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Stock Assessment of Georges Bank Yellowtail Flounder for 2016

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ABSTRACT

The combined Canada/US Yellowtail Flounder catch in 2015 was 118 mt, with neither country filling its portion of the quota. This is the lowest catch in the time series which began in 1935. Despite the low catch, the mean of the three bottom trawl surveys declined.

The empirical approach recommended at the 2014 Diagnostic Benchmark was applied in this year's assessment update. The three recent bottom trawl surveys were scaled to absolute biomass estimates, averaged, and an exploitation rate of 2% to 16% was applied to generate catch advice of 31 mt to 245 mt.

Sensitivity analyses were conducted for the catch advice and historical exploitation rates under different survey catchability values. Applying the historical exploitation rates associated with the quota or actual catch to the survey absolute biomass produces catch advice that is independent of the survey catchability assumption: 260 mt for the historical quota exploitation rate and 118 mt for the historical actual catch exploitation rate.

RÉSUMÉ

INTRODUCTION

The Georges Bank Yellowtail Flounder *(Limanda ferruginea)* stock is a transboundary resource in Canadian and US jurisdictions. This paper updates the last stock assessment of Yellowtail Flounder on Georges Bank, completed by Canada and the US (Legault et al. 2015), taking into account advice from the 2014 Diagnostic and Empirical Approach Benchmark (hereafter 2014 Diagnostic Benchmark; O'Brien and Clark 2014). During the June 2014 Transboundary Resources Assessment Committee (TRAC) assessment, it was decided to no longer use the virtual population analysis model which had previously provided stock condition and catch advice. This assessment follows that decision and does not provide any stock assessment model results. The 2014 Diagnostic Benchmark recommended an empirical approach to providing catch advice based on the three bottom trawl surveys and an assumed exploitation rate.

Last year, the empirical approach for catch advice was used with an exploitation rate of 2% to 16% resulting in a total quota of 45 mt to 359 mt. The TRAC also provided an option of a constant catch of 354 mt. The Transboundary Management Guidance Committee (TMGC) selected the combined US-Canada catch quota for 2015 to be 354 mt.

MANAGEMENT

The management unit currently recognized by Canada and the US for the transboundary Georges Bank stock includes the entire bank east of the Great South Channel to the Northeast Peak, encompassing Canadian fisheries statistical areas 5Zj, 5Zm, 5Zn and 5Zh (Figure 1a) and US statistical reporting areas 522, 525, 551, 552, 561 and 562 (Figure 1b).

THE FISHERIES

Exploitation of the Georges Bank Yellowtail Flounder stock began in the mid-1930s by the US trawler fleet. Catch (including discards) increased from 400 mt in 1935 to the highest annual catches during 1963-1976 (average: 17,500 mt) and included modest catches by distant water fleets (Table 1 and Figure 2a). A directed Canadian fishery began on eastern Georges Bank in 1993, pursued mainly by small otter trawlers (< 20 m). In 2001, the decision was made to manage the stock as a transboundary resource in Canadian and US jurisdictions (TMGC 2002). Since 2004, decreasing quotas, and catches below these quotas, have resulted in a declining trend in catches through 2015 (Figure 2b). Catch in 2015 was 118 mt, the lowest value over the time series (1935-2015).

UNITED STATES

The principle fishing gear used in the US fishery to catch Yellowtail Flounder is the otter trawl, accounting for more than 95% of the total US landings in recent years, although scallop dredges have accounted for some historical landings. Recreational fishing for Yellowtail Flounder is negligible.

Landings of Yellowtail Flounder from Georges Bank by the US fishery during 1994-2015 were derived from the trip-based allocation algorithm (GARM 2007; Legault et al. 2008; Palmer 2008; Wigley et al. 2007a). US landings have been limited by quotas in recent years. Total US Yellowtail Flounder landings (excluding discards) for the 2015 fishery were 63 mt (Table 1 and Figure 2a-b).

US discarded catch for years 1994-2015 was estimated using the Standardized Bycatch Reporting Methodology (SBRM) as recommended in the GARM III Data meeting (GARM 2007, Wigley et al. 2007b). Observed ratios of discards of Yellowtail Flounder to kept of all species for large mesh otter trawl, small mesh otter trawl, and scallop dredge were applied to the total landings by these gears and by half-year (Table 2). Large and small mesh otter trawl gears were separated at 5.5 inch (14 cm) cod-end mesh size. Total discards of Yellowtail in the US were 41 mt.

The total US catch of Georges Bank Yellowtail Flounder in 2015, including discards, was 104 mt.

The US Georges Bank Yellowtail Flounder quota for fishing year 2015 (1 May 2015 to 30 April 2016 for groundfish and 1 March 2015 to 28 February 2016 for scallops) was set at 248 mt. Monitoring of the US catches relative to the quota was based on Vessel Monitoring Systems (VMS) and a call-in system for both landings and discards. Reporting on the Regional Office webpage (NOAA Fisheries Northeast Multispecies (Groundfish) Monitoring Reports) indicates the US groundfish fishery caught 18.9% of its 203 mt sub-quota and the scallop fleet caught 78.1% of its 38 mt sub-quota for their 2015 fishing years.

Uncertainty in the US catch of Georges Bank Yellowtail Flounder has increased this year due to allegations of catch misreporting currently under litigation.

CANADA

Canadian fishermen initiated a directed fishery for Yellowtail Flounder on Georges Bank in 1993, but landings have been less than 100 mt every year since 2004, with less than 1 mt in both 2013 and 2014 and 3 mt in 2015. Since 2004, with the exception of 2011 and 2012, there has been no directed Canadian Yellowtail Flounder fishery (the fishery is not permitted to target Yellowtail Flounder, nor use gear appropriate for targeting this species); the Canadian quota has been reserved to cover bycatch in the commercial groundfish and scallop fisheries. From 2004-2011, and during 2013-2015, most of the reported Yellowtail Flounder landings were from trips directed for Haddock.

The Canadian offshore scallop fishery is the only source of Canadian Yellowtail Flounder discards on Georges Bank. Discards are estimated from at-sea observer deployments using the methodology documented in Van Eeckhaute et al. (2005). Since August 2004, there has been routine observer coverage on vessels in the Canadian scallop fishery on Georges Bank (Table 3). Discards for the years 2004-2015 were obtained by estimating a monthly prorated discard rate (kg/(hr*meters)), using a 3-month moving-average calculation to account for the seasonal pattern in bycatch rate, applied to a monthly standardized effort (Tables 4-5) (Sameoto et al. 2013; Van Eeckhaute et al. 2011). The result of these calculations for 2015 is a discard estimate of 11 mt, the lowest in the time series (Table 1).

For 2015, the total Canadian catch, including discards, was 14 mt, which is 13% of the 2015 quota of 106 mt.

LENGTH AND AGE COMPOSITION

Despite low landings, the level of US port sampling continued to be strong in 2015, with 1,426 length measurements available, resulting in 2,254 lengths per 100 mt of landings (Table 6). This level of sampling has generally resulted in high precision (i.e. low coefficients of variation) for the US landings at age from 1994-2015 (Table 7). The port samples also provided 514 age measurements for use in age-length keys. The Northeast Fisheries Observer Program provided an additional 993 length measurements of discarded fish, which were combined with the port samples to characterize the size composition of the US catch.

In 2015, no samples were collected from the 3 mt of Canadian landings (Table 6). The Canadian landings at age were assumed to follow the same proportions at age as the US landings and to have the same weights at age as the US landings.

The US discard length frequencies were generated from observer data, expanded to the total weight of discards by gear type and half year. Large and small mesh discards accounted for only a small portion of the total discards. Scallop dredge discards were mainly legal-sized fish, as has been typically seen for dredge gear in the past.

The size composition of Yellowtail Flounder discards in the Canadian offshore scallop fishery was estimated by half year using length measurements obtained from 20 observed trips in 2015. These were prorated to the total estimated bycatch at size using the corresponding half year length-weight relationship and the estimated half year bycatch (mt) calculated using the methods of Stone and Gavaris (2005).

The low magnitude of both landings and discards by both countries make comparisons of length distributions uninformative.

Percent agreement on scale ages by the US readers continues to be high (>85% for most studies) with no indication of bias (Results of all QA/QC Exercises for Yellowtail Flounder, *Limanda ferruginea*).

For the US fishery, sample length frequencies were expanded to total landings at size using the ratio of landings to sample weight (predicted from length-weight relationships by season; Lux 1969), and apportioned to age using pooled-sex age-length keys in half year groups. Landings were converted by market category and half year, while discards were converted by gear and half-year. The age-length keys for the US landings used only age samples from US port samples, while age-length keys for the US discards used age samples from US surveys and port samples.

No scale samples were available for the Canadian fishery in 2015. Therefore, the Canadian discards at length were converted to catch at age using the US age-length keys by half-year.

Since the mid 1990s, ages 2-4 have constituted most of the exploited population, with very low catches of age 1 fish due to the implementation of larger mesh (increased from 5.5 to 6 inches in May 1994) in the cod-end of US commercial trawl gear (Table 8 and Figure 3).

The fishery mean weights at age for Canadian and US landings and discards were derived using the applicable age-length keys, length frequencies, and length-weight relationships. The combined fishery weights at age were calculated from Canadian and US landings and discards, weighted by the respective catch at age (Table 9 and Figure 4).

ABUNDANCE INDICES

Research bottom trawl surveys are conducted annually on Georges Bank by Fisheries and Oceans Canada (DFO) in February and by the US National Marine Fisheries Service (NMFS) Northeast Fisheries Science Center (NEFSC) in April (denoted spring) and October (denoted fall). Both agencies use a stratified random design, though different strata boundaries are used (Figure 5).

The NMFS spring and fall bottom trawl (strata 13-21) and DFO bottom trawl (strata 5Z1-5Z4) survey catches were used to estimate relative stock biomass and relative abundance at age for Georges Bank Yellowtail Flounder. The NMFS scallop survey did not operate in Canadian waters in 2015 (the fifth year in a row this has occurred) and so cannot be used to estimate abundance of Yellowtail Flounder on all of Georges Bank. Conversion coefficients, which adjust for survey door, vessel, and net changes in NMFS groundfish surveys (1.22 for BMV oval doors, 0.85 for the former NOAA ship *Delaware II* relative to the former NOAA ship *Albatross IV*, and

1.76 for the Yankee 41 net; Rago et al. 1994; Byrne and Forrester 1991) were applied to the catch of each tow for years 1973-2008.

Beginning in 2009, the NMFS bottom trawl surveys were conducted with a new vessel, the NOAA ship *Henry B. Bigelow*, which uses a different net and protocols from the previous survey vessel. Conversion coefficients by length have been estimated for Yellowtail Flounder (Brooks et al. 2010) and were applied in this assessment when examining the entire survey time series, but not in the empirical approach.

The NMFS spring survey in 2016 was delayed due to mechanical issues. Scales from Yellowtail Flounder caught during this survey were not available in time to provide catch at age information for this survey for the 2016 TRAC meeting. There is no indication that the survey delay impacted the survey abundance estimates.

Trends in Yellowtail Flounder biomass indices from the three surveys track each other quite well over the past two decades, with the exception of the DFO survey in 2008 and 2009, which were influenced by single large tows (Tables 10-12; Figures 6-7). The 2016 DFO biomass is the eighth smallest in the 30 year time series. The 2016 NMFS spring biomass is the lowest in the 49 year time series. The 2015 NMFS fall biomass is the third lowest in the 53 year time series. These survey biomass levels are similar to those observed in the mid-1990s when the stock was declared collapsed (Stone et al. 2004).

The spatial distribution of catches (weight/tow) for the most recent year compared with the previous ten year average for the three groundfish surveys show that Yellowtail Flounder distribution on Georges Bank in the most recent year has been consistent relative to the previous ten years (Figure 8a-b). The delay in the 2016 NMFS spring survey did not appear to cause a change in the distribution of yellowtail flounder (Figure 8c). Since 1996, most of the DFO survey biomass and abundance of Yellowtail Flounder has occurred in strata 5Z2 and 5Z4 (Figure 9a). However, in 2008 and 2009 almost the entire Canadian survey catch occurred in just one or two tows in stratum 5Z1, making interpretation of trends over time difficult. The NMFS bottom trawl surveys have been dominated by stratum 16 since the mid 1990s (Figure 9b-c).

Age-structured indices of abundance for NMFS spring and fall surveys were derived using survey specific age-length keys (Tables 10-12; Figure 10a-c). There is some indication of cohort tracking in all three of the bottom trawl surveys (Figure 11a-c). Even though each index is noisy, the age specific trends track relatively well among the three surveys (Figure 12).

The condition factor (Fulton’s K) of Yellowtail Flounder has declined during the available time series in all three surveys (Figure 13a-b).

Relative fishing mortality (fishery catch biomass/survey biomass, scaled to the mean for 1987-2007) was quite variable but followed a similar trend for all three surveys, with a sharp decline to low levels since 1995 (Figure 14). In contrast, time series of cohort total mortality (Z) estimated from the three bottom trawl surveys indicate high values since 1995 (Figure 15a-c).

EMPIRICAL APPROACH

The 2014 Diagnostic Benchmark recommended an empirical approach be considered for catch advice. The three bottom trawl surveys are used to create a model-free estimate of population abundance. For the two NMFS surveys, the *Henry B. Bigelow* data are used directly (i.e. un-calibrated values) in these calculations to avoid the complexities that arise due to calibration with the *Albatross IV* (Table 13). The stratified mean catch per tow in weight is expanded to total biomass based on the ratio of the total area surveyed to the area of a single trawl (Table 14). This minimum swept area biomass is divided by the catchability of 0.37 to create an estimate of the biomass. A literature estimate of the catchability of the gear, meaning the number of

Yellowtail Flounder in the path of the tow which were caught, is used to expand the minimum swept area amount to total abundance. This literature value for catchability was derived in working paper 13 of the 2014 Diagnostic Benchmark as the mean of the value 0.22 in Harden Jones et al. (1977) and four values of 0.33, 0.42, 0.43, and 0.45 in Somerton et al. (2007). The Harden Jones et al. (1977) study was conducted with English plaice in the North Sea using a Granton otter trawl. The Somerton et al. (2007) study was conducted with four flatfish species (arrowtooth flounder, flathead sole, rex sole, and Dover sole) in the Gulf of Alaska using a Poly nor'eastern survey trawl. The survey biomass estimates from DFO and the NMFS spring survey in year t and the NMFS fall survey in year t-1 are averaged to form the estimate of population biomass in year t. Multiplying the average biomass by an exploitation rate of 0.02 to 0.16 results in the range of catch advice for year t+1 (Table 15). The catch advice for 2017 is 31 mt to 245 mt.

For context, recent quotas correspond to exploitation rates of 10-36% (mean 17%) and recent catches correspond to exploitation rates of 4-16% (mean 8%; Table 16). Despite catches averaging well below the upper end of the range of acceptable exploitation rates (2-16%), the surveys have declined substantially during this period. This indicates that the fishery may not be driving the decline in the population, but is of concern for the health of the stock. It is important to note that quotas for years 2010 to 2014 were not set according to the empirical method.

A sensitivity analysis was conducted to explore the impact of changing the survey catchability value. Catch advice and historical exploitation rates were computed for a range of survey catchability values (0.2, 0.3, 0.4, 0.5). The change in average biomass from the three surveys under a new survey catchability value (assuming it applies to all three surveys) is calculated as Avg * 0.37 / q where Avg denotes the the average survey biomass, 0.37 is the current survey catchability, and q is the new survey catchability for the sensitivity analysis. Lower q values produce higher estimated biomass (Figure 16a), although the trend is the same for all values of q (Figure 16b). Catch advice is derived by multiplying the average biomass by an exploitation rate from 2% to 16%. The historical exploitation rates for the quota and actual catch can be computed by dividing each time series by the average biomass (Figure 17). Both the quota and catch historical exploitation rates have been relatively constant, with the exception of 2011. The catch advice for 2016 decreases with increasing q while the historical exploitation rates increase with increasing q (Figure 18). If the historical exploitation rate is applied as the exploitation rate for catch advice based on not increasing the exploitation rate when stock conditions are poor, the resulting catch advice is independent of the survey catchability. This can be demonstrated mathematically. Let C_{2017} be the catch advice for 2017. It is derived by multiplying the average survey biomass in 2016 (B_{2016}) by a relative exploitation rate (μ). The average survey biomass in year y is the minimum swept area biomass for that year (b_y) divided by the survey catchability (q). The historical relative exploitation rate is the average of the quota or actual catch (C_y) divided by the average survey biomass

$$\mu = \frac{1}{n}\sum_{y=1}^{n}\frac{C_y}{B_y}$$

Thus,

$$C_{2017} \;=\; B_{2016} \cdot \mu \;=\; \frac{b_{2016}}{q} \cdot \frac{1}{n}\sum_{y=1}^{n}\frac{C_y}{B_y} \;=\; \frac{b_{2016}}{q} \cdot \frac{1}{n}\sum_{y=1}^{n}\frac{C_y}{b_y/q}$$

Since survey catchability is a constant, it can be factored out of the summation

$$C_{2017} = \frac{b_{2016}}{q} \cdot \frac{1}{n/q}\sum_{y=1}^{n}\frac{C_y}{b_y}$$

The two survey catchabilities now cancel producing catch advice that does not depend on survey catchability

$$C_{2017} = b_{2016} \cdot \frac{1}{n}\sum_{y=1}^{n}\frac{C_y}{b_y}$$

Applying the historical exploitation rate associated with the quota results in catch advice for 2017 of 260 mt, while applying the historical exploitation rate associated with the actual catch results in catch advice for 2017 of 118 mt (Table 17). During the TRAC meeting, it was suggested that uncertainty about these catch advice values could be generated by using the minimum and maximum historical exploitation rates during the period used for the average value. The results of these calculations are 155-554 mt for the historical exploitation rates associated with quotas and 68-245 mt for the historical exploitation rates associated with actual catches during 2010-2015. Both ranges are independent of the survey catchability value used. These ranges should not be considered as probability statements, but rather simply reflect the range of exploitation rates observed during 2010-2015, a period of decline for Yellowtail Flounder on Georges Bank.

MANAGEMENT CONSIDERATIONS

During the 2014 Diagnostic Benchmark, considerations were provided as reasons to decrease or to maintain or increase the quota. The assessment findings this year support reasons to both decrease the quota and to maintain or increase the quota for 2017. Last year’s catch was less than half the quota, the relative F continues to be low, and bycatch avoidance programs continue, which support maintaining or increasing the quota. The mean of the three surveys declined last year, recent recruitment continues to be below average, and fish condition (i.e., Fulton’s K) continues to be low relative to the available time series, which support decreasing the quota.

TRAC MEETING ANALYSES

During the TRAC meeting, a reviewer requested a comparison of the fish condition factor (weight at length) and the survey biomass. The request was premised on the idea that density dependence may be playing a role in fish condition whereby individual Yellowtail Flounder would be lighter at a given length when the stock was larger due to food competition. A strong negative relationship was expected between fish condition and survey biomass if this hypothesis was correct. Fulton’s K, a measure of fish condition factor, was compared to survey biomass for all three surveys (Figure 19). There was not a significant relationship between the variables for any of the surveys (the DFO survey was examined both with and without the 2008 and 2009 data to explore if the large single tows had an effect on the relationship). This hypothesis was clearly demonstrated to be false and will not be examined in future assessments.

During the TRAC meeting, a reviewer asked whether times series of recruits per spawning stock biomass had been examined using only data from the surveys. The request was premised on the concern that changes in recruits per spawning stock biomass could be masking important trends in recruitment. For example, if recruits per spawning stock biomass increased over time, it could result in recruitment staying relatively high while spawning stock biomass declined, which would be of biological concern because this pattern could not continue indefinitely. Alternatively, if recruits per spawning stock biomass declined at low spawning stock biomass, this could be an indication of depensation in the stock-recruitment relationship, which would be concerning for the ability of the stock to rebuild even under no fishing.There was insufficient time during the TRAC meeting to present this analysis. For each of the three surveys, both age

1 and age 2 were used for recruitment and appropriately lagged relative to total biomass from that survey to create a proxy for the recruits per spawning stock biomass. Age 2 was examined because the age 1 survey values contained many zeros. The time series of recruits per survey biomass were variable without strong trend in all cases (Figure 20). There is an indication of depensation in recent years (Figure 21). This analysis will be continued in future assessments to track whether these preliminary indications of depensation in the stock-recruitment relationship continue, as this would have strong implications for the (in)ability of the stock to rebuild even under no fishing.

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TABLES

Table 1. 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 1. 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%

Table 2. Derivation of Georges Bank Yellowtail Flounder US discards (mt) calculated as the product of the ratio estimator (d:k – discard to kept all species on observed trips in a stratum) and total kept (K_all) in each stratum. Coefficient of variation (CV) provided by gear and year.

		Small Mesh Trawl					Large Mesh Trawl					Scallop Dredge					Total
Year	**Half**	**ntrips**	**d:k**	**K_all (mt)**	**D (mt)**	**CV**	**ntrips**	**d:k**	**K_all (mt)**	**D (mt)**	**CV**	**ntrips**	**d:k**	**K_all (mt)**	**D (mt)**	**CV**	**D (mt)**
1994	1	1	0.0000	1090	0		16	0.0013	7698	10		1	0.0001	2739	0		11
	2	1	0.0000	1316	0		6	0.0199	6445	128		4	0.0039	2531	10		138
1994 Total		**2**			**0**	**0%**	**22**			**138**	**150%**	**5**			**10**	**6%**	**148**
1995	1	1	0.0000	2331	0		27	0.0023	6256	14		1	0.0017	522	1		15
	2	1	0.0000	919	0		10	0.0055	3844	21		2	0.0017	3634	6		28
1995 Total		**2**			**0**	**0%**	**37**			**36**	**70%**	**3**			**7**	**20%**	**43**
1996	1	2	0.0000	3982	0		12	0.0066	7094	47		2	0.0025	2132	5		52
	2	1	0.0000	1470	0		1	0.0005	7269	4		2	0.0081	4960	40		44
1996 Total		**3**			**0**	**0%**	**13**			**51**	**30%**	**4**			**45**	**0%**	**96**
1997	1	1	0.0000	2102	0		3	0.0247	8215	203		3	0.0048	4044	19		222
	2			1391	0		3	0.0019	4098	8		3	0.0250	3903	97		105
1997 Total		**1**			**0**	**0%**	**6**			**211**	**22%**	**6**			**117**	**74%**	**327**
1998	1	1	0.0000	1808	0		3	0.0219	8059	177		2	0.0065	3849	25		202
	2			3111	0		2	0.0015	5611	8		3	0.0551	4945	272		280
1998 Total		**1**			**0**	**0%**	**5**			**185**	**66%**	**5**			**297**	**46%**	**482**
1999	1	1	0.0000	3868	0		2	0.0010	9391	9		4	0.0152	8806	134		143
	2			2638	0		5	0.0005	4755	2		15	0.0176	24524	432		434
1999 Total		**1**			**0**	**0%**	**7**			**11**	**67%**	**19**			**566**	**13%**	**577**
2000	1	2	0.0000	3665	0		6	0.0014	10869	15		25	0.0457	8320	380		395
	2	2	0.0272	1665	0		11	0.0015	6421	10		154	0.0181	15991	289		299
2000 Total		**4**			**0**	**90%**	**17**			**25**	**71%**	**179**			**669**	**12%**	**694**
2001	1	5	0.0045	2347	0		13	0.0038	13047	49		16	0.0019	7728	14		63
	2	2	0.0000	3461	0		13	0.0002	6716	1			0.0019	7162	13		15
2001 Total		**7**			**0**	**105%**	**26**			**50**	**51%**	**16**			**28**	**7%**	**78**
2002	1	1	0.0000	2420	0		11	0.0010	14525	14			0.0035	2074	7		21
	2	6	0.0001	2243	0		37	0.0015	6196	10		4	0.0035	6134	22		31
2002 Total		**7**			**0**	**79%**	**48**			**24**	**42%**	**4**			**29**	**27%**	**53**
2003	1	7	0.0001	2350	0		61	0.0064	15264	97			0.0149	9612	143		241
	2	7	0.0002	4764	1		46	0.0021	8438	18		2	0.0149	10083	150		169
2003 Total		**14**			**1**	**95%**	**107**			**115**	**39%**	**2**			**293**	**0%**	**410**
2004	1	5	0.0005	2504	1		68	0.0078	14130	111		2	0.0001	2942	0		112
	2	12	0.0215	2508	54		86	0.0179	11958	214		28	0.0058	13885	81		348
2004 Total		**17**			**55**	**62%**	**154**			**324**	**20%**	**30**			**81**	**21%**	**460**

Table 2. Continued.

