K. Georges Bank winter flounder

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1.0 Background

The Georges Bank (GB) winter flounder stock was last assessed in September 2005 during a Groundfish Assessment Review Meeting (GARM) meeting (NEFSC 2005). The assessment consisted of an updated run of the SARC 34 ASPIC production model (Prager 2004), because the results of the VPA model runs were considered unreliable at SARC 34, primarily due to poorly sampled fishery length and age compositions during the terminal years of the assessment period (NEFSC 2002a). Input data to the 2005 GARM model included landings (1964-2004) and NEFSC fall (1964-2004) and spring (1968-2005, lagged back one year) survey relative biomass indices.

The biological reference point estimates from the SARC 34 ASPIC model were also recommended for implementation by the 2002 Working Group on Re-estimation of Biological Reference Points for New England Groundfish (NEFSC 2002b). The current reference points are: $F_{MSY} = 0.32$, $B_{MSY} = 9{,}400$ mt, and MSY = 3,000 mt. The 2002 Working Group concluded that the use of absolute reference point values from the ASPIC model (based on total biomass rather than exploitable biomass) are appropriate because the NEFSC surveys appear to measure the biomass of the exploitable portion of the stock. However, ASPIC-based biological reference points are re-estimated each time the model is run and model estimates of relative total biomass (B_t/B_{MSY}) and fishing mortality rates (F_t/F_{MSY}) are more precisely estimated than the absolute values (Prager 1995). As a result, the 2005 GARM review panel concluded that bias-corrected relative estimates of annual total biomass and fishing mortality rates from the updated ASPIC model run should be compared to relative biological reference points (biomass threshold = 0.5, fishing mortality rate threshold = 1.0) to determine stock status. In 2005, it was determined that the stock was not overfished, but overfishing was occurring.

For the current GARM, the use of a Virtual Population Assessment model (VPA) was selected because of improved biological sampling of the fishery since the SARC34 VPA, the need to assess changes in the population's truncated age structure, and to avoid the pitfalls associated with the biomass-based ASPIC model. Initial estimates of discards-at-age, for the bottom trawl and scallop dredge fleets, are also included in the updated version of the model. Additional assessment details and supporting information can be found in the Appendix of the GARM-III Report (NEFSC 2008).

2.0 The Fishery

Landings

The stock boundary includes statistical areas 522-525, 542, 551-552 and 561-562 (Figure K1). Commercial landings data are available for 1964-2007. During 1964 through May of 1994, U.S. commercial landings and fishery-related data were collected and entered into a Federal database by NMFS port agents. Since then, such data have been electronically reported by fish dealers. However, fishing location (statistical area) and fishing effort data related to the landings are only available in the Vessel Trip Report database, which contains logbook data which are self-reported by fishermen. Consequently, the landings data and biological sampling data were

allocated to stock areas (Statistical Areas) based on Vessel Trip Report data using the method described in Wigley et al. (2007a).

There are no significant recreational landings of winter flounder from Georges Bank. Total commercial landings are predominately from the U.S. bottom trawl fleet, but landings from Georges Bank have also been reported in the Canadian groundfish trawl fisheries, since 1964, as bycatch in the haddock and cod fisheries (Heath Stone pers. comm.). During 1964-1977, landings were also reported by the former USSR (Table K1, Figure K2). Canadian landings generally comprised a low percentage (1-2 %) of the total landings until 1994, at which time Canadian landings increased from 6 % of the total to a peak of 24 % in 2001 (529 mt). The increasing trend in Canadian landings occurred primarily during the second half of the year because since 1994 there has been a Canadian prohibition on trawling for groundfish on Georges Bank during January-May (Eeckhaute and Brodziak 2005). After 2001, Canadian landings declined from 10% of the total landings in 2002 to 1.5% in 2007 (12 mt).

Total landings increased during 1964-1972, reaching a peak of 4,509 mt in 1972, then declined to1,892 mt in 1976 (Figure K2, Table K1). A sustained period of high landings occurred during 1977-1984, ranging from 3,061-4,009 mt. After 1984, landings gradually declined to 783 mt in 1995 then increased again to 3,139 mt in 2003. Thereafter, landings declined rapidly and reached the lowest level on record in 2007 (787 mt).

A majority of the annual U.S. landings (92-100 %) are taken with bottom trawls (Table K2). Most of the remainder of the total landings is taken by the scallop dredge fleet. During most years since 1982, landings taken by the scallop dredge fleet have been less than 1%. However, a high period of landings by the scallop dredge fleet (4-8% of the total landings) occurred during 1988-1993 and in 2005 (6% of the total landings).

Discards

Initial estimates of GB winter flounder discards, during 1964-2006, are provided for the large mesh bottom trawl fleet (codend mesh size ≥ 5.5 inches), small mesh groundfish fleet (codend mesh size < 5.5 inches), and the sea scallop dredge fleet ("limited permits" only) in Tables K3 and K4. Discards (mt) for 1989-2006 were estimated based on fisheries observer data and the landings data using the combined ratio method described in Wigley et al. (2007b). The discard ratio estimator consisted of discards of GB winter flounder divided by the sum of all species kept by a particular fleet. Discards were estimated by quarter and cells with fewer than two trips were imputed using annual

Values (Appendix Table K1; NEFSC 2008). Due to a lack of fisheries observer data, prior to 1989 for the trawl fleets and prior to 1992 for the scallop fleet, discard estimates were hindcast back to 1964 based on the following equation:

$$\hat{D}_{t,h} = \bar{r}_{c,2003-2004,h} * K_{t,h} \quad (1)$$

where:

$\hat{D}_{t,h}$ is the annual discarded pounds of GB winter flounder for fleet *h* in year *t*

