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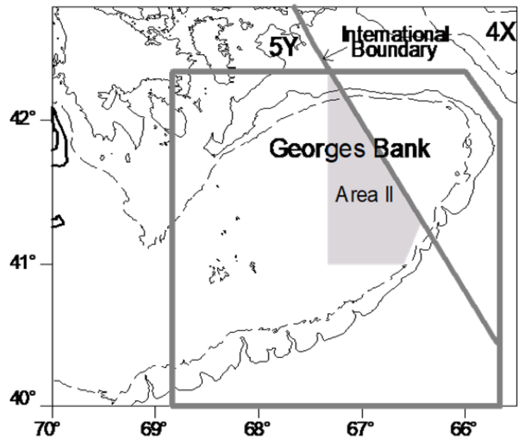
NOAA FISHERIES
NATIONAL MARINE FISHERIES SERVICE

Transboundary Resources Assessment Committee

Status Report 2020/03

GEORGES BANK YELLOWTAIL FLOUNDER

[5Zhjmn; 522,525,551,552,561,562]



Summary

- Combined Canada and USA catches in 2019 were 8 mt.
- The declining trend in survey biomass to low levels, despite reductions in catch to historical low amounts, indicates a poor state of the resource.
- Recent catch is low relative to the biomass estimated from the surveys but catch curve analyses indicate declining but high total mortality rates (Z above 1 for most years).
- Stock biomass is low and productivity is poor.
- An empirical approach (based on survey catches developed during the 2014 Georges Bank Yellowtail Flounder Diagnostic and Empirical Approach Benchmark and updated during the 2017 intersession conference call) was applied to generate catch advice.
- The Transboundary Resources Assessment Committee (TRAC) recommends an upper bound for the exploitation rate of 6% for catch advice, which results in 125 mt for 2021.
- The TRAC recommends low exploitation to allow for the possibility of rebuilding.
- For future catch advice, the TRAC suggests changing the approach for setting the quota from the empirical approach to a fixed quota. The fixed quota would remain until the average survey biomass fell outside the reference limits set by the Transboundary Management Guidance Committee (TMGC).
- There was no 2020 National Marine Fisheries Service (NMFS) spring survey due to the COVID-19 pandemic. For the sake of completeness and comparability with previous TRAC Status Reports (TSRs), a number of tables and figures that could not be updated due to this missing data are included in the Appendix.

TRAC Review Process

In 2017 Transboundary Resources Assessment Committee (TRAC) introduced a new process of review for Eastern Georges Bank Cod and Haddock and Georges Bank Yellowtail Flounder. This process was reviewed by TRAC and Transboundary Management Guidance Committee (TMGC) following its first implementation in 2017, and some modifications were made to further improve clarity in the process. An overview of the entire process has been saved in the National Oceanic and Atmospheric Administration repository and is available online as a downloadable file.

Table 1. Catches (mt)

		2014	2015	2016	2017	2018	2019	2020	Avg[1]	Min[1]	Max[1]
Canada[2]	**Quota**	72	106	85	93	87	34	42			
	Landed	1	3	1	<1	<1	<1		405	<1	2,913
	Discard	14	11	10	2	3	4		401	2	815
USA[2]	**Quota[3]**	328	248	269	207	213	106	120			
	Catch[3]	122	68	26	84	40	5[4]				
	Landed	70	63	26	35	32	3		3,632	3	15,899
	Discard	74	41	7	57	11	2		497	2	3,021
Total[2]	**Quota[5]**	400	354	354	300	300	140	162			
	Catch[5]	136	82	36	87	42	9[4]				
	Catch[6]	159	118	44	95	45	8		4,972	8	17,211

[1] 1973–2019
[2] unless otherwise noted, all values reported are for calendar year
[3] for fishing year May 1–April 30
[4] preliminary estimate
[5] for Canadian calendar year and USA fishing year May 1–April 30
[6] sum of Canadian landed, Canadian discard, and USA catch (includes discards)

Fishery

Total catches of Georges Bank Yellowtail Flounder peaked at about 21,000 mt in both 1969 and 1970 (Figure 1). The combined Canada/USA catch increased from 1995 through 2001, averaged 6,300 mt during 2002–2004, but declined to 8 mt in 2019 (Table 1) due in part to restrictive management measures.

The 2019 Canadian catch of 4 mt was 12% of the 34 mt quota, with landings of <1 mt and estimated discards of 4 mt from the sea scallop dredge fishery.

USA catches in calendar year 2019 were 4 mt, with landings of 3 mt and discards of 2 mt. The USA landings in calendar year 2019 were predominantly from the trawl fishery, while discards were predominantly from the scallop dredge fishery. Preliminary estimates of the USA catches (landings plus discards) for fishing year 2019 were 8% of the 106 mt quota.

Harvest Strategy and Reference Points

The TMGC has adopted a strategy to maintain a low to neutral risk of exceeding the fishing mortality limit reference, F_{ref} = 0.25 (established in 2002 by the TMGC). When stock conditions are poor, fishing mortality rates should be further reduced to promote rebuilding. Due to the lack of an assessment model, an estimate of fishing mortality rate can no longer be calculated. Status determination relative to reference points is not possible because reference points have not been defined.

State of Resource

The declining trend in survey biomass to low levels, despite reductions in catch to historical low amounts, indicates a poor state of the resource. Recent catch is low relative to the biomass estimated from the surveys (relative F; Figure 2) but catch curve analyses (Sinclair Z) indicate declining, but high, total mortality rates (Z above 1 for most years; Figure 3). However, the low catches in the survey in recent years make interpretation of the current relative F and survey Z difficult. Fishing does not appear to be a major driver of stock status currently, although large amounts of missing catch (see Special Comment below) could change this interpretation and the many negative signals for this stock require continued low catches to protect what remains of the stock.

Productivity

Recruitment, spatial distribution, and fish growth typically reflect changes in the productive potential. Recent **recruitment** has generally been below average (Figure 4) and age structure is truncated (i.e., both fewer young fish and fewer old fish). Recent **spatial distribution patterns** from the three bottom-trawl surveys generally follow the ten-year average, although low survey catches make these comparisons difficult. **Growth,** as measured by length-at-age in the surveys, has been variable without trend, and Yellowtail Flounder condition factor (weight-at-length) has been poor recently, although low survey catches makes interpreting these trends difficult. Stock biomass is low and productivity is poor.

Outlook and TRAC Advice

This outlook is provided in terms of an empirical approach from the 2014 Georges Bank Yellowtail Flounder Diagnostic and Empirical Approach Benchmark, subsequent TRAC meeting in 2014, and intersessional TRAC conference call in June 2017. The empirical approach averages estimates of biomass from the Fisheries and Oceans Canada (DFO) spring, National Marine Fisheries Service **(**NMFS) spring, and NMFS fall surveys (Figure 5), and applies an exploitation rate to this average to generate catch advice. In 2020, the NMFS spring survey on Georges Bank was not conducted due to the COVID-19 pandemic. Catch advice for 2021 was computed using only the 2020 DFO spring and 2019 NMFS fall surveys.

During the 2014 Benchmark, considerations were provided as reasons to decrease, or to maintain, or increase the quota. The assessment findings this year show both positive and negative signals. The following are positive signals: the 2019 catch was 6% of the quota; the relative F continues to be low; one of the two available surveys increased; the NMFS fall survey indicated an increasing abundance of age 6+ fish; and survey total mortality decreased to low values in one of the surveys. The negative signals are: the two available surveys were the second- (DFO spring) and third- (NMFS fall) lowest surveys in their respective time series; recent recruitment continues to be below average; and the abundance of age 6+ fish from the DFO spring survey did not increase.

The 2017 TRAC Status Report (TSR) noted the reasons for changing the exploitation rate range from 2%–16% to 2%–6% were: the change from door spread to wing spread; the change from survey catchability of 0.37 to 0.31; and the decline in the surveys during the time series available. There were no changes to the empirical approach this year, compared to last year, other than adding the two available new survey values. Thus, the absence of any changes in the empirical approach means no change in the exploitation rate this year. Additionally, the mix of both negative and positive signals and overall low survey abundance does not warrant any changes.

The TRAC recommends an upper bound for the exploitation rate of 6% for catch advice, which results in 125 mt for 2021. Survey biomass decreased 97% from 2010 to 2020 (Table 2). Historical exploitation rates can be computed from either the quota or the catch.

The TRAC used the exploitation rate associated with the quota to set the catch advice because it has limited the catch directly and indirectly. The average exploitation rate associated with the quota for years 2010 to 2017 is 6% and ranged from 3% to 11% (Table 3). The TRAC notes that increasing the exploitation rate above the average from 2010 to 2017, when the stock declined substantially, is risky and reduces the chances of rebuilding. Including 2018 to 2020 quotas increases the average exploitation rate to 8%, but the TRAC recommends maintaining the current 6% exploitation rate for 2021 because the changes in the survey biomass and catch history are not deemed sufficient to warrant changing the exploitation rate. The average exploitation rate associated with the catch for years 2010 to 2019 is 2% and ranged from <1% to 5%. During 2010 to 2019, the catch has averaged 35% of the quota, ranging from 6% to 63%. The TRAC recognizes that catch has been well below the quota recently and expects this to continue in the future if current management measures continue and there is not a significant change in stock abundance. If quota utilization increases, the exploitation rate used to provide catch advice may need to be reconsidered. The TRAC recommends low exploitation to allow for the possibility of rebuilding.