		Small Mesh Trawl					Large Mesh Trawl					Scallop Dredge					Total
Year	**Half**	**ntrips**	**d:k**	**K_all (mt)**	**D (mt)**	**CV**	**ntrips**	**d:k**	**K_all (mt)**	**D (mt)**	**CV**	**ntrips**	**d:k**	**K_all (mt)**	**D (mt)**	**CV**	**D (mt)**
2005	1	41	0.0206	1448	30		369	0.0092	9935	92		8	0.0032	8217	27		148
	2	36	0.0068	3207	22		200	0.0094	8988	85		55	0.0041	38751	159		266
2005 Total		**77**			**52**	**28%**	**569**			**177**	**12%**	**63**			**186**	**20%**	**414**
2006	1	11	0.0004	824	0		182	0.0074	7008	52		13	0.0015	20457	30		83
	2	6	0.0127	1995	25		121	0.0111	4963	55		54	0.0056	39378	221		301
2006 Total		**17**			**26**	**95%**	**303**			**107**	**14%**	**67**			**251**	**19%**	**384**
2007	1	8	0.0016	3521	5		148	0.0166	8392	139		17	0.0031	12737	39		184
	2	4	0.0438	2377	104		156	0.0237	5236	124		42	0.0036	22445	81		309
2007 Total		**12**			**110**	**86%**	**304**			**264**	**10%**	**59**			**120**	**24%**	**493**
2008	1	4	0.0000	1557	0		184	0.0224	6966	156		20	0.0066	6322	42		198
	2	4	0.0223	1145	26		213	0.0144	6904	99		22	0.0079	10951	86		211
2008 Total		**8**			**26**	**264%**	**397**			**255**	**8%**	**42**			**128**	**15%**	**409**
2009	1	10	0.0000	1158	0		180	0.0339	8008	271		36	0.0079	18403	146		417
	2	13	0.0157	1546	24		162	0.0364	8066	294		22	0.0013	18287	24		342
2009 Total		**23**			**24**	**73%**	**342**			**565**	**13%**	**58**			**170**	**17%**	**759**
2010	1	17	0.0035	2341	8		181	0.0222	9814	218		3	0.0041	1352	5		231
	2	17	0.0106	2079	22		130	0.0064	5097	33		5	0.0005	6000	3		58
2010 Total		**34**			**30**	**39%**	**311**			**250**	**17%**	**8**			**8**	**48%**	**289**
2011	1	12	0.0049	2504	12		163	0.0040	7807	31		2	0.0133	2920	39		83
	2	18	0.0094	2162	20		147	0.0050	4735	24		68	0.0017	39557	65		109
2011 Total		**30**			**33**	**38%**	**310**			**55**	**10%**	**70**			**104**	**53%**	**192**
2012	1	8	0.0145	1686	24		117	0.0037	4997	18		24	0.0011	15118	17		59
	2	2	0.0001	1713	0		121	0.0017	3861	7		78	0.0036	34008	122		129
2012 Total		**10**			**24**	**89%**	**238**			**25**	**12%**	**102**			**139**	**23%**	**188**
2013	1	16	0.0004	2435	1		80	0.0013	2849	4		36	0.0012	15148	19		23
	2	15	0.0010	1832	2		94	0.0024	3385	8		30	0.0010	15145	16		26
2013 Total		**31**			**3**	**28%**	**174**			**12**	**16%**	**66**			**34**	**19%**	**49**
2014	1	12	0.0006	3189	2		110	0.0012	4393	5		13	0.0021	9414	19		26
	2	28	0.0006	2156	1		105	0.0007	3245	2		34	0.0036	12244	44		48
2014 Total		**40**			**3**	**29%**	**215**			**8**	**21%**	**47**			**64**	**14%**	**74**
2015	1	18	0.0000	2857	0		102	0.0004	6154	3		41	0.0018	16872	30		33
	2	25	0.0000	2884	0		68	0.0003	2926	1		13	0.0011	5958	7		8
2015 Total		**43**			**0**	**56%**	**170**			**4**	**25%**	**54**			**37**	**19%**	**41**

Table 3. Number of trips observed in the Canadian scallop fishery.

Year	Ntrips
2004	5
2005	11
2006	11
2007	14
2008	23
2009	21
2010	24
2011	22
2012	20
2013	17
2014	24
2015	20

*Table 4. Prorated discards (kg) and fishing effort (hr*meters, or hm) for Georges Bank Yellowtail Flounder from International Observer Program (IOP) trips of the Canadian scallop fishery in 2015.*

		Proration			**Discards (kg)**		**Effort (hm)**
		Number of Dredges					
IOP Trip	**Board Date**	**Observed**	**Total**	**Proportion**	**Observed**	**Prorated**	
J15-0054	1/28/2015	524	1031	0.51	38	75	2704
J15-0013	2/18/2015	371	705	0.53	12	23	1716
J15-0079	3/23/2015	812	1638	0.50	19	38	2084
J15-0154	4/13/2015	232	462	0.50	47	94	750
J15-0096	4/20/2015	634	1260	0.50	49	97	1942
J15-0166	5/13/2015	643	1163	0.55	213	385	2516
J15-0111	5/17/2015	286	544	0.53	21	40	1298
J15-0205	6/22/2015	381	736	0.52	122	236	1242
J15-0267	6/22/2015	196	370	0.53	27	51	697
J15-0351	7/12/2015	268	586	0.46	29	63	1332
J15-0223	7/13/2015	548	1054	0.52	0	0	1621
J15-0471	8/17/2015	274	502	0.55	19	35	1255
J15-0494	8/25/2015	182	340	0.54	29	54	728
J15-0572	9/8/2015	220	414	0.53	31	58	990
J15-0583	9/15/2015	796	1544	0.52	1	2	1934
J15-0623	10/7/2015	326	652	0.50	12	24	1451
J15-0617	10/7/2015	602	1176	0.51	25	49	1833
J15-0632	10/12/2015	590	1212	0.49	5	10	1949
J15-0669	11/13/2015	678	1356	0.50	6	12	1791
J15-0528	11/19/2015	698	1336	0.52	4	8	1947

Table 5. Three month moving-average (ma) discard rate (kg/hm), standardized fishing effort (hm), and discards (mt) of Georges Bank Yellowtail Flounder from the Canadian scallop fishery in 2015.

				3-month ma			
Year	**Month**	**Monthly Prorated Discards (kg)**	**Monthly Effort (hm)**	**Discard Rate (kg/hm)**	**Effort (hm)**	**ma Discards (mt)**	**Cum. Annual Discards (mt)**
2015	Jan	0	0	0.022	477	0	0
	Feb	75	2704	0.021	3757	0	0
	Mar	61	3800	0.036	10845	0	0
	Apr	191	2692	0.066	20130	1	2
	May	425	3814	0.107	36335	4	6
	Jun	287	1939	0.088	19835	2	7
	Jul	63	3010	0.063	32502	2	10
	Aug	89	1983	0.027	30715	1	10
	Sep	60	2924	0.023	24280	1	11
	Oct	83	5233	0.014	17864	0	11
	Nov	20	3738	0.011	10041	0	11
	Dec	0	0	0.005	7236	0	11

Table 6. Port samples used in the estimation of landings at age for Georges Bank Yellowtail Flounder in 2015 from US and Canadian sources.

	Landings (mt)					Port Sampling (Number of Lengths or Ages)						
US	Market Category					Market Category					Lengths	Number
Half	Uncl.	Large	Small	Medium	Total	Uncl.	Large	Small	Medium	Total	per 100mt	of Ages
1	1	25	13	1	40		569	174		743		
2	0	17	6	0	23		400	283		683		
Total	1	43	19	1	63		969	457		1426	2254	514
Canada											Lengths	Number
Quarter					Total					Total	per 100mt	of Ages
1												
2					2							
3					1							
4												
Total					3						0	0

Table 7. Coefficient of variation for US landings at age of Georges Bank Yellowtail Flounder by year.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+
1994		57%	6%	14%	27%	41%
1995		27%	11%	13%	22%	40%
1996		23%	7%	15%	26%	60%
1997		17%	11%	8%	30%	35%
1998		64%	31%	16%	36%	30%
1999	97%	21%	9%	25%	33%	34%
2000		11%	9%	11%	20%	32%
2001		17%	11%	10%	22%	48%
2002	76%	15%	11%	11%	15%	22%
2003		16%	8%	9%	11%	16%
2004		53%	8%	6%	9%	11%
2005		11%	4%	6%	12%	16%
2006		10%	5%	6%	6%	13%
2007	103%	10%	5%	6%	14%	19%
2008		17%	4%	6%	17%	33%
2009		14%	4%	4%	6%	23%
2010		20%	5%	4%	6%	14%
2011	98%	19%	6%	4%	7%	15%
2012		23%	10%	6%	12%	45%
2013	167%	24%	10%	9%	9%	27%
2014		39%	12%	10%	12%	22%
2015		14%	8%	5%	3%	10%

Table 8. Total catch at age including discards (number in 000s of fish) for Georges Bank Yellowtail Flounder.

	Age												
Year	1	2	3	4	5	6	7	8	9	10	11	12	**Total**
1973	359	5175	13565	9473	3815	1285	283	55	23	4	0	0	34037
1974	2368	9500	8294	7658	3643	878	464	106	71	0	0	0	32982
1975	4636	26394	7375	3540	2175	708	327	132	26	14	0	0	45328
1976	635	31938	5502	1426	574	453	304	95	54	11	2	0	40993
1977	378	9094	10567	1846	419	231	134	82	37	10	0	0	22799
1978	9962	3542	4580	1914	540	120	45	16	17	7	6	0	20748
1979	321	10517	3789	1432	623	167	95	31	27	1	3	0	17006
1980	318	3994	9685	1538	352	96	5	11	1	0	0	0	16000
1981	107	1097	5963	4920	854	135	5	2	3	0	0	0	13088
1982	2164	18091	7480	3401	1095	68	20	7	0	0	0	0	32327
1983	703	7998	16661	2476	680	122	13	16	4	0	0	0	28672
1984	514	2018	4535	5043	1796	294	47	39	0	0	0	0	14285
1985	970	4374	1058	818	517	73	8	0	0	0	0	0	7817
1986	179	6402	1127	389	204	80	17	15	0	1	0	0	8414
1987	156	3284	3137	983	192	48	38	26	25	0	0	0	7890
1988	499	3003	1544	846	227	24	26	3	0	0	0	0	6172
1989	190	2175	1121	428	110	18	12	0	0	0	0	0	4054
1990	231	2114	6996	978	140	21	6	0	0	0	0	0	10485
1991	663	147	1491	3011	383	67	4	0	0	0	0	0	5767
1992	2414	9167	2971	1473	603	33	7	1	1	0	0	0	16671
1993	5233	1386	3327	2326	411	84	5	1	0	0	0	0	12773
1994	71	1336	6302	1819	477	120	20	3	0	0	0	0	10150
1995	47	313	1435	879	170	25	10	1	0	0	0	0	2880
1996	101	681	2064	885	201	13	10	5	0	0	0	0	3960
1997	82	1132	1832	1857	378	39	43	7	1	0	0	0	5371
1998	169	1991	3388	1885	1121	122	18	3	0	3	0	0	8700
1999	60	2753	4195	1548	794	264	32	4	1	0	0	0	9651
2000	132	3864	5714	3173	826	420	66	38	4	0	0	0	14237
2001	176	2884	6956	2893	1004	291	216	13	4	0	0	0	14438
2002	212	4169	3446	1916	683	269	144	57	10	6	0	0	10911
2003	160	3919	4710	2320	782	282	243	96	47	23	2	0	12585
2004	61	1152	3184	3824	1970	889	409	78	74	18	2	0	11661
2005	60	1580	4032	1707	392	132	37	16	0	0	0	0	7956
2006	150	1251	1577	923	358	123	65	14	7	3	0	0	4470
2007	51	1493	1708	664	137	44	9	2	0	0	0	0	4108
2008	28	490	1897	853	125	17	8	0	0	0	0	0	3417
2009	17	283	1266	1360	516	59	10	4	0	0	0	0	3516
2010	2	141	651	899	449	88	10	2	0	0	0	0	2241
2011	11	166	775	904	310	67	8	1	0	0	0	0	2242
2012	12	108	370	579	240	38	4	4	0	0	0	0	1355
2013	15	61	99	148	91	19	2	0	0	0	0	0	435
2014	6	43	90	98	50	19	3	0	0	0	0	0	311
2015	1	30	61	58	51	21	6	2	0	0	0	0	230

Table 9. Mean weight at age (kg) for the total catch including US and Canadian discards, for Georges Bank Yellowtail Flounder.

	Age											
Year	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	
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				

Table 10. DFO 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	Age1	Age2	Age3	Age4	Age5	Age6+	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

Table 11. NMFS spring survey indices of abundance for Georges Bank Yellowtail Flounder in both numbers and kg per tow, along with the CV for the biomass estimates.

Year	1	2	3	4	5	6+	B(kg/tow)	CV(B)
1968	0.335	3.176	3.580	0.304	0.073	0.310	2.791	0.236
1969	1.108	9.313	11.121	3.175	1.345	0.699	11.170	0.305
1970	0.093	4.485	6.030	2.422	0.570	0.311	5.146	0.161
1971	0.835	3.516	4.813	3.300	0.780	0.320	4.619	0.200
1972	0.141	6.923	7.050	3.705	1.127	0.239	6.455	0.229
1973	1.940	3.281	2.379	1.068	0.412	0.217	2.939	0.181
1974	0.317	2.234	1.850	1.262	0.347	0.282	2.720	0.193
1975	0.422	3.006	0.834	0.271	0.208	0.089	1.676	0.239
1976	1.112	4.315	1.253	0.312	0.197	0.112	2.273	0.173
1977	0.000	0.674	1.131	0.396	0.063	0.013	0.999	0.329
1978	0.940	0.802	0.510	0.220	0.027	0.008	0.742	0.209
1979	0.406	2.016	0.407	0.338	0.061	0.092	1.271	0.210
1980	0.057	4.666	5.787	0.475	0.057	0.036	4.456	0.368
1981	0.017	1.020	1.777	0.720	0.213	0.059	1.960	0.351
1982	0.045	3.767	1.130	1.022	0.458	0.091	2.500	0.201
1983	0.000	1.865	2.728	0.530	0.123	0.245	2.642	0.315
1984	0.000	0.093	0.831	0.863	0.896	0.183	1.646	0.466
1985	0.110	2.199	0.262	0.282	0.148	0.000	0.988	0.532
1986	0.027	1.806	0.291	0.056	0.137	0.055	0.847	0.323
1987	0.027	0.076	0.137	0.133	0.053	0.055	0.329	0.375
1988	0.078	0.275	0.366	0.242	0.199	0.027	0.566	0.281
1989	0.047	0.424	0.739	0.290	0.061	0.045	0.729	0.287
1990	0.000	0.110	1.063	0.369	0.163	0.057	0.699	0.333
1991	0.435	0.000	0.254	0.685	0.263	0.021	0.631	0.264
1992	0.000	2.048	1.897	0.641	0.165	0.017	1.566	0.494
1993	0.046	0.290	0.501	0.317	0.027	0.000	0.482	0.277
1994	0.000	0.621	0.633	0.354	0.145	0.040	0.660	0.237
1995	0.040	1.179	4.812	1.485	0.640	0.010	2.579	0.637
1996	0.025	0.987	2.626	2.701	0.610	0.058	2.853	0.332
1997	0.019	1.169	3.733	4.080	0.703	0.134	4.359	0.266
1998	0.000	2.081	1.053	1.157	0.760	0.350	2.324	0.239
1999	0.050	4.746	10.819	2.721	1.623	0.779	9.307	0.448

Table 11. Continued.

Year	1	2	3	4	5	6+	B(kg/tow)	CV(B)
2000	0.183	4.819	7.666	2.914	0.813	0.524	6.696	0.231
2001	0.000	2.315	6.563	2.411	0.484	0.453	5.006	0.343
2002	0.188	2.412	12.334	4.078	1.741	0.871	9.563	0.290
2003	0.202	4.370	6.764	2.876	0.442	0.862	6.722	0.428
2004	0.049	0.986	2.179	0.735	0.255	0.217	1.891	0.278
2005	0.000	2.013	5.080	2.404	0.270	0.115	3.407	0.346
2006	0.509	0.935	3.523	2.177	0.317	0.082	2.420	0.193
2007	0.090	5.048	6.263	2.846	0.556	0.129	4.701	0.227
2008	0.000	2.274	5.071	1.732	0.310	0.027	3.247	0.239
2009	0.211	0.600	7.446	4.653	1.002	0.191	4.856	0.230
2010	0.017	0.694	5.412	8.451	2.721	0.654	5.944	0.273
2011	0.031	0.243	3.331	3.735	0.964	0.108	2.561	0.238
2012	0.095	0.718	4.178	5.745	1.411	0.200	3.995	0.481
2013	0.048	0.376	1.006	1.401	0.657	0.124	1.104	0.224
2014	0.027	0.234	0.679	0.682	0.367	0.196	0.740	0.188
2015	0.000	0.183	0.513	0.420	0.368	0.049	0.507	0.209
2016	Ages not available for 2016 TRAC due to spring survey delays						0.312	0.267

Table 12. NMFS fall 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	1	2	3	4	5	6+	B(kg/tow)	CV(B)
1963	14.722	7.896	11.227	1.859	0.495	0.549	12.788	0.209
1964	1.722	9.806	7.312	5.967	2.714	0.488	13.567	0.430
1965	1.197	5.705	5.988	3.532	1.573	0.334	9.120	0.355
1966	11.663	2.251	1.685	0.898	0.101	0.000	3.928	0.362
1967	8.985	9.407	2.727	1.037	0.342	0.103	7.670	0.279
1968	11.671	12.057	5.758	0.745	0.965	0.058	10.536	0.253
1969	9.949	10.923	5.217	1.811	0.337	0.461	9.807	0.268
1970	4.610	5.132	3.144	1.952	0.452	0.080	4.979	0.303
1971	3.627	6.976	4.914	2.250	0.498	0.298	6.365	0.216
1972	2.462	6.525	4.824	2.094	0.610	0.342	6.328	0.289
1973	2.494	5.498	5.104	2.944	1.217	0.618	6.490	0.319
1974	4.623	2.864	1.516	1.060	0.458	0.379	3.669	0.199
1975	4.625	2.511	0.877	0.572	0.334	0.063	2.326	0.169
1976	0.344	1.920	0.474	0.117	0.122	0.100	1.508	0.252
1977	0.934	2.212	1.621	0.617	0.105	0.126	2.781	0.208
1978	4.760	1.281	0.780	0.411	0.136	0.036	2.343	0.205
1979	1.321	2.069	0.261	0.120	0.138	0.112	1.494	0.296
1980	0.766	5.120	6.091	0.682	0.219	0.258	6.607	0.217
1981	1.595	2.349	1.641	0.588	0.079	0.054	2.576	0.333
1982	2.425	2.184	1.590	0.423	0.089	0.000	2.270	0.314
1983	0.109	2.284	1.915	0.511	0.031	0.049	2.131	0.239
1984	0.661	0.400	0.306	0.243	0.075	0.063	0.593	0.329
1985	1.377	0.516	0.171	0.051	0.081	0.000	0.709	0.276
1986	0.282	1.108	0.349	0.074	0.000	0.000	0.820	0.389
1987	0.129	0.373	0.396	0.053	0.080	0.000	0.509	0.292
1988	0.019	0.213	0.107	0.027	0.000	0.000	0.171	0.342
1989	0.248	1.993	0.773	0.079	0.056	0.000	0.977	0.628
1990	0.000	0.370	1.473	0.294	0.000	0.000	0.725	0.338
1991	2.101	0.275	0.439	0.358	0.000	0.000	0.730	0.308
1992	0.151	0.396	0.712	0.162	0.144	0.027	0.576	0.313
1993	0.839	0.139	0.586	0.536	0.000	0.022	0.546	0.445
1994	1.195	0.221	0.983	0.713	0.263	0.057	0.897	0.332
1995	0.276	0.119	0.346	0.275	0.046	0.013	0.354	0.387
1996	0.149	0.352	1.869	0.447	0.075	0.000	1.303	0.608
1997	1.393	0.533	3.442	2.090	1.071	0.082	3.781	0.361
1998	1.900	4.817	4.202	1.190	0.298	0.074	4.347	0.366
1999	3.090	8.423	5.727	1.433	1.437	0.261	7.973	0.227

Table 12. Continued.

Year	1	2	3	4	5	6+	B(kg/tow)	CV(B)
2000	0.629	1.697	4.814	2.421	0.948	0.827	5.838	0.518
2001	3.518	6.268	8.092	2.601	1.718	2.048	11.553	0.406
2002	2.093	5.751	2.127	0.594	0.277	0.055	3.754	0.533
2003	1.077	5.031	2.809	0.565	0.100	0.191	4.038	0.328
2004	0.876	5.508	5.010	2.107	0.924	0.176	5.117	0.465
2005	0.313	2.095	3.763	0.614	0.185	0.000	2.463	0.535
2006	6.194	6.251	3.664	1.167	0.255	0.046	4.521	0.268
2007	1.058	11.447	7.866	1.998	0.383	0.094	8.151	0.315
2008	0.168	7.174	9.883	1.033	0.000	0.000	7.109	0.299
2009	0.477	4.382	12.202	2.219	0.631	0.064	6.744	0.284
2010	0.125	2.811	4.507	0.781	0.298	0.000	2.247	0.307
2011	0.237	2.865	3.897	1.106	0.145	0.010	2.452	0.277
2012	0.195	1.475	3.658	1.586	0.441	0.014	2.520	0.470
2013	0.332	1.028	0.940	0.537	0.116	0.044	0.875	0.375
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	0.655

Table 13. Survey indices of abundance (kg/tow) used in the Empirical Approach. The NMFS spring and fall survey values are in Henry B. Bigelow units.

