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Stock Assessment of Georges Bank Yellowtail Flounder for 2014

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ABSTRACT

The combined Canada/US yellowtail flounder catch in 2013 was 218 mt, with neither country filling its portion of the quota. This is the lowest catch in the time series which began in 1935. Despite the low catch, all three bottom trawl surveys declined to low values relative to their entire time series. All three bottom trawl surveys indicate low recruitment for the most recent four 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. It also adds four additional VPAs with M increased to 0.4 for the entire time series and M increased to 0.4 for years 1973 to 2004 and increased to 0.9 or 1.0 for years 2005 onward in response to recommendations made at the 2014 Diagnostic Benchmark. All four constant M VPA formulations exhibit strong retrospective patterns and rho adjustments are recommended for both determining stock status and providing catch advice from these runs, while the increased M since 2005 VPA formulations do not exhibit retrospective patterns. Catches of less than 100 up to 300 mt are required to achieve the TMGC objective of not overfishing, but this advice does not account for the guidance to reduce the fishing mortality rate when stock conditions are poor.

The empirical approach recommended at the 2014 Diagnostic Benchmark was applied. The three recent bottom trawl surveys were scaled to absolute biomass estimates, averaged, and an exploitation rate of 25% was applied to generate catch advice of 553 mt. This amount of catch is greater than one of the individual surveys. There are also a number of sources of uncertainty which need to be considered, the most important being the exploitation rate to apply.

RÉSUMÉ

INTRODUCTION

The Georges Bank yellowtail flounder *(Limanda ferruginea)* stock is a transboundary resource in Canadian and US jurisdictions. This paper updates the last stock assessment of yellowtail flounder on Georges Bank, completed by Canada and the US (Legault et al. 2012), taking into account advice from the 2005 benchmark review (TRAC 2005) and the 2014 Diagnostic Benchmark (TRAC 2014). A primary objective of both benchmark reviews was to address the retrospective pattern that had been apparent from assessments conducted during the past several years. During the 2005 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 2005 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.

The 2014 Diagnostic Benchmark recommended an empirical approach to providing catch advice based on the three bottom trawl surveys and an assumed exploitation rate. This benchmark also recommended increasing the natural mortality rate from 0.2 to 0.4 and consideration of additional increase in recent years due to disease. Another recommendation from this benchmark was to use surveys for partial areas of Georges Bank as a test of the VPA results, if the VPA biomass estimates for the whole bank are less than the biomass estimates from a partial area then this can be used to reject the VPA if uncertainty in both estimates is considered. The 2014 Diagnostic Benchmark was a large undertaking with 46 working papers with 105 authors (56 unique) from 10 institutions totaling just over 1,000 pages.

Last year, 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 2014 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 2014 catches on these unadjusted model projection results. Instead, both the Split Series and Single Series models had their population abundance at the start of 2013 reduced based on the Mohn's rho for spawning stock biomass. These projections had much lower catch advice in 2014 compared to the unadjusted projections. Based on examination of these two analyses, the TRAC concluded that to achieve a high probability that F in 2014 will be less than Fref, a 2014 quota of less than 200 mt would be required. In order to achieve high probability that adult biomass will increase from 2014 to 2015, a 2014 quota of less than 500 mt would be required. Due to the assumption used for the 2012 year class in the projections, the increase in adult biomass will be optimistic if the 2012 year class is as poor as the recent year classes. The TRAC concluded catches well below 500 mt are likely needed to achieve the harvest strategy. The Transboundary Management Guidance Committee (TMGC) negotiated the combined US-Canada catch quota for 2014 to be 400 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 and 2014 benchmark assessments. 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 2013 (catch in 2013 = 218 mt, the lowest value in the time series 1935-2013).

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 1994-2013 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 2013 fishery were 130 mt, a 71% decrease from 2012 (Table 1 and Figure 2).

US discarded catch for years 1994-2013 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 20% of the US catch in years 1994-2013 (Table 1 and Figure 2). Total discards of yellowtail in the US decreased 74% from 2012 (188 mt) to 2013 (49 mt). All three gears exhibited decreases in discards with relatively small coefficients of variation (Table 2).

The total US catch of Georges Bank yellowtail flounder in 2013, including discards, was 179 mt. This value can be compared to the quota monitoring estimated catch of 187 mt for calendar year 2013, data kindly provided by Dan Caless of the Greater Atlantic Regional Fisheries 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 215 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 35.6% of its sub-quota (55 mt) for the 2013 fishing year and the scallop fleet caught 90% of its sub-quota (42 mt) for the 2013 fishing year. The overall US catch from all fleets was below the US quota for fishing year 2013.

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 <1 mt in 2013. From 2004-2011 and in 2013, most of the reported yellowtail landings were from trips directed for haddock. In 2012, there were 9 trips directed for yellowtail flounder that 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 (Table 4). Discards for the years 2004-2013 were obtained by estimating a monthly prorated discard rate (kg/(hr*meters)), using a 3-month moving-average calculation to account for the seasonal pattern in bycatch rate, applied to a monthly standardized effort (Tables 5-6) (Van Eeckhaute et al. 2010). This approach resulted in slightly different discard estimates for years 2005-2012 than the previously presented values based on a kg/hr effort metric. The result of these calculations for 2013 is a discard estimate of 39 mt, the lowest in the time series (Table 1 and Figure 2).

For 2013, the total Canadian catch, including discards, was 39 mt, a 57% decrease from 2012, which is 14% of the 2013 TAC of 285 mt.

Length and Age Composition

The level of US port sampling continued to be strong in 2013, with 2,138 length measurements available from 30 samples, resulting in 1,650 lengths/100 mt of landings (Table 7). This level of sampling has generally resulted in increased precision (i.e. low coefficients of variation) for the US landings at age from 1994-2013, as estimated by a bootstrapping procedure (Table 8). The port samples also provided 607 age measurements for use in age-length keys. The Northeast Fisheries Observer Program provided an additional 1,382 length measurements of discarded fish from 318 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 2013, no samples were collected from the <1 mt of Canadian landings (Table 7). The Canadian landings at age were assumed to follow the same proportions at age as the US landings and to have the same weights at age as the US landings.

The US discard length frequencies were generated from observer data, expanded to the total weight of discards by gear type and half year. Large 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 17 observed trips in 2013. 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 2013 size composition of yellowtail catch by country shows identical length distributions for landings by the US and Canada as described above (Figure 5). US discards were slightly larger in mean size but similar in spread of the distributions relative to Canadian discards (Figure 6). The total catch was also shifted towards larger fish for the US than Canada, 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 (http://www.nefsc.noaa.gov/fbp/QA-QC/yt-results.html).

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 2013. Therefore, the Canadian discards at length were converted to catch at age using the US age-length keys by half-year and catch type (landings vs discards). Canadian landings and discards accounted for 0.2% and 18% of the total 2013 catch respectively.

In 2013, ages 4 and 5 (2009 and 2008 year-classes, respectively) dominated US landings, while ages 2 - 4 dominated US and Canadian discards, with only minor contribution from Canadian landings (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 9 and Figure 9a-b). Despite management measures intended to reduce fishing effort over the past several years, there are few fish older 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 10 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 age 1 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.

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 11) and were applied in this assessment.

Given the calibration at length for the US spring and fall surveys, 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 any of the recent US spring or fall surveys (Figure 12).

Based on the recommendation of the 2014 Diagnostic Benchmark (TRAC Proceedings in prep.), the catch per tow for each of the three bottom trawl surveys was converted to absolute abundance estimates. These calculations start by using the door width for each net to compute the area trawled by a single tow in each survey (Table 12). The mean catch per tow is then expanded to a minimum swept area amount by multiplying by the ratio of the total area to the area swept by a single tow. A literature estimate of the catchability of the gear, meaning the number of yellowtail in the path of the tow which were caught, is used to expand the minimum swept area amount to total abundance. This literature value for catchability was derived in working paper 13 of the 2014 Diagnostic Benchmark as the mean of the value 0.22 in Harden Jones et al. (1977) and four values of 0.33, 0.42, 0.43, and 0.45 in Somerton et al. (2009). The Harden Jones et al. (1977) study was conducted with English plaice in the North Sea using a Granton otter trawl and the Somerton et al. (2009) study was conducted with four flatfish species (arrowtooth flounder, flathead sole, rex sole, and Dover sole) in the Gulf of Alaska using a Poly nor'eastern survey trawl. For ease of comparison with the VPA estimates, the total abundance values from the DFO and US bottom trawl surveys are divided by 1,000. Thus, catch per tow in numbers of fish and kg multiplied by the conversion factor 566.527 (DFO) or 1311.655 (US spring and fall in *Albatross IV* units) results in estimated abundance in thousands of fish and metric tons (Table 12).

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 13a-f). 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 13 and Figure 13e-f). 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 2014 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 decreased in both 2013 and 2014 (Table 14 and Figure 13b,c,f). 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 and declined in 2013 (Table 15 and Figure 13b,d,f). 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 in years when the entire bank was surveyed (Table 16 and Figure 13b). 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 13-16 and Figure 13e).

The spatial distribution of catches (weight/tow) for the most recent year compared with the previous ten year average for the three groundfish surveys show that yellowtail flounder distribution on Georges Bank in the most recent year has been consistent relative to the previous ten years (Figure 14a-b). Note the 2009 through 2014 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 15a). 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 15b-c).

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-m). Even though each index is noisy, the age specific trends track relatively well among the four surveys (Tables 13-16 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 years indicates a return towards the mean. The condition factor (Fulton’s K) for male and female yellowtail flounder in the DFO survey shows more of a continued decline (Figure 18c).

Trends in relative fishing mortality and total mortality from the surveys were examined as part of the 2005 assessment benchmark formulations. Relative fishing mortality (fishery catch biomass/survey biomass, scaled to the mean for 1987-2007) was quite variable but followed a similar trend for all 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.

EMPIRICAL APPROACH

The 2014 Diagnostic Benchmark recommended an empirical approach be considered for catch advice (TRAC 2014 Proceedings In prep.). The three bottom trawl surveys are used to create a model-free estimate of population abundance which can either be compared with the catch to create an exploitation rate or have an exploitation rate applied to create catch advice. The *Henry B. Bigelow* data are used directly in these calculations to avoid the complexities that arise due to calibration with the *Albatross IV*. The stratified mean catch per tow in weight is expanded to total biomass based on the ratio of the total area surveyed to the area of a single trawl. Due to the different footprint of the *Henry B. Bigelow* relative to the *Albatross IV*, the estimated biomass values for the NEFSC spring and fall surveys differ from the values presented earlier for the *Albatross IV* converted time series (Table 17). This minimum swept area biomass is divided by the catchability of 0.37 to create an estimate of the biomass. The survey biomass estimates from DFO and the NEFSC spring survey in year t and the NEFSC fall survey in year t-1 are averaged to form the estimate of population biomass in year t. Multiplying the mean biomass by an exploitation rate of 0.25 results in the catch advice for year t+1 (Table 17).

This approach to providing catch advice can result in some odd situations. For example, for both 2012 and 2013 the DFO estimate of population biomass is less than the catch advice derived from the average biomass in those years (Table 17). The empirical approach also ignores the uncertainty in both the catch/tow values and the catchability value used to expand the minimum swept area population estimate to a population estimate. The uncertainty in the surveys can be approximated quickly from the coefficient of variation associated with each annual survey (provided in the earlier survey tables). Random draws from each of the surveys given the point estimate, the CV, and an assumption of normal distributions can be averaged over the three surveys to create a distribution of population biomass. Applying the constant exploitation rate to the distribution of population biomass, results in a distribution of catch advice in each year. These distributions are summarized according to some common percentiles (Table 18). Alternatively, the point estimates for annual catch per tow can be converted to a distribution of annual population abundances by dividing each value by a beta distribution for the catchability of the surveys. Application of the constant exploitation rate again results in a distribution of catch advice (Table 18). This beta distribution was formed using the method of moments given a mean value of 0.37 and CV of 0.26, based on the decision made at the Diagnostic Benchmark meeting. Finally, both sources of uncertainty can be included in the distribution of population abundance and multiplied by the constant exploitation rate to provide distributions of catch advice (Table 18). As can be seen by comparing the resulting catch advice distributions, the uncertainty in survey catchability causes greater variability in the catch advice than the uncertainty in the surveys. Using both sources of uncertainty increases the amount of uncertainty in the catch advice. This uncertainty should be considered if this approach is used to provide catch advice.

One additional source of uncertainty in the empirical approach is the exploitation rate to apply. Since the exploitation rate is a direct multiplier of the population biomass to generate the catch advice, the catch advice will change linearly with changes in the exploitation rate. Halving or doubling the exploitation rate will result in halving or doubling the catch advice. The exploitation rate of 0.25 was derived from equilibrium per recruit calculations under the assumption that the natural mortality rate in recent years was greater than the new value of 0.4. This assumption was based on a mass balance equation which demonstrated that given the estimated catch and survey values, an additional source of mortality must be occurring to account for the continued decline of the population. Equilibrium exploitation rate, defined as the ratio of yield per recruit to total biomass per recruit, ranged between 0.24 and 0.27 at $F_{0.1}$ and between 0.22 and 0.24 at $F_{40\%}$ for M between 0.4 and 1.1. This approach assumes that the target F increases when M increases within the time series of the assessment, counter to the approach recommended for Eastern Georges Bank cod which recommends a decrease in the target F when M increases within the time series of an assessment. For example, using the results from last year's Split Series assessment and the same definition of exploitation rate (ypr/tsb), but holding the target fishing mortality rate at 0.52 (the estimate of $F_{40\%MSP}$ using those data) results in target exploitation rates decreasing from 0.20 to 0.07 when M increases from 0.4 to 1.1. The EGB cod approach of decreasing the F target when M increases within the assessment time series would result in even lower exploitation rates as M increases within the assessment time series (ypr/tsb).

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). 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 were provided for recommending catch advice in 2013. As mentioned above, the 2014 Diagnostic Benchmark recommended a change in the natural mortality rate from 0.2 to 0.4. The M=0.2 results are shown for comparison with previous years, while the M=0.4 are now considered the best estimates. There is a possibility that M has increased even more in recent years. See Table 19 for a summary of changes to the VPA formulations since the 2005 assessment benchmark noting that the decision regarding which model(s), if any, to use for 2014 have not been made yet.

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 v3.4. 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 either 0.2 or 0.4 for all ages and years, or else increase from 0.4 to either 0.9 or 1.0 in 2005 (see below). 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, with the exception of the change in the natural mortality rate (Legault et al. 2013). 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, 2013). 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.

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 2013, 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 2014
(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 2014
(note: s_5 = NMFS spring (Yankee 36), ages a = 1 to 6+, time t = 2009-2014 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 2013.5
(note: s_7 = NMFS fall, ages a = 1 to 6+, time t = 2009.5-2013.5 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 2013.5
(note: the NMFS scallop survey was not used for years 1986, 1989, 1999, 2000, 2008, 2011, 2012, or 2013)

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 (2014) was assumed equal to the geometric mean over the most recent 10 years (2004-2013). Population abundance in the terminal year plus one (2014) was estimated directly for ages 2-5.

Building the Bridge

There were two changes to the data from the 2013 TRAC assessment. The Canadian discards at age were revised for 2005 through 2012 and small changes in the recent US surveys were found. 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 2013 TRAC assessment and had only a minor impact on results (trend lines not noticeably different from 2013 TRAC for F, SSB, or recruitment; Figure 22).

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

Diagnostics

As expected, both the Split Series and Single Series VPA with M=0.2 and M=0.4 (four combinations) resulted in strong retrospective patterns (described in detail below). Evidence was presented at the Diagnostic Benchmark that the natural mortality rate had increased in recent years. Coincidentally, an increase in recent M could address the retrospective pattern. Thus, for the recommended value of M=0.4, a search was conducted for a recent M (years 2005 to present) that would remove the retrospective pattern for the two VPA formulations. The recent value of M needed to remove the retrospective patterns in F and SSB were 0.9 and 1.0 for the Split Series and Single Series VPAs, respectively (Figure 23a-b). Results for all six combinations (Split Series vs Single Series and M=0.2 vs 0.4 vs 0.4 with recent increase) are presented below to allow comparisons among the model formulations and account for the recommendations from the 2005 Assessment Benchmark and the 2014 Diagnostic Benchmark.

The six VPAs 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 20a-f). 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 magnitude of relative error and relative bias at age was similar among the six VPAs despite changes in the estimated population abundances (Table 20a-f).

Survey catchability constants (q) for the three Split Series VPAs also followed similar patterns to previous assessments (Table 20a-c and Figure 24a-c). 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). 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). This pattern remains in the Split Series M0409 VPA despite the recent years not exhibiting a retrospective pattern because there is still a change in the data between 1994 and 1995 which caused the Split Series VPA to first be used. The survey catchability constants (q) for the three Single Series VPAs follow similar patterns over ages to the Split Series VPAs, but at a magnitude between the early and recent q values of the Split Series VPAs (Table 20d-f and Figure 24d-f).

Patterning in the residuals of all six VPAs can be observed with mainly positive or negative residuals during different periods throughout the time series (Figure 25a-f). Generally the Split Series are better than the Split Series, there are not large differences between the M=0.2 and M=0.4 VPAs, and the cases with an increased M in recent years are better than the constant M.

Retrospective analysis for the four constant M VPAs indicate a strong tendency to overestimate spawning stock biomass and recruitment and underestimate F, relative to the terminal year (Table 21a-b and Figure 26a-l). These retrospective patterns are stronger than observed in the Base Case formulations of previous assessments (Legault et al. 2009, 2010, 2011, 2012, 2013). The two VPAs with increased M since 2005 result in no retrospective pattern due to the method used to select the value of M for the recent years.

During the 2014 Diagnostic Benchmark, the TRAC agreed that the empirical estimates of biomass from surveys not included in the VPA due to only partial coverage of Georges Bank should be used to inform and evaluate consistency of VPA biomass estimates. Model results well below the absolute estimates can be used to reject model results, but only when uncertainty in both estimates indicates a real difference. There were six working papers presented at the Diagnostic Benchmark meeting which provided biomass estimates from surveys not included in the VPA. Comparison of these estimates with the six VPAs shows that the Split Series M02, Split Series M04, and Single Series M02 VPAs have SSB and mean biomass estimates below at least one of the independent surveys (Figure 27a,b,d). The Single Series M04 VPA and the two VPAs with increased M since 2005 pass this test (Figure 27c,e,f).

Based on historical precedence, the Split Series VPA with either M=0.2 or M=0.4 and a retrospective adjustment is recommended as the basis for estimating current stock size and fishing mortality rate. However, both these models failed the evaluation relative to independent surveys. Based on previous TRAC and NEFMC SSC advice, none of the four constant M VPAs without a retrospective adjustment should be used for estimating current stock size or providing catch advice due to their large retrospective patterns. This leaves the Single Series M04 VPA with rho adjustment and the two VPAs with increased M since 2005 as possible models for estimating current stock size and fishing mortality rate. However, the Single Series M04 VPA has a very strong retrospective pattern and the Split Series M0409 and Single Series M0410 have unexplained recruitment trends. Furthermore, the use of either VPA with increased M in recent years for stock status requires the determination of an appropriate fishing mortality reference value. Thus, there is no clear choice for providing stock status. Instead, general statements will be made comparing the results from the six VPAs.

STOCK STATUS

Population abundance at age for the start of the year was estimated for years 1973-2014 (Table 22a-f) along with estimates of fishing mortality rates at age during years 1973-2013 (Table 23a-f). Due to the backward convergence of VPA, the Split and Single Series VPAs with the same M have identical estimates for early years, diverging since around 2000. The fishery weights at age, assumed to represent mid-year weights, were used to derive beginning of year weights at age (Table 24), and these were used to calculate beginning of year population biomass (Table 25a-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).

Adult population biomass (Jan-1, ages 3+) increased from a low in 1995 to a relative peak in 2003 according to all six VPAs (Table 25a-b and Figures 28a-f, 29a-b). The two sets of lines during the period 1973 through 2003 are due to the two different M values during this time period, with the higher set of lines associated with M=0.4 and the lower set of lines associated with M=0.2. Adult biomass estimated by the four constant M VPAs declined to low values in 2006 and then either continued a slight decline in the M=0.2 VPAs or else increased in the M=0.4 VPAs. Note that all four constant M VPAs have strong retrospective patterns that result in rho adjusted estimates of adult biomass in 2014 at the lowest values in their time series (Table 26). The two VPAs with increased M since 2005 had a second peak in adult biomass in 2008 then decreased to low values in 2014. Spawning stock biomass for the six VPAs followed similar patterns as adult biomass (Tables 25a-b, 26 and Figure 30a-b).

Age 1 recruitment estimated by the four constant M VPAs has been much lower in recent years than in previous years, while age 1 recruitment estimated by the two VPAs with increased M since 2005 estimate the highest recruitment occurred during 2005 and 2006 (Table 22a-f and Figure 31a-b). The high recruitments in the early 2000s estimated by the two VPAs with increased M since 2005 are simply a reflection that many more age 1 fish are needed to account for the observed catch when M is 0.9 or 1.0 than when M is 0.4. Recruitment signals of this magnitude were not observed in any of the surveys. The low recent recruitment limits the ability of the stock to produce yield or rebuild. Note the opposite pattern in the retrospective pattern for the two VPAs with increased M since 2005 relative to the four constant M VPAs (Figure 31b).

Fishing mortality for fully recruited ages 4+ was close to or above 1.0 between 1973 and 1995, fluctuated between 0.36 and 0.97 during 1996-2003, increased in 2004, and then declined to a low value in 2013 in all six VPAs (Table 23a-f and Figure 32a-b). The strong retrospective patterns in the four constant M VPAs results in the rho adjusted F values being above the current reference point of $F_{ref} = 0.25$, although this reference point may not be appropriate for VPAs that use an M value different than 0.2 (Table 27 and see Fishery Reference Points section below).

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 25a-b and Figure 33a-c).

The bootstrap uncertainty estimates do not capture the full amount of uncertainty in this assessment due to the strong retrospective patterns in the four constant M VPA results and the large sudden change in M in the two VPAs with increased M since 2005. 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 six VPAs show how large these changes are for the constant M VPAs and how small the rho adjustments are for the two VPAs with increased M since 2005 (Table 26 and Figure 34).

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 0.28-0.30 for the two M=0.2 VPAs, but much larger values for the other four VPAs (Tables 27-28). As mentioned above, if the natural mortality rate used in the VPA is changed from 0.2, then the F_{ref} value should be changed. If M is constant at 0.4, then F_{ref} of 0.60-0.77

would result from $F_{40\%MSP}$ or $F_{0.1}$. If M increases within the time series, then TRAC will need to provide guidance on the scientific information needed to negotiate a new F_{ref}.

Stock and Recruitment

The TMGC does not have an explicit biomass target. There is evidence of reduced recruitment at low levels (below approximately 5,000 mt) of spawning stock biomass (Figures 35a-c and 36a-f). 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 (rho adjusted SSB_{2013}/SSB_{MSY} < 6% for all six VPAs).

Rebuilding projections are required in the US when stocks are overfished (defined as SSB < ½ SSB_{MSY}). 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. This is obviously not the case for four of the VPAs, so new estimates of SSB_{MSY} will be required if any of these four VPAs are selected for providing catch advice. 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.

OUTLOOK

This outlook is provided in terms of consequences with respect to the harvest reference points for alternative catch quotas in 2015. 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 all six VPAs were made using 2011-2013 average fishery partial recruitment and fishery weights at age to account for the most recent conditions in the fishery and biological characteristics (Table 28). Deterministic projections were made for all six VPAs with and without rho adjustment for comparative purposes (Table 29a-l). Following previous practice, the rho adjusted 2014 Jan-1 population abundance at age values used the SSB rho value for all ages. All the projections assume a catch in 2014 equal to the 400 mt total quota and apply F_{ref}=0.25 in 2015. This catch results in wide range of fully selected fishing mortality rates for the twelve projections ranging from 0.09 to 1.82. Fishing at F_{ref} in 2015 allows the adult (ages 3+) Jan-1 biomass to increase in all twelve projections, but this is due to the large cohort age 1 in 2014. This dependence of an increased biomass from year two to year three in the projection has been documented in the past two assessments (Legault et al. 2012, 2013) and is not demonstrated again in this assessment. The fishery yield in 2015 ranges from 49 to 333 mt for the six rho adjusted projections, which contrasts with the range of 224 to 1,063 mt for the six unadjusted projections. The TRAC has recommended not using unadjusted projections in cases when strong retrospective patterns are present. 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 2015 and the probability of stock increase, meaning the change in adult (ages 3+) Jan-1 biomass from 2015 to 2016, resulting from given quotas being set in 2015. These stochastic projections use bootstrapped realizations of the 2014 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 2015 or 2016 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 2015 is set to 0.25 are minor, as can be observed by comparing Table 29a-l with Table 30.

The stochastic projection results for the four unadjusted constant M VPA projections are shown in Tables 29-32 for completeness only. They are shown in Tables 30-32 using a different font to reflect the recommendation from previous TRAC meetings to not use these projections for catch advice due to strong retrospective patterns. The remaining eight projections require a 2015 catch of between <100 and 300 to have a neutral risk of exceeding F_{ref} (Table 31a-c and Figure 37a-b), similar to the catch advice from last year. As noted above, F_{ref} may not be appropriate for many of the projections. For demonstration purposes the probability that 2015 F is greater than or equal to 0.6 was computed for all twelve projections (Table 32). As noted above in the deterministic projections, the adult biomass is expected to increase from 2015 to 2016 due to the use of the geometric mean recruitment for the 2014 age 1 value almost regardless of the fishing mortality rate in 2015. Thus, the metric of adult biomass increase from 2015 to 2016 is not informative from these projections. The risk of overfishing increases rapidly with small changes in the 2015 quota, so catches associated with 25% and 75% risk of overfishing are not presented (Figure 37a-b). The change in adult biomass from 2015 to 2016 is close to a linear function of the 2015 catch, but almost all projections resulting in increased biomass due to the large value assumed for the 2014 age 1 cohort (Figure 38a-b). The change in probability of biomass increase (or a 10% increase) from one to zero occurs over a relatively small range of 2015 catch for some of the rho adjusted projections (Figure 39a-b).

Age structure, fish growth, and spatial distribution reflect stock productivity. As discussed in detail at the 2014 Diagnostic Benchmark, the interpretation of the current age structure depends on the natural mortality rate assumed in equilibrium calculations. When M is 0.2, the current age structure appears to be highly truncated, while when M is 0.4 the current age structure appears only slightly truncated on a proportion basis, and when M is 0.9 or 1.0 the current age structure appears good on a proportional basis (Figure 40a-f). However, the age structure in 2013 relative to the average of 1973 through 2012 shows large reductions in absolute numbers of fish at young ages in all six scenarios. 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 (at older, younger, or all ages) and reduced but improving condition factor indicate current resource productivity is lower than historical levels.

MANAGEMENT CONSIDERATIONS

Although the Split Series VPA has been used previously 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 in 2012 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 41). 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 estimates for fishing mortality rates and biomass from the 2012 assessment. These comparisons were kindly provided by Tom Nies (New England Fishery Management Council) and are shown in the Appendix. This table was not updated this year due to the multiple VPAs considered. 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 F_{ref}. 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 2013 projected from previous assessments with the observed values measured for 2013 (Figure 42). The three projections from the 2012 and 2013 TRAC meetings are from the Split Series model. The current estimate is simply the catch at age in numbers multiplied by the catch weight at age. The 2012 and 2013 projections without retrospective adjustments shows more catch at old ages both in absolute and relative terms than the actual 2013 catch observed in this assessment. In contrast, the 2012 rho adjusted projections are close in magnitude to the actual catch, although even these projections have proportionally too many old fish in the catch. 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	247	0	3852	17%
2006	1196	384	25	452	0	2057	41%
2007	1058	493	17	97	0	1664	35%
2008	937	409	41	112	0	1499	35%
2009	959	759	5	84	0	1806	47%
2010	654	289	17	210	0	1170	43%
2011	904	192	22	53	0	1171	21%
2012	443	188	46	48	0	725	33%
2013	130	49	1	39	0	218	40%

Table 2. Derivation of Georges Bank yellowtail flounder US discards (mt) calculated as the product of the ratio estimator (d:k – discard to kept all species on 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 2. continued

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

Table 3. Comparison of US and catch (mt) in calendar year 2013 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)	146	41	187
Assessment (mt)	137	42	179
Diff (QM-Assess) (mt)	9	-1	9
Rel Diff (Diff/Assess)	7%	-2%	5%

Table 4. Number of trips observed in the Canadian scallop fishery.

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

Table 5. Prorated discards (kg) and fishing effort (hm) for Georges Bank yellowtail flounder from International Observer Program (IOP) trips of the Canadian scallop fishery in 2013.

		Proration			Discards		Effort
		Number of Dredges			(kg)		(hm)
IOP Trip	Board Date	Observed	Total	Proportion	Observed	Prorated	
J13-0006	1/28/2013	283	498	0.57	91	160	1212
J13-0092	2/11/2013	678	1270	0.53	42	79	2556
J13-0010	2/16/2013	502	981	0.51	25	49	1491
J13-0106	3/22/2013	555	1031	0.54	166	308	1656
J13-0015	3/27/2013	226	402	0.56	56	100	626
J13-0152	4/4/2013	581	1192	0.49	435	892	1791
J13-0121	4/17/2013	232	432	0.54	83	155	969
J13-0140	5/19/2013	135	261	0.52	6	12	596
J13-0145	5/25/2013	304	584	0.52	425	816	856
J13-0247	6/18/2013	174	328	0.53	53	100	768
J13-0282	7/8/2013	528	998	0.53	48	91	1526
J13-0353	7/21/2013	616	1138	0.54	104	192	1526
J13-0319	8/21/2013	261	495	0.53	317	601	1060
J13-0393	8/22/2013	681	1341	0.51	9	18	1837
J13-0486	10/16/2013	837	1533	0.55	35	64	1838
J13-0490	10/18/2013	172	254	0.68	25	37	634
J13-0336	10/20/2013	521	1028	0.51	33	65	1399

Table 6. Three month moving-average (ma) discard rate (kg/hm), standardized fishing effort (hm), and discards (mt) of Georges Bank yellowtail flounder from the Canadian scallop fishery in 2013. Moving-average calculations include trips from Dec. 2012.

				3-month ma			
Year	Month	Monthly Prorated Discards (kg)	Monthly Effort (hm)	Discard Rate (kg/hm)	***Effort (hm)	ma Discards (mt)	Cum. Annual Discards (mt)
2013	**Jan	0	0	0.055	406	0	0
	Feb	288	5259	0.092	7800	1	1
	Mar	408	2282	0.169	12364	2	3
	Apr	1047	2760	0.352	25684	9	12
	May	828	1452	0.397	26694	11	22
	Jun	100	768	0.230	18757	4	27
	Jul	283	3052	0.149	21088	3	30
	Aug	619	2897	0.152	32794	5	35
	**Sep	0	0	0.116	27609	3	38
	Oct	166	3871	0.043	11823	1	39
	**Nov	0	0	0.043	2213	0	39
	**Dec	0	0	0.008	733	0	39

** No observed trips in Jan., Sep., Nov., or Dec.; assumed discards and effort were same as Dec. 2012, Aug. 2013, Oct. 2013, and Oct. 2013, respectively.

Table 7. Port samples used in the estimation of landings at age for Georges Bank yellowtail flounder in 2013 from US and Canadian sources.

	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	0	91	22	0	113		897	551		1448		
2	0	13	3	0	16		481	209		690		
Total	1	103	25	0	130		1378	760		2138	1650	607
Canada											Lengths	Number
Quarter					Total					Total	per 100mt	of Ages
1												
2												
3												
4												
Total					<1						0	0

Table 8. Coefficient of variation for US landings at age of Georges Bank yellowtail flounder by year.

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

Table 9. Total catch at age including discards (number in 000s of fish) for Georges Bank yellowtail flounder. Note the 2005-2012 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	1580	4032	1707	392	132	37	16	0	0	0	0	7956
2006	150	1251	1577	923	358	123	65	14	7	3	0	0	4470
2007	51	1493	1708	664	137	44	9	2	0	0	0	0	4108
2008	28	490	1897	853	125	17	8	0	0	0	0	0	3417
2009	17	283	1266	1360	516	59	10	4	0	0	0	0	3516
2010	2	141	651	899	449	88	10	2	0	0	0	0	2241
2011	11	166	775	904	310	67	8	1	0	0	0	0	2242
2012	12	108	370	579	240	38	4	4	0	0	0	0	1355
2013	15	61	99	148	91	19	2	0	0	0	0	0	435

Table 10. Mean weight at age (kg) for the total catch including US and Canadian discards, for Georges Bank yellowtail flounder. Note the 2005-2012 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	0.311	0.415	0.557	0.761	0.917	1.066	1.186	1.263	1.225	1.599	
2007	0.154	0.290	0.409	0.541	0.784	0.968	1.108	1.766				
2008	0.047	0.302	0.415	0.533	0.675	0.882	1.130					
2009	0.155	0.328	0.434	0.538	0.699	0.879	1.050	1.328				
2010	0.175	0.323	0.432	0.519	0.661	0.777	0.997	1.176				
2011	0.128	0.337	0.461	0.553	0.646	0.739	0.811	0.851				
2012	0.185	0.338	0.452	0.555	0.671	0.792	0.935	0.798				
2013	0.193	0.263	0.393	0.533	0.689	0.825	1.002	1.183				

Table 11. 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 12. Derivation of conversion factors relating catch per tow in numbers of fish and kg to abundance estimates in thousands of fish and metric tons. See text for details.

	DFO	US Spring and Fall
Total Area in Set =	7421	10871
Area Swept by Tow =	0.035403	0.0224
Catchability =	0.37	0.37
Units in VPA =	1000	1000
Conversion Factor =	566.527	1311.655

Table 13. DFO spring survey indices of 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	67.8	676.7	1115.8	279.0	49.4	27.9	1.126	27%
1988	0.0	1005.9	722.4	345.6	157.6	13.3	1.113	22%
1989	64.7	581.8	345.2	166.8	37.6	12.7	0.424	26%
1990	0.0	1352.1	2055.1	518.0	118.3	7.8	1.363	22%
1991	13.9	486.2	671.9	2129.9	297.6	8.2	1.584	33%
1992	31.4	6254.1	2082.9	560.7	198.0	16.9	2.230	16%
1993	44.5	1377.3	2314.2	2308.9	502.2	73.7	2.380	15%
1994	0.0	3431.0	1962.7	1702.8	442.7	117.1	2.480	23%
1995	119.0	708.5	2466.2	1442.1	366.3	57.3	1.826	20%
1996	252.7	4045.9	5197.4	3062.9	654.5	69.5	4.778	22%
1997	12.2	7071.4	7875.8	9273.5	2291.2	379.7	11.975	23%
1998	506.1	1886.8	2780.1	2455.5	1126.5	316.4	3.867	24%
1999	89.9	11818.5	11802.8	4345.0	3031.0	1246.4	15.916	32%
2000	6.1	7798.0	15546.4	10901.7	2871.7	2089.9	17.972	25%
2001	165.1	11271.7	23864.3	7538.8	2595.5	1357.8	19.962	42%
2002	50.0	6776.9	17570.6	6931.1	3145.7	1604.8	18.648	31%
2003	50.7	6735.5	13946.5	6280.3	1937.8	1126.0	14.638	32%
2004	18.5	2039.2	9212.0	5215.1	1287.5	802.3	8.157	31%
2005	339.9	907.7	15839.5	11650.0	3226.9	886.3	12.033	53%
2006	352.7	2771.9	10537.3	3723.2	464.3	134.6	5.927	44%
2007	98.1	6888.7	15697.1	7250.9	1296.5	140.7	12.021	43%
2008	0.0	27371.6	96515.0	32359.7	4565.6	31.1	60.648	94%
2009	12.1	4838.2	78156.4	66264.7	11273.8	2699.2	64.905	79%
2010	0.0	277.1	5320.8	11865.1	2001.5	724.8	8.233	29%
2011	12.5	368.7	3451.8	4648.6	963.5	185.4	3.450	29%
2012	25.1	365.0	4670.0	6471.5	1754.0	256.7	5.063	36%
2013	46.0	72.9	470.7	710.5	342.4	79.4	0.629	33%
2014	16.9	224.0	420.1	544.1	266.6	10.2	0.462	34%

Table 14. NEFSC spring survey indices of abundance for Georges Bank yellowtail flounder in thousands of fish and thousands of metric tons, along with the CV for the biomass estimates.

Year	age1	age2	age3	age4	age5	age6+	B (000 mt)	CV(B)
1968	244.9	4361.3	4694.9	398.9	95.8	406.5	3.661	23%
1969	1414.6	12253.7	14586.4	4164.1	1763.8	916.5	14.652	29%
1970	106.0	5898.4	7909.8	3176.8	747.3	408.1	6.749	15%
1971	1095.1	4612.0	6313.0	4328.2	1023.1	419.7	6.058	19%
1972	185.1	9080.2	9247.4	4859.2	1478.0	313.5	8.467	21%
1973	2544.5	4303.1	3120.8	1401.0	539.7	284.1	3.854	17%
1974	416.5	2930.4	2426.3	1655.4	455.3	370.0	3.567	18%
1975	553.0	3943.2	1093.4	354.8	272.3	116.6	2.198	22%
1976	1362.7	5755.4	1643.2	408.7	258.4	146.5	2.981	17%
1977	0.0	883.8	1483.4	491.5	110.7	17.3	1.310	31%
1978	1232.7	1051.9	668.2	289.1	34.8	10.4	0.973	19%
1979	532.4	2644.3	534.1	443.6	79.4	119.9	1.667	21%
1980	74.8	6119.8	7590.8	622.4	74.4	47.7	5.845	35%
1981	15.3	1345.8	2330.0	944.4	279.6	76.9	2.571	33%
1982	59.5	4941.3	1481.8	1341.2	600.7	119.4	3.279	20%
1983	0.0	2446.0	3578.1	695.2	161.6	320.7	3.465	30%
1984	0.0	122.0	1089.2	1132.4	1095.1	319.7	2.159	43%
1985	143.8	2884.1	343.8	369.5	193.7	0.0	1.296	51%
1986	35.9	2369.0	382.0	73.8	179.6	71.9	1.111	31%
1987	35.9	99.0	179.7	174.7	68.9	71.9	0.431	37%
1988	102.0	360.7	480.1	317.2	261.0	35.9	0.742	26%
1989	61.1	528.7	996.9	379.7	80.1	58.8	0.956	26%
1990	0.0	86.0	1452.3	484.3	151.6	136.1	0.917	32%
1991	571.0	0.0	333.7	898.7	345.2	27.0	0.828	25%
1992	0.0	2686.1	2487.4	840.2	216.2	22.6	2.054	46%
1993	60.5	379.9	656.5	416.1	35.2	0.0	0.632	26%
1994	0.0	813.9	830.7	464.3	189.8	52.3	0.866	22%
1995	52.7	1546.7	6311.3	1948.2	839.9	12.9	3.383	60%
1996	32.9	1294.7	3444.0	3542.9	799.5	75.9	3.742	31%
1997	24.5	1533.1	4896.0	5352.3	922.1	175.2	5.717	24%
1998	0.0	2729.8	1381.3	1518.1	996.1	458.9	3.048	22%
1999	65.8	6224.7	14191.5	3568.2	2128.7	1022.0	12.207	42%
2000	239.6	6321.1	10054.8	3822.3	1066.5	687.0	8.782	23%
2001	0.0	3036.1	8608.8	3162.1	634.1	594.2	6.566	33%
2002	246.5	3164.2	16177.2	5349.2	2284.2	1142.5	12.543	26%
2003	265.0	5731.7	8871.5	3772.8	579.2	1130.9	8.816	40%
2004	63.6	1293.7	2857.3	891.8	334.7	356.5	2.480	27%
2005	0.0	2639.8	6663.5	3152.3	353.8	150.6	4.469	33%
2006	666.8	1226.8	4620.6	2854.9	415.8	107.8	3.175	19%
2007	117.7	6621.2	8215.0	3732.8	729.7	169.2	6.167	22%
2008	0.0	2982.0	6650.6	2271.8	405.8	36.0	4.259	22%
2009	276.9	786.3	9765.9	6102.6	1314.2	250.6	6.369	22%
2010	22.3	909.8	7098.2	11085.7	3568.5	858.2	7.797	26%
2011	40.6	318.4	4369.4	4898.9	1264.5	141.7	3.359	23%
2012	125.3	941.8	5479.4	7535.6	1851.2	262.7	5.240	46%
2013	62.7	493.1	1319.3	1836.9	861.0	162.9	1.448	21%
2014	34.4	294.3	861.8	868.0	470.5	251.4	0.944	18%

Table 15. NEFSC fall survey indices of 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)
1963.5	19309.5	10356.2	14725.8	2437.8	649.3	719.8	16.774	19%
1964.5	2258.5	12861.2	9590.8	7826.0	3559.7	639.6	17.795	40%
1965.5	1570.4	7482.5	7853.9	4632.1	2163.4	338.7	11.962	32%
1966.5	15297.7	2951.9	2209.9	1178.3	132.9	0.0	5.152	32%
1967.5	11784.8	12339.1	3576.6	1360.4	404.5	178.8	10.060	26%
1968.5	15308.5	15814.2	7552.5	976.7	1266.0	76.2	13.820	23%
1969.5	13049.7	14326.8	6843.4	2374.9	441.9	604.9	12.864	26%
1970.5	6047.1	6731.4	4123.2	2560.4	592.2	105.2	6.531	28%
1971.5	4756.7	9149.8	6445.9	2951.1	653.2	390.6	8.348	21%
1972.5	3266.0	8557.9	6327.4	2747.1	800.1	448.2	8.300	28%
1973.5	3270.9	7210.8	6695.2	3861.4	1596.2	810.7	8.512	30%
1974.5	6063.1	3756.1	1988.6	1390.6	600.3	497.4	4.812	19%
1975.5	6146.8	3293.7	1151.0	750.3	438.4	82.6	3.051	16%
1976.5	450.7	2518.8	622.0	153.5	160.2	131.4	1.977	25%
1977.5	1225.2	2901.5	2125.4	831.6	138.2	142.8	3.647	20%
1978.5	6244.0	1680.1	1023.2	539.5	177.9	47.2	3.073	20%
1979.5	1732.4	2714.2	342.9	157.7	181.5	146.8	1.960	29%
1980.5	1004.9	6716.2	7989.2	894.5	286.9	339.1	8.665	22%
1981.5	2092.2	3080.3	2152.4	771.0	103.2	71.4	3.379	32%
1982.5	3180.1	2865.3	2085.7	554.6	117.0	0.0	2.977	30%
1983.5	142.8	2995.2	2511.4	669.9	40.4	64.4	2.795	22%
1984.5	867.0	524.4	401.0	318.9	98.2	82.0	0.778	31%
1985.5	1770.6	712.9	224.2	66.4	105.9	0.0	0.930	26%
1986.5	369.5	1452.8	457.6	97.2	0.0	0.0	1.075	37%
1987.5	133.4	525.4	519.7	69.5	104.1	0.0	0.667	28%
1988.5	24.5	279.4	140.5	35.9	0.0	0.0	0.224	32%
1989.5	325.7	2613.6	1014.0	103.5	72.9	0.0	1.281	58%
1990.5	0.0	485.4	1932.3	386.3	0.0	0.0	0.950	33%
1991.5	2755.1	360.8	575.9	469.2	0.0	0.0	0.957	29%
1992.5	198.3	518.8	933.8	212.4	188.4	35.9	0.756	30%
1993.5	1100.9	182.7	768.6	703.2	0.0	28.9	0.716	42%
1994.5	1567.3	290.0	1289.4	935.3	344.4	74.1	1.177	32%
1995.5	361.8	156.0	452.9	361.1	60.3	16.4	0.464	35%
1996.5	195.0	461.2	2451.1	585.8	98.2	0.0	1.709	58%
1997.5	1826.7	699.6	4514.8	2741.2	1405.2	107.8	4.959	35%
1998.5	2492.4	6318.0	5512.0	1560.2	391.3	96.9	5.702	34%
1999.5	4052.4	11048.5	7512.0	1878.8	1884.1	341.6	10.457	21%

Table 15. continued

Year	age1	age2	age3	age4	age5	age6+	B (000 mt)	CV(B)
2000.5	825.4	2226.4	6314.2	3176.0	1242.8	1084.6	7.657	49%
2001.5	4613.7	8221.1	10613.1	3411.9	2253.8	2686.8	15.153	40%
2002.5	2745.2	7542.9	2789.9	778.5	399.4	35.9	4.924	51%
2003.5	1412.5	6598.4	3683.7	740.6	131.0	250.9	5.296	33%
2004.5	1149.0	7224.5	6570.9	2762.7	1212.2	230.7	6.711	46%
2005.5	410.8	2748.0	4935.2	805.2	242.3	0.0	3.230	52%
2006.5	8124.4	8198.9	4806.3	1531.0	334.7	59.9	5.930	27%
2007.5	1387.2	15014.8	10317.2	2621.1	501.7	122.8	10.691	31%
2008.5	220.0	9409.7	12963.1	1355.1	0.0	0.0	9.325	28%
2009.5	625.0	5747.8	16004.4	2910.7	827.1	83.6	8.845	26%
2010.5	164.1	3686.6	5912.3	1023.6	390.3	0.0	2.947	30%
2011.5	310.2	3757.6	5111.7	1450.8	190.6	13.0	3.216	25%
2012.5	255.9	1935.1	4797.9	2079.7	578.4	18.7	3.305	44%
2013.5	435.4	1348.7	1232.3	703.8	151.6	57.7	1.147	36%

Table 16. 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, 2012, and 2013 surveys did not fully cover the Canadian portion of Georges Bank (D. Hart, pers. comm.).

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							
2013.5							

Table 17. Empirical approach used to derive catch advice. The mean of the three bottom trawl survey population biomass values is denoted Avg. The catch advice is computed as Avg * 0.25, the exploitation rate. The catch advice year is the year when the catch advice would be used as the quota.

Year	DFO	Spring	Fall (year-1)	Avg (mt)	Catch Advice (mt)	Catch Advice Year
2010	8233	22181	26936	19117	4779	2011
2011	3450	9557	8976	7328	1832	2012
2012	5063	14908	9793	9921	2480	2013
2013	629	4119	10065	4938	1234	2014
2014	462	2684	3493	2213	553	2015

Table 18. Selected percentiles of the empirical approach catch advice distributions (mt) considering uncertainty only in the catch/tow of the surveys (top block), only in the survey catchability (middle block), and in both (bottom block).

Year	2.50%	5%	10%	50%	90%	95%	97.50%
Catch/tow Varies							
2010	3229	3486	3771	4780	5790	6070	6307
2011	1247	1340	1449	1833	2218	2327	2422
2012	1253	1452	1682	2481	3282	3514	3708
2013	488	610	749	1235	1722	1860	1979
2014	332	368	409	554	698	740	776
Catchability Varies							
2010	2510	2823	3206	4735	6427	6902	7308
2011	962	1082	1229	1815	2463	2645	2801
2012	1303	1465	1664	2458	3335	3582	3793
2013	648	729	828	1223	1660	1783	1888
2014	291	327	371	548	744	799	846
Both Catch/tow and Catchability Varies							
2010	2272	2578	2968	4651	6773	7433	8039
2011	870	990	1142	1787	2593	2845	3077
2012	978	1165	1394	2388	3694	4125	4515
2013	404	505	632	1184	1913	2154	2378
2014	245	283	330	536	802	889	965

Table 19. Summary of changes to VPA benchmark formulation over time (Year denotes year the assessment was conducted). Models in bold font were used for status determination and to provide catch advice. The decision regarding which model(s), if any, to use for 2014 have not been made yet.

Year	Model	Features or changes
2005	Base Case	The previously used assessment model, surveys not split, ages 1-6+
Benchmark	Minor Change	Ages expanded to 1-12 with no plus group
	Major Change	Ages expanded to 1-12 with no plus group, surveys split between 1994 and 1995, non-linear relationship between indices of abundance and estimated population for ages 1-3
2005	Base Case	same as benchmark Base Case
Assessment	Minor Change	dropped due to convergence issues
	Major Change	same as Base Case except surveys split between 1994 and 1995
2006	Base Case	same as 2005 assessment Base Case
	Major Change	same as 2005 assessment Major Change
2007	Base Case	same as 2006 Base Case
	Major Change	same as 2006 Major Change
2008	Base Case	same as 2007 Base Case
	Major Change	same as 2007 Major Change
2009	Base Case	same as 2008 Base Case
	Including	same as 2008 Major Change
	Excluding	same as 2008 Major Change except the 2008 and 2009 DFO survey values were not included in the tuning
2010	Single Series	same as 2009 Base Case
	Split Series	same as 2009 Including except the 2008 and 2009 DFO survey values were downweighted to account for their higher uncertainty due to single large tows
2011	**Single Series**	same as 2010 Single Series except with rho adjustment applied in projections
	Split Series	same as 2010 Split Series except rho adjustment applied in projections
2012	**Single Series**	same as 2011 Single Series
	Split Series	same as 2011 Split Series
	Increase M	same as 2011 Single Series except M in years 2005 onward increased from 0.2 to 0.9 to "fix" retrospective pattern
	Increase Catch	same as 2011 Single Series except catch in years 2005 onward multiplied by 5 to "fix" retrospective pattern
	Increase M&C	same as 2011 Single Series except M in years 2005 onward increased from 0.2 to 0.5 and catch multiplied by 3.5 to "fix" retrospective pattern
2013	**Single Series**	same as 2012 Single Series
	Split Series	same as 2012 Split Series
2014	Single M02	same as 2013 Single Series

Single M04	same as 2013 Single Series except M increased from 0.2 to 0.4 for all years
Single M0410	same as 2013 Single Series except M increased from 0.2 to 0.4 for years 1973-2004 and from 0.2 to 1.0 for years 2005 onward
Split M02	same as 2013 Split Series
Split M04	same as 2013 Split Series except M increased from 0.2 to 0.4 for all years
Split M0409	same as 2013 Split Series except M increased from 0.2 to 0.4 for years 1973-2004 and from 0.2 to 0.9 for years 2005 onward

Table 20a. Statistical properties of estimates for population abundance and survey catchability constants (scallop x10^3) for Georges Bank yellowtail flounder for the Split Series M02 VPA.

		Bootstrap			
Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
	Population Abundance				
2	1811	984	54%	225	12%
3	1021	423	41%	81	8%
4	811	280	35%	31	4%
5	588	143	24%	4	1%
	Survey Calibration Constants				
DFO Survey: 1987-1994					
2	0.130	0.044	34%	0.006	5%
3	0.209	0.029	14%	0.000	0%
4	0.351	0.064	18%	0.007	2%
5	0.393	0.087	22%	0.010	3%
6+	0.229	0.059	26%	0.007	3%
DFO Survey: 1995-2014					
2	0.331	0.077	23%	0.009	3%
3	1.646	0.351	21%	0.039	2%
4	2.317	0.500	22%	0.078	3%
5	1.831	0.380	21%	0.045	2%
6+	1.147	0.334	29%	0.056	5%
NMFS Spring Survey: Yankee 41, 1973-1981					
1	0.010	0.008	77%	0.002	18%
2	0.102	0.019	18%	0.003	3%
3	0.129	0.022	17%	0.001	1%
4	0.125	0.015	12%	0.001	1%
5	0.103	0.020	19%	0.002	2%
6+	0.097	0.034	35%	0.006	6%
NMFS Spring Survey: Yankee 36, 1982-1994					
1	0.006	0.001	25%	0.000	4%
2	0.062	0.021	34%	0.002	3%
3	0.129	0.019	15%	0.002	1%
4	0.206	0.026	13%	0.002	1%
5	0.309	0.062	20%	0.005	2%
6+	0.572	0.124	22%	0.007	1%

Table 20a. continued

Age	Estimate	Bootstrap Standard Error	Bootstrap Relative Error	Bootstrap Bias	Bootstrap Relative Bias
NMFS Spring Survey: Yankee 36, 1995-2014					
1	0.013	0.005	34%	0.001	5%
2	0.261	0.035	13%	0.003	1%
3	1.088	0.174	16%	0.013	1%
4	1.340	0.270	20%	0.022	2%
5	1.072	0.220	20%	0.024	2%
6+	0.881	0.153	17%	0.010	1%
NMFS Fall Survey: 1973-1994					
1	0.054	0.014	26%	0.002	4%
2	0.118	0.019	16%	0.001	1%
3	0.203	0.021	10%	0.002	1%
4	0.211	0.029	14%	0.002	1%
5	0.277	0.050	18%	0.003	1%
6+	0.414	0.084	20%	0.008	2%
NMFS Fall Survey: 1995-2013					
1	0.123	0.025	21%	0.001	1%
2	0.587	0.193	33%	0.025	4%
3	1.306	0.288	22%	0.020	2%
4	0.911	0.169	19%	0.012	1%
5	0.794	0.175	22%	0.017	2%
6+	0.526	0.162	31%	0.020	4%
NMFS Scallop Survey: 1982-1994					
1	0.026	0.008	30%	0.001	5%
NMFS Scallop Survey: 1995-2013					
1	0.064	0.009	14%	0.000	0%

Table 20b. Statistical properties of estimates for population abundance and survey catchability constants (scallop x10^3) for Georges Bank yellowtail flounder for the Split Series M04 VPA.

		Bootstrap			
Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
	Population Abundance				
2	2935	1637	56%	383	13%
3	1406	586	42%	116	8%
4	989	334	34%	38	4%
5	827	177	21%	2	0%
	Survey Calibration Constants				
DFO Survey: 1987-1994					
2	0.090	0.030	34%	0.004	4%
3	0.166	0.025	15%	0.000	0%
4	0.295	0.055	19%	0.006	2%
5	0.330	0.074	23%	0.009	3%
6+	0.192	0.050	26%	0.006	3%
DFO Survey: 1995-2014					
2	0.203	0.050	25%	0.006	3%
3	1.167	0.253	22%	0.030	3%
4	1.741	0.377	22%	0.062	4%
5	1.366	0.287	21%	0.034	3%
6+	0.856	0.252	29%	0.043	5%
NMFS Spring Survey: Yankee 41, 1973-1981					
1	0.006	0.005	77%	0.001	18%
2	0.074	0.014	18%	0.002	3%
3	0.102	0.018	17%	0.001	1%
4	0.101	0.012	11%	0.001	1%
5	0.083	0.016	20%	0.002	2%
6+	0.079	0.027	35%	0.005	6%
NMFS Spring Survey: Yankee 36, 1982-1994					
1	0.004	0.001	26%	0.000	4%
2	0.045	0.016	35%	0.002	3%
3	0.103	0.015	15%	0.001	1%
4	0.171	0.022	13%	0.002	1%
5	0.257	0.052	20%	0.004	2%
6+	0.475	0.101	21%	0.005	1%

Table 20b. continued

Age	Estimate	Bootstrap Standard Error	Relative Error	Bias	Relative Bias
NMFS Spring Survey: Yankee 36, 1995-2014					
1	0.007	0.002	35%	0.000	5%
2	0.161	0.023	14%	0.002	1%
3	0.771	0.119	15%	0.009	1%
4	1.007	0.196	19%	0.016	2%
5	0.800	0.155	19%	0.016	2%
6+	0.657	0.109	17%	0.007	1%
NMFS Fall Survey: 1973-1994					
1	0.035	0.009	27%	0.001	4%
2	0.089	0.015	16%	0.001	1%
3	0.164	0.017	10%	0.001	1%
4	0.173	0.023	14%	0.001	1%
5	0.226	0.041	18%	0.002	1%
6+	0.339	0.069	20%	0.007	2%
NMFS Fall Survey: 1995-2013					
1	0.069	0.015	21%	0.001	1%
2	0.386	0.128	33%	0.017	4%
3	0.950	0.208	22%	0.016	2%
4	0.682	0.125	18%	0.009	1%
5	0.595	0.133	22%	0.013	2%
6+	0.394	0.121	31%	0.015	4%
NMFS Scallop Survey: 1982-1994					
1	0.017	0.005	29%	0.001	5%
NMFS Scallop Survey: 1995-2013					
1	0.036	0.005	15%	0.000	1%

Table 20c. Statistical properties of estimates for population abundance and survey catchability constants (scallop x10^3) for Georges Bank yellowtail flounder for the Split Series M0409 VPA.

		Bootstrap			
Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
	Population Abundance				
2	5006	2679	54%	617	12%
3	1699	599	35%	90	5%
4	878	242	28%	21	2%
5	417	78	19%	-1	0%
	Survey Calibration Constants				
DFO Survey: 1987-1994					
2	0.090	0.030	34%	0.004	5%
3	0.166	0.025	15%	0.000	0%
4	0.294	0.056	19%	0.006	2%
5	0.330	0.075	23%	0.010	3%
6+	0.192	0.049	26%	0.005	3%
DFO Survey: 1995-2014					
2	0.107	0.031	29%	0.004	4%
3	0.757	0.126	17%	0.012	2%
4	1.263	0.178	14%	0.021	2%
5	1.019	0.158	15%	0.018	2%
6+	0.638	0.157	25%	0.022	3%
NMFS Spring Survey: Yankee 41, 1973-1981					
1	0.006	0.005	75%	0.001	18%
2	0.074	0.013	18%	0.002	3%
3	0.102	0.018	18%	0.001	1%
4	0.101	0.012	12%	0.001	1%
5	0.083	0.016	19%	0.002	2%
6+	0.079	0.027	34%	0.005	6%
NMFS Spring Survey: Yankee 36, 1982-1994					
1	0.004	0.001	25%	0.000	4%
2	0.045	0.016	35%	0.002	4%
3	0.103	0.015	15%	0.002	2%
4	0.171	0.022	13%	0.002	1%
5	0.257	0.051	20%	0.004	1%
6+	0.475	0.101	21%	0.009	2%

Table 20c. continued

Age	Estimate	Bootstrap Standard Error	Relative Error	Bias	Relative Bias
NMFS Spring Survey: Yankee 36, 1995-2014					
1	0.003	0.001	24%	0.000	2%
2	0.084	0.013	15%	0.001	2%
3	0.500	0.063	13%	0.003	1%
4	0.730	0.120	16%	0.006	1%
5	0.597	0.109	18%	0.012	2%
6+	0.490	0.082	17%	0.007	1%
NMFS Fall Survey: 1973-1994					
1	0.035	0.009	26%	0.001	4%
2	0.089	0.015	16%	0.001	1%
3	0.164	0.018	11%	0.001	1%
4	0.173	0.023	13%	0.001	1%
5	0.226	0.041	18%	0.003	1%
6+	0.339	0.068	20%	0.006	2%
NMFS Fall Survey: 1995-2013					
1	0.031	0.007	23%	0.000	2%
2	0.220	0.056	26%	0.005	2%
3	0.638	0.108	17%	0.008	1%
4	0.492	0.073	15%	0.005	1%
5	0.445	0.088	20%	0.009	2%
6+	0.307	0.093	30%	0.011	3%
NMFS Scallop Survey: 1982-1994					
1	0.017	0.005	30%	0.001	4%
NMFS Scallop Survey: 1995-2013					
1	0.016	0.003	21%	0.000	2%

Table 20d. Statistical properties of estimates for population abundance and survey catchability constants (scallop x10^3) for Georges Bank yellowtail flounder for the Single Series M02 VPA.

		Bootstrap			
Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
	Population Abundance				
2	2995	1939	65%	405	14%
3	2014	937	47%	183	9%
4	1801	709	39%	121	7%
5	2251	477	21%	40	2%
	Survey Calibration Constants				
DFO Survey: 1987-2014					
2	0.221	0.049	22%	0.005	2%
3	0.807	0.196	24%	0.032	4%
4	1.193	0.271	23%	0.019	2%
5	1.021	0.228	22%	0.024	2%
6+	0.626	0.178	28%	0.024	4%
NMFS Spring Survey: Yankee 36, 1982-2014					
1	0.009	0.002	22%	0.000	2%
2	0.135	0.025	18%	0.003	2%
3	0.423	0.088	21%	0.006	1%
4	0.576	0.113	20%	0.009	2%
5	0.581	0.099	17%	0.000	0%
6+	0.663	0.094	14%	0.007	1%
NMFS Fall Survey: 1973-2013					
1	0.072	0.012	17%	0.001	2%
2	0.229	0.045	20%	0.005	2%
3	0.446	0.078	18%	0.005	1%
4	0.384	0.058	15%	0.005	1%
5	0.434	0.074	17%	0.005	1%
6+	0.423	0.085	20%	0.008	2%
NMFS Scallop Survey: 1982-2013					
1	0.039	0.007	19%	0.001	2%

Table 20e. Statistical properties of estimates for population abundance and survey catchability constants (scallop x10^3) for Georges Bank yellowtail flounder for the Single Series M04 VPA.

		Bootstrap			
Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
	Population Abundance				
2	4626	2966	64%	625	14%
3	2635	1181	45%	226	9%
4	2057	764	37%	126	6%
5	2866	524	18%	34	1%
	Survey Calibration Constants				
DFO Survey: 1987-2014					
2	0.138	0.031	22%	0.003	2%
3	0.579	0.136	24%	0.023	4%
4	0.907	0.197	22%	0.013	1%
5	0.773	0.168	22%	0.017	2%
6+	0.474	0.130	27%	0.017	4%
NMFS Spring Survey: Yankee 36, 1982-2014					
1	0.005	0.001	22%	0.000	2%
2	0.087	0.016	18%	0.002	2%
3	0.308	0.059	19%	0.003	1%
4	0.443	0.081	18%	0.006	1%
5	0.445	0.071	16%	0.000	0%
6+	0.505	0.069	14%	0.005	1%
NMFS Fall Survey: 1973-2013					
1	0.043	0.007	17%	0.001	2%
2	0.160	0.030	19%	0.003	2%
3	0.338	0.056	17%	0.003	1%
4	0.297	0.043	14%	0.004	1%
5	0.334	0.056	17%	0.004	1%
6+	0.327	0.067	20%	0.006	2%
NMFS Scallop Survey: 1982-2013					
1	0.023	0.004	18%	0.000	2%

Table 20f. Statistical properties of estimates for population abundance and survey catchability constants (scallop x10^3) for Georges Bank yellowtail flounder for the Single Series M0410 VPA.

		Bootstrap			
Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
	Population Abundance				
2	5941	3491	59%	639	11%
3	2332	950	41%	168	7%
4	1281	407	32%	60	5%
5	620	103	17%	3	0%
	Survey Calibration Constants				
DFO Survey: 1987-2014					
2	0.083	0.021	25%	0.003	3%
3	0.415	0.070	17%	0.007	2%
4	0.718	0.108	15%	0.004	1%
5	0.636	0.096	15%	0.009	1%
6+	0.390	0.084	22%	0.011	3%
NMFS Spring Survey: Yankee 36, 1982-2014					
1	0.002	0.000	18%	0.000	2%
2	0.056	0.009	17%	0.001	2%
3	0.233	0.036	15%	0.001	0%
4	0.363	0.057	16%	0.003	1%
5	0.377	0.056	15%	0.002	1%
6+	0.423	0.058	14%	0.006	1%
NMFS Fall Survey: 1973-2013					
1	0.028	0.005	18%	0.001	2%
2	0.120	0.017	14%	0.001	1%
3	0.277	0.035	13%	0.001	0%
4	0.255	0.030	12%	0.003	1%
5	0.289	0.043	15%	0.002	1%
6+	0.292	0.057	19%	0.004	2%
NMFS Scallop Survey: 1982-2013					
1	0.014	0.003	20%	0.000	2%

Table 21a. Retrospective rho statistics for fishing mortality rate (ages 4+), spawning stock biomass, and age 1 recruitment based on seven peels of the three Split Series VPAs.

	M02			M04			M0409		
Peel	F	SSB	R	F	SSB	R	F	SSB	R
1	-0.485	0.627	0.331	-0.487	0.530	0.313	-0.047	0.011	0.058
2	-0.665	1.328	0.805	-0.702	1.267	0.729	-0.051	-0.028	0.073
3	-0.818	2.402	-0.240	-0.811	2.092	-0.379	-0.065	-0.133	-0.652
4	-0.824	3.771	0.570	-0.809	3.341	0.330	-0.020	0.114	-0.521
5	-0.768	4.286	0.059	-0.754	4.007	-0.074	0.346	0.216	-0.748
6	-0.732	2.648	2.225	-0.744	2.638	2.083	0.150	-0.124	-0.310
7	-0.477	1.197	4.950	-0.575	1.287	4.971	0.126	-0.420	0.237
mean	-0.681	2.323	1.243	-0.697	2.166	1.139	0.063	-0.052	-0.266

Table 21b. Retrospective rho statistics for fishing mortality rate (ages 4+), spawning stock biomass, and age 1 recruitment based on seven peels of the three Single Series VPAs.

	M02			M04			M0410		
Peel	F	SSB	R	F	SSB	R	F	SSB	R
1	-0.640	0.907	0.124	-0.591	0.641	0.097	-0.049	-0.041	-0.183
2	-0.856	2.732	0.427	-0.806	1.653	0.318	-0.071	-0.081	-0.287
3	-0.918	5.216	-0.524	-0.878	3.012	-0.663	-0.077	-0.137	-0.768
4	-0.917	7.786	0.370	-0.886	5.230	-0.084	-0.033	0.069	-0.680
5	-0.901	8.634	0.267	-0.875	6.626	-0.141	0.194	0.124	-0.814
6	-0.888	5.655	3.239	-0.880	4.783	2.338	-0.038	-0.188	-0.521
7	-0.792	3.362	7.286	-0.835	3.294	6.305	-0.215	-0.387	-0.099
mean	-0.845	4.899	1.599	-0.822	3.606	1.167	-0.041	-0.092	-0.479

Table 22a. Beginning of year population abundance in numbers (000s) for Georges Bank yellowtail flounder from the Split Series M02 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	19790	10935	7174	5103	1039	246	44287
1998	22377	16129	7932	4227	2515	328	53507
1999	24507	18168	11411	3465	1777	675	60003
2000	19743	20010	12396	5585	1454	930	60119
2001	22165	16045	12907	5046	1751	916	58830
2002	15101	17988	10542	4373	1559	1108	50671
2003	10533	12172	10980	5540	1869	1656	42750
2004	6736	8479	6451	4779	2462	1837	30743
2005	8335	5460	5904	2442	561	265	22966
2006	9810	6770	3052	1269	491	290	21682
2007	5812	7896	4417	1093	225	91	19534
2008	4465	4712	5121	2087	306	60	16751
2009	3836	3631	3417	2494	946	135	14458
2010	2436	3125	2717	1664	831	185	10957
2011	1798	1993	2431	1639	562	137	8561
2012	1618	1462	1482	1295	538	103	6498
2013	2228	1314	1100	881	543	130	6196
2014	3924	1811	1021	811	588	450	8605

Table 22b. Beginning of year population abundance in numbers (000s) for Georges Bank yellowtail flounder from the Split Series M04 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	46684	34147	37735	21482	8651	3741	152441
1974	76885	31001	18709	14463	6880	2870	150808
1975	103644	49615	13170	5957	3660	2031	178078
1976	39355	65711	12464	3033	1222	1953	123738
1977	30745	25865	18784	3987	904	1069	81353
1978	86593	20302	10072	4290	1209	473	122940
1979	46100	49983	10750	3120	1357	707	112018
1980	45083	30641	25034	4179	956	306	106198
1981	100705	29961	17309	9061	1574	268	158878
1982	34311	67417	19193	6836	2202	193	130152
1983	10415	21244	30665	6905	1895	431	71555
1984	16996	6412	7861	7443	2651	560	41923
1985	25212	10975	2682	1713	1081	169	41832
1986	13311	16112	3874	955	500	279	35031
1987	15651	8777	5702	1692	331	236	32390
1988	40196	10364	3264	1355	364	85	55628
1989	17053	26538	4539	965	248	69	49413
1990	20982	11277	16026	2142	307	57	50791
1991	34901	13877	5854	5187	660	123	60602
1992	28972	22856	9182	2726	1116	78	64929
1993	23466	17464	8021	3777	668	147	53543
1994	30600	11517	10583	2731	715	216	56363
1995	25377	20454	6639	2160	418	91	55139
1996	26483	16973	13457	3294	749	103	61058
1997	38498	17670	10824	7353	1498	355	76198
1998	41869	25740	10926	5777	3436	448	88195
1999	44522	27928	15639	4610	2364	898	95962
2000	37475	29795	16491	7115	1853	1185	93914
2001	38071	25013	16848	6488	2251	1178	89849
2002	25210	25377	14433	5759	2053	1459	74291
2003	17785	16727	13645	6903	2328	2064	59451
2004	11773	11792	8059	5382	2772	2068	41847
2005	16445	7842	6971	2866	658	311	35094
2006	18849	10975	3983	1511	585	346	36248
2007	11785	12513	6344	1414	291	118	32466
2008	9955	7859	7179	2881	422	82	28379
2009	8964	6651	4871	3289	1247	178	25199
2010	5983	5994	4228	2248	1122	250	19825
2011	3759	4009	3903	2308	791	193	14964
2012	3253	2511	2552	1992	827	158	11293
2013	4396	2171	1595	1412	871	208	10654
2014	8112	2935	1406	989	827	632	14901

Table 22c. Beginning of year population abundance in numbers (000s) for Georges Bank yellowtail flounder from the Split Series M0409 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	46684	34147	37735	21482	8651	3741	152441
1974	76885	31001	18709	14463	6880	2870	150808
1975	103644	49615	13170	5957	3660	2031	178078
1976	39355	65711	12464	3033	1222	1953	123738
1977	30745	25865	18784	3987	904	1069	81353
1978	86593	20302	10072	4290	1209	473	122940
1979	46100	49983	10750	3120	1357	707	112018
1980	45083	30641	25034	4179	956	306	106198
1981	100705	29961	17309	9061	1574	268	158878
1982	34311	67417	19193	6836	2202	193	130152
1983	10415	21244	30665	6905	1895	431	71555
1984	16996	6412	7861	7443	2651	560	41923
1985	25212	10975	2682	1713	1081	169	41832
1986	13311	16112	3874	955	500	279	35031
1987	15651	8777	5702	1692	331	236	32390
1988	40196	10364	3264	1355	364	85	55628
1989	17054	26539	4539	965	248	69	49413
1990	20983	11277	16026	2142	307	57	50793
1991	34904	13878	5854	5187	660	123	60606
1992	28983	22858	9183	2726	1116	78	64944
1993	23498	17472	8023	3777	668	147	53585
1994	30706	11539	10588	2732	716	216	56497
1995	25496	20525	6653	2164	419	91	55348
1996	26638	17052	13504	3304	751	103	61352
1997	38893	17774	10878	7385	1504	356	76790
1998	42621	26004	10996	5812	3458	451	89342
1999	45920	28433	15817	4657	2388	907	98121
2000	40203	30732	16829	7233	1884	1205	98087
2001	41614	26842	17475	6713	2329	1218	96192
2002	34900	27752	15658	6174	2201	1564	88249
2003	34167	23222	15234	7721	2604	2308	85257
2004	49415	22773	12403	6439	3317	2475	96820
2005	149483	33074	14330	5756	1322	624	204589
2006	141121	60738	12478	3434	1330	785	219886
2007	85093	57283	23925	4116	847	344	171608
2008	68585	34565	22371	8682	1272	248	135724
2009	48439	27867	13752	7938	3010	429	101434
2010	22526	19683	11155	4819	2406	535	61125
2011	14387	9157	7916	4137	1418	346	37361
2012	10520	5843	3621	2746	1140	218	24088
2013	12334	4270	2309	1247	769	184	21113
2014	40674	5006	1699	878	417	319	48992

Table 22d. Beginning of year population abundance in numbers (000s) for Georges Bank yellowtail flounder from the Single Series M02 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	19790	10935	7174	5103	1039	246	44287
1998	22377	16129	7932	4227	2515	328	53507
1999	24507	18168	11411	3465	1777	675	60003
2000	19744	20011	12396	5585	1454	930	60120
2001	22166	16046	12907	5046	1751	916	58832
2002	15105	17989	10542	4374	1559	1108	50677
2003	10542	12176	10981	5541	1869	1656	42764
2004	6768	8486	6454	4780	2462	1837	30786
2005	8510	5486	5910	2444	561	265	23176
2006	10185	6913	3073	1274	493	291	22229
2007	6419	8203	4534	1111	229	93	20588
2008	5896	5209	5372	2182	320	62	19042
2009	6636	4802	3823	2698	1023	146	19130
2010	6139	5418	3676	1995	996	222	18446
2011	3602	5024	4308	2424	831	203	16392
2012	3099	2939	3964	2829	1175	225	14231
2013	3674	2526	2309	2912	1796	430	13647
2014	5714	2995	2014	1801	2251	1720	16494

Table 22e. Beginning of year population abundance in numbers (000s) for Georges Bank yellowtail flounder from the Single Series M04 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	46684	34147	37735	21482	8651	3741	152441
1974	76885	31001	18709	14463	6880	2870	150808
1975	103644	49615	13170	5957	3660	2031	178078
1976	39355	65711	12464	3033	1222	1953	123738
1977	30745	25865	18784	3987	904	1069	81353
1978	86593	20302	10072	4290	1209	473	122940
1979	46100	49983	10750	3120	1357	707	112018
1980	45083	30641	25034	4179	956	306	106198
1981	100705	29961	17309	9061	1574	268	158878
1982	34311	67417	19193	6836	2202	193	130152
1983	10415	21244	30665	6905	1895	431	71555
1984	16996	6412	7861	7443	2651	560	41923
1985	25212	10975	2682	1713	1081	169	41832
1986	13311	16112	3874	955	500	279	35031
1987	15651	8777	5702	1692	331	236	32390
1988	40196	10364	3264	1355	364	85	55628
1989	17053	26538	4539	965	248	69	49413
1990	20982	11277	16026	2142	307	57	50791
1991	34901	13877	5854	5187	660	123	60602
1992	28972	22856	9182	2726	1116	78	64929
1993	23466	17464	8021	3777	668	147	53543
1994	30601	11517	10583	2731	715	216	56363
1995	25378	20455	6639	2161	418	91	55141
1996	26484	16973	13457	3294	749	103	61060
1997	38501	17671	10825	7353	1498	355	76201
1998	41873	25741	10927	5777	3437	448	88202
1999	44530	27931	15640	4611	2364	898	95975
2000	37491	29801	16493	7116	1853	1185	93939
2001	38092	25024	16851	6490	2252	1178	89887
2002	25267	25391	14441	5762	2054	1460	74374
2003	17881	16765	13654	6908	2330	2065	59603
2004	12063	11856	8085	5388	2775	2071	42239
2005	17735	8037	7014	2883	662	313	36645
2006	21117	11840	4114	1538	596	352	39556
2007	14792	14033	6924	1500	309	125	37683
2008	15767	9874	8198	3268	479	93	37678
2009	18287	10546	6221	3969	1505	214	40743
2010	16087	12244	6839	3150	1573	350	40243
2011	7307	10782	8093	4057	1391	339	31969
2012	5988	4889	7092	4797	1992	381	25139
2013	6919	4004	3190	4454	2747	657	21971
2014	12509	4626	2635	2057	2866	2190	26883

Table 22f. Beginning of year population abundance in numbers (000s) for Georges Bank yellowtail flounder from the Single Series M0410 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	46684	34147	37735	21482	8651	3741	152441
1974	76885	31001	18709	14463	6880	2870	150808
1975	103644	49615	13170	5957	3660	2031	178078
1976	39355	65711	12464	3033	1222	1953	123738
1977	30745	25865	18784	3987	904	1069	81353
1978	86593	20302	10072	4290	1209	473	122940
1979	46100	49983	10750	3120	1357	707	112018
1980	45083	30641	25034	4179	956	306	106198
1981	100705	29961	17309	9061	1574	268	158878
1982	34311	67417	19193	6836	2202	193	130152
1983	10415	21244	30665	6905	1895	431	71555
1984	16996	6412	7861	7443	2651	560	41923
1985	25212	10975	2682	1713	1081	169	41832
1986	13311	16112	3874	955	500	279	35031
1987	15651	8777	5702	1692	331	236	32390
1988	40196	10364	3264	1355	364	85	55628
1989	17054	26539	4539	965	248	69	49414
1990	20984	11277	16026	2142	307	57	50794
1991	34907	13879	5854	5187	660	123	60610
1992	28992	22860	9184	2726	1116	78	64955
1993	23521	17477	8024	3778	668	147	53615
1994	30781	11554	10592	2732	716	216	56591
1995	25579	20575	6663	2166	419	91	55494
1996	26747	17108	13538	3311	753	103	61559
1997	39170	17847	10915	7407	1509	357	77206
1998	43150	26190	11045	5837	3473	453	90148
1999	46903	28787	15941	4689	2404	913	99639
2000	42124	31391	17067	7316	1905	1219	101022
2001	44109	28129	17917	6871	2384	1247	100657
2002	41893	29424	16521	6466	2305	1638	98247
2003	46145	27909	16354	8298	2799	2481	103986
2004	83823	30802	15540	7185	3701	2761	143812
2005	293491	56139	19712	7852	1803	851	379847
2006	262734	107934	19736	4975	1927	1138	398445
2007	157986	96567	38980	6353	1307	531	301724
2008	130185	58090	34658	13351	1956	382	238622
2009	92223	47876	21086	11654	4420	630	177888
2010	43520	33917	17448	7026	3508	780	106200
2011	27366	16009	12395	6042	2071	505	64388
2012	17510	10061	5793	4113	1708	327	39510
2013	16174	6435	3638	1918	1183	283	29630
2014	72719	5941	2332	1281	620	474	83368

Table 23a. Fishing mortality rate for Georges Bank yellowtail from the Split Series M02 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	0.38	1.34	1.40	1.40	1.40	1.40
2006	0.02	0.23	0.83	1.53	1.53	1.53	1.53
2007	0.01	0.23	0.55	1.07	1.07	1.07	1.07
2008	0.01	0.12	0.52	0.59	0.59	0.59	0.59
2009	0.01	0.09	0.52	0.90	0.90	0.90	0.90
2010	0.00	0.05	0.31	0.89	0.89	0.89	0.89
2011	0.01	0.10	0.43	0.91	0.91	0.91	0.91
2012	0.01	0.08	0.32	0.67	0.67	0.67	0.67
2013	0.01	0.05	0.10	0.20	0.20	0.20	0.20

Table 23b. Fishing mortality rate for Georges Bank yellowtail from the Split Series M04 VPA.

