

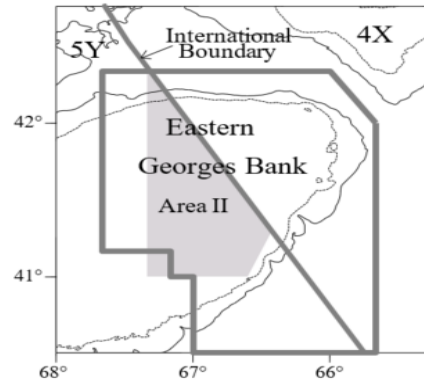


Transboundary Resources Assessment Committee

Status Report 2021/01

EASTERN GEORGES BANK COD

[5Zjm; 551,552,561,562]



Summary

- Combined Canada and USA catches in 2020 were 444 mt, including 18 mt of discards.
- Catches by length for the Canadian fishery peaked at 61 cm (24 in) in 2020.
- The 2021 Fisheries and Oceans Canada (DFO) survey swept area biomass value represents a new series low, while the National Marine Fisheries Service (NMFS) spring survey value is comparable to four of the previous six years.
- Cod condition remains below the long-term mean for the DFO spring survey, while 2021 condition from the NMFS spring survey has reached the highest level since the early 1990s.
- All other fishery and survey indicators remain generally consistent with those of the previous year, with no signs of recent large recruitment events for this stock, indicating that stock status remains poor.
- There was no 2020 NMFS fall survey due to COVID-19 pandemic restrictions. Ageing data from the 2021 NMFS spring survey were not yet available. Only aggregate landings and discards were available from the USA commercial fishery. The length and age composition information is not currently available for the 2020 USA fishery.
- Based on the approved Management Procedures, the range of catch advice for 2022 is 520 mt–650 mt. Available indicators remained generally consistent with the previous years, except NMFS spring condition (highest since 1990s) and DFO biomass index (series low). With one of the two available surveys reaching a new series low for biomass in 2021, consideration should be given to the 2022 Total Allowable Catch (TAC) being in the lower part of the catch advice range.
- The current application of the Data Limited Methods tool (DLMtool) is only intended as a short-term solution and should be replaced or supplemented with at least one functioning population model as soon as possible. The Transboundary Resource Assessment Committee (TRAC) strongly recommends a benchmark for this stock.

Fishery

Combined Canada/USA catches in 2020 were 444 mt, including 18 mt of discards, with a quota of 650 mt (Table 1). Historically, catches averaged 17,200 mt between 1978 and 1993, peaking at 26,463 mt in 1982. Catches declined to 1,683 mt in 1995, then fluctuated at about 3,000 mt until 2004, and have subsequently declined (Table 2).

Canadian catches decreased from 396 mt in 2019 to 377 mt in 2020 which is the lowest in the time series (Table A1). Discards of cod were estimated at 4 mt from the mobile gear fleet and 11 mt from the Canadian scallop fishery in 2020. The landings occurred primarily during the third and fourth quarter, using longline (46%), otter trawl (43%), and gillnet (11%) gears (Figure A1).

USA catches increased from 31 mt in 2019 to 67 mt in 2020 (Table A1). Estimated discards of cod for 2020 were 2.5 mt. Only the aggregate landing and discard data are currently available for the USA.

Table 1. Catches of eastern Georges Bank Cod (thousands mt).

		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Avg ¹	Min ¹	Max ¹
Canada ⁵	Quota	0.9	0.5	0.5	0.5	0.5	0.5	0.6	0.7	0.5	0.4			
	Catch	0.7	0.5	0.4	0.5	0.5	0.4	0.5	0.5	0.4	0.4	4.7	0.4	17.9
	Landed	0.7	0.4	0.4	0.4	0.5	0.4	0.5	0.5	0.4	0.4	4.6	0.4	17.8
	Discard	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1
USA ⁵	Quota ²	0.2	0.2	0.1	0.2	0.1	0.1	0.1	0.3	0.2	0.2			
	Catch ²	0.2	<0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1 ⁶	<0.1 ⁶			
	Landed	0.3	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	2.9	<0.1	10.6
	Discard	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3
Total	Quota	1.1	0.7	0.6	0.7	0.7	0.6	0.7	1.0	0.7	0.6			
	Catch ^{3,4}	0.9	0.5	0.4	0.5	0.6	0.5	0.5	0.6	0.4				
	Catch	1.0	0.6	0.4	0.6	0.6	0.5	0.5	0.6	0.5	0.4	7.6	0.4	26.5

¹1978-2019²for fishing year from May 1-April 30³for Canadian calendar year and USA fishing year May 1-April 30⁴sum of Canadian landed, Canadian discard, and USA catch (includes discards)⁵ unless otherwise noted, all values reported are for calendar year⁶ values reported for calendar year, not fishing year (May 1 to April 30)

The **size composition** of the 2020 Canadian fishery catches (landings and discards) were derived from the pooled port samples and at-sea samples from all principal gears and seasons (Table A2). Catches in 2020 peaked at 61 cm (24 in) for the Canadian fishery representing a slight increase from the 2019 fishing season (Figure A2). The size composition information is not currently available for the 2020 USA fishery.

The age composition is summarized for the Canadian fishery. The 2018 year class at age 3 was a major contributor to the Canadian 2020 fishery catch (45% of the fish by number), followed distantly by the 2019 year class at age 2 (18% by number) and the 2017 year class at age 4 (17% by number) (Figure 3; Figure 4). In 2020, fish ages 8+ accounted for <1% of the individuals caught in the Canadian fishery. The age composition information is not currently available for the 2020 USA fishery.

Harvest Strategy and Reference Points

The Transboundary Management Guidance Committee (TMGC) has adopted a strategy to maintain a low to neutral risk of exceeding the fishing mortality limit reference, $F_{ref} = 0.18$ (TMGC 2003). When stock conditions are poor, fishing mortality rates should be further reduced to promote rebuilding. With the rejection of the 2013 Benchmark models and the implementation of the DLMtool simulation framework, an estimate of fishing mortality can no longer be calculated.

DLMtool Application

Following the rejection of the Eastern Georges Bank (EGB) cod stock assessment models in 2018, the TRAC applied the Data Limited Methods Tool (DLMtool) to identify a simple, simulation tested method of providing advice until a Benchmark can be held for this stock. Prior to completion of this application, the TRAC was asked to examine survey and fishery indicators and determine if there is a need to revisit the 2018 TRAC advice of 650 mt, resulting in a carry-over of that advice in each year (TRAC 2018, TRAC 2019, TRAC 2020). On April 22nd, 2021, the

outputs of the simulation were presented at a TMGC Intercessional (TRAC 2021), with the TMGC selecting two Management Procedures (MP) to provide interim advice: status quo (650 mt) and status quo minus 20% (520 mt). Given the simulated low productivity state for this stock, none of the MPs considered are expected to substantially change the current state of the EGB cod stock, as long as conditions of low productivity persist.

Given the parameterization of the DLMtool application, and the existence of six operating models, the reference points coming out of the simulation testing were not deemed appropriate for use in evaluation of the Management Procedures. Consequently, a TMGC sub-working group developed and refined three short to medium term Management Objectives with five evaluation criteria and one performance metric to help evaluate the performance of the Management Procedures identified in Table A3.

The application of DLMtool to EGB cod required several assumptions about the current biological metrics of the stock, namely weight, growth and maturity (TRAC 2021). The outputs of the simulation testing remain valid as long as these biological assumptions hold. The DLMtool uses empirical data up to 2018 as the basis for these assumptions, which leaves room to test whether these assumptions hold as additional years of information become available. This year, the weight at age, growth, and maturity assumptions were compared to empirical survey data from the available 2019, 2020, and 2021 NMFS and DFO surveys. Due to the cancellation of the NMFS spring and NMFS fall survey in 2020, only the DFO survey data were used in the 2020 dataset, with both DFO and NMFS spring contributing to the 2021 dataset. All new values remain within the range used for the assumptions of weight at age, growth, and maturity, although the 2021 information falls along the outer limits of the growth parameters (Figures A5, A6, A7).

State of the Resource

Without an assessment model, the state of the resource is described by summarizing relevant survey trends. The 2021 survey **swept area biomass** was 1,821 mt for the DFO spring survey and 2,891 mt for the NMFS spring survey (Table A4; Figure A8). The 2021 DFO survey swept area biomass value represents a new series low, while the NMFS spring value is comparable to four of the previous six years (Table A4; Figure A8). The **swept area abundance** from the DFO survey decreased from 3.3 million in 2020 to 1.1 million in 2021, and remains below the series mean (1986–2021, 5.3 million fish) (Table A5).

The 2020 USA NMFS surveys were cancelled and the 2021 USA NMFS spring survey ageing data are not yet available. Consequently, the updated total mortality estimates are only provided for the DFO spring survey through 2021, while analyses for the NMFS spring survey and relative mortality will be provided for the 2022 TRAC.

Total mortality (Z) was calculated by two age groups (ages 4–5 and ages 6–8) using DFO survey abundance indices, fitted with a LOESS smooth to help track trends (Figure A10). Total mortality on ages 4 and 5 has been lower than the older group since the 1990s. Total mortality in both age groups remains high.

Total survey Z was also calculated using the Sinclair (2001) approach for the DFO spring survey, as was suggested for Georges Bank Yellowtail Flounder at the 2016 TRAC (Sinclair 2001; Curran and Brooks 2016). Ages 6–9 were used to calculate total survey Z for DFO, with Z values generally remaining high in recent years (Figure A11). The increasing occurrence of year and age combinations with no Cod observed in the surveys, particularly for the older ages, is problematic for these simple calculations of survey Z . There is still high unexplained mortality to be investigated for this stock. Although relative fishing mortality could not be calculated due to the absence of ages, in previous years relative mortality remained low while total mortality

estimates from the survey continue to be high. Estimated fishing removals are insufficient to support the high estimate of total mortality for eastern Georges Bank Cod.

Productivity

The **spatial distributions** of cod for the 2021 DFO and NMFS spring surveys remained broad, but large survey sets recorded along the northeastern edge of Georges Bank in the previous ten years were conspicuously absent in 2021 (Figure A12). The catches from the DFO spring survey were distributed across the Canadian portion of the bank, while the NMFS spring catches were broadly distributed across all of eastern Georges Bank. Given the more uniform magnitude of catches, the accompanying coefficients of variation were relatively low for both surveys (Figure A9).

The **length frequency** of the survey catch in the 2021 DFO spring survey peaked at 61 cm (24 in) and the 2021 NMFS spring survey peaked at 55 cm (22 in). Recent surveys continued to see fewer larger individuals compared to the previous ten years, and the 2021 catches were particularly flat-topped compared to the previous available year (Figure A13).

