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Stock Assessment of Georges Bank Haddock, 1931-2004

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Abstract

The Georges Bank haddock stock assessment is updated through 2004. Assessment results show that fishing mortality has remained below the overfishing threshold since 1995 and that spawning biomass has increased substantially in recent years, but still remains below 0.5 of B_{MSY}. As such, the stock is currently overfished but is not experiencing overfishing. Recruitment has increased markedly in recent years, with two strong year classes (1998 and 2000) currently providing much of the fishery yield. The 2003 year class is one of the largest ever recorded and has the potential to rebuild the stock in a few years if fishing mortality remains low. Decreases in mean weight at age during 2001-2004 may be due to density-dependent growth or to changes in trophic interactions. Overall, the Georges Bank haddock stock is rapidly recovering from the severely depleted condition observed in the mid-1990s.

1. INTRODUCTION

The Georges Bank haddock stock has been commercially exploited since the 1880s (German 1987). Fishing intensity on the stock increased during the 20th century as harvest technology improved and fishing effort increased (Hennemuth and Rockwell 1987, Murawski et al. 2002). Prior to the mid-1990s, Georges Bank haddock had been overfished by modern standards for several decades (Brodziak and Link 2002). The stock experienced significant long-term declines in spawning biomass and recruitment since the 1960s (Brodziak et al. 2001) and collapsed in the early 1990s (NEFSC 1994). Fishery management measures implemented since 1994 have included large year-round closed areas, restrictions on fishing effort, and increases in trawl mesh size (Fogarty and Murawski 1998) and have decreased fishing mortality and led to marked increases in stock size (Brodziak et al. 2002). Further information on the Georges Bank haddock fishery, stock assessment, and biology is available in Brodziak et al. (2002), Brodziak (2005), Brodziak and Legault (2005), Brown and Munroe (2000), Clark et al. (1982), German (1987), Hennemuth and Rockwell (1987), Van Eeckhaute and Brodziak (2004), and Van Eeckhaute and Brodziak (2005).

The Georges Bank haddock stock is a transboundary resource shared by the U.S. and Canada since implementation of the Hague Line in October 1984 (Christie 1987). The eastern Georges Bank haddock management unit is jointly managed by the two countries (Figure 1) while the U.S. manages the western Georges Bank unit. In May 2004, a formal quota sharing agreement between Canada and the U.S. was implemented for the eastern Georges Bank haddock management unit. This agreement includes total allowable catch allocations for each country as well as in-season monitoring of the catch of haddock.

The Georges Bank haddock stock was last assessed at the 2002 Groundfish Assessment Review Meeting (Brodziak et al. 2002). Based on that assessment of the combined western and eastern Georges Bank management units (Figure 1) through 2001, the stock was overfished but not experiencing overfishing. Spawning biomass in 2001 was 74,400 mt, roughly 30% of B_{MSY} but over 6-fold greater than the near-record low of 11,400 mt in 1993. Fishing mortality in 2001 was F=0.22, roughly 85% of F_{MSY} (F_{MSY} =0.26). In this paper, we update the Georges Bank haddock stock assessment using revised fishery data for 1972-2001 along with fishery data for 2002-2004 and research survey data for 2002-2005. Current estimates of spawning biomass and fishing mortality are used to determine stock status. Sensitivity analyses of 2002 assessment results to changes in tuned virtual population analysis (VPA) software and revised fishery and biological data are also conducted.

2. THE FISHERY

The Georges Bank haddock stock has been commercially exploited since the 19th century with reliable catch statistics available beginning in 1904 (Table 1.1, Figure 2). Since then, the fishery for Georges Bank haddock has gone through seven periods: (1) the initial expansion from 1904-1923 when annual catch averaged 17,400 mt; (2) the rapid expansion and decline during 1924-1930 when catches averaged 73,200 mt; (3) the thirty-year period of fishery stability during 1931-1960 when annual catch averaged 46,300 mt; (4) the rapid expansion and decline during 1961-1968 when catches averaged 73,000 mt and foreign distant water fleets began to harvest the resource (Table 1.2); (5) the pre-Hague line fishery during 1969-1984 when catches averaged about 13,500 mt; (6) the fishery nadir during 1985-2000 when catches averaged only 5,600 mt; and (7) the nascent recovery from 2001-2004 when annual catches have increased to average

13,700 mt per year. Catches have generally increased each year since 1995 as the stock has been rebuilding under restrictive management measures. In 2004, the total commercial catch was 17,600 mt, over 7-fold larger than the lowest recorded catch in 1995.

2.1. Commercial Landings

U.S. haddock landings during 2001-2004 were derived from mandatory dealer reports and fishing vessel logbooks as in previous assessments conducted since 1994. Landings were prorated into stock areas (Figure 1) using vessel trip reports (VTR) and dealer data available at the time of the assessment preparation (through July 2005). The stratification design for the Georges Bank haddock stock was based on market category (large, scrod), port group, gear group and calendar quarter as in previous assessments. These standard prorations are considered preliminary since VTR data processing and auditing procedures have not been finalized. As a result, minor changes in landings by stock area may occur through time. For example, the revised prorated U.S. Georges Bank haddock landings totaled 4,631 mt in 2001, a 0.1% decrease from the prorated value in the last assessment (Brodziak et al. 2002). As in previous years, most U.S. landings during 2001-2004 were taken with otter trawl gear (Table 2). U.S. landings in 2004 totaled 7,179 mt, a 55% increase over 2001 (Table 2).

Canadian landings during 2001-2004 were taken from the most recent assessment of eastern Georges Bank haddock (Van Eeckhaute and Brodziak 2005). Canadian landings data are obtained through dockside monitoring and at-sea observers. As in previous years, most Canadian landings during 2001-2004 were taken by otter trawl and longline gear (Table 2). Canadian landings in 2004 totaled 9,745 mt, a 44% increase over 2001 landings.

Total U.S. and Canadian landings of Georges Bank haddock during 1964-2004 averaged 14,876 mt per year (Table 2). Total annual landings were relatively high during the 1960s, declined during the 1970s, and briefly increased in the late-1970s and early-1980s due to the recruitment of the strong 1975 and 1978 year classes. Total landings declined to less than 9,000 mt during 1985-2000, but since 2001 have exceeded 11,000 mt. The U.S. percentage of total landings decreased from over 70% in the 1960s to a low of 8% in 1994 and 1996. Since 1999, the U.S. percentage has generally been above 40%.

2.2. Recreational Landings

Recreational landings of Georges Bank haddock are usually low (<100 mt/yr) although party charter vessels may target haddock on some trips. Estimates of the annual recreational catch using data collected by the Marine Recreational Fishery Statistics Survey during 2001-2004 ranged from 0% to <0.1% of the commercial catch. As such, recreational landings of Georges Bank haddock were considered to be negligible and were not included in the total landings estimates.

2.3. Commercial Discards

Discards of Georges Bank haddock in the U.S. fishery are believed to have remained at a relatively low and constant level since the mid-1950s (Brown and Munroe 2000). Estimated discards have been included in years when resource conditions or management regulations have

led to haddock discards substantially higher than the low background level. In particular, discards were included in the total catch during 1974, 1977, 1978, and 1980 when the strong 1975 and 1978 year classes were heavily discarded. Discards were also included during 1994-1998 when low trip limits generated substantial regulatory discards of Georges Bank haddock. Since then, the Georges Bank haddock stock has produced three strong year classes (1998, 2000, and 2003) that were subject to discarding during 2001-2004. To account for potential discards of these large year classes and also to provide a total accounting of total fishery removals in recent years, U.S. commercial discards were incorporated into the total catch estimates during 2001-2004.

U.S. discards of Georges Bank haddock during 2001-2004 were estimated fishery observer sampling data for western and eastern Georges Bank. Fishing trips with observers accounted for 2% of the U.S. western Georges Bank catch in 2001 and 14% in 2004 (Table 3.1). On eastern Georges Bank, observed catches increased from 1% of the U.S. catch in 2001 to 9% in 2004 (Table 3.2). Recent increases in U.S. observer coverage of haddock landings reflect increases in the total number of observed groundfish trips.

Quarterly U.S. discards of haddock for the western and eastern Georges Bank management units (Figure 1) during 2001-2004 were estimated for otter trawl, longline (hook), gillnet, and other (all other gears that captured haddock) fishing gears using reported landings and observed discard to kept ratios as in previous assessments (Brown and Munroe 2000). Discard to kept ratios for quarters with no observer data were imputed using an average ratio for that gear type. U.S. discards of western Georges Bank haddock increased from about 100 mt during 2001-2003 to over 400 mt in 2004 (Table 4.1). US discards of eastern Georges Bank haddock increased from about 50 mt during 2001-2003 to over 150 mt in 2004 (Table 4.2).

Canadian fishing vessels are required to land their entire catch of Georges Bank haddock (i.e., full retention is mandated). Discarding of Georges Bank haddock may occur, however, in the Canadian sea scallop fishery which has been prohibited from retaining haddock since 1995. Estimates of discards of eastern Georges Bank haddock in the Canadian sea scallop fishery during 1972-2004 (Van Eeckhaute and Brodziak 2005) were also included in the updated fishery catch data. Canadian scallop fishery discards of haddock ranged from a high of 186 mt in 1985 to a low of 29 mt in 2000 and have remained below 100 mt since 1998. The Canadian scallop fishery discards of haddock are included in the updated total catch time series of Georges Bank haddock (Tables 1.1 and 1.2).

2.4. Commercial Port Sampling

U.S. commercial fishery length sampling intensity for western Georges Bank haddock averaged over 200 lengths/100 mt during 2001, 2003 and 2004, but was only 124 lengths/100 mt in 2002 (Table 5.1). Age sampling averaged about 50 ages/100 mt during 2001-2004. Sampling intensity for eastern Georges Bank haddock during 2001-2004 was similar to that for western Georges Bank (Table 5.2), although there were some quarters where no market category length samples were available due to low landings. U.S. vessels fishing for haddock use similar otter trawl gear in both management areas and observed fishery length composition data are also similar across areas. U.S. commercial length frequency data for eastern Georges Bank haddock were augmented with length composition data from U.S. statistical areas 521, 522 and 525 during 2001-2002 and areas 522, and 525 during 2003-2004 to provide quarterly fishery length composition data. U.S. discard length compositions for western and eastern Georges Bank were

derived from domestic fishery observer data. Discard length compositions for quarters with no observer data were imputed using an average discard length frequency by gear type.

The annual size composition of the Canadian eastern Georges Bank haddock catch during 2001-2004 was characterized using 67905, 46802, 69398, and 78113 length samples, respectively. These samples were collected from all principal fishing gears (otter trawl, gillnet, and longline) by month. The annual sampling intensities for the Canadian eastern Georges Bank haddock fishery during 2001-2004 were 1003 lengths per 100 mt, 721 lengths per 100 mt, 1024 lengths per 100 mt, and 801 lengths per 100 mt, respectively. Details of the Canadian commercial fishery port and at-sea observer sampling intensity for eastern Georges Bank haddock during 2001-2004 are reported in Gavaris and Van Eeckhaute (2002),Van Eeckhaute, Gavaris, and Brodziak (2003), Van Eeckhaute and Brodziak (2004), and Van Eeckhaute and Brodziak (2005).

2.5. Commercial Catch at Length Composition

U.S. commercial fishery landings and discarded numbers at length were calculated from the available length composition data for western and eastern Georges Bank during 2001-2004. In 2001, the U.S. fishery caught about 1.9 million haddock on western Georges Bank and roughly 320 thousand haddock on eastern Georges Bank (Tables 6.1 and 6.2). The average length of the U.S. haddock caught in 2001 was about 2% larger on western Georges Bank in comparison to eastern Georges Bank (Figures 3.1 and 3.2). In 2002, the U.S fishery caught 2.5 million haddock on western Georges Bank and 504 thousand fish on western and eastern Georges Bank (Tables 6.1 and 6.2). The average length of U.S. haddock caught on western Georges Bank haddock was 7% greater than on eastern Georges Bank haddock (Figures 3.3 and 3.4). Total U.S. haddock catches on western and eastern Georges Bank were 1.9 million and 822 thousand fish, respectively, in 2003 (Figure 3.5), with the average length of haddock caught on western Georges Bank about 3% greater than on eastern Georges Bank (Figure 3.6). In 2004, the U.S. fishery caught 3.4 and 1.3 million haddock, respectively, on western and eastern Georges Bank (Tables 6.1 and 6.2). The average length of haddock caught on western Georges Bank haddock was about 3% greater than on eastern Georges Bank (Figures 3.7 and 3.8).

Canadian commercial fishery landings and discarded numbers at length were calculated from the available length composition data for eastern Georges Bank during 2001-2004. The annual size composition of the Canadian otter trawl catch of eastern Georges Bank haddock averaged 51 cm during 2001-2004. In contrast, the Canadian longline catch averaged 58 cm during 2001-2002, was 57 cm in 2003, and declined to 54 cm in 2004. Details of the Canadian commercial fishery catch at length of eastern Georges Bank haddock during 2001-2004 are reported in Gavaris and Van Eeckhaute (2002), Van Eeckhaute, Gavaris, and Brodziak (2003), Van Eeckhaute and Brodziak (2004), and Van Eeckhaute and Brodziak (2005).

2.6. Commercial Fishery Catch at Age

Total catch numbers at age of Georges Bank haddock were estimated using available fishery length and age composition data during 2001-2004. The accuracy and precision of age composition data were evaluated and found to be satisfactory for age-structured assessment analyses (Appendix). The Canadian catch at age of eastern Georges Bank haddock during 1972-2004 was taken from the most recent assessment of this management unit (Van Eeckhaute and

Brodziak 2005). The U.S. catch at age of western and eastern Georges Bank haddock during 2001-2004 was estimated using fishery length and age-length composition data collected by port samplers and fishery observers, along with research survey age-length composition data to characterize sublegal discards.

Annual US catch numbers at age of landed and discarded haddock during 2001-2004 for western (Table 6.1) and eastern Georges Bank haddock (Table 6.2) were computed using quarterly age-length keys. The U.S. catch at age of western Georges Bank haddock was dominated by the strong 1998 year class which contributed 27%, 39%, 50%, and 37% of total catch numbers in 2001 to 2004. In 2004, the strong 2000 year class contributed 29% of total western Georges Bank catch while the very strong 2003 year class contributed 11% at age-1. For eastern Georges Bank haddock, there were limited age-length data in some quarters (Table 5.2). As a result, Canadian commercial fishery age-length keys from eastern Georges Bank were used to augment US age-length composition data for quarters 2, 3, and 4, while the Canadian spring survey age-length key was used for quarter 1. The 1998 year class was also prominent in U.S. catches of eastern Georges Bank haddock and contributed 25%, 37%, 37%, and 20% respectively of total catch numbers in 2001 to 2004 (Table 6.2). In 2004, the strong 2000 year class was dominant and contributed 31% of the total U.S. catch on eastern Georges Bank. The 2003 year class contributed about 12% of the total U.S. eastern Georges Bank catch in 2004.

Canadian catch numbers at age on eastern Georges Bank during 2001-2004 (Table 6.3) were derived using quarterly age-length composition and fishery length composition data from the most recent assessment (Van Eeckhaute and Brodziak 2005). Similar to the U.S. catch, the 1998 year class dominated Canadian catches and contributed 44%, 48%, 29%, and 20% respectively of the total Canadian haddock catch during 2001-2004. In 2004, the strong 2000 year class became dominant and contributed 54% of the total Canadian catch while the 2003 year class only contributed 3%.

The total catch at age of Georges Bank haddock during 1963-2004 was assembled by combining the western Georges Bank and eastern Georges Bank U.S. and Canadian catch-at-age matrices (Table 7). This was the catch at age input to the tuned virtual population analysis.

2.7. Commercial Fishery Mean Weights at Age

Commercial fishery mean weights at age of U.S. western and U.S. and Canadian eastern Georges Bank haddock catches were computed for landings and discards (Table 8). Mean weight-at-age data for western and for U.S. and Canadian eastern Georges Bank haddock were averaged to derive the mean weights at age of Georges Bank haddock during 2001-2004 (Table 9). Commercial fishery mean weights at age of Georges Bank haddock during 2001-2004 were below their long-term average for all age classes, with declines ranging from -7% to -44%. The consistent pattern of declining weight at age suggests that density-dependent growth or possibly environmental changes have reduced commercial haddock size at age in recent years.

3. STOCK ABUNDANCE INDICES AND LIFE HISTORY PARAMETERS

3.1. U.S. Research Survey Abundance Indices

The annual NEFSC autumn bottom trawl survey was initiated in 1963 and the annual NEFSC spring bottom trawl survey in 1968. NEFSC spring survey and autumn survey stratified

mean number and weight per tow indices were computed using survey catch data from strata 13-25 and 29-30 during 1963 to 2005 (Table 10, Figures 4 and 5). Haddock survey indices were adjusted for estimated differences in the fishing power of the R/V *Albatross IV* and the R/V *Delaware II*, where the R/V *Albatross IV* was the standard (Table 11). In addition, haddock survey indices were adjusted for estimated differences in catchability of BMV trawl doors (used prior to 1985) versus polyvalent trawl doors (1985 onwards). During 1972-1981, the NEFSC spring survey deployed a different net (Yankee 41) than the standard net (Yankee 36). No survey adjustment coefficients were estimated for this gear change (Sissenwine and Bowman 1978). As a result, the nine years of spring survey data collected during 1972-1981 were treated as a separate survey abundance index series in tuning the VPA analysis. NEFSC spring and autumn survey catch at length data (Figures 6.1-6.5) and survey-specific age-length keys were used to compute stratified mean number per tow at age through time (Table 12 and 13, Figures 7.1-7.2) and by age class (Figures 8.1-8.2 and Figures 9.1-9.2). Note that the 2005 autumn survey data were not available at the time of assessment preparation and were not used as inputs to the tuned VPA analysis.

3.2. Canadian Research Survey Abundance Indices

The Canadian DFO initiated a winter bottom trawl survey on Georges Bank in 1986. Canadian winter survey stratified mean number per tow indices (Figure 5) were computed using standardized research survey data collected by the R/V *Needler* on Georges Bank during 1986 to 2004. Canadian winter survey catch per tow at age indices during 1986-2004 (Table 14, Figure 9.3) were computed using survey-specific age-length keys (L. Van Eeckhaute, DFO, pers. comm.). In 2005, the R/V *Needler* was not available to complete the entire Georges Bank winter survey and the R/V *Templeman* was used. Because no inter-vessel calibration data exists for these two vessels, the 2005 Canadian winter survey data were not used as inputs to the tuned VPA analysis.

3.3. Trends in Survey Abundance Indices

The NEFSC spring and autumn abundance indices exhibit similar trends through time (Figure 5). Autumn indices declined from record highs in the 1960s to low levels in the early-1970s. The spring and autumn indices both increased in the mid-1970s due to the strong 1975 and 1978 year classes and then declined in the early 1980s. Both U.S. and Canadian abundance indices were low from the mid-1980s to the mid-1990s and have since increased.

3.4. Natural Mortality

Natural mortality was assumed to be 0.2 in this assessment, as in previous assessments of the Georges Bank haddock stock (Brown and Munroe 2000, Brodziak et al. 2002) and eastern Georges Bank haddock management unit (Van Eeckhaute and Brodziak 2005). Catches of haddock in excess of 15 years of age in both U.S. and Canadian survey time series are consistent with this assumption for natural mortality.

3.5. Research Survey Mean Weights at Age

Time series of mean weights at age of Georges Bank haddock captured during NEFSC spring and autumn surveys and the Canadian winter survey were evaluated to determine whether trends in survey mean weights at age were consistent with those in the commercial fishery during 2001-2005. NEFSC spring survey mean weights at age of Georges Bank haddock were substantially below their long-term averages (Table 15.1). Declines in spring mean weight at age ranged from -23% at age-7 to -37% at age-8. NEFSC autumn survey mean weights at age showed similar declines (Table 15.2), with weights at age during 2001-2004 ranging from -22% (age-1 and age-2) to -55% (age-8) of their long-term averages. Canadian winter survey mean weights at age also showed recent declines (Table 15.3), with weights at age during 2001-2004 ranging from -7% at age-3 to -25% at age-1 of their long-term averages. Overall, there was a consistent pattern in declining mean weights at age across age groups and research surveys.

3.6. Research Survey Mean Lengths at Age

Mean lengths at age of Georges Bank haddock in the NEFSC spring and autumn surveys were examined to evaluate changes during 2001-2005 relative to the long-term (1963-2005) average. Age groups with fewer than 3 samples or older than age-9 were excluded from the analysis due to low sample size.

For age-0 haddock, recent mean length was 9% below the long-term autumn average (Figure 10.1). Similarly, for age-1 and age-2 haddock, recent mean lengths at age were 11% and 9% respectively, below the long-term average during spring and autumn (Figures 10.2 and 10.3). Mean lengths of age-3 haddock were 10% and 11% below their long-term average (Figure 10.4), while recent mean lengths at age for age-4 and age-5 haddock were 9% and 10% below the long-term average during spring and autumn (Figures 10.5 and 10.6). Recent mean lengths at age for age-6 through age-9 haddock during spring were 5%, 4%, 9%, and 3% respectively, below their long-term averages (Figures 10.7 to 10.10). Similarly, in the autumn surveys, recent mean lengths for age-6 through age-8 haddock were 12%, 9%, and 8% respectively, below their long-term average (Figure 10.7-10.9). Overall, in recent years there was a consistent decline of about 10% in mean length at age across age groups.

3.7. Research Survey Weight at Length Relationships

Individual length and weight measurements of Georges Bank haddock obtained during spring and fall bottom trawl surveys conducted since 1992 were used to evaluate whether any changes in length-weight relationships have occurred. Linear regression was applied to log-transformed length-weight data to estimate the scaling parameter "A" and the exponent parameter "B" of the allometric equation (Table 16) for predicting weight (W) for a given length (L), $W = A \cdot L^B$.

For each survey, the point estimate of the scale coefficient "A" was adjusted for transformation bias using the low-bias estimator given in Hayes et al. (1995). The nonparametric bootstrap (Efron and Tibshirani 1993) was applied to estimate standard errors of the length-weight parameters.

Annual spring survey length-weight relationships during 1992-2000 (Figure 11.1) and 2001-2005 (Figure 11.2) were generally similar to the overall average spring length-weight relationship for 1992-2005, although spring weight at length was below average in 1994 and 2003. Annual autumn length-weight relationships during 1992-2000 (Figure 11.3) and 2001-2004 (Figure 11.4) were also similar to the average autumn relationship, although autumn weight at length was slightly below average during 2001-2004.

Haddock condition was evaluated using the predicted mean weights at lengths at 25, 50, and 75 cm using the spring and autumn survey length-weight relationships (Figures 12.1-12.2). Haddock condition was relatively constant during 1992-2005 with some suggestion of modest declines in recent years. Average predicted spring weights during 2001-2005 for lengths 25, 50, and 75 cm were 6%, 5%, and 5% below the 1992-2005 average. Similarly, average predicted autumn weights for lengths 25, 50, and 75 cm were 5%, 3%, and 2% below the 1992-2004 average. Hence, haddock condition factor appears to have had a minor impact on recent declines in mean weights at age relative to the 2001-2005 declines in mean length at age.

3.8. Proportion Mature at Age

Maturity data for individual Georges Bank haddock have been collected during spring and autumn bottom trawl surveys since 1992. Logistic regression was applied to derive the recent female proportion mature at age-k (P_k), where $P_k = \frac{1}{1+e^{-a-b\cdot k}}$, (Table 17) using the same approach as in previous assessments (Brodziak et al. 2002, Brown and Munroe 2000). Parameter estimates were a=-4.7330 and b=2.5685. Predicted proportion mature at age was approximately equal to the observed proportion mature at age for all ages except age-1, for which the predicted percent mature was 10% and the observed percent mature was only 1%. Given the discrepancy between model prediction and observed percent mature at age-1, the observed female percent maturity at age-1 of 1% was used in subsequent analyses (Table 17). The logistic regression results indicate that female median age at maturity of Georges Bank haddock during 2001-2004 was 1.8 years with a standard error of 0.2 years.

4. ESTIMATES OF STOCK SIZE AND FISHING MORTALITY

4.1. Virtual Population Analysis Formulation

Virtual population analysis (VPA) was used to estimate Georges Bank haddock stock size and fishing mortality at age during 1963-2004. Because this assessment is an update and not a benchmark assessment, alternative models, such as statistical catch at age analysis, were not applied. The VPA formulation (Table 18) was identical to that used in the 2002 GARM assessment (Brodziak et al. 2002). The updated VPA included U.S. research survey indices from 2001-2005 and Canadian research survey indices from 2001-2004 as well as updated catch-at-age data for 1972-2004. The precision of VPA estimates was evaluated using nonparametric bootstrap analysis of tuning indices. VPA estimates of spawning stock size and fishing mortality during 1931-1962 were taken from Brown and Munroe (2000). The historic VPA estimates are for a period when no research survey tuning indices are available and are not affected by updated catch data in this assessment.

4.2. VPA Diagnostics

VPA diagnostics indicated a good overall fit to the survey data, the current assessment exhibited the lowest mean squared residual observed in the last seven assessments (Table 18). Coefficients of variation of numbers at age estimates for ages 1-8 in the terminal year plus one ranged from 58% at age-1 to 23% at age-6. Maximum coefficients of variation of catchability in the surveys ranged from 0.15 (NEFSC fall survey) to 0.51 (NEFSC spring survey Yankee 41 net, 1973-81. VPA residual patterns were generally without trend (Figure 13) although year effects were apparent across ages in some cases (e.g., 2002 NEFSC spring survey residuals were negative for all ages).

4.3. VPA Results

Georges Bank haddock stock size changed markedly during 1963-2005 (Table 19, Figure 14.1). VPA results indicate that stock size averaged 352 million fish during 1963-1968, but was reduced by more than 10-fold to an average of about 26 million fish during 1969-1974. Stock size increased to average 76 million fish during 1975-1984 due to the recruitment of the strong 1975 and 1978 year classes, but subsequently declined and averaged only 27 million fish during 1985-1994. With the implementation of restrictive management measures in the mid-1990s, stock size increased and averaged 67 million fish during 1995-2000. Georges Bank haddock stock size increased 4-fold from 164 million in 2001 to 712 million in 2005 due to moderate fishing mortality and the recruitment of the strong 2000 and 2003 year classes.

Georges Bank haddock spawning biomass also changed substantially over the past five decades. Spawning biomass peaked in the 1960s averaging 132 kt during 1963-1968 (Table 20, Figure 14.2), declined to a near-record low of 15 kt in 1973, and averaged only 27 kt during 1969-1974. Spawning biomass increased moderately to average 48 kt during 1975-1984 and then declined again, averaging only 23 kt during 1985-1994, with a record low of 14.6 kt in 1993. During the mid-1990s, spawning biomass increased. Since 2001 spawning biomass has approached levels observed in the 1960s and averaged 115 kt during 2001-2004. Spawning biomass increased by 22% from 96 kt in 2001 to 117 kt in 2004.

Fishing mortality (unweighted average of age-4 through age-7 Fs) on Georges Bank haddock ranged from less than 0.1 to over 0.6 during 1963-2004 (Tables 21 and 22, Figure 14.3). F averaged 0.52 during 1963-1968 and declined to a low of 0.06 in 1974. F increased over 5-fold in the mid-1980s and averaged 0.35 during 1985-1994. Fishing mortality declined in the mid-1990s and since 1995 has remained below the overfishing threshold of F_{MSY}=0.26, although fishing mortality increased 33% from F=0.18 in 2001 to F=0.24 in 2004.

Georges Bank haddock recruitment (stock size at age-1) fluctuated substantially during 1963-2005 ranging from a low of 0.3 million age-1 fish in 1971 to a high of 788.9 million in 2003 (Table 19, Figure 14.4). Recruitment during 1963-1968 averaged 117 million fish and was dominated by the exceptional 1963 year class (462 million age-1 fish). Recruitment declined to average only 8 million fish during 1969-1974, but subsequently increased and averaged 26 million fish during 1975-1984, primarily due to the strong 1975 (106 million) and 1978 (84 million) year classes (YCs). Recruitment averaged only 8 million fish during 1985-1994, but increased to average 22 million fish during 1995-2000. Since 2001, recruitment has averaged 179 million fish. In particular, the 1998 (47 million) and 2000 (91 million) year classes are

strong, while the 2003 year class (789 million) currently appears to be the largest observed (Figure 14.4).

4.4. Stock-Recruitment Relationship

Analyses stock-recruitment data indicate that spawning stock size affects recruitment of Georges Bank haddock (Brodziak and Legault 2005; Brodziak et al. 2001, NEFSC 2002). For example, Brodziak et al. (2001) found that when spawning stock biomass is above 82 kt, the odds of recruitment being above average is 20 times greater than when biomass is below 82 kt and the average YC size is 5-fold higher. Thus, recruitment is higher, on average, when spawning biomass exceeds a threshold value.

The Working Group on the Re-evaluation of Reference Points for New England Groundfish determined that an appropriate productivity threshold for Georges Bank haddock was 75 kt of spawning biomass (NEFSC 2002). Above this threshold, average recruitment is 96 million age-1 fish (Figure 15) while below this threshold average recruitment is about 21 million fish. When spawning biomass is above 75 kt, the odds of achieving recruitment above the 1931-2005 median value are 23 times greater than when spawning biomass is below 75 kt. This difference is highly significant ($P < 0.001$) based on Fisher's exact test applied to the 2x2 contingency table of stock-recruitment data.

Survival ratios of Georges Bank haddock, as indexed by recruitment per spawning biomass, fluctuated about an average of 0.72 recruits per kg (R/S) during 1931-2004 (Figure 16). Survival ratios averaged 0.77 R/S with a standard error of 0.07 during 1931-1960 when spawning biomass averaged 102 kt. Since then survival ratios have declined 12% on average to 0.68 R/S with a standard error of 0.18 during 1961-2004 when spawning biomass averaged 64 kt. Since 1961, three strong year classes (1963, 1975, and 2003) have had survival ratios of roughly 3 or higher (Figure 16). Each of these year classes experienced very high survival during early life history stages, suggesting the influence of favorable environmental conditions in inducing large recruitment events. Spawning biomass also affects survival ratios as survival ratios average 0.82 when spawning biomass is above 75 kt in comparison to only 0.59 (-28%) when spawning biomass is below 75 kt.

4.5. Precision of Stock Size and Fishing Mortality Estimates

Bootstrap analyses of estimates of Georges Bank haddock stock size (Figure 17.1), spawning biomass (Figure 17.2), and fishing mortality (Figure 17.3) show some variability beginning in the late-1990s. Prior to that, the VPA estimates are unaffected by the precision of estimates of recent cohorts. The relatively high variability in stock size estimates in recent years is primarily due to uncertainty in the estimated size of the 2003 year class at age-1 in 2004 (Figure 18.1) and at age-2 in 2005 (Figure 18.2, CV=34%). Bootstrap analyses also indicate that estimates of spawning biomass and average F in 2004 are relatively precise, having coefficients of variation between 13% to 18% (Table 23, Figure 19).

4.6. Retrospective Analysis

Retrospective analysis was used to evaluate whether there were any patterns in recent estimates of spawning biomass, fishing mortality, and recruitment. In this evaluation, the tuned VPA model was rerun after deleting the most recent year of data, and corresponding estimates of the current year spawning biomass and fishing mortality were then compared. The average of the one-year retrospective changes calculated for five pairs of years (2004/2003, 2003/2002, 2002/2001, 2001/2000 and 2000/1999) was used to judge whether a retrospective pattern existed. Average changes of less than ±10% were considered to show no pattern, changes of ±10% to 20% were considered to indicate a moderate retrospective pattern, and changes over ±20% were considered to have a strong retrospective pattern. A positive retrospective pattern indicated that, on average, the estimated value of spawning biomass, fishing mortality, or recruitment increased when another year of data was added to the assessment.

Estimates of spawning biomass exhibited no retrospective pattern (Figure 20.1). On average, spawning biomass estimates for the last year of the VPA changed by +3% when an additional year of data was added. Fishing mortality estimates also exhibited no retrospective pattern (Figure 20.2) with an average change of -3% during 1999-2004. Estimates of Georges Bank haddock recruitment also did not have a retrospective pattern (Figure 20.3) with an average change of only +5% during 1999-2004. Overall, the retrospective analysis showed that estimates of Georges Bank haddock spawning biomass, fishing mortality, and recruitment had no retrospective pattern.

4.7. Sensitivity Analysis on Effect of Updated VPA Software and Updated Fishery and Biological Data on 2002 VPA Results

Two sensitivity analyses were conducted to evaluate how changes in VPA software and Georges Bank haddock catch data affected VPA results. In 2004, the NEFSC VPA software was enhanced to include more options for estimation of stock size and F. The old software (FACT) was compared to the new software (GARM) using the VPA input data for Georges Bank haddock from the 2002 assessment (Brodziak et al. 2002). Results of this comparison showed that there were only minor differences in 2001 estimates of numbers-at-age in the terminal year plus one, fishing mortality at age in the terminal year, average F, and spawning biomass (Table 24). Overall, the software change had no significant impact on VPA results.

The input data for the Georges Bank haddock VPA was also revised in this assessment to include Canadian scallop fishery discards in the catch at age for 1972-2004, US discard-at-age estimates for 2001-2004, updated proration of 2001 US haddock landings to stock area, revised mean weight-at-age data in 2001, and revised female percent mature at age in 2001. The effect of using the revised data with the GARM VPA software was compared to the effect of using the old data with the FACT VPA software (Table 24). The use of the new data increased estimates of stock size at age and spawning biomass by roughly 10% (Table 24) but had no discernable effect on estimates of fishing mortality. The primary effect of using the revised catch data was to increase stock size to account for increases in catch at age due to the inclusion of additional estimates of fishery discards.

5. GEORGES BANK HADDOCK STOCK STATUS

The U.S. Sustainable Fisheries Act of 1996 requires that fishery conservation and management measures prevent overfishing and rebuild depleted stocks to biomasses consistent with producing maximum sustainable yield (MSY). Overfishing occurs whenever fishing mortality exceeds a threshold that jeopardizes the reproductive capacity of a stock to produce maximum sustainable yield. Guidelines to the Act also specify that a depleted resource is one that has been reduced below a minimum stock size threshold. For Georges Bank and Gulf of Maine haddock, the minimum stock size threshold is one-half the biomass needed to produce MSY (B_{MSY}). It is possible for a stock to be classified as overfished (due to previous overharvesting) even though the annual harvest rate is below the overfishing threshold. This has been the case for haddock, which has been rebuilding in recent years.

5.1. Biological Reference Points

For Georges Bank haddock, spawning biomass (B_{MSY}) and the fishing mortality to produce MSY (F_{MSY}) are B_{MSY} = 250,300 mt and F_{MSY} = 0.26 (NEFSC 2002). The overfished threshold ($B_{THRESHOLD}$) for Georges Bank haddock is $B_{THRESHOLD}$ = ½ B_{MSY} = 125,200 mt. The overfishing threshold ($F_{THRESHOLD}$) for Georges Bank haddock is $F_{THRESHOLD} = F_{MSY}$ = 0.26.

5.2. Stock Status in 2004

In 2004, spawning biomass was 116,800 mt (93% of $B_{THRESHOLD}$ and 47% of B_{MSY}). Therefore, the Georges Bank haddock stock was overfished in 2004 (Figure 21). In 2004, the fishing mortality was 0.24 (92% of $F_{THRESHOLD}$). Therefore, overfishing was not occurring on the Georges Bank haddock stock in 2004 (Figure 22).

5.3. Comparison with Projected Amendment 13 Rebuilding Trajectory

The formal rebuilding plan for Georges Bank haddock adopted in Amendment 13 calls for fishing at the overfishing threshold F_{MSY}=0.26 during 2004-2008 (NEFMC 2003). In 2009, the fishing mortality would be reduced marginally to $F_{REBUILD}$=0.245, a value projected to produce at least a 50% chance that spawning biomass will meet or exceed B_{MSY}=250,300 mt in 2014. This rebuilding strategy is subject to change in 2008 if observed progress towards rebuilding spawning biomass or reducing fishing mortality is not consistent with the projected rebuilding trajectory.

The projected Amendment 13 rebuilding trajectory for Georges Bank haddock was compared to VPA estimates of spawning biomass and fishing mortality in 2004. For this stock, an adaptive rebuilding plan was adopted in which $F_{REBUILD}=F_{MSY}$=0.26 during 2004-2008. Median spawning biomass on the rebuilding trajectory was projected to be 129.8 kt in 2004 (Figure 23.1). For comparison, the projected 80% confidence interval for SB_{2004} was (97.9, 138.8) kt and the $SSB_{REBUILD}$ in 2004 falls within the probable range of the VPA estimate of SSB_{2004}. Similarly, the 80% confidence interval based on bootstrapping was (0.21, 0.31) and the $F_{REBUILD}$ value for 2004 falls within the probable range of the VPA estimate of F_{2004} (Figure

23.2). Overall, current estimates of SB and F are consistent with projected values on the Amendment 13 rebuilding trajectory.

6. CONCLUSIONS

Fishery management measures implemented since 1994 have decreased fishing mortality on Georges Bank haddock. Fishing mortality on the stock averaged F=0.35 per year during 1980-1993, or about 36% higher than the current overfishing limit (F_{MSY} =0.26) for this resource. Since 1994, annual fishing mortality for Georges Bank haddock has averaged about F=0.17, about 50% lower than during 1980-93 and 30% below F_{MSY}.

The response of the Georges Bank haddock to reductions in fishing mortality during the 1990s was dramatic. Under persistent overfishing in the 1980s, spawning biomass declined from 67,400 mt in 1980 to only 14,600 mt in 1993. Since 1994, spawning biomass has increased substantially as fishing mortality has declined. By 2003, spawning biomass had increased to 131,900 mt, the highest level since 1966 and over a 9-fold increase since 1993. However, even though stock size has increased markedly in recent years, the Georges Bank haddock stock is still overfished as spawning biomass is still less than half of the rebuilding target.

Recruitment of Georges Bank haddock displayed a similar positive response to reduced fishing mortality. Recruitment averaged only 8 million age-1 recruits per year during 1980-1993. Since 1994, average recruitment has increased over 10-fold to about 87 million fish. Prospects remain positive for continued high recruitment as spawning biomass is currently above the 75 kt threshold. Recent U.S. and Canadian assessments and research survey data suggest that the 2003 year class is exceptionally abundant. This year class has the potential to rebuild the stock to B_{MSY} in a few years if fishing mortality remains below F_{MSY}.

Recruits per spawner data shows that survival ratios for Georges Bank haddock were relatively low from the late-1960s to early-1990s in comparison to ratios during the 1930s-1960s. The impact of large-scale area closures to fishing, reductions in fishing effort, and trawl mesh size increases during the 1990s have all had a positive effect on recruits per spawning biomass (R/SB). During 1980-1993, R/SB averaged about 0.33 recruits per kg. Since 1994, average R/SB, excluding the exceptional 2003 year class, has increased to 0.46 recruits per kg. Further increases in R/SB may still occur since, at least historically, the expected value of R/SB was higher. Overall, the recent increases in R/SB indicate that survival ratios are approaching the historical average of about 0.76 recruits per kg observed during 1931-1960, despite recent decreases in fish size at age. If the recent increases in recruitment and survival can be sustained, it is possible that historic yields on the order of 50,000 mt per year may be achievable.

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Table 1.1. Total catches of Georges Bank haddock (mt, live), 1904-2004

Year	Georges Bank haddock catch biomass (mt)	Year	Georges Bank haddock catch biomass (mt)	Year	Georges Bank haddock catch biomass (mt)
1904	19740	1938	47773	1972	5866
1905	11975	1939	54054	1973	5429
1906	12678	1940	47906	1974	4450
1907	9497	1941	62944	1975	5606
1908	10804	1942	55376	1976	4484
1909	5226	1943	46323	1977	10994
1910	9752	1944	49637	1978	22516
1911	10828	1945	40473	1979	19647
1912	11887	1946	53719	1980	27638
1913	7538	1947	54431	1981	25011
1914	4771	1948	48360	1982	17627
1915	7899	1949	42254	1983	12009
1916	4265	1950	41273	1984	10394
1917	14100	1951	47318	1985	7943
1918	24800	1952	43252	1986	6846
1919	39400	1953	35926	1987	6997
1920	49600	1954	46388	1988	6689
1921	29700	1955	40851	1989	4627
1922	30800	1956	51144	1990	5469
1923	32900	1957	48561	1991	6958
1924	36900	1958	37322	1992	6196
1925	41400	1959	36051	1993	4528
1926	51300	1960	40877	1994	2743
1927	73900	1961	46650	1995	2351
1928	98600	1962	54004	1996	4008
1929	115500	1963	54846	1997	3570
1930	95000	1964	64086	1998	5314
1931	59486	1965	150362	1999	6504
1932	54512	1966	121274	2000	8797
1933	42215	1967	51469	2001	11505
1934	25795	1968	40923	2002	12994
1935	40944	1969	22252	2003	12576
1936	43445	1970	11300	2004	17584
1937	49359	1971	10862		

Average 1904-1923	17408
Average 1924-1930	73229
Average 1931-1960	46266
Average 1961-1968	72952
Average 1969-1984	13505
Average 1985-2000	5596
Average 2001-2004	13665

Table 1.2. Total catches of Georges Bank haddock (mt, live) by country, 1960-2004

Year	USA	Canada	USSR	Spain	Other	Total
1960	40800	77	0	0	0	40877
1961	46384	266	0	0	0	46650
1962	49409	3461	1134	0	0	54004
1963	44150	8379	2317	0	0	54846
1964	46512	11625	5483	2	464	64086
1965	52823	14889	81882	10	758	150362
1966	52918	18292	48409	1111	544	121274
1967	34728	13040	2316	1355	30	51469
1968	25469	9323	1397	3014	1720	40923
1969	16456	3990	65	1201	540	22252
1970	8415	1978	103	782	22	11300
1971	7306	1630	374	1310	242	10862
1972	3869	742	137	1098	20	5866
1973	2777	1661	602	386	3	5429
1974	2396	622	109	764	559	4450
1975	3989	1544	8	61	4	5606
1976	2904	1521	4	46	9	4484
1977	7934	3060	0	0	0	10994
1978	12160	10356	0	0	0	22516
1979	14279	5368	0	0	0	19647
1980	17470	10168	0	0	0	27638
1981	19176	5835	0	0	0	25011
1982	12625	5002	0	0	0	17627
1983	8682	3327	0	0	0	12009
1984	8807	1587	0	0	0	10394
1985	4273	3670	0	0	0	7943
1986	3339	3507	0	0	0	6846
1987	2156	4841	0	0	0	6997
1988	2492	4197	0	0	0	6689
1989	1430	3197	0	0	0	4627
1990	2001	3468	0	0	0	5469
1991	1395	5563	0	0	0	6958
1992	2005	4191	0	0	0	6196
1993	687	3841	0	0	0	4528
1994	218	2525	0	0	0	2743
1995	218	2133	0	0	0	2351
1996	313	3695	0	0	0	4008
1997	888	2682	0	0	0	3570
1998	1841	3473	0	0	0	5314
1999	2775	3729	0	0	0	6504
2000	3366	5431	0	0	0	8797
2001	4754	6751	0	0	0	11505
2002	6477	6517	0	0	0	12994
2003	5703	6873	0	0	0	12576
2004	7746	9838	0	0	0	17584
Average 1960-2004	13256	5064	3208	248	109	21884
Average 1961-1968	44049	9909	17867	687	440	72952
Average 1969-1984	9328	3649	88	353	87	13505
Average 1985-2000	1837	3759	0	0	0	5596
Average 2001-2004	6170	7495	0	0	0	13665

Table 2. U.S. and Canadian commercial landings (mt) of Georges Bank haddock, by gear type, 1964-2004

	United States				Canada					
Year	Otter Trawl	Longline	Other	U.S. Total	Otter Trawl	Longline	Other	Canadian Total	U.S. and Canada Total	U.S. Percent of Total
1964	45617	742	153	46512	11624	1	0	11625	58137	80%
1965	52034	716	73	52823	14862	22	5	14889	67712	78%
1966	51686	1127	105	52918	17905	63	324	18292	71210	74%
1967	33825	814	89	34728	12923	96	21	13040	47768	73%
1968	24930	495	44	25469	9201	111	11	9323	34792	73%
1969	15494	950	12	16456	3955	22	13	3990	20446	80%
1970	7979	430	6	8415	1900	76	2	1978	10393	81%
1971	7004	300	2	7306	1475	154	1	1630	8936	82%
1972	3674	190	5	3869	411	198	0	609	4478	86%
1973	2675	100	2	2777	1461	102	0	1358	4135	67%
1974	2308	80	8	2396	374	87	1	462	2858	84%
1975	3839	143	7	3989	1247	111	0	1358	5347	75%
1976	2840	51	13	2904	1192	154	15	1361	4265	68%
1977	7842	36	56	7934	2814	94	1	2909	10843	73%
1978	11962	63	135	12160	9716	171	292	10179	22339	54%
1979	14138	30	111	14279	4907	274	1	5182	19461	73%
1980	17170	30	270	17470	9510	590	1	10101	27571	63%
1981	19031	3	142	19176	4644	1015	0	5659	24835	77%
1982	12484	2	139	12625	4222	709	0	4931	17556	72%
1983	8588	35	59	8682	2396	813	3	3212	11894	73%
1984	8661	79	67	8807	624	838	1	1463	10270	86%
1985	4194	43	36	4273	2745	626	41	3484	7757	55%
1986	3298	24	17	3339	2734	594	35	3415	6754	49%
1987	2124	21	11	2156	3521	1046	89	4703	6859	31%
1988	2408	32	52	2492	3183	695	97	4046	6538	38%
1989	1356	24	50	1430	1976	977	106	3060	4490	32%
1990	1949	15	37	2001	2411	853	76	3340	5341	37%
1991	1340	28	27	1395	4028	1309	119	5456	6851	20%
1992	1974	17	14	2005	2583	1384	90	4058	6063	33%
1993	659	16	12	687	2489	1143	96	3727	4414	16%
1994	175	33	10	218	1597	714	100	2411	2629	8%
1995	144	59	15	218	1647	390	28	2065	2283	10%
1996	210	63	40	313	2689	947	26	3663	3976	8%
1997	754	76	58	888	1991	722	36	2749	3637	24%
1998	1692	55	94	1841	2422	921	27	3371	5212	35%
1999	2605	27	143	2775	2760	887	33	3680	6455	43%
2000	3217	31	118	3366	4146	1186	71	5402	8768	38%
2001	4443	49	139	4631	5112	1633	29	6774	11405	41%
2002	6081	40	209	6330	4954	1521	12	6488	12818	49%
2003	5353	160	52	5564	4985	1776	14	6775	12339	45%
2004	6596	474	110	7179	7744	2000	1	9745	16924	42%
Average	9862	188	67	10117	4465	659	44	5170	15287	54%
Minimum	144	2	2	218	374	1	0	462	2283	8%
Maximum	52034	1127	270	52918	17905	2000	324	18292	71210	86%

Table 3.1. Number of observed trips used to compute western Georges Bank haddock ratios discard to kept by year, gear, quarter, and total kept catch (mt) during 2001-2004.