	Age Group						
Year	1	2	3	4	5	6+	4-5
1973	0.01	0.20	0.56	0.74	0.74	0.74	0.74
1974	0.04	0.46	0.74	0.97	0.97	0.97	0.97
1975	0.06	0.98	1.07	1.18	1.18	1.18	1.18
1976	0.02	0.85	0.74	0.81	0.81	0.81	0.81
1977	0.02	0.54	1.08	0.79	0.79	0.79	0.79
1978	0.15	0.24	0.77	0.75	0.75	0.75	0.75
1979	0.01	0.29	0.54	0.78	0.78	0.78	0.78
1980	0.01	0.17	0.62	0.58	0.58	0.58	0.58
1981	0.00	0.05	0.53	1.01	1.01	1.01	1.01
1982	0.08	0.39	0.62	0.88	0.88	0.88	0.88
1983	0.09	0.59	1.02	0.56	0.56	0.56	0.56
1984	0.04	0.47	1.12	1.53	1.53	1.53	1.53
1985	0.05	0.64	0.63	0.83	0.83	0.83	0.83
1986	0.02	0.64	0.43	0.66	0.66	0.66	0.66
1987	0.01	0.59	1.04	1.14	1.14	1.14	1.14
1988	0.02	0.43	0.82	1.30	1.30	1.30	1.30
1989	0.01	0.10	0.35	0.75	0.75	0.75	0.75
1990	0.01	0.26	0.73	0.78	0.78	0.78	0.78
1991	0.02	0.01	0.36	1.14	1.14	1.14	1.14
1992	0.11	0.65	0.49	1.01	1.01	1.01	1.01
1993	0.31	0.10	0.68	1.26	1.26	1.26	1.26
1994	0.00	0.15	1.19	1.48	1.48	1.48	1.48
1995	0.00	0.02	0.30	0.66	0.66	0.66	0.66
1996	0.00	0.05	0.20	0.39	0.39	0.39	0.39
1997	0.00	0.08	0.23	0.36	0.36	0.36	0.36
1998	0.00	0.10	0.46	0.49	0.49	0.49	0.49
1999	0.00	0.13	0.39	0.51	0.51	0.51	0.51
2000	0.00	0.17	0.53	0.75	0.75	0.75	0.75
2001	0.01	0.15	0.67	0.75	0.75	0.75	0.75
2002	0.01	0.22	0.34	0.51	0.51	0.51	0.51
2003	0.01	0.33	0.53	0.51	0.51	0.51	0.51
2004	0.01	0.13	0.63	1.70	1.70	1.70	1.70
2005	0.00	0.28	1.13	1.19	1.19	1.19	1.19
2006	0.01	0.15	0.64	1.25	1.25	1.25	1.25
2007	0.01	0.16	0.39	0.81	0.81	0.81	0.81
2008	0.00	0.08	0.38	0.44	0.44	0.44	0.44
2009	0.00	0.05	0.37	0.68	0.68	0.68	0.68
2010	0.00	0.03	0.21	0.64	0.64	0.64	0.64
2011	0.00	0.05	0.27	0.63	0.63	0.63	0.63
2012	0.00	0.05	0.19	0.43	0.43	0.43	0.43
2013	0.00	0.03	0.08	0.14	0.14	0.14	0.14

Table 23c. Fishing mortality rate for Georges Bank yellowtail from the Split Series M0409 VPA.

	Age Group						
Year	1	2	3	4	5	6+	4-5
1973	0.01	0.20	0.56	0.74	0.74	0.74	0.74
1974	0.04	0.46	0.74	0.97	0.97	0.97	0.97
1975	0.06	0.98	1.07	1.18	1.18	1.18	1.18
1976	0.02	0.85	0.74	0.81	0.81	0.81	0.81
1977	0.02	0.54	1.08	0.79	0.79	0.79	0.79
1978	0.15	0.24	0.77	0.75	0.75	0.75	0.75
1979	0.01	0.29	0.54	0.78	0.78	0.78	0.78
1980	0.01	0.17	0.62	0.58	0.58	0.58	0.58
1981	0.00	0.05	0.53	1.01	1.01	1.01	1.01
1982	0.08	0.39	0.62	0.88	0.88	0.88	0.88
1983	0.09	0.59	1.02	0.56	0.56	0.56	0.56
1984	0.04	0.47	1.12	1.53	1.53	1.53	1.53
1985	0.05	0.64	0.63	0.83	0.83	0.83	0.83
1986	0.02	0.64	0.43	0.66	0.66	0.66	0.66
1987	0.01	0.59	1.04	1.14	1.14	1.14	1.14
1988	0.02	0.43	0.82	1.30	1.30	1.30	1.30
1989	0.01	0.10	0.35	0.75	0.75	0.75	0.75
1990	0.01	0.26	0.73	0.78	0.78	0.78	0.78
1991	0.02	0.01	0.36	1.14	1.14	1.14	1.14
1992	0.11	0.65	0.49	1.01	1.01	1.01	1.01
1993	0.31	0.10	0.68	1.26	1.26	1.26	1.26
1994	0.00	0.15	1.19	1.47	1.47	1.47	1.47
1995	0.00	0.02	0.30	0.66	0.66	0.66	0.66
1996	0.00	0.05	0.20	0.39	0.39	0.39	0.39
1997	0.00	0.08	0.23	0.36	0.36	0.36	0.36
1998	0.00	0.10	0.46	0.49	0.49	0.49	0.49
1999	0.00	0.12	0.38	0.51	0.51	0.51	0.51
2000	0.00	0.16	0.52	0.73	0.73	0.73	0.73
2001	0.01	0.14	0.64	0.72	0.72	0.72	0.72
2002	0.01	0.20	0.31	0.46	0.46	0.46	0.46
2003	0.01	0.23	0.46	0.45	0.45	0.45	0.45
2004	0.00	0.06	0.37	1.18	1.18	1.18	1.18
2005	0.00	0.07	0.53	0.57	0.57	0.57	0.57
2006	0.00	0.03	0.21	0.50	0.50	0.50	0.50
2007	0.00	0.04	0.11	0.27	0.27	0.27	0.27
2008	0.00	0.02	0.14	0.16	0.16	0.16	0.16
2009	0.00	0.02	0.15	0.29	0.29	0.29	0.29
2010	0.00	0.01	0.09	0.32	0.32	0.32	0.32
2011	0.00	0.03	0.16	0.39	0.39	0.39	0.39
2012	0.00	0.03	0.17	0.37	0.37	0.37	0.37
2013	0.00	0.02	0.07	0.19	0.19	0.19	0.19

Table 23d. Fishing mortality rate for Georges Bank yellowtail from the Single Series M02 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	0.38	1.33	1.40	1.40	1.40	1.40
2006	0.02	0.22	0.82	1.52	1.52	1.52	1.52
2007	0.01	0.22	0.53	1.04	1.04	1.04	1.04
2008	0.01	0.11	0.49	0.56	0.56	0.56	0.56
2009	0.00	0.07	0.45	0.80	0.80	0.80	0.80
2010	0.00	0.03	0.22	0.68	0.68	0.68	0.68
2011	0.00	0.04	0.22	0.52	0.52	0.52	0.52
2012	0.00	0.04	0.11	0.25	0.25	0.25	0.25
2013	0.00	0.03	0.05	0.06	0.06	0.06	0.06

Table 23e. Fishing mortality rate for Georges Bank yellowtail from the Single Series M04 VPA.

	Age Group						
Year	1	2	3	4	5	6+	4-5
1973	0.01	0.20	0.56	0.74	0.74	0.74	0.74
1974	0.04	0.46	0.74	0.97	0.97	0.97	0.97
1975	0.06	0.98	1.07	1.18	1.18	1.18	1.18
1976	0.02	0.85	0.74	0.81	0.81	0.81	0.81
1977	0.02	0.54	1.08	0.79	0.79	0.79	0.79
1978	0.15	0.24	0.77	0.75	0.75	0.75	0.75
1979	0.01	0.29	0.54	0.78	0.78	0.78	0.78
1980	0.01	0.17	0.62	0.58	0.58	0.58	0.58
1981	0.00	0.05	0.53	1.01	1.01	1.01	1.01
1982	0.08	0.39	0.62	0.88	0.88	0.88	0.88
1983	0.09	0.59	1.02	0.56	0.56	0.56	0.56
1984	0.04	0.47	1.12	1.53	1.53	1.53	1.53
1985	0.05	0.64	0.63	0.83	0.83	0.83	0.83
1986	0.02	0.64	0.43	0.66	0.66	0.66	0.66
1987	0.01	0.59	1.04	1.14	1.14	1.14	1.14
1988	0.02	0.43	0.82	1.30	1.30	1.30	1.30
1989	0.01	0.10	0.35	0.75	0.75	0.75	0.75
1990	0.01	0.26	0.73	0.78	0.78	0.78	0.78
1991	0.02	0.01	0.36	1.14	1.14	1.14	1.14
1992	0.11	0.65	0.49	1.01	1.01	1.01	1.01
1993	0.31	0.10	0.68	1.26	1.26	1.26	1.26
1994	0.00	0.15	1.19	1.48	1.48	1.48	1.48
1995	0.00	0.02	0.30	0.66	0.66	0.66	0.66
1996	0.00	0.05	0.20	0.39	0.39	0.39	0.39
1997	0.00	0.08	0.23	0.36	0.36	0.36	0.36
1998	0.00	0.10	0.46	0.49	0.49	0.49	0.49
1999	0.00	0.13	0.39	0.51	0.51	0.51	0.51
2000	0.00	0.17	0.53	0.75	0.75	0.75	0.75
2001	0.01	0.15	0.67	0.75	0.75	0.75	0.75
2002	0.01	0.22	0.34	0.51	0.51	0.51	0.51
2003	0.01	0.33	0.53	0.51	0.51	0.51	0.51
2004	0.01	0.12	0.63	1.70	1.70	1.70	1.70
2005	0.00	0.27	1.12	1.18	1.18	1.18	1.18
2006	0.01	0.14	0.61	1.21	1.21	1.21	1.21
2007	0.00	0.14	0.35	0.74	0.74	0.74	0.74
2008	0.00	0.06	0.33	0.38	0.38	0.38	0.38
2009	0.00	0.03	0.28	0.53	0.53	0.53	0.53
2010	0.00	0.01	0.12	0.42	0.42	0.42	0.42
2011	0.00	0.02	0.12	0.31	0.31	0.31	0.31
2012	0.00	0.03	0.07	0.16	0.16	0.16	0.16
2013	0.00	0.02	0.04	0.04	0.04	0.04	0.04

Table 23f. Fishing mortality rate for Georges Bank yellowtail from the Single Series M0410 VPA.

	Age Group						
Year	1	2	3	4	5	6+	4-5
1973	0.01	0.20	0.56	0.74	0.74	0.74	0.74
1974	0.04	0.46	0.74	0.97	0.97	0.97	0.97
1975	0.06	0.98	1.07	1.18	1.18	1.18	1.18
1976	0.02	0.85	0.74	0.81	0.81	0.81	0.81
1977	0.02	0.54	1.08	0.79	0.79	0.79	0.79
1978	0.15	0.24	0.77	0.75	0.75	0.75	0.75
1979	0.01	0.29	0.54	0.78	0.78	0.78	0.78
1980	0.01	0.17	0.62	0.58	0.58	0.58	0.58
1981	0.00	0.05	0.53	1.01	1.01	1.01	1.01
1982	0.08	0.39	0.62	0.88	0.88	0.88	0.88
1983	0.09	0.59	1.02	0.56	0.56	0.56	0.56
1984	0.04	0.47	1.12	1.53	1.53	1.53	1.53
1985	0.05	0.64	0.63	0.83	0.83	0.83	0.83
1986	0.02	0.64	0.43	0.66	0.66	0.66	0.66
1987	0.01	0.59	1.04	1.14	1.14	1.14	1.14
1988	0.02	0.43	0.82	1.30	1.30	1.30	1.30
1989	0.01	0.10	0.35	0.75	0.75	0.75	0.75
1990	0.01	0.26	0.73	0.78	0.78	0.78	0.78
1991	0.02	0.01	0.36	1.14	1.14	1.14	1.14
1992	0.11	0.65	0.49	1.01	1.01	1.01	1.01
1993	0.31	0.10	0.68	1.26	1.26	1.26	1.26
1994	0.00	0.15	1.19	1.47	1.47	1.47	1.47
1995	0.00	0.02	0.30	0.66	0.66	0.66	0.66
1996	0.00	0.05	0.20	0.39	0.39	0.39	0.39
1997	0.00	0.08	0.23	0.36	0.36	0.36	0.36
1998	0.00	0.10	0.46	0.49	0.49	0.49	0.49
1999	0.00	0.12	0.38	0.50	0.50	0.50	0.50
2000	0.00	0.16	0.51	0.72	0.72	0.72	0.72
2001	0.00	0.13	0.62	0.69	0.69	0.69	0.69
2002	0.01	0.19	0.29	0.44	0.44	0.44	0.44
2003	0.00	0.19	0.42	0.41	0.41	0.41	0.41
2004	0.00	0.05	0.28	0.98	0.98	0.98	0.98
2005	0.00	0.05	0.38	0.40	0.40	0.40	0.40
2006	0.00	0.02	0.13	0.34	0.34	0.34	0.34
2007	0.00	0.02	0.07	0.18	0.18	0.18	0.18
2008	0.00	0.01	0.09	0.11	0.11	0.11	0.11
2009	0.00	0.01	0.10	0.20	0.20	0.20	0.20
2010	0.00	0.01	0.06	0.22	0.22	0.22	0.22
2011	0.00	0.02	0.10	0.26	0.26	0.26	0.26
2012	0.00	0.02	0.11	0.25	0.25	0.25	0.25
2013	0.00	0.02	0.04	0.13	0.13	0.13	0.13

Table 24. Beginning of year weight (kg) at age for Georges Bank yellowtail. The 2014 values are set equal to the average of the 2011-2013 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	0.357	0.474	0.661	1.023
2008	0.018	0.216	0.347	0.467	0.604	0.961
2009	0.107	0.124	0.362	0.473	0.610	0.929
2010	0.126	0.224	0.376	0.475	0.596	0.807
2011	0.079	0.243	0.386	0.489	0.579	0.748
2012	0.155	0.208	0.390	0.506	0.609	0.806
2013	0.169	0.221	0.365	0.491	0.618	0.848
2014	0.134	0.224	0.380	0.495	0.602	0.801

Table 25a. Beginning of year biomass (mt) and spawning stock biomass (mt) for Georges Bank yellowtail from the three Split Series VPAs.

	M02				M04				M0409		
Year	B1p	B3p	SSB		B1p	B3p	SSB		B1p	B3p	SSB
1973	34860	26206	22161		45486	32979	27678		45486	32979	27678
1974	26134	18088	14780		33048	21934	17949		33048	21934	17949
1975	22723	10184	9014		28684	12180	11057		28684	12180	11057
1976	18984	7408	10024		24053	9324	12426		24053	9324	12426
1977	14447	9447	8351		18704	11565	10472		18704	11565	10472
1978	12146	6418	6169		16901	8107	8025		16901	8107	8025
1979	14070	5818	8501		19821	7538	11206		19821	7538	11206
1980	15820	10540	10884		21782	13409	13970		21782	13409	13970
1981	18890	10430	10144		26444	13109	13186		26444	13109	13186
1982	21994	10493	12975		28662	13285	16329		28662	13285	16329
1983	17637	13841	11103		21704	16667	13215		21704	16667	13215
1984	9121	7075	3847		11253	8236	4652		11253	8236	4652
1985	6283	2040	2558		8544	2565	3249		8544	2565	3249
1986	6628	2293	3210		8724	2921	3950		8724	2921	3950
1987	5599	3282	2750		7159	3883	3309		7159	3883	3309
1988	4905	2113	2198		6951	2563	2828		6951	2563	2828
1989	6004	2088	4170		8621	2751	5528		8622	2751	5528
1990	7947	5845	4750		10593	7206	5902		10593	7206	5903
1991	7004	3834	3485		9628	4724	4436		9628	4724	4436
1992	8153	3735	4472		10660	4616	5488		10662	4616	5489
1993	6893	3964	3966		9197	4778	4940		9201	4779	4942
1994	7443	4228	2823		11883	5079	3833		11906	5081	3837
1995	6229	2145	2941		11383	3163	4700		11422	3169	4714
1996	7275	4185	4992		12175	6478	7677		12226	6500	7707
1997	11304	5683	6379		18605	8352	9214		18734	8390	9265
1998	13540	6649	7259		20878	9118	10112		21096	9175	10200
1999	16241	7997	9592		24496	10817	12996		24947	10934	13191
2000	19357	10197	10259		28395	13285	13634		29400	13532	14015
2001	19464	10330	9251		28344	13388	12457		30075	13870	13181
2002	18445	9109	10102		26372	12225	13243		30486	13183	14529
2003	16883	10887	10024		22456	13550	12163		29418	15144	14599
2004	11831	8525	5402		14912	9916	6471		27036	12958	10763
2005	6097	4019	3121		8046	4732	3825		29495	9623	9636
2006	4280	2402	2279		6209	2991	3114		28056	8086	11142
2007	4319	2335	2668		6673	3246	3809		30509	11393	13378
2008	4089	2993	3087		6042	4170	4320		21498	12822	12796
2009	3980	3118	2896		6032	4244	4109		19628	10964	10731
2010	3463	2457	2333		5625	3529	3486		15598	8353	7809
2011	2793	2168	1970		4507	3237	3091		9514	6157	5262
2012	2199	1644	1534		3662	2635	2463		6520	3672	3085
2013	1946	1279	1318		3211	1990	1941		5110	2085	1796
2014		1504				2028				1587	

Table 25b. Beginning of year biomass (mt) and spawning stock biomass (mt) for Georges Bank yellowtail from the three Single Series VPAs.

	M02				M04				M0410		
Year	B1p	B3p	SSB		B1p	B3p	SSB		B1p	B3p	SSB
1973	34860	26206	22161		45486	32979	27678		45486	32979	27678
1974	26134	18088	14780		33048	21934	17949		33048	21934	17949
1975	22723	10184	9014		28684	12180	11057		28684	12180	11057
1976	18984	7408	10024		24053	9324	12426		24053	9324	12426
1977	14447	9447	8351		18704	11565	10472		18704	11565	10472
1978	12146	6418	6169		16901	8107	8025		16901	8107	8025
1979	14070	5818	8501		19821	7538	11206		19821	7538	11206
1980	15820	10540	10884		21782	13409	13970		21782	13409	13970
1981	18890	10430	10144		26444	13109	13186		26444	13109	13186
1982	21994	10493	12975		28662	13285	16329		28662	13285	16329
1983	17637	13841	11103		21704	16667	13215		21704	16667	13215
1984	9121	7075	3847		11253	8236	4652		11253	8236	4652
1985	6283	2040	2558		8544	2565	3249		8544	2565	3249
1986	6628	2293	3210		8724	2921	3950		8724	2921	3950
1987	5599	3282	2750		7159	3883	3309		7159	3883	3309
1988	4905	2113	2198		6951	2563	2828		6951	2563	2828
1989	6004	2088	4170		8621	2751	5528		8622	2751	5528
1990	7947	5845	4750		10593	7206	5902		10594	7206	5903
1991	7004	3834	3485		9628	4724	4436		9629	4724	4436
1992	8153	3735	4472		10660	4616	5488		10663	4616	5489
1993	6893	3964	3966		9197	4778	4940		9204	4780	4943
1994	7443	4228	2823		11883	5079	3833		11922	5082	3841
1995	6229	2145	2941		11383	3163	4700		11449	3174	4724
1996	7275	4185	4992		12175	6478	7677		12261	6515	7729
1997	11304	5683	6379		18606	8352	9215		18824	8417	9300
1998	13541	6649	7259		20879	9118	10113		21249	9215	10262
1999	16241	7997	9592		24498	10818	12997		25263	11016	13327
2000	19357	10197	10259		28401	13286	13636		30107	13706	14282
2001	19465	10330	9251		28355	13391	12461		31292	14209	13689
2002	18447	9110	10103		26396	12231	13250		33424	13857	15432
2003	16887	10888	10025		22497	13560	12178		34447	16268	16322
2004	11840	8527	5405		14995	9934	6497		36995	15133	13759
2005	6121	4023	3130		8222	4761	3884		49843	13186	14368
2006	4342	2414	2312		6585	3067	3295		48529	12340	18161
2007	4492	2389	2764		7529	3512	4240		52141	18318	21371
2008	4364	3136	3307		7159	4749	5128		34653	19806	19699
2009	4728	3419	3395		8519	5245	5603		32273	16422	16392
2010	5090	3104	3326		10058	5290	5939		25702	12624	11977
2011	4984	3480	3821		9359	6165	6836		15357	9314	8108
2012	4967	3875	4040		8661	6715	6606		10455	5645	4822
2013	4924	3746	3903		7657	5605	5433		7390	3239	2705
2014		4390				5500				2274	

Table 26. 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

	M02		M04		M0409	
	Est	Rho Adj	Est	Rho Adj	Est	Rho Adj
2012 F	0.20	0.64	0.14	0.45	0.19	0.18
2012 R	2228	993	4396	2055	12334	16805
2012 SSB	1318	397	1941	613	1796	1894
2013 Adult B	1504	453	2028	641	1587	1674

Single Series

	M02		M04		M0410	
	Est	Rho Adj	Est	Rho Adj	Est	Rho Adj
2012 F	0.06	0.37	0.04	0.23	0.13	0.13
2012 R	3674	1414	6919	3193	16174	31028
2012 SSB	3903	662	5433	1180	2705	2978
2013 Adult B	4390	744	5500	1194	2274	2503

Table 27. Per recruit analysis for the six VPAs. SSBPR=spawning stock biomass per recruit, YPR=yield per recruit, TSBPR=total stock biomass per recruit. The most recent M is used in the calculations for the two VPAs with increased M since 2005.

	Split Series			Single Series		
	M02	M04	M0409	M02	M04	M0410
SSBPR F=0	2.416	0.774	0.136	2.416	0.774	0.104
F40%	0.295	0.699	3.606	0.276	0.603	4.495
YPR F40%	0.225	0.134	0.058	0.222	0.132	0.052
SSBPR F40%	0.966	0.310	0.055	0.967	0.310	0.042
TSBPR F40%	1.289	0.592	0.274	1.287	0.589	0.252
YPR/TSBPR F40%	0.175	0.226	0.213	0.172	0.224	0.205
F0.1	0.295	0.614	2.623	0.286	0.596	3.495
YPR F0.1	0.225	0.129	0.052	0.224	0.132	0.047
SSBPR F0.1	0.967	0.331	0.063	0.946	0.312	0.047
TSBPR F0.1	1.290	0.614	0.283	1.266	0.591	0.257
YPR/TSBPR F0.1	0.175	0.210	0.185	0.177	0.223	0.183

Table 28. 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						
M02	0.019	0.163	0.488	1	1	1
M04	0.016	0.154	0.488	1	1	1
M0409	0.006	0.086	0.399	1	1	1
Partial Recruitment to the Fishery Single Series VPA						
M02	0.034	0.233	0.564	1	1	1
M04	0.028	0.228	0.582	1	1	1
M0410	0.006	0.083	0.388	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)						
	0.134	0.224	0.38	0.495	0.602	0.801
Average Weight for Catch (kg)						
	0.169	0.313	0.435	0.547	0.669	0.801

Table 29a. Deterministic projections from the Split Series M02 VPA for Georges Bank yellowtail assuming the quota is caught next year and F_{ref} is applied in the quota year. These projections are not recommended for consideration due to not accounting for the strong retrospective pattern in this VPA.

	Age Group							
Year	1	2	3	4	5	6+	1+	3+
Fishing Mortality								
2014	0.006	0.054	0.162	0.333	0.333	0.333		
2015	0.005	0.041	0.122	0.25	0.25	0.25		
Jan-1 Population Numbers (000s)								
2014	3924	1811	1021	811	588	450		
2015	3924	3193	1405	711	476	609		
2016	3924	3198	2509	1018	453	692		
Jan-1 Population Biomass (mt)								
2014	526	406	388	401	354	360	2435	1504
2015	526	715	534	352	287	488	2901	1660
2016	526	716	954	504	273	554	3527	2285
Spawning Stock Biomass (mt)								
2014	0	236	369	355	315	288	1564	
2015	0	418	517	322	264	405	1925	
Catch Numbers (000s)								
2014	22	87	139	209	152	116		
2015	17	116	147	143	96	123		
Fishery Yield (mt including discards)								
2014	4	27	60	114	101	93	**400**	
2015	3	36	64	78	64	98	**343**	

Table 29b. Deterministic projections from the Split Series M02 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								
2014	0.035	0.297	0.888	1.821	1.821	1.821		
2015	0.005	0.041	0.122	0.25	0.25	0.25		
Jan-1 Population Numbers (000s)								
2014	1181	545	307	244	177	135		
2015	1181	934	332	103	32	41		
2016	1181	962	734	240	66	47		
Jan-1 Population Biomass (mt)								
2014	158	122	117	121	107	108	733	452
2015	158	209	126	51	19	33	597	230
2016	158	216	279	119	40	38	849	475
Spawning Stock Biomass (mt)								
2014	0	64	82	58	51	47	301	
2015	0	122	122	47	18	27	337	
Catch Numbers (000s)								
2014	36	127	166	191	138	106		
2015	5	34	35	21	7	8		
Fishery Yield (mt including discards)								
2014	6	40	72	104	93	85	**400**	
2015	1	11	15	11	4	7	**49**	

Table 29c. Deterministic projections from the Split Series M04 VPA for Georges Bank yellowtail assuming the quota is caught next year and F_{ref} is applied in the quota year. These projections are not recommended for consideration due to not accounting for the strong retrospective pattern in this VPA.

	Age Group							
Year	1	2	3	4	5	6+	1+	3+
Fishing Mortality								
2014	0.004	0.04	0.127	0.26	0.26	0.26		
2015	0.004	0.038	0.122	0.25	0.25	0.25		
Jan-1 Population Numbers (000s)								
2014	8112	2935	1406	989	827	632		
2015	8112	5415	1890	830	511	754		
2016	8112	5416	3493	1121	433	660		
Jan-1 Population Biomass (mt)								
2014	1087	657	534	489	498	506	3772	2028
2015	1087	1213	718	411	308	604	4340	2040
2016	1087	1213	1327	555	261	529	4972	2672
Spawning Stock Biomass (mt)								
2014	0	353	475	411	420	385	2043	
2015	0	652	640	346	261	461	2359	
Catch Numbers (000s)								
2014	28	95	139	188	158	120		
2015	27	169	180	153	94	139		
Fishery Yield (mt including discards)								
2014	5	30	60	103	105	97	**400**	
2015	5	53	78	83	63	111	**393**	

Table 29d. Deterministic projections from the Split Series M04 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								
2014	0.018	0.17	0.539	1.104	1.104	1.104		
2015	0.004	0.038	0.122	0.25	0.25	0.25		
Jan-1 Population Numbers (000s)								
2014	2562	927	444	312	261	200		
2015	2562	1687	524	174	69	102		
2016	2562	1711	1088	311	91	90		
Jan-1 Population Biomass (mt)								
2014	343	208	169	155	157	160	1191	640
2015	343	378	199	86	42	82	1130	409
2016	343	383	414	154	55	72	1420	694
Spawning Stock Biomass (mt)								
2014	0	106	126	91	93	85	502	
2015	0	203	177	72	35	63	551	
Catch Numbers (000s)								
2014	37	120	155	178	149	114		
2015	8	53	50	32	13	19		
Fishery Yield (mt including discards)								
2014	6	38	68	98	100	91	**400**	
2015	1	16	22	17	9	15	**81**	

Table 29e. Deterministic projections from the Split Series M0409 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								
2014	0.003	0.041	0.189	0.473	0.473	0.473		
2015	0.002	0.022	0.1	0.25	0.25	0.25		
Jan-1 Population Numbers (000s)								
2014	40674	5006	1699	878	417	319		
2015	40674	16490	1954	572	222	187		
2016	40674	16512	6562	719	181	129		
Jan-1 Population Biomass (mt)								
2014	5450	1121	645	435	251	255	8158	1587
2015	5450	3694	743	283	134	149	10453	1309
2016	5450	3699	2493	356	109	104	12211	3062
Spawning Stock Biomass (mt)								
2014	0	489	454	271	158	144	1516	
2015	0	1624	542	194	92	93	2544	
Catch Numbers (000s)								
2014	76	132	195	226	107	82		
2015	40	232	123	85	33	28		
Fishery Yield (mt including discards)								
2014	13	41	85	123	72	66	**400**	
2015	7	73	54	46	22	22	**224**	

Table 29f. Deterministic projections from the Split Series M0409 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								
2014	0.003	0.038	0.177	0.445	0.445	0.445		
2015	0.002	0.022	0.1	0.25	0.25	0.25		
Jan-1 Population Numbers (000s)								
2014	42904	5280	1792	926	440	336		
2015	42904	17397	2066	610	241	202		
2016	42904	17417	6923	760	193	141		
Jan-1 Population Biomass (mt)								
2014	5749	1183	681	458	265	269	8605	1674
2015	5749	3897	785	302	145	162	11041	1395
2016	5749	3901	2631	376	116	113	12886	3236
Spawning Stock Biomass (mt)								
2014	0	516	481	289	168	154	1609	
2015	0	1714	573	207	100	100	2694	
Catch Numbers (000s)								
2014	75	131	195	226	108	82		
2015	42	244	130	91	36	30		
Fishery Yield (mt including discards)								
2014	13	41	85	124	72	66	**400**	
2015	7	76	57	50	24	24	**238**	

Table 29g. Deterministic projections from the Single Series M02 VPA for Georges Bank yellowtail assuming the quota is caught next year and F_{ref} is applied in the quota year. These projections are not recommended for consideration due to not accounting for the strong retrospective pattern in this VPA.

	Age Group							
Year	1	2	3	4	5	6+	1+	3+
Fishing Mortality								
2014	0.003	0.023	0.056	0.1	0.1	0.1		
2015	0.008	0.058	0.141	0.25	0.25	0.25		
Jan-1 Population Numbers (000s)								
2014	5714	2995	2014	1801	2251	1720		
2015	5714	4662	2396	1558	1334	2942		
2016	5714	4639	3601	1703	994	2727		
Jan-1 Population Biomass (mt)								
2014	766	671	765	891	1355	1378	5826	4390
2015	766	1044	910	771	803	2357	6651	4841
2016	766	1039	1368	843	598	2184	6799	4994
Spawning Stock Biomass (mt)								
2014	0	395	761	869	1329	1216	4570	
2015	0	605	874	707	740	1954	4880	
Catch Numbers (000s)								
2014	18	62	100	155	194	148		
2015	44	239	286	314	269	592		
Fishery Yield (mt including discards)								
2014	3	20	44	85	130	119	**400**	
2015	7	75	125	172	180	474	**1033**	

Table 29h. Deterministic projections from the Single Series M02 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								
2014	0.026	0.18	0.436	0.774	0.774	0.774		
2015	0.008	0.058	0.141	0.25	0.25	0.25		
Jan-1 Population Numbers (000s)								
2014	969	508	341	305	382	292		
2015	969	772	347	181	115	254		
2016	969	786	597	247	115	236		
Jan-1 Population Biomass (mt)								
2014	130	114	130	151	230	234	988	744
2015	130	173	132	89	69	204	797	494
2016	130	176	227	122	69	189	913	607
Spawning Stock Biomass (mt)								
2014	0	63	110	111	170	156	610	
2015	0	100	127	82	64	169	542	
Catch Numbers (000s)								
2014	23	76	110	151	189	144		
2015	7	40	41	36	23	51		
Fishery Yield (mt including discards)								
2014	4	24	48	83	126	116	**400**	
2015	1	12	18	20	16	41	**108**	

Table 29i. Deterministic projections from the Single Series M04 VPA for Georges Bank yellowtail assuming the quota is caught next year and F_{ref} is applied in the quota year. These projections are not recommended for consideration due to not accounting for the strong retrospective pattern in this VPA.

	Age Group							
Year	1	2	3	4	5	6+	1+	3+
Fishing Mortality								
2014	0.002	0.02	0.05	0.086	0.086	0.086		
2015	0.007	0.057	0.146	0.25	0.25	0.25		
Jan-1 Population Numbers (000s)								
2014	12509	4626	2635	2057	2866	2190		
2015	12509	8365	3041	1680	1266	3110		
2016	12509	8327	5297	1762	877	2284		
Jan-1 Population Biomass (mt)								
2014	1676	1036	1001	1018	1725	1755	8212	5499
2015	1676	1874	1155	832	762	2491	8790	5240
2016	1676	1865	2013	872	528	1830	8784	5243
Spawning Stock Biomass (mt)								
2014	0	562	919	919	1566	1433	5398	
2015	0	1000	1019	701	646	1900	5266	
Catch Numbers (000s)								
2014	25	74	106	140	195	149		
2015	72	383	341	309	233	572		
Fishery Yield (mt including discards)								
2014	4	23	46	77	130	119	**400**	
2015	12	120	148	169	156	458	**1063**	

Table 29j. Deterministic projections from the Single Series M04 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								
2014	0.013	0.105	0.267	0.459	0.459	0.459		
2015	0.007	0.057	0.146	0.25	0.25	0.25		
Jan-1 Population Numbers (000s)								
2014	2716	1004	572	447	622	476		
2015	2716	1797	606	294	189	465		
2016	2716	1808	1138	351	153	342		
Jan-1 Population Biomass (mt)								
2014	364	225	217	221	375	381	1783	1194
2015	364	403	230	145	114	372	1629	862
2016	364	405	432	174	92	274	1741	972
Spawning Stock Biomass (mt)								
2014	0	118	182	171	291	266	1028	
2015	0	215	203	122	97	284	921	
Catch Numbers (000s)								
2014	29	83	112	138	192	146		
2015	16	82	68	54	35	85		
Fishery Yield (mt including discards)								
2014	5	26	49	75	128	117	**400**	
2015	3	26	30	30	23	68	**179**	

Table 29k. Deterministic projections from the Single Series M0410 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								
2014	0.002	0.028	0.129	0.332	0.332	0.332		
2015	0.002	0.021	0.097	0.25	0.25	0.25		
Jan-1 Population Numbers (000s)								
2014	72719	5941	2332	1281	620	474		
2015	72719	26699	2126	754	338	289		
2016	72719	26712	9620	710	216	180		
Jan-1 Population Biomass (mt)								
2014	9744	1331	886	634	373	380	13349	2273
2015	9744	5980	808	373	204	231	17341	1616
2016	9744	5983	3656	351	130	144	20009	4281
Spawning Stock Biomass (mt)								
2014	0	560	613	402	238	218	2031	
2015	0	2523	566	245	134	137	3606	
Catch Numbers (000s)								
2014	91	102	180	235	114	87		
2015	69	347	125	108	48	41		
Fishery Yield (mt including discards)								
2014	15	32	78	128	76	70	**400**	
2015	12	109	54	59	32	33	**299**	

Table 29l. Deterministic projections from the Single Series M0410 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								
2014	0.002	0.025	0.116	0.298	0.298	0.298		
2015	0.002	0.021	0.097	0.25	0.25	0.25		
Jan-1 Population Numbers (000s)								
2014	80045	6540	2567	1410	683	522		
2015	80045	29394	2347	841	385	329		
2016	80045	29403	10591	784	241	204		
Jan-1 Population Biomass (mt)								
2014	10726	1465	975	698	411	418	14693	2503
2015	10726	6584	892	416	232	263	19114	1803
2016	10726	6586	4025	388	145	164	22034	4721
Spawning Stock Biomass (mt)								
2014	0	617	678	449	266	243	2254	
2015	0	2778	625	273	153	156	3986	
Catch Numbers (000s)								
2014	91	101	179	236	114	87		
2015	76	382	138	120	55	47		
Fishery Yield (mt including discards)								
2014	15	32	78	129	76	70	**400**	
2015	13	120	60	66	37	38	**333**	

Table 30. 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 2015, Adult Jan-1 B=median beginning year age 3+ biomass in 2015, SSB=spawning stock biomass in 2015, delta B = change in median adult Jan-1 biomass from 2015 to 2016, P(B inc) = probability that adult Jan-1 biomass will increase from 2015 to 2016, P(B inc 10%) = probability that adult Jan-1 biomass will increase by at least 10% from 2015 to 2016. Results shown in a light gray font indicate that they do not sufficiently address the retrospective problem.

	Split Series			Single Series		
	M02	M04	M0409	M02	M04	M0410
Fref=0.25						
Catch	360	411	226	1087	1127	299
Adult Jan-1 B	1732	2127	1346	5082	5455	1658
SSB	1991	2437	2561	5088	5437	3660
delta B	36%	29%	128%	2%	-2%	160%
P(B inc)	1	1	1	0.779	0.334	1
P(B inc 10%)	1	0.996	1	0.021	0	1
Fref=0.25 rho adjusted						
Catch	60	93	240	129	207	332
Adult Jan-1 B	253	435	1434	534	909	1851
SSB	359	575	2711	579	958	4047
delta B	96%	64%	127%	19%	10%	157%
P(B inc)	1	1	1	1	0.973	1
P(B inc 10%)	1	1	1	0.913	0.503	1
75%Fref=0.1875						
Catch	277	315	172	836	865	227
Adult Jan-1 B	1732	2127	1346	5082	5455	1658
SSB	2024	2480	2581	5204	5543	3686
delta B	40%	33%	131%	7%	2%	163%
P(B inc)	1	1	1	0.989	0.841	1
P(B inc 10%)	1	0.998	1	0.186	0.026	1
75%Fref=0.1875 rho adjusted						
Catch	46	71	183	99	159	253
Adult Jan-1 B	253	435	1434	534	909	1851
SSB	363	583	2732	591	977	4076
delta B	101%	68%	129%	24%	14%	160%
P(B inc)	1	1	1	1	0.997	1
P(B inc 10%)	1	1	1	0.985	0.784	1

Table 31a. Implications of five 2015 quotas (100-500 mt) in four Split Series projection scenarios: P(F>Fref) = probability fishing mortality rate in 2015 will exceed F_{ref}, F2015 = median 2015 F, delta B = relative change in median biomass from 2015 to 2016, P(B inc) = probability median adult Jan-1 biomass will increase or P(B inc 10%) = increase by at least 10%. Results for Split Series M02 rho adjusted 400-500 mt quotas not shown due to fewer than 90% of the projections completing (stock size too small to allow these catches in the projections which did not complete). Results shown in a light gray font indicate that they do not sufficiently address the retrospective problem.

	2015 Quota (mt)				
	100	200	300	400	500
Split Series M02					
P(F>Fref)	0.00	0.01	0.20	0.68	0.94
F2014	0.06	0.13	0.20	0.28	0.36
delta B	50%	45%	39%	33%	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 M02 rho adjusted					
P(F>Fref)	0.94	1.00	1.00		
F2014	0.44	1.01	1.74		
delta B	82%	48%	19%		
P(B inc)	1.00	1.00	0.95		
P(B inc 10%)	1.00	1.00	0.74		
Split Series M04					
P(F>Fref)	0.00	0.00	0.05	0.45	0.83
F2014	0.06	0.12	0.18	0.24	0.31
delta B	42%	37%	33%	29%	25%
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 M04 rho adjusted					
P(F>Fref)	0.60	1.00	1.00	1.00	0.99
F2014	0.27	0.59	0.98	1.44	1.99
delta B	62%	44%	26%	9%	-6%
P(B inc)	1.00	1.00	1.00	0.97	0.21
P(B inc 10%)	1.00	1.00	0.99	0.40	0.06

Table 31b. Implications of five 2015 quotas (100-500 mt) in four Single Series projection scenarios: P(F>Fref) = probability fishing mortality rate in 2015 will exceed F_{ref}, F2015 = median 2015 F, delta B = relative change in median biomass from 2015 to 2016, P(B inc) = probability median adult Jan-1 biomass will increase or P(B inc 10%) = increase by at least 10%.

	2015 Quota (mt)				
	100	200	300	400	500
Single Series M02					
P(F>Fref)	0.00	0.00	0.00	0.00	0.00
F2014	0.02	0.04	0.06	0.09	0.11
delta B	21%	19%	17%	15%	13%
P(B inc)	1.00	1.00	1.00	1.00	1.00
P(B inc 10%)	1.00	1.00	1.00	0.98	0.93
Single Series M02 rho adjusted					
P(F>Fref)	0.18	0.97	1.00	1.00	1.00
F2014	0.19	0.41	0.67	0.98	1.37
delta B	24%	8%	-8%	-23%	-37%
P(B inc)	1.00	0.99	0.04	0.00	0.00
P(B inc 10%)	1.00	0.29	0.00	0.00	0.00
Single Series M04					
P(F>Fref)	0.00	0.00	0.00	0.00	0.00
F2014	0.02	0.04	0.06	0.08	0.11
delta B	14%	13%	11%	10%	8%
P(B inc)	1.00	1.00	1.00	1.00	1.00
P(B inc 10%)	0.95	0.89	0.74	0.48	0.22
Single Series M04 rho adjusted					
P(F>Fref)	0.00	0.43	0.97	1.00	1.00
F2014	0.12	0.24	0.38	0.53	0.69
delta B	19%	11%	2%	-6%	-14%
P(B inc)	1.00	1.00	0.89	0.00	0.00
P(B inc 10%)	0.99	0.61	0.01	0.00	0.00

Table 31c. Implications of five 2015 quotas (100-500 mt) in four projection scenarios when M increased since 2005: P(F>Fref) = probability fishing mortality rate in 2015 will exceed F_{ref}, F2015 = median 2015 F, delta B = relative change in median biomass from 2015 to 2016, P(B inc) = probability median adult Jan-1 biomass will increase or P(B inc 10%) = increase by at least 10%.

	2015 Quota (mt)				
	100	200	300	400	500
Split Series M0409					
P(F>Fref)	0.00	0.27	0.91	1.00	1.00
F2014	0.11	0.22	0.34	0.46	0.60
delta B	135%	130%	124%	119%	115%
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 M0409 rho adjusted					
P(F>Fref)	0.00	0.17	0.85	1.00	1.00
F2014	0.10	0.21	0.32	0.43	0.56
delta B	133%	128%	124%	119%	114%
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
Single Series M0410					
P(F>Fref)	0.00	0.01	0.50	0.94	1.00
F2014	0.08	0.16	0.25	0.34	0.43
delta B	168%	164%	160%	156%	152%
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
Single Series M0410 rho adjusted					
P(F>Fref)	0.00	0.00	0.28	0.85	0.99
F2014	0.07	0.15	0.22	0.30	0.39
delta B	165%	162%	158%	155%	151%
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

Table 32. Probability that F in 2015 was greater than or equal to 0.6 for the twelve scenarios. Results shown in a light gray font indicate that they do not sufficiently address the retrospective problem.

P(F>=0.6)	2015 Quota (mt)				
	100	200	300	400	500
SplitM02	0.00	0.00	0.00	0.00	0.02
SplitM04	0.00	0.00	0.00	0.00	0.00
SplitM0409	0.00	0.00	0.00	0.11	0.49
SingleM02	0.00	0.00	0.00	0.00	0.00
SingleM04	0.00	0.00	0.00	0.00	0.00
SingleM0410	0.00	0.00	0.00	0.00	0.05
SplitM02rho	0.25	0.90	0.99	0.95	0.91
SplitM04rho	0.01	0.49	0.93	1.00	0.99
SplitM0409rho	0.00	0.00	0.00	0.06	0.37
SingleM02rho	0.00	0.13	0.65	0.95	0.99
SingleM04rho	0.00	0.00	0.03	0.28	0.74
SingleM0410rho	0.00	0.00	0.00	0.00	0.01

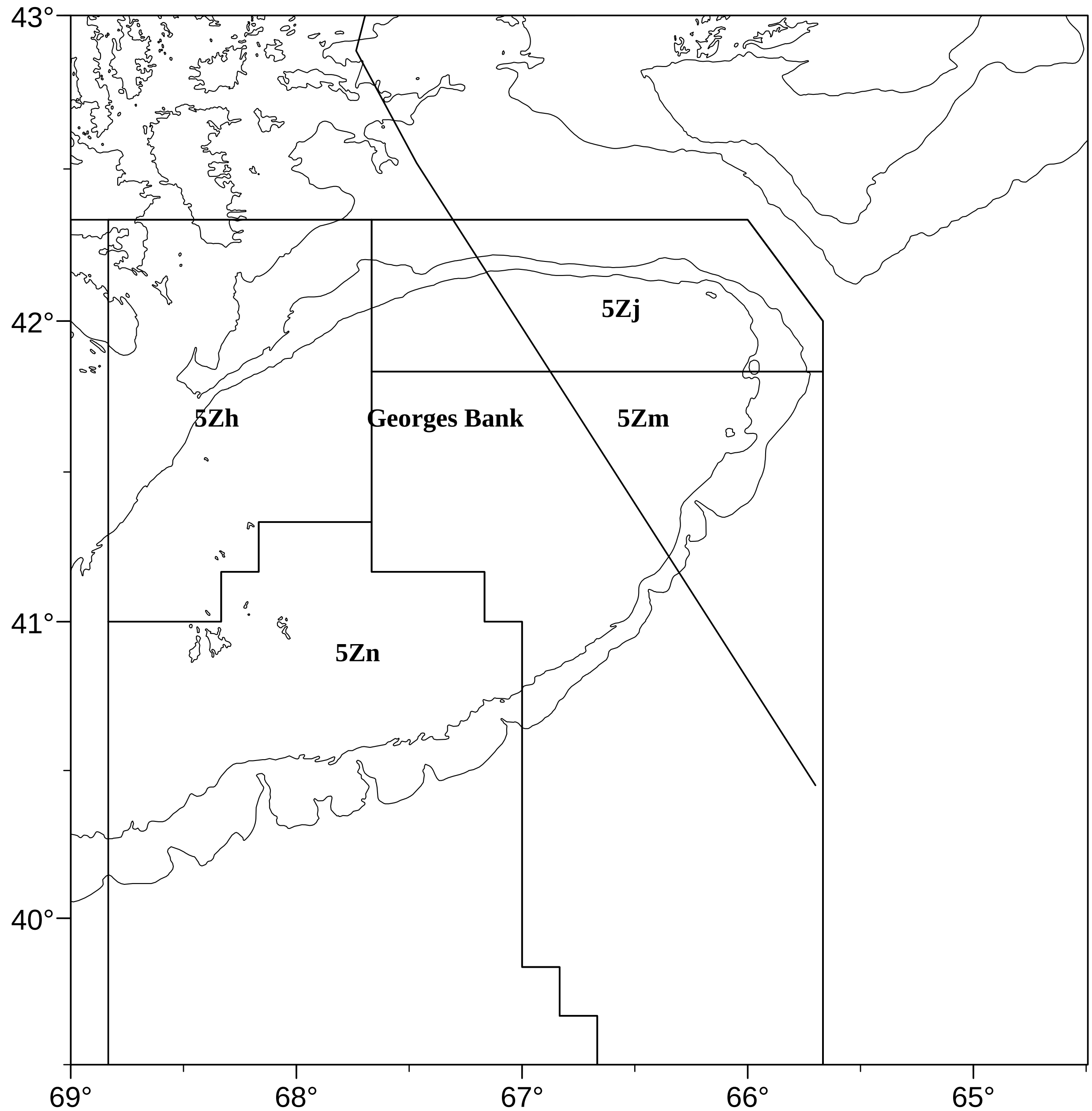


Figure 1a. Location of statistical unit areas for Canadian fisheries in NAFO Subdivision 5Ze.

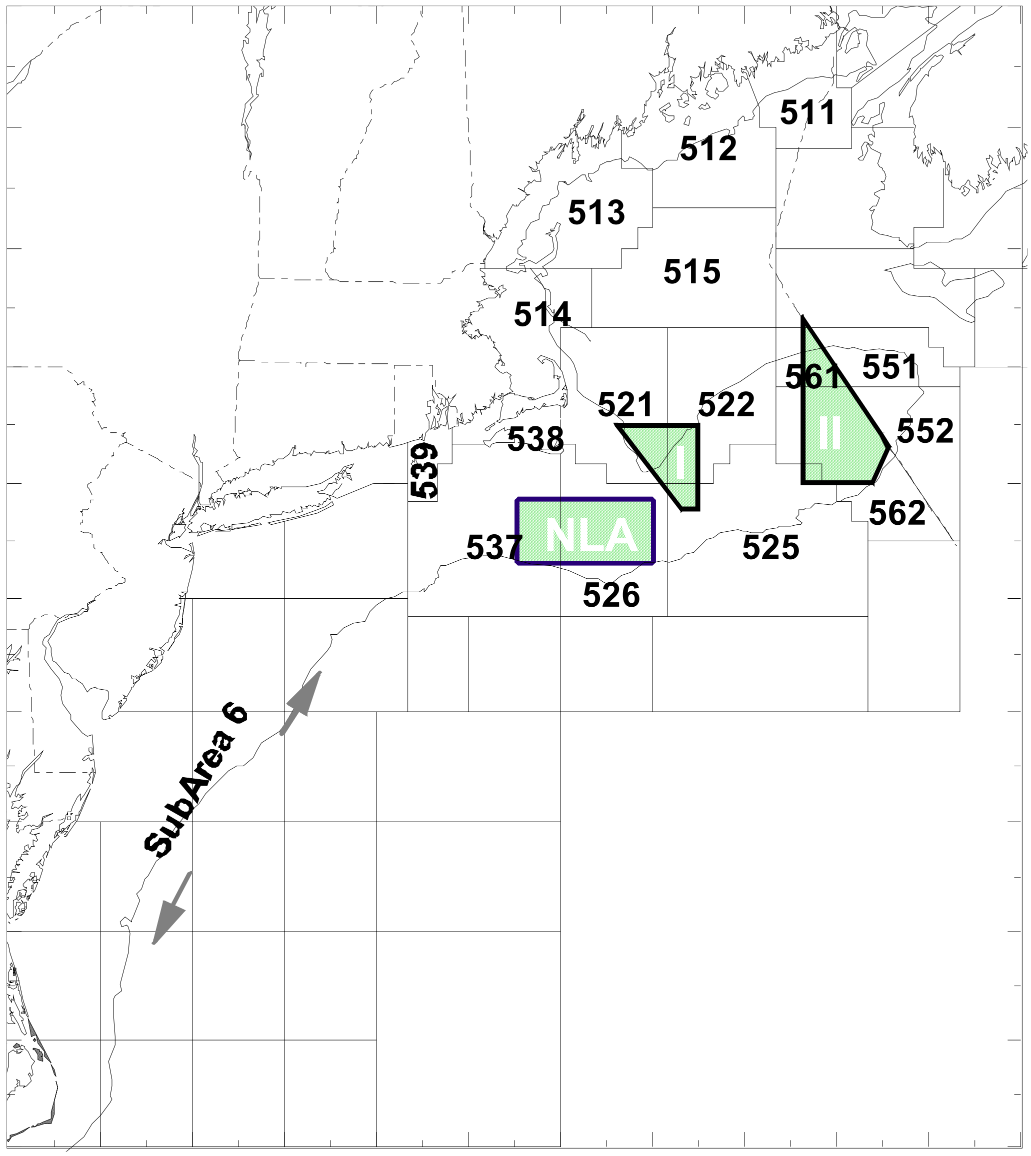


Figure 1b. Statistical areas used for monitoring northeast US fisheries. Catches from areas 522, 525, 551, 552, 561 and 562 are included in the Georges Bank yellowtail flounder assessment. Shaded areas have been closed to fishing year-round since 1994, with exceptions.

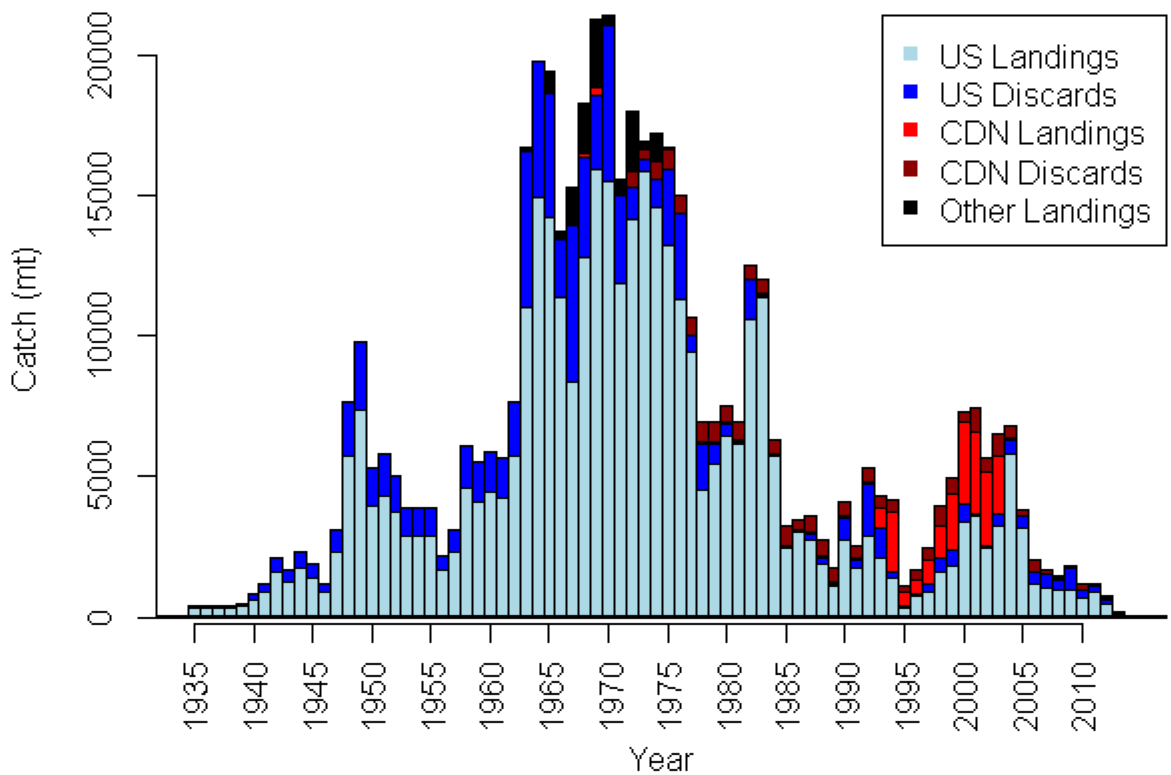


Figure 2. Catch (landings plus discards) of Georges Bank yellowtail flounder by nation and year.

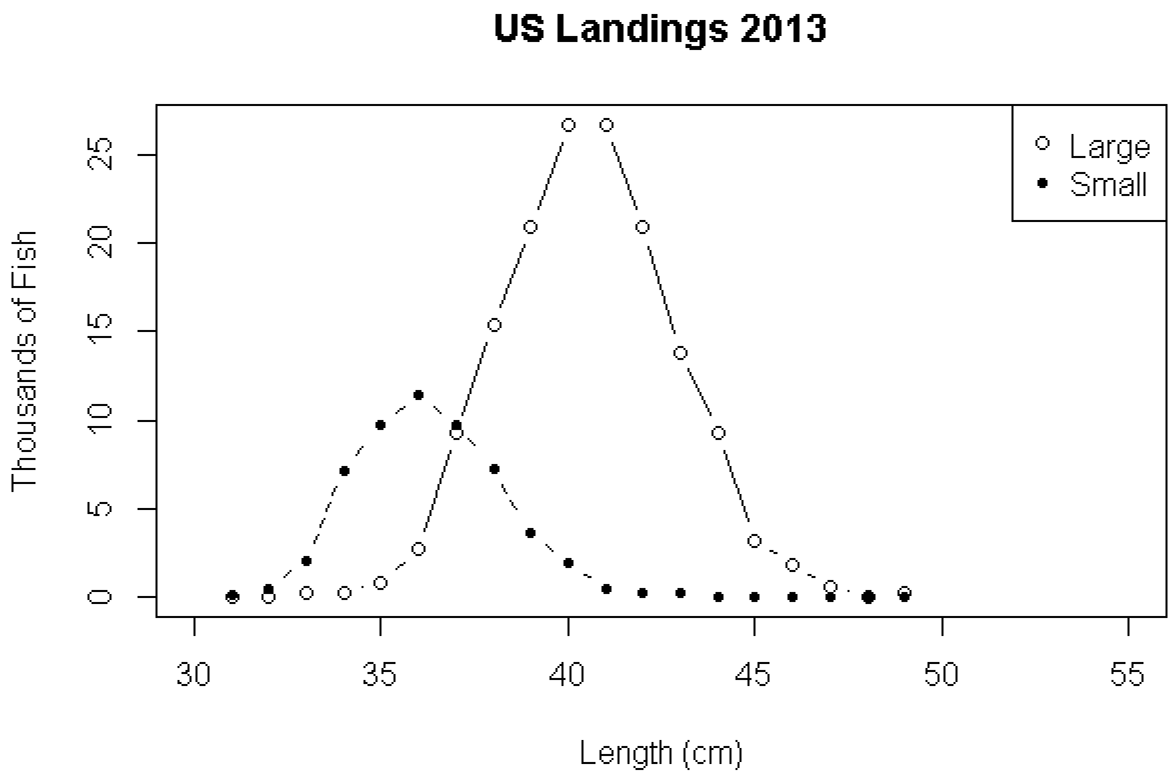


Figure 3. US landings of Georges Bank yellowtail by market category.

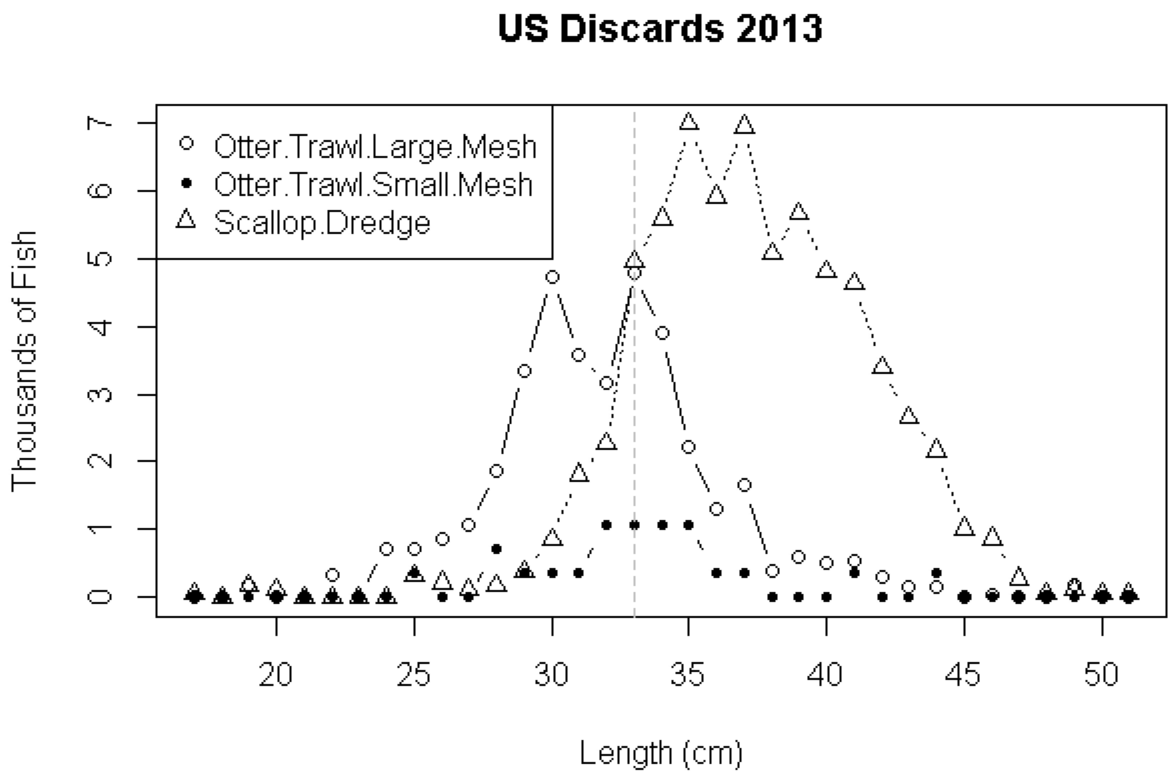


Figure 4. US yellowtail flounder discard length frequencies by gear. The vertical line at 33 cm denotes the US minimum legal size for landing yellowtail flounder. The distinction between large and small mesh in the cod end of the trawl occurs at 5.5 inches (14 cm).

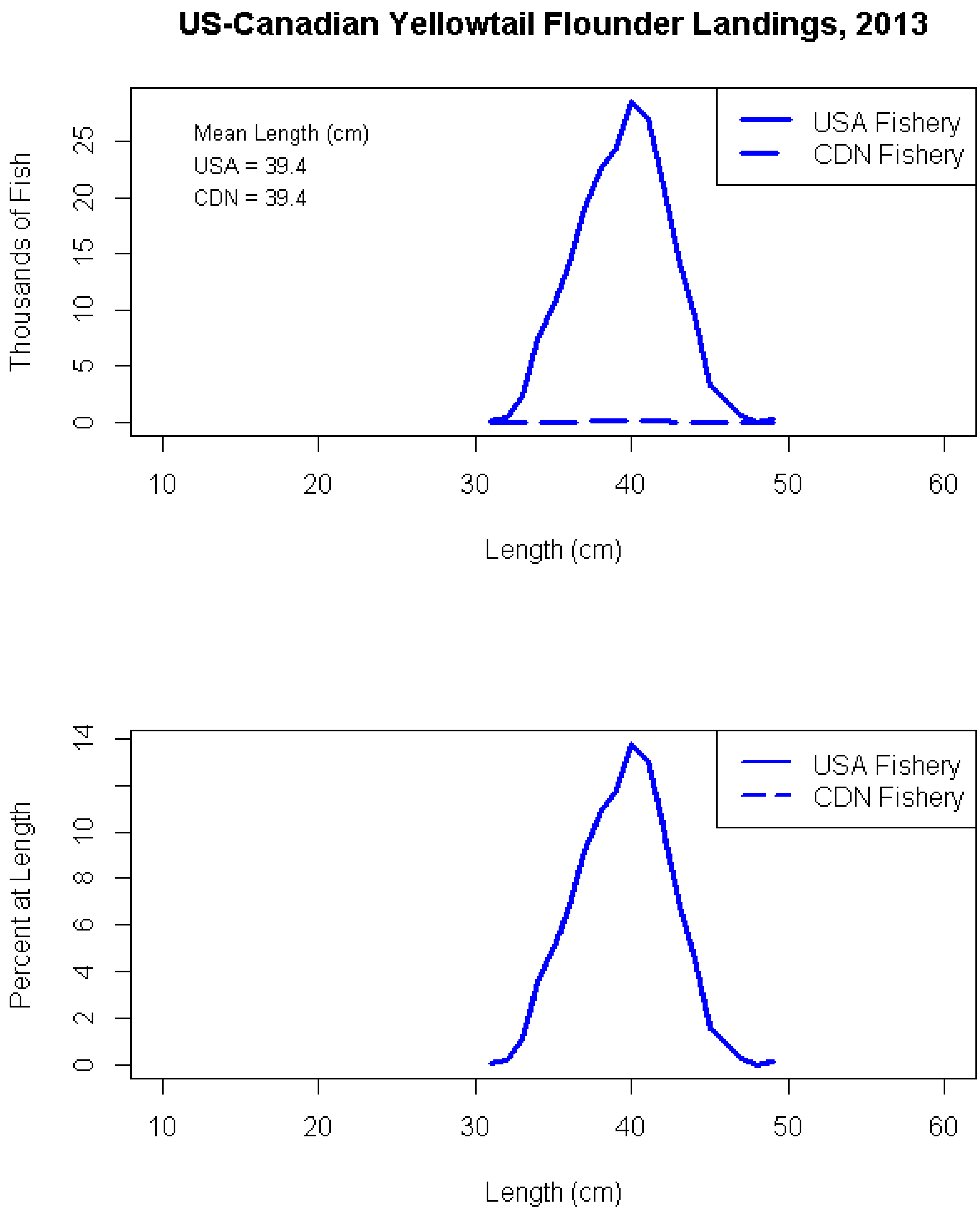


Figure 5. Comparison of US and Canadian landings at length for Georges Bank yellowtail flounder.

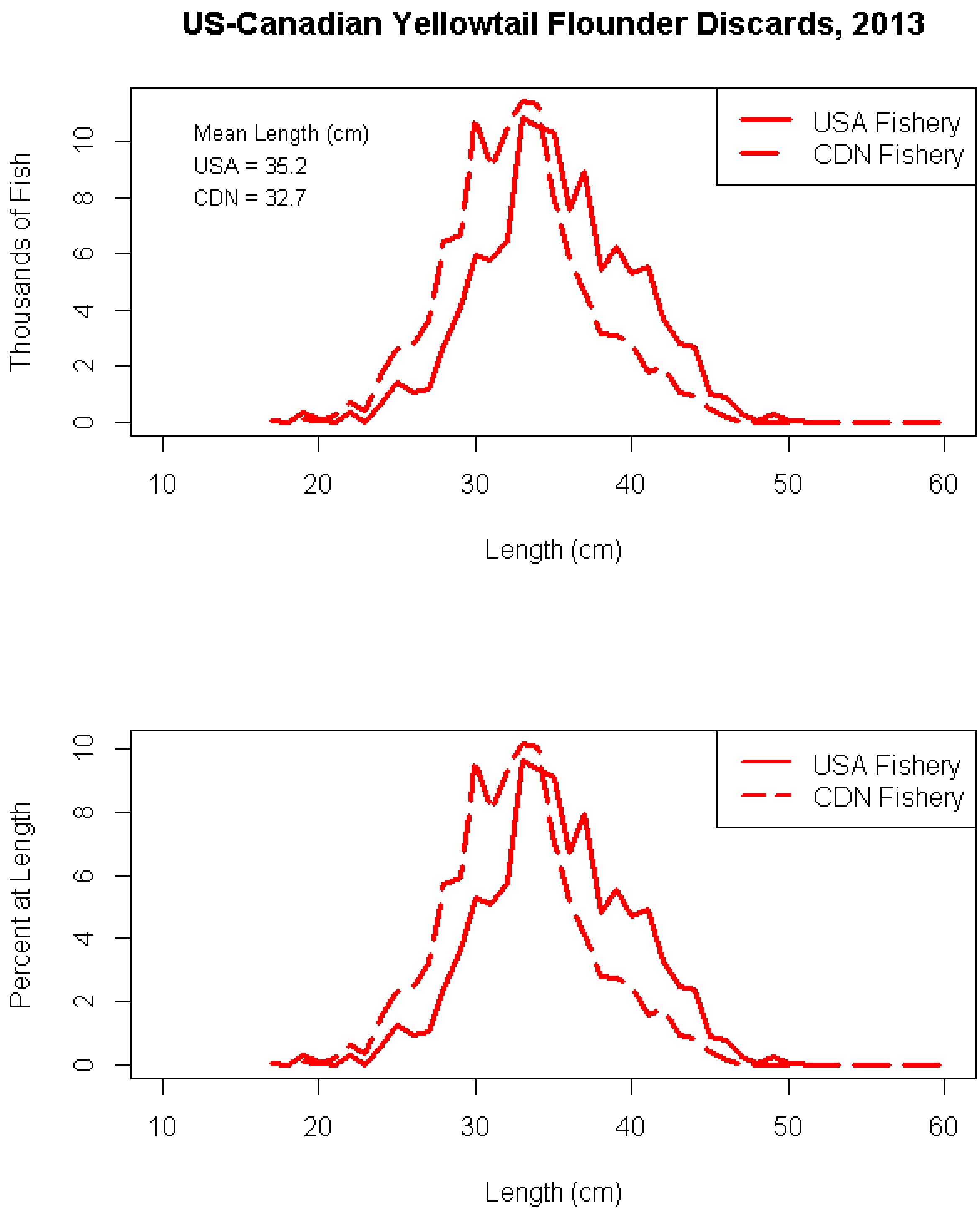


Figure 6. Comparison of US and Canadian discards at length for Georges Bank yellowtail flounder.

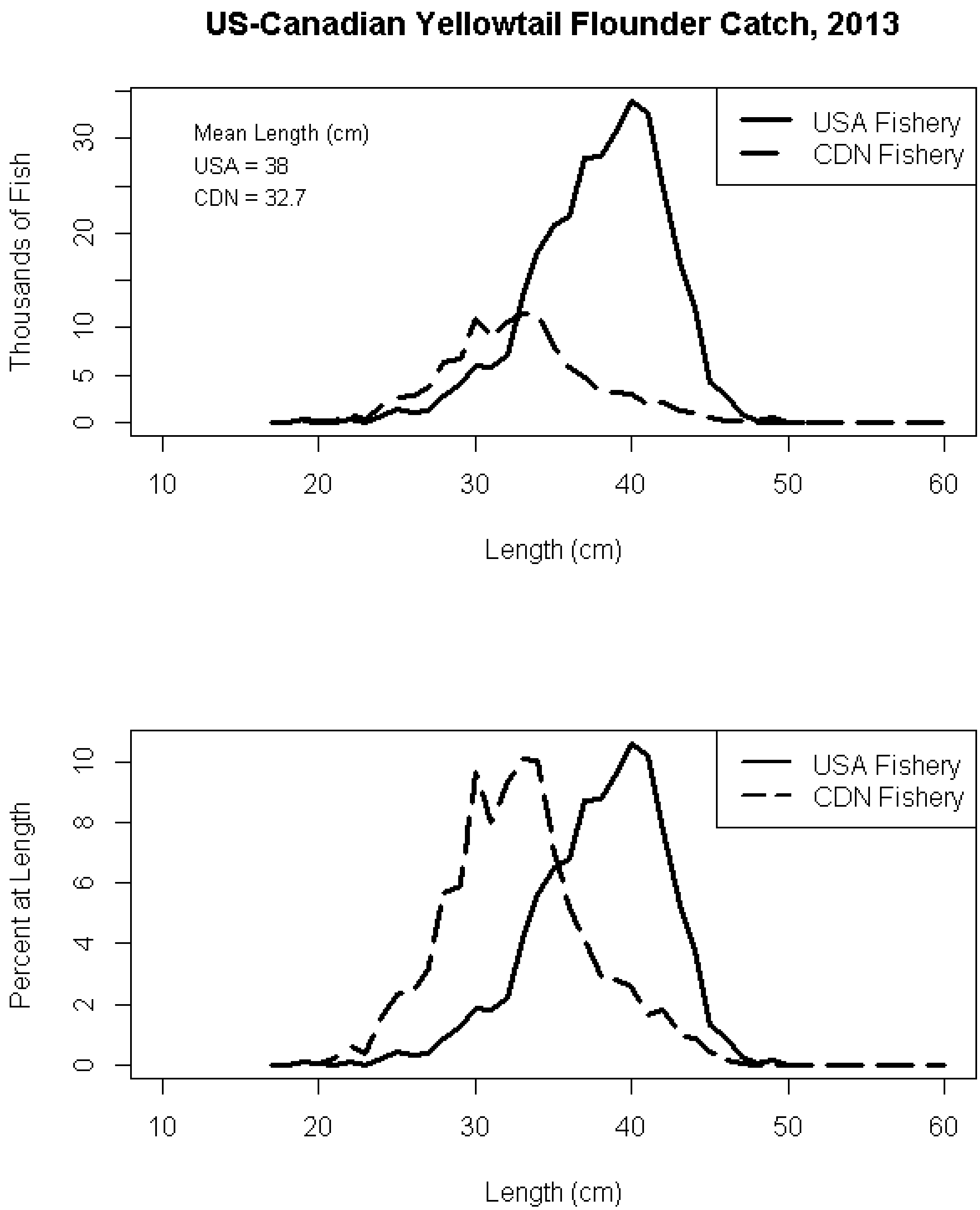


Figure 7. Comparison of US and Canadian catch (landings plus discards) at length for Georges Bank yellowtail flounder.

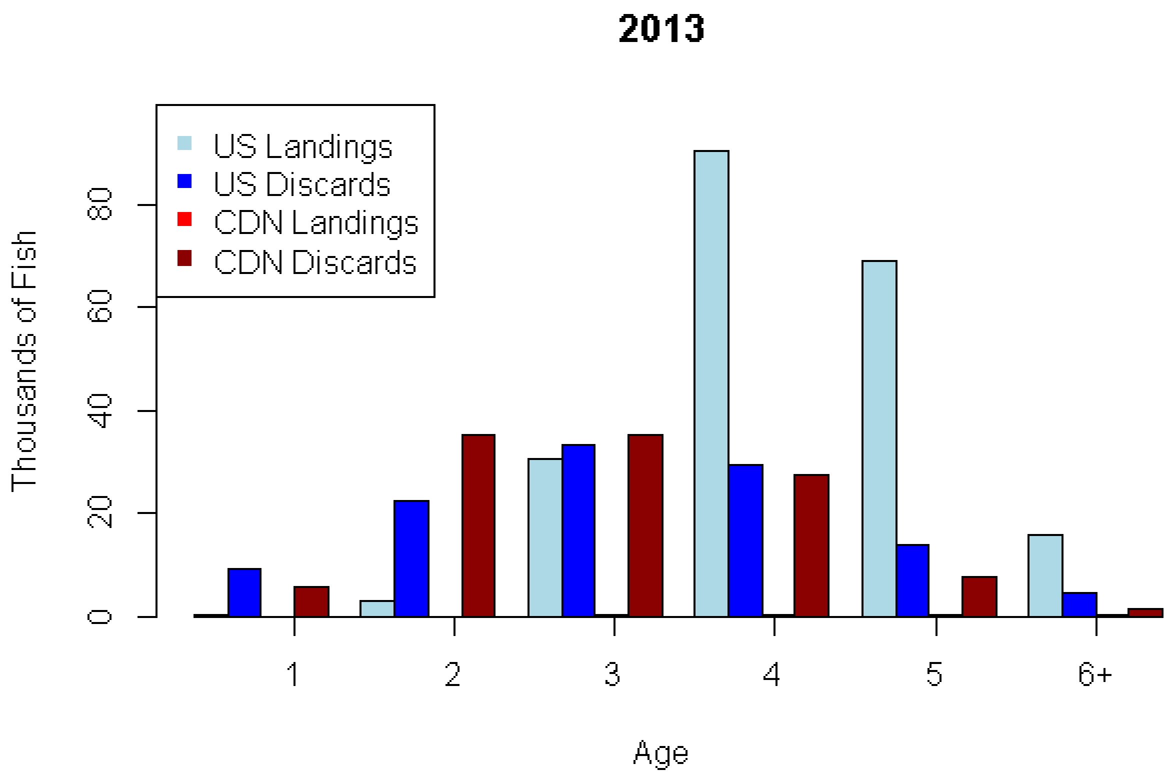


Figure 8. Catch at age of Georges Bank yellowtail flounder from the four components of Canadian and US landings and discards.