Fulton's **condition factor** (K) could only be updated with the most recent information for two of the three surveys (Figure A14). The surveys showed a downward trend throughout the series until 2009, when K either stabilized or began to increase for all three surveys (Figure 14). With the most recent data, cod K remains below the long-term mean for the DFO spring survey, while K from the 2021 NMFS spring survey has reached the highest level since the early 1990s.

Outlook

Available survey and fishery indicators remained generally consistent with the previous year's, although one of the two available surveys reached a new series low for biomass in 2021 and another is showing a record high for Cod condition (Table A6). The 2020 commercial catch was the second-lowest in the time series, representing a small increase from the series low in the previous year. All other fishery and survey indicators remain generally consistent with those of the previous year, with no signs of recent large recruitment events for this stock, indicating that stock status remains poor.

Given that the biological assumptions going into DLMtool are maintained, the simulated operating models remain appropriate. Based on the approved Management Procedures, the range of catch advice for 2022 is 520 mt–650 mt. Available indicators remained generally consistent with the previous years', except NMFS spring condition (highest since 1990s) and DFO biomass index (series low). With one of the two available surveys reaching a new series low for biomass in 2021, consideration should be given to the 2022 TAC being in the lower part of the catch advice range. There is a need to continue annual evaluation of whether the assumptions made in the projections of the DLMtool remain realistic. Although the simulation testing provided some improvement over the previous approach to generating advice by providing estimates of risk around the Management Procedures involved, it is intended as a short-term, interim solution. The TRAC strongly recommends a benchmark for this stock.

Special Considerations

Estimated removals in recent years in USA catches are a source of uncertainty. Further investigation is needed into the ecological role of cod and the potential implications of these changes on the recent productivity trends of Cod. In addition, investigation into the recent levels of natural mortality on eastern Georges Bank is recommended.

The USA commercial fishery data processing system is undergoing a change. The new system is called the Catch Accounting and Monitoring System (CAMS). Due to delays in implementation, the 2020 USA commercial fishery data could not be processed in time for this meeting. The data presented in this report was kindly provided by Dan Caless (NOAA Fisheries Greater Atlantic Regional Fisheries Office).

Finally, the current application of the DLMtool is only intended as a short-term solution and should be replaced or supplemented with at least one functioning population model as soon as possible. The DLMtool application assumes that all of the TAC is realized every year, while the actual catches have not exceeded the TAC since 2009. Actual catches have been 32–41% below TAC since 2018, due to restrictive management measures.

Source Documents

Curran, J.J. and E.N. Brooks, editors. 2016. Proceedings of the Transboundary Resources Assessment Committee (TRAC): Eastern Georges Bank Cod and Haddock, and Georges Bank Yellowtail Flounder. Report of Meeting held 12-14 Jul. 2016. TRAC Proceedings 2016/01.

Sinclair, A.F. 2001. Natural mortality of cod (*Gadus morhua*) in the southern Gulf of St. Lawrence. ICES J. Mar. Sci. 58: 1–10.

TMGC. 2003. Placeholder for reference on Page 3.

TRAC. 2018. Eastern Georges Bank Cod. TRAC Status Report 2018/01.

TRAC. 2019. Eastern Georges Bank Cod. TRAC Reference Document 2019/XX. Placeholder to update reference

TRAC. 2020. Eastern Georges Bank Cod. TRAC Status Report 2020/01.

TRAC. 2021. DLMtool Overview. TRAC Ref. Doc. Placeholder to update reference.

Correct Citation

TRAC. 2021. Eastern Georges Bank Cod. TRAC Status Report 2021/01.

APPENDIX – ADDITIONAL TABLES AND FIGURES REQUESTED FOR EXPANDED TSR

Table A1. Catches (mt) of Cod from eastern Georges Bank, 1978 to 2020. Total Allowable Catch (TAC) is reported for calendar year.

Year	Canada					USA				Combined	
	Landings	Discards Scallop	Discards Groundfish	Total Catch	TAC	Landings	Discards	Total Catch	TAC	Catch	TAC
1978	8,777	98	-	8,875	-	5,502	-	5,502	-	14,377	-
1979	5,979	103	-	6,082	-	6,408	-	6,408	-	12,490	-
1980	8,066	83	-	8,149	-	6,418	-	6,418	-	14,567	-
1981	8,508	98	-	8,606	-	8,092	-	8,092	-	16,698	-
1982	17,827	71	-	17,898	-	8,565	-	8,565	-	26,463	-
1983	12,131	65	-	12,196	-	8,572	-	8,572	-	20,769	-
1984	5,761	68	-	5,829	-	10,558	-	10,558	-	16,387	-
1985	10,442	103	-	10,545	-	6,641	-	6,641	-	17,186	-
1986	8,504	51	-	8,555	-	5,696	-	5,696	-	14,251	-
1987	11,844	76	-	11,920	-	4,793	-	4,793	-	16,713	-
1988	12,741	83	-	12,824	-	7,645	-	7,645	-	20,470	-
1989	7,895	76	-	7,971	-	6,182	84	6,267	-	14,238	-
1990	14,364	70	-	14,434	-	6,414	69	6,483	-	20,917	-
1991	13,467	65	-	13,532	-	6,353	112	6,464	-	19,997	-
1992	11,667	71	-	11,738	-	5,080	177	5,257	-	16,995	-
1993	8,526	63	-	8,589	-	4,019	57	4,077	-	12,665	-
1994	5,277	63	-	5,340	-	998	5	1,003	-	6,343	-
1995	1,102	38	-	1,140	-	543	0.2	544	-	1,683	-
1996	1,924	56	0.0	1,980	-	676	1	677	-	2,657	-
1997	2,919	58	428	3,405	-	549	6	555	-	3,960	-
1998	1,907	92	273	2,272	-	679	7	686	-	2,959	-
1999	1,818	85	253	2,156	-	1,195	9	1,204	-	3,360	-
2000	1,572	69	0.0	1,641	-	772	16	788	-	2,429	-
2001	2,143	143	0.0	2,286	-	1,488	146	1,634	-	3,920	-
2002	1,278	94	0.0	1,372	-	1,688	9	1,697	-	3,069	-
2003	1,317	200	-	1,528	-	1,851	85	1,935	-	3,463	-
2004	1,112	145	-	1,257	NA	1,006	57	1,063	NA	2,321	1,300
2005	630	84	144	859	NA	171	199	370	NA	1,228	1,000
2006	1,096	112	237	1,445	NA	131	94	226	NA	1,671	1,700
2007	1,108	114	0.0 ¹	1,222	NA	234	279	513	NA	1,735	1,900

¹ Discards for the Mobile Fleet were calculated to be 0. Discards for the Fixed Gear fleet were not calculated due to low observer coverage.

Year	Canada					USA				Combined	
	Landings	Discards Scallop	Discards Groundfish	Total Catch	TAC	Landings	Discards	Total Catch	TAC	Catch	TAC
2008	1,390	36	103	1,529	1,633	224	20	244	667	1,774	2,300
2009	1,003	69	137	1,209	1,173	433	147	580	527	1,789	1,700
2010	748	44	48	840	1,012	357	97	454	338	1,294	1,350
2011	702	29	13	743	850	267	20	287	200	1,030	1,050
2012	395	42	31	468	612	96	52	148	63	616	675
2013	385	18	21	424	504	24	16	40	96	464	600
2014	430	15	13	458	546	114	2	116	154	574	700
2015	472	13	7	492	526	111	5	116	124	608	650
2016	428	9	3	440	488	92	5	97	136	537	624
2017	474	7	7	488	584	34	4	38	146	526	730
2018	510	5	2	517	694	47	2	48	257	565	951
2019	388	5	3	396	461.5	30	1	31	189	428	650
2020	362	11	4	377	461.5	64	3	67	189	444	650
Min	362	5	0	377		24	<1	31		428	
Max	17,827	200	428	17,898		10,558	279	10,558		26,463	
Ave	4,637	67	75	4,745		2,810	58	2,851		7,796	

Table A2. Length and age samples from the USA and Canadian fisheries on eastern Georges Bank. For Canadian fisheries, at-sea observer samples are included since 1990. The first quarter age samples are supplemented with USA fishery age samples from 5Zjm for 1978–1986 and Fisheries and Oceans Canada survey age samples for 1987–2020; the numbers are shown in brackets. The highlighted numbers include samples from western Georges Bank. “-” indicates commercial data from the USA fishery is not available for 2020.

Year	USA		Canada	
	Lengths	Ages	Lengths	Ages
1978	2,294	384	7,684	1,364
1979	2,384	402	3,103	796 (205)
1980	2,080	286	2,784	728 (192)
1981	1,498	455	4,147	897
1982	4,466	778	4,705	1,126 (268)
1983	3,906	903	3,822	754 (150)
1984	3,891	1,130	1,889	1,243 (858)
1985	2,076	597	7,031	1,309 (351)
1986	2,145	643	5,890	991 (103)
1987	1,865	524	9,133	1,429 (193)
1988	3,229	797	11,350	2,437 (510)
1989	1,572	347	8,726	1,561
1990	2,395	552	31,974	2,825 (1,153)
1991	1,969	442	27,869	1,782
1992	2,048	489	29,082	2,215 (359)
1993	2,215	569	31,588	2,146
1994	898	180	27,972	1,268
1995	2645	14	6,660	548
1996	4,895	1,163	26,069	828
1997	1,761	82	31,617	1,216
1998	1,301	338	26,180	1,643
1999	726	228	26,232	1,290 (410)
2000	500	121	20,582	1,374
2001	1,434	397	19,055	1,505
2002	1,424	429	16,119	1,252
2003	1,367	416	19,757	1,070
2004	1,547	517	18,392	1,357
2005	297	65	23,937	1,483 (697)
2006	446	151	44,708	1,460 (648)
2007	589	183	141,607	1,647 (456)

Year	USA		Canada	
	Lengths	Ages	Lengths	Ages
2008	972	295	64,387	1,709 (495)
2009	1,286	326	48,335	1,725 (246)
2010	1,446	333	30,594	1,455 (433)
2011	1,203	213	40,936	1,655 (536)
2012	598	746 ¹	49,447	1,115 (216)
2013	2,951	842	75,275	1,334 (319)
2014	547	85	50,501	1,141 (184)
2015	4,677	1,049 ²	74,028	970 (202)
2016	715	149	76,869	990 (282)
2017	4,120	1,150 ³	50,902	1,039 (334) ⁴
2018	1,695	412	54,609	1,254 (309) ⁵
2019	1,180 ⁶	288 ⁷	60,851	1,401 (190)
2020	-	-	67,598	1,199 (259)

¹ Age and length data supplemented with ages from statistical areas 522 and 525.

² Age and length data supplemented with ages from statistical area 522.

