



STOCK STATUS UPDATE OF UNIT 3 REDFISH FOR 2020

Context

A 10,000 metric tonnes (t) Total Allowable Catch (TAC) was implemented for Unit 3 Redfish (4X+ 4Wdehkl) in 1993 based on the 1991 TAC for the previous management unit (4VWX), prorated by historical (1981–1990) catches in the Statistical Unit Areas that comprise Unit 3 (Atkinson and Power 1991). This TAC was maintained from 1993–1998 based on conclusions from a series of stock status reports, which indicated that stock conditions were not expected to decline in coming years (Branton and Halliday 1994; Branton 1995, 1996, 1997, 1998). The TAC was reduced in 1999 to 9,450 t and to 9,000 t in 2000, due to lower catch rates in 4W and a shift in fishing effort from 4W to 4X (Branton 1999), and has remained at this level.

Conservation measures for Unit 3 Redfish currently include protocols for protecting small fish below the minimum size of 22 cm Fork Length (FL) (i.e., closure areas; small fish amounts not to exceed 15% of catch/trip), 100% dockside monitoring and electronic vessel monitoring (VMS), mandatory hail out and hail in, and a target level of 10–20% at-sea observer coverage.

Information on the status of Unit 3 Redfish (i.e., distribution, abundance, biomass) from 1999–2002 was provided through a series of CSAS Research Documents, which included a synopsis of the Fisheries and Oceans Canada (DFO) Summer Research Vessel (RV) Survey trends back to 1970 for selected groundfish stocks (e.g., Branton and Black 2002). Since 2009, the status of Unit 3 Redfish has been updated through a series of CSAS Science Responses (e.g., DFO 2017a), based on Maritimes Region RV Survey trends in biomass and abundance. Following the development of biological reference points consistent with the Precautionary Approach (DFO 2012), the DFO Summer RV Survey Trends Science Responses from 2014 to 2019 have included plots of the mature biomass index for redfish > 22 cm FL relative to the Upper Stock Reference (USR; 80% of Biomass at Maximum Sustainable Yield [B_{msy}] proxy) and the Limit Reference Point (LRP; 40% of B_{msy} proxy) (DFO 2020). In 2015, a zonal peer review of the assessment framework for Units 1–3 Redfish (DFO 2017b) included a detailed review of Unit 3 Redfish stock status; however, this information has not yet been published, so there has been no new information available on the fishery for several years.

DFO Resource Management asked Science to review biological and fishery information on Unit 3 Redfish, to evaluate the status of the stock relative to adopted reference points and report on bycatch of non-target species in the Unit 3 Redfish Fishery (DFO 2019). This Science Response Report provides a stock status update of Unit 3 Redfish using the most up to date landings and RV survey data.

This Science Response Report results from the Regional Science Response Process of December 1–2, 2020, on the Stock Status Updates of Groundfish Stocks in the Maritimes Region.

Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada \(DFO\) Science Advisory Schedule](#) as they become available.

Background

Biology

Redfish, known commercially as ocean perch, occur on both sides of the Atlantic Ocean. They are found along the slopes of fishing banks, in deep channels and off the edge of the continental shelf at depths ranging from 100 to 700 m. In the northwest Atlantic, redfish range from Baffin Island in the north to the coast of New Jersey in the south. Two species of redfish are found on the Scotian Shelf: Acadian Redfish (*Sebastes fasciatus*), which occur in the deep basins and at the edge of the continental shelf, and Deepwater Redfish (*Sebastes mentella*), which occur in deeper waters off the continental shelf and in the Laurentian Channel. These two species are difficult to distinguish visually and, as a result, both commercial and research-survey catches are not separated.

Redfish are ovoviviparous as fertilization is internal and young are born live. Mating occurs in the fall (September–December) and females carry the developing young until release during spring and early summer (April–July). Larvae develop in surface waters and move to deeper waters as development progresses. Redfish are sexually dimorphic with females growing faster than males after age 10. The average length at which 50% of redfish on Scotian Shelf are mature is 24–26 cm FL for females and 16–17 cm FL for males. They are slow growing (8–10 years to reach a size of 25 cm FL), long-lived, and characterized by a late age of sexual maturation (7–9 years to reach sexual maturity). This means that they are sensitive to overfishing and slow to recover from depletion (as evidenced by northern stocks). Recruitment success varies significantly, with long periods of low recruitment coupled with sporadic occurrences of strong year classes occurring at unpredictable and irregular intervals. Redfish are semi-pelagic and exhibit diel movement patterns, rising off bottom at night to feed. Food consists primarily of pelagic crustaceans such as amphipods, copepods, and euphausiids; fish become an important part of the diet as redfish increase in size.

Description of the Fishery

Redfish on the Scotian Shelf were historically managed as a NAFO Division 4VWX stock. In response to a new understanding of stock structure (Atkinson and Power 1991), a new management area for Unit 3 Redfish was implemented in the 1993 Groundfish Management Plan and consists of Statistical Unit Areas 4X and 4Wdehkl (Figure 1). Genetic research has shown that redfish in Unit 3 are almost exclusively *S. fasciatus* and belong to a separate stock from *S. fasciatus* in Unit 1 (Gulf of St. Lawrence/northern Laurentian Channel) and Unit 2 (southern Laurentian Channel/Western Grand Bank) (Morin et al. 2004). Unit 3 Redfish are also considered to be separate from the Gulf of Maine/Georges Bank stock.