Western Georges Bank 2001			Landings=	**4022.3**						
	QTR 1		**QTR2**		**QTR 3**		**QTR 4**		**2001 Total**	
	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch (mt)
HOOK	0		0		0		0		0	0.0
OTTER TRAWL	14	48.7	11	21.2	8	16.5	10	5.7	43	92.2
GILLNET	2	0.1	1	0.1	2	0.0	2	0.1	7	0.2
OTHER	0		1	0.0	0		1	0.0	2	0.0
Total	16	48.8	13	21.3	10	16.5	13	5.7	52	92.4
									% Sampled	**2%**
Western Georges Bank 2002			Landings=	**5413.6**						
	QTR 1		**QTR2**		**QTR 3**		**QTR 4**		**2002 Total**	
	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch (mt)
HOOK	0		0		2	0.4	3	0.2	5	0.6
OTTER TRAWL	6	5.9	11	19.5	33	139.1	51	92.6	101	257.2
GILLNET	3	0.2	2	1.2	5	0.0	1	0.0	11	1.4
OTHER	0		2	0.1	4	0.2	1	0.0	7	0.4
Total	9	6.2	15	20.9	44	139.8	56	92.8	124	259.6
									% Sampled	**5%**
Western Georges Bank 2003			Landings=	**4000.9**						
	QTR 1		**QTR2**		**QTR 3**		**QTR 4**		**2003 Total**	
	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch (mt)
HOOK	3	0.1	0	0.0	0	0.0	0	0.0	3	0.1
OTTER TRAWL	47	78.7	44	107.6	29	27.8	38	75.7	158	289.7
GILLNET	1	0.0	10	0.3	14	0.2	13	0.2	38	0.6
OTHER	3	0.0	2	0.0	2	0.0	4	0.0	11	0.0
Total	54	78.8	56	107.9	45	27.9	55	75.9	210	290.4
									% Sampled	**7%**
Western Georges Bank 2004			Landings=	**5383.7**						
	QTR 1		**QTR2**		**QTR 3**		**QTR 4**		**2004 Total**	
	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch (mt)
HOOK	0		1	0.0	8	13.1	101	220.3	110	233.4
OTTER TRAWL	53	85.0	51	196.9	44	94.3	93	138.0	241	514.1
GILLNET	5	0.0	25	0.9	15	1.5	12	0.3	57	2.7
OTHER	0		1	0.0	10	0.1	11	0.4	22	0.5
Total	58	85.1	78	197.7	77	109.0	217	359.0	430	750.8
									% Sampled	**14%**

Table 3.2. Number of observed trips used to compute eastern Georges Bank haddock ratios discard to kept by year, gear, quarter, and total kept catch (mt) during 2001-2004.

Eastern Georges Bank 2001			Landings=	**608.4**						
	QTR 1		**QTR2**		**QTR 3**		**QTR 4**		**2001 Total**	
	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch (mt)
HOOK	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
OTTER TRAWL	3	3.8	3	0.2	1	0.0	3	0.5	10	4.5
GILLNET	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
OTHER	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	3	3.8	3	0.2	1	0.0	3	0.5	10	4.5
									% Sampled	**1%**
Eastern Georges Bank 2002			Landings=	**916.0**						
	QTR 1		**QTR2**		**QTR 3**		**QTR 4**		**2002 Total**	
	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch (mt)
HOOK	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
OTTER TRAWL	4	1.4	6	7.9	8	4.1	9	2.0	27	15.4
GILLNET	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
OTHER	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	4	1.4	6	7.9	8	4.1	9	2.0	27	15.4
									% Sampled	**2%**
Eastern Georges Bank 2003			Landings=	**1563.4**						
	QTR 1		**QTR2**		**QTR 3**		**QTR 4**		**2003 Total**	
	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch (mt)
HOOK	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
OTTER TRAWL	16	7.0	31	71.7	8	2.1	13	26.1	68	106.8
GILLNET	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
OTHER	0	0.0	0	0.0	0	0.0	3	0.0	3	0.0
Total	16	7.0	31	71.7	8	2.1	16	26.1	71	106.8
									% Sampled	**7%**
Eastern Georges Bank 2004			Landings=	**1795.8**						
	QTR 1		**QTR2**		**QTR 3**		**QTR 4**		**2004 Total**	
	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch	number of trips	total kept catch (mt)
HOOK	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
OTTER TRAWL	23	34.3	22	85.2	27	36.2	4	0.2	76	155.9
GILLNET	0	0.0	0	0.0	1	0.3	0	0.0	1	0.3
OTHER	1	0.0	0	0.0	0	0.0	0	0.0	1	0.0
Total	24	34.3	22	85.2	28	36.5	4	0.2	78	156.3
									% Sampled	**9%**

Table 4.1. Total U.S. Catch of western Georges Bank (WGB) haddock catch (mt) using estimated discards from observer data, 2001-2004

WGB 2001		QTR 1				QTR 2				QTR 3				QTR 4			
	Annual Landings (mt)	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch
HOOK	49.28	0.12	4.59	0.54	5.13	0.12	2.92	0.34	3.26	0.12	38.60	4.56	43.16	0.12	3.17	0.37	3.54
OTTER TRAWL	3835.88	0.01	1332.44	18.31	1350.75	0.03	887.42	28.48	915.90	0.01	1050.58	14.11	1064.69	0.03	565.44	15.02	580.46
GILLNET	137.07	0.01	70.78	0.73	71.51	0.00	33.16	0.00	33.16	0.06	18.79	1.11	19.90	0.02	14.34	0.31	14.65
OTHER	0.05			0.00	0.00			0.00	0.00			0.00	0.00	0.13	0.05	0.01	0.06
Totals by QTR			1407.81	19.58	1427.39		923.50	28.82	952.32		1107.97	19.77	1127.74		583.00	15.71	598.71
Total Landings	4022																
Total Discards	84																
Total DK Ratio	2%																
Total Catch 2001	4106																

WGB 2002		QTR 1				QTR 2				QTR 3				QTR 4			
	Annual Landings (mt)	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch
HOOK	39.54	0.12	11.81	1.39	13.20	0.12	2.67	0.32	2.99	0.07	19.30	1.29	20.59	0.19	5.76	1.07	6.83
OTTER TRAWL	5166.02	0.04	1405.93	49.88	1455.81	0.01	1718.57	15.90	1734.47	0.01	1336.95	13.64	1350.59	0.02	704.57	15.23	719.80
GILLNET	203.86	0.01	70.37	0.57	70.94	0.00	52.67	0.14	52.81	0.17	73.06	12.18	85.24	0.01	7.76	0.05	7.81
OTHER	4.17	0.13	0.02	0.00	0.02	0.13	3.91	0.52	4.43	0.13	0.09	0.01	0.10	0.13	0.15	0.02	0.17
Totals by QTR			1488.13	51.85	1539.98		1777.82	16.87	1794.69		1429.40	27.11	1456.51		718.24	16.37	734.61
Total Landings	5414																
Total Discards	112																
Total DK Ratio	2%																
Total Catch 2002	5526																

WGB 2003		QTR 1				QTR 2				QTR 3				QTR 4			
	Annual Landings (mt)	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch
HOOK	159.72	0.24	8.67	2.05	10.72	0.12	1.16	0.14	1.30	0.12	31.10	3.67	34.77	0.12	118.79	14.03	132.82
OTTER TRAWL	3789.61	0.01	1354.12	18.82	1372.94	0.01	1354.20	17.88	1372.08	0.02	511.16	7.82	518.98	0.01	570.13	6.56	576.69
GILLNET	47.87	0.00	3.44	0.00	3.44	0.11	8.51	0.91	9.42	0.10	26.31	2.58	28.89	0.06	9.61	0.62	10.23
OTHER	3.71	0.13	0.03	0.00	0.03	0.13	3.31	0.44	3.75	0.13	0.36	0.05	0.41	0.13	0.01	0.00	0.01
Totals by QTR			1366.26	20.88	1387.14		1367.18	19.36	1386.54		568.93	14.12	583.05		698.54	21.20	719.74
Total Landings	4001																
Total Discards	76																
Total DK Ratio	2%																
Total Catch 2003	4076																

WGB 2004		QTR 1				QTR 2				QTR 3				QTR 4			
	Annual Landings (mt)	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch
HOOK	472.46	0.01	44.82	0.64	45.46	0.01	2.65	0.04	2.69	0.01	64.17	0.71	64.88	0.01	360.82	5.23	366.05
OTTER TRAWL	4801.31	0.12	1380.47	164.69	1545.16	0.04	1484.08	55.21	1539.29	0.12	934.64	109.82	1044.46	0.06	1002.12	57.61	1059.73
GILLNET	25.69	0.09	2.58	0.22	2.80	0.06	6.23	0.38	6.61	0.03	14.50	0.41	14.91	0.14	2.38	0.33	2.71
OTHER	84.22	0.21	0.01	0.00	0.01	0.21	47.31	10.07	57.38	0.13	36.90	4.85	41.75			0.00	0.00
Totals by QTR			1427.88	165.56	1593.44		1540.27	65.69	1605.96		1050.21	115.79	1166.00		1365.32	63.17	1428.49
Total Landings	5384																
Total Discards	410																
Total DK Ratio	8%																
Total Catch 2004	5794																

Table 4.2. Total U.S. Catch of eastern Georges Bank (EGB) haddock catch (mt) using estimated discards from observer data, 2001-2004

EGB 2001		QTR 1				QTR 2				QTR 3				QTR 4			
	Annual Landings (mt)	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch
HOOK				0.00	0.00			0.00	0.00			0.00	0.00			0.00	0.00
OTTER TRAWL	606.60	0.03	172.30	4.34	176.64	0.10	308.10	31.58	339.68	0.03	57.21	1.57	58.78	0.03	68.99	2.03	71.02
GILLNET	1.83	0.02	0.92	0.02	0.94	0.02	0.91	0.02	0.93			0.00	0.00			0.00	0.00
OTHER				0.00	0.00			0.00	0.00			0.00	0.00			0.00	0.00
Totals by QTR			173.22	4.35	177.57		309.01	31.60	340.61		57.21	1.57	58.78		68.99	2.03	71.02
Total Landings	608																
Total Discards	40																
Total DK Ratio	7%																
Total Catch 2001	648																

EGB 2002		QTR 1				QTR 2				QTR 3				QTR 4			
	Annual Landings (mt)	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch
HOOK				0.00	0.00			0.00	0.00			0.00	0.00			0.00	0.00
OTTER TRAWL	914.84	0.07	165.14	11.92	177.06	0.04	573.08	20.32	593.40	0.02	98.81	1.80	100.61	0.01	77.81	0.81	78.62
GILLNET				0.00	0.00			0.00	0.00			0.00	0.00			0.00	0.00
OTHER	1.20			0.00	0.00	0.12	1.17	0.14	1.31	0.12	0.03	0.00	0.03			0.00	0.00
Totals by QTR			165.14	11.92	177.06		574.25	20.45	594.70		98.84	1.80	100.64		77.81	0.81	78.62
Total Landings	916																
Total Discards	35																
Total DK Ratio	4%																
Total Catch 2002	951																

EGB 2003		QTR 1				QTR 2				QTR 3				QTR 4			
	Annual Landings (mt)	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch
HOOK				0.00	0.00			0.00	0.00			0.00	0.00			0.00	0.00
OTTER TRAWL	1563.40	0.03	179.41	4.66	184.07	0.04	1041.06	42.16	1083.22	0.04	92.09	3.54	95.63	0.05	250.84	13.04	263.88
GILLNET				0.00	0.00			0.00	0.00			0.00	0.00			0.00	0.00
OTHER				0.00	0.00			0.00	0.00			0.00	0.00			0.00	0.00
Totals by QTR			179.41	4.66	184.07		1041.06	42.16	1083.22		92.09	3.54	95.63		250.84	13.04	263.88
Total Landings	1563																
Total Discards	63																
Total DK Ratio	4%																
Total Catch 2003	1627																

EGB 2004		QTR 1				QTR 2				QTR 3				QTR 4			
	Annual Landings (mt)	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch	D/K Ratio	Landings	Discards	Total Catch
HOOK	1.11			0.00	0.00			0.00	0.00			0.00	0.00	0.01	1.11	0.02	1.13
OTTER TRAWL	1794.26	0.04	265.84	11.11	276.95	0.09	1195.85	109.47	1305.32	0.11	309.01	34.28	343.29	0.04	23.56	0.99	24.55
GILLNET	0.40	0.05	0.32	0.01	0.33	0.05	0.08	0.00	0.08			0.00	0.00			0.00	0.00
OTHER				0.00	0.00			0.00	0.00			0.00	0.00			0.00	0.00
Totals by QTR			266.16	11.12	277.28		1195.93	109.47	1305.40		309.01	34.28	343.29		24.67	1.00	25.67
Total Landings	1796																
Total Discards	156																
Total DK Ratio	9%																
Total Catch 2004	1952																

Table 5.1. U.S. landings and sampling intensity of western Georges Bank haddock by quarter and market category, 2001-2004

2001	Market Category Landings (mt)			
Qtr	Large	Scrod	Uncl	Total
1	978	355	74	1408
2	655	249	20	924
3	611	493	4	1108
4	297	284	2	583
Total	2541	1381	100	4022
Qtr	Lengths per 100 mt			
1	75	97	0	173
2	123	91	0	214
3	211	122	0	334
4	313	120	0	433
Avg	158	106	0	264
Qtr	Ages per 100 mt			
1	25	39	0	64
2	49	28	0	77
3	73	35	0	108
4	103	38	0	141
Avg	55	35	0	90

2002	Market Category Landings (mt)			
Qtr	Large	Scrod	Uncl	Total
1	1037	438	14	1488
2	1074	594	110	1778
3	978	419	32	1429
4	446	264	8	718
Total	3534	1715	164	5414
Qtr	Lengths per 100 mt			
1	38	45	0	82
2	18	26	0	44
3	101	99	0	200
4	139	122	0	261
Avg	61	63	0	124
Qtr	Ages per 100 mt			
1	17	15	0	33
2	6	12	0	17
3	33	26	0	59
4	39	42	0	82
Avg	21	20	0	41

2003	Market Category Landings (mt)			
Qtr	Large	Scrod	Uncl	Total
1	895	457	15	1366
2	773	555	40	1367
3	337	225	7	569
4	394	267	38	699
Total	2398	1503	100	4001
Qtr	Lengths per 100 mt			
1	62	65	0	127
2	116	77	0	192
3	241	126	0	367
4	245	101	0	346
Avg	138	84	0	222
Qtr	Ages per 100 mt			
1	17	21	0	38
2	29	27	0	57
3	79	37	0	116
4	71	30	0	101
Avg	39	27	0	67

2004	Market Category Landings (mt)			
Qtr	Large	Scrod	Uncl	Total
1	837	548	43	1428
2	570	883	87	1540
3	363	523	163	1050
4	486	780	99	1365
Total	2256	2735	393	5384
Qtr	Lengths per 100 mt			
1	120	73	0	193
2	119	20	0	139
3	205	97	0	302
4	242	131	0	373
Avg	167	77	0	245
Qtr	Ages per 100 mt			
1	36	24	0	59
2	15	3	0	18
3	36	17	0	53
4	34	16	0	50
Avg	29	15	0	44

Table 5.2. U.S. landings and sampling intensity of eastern Georges Bank haddock by quarter and market category, 2001-2004

2001	Market Category Landings (mt)			
Qtr	Large	Scrod	Uncl	Total
1	61	110	3	173
2	162	144	2	309
3	38	19		57
4	47	22		69
Total	309	295	5	608
Qtr	Lengths per 100 mt			
1	337	68	0	405
2	186	39	0	225
3	0	281	0	281
4	0	0	0	0
Avg	190	65	0	256
Qtr	Ages per 100 mt			
1	111	23	0	134
2	51	17	0	68
3	0	132	0	132
4	0	0	0	0
Avg	58	28	0	85

2002	Market Category Landings (mt)			
Qtr	Large	Scrod	Uncl	Total
1	96	68	1	165
2	279	281	14	574
3	56	43	0	99
4	51	24	2	78
Total	482	416	18	916
Qtr	Lengths per 100 mt			
1	94	0	0	94
2	92	47	0	139
3	275	0	0	275
4	0	0	0	0
Avg	105	29	0	134
Qtr	Ages per 100 mt			
1	47	0	0	47
2	27	18	0	45
3	66	0	0	66
4	0	0	0	0
Avg	33	11	0	44

2003	Market Category Landings (mt)			
Qtr	Large	Scrod	Uncl	Total
1	82	96	0	179
2	493	540	8	1041
3	50	37	6	92
4	26	222	3	251
Total	652	894	17	1563
Qtr	Lengths per 100 mt			
1	119	0	0	119
2	128	53	0	182
3	219	0	0	219
4	427	43	0	470
Avg	180	42	0	223
Qtr	Ages per 100 mt			
1	43	0	0	43
2	36	14	0	50
3	84	0	0	84
4	95	12	0	107
Avg	49	12	0	60

2004	Market Category Landings (mt)			
Qtr	Large	Scrod	Uncl	Total
1	71	193	3	266
2	233	960	3	1196
3	65	238	6	309
4	4	21	0	25
Total	372	1411	12	1796
Qtr	Lengths per 100 mt			
1	147	0	0	147
2	138	37	0	174
3	339	97	0	437
4	0	0	0	0
Avg	172	41	0	213
Qtr	Ages per 100 mt			
1	35	0	0	35
2	33	9	0	41
3	59	27	0	86
4	0	0	0	0
Avg	37	11	0	48

Table 6.1. U.S. catch numbers (000s) at age of western Georges Bank haddock, 2001-2004

2001 Catch at age (thousands of fish)

	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+	Total
Landings at age 2001	0.0	58.4	479.2	287.3	369.8	299.2	181.5	93.8	56.2	1825.6
Discards at age 2001	4.3	7.1	23.9	13.3	7.8	4.9	2.9	1.1	0.6	65.9
Catch at age 2001	4.3	65.5	503.1	300.6	377.6	304.1	184.4	94.9	56.8	1891.5

2002 Catch at age (thousands of fish)

	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+	Total
Landings at age 2002	0.0	2.2	70.8	925.0	430.1	351.5	195.0	139.0	219.1	2332.8
Discards at age 2002	1.0	46.6	18.3	42.1	7.4	3.5	0.9	0.8	1.3	121.9
Catch at age 2002	1.0	48.8	89.1	967.1	437.5	355.0	195.9	139.8	220.4	2454.7

2003 Catch at age (thousands of fish)

	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+	Total
Landings at age 2003	0.0	0.8	82.6	144.9	926.4	178.6	246.3	93.0	144.7	1817.1
Discards at age 2003	1.1	4.1	28.8	6.1	20.3	2.1	2.4	0.9	1.7	67.4
Catch at age 2003	1.1	4.9	111.4	151.0	946.7	180.7	248.7	93.9	146.4	1884.5

2004 Catch at age (thousands of fish)

	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+	Total
Landings at age 2004	0.0	0.2	23.3	760.6	212.7	1202.7	178.4	125.9	136.5	2640.6
Discards at age 2004	375.1	19.3	34.4	206.8	22.5	58.2	10.3	2.1	3.0	731.6
Catch at age 2004	375.1	19.5	57.7	967.4	235.2	1260.9	188.7	128.0	139.5	3372.2

Table 6.2. U.S. catch at age of eastern Georges Bank haddock, 2001-2004

2001 US Catch at age (thousands of fish)

	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+	Total
Landings at age 2001	0.0	0.7	71.0	35.2	68.9	29.5	20.2	26.3	40.4	292.2
Discards at age 2001	1.0	3.3	10.4	3.5	4.0	1.4	1.1	1.3	2.1	28.1
Catch at age 2001	1.0	4.0	81.4	38.7	72.9	30.9	21.3	27.6	42.5	320.3

2002 US Catch at age (thousands of fish)

	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+	Total
Landings at age 2002	0.0	5.4	12.5	176.3	52.7	75.0	26.5	22.1	60.3	430.8
Discards at age 2002	0.1	48.0	12.4	10.0	1.1	0.8	0.1	0.2	0.1	72.8
Catch at age 2002	0.1	53.4	24.9	186.3	53.8	75.8	26.6	22.3	60.4	503.6

2003 US Catch at age (thousands of fish)

	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+	Total
Landings at age 2003	0.0	0.0	94.8	46.6	295.8	77.4	105.2	43.2	91.5	754.5
Discards at age 2003	3.8	2.8	35.5	7.1	11.6	2.6	2.0	0.6	1.3	67.3
Catch at age 2003	3.8	2.8	130.3	53.7	307.4	80.0	107.2	43.8	92.8	821.8

2004 US Catch at age (thousands of fish)

	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+	Total
Landings at age 2004	0.0	0.0	1.3	340.3	152.0	246.7	104.3	94.7	74.5	1013.8
Discards at age 2004	165.6	15.0	24.5	67.9	24.8	17.4	6.7	0.9	0.7	323.5
Catch at age 2004	165.6	15.0	25.8	408.2	176.8	264.1	111.0	95.6	75.2	1337.3

Table 6.3. Canadian catch at age of eastern Georges Bank haddock (thousands of fish), 2001-2004

Year	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+	Total
2001	26.0	63.0	1638.6	486.3	758.1	224.1	177.7	198.4	151.5	3723.7
2002	0.9	303.6	197.1	1675.7	316.2	581.2	83.4	83.7	217.6	3459.4
2003	1.2	6.2	1674.7	227.3	1152.6	339.0	362.8	63.2	134.2	3961.2
2004	178.4	3.0	37.2	3185.8	410.2	1215.9	401.0	322.4	184.8	5938.7

Table 7. Georges Bank haddock catch at age (thousands of fish), 1963-2004

Year	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+	Total
1963	2910	4047	7418	11152	8198	2205	1405	721	1096	39152
1964	10101	15935	4554	4776	8722	5794	2082	1028	1332	54324
1965	9601	125818	44496	5356	4391	6690	3772	1094	1366	202584
1966	114	6843	100810	19167	2768	2591	2332	1268	867	136760
1967	1150	168	2891	20667	10338	1209	993	917	698	39031
1968	8	2994	709	1921	14519	3499	667	453	842	25612
1969	2	11	1698	448	654	5954	1574	225	570	11136
1970	46	158	16	570	186	214	2308	746	464	4708
1971	1	1375	223	40	289	246	285	1469	928	4856
1972	160	2	460	83	33	123	80	68	1265	2273
1973	2607	2113	3	393	54	31	78	15	455	5750
1974	48	4481	682	2	73	2	2	55	258	5602
1975	199	1069	1928	388	4	43	4	4	91	3731
1976	149	491	570	913	224	0	24	4	116	2491
1977	1	19858	190	689	522	362	4	40	113	21778
1978	1	767	14509	307	571	521	140	14	68	16899
1979	1	26	1742	7238	530	414	318	97	46	10413
1980	8	31170	349	980	6087	597	549	154	81	39976
1981	1	1755	11076	837	944	2590	333	159	95	17791
1982	1	1174	1645	3761	394	573	1127	107	111	8893
1983	0	216	821	697	2261	275	188	808	77	5343
1984	0	94	301	736	402	1500	237	270	550	4090
1985	0	2464	563	199	472	233	539	80	156	4706
1986	6	55	2848	226	148	175	152	270	61	3941
1987	0	2035	132	1645	124	74	91	108	138	4348
1988	4	53	2439	137	953	152	56	65	108	3969
1989	0	1302	89	904	147	369	47	29	46	2933
1990	2	11	1480	176	889	100	181	47	45	2932
1991	6	456	93	2186	104	417	74	157	73	3565
1992	7	252	327	135	1560	113	330	28	96	2848
1993	7	297	359	307	107	676	39	163	78	2031
1994	1	281	846	178	68	72	157	45	45	1693
1995	9	92	615	471	62	32	8	58	19	1367
1996	5	54	577	958	470	69	22	5	8	2169
1997	30	178	290	768	556	216	19	16	40	2114
1998	1	203	423	511	705	536	151	22	42	2594
1999	1	40	1070	587	502	514	338	144	41	3235
2000	0	392	620	1583	558	497	362	246	86	4263
2001	31	133	2223	826	1209	559	383	321	251	5935
2002	2	406	311	2829	808	1012	306	246	498	6418
2003	6	14	1916	432	2407	600	719	201	373	6668
2004	719	38	121	4561	822	2741	701	546	400	10648
Average 1963-2004	665	5460	5106	2399	1782	1062	552	298	336	17656
Average 1980-1999	5	2109	1317	820	848	464	232	137	95	6027
Average 2000-2004	152	196	1038	2046	1161	1082	494	312	322	6786

Table 8. Mean weights at age of western and eastern Georges Bank haddock landings and discards, 2001-2004

Mean weights at age (kg) of western Georges Bank haddock landings, 2001-2004

Year	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+
2001	0.25	1.34	1.47	1.80	2.29	2.68	3.11	3.18	3.76
2002	0.35	1.19	1.39	1.75	1.99	2.71	3.35	3.49	3.38
2003	0.32	1.05	1.35	1.73	1.88	2.37	2.77	3.35	3.30
2004	0.16	0.95	1.25	1.59	1.92	2.07	2.34	3.02	3.28

Mean weights at age (kg) of U.S. eastern Georges Bank haddock landings, 2001-2004

Year	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+
2001	0.25	1.13	1.29	1.60	2.04	2.34	2.19	2.74	3.31
2002	0.35	1.07	1.18	1.56	1.74	2.44	2.97	3.10	3.31
2003	0.32	1.05	1.31	1.52	1.83	1.99	2.54	2.89	3.09
2004	0.16	0.95	1.05	1.40	1.52	1.84	1.96	2.39	2.73

Mean weights at age (kg) of Canadian eastern Georges Bank haddock landings, 2001-2004

Year	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+
2001	0.39	1.10	1.47	1.76	2.11	2.37	2.19	2.52	3.31
2002	0.41	1.01	1.42	1.76	1.94	2.34	2.66	2.38	3.31
2003	0.48	0.76	1.38	1.59	1.85	1.89	2.34	2.84	3.09
2004	0.48	0.59	1.10	1.51	1.64	1.88	2.00	2.28	2.73

Mean weights at age (kg) of western Georges Bank haddock discards 2001-2004

Year	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+
2001	0.18	0.64	1.06	1.33	1.78	1.95	2.73	1.85	3.45
2002	0.23	0.58	0.77	1.12	1.33	1.93	2.09	1.73	2.65
2003	0.21	0.50	0.90	1.09	1.48	1.86	2.47	2.98	2.27
2004	0.12	0.37	0.84	1.17	1.18	1.61	1.59	2.08	2.61

Mean weights at age (kg) of U.S. eastern Georges Bank haddock discards 2001-2004

Year	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+
2001	0.18	0.64	1.06	1.33	1.78	1.95	2.73	1.85	3.19
2002	0.23	0.58	0.77	1.12	1.33	1.93	2.09	1.73	2.58
2003	0.21	0.50	0.90	1.09	1.48	1.86	2.47	2.98	2.42
2004	0.12	0.37	0.84	1.17	1.18	1.61	1.59	2.08	2.45

Table 9. Georges Bank haddock mean catch weights at age (kg) for ages 1 to 9+, 1963-2004

Year	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+
1963	0.57	0.87	1.18	1.47	1.68	2.15	2.35	3.04	3.10
1964	0.50	0.83	1.12	1.43	1.64	2.01	2.40	2.64	2.97
1965	0.58	0.69	1.03	1.35	1.67	1.99	2.26	2.66	3.11
1966	0.58	0.73	0.89	1.26	1.70	2.07	2.28	2.87	3.18
1967	0.66	0.70	0.95	1.18	1.42	2.05	2.31	2.66	3.10
1968	0.59	0.81	1.05	1.32	1.57	2.10	2.32	2.62	2.86
1969	0.52	0.78	1.10	1.69	1.75	1.99	2.52	2.99	3.63
1970	0.71	1.27	1.22	1.93	2.19	2.39	2.58	3.23	3.75
1971	0.67	1.03	1.31	1.74	2.39	2.81	2.92	3.10	3.72
1972	0.62	1.03	1.74	2.04	2.42	2.92	3.06	3.44	3.66
1973	0.60	1.03	1.58	2.13	2.41	3.29	3.42	3.86	3.94
1974	0.72	1.06	1.82	2.32	2.83	3.76	4.05	3.92	4.26
1975	0.62	0.98	1.63	2.21	2.20	2.94	4.00	4.05	4.33
1976	0.50	0.99	1.39	1.99	2.66	3.08	3.69	4.67	4.94
1977	0.53	1.07	1.44	2.17	2.73	3.21	4.15	4.00	4.99
1978	0.53	0.94	1.50	2.04	2.79	3.19	3.37	3.61	5.11
1979	0.53	1.00	1.28	2.02	2.51	3.14	3.78	3.79	4.87
1980	0.55	0.94	1.21	1.73	2.17	2.82	3.60	3.56	3.87
1981	0.39	0.87	1.24	1.83	2.30	2.72	3.71	4.04	4.44
1982	0.22	0.97	1.45	1.88	2.37	2.76	3.24	3.96	4.09
1983	0.33	1.02	1.37	1.83	2.21	2.65	3.25	3.36	4.27
1984	0.33	0.92	1.32	1.83	2.20	2.67	2.96	3.41	3.72
1985	0.33	0.99	1.39	1.98	2.46	2.72	3.06	3.72	3.80
1986	0.45	0.94	1.36	1.83	2.56	2.83	2.96	3.46	3.78
1987	0.43	0.83	1.43	2.00	2.25	2.63	3.02	3.77	4.29
1988	0.42	0.98	1.34	1.68	2.06	2.45	2.97	3.49	3.96
1989	0.53	0.89	1.48	1.79	2.21	2.57	3.24	3.56	3.82
1990	0.64	0.97	1.48	1.78	2.12	2.55	2.81	2.99	4.16
1991	0.58	1.20	1.31	1.82	2.18	2.65	2.85	3.05	4.34
1992	0.54	1.18	1.64	1.77	2.19	2.52	2.97	3.37	4.27
1993	0.66	1.17	1.73	2.17	2.12	2.63	2.65	3.12	4.01
1994	0.45	1.09	1.64	2.21	2.63	2.73	2.90	3.78	4.55
1995	0.43	0.97	1.49	2.03	2.54	2.82	3.28	3.09	3.98
1996	0.46	1.10	1.50	1.84	2.33	2.54	3.42	3.52	3.71
1997	0.42	1.00	1.69	1.89	2.21	2.55	3.14	3.38	3.66
1998	0.51	0.97	1.49	1.92	2.33	2.69	3.03	3.04	4.07
1999	0.68	1.10	1.53	1.83	2.11	2.34	2.70	2.97	3.68
2000	0.66	1.13	1.46	1.89	2.25	2.37	2.73	2.99	3.30
2001	0.36	1.17	1.46	1.75	2.16	2.53	2.63	2.73	3.41
2002	0.30	0.91	1.34	1.73	1.95	2.47	3.13	3.07	3.34
2003	0.26	0.65	1.36	1.61	1.85	2.05	2.52	3.09	3.17
2004	0.21	0.39	1.00	1.50	1.67	1.95	2.07	2.47	2.91
Average 1963-2004	0.50	0.96	1.38	1.82	2.19	2.60	3.01	3.34	3.86
Average 2001-2004	0.28	0.78	1.29	1.65	1.91	2.25	2.59	2.84	3.21
Percent Change	-44%	-18%	-7%	-9%	-13%	-14%	-14%	-15%	-17%

Table 10. Stratified mean number and weight per tow of Georges Bank haddock from NEFSC spring and autumn surveys, 1963-2005

	Spring Survey		Autumn Survey	
Year	Number/Tow	Weight (kg)/Tow	Number/Tow	Weight (kg)/Tow
1963			145.0	79.8
1964			193.2	96.8
1965			101.7	72.8
1966			33.3	29.9
1967			17.7	25.5
1968	13.8	20.6	7.5	15.4
1969	7.3	16.9	3.4	8.4
1970	6.0	17.1	7.7	13.5
1971	2.8	5.0	4.2	5.6
1972	6.4	7.4	11.4	8.5
1973	37.6	15.4	14.9	9.8
1974	19.0	17.7	4.1	4.0
1975	6.2	8.2	31.0	15.1
1976	83.2	15.7	71.1	35.8
1977	36.9	26.6	23.3	27.5
1978	19.4	31.3	25.3	18.1
1979	45.5	19.8	52.2	32.0
1980	60.1	53.9	30.5	22.0
1981	31.2	38.0	13.5	14.0
1982	8.6	13.1	5.0	7.3
1983	5.6	13.2	8.0	5.8
1984	6.2	7.5	5.4	4.5
1985	8.9	11.1	14.2	3.9
1986	5.9	5.9	6.8	5.1
1987	5.0	5.6	3.6	2.6
1988	3.4	3.4	5.4	5.6
1989	5.4	4.7	4.3	4.7
1990	7.7	7.6	2.9	2.6
1991	4.0	4.4	2.9	0.9
1992	1.2	1.4	6.1	3.2
1993	2.8	2.5	8.1	4.3
1994	5.0	3.6	3.6	2.9
1995	5.6	5.7	17.1	10.7
1996	23.4	25.7	4.5	4.1
1997	13.0	18.5	6.2	6.5
1998	7.3	6.1	11.1	5.8
1999	16.7	7.7	23.1	33.1
2000	14.3	17.9	18.0	15.4
2001	14.9	6.1	22.7	20.0
2002	32.3	22.3	42.1	36.3
2003	14.8	15.6	169.5	23.0
2004	140.5	41.4	187.0	55.8
2005	59.8	17.7	90.5	39.4
Average 1963-2005	20.7	14.8	33.9	19.5
Average 1980-1989	11.3	12.0	9.1	7.5
Average 2000-2005	52.5	20.6	102.4	34.9

Table 11. Conversion factors used to adjust for changes in door type and survey vessel in the NMFS surveys during 1968-2005.

		Spring		Fall	
Year	Door	Vessel	Conversion	Vessel	Conversion
1968	BMV	Albatross IV	1.49	Albatross IV	1.49
1969	BMV	Albatross IV	1.49	Albatross IV	1.49
1970	BMV	Albatross IV	1.49	Albatross IV	1.49
1971	BMV	Albatross IV	1.49	Albatross IV	1.49
1972	BMV	Albatross IV	1.49	Albatross IV	1.49
1973	BMV	Albatross IV	1.49	Albatross IV	1.49
1974	BMV	Albatross IV	1.49	Albatross IV	1.49
1975	BMV	Albatross IV	1.49	Albatross IV	1.49
1976	BMV	Albatross IV	1.49	Albatross IV	1.49
1977	BMV	Albatross IV	1.49	Delaware II	1.2218
1978	BMV	Albatross IV	1.49	Delaware II	1.2218
1979	BMV	Albatross IV	1.49	Delaware II	1.2218
1980	BMV	Albatross IV	1.49	Delaware II	1.2218
1981	BMV	Delaware II	1.2218	Delaware II	1.2218
1982	BMV	Delaware II	1.2218	Albatross IV	1.49
1983	BMV	Albatross IV	1.49	Albatross IV	1.49
1984	BMV	Albatross IV	1.49	Albatross IV	1.49
1985	Polyvalent	Albatross IV	1	Albatross IV	1
1986	Polyvalent	Albatross IV	1	Albatross IV	1
1987	Polyvalent	Albatross IV	1	Albatross IV	1
1988	Polyvalent	Albatross IV	1	Albatross IV	1
1989	Polyvalent	Delaware II	0.82	Delaware II	0.82
1990	Polyvalent	Delaware II	0.82	Delaware II	0.82
1991	Polyvalent	Delaware II	0.82	Delaware II	0.82
1992	Polyvalent	Albatross IV	1	Albatross IV	1
1993	Polyvalent	Albatross IV	1	Delaware II	0.82
1994	Polyvalent	Delaware II	0.82	Albatross IV	1
1995	Polyvalent	Albatross IV	1	Albatross IV	1
1996	Polyvalent	Albatross IV	1	Albatross IV	1
1997	Polyvalent	Albatross IV	1	Albatross IV	1
1998	Polyvalent	Albatross IV	1	Albatross IV	1
1999	Polyvalent	Albatross IV	1	Albatross IV	1
2000	Polyvalent	Albatross IV	1	Albatross IV	1
2001	Polyvalent	Albatross IV	1	Albatross IV	1
2002	Polyvalent	Albatross IV	1	Albatross IV	1
2003	Polyvalent	Delaware II	0.82	Delaware II	0.82
2004	Polyvalent	Albatross IV	1	Albatross IV	1
2005	Polyvalent	Albatross IV	1	Albatross IV	1

Table 12. Georges Bank haddock NEFSC spring survey stratified mean number per tow at age indices (ages 1 through 9 and older), 1968-2005

Year	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+
1968	0.40	2.83	0.46	0.70	6.72	1.68	0.25	0.45	0.34
1969	0.00	0.07	0.58	0.25	0.42	4.23	1.03	0.28	0.46
1970	0.67	0.25	0.00	0.33	0.46	0.46	2.00	0.98	0.85
1971	0.00	1.16	0.25	0.00	0.12	0.12	0.09	0.82	0.22
1972	4.02	0.09	0.61	0.12	0.03	0.04	0.13	0.03	1.30
1973	30.68	4.84	0.00	0.54	0.09	0.00	0.18	0.01	1.28
1974	2.13	13.29	2.86	0.00	0.24	0.00	0.01	0.10	0.37
1975	0.94	0.97	3.32	0.63	0.00	0.13	0.09	0.01	0.15
1976	80.79	0.30	0.60	0.92	0.43	0.00	0.04	0.00	0.10
1977	0.61	33.41	0.42	1.22	0.60	0.45	0.00	0.04	0.12
1978	0.07	0.97	15.93	0.36	0.94	0.82	0.16	0.06	0.10
1979	36.12	1.58	1.13	5.71	0.33	0.16	0.37	0.06	0.04
1980	5.20	46.70	0.51	1.04	4.87	0.67	0.37	0.46	0.24
1981	3.30	3.29	19.49	2.19	0.76	1.78	0.24	0.11	0.05
1982	0.76	1.53	0.94	4.07	0.42	0.28	0.61	0.00	0.00
1983	0.43	0.55	0.58	0.22	2.41	0.01	0.04	1.16	0.18
1984	2.09	1.18	0.64	0.63	0.58	0.72	0.07	0.04	0.30
1985	0.00	4.96	0.76	0.40	0.87	0.34	1.17	0.10	0.25
1986	2.49	0.18	2.06	0.24	0.11	0.21	0.12	0.33	0.11
1987	0.00	3.62	0.06	0.81	0.08	0.10	0.05	0.22	0.01
1988	1.55	0.04	0.99	0.13	0.32	0.12	0.11	0.12	0.00
1989	0.02	3.49	0.45	0.71	0.14	0.41	0.06	0.05	0.01
1990	0.86	0.00	5.72	0.33	0.58	0.06	0.13	0.00	0.01
1991	0.54	1.07	0.24	1.85	0.09	0.10	0.02	0.04	0.02
1992	0.40	0.18	0.11	0.07	0.33	0.03	0.03	0.03	0.00
1993	1.17	0.65	0.18	0.14	0.12	0.37	0.06	0.02	0.02
1994	0.70	2.68	1.00	0.15	0.10	0.07	0.16	0.02	0.05
1995	0.50	1.29	2.32	0.91	0.17	0.11	0.03	0.18	0.11
1996	1.09	4.59	8.86	5.21	2.62	0.35	0.07	0.07	0.00
1997	1.79	1.02	3.35	3.66	2.01	0.89	0.13	0.07	0.00
1998	0.82	2.95	1.25	1.06	0.85	0.21	0.06	0.01	0.06
1999	10.21	2.03	2.14	0.72	0.64	0.51	0.20	0.20	0.02
2000	1.83	2.37	4.10	2.01	1.11	1.11	1.01	0.48	0.13
2001	10.01	0.86	2.44	0.83	0.30	0.21	0.12	0.08	0.07
2002	0.18	19.25	6.72	3.22	1.09	0.48	0.61	0.17	0.53
2003	0.01	0.25	5.45	1.21	4.85	0.96	1.14	0.86	0.89
2004	112.14	1.85	1.20	9.06	2.18	2.67	0.43	0.96	0.42
2005	0.80	53.34	0.16	0.38	3.35	0.45	1.01	0.19	0.08
Average 1968-2005	8.30	5.78	2.58	1.37	1.09	0.56	0.33	0.23	0.23
Maximum 1968-2005	112.14	53.34	19.49	9.06	6.72	4.23	2.00	1.16	1.30
Average 1980-1999	1.70	4.10	2.58	1.23	0.90	0.37	0.19	0.16	0.07
Average 2000-2005	20.83	12.99	3.34	2.79	2.15	0.98	0.72	0.46	0.35

Table 13. Georges Bank haddock NEFSC autumn survey stratified mean number per tow at age indices (ages 1 through 9 and older), 1963-2005

Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+
1963	83.93	25.39	9.22	6.81	8.34	5.95	2.04	1.68	1.18	0.46
1964	2.37	112.87	63.74	5.83	1.79	3.81	1.56	0.69	0.25	0.33
1965	0.33	10.16	77.39	9.70	1.07	0.80	0.91	0.80	0.25	0.27
1966	6.14	0.95	2.89	18.39	3.35	0.52	0.49	0.33	0.12	0.07
1967	0.03	6.72	0.36	1.00	6.76	1.62	0.49	0.21	0.33	0.18
1968	0.09	0.06	0.95	0.13	0.33	3.86	1.27	0.27	0.16	0.39
1969	0.39	0.03	0.00	0.28	0.13	0.16	1.52	0.51	0.09	0.27
1970	0.04	4.13	0.21	0.01	0.28	0.27	0.51	1.37	0.48	0.40
1971	2.43	0.00	0.31	0.07	0.01	0.22	0.03	0.09	0.75	0.28
1972	6.75	2.52	0.00	0.52	0.09	0.00	0.09	0.06	0.03	1.30
1973	3.23	9.00	1.61	0.00	0.19	0.04	0.00	0.07	0.01	0.72
1974	0.75	1.77	0.98	0.31	0.00	0.01	0.00	0.00	0.00	0.22
1975	23.48	0.63	0.72	4.86	0.92	0.00	0.03	0.00	0.01	0.30
1976	4.32	64.17	0.52	0.54	0.82	0.30	0.00	0.04	0.10	0.25
1977	0.13	2.14	18.73	0.56	0.57	0.64	0.34	0.04	0.01	0.09
1978	13.22	0.84	1.04	9.27	0.18	0.26	0.45	0.01	0.00	0.01
1979	1.32	45.57	0.04	0.90	3.81	0.26	0.28	0.05	0.01	0.00
1980	11.68	2.71	12.72	0.45	0.18	1.70	0.48	0.46	0.09	0.06
1981	0.38	6.13	2.08	3.70	0.21	0.42	0.53	0.00	0.00	0.01
1982	1.36	0.00	1.33	0.34	1.40	0.13	0.07	0.21	0.01	0.10
1983	5.80	0.24	0.21	0.27	0.30	0.94	0.12	0.00	0.10	0.01
1984	0.03	3.32	0.88	0.24	0.28	0.06	0.45	0.00	0.00	0.12
1985	11.35	0.65	1.53	0.22	0.05	0.10	0.07	0.17	0.00	0.05
1986	0.00	5.11	0.09	1.21	0.06	0.13	0.13	0.02	0.03	0.03
1987	1.80	0.00	0.79	0.10	0.77	0.06	0.06	0.02	0.02	0.00
1988	0.07	3.02	0.18	1.30	0.12	0.40	0.12	0.11	0.00	0.03
1989	0.47	0.05	2.71	0.20	0.66	0.09	0.13	0.02	0.02	0.00
1990	0.77	0.67	0.02	1.19	0.05	0.17	0.04	0.00	0.00	0.00
1991	2.16	0.21	0.24	0.05	0.22	0.02	0.02	0.00	0.00	0.02
1992	2.85	2.08	0.23	0.24	0.00	0.47	0.02	0.08	0.03	0.06
1993	1.52	4.04	2.01	0.30	0.00	0.06	0.15	0.02	0.00	0.00
1994	0.91	0.77	0.81	0.67	0.12	0.05	0.02	0.17	0.06	0.00
1995	2.27	7.14	4.90	2.32	0.38	0.01	0.00	0.07	0.02	0.00
1996	1.31	0.54	0.93	1.04	0.49	0.14	0.01	0.01	0.00	0.01
1997	0.32	2.47	1.47	0.75	0.55	0.33	0.13	0.00	0.07	0.08
1998	4.32	2.79	2.47	0.72	0.41	0.18	0.16	0.02	0.00	0.01
1999	1.82	0.84	3.37	8.05	3.52	2.32	0.82	1.32	0.75	0.31
2000	4.14	2.82	5.48	3.10	1.10	0.66	0.13	0.27	0.09	0.19
2001	0.85	8.77	1.68	7.44	2.12	1.16	0.36	0.22	0.13	0.01
2002	0.12	1.91	22.27	5.45	8.54	1.87	0.62	0.53	0.68	0.10
2003	154.54	0.07	0.45	8.55	1.77	3.36	0.29	0.28	0.00	0.22
2004	1.63	163.65	0.22	0.84	13.62	1.18	4.54	0.50	0.67	0.15
2005	4.26	1.77	77.24	0.28	0.70	4.74	0.48	0.84	0.11	0.12
Average 1963-2005	8.50	11.83	7.56	2.52	1.54	0.92	0.46	0.27	0.15	0.17
Maximum 1963-2005	154.54	163.65	77.39	18.39	13.62	5.95	4.54	1.68	1.18	1.30
Average 1980-1999	2.56	2.14	1.95	1.17	0.49	0.39	0.18	0.14	0.06	0.05
Average 2000-2005	27.59	29.83	17.89	4.28	4.64	2.16	1.07	0.44	0.28	0.13

Table 14. Georges Bank haddock Canadian winter survey stratified mean number per tow at age indices (ages 1 through 8), 1986-2004

Year	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8
1986	4.06	0.22	6.05	1.07	0.19	0.29	0.34	0.37
1987	0.03	3.04	0.69	2.51	0.67	0.08	0.30	0.10
1988	1.47	0.05	8.53	0.17	2.85	0.18	0.17	0.11
1989	0.03	5.34	0.72	2.12	0.19	0.42	0.03	0.03
1990	0.93	0.11	9.87	0.13	3.36	0.23	1.09	0.13
1991	0.75	1.67	0.14	8.99	0.11	1.60	0.09	0.44
1992	3.30	2.95	1.13	0.17	3.82	0.03	1.06	0.04
1993	3.96	2.16	0.55	0.45	0.04	1.28	0.02	0.32
1994	3.32	11.52	4.08	0.42	0.24	0.02	0.70	0.01
1995	1.94	2.62	4.30	2.22	0.56	0.03	0.00	0.48
1996	6.11	2.89	4.84	5.04	2.92	0.26	0.24	0.04
1997	1.74	1.16	0.99	2.34	2.37	1.70	0.23	0.09
1998	2.41	8.18	3.08	2.57	3.76	3.67	1.98	0.24
1999	19.75	3.41	7.16	2.21	1.40	1.35	1.26	0.33
2000	18.33	68.60	9.32	8.91	2.11	1.55	1.94	1.14
2001	22.28	2.83	10.88	3.09	4.13	1.29	1.15	1.41
2002	1.98	31.70	6.65	15.36	4.32	5.32	1.59	1.32
2003	1.37	2.55	69.32	5.14	13.24	2.94	2.69	1.21
2004	147.70	0.41	1.99	39.57	3.94	7.38	1.24	0.73
Average 1986-2004	12.71	7.97	7.91	5.39	2.64	1.56	0.85	0.45
Maximum 1986-2004	147.70	68.60	69.32	39.57	13.24	7.38	2.69	1.41
Average 1986-1999	3.56	3.24	3.72	2.17	1.61	0.80	0.54	0.20
Average 2000-2004	38.33	21.22	19.63	14.41	5.55	3.69	1.72	1.16

Table 15.1. Georges Bank haddock mean weights (kg) at age for ages 1 to 9 during the NEFSC spring survey, 1968-2005. Blank cells have no age samples.