$\bar{r}_{c,2003-2004,h}$ is an average combined D/K ratio (discarded pounds of GB winter flounder / total pounds of all species kept) for the fleet *h* during either 2003-2004 (for the trawl fleets) or 1992-1998 (for the scallop dredge fleet)

$K_{t,h}$ is the total pounds of all species kept (landed) for fleet *h* in year *t*

During 1964-1975, discards were predominately (49-87%) attributable to the large mesh groundfish trawl fleet (listed in Table K3 as the small mesh fleet because the minimum codend mesh size prior to 1982 was less than 5.5 in.) (Table K3). During 1976-2007, discards were primarily attributable to the scallop dredge fleet during most years, ranging between 66% and 100%. Discards ranged from 1-25 % of the total landings during 1964-2007 and were higher during 1964-1991 than during 1992-2007 (Table K1). Discards reached a peak of 314 mt in 1991 then declined sharply to their lowest level (1 mt) in 1995. During 1999-2003, discards declined from 85 mt in 1999 to 9 mt in 2003, but have increased since then. Discards nearly doubled between between 2006 (110 mt) and 2007 (193) mt and predominately from the scallop dredge fleet. The precision of the annual discard estimates varies by fleet (Table K4) and the precision of the annual estimates of total discards, during most years since 2000, is fairly high (Table K3).

Catches

Catches increased during 1964-1972, reaching a peak of 4,600 mt in 1972, then declined to 2,000 mt in 1976 (Figure K3, Table K1). Catches subsequently increased to 4,300 mt in 1981 then gradually declined to a time series low of 800 mt in 1995. Catches increased to 3,100 mt in 2003 then declined to 980 mt in 2007.

Historical catches are likely to have been higher than those observed since 1964 because the U.S. landings alone reached a peak of 4,089 mt in 1945, close to the magnitude of the 1964-2007 peak in catch (4,608 mt), and without the addition of discards, at a time when codend mesh sizes were smaller, and landings from international fleets (Figure K4).

Landings-at-age

There is no sampling program for length and age composition data from the Canadian landings of Georges Bank winter flounder, but length and age samples from the U.S. landings were collected by market category and quarter during 1982-2007. Samples are collected for eight market categories (Lemon Sole = 1201, Extra Large = 1204, Large = 1202, Large /Mixed = 1205, Medium = 1206, Small = 1203, Peewee = 1207, and Unclassified = 1200). However, the data were binned as Lemon Sole (1201 and 1204), Large (1202 and 1205) and Small (1203, 1206 and 1207) because these three market categories comprise a majority of the landings during 1982-2007. The annual sampling intensity of lengths ranged between 14 mt and 269 mt landed per 100 lengths measured during 1982-2007 (Table K5). Sampling intensity was lowest during 1996-2000. During 1998 and 1999 there were no lemon sole samples (the largest market category size) and only one large sample collected each of these two years (Table K6) although this market category represented 42% and 45% of the total landings, respectively, during this period (Table K7). After 2000, sampling intensity improved substantially and was highest in recent years (2004-2007). During 1982-2002, most of the landings consisted of Large and Small fish, but since 2003, the landings have been dominated by larger fish (Lemon Sole and Large, Table K7) and sampling intensity of these larger fish has increased as well.

During most years, biological sampling of the landings was adequate to construct the landings-at-age (LAA) matrix by applying commercial age-length keys to commercial numbers at length on either a quarterly or half-year basis by market category group (Table K8). The LAA matrix for 1982-1993 was based on that provided in Brown et al. (2000) and was updated for 1994-2007 using the allocation scheme noted above for landings and age and length samples. The LAA matrix includes U.S. and Canadian landings during 1982-2007 (Table K9). The U.S. unclassified market category samples and the Canadian landings were

assumed to have the same age compositions as the sampled U.S. landings and the U.S. LAA was adjusted by a raising factor to incorporate the Canadian landings. Large year classes are trackable in the landings-at-age matrix. For example, large numbers of fish from the 1994 cohort were landed as age 1 fish in 1995, as age 2 in 1996 and as age 3 fish in 1997. Landings of age 1 fish are insignificant during most years (Table K9). During 1982-1984, the landings were dominated by age 3-5 fish and were dominated by age 2-4 fish during 1985-2000. During 2001-2007, the landings were dominated by age 3-5 fish.

