MARITIMES RESEARCH VESSEL SURVEY TRENDS ON THE SCOTIAN SHELF AND BAY OF FUNDY

Context

Fisheries and Oceans Canada DFO has conducted Summer Research Vessel (RV) surveys in the Maritimes Region, Northwest Atlantic Fisheries Organization (NAFO) divisions 4VWX5Yb, using a standardized protocol since 1970 (Figure 1). Results of these surveys provide information on trends in abundance for most groundfish species in the Maritimes Region. While these data reflect trends in biomass and abundance and are a critical part of science-based stock assessments, a full assessment, including other sources of data, would be required to evaluate the impacts of management measures on population status. Resource Management requested a review of the DFO RV Survey information on the following list of fish stocks: 4Vn Atlantic Cod, 4VsW Atlantic Cod, 4X5Y Atlantic Cod, 4VW Haddock, 4X5Y Haddock, 4X White Hake, 4VW White Hake, 4VWX Silver Hake, 4VWX+5 Pollock, Unit II redfish, Unit III redfish, 3NOPs4VWX5Zc Atlantic Halibut, 4VW and 4X American Plaice, 4VW and 4X Witch Flounder, 4VW and 4X Winter Flounder, 4VW and 4X Yellowtail Founder, 4VW and 4X Smooth Skate, 4VW and 4X Thorny Skate, 4VW and 4X Barndoor Skate, 4VW and 4X Winter Skate, 4VW and 4X Little Skate, 4VW and 4X Atlantic Wolffish, 4VW and 4X Monkfish, 4VW and 4X Longhorn Sculpin, and 4VWX Spiny Dogfish, 4X Red Hake, 4VW Red Hake, 4X Sea Raven, 4VW Sea Raven, 4X Ocean Pout, and 4VW Ocean Pout. In addition, biomass trends relative to the Scotia Fundy Groundfish Advisory Committee (SFGAC) accepted biomass reference points were requested for White Hake (biomass for lengths > 41 cm in 4X) and Unit III redfish (biomass for lengths > 22 cm). The survey information will be used by DFO Resource Management as background for discussions with various stakeholders on recommendations for management measures and to determine which stocks should be reviewed in more detail in 2018.

This Science Response Report results from the Science Response Process of December 4, 2017, on the Maritimes Research Vessel Survey Trends on the Scotian Shelf and the Bay of Fundy.

Background

The DFO Summer Research Vessel (RV) Survey of the Scotian Shelf and Bay of Fundy has been conducted annually since 1970. The surveys follow a stratified random sampling design, and include sampling of fish and invertebrates using a bottom otter trawl. These surveys are the primary data source for monitoring trends in species distribution, abundance, and biological condition within the region. There were changes to the net used and the vessel conducting the survey in 1982 and 1983, along with some changes in data collection protocols. These changes may affect the biomass trends for some species. For long-term averages, the most appropriate starting point has been selected for each species (for details see Clark and Emberley 2011).

The bottom trawl surveys were designed to provide abundance trends for fish and invertebrates between depths of about 30 m to 400 m. Survey indices are expected to be proportional to abundance for most species.

Strata boundaries are shown in Figure 2 for the 4VWX5 area. Sampling was conducted in all 4VWX5Yb strata and in the deeper strata of area 5Zc (Canadian portion of 5Z). Sampled area expanded to include strata 558 and 559 in 2015 and 5Z2 in 2016. Catch distribution plots for the entire DFO Summer RV Survey area are provided for a suite of species which are commonly caught in the 4VWX groundfish fishery. Biomass index trends are shown for the area appropriate for each stock. Comparisons of 2016 and 2017 length frequencies from the survey catch to the long-term mean (from beginning of survey series, or the period deemed appropriate for that particular species, to 2015) are also included, using data from the geographic areas that are used in assessments for those stocks. The expanded survey strata are not used in biomass or length frequency calculations because they have only been sampled for a short time frame. With additional years of data, a methodology will be developed to interpret indices including these data relative to earlier period and then these strata will be included in calculations.

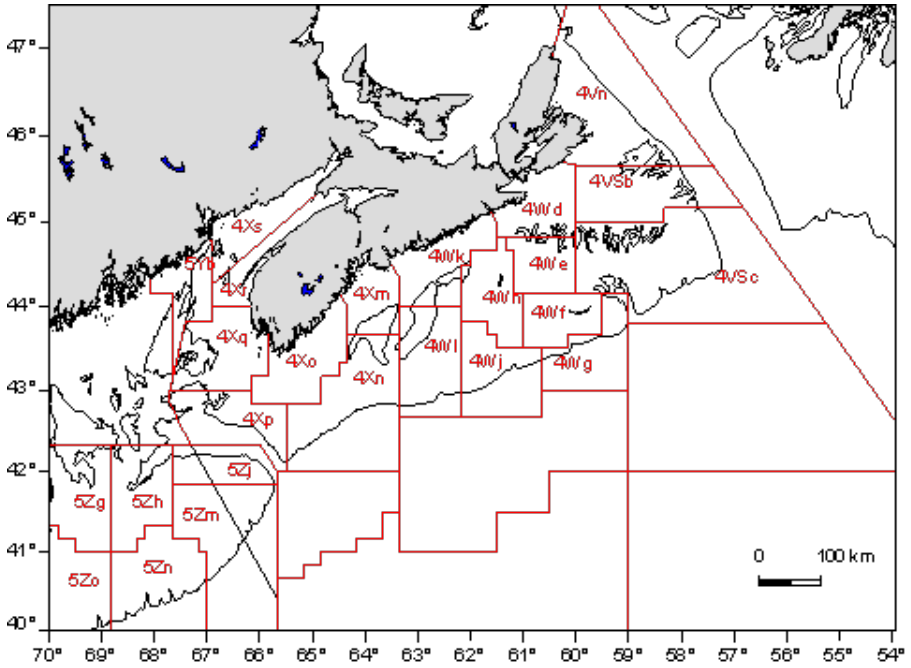


Figure 1. Northwest Atlantic Fisheries Organization (NAFO) Unit Areas.

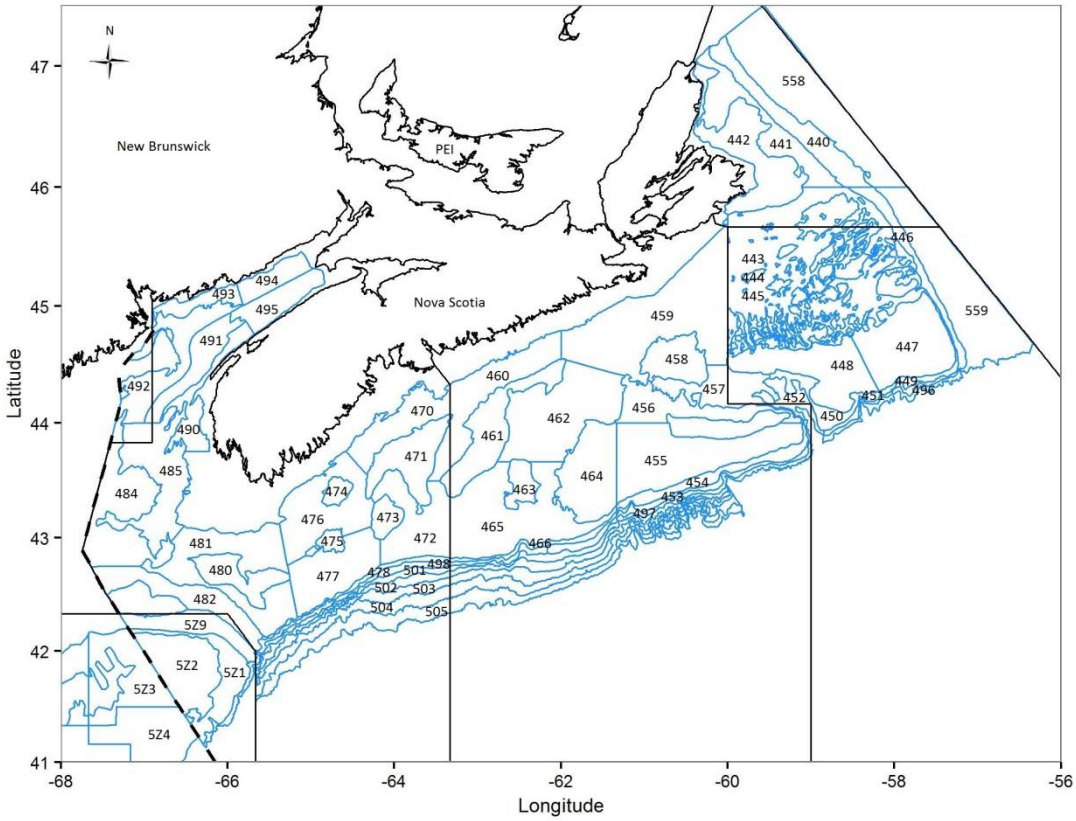


Figure 2. Fisheries and Oceans Canada DFO Summer RV Survey strata.

Analysis

The stratified random survey design ensures that sampling takes places throughout the range covered by the survey. The strata were originally selected to represent different depths and habitats. Sampling occurs at randomly selected stations within all strata. The data are averaged within each stratum, weighted by stratum area and then summed over all appropriate strata for each stock. While this ensures that sampling is representative of the entire area, low sampling intensity means that there is high variability, particularly for stocks which are highly aggregated or which inhabit only a small part of the entire survey area; single data points in the biomass series should be interpreted with caution as large inter-annual changes could simply reflect variability in the data rather than changes in population abundance. Comparisons between the long-term and short-term averages may be more useful for representing the relative status of the population. Large inter-annual changes could also reflect the appearance of a strong-year-class, or, conversely the impact of a single large tow; thus, biomass indices should be interpreted with reference to the length-frequency data and the distribution of catches to see if there are other data to aid interpretation.

The time-series of survey biomass indices and the three year running geometric mean are compared to 40% and 80% of the long-term geometric mean (GM) to provide context for biomass levels. The geometric mean was selected for these comparisons to reduce the impact of very high values observed in some years. The values are presented in Table 1. Information on the calculation of these indices is contained in Stone and Gross (2012).This can also be used as an indication of recruitment strength for species such as Haddock where recruitment pulses are apparent in the length frequency.

Table 1. DFO Summer RV Survey biomass indices (tonnes) for species by stock/region for 2015, 2016, 2017, current three year geometric mean (GM) biomass index, and 40% and 80% of the long-term geometric mean biomass index (1970-2016).

Stock/Region (page number)	2015	2016	2017	Current 3yr GM	40% Long-term GM	80% Long-term GM
4X Atlantic Cod (7)	3,722	5,195	3,068	3,900	5,873	11,745
4VsW Atlantic Cod (8)	3,464	1,691	10,217	3,911	10,516	21,033
4Vn Atlantic Cod (9)	1,729	20,643	1,296	3,590	3,394	6,789
4VW Haddock (12)	20,093	32,209	35,796	28,507	19,153	38,305
4X Haddock (11)	69,820	62,550	38,456	55,207	19,962	39,926
4VW White Hake (15)	5,767	5,221	4,150	5,000	3,074	6,147
4X White Hake (14)	6,452	11,216	6,735	7,873	5,842	11,683
4VWX Silver Hake * (18)	40,230	46,074	31,321	38,727	13,788	6,894
4X West Silver Hake * (19)	8,573	12,719	10,112	10,330	1,258	2,516
Western Component Pollock (21)	5,199	32,192	15,052	13,606	7,983	15,935
Eastern Component Pollock (22)	22,190	15,754	3,222	10,405	7,417	14,835
Unit II redfish (24)	14,675	64,701	28,808	30,130	16,942	33,885
Unit III redfish (25)	176,411	345,767	141,450	205,102	36,605	73,210
4X American Plaice (33)	273	299	276	283	630	1,260
4VW American Plaice (34)	5,669	3,515	5,763	4,861	15,466	7,733
4X Witch Flounder (36)	1,684	1,344	984	1,306	597	1,195
4VW Witch Flounder (37)	2,932	6,457	4,803	4,497	1,377	2,754
4X Yellowtail Flounder (30)	466	106	61	145	193	387
4VW Yellowtail Flounder (31)	9,690	9,973	7,984	9,172	4,906	9,816
4X Winter Flounder (39)	6,250	4,760	3,626	4,761	1,019	2,037
4VW Winter Flounder (40)	1,366	299	577	618	254	491
3NOPs4VWX5Zc Atlantic Halibut (28)	10,789	11,501	15,437	12,419	1,275	2,549
4X Atlantic Wolffish (42)	208	113	82	124	454	908
4VW Atlantic Wolffish (43)	142	159	354	200	506	1,011
4X Monkfish (45)	803	853	1,906	1,093	616	1,233
4VW Monkfish (46)	638	928	863	800	814	1,629
4X Smooth Skate (63)	339	476	224	330	145	289
4VW Smooth Skate (64)	81	160	140	122	118	236
4X Thorny Skate (54)	606	69	113	168	794	1,588
4VW Thorny Skate (55)	1,111	1,184	1,858	1,347	2,707	5,415
4X Barndoor Skate (51)	1,453	2,269	2,457	2,008	24	48
4VW Barndoor Skate (52)	253	1,169	1,340	735	5	10
4X Winter Skate (57)	2,968	3,805	2,615	3,091	574	1,148
4VW Winter Skate (58)	577	876	562	658	1,601	3,202
4X Little Skate (60)	1,726	1,325	1,013	1,342	181	362
4VW Little Skate (61)	0	44	136	18	12	24
4VWX Spiny Dogfish (66)	42,472	114,542	110,494	81,308	31,915	63,830
4X Longhorn Sculpin (48)	1,568	1,241	1,013	1,254	516	1,032
4VW Longhorn Sculpin (49)	2,147	1,085	1,043	1,345	868	1,736
4X Red Hake (68)	2,188	1,568	1,419	1,695	489	979
4VW Red Hake (69)	1,015	2,681	1,149	1,463	378	757
4X Ocean Pout (74)	153	139	95	126	183	366
4VW Ocean Pout (75)	1	8	12	5	53	105
4X Sea Raven (71)	2,232	1,983	1,213	1,751	684	1,368
4VW Sea Raven (72)	1,881	708	1,475	1,252	331	661

*For Silver Hake and Red Hake, long-term average is 1982 – 2016

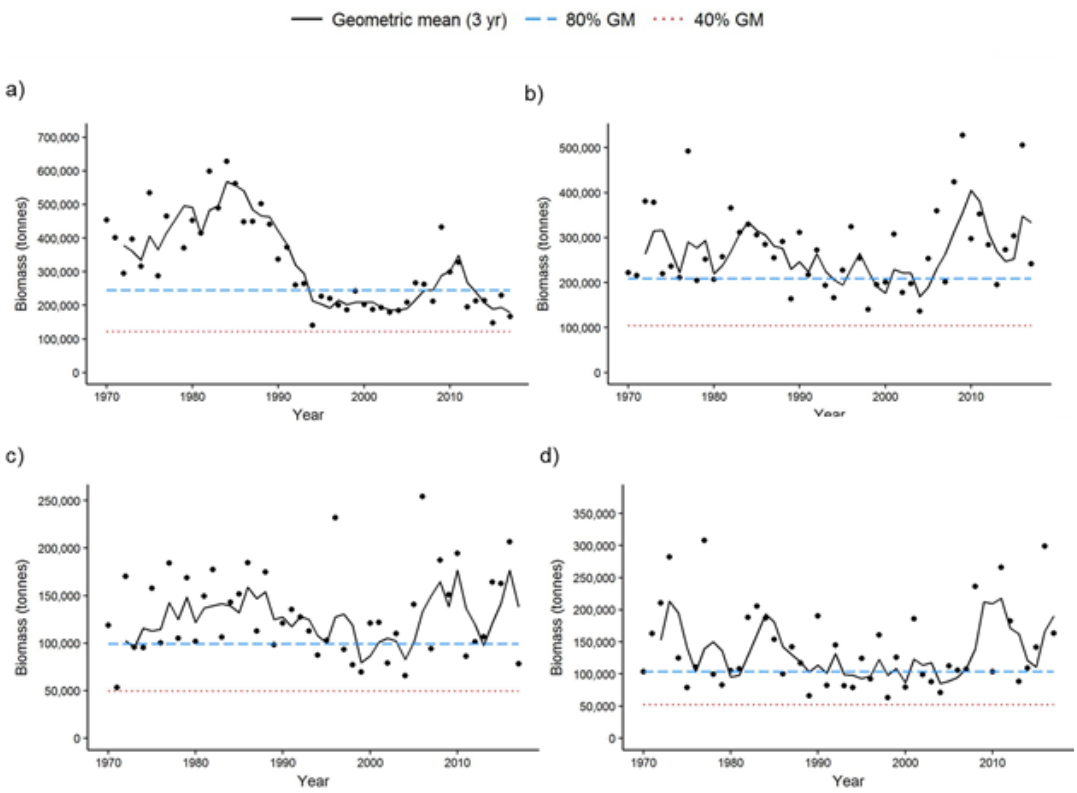


Figure 3. Total biomass index of demersal fish species in: a) 4VW (strata 440-466), b) 4X (470-495), c) 4X west (482-495), and d) 4X east (strata 470-481) from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

Total biomass index for demersal fish from the survey remains low in 4VW (Figure 3a). Biomass declined on the eastern Shelf in the early 1990s and has generally remained low since. The total biomass index for 4X shows high interannual variability but no clear trend over time (Figure 3b). The high value in 2016 was primarily due to large catches of redfish. The large drop in biomass for 4X from 2016 – 2017 was primarily a result of lower catches of redfish; however, catches were also lower in 4X this year for most demersal species. The period of low biomass in 4X east (Figure 3c) began earlier and lasted longer than in 4X west (Figure 3d), but biomass for demersal fish has returned to levels seen in the 1980s in both parts of 4X.

A three year geometric mean through the 4X demersal fish biomass data may better reflect actual biomass trends. Similarly, changes in biomass indices from one year to the next for individual species should be interpreted cautiously. For those species where a population model is used, the inter-annual variability in population biomass estimates is lower than the variability in survey estimates. Additional information from commercial landings and age composition can help in interpreting survey data.

Of note in the data, particularly for Cod and Haddock, is the increased abundance of young-of-the-year fish (Age 0). The short-term median length frequency shows a strong mode at <10 cm for both Cod and Haddock. This is not thought to be indicative of stronger recent recruitment, rather this likely reflects earlier spawning and thus these fish are available to the July survey in recent years when in the past they would have still been in the pelagic phase in July.

Atlantic Cod

The largest Atlantic Cod (*Gadus morhua*) catches came from Georges Bank and Banquereau Bank. There were no catches >50kg in 4X in 2017. The large increase in biomass in 4VW is primarily driven by large Atlantic Cod. This does not appear to track in the length frequency from 2016 and may be an anomaly. In 4X, the 2013 year class had been apparent in the length frequencies for 2015 (peaking between 35 cm and 45 cm) and 2016 (peaking between 50 cm and 60 cm) but does not appear as a clear mode in the 2017 survey length frequency.

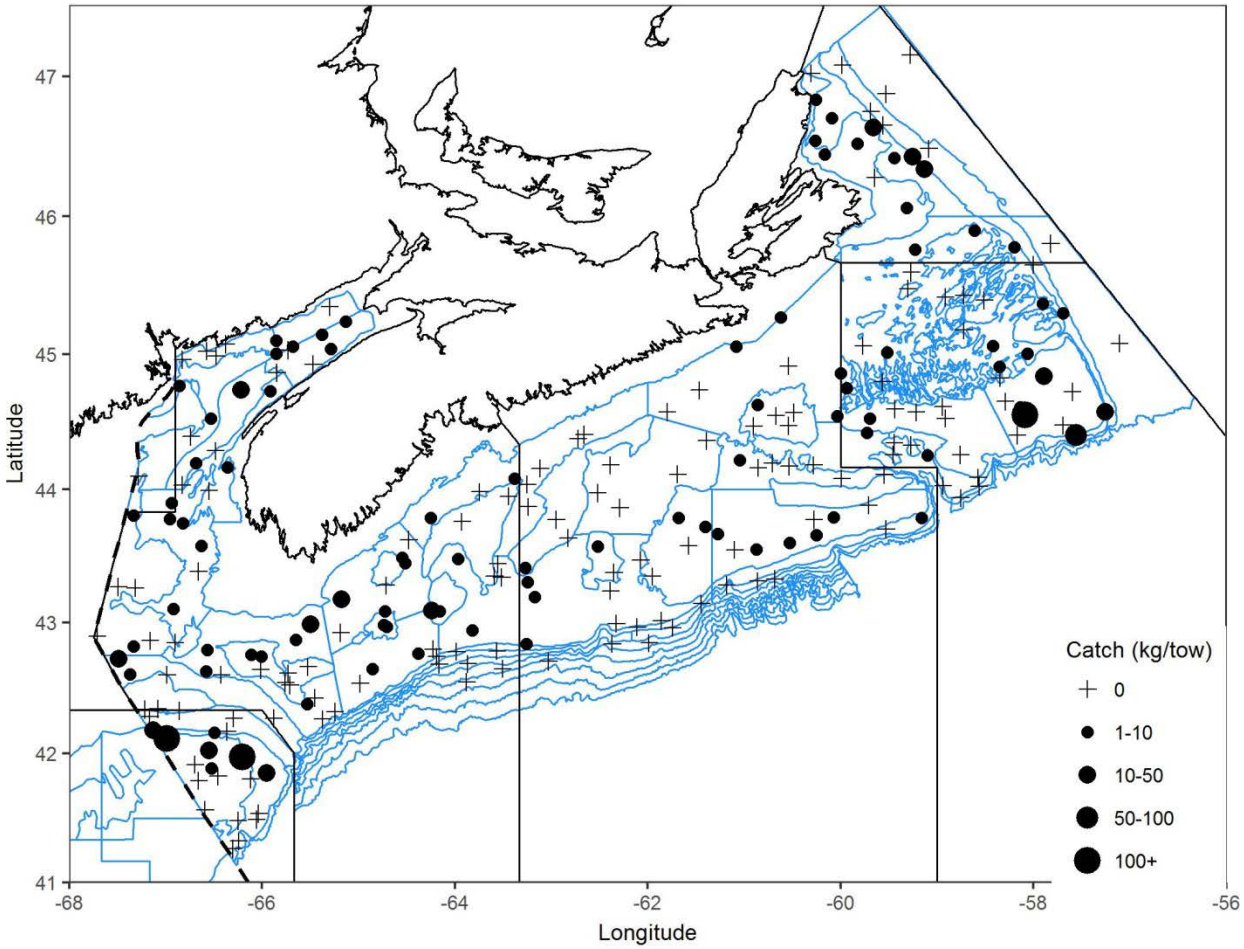


Figure 4a. Distribution of Atlantic Cod catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

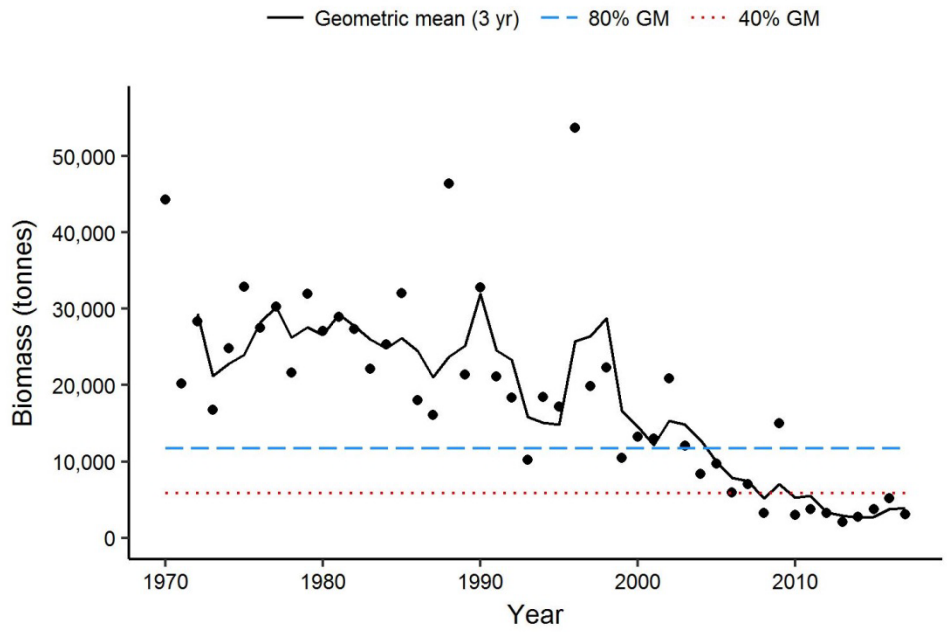


Figure 4b. Biomass index for Atlantic Cod in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

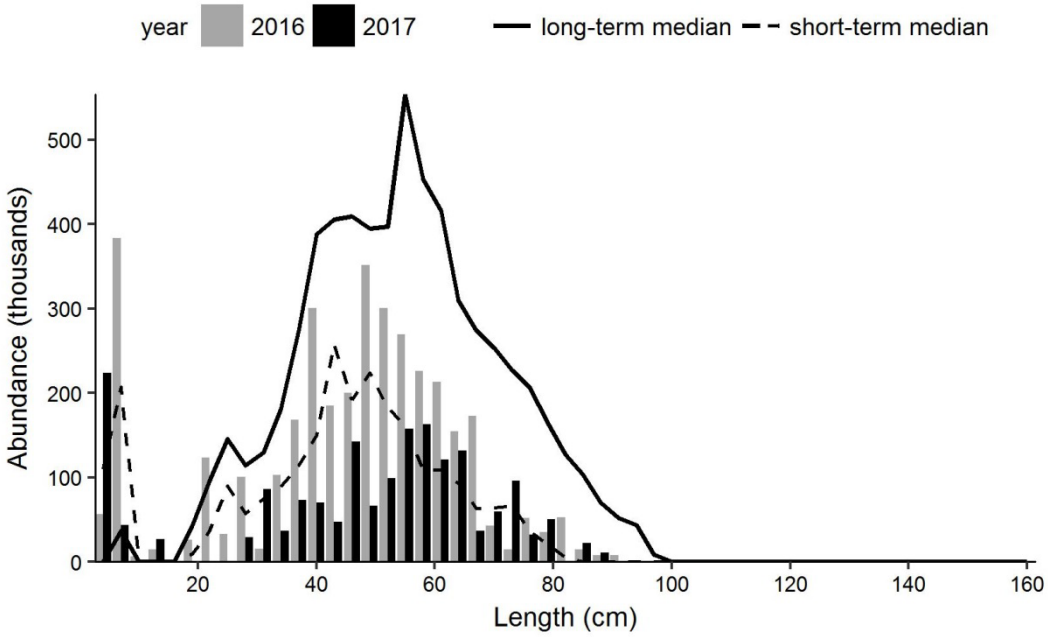


Figure 4c. Length frequency indices for Atlantic Cod in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

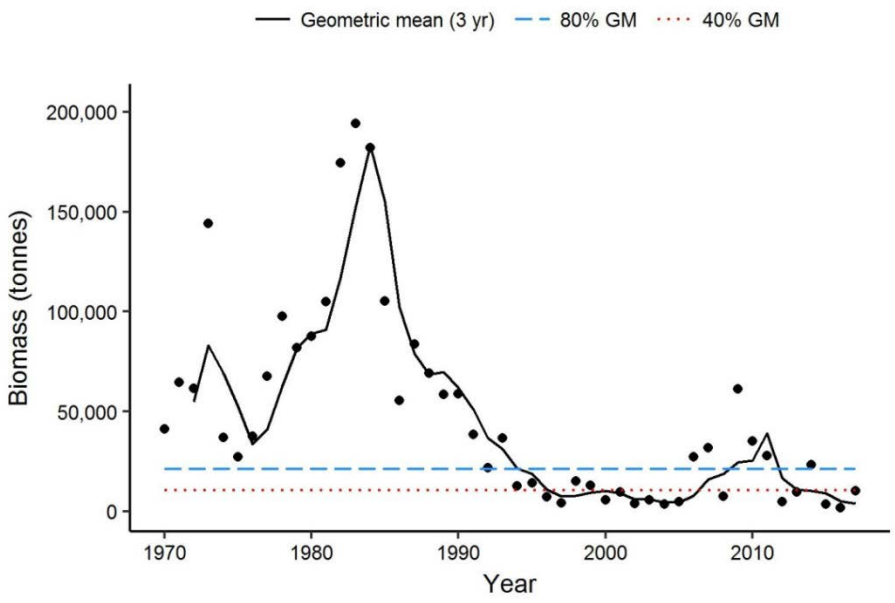


Figure 4d. Biomass index for Atlantic Cod in 4VsW from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

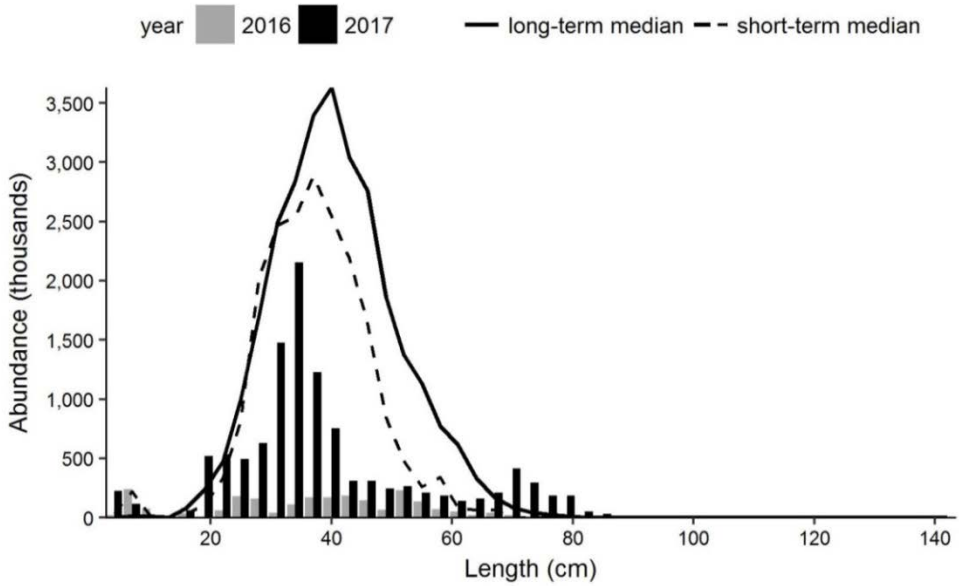


Figure 4e. Length frequency indices for Atlantic Cod in 4VsW from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

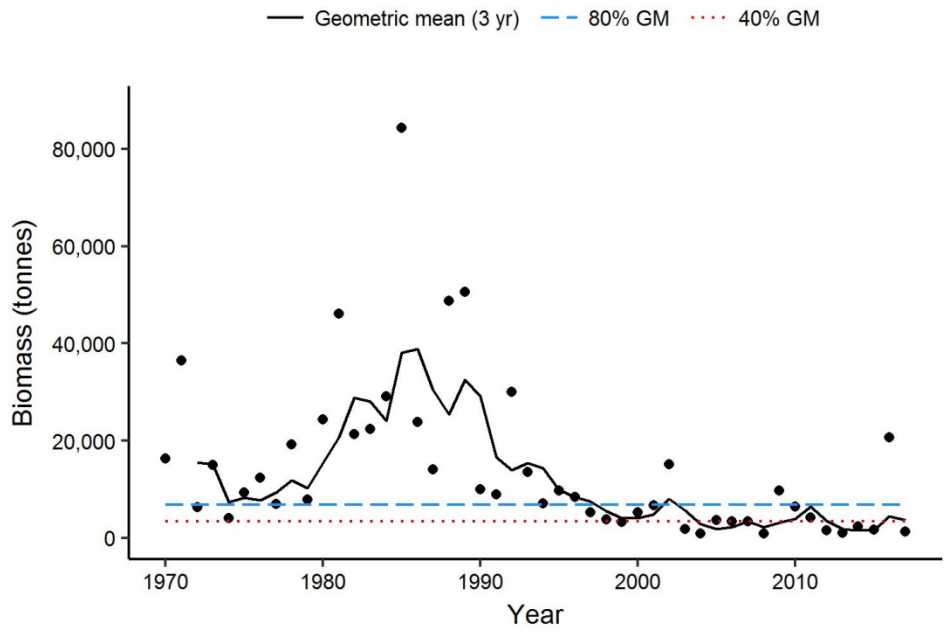


Figure 4f. Biomass index for Atlantic Cod in 4Vn from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

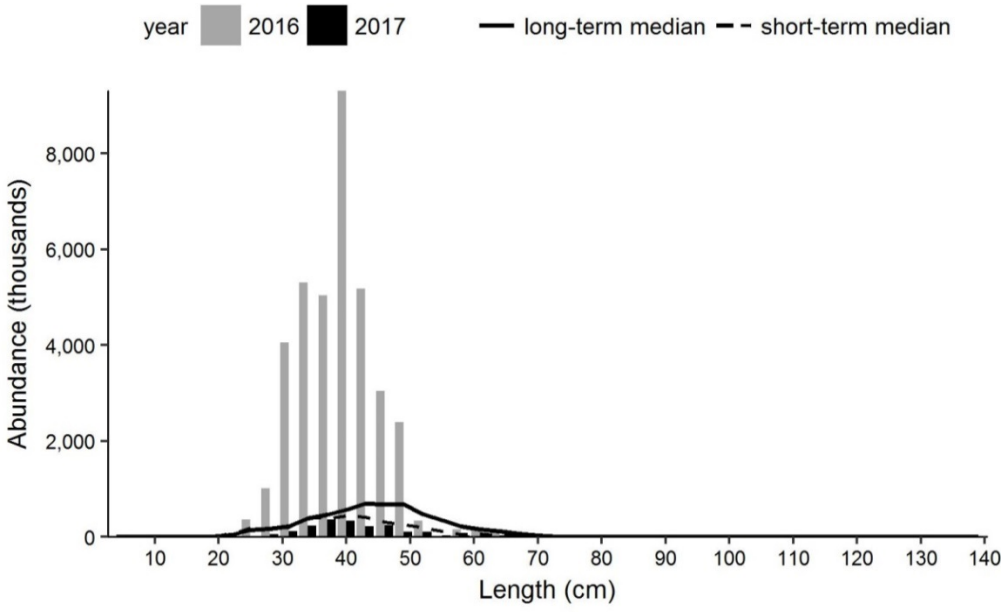


Figure 4g. Length frequency indices for Atlantic Cod in 4Vn from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Haddock

There were very few sets where the catch of Haddock (*Melanogrammus aeglefinus*) exceeded 100 kg in 4X in 2017. While Haddock were caught in almost every set in 4X, the biomass index was much lower than in 2015 and 2016. The 2013 year-class had provided a clear mode in the length frequencies in the surveys from 2013 to 2016. The numbers at length are generally below the short-term median in 2016 and 2017 for fish above 40 cm.

In 4VW, the biomass remains near 80% of the long-term mean and the progression of the modal length representing the 2013 year-class is evident. The modal length in 2017 is 34 cm, the same as in 4X. This is unusual as length-at-age generally differs between these regions and the long-term average length frequencies reflect this in having differing modal lengths.