	Age Class								
Year	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9
1968	0.15	0.64	1.04	1.34	1.50	2.14	3.05	3.02	4.40
1969	0.04	0.39	1.53	1.63	1.89	2.22	2.53	3.82	4.03
1970	0.13	0.41		1.95	2.63	2.59	3.00	3.98	4.34
1971		0.66	0.83	1.23	2.37	2.47	2.53	2.67	3.11
1972	0.13	0.25	1.52	1.80	2.16	2.95	3.72	3.54	3.66
1973	0.18	0.62		2.04	2.35		3.15	4.25	
1974	0.11	0.79	1.43		2.93		2.90	4.47	
1975	0.18	0.70	1.44	1.89	3.23	3.17	3.31	3.85	5.08
1976	0.13	0.75	1.38	2.26	2.87		3.54		
1977	0.10	0.60	1.39	1.98	2.39	3.18	4.32	4.96	4.32
1978	0.11	0.62	1.44	2.50	2.88	3.46	3.66	4.39	2.86
1979	0.12	0.31	1.23	1.77	2.49	3.55	3.79	4.27	4.52
1980	0.15	0.65	1.08	1.76	2.68	3.35	4.47	4.42	4.03
1981	0.10	0.64	1.20	1.49	2.57	3.03	3.21	5.24	5.97
1982	0.10	0.47	1.08	1.57	2.19	2.81	3.82	4.62	
1983	0.11	0.43	1.15	1.52	2.47	2.17	4.24	4.04	5.71
1984	0.14	0.33	1.04	1.75	2.19	2.84	3.34	4.90	3.30
1985	0.10	0.44	0.88	1.56	2.02	2.57	3.11	4.01	5.38
1986	0.14	0.57	1.12	1.47	2.77	2.89	2.54	3.42	3.44
1987	0.24	0.60	1.75	2.00	2.72	3.11	3.14	3.86	6.54
1988	0.12	0.53	0.95	1.51	2.19	3.10	3.75	5.11	4.82
1989	0.09	0.45	0.66	1.39	1.79	2.82	3.37	3.88	5.00
1990	0.20	0.36	0.94	1.02	1.93	2.31	3.35	4.43	4.43
1991	0.16	0.67	0.97	1.40	2.01	2.23	2.39	3.55	4.91
1992	0.15	0.71	1.63	1.95	1.98	2.08	3.47	3.47	
1993	0.14	0.56	1.07	1.85	2.11	2.54	2.86	3.07	3.72
1994	0.13	0.51	1.03	1.50	2.24	1.82	2.46	2.20	3.10
1995	0.12	0.51	0.91	1.50	1.62	2.41	2.31	3.02	3.77
1996	0.16	0.55	0.92	1.42	1.92	1.89	2.99	1.43	2.83
1997	0.16	0.60	1.35	1.73	2.04	2.32	2.71	2.55	3.25
1998	0.11	0.54	0.80	1.13	1.68	2.01	2.35	4.40	
1999	0.09	0.24	0.94	1.49	1.65	1.95	2.47	2.69	3.12
2000	0.15	0.49	0.75	1.48	2.17	2.43	2.97	2.91	3.27
2001	0.10	0.45	0.88	1.12	1.54	1.98	3.08	1.89	3.18
2002	0.10	0.42	0.60	1.12	1.54	2.33	2.74	2.43	3.57
2003	0.10	0.37	0.72	0.94	1.34	1.99	2.55	2.98	2.43
2004	0.09	0.21	0.74	1.11	1.10	1.49	1.55	1.84	2.33
2005	0.05	0.18	0.60	0.82	1.31	1.50	1.83	2.08	2.50
Average 1968-2005	0.13	0.51	1.08	1.57	2.14	2.51	3.07	3.56	3.97
Average 2001-2005	0.09	0.33	0.71	1.02	1.37	1.86	2.35	2.24	2.80
Percent Change	-30%	-35%	-35%	-35%	-36%	-26%	-23%	-37%	-29%

Table 15.2. Georges Bank haddock mean weights (kg) at age for ages 0 to 9 during the NEFSC autumn survey, 1963-2004. Blank cells have no age samples.

	Age Class									
Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9
1963	0.04	0.43	0.78	1.48	1.91	2.42	3.11	3.21	3.81	4.09
1964	0.04	0.29	0.55	1.25	2.03	2.21	3.01	3.44	3.85	4.68
1965	0.02	0.32	0.63	1.00	1.67	2.13	2.93	3.38	4.36	3.98
1966	0.04	0.28	0.65	0.98	1.48	1.85	2.87	4.02	4.18	4.38
1967	0.10	0.60	1.00	1.61	1.74	2.14	3.35	4.08	4.56	4.34
1968	0.03	0.23	1.01	1.23	1.57	2.00	2.47	3.17	3.18	3.87
1969	0.05	0.11	1.03	1.94	2.12	2.45	2.65	2.92	3.07	3.64
1970	0.10	0.64	1.32	1.72	2.41	2.29	2.79	3.01	3.79	4.60
1971	0.04	0.02	1.52	1.74	2.85	2.80	2.26	3.37	3.59	4.18
1972	0.04	0.45		2.13	2.61	5.87	2.50	3.80	3.06	3.70
1973	0.02	0.44	1.22		2.51	3.56		3.88	4.62	3.44
1974	0.07	0.40	1.37	2.09	4.33	3.19	4.33	4.33	4.33	5.35
1975	0.04	0.22	1.07	1.81	2.36		4.98	5.90	4.87	4.87
1976	0.03	0.46	1.13	1.54	2.69	3.14		5.18	4.59	5.18
1977	0.08	0.41	1.06	2.06	2.73	3.27	3.71	6.48	5.21	
1978	0.04	0.11	0.90	1.48	2.58	2.99	3.30	5.00		6.17
1979	0.03	0.44	1.11	1.72	2.16	3.35	4.03	3.85	3.25	
1980	0.03	0.41	0.92	1.10	1.97	2.40	3.24	3.93	3.89	
1981	0.04	0.42	0.83	1.52	2.18	2.84	3.31		5.42	4.46
1982	0.02	0.04	0.56	1.22	2.08	2.36	3.42	2.96	3.79	3.96
1983	0.07	0.40	0.48	1.46	2.44	2.86	3.37	3.94	4.39	3.72
1984	0.04	0.38	0.55	1.54	1.83	2.58	2.78			3.03
1985	0.07	0.17	0.82	1.28	1.65	2.84	2.94	3.23	4.25	3.76
1986	0.08	0.40	0.66	1.44	1.94	2.76	3.12	3.37	3.90	6.72
1987	0.03	0.42	0.78	1.23	1.75	1.90	2.98	2.45	3.53	
1988	0.01	0.36	0.75	1.46	2.39	2.69	3.84	3.52	5.43	3.93
1989	0.06	0.23	0.78	1.52	1.78	2.47	3.28	3.26	6.93	
1990	0.06	0.53	0.89	1.33	2.03	2.28	3.07	3.19		
1991	0.03	0.41	0.99	1.23	1.53	1.73	3.04			4.23
1992	0.05	0.35	1.06	1.71		2.24	2.65	2.76	2.71	3.56
1993	0.03	0.40	0.87	1.30		1.31	2.91	3.34		
1994	0.03	0.33	0.72	1.56	1.77	2.17	2.06	2.80	3.16	
1995	0.04	0.41	0.80	1.19	1.90	2.33		2.60	2.91	
1996	0.04	0.40	1.07	1.43	1.92	2.33	4.30	4.30		4.87
1997	0.03	0.45	1.00	1.69	1.64	2.20	3.64		4.00	3.24
1998	0.04	0.38	0.87	1.36	1.57	1.81	2.12	4.63		
1999	0.06	0.34	0.88	1.48	1.74	1.78	2.60	1.89	2.54	3.33
2000	0.04	0.39	0.78	1.41	1.91	2.36	2.70	2.55	3.18	2.49
2001	0.04	0.25	0.84	1.24	1.55	2.02	1.92	2.37	1.81	4.84
2002	0.03	0.35	0.73	0.93	1.11	1.13	1.54	1.45	1.04	1.84
2003	0.03	0.32	0.63	1.07	1.25	1.62	1.73	2.39		1.65
2004	0.02	0.16	0.54	0.93	1.22	1.24	1.71	1.60	2.28	2.54
Average 1963-2004	0.04	0.35	0.88	1.45	2.02	2.44	2.99	3.46	3.81	4.02
Average 2001-2004	0.03	0.27	0.68	1.04	1.28	1.50	1.73	1.96	1.71	2.72
Percent Change	-36%	-22%	-22%	-28%	-37%	-38%	-42%	-44%	-55%	-32%

Table 15.3. Georges Bank haddock mean weights (kg) at age for ages 1 to 9 and older during the Canadian winter survey, 1986-2004. Blank cells have no age samples.

	Age Class								
Year	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+
1986	0.14	0.45	0.97	1.45	3.04	2.85	3.60	3.38	3.92
1987	0.15	0.50	0.72	1.67	2.01	2.55	3.15	3.15	3.63
1988	0.10	0.47	0.93	1.80	1.82	1.92	2.72	3.26	3.87
1989	0.06	0.47	0.65	1.39	2.00	2.53	2.16	2.86	3.14
1990	0.15	0.53	0.92	1.18	1.86	2.07	2.51	2.82	3.47
1991	0.12	0.69	0.80	1.51	1.70	2.43	2.11	3.12	3.43
1992	0.12	0.60	1.12	1.06	2.08	2.17	2.71	2.28	3.44
1993	0.12	0.48	1.23	1.80	1.27	2.33	2.34	2.74	3.28
1994	0.11	0.47	1.05	1.62	1.93	2.15	3.15	2.69	3.08
1995	0.09	0.49	0.96	1.56	2.22	2.45		2.99	3.18
1996	0.14	0.50	0.92	1.32	1.93	2.56	2.90	2.61	3.59
1997	0.13	0.51	0.78	1.21	1.66	2.18	2.45	2.58	3.16
1998	0.11	0.54	1.04	1.16	1.57	1.95	2.61	3.56	3.46
1999	0.13	0.47	0.91	1.29	1.26	1.87	2.13	2.72	2.99
2000	0.12	0.54	0.95	1.48	1.87	1.79	2.30	2.51	2.90
2001	0.09	0.52	1.01	1.37	1.80	2.17	2.25	2.59	2.93
2002	0.10	0.33	0.78	1.14	1.49	1.97	2.18	2.21	2.71
2003	0.08	0.37	0.85	1.06	1.48	1.65	2.21	2.23	2.49
2004	0.06	0.31	0.78	1.15	1.31	1.56	1.62	1.96	2.22
Average 1986-2004	0.11	0.49	0.91	1.38	1.81	2.16	2.51	2.75	3.20
Average 2001-2004	0.08	0.38	0.85	1.18	1.52	1.83	2.06	2.25	2.58
Percent Change	-25%	-21%	-7%	-14%	-16%	-15%	-18%	-18%	-19%

Table 16. NEFSC spring and autumn survey length (L) -weight (W) relationship parameters (A and B) for Georges Bank haddock during 1992-2005, with associated standard errors (s). Weight is in grams and length is in centimeters.

	Spring Survey				Autumn Survey			
Year	A	σ_A	B	σ_B	A	σ_A	B	σ_B
1992	0.00646	0.00061	3.116	0.026	0.00820	0.00071	3.068	0.02327
1993	0.00681	0.00045	3.103	0.018	0.00705	0.00032	3.109	0.01307
1994	0.01149	0.00089	2.958	0.021	0.00733	0.00055	3.087	0.02025
1995	0.00943	0.00060	3.019	0.017	0.00846	0.00045	3.048	0.01453
1996	0.00990	0.00073	3.010	0.019	0.00872	0.00040	3.052	0.01254
1997	0.00831	0.00044	3.047	0.014	0.00841	0.00032	3.059	0.01017
1998	0.00719	0.00053	3.088	0.020	0.00752	0.00026	3.087	0.01003
1999	0.00748	0.00033	3.075	0.012	0.01021	0.00048	3.013	0.01252
2000	0.00833	0.00047	3.057	0.015	0.00723	0.00038	3.096	0.01396
2001	0.00713	0.00037	3.075	0.015	0.00597	0.00028	3.136	0.01306
2002	0.00818	0.00044	3.036	0.015	0.00848	0.00053	3.043	0.01651
2003	0.01106	0.00086	2.956	0.020	0.00704	0.00019	3.097	0.00817
2004	0.00467	0.00018	3.172	0.011	0.00572	0.00017	3.138	0.00836
2005	0.00601	0.00023	3.108	0.011				
Average 1992-2005	0.00803	0.00051	3.059	0.017	0.00772	0.00039	3.079	0.014

Table 17. Georges Bank haddock percent female mature at age, 1963-2004.

	Age				
Year	1	2	3	4	Source
1963-1967	0	0	78	100	Clark and Overholtz (1979)
1968 - 1972	0	28	76	100	Livingstone (pers. comm., March 1980) as cited in Clark et al. (1982)
1973 - 1976	0	34	92	100	Livingstone (pers. comm., March 1980) as cited in Clark et al. (1982)
1977	0	61	100	100	Overholtz (1987)
1978	0	26	99	100	Overholtz (1987)
1979	0	8	71	100	Overholtz (1987)
1980	0	41	100	100	Overholtz (1987)
1981	0	52	94	100	Overholtz (1987)
1982	0	31	67	100	Overholtz (1987)
1983	0	11	39	100	Overholtz (1987)
1984	12	33	94	100	O'Brien (pers. comm.)
1985 - 1987	39	73	92	98	Brown et al. (2000)
1988 - 1990	3	33	89	99	Brown et al. (2000)
1991 - 1992	5	72	99	100	Brown et al. (2000)
1993 - 1994	7	30	71	94	Brown et al. (2000)
1995 - 1997	2	34	93	100	Brown et al. (2000)
1998 - 2000	4	49	95	100	Brown et al. (2000)
2001-2004	1	60	95	99	Current Assessment

Table 18. Georges Bank haddock virtual population analysis (VPA) run descriptions including a summary of accepted VPA formulations from the previous six stock assessments (SARC-24, SARC-27, NDWG-1999, TRAC-2000, TRAC-2001, GARM 2002) and the current assessment (GARM 2005).

VPA Formulation	SARC-24	SARC-27	NDWG-1999	TRAC-2000	TRAC-2001	GARM 2002	GARM 2005
Terminal Year of Catch at Age	1996	1997	1998	1999	2000	2001	2004
Ages Estimated	1-8	1-8	1-8	1-8	1-8	1-8	1-8
Tuning Indices							
US Spring 1-8	Yes	Yes	Yes	Yes	Yes	Yes	Yes
US Spring 1973-1981 (Yankee 41 years) separate index	No	Yes	Yes	Yes	Yes	Yes	Yes
Canada Spring 1-8	Yes	Yes	Yes	Yes	Yes	Yes	Yes
US Autumn 0-5 Lagged	Yes	Yes	Yes	Yes	Yes	Yes	Yes
US Autumn 6-8 Lagged	Yes	No	No	No	No	No	No
Terminal Year US Spring Indices	No	No	Yes	No	No	Yes	Yes
Discards							
Post 1993 Discard Estimates Included	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Diagnostics							
Sum of Squares	398.66	338.16	352.20	375.25	386.81	404.75	433.31
Mean squared residual	0.725	0.696	0.683	0.708	0.701	0.695	0.647
CV n1	0.62	0.61	0.49	0.61	0.61	0.50	0.58
CV n2	0.40	0.39	0.35	0.39	0.39	0.35	0.37
CV n3	0.31	0.31	0.29	0.31	0.31	0.29	0.3
CV n4	0.29	0.27	0.27	0.29	0.28	0.27	0.26
CV n5	0.27	0.27	0.25	0.27	0.28	0.26	0.25
CV n6	0.26	0.25	0.26	0.26	0.25	0.26	0.23
CV n7	0.33	0.27	0.25	0.30	0.27	0.28	0.3
CV n8	0.34	0.31	0.27	0.29	0.30	0.31	0.34
Max CV q (US Spring)	0.17	N/A	N/A	N/A	N/A	N/A	N/A
Max CV q (US Spring - Yankee 36)	N/A	0.21	0.19	0.20	0.19	0.18	0.2
Max CV q (US Spring - Yankee 41)	N/A	0.34	0.34	0.35	0.34	0.34	0.51
Max CV q (Canadian Spring)	0.26	0.25	0.24	0.23	0.23	0.22	0.24
Max CV q (US Autumn)	0.17	0.15	0.15	0.15	0.14	0.14	0.15

Table 19. VPA estimates of Georges Bank haddock beginning year stock numbers at age, 1963-2005.

AGE	1963	1964	1965	1966	1967
1	189461.	462186.	32366.	4090.	14686.
2	31983.	152489.	369285.	17883.	3246.
3	32327.	22539.	110482.	189565.	8515.
4	44770.	19798.	14357.	50644.	65418.
5	28469.	26634.	11917.	6958.	24302.
6	9017.	15949.	13985.	5824.	3220.
7	5326.	5401.	7868.	5480.	2453.
8	2757.	3099.	2558.	3075.	2401.
9	4190.	4055.	3741.	2956.	3026.
Total	348300.	712151.	566560.	286474.	127267.

AGE	1968	1969	1970	1971	1972
1	482.	1045.	4696.	317.	8610.
2	10987.	388.	853.	3803.	259.
3	2506.	6307.	307.	557.	1882.
4	4380.	1415.	3639.	237.	256.
5	35021.	1869.	757.	2466.	158.
6	10654.	15687.	944.	452.	1758.
7	1553.	5585.	7513.	581.	151.
8	1120.	676.	3159.	4080.	221.
9	2995.	2208.	1647.	2848.	3524.
Total	69698.	35179.	23516.	15342.	16820.

AGE	1973	1974	1975	1976	1977
1	19727.	10615.	7856.	105602.	14031.
2	6905.	13802.	8648.	6253.	86324.
3	210.	3757.	7282.	6116.	4677.
4	1127.	169.	2463.	4230.	4493.
5	135.	571.	137.	1667.	2643.
6	100.	62.	402.	108.	1163.
7	1329.	55.	49.	290.	89.
8	53.	1017.	43.	37.	216.
9	1873.	1154.	1496.	1174.	883.
Total	31459.	31202.	28374.	125476.	114518.

AGE	1978	1979	1980	1981	1982
1	6179.	83910.	10592.	7402.	2510.
2	11487.	5058.	68693.	8665.	6060.
3	52825.	8713.	4118.	28399.	5515.
4	3658.	30221.	5566.	3057.	13337.
5	3058.	2718.	18238.	3674.	1751.
6	1694.	1989.	1748.	9474.	2161.
7	628.	919.	1256.	896.	5431.
8	69.	388.	468.	538.	435.
9	762.	607.	686.	733.	812.
Total	80359.	134522.	111364.	62838.	38011.

Table 19 Continued.

AGE	1983	1984	1985	1986	1987
1	3207.	17565.	1844.	15267.	1995.
2	2054.	2626.	14380.	1510.	12494.
3	3905.	1487.	2065.	9555.	1187.
4	3039.	2459.	947.	1185.	5267.
5	7543.	1862.	1353.	596.	767.
6	1079.	4146.	1163.	684.	355.
7	1254.	637.	2051.	742.	403.
8	3432.	857.	309.	1195.	471.
9	825.	2690.	2168.	1816.	2168.
Total	26339.	34329.	26280.	32551.	25107.

AGE	1988	1989	1990	1991	1992
1	17052.	1112.	2841.	2552.	10401.
2	1633.	13957.	911.	2324.	2084.
3	8397.	1289.	10253.	735.	1493.
4	853.	4685.	976.	7062.	519.
5	2836.	575.	3023.	640.	3821.
6	516.	1468.	338.	1677.	431.
7	224.	285.	871.	187.	998.
8	248.	133.	191.	550.	87.
9	1939.	1634.	1379.	1202.	1228.
Total	33698.	25140.	20782.	16930.	21061.

AGE	1993	1994	1995	1996	1997
1	15415.	16091.	12443.	12222.	25106.
2	8509.	12614.	13173.	10179.	10002.
3	1479.	6698.	10074.	10702.	8284.
4	928.	888.	4722.	7694.	8241.
5	304.	485.	567.	3442.	5435.
6	1733.	153.	336.	409.	2395.
7	251.	814.	61.	245.	273.
8	522.	170.	525.	42.	181.
9	965.	1000.	877.	1079.	905.
Total	30105.	38915.	42778.	46013.	60822.

AGE	1998	1999	2000	2001	2002
1	13722.	46906.	18902.	90863.	5359.
2	20528.	11233.	38400.	15474.	74364.
3	8028.	16623.	9161.	31085.	12549.
4	6521.	6191.	12644.	6941.	23445.
5	6055.	4878.	4540.	8926.	4938.
6	3949.	4322.	3542.	3215.	6219.
7	1766.	2750.	3075.	2452.	2129.
8	206.	1309.	1947.	2191.	1663.
9	839.	798.	1558.	2571.	3384.
Total	61612.	95011.	93769.	163717.	134049.

Table 19 Continued.

AGE	2003	2004	2005
1	1335.	788886.	9879.
2	4386.	1088.	645236.
3	60518.	3578.	857.
4	9993.	47817.	2821.
5	16646.	7792.	35037.
6	3316.	11460.	5638.
7	4180.	2175.	6920.
8	1467.	2776.	1153.
9	3461.	3517.	4301.
Total	105302.	869090.	711840.

Table 20. VPA estimates of Georges Bank haddock spawning stock biomass (mt), 1963-2004.

AGE	1963	1964	1965	1966	1967
1	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	23910.	15503.	65562.	88804.	4684.
4	54720.	22653.	14729.	48018.	57345.
5	37829.	35203.	15397.	8693.	26450.
6	16142.	24562.	19988.	8724.	5009.
7	10314.	10178.	13259.	9497.	4410.
8	6440.	6559.	5254.	6415.	4914.
9	11355.	10249.	9744.	8115.	8294.
Total	160710.	124907.	143932.	178266.	111107.

AGE	1968	1969	1970	1971	1972
1	0.	0.	0.	0.	0.
2	1958.	69.	175.	764.	57.
3	1415.	3943.	214.	449.	1685.
4	3964.	1612.	4810.	312.	357.
5	38997.	2395.	1280.	4866.	290.
6	15654.	23067.	1710.	853.	4331.
7	2751.	11142.	14614.	1205.	341.
8	2266.	1511.	7955.	9685.	602.
9	7431.	7015.	5357.	9025.	10831.
Total	74435.	50755.	36114.	27160.	18494.

AGE	1973	1974	1975	1976	1977
1	0.	0.	0.	0.	0.
2	1611.	3190.	2265.	1549.	18428.
3	234.	4259.	7688.	6080.	4254.
4	1830.	307.	4480.	6773.	7088.
5	247.	1283.	291.	3695.	5511.
6	243.	177.	1068.	268.	2913.
7	3928.	187.	177.	887.	297.
8	157.	3489.	160.	146.	745.
9	6495.	4357.	6054.	5358.	4034.
Total	14745.	17249.	22184.	24755.	43270.

AGE	1978	1979	1980	1981	1982
1	0.	0.	0.	0.	0.
2	2497.	1154.	12829.	1767.	1102.
3	47145.	6921.	3405.	20558.	4323.
4	5820.	46365.	7466.	3957.	17658.
5	6757.	5507.	32417.	6418.	3231.
6	4290.	5249.	3935.	20028.	4751.
7	1830.	2695.	3417.	2419.	14374.
8	238.	1217.	1459.	1769.	1466.
9	3611.	2750.	2437.	2978.	3034.
Total	72188.	71859.	67365.	59894.	49941.

Table 20 Continued.

AGE	1983	1984	1985	1986	1987
1	0.	382.	82.	1155.	130.
2	296.	450.	4824.	515.	4493.
3	3248.	1449.	1849.	8693.	1153.
4	4380.	3353.	1336.	1661.	7292.
5	13238.	3321.	2421.	1180.	1409.
6	2371.	8446.	2543.	1582.	822.
7	3415.	1489.	5122.	1879.	1043.
8	9997.	2443.	899.	3446.	1391.
9	3263.	8934.	7677.	6469.	8690.
Total	40208.	30266.	26753.	26579.	26423.

AGE	1988	1989	1990	1991	1992
1	1123.	100.	126.	99.	361.
2	650.	5135.	347.	1022.	885.
3	6965.	1318.	10077.	714.	1748.
4	1174.	6373.	1411.	9833.	684.
5	4883.	970.	5082.	1143.	6249.
6	1044.	2964.	692.	3488.	883.
7	549.	727.	2085.	416.	2378.
8	704.	383.	522.	1394.	229.
9	7190.	5892.	5407.	4874.	4872.
Total	24281.	23862.	25749.	22983.	18289.

AGE	1993	1994	1995	1996	1997
1	525.	326.	63.	72.	130.
2	1907.	3036.	2796.	2256.	2171.
3	1317.	6040.	11293.	11339.	9992.
4	1399.	1458.	7958.	11669.	12838.
5	495.	1057.	1239.	6820.	10121.
6	3438.	292.	844.	939.	5400.
7	588.	2014.	166.	706.	718.
8	1360.	470.	1447.	131.	570.
9	3599.	4271.	3303.	3801.	3109.
Total	14629.	18963.	29109.	37732.	45049.

AGE	1998	1999	2000	2001	2002
1	91.	468.	180.	194.	11.
2	4202.	2722.	10855.	7775.	24190.
3	8609.	17742.	10200.	35383.	14099.
4	10915.	9445.	19705.	10113.	33897.
5	11690.	9058.	8455.	16478.	8265.
6	8798.	9273.	7229.	6916.	13008.
7	4550.	6791.	7143.	5555.	5451.
8	587.	3618.	5066.	5446.	4295.
9	3201.	2754.	4813.	8107.	10280.
Total	52642.	61872.	73646.	95968.	113496.

Table 20 Continued.

AGE	2003	2004
1	3.	1058.
2	1111.	196.
3	60302.	2578.
4	13651.	62496.
5	27202.	11785.
6	5961.	19229.
7	9422.	3821.
8	4165.	6196.
9	10100.	9430.
Total	131916.	116787.

Table 21. VPA estimates of Georges Bank haddock fishing mortality at age, 1963-2004.

AGE	1963	1964	1965	1966	1967
1	0.0171	0.0244	0.3933	0.0312	0.0902
2	0.1500	0.1222	0.4668	0.5420	0.0587
3	0.2903	0.2510	0.5800	0.8639	0.4648
4	0.3194	0.3076	0.5243	0.5343	0.4248
5	0.3794	0.4442	0.5160	0.5706	0.6246
6	0.3125	0.5066	0.7370	0.6646	0.5288
7	0.3416	0.5473	0.7393	0.6250	0.5840
8	0.3382	0.4514	0.6292	0.5986	0.5406
9	0.3382	0.4458	0.5099	0.3879	0.2921

AGE	1968	1969	1970	1971	1972
1	0.0185	0.0021	0.0109	0.0035	0.0207
2	0.3551	0.0318	0.2275	0.5035	0.0086
3	0.3715	0.3500	0.0591	0.5761	0.3127
4	0.6515	0.4260	0.1891	0.2051	0.4378
5	0.6031	0.4828	0.3145	0.1381	0.2576
6	0.4458	0.5362	0.2862	0.8949	0.0801
7	0.6327	0.3697	0.4105	0.7651	0.8527
8	0.5833	0.4537	0.3000	0.5008	0.4070
9	0.3686	0.3331	0.3695	0.4414	0.4987

AGE	1973	1974	1975	1976	1977
1	0.1572	0.0050	0.0283	0.0016	0.0001
2	0.4085	0.4395	0.1463	0.0904	0.2911
3	0.0164	0.2224	0.3432	0.1084	0.0457
4	0.4808	0.0138	0.1902	0.2705	0.1849
5	0.5727	0.1509	0.0336	0.1600	0.2448
6	0.4079	0.0378	0.1266	0.0001	0.4170
7	0.0672	0.0434	0.0961	0.0952	0.0524
8	0.3822	0.0614	0.1117	0.1314	0.2248
9	0.3103	0.2822	0.0694	0.1153	0.1512

AGE	1978	1979	1980	1981	1982
1	0.0002	0.0001	0.0008	0.0001	0.0004
2	0.0764	0.0057	0.6833	0.2518	0.2393
3	0.3585	0.2481	0.0980	0.5558	0.3959
4	0.0971	0.3050	0.2152	0.3571	0.3699
5	0.2299	0.2412	0.4549	0.3310	0.2837
6	0.4112	0.2595	0.4685	0.3565	0.3440
7	0.2812	0.4760	0.6482	0.5227	0.2588
8	0.2549	0.3204	0.4467	0.3918	0.3141
9	0.1026	0.0880	0.1401	0.1534	0.1626

Table 21 Continued.

AGE	1983	1984	1985	1986	1987
1	0.0001	0.0001	0.0001	0.0004	0.0001
2	0.1231	0.0403	0.2087	0.0408	0.1974
3	0.2626	0.2512	0.3555	0.3956	0.1302
4	0.2901	0.3975	0.2621	0.2353	0.4190
5	0.3984	0.2706	0.4812	0.3179	0.1967
6	0.3275	0.5039	0.2493	0.3301	0.2618
7	0.1801	0.5219	0.3398	0.2549	0.2844
8	0.2990	0.4235	0.3331	0.2846	0.2905
9	0.1081	0.2542	0.0824	0.0376	0.0726

AGE	1988	1989	1990	1991	1992
1	0.0003	0.0001	0.0008	0.0026	0.0008
2	0.0366	0.1084	0.0138	0.2427	0.1430
3	0.3834	0.0787	0.1729	0.1492	0.2751
4	0.1945	0.2383	0.2212	0.4143	0.3357
5	0.4584	0.3303	0.3891	0.1961	0.5906
6	0.3916	0.3227	0.3930	0.3187	0.3407
7	0.3229	0.2017	0.2596	0.5688	0.4493
8	0.3419	0.2733	0.3157	0.3745	0.4291
9	0.0636	0.0318	0.0367	0.0695	0.0901

AGE	1993	1994	1995	1996	1997
1	0.0005	0.0001	0.0008	0.0005	0.0013
2	0.0393	0.0248	0.0077	0.0059	0.0198
3	0.3099	0.1496	0.0696	0.0613	0.0394
4	0.4491	0.2482	0.1163	0.1475	0.1083
5	0.4856	0.1686	0.1275	0.1627	0.1196
6	0.5560	0.7245	0.1128	0.2056	0.1045
7	0.1875	0.2388	0.1653	0.1050	0.0804
8	0.4196	0.3450	0.1305	0.1552	0.1032
9	0.0933	0.0504	0.0235	0.0082	0.0503

AGE	1998	1999	2000	2001	2002
1	0.0001	0.0001	0.0001	0.0004	0.0004
2	0.0110	0.0039	0.0113	0.0095	0.0060
3	0.0598	0.0736	0.0775	0.0821	0.0277
4	0.0903	0.1102	0.1483	0.1403	0.1425
5	0.1372	0.1202	0.1453	0.1613	0.1982
6	0.1619	0.1403	0.1675	0.2122	0.1972
7	0.0992	0.1452	0.1389	0.1887	0.1721
8	0.1221	0.1290	0.1500	0.1757	0.1775
9	0.0565	0.0586	0.0624	0.1137	0.1768

Table 21 Continued.

AGE	2003	2004
1	0.0051	0.0010
2	0.0035	0.0388
3	0.0355	0.0379
4	0.0488	0.1110
5	0.1732	0.1235
6	0.2216	0.3045
7	0.2095	0.4352
8	0.1633	0.2436
9	0.1264	0.1336

Table 22. VPA estimates of Georges Bank haddock average fishing mortality for ages 4-7, 1963-2004.

Average Fishing Mortality For Ages 4-7

Year	Average F	N Weighted	Biomass Wtd	Catch Wtd
1963	0.3382	0.3395	0.3396	0.3415
1964	0.4514	0.4272	0.4404	0.4406
1965	0.6292	0.6192	0.6373	0.6330
1966	0.5986	0.5562	0.5657	0.5585
1967	0.5406	0.4833	0.4967	0.4956
1968	0.5833	0.5756	0.5687	0.5819
1969	0.4537	0.4879	0.4811	0.4961
1970	0.3000	0.3330	0.3500	0.3584
1971	0.5008	0.3315	0.3592	0.5655
1972	0.4070	0.1819	0.1744	0.3853
1973	0.3822	0.2785	0.2320	0.4274
1974	0.0614	0.1087	0.1096	0.1413
1975	0.1117	0.1733	0.1690	0.1816
1976	0.1314	0.2285	0.2170	0.2455
1977	0.2248	0.2346	0.2480	0.2576
1978	0.2549	0.2137	0.2385	0.2694
1979	0.3204	0.3021	0.3033	0.3052
1980	0.4467	0.4151	0.4349	0.4402
1981	0.3918	0.3598	0.3644	0.3633
1982	0.3141	0.3342	0.3206	0.3402
1983	0.2990	0.3458	0.3406	0.3586
1984	0.4235	0.4287	0.4395	0.4455
1985	0.3331	0.3421	0.3421	0.3607
1986	0.2846	0.2754	0.2806	0.2807
1987	0.2905	0.3777	0.3664	0.3923
1988	0.3419	0.3930	0.4007	0.4168
1989	0.2733	0.2620	0.2668	0.2676
1990	0.3157	0.3363	0.3358	0.3500
1991	0.3745	0.3859	0.3810	0.3959
1992	0.4291	0.5246	0.5211	0.5395
1993	0.4196	0.4897	0.4905	0.5075
1994	0.3450	0.2596	0.2594	0.3061
1995	0.1305	0.1178	0.1182	0.1181
1996	0.1552	0.1530	0.1539	0.1542
1997	0.1032	0.1110	0.1108	0.1114
1998	0.1221	0.1221	0.1244	0.1285
1999	0.1290	0.1254	0.1278	0.1268
2000	0.1500	0.1494	0.1494	0.1498
2001	0.1757	0.1653	0.1689	0.1686
2002	0.1775	0.1610	0.1645	0.1646
2003	0.1633	0.1460	0.1550	0.1736
2004	0.2436	0.1546	0.1654	0.1980

Table 23. Bootstrap analyses of VPA estimates of Georges Bank haddock 2005 stock size at age (000s), 2004 fishing mortality at age, 2004 **average fishing** mortality for ages 4-7, and 2005 January 1st, 2004 **mean, and 2004 spawning** biomass (mt).

Number of Bootstrap Repetitions Requested = 1000
Number of Bootstrap Repetitions Completed = 1000
Bootstrap Output Variable: Stock Estimates (2005)

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
N 1	9879.	11928.	8374.	0.7020
N 2	645236.	669643.	226845.	0.3388
N 3	857.	892.	313.	0.3508
N 4	2821.	2879.	745.	0.2588
N 5	35037.	35659.	8156.	0.2287
N 6	5638.	5756.	1296.	0.2252
N 7	6920.	7230.	2155.	0.2980
N 8	1153.	1190.	416.	0.3496

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
N 1	2050.	273.	20.7478	7829.	1.0695
N 2	24407.	7215.	3.7827	620828.	0.3654
N 3	35.	10.	4.1217	821.	0.3810
N 4	58.	24.	2.0669	2762.	0.2697
N 5	623.	259.	1.7771	34414.	0.2370
N 6	118.	41.	2.0902	5521.	0.2348
N 7	311.	69.	4.4928	6609.	0.3260
N 8	38.	13.	3.2651	1115.	0.3732

	LOWER 80. % CI	UPPER 80. % CI
N 1	4074.	22316.
N 2	372811.	1000000.
N 3	540.	1280.
N 4	1982.	3882.
N 5	25379.	46652.
N 6	4212.	7452.
N 7	4689.	9987.
N 8	673.	1738.

Table 23 Continued.

Bootstrap Output Variable: Fishing Mortality at Age (2004)

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
AGE 1	0.0010	0.0011	0.000489	0.4380
AGE 2	0.0388	0.0757	0.345088	4.5602
AGE 3	0.0379	0.0397	0.010666	0.2687
AGE 4	0.1110	0.1146	0.026292	0.2295
AGE 5	0.1235	0.1266	0.026893	0.2124
AGE 6	0.3045	0.3130	0.081932	0.2618
AGE 7	0.4352	0.4625	0.145436	0.3145
AGE 8	0.2436	0.2542	0.042497	0.1672
AGE 9	0.1336	0.1368	0.019333	0.1413

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
AGE 1	0.000111	0.000016	11.0555	0.0009	0.5469
AGE 2	0.036913	0.010975	95.2357	0.0018	186.8730
AGE 3	0.001784	0.000342	4.7077	0.0361	0.2953
AGE 4	0.003586	0.000839	3.2305	0.1074	0.2448
AGE 5	0.003092	0.000856	2.5032	0.1204	0.2233
AGE 6	0.008465	0.002605	2.7796	0.2961	0.2767
AGE 7	0.027329	0.004680	6.2801	0.4078	0.3566
AGE 8	0.010618	0.001385	4.3596	0.2329	0.1824
AGE 9	0.003256	0.000620	2.4374	0.1303	0.1484

	LOWER 80. % CI	UPPER 80. % CI
AGE 1	0.000649	0.001740
AGE 2	0.026040	0.060798
AGE 3	0.027659	0.053442
AGE 4	0.084460	0.149963
AGE 5	0.094689	0.161942
AGE 6	0.220269	0.421159
AGE 7	0.308434	0.654753
AGE 8	0.206285	0.308014
AGE 9	0.114521	0.161721

Table 23 Continued.

Bootstrap Output Variable: Average F (2004) AGES 4 - 7

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
AVG F	0.2436	0.2542	0.042497	0.1672
N WTD	0.1546	0.1561	0.025912	0.1660
B WTD	0.1654	0.1665	0.026543	0.1594
C WTD	0.1980	0.2050	0.031608	0.1542

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
AVG F	0.010618	0.001385	4.3596	0.2329	0.1824
N WTD	0.001450	0.000821	0.9380	0.1532	0.1692
B WTD	0.001138	0.000840	0.6883	0.1642	0.1616
C WTD	0.006940	0.001023	3.5050	0.1911	0.1654

	LOWER 80. % CI	UPPER 80. % CI
AVG F	0.206285	0.308014
N WTD	0.125718	0.191840
B WTD	0.134996	0.202197
C WTD	0.166422	0.245121

Table 23 Continued.

Bootstrap Output Variable: Biomass

JAN-1 Biomass (2005) Mean Biomass & SSB (2004)

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
JAN-1	400941.	414366.	103492.	0.2498
MEAN	262848.	270521.	56581.	0.2092
SSB	116787.	118758.	15999.	0.1347

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
JAN-1	13425.	3300.	3.3483	387517.	0.2671
MEAN	7673.	1806.	2.9192	255175.	0.2217
SSB	1970.	510.	1.6870	114817.	0.1393

	LOWER 80. % CI	UPPER 80. % CI
JAN-1	277047.	560287.
MEAN	195966.	348123.
SSB	97942.	138829.

Table 24. Comparative Results from ADAPT/VPA runs incorporating software and data updates since the 2002 GARM.

	GARM/FACT	GARM/NFT	Updated Data/NFT [1]
Terminal Year	2001	2001	2001
RSS	404.747	397.378	397.886
N t+1 age 1 (cv)	4450 (0.50)	4449 (0.48)	4527 (0.48)
N t+1 age 2 (cv)	61500 (0.35)	61423 (0.34)	62483 (0.34)
N t+1 age 3 (cv)	11700 (0.29)	11741 (0.28)	11944 (0.28)
N t+1 age 4 (cv)	19400 (0.27)	19471 (0.26)	19793 (0.26)
N t+1 age 5 (cv)	5173 (0.26)	5262 (0.25)	5351 (0.25)
N t+1 age 6 (cv)	4330 (0.26)	4224 (0.27)	4311 (0.27)
N t+1 age 7 (cv)	1740 (0.28)	1772 (0.27)	1812 (0.27)
N t+1 age 8 (cv)	1020 (0.31)	1229 (0.28)	1259 (0.28)
F age 1	0.00	0.00	0.00
F age 2	0.01	0.01	0.01
F age 3	0.10	0.09	0.10
F age 4	0.13	0.13	0.13
F age 5	0.22	0.23	0.23
F age 6	0.25	0.25	0.25
F age 7	0.29	0.24	0.24
F age 8	0.22	0.21	0.21
F (ages 4-7)	0.21	0.21	0.21
SSB (mt)	74429	77719	82315

[1] Revised data includes revised catch biomass and catch-at-age data for 1972-2001 which includes Canadian sea scallop fishery discards and updated catch proration, mean weights-at-age, discard, and female percent mature at age data for 2001.

Figure 1. Western and eastern Georges Bank haddock management units.

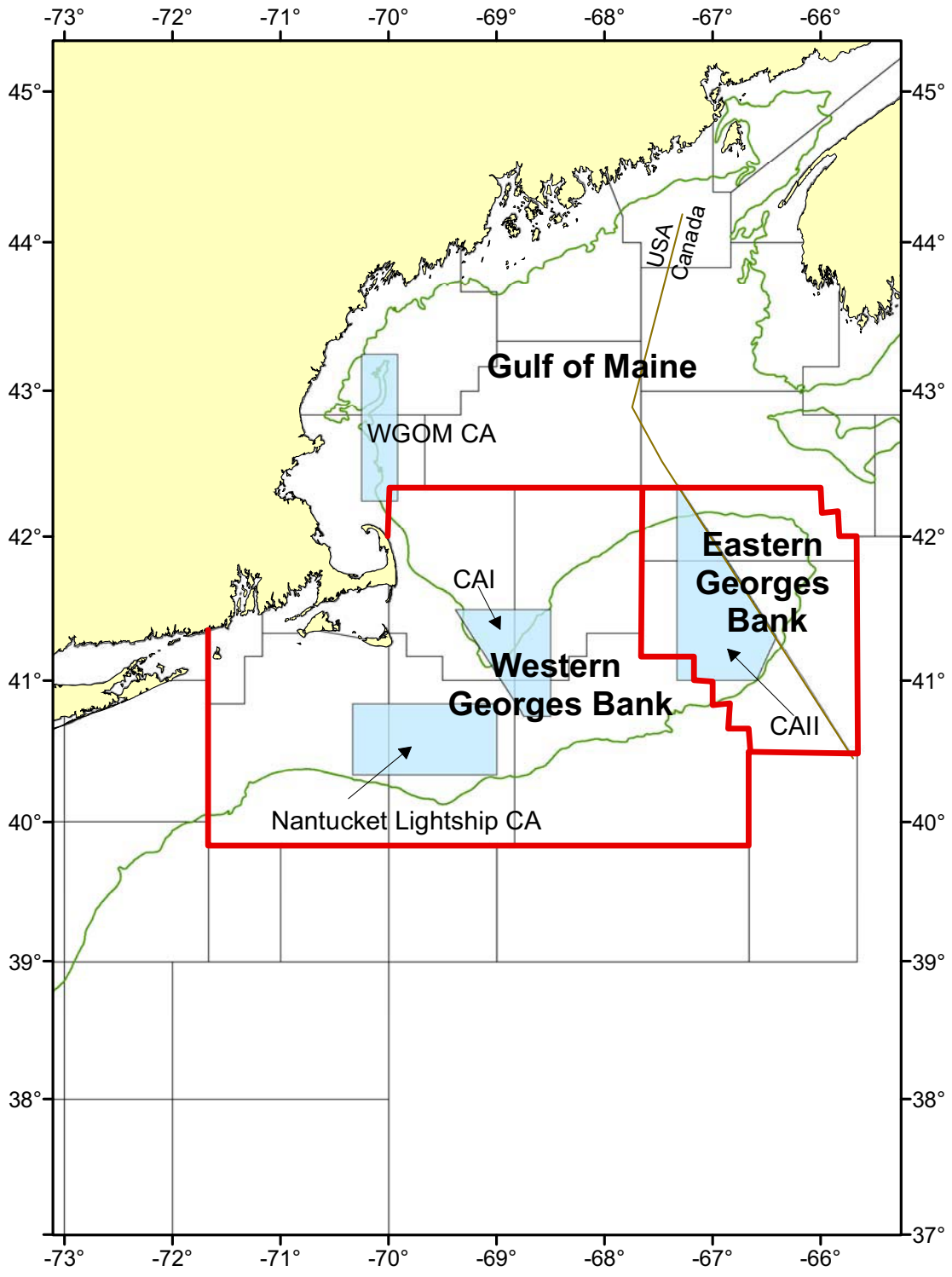


Figure 2. Total commercial catch (thousand mt) of Georges Bank haddock, 1904-2004.

