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# Stock Assessment of Georges Bank Yellowtail Flounder for 2013


Christopher M. Legault[1], Larry Alade[1], W. Eric Gross[2], and Heath H. Stone[2]

[1] National Marine Fisheries Service
Northeast Fisheries Science Center
166 Water Street
Wood's Hole, MA, 02543

[2] Department of Fisheries and Oceans
St. Andrews Biological Station
531 Brandy Cove Road
St. Andrews, New Brunswick, E5B 2L9



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## ABSTRACT

The combined Canada/US yellowtail flounder catch in 2012 was 722 mt, with neither country filling its portion of the quota. This is the first time since 1940 the catch has been less than 1,000 mt. Despite the low catch, the two bottom trawl surveys conducted in spring 2013 declined to low values relative to their entire time series. All three bottom trawl surveys indicate low recruitment for the most recent three cohorts.

This assessment updates the Split Series and Single Series virtual population analysis (VPA) formulations that were approved at the last benchmark assessment to estimate stock size and fishing mortality. Both formulations exhibit strong retrospective patterns and rho adjustments are recommended for both determining stock status and providing catch advice. When the rho adjustments are applied, both formulations indicate low adult biomass at the start of 2013 (826 mt or 1,683 mt) and high fishing mortality in 2012 (F = 0.78 or 0.45). Catches of less than 200 or less than 500 mt are required to achieve the TMGC objective of not overfishing or allowing adult biomass to increase. Due to the assumption used for the 2012 year-class in the projections (geometric mean of recent ten years), the increase in adult biomass will be optimistic if the 2012 year-class is as poor as the recent year-classes.

## RÉSUMÉ

En 2012, les prises combinées de limande à queue jaune au Canada et aux États-Unis étaient de 722 tm; aucun des deux pays n'avait atteint sa partie du quota. C'était la première fois depuis 1940 que les prises étaient inférieures à 1 000 tm. Malgré les faibles prises, les deux relevés au chalut de fond qui ont été effectués au printemps 2013 ont diminué à de faibles valeurs comparativement à l'ensemble de leur série chronologique. Les trois relevés au chalut de fond ont indiqué un faible recrutement pour les trois cohortes les plus récentes.

La présente évaluation apporte une mise à jour aux formules d'analyses de populations virtuelles à série fractionnée et à série unique qui ont été approuvées à la dernière évaluation des points de référence et qui servent à estimer la taille du stock et le taux de mortalité des poissons. Les deux formules affichent de fortes tendances rétrospectives, et des corrections rho sont recommandées pour déterminer l'état du stock et prodiguer des conseils relatifs aux prises. Lorsque les corrections rho sont appliquées, les deux formules indiquent une faible biomasse des adultes au début de 2013 (826 tm ou 1 683 tm) et un taux élevé de mortalité par pêche en 2012 (F = 0,78 ou 0,45). Des prises de moins de 200 ou de moins de 500 tm sont nécessaires pour atteindre l'objectif du Comité d'orientation de la gestion des stocks transfrontaliers, qui vise à éviter la surpêche et à permettre l'augmentation de la biomasse des adultes. En raison de l'hypothèse utilisée dans les projections pour la classe d'âge de 2012 (moyenne géométrique des dix dernières années), l'augmentation de la biomasse des adultes sera optimiste si cette classe d'âge est aussi faible que les classes d'âge récentes.

## 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. 2012), taking into account advice from the 2005 benchmark review (TRAC 2005). A primary objective of the benchmark review was to address the retrospective pattern that had been apparent from assessments conducted during the past several years. During the benchmark assessment meeting, several analytical models were reviewed, all of which indicated that the fishery catch at age and survey abundance at age show differences that cannot be reconciled. Various possible reasons for the retrospective pattern were identified including an increase in natural mortality, large amounts of unreported catch, and changes in survey catchability since 1995. The consensus view from the benchmark meeting was that management advice should be formulated on the basis of results from several approaches:

- Analysis of data from survey and fishery (trends in relative fishing mortality (F) and total mortality (Z))
- Base Case Virtual Population Analysis (VPA) model formulation from the 2004 assessment
- Two new VPA model formulations with minor and major changes to Base Case

The analytical methods used in the current assessment are based on revised model formulations adopted during the 2005 Transboundary Resources Assessment Committee (TRAC) benchmark review using updated information from both countries on catches and survey indices of abundance. During the 2009 TRAC meeting, it was decided that neither the Base Case nor Minor Change VPA would be considered any longer because neither had been used for management advice in a number of years (O'Brien and Worcester 2009). The Major Change model will be referred to as the "Split Series" model in this document since it is now the default model, while the Base Case model will be referred to as the "Single Series" model.

Last year, in 2012, the Split Series VPA model was used as the basis of status determination. This model downweighted the Canadian 2008 and 2009 surveys in the tuning process to account for their higher uncertainty caused by single large catches of yellowtail flounder in those years. This formulation indicated that catches have not reduced fishing mortality (F) below $F_{ref}$ and have not had the expected effect on adult (age 3+) biomass or spawning stock biomass. If the 2013 catch quota had been set based on this model, this pattern of failing to achieve management objectives was expected to continue given the model's retrospective pattern. The TRAC recommended not basing 2013 catches on these unadjusted model projection results. Instead, five analyses were considered to address the retrospective bias to characterize the uncertainty and risk in catch advice. Both the Split Series and Single Series models had their population abundance at the start of 2012 reduced based on the Mohn's rho for spawning stock biomass. These projections had much lower catch advice in 2013 compared to the unadjusted projections. Alternative "fixes" to the retrospective pattern within the assessment model were employed by increasing recent catch, natural mortality, or both. These models and projections resulted in similar catch advice to the retrospective-adjusted Split Series and Single Series results. Based on examination of these five analyses, the TRAC concluded that to achieve both a high probability that F in 2013 will be less than Fref and that adult biomass will increase, a 2013 quota of approximately 200 mt would be required. A quota of 400-500 mt had both positive and negative aspects among the five analyses, with either F in 2013 being below $F_{ref}$ or adult biomass increasing, but not both. The Transboundary Management Guidance Committee (TMGC) negotiated the combined US-Canada catch quota for 2013 to be 500 mt.

Yellowtail flounder range from southern Labrador to Chesapeake Bay and are typically caught at depths between 30 and 70 m. A major concentration occurs on Georges Bank from the Northeast Peak to the east of the Great South Channel. Yellowtail flounder have previously been described as relatively sedentary. However, there are also studies that counter this classification with off bottom movements (Walsh and Morgan 2004; Cadrin and Westwood 2004), limited seasonal movements (Royce et al. 1959; Lux 1963; Stone and Nelson 2003), and transboundary movements both east and west across the Hague Line (Stone and Nelson 2003; Cadrin 2005). On Georges Bank, spawning occurs during late spring and summer, peaking in May. Eggs are deposited on or near the bottom and, after fertilization, float to the surface where they drift during development. Larvae are pelagic for a month or more; then they become demersal and settle to benthic habitats. Based on the distribution of both ichthyoplankton and mature adults, spawning occurs on both sides of the Hague Line. Growth is sexually dimorphic, with females growing at a faster rate than males (Lux and Nichy 1969; Moseley 1986; Cadrin 2003). Yellowtail flounder maturation occurs earlier than in most flatfish with approximately half of females mature at age 2 and nearly all females mature at age 3.

## MANAGEMENT

Historical and new information pertaining to the current management unit for the Georges Bank yellowtail flounder stock was reviewed during the 2005 benchmark assessment. Tagging data, larval distribution, vital population parameters (i.e. growth, survival, recruitment, reproduction, abundance), and geographic patterns of landings and survey data indicate that Georges Bank yellowtail flounder comprise a relatively discrete stock, separate from those on the western Scotian Shelf, off Cape Cod, and in southern New England waters (Royce et al. 1959; Lux 1963; Neilson et al. 1986; Begg et al. 1999; Cadrin 2003; Stone and Nelson 2003). Based on information from comprehensive reviews by Cadrin (2003; 2010) and recent results from cooperative science/industry tagging programs conducted by Canada and the US, there does not appear to be any justification for redefining the geographic boundaries of the Georges Bank yellowtail flounder stock management unit.

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). Both Canada and the US employ the same management unit.

In 1984, the International Court of Justice (ICJ) determined US and Canadian jurisdictions for Georges Bank fishery resources (ICJ 1984). At that time, there was no Canadian fishery for yellowtail. When a Canadian fishery developed in the early 1990s, Canada and US were exchanging information but conducting separate assessments. In the late 1990s, joint assessments were developed, and in 2001 a sharing agreement was formed (TMGC 2002). Since the establishment of the US and Canada sharing agreement in 2001, advice for the Georges Bank yellowtail flounder relied primarily on a bilateral management system provided by the TMGC. The agreement includes TAC for each country based on a formulaic calculation using both historical catch and current spatial stock distribution as determined by the three bottom trawl surveys. The quota sharing agreement between the two countries requires that catches from all sources be counted against the national allocations, regardless of whether the catch was landed or discarded. When accounting for catch, the assumption has always been made that all discarded fish die. Recent field work has demonstrated high discard mortality rates for yellowtail flounder (Barkley and Cadrin 2012), supporting this assumption. Although there is coordination between the US and Canadian fishery management, objectives between the two countries remain inconsistent, with US law requiring stock biomass rebuilding targets that are not part of Canadian management. The passage of the International Fisheries Clarification Act in 2010 (Shark and Fishery Conservation Act 2011) relaxed the US rebuilding requirements, allowing more consistent management between the two countries.

## THE FISHERIES

Exploitation of the Georges Bank yellowtail flounder stock began in the mid 1930s by the US trawler fleet. Landings (including discards) increased from 400 mt in 1935 to 9,800 mt in 1949, then decreased in the early 1950s to 2,200 mt in 1956, and increased again in the late 1950s (Table 1 and Figure 2). The highest annual catches occurred during 1963-1976 (average: 17,500 mt) and included modest catches by distant water fleets (Table 1 and Figure 2). No catches of yellowtail by nations other than Canada and US have occurred since 1975. In 2001, the decision was made to manage the stock as a transboundary resource in Canadian and US jurisdictions (TMGC 2002). Catches averaged around 3,500 mt between 1985 and 1994, and then dropped to a low of 1,135 mt in 1995 when fishing effort was markedly reduced in order to allow the stock to rebuild. The US fishery in the management area has been constrained by spatial expansion of Closed Area II in 1994 (Figure 1b) and by extension to year-round closure in December 1994, as well as mesh size and gear regulations and limits on days fished. In 2004, a Yellowtail Special Access Program (SAP) in Closed Area II allowed the US bottom trawl fishery short-term access to the area for the first time since 1995. This SAP did not continue in subsequent years. In 2010, a Haddock SAP in Closed Area II allowed the US bottom trawl fishery short-term access to the area and some yellowtail flounder were caught as bycatch in this fishery. A directed Canadian fishery began on eastern Georges Bank in 1993, pursued mainly by small otter trawlers (< 20 m). Catches by both nations (including discards) steadily increased (with increasing quotas) from a low of 1,135 mt in 1995, when the stock was considered to be in a collapsed state, to 7,419 mt in 2001. Since 2004, decreasing quotas and an inability of Canadian fishermen to fill their portion of the quota have resulted in a declining trend in catches through 2012 (catch in 2012 = 722 mt).

### 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. US trawlers that land yellowtail flounder generally target multiple species on the southwest part of the Bank, and on the northern edge along the western and southern boundaries of Closed Area II. Recreational fishing for yellowtail is negligible.

Landings of yellowtail flounder from Georges Bank by the US fishery during 1994-2012 were derived from the trip-based allocation described in the GARM III Data meeting (GARM 2007; Legault et al. 2008b; Palmer 2008; Wigley et al. 2007a). US landings have been limited by quotas in recent years. Total US yellowtail landings (excluding discards) for the 2012 fishery were 443 mt, a 51% decrease from 2011 (Table 1 and Figure 2).

US discarded catch for years 1994-2012 was estimated using the Standardized Bycatch Reporting Methodology (SBRM) 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. Large and small mesh otter trawl gears were separated at 5.5 inch (14 cm) cod-end mesh size. The large mesh fishery mainly targets groundfish, monkfish, skates, dogfish, and fluke (summer flounder), while the small mesh fishery mainly targets whiting (silver hake), herring, mackerel, and squid. Uncertainty in the discard estimates was estimated based on the SBRM approach detailed in the GARM III Data meeting (GARM 2007; Wigley et al. 2007b). Average annual US discards were approximately 19% of the US catch in years 1994-2012 (Table 1 and Figure 2). Total discards of yellowtail in the US remained essentially the same from 2011 (192 mt) to 2012 (188 mt). A decrease in the large and small mesh trawl discards was offset by an increase in scallop dredge discards (Table 2a).

The total US catch of Georges Bank yellowtail flounder in 2012, including discards, was 631 mt. This value can be compared to the quota monitoring estimated catch of 644 mt for calendar year 2012, data kindly provided by Dan Caless of the Northeast Regional Office (Table 3). The strong similarity from the two estimates both this year and last year is encouraging, as this has not always been the case in the past.

The US Georges Bank yellowtail flounder quota for fishing year 2012 (1 May 2012 to 30 April 2013) was set at 564 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 (http://www.nero.noaa.gov/ro/fso/MultiMonReports.htm) indicates the US groundfish fishery caught 58.5% of its sub-quota (368 mt) for the 2012 fishing year and the scallop fleet caught 104% of its sub-quota (164 mt) for the 2012 fishing year. However, the slight overage of the scallop fleet is due to this fleet transferring some of its original sub-quota to the groundfish fleet mid-year. The overall US catch from all fleets was below the US quota for fishing year 2012.

## CANADA

Canadian fishermen initiated a directed fishery for yellowtail flounder on Georges Bank in 1993. Prior to 1993, Canadian landings were low, typically less than 100 mt (Table 1 and Figure 2). Landings of 2,139 mt of yellowtail occurred in 1994, when the fishery was unrestricted. After a TAC of 400 mt was established, yellowtail landings dropped to 464 mt in 1995. Subsequently, both quotas and landings increased and in 2001 landings reached a peak at 2,913 mt. The majority of Canadian landings of yellowtail flounder were made by otter trawl from vessels less than 20 m (tonnage classes 1-3). The fishery generally occurred from June to December, with most landings in the third quarter. Since 2004, there has been no directed Canadian fishery because fishermen have not been able to find commercial densities of yellowtail flounder. Landings have been less than 100 mt every year since 2004, with a low of 5 mt in 2009, and 46 mt reported in 2012. From 2004-2011, most of the reported yellowtail landings were from trips directed for haddock. In 2012, there were 9 trips directed for yellowtail flounder. These directed trips caught most of the landed yellowtail.

The Canadian offshore scallop fishery is the source of Canadian yellowtail flounder discards on Georges Bank. As a result of the 2005 benchmark review, these data are now incorporated into the Canadian fishery catch and catch at age for 1973 onward (TRAC 2005). Discards are not recorded in the Canadian fishery statistics and are therefore 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. A total of 5 trips were observed in 2004, 11 in 2005, 11 in 2006, 14 in 2007, 23 in 2008, 21 in 2009, 24 in 2010, 22 in 2011, and 20 in 2012. Discards for the years 2004-2012 were obtained by estimating a monthly prorated discard rate (kg/hr), using a 3-month moving-average calculation to account for the seasonal pattern in bycatch rate, applied to a monthly standardized effort (Table 2b-c) (Van Eeckhaute et al. 2010). The result of these calculations for 2012 is a discard estimate of 45 mt, the lowest in the time series (Table 1 and Figure 2).

For 2012, the total Canadian catch, including discards, was 91 mt, a 25% increase from 2011, which is 16% of the 2012 TAC of 586 mt.

## LENGTH AND AGE COMPOSITION

The level of US port sampling continued to be strong in 2012, with 4,293 length measurements available from 50 samples, resulting in 969 lengths/100 mt of landings (Table 4). This level of sampling has generally resulted in increased precision (i.e. low coefficients of variation) for the US landings at age from 1994-2012, as estimated by a bootstrapping procedure (Table 5). The port samples also provided 898 age measurements for use in age-length keys. The Northeast Fisheries Observer Program provided an additional 3,502 length measurements of discarded fish from 464 trips, which were combined with the port samples to characterize the size composition of the US catch.

The US landings are classified by market category (large, small, medium, and unclassified) and this categorization is used to determine the size and age distributions. Both the amount and the proportion of yellowtail landed in the large market category have generally increased since 1995 (from approximately 50% to approximately 75%). Examination of the size distributions of the large and small market categories continues to show some overlap in the 36-38 cm range, but overall discrimination between the groups was apparent (Figure 3).

In 2012, three port samples (697 length measurements) and nine observer samples (10,879 length measurements) were collected from the 46 mt of Canadian landings (Table 4). These samples were expanded to the total catch using sex-specific length-weight relationships.

The US discard length frequencies were generated from observer data, expanded to the total weight of discards by gear type and half year. Large mesh trawl discards showed a strong peak near the minimum allowed size (Figure 4). Small mesh discards accounted for only a small portion of the total discards and had few fish measured for length, resulting in a disjointed distribution of fish at length (Figure 4). The small mesh otter trawl fishery is prohibited from landing groundfish, so can have discards of fish above the minimum size regulation. Scallop dredge discards were mainly legal-sized fish, as has been typically seen for dredge gear in the past (Figure 4).

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 2012. 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).

A comparison of the 2012 size composition of yellowtail catch by country shows quite similar length distributions for landings by the US and Canada (Figure 5). US discards were also quite similar in both mean size and spread in the distributions relative to Canadian discards (Figure 6). The total catch also had similar mean size and spread in the distribution for the two countries, although the low magnitude of Canadian catch relative to US catch makes this comparison suspect (Figure 7).

Although otoliths are used to determine ages for Grand Bank yellowtail (Walsh and Burnett 2001), age determination of Georges Bank yellowtail flounder using otoliths is hampered by the presence of weak, diffuse, or split opaque zones and strong checks, which can make interpretation of annuli subjective and difficult (Stone and Perley 2002). Therefore, scales are the preferred structure for aging Georges Bank yellowtail flounder. Percent agreement on scale ages by the US readers continues to be high (>85% for most studies) with no indication of bias.

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. In the past, the age-length keys for the US discards used age samples from at-sea observers of the discarded catch supplemented with US surveys. Since 2004, the scales collected by the observers have not been aged, so the US surveys and commercial landings provided ages.

No scale samples were available for the Canadian fishery in 2012. Therefore, the Canadian landings and discards at length were converted to catch at age using the US age-length keys by half-year and catch type (landings or discards). Canadian landings and discards each accounted for 6% of the total 2012 catch.

In 2012, ages 3 through 5 (2009 - 2007 year-classes, respectively) dominated US landings, while ages 3 and 4 dominated US discards, with only minor contributions from Canadian landings and discards (Figure 8). 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 6 and Figure 9). Despite management measures intended to reduce fishing effort over the past several years, there are few fish greater than age 5 in the catch at age.

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 mean weight at age (kg) for the Canadian and US landings were quite similar and generally were more variable at older ages (5+) during the mid 1980s to the mid 1990s. The combined fishery weights at age were calculated from Canadian and US landings and discards, weighting by the respective catch at age (Table 7 and Figure 10). Weights at age have been increasing recently, following a decline during the mid 2000s, and are returning to levels seen in the late 1970s/early 1980s. Recent weights at age (WAA) values are above average for ages 1 and 2 and below average for the other ages, but all ages are within the range of past WAA calculations since 1973.

## ABUNDANCE INDICES

Research bottom trawl surveys are conducted annually on Georges Bank by the Canadian Department of Fisheries and Oceans (DFO) in February (denoted spring) 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 defined (Figure 11).

The NMFS spring and fall bottom trawl survey catches (strata 13-21), NMFS scallop survey catches (scallop strata 54, 55, 58-72, 74), and DFO spring bottom trawl survey catches (strata 5Z1-5Z4) were used to estimate relative stock biomass and relative abundance at age for Georges Bank yellowtail. 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.

There continues to be high variability in the survey indices. Specifically, 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; Table 8) and were applied in this assessment. The DFO 2008 and 2009 surveys encountered individual tows that were much larger than any seen previously, or since, in the time series.

Trends in yellowtail flounder biomass indices from the four 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 (Figure 12a-d). The minimum swept area biomass estimated from the DFO survey increased from 1995 to 2001, declined through 2004, fluctuated through 2007, and then increased dramatically in 2008 and 2009 due to single large tows in each year, as seen by the unusually large coefficients of variation for those years (Table 9 and Figure 12b-d). Exclusion of these single tows resulted in a decline in the indices by about an order of magnitude, as shown in previous assessments (Legault et al. 2009, 2010, 2011). The 2013 DFO biomass is the second smallest in the time series. The NMFS spring series was high in the mid 1970s, low in the late 1980s through mid 1990s, high from 1999 through 2003, medium from 2004 through 2012, and showed a large drop in 2013 (Table 10 and Figure 12b,d). The NMFS fall survey, which is the longest time series, was high in the mid 1960s through mid 1970s, low in the mid 1980s through mid 1990s, increased through 2001, declined through 2005, and has remained at levels comparable to the late 1960s for years 2007-2009, but in 2010 through 2012 declined to the values comparable to the early 1980s (Table 11 and Figure 12b,d). The scallop survey stratified mean catch per tow shows a strong increase from low levels in the mid 1990s to a peak in 1998 followed by a decline through 2005, and has fluctuated since (Table 12 and Figure 12b). Both the NMFS spring and fall survey indices show high inter-annual variability during the periods of high abundance (i.e. the 1960s and 1970s), which may reflect the patchy distribution of yellowtail on Georges Bank. The coefficients of variation of the three groundfish surveys are generally comparable, with the exception of the unusually large values for the DFO survey in 2008 and 2009 due to the single large tows each year (Tables 9-11 and Figure 12c).

The 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 13a-b). Note the 2009 through 2013 NEFSC 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). Since 1996, most of the DFO survey biomass and abundance of yellowtail flounder has occurred in strata 5Z2 and 5Z4 (Figure 14a). 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 NEFSC bottom trawl surveys have been dominated by stratum 16 since the mid 1990s (Figure 14b-c).

Given the calibration at length for the US spring and fall surveys (Table 8), the question was raised during a previous TRAC meeting whether there were indications of recruiting year-classes in the uncalibrated *Henry B. Bigelow* data that were removed by the calibration to *Albatross IV* units. The raw length distributions from the *Henry B. Bigelow* were plotted together with the calibrated length distributions in Albatross IV units and no indication of strong year-classes at small lengths (< 30 cm) were observed in the US spring 2010-2013 or US fall 2010-2012 surveys (Figure 15).

Age-structured indices of abundance for NMFS spring and fall surveys were derived using survey specific age-length keys. Prior to 2004, age-length keys from NMFS spring surveys had been substituted to derive age composition for same-year DFO spring surveys, as no ages were available from the DFO surveys because of difficulties associated with age interpretation from otoliths (Stone and Perley 2002). To avoid having to use substituted age data, NMFS personnel have been ageing scales collected on DFO surveys since 2004 and continued to do so this year.

There is some indication of cohort tracking in all three of the bottom trawl surveys (Figure 16a-h). Even though each index is noisy, the age specific trends track relatively well among the four surveys (Tables 9-12 and Figure 17a-b).

Measurements of individual yellowtail flounder length and weight were collected from the US spring and fall surveys to examine whether changes in condition have occurred over time (Figure 18a-b). Median weights at length from both surveys indicate a declining trend for yellowtail flounder 33-44 cm, sizes associated with the majority of commercial catch, although the most recent year indicates a return towards the mean. A similar pattern was found in the condition factor (Fulton's K) for male and female yellowtail flounder in the DFO survey (Figure 18c).

Trends in relative fishing mortality and total mortality from the surveys were examined as part of the consensus benchmark formulations agreed to at the second benchmark assessment meeting in April 2005. Relative fishing mortality (fishery catch biomass/survey biomass, scaled to the mean for 1987-2010) was quite variable but followed a similar trend for all four surveys, with a sharp decline to low levels since 1995 (Figure 19). In contrast, estimates of total mortality rates from the surveys for ages 2, 3 and 4-6, although noisy, were without trend and indicate no overall reduction in mortality since 1995 (Figure 20). Similarly, time series of cohort Z estimated from the three bottom trawl surveys do not indicate a reduction in recent years (Figure 21a-c). This disparity in the basic data continues to cause difficulty for the stock assessment of Georges Bank yellowtail flounder.

## ESTIMATION OF STOCK PARAMETERS

Results from assessment analyses conducted in recent years have displayed: a) retrospective patterns; b) residual patterns that are indicative of a discontinuity starting in 1995; and c) fishing mortality rates that are not consistent with the decline in abundance along cohorts evident in the survey data. Essentially, the catch at age data and assumed natural mortality rate cannot be reconciled with the change in survey abundance indices from ages 2 and 3 to ages 4 and older.

The empirical evidence suggests that significant modifications to the population and fishery dynamics assumptions are required to reconcile the fishery and the survey observations. Models that adopt such modifications imply major consequences on underlying processes or fishery monitoring procedures. The magnitude of implied changes to natural mortality rate, survey catchability relationships, or unreported catch is so great that the acceptability of models that incorporate these effects is suspect. However, these models may provide better catch advice for management of this resource than ignoring the changes in underlying processes (ICES 2008).

In view of these reservations, adoption of a benchmark formulation that incorporated these modifications to assumptions as the sole basis for management advice was not advocated (TRAC 2005). Therefore, the TRAC recommended that management advice be formulated after considering the results from three VPA approaches: Base Case (now called Single Series), Minor Change, and Major Change (now called Split Series). The Minor Change VPA was never used in any subsequent assessment (Stone and Legault 2005; Legault et al. 2006, 2007, 2008a) and it was agreed during the 2009 TRAC that it would not be continued in the future (Legault et al. 2009). The Single Series VPA was continued for a number of years after the benchmark, but was not used to provide management advice for five years (Legault et al. 2006, 2007, 2008a, 2009, 2010). At the 2011 TRAC meeting, the re-emergence of a retrospective pattern in the Split Series VPA model led to the re-evaluation of the Single Series VPA model. The Single Series VPA continued to show a stronger retrospective pattern than the Split Series VPA, but some TRAC participants considered it better to use just a single retrospective adjustment (the Mohn's rho adjustment to starting population abundance for projections) rather than two (splitting the surveys and applying a retrospective adjustment). As described above, at the 2012 TRAC the Split Series VPA with retrospective adjustment, the Single Series VPA with retrospective adjustment, and three alternative retrospective "fixes" were used to provide catch advice. This large number of models caused concern and led to a Term of Reference at the Eastern Georges Bank cod benchmark assessment meeting to review criteria for evaluation and modification of benchmark assessments. Based on these discussions, only the Split Series VPA with retrospective adjustment and Single Series VPA with retrospective adjustments are provided for recommending catch advice this year. The Split Series VPA remains the default approach for determining current status and providing management advice. The Single Series VPA results are presented below alongside the Split Series VPA results simply to facilitate comparison between the two models.

The VPA is calibrated using the adaptive framework ADAPT (Conser and Powers 1990; Gavaris 1988; Parrack 1986) to calibrate the sequential population analysis with the research survey abundance trend results, specifically the NOAA Fisheries Toolbox VPA v3.3. The model formulation employed assumed error in the catch at age was negligible. Errors in the abundance indices were assumed independent and identically distributed after taking natural logarithms of the values. The exception to this assumption is the DFO survey values for 2008 and 2009 were downweighted (residuals multiplied by 0.5) to reflect the higher uncertainty associated with these observations relative to all other survey observations. Zero observations for abundance indices were treated as missing data, because the logarithm of zero is undefined. The annual natural mortality rate, M, was assumed constant and equal to 0.2 for all ages and years. The fishing mortality rates for age groups 4, 5 and 6+ were assumed equal. These model assumptions and methods were the same as those applied in the last assessment (Legault et al. 2012). Both point estimates and bootstrap statistics of the estimated parameters were derived using only the US software for this assessment.

The Split Series VPA recommended during the benchmark assessment expanded the ages from 6+ to 12, assumed a constant small number of fish (1000) survived to the start of age 13, allowed power relationships between indices and population abundance for younger ages (1-3), and split the survey time series between 1994 and 1995. This model could not be fit well in previous assessments (Legault et al. 2006, 2007, 2008a) due to a lack of catch at older ages creating bimodal bootstrap distributions. Following the precedent of previous assessments, the Split Series VPA was reformulated to be the same as the Single Series VPA (i.e. by reverting to ages 1-6+ for the catch at age), with the exception that the survey time series were split at 1995 (Legault et al. 2006, 2007, 2008a, 2009, 2010, 2011, 2012). This means that indices and population abundance are assumed linearly related at all ages and that a 6+ group is used for all fish aged 6 and older in the population dynamics equations. Splitting the survey series had been sufficient to remove the retrospective pattern and the pattern in residuals until the 2011 assessment, and was recommended for management advice because it more closely followed the pattern observed in the indices. This Split Series formulation was used again this year to provide management advice.

The Split Series VPA used revised annual catch at age (including US and Canadian discards), $C_{a,t}$, for ages $a$ = 1 to 6+, and time $t$ = 1973 to 2012, where $t$ represents the beginning of the time interval during which the catch was taken. The VPA was calibrated to bottom trawl survey indices, $I_{s,a,t}$, for:

$s_1$ = DFO spring, ages *a* = 2 to 6+, time *t* = 1987 to 1994

$s_2$ = DFO spring, ages *a* = 2 to 6+, time *t* = 1995 to 2013

(note: $s_2$ = DFO spring, ages *a* = 2 to 6+, time *t* = 2008 to 2009 residuals were downweighted)

$s_3$ = NMFS spring (Yankee 41), ages *a* = 1 to 6+, time *t* = 1973 to 1981

$s_4$ = NMFS spring (Yankee 36), ages *a* = 1 to 6+, time *t* = 1982 to 1994

$s_5$ = NMFS spring (Yankee 36), ages *a* = 1 to 6+, time *t* = 1995 to 2013

(note: $s_5$ = NMFS spring (Yankee 36), ages *a* = 1 to 6+, time *t* = 2009-2013 were converted from *Henry B. Bigelow* to *Albatross IV* equivalent)

$s_6$ = NMFS fall, ages *a* = 1 to 6+, time *t* = 1973.5 to 1994.5

$s_7$ = NMFS fall, ages *a* = 1 to 6+, time *t* = 1995.5 to 2012.5

(note: $s_7$ = NMFS fall, ages *a* = 1 to 6+, time *t* = 2009.5-2012.5 were converted from *Henry B. Bigelow* to *Albatross IV* equivalent)

$s_8$ = NMFS scallop, age *a* = 1, time *t* = 1982.5 to 1994.5

$s_9$ = NMFS scallop, age a = *1*, time *t* = 1995.5 to 2012.5

(note: the NMFS scallop survey was not used for years 1986, 1989, 1999, 2000, 2008, 2011, or 2012)

Splitting the survey time series between 1994 and 1995 could not be justified based on changes in the survey design or implementation. Rather the split is considered to alias unknown mechanisms causing the retrospective pattern in the Single Series VPA. Population abundance at age 1 in the terminal year plus one (2013) was assumed equal to the geometric mean over the most recent 10 years (2003-2012). Population abundance in the terminal year plus one (2013) was estimated directly for ages 2-5.

## BUILDING THE BRIDGE

There was only one change to the data from the 2012 TRAC assessment. The Canadian landings at age were revised for 2010 and 2011. These were small changes resulting in changes to the total catch at age of <2% for all ages and changes to the total weights at age of <1%. These small data changes were evaluated relative to the final 2012 TRAC assessment and had only a minor impact on results (trend lines not visibly different from 2012 TRAC for F, SSB, or recruitment; Figure 22).

These revised catch data were the starting point for the new assessment, which then added a year of catch and survey indices.

## DIAGNOSTICS

The Split Series VPA performed similarly compared to previous assessments in terms of relative error and bias in the population abundance estimates with lower relative error and bias at older ages than at younger ages (Table 13a). This pattern of higher uncertainty in the younger ages has been seen in previous assessments and is due to having less information about these cohorts. The Single Series VPA had slightly higher uncertainty and bias in the population abundance estimates (Table 13b).

Survey catchability constants (q) for the Split Series VPA also followed similar patterns to previous assessments (Table 13a and Figure 23a). The most notable pattern was the increase in estimated values at nearly all ages between the pre-1995 and the recent period (1995 to present), with some ages showing more than a seven-fold increase and averaging a four-fold increase. There have been no changes in the survey design or operations that can explain such changes. These changes in q are considered to be aliasing unknown mechanisms for the sole purpose of producing a better fitting model. Management strategy evaluations have demonstrated that even if the true source of the retrospective pattern is misreported catch or changes in natural mortality, this approach of splitting the time series to address the retrospective problem produces better performance (true F closer to target F, and thus better catch advice) than ignoring the retrospective pattern (ICES 2008). The survey catchability constants (q) for the Single Series VPA follow a similar pattern over ages to the Split Series VPA, but at a magnitude between the early and recent q values of the Split Series VPA (Table 13b and Figure 23b).

The Split Series VPA residuals exhibit some patterning with mainly positive or negative residuals during different periods throughout the time series (Figure 24a). This patterning is worse than has been seen for the Split Series VPA in previous years. The plotted residuals for the 2008 and 2009 DFO survey account for the downweighting used in the fitting, but still appear as strong positive residuals (observed values larger than predicted) except for age 6+ in 2008. The standard sampling protocol in 2008 did not collect any age 6+ yellowtail flounder in the large tow that year. The Single Series VPA residuals exhibit a worse patterning with large blocks of mainly positive or negative residuals (Figure 24b).

An alternative method to view the change in catchability is to plot the relative catchability (the survey observation divided by the estimated beginning of year population abundance) with the Split Series estimate of catchability overlaid as lines (Figure 25a-c). These plots do not adjust the population abundance to account for the time of the survey. The changes in relative catchability appear strong and consistent for many surveys and ages, as opposed to being driven by just one or two outlier values, further supporting the approach of splitting the surveys. The similar set of plots for the Single Series VPA shows the strong patterning in residuals in the standard residual plots with many consecutive years having the dots above or below the lines (Figure 25d-f).

Retrospective analysis for the Split Series VPA indicate a strong tendency to overestimate spawning stock biomass and recruitment and underestimate F, relative to the terminal year (Table 14a and Figure 26a-b). These retrospective patterns are about as strong as observed in the Base Case formulations of previous assessments (Legault et al. 2009, 2010, 2011). The Single Series VPA exhibited retrospective patterns in the same directions as, but at a much greater magnitude than, the Split Series VPA (Table 14b and Figure 26c-d).

Despite the strong retrospective pattern in spawning stock biomass and fishing mortality rate, the Split Series VPA is recommended as the basis for estimating current stock size and fishing mortality rate. However, a retrospective adjustment should be applied when providing catch advice.

## STOCK STATUS

Results from the Split Series VPA were used to evaluate the status of the stock in 2012. Population abundance at age for the start of the year was estimated for years 1973-2013 (Table 15a) along with estimates of fishing mortality rates at age during years 1973-2012 (Table 16a). Due to the backward convergence of VPA, the Single Series VPA has identical estimates with the Split Series VPA for early years, diverging starting in 1998 for population abundance at age (Table 15b) and in 2005 for fishing mortality rates at age (Table 16b) (the years differ due to the different level of precision used to display population abundance and fishing mortality rates at age). The fishery weights at age, assumed to represent mid-year weights, were used to derive beginning of year weights at age (Table 17), and these were used to calculate beginning of year population biomass (Table 18a-b). In the US, spawning stock biomass is the legal status determination criterion and is computed assuming maturity at age and the proportion of mortality within a year that occurs prior to spawning (p = 0.4167).

Based on the Split Series VPA, adult population biomass (Jan-1, ages 3+) increased from a low of 2,100 mt in 1995 to 10,900 mt in 2003, declined to 2,400 mt in 2007, averaged 3,100 from 2007 to 2011, and decreased to 2,500 mt at the beginning of 2013 (Table 18a and Figure 27a). Total population biomass (age 1+) has generally tracked the three groundfish surveys, although splitting the series between 1994 and 1995 implies high catchability of the surveys in recent years (Table 18a and Figure 28a). Spawning stock biomass in 2012 was estimated to be 2,600 mt (80% confidence interval: 2,180-3,244 mt). These 2012 values are well below the TRAC 2012 estimates for 2011 and reflect the strong retrospective pattern in spawning stock biomass. For comparison, the corresponding tables and figures for the Single Series VPA are provided in Table 18b and Figures 27b and 28b.

During 1973-2012, recruitment averaged 18.9 million fish at age 1 but has been below this average since 2002 (Table 15a and Figure 29a). The 2005 year-class is estimated at 10.1 million age 1 fish in 2006, well below previous estimates of this year-class. The 2009-2011 age-classes are estimated to be less than 3 million age 1 fish, and are the lowest in the time series. The low recent recruitment limits the ability of the stock to produce yield or rebuild. The Single Series VPA also estimates recent recruitment to be the lowest in its time series (Table 15b and Figure 29a).

Fishing mortality for fully recruited ages 4+ was close to or above 1.0 between 1973 and 1995, fluctuated between 0.51 and 0.97 during 1996-2003, increased in 2004 to 1.94, and then declined to 0.60 in 2011. In 2012, F was estimated to be 0.32 (80% confidence interval for 2012: 0.24-0.41), above the reference point of $F_{ref}$ = 0.25 (Table 16a). This pattern in F does not correspond with the relative fishing mortality rate pattern estimated as catch/survey (Figure 19). The relative F pattern shows a sudden decline in 1995 and continued low levels since then. The Single Series VPA has the same trend in F as the Split Series VPA through 2005, then declines at a faster rate to 0.09 in 2012 (Table 16b).

The bootstrap uncertainty estimates do not capture the full amount of uncertainty in this assessment due to the strong retrospective patterns in both the Split Series and Single Series VPA results. A retrospective adjustment has been recommended in the past by TRAC for catch advice to account for this additional uncertainty. The retrospective adjustment is computed as 1/(1+rho) and is multiplied by the point estimate to create the rho adjusted values. Application of this rho adjustment to terminal year estimates from the Split Series and Single Series show how large these changes are, with the Single Series changes much larger than the Split Series changes (Table 19). Application of the rho adjustment produces 2012 F values well above Fref for both models, as well as the lowest estimates of spawning stock biomass and adult biomass in their respective time series (Figures 29-30). The 2012 recruitment estimate (R), already the lowest in the time series, is further reduced by application of the rho adjustment.

# FISHERY REFERENCE POINTS

## PER RECRUIT REFERENCE POINTS

The current reference fishing mortality rate used by the TMGC ($F_{ref}$=0.25, ages 4+) was derived from both $F_{0.1}$ and $F_{40\%MSP}$ calculations, which were numerically equal in value when the $F_{ref}$ value was selected (TMGC 2003). Both the 2002 and 2008 assessment yield per recruit analysis (NEFSC 2002, 2008) confirmed that both these values remain at 0.25. This is the same value as the $F_{MSY}$ proxy of $F_{40\%MSP}$ used for US management (NEFSC 2008). The current three year averages for weights at age and fishery partial recruitment produce estimates for both $F_{40\%MSP}$ and $F_{0.1}$ of 0.30. This suggests that $F_{ref}$ is relatively robust to the changes in partial recruitment observed over the years.

## STOCK AND RECRUITMENT

The TMGC does not have an explicit biomass target. There is evidence of reduced recruitment at low levels (below 5,000 mt) of spawning stock biomass (Figure 31a-b). A similar pattern is seen in the Single Series VPA (Figure 31c-d). In the US, a similar stock-recruitment relationship from the GARM III assessment (NEFSC 2008) was used to estimate the $SSB_{MSY}$ proxy by projecting the population for many years with $F = F_{40\%MSP}$ and recruitment randomly selecting from the cumulative distribution function of recruitment observed at SSB > 5,000 mt. The $SSB_{MSY}$ level of 43,200 mt of spawning stock biomass was set as the rebuilding goal in the US for this stock (NEFSC 2008). Spawning stock biomass is currently well below the US rebuilding goal ($SSB_{2012}/SSB_{MSY}$ = 6%, rho adjusted $SSB_{2012}/SSB_{MSY}$ = 2%).

# OUTLOOK

This outlook is provided in terms of consequences with respect to the harvest reference points for alternative catch quotas in 2014. Uncertainty about current biomass generates uncertainty in forecast results, which is expressed here as the risk of exceeding $F_{ref}$ = 0.25. The risk calculations assist in evaluating the consequences of alternative catch quotas by providing a general measure of the uncertainties. However, they are dependent on the data and model assumptions and do not include uncertainty due to variations in weight at age, partial recruitment to the fishery, natural mortality, systematic errors in data reporting, or the possibility that the model may not reflect stock dynamics closely enough.

Projections for both the Split Series and Single Series VPA were made using 2010-2012 average fishery partial recruitment and fishery weights at age to account for the most recent conditions in the fishery and biological characteristics (Table 20a). Deterministic projections were made for both VPA models with and without rho adjustment for comparative purposes (Table 20b-e). Following previous practice, the 2013 rho adjusted values used the SSB rho value for all ages. All the projections assume a catch in 2013 equal to the 500 mt total quota and apply $F_{ref}$ in 2014. This catch results in a fully selected fishing mortality rate below $F_{ref}$ for both unadjusted models (0.246 and 0.069 for the Split Series and Single Series, respectively), but above $F_{ref}$ for both rho adjusted models (0.975 and 0.367 for the Split Series and Single Series, respectively). Fishing at $F_{ref}$ in 2014 causes the adult (ages 3+) Jan-1 biomass to increase for both rho adjusted models and the Split Series unadjusted model, but decrease for the unadjusted Single Series model. Note the importance in all four cases of the assumed recruitment value at age 1 in 2013, which is age 3 in 2015, when calculating the change in adult biomass from 2014 to 2015. The unadjusted projections result in 2014 catches of 535 mt and 1,754 mt for the Split Series and Single Series VPA models, respectively. The TRAC has recommended not using these unadjusted projections because of the additional uncertainty in the assessment due to the retrospective patterns. When the rho adjustments are applied, the projections result in 2014 catches of 112 mt and 293 mt for the Split Series and Single Series VPA models, respectively. These deterministic projections are provided to allow tracking of cohort effects and comparison of proportional impacts by age in each year of the projections.

The TRAC uses stochastic projections to examine the risk of overfishing, meaning exceeding $F_{ref}$, in 2014 and the probability of stock increase, meaning the change in adult (ages 3+) Jan-1 biomass from 2014 to 2015, resulting from given quotas being set in 2014. These stochastic projections use bootstrapped realizations of the 2013 population abundance at age to characterize the uncertainty of starting conditions and randomly draw from a two stage cumulative distribution function of recruitment estimates as described above in the Stock and Recruitment section. However, there is essentially no impact of the recruitment assumption at age 1 in year 2014 or 2015 on the TRAC risk of overfishing or change in adult biomass, as can be seen by tracking these cohorts in the deterministic projection tables. All other aspects of the stochastic projections are the same as the deterministic projections described above. The changes between deterministic and stochastic projections when F in 2014 is set to 0.25 are minor, as can be observed by comparing Table 20b-e with Table 21.

The stochastic projection results for the unadjusted Split Series and Single Series VPAs are shown in Tables 21-22 for completeness only. They are shown in a different font to reflect the recommendation from previous TRAC meetings to not use these projections for catch advice. The rho adjusted Split Series and Single Series VPAs require a 2014 catch of between 100 and 200 or between 300 and 400 mt to have a neutral risk of exceeding $F_{ref}$ (Table 22). A 2014 catch of less than 500 mt is required to have a neutral risk of adult biomass increase from 2014 to 2015 for the rho adjusted Split Series VPA, while the rho adjusted Single Series VPA requires a 2014 catch less than 400 mt. These catch recommendations regarding risk of overfishing and probability of adult biomass increase are similar to, but slightly less than, the TRAC recommendations from last year. The risk of overfishing increases rapidly with small changes in the 2014 quota for both rho adjusted models, so catches associated with 25% and 75% risk of overfishing are not presented (Figure 32). The change in adult biomass from 2014 to 2015 is close to a linear function of the 2014 catch, with potentially large decreases in both rho adjusted models for catches above 500 mt (Figure 33). The change in probability of biomass increase (or a 10% increase) from one to zero occurs over a relatively small range of 2014 catch (Figure 34). All these metrics indicate that small changes in the 2014 quota can have disproportionately large impacts on the ability to achieve management objectives.

Of particular importance in these projections is the assumption that the age 1 abundance in 2013 is set to the geometric mean of the estimated recruitment in the previous ten years. Tracing the cohort that is age 1 in 2012 through the deterministic projection table, it can be seen that the 2014 catch is only impacted a small amount, but the change in adult (age 3+) Jan-1 biomass from 2014 to 2015 can be influenced substantially by this assumption. Given the decline in recruitment observed in recent years (Table 15), a sensitivity analysis was conducted to determine the importance of the ten year geometric mean assumption for the 2013 age 1 value in the projection results. The age 1 2013 estimate was multiplied by a value ranging from zero to two in steps of 0.1 for the Split Series VPA results and the 2014 fishing mortality rate was set equal to $F_{ref}$=0.25 in the projections. The 2014 catch changed less than 100 mt while the relative change in median adult Jan-1 biomass from 2014 to 2015 was much more strongly impacted (Figure 35). For example, if the 2013 age 1 abundance was reduced by half, a value more consistent with the most recent recruitments, the relative change in median biomass would be a 0% increase instead of showing a 20% increase. This dependence of the change in biomass metric on the assumption made for the 2013 age 1 abundance should be considered when making catch advice decisions considering expected changes in biomass.

To achieve the TMGC objective of a fishing mortality rate below $F_{ref}$, catch in 2014 should be no more than 150 mt (Table 22). Taking into account both the probability of overfishing and the relative change in biomass, as was done by the TRAC last year, leads to the conclusion that catch in 2014 should be no greater than 400 mt (Table 22).

Rebuilding projections are required in the US when stocks are overfished. The rebuilding target for Georges Bank yellowtail flounder is a spawning stock biomass of 43,200 mt (denoted $SSB_{MSY}$). This value was set during GARM III (NEFSC 2008) based on using $F_{40\%MSP}$ as a proxy for $F_{MSY}$ and conducting stochastic projections fishing at this rate for 100 years. The median SSB at the end of these 100 year projections was set as the $SSB_{MSY}$ proxy. These projections depend on weights at age, fishery partial recruitment, maturity at age, natural mortality at age, and recruitment assumptions. If any of these data are changed, the resulting $SSB_{MSY}$ proxy will change; however, these changes are typically assumed to be minor and the accepted value (currently 43,200 mt) is kept as the rebuilding target. The original rebuilding target year was 2014. However, the International Fisheries Clarification Act allowed extension of the rebuilding time. The New England Fisheries Management Council has set the new rebuilding end date as 2032. This is so far into the future that no rebuilding projections were considered. As the rebuilding date gets closer, the biomass reference point for this stock should be re-evaluated in light of current fishery, biological, and environmental conditions.

Age structure, fish growth, and spatial distribution reflect stock productivity. The current age structure indicates that very little rebuilding of ages 6 and older has occurred (Figure 36). This pattern holds for all the scenarios examined. The 2012 population abundance proportions at age are essentially the same for ages 1 through 4, indicating the recent poor recruitment. Far fewer older fish (6+) are estimated in the VPA in comparison with the population at equilibrium, which is inconsistent with the perception of recent low exploitation from the relative F calculations, but is consistent with the high total mortality estimates from all three surveys. Growth has been variable without strong trends, but condition factor has declined over the last decade. Spatial distribution patterns from the three groundfish surveys generally follow historical averages. Truncated age structure and reduced (but improving) condition factor indicate current resource productivity is lower than historical levels.

## MANAGEMENT CONSIDERATIONS

This assessment is hampered by an inconsistency between the recent reduction in catch and the limited rebuilding of age structure in either the fishery or survey catches. The noisy character of the indices causes difficulty in tuning age structured models.

Although the Split Series VPA is used for management decisions, the mechanisms for the large changes in survey catchability are not easily explained. These changes in survey catchability are most appropriately thought of as aliasing an unknown mechanism that produces a better fitting model. The inability to plausibly explain these survey catchability changes causes increased uncertainty in this assessment relative to other assessments. Although the intention of the Split Series VPA was to eliminate the retrospective pattern, the pattern has re-emerged. Consideration of a number of alternative “fixes” to the retrospective pattern last year indicated that the catch advice was robust to how these inconsistencies in the data were treated and gave support to the management advice for this stock (Legault et al. 2012).

Consistent management by Canada and the US is required to ensure that conservation objectives are not compromised.

The change from previous assessments can be seen by examining the historical retrospective analysis, which plots the results from previous assessments instead of peeling back years from the current assessment (Figure 37). The historical retrospective analysis incorporates all data and model formulation changes as well as the number of years in the assessment. The change in the strength of the 2005 year-class (shown at age 1 in 2006 in the recruitment panel) contributes to the change in estimated spawning stock biomass, similar to the assessment retrospective analysis. However, the retrospective pattern is continuing, despite the reduction in the strength of the 2005 year-class in the last three assessments. So there is more than just a missed year-class that is generating the retrospective pattern.

The performance of the catch advice provided historically for this stock can be examined by comparing the expectation when the advice was provided with what the current assessment estimates for fishing mortality rates and biomass. These comparisons were kindly provided by Tom Nies (staff member of the New England Fishery Management Council, NEFMC) and are shown in the Appendix. The results demonstrate the impact of the retrospective pattern. Catch advice was provided which was expected to cause a fishing mortality rate of $F_{ref}$ or lower. The actual catch was usually less than the quota, yet the current assessment estimates a fishing mortality rate much higher than Fref. This is due to the directional bias of the retrospective pattern. Since the biomass was estimated too high, the catch advice was set too high. Once the biomass is estimated at a lower amount, then that same catch has an associated fishing mortality rate well above the one originally used to set the catch advice. Changes in weight at age, partial recruitment to the fishery, and recruitment can also impact the accuracy of the projections. The past performance of catch advice should be considered when setting future catch quotas.

An additional perspective on the past performance of catch advice can be made by comparing the catch at age in weight for 2012 projected from previous assessments with the observed values measured for 2012 (Figure 38). The two projections from the 2011 and 2012 TRAC meetings are both from the Split Series model and do not make any retrospective adjustments. The current estimate is simply the catch at age in numbers multiplied by the catch weight at age. The 2011 projection shows more catch from ages 6+ than for all ages combined from the current assessment. The 2012 projection has 51% of the catch in ages 5+, while the current assessment has only 27% of the catch in ages 5+. This difference between projected and observed age structure is due to whatever mechanism is causing the retrospective pattern and lies at the heart of the difficulties faced by this assessment.