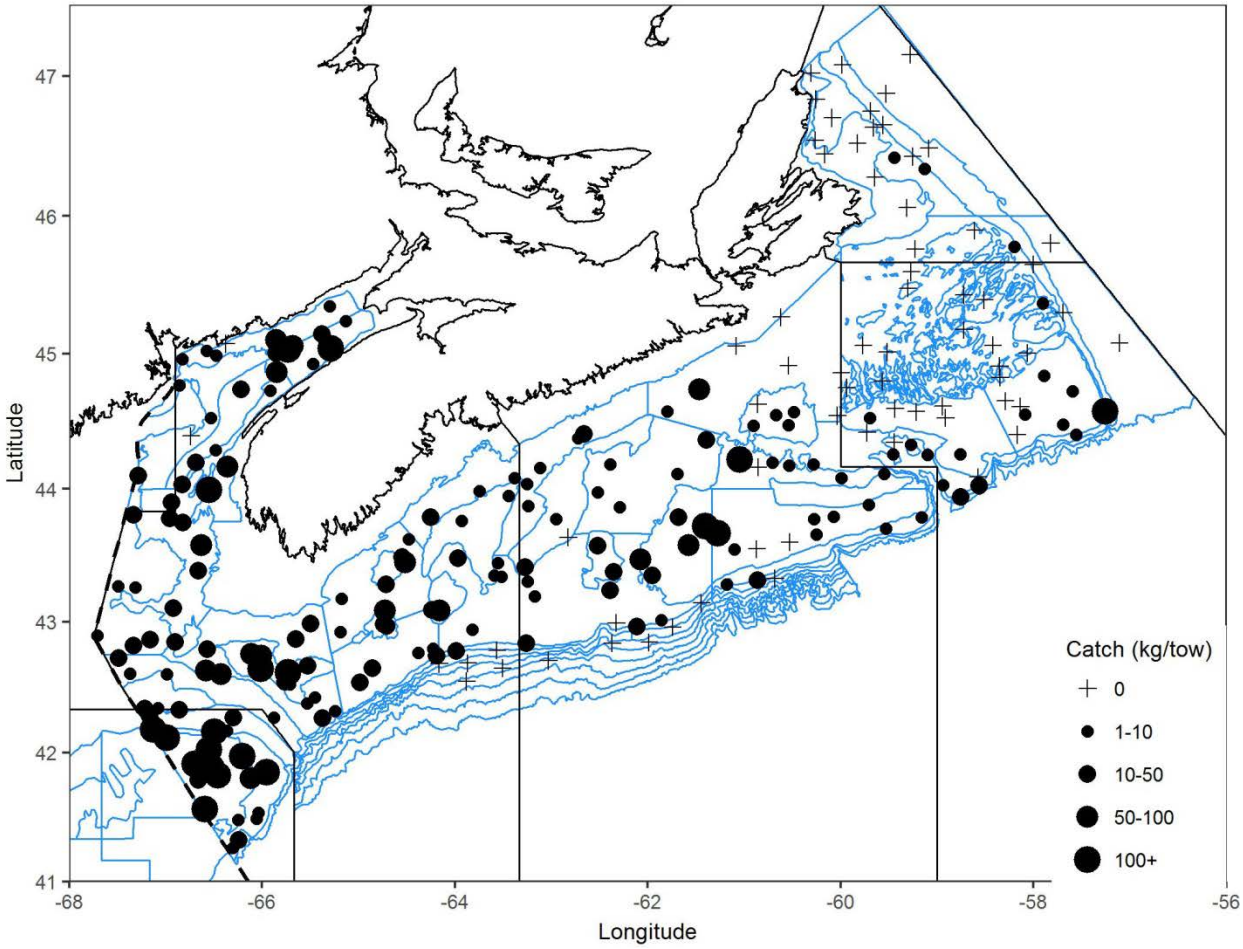


Figure 5a. Distribution of Haddock catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

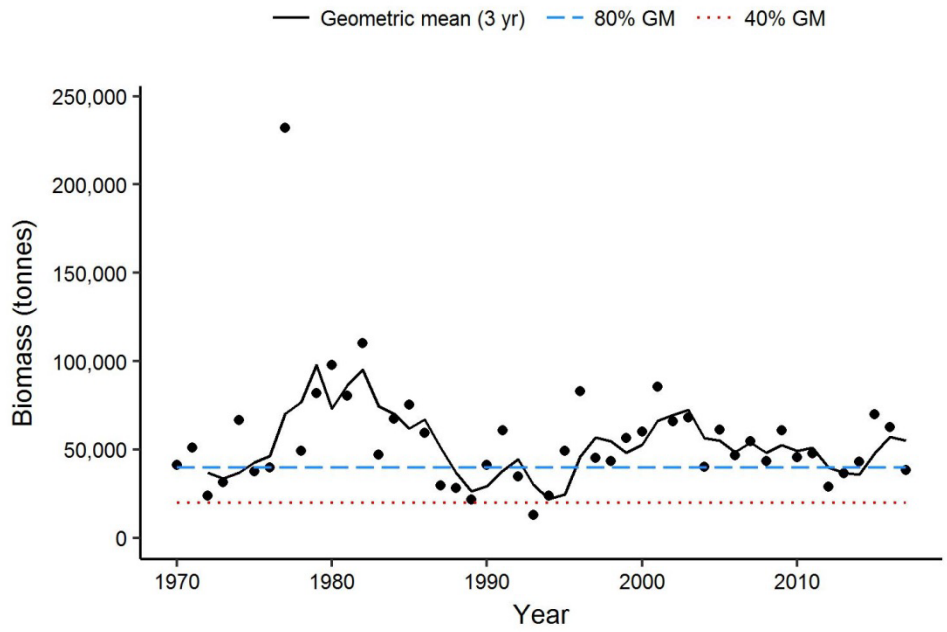


Figure 5b. Biomass index for Haddock in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

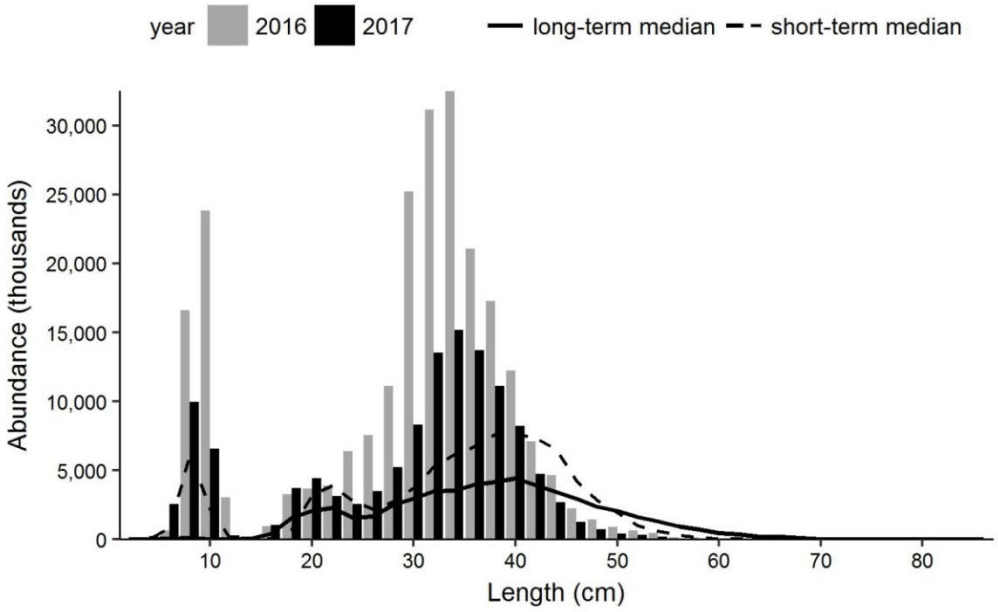


Figure 5c. Length frequency indices for Haddock in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

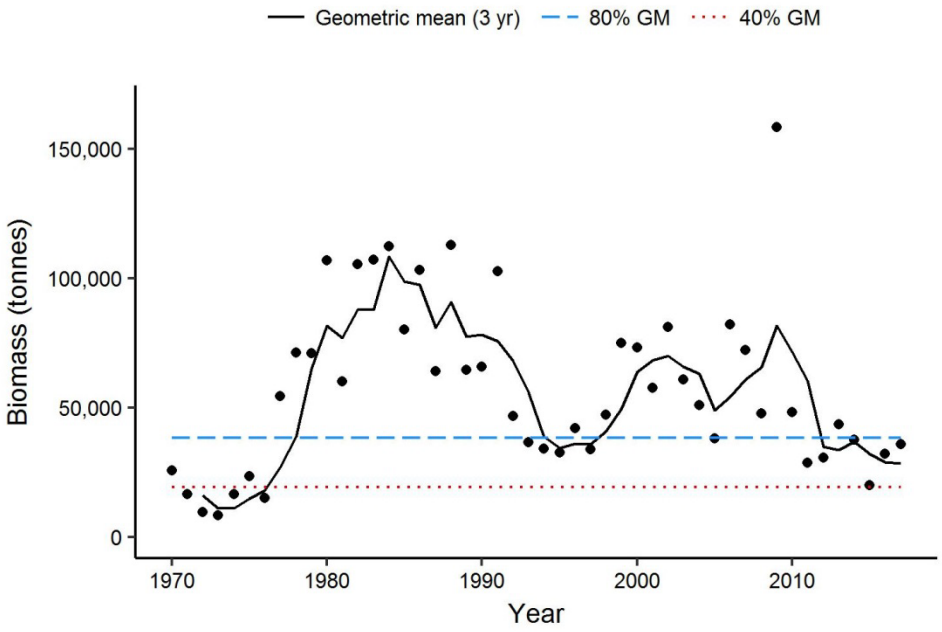


Figure 5d. Biomass index for Haddock in 4VW from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

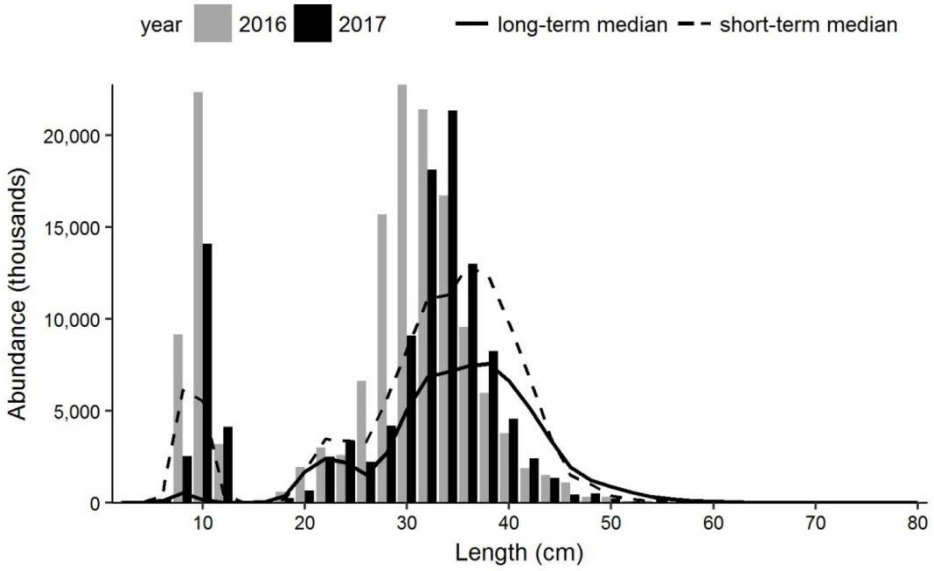


Figure 5e. Length frequency indices for Haddock in 4VW from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

White Hake

White Hake (*Urophycis tenuis*) are broadly distributed in deeper waters along the shelf edge and in basins of the Scotian Shelf and Gulf of Maine. There was only one set in 2017, at the mouth of the Bay of Fundy, where a catch of over 50 kg was recorded. White Hake biomass indices have been low relative to the long-term. In 2016, catches in 4X included large numbers of juveniles, peaking at 35 cm. This mode is not seen in the 2017 survey indices. . The biomass index for 4X White Hake >41 cm remained below the RPA defined critical biomass reference point (three year geometric mean; Guenette and Clark, 2016) in 2017. The biomass index for 4VW White Hake >41 cm has been below the RPA defined critical biomass reference point since 2003.

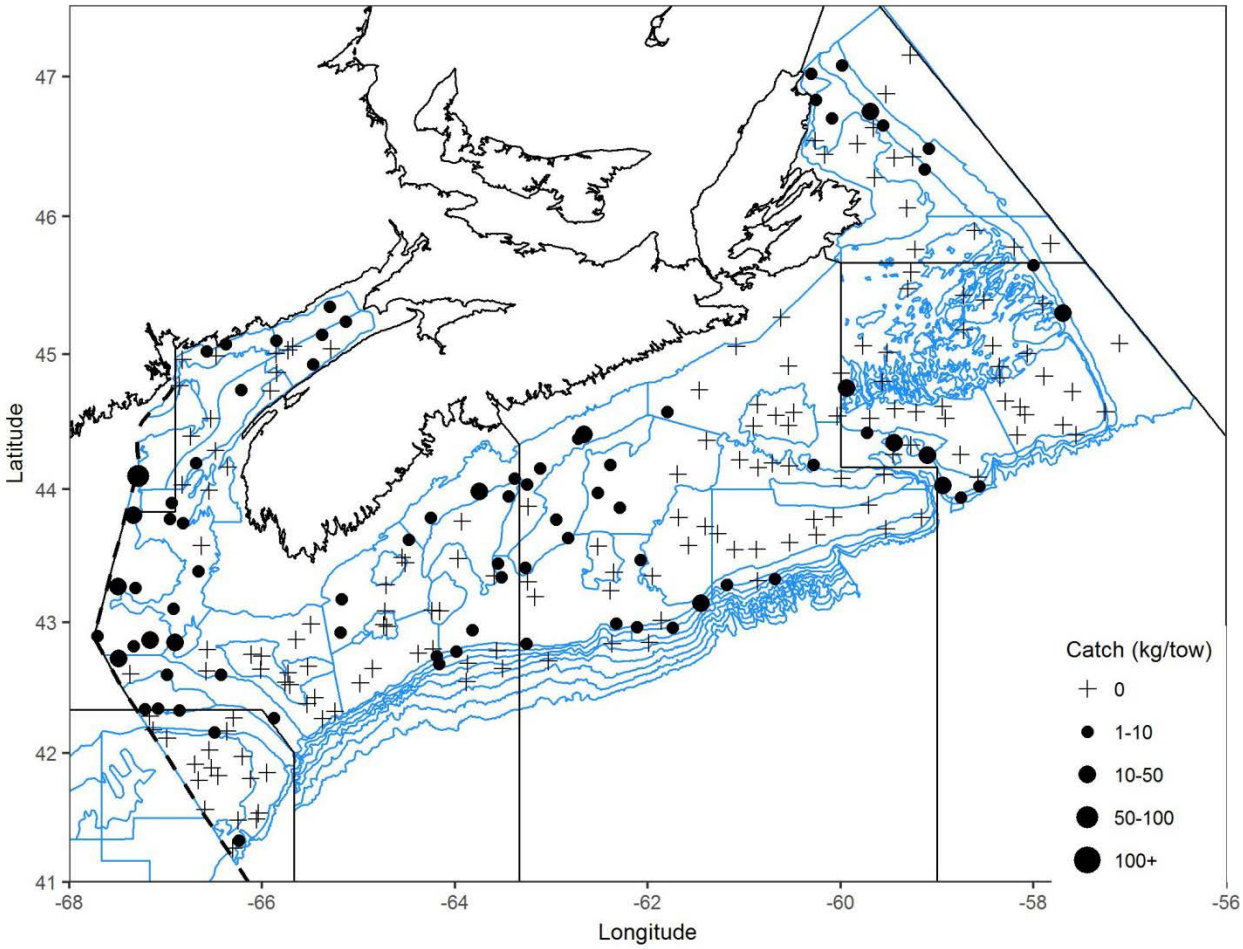


Figure 6a. Distribution of White Hake catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

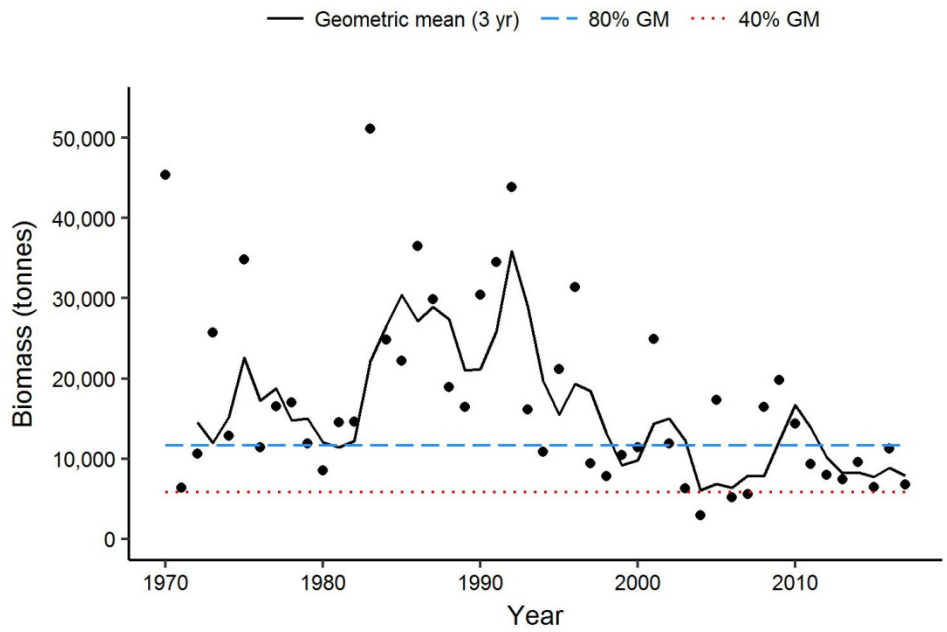


Figure 6b. Biomass index for White Hake in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

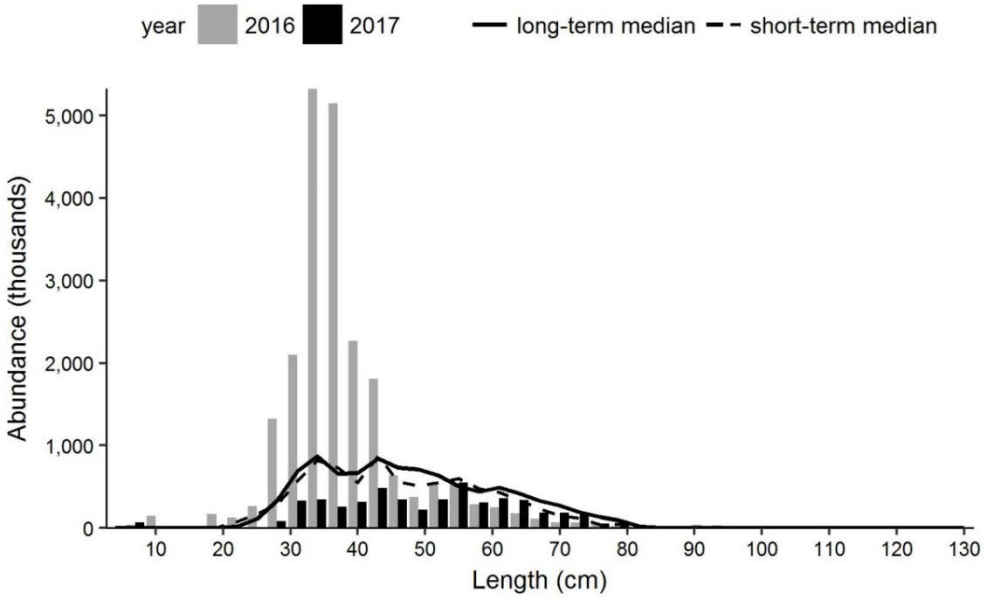


Figure 6c. Length frequency indices for White Hake in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

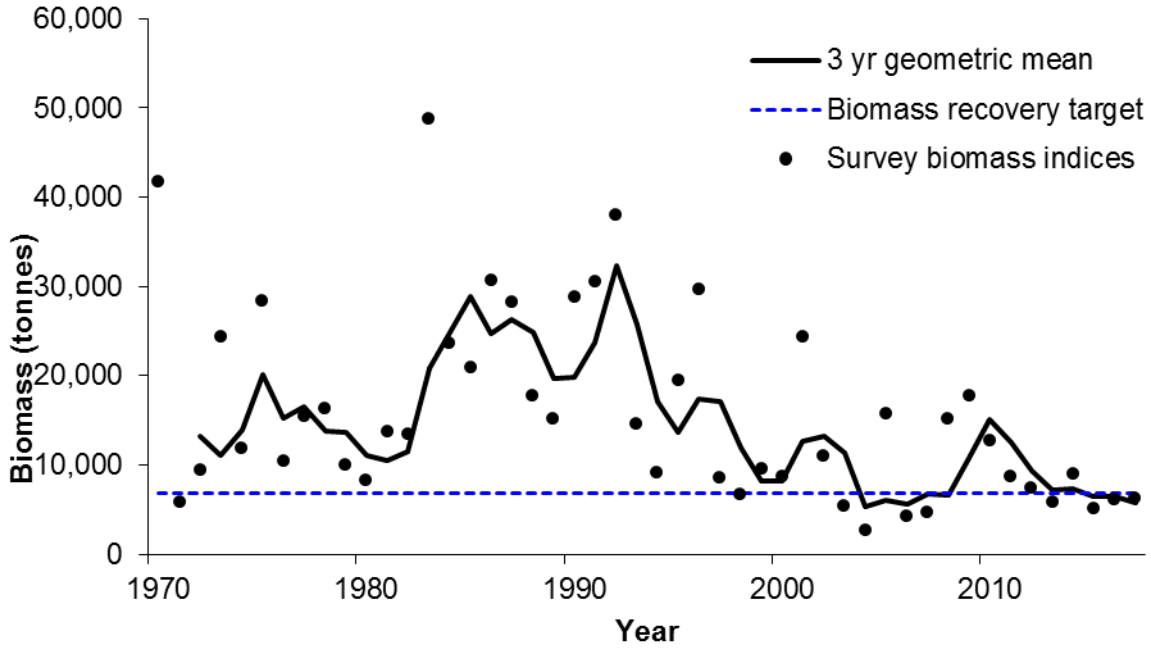
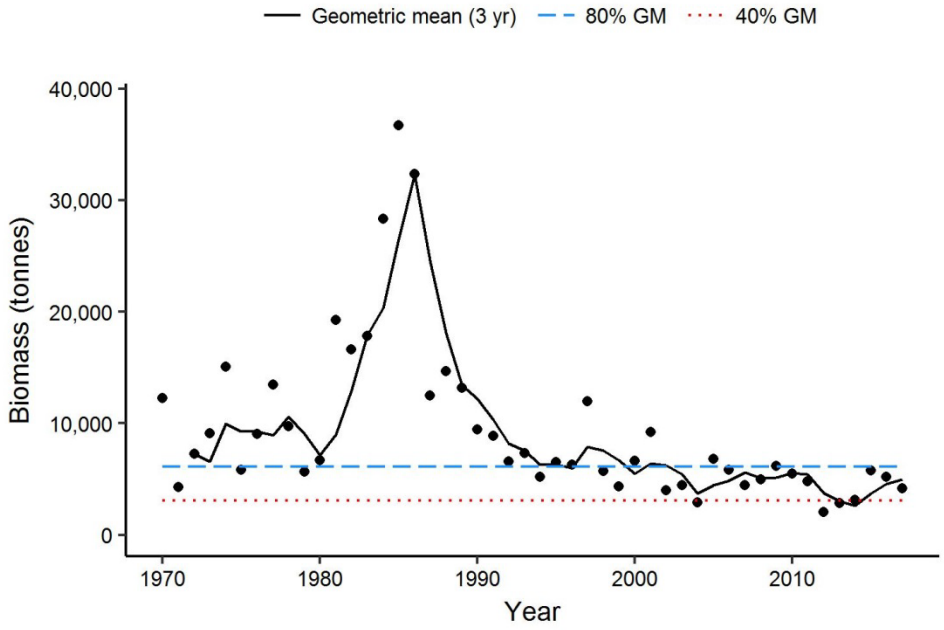


Figure 6d. Biomass index for 4X White Hake >41 cm from the DFO Summer RV Survey represented by the black circles. The solid black line represents the three year geometric mean. The dashed blue line represents the lower limit reference point.



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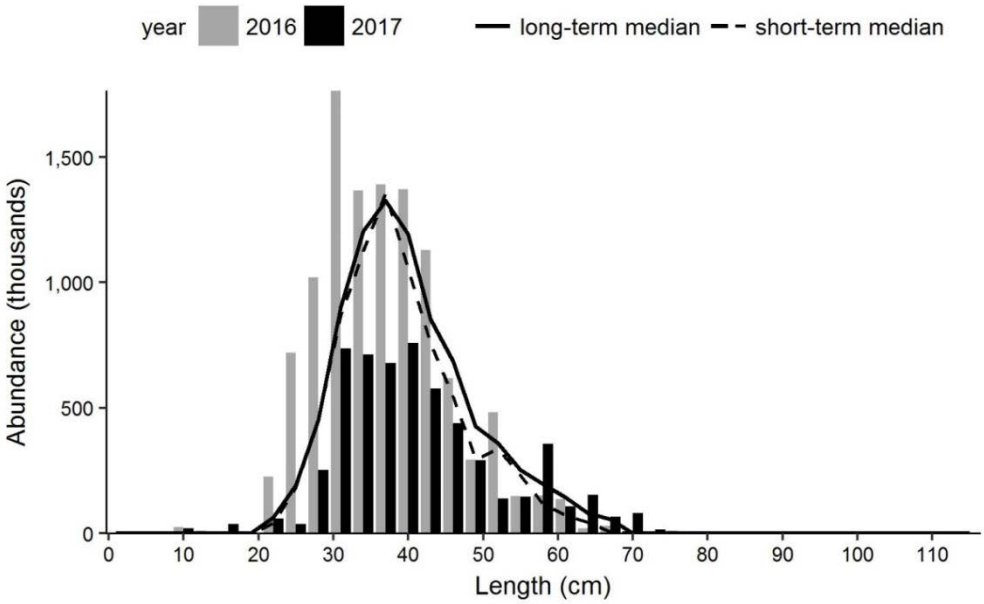

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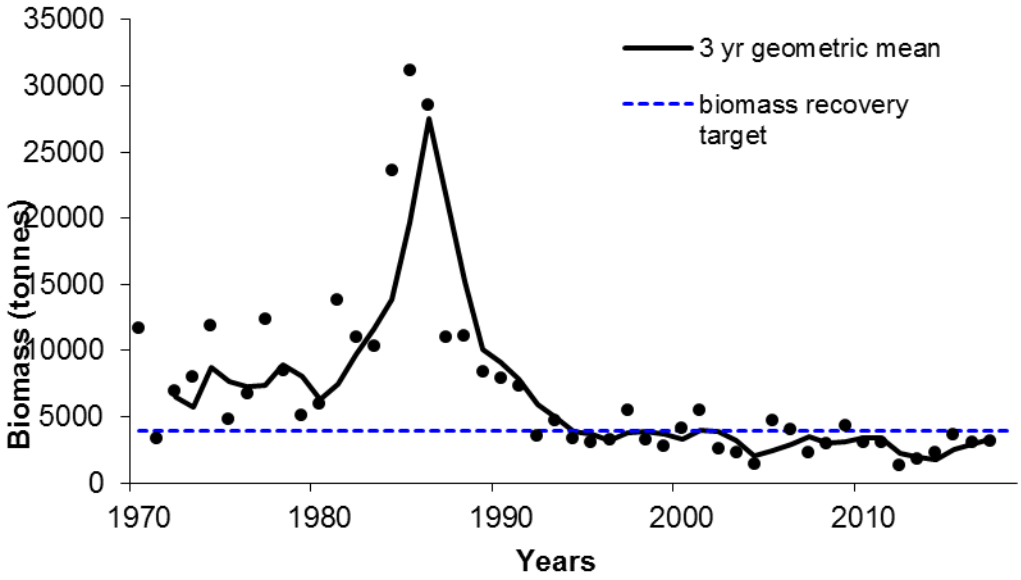

Figure 6g. Biomass index for 4VW White Hake >41 from the DFO Summer RV Survey represented by the black circles. The solid black line represents the three year geometric mean. The dashed blue line represents the lower limit reference point.

Silver Hake

Silver Hake (*Merluccius bilinearis*) were caught throughout most of the survey area, with the largest catches in the Gulf of Maine, near Browns Bank and on Sable Island Bank. The biomass index for the Scotian Shelf stock area (4VWX east) remains above 80% of the long-term mean and a strong mode at 15 cm is indicative of above average recruitment for the 2016 year-class. The biomass index and abundance in the Bay of Fundy (4X west) have been high since 2010, with fish >25 cm commonly encountered. The long-term median is zero for these lengths in the Bay of Fundy, indicating they were generally absent from the catch in the past.

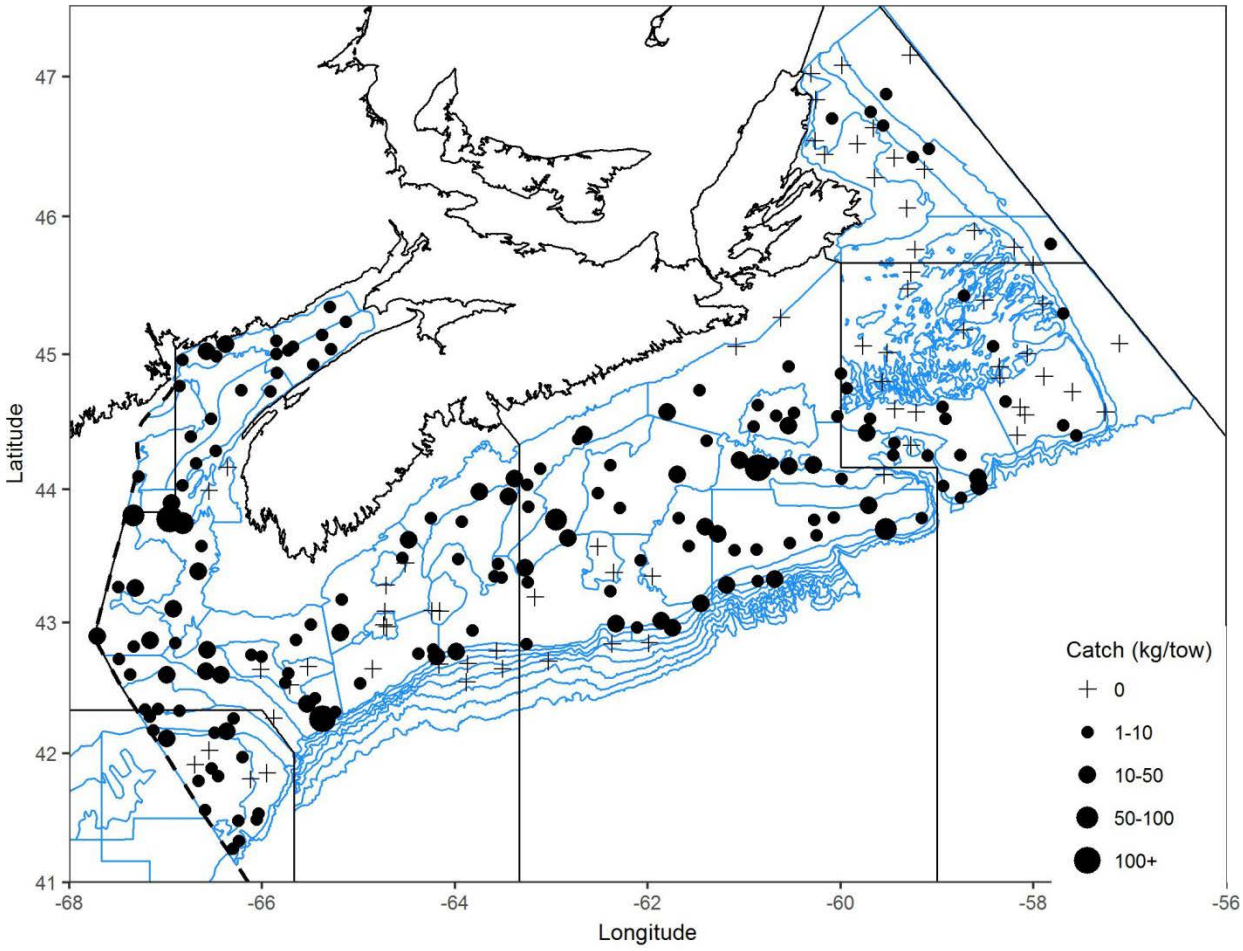

Figure 7a. Distribution of Silver Hake catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

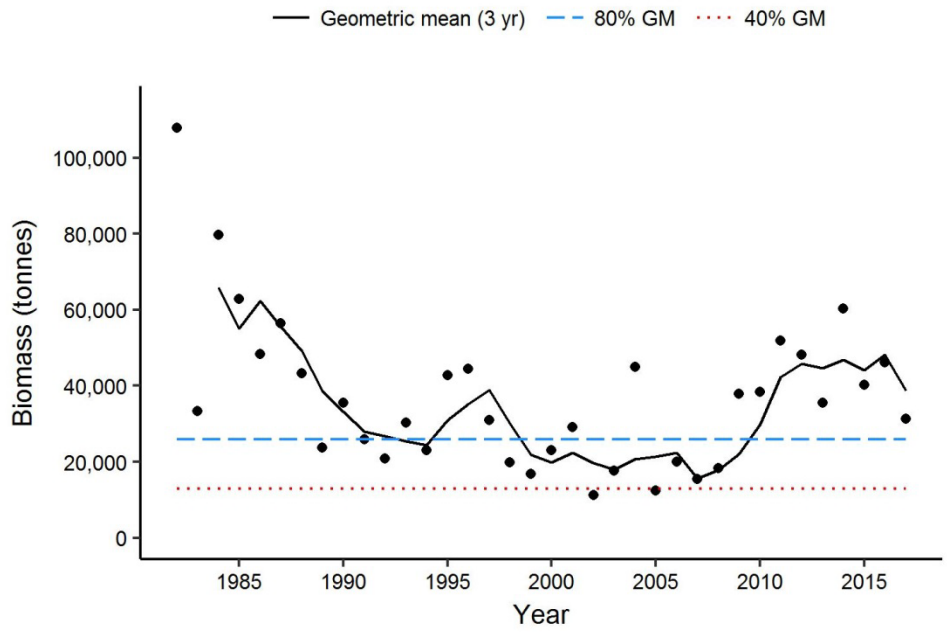

Figure 7b. Biomass index for Silver Hake in 4VWX east (strata 440-483) from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1982-2016), respectively. The black dots represent the biomass index for that year.

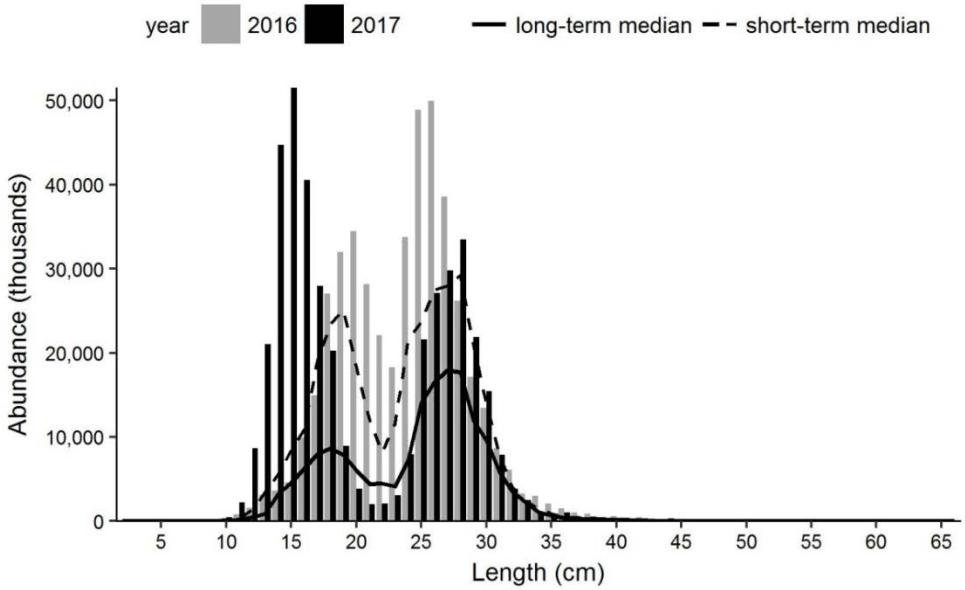

Figure 7c. Length frequency indices for Silver Hake in 4VWX east (strata 440-483) from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1982-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

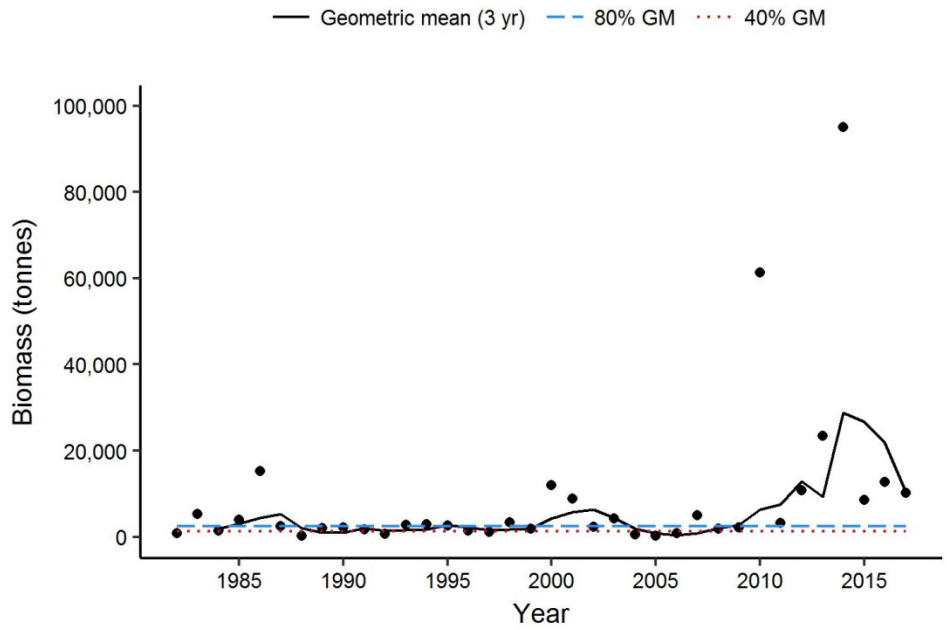

Figure 7d. Biomass index for Silver Hake in 4X west (strata 484-495) from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1982-2016), respectively. The black dots represent the biomass index for that year.

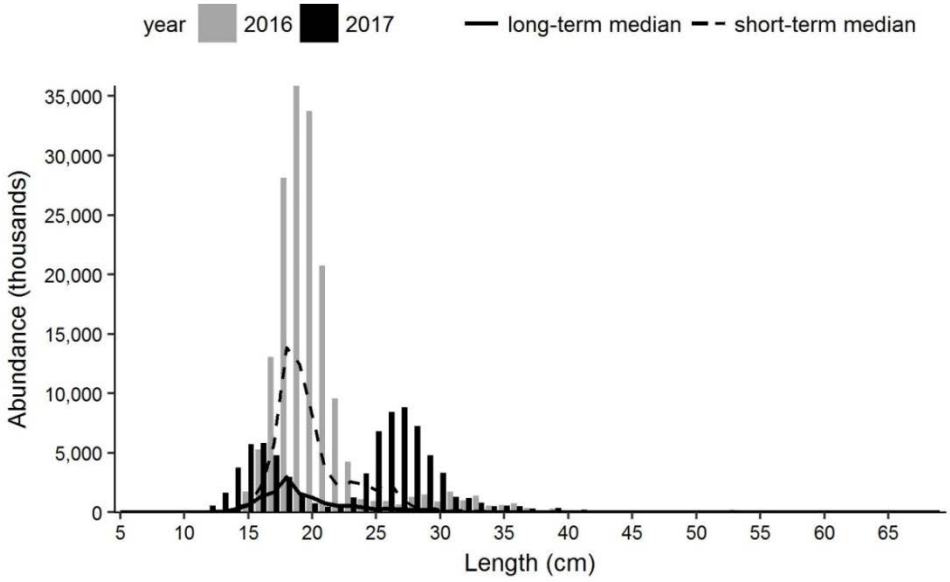

Figure 7e. Length frequency indices for Silver Hake in 4X west (strata 484-495) from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1982-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Pollock

Pollock (*Pollachius virens*) were caught primarily on Georges Bank and in the Gulf of Maine. The Western Component biomass index is close to 80% of the long-term mean. Indices at length of Western Component Pollock were above both the long-term and short-term median for small Pollock, but below average for lengths greater than 64 cm. Very few Pollock were caught in the east, and indices at length were all below the short-term median for Eastern Pollock, much lower than in 2016.