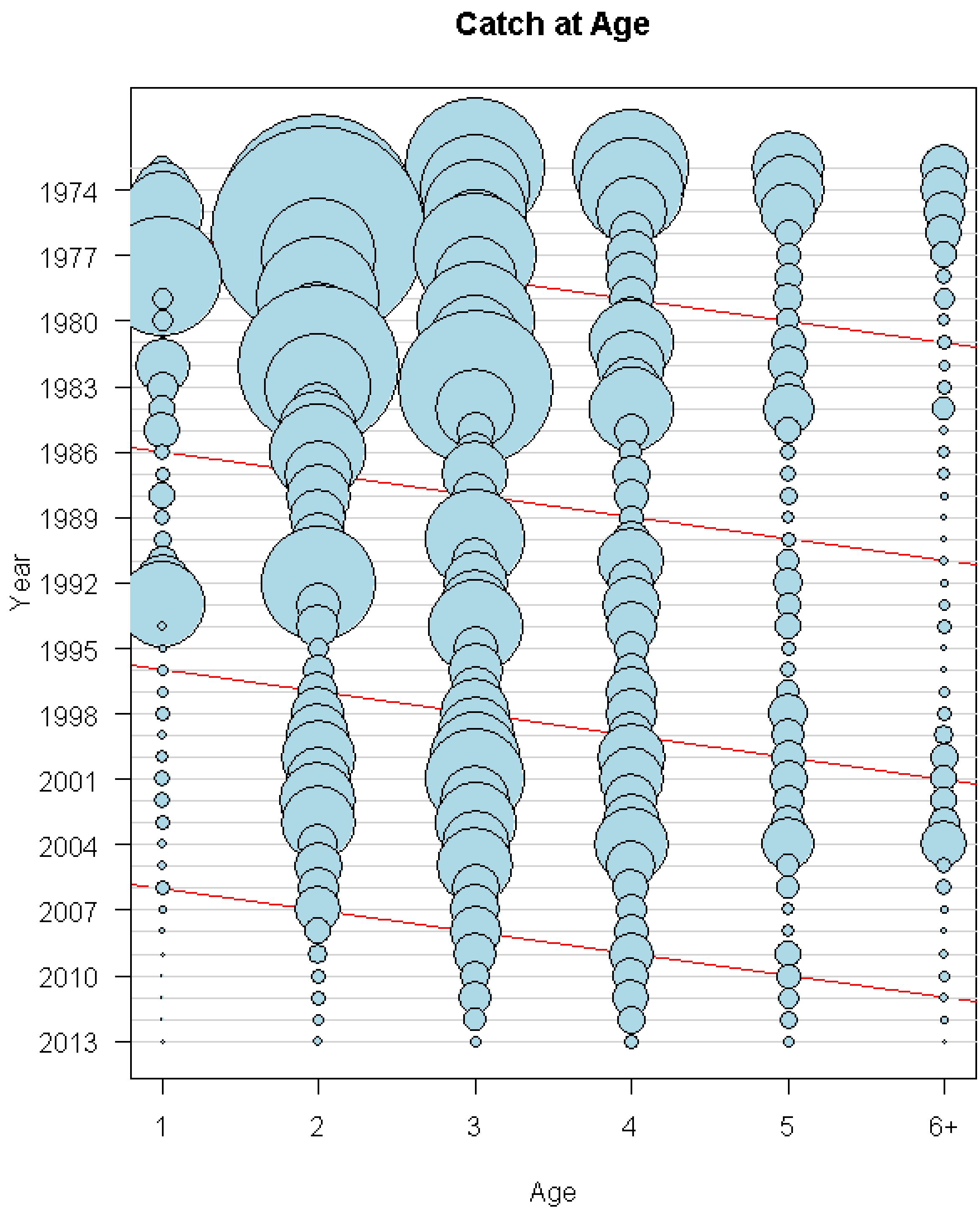


Figure 9a. Catch at age for Georges Bank yellowtail flounder, Canadian and US fisheries combined. (The area of the bubble is proportional to the magnitude of the catch). Diagonal red lines denote the 1975, 1985, 1995, and 2005 year-classes.

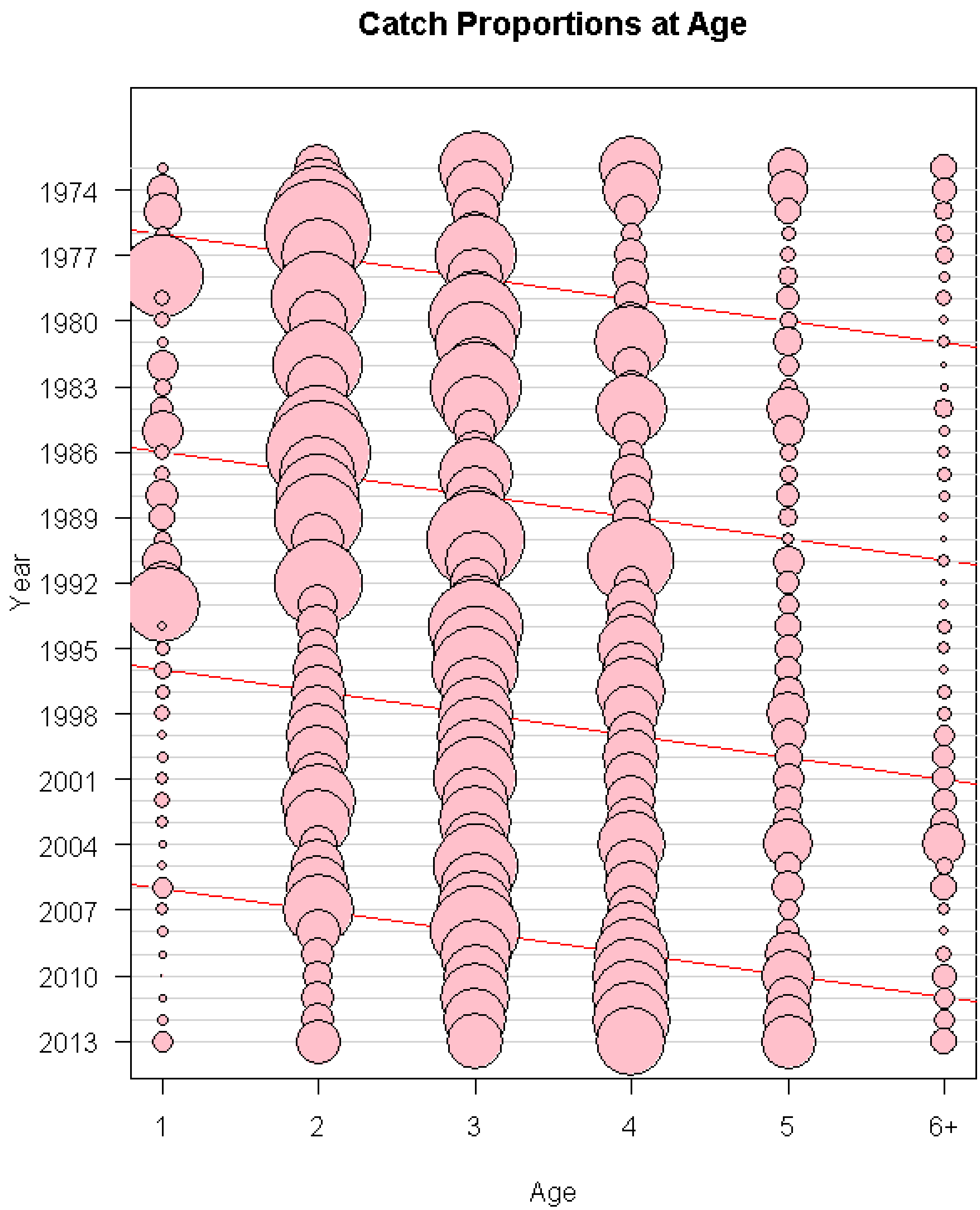


Figure 9b. Proportions of catch at age for Georges Bank yellowtail flounder, Canadian and US fisheries combined. (The area of the bubble is proportional to the magnitude of the proportion). Diagonal red lines denote the 1975, 1985, 1995, and 2005 year-classes.

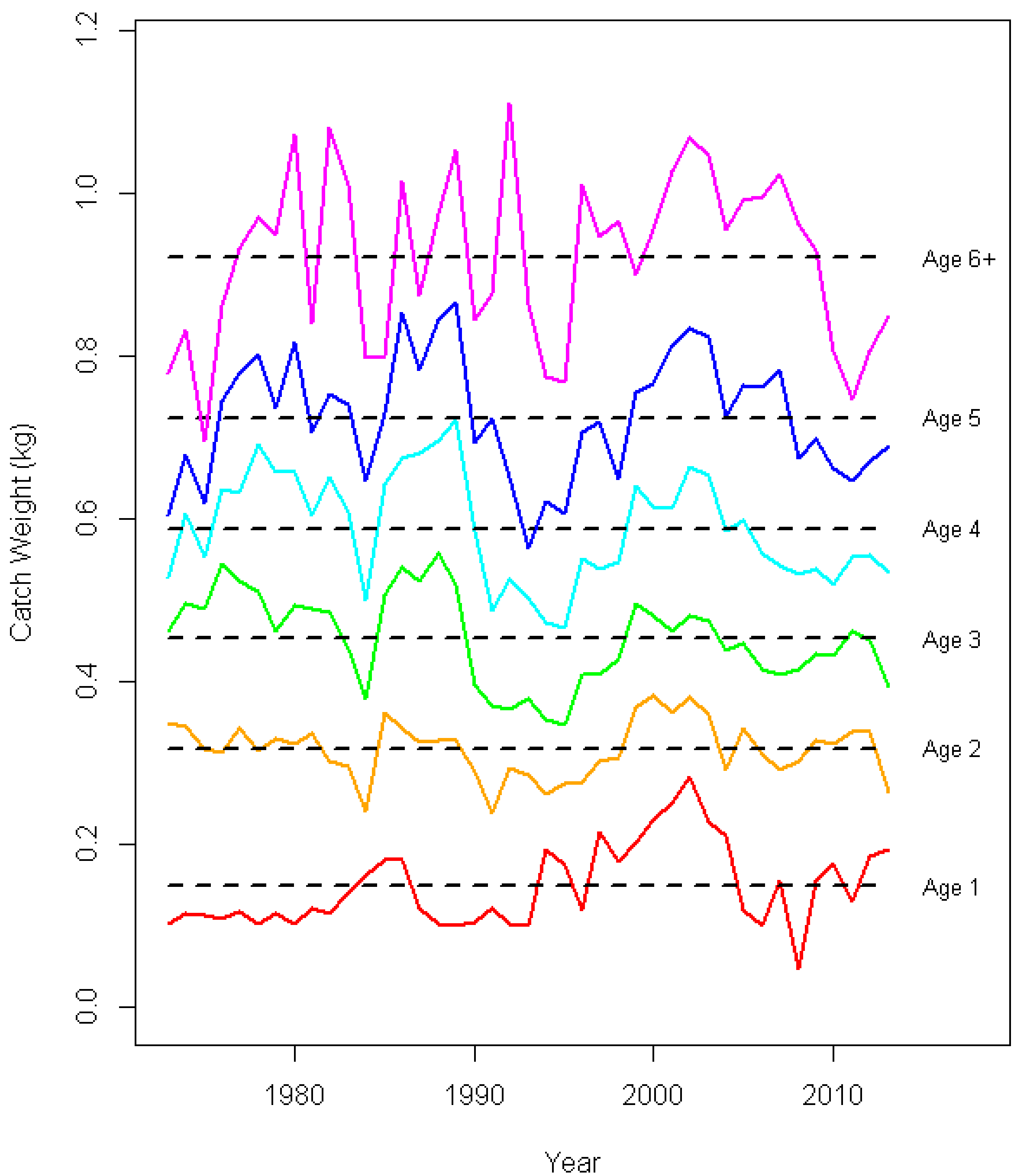


Figure 10. Trends in mean weight at age from the Georges Bank yellowtail fishery (Canada and US combined, including discards). Dashed lines denote average of time series.

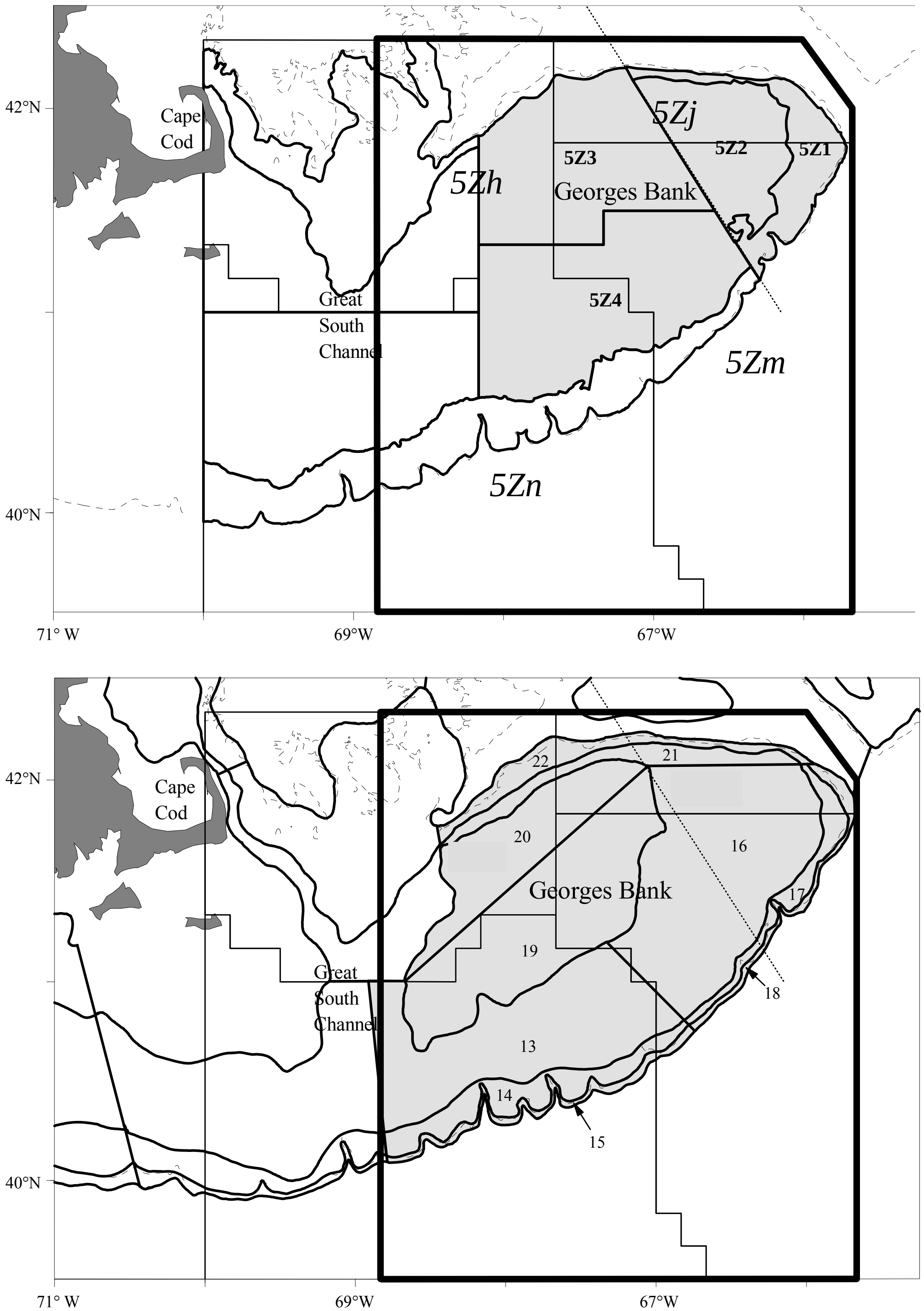


Figure 11. DFO (top) and NMFS (bottom) strata used to derive research survey abundance indices for Georges Bank groundfish surveys. Note NMFS stratum 22 is not used in assessment.

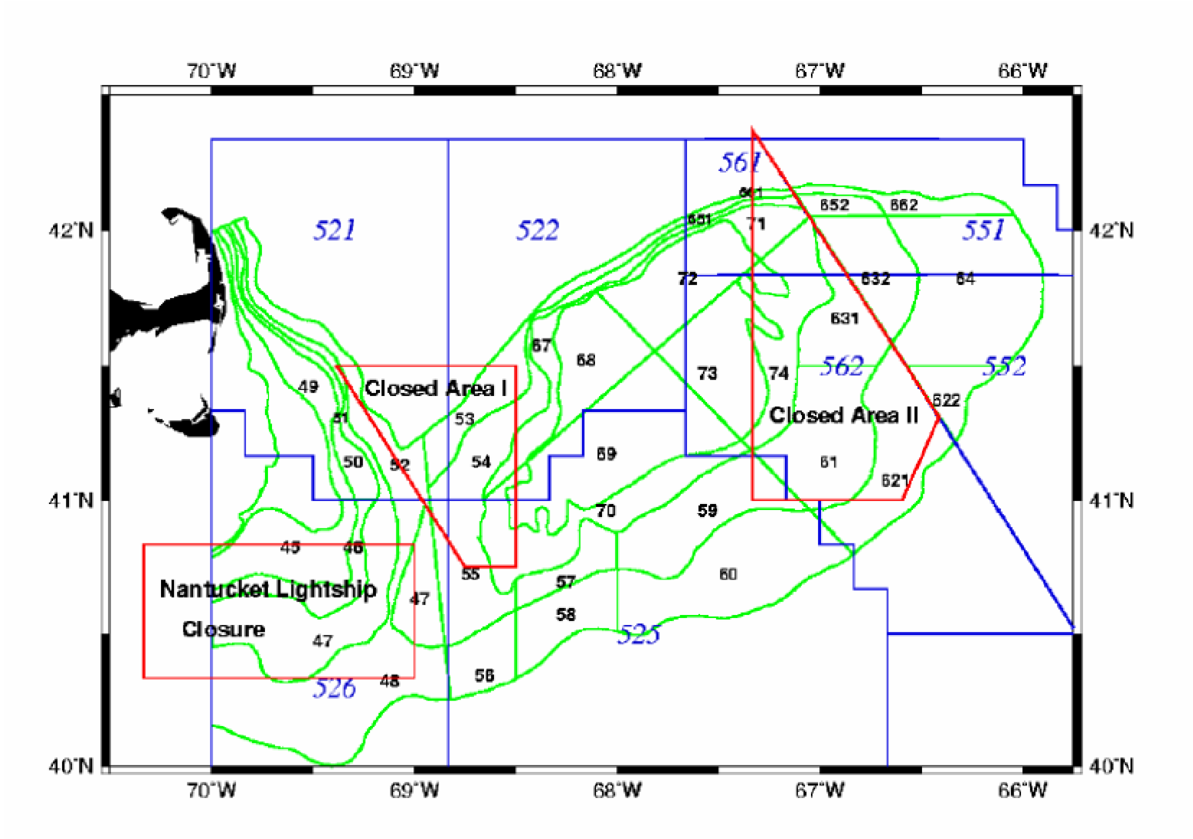


Figure 11. (continued) NMFS scallop survey strata used to derive research survey abundance indices for Georges Bank groundfish surveys. Strata 54, 55, 58-72, and 74 are used to estimate the abundance of yellowtail flounder for this assessment.

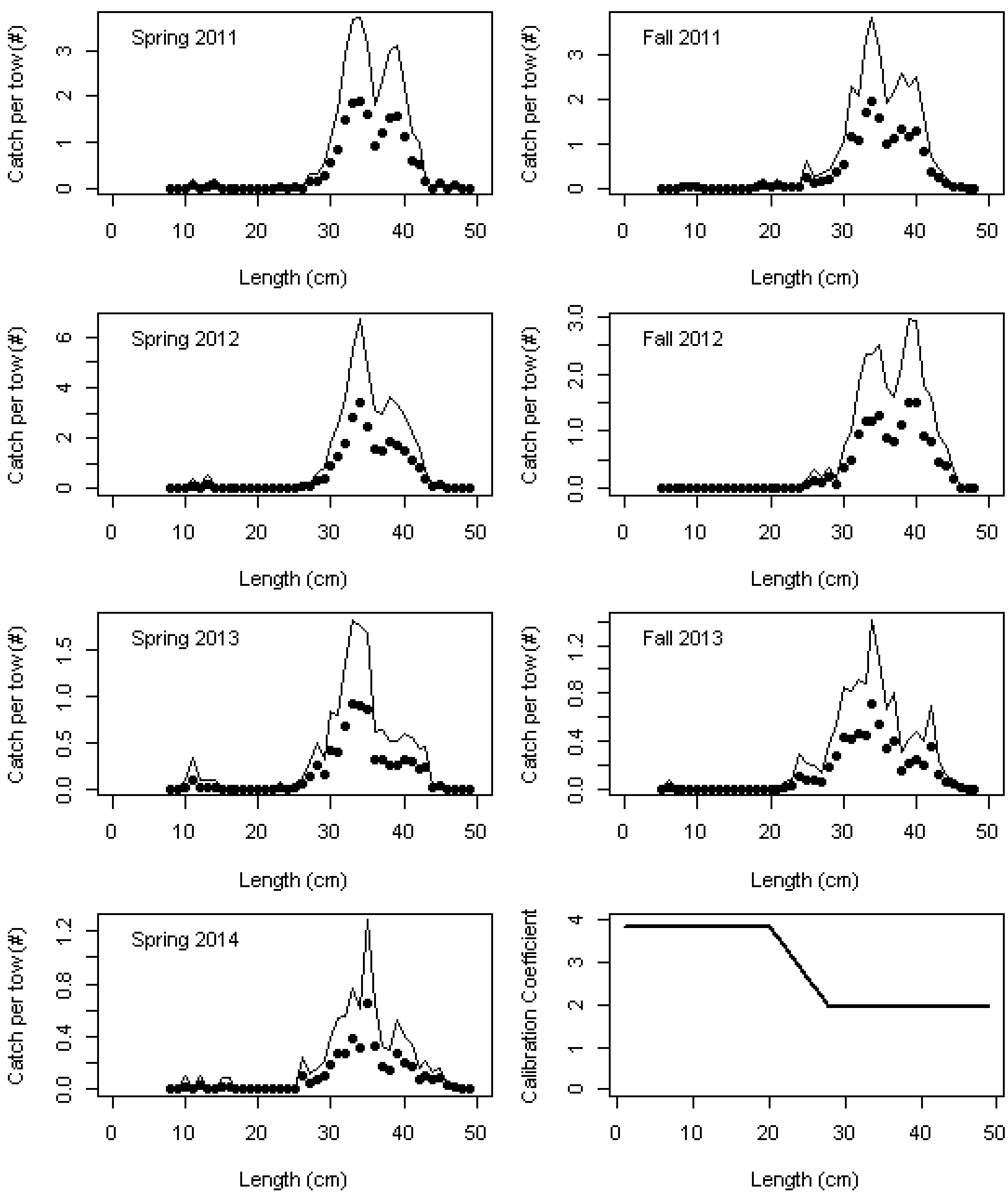


Figure 12. Catch per tow in numbers of fish for the US spring and fall surveys by the *Henry B. Bigelow*. The lines denote the original observations and the dots the calibrated values converted to *Albatross IV* units. The calibration is calculated using the curve in the lower right panel (Calibrated = Original/Calibration Coefficient).

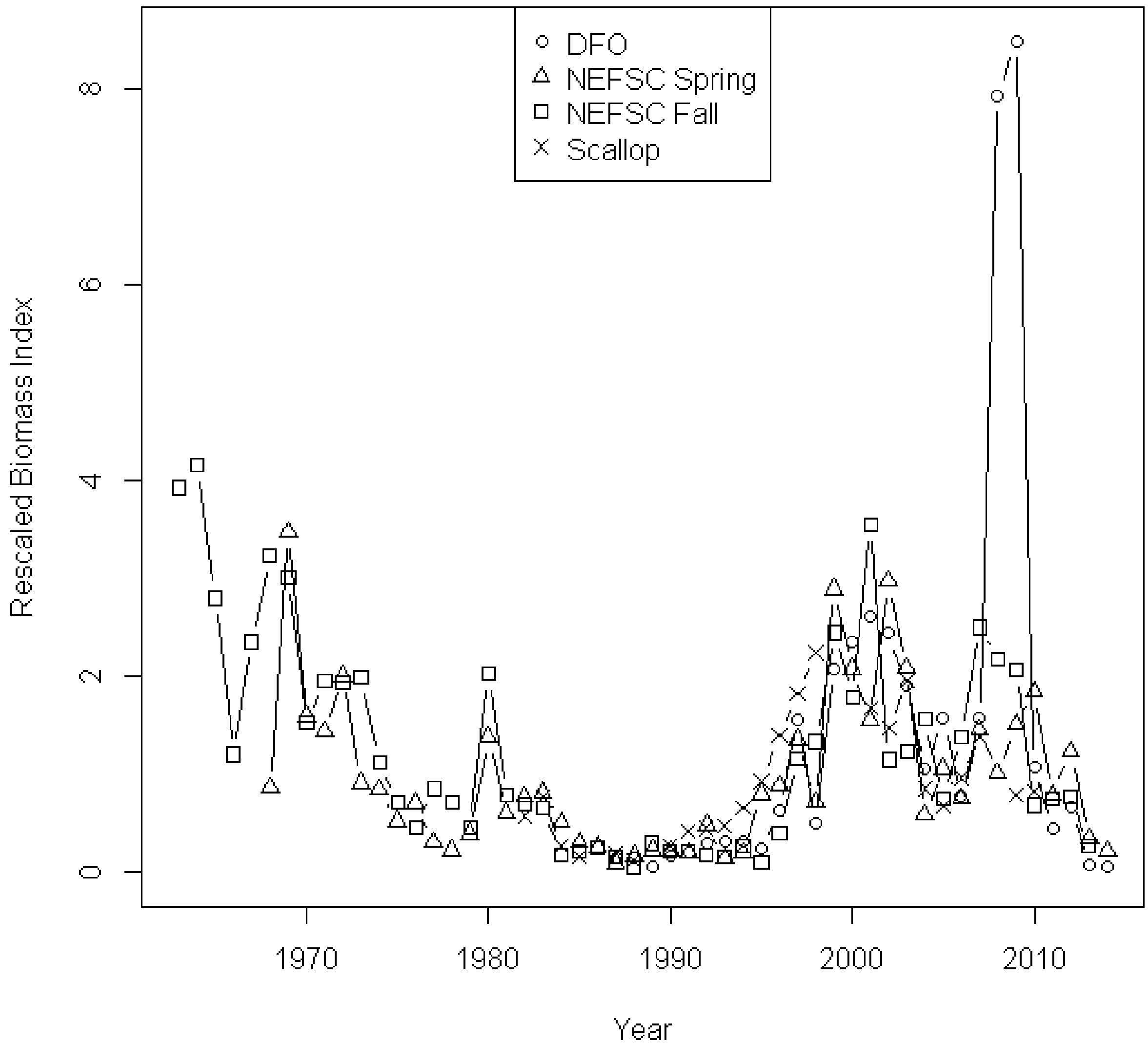


Figure 13a. Four survey biomass indices (DFO, NEFSC spring, NEFSC fall and NEFSC scallop) for yellowtail flounder on Georges Bank rescaled to their respective means for years 1987-2007.

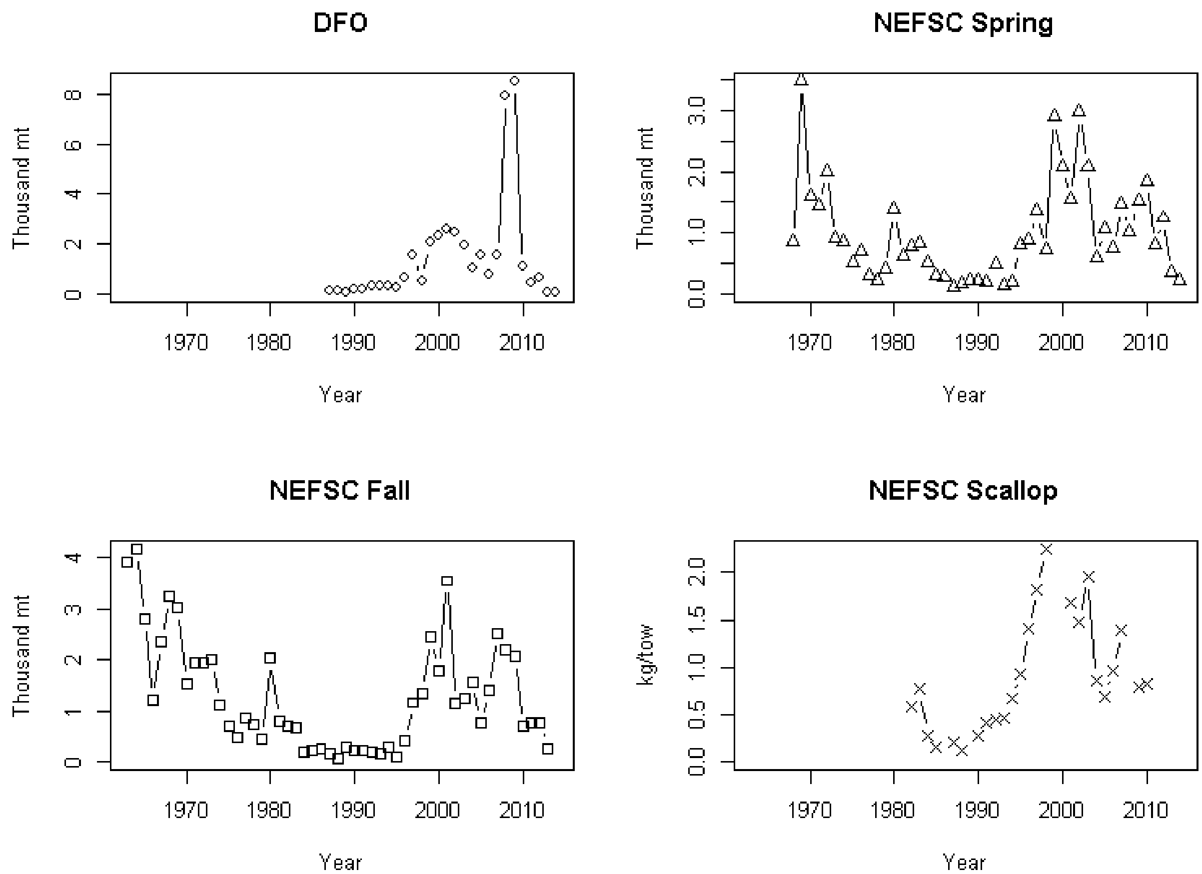


Figure 13b. Survey biomass for yellowtail flounder on Georges Bank in units of thousand metric tons (DFO, NEFSC spring, NEFSC fall, all three are minimum swept area biomass values) or kg/tow (NEFSC scallop, stratified mean catch per tow).

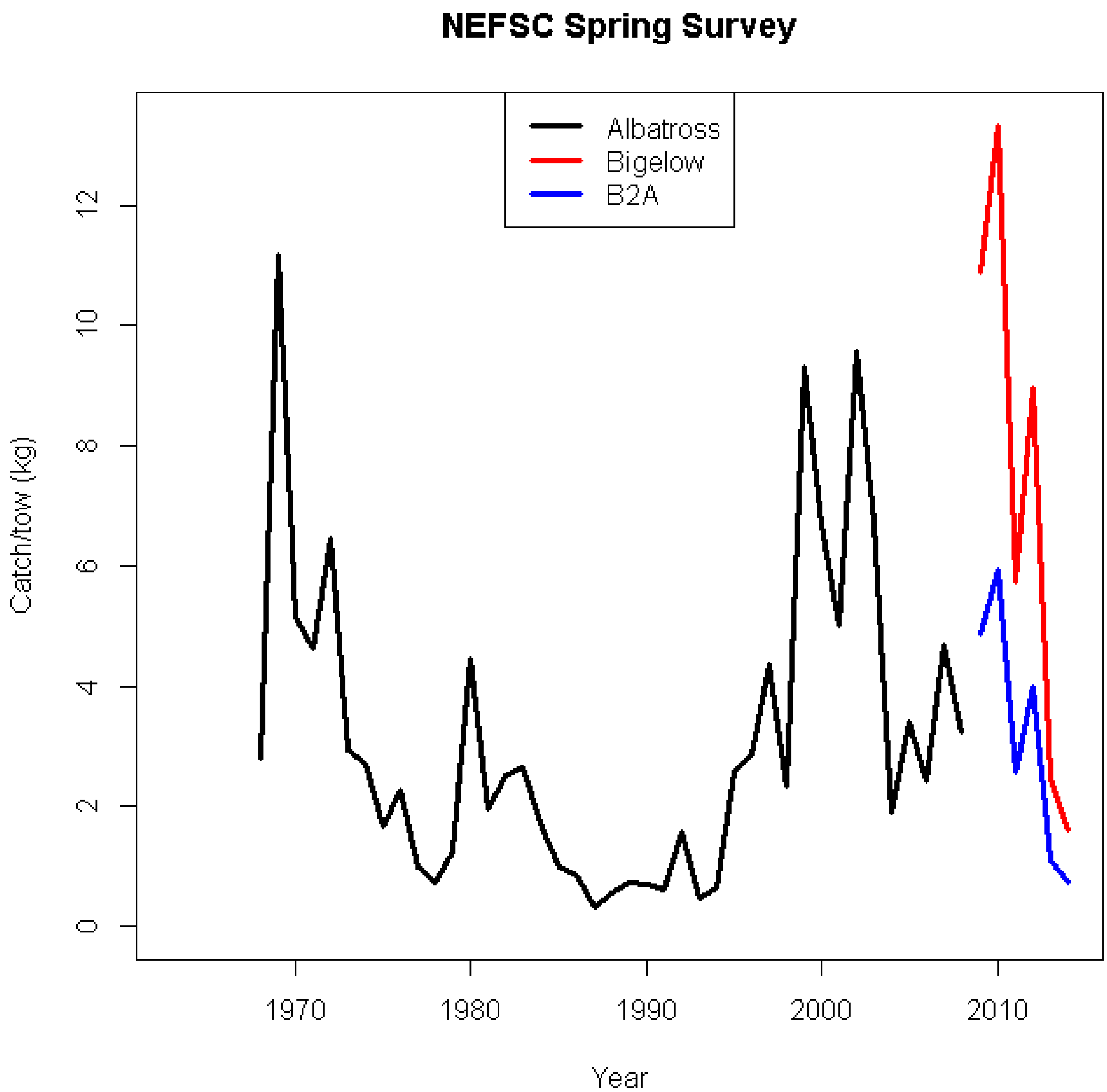


Figure 13c. NEFSC spring survey catch per tow (kg) showing the conversion between the two time series. B2A denotes catches from the *Henry B. Bigelow* converted to *Albatross IV* units.

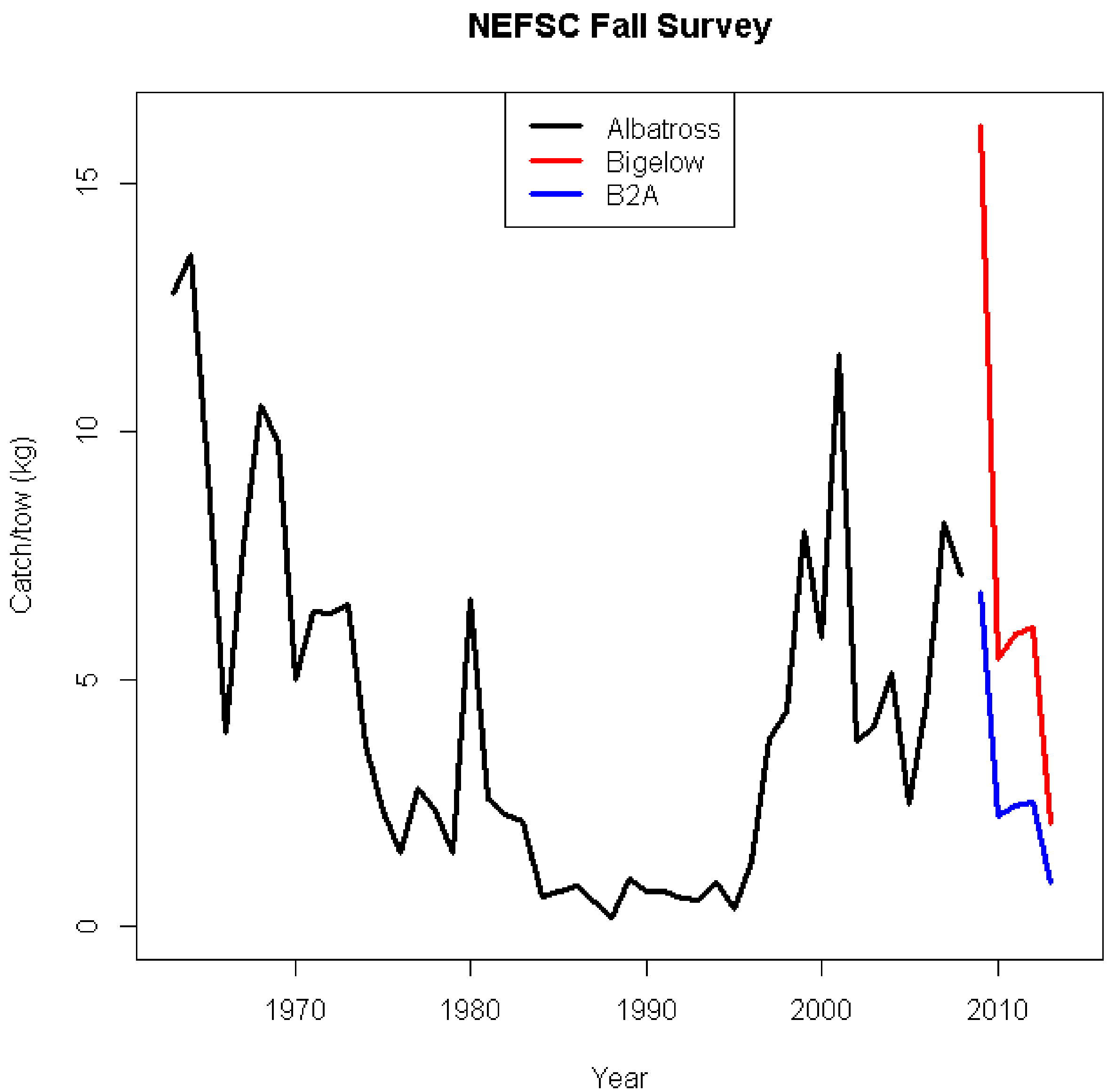


Figure 13d. NEFSC fall survey catch per tow (kg) showing the conversion between the two time series. B2A denotes catches from the *Henry B. Bigelow* converted to *Albatross IV* units.

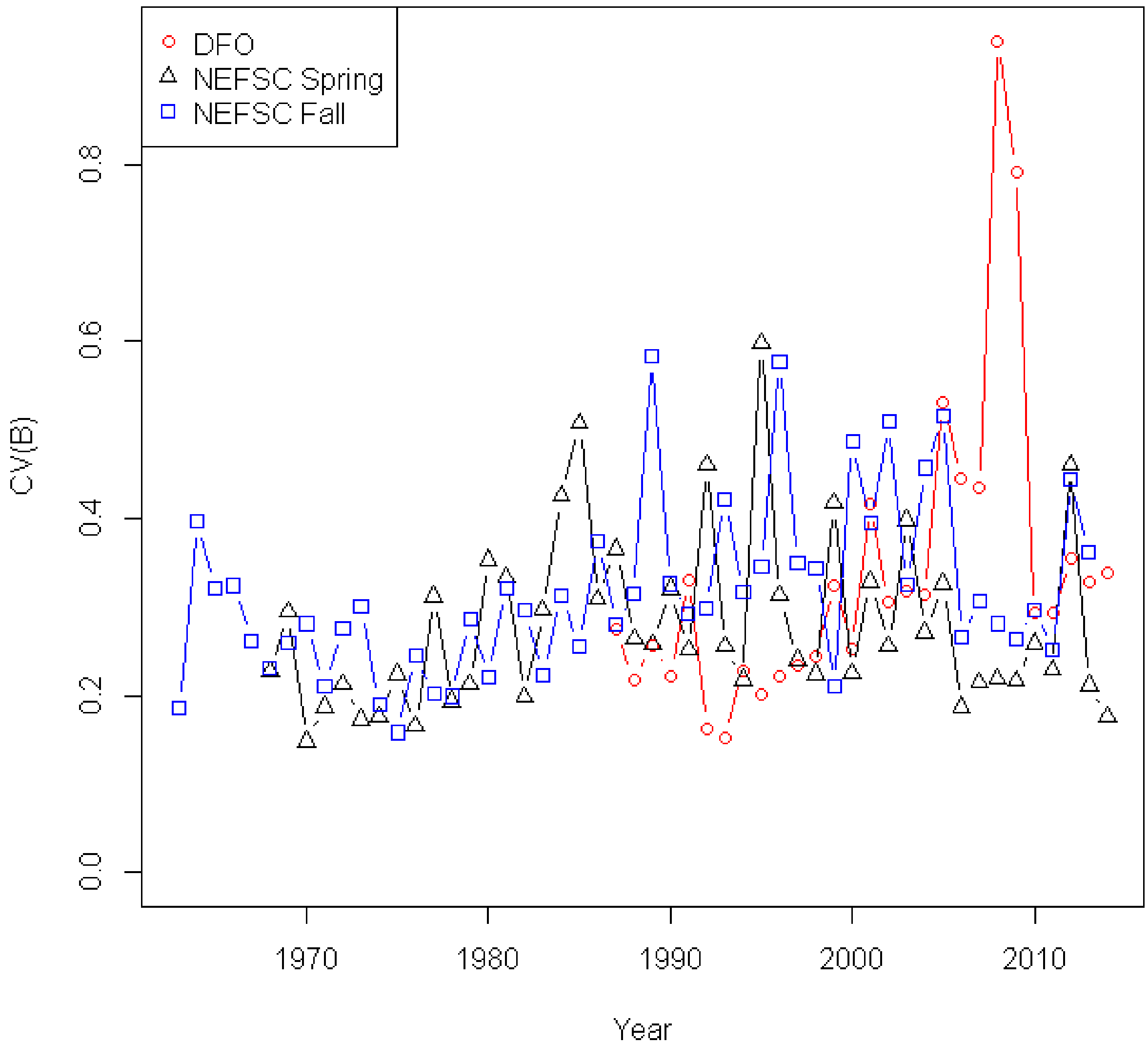


Figure 13e. Survey biomass coefficients of variation for yellowtail flounder on Georges Bank for the three bottom trawl surveys.

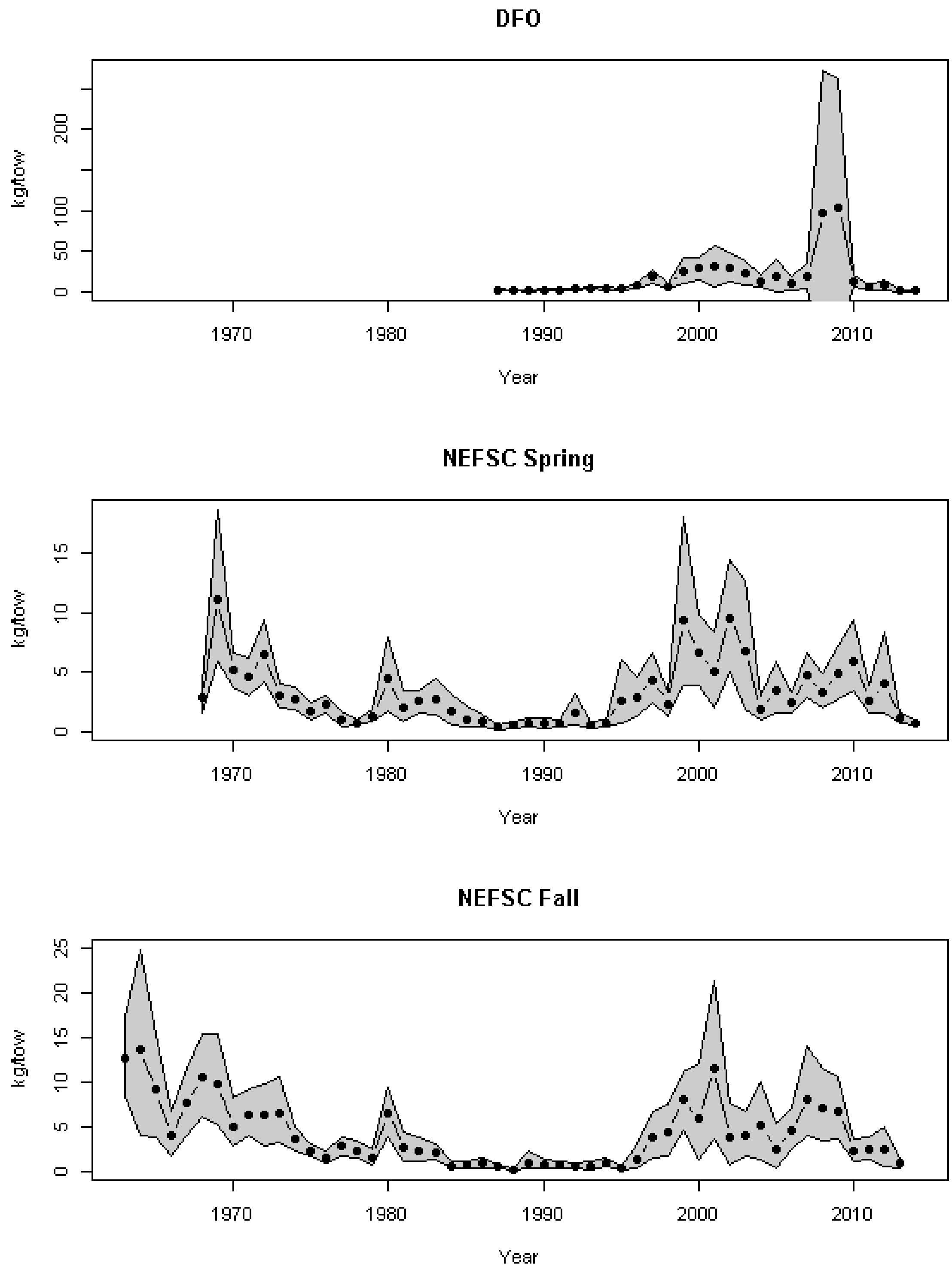


Figure 13f. Survey biomass for yellowtail flounder on Georges Bank in units of kg/tow with 95% confidence intervals from +/- 1.96*stdev (DFO) or bootstrapping (NEFSC spring and NEFSC fall) for years in the assessment.

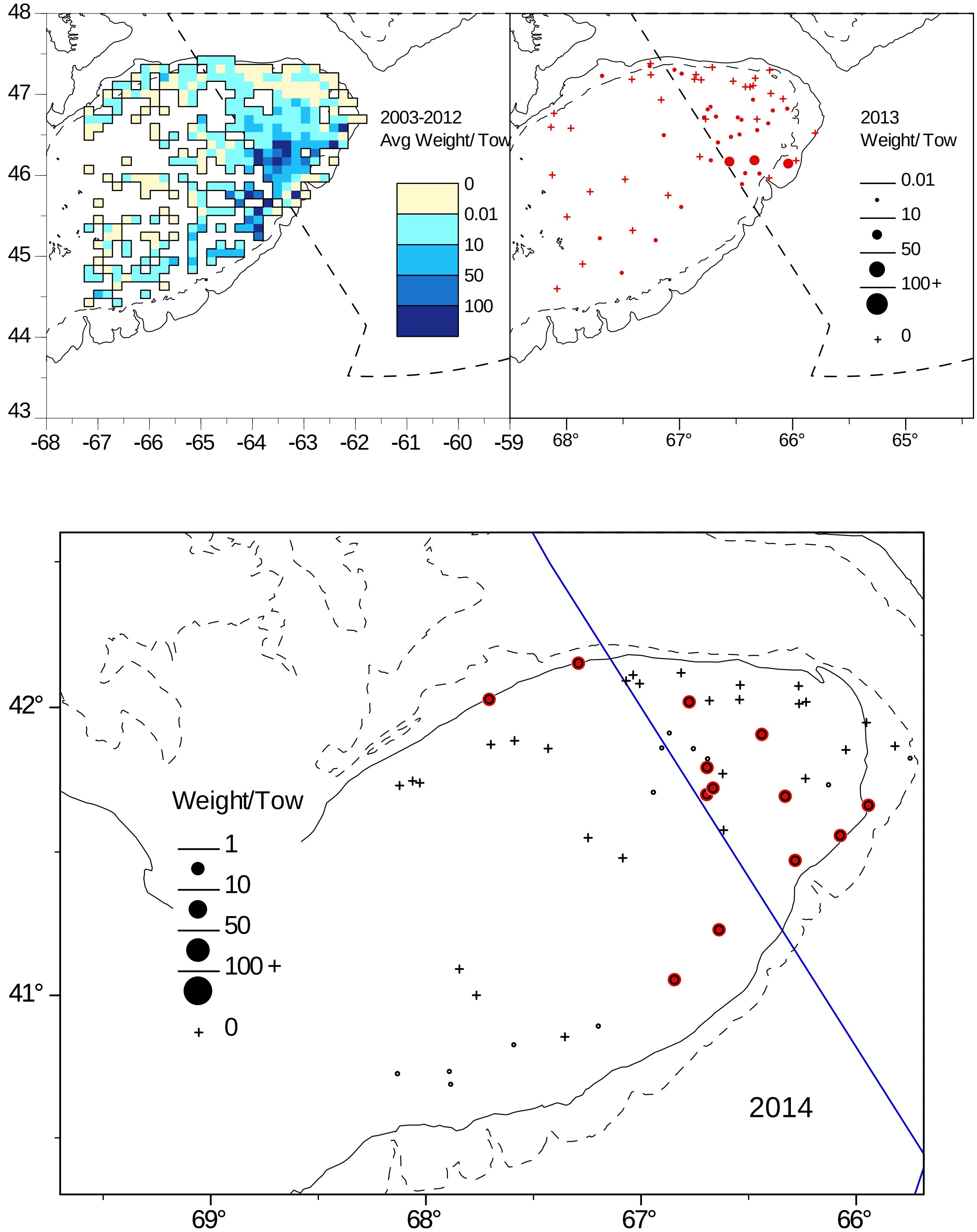


Figure 14a. Catch of yellowtail in weight (kg) per tow for DFO survey. Top left panel shows 2003-2012 average, top right panel shows 2013 catch per tow for comparison.

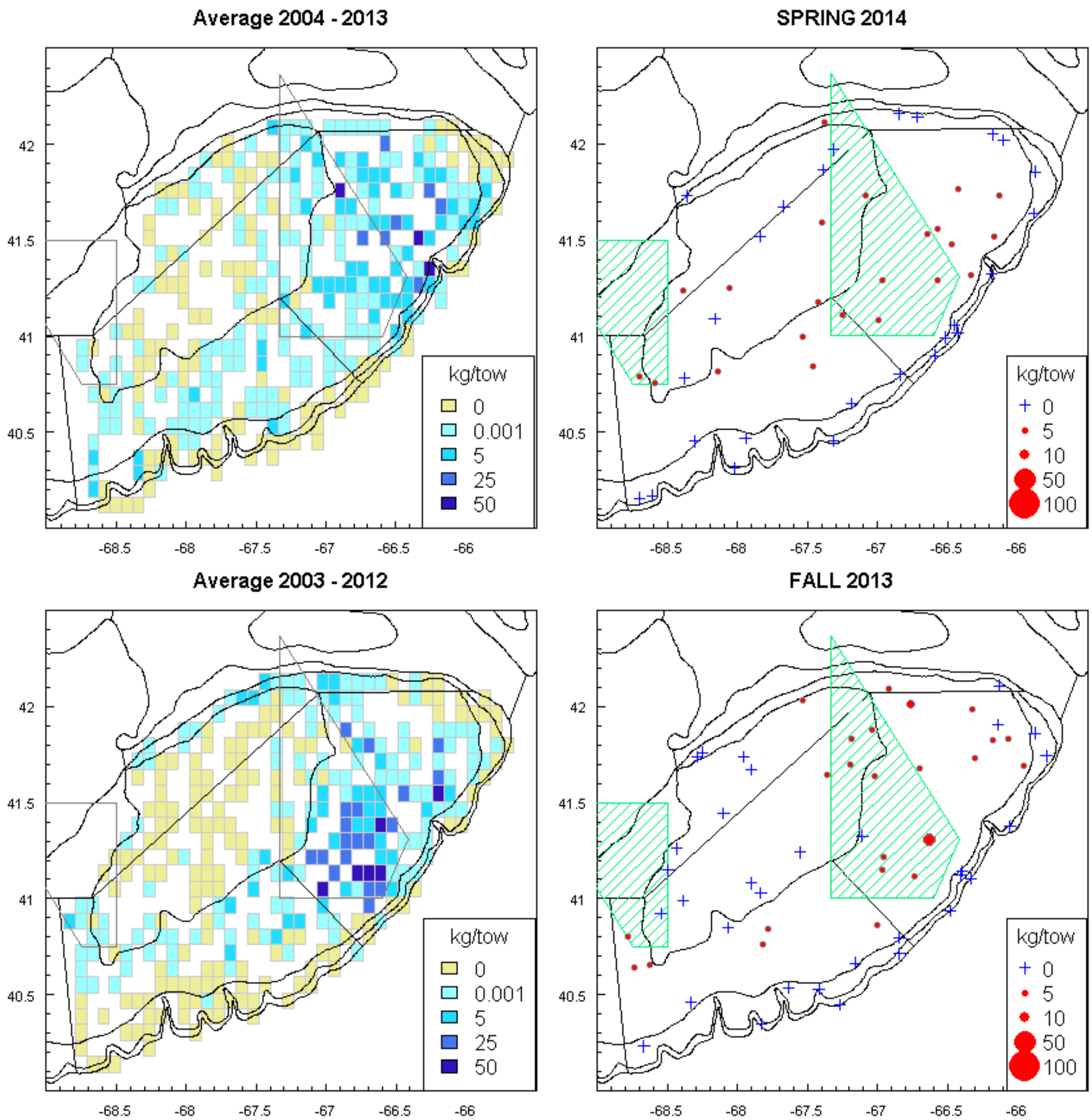


Figure 14b. Catch of yellowtail in weight (kg) per tow for NEFSC spring (top) and NEFSC fall (bottom) surveys. Left panels show previous 10 year averages, right panels most recent data. Note the 2009 - 2013 survey values were adjusted from *Henry B. Bigelow* to *Albatross IV* equivalents by dividing *Henry B. Bigelow* catch in weight by 2.244 (spring) or 2.402 (fall).

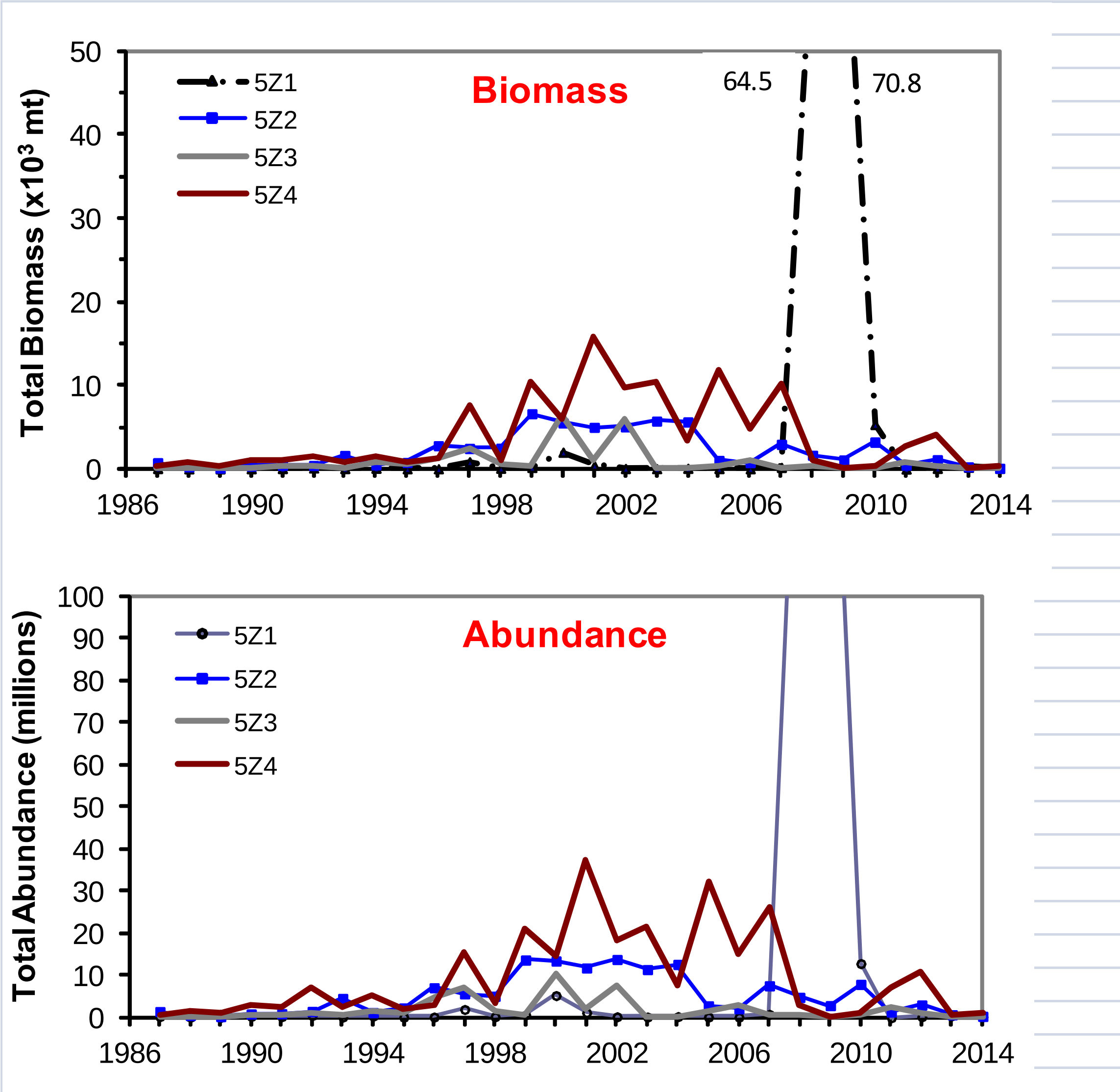


Figure 15a. DFO spring survey estimates of total biomass (top panel) and total number (bottom panel) by stratum area for yellowtail flounder on Georges Bank.

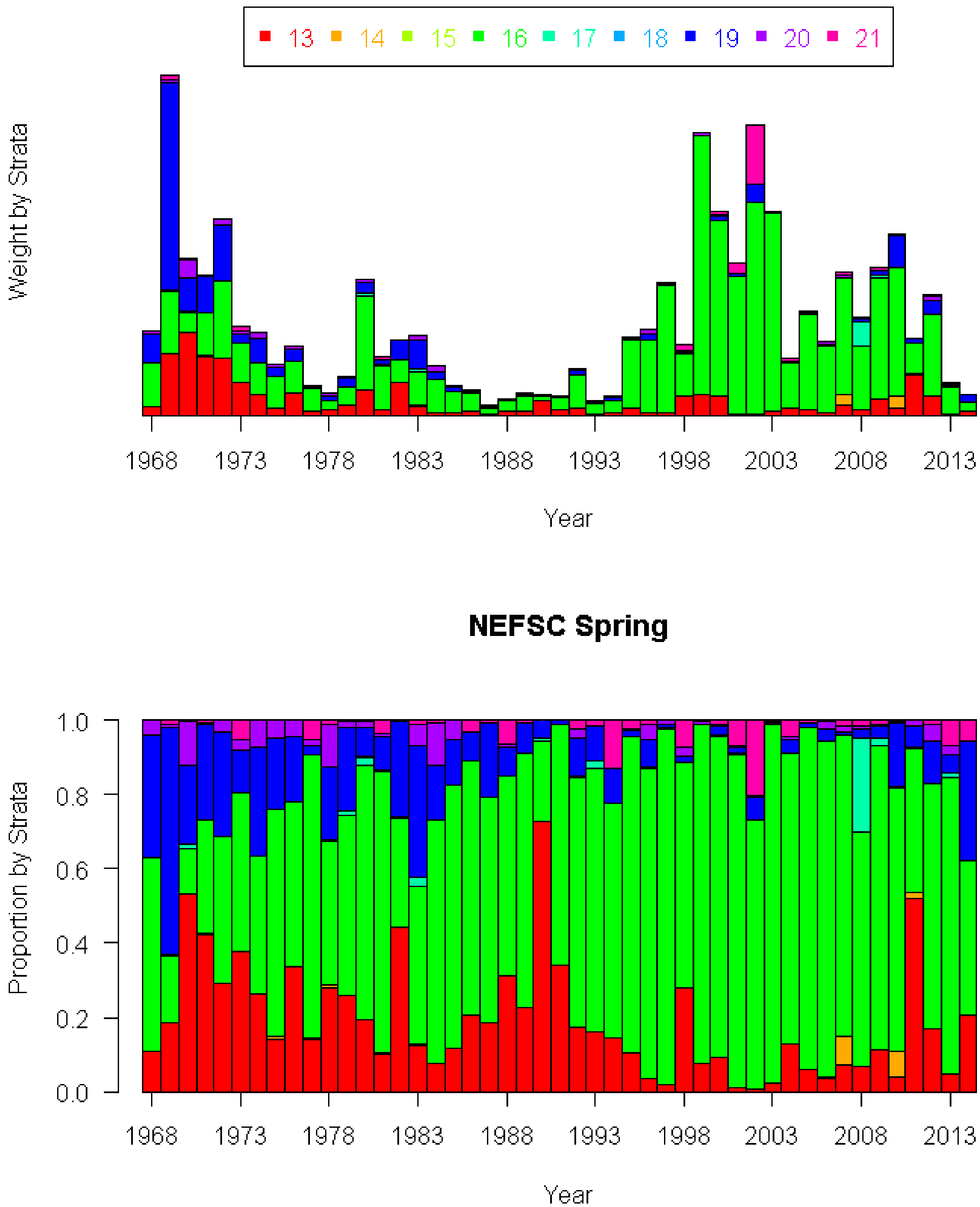


Figure 15b. NEFSC spring survey estimates of total biomass (top panel) and proportion (bottom panel) by stratum for yellowtail flounder on Georges Bank.

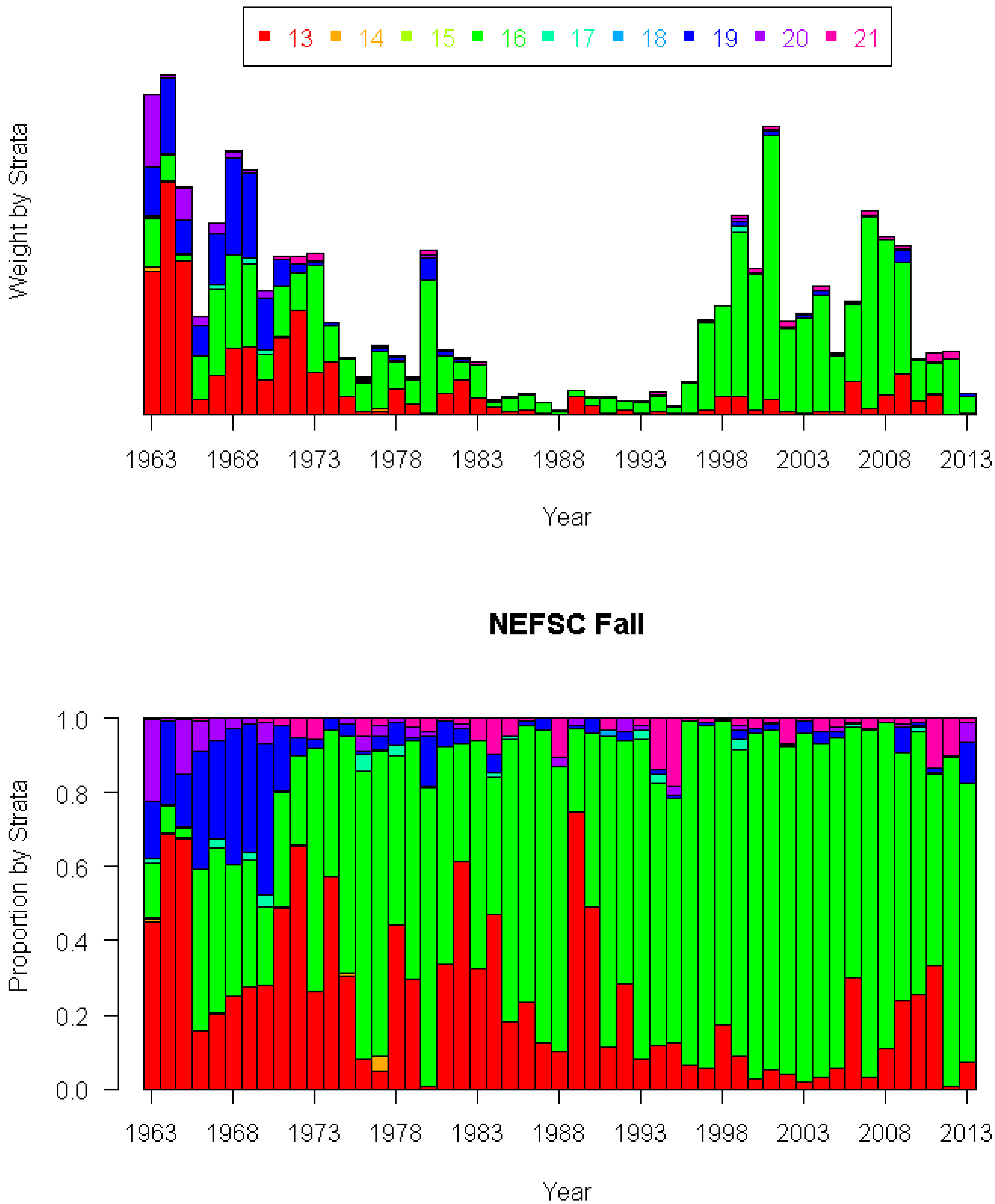


Figure 15c. NEFSC fall survey estimates of total biomass (top panel) and proportion (bottom panel) by stratum for yellowtail flounder on Georges Bank.

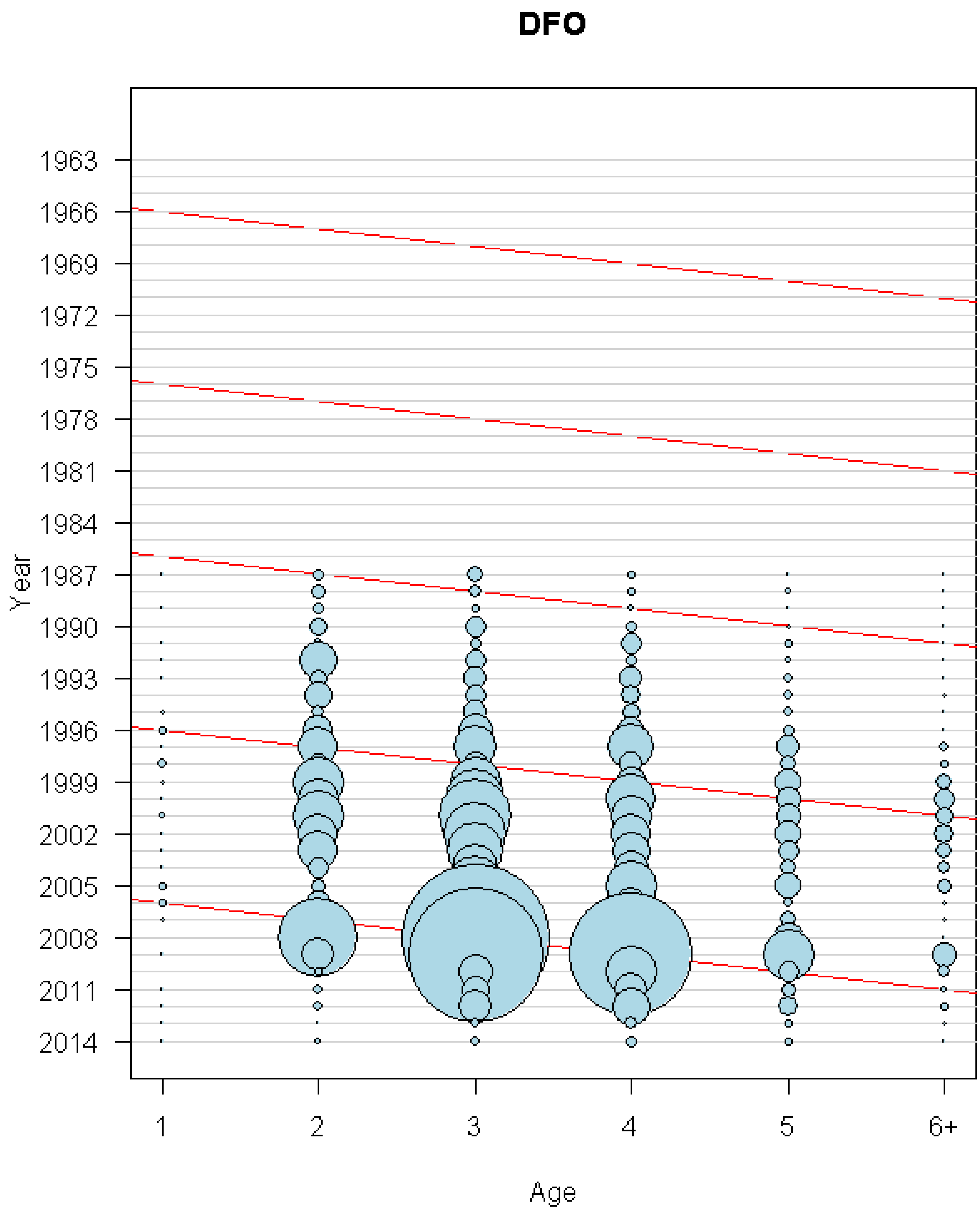


Figure 16a. Age specific indices of abundance for the DFO spring survey including the large tows in 2008 and 2009 (the area of the bubble is proportional to the magnitude). Diagonal red lines denote the 1965, 1975, 1985, 1995, and 2005 year-classes.

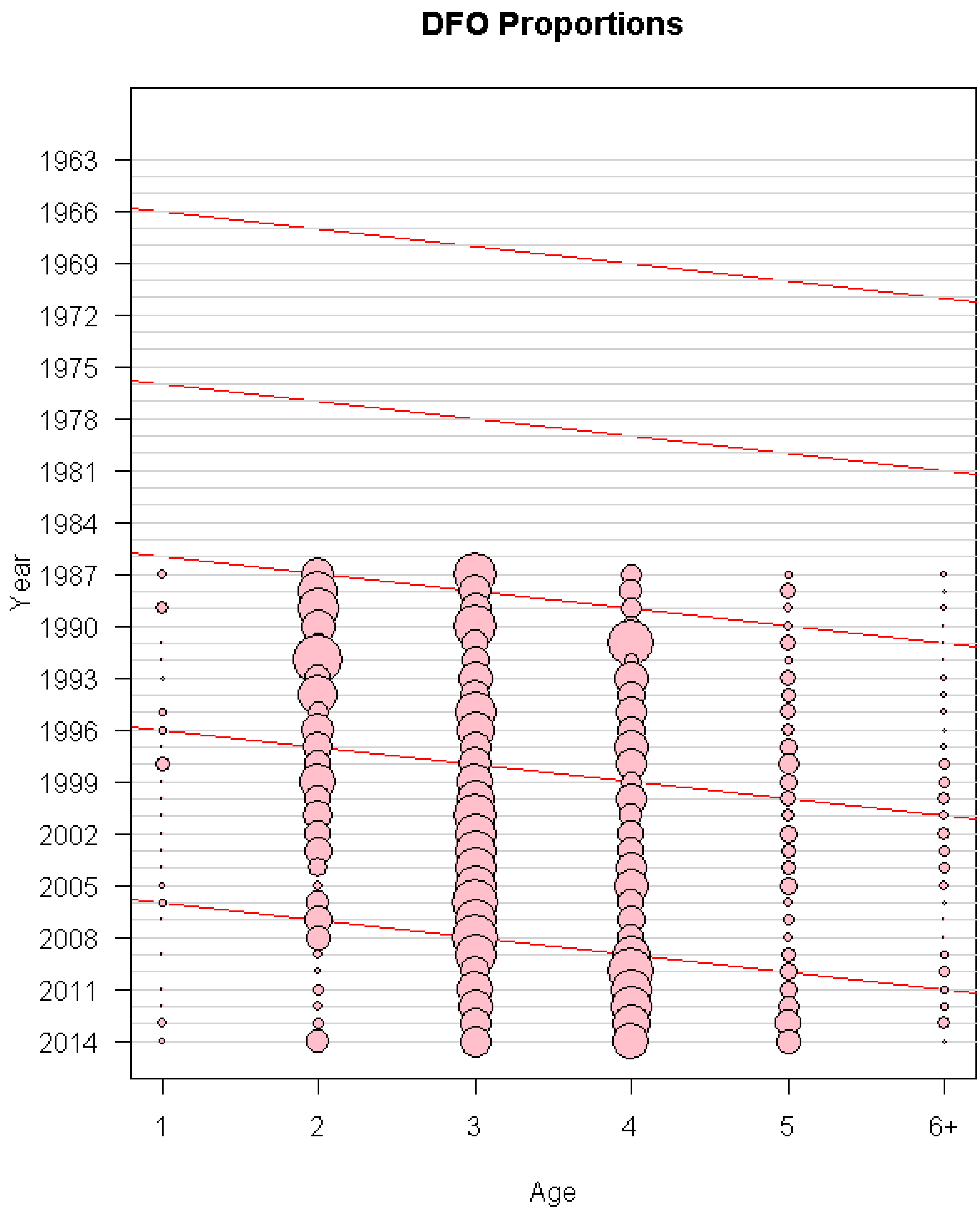


Figure 16b. Proportions of age specific indices of abundance for the DFO spring survey including the large tows in 2008 and 2009 (the area of the bubble is proportional to the magnitude). Diagonal red lines denote the 1965, 1975, 1985, 1995, and 2005 year-classes.