Discards-at-age

The annual number of lengths sampled from winter flounder discards in the bottom trawl and scallop dredge fisheries were inadequate to characterize discard length compositions during most years (Table K10). As a result, discards at age were characterized based on the assumption that fish smaller than the minimum regulatory size limits were discarded. The minimum size limit for winter flounder in the bottom trawl fishery was 28 cm during 1986-April, 1994 and has been 30 cm since then. Examination of length-at-age data indicates that fish of this size are one year old in the NEFSC fall surveys and two years old in the spring surveys. Therefore, discards at age for the bottom trawl fleet, during 1982-2001, were estimated by dividing the estimated weight of discarded winter flounder from the bottom trawl fleet, during January-June, by the annual mean weights of age 2 fish from the NEFSC spring surveys. Likewise, winter flounder discard weights for July-December were divided by the annual mean weights of age 1 fish from the NEFSC fall surveys. Discards at age for the bottom trawl fleet, during 2002-2007, were estimated by using the discard numbers at length, binned as January-June and July-December, to characterize the proportion discarded at length and ages were determined by applying the NEFSC spring and fall survey age-length keys and length-weight relationships, respectively. Length compositions of discarded fish in the bottom trawl fishery indicate that for most years during 2002-2007, discarding of all sizes of winter flounder occurred (Figure K5), particularly since the establishment of Georges Bank winter flounder trip limits in May of 2006. Length samples of winter flounder discarded in the scallop dredge fishery are also limited (Table K10). The limited discard length composition data suggested that, in general, all sizes of winter flounder are discarded (Figure K6). Therefore, discards at age for the scallop dredge fishery were estimated by scaling up the LAA by the ratio of scallop dredge discards to total landings. During years when sufficient numbers of length samples of winter flounder discards were available, 1997 and 2004-2007, these annual length frequency distributions were used to characterize the proportion of discards at length for the scallop dredge fleet and ages were determined using the fall survey age-length keys and length-weight relationships because most discards occurred during the second half of the year. There were no data available to estimate Canadian discards of GB winter flounder in either the groundfish trawl fleet or the scallop dredge fleet. Since 1994, the Canadian groundfish fishery on Georges Bank has been closed during January-May and Canadian regulations do not permit discarding of groundfish species and the scallop fishery is not permitted to land groundfish (Van Eeckhaute and Brodziak 2005). Consequently, any discarding is expected during May-December in the groundfish trawl fishery and throughout the year in the scallop dredge fishery that operate on the Canadian side of Georges Bank. Discards occur across all age categories, but primarily ages 2-4 during 1982-1997 and ages 3-5 during 1998-2003 (Table K11). Total discards were lower after 2004 than before and discards of age 1 fish were much higher prior to the 1994 when the minimum codend mesh size (5.5 in) and minimum fish retention size (28 cm) was smaller.

Catch-at-age

The catch-at-age (CAA) consists of the combined U.S. and Canadian landings-at-age and discards-at-age for the U.S. large and small groundfish bottom trawl fleets and the scallop dredge fleet, during 1982-2007, for ages 1-6 with a 7+ age group. Trends in mean weights at age in the catch remained relatively stable between 1982 and 1996 then declined through 1998 for ages 3-5 and became more variable for older age groups, likely due to poor sampling (Figure K7, Table K12). However, during 2000 and 2001-2006, mean weights in the catch have been increasing for all age groups except age one, but particularly for ages 4 and older. Mean weights for ages 3-7+ declined slightly between 2006 and 2007. The catch-at-age is presented in Table K13.

2.0 Research Survey Data

Relative biomass (stratified mean kg per tow) and abundance (stratified mean number per tow) indices were derived from the NEFSC spring (April, 1968-2008) and autumn (October, 1963-2007) bottom trawl surveys, for offshore strata 13-23 (Figure K8), as well the Canadian spring bottom trawl surveys (February, 1987-2008) for strata 5Z1-Z4 (Figure K9). NEFSC survey indices prior to 1985 were standardized for gear changes (weight = 1.86 and numbers = 2.02, Sissenwine and Bowman 1978) and trawl door changes (weight = 1.39 and numbers = 1.4, Byrne and Forrester 1991). In addition, the NEFSC survey indices were revised to include offshore strata 13-23 rather than the strata set from previous assessments (strata 13-22) because a majority of fish caught in stratum 23 exhibit a Georges Bank-type growth pattern which is much more rapid than the growth patterns of the other two winter flounder stocks and which is readily apparent to the ageing analyst as a much greater distance between the first and second annuli (Jay Burnett pers. comm.). In addition, the relative abundance of winter flounder caught in stratum 23 is similar to the relative abundance of winter flounder caught in the Georges Bank strata (13-22, Appendix Figure K1). The addition of fish from stratum 23 mainly affects the fall survey indices because winter flounder densities in stratum 23 are low during spring (Appendix Figure K2).

Despite considerable inter-annual variability, the NEFSC fall survey relative abundance indices show an increasing trend during the 1970's, followed by a declining trend during the 1980s to a time series low in 1991 (Figure K10, Table K14). Thereafter, relative abundance increased through 2001 then declined and was below the 1963-2006 median during 2005-2007. Trends in the NEFSC spring survey relative abundance indices exhibited more inter-annual variability, but trends were similar to the fall survey time series after 1982. NEFSC spring survey abundance indices were at the lowest levels on record during 2006 and 2007. The second highest abundance index of the time series occurred in 2008. However, most of the fish were caught at two consecutively sampled stations and consisted of a broad range of sizes. Relative abundance trends in the Canadian survey were similar to those in the NEFSC spring survey during most years but were of greater magnitude during blocks of years (1988-1990 and 1993-1997). Similar to the NEFSC spring survey, relative abundance indices from the Canadian surveys were at the lowest levels observed during 2006-2008.

In order to estimate catchability coefficients for each survey (q) in the VPA, annual relative abundance indices were converted to annual minimum population sizes. Minimum population sizes at age (000's) are presented for the U.S. fall (1981-2007, ages 0-6 lagged forward one year and age) and spring bottom trawl surveys (1982-2008) and the Canadian spring bottom trawl surveys (1987-2008) in Tables K15, K16, and K17, respectively. Age samples are not collected during Canadian bottom trawl surveys so the NEFSC spring survey age-length

keys, augmented during some years with commercial age-length keys from the first quarter of the corresponding year (when larger fisher were caught), were used to partition stratified mean numbers at length from the Canadian surveys into numbers at age. Although the indices are highly variable, large cohorts appear to track through the numbers-at-age matrices for the 1980, 1987, 1994, and 1998-2001 cohorts (Figure K11). Age truncation occurred between 1983 and 1997 during which time the population was dominated by four age groups rather than seven or more. During 1997-2004, the age structure improved but has since become truncated again. Both the U.S. and Canadian spring surveys show reduced numbers of age 1-3 fish (and age 4 fish in the CA surveys) after 2000. The U.S. spring survey numbers at age during 2008 were some of the highest on record for a broad number of ages (ages 1-5, Figure K11B). This characteristic, combined with the fact that these indices do not track back to large year classes suggests that the indices are likely just an effect of high catches from two consecutively sampled stations.