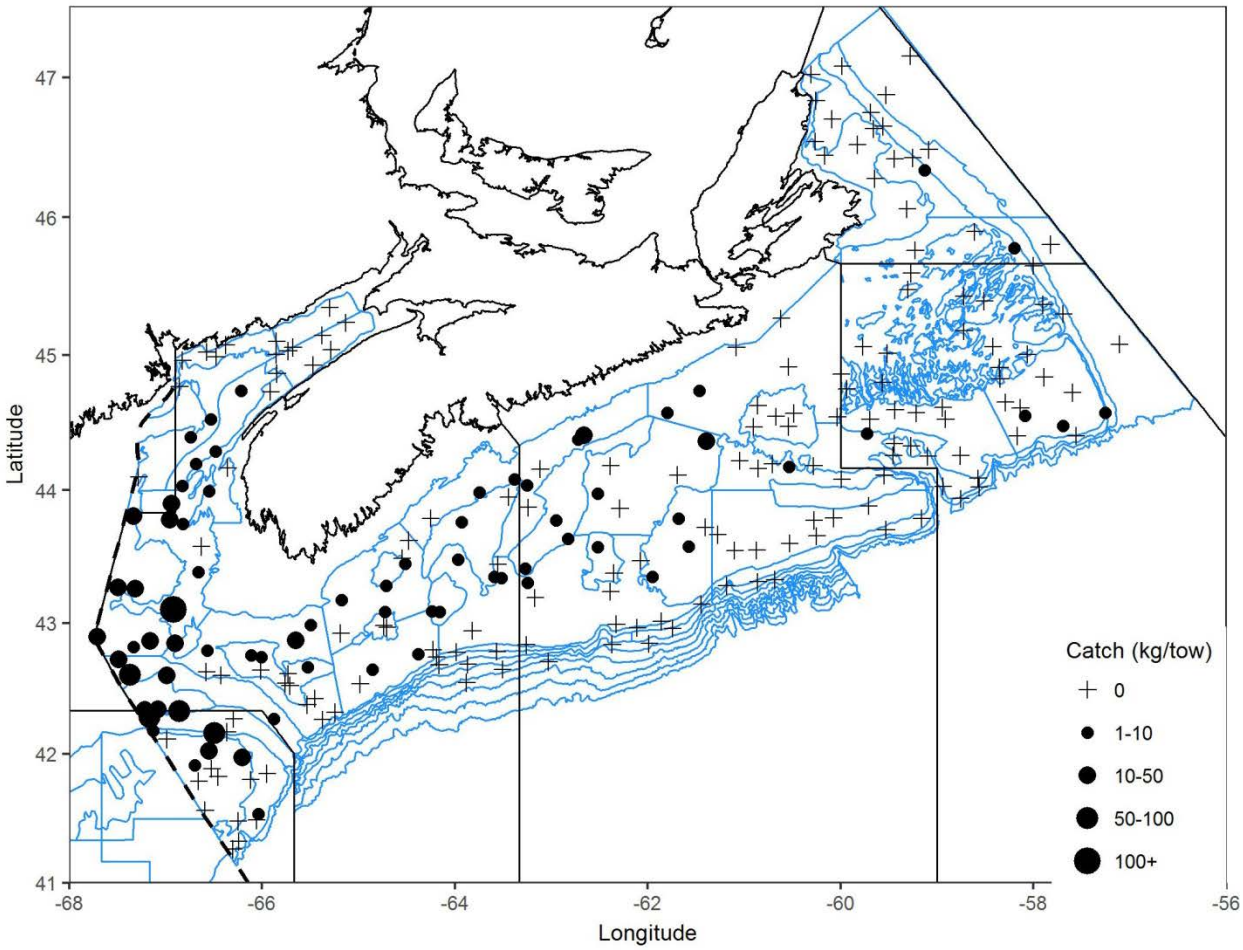

Figure 8a. Distribution of Pollock catches during the 2017 DFO Summer RV Survey including the Laurentian channel and Georges Bank. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

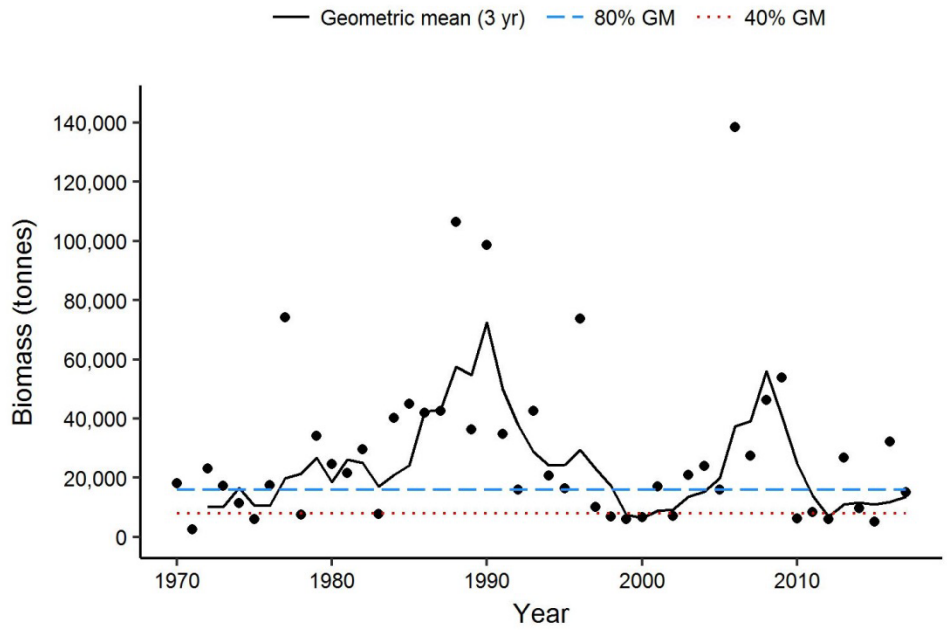

Figure 8b. Biomass index for Western Component Pollock (strata 474, 476, 480-495) from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

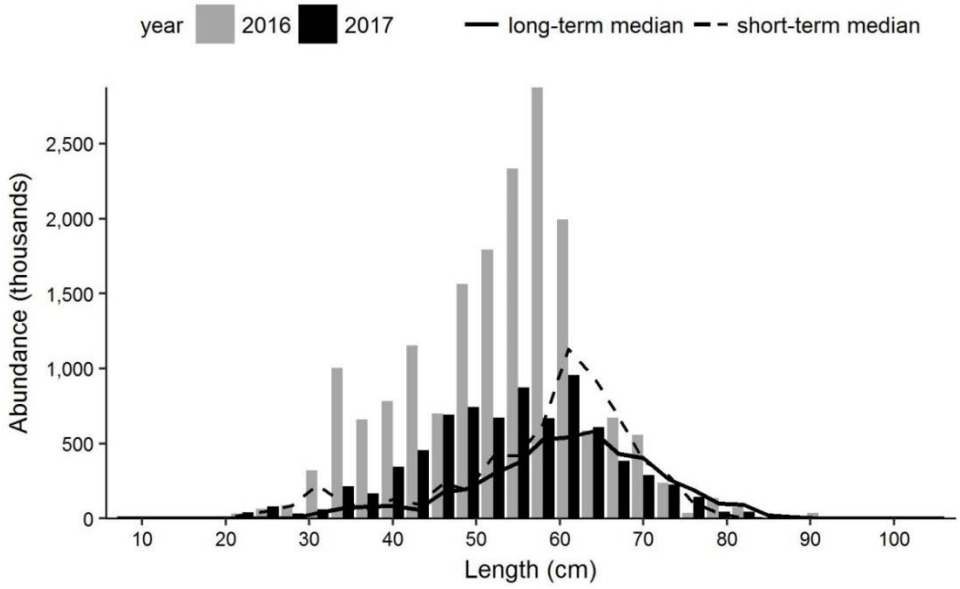

Figure 8c. Length frequency indices for Western Component Pollock (strata 474, 476, 480-495) from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

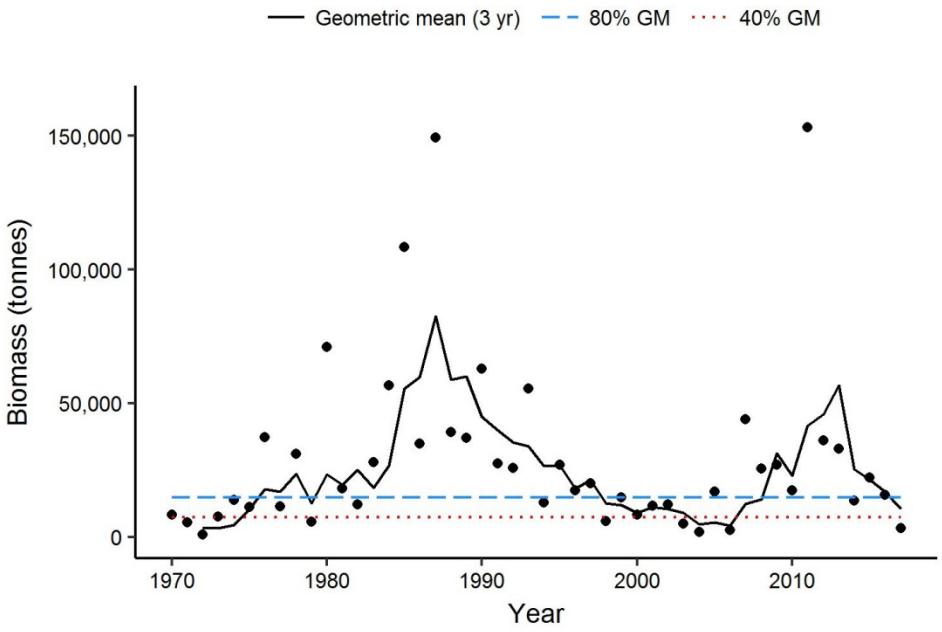

Figure 8d. Biomass index for Eastern Component Pollock (strata 440-473, 475, 477, 478) from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

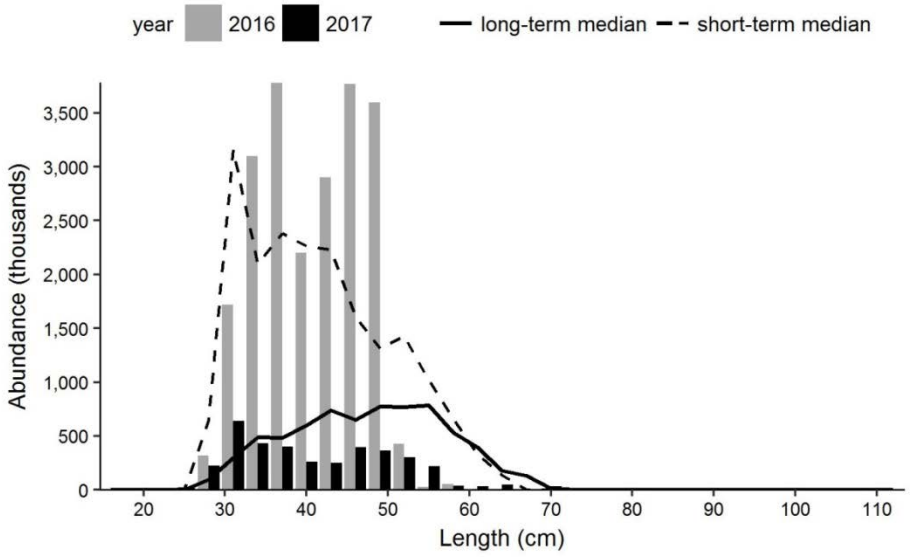

Figure 8e. Length frequency indices for Eastern Component Pollock (strata 440-473, 475, 477, 478) from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Redfish

Catches of redfish were largest along the Laurentian Channel and in the central Scotian Shelf. The deep water of the Laurentian Channel has only been included in the summer survey coverage for three years and thus it is not used in the abundance index. The data are available for use in redfish assessments and should be included in indices once detailed analyses have been undertaken.

Biomass indices for Unit II redfish have high inter-annual variability. In 2017, the survey caught very few redfish >25 cm, unlike in 2016. The three year average biomass index remains near 80% of the long-term mean.

In Unit III, biomass indices have been high in recent years and remain high in 2017. The short-term median abundance indices are generally higher than the long-term, reflecting the recent high abundance. The mature biomass index (five year average biomass for fish > 22 cm) is at the second highest point in the time series in 2017 and remains in the healthy zone.

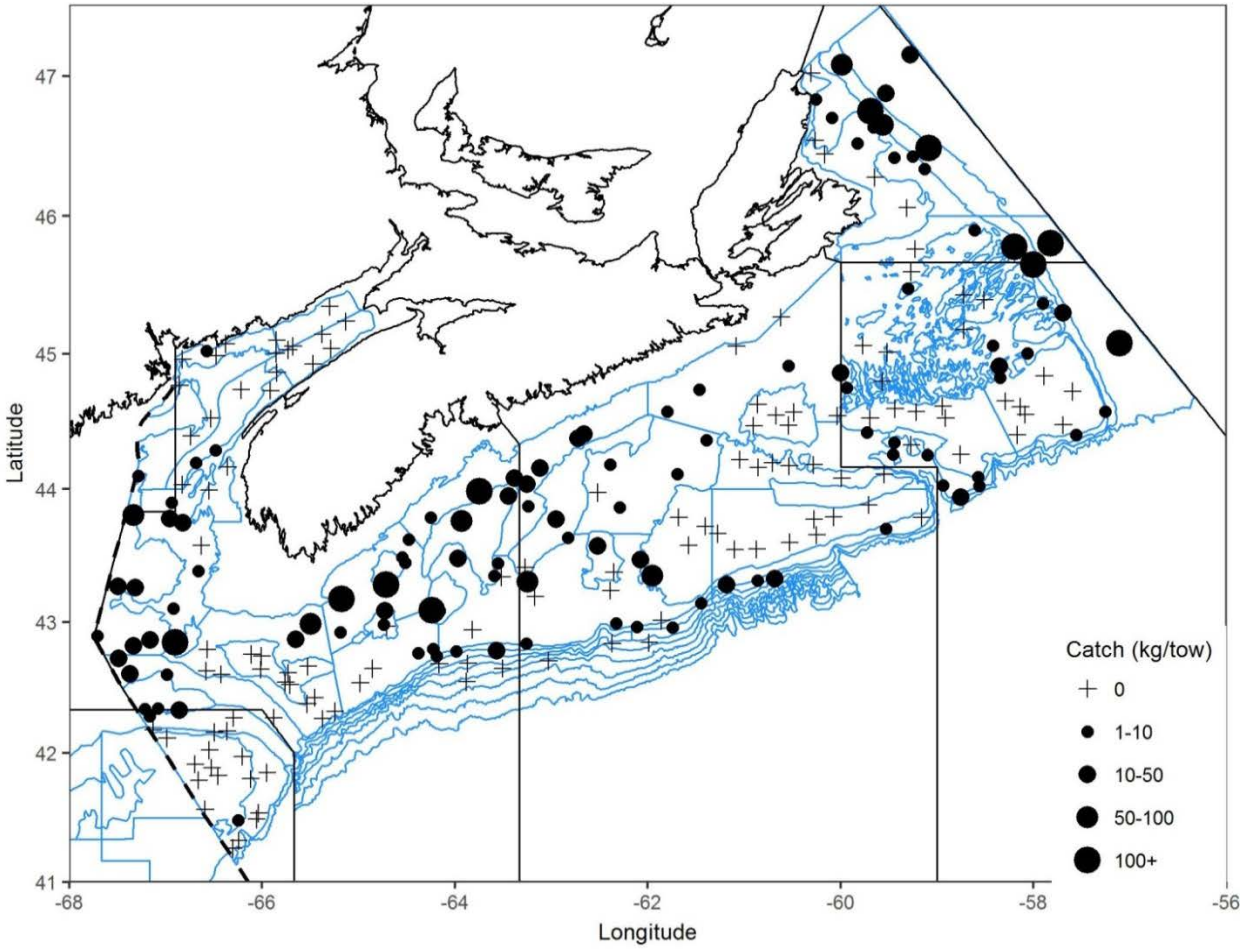

Figure 9a. Distribution of Redfish catches during the 2017 DFO Summer RV Survey including the Laurentian channel and Georges Bank. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

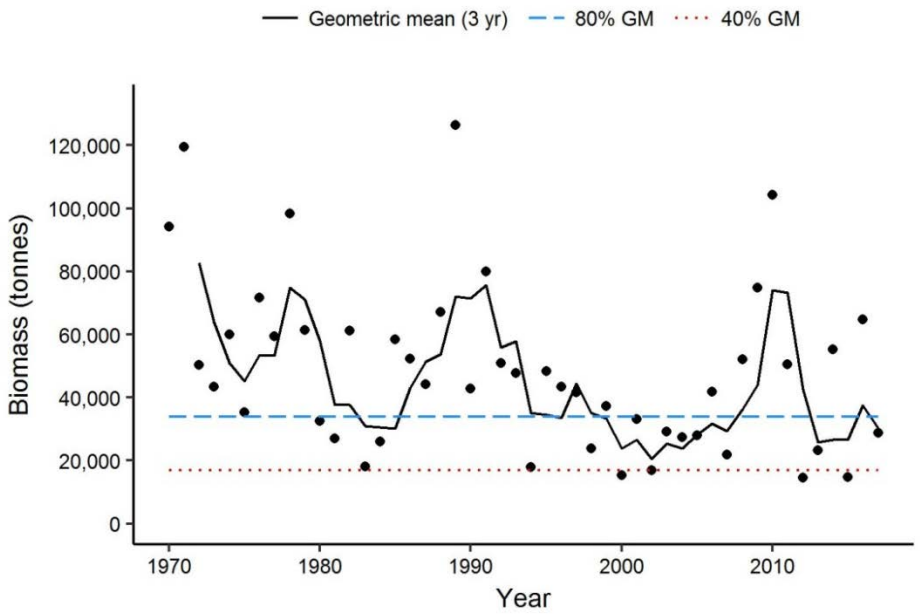

Figure 9b. Biomass index for Unit II redfish (strata 440-456, 464) from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

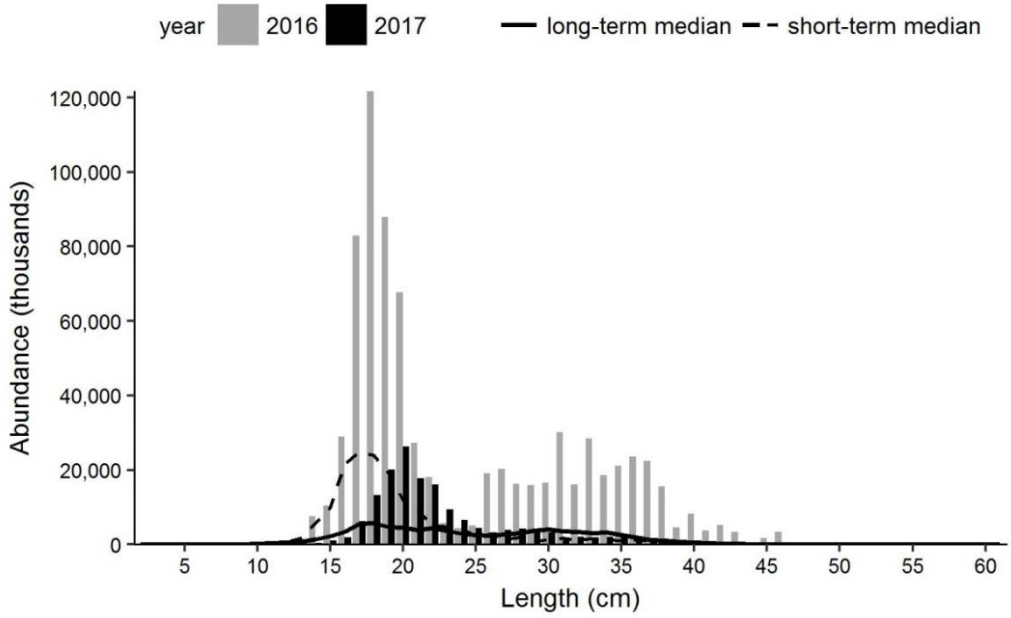

Figure 9c. Length frequency indices for Unit II redfish (strata 440-456, 464) from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

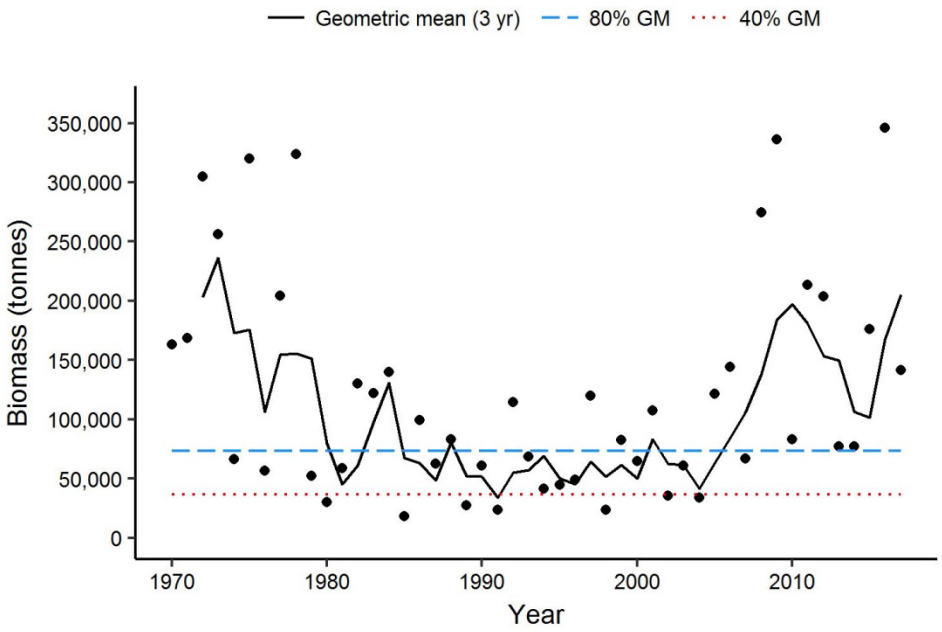

Figure 9d. Biomass index for Unit III redfish (strata 457-463, 465-485) from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

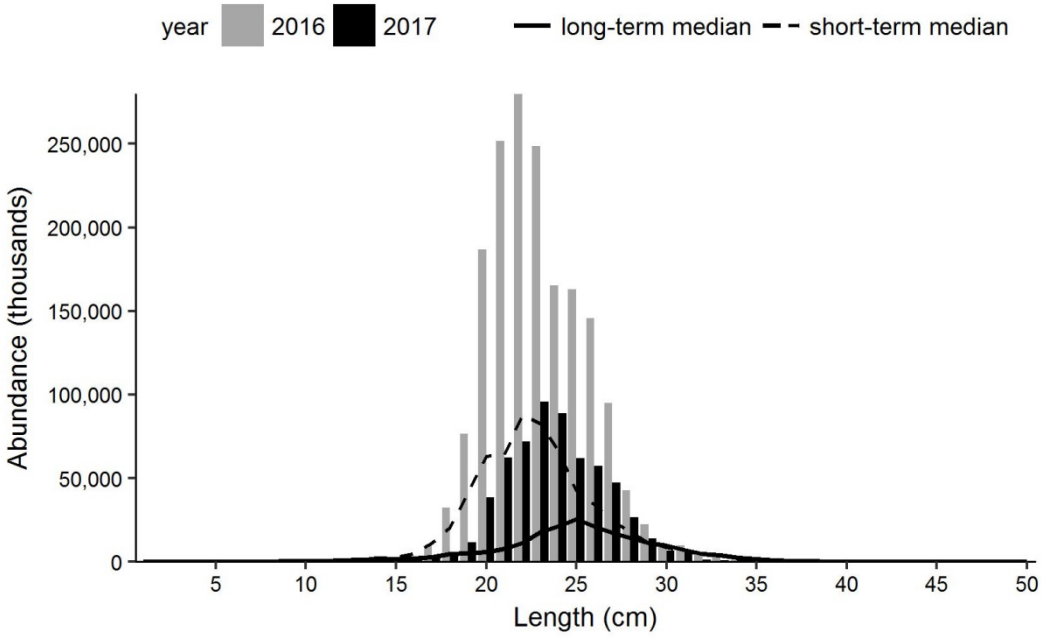

Figure 9e. Length frequency indices for Unit III redfish (strata 457-463, 465-485) from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

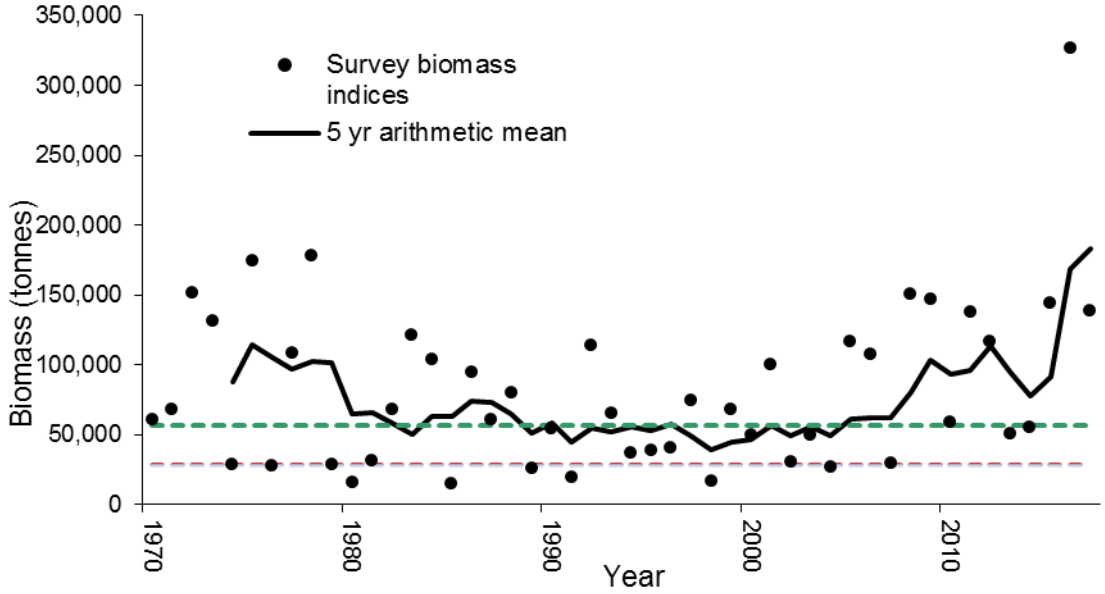

Figure 9f. Biomass index for Unit III redfish > 22 cm from the DFO Summer RV Survey represented by the black circles. The solid black line represents the 5 year arithmetic mean. The dashed green line represents the lower limit reference point and the dashed green line represents the upper limit reference point.

Atlantic Halibut

Atlantic Halibut (*Hippoglossus hippoglossus*) catches were wide-spread in the survey area. The biomass index continues to rise and was the highest in the series in 2017 at about 15,000 t. Indices for fish <45 cm were well below the short-term median in both 2016 and 2017, suggesting recruitment may be low for these year-classes.

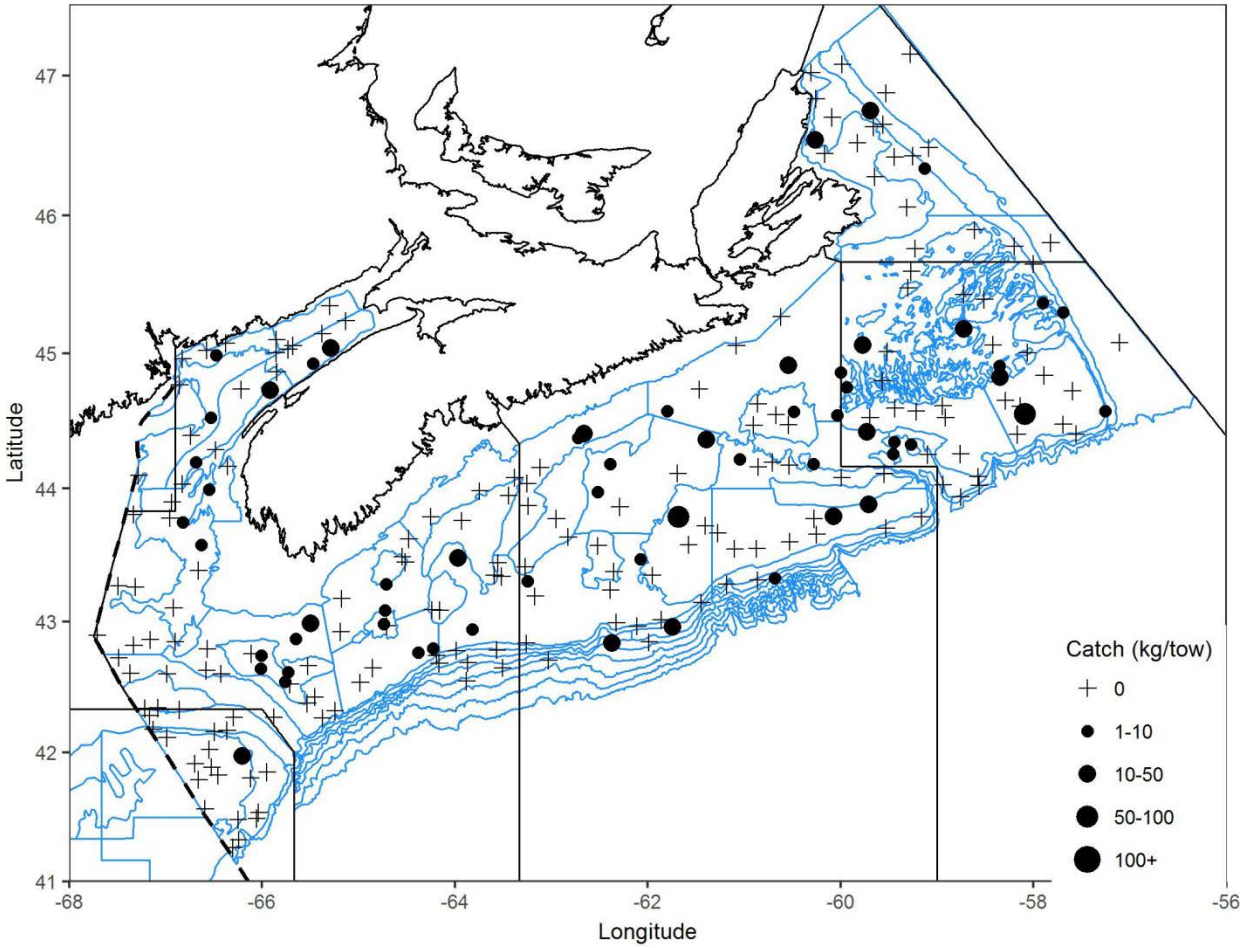

Figure 10a. Distribution of Atlantic Halibut catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

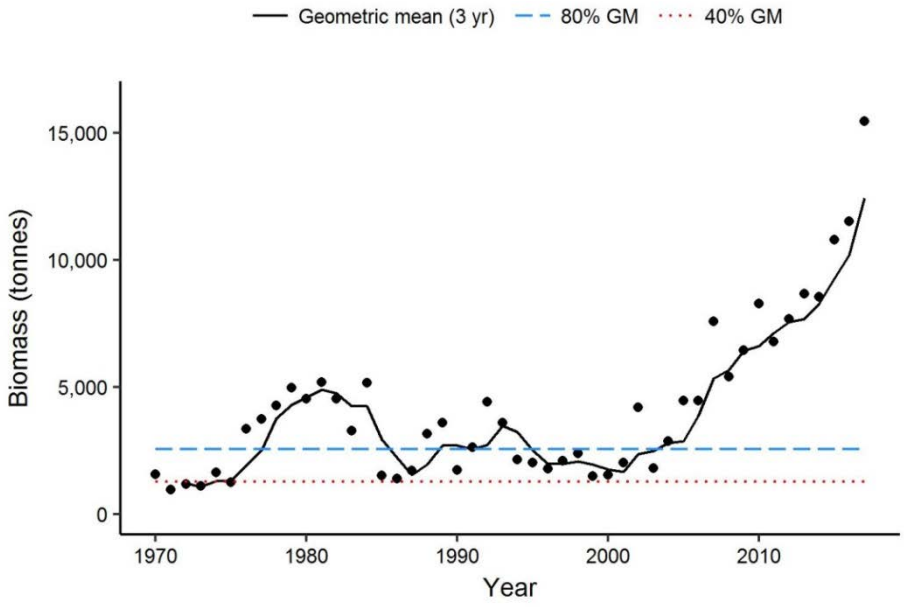

Figure 10b. Biomass index for 3NOPs4VWX5Zc Atlantic Halibut in 4VWX from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year

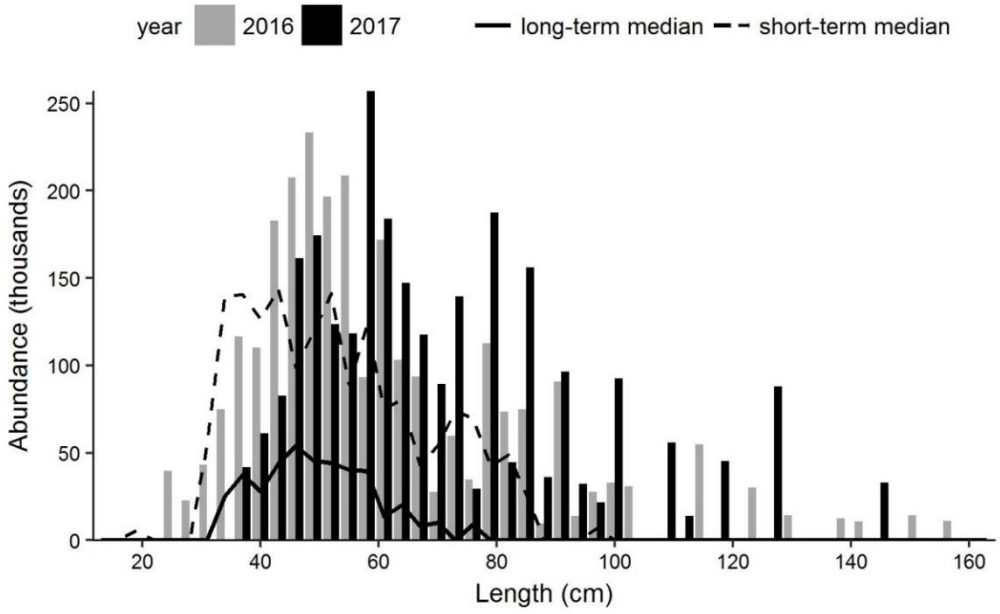

Figure 10c. Length frequency indices for 3NOPs4VWX5Zc Atlantic Halibut in 4VWX from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Yellowtail Flounder

Yellowtail Flounder (*Limanda ferruginea*) were caught primarily in 4Vs and south-eastern 4W. Catches in 4X were restricted to Browns Bank. The biomass index for 4X in 2017 was the lowest in the series and the length frequency indices were below long-term and short-term medians, with no fish above 33 cm caught in 2017. In 4VW, there has been little change in the three year mean of the biomass index in the last 15 years. The indices at length are below the long-term and short-term median in 2017 for larger Yellowtail in 4VW, but well above the median between 17 cm and 20 cm, suggesting a strong incoming year class.

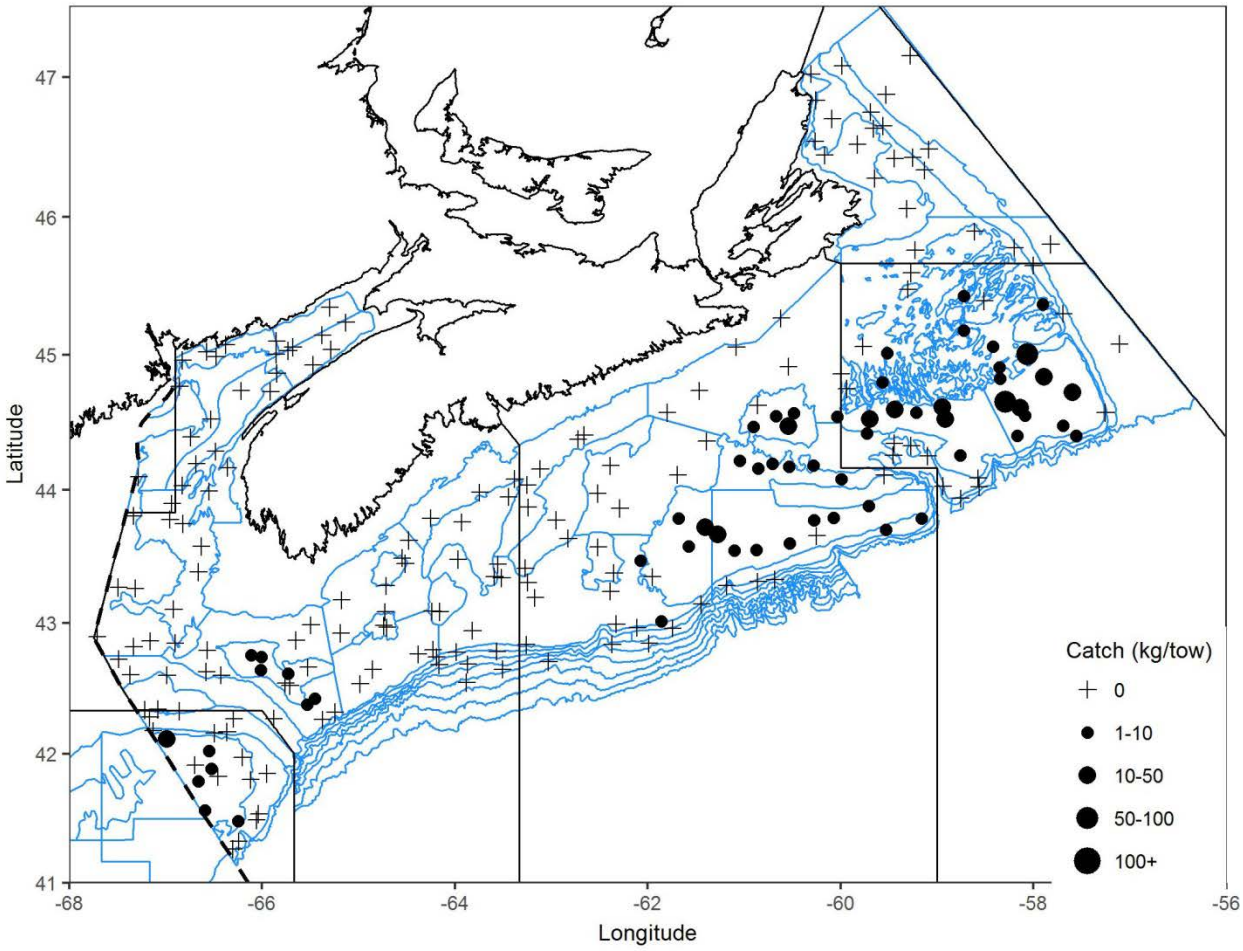

Figure 11a. Distribution of Yellowtail Flounder catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

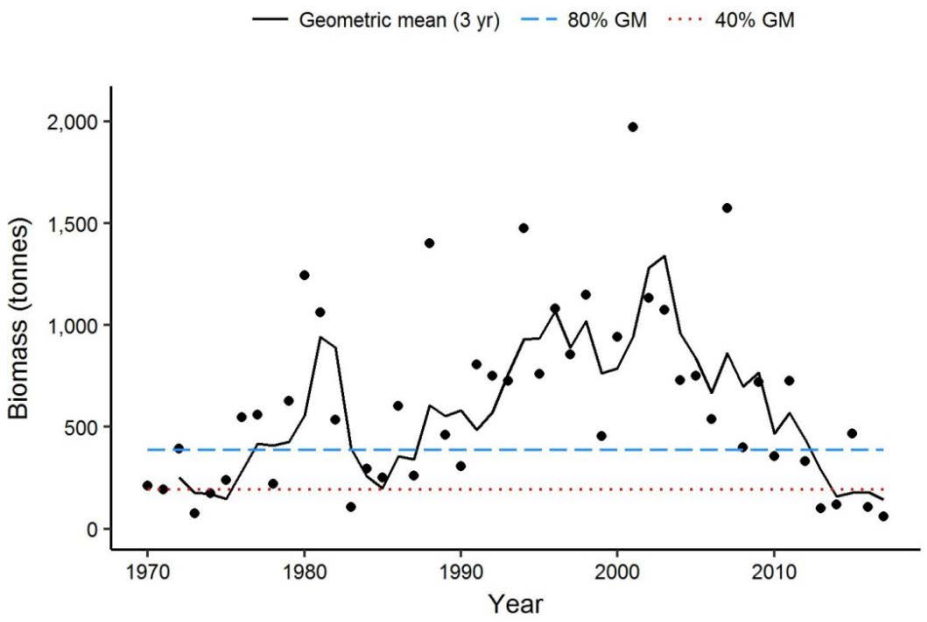

Figure 11b. Biomass index for Yellowtail Flounder in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

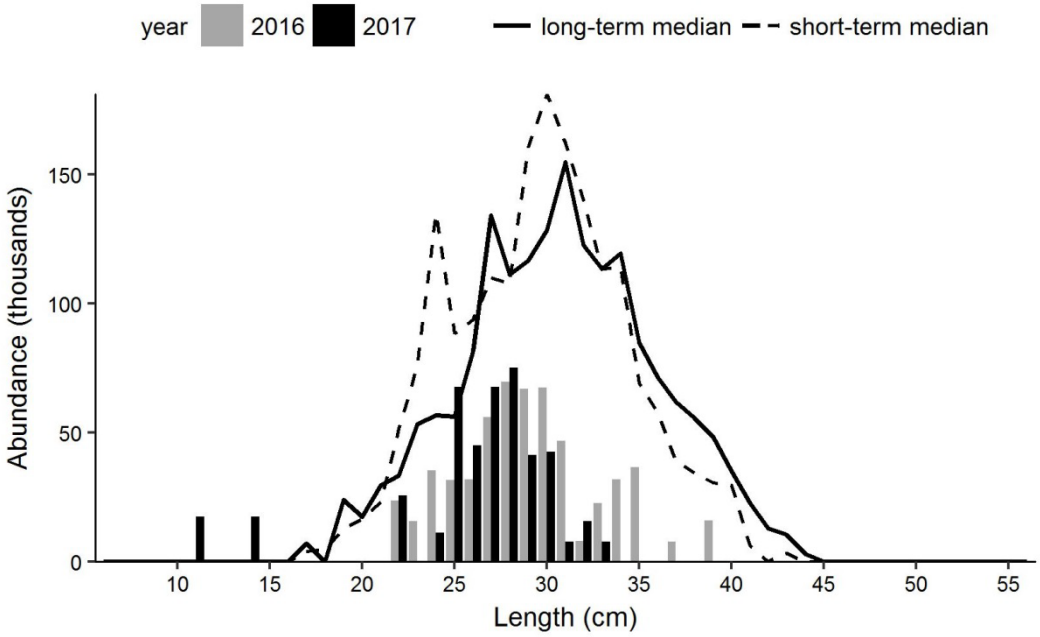

Figure 11c. Length frequency indices for Yellowtail Flounder in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

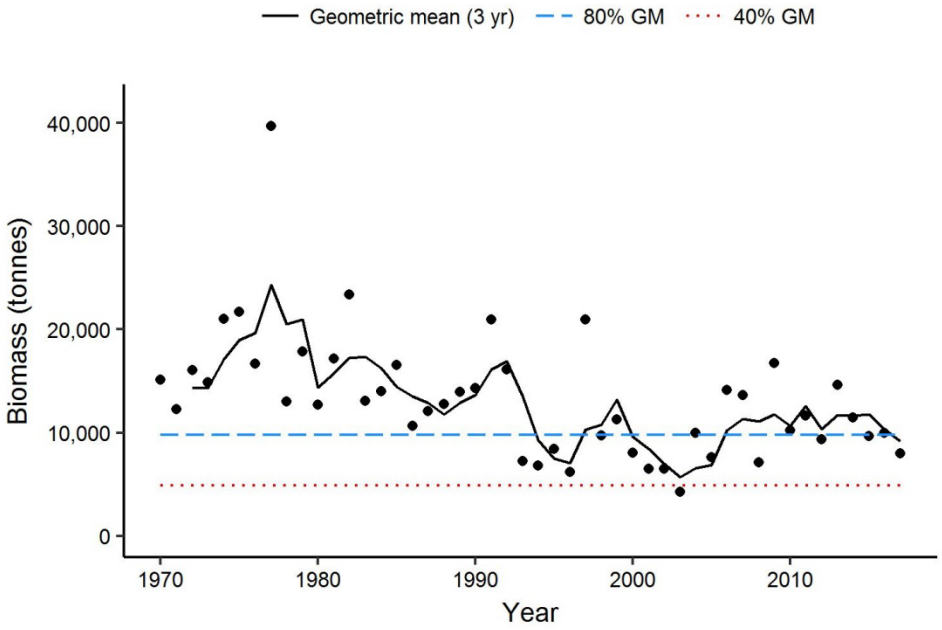

Figure 11d. Biomass index for Yellowtail Flounder in 4VW from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

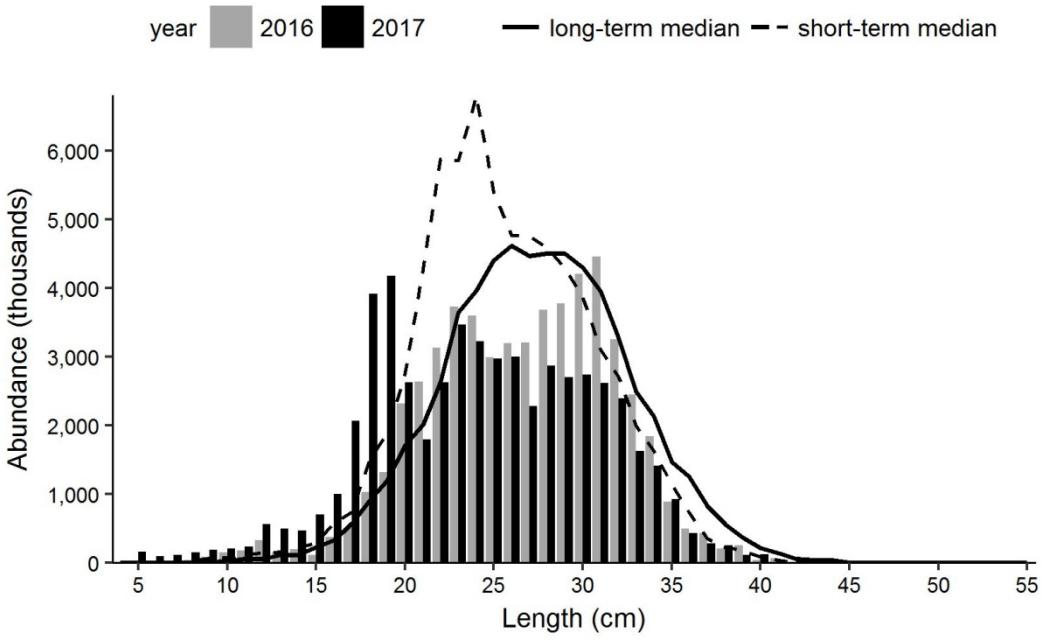

Figure 11e. Length frequency indices for Yellowtail Flounder in 4VW from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

American Plaice

American Plaice (*Hippoglossoides platessoides*) catches were generally small in the 2017 survey. The three lowest biomass indices in the series for 4X are 2015 – 2017 and the 4 lowest in 4VW are 2014 – 2017. Abundance is low at all lengths in both 4X and 4VW.