Year	DFO	NMFS spring	NMFS fall (year-1)
2010	14.532	13.339	16.198
2011	6.091	5.747	5.398
2012	8.937	8.965	5.889
2013	1.109	2.477	6.053
2014	0.816	1.662	2.101
2015	1.308	1.137	2.460
2016	2.748	0.700	1.127

Table 14. Derivation of conversion factors relating catch per tow in kg to abundance estimates in thousands of mt. The area units are square kilometers. See text for details.

	DFO	NMFS Spring and Fall
Total Area in Set =	25453	37286
Area Swept by Tow =	0.1214	0.0606
Catchability =	0.37	0.37
Units kg to mt =	1000	1000
Conversion Factor =	566.527	1662.92

Table 15. Empirical approach used to derive catch advice. The mean of the three bottom trawl survey population biomass values is denoted Avg. The catch advice is computed as the exploitation rate (mu) multiplied by Avg. The catch advice year is applied in the year following (e.g., the 2016 row of catch advice will be applied in 2017).

					mu =	2%	16%
Year	DFO	Spring	Fall (year-1)	Avg (mt)		Catch Advice (mt)	Catch Advice (mt)
2010	8,233	22,181	26,936	19,117		382	3,059
2011	3,450	9,557	8,976	7,328		147	1,172
2012	5,063	14,908	9,793	9,921		198	1,587
2013	629	4,119	10,065	4,938		99	790
2014	462	2,763	3,493	2,240		45	358
2015	741	1,891	4,092	2,241		45	359
2016	1,557	1,165	1,875	1,532		31	245

Table 16. Recent quotas and catches by year and corresponding exploitation rates (computed by dividing annual quota or catch by the average survey biomass in Table 16). Model type refers to the approach used to set the quota for that year.

Assmt Year	Quota Year	Quota (mt)	Catch (mt)	Quota/Avg	Catch/Avg	Model Type
2009	2010	1956	1170	10%	6%	VPA
2010	2011	2650	1171	36%	16%	VPA
2011	2012	1150	725	12%	7%	VPA
2012	2013	500	218	10%	4%	VPA
2013	2014	400	159	18%	7%	VPA
2014	2015	354	118	16%	5%	Empirical
	mean	1168	593	17%	8%	

Table 17. Catch advice for 2017 derived by multiplying the average survey biomass in 2016 by the historical exploitation rate associated with the quota (μ_{quota}) or the actual catch (μ_{catch}) for a range of survey catchability values.

	Survey catchability				
	0.2	0.3	0.37	0.4	0.5
B_{2016}	2834	1889	1532	1417	1134
μ_{quota}	0.092	0.138	0.170	0.183	0.229
B_{2016}* μ_{quota}	260	260	260	260	260
μ_{catch}	0.042	0.062	0.077	0.083	0.104
B_{2016}* μ_{catch}	118	118	118	118	118

FIGURES

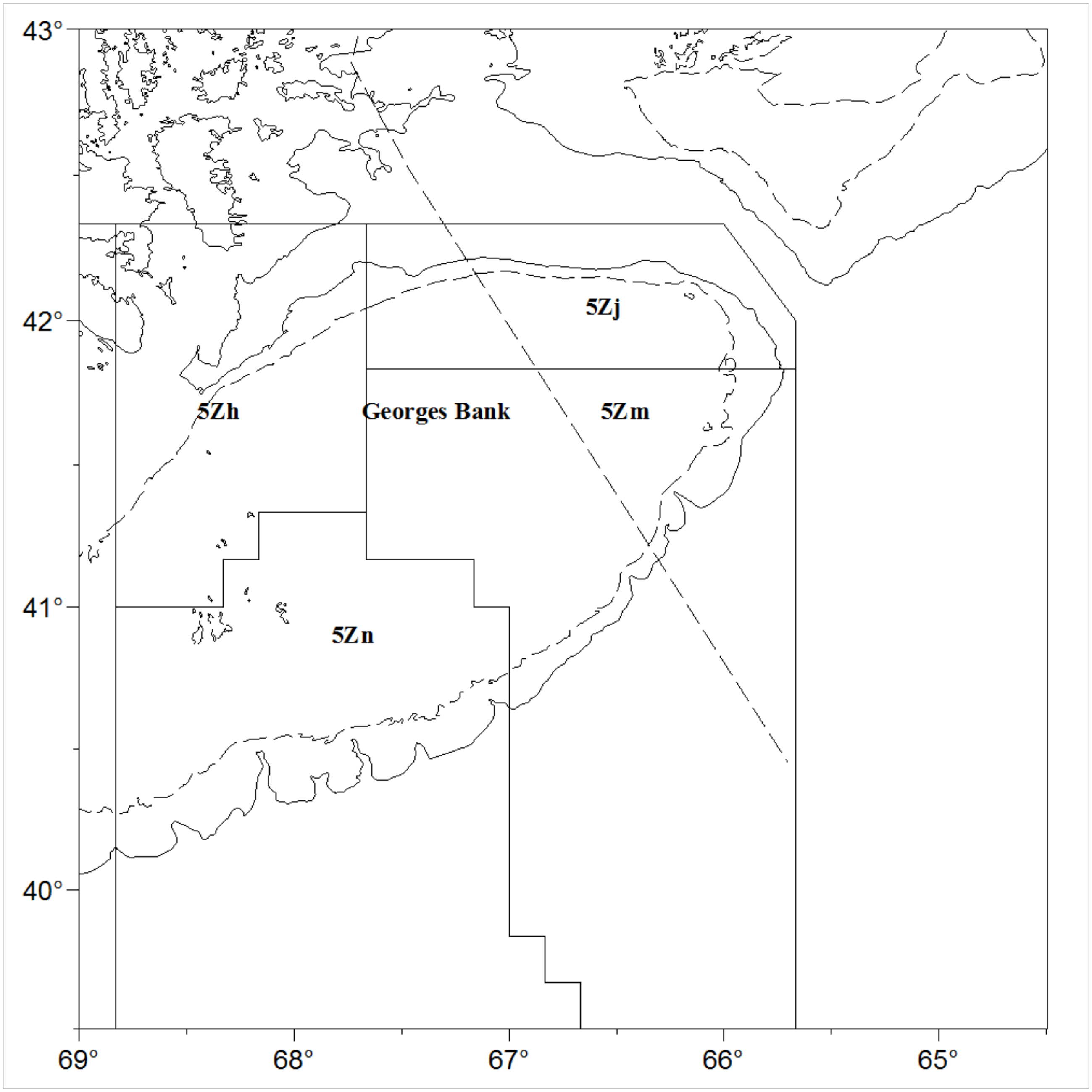

Figure 1a. Location of statistical unit areas for Canadian fisheries in NAFO Subdivision 5Ze.Catches of Yellowtail Flounder in areas 5Zhjmn are used in this assessment.

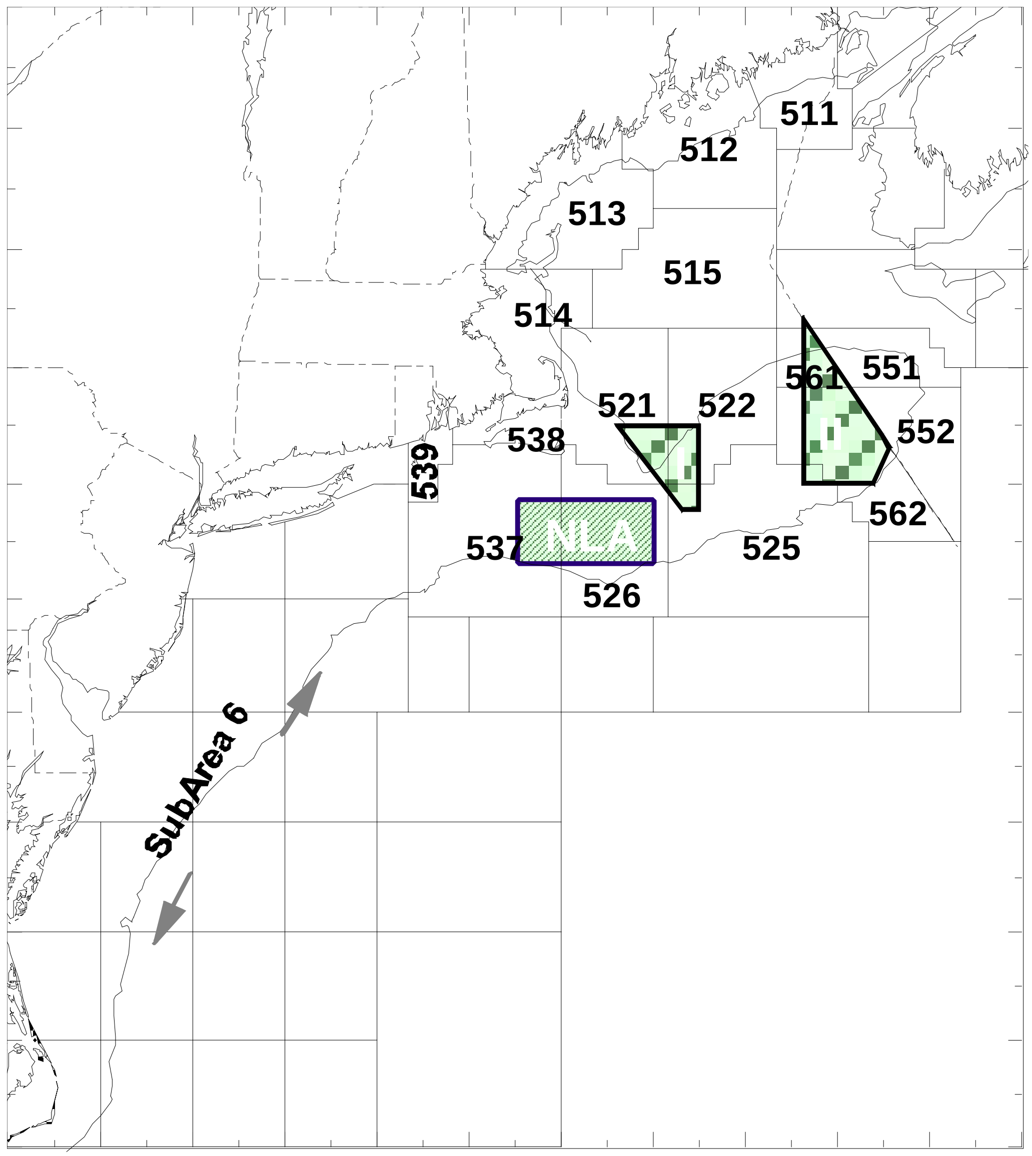

Figure 1b. Statistical areas used for monitoring northeast US fisheries. Catches from areas 522, 525, 551, 552, 561 and 562 are included in the Georges Bank Yellowtail Flounder assessment. Shaded areas have been closed to fishing year-round since 1994, with exceptions.

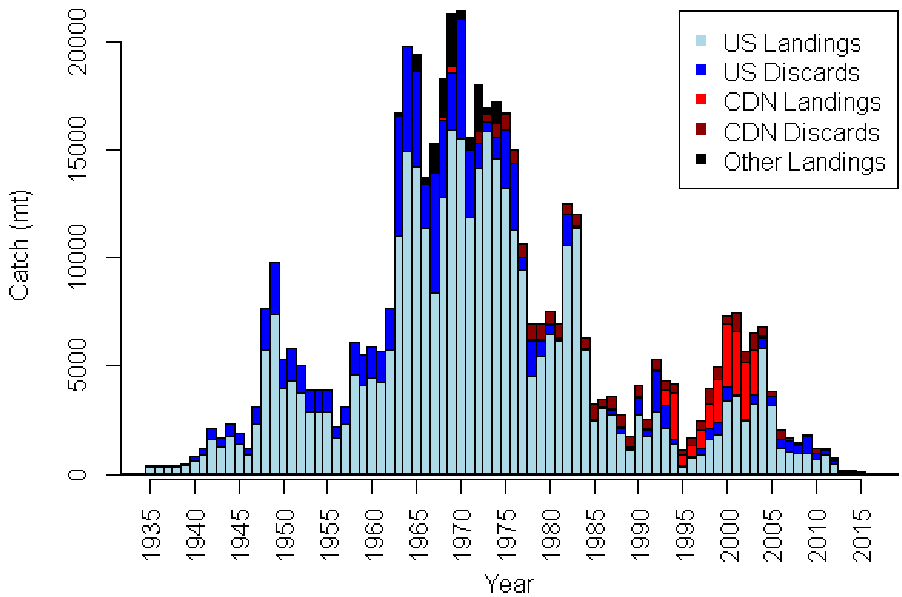

Figure 2a. Catch (landings plus discards) of Georges Bank Yellowtail Flounder by nation and year.

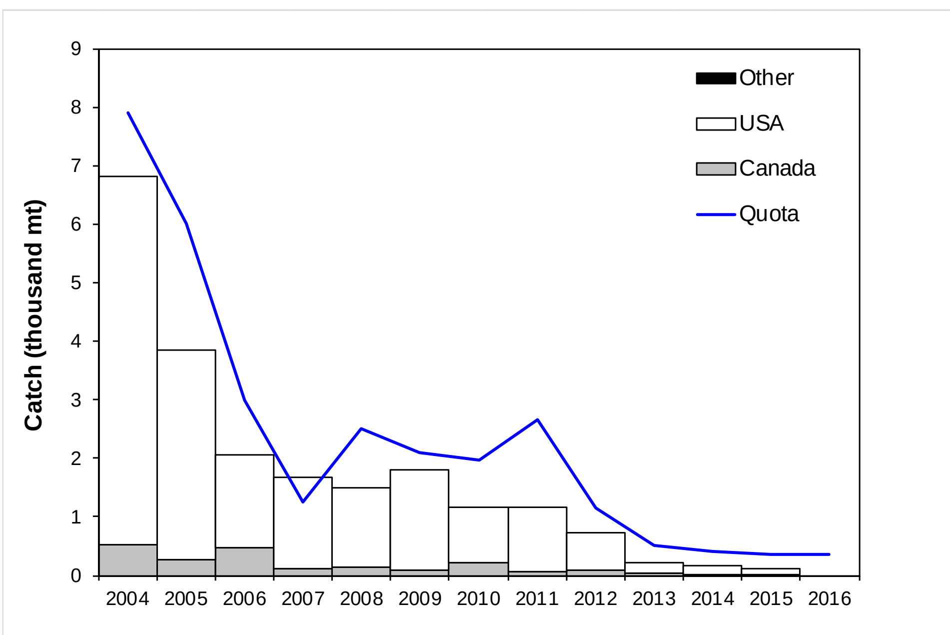

Figure 2b. Recent catches by country and quotas. Note the US quota is not applied for the calendar year and that in 2010 the TMGC could not agree on a quota, so the 2010 value is the sum of the implemented quotas by each country.

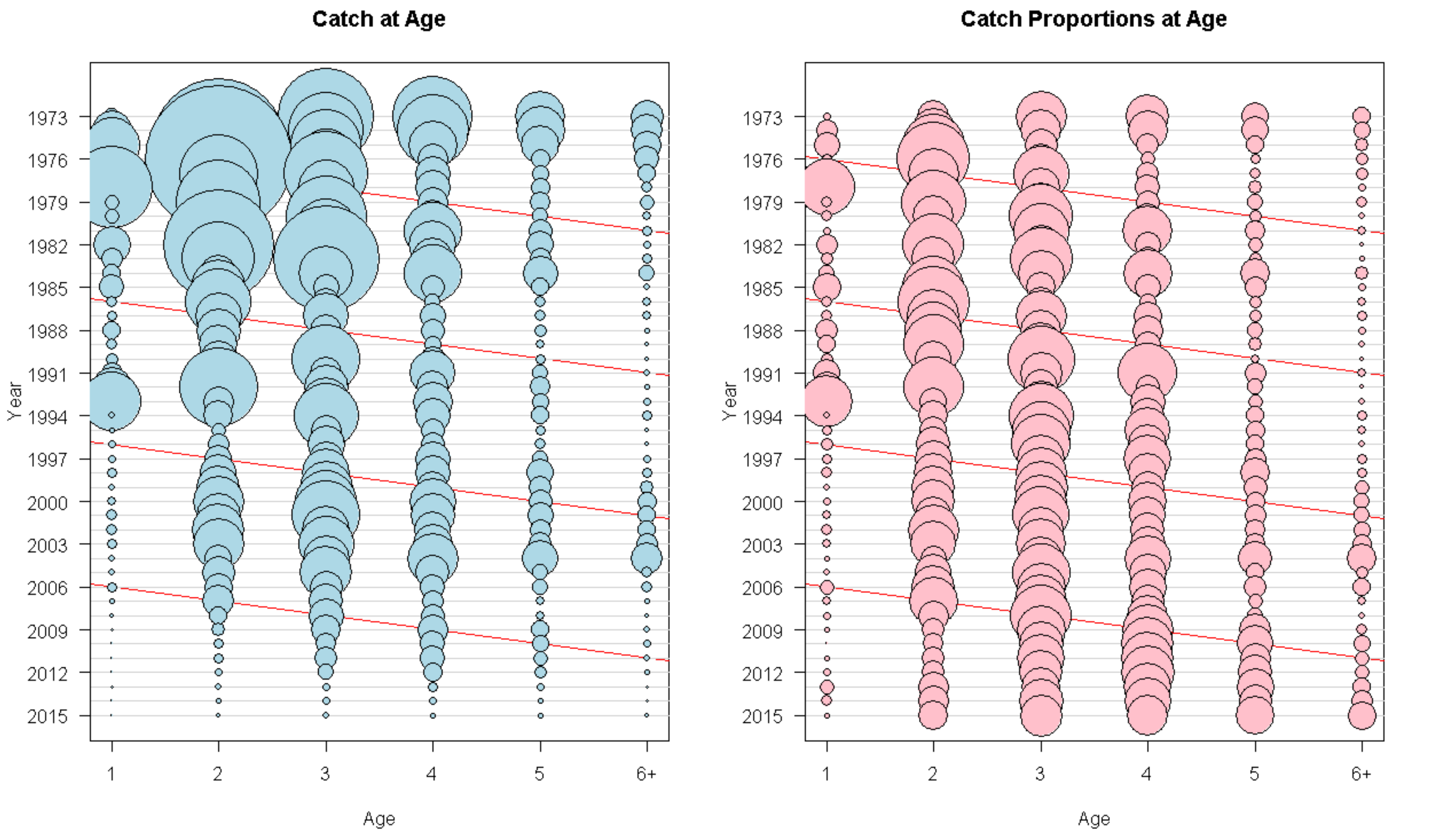

Figure 3. Catch at age (left panel) and catch proportions at age (right panel) for Georges Bank Yellowtail Flounder (Canadian and US fisheries combined). The area of the bubble is proportional to the magnitude of the catch or proportion. Diagonal red lines denote the 1975, 1985, 1995, and 2005 year-classes.

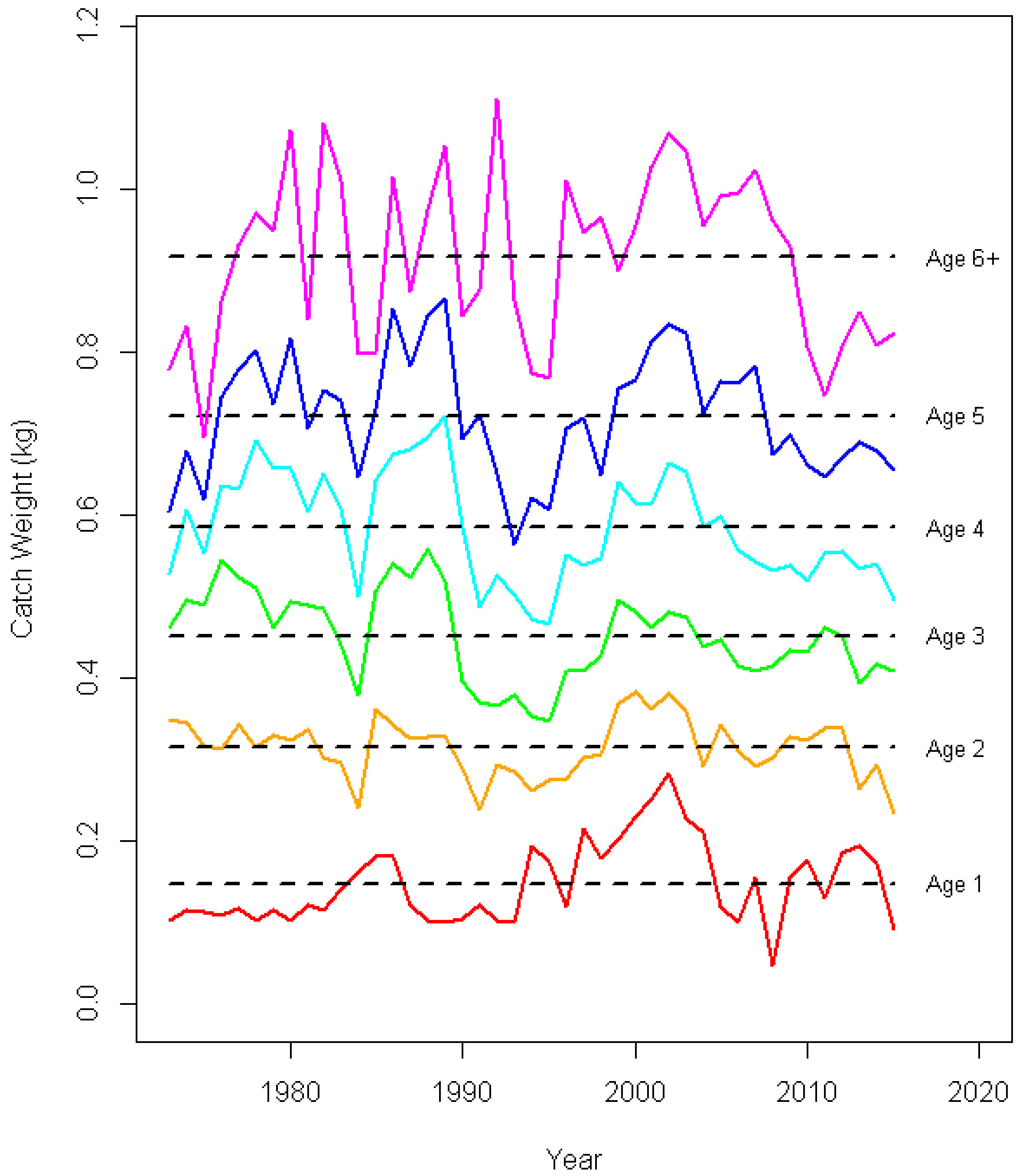

Figure 4. Trends in mean weight at age from the Georges Bank Yellowtail Flounder fishery (Canada and US combined, including discards). Dashed lines denote average of time series.