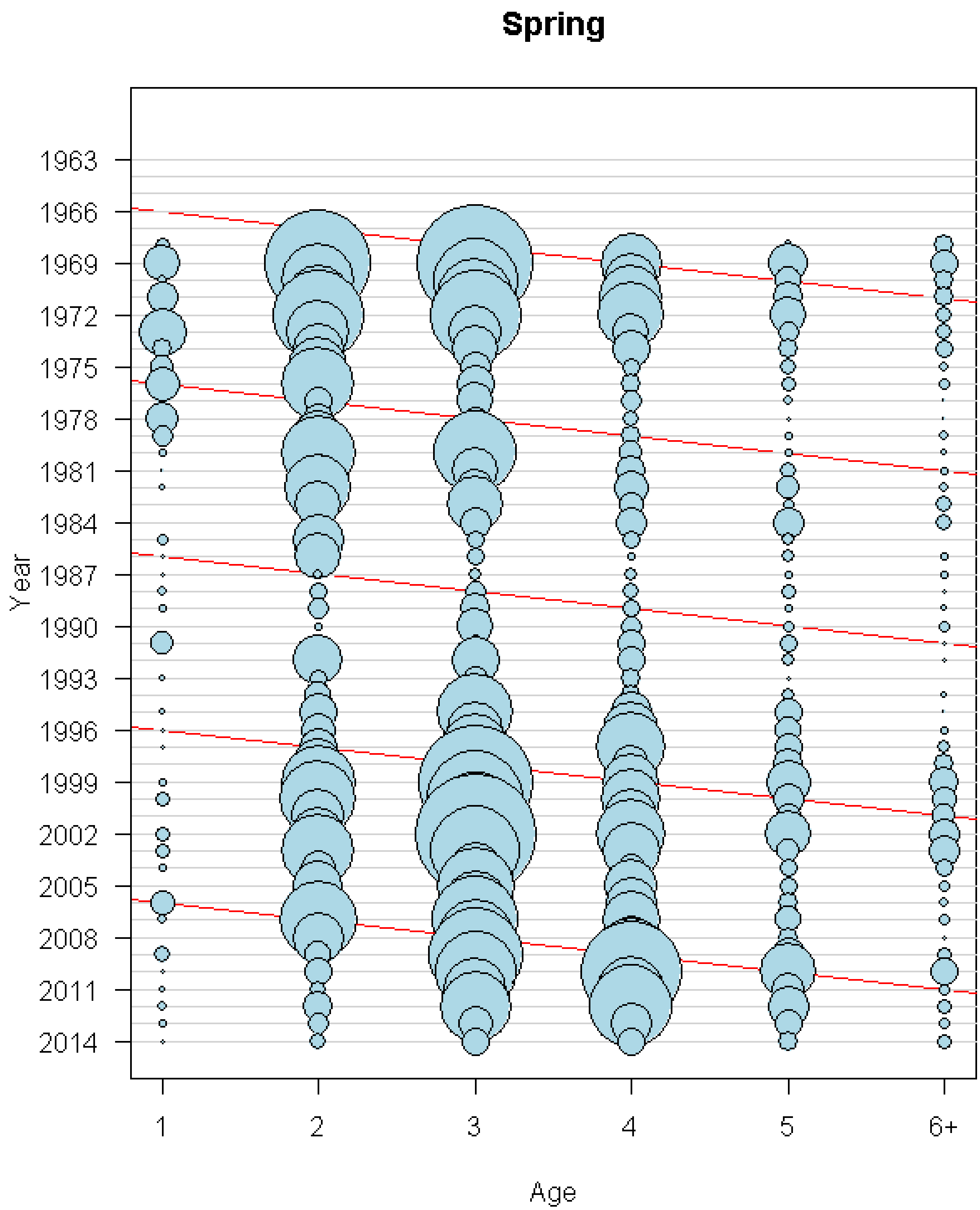


Figure 16c. Age specific indices of abundance for the NMFS spring survey (the area of the bubble is proportional to the magnitude). Diagonal red lines denote the 1965, 1975, 1985, 1995, and 2005 year-classes.

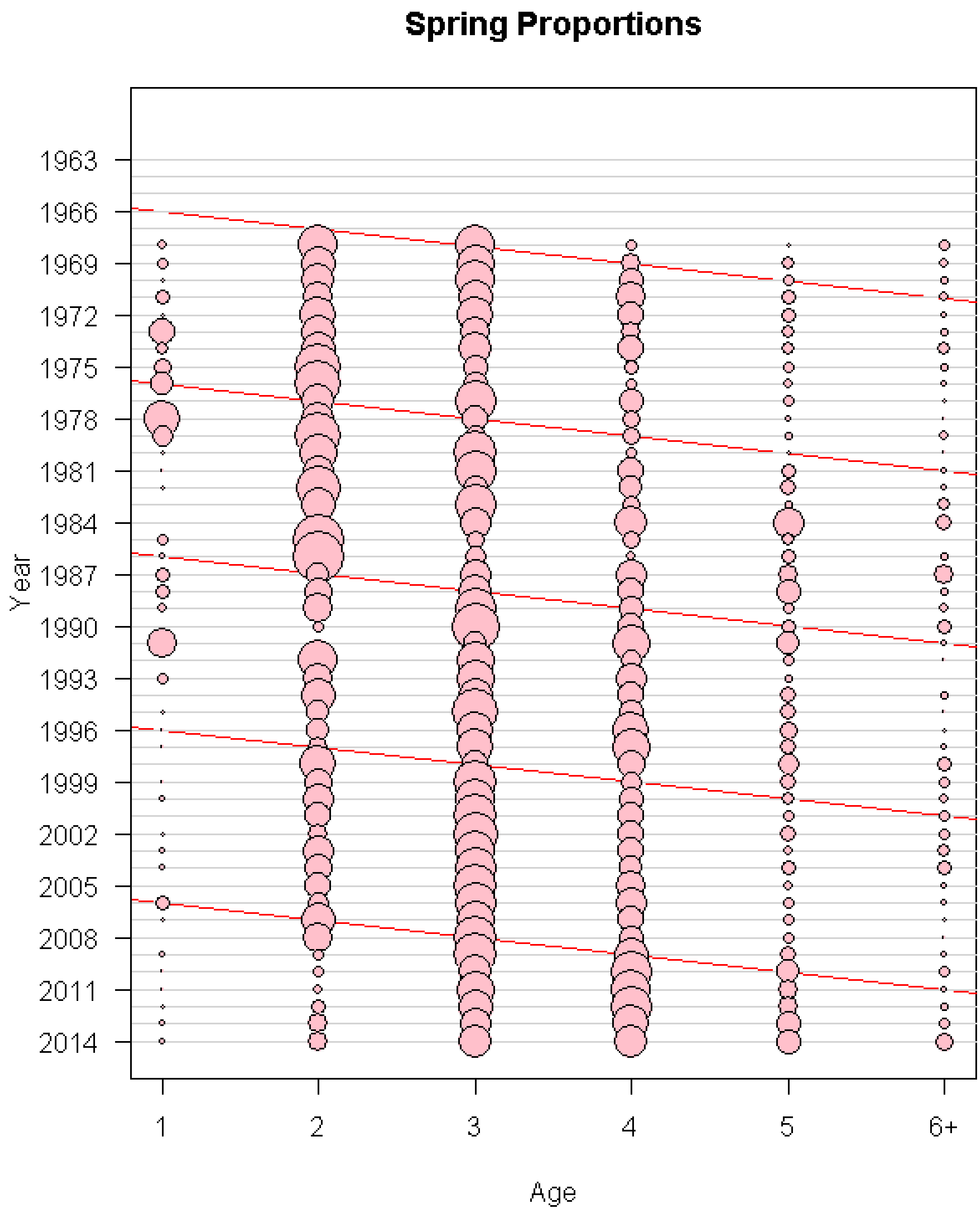


Figure 16d. Proportions of age specific indices of abundance for the NMFS spring survey (the area of the bubble is proportional to the magnitude). Diagonal red lines denote the 1965, 1975, 1985, 1995, and 2005 year-classes.

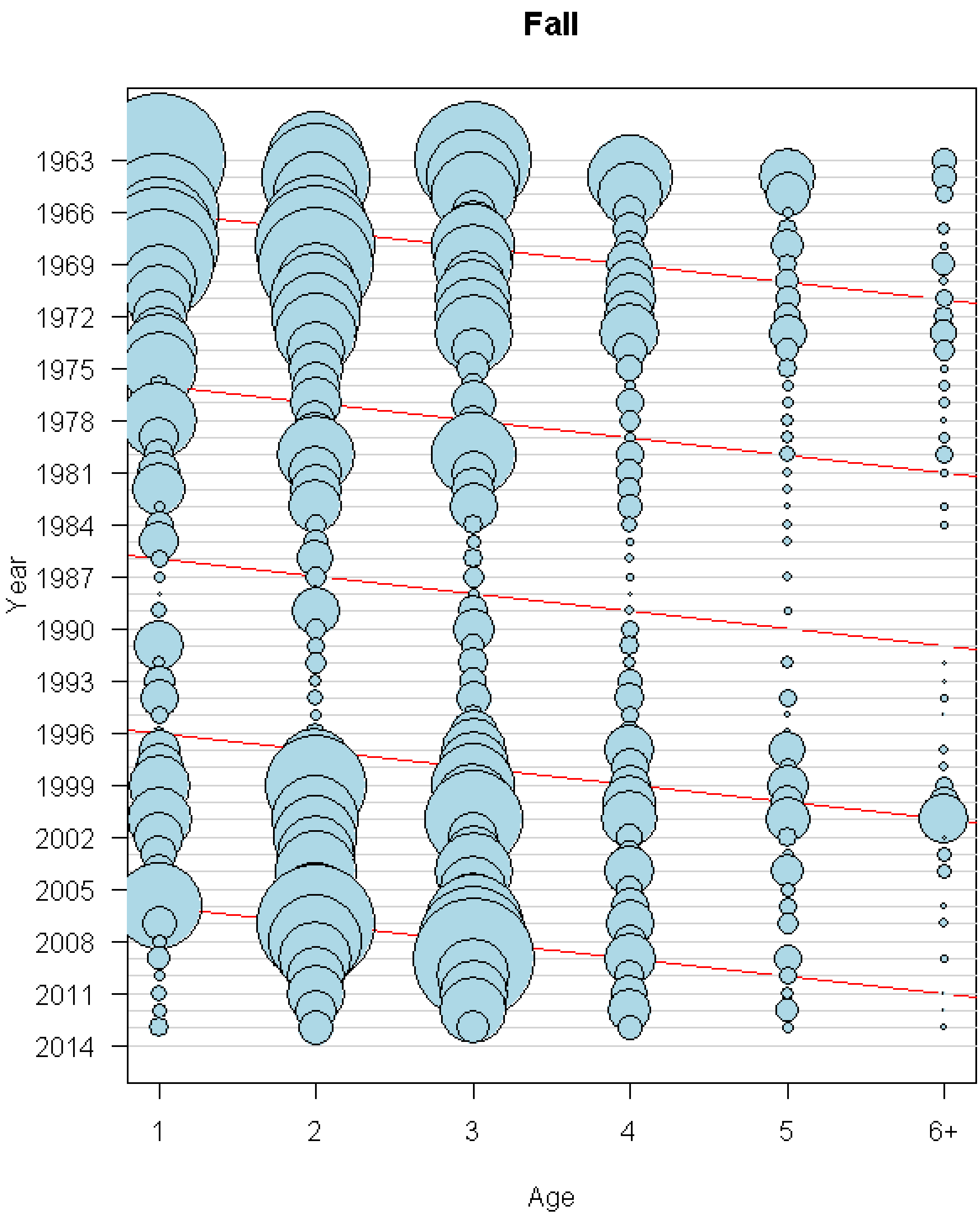


Figure 16e. Age specific indices of abundance for the NMFS fall survey (the area of the bubble is proportional to the magnitude). Diagonal red lines denote the 1965, 1975, 1985, 1995, and 2005 year-classes.

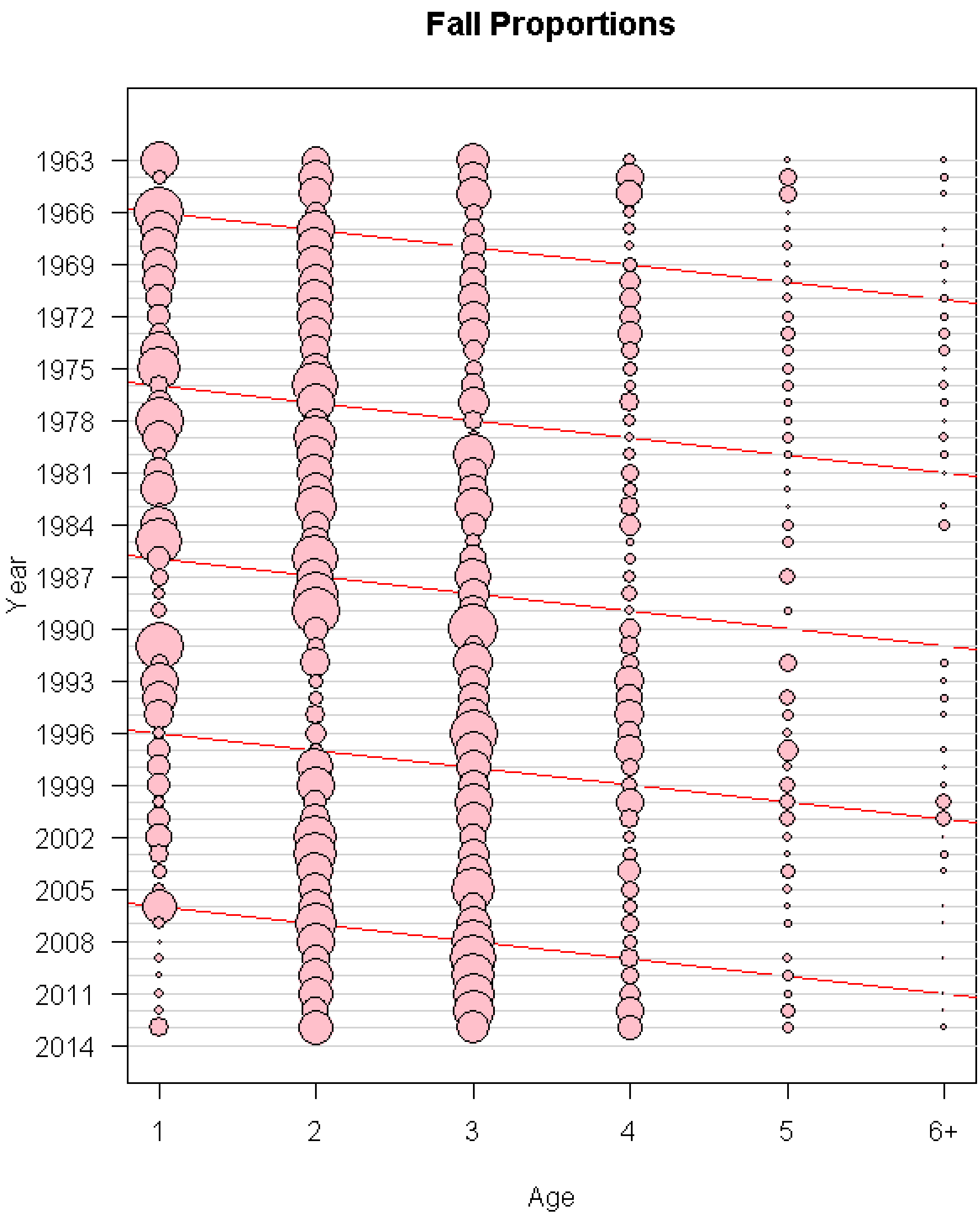


Figure 16f. Proportions of age specific indices of abundance for the NMFS fall survey (the area of the bubble is proportional to the magnitude). Diagonal red lines denote the 1965, 1975, 1985, 1995, and 2005 year-classes.

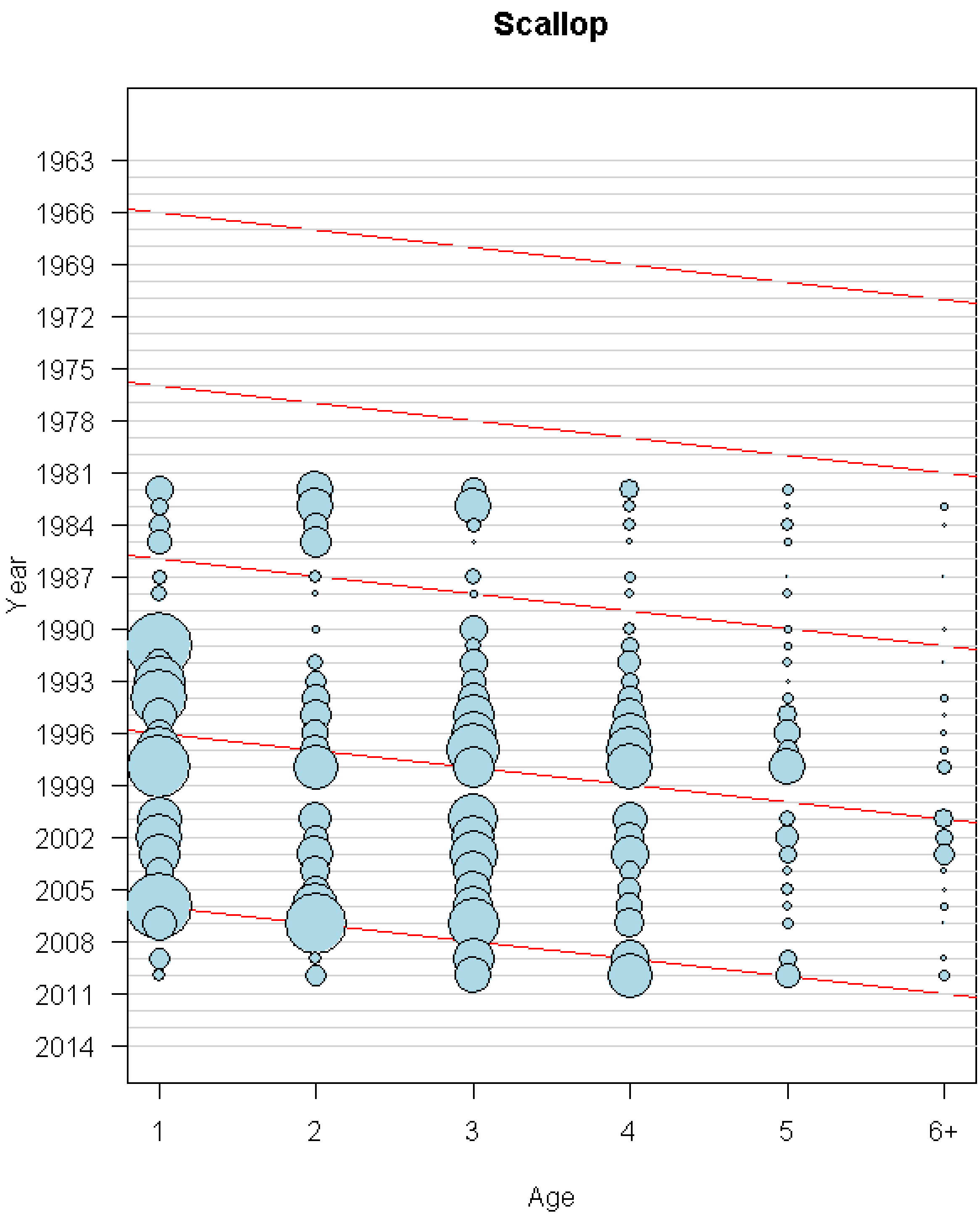


Figure 16g. Age specific indices of abundance for the NMFS scallop survey, note years 1986, 1989, 1999, 2000, and 2008 are not included (the area of the bubble is proportional to the magnitude). Diagonal red lines denote the 1965, 1975, 1985, 1995, and 2005 year-classes.

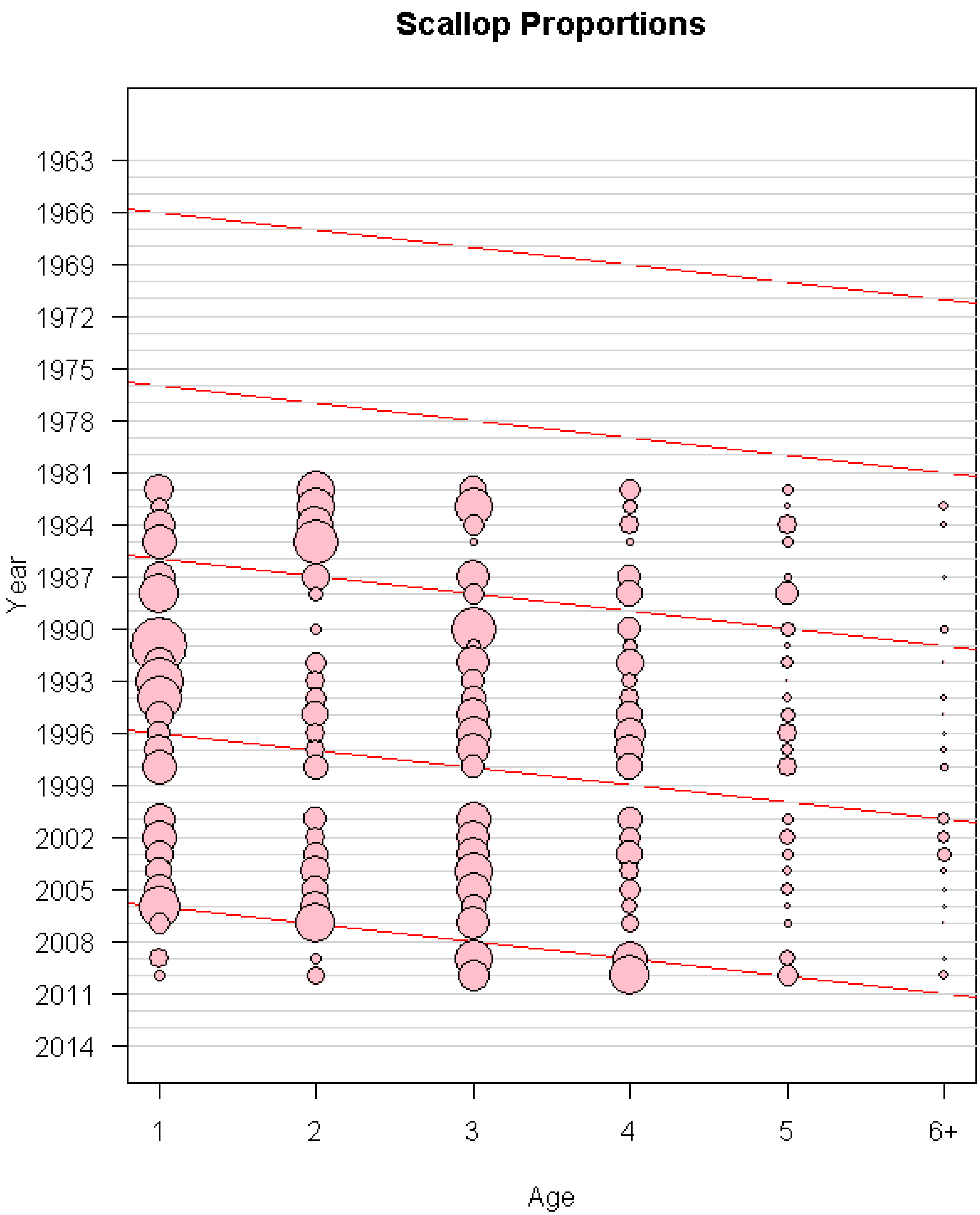


Figure 16h. Proportions of age specific indices of abundance for the NMFS scallop survey, note years 1986, 1989, 1999, 2000, and 2008 are not included (the area of the bubble is proportional to the magnitude). Diagonal red lines denote the 1965, 1975, 1985, 1995, and 2005 year-classes.

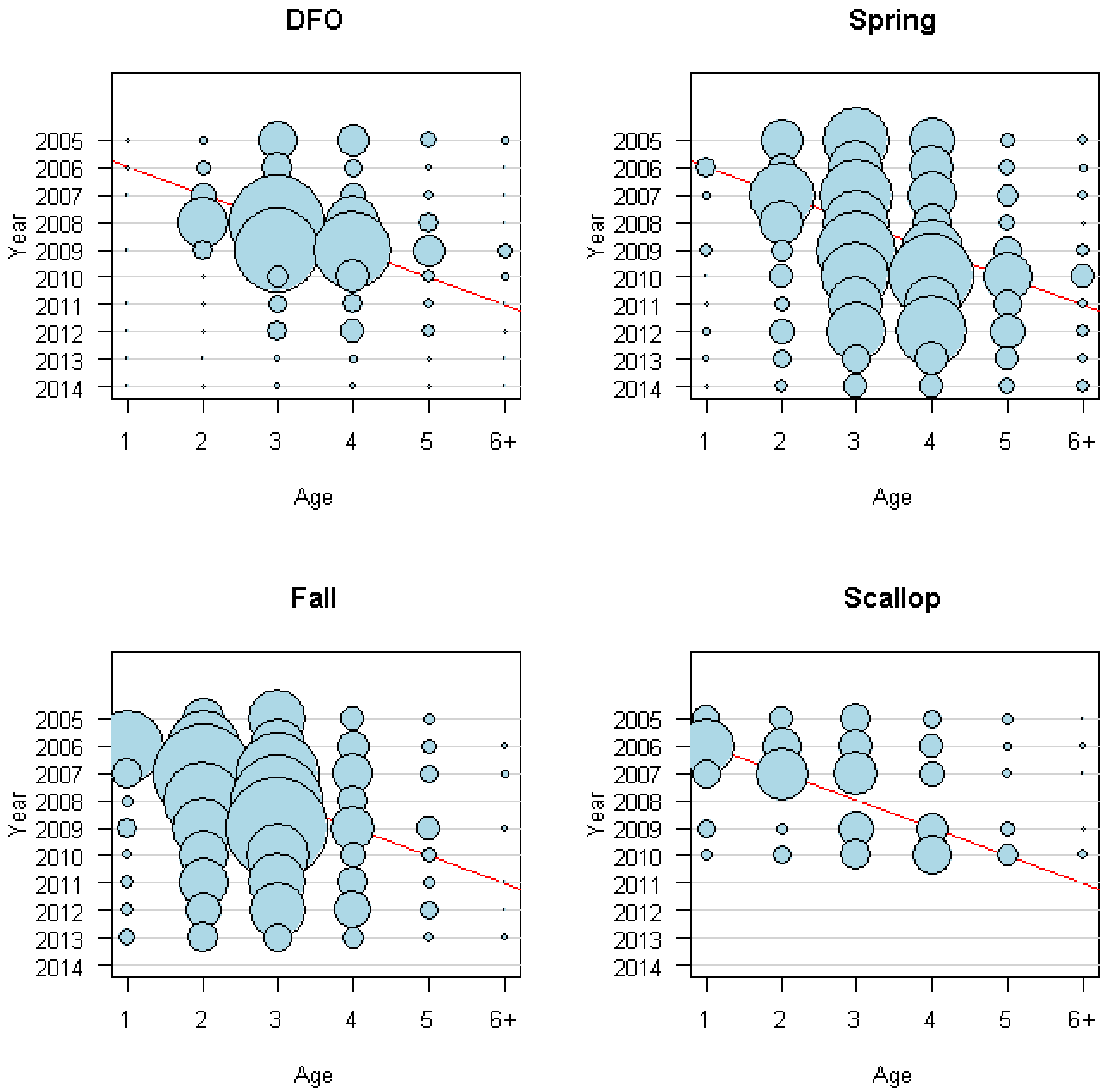


Figure 16i. Age specific indices of abundance for the recent years of the four surveys, note year 2008 is not included in the scallop plot (the area of the bubble is proportional to the magnitude). The red diagonal line denotes the 2005 year-class.

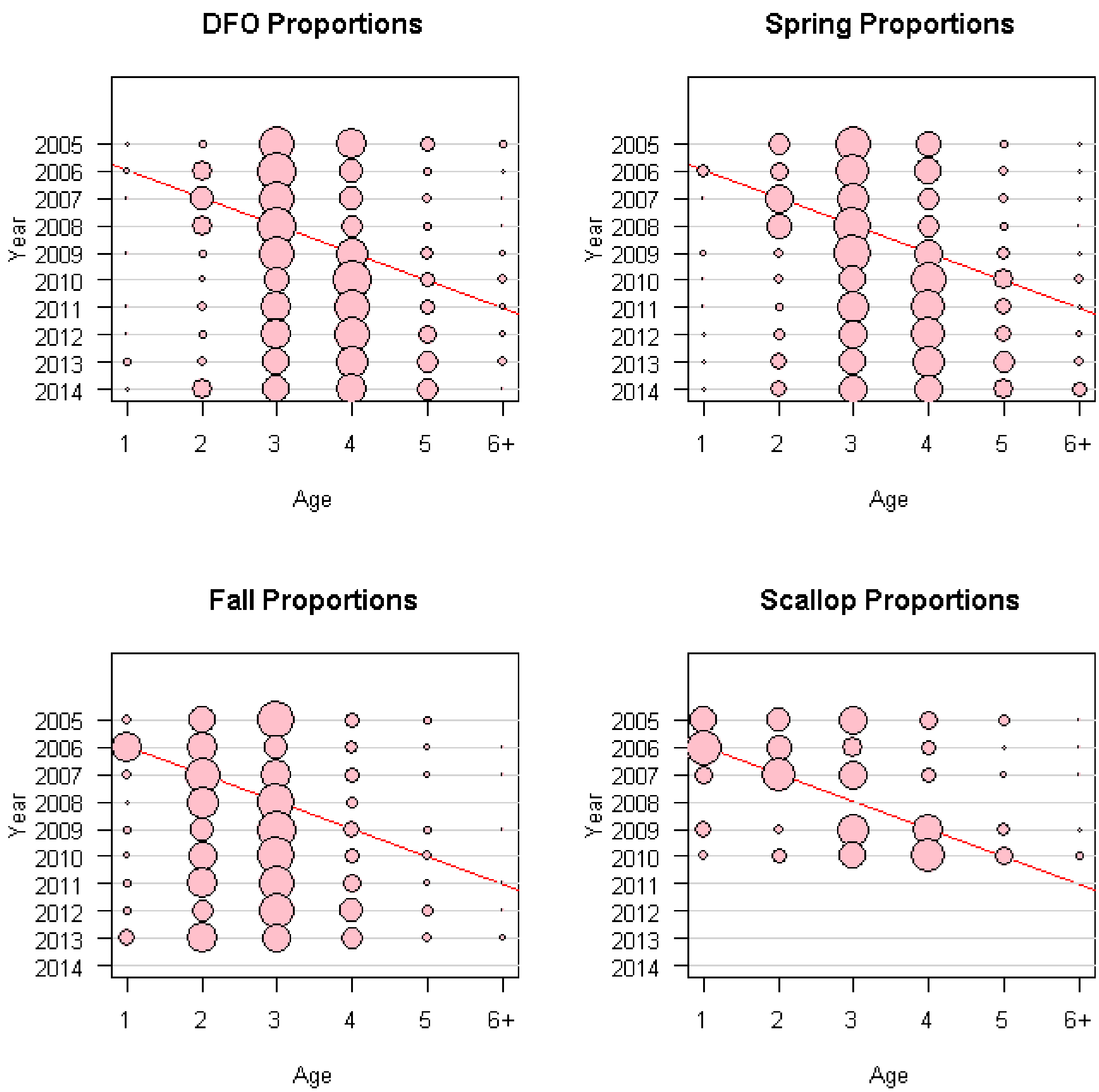


Figure 16j. Proportions of age specific indices of abundance for the recent years of the four surveys, note year 2008 is not included in the scallop plot (the area of the bubble is proportional to the magnitude). The red diagonal line denotes the 2005 year-class.

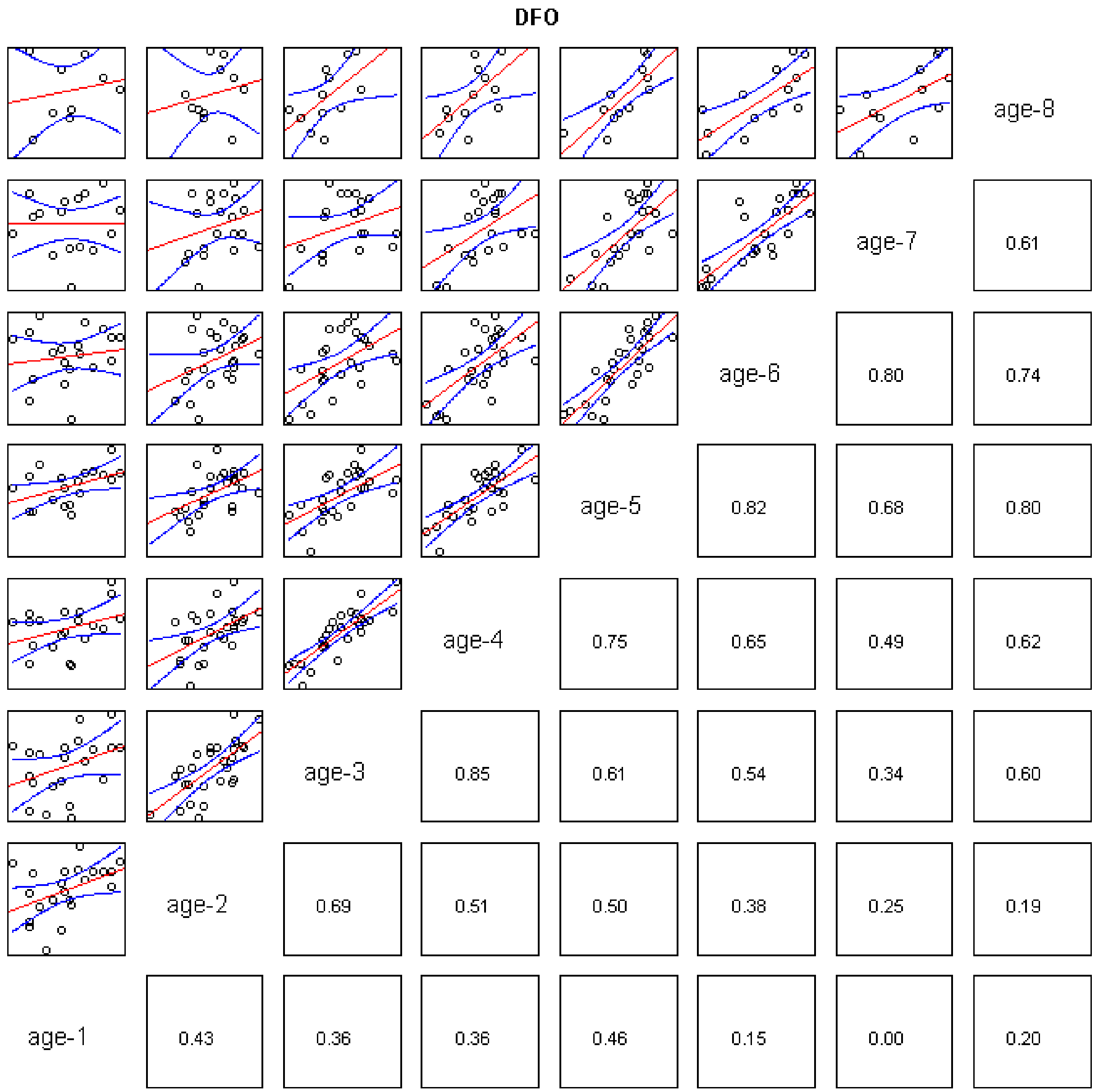


Figure 16k. DFO survey catch at age by cohort on log scale. Red lines denote linear regression and blue lines denote 95% prediction interval for the linear regression. Correlation values are shown in lower right triangle.

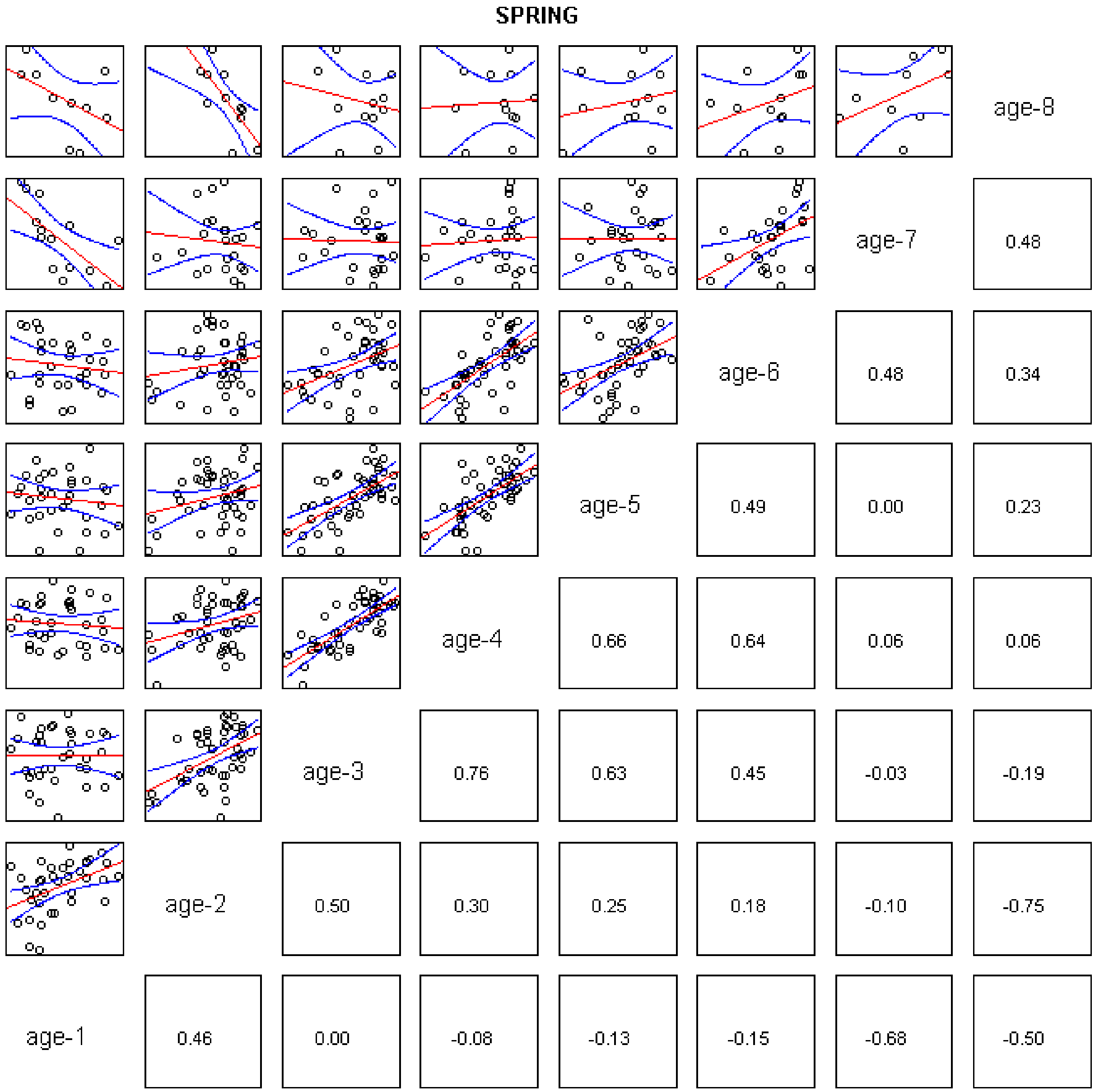


Figure 16l. NEFSC spring survey catch at age by cohort on log scale. Red lines denote linear regression and blue lines denote 95% prediction interval for the linear regression. Correlation values are shown in lower right triangle.

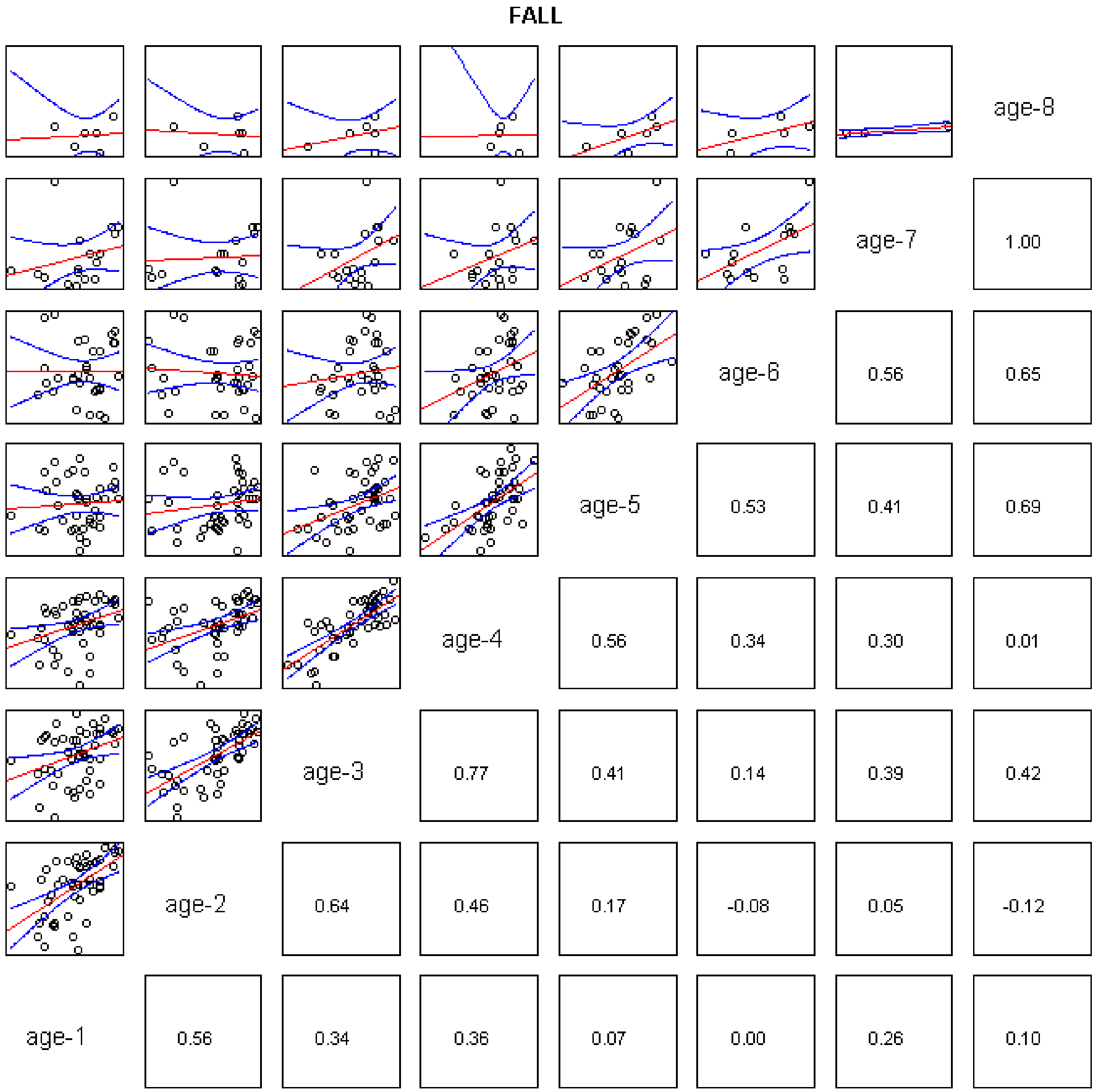


Figure 16m. NEFSC fall survey catch at age by cohort on log scale. Red lines denote linear regression and blue lines denote 95% prediction interval for the linear regression. Correlation values are shown in lower right triangle.

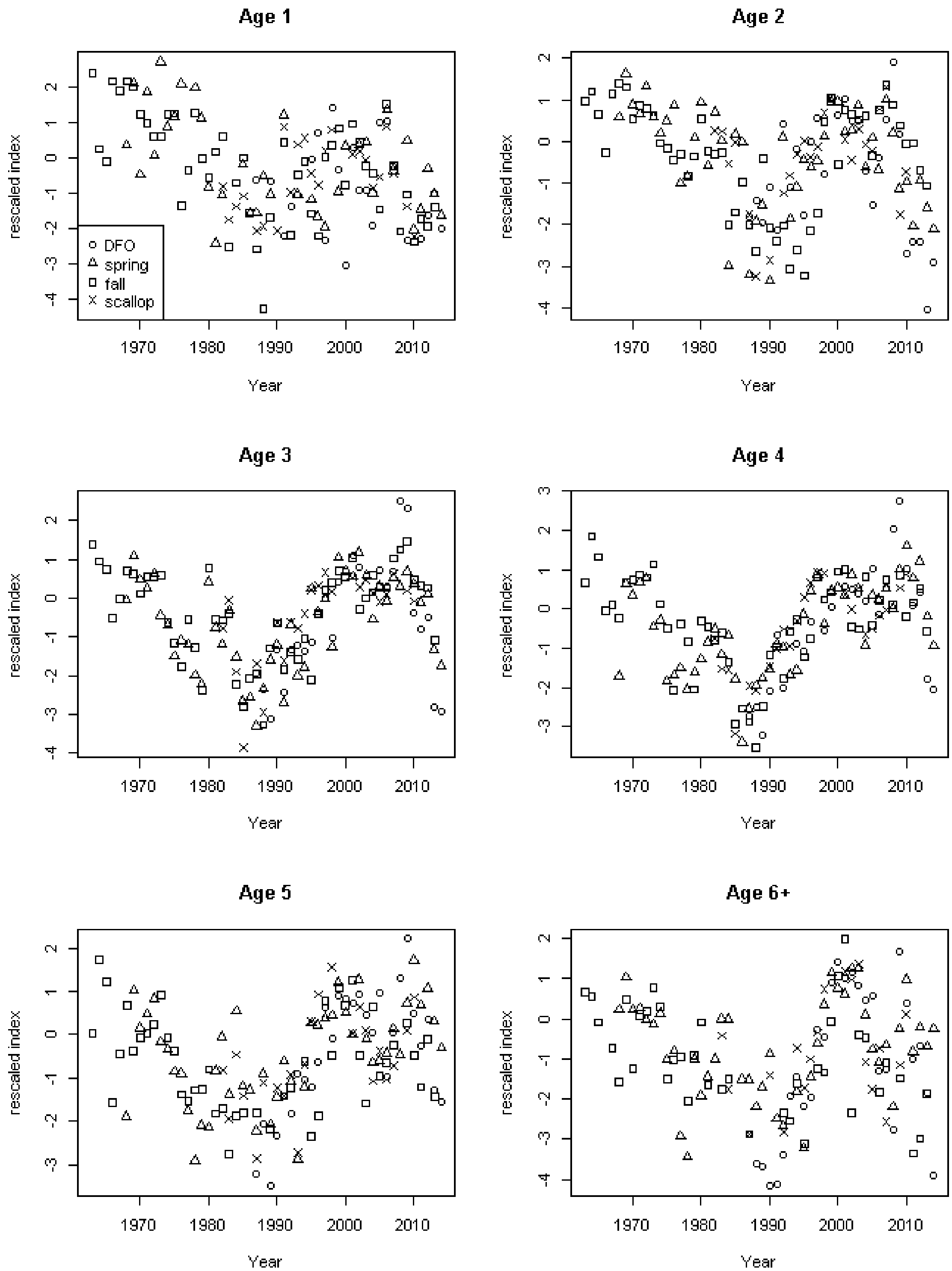


Figure 17a. Standardized catch/tow in numbers at age for the four surveys plotted on natural log scale. The standardization was merely the division of each index value by the mean of the associated time series. Circles denote the DFO survey, triangles the NEFSC spring survey, squares the NEFSC fall survey,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

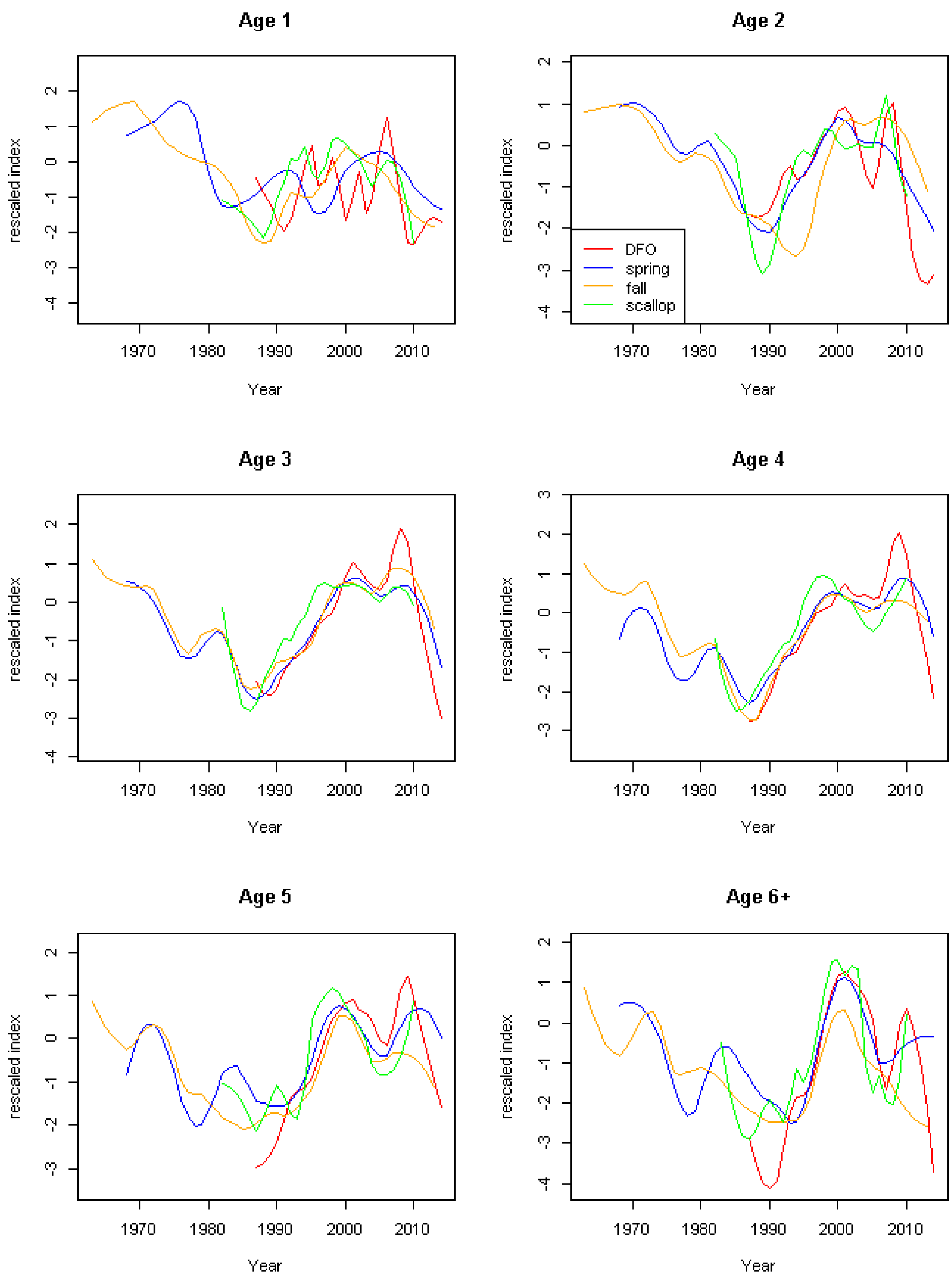


Figure 17b. Same as Figure 17a except the rescaled index values have been smoothed with a loess fit using 30% span to more clearly demonstrate similarities or differences among the surveys.

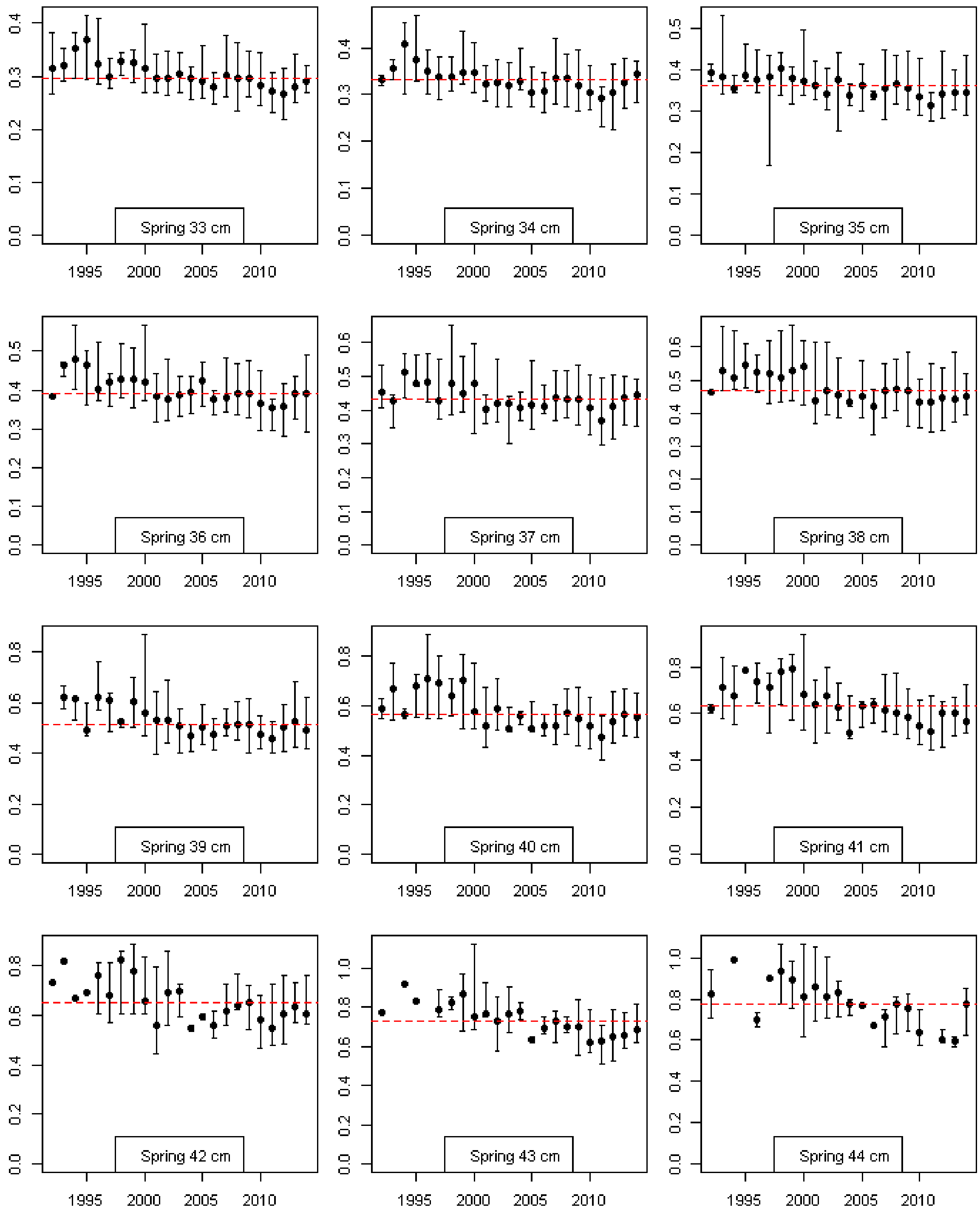


Figure 18a. Median and 2.5%ile and 97.5%ile of measured weight (kg) at length by year from the NEFSC spring survey. The horizontal dashed red line denotes the median of the medians.

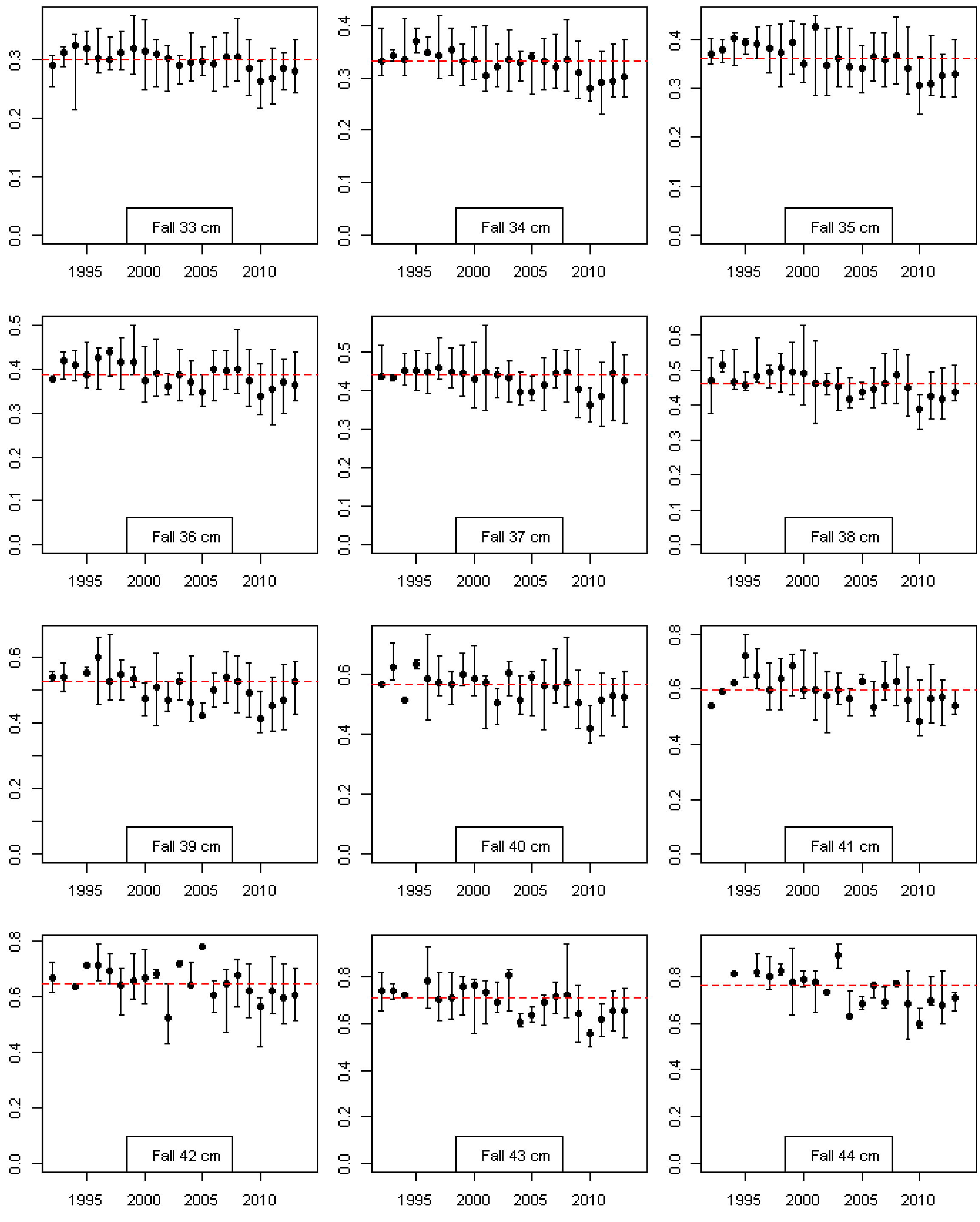


Figure 18b. Median and 2.5%ile and 97.5%ile of measured weight (kg) at length by year from the NEFSC fall survey. The horizontal dashed red line denotes the median of the medians.

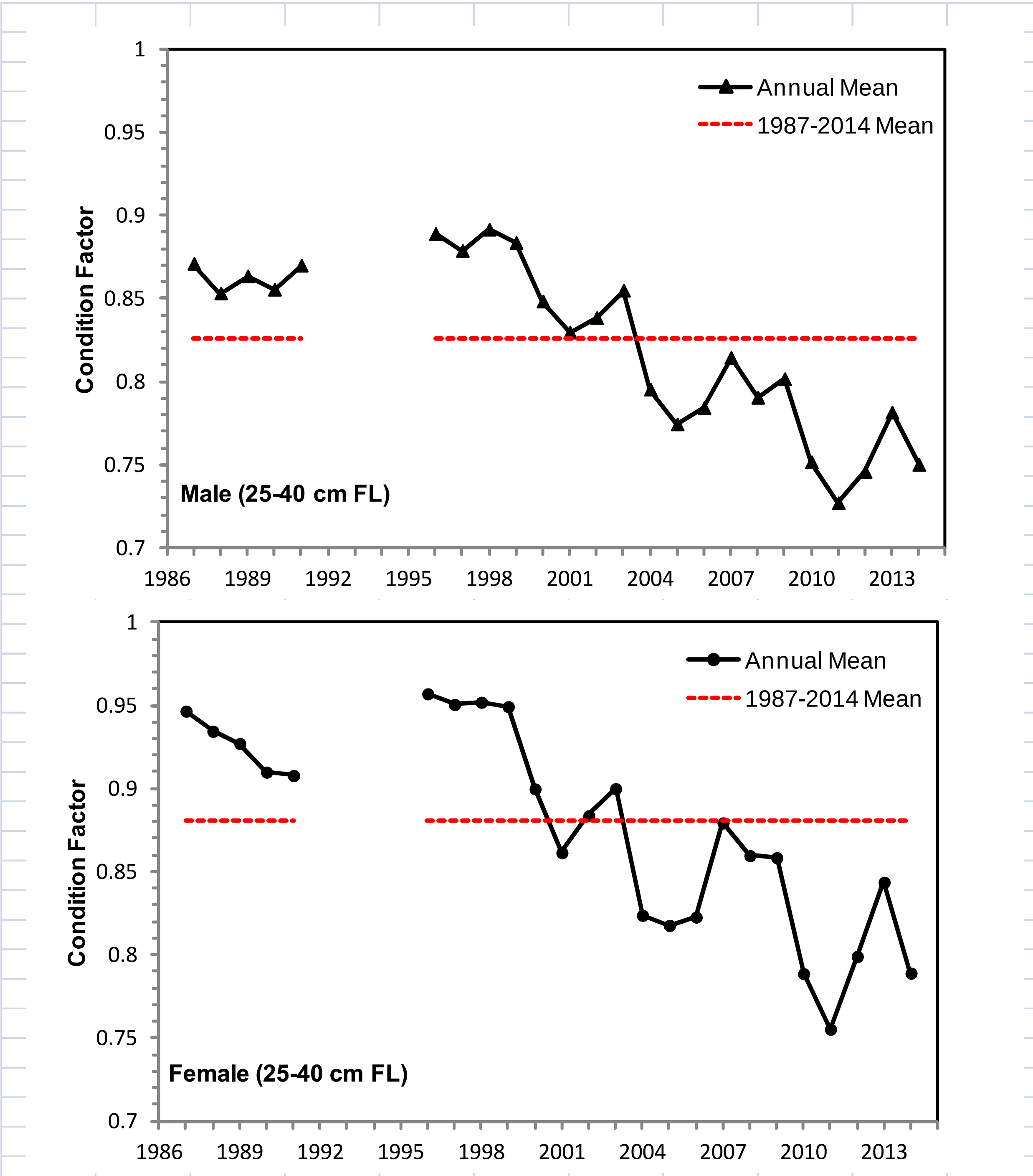


Figure 18c. Condition factor (Fulton's K) for male and female yellowtail flounder in the DFO survey.

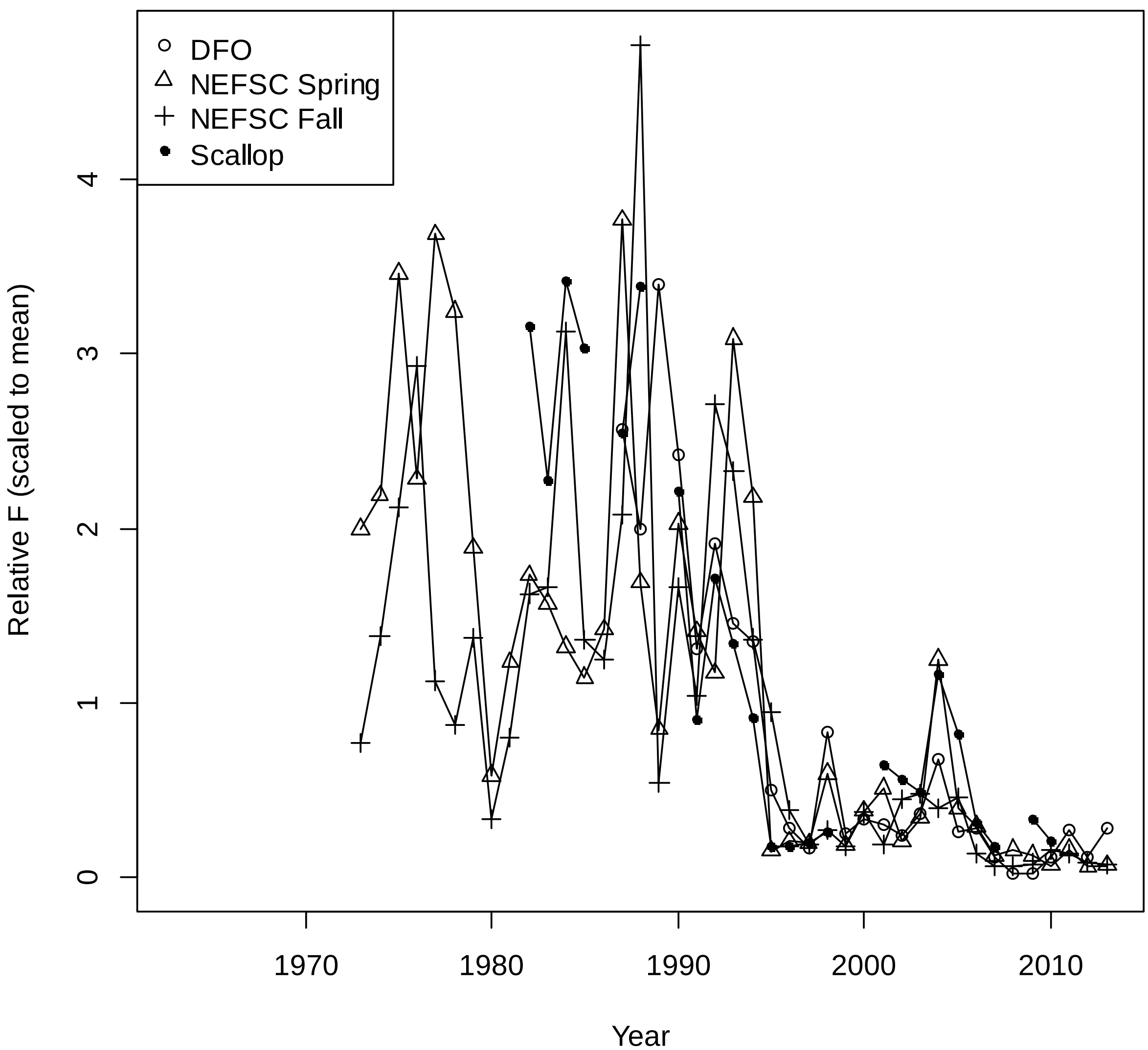


Figure 19. Trends in relative fishing mortality (catch biomass/survey biomass), standardized to the mean for 1987-2007.

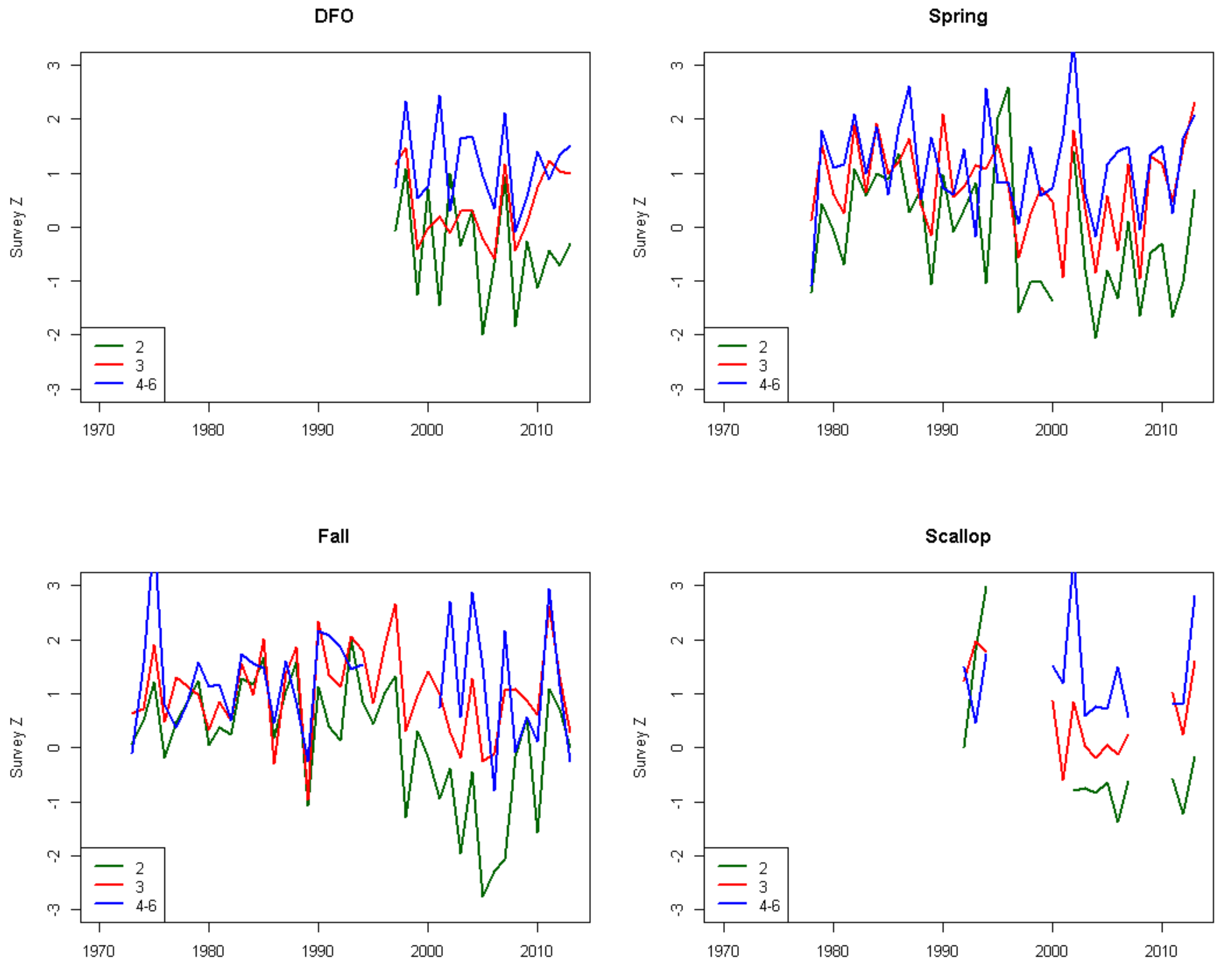


Figure 20. Trends in total mortality (Z) for ages 2, 3, and 4-6 from the four surveys.