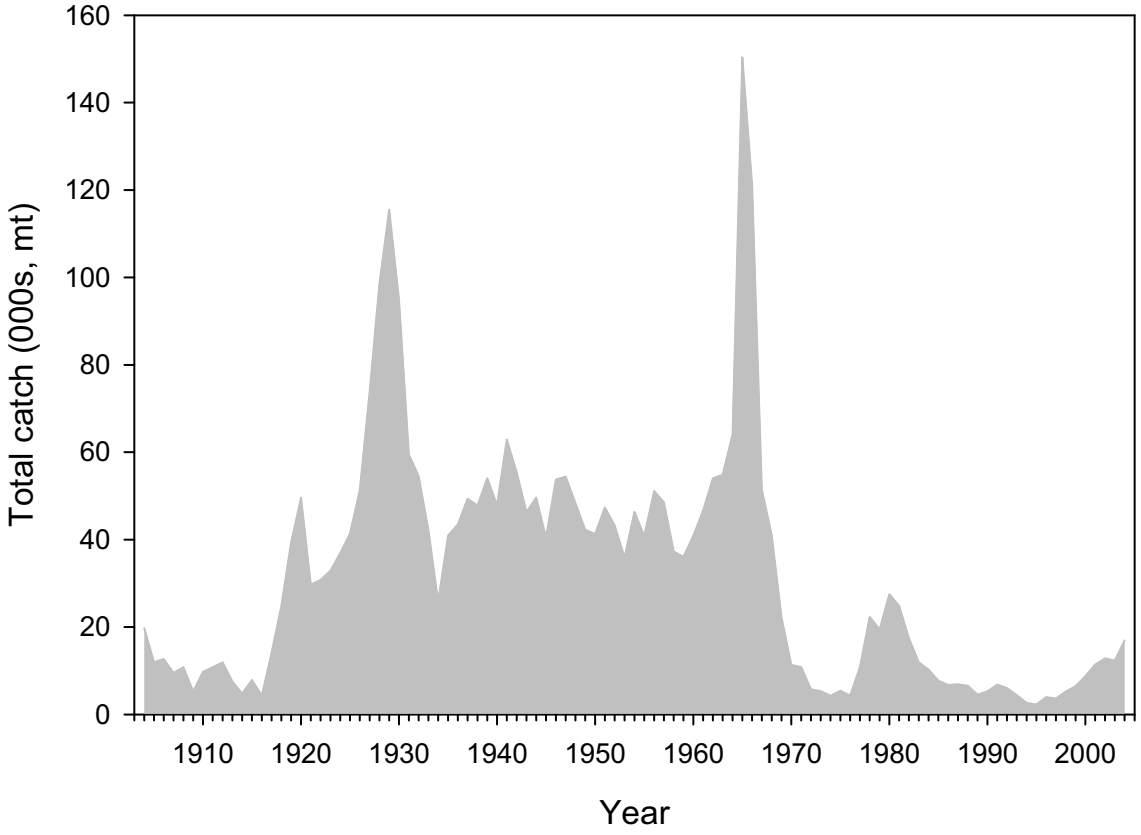


Figure 3.1. U.S. catch at length (cm) of western and eastern Georges Bank haddock in 2001 along with mean fish length (μ) of landed and discarded fish.

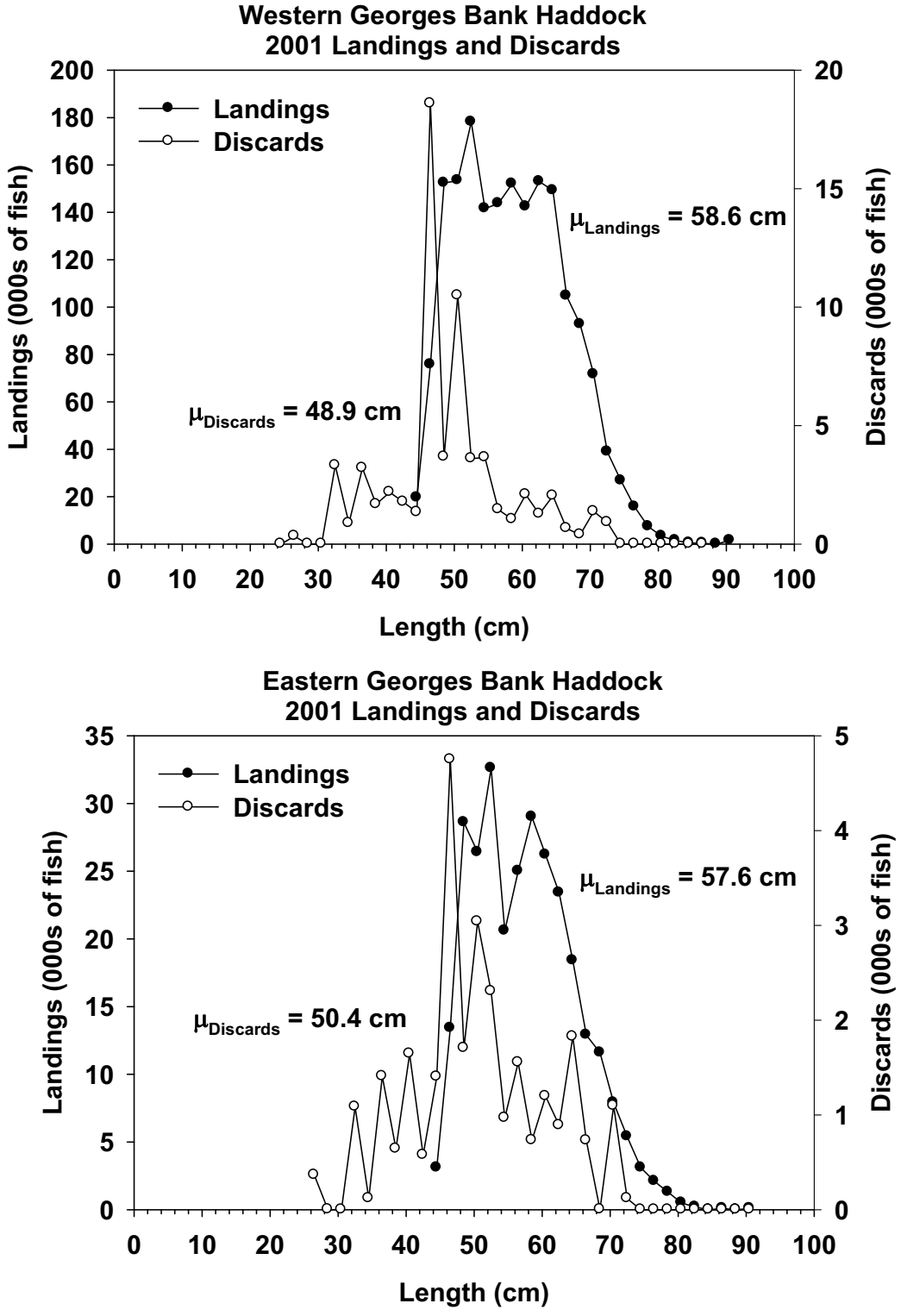


Figure 3.2. U.S. proportion of total catch at length (cm) of western and eastern Georges Bank haddock in 2001 along with mean fish length (μ) by management unit.

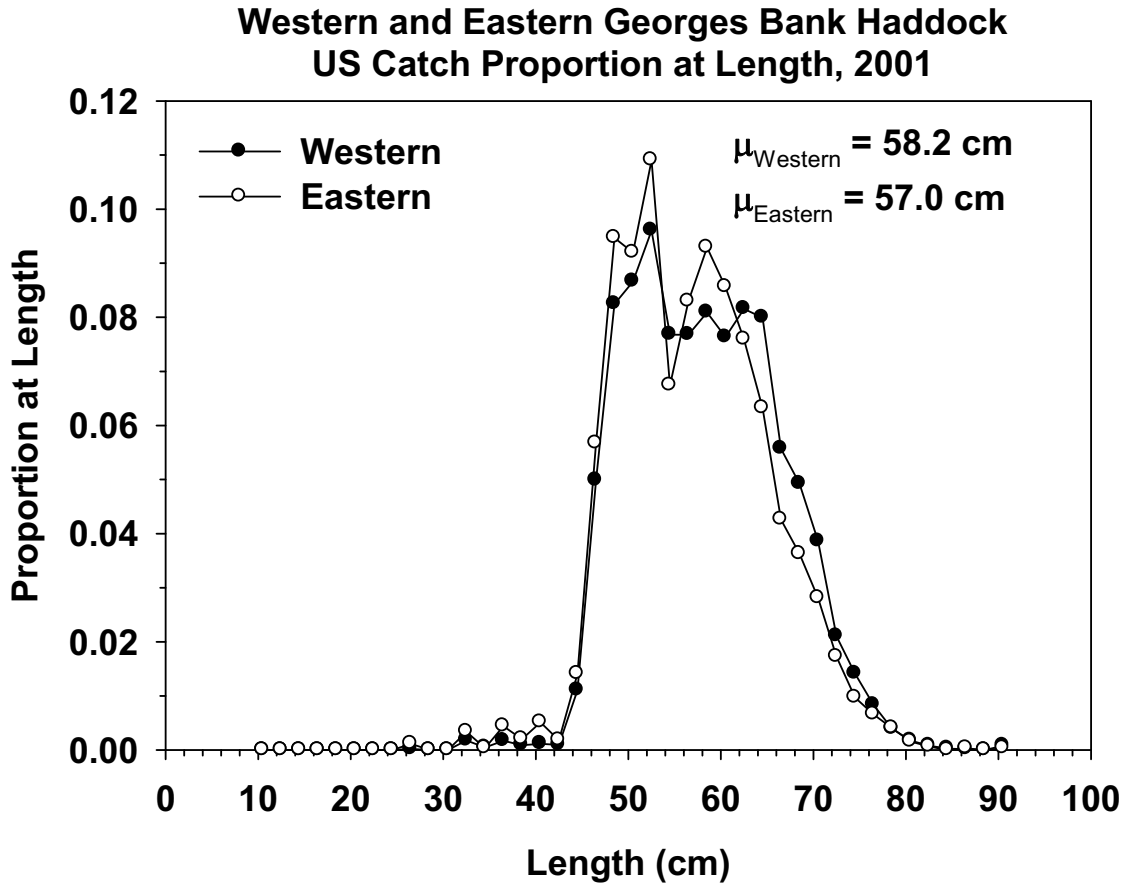


Figure 3.3. U.S. catch at length (cm) of western and eastern Georges Bank haddock in 2002 along with mean fish length (μ) of landed and discarded fish.

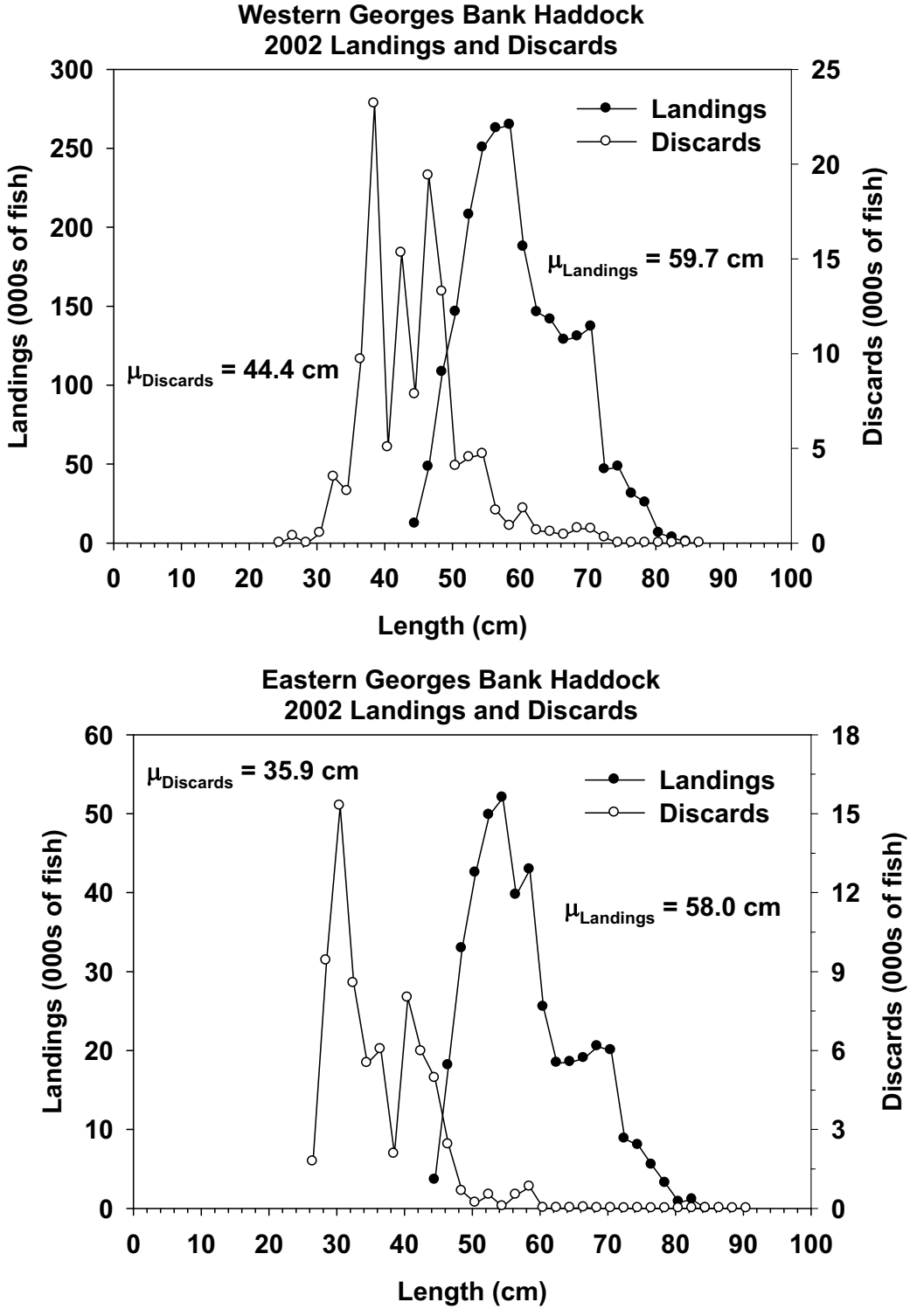


Figure 3.4. U.S. proportion of total catch at length (cm) of western and eastern Georges Bank haddock in 2002 along with mean fish length (μ) by management unit.

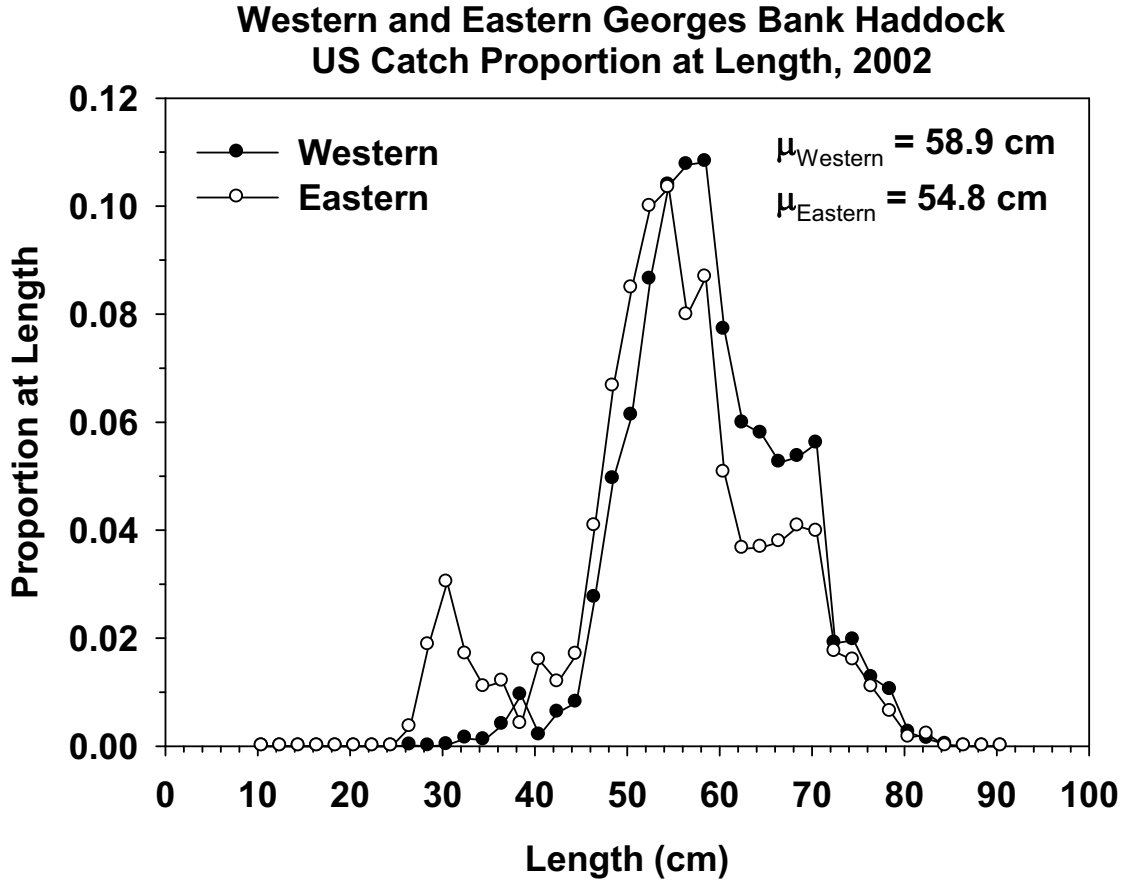


Figure 3.5. U.S. catch at length (cm) of western and eastern Georges Bank haddock in 2003 along with mean fish length (μ) of landed and discarded fish.

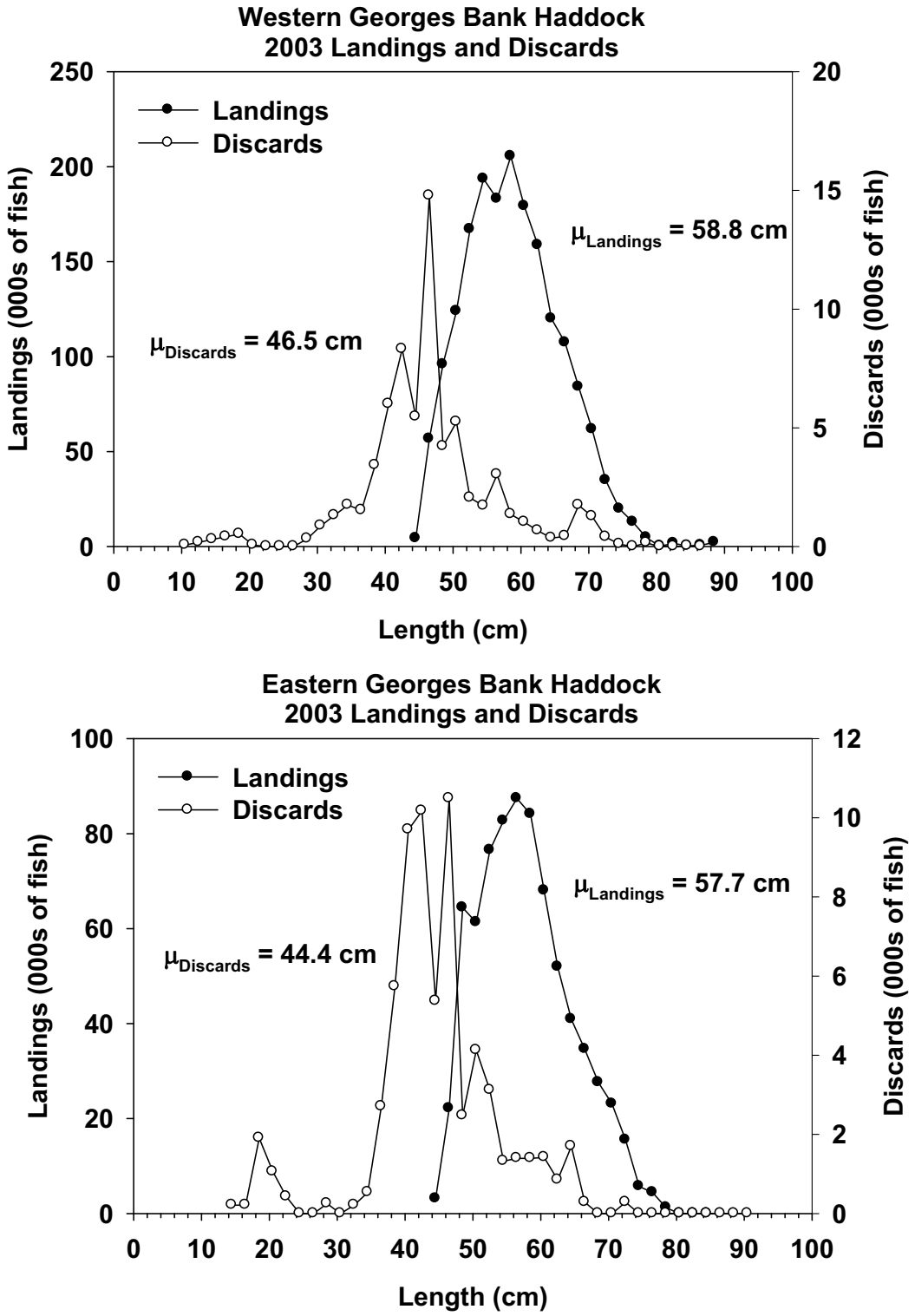


Figure 3.6. U.S. proportion of total catch at length (cm) of western and eastern Georges Bank haddock in 2003 along with mean fish length (μ) by management unit.

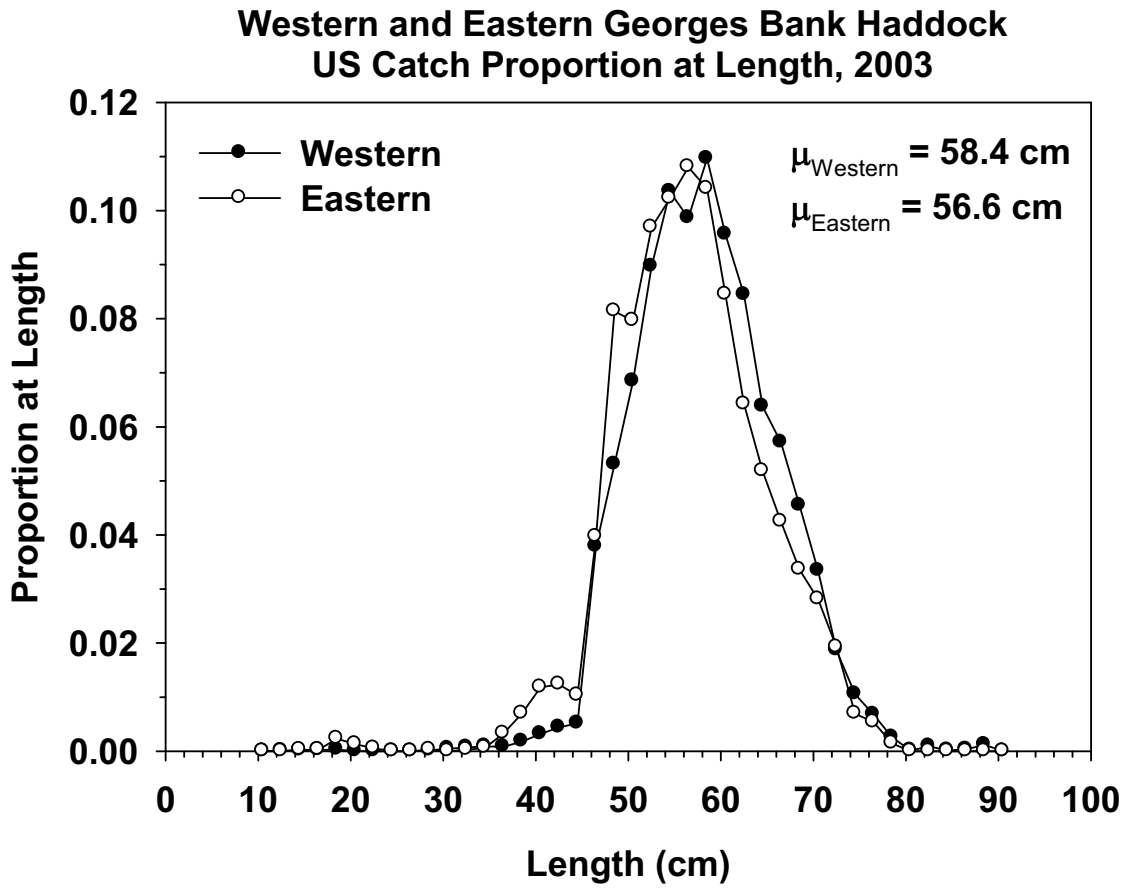


Figure 3.7. U.S. catch at length (cm) of western and eastern Georges Bank haddock in 2004 along with mean fish length (μ) of landed and discarded fish.

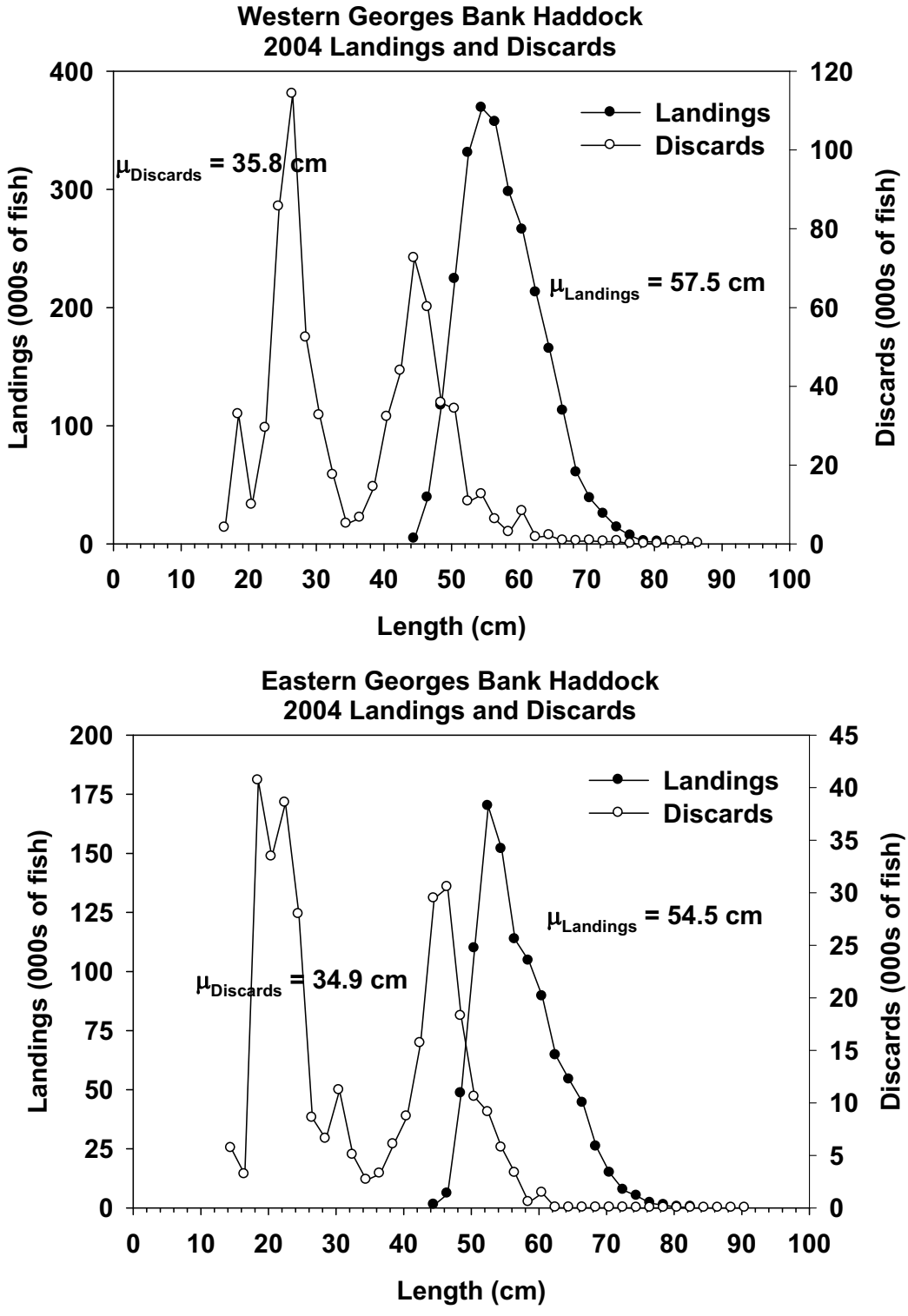


Figure 3.8. U.S. proportion of total catch at length (cm) of western and eastern Georges Bank haddock in 2004 along with mean fish length (μ) by management unit.

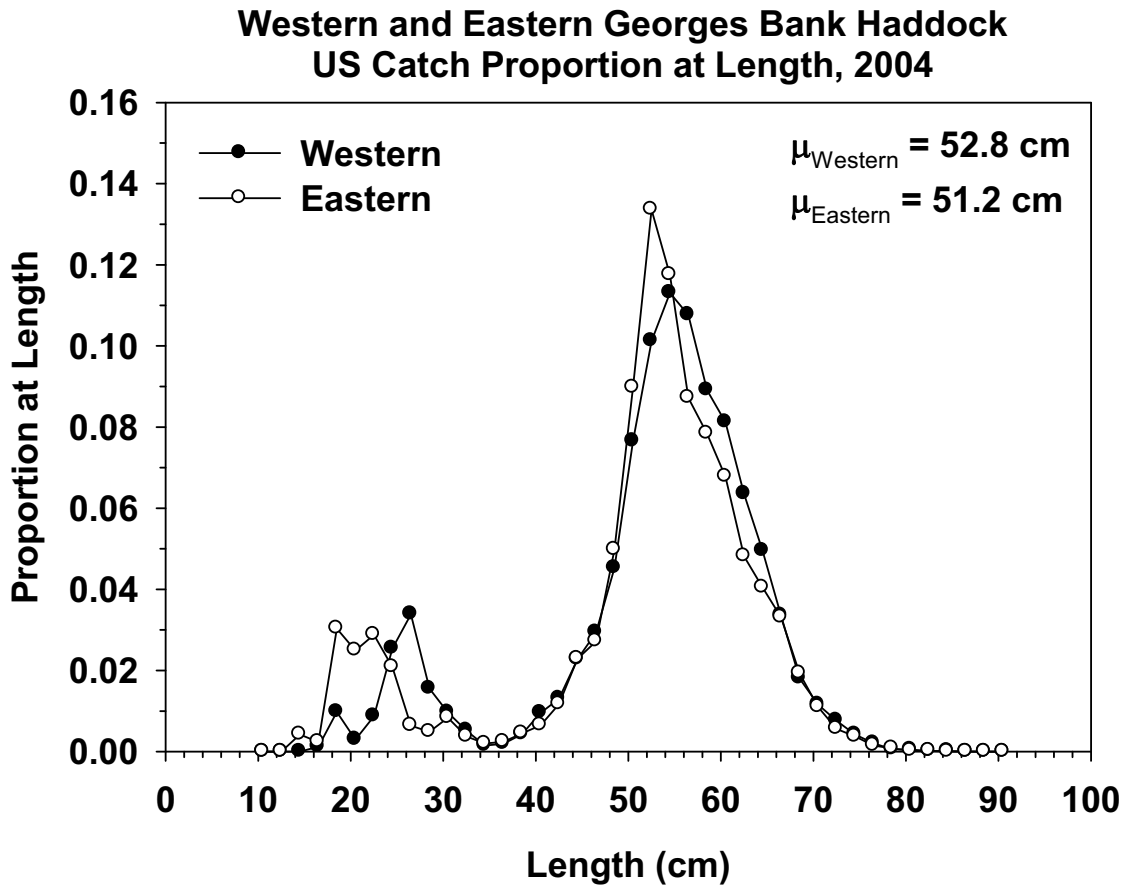


Figure 4. NEFSC bottom trawl survey strata (green shading) used to calculate relative abundance indices for the Georges Bank haddock assessment (offshore strata: 13-25, 29-30).

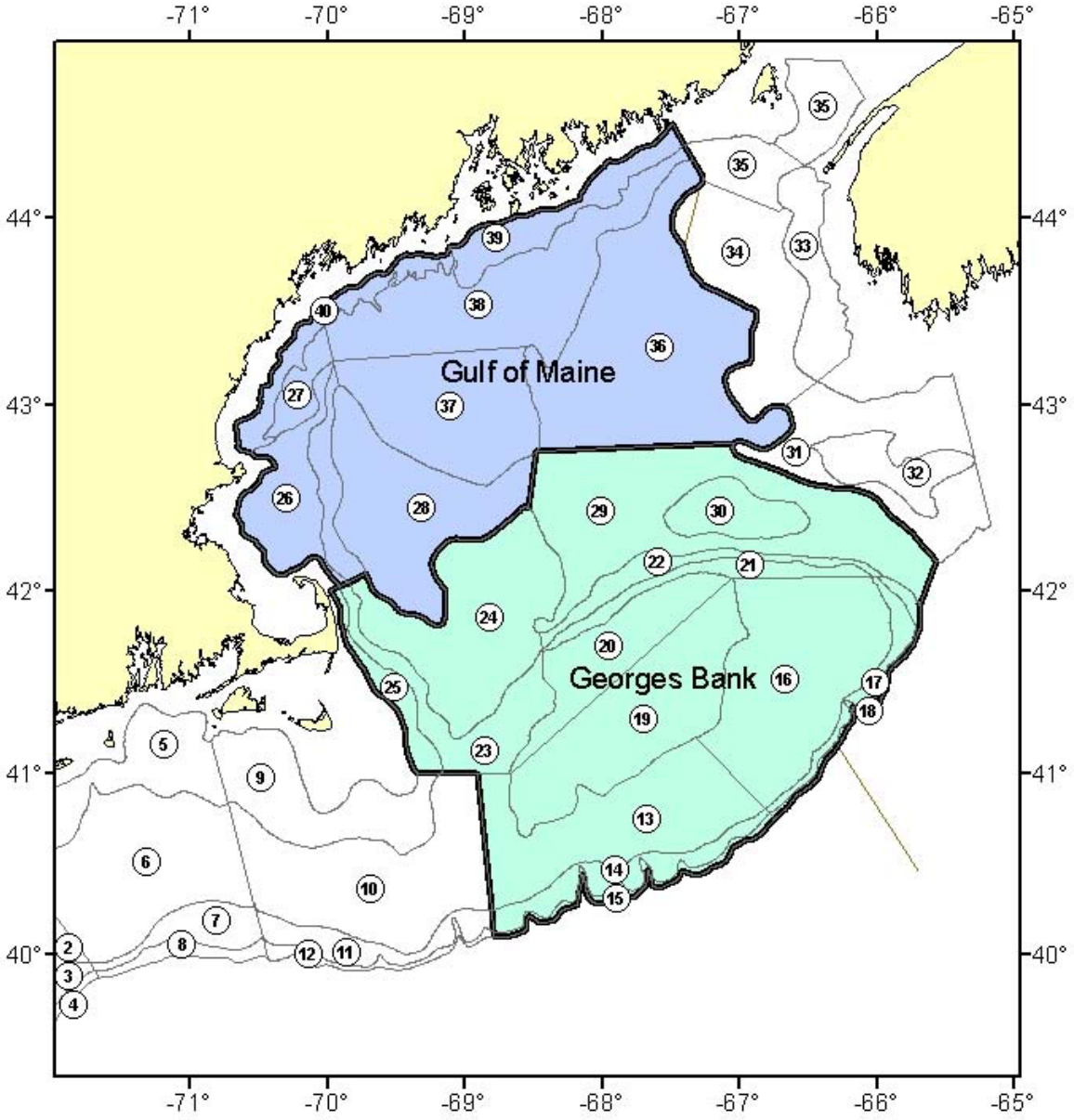


Figure 5. U.S. and Canadian research survey abundance indices for Georges Bank haddock, 1963-2005.

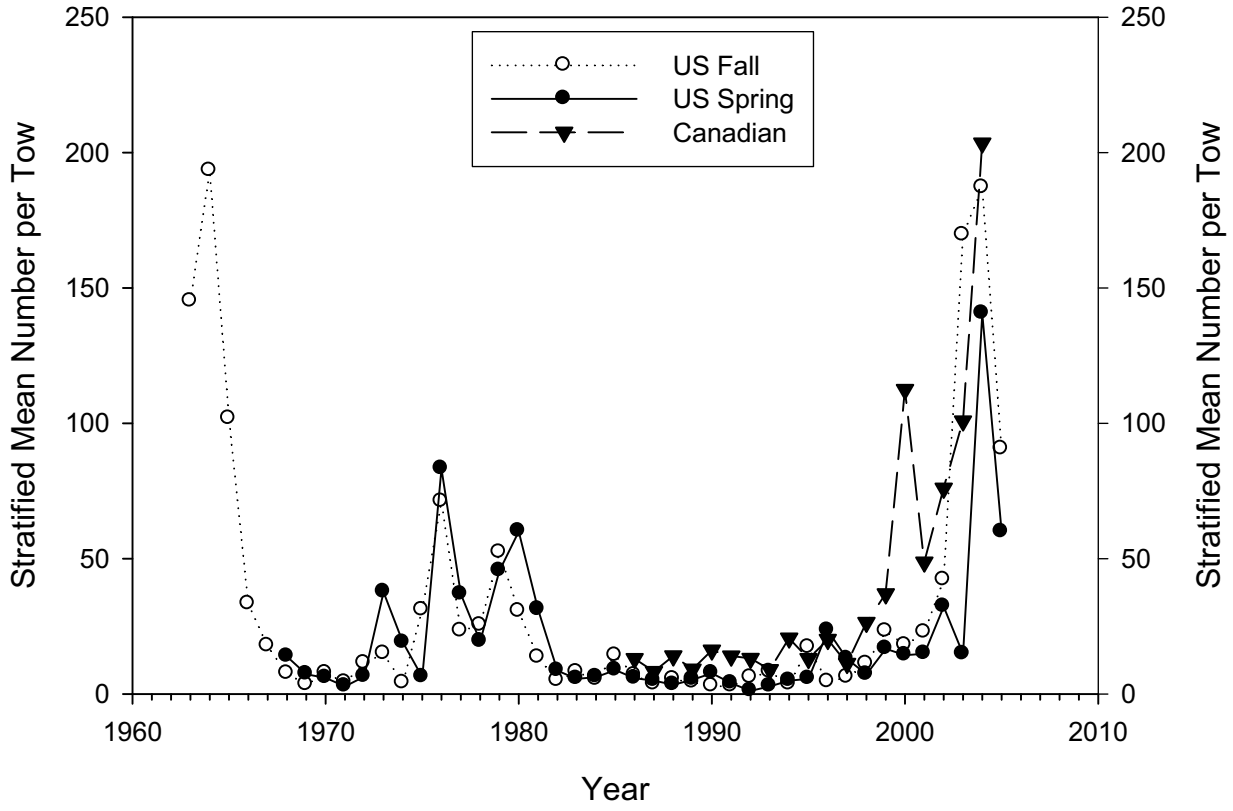


Figure 6.1. Georges Bank haddock length composition from the NEFSC spring and autumn bottom trawl surveys, 1963-1972.

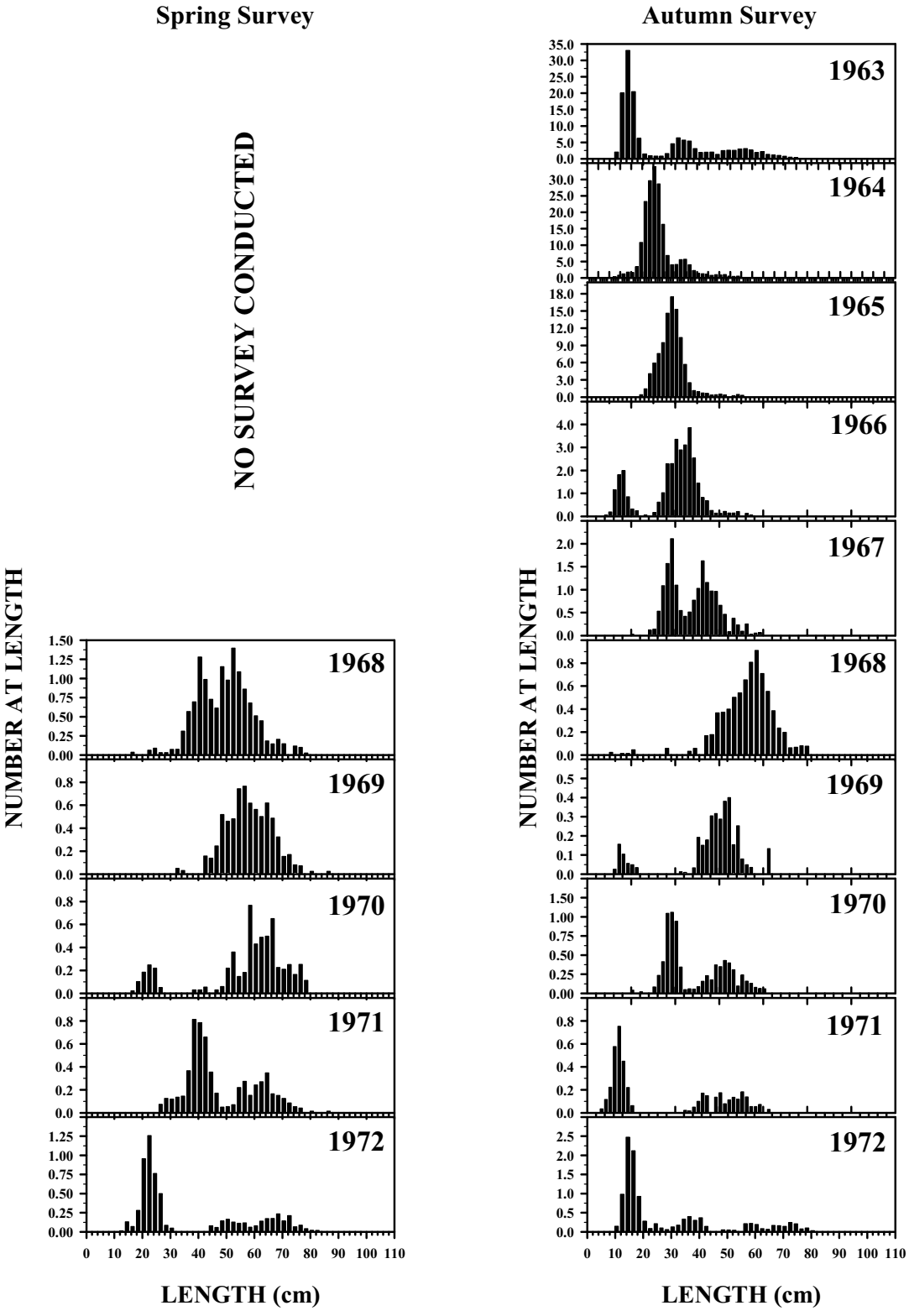


Figure 6.2. Georges Bank haddock length composition from the NEFSC spring and autumn bottom trawl surveys, 1973-1982.

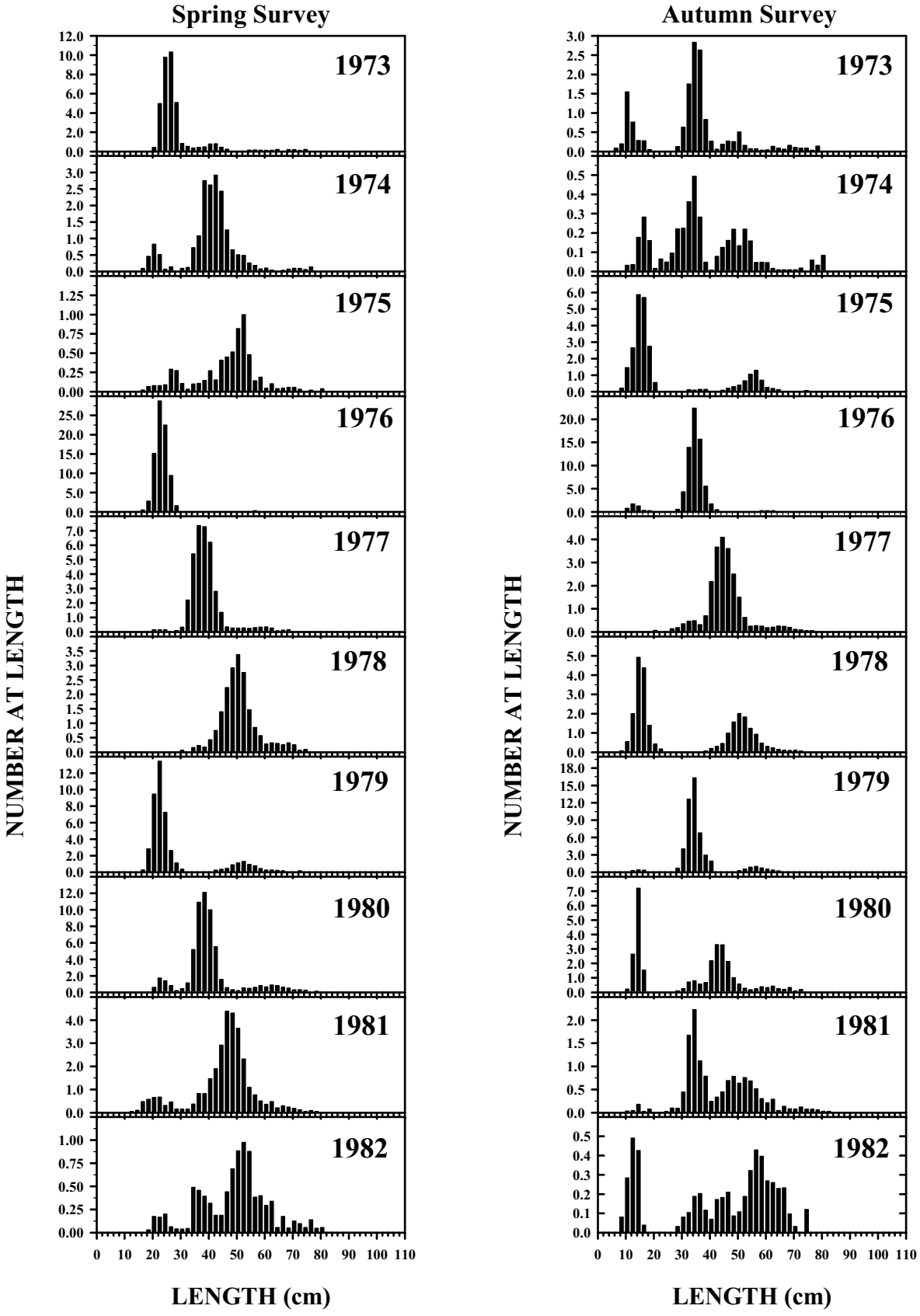


Figure 6.3. Georges Bank haddock length composition from the NEFSC spring and autumn bottom trawl surveys, 1983-1992.

