SA 0 and SA 2 + Div. 3K management areas for redfish.

Context:

In the Northwest Atlantic, redfish (Sebastes spp.) range from Baffin Island in the north to waters off New Jersey in the south and are managed as several discrete stocks. The status of the two northern most stocks: Northwest Atlantic Fisheries Organization (NAFO) Subarea (SA) 2 (includes Divs. 2G, 2H, and 2J) + Div. 3K, and NAFO SA 0 (includes Divs. 0A and 0B) was assessed in spring 2021. The assessments were based on a complex of redfish species (S. mentella, S. fasciatus, S. norvegicus) with the presumption that the predominant species in each complex was likely S. mentella. However, fish from neither stock are separated by species in the research or industry surveys or in the catch data. Redfish are very slow-growing and long-lived. Very strong recruitment pulses occur occasionally, but they do not always persist to contribute to the adult populations. Connections with adjacent populations are poorly understood. Redfish often form patchy aggregations that at times are very dense, which may contribute to high variability in catches. Current data on maturity and aging are not available for either stock. Assessments for both stocks are based on survey indices. From 1997 to the present, the SA 2 + Div. 3K stock has been under moratorium to directed fishing, and a fishery has never been established in SA 0. While there is no defined Precautionary Approach (PA) framework for either stock, current total survey biomass levels remain low. This Science Advisory Report is from the May 4–7, 2021 Zonal Peer Review 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.

January 2023

SUMMARY

This meeting assessed two redfish (*Sebastes spp.*) stocks, NAFO Subarea (SA) 2 + Division (Div.) 3K and NAFO SA 0. These stocks are assessed and managed as a species complex that has been historically dominated by *S. mentella* and also includes *S. fasciatus* and *S. norvegicus*.

Environmental and Ecosystem Information

- The warmest period of ocean temperatures over the last 70 years in Divs. 2HJ3K was the 1960s and the coldest was the early-1990s. Between the early 1990s and the early 2010s, a sustained warming trend was observed. After a short return to cooler near average conditions in the mid-2010s, temperatures warmed again during 2018–20 at bottom and Cold Intermediate Layer (CIL) depths.
- In Divs. 2HJ3K, higher nitrate inventories since roughly 2015 have resulted in improved primary (chlorophyll biomass) and secondary (zooplankton biomass) production indices over the past 4–5 years. Since the mid-2010s, the zooplankton community has undergone structural changes characterized by a higher proportion of small copepods along with an increase in overall biomass. Changes in zooplankton seasonality (lower spring and higher summer and fall signals) and community size structure (fewer large, energy-rich calanoids and more small copepods) may impact energy transfer to higher trophic levels.
- Ecosystem conditions in the Newfoundland and Labrador (NL) bioregion continue to be indicative of limited productivity of the surveyed fish and shellfish community, with total biomass levels much lower than prior to the fisheries collapse in the early 1990s. Following some improvement between the mid-1990s and mid-2010s, total biomass declined after 2015. While there have been improvements since, current total biomass has not returned to the 2010–15 levels. Increases in medium-large predatory groundfish from 2010–15 were primarily associated with bottom-up processes, including availability of capelin and shrimp.
- An ocean climate index derived for Subarea 1 (considered representative for Div. 0B), including sea surface temperatures from West Greenland shelf, Labrador Sea and Hudson Strait, was at its highest value in 2019 since the record-high of 2010.
- The initiation of the spring phytoplankton bloom in Div. 0B was delayed for a second consecutive year in 2019, compared to the 1998–2015 average and total spring bloom production was below normal in 2019.
- Fish species diversity is greater in Div. 0B than in 0A. *S. mentella* was common to both divisions and was identified as an indicator species in a fish assemblage occupying the shallow, warm water of the South Baffin shelf. Additionally, *S. mentella* have been found to comprise 10% (wet weight) of the diet of Greenland halibut caught in 0B.

Subarea 2 and Division 3K Redfish Assessment

- The 2020 Divs. 2J3K recruitment index (abundance of redfish < 15 cm length) was substantially higher than any value observed previously in the time series (1978–2020). Signals indicate that recruitment was also high in Divs. 2H and 2G in 2020. Redfish recruitment is episodic and conditions that produce strong recruitment are not understood, including the potential for recruits to originate from neighbouring areas.
- The Divs. 2J3K abundance index from the fall DFO research survey generally declined from 2011–2017, followed by a sharp increase in 2020, to the third highest value in the time

series (1978–2020). Abundance indices from surveys conducted in 2H (1978–2020) and 2G (2005–20) were at time series highs in 2020. Biomass indices across all survey areas were comparable to the observed abundance trends, with the exception of recent increases in abundance that were not reflected in the biomass indices (since these increases have been driven by very small fish that do not yet contribute significantly to biomass).

- While the fishery remains under moratorium (in place since 1997), the impacts of removals (bycatch landings and discards) from other fisheries on the stock are currently unknown. Redfish removals, mainly of small sized fish, averaged 55 t from 2015–19, but increased to more than 200 t in 2020 across the stock area, which occurred predominantly in the 2G shrimp fishery. Even small amounts of removals, by weight, can equate to large numbers when fish are small.
- There is currently no accepted population model for this stock and projections could not be generated. Redfish are very slow-growing and strong recruitment pulses do not always persist. Therefore it is unknown whether the 2020 pulse will make a significant contribution to the stock or any potential fishery.
- While there is no defined PA framework for this stock, current total survey biomass levels remain low; therefore, it is advised that management measures focus on encouraging stock growth.

Subarea 0 Redfish Assessment

- There is no commercial redfish fishery in Subarea 0. Fishing mortality is limited to bycatch, mainly of small fish caught in shrimp fisheries, and to a lesser extent in Greenland halibut fisheries. Annual total bycatch for both the shrimp and Greenland halibut fisheries peaked in 2005 (229 t) and since declined to less than 50 t per year (2014–19). Small amounts of bycatch, by weight, can equate to large numbers of removals when fish are small, but overall impacts of bycatch on the stock are not currently known.
- Abundance and biomass indices from DFO research surveys in Divs. 0A (1999–2019) and 0B (2000–16) peaked in 2012 and have since declined to levels similar to the time series lows of the early 2000s.
- Abundance and biomass indices in the Northern Shrimp Research Foundation (NSRF) survey of Shrimp Fishing Areas (SFAs) 2, 3 and Resolution Island, which are primarily composed of redfish < 20 cm, reached higher levels in the mid-2000s, subsequently declined and then reached a time series high in 2020. The SFA 2 survey is considered most representative as an index for this stock; the survey biomass and abundance indices decreased from 2010–19 with a sudden increase in 2020.
- A recruitment index of < 15 cm redfish is not available for SA 0. The multispecies survey is conducted at depths greater than 400 m and therefore has low catches of redfish < 15 cm which occupy shallower habitats. The NSRF survey occurs at depths at which < 15 cm redfish occur but length frequency data are not collected.
- Length-frequency data from DFO multispecies surveys in Divs. 0A and 0B indicate that in Div. 0A few year classes are present with no evidence of incoming recruitment since 2016, while in Div. 0B there is a broader range of year classes, with more consistent recruitment signals.
- There is currently no accepted population model for this stock and projections could not be generated. Redfish are very slow growing and strong recruitment pulses do not always

persist. Therefore, it is unknown whether the 2020 pulse in the SFA 2 survey index will make a significant contribution to the stock or any potential fishery.

- There is no defined PA framework for this stock. Given the declining trend in the SFA 2 biomass time series prior to 2020 and the uncertainty around the persistence of the peak observed in 2020, it is advised that management measures take a cautionary approach to managing this cohort until it achieves exploitable size.

INTRODUCTION

Redfish are part of the Sebastidae family of fishes that are distributed in temperate to Arctic marine habitats on both sides of the North Atlantic Ocean. Deepwater redfish (*Sebastes mentella*), Acadian redfish (*S. fasciatus)*, and Golden redfish (*S. norvegicus, formerly S. marinus*) are difficult to differentiate due to similarities in morphology and colouration (Coad and Reist 2018). In the northwest Atlantic, these three species of redfish are reported and managed together as *Sebastes* spp. complexes in NAFO SA 2+ Div. 3K (includes Divs. 2G, 2H, 2J, and 3K) and also in SA 0 (includes Divs. 0A and 0B) (Figure 1).

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) considers redfish stocks in SA 2+3K and SA 0 to be part of larger populations (Northern Population of Deepwater redfish and Atlantic population of Acadian redfish) and suggested that these populations have declined by over 95% compared to their highest historical level. In April 2010, COSEWIC labelled both populations as “Threatened” (COSEWIC 2010). However in the last decade, high recruitment pulses have been observed in neighbouring populations indicative of potential improved conditions for redfish survival.

In SA 2 + Div. 3K a moratorium on directed fishing on redfish has been in effect since 1997 and a fishery has never been established in SA 0. However, redfish are regularly captured as bycatch in commercial fisheries targeting shrimp (*Pandalus borealis* and *P. montagui)* and to a lesser extent, Greenland halibut (*Reinhardtius hippglossoides*). These fisheries do not differentiate redfish bycatch by species.