The TRAC has used an exploitation rate of 6% for the past three years to set the catch advice, but the justification for this exploitation rate has changed over time, causing confusion. The main factor is that the continued low abundance of fish observed in the surveys does not provide support for changing the exploitation rate. One possible way forward is to set a constant quota and to not change the quota unless the average survey biomass increases or decreases beyond agreed bounds (see Special Comment below). These bounds would be set by TMGC to indicate when changes to the stock warrant exploration of alternative exploitation rates. The recent minor changes to the quota do not appear to be impacting either the fishery (in that the fishery continues to harvest below the quota) or the fish population (i.e., no apparent rebuilding), so this new approach would reduce the time expended to monitor the stock and provide management advice. If this new approach cannot be implemented for the 2021 quota it could be considered by the TMGC this year so that it could be used for the 2022 quota.

Table 2. Survey biomass from the three bottom-trawl surveys, an arithmetic average of these biomasses, and catch advice for an exploitation rate of 6%. Catch advice is implemented in the following year (e.g., the row of 2020 catch advice would be implemented in 2021).

			Biomass (mt)		
Year	DFO	Spring	Fall (Year -1)	Average	Catch Advice (mt)
2010	29,452	68,752	83,490	60,565	3,634
2011	12,344	29,621	27,821	23,262	1,396
2012	18,113	46,209	30,354	31,559	1,894
2013	2,249	12,766	31,199	15,404	924
2014	1,654	8,564	10,828	7,015	421
2015	2,650	5,861	12,682	7,064	424
2016	5,569	3,610	5,811	4,997	300
2017	1,104	2,819	5,432	3,118	187
2018	812	143	2,424	1,126	68
2019	182	3,735	6,047	3,322	199
2020	404	NA	3,749	2,077	125

Table 3. Recent quotas and catches by year and associated exploitation rates (computed by dividing by the average survey biomass in Table 2). (VPA = Virtual Population Analysis.). A dash (-) indicates no available data.

Year	Quota (mt)	Catch (mt)	Quota/Avg	Catch/Avg	Model Type
2010	1,956	1,170	3%	2%	VPA
2011	2,650	1,171	11%	5%	VPA
2012	1,150	725	4%	2%	VPA
2013	500	218	3%	1%	VPA
2014	400	159	6%	2%	VPA
2015	354	118	5%	2%	Empirical
2016	354	44	7%	1%	Empirical
2017	300	95	10%	3%	Empirical
2018	300	45	27%	4%	Empirical
2019	140	8	4%	0%	Empirical
2020	162	-	8%	-	Empirical
Mean	751	375	8%[1]	2%	-

[1] *The average Quota/Avg for years 2010–2017 is 6%.*

Special Considerations

- Results from the most recent surveys are considered valid for use in the empirical approach despite the lack of a NMFS spring 2020 survey due to COVID-19.
- Future Approach for Catch Advice: The TRAC suggests changing the approach for setting the quota from the Empirical Approach to a fixed quota. The fixed quota would remain until the average survey biomass fell outside the limits set by the TMGC. For example, an annual quota of up to ZZZ[1] mt could be set by TMGC and not changed until the average survey biomass exceeded the limits. The TRAC proposes limits for the average survey biomass of XXX to Y,YYY mt. These limits could be derived by examining the uncertainty in the average

1 TRAC did not come to an agreement on what the constant quota should be; possible values for the average survey biomass limits were not suggested. The ZZZ, XXX, and Y,YYY placeholders indicate decisions are needed; TRAC could not provide recommendations at this time.

survey biomass in recent years. This new approach requires annual monitoring of the average survey biomass to determine whether it falls outside the limits.

- The TRAC discussed uncertainties in the catch estimation including: 1) low catches in the fishery make sampling challenging including catch and weight-at-age estimation; 2) adjustments have not been made to historical US catch to account for catch misreporting; 3) the New England Fishery Management Council's Groundfish Plan Development Team found an observer effect which could impact discard estimates; and 4) research catch is not included in total removals. To date, the magnitude of these potential missing catches has been difficult to quantify.

Source Documents

Clark, K. and E. N. Brooks, editors. 2017. Proceedings of the Transboundary Resources Assessment Committee (TRAC): Eastern Georges Bank Cod and Haddock, and Georges Bank Yellowtail Flounder: Report of Meeting held 11–14 July 2017. TRAC Proceedings 2017/XX. (not yet publicly available)

Trinko-Lake, T. and M. Greenlaw, editors. 2020. Proceedings of the Transboundary Resources Assessment Committee: Report of Meeting held 7–9 July 2020. TRAC Proceedings 2020/01.

O'Brien, L., and K. Clark, editors. 2014. Proceedings of the Transboundary Resources Assessment Committee for Georges Bank Yellowtail Flounder Diagnostic and Empirical Approach Benchmark: Report of Meeting held 14–18 April 2014. TRAC Proceedings 2014/01. (not yet publicly available)

Correct Citation

TRAC. 2020. Georges Bank Yellowtail Flounder. TRAC Status Report 2020/03.

Figures

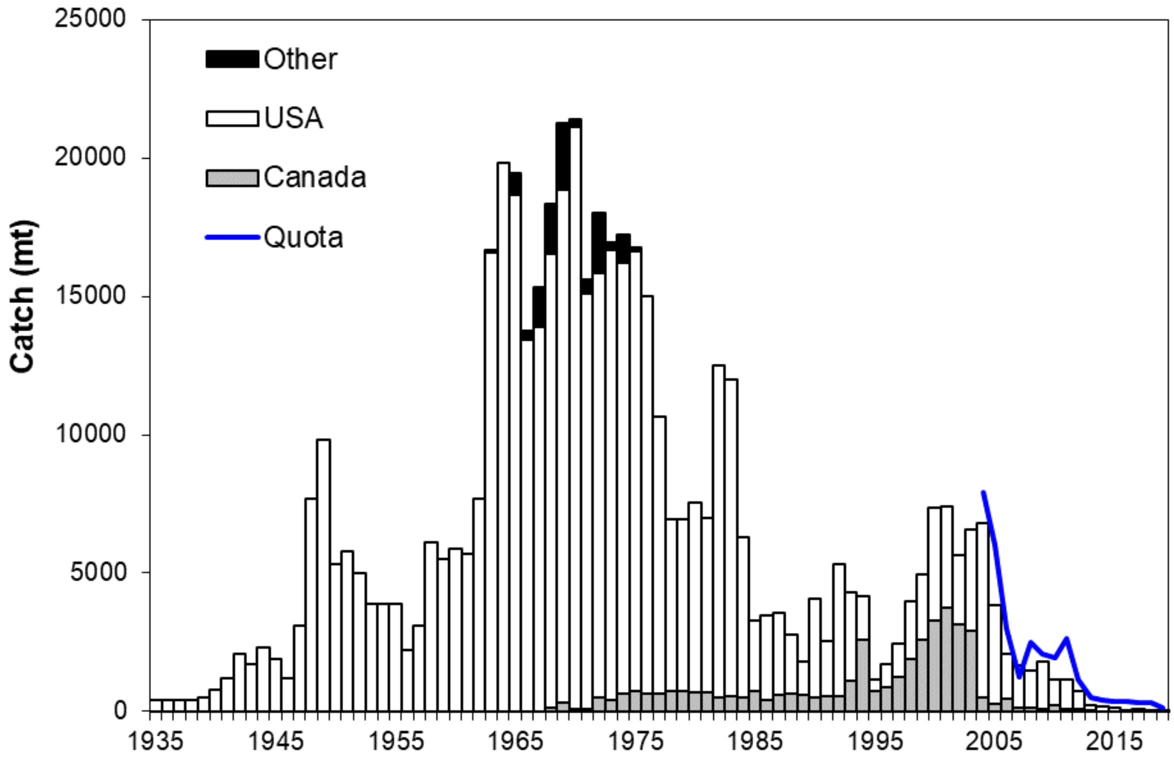


Figure 1. Catches and quota for Georges Bank Yellowtail Flounder (1935–2019).

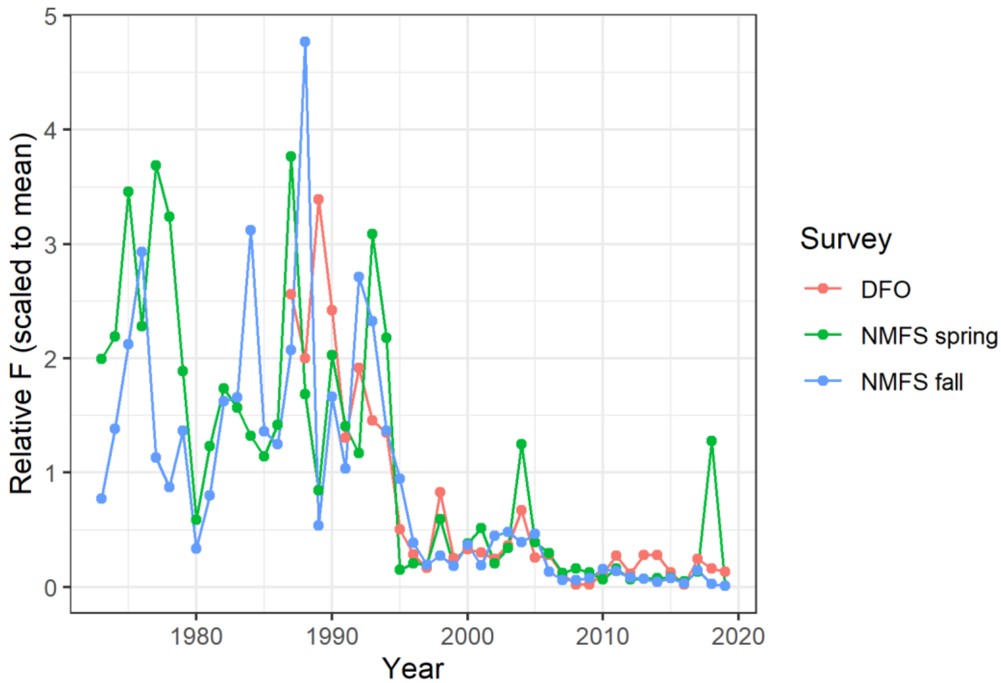


Figure 2. Relative F (catch in mt divided by survey catch in kg per tow) scaled to the mean value during 1987–2007 for the three surveys. Please see note in State of the Resource about recent low survey catches.