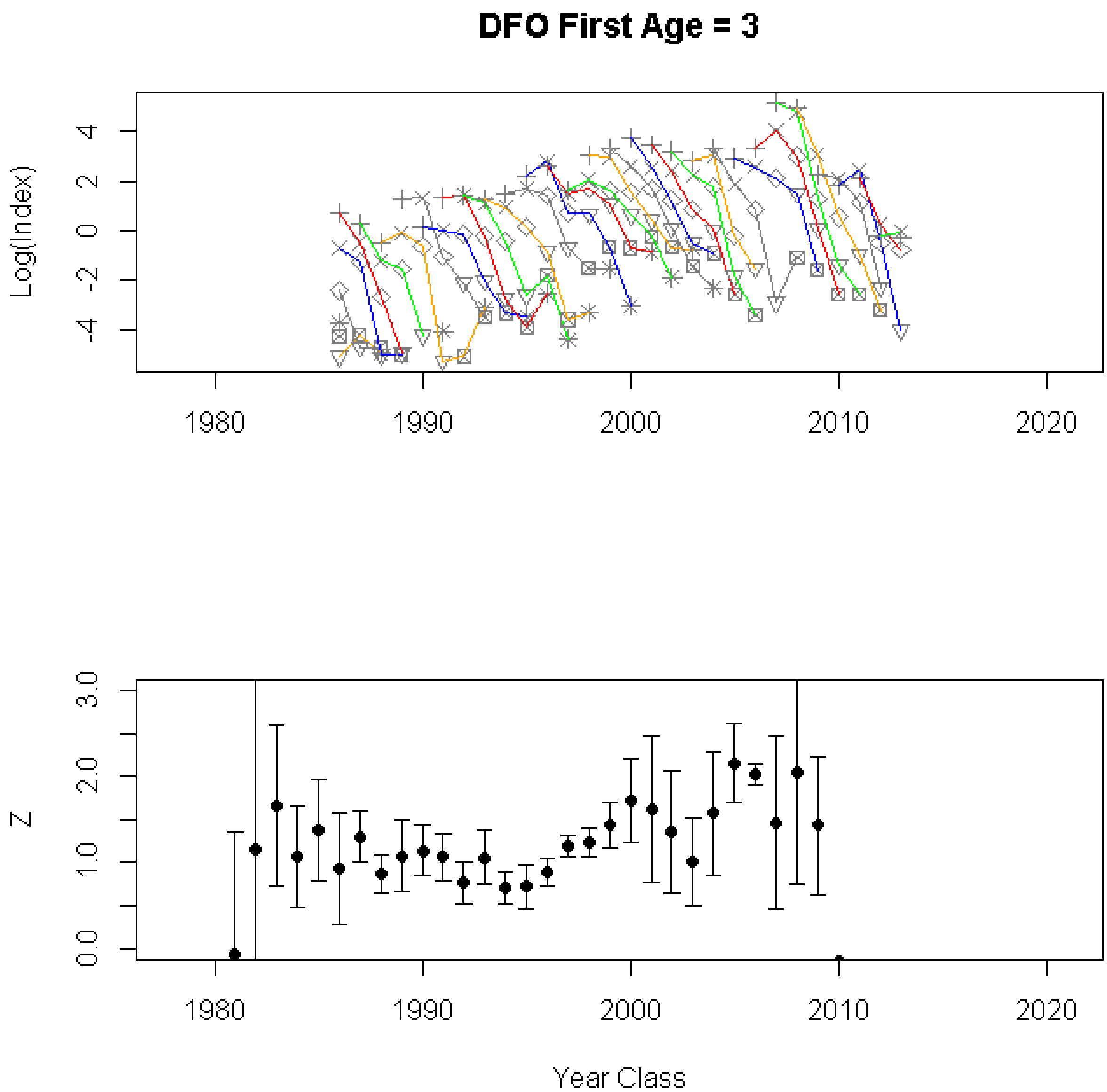


Figure 21a. Catch curve for DFO survey using age 3 as first age in Z calculation. Top panel shows log of survey catch at age, with symbols denoting ages and colored lines connecting cohorts. Bottom panel shows estimated total mortality rate (Z) from catch curve with 80% confidence interval by year class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

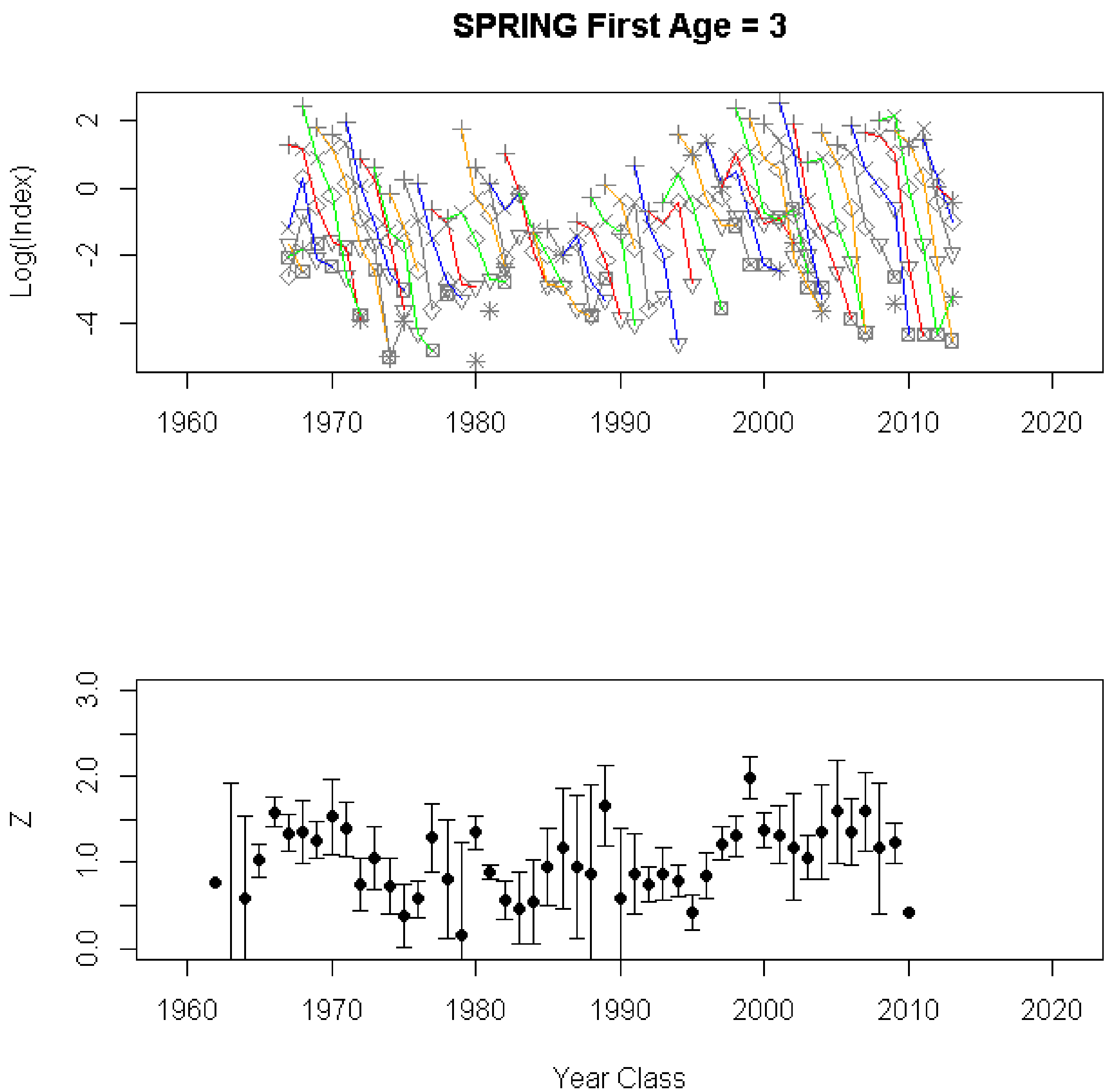


Figure 21b. Catch curve for NEFSC spring survey using age 3 as first age in Z calculation. Top panel shows log of survey catch at age, with symbols denoting ages and colored lines connecting cohorts. Bottom panel shows estimated total mortality rate (Z) from catch curve with 80% confidence interval by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

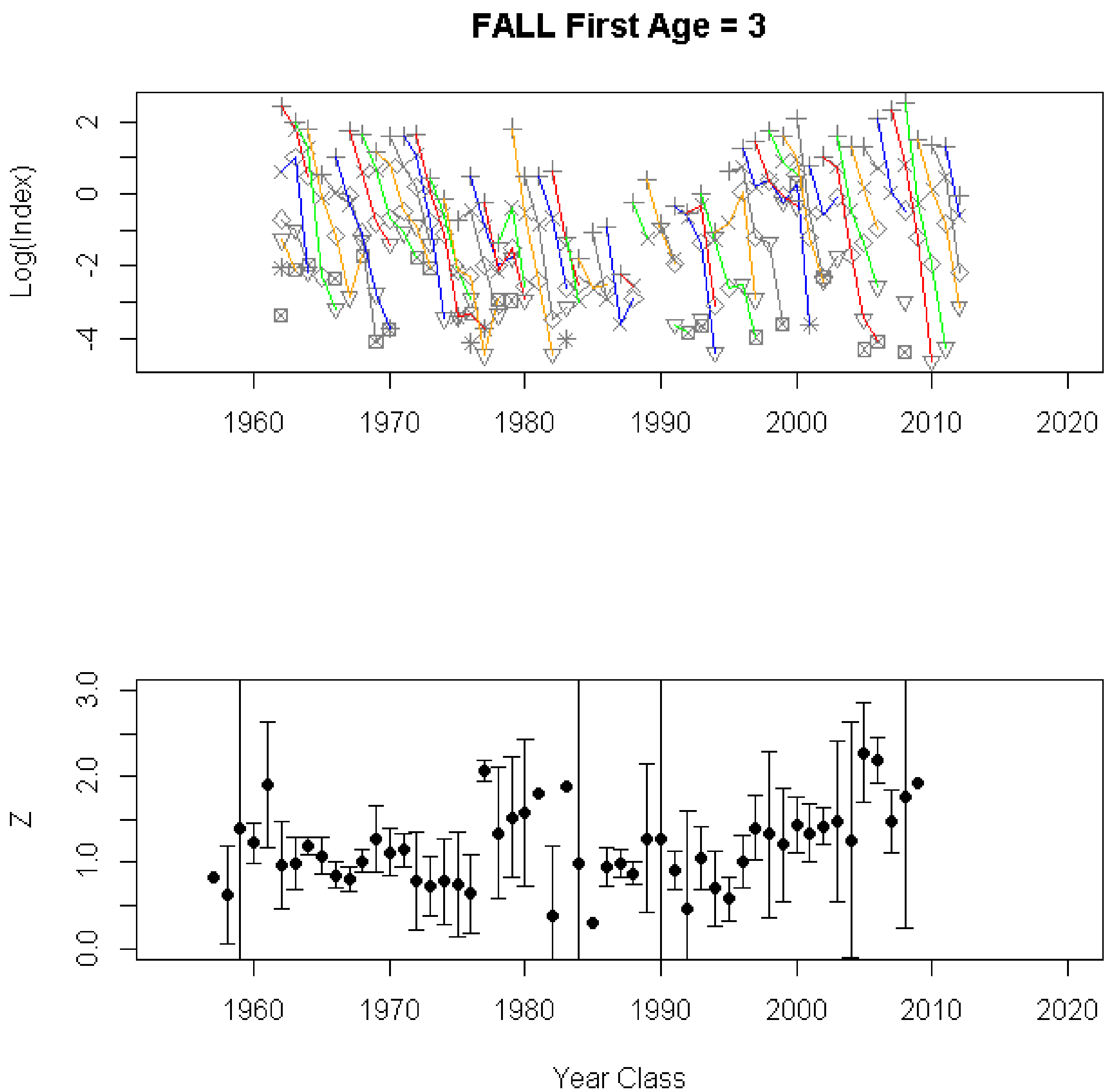


Figure 21c. Catch curve for NEFSC fall survey using age 3 as first age in Z calculation. Top panel shows log of survey catch at age, with symbols denoting ages and colored lines connecting cohorts. Bottom panel shows estimated total mortality rate (Z) from catch curve with 80% confidence interval by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

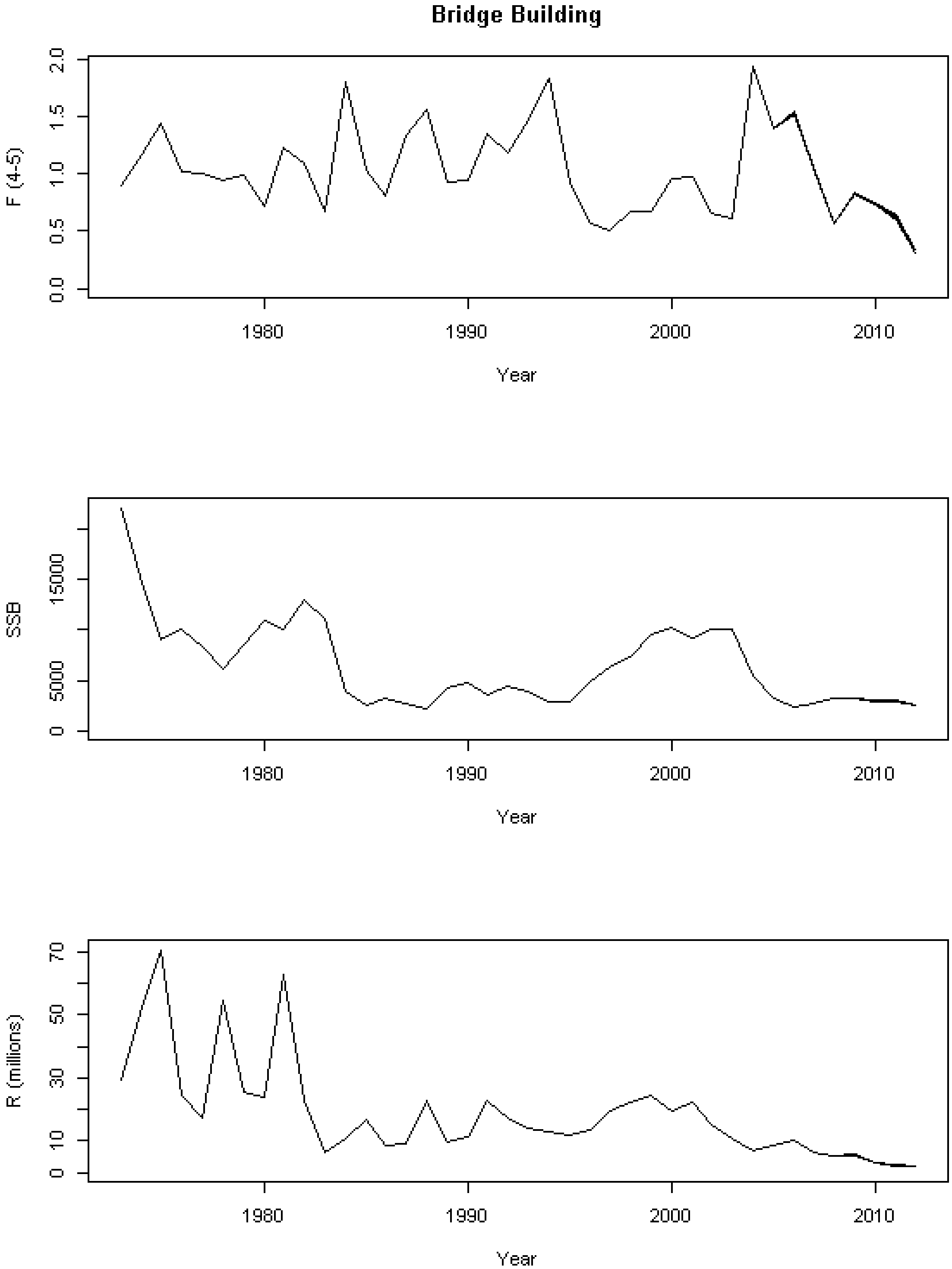


Figure 22. Fishing mortality rate (ages 4+, top panel), spawning stock biomass (mt, middle panel) and recruitment (millions of age 1 fish, bottom panel) for the TRAC 2013 assessment and updates to the data (see text: Building the Bridge). There are four lines in each panel.

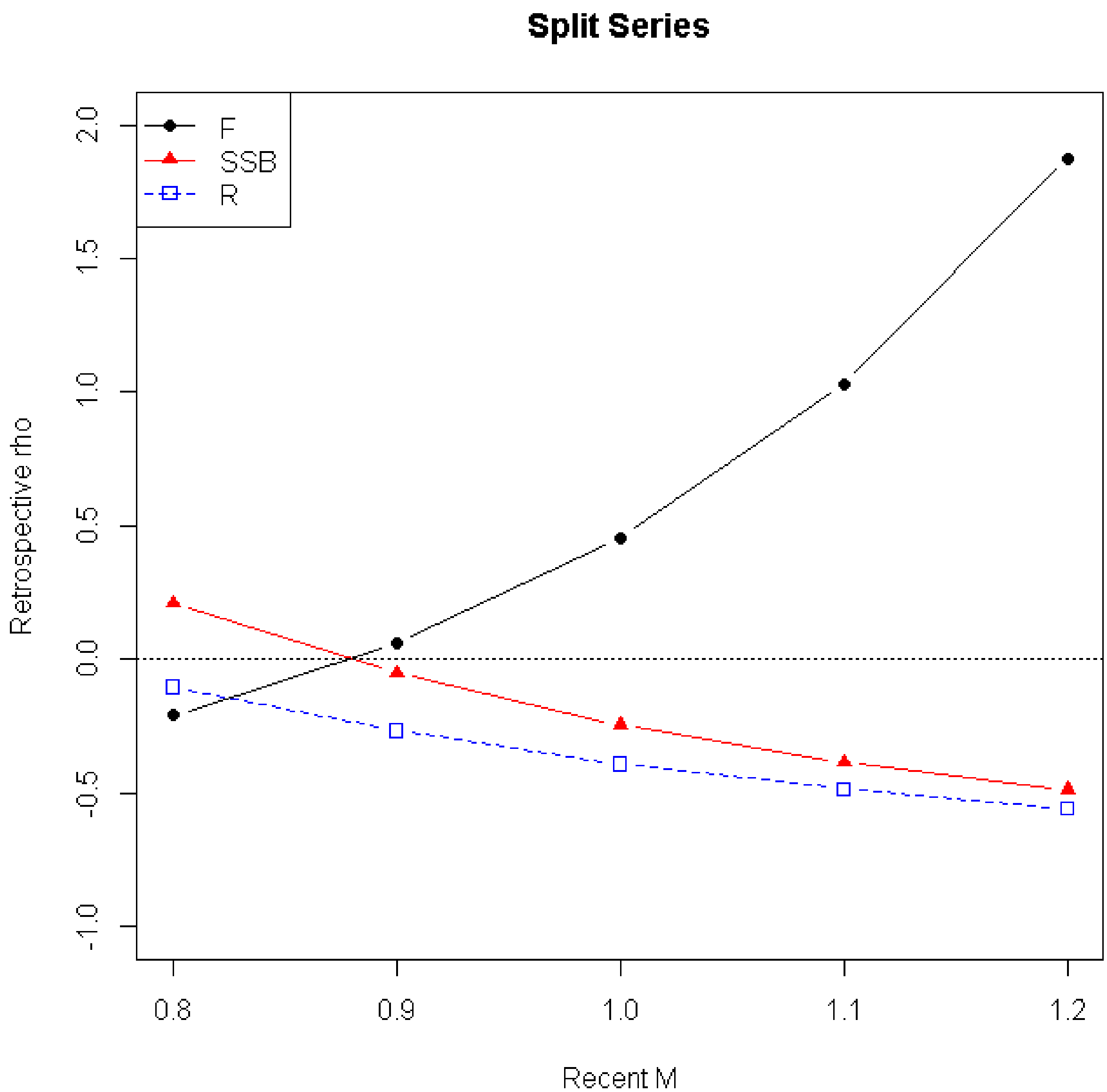


Figure 23a. Retrospective rho values for F, SSB, and R for the Split Series VPA with M=0.4 and recent M beginning in 2005.

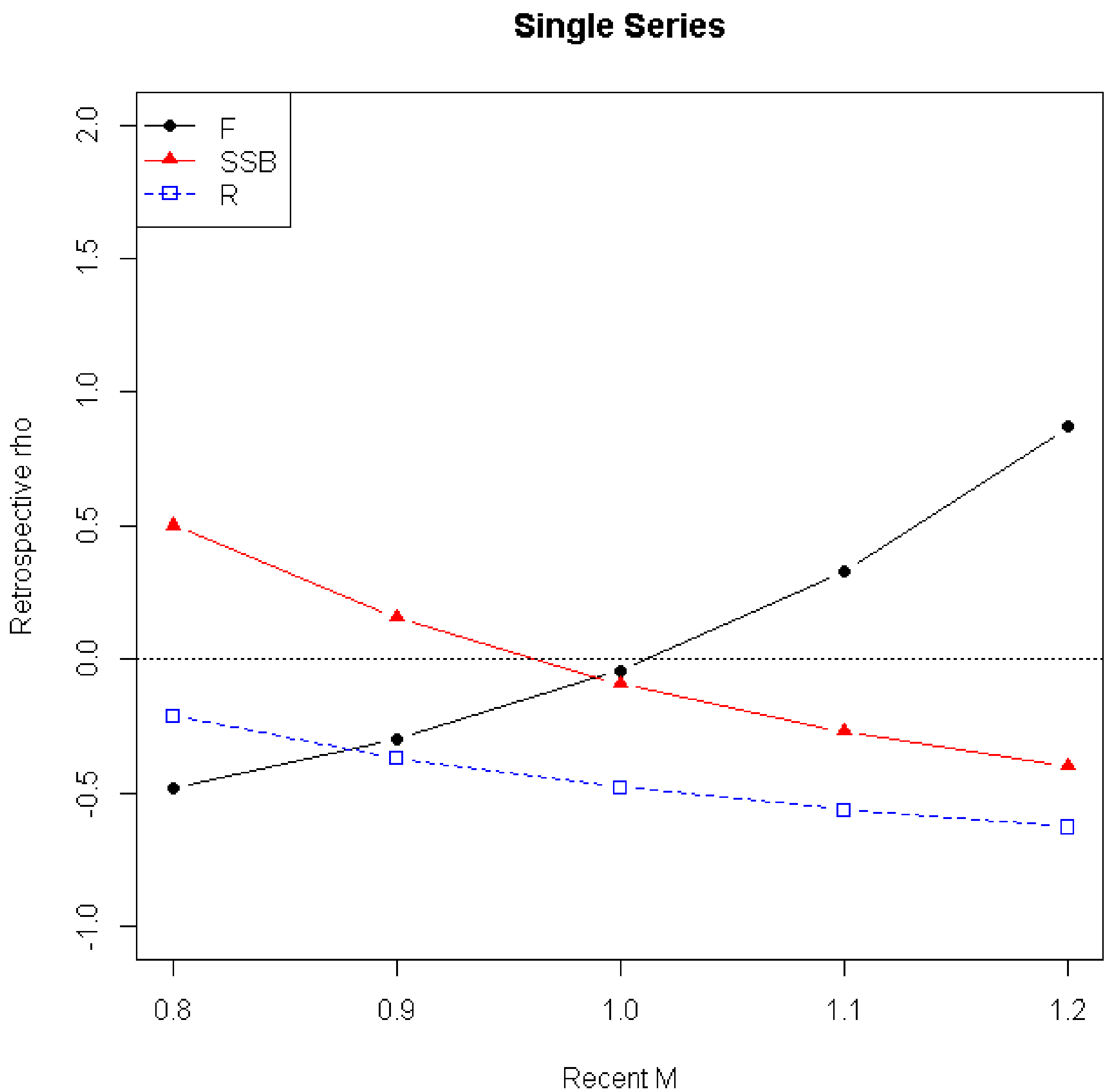


Figure 23b. Retrospective rho values for F, SSB, and R for the Single Series VPA with M=0.4 and recent M beginning in 2005.

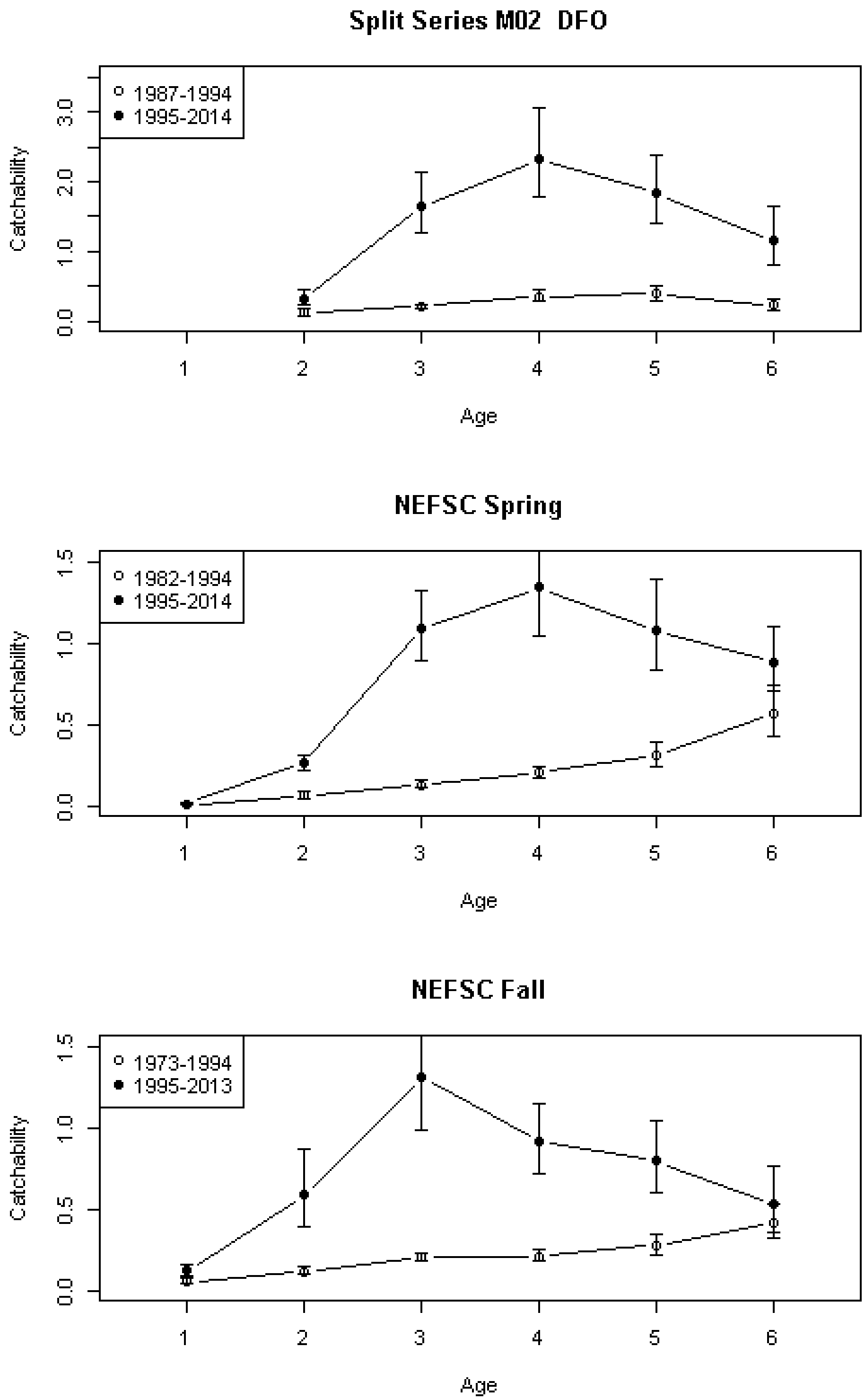


Figure 24a. Catchability coefficients (q) from the Split Series M02 VPA with bootstrapped 80% confidence intervals.

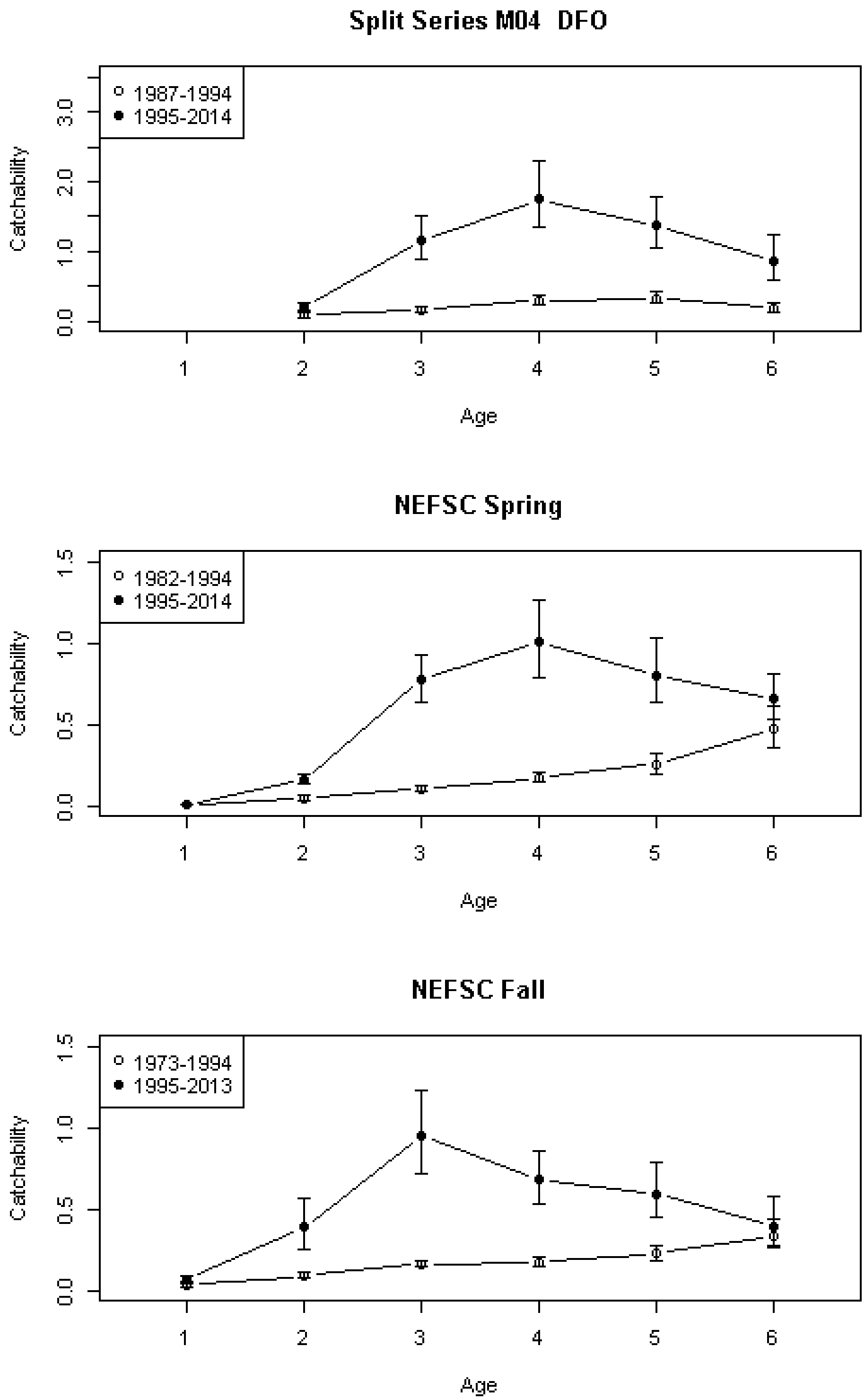


Figure 24b. Catchability coefficients (q) from the Split Series M04 VPA with bootstrapped 80% confidence intervals.

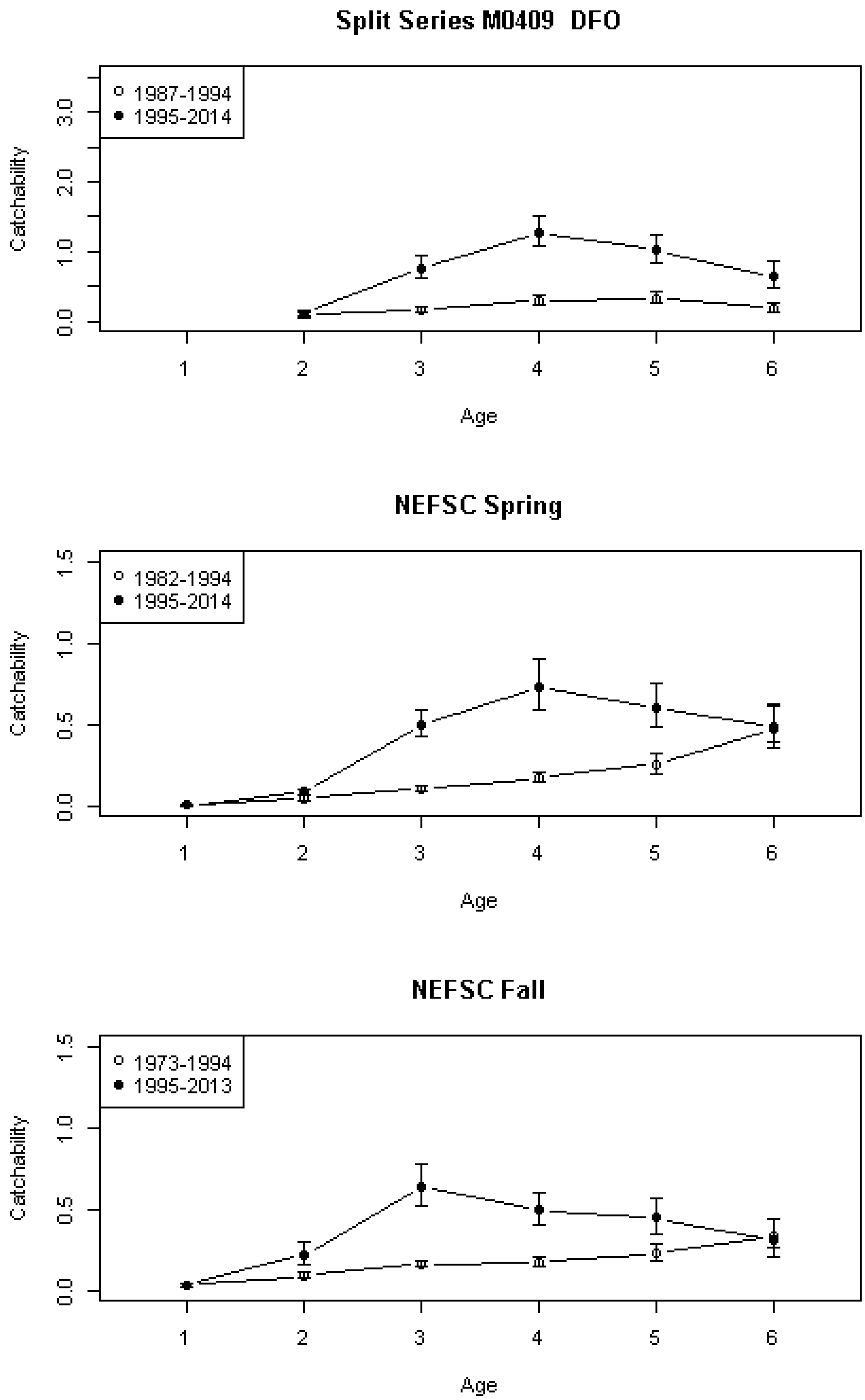


Figure 24c. Catchability coefficients (q) from the Split Series M0409 VPA with bootstrapped 80% confidence intervals.

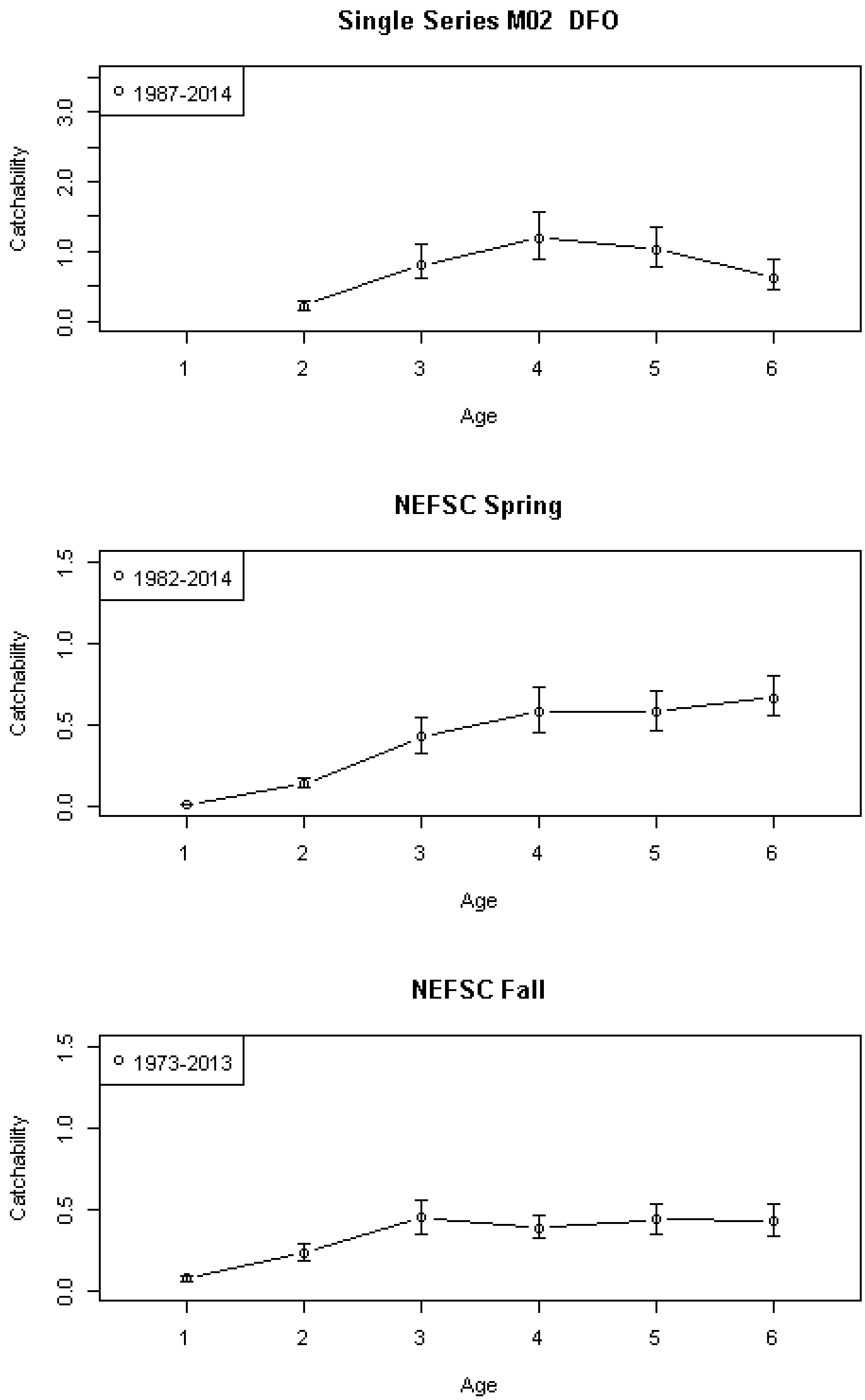


Figure 24d. Catchability coefficients (q) from the Single Series M02 VPA with bootstrapped 80% confidence intervals.

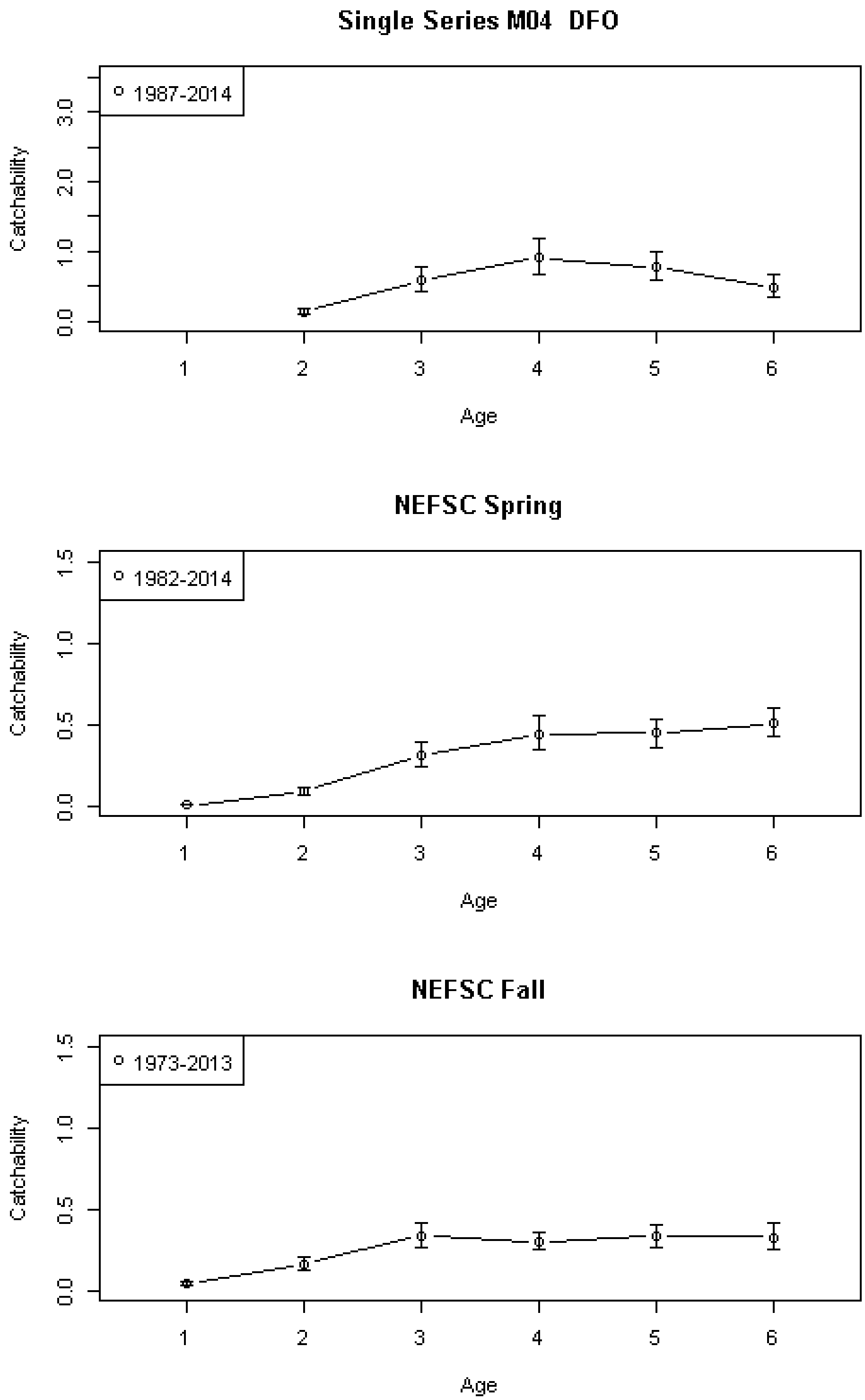


Figure 24e. Catchability coefficients (q) from the Single Series M04 VPA with bootstrapped 80% confidence intervals.

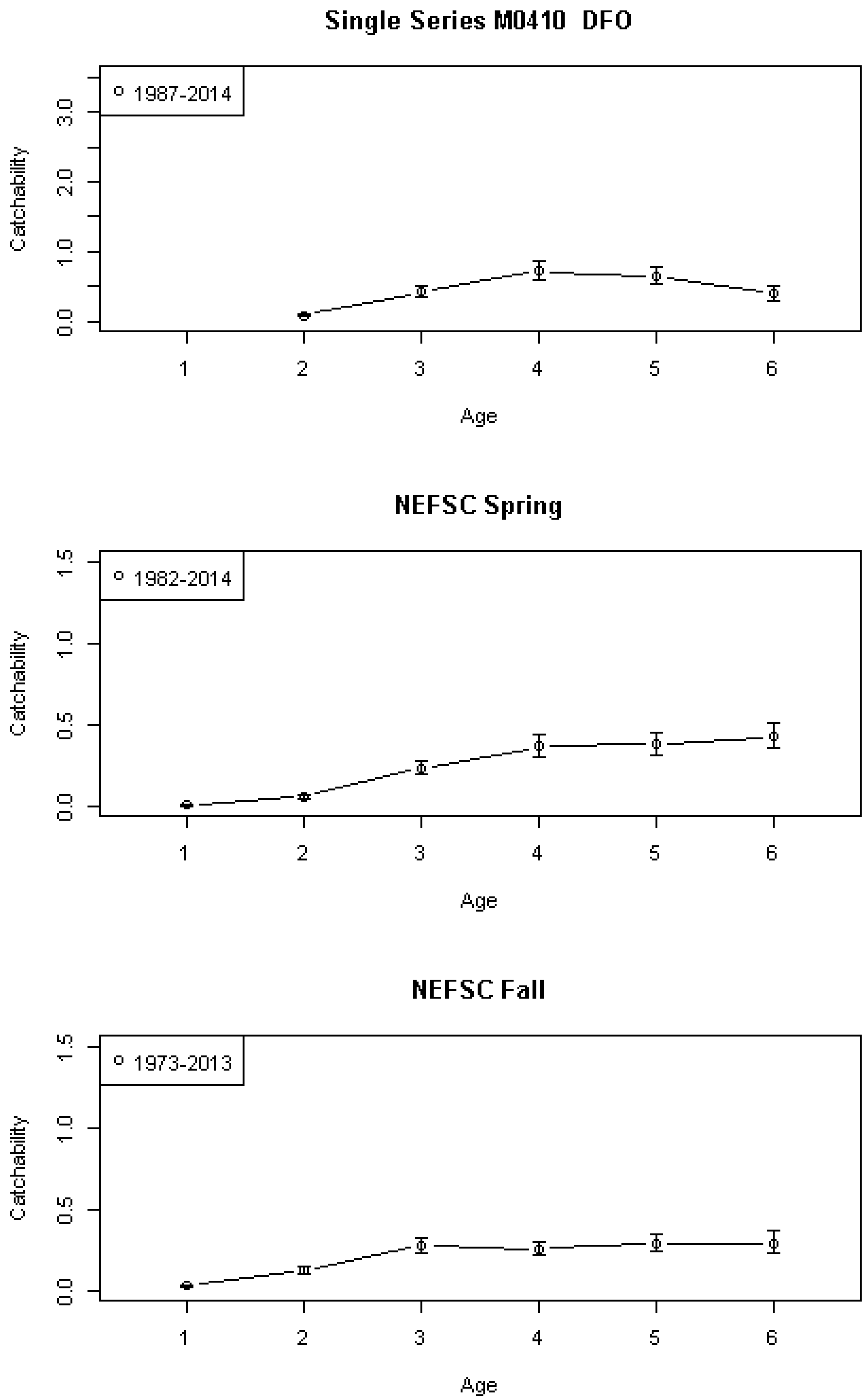


Figure 24f. Catchability coefficients (q) from the Single Series M0410 VPA with bootstrapped 80% confidence intervals.

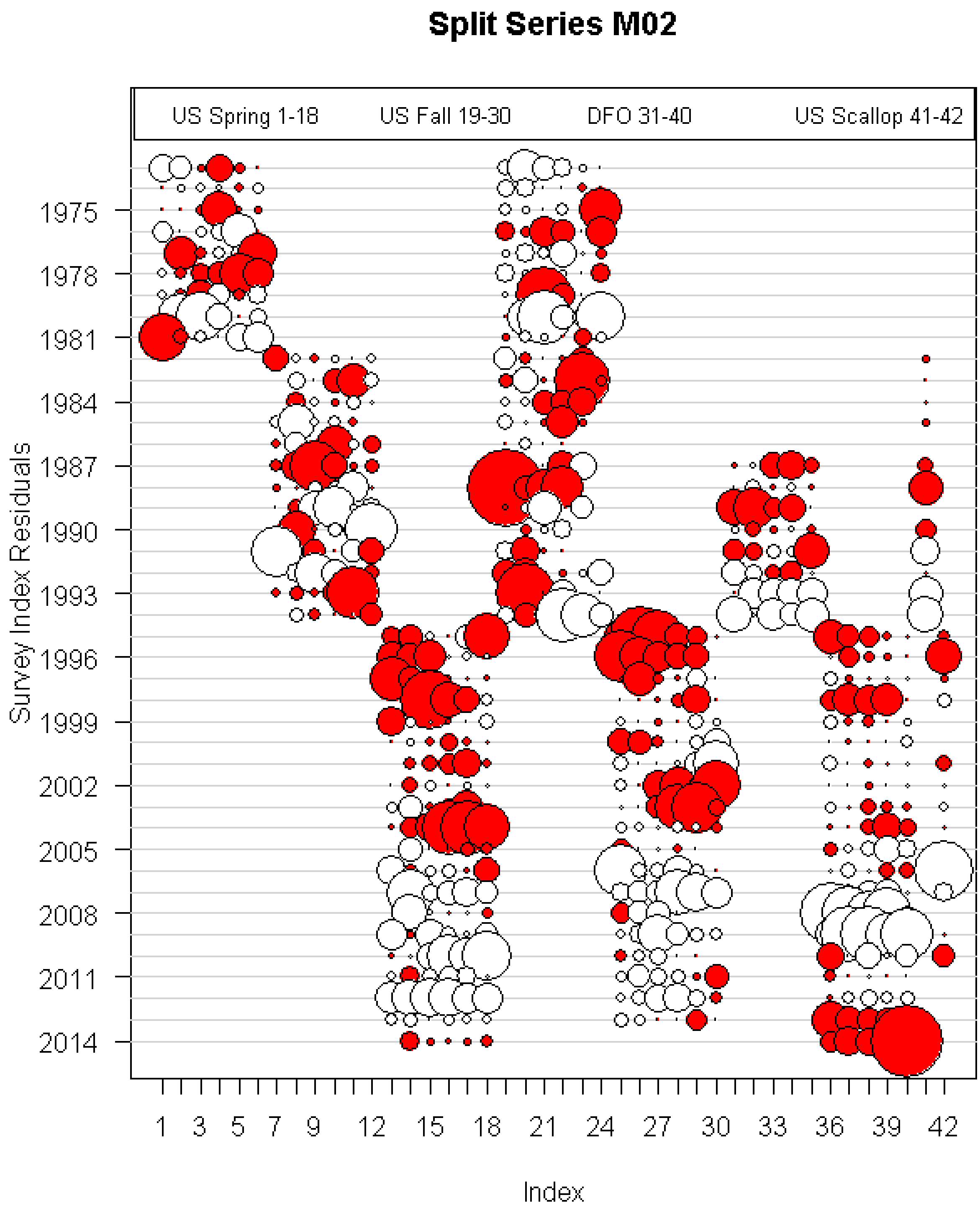


Figure 25a. Age by age residuals from the Split Series M02 VPA for log scale predicted minus observed population abundances, Georges Bank yellowtail flounder (bubble size is proportional to magnitude). The red symbols denote negative residuals, and white symbols denote positive residuals.

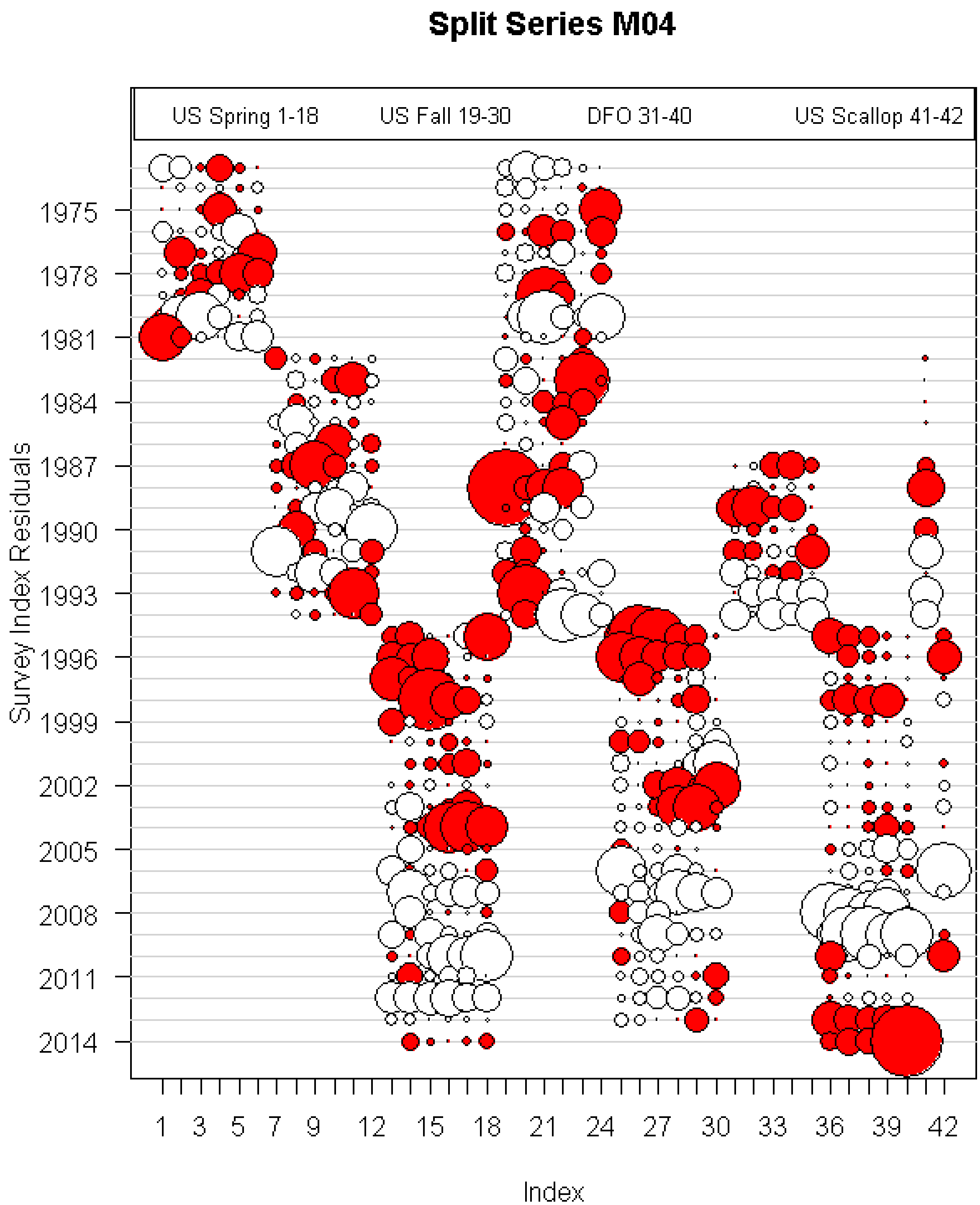


Figure 25b. Age by age residuals from the Split Series M04 VPA for log scale predicted minus observed population abundances, Georges Bank yellowtail flounder (bubble size is proportional to magnitude). The red symbols denote negative residuals, and white symbols denote positive residuals.

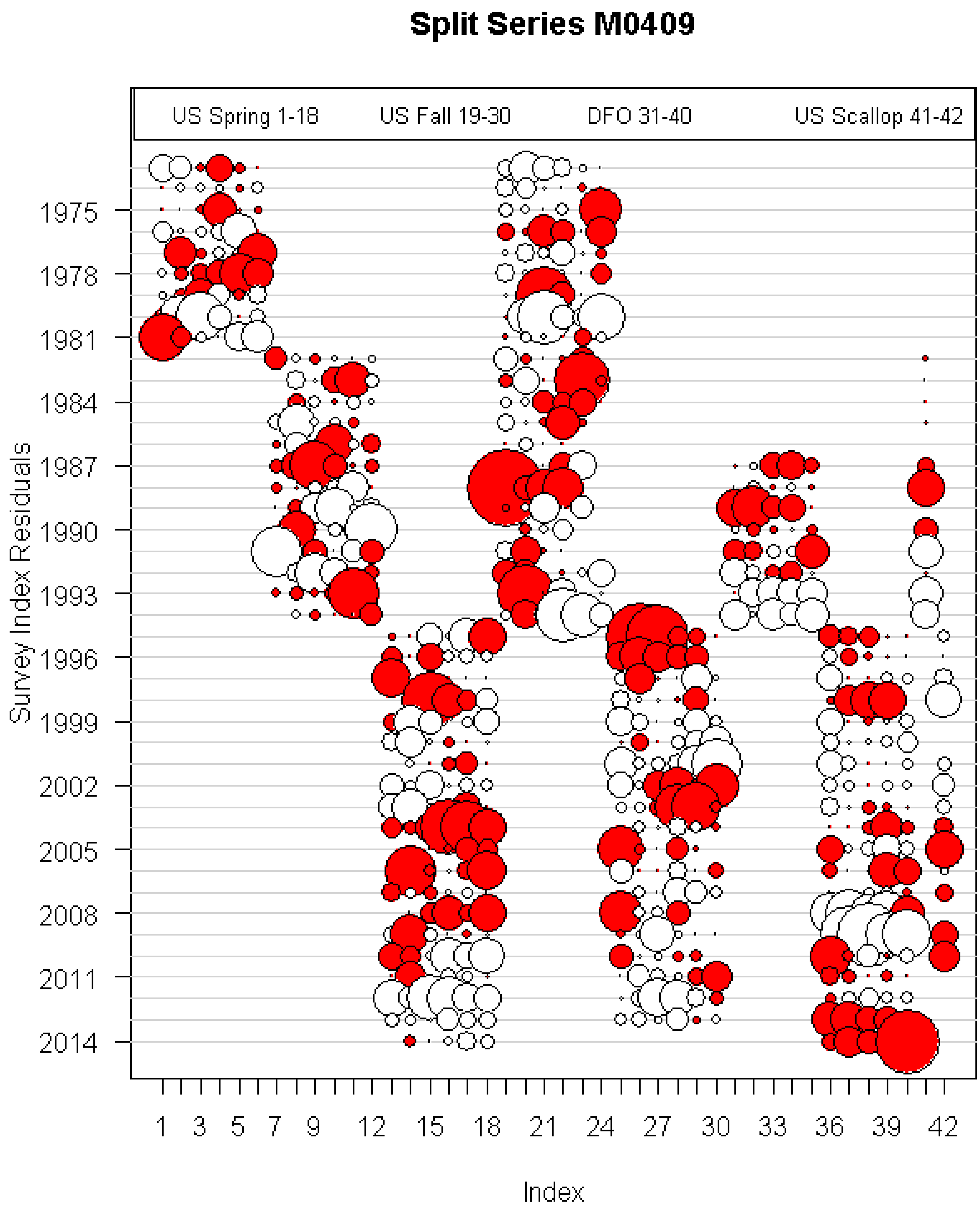


Figure 25c. Age by age residuals from the Split Series M0409 VPA for log scale predicted minus observed population abundances, Georges Bank yellowtail flounder (bubble size is proportional to magnitude). The red symbols denote negative residuals, and white symbols denote positive residuals.

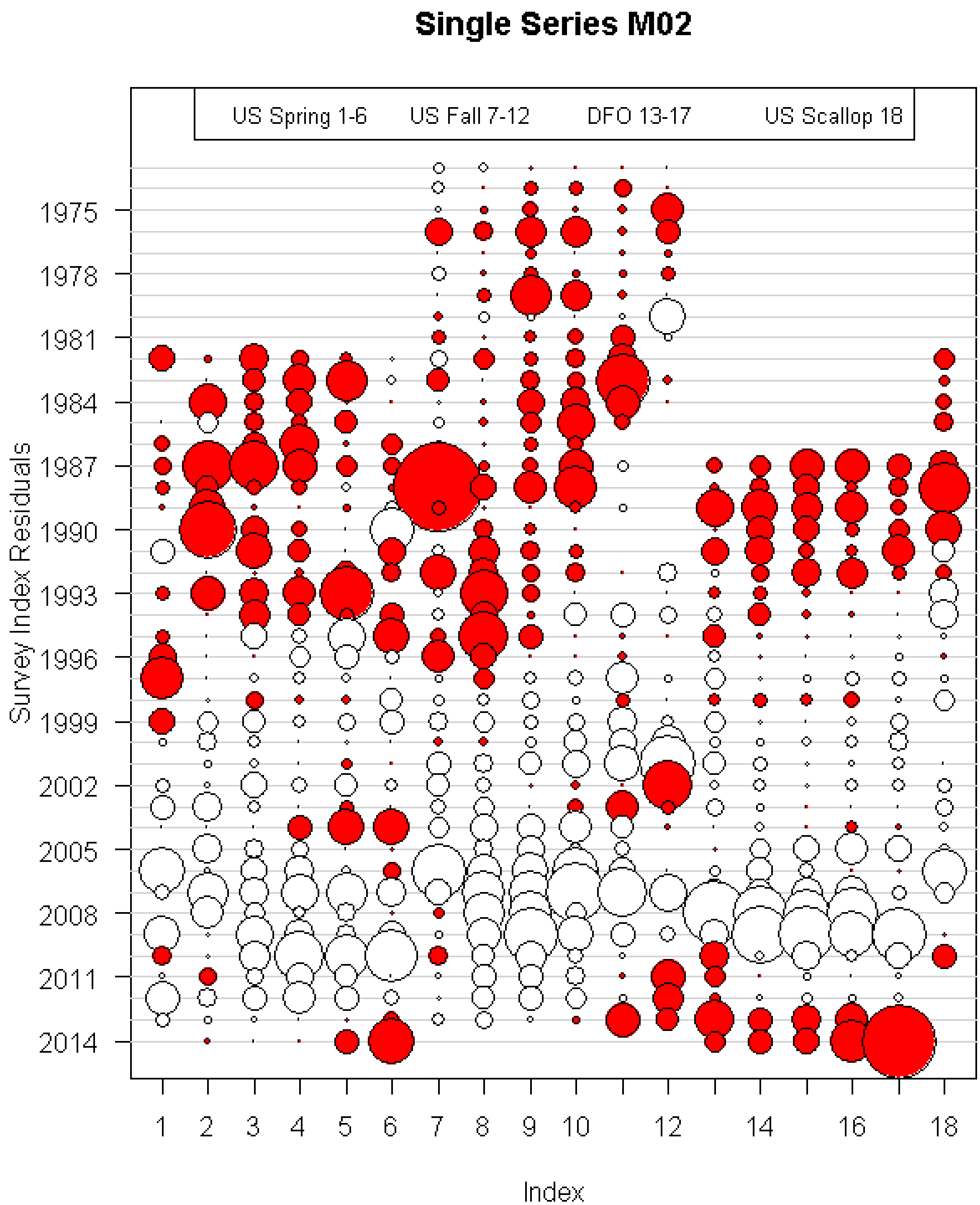


Figure 25d. Age by age residuals from the Single Series M02 VPA for log scale predicted minus observed population abundances, Georges Bank yellowtail flounder (bubble size is proportional to magnitude). The red symbols denote negative residuals, and white symbols denote positive residuals.

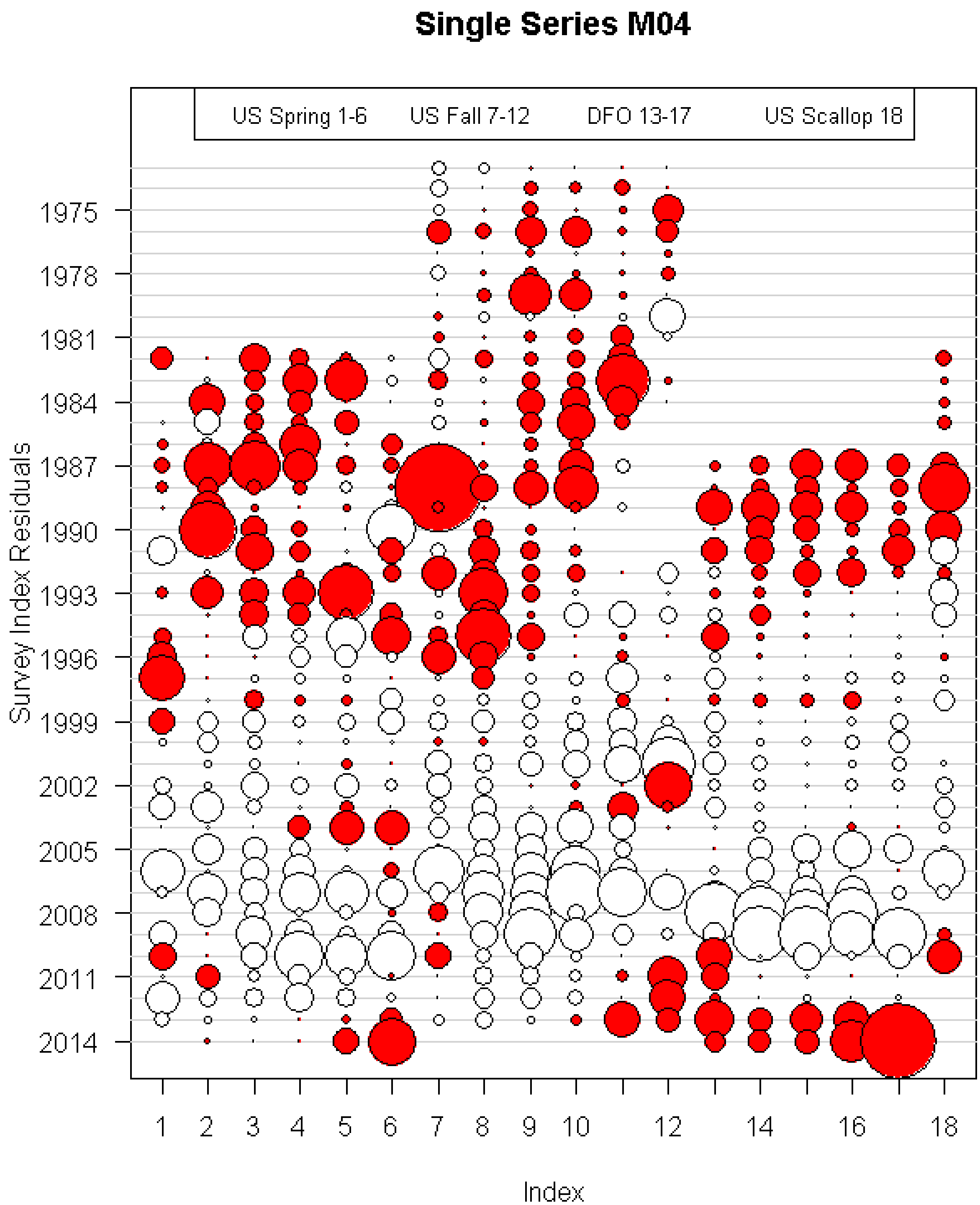


Figure 25e. Age by age residuals from the Single Series M04 VPA for log scale predicted minus observed population abundances, Georges Bank yellowtail flounder (bubble size is proportional to magnitude). The red symbols denote negative residuals, and white symbols denote positive residuals.

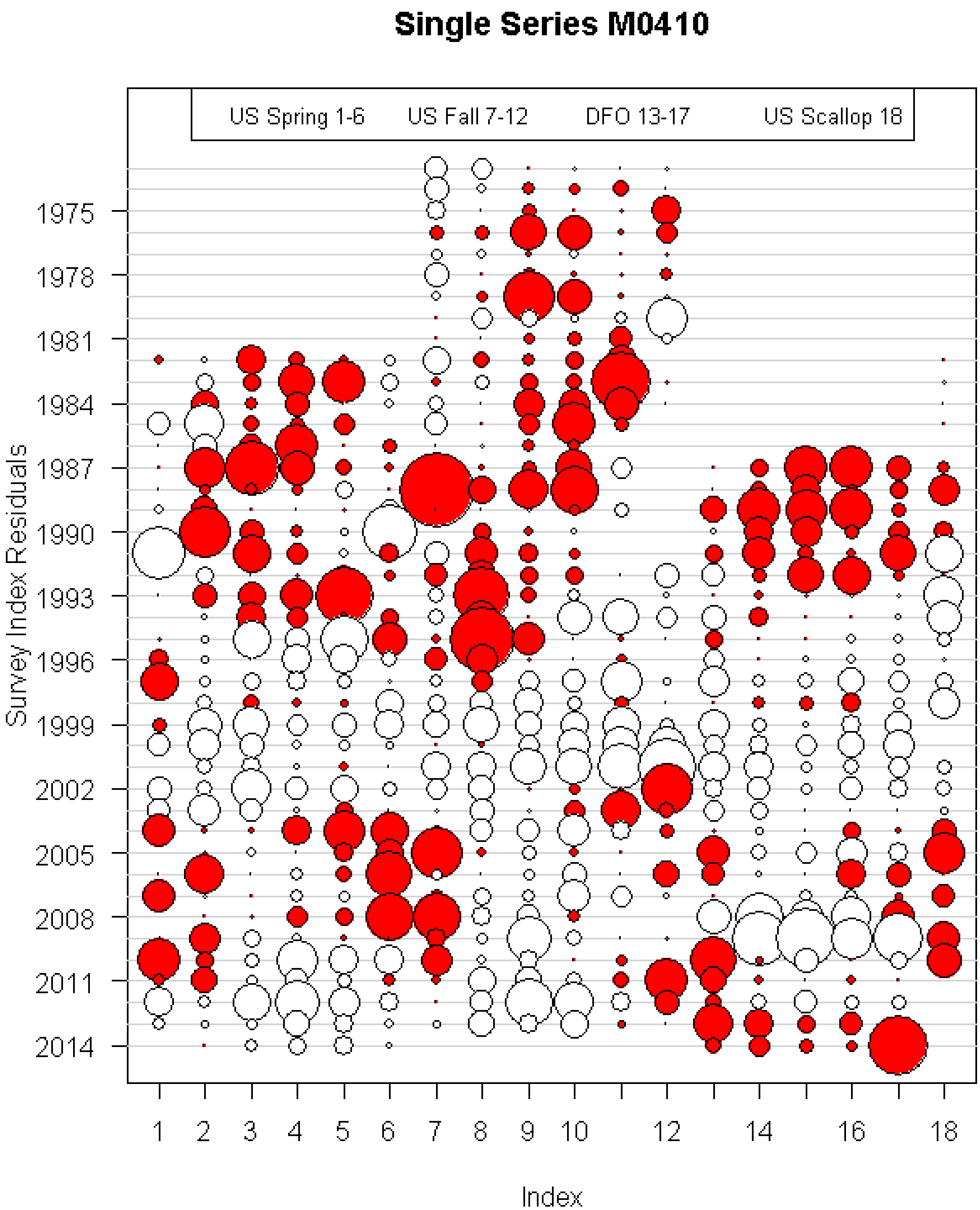


Figure 25f. Age by age residuals from the Single Series M0410 VPA for log scale predicted minus observed population abundances, Georges Bank yellowtail flounder (bubble size is proportional to magnitude). The red symbols denote negative residuals, and white symbols denote positive residuals.

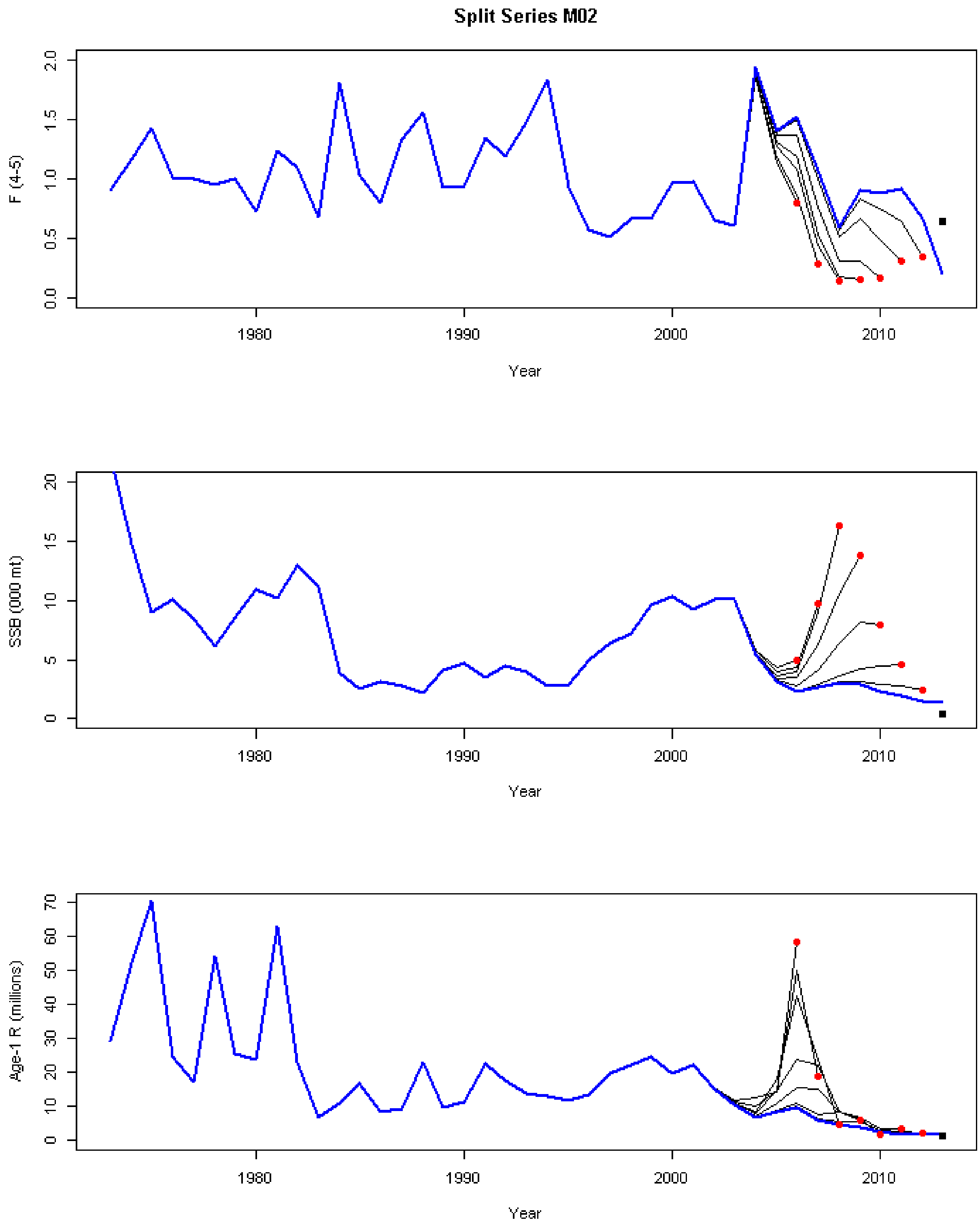


Figure 26a. Retrospective analysis of Georges Bank yellowtail flounder from the Split Series M02 VPA for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel). The black squares show the rho adjusted values for 2013.

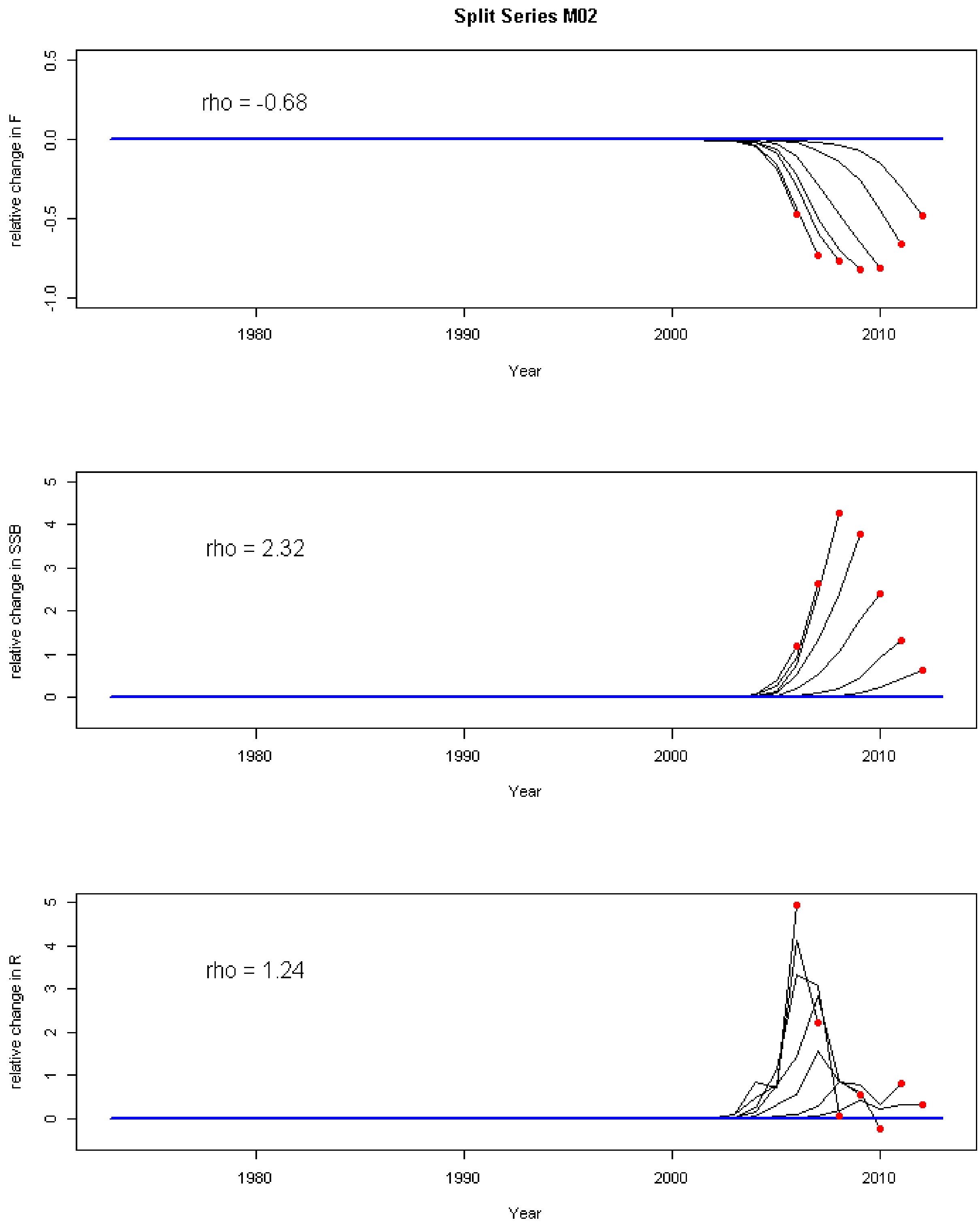


Figure 26b. Relative retrospective plots for Georges Bank yellowtail flounder from Split Series M02 VPA with Mohn's rho calculated from seven year peel for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel).

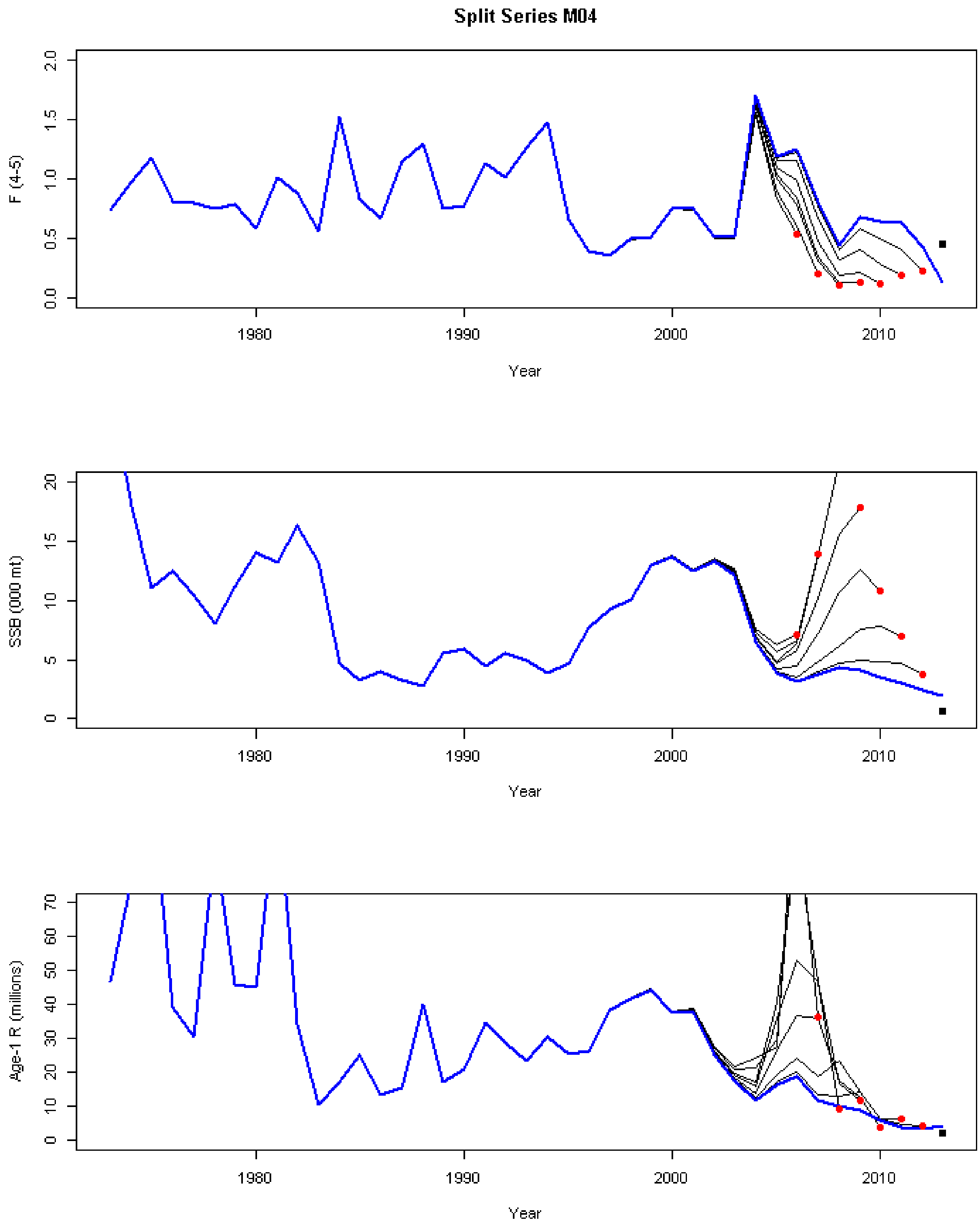


Figure 26c. Retrospective analysis of Georges Bank yellowtail flounder from the Split Series M04 VPA for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel). The black squares show the rho adjusted values for 2013.