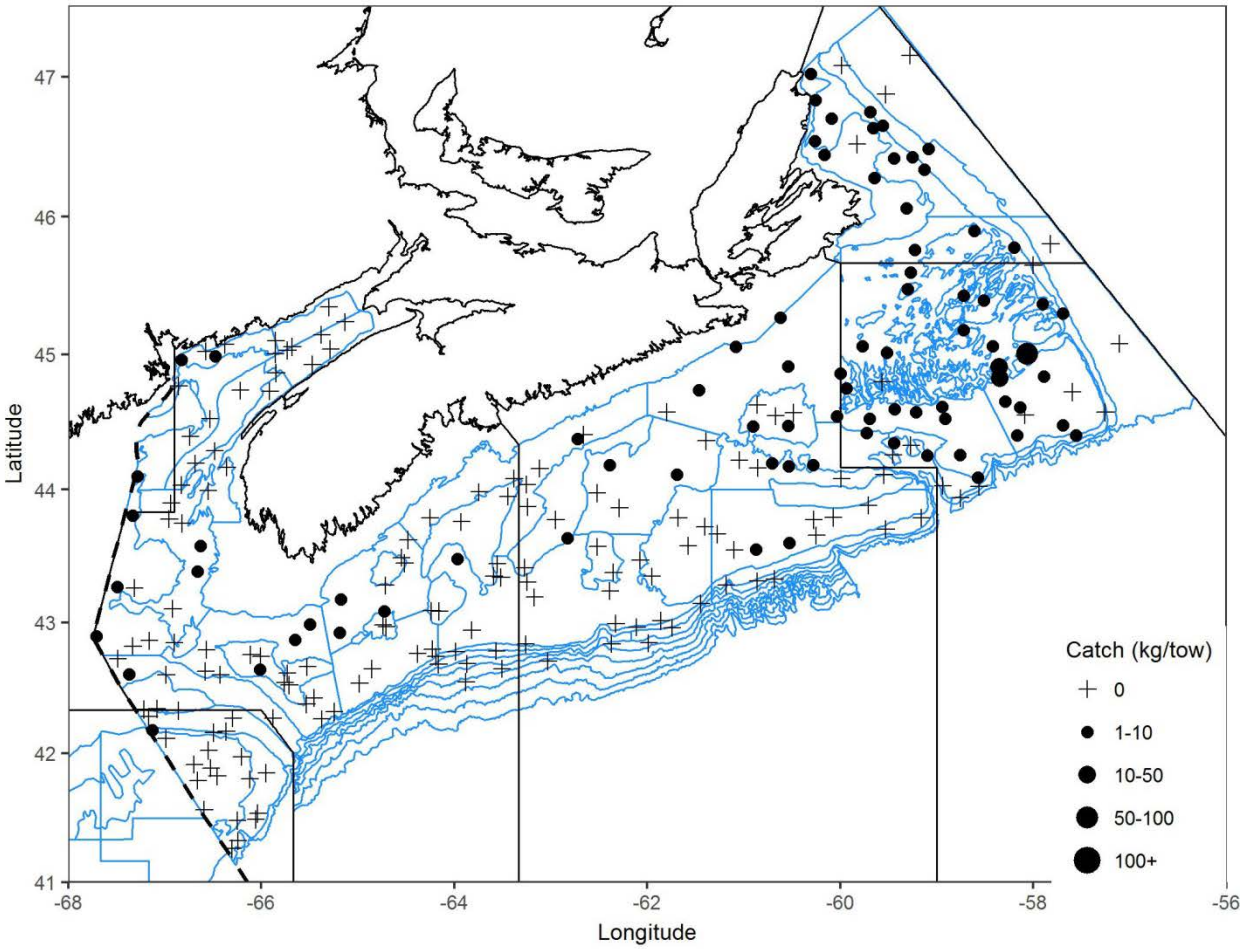

Figure 12a. Distribution of American Plaice catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

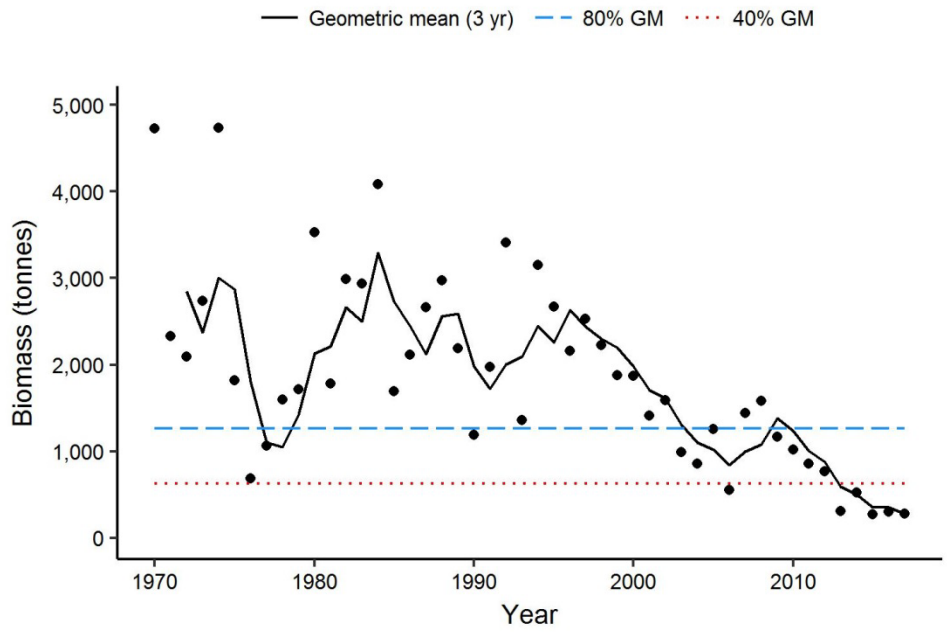

Figure 12b. Biomass index for American Plaice in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

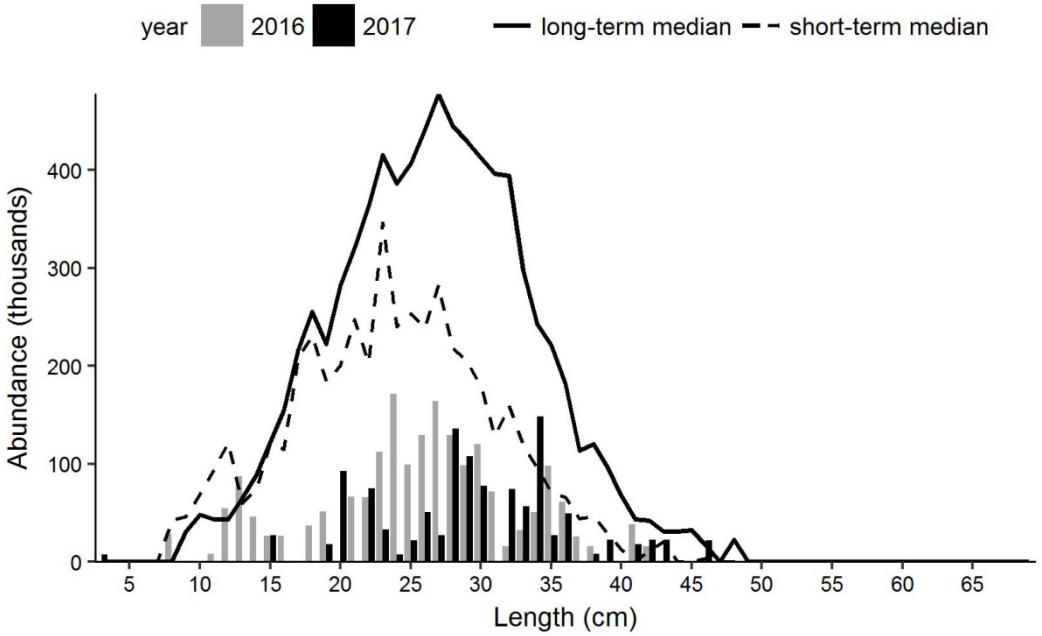

Figure 12c. Length frequency indices for American Plaice in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

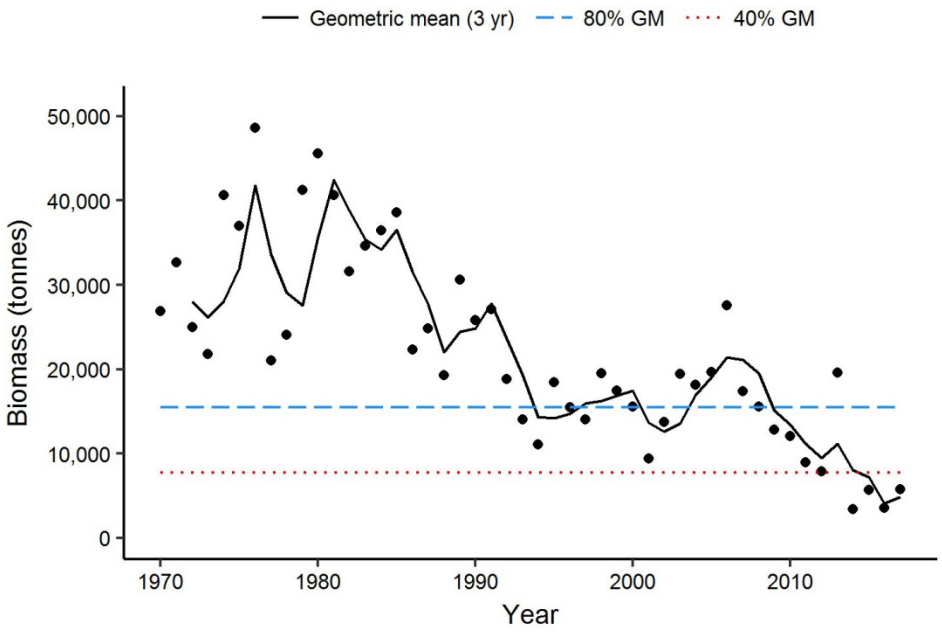

Figure 12d. Biomass index for American Plaice in 4VW from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

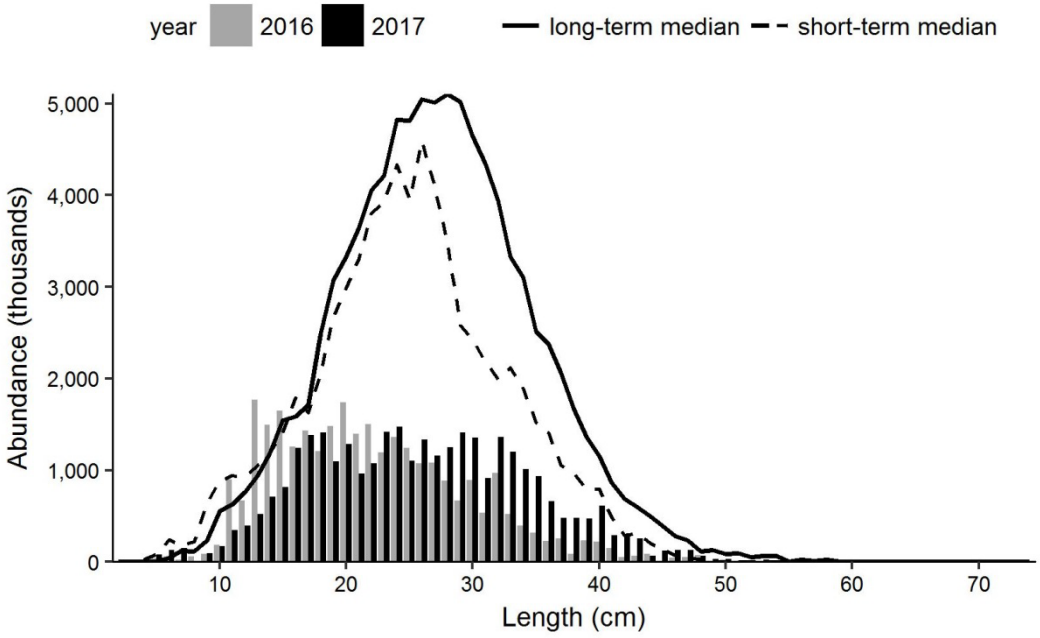

Figure 12e. Length frequency indices for American Plaice in 4VW from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Witch Flounder

Witch Flounder (*Glyptocephalus cynoglossus*) were widespread in the survey area in 2017. The three year mean biomass index has fluctuated around 80% of the long-term mean in 4X for the last 20 years and the length frequency indices in both 2016 and 2017 are similar to or above the short-term median. Witch Flounder above 45 cm have been largely absent from catches in the last 20 years. In 4VW, the biomass indices for both 2016 and 2017 are well above 80% of the long-term mean and the abundance indices are also high for most lengths relative to both the long-term and short-term averages.

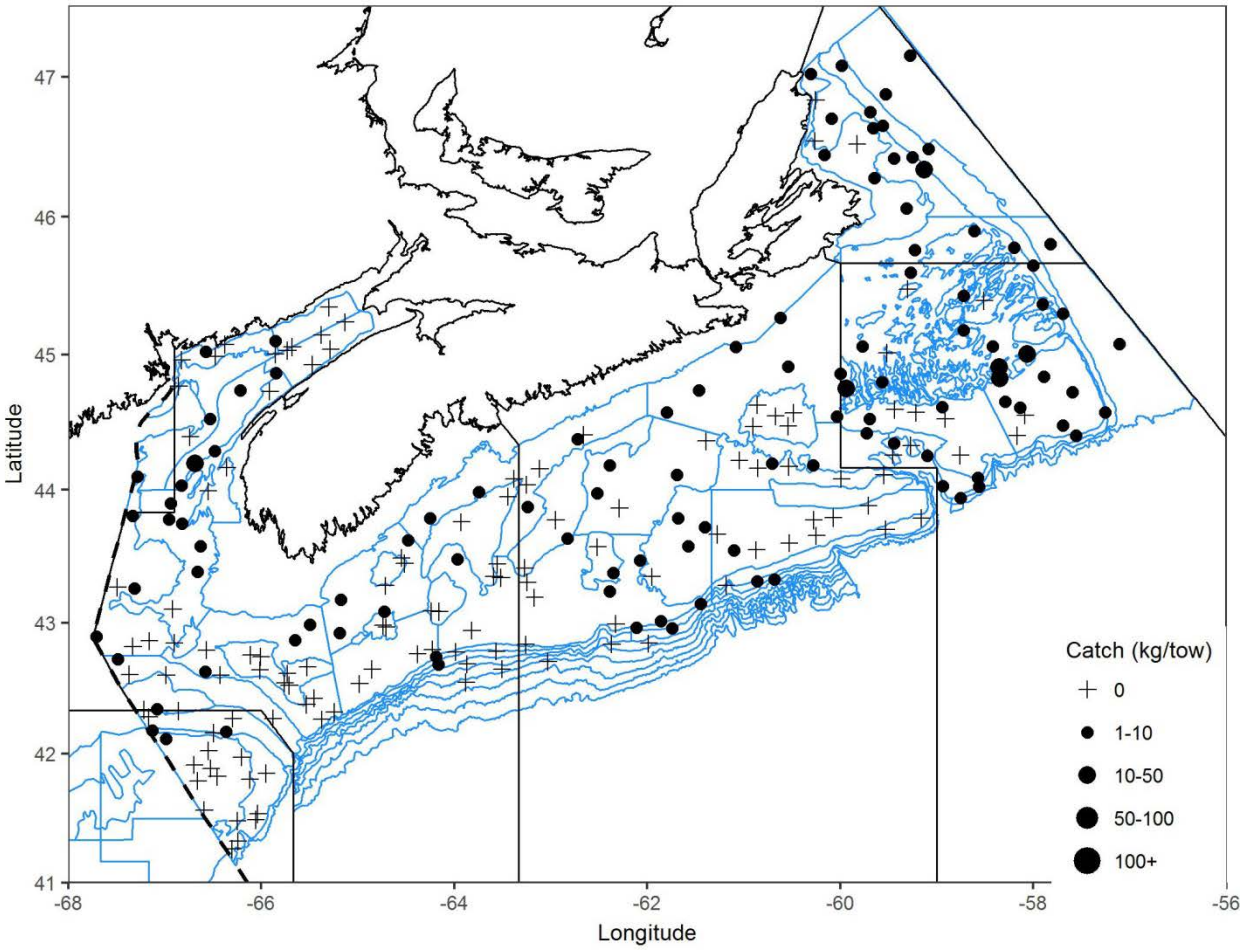

Figure 13a. Distribution of Witch Flounder catches during the 2016 DFO Summer Research Vessel survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

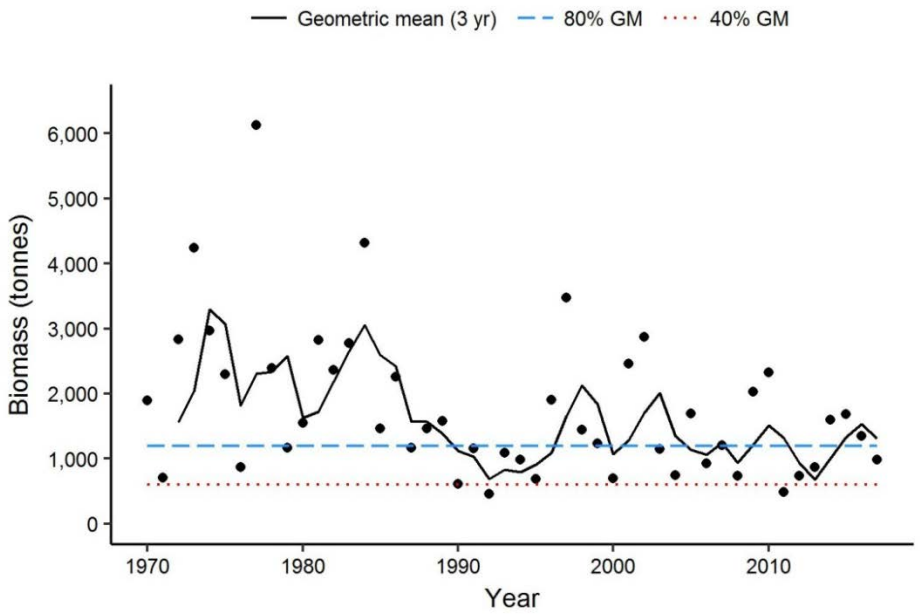

Figure 13b. Biomass index for Witch Flounder in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

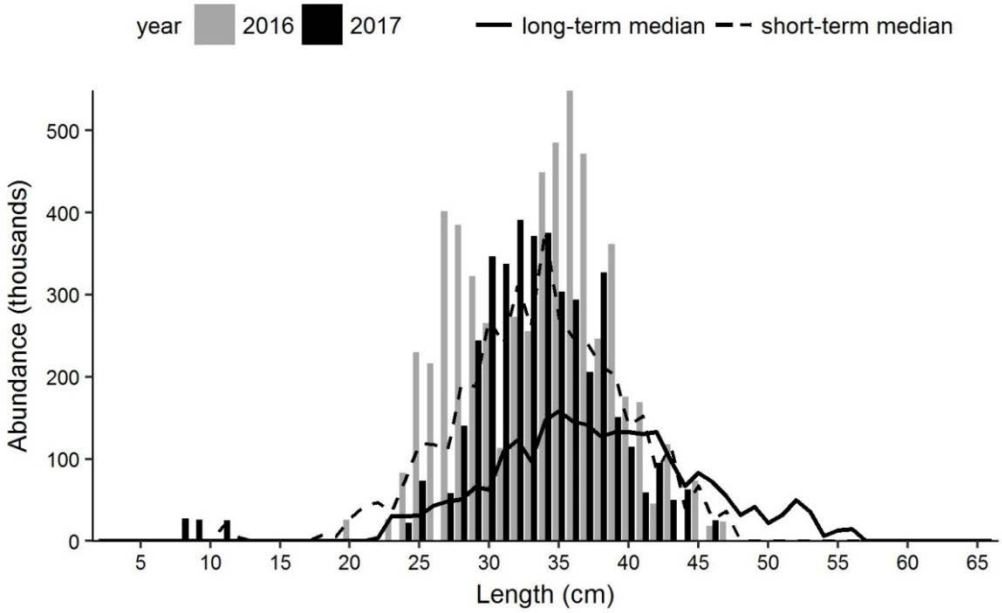

Figure 13c. Length frequency indices for Witch Flounder in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

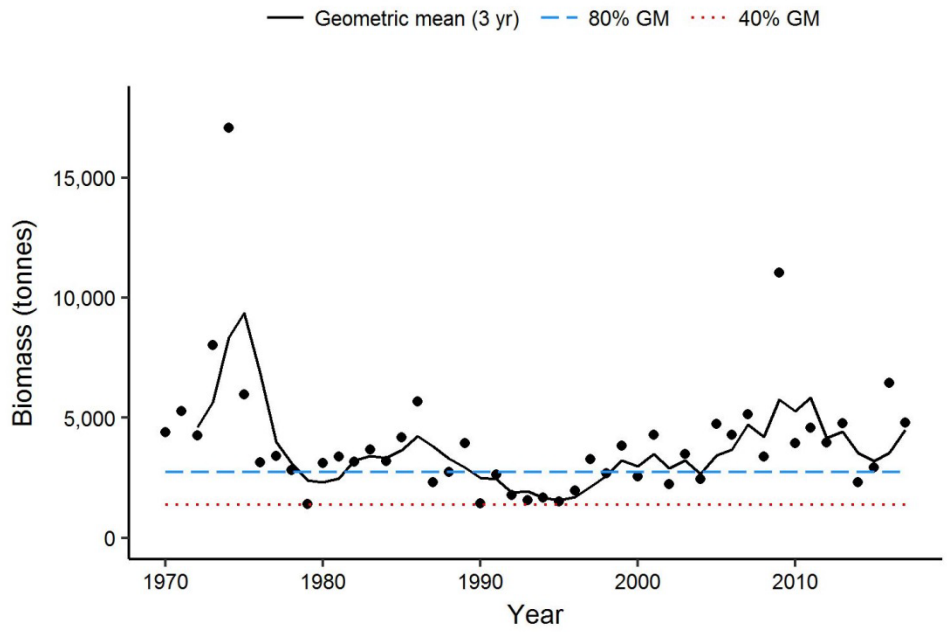

Figure 13d. Biomass index for Witch Flounder in 4VW from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

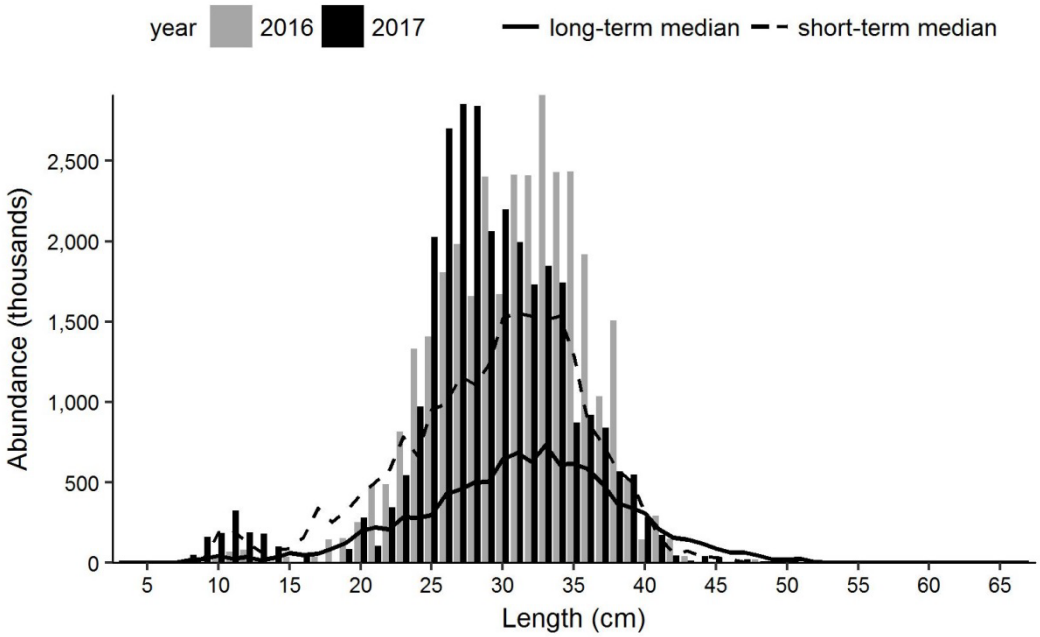

Figure 13e. Length frequency indices for Witch Flounder in 4VW from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Winter Flounder

Winter Flounder (*Pseudopleuronectes americanus*) were caught primarily at the western end of the survey area in 2017. Biomass indices in 4X have generally been higher since 1990. The short-term median indices at length are generally higher than the long-term medians. In 2017, the indices at length are above long-term medians for smaller fish and below the long-term medians for larger fish. In 4VW, the biomass index has fluctuated around 80% of the long-term mean since about 2010. Indices at length are generally at or above the short-term median in 2017. Winter Flounder >35 cm have rarely been caught in 4VW in recent years.

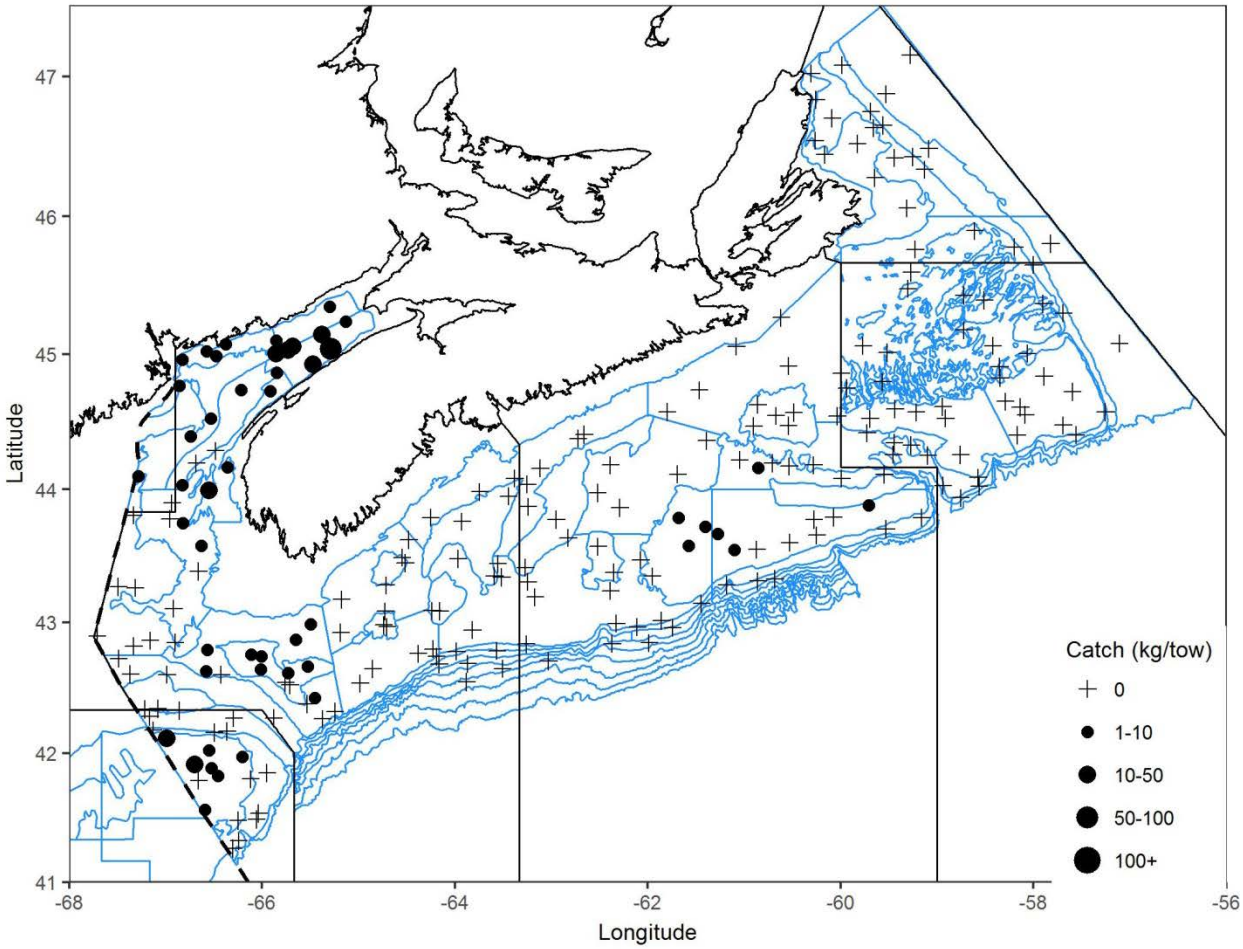

Figure 14a. Distribution of Winter Flounder catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

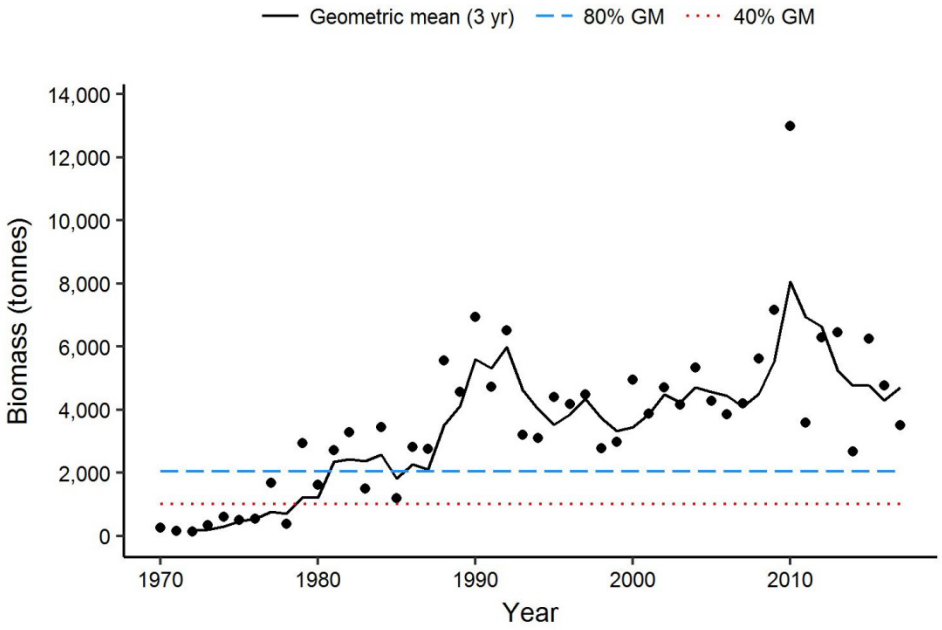

Figure 14b. Biomass index for Winter Flounder in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

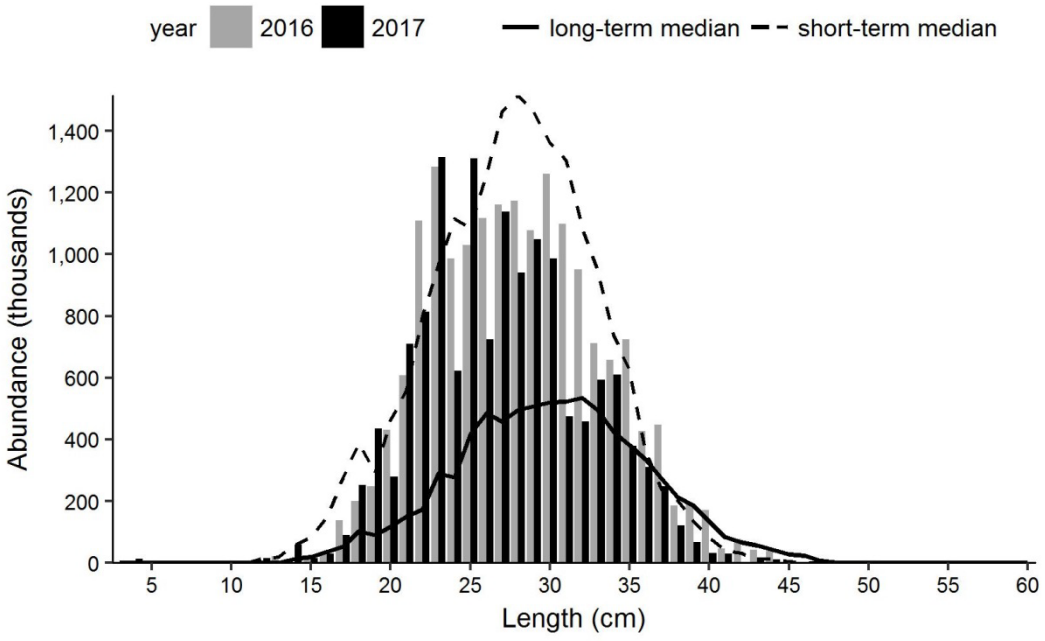

Figure 14c. Length frequency indices for Winter Flounder in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

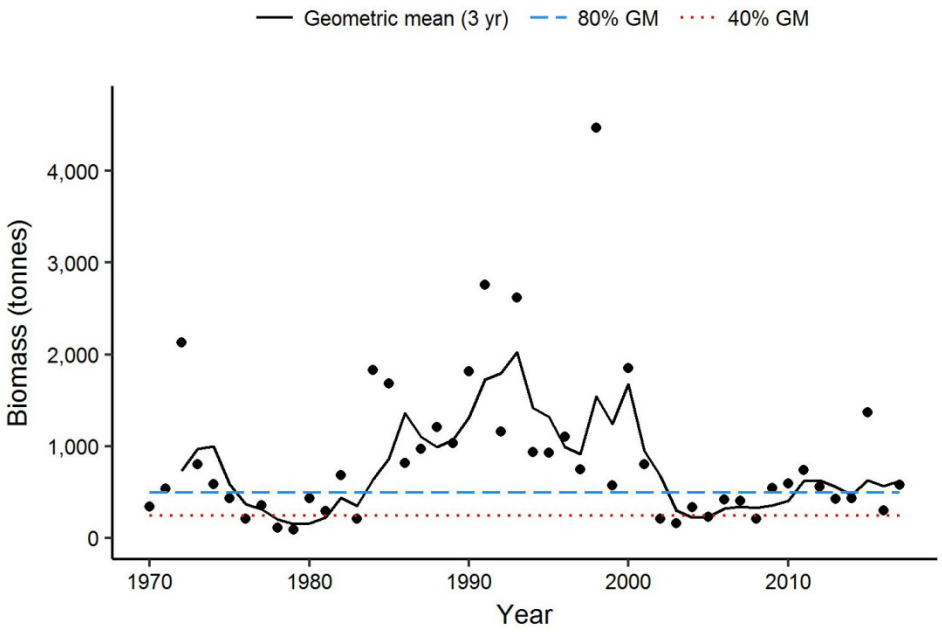

Figure 14d. Biomass index for Winter Flounder in 4VW from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

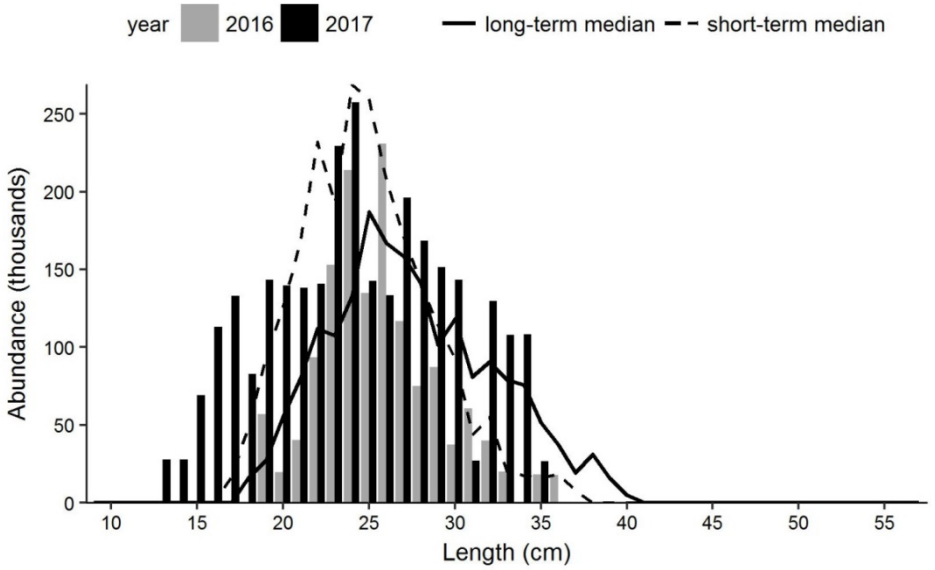

Figure 14e. Length frequency indices for Winter Flounder in 4VW from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Atlantic Wolffish

Atlantic Wolffish (*Anarhichas lupus*) catches in 2017 were restricted mostly to sets in 4V. Biomass indices have been very low for the last 5 years in 4X, with very few specimens caught in 2017. In 4VW, the indices at length were close to the long-term and short-term medians in 2017. The biomass index in 4VW was slightly higher than in 2016 but remains below 40% of the long-term mean.