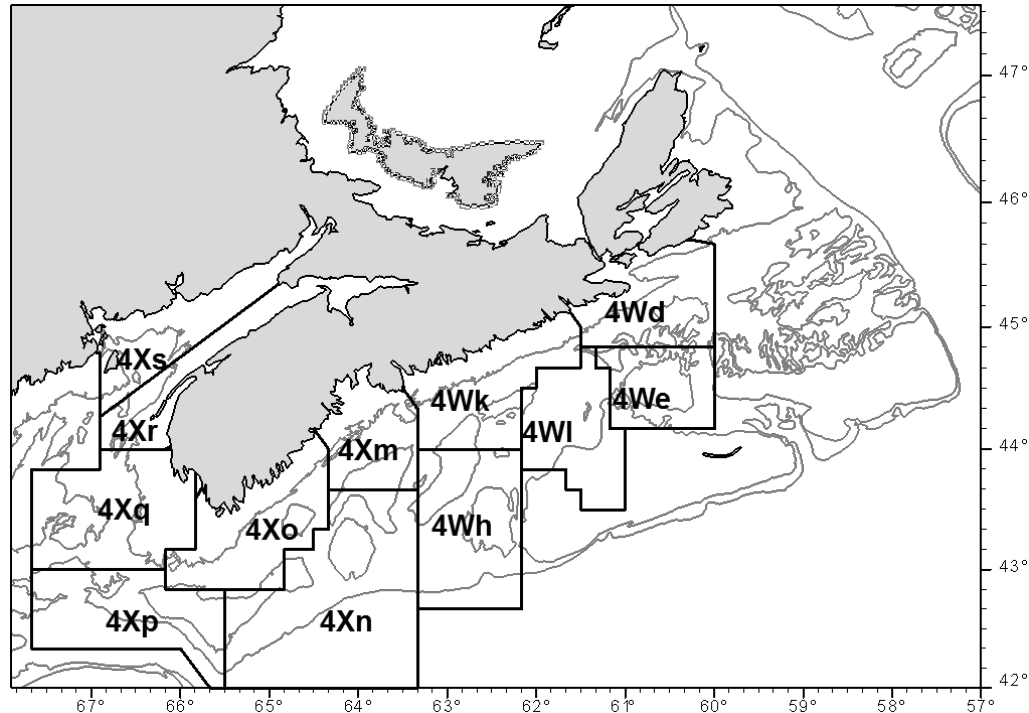


Figure 1. Unit 3 Redfish management area 4X+4Wdehkl.

Within the Unit 3 management area, the main geographic areas fished over the past 5 years include Crowell and Jordan basins (4Xpq), the Scotian Shelf slope (4Xn, 4Wh), the Sambro Bank area (4Xm, 4Wk), and the northern edge of La Have Basin (4Xm). In some years, fishing activity has also occurred on Browns and Baccaro banks, La Have Bank, and in Emerald Basin. Redfish are fished primarily using bottom trawls with small-mesh cod ends (110–115 mm diamond mesh) and are sold as fillets or used for lobster bait.

Two areas in 4X have been closed to small-mesh gear due to persistent catches of undersized redfish, one in 4Xo (“Bowtie Closure”, implemented in 1995) and the other in 4Xmn (“Second Closure”, implemented in 2013). Redfish ≤ 22 cm FL are considered immature and there are restrictions on the proportion of these small fish in the landed catch per trip (i.e., no more than 15%).

Total landings of Unit 3 Redfish reached 18,000 t in the early 1970s when foreign fleets (mostly from the USA) fished on Scotian Shelf (Table 1; Figure 2). Catches by foreign fleets declined after implementation of the 200-mile limit in 1977 and dropped off entirely by the early 1990s. Canadian landings have averaged 4,000 t since 1970, peaking at 9,000 t in 1974 and more recently at 8,000 t in 2012. During the 1970s, landings were dominated by catches in 4W, but, after 1980, they shifted to 4X, which has accounted for about 87% of landings from 1980 to 2020 and 97% of landings in 2020. Within 4X, there was a shift in landings from 4Xmno to 4Xpq in the late 1990s, probably to reduce capture of small fish. The TAC has been 9,000 t since 2000; landings have not exceeded this amount and were 4,383 t in 2019 and, as of November 13th, 2020, were at 2,948 t. Between 2010 and 2019, quarter 2 accounts for most landings (53%), followed by quarter 3 (23%), quarter 4 (13%), and quarter 1 (11%).

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Table 1. Total reported Canadian and foreign landings (metric tonnes) of Unit 3 Redfish from 1970–2020. Ten-year annual average landings represent 1970 to 2019.

	Year(s)	Canada		USA		USSR	Other	Total	TAC	FY ¹
		4X	4Wdehkl	4X	4Wdehkl					
Decadal Average	1970–79	2042	2036	2966	2254	394	92	-	-	-
Decadal Average	1980–89	3229	1175	510	0	1.8	2.3	-	-	-
Decadal Average	1990–99	3932	393	5	0	26	28	-	-	-
Decadal Average	2000–09	3595	100	0	0	0	3	-	-	-
Decadal Average	2010–19	4163	612	0	0	0	0	-	-	-
Annual	2011	6052	685	0	0	0	0	6736	9000	7268
Annual	2012	7245	562	0	0	0	0	7807	9000	6510
Annual	2013	2914	1108	0	0	0	0	4022	9000	4240
Annual	2014	2524	1356	0	0	0	0	3880	9000	3579
Annual	2015	2591	593	0	0	0	0	3184	9000	3516
Annual	2016	3767	384	0	0	0	0	4151	9000	3948
Annual	2017	4173	398	0	0	0	0	4571	9000	4533
Annual	2018	3399	202	0	0	0	0	3601	9000	3649
Annual	2019	4160	223	0	0	0	0	4383	9000	4316
Annual	2020 ²	2860	88	0	0	0	0	2948	9000	2785

¹ Fishing Year Landings (April 1–March 31)

² Landings for 2020 are preliminary, from the Maritimes Fisheries Information System (MARFIS) as of November 13, 2020.