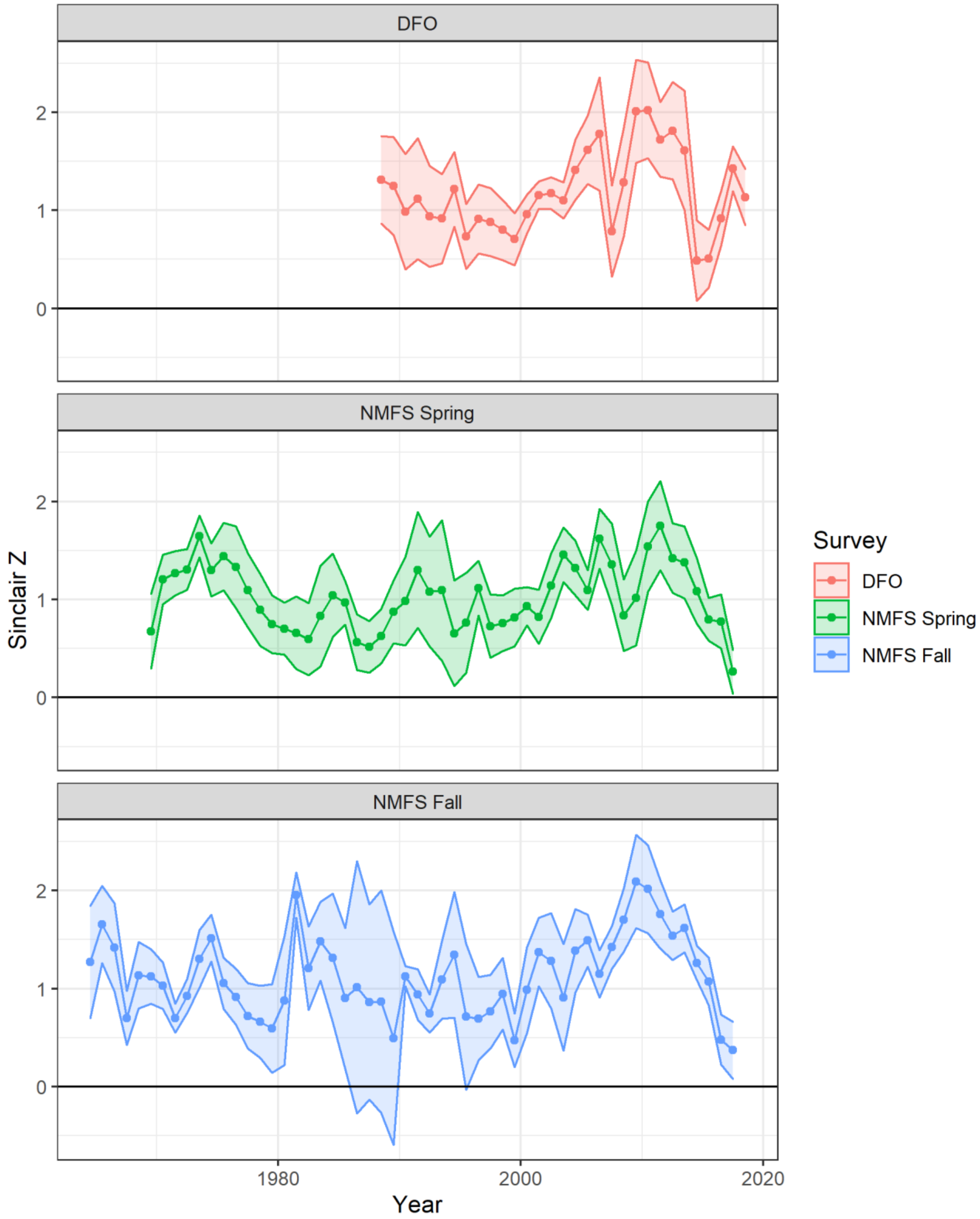


Figure 3. Total mortality (Z) from the three surveys using the Sinclair method with a four-year-moving window for ages 3 to 8. Please see note in State of the Resource about recent survey catches.

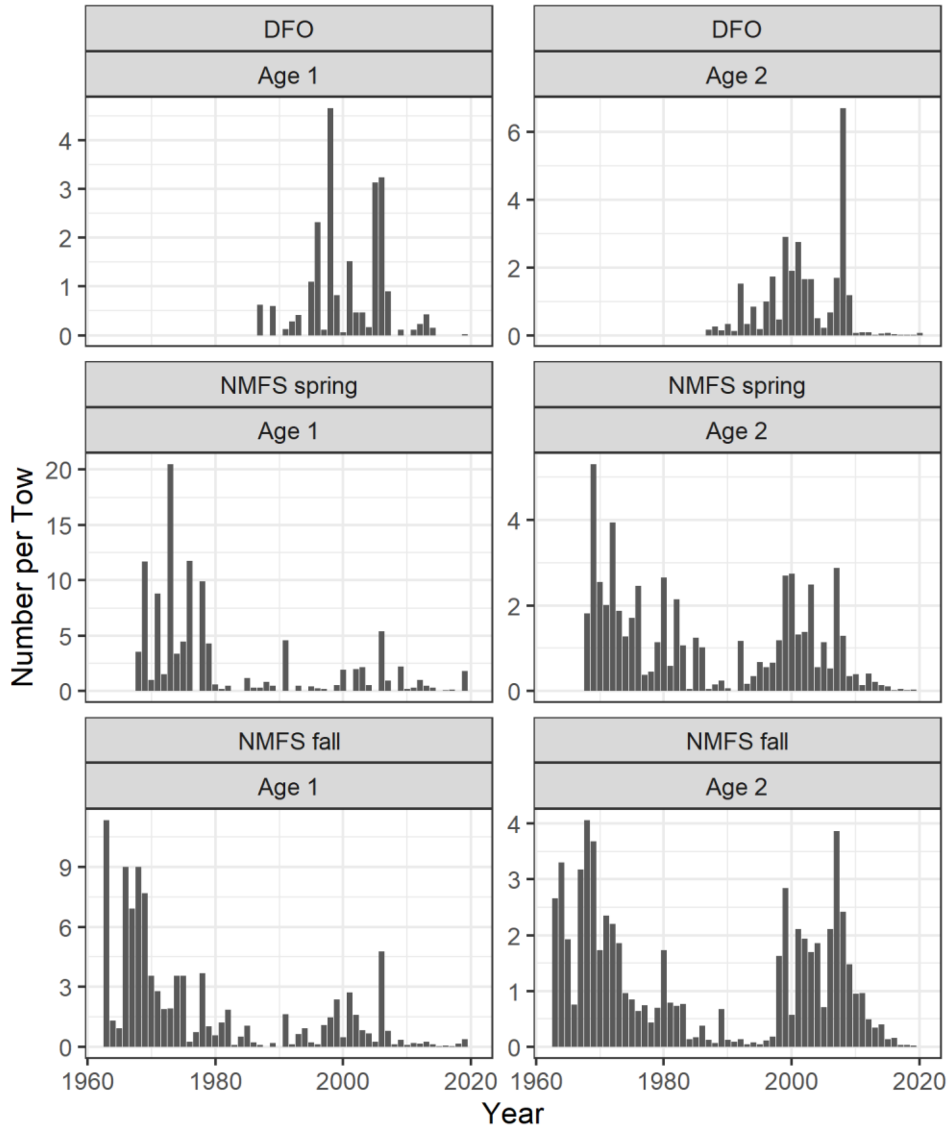


Figure 4. Estimates of recruitment (age 1 has many zeros, so age 2 also shown) from the three bottom-trawl surveys. Note the 2020 NMFS spring survey was not conducted due to Covid-19.