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*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 | 246 | 0 | 3851 | 17% |
| 2006 | 1196 | 384 | 25 | 504 | 0 | 2109 | 42% |
| 2007 | 1058 | 493 | 17 | 94 | 0 | 1662 | 35% |
| 2008 | 937 | 409 | 41 | 117 | 0 | 1504 | 35% |
| 2009 | 959 | 759 | 5 | 84 | 0 | 1806 | 47% |
| 2010 | 654 | 289 | 17 | 200 | 0 | 1160 | 42% |
| 2011 | 904 | 192 | 22 | 50 | 0 | 1169 | 21% |
| 2012 | 443 | 188 | 46 | 45 | 0 | 722 | 32% |

*Table 2a. 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 a trip 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 2a. (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** |

*Table 2b. Prorated discards (kg) and fishing effort (hr) for Georges Bank yellowtail flounder from International Observer Program (IOP) trips of the Canadian scallop fishery in 2012.*

| | | Proration | | | Discards | | Effort |
|---|---|---|---|---|---|---|---|
| | | Number of Dredges | | | (kg) | | (hr) |
| IOP Trip | Board Date | Observed | Total | Proportion | Observed | Prorated | |
| J11-0593 | 12/5/2011 | 588 | 1188 | 0.49 | 27 | 55 | 217 |
| J11-0471 | 12/7/2011 | 641 | 1277 | 0.50 | 5 | 10 | 235 |
| J12-0046/48 | 1/28/2012 | 626 | 1221 | 0.51 | 11 | 21 | 238 |
| J12-0019 | 2/14/2012 | 684 | 1367 | 0.50 | 238 | 476 | 285 |
| J12-0074 | 3/7/2012 | 609 | 1240 | 0.49 | 640 | 1303 | 245 |
| J12-0105 | 3/16/2012 | 196 | 366 | 0.54 | 589 | 1100 | 98 |
| J12-0154 | 4/10/2012 | 143 | 234 | 0.61 | 3 | 5 | 17 |
| J12-0121 | 4/12/2012 | 315 | 635 | 0.50 | 209 | 421 | 90 |
| J12-0169 | 5/1/2012 | 188 | 294 | 0.64 | 49 | 77 | 41 |
| J12-0141 | 5/11/2012 | 401 | 811 | 0.49 | 188 | 380 | 117 |
| J12-0187 | 5/28/2012 | 226 | 390 | 0.58 | 24 | 41 | 77 |
| J12-0315 | 6/9/2012 | 559 | 1143 | 0.49 | 244 | 499 | 175 |
| J12-0341 | 7/9/2012 | 576 | 1140 | 0.51 | 152 | 301 | 181 |
| J12-0219 | 7/17/2012 | 326 | 648 | 0.50 | 86 | 171 | 127 |
| J12-0420 | 8/13/2012 | 196 | 382 | 0.51 | 41 | 80 | 119 |
| J12-0426 | 8/21/2012 | 699 | 1337 | 0.52 | 140 | 268 | 196 |
| J12-0475 | 9/19/2012 | 277 | 573 | 0.48 | 58 | 120 | 90 |
| J12-0476 | 9/20/2012 | 775 | 1513 | 0.51 | 81 | 158 | 202 |
| J12-0528 | 10/5/2012 | 618 | 1275 | 0.48 | 284 | 586 | 211 |
| J12-0543 | 10/17/2012 | 296 | 498 | 0.59 | 50 | 84 | 100 |
| J12-0494 | 11/7/2012 | 415 | 809 | 0.51 | 129 | 251 | 148 |
| J12-0496 | 11/11/2012 | 655 | 1195 | 0.55 | 62 | 113 | 217 |

*Table 2c. Three month moving-average (ma) discard rate (kg/hr), standardized fishing effort (hr), and discards (mt) of Georges Bank yellowtail flounder from the Canadian scallop fishery in 2012. Moving-average calculations include trips from Dec. 2011.*

| | | | | 3-month ma | | | |
|---|---|---|---|---|---|---|---|
| **Year** | **Month** | **Monthly Prorated Discards (kg)** | **Monthly Effort (hr)** | **Discard Rate (kg/hr)** | *****Effort (hr)** | **ma Discards (mt)** | **Cum. Annual Discards (mt)** |
| *2011 | Dec | 65 | 452 | | | | |
| 2012 | **Jan | 0 | 0 | 0.576 | 30 | 0 | 0 |
| | Feb | 497 | 523 | 3.351 | 538 | 2 | 2 |
| | Mar | 2403 | 343 | 3.422 | 938 | 3 | 5 |
| | Apr | 426 | 107 | 5.414 | 2400 | 13 | 18 |
| | May | 457 | 158 | 2.758 | 3457 | 10 | 28 |
| | Jun | 540 | 252 | 2.048 | 2579 | 5 | 33 |
| | Jul | 472 | 308 | 1.555 | 3104 | 5 | 38 |
| | Aug | 348 | 315 | 1.200 | 2751 | 3 | 41 |
| | Sep | 278 | 292 | 1.411 | 1085 | 2 | 42 |
| | Oct | 670 | 311 | 1.356 | 1115 | 2 | 44 |
| | Nov | 365 | 365 | 1.531 | 723 | 1 | 45 |
| | **Dec | 0 | 0 | 0.999 | 312 | 0 | 45 |

*includes trips from Dec. 2011 for moving-average calculations.
** No observed trips in Jan. or Dec.; assumed discards and effort were same as Dec. 2011 and Nov. 2012, respectively.
***Effort hours are standardized to freezer-trawler hour equivalents

*Table 3. Comparison of US and catch (mt) in calendar year 2012 estimated by the US quota monitoring system (within year) and the values used in the assessment (end of year).*

| | Jan-Jun | Jul-Dec | All Months |
|---|---|---|---|
| Quota Monitoring (mt) | 402 | 243 | 644 |
| Assessment (mt) | 388 | 243 | 631 |
| Diff (QM-Assess) (mt) | 13 | 0 | 13 |
| Rel Diff (Diff/Assess) | 3% | 0% | 2% |

*Table 4. Port samples used in the estimation of landings at age for Georges Bank yellowtail flounder in 2012 from US and Canadian sources. Note the Canadian port samples include at-sea observer length measurements for 2012.*

| | Landings (metric tons) | | | | | 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 | 16 | 223 | 89 | 0 | 329 | | 878 | 563 | | 1441 | | |
| 2 | 3 | 82 | 28 | 0 | 114 | | 1665 | 1187 | | 2852 | | |
| Total | 19 | 305 | 118 | 1 | 443 | | 2543 | 1750 | | 4293 | 969 | 898 |
| **Canada** | | | | | | | | | | | Lengths | Number |
| Quarter | | | | | Total | | | | | Total | per 100mt | of Ages |
| 1 | | | | | | | | | | | | |
| 2 | | | | | 5 | | | | | | | |
| 3 | | | | | 16 | | | | | 2956 | | |
| 4 | | | | | 25 | | | | | 8620 | | |
| Total | | | | | 46 | | | | | 11576 | 25165 | 0 |

*Table 5. 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% |

*Table 6. Total catch at age including discards (number in 000s of fish) for Georges Bank yellowtail flounder. Note the 2010 and 2011 values have changed slightly (<2%) from last year's assessment.*

| | 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 | 1579 | 4031 | 1707 | 392 | 132 | 37 | 16 | 0 | 0 | 0 | 0 | 7954 |
| 2006 | 152 | 1293 | 1626 | 947 | 364 | 124 | 66 | 14 | 7 | 3 | 0 | 0 | 4596 |
| 2007 | 51 | 1491 | 1705 | 662 | 136 | 44 | 9 | 2 | 0 | 0 | 0 | 0 | 4101 |
| 2008 | 29 | 493 | 1903 | 855 | 125 | 17 | 8 | 0 | 0 | 0 | 0 | 0 | 3430 |
| 2009 | 17 | 284 | 1266 | 1361 | 516 | 59 | 10 | 4 | 0 | 0 | 0 | 0 | 3517 |
| 2010 | 2 | 139 | 643 | 890 | 445 | 87 | 10 | 2 | 0 | 0 | 0 | 0 | 2218 |
| 2011 | 11 | 165 | 773 | 902 | 309 | 67 | 8 | 1 | 0 | 0 | 0 | 0 | 2235 |
| 2012 | 12 | 107 | 368 | 577 | 240 | 38 | 4 | 4 | 0 | 0 | 0 | 0 | 1349 |

*Table 7. Mean weight at age (kg) for the total catch including US and Canadian discards, for Georges Bank yellowtail flounder. Note the 2010 and 2011 values have changed slightly (<1%) from last year's assessment.*

| | 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 | 0.310 | 0.415 | 0.557 | 0.761 | 0.917 | 1.066 | 1.185 | 1.263 | 1.224 | 1.599 | |
| 2007 | 0.154 | 0.290 | 0.409 | 0.542 | 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 | 0.174 | 0.323 | 0.432 | 0.519 | 0.661 | 0.777 | 0.997 | 1.175 | | | | |
| 2011 | 0.128 | 0.337 | 0.461 | 0.553 | 0.646 | 0.739 | 0.811 | 0.851 | | | | |
| 2012 | 0.185 | 0.339 | 0.452 | 0.555 | 0.671 | 0.792 | 0.934 | 0.797 | | | | |

*Table 8. Length based calibration factors for yellowtail flounder (see Brooks et al. 2010 for details of derivation). Numbers at length from Henry B. Bigelow tows should be divided by the calibration factor in the corresponding length bin. It is recommended that these calibration factors be applied with all 6 digits to the right of the decimal point.*

| Length | Calibration |
|---|---|
| ≤18 | 3.857302 |
| 19 | 3.857302 |
| 20 | 3.857302 |
| 21 | 3.621597 |
| 22 | 3.385892 |
| 23 | 3.150187 |
| 24 | 2.914482 |
| 25 | 2.678777 |
| 26 | 2.443072 |
| 27 | 2.207367 |
| 28 | 1.971662 |
| 29 | 1.971657 |
| ≥30 | 1.971657 |

*Table 9. DFO spring survey indices of minimum swept area abundance for Georges Bank yellowtail flounder in thousands of fish and thousands of metric tons, along with the coefficient of variation (CV) for the biomass estimates.*

| Year | Age1 | Age2 | Age3 | Age4 | Age5 | Age6+ | B(000 mt) | CV(B) |
|---|---|---|---|---|---|---|---|---|
| 1987 | 75.2 | 751.1 | 1238.5 | 309.7 | 54.9 | 30.9 | 1.250 | 27% |
| 1988 | 0.0 | 1116.5 | 801.9 | 383.6 | 174.9 | 14.8 | 1.235 | 22% |
| 1989 | 71.8 | 645.8 | 383.2 | 185.2 | 41.8 | 14.1 | 0.471 | 26% |
| 1990 | 0.0 | 1500.9 | 2281.1 | 575.0 | 131.3 | 8.6 | 1.513 | 22% |
| 1991 | 15.4 | 539.6 | 745.8 | 2364.1 | 330.3 | 9.1 | 1.758 | 33% |
| 1992 | 34.8 | 6942.1 | 2312.0 | 622.4 | 219.8 | 18.8 | 2.475 | 16% |
| 1993 | 49.4 | 1528.8 | 2568.8 | 2562.9 | 557.5 | 81.8 | 2.642 | 15% |
| 1994 | 0.0 | 3808.4 | 2178.6 | 1890.1 | 491.4 | 130.0 | 2.753 | 23% |
| 1995 | 132.0 | 786.5 | 2737.4 | 1600.8 | 406.6 | 63.6 | 2.027 | 20% |
| 1996 | 280.5 | 4491.0 | 5769.2 | 3399.8 | 726.5 | 77.2 | 5.303 | 22% |
| 1997 | 13.6 | 7849.2 | 8742.1 | 10293.6 | 2543.2 | 421.5 | 13.293 | 23% |
| 1998 | 561.7 | 2094.3 | 3085.9 | 2725.6 | 1250.4 | 351.2 | 4.293 | 24% |
| 1999 | 99.8 | 13118.5 | 13101.2 | 4822.9 | 3364.5 | 1383.5 | 17.666 | 32% |
| 2000 | 6.8 | 8655.8 | 17256.5 | 12100.9 | 3187.6 | 2319.8 | 19.949 | 25% |
| 2001 | 183.3 | 12511.6 | 26489.4 | 8368.0 | 2881.0 | 1507.2 | 22.158 | 42% |
| 2002 | 55.5 | 7522.3 | 19503.3 | 7693.6 | 3491.7 | 1781.4 | 20.699 | 31% |
| 2003 | 56.3 | 7476.4 | 15480.7 | 6971.1 | 2151.0 | 1249.9 | 16.249 | 32% |
| 2004 | 20.6 | 2263.5 | 10225.3 | 5788.7 | 1429.2 | 890.5 | 9.054 | 31% |
| 2005 | 377.3 | 1007.5 | 17581.9 | 12931.4 | 3581.9 | 983.8 | 13.357 | 53% |
| 2006 | 391.5 | 3076.8 | 11696.4 | 4132.7 | 515.4 | 149.4 | 6.579 | 44% |
| 2007 | 108.9 | 7646.4 | 17423.7 | 8048.5 | 1439.1 | 156.2 | 13.344 | 43% |
| 2008 | 0.0 | 30382.5 | 107131.7 | 35919.3 | 5067.8 | 34.5 | 67.319 | 94% |
| 2009 | 13.4 | 5370.4 | 86753.6 | 73553.8 | 12513.9 | 2996.1 | 72.044 | 79% |
| 2010 | 0.0 | 307.6 | 5906.1 | 13170.2 | 2221.7 | 804.5 | 9.138 | 29% |
| 2011 | 13.9 | 409.3 | 3831.5 | 5159.9 | 1069.5 | 205.8 | 3.830 | 29% |
| 2012 | 27.9 | 405.2 | 5183.7 | 7183.4 | 1946.9 | 284.9 | 5.620 | 36% |
| 2013 | 51.0 | 80.9 | 522.5 | 788.6 | 380.1 | 88.2 | 0.698 | 33% |

*Table 10. NEFSC spring survey indices of minimum swept area abundance for Georges Bank yellowtail flounder in thousands of fish and thousands of metric tons, along with the coefficient of variation (CV) for the biomass estimates.*

| Year | Age1 | Age2 | Age3 | Age4 | Age5 | Age6+ | B (000 mt) | CV(B) |
|---|---|---|---|---|---|---|---|---|
| 1968 | 181.2 | 3227.3 | 3474.3 | 295.2 | 70.9 | 300.8 | 2.709 | 23% |
| 1969 | 1046.8 | 9067.8 | 10793.9 | 3081.4 | 1305.2 | 678.2 | 10.842 | 29% |
| 1970 | 78.4 | 4364.8 | 5853.3 | 2350.9 | 553.0 | 302.0 | 4.994 | 15% |
| 1971 | 810.4 | 3412.9 | 4671.6 | 3202.9 | 757.1 | 310.6 | 4.483 | 19% |
| 1972 | 137.0 | 6719.3 | 6843.1 | 3595.8 | 1093.7 | 232.0 | 6.266 | 21% |
| 1973 | 1882.9 | 3184.3 | 2309.4 | 1036.7 | 399.4 | 210.2 | 2.852 | 17% |
| 1974 | 308.2 | 2168.5 | 1795.5 | 1225.0 | 336.9 | 273.8 | 2.640 | 18% |
| 1975 | 409.2 | 2918.0 | 809.1 | 262.6 | 201.5 | 86.3 | 1.626 | 22% |
| 1976 | 1008.4 | 4259.0 | 1216.0 | 302.4 | 191.2 | 108.4 | 2.206 | 17% |
| 1977 | 0.0 | 654.0 | 1097.7 | 363.7 | 81.9 | 12.8 | 0.970 | 31% |
| 1978 | 912.2 | 778.4 | 494.4 | 213.9 | 25.7 | 7.7 | 0.720 | 19% |
| 1979 | 394.0 | 1956.8 | 395.2 | 328.3 | 58.7 | 88.7 | 1.234 | 21% |
| 1980 | 55.3 | 4528.6 | 5617.2 | 460.6 | 55.0 | 35.3 | 4.325 | 35% |
| 1981 | 11.4 | 995.9 | 1724.2 | 698.9 | 206.9 | 56.9 | 1.903 | 33% |
| 1982 | 44.1 | 3656.5 | 1096.5 | 992.5 | 444.5 | 88.3 | 2.426 | 20% |
| 1983 | 0.0 | 1810.0 | 2647.8 | 514.4 | 119.6 | 237.3 | 2.564 | 30% |
| 1984 | 0.0 | 90.3 | 806.0 | 837.9 | 810.4 | 236.5 | 1.598 | 43% |
| 1985 | 106.4 | 2134.2 | 254.4 | 273.4 | 143.4 | 0.0 | 0.959 | 51% |
| 1986 | 26.6 | 1753.0 | 282.6 | 54.6 | 132.9 | 53.2 | 0.823 | 31% |
| 1987 | 26.6 | 73.3 | 133.0 | 129.3 | 51.0 | 53.2 | 0.319 | 37% |
| 1988 | 75.5 | 266.9 | 355.2 | 234.7 | 193.2 | 26.6 | 0.549 | 26% |
| 1989 | 45.2 | 391.3 | 737.7 | 281.0 | 59.3 | 43.5 | 0.708 | 26% |
| 1990 | 0.0 | 63.7 | 1074.7 | 358.4 | 112.2 | 100.8 | 0.678 | 32% |
| 1991 | 422.5 | 0.0 | 246.9 | 665.1 | 255.5 | 20.0 | 0.612 | 25% |
| 1992 | 0.0 | 1987.7 | 1840.7 | 621.8 | 160.0 | 16.7 | 1.520 | 46% |
| 1993 | 44.7 | 281.1 | 485.8 | 307.9 | 26.0 | 0.0 | 0.468 | 26% |
| 1994 | 0.0 | 602.3 | 614.7 | 343.6 | 140.4 | 38.7 | 0.641 | 22% |
| 1995 | 39.0 | 1144.6 | 4670.4 | 1441.7 | 621.5 | 9.5 | 2.504 | 60% |
| 1996 | 24.4 | 958.1 | 2548.6 | 2621.8 | 591.6 | 56.2 | 2.769 | 31% |
| 1997 | 18.2 | 1134.5 | 3623.1 | 3960.7 | 682.3 | 129.7 | 4.231 | 24% |
| 1998 | 0.0 | 2020.1 | 1022.2 | 1123.4 | 737.1 | 339.6 | 2.256 | 22% |
| 1999 | 48.7 | 4606.3 | 10501.7 | 2640.5 | 1575.2 | 756.3 | 9.033 | 42% |
| 2000 | 177.3 | 4677.6 | 7440.5 | 2828.5 | 789.2 | 508.4 | 6.499 | 23% |
| 2001 | 0.0 | 2246.7 | 6370.5 | 2340.0 | 469.2 | 439.7 | 4.859 | 33% |
| 2002 | 182.4 | 2341.5 | 11971.1 | 3958.4 | 1690.3 | 845.4 | 9.282 | 26% |
| 2003 | 196.1 | 4241.4 | 6564.9 | 2791.9 | 428.6 | 836.9 | 6.524 | 40% |
| 2004 | 47.1 | 957.3 | 2114.4 | 659.9 | 247.7 | 263.8 | 1.835 | 27% |
| 2005 | 0.0 | 1953.5 | 4931.0 | 2332.7 | 261.8 | 111.4 | 3.307 | 33% |
| 2006 | 493.5 | 907.8 | 3419.2 | 2112.7 | 307.7 | 79.8 | 2.349 | 19% |
| 2007 | 87.1 | 4899.7 | 6079.1 | 2762.3 | 540.0 | 125.2 | 4.563 | 22% |
| 2008 | 0.0 | 2206.7 | 4921.5 | 1681.1 | 300.3 | 26.6 | 3.152 | 22% |
| 2009 | 218.8 | 546.4 | 6978.7 | 4456.8 | 964.1 | 186.3 | 4.619 | 22% |
| 2010 | 16.5 | 662.8 | 5181.0 | 8057.2 | 2584.0 | 613.9 | 5.662 | 27% |
| 2011 | 26.9 | 236.6 | 3116.0 | 3512.9 | 914.1 | 100.6 | 2.419 | 23% |
| 2012 | 92.7 | 530.1 | 3476.9 | 6141.4 | 1563.6 | 180.3 | 3.878 | 49% |
| 2013 | 46.4 | 442.0 | 928.0 | 1103.9 | 725.8 | 258.5 | 1.071 | 21% |

*Table 11. NEFSC fall survey indices of minimum swept area abundance for Georges Bank yellowtail flounder in thousands of fish and thousands of metric tons, along with the coefficient of variation (CV) for the biomass estimates. (Note: These surveys are assumed to occur at the midpoint of the year.)*

| Year | Age1 | Age2 | Age3 | Age4 | Age5 | Age6+ | B (000 mt) | CV(B) |
|---|---|---|---|---|---|---|---|---|
| 1963.5 | 14289.1 | 7663.6 | 10897.1 | 1804.0 | 480.5 | 532.7 | 12.413 | 19% |
| 1964.5 | 1671.3 | 9517.3 | 7097.2 | 5791.2 | 2634.2 | 473.3 | 13.168 | 40% |
| 1965.5 | 1162.1 | 5537.0 | 5811.9 | 3427.8 | 1600.9 | 250.6 | 8.852 | 32% |
| 1966.5 | 11320.3 | 2184.4 | 1635.3 | 871.9 | 98.3 | 0.0 | 3.813 | 32% |
| 1967.5 | 8720.8 | 9131.0 | 2646.7 | 1006.7 | 299.3 | 132.3 | 7.445 | 26% |
| 1968.5 | 11328.3 | 11702.5 | 5588.9 | 722.7 | 936.8 | 56.4 | 10.227 | 23% |
| 1969.5 | 9656.7 | 10601.8 | 5064.1 | 1757.4 | 327.0 | 447.7 | 9.519 | 26% |
| 1970.5 | 4474.9 | 4981.2 | 3051.2 | 1894.7 | 438.2 | 77.8 | 4.833 | 28% |
| 1971.5 | 3520.0 | 6770.9 | 4769.9 | 2183.8 | 483.4 | 289.1 | 6.178 | 21% |
| 1972.5 | 2416.9 | 6332.8 | 4682.3 | 2032.9 | 592.1 | 331.7 | 6.142 | 28% |
| 1973.5 | 2420.4 | 5336.0 | 4954.5 | 2857.4 | 1181.2 | 599.9 | 6.299 | 30% |
| 1974.5 | 4486.7 | 2779.5 | 1471.6 | 1029.1 | 444.3 | 368.1 | 3.561 | 19% |
| 1975.5 | 4548.6 | 2437.3 | 851.7 | 555.2 | 324.4 | 61.1 | 2.257 | 16% |
| 1976.5 | 333.5 | 1863.9 | 460.3 | 113.6 | 118.5 | 97.3 | 1.463 | 25% |
| 1977.5 | 906.7 | 2147.1 | 1572.8 | 615.4 | 102.3 | 105.7 | 2.699 | 20% |
| 1978.5 | 4620.6 | 1243.3 | 757.2 | 399.2 | 131.6 | 34.9 | 2.274 | 20% |
| 1979.5 | 1282.0 | 2008.5 | 253.7 | 116.7 | 134.3 | 108.6 | 1.450 | 29% |
| 1980.5 | 743.6 | 4970.0 | 5912.0 | 662.0 | 212.3 | 250.9 | 6.412 | 22% |
| 1981.5 | 1548.2 | 2279.4 | 1592.8 | 570.5 | 76.4 | 52.8 | 2.500 | 32% |
| 1982.5 | 2353.3 | 2120.3 | 1543.4 | 410.4 | 86.6 | 0.0 | 2.203 | 30% |
| 1983.5 | 105.7 | 2216.4 | 1858.5 | 495.7 | 29.9 | 47.7 | 2.068 | 22% |
| 1984.5 | 641.6 | 388.1 | 296.7 | 236.0 | 72.7 | 60.7 | 0.576 | 31% |
| 1985.5 | 1310.2 | 527.5 | 165.9 | 49.1 | 78.3 | 0.0 | 0.688 | 26% |
| 1986.5 | 273.4 | 1075.1 | 338.7 | 71.9 | 0.0 | 0.0 | 0.796 | 37% |
| 1987.5 | 98.7 | 388.8 | 384.6 | 51.4 | 77.1 | 0.0 | 0.494 | 28% |
| 1988.5 | 18.2 | 206.7 | 104.0 | 26.6 | 0.0 | 0.0 | 0.165 | 32% |
| 1989.5 | 241.0 | 1934.1 | 750.4 | 76.6 | 54.0 | 0.0 | 0.948 | 58% |
| 1990.5 | 0.0 | 359.2 | 1429.9 | 285.8 | 0.0 | 0.0 | 0.703 | 33% |
| 1991.5 | 2038.8 | 267.0 | 426.2 | 347.2 | 0.0 | 0.0 | 0.708 | 29% |
| 1992.5 | 146.8 | 383.9 | 691.0 | 157.1 | 139.4 | 26.6 | 0.559 | 30% |
| 1993.5 | 814.6 | 135.2 | 568.8 | 520.4 | 0.0 | 21.4 | 0.529 | 42% |
| 1994.5 | 1159.8 | 214.6 | 954.1 | 692.2 | 254.9 | 54.8 | 0.871 | 32% |
| 1995.5 | 267.7 | 115.4 | 335.2 | 267.2 | 44.6 | 12.1 | 0.344 | 35% |
| 1996.5 | 144.3 | 341.3 | 1813.8 | 433.5 | 72.7 | 0.0 | 1.265 | 58% |
| 1997.5 | 1351.8 | 517.7 | 3341.0 | 2028.5 | 1039.8 | 79.8 | 3.670 | 35% |
| 1998.5 | 1844.4 | 4675.3 | 4078.9 | 1154.6 | 289.5 | 71.7 | 4.220 | 34% |
| 1999.5 | 2998.7 | 8175.9 | 5558.9 | 1390.3 | 1394.2 | 252.8 | 7.738 | 21% |
| 2000.5 | 610.8 | 1647.5 | 4672.5 | 2350.3 | 919.7 | 802.6 | 5.666 | 49% |
| 2001.5 | 3414.2 | 6083.6 | 7853.7 | 2524.8 | 1667.8 | 1988.2 | 11.213 | 40% |
| 2002.5 | 2031.4 | 5581.8 | 2064.5 | 576.1 | 295.6 | 26.6 | 3.644 | 51% |
| 2003.5 | 1045.3 | 4882.8 | 2725.9 | 548.0 | 97.0 | 185.7 | 3.919 | 33% |
| 2004.5 | 850.3 | 5346.1 | 4862.4 | 2044.4 | 897.1 | 170.7 | 4.966 | 46% |
| 2005.5 | 304.0 | 2033.6 | 3652.1 | 595.9 | 179.3 | 0.0 | 2.391 | 52% |
| 2006.5 | 6012.1 | 6067.2 | 3556.7 | 1132.9 | 247.7 | 44.4 | 4.388 | 27% |
| 2007.5 | 1026.5 | 11110.9 | 7634.7 | 1939.6 | 371.3 | 90.9 | 7.912 | 31% |
| 2008.5 | 162.8 | 6963.2 | 9592.7 | 1002.8 | 0.0 | 0.0 | 6.900 | 28% |
| 2009.5 | 445.8 | 4169.4 | 11531.5 | 2072.0 | 588.3 | 57.9 | 6.797 | 27% |

| Year | Age1 | Age2 | Age3 | Age4 | Age5 | Age6+ | B (000 mt) | CV(B) |
|---|---|---|---|---|---|---|---|---|
| 2010.5 | 115.4 | 2661.6 | 4205.3 | 719.7 | 272.7 | 0.0 | 2.242 | 30% |
| 2011.5 | 234.4 | 2795.0 | 3756.5 | 1079.7 | 141.8 | 9.6 | 2.380 | 26% |
| 2012.5 | 189.3 | 1432.0 | 3550.5 | 1539.0 | 428.0 | 13.8 | 2.446 | 47% |

*Table 12. NEFSC scallop survey index of abundance (stratified mean #/tow) for Georges Bank yellowtail flounder and index of total biomass (stratified mean kg/tow). Note the values for 1989 and 1999 are considered too uncertain for use as a tuning index and the 1986, 2000, 2008, 2011, and 2012 surveys did not fully cover the Canadian portion of Georges Bank (D. Hart, pers. comm.). (Note: These surveys are assumed to occur at the midpoint of the year.)*

| Year | Age1 | Age2 | Age3 | Age4 | Age5 | Age6+ | B (kg/tow) |
|---|---|---|---|---|---|---|---|
| 1982.5 | 0.3505 | 0.5851 | 0.2863 | 0.1768 | 0.0541 | 0.0000 | 0.527 |
| 1983.5 | 0.1389 | 0.5693 | 0.5811 | 0.0828 | 0.0176 | 0.0339 | 0.699 |
| 1984.5 | 0.2021 | 0.2606 | 0.0935 | 0.0813 | 0.0765 | 0.0089 | 0.244 |
| 1985.5 | 0.2717 | 0.4373 | 0.0131 | 0.0158 | 0.0295 | 0.0000 | 0.143 |
| 1986.5 | | | | | | | |
| 1987.5 | 0.1031 | 0.0776 | 0.1154 | 0.0541 | 0.0069 | 0.0029 | 0.187 |
| 1988.5 | 0.1175 | 0.0172 | 0.0324 | 0.0475 | 0.0401 | 0.0000 | 0.108 |
| 1989.5 | | | | | | | |
| 1990.5 | 0.1020 | 0.0257 | 0.3312 | 0.0861 | 0.0356 | 0.0126 | 0.245 |
| 1991.5 | 1.9094 | 0.0000 | 0.1248 | 0.1383 | 0.0296 | 0.0000 | 0.377 |
| 1992.5 | 0.3032 | 0.1281 | 0.3407 | 0.2285 | 0.0482 | 0.0030 | 0.409 |
| 1993.5 | 1.1636 | 0.1966 | 0.2860 | 0.1457 | 0.0081 | 0.0000 | 0.427 |
| 1994.5 | 1.4197 | 0.3308 | 0.4193 | 0.2807 | 0.0614 | 0.0246 | 0.603 |
| 1995.5 | 0.5183 | 0.4546 | 0.7705 | 0.5047 | 0.1627 | 0.0091 | 0.846 |
| 1996.5 | 0.3673 | 0.3037 | 0.8574 | 0.7357 | 0.3089 | 0.0188 | 1.271 |
| 1997.5 | 0.9682 | 0.3956 | 1.2006 | 0.9694 | 0.2008 | 0.0362 | 1.659 |
| 1998.5 | 1.7583 | 0.8858 | 0.7353 | 0.9479 | 0.5744 | 0.1074 | 2.041 |
| 1999.5 | | | | | | | |
| 2000.5 | | | | | | | |
| 2001.5 | 0.8943 | 0.4727 | 1.0595 | 0.5453 | 0.1249 | 0.1669 | 1.525 |
| 2002.5 | 0.9561 | 0.2885 | 0.8333 | 0.3803 | 0.2290 | 0.1358 | 1.336 |
| 2003.5 | 0.7469 | 0.6047 | 0.9887 | 0.6538 | 0.1330 | 0.1980 | 1.783 |
| 2004.5 | 0.3459 | 0.4124 | 0.7100 | 0.1994 | 0.0415 | 0.0175 | 0.777 |
| 2005.5 | 0.4657 | 0.3523 | 0.5743 | 0.2279 | 0.0842 | 0.0090 | 0.623 |
| 2006.5 | 1.9150 | 0.9652 | 0.6833 | 0.3202 | 0.0429 | 0.0247 | 0.880 |
| 2007.5 | 0.5074 | 1.6374 | 1.1764 | 0.3705 | 0.0592 | 0.0040 | 1.265 |
| 2008.5 | | | | | | | |
| 2009.5 | 0.2021 | 0.0775 | 0.7519 | 0.6516 | 0.1352 | 0.0162 | 0.719 |
| 2010.5 | 0.0862 | 0.2131 | 0.5783 | 0.9095 | 0.2878 | 0.0581 | 0.749 |
| 2011.5 | | | | | | | |
| 2012.5 | | | | | | | |

*Table 13a. Statistical properties of estimates for population abundance and survey catchability constants (scallop x103) for Georges Bank yellowtail flounder for the Split Series VPA.*

| | | Bootstrap | | | |
|---|---|---|---|---|---|
| Age | Estimate | Standard Error | Relative Error | Bias | Relative Bias |
| **Population Abundance** | | | | | |
| 2 | 1855 | 1018 | 55% | 188 | 10% |
| 3 | 1410 | 602 | 43% | 115 | 8% |
| 4 | 1128 | 388 | 34% | 52 | 5% |
| 5 | 1394 | 346 | 25% | 34 | 2% |
| **Survey Catchability Constants** | | | | | |
| DFO Survey: 1987-1994 | | | | | |
| 2 | 0.145 | 0.048 | 33% | 0.005 | 4% |
| 3 | 0.232 | 0.033 | 14% | 0.005 | 2% |
| 4 | 0.389 | 0.074 | 19% | 0.005 | 1% |
| 5 | 0.436 | 0.096 | 22% | 0.005 | 1% |
| 6+ | 0.254 | 0.061 | 24% | 0.008 | 3% |
| DFO Survey: 1995-2013 | | | | | |
| 2 | 0.358 | 0.099 | 28% | 0.016 | 5% |
| 3 | 1.844 | 0.397 | 22% | 0.036 | 2% |
| 4 | 2.555 | 0.530 | 21% | 0.042 | 2% |
| 5 | 1.963 | 0.421 | 21% | 0.013 | 1% |
| 6+ | 1.352 | 0.305 | 23% | 0.024 | 2% |
| NMFS Spring Survey: Yankee 41, 1973-1981 | | | | | |
| 1 | 0.007 | 0.006 | 76% | 0.001 | 18% |
| 2 | 0.076 | 0.014 | 19% | 0.001 | 2% |
| 3 | 0.096 | 0.016 | 17% | 0.000 | 0% |
| 4 | 0.093 | 0.011 | 12% | 0.001 | 1% |
| 5 | 0.076 | 0.015 | 20% | 0.001 | 1% |
| 6+ | 0.072 | 0.023 | 32% | 0.004 | 5% |
| NMFS Spring Survey: Yankee 36, 1982-1994 | | | | | |
| 1 | 0.004 | 0.001 | 24% | 0.000 | 2% |
| 2 | 0.046 | 0.015 | 33% | 0.003 | 6% |
| 3 | 0.095 | 0.015 | 15% | 0.001 | 1% |
| 4 | 0.152 | 0.020 | 13% | 0.001 | 1% |
| 5 | 0.229 | 0.044 | 19% | 0.004 | 2% |
| 6+ | 0.423 | 0.094 | 22% | 0.010 | 2% |

*Table 13a. (Continued)*

| | | Bootstrap | | | |
|---|---|---|---|---|---|
| Age | Estimate | Standard Error | Relative Error | Bias | Relative Bias |
| NMFS Spring Survey: Yankee 36, 1995-2013 | | | | | |
| 1 | 0.009 | 0.003 | 34% | 0.000 | 4% |
| 2 | 0.182 | 0.024 | 13% | 0.002 | 1% |
| 3 | 0.754 | 0.124 | 16% | 0.017 | 2% |
| 4 | 0.925 | 0.168 | 18% | 0.009 | 1% |
| 5 | 0.731 | 0.147 | 20% | 0.017 | 2% |
| 6+ | 0.596 | 0.106 | 18% | 0.008 | 1% |
| NMFS Fall Survey: 1973-1994 | | | | | |
| 1 | 0.040 | 0.010 | 26% | 0.002 | 5% |
| 2 | 0.088 | 0.013 | 15% | 0.001 | 1% |
| 3 | 0.150 | 0.015 | 10% | 0.000 | 0% |
| 4 | 0.156 | 0.020 | 13% | 0.002 | 1% |
| 5 | 0.205 | 0.040 | 20% | 0.003 | 2% |
| 6+ | 0.306 | 0.064 | 21% | 0.006 | 2% |
| NMFS Fall Survey: 1995-2012 | | | | | |
| 1 | 0.081 | 0.018 | 23% | 0.002 | 3% |
| 2 | 0.391 | 0.131 | 33% | 0.018 | 5% |
| 3 | 0.903 | 0.208 | 23% | 0.028 | 3% |
| 4 | 0.615 | 0.112 | 18% | 0.007 | 1% |
| 5 | 0.563 | 0.131 | 23% | 0.009 | 2% |
| 6+ | 0.353 | 0.121 | 34% | 0.016 | 5% |
| NMFS Scallop Survey: 1982-1994 | | | | | |
| 1 | 0.026 | 0.008 | 32% | 0.001 | 5% |
| NMFS Scallop Survey: 1995-2012 | | | | | |
| 1 | 0.060 | 0.008 | 14% | 0.001 | 1% |

*Table 13b. Statistical properties of estimates for population abundance and survey catchability constants (scallop x103) for Georges Bank yellowtail flounder for the Single Series VPA.*

| | | Bootstrap | | | |
|---|---|---|---|---|---|
| Age | Estimate | Standard Error | Relative Error | Bias | Relative Bias |
| | **Population Abundance** | | | | |
| 2 | 2993 | 1843 | 62% | 463 | 15% |
| 3 | 2757 | 1318 | 48% | 223 | 8% |
| 4 | 2552 | 999 | 39% | 200 | 8% |
| 5 | 5677 | 1175 | 21% | 143 | 3% |
| | **Survey Catchability Constants** | | | | |
| DFO Survey: 1987-2013 | | | | | |
| 2 | 0.237 | 0.056 | 24% | 0.007 | 3% |
| 3 | 0.873 | 0.209 | 24% | 0.024 | 3% |
| 4 | 1.276 | 0.278 | 22% | 0.021 | 2% |
| 5 | 1.073 | 0.244 | 23% | 0.023 | 2% |
| 6+ | 0.703 | 0.181 | 26% | 0.021 | 3% |
| NMFS Spring Survey: Yankee 36, 1982-2013 | | | | | |
| 1 | 0.006 | 0.001 | 22% | 0.000 | 3% |
| 2 | 0.094 | 0.017 | 18% | 0.001 | 1% |
| 3 | 0.291 | 0.058 | 20% | 0.004 | 1% |
| 4 | 0.396 | 0.074 | 19% | 0.007 | 2% |
| 5 | 0.399 | 0.065 | 16% | 0.008 | 2% |
| 6+ | 0.455 | 0.066 | 15% | 0.005 | 1% |
| NMFS Fall Survey: 1973-2012 | | | | | |
| 1 | 0.050 | 0.009 | 17% | 0.000 | 1% |
| 2 | 0.157 | 0.031 | 19% | 0.004 | 2% |
| 3 | 0.310 | 0.051 | 17% | 0.005 | 2% |
| 4 | 0.265 | 0.038 | 14% | 0.002 | 1% |
| 5 | 0.308 | 0.055 | 18% | 0.005 | 2% |
| 6+ | 0.299 | 0.068 | 23% | 0.008 | 3% |
| NMFS Scallop Survey: 1982-2012 | | | | | |
| 1 | 0.038 | 0.007 | 18% | 0.001 | 1% |

*Table 14a. Retrospective rho statistics for fishing mortality rate (ages 4+), spawning stock biomass, and age 1 recruitment based on seven peels of the Split Series VPA.*

| Peel | F | SSB | R |
|---|---|---|---|
| 1 | -0.486 | 0.524 | 0.311 |
| 2 | -0.774 | 1.585 | -0.365 |
| 3 | -0.806 | 3.232 | 0.054 |
| 4 | -0.757 | 4.037 | -0.151 |
| 5 | -0.725 | 2.559 | 2.020 |
| 6 | -0.471 | 1.165 | 4.803 |
| 7 | -0.131 | 0.795 | -0.018 |
| mean | -0.593 | 1.985 | 0.951 |

*Table 14b. Retrospective rho statistics for fishing mortality rate (ages 4+), spawning stock biomass, and age 1 recruitment based on seven peels of the Single Series VPA.*

| Peel | F | SSB | R |
|---|---|---|---|
| 1 | -0.664 | 0.754 | 0.098 |
| 2 | -0.857 | 2.203 | -0.472 |
| 3 | -0.888 | 5.025 | -0.403 |
| 4 | -0.883 | 6.996 | -0.293 |
| 5 | -0.878 | 5.010 | 2.294 |
| 6 | -0.785 | 3.153 | 6.449 |
| 7 | -0.686 | 2.725 | 0.474 |
| mean | -0.806 | 3.695 | 1.164 |

*Table 15a. Beginning of year population abundance in numbers (000s) for Georges Bank yellowtail flounder from the Split Series VPA. The age 1 value in the last year is the geometric mean of the previous ten years.*

| | Age Group | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6+ | Total |
| 1973 | 29384 | 24172 | 29516 | 17300 | 6966 | 3013 | 110351 |
| 1974 | 52184 | 23733 | 15136 | 12051 | 5732 | 2391 | 111229 |
| 1975 | 70632 | 40588 | 10930 | 5010 | 3079 | 1709 | 131948 |
| 1976 | 24731 | 53646 | 9852 | 2425 | 977 | 1562 | 93193 |
| 1977 | 17283 | 19674 | 15554 | 3171 | 719 | 850 | 57252 |
| 1978 | 54437 | 13809 | 7987 | 3390 | 956 | 373 | 80953 |
| 1979 | 25508 | 35604 | 8124 | 2468 | 1073 | 559 | 73336 |
| 1980 | 24034 | 20595 | 19711 | 3268 | 747 | 239 | 68594 |
| 1981 | 62997 | 19390 | 13268 | 7499 | 1302 | 221 | 104677 |
| 1982 | 22846 | 51480 | 14885 | 5535 | 1783 | 156 | 96685 |
| 1983 | 6581 | 16754 | 25937 | 5517 | 1514 | 345 | 56648 |
| 1984 | 10843 | 4755 | 6579 | 6472 | 2305 | 487 | 31441 |
| 1985 | 16749 | 8414 | 2089 | 1379 | 870 | 136 | 29636 |
| 1986 | 8473 | 12837 | 2991 | 767 | 402 | 224 | 25695 |
| 1987 | 9193 | 6776 | 4801 | 1440 | 282 | 201 | 22692 |
| 1988 | 22841 | 7386 | 2617 | 1153 | 309 | 73 | 34379 |
| 1989 | 9661 | 18250 | 3361 | 771 | 198 | 55 | 32296 |
| 1990 | 11217 | 7738 | 12981 | 1747 | 250 | 47 | 33980 |
| 1991 | 22557 | 8975 | 4437 | 4399 | 560 | 104 | 41032 |
| 1992 | 17518 | 17869 | 7215 | 2296 | 940 | 65 | 45903 |
| 1993 | 13938 | 12168 | 6459 | 3250 | 574 | 126 | 36515 |
| 1994 | 13178 | 6725 | 8713 | 2323 | 609 | 184 | 31732 |
| 1995 | 11670 | 10725 | 4304 | 1576 | 305 | 66 | 28646 |
| 1996 | 13467 | 9512 | 8499 | 2237 | 509 | 70 | 34293 |
| 1997 | 19791 | 10935 | 7174 | 5103 | 1039 | 246 | 44288 |
| 1998 | 22377 | 16129 | 7932 | 4227 | 2515 | 328 | 53508 |
| 1999 | 24508 | 18169 | 11411 | 3465 | 1777 | 675 | 60005 |
| 2000 | 19746 | 20011 | 12396 | 5585 | 1454 | 930 | 60124 |
| 2001 | 22169 | 16048 | 12908 | 5046 | 1751 | 916 | 58838 |
| 2002 | 15117 | 17992 | 10544 | 4374 | 1559 | 1108 | 50694 |
| 2003 | 10584 | 12185 | 10983 | 5542 | 1869 | 1657 | 42820 |
| 2004 | 6833 | 8521 | 6462 | 4781 | 2463 | 1838 | 30897 |
| 2005 | 8505 | 5539 | 5938 | 2451 | 563 | 266 | 23262 |
| 2006 | 10068 | 6910 | 3117 | 1297 | 499 | 293 | 22184 |
| 2007 | 6213 | 8106 | 4494 | 1104 | 227 | 92 | 20236 |
| 2008 | 5424 | 5041 | 5295 | 2153 | 315 | 62 | 18289 |
| 2009 | 5727 | 4415 | 3682 | 2630 | 997 | 142 | 17593 |
| 2010 | 2883 | 4673 | 3359 | 1880 | 940 | 210 | 13944 |
| 2011 | 2260 | 2358 | 3701 | 2171 | 745 | 182 | 11417 |

| | Age Group | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6+ | Total |
| 2012 | 2278 | 1841 | 1782 | 2335 | 971 | 186 | 9393 |
| 2013 | 5308 | 1855 | 1410 | 1128 | 1394 | 690 | 11785 |

*Table 15b. Beginning of year population abundance in numbers (000s) for Georges Bank yellowtail flounder from the Single Series VPA. The age 1 value in the last year is the geometric mean of the previous ten years.*

| | Age Group | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6+ | Total |
| 1973 | 29384 | 24172 | 29516 | 17300 | 6966 | 3013 | 110351 |
| 1974 | 52184 | 23733 | 15136 | 12051 | 5732 | 2391 | 111229 |
| 1975 | 70632 | 40588 | 10930 | 5010 | 3079 | 1709 | 131948 |
| 1976 | 24731 | 53646 | 9852 | 2425 | 977 | 1562 | 93193 |
| 1977 | 17283 | 19674 | 15554 | 3171 | 719 | 850 | 57252 |
| 1978 | 54437 | 13809 | 7987 | 3390 | 956 | 373 | 80953 |
| 1979 | 25508 | 35604 | 8124 | 2468 | 1073 | 559 | 73336 |
| 1980 | 24034 | 20595 | 19711 | 3268 | 747 | 239 | 68594 |
| 1981 | 62997 | 19390 | 13268 | 7499 | 1302 | 221 | 104677 |
| 1982 | 22846 | 51480 | 14885 | 5535 | 1783 | 156 | 96685 |
| 1983 | 6581 | 16754 | 25937 | 5517 | 1514 | 345 | 56648 |
| 1984 | 10843 | 4755 | 6579 | 6472 | 2305 | 487 | 31441 |
| 1985 | 16749 | 8414 | 2089 | 1379 | 870 | 136 | 29636 |
| 1986 | 8473 | 12837 | 2991 | 767 | 402 | 224 | 25695 |
| 1987 | 9193 | 6776 | 4801 | 1440 | 282 | 201 | 22692 |
| 1988 | 22841 | 7386 | 2617 | 1153 | 309 | 73 | 34379 |
| 1989 | 9661 | 18250 | 3361 | 771 | 198 | 55 | 32296 |
| 1990 | 11217 | 7738 | 12981 | 1747 | 250 | 47 | 33980 |
| 1991 | 22557 | 8975 | 4437 | 4399 | 560 | 104 | 41032 |
| 1992 | 17518 | 17869 | 7215 | 2296 | 940 | 65 | 45903 |
| 1993 | 13938 | 12168 | 6459 | 3250 | 574 | 126 | 36515 |
| 1994 | 13178 | 6725 | 8713 | 2323 | 609 | 184 | 31732 |
| 1995 | 11670 | 10725 | 4304 | 1576 | 305 | 66 | 28646 |
| 1996 | 13467 | 9512 | 8499 | 2237 | 509 | 70 | 34293 |
| 1997 | 19791 | 10935 | 7174 | 5103 | 1039 | 246 | 44288 |
| 1998 | 22378 | 16129 | 7932 | 4227 | 2515 | 328 | 53509 |
| 1999 | 24509 | 18169 | 11411 | 3465 | 1777 | 675 | 60007 |
| 2000 | 19749 | 20012 | 12396 | 5585 | 1454 | 930 | 60128 |
| 2001 | 22173 | 16050 | 12908 | 5047 | 1751 | 916 | 58846 |
| 2002 | 15131 | 17995 | 10545 | 4375 | 1560 | 1108 | 50714 |
| 2003 | 10612 | 12197 | 10986 | 5543 | 1870 | 1657 | 42865 |
| 2004 | 6941 | 8544 | 6471 | 4784 | 2464 | 1838 | 31042 |
| 2005 | 9094 | 5628 | 5957 | 2458 | 565 | 266 | 23968 |
| 2006 | 11332 | 7392 | 3190 | 1312 | 504 | 297 | 24027 |
| 2007 | 8262 | 9141 | 4888 | 1162 | 239 | 97 | 23790 |
| 2008 | 10281 | 6718 | 6141 | 2474 | 363 | 71 | 26048 |
| 2009 | 15268 | 8391 | 5056 | 3320 | 1259 | 179 | 33474 |
| 2010 | 5478 | 12485 | 6614 | 3001 | 1501 | 335 | 29415 |
| 2011 | 4270 | 4483 | 10096 | 4835 | 1659 | 405 | 25749 |

| | Age Group | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6+ | Total |
| 2012 | 3669 | 3486 | 3522 | 7569 | 3147 | 603 | 21996 |
| 2013 | 7811 | 2993 | 2757 | 2552 | 5677 | 2813 | 24603 |

*Table 16a. Fishing mortality rate for Georges Bank yellowtail from the Split Series VPA.*

| | Age Group | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6+ | 4-5 |
| 1973 | 0.01 | 0.27 | 0.70 | 0.90 | 0.90 | 0.90 | 0.90 |
| 1974 | 0.05 | 0.58 | 0.91 | 1.16 | 1.16 | 1.16 | 1.16 |
| 1975 | 0.08 | 1.22 | 1.31 | 1.43 | 1.43 | 1.43 | 1.43 |
| 1976 | 0.03 | 1.04 | 0.93 | 1.02 | 1.02 | 1.02 | 1.02 |
| 1977 | 0.02 | 0.70 | 1.32 | 1.00 | 1.00 | 1.00 | 1.00 |
| 1978 | 0.22 | 0.33 | 0.97 | 0.95 | 0.95 | 0.95 | 0.95 |
| 1979 | 0.01 | 0.39 | 0.71 | 0.99 | 0.99 | 0.99 | 0.99 |
| 1980 | 0.01 | 0.24 | 0.77 | 0.72 | 0.72 | 0.72 | 0.72 |
| 1981 | 0.00 | 0.06 | 0.67 | 1.24 | 1.24 | 1.24 | 1.24 |
| 1982 | 0.11 | 0.49 | 0.79 | 1.10 | 1.10 | 1.10 | 1.10 |
| 1983 | 0.13 | 0.73 | 1.19 | 0.67 | 0.67 | 0.67 | 0.67 |
| 1984 | 0.05 | 0.62 | 1.36 | 1.81 | 1.81 | 1.81 | 1.81 |
| 1985 | 0.07 | 0.83 | 0.80 | 1.03 | 1.03 | 1.03 | 1.03 |
| 1986 | 0.02 | 0.78 | 0.53 | 0.80 | 0.80 | 0.80 | 0.80 |
| 1987 | 0.02 | 0.75 | 1.23 | 1.34 | 1.34 | 1.34 | 1.34 |
| 1988 | 0.02 | 0.59 | 1.02 | 1.56 | 1.56 | 1.56 | 1.56 |
| 1989 | 0.02 | 0.14 | 0.45 | 0.93 | 0.93 | 0.93 | 0.93 |
| 1990 | 0.02 | 0.36 | 0.88 | 0.94 | 0.94 | 0.94 | 0.94 |
| 1991 | 0.03 | 0.02 | 0.46 | 1.34 | 1.34 | 1.34 | 1.34 |
| 1992 | 0.16 | 0.82 | 0.60 | 1.19 | 1.19 | 1.19 | 1.19 |
| 1993 | 0.53 | 0.13 | 0.82 | 1.47 | 1.47 | 1.47 | 1.47 |
| 1994 | 0.01 | 0.25 | 1.51 | 1.83 | 1.83 | 1.83 | 1.83 |
| 1995 | 0.00 | 0.03 | 0.45 | 0.93 | 0.93 | 0.93 | 0.93 |
| 1996 | 0.01 | 0.08 | 0.31 | 0.57 | 0.57 | 0.57 | 0.57 |
| 1997 | 0.00 | 0.12 | 0.33 | 0.51 | 0.51 | 0.51 | 0.51 |
| 1998 | 0.01 | 0.15 | 0.63 | 0.67 | 0.67 | 0.67 | 0.67 |
| 1999 | 0.00 | 0.18 | 0.51 | 0.67 | 0.67 | 0.67 | 0.67 |
| 2000 | 0.01 | 0.24 | 0.70 | 0.96 | 0.96 | 0.96 | 0.96 |
| 2001 | 0.01 | 0.22 | 0.88 | 0.97 | 0.97 | 0.97 | 0.97 |
| 2002 | 0.02 | 0.29 | 0.44 | 0.65 | 0.65 | 0.65 | 0.65 |
| 2003 | 0.02 | 0.43 | 0.63 | 0.61 | 0.61 | 0.61 | 0.61 |
| 2004 | 0.01 | 0.16 | 0.77 | 1.94 | 1.94 | 1.94 | 1.94 |
| 2005 | 0.01 | 0.37 | 1.32 | 1.39 | 1.39 | 1.39 | 1.39 |
| 2006 | 0.02 | 0.23 | 0.84 | 1.54 | 1.54 | 1.54 | 1.54 |
| 2007 | 0.01 | 0.23 | 0.54 | 1.05 | 1.05 | 1.05 | 1.05 |
| 2008 | 0.01 | 0.11 | 0.50 | 0.57 | 0.57 | 0.57 | 0.57 |
| 2009 | 0.00 | 0.07 | 0.47 | 0.83 | 0.83 | 0.83 | 0.83 |
| 2010 | 0.00 | 0.03 | 0.24 | 0.73 | 0.73 | 0.73 | 0.73 |
| 2011 | 0.01 | 0.08 | 0.26 | 0.60 | 0.60 | 0.60 | 0.60 |
| 2012 | 0.01 | 0.07 | 0.26 | 0.32 | 0.32 | 0.32 | 0.32 |