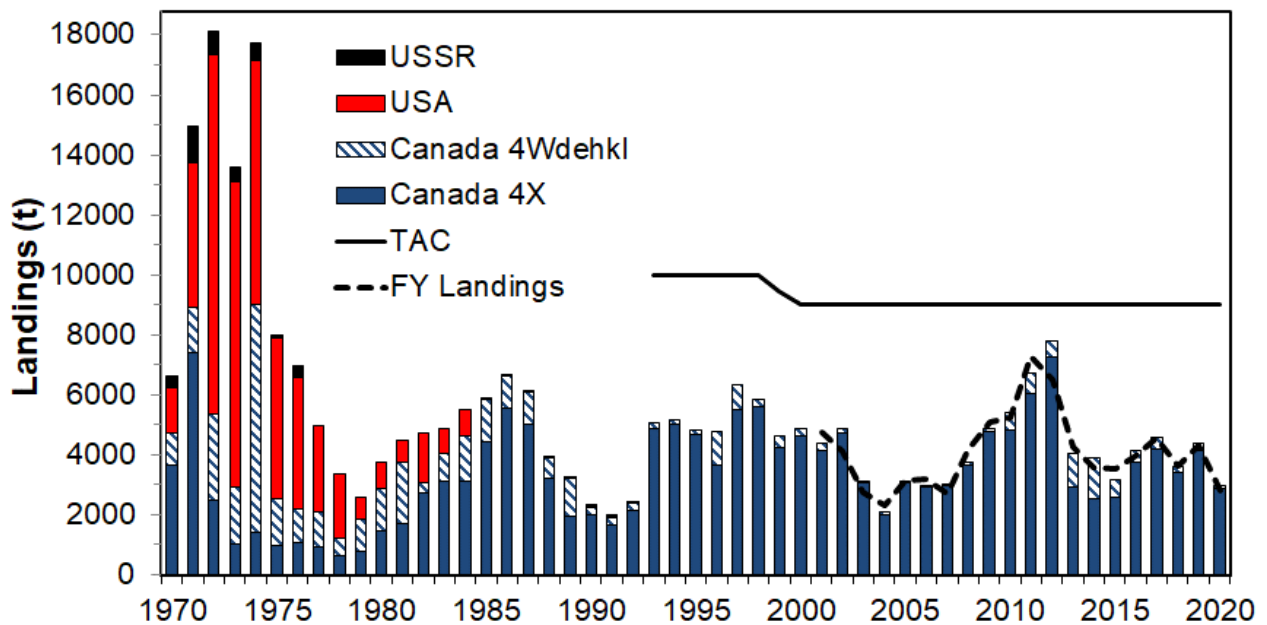


Figure 2. Unit 3 (4X+4Wdehkl) Redfish landings (metric tonnes) from 1970–2020 (histograms = calendar year; dashed black line = Fishing Year). The solid black line is the Canadian Total Allowable Catch (TAC).

Assessment Framework

While no formal modelling approach has been developed to determine stock status, empirically-determined reference points have been calculated for Unit 3 Redfish using DFO Summer RV Survey data for mature biomass (> 22 cm FL) (DFO 2012). A proxy for B_{msy} (73,000 t) was calculated as the survey mean mature biomass from 1970–2010. Forty percent of the B_{msy} proxy was presented as the LRP (29,000 t) and 80% as the USR (58,000 t). The mature biomass index from the DFO Summer RV Survey (smoothed using the 5-year arithmetic moving average) is used to determine current stock biomass in relation to biological reference points.

Analysis and Response

DFO Summer Research Vessel Survey

A stratified-random bottom-trawl survey of the Scotian Shelf/Bay of Fundy has been conducted in July and August since 1970 and, with the exception of 2018, has provided complete coverage of the entire Unit 3 stock area (defined as strata 456, 458–495 in Branton and Halliday 1994). Mature redfish biomass was calculated using stratified total abundance at size (for lengths > 22 cm FL) and the length-weight relationship for combined sexes calculated using length and weight data from 1992–2019 (time period for electronic balances).

Not all strata in 4W were sampled during the 2018 DFO Summer RV Survey; therefore, in 2018, the biomass index time series for 1970–2018 was recalculated using only the strata covered in the 2018 survey (460, 461, 465, 470–495). Since most of the Unit 3 Redfish biomass occurs in the NAFO Area 4X (Strata 470–495), the trajectories for total and mature biomass indices are very similar for all of the Unit 3 strata compared to the strata sampled in 2018 (DFO 2019). As a result, all Unit 3 Redfish strata (456, 458–495) were used to calculate the 1970–2020 biomass index.

Total and mature biomass declined from the late 1970s to the early 1990s, was low but variable through to the mid-2000s, then increased to higher levels from 2007–2016 (Figure 3). Much of the total biomass in 2008–2009 (44–55%) and 2011–2012 (36–40%) was comprised of immature fish (≤ 22 cm FL), which may indicate earlier periods of strong recruitment. The 2020 survey results indicate that the total and mature biomass has remained relatively stable since 2018 at levels comparable to the 1990s.