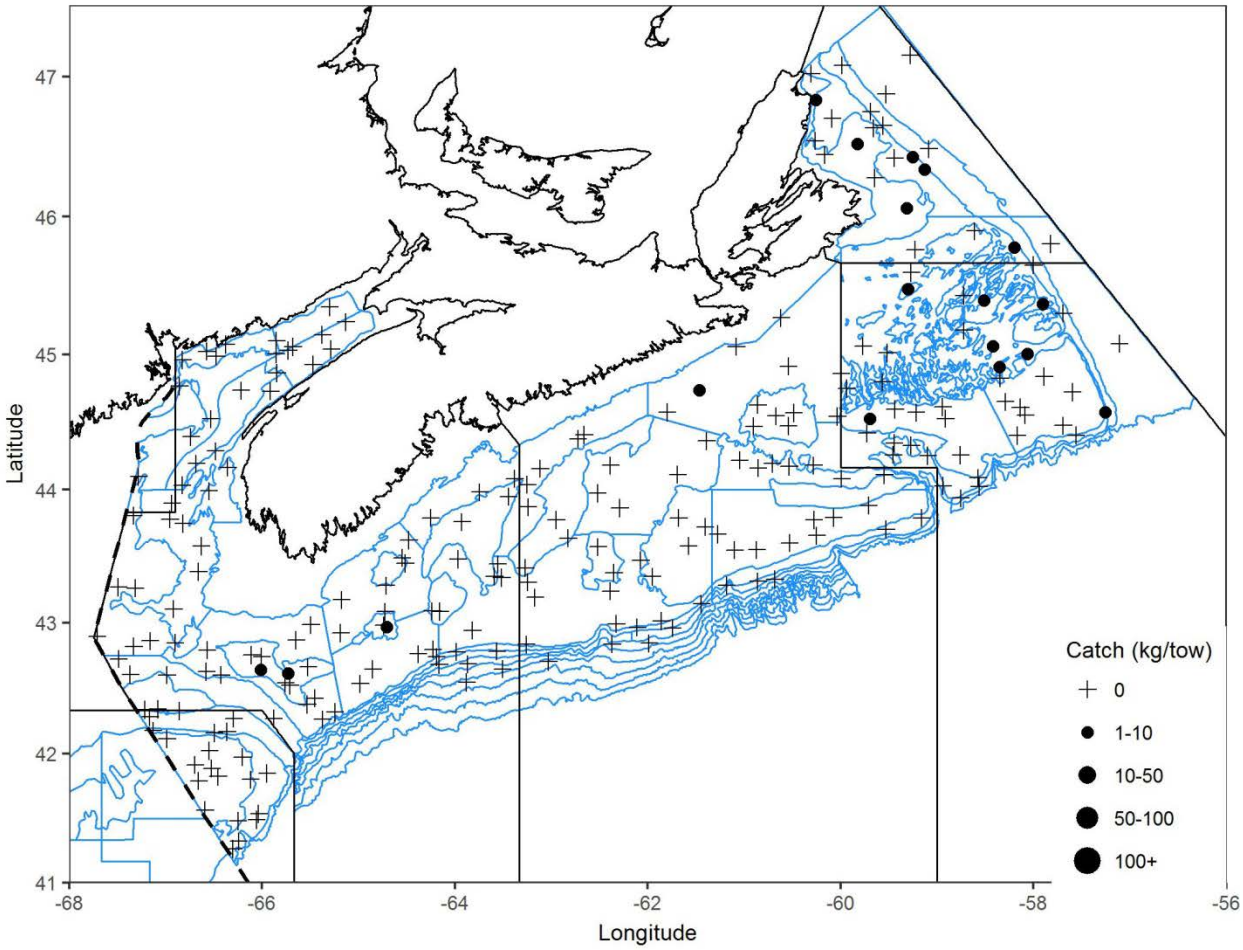

Figure 15a. Distribution of Atlantic Wolffish catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

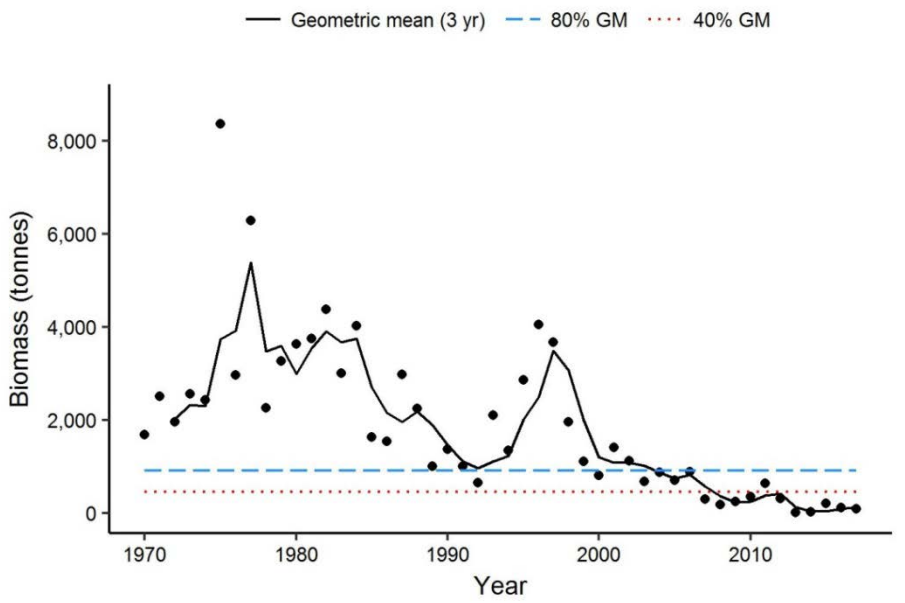

Figure 15b. Biomass index for Atlantic Wolffish in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

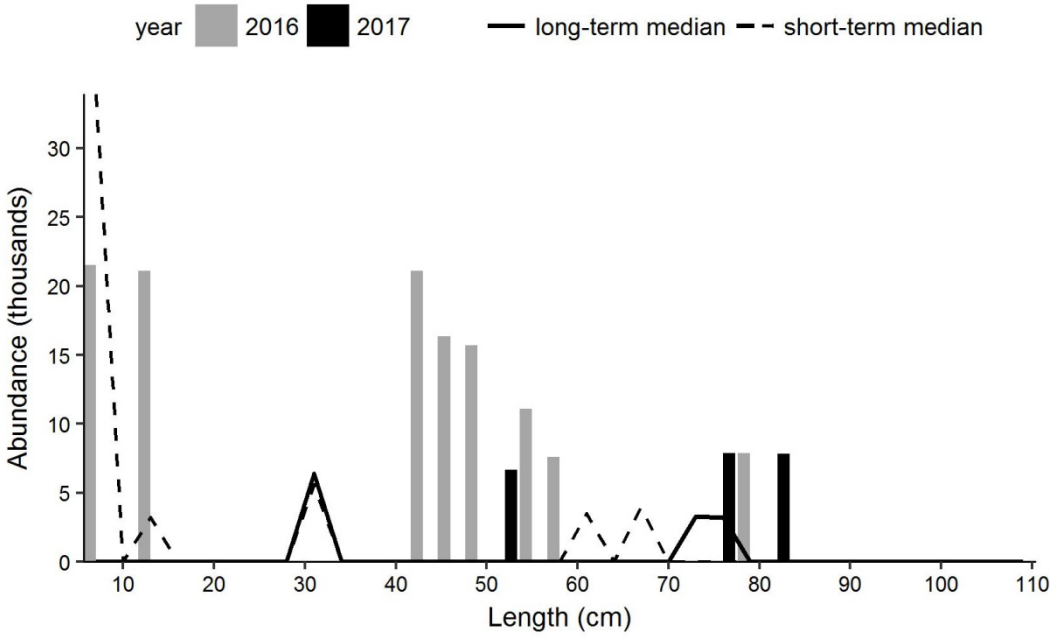

Figure 15c. Length frequency indices for Atlantic Wolffish in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

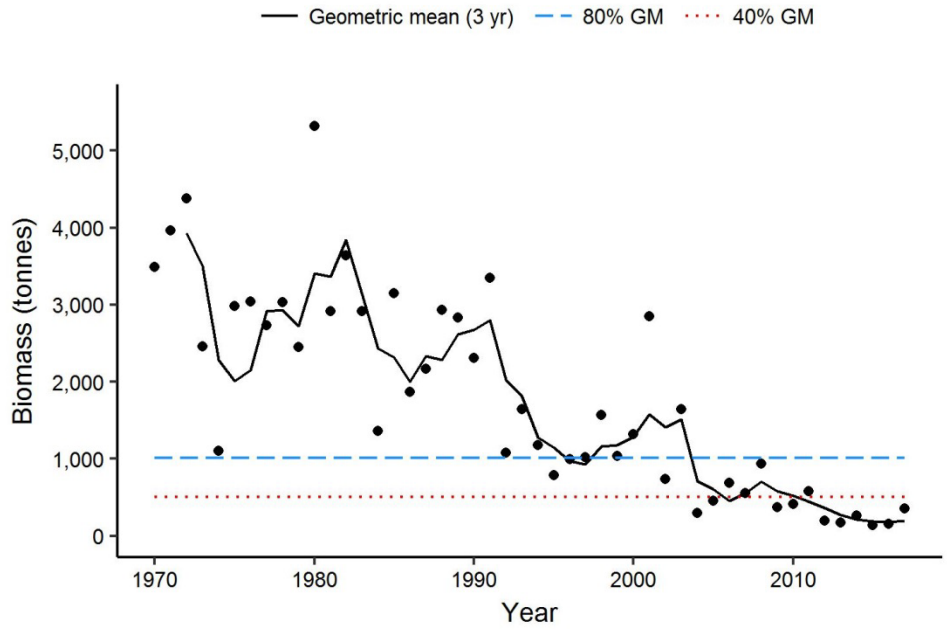

Figure 15d. Biomass index for Atlantic Wolffish in 4VW from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

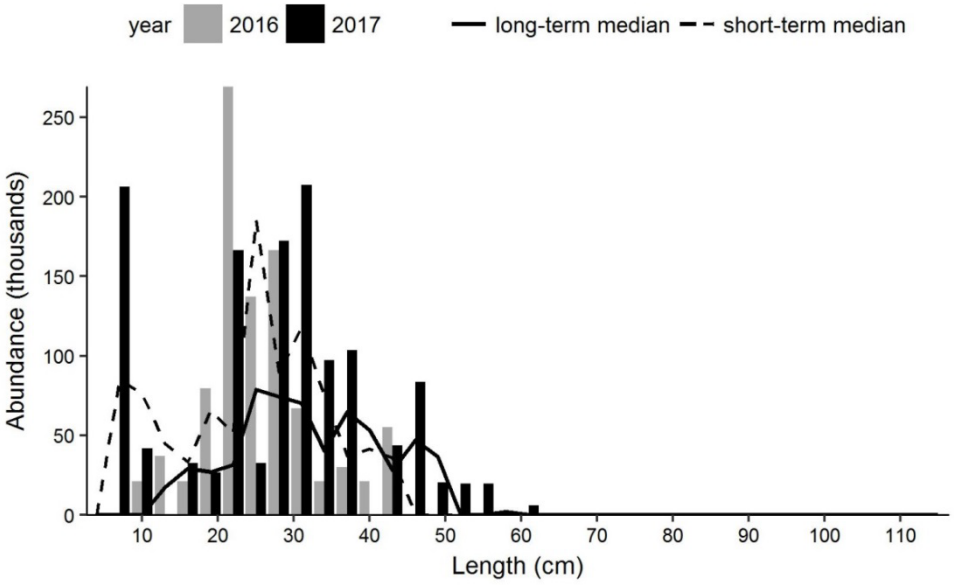

Figure 15e. Length frequency indices for Atlantic Wolffish in 4VW from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Monkfish

Monkfish (*Lophius americanus*) were caught primarily in the Gulf of Maine and western Scotian Shelf. The biomass index in 2017 for 4X was the highest since 2003 and the indices at length were generally above both the long-term and short-term medians. The progression of a strong year-class has been tracked for the last three years in the survey indices, showing as a mode between 40 and 50 cm in 2017. Biomass indices have been close to 40% of the long-term mean in 4VW for the last 20 years, with very few fish in the catch again in 2017.

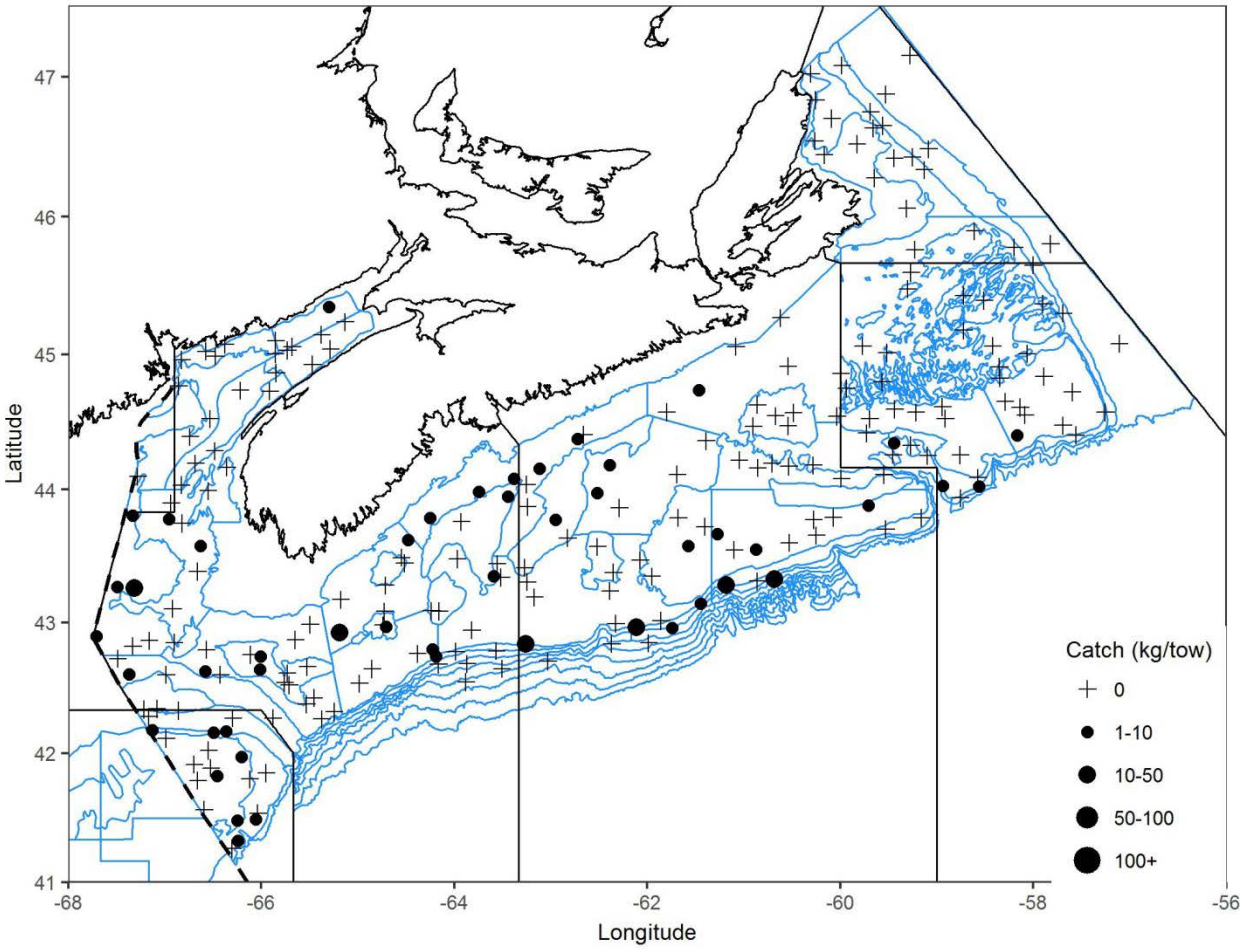

Figure 16a. Distribution of Monkfish catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

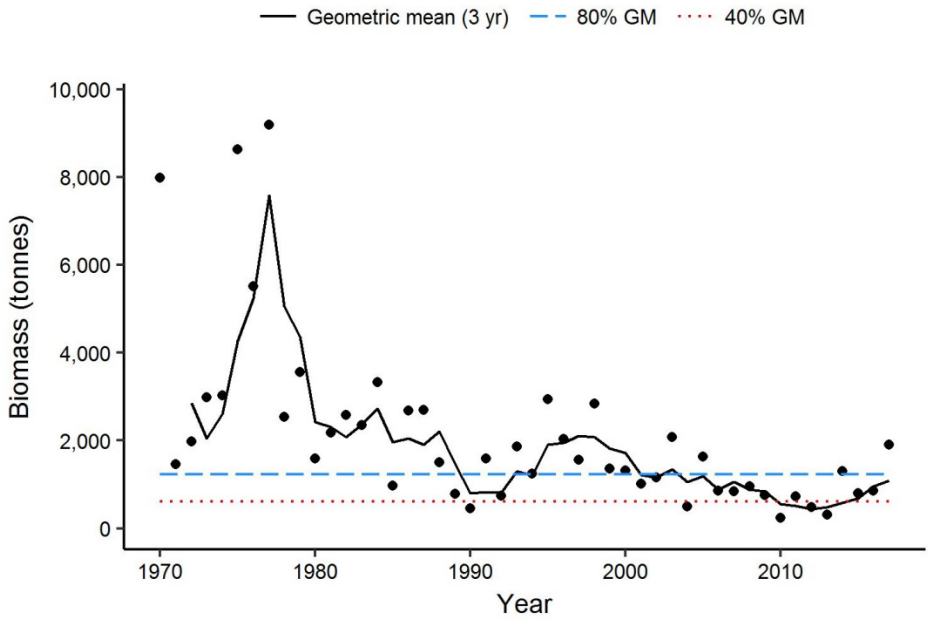

Figure 16b. Biomass index for Monkfish in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

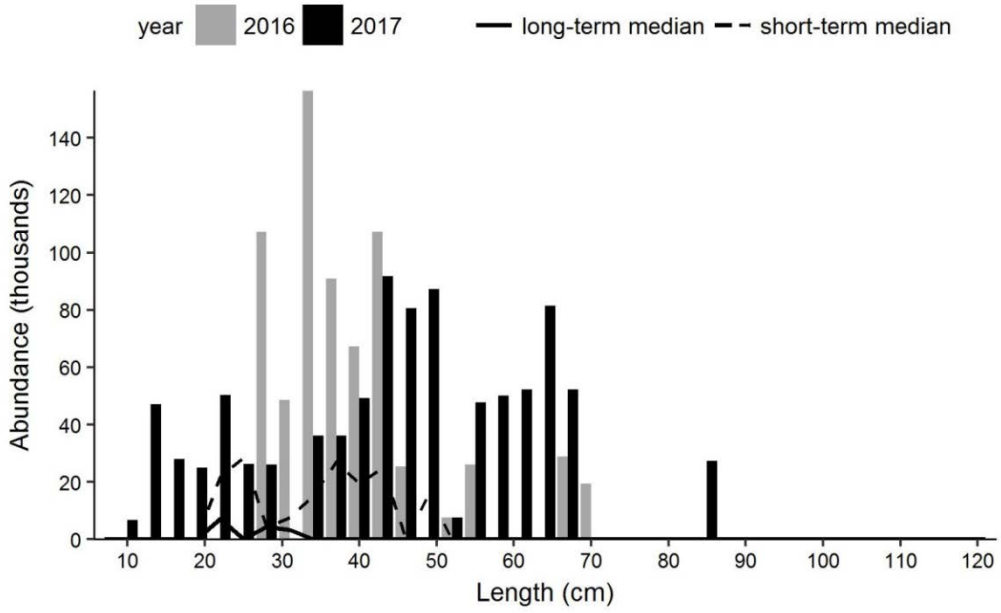

Figure 16c. Length frequency indices for Monkfish in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

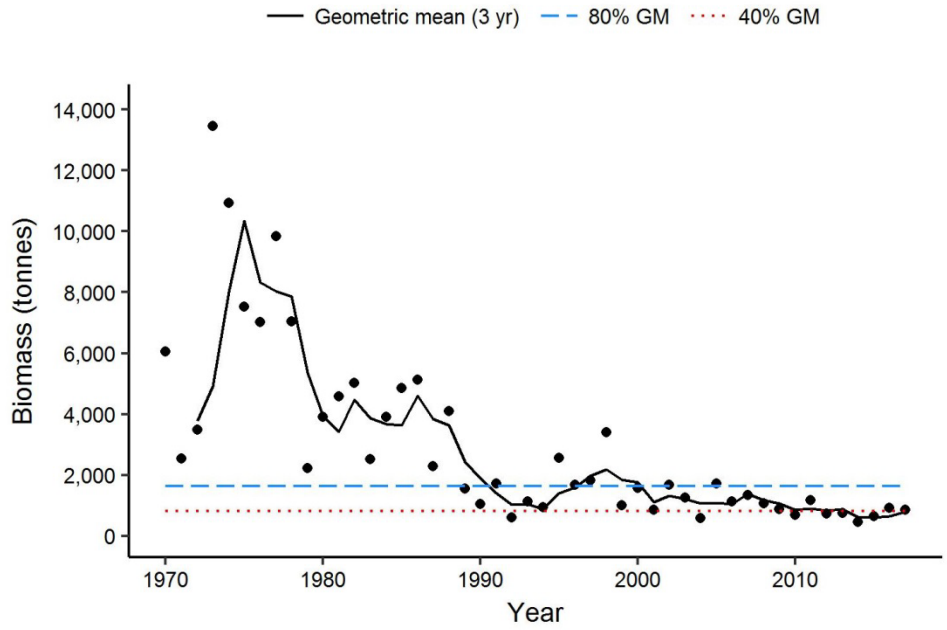

Figure 16d. Biomass index for Monkfish in 4VW from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

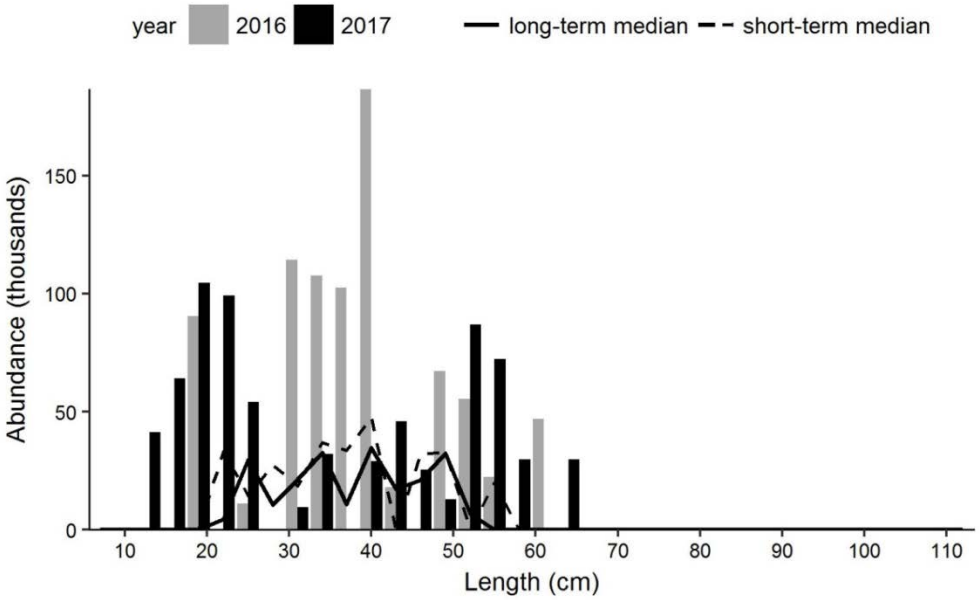

Figure 16e. Length frequency indices for Monkfish in 4VW from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Longhorn Sculpin

Longhorn Sculpin (*Myoxocephalus octodecemspinosus*) are caught primarily on the Scotian Shelf banks and in the Bay of Fundy. The three year mean biomass index is above 80% of the long-term mean in 4X but below it in 4VW. Indices at length are similar to the long-term median values in 4X, while in 4VW, they are generally above the median for lengths <20 cm and below median for larger fish.

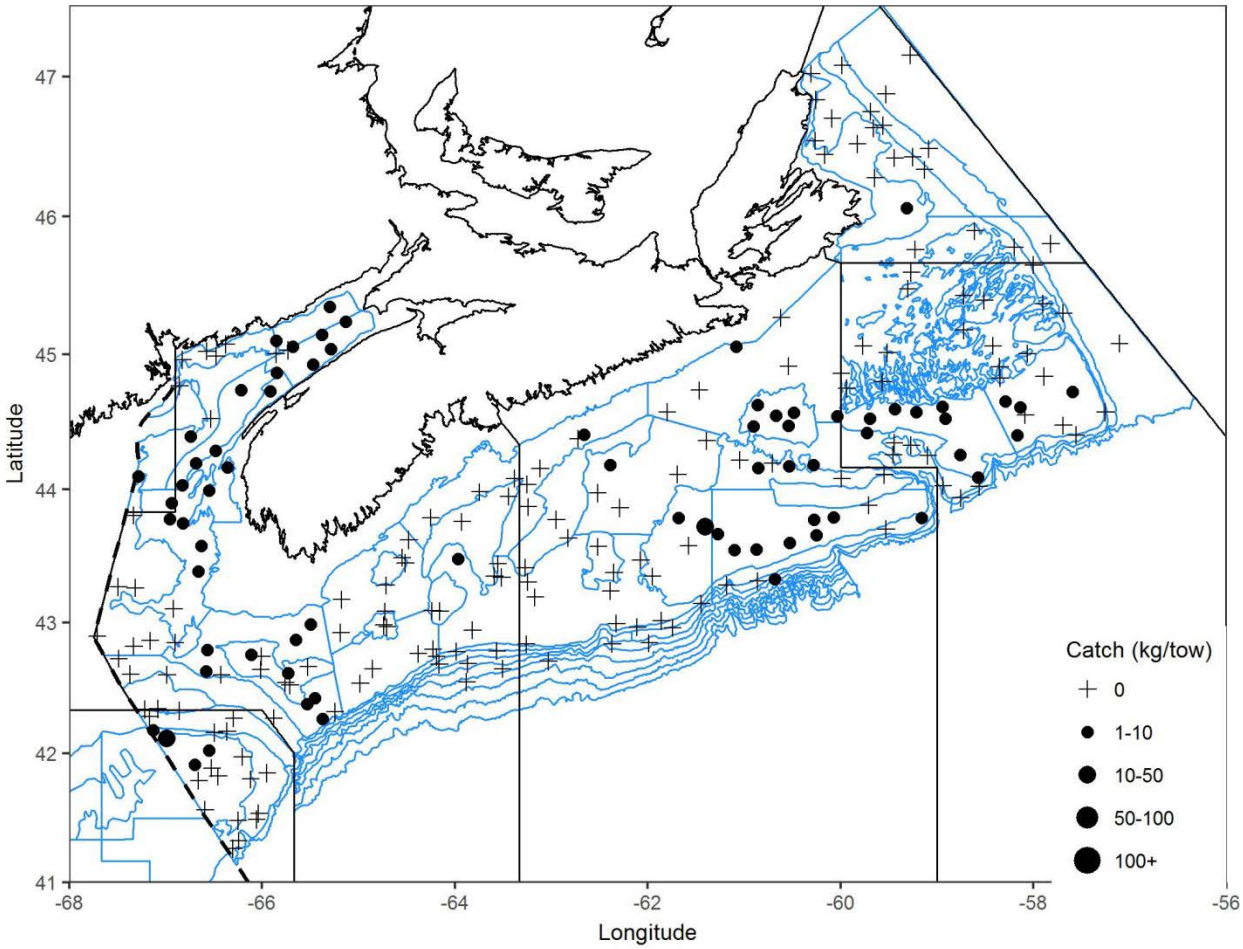

Figure 17a. Distribution of Longhorn Sculpin catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

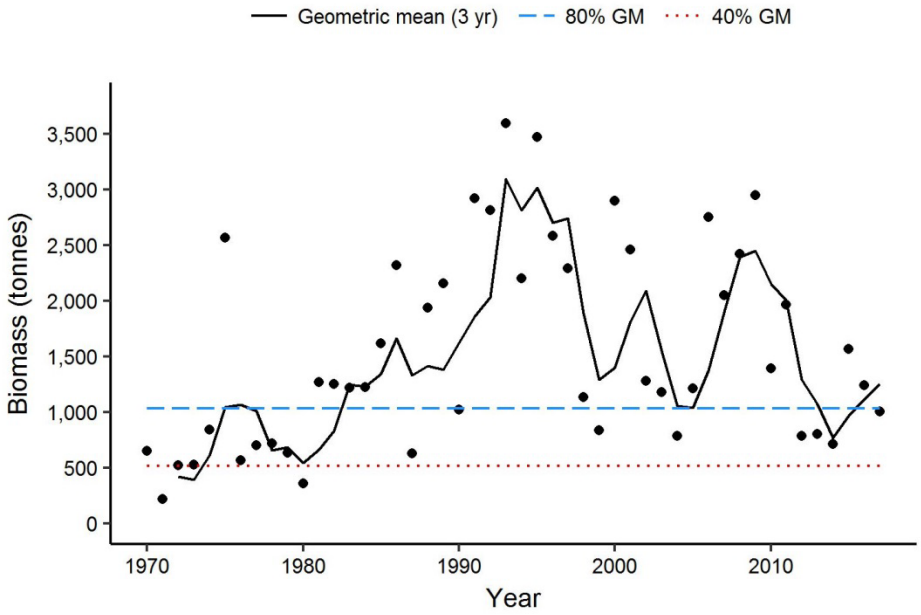

Figure 17b. Biomass index for Longhorn Sculpin in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year

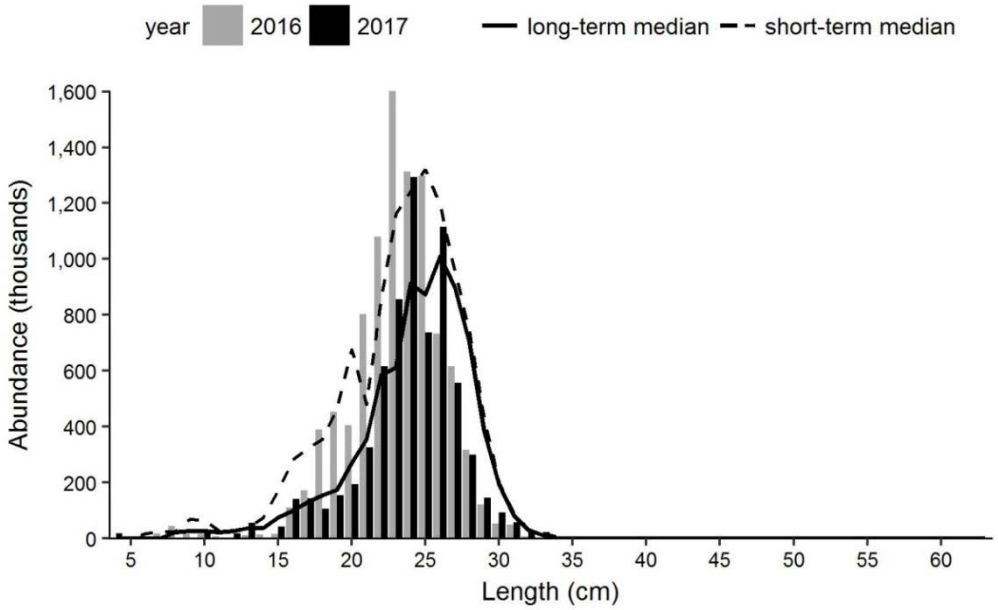

Figure 17c. Length frequency indices for Longhorn Sculpin in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

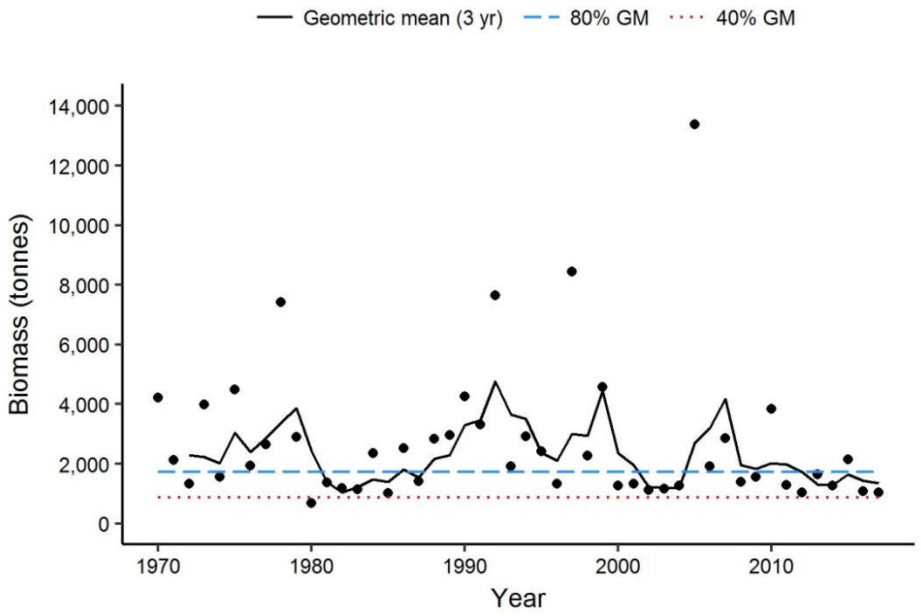

Figure 17d. Biomass index for Longhorn Sculpin in 4VW from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

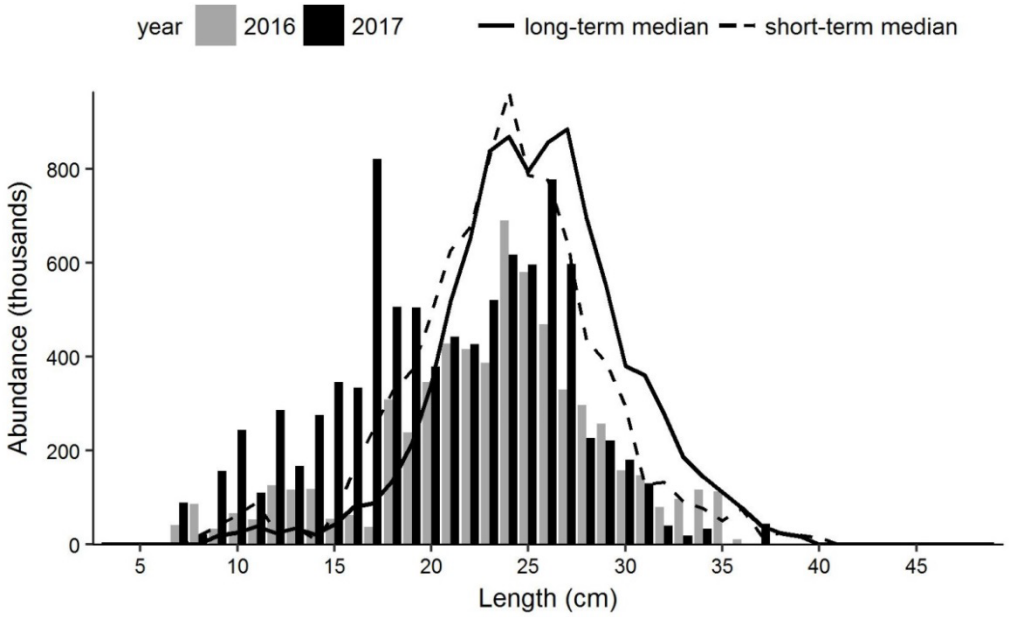

Figure 17e. Length frequency indices for Longhorn Sculpin in 4VW from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Barndoor Skate

Barndoor Skate (*Dipturus laevis*) were caught primarily on Georges Bank as well as in and around the Fundian Channel in 4X. They were also caught along the edges of Emerald and LaHave Basin and in sets along the shelf edge. The three year mean of the biomass index was the second highest in the series for 4X in 2017 and third highest for 4VW. Prior to 1998, catches are close to zero for all sizes of Barndoor Skates, so the medians are zero for all lengths. In 2017, fish were caught at lengths ranging from 64 to 127 cm.

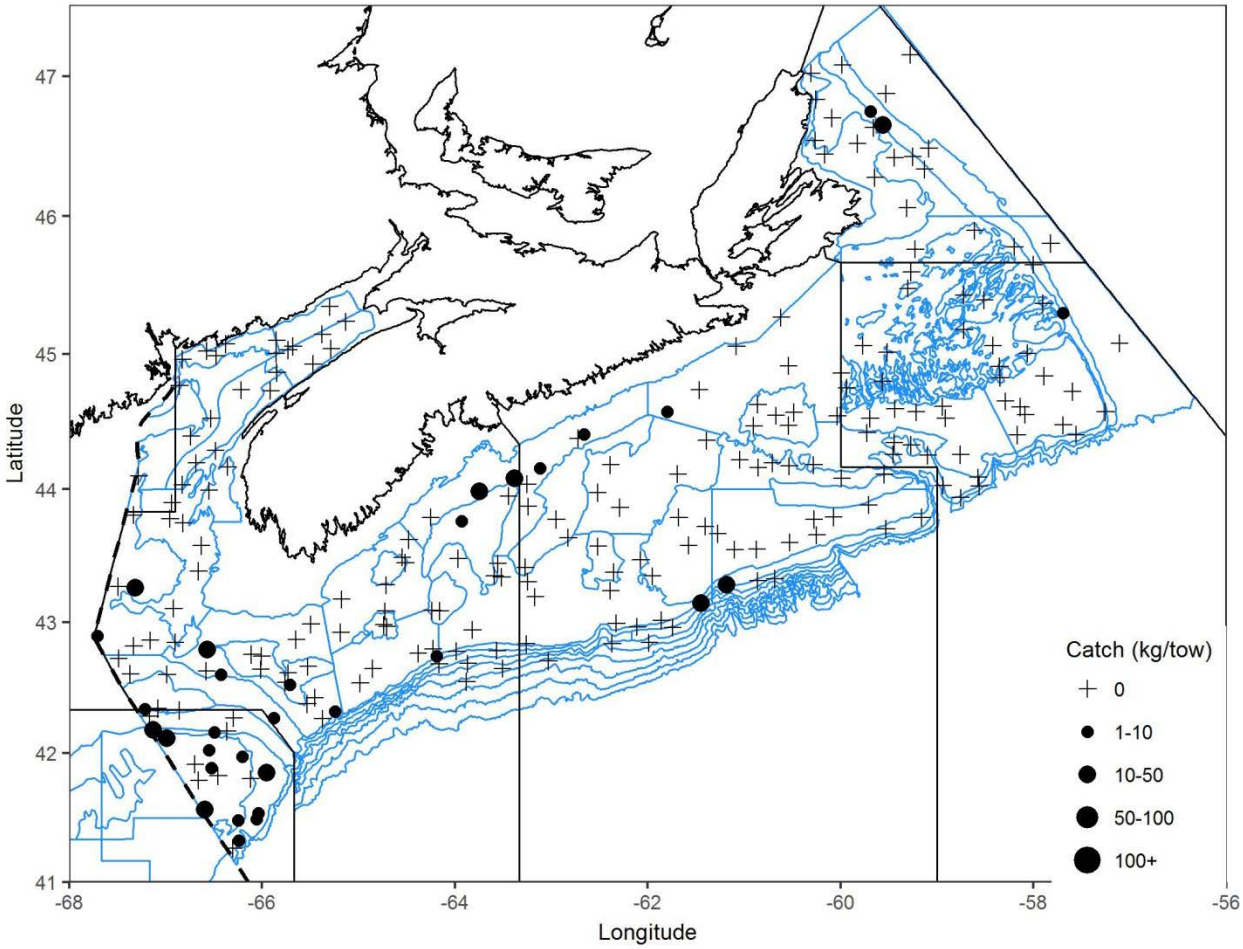

Figure 18a. Distribution of Barndoor Skate catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

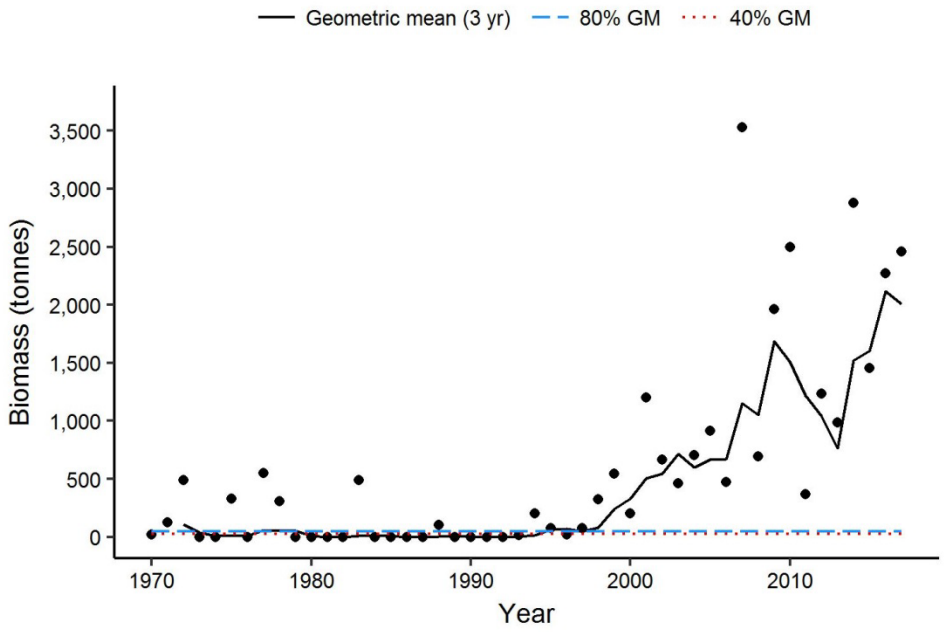

Figure 18b. Biomass index for Barndoor Skate in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

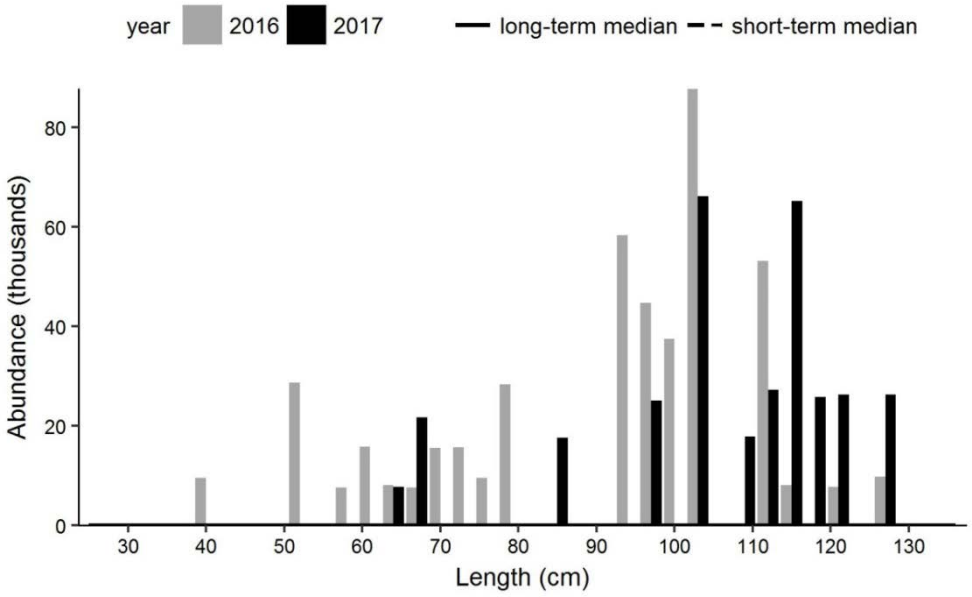

Figure 18c. Length frequency indices for Barndoor Skate in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

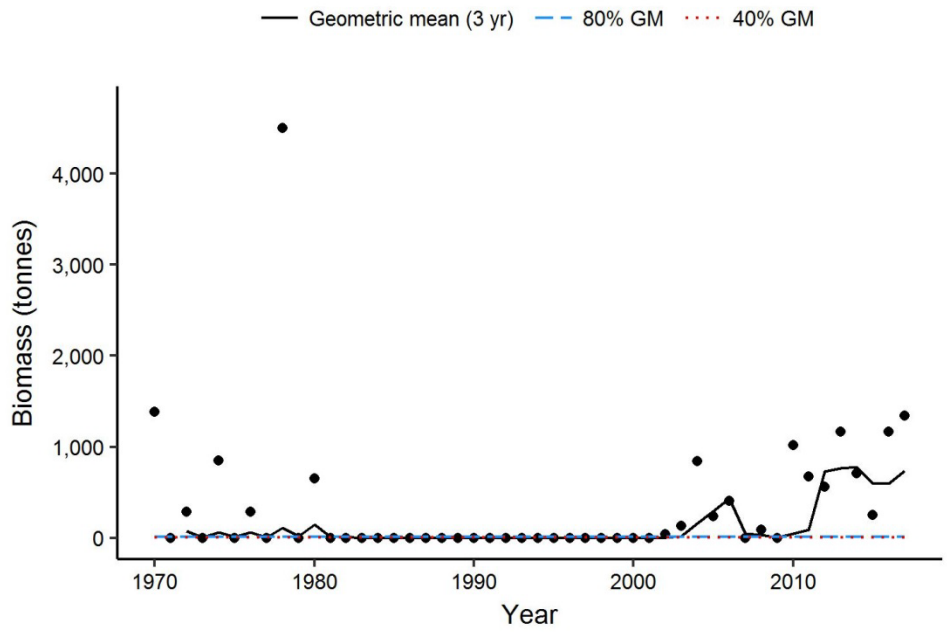

Figure 18d. Biomass index for Barndoor Skate in 4VW from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

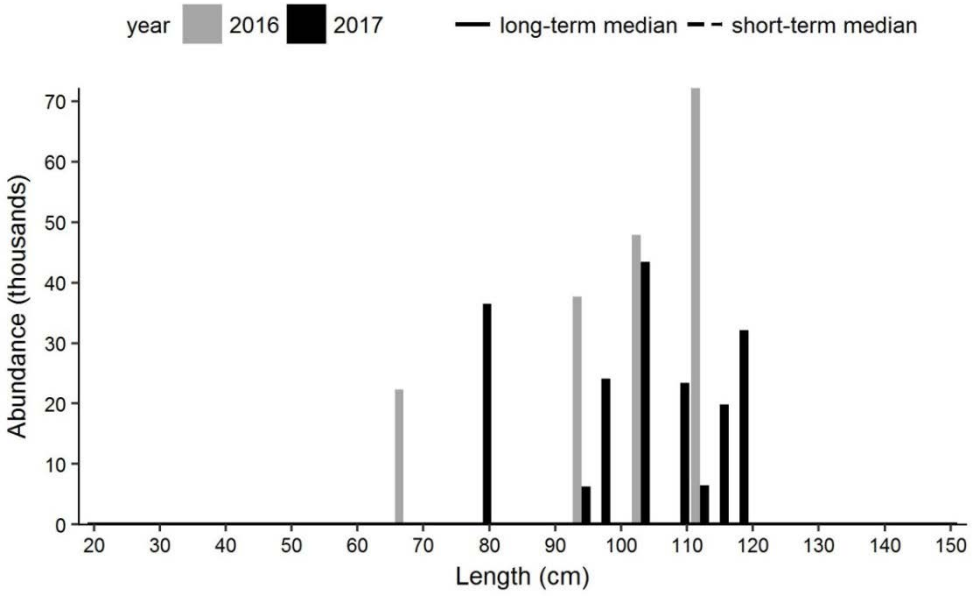

Figure 18e. Length frequency indices for Barndoor Skate in 4VW from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Thorny Skate

Thorny Skate (*Amblyraja radiata*) catches in 2017 were restricted primarily to 4V. Biomass indices in 2017 were among the lowest in the series for both 4X and 4VW and the three year mean biomass remains below 40% of the long-term mean in both areas.