³ Age and length data supplemented with ages from statistical areas 522 and 525.

⁴ Survey ALK used to supplement quarter 1 age and length data for scallop discards only

⁵ Survey ALK used to supplement quarter 1 age and length data for scallop discards only

⁶ Age and Length data from landings only from statistical areas 522 and 561, as well as 521 for just ages

⁷ Age and Length data from landings only from statistical areas 522 and 561, as well as 521 for just ages

Table A3. Proposed Management Objectives (MO), along with their respective timelines and example evaluation criteria.

Management Objective	Description	Timeline	Evaluation Criteria
MO_1	- There should be a less than 25% probability of the stock exceeding a conservative F strategy.	2030	$P(F > 0.1) < 0.25$
MO_2	- In general, when stock conditions are poor, Rebuilding to a level 1.5 and 2.5 times the current biomass should be achieved in a reasonable timeframe (11-15 years) with a high degree of probability (75%).	2030	$P(SSB > 2.5 * SSB_{2017}) > 0.75$ $P(SSB > 1.5 * SSB_{2017}) > 0.75$
MO_3	- The long-term objective for 5Z Atlantic cod is to grow the stock out of poor condition, and maintain Spawning Stock Biomass (SSB) at a level 1.5 or 2.5 times the current SSB.	2030	$[P(SSB > 2.5 * SSB_{2017}) > 0.5]_{3yrs}$ $[P(SSB > 1.5 * SSB_{2017}) > 0.5]_{3yrs}$
MO_4*	- Stability in TAC between management periods. i.e. Any increase or decrease in TAC between management periods should be less than 10-20%.	N/A	$ TAC_{Y1} - TAC_{Y2} < 0.15$

*Used as a performance metric, instead of an actual objective

Table A4. Swept area biomass (mt) for eastern Georges Bank cod from the Fisheries and Oceans (DFO), National Marine Fisheries Service (NMFS) spring and fall surveys. Conversion factors to account for vessel and trawl door changes have been applied. The biomass conversion factor used for the Henry B. Bigelow since 2009 is 1.58 ($B_{survey} = B_{bigelow} / 1.58$). “-“ indicates no data available.

Year	NMFS Fall	NMFS Spring	DFO
1970	5,054	7,801	-
1971	5,287	10,435	-
1972	3,947	13,779	-
1973	11,697	82,311	-
1974	2,741	27,269	-
1975	5,246	23,503	-
1976	5,082	10,354	-
1977	9,509	9,335	-
1978	12,213	22,731	-
1979	13,050	12,831	-
1980	4,494	20,520	-
1981	7,256	18,568	-
1982	2,216	172,300	-
1983	2,449	20,376	-
1984	7,018	4,808	-
1985	2,390	23,190	-
1986	2,174	12,532	18,633
1987	2,634	7,615	8,824
1988	6,764	9,294	19,452
1989	5,145	12,104	14,547
1990	5,121	10,828	56,665
1991	435	9,391	25,068
1992	1,734	6,113	14,581
1993	606	6,598	16,545
1994	1,734	1,294	13,140
1995	1,220	10,113	8,118
1996	1,790	6,613	32,173
1997	1,875	4,051	11,004
1998	2,970	12,267	5,006
1999	1,044	5,308	9,178

Year	NMFS Fall	NMFS Spring	DFO
2000	895	7,374	32,298
2001	1,159	3,721	18,037
2002	11,525	4,432	20,333
2003	608	6,405	6,218
2004	8,347	21,080	5,661
2005	1,446	4,407	26,200
2006	2,165	7,331	12,546
2007	424	6,066	11,228
2008	792	5,327	13,657
2009	1,203	4,343	23,180
2010	732	3,587	26,352
2011	2,304	1,724	8,437
2012	609	4,864	2,449
2013	2,566	9,616	11,113
2014	1,376	3,254	2,409
2015	3,570	1,748	3,594
2016	5,438	3,579	3,656
2017	653	13,479	14,566
2018	2,549	3,097	7,198
2019	1,621	9,228	4,059
2020	-	-	4,214
2021	-	2,819	1,821

Table A5. Indices of swept area abundance (thousands) for eastern Georges Bank Cod from the Fisheries and Oceans Canada (DFO) survey, 1986–2019.

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total
1986	0	770	3538	3204	331	692	445	219	35	66	0	10	0	0	0	0	0	9311
1987	0	48	1791	642	753	162	89	181	89	13	13	0	13	16	0	0	0	3812
1988	0	148	450	5337	565	838	95	79	179	18	12	4	0	16	0	0	0	7741
1989	0	350	2169	764	1706	258	332	42	85	112	5	32	8	5	0	0	0	5868
1990	20	106	795	3471	1953	4402	535	1094	144	157	289	65	52	37	0	0	5	13125
1991	0	1198	1019	1408	1639	882	1195	148	249	38	45	30	12	5	8	0	0	7876
1992	0	48	2049	1221	409	643	451	300	93	38	0	3	3	18	0	0	0	5276
1993	0	31	355	1723	622	370	754	274	268	51	31	0	20	6	0	0	0	4504
1994	0	13	629	691	1289	477	182	363	84	119	12	0	0	0	8	5	0	3871
1995	0	32	187	1240	757	520	186	44	67	28	18	8	6	0	0	0	0	3093
1996	0	90	203	1744	4337	1432	1034	445	107	149	39	4	0	0	5	0	0	9590
1997	0	30	376	568	1325	1262	216	50	35	23	17	0	3	0	0	0	0	3905
1998	0	6	582	831	322	317	238	56	29	7	8	3	4	0	0	0	0	2402
1999	0	3	156	1298	1090	449	317	190	10	28	5	9	0	3	0	0	0	3561
2000	0	0	423	1294	4967	2157	1031	510	317	20	23	12	0	0	0	0	0	10754
2001	0	3	37	802	519	1391	645	334	224	225	36	24	7	0	0	0	0	4248
2002	0	0	118	477	2097	694	1283	458	188	63	76	7	0	0	0	0	0	5462
2003	0	0	8	200	510	867	194	219	69	12	0	0	0	0	0	0	0	2078
2004	0	427	40	246	381	422	353	59	108	25	5	0	3	0	0	0	0	2069
2005	0	25	1025	1398	7149	1766	816	743	60	87	8	4	0	0	0	0	0	13082
2006	0	0	41	1500	673	1779	757	217	216	83	34	10	15	0	0	0	0	5325
2007	0	18	130	549	2606	379	653	119	81	53	0	4	0	0	0	0	0	4591
2008	0	12	147	1027	755	2978	194	392	41	4	20	0	0	0	0	0	0	5569
2009	0	11	51	2487	2261	519	2955	0	82	0	0	0	18	0	0	0	0	8384
2010	0	5	92	956	4105	1781	703	1828	65	84	5	0	0	0	0	0	0	9623

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total
2011	0	193	271	766	952	1324	256	67	112	14	8	2	0	0	0	0	0	3965
2012	0	9	149	327	315	195	158	7	18	4	0	0	0	0	0	0	0	1182
2013	0	0	431	3754	2173	285	81	52	10	0	0	0	0	0	0	0	0	6786
2014	0	76	9	360	538	169	35	0	27	0	0	0	0	0	0	0	0	1213
2015	0	0	476	152	598	439	97	7	0	0	0	0	0	0	0	0	0	1770
2016	0	8	197	1004	199	273	147	16	4	0	0	0	0	0	0	0	0	1848
2017	0	5	52	1660	5897	194	270	188	0	0	0	0	0	0	0	0	0	8266
2018	0	39	149	520	1060	1610	77	50	7	0	0	0	0	0	0	0	0	3512
2019	0	9	269	1005	574	389	284	0	0	6	6	0	0	0	0	0	0	2542
2020	0	32	466	1753	620	330	49	20	5	0	0	0	0	0	0	0	0	3274
2021	4	62	189	297	394	101	43	6	27	0	0	0	0	0	0	0	0	1124

Table A6. Summary of change in fishery and survey indicators from 2020 to 2021 Transboundary Resource Assessment Committee (TRAC). In cases where 2020 information is not available, the comparison is made to 2019 information. CDN=Canada. DFO=Fisheries and Oceans Canada. NMFS=National Marine Fisheries Service.

Indicators	2019 TRAC	2020 TRAC	2021 TRAC	Summary
Fishery Catch	Landings = 556mt Discards = 9mt	Landings= 418 mt Discards= 9 mt	Landings = 426 mt Discards = 18 mt	Increase in landings Increase in discards
Fishery Catch at Length	CDN: 61cm (24 in) USA: 65cm (26 in)	CDN: 58 cm (23 in) USA: 60 cm (24 in)	CDN: 61 cm (24 in) USA: NA	CDN fishery: Slight Increase USA fishery: NA
Fishery Catch at Age	2013 year class (37% by number and 45% by weight)	2016 (26% by number), 2017 (23%), and 2015 (22%) year classes	Only Canadian data: 2017 year class (45% by number)	Pulled primarily by one yearclass, versus multiple contributors in the previous year (**Based only on Canadian data)
Survey Catch at Length	DFO: 52cm (20.5in) NMFS spr: 55cm (22in) NMFS fall (multiple peaks (12, 34 and 58cm)	DFO: 52 cm (20.5 in) NMFS spr: NA NMFS fall: multiple peaks (34 and 64 cm)	DFO: 61 cm (24 in) NMFS spr: 55 cm (22 in) NMFS fall: NA	DFO: Increase in peak size, but CAL below 10 year mean at most lengths NMFS spr: NA (comparable peak to 2019, with CAL below 10 year mean at most lengths) NMFS fall: NA

Indicators	2019 TRAC	2020 TRAC	2021 TRAC	Summary
Survey Catch at Age	DFO: 2016 yc (age 3) NMFS spr: 2015yc (age 4) NMFS fall (2017yc)	DFO: Dominated by 2017 yc NMFS spr: NA NMFS fall: No dominant age class	DFO: Multiple major contributors (2017 and 2018yc) NMFS spr: NA NMFS fall: NA	
Swept Area Abundance	DFO: 2.5 million NMFS spr: 5.3 million NMFS fall: 1.3 million	DFO: 3.3 million NMFS spr: NA NMFS fall: 638 000	DFO: 1.1 million NMFS spr: 1.5 million NMFS fall: NA	DFO: Decrease NMFS spr : NA NMFS fall: NA
Biomass	DFO: 4,059 NMFS spr: 9,228 NMFS fall: 2,549	DFO: 4,214 NMFS spr: NA NMFS fall: 1,621	DFO: 1,821 NMFS spr: 2,819 NMFS fall: NA	DFO: Decrease to new series low NMFS spr : Decrease from 2019 NMFS fall: NA
Condition	DFO: < long term mean NMFS spr: > long term mean NMFS fall: at long term mean	DFO: < long term mean NMFS spr: NA NMFS fall: > long term mean	DFO: < long term mean NMFS spr: > long term mean NMFS fall: NA	DFO: No change NMFS spr : Increase to highest since 1990s NMFS fall : NA
Total Mortality on older ages	DFO: high NMFS spr: high	DFO: high NMFS spr: NA	DFO: high NMFS spr: NA	DFO: No change NMFS spr: NA