Maturity and age data for females from the NEFSC spring surveys were used to derive the proportion mature-at-age for input to the VPA and to compute age at 50% maturity during 1982-2008. The female A_{50} is approximately 2 years (Appendix Figure K3) and all fish are mature by age 4, and in recent years, by age 3 (Appendix Figure K4). There has been an increase in the female A_{50} since 2005 that is more pronounced in females than males (Appendix Figure K3) and which is reflected in a reduction in the proportion of mature age 2 females during this time period (Appendix Figure K4). These maturity-at-age trends are also concurrent with a declining trend, after 2003, in the mean weight and length of females caught in the fall surveys (Appendix Figure K5). However, a time series average of the proportion mature-at-age rather than a moving window was used in the VPA because the sample size on which the recent declining trend in the female proportion mature-at-age is based has also been declining (Appendix Figure K3). Since 2001, all winter flounder caught in strata 13-23 during NEFSC spring and fall surveys are sampled for age and maturity, and as relative abundance has declined, so has the number of maturity and age samples.

4.0 Assessment

Input Data and Analyses

The catch at age input to the VPA consisted of combined U.S. and Canadian landings during 1982-2007 for ages 1-6 with a 7+ age group. The VPA was calibrated using minimum population abundance at age indices from the U.S. spring (1982-2008, ages 1-7) and fall bottom trawl surveys (1981-2007, ages 0-6 lagged forward one year and age) and the Canadian spring bottom trawl surveys (1987-2008, ages 1-7) in order to estimate catchability coefficients (q) for each survey. Stock size was estimated for ages 2-6 in the terminal year+1. The natural mortality rate was assumed as 0.2 per year. Maturity data from the 1982-2008 NEFSC spring surveys were used to estimate the average proportion mature at age for 1982-2008. The time series average maturity vector for ages 1-7+ (0.08, 0.54, 0.94, 1.00, 1.00, 1.00, 1.00, respectively) was used in the VPA analysis.

Precision of the 2007 spawning stock biomass and fully recruited fishing mortality were derived from 1,000 bootstrap replicates of the VPA. A retrospective analysis of terminal year estimates of age 1 recruitment, fully recruited fishing mortality on ages 4-6, and SSB were also carried out back to 1993.

VPA Diagnostics

Residuals patterns were evident for a number of ages included in each of the three VPA calibration indices. For example, residuals patterns were negative for abundance indices of age 2 and 3 fish from the NEFSC spring surveys, during 2001-2007, and for age 6 fish during 1993-1997 (Figure K12). Residuals for the NEFSC spring surveys were positive for age 1 fish during 1990-1995 and age 2 fish during 1990-1996, as well as for age 6 fish during 1999-2003 and for age 7 fish during 1998-2002. The Canadian spring survey indices for ages 2-4 showed major residuals trends (Figure K13), both positive and negative, but the patterns differed from those evident in the NEFSC spring surveys. Residuals patterns for the NEFSC fall survey abundance indices were evident during some years for ages 4-7 (actually ages 3-6 lagged forward one year and age) and were generally positive (Figure K14). In order to determine whether omitting certain tuning indices would remove the observed residuals patterns and improve the retrospective pattern, the following additional VPA formulations were run: all indices except the CA series; all indices except ages 1-3 in the CA series; NEFSC spring surveys ages 4-7 plus fall surveys ages 1-7; and all indices except the CA series and ages 1-3 from the fall surveys. However, all of these runs resulted in worse retrospective patterns and shifted the residuals patterns to other ages and years. A VPA run involving a pre- and post-1994 split for all of the survey time series has removed retrospective patterns for GB yellowtail flounder. However, such a run resulted in very strong retrospective patterns in F and SSB, probably because 1994 was generally not a problematic year for the GB winter flounder stock with respect to residuals patterns.

VPA estimates of survey catchability coefficients (q), by age, indicate that catchabilities for all three surveys increased with age for ages 1-6 then decreased for age 7 but the decrease was not significant (Figure K15). Catchabilities were higher for the NEFSC fall surveys than the NEFSC spring surveys (e.g., q = 0.33 and 0.25 for age 6, respectively). Catchabilities for the Canadian spring surveys can be compared across ages but not between surveys because the ships and gear were different.

A plot of the VPA average of back-calculated partial recruitment across ages, and scaled by the highest value, was prepared for each of three time periods (1983-1993, 1994-2001, and 2002-2007) within which occurred major changes in the minimum codend mesh size for bottom trawls. A flat-topped logistic curve was present in all three cases (Figure K16).

Very mild retrospective patterns were present for terminal year estimates of fishing mortality rates (underestimation of F) and spawning stock biomass (overestimation of SSB, Figure K17A and B). There was no retrospective pattern for terminal year age 1 recruitment, but the estimates were highly variable (Figure K17C). In order to quantitatively evaluate the severity of the retrospective pattern, the rho statistic of Mohn (1999) was computed for each year during 2000-2006. The Mohn statistic is a relative measure defined as the sum of relative difference between an estimated quantity from an assessment with a reduced time series and the same quantity estimated from the full time series:

$$\rho = \sum_{y=1}^{npeels} \frac{X_{Y-y,tip} - X_{Y-y,ref}}{X_{Y-y,ref}} \qquad (1)$$