In 2016, a Canadian Science Advisory Secretariat process provided advice on the status of redfish stocks in NAFO SA 2 + Div. 3K and in SA 0. At that time, the recent (2010–2015) Divs. 2J3K redfish survey biomass was almost half the pre-collapse (1978–1990) level, while the recruitment index (based on survey abundance of redfish < 15 cm) was above average, with a time-series high in 2014. That was the first assessment of redfish in NAFO SA 0 and concluded that the Eastern Assessment Zone (includes area within SFA 2) biomass index was relatively stable, there had been an increase in the proportion of Deepwater redfish with lengths greater than 20 cm in Div. 0B between 2001–02 and 2013–15, and bycatch of 200 t annually did not appear to be causing harm to the stock.

ASSESSMENT: SUBAREA 2 AND DIVISION 3K REDFISH

The assessment of the redfish species complex in SA 2 + Div. 3K considered information on landings, bycatch and discards from all countries (1959–2020) in conjunction with analyses of data from the Canadian research vessel surveys conducted in SA 2 + Div. 3K in the fall from 1978 to 2020.

Oceanography and Ecosystem

The SA 2 + Div. 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 system which transports colder, relatively fresh Arctic water along the shelf, as well as warmer saltier Labrador Sea water along the continental slope. Sub-surface hydrographic properties on the shelf (e.g., bottom temperature and CIL) are largely determined by the previous winter conditions and these properties are carried over by this current system. Summer conditions are influenced by other factors such as local winds, freshwater runoff and air temperatures. The main findings from a recent analysis of historical climate data showed 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 reached the coldest on record in the early 1990s and remained below the climatological (1991–2020) average until the mid-1990s. Since that time, there has been a significant warming trend with temperatures reaching record highs around 2010–2011. After a short return to colder temperatures between about 2014 to 2017, recent years (2018–20) suggest a return to a warming trend (Cyr and Galbraith 2021). Primary production (based on nitrate and chlorophyll) and zooplankton abundance (mostly dominated by copepods) in the region have shown an increasing trend since the mid-2010s.

Following the 1990s collapse of groundfish and change in ecosystem structure in the NL bioregion, improved availability of prey (such as capelin) led to improvements in the groundfish community in the mid to late-2000s. Despite the improvements in the 2000s, groundfish biomass did not return to pre-collapse levels.The overall finfish biomass remained fairly stable untill 2010–2015, however declines have been noticed in recent years following reduced availability of capelin and shrimp (Koen-Alonso and Cuff 2018, DFO unpublished data). In the northern areas, redfish are becoming important prey items and are being recorded in the diets of Atlantic cod, Greenland halibut, and American plaice (DFO unpublished data). Redfish, themselves have a very varied diet. Diets of large redfish include invertebrates and fish such as capelin, mesopelagic fish, and some small redfish, while diets of small redfish are primarily dominated by invertebrates.

Fishery Removals

The estimate of fishery removals is based on landings data from outside of Canada's EEZ (obtained from NAFO Statlant 21A); Canadian landings (compiled by Policy and Economics branch of DFO NL); and bycatch estimates (derived from at-sea observer sampling).The highest recorded catch of SA 2 + Div. 3K redfish was 187,000 t in 1959, and the majority of the catches during 1959–77 were taken by non-Canadian fleets (Figure 2). From 1978 onwards, redfish catches have been from primarily Canadian fleets. A Total Allowable Catch (TAC) of 30,000 t was implemented in 1974.

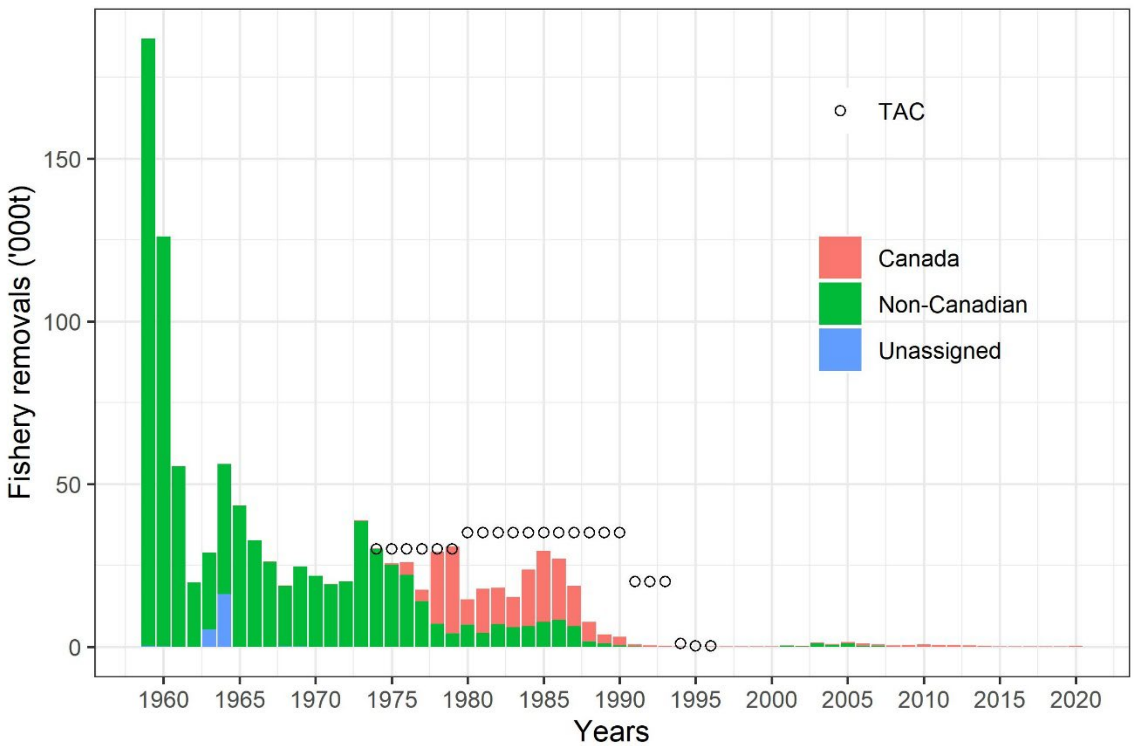

Figure 2. Redfish reported removals in SA 2+Div 3K by Canadian (including discards) and non-Canadian fleets. Circles represent Total Allowable Catch (TAC). There has been no directed fishing since 1997.

The TAC was revised upward to 35,000 t in 1980 and downward to 20,000 t in 1991 and to 1000 t in 1994. In 1995, the TAC was further lowered to 200 t and held there for two years until 1996 (Figure 2 and Figure 3). Since 1997, a moratorium on directed fishing has been in place and removals are comprised of discards from the shrimp and Greenland halibut fisheries, which combined have ranged between 30 t and 600 t and averaged 240 t annually. In 2020, over 98% of total discards were from the shrimp fishery, predominantly in Div. 2G (Figure 4). Note that Russian (2001–07) and Lithuanian (2001–11) catches are considered to be from the Irminger Sea population of redfish and are not included in SA 2 + Div. 3K removal totals for those years.