*Table 16b. Fishing mortality rate for Georges Bank yellowtail from the Single Series VPA.*

| | Age Group | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6+ | 4-5 |
| 1973 | 0.01 | 0.27 | 0.70 | 0.90 | 0.90 | 0.90 | 0.90 |
| 1974 | 0.05 | 0.58 | 0.91 | 1.16 | 1.16 | 1.16 | 1.16 |
| 1975 | 0.08 | 1.22 | 1.31 | 1.43 | 1.43 | 1.43 | 1.43 |
| 1976 | 0.03 | 1.04 | 0.93 | 1.02 | 1.02 | 1.02 | 1.02 |
| 1977 | 0.02 | 0.70 | 1.32 | 1.00 | 1.00 | 1.00 | 1.00 |
| 1978 | 0.22 | 0.33 | 0.97 | 0.95 | 0.95 | 0.95 | 0.95 |
| 1979 | 0.01 | 0.39 | 0.71 | 0.99 | 0.99 | 0.99 | 0.99 |
| 1980 | 0.01 | 0.24 | 0.77 | 0.72 | 0.72 | 0.72 | 0.72 |
| 1981 | 0.00 | 0.06 | 0.67 | 1.24 | 1.24 | 1.24 | 1.24 |
| 1982 | 0.11 | 0.49 | 0.79 | 1.10 | 1.10 | 1.10 | 1.10 |
| 1983 | 0.13 | 0.73 | 1.19 | 0.67 | 0.67 | 0.67 | 0.67 |
| 1984 | 0.05 | 0.62 | 1.36 | 1.81 | 1.81 | 1.81 | 1.81 |
| 1985 | 0.07 | 0.83 | 0.80 | 1.03 | 1.03 | 1.03 | 1.03 |
| 1986 | 0.02 | 0.78 | 0.53 | 0.80 | 0.80 | 0.80 | 0.80 |
| 1987 | 0.02 | 0.75 | 1.23 | 1.34 | 1.34 | 1.34 | 1.34 |
| 1988 | 0.02 | 0.59 | 1.02 | 1.56 | 1.56 | 1.56 | 1.56 |
| 1989 | 0.02 | 0.14 | 0.45 | 0.93 | 0.93 | 0.93 | 0.93 |
| 1990 | 0.02 | 0.36 | 0.88 | 0.94 | 0.94 | 0.94 | 0.94 |
| 1991 | 0.03 | 0.02 | 0.46 | 1.34 | 1.34 | 1.34 | 1.34 |
| 1992 | 0.16 | 0.82 | 0.60 | 1.19 | 1.19 | 1.19 | 1.19 |
| 1993 | 0.53 | 0.13 | 0.82 | 1.47 | 1.47 | 1.47 | 1.47 |
| 1994 | 0.01 | 0.25 | 1.51 | 1.83 | 1.83 | 1.83 | 1.83 |
| 1995 | 0.00 | 0.03 | 0.45 | 0.93 | 0.93 | 0.93 | 0.93 |
| 1996 | 0.01 | 0.08 | 0.31 | 0.57 | 0.57 | 0.57 | 0.57 |
| 1997 | 0.00 | 0.12 | 0.33 | 0.51 | 0.51 | 0.51 | 0.51 |
| 1998 | 0.01 | 0.15 | 0.63 | 0.67 | 0.67 | 0.67 | 0.67 |
| 1999 | 0.00 | 0.18 | 0.51 | 0.67 | 0.67 | 0.67 | 0.67 |
| 2000 | 0.01 | 0.24 | 0.70 | 0.96 | 0.96 | 0.96 | 0.96 |
| 2001 | 0.01 | 0.22 | 0.88 | 0.97 | 0.97 | 0.97 | 0.97 |
| 2002 | 0.02 | 0.29 | 0.44 | 0.65 | 0.65 | 0.65 | 0.65 |
| 2003 | 0.02 | 0.43 | 0.63 | 0.61 | 0.61 | 0.61 | 0.61 |
| 2004 | 0.01 | 0.16 | 0.77 | 1.94 | 1.94 | 1.94 | 1.94 |
| 2005 | 0.01 | 0.37 | 1.31 | 1.38 | 1.38 | 1.38 | 1.38 |
| 2006 | 0.01 | 0.21 | 0.81 | 1.50 | 1.50 | 1.50 | 1.50 |
| 2007 | 0.01 | 0.20 | 0.48 | 0.96 | 0.96 | 0.96 | 0.96 |
| 2008 | 0.00 | 0.08 | 0.41 | 0.48 | 0.48 | 0.48 | 0.48 |
| 2009 | 0.00 | 0.04 | 0.32 | 0.59 | 0.59 | 0.59 | 0.59 |
| 2010 | 0.00 | 0.01 | 0.11 | 0.39 | 0.39 | 0.39 | 0.39 |
| 2011 | 0.00 | 0.04 | 0.09 | 0.23 | 0.23 | 0.23 | 0.23 |
| 2012 | 0.00 | 0.03 | 0.12 | 0.09 | 0.09 | 0.09 | 0.09 |

*Table 17. Beginning of year weight (kg) at age for Georges Bank yellowtail. The 2013 values are set equal to the average of the 2010-2012 values.*

| | Age Group | | | | | |
|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6+ |
| 1973 | 0.055 | 0.292 | 0.403 | 0.465 | 0.564 | 0.778 |
| 1974 | 0.069 | 0.186 | 0.416 | 0.530 | 0.598 | 0.832 |
| 1975 | 0.068 | 0.191 | 0.410 | 0.524 | 0.613 | 0.695 |
| 1976 | 0.061 | 0.188 | 0.415 | 0.557 | 0.642 | 0.861 |
| 1977 | 0.071 | 0.192 | 0.404 | 0.587 | 0.704 | 0.931 |
| 1978 | 0.057 | 0.191 | 0.418 | 0.601 | 0.713 | 0.970 |
| 1979 | 0.068 | 0.183 | 0.381 | 0.578 | 0.713 | 0.950 |
| 1980 | 0.056 | 0.192 | 0.403 | 0.551 | 0.732 | 1.072 |
| 1981 | 0.078 | 0.184 | 0.397 | 0.546 | 0.681 | 0.840 |
| 1982 | 0.072 | 0.192 | 0.403 | 0.564 | 0.675 | 1.082 |
| 1983 | 0.107 | 0.185 | 0.364 | 0.543 | 0.694 | 1.010 |
| 1984 | 0.109 | 0.183 | 0.335 | 0.470 | 0.627 | 0.797 |
| 1985 | 0.132 | 0.242 | 0.347 | 0.493 | 0.604 | 0.800 |
| 1986 | 0.135 | 0.248 | 0.442 | 0.583 | 0.741 | 1.015 |
| 1987 | 0.074 | 0.242 | 0.423 | 0.606 | 0.727 | 0.875 |
| 1988 | 0.058 | 0.199 | 0.425 | 0.604 | 0.758 | 0.975 |
| 1989 | 0.059 | 0.184 | 0.413 | 0.633 | 0.776 | 1.053 |
| 1990 | 0.070 | 0.170 | 0.359 | 0.552 | 0.706 | 0.845 |
| 1991 | 0.078 | 0.158 | 0.327 | 0.438 | 0.650 | 0.877 |
| 1992 | 0.060 | 0.188 | 0.294 | 0.441 | 0.563 | 1.110 |
| 1993 | 0.062 | 0.170 | 0.333 | 0.428 | 0.545 | 0.863 |
| 1994 | 0.162 | 0.161 | 0.317 | 0.423 | 0.558 | 0.775 |
| 1995 | 0.138 | 0.230 | 0.300 | 0.405 | 0.535 | 0.768 |
| 1996 | 0.075 | 0.219 | 0.335 | 0.438 | 0.573 | 1.012 |
| 1997 | 0.179 | 0.190 | 0.336 | 0.468 | 0.630 | 0.947 |
| 1998 | 0.124 | 0.256 | 0.360 | 0.472 | 0.591 | 0.966 |
| 1999 | 0.147 | 0.256 | 0.389 | 0.523 | 0.642 | 0.901 |
| 2000 | 0.182 | 0.278 | 0.420 | 0.552 | 0.700 | 0.954 |
| 2001 | 0.204 | 0.288 | 0.420 | 0.542 | 0.707 | 1.027 |
| 2002 | 0.250 | 0.309 | 0.417 | 0.553 | 0.714 | 1.068 |
| 2003 | 0.202 | 0.318 | 0.425 | 0.560 | 0.740 | 1.048 |
| 2004 | 0.166 | 0.258 | 0.397 | 0.527 | 0.689 | 0.956 |
| 2005 | 0.074 | 0.268 | 0.361 | 0.511 | 0.668 | 0.991 |
| 2006 | 0.059 | 0.192 | 0.376 | 0.499 | 0.674 | 0.996 |
| 2007 | 0.110 | 0.170 | 0.356 | 0.474 | 0.661 | 1.023 |
| 2008 | 0.018 | 0.216 | 0.347 | 0.467 | 0.605 | 0.962 |
| 2009 | 0.107 | 0.124 | 0.362 | 0.473 | 0.610 | 0.929 |
| 2010 | 0.125 | 0.224 | 0.376 | 0.475 | 0.596 | 0.808 |
| 2011 | 0.079 | 0.242 | 0.386 | 0.489 | 0.579 | 0.747 |
| 2012 | 0.164 | 0.208 | 0.390 | 0.506 | 0.609 | 0.806 |
| 2013 | 0.123 | 0.225 | 0.384 | 0.490 | 0.595 | 0.787 |

*Table 18a. Beginning of year biomass (mt) and spawning stock biomass (mt) for Georges Bank yellowtail from the Split Series VPA.*

| | Beginning Biomass | | |
|---|---|---|---|
| Year | 1+ | 3+ | SSB |
| 1973 | 34860 | 26206 | 22161 |
| 1974 | 26134 | 18088 | 14780 |
| 1975 | 22723 | 10184 | 9014 |
| 1976 | 18984 | 7408 | 10024 |
| 1977 | 14447 | 9447 | 8351 |
| 1978 | 12146 | 6418 | 6169 |
| 1979 | 14070 | 5818 | 8501 |
| 1980 | 15820 | 10540 | 10884 |
| 1981 | 18890 | 10430 | 10144 |
| 1982 | 21994 | 10493 | 12975 |
| 1983 | 17637 | 13841 | 11103 |
| 1984 | 9121 | 7075 | 3847 |
| 1985 | 6283 | 2040 | 2558 |
| 1986 | 6628 | 2293 | 3210 |
| 1987 | 5599 | 3282 | 2750 |
| 1988 | 4905 | 2113 | 2198 |
| 1989 | 6004 | 2088 | 4170 |
| 1990 | 7947 | 5845 | 4750 |
| 1991 | 7004 | 3834 | 3485 |
| 1992 | 8153 | 3735 | 4472 |
| 1993 | 6893 | 3964 | 3966 |
| 1994 | 7443 | 4228 | 2823 |
| 1995 | 6229 | 2145 | 2941 |
| 1996 | 7275 | 4185 | 4992 |
| 1997 | 11304 | 5683 | 6379 |
| 1998 | 13541 | 6649 | 7259 |
| 1999 | 16242 | 7997 | 9592 |
| 2000 | 19358 | 10197 | 10259 |
| 2001 | 19467 | 10331 | 9252 |
| 2002 | 18452 | 9111 | 10104 |
| 2003 | 16900 | 10890 | 10029 |
| 2004 | 11865 | 8532 | 5416 |
| 2005 | 6150 | 4038 | 3159 |
| 2006 | 4367 | 2448 | 2314 |
| 2007 | 4432 | 2369 | 2734 |
| 2008 | 4276 | 3092 | 3234 |
| 2009 | 4480 | 3316 | 3227 |
| 2010 | 4293 | 2886 | 3004 |
| 2011 | 3805 | 3056 | 2988 |
| 2012 | 3376 | 2618 | 2593 |
| 2013 | | 2467 | |

*Table 18b. Beginning of year biomass (mt) and spawning stock biomass (mt) for Georges Bank yellowtail from the Single Series VPA.*

| | Beginning Biomass | | |
|---|---|---|---|
| Year | 1+ | 3+ | SSB |
| 1973 | 34860 | 26206 | 22161 |
| 1974 | 26134 | 18088 | 14780 |
| 1975 | 22723 | 10184 | 9014 |
| 1976 | 18984 | 7408 | 10024 |
| 1977 | 14447 | 9447 | 8351 |
| 1978 | 12146 | 6418 | 6169 |
| 1979 | 14070 | 5818 | 8501 |
| 1980 | 15820 | 10540 | 10884 |
| 1981 | 18890 | 10430 | 10144 |
| 1982 | 21994 | 10493 | 12975 |
| 1983 | 17637 | 13841 | 11103 |
| 1984 | 9121 | 7075 | 3847 |
| 1985 | 6283 | 2040 | 2558 |
| 1986 | 6628 | 2293 | 3210 |
| 1987 | 5599 | 3282 | 2750 |
| 1988 | 4905 | 2113 | 2198 |
| 1989 | 6004 | 2088 | 4170 |
| 1990 | 7947 | 5845 | 4750 |
| 1991 | 7004 | 3834 | 3485 |
| 1992 | 8153 | 3735 | 4472 |
| 1993 | 6893 | 3964 | 3966 |
| 1994 | 7443 | 4228 | 2823 |
| 1995 | 6229 | 2145 | 2941 |
| 1996 | 7275 | 4185 | 4992 |
| 1997 | 11304 | 5683 | 6379 |
| 1998 | 13541 | 6649 | 7259 |
| 1999 | 16242 | 7997 | 9592 |
| 2000 | 19359 | 10198 | 10259 |
| 2001 | 19469 | 10331 | 9253 |
| 2002 | 18457 | 9112 | 10106 |
| 2003 | 16913 | 10893 | 10034 |
| 2004 | 11895 | 8539 | 5427 |
| 2005 | 6230 | 4051 | 3188 |
| 2006 | 4576 | 2491 | 2426 |
| 2007 | 5015 | 2550 | 3058 |
| 2008 | 5205 | 3573 | 3971 |
| 2009 | 7016 | 4334 | 4894 |
| 2010 | 8559 | 5080 | 6333 |
| 2011 | 8944 | 7522 | 8008 |
| 2012 | 8935 | 7606 | 7872 |
| 2013 | | 7899 | |

*Table 19. Estimated and rho adjusted values for the Split Series VPA and Single Series VPA. Note the SSB rho value was used to adjust the adult biomass estimate.*

| | Split Series | | Single Series | |
|---|---|---|---|---|
| | estimate | rho adjusted | estimate | rho adjusted |
| 2012 F | 0.32 | 0.78 | 0.09 | 0.45 |
| 2012 R | 2278 | 1168 | 3669 | 1696 |
| 2012 SSB | 2593 | 869 | 7872 | 1677 |
| 2013 Adult B | 2467 | 826 | 7899 | 1683 |

*Table 20a. Recent three year averages of partial recruitment to the fishery, maturity, beginning of year weights at age and catch weights at age used in projections.*

| | Age Group | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6+ |
| Partial Recruitment to the Fishery Split Series VPA | | | | | | |
| | 0.009 | 0.129 | 0.523 | 1 | 1 | 1 |
| Partial Recruitment to the Fishery Single Series VPA | | | | | | |
| | 0.016 | 0.182 | 0.615 | 1 | 1 | 1 |
| Maturity | | | | | | |
| | 0 | 0.462 | 0.967 | 1 | 1 | 1 |
| Fraction of M before Spawning = | | | | 0.4167 | | |
| Fraction of F before Spawning = | | | | 0.4167 | | |
| Jan-1 Weight for Population (kg) | | | | | | |
| | 0.123 | 0.225 | 0.384 | 0.49 | 0.595 | 0.787 |
| Average Weight for Catch (kg) | | | | | | |
| | 0.162 | 0.333 | 0.448 | 0.542 | 0.659 | 0.787 |

*Table 20b. Deterministic projections from the Split Series VPA for Georges Bank yellowtail assuming the quota is caught next year and $F_{ref}$ is applied in the quota year.*

| | Age Group | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6+ | 1+ | 3+ |
| Fishing Mortality | | | | | | | | |
| 2013 | 0.002 | 0.032 | 0.129 | 0.246 | 0.246 | 0.246 | | |
| 2014 | 0.002 | 0.032 | 0.131 | 0.25 | 0.25 | 0.25 | | |
| Jan-1 Population Numbers (000s) | | | | | | | | |
| 2013 | 5308 | 1855 | 1410 | 1128 | 1394 | 690 | | |
| 2014 | 5308 | 4336 | 1471 | 1015 | 722 | 1334 | | |
| 2015 | 5308 | 4336 | 3437 | 1057 | 647 | 1311 | | |
| Jan-1 Population Biomass (mt) | | | | | | | | |
| 2013 | 653 | 417 | 542 | 553 | 829 | 543 | 3537 | 2467 |
| 2014 | 653 | 976 | 565 | 498 | 430 | 1050 | 4171 | 2542 |
| 2015 | 653 | 976 | 1320 | 518 | 385 | 1032 | 4883 | 3255 |
| Spawning Stock Biomass (mt) | | | | | | | | |
| 2013 | 0 | 259 | 533 | 508 | 763 | 451 | 2514 | |
| 2014 | 0 | 606 | 555 | 456 | 395 | 871 | 2882 | |
| Catch Numbers (000s) | | | | | | | | |
| 2013 | 11 | 53 | 155 | 224 | 277 | 137 | | |
| 2014 | 11 | 125 | 164 | 204 | 145 | 269 | | |
| Fishery Yield (mt including discards) | | | | | | | | |
| 2013 | 2 | 17 | 69 | 121 | 182 | 108 | **500** | |
| 2014 | 2 | 42 | 73 | 111 | 96 | 211 | **535** | |

*Table 20c. Deterministic projections from the Split Series VPA with SSB rho adjustment applied to all ages in the first year for Georges Bank yellowtail assuming the quota is caught next year and $F_{ref}$ is applied in the quota year.*

| | Age Group | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6+ | 1+ | 3+ |
| Fishing Mortality | | | | | | | | |
| 2013 | 0.009 | 0.126 | 0.510 | 0.975 | 0.975 | 0.975 | | |
| 2014 | 0.002 | 0.032 | 0.131 | 0.25 | 0.25 | 0.25 | | |
| Jan-1 Population Numbers (000s) | | | | | | | | |
| 2013 | 1778 | 621 | 472 | 378 | 467 | 231 | | |
| 2014 | 1778 | 1443 | 449 | 232 | 117 | 216 | | |
| 2015 | 1778 | 1452 | 1144 | 322 | 148 | 212 | | |
| Jan-1 Population Biomass (mt) | | | | | | | | |
| 2013 | 219 | 140 | 181 | 185 | 278 | 182 | 1185 | 826 |
| 2014 | 219 | 325 | 172 | 114 | 69 | 170 | 1069 | 525 |
| 2015 | 219 | 327 | 439 | 158 | 88 | 167 | 1398 | 852 |
| Spawning Stock Biomass (mt) | | | | | | | | |
| 2013 | 0 | 83 | 152 | 126 | 189 | 112 | 661 | |
| 2014 | 0 | 202 | 169 | 104 | 64 | 141 | 680 | |
| Catch Numbers (000s) | | | | | | | | |
| 2013 | 14 | 67 | 172 | 217 | 268 | 133 | | |
| 2014 | 4 | 42 | 50 | 47 | 24 | 43 | | |
| Fishery Yield (mt including discards) | | | | | | | | |
| 2013 | 2 | 22 | 77 | 117 | 176 | 104 | **500** | |
| 2014 | 1 | 14 | 22 | 25 | 15 | 34 | **112** | |

*Table 20d. Deterministic projections from the Single Series VPA for Georges Bank yellowtail assuming the quota is caught next year and $F_{ref}$ is applied in the quota year.*

| | Age Group | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6+ | 1+ | 3+ |
| Fishing Mortality | | | | | | | | |
| 2013 | 0.001 | 0.012 | 0.042 | 0.069 | 0.069 | 0.069 | | |
| 2014 | 0.004 | 0.046 | 0.154 | 0.25 | 0.25 | 0.25 | | |
| Jan-1 Population Numbers (000s) | | | | | | | | |
| 2013 | 7811 | 2993 | 2757 | 2552 | 5677 | 2813 | | |
| 2014 | 7811 | 6388 | 2420 | 2164 | 1951 | 6490 | | |
| 2015 | 7811 | 6369 | 4997 | 1699 | 1380 | 5382 | | |
| Jan-1 Population Biomass (mt) | | | | | | | | |
| 2013 | 961 | 673 | 1059 | 1250 | 3378 | 2213 | 9535 | 7901 |
| 2014 | 961 | 1437 | 929 | 1061 | 1161 | 5108 | 10656 | 8258 |
| 2015 | 961 | 1433 | 1919 | 833 | 821 | 4236 | 10202 | 7808 |
| Spawning Stock Biomass (mt) | | | | | | | | |
| 2013 | 0 | 421 | 1080 | 1237 | 3345 | 1979 | 8062 | |
| 2014 | 0 | 887 | 905 | 972 | 1066 | 4234 | 8065 | |
| Catch Numbers (000s) | | | | | | | | |
| 2013 | 8 | 34 | 103 | 153 | 341 | 169 | | |
| 2014 | 28 | 258 | 313 | 436 | 393 | 1307 | | |
| Fishery Yield (mt including discards) | | | | | | | | |
| 2013 | 1 | 11 | 46 | 83 | 225 | 133 | **500** | |
| 2014 | 5 | 86 | 140 | 236 | 259 | 1028 | **1754** | |

*Table 20e. Deterministic projections from the Single Series VPA with SSB rho adjustment applied to all ages in the first year for Georges Bank yellowtail assuming the quota is caught next year and $F_{ref}$ is applied in the quota year.*

| | Age Group | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6+ | 1+ | 3+ |
| Fishing Mortality | | | | | | | | |
| 2013 | 0.006 | 0.067 | 0.226 | 0.367 | 0.367 | 0.367 | | |
| 2014 | 0.004 | 0.046 | 0.154 | 0.25 | 0.25 | 0.25 | | |
| Jan-1 Population Numbers (000s) | | | | | | | | |
| 2013 | 1664 | 638 | 587 | 544 | 1209 | 599 | | |
| 2014 | 1664 | 1354 | 488 | 384 | 308 | 1026 | | |
| 2015 | 1664 | 1357 | 1059 | 343 | 245 | 851 | | |
| Jan-1 Population Biomass (mt) | | | | | | | | |
| 2013 | 205 | 143 | 226 | 266 | 719 | 471 | 2031 | 1683 |
| 2014 | 205 | 305 | 187 | 188 | 183 | 807 | 1876 | 1366 |
| 2015 | 205 | 305 | 407 | 168 | 146 | 669 | 1900 | 1390 |
| Spawning Stock Biomass (mt) | | | | | | | | |
| 2013 | 0 | 88 | 213 | 233 | 629 | 372 | 1535 | |
| 2014 | 0 | 188 | 183 | 172 | 168 | 669 | 1381 | |
| Catch Numbers (000s) | | | | | | | | |
| 2013 | 9 | 37 | 108 | 152 | 339 | 168 | | |
| 2014 | 6 | 55 | 63 | 77 | 62 | 207 | | |
| Fishery Yield (mt including discards) | | | | | | | | |
| 2013 | 1 | 12 | 48 | 83 | 223 | 132 | **500** | |
| 2014 | 1 | 18 | 28 | 42 | 41 | 163 | **293** | |

*Table 21. Projection results under two fishing mortality rates: $F_{ref}$=0.25 and 75% $F_{ref}$=0.1875. The rows definitions are Catch=median Catch (mt) in 2014, Adult Jan-1 B=median beginning year age 3+ biomass in 2014, delta B = change in median adult Jan-1 biomass from 2014 to 2015, P(B inc) = probability that adult Jan-1 biomass will increase from 2014 to 2015, P(B inc 10%) = probability that adult Jan-1 biomass will increase by at least 10% from 2014 to 2015. The column definitions are Split=Split Series VPA, adjSp=Split Series VPA adjusted for SSB retrospective, Single=Single Series VPA, adjSi=Single Series VPA adjusted for SSB retrospective. The Split and Single results are shown in a different font to indicate that they do not sufficiently address the retrospective problem.*

| | Split | adjSp | Single | adjSi |
|---|---|---|---|---|
| **Fref = 0.25** | | | | |
| Catch | 562 | 123 | 1833 | 314 |
| Adult Jan-1 B | 2671 | 569 | 8620 | 1443 |
| delta B | 26% | 56% | -6% | 1% |
| P(B inc) | 1 | 1 | 0.031 | 0.563 |
| P(B inc 10%) | 0.997 | 1 | 0 | 0.044 |
| | | | | |
| **F75%Fref = 0.1875** | | | | |
| Catch | 432 | 95 | 1412 | 242 |
| Adult Jan-1 B | 2671 | 569 | 8620 | 1443 |
| delta B | 31% | 61% | -1% | 5% |
| P(B inc) | 1 | 1 | 0.36 | 0.888 |
| P(B inc 10%) | 1 | 1 | 0 | 0.21 |

*Table 22. Implications of five 2014 quotas (100-500 mt) in four projection scenarios described in Table 20: P(F>Fref) = probability fishing mortality rate in 2014 will exceed $F_{ref}$, F2014 = median 2014 F, delta B = relative change in median biomass from 2014 to 2015, P(B inc) = probability median adult Jan-1 biomass will increase or P(B inc 10%) = increase by at least 10%. The Split Series and Single Series unadjusted results are shown in a different font to indicate that they do not sufficiently address the retrospective problem.*

| | 2014 Quota (mt) | | | | |
|---|---|---|---|---|---|
| | 100 | 200 | 300 | 400 | 500 |
| **Split Series** | | | | | |
| P(F>Fref) | 0.00 | 0.00 | 0.00 | 0.05 | 0.29 |
| F2014 | 0.04 | 0.08 | 0.13 | 0.17 | 0.22 |
| delta B | 42% | 39% | 35% | 32% | 28% |
| P(B inc) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| P(B inc 10%) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Split Series rho adjusted** | | | | | |
| P(F>Fref) | 0.26 | 0.97 | 1.00 | 1.00 | 1.00 |
| F2014 | 0.20 | 0.43 | 0.71 | 1.05 | 1.48 |
| delta B | 60% | 44% | 27% | 11% | -4% |
| P(B inc) | 1.00 | 1.00 | 1.00 | 1.00 | 0.21 |
| P(B inc 10%) | 1.00 | 1.00 | 1.00 | 0.66 | 0.02 |
| **Single Series** | | | | | |
| P(F>Fref) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| F2014 | 0.01 | 0.02 | 0.04 | 0.05 | 0.06 |
| delta B | 13% | 12% | 11% | 10% | 9% |
| P(B inc) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| P(B inc 10%) | 0.84 | 0.75 | 0.63 | 0.49 | 0.33 |
| **Single Series rho adjusted** | | | | | |
| P(F>Fref) | 0.00 | 0.02 | 0.42 | 0.89 | 0.99 |
| F2014 | 0.07 | 0.15 | 0.24 | 0.33 | 0.43 |
| delta B | 14% | 8% | 1% | -5% | -11% |
| P(B inc) | 1.00 | 1.00 | 0.72 | 0.04 | 0.00 |
| P(B inc 10%) | 0.89 | 0.28 | 0.00 | 0.00 | 0.00 |

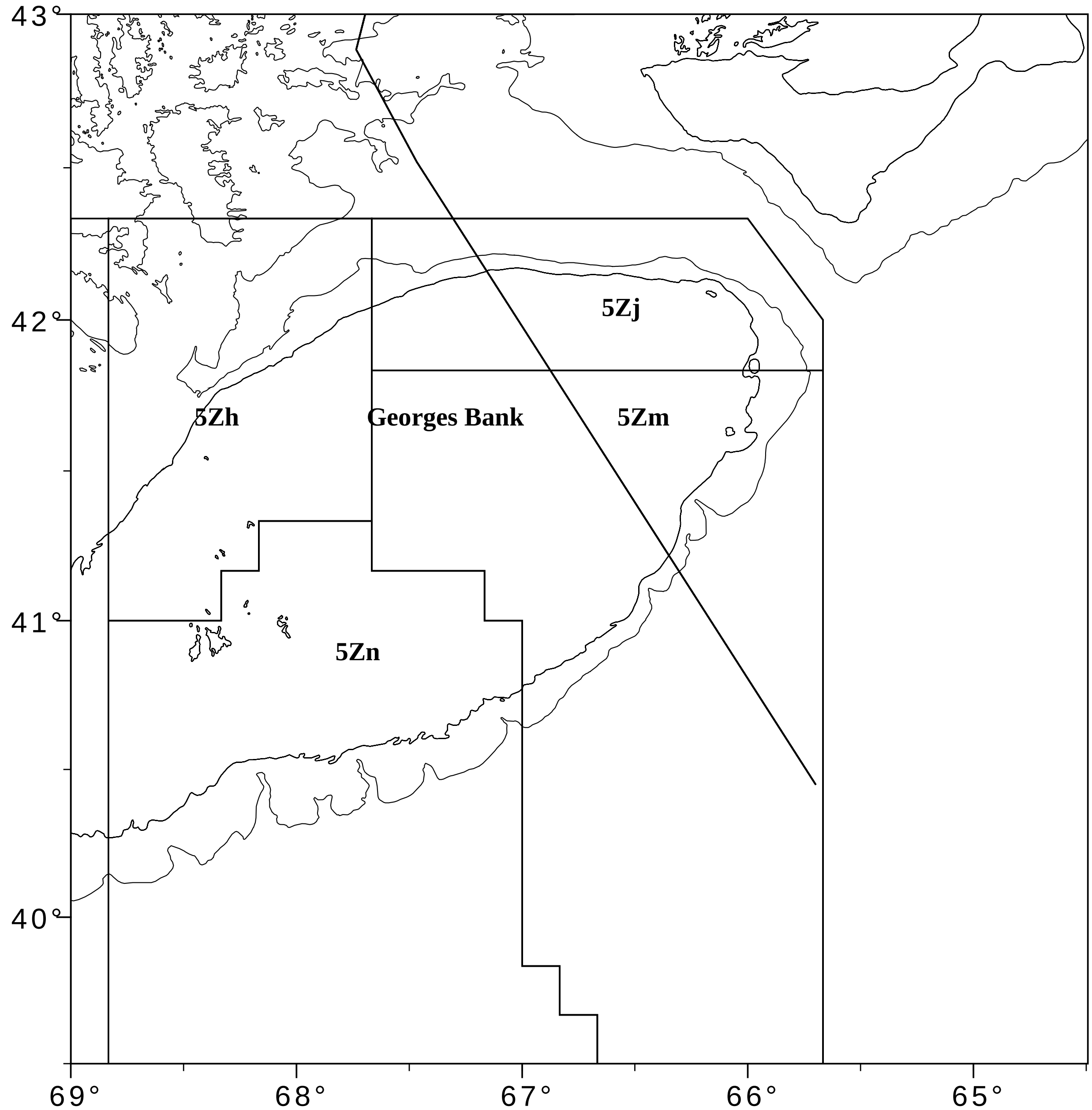



***Figure 1a**. Location of statistical unit areas for Canadian fisheries in NAFO Subdivision 5Ze.*

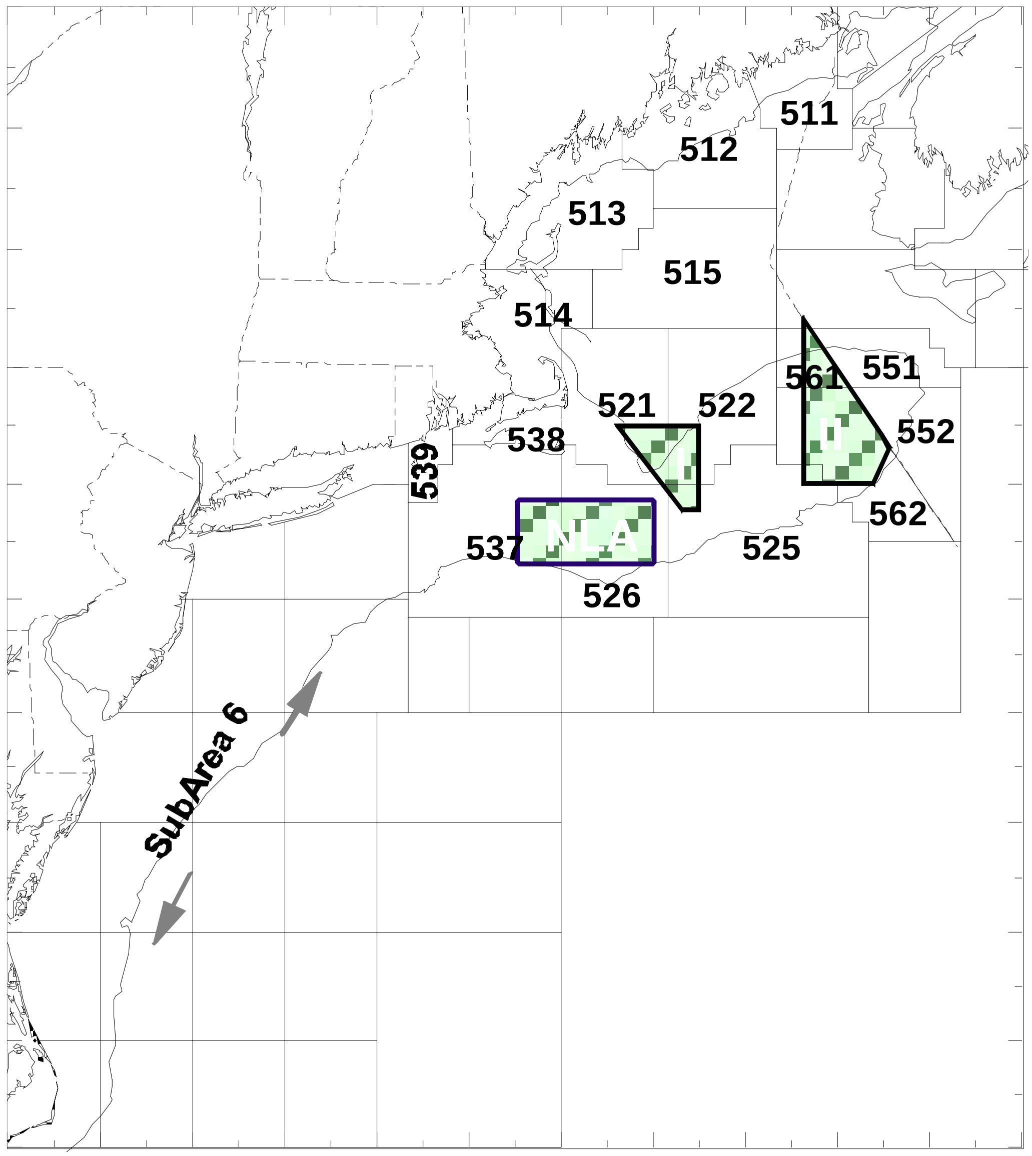



*Figure 1b. Statistical areas used for monitoring northeast US fisheries. Catches from areas 522, 525, 551, 552, 561 and 562 are included in the Georges Bank yellowtail flounder assessment. Shaded areas have been closed to fishing year-round since 1994, with exceptions.*

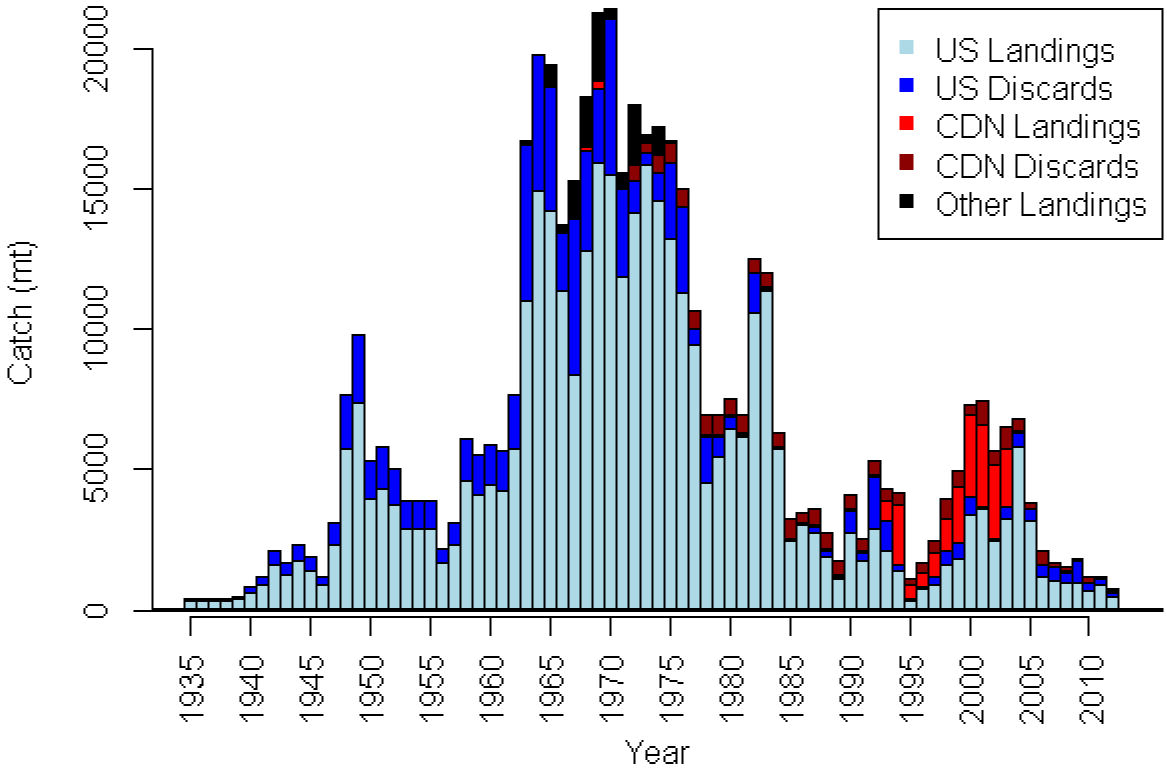



*Figure 2. Catch (landings plus discards) of Georges Bank yellowtail flounder by nation and year.*

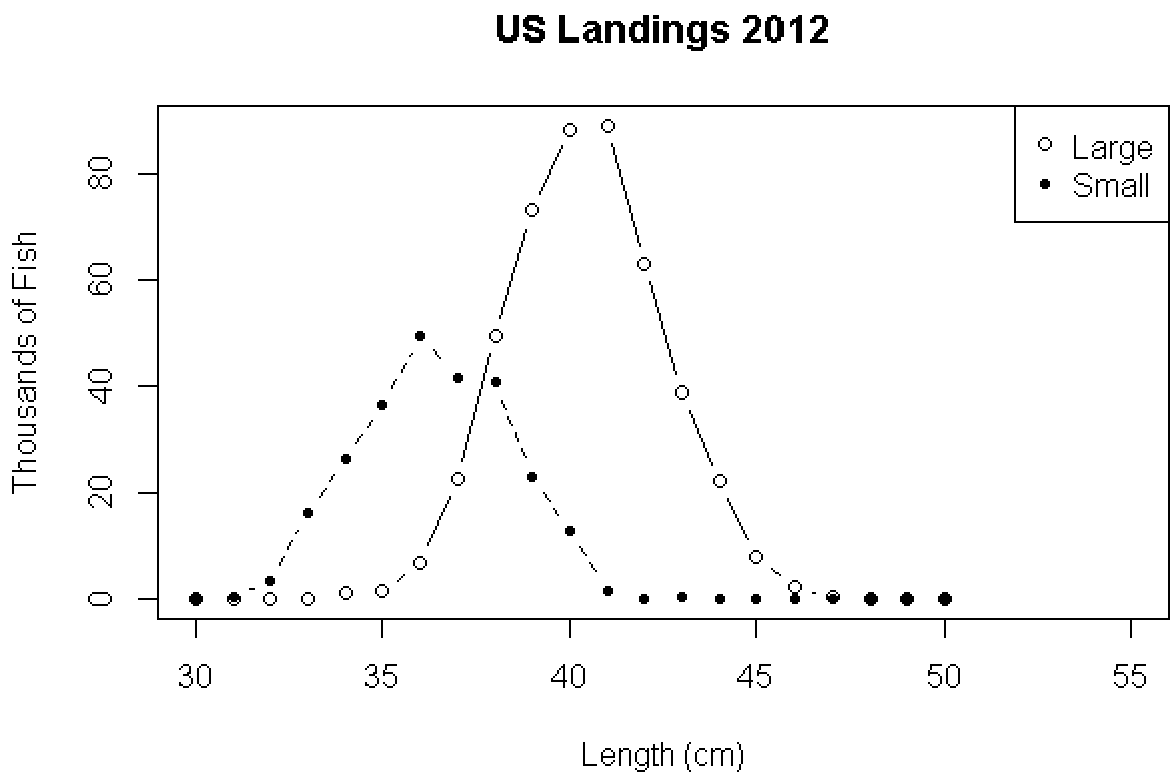



*Figure 3. US landings of Georges Bank yellowtail by market category.*

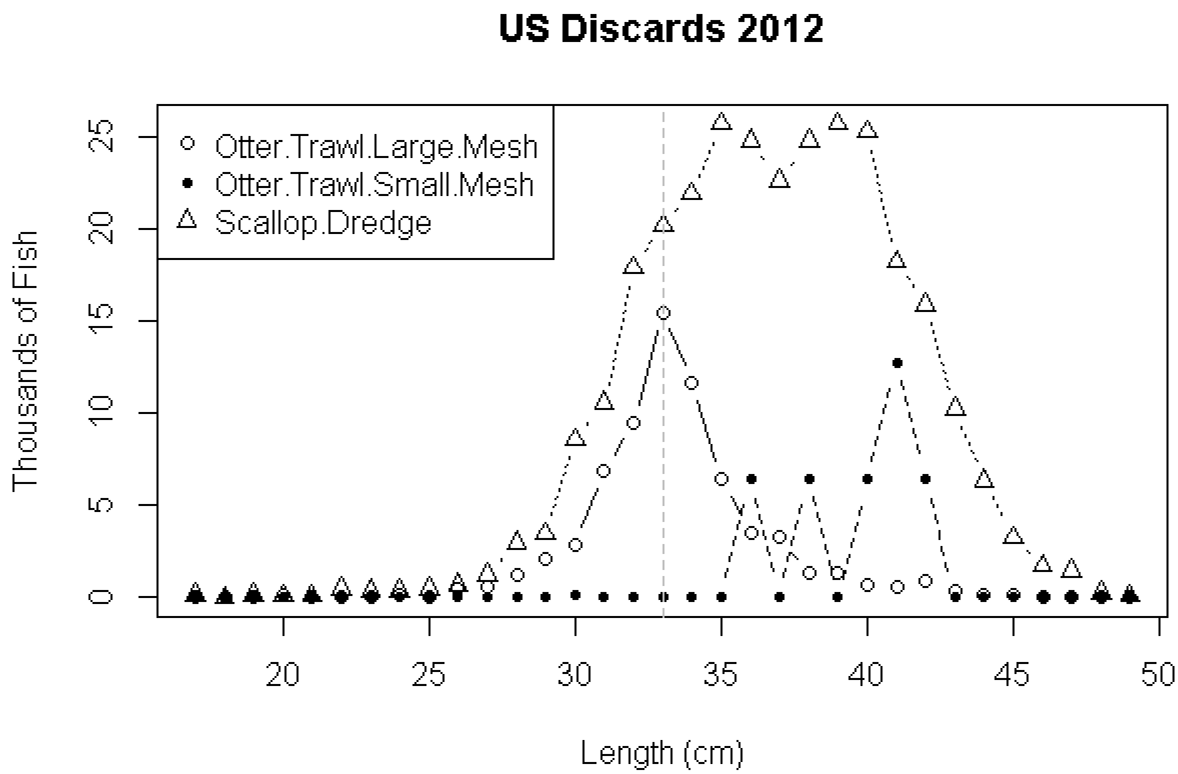



*Figure 4. US yellowtail flounder discard length frequencies by gear. The vertical line at 33 cm denotes the US minimum legal size for landing yellowtail flounder. The distinction between large and small mesh in the cod end of the trawl occurs at 5.5 inches (14 cm).*

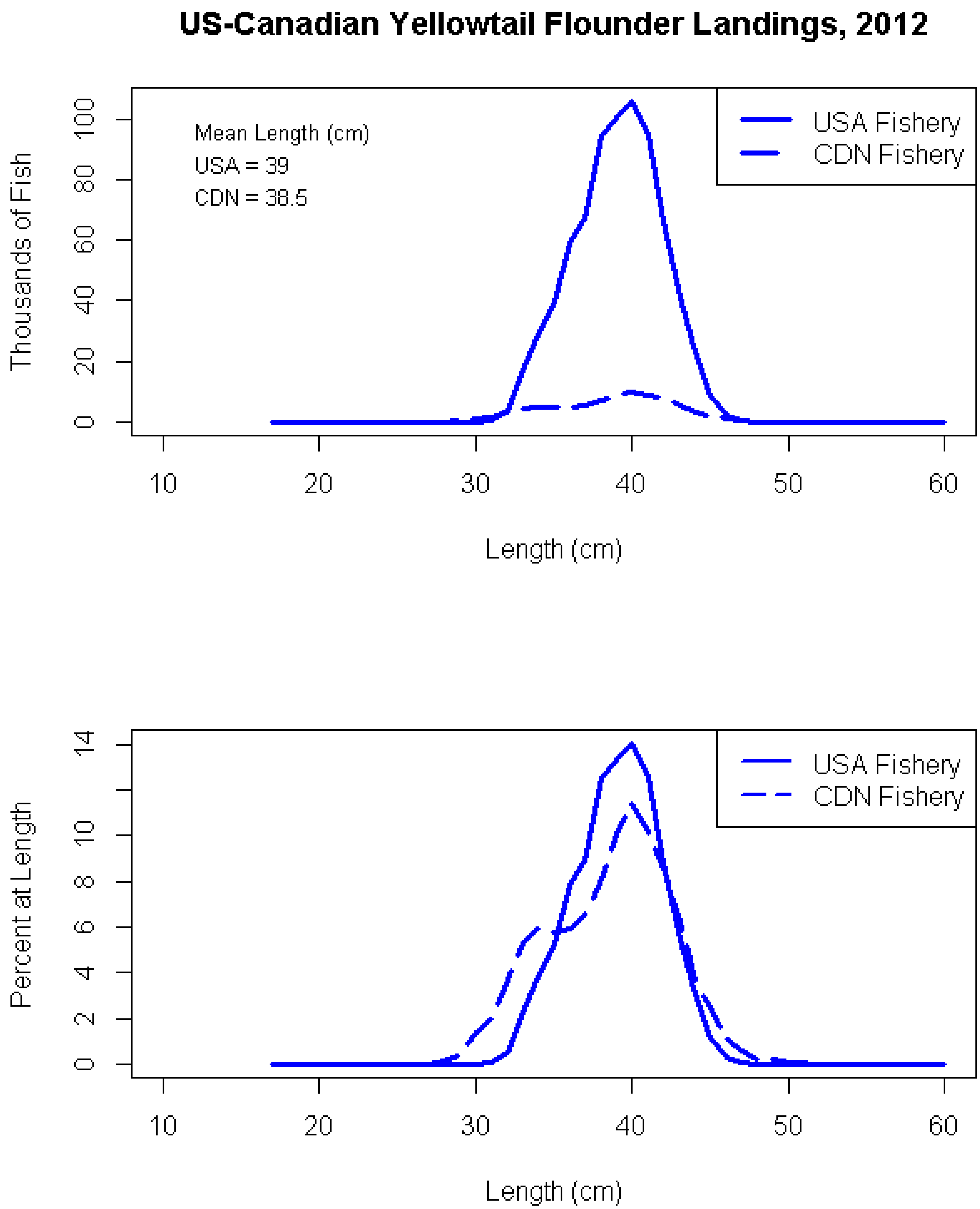



*Figure 5. Comparison of US and Canadian landings at length for Georges Bank yellowtail flounder.*

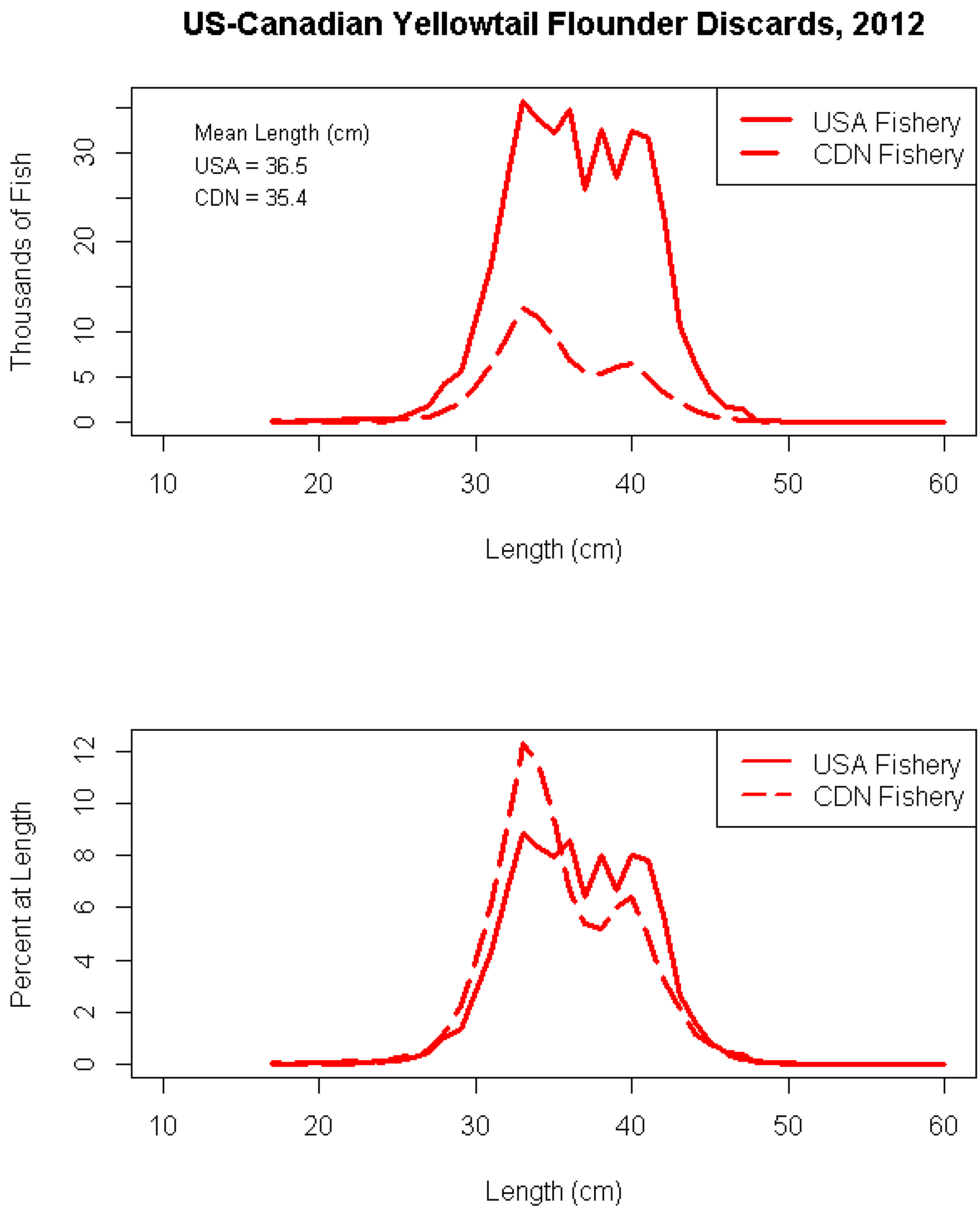



*Figure 6. Comparison of US and Canadian discards at length for Georges Bank yellowtail flounder.*