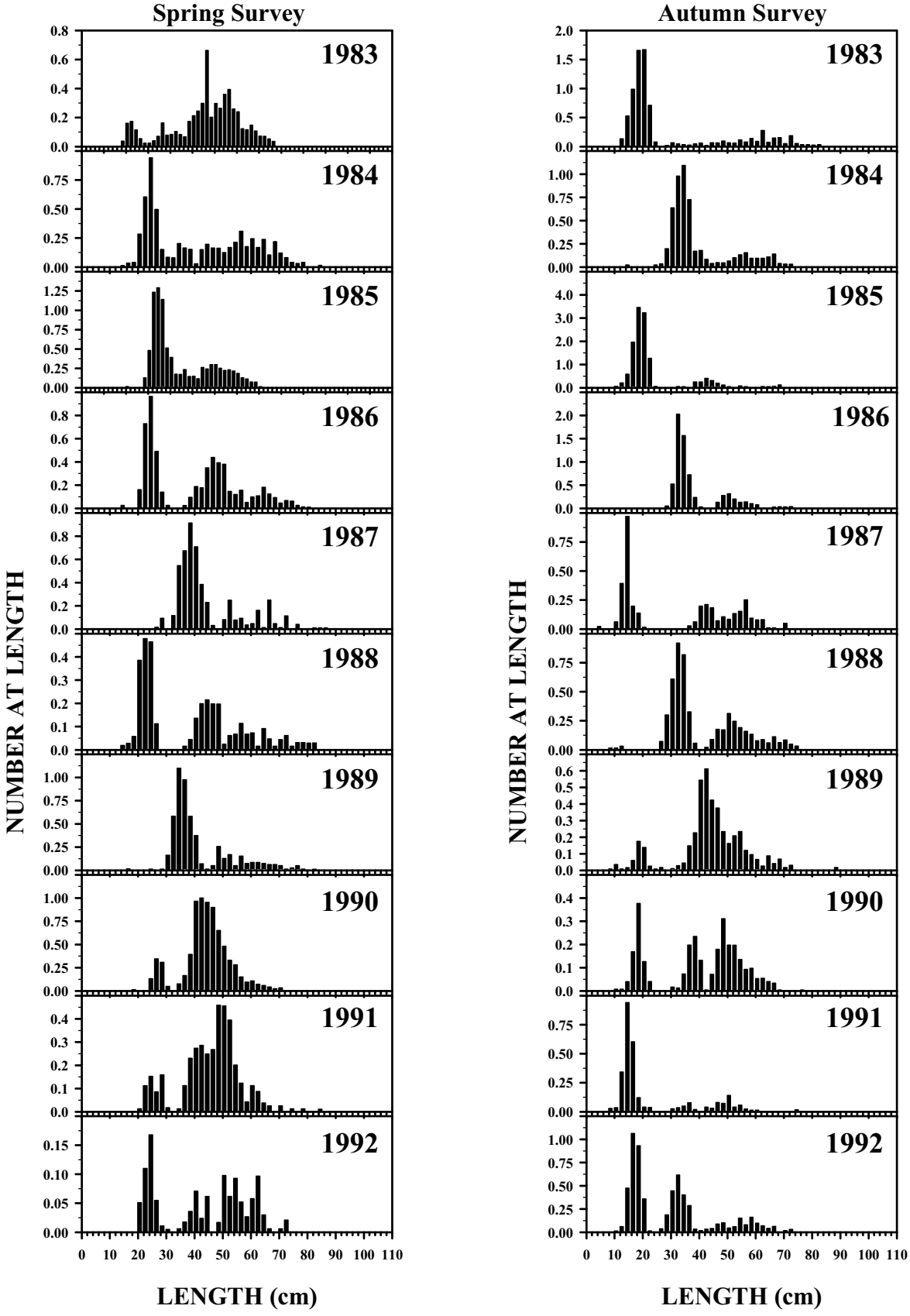


Figure 6.4. Georges Bank haddock length composition from the NEFSC spring and autumn bottom trawl surveys, 1993-2003.

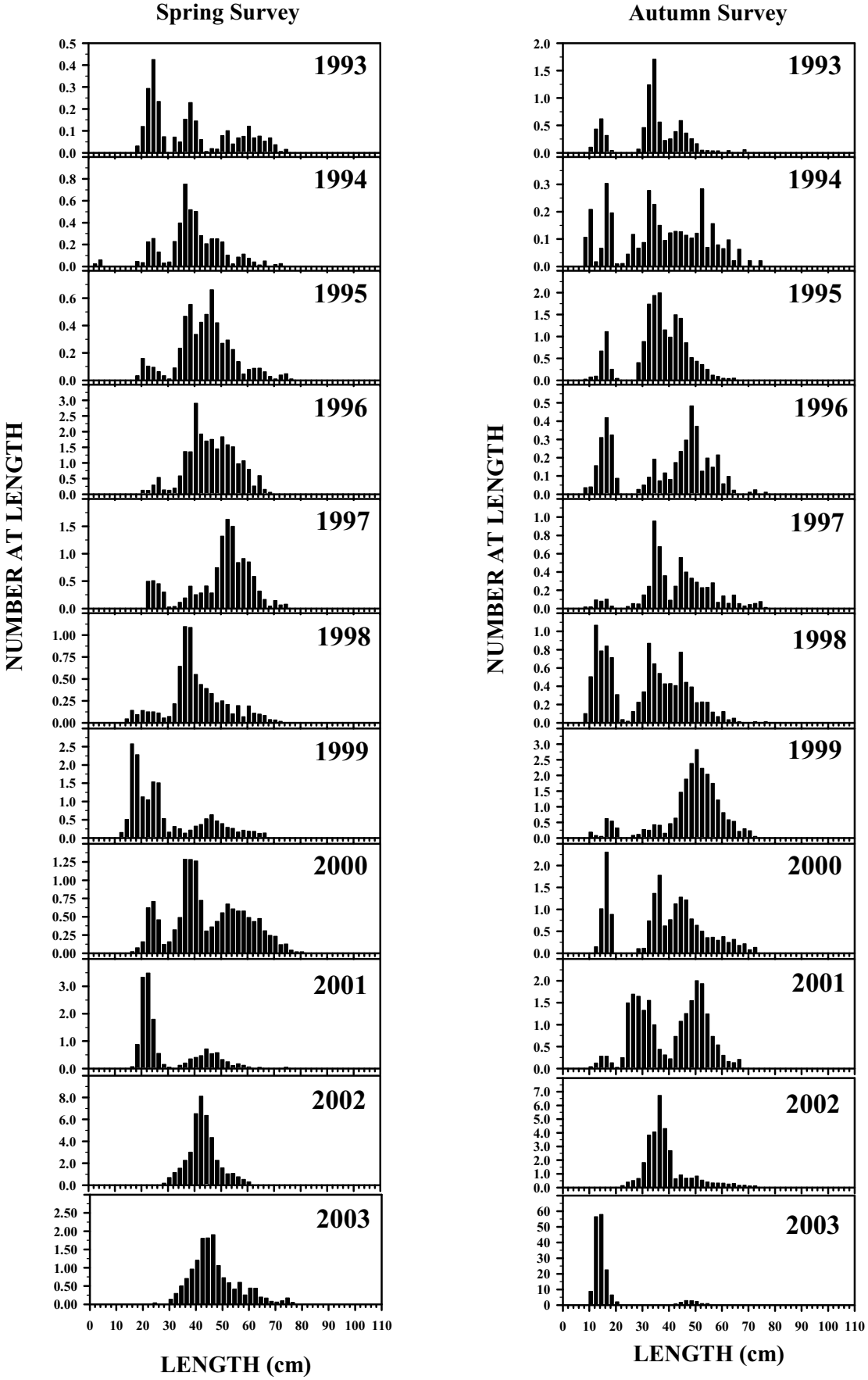


Figure 6.5. Georges Bank haddock length composition from the NEFSC spring and autumn bottom trawl surveys, 2004-2005.

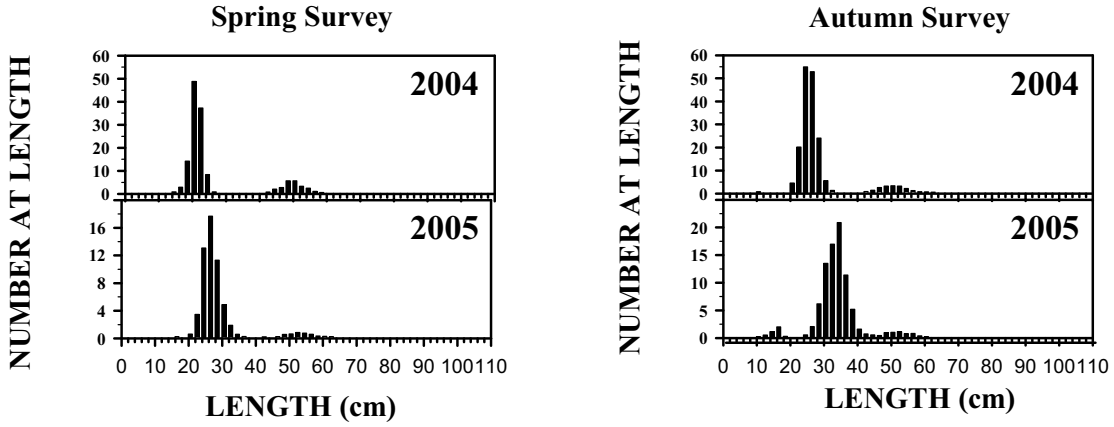


Figure 7.1. Georges Bank haddock NEFSC spring bottom trawl survey stratified mean number of fish per tow at age, 1968-2005.

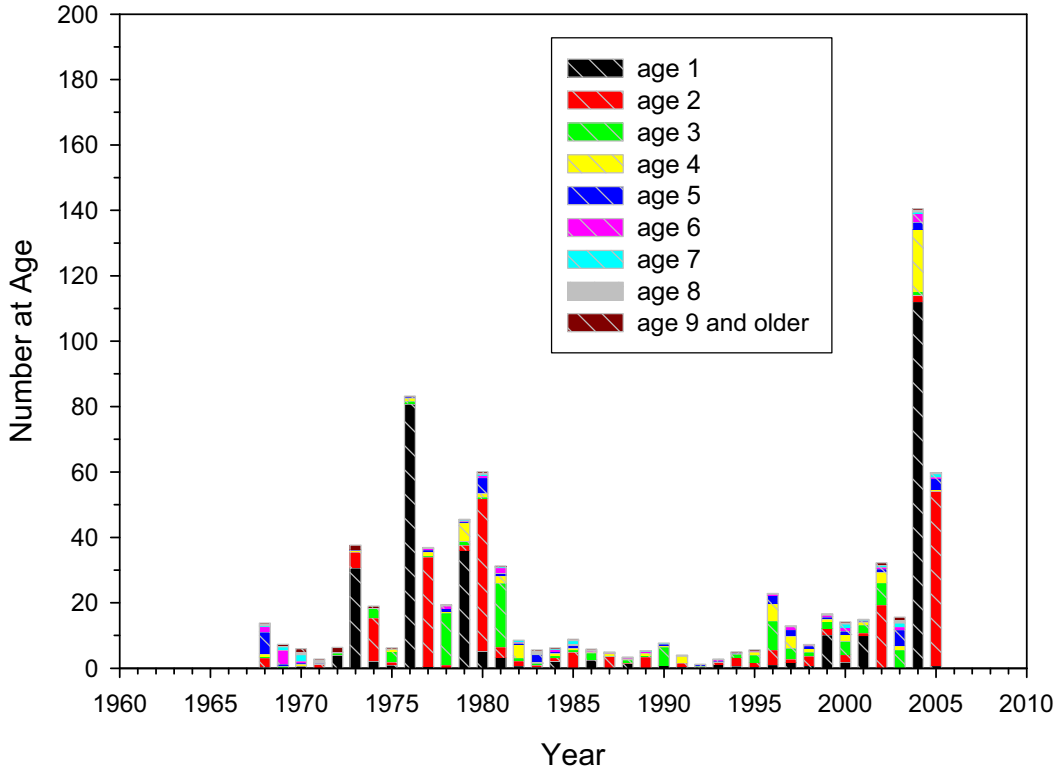


Figure 7.2. Georges Bank haddock NEFSC autumn bottom trawl survey stratified mean number of fish per tow at age, 1963-2005.

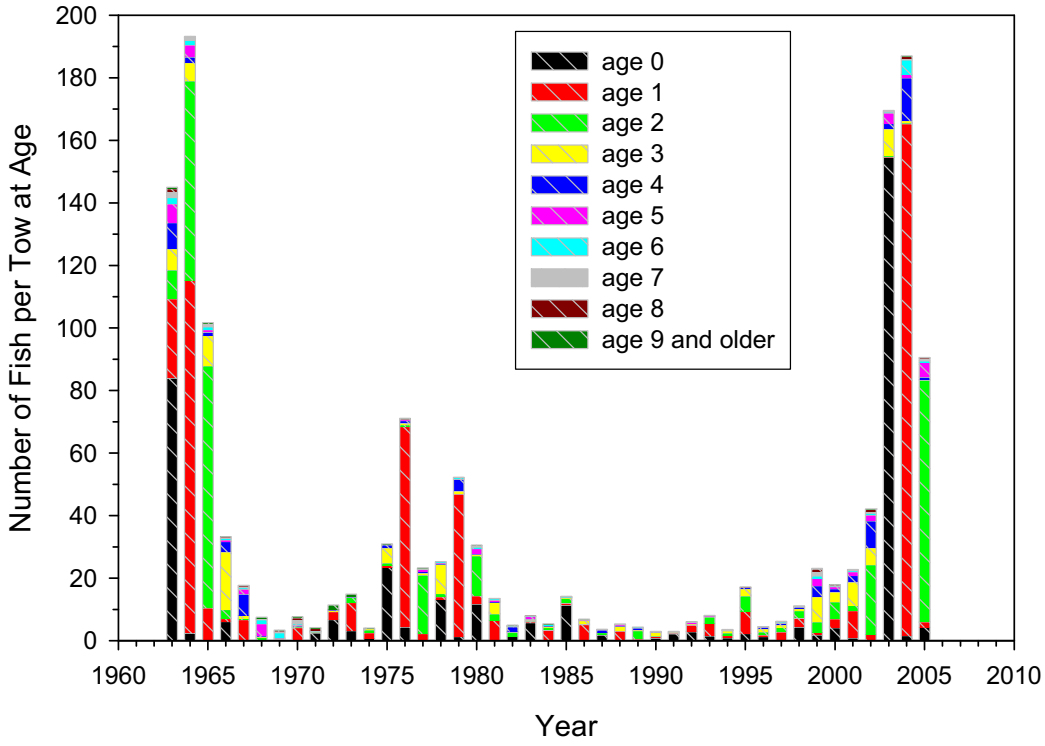


Figure 8.1. Georges Bank haddock NEFSC spring survey number at age by age group (1 through 9+), 1968-2005.

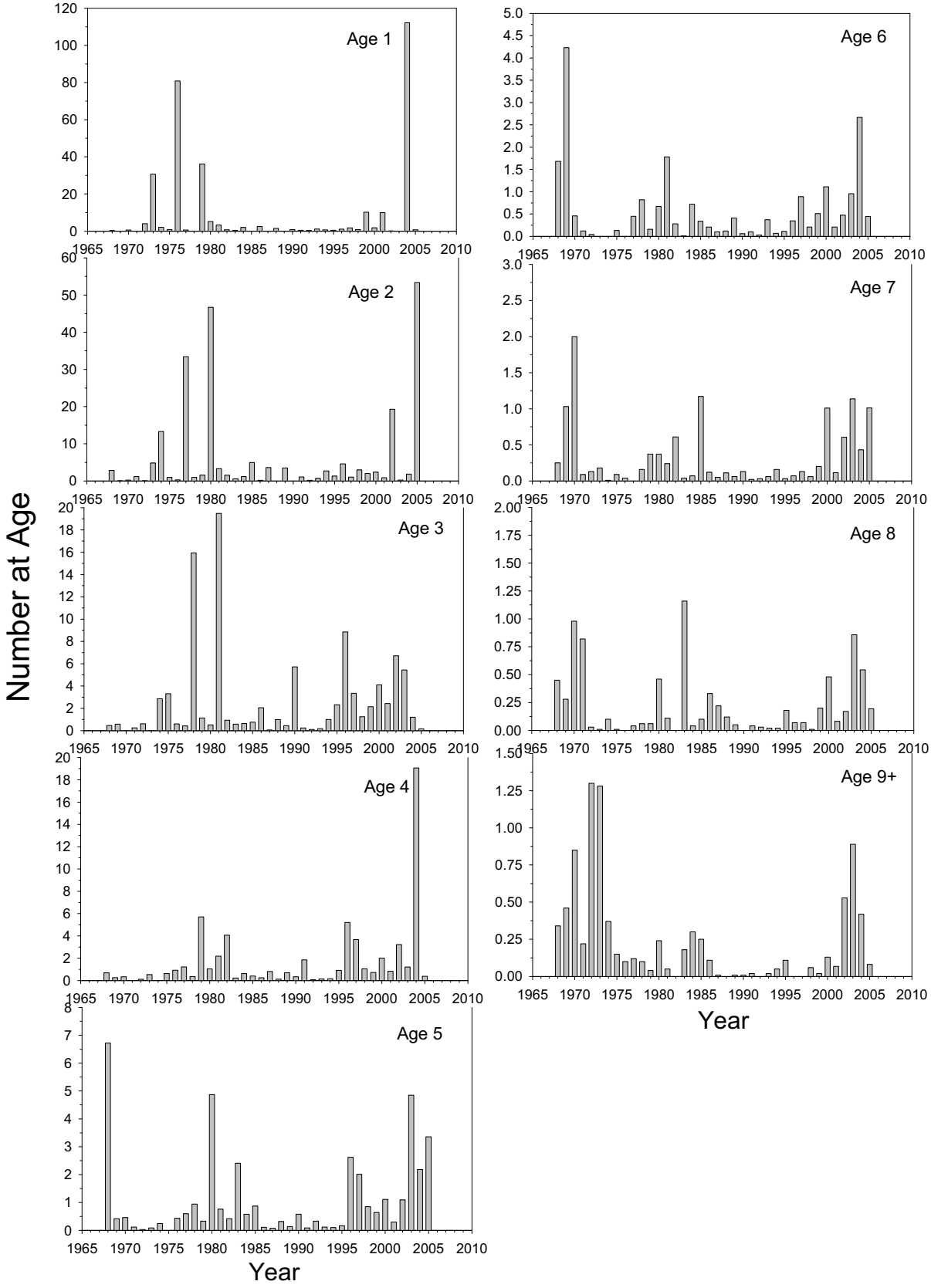


Figure 8.2. Georges Bank haddock NEFSC autumn survey number at age by age group (1 through 9+), 1963-2005.

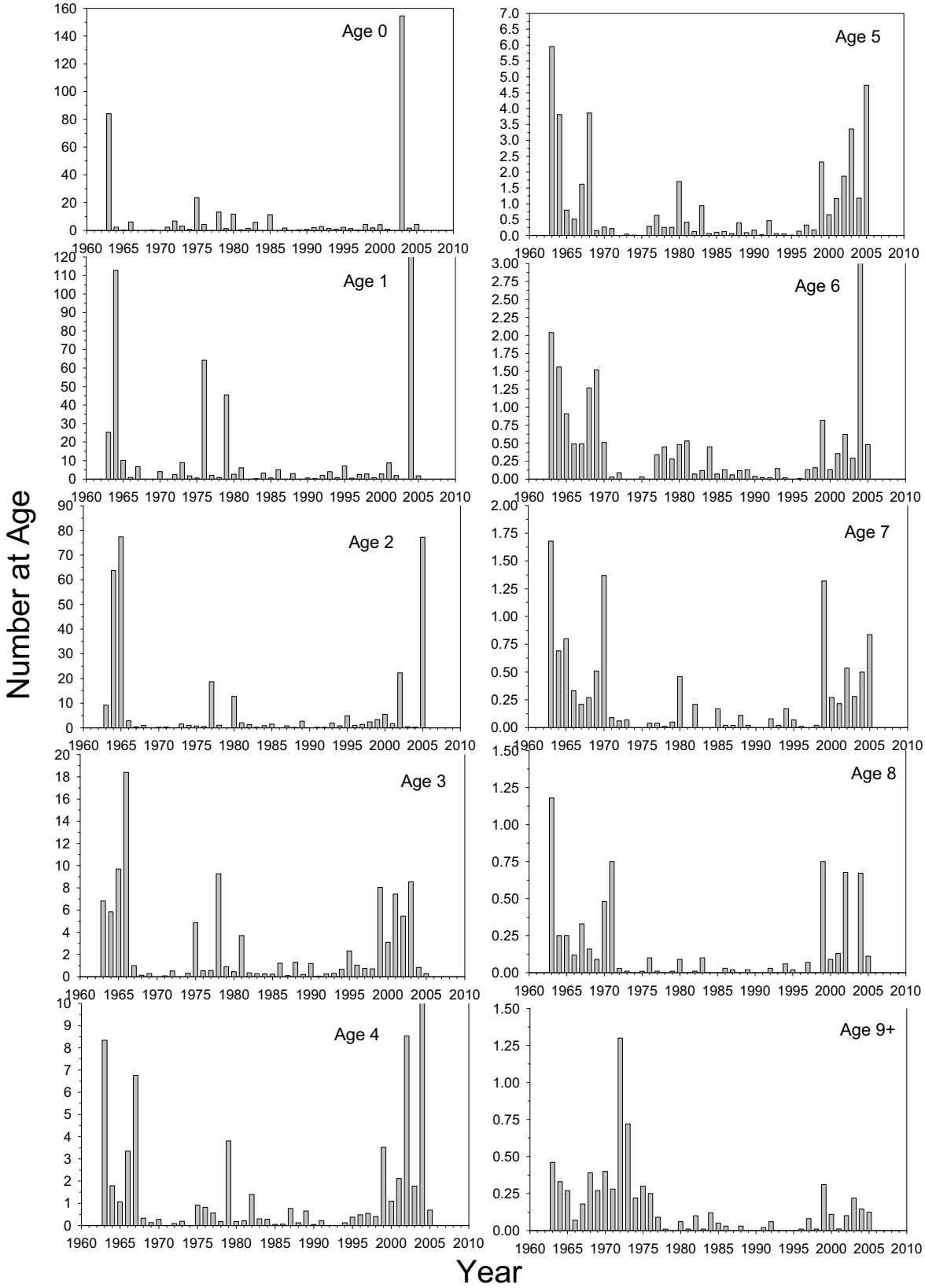


Figure 9.1. Georges Bank haddock NEFSC spring survey catch per tow indices by age group and year.

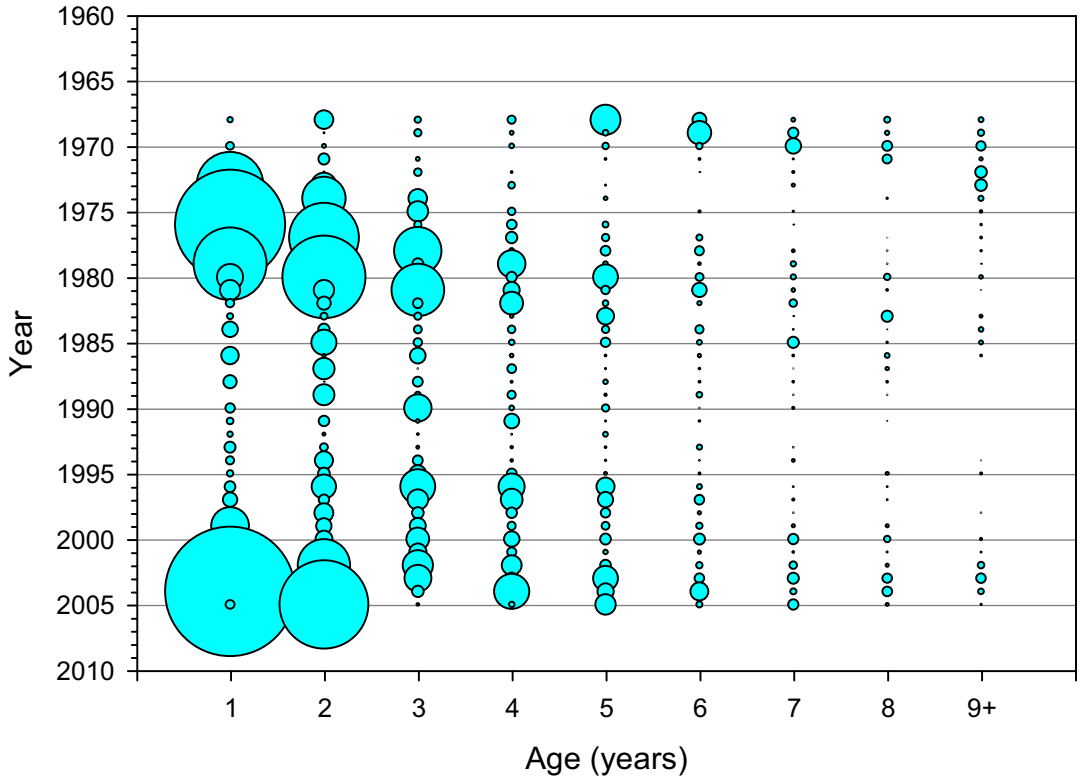


Figure 9.2. Georges Bank haddock NEFSC autumn survey catch per tow indices by age group and year.

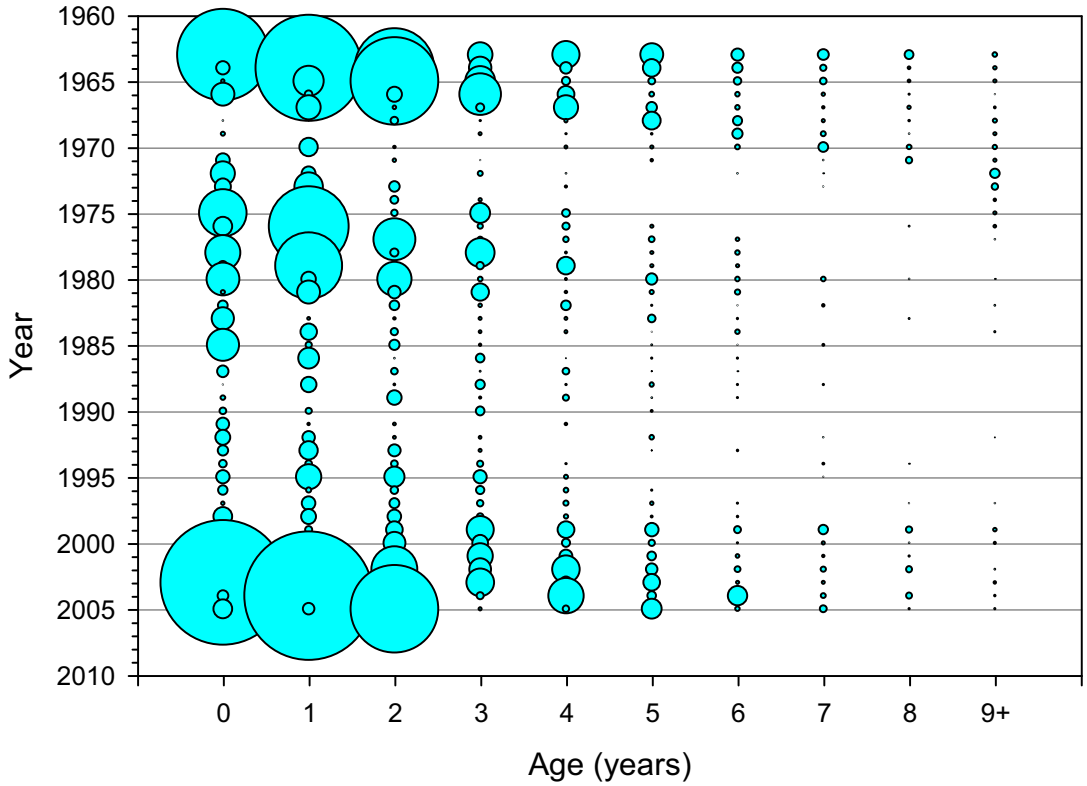


Figure 9.3. Georges Bank haddock Canadian winter survey catch per tow indices by age group and year.

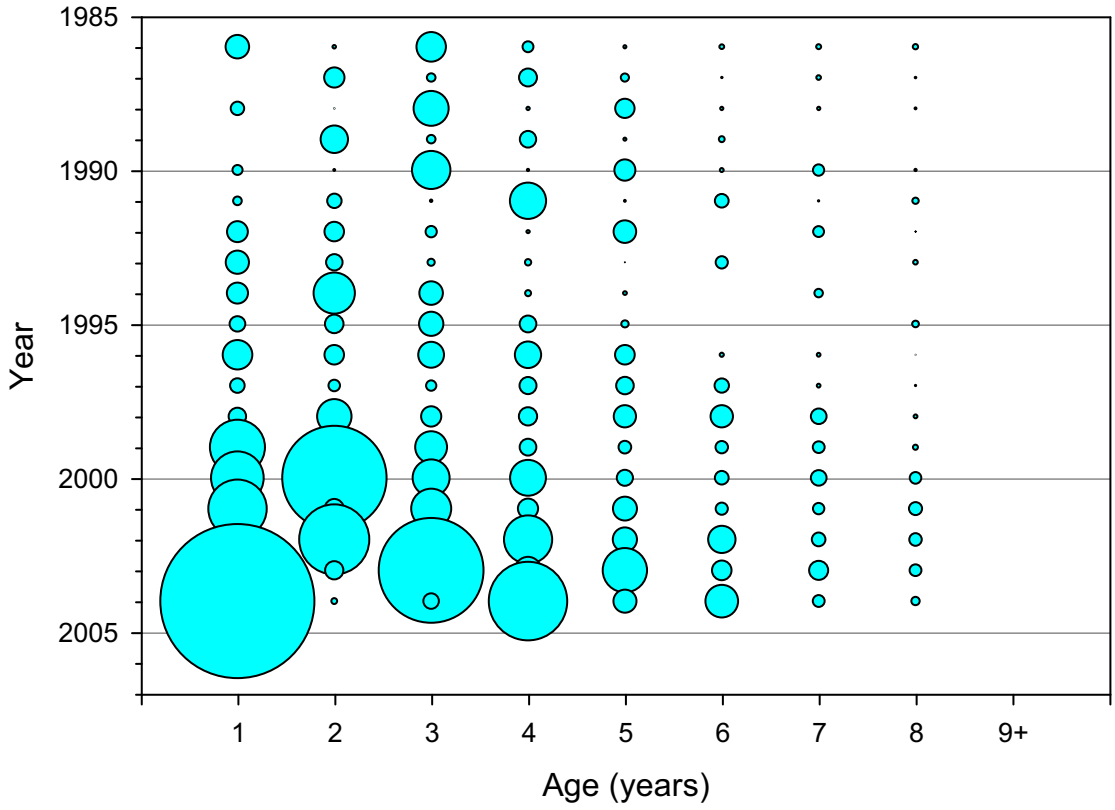


Figure 10.1. Georges Bank haddock mean length at age-0 NEFSC fall surveys, 1963-2004.

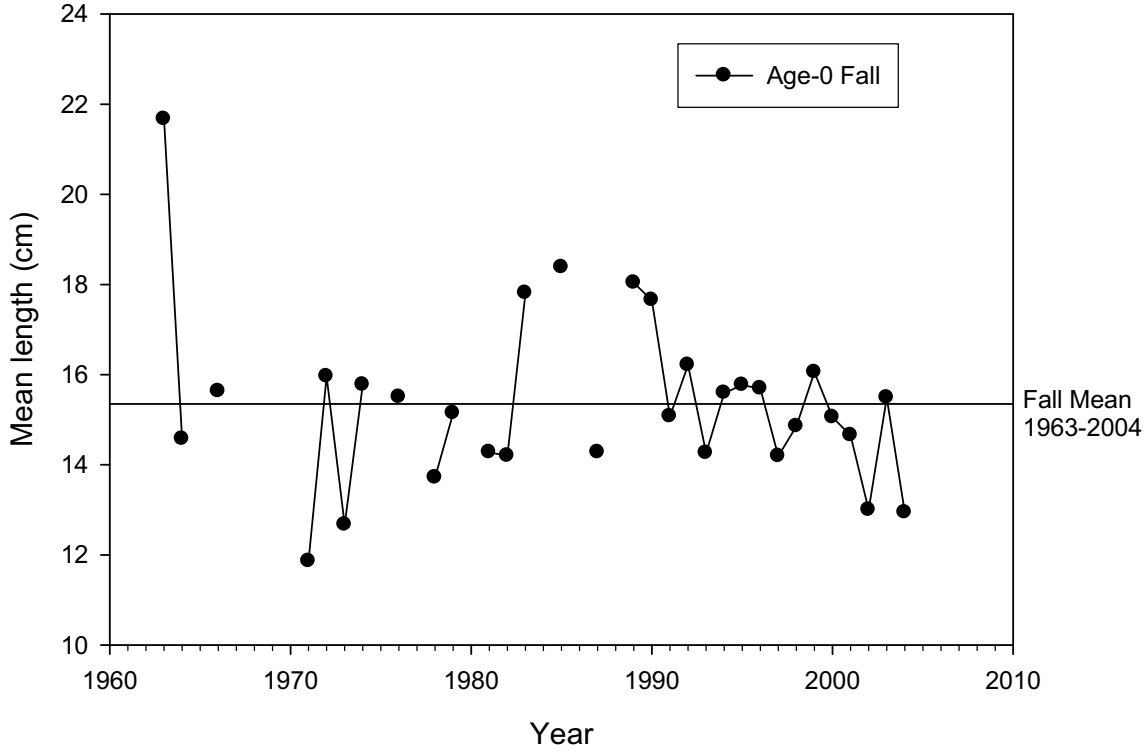


Figure 10.2. Georges Bank haddock mean length at age-1 NEFSC spring and fall surveys, 1963-2005.

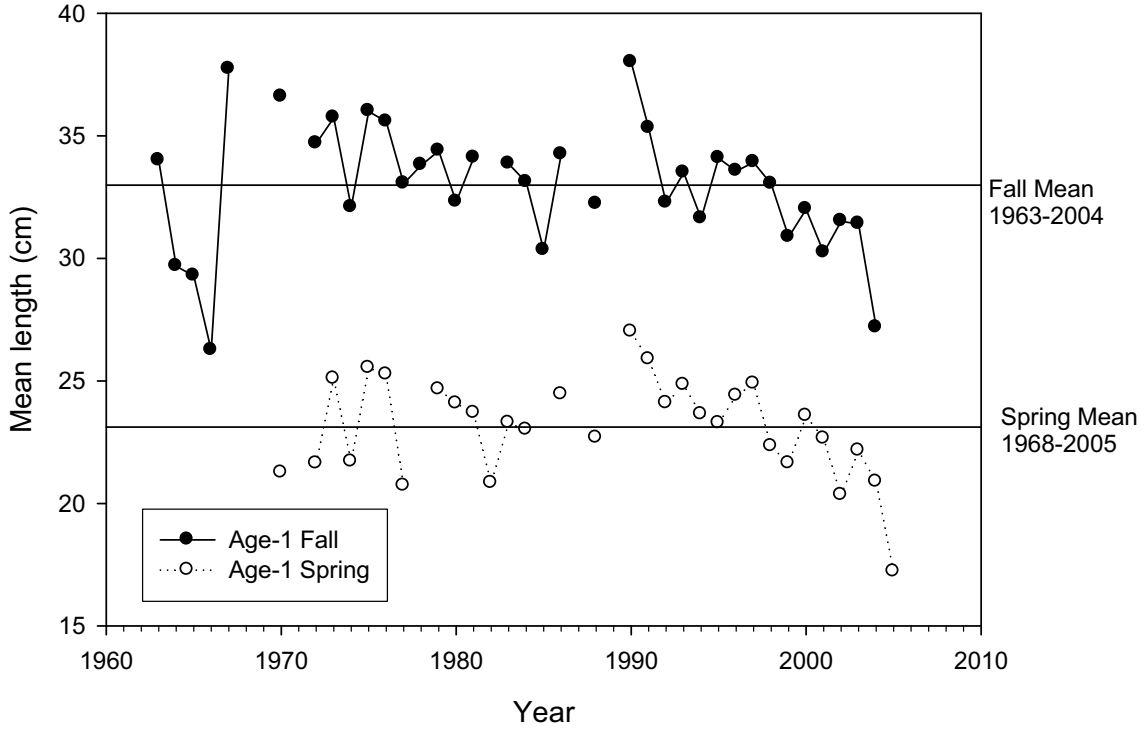


Figure 10.3. Georges Bank haddock mean length at age-2 NEFSC spring and fall surveys, 1963-2005.

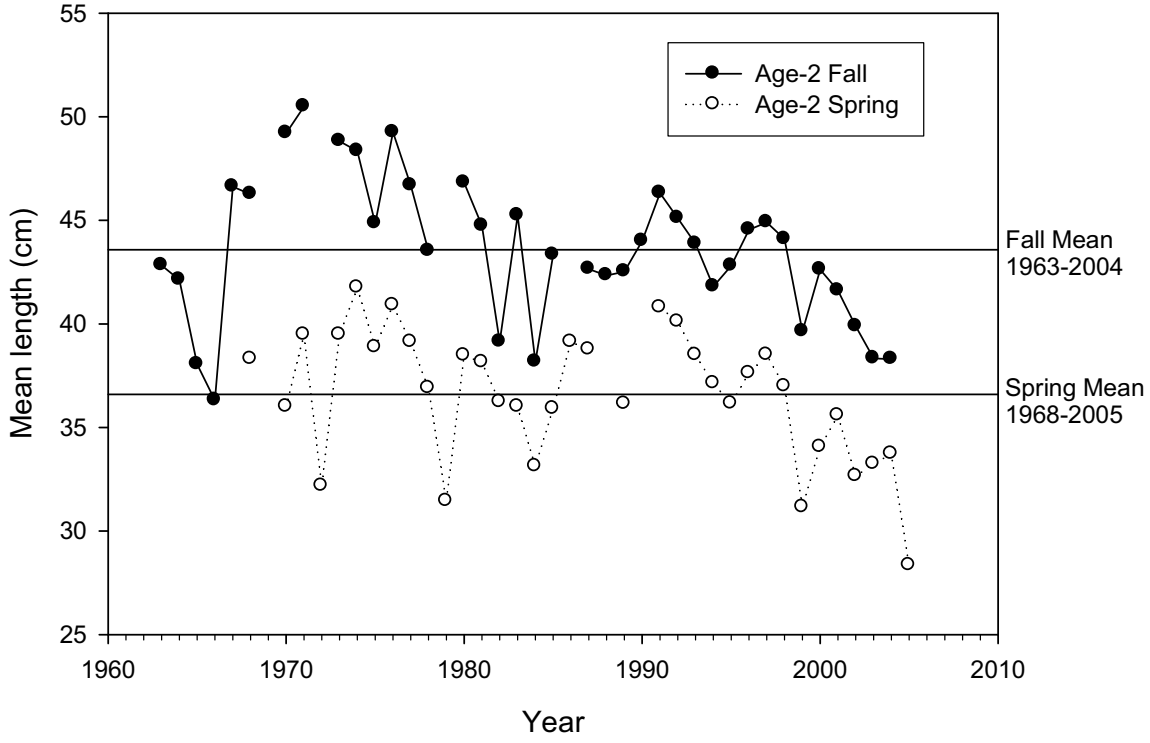


Figure 10.4. Georges Bank haddock mean length at age-3 NEFSC spring and fall surveys, 1963-2005.

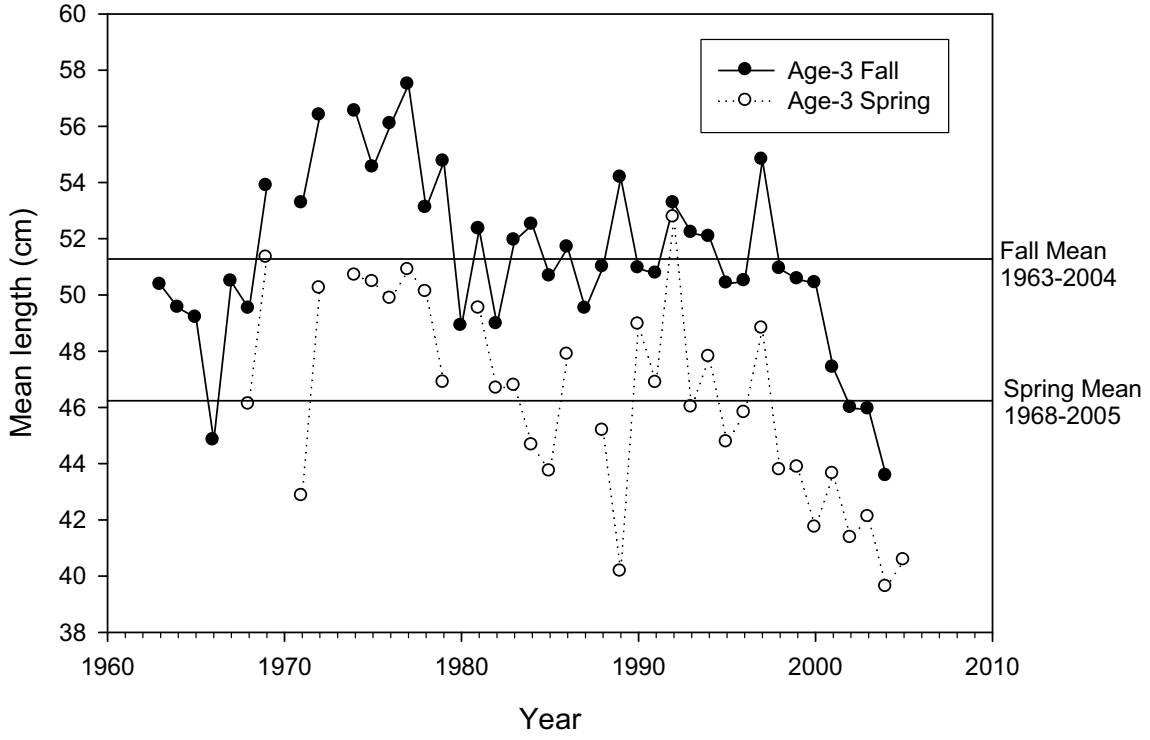


Figure 10.5. Georges Bank haddock mean length at age-4 NEFSC spring and fall surveys, 1963-2005.

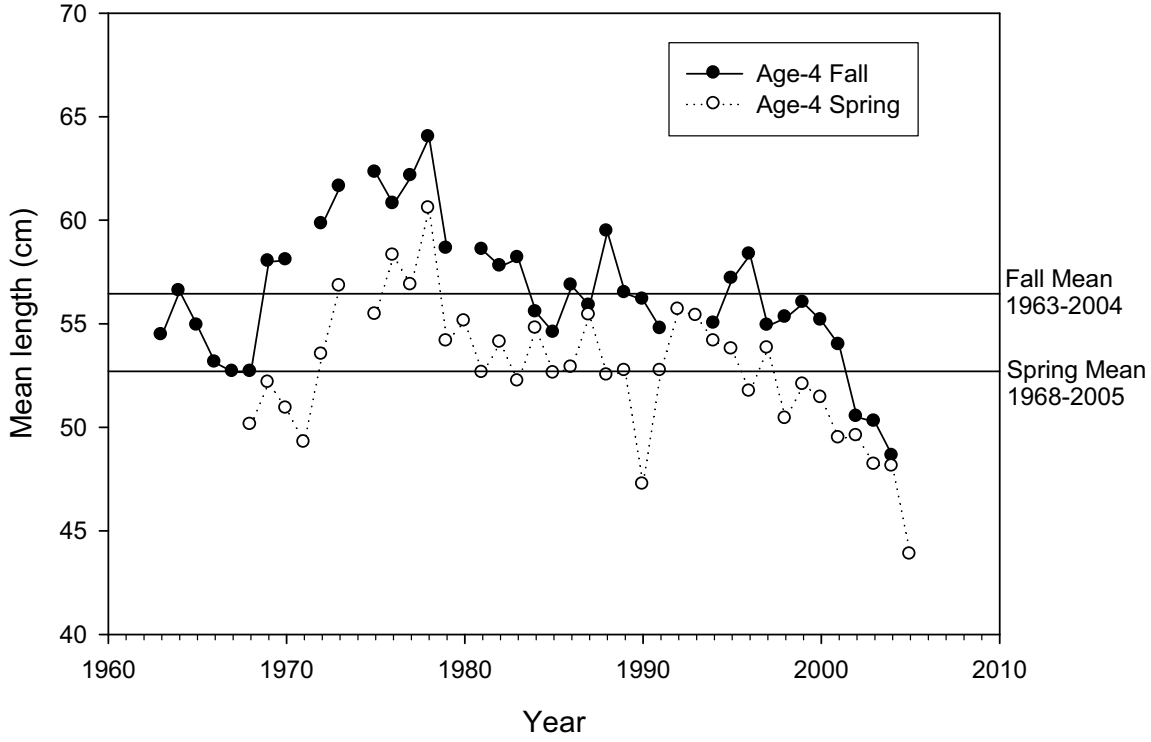


Figure 10.6. Georges Bank haddock mean length at age-5 NEFSC spring and fall surveys, 1963-2005.