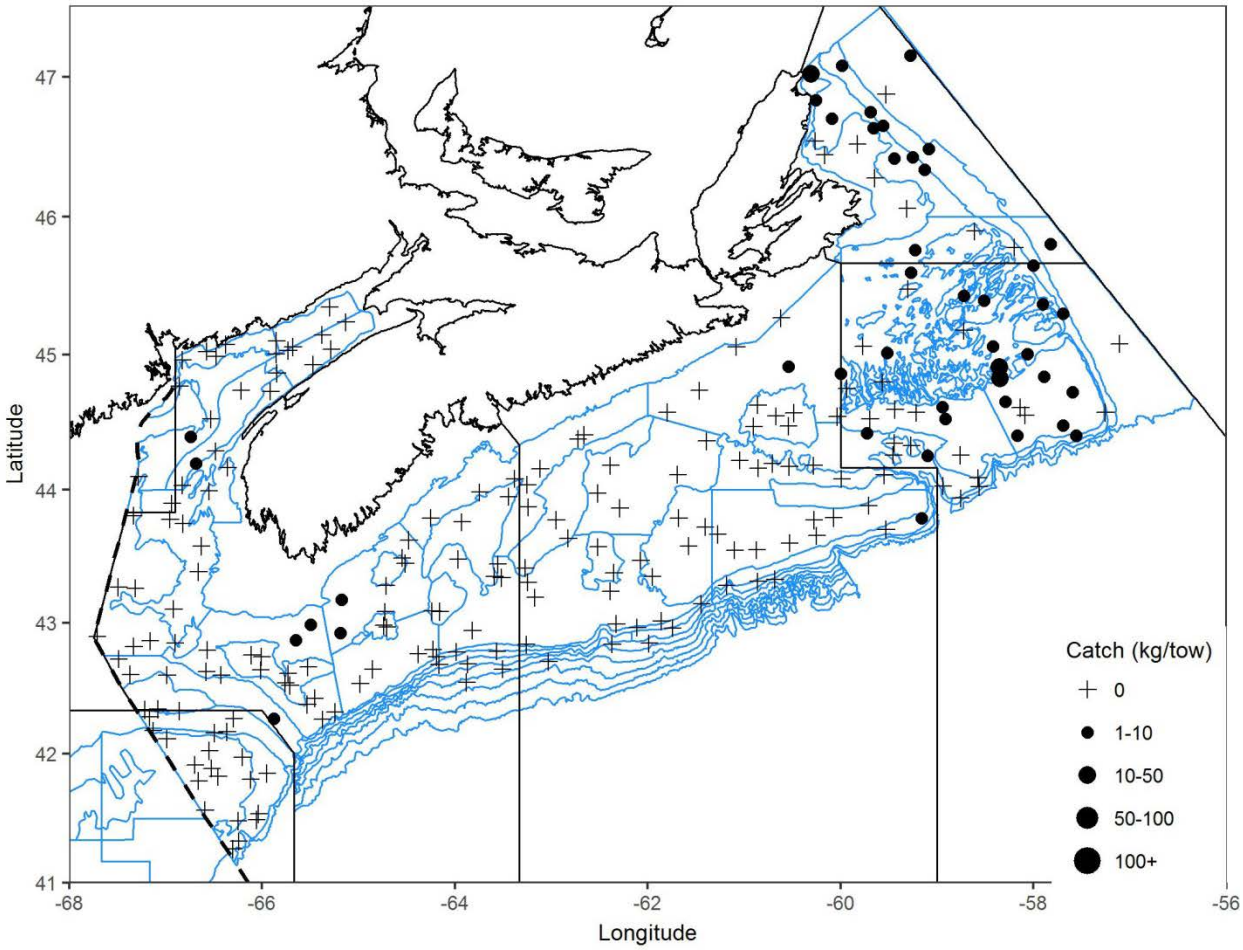

Figure 19a. Distribution of Thorny Skate catches during the 2017 DFO Summer RV Survey including the Laurentian channel and Georges Bank. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

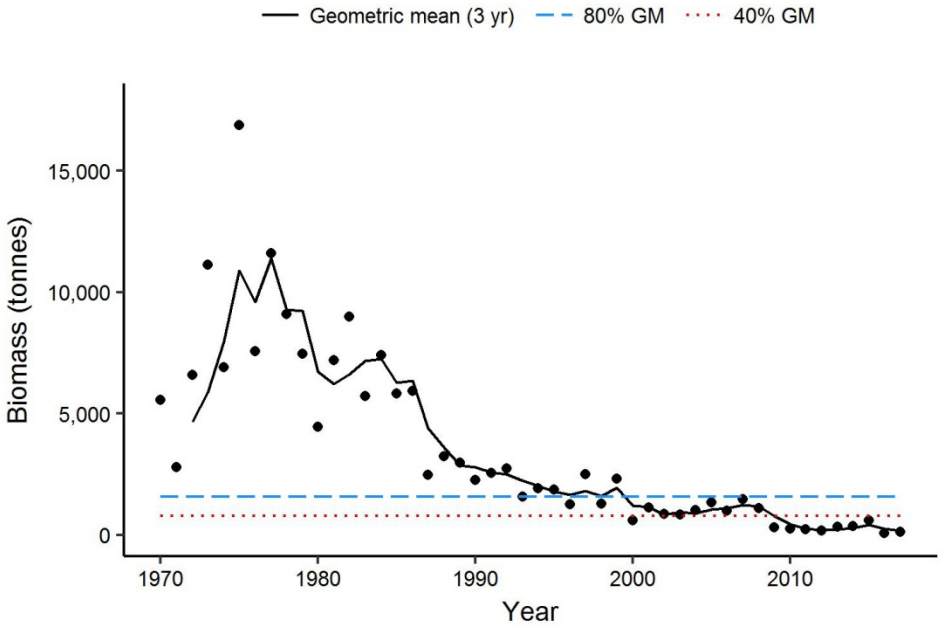

Figure 19b. Biomass index for Thorny Skate in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

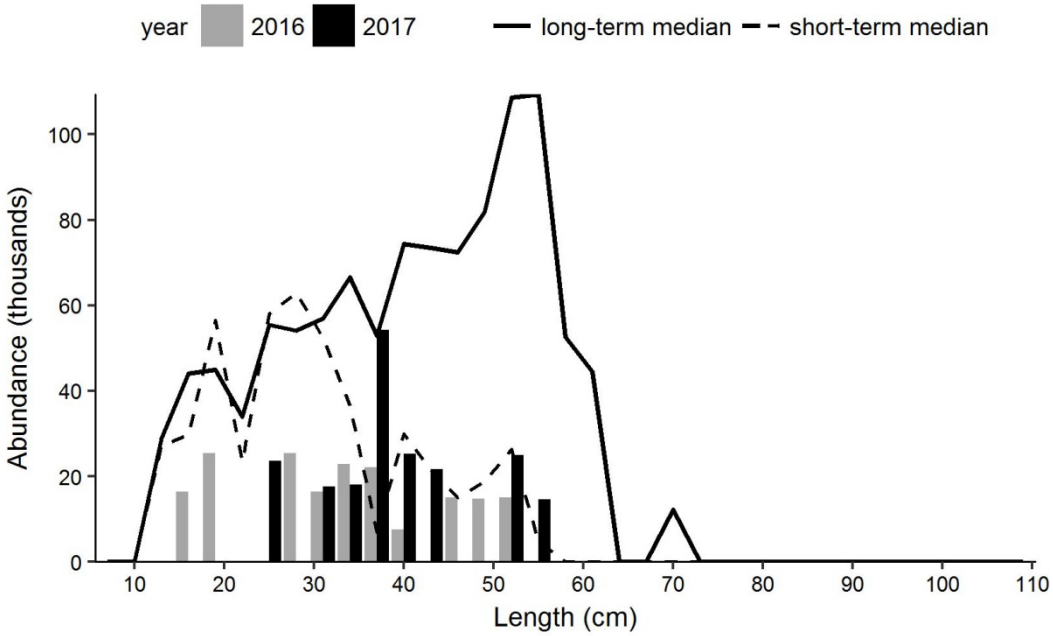

Figure 19c. Length frequency indices for Thorny Skate in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

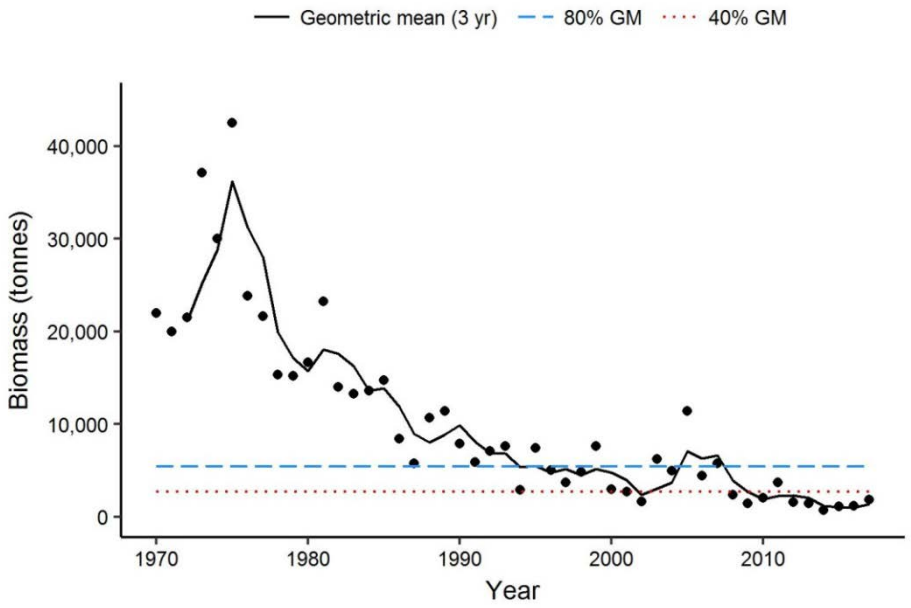

Figure 19d. Biomass index for Thorny Skate in 4VW from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

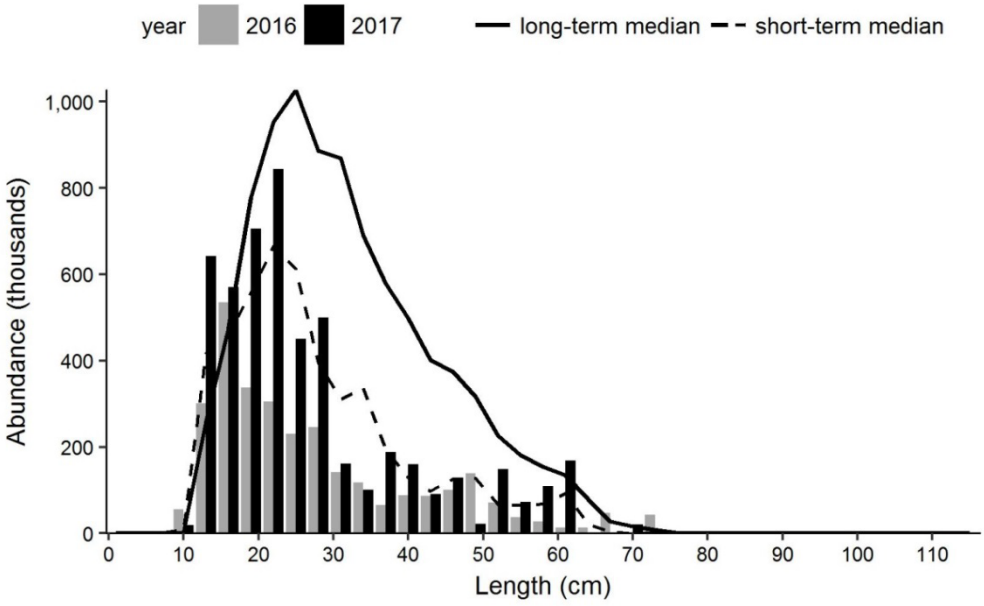

Figure 19e. Length frequency indices for Thorny Skate in 4VW from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Winter Skate

Winter Skate (*Leucoraja ocellata*) and **Little Skate** (*Leucoraja erinacea*) cannot be reliably distinguished at lengths less than about 40 cm (for more information, see McEachran and Musick 1973). The practise at sea in most years was to record immature skates for which the identification was uncertain as Winter Skates. Given that the majority of the skates recorded as Winter Skates in the surveys are in this length range, the biomass trends were influenced by the contribution of fish for which identification was uncertain. For this document, only Winter Skates >40 cm are included in calculating the biomass indices.

Winter Skate were caught primarily on Georges Bank and in the Bay of Fundy in 2017.

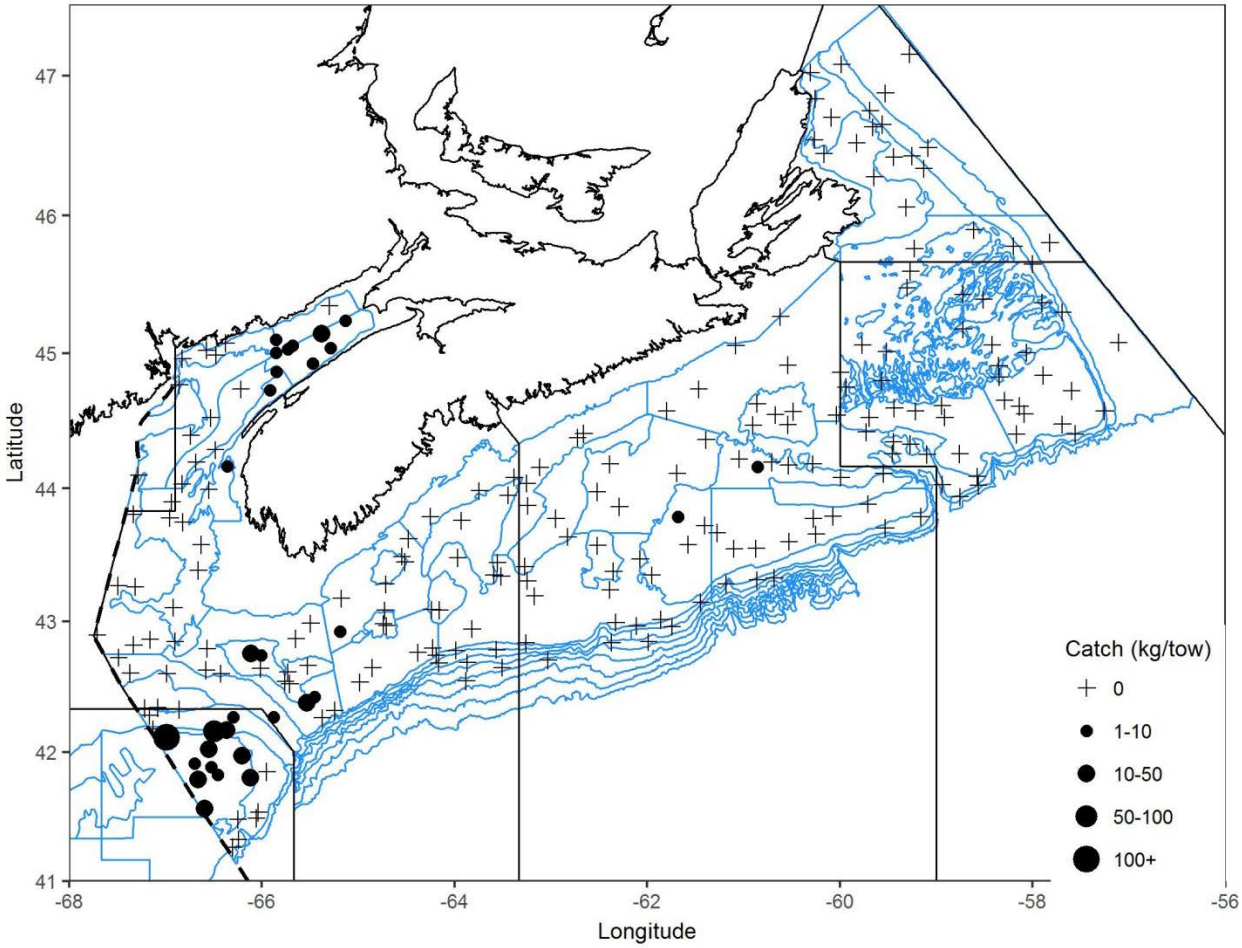

Figure 20a. Distribution of Winter Skate catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

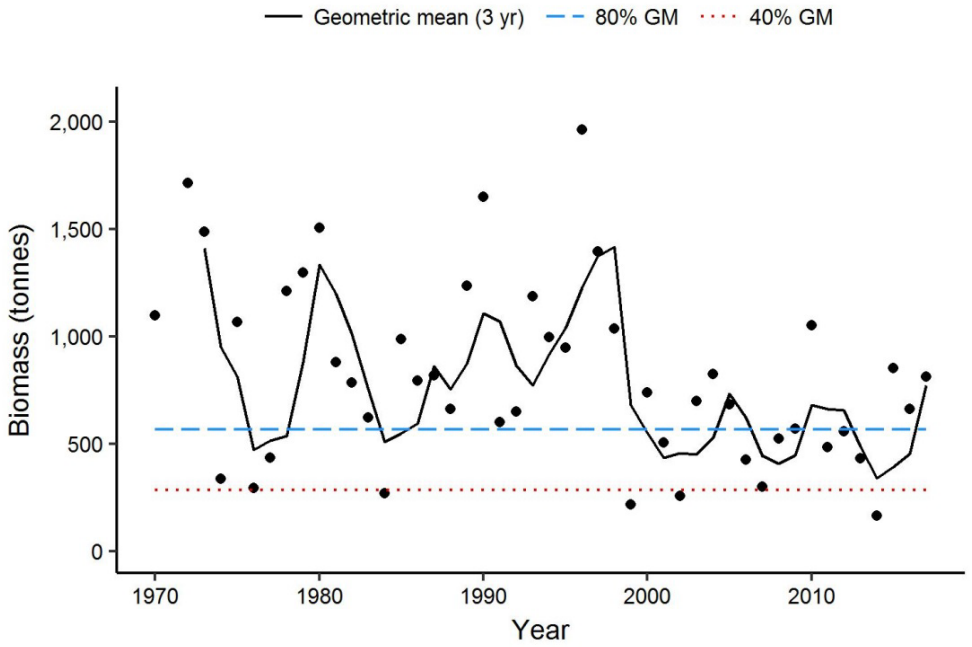

Figure 20b. Biomass index for Winter Skate in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

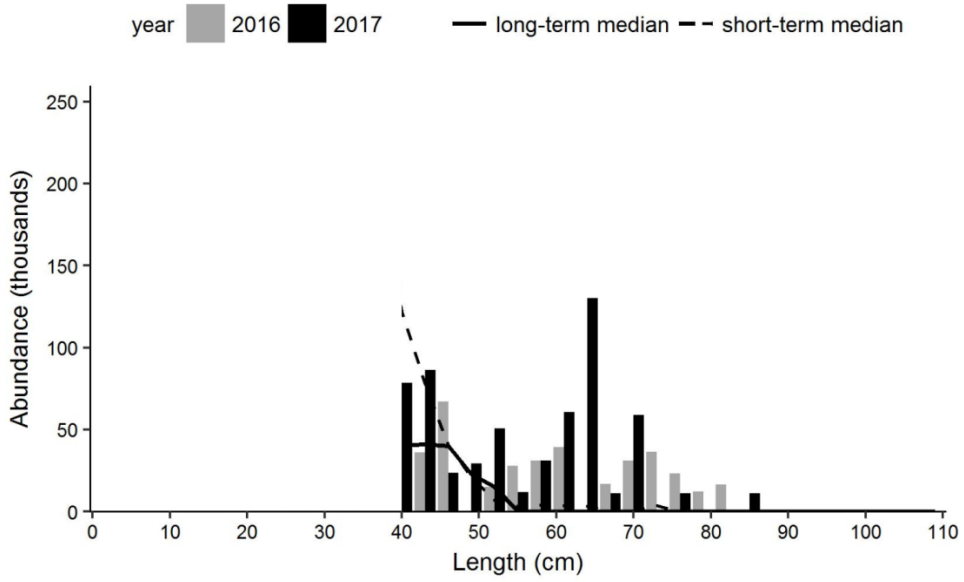

Figure 20c. Length frequency indices for Winter Skate in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

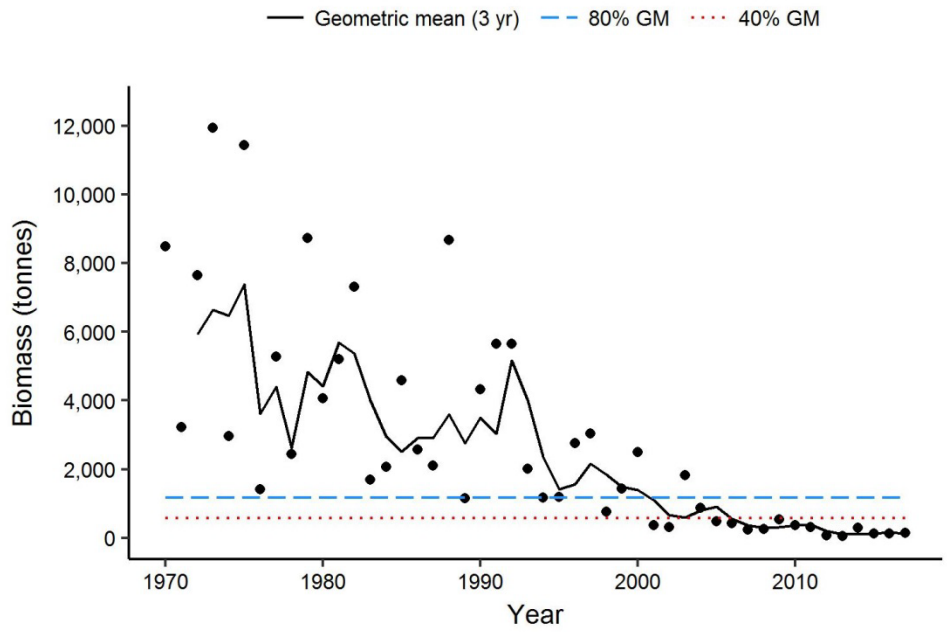

Figure 20d. Biomass index for Winter Skate in 4VW from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

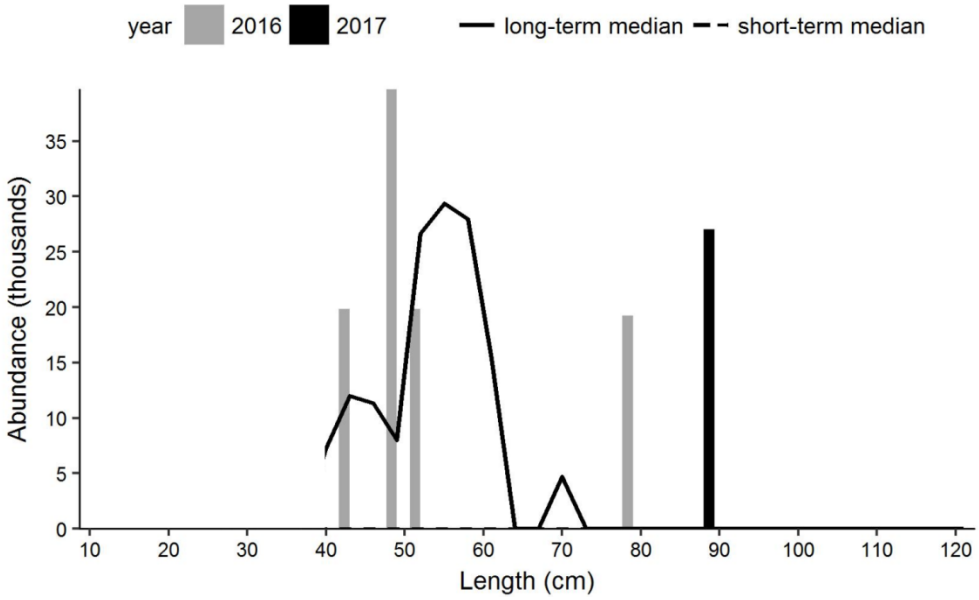

Figure 20e. Length frequency indices for Winter Skate in 4VW from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Little Skate

Winter Skate (*Leucoraja ocellata*) and **Little Skate** (*Leucoraja erinacea*) cannot be reliably distinguished when immature (for more information, see McEachran and Musick 1973). The practise at sea in most years was to record these immature skates as Winter Skates. Little Skate begin to mature at about 32 cm and can then be easily distinguished from Winter Skate. For this document, only Little Skates >32 cm are included in the long-term average length frequency.

Little Skate are caught primarily in Western 4X and on Georges Bank. The biomass index in 2017 remained high and abundance indices remained high for Little Skate for most lengths. The geographic range of Little Skate does not extend far into 4VW. In 4VW, the median catch at most lengths for the survey indices was zero and the biomass indices were very low.

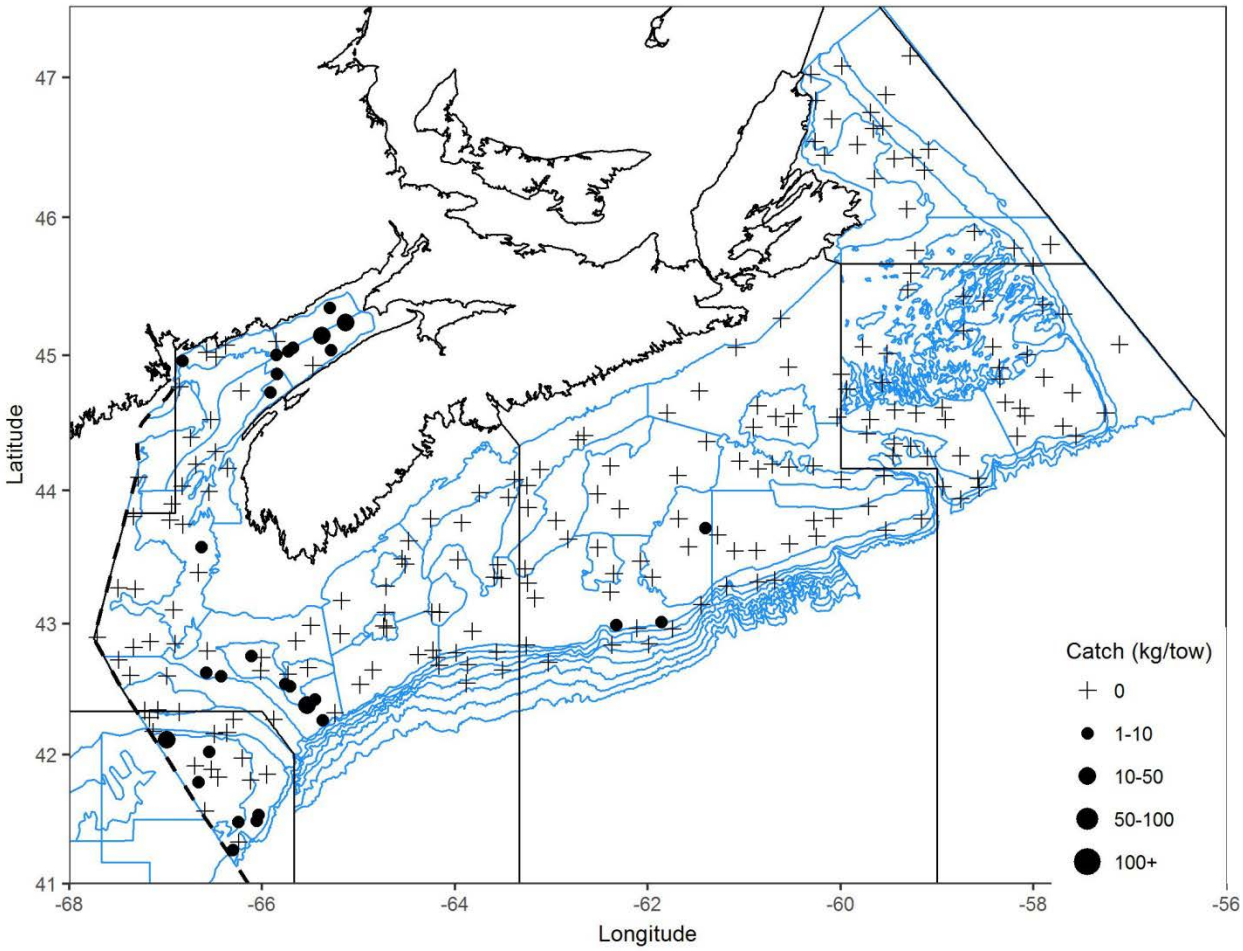

Figure 21a. Distribution of Little Skate catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

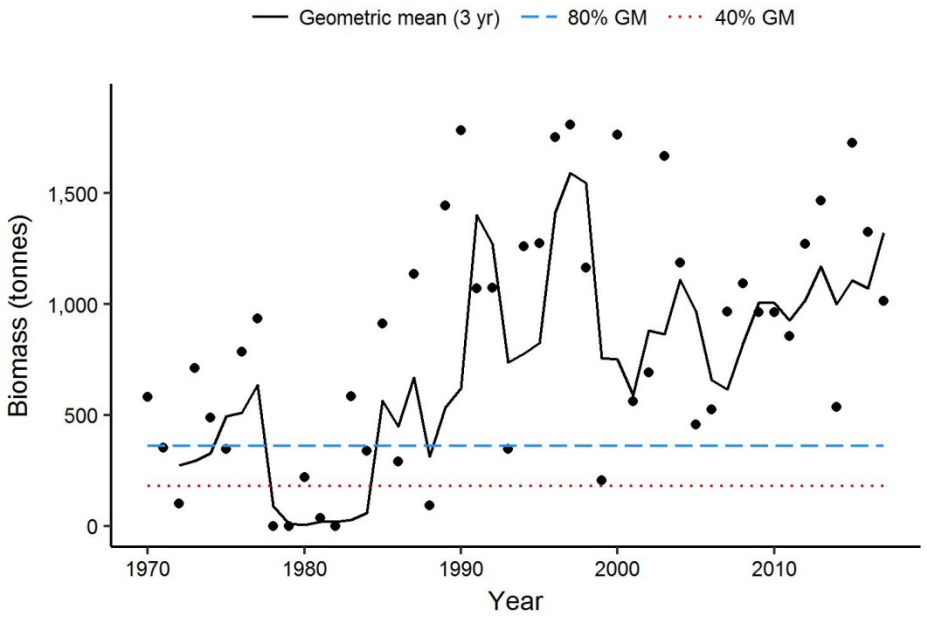

Figure 21b. Biomass index for Little Skate in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

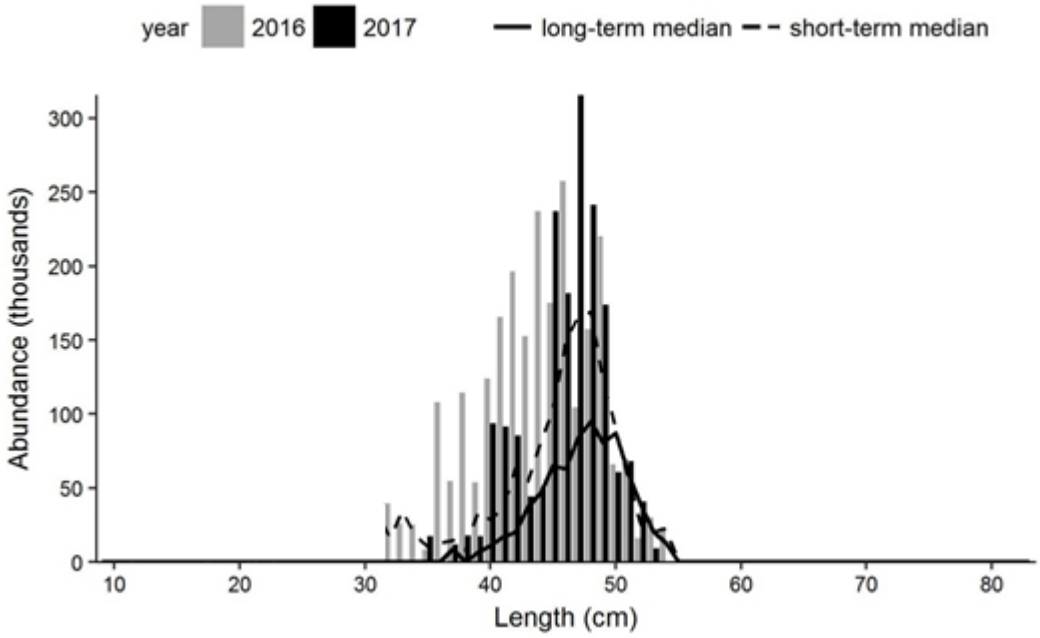

Figure 21c. Length frequency indices for Little Skate in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

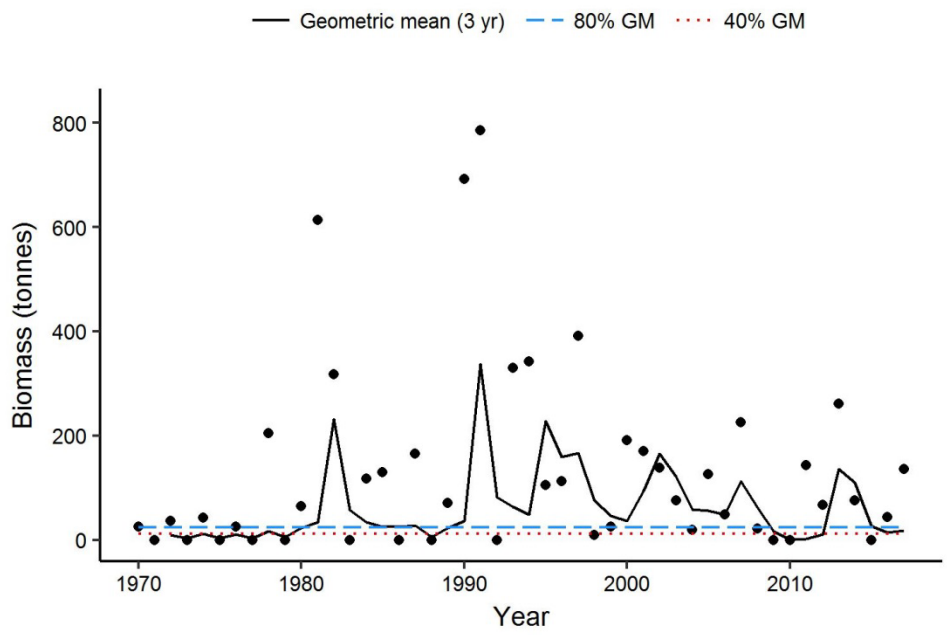

Figure 21d. Biomass index for Little Skate in 4VW from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

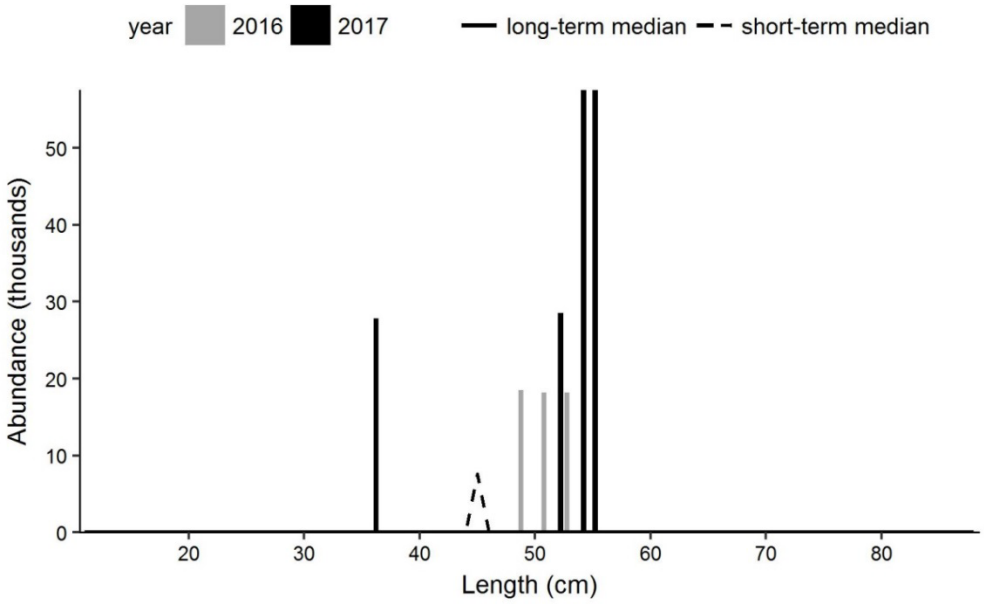

Figure 21e. Length frequency indices for Little Skate in 4VW from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Smooth Skate

Smooth Skate (*Malacoraja senta*) are caught at the eastern and western ends of the survey area. In 4X, the biomass index appears to have increased from a low in the early 1990's and has fluctuated around 80% of the long-term mean in recent years. The biomass index in 4VW remains low relative to the long-term mean, with few large Smooth Skate caught in either 2016 or 2017.