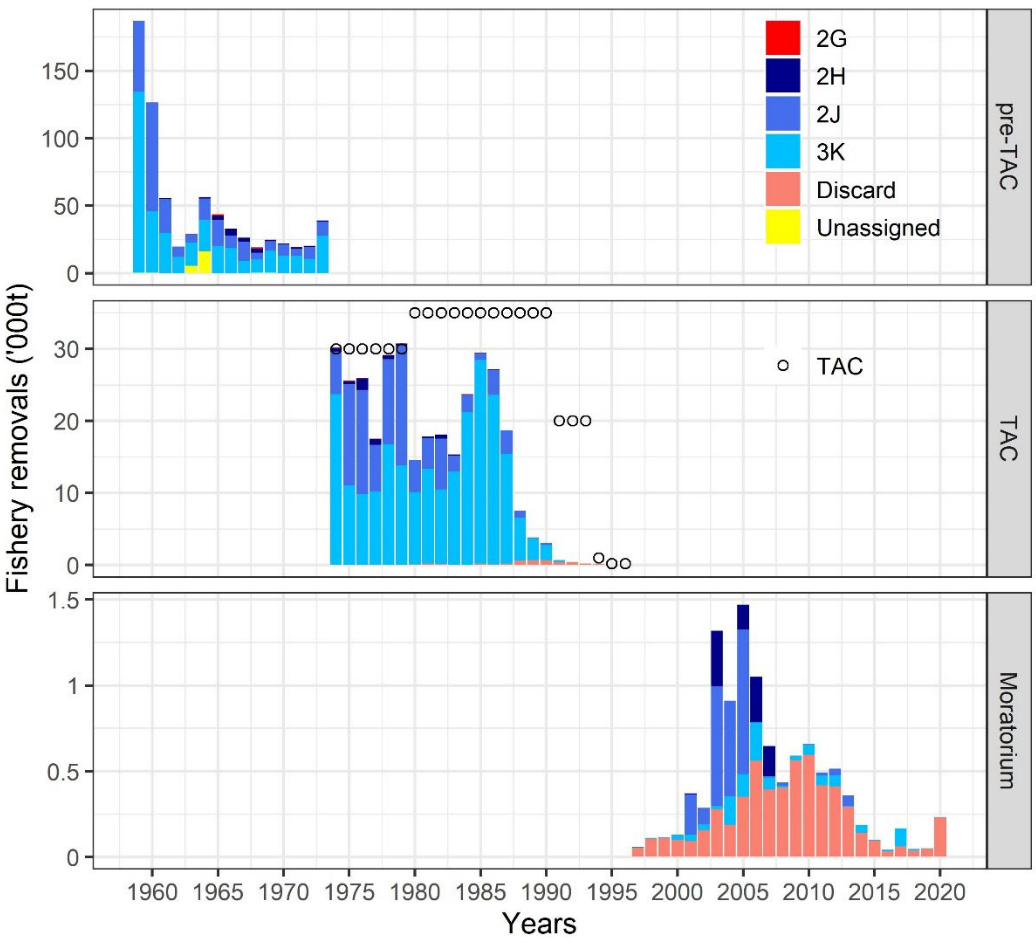

Figure 3. Redfish reported removals split into three phases: before the TAC regulation (pre-TAC), during TAC, and during the moratorium. The "Discard" portion of the plot also includes landed bycatch.

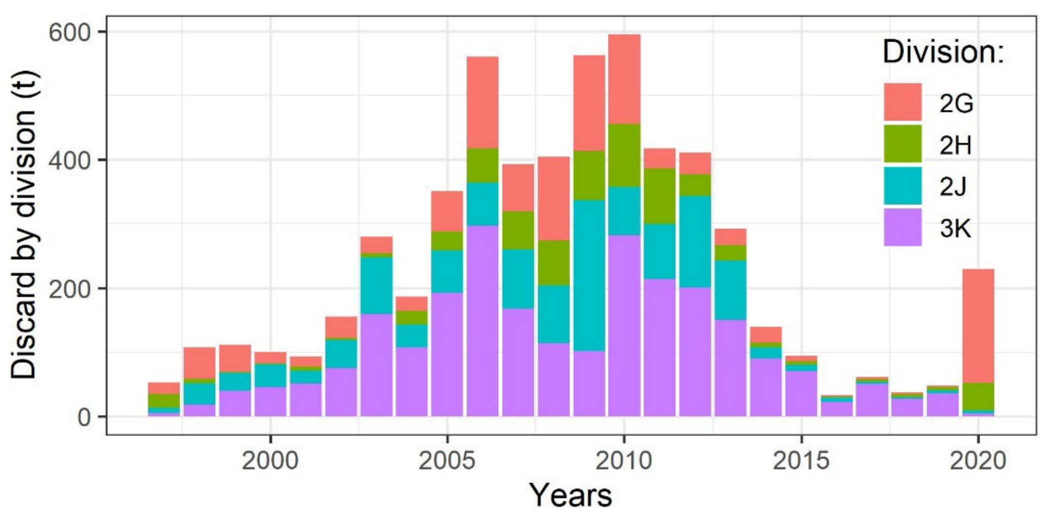

Figure 4. Division-wise redfish discard in SA 2+Div 3K. The discard data also includes landed bycatch.

Survey design

Research vessel (RV) multi-species bottom trawl surveys using a depth-stratified random design were conducted in the fall Divs. 2J and 3K from 1978 to 1995, with coverage of depths to 1000 m and from 1996 to 2020 with coverage to 1500 m. RV surveys in Div. 2G were conducted sporadically between 1978 and 1999 with varying spatial coverage and timing. Div. 2H surveys were conducted sporadically between 1978 and 2010, and annually thereafter (Figure 5). Coverage in Div. 2H surveys was extended from 1,000 m to 1,500 m in 1996.

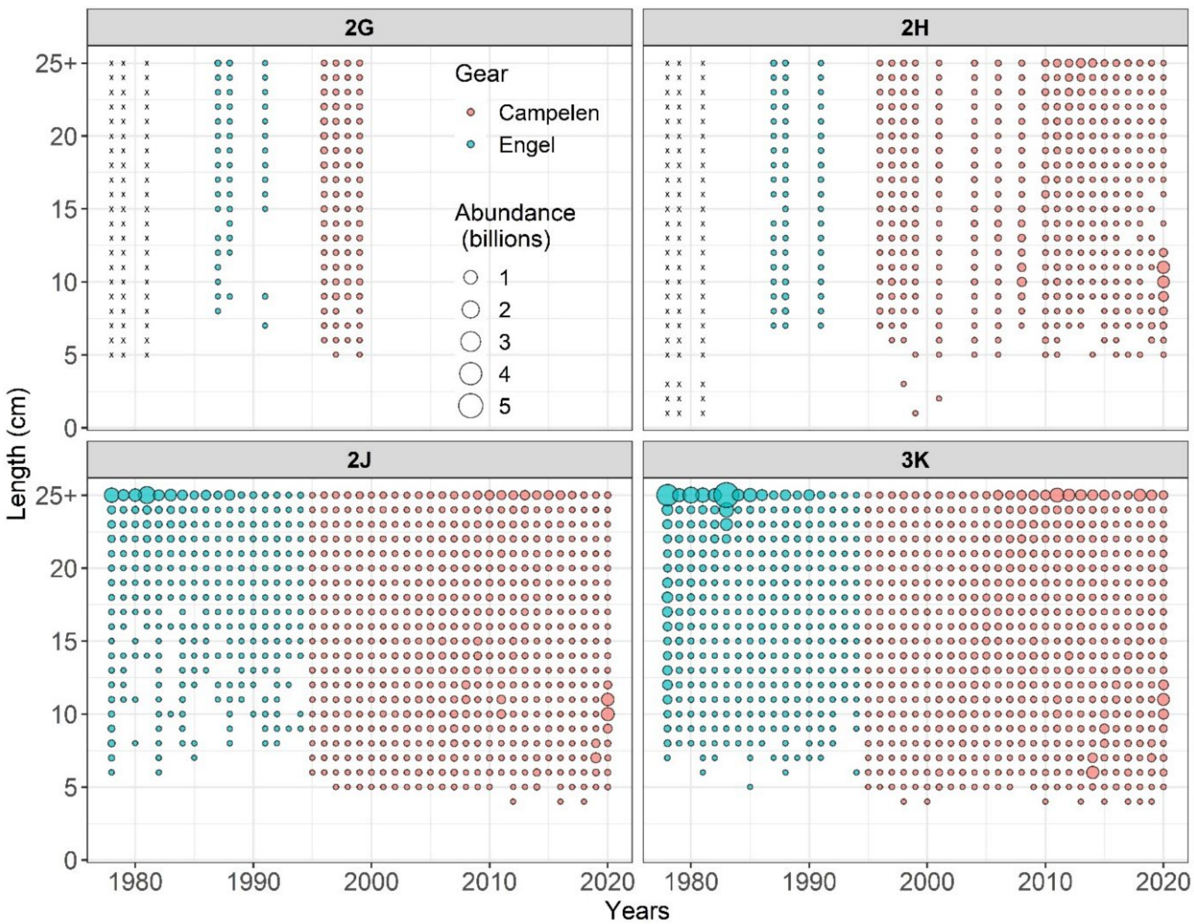

Figure 5. Bubble plots indicating years with Canadian fall RV survey coverage in NAFO Divs. 2GHJ3K. Bubbles size is proportional to the survey estimate of redfish abundance-at-length. The colors differentiate indices obtained from Engel and Campelen trawl gear. The symbol "x" in the plot indicates years where survey was done, but length-frequencies were not produced.

Prior to fall 1995, RV surveys were conducted with an Engel 145 high lift otter trawl with a small mesh liner (29 mm) in the codend and 30 minute tow duration at a speed of 3 knots. In fall 1995 a Campelen 1800 shrimp trawl was introduced with a 12 mm liner in the codend and15 minute tow durations at a speed of 3 knots. Comparative fishing trials were conducted between the new vessel and gear (CCGS *Teleost* with Campelen 1800 shrimp trawl) and the previous vessel and gear (MV *Gadus Atlantica* with Engel 145 Otter trawl). The data collected were analysed by length groups to provide a means to convert the older data time series into Campelen equivalents (Power and Orr 2001). Campelen data and Campelen-equivalents were used in the assessment.

Survey abundance and biomass

This assessment is based on RV survey data, and no population modelling is involved: The survey estimates presented here should be considered relative, not absolute estimates of population abundance or biomass. The terms ‘survey abundance’ and ‘survey biomass’ or ‘index’/ or ‘indices’ are used to emphasize this distinction. The mean number or weight per tow of RV survey is raised at the strata level, and the sum of the values across all index strata gives the estimates of survey abundance or survey biomass.