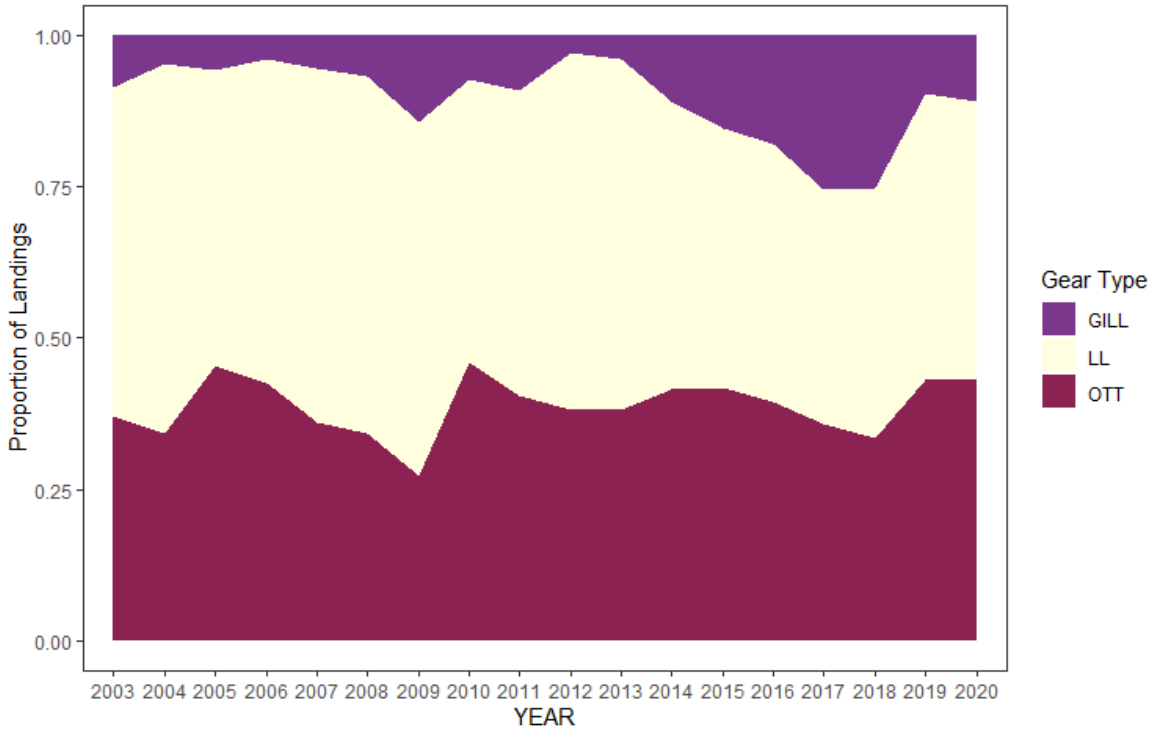


Figure A1. Proportional landings of Cod by gear from eastern Georges Bank for Canada (2002–2020). Commercial data from the USA fishery were not available for the 2020 fishing year.

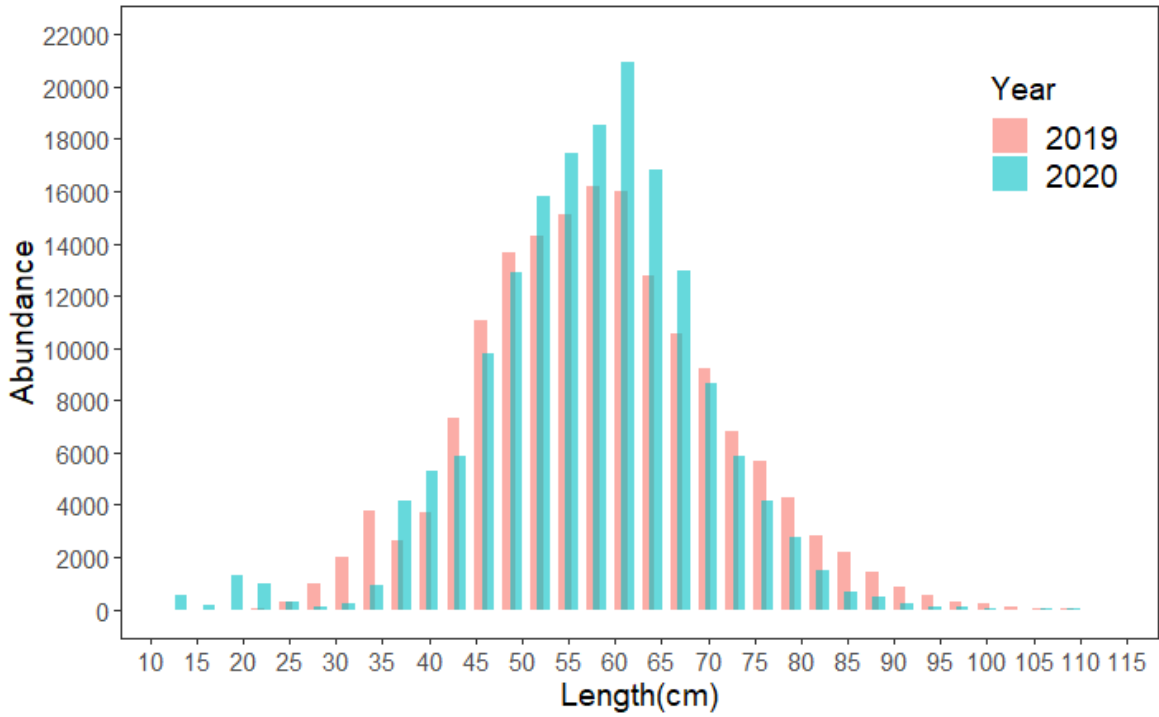


Figure A2. Length frequency of Cod catch (landings and discards) from the 2019 and 2020 Canadian fisheries on eastern Georges Bank. Commercial data from the USA fishery were not available for the 2020 fishing year.

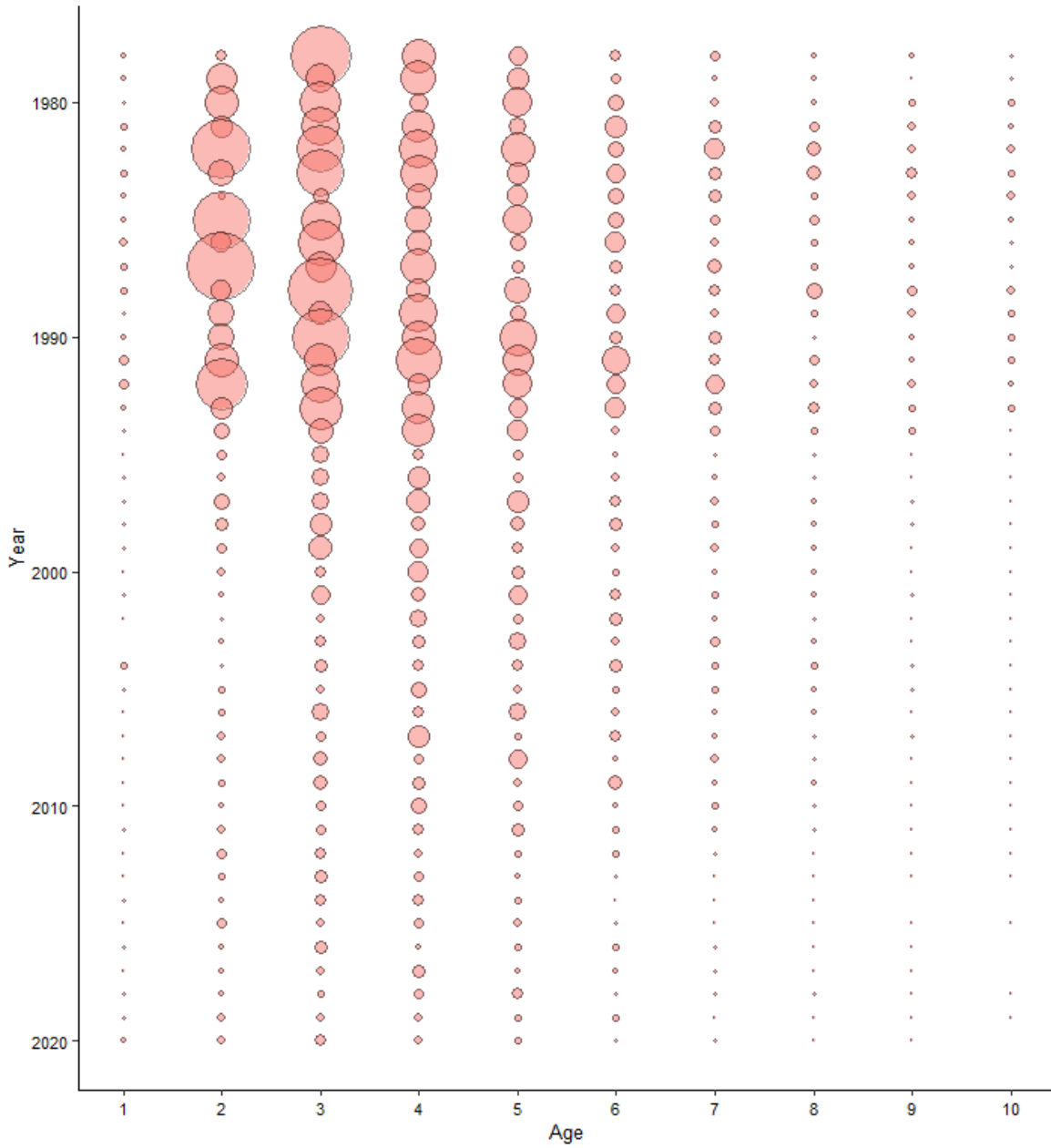


Figure A3. Fishery Catch-at-Age for the Canadian fishery, updated through until 2020. Size of bubbles is representative of abundance.