where X denotes the average F for ages 4-6 and SSB from the stock assessment, y denotes year (i.e., 2000-2006), n peels denotes the number of years that are dropped in successive fashion from the assessment rerun, Y is the last year in the full time series (i.e., 2007), tip denotes the terminal estimate from an assessment with a reduced time series, and ref denotes the assessment using the full time series. The rho value is zero when the peeled assessments match exactly with the full time series assessment, or when the differences between the peeled assessments and full

time series assessment are balanced both positive and negative. The former case has no change from year to year, while the latter case would be characterized as exhibiting noise but not a retrospective pattern. Rho becomes large, either positive or negative, when there is a consistent retrospective pattern (change in the peeled assessments relative to the full time series assessment). For GB winter flounder, relative differences in estimates of average F, SSB and age 1 recruitment, during year t (for 2000-2006) versus 2007, are presented in Figure K18. The average Mohn rho values estimated for 2000-2006 were quite low for F and SSB (Table K18). The average rho value for age 1 recruitment was slightly higher, as expected, due to the high variability in the annual estimates of this variable during 2000-2006.

VPA Results

VPA estimates of Jan. 1 population size (numbers, 000's), fishing mortality rates, and spawning stock biomass (mt) are presented in Tables K19-21, respectively. Fishing mortality (average F for fully recruited fish, ages 4-6) was highest during 1984-1993, ranging between 0.65 and 1.32, then declined to levels ranging between 0.38 and 0.64 during 1994-1998 (Figure K19A, Table K20). Fishing mortality was low (0.32) during 1999 and 2000 then increased rapidly to 0.97 in 2003 and was followed by a rapid decline to a record low of 0.25 in 2006. The fishing mortality rate in 2007 was 0.28. SSB declined rapidly from a time series peak of 16,300 mt in 1982 to 5,573 mt in 1985, and then increased slightly through 1987 to 7,519 mt (Figure K19B, Table K21). After 1987, SSB declined again to a time series low of 3,226 mt in 1994. SSB subsequently increased to 10,924 mt in 2000, but then declined to 4,478 mt in 2005. SSB increased slightly thereafter to 4,964 mt in 2007. Trends in age 1 recruitment (numbers) indicate two periods of rise-and-fall. Recruitment increased from 5.9 million fish in 1983 to a time series peak of 18.6 million fish in 1988, and then declined to 3.4 million fish in 1993 (Figure K19C, Table K19). Recruitment increased again to fairly high levels during 1995-1999 (9.9-14.6 million fish) then declined to the lowest level on record (2.6 million fish) in 2005. Recruitment of age 1 fish increase to 12.1 million fish in 2007, but in 2008 is estimated to be much lower (5.1 million fish). However, the 2008 estimate is uncertain because it is based solely on survey indices. Stock size declined between 2000 and 2005, from 36.2 to 12.3 million fish then increased to 22.5 million fish in 2008 (Table K19).

Bootstrap results suggest that the 2007 estimates of fully recruited average F on ages 4-6 and spawning stock biomass are fairly precise with CVs of 20% and 24%, respectively. There is an 80% probability that the 2007 average F for ages 4-6 is between 0.22 and 0.37 (Figure K20). There is an 80% probability that the 2007 SSB estimate is between 4,204 mt and 6,249 mt (Figure K20). Bootstrapped estimates of the 2008 stock sizes and 2007 fishing mortality rates at age are presented in Table K22 and Table K23, respectively.

5.0 Biological Reference Points

A YPR and SSB/R model (Thompson and Bell 1934) were used to estimate an F_{MSY} proxy of $F_{40\%\ MSP}$. Input data for the YPR and SSB/R model included: the fishery selectivity vector, proportion mature at age, and the 2003-2007 mean catch weights, mean stock weights, and spawning stock weights from the VPA (Table K24). The yield-per-recruit and SSB-per-recruit analysis resulted in an F_{MSY} proxy estimate for $F_{40\%}$ of 0.26.

At the GARM III BRP meeting, the review panel determined the stock-recruitment relationship predicted from a Beverton-Holt model was not well defined by any particular model (e.g., Beverton-Holt). As a result, BRPs were derived based on the empirical cumulative distribution function of age 1 recruitment from the VPA and assumed that recruitment is independent of stock size. A long-term (100-year) stochastic projection was run using an age-structured projection model, AGEPRO software (v. 3.13) from the NOAA Fisheries Toolbox, assuming a constant harvest scenario of $F_{40\%} = 0.26$ (from the YPR model) to predict the median MSY and SSB_{MSY} under equilibrium conditions. The projection included the data presented in Table K24. The entire recruitment time series was included in the analysis with the exception of the 2008 data point due to the uncertainty of this value which is based solely on survey data. Median SSB_{MSY} and MSY estimates from the projection were 16,000 mt and 3,500 mt, respectively. The current and re-estimated BRPs are presented in Table K25. Several factors suggest that the estimated SSB_{MSY} value for this stock is reasonable. Firstly, SSB_{MSY} was derived based on the average selectivity during 2003-2007, a period of time when full selectivity shifted from age 4 to age 5 (Figure K16). Secondly, the SSB estimate from the first year of the VPA, in 1982, is the same as the SSB_{MSY} value (16,000 mt) and ASPIC model results from the 2005 GARM confirm that total biomass during 1964-2004 was highest prior to 1982, the intial year of the VPA (NEFSC 2005).