Survey abundance and biomass trends for redfish in SA 2 + Div. 3K are based primarily upon survey indices from Divs. 2J + 3K only, due to sporadic or inconsistent sampling in Divs. 2GH. Div. 2G was last sampled in 1999 and Div. 2H has only been consistently sampled since 2010 (Figure 5).

Abundance indices for the fall survey in Divs. 2J3K generally declined from 2010 to 2017, then increased sharply in 2020, to the third highest value in the time series (1978–2020) (Figure 6).

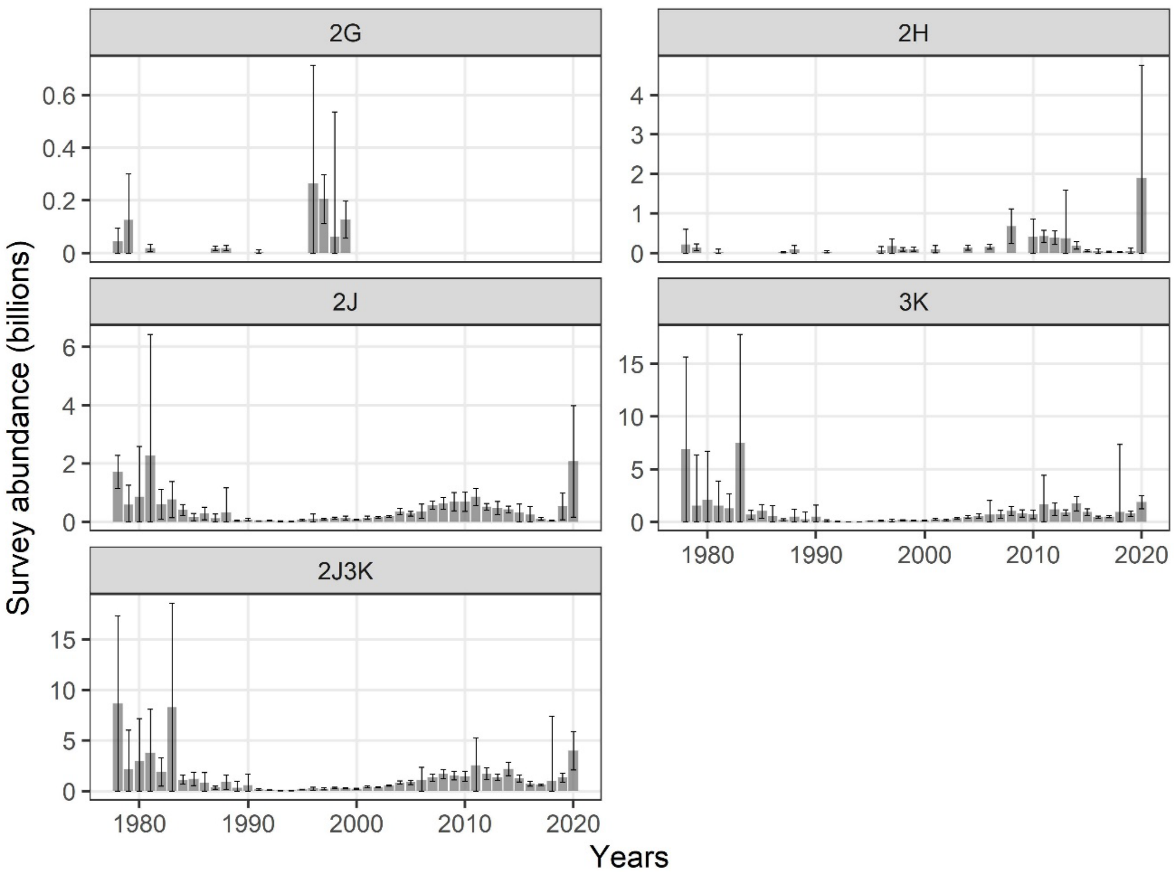

Figure 6. DFO-RV survey abundance for redfish in each NAFO division. Vertical lines in each bar represent 95% confidence intervals. Years with no bar represent years where no RV survey occurred.

There was a similar trend in the biomass indices from Divs. 2J3K, except in the recent three years (Figure 7). Index values for 2019 and 2020 were lower than the 2018 value, primarily because the abundance indices are driven by the higher number of young fish in recent years that do not yet contribute significantly to biomass. Survey abundance and biomass values in Div. 2J were on average 42–44% less than those in Div. 3K.

The years 2010–2020 represent the only comparable period of complete survey sampling within each of Divs. 2H, 2J, and 3K. During this period, the average contribution of Divs. 2H, 2J, and 3K to total survey abundance were 12.5%, 26.5%, 61%, respectively, and contributions to total survey biomass were 9.5%, 28%, and 62.5%, respectively.

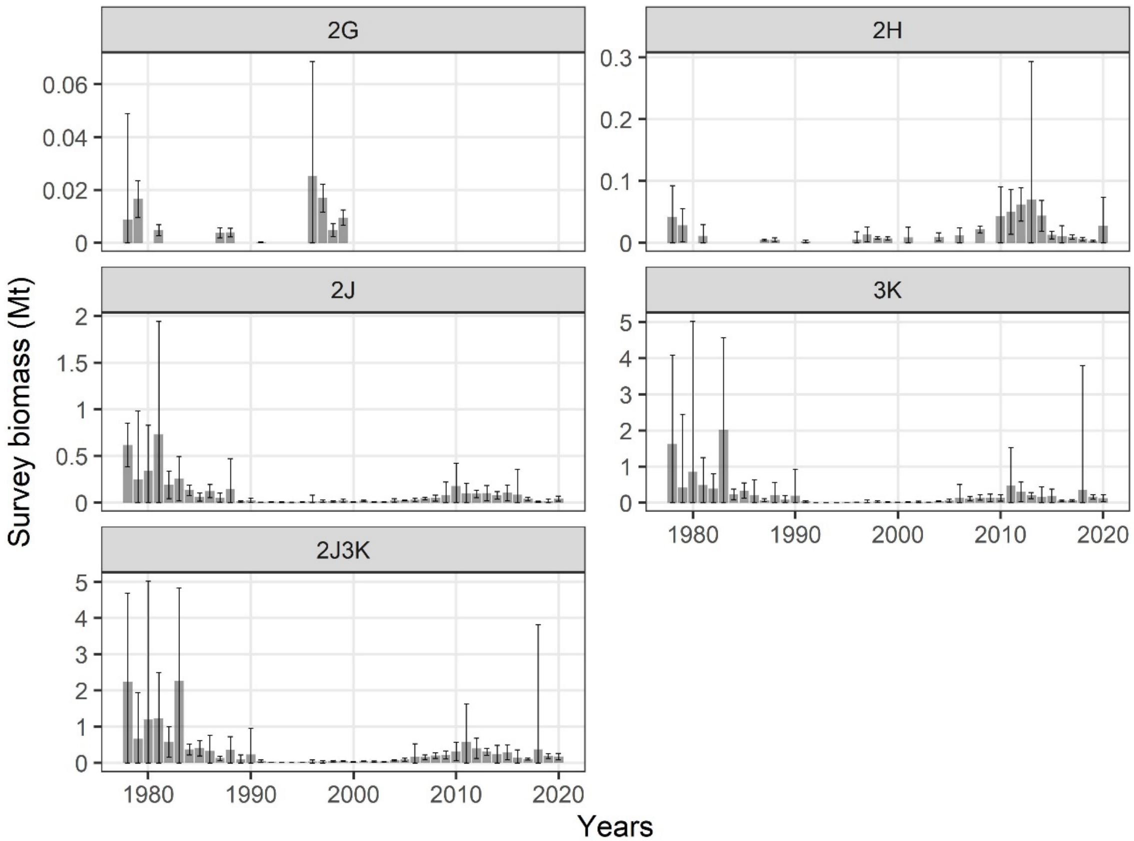

Figure 7. DFO-RV survey biomass (million tonnes) for redfish in each NAFO division. Vertical lines in each bar represent 95% confidence intervals. Years with no bars represent years where no RV survey occurred.

Starting in 2005, a portion of Div. 2G has been included in the NSRF survey. Redfish abundance and biomass indices for Div. 2G from the NSRF survey showed an increase from 2005 to 2010, followed by a decline to series low or near low levels by 2019. This was followed by an exceptional increase in abundance in 2020. The increase in biomass in 2020 is also substantial but not as high as observed for the abundance (Figure 8), mainly because the increased abundance of young fish did not contribute much to the biomass.