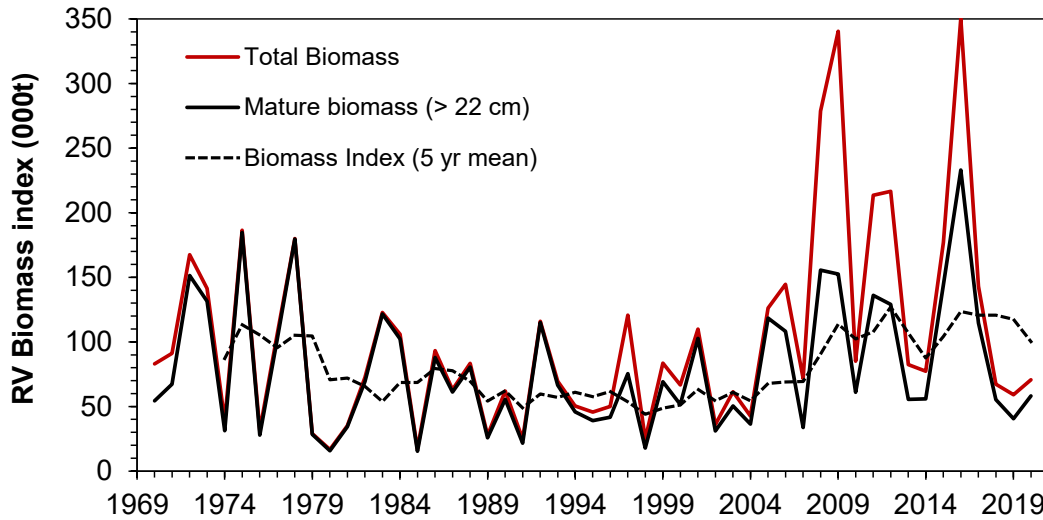


Figure 3. DFO Summer RV Survey total biomass, mature biomass ($t \times 10^3$, > 22 cm FL), and mature biomass index (5-year moving average) for Unit 3 Redfish strata (456, 458–495) from 1970–2020.

The DFO Summer RV Survey total abundance-at-length remained stable from 2019 to 2020 (Figure 4). The 2020 abundance-at-length peaked at a larger size than the 2019 abundance-at-length (i.e., 24 cm versus 21 cm). The short-term median abundance index (2009–2018) was higher than the long-term median abundance index (1970–2018) but peaked at smaller size (i.e., 23 cm versus 25 cm FL), indicating higher abundance of smaller fish during the short-term period. The 2020 abundance-at-length was higher for most sizes compared to long-term median but was below the short-term median, reflecting the recent drop in abundance.

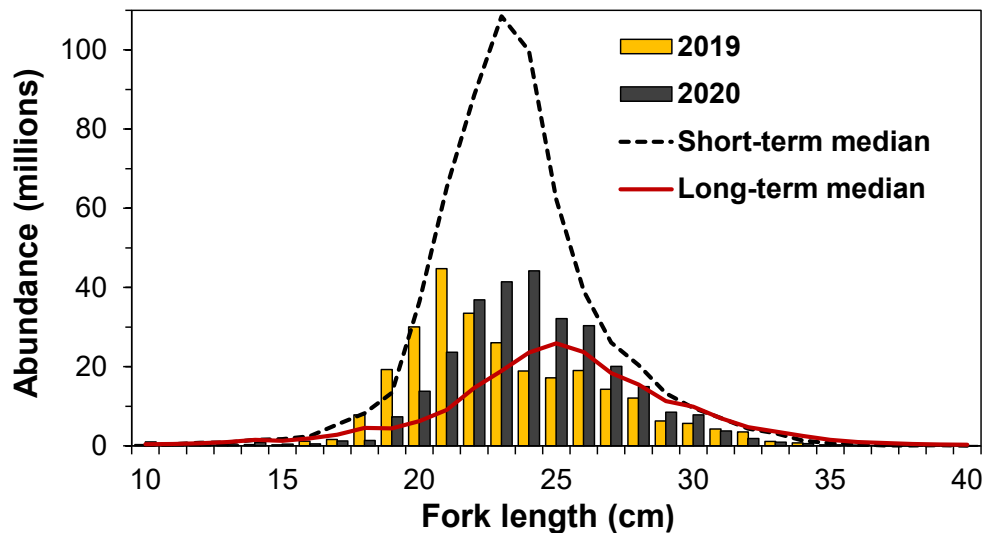


Figure 4. Length-frequency indices for Unit 3 Redfish from DFO Summer RV Survey, 1970–2020. Black bars represent the numbers-at-length in millions from the 2020 survey; yellow bars represent numbers-at-length in millions from the 2019 survey. The red line represents the long-term median abundance-at-length (1970–2018), and the dashed black line is the short-term median abundance-at-length (2009–2018).

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Condition

The condition factor, Fulton's K (weight/length³), was calculated separately for males 23–40 cm FL and females 23–45 cm FL. During the 1970s and 1980s, K was higher for both sexes, but because spring balances were used during this period, it is not clear how precise these data are (Figure 5). For 1992–2020 (the time period for electronic balances), K has generally hovered around the 1992–2020 average for males and shown no consistent directional change. For females, K has shown a declining trend since 2009 and remains below the 1992–2020 average.

The reason for this is unclear, but warmer water temperatures in recent years may result in more spawning before the survey takes place. Similar declines in condition have been observed for other Scotian Shelf species, such as Silver Hake (Stone et al. 2013), Pollock (Stone 2011), and Haddock (Stone and Hanson 2015).