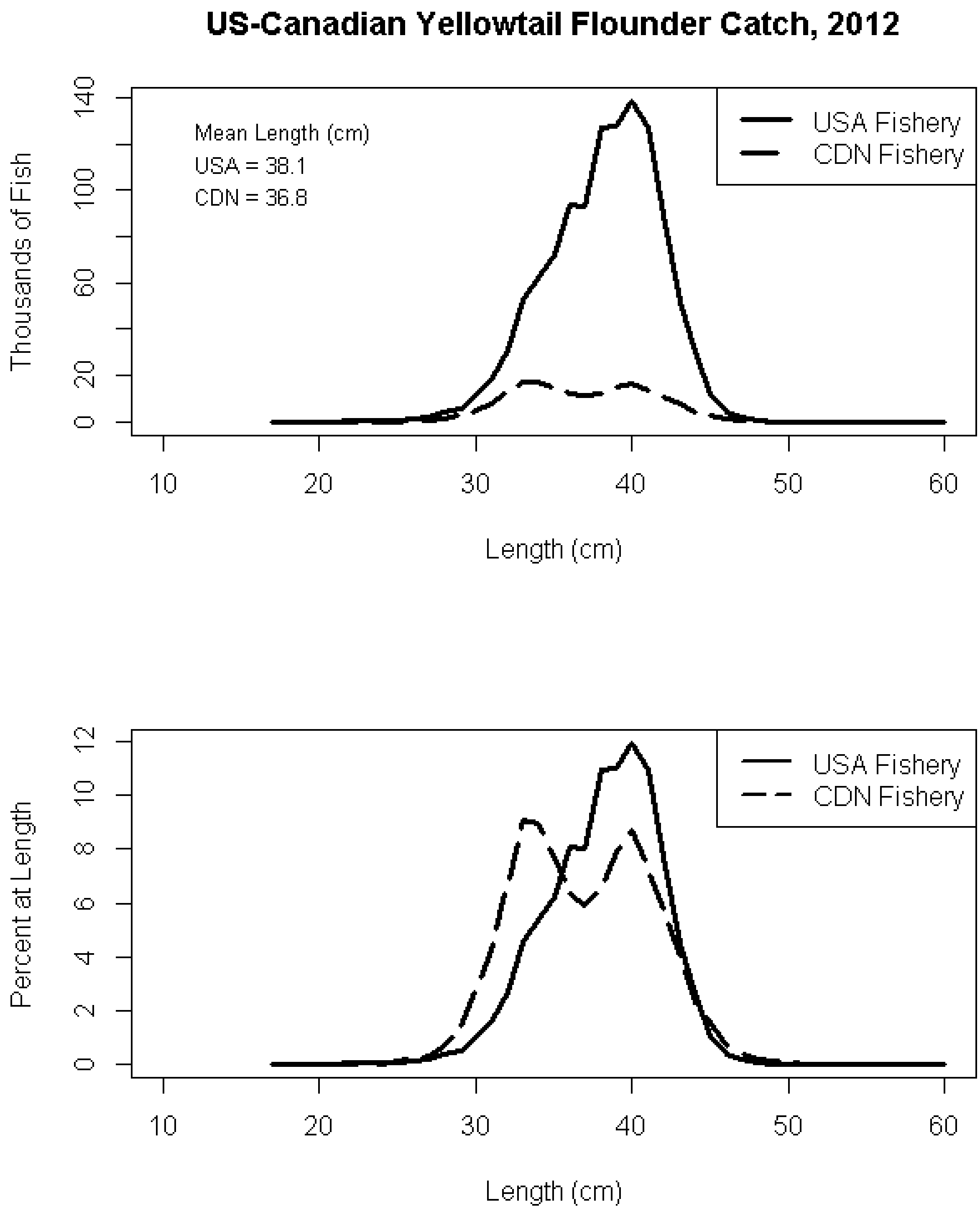



*Figure 7. Comparison of US and Canadian catch (landings plus discards) at length for Georges Bank yellowtail flounder.*

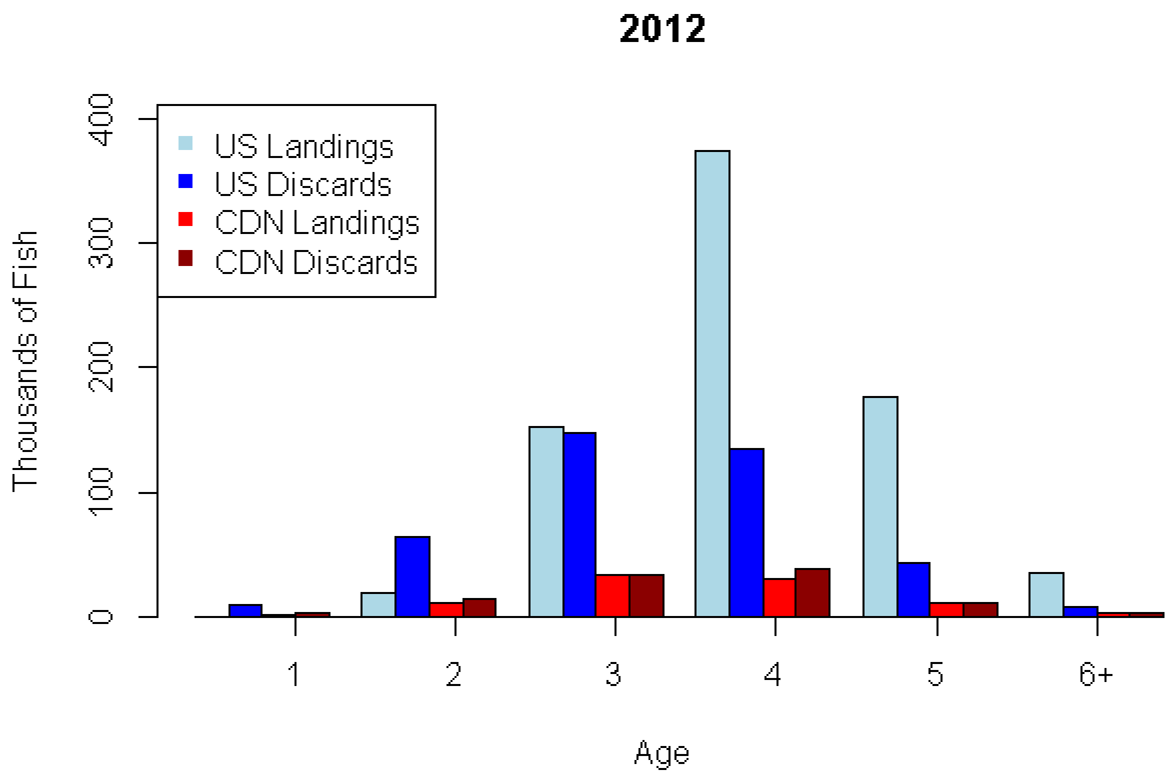



*Figure 8. Catch at age of Georges Bank yellowtail flounder from the four components of Canadian and US landings and discards.*

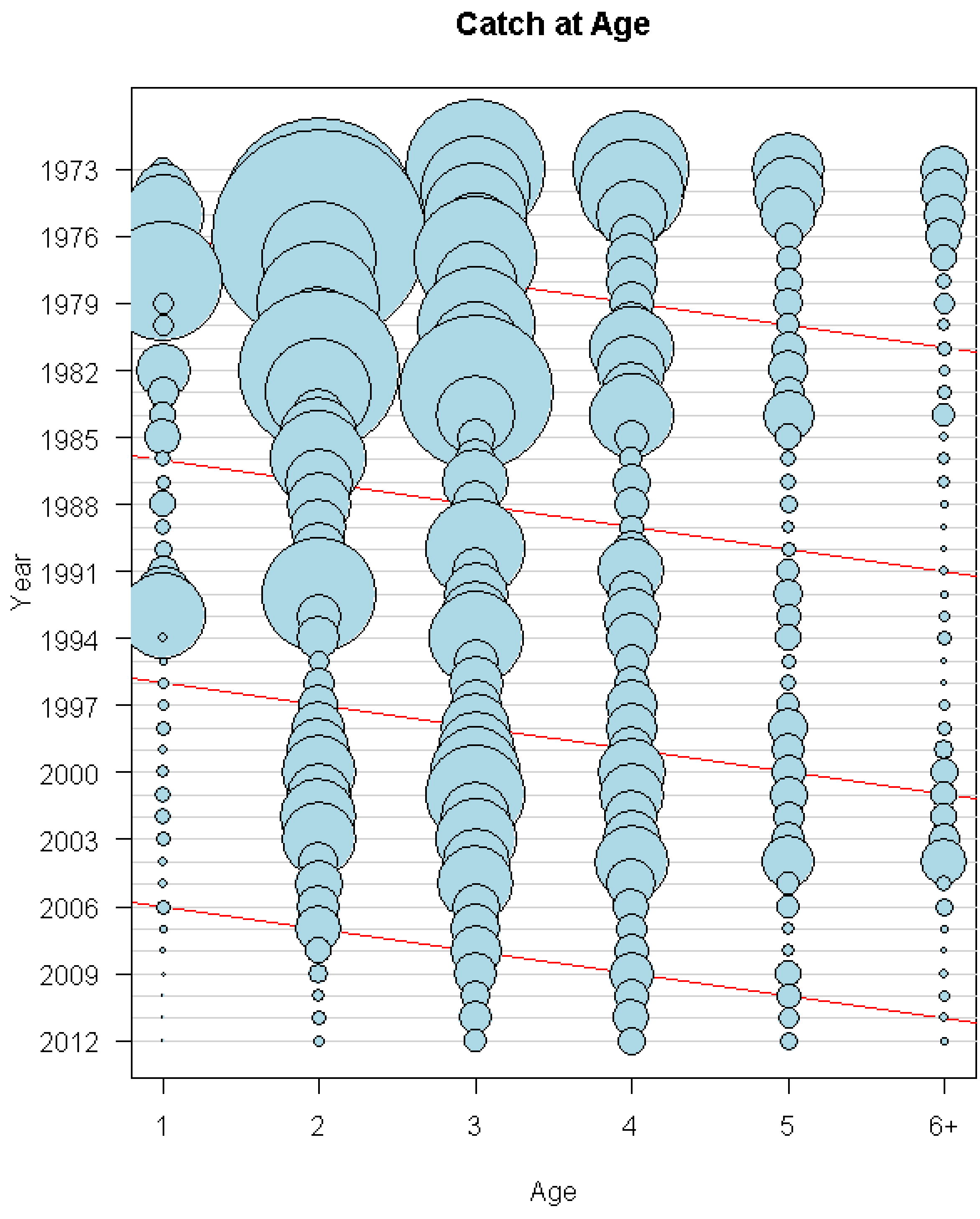



*Figure 9. Catch at age for Georges Bank yellowtail flounder, Canadian and US fisheries combined. (The area of the bubble is proportional to the magnitude of the catch). Diagonal red lines denote the 1975, 1985, 1995, and 2005 year-classes.*

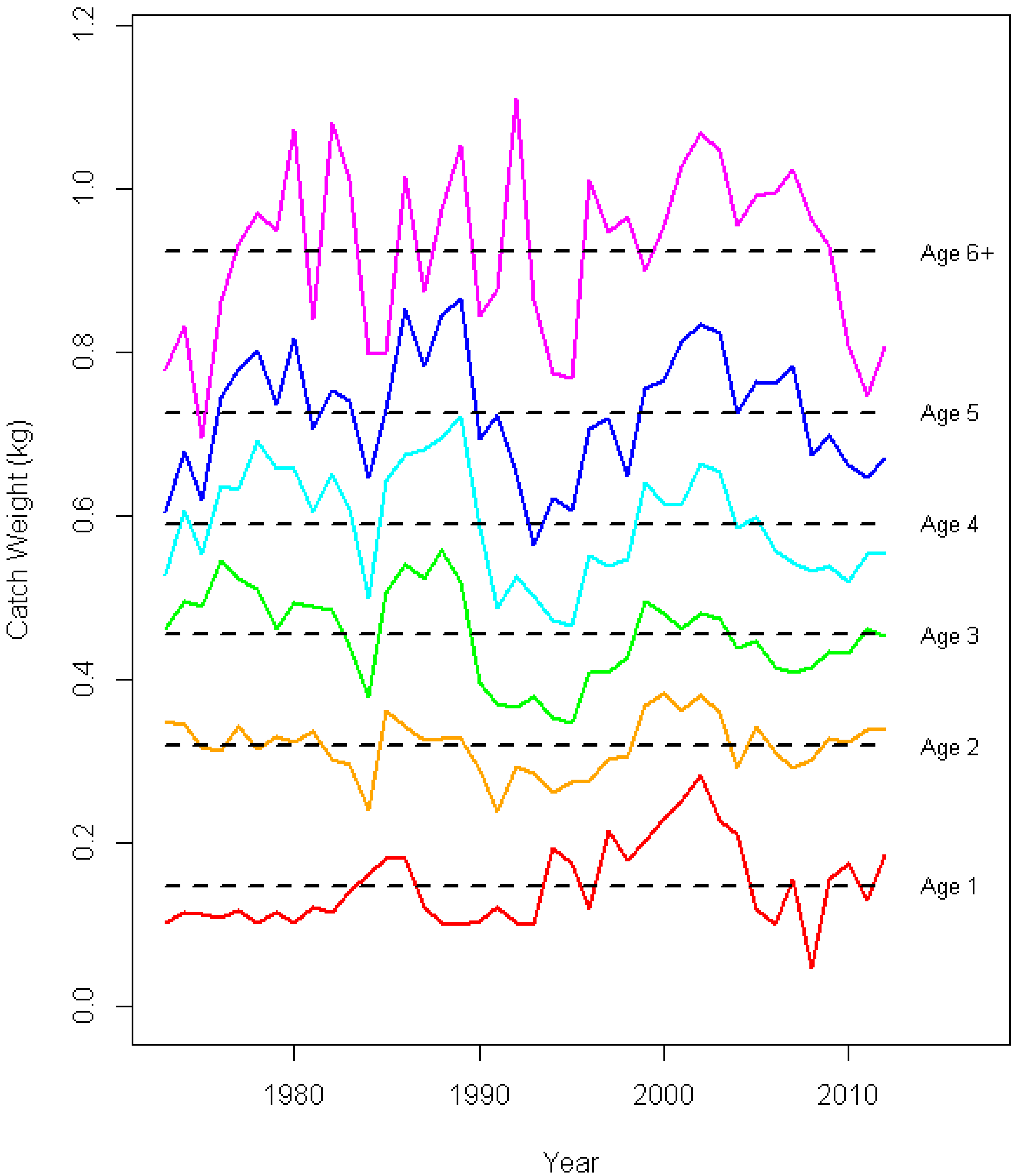



*Figure 10. Trends in mean weight at age from the Georges Bank yellowtail fishery (Canada and US combined, including discards). Dashed lines denote average of time series.*

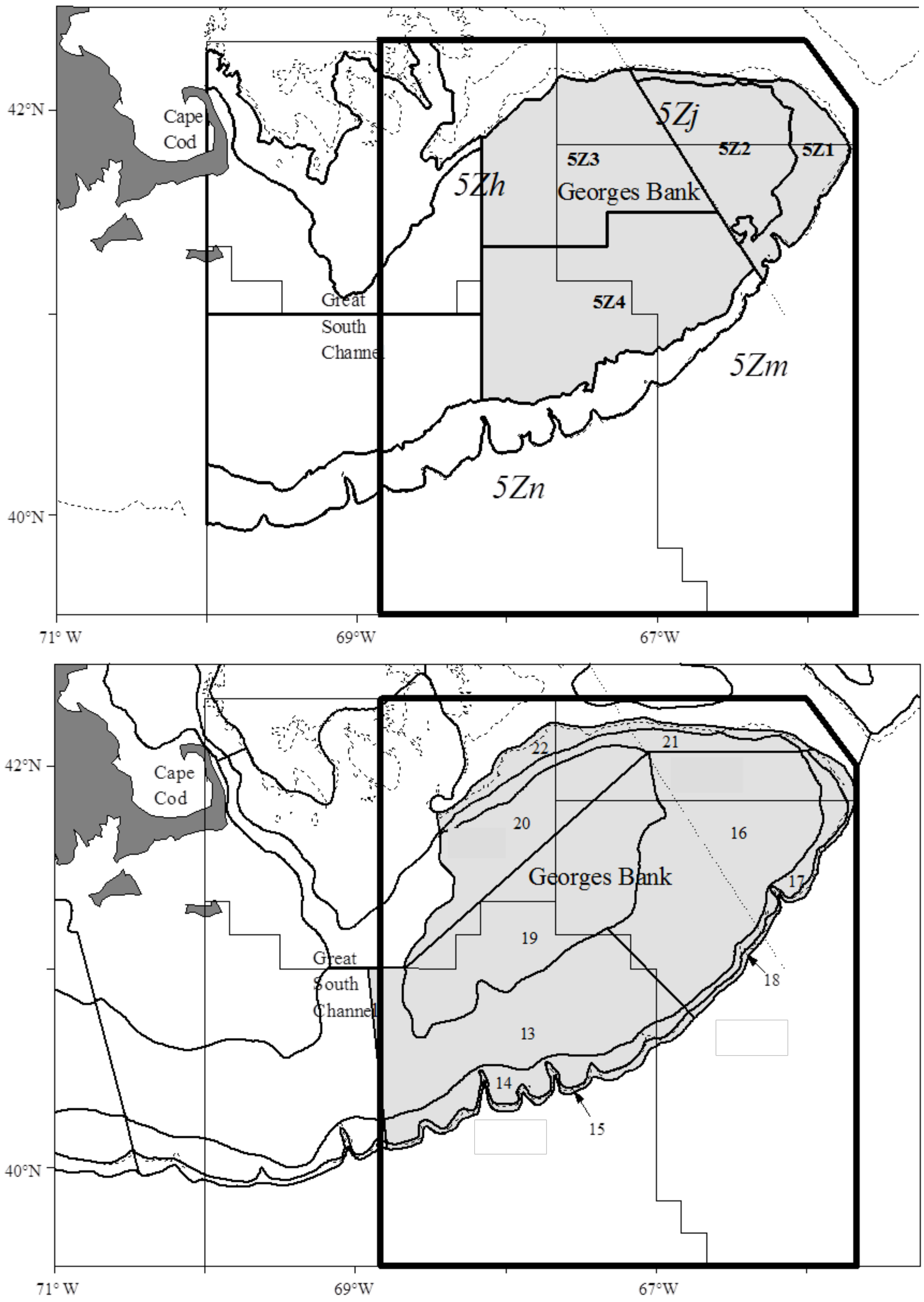



*Figure 11. DFO (top) and NMFS (bottom) strata used to derive research survey abundance indices for Georges Bank groundfish surveys. Note NMFS stratum 22 is not used in assessment.*

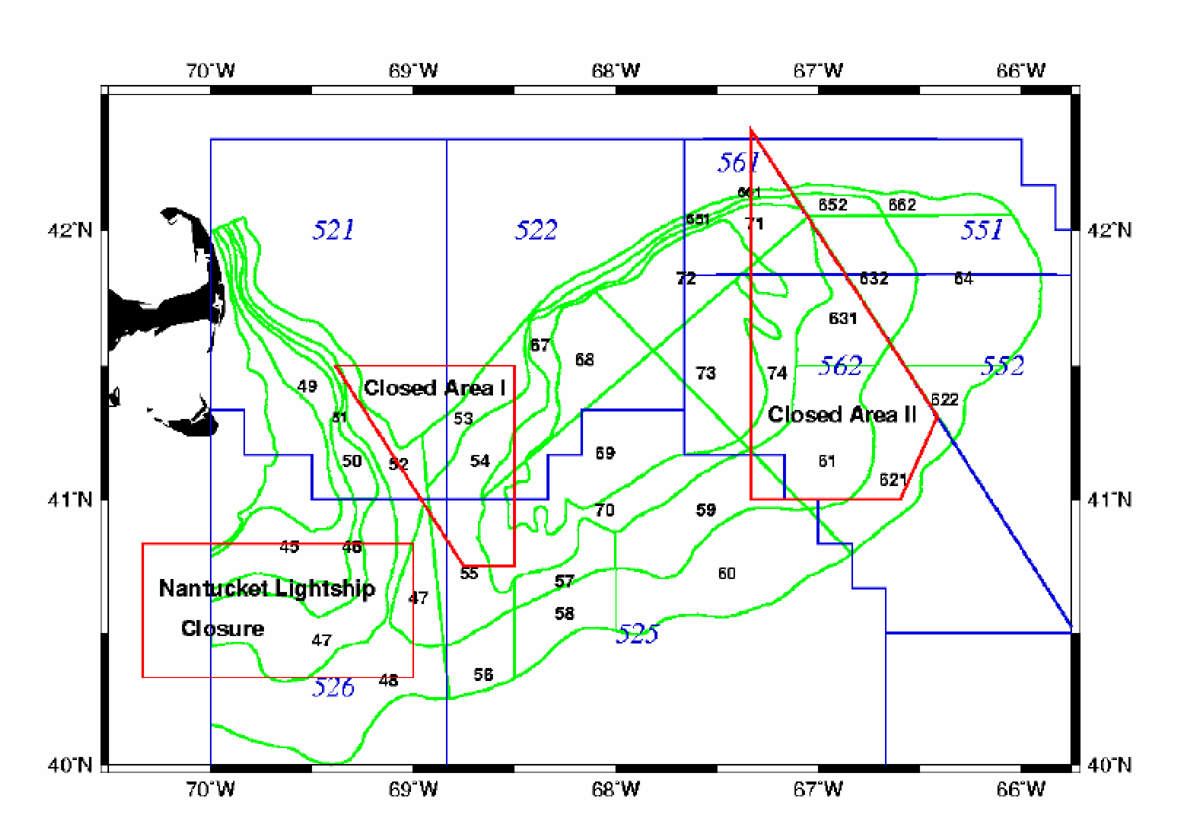



*Figure 11. (continued) NMFS scallop survey strata used to derive research survey abundance indices for Georges Bank groundfish surveys. Strata 54, 55, 58-72, and 74 are used to estimate the abundance of yellowtail flounder for this assessment.*

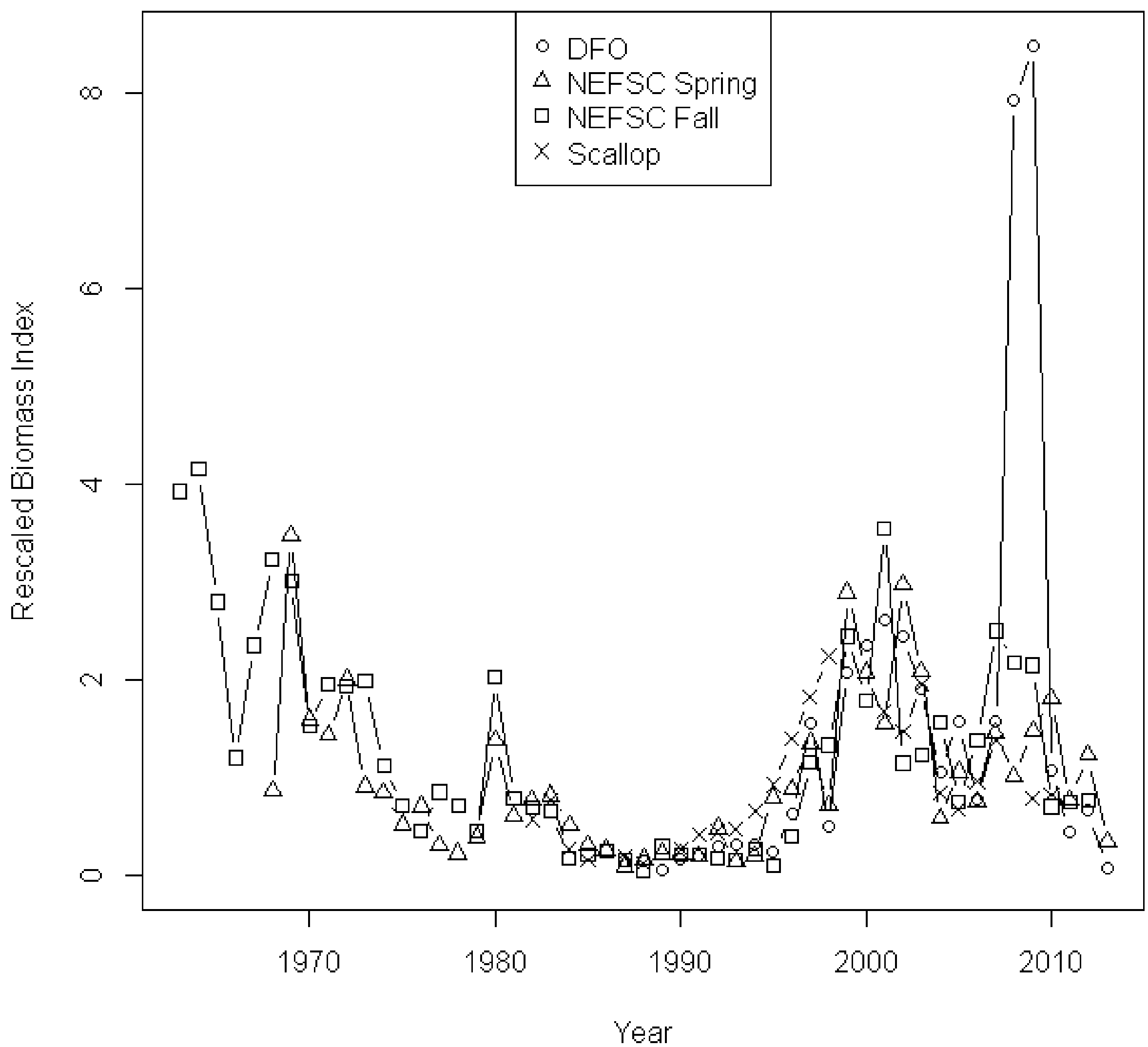



*Figure 12a. Four survey biomass indices (DFO, NEFSC spring, NEFSC fall and NEFSC scallop) for yellowtail flounder on Georges Bank rescaled to their respective means for years 1987-2007.*

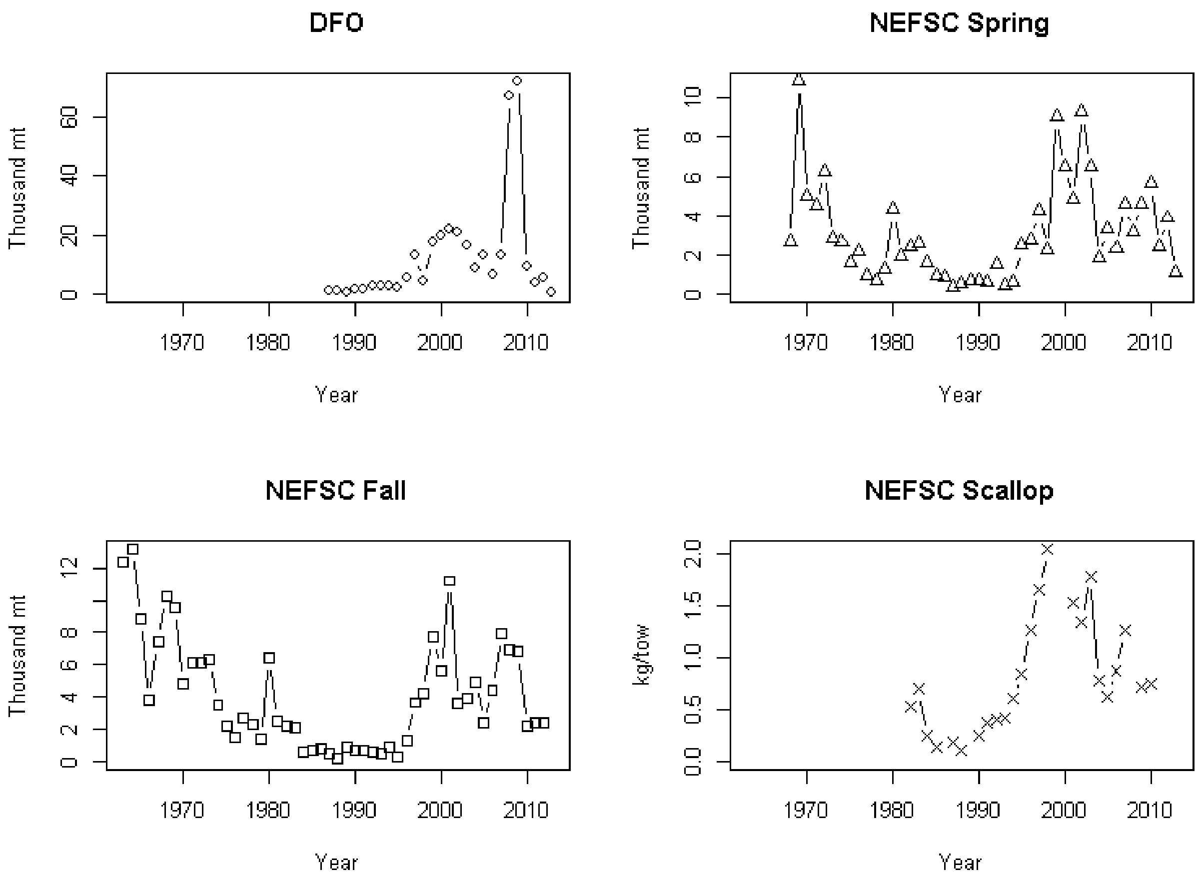



*Figure 12b. Survey biomass for yellowtail flounder on Georges Bank in units of thousand metric tons (DFO, NEFSC spring, NEFSC fall, all three are minimum swept area biomass values) or kg/tow (NEFSC scallop, stratified mean catch per tow).*

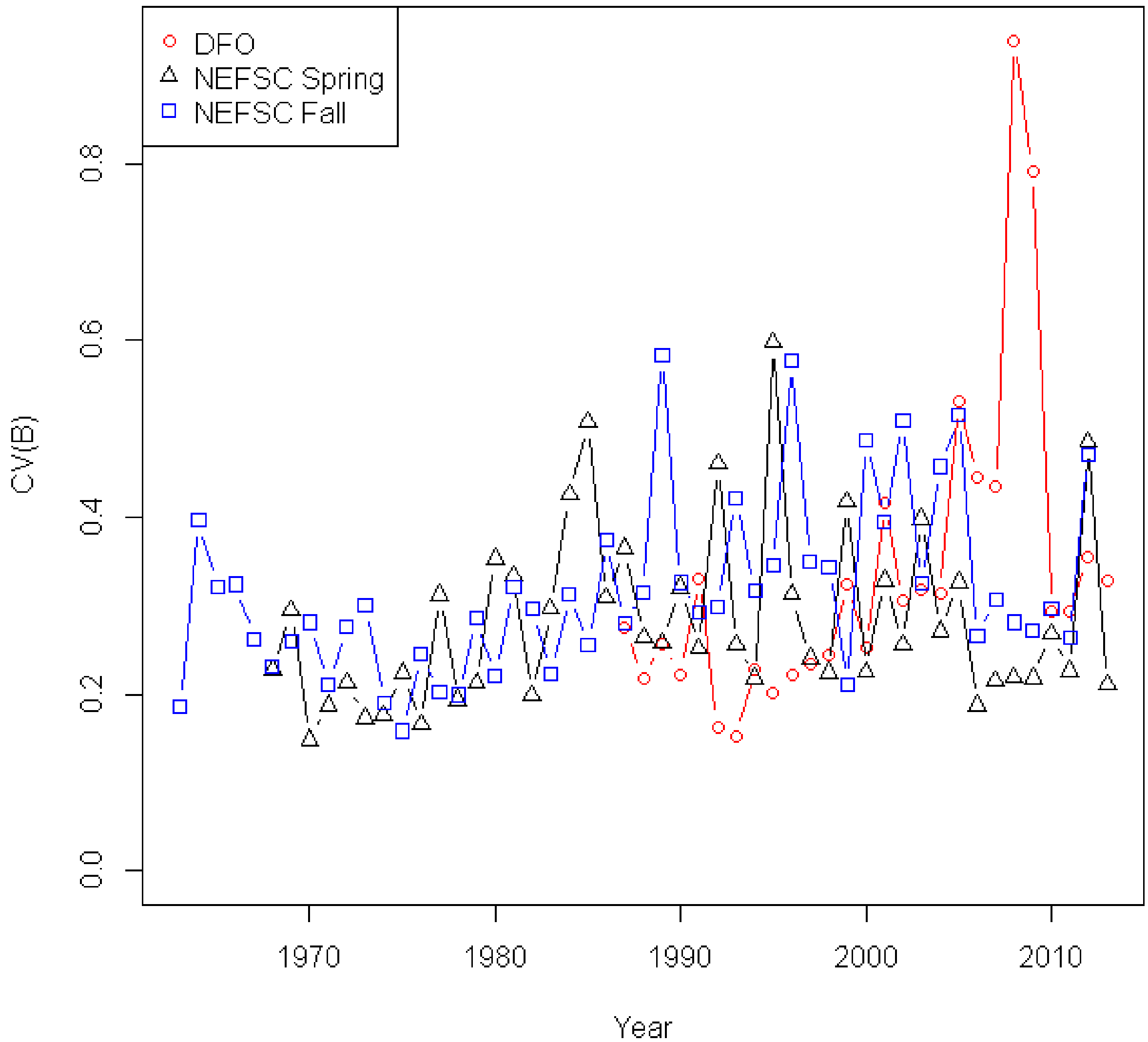



*Figure 12c. Survey biomass coefficients of variation for yellowtail flounder on Georges Bank for the three bottom trawl surveys.*

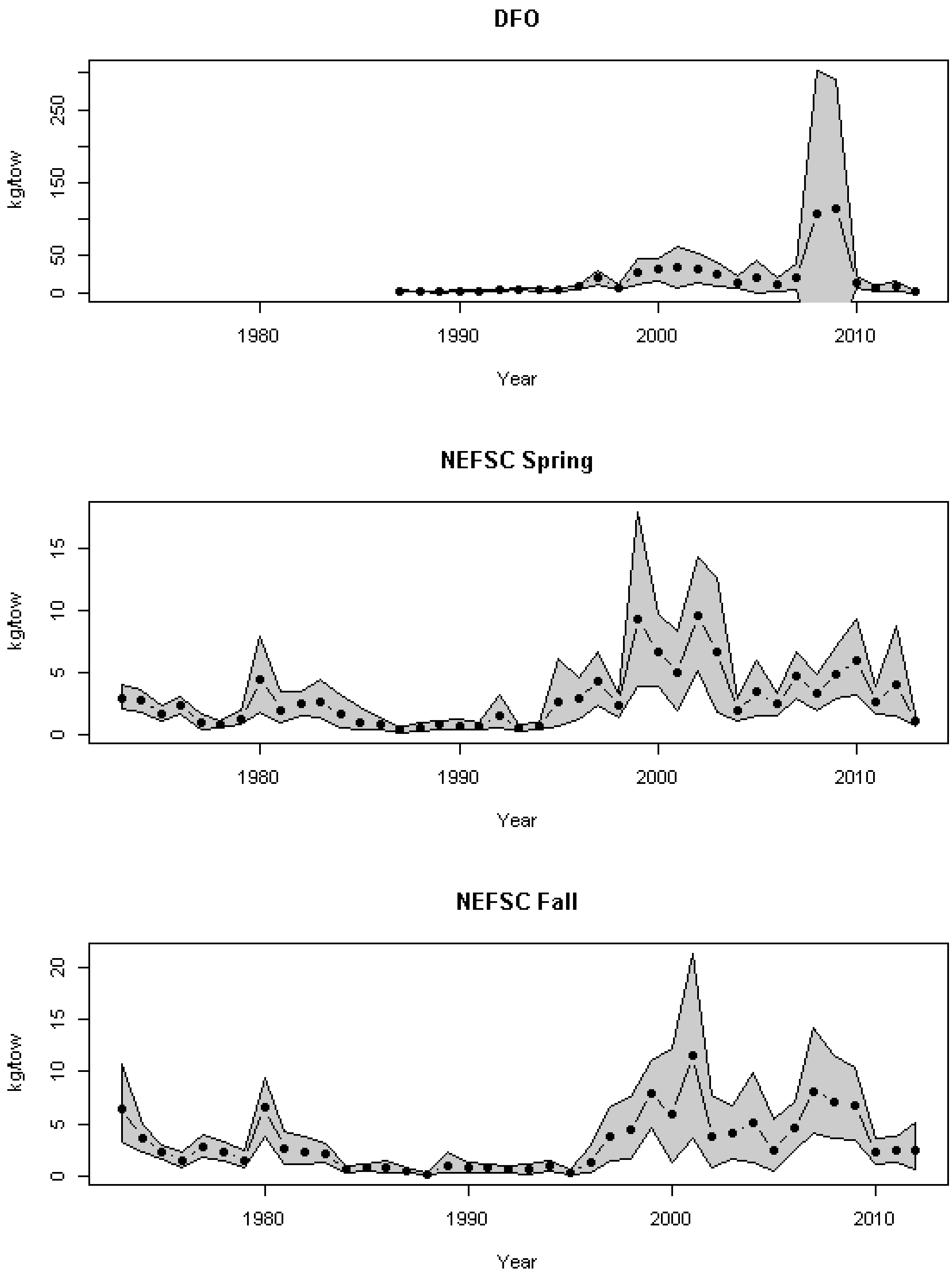



*Figure 12d. Survey biomass for yellowtail flounder on Georges Bank in units of kg/tow with 95% confidence intervals from +/- 1.96*stdev (DFO) or bootstrapping (NEFSC spring and NEFSC fall) for years in the assessment.*

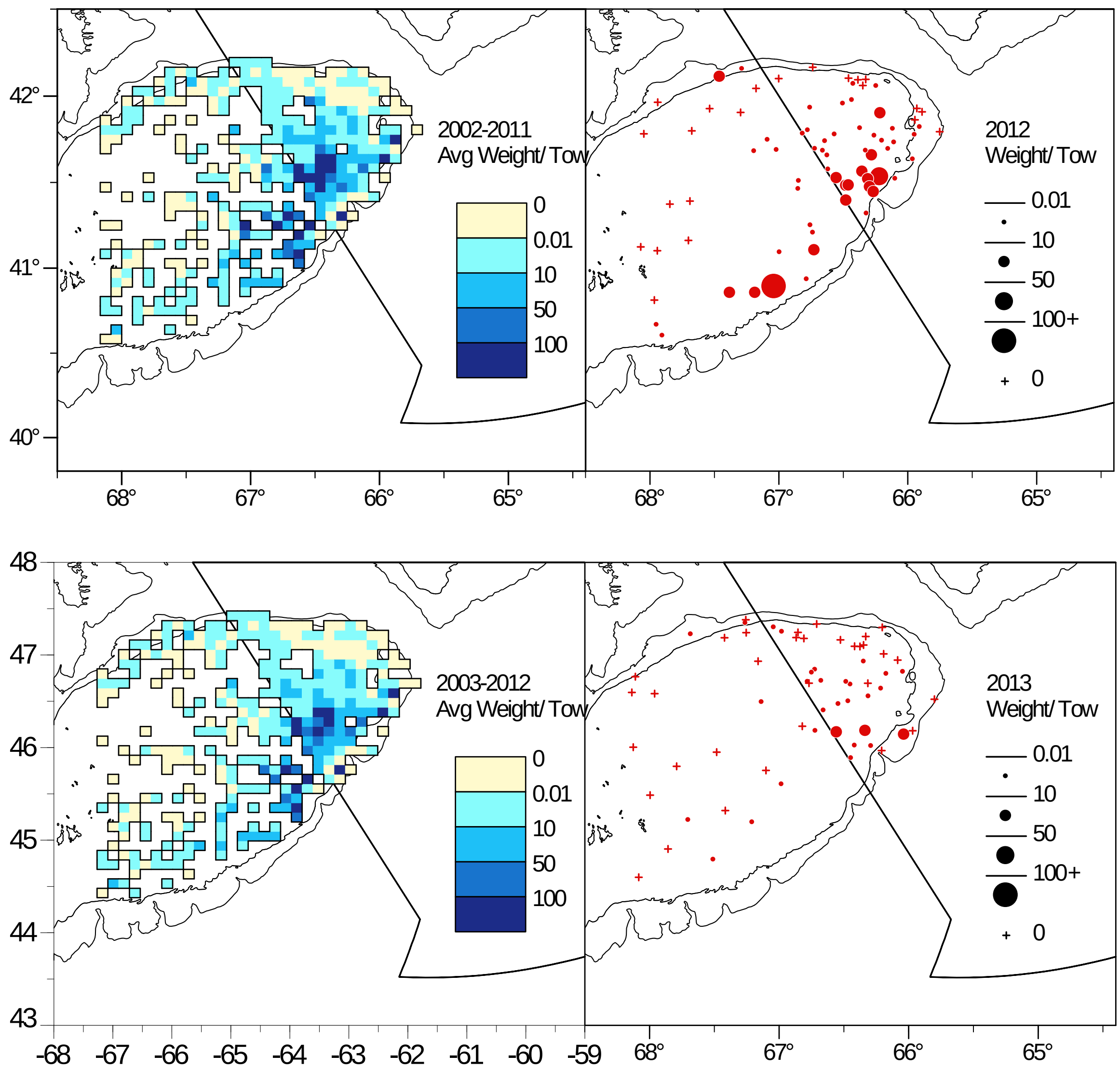



*Figure 13a. Catch of yellowtail in weight (kg) per tow for DFO survey. Left panel shows previous 10 year averages, right panel most recent data. Catch for 2012 and 2013 shown for comparison between years.*

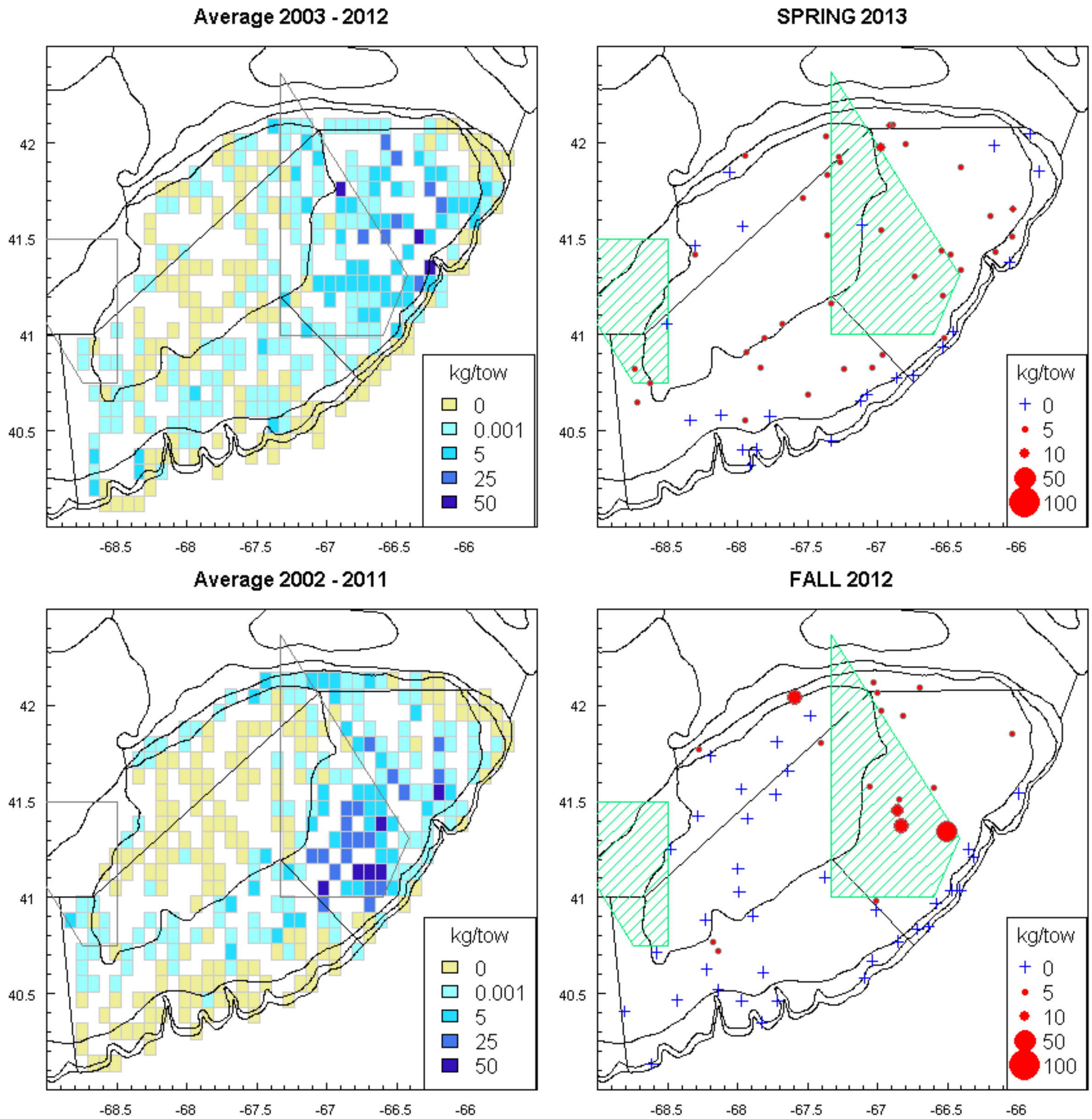



*Figure 13b. Catch of yellowtail in weight (kg) per tow for NEFSC spring (top) and NEFSC fall (bottom) surveys. Left panels show previous 10 year averages, right panels most recent data. Note the 2009 - 2013 survey values were adjusted from Henry B. Bigelow to Albatross IV equivalents by dividing Henry B. Bigelow catch in weight by 2.244 (spring) or 2.402 (fall).*

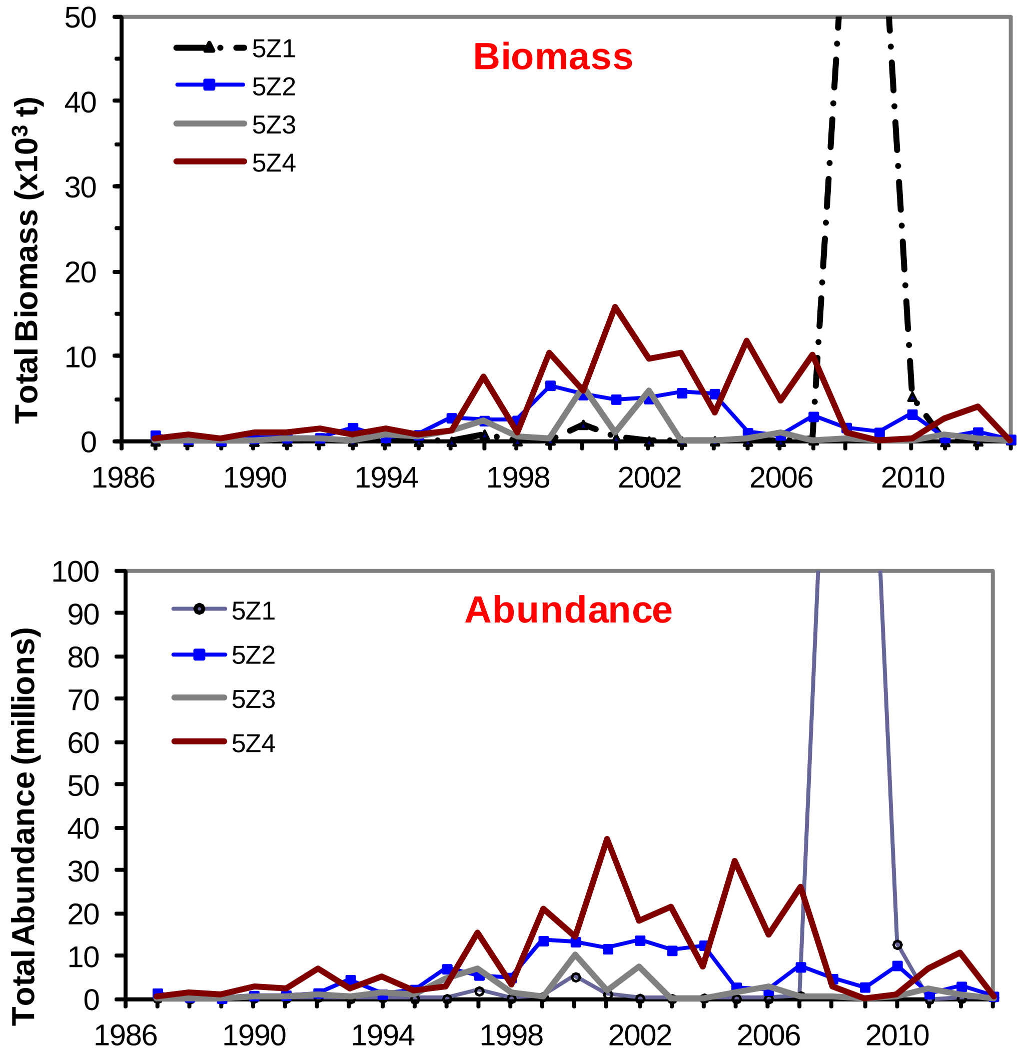
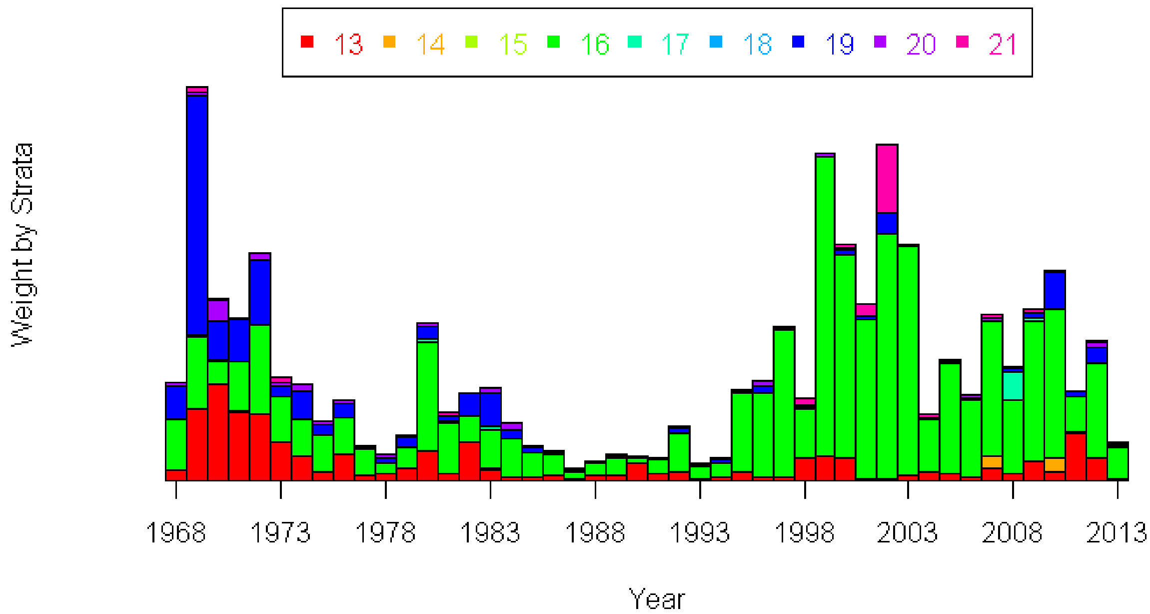



*Figure 14a. DFO spring survey estimates of total biomass (top panel) and total number (bottom panel) by stratum area for yellowtail flounder on Georges Bank.*




**NEFSC Spring**

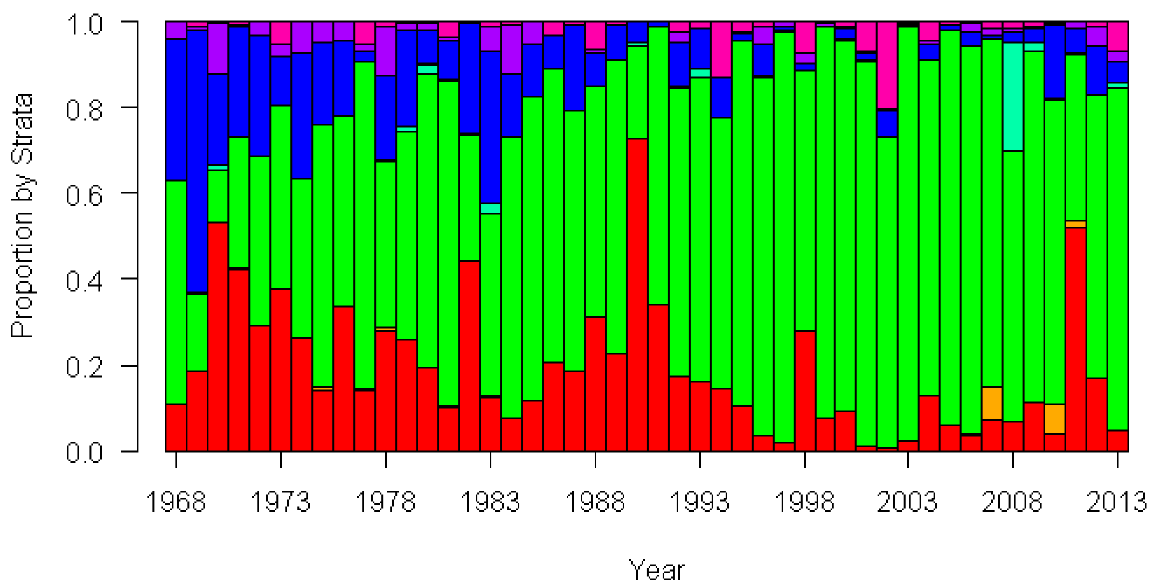



*Figure 14b. NEFSC spring survey estimates of total biomass (top panel) and proportion (bottom panel) by stratum for yellowtail flounder on Georges Bank.*