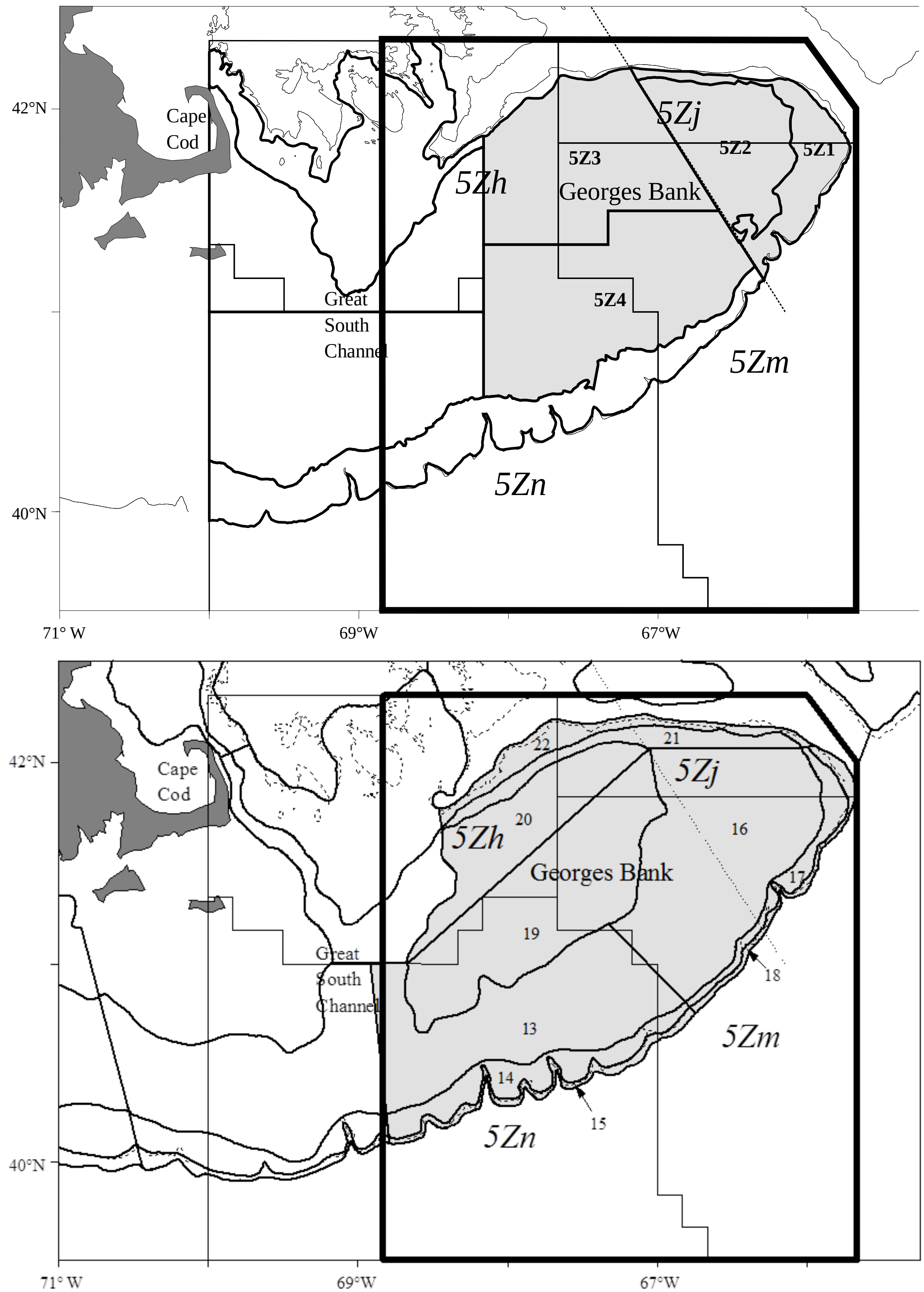

Figure 5. DFO (top) and NMFS (bottom) strata used to derive research survey abundance indices for Georges Bank groundfish surveys. Note NMFS stratum 22 is not used in assessment.

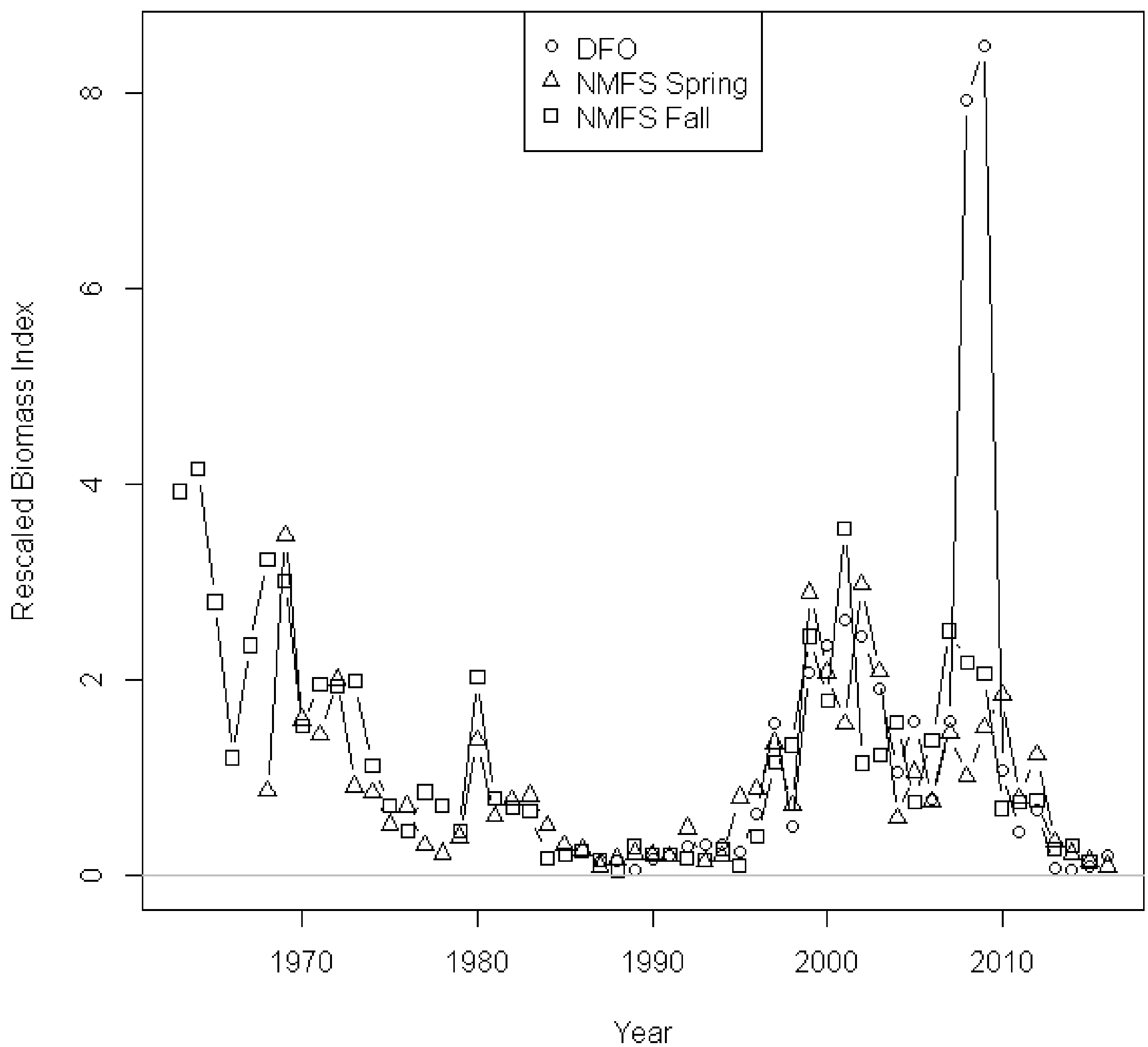

Figure 6. Three survey biomass indices (DFO, NMFS spring, and NMFS fall) for Yellowtail Flounder on Georges Bank rescaled to their respective means for years 1987-2007.

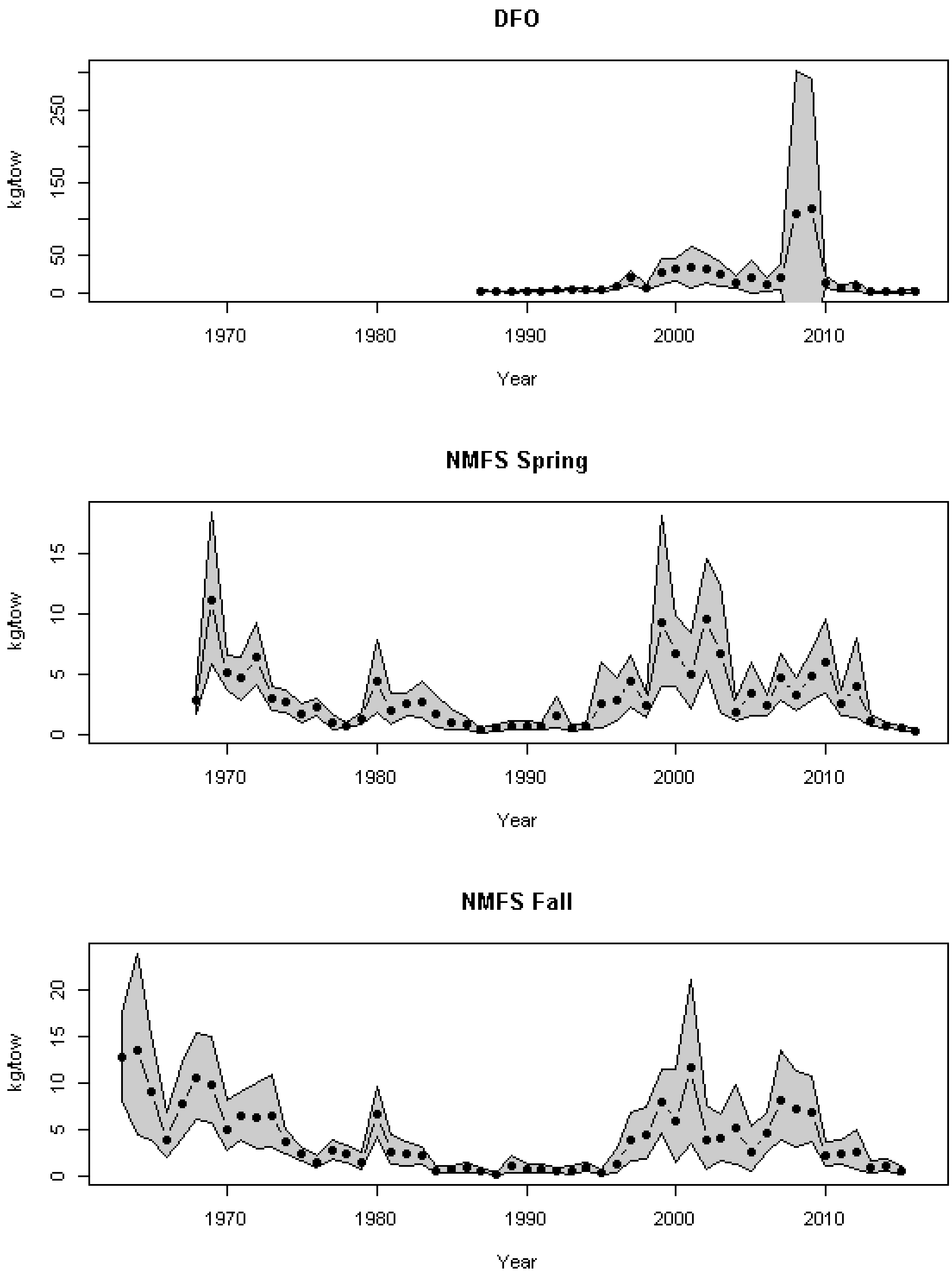

*Figure 7. Survey biomass for Yellowtail Flounder on Georges Bank in units of kg/tow with 95% confidence intervals from +/- 1.96*stdev (DFO) or bootstrapping (NMFS spring and NMFS fall).*

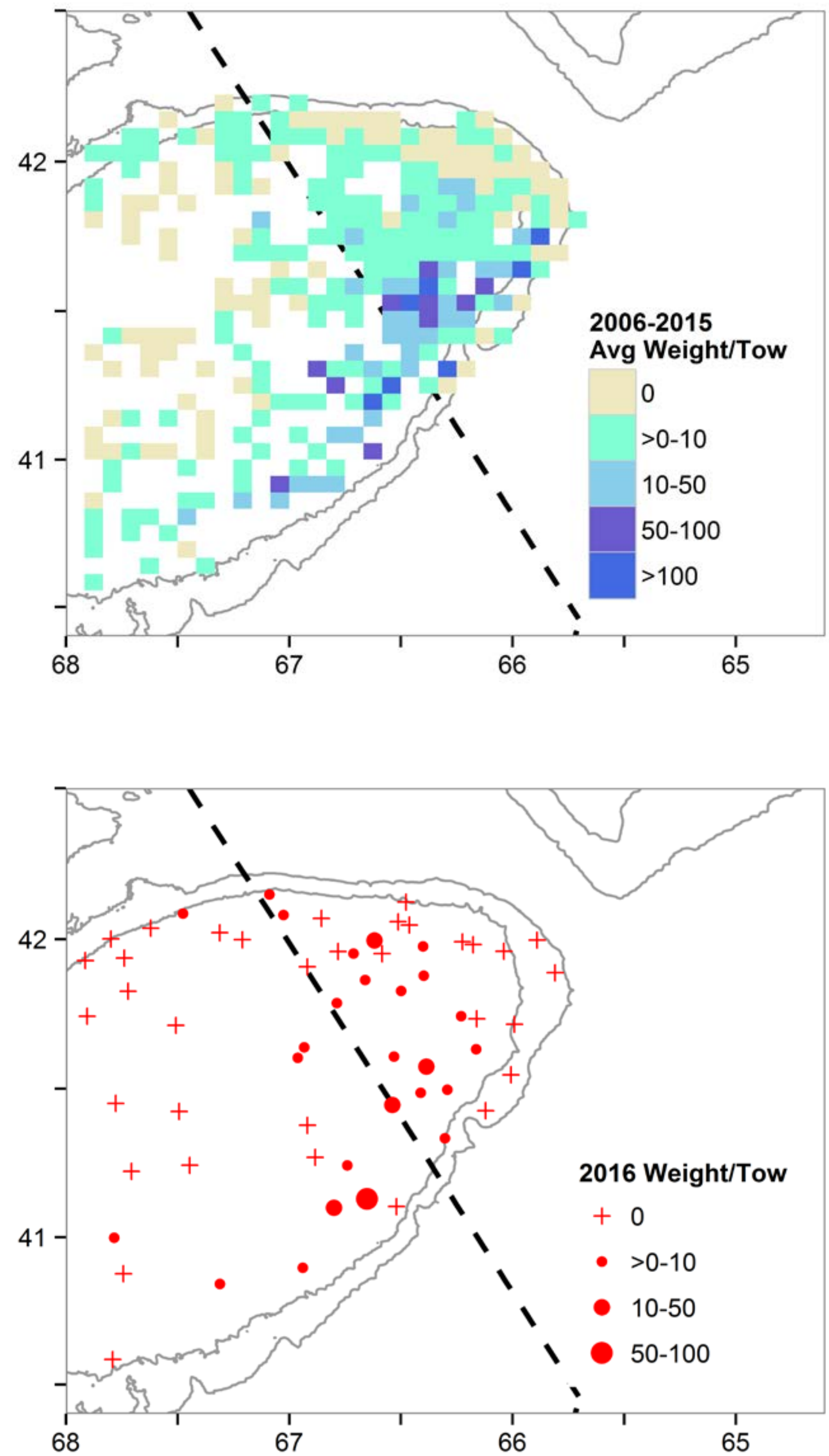

Figure 8a. Catch of Yellowtail in weight (kg) per tow for DFO survey: recent ten year average (top panel) and most recent year (bottom panel).

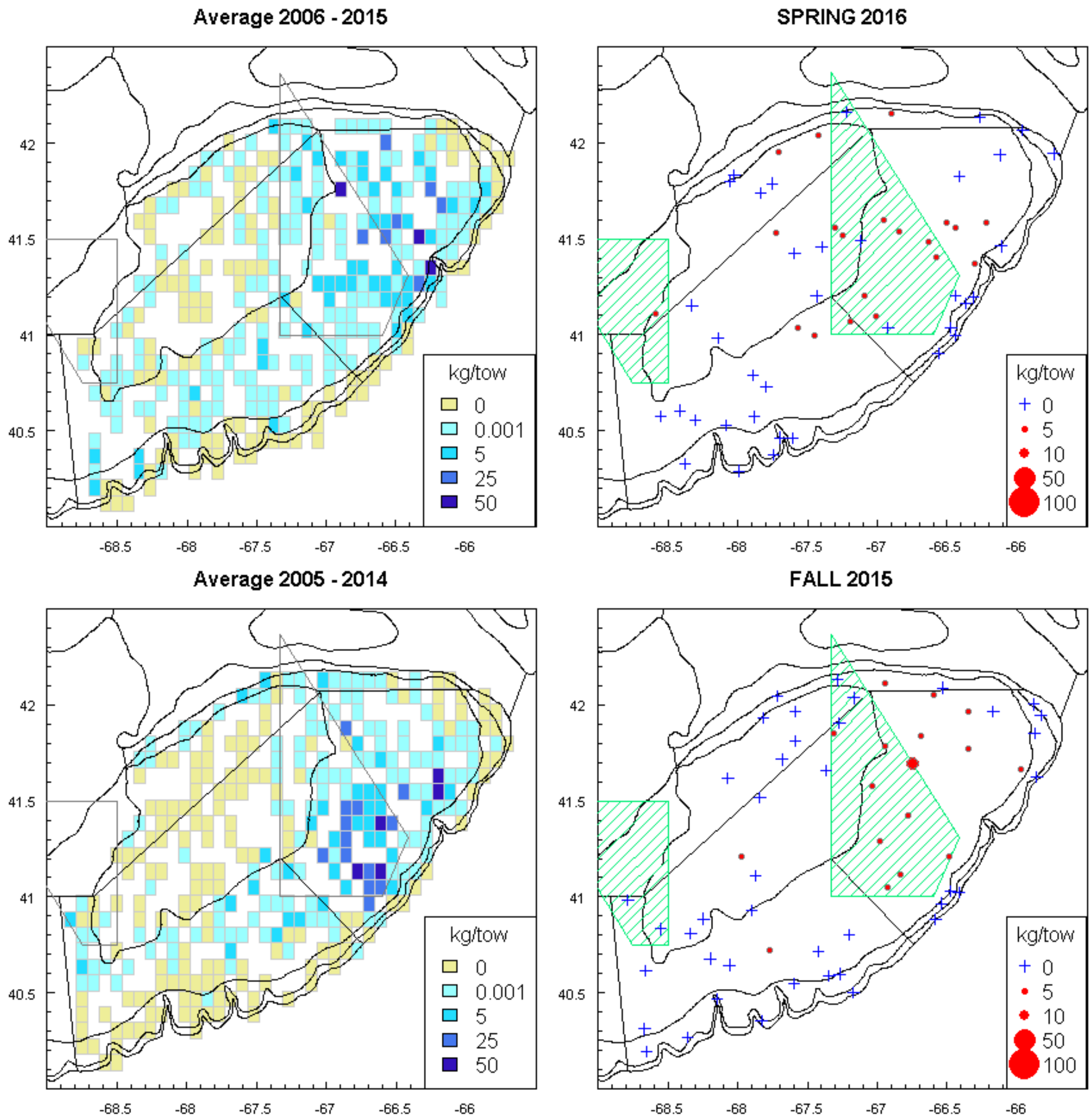

Figure 8b. Catch of Yellowtail in weight (kg) per tow for NMFS spring (top) and NMFS fall (bottom) surveys. Left panels show previous 10 year averages, right panels most recent data. Note the 2009-2015 survey values were adjusted from Henry B. Bigelow to Albatross IV equivalents by dividing Henry B. Bigelow catch in weight by 2.244 (spring) or 2.402 (fall).

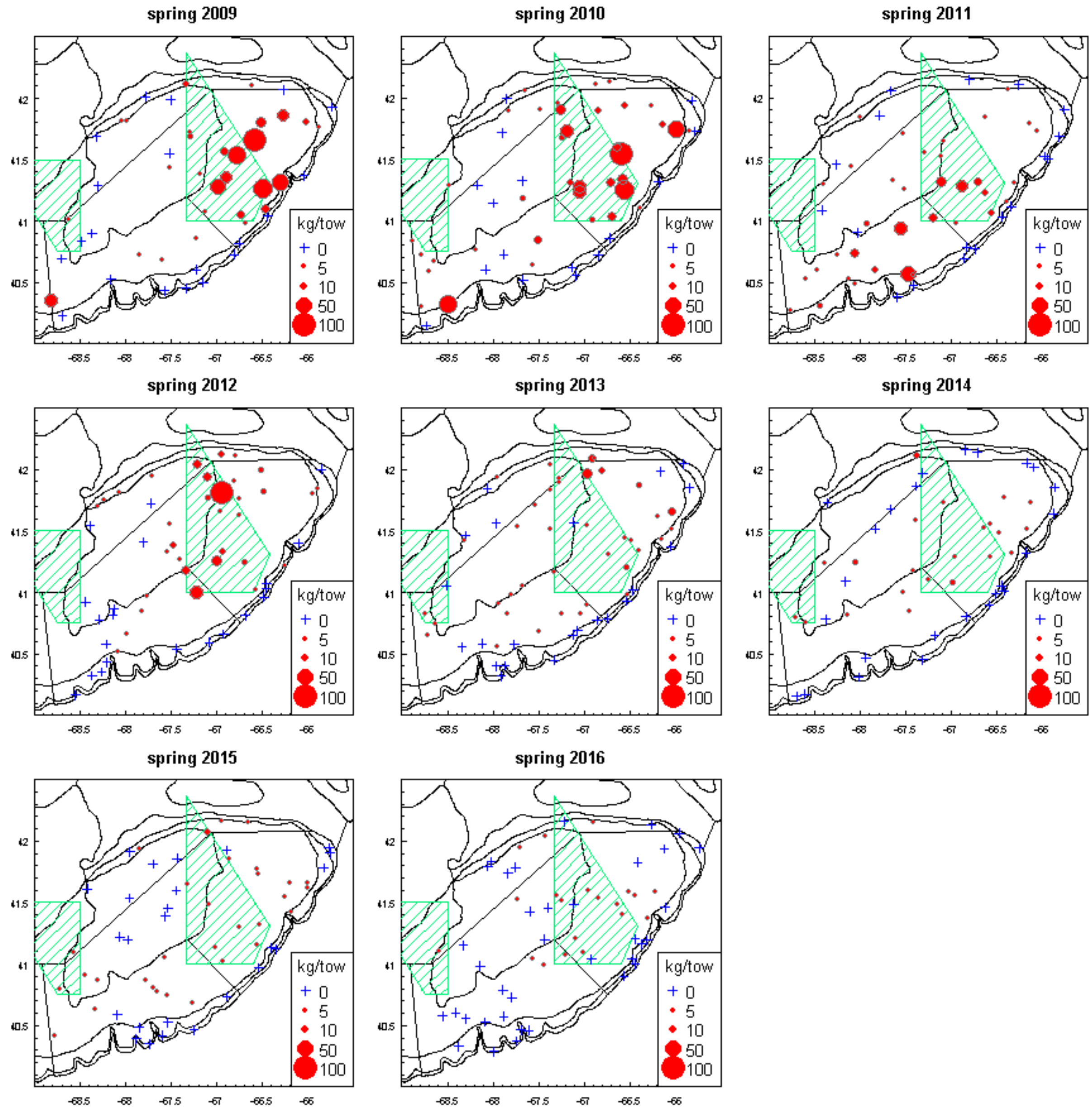

Figure 8c. Catch of Yellowtail in weight (kg) per tow for NMFS spring surveys conducted by Henry B. Bigelow without adjustment.