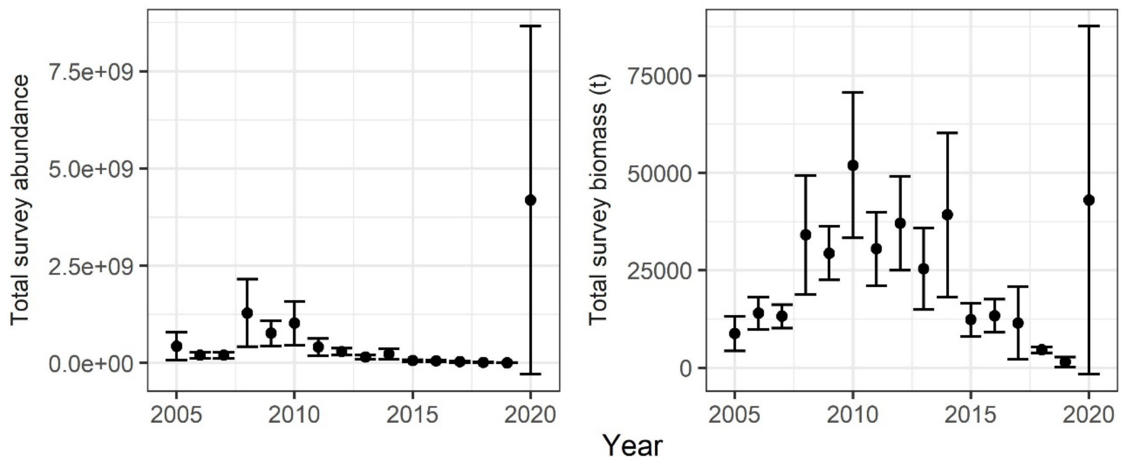

Figure 8. Redfish abundance and biomass (t) from the NSRF survey in Div. 2G. Source: DFO Arctic region.

Recruitment

A recruitment index (Figure 9), calculated as the abundance of redfish less than 15 cm, was relatively low (average about 36 million) from 1979 to 2000 in Divs. 2J3K. Since then, the recruitment index has generally been near or above the time series average of 331 million redfish. In 2020, the recruitment index was exceptionally high and reached 3538 million. Div. 2H also shows exceptionally high recruitment in 2020 (Figure 9). Length-frequency information is not available from the NSRF survey in Div. 2G. Redfish recruitment is episodic and conditions that produce strong recruitment are not understood, including the potential for recruits to originate from neighboring areas; therefore, it is unclear how the high number of young fish observed in 2020 will contribute to future fisheries.

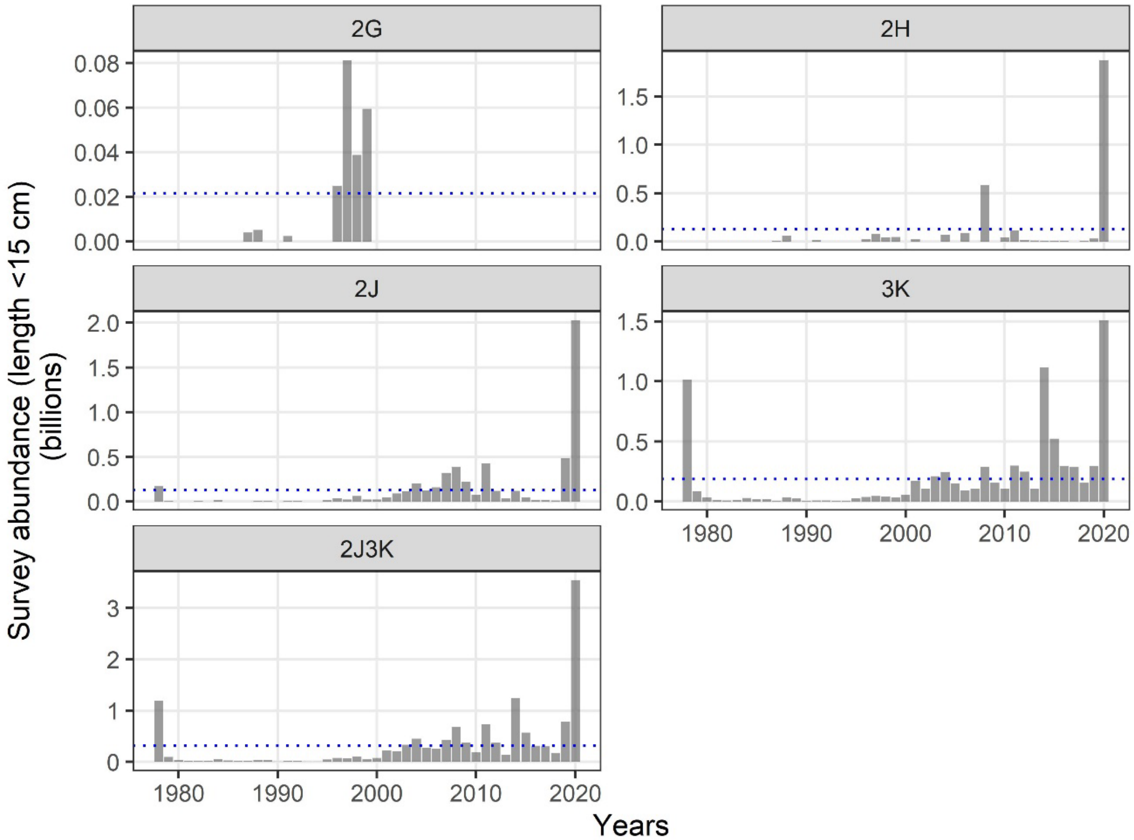

Figure 9. Recruitment index for redfish in SA 2 + Div. 3K based on total survey abundance estimates of redfish less than 15 cm. Dotted lines show the mean of the time-series.

Sources of Uncertainty

Redfish in SA 2 + Div. 3K are composed of a mixture of species consisting primarily of *S. mentella*, with lesser amounts of *S. fasciatus*, and sporadic occurrences of *S. norvegicus*. *S. mentella* and *S. fasciatus* are similar in appearance and are not separated in either commercial or research survey catch and *S.norvegicus* are only separated at larger sizes (> 25cm).

The catch was estimated from the combination of Statlant 21A and the DFO NL reported landings available from Policy and Economics Branch and upscaling of observer data. With respect to data from Statlant 21A, Russian (2001–08) and Lithuanian (2001–11) catches assigned to Div. 2J are fished outside the 200 nautical miles limit and quite likely originate from the Irminger Sea pelagic stock (Power 2001), and therefore, are not included in the removals reported in this document. It has been hypothesized that the Irminger Sea pelagic stock has shifted its summer distribution and that a portion now extends into Div. 1F and to some degree into Div. 2J (Paramonov 2008). Redfish bycatch estimation is based on the observer records of redfish bycatch from shrimp and Greenland halibut tows. All tows are not observed for these fisheries in every division and every year, therefore, we scaled up the observer records of redfish bycatch according to total landing in the shrimp and Greenland halibut fisheries by division and year. This scaling process leads to some uncertainty in the bycatch estimates.

A number of factors are contributing to uncertainty around the recent pulse observed in juvenile recruitment. Redfish are known as an episodically recruiting species where large year-classes may occur only once a decade or less frequently, even in healthy populations. In 2020, recruitment appeared to be at historically high levels, however the drivers of this recruitment pulse are not clearly understood, including the question of whether or not this recruitment pulse originated from within the stock area or from neighbouring stocks, which have also noted high recruitment in recent years. One aspect to consider here in making the conclusion about historical high recruitment in 2020 is that the Campelen trawls catch small fish (< 20 cm) more effectively than Engel trawls (which were used prior to 1995). Following comparative fishing experiments, conversion factors (catchability ratios) were developed to standardize catch rates across Engel and Campelen tows (i.e., essentially converting older Engel trawl catches into Campelen-equivalent catches). The conversion factor for redfish < 10 cm was assumed to be the same as for redfish equal to 10 cm because sample sizes were too small at lengths < 10 cm to generate a reliable conversion factor (Power and Orr 2001). Therefore, long-term trends need to be interpreted with caution as surveys before 1995 are in Campelen-equivalent units, and may under-represent actual recruitment in the pre-1995 period. Redfish survey catchability can also vary significantly due to biological (formation of dense aggregations) or environmental (water temperature effects or depth range) reasons. This can result in inconsistent catch within surveys, leading to high inter-annual variation.

Though some information on aging redfish is available prior to 2000s, aging data is not available for recent years mainly because it is challenging to accurately age this species.

Factors such as (1) lack of survey-at-age data, (2) lack of commercial catch-at-age data, (3) episodic recruitment, and (4) difficulties in differentiating among species are the major impediments for the development of redfish stock-assessment models.

ASSESSMENT: SUBAREA 0 REDFISH

Oceanography and Ecosystem

Much of SA 0 is covered in sea ice from December to June (Ribergaard 2014) and the ecosystem within Baffin Bay and Davis Strait is influenced by the annual dynamics of sea ice formation and melting. The relatively shallow shelf extending southeast off the coast of Baffin Island is dominated by relatively cold (0°C), low salinity water flowing south along the coast, as well as currents flowing out of Hudson Strait. These currents mix the warmer (3–4°C) and more saline West Greenland current at about 64°N in the Labrador Sea near Resolution Island (Buch 2000, Cyr et al. 2020).