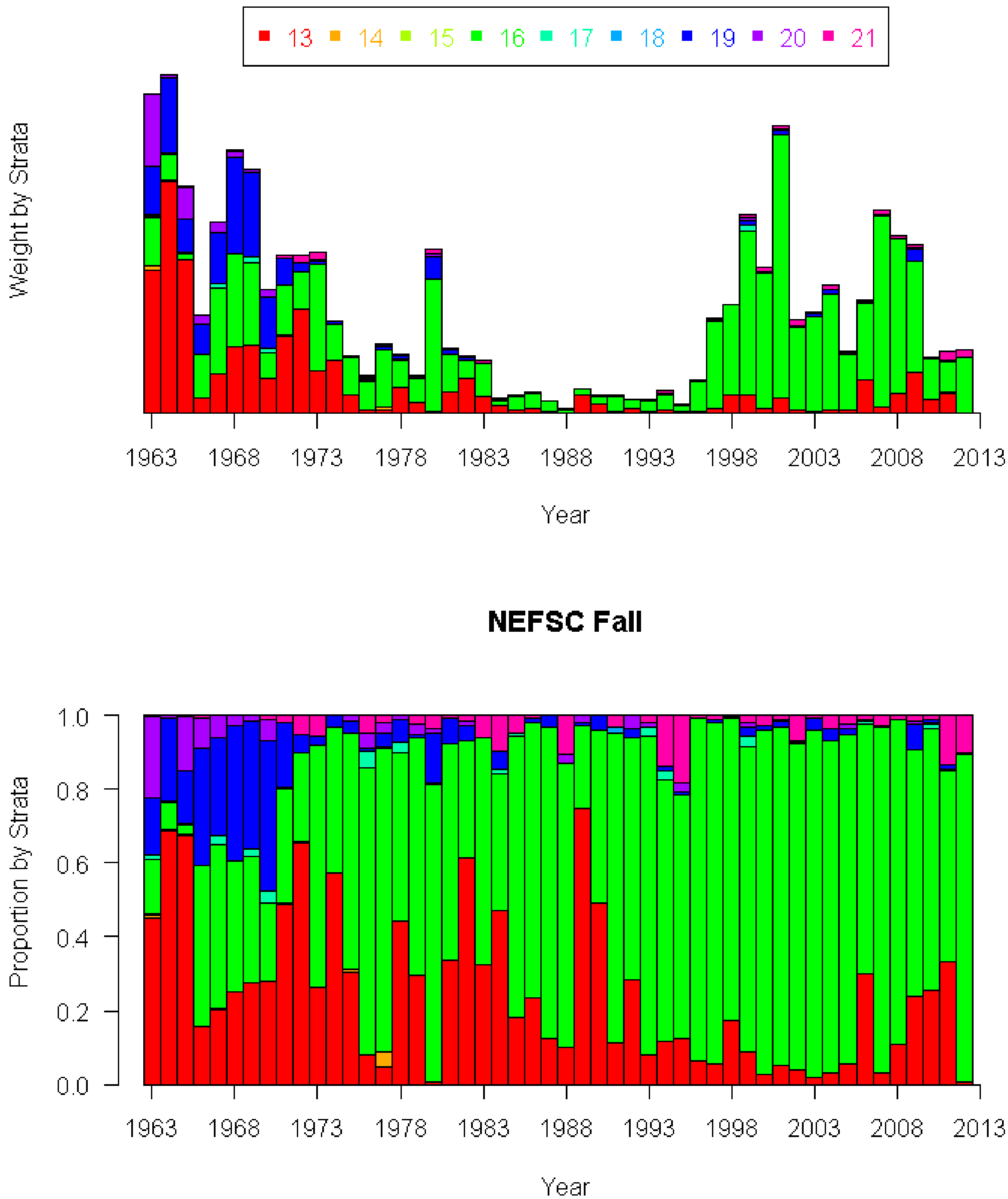



*Figure 14c. NEFSC fall survey estimates of total biomass (top panel) and proportion (bottom panel) by stratum for yellowtail flounder on Georges Bank.*

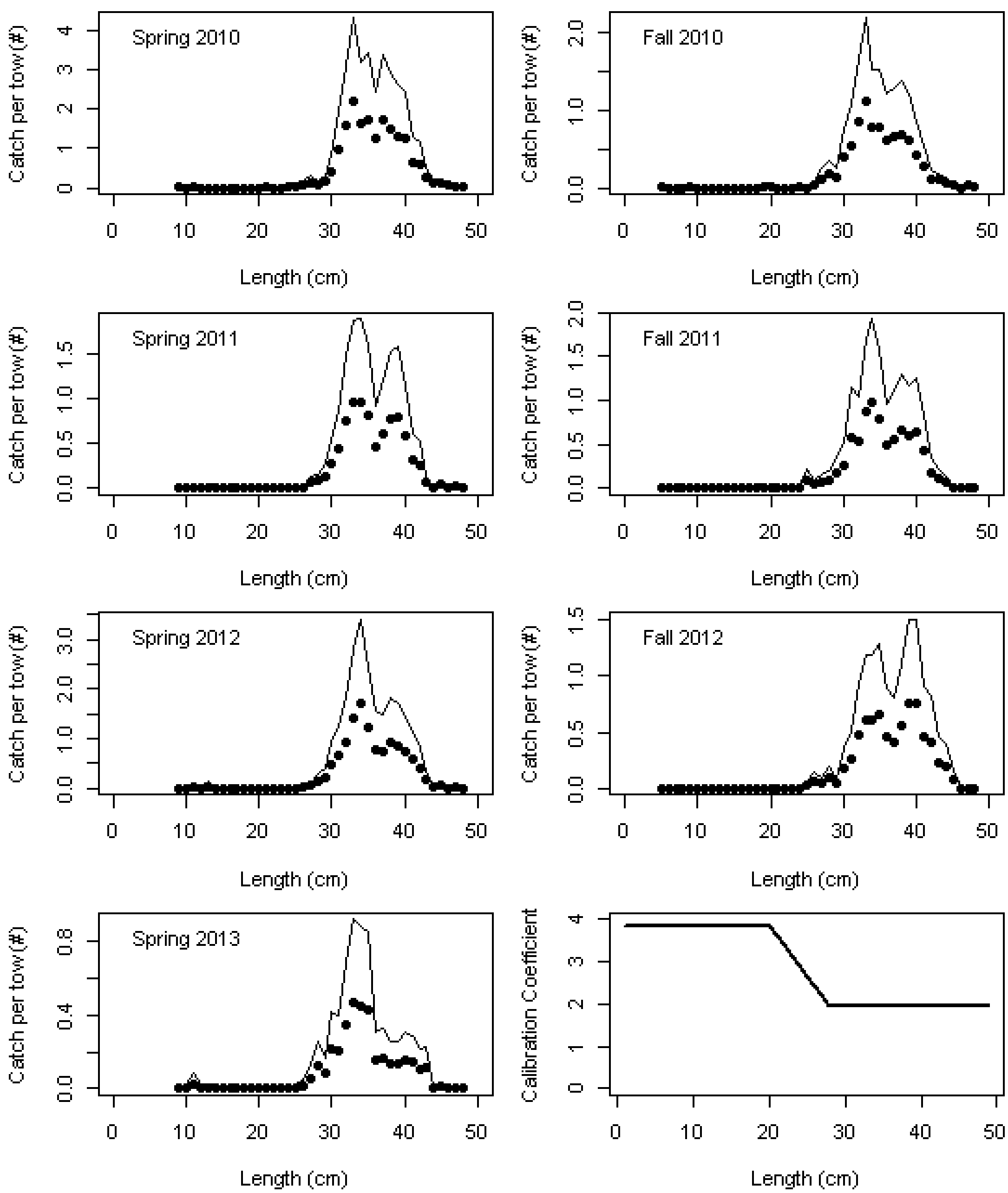



*Figure 15. Catch per tow in numbers of fish for the US spring and fall surveys by the Henry B. Bigelow. The lines denote the original observations and the dots the calibrated values converted to Albatross IV units. The calibration is calculated using the curve in the lower right panel (Calibrated = Original/Calibration Coefficient).*

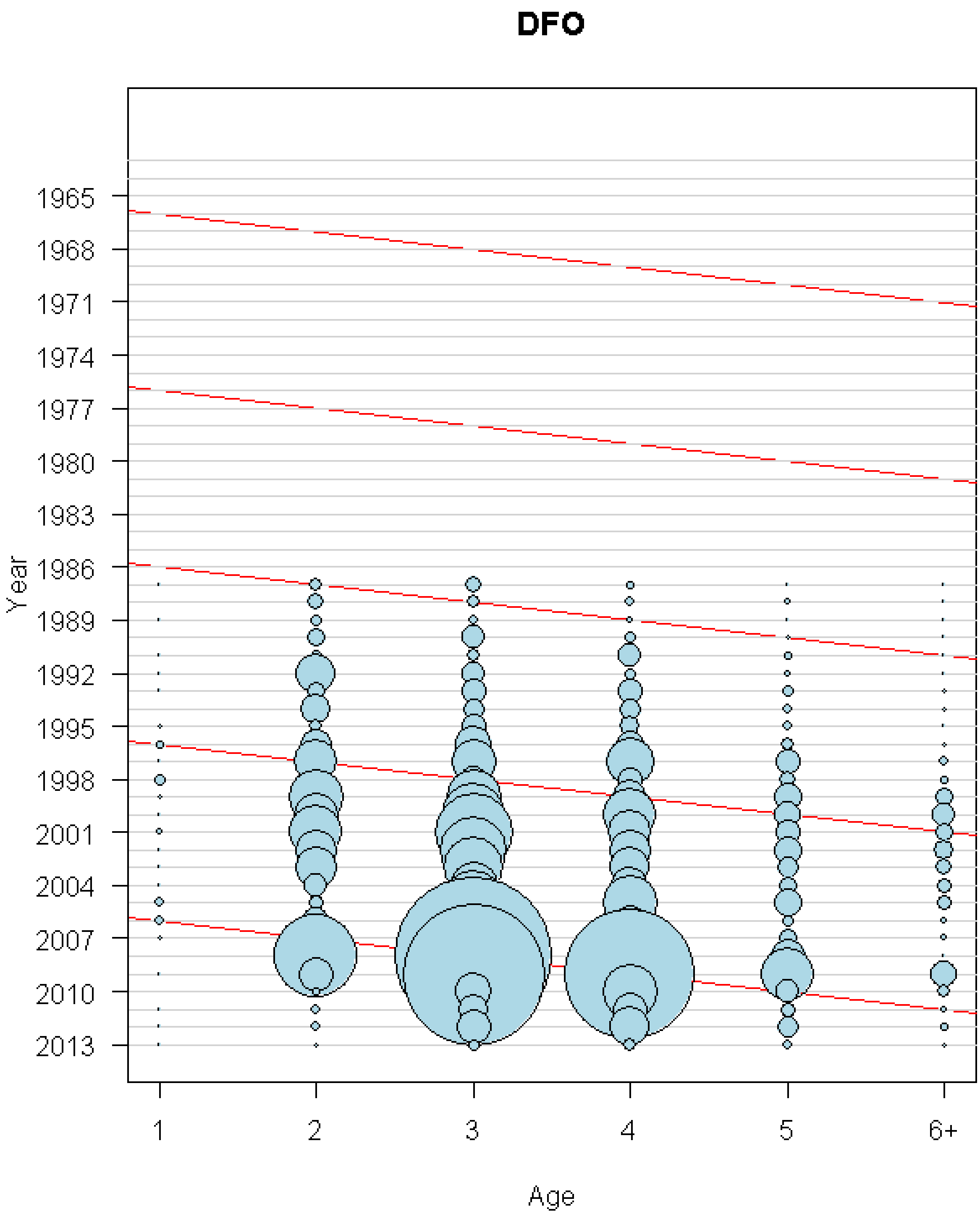



*Figure 16a. Age specific indices of abundance for the DFO spring survey including the large tows in 2008 and 2009 (the area of the bubble is proportional to the magnitude). Diagonal red lines denote the 1965, 1975, 1985, 1995, and 2005 year-classes.*

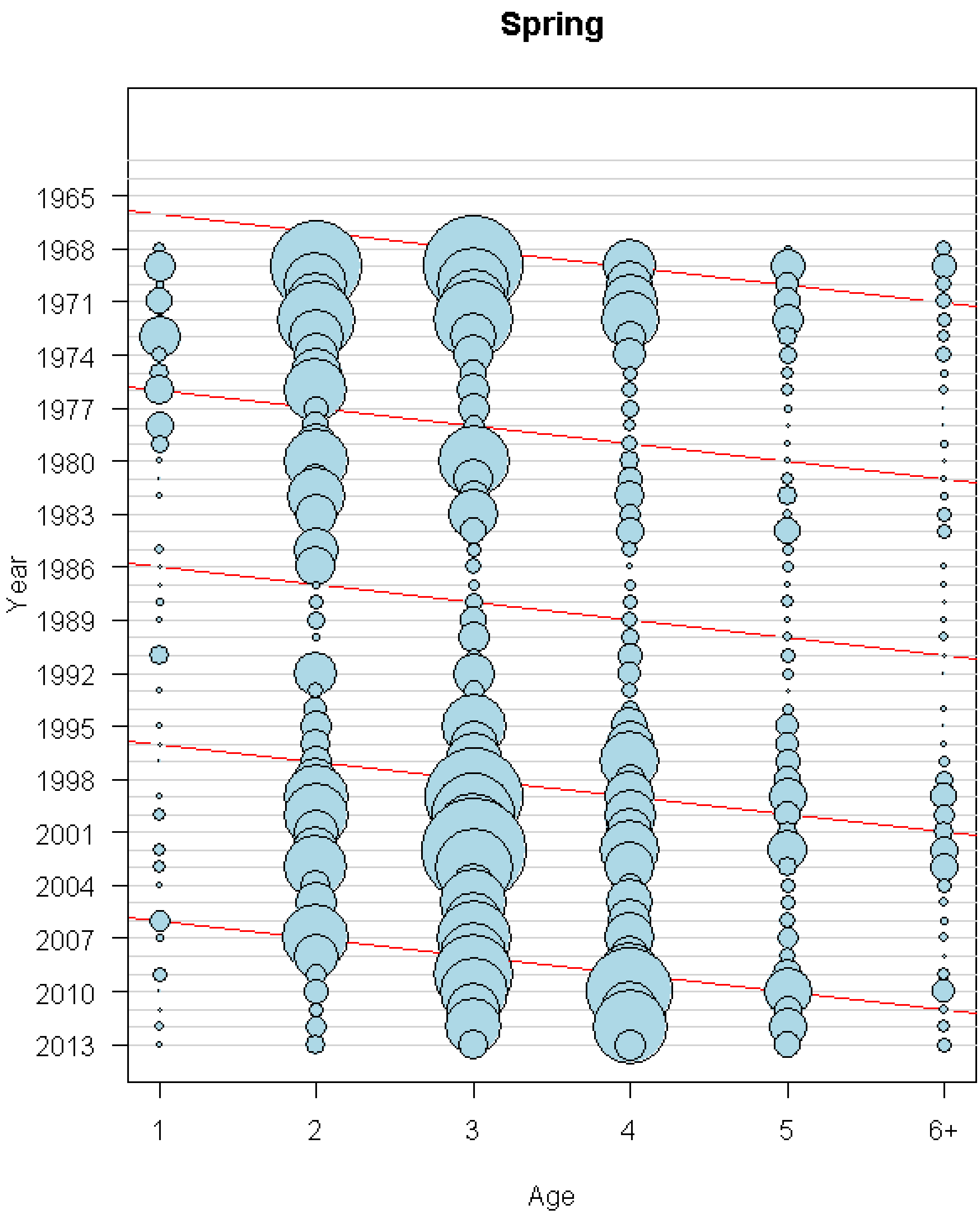



*Figure 16b. Age specific indices of abundance for the NMFS spring survey (the area of the bubble is proportional to the magnitude). Diagonal red lines denote the 1965, 1975, 1985, 1995, and 2005 year-classes.*

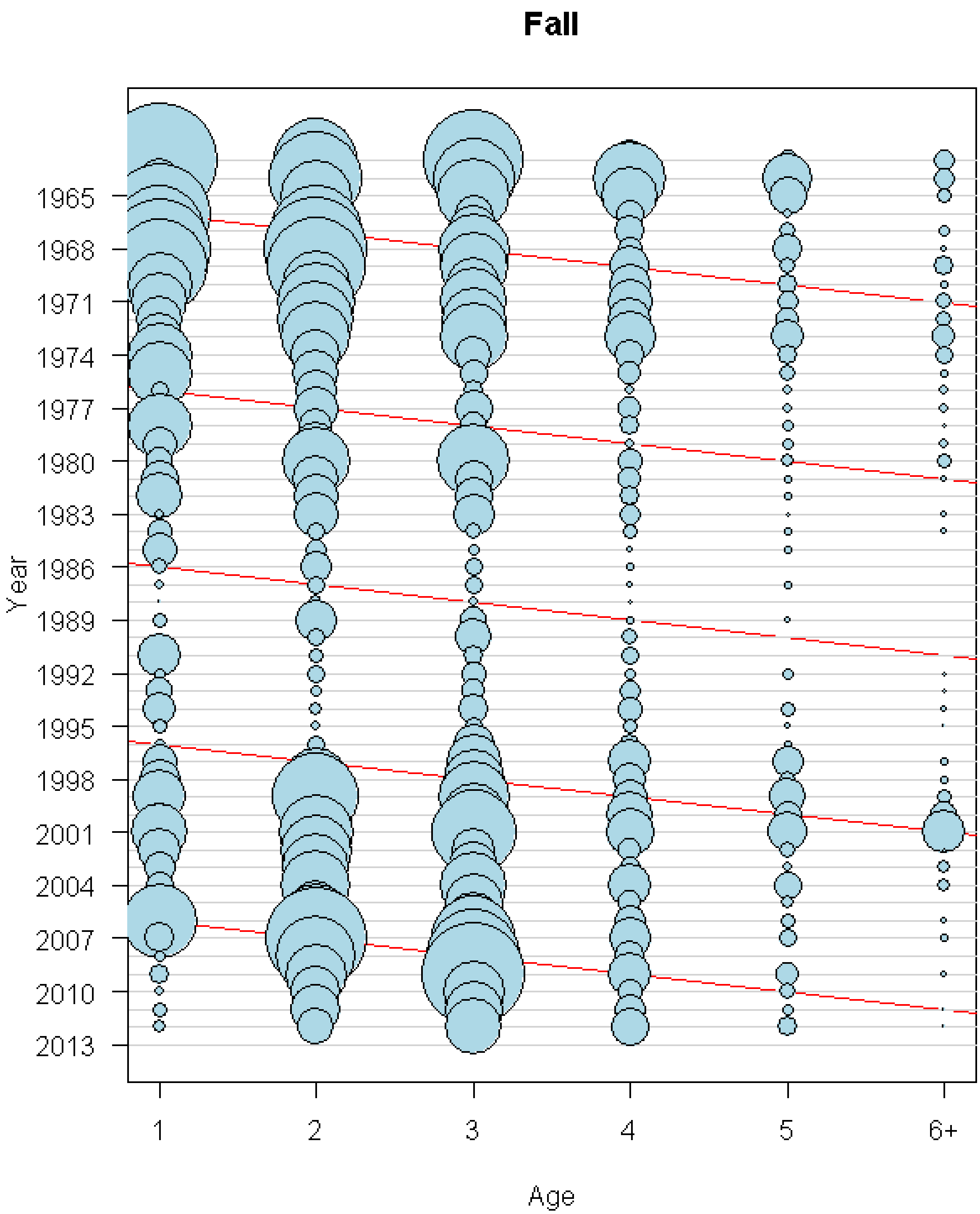



*Figure 16c. Age specific indices of abundance for the NMFS fall survey (the area of the bubble is proportional to the magnitude). Diagonal red lines denote the 1965, 1975, 1985, 1995, and 2005 year-classes.*

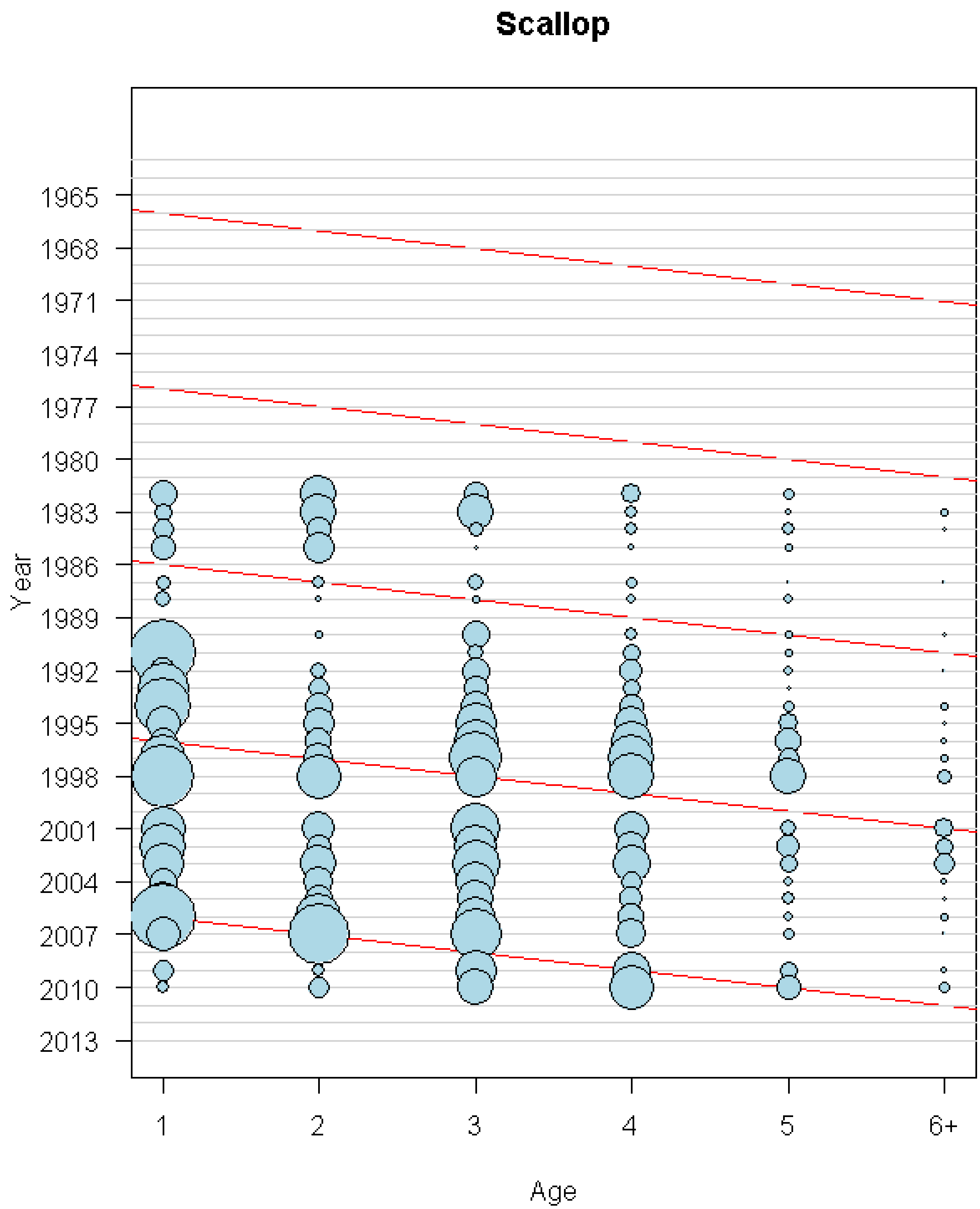



*Figure 16d. Age specific indices of abundance for the NMFS scallop survey, note years 1986, 1989, 1999, 2000, and 2008 are not included (the area of the bubble is proportional to the magnitude). Diagonal red lines denote the 1965, 1975, 1985, 1995, and 2005 year-classes.*

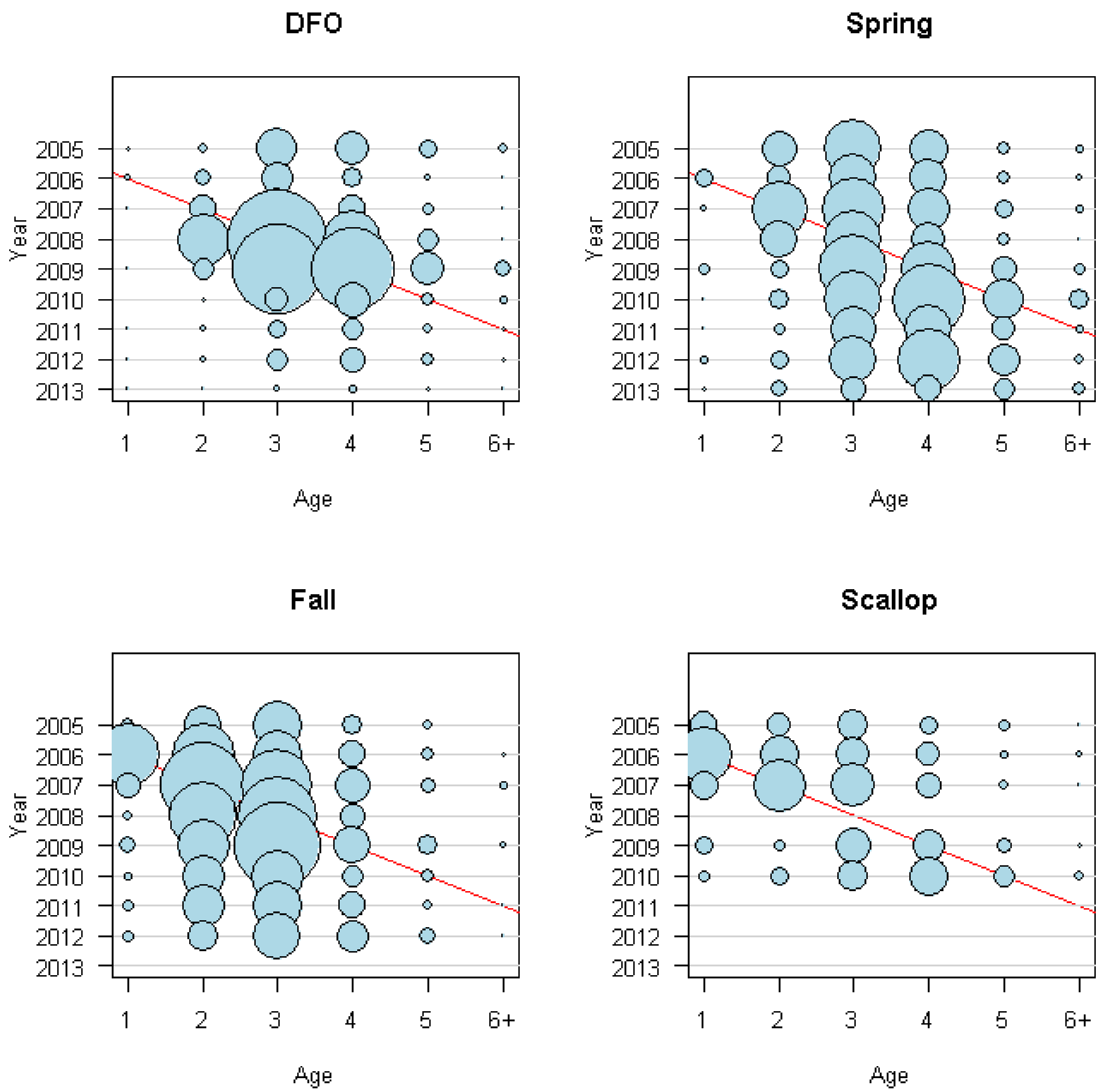



*Figure 16e. Age specific indices of abundance for the recent years of the four surveys, note year 2008 is not included in the scallop plot (the area of the bubble is proportional to the magnitude). The red diagonal line denotes the 2005 year-class.*

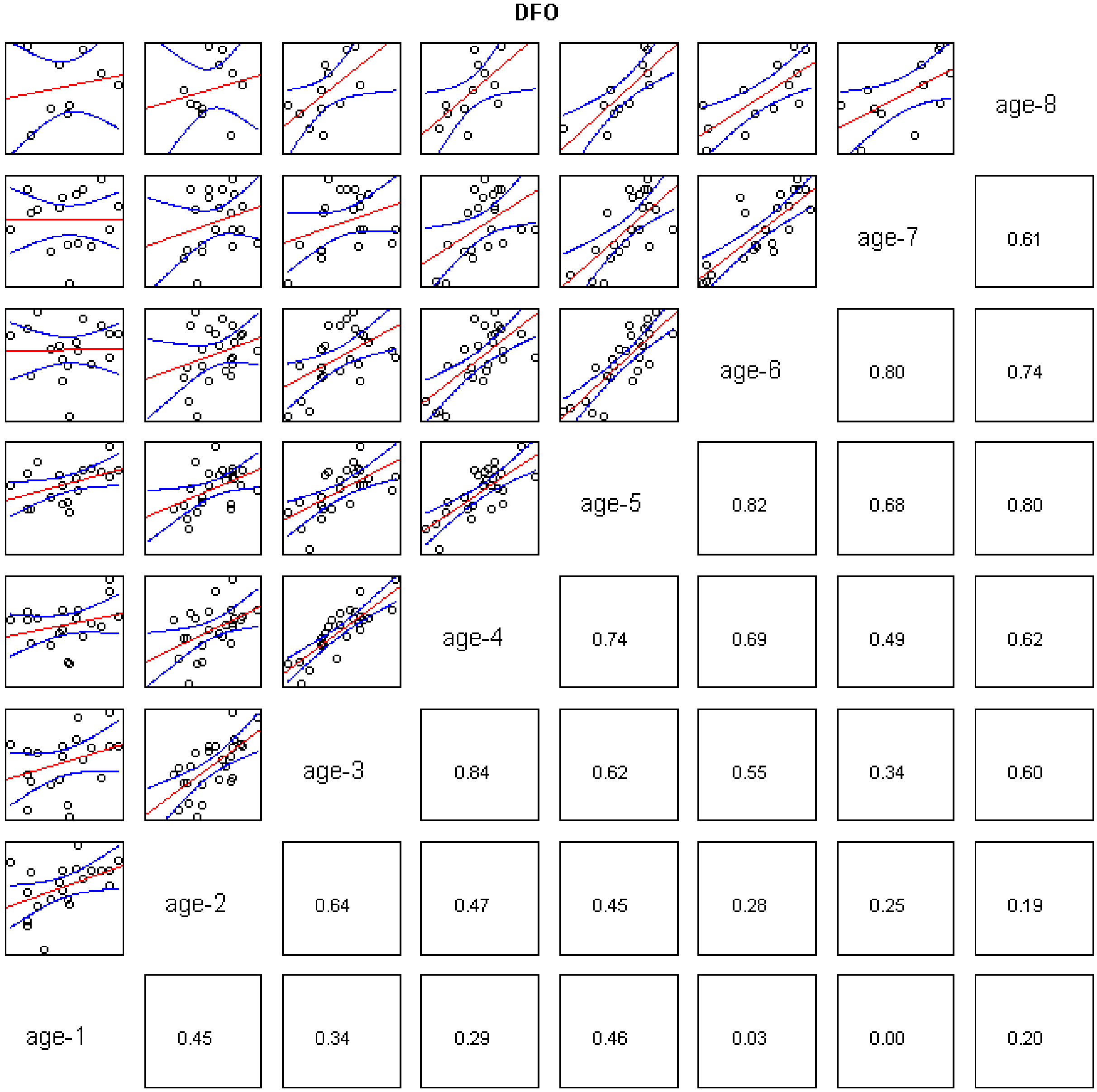



*Figure 16f. DFO survey catch at age by cohort on log scale. Red lines denote linear regression and blue lines denote 95% prediction interval for the linear regression. Correlation values are shown in lower right triangle.*

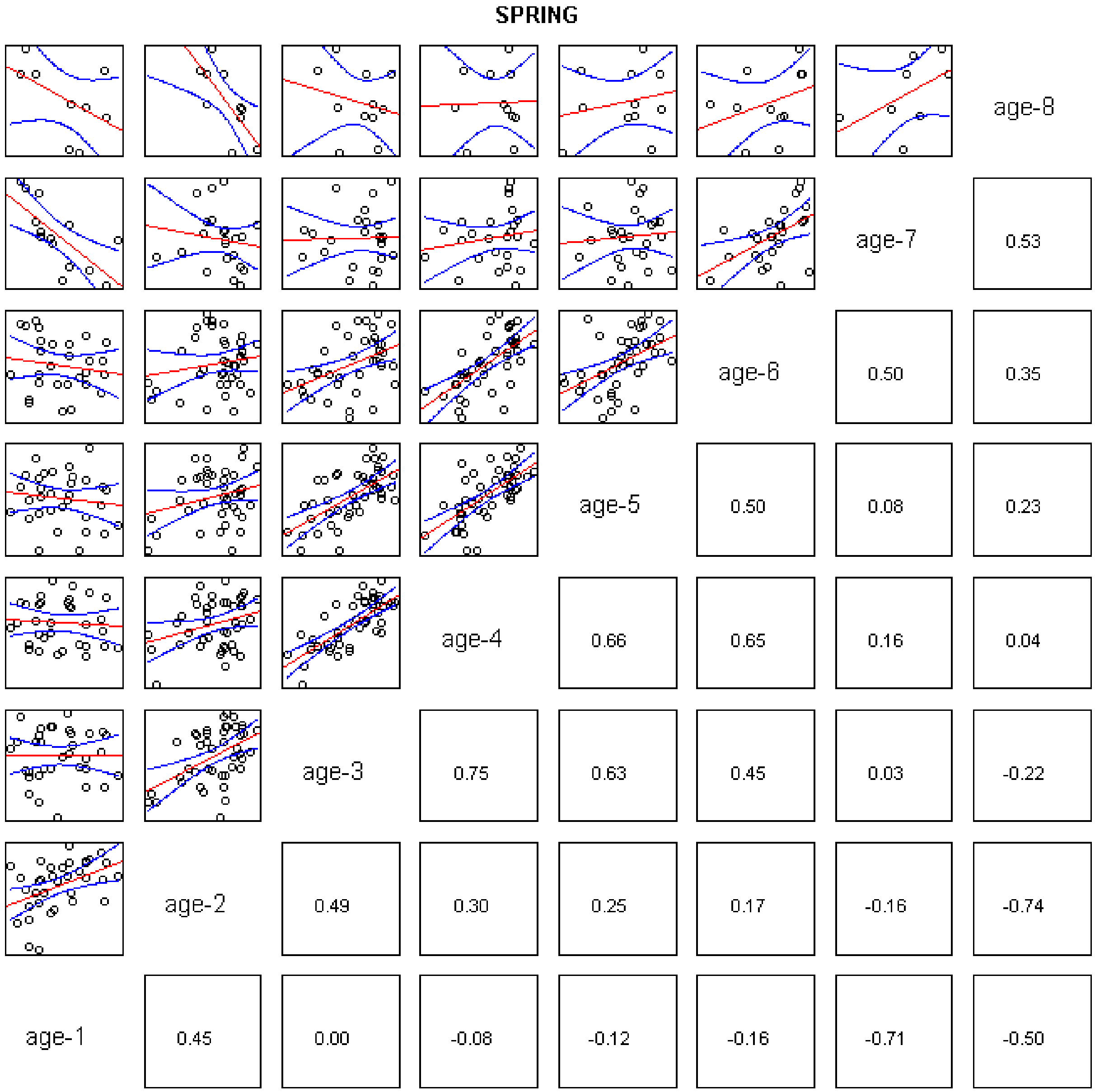



*Figure 16g. NEFSC spring survey catch at age by cohort on log scale. Red lines denote linear regression and blue lines denote 95% prediction interval for the linear regression. Correlation values are shown in lower right triangle.*

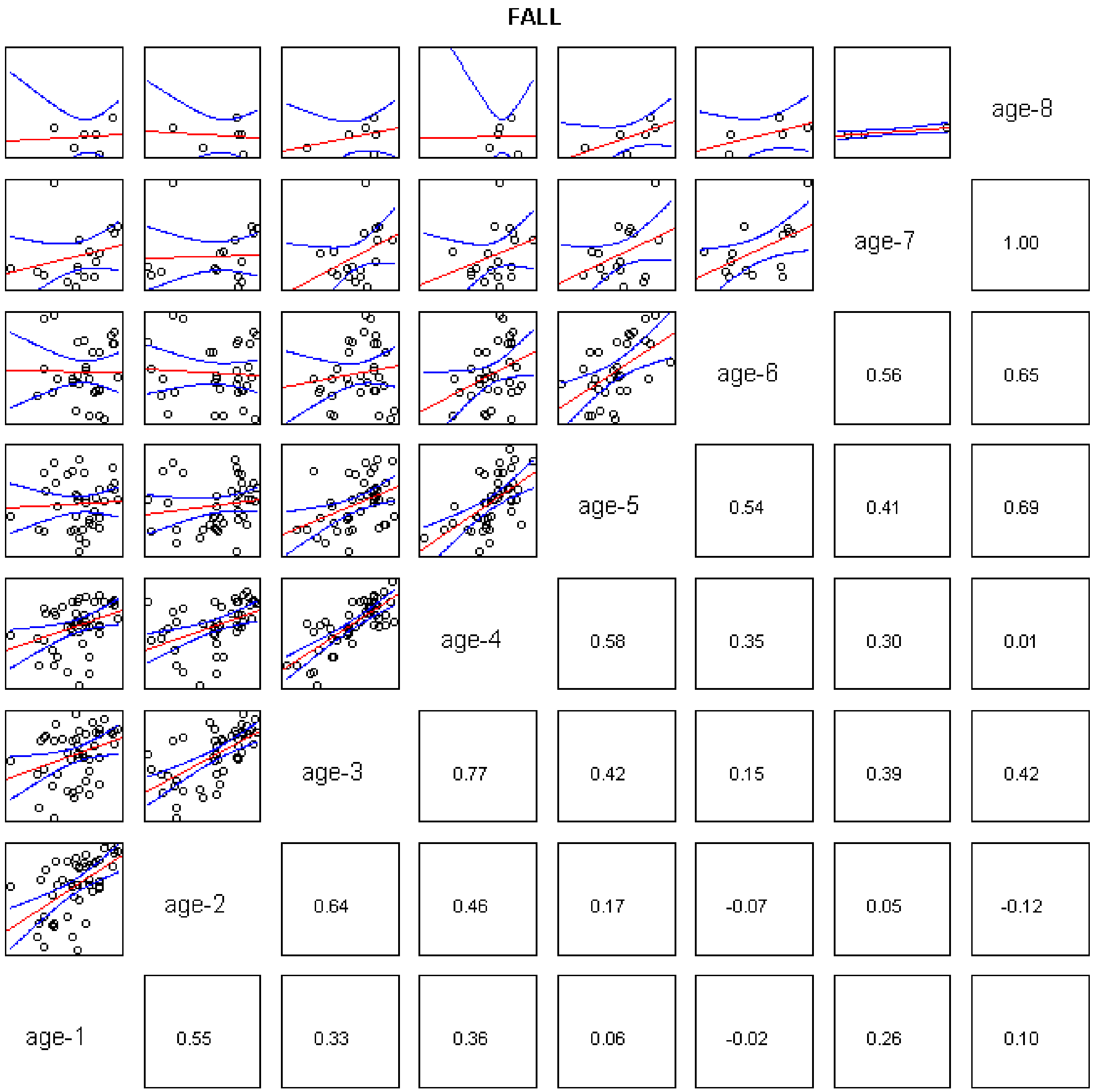



*Figure 16h. NEFSC fall survey catch at age by cohort on log scale. Red lines denote linear regression and blue lines denote 95% prediction interval for the linear regression. Correlation values are shown in lower right triangle.*

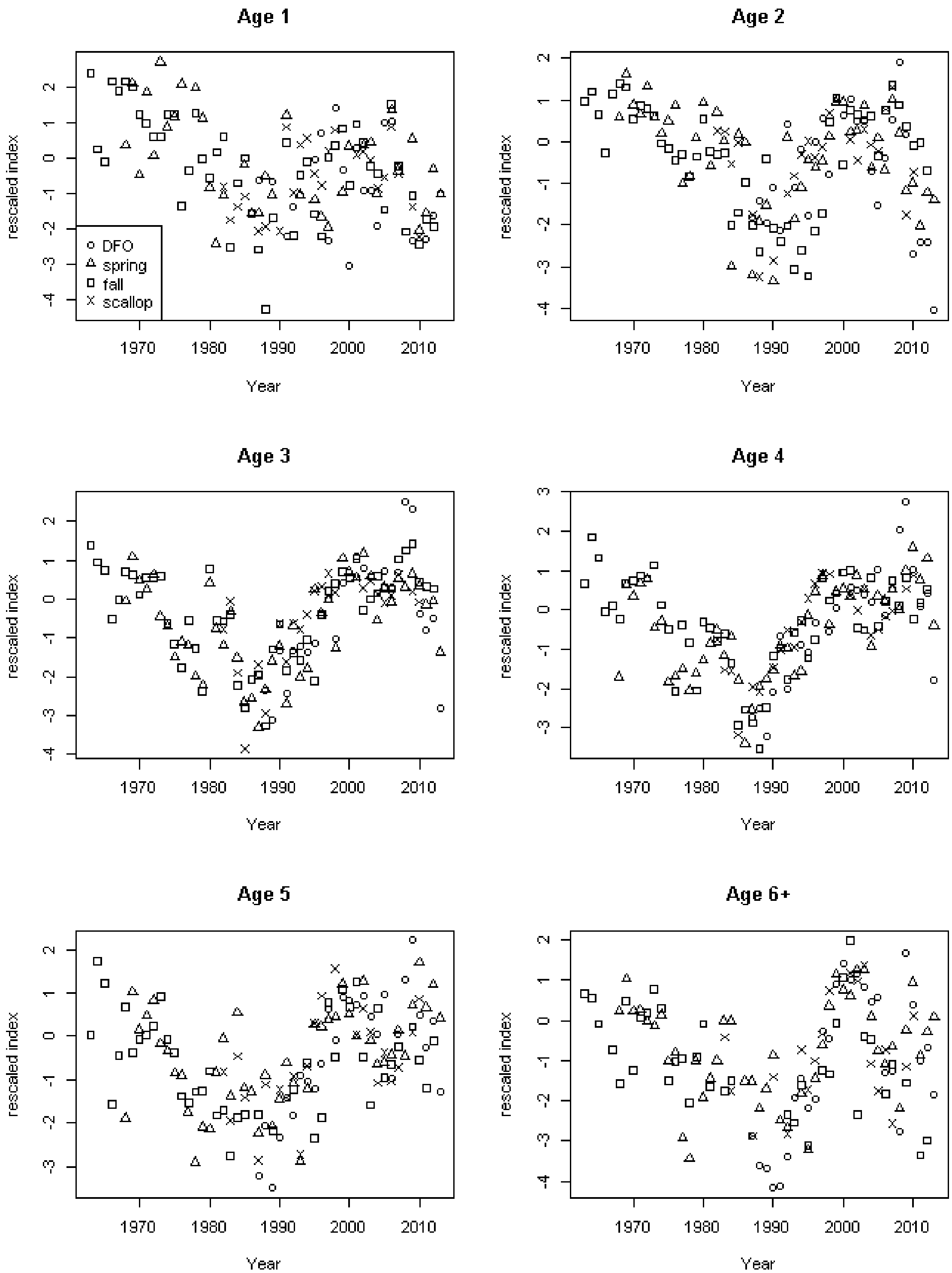



*Figure 17a. Standardized catch/tow in numbers at age for the four surveys plotted on natural log scale. The standardization was merely the division of each index value by the mean of the associated time series. Circles denote the DFO survey, triangles the NEFSC spring survey, squares the NEFSC fall survey, and crosses the NEFSC scallop survey.*

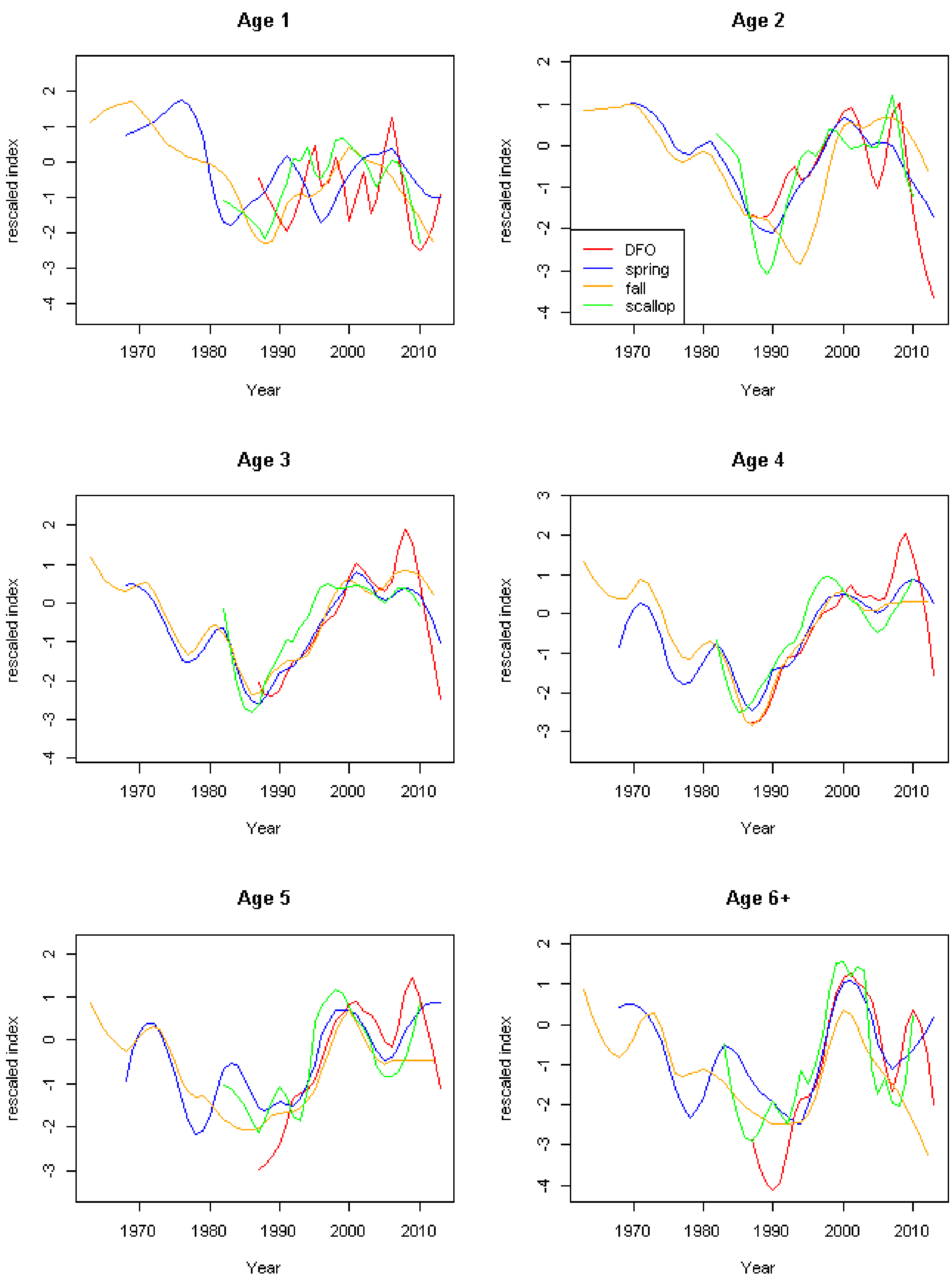



*Figure 17b. Same as Figure 17a except the rescaled index values have been smoothed with a loess fit using 30% span to more clearly demonstrate similarities or differences among the surveys.*

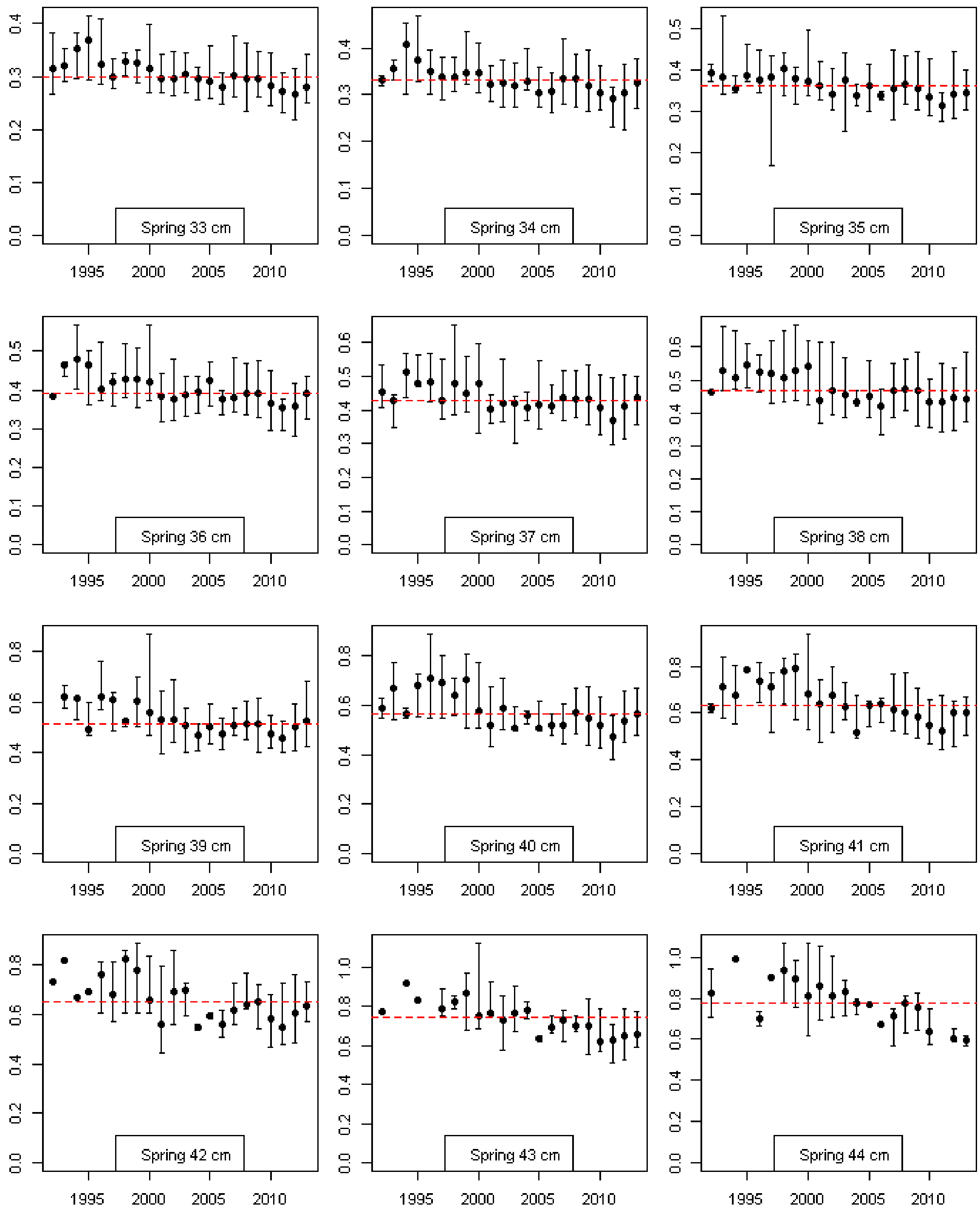



*Figure 18a. Median and 2.5%ile and 97.5%ile of measured weight (kg) at length by year from the NEFSC spring survey. The horizontal dashed red line denotes the median of the medians.*

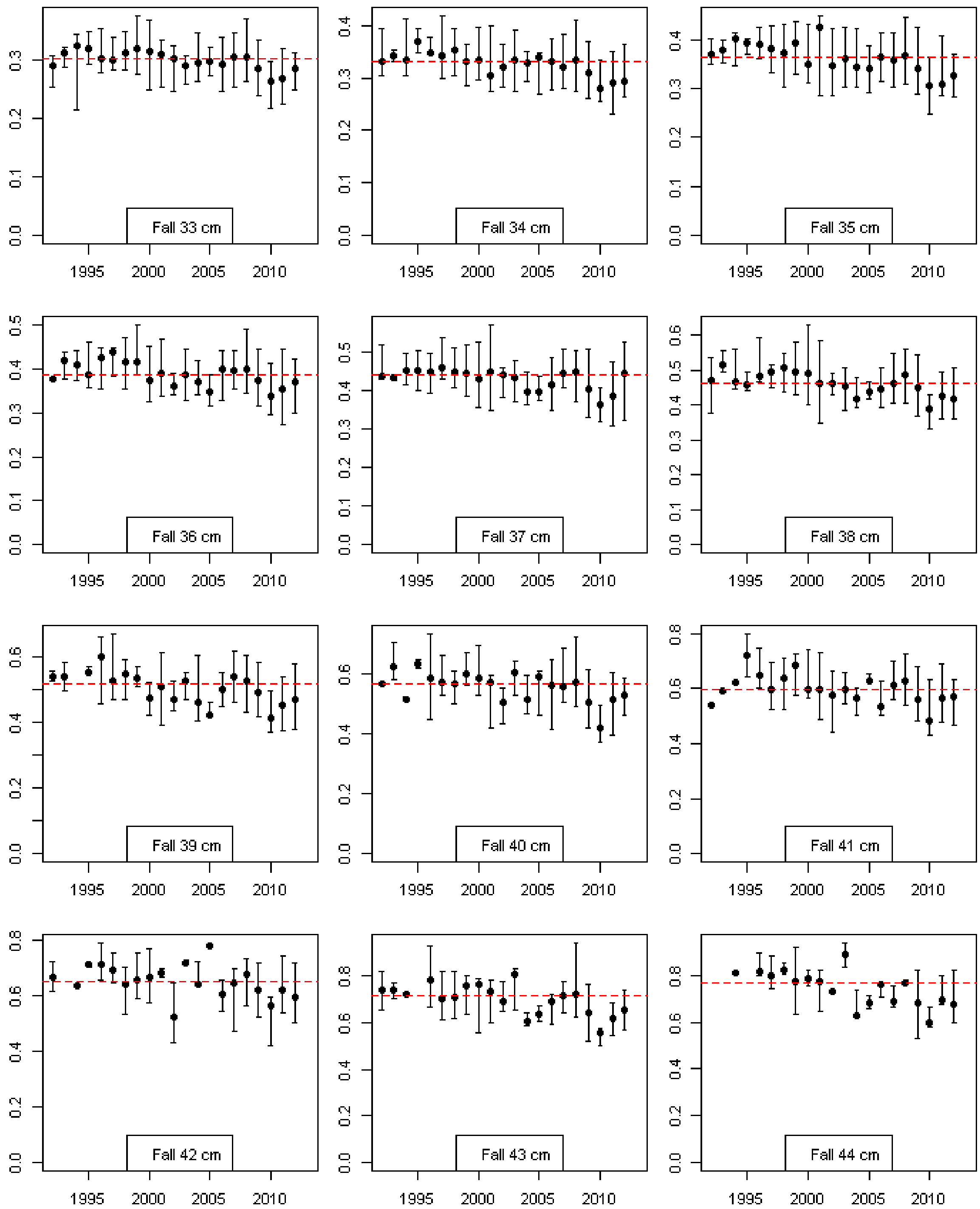



*Figure 18b. Median and 2.5%ile and 97.5%ile of measured weight (kg) at length by year from the NEFSC fall survey. The horizontal dashed red line denotes the median of the medians.*