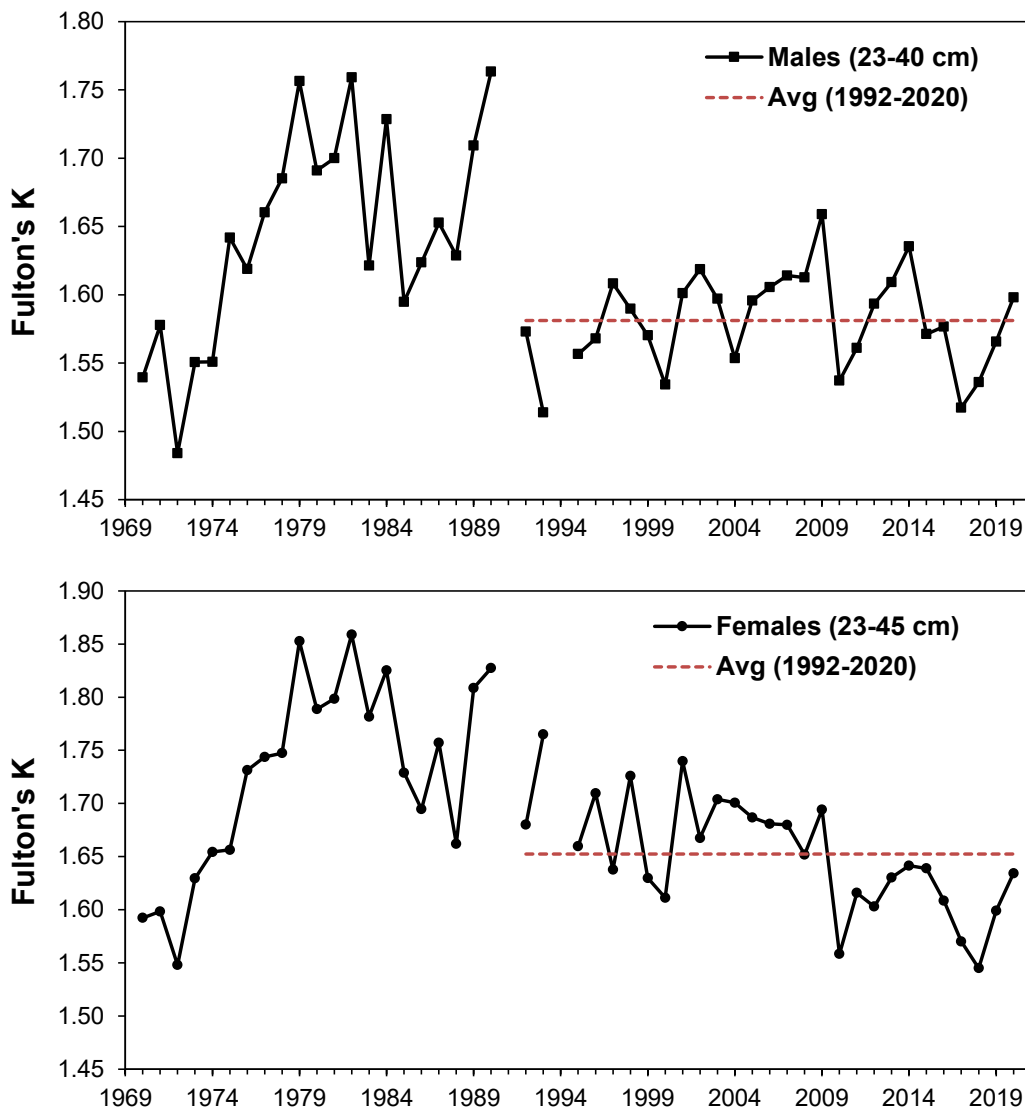


Figure 5. Fulton's K (weight(g)/length(cm)³) for male (23–40 cm FL; upper panel) and female (23–45 cm FL; lower panel) redfish from DFO Summer RV Survey length and weight data for 1970–2020.

Fishery Average Size and Percent ≤ 22 cm FL

The average size of redfish (weighted mean length calculated from the fishery catch-at-size) declined from the mid-1970s to the late 2000s, but it has been increasing since 2011 (Figure 6). The percentage of small fish in the catch exceeded the 15% tolerance level from 1990–2002 and more recently from 2007–2014. Implementation of the “Second Closure” area (4Xmn) in 2013 may have helped to reduce the catch of small redfish (≤ 22 cm FL) in recent years, leading to an increase in average size since 2011 along with growth of cohorts in the fishery.