6.0 Projections

Stochastic projections were run using AGEPRO software to predict catch and biomass levels during 2009-2018 under the following three scenarios: F status quo ($F_{sq} = 0.28$), F_{MSY} proxy ($F_{40\%} = 0.26$), and F rebuild (to SSB_{MSY} of 16,000 mt). The catch in 2008 was assumed to be the same as the 2007 catch (980 mt). Under all three scenarios, the projected catch for 2009 is more than double the 2007 catch of 980 mt for F_{sq} and nearly double for F_{MSY} and $F_{REBUILD}$ (Table K26). Likewise, the projected SSB in 2009 is nearly double for F_{sq} and F_{MSY}. Higher catches are predicted in 2009 because the 2006 year class, the largest since 1998 and of similar size (Figure K21), will be supporting the fishery in 2009. However, it should be noted that discards of winter flounder from Georges Bank nearly doubled between 2006 and 2007, due to increased discarding by the scallop dredge fleet and secondarily by the large mesh bottom trawl fleet. In 2007, discards represented 20% of the catch.

7.0 Summary

The fishing mortality rate in 2007 (0.28) was higher than the value of the F_{MSY} proxy (0.26), indicating that overfishing was occurring in 2007 (Table K25). The spawning stock biomass in 2007 (4,964 mt) was well below the SSB_{MSY} target (8,000 mt), indicating that the stock was also overfished in 2007 (Table K25, Figure K22). The 2007 estimates of average F and SSB do not require adjustments for the VPA retrospective pattern because the 2000-2006 average rho values for average F and SSB fell within the 80% confidence limits of the average F and SSB estimates.

Landings have been decreasing since 2003 and were at the second lowest level on record in 2007 (787 mt). However, regulatory discards increased during 2005-2007, primarily in the scallop fishery, but also the large mesh trawl fishery. Overall, catches declined during 2003-2007, but relative abundance and biomass indices from NEFSC and Canadian surveys have also

declined to below median levels. During 1997-2004, the age structure improved but has since become truncated again. Both the U.S. and Canadian spring surveys show reduced numbers of age 1-3 fish (and age 4 fish in the CA surveys) after 2000.

Average fishing mortality rates (average F) on age 4-6 fish declined from 0.97 in 2003 to 0.25 in 2006. However, average F increased slightly in 2007 (0.28) to a level slightly above the F_{MSY} proxy. Therefore, overfishing was occurring in 2007. The age range comprising a majority of the spawning stock biomass has become reduced from a broad range of ages to fewer, younger ages. Spawning stock biomass declined by nearly half between 2000 (10,924 mt) and 2005 (4,478 mt), then increased gradually to 4,964 in 2007 but remained well below the SS_{BMSY} value of 16,000 mt. Therefore, the stock was overfished in 2007. The 2009 catch projections are much higher than the actual 2007 catch because the 2006 year class, the largest since 1998 and of similar size, is assumed to support the fishery in 2009. However, the projections assume 2007 catch levels in 2008 and discards have been increasing in recent years and represented 20% of the catch in 2007.

Sources of uncertainty include the underestimation of total discards because discards in the Canadian groundfish trawl fleet and sea scallop fleet are not available. In addition, the lack of adequate discard size composition data for the U.S. large mesh bottom trawl fleet and sea scallop fleet results in imprecise estimates of discards by age. The lack of age-length keys for the Canadian spring surveys requires the use of U.S. commercial age-length keys (for fish greater than 60 cm) in combination with the NEFSC spring survey age-length keys to assign ages to the broader size range of fish caught in the Canadian spring surveys than in either of the NEFSC spring or fall surveys. The cause of the recent decline in the female age at 50% maturity, since 2005, cannot be attributed to the decline in the NEFSC fall survey mean weight- and length-at-age which has occurred since 2003, because a concurrent decline in female age and maturity samples has also occurred.

8.0 Panel Discussion/Comments

Conclusions

The age-based VPA considered in GARM III is a significant improvement over the Surplus Production Model used in GARM II. There was such a small retrospective pattern in the VPA Base run that it did not require an adjustment. The Panel accepted the VPA Base run as Final and the best available to provide management advice on stock status and from which to base stock and rebuilding plan projections.

The Panel had a number of concerns with the Base VPA run. Year – classes were not being tracked well in the model, similar to the situation in the other winter flounder stocks although the problem here is not as severe. Another concern is the apparent lack of correlation between catch and surveys in the recent time period. The Panel reiterated its earlier comment that the Winter Flounder stocks be considered as a stock complex for assessment purposes (See Panel Conclusions on Gulf of Maine Winter Flounder).

The Panel queried why the resource was declining when harvest has not exceeded MSY levels since 1984. This issue requires further exploration.

Research Recommendations

Assessment approaches needs to be explored that consider all three Winter Flounder stocks as a stock complex within which there is significant interaction amongst the individual stock components.

Further examination of the reasons for why the resource has declined when harvest has not exceeded MSY since 1984 needs to be undertaken.

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10.0 Acknowledgements

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Table K1. Landings, discards, and catches (mt) of Georges Bank winter flounder during 1964-2007.