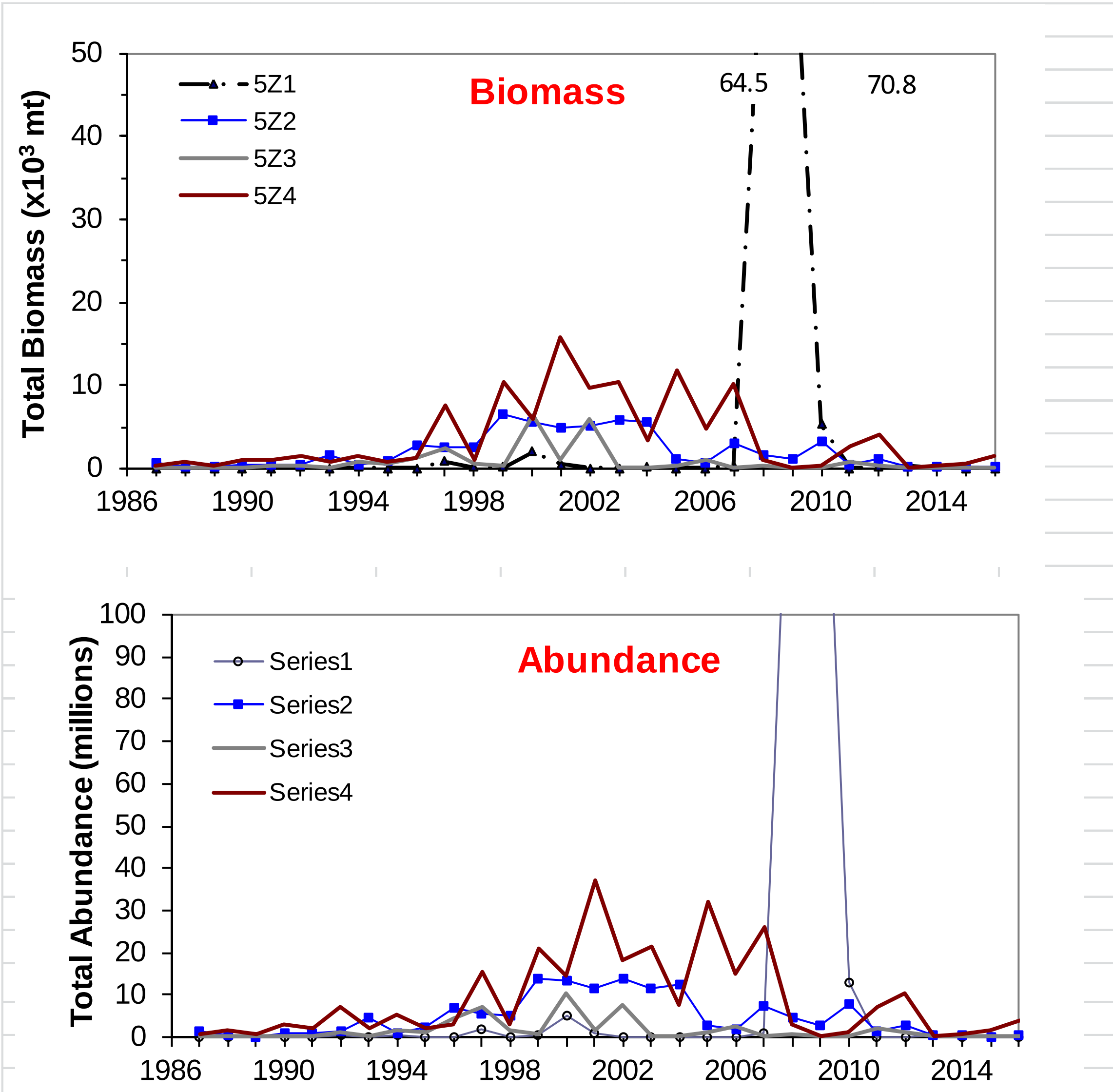

Figure 9a. DFO survey estimates of total biomass (top panel) and total number (bottom panel) by stratum area for Yellowtail Flounder on Georges Bank.

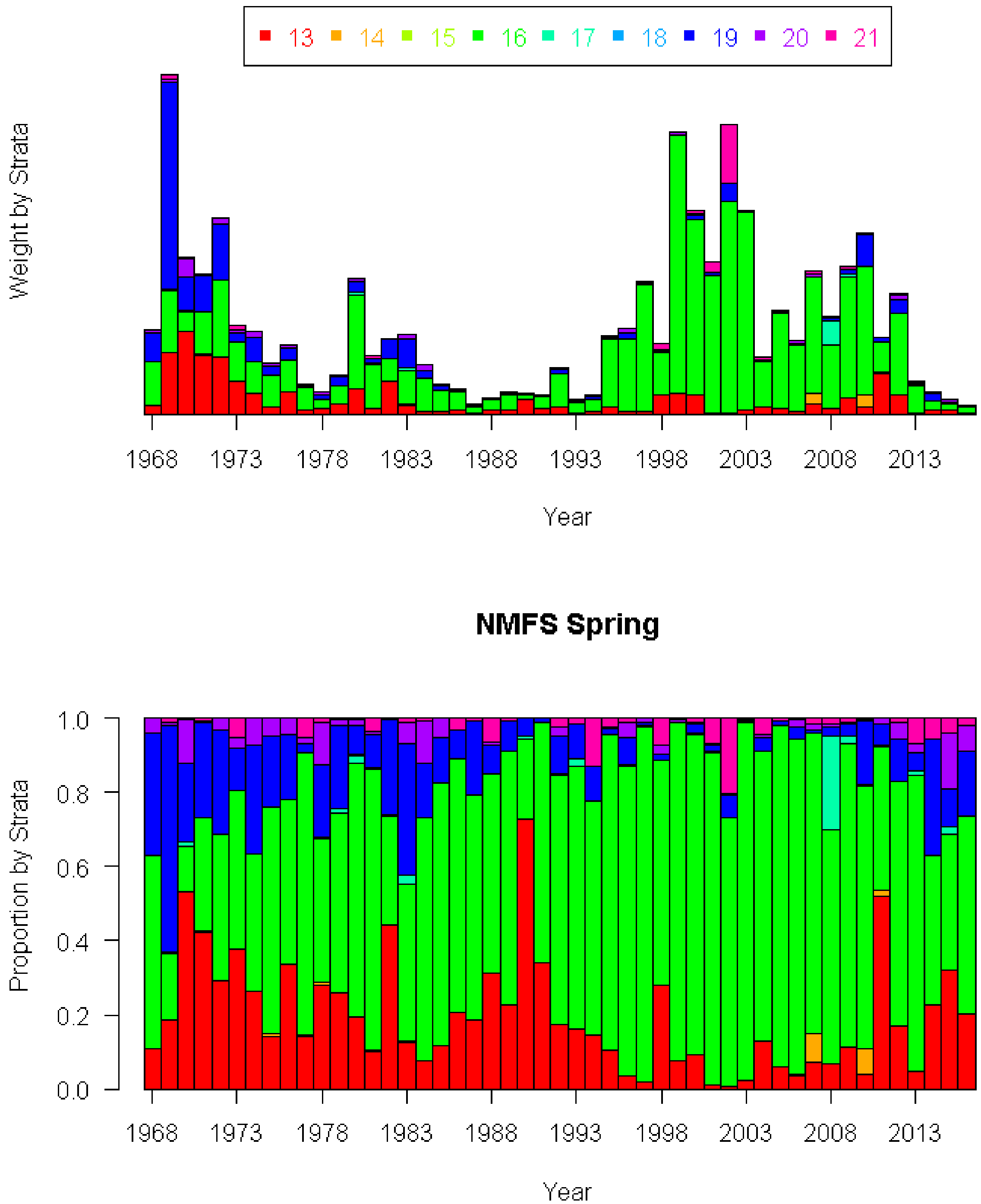

Figure 9b. NMFS spring survey estimates of total biomass (top panel) and proportion (bottom panel) by stratum for Yellowtail Flounder on Georges Bank.

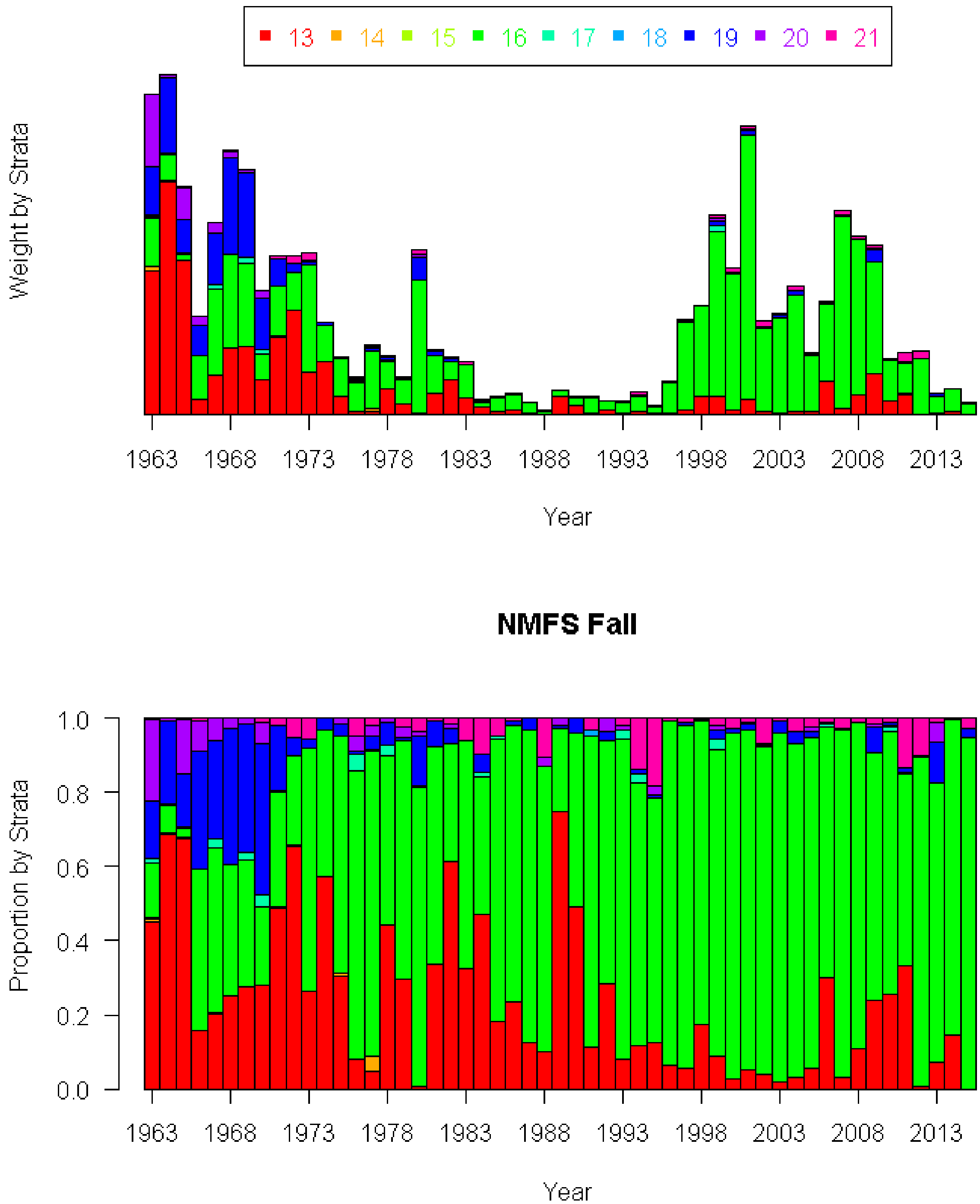

Figure 9c. NMFS fall survey estimates of total biomass (top panel) and proportion (bottom panel) by stratum for Yellowtail Flounder on Georges Bank.

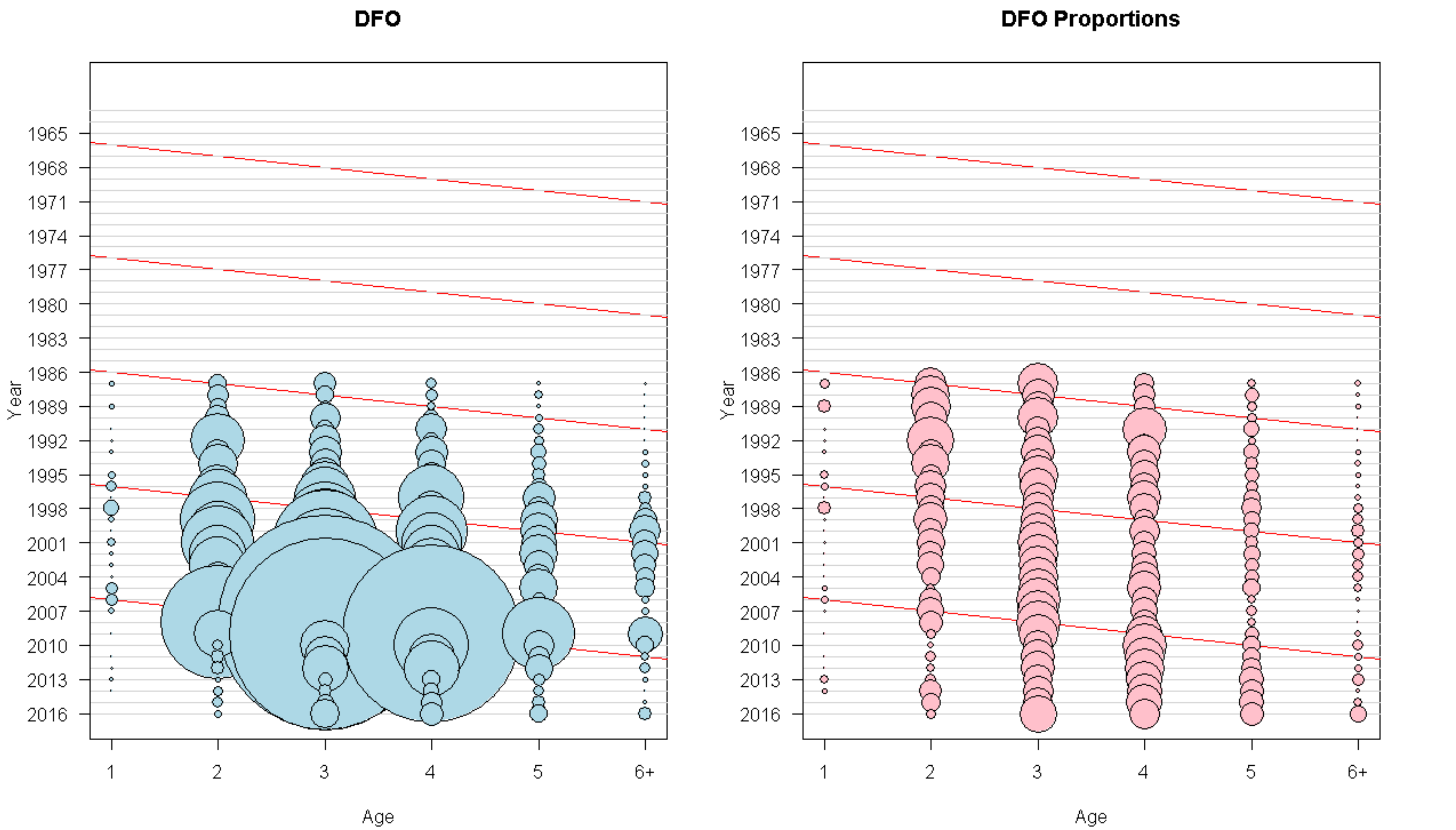

Figure 10a. Age specific indices of abundance for the DFO survey including the large tows in 2008 and 2009 (the area of the bubble is proportional to the magnitude). Diagonal red lines denote the 1965, 1975, 1985, 1995, and 2005 year-classes.

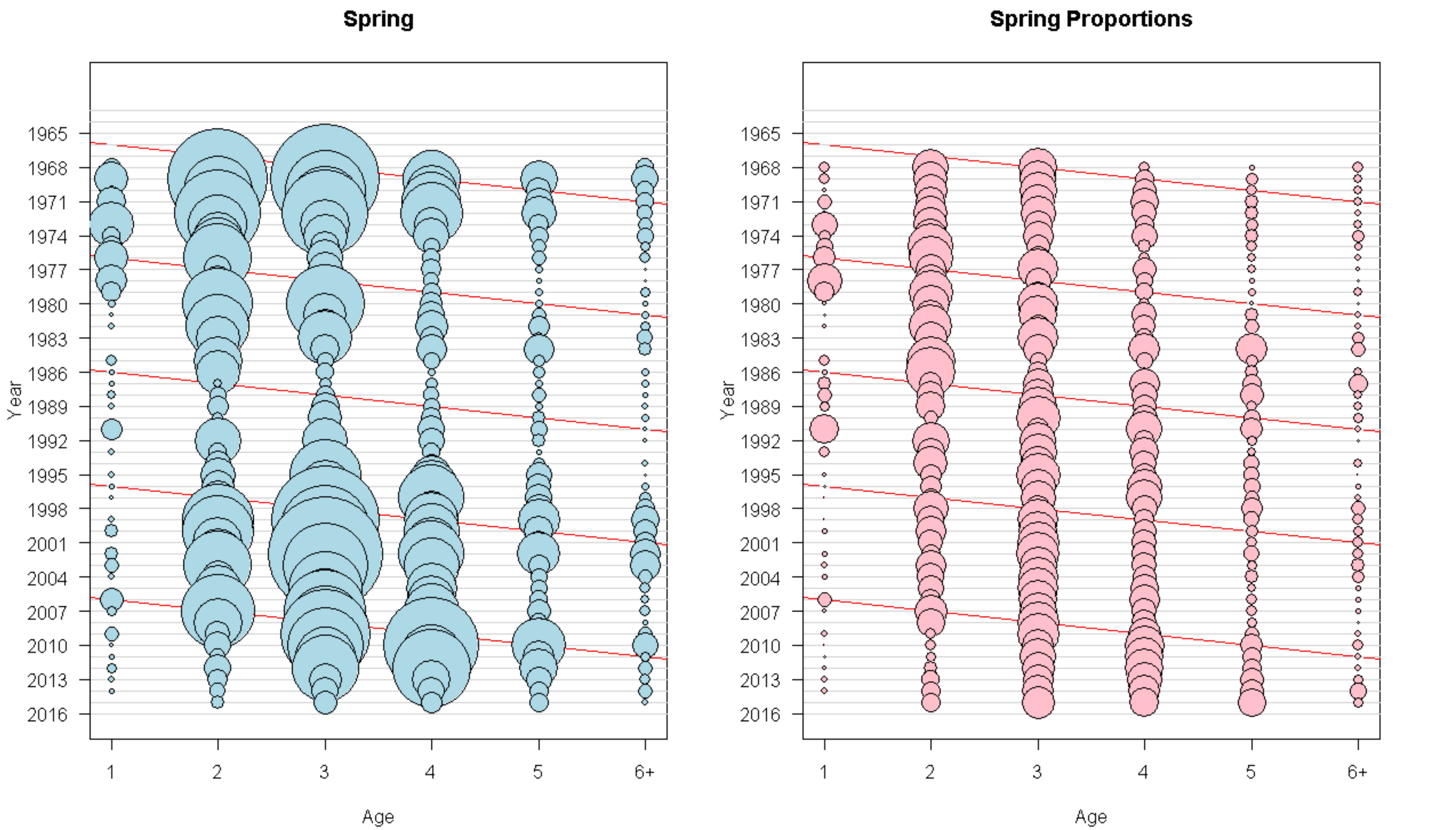

Figure 10b. Age specific indices of abundance for the NMFS spring survey (the area of the bubble is proportional to the magnitude). Diagonal red lines denote the 1965, 1975, 1985, 1995, and 2005 year-classes. Note 2016 age data not available due to survey delays.

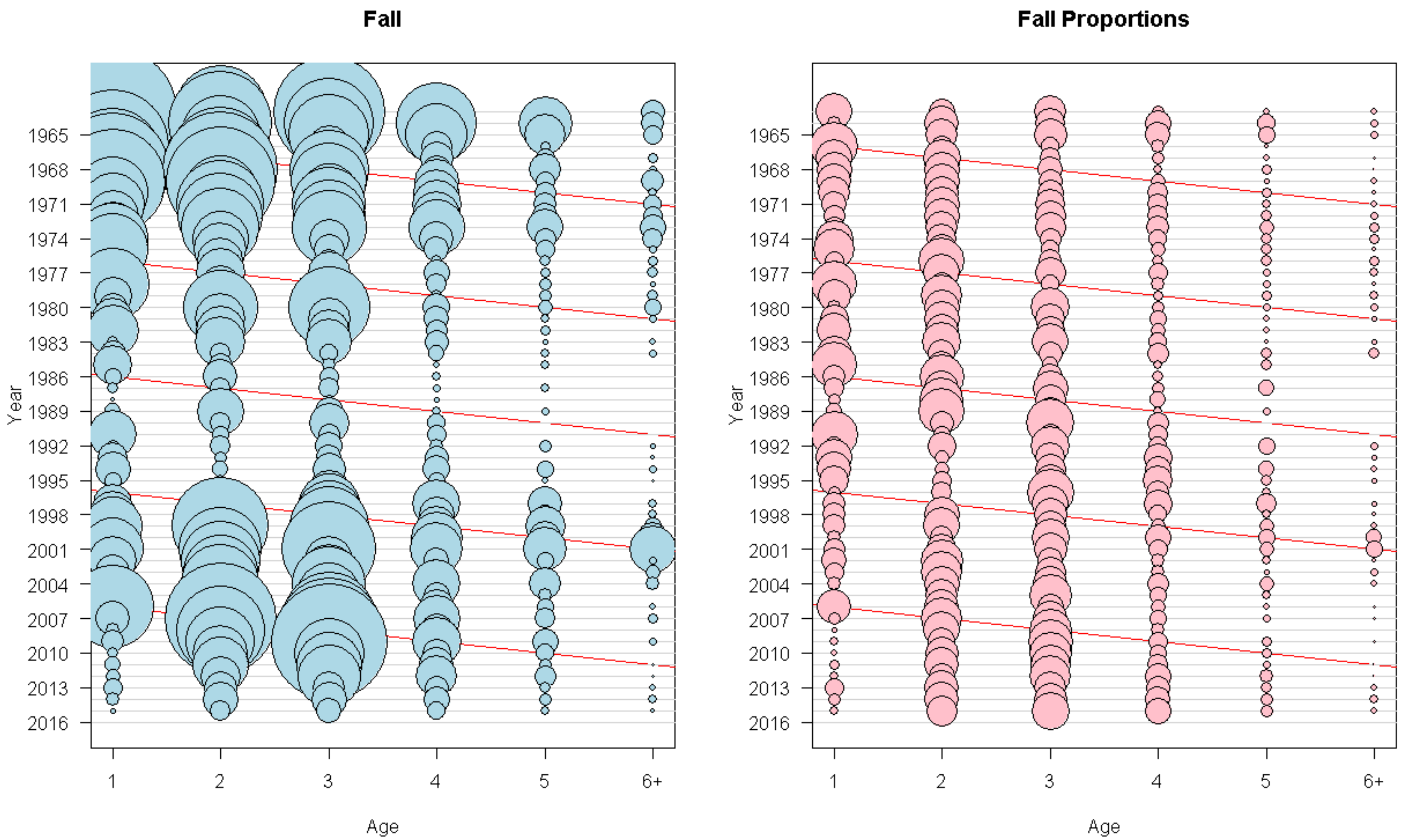

Figure 10c. Age specific indices of abundance for the NMFS fall survey (the area of the bubble is proportional to the magnitude). Diagonal red lines denote the 1965, 1975, 1985, 1995, and 2005 year-classes.