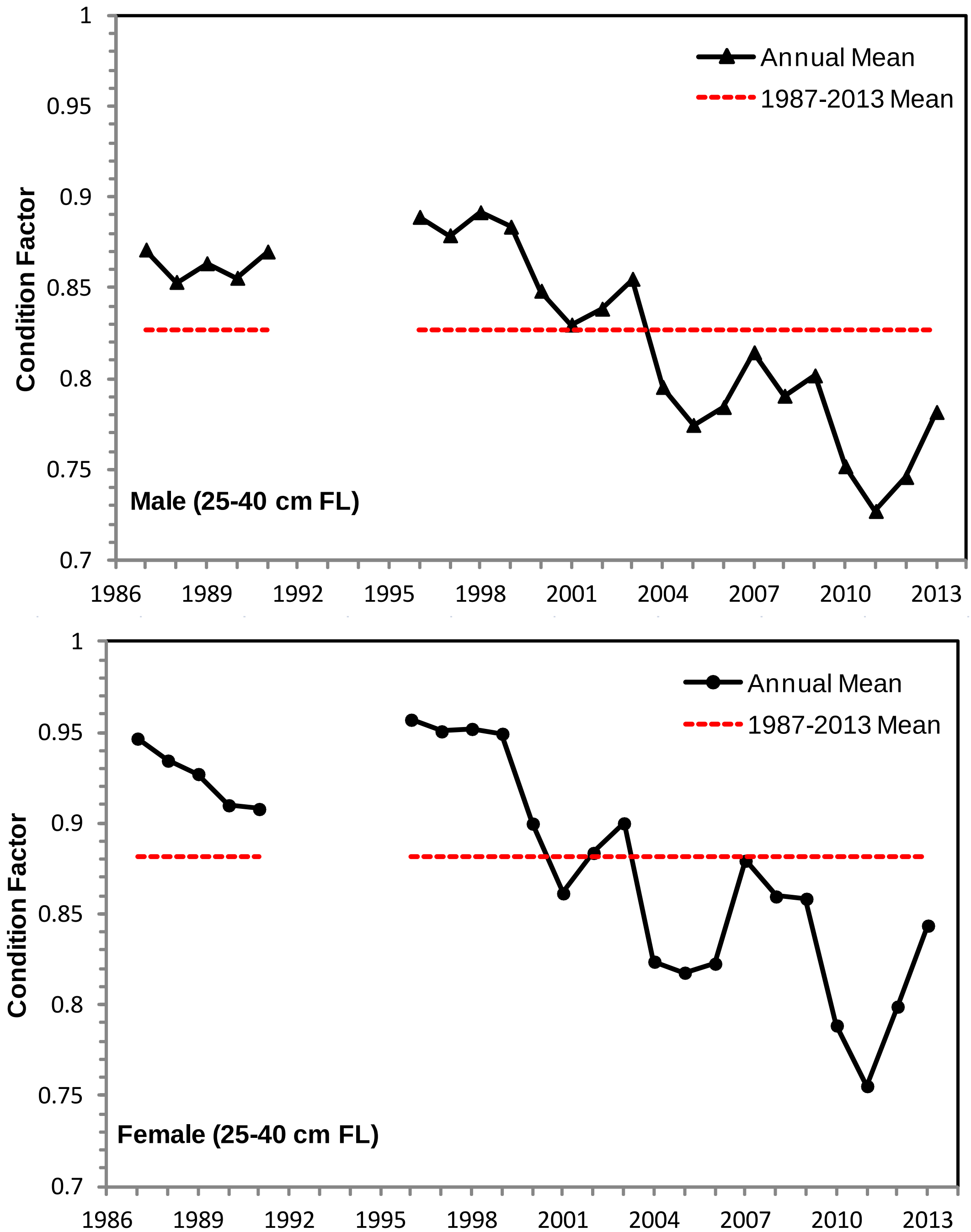



*Figure 18c. Condition factor (Fulton's K) for male and female yellowtail flounder in the DFO survey.*

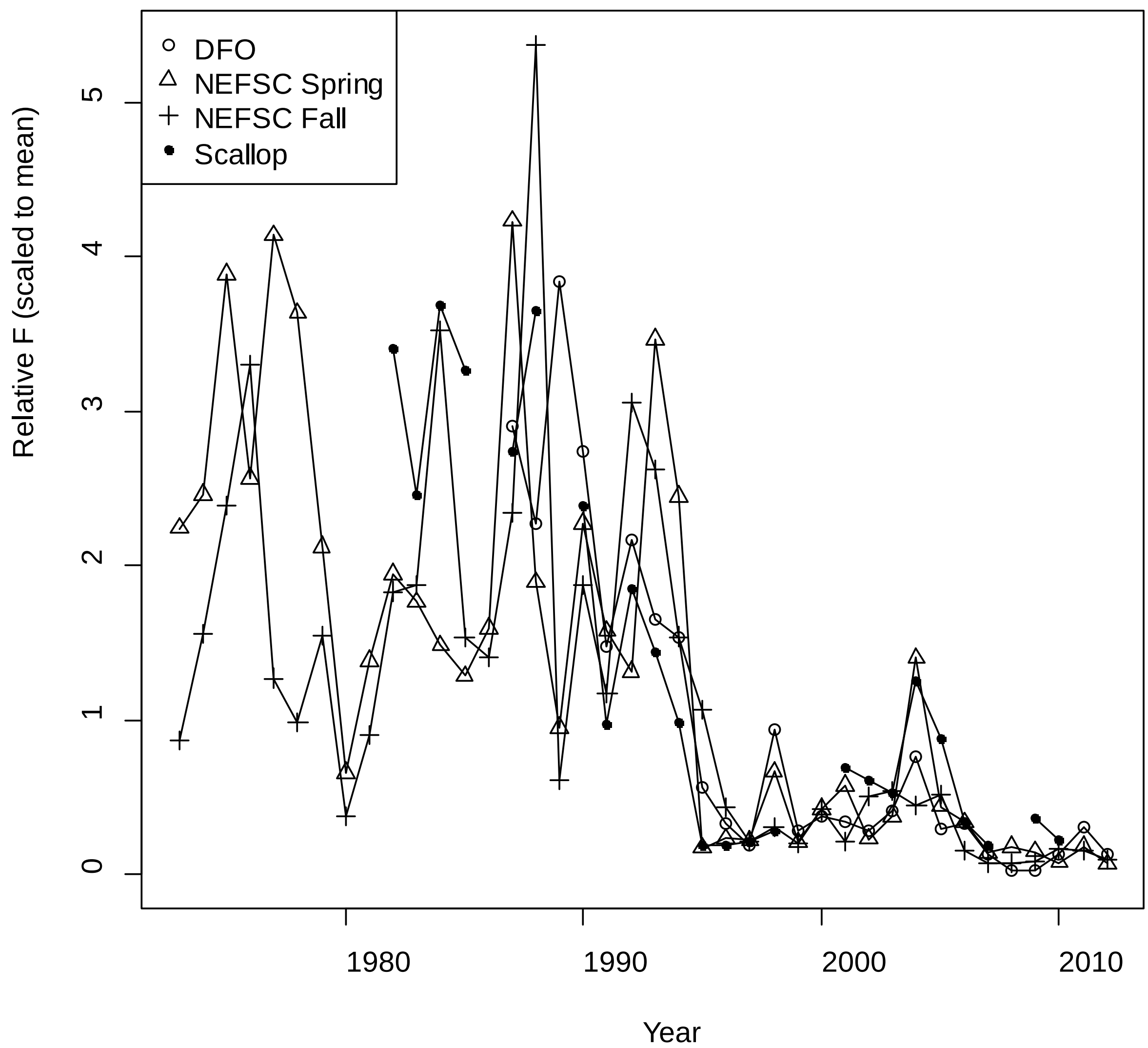



*Figure 19. Trends in relative fishing mortality (catch biomass/survey biomass), standardized to the mean for 1987-2010.*

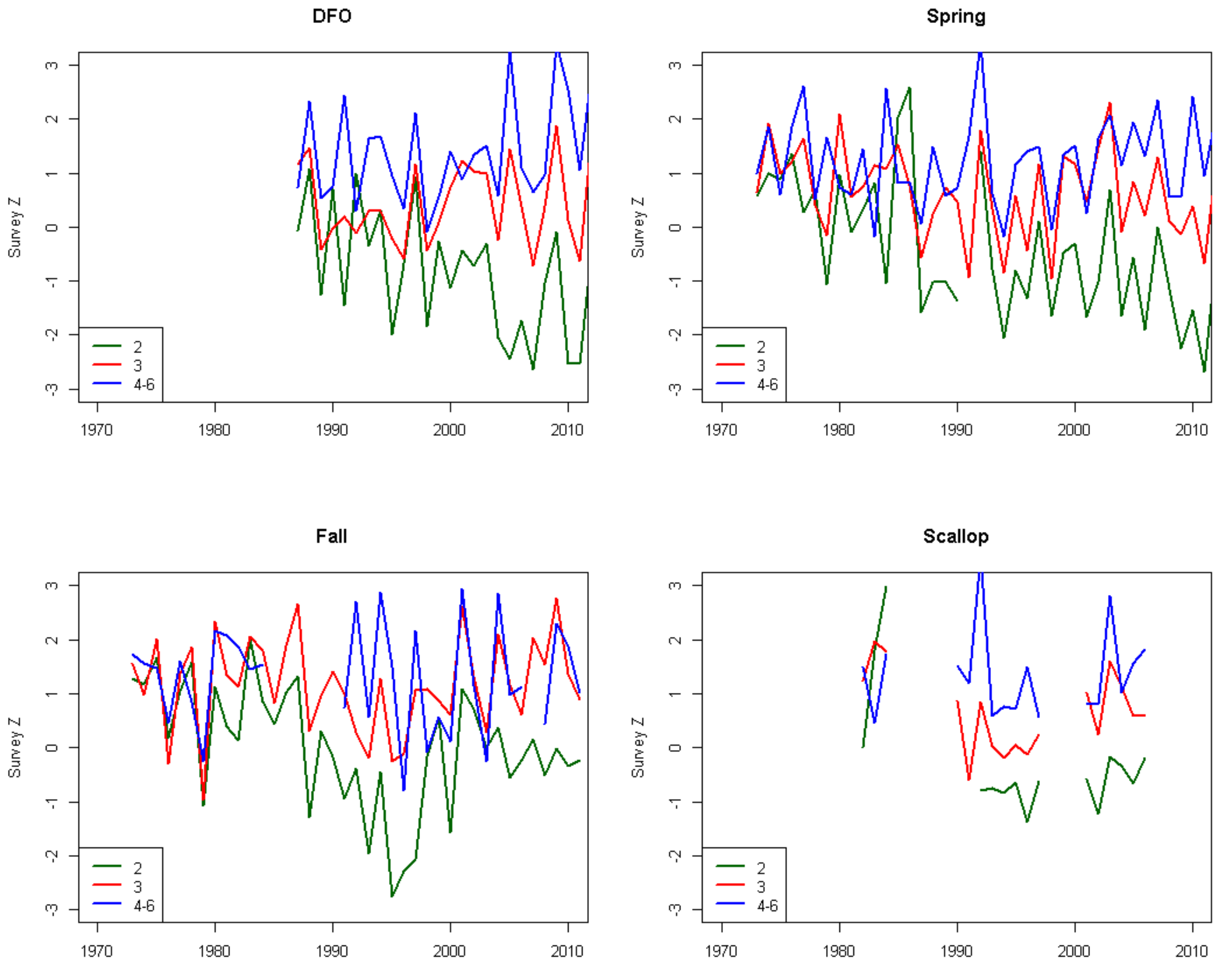



*Figure 20. Trends in total mortality (Z) for ages 2, 3, and 4-6 from the four surveys.*

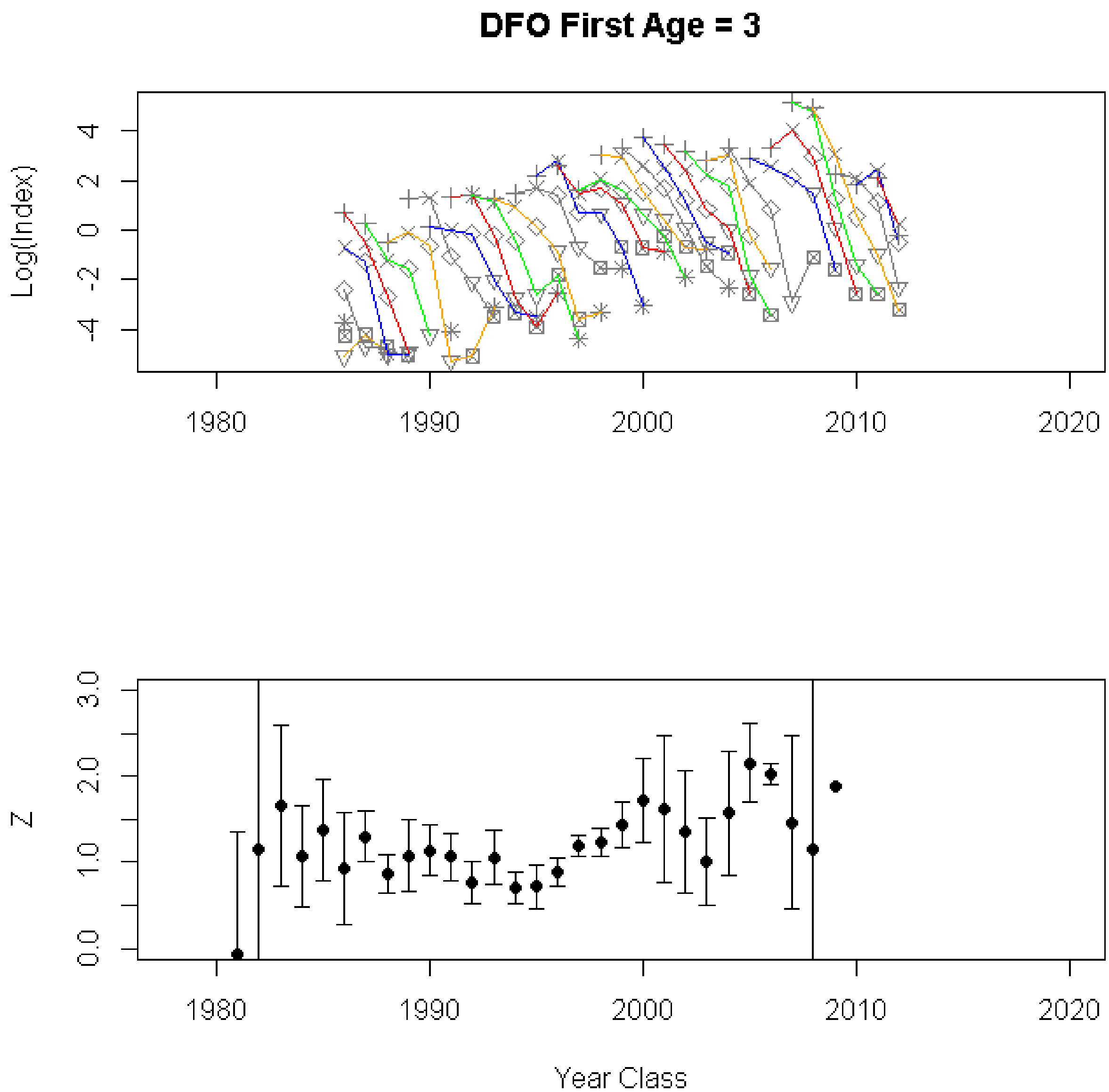



*Figure 21a. Catch curve for DFO survey using age 3 as first age in Z calculation. Top panel shows log of survey catch at age, with symbols denoting ages and colored lines connecting cohorts. Bottom panel shows estimated total mortality rate (Z) from catch curve with 80% confidence interval by year class of cohort (age 0).*

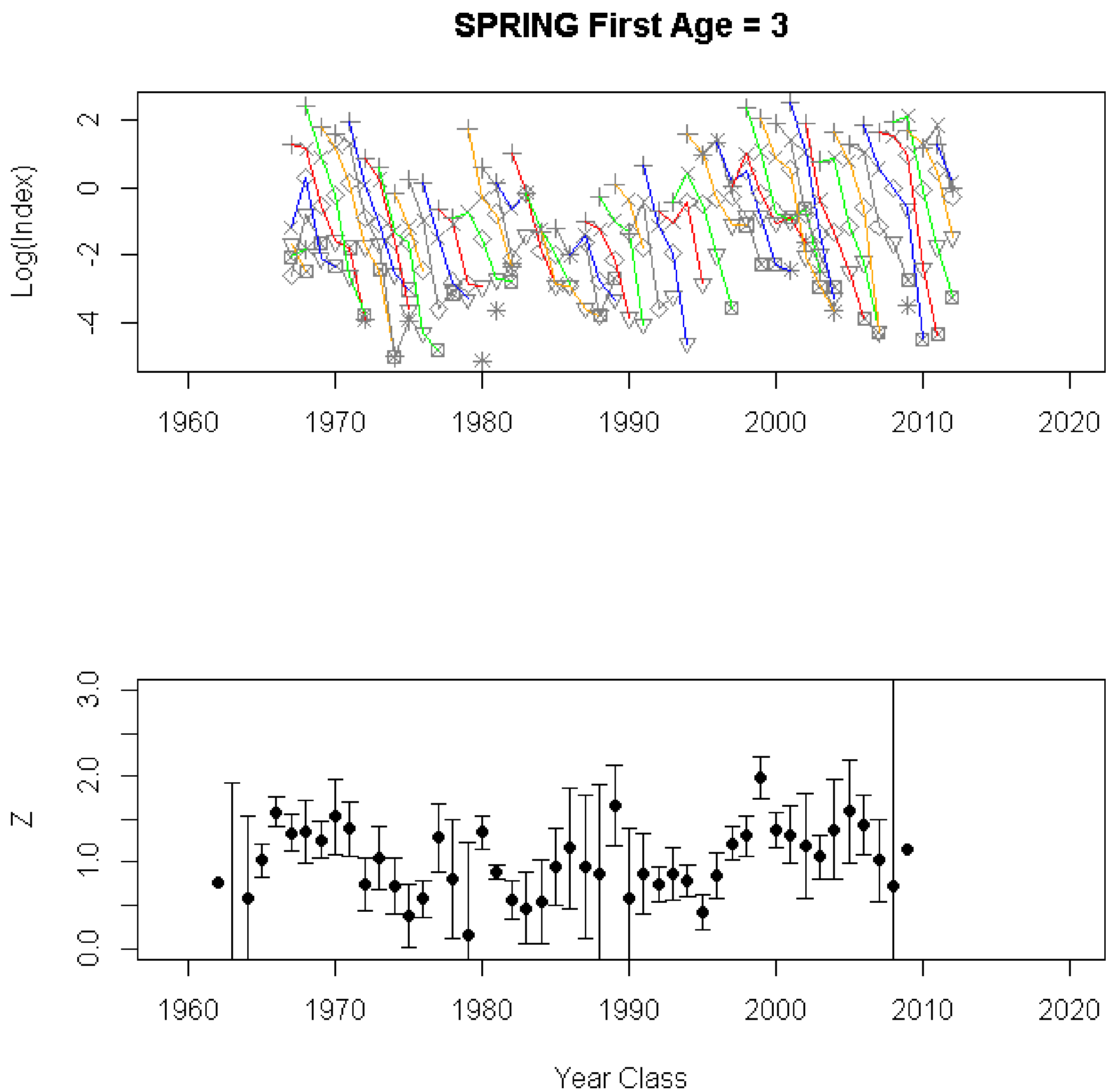



*Figure 21b. Catch curve for NEFSC spring survey using age 3 as first age in Z calculation. Top panel shows log of survey catch at age, with symbols denoting ages and colored lines connecting cohorts. Bottom panel shows estimated total mortality rate (Z) from catch curve with 80% confidence interval by year class of cohort (age 0).*

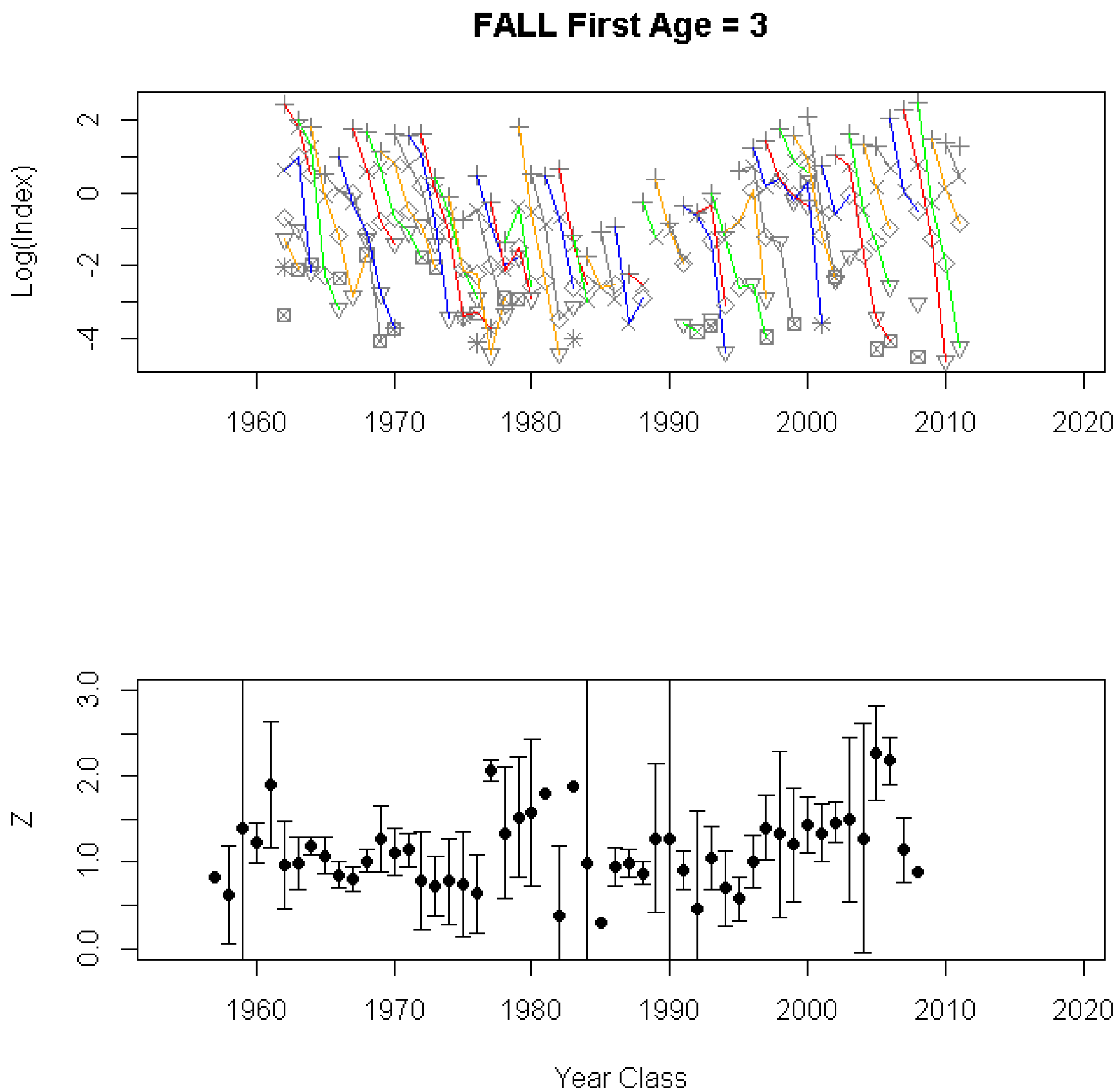



*Figure 21c. Catch curve for NEFSC fall survey using age 3 as first age in Z calculation. Top panel shows log of survey catch at age, with symbols denoting ages and colored lines connecting cohorts. Bottom panel shows estimated total mortality rate (Z) from catch curve with 80% confidence interval by year class of cohort (age 0).*

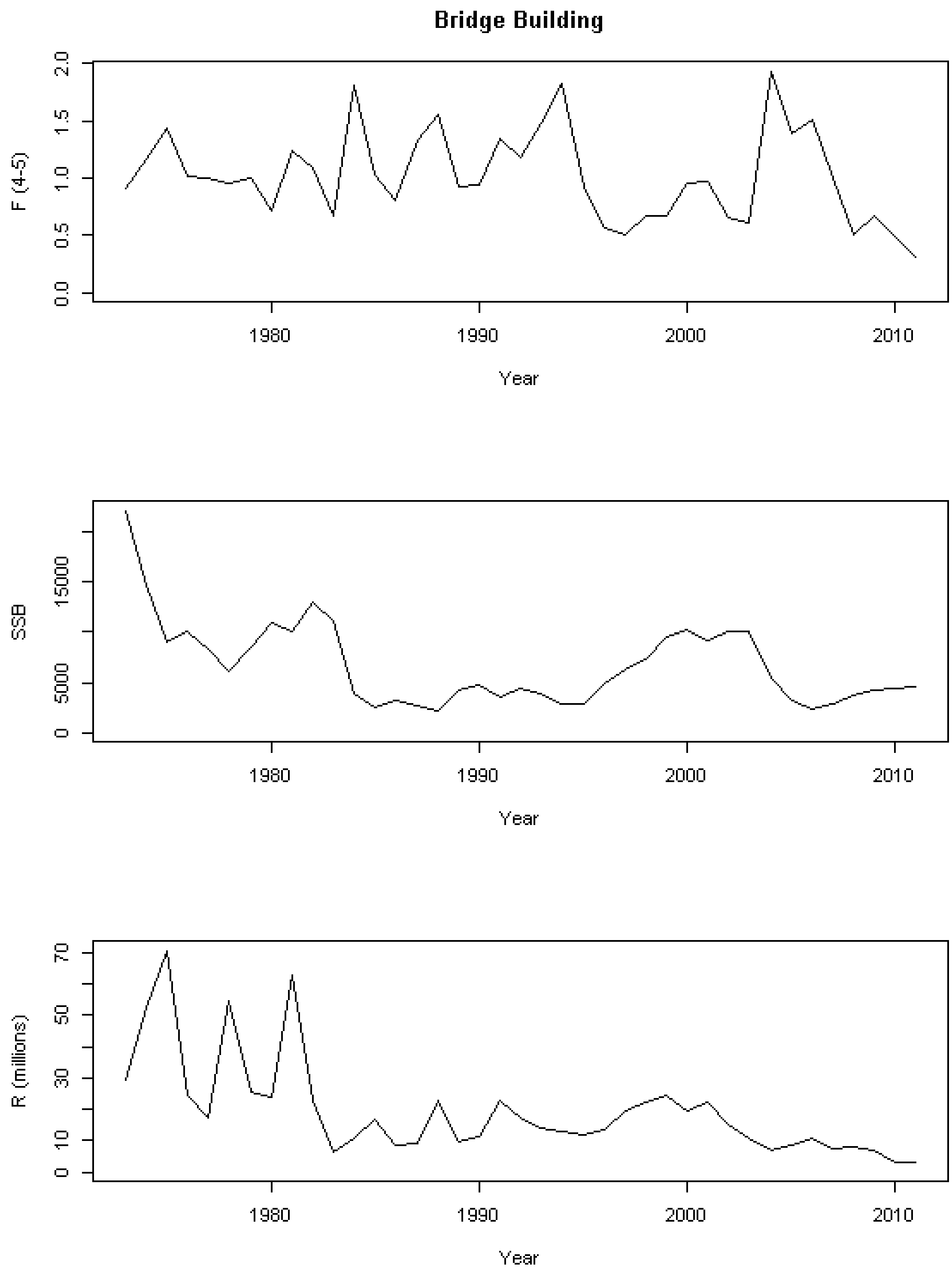



*Figure 22. Fishing mortality rate (ages 4+, top panel), spawning stock biomass (mt, middle panel) and recruitment (millions of age 1 fish, bottom panel) for the TRAC 2012 assessment and updates to the catch data (see text: Building the Bridge). There are two lines in each panel, but they are indistinguishable.*

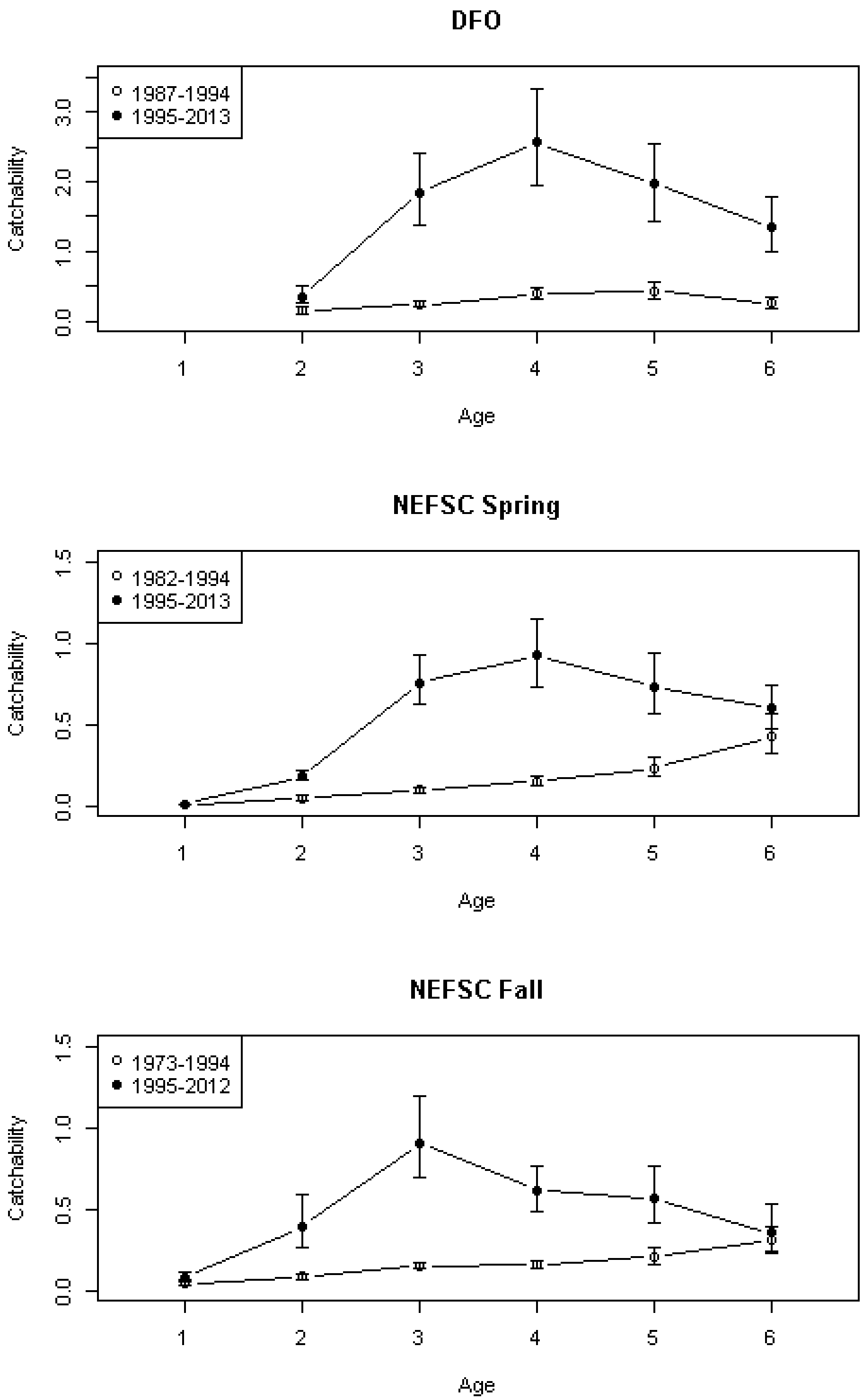



*Figure 23a. Catchability coefficients (q) from the Split Series VPA with bootstrapped 80% confidence intervals.*

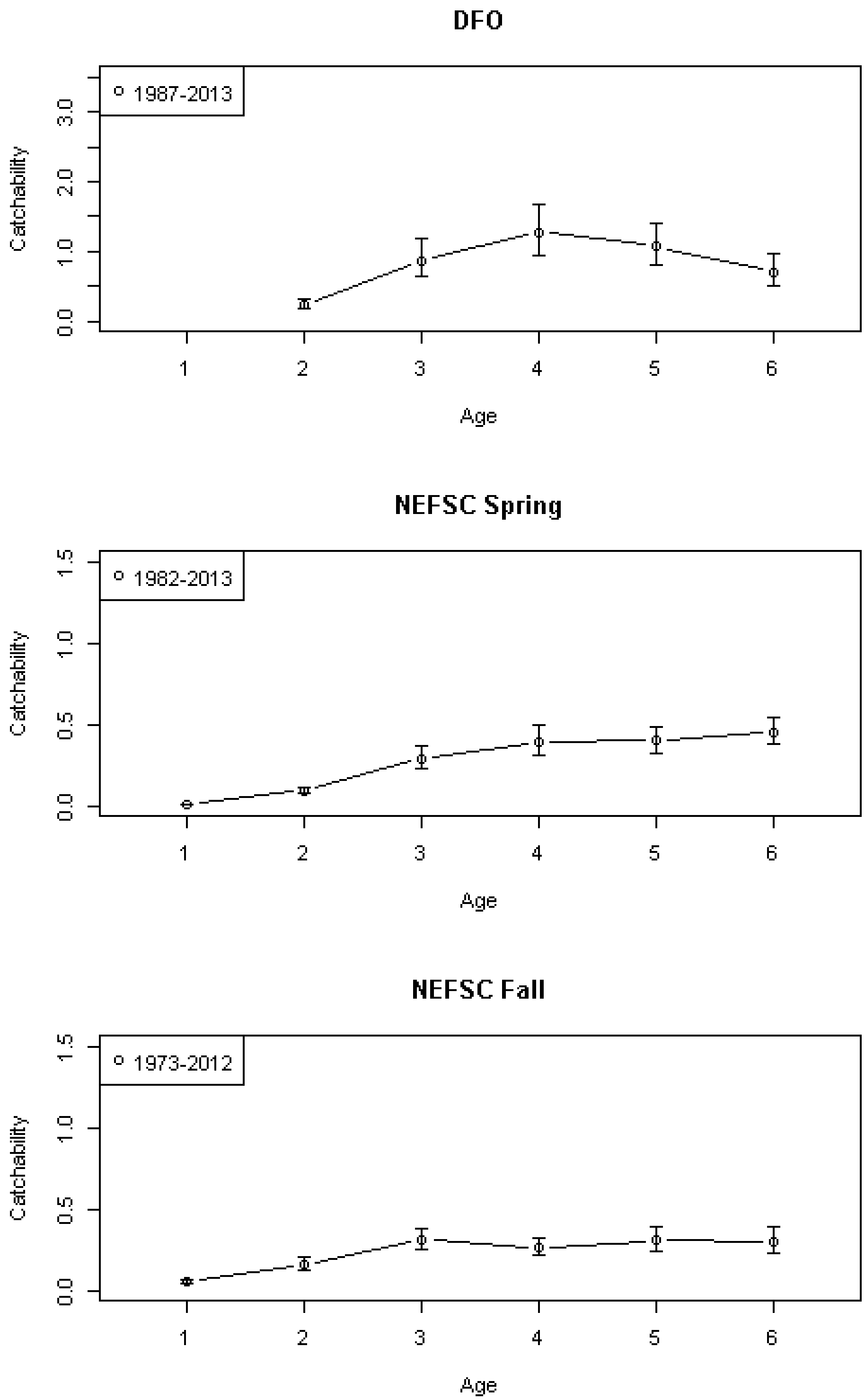



*Figure 23b. Catchability coefficients (q) from the Single Series VPA with bootstrapped 80% confidence intervals.*

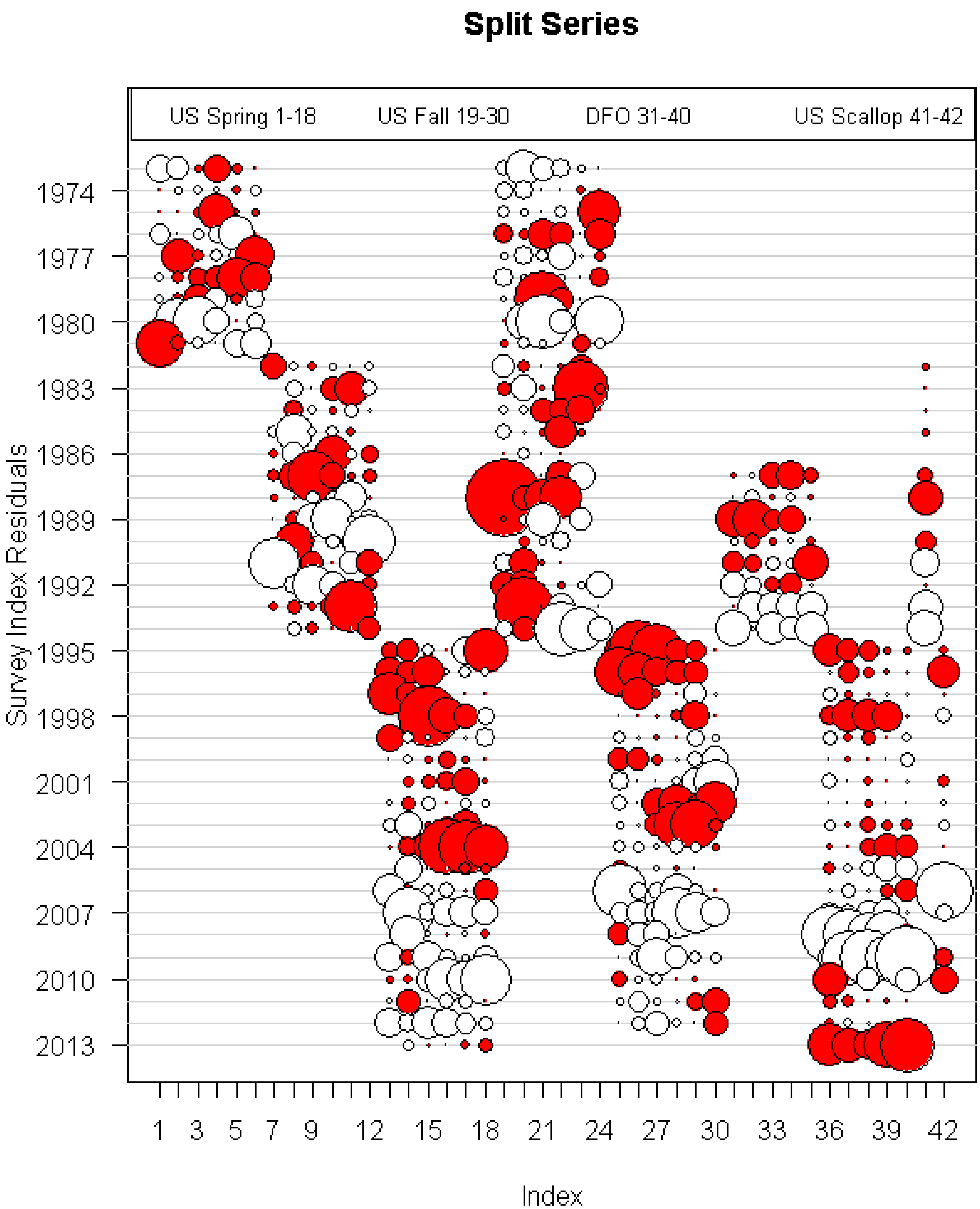



*Figure 24a. Age by age residuals from the Split Series VPA for log scale predicted minus observed population abundances, Georges Bank yellowtail flounder (bubble size is proportional to magnitude). The red symbols denote negative residuals, and white symbols denote positive residuals.*

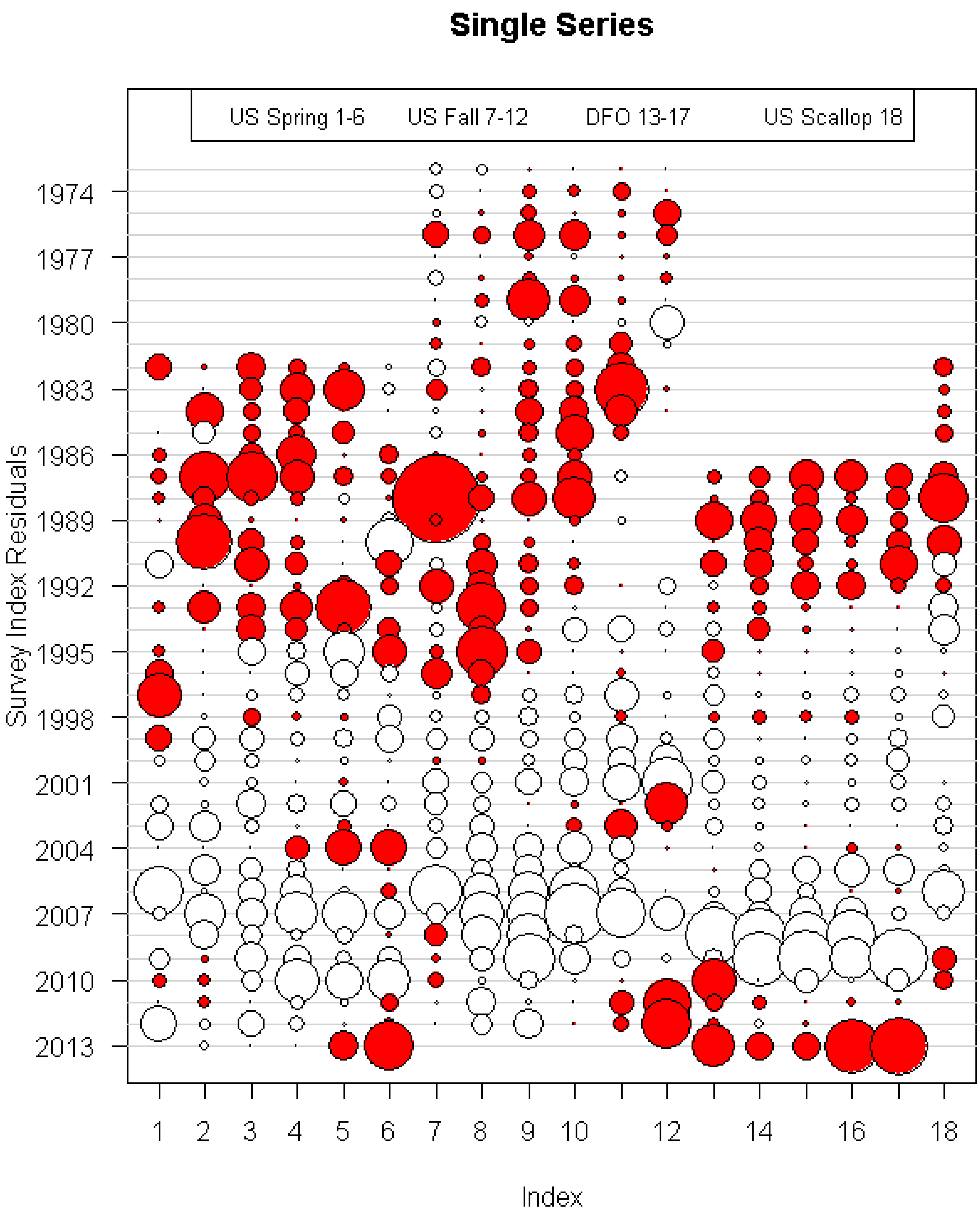



*Figure 24b. Age by age residuals from the Single Series VPA for log scale predicted minus observed population abundances, Georges Bank yellowtail flounder (bubble size is proportional to magnitude). The red symbols denote negative residuals, and white symbols denote positive residuals.*

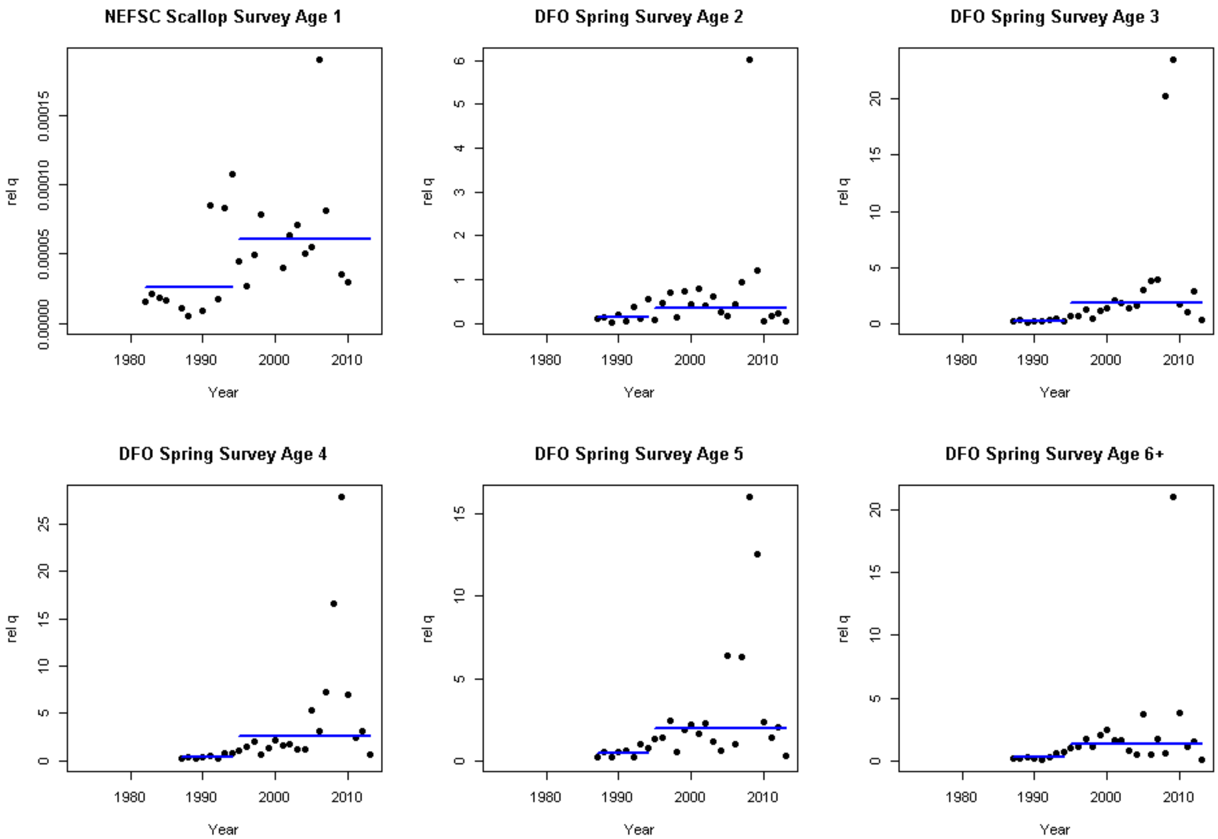



*Figure 25a. Estimated catchability coefficients (q) from the Split Series VPA (lines) and relative q values for the NEFSC scallop survey at age 1 and the DFO survey at ages 2 through 6+. The relative q values are computed as the observed survey value (as a minimum swept area estimate) divided by the population abundance at that age at the start of that year (no adjustment for timing of the survey).*

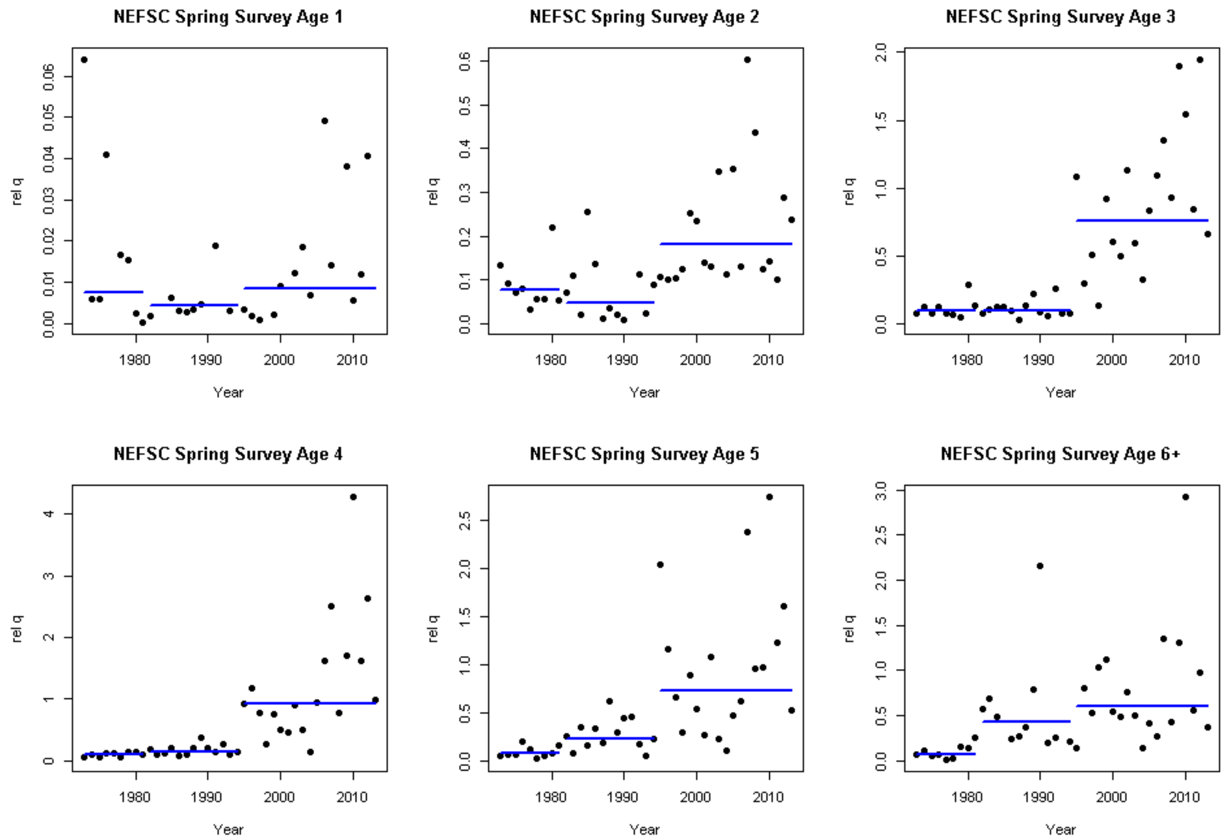



*Figure 25b. Estimated catchability coefficients (q) from the Split Series VPA (lines) and relative q values for the NEFSC spring survey.*