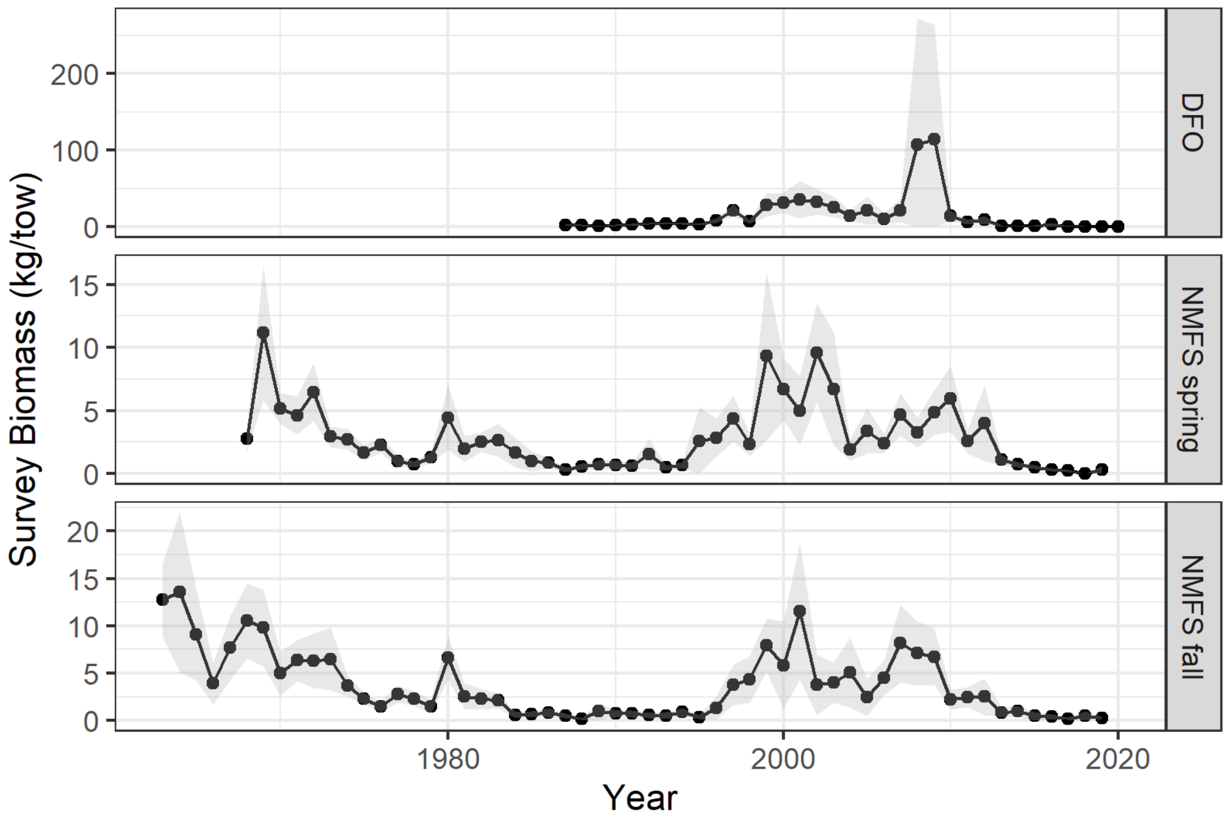


Figure 5. Bottom-trawl-survey catch rates (in biomass) for Georges Bank Yellowtail Flounder (filled circles) with 90% confidence intervals (gray area). Note that the amount of Georges Bank area covered in the DFO spring and NMFS surveys differs and that the NMFS surveys have been standardized to Albatross units. Note the 2020 NMFS spring survey was not conducted due to Covid-19.

Appendix

Table A1. Annual catch (mt) of Georges Bank Yellowtail Flounder.

Year	US Landings	US Discards	Canada Landings	Canada Discards	Other Landings	Total Catch	% discards
1935	300	100	0	0	0	400	25%
1936	300	100	0	0	0	400	25%
1937	300	100	0	0	0	400	25%
1938	300	100	0	0	0	400	25%
1939	375	125	0	0	0	500	25%
1940	600	200	0	0	0	800	25%
1941	900	300	0	0	0	1200	25%
1942	1575	525	0	0	0	2100	25%
1943	1275	425	0	0	0	1700	25%
1944	1725	575	0	0	0	2300	25%
1945	1425	475	0	0	0	1900	25%
1946	900	300	0	0	0	1200	25%
1947	2325	775	0	0	0	3100	25%
1948	5775	1925	0	0	0	7700	25%
1949	7350	2450	0	0	0	9800	25%
1950	3975	1325	0	0	0	5300	25%
1951	4350	1450	0	0	0	5800	25%
1952	3750	1250	0	0	0	5000	25%
1953	2925	975	0	0	0	3900	25%
1954	2925	975	0	0	0	3900	25%
1955	2925	975	0	0	0	3900	25%
1956	1650	550	0	0	0	2200	25%
1957	2325	775	0	0	0	3100	25%
1958	4575	1525	0	0	0	6100	25%
1959	4125	1375	0	0	0	5500	25%
1960	4425	1475	0	0	0	5900	25%
1961	4275	1425	0	0	0	5700	25%
1962	5775	1925	0	0	0	7700	25%
1963	10990	5600	0	0	100	16690	34%
1964	14914	4900	0	0	0	19814	25%
1965	14248	4400	0	0	800	19448	23%
1966	11341	2100	0	0	300	13741	15%
1967	8407	5500	0	0	1400	15307	36%
1968	12799	3600	122	0	1800	18321	20%
1969	15944	2600	327	0	2400	21271	12%
1970	15506	5533	71	0	300	21410	26%
1971	11878	3127	105	0	500	15610	20%
1972	14157	1159	8	515	2200	18039	9%
1973	15899	364	12	378	300	16953	4%
1974	14607	980	5	619	1000	17211	9%
1975	13205	2715	8	722	100	16750	21%
1976	11336	3021	12	619	0	14988	24%
1977	9444	567	44	584	0	10639	11%
1978	4519	1669	69	687	0	6944	34%

Table A1. Continued.

Year	US Landings	US Discards	Canada Landings	Canada Discards	Other Landings	Total Catch	% discards
1979	5475	720	19	722	0	6935	21%
1980	6481	382	92	584	0	7539	13%
1981	6182	95	15	687	0	6979	11%
1982	10621	1376	22	502	0	12520	15%
1983	11350	72	106	460	0	11989	4%
1984	5763	28	8	481	0	6280	8%
1985	2477	43	25	722	0	3267	23%
1986	3041	19	57	357	0	3474	11%
1987	2742	233	69	536	0	3580	21%
1988	1866	252	56	584	0	2759	30%
1989	1134	73	40	536	0	1783	34%
1990	2751	818	25	495	0	4089	32%
1991	1784	246	81	454	0	2564	27%
1992	2859	1873	65	502	0	5299	45%
1993	2089	1089	682	440	0	4300	36%
1994	1431	148	2139	440	0	4158	14%
1995	360	43	464	268	0	1135	27%
1996	743	96	472	388	0	1700	28%
1997	888	327	810	438	0	2464	31%
1998	1619	482	1175	708	0	3985	30%
1999	1818	577	1971	597	0	4963	24%
2000	3373	694	2859	415	0	7341	15%
2001	3613	78	2913	815	0	7419	12%
2002	2476	53	2642	493	0	5663	10%
2003	3236	410	2107	809	0	6562	19%
2004	5837	460	96	422	0	6815	13%
2005	3161	414	30	247	0	3852	17%
2006	1196	384	25	452	0	2057	41%
2007	1058	493	17	97	0	1664	35%
2008	937	409	41	112	0	1499	35%
2009	959	759	5	84	0	1806	47%
2010	654	289	17	210	0	1170	43%
2011	904	192	22	53	0	1171	21%
2012	443	188	46	48	0	725	33%
2013	130	49	1	39	0	218	40%
2014	70	74	1	14	0	159	56%
2015	63	41	3	11	0	118	44%
2016	26	7	1	10	0	44	39%
2017	35	57	<1	2	0	95	63%
2018	32	11	<1	3	0	45	29%
2019	3	2	<1	4	0	8	65%

Table A2. Mean weight-at-age (kg) for the total catch of US and Canadian landings and discards, for Georges Bank Yellowtail Flounder. A dash (-) indicates no data available.

Year	Age											
	1	2	3	4	5	6	7	8	9	10	11	12
1973	0.101	0.348	0.462	0.527	0.603	0.690	1.063	1.131	1.275	1.389	1.170	-
1974	0.115	0.344	0.496	0.607	0.678	0.723	0.904	1.245	1.090	-	1.496	1.496
1975	0.113	0.316	0.489	0.554	0.619	0.690	0.691	0.654	1.052	0.812	-	-
1976	0.108	0.312	0.544	0.635	0.744	0.813	0.854	0.881	1.132	1.363	1.923	-
1977	0.116	0.342	0.524	0.633	0.780	0.860	1.026	1.008	0.866	0.913	-	-
1978	0.102	0.314	0.510	0.690	0.803	0.903	0.947	1.008	1.227	1.581	0.916	-
1979	0.114	0.329	0.462	0.656	0.736	0.844	0.995	0.906	1.357	1.734	1.911	-
1980	0.101	0.322	0.493	0.656	0.816	1.048	1.208	1.206	1.239	-	-	-
1981	0.122	0.335	0.489	0.604	0.707	0.821	0.844	1.599	1.104	-	-	-
1982	0.115	0.301	0.485	0.650	0.754	1.065	1.037	1.361	-	-	-	-
1983	0.140	0.296	0.441	0.607	0.740	0.964	1.005	1.304	1.239	-	-	-
1984	0.162	0.239	0.379	0.500	0.647	0.743	0.944	1.032	-	-	-	-
1985	0.181	0.361	0.505	0.642	0.729	0.808	0.728	-	-		-	-
1986	0.181	0.341	0.540	0.674	0.854	0.976	0.950	1.250	-	1.686	-	-
1987	0.121	0.324	0.524	0.680	0.784	0.993	0.838	0.771	0.809	-	-	-
1988	0.103	0.328	0.557	0.696	0.844	1.042	0.865	1.385	-	-	-	-
1989	0.100	0.327	0.520	0.720	0.866	0.970	1.172	1.128	-	-	-	-
1990	0.105	0.290	0.395	0.585	0.693	0.787	1.057	-	-	-	-	-
1991	0.121	0.237	0.369	0.486	0.723	0.850	1.306	-	-	-	-	-
1992	0.101	0.293	0.365	0.526	0.651	1.098	1.125	1.303	1.303	-	-	-
1993	0.100	0.285	0.379	0.501	0.564	0.843	1.130	1.044	-	-	-	-
1994	0.193	0.260	0.353	0.472	0.621	0.780	0.678	1.148	-	-	-	-
1995	0.174	0.275	0.347	0.465	0.607	0.720	0.916	0.532	-	-	-	-
1996	0.119	0.276	0.407	0.552	0.707	0.918	1.031	1.216	-	-	-	-
1997	0.214	0.302	0.408	0.538	0.718	1.039	0.827	1.136	1.113		-	-
1998	0.178	0.305	0.428	0.546	0.649	0.936	1.063	1.195	-	1.442	-	-
1999	0.202	0.368	0.495	0.640	0.755	0.870	1.078	1.292	1.822	-	-	-
2000	0.229	0.383	0.480	0.615	0.766	0.934	1.023	1.023	1.296	-	-	-
2001	0.251	0.362	0.460	0.612	0.812	1.011	1.024	1.278	1.552	-	-	-
2002	0.282	0.381	0.480	0.665	0.833	0.985	1.100	1.286	1.389	1.483	-	-
2003	0.228	0.359	0.474	0.653	0.824	0.957	1.033	1.144	1.267	1.418	1.505	-
2004	0.211	0.292	0.438	0.585	0.726	0.883	1.002	1.192	1.222	1.305	1.421	-