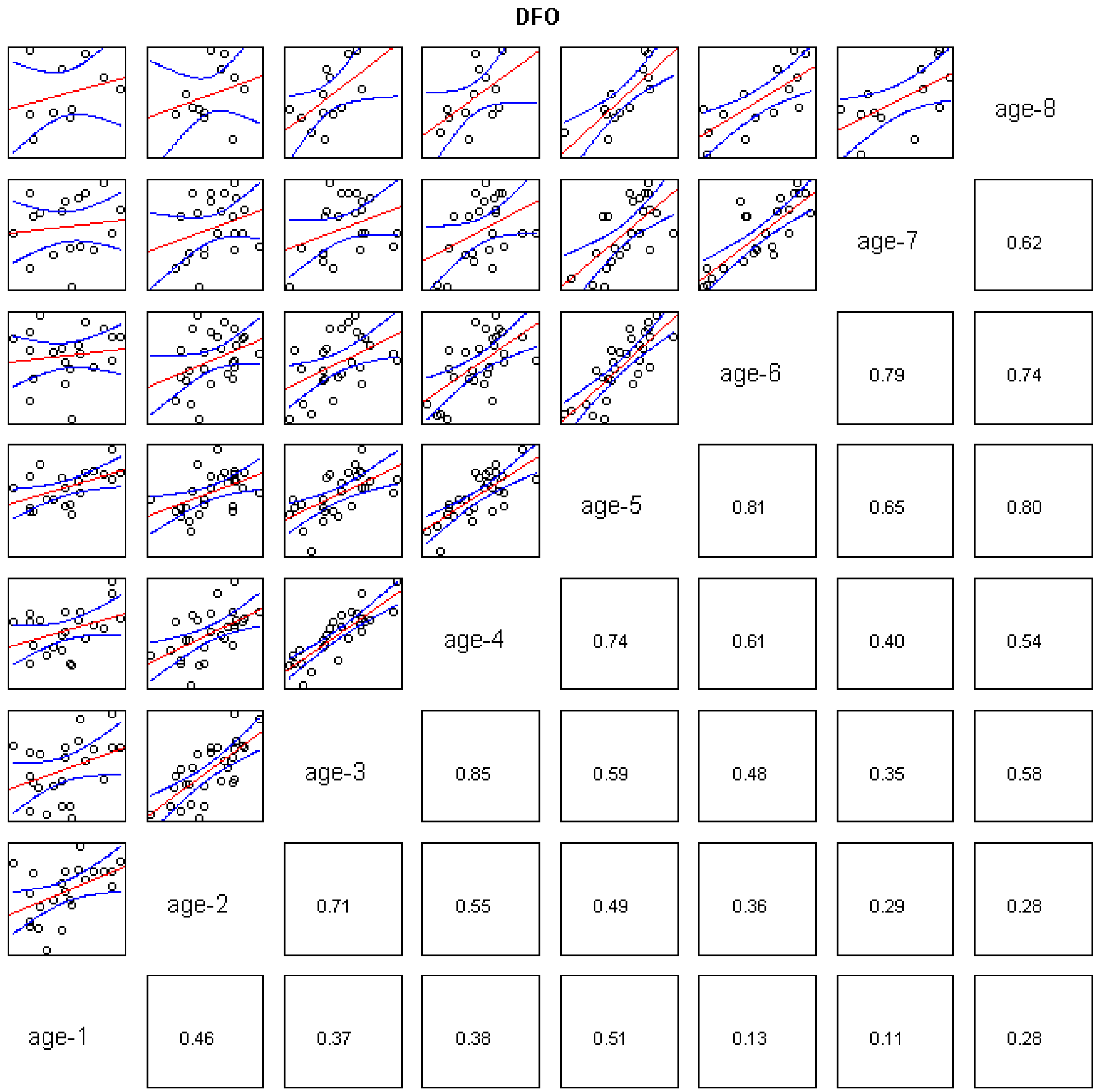

Figure 11a. DFO survey catch at age by cohort on log scale. Red lines denote linear regression and blue lines denote 95% prediction interval for the linear regression. Correlation values are shown in lower right triangle.

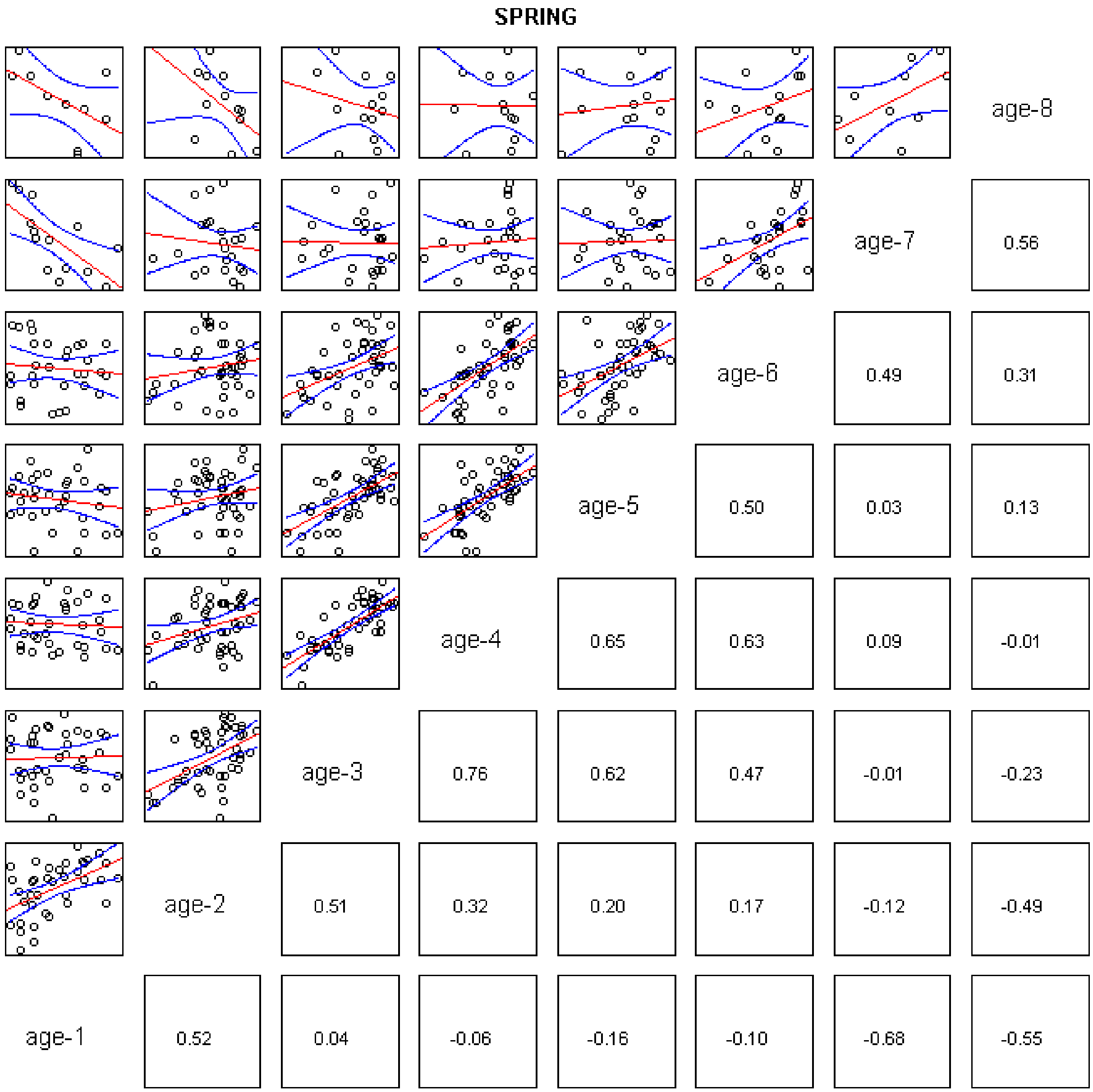

Figure 11b. NMFS spring survey catch at age by cohort on log scale. Red lines denote linear regression and blue lines denote 95% prediction interval for the linear regression. Correlation values are shown in lower right triangle. Note 2016 age data not available due to survey delays.

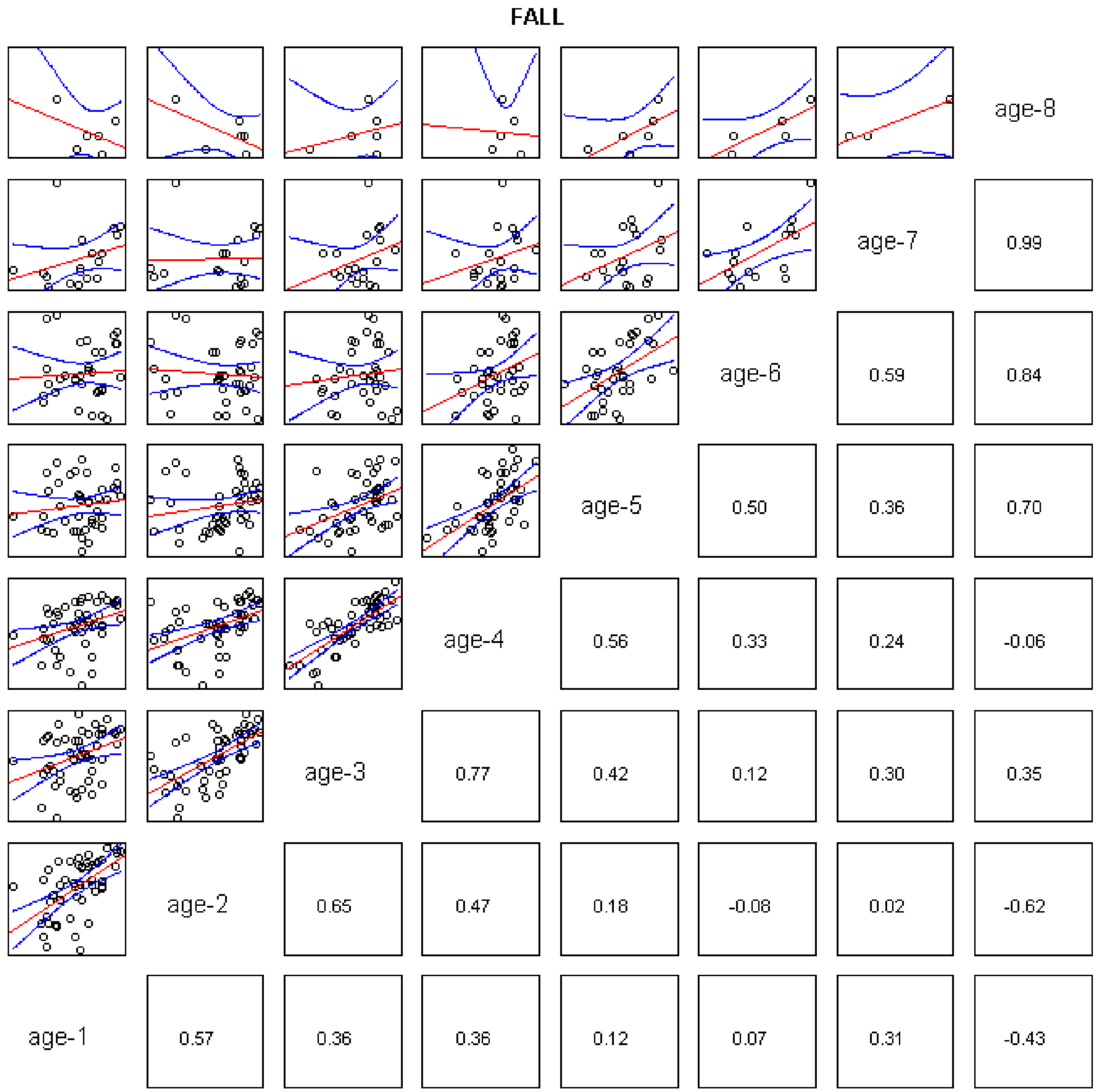

Figure 11c. NMFS fall survey catch at age by cohort on log scale. Red lines denote linear regression and blue lines denote 95% prediction interval for the linear regression. Correlation values are shown in lower right triangle.

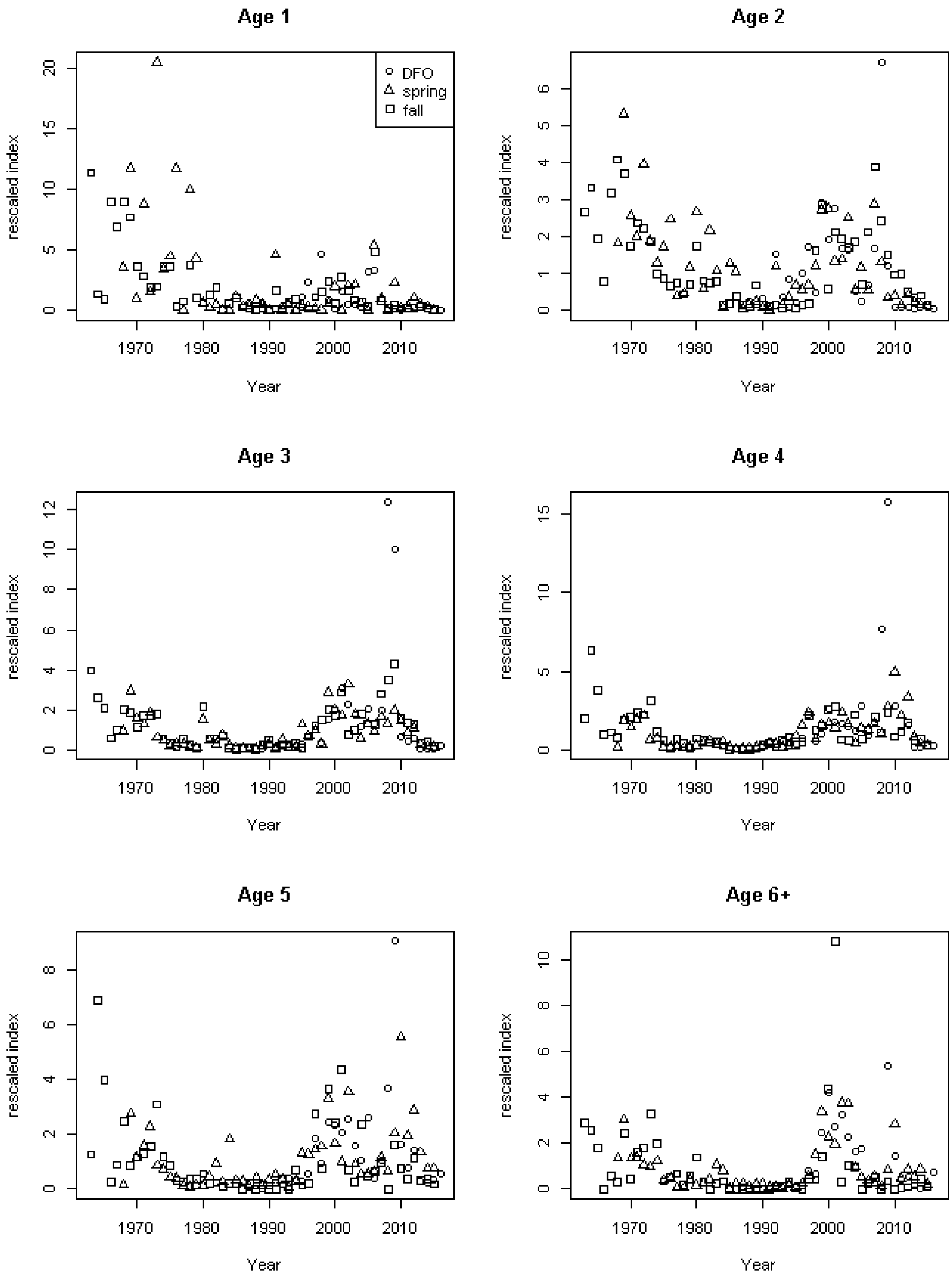

Figure 12. Standardized catch/tow in numbers at age for the three surveys. The standardization was the division of each index value by the mean of the index during 1987 through 2007. Circles denote the DFO survey, triangles the NMFS spring survey, and squares the NMFS fall survey. Note 2016 NMFS spring survey age data not available due to survey delays.

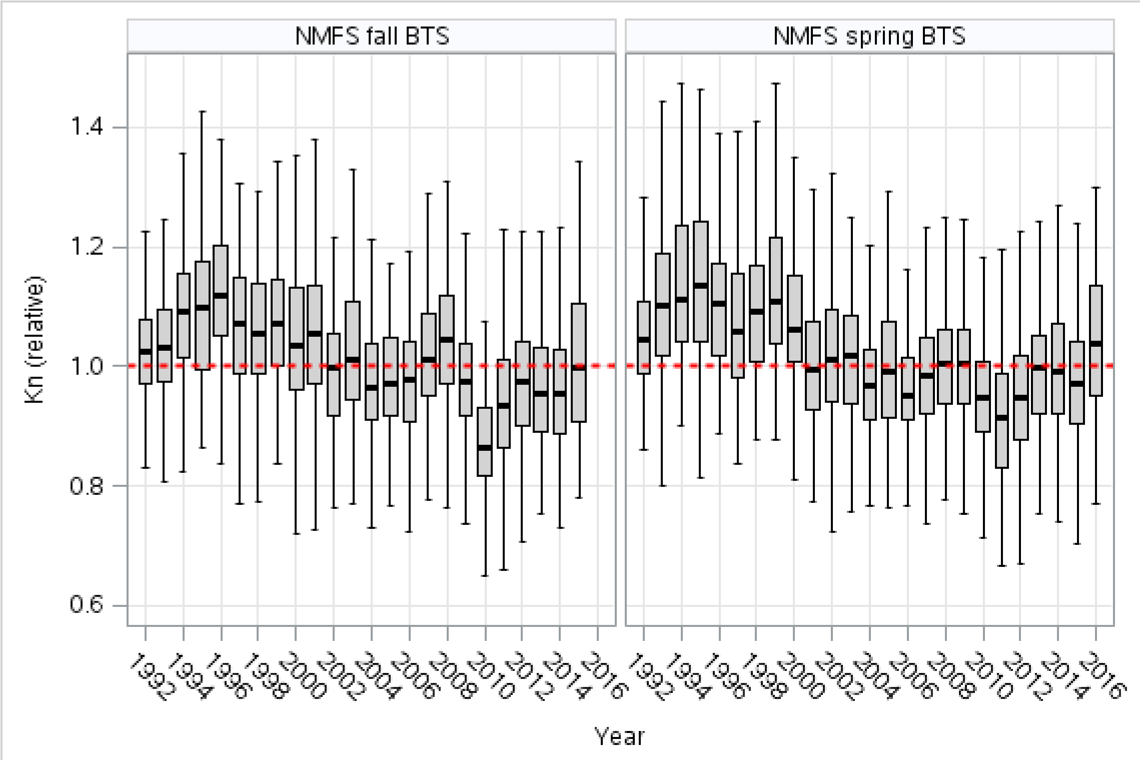

Figure 13a. Condition factor (Fulton's K) of Georges Bank Yellowtail Flounder from the NMFS fall and spring surveys.

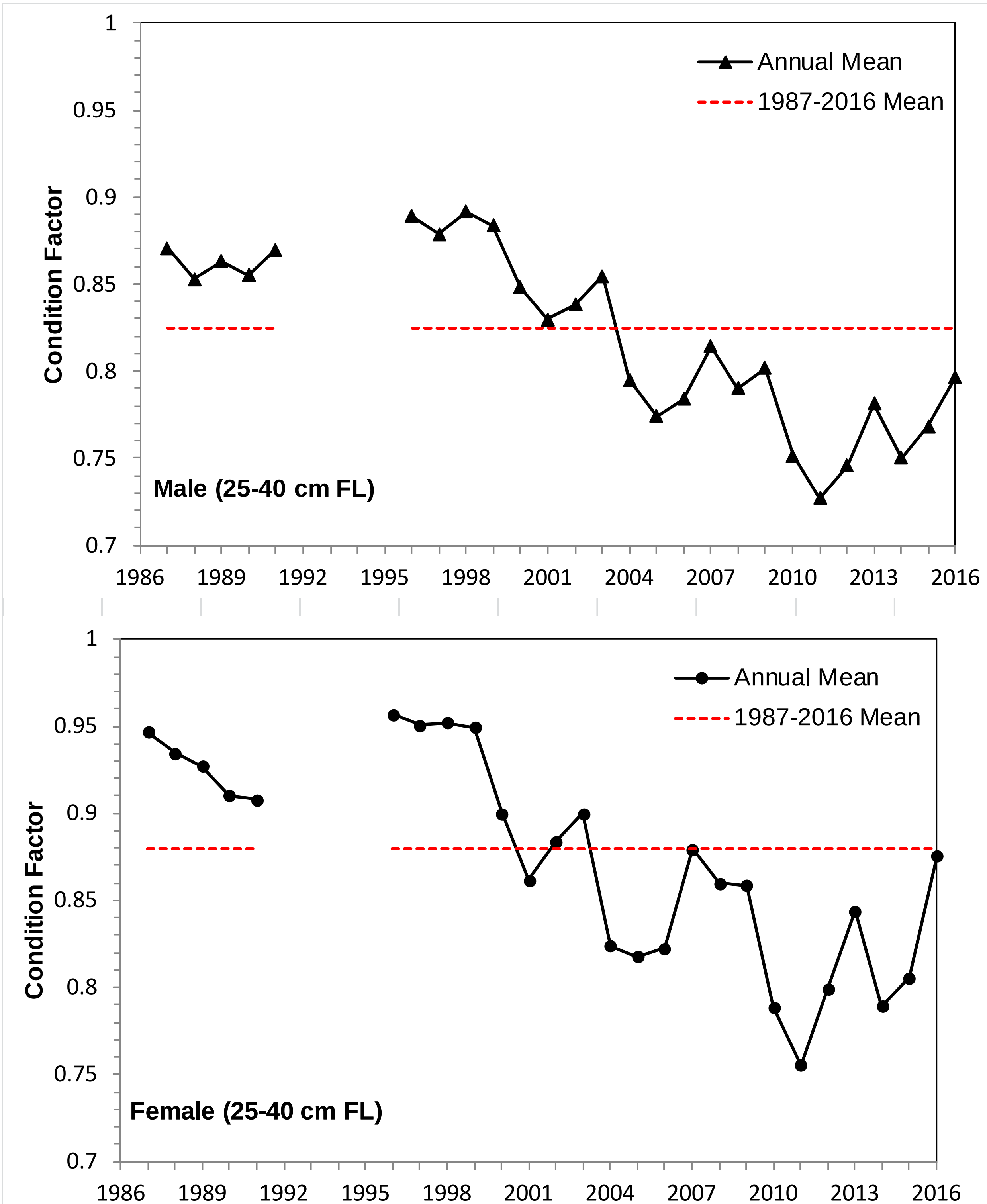

Figure 13b. Condition factor (Fulton's K) for male and female Yellowtail Flounder in the DFO survey.