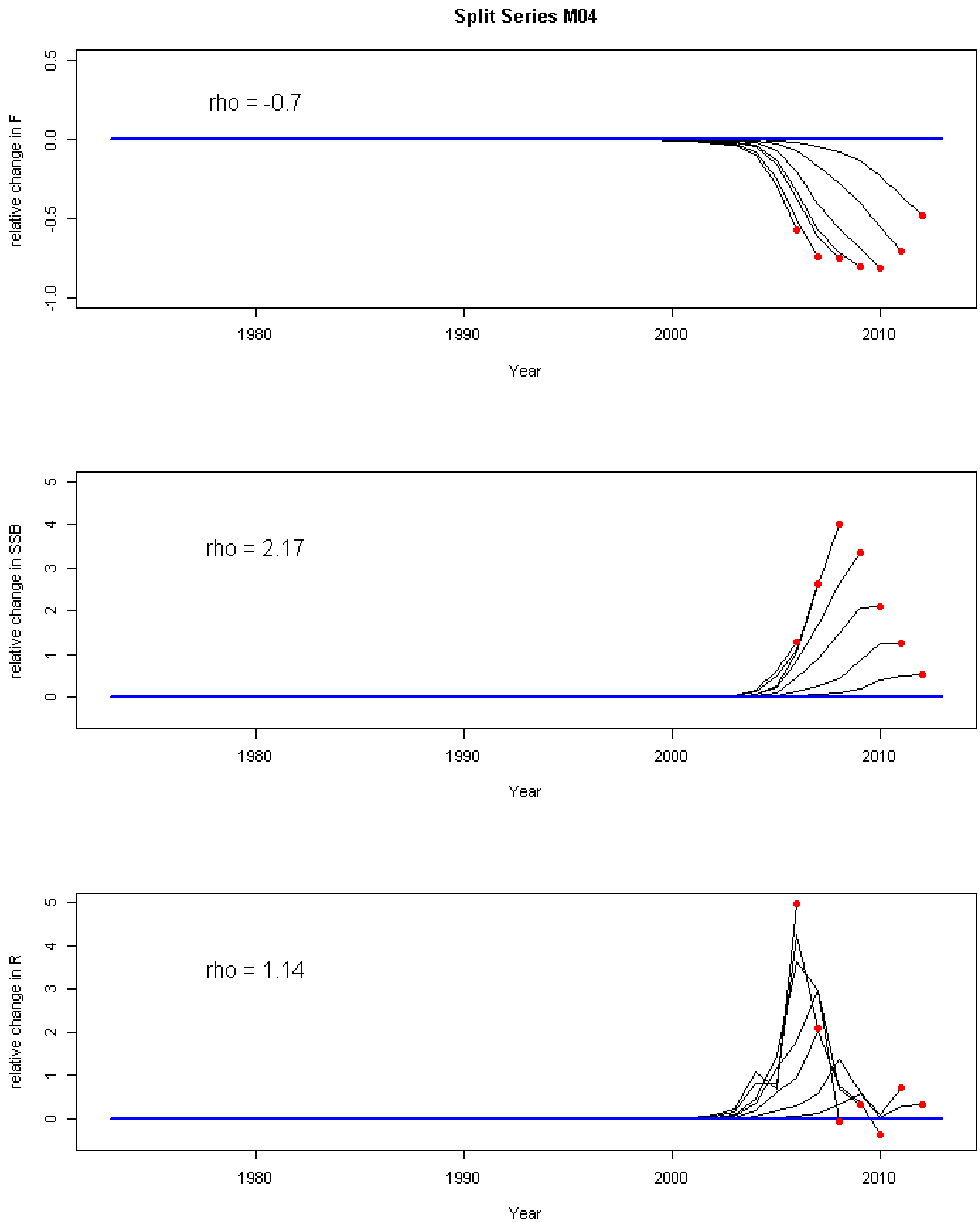


Figure 26d. Relative retrospective plots for Georges Bank yellowtail flounder from Split Series M04 VPA with Mohn's rho calculated from seven year peel for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel).

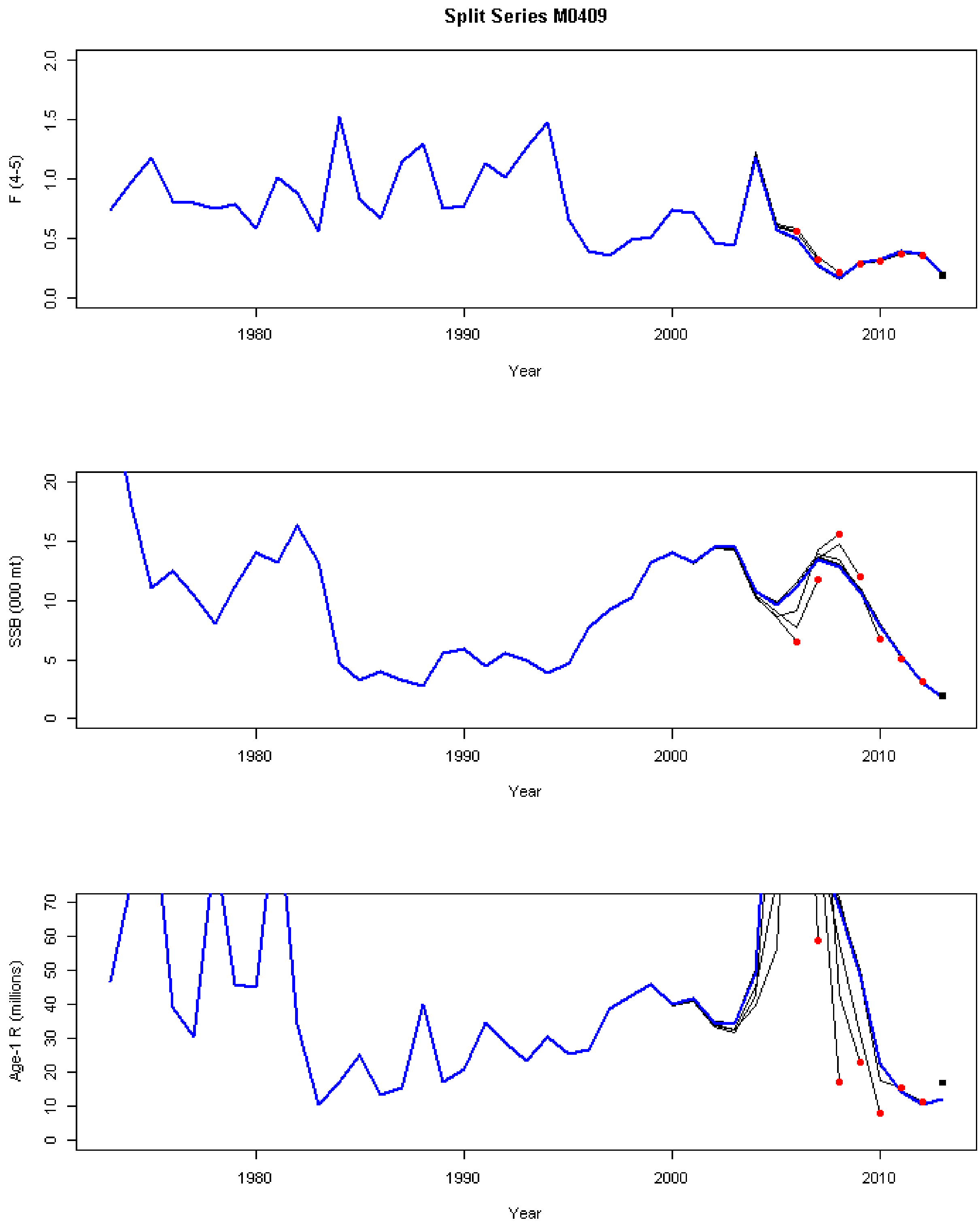


Figure 26e. Retrospective analysis of Georges Bank yellowtail flounder from the Split Series M0409 VPA for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel). The black squares show the rho adjusted values for 2013.

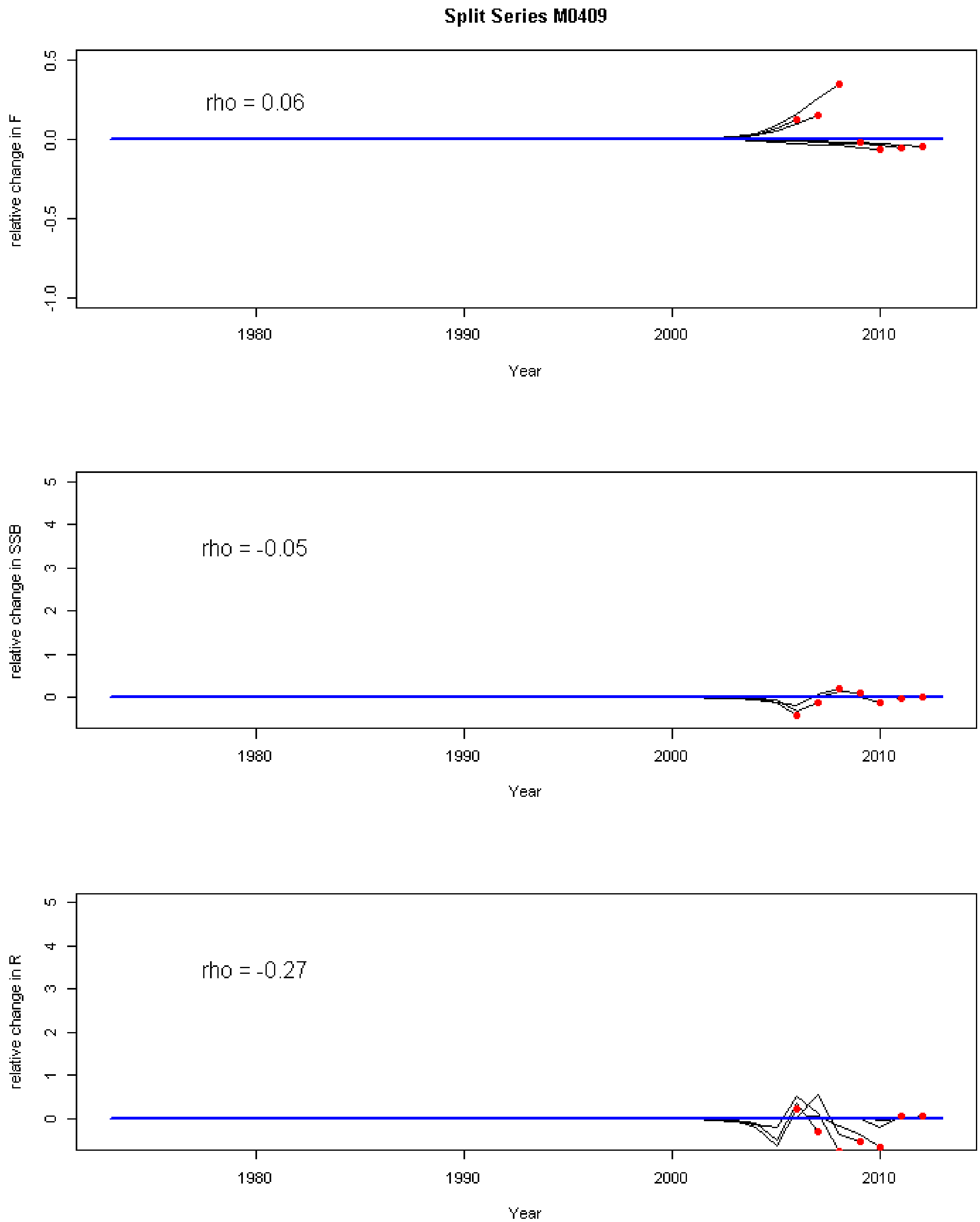


Figure 26f. Relative retrospective plots for Georges Bank yellowtail flounder from Split Series M0409 VPA with Mohn's rho calculated from seven year peel for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel).

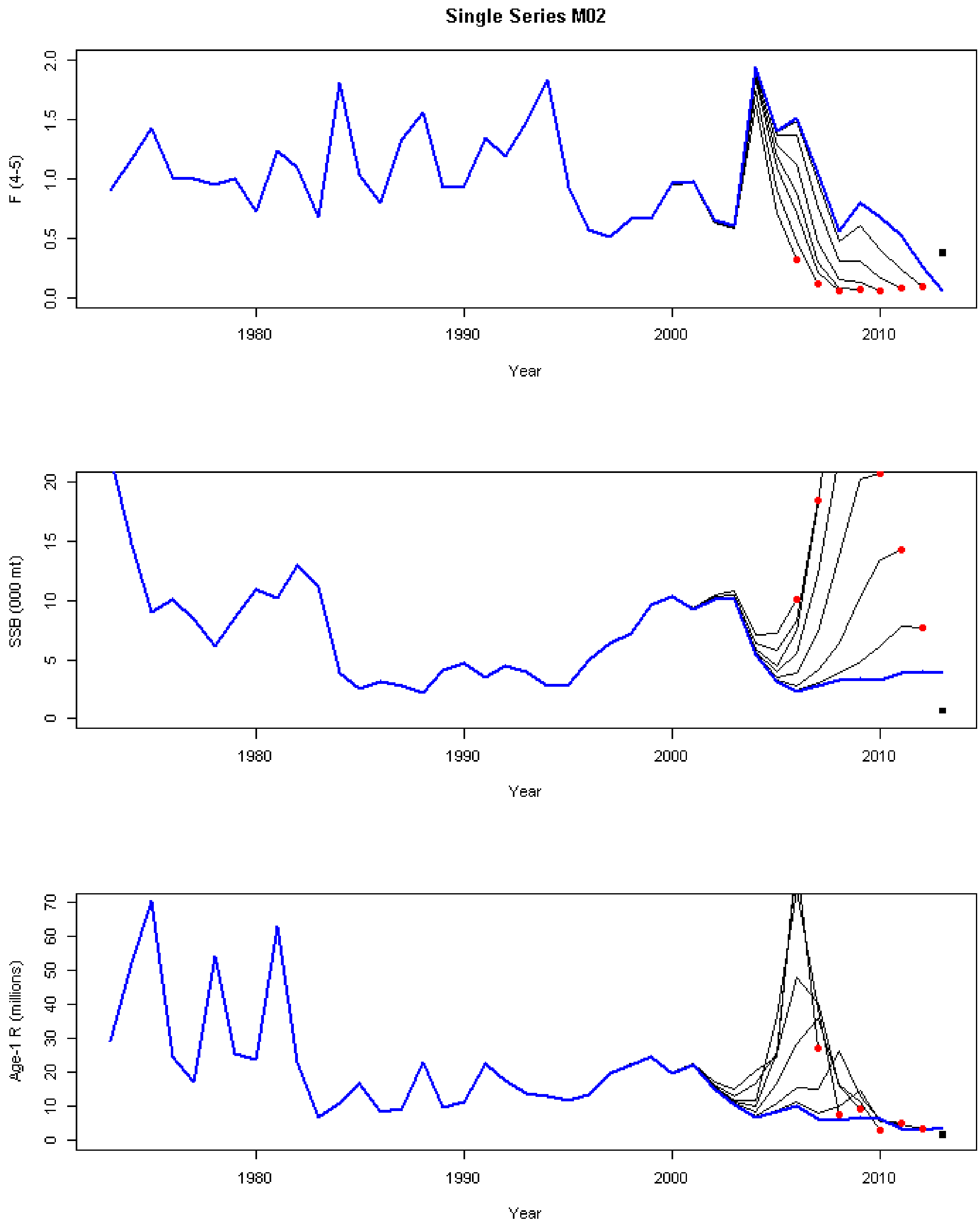


Figure 26g. Retrospective analysis of Georges Bank yellowtail flounder from the Single Series M02 VPA for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel). The black squares show the rho adjusted values for 2013.

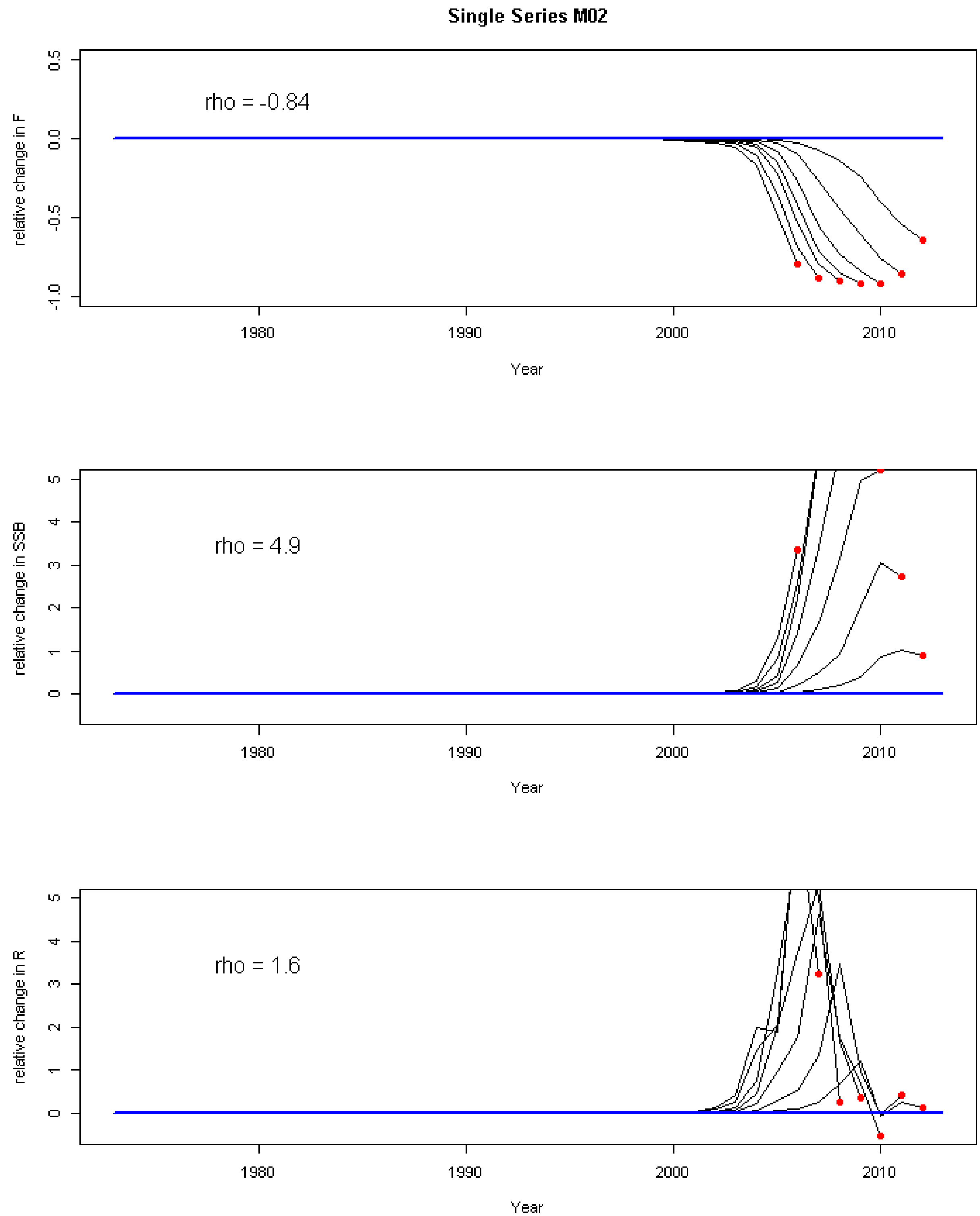


Figure 26h. Relative retrospective plots for Georges Bank yellowtail flounder from Single Series M02 VPA with Mohn's rho calculated from seven year peel for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel).

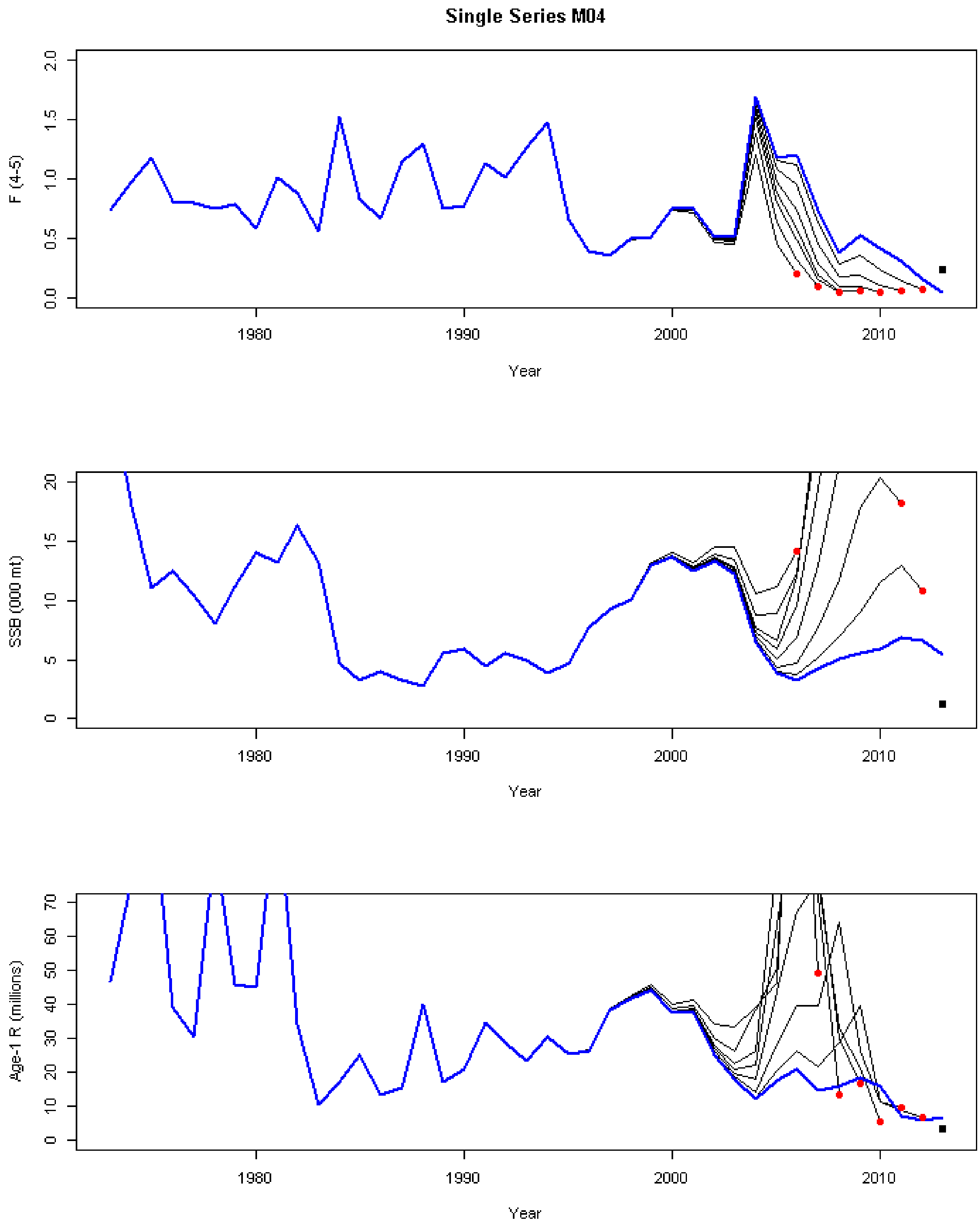


Figure 26i. Retrospective analysis of Georges Bank yellowtail flounder from the Single Series M04 VPA for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel). The black squares show the rho adjusted values for 2013.

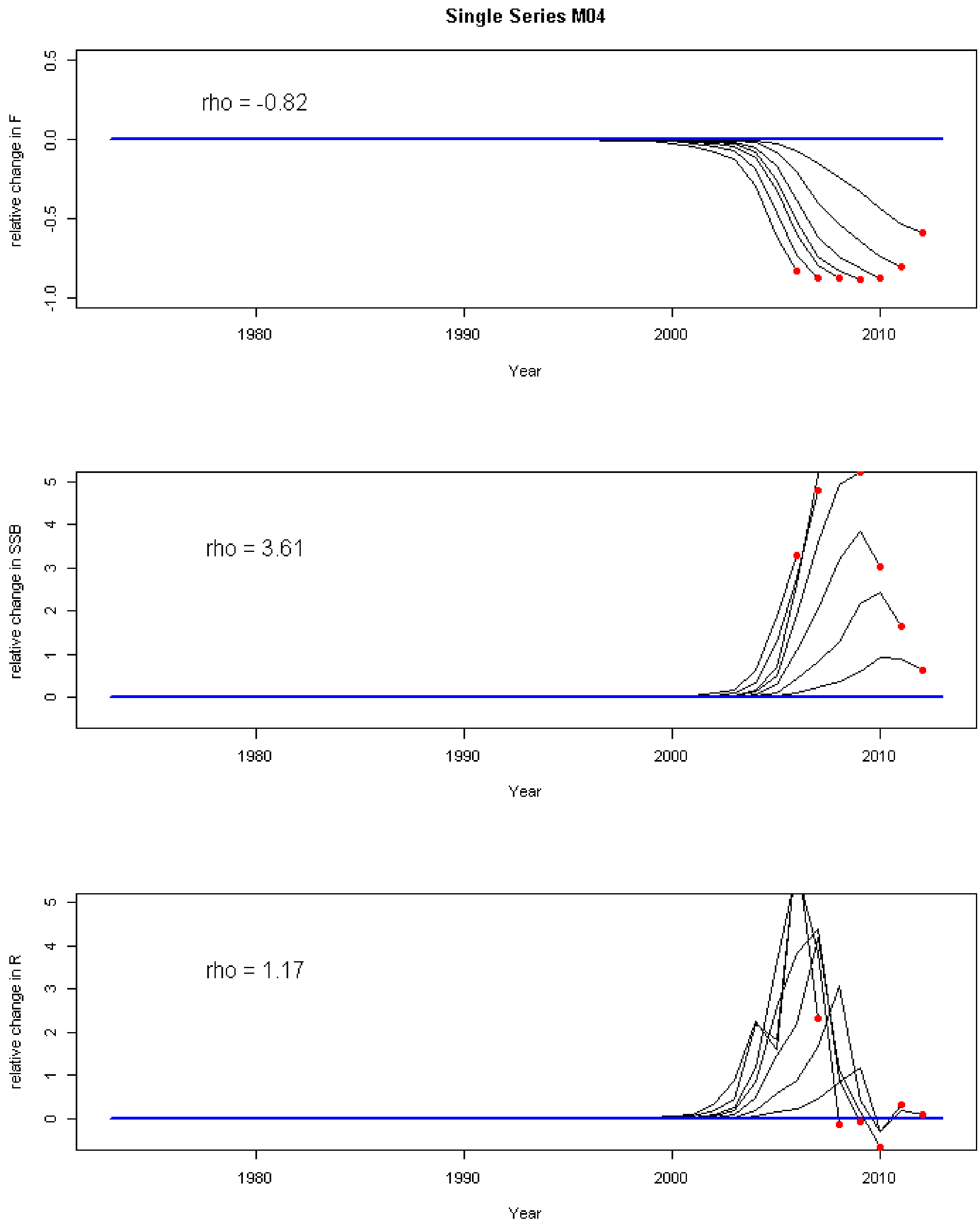


Figure 26j. Relative retrospective plots for Georges Bank yellowtail flounder from Single Series M04 VPA with Mohn's rho calculated from seven year peel for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel).

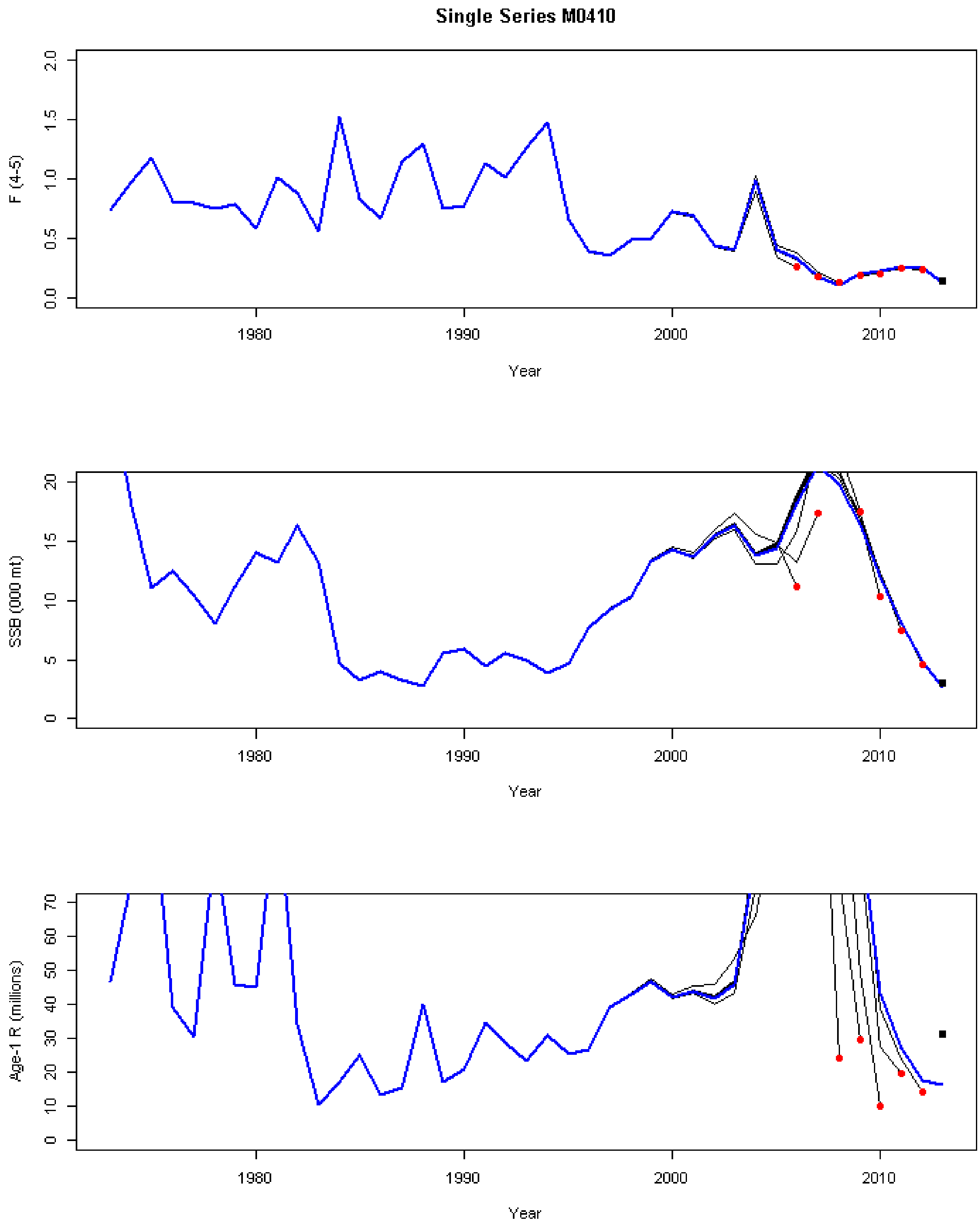


Figure 26k. Retrospective analysis of Georges Bank yellowtail flounder from the Single Series M0410 VPA for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel). The black squares show the rho adjusted values for 2013.

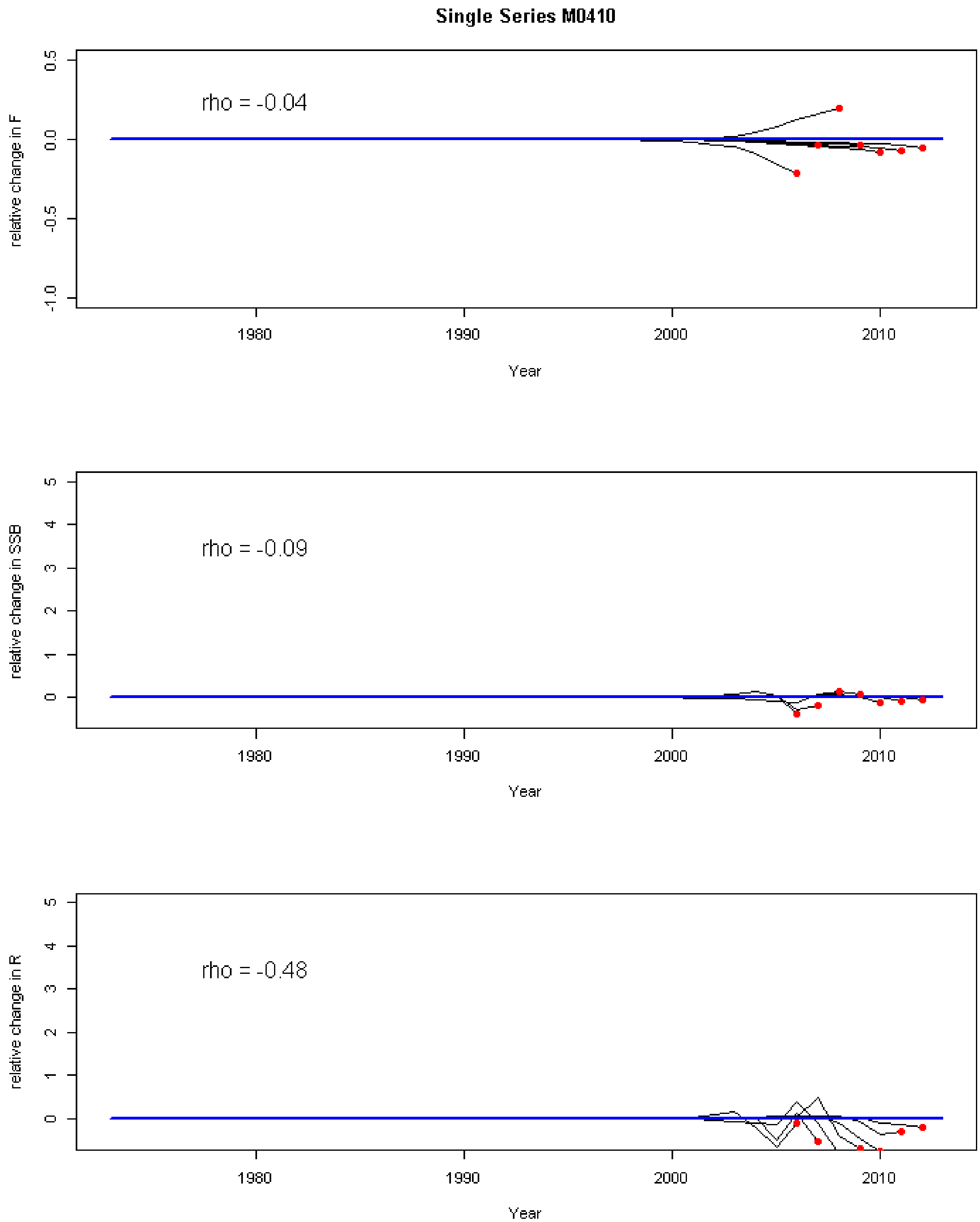


Figure 26l. Relative retrospective plots for Georges Bank yellowtail flounder from Single Series M0410 VPA with Mohn's rho calculated from seven year peel for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel).

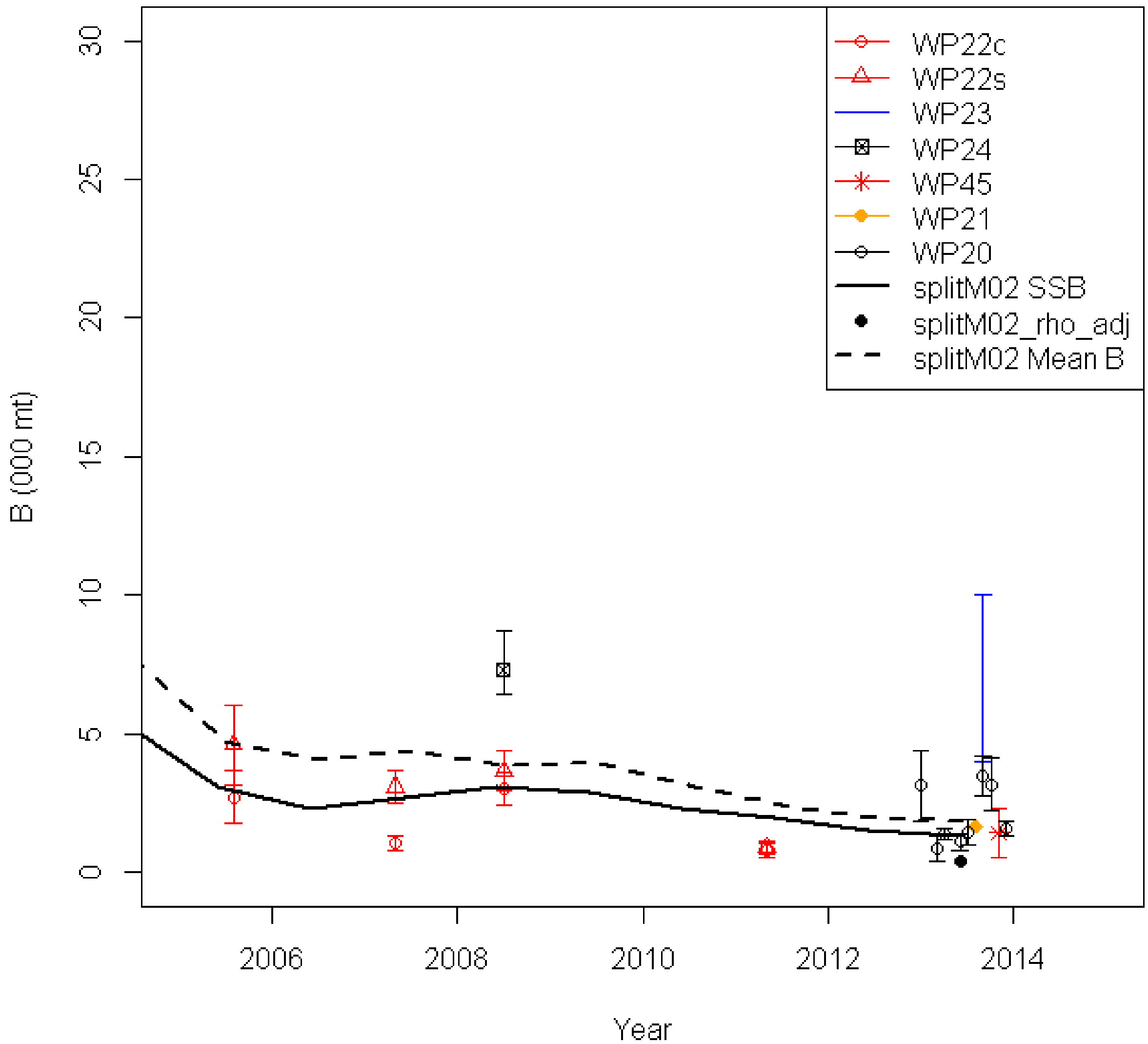


Figure 27a. Comparison of biomass estimated by surveys which covered only part of Georges Bank with the spawning stock biomass, rho adjusted spawning stock biomass in the terminal year, and the mean biomass from the Split Series M02 VPA.

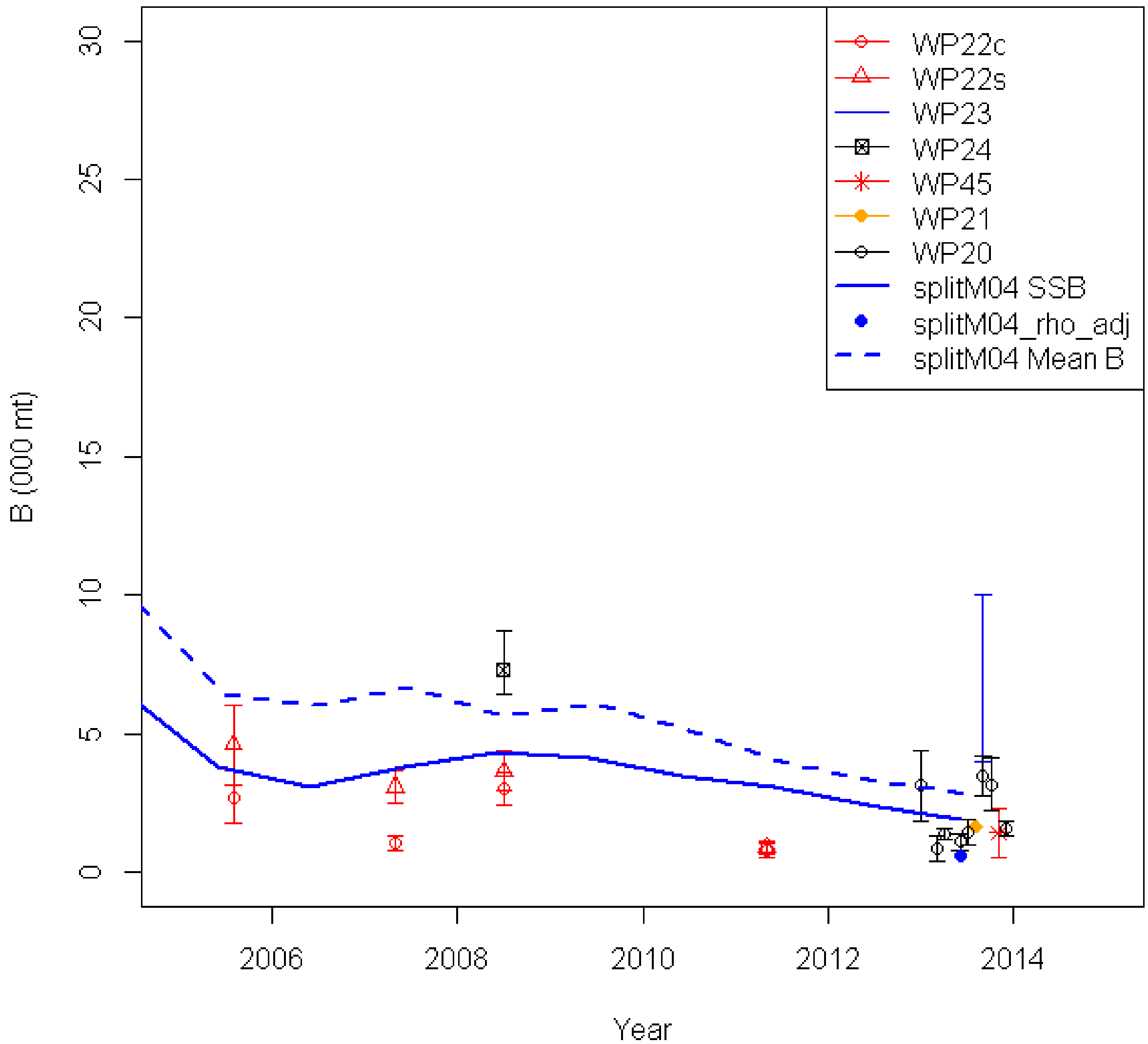


Figure 27b. Comparison of biomass estimated by surveys which covered only part of Georges Bank with the spawning stock biomass, rho adjusted spawning stock biomass in the terminal year, and the mean biomass from the Split Series M04 VPA.

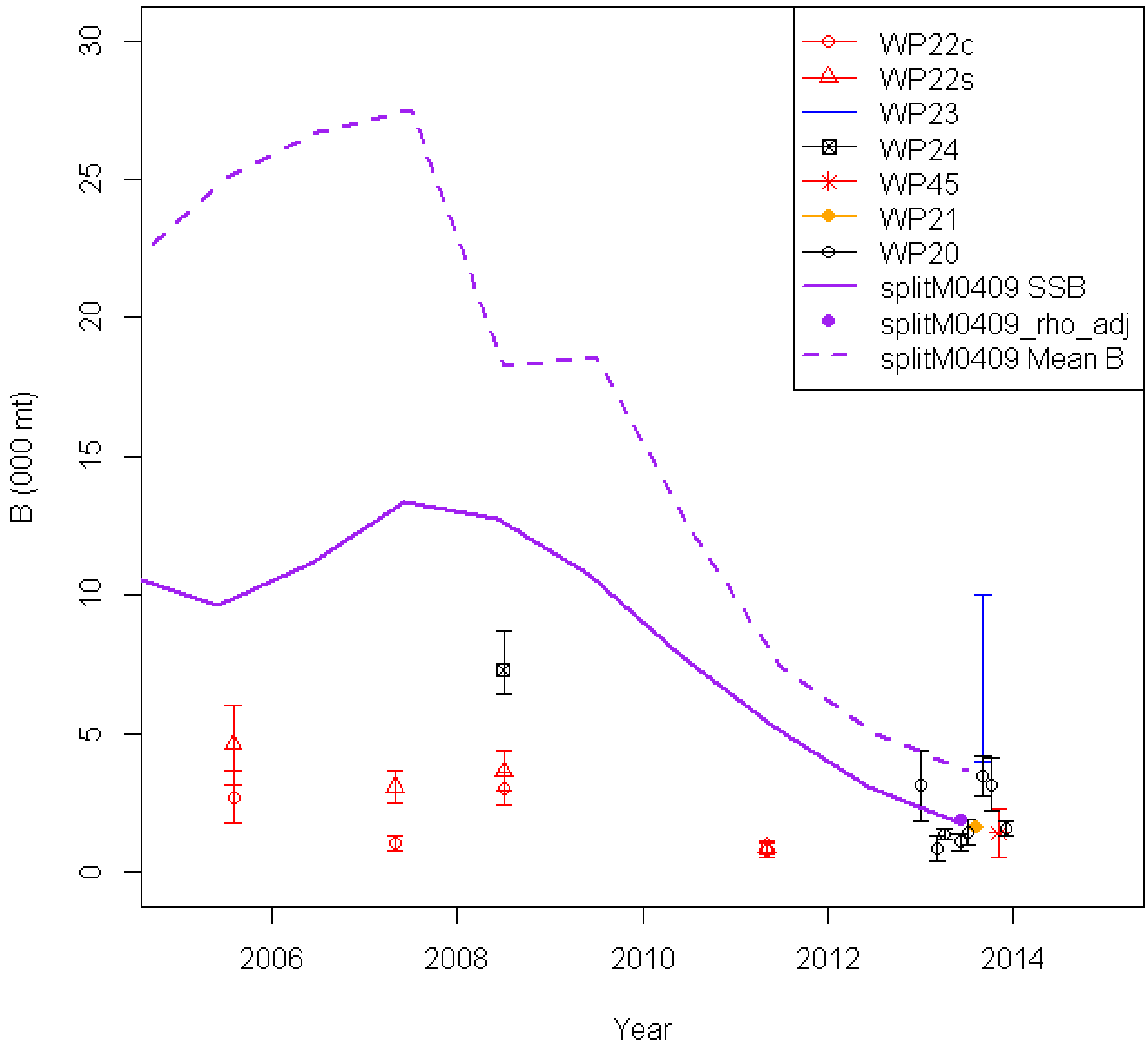


Figure 27c. Comparison of biomass estimated by surveys which covered only part of Georges Bank with the spawning stock biomass, rho adjusted spawning stock biomass in the terminal year, and the mean biomass from the Split Series M0409 VPA.

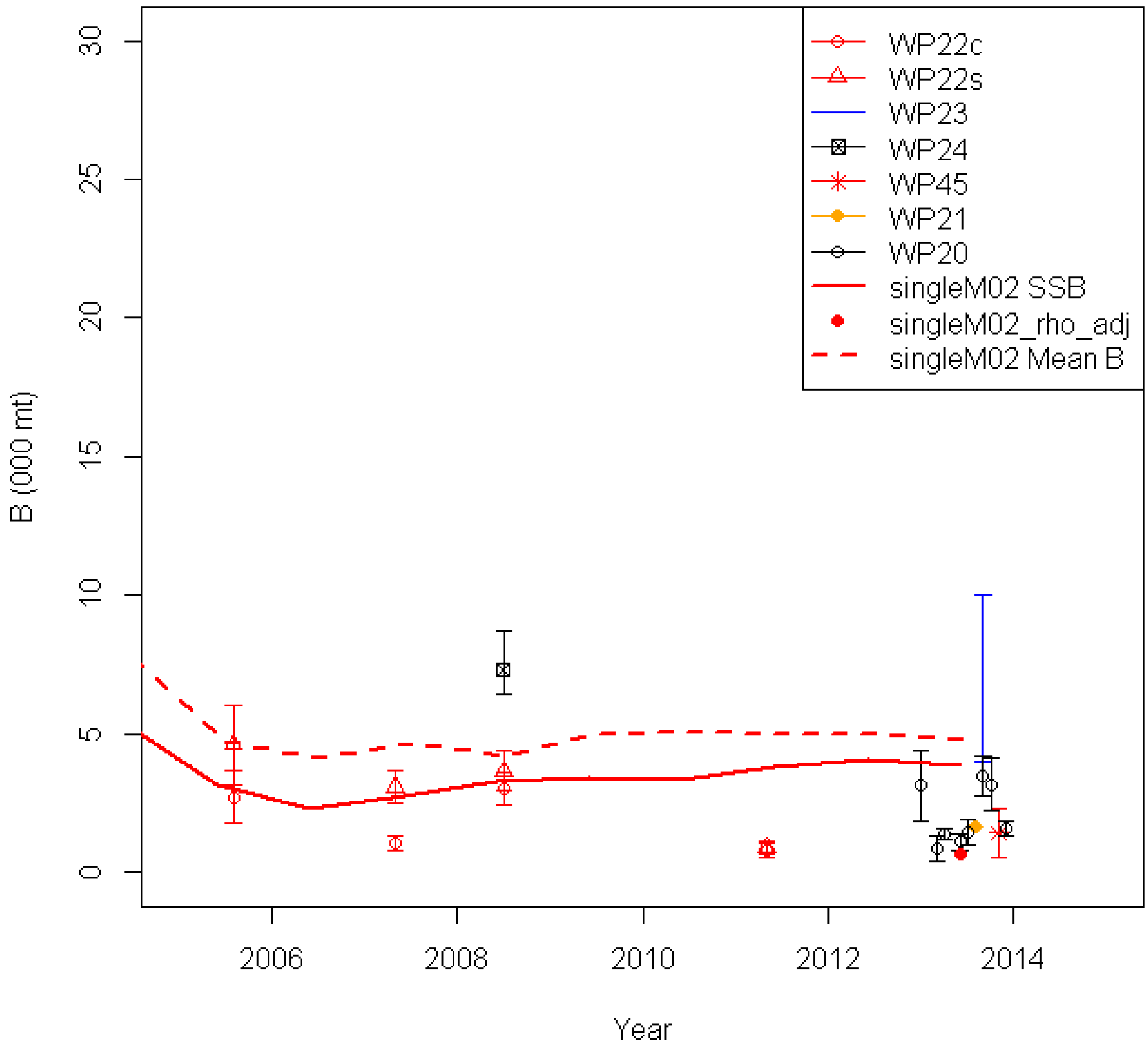


Figure 27d. Comparison of biomass estimated by surveys which covered only part of Georges Bank with the spawning stock biomass, rho adjusted spawning stock biomass in the terminal year, and the mean biomass from the Single Series M02 VPA.

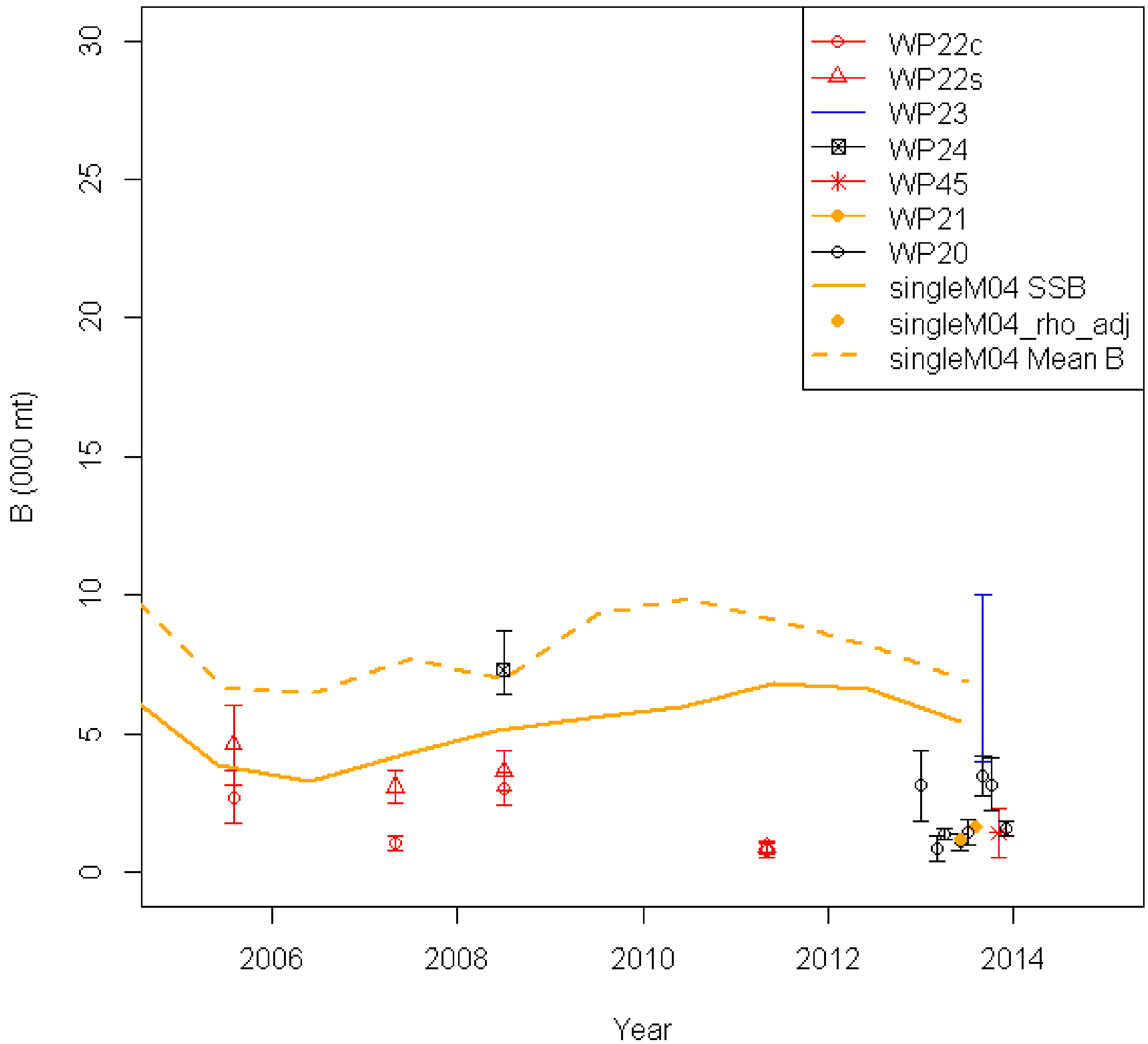


Figure 27e. Comparison of biomass estimated by surveys which covered only part of Georges Bank with the spawning stock biomass, rho adjusted spawning stock biomass in the terminal year, and the mean biomass from the Single Series M04 VPA.

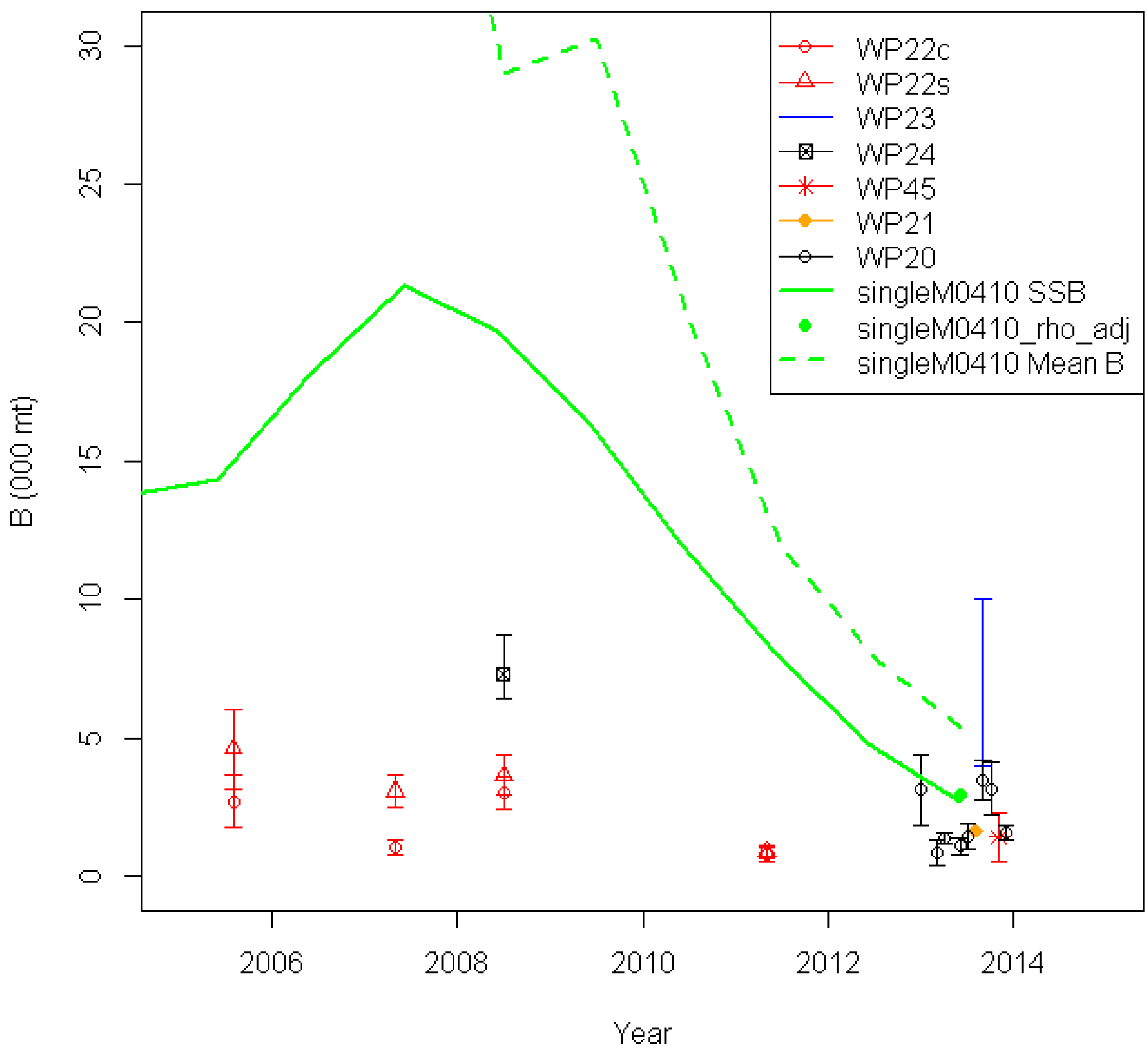


Figure 27f. Comparison of biomass estimated by surveys which covered only part of Georges Bank with the spawning stock biomass, rho adjusted spawning stock biomass in the terminal year, and the mean biomass from the Single Series M0410 VPA.

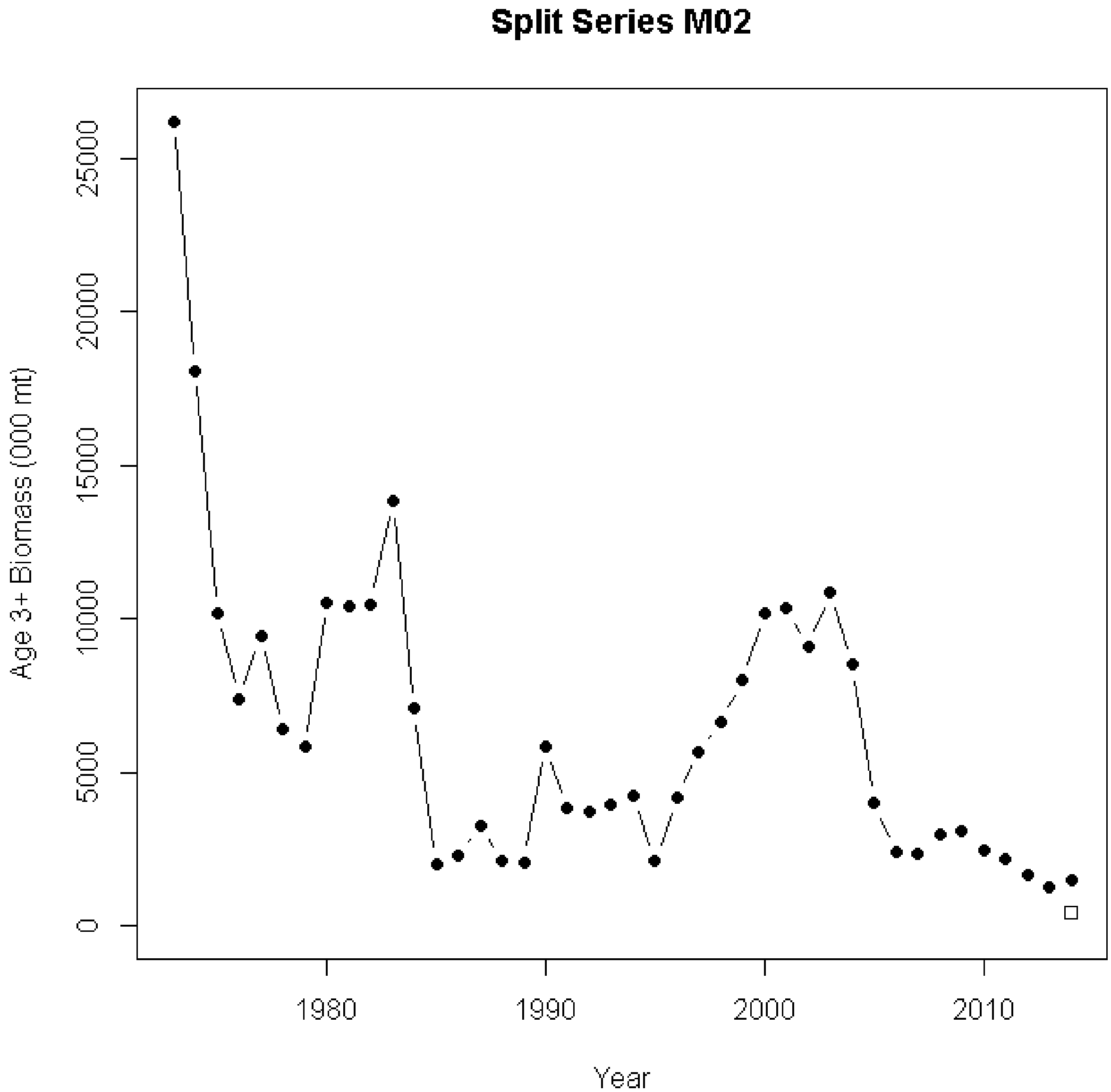


Figure 28a. Adult biomass (ages 3+, Jan-1) from the Split Series M02 VPA. The open square shows the rho adjusted values for 2014 using the SSB rho to make the adjustment.

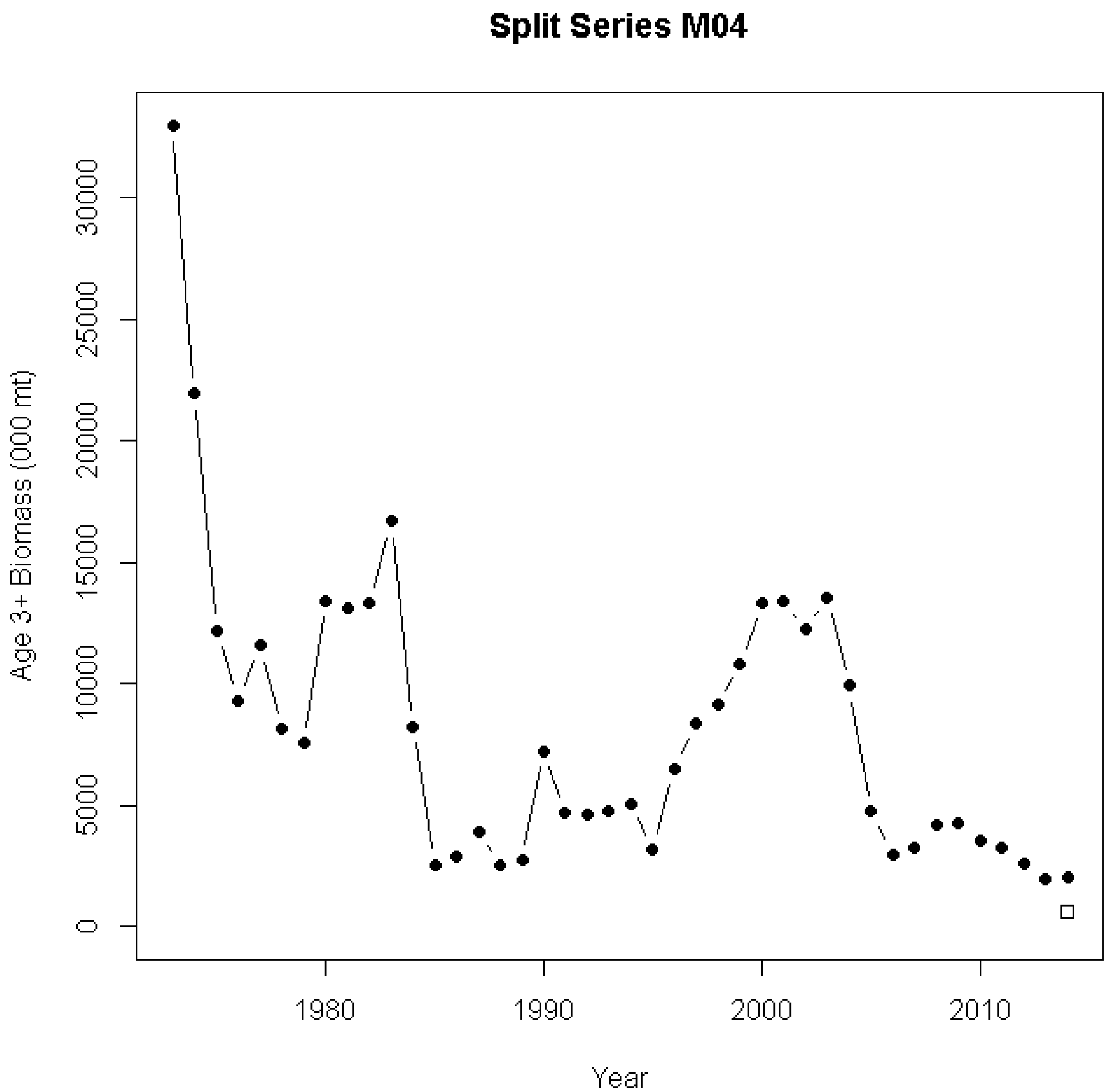


Figure 28b. Adult biomass (ages 3+, Jan-1) from the Split Series M04 VPA. The open square shows the rho adjusted values for 2014 using the SSB rho to make the adjustment.

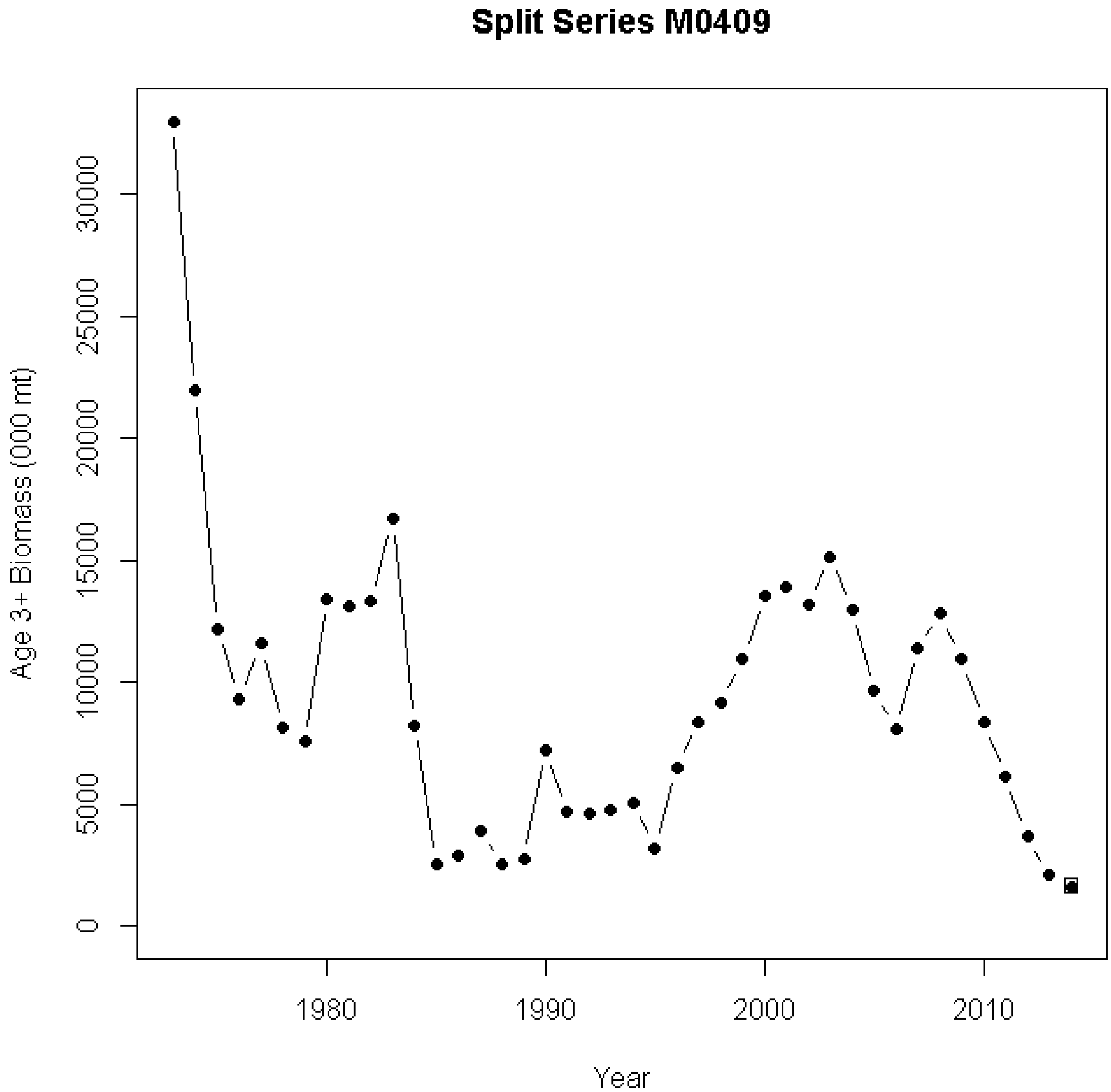


Figure 28c. Adult biomass (ages 3+, Jan-1) from the Split Series M0409 VPA. The open square shows the rho adjusted values for 2014 using the SSB rho to make the adjustment.

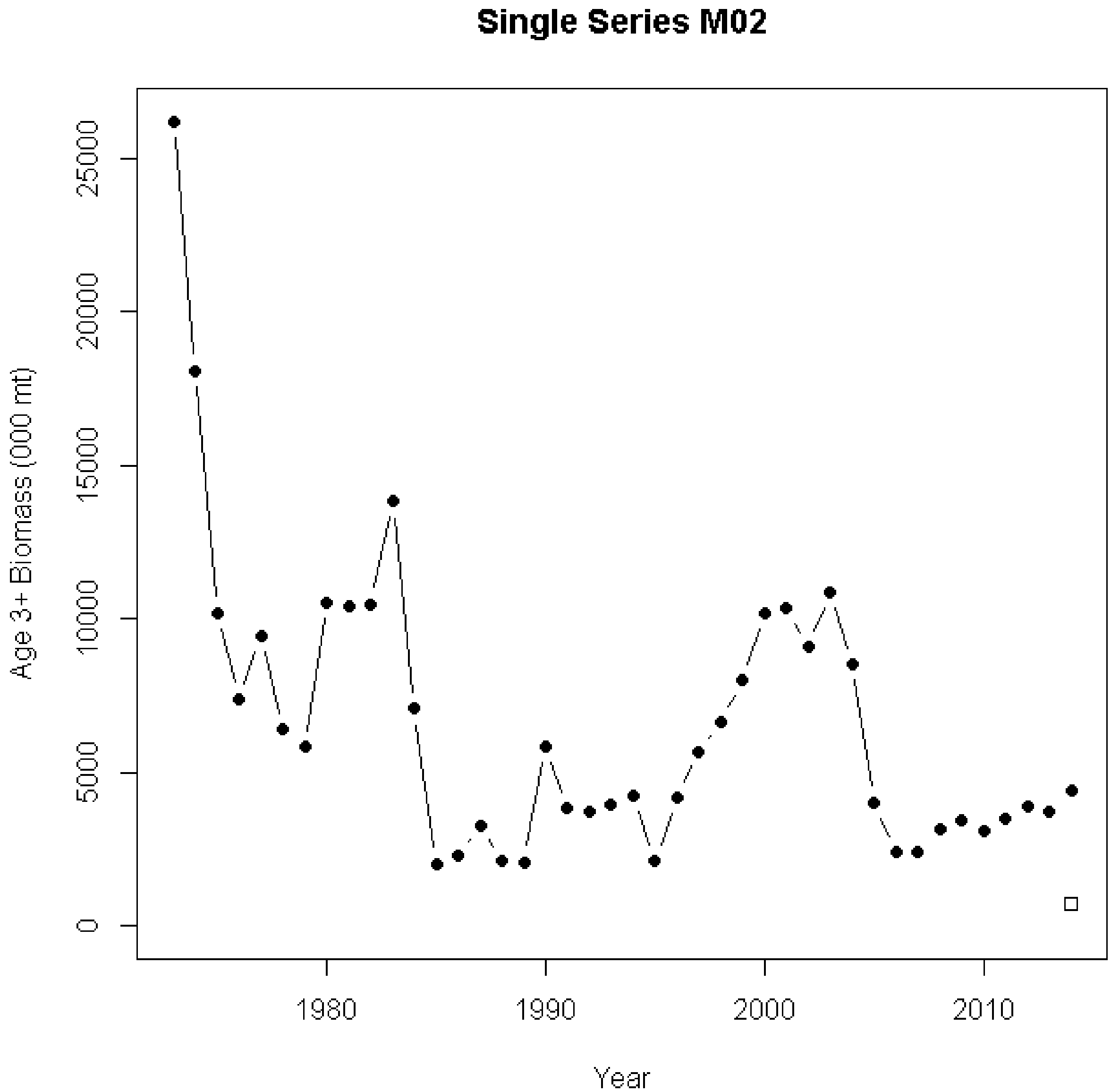


Figure 28d. Adult biomass (ages 3+, Jan-1) from the Single Series M02 VPA. The open square shows the rho adjusted values for 2014 using the SSB rho to make the adjustment.