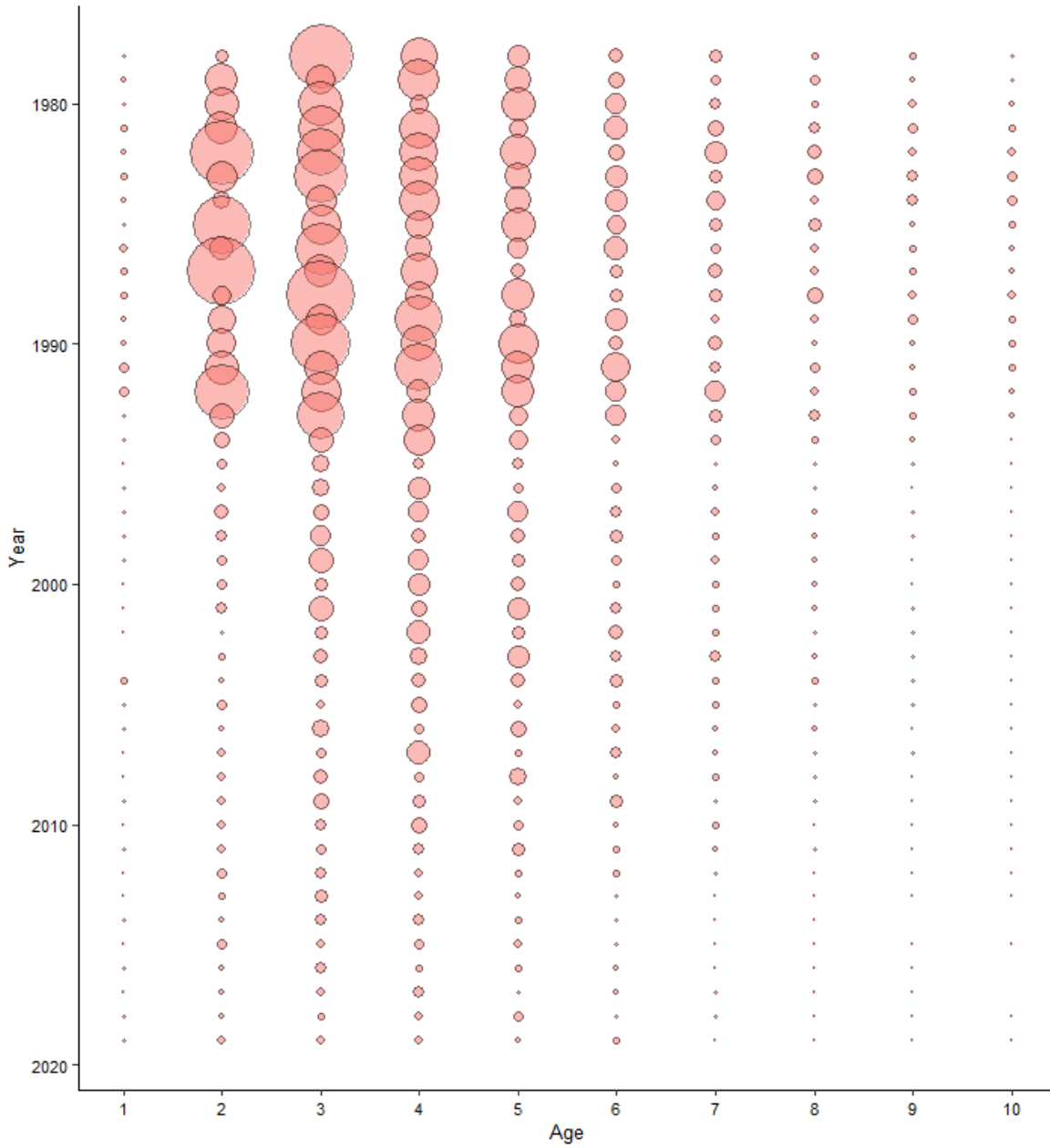


Figure A4. Combined Canada and USA fishery Catch at Age for eastern Georges Bank Cod, updated through until 2019. Size of bubbles is representative of abundance.

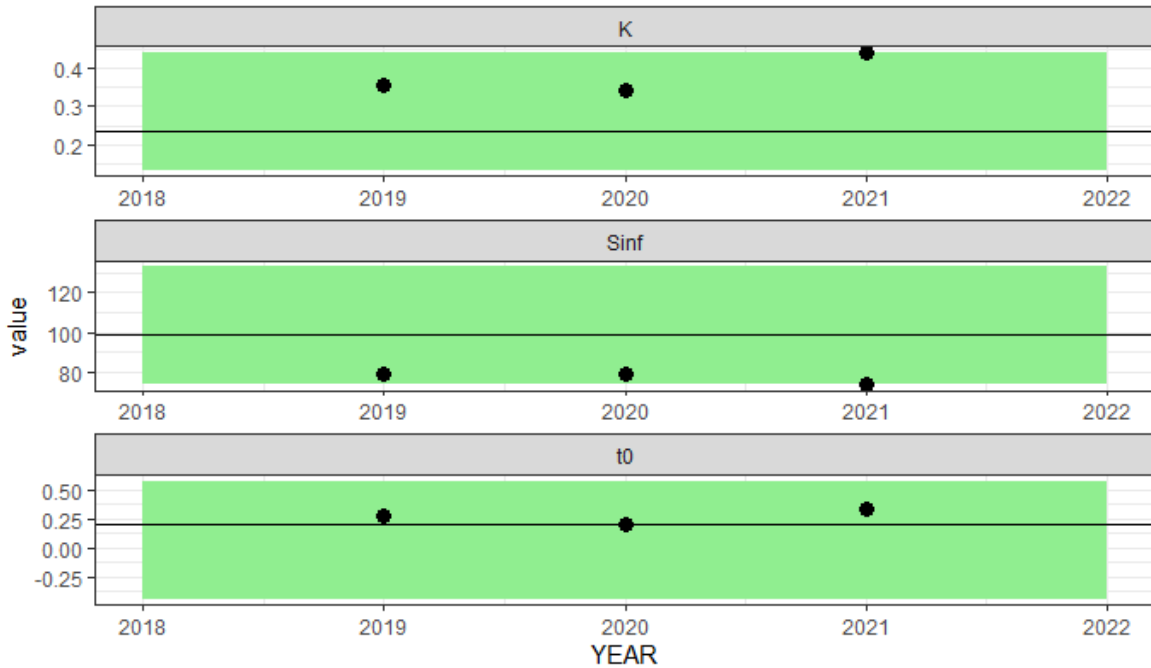


Figure A5. Temporal trends in von Bertalanffy growth parameters fit to survey data, for years 2019–2021. Points are annual growth curve fits, horizontal lines are growth curve fits spanning time period used in the DLMtool projection assumptions (2003–2019), and green rectangles indicate quantiles (0.01% and 99.9%) of that time period.

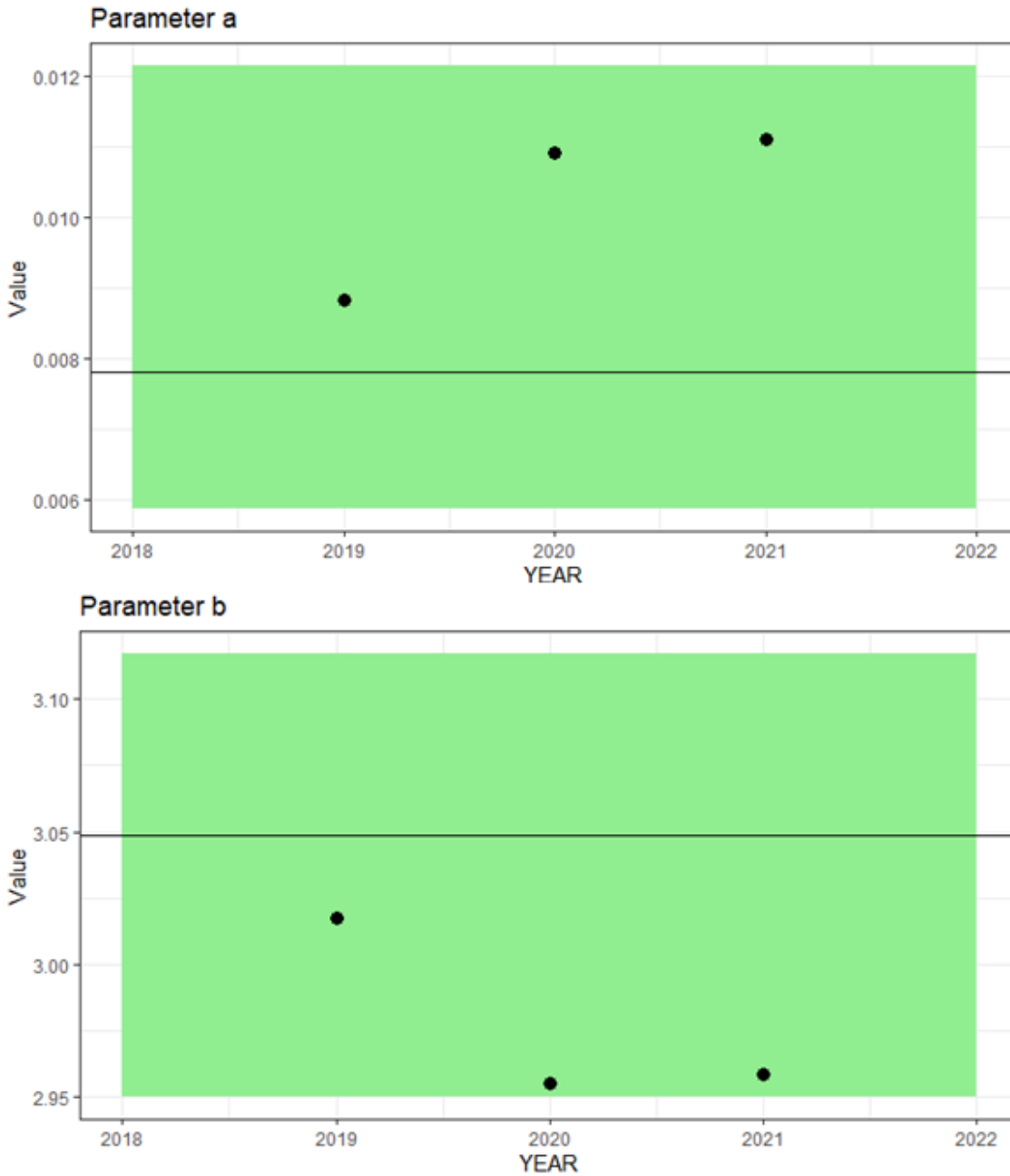


Figure A6. Trend in length-weight parameters for years 2019–2021. Horizontal lines indicate a (0.007812815) and b (3.048425056) values used in the projection assumptions in DLMtool, based on the complete time series (1980–2021). Green rectangles indicate quantiles (0.01% and 99.9%) for that time series.