Year	Age											
	1	2	3	4	5	6	7	8	9	10	11	12
2005	0.119	0.341	0.447	0.597	0.763	0.965	0.993	1.198	1.578	1.578	-	-
2006	0.100	0.311	0.415	0.557	0.761	0.917	1.066	1.186	1.263	1.225	1.599	-
2007	0.154	0.290	0.409	0.541	0.784	0.968	1.108	1.766	-	-	-	-
2008	0.047	0.302	0.415	0.533	0.675	0.882	1.130	-	-	-	-	-
2009	0.155	0.328	0.434	0.538	0.699	0.879	1.050	1.328	-	-	-	-
2010	0.175	0.323	0.432	0.519	0.661	0.777	0.997	1.176	-	-	-	-
2011	0.128	0.337	0.461	0.553	0.646	0.739	0.811	0.851	-	-	-	-
2012	0.185	0.338	0.452	0.555	0.671	0.792	0.935	0.798	-	-	-	-
2013	0.193	0.263	0.393	0.533	0.689	0.825	1.002	1.183	-	-	-	-
2014	0.171	0.292	0.417	0.541	0.679	0.799	0.883	0.814	0.864	-	-	-
2015	0.091	0.233	0.408	0.496	0.656	0.800	0.890	0.893	-	-	-	-
2016	0.025	0.186	0.418	0.507	0.611	0.650	0.862	0.952	-	-	-	-
2017	0.094	0.306	0.395	0.490	0.564	0.644	0.732	0.778	0.799	0.830	-	-
2018	0.154	0.202	0.388	0.425	0.594	0.667	0.767	0.771	1.088	-	-	-
2019	0.088	0.232	0.404	0.506	0.642	0.619	0.817	0.804	1.148	-	1.048	-

Table A3. DFO spring survey indices of abundance for Georges Bank Yellowtail Flounder in both numbers and kg per tow, along with the Coefficient of Variation (CV) for the biomass estimates.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+	B(kg/tow)	CV(B)
1987	0.120	1.194	1.970	0.492	0.087	0.049	1.987	0.274
1988	0.000	1.776	1.275	0.610	0.278	0.024	1.964	0.217
1989	0.114	1.027	0.609	0.294	0.066	0.022	0.748	0.257
1990	0.000	2.387	3.628	0.914	0.209	0.014	2.405	0.222
1991	0.024	0.858	1.186	3.759	0.525	0.014	2.796	0.330
1992	0.055	11.039	3.677	0.990	0.350	0.030	3.937	0.163
1993	0.079	2.431	4.085	4.076	0.887	0.130	4.201	0.151
1994	0.000	6.056	3.464	3.006	0.781	0.207	4.378	0.228
1995	0.210	1.251	4.353	2.546	0.647	0.101	3.223	0.201
1996	0.446	7.142	9.174	5.406	1.155	0.123	8.433	0.223
1997	0.022	12.482	13.902	16.369	4.044	0.670	21.138	0.233
1998	0.893	3.330	4.907	4.334	1.988	0.558	6.826	0.244
1999	0.159	20.861	20.834	7.669	5.350	2.200	28.093	0.325
2000	0.011	13.765	27.442	19.243	5.069	3.689	31.723	0.253
2001	0.291	19.896	42.124	13.307	4.581	2.397	35.236	0.416
2002	0.088	11.962	31.015	12.234	5.553	2.833	32.916	0.305
2003	0.089	11.889	24.618	11.086	3.421	1.988	25.839	0.317
2004	0.033	3.599	16.260	9.205	2.273	1.416	14.397	0.313
2005	0.600	1.602	27.959	20.564	5.696	1.565	21.240	0.530
2006	0.623	4.893	18.600	6.572	0.820	0.238	10.462	0.444
2007	0.173	12.159	27.708	12.799	2.288	0.248	21.219	0.435
2008	0.000	48.315	170.363	57.119	8.059	0.055	107.052	0.939
2009	0.021	8.540	137.957	116.966	19.900	4.764	114.566	0.791
2010	0.000	0.489	9.392	20.943	3.533	1.279	14.532	0.294
2011	0.022	0.651	6.093	8.205	1.701	0.327	6.091	0.294
2012	0.044	0.644	8.243	11.423	3.096	0.453	8.937	0.356
2013	0.081	0.129	0.831	1.254	0.604	0.140	1.109	0.328
2014	0.030	0.395	0.741	0.960	0.471	0.018	0.816	0.337
2015	0.000	0.467	1.112	1.659	0.747	0.093	1.308	0.367
2016	0.000	0.218	3.151	2.104	1.257	0.657	2.748	0.608
2017	0.000	0.014	0.185	0.435	0.437	0.388	0.545	0.469
2018	0.000	0.006	0.263	0.194	0.315	0.223	0.401	0.378
2019	0.005	0.053	0.029	0.045	0.005	0.092	0.090	0.381
2020	0.000	0.453	0.266	0.059	0.025	0.065	0.199	0.333

Table A4. NMFS spring survey indices of abundance for Georges Bank Yellowtail Flounder in both numbers and kg per tow in Albatross units, along with the Coefficient of Variation (CV) for the biomass estimates.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+	B(kg/tow)	CV(B)
1968	0.335	3.176	3.580	0.304	0.073	0.310	2.791	0.214
1969	1.108	9.313	11.121	3.175	1.345	0.699	11.170	0.291
1970	0.093	4.485	6.030	2.422	0.570	0.311	5.146	0.146
1971	0.835	3.516	4.813	3.300	0.780	0.320	4.619	0.198
1972	0.141	6.923	7.050	3.705	1.127	0.239	6.455	0.214
1973	1.940	3.281	2.379	1.068	0.412	0.217	2.939	0.174
1974	0.317	2.234	1.850	1.262	0.347	0.282	2.720	0.186
1975	0.422	3.006	0.834	0.271	0.208	0.089	1.676	0.224
1976	1.112	4.315	1.253	0.312	0.197	0.112	2.273	0.162
1977	0.000	0.674	1.131	0.396	0.063	0.013	0.999	0.312
1978	0.940	0.802	0.510	0.220	0.027	0.008	0.742	0.197
1979	0.406	2.016	0.407	0.338	0.061	0.092	1.271	0.209
1980	0.057	4.666	5.787	0.475	0.057	0.036	4.456	0.350
1981	0.017	1.020	1.777	0.720	0.213	0.059	1.960	0.322
1982	0.045	3.767	1.130	1.022	0.458	0.091	2.500	0.190
1983	0.000	1.865	2.728	0.530	0.123	0.245	2.642	0.294
1984	0.000	0.093	0.831	0.863	0.896	0.183	1.646	0.428
1985	0.110	2.199	0.262	0.282	0.148	0.000	0.988	0.501
1986	0.027	1.806	0.291	0.056	0.137	0.055	0.847	0.298
1987	0.027	0.076	0.137	0.133	0.053	0.055	0.329	0.365
1988	0.078	0.275	0.366	0.242	0.199	0.027	0.566	0.257
1989	0.047	0.424	0.739	0.290	0.061	0.045	0.729	0.270
1990	0.000	0.110	1.063	0.369	0.163	0.057	0.699	0.312
1991	0.435	0.000	0.254	0.685	0.263	0.021	0.631	0.247
1992	0.000	2.048	1.897	0.641	0.165	0.017	1.566	0.470
1993	0.046	0.290	0.501	0.317	0.027	0.000	0.482	0.263
1994	0.000	0.621	0.633	0.354	0.145	0.040	0.660	0.223
1995	0.040	1.179	4.812	1.485	0.640	0.010	2.579	0.631
1996	0.025	0.987	2.626	2.701	0.610	0.058	2.853	0.320
1997	0.019	1.169	3.733	4.080	0.703	0.134	4.359	0.257
1998	0.000	2.081	1.053	1.157	0.760	0.350	2.324	0.234
1999	0.050	4.746	10.819	2.721	1.623	0.779	9.307	0.433