YEAR	522-525 561-562 USA[1]	5Ze[2] (521-526 and 541-562) CA	5Ze[2] (521-526 and 541-562) USSR	5Z (521-562) CA	5Z (521-562) USSR	TOTAL LANDINGS	DISCARDS	CATCH
1964	1,370			146		1,516	231	1,747
1965	1,175			199	312	1,686	165	1,851
1966	1,876			164	156	2,196	137	2,333
1967	1,916			83	349	2,348	106	2,454
1968	1,569	57	372			1,998	140	2,138
1969	2,165	116	235			2,516	117	2,633
1970	2,613	61	40			2,714	109	2,824
1971	3,089	62	1,029			4,180	105	4,286
1972	2,802	8	1,699			4,509	98	4,608
1973	2,267	14	693			2,974	94	3,068
1974	2,123	12	82			2,217	98	2,315
1975	2,407	13	515			2,935	118	3,053
1976	1,876	15	1			1,892	142	2,034
1977	3,569	15	7			3,591	207	3,798
1978	3,183	65				3,248	262	3,510
1979	3,042	19				3,061	257	3,319
1980	3,928	44				3,972	255	4,227
1981	3,990	19				4,009	281	4,290
1982	2,959	19				2,978	246	3,224
1983	3,894	14				3,908	225	4,133
1984	3,927	4				3,931	195	4,126
1985	2,151	12				2,163	158	2,321
1986	1,761	25				1,786	182	1,968
1987	2,637	32				2,669	272	2,941
1988	2,804	55				2,859	293	3,152
1989	1,880	11				1,891	316	2,207
1990	1,898	55				1,953	338	2,291
1991	1,814	14				1,828	314	2,142
1992	1,822	27				1,849	29	1,877
1993	1,662	21				1,683	11	1,693
1994	931	65				996	10	1,005
1995	729	54				783	1	784
1996	1,370	71				1,441	26	1,467

Table K1 – continued.

YEAR	522-525 561-562 USA[1]	5Ze[2] (521-526 and 541-562) CA	5Ze[2] (521-526 and 541-562) USSR	5Z (521-562) CA	5Z (521-562) USSR	TOTAL LANDINGS	DISCARDS	CATCH
1997	1,226	143				1,369	69	1,438
1998	1,308	93				1,401	52	1,453
1999	939	104				1,043	85	1,128
2000	1,603	161				1,764	65	1,829
2001	1,674	529				2,203	11	2,214
2002	2,100	244				2,344	20	2,364
2003	2,829	310				3,139	9	3,149
2004	2,660	191				2,851	69	2,921
2005	2,012	73				2,085	118	2,202
2006	825	55				880	110	990
2007	775	12				787	193	980

[1] USA landings prior to 1985 include those from Statistical Areas 551 and 552, and since May of 1994, landings have been self-reported by dealers and were allocated to statistical areas based on Vessel Trip Report data.
[2] Includes landings from statistical areas 521, 526, and 541 which are outside of the Georges Bank winter flounder stock area.

Table K2. Landings (mt) of Georges Bank winter flounder, by major gear type, during 1964-2007.

	Landings (mt)			
Year	Bottom Trawl	Scallop Dredge	Other	Total
1964	1,359	11.2	0.0	1,370
1965	1,174	0.9	0.0	1,175
1966	1,850	4.2	21.6	1,876
1967	1,914	1.8	0.0	1,916
1968	1,564	4.6	0.0	1,569
1969	2,163	1.8	0.0	2,165
1970	2,609	4.4	0.0	2,613
1971	3,085	4.8	0.0	3,089
1972	2,795	7.9	0.0	2,802
1973	2,264	3.4	0.1	2,267
1974	2,115	7.7	0.0	2,123
1975	2,385	0.0	22.6	2,407
1976	1,873	1.0	1.6	1,876
1977	3,568	1.1	0.5	3,569
1978	3,164	17.9	1.1	3,183
1979	3,018	24.9	0.0	3,042
1980	3,885	42.5	0.3	3,928
1981	3,932	53.5	3.7	3,990
1982	2,917	41.2	0.1	2,959
1983	3,861	25.4	7.2	3,894
1984	3,897	18.4	11.1	3,927
1985	2,145	3.1	3.1	2,151
1986	1,723	36.0	2.3	1,761
1987	2,559	77.9	0.0	2,637
1988	2,697	106.4	0.0	2,804
1989	1,760	119.7	0.0	1,880
1990	1,778	118.1	1.6	1,898
1991	1,672	141.1	0.7	1,814
1992	1,677	136.3	8.6	1,822
1993	1,534	115.4	12.4	1,662
1994	894	21.6	15.3	931
1995	716	8.5	4.9	729
1996	1,365	4.6	0.7	1,370
1997	1,211	12.0	3.2	1,226
1998	1,274	13.3	20.5	1,308
1999	925	11.2	2.5	939
2000	1,545	23.1	35.2	1,603
2001	1,667	6.3	0.3	1,674
2002	2,092	1.0	7.1	2,100
2003	2,826	0.4	3.2	2,829
2004	2,627	4.5	28.7	2,660
2005	1,892	111.8	7.8	2,012
2006	778	21.9	25.8	825
2007	754	11.1	9.8	775

Table K3. Georges Bank winter flounder discards (mt) for large mesh (codend mesh ≥ 5.5 in.) and small mesh (codend mesh < 5.5 in.) groundfish bottom trawl fisheries and the scallop dredge/trawl fisheries.