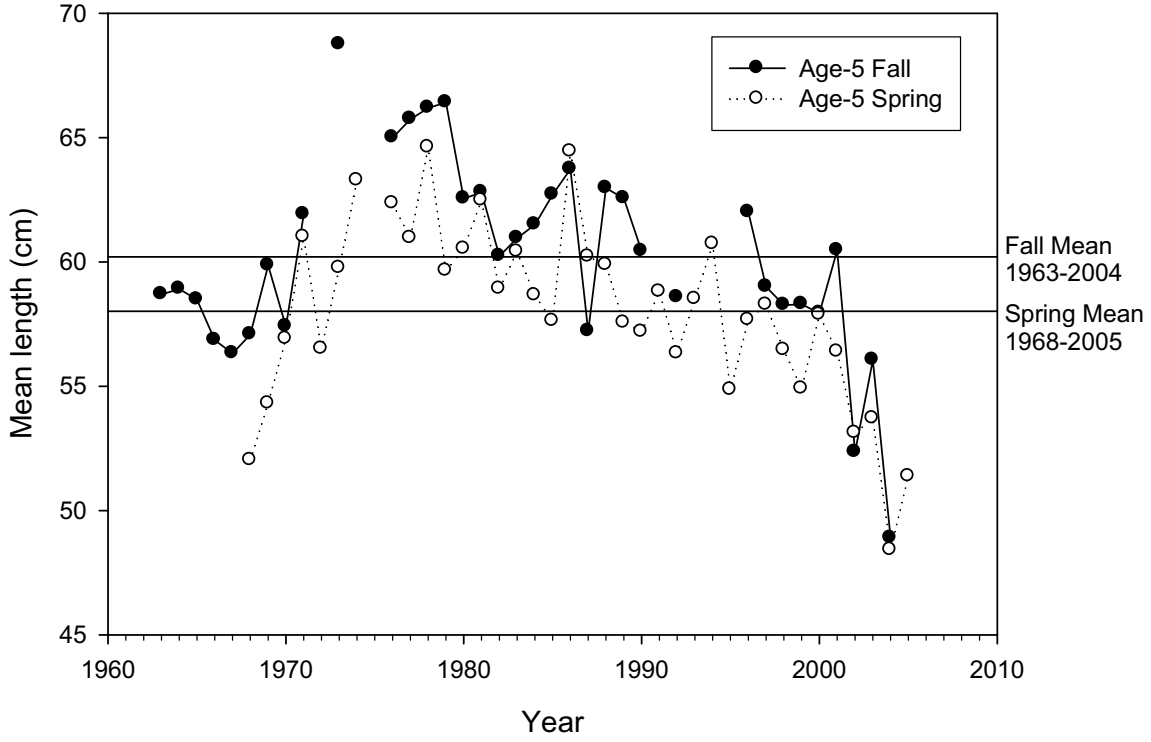


Figure 10.7. Georges Bank haddock mean length at age-6 NEFSC spring and fall surveys, 1963-2005.

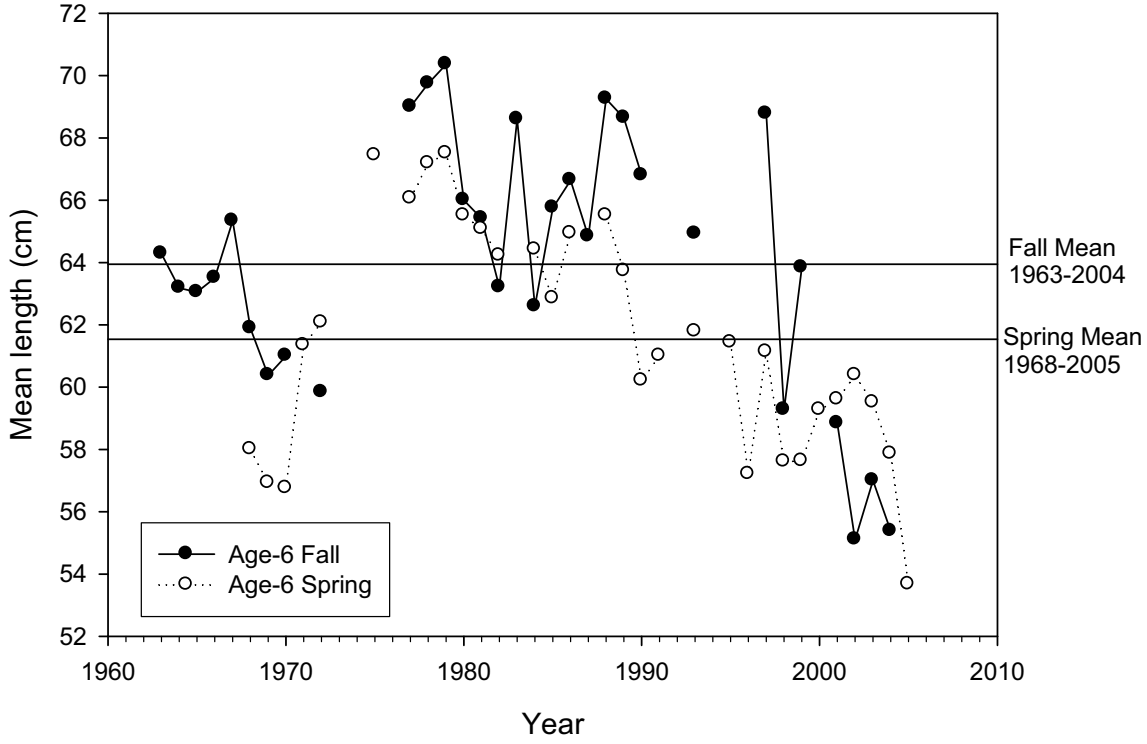


Figure 10.8. Georges Bank haddock mean length at age-7 NEFSC spring and fall surveys, 1963-2005.

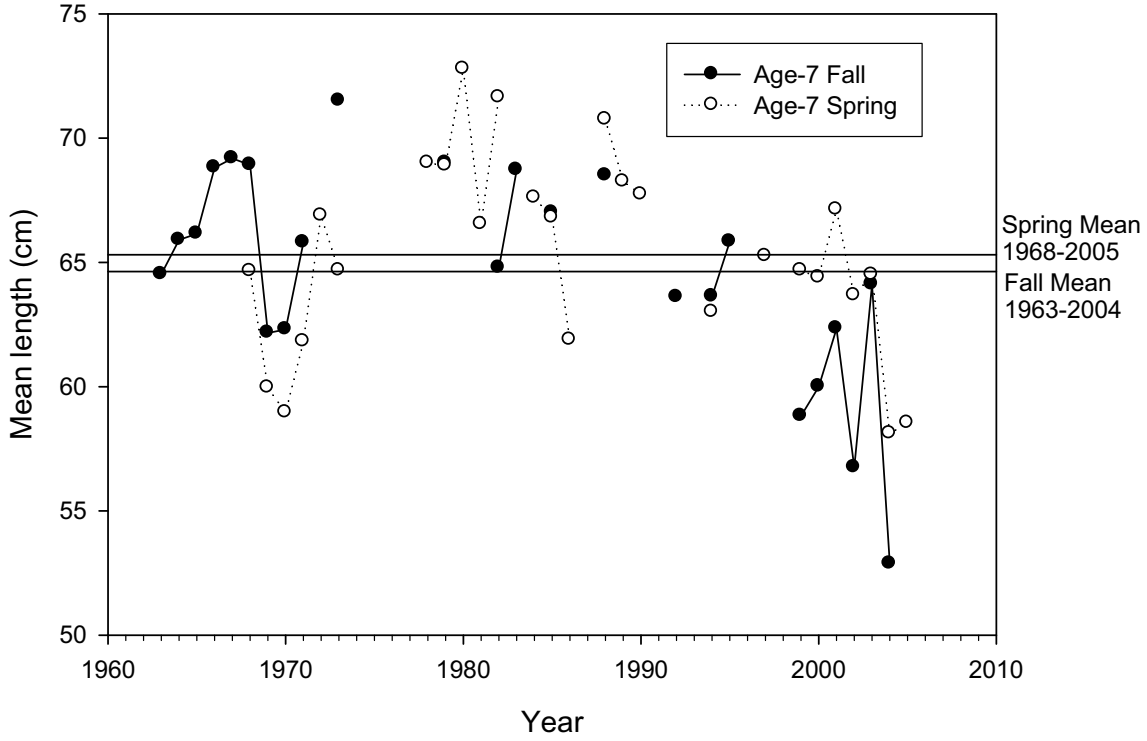


Figure 10.9. Georges Bank haddock mean length at age-8 NEFSC spring and fall surveys, 1963-2005.

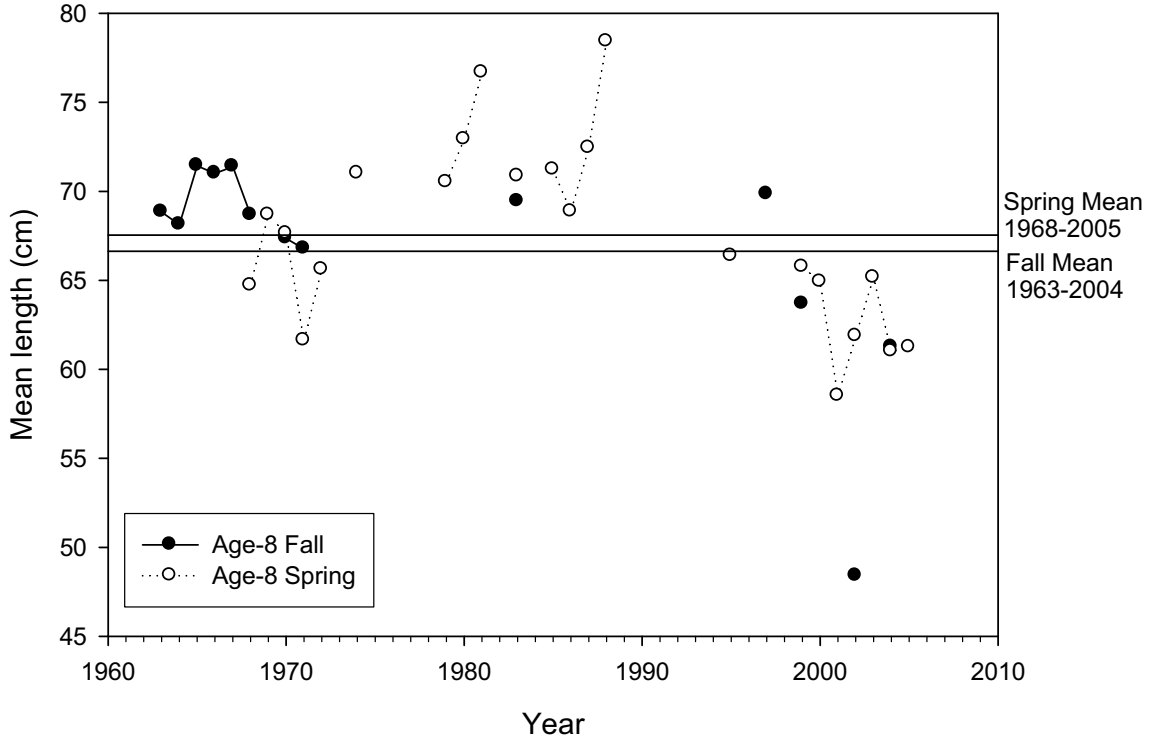


Figure 10.10. Georges Bank haddock mean length at age-9 NEFSC spring and fall surveys, 1963-2005.

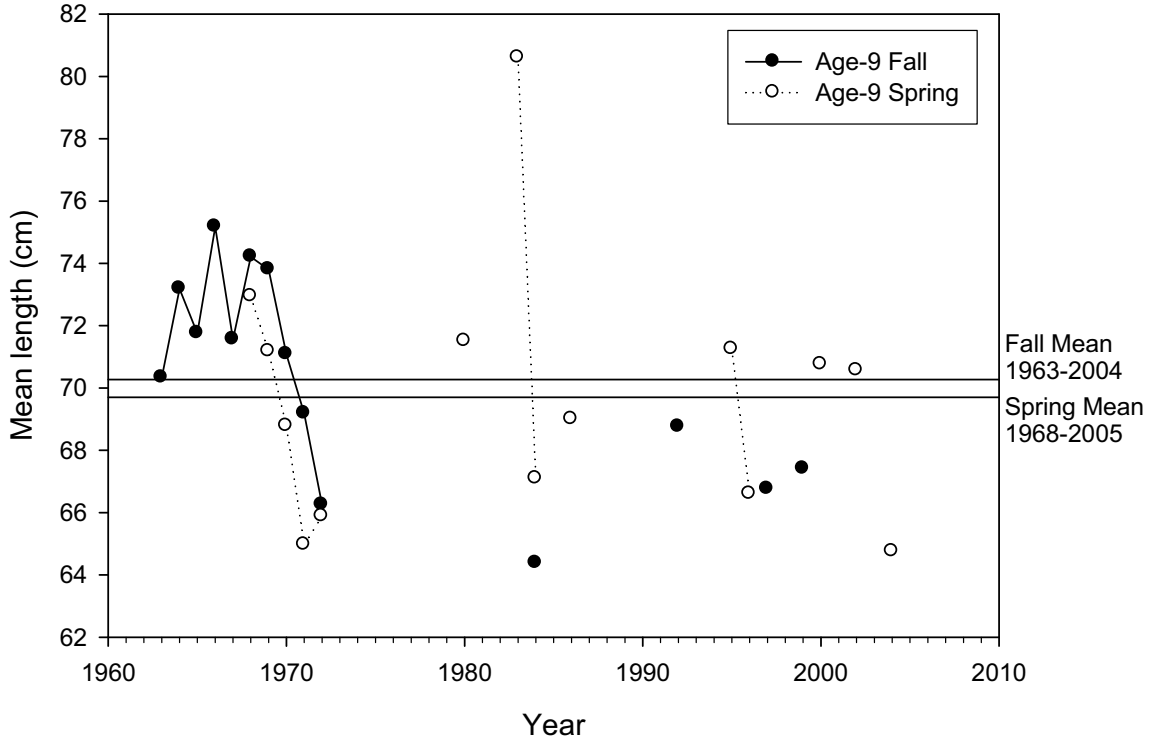


Figure 11.1. Georges Bank haddock spring length-weight relationships during NEFSC spring survey, 1992-2000.

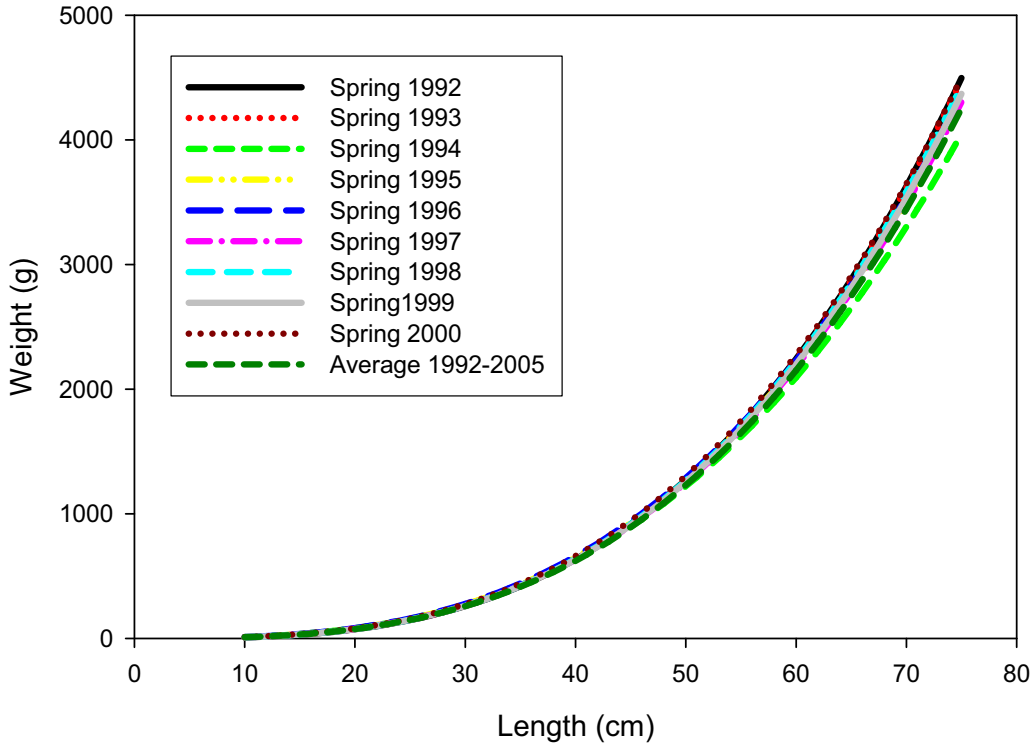


Figure 11.2. Georges Bank haddock spring length-weight relationships during NEFSC spring survey, 2001-2005.

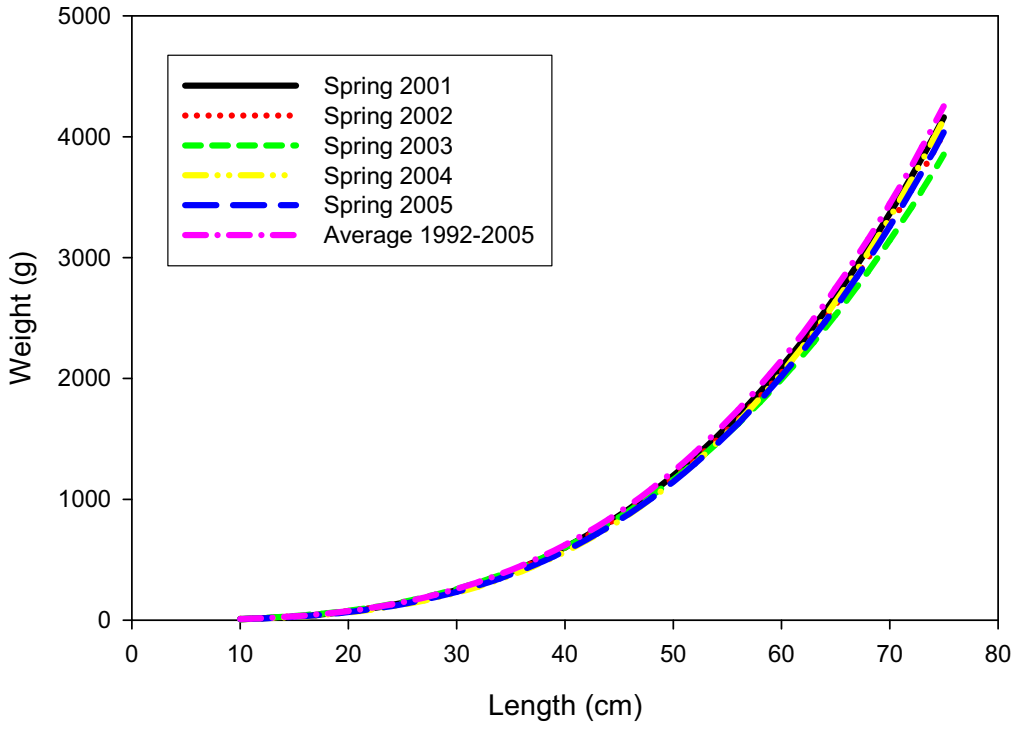


Figure 11.3. Georges Bank haddock spring length-weight relationships during NEFSC autumn survey, 1992-2000.

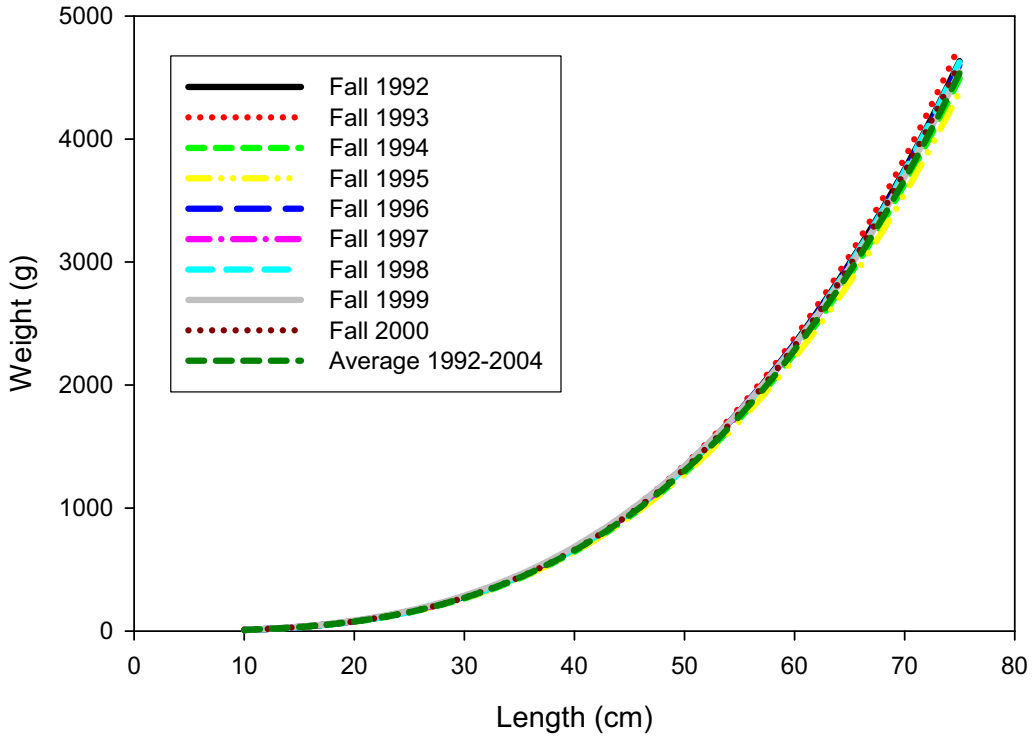


Figure 11.4. Georges Bank haddock spring length-weight relationships during NEFSC autumn survey, 2001-2004.

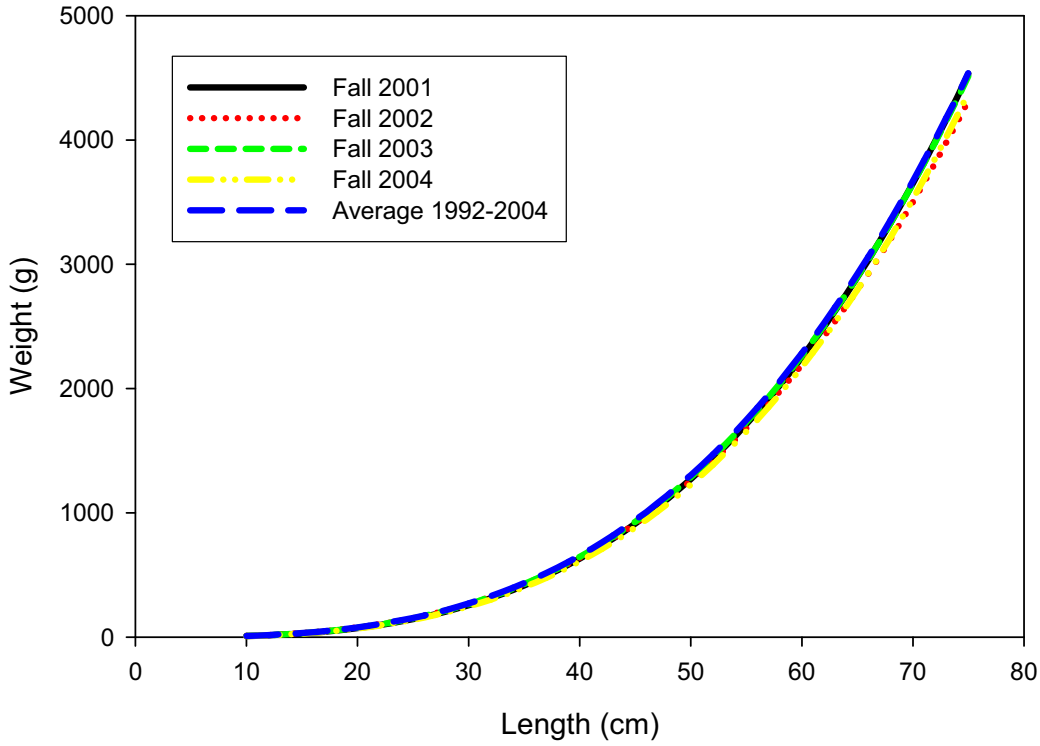


Figure 12.1. Georges Bank haddock spring predicted weight at length during NEFSC spring surveys, 1992-2005.

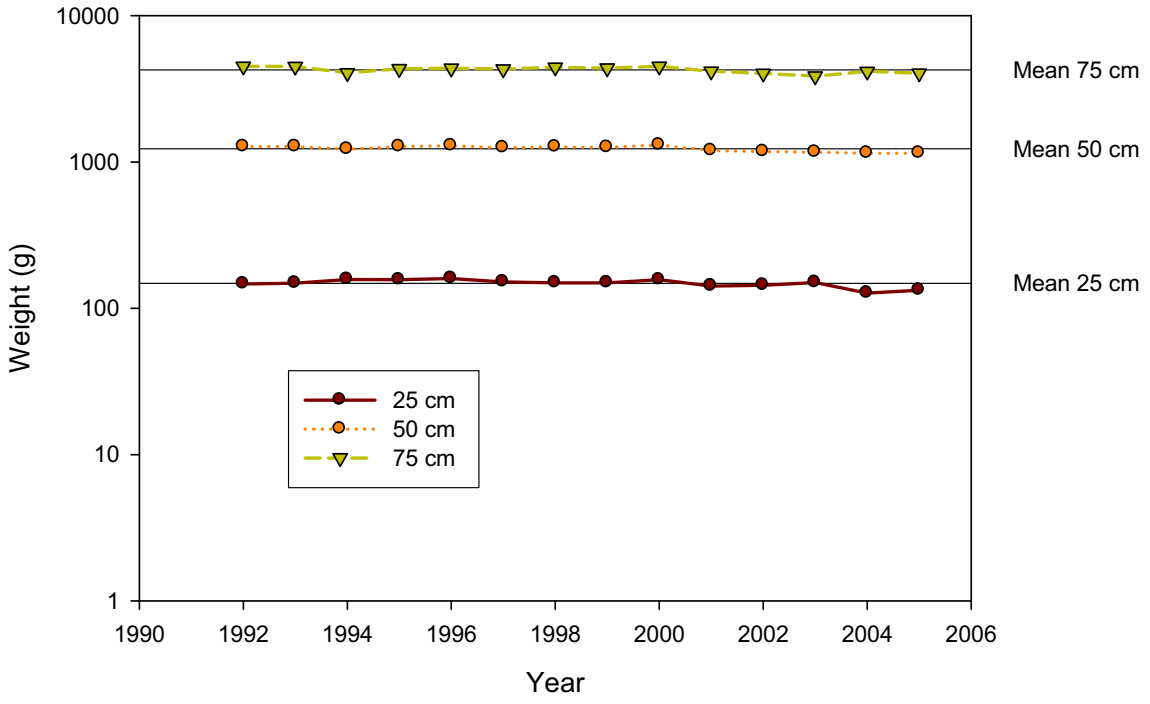


Figure 12.2. Georges Bank haddock fall predicted weight at length during NEFSC fall surveys, 1992-2004.

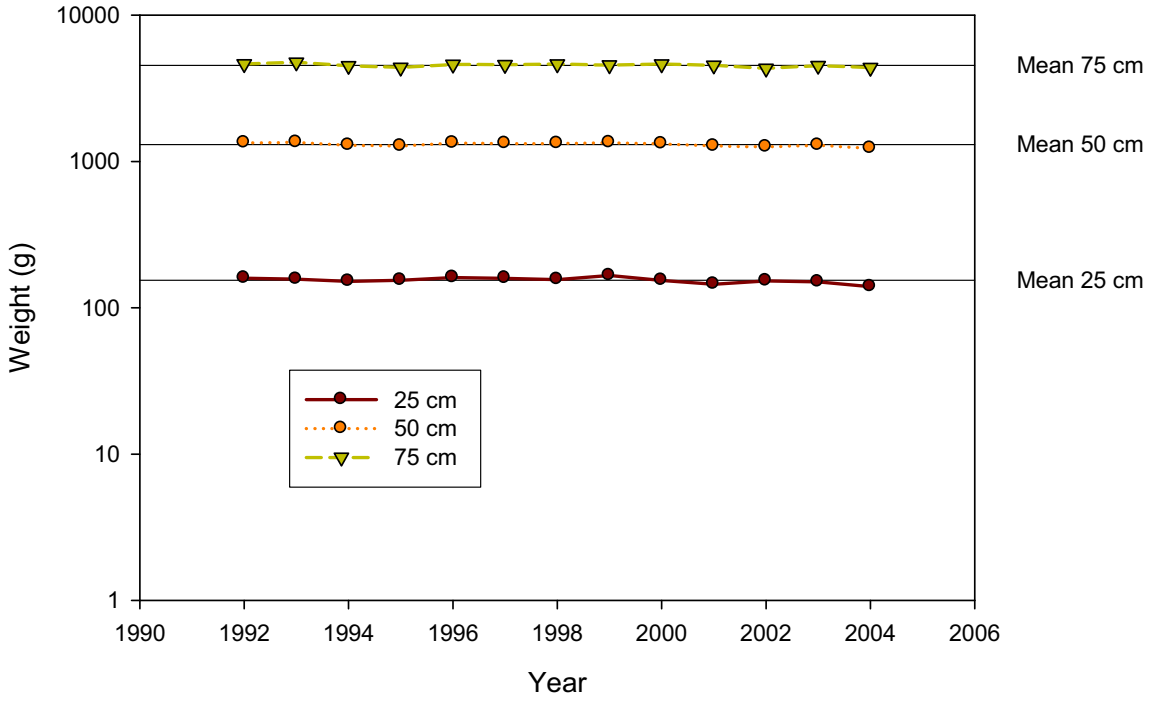


Figure 13. Georges Bank haddock standardized VPA tuning residuals, age-2 through age-8 by survey (NMFS Spring: 1968-72 and 1982-2005; NMFS Spring41: 1973-1981; NMFS Autumn: 1963-2004; Canadian Winter: 1986-2004).

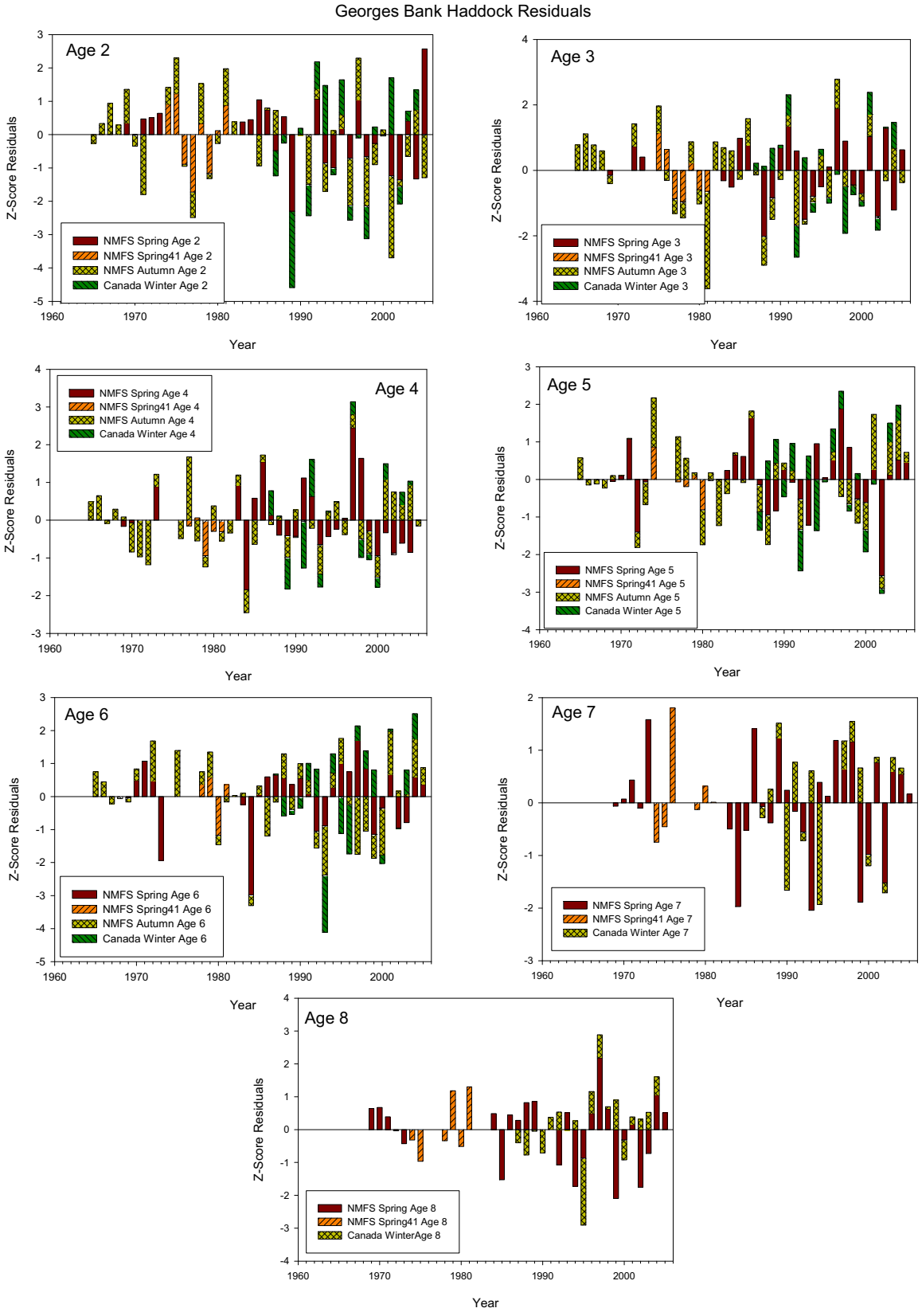


Figure 14.1. VPA estimates of Georges Bank haddock total stock size (age-1 and older at the start of the year), 1963-2005.

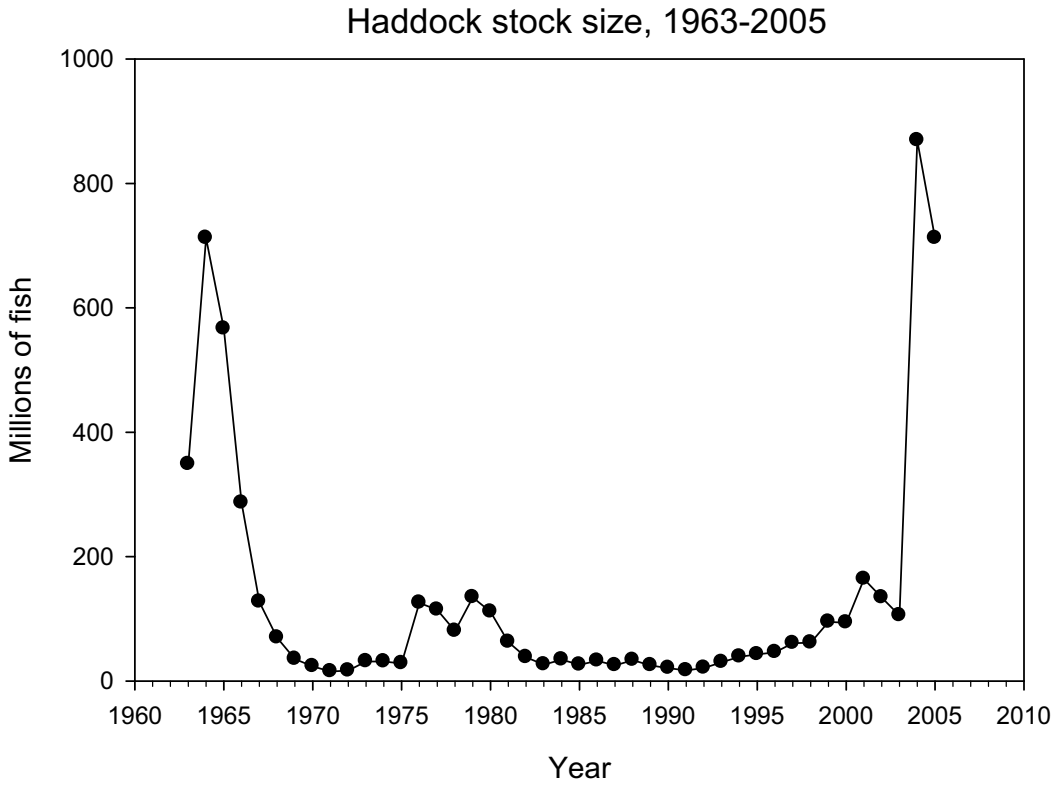


Figure 14.2. VPA estimates of Georges Bank haddock spawning biomass (total weight of mature fish at mid-point of spawning season), 1963-2004.

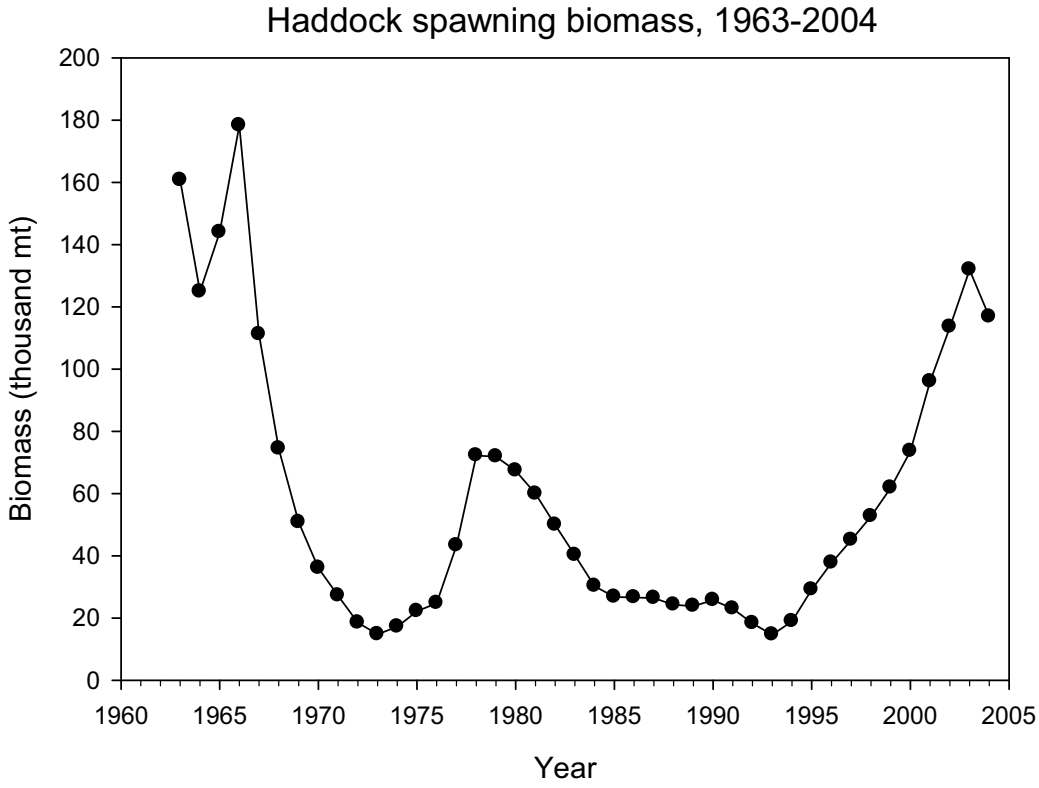


Figure 14.3. VPA estimates of Georges Bank haddock fishing mortality (ages 4-7, unweighted), 1963-2004.

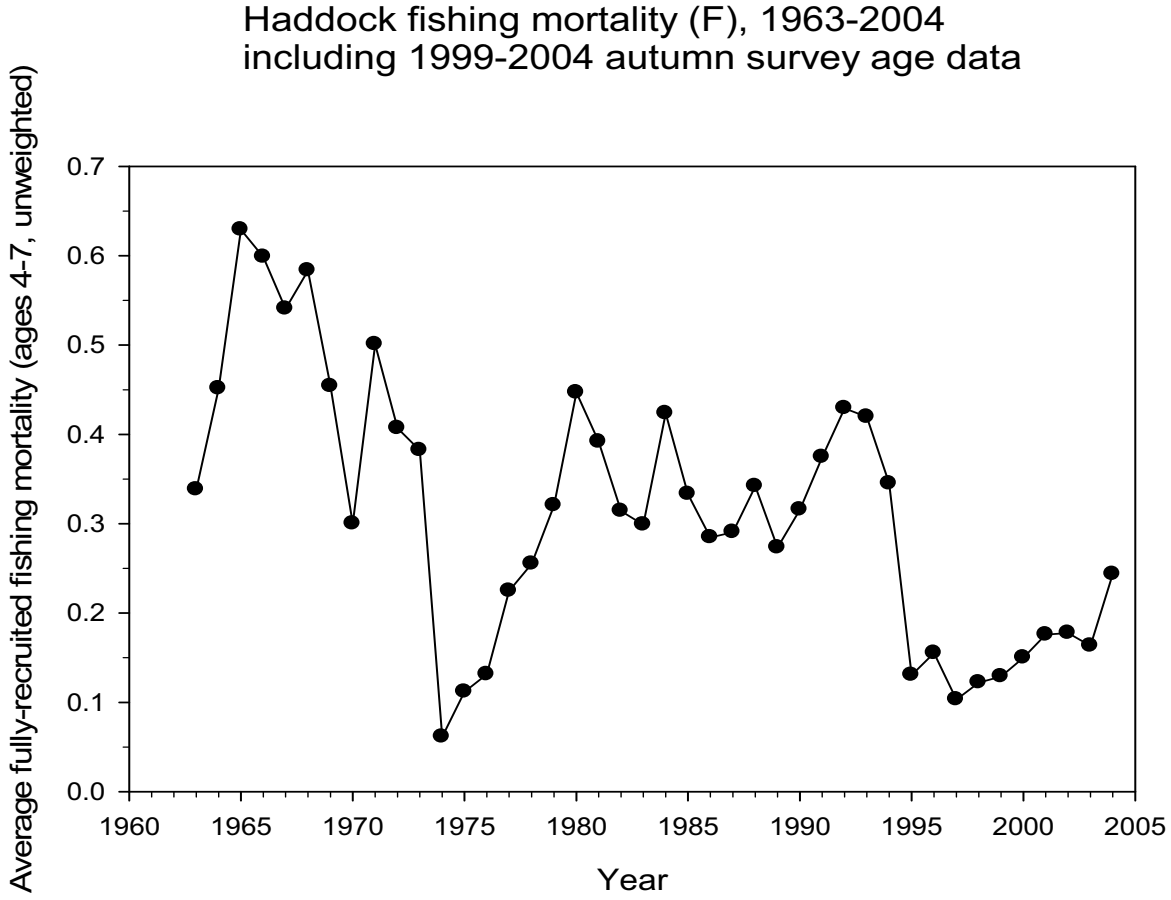


Figure 14.4. VPA estimates of Georges Bank haddock recruitment, 1963-2005.

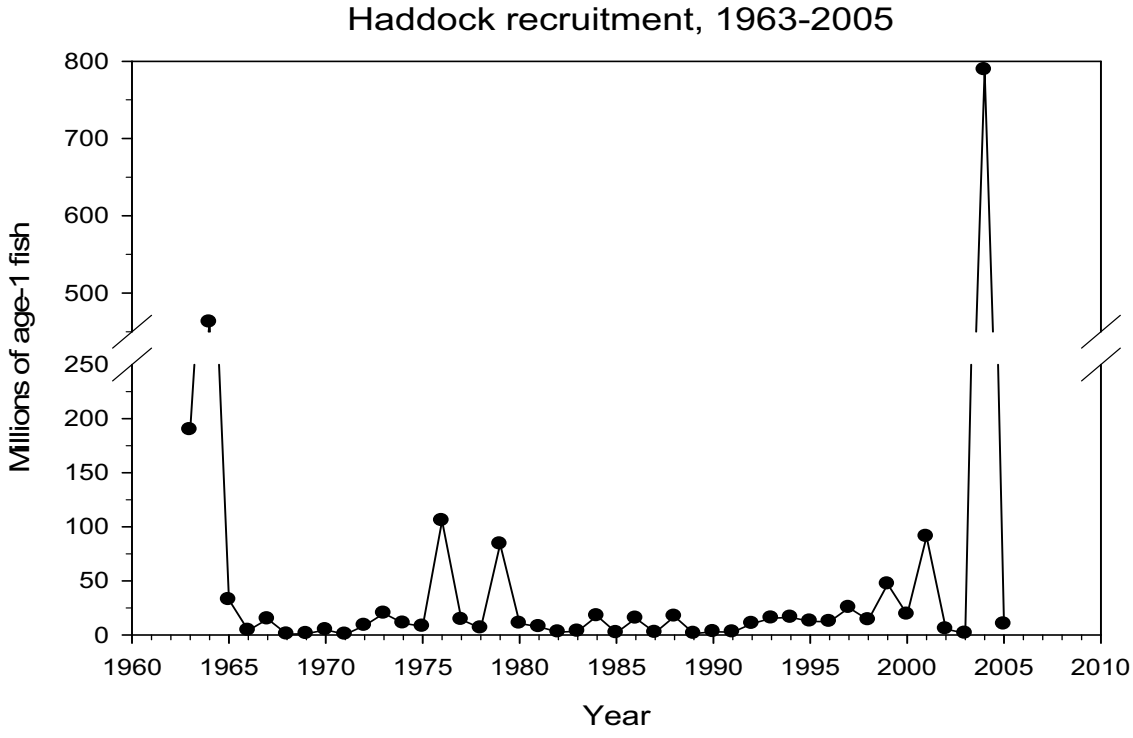


Figure 15. Georges Bank haddock distribution of recruitment and spawning stock biomass above and below 75 kt of spawning stock biomass, 1931-2004.

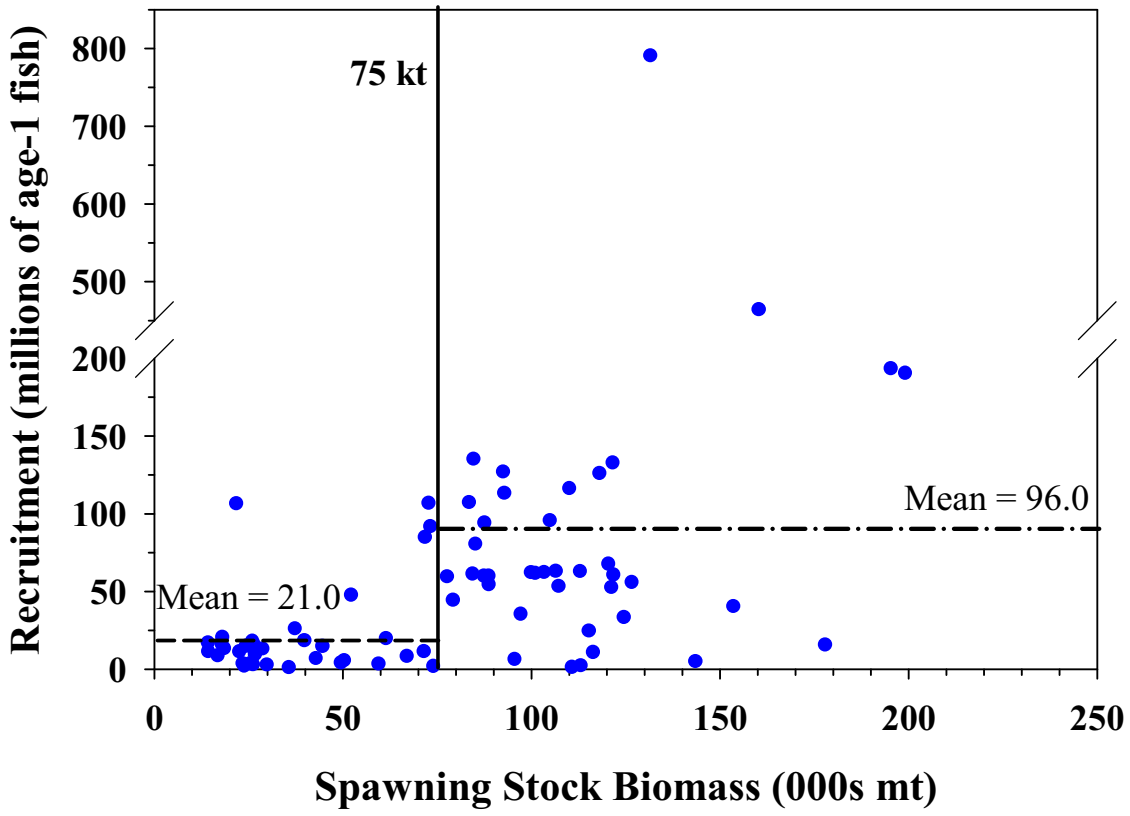


Figure 16. Georges Bank haddock survival ratios, 1931-2004.