DFO has not conducted regular oceanographic surveys in SA 0. However, temperature and salinity data are collected during surveys using trawl-mounted CTDs. Mean near-bottom temperatures for Div. 0A (south of 72°N), generally ranged from to -0.2 to 1.7°C and declined with depth (Treble 2020). Bottom temperatures in Div. 0B are warmer (2.1 to 4.1°C), with the warmest temperatures at depths of 800 to 1000 m (Treble 2017).

An ocean climate index developed for SA 1 is considered representative for Div. 0B (Bélanger et al. 2020, Cyr et al. 2020); in 2019 this index was at its highest value since a record-high in 2010, and the third-highest since the beginning of the time series in 1985. In addition, the phytoplankton spring bloom and magnitude were derived from three sampling grids (Hudson Strait, Labrador Sea and West Greenland shelf) for the reference period of 1998–2015 (Bélanger et al. 2020). The initiation of the spring bloom was delayed for a second consecutive year in 2019 compared to the 1998–2015 time series. In 2019, the total spring bloom production (magnitude) was below the annual standardized anomaly (Bélanger et al. 2020).

Deepwater redfish is considered to be a representative species to characterize fish assemblages occupying shallow, warm waters of the South Baffin Shelf (Jørgensen et al. 2005). Within the ecosystem, redfish are prey for larger fish species such as Greenland halibut off Labrador and the Grand Banks of Newfoundland (Dwyer et al. 2010). In Div. 0B redfish were found to comprise approximately 10% of Greenland halibut diet (DFO unpublished data). Redfish stomach contents are difficult to assess because most individuals have everted their stomachs upon capture; however, redfish prey on zooplankton, shrimp and small fishes, changing their primary prey as they grow (Polaczek et al. 2023).

Fishery Removals

The shrimp and Greenland halibut trawl fisheries in SA 0 are required to have at-sea observers on all trips, therefore, there is good data on the bycatch of redfish from these fisheries. Redfish bycatch increased through time (1992–2019) in the Greenland halibut fishery (Figure 10). Both changes in fishing effort (increased since 2011) and catchability of redfish as they grow contribute to this observed increase. The highest value of redfish bycatch was 49 t (2013) and subsequent declines in bycatch totals were observed, with recent values at 15 t (2018) and 10 t (2019). Redfish bycatch through time (1980–2018) in the shrimp fishery has been highly variable with the highest total bycatch observed in 1996 at 362 t. In 1997, the Nordmore grate was introduced to the fishery with a grate spacing of 28 mm (Sifred 2010); a decline in redfish bycatch has been observed thereafter with the highest value occurring in 2005 at 222 t. During 2006–2011 redfish bycatch in the shrimp fishery was between 30 and 111 t and from 2012–2018 was less than 12 t annually. Redfish bycatch for the 2019 and 2020 shrimp fishery and 2020 Greenland halibut fishery were not available at the time of the 2021 CSAS meeting. Based on evidence from DFO Resource Management concerning implementation of move away provisions in the shrimp fishery and discussions with industry partners, redfish bycatch in 2020 is anticipated to be higher than the 2012–2018 values.

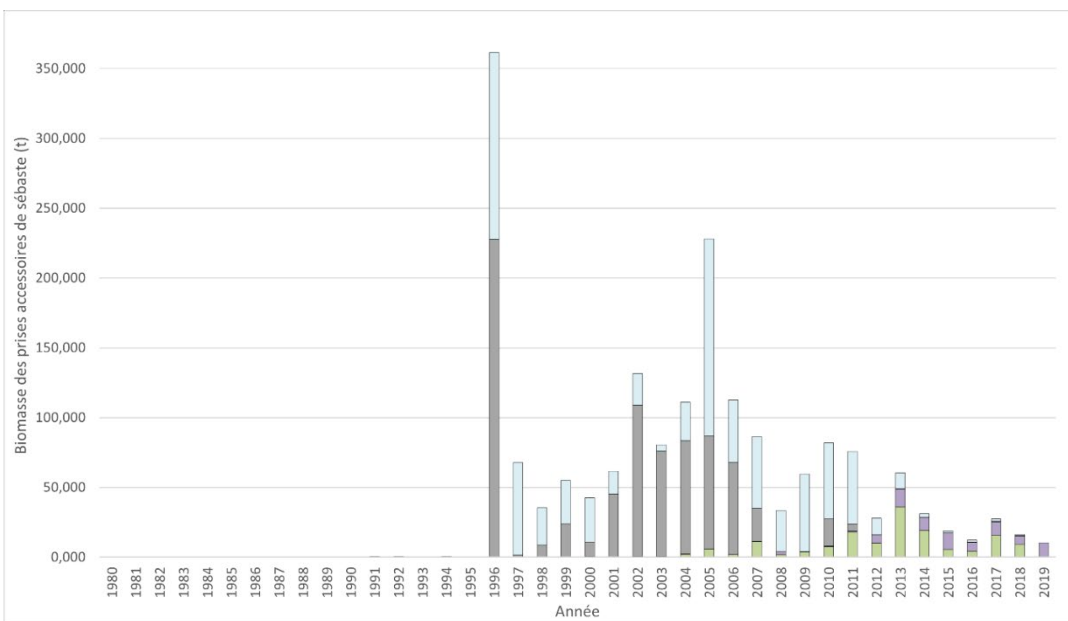

Figure 10. Redfish bycatch (t) in Greenland halibut (green (Div. 0B) and purple (Div. 0A)) and shrimp (grey (Div. 0A) and light blue (Div. 0B)) fisheries. The shrimp fishery bycatch data spans 1980 to 2018 with the Nordmore grate (28 mm spacing) introduced in 1997 (dashed line; Siferd 2010). The Greenland halibut fishery bycatch data spans 1992 to 2019 with an expansion of the fishery to Div. 0A in 1999 and regular increases in effort since then (Treble and Nogueira 2020).

Survey Design

Over the years 1999 to 2019, surveys have been conducted within SA 0, Ungava Bay/Hudson Strait (SFA 3) and Div. 2G to address different objectives. They have covered different fish and shrimp management areas, using different gears and including different depths. These surveys were examined for use in the assessment of SA 0 redfish. The NSRF SFA 2 survey (Figure 11) was found to be the most representative as an index for SA 0 stock as it included areas where redfish were most abundant.

DFO conducted depth-stratified (400 m to 1,500 m) bottom trawl surveys in portions of Divs. 0A and 0B (Figure 1) in the fall (September–November) during 1999 to 2017, in collaboration with the Greenland Institute of Natural Resources and the RV *Pâmiut*. In 2019, the RV *Helga Maria* replaced the *Pâmiut* and the survey in southern Div. 0A was completed in mid-August. An Alfredo III trawl with 140 mm mesh and a 30 mm mesh liner in the codend was used for these surveys, tow speed was 3 knots and duration 30 minutes. All fish were sampled for individual length and weight and redfish were identified to species (Scott and Scott 1988, Coad and Reist 2018). Description of the survey methods can be found in Treble (2018). A comparison of gear performance found differences between the RV *Pâmiut* and the RV *Helga Maria*, particularly at depths beyond 700 m (Nogueira and Treble 2020). Given differences in survey timing and gear performance, the comparability of 2019 estimates of redfish with previous years is uncertain. However, abundance of redfish in Div. 0A is low and this survey is not used as an index of abundance for the SA 0 stock.

The NSRF conducted surveys, based on plans designed by DFO Science, in SFA 2, 3 (Ungava Bay/Hudson Strait) and the Resolution Island Area (RISA) (Figure 11) from 2005 to 2020, during summer (July-August), at depths of 100 to 750 m. Different fishing vessels (FV) have been used: FV *Cape Ballard* (2005–2011), FV *Kinguk* (2014), FV *Katsheshuk II* (2015), and FV *Aqviq* (2012, 2013, 2016–2018). The impact of changes in vessel on gear catchability have not been investigated. From 2005–2007 a standard Campelen 1800 shrimp trawl (12.7 mm codend mesh) was used. However, high incidences of tear ups led to modifications in trawl design including increased footgear size, and additional floatation on the fishing line and lower belly seams (Siferd and Legge 2014). Flume tank tests found that these modifications did not severely affect trawl geometry (Siferd and Legge 2014). The modified Campelen 1800 shrimp trawl has been used since 2008 in SFA 2 and since 2014 in SFA 3. Fish caught in the NSRF surveys are identified but only total count and weight data are recorded for each set and redfish have not been identified to species in most years. See Siferd (2014) for details on stratification and survey area. Note that SFA 3 and Div. 2G are outside the SA 0 stock area. Brief information from NSRF survey in 2G is included in the earlier section for the SA 2 + Div. 3K stock. Information from survey in SFA 3 is not included here, but can be found in the research document that is being prepared to support this report.