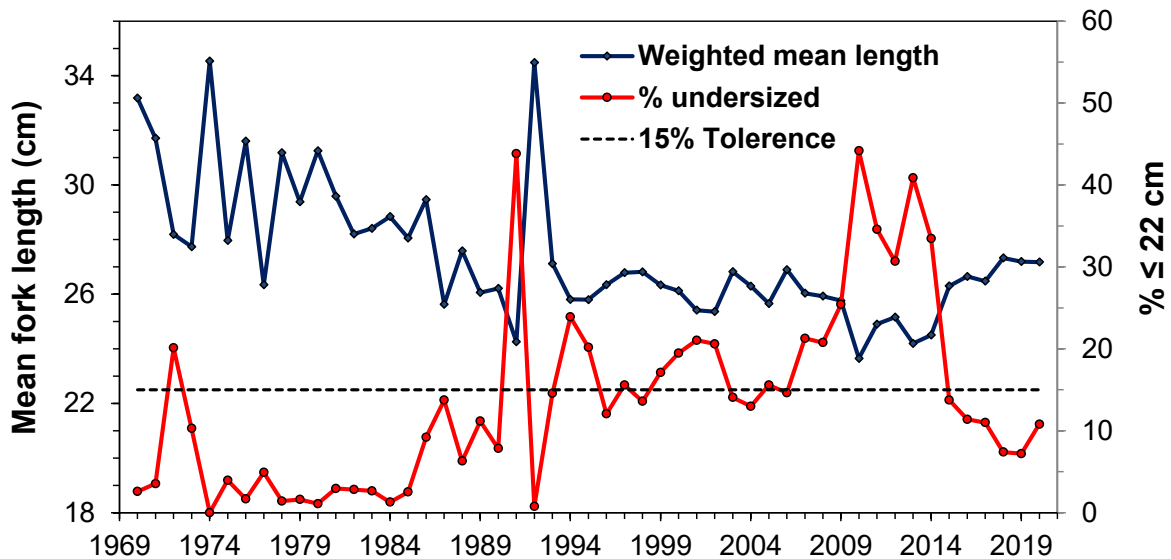


Figure 6. Weighted mean length (cm) of redfish from the commercial fishery catch-at-size and percentage of catch-at-size ≤ 22 cm FL for 1970–2020. The dashed line indicates the 15% tolerance level.

Reported Landings of Redfish and Bycatch Species

The 4X component of the Unit 3 management unit has more mixed-species bycatch landings than 4W, so bycatch landings are presented separately for both areas (Figure 7). Bycatch landings for 2011–2020 from the MARFIS commercial landings database averaged 22% of total landed catch in the 4X fishery compared to 8% in 4W. For 2011–2020, the most common landed bycatch species in 4X is Pollock (9%), followed by Haddock (7%), White Hake (3%), and Atlantic Cod (1%). Pollock is also the main bycatch in 4Wdehkl but at a lower level (4%), followed by Monkfish (1%), non-specified skates (1%), and White Hake (1%).

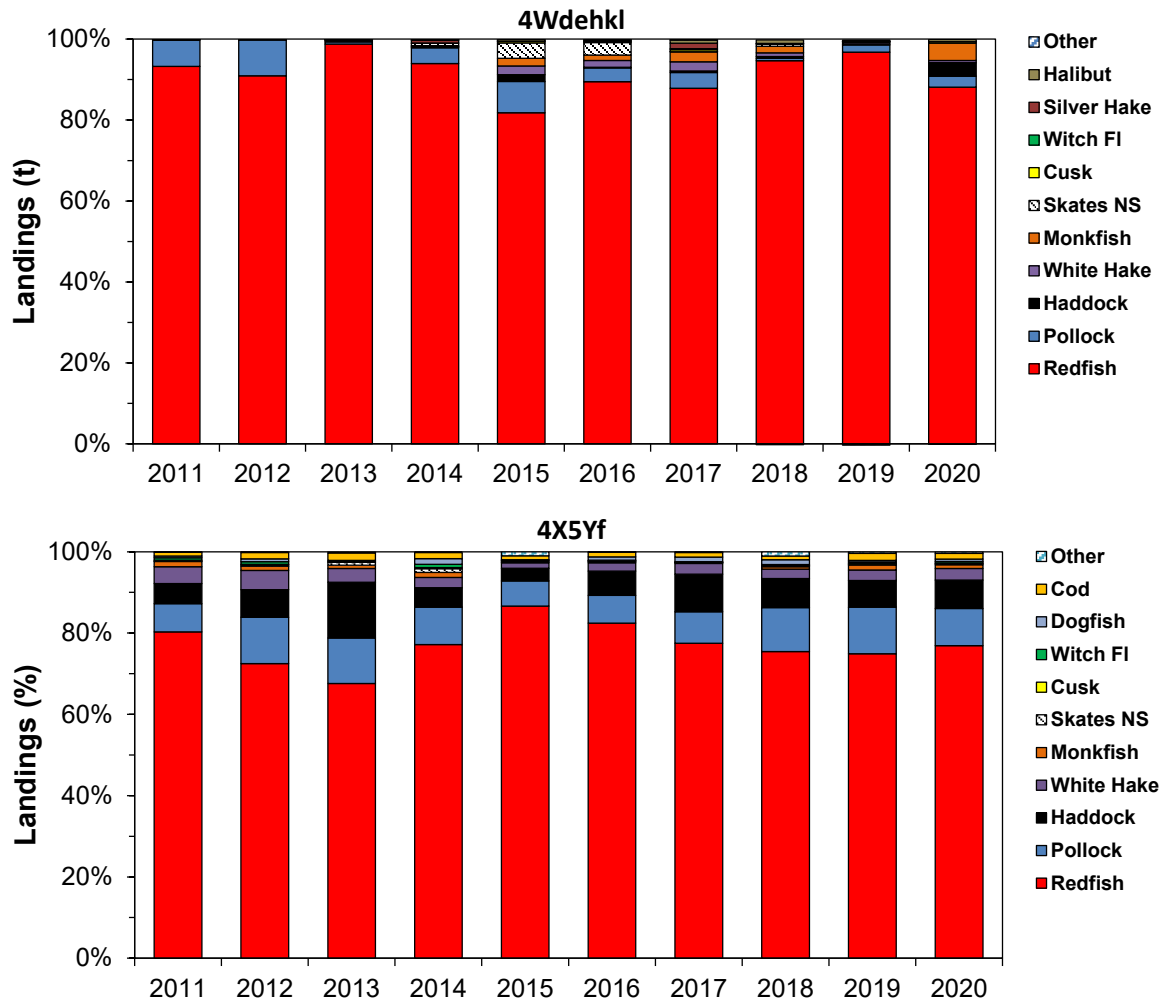


Figure 7. Percentage of landings by species from the Unit 3 Redfish fisheries in 4X (lower panel) and 4Wdehkl (upper panel), 2011–2020.