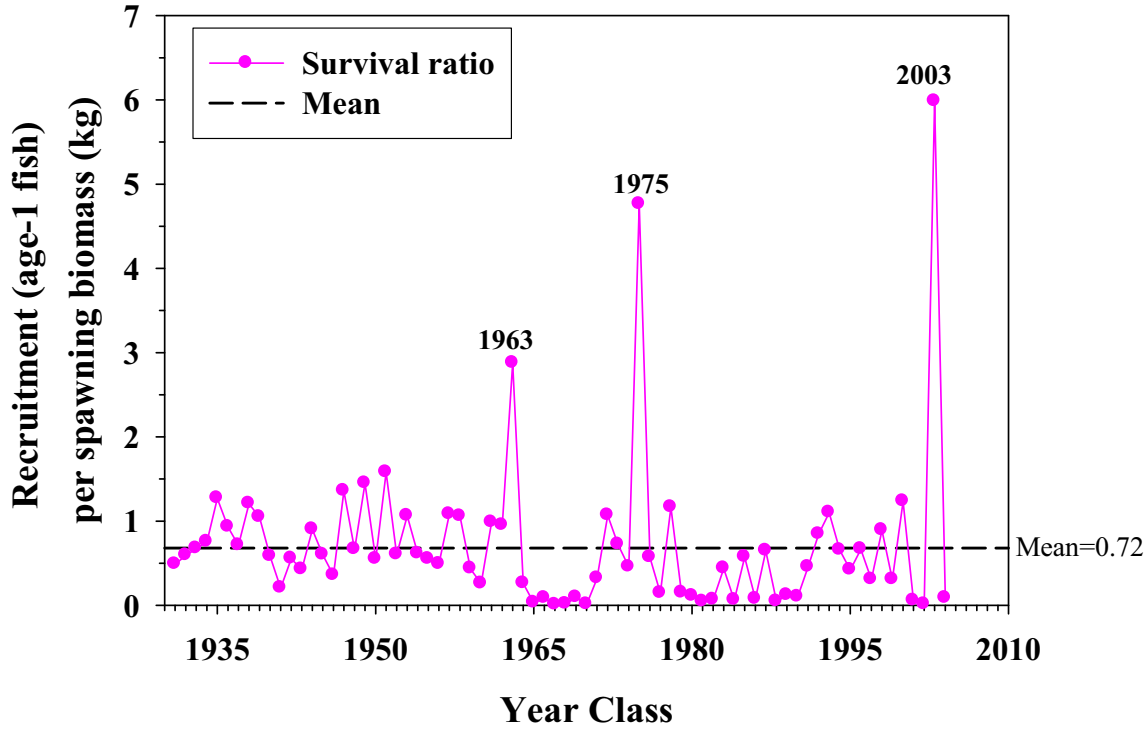


Figure 17.1. Upper and lower 80% confidence intervals (CI) for 1995-2005 estimates of Georges Bank haddock stock size from bootstrap analysis.

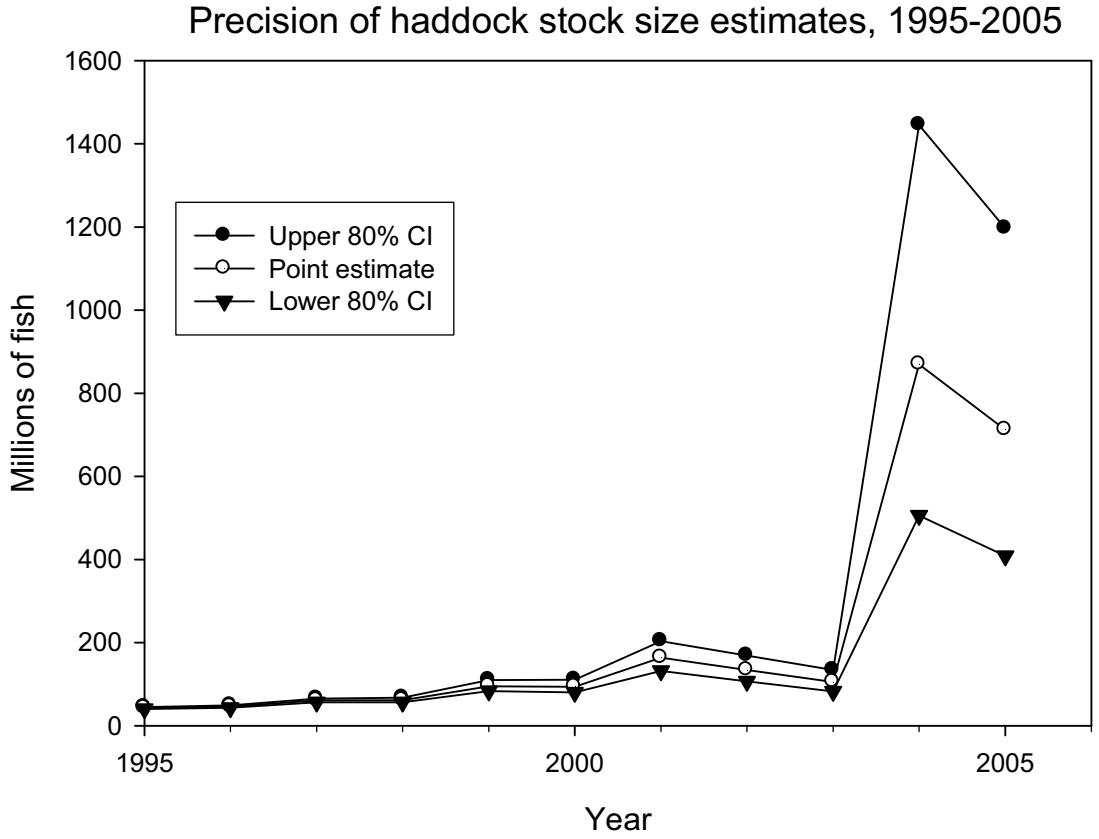


Figure 17.2. Upper and lower 80% confidence intervals (CI) for 1995-2004 estimates of Georges Bank haddock spawning biomass from bootstrap analysis.

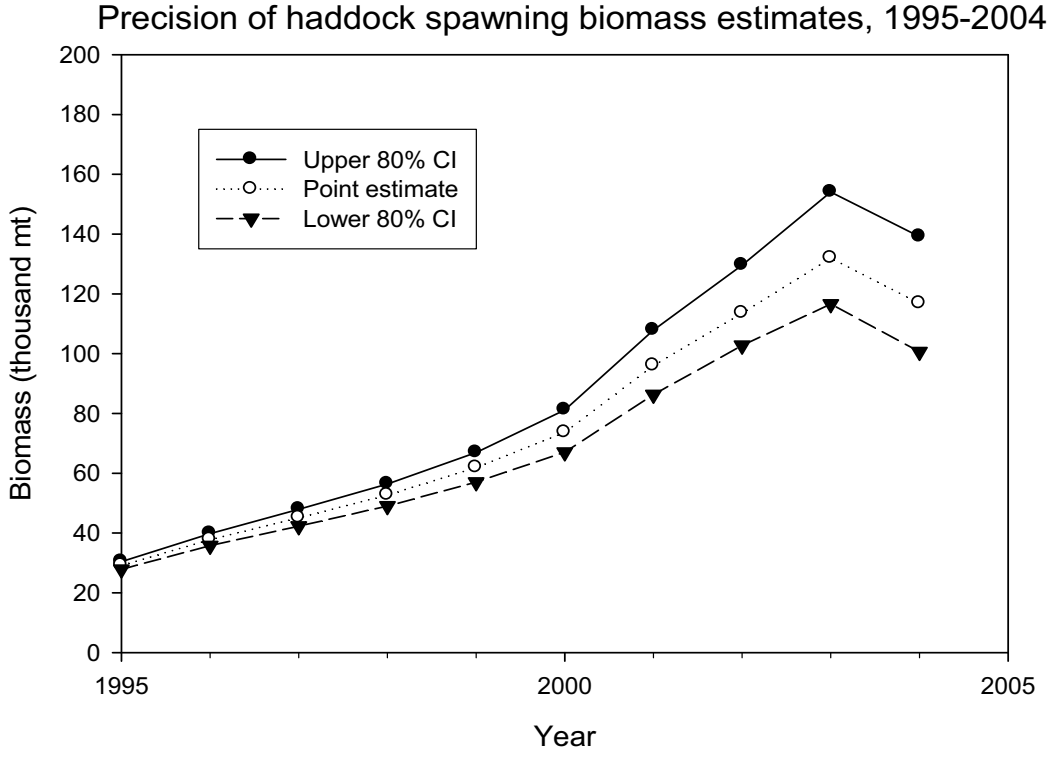


Figure 17.3. Upper and lower 80% confidence intervals (CI) for 1995-2004 estimates of Georges Bank haddock fishing mortality from bootstrap analysis.

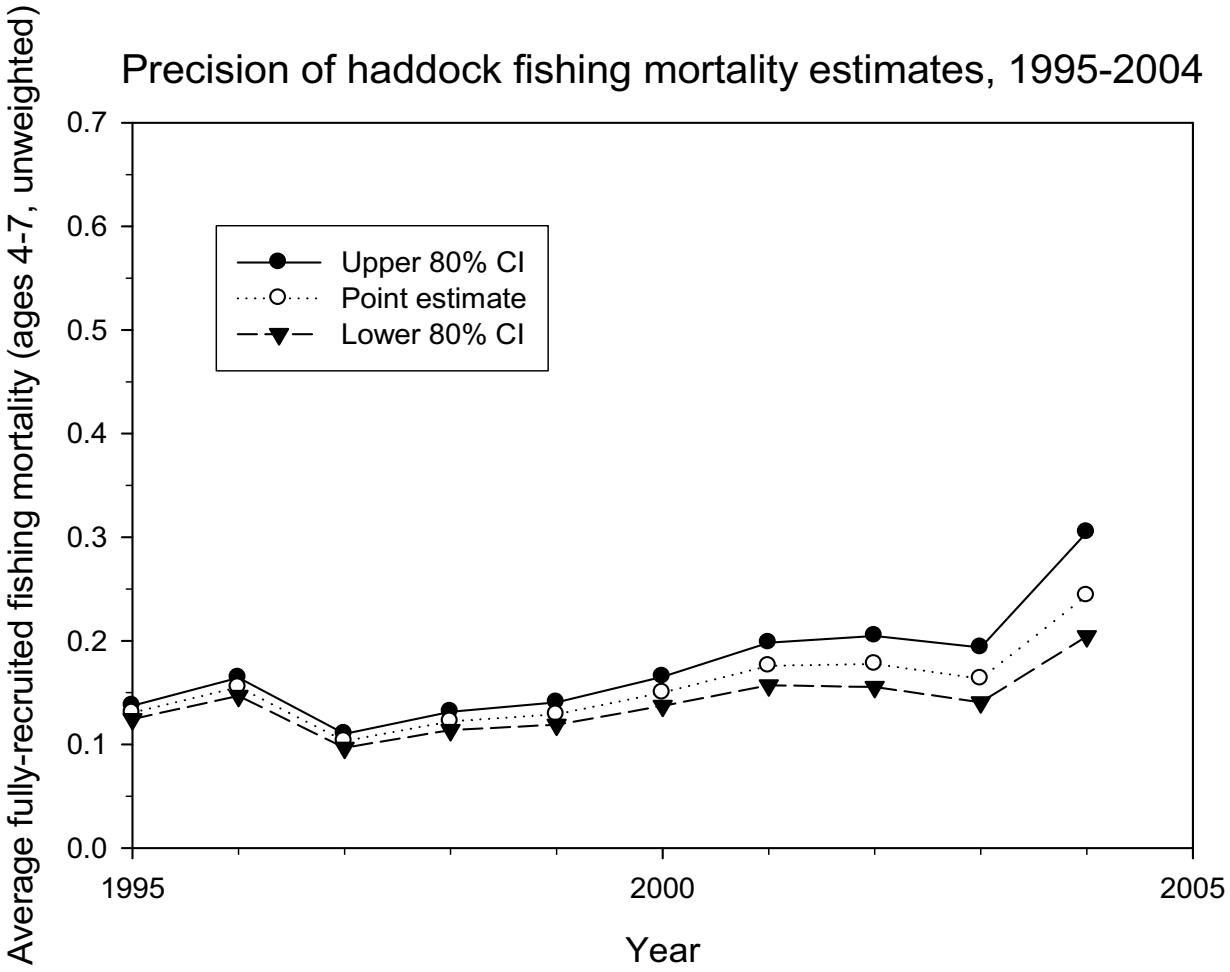


Figure 18.1. Bootstrap distribution of estimate of the 2003 Georges Bank haddock year class size at age-1 in 2004.

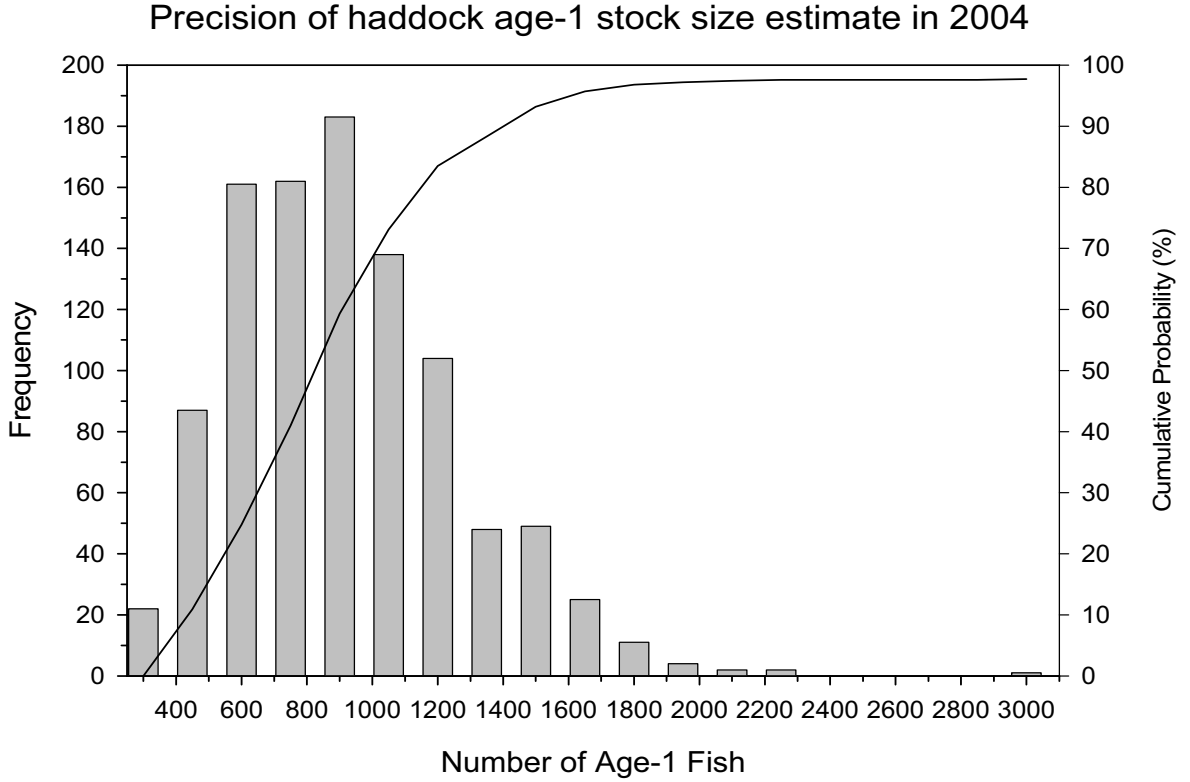


Figure 18.2. Bootstrap distribution of estimate of the 2003 Georges Bank haddock year class size at age-2 in 2005.

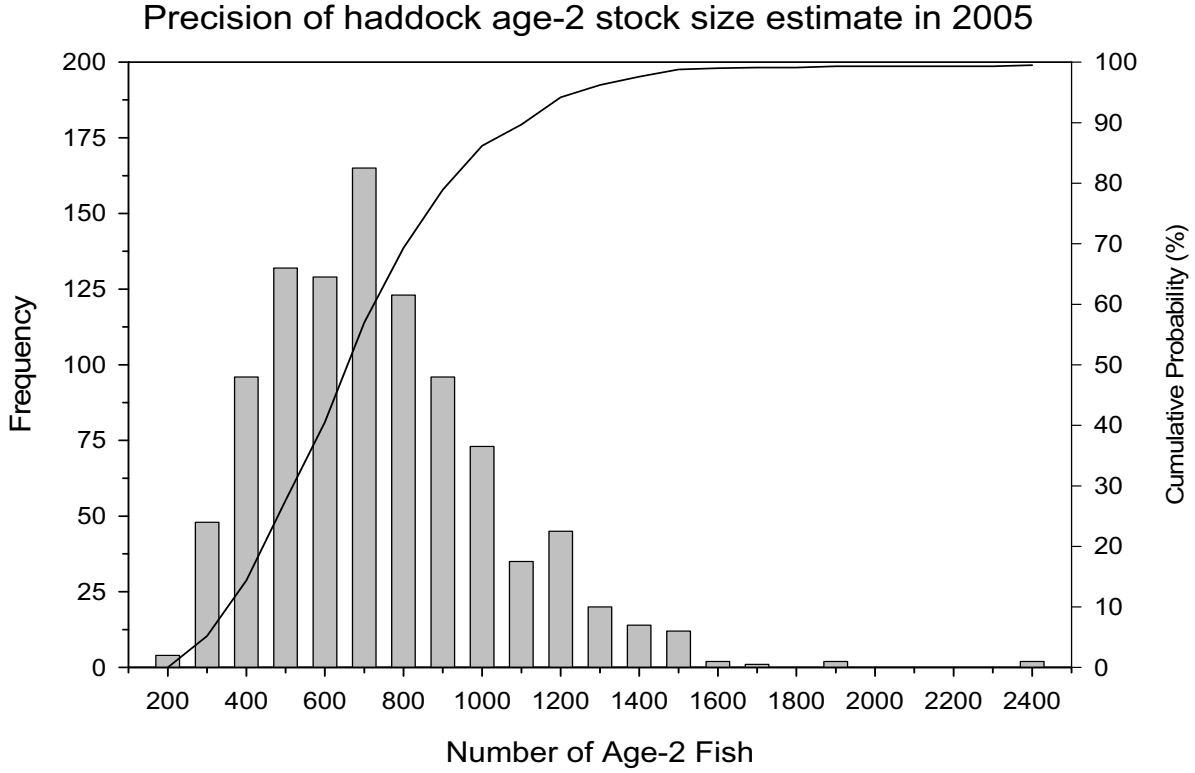
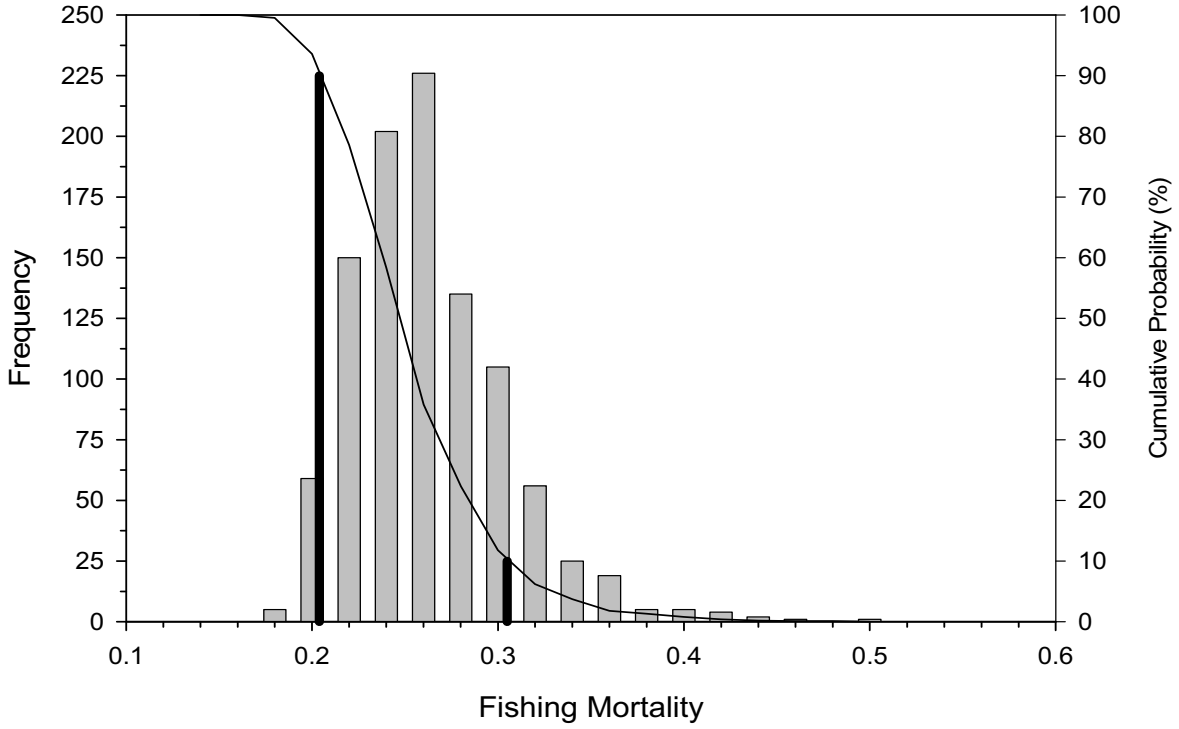
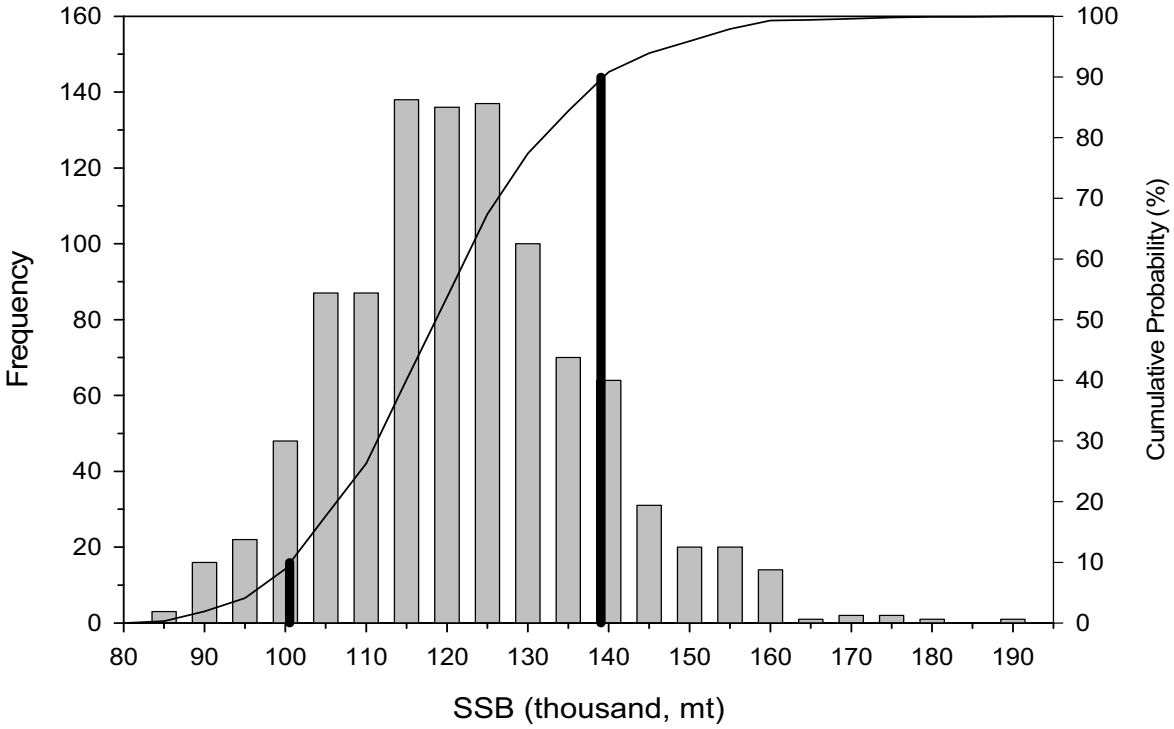


Figure 19. Precision of 2004 estimates of fishing mortality and spawning.



Precision of the estimated fully recruited F in 2004 based on 1000 bootstrap realizations of the VPA for Georges Bank Haddock.



Precision of the estimated spawning stock biomass in 2004 based on 1000 bootstrap realizations of the VPA for Georges Bank Haddock.

Figure 20.1. Retrospective analysis of VPA estimates of Georges Bank haddock spawning biomass, 1999-2004.

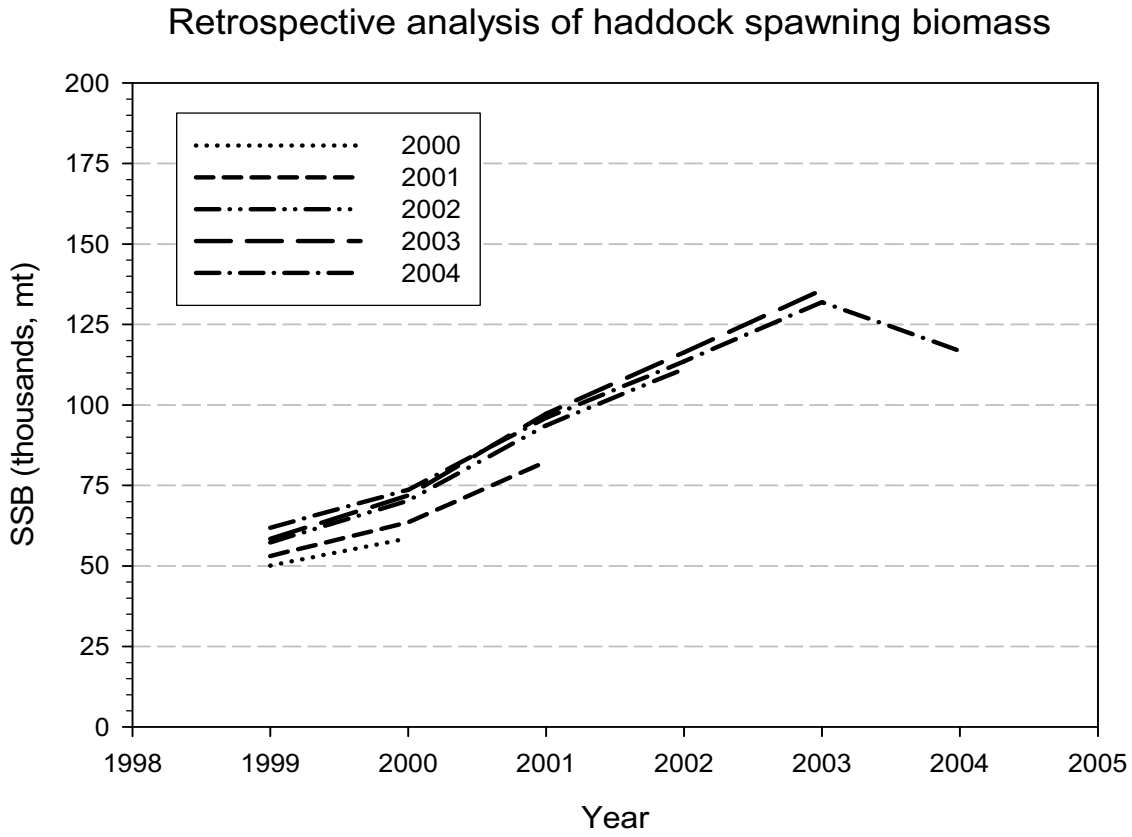


Figure 20.2. Retrospective analysis of VPA estimates of Georges Bank haddock fishing mortality, 1999-2004.

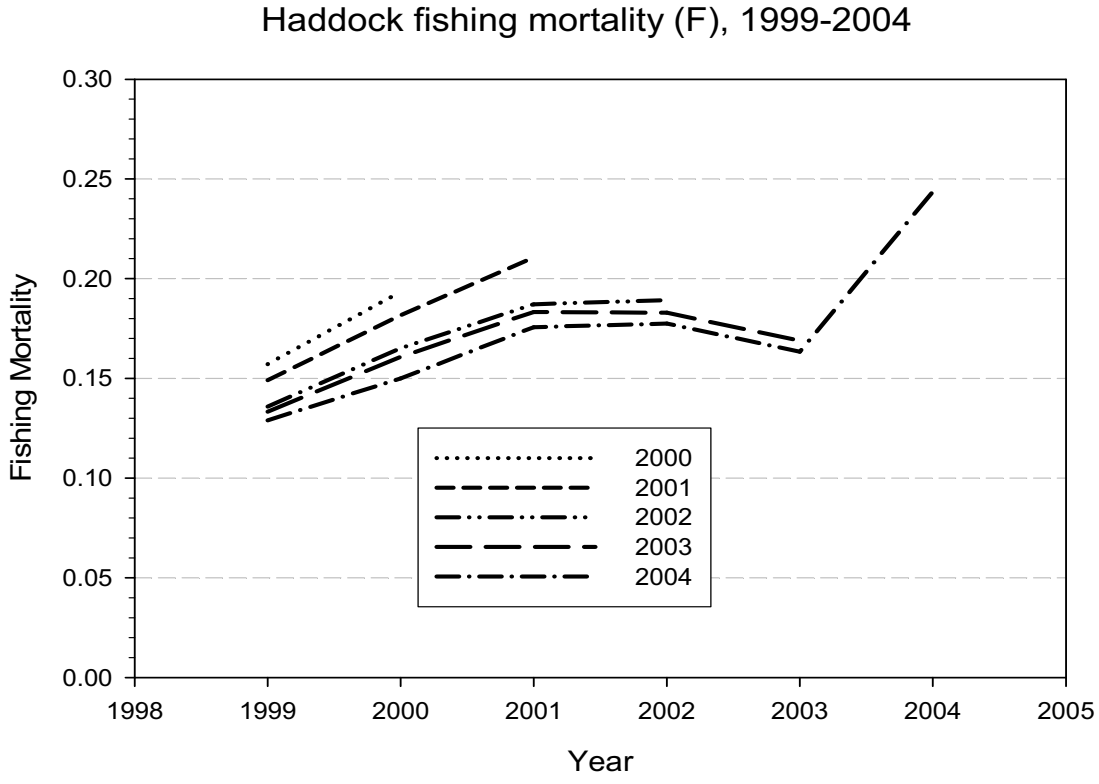


Figure 20.3. Retrospective analysis of VPA estimates of Georges Bank haddock recruitment, 1999-2004.

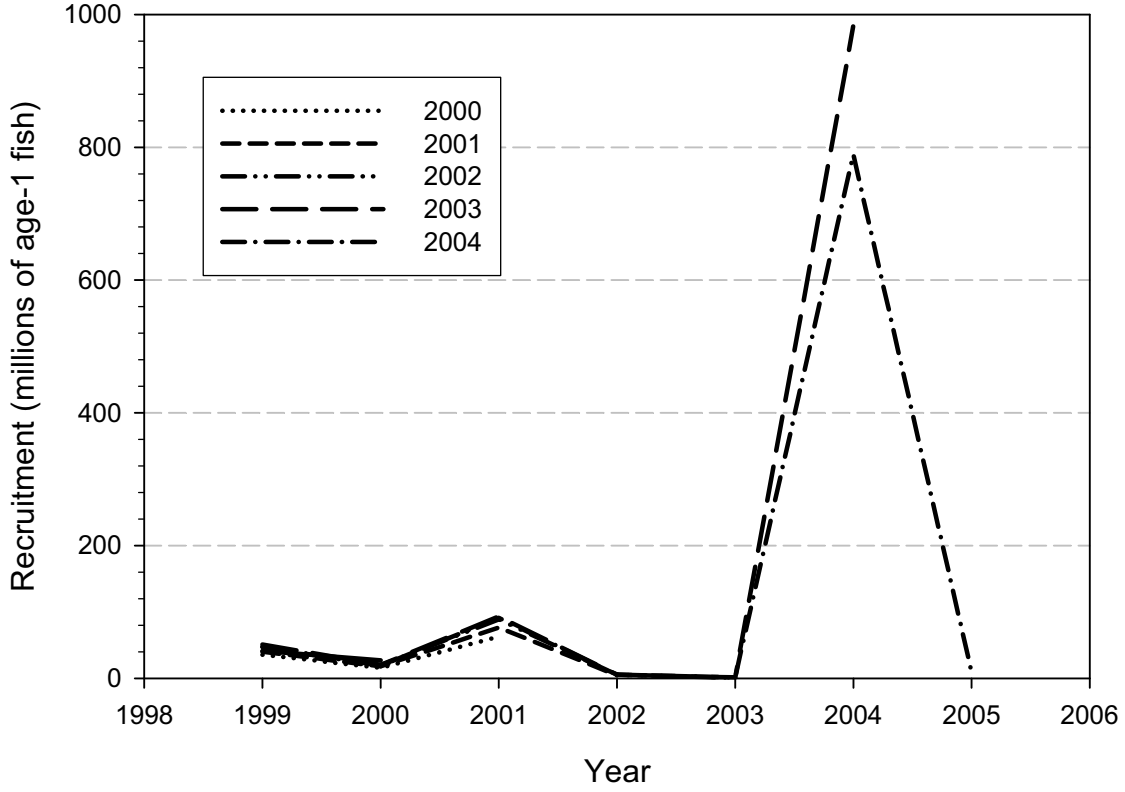


Figure 21. Trends in spawning stock biomass (line) and recruitment (bars) for Georges Bank haddock from 1931-2004.

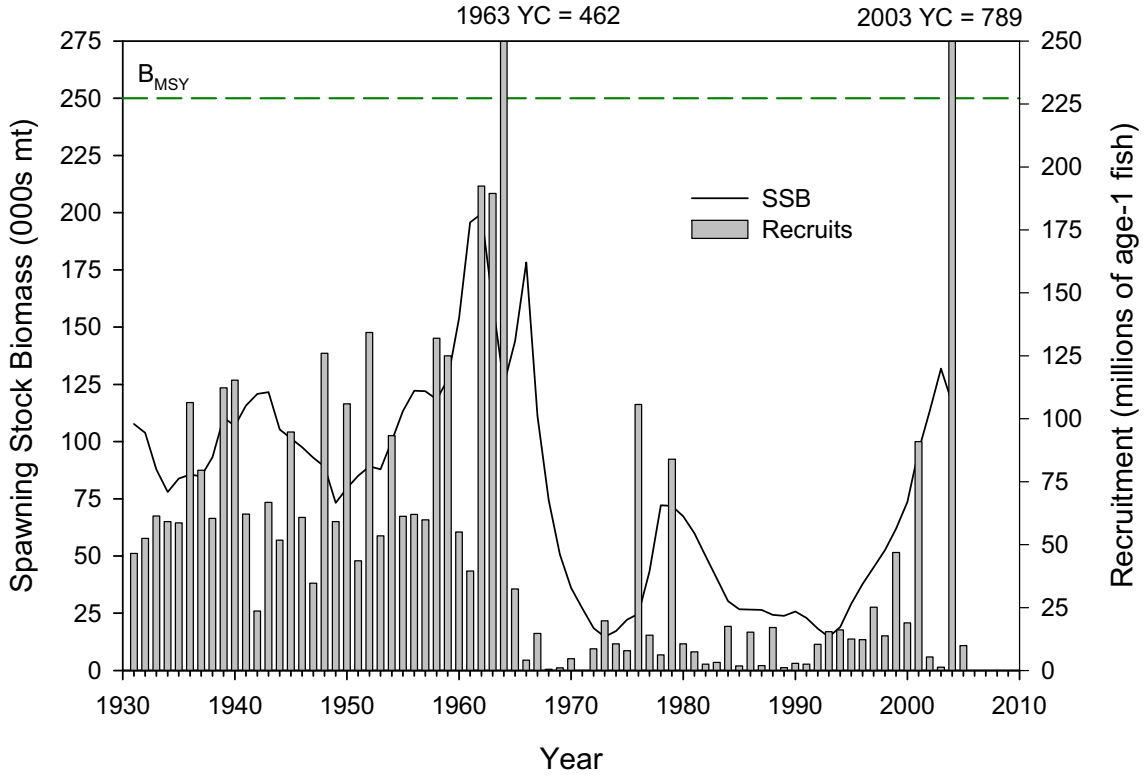


Figure 22. Trends in commercial catch biomass (shaded area, thousand mt) and fishing mortality (solid line, unweighted average for ages 4-7) for Georges Bank haddock, 1931-2004.

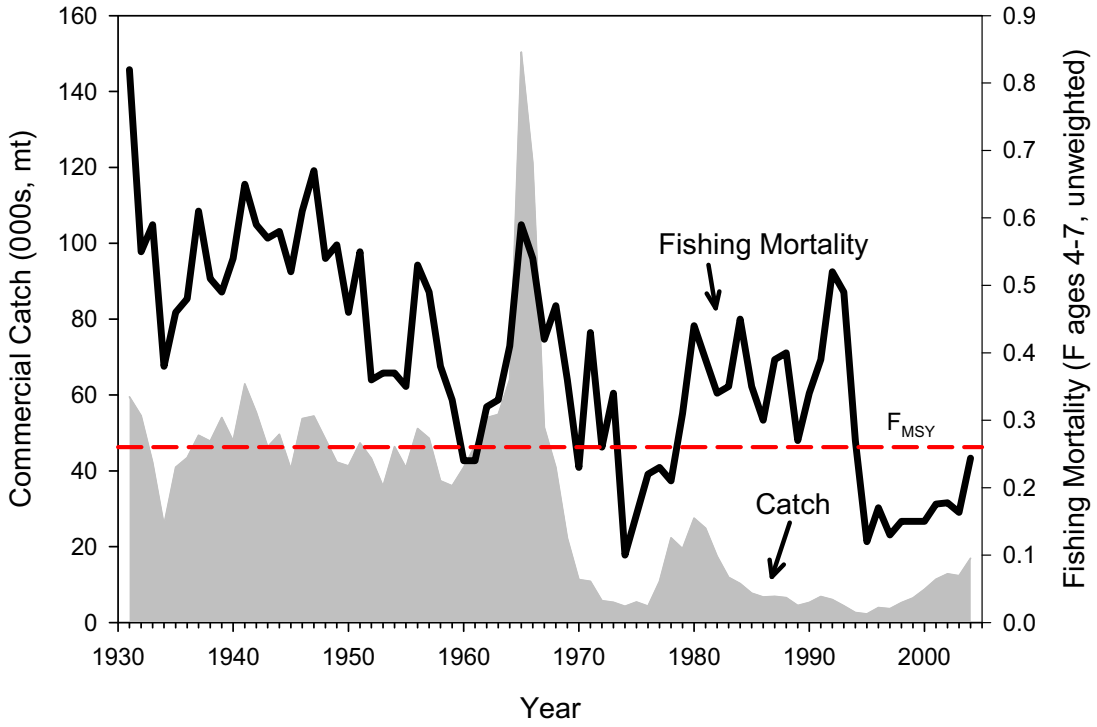


Figure 23.1. Projected Georges Bank haddock spawning biomass (SB) under Amendment 13 Rebuilding Plan and 80% confidence interval along with 2004 estimate of SB with +/- 1 standard error.

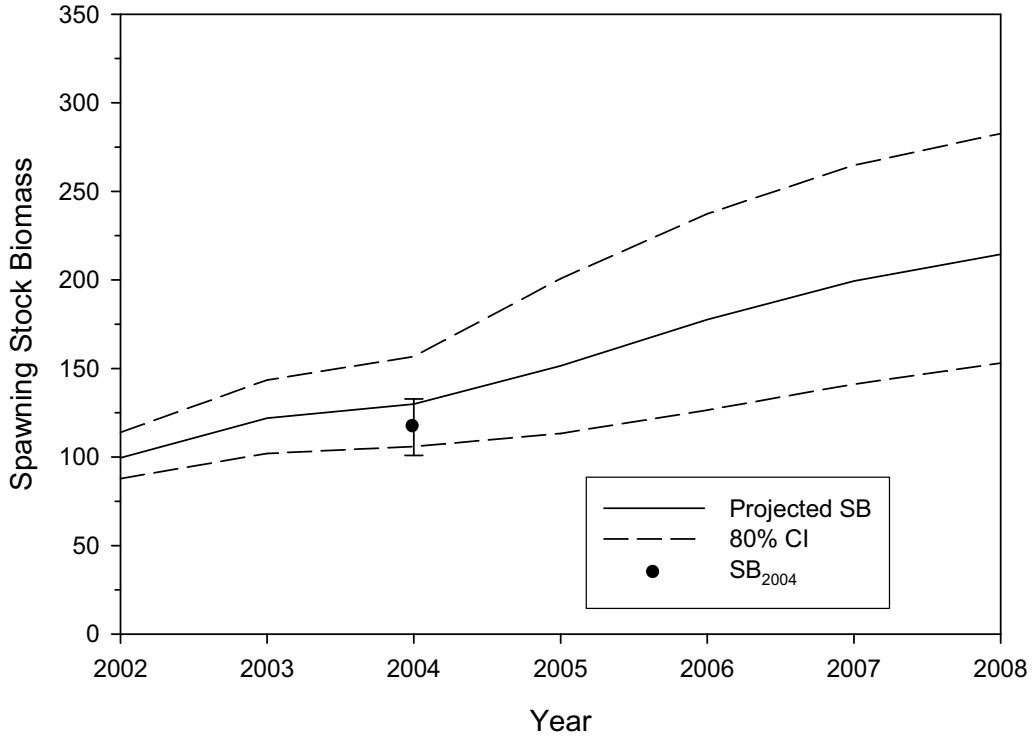
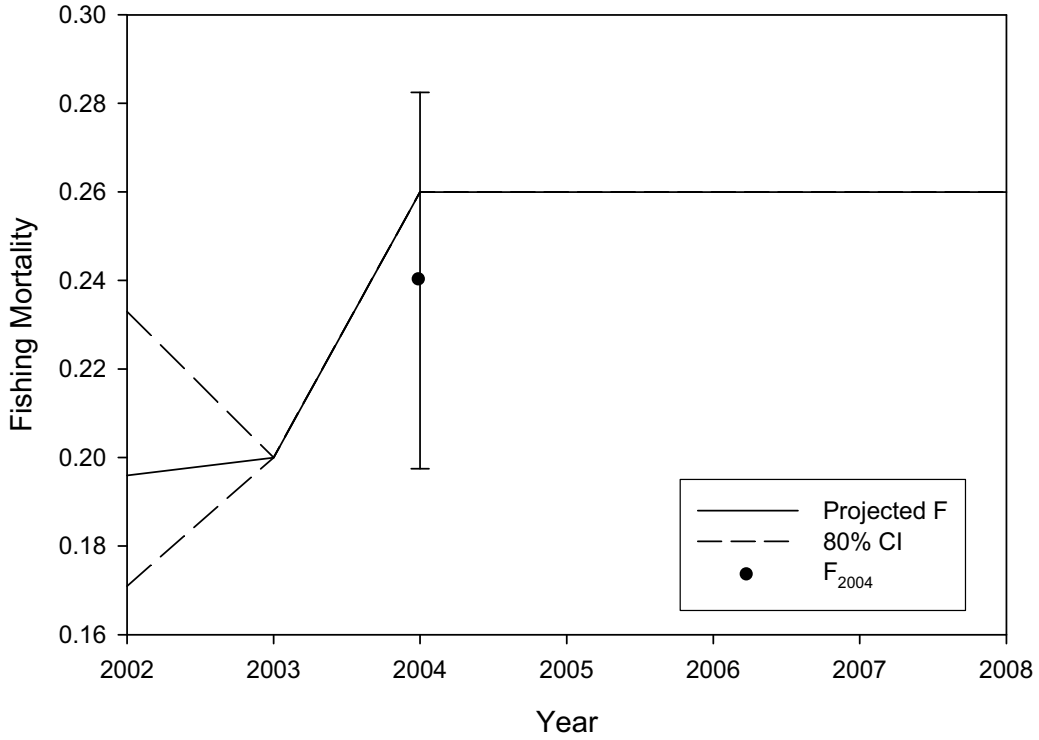


Figure 23.2. Projected Georges Bank haddock fishing mortality (F) under Amendment 13 Rebuilding Plan and 80% confidence interval along with 2004 estimate of F with +/- 1 standard error.



Appendix. Evaluation of accuracy and precision of U.S. haddock aging during 2004–2005.

A.1. Introduction

For decades, US and Canadian scientists have routinely determined the ages of Georges Bank haddock (*Melanogrammus aeglefinus*) collected from the commercial fishery and research surveys and have used the same otolith aging approaches. These production aging data have provided important size-at-age information for conducting the analytical VPA assessment. In the spring of 2004, a new set of quality control tests were initiated to evaluate the amount of aging error and bias associated with production ages. In this context, tests of age reader accuracy can be thought of as how often the correct age is obtained while tests of precision reflect how often the same age is obtained (Campana 2001). Such measures are important components of a quality control monitoring program.

Acceptable levels of age determination accuracy and precision are highly influenced by species, age structure, and age reader experience. Although percent agreement is affected by these factors, the Northeast Fisheries Science Center (NEFSC) aging lab has long considered percent agreement levels above 85–90% to be acceptable for most species. In terms of the total coefficient of variation (CV), various aging labs around the world consider levels under 5% to be acceptable for species of moderate longevity and aging complexity (Campana 2001), such as haddock.

A.2. Methods

Accuracy of age determination was measured by re-aging a portion (50–100 fish) of the haddock reference collection. Accuracy tests were conducted after completion of production aging in August 2004 and June 2005. This allowed for detection and quantification of any age reader bias. In the future, accuracy tests will also be conducted prior to production aging.