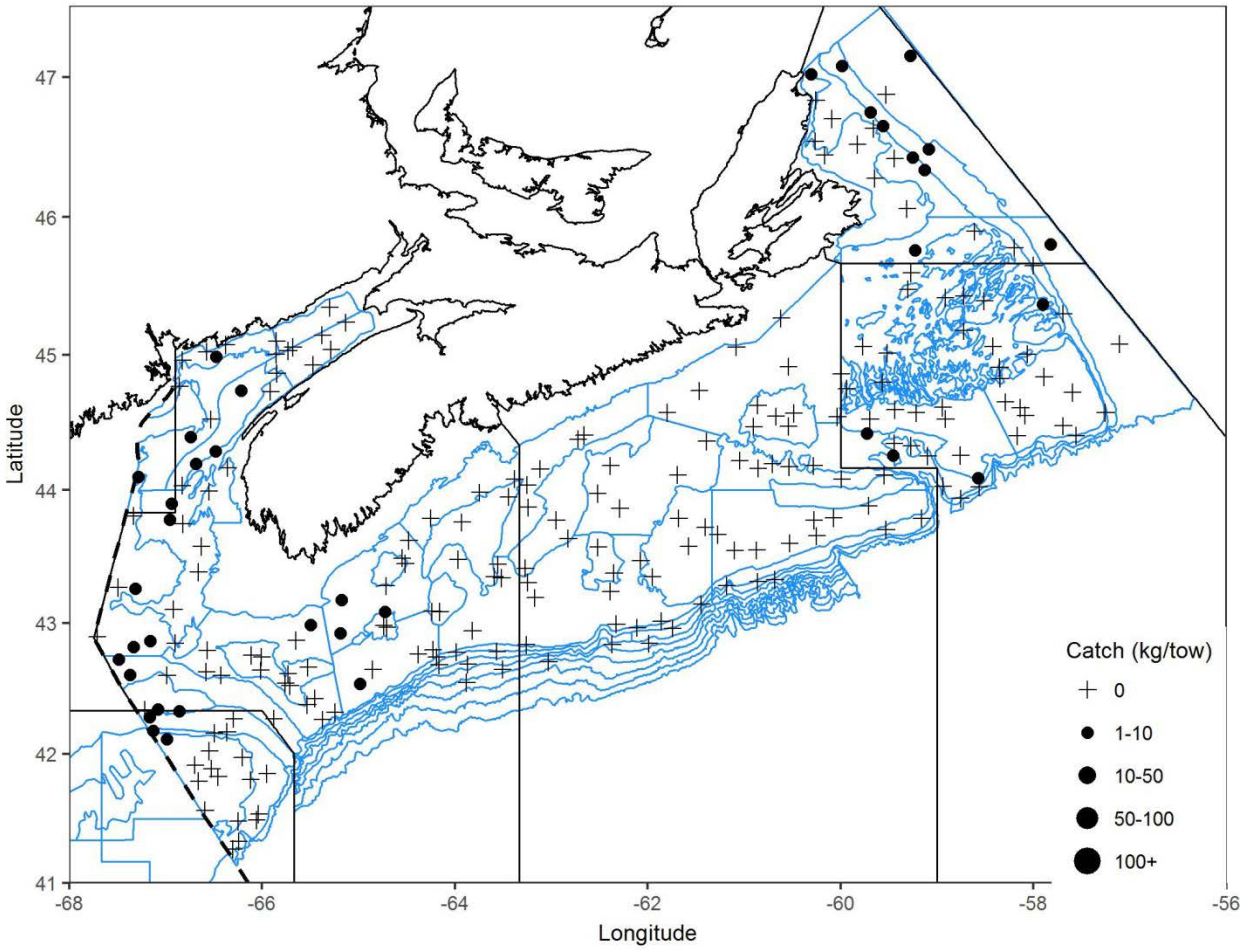

Figure 22a. Distribution of Smooth Skate catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

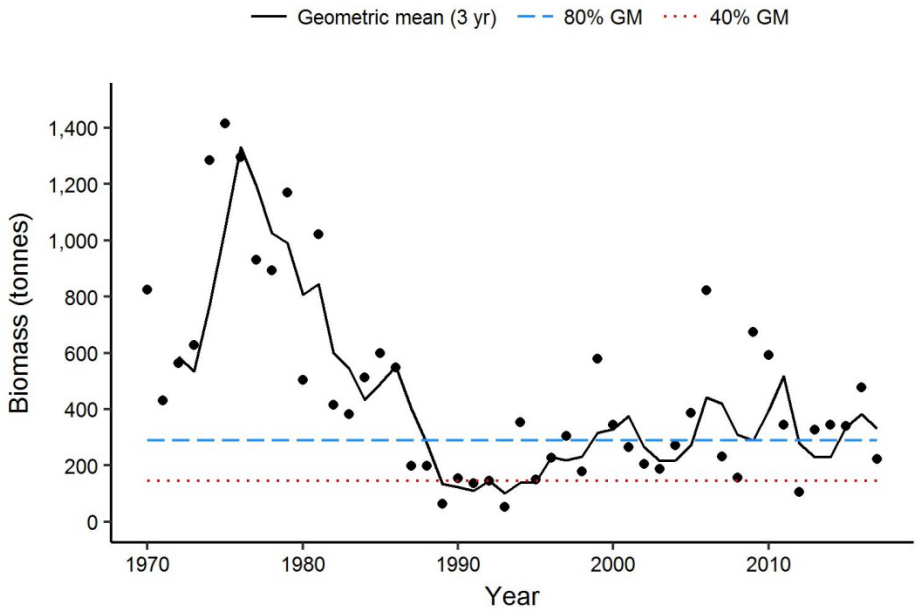

Figure 22b. Biomass index for Smooth Skate in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

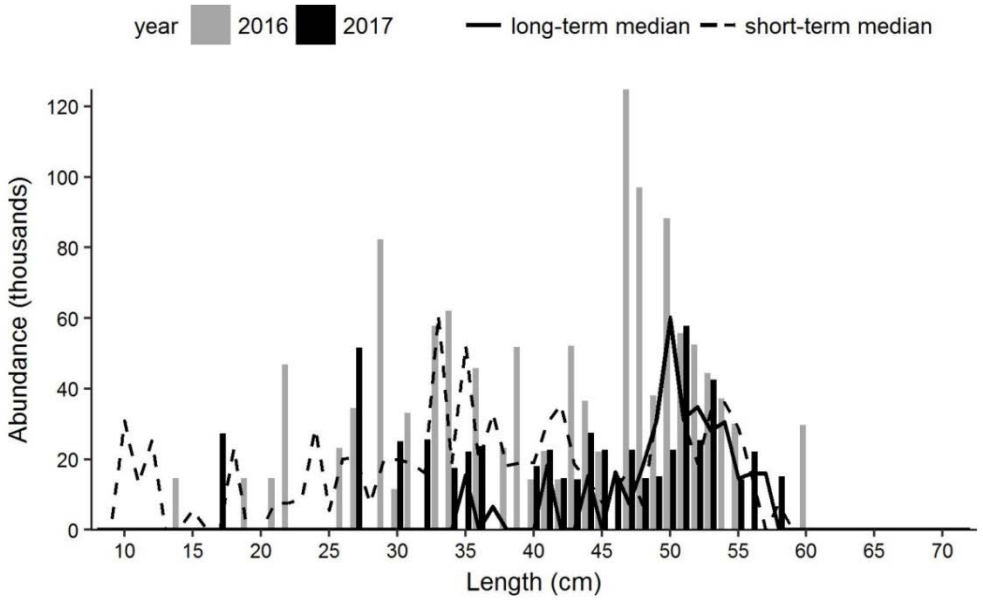

Figure 22c. Length frequency indices for Smooth Skate in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

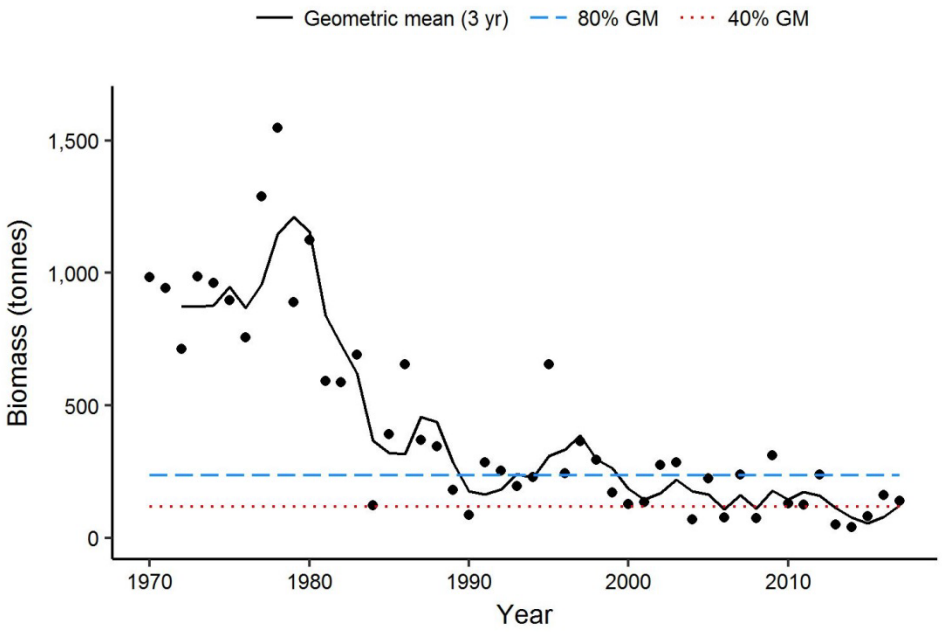

Figure 22d. Biomass index for Smooth Skate in 4VW from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

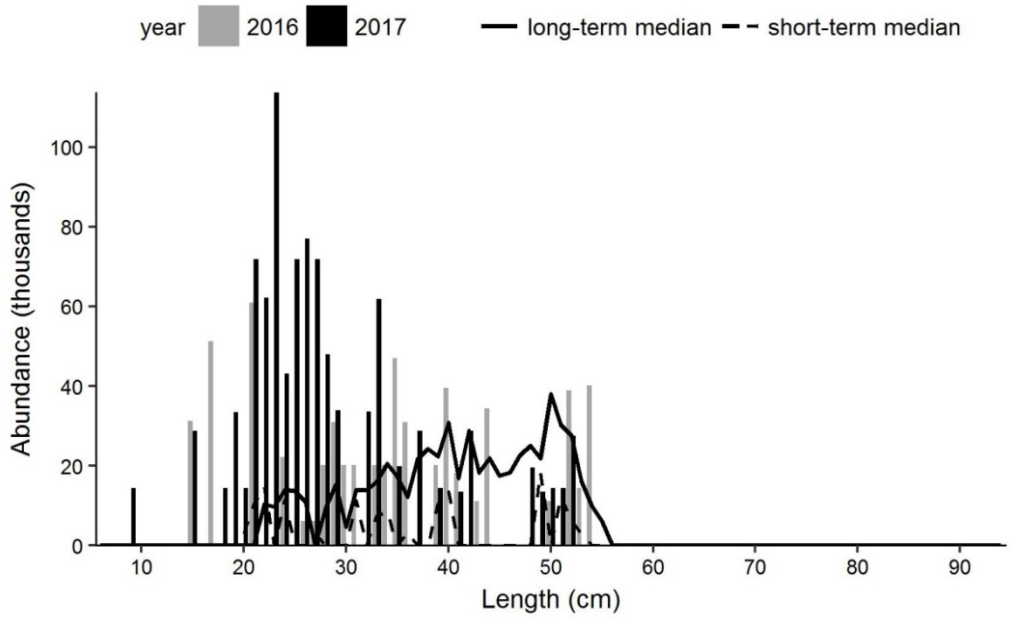

Figure 22e. Length frequency indices for Smooth Skate in 4VW from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Spiny Dogfish

Spiny Dogfish (*Squalus acanthias*) are well distributed in 4X and on Georges Bank with the largest set in 2017 (6,500 kg) taken on Georges Bank. Inter-annual variability in survey catch is high for Spiny Dogfish. The three-year average biomass index is above 80% of the long-term mean in 2017. The indices at length are at or above the median values at all lengths. The Spiny Dogfish population extends across the Canada – US boundary, with the majority of the population in US waters in most years; the DFO Summer RV Survey is not used on its own as an index of abundance for the stock assessment.

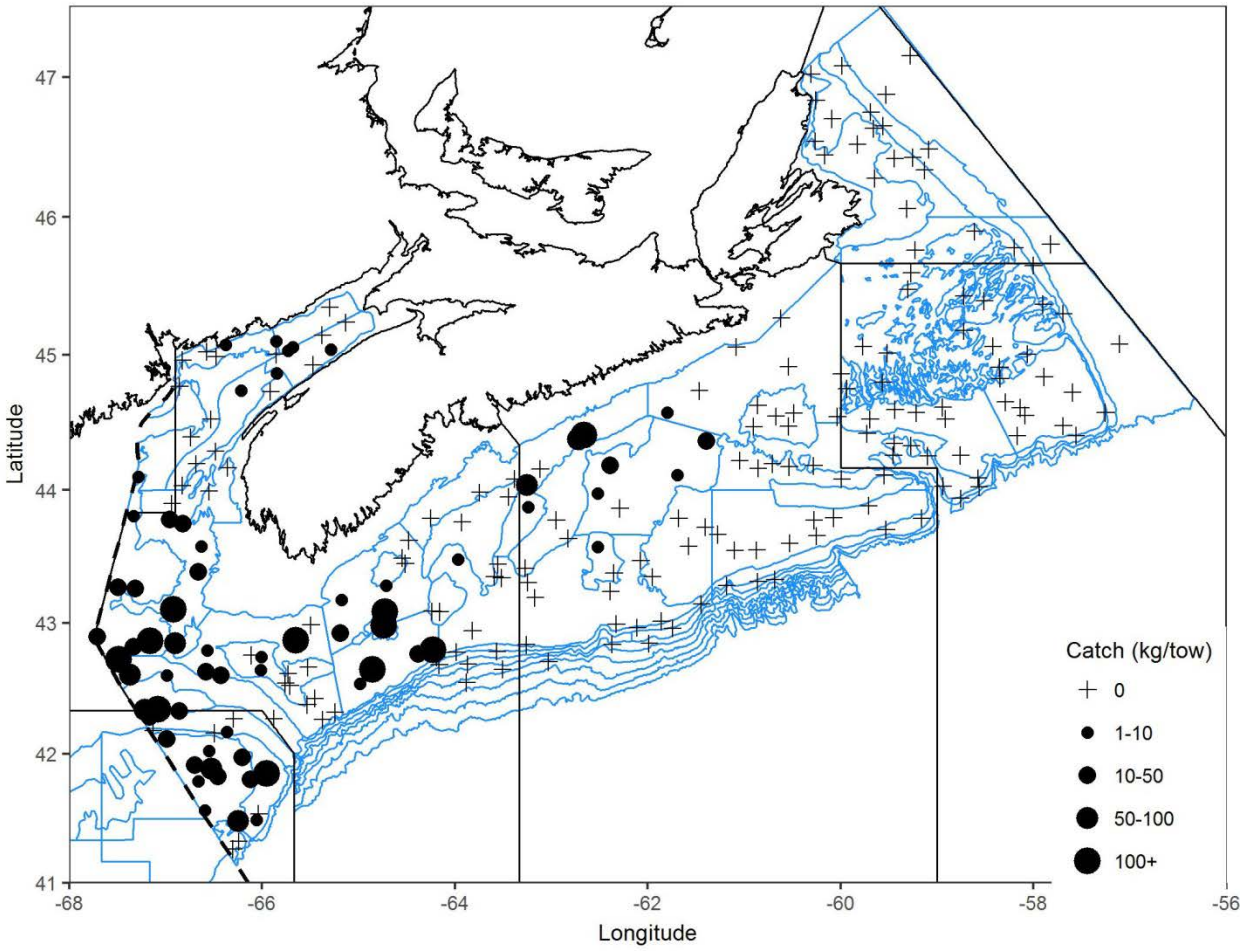

Figure 23a. Distribution of Spiny Dogfish catches during the 2016 DFO Summer Research Vessel survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

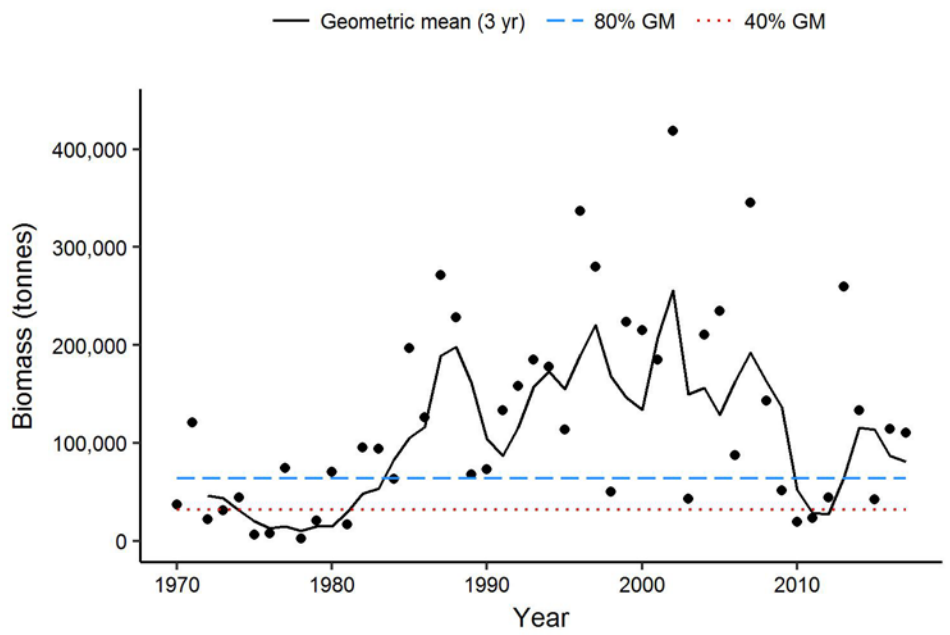

Figure 23b. Biomass index for Spiny Dogfish in 4VWX from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

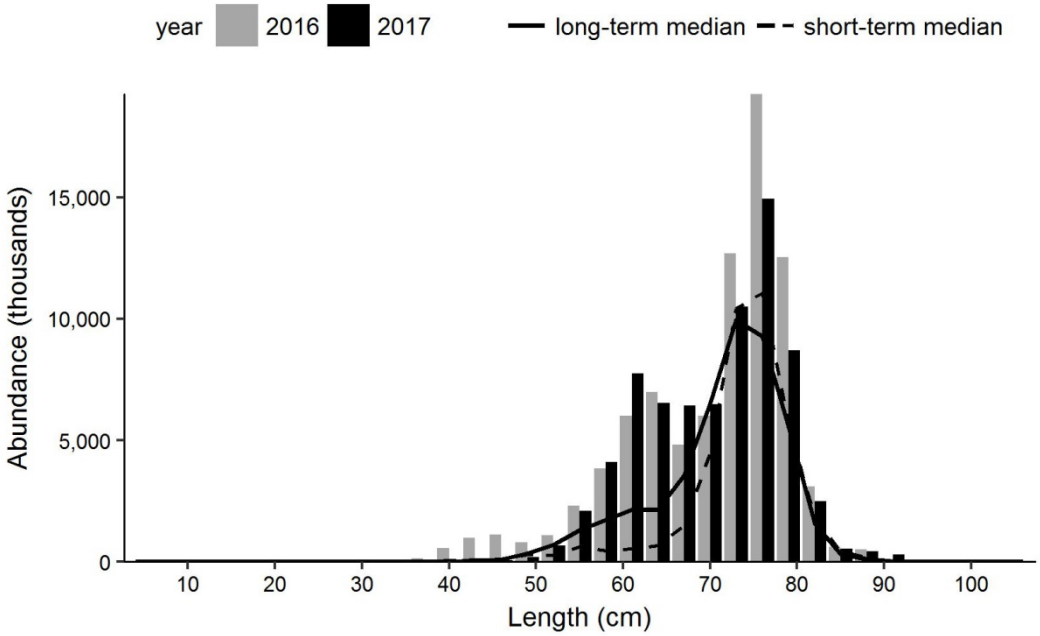

Figure 23c. Length frequency indices for Spiny Dogfish in 4VWX from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Red Hake

Red Hake (*Urophycis chuss*) can be difficult to distinguish from White Hake. Prior to about 1985, these two species were not consistently separated. The standard guide to Canadian Atlantic fishes (Leim and Scott 1966) did not differentiate them.

Red Hake were caught throughout 4X and 4W in 2017 but are seldom found in 4V. The short-term median numbers at length are generally higher than the long-term median in both 4X and 4VW, indicating a general increase in abundance. The indices at length in 2017 are generally above the short-term median values in both areas. In 4VW, the biomass index has been increasing since about 2010. In 2017, the three year median biomass index is the highest recorded since 1989.

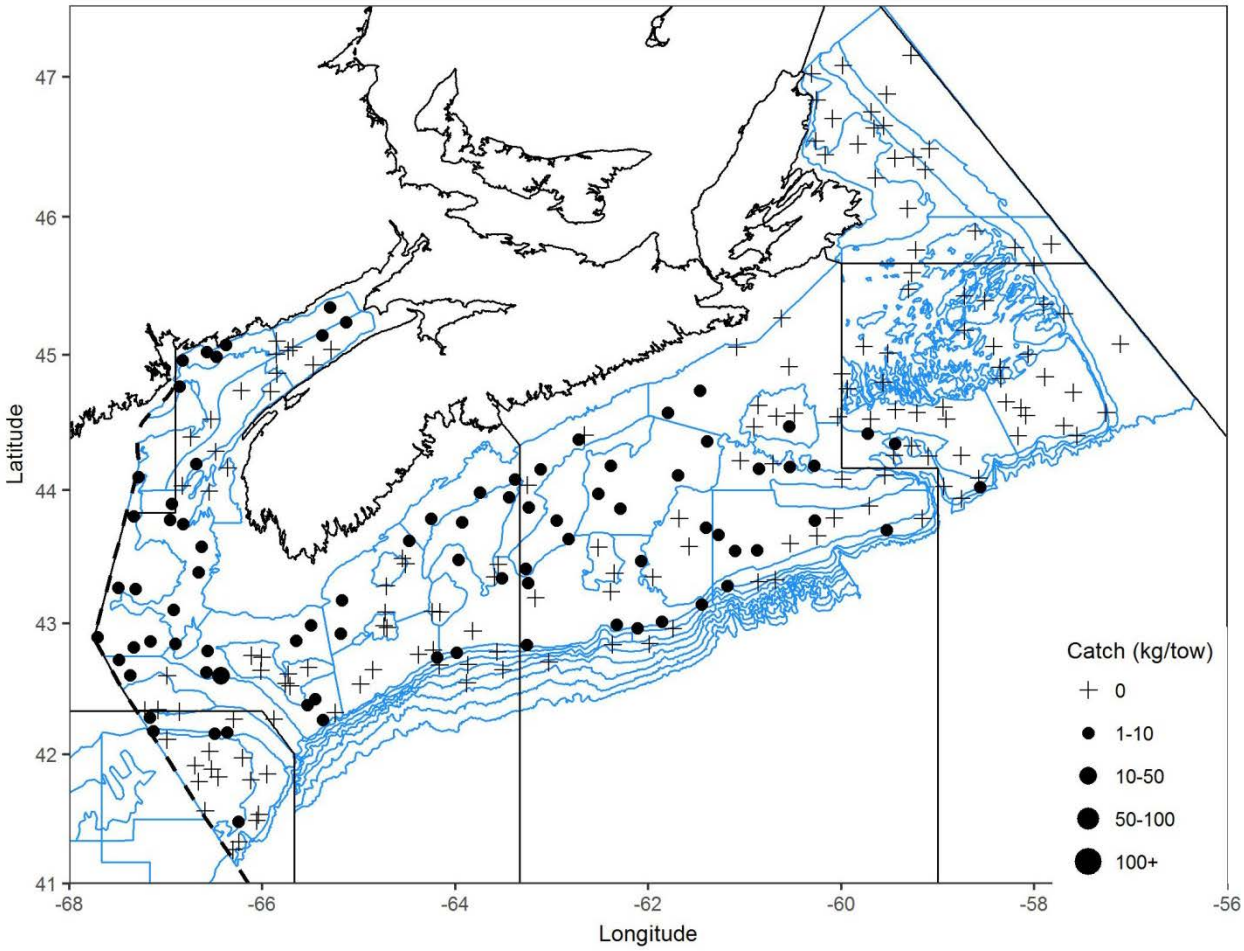

Figure 24a. Distribution of Red Hake catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

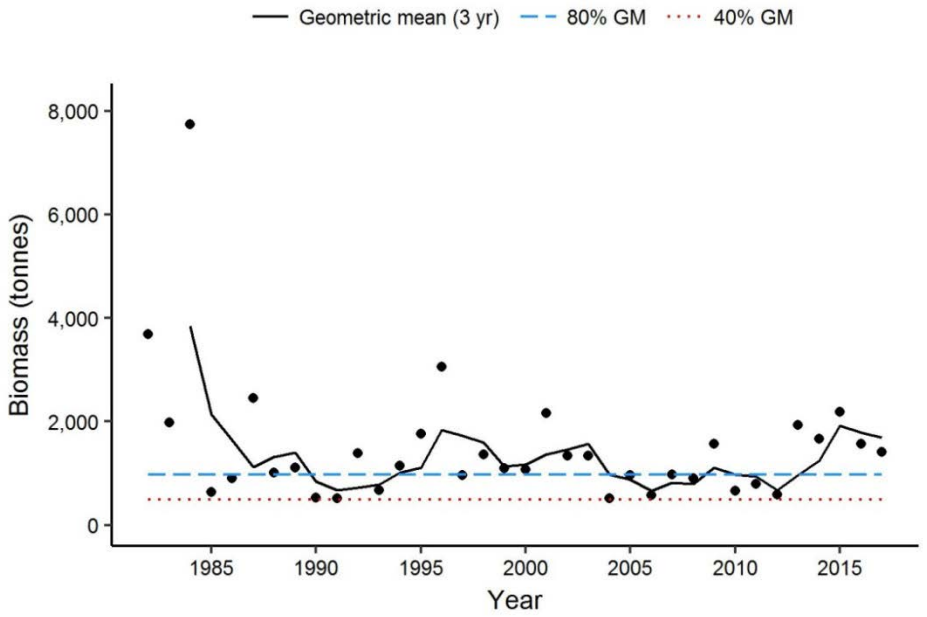

Figure 24b. Biomass index for Red Hake in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

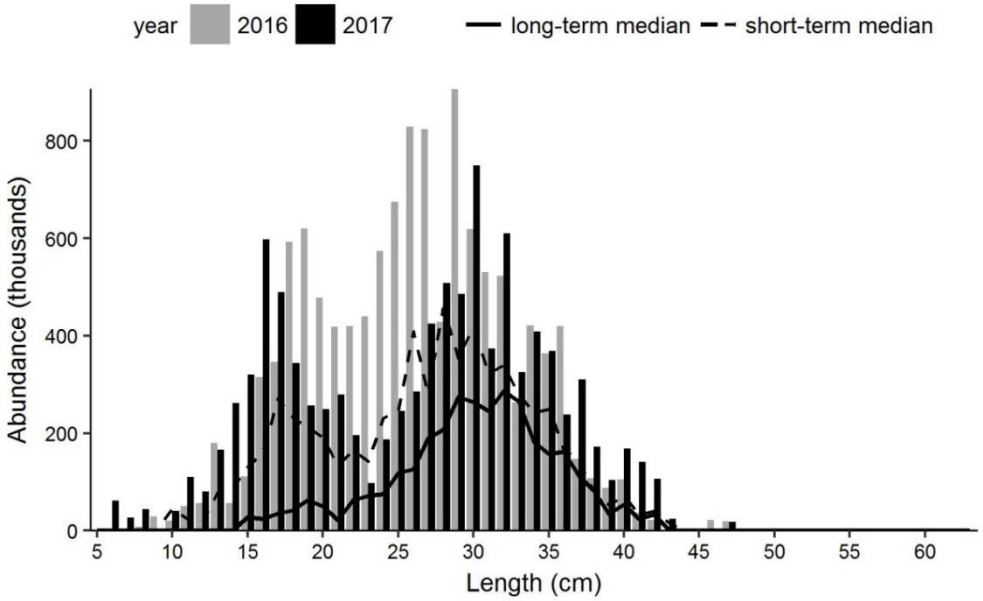

Figure 24c. Length frequency indices for Red Hake in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

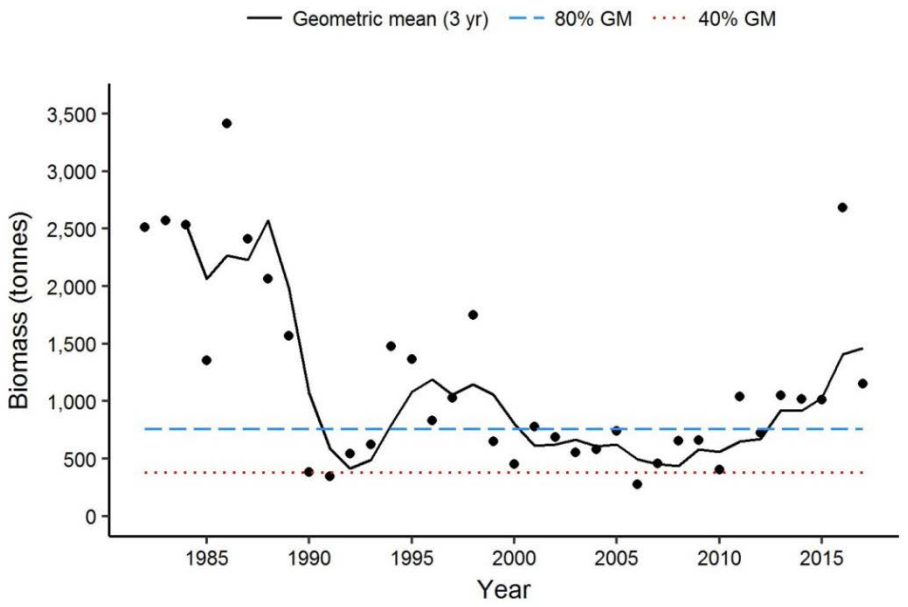

Figure 24d. Biomass index for Red Hake in 4VW from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

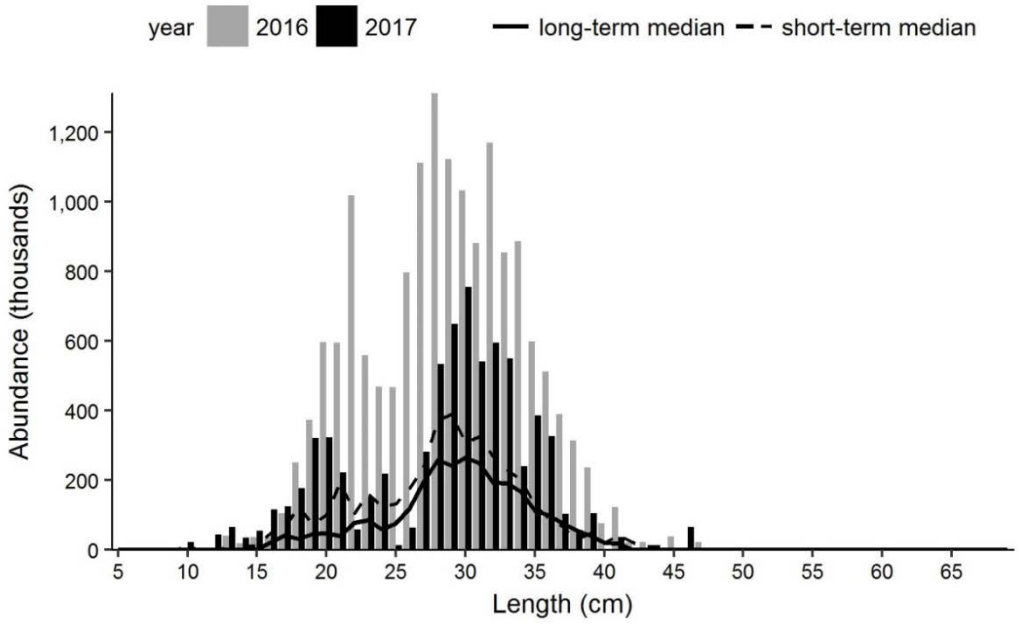

Figure 24e. Length frequency indices for Red Hake in 4VW from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Sea Raven

Sea Raven (*Hemitripteridae americanus*) are caught primarily on the Banks and in the Bay of Fundy, with the largest sets taken in the Bay and on Banquereau Bank. In 4X, the three-year average biomass index remains high, but the 2017 catch was the lowest since 2003 and the indices at length are below the short-term median for most lengths. In 4VW, the survey biomass index was among the highest in the series in 2017 and the indices at length are above both medians for most lengths.

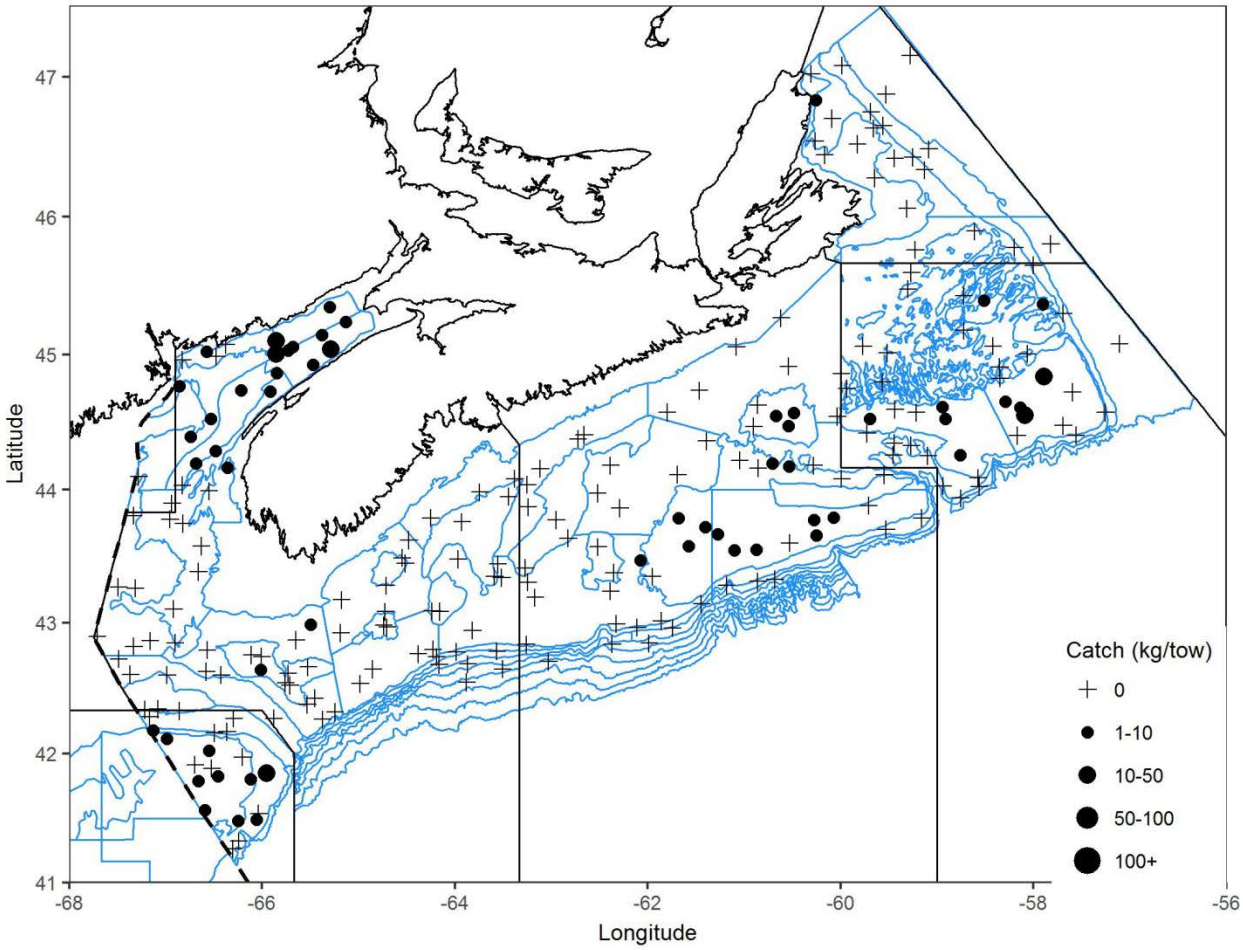

Figure 25a. Distribution of Sea Raven catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

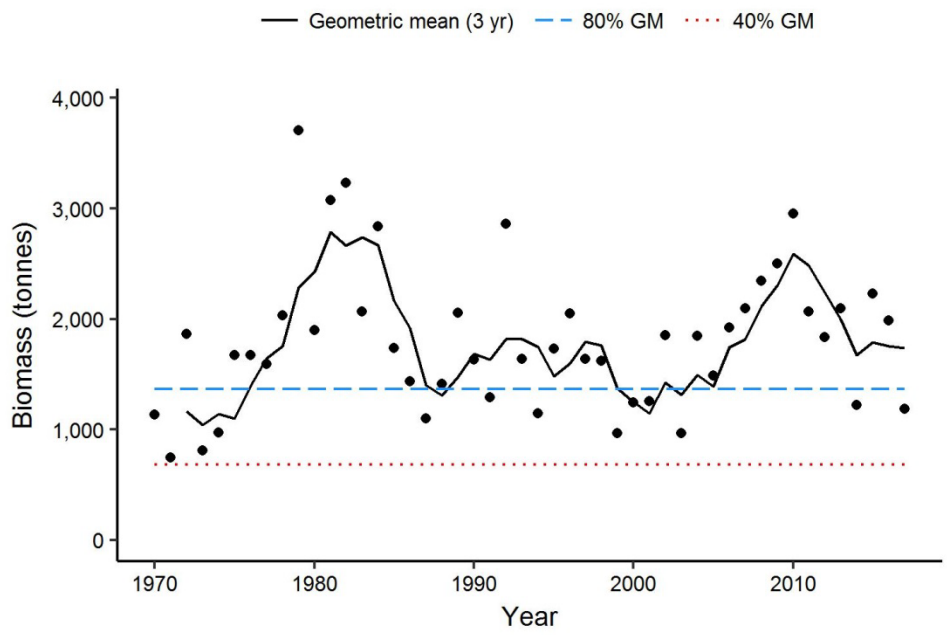

Figure 25b. Biomass index for Sea Raven in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

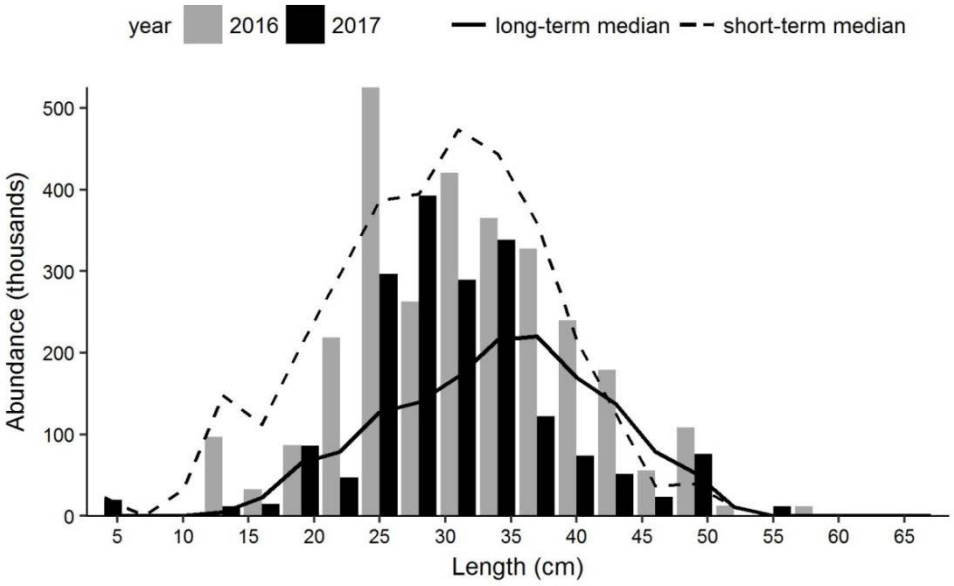

Figure 25c. Length frequency indices for Sea Raven in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

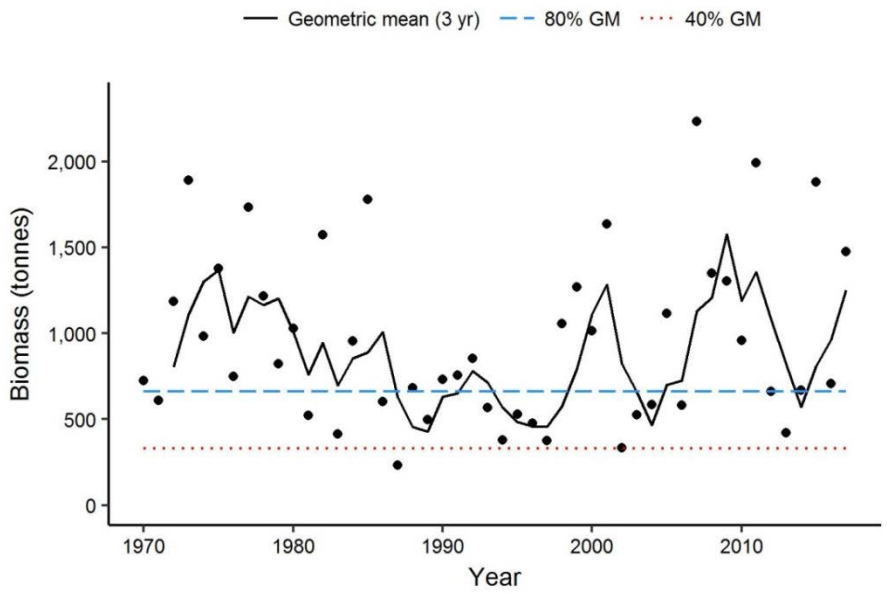

Figure 25d. Biomass index for Sea Raven in 4VW from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

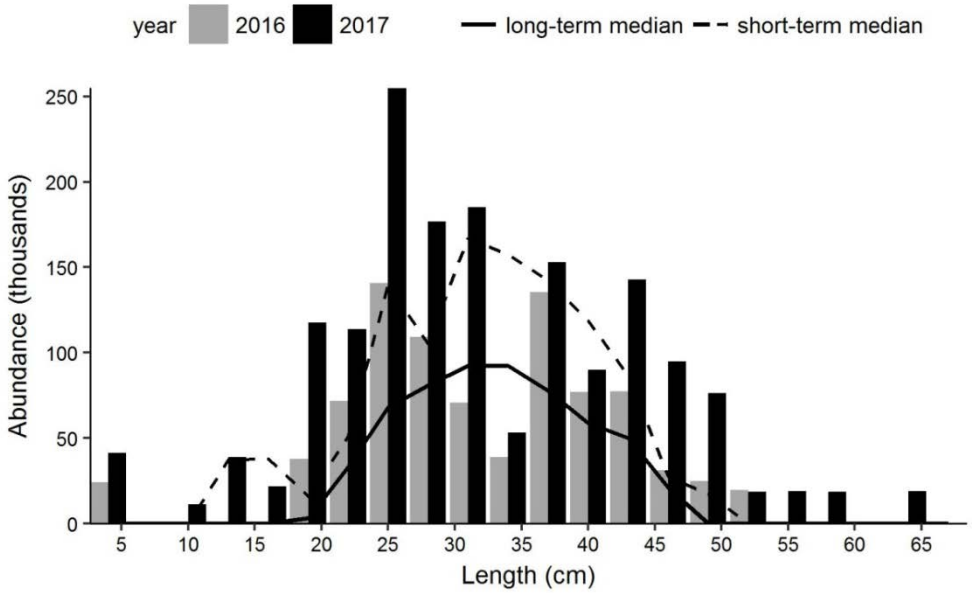

Figure 25e. Length frequency indices for Sea Raven in 4VW from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Ocean Pout

Ocean Pout (*Zoarces americanus*) were caught in only a few sets in 2017. The biomass indices have been below 40% of the long-term mean for the last 4 years in 4X and the last 6 years in 4VW. Catches of larger Ocean Pout are very low relative to the median values in both areas.