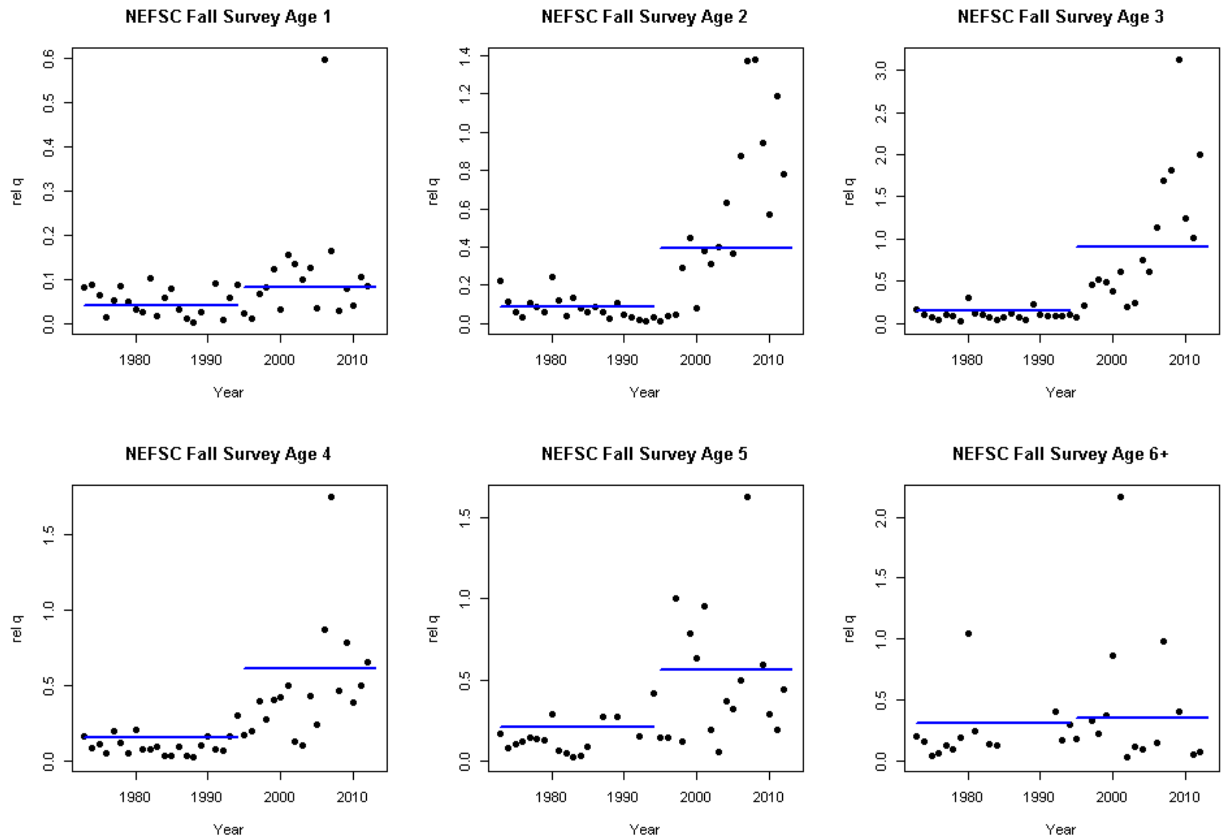



*Figure 25c. Estimated catchability coefficients (q) from the Split Series VPA (lines) and relative q values for the NEFSC fall survey.*

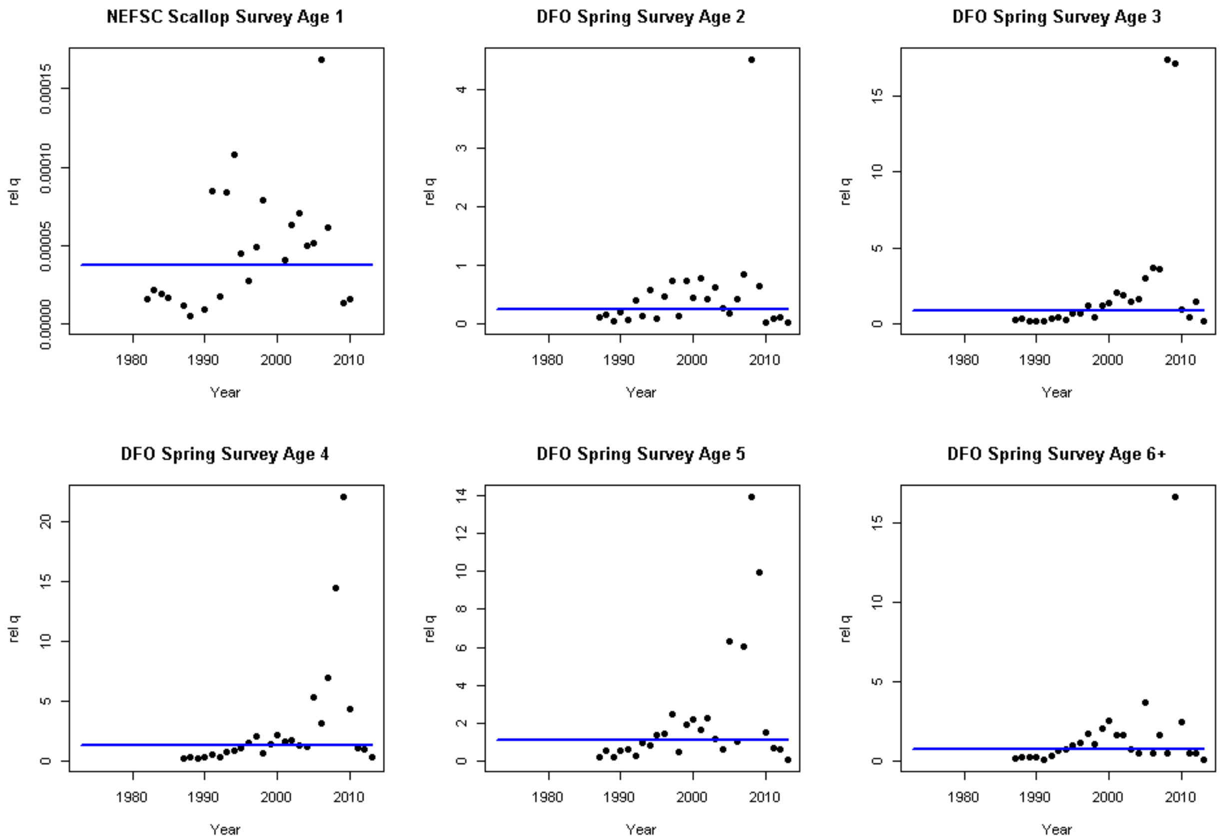



*Figure 25d. Estimated catchability coefficients (q) from the Single Series VPA (lines) and relative q values for the NEFSC scallop survey at age 1 and the DFO survey at ages 2 through 6+.*

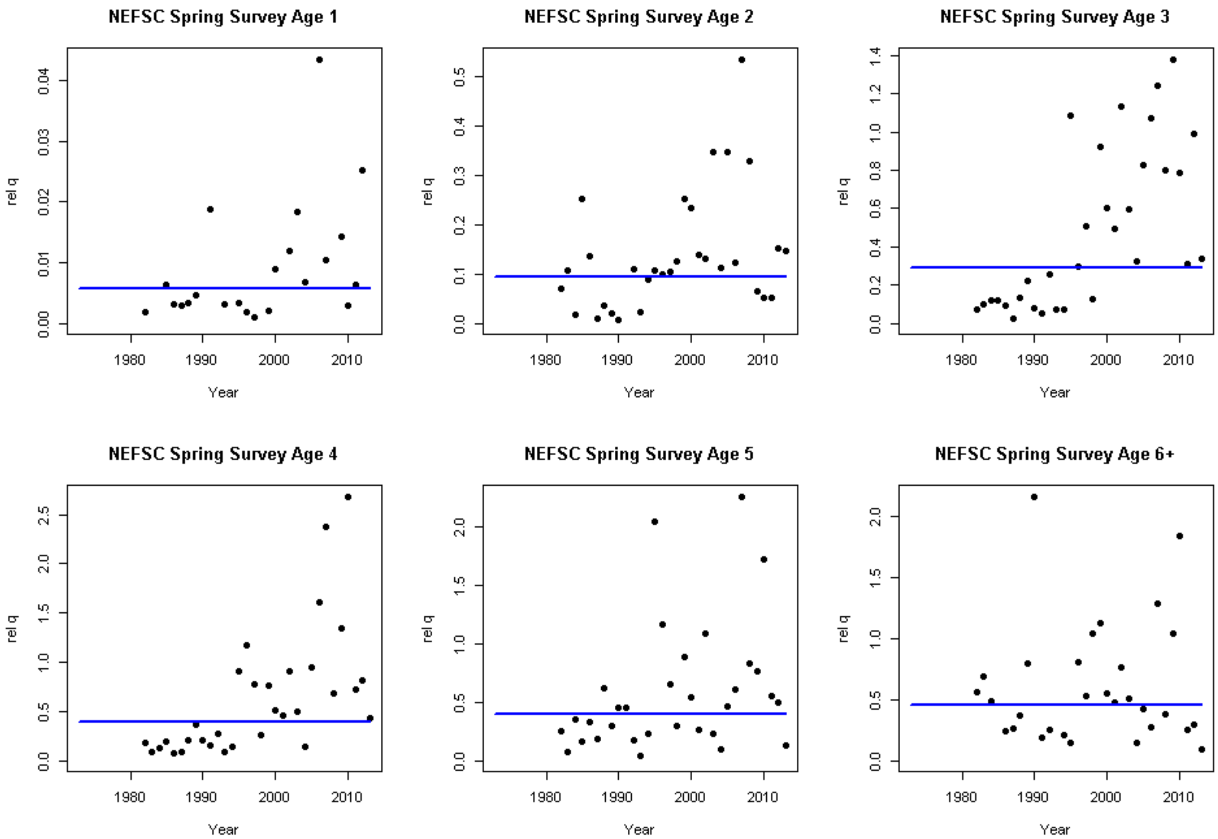



*Figure 25e. Estimated catchability coefficients (q) from the Single Series VPA (lines) and relative q values for the NEFSC spring survey.*

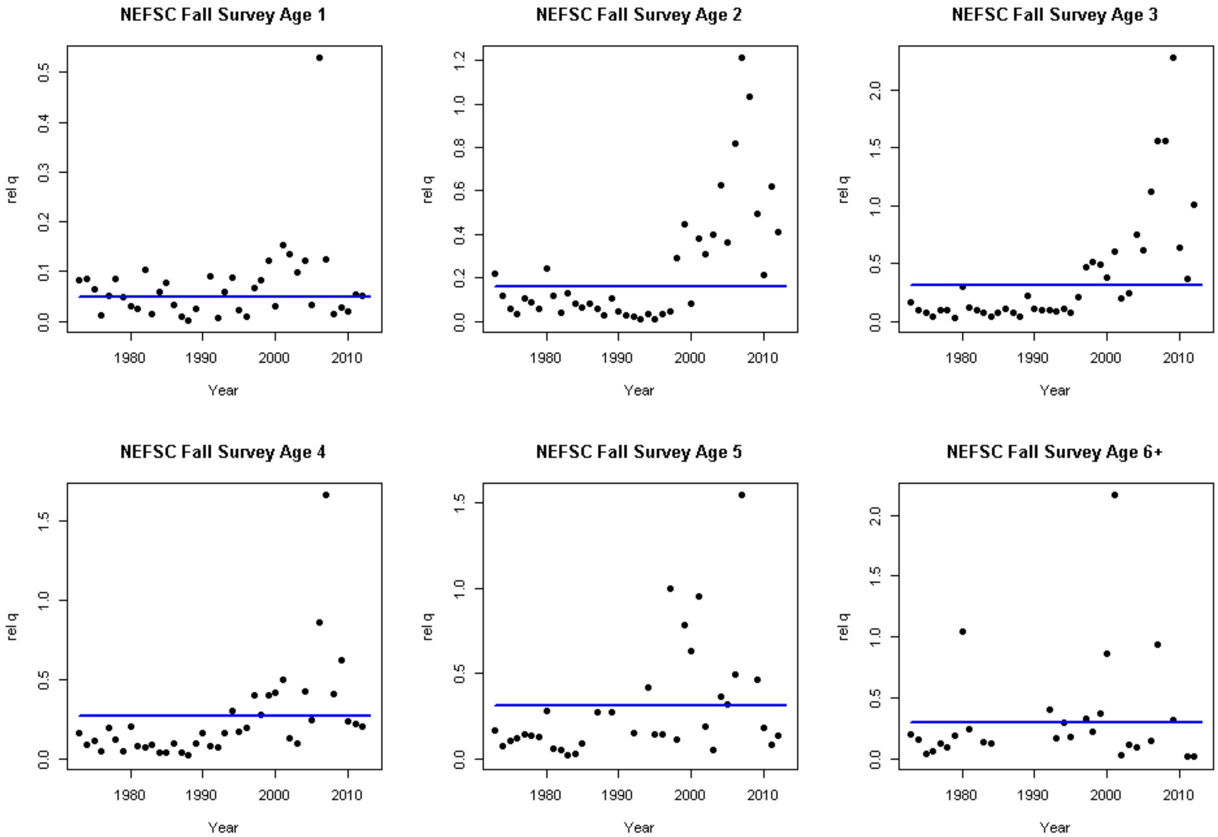



*Figure 25f. Estimated catchability coefficients (q) from the Single Series VPA (lines) and relative q values for the NEFSC fall survey.*

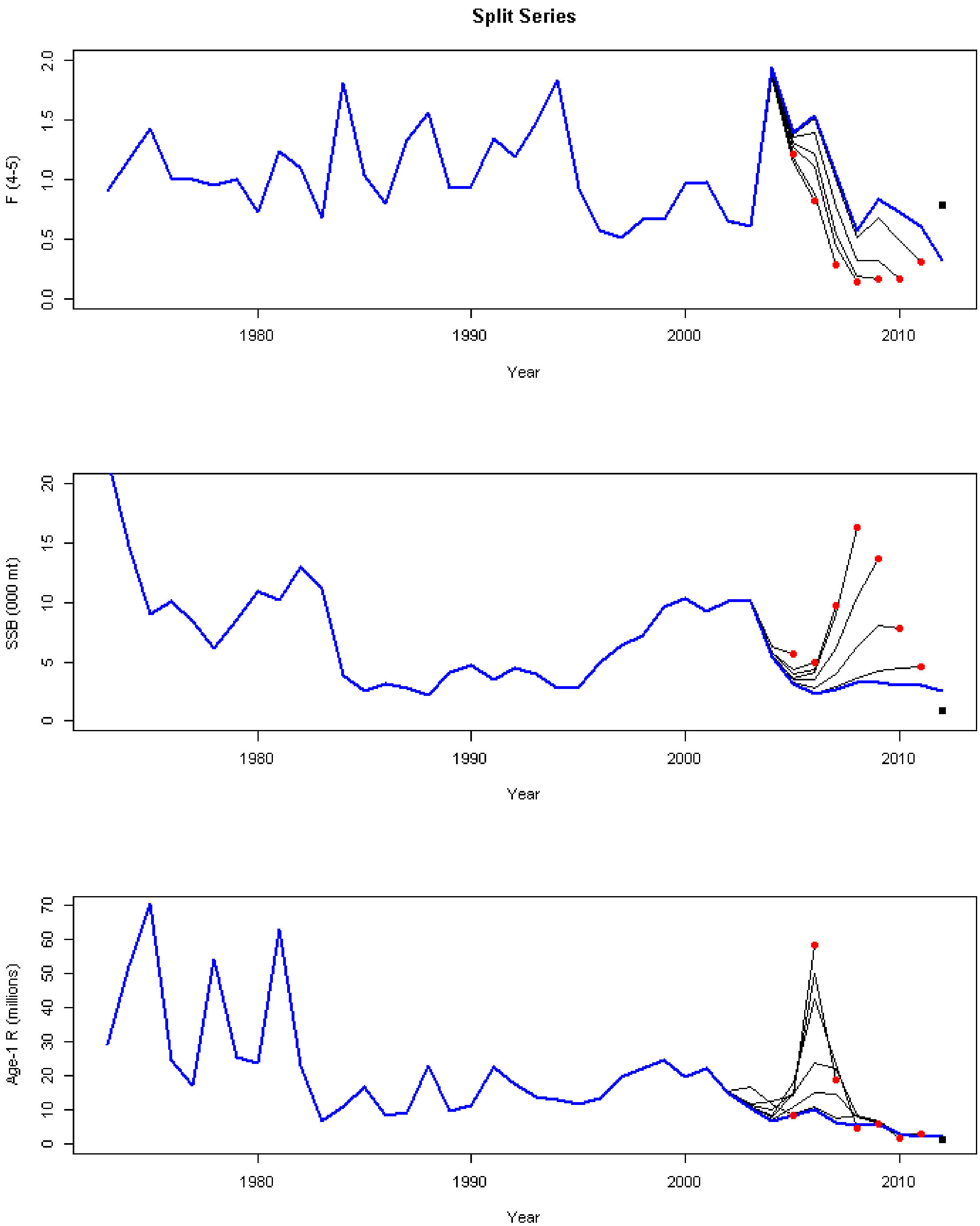



*Figure 26a. Retrospective analysis of Georges Bank yellowtail flounder from the Split Series VPA for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel). The black squares show the rho adjusted values for 2012.*

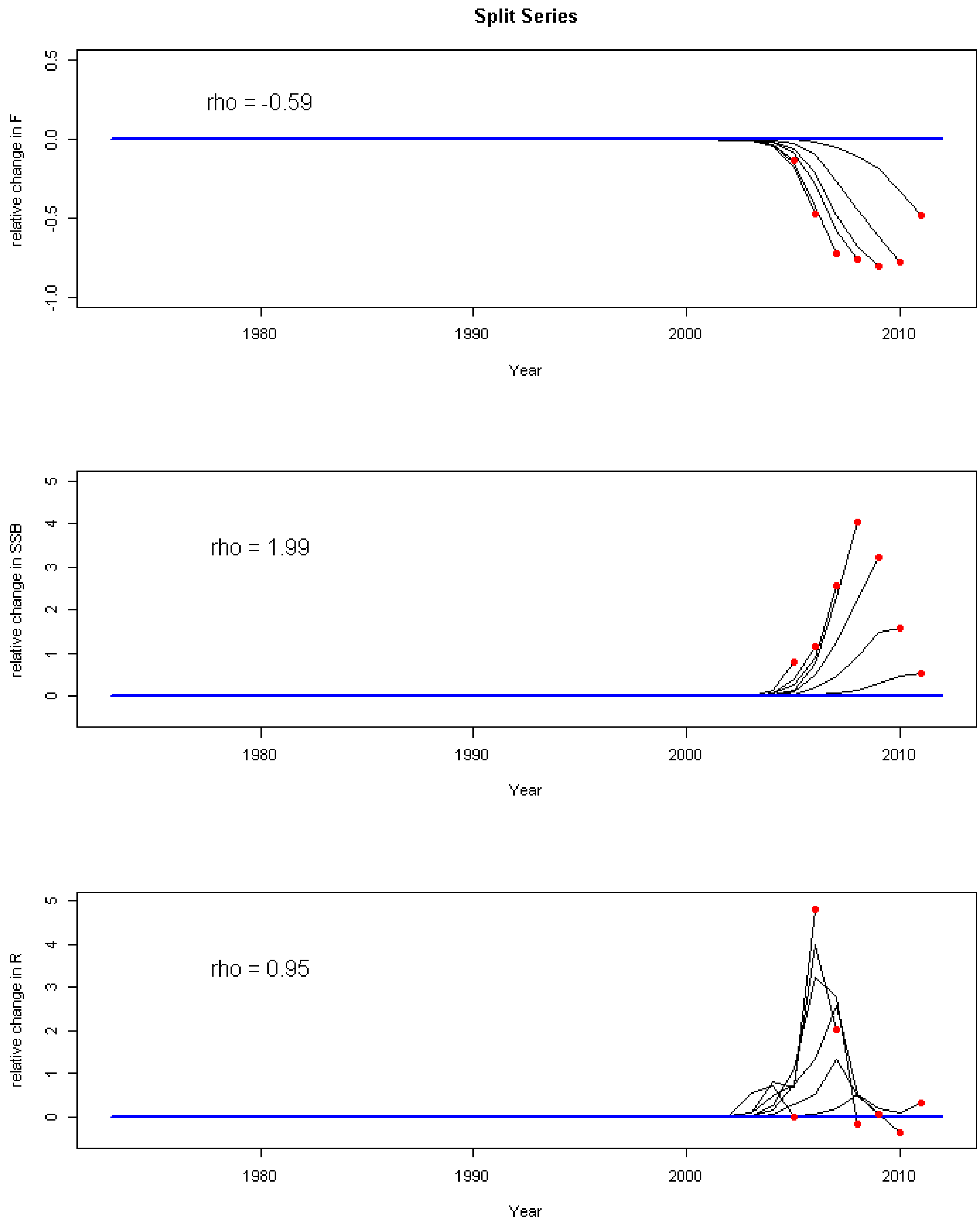



*Figure 26b. Relative retrospective plots for Georges Bank yellowtail flounder from Split Series VPA with Mohn's rho calculated from seven year peel for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel).*

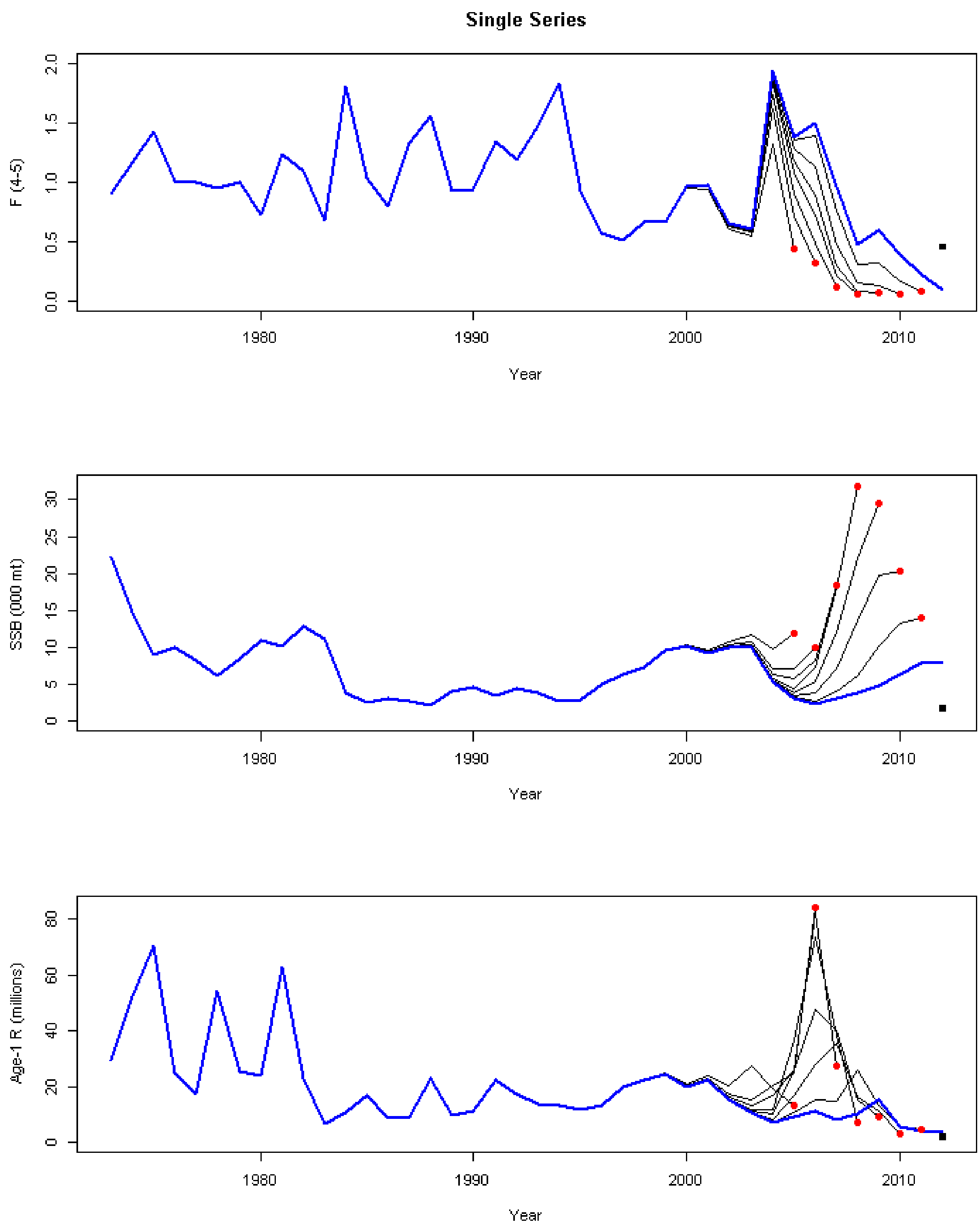



*Figure 26c. Retrospective analysis of Georges Bank yellowtail flounder from the Single Series VPA for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel). The black squares show the rho adjusted values for 2012.*

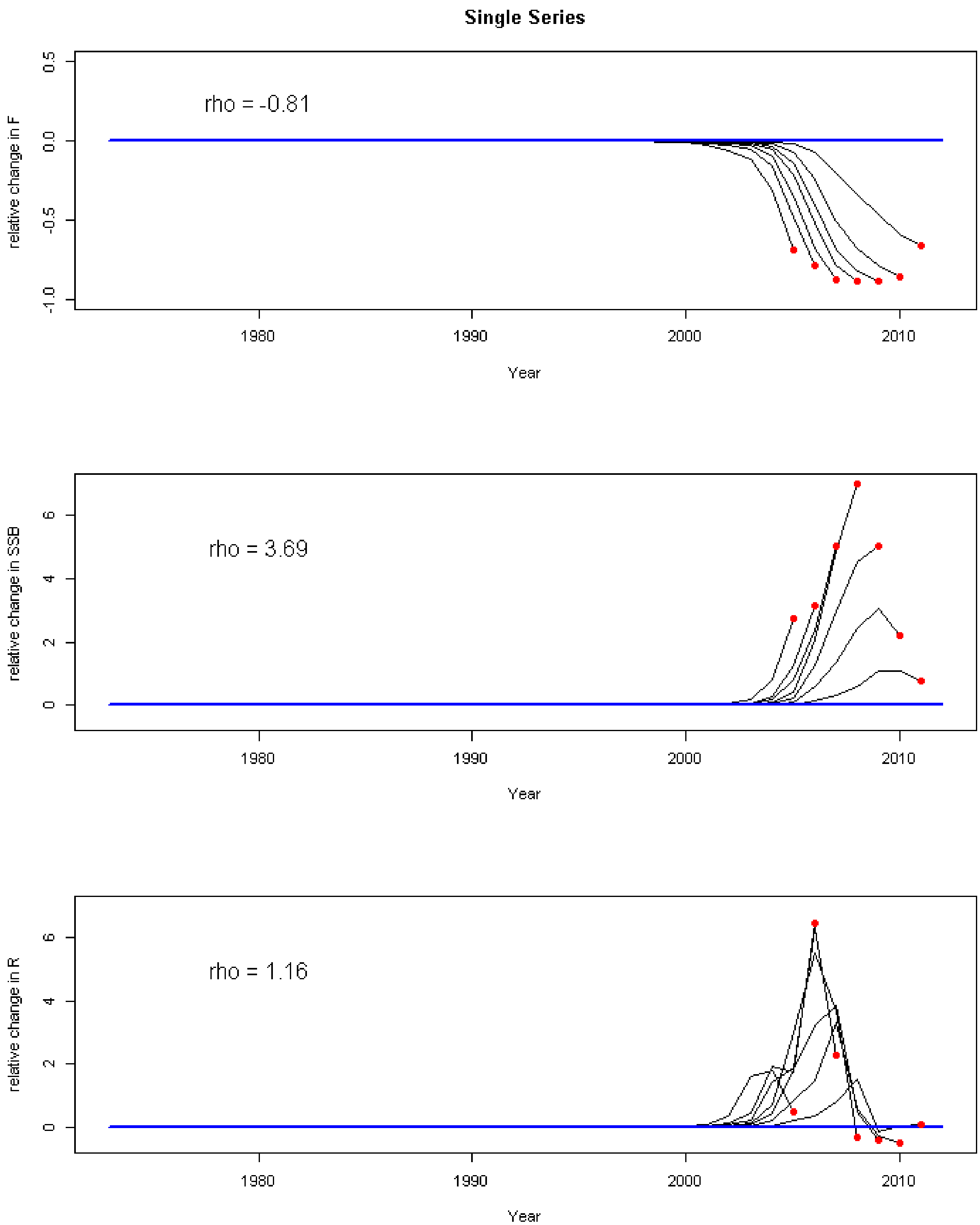



*Figure 26d. Relative retrospective plots for Georges Bank yellowtail flounder from Single Series VPA with Mohn's rho calculated from seven year peel for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel).*

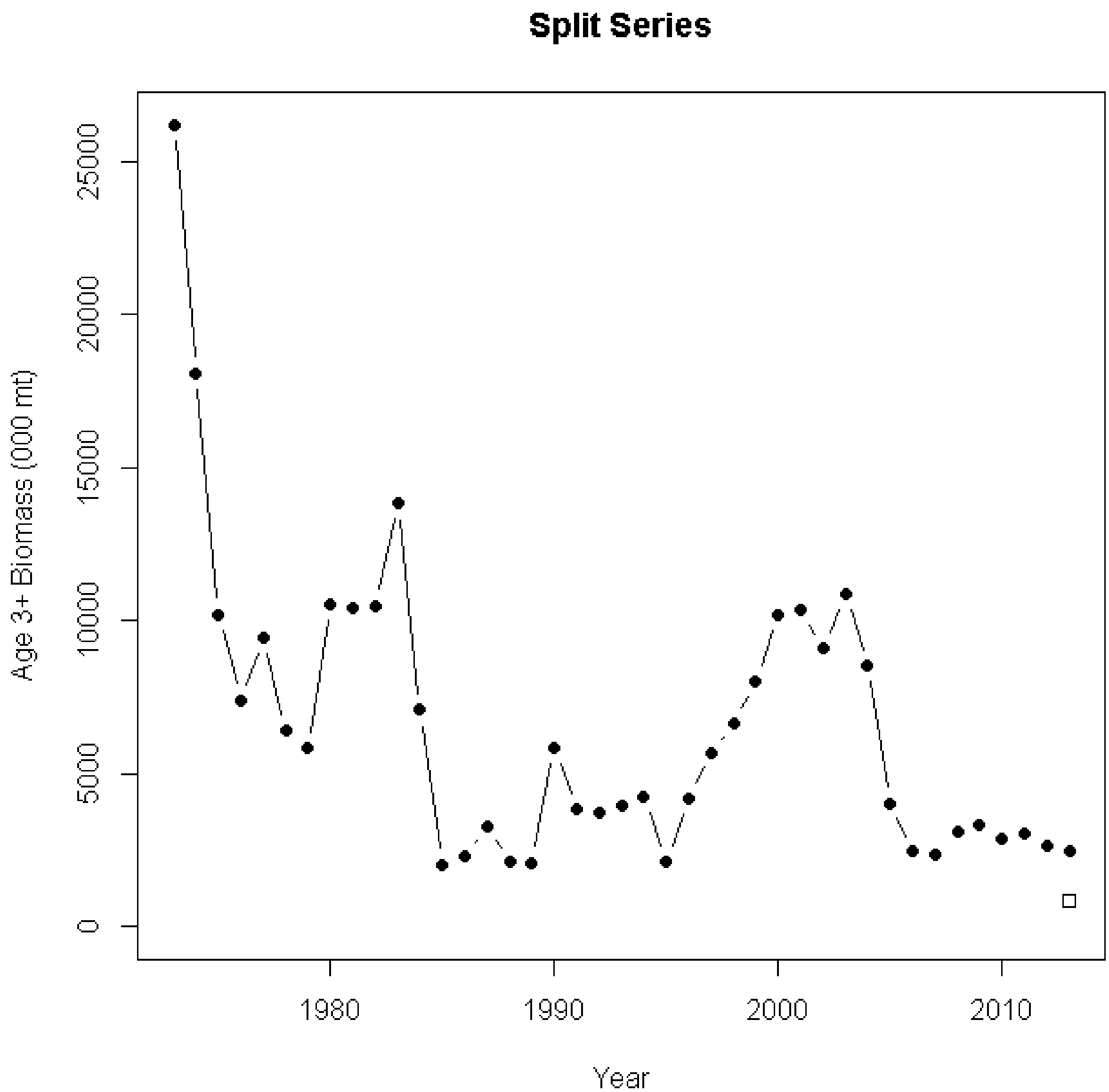



*Figure 27a. Adult biomass (ages 3+, Jan-1) from the Split Series VPA. The open square shows the rho adjusted values for 2013 using the SSB rho to make the adjustment.*

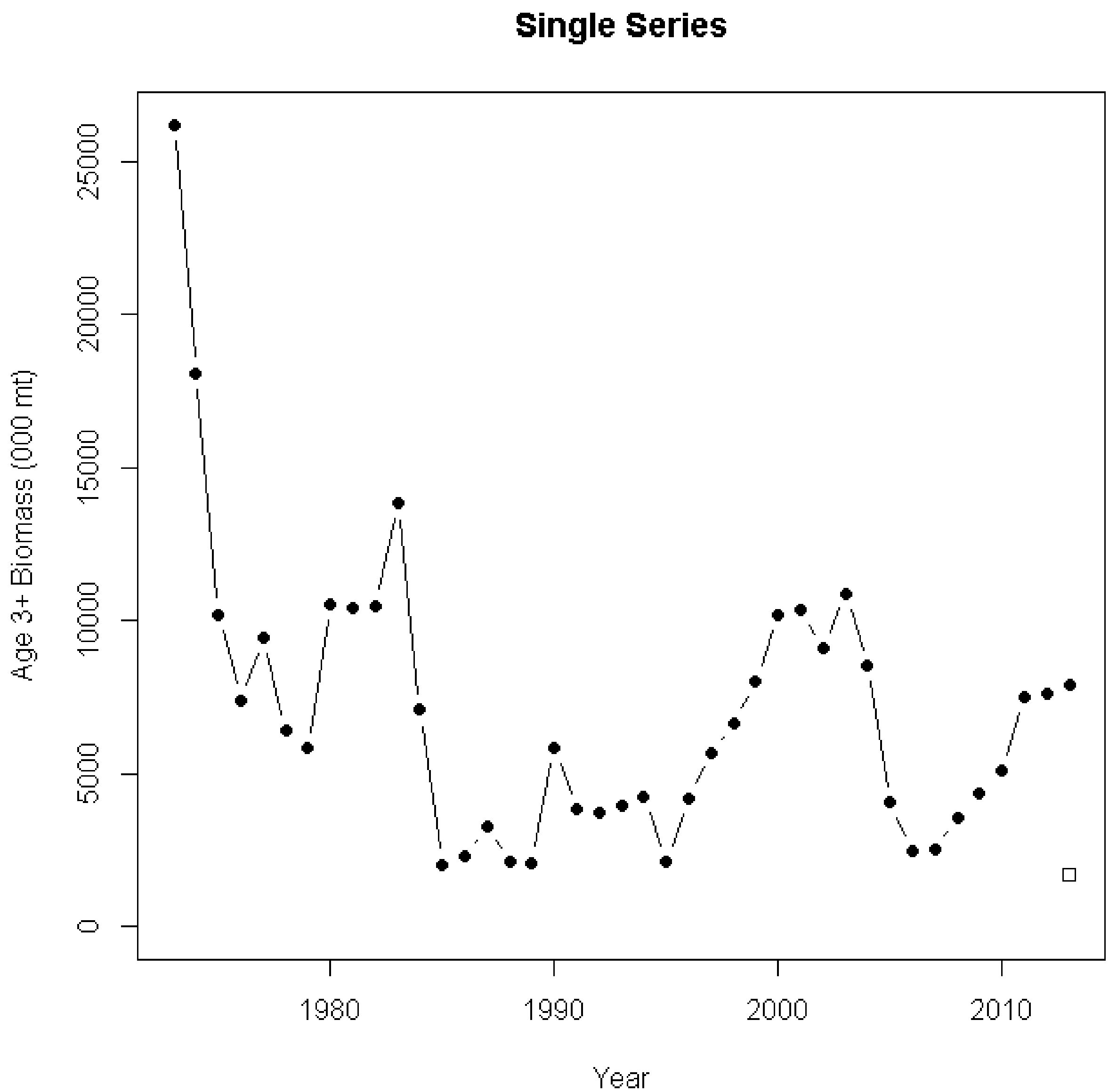



*Figure 27b. Adult biomass (ages 3+, Jan-1) from the Single Series VPA. The open square shows the rho adjusted values for 2013 using the SSB rho to make the adjustment.*

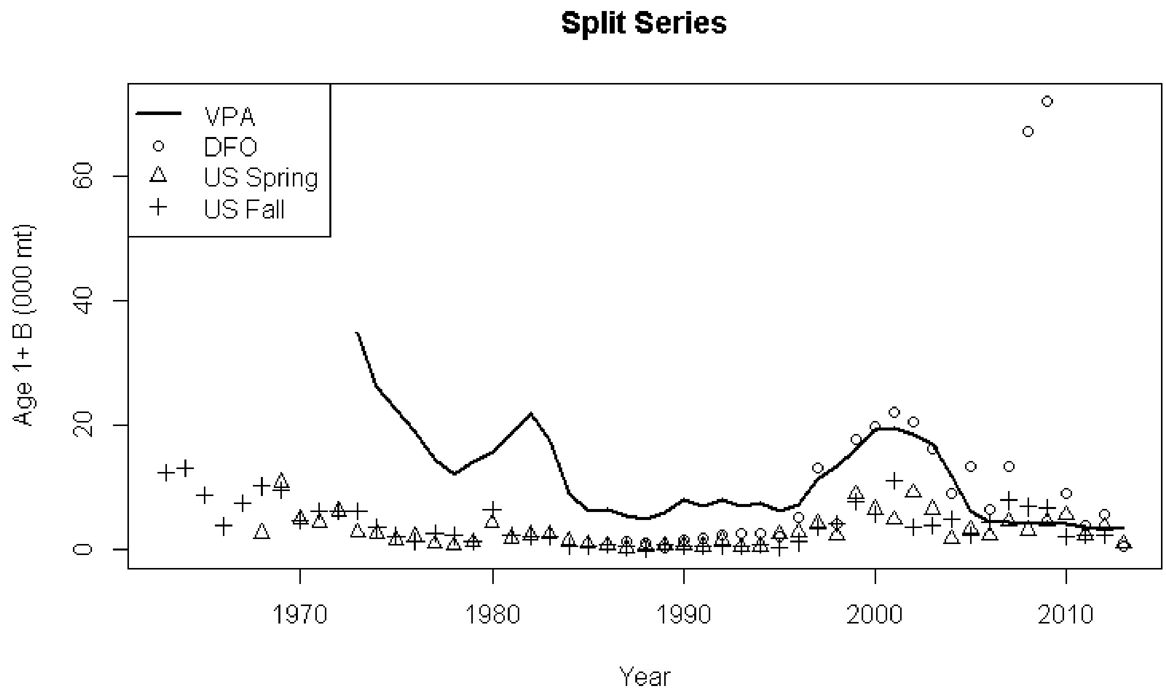



*Figure 28a. Jan-1 age 1+ biomass estimated by the Split Series VPA and from the three groundfish surveys in minimum swept area values. The final VPA value uses the geometric mean of the previous ten years for the age 1 recruitment.*

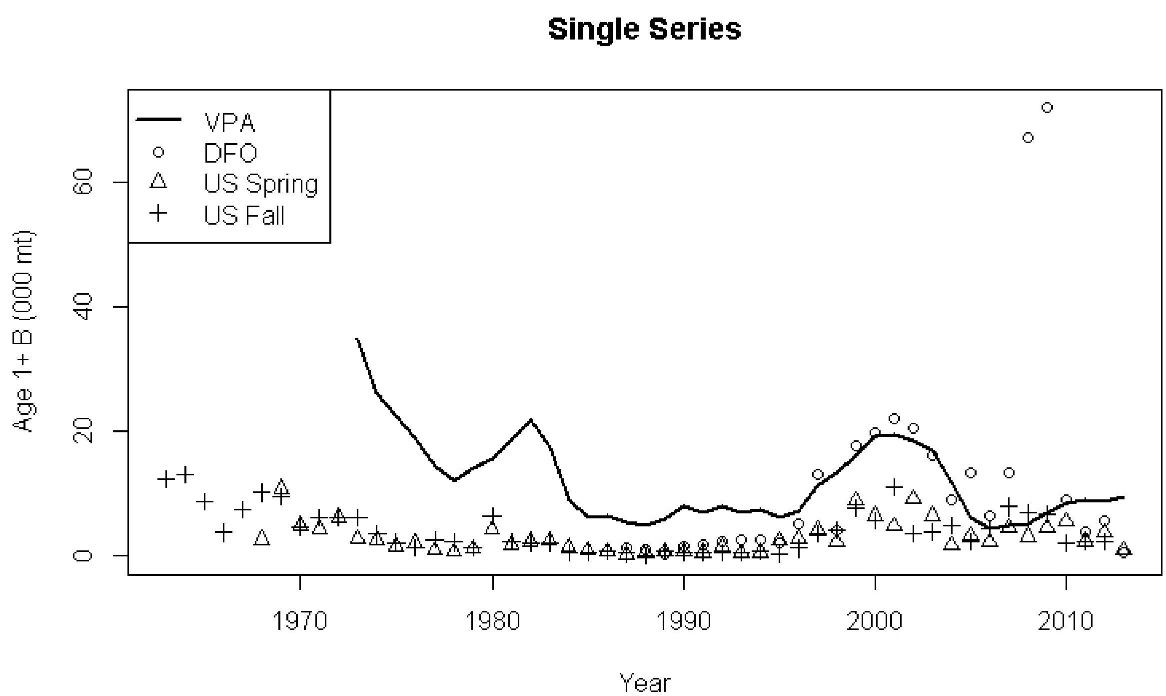



*Figure 28b. Jan-1 age 1+ biomass estimated by the Single Series VPA and from the three groundfish surveys in minimum swept area values. The final VPA value uses the geometric mean of the previous ten years for the age 1 recruitment.*

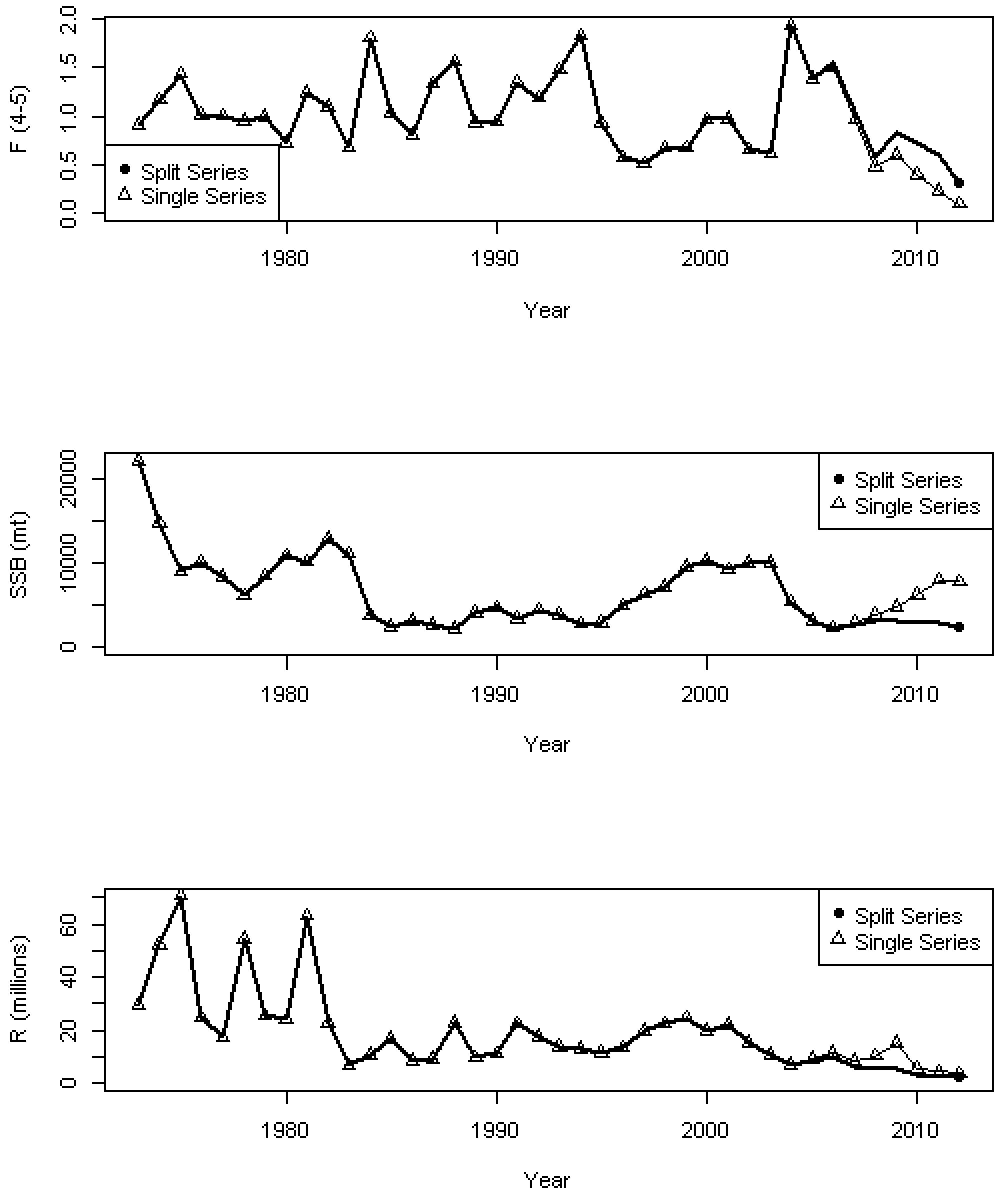



*Figure 29a. Fishing mortality rate (ages 4-5; top panel), spawning stock biomass (mt; middle panel), and age 1 recruitment (millions of fish; bottom panel) for the Split Series VPA and Single Series VPA.*

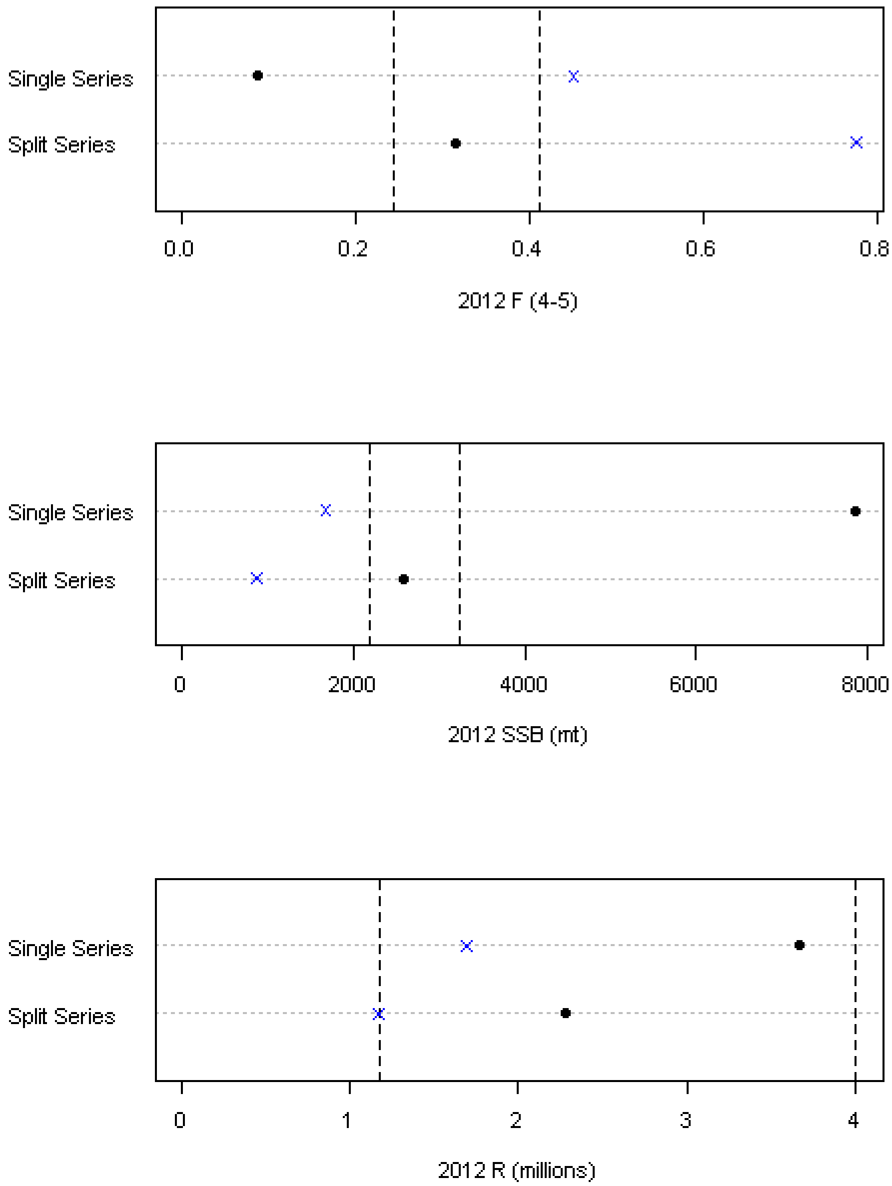



*Figure 29b. Dotcharts of 2012 fishing mortality rate (ages 4-5; top panel), spawning stock biomass (mt; middle panel), and age 1 recruitment (millions of fish; bottom panel) for the Split Series and Single Series VPAs. The filled circles denote the point estimates while the blue crosses denote the rho adjusted values for each run. The vertical lines denote the 80% confidence interval for the Split Series VPA point estimate.*

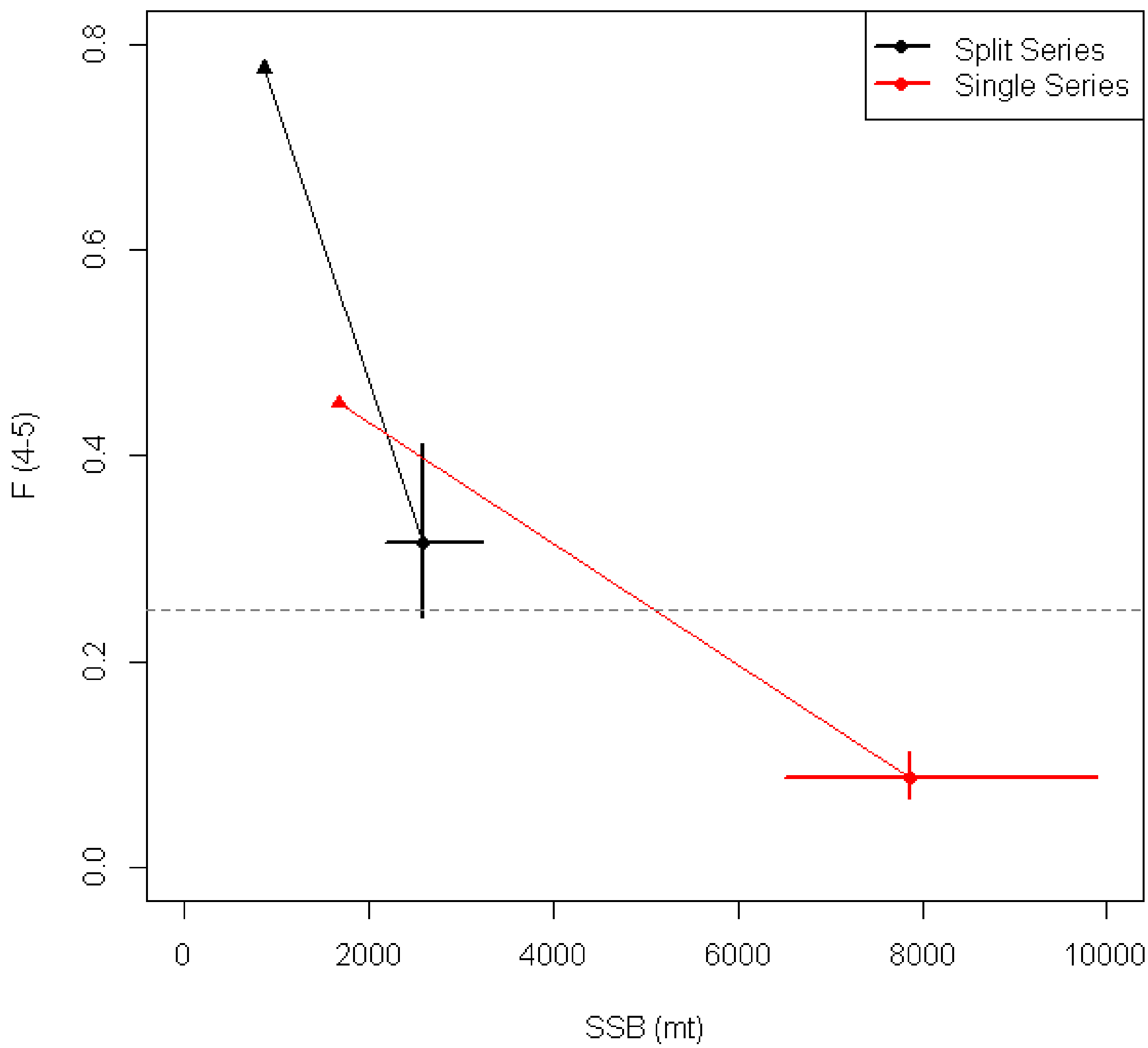



*Figure 30. Point estimates of terminal year SSB (mt) and F (ages 4+) with 80% confidence intervals (horizontal and vertical lines) and rho adjusted estimates of SSB and F (triangles) for the Split Series VPA and the Single Series VPA. The horizontal dashed line denotes Fref=0.25.*