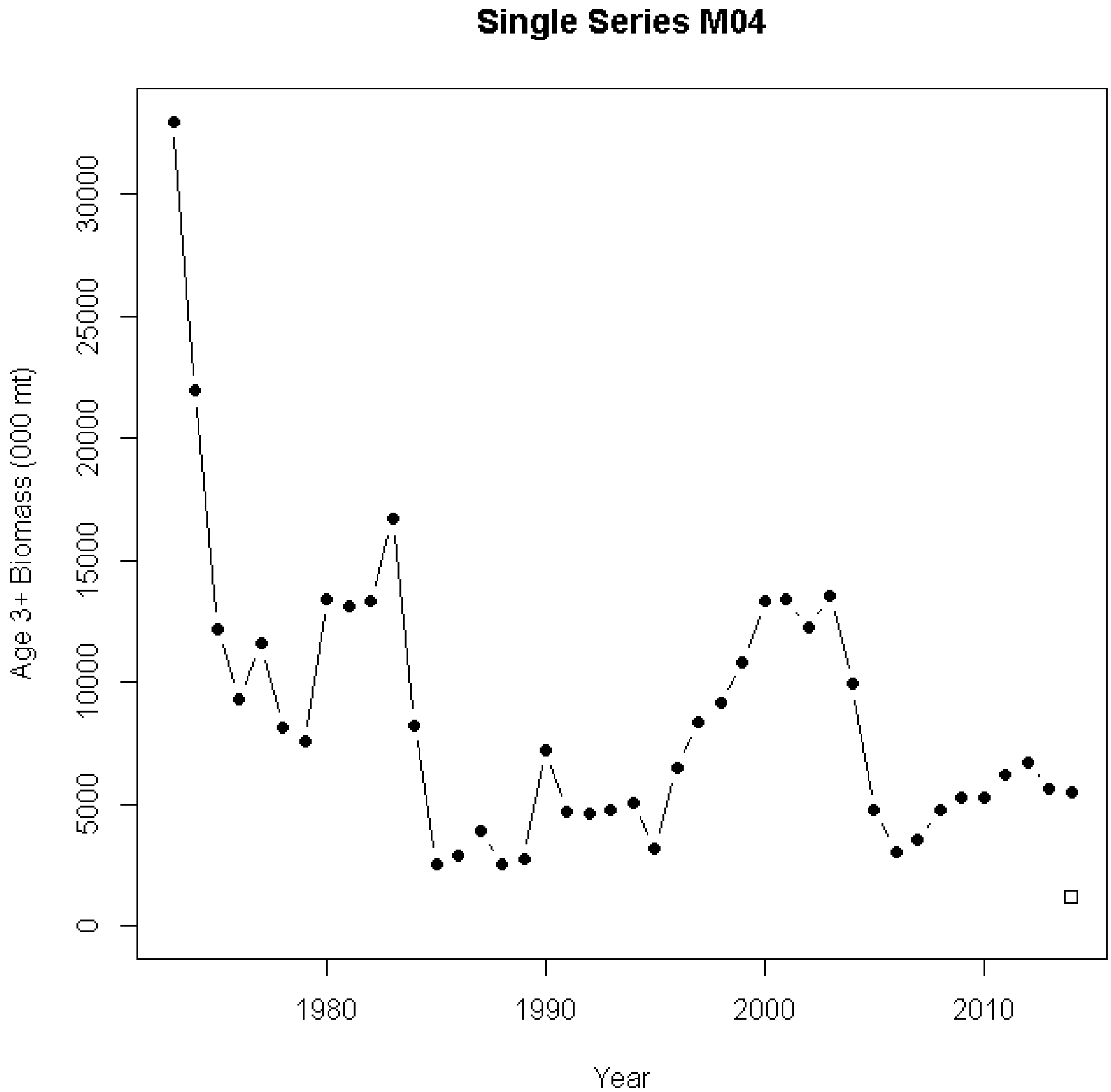


Figure 28e. Adult biomass (ages 3+, Jan-1) from the Single Series M04 VPA. The open square shows the rho adjusted values for 2014 using the SSB rho to make the adjustment.

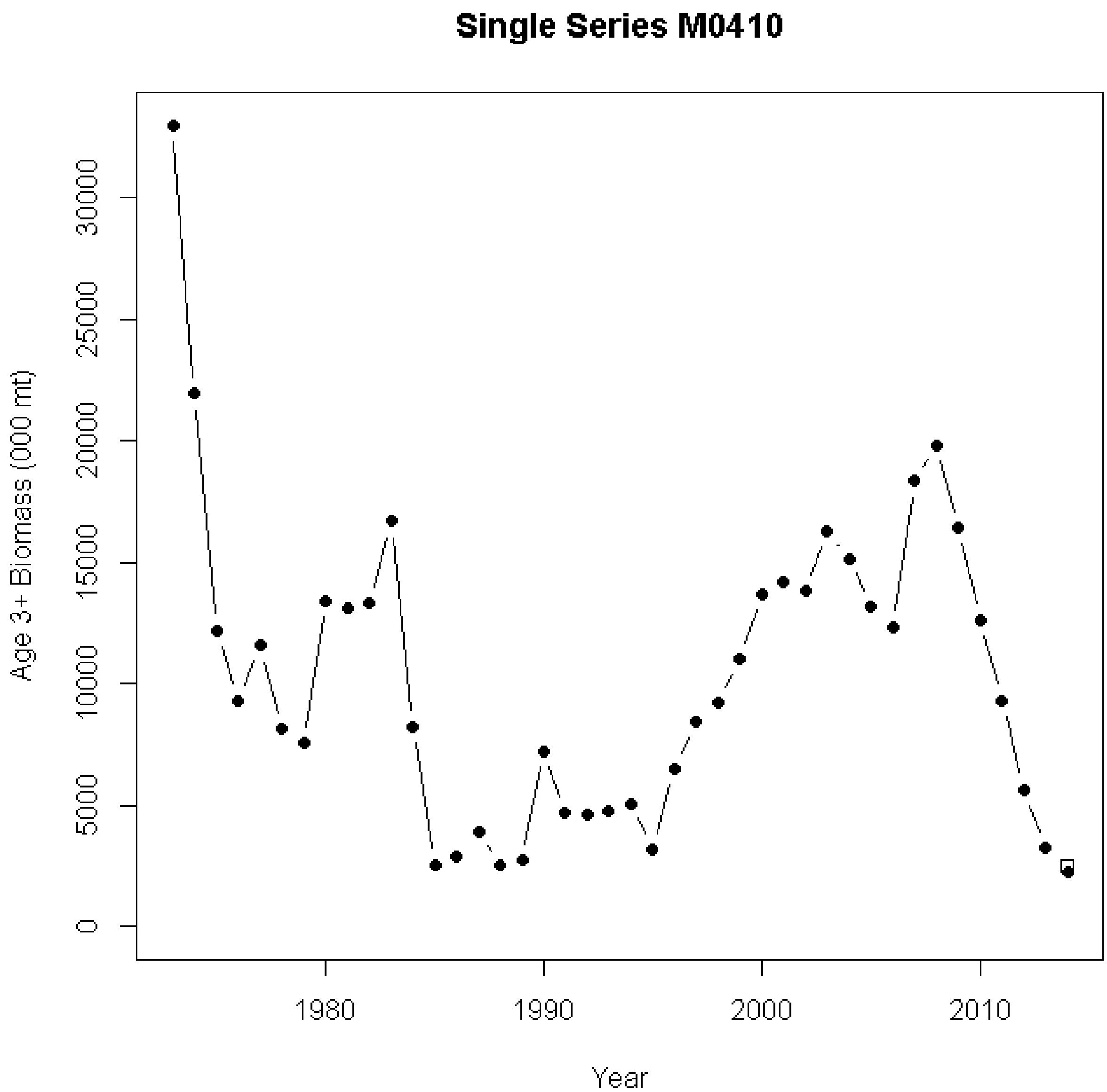


Figure 28f. Adult biomass (ages 3+, Jan-1) from the Single Series M0410 VPA. The open square shows the rho adjusted values for 2014 using the SSB rho to make the adjustment.

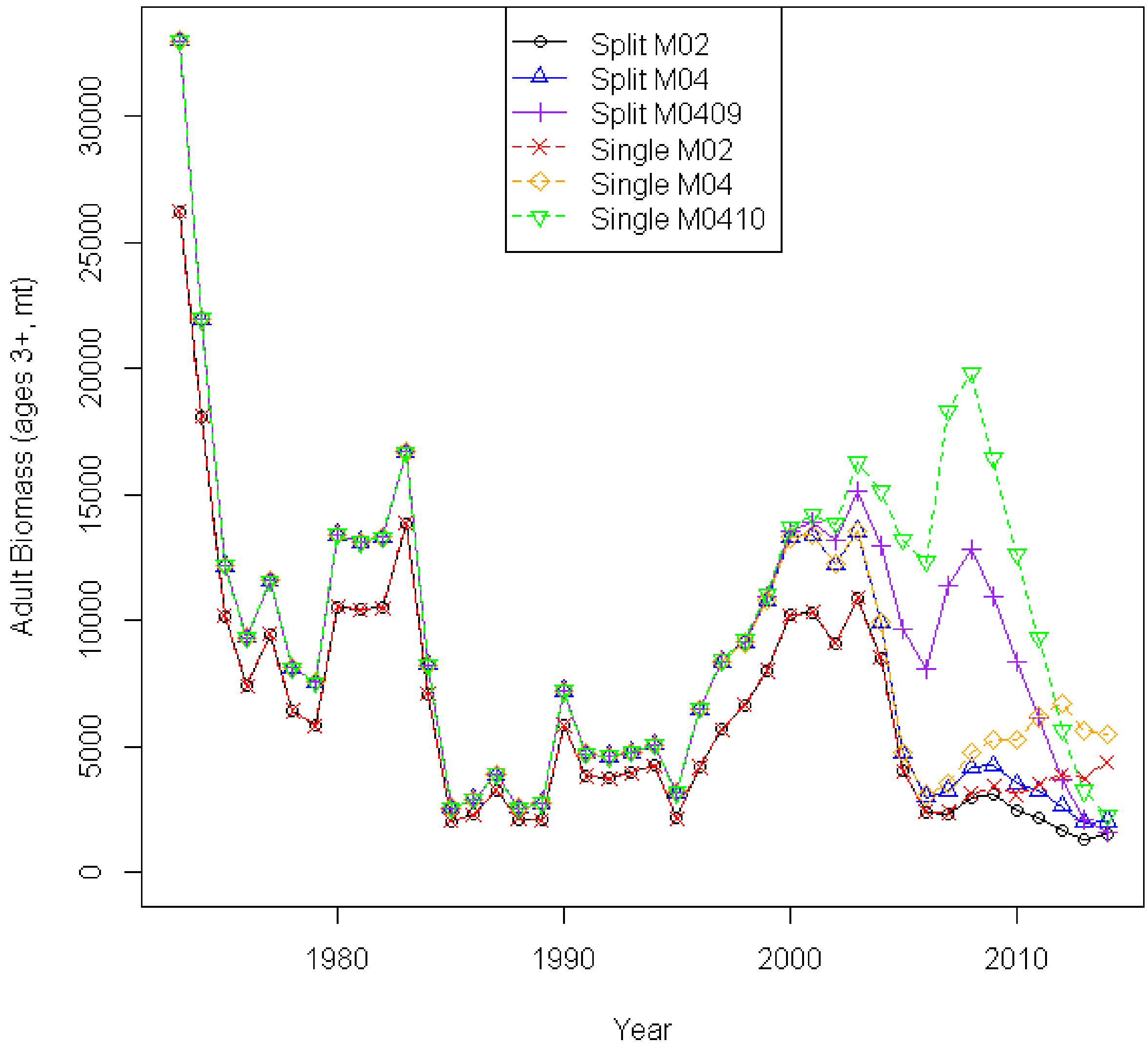


Figure 29a. Jan-1 Adult (ages 3+) biomass (mt) estimated by the six VPAs.

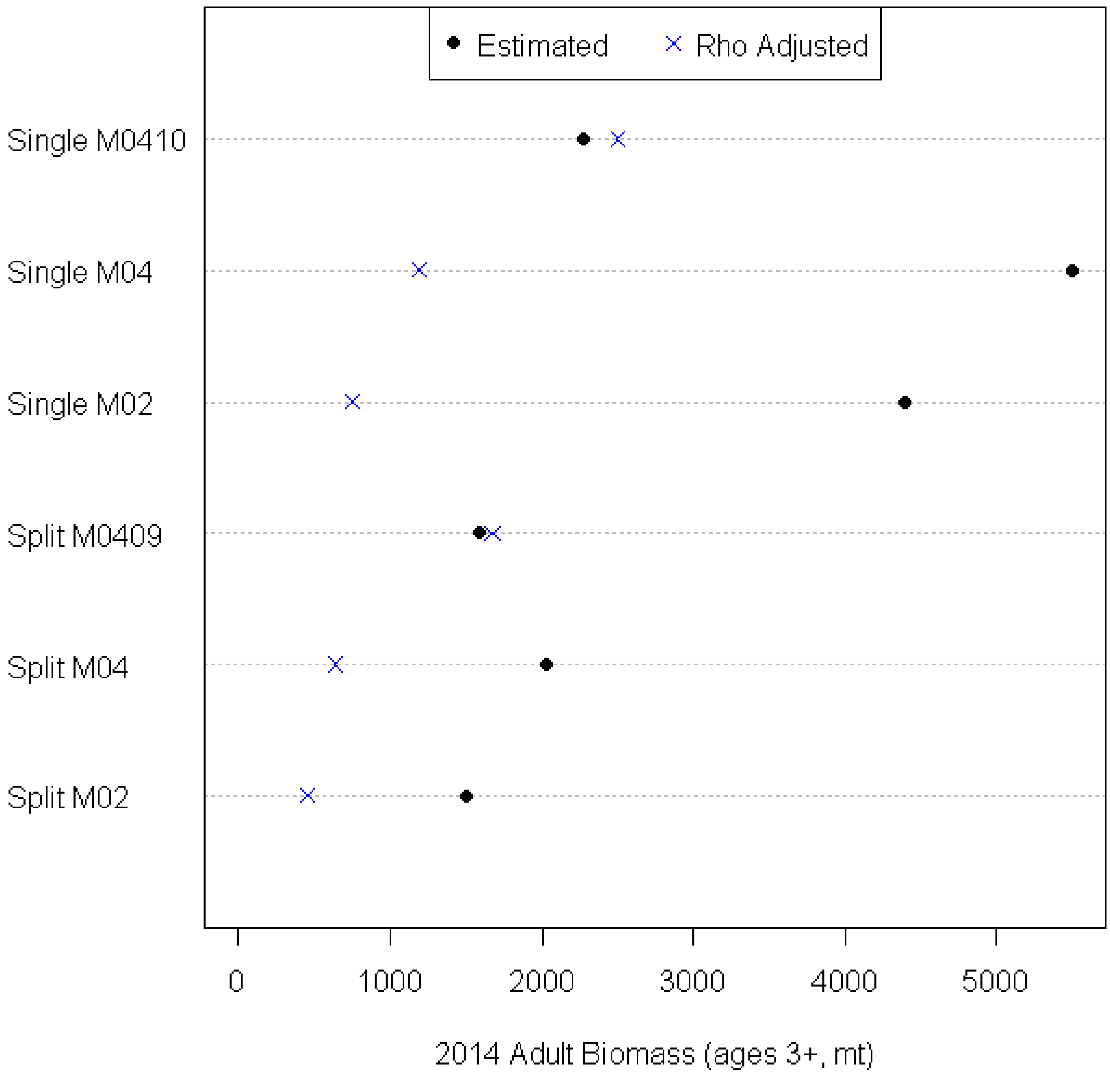


Figure 29b. Dotchart of the 2014 Jan-1 Adult (ages 3+) biomass (mt) for the six VPAs. The filled circles denote the point estimates while the blue crosses denote the rho adjusted values for each run.

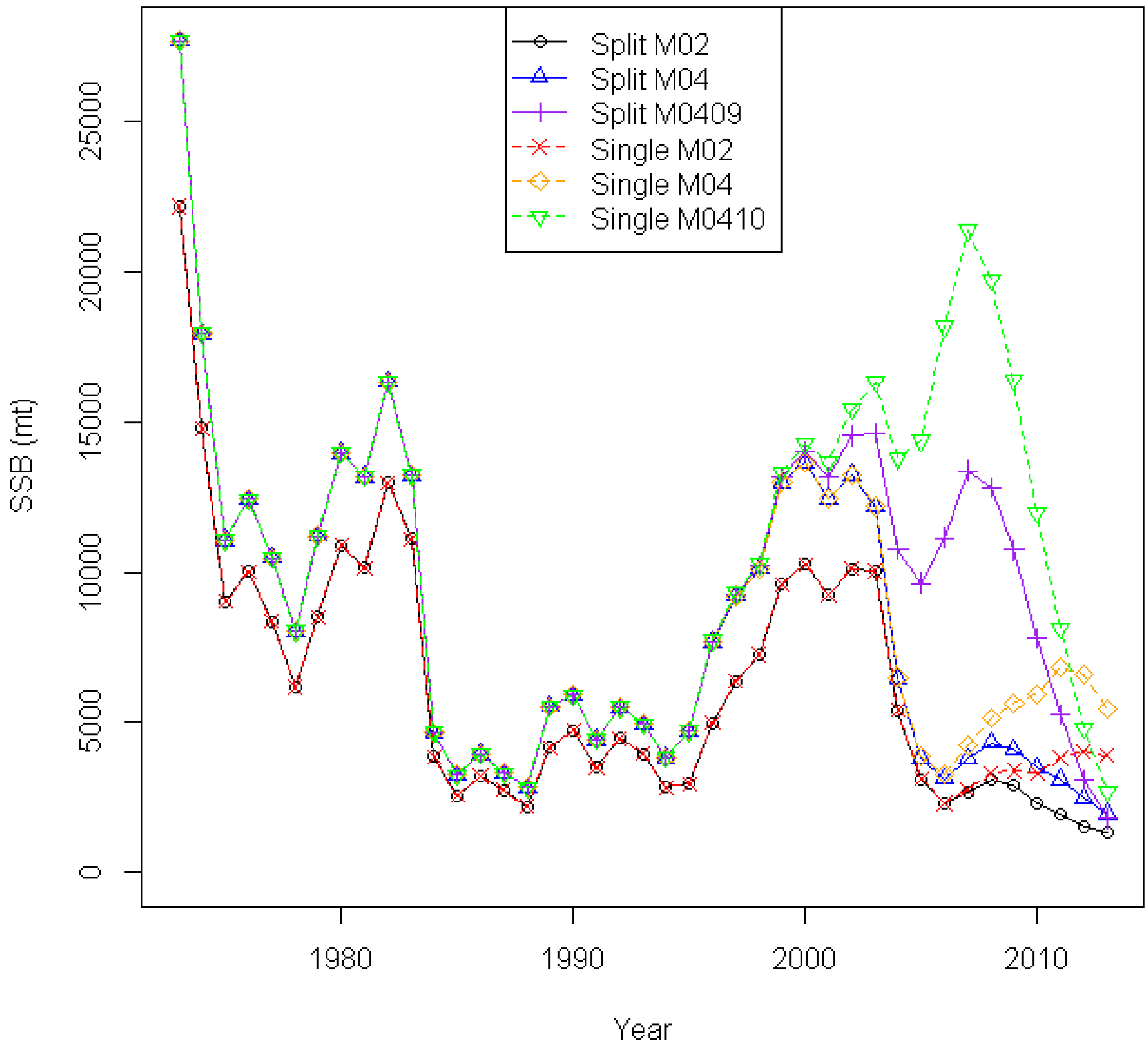


Figure 30a. Spawning stock biomass (mt) estimated by the six VPAs.

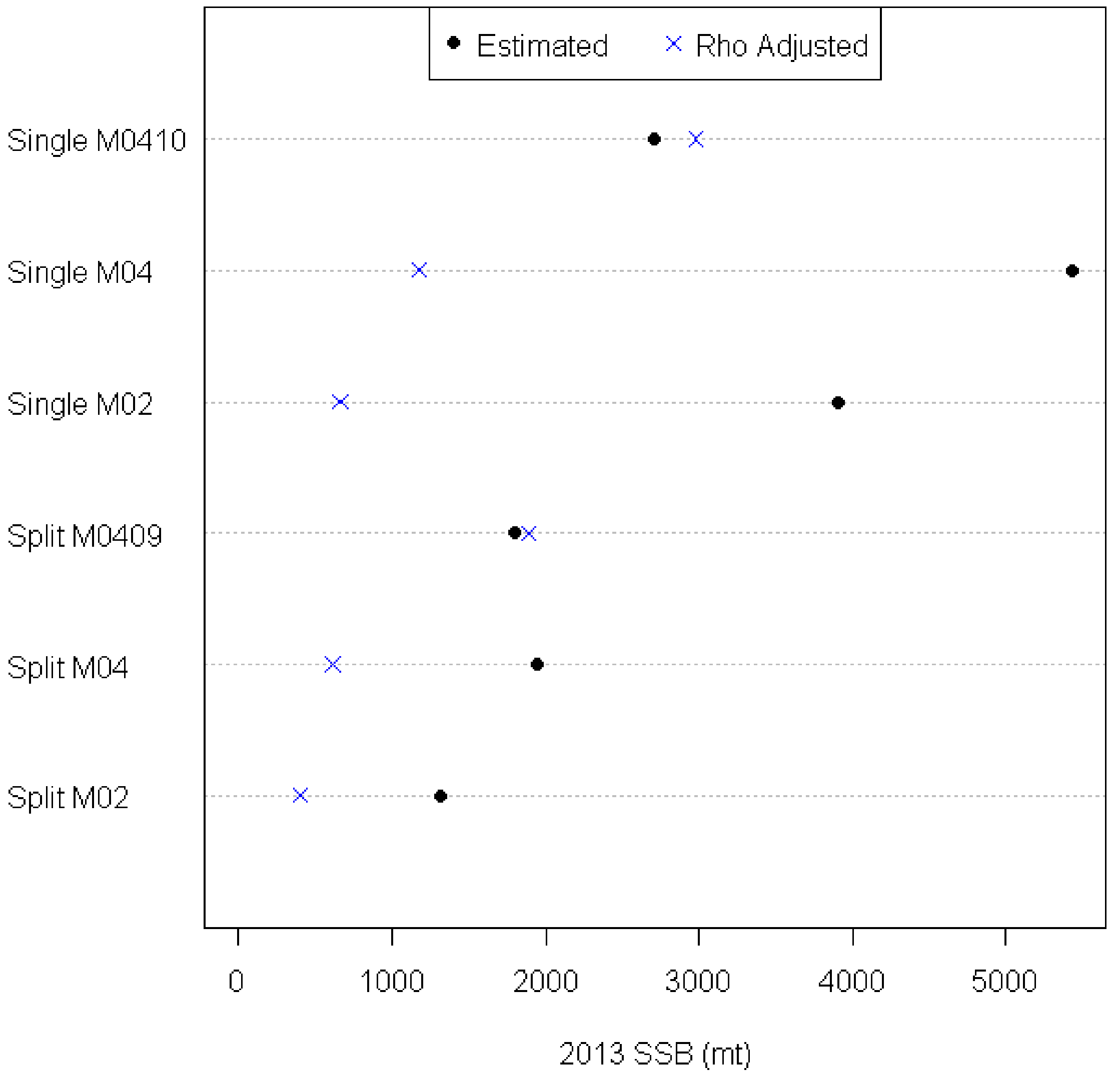


Figure 30b. Dotchart of the 2013 spawning stock biomass (mt) for the six VPAs. The filled circles denote the point estimates while the blue crosses denote the rho adjusted values for each run.

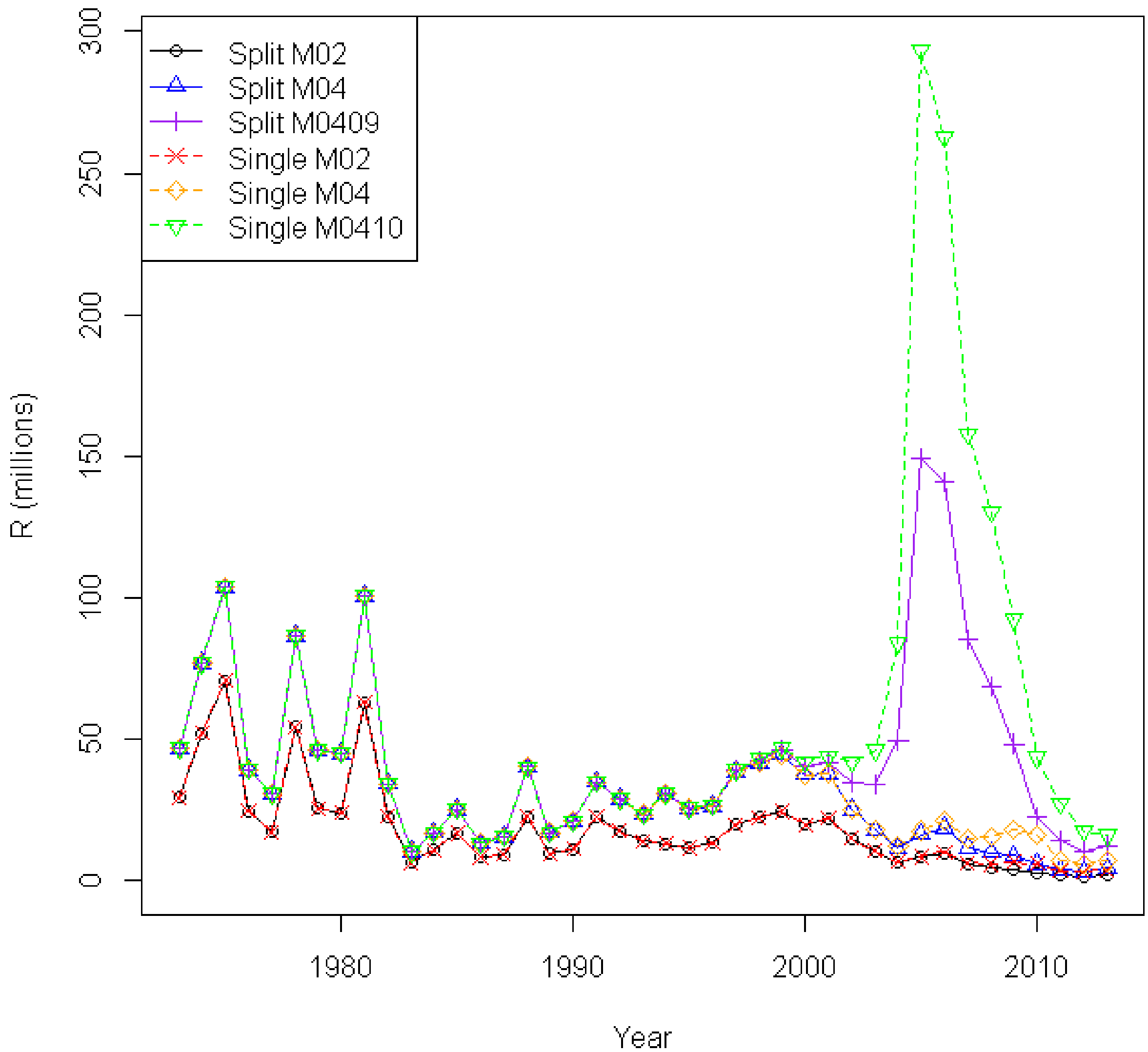


Figure 31a. Age 1 recruitment (millions of fish) estimated by the six VPAs.

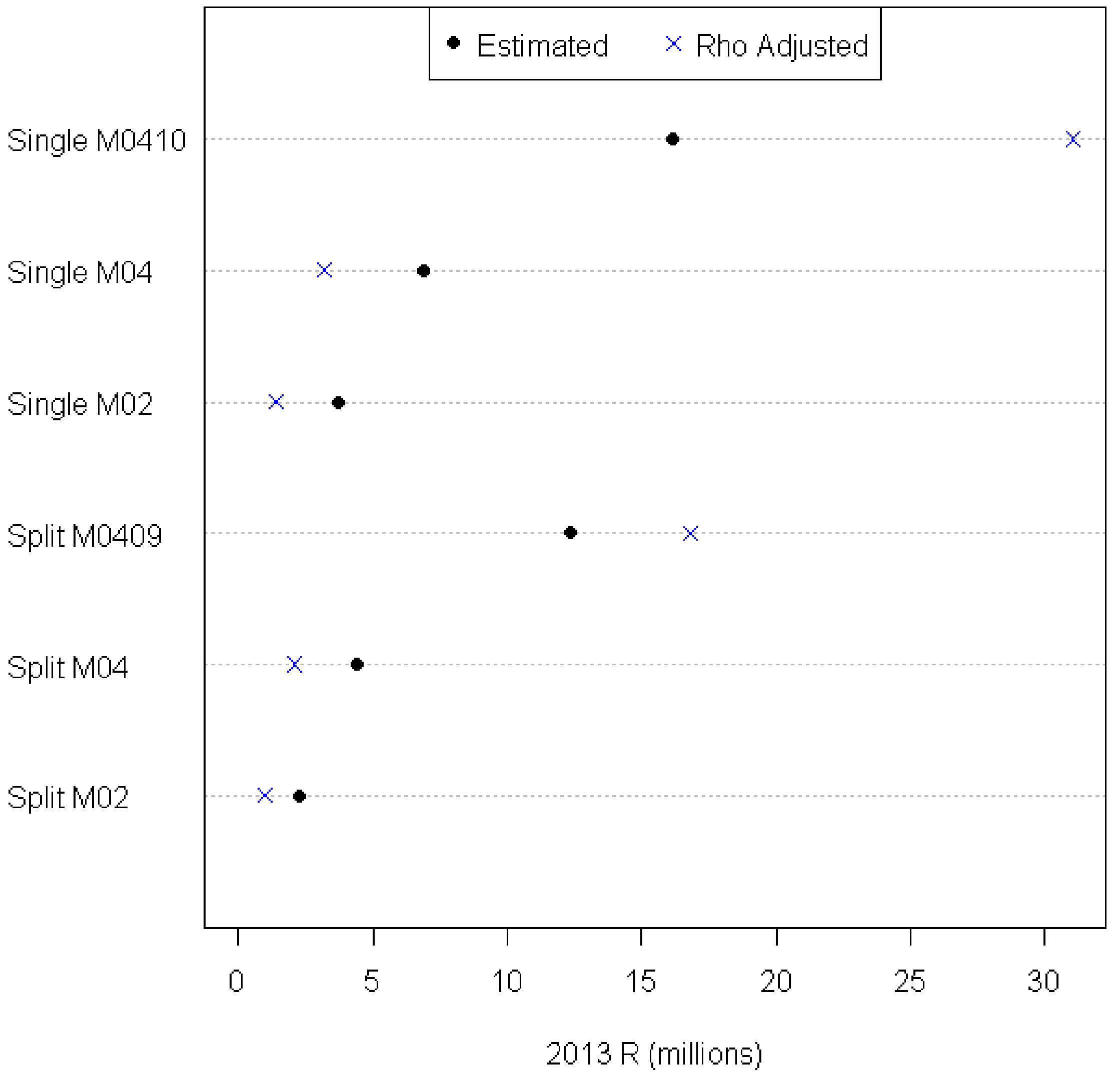


Figure 31b. Dotchart of the 2013 age 1 recruitment (millions of fish) for the six VPAs. The filled circles denote the point estimates while the blue crosses denote the rho adjusted values for each run.

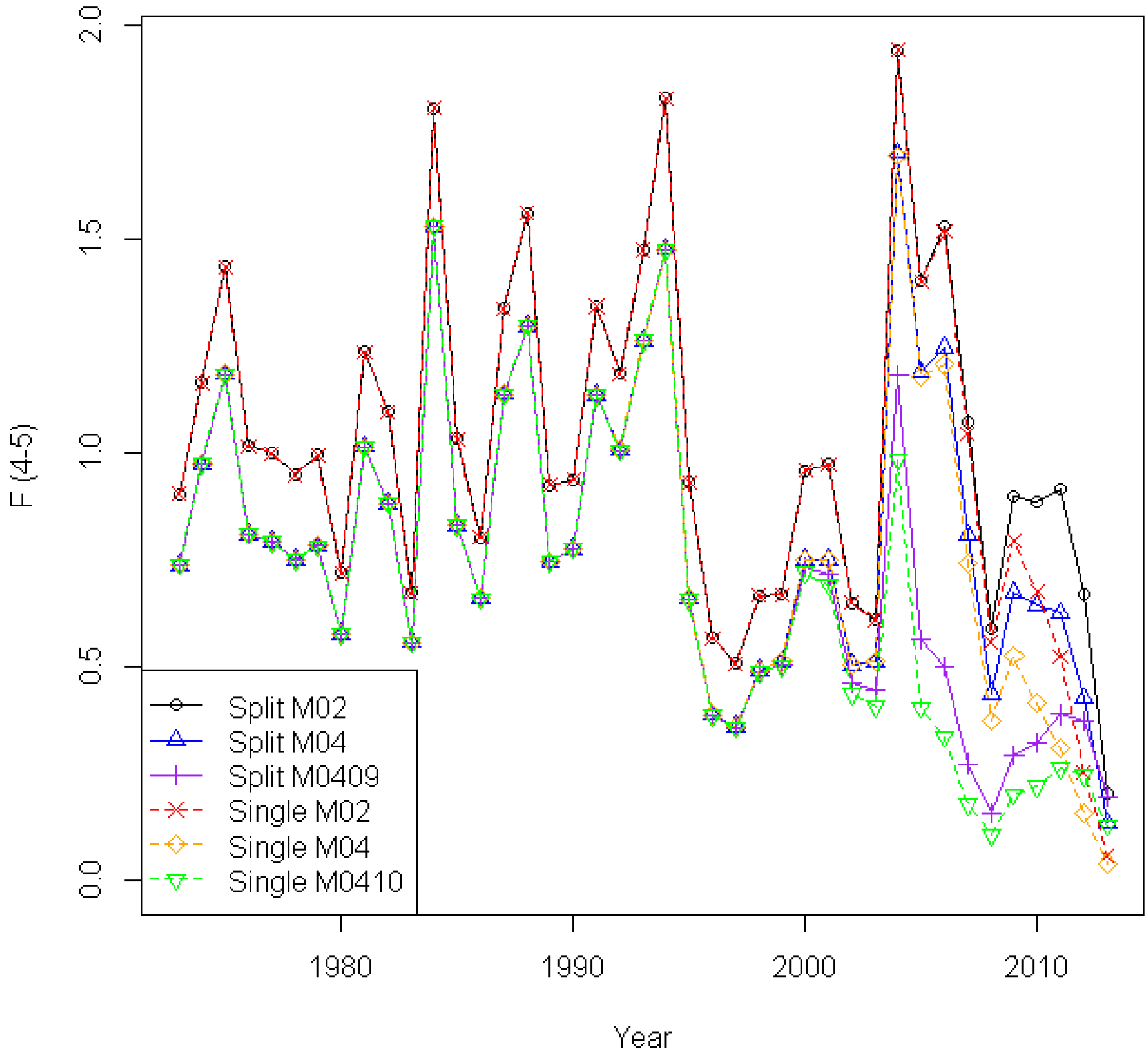


Figure 32a. Fishing mortality rate (ages 4-5) estimated by the six VPAs.

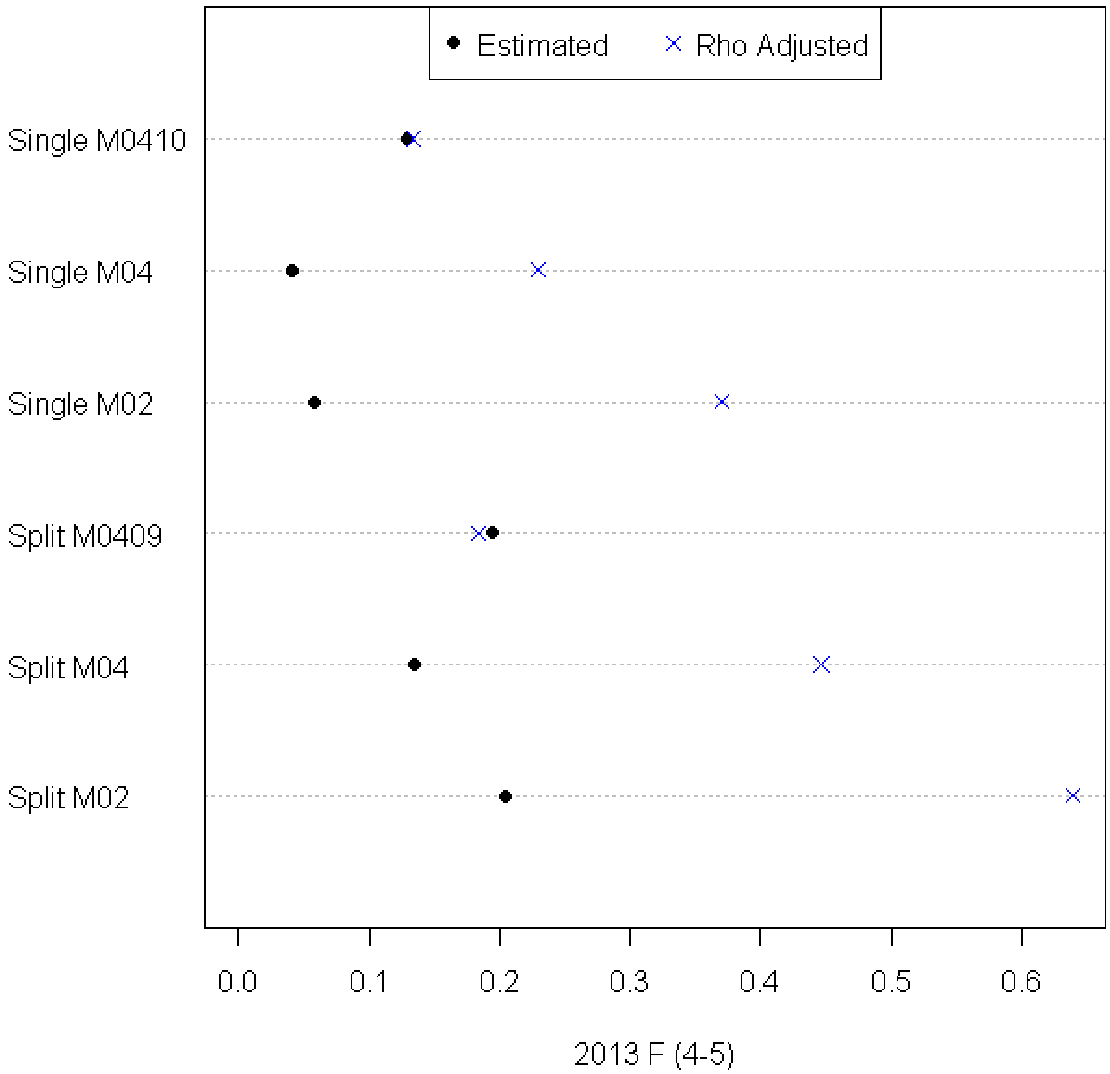
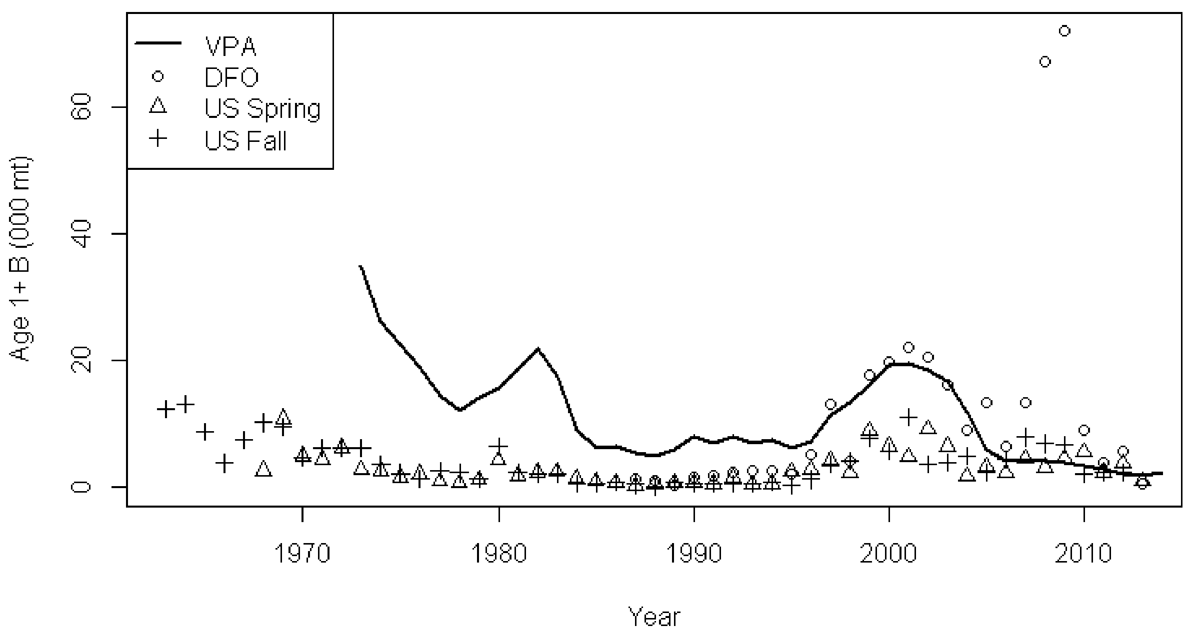


Figure 32b. Dotchart of the 2013 fishing mortality rate (ages 4-5) for the six VPAs. The filled circles denote the point estimates while the blue crosses denote the rho adjusted values for each run.

Split Series M02



Single Series M02

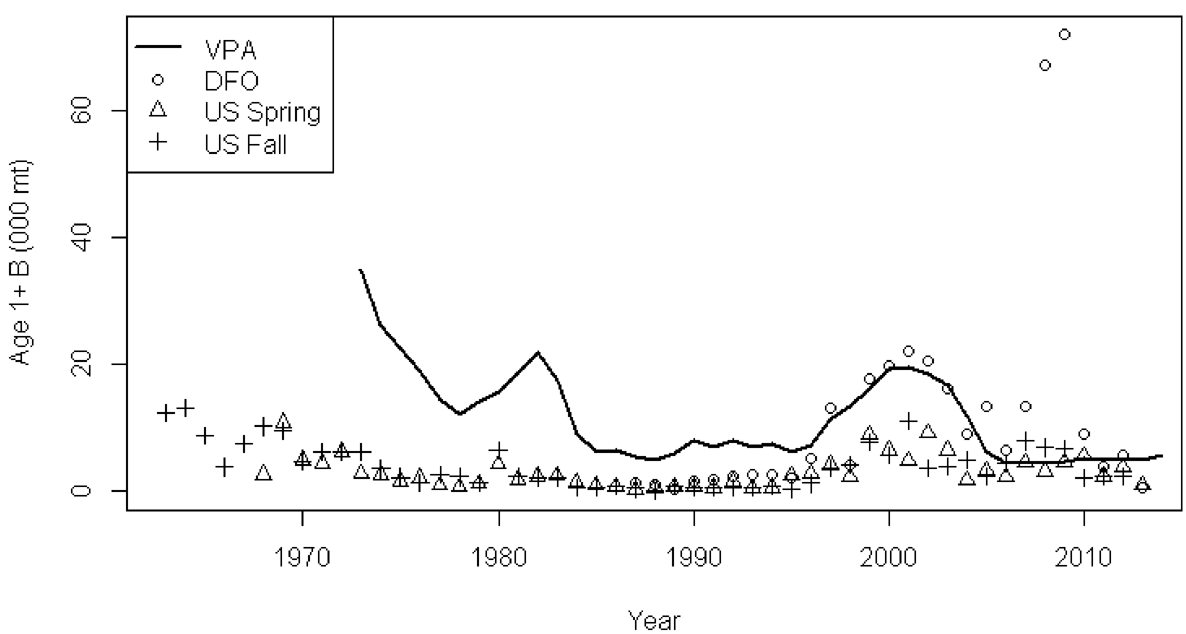


Figure 33a. Jan-1 age 1+ biomass estimated by the Split Series M02 VPA (top panel) and by the Single Series M02 VPA (bottom panel) and from the three groundfish surveys in minimum swept area values. The final VPA value uses the geometric mean of the previous ten years for the age 1 recruitment.

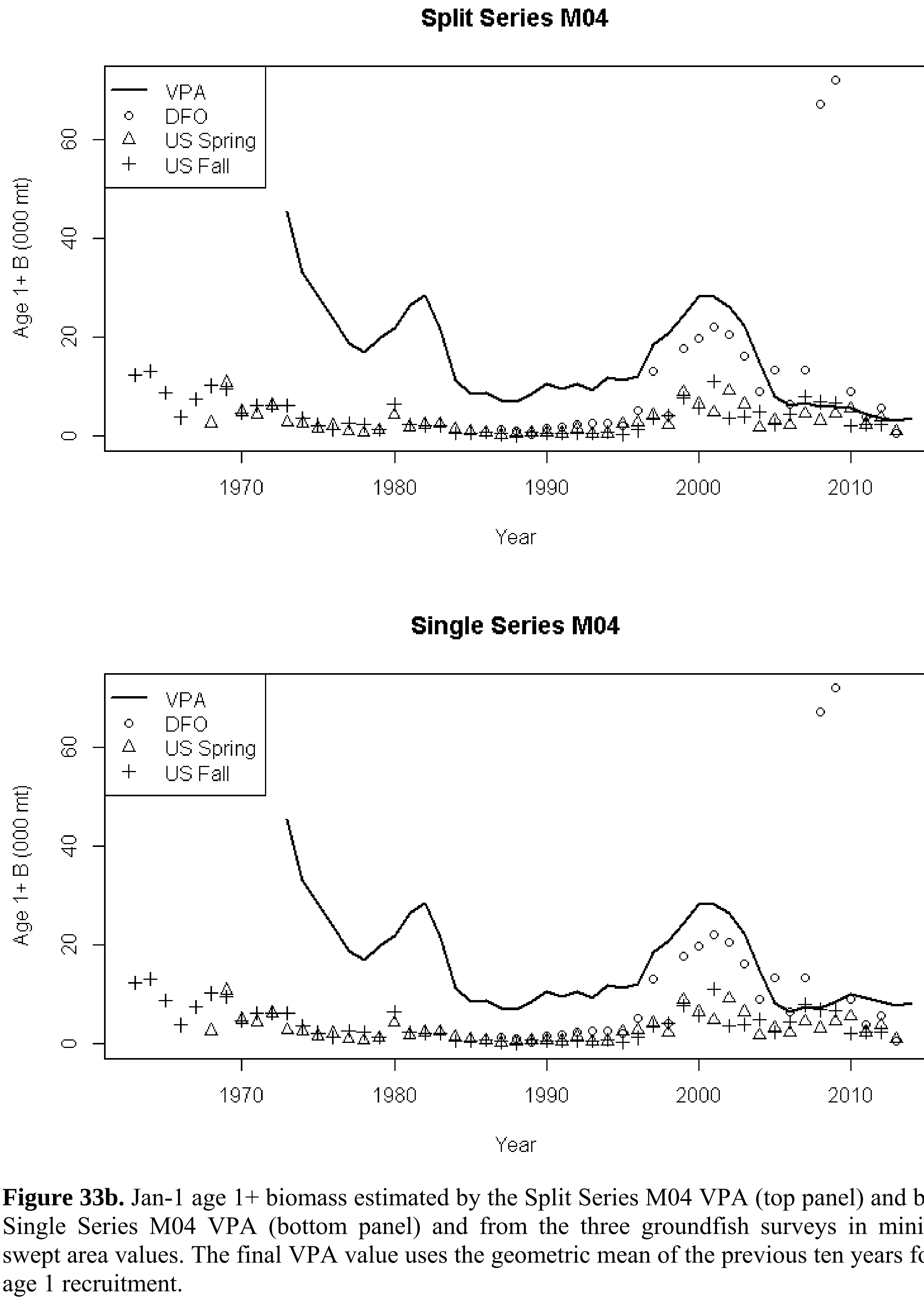
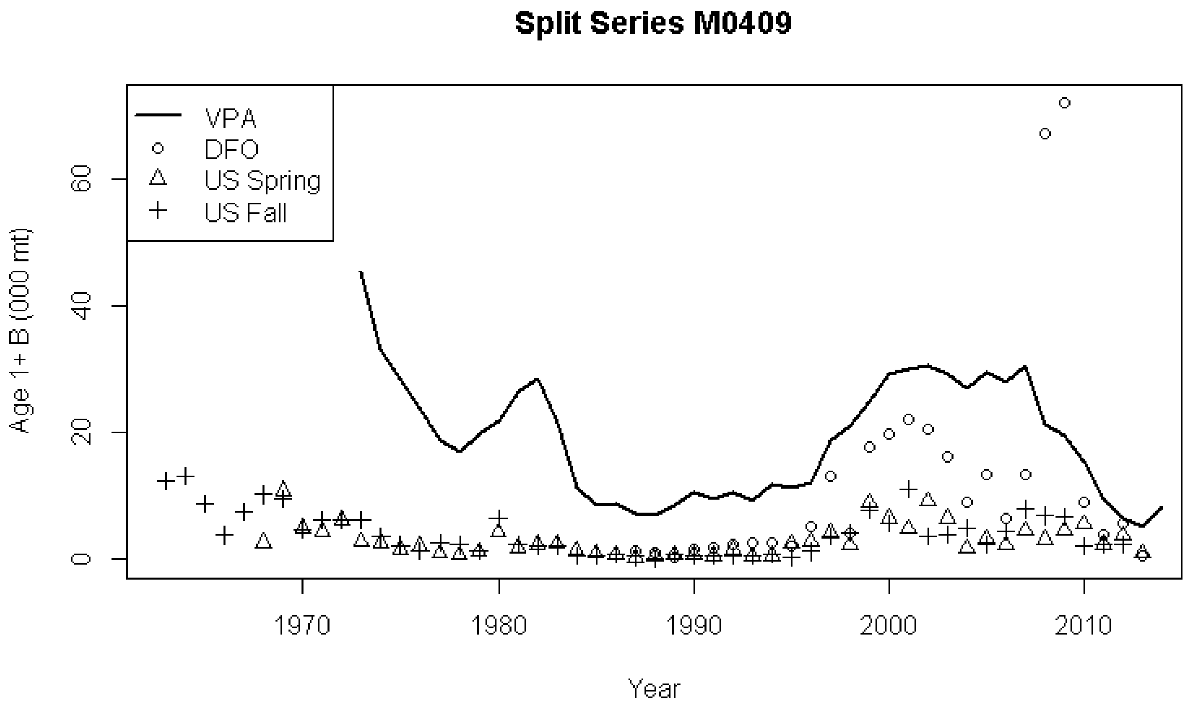


Figure 33b. Jan-1 age 1+ biomass estimated by the Split Series M04 VPA (top panel) and by the Single Series M04 VPA (bottom panel) and from the three groundfish surveys in minimum swept area values. The final VPA value uses the geometric mean of the previous ten years for the age 1 recruitment.



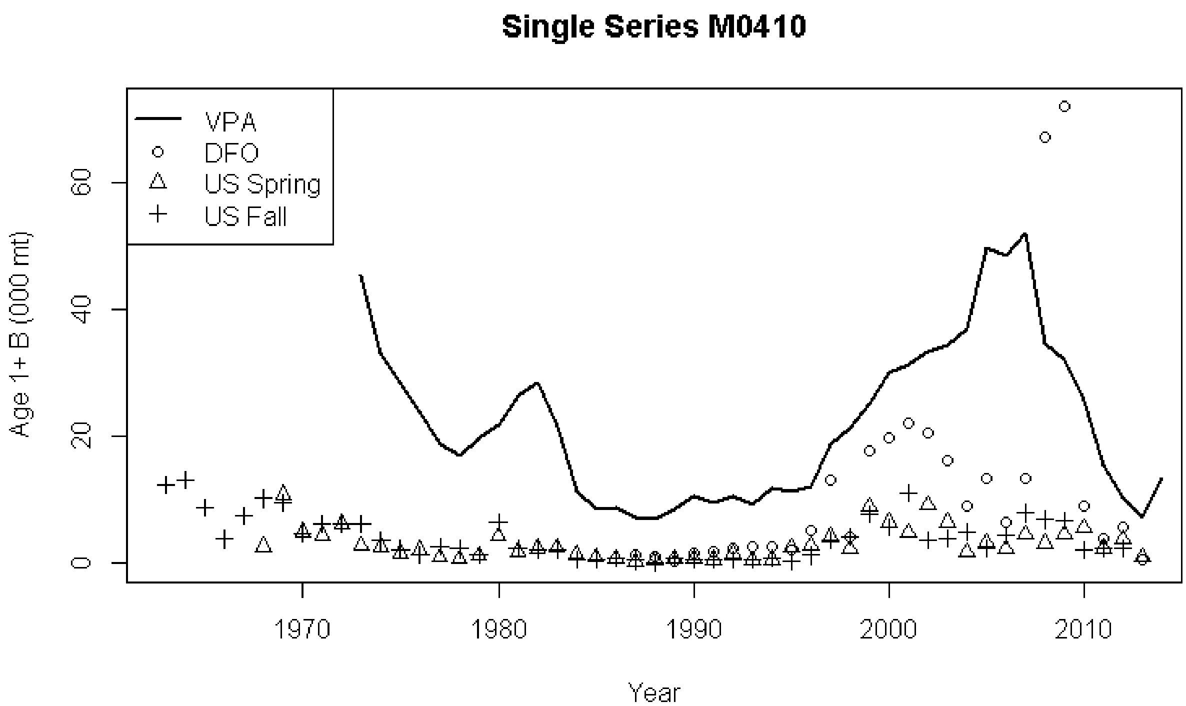


Figure 33c. Jan-1 age 1+ biomass estimated by the Split Series M0409 VPA (top panel) and by the Single Series M0410 VPA (bottom panel) and from the three groundfish surveys in minimum swept area values. The final VPA value uses the geometric mean of the previous ten years for the age 1 recruitment.

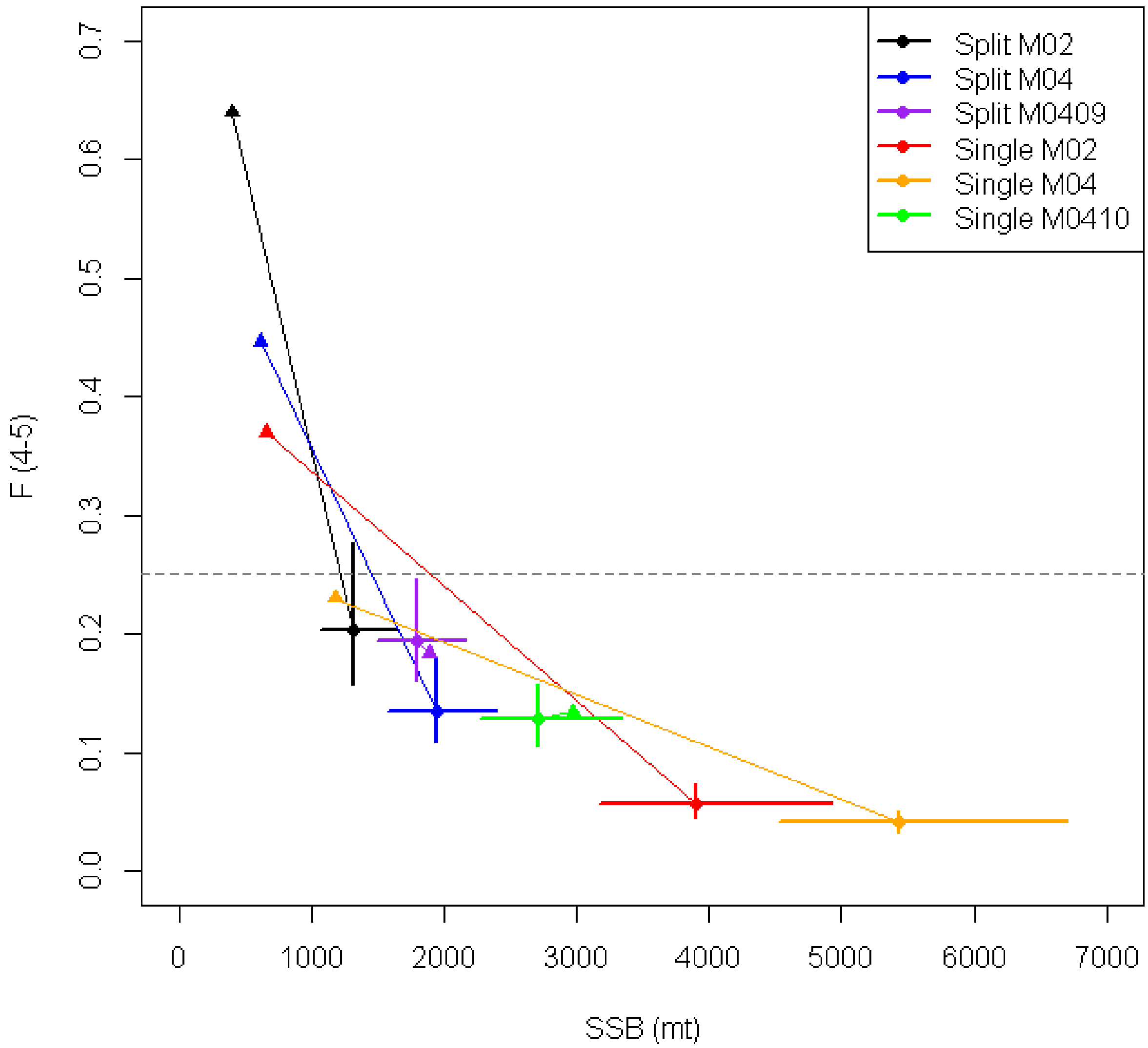
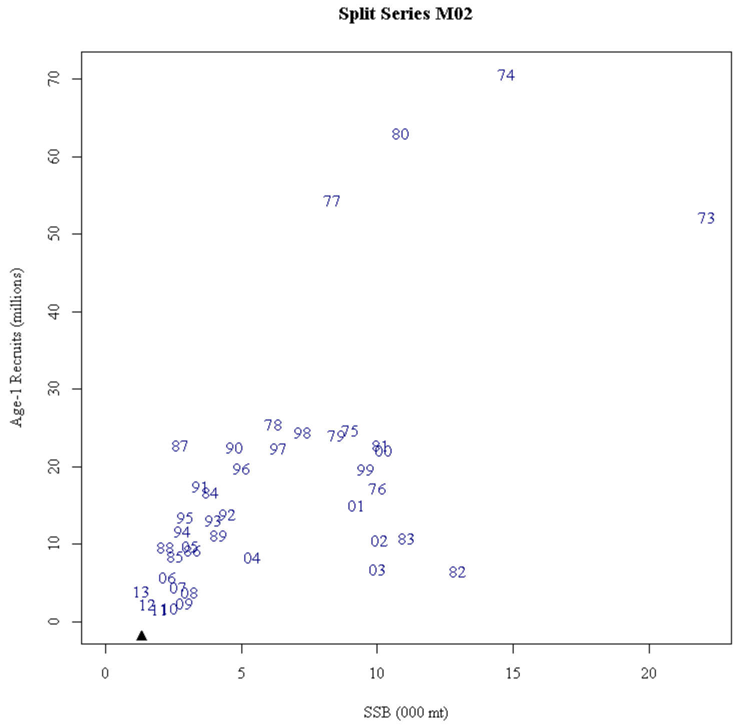


Figure 34. Point estimates of terminal year SSB (mt) and F (ages 4+) with 80% confidence intervals (horizontal and vertical lines) and rho adjusted estimates of SSB and F (triangles) for the six combinations of VPAs. The horizontal dashed line denotes F_{ref}=0.25.



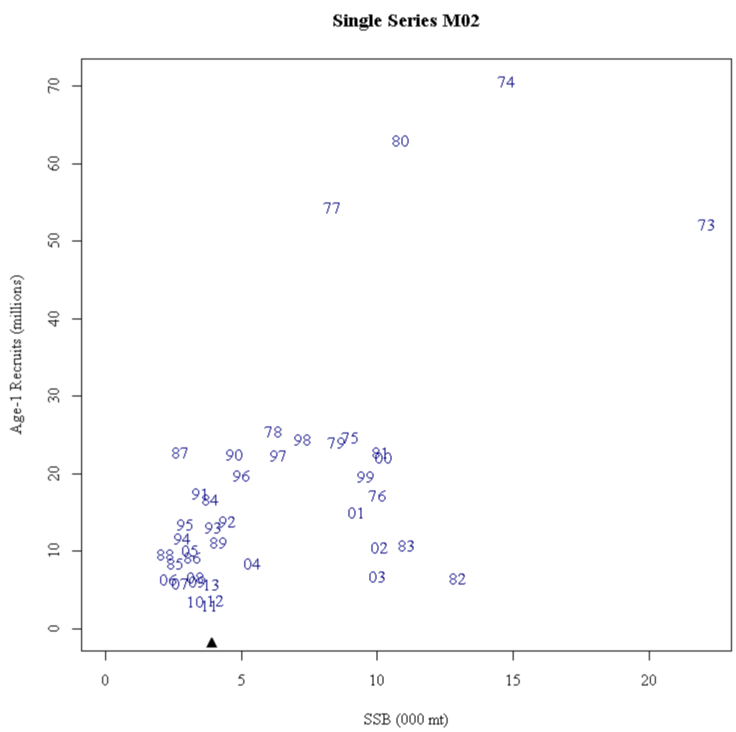


Figure 35a. Stock recruitment relationship from the Split Series M02 VPA and the Single Series M02 VPA. The number denotes year-class (year of SSB and year when recruitment was age 0). The triangle denotes the spawning stock biomass in 2013 (the 13 label shows the geometric mean of the recent 10 years of recruitment).

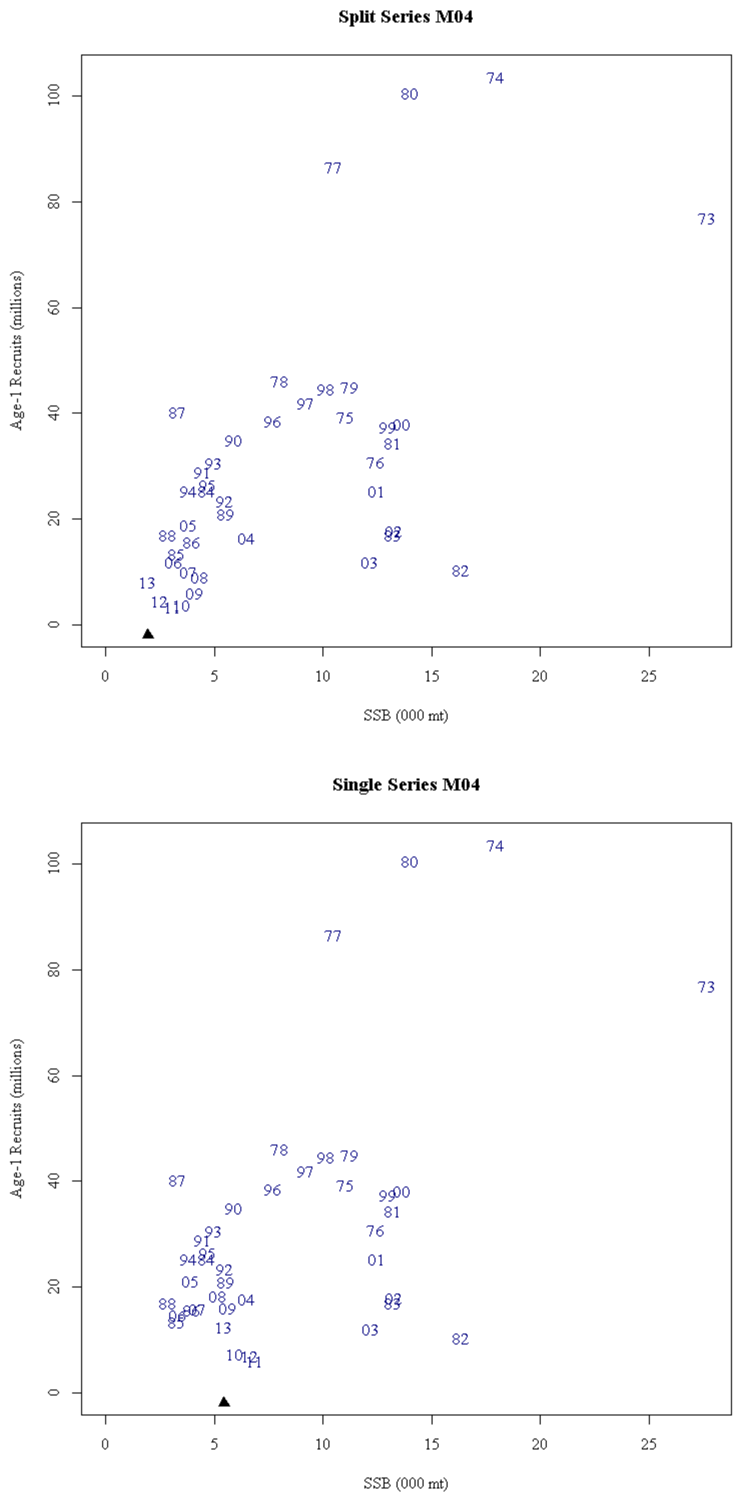


Figure 35b. Stock recruitment relationship from the Split Series M04 VPA and the Single Series M04 VPA. The number denotes year-class (year of SSB and year when recruitment was age 0). The triangle denotes the spawning stock biomass in 2013 (the 13 label shows the geometric mean of the recent 10 years of recruitment).

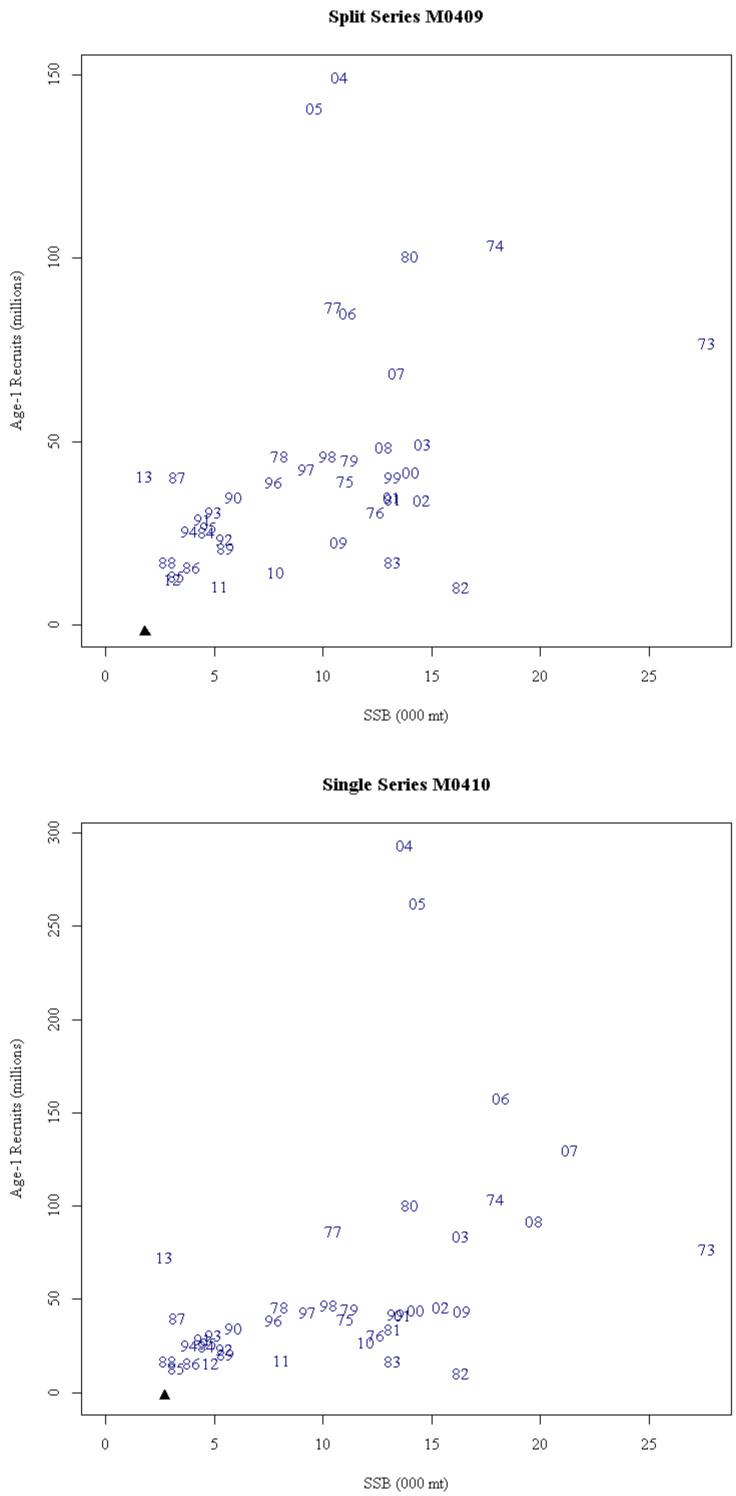


Figure 35c. Stock recruitment relationship from the Split Series M0409 VPA and the Single Series M0410 VPA. The number denotes year-class (year of SSB and year when recruitment was age 0). The triangle denotes the spawning stock biomass in 2013 (the 13 label shows the geometric mean of the recent 10 years of recruitment).

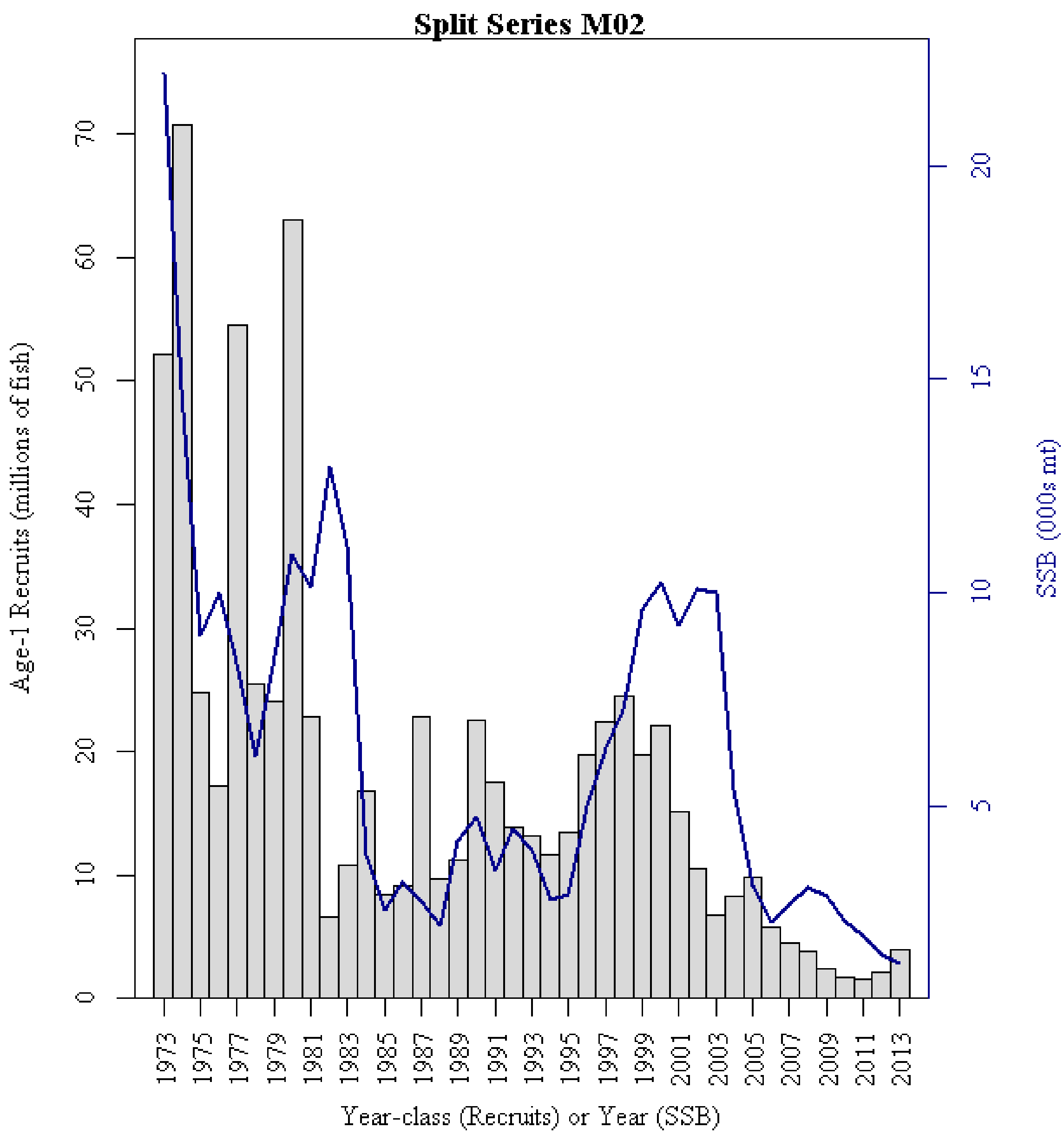


Figure 36a. Estimated age 1 recruitment in millions of fish (denoted by bars) and spawning stock biomass in thousands of metric tons (denoted by solid line) by year-class (recruitment) or year (SSB) from the Split Series M02 VPA. The 2013 recruitment year-class is the geometric mean of the previous ten years.

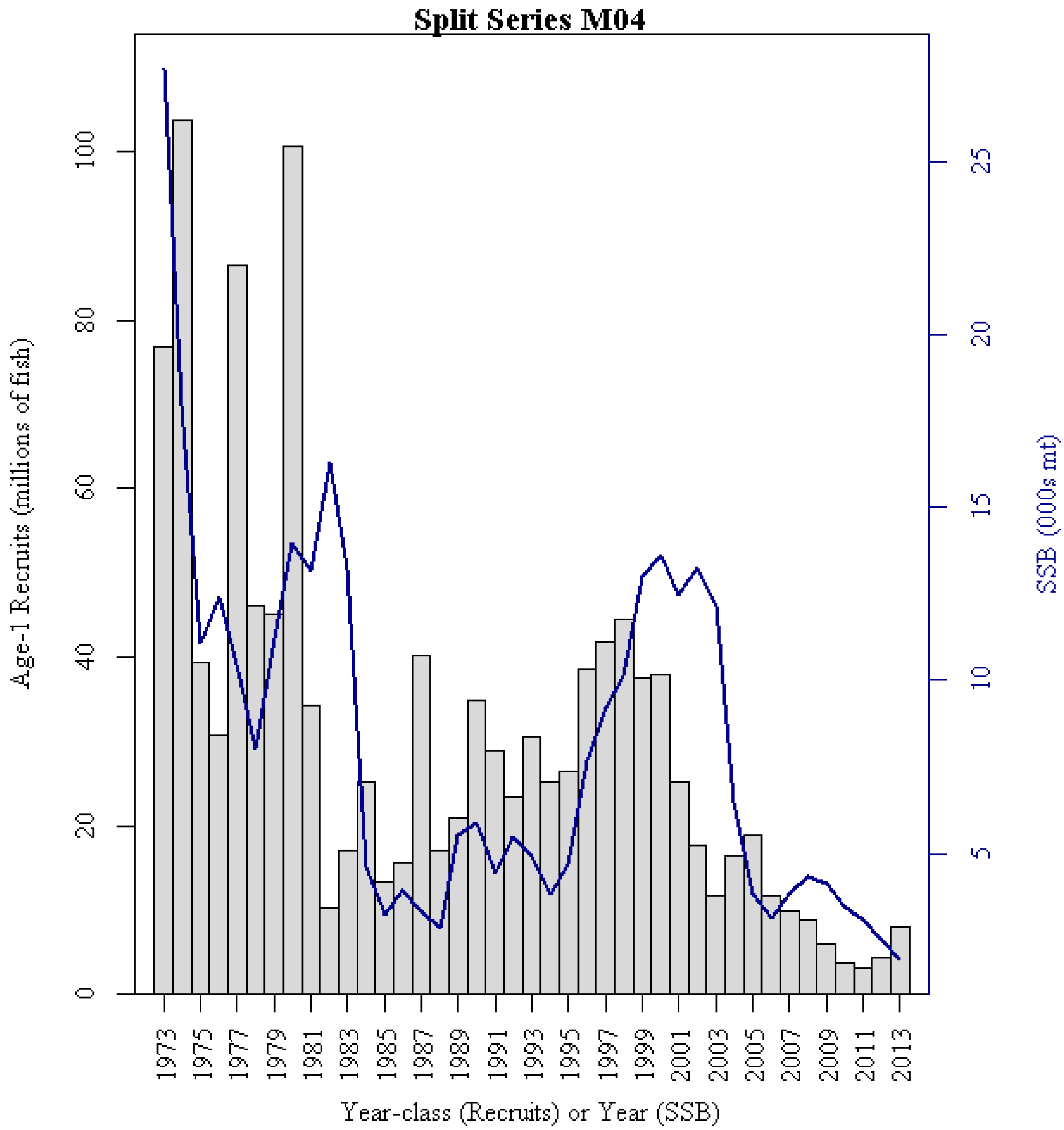


Figure 36b. Estimated age 1 recruitment in millions of fish (denoted by bars) and spawning stock biomass in thousands of metric tons (denoted by solid line) by year-class (recruitment) or year (SSB) from the Split Series M04 VPA. The 2013 recruitment year-class is the geometric mean of the previous ten years.