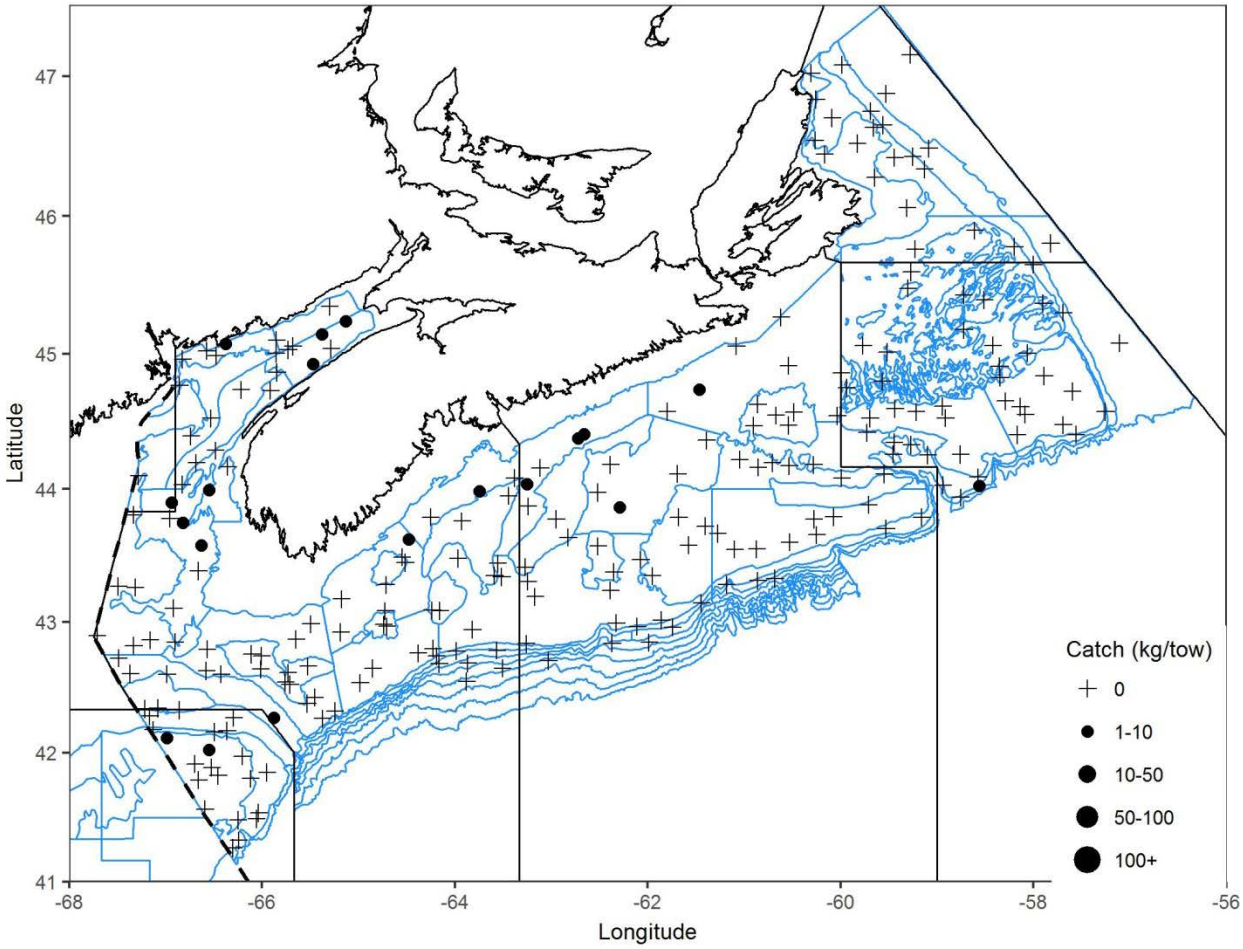

Figure 26a. Distribution of Ocean Pout catches during the 2017 DFO Summer RV Survey. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size.

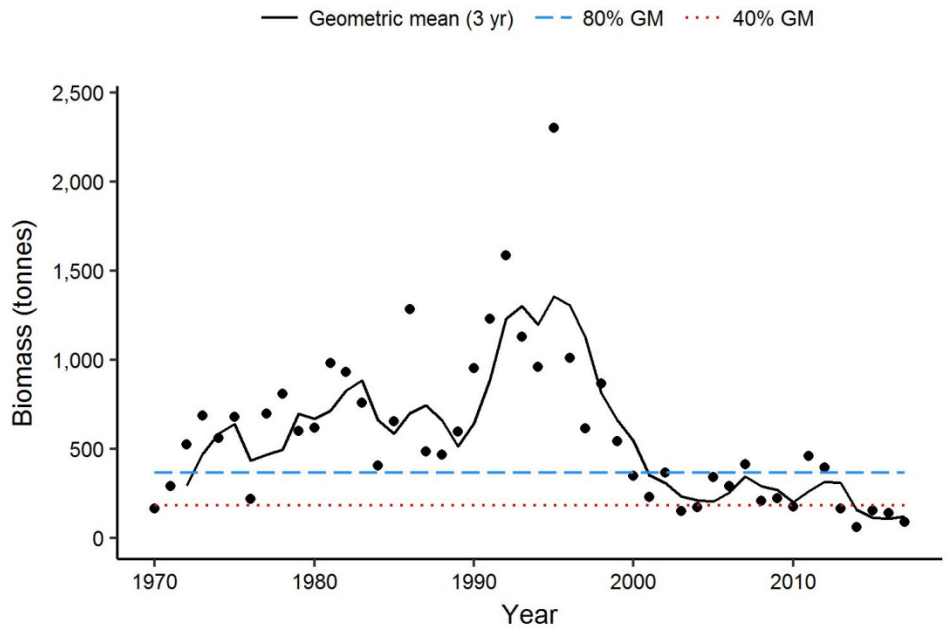

Figure 26b. Biomass index for Ocean Pout in 4X from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

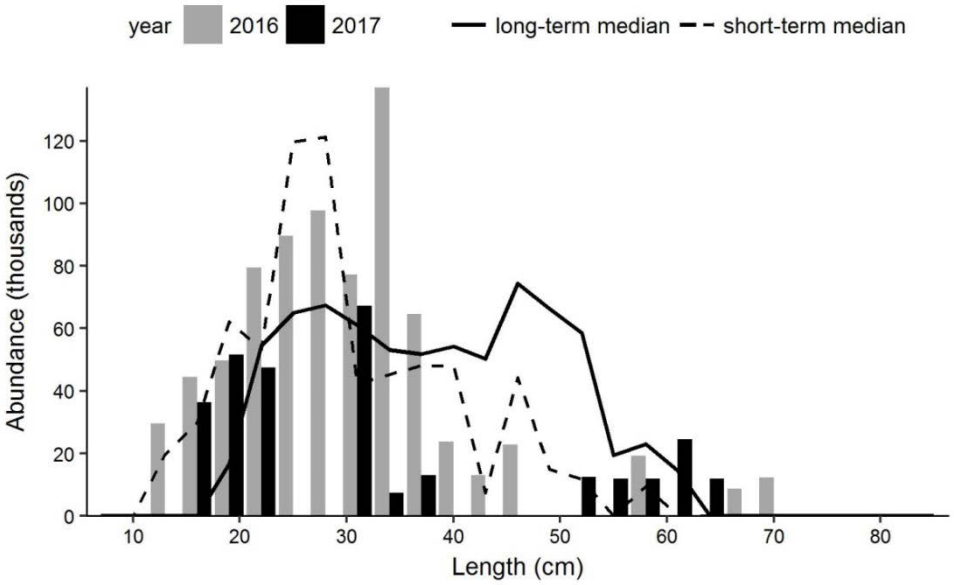

Figure 26c. Length frequency indices for Ocean Pout in 4X from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

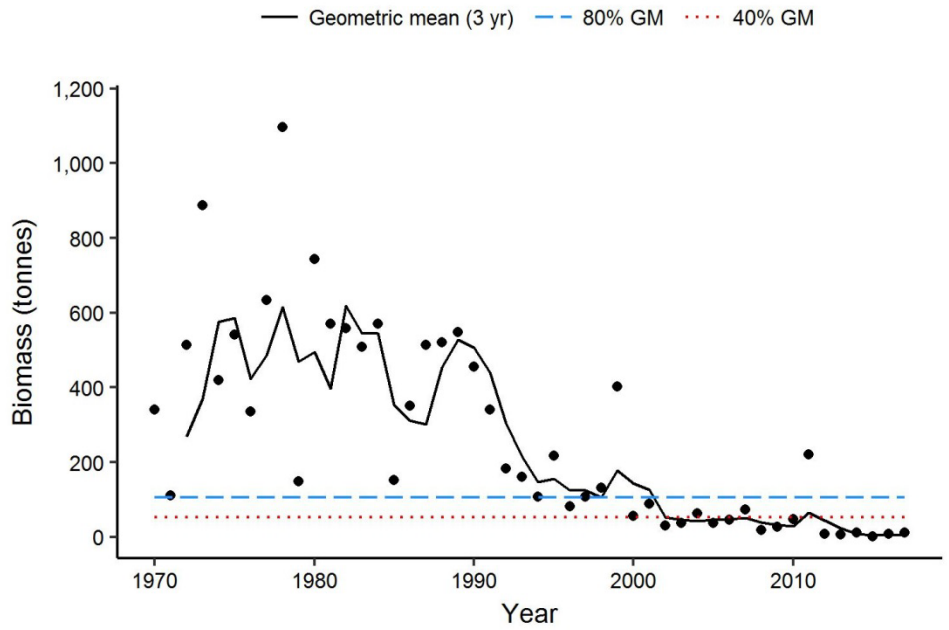

Figure 26d. Biomass index for Ocean Pout in 4VW from the DFO Summer RV Survey. The three year geometric mean biomass index is represented by the solid black line. The dashed blue and red lines represent 80% and 40% of the long-term geometric mean (1970-2016), respectively. The black dots represent the biomass index for that year.

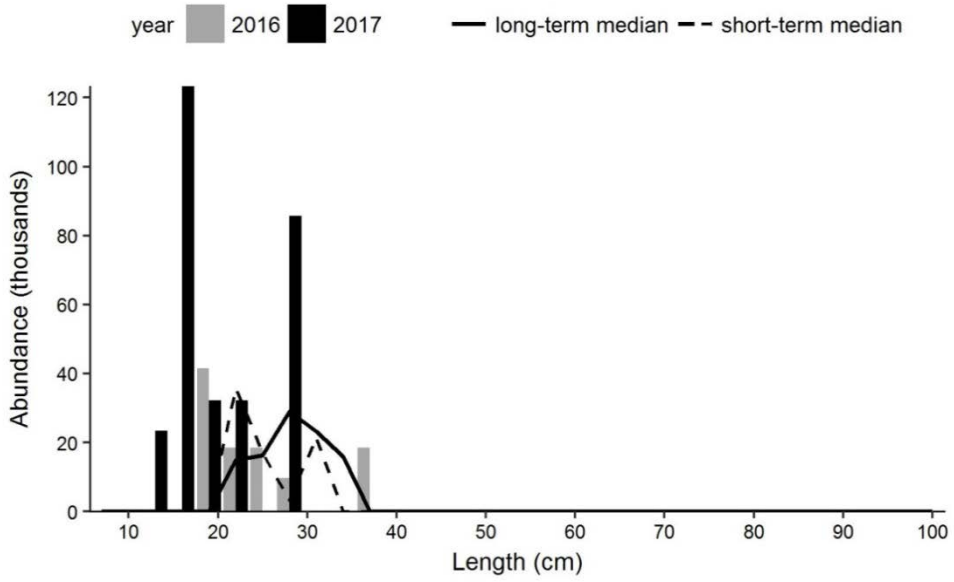

Figure 26e. Length frequency indices for Ocean Pout in 4VW from the DFO Summer RV Survey. Black bars represent the number in thousands at length from the 2017 survey. Grey bars represent the number in thousands at length from the 2016 survey. The solid black line represents the median in thousands at length for the time period 1970-2015. The dashed black line represents the median in thousands at length for the time period 2006-2015.

Warm Water Species

Species of fish more commonly observed south of Canadian waters have been increasing in prevalence in the catch of Maritimes Research Vessel Survey. These species include those who have been regularly observed on Georges Bank and are now becoming common further north on the Scotian Shelf, as well as some who had rarely or never been caught before. Many look quite distinctive but some could be mistaken for commercial fish common to the area (Figure 27).

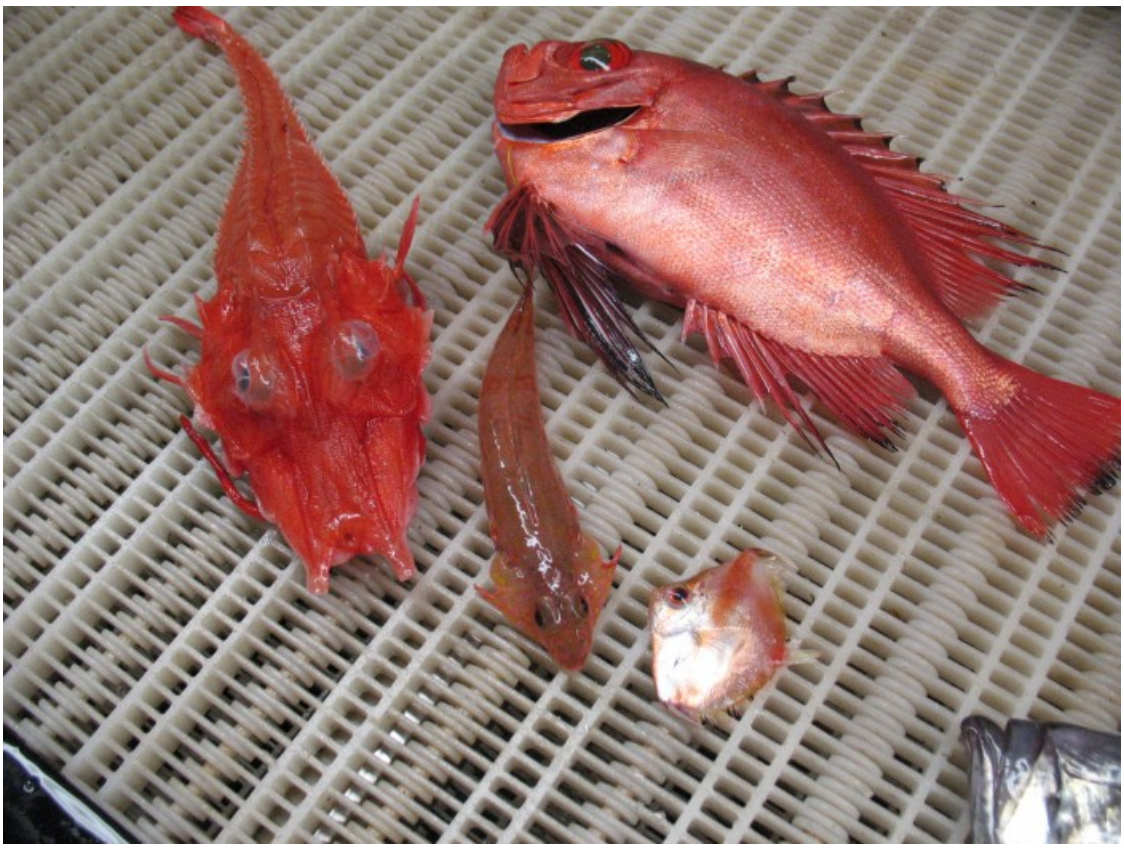

Figure 27. A variety of 'exotic' fishes captured in a set on the Scotian Shelf. Armored Sea Robin (Peristedion miniatum), Spotfin Dragonet (Foetorepus agassizi), Glasseye Snapper (Heteropriacanthus cruentatus), Deep Bodied Boarfish (Antigonia capros), and John Dory (Zenopsis ocellata).

The average bottom temperature recorded during the summer survey time series is 5.7° C. This varies annually, but the last 6 years have, in general, been the warmest in the series (Figure 28). Bottom temperature varies greatly across the area covered, ranging from below 2° C to above 11° C. This variation in temperature influences species assemblage dynamics over the area. The warmest waters are found in the Fundian Channel, along the edge of the Scotian Shelf, in the central Scotian Shelf and in shallow waters around Sable Island.

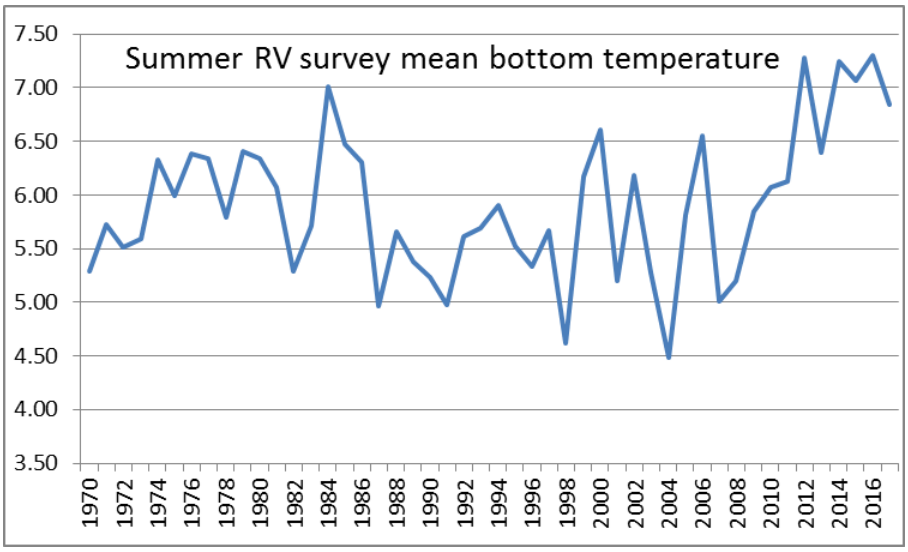

Figure 28. Average annual bottom temperature (°C) from the DFO Summer RV Survey in 4VWX

Several species, including Butterfish (*Peprilus triacanthus*), Mackerel (*Scomber scomberus*), Shad (*Alosa sapidissima*), Atlantic Sturgeon (*Acipenser oxyrhynchus*), and Barndoor Skate (*Raja laevis*), which have been caught at temperatures averaging >8.5° C, have been found on the Scotian Shelf throughout the survey time series. Twenty-four additional species have been caught at temperatures averaging >8.5° C but have only appeared in the survey catch sporadically throughout the time series. These appearances are becoming more common.

Blackbelly Rosefish (Helicolenus dactylopterus) have been captured in 4X every year since 1980 and appear to have colonized the area. The geographic area they occupy in 4X has increased since 1980 (Figure 29), while their biomass index remained very low until the early 1990s then increased tenfold to an average of above 1500 t annually in the last 10 years (Figure 30). The timing of this increase coincides with their appearance in the North Sea in the eastern Atlantic (Heessen et al. 1996) in 1991. While the 'invasion' of the North Sea was restricted largely to one year-class of fish, a broad range of lengths and ages are present in 4X.

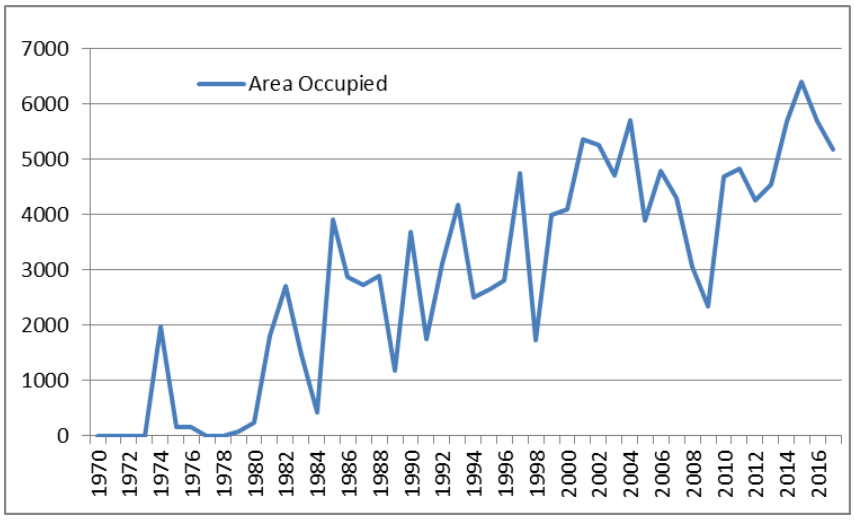

Figure 29. Area Occupied (nautical miles^2) for Blackbelly Rosefish from the summer survey.

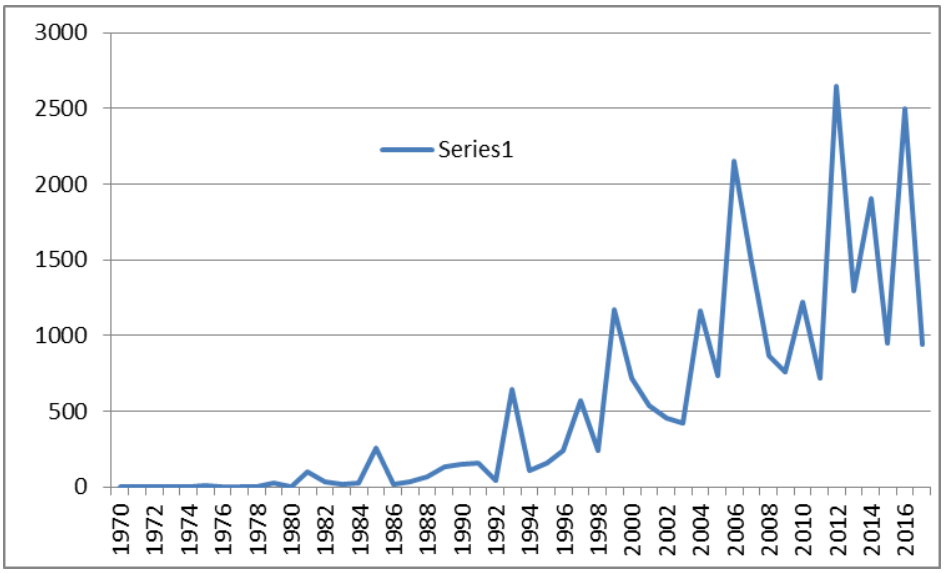

Figure 30. Biomass index for Blackbelly Rosefish in 4X from the DFO Summer RV Survey.

Blackbelly Rosefish are similar in appearance to redfish and may appear as bycatch with redfish in the Fundian channel. They are found within the warmer parts of the survey area, and their distribution has expanded along the Shelf edge as far as The Gully since 2010 (Figure 31).

Tomcod (*Microgadus tomcod*), Gulf-Stream Flounder (*Citharichthys arctifrons*), Four-Spot Flounder (*Paralichthys oblongus*) and Brill (*Scophthalmus aquosus*) are the only species that have been captured in last five year that were either rarely or never reported in the 1970s. Brill and Tomcod are both found in the upper Bay of Fundy. Tomcod are too small to be taken in commercial fisheries, but Brill may be seen as bycatch in the Winter Flounder fishery. While they are both common in the Bay of Fundy, the biomass index for Brill is only 1% - 2% of the index for Winter Flounder so they are not expected to be common as bycatch.

Other warm water species captured in 4X in the last five years include American John Dory, Stout Beardfish, Thorny Tinselfish, Conger Eel (*Conger oceanicus*), and Atlantic Torpedo Ray (*Torpedo nobiliana*). The first time any of these species was captured was in 1987. They have been found along the shelf edge and close to Georges Bank. These species have been caught more frequently in 4W.

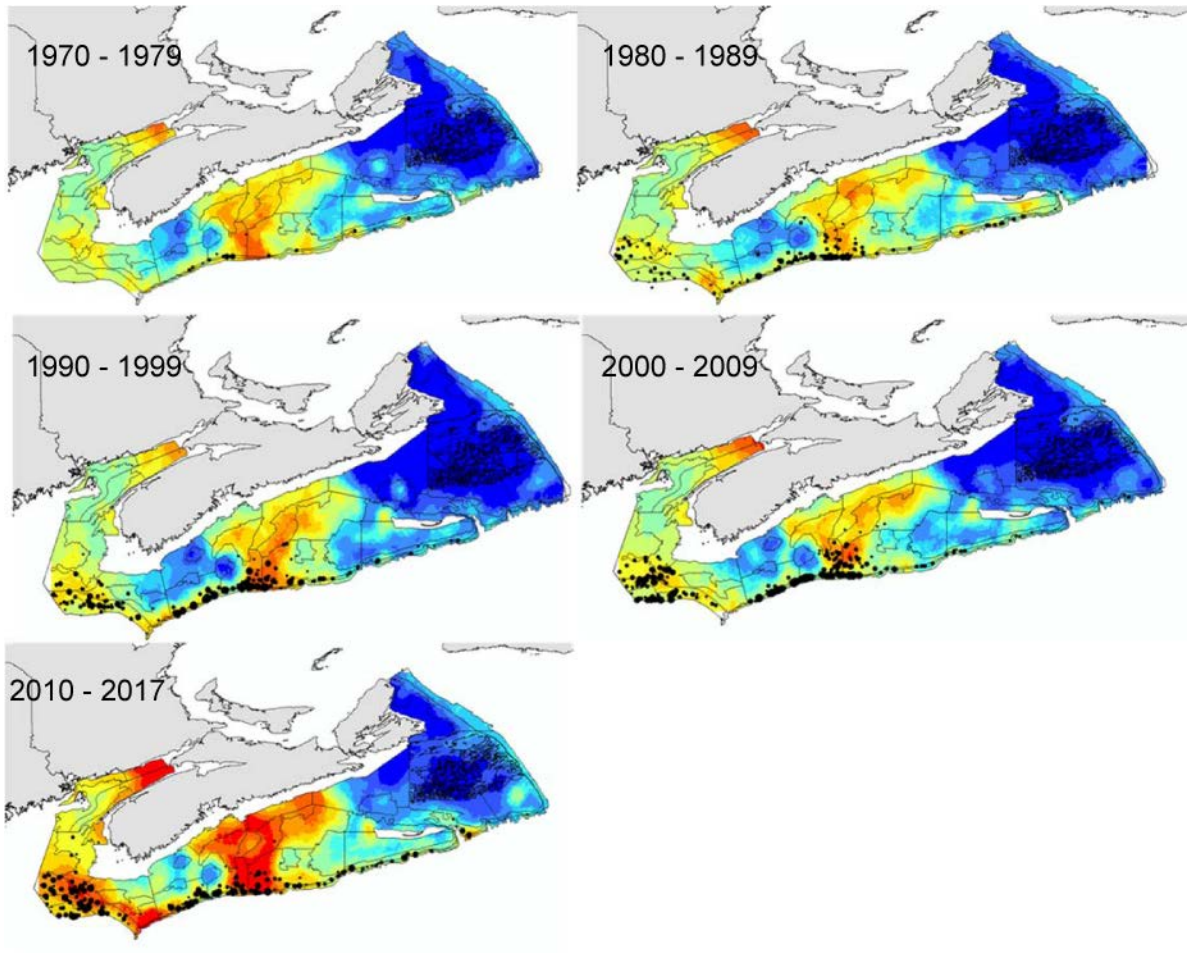

Figure 31. Decadal distribution of captures of Blackbelly Rosefish overlaid on the average temperature for each time period.

The number of warm-water species captured has been increasing, as has the frequency with which they are captured. This increase is evident in both 4X and 4VW, but it has recently become more pronounced in 4VW (Figure 32 and 33).

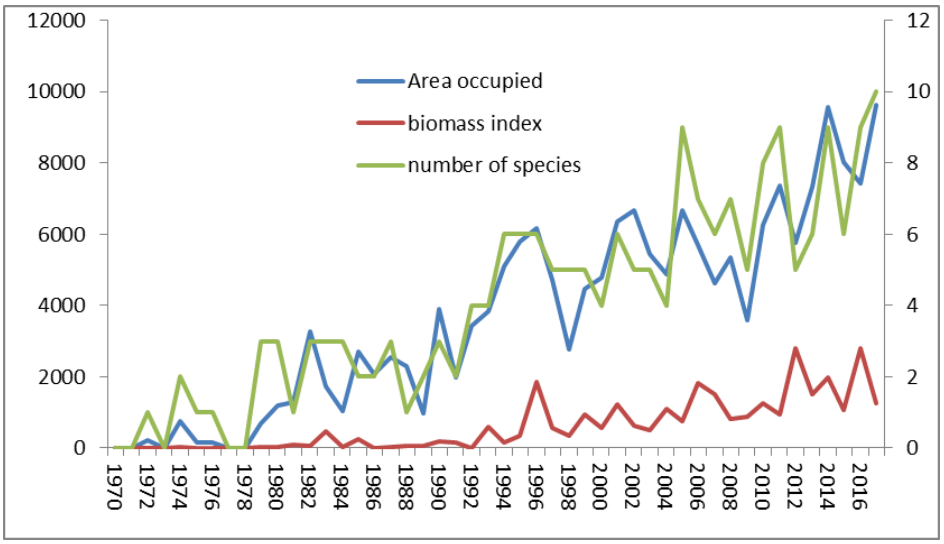

Figure 32. Occurrence, biomass (t), and area occupied (nautical miles^2) of warm water species captured in 4X during the summer survey

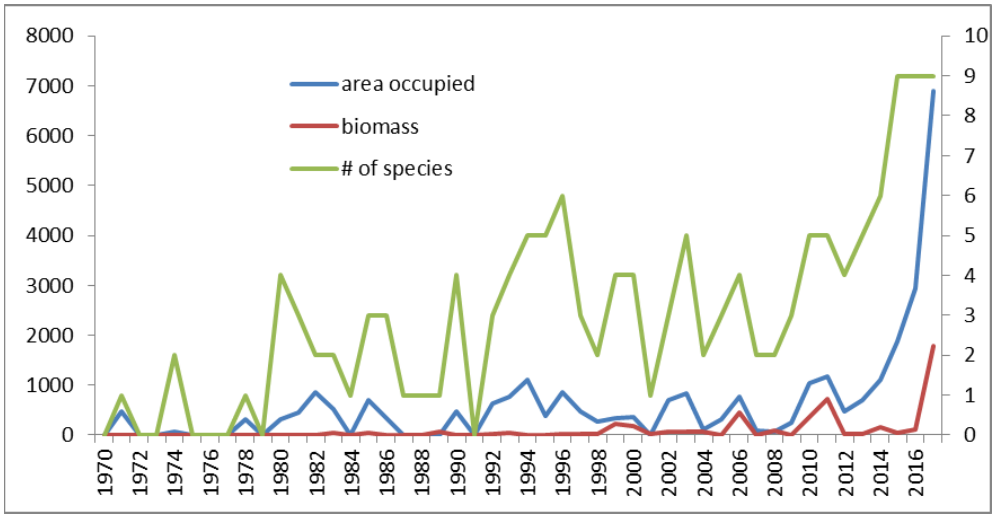

Figure 33. Occurrence, biomass (t) and area occupied (nautical miles^2) of warm water species captured in 4VW during the summer survey

In 4W, American John Dory, Stout Beardfish, Four-Spot Flounder and Blackbelly Rosefish were each caught once in the 1970s. More recently, American John Dory and Stout Beardfish have been captured in each of the last three years, Four-Spot Flounder in each of the last five years and Blackbelly Rosefish have been caught in every year since 1992. Six other warm water species were caught in 4W in 2017: Thorny Tinselfish, Fawn Cusk-Eel (*Lepophidium profundorum*), Atlantic Torpedo Ray, Spotted Hake (*Urophycis regia*), and Shortnose Greeneye (*Chlorophthalmus agassizi*). The distribution of capture for these species is clearly associated with areas of warm water in all time periods and has expanded along with the expansion of warm bottom temperatures.

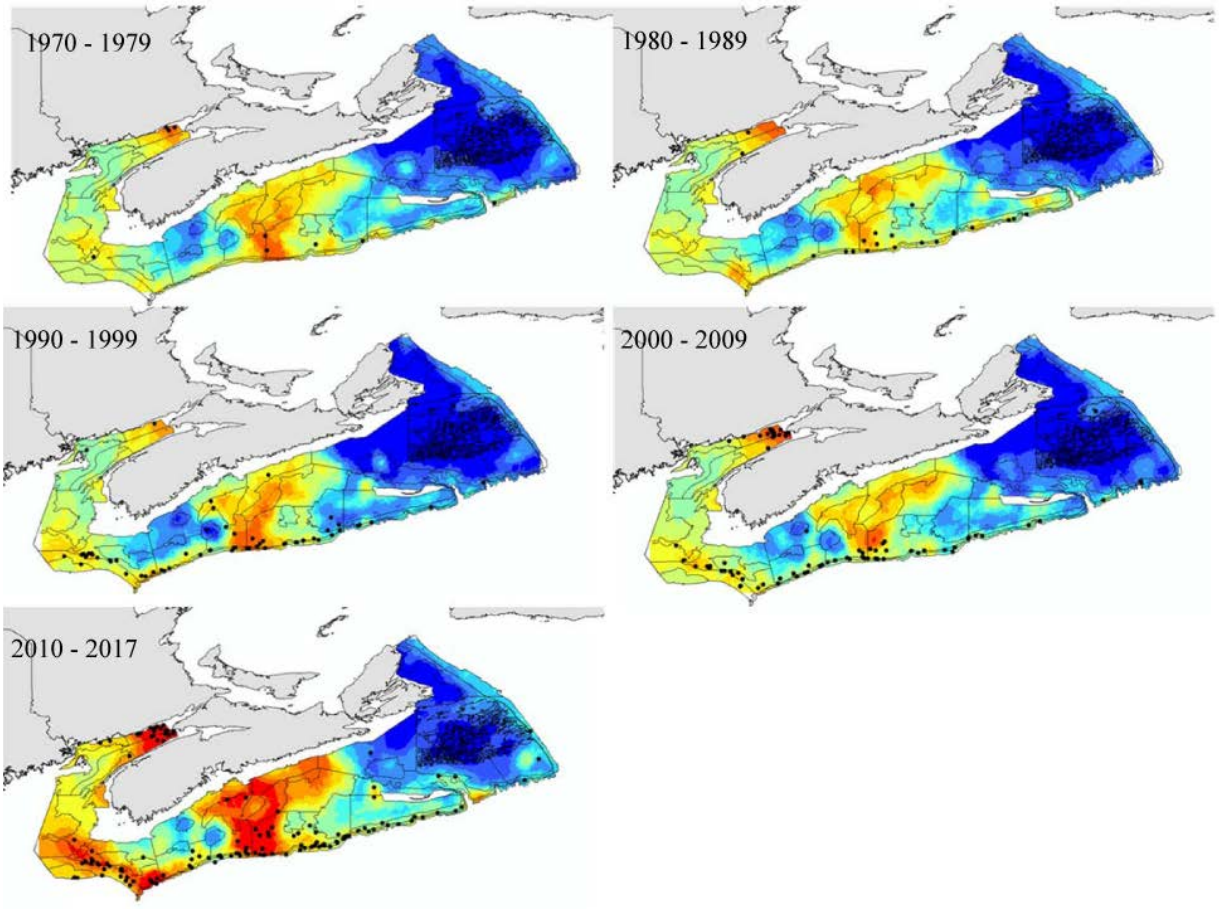

Figure 34. Decadal distribution of captures of warm water fish species overlaid on the average temperature for each time period

The total biomass index for the 24 species caught at temperatures averaging >8.5° C has exceeded 3,000 t in 2016 and 2017 for 4X and 4VW combined. While this remains fairly low relative to the overall groundfish biomass, it was roughly 50% of the combined 4VsW and 4X Cod biomass index in 2016 and 25% in 2017. The prevalence of these species in survey catches and their distribution on the shelf has clearly increased, suggesting that some will be taken as bycatch in regional fisheries.

Conclusions

The highest catches in 2017 were from redfish, Dogfish, Haddock, Herring, Squid, Lobster and Silver Hake, in that order (Table 1). Total biomass index for demersal fish from the survey remains low in 4VW (Figure 3a). In 4X, there is high inter-annual variability in total biomass index. While biomass appears to have been low for about 15 years in the middle of the time series, the total biomass indices recorded in last decade are similar in magnitude to those seen in the early part of the time series (Figure 3b). The survey biomass indices declined for most demersal fish in 4X from 2016 to 2017 (Table 1). It is not clear what led to this general pattern.

The three year geometric mean biomass indices for Halibut and Unit III redfish >22 cm were the highest in the time series in 2017 and the index for Barndoor Skate in 4X in 2017 was only exceeded in 2016. Conversely, the three year geometric mean biomass indices for 4X Thorny

Skate, 4X Yellowtail Flounder, 4X American Plaice, 4VW Cod, 4VW American Plaice and Ocean Pout in both 4X and 4VW were at their lowest or second lowest levels in 2017; all were at <40% of the long-term geometric mean biomass. Similarly, biomass indices for Atlantic Wolffish remain at very low levels in both 4X and 4VW.

Biomass indices for White Hake in both 4X and 4VW are in the critical zone in 2017 relative to the precautionary approach reference points.

The three year geometric mean biomass indices for Smooth Skate are above 80% of the long-term geometric mean in 4X and above 40% of the long-term geometric mean in 4VW.

Changes in biomass indices from one year to the next for individual species should be interpreted cautiously. A three year geometric mean of the survey biomass indices reduces the apparent variability in biomass estimates and may better reflect actual biomass trends. For those species where a population model is used, the inter-annual variability in population biomass estimates is lower than the variability in survey estimates. Additional information from commercial landings and age composition, where available, can help in interpreting survey data.

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