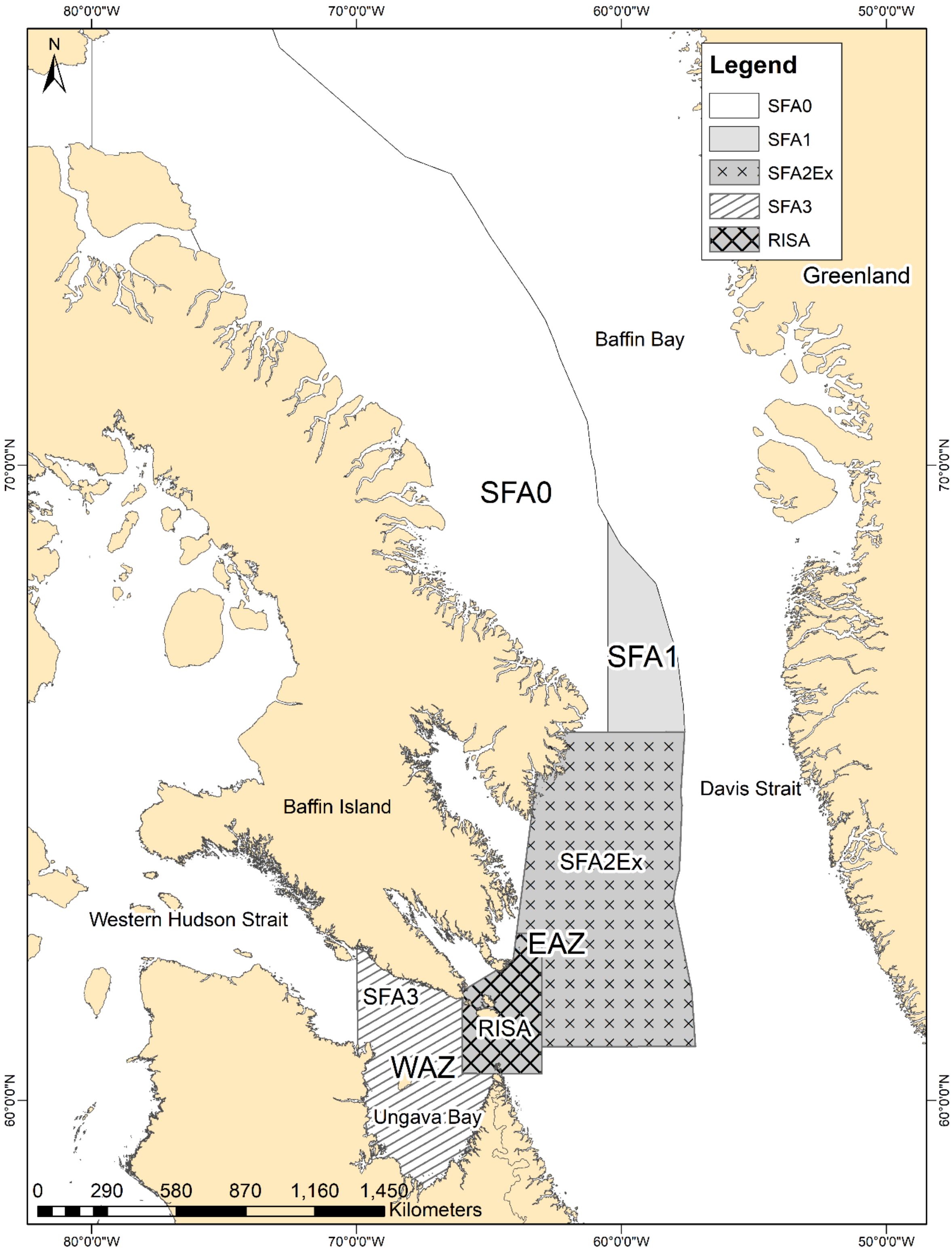

Figure 11. Shrimp Fishing Areas (SFAs 0, 1, 2 ,3 and RISA).

Survey abundance and biomass

In Div. 0A, survey abundance and biomass indices followed similar trends, declining from 1999 to 2004, then increasing to time series highs in 2012, followed by declining trends to series lows in 2017 and 2019, no surveys were conducted in 2018 or 2020 (Figure 12A). There is a gap in the Div. 0B survey from 2002 to 2010 that makes it difficult to interpret trends across the full time period. However, from 2011 to 2016 there were declining trends in both abundance and biomass indices (Figure 12B). Redfish were more abundant in Div. 0B than in 0A.

Redfish abundance and biomass indices for RISA increased from 2005–2006 to the late 2000s and early 2010s, followed by declines to series lows or near low levels by 2019. There was a substantial increase in 2020 (Figure 12C). The SFA 2 indices of abundance and biomass followed similar patterns, with the exception of a series high value in the biomass index in 2010; with declining trends from 2005 through to 2019, then a substantial increase in 2020 (Figure 12D).

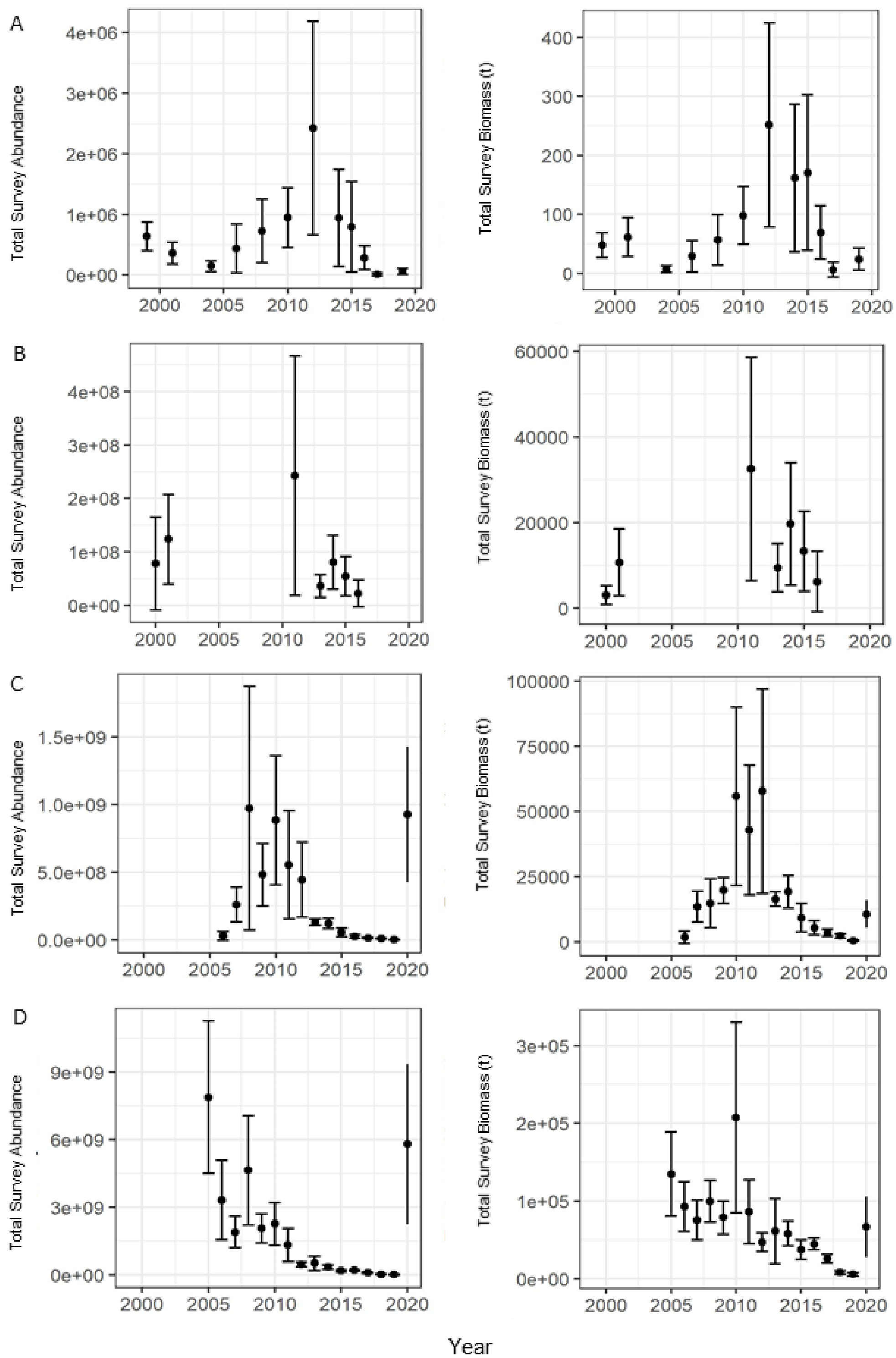

Figure 12. Redfish abundance and biomass (t) indices for DFO surveys in Div. 0A (A), Div. 0B (B), and NSRF surveys in RISA (C) and SFA 2 (D).