Observer Coverage and Bycatch

Estimates of at-sea observer-coverage levels for the redfish fishery use data from the Industry Survey - Observer Program Database and the MARFIS Commercial Landings Database for mobile gear with 110–115 mm diamond-mesh cod ends (82% of total landings). On average, about 8% of redfish landings and trips have been observed over the past 5 years (Table 2). With the exception of 2018, coverage has been below the 10–20% target level proposed by Resource Management.

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Table 2. Percent at-sea observer coverage (observed redfish catch/total redfish landings; observed redfish trips/total redfish trips) for the directed mobile gear redfish fishery in Unit 3, 2016–2020.

Year	Total Landings (t)	Total Trips	Obs RF Catch (t)	Obs RF Trips	Obs RF Land (%)	Obs RF Trips (%)
2016	3534.9	165	233.7	10	6.6	6.1
2017	3775.7	214	359.2	21	9.5	9.8
2018	2929.3	166	298.0	17	10.2	10.2
2019	3434.9	183	300.8	16	8.8	8.7
2020	2467.4	150	75.3	5	3.1	3.3
Avg (2016–2020)					7.6	7.5

Observer data from 2000–2020 (397 trips in 4X5Yf and 63 trips in 4Wdehkl) indicate that 92% and 96% of the total observed catch (kept + discarded) from Unit 3 Redfish trips is retained in 4X5Yf and 4Wdehkl, respectively. At-sea observers recorded similar proportions of retained bycatch as reported in the commercial landings database. Redfish (76%), Pollock (13%), Haddock (6%), White Hake (2%), and Atlantic Cod (1%) are reported as the main species retained in 4X compared to redfish (80%), Pollock (16%), and Haddock (1%) in 4Wdehkl. Total discard amounts are low and represent 8% of observed catches in 4X and 4% in 4Wdehkl for 2000–2020. Discarded species in 4X include Spiny Dogfish (6%), American Lobster (0.4%), and Barndoor Skate (0.2%), and, in 4Wdehkl, include Barndoor Skate (1%), redfish (0.9%), Pollock (0.7%), and Spiny Dogfish (0.4%).

Harvest Control Rule

The smoothed (5-year moving average) mature biomass index from the DFO Summer RV Survey is used to determine the current stock biomass in relation to biological reference points. Management Strategies for Unit 3 Redfish, outlined in the 2017 Groundfish Integrated Fishery Management Plan for the Maritimes Region, indicate that a TAC may be set to achieve a maximum 9% exploitation rate based on the index when it is above the USR. When mature biomass is below the LRP, the TAC is reduced so that the exploitation rate does not exceed 3% of the index. When the stock is above B_{msy}, a moderate increase may be considered, not to exceed 12%. The smoothed biomass index has never fallen below the LRP. The stock has been above the USR (58,000 t) since 2004 and above B_{msy} (73,000 t) since 2007. The 2020 TAC of 9,000 t was within the maximum 9% exploitation rate of the 2020 Summer RV Survey mature biomass index.

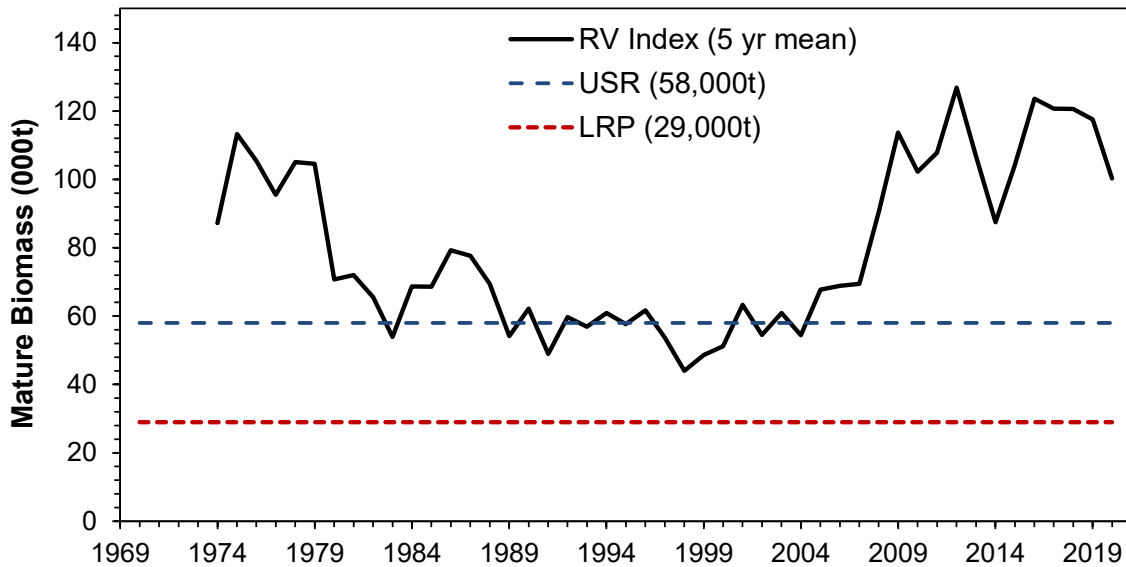


Figure 8. Mature biomass index (5-year smoothed moving average) calculated for Unit 3 Redfish strata (456, 458–495; 1970–2020). Dashed blue line = Upper Stock Reference (58,000 t). Dashed red line = Limit Reference Point (28,000 t).