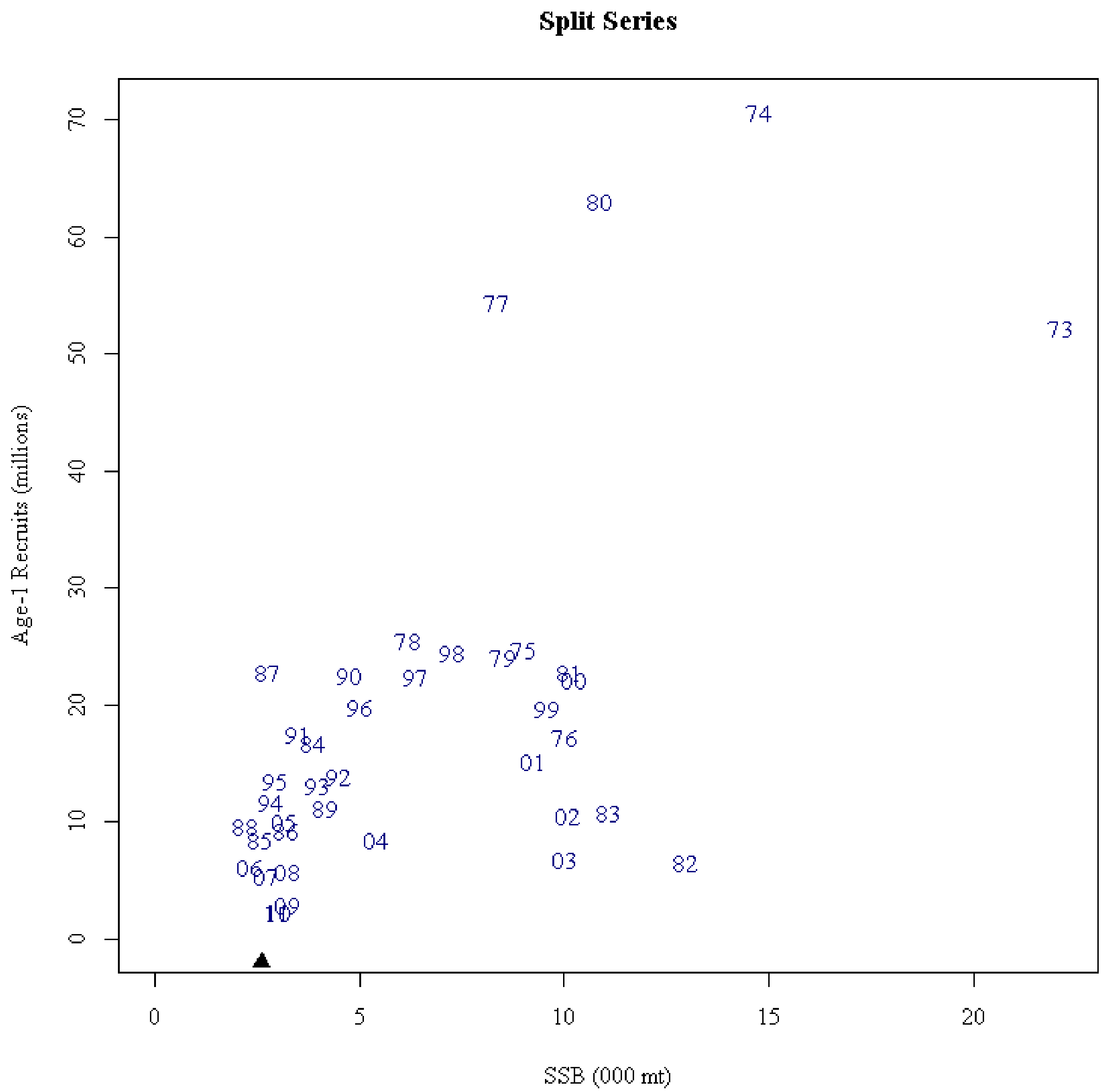



*Figure 31a. Stock recruitment relationship from the Split Series VPA. The number denotes year-class (year of SSB and year when recruitment was age 0). The triangle denotes the spawning stock biomass in 2012.*

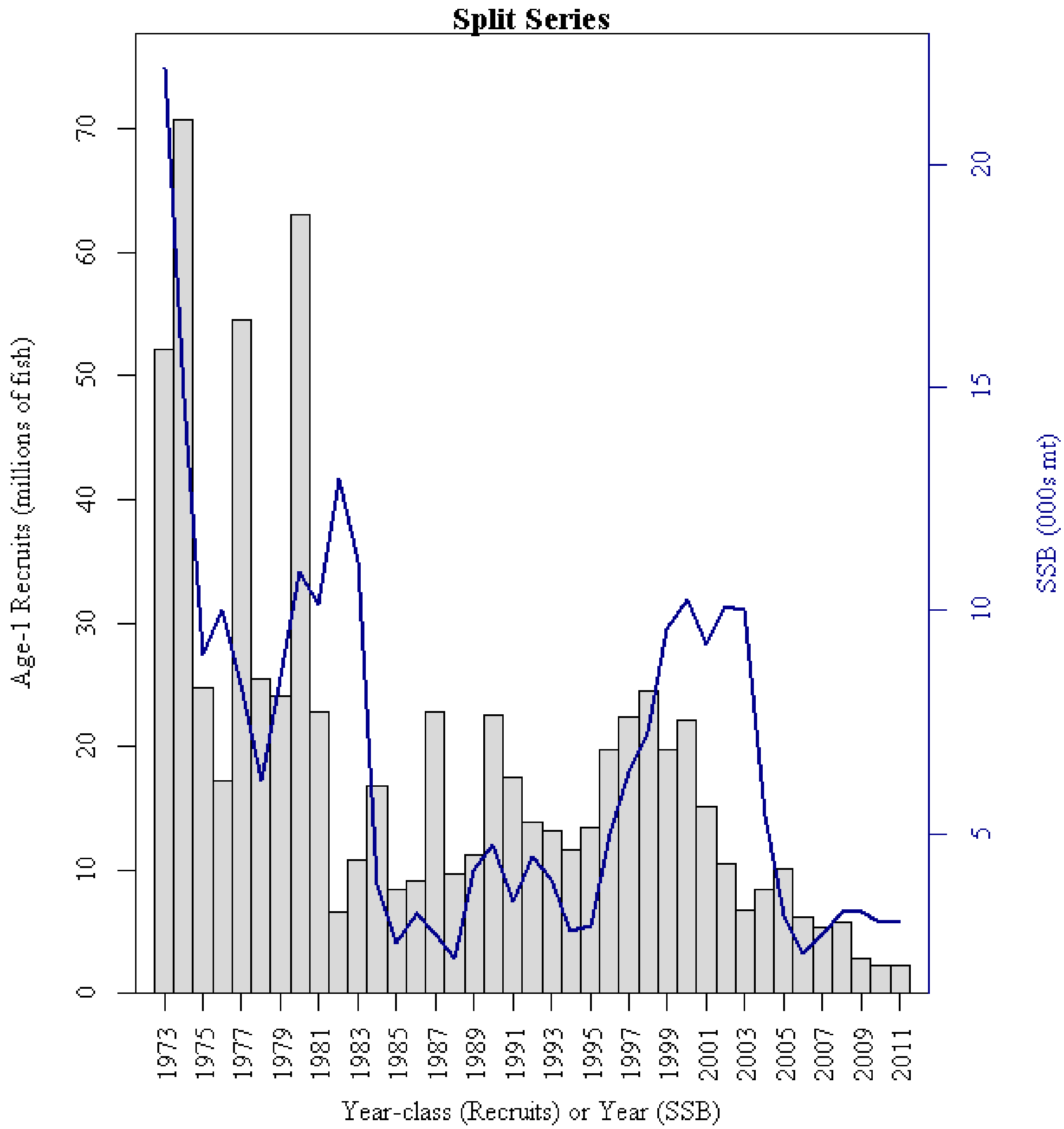



*Figure 31b. Estimated age 1 recruitment in millions of fish (denoted by bars) and spawning stock biomass in thousands of metric tons (denoted by solid line) by year-class (recruitment) or year (SSB) from the Split Series VPA.*

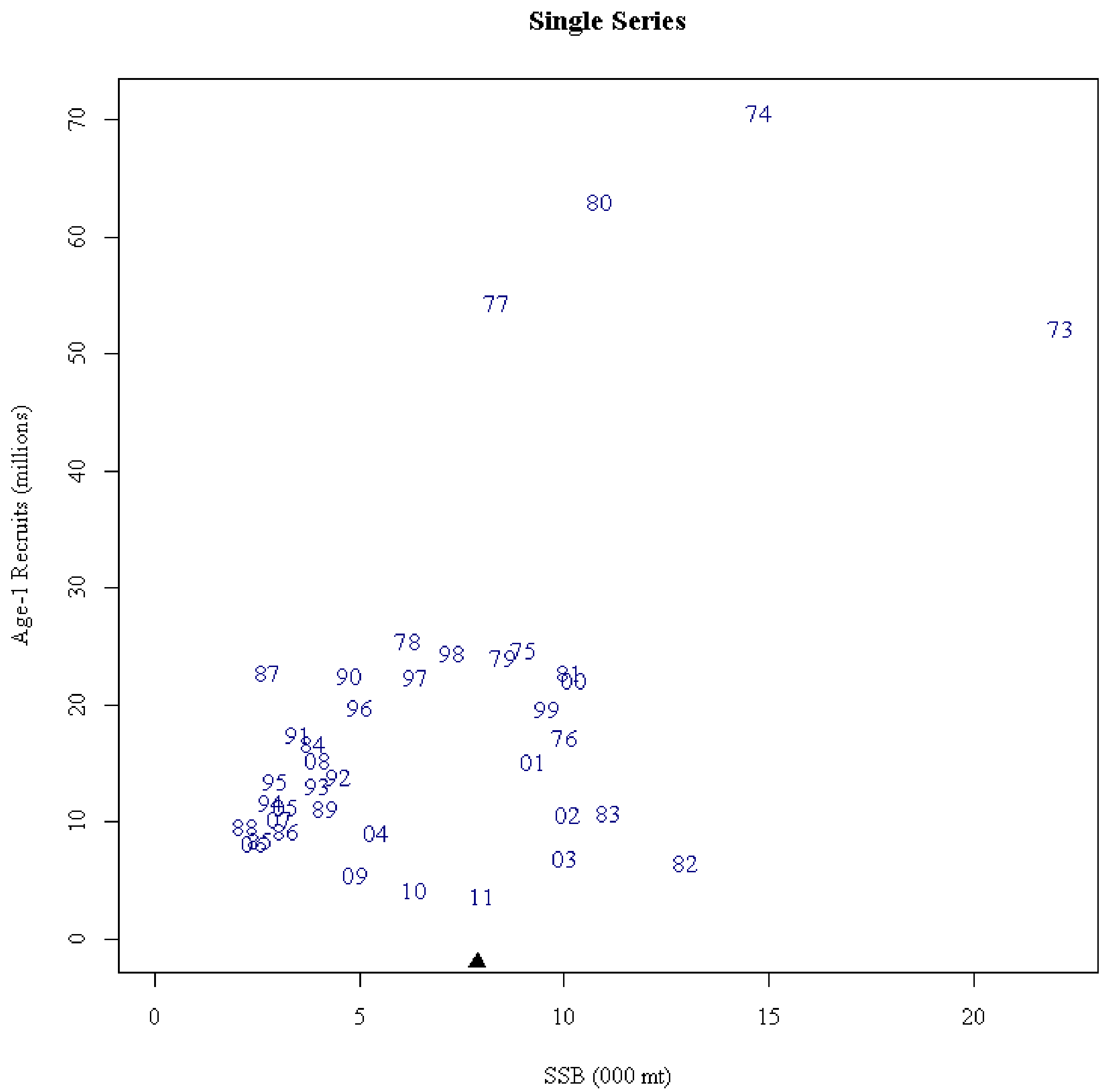



*Figure 31c. Stock recruitment relationship from the Single Series VPA. The number denotes year-class (year of SSB and year when recruitment was age 0). The triangle denotes the spawning stock biomass in 2012.*

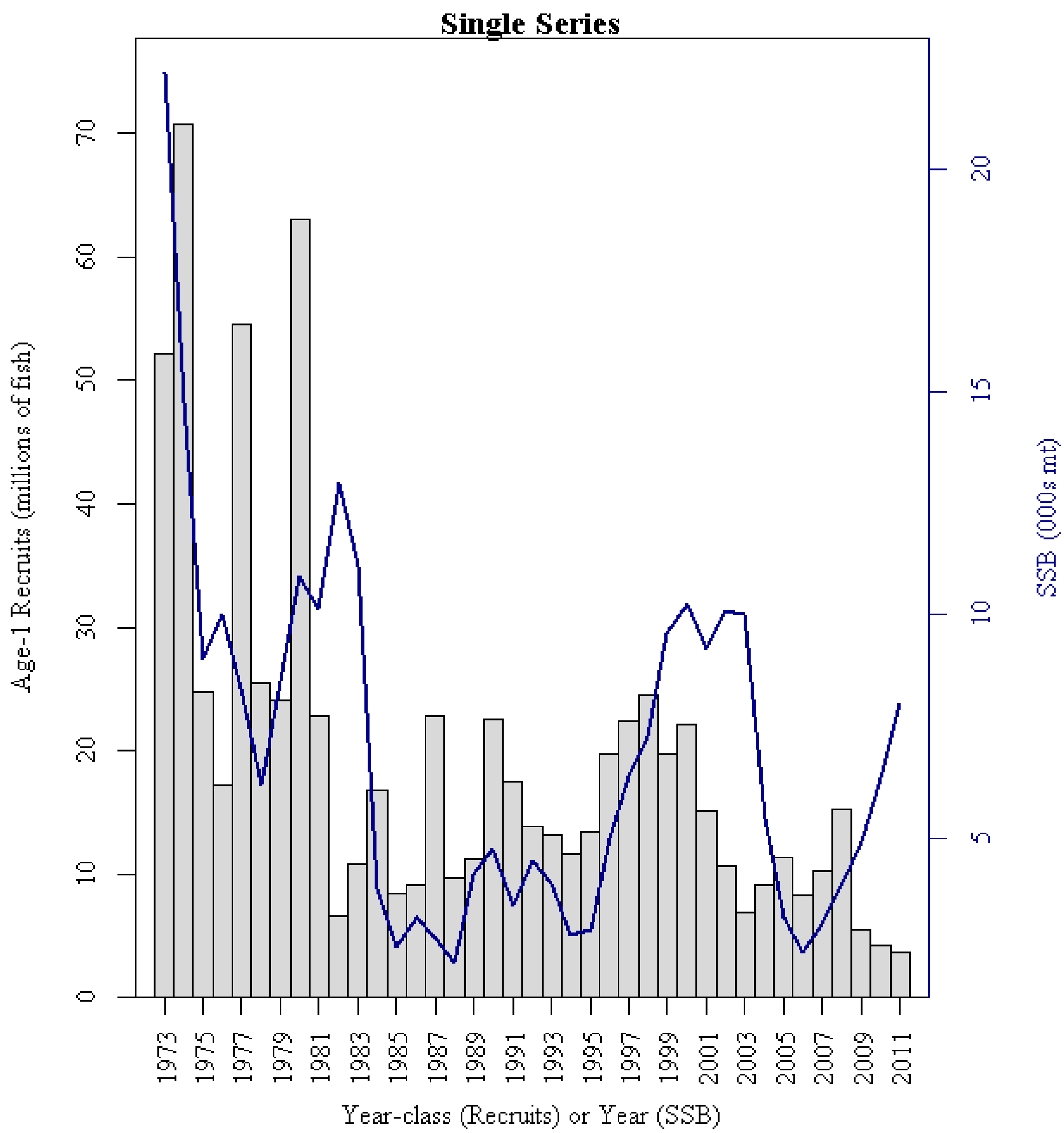



*Figure 31d. Estimated age 1 recruitment in millions of fish (denoted by bars) and spawning stock biomass in thousands of metric tons (denoted by solid line) by year-class (recruitment) or year (SSB) from the Single Series VPA.*

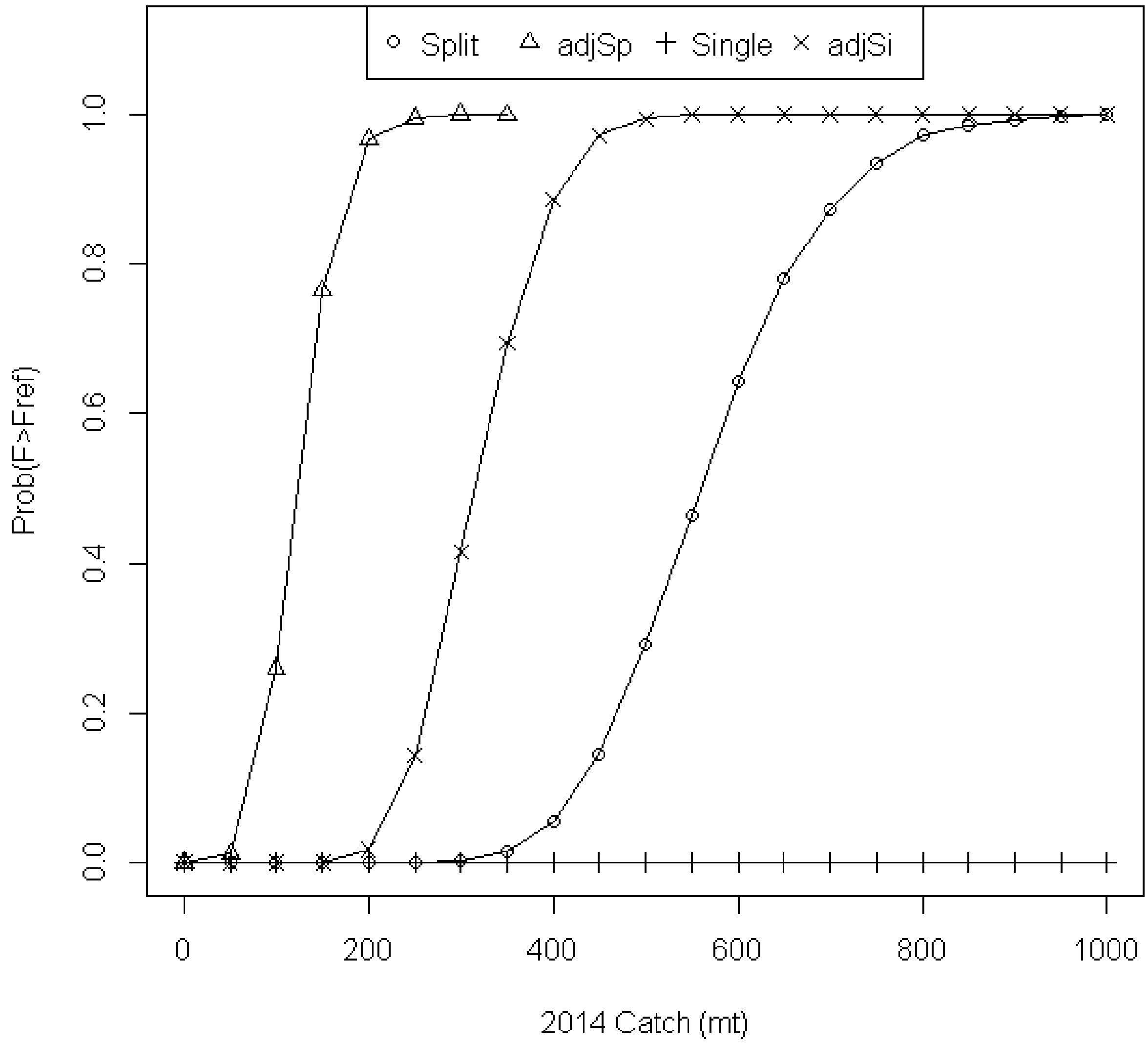



*Figure 32. Probability the fishing mortality rate in 2014 is greater than $F_{ref}$=0.25 for a range of catch values in 2014 and four projection scenarios. The four scenario labels are defined in Table 20.*

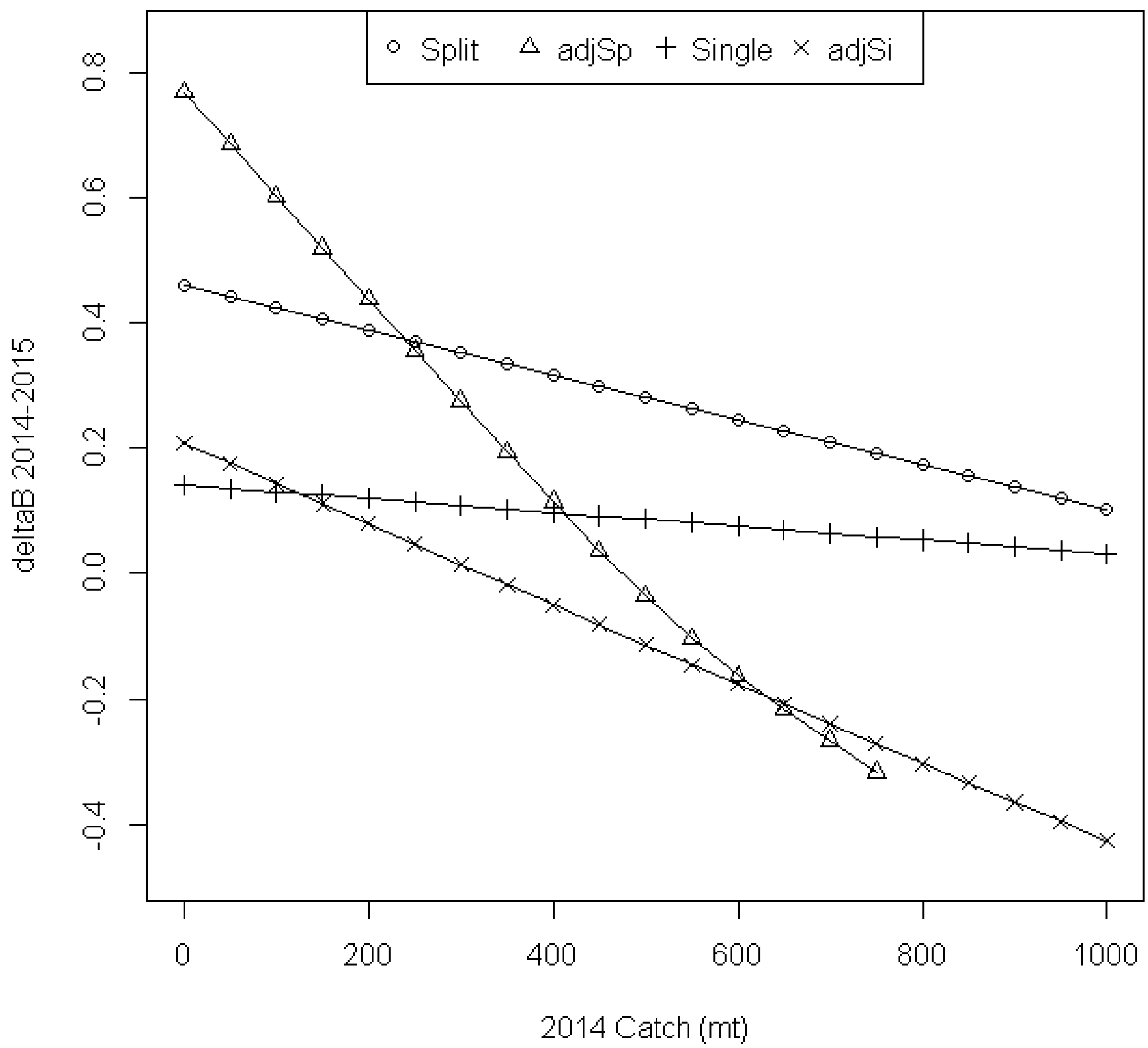
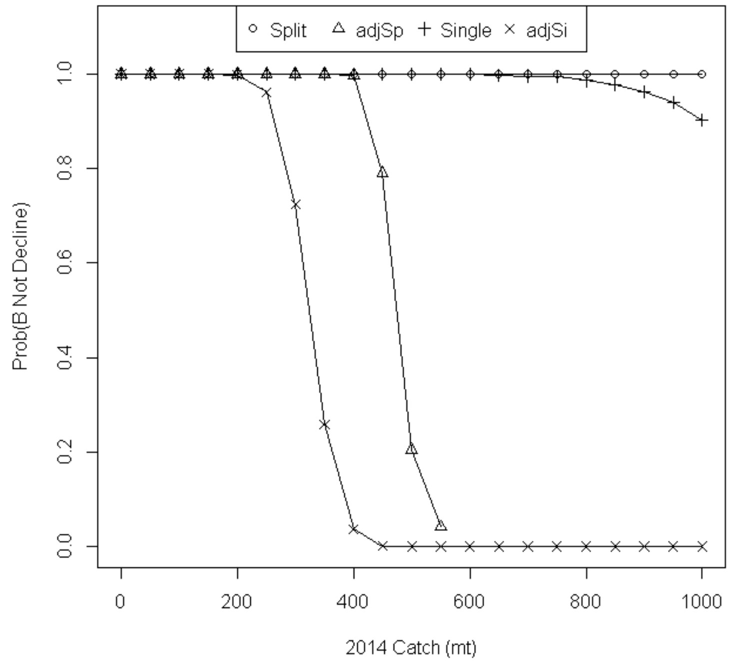



*Figure 33. Relative change in median adult Jan-1 biomass from 2014 to 2015 for a range of catch values in 2014 and four projection scenarios. The four scenario labels are defined in Table 20.*



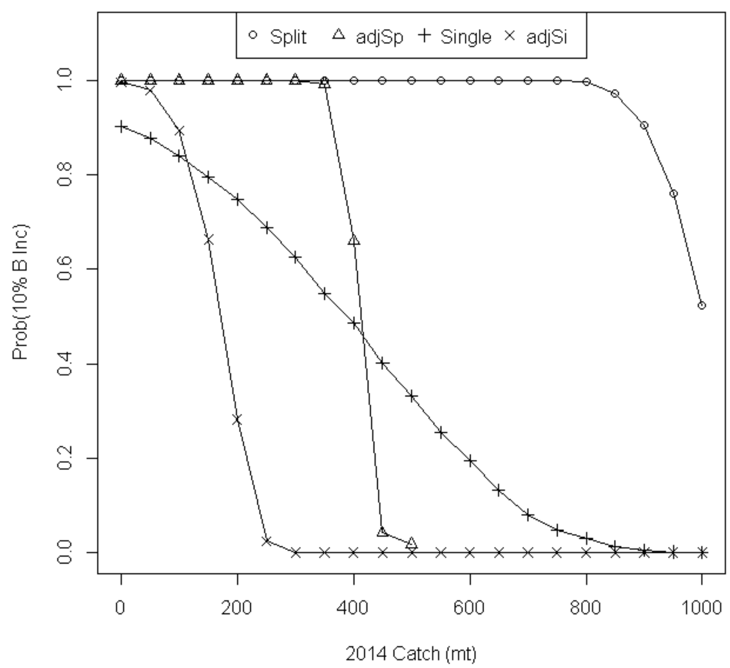




*Figure 34. Probability adult Jan-1 biomass will not decline (top panel) or will increase by at least 10% (bottom panel) from 2014 to 2015 for a range of catch values in 2014 and four projection scenarios. The four scenario labels are defined in Table 20.*

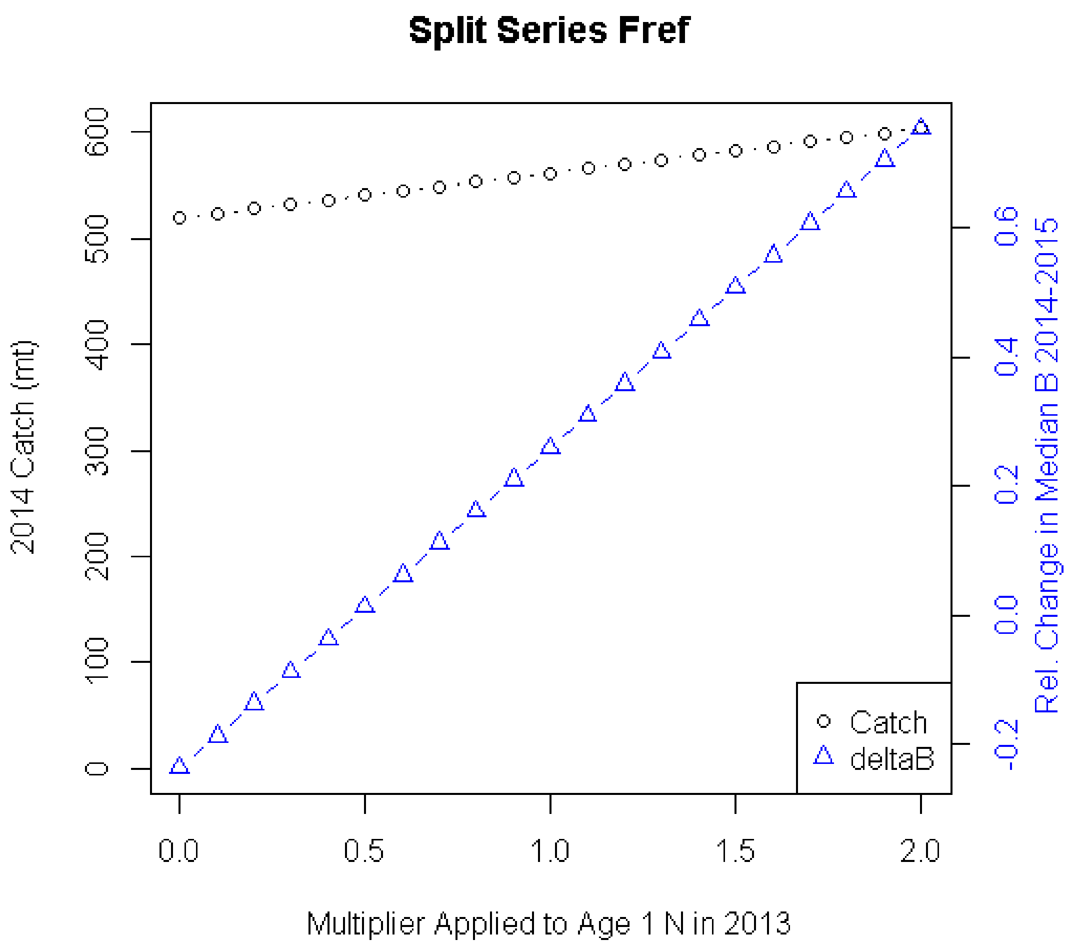



*Figure 35. Median catch (mt) in 2014 and relative change in median adult Jan-1 biomass from 2014 to 2015 for a range of multipliers applied to the age 1 abundance in 2013 used in the Split Series projections.*

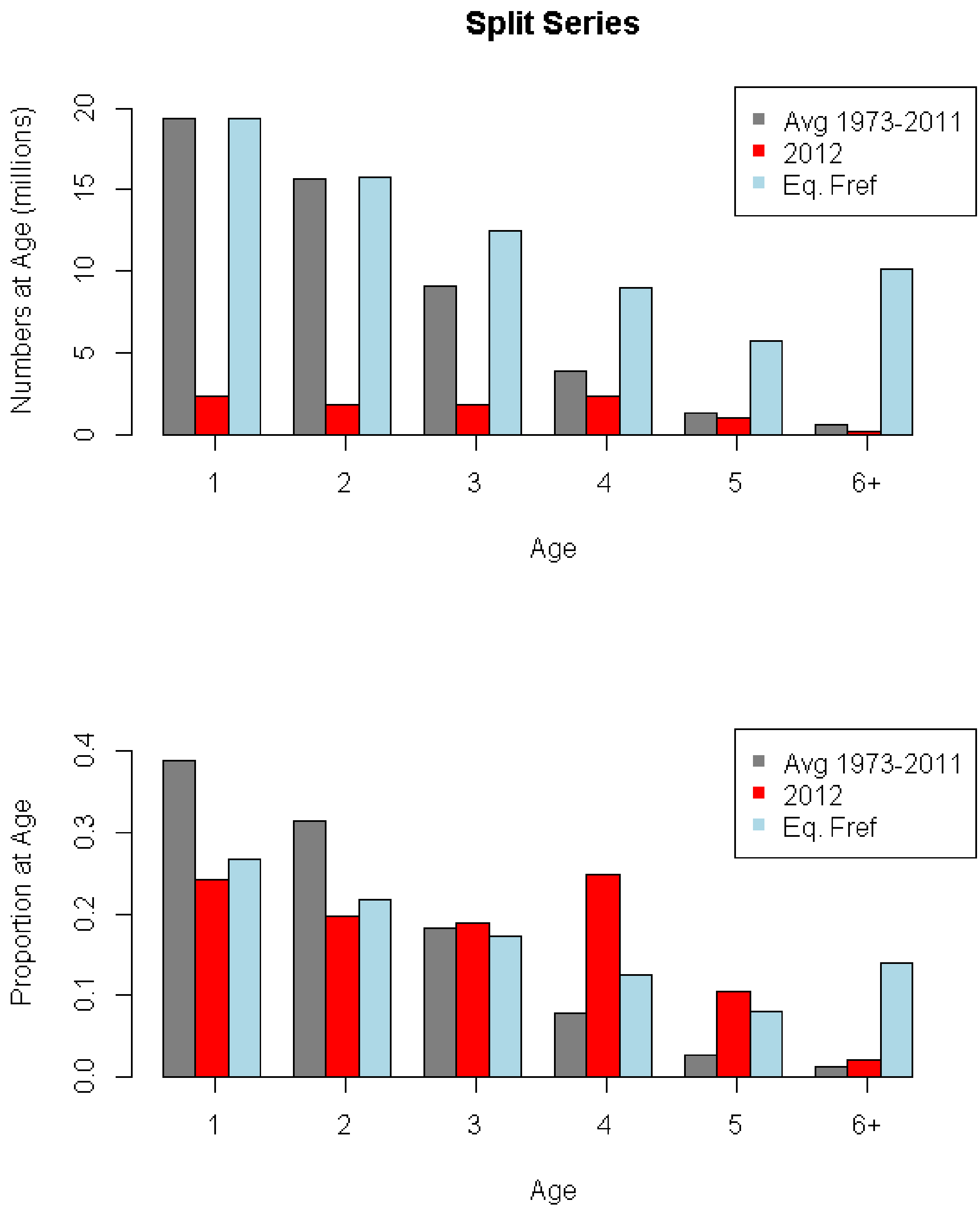
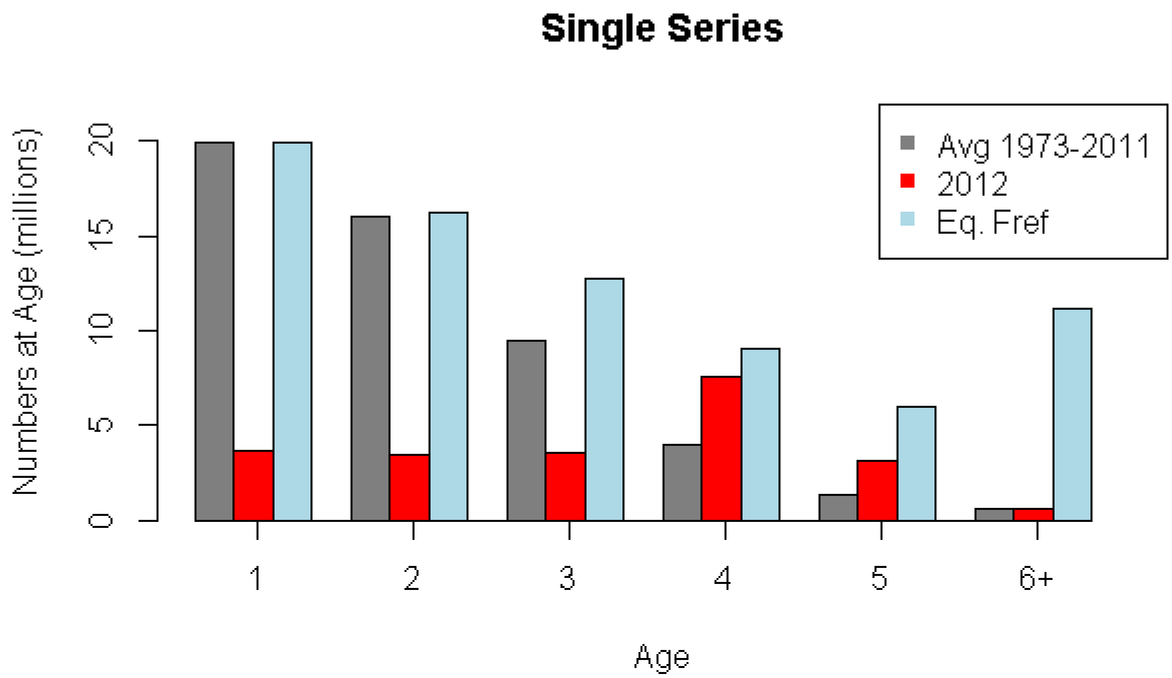



*Figure 36a. Comparison of the population abundance at age distributions for the Split Series VPA among the average of 1973-2011, 2012, and that expected when the population is fished in equilibrium at $F_{ref}$=0.25. The equilibrium numbers at age 1 in the top panel are set equal to the average for years 1973-2010. The bottom panel shows the proportions at age instead of numbers.*



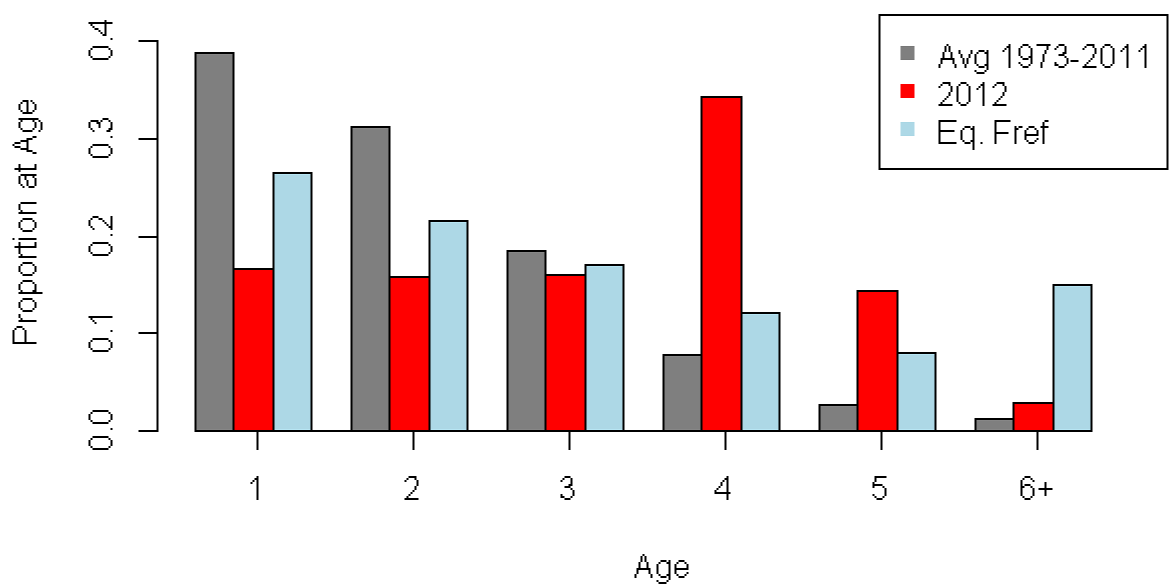




*Figure 36b. Comparison of the population abundance at age distributions for the Single Series VPA among the average of 1973-2011, 2012, and that expected when the population is fished in equilibrium at $F_{ref}$=0.25. The equilibrium numbers at age 1 in the top panel are set equal to the average for years 1973-2010. The bottom panel shows the proportions at age instead of numbers.*

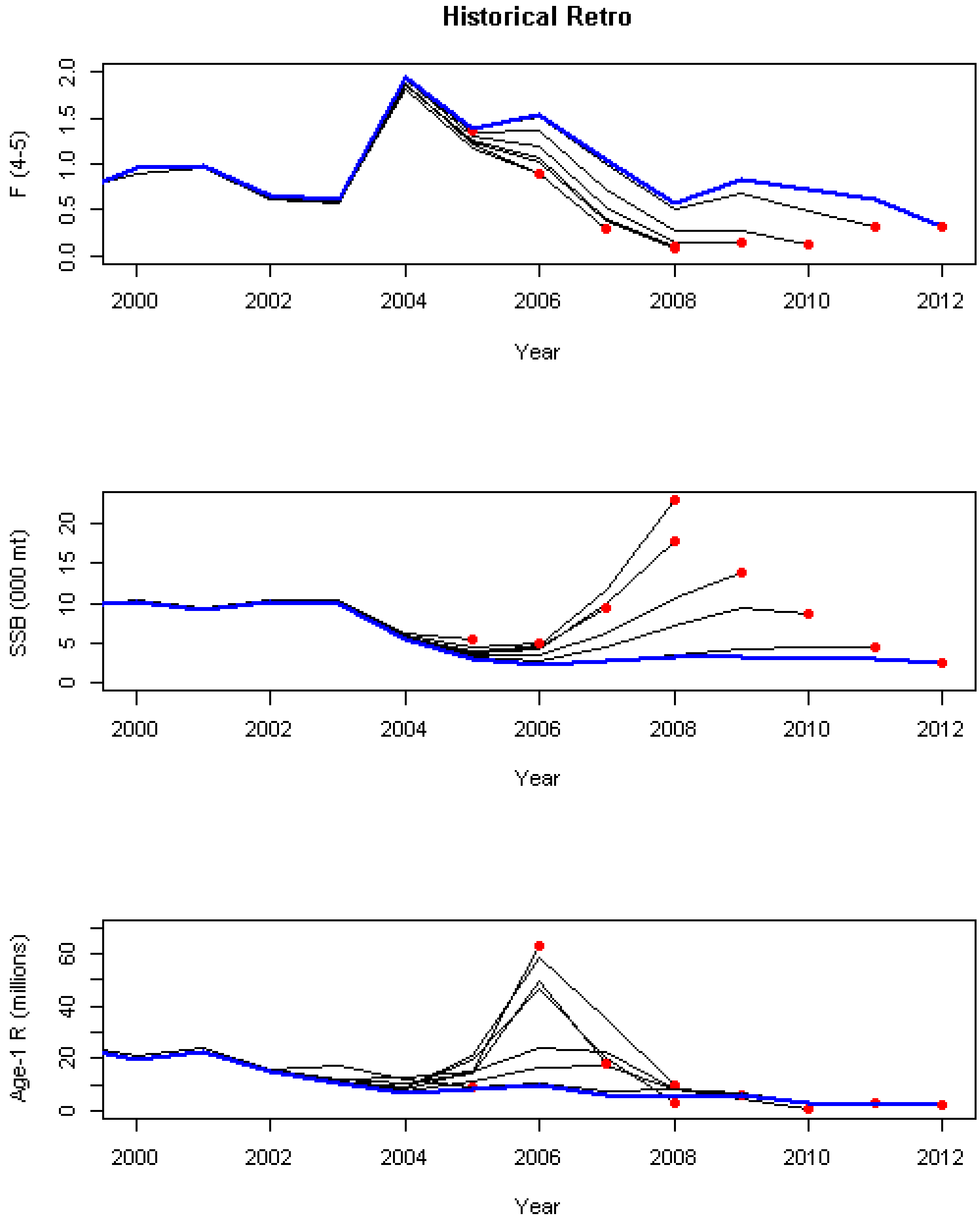



*Figure 37. Historical retrospective analysis of Georges Bank yellowtail flounder assessments from this and the previous seven TRAC Split Series VPAs for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel). Note there are two lines plotted for TRAC 2009 (terminal year 2008), the "Including" and "Excluding" formulations.*

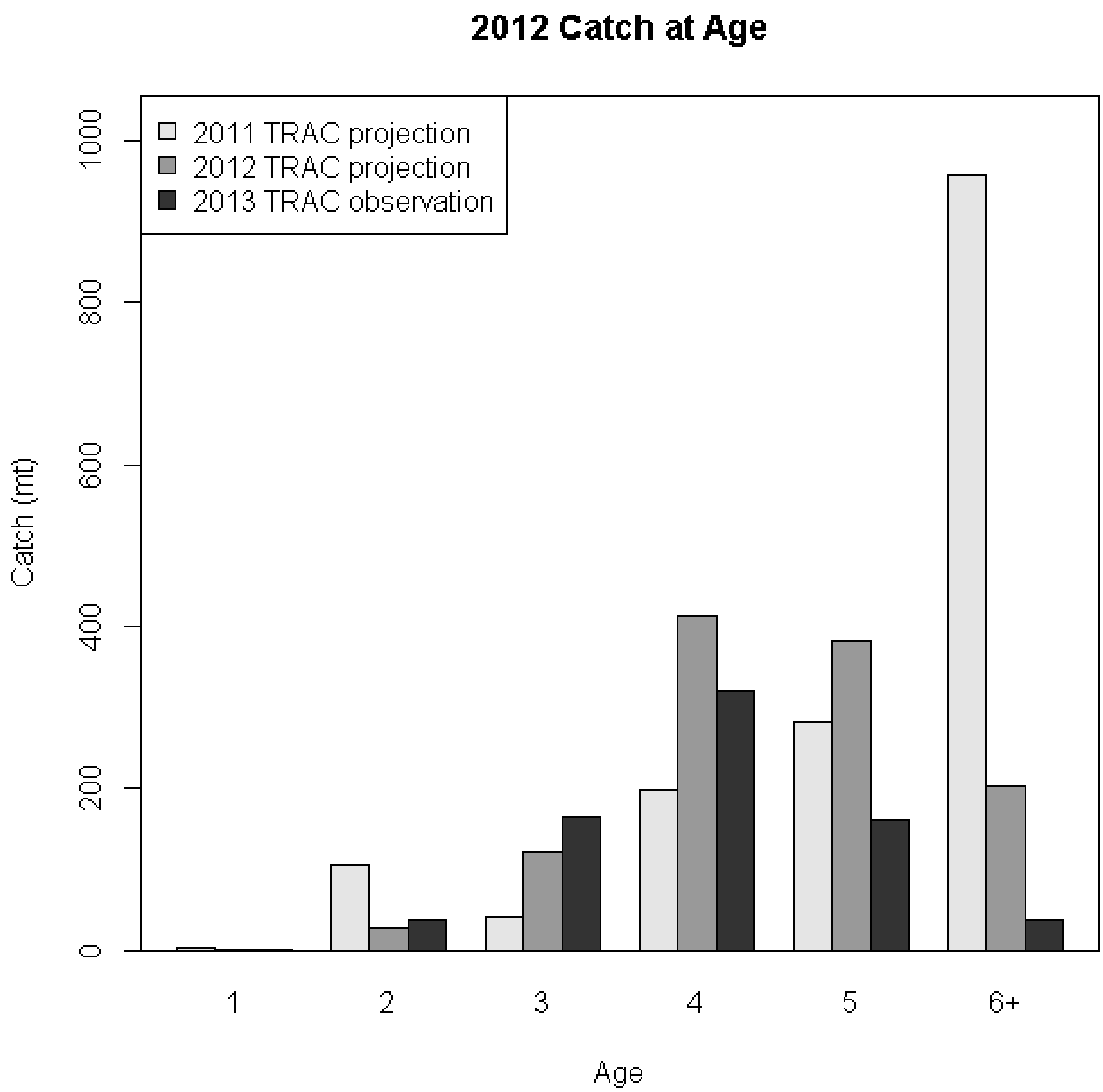



*Figure 38. Catch (mt) at age in 2012 projected from the previous two TRAC assessments compared to the 2012 values observed in this assessment. Both projections are from the Split Series deterministic table in their respective assessment documents and do not include any retrospective adjustments.*

# 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<br>(2) 6,836 mt | Neutral risk of exceeding Fref (1)VPA (2)SPM | NA | NA | 4,441 mt/ 50% risk of exceeding Fref (VPA) | Exceeded Fref (2.6X) |
| 2000 | 2000 | 7,800 mt | Neutral risk of exceeding Fref | NA | NA | 6,895 mt/About 30% risk of exceeding Fref | Exceeded Fref (3.6X) |
| 2001 | 2001 | 9,200 mt | Neutral risk of exceeding Fref | NA | NA | 6,790 mt/Less than 10% risk of exceeding Fref | Exceeded Fref (3.8X) |
| 2002 | 2002 | 10,300 mt | Neutral risk of exceeding Fref | NA | NA | 6,100 mt/Less than 1% risk of exceeding Fref | Exceeded Fref (2.5X) |
| *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*<br><br>Now F = 1.94<br>Age 3+ biomass decreased 53% 04-05 |
| 2004 | 2005 | 4,000 mt | Deterministic; other models give higher catch but less than 2004 quota | 6,000 mt | Moving towards Fref | 3,851 mt | *F = 1.37*<br>*Age 3+ biomass decreased 5% 05-06*<br><br>Now F = 1.39<br>Age 3+ biomass decreased 39% 05-06 |

[1] Prior to implementation of US/CA Understanding

| TRAC | Catch Year | TRAC Analysis/Recommendation | | TMGC Decision | | Actual Catch[1]/Compared to Risk Analysis | Actual Result[2] |
|---|---|---|---|---|---|---|---|
| | | Amount | Rationale | Amount | Rationale | | |
| 2005 | 2006 | (1) 4,200<br>(2) 2,100<br><br><br><br>(3) 3,000 - 3,500 | Neutral risk of exceeding F ref (1-base case; 2 – major change)<br>(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) | 2,109 mt/<br>(1) Less than 10% risk of exceeding Fref<br>(2) Neutral risk of exceeding Fref | *F = 0.89*<br>*Age 3+ biomass increased 41% 06-07*<br><br>Now F = 1.54<br>Age 3+ biomass decreased 3% 06-07 |
| 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 | 1,662 mt<br>About 75 percent probability of exceeding Fref | *F = 0.29*<br>*Age 3+ biomass increased 211% 07-08*<br><br>Now F=1.05<br>Age 3+ biomass increased 31% 07-08 |
| 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 | 1,504 mt<br>No risk plot; expected less than median risk of exceeding Fref | *F~0.09*<br>*Age 3+ biomass increased between 35%-52%*<br><br>Now F=0.57<br>Age 3+ biomass increased 7% 08-09 |
| 2008 | 2009 | (1) 4,600 mt<br><br><br><br>2) 2,100 mt | (1) Neutral risk of exceeding Fref; 9% increase from 2009-2010<br>(2) U.S. rebuilding plan | 2,100 mt | U.S. rebuilding requirements; expect F=0.11; no risk of exceeding Fref | 1,806 mt<br>No risk of exceeding Fref | *F=0.15*<br>*Age 3+ biomass increased 11%*<br><br>Now F=0.83<br>Age 3+ biomass decreased 13% 09-10 |

| TRAC | Catch Year | TRAC Analysis/Recommendation | | TMGC Decision | | Actual Catch[1]/Compared to Risk Analysis | Actual Result[2] |
|---|---|---|---|---|---|---|---|
| | | Amount | Rationale | Amount | Rationale | | |
| 2009 | 2010 | (1) 5,000 – 7,000 mt<br><br>(2) 450 – 2,600 mt | (1) Neutral risk of exceeding Fref under two model formulations<br>(2) U.S. rebuilding requirements | No agreement. Individual TACs total 1,975 mt | No agreement | 1,160 mt<br>No risk of exceeding Fref<br>About 15% increase in median biomass expected | *F=0.13*<br>*3+ Biomass increased 6% 10-11*<br><br>Now F=0.73<br>Age 3+ biomass increased 6% 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 | 1,169 mt<br>No risk of exceeding Fref<br>About 15% increase in biomass expected | *F=0.31*<br>*Age 3+ biomass decreased 5% 11-12*<br><br>Now F=0.6<br>Age 3+ biomass decreased 14% 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 | | 722 mt | *F=0.32*<br>*Age 3+ biomass decreased 6% 12-13* |
| 2012 | 2013 | (1) 200-500 mt | (1) trade-off between risk of overfishing and change in biomass from five projections | 500 mt | | | |