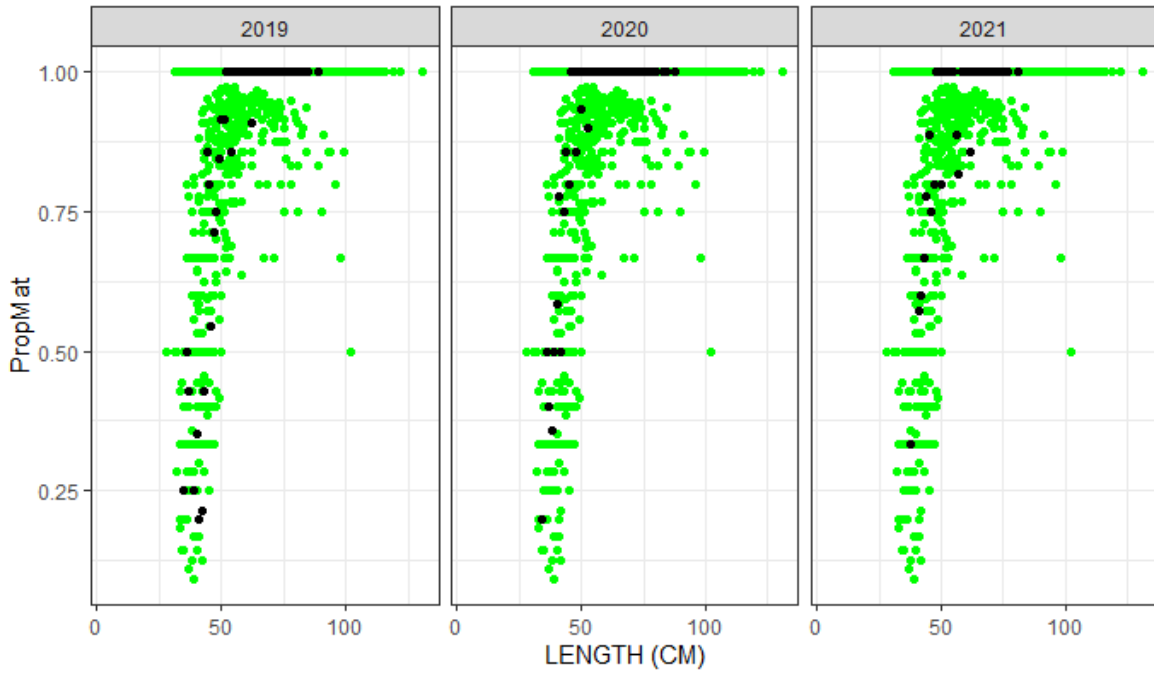


Figure A7. The pooled National Marine Fisheries Service (NMFS) and Fisheries and Oceans Canada (DFO) spring survey length-at-maturity data from 2000–2018 used to inform the L50–L95 assumptions for DLMtool projections (green). The black points indicate the data available since then from the NMFS spring (2019 and 2021) and DFO spring (2019–2021) surveys.

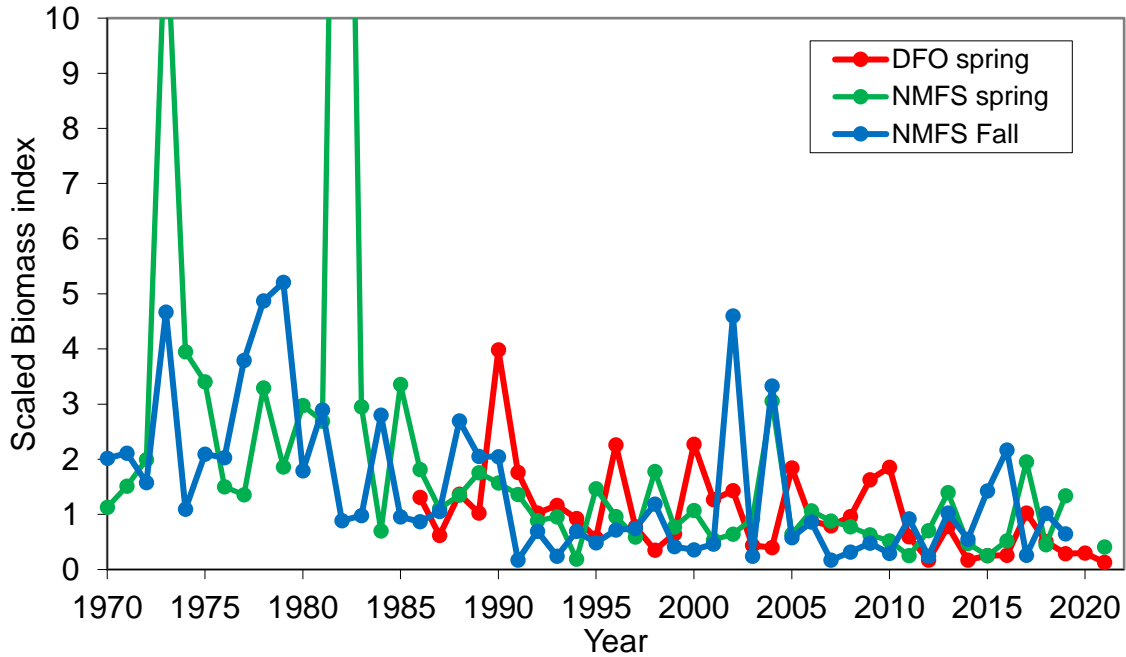


Figure A8. Survey biomass indices (ages 1+) for eastern Georges Bank Cod from the Fisheries and Oceans Canada (DFO) spring (2021), National Marine Fisheries Service (NMFS) spring (2021), and NMFS fall (2019) surveys scaled to their respective time series means. There was no NMFS fall survey in 2020.

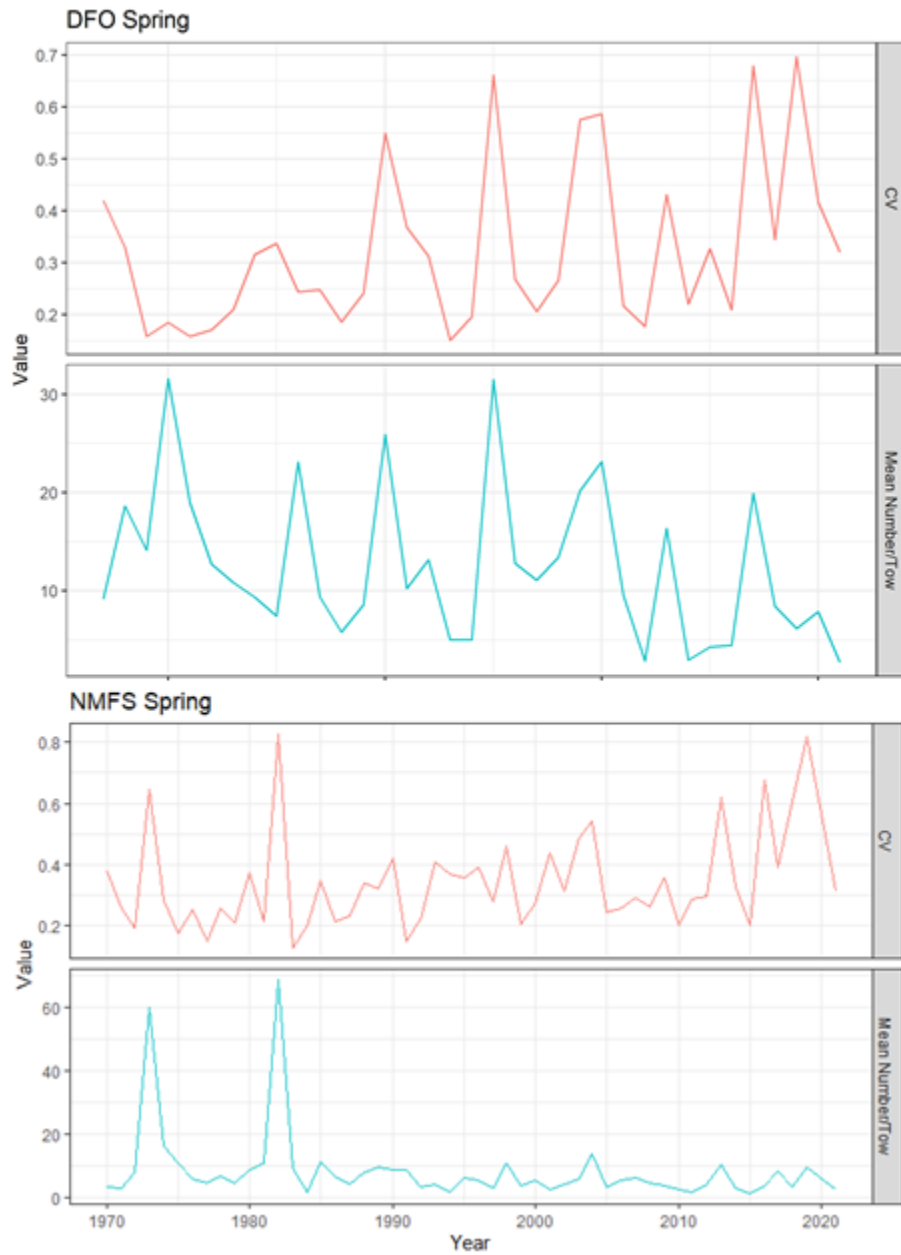


Figure A9. Stratified mean number-per-tow and coefficient of variation (CV) for Fisheries and Oceans Canada (DFO; top) and National Marine Fisheries Service (NMFS; bottom) spring survey catch of eastern Georges Bank Cod. There was no 2020 NMFS fall survey.