Table A4. Continued.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+	B(kg/tow)	CV(B)
2000	0.183	4.819	7.666	2.914	0.813	0.524	6.696	0.221
2001	0.000	2.315	6.563	2.411	0.484	0.453	5.006	0.329
2002	0.188	2.412	12.334	4.078	1.741	0.871	9.563	0.250
2003	0.202	4.370	6.764	2.876	0.442	0.862	6.722	0.405
2004	0.049	0.986	2.179	0.735	0.255	0.217	1.891	0.261
2005	0.000	2.013	5.080	2.404	0.270	0.115	3.407	0.325
2006	0.509	0.935	3.523	2.177	0.317	0.082	2.420	0.182
2007	0.090	5.048	6.263	2.846	0.556	0.129	4.701	0.217
2008	0.000	2.274	5.071	1.732	0.310	0.027	3.247	0.218
2009	0.211	0.600	7.446	4.653	1.002	0.191	4.856	0.223
2010	0.017	0.694	5.412	8.451	2.721	0.654	5.944	0.267
2011	0.031	0.243	3.331	3.735	0.964	0.108	2.561	0.226
2012	0.095	0.718	4.178	5.745	1.411	0.200	3.995	0.455
2013	0.048	0.376	1.006	1.401	0.657	0.124	1.104	0.218
2014	0.027	0.234	0.679	0.682	0.367	0.196	0.740	0.175
2015	0.000	0.183	0.513	0.420	0.368	0.049	0.507	0.189
2016	0.006	0.022	0.233	0.283	0.072	0.133	0.312	0.252
2017	0.012	0.095	0.070	0.109	0.180	0.177	0.244	0.212
2018	0.000	0.022	0.000	0.000	0.000	0.013	0.012	0.632
2019	0.171	0.062	0.086	0.060	0.038	0.372	0.323	0.516
2020	NA	NA	NA	NA	NA	NA	NA	NA

Table A5. NMFS fall survey indices of abundance for Georges Bank Yellowtail Flounder in both numbers and kg per tow in Albatross units, along with the Coefficient of Variation (CV) for the biomass estimates.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+	B(kg/tow)	CV(B)
1963	14.722	7.896	11.227	1.859	0.495	0.549	12.788	0.187
1964	1.722	9.806	7.312	5.967	2.714	0.488	13.567	0.378
1965	1.197	5.705	5.988	3.532	1.573	0.334	9.120	0.326
1966	11.663	2.251	1.685	0.898	0.101	0.000	3.928	0.335
1967	8.985	9.407	2.727	1.037	0.342	0.103	7.670	0.270
1968	11.671	12.057	5.758	0.745	0.965	0.058	10.536	0.229
1969	9.949	10.923	5.217	1.811	0.337	0.461	9.807	0.250
1970	4.610	5.132	3.144	1.952	0.452	0.080	4.979	0.287
1971	3.627	6.976	4.914	2.250	0.498	0.298	6.365	0.209
1972	2.462	6.525	4.824	2.094	0.610	0.342	6.328	0.273
1973	2.494	5.498	5.104	2.944	1.217	0.618	6.490	0.311
1974	4.623	2.864	1.516	1.060	0.458	0.379	3.669	0.179
1975	4.625	2.511	0.877	0.572	0.334	0.063	2.326	0.164
1976	0.344	1.920	0.474	0.117	0.122	0.100	1.508	0.233
1977	0.934	2.212	1.621	0.617	0.105	0.126	2.781	0.192
1978	4.760	1.281	0.780	0.411	0.136	0.036	2.343	0.204
1979	1.321	2.069	0.261	0.120	0.138	0.112	1.494	0.294
1980	0.766	5.120	6.091	0.682	0.219	0.258	6.607	0.210
1981	1.595	2.349	1.641	0.588	0.079	0.054	2.576	0.322
1982	2.425	2.184	1.590	0.423	0.089	0.000	2.270	0.290
1983	0.109	2.284	1.915	0.511	0.031	0.049	2.131	0.222
1984	0.661	0.400	0.306	0.243	0.075	0.063	0.593	0.305
1985	1.377	0.516	0.171	0.051	0.081	0.000	0.709	0.266
1986	0.282	1.108	0.349	0.074	0.000	0.000	0.820	0.371
1987	0.129	0.373	0.396	0.053	0.080	0.000	0.509	0.280
1988	0.019	0.213	0.107	0.027	0.000	0.000	0.171	0.325
1989	0.248	1.993	0.773	0.079	0.056	0.000	0.977	0.582
1990	0.000	0.370	1.473	0.294	0.000	0.000	0.725	0.323
1991	2.101	0.275	0.439	0.358	0.000	0.000	0.730	0.293
1992	0.151	0.396	0.712	0.162	0.144	0.027	0.576	0.287
1993	0.839	0.139	0.586	0.536	0.000	0.022	0.546	0.426
1994	1.195	0.221	0.983	0.713	0.263	0.057	0.897	0.311
1995	0.276	0.119	0.346	0.275	0.046	0.013	0.354	0.359
1996	0.149	0.352	1.869	0.447	0.075	0.000	1.303	0.570
1997	1.393	0.533	3.442	2.090	1.071	0.082	3.781	0.344
1998	1.900	4.817	4.202	1.190	0.298	0.074	4.347	0.347
1999	3.090	8.423	5.727	1.433	1.437	0.261	7.973	0.215

Table A5. Continued.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+	B(kg/tow)	CV(B)
2000	0.629	1.697	4.814	2.421	0.948	0.827	5.838	0.482
2001	3.518	6.268	8.092	2.601	1.718	2.048	11.553	0.381
2002	2.093	5.751	2.127	0.594	0.277	0.055	3.754	0.517
2003	1.077	5.031	2.809	0.565	0.100	0.191	4.038	0.316
2004	0.876	5.508	5.010	2.107	0.924	0.176	5.117	0.436
2005	0.313	2.095	3.763	0.614	0.185	0.000	2.463	0.492
2006	6.194	6.251	3.664	1.167	0.255	0.046	4.521	0.247
2007	1.058	11.447	7.866	1.998	0.383	0.094	8.151	0.309
2008	0.168	7.174	9.883	1.033	0.000	0.000	7.109	0.291
2009	0.477	4.382	12.202	2.219	0.631	0.064	6.744	0.269
2010	0.125	2.811	4.507	0.781	0.298	0.000	2.247	0.283
2011	0.237	2.865	3.897	1.106	0.145	0.010	2.452	0.264
2012	0.195	1.475	3.658	1.586	0.441	0.014	2.520	0.459
2013	0.332	1.028	0.940	0.537	0.116	0.044	0.875	0.369
2014	0.163	1.177	1.123	0.647	0.146	0.084	1.024	0.334
2015	0.031	0.394	0.589	0.303	0.069	0.020	0.469	0.619
2016	0.077	0.460	0.553	0.258	0.085	0.044	0.439	0.361
2017	0.047	0.105	0.142	0.172	0.042	0.097	0.196	0.355
2018	0.197	0.113	0.344	0.438	0.247	0.190	0.488	0.596
2019	0.491	0.067	0.056	0.084	0.020	0.308	0.303	0.267

Table A6. Catch advice for 2021 associated with the full range of exploitation rates from the 2014 benchmark.

Exploitation Rate	Catch Advice (mt)
2%	42
4%	83
6%	125
8%	166
10%	208
12%	249
14%	291
16%	332

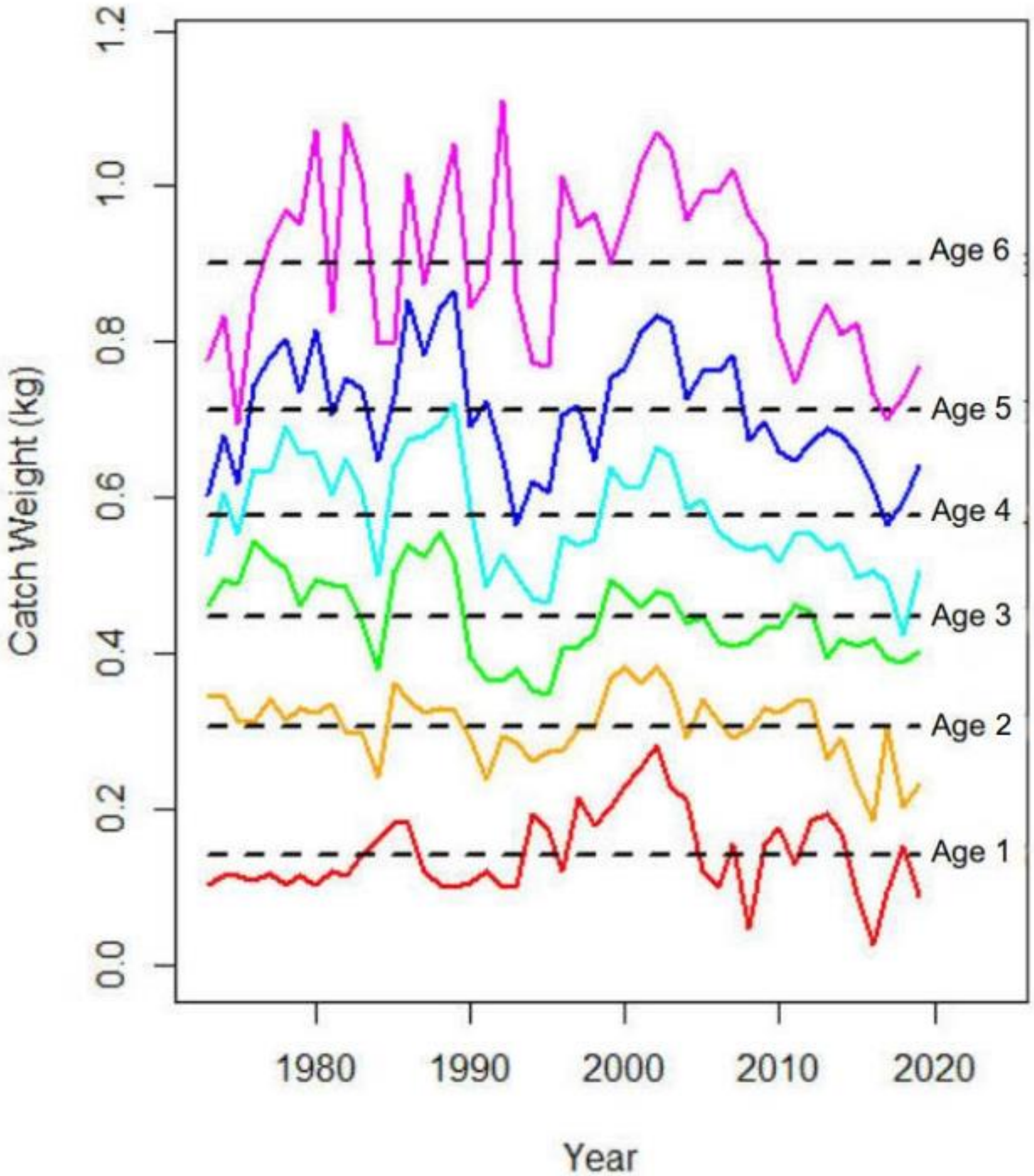


Figure A1. Trends in mean weight-at-age from the Georges Bank Yellowtail Flounder fishery (Canada and US combined, including discards). Dashed lines denote average of time series.