Recruitment

Length-Frequency Distribution

Redfish length data are available from DFO surveys conducted in Divs. 0A and 0B. (Figure 13). From 1999 to 2012, the Div. 0A length-frequency distribution for the redfish was centered around 10–15 cm fork length with 1–3 year classes present. From 2014 to 2016, lengths increased and peaks were centered around 22 cm fork length, still with 1–3 year classes present. In 2017 and 2019 the length-frequency distribution showed a single peak centered around 27 cm and 30 cm, respectively. Redfish in Div. 0B show a wider length-frequency distribution with more pronounced, multiple peaks within each year, suggesting the ongoing presence of several year classes. The minimum length at which redfish are considered commercially marketable is 22 cm.

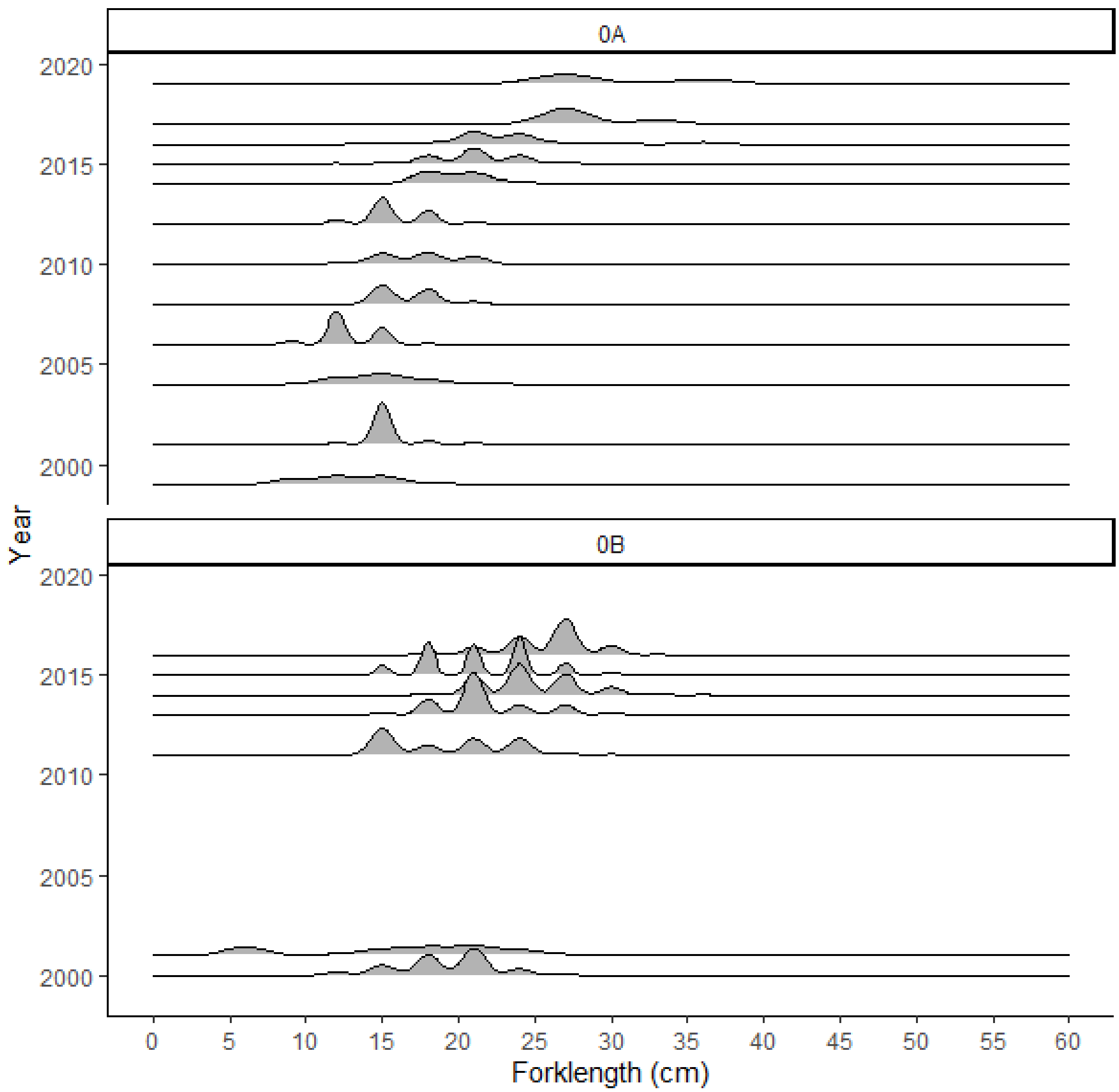

Figure 13. Length-frequency distributions for redfish caught in DFO surveys Div. 0A (A) and Div. 0B (B).

Recruitment Index

A recruitment index of < 15 cm redfish is not available for SA 0. The multispecies survey is conducted at depths greater than 400 m and therefore has low catches of redfish < 15 cm which use shallower habitats. The NSRF survey occurs at depths at which < 15 cm redfish occur but length frequency data are not collected.

Sources of Uncertainty

Redfish in SA 0 are composed primarily of *S. mentella*, with lesser amounts of *S. norvegicus*, and *S. fasciatus.* These species are similar in appearance and are not separated in the commercial or NSRF survey catches. Science staff on DFO surveys in SA 0 do make an effort to identify redfish to the species level.

The primary index for SA 0, the NSRF survey in SFA 2, has several short-comings: it began in 2005, so is a relatively short time series with which to assess a long-lived species like redfish; the survey does not sample deeper than 800 m, so does not fully sample all the known redfish habitat; and length data are not collected.

The source/driver of the increase in abundance observed in 2020 is not entirely understood and age data are not available, making assessment difficult.

CONCLUSIONS AND ADVICE

Information available to evaluate the status of redfish in SA 2 + 3K included commercial catch (1959–2020) and research bottom trawl data from fall surveys conducted by Canada from 1978 to 2020. Landings were highest at 187,000 t in 1959, but declined to an average of 2,000 t annually from 1988 to 1996. There has been a fishery moratorium since 1997. During the moratorium, catches have been predominately from bycatch in the shrimp and Greenland halibut fisheries. Redfish bycatch and discards during the moratorium ranged from 30 to 600 t annually with an average annual estimate of 240 t. Biomass and abundance indices for the management unit of SA 2 + Div. 3K are based primarily upon survey indices from Divs. 2J + 3K only, due to sporadic or inconsistent sampling in Divs. 2G and 2H. Abundance indices for the fall research survey in Divs. 2J3K generally declined from 2010 to 2017, then increased sharply in 2020, to the third highest value in the time-series (1978–2020). There was a similar trend in the biomass indices, except index values for 2019 and 2020 were lower than the 2018 value. The recruitment index based on fish less than 15 cm, was the highest in the time-series during 2020 and roughly three times higher than the second highest value. Prediction of future stock growth from recent high recruitment is difficult because redfish are slow growing species. This is further complicated because the impact of bycatch landings and discards of juvenile fish is not well understood. In the absence of a limit reference point (LRP), it is not possible to determine the zone within the PA framework that SA2 + Div. 3K redfish currently reside in. Although total abundance has increased in recent years owing to high recruitment, current total survey biomass levels have remained low.

Information available to evaluate the status of redfish in SA 0 included bycatch data from commercial fisheries on northern shrimp and Greenland halibut and data from DFO and NSRF bottom trawl surveys conducted from 1999 to 2020. Overall bycatch peaked in 1996 (shrimp fishery: 362 t) and 2005 (Greenland halibut fishery: 6 t; shrimp fishery: 222 t) and then declined to series low levels in 2018 (Greenland halibut fishery: 6 t; shrimp fishery: 1 t) and 2019 (Greenland halibut fishery: 10 t; shrimp fishery: no data available). The NSRF SFA 2 survey was considered most representative of the SA 0 redfish stock. Prior to a substantial increase in 2020, the SFA 2 biomass and abundance indices had declined from the beginning of the time series in 2005 to a series low in 2019. NSRF surveys conducted within the SA 0 (i.e., SFA 3 and RISA) also recorded high redfish abundance and biomass in 2020. These high index values coincided with predicted high levels of bycatch of redfish in the 2020 shrimp fishery based upon implementation of move away provisions found in license conditions (as described in DFO 2018) and discussion with participants in the 2020 northern shrimp fishery. Redfish are very slow growing and strong recruitment pulses do not always persist, therefore, it is unknown whether the increase in abundance observed in the SFA 2 survey index in 2020 will make a significant contribution to the stock or any potential fishery.

Since prediction of future stock growth from recent high recruitment in both the stocks (NAFO SA 2 + Div.3K and NAFO SA 0) is difficult, it is advised that management measures take a precautionary approach to managing these cohorts until they achieve exploitable size.

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SOURCES OF INFORMATION

This Science Advisory Report is from the May 4–7, 2021 Zonal Advisory Meeting on the Assessment of Redfish in Northwest Atlantic Fisheries Organization (NAFO) Subarea 0, and Subarea 2 + Division 3K. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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