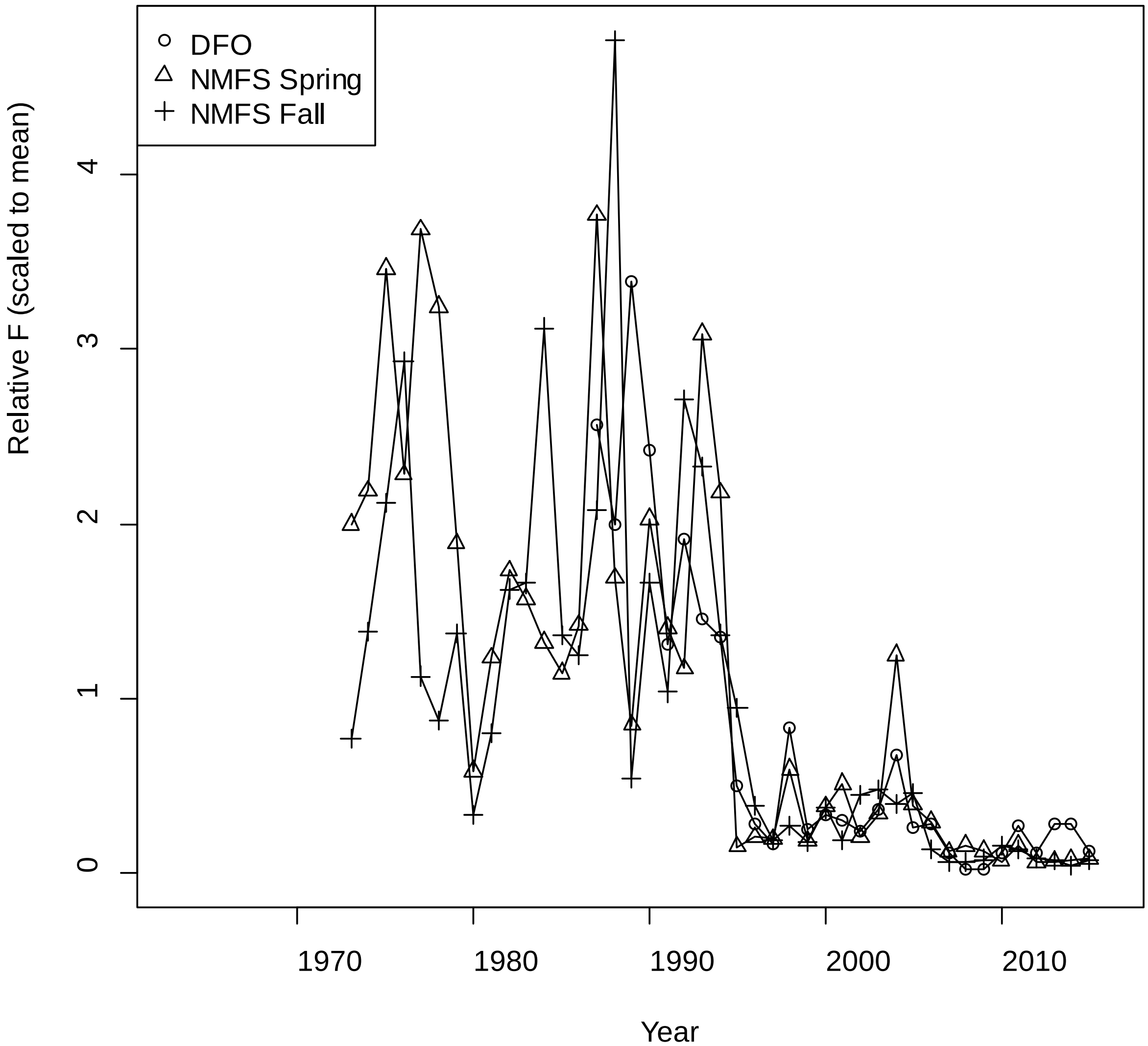

Figure 14. Trends in relative fishing mortality (catch biomass/survey biomass), or relative F, standardized to the mean for 1987-2007.

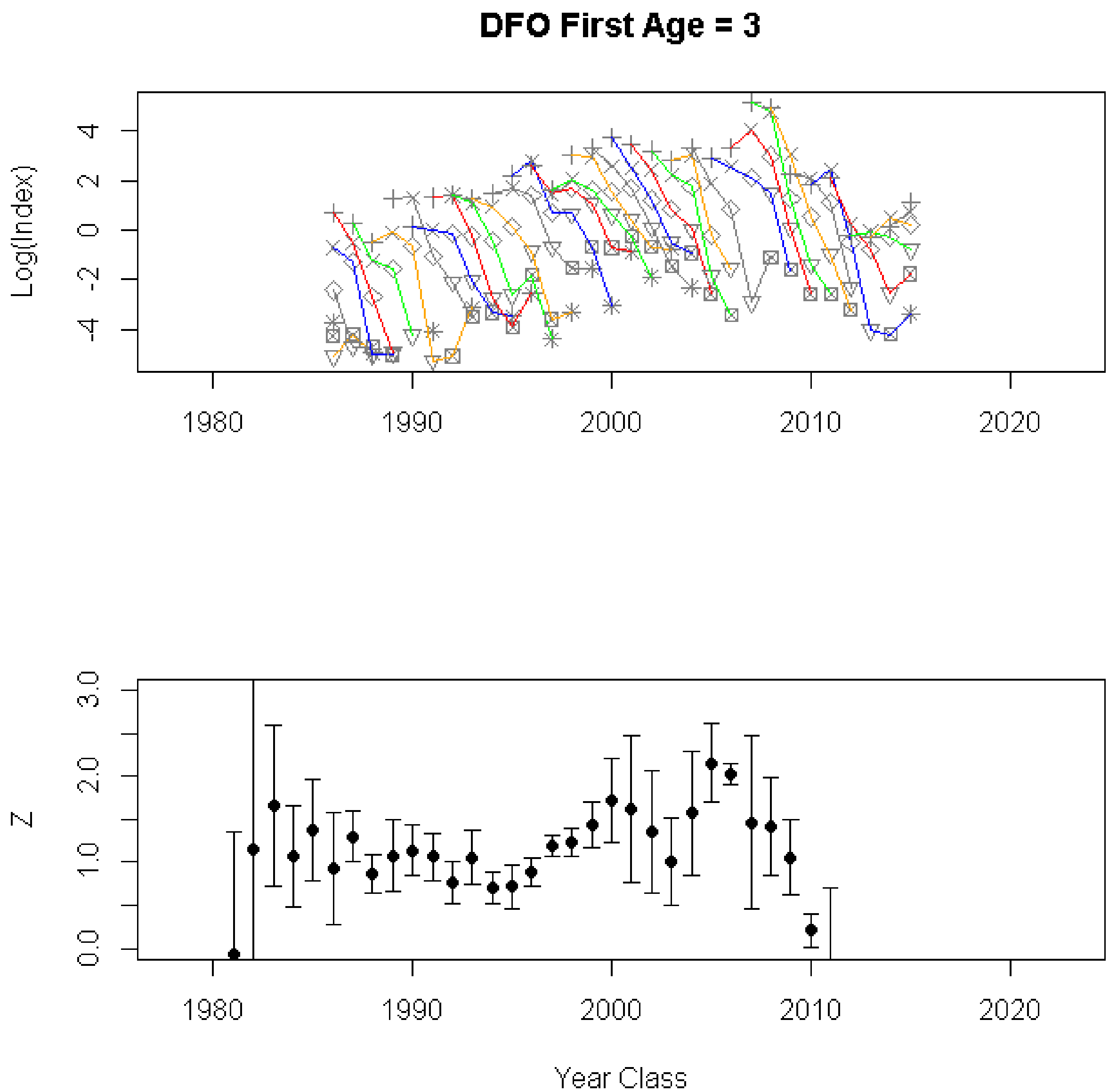

Figure 15a. Catch curve for DFO survey using age 3 as first age in Z calculation. Top panel shows log of survey catch at age, with symbols denoting ages and colored lines connecting cohorts. Bottom panel shows estimated total mortality rate (Z) from catch curve with 80% confidence interval by year class of cohort (age 0).

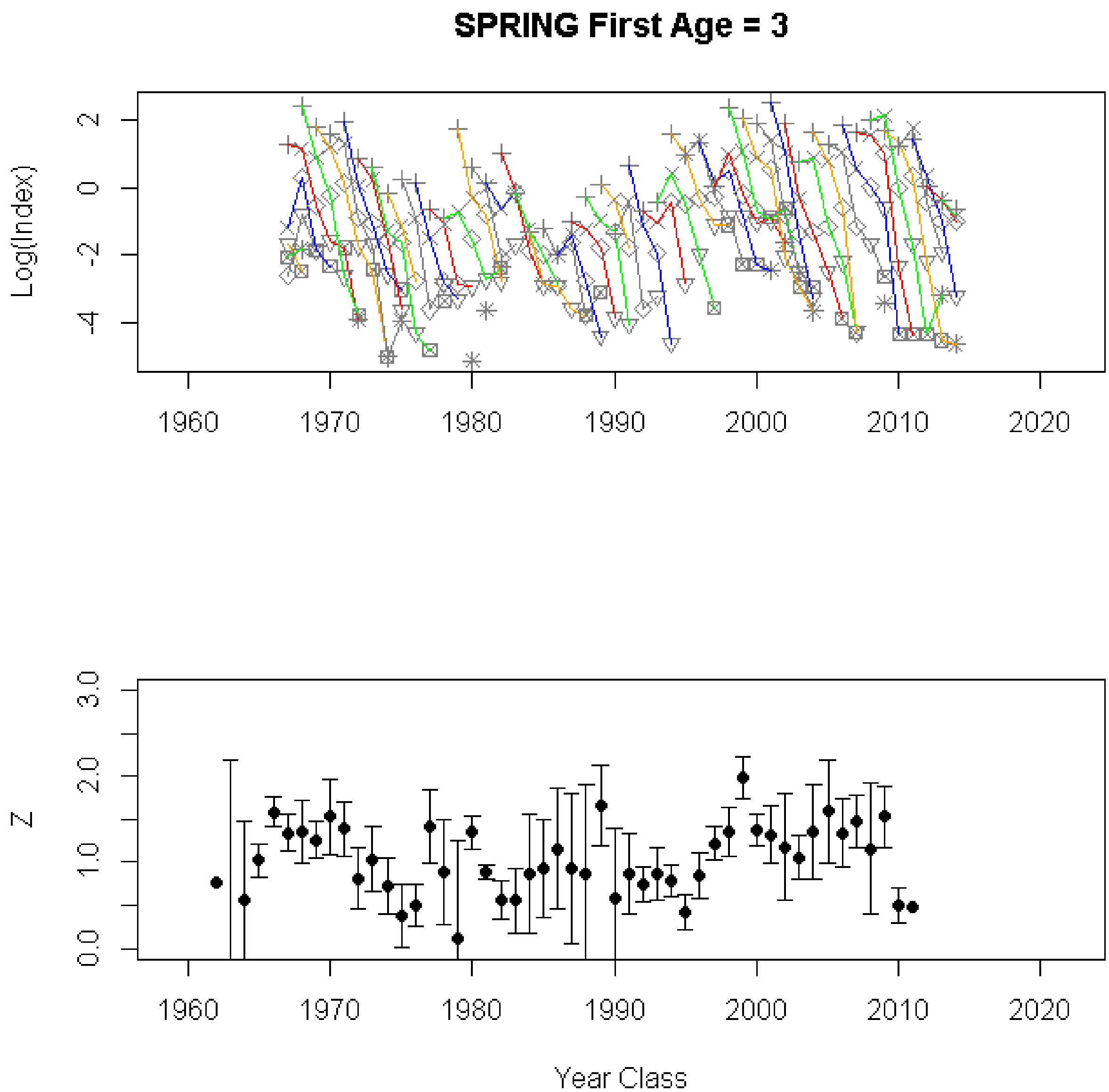

Figure 15b. Catch curve for NMFS spring survey using age 3 as first age in Z calculation. Top panel shows log of survey catch at age, with symbols denoting ages and colored lines connecting cohorts. Bottom panel shows estimated total mortality rate (Z) from catch curve with 80% confidence interval by year class of cohort (age 0). Note this figure is the same as in last year's report due to lack of age data for 2016 due to survey delays.

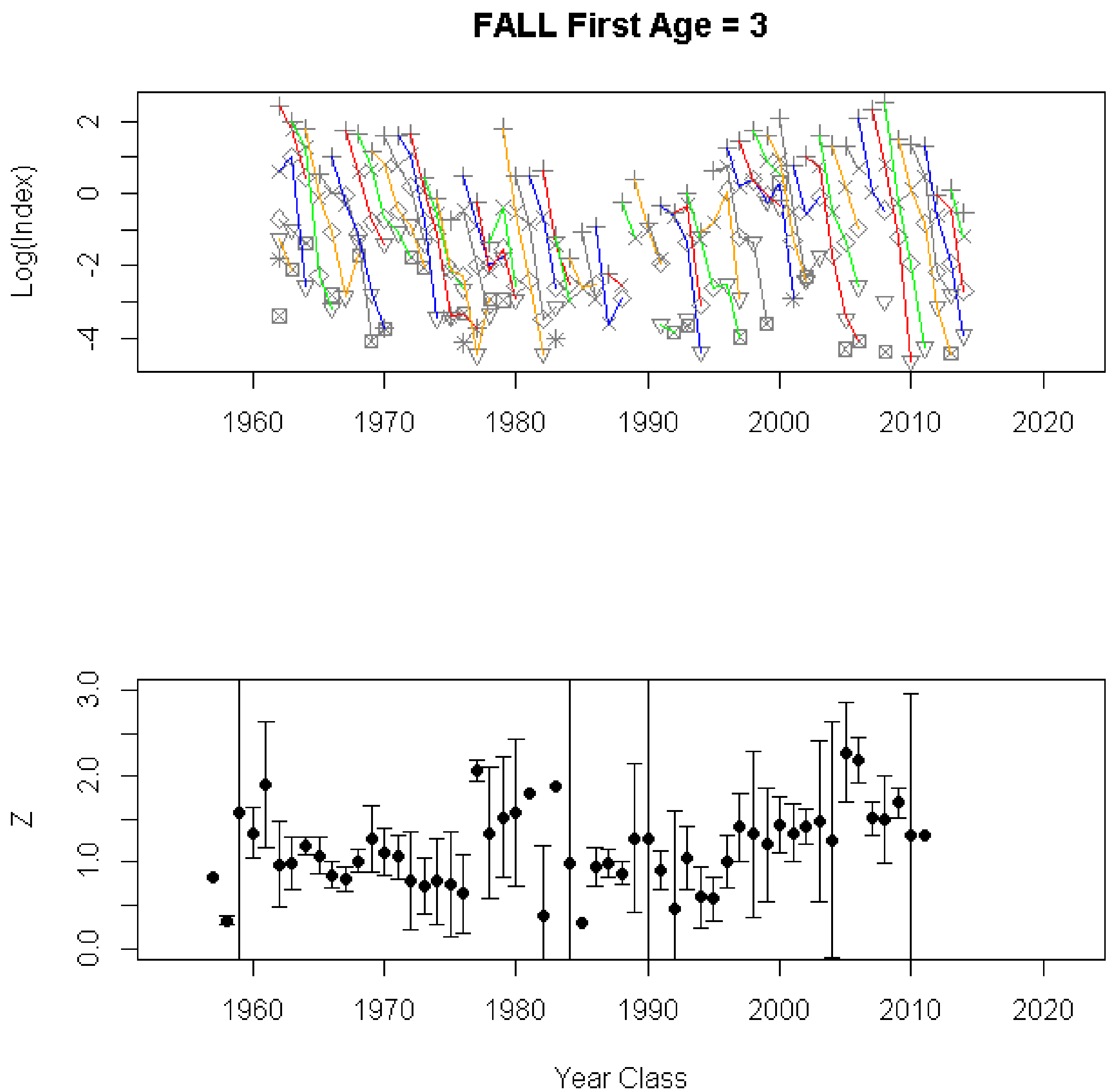

Figure 15c. Catch curve for NMFS fall survey using age 3 as first age in Z calculation. Top panel shows log of survey catch at age, with symbols denoting ages and colored lines connecting cohorts. Bottom panel shows estimated total mortality rate (Z) from catch curve with 80% confidence interval by year class of cohort (age 0).

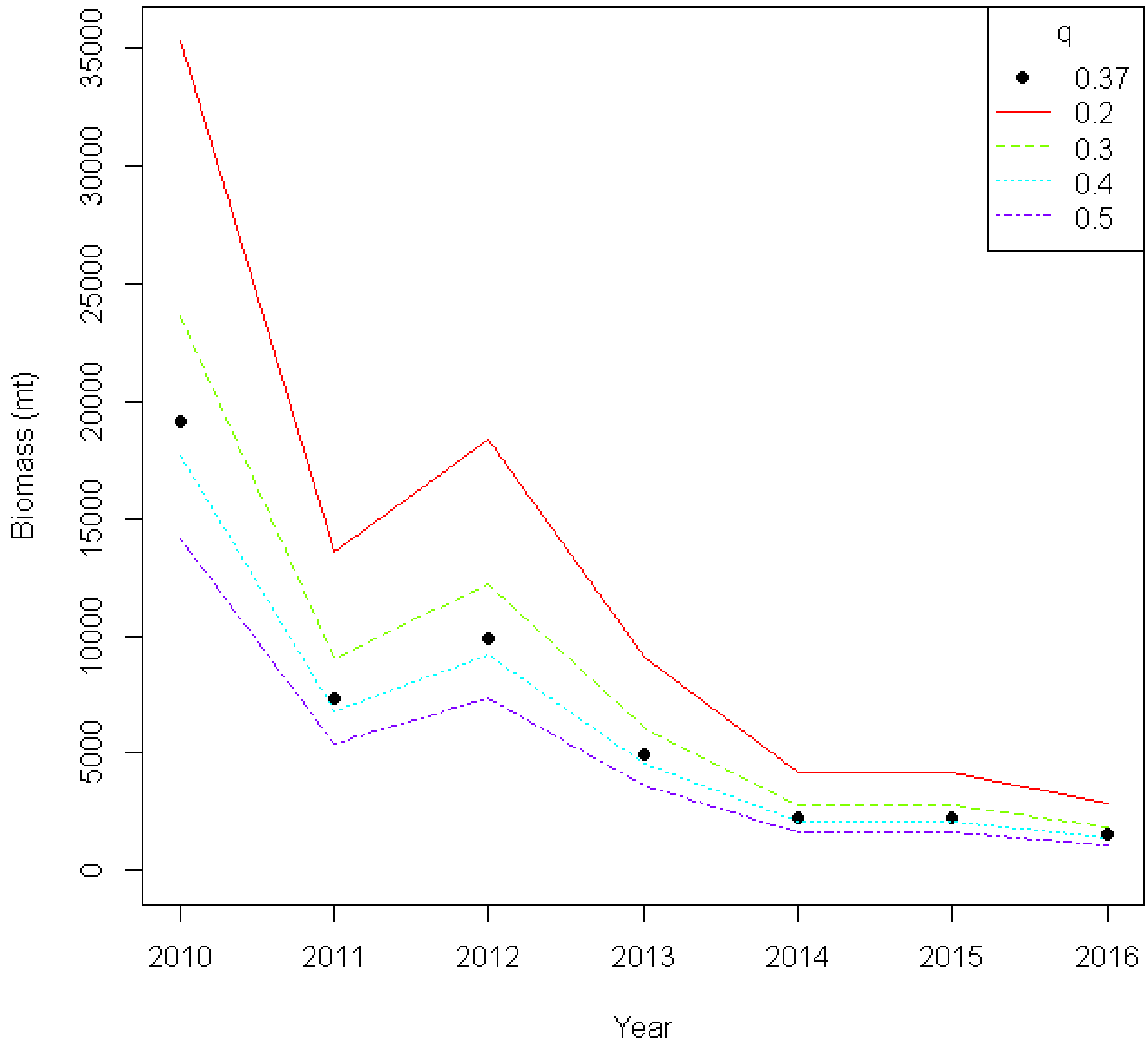

Figure 16a. Estimated biomass based on the average of the three surveys under a range of survey catchability (q) values.