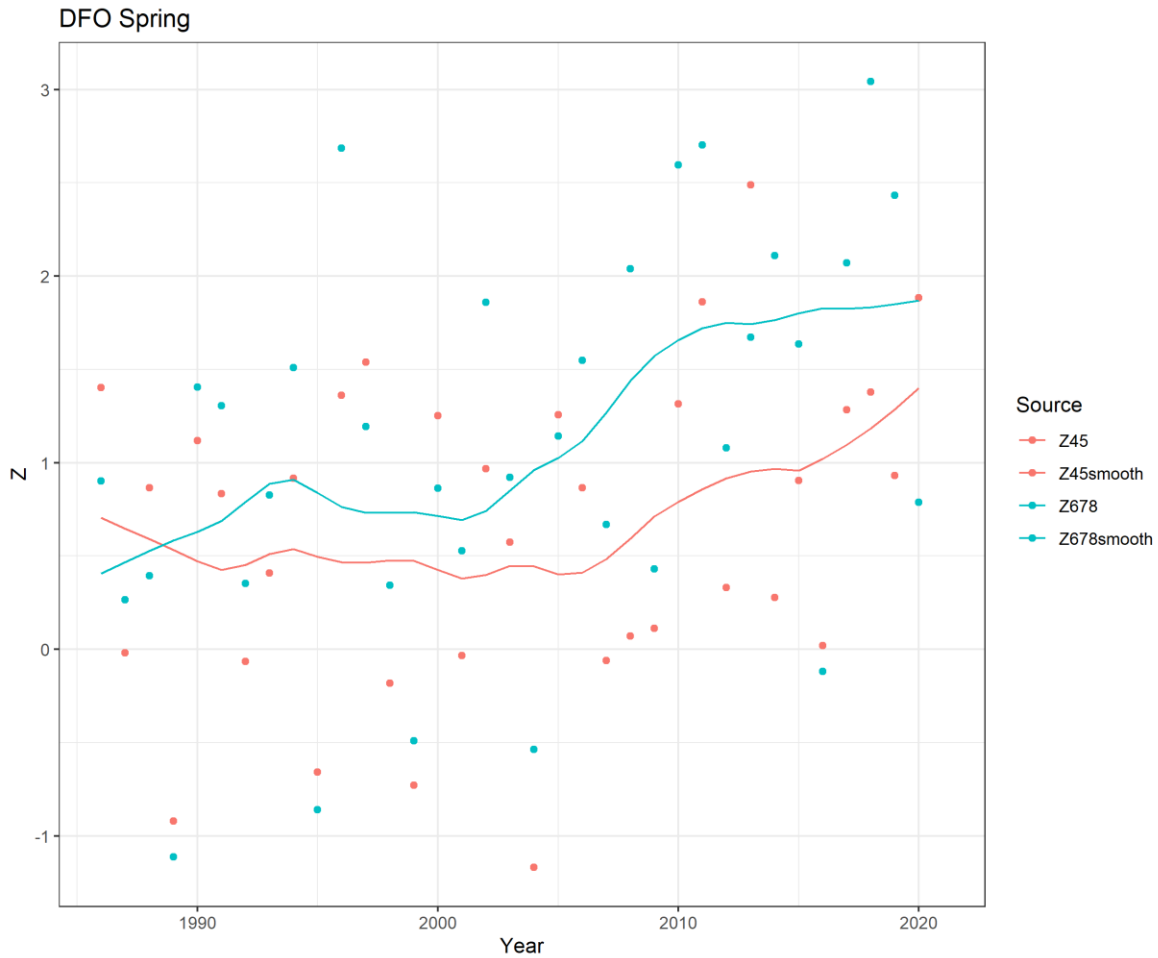


Figure A10. Total mortality (Z) calculated using the Fisheries and Oceans Canada (DFO) spring survey data for eastern Georges Bank Cod. Colour of the points refers to the age-group the mortality was calculated for (Z45 - ages 4 and 5; Z678 - ages 6, 7 and 8). Line is a smoother applied to the point data. There was no National Marine Fisheries Service (NMFS) fall survey in 2020 and age data from the NMFS spring survey in 2021 were not available.

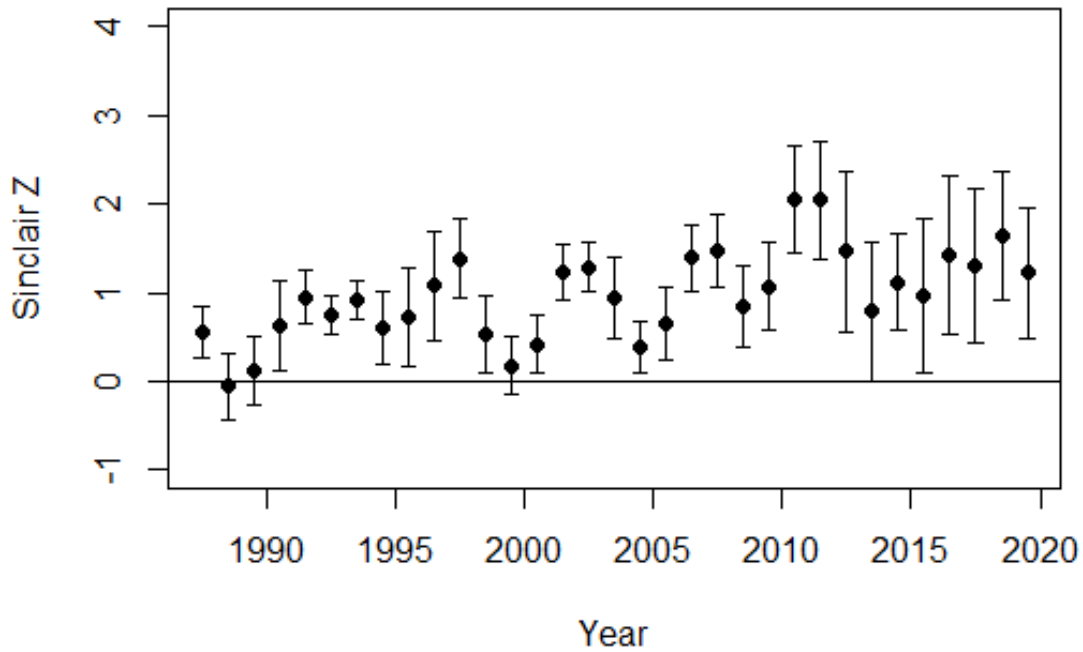


Figure A11. Empirical estimate of total mortality for the Fisheries and Oceans Canada (DFO; ages 6–9) spring survey. There was no National Marine Fisheries Service (NMFS) fall survey in 2020 and age data from the NMFS spring survey in 2021 were not available.

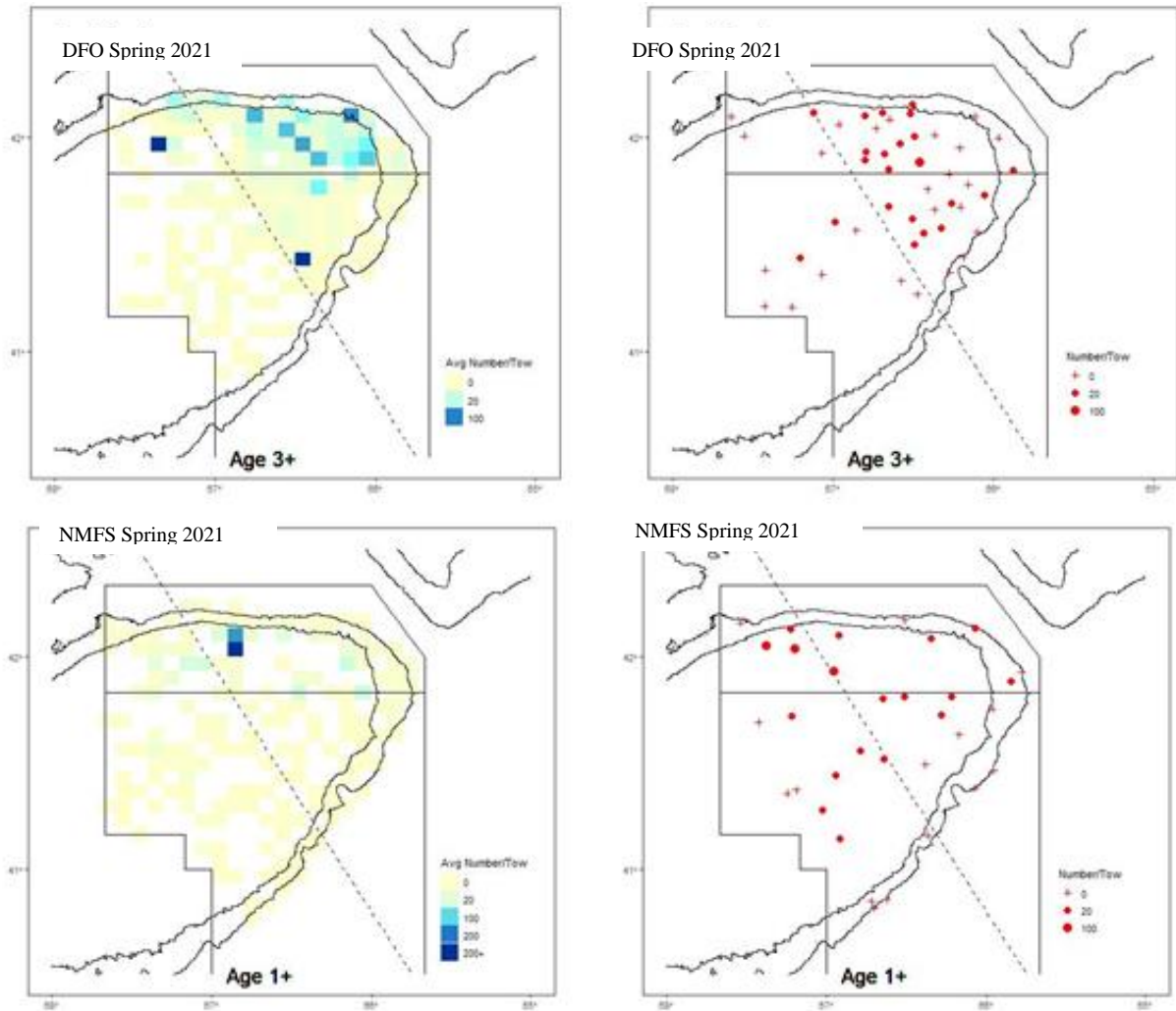


Figure A12. Spatial distribution of age 3+ Cod on eastern Georges Bank from the Fisheries and Oceans (DFO) survey for 2021 (top right) compared to the average for 2011–2020 (top left), and spatial distribution of age 1+ Cod on eastern Georges Bank from the National Marine Fisheries Service (NMFS) spring survey for 2021 (bottom right) compared the average for 2011–2020 (bottom left) There was neither a spring, nor fall, NMFS survey in 2020. Ageing data for the NMFS spring survey 2021 is not yet available.