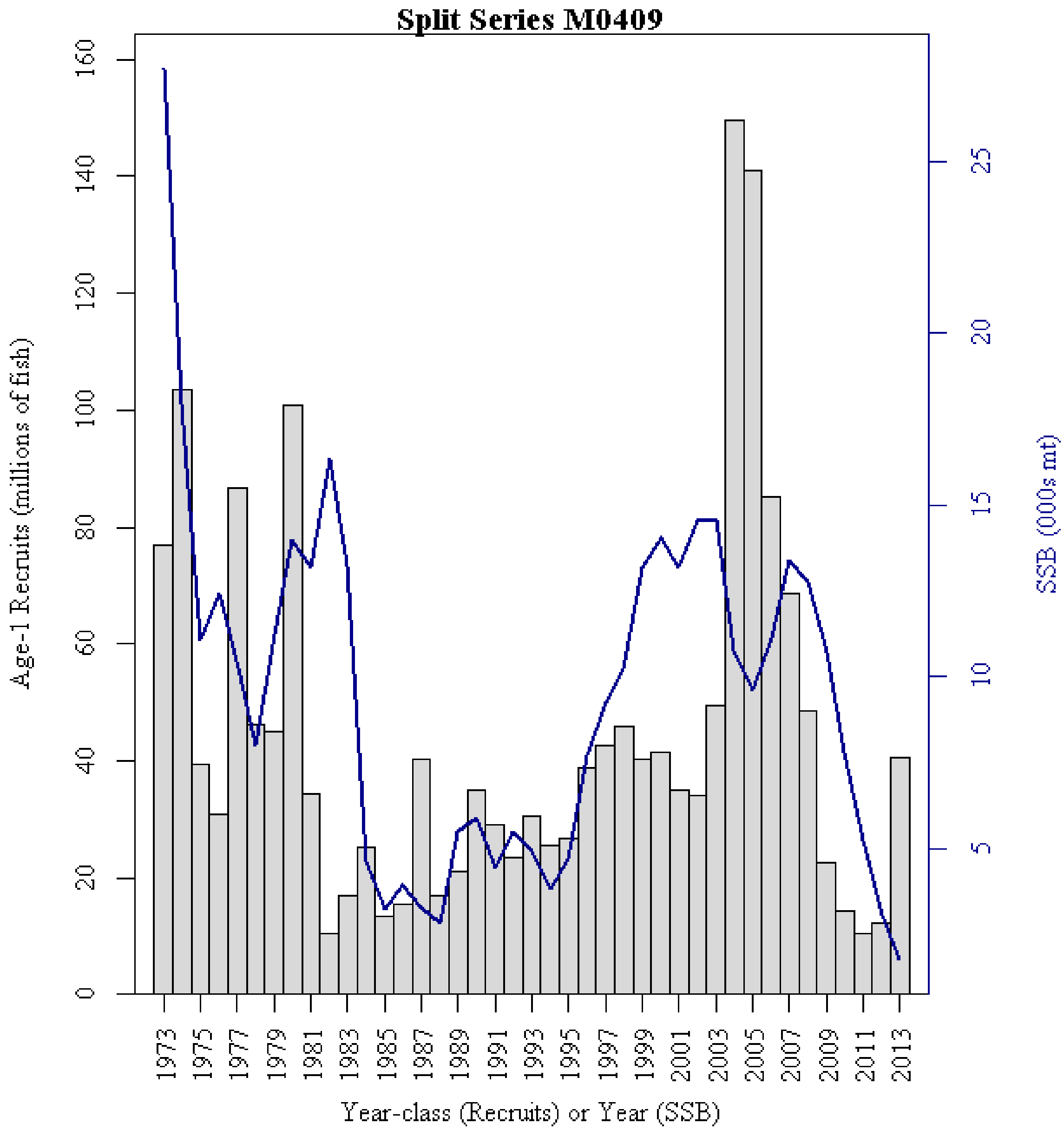


Figure 36c. Estimated age 1 recruitment in millions of fish (denoted by bars) and spawning stock biomass in thousands of metric tons (denoted by solid line) by year-class (recruitment) or year (SSB) from the Split Series M0409 VPA. The 2013 recruitment year-class is the geometric mean of the previous ten years.

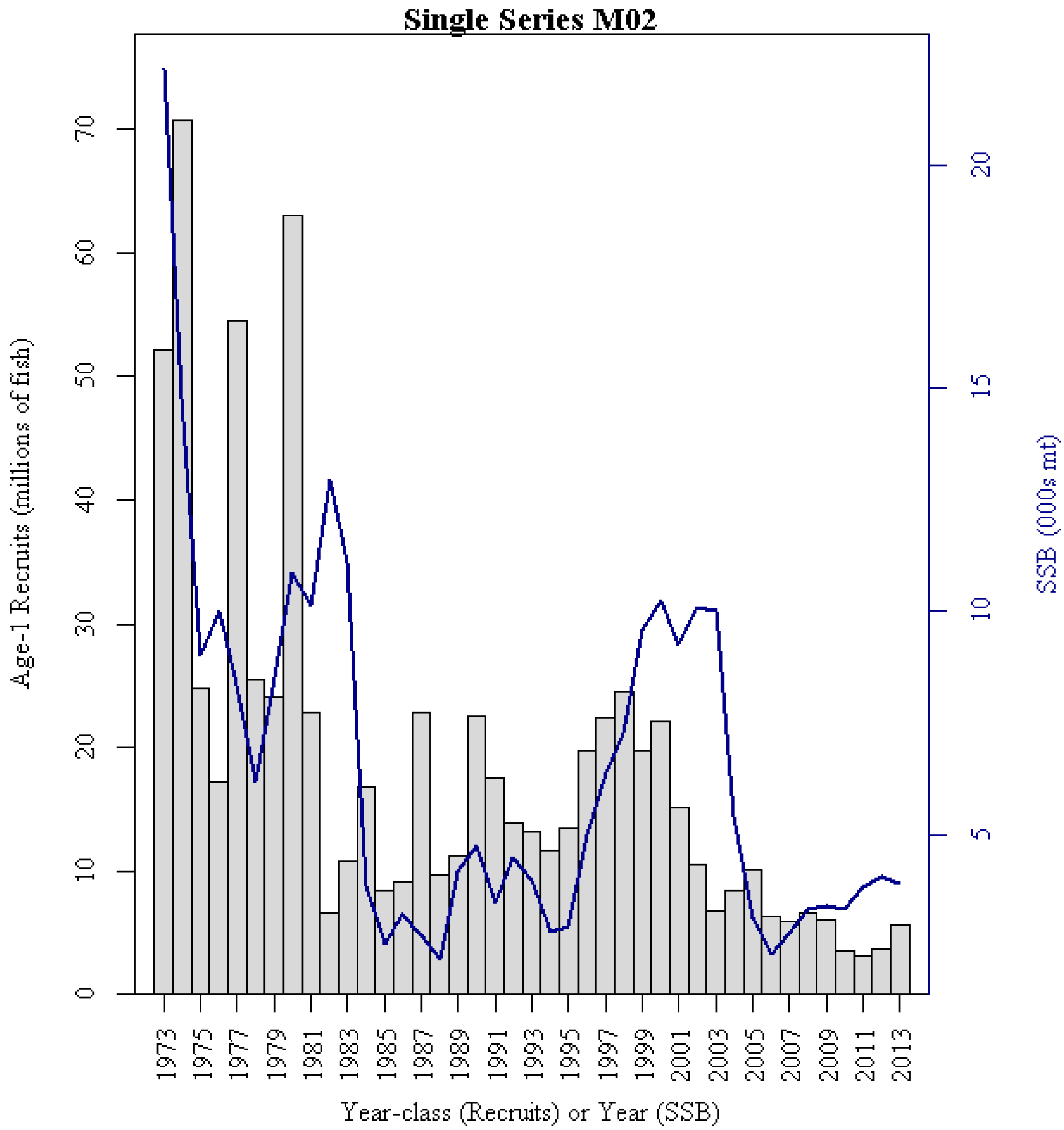


Figure 36d. Estimated age 1 recruitment in millions of fish (denoted by bars) and spawning stock biomass in thousands of metric tons (denoted by solid line) by year-class (recruitment) or year (SSB) from the Single Series M02 VPA. The 2013 recruitment year-class is the geometric mean of the previous ten years.

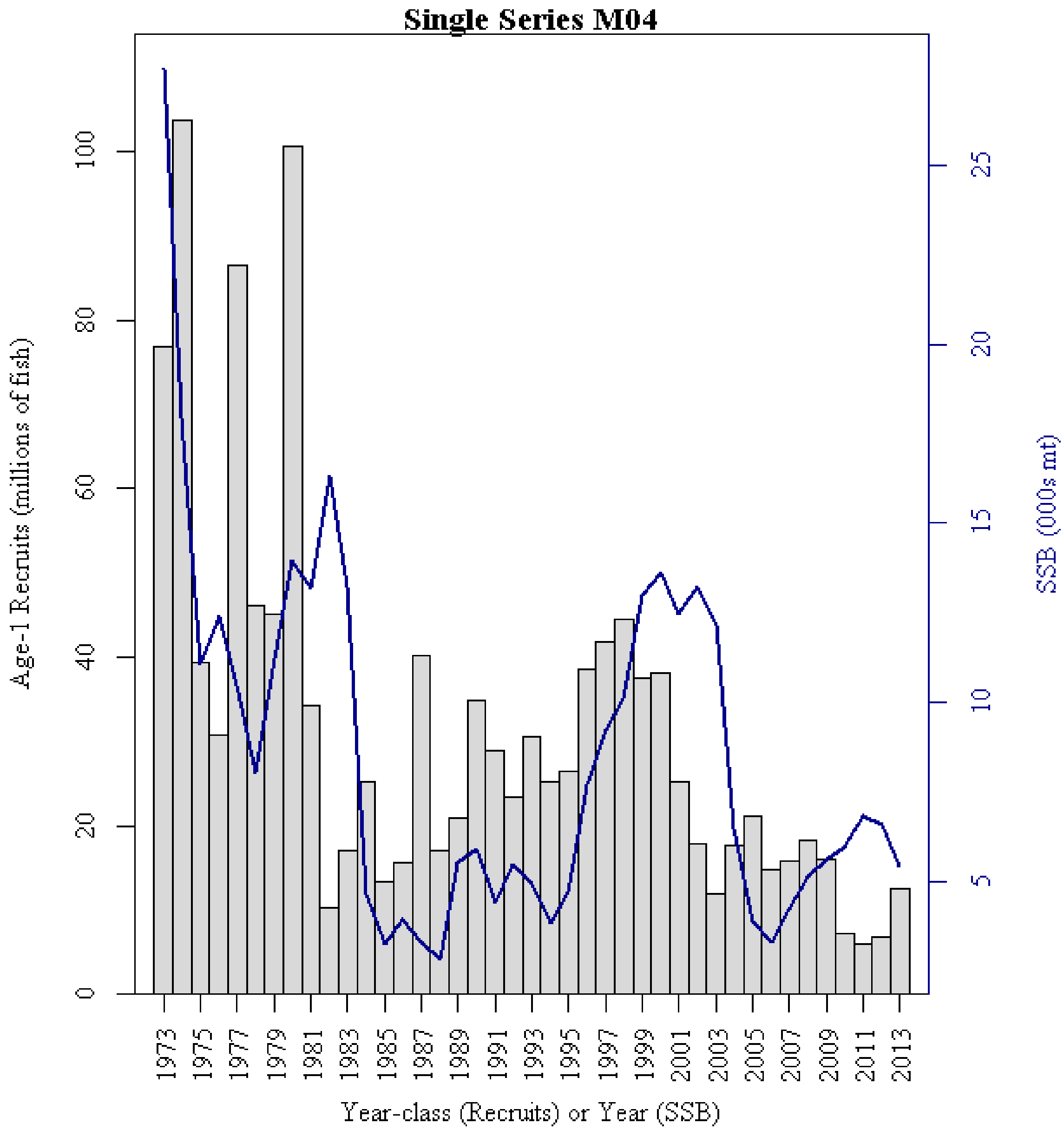


Figure 36e. Estimated age 1 recruitment in millions of fish (denoted by bars) and spawning stock biomass in thousands of metric tons (denoted by solid line) by year-class (recruitment) or year (SSB) from the Single Series M04 VPA. The 2013 recruitment year-class is the geometric mean of the previous ten years.

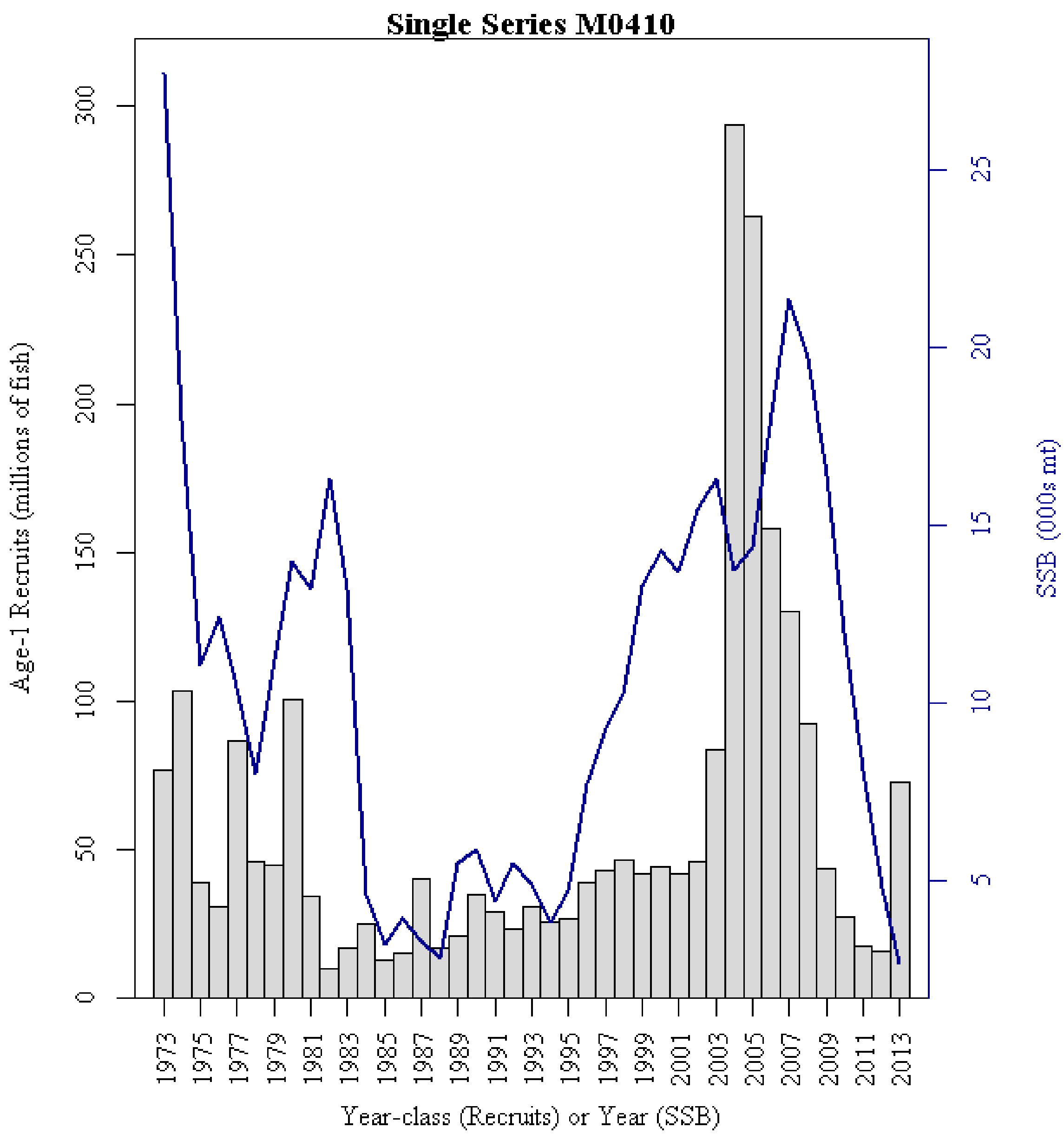


Figure 36f. Estimated age 1 recruitment in millions of fish (denoted by bars) and spawning stock biomass in thousands of metric tons (denoted by solid line) by year-class (recruitment) or year (SSB) from the Single Series M0410 VPA. The 2013 recruitment year-class is the geometric mean of the previous ten years.

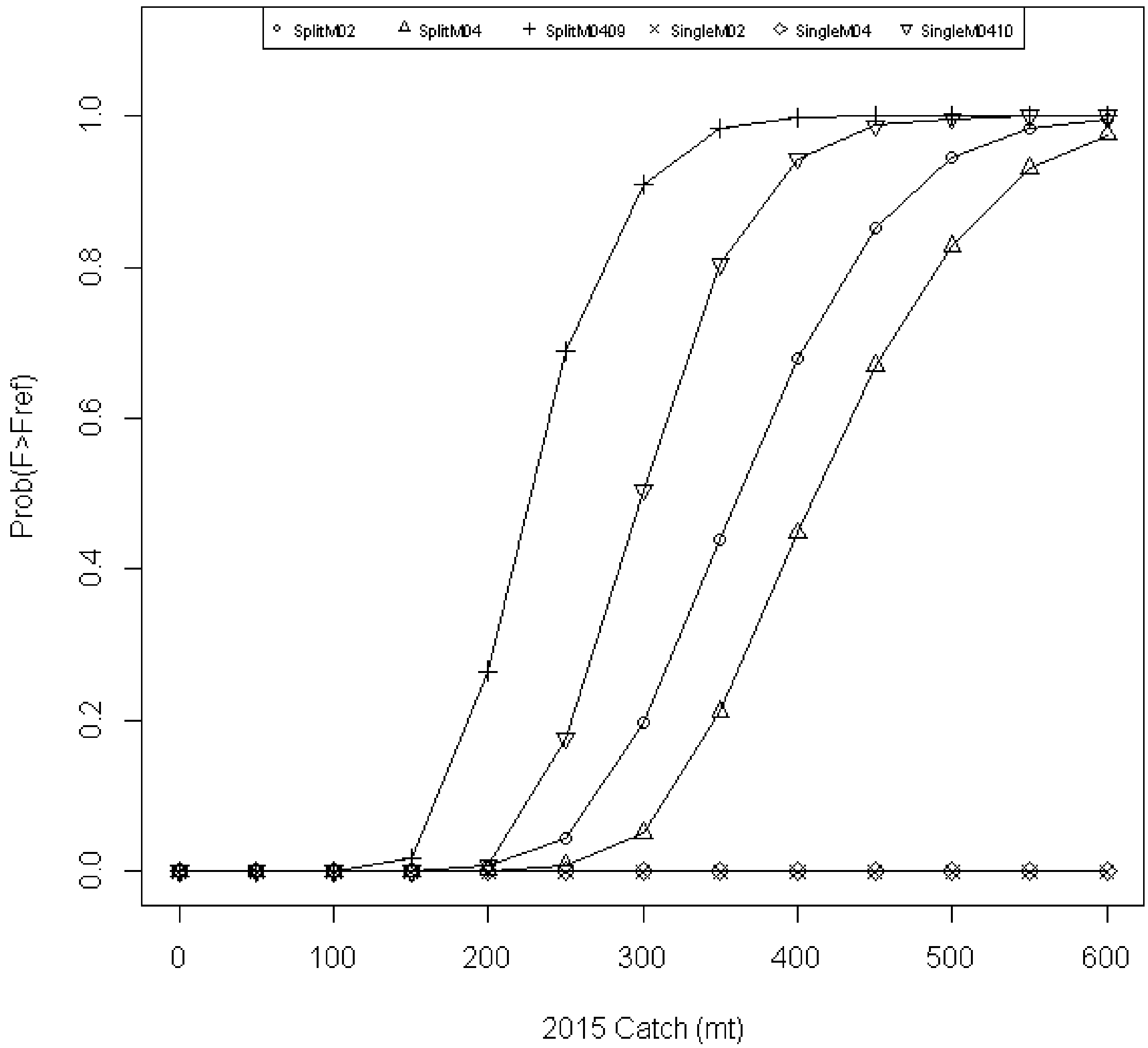


Figure 37a. Probability the fishing mortality rate in 2015 is greater than F_{ref}=0.25 for a range of catch values in 2015 and six projection scenarios with no adjustment to the starting population size.

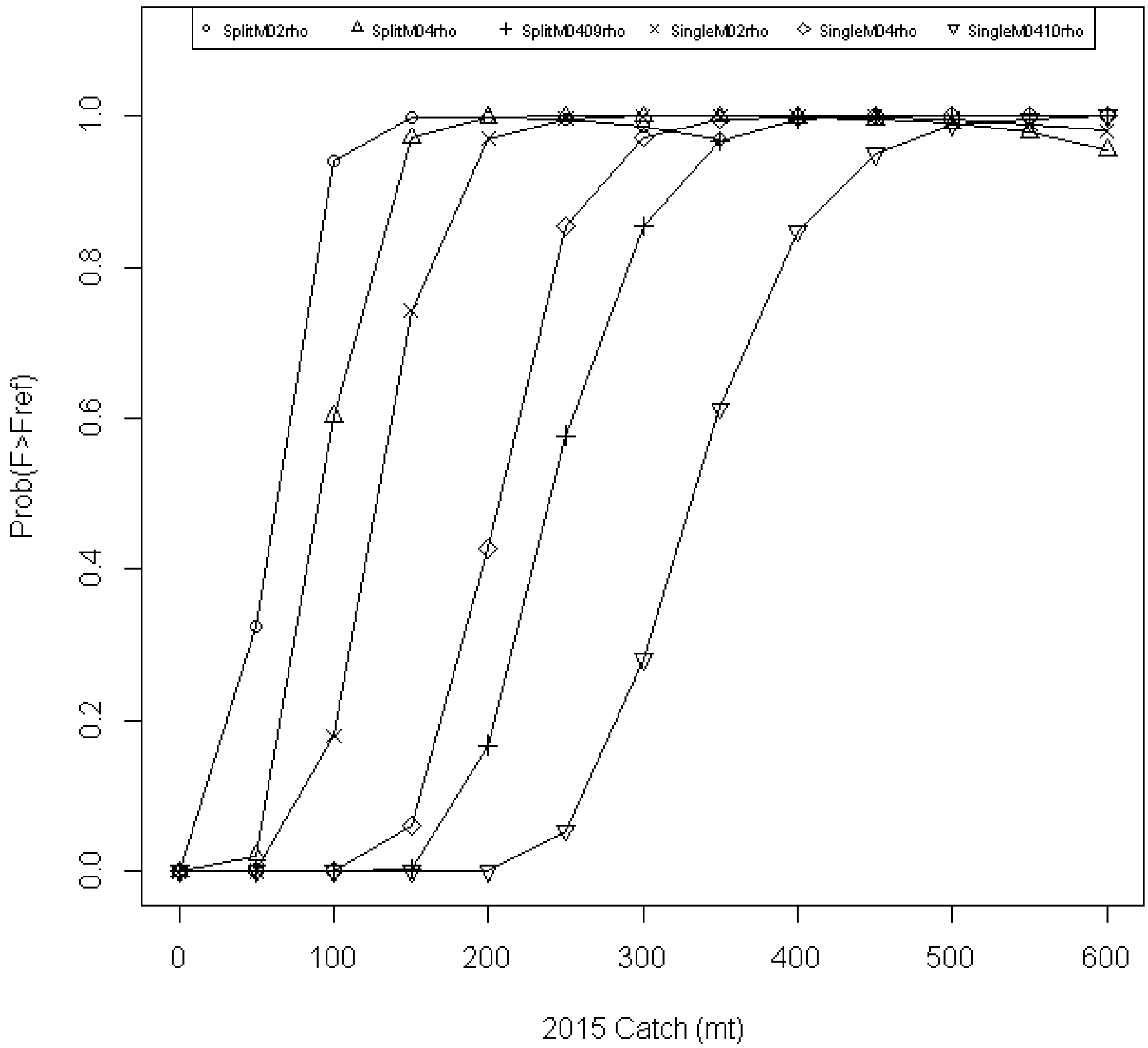


Figure 37b. Probability the fishing mortality rate in 2015 is greater than F_{ref}=0.25 for a range of catch values in 2015 and six projection scenarios with the starting population size rho adjusted.

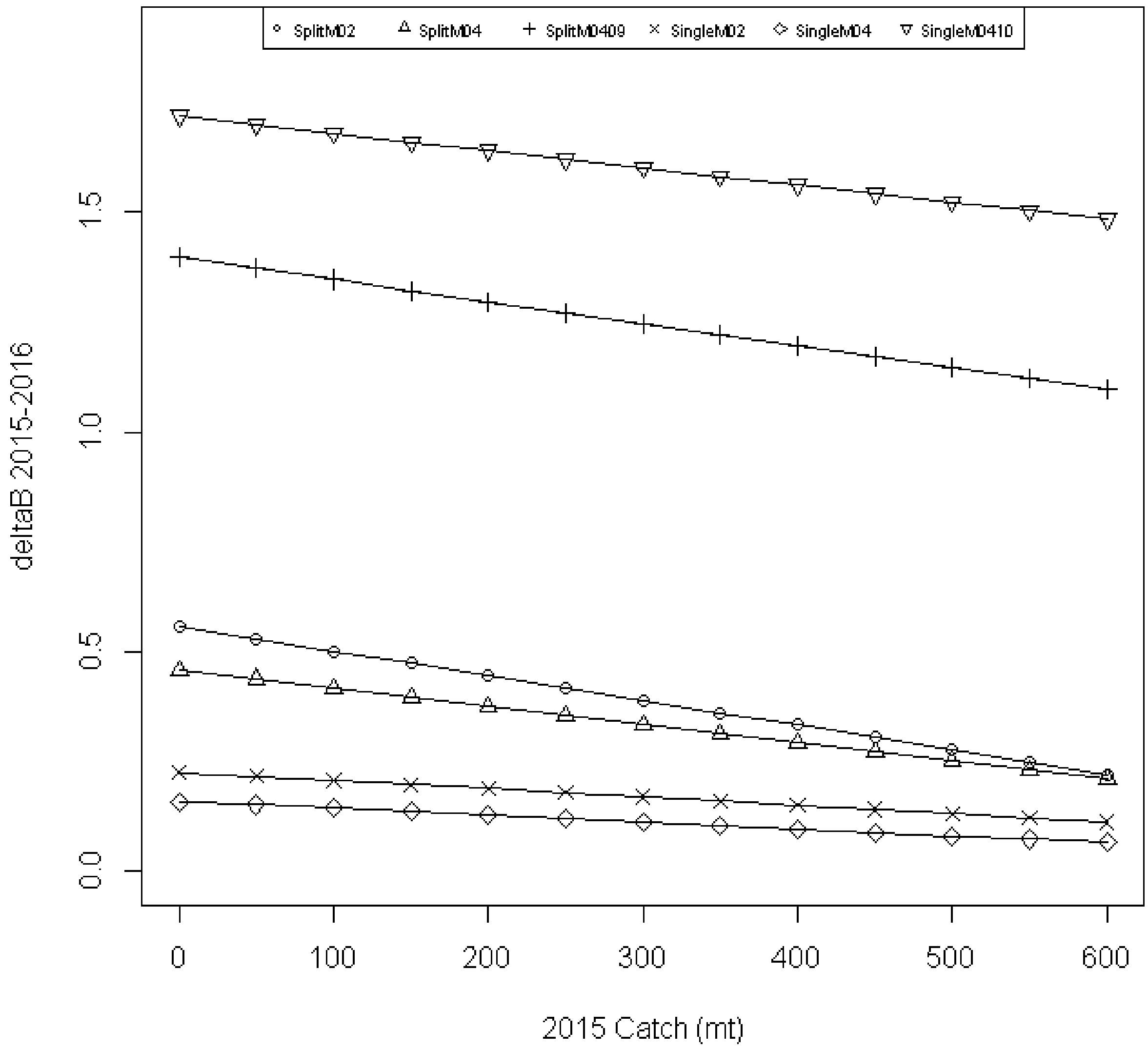


Figure 38a. Relative change in median adult Jan-1 biomass from 2015 to 2016 for a range of catch values in 2015 and six projection scenarios with no adjustment to the starting population size.

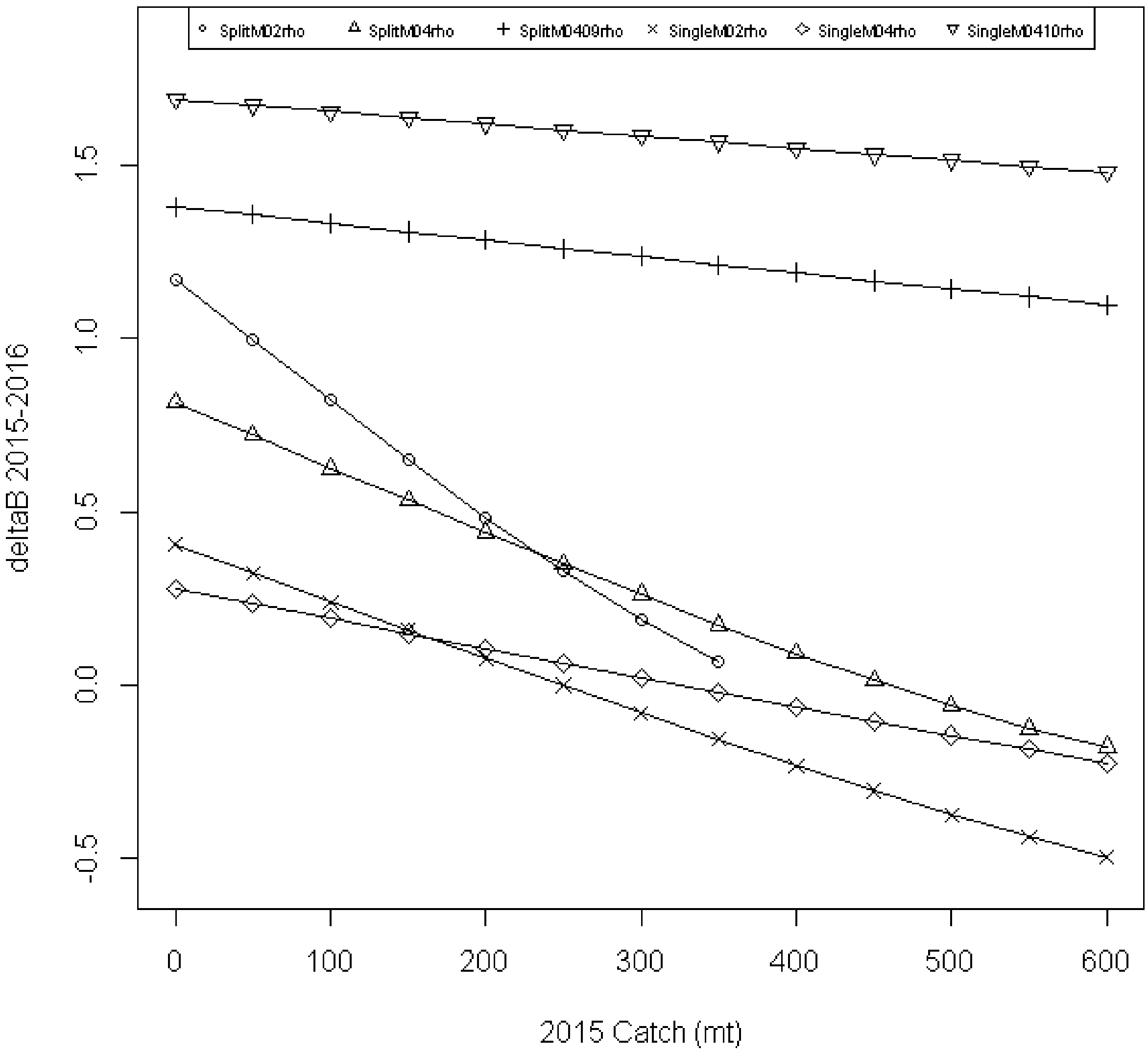


Figure 38b. Relative change in median adult Jan-1 biomass from 2015 to 2016 for a range of catch values in 2015 and six projection scenarios with the starting population size rho adjusted.

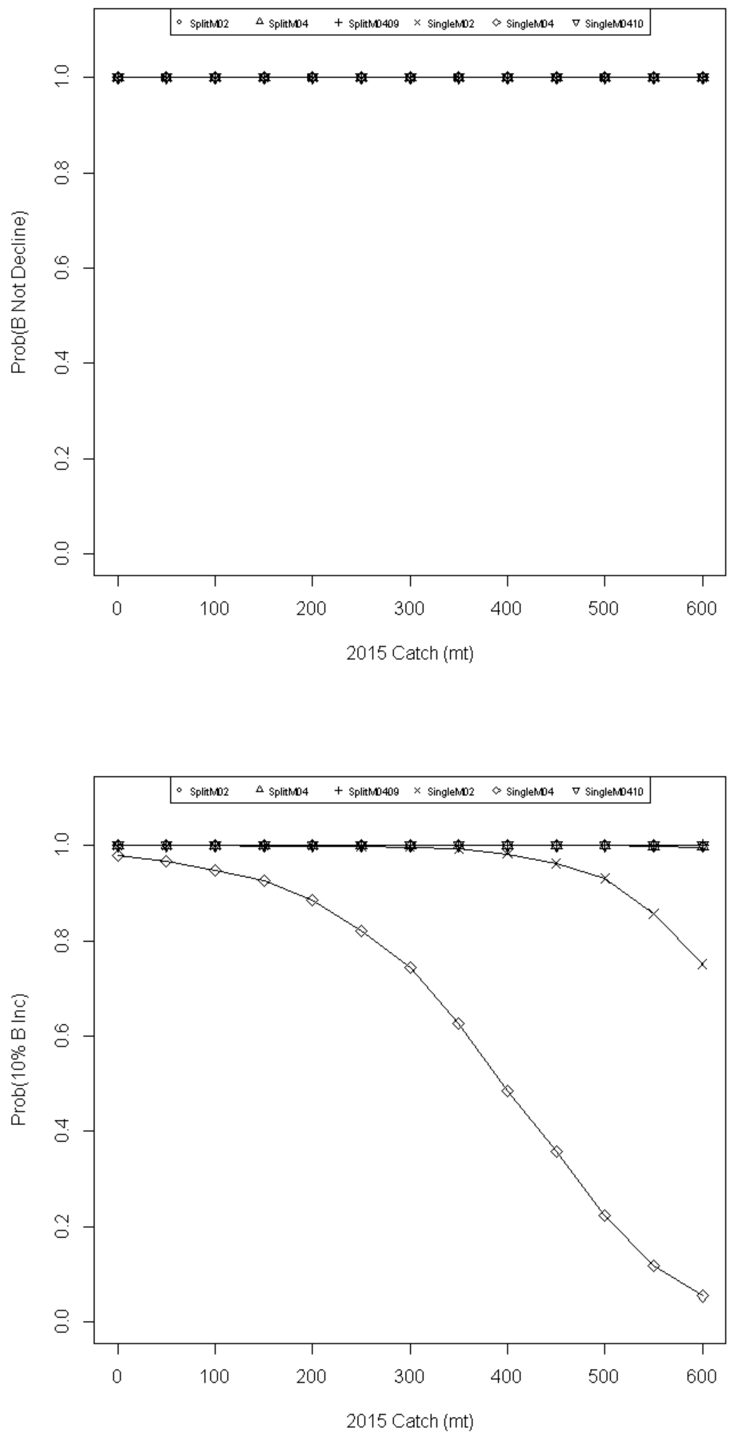


Figure 39a. Probability adult Jan-1 biomass will not decline (top panel) or will increase by at least 10% (bottom panel) from 2015 to 2016 for a range of catch values in 2015 and six projection scenarios with no adjustment to the starting population size.

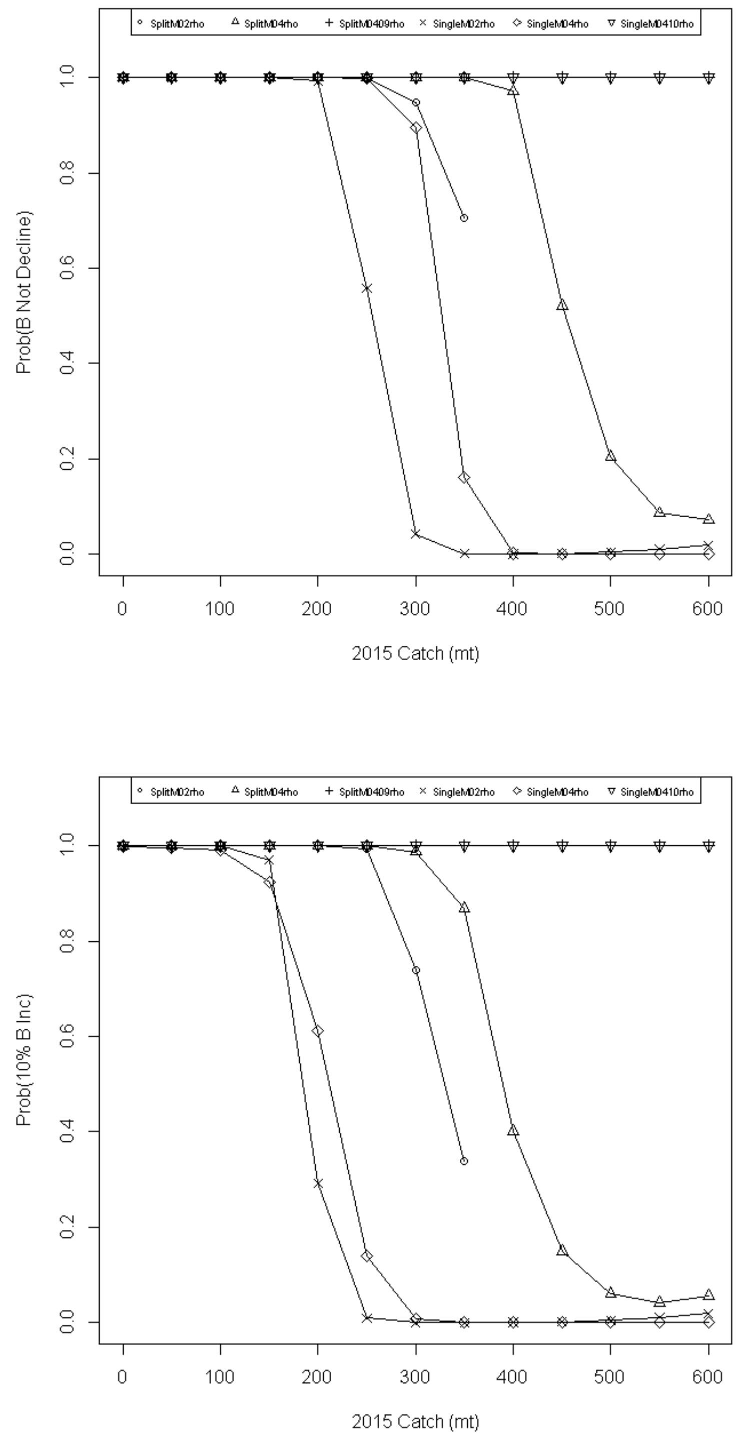


Figure 39b. Probability adult Jan-1 biomass will not decline (top panel) or will increase by at least 10% (bottom panel) from 2015 to 2016 for a range of catch values in 2015 and six projection scenarios with the starting population size rho adjusted.

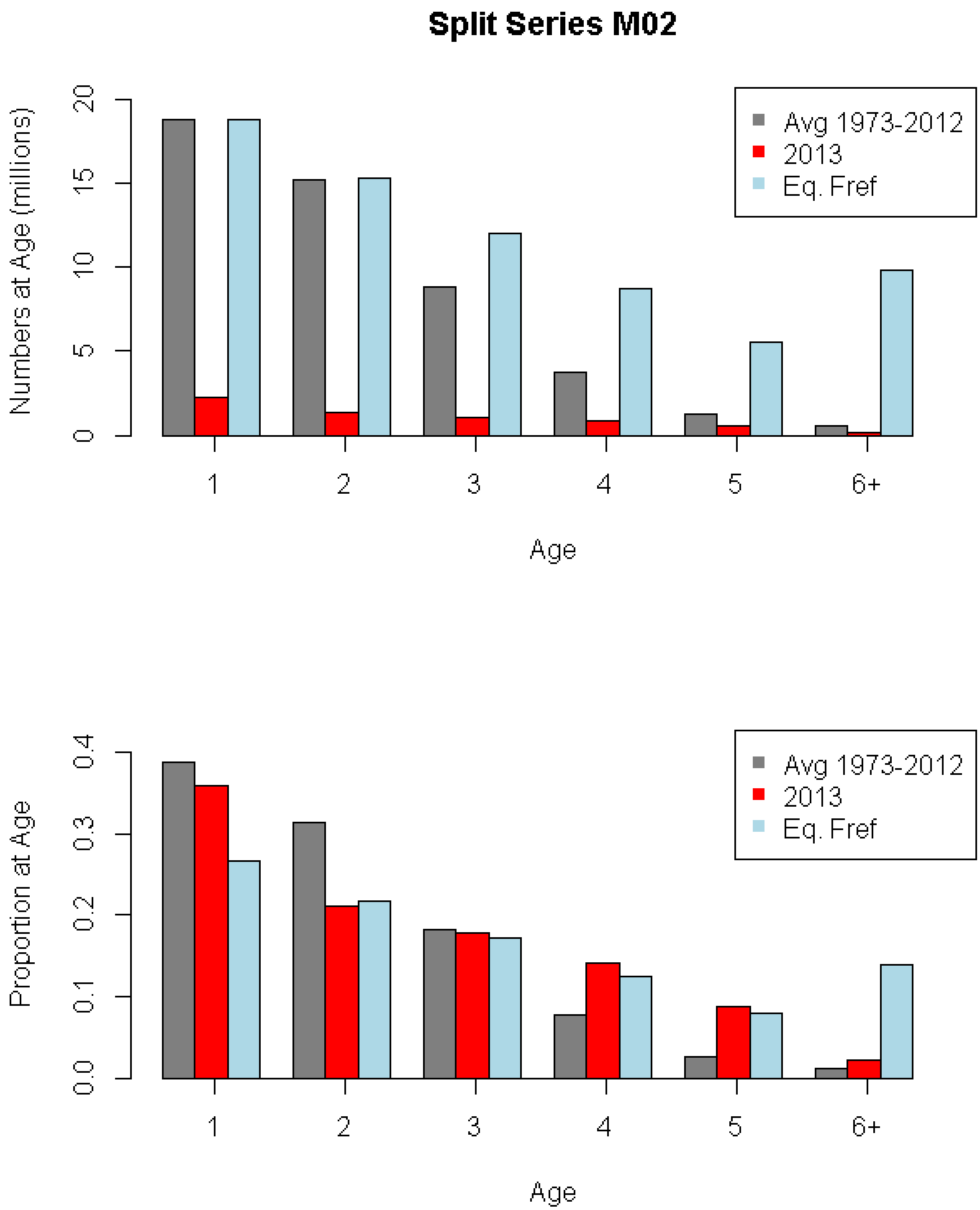


Figure 40a. Comparison of the population abundance at age distributions for the Split Series M02 VPA among the average of 1973-2012, 2013, and that expected when the population is fished in equilibrium at F_{ref}=0.25. The equilibrium numbers at age 1 in the top panel are set equal to the average for years 1973-2012. The bottom panel shows the proportions at age instead of numbers.

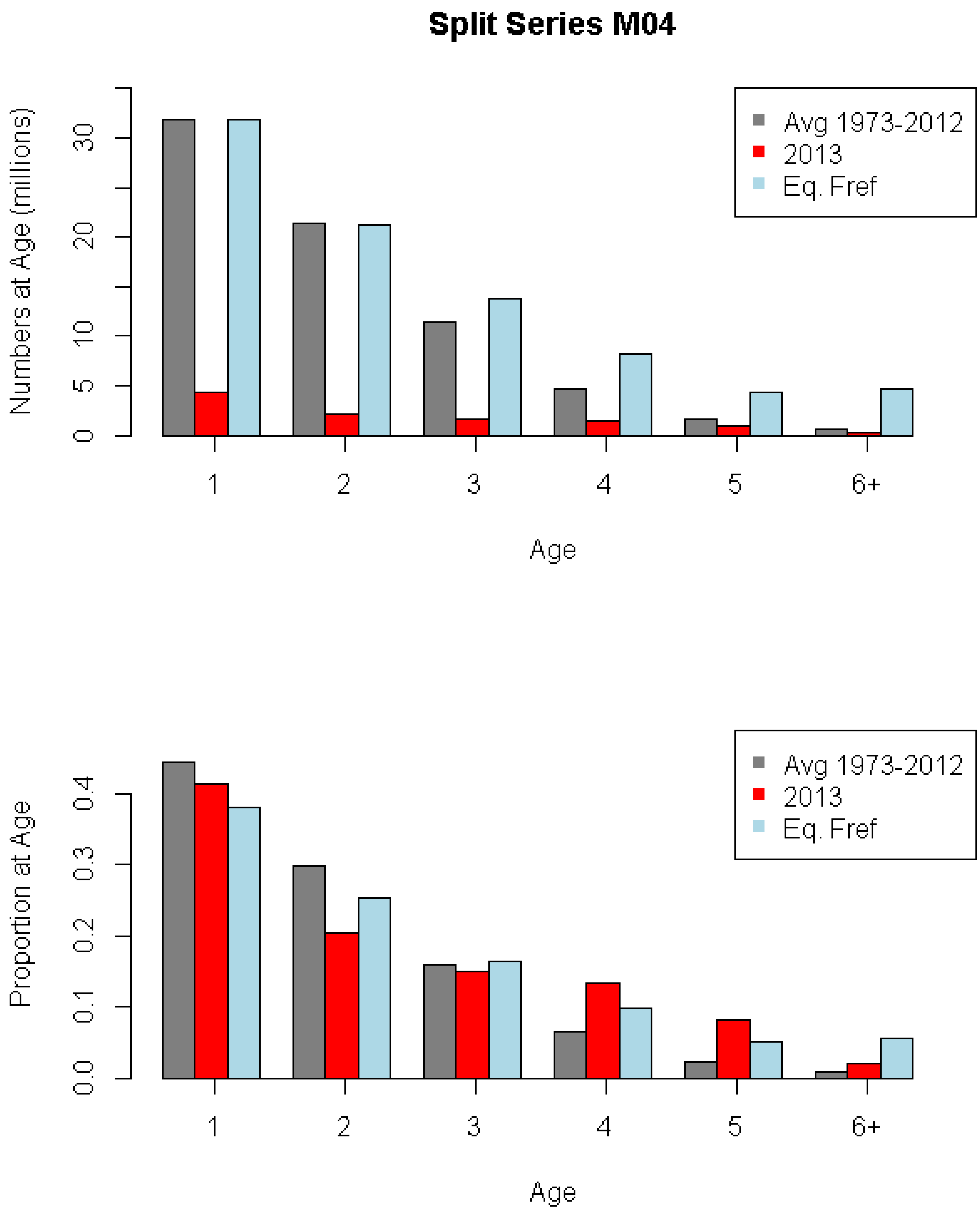


Figure 40b. Comparison of the population abundance at age distributions for the Split Series M04 VPA among the average of 1973-2012, 2013, and that expected when the population is fished in equilibrium at F_{ref}=0.25. The equilibrium numbers at age 1 in the top panel are set equal to the average for years 1973-2012. The bottom panel shows the proportions at age instead of numbers.

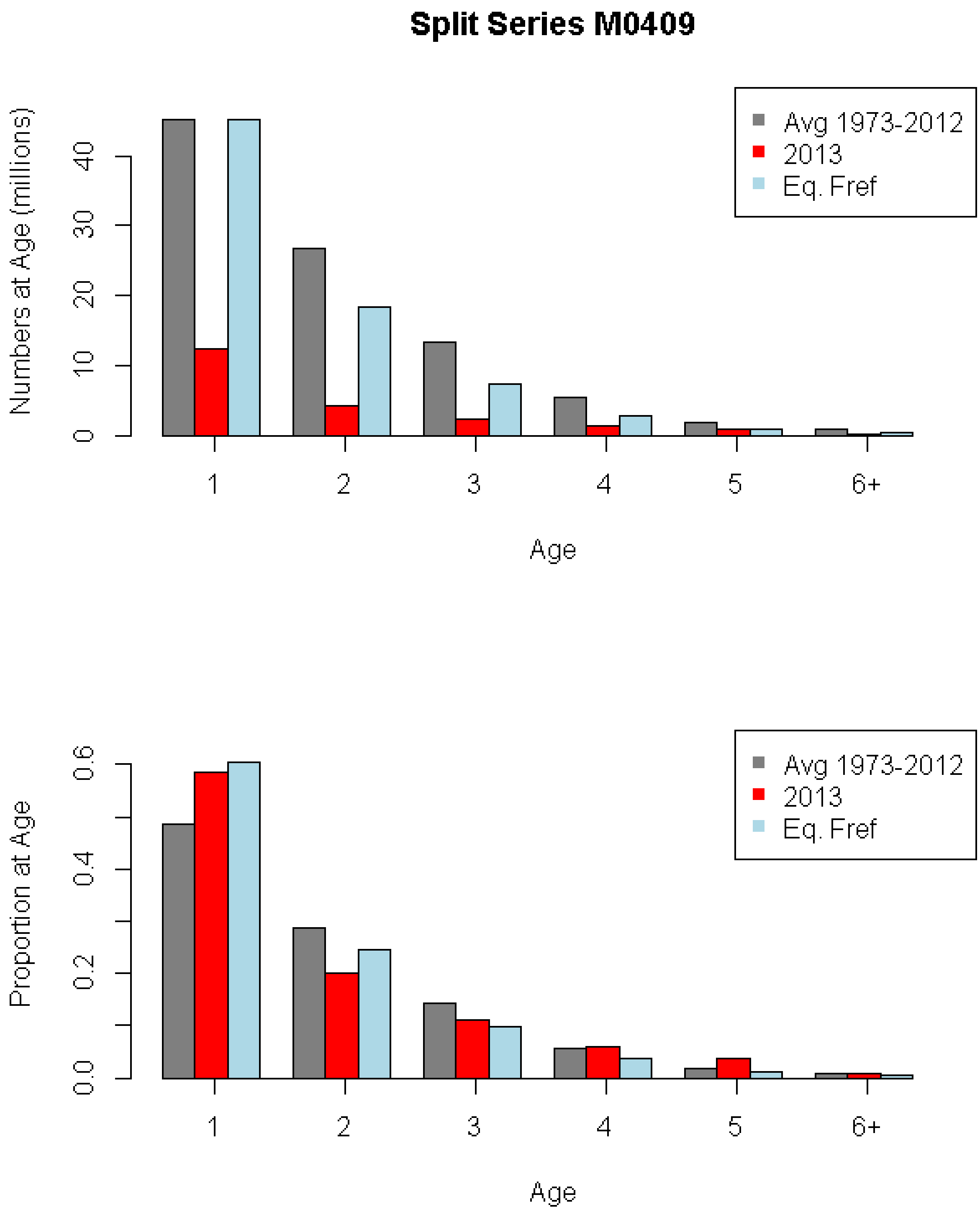
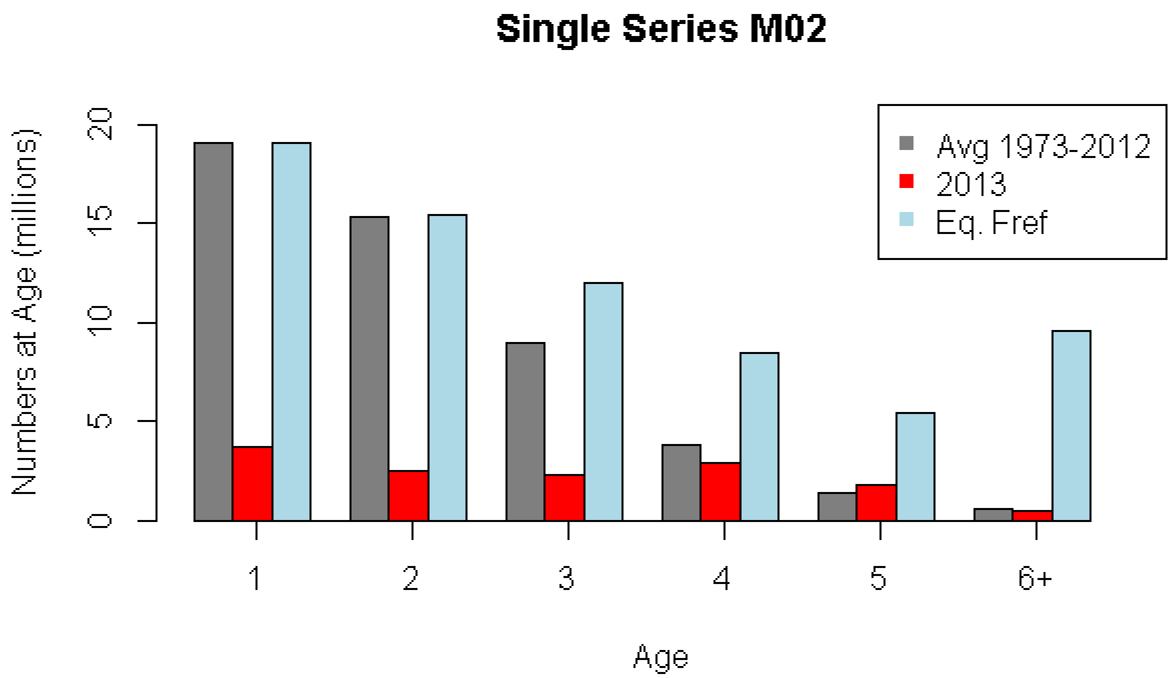


Figure 40c. Comparison of the population abundance at age distributions for the Split Series M0409 VPA among the average of 1973-2012, 2013, and that expected when the population is fished in equilibrium at F_{ref}=0.25. The equilibrium numbers at age 1 in the top panel are set equal to the average for years 1973-2012. The bottom panel shows the proportions at age instead of numbers.



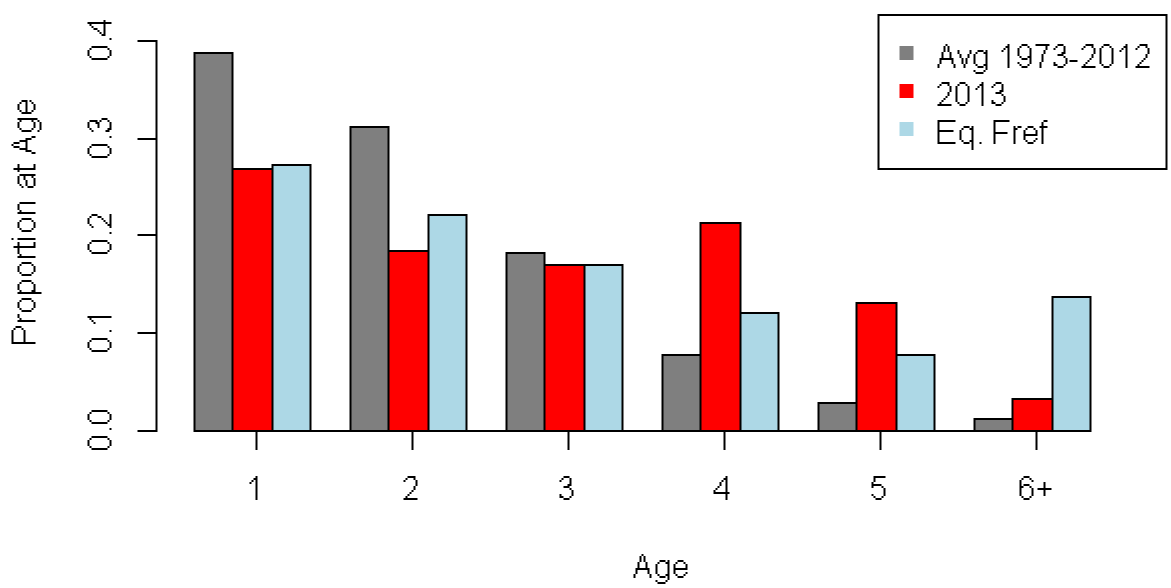
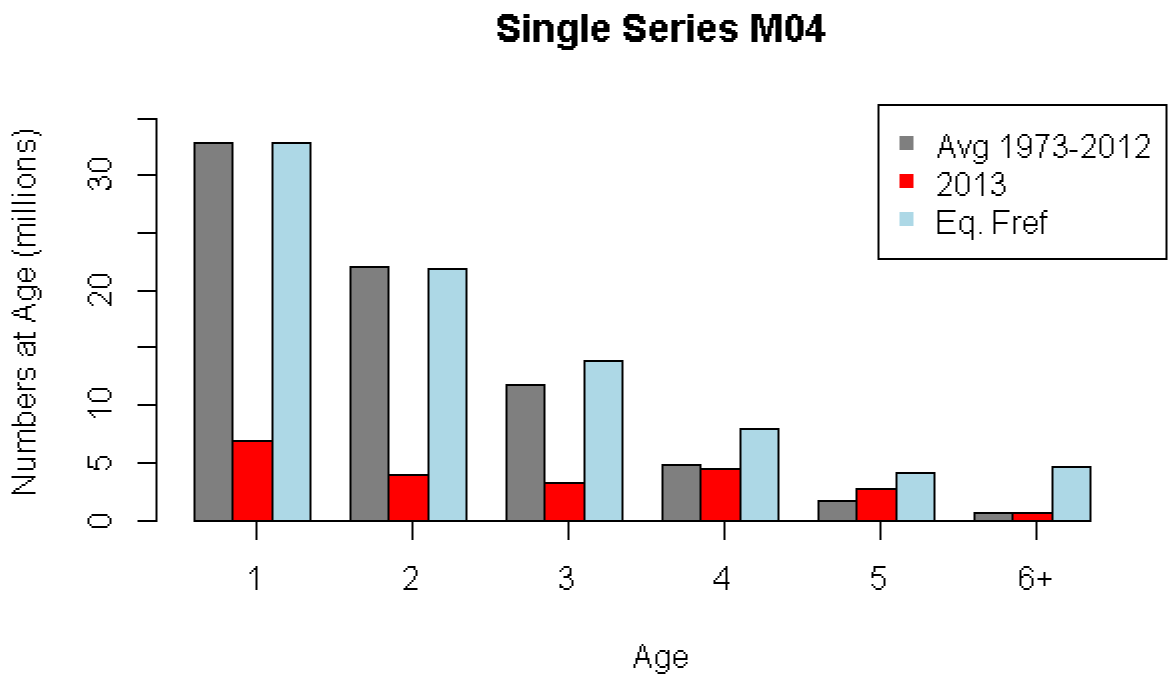


Figure 40d. Comparison of the population abundance at age distributions for the Single Series M02 VPA among the average of 1973-2012, 2013, and that expected when the population is fished in equilibrium at F_{ref}=0.25. The equilibrium numbers at age 1 in the top panel are set equal to the average for years 1973-2012. The bottom panel shows the proportions at age instead of numbers.



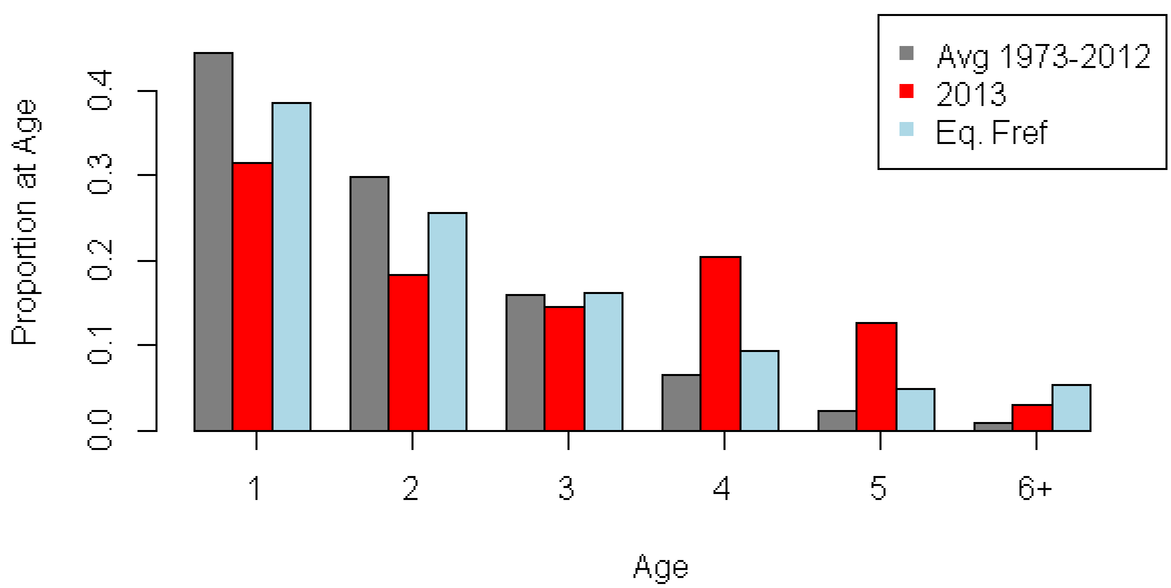


Figure 40e. Comparison of the population abundance at age distributions for the Single Series M04 VPA among the average of 1973-2012, 2013, and that expected when the population is fished in equilibrium at F_{ref}=0.25. The equilibrium numbers at age 1 in the top panel are set equal to the average for years 1973-2012. The bottom panel shows the proportions at age instead of numbers.

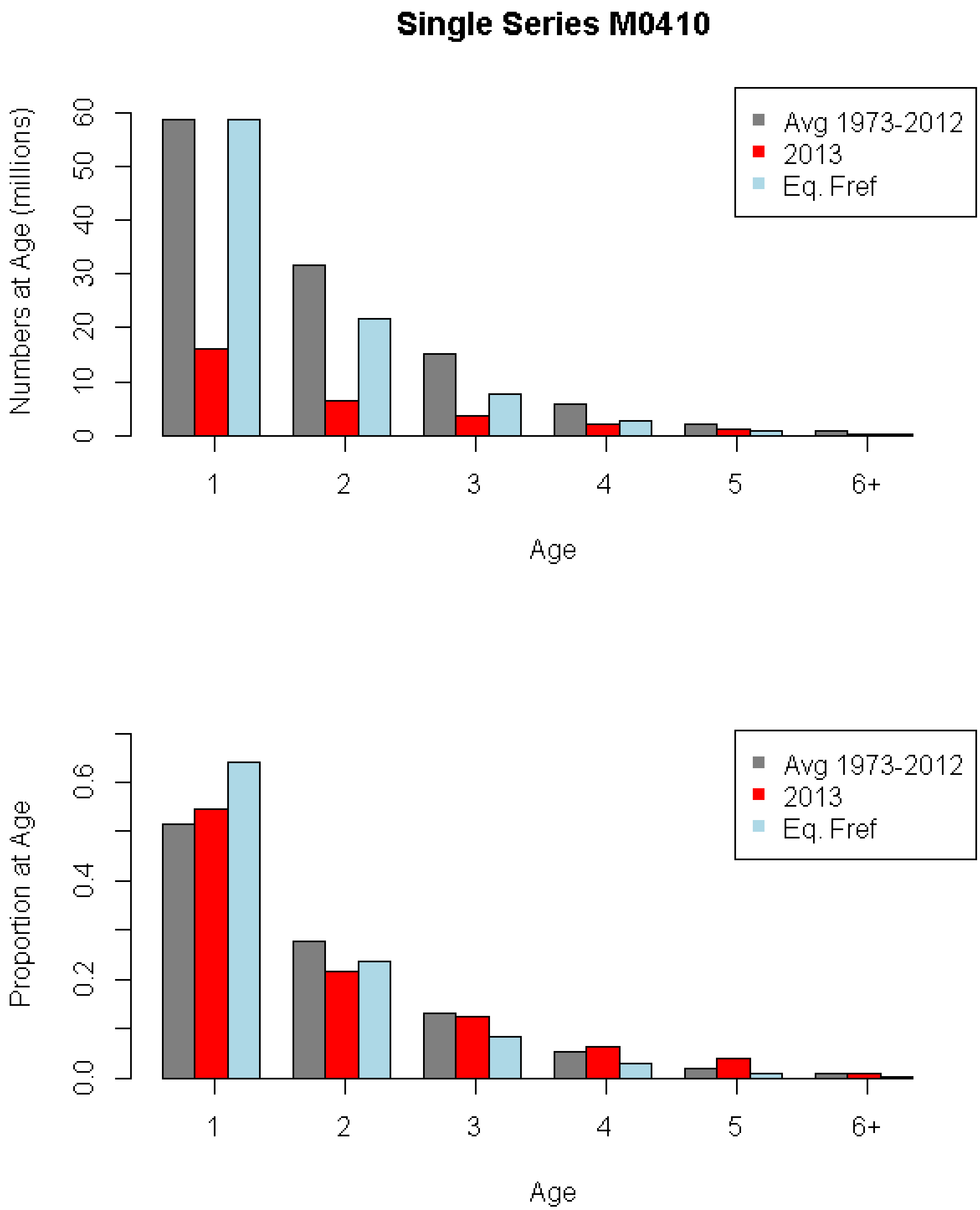


Figure 40f. Comparison of the population abundance at age distributions for the Single Series M0410 VPA among the average of 1973-2012, 2013, and that expected when the population is fished in equilibrium at F_{ref}=0.25. The equilibrium numbers at age 1 in the top panel are set equal to the average for years 1973-2012. The bottom panel shows the proportions at age instead of numbers.

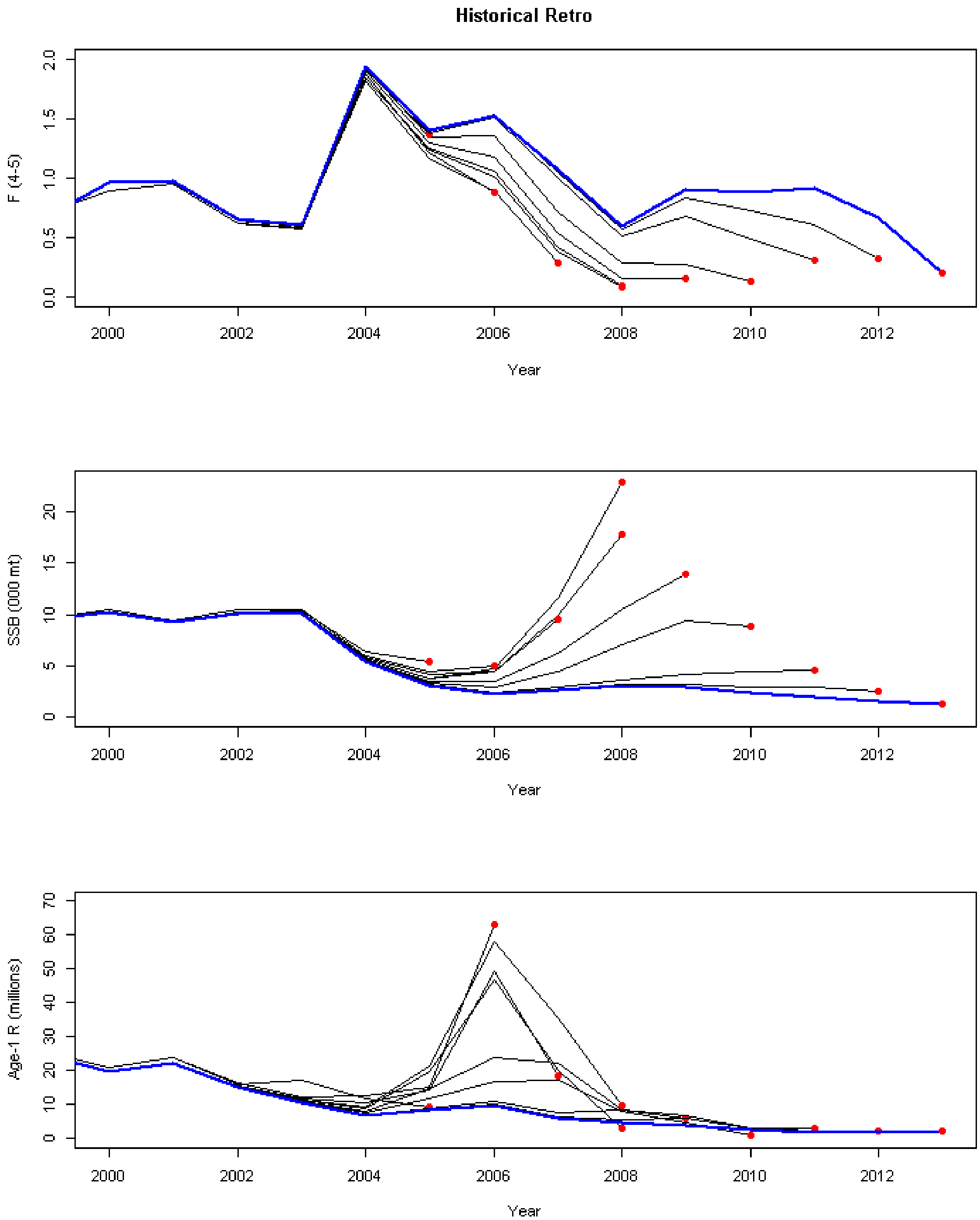


Figure 41. Historical retrospective analysis of Georges Bank yellowtail flounder assessments from this and the previous eight TRAC Split Series VPAs with M=0.2 for age 4+ fishing mortality (top panel), spawning stock biomass (middle panel), and age 1 recruitment (lower panel). Note there are two lines plotted for TRAC 2009 (terminal year 2008), the “Including” and “Excluding” formulations.

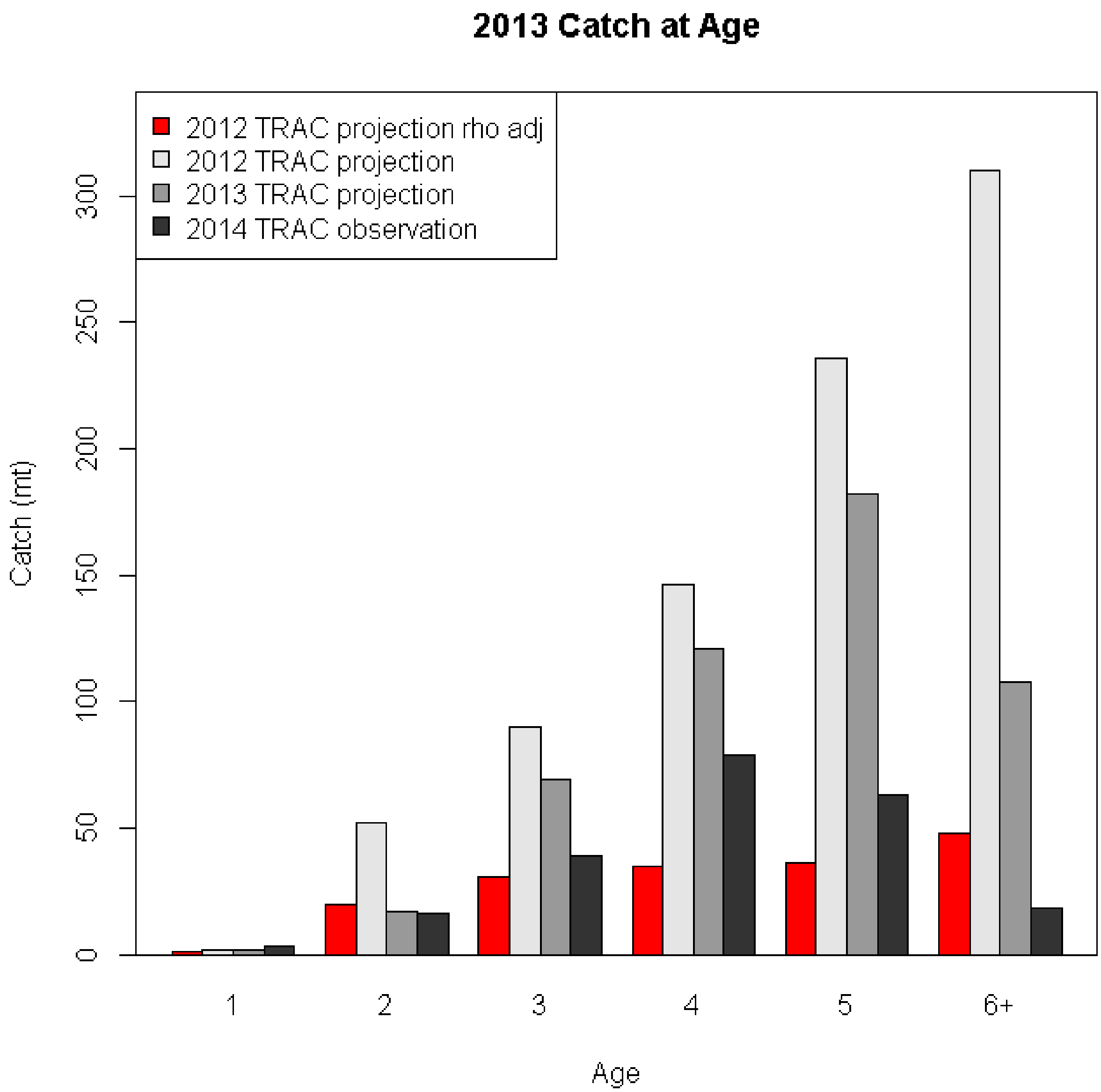


Figure 42. Catch (mt) at age in 2013 projected from the previous two TRAC assessments compared to the 2013 values observed in this assessment. The three projections are from the Split Series deterministic table in their respective assessment documents. The 2012 TRAC projections assumed F would be Fref=0.25, while the 2013 TRAC projections assumed the full quota of 500 mt would be caught. The total catch in the three projections were 171, 836, and 499 mt, respectively, while the actual total catch was 218 mt.

APPENDIX

The table below was kindly initiated by Tom Nies (NEFMC). It summarizes the performance of the management system. It reports the TRAC advice, TMGC quota decision, actual catch, and realized stock conditions for Georges Bank yellowtail flounder.

(1) All catches are calendar year catches
(2) Values in italics are assessment results in year immediately following the catch year; values in normal font are results from this assessment

TRAC	**Catch Year**	**TRAC Analysis/Recommendation**		**TMGC Decision**		**Actual Catch[(1)]/Compared to Risk Analysis**	**Actual Result[(2)]**
		Amount	**Rationale**	**Amount**	**Rationale**		
1999[1]	1999	(1) 4,383 mt (2) 6,836 mt	Neutral risk of exceeding Fref (1)VPA (2)SPM	NA	NA	4,441 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* Now F = 1.94 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* *Age 3+ biomass decreased 5% 05-06* Now F = 1.39 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)]
2005	2006	(1) 4,200 (2) 2,100 (3) 3,000 -3,500	Neutral risk of exceeding F ref (1-base case; 2 – major change) (3) Low risk of not achieving 20% biomass increase	3,000 mt	Base case TAC adjusted for retrospective pattern, result is similar to major change TAC (projections redone at TMGC)	2,109 mt/ (1) Less than 10% risk of exceeding Fref (2) Neutral risk of exceeding Fref	*F = 0.89* *Age 3+ biomass increased 41% 06-07* Now F = 1.54 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 About 75 percent probability of exceeding Fref	*F = 0.29* *Age 3+ biomass increased 211% 07-08* Now F=1.05 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 No risk plot; expected less than median risk of exceeding Fref	*F~0.09* *Age 3+ biomass increased between 35%-52%* Now F=0.57 Age 3+ biomass increased 7% 08-09
2008	2009	(1) 4,600 mt 2) 2,100 mt	(1) Neutral risk of exceeding Fref; 9% increase from 2009-2010 (2) U.S. rebuilding plan	2,100 mt	U.S. rebuilding requirements; expect F=0.11; no risk of exceeding Fref	1,806 mt No risk of exceeding Fref	*F=0.15* *Age 3+ biomass increased 11%* Now F=0.83 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]**
2009	2010	(1) 5,000 – 7,000 mt (2) 450 – 2,600 mt	(1) Neutral risk of exceeding Fref under two model formulations (2) U.S. rebuilding requirements	No agreement. Individual TACs total 1,975 mt	No agreement	1,160 mt No risk of exceeding Fref About 15% increase in median biomass expected	*F=0.13* *3+ Biomass increased 6% 10-11* Now F=0.73 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 No risk of exceeding Fref About 15% increase in biomass expected	*F=0.31* *Age 3+ biomass decreased 5% 11-12* Now F=0.6 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* *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			