Relative Fishing Mortality

A target Removal Reference (RR = 0.068) was proposed based on the maximum Relative Fishing Mortality (Relative F) that would not result in a reduction in population biomass. This value, also known as the replacement ratio, was determined by using an “index based” assessment methodology (NEFSC 2002), with a 3-year smoothed moving average of the DFO Summer RV Survey mature biomass index based on data for 1970–2010 (DFO 2012).

Relative F is calculated as Fishery Landings/DFO Summer RV Survey mature biomass index (smoothed with 3-year moving average) (Figure 9). The highest values occurred in the early 1970s, mid-1980s, and late 1990s when landings were high relative to the mature biomass index. With increasing mature biomass, Relative F has been at, or below, the proposed 1970–2010 RR (0.068) since 2003. Relative F was estimated at 0.062 for 2019 and 0.057 for 2020, indicating that current exploitation remains below the proposed RR but has increased since 2018.

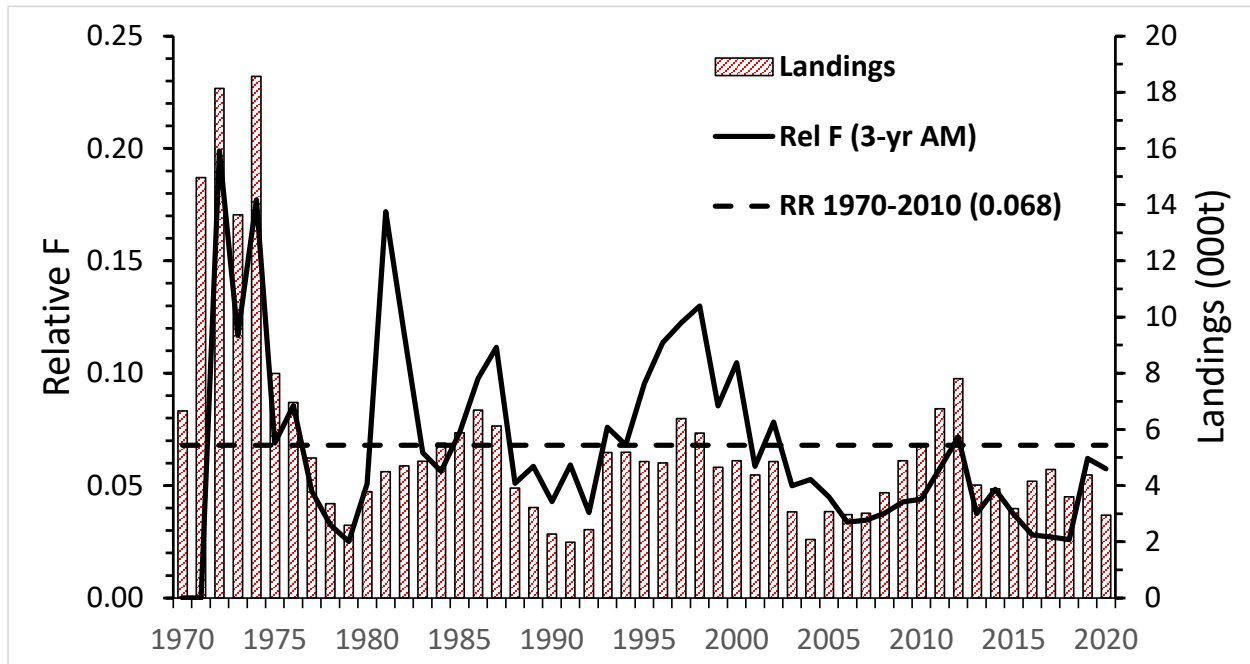


Figure 9. Relative Fishing Mortality (Fishery Landings/Survey Mature Biomass Index with 3-yr smooth; black line) and total landings (000 t; red histograms) for Unit 3 Redfish, 1970–2020. The proposed Removal Reference (RR), calculated using the index method, is shown for 1970–2010 (dashed black line).

Conclusions

The TAC for Unit 3 Redfish has been 9,000 t since 2000, and total landings have generally been less than half this amount over the past 20 years. The average size of redfish in the fishery catch-at-length has been increasing since 2011, and the percentage of immature fish (≤ 22 cm FL) in the catch-at-length has remained less than the 15% tolerance since 2014.

The 4X component of the Unit 3 management unit is more of a mixed-species fishery than 4Wdehkl, with bycatch landings for 2011–2020 averaging 22% of total landed catch in 4X compared to 8% in 4Wdehkl. Pollock is the most commonly landed bycatch species in both areas. About 8% of redfish landings and trips have been observed over the past 5 years, with at-sea observers recording similar proportions of retained bycatch as reported in the commercial landings database. Discard amounts are low and estimated to be 8% of total observed catches in 4X and 4% in 4Wdehkl for 2000–2020. The main discarded species are Spiny Dogfish, American Lobster, and Barndoor Skate, all at low levels.

The DFO Summer RV Survey results indicate that the total and mature Unit 3 Redfish biomass has remained relatively stable since 2018 at levels comparable to the 1990s. The mature biomass index has never fallen below the LRP, and the stock has been above the USR since 2004, indicating the stock is in the Healthy Zone.

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