The reference collection consists of sectioned otoliths from Georges Bank haddock captured on various NEFSC spring and autumn bottom trawl surveys. Fish included in the annual aging exchange between NEFSC and the Canadian Department of Fisheries and Oceans, for which the ages were agreed upon by both U.S. and Canadian age readers, were added to the NEFSC haddock reference collection. Therefore, the reference age for each fish was reached by consensus among at least two age readers.

Precision tests were conducted soon after completion of each segment (survey or commercial quarter) of samples. These exercises were separated by stock area if production ages for the two stocks were determined at different times.

For these tests, a random sub-sample of about 50 (range 30–100) fish was selected from the production sample. This subsample was then re-aged by the age reader. When re-aging fish, the same data were available as during production aging, i.e. fish length, date captured, and area captured. Precision measurements were calculated by comparing the test ages generated during the exercise against the ages obtained for the same fish during production aging. These measures can quantify the amount of random error associated with a given production age, and indicate if any change occurred in the way fish are aged between the time of production aging and the test exercise.

Age-reader precision was estimated for haddock for all sets of production ages generated since the start of 2004. This includes U.S. commercial landings for all quarters of both 2003, where the Georges Bank (GB) and Gulf of Maine stocks were aged separately, and 2004, where stock areas were mixed during aging. U.S. bottom trawl surveys for which precision exercises were completed are as follows: 2003 Fall (GB), 2004 Spring (GB), 2004 Fall (mixed stocks), and 2005 Spring (mixed stocks).

During age-testing exercises, no attempts were made to improve results with repeated readings. There was also no attempt to revise the original production ages in cases where differences occurred. Results are presented in terms of percentage agreement, total coefficient of variation (CV), age bias plots, and age agreement matrices (Campana et al. 1995; Campana 2001). In cases where the percent agreement dropped below 90%, a Bowker's test (Bowker 1948; Hoenig et al. 1995) was also used to measure symmetry.

A.3. Results and Discussion

A total of 157 haddock were used in the two accuracy tests, including fish with reference ages of up to 12 years. In these exercises, the age reader achieved total CVs of 2.3% and 1.3%, with 90% and 94% agreement respectively (Table A1, Figures A1–A2). This represents an acceptable level of accuracy for this species.

For the four precision exercises on survey samples, a total of 291 haddock were included, with production ages of up to 9–13 years in each exercise. For the commercial samples, 357 haddock were used in eight precision exercises. These exercises included fish with maximum production ages of 10–12 years. Results are presented in Figures A3–A14, and summarized in Table A2.

For all haddock precision exercises, a median total CV level of 0.8% and a median of 94% agreement were attained. These values ranged between 0.2% and 2.6% total CV, with 76% to 98% agreement (Table A2, Figures A3–A14). The agreement level fell below 90% in the four exercises on 2003 commercial samples. In all these cases, the Bowker's test found no significant deviation from symmetry ($P>0.25$). These results indicate a high level of consistency in age determinations for this species.

For the 49 fish (8% of all fish that were re-aged) in which the production and test ages differed, only three fish differed by 2 years, and none differed by 3 or more years. There may have been a modest bias toward subtracting one year while determining test ages, however, as there were 29 fish in which the age dropped by one year between the two readings, and only 17 fish for which the age was raised by one year.

The relatively high accuracy obtained in re-aging samples from the Georges Bank reference collection and the consistently high precision of age readings supports the conclusion that recent age determinations for Georges Bank haddock have been adequate for stock assessment purposes.

A.4. References.

Bowker AH. 1948. A test for symmetry in contingency tables. J. Am. Stat. Assoc. 43:572–574.

Campana SE, Annand MC, McMillan JI. 1995. Graphical and statistical methods for determining the consistency of age determinations. Trans. Am. Fish. Soc. 124:131-138.

Campana SE. 2001. Accuracy, precision, and quality control in age determination, including a review of the use and abuse of age validation methods. J. Fish. Biol. 59:197-242.

Hoenig JM, Morgan MJ, Brown CA. 1995. Analysing differences between two age determination methods by tests of symmetry. Can. J. Fish. Aquat. Sci. 52:364-368.

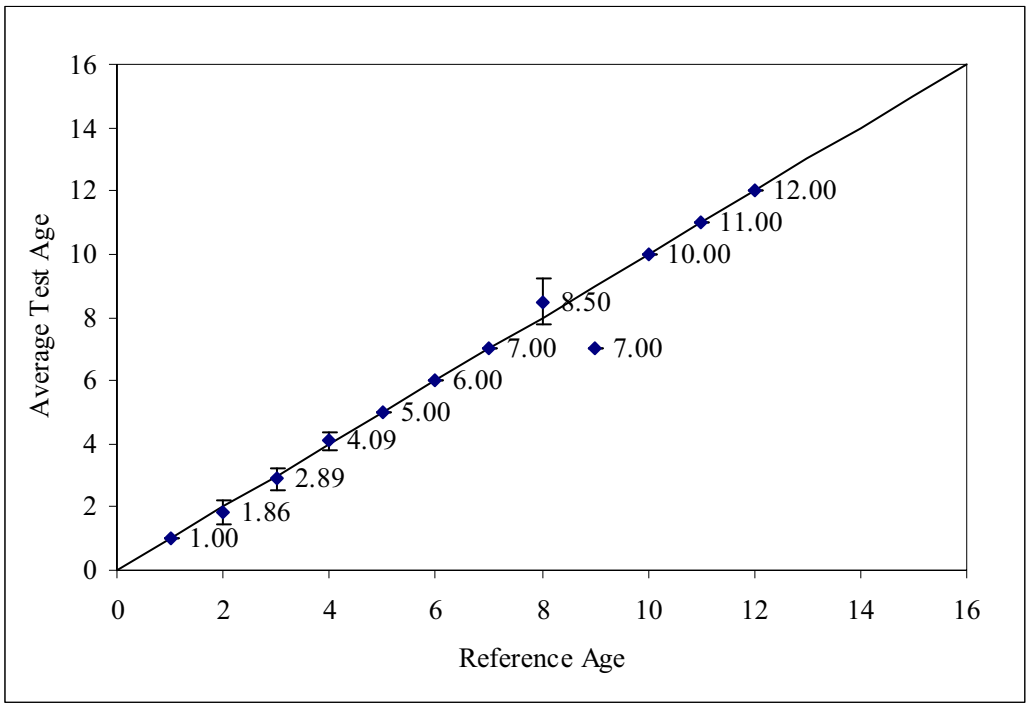
Table A1. Results of both haddock accuracy tests, listing associated figures.

Figure	Source	Date of Test	*N*	Agreement (%)	Total CV (%)
1	Reference Collection	Aug. 2004	50	90.0	2.34
2	Reference Collection	June 2005	107	93.5	1.26

Table A2. Results of all haddock precision exercises, with list of associated figures. The stock area column indicates whether each exercise was on Georges Bank (GB) samples only, or if the two stocks were mixed.

Figure	Source	Stock Area	Date of Test	*N*	Agreement (%)	Total CV (%)
Survey Samples						
3	Autumn 2003	GB	April 2004	48	95.8	0.75
4	Spring 2004	GB	May 2004	65	95.4	0.68
5	Autumn 2004	mixed	Jan. 2005	102	95.1	0.71
6	Spring 2005	mixed	May 2005	76	96.1	0.89
Commercial Samples						
7	1st Quarter 2003	GB	March 2004	34	82.4	2.20
8	2nd Quarter 2003	GB	April 2004	40	87.5	1.71
9	3rd Quarter 2003	GB	April 2004	33	75.8	2.58
10	4th Quarter 2003	GB	April 2004	35	88.6	1.71
11	1st Quarter 2004	mixed	Jan. 2005	56	92.9	0.69
12	2nd Quarter 2004	mixed	March 2005	55	90.9	0.94
13	3rd Quarter 2004	mixed	April 2005	44	97.7	0.25
14	4th Quarter 2004	mixed	April 2005	60	95.0	0.44

Figure A1. Results of August 2004 haddock age-reader accuracy exercise against randomly selected samples from the NEFSC haddock reference collection. Error bars indicate 95% confidence intervals.

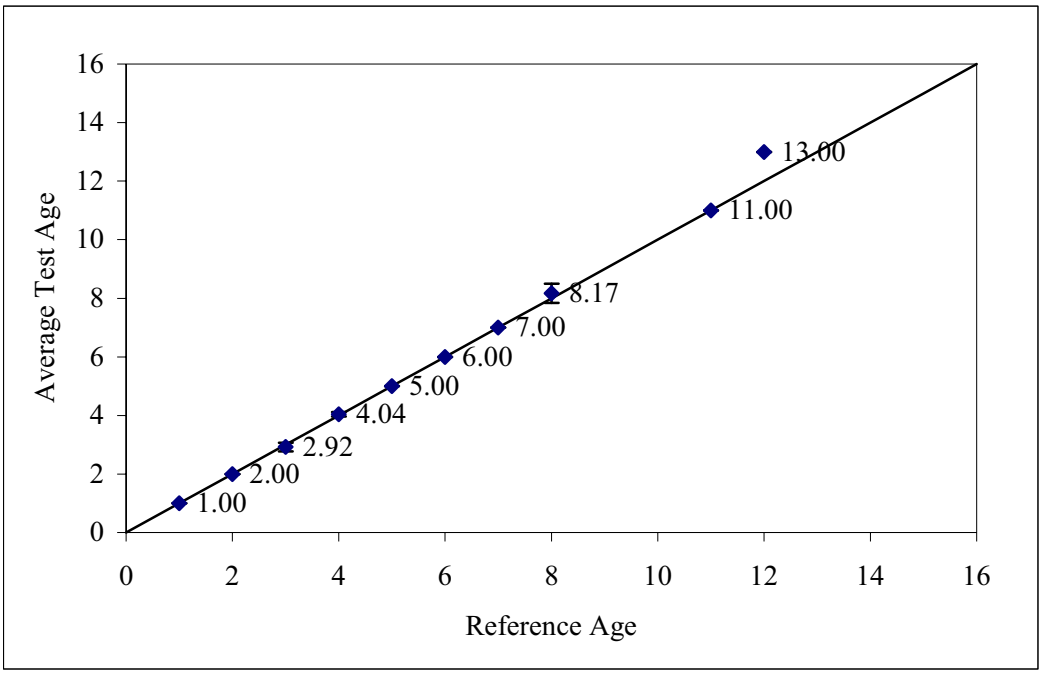


N Aged	50
N Agreed	45
Disagreed	5

Total CV	2.34%
%Agreement	90.0%

Ref Age \ Test Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
0																		
1		5																5
2		1	6															7
3			1	8														9
4					10	1												11
5						6												6
6							4											4
7								2										2
8									1	1								2
9								1										1
10											1							1
11												1						1
12													1					1
13																		
14																		
15																		
16																		
Total		6	7	8	10	7	4	3	1	1	1	1	1					50

Figure A2. Results of June 2005 haddock age-reader accuracy exercise against randomly selected samples from the NEFSC haddock reference collection. Error bars indicate 95% confidence intervals.



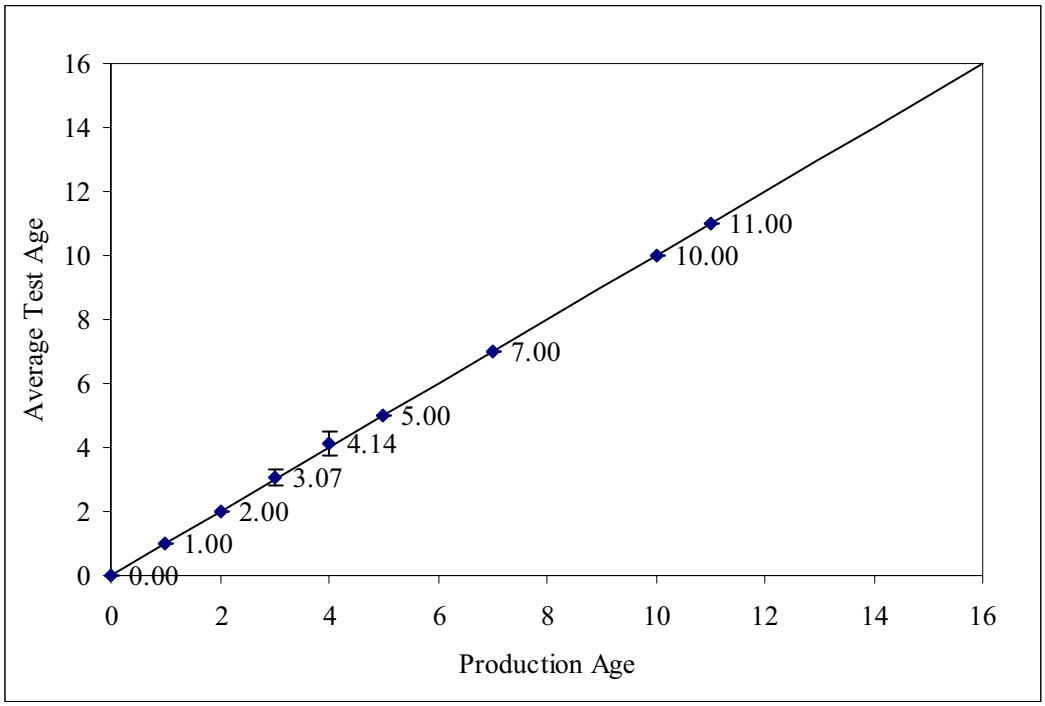
N Aged	107
N Agreed	100
Disagreed	7

Total CV	1.26%
%Agreement	93.5%

Test Age

Ref Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
0																		
1		9																9
2			14															14
3			3	22	1													26
4					25	1												26
5						13												13
6							8											8
7								3										3
8									5	1								6
9																		
10																		
11												1						1
12														1				1
13																		
14																		
15																		
16																		
Total		9	17	22	26	14	8	3	5	1		1		1				107

Figure A3. Results of haddock age-reader precision exercise against randomly selected samples from the NEFSC 2003 autumn bottom trawl survey, including only samples from Georges Bank. Error bars indicate 95% confidence intervals.

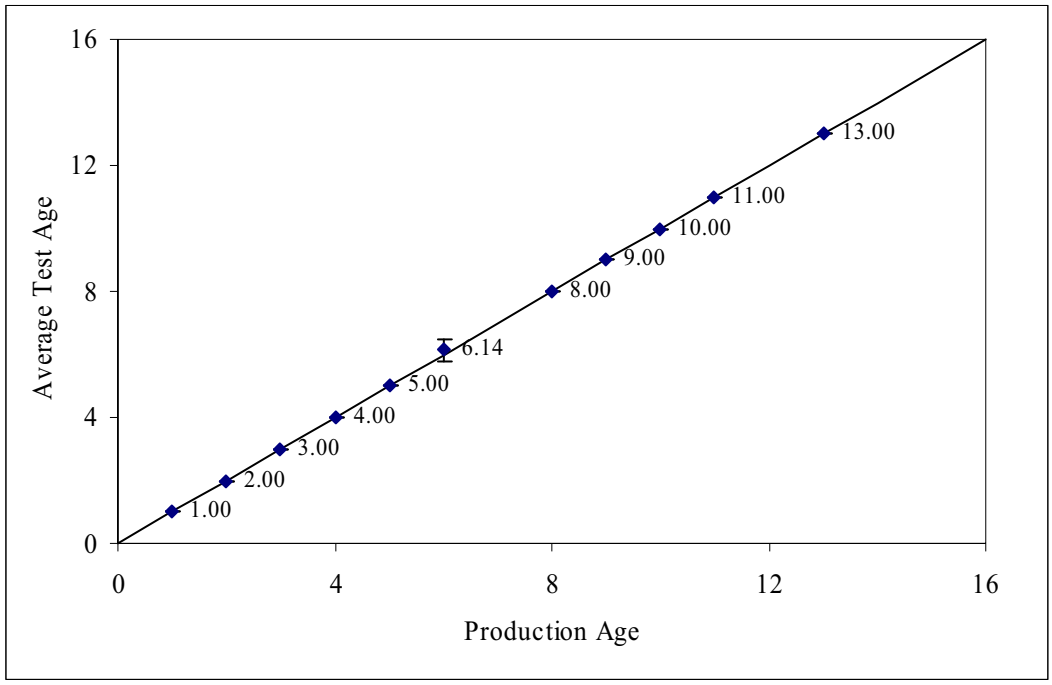


N Aged	48
N Agreed	46
Disagreed	2

Total CV	0.75%
%Agreement	95.8%

Prod Age \ Test Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
0	13																	13
1		2																2
2			2															2
3				13	1													14
4					6	1												7
5						5												5
6																		
7								2										2
8																		
9																		
10											1							1
11												2						2
12																		
13																		
14																		
15																		
16																		
Total	13	2	2	13	7	6		2			1	2						48

Figure A4. Results of haddock age-reader precision exercise against randomly selected samples from the NEFSC 2004 spring bottom trawl survey, primarily including samples from Georges Bank. Error bars indicate 95% confidence intervals.

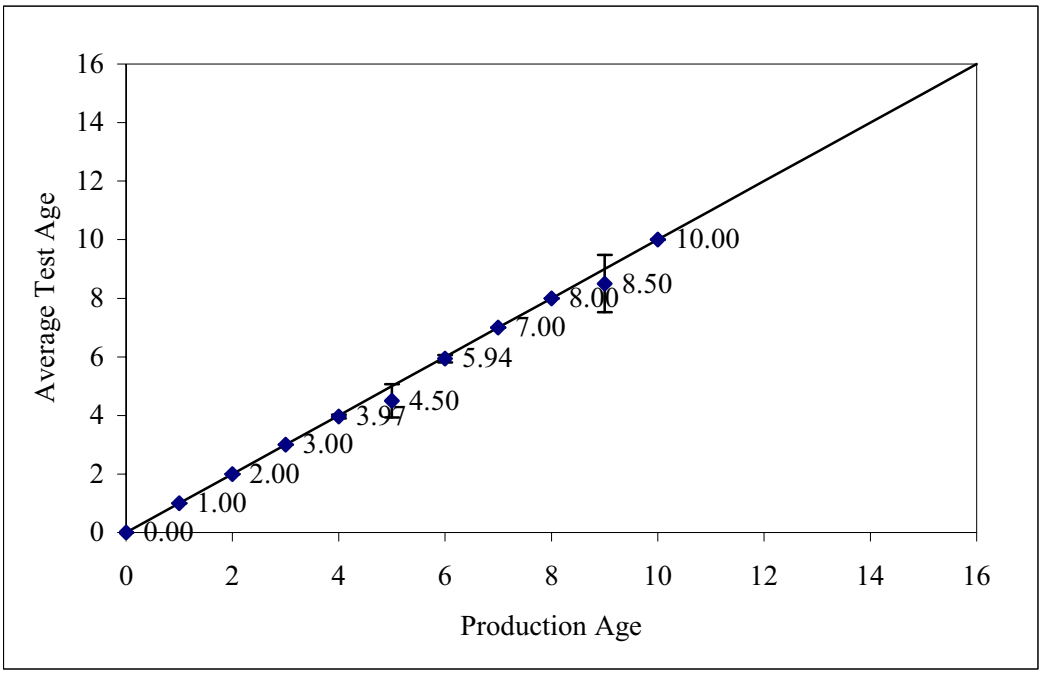


N Aged	65
N Agreed	62
Disagreed	3

Total CV	0.68%
%Agreement	95.4%

Prod Age \ Test Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
0																		
1		17																17
2			2															2
3				4														4
4					17													17
5						4												4
6						1	11	1	1									14
7																		
8									1									1
9										1								1
10											2							2
11												2						2
12																		
13														1				1
14																		
15																		
16																		
Total		17	2	4	17	5	11	1	2	1	2	2		1				65

Figure A5. Results of haddock age-reader precision exercise against randomly selected samples from the NEFSC 2004 autumn bottom trawl survey, including samples from both stock areas. Error bars indicate 95% confidence intervals.

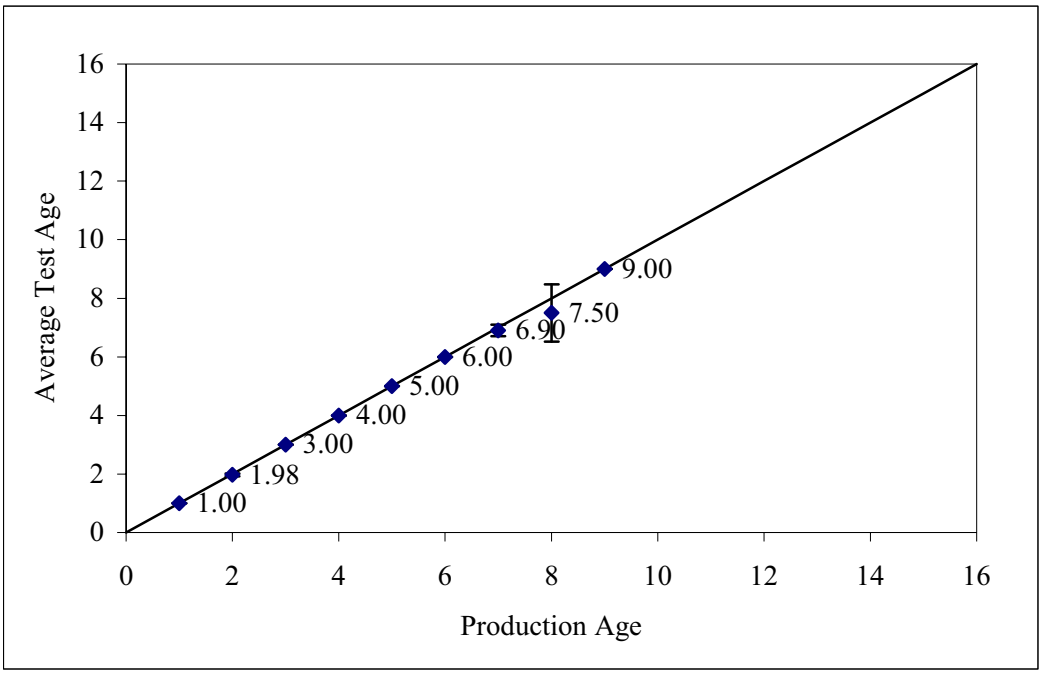


N Aged	102
N Agreed	97
Disagreed	5

Total CV	0.71%
%Agreement	95.1%

Prod Age \ Test Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
0	8																	8
1		28																28
2			1															1
3				3														3
4				1	29													30
5					2	2												4
6						1	15											16
7								3										3
8									6									6
9									1	1								2
10											1							1
11																		
12																		
13																		
14																		
15																		
16																		
Total	8	28	1	4	31	3	15	3	7	1	1							102

Figure A6. Results of haddock age-reader precision exercise against randomly selected samples from the NEFSC 2005 spring bottom trawl survey (both stock areas). Error bars indicate 95% confidence intervals.

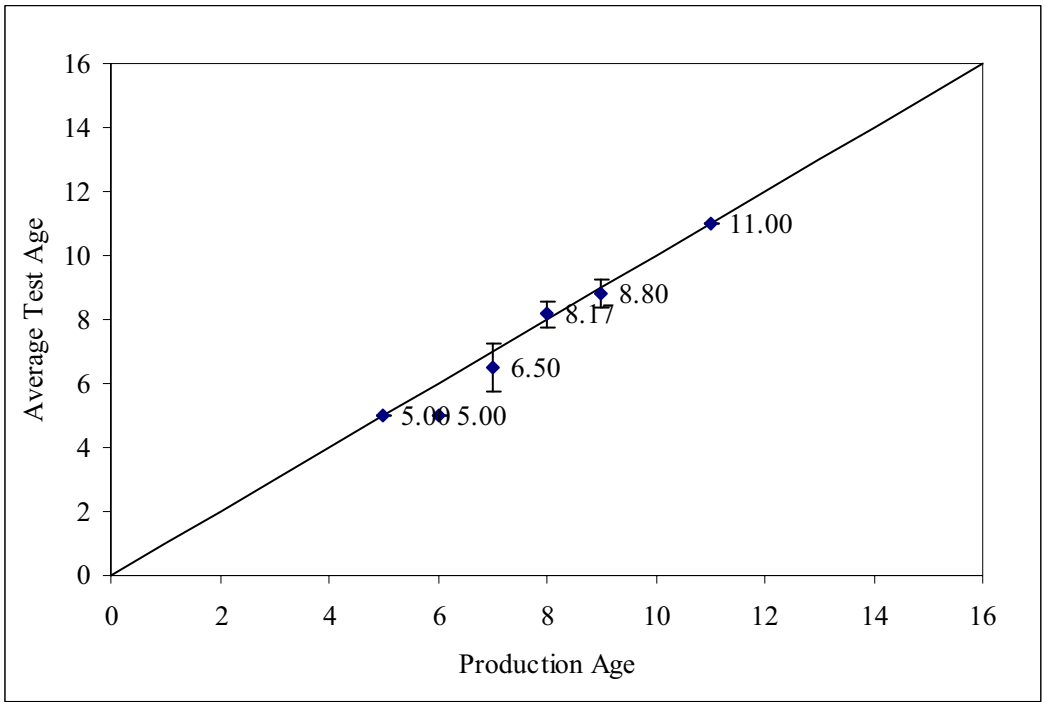


N Aged	76
N Agreed	73
Disagreed	3

Total CV	0.89%
%Agreement	96.1%

Prod Age \ Test Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
0																		
1			2															2
2		1	39															40
3				1														1
4					4													4
5						11												11
6							5											5
7							1	9										10
8								1	1									2
9										1								1
10																		
11																		
12																		
13																		
14																		
15																		
16																		
Total		3	39	1	4	11	6	10	1	1								76

Figure A7. Results of haddock age-reader precision exercise against randomly selected samples from Quarter 1 of 2003 U.S. commercial landings for Georges Bank. Error bars indicate 95% confidence intervals.

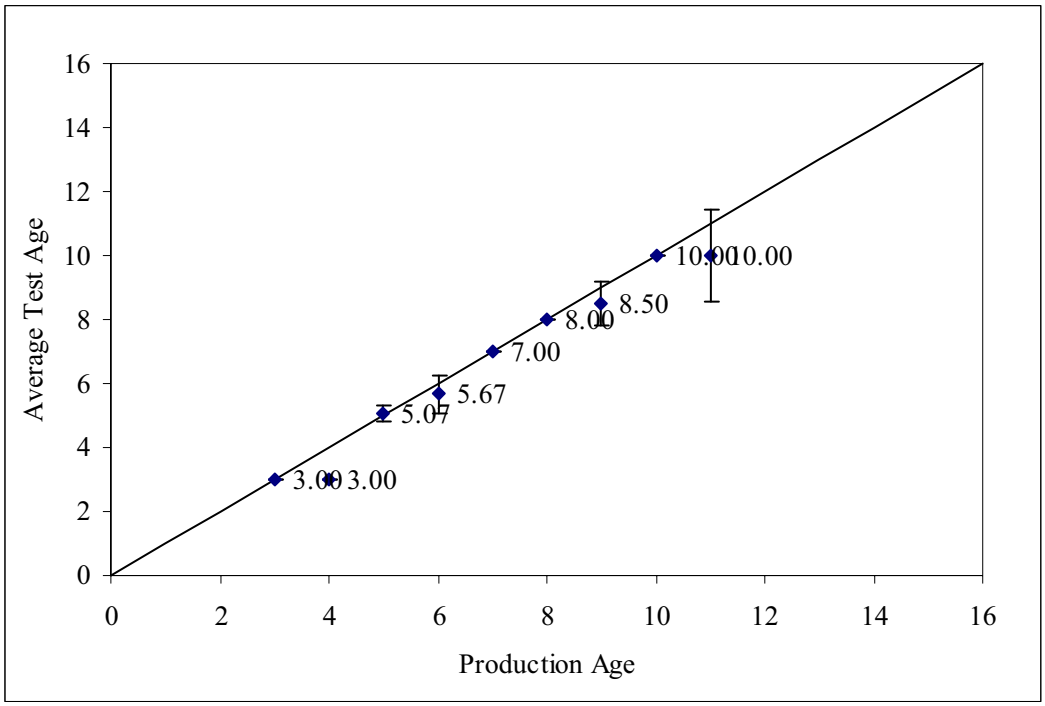


N Aged	34
N Agreed	28
Disagreed	6

Total CV	2.20%
%Agreement	82.4%

Prod Age \ Test Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
0																		
1																		
2																		
3																		
4																		
5						13												13
6						1												1
7						1	2	5										8
8									5	1								6
9									1	4								5
10																		
11												1						1
12																		
13																		
14																		
15																		
16																		
Total						15	2	5	6	5		1						34

Figure A8. Results of haddock age-reader precision exercise against randomly selected samples from Quarter 2 of 2003 U.S. commercial landings for Georges Bank. Error bars indicate 95% confidence intervals.

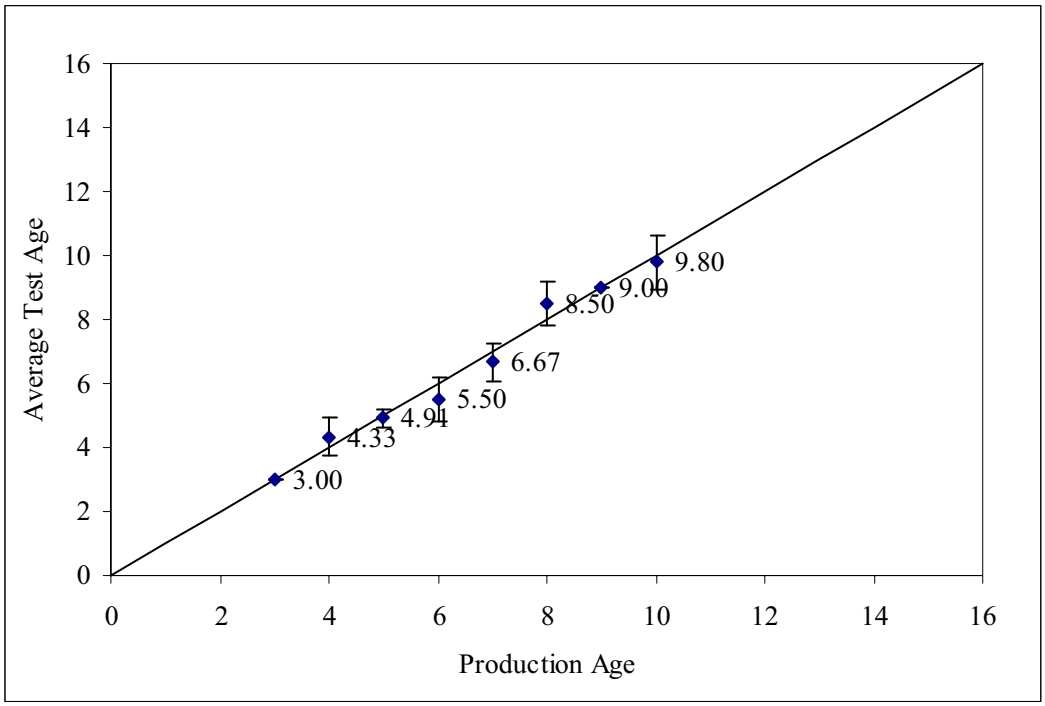


N Aged	40	Total CV	1.71%
N Agreed	35		
Disagreed	5	%Agreement	87.5%

Test Age

Prod Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
0																		
1																		
2																		
3				1														1
4				1														1
5						14	1											15
6						1	2											3
7								5										5
8									7									7
9									1	1								2
10											4							4
11										1		1						2
12																		
13																		
14																		
15																		
16																		
Total				2		15	3	5	8	2	4	1						40

Figure A9. Results of haddock age-reader precision exercise against randomly selected samples from Quarter 3 of 2003 U.S. commercial landings for Georges Bank. Error bars indicate 95% confidence intervals.

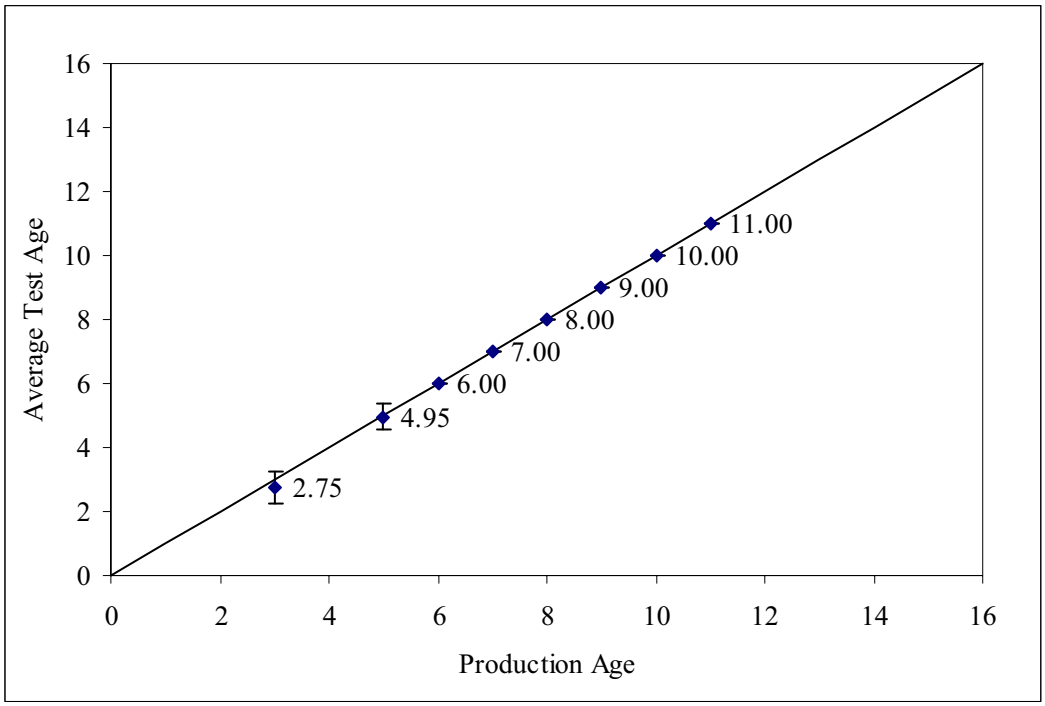


N Aged	33	Total CV	2.58%
N Agreed	25		
Disagreed	8	%Agreement	75.8%

Test Age

Prod Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
0																		
1																		
2																		
3				3														3
4					2	1												3
5					1	10												11
6						1	1											2
7							1	2										3
8									1	1								2
9										4								4
10										2	2	1						5
11																		
12																		
13																		
14																		
15																		
16																		
Total				3	3	12	2	2	1	7	2	1						33

Figure A10. Results of haddock age-reader precision exercise against randomly selected samples from Quarter 4 of 2003 U.S. commercial landings for Georges Bank. Error bars indicate 95% confidence intervals.

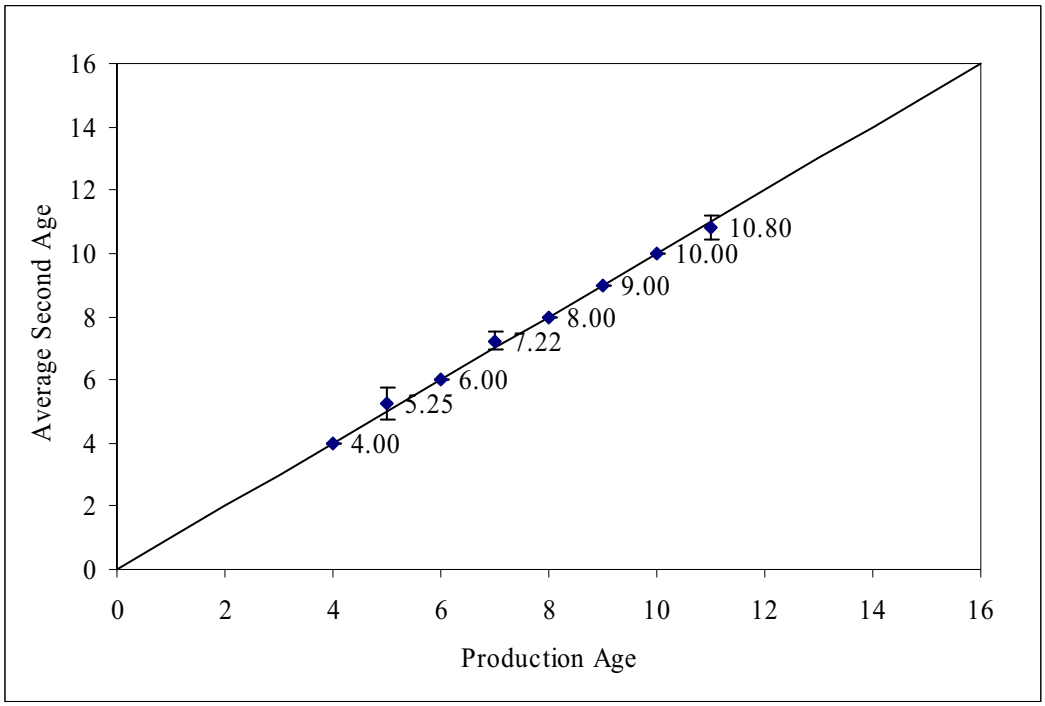


N Aged	35
N Agreed	31
Disagreed	4

Total CV	1.71%
%Agreement	88.6%

Prod Age \ Test Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
0																		
1																		
2																		
3			1	3														4
4																		
5					2	16	1											19
6							4											4
7								1										1
8									2									2
9										2								2
10											2							2
11												1						1
12																		
13																		
14																		
15																		
16																		
Total			1	3	2	16	5	1	2	2	2	1						35

Figure A11. Results of haddock age-reader precision exercise against randomly selected samples from Quarter 1 of 2004 U.S. commercial landings (both stock areas). Error bars indicate 95% confidence intervals.

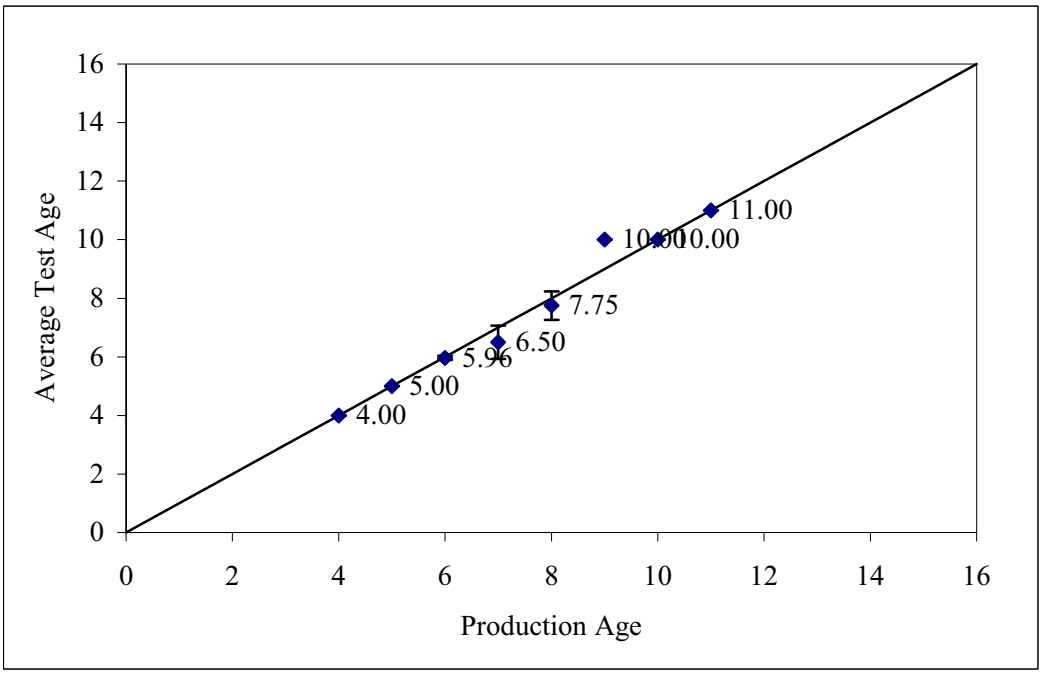


N Aged	56
N Agreed	52
Disagreed	4

Total CV	0.69%
%Agreement	92.9%

Prod Age \ Test Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
0																		
1																		
2																		
3																		
4					4													4
5						3	1											4
6							22											22
7								7	2									9
8									7									7
9										2								2
10											3							3
11											1	4						5
12																		
13																		
14																		
15																		
16																		
Total					4	3	23	7	9	2	4	4						56

Figure A12. Results of haddock age-reader precision exercise against randomly selected samples from Quarter 2 of 2004 U.S. commercial landings (both stock areas). Error bars indicate 95% confidence intervals.

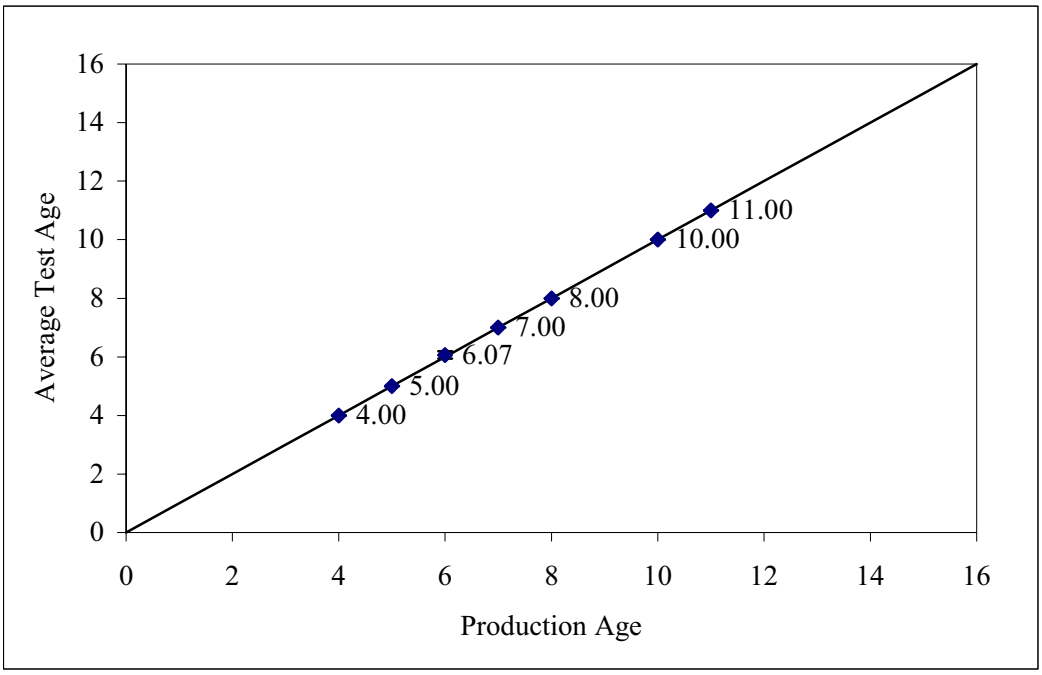


N Aged	55
N Agreed	50
Disagreed	5

Total CV	0.94%
%Agreement	90.9%

Prod Age \ Test Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
0																		
1																		
2																		
3																		
4					7													7
5						9												9
6						1	27											28
7							2	2										4
8								1	3									4
9											1							1
10											1							1
11												1						1
12																		
13																		
14																		
15																		
16																		
Total					7	10	29	3	3		2	1						55

Figure A13. Results of haddock age-reader precision exercise against randomly selected samples from Quarter 3 of 2004 U.S. commercial landings (both stock areas). Error bars indicate 95% confidence intervals.

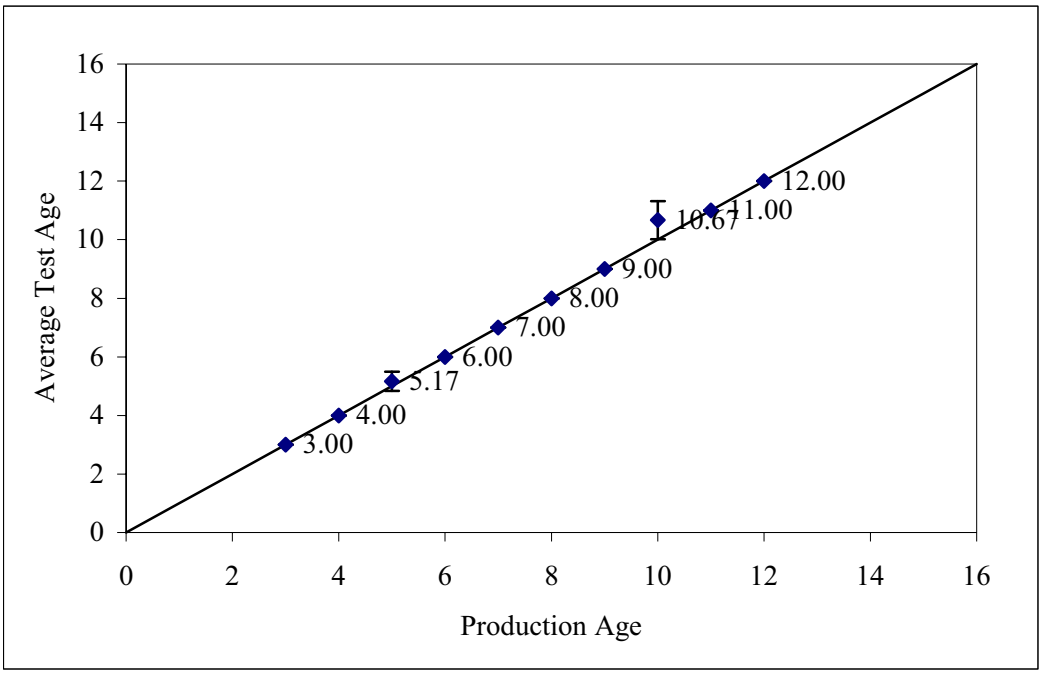


N Aged	44
N Agreed	43
Disagreed	1

Total CV	0.25%
%Agreement	97.7%

Prod Age \ Test Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
0																		
1																		
2																		
3																		
4					10													10
5						3												3
6							14	1										15
7								6										6
8									3									3
9																		
10											4							4
11												3						3
12																		
13																		
14																		
15																		
16																		
Total					10	3	14	7	3		4	3						44

Figure A14. Results of haddock age-reader precision exercise against randomly selected samples from Quarter 4 of 2004 U.S. commercial landings (both stock areas). Error bars indicate 95% confidence intervals.



N Aged	60
N Agreed	57
Disagreed	3

Total CV	0.44%
%Agreement	95.0%

Prod Age \ Test Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
0																		
1																		
2																		
3				1														1
4					17													17
5						5	1											6
6							24											24
7								3										3
8									2									2
9										2								2
10											1	2						3
11												1						1
12													1					1
13																		
14																		
15																		
16																		
Total				1	17	5	25	3	2	2	1	3	1					60

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