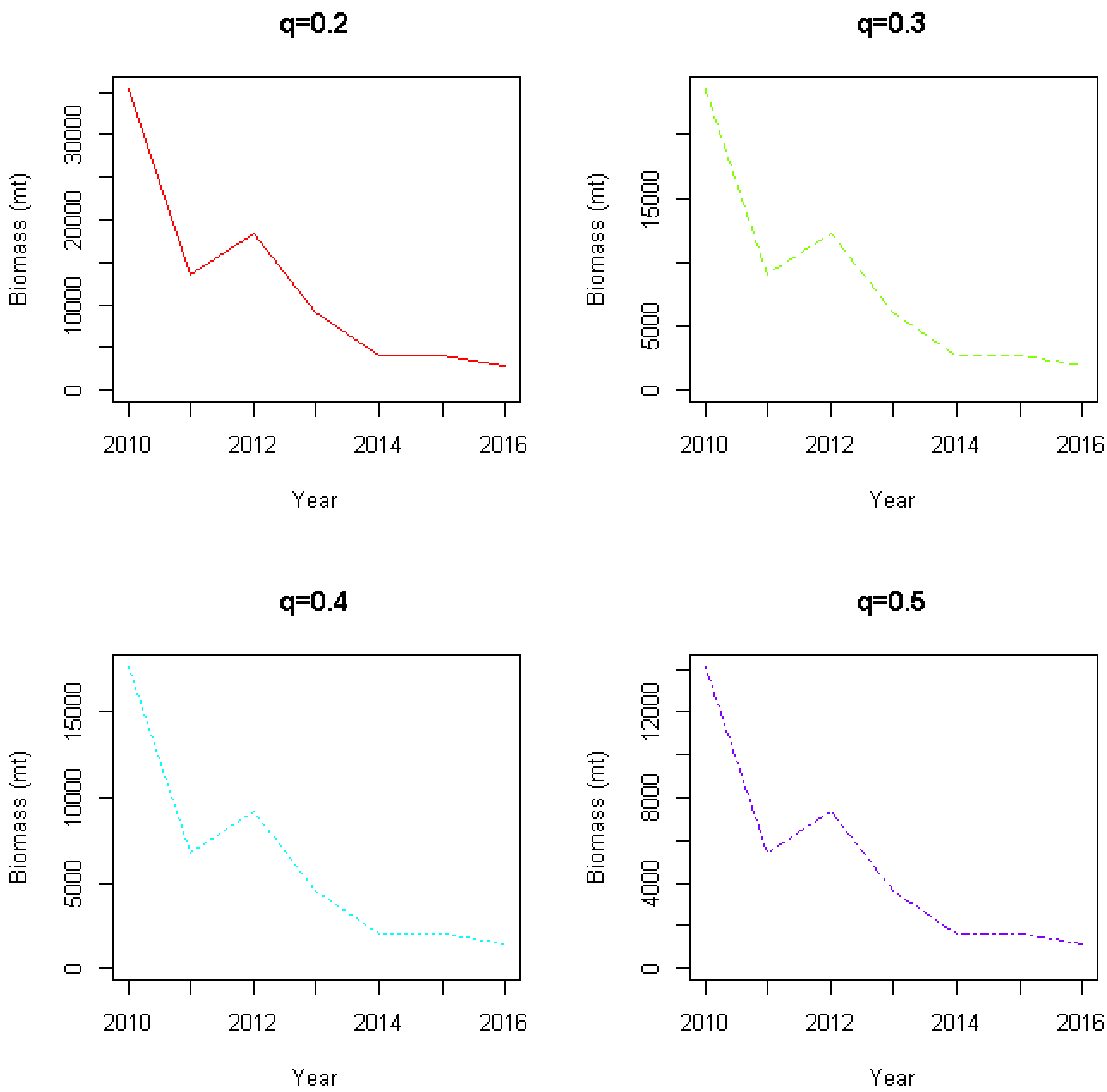

Figure 16b. Same as Figure 16a, except each time series has a different y-axis scale to demonstrate that the trends are identical.

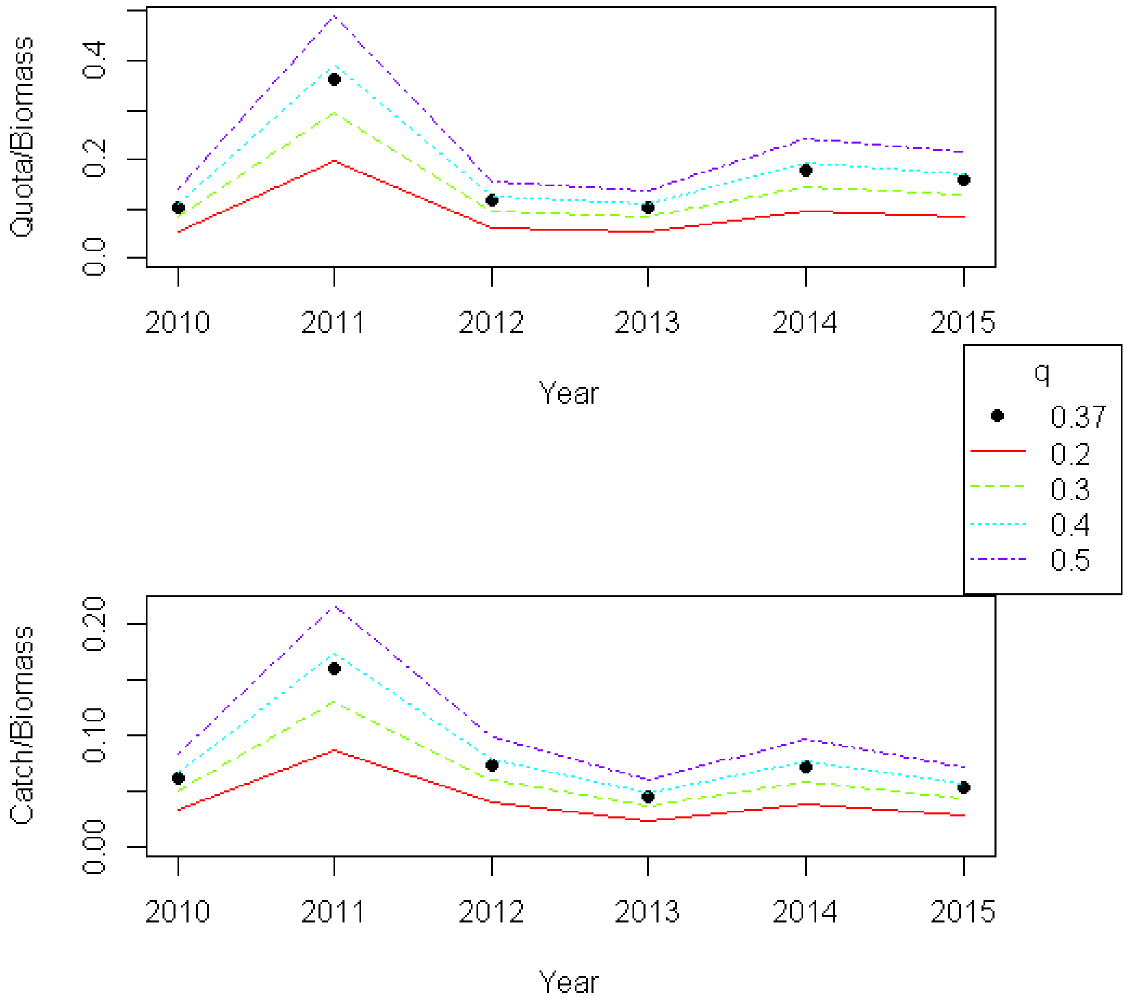

Figure 17. Historical exploitation rates for quota (top panel) and catch (bottom panel) for a range of survey catchability (q) values.

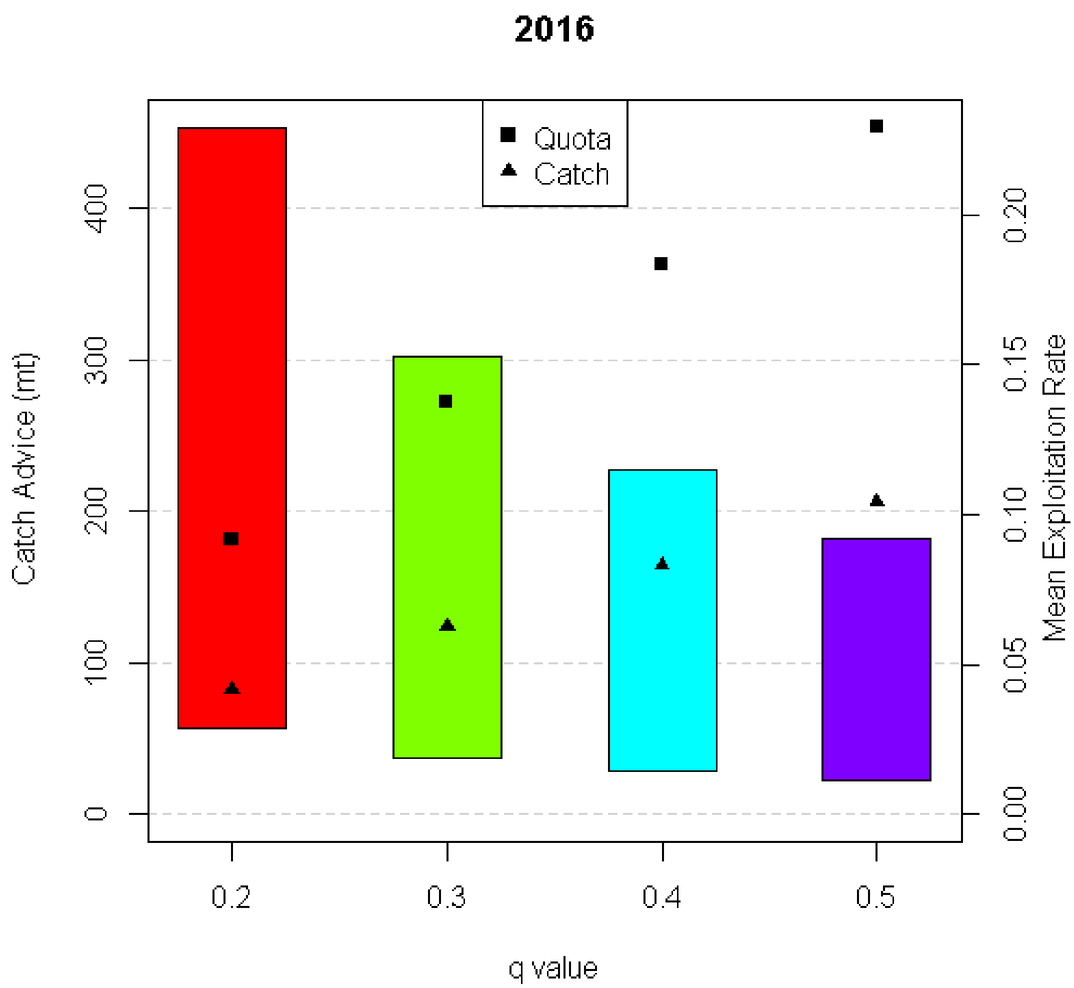

Figure 18. Catch advice for 2016 for a range of survey catchability (q) values where the bottom of the bar corresponds to an applied exploitation rate of 2% and the top of the bar corresponds to an applied exploitation rate of 16%. The mean of the historical exploitation rates are shown on the second y-axis using squares for quota/biomass and triangles for catch/biomass.

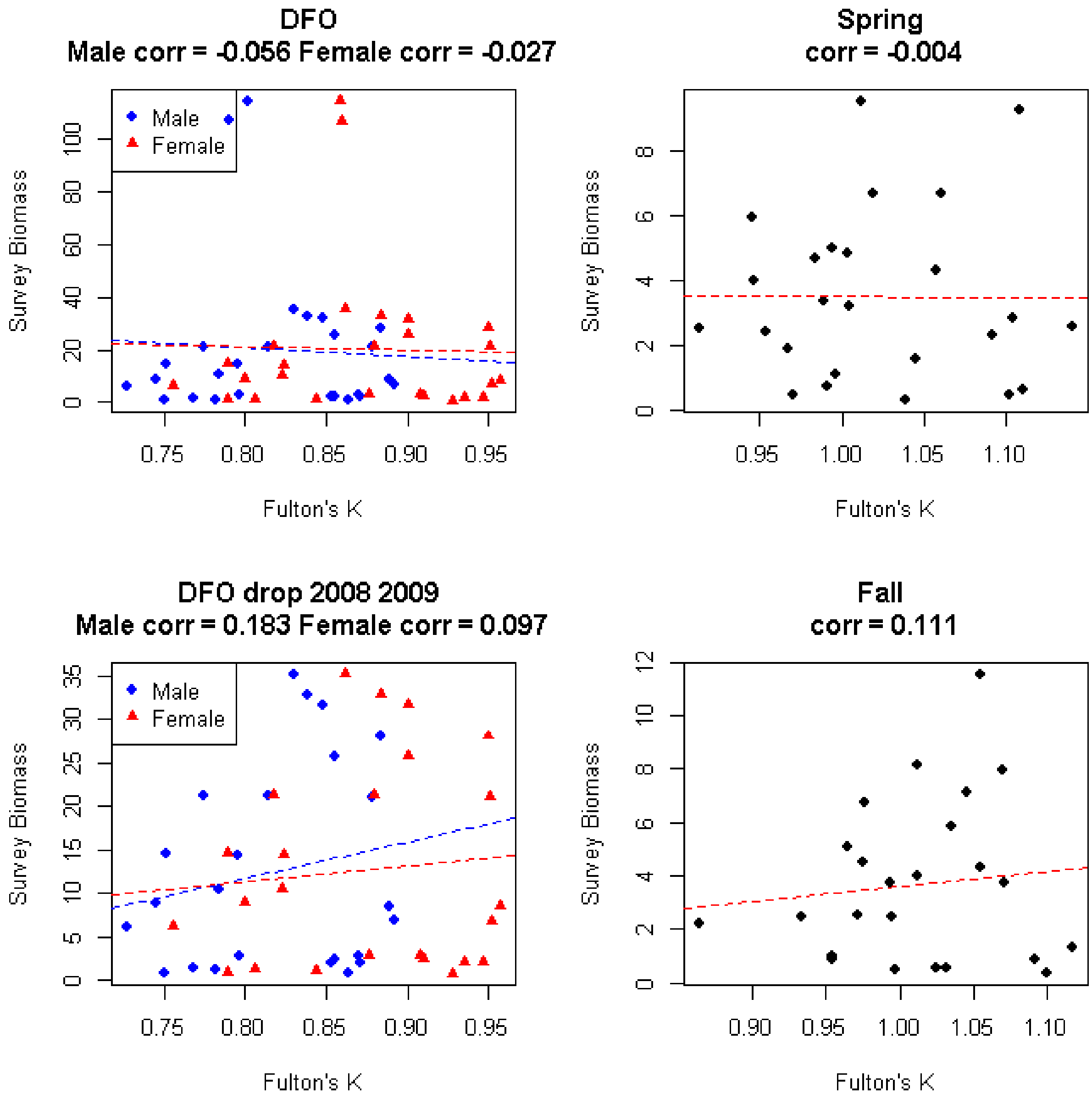

Figure 19. Relationship between survey biomass and condition factor (Fulton's K) for the three bottom trawl surveys. The DFO survey shown the relationship for male and female yellowtail flounder using different symbols. The DFO survey relationship is shown twice, once including the 2008 and 2009 values and once without those years due to the influence of single tows in each year. The lines are simple regressions through the data and the correlations are shown in the title of each plot.

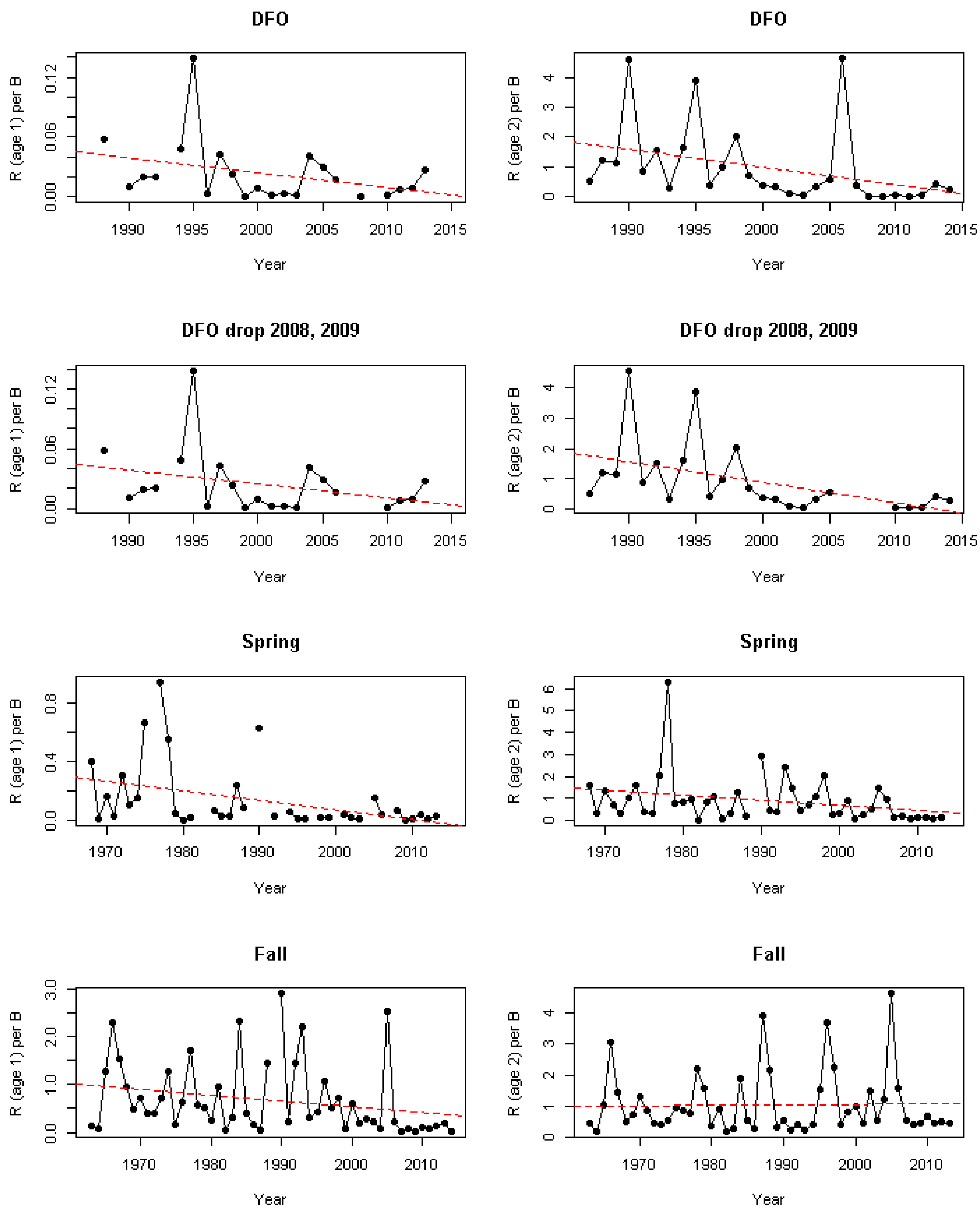

Figure 20. Recruits (at age 1 in left panels, at age 2 in right panels) per total biomass (a proxy for recruits per spawning stock biomass) over time from the three bottom trawl surveys. The DFO results are shown twice, once including the 2008 and 2009 values and once without to examine the influence of those years. The red dashed lines are simple linear regressions to indicate trends.

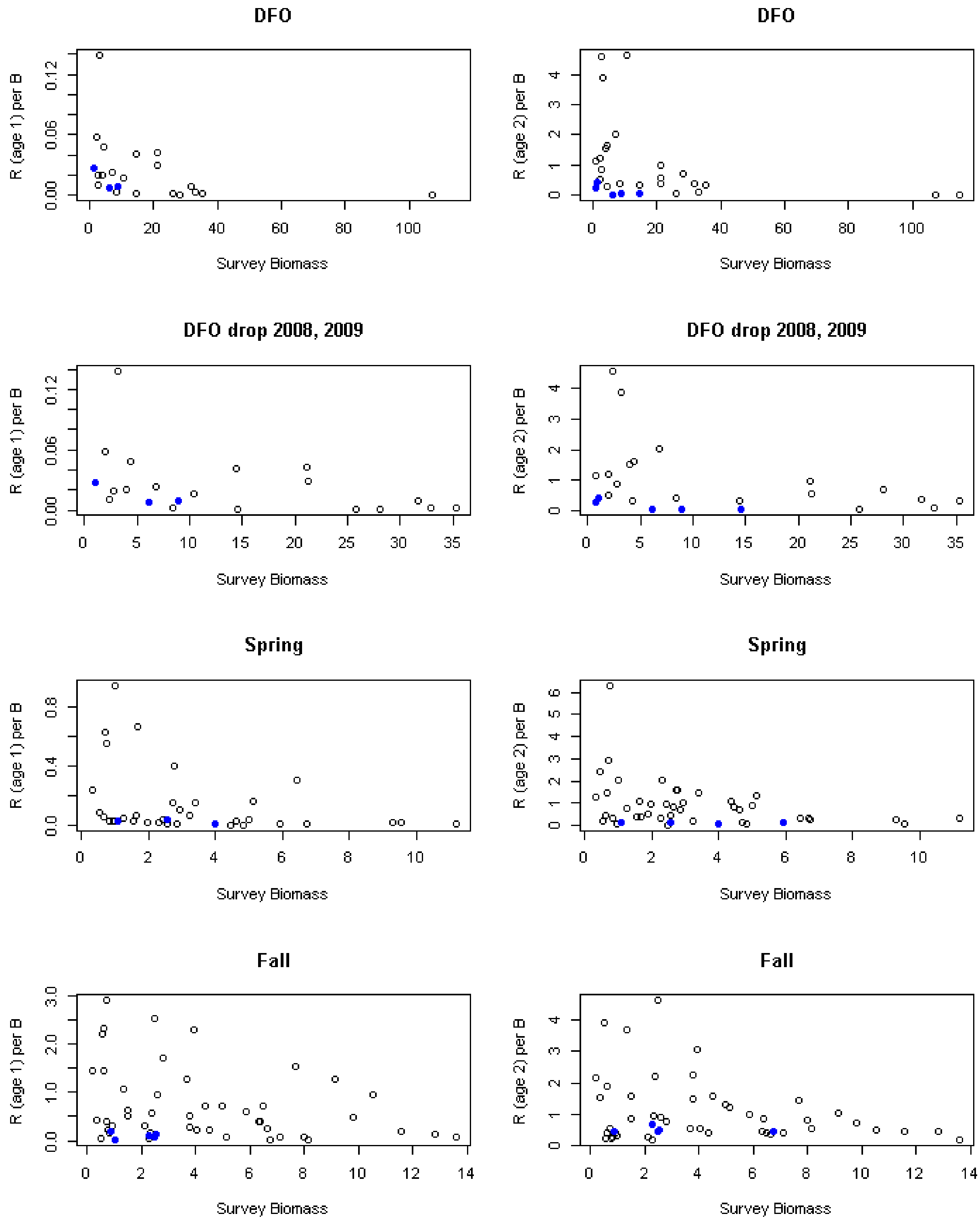

Figure 21. Recruits (at age 1 in left panels, at age 2 in right panels) per total biomass (a proxy for recruits per spawning stock biomass) in relation to the survey biomass. Blue filled circles denote the most recent five years (not all plots show each year due to zeros treated as missing values).

APPENDIX

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

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

[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**		
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 objections to a 1,500 mt TAC)	Neutral risk of exceeding Fref	1,664 mt About 75 percent probability of exceeding Fref	*F = 0.29* *Age 3+ biomass increased 211% 07-08* 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

TRAC	Catch Year	TRAC Analysis/Recommendation		TMGC Decision		Actual Catch[1]/Compared to Risk Analysis	Actual Result[2]
		Amount	Rationale	Amount	Rationale		
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

TRAC	Catch Year	TRAC Analysis/Recommendation		TMGC Decision		Actual Catch[1]/Compared to Risk Analysis	Actual Result[2]
		Amount	**Rationale**	**Amount**	**Rationale**		
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 32% 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)		
2016	2017	(1) 31-245 mt (2) 354 mt	(1) constant exploitation rate 2%-16% (2) constant quota				