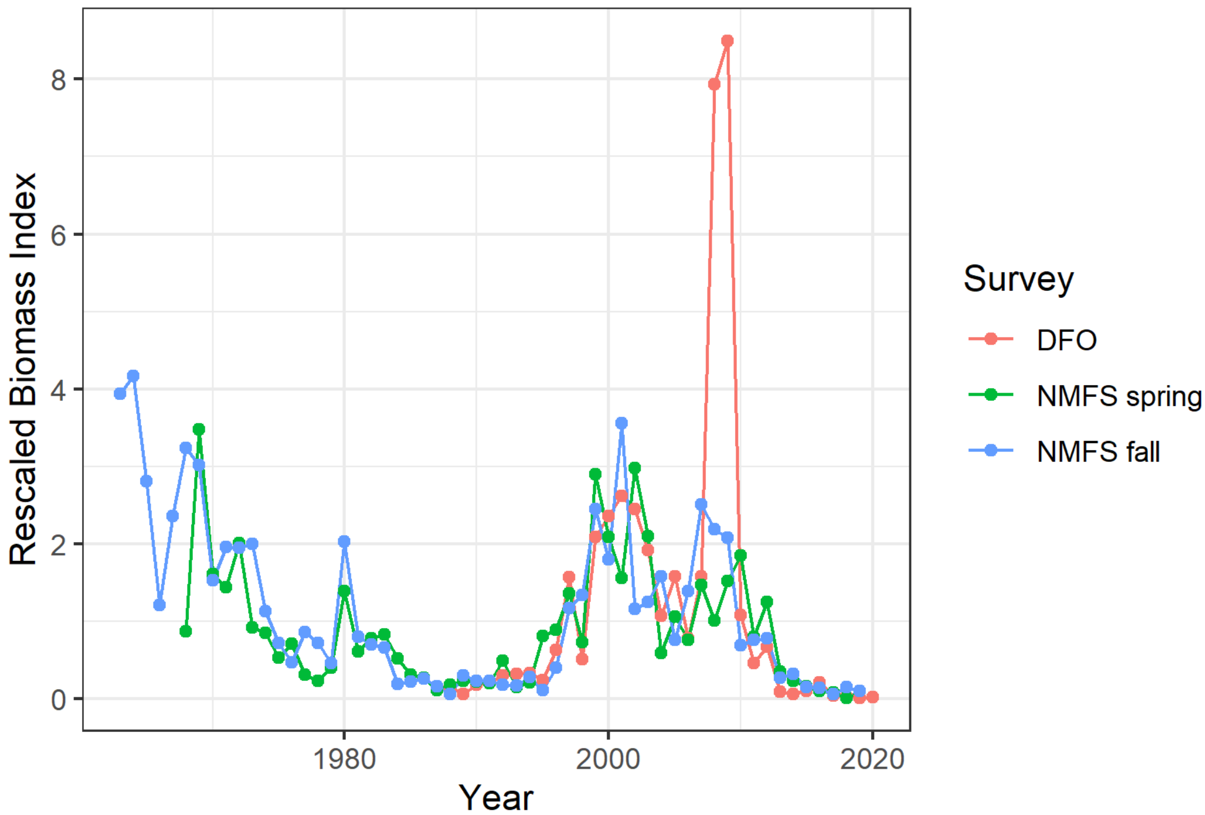


Figure A2. Three survey biomass indices (DFO spring, NMFS spring, and NMFS fall) for Yellowtail Flounder on Georges Bank rescaled to their respective means for years 1987–2007.

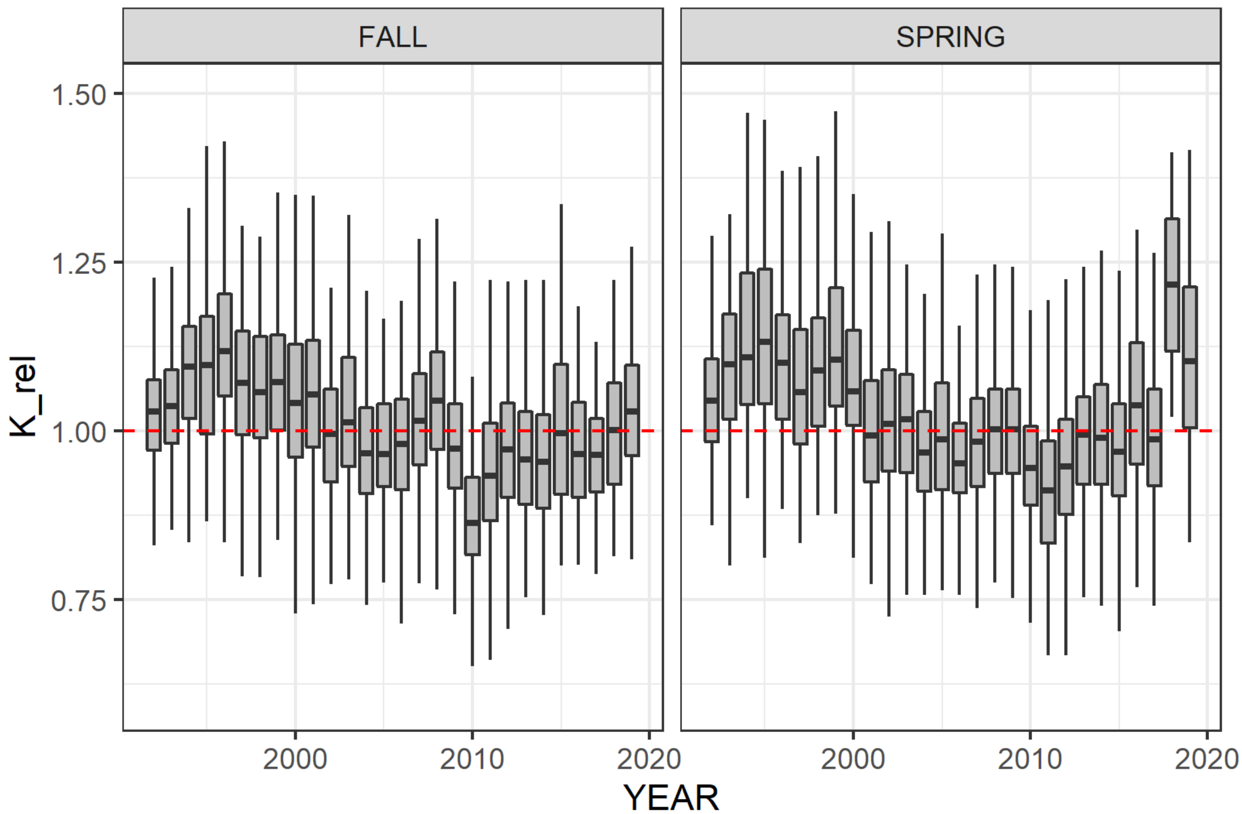


Figure A3. Condition factor (Fulton's K) of Georges Bank Yellowtail Flounder from the NMFS fall and spring surveys (1992–2019).