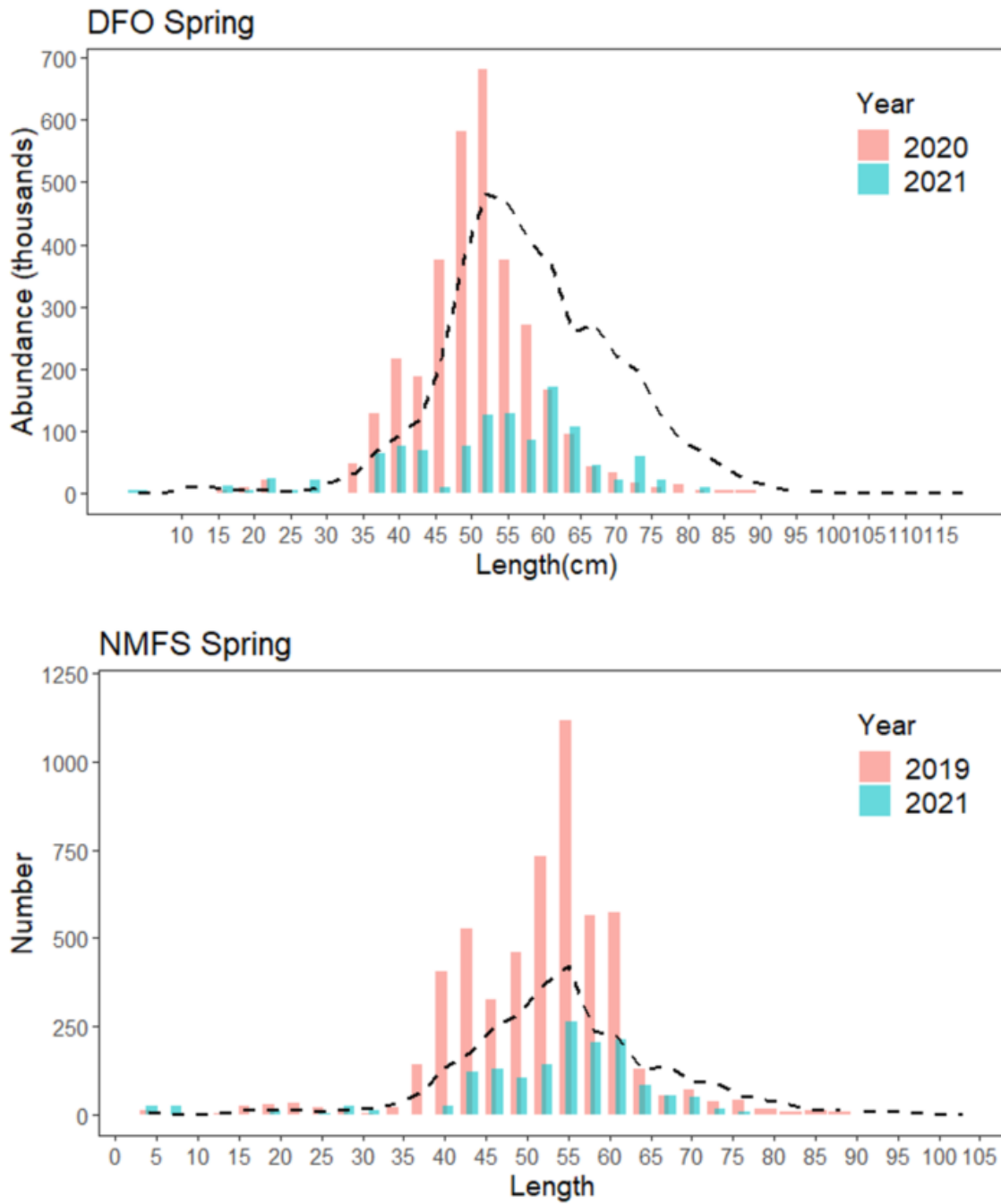


Figure A13. Length frequency distribution of the Fisheries and Oceans Canada (DFO; 2020 and 2021) and National Marine Fisheries Service (NMFS; 2019 and 2021) spring surveys. Bars represent the most recent two years and the dashed line shows the average distribution from the previous ten years (2010–2020). The NMFS spring survey plot compares 2019 and 2021 because there was no NMFS spring survey in 2020.

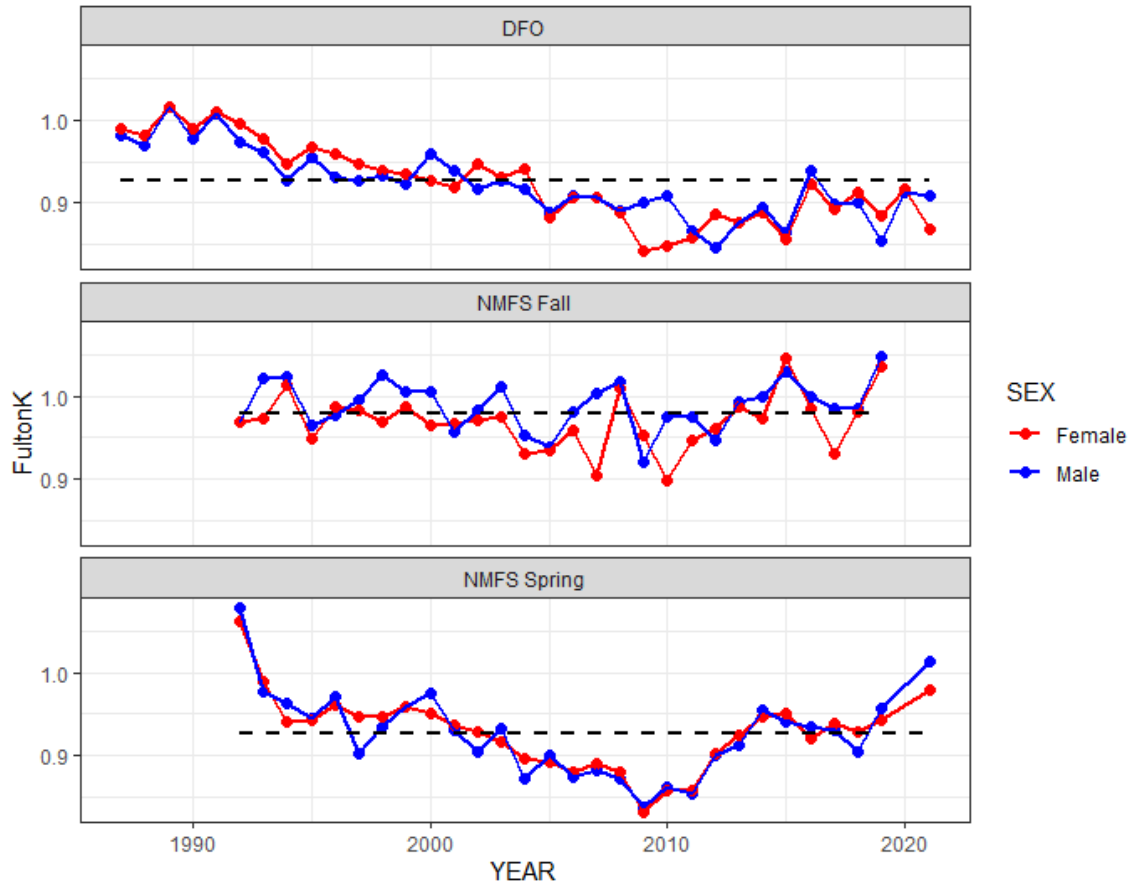


Figure A14. Fish condition (Fulton's K) of post-spawning Cod for eastern Georges Bank from the 2021 Fisheries and Oceans Canada (DFO) and National Marine Fisheries Service (NMFS) spring surveys. The dashed lines shows the time series mean. There was no 2020 NMFS fall survey.

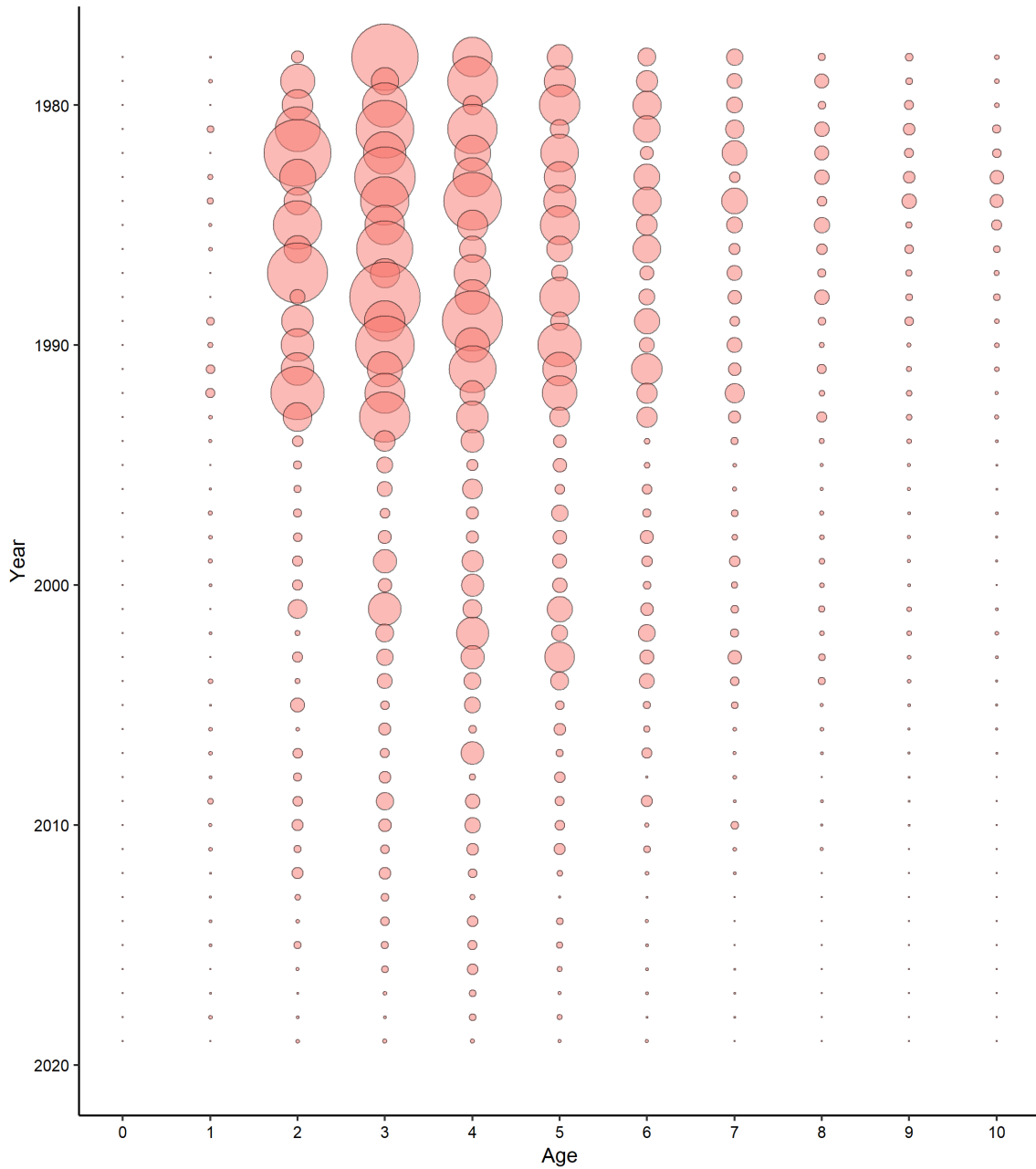


Figure A15. Fishery Catch at Age for the USA fishery, updated through until 2019. Size of bubbles is representative of abundance.