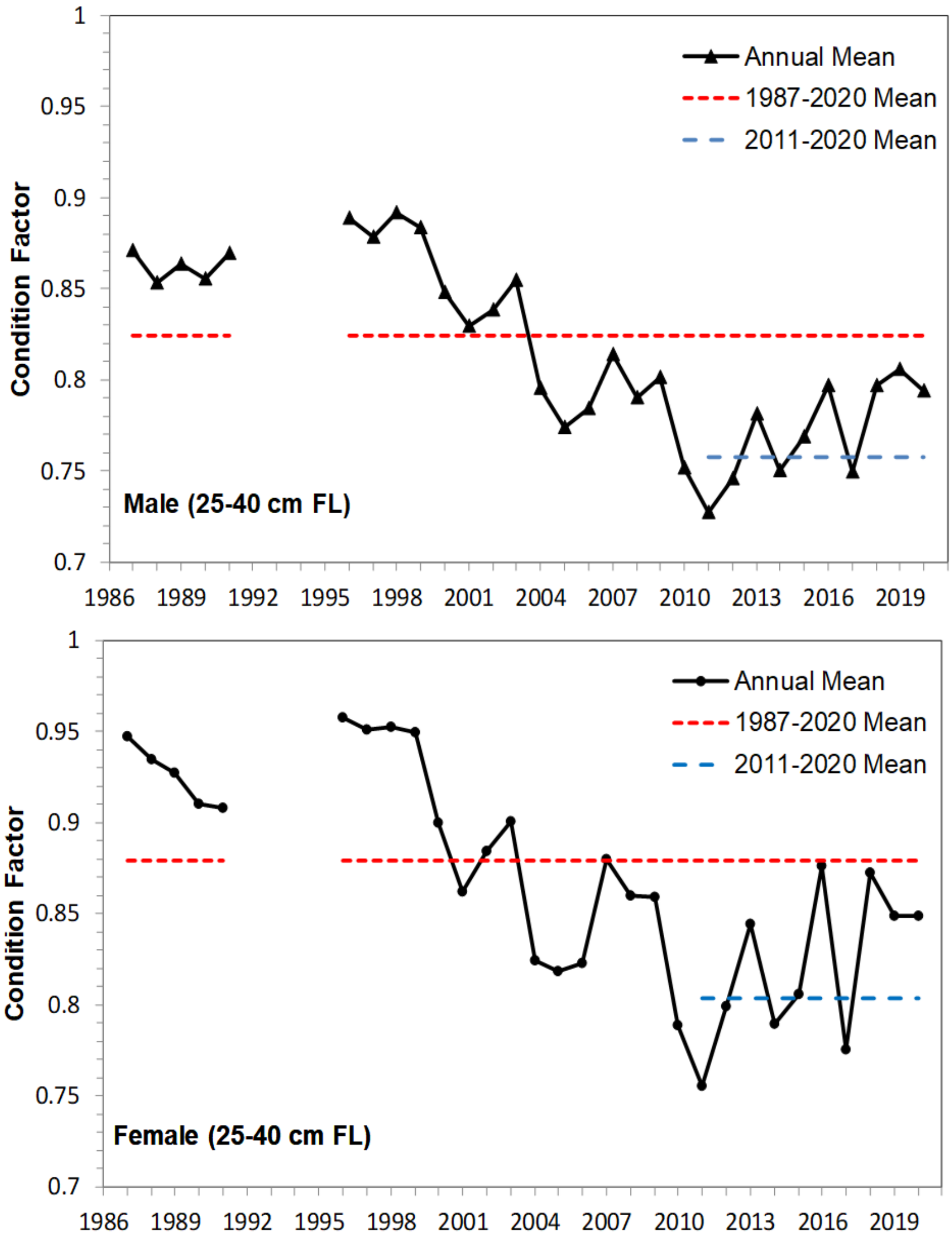


Figure A4. Condition factor (Fulton's K) for male and female Yellowtail Flounder in the DFO spring survey.

Management Table

Table A7. The table below was kindly initiated by Tom Nies (NEFMC). It summarizes the performance of the management system. It reports the TRAC advice, TMGC quota decision, actual catch, and realized stock conditions for Georges Bank Yellowtail Flounder. (1) All catches are calendar-year catches. (2) Values in italics are assessment results in year immediately following the catch year; values in normal font are results from this assessment. VPA=Virtual Population Analysis and SPM=Surplus Production Model.

TRAC	Catch Year	TRAC Analysis/Recommendation		TMGC Decision		Actual Catch(1)/Compared to Risk Analysis	Actual Result(2)
		Amount	Rationale	Amount	Rationale		
1999[1]	1999	(1) 4,383 mt (2) 6,836 mt	Neutral risk of exceeding Fref (1)VPA (2)SPM	NA	NA	4,963 mt/ 50% risk of exceeding Fref (VPA)	-
2000	2000	7,800 mt	Neutral risk of exceeding Fref	NA	NA	7,341 mt/About 30% risk of exceeding Fref	-
2001	2001	9,200 mt	Neutral risk of exceeding Fref	NA	NA	7,419 mt/Less than 10% risk of exceeding Fref	-
2002	2002	10,300 mt	Neutral risk of exceeding Fref	NA	NA	5,663 mt/Less than 1% risk of exceeding Fref	-
Transition to TMGC process in following year; note catch year differs from TRAC year in following lines							
2003	2004	-	No confidence in projections; status quo catch may be appropriate	7,900 mt	Neutral risk of exceeding Fref, biomass stable; recent catches between 6,100–7,800 mt	6,815 mt	*F above 1.0* Now NA
2004	2005	4,000 mt	Deterministic; other models give higher catch but less than 2004 quota	6,000 mt	Moving towards Fref	3,852 mt	*F = 1.37* *Age 3+ biomass decreased 5% 05-06* Now NA
2005	2006	(1) 4,200 (2) 2,100 (3) 3,000–3,500	Neutral risk of exceeding F ref (1-base case; 2-major change) (3) Low risk of not achieving 20% biomass increase	3,000 mt	Base case TAC adjusted for retrospective pattern, result is similar to major change TAC (projections redone at TMGC)	2,057 mt/ (1) Less than 10% risk of exceeding Fref (2) Neutral risk of exceeding Fref	*F = 0.89* *Age 3+ biomass increased 41% 06-07* Now NA
2006	2007	1,250 mt	Neutral risk of exceeding Fref; 66% increase in SSB from 2007 to 2008	1,250 mt (revised after US	Neutral risk of exceeding Fref	1,664 mt About 75 percent	*F = 0.29* *Age 3+ biomass increased 211% 07-08*

[1] Prior to implementation of US/CAN Understanding

TRAC	Catch Year	TRAC Analysis/Recommendation		TMGC Decision		Actual Catch[(1)]/Compared to Risk Analysis	Actual Result[(2)]
		Amount	Rationale	Amount	Rationale		
				objections to a 1,500 mt TAC)		probability of exceeding Fref	Now NA
2007	2008	3,500 mt	Neutral risk of exceeding Fref; 16% increase in age 3+ biomass from 2008 to 2009	2,500 mt	Expect F=0.17, less than neutral risk of exceeding Fref	1,499 mt No risk plot; expected less than median risk of exceeding Fref	*F~0.09* *Age 3+ biomass increased between 35%–52%* Now NA
2008	2009	(1) 4,600 mt 2) 2,100 mt	(1) Neutral risk of exceeding Fref; 9% increase from 2009-2010 (2) U.S. rebuilding plan	2,100 mt	U.S. rebuilding requirements; expect F=0.11; no risk of exceeding Fref	1,806 mt No risk of exceeding Fref	*F=0.15* *Age 3+ biomass increased 11%* Now NA
2009	2010	(1) 5,000 – 7,000 mt (2) 450 – 2,600 mt	(1) Neutral risk of exceeding Fref under two model formulations (2) U.S. rebuilding requirements	No agreement. Individual TACs total 1,975 mt	No agreement	1,170 mt No risk of exceeding Fref About 15% increase in median biomass expected	*F=0.13* *3+ Biomass increased 6% 10-11* Now Avg survey B decreased 62% 10-11
2010	2011	(1) 3,400 mt	(1) Neutral risk of exceeding Fref; no change in age 3+ biomass	2,650 mt	Low probability of exceeding Fref; expected 5% increase in biomass from 11 to 12	1,171 mt No risk of exceeding Fref About 15% increase in biomass expected	*F=0.31* *Age 3+ biomass decreased 5% 11-12* Now Avg survey B increased 35% 11-12
2011	2012	(1) 900–1,400 mt	(1) trade-off between risk of overfishing and change in biomass from three projections	1,150 mt	Low probability of exceeding Fref; expected increase in biomass from 12 to 13	725 mt	*F=0.32* *Age 3+ biomass decreased 6% 12-13* Now Avg survey B decreased 50% 12-13
2012	2013	(1) 200–500 mt	(1) trade-off between risk of overfishing and change in biomass from five projections	500 mt	Trade-off risk of F>Fref and biomass increase among 5 sensitivity analyses	218 mt	*F=0.32 (0.78 rho adjusted)* Now Avg survey B decreased 55% 13-14
2013	2014	(1) 200 mt (2) 500 mt	(1) F<Fref (2) B increase	400 mt	Reduction from 2013 quota, allow rebuilding	159 mt	Now Avg survey B increased 0% 14-15
2014	2015	(1) 45–354 mt (2) 400 mt	(1) constant exploitation rate 2%–16% (2) constant quota	354 mt	One year quota at 16% exploitation rate, reduction from 2014 quota	118 mt	Now Avg survey B decreased 31% 15-16
2015	2016	(1) 45–359 mt (2) 354 mt	(1) constant exploitation rate 2%–16% (2) constant quota	354 mt	Constant quota (and essentially no change in surveys)	44 mt	Now Avg survey B decreased 36% 16-17

TRAC	Catch Year	TRAC Analysis/Recommendation		TMGC Decision		Actual Catch(1)/Compared to Risk Analysis	Actual Result(2)
		Amount	Rationale	Amount	Rationale		
2016	2017	(1) 31–245 mt	(1) constant exploitation rate 2%–16%	300 mt	Decline in surveys and low inter-annual changes in quota	95 mt	Now Avg survey B decreased 64% 17-18
2017	2018	62–187 mt	Constant exploitation rate 2%–6%	300 mt	Balance Yellowtail Flounder stock conditions and the utilization of other species	45 mt	Now Avg survey B increased 195% 18-19
2018	2019	68 mt	Exploitation rate 6%	140 mt	Balance Yellowtail Flounder stock conditions and the utilization of other species	8 mt	Now Avg survey B decreased 37% 19-20 (note 2020 survey B based on only two surveys due to Covid-19)
2019	2020	199 mt	Exploitation rate 6%	162 mt	Balance Yellowtail Flounder stock conditions and the utilization of other species	-	-