	Discards (mt)				
Year	Large mesh	Small mesh	Scallop dredge	Total	CV
1964		112.1	118.4	230.6	
1965		135.4	29.7	165.1	
1966		118.9	18.2	137.1	
1967		82.0	24.0	106.0	
1968		74.1	65.9	140.0	
1969		74.8	42.2	117.0	
1970		72.6	36.8	109.4	
1971		69.5	35.9	105.4	
1972		61.4	36.7	98.1	
1973		61.1	32.8	94.0	
1974		59.7	38.3	97.9	
1975		60.4	57.6	118.0	
1976		48.8	93.0	141.9	
1977		68.3	138.8	207.0	
1978		77.0	184.9	261.9	
1979		75.8	181.7	257.4	
1980		83.1	171.6	254.7	
1981		97.3	184.0	281.3	
1982	11.4	72.3	162.6	246.3	
1983	39.8	21.8	163.6	225.3	
1984	47.3	3.3	144.5	195.1	
1985	28.9	1.6	127.7	158.2	
1986	23.3	1.6	156.6	181.5	
1987	24.8	1.9	245.5	272.1	
1988	28.3	6.4	258.3	293.0	
1989	13.8	0.1	302.4	316.2	
1990	15.7	0.0	322.3	338.0	
1991	1.9	0.0	311.9	313.8	
1992	8.5	0.0	20.3	28.8	0.22
1993	2.5	0.0	8.1	10.6	0.49
1994	2.3	0.9	6.4	9.5	0.16
1995	1.1	0.0	0.0	1.1	0.56
1996	8.3	0.0	17.4	25.7	0.31
1997	0.0	0.0	69.2	69.2	
1998	0.1	0.0	51.5	51.7	0.01
1999	44.0	0.0	41.2	85.2	0.46
2000	16.7	0.1	48.2	64.9	0.31
2001	2.4	0.0	8.3	10.7	0.15
2002	3.1	0.0	16.5	19.7	0.13
2003	6.5	0.9	2.1	9.5	0.34
2004	46.6	15.4	7.3	69.3	0.48
2005	15.0	15.3	87.5	117.9	0.09
2006	26.3	14.9	68.8	110.0	0.12
2007	51.1	12.6	129.5	193.0	0.18

Table K4. Summary of Georges Bank winter flounder discards (mt) estimated for large (codenc mesh size ≥ 5.5 in.) and small mesh (codend mesh size < 5.5 in.) groundfish bottom trawl fishe and the scallop dredge/trawl fisheries (limited permit category), 1964-2007. D/K represents discards of GB winter flounder/weight of all species kept. Discards were hindcast for: large me bottom trawls (1982-1988); small mesh groundfish bottom trawls (1964-1988); and scallop dredges (1964-1991).

	Large Mesh Bottom Trawl			
YEAR	**N observed trips**	**D/K**	**Discards (mt)**	**CV**
1982			11.4	
1983			39.8	
1984			47.3	
1985			28.9	
1986			23.3	
1987			24.8	
1988			28.3	
1989	17	0.00069	13.8	0.59
1990	13	0.00070	15.7	0.80
1991	13	0.00017	1.9	0.37
1992	16	0.00045	8.5	0.60
1993	17	0.00014	2.5	1.69
1994	22	0.00019	2.3	0.65
1995	37	0.00011	1.1	0.52
1996	13	0.00076	8.3	0.81
1997	6	0.00000	0.0	
1998	5	0.00003	0.1	0.47
1999	7	0.00373	44.0	0.70
2000	17	0.00088	16.7	1.24
2001	26	0.00012	2.4	0.70
2002	48	0.00016	3.1	0.86
2003	107	0.00028	6.5	0.46
2004	154	0.00188	46.6	0.59
2005	569	0.00081	15.0	0.25
2006	303	0.00221	26.3	0.31
2007	302	0.00388	51.1	0.26

Table K4 (cont.)

	Small Mesh Groundfish Bottom Trawl			
YEAR	**N observed trips**	**D/K**	**Discards (mt)**	**CV**
1964			112.1	
1965			135.4	
1966			118.9	
1967			82.0	
1968			74.1	
1969			74.8	
1970			72.6	
1971			69.5	
1972			61.4	
1973			61.1	
1974			59.7	
1975			60.4	
1976			48.8	
1977			68.3	
1978			77.0	
1979			75.8	
1980			83.1	
1981			97.3	
1982			72.3	
1983			21.8	
1984			3.3	
1985			1.6	
1986			1.6	
1987			1.9	
1988			6.4	
1989	15	0.00001	0.1	0.87
1990	8	0.00000	0.0	
1991	8	0.00000	0.0	
1992	6	0.00000	0.0	
1993	1	0.00000	0.0	
1994	2	0.01141	0.9	0.00
1995	3	0.00000	0.0	
1996	2	0.00000	0.0	
1997	1	0.00000	0.0	
1998	1	0.00000	0.0	
1999	1	0.00000	0.0	
2000	5	0.00003	0.1	0.97
2001	7	0.00000	0.0	
2002	7	0.00002	0.0	0.82
2003	15	0.00010	0.9	0.85
2004	17	0.00363	15.4	0.89
2005	79	0.00279	15.3	0.64
2006	18	0.00461	14.9	0.77
2007	12	0.00207	12.6	2.48

Table.K4 (cont.)

	Scallop dredge/trawl, Limited category permits			
YEAR	**N observed trips**	**D/K**	**Discards (mt)**	**CV**
1964			118.4	
1965			29.7	
1966			18.2	
1967			24.0	
1968			65.9	
1969			42.2	
1970			36.8	
1971			35.9	
1972			36.7	
1973			32.8	
1974			38.3	
1975			57.6	
1976			93.0	
1977			138.8	
1978			184.9	
1979			181.7	
1980			171.6	
1981			184.0	
1982			162.6	
1983			163.6	
1984			144.5	
1985			127.7	
1986			156.6	
1987			245.5	
1988			258.3	
1989			302.4	
1990			322.3	
1991			311.9	
1992	6	0.00101	20.3	0.98
1993	8	0.00030	8.1	3.06
1994	5	0.00156	6.4	0.91
1995	3	0.00004	0.0	0.00
1996	54	0.00331	17.4	0.00
1997	6	0.00951	69.2	0.78
1998	4	0.00677	51.5	1.51
1999	19	0.00124	41.2	0.59
2000	179	0.00209	48.2	0.14
2001	16	0.00203	8.3	0.21
2002	4	0.00305	16.5	0.56
2003	2	0.00024	2.1	0.00
2004	30	0.00045	7.3	0.28
2005	62	0.00186	87.5	0.28
2006	68	0.00119	68.8	0.37
2007	59	0.00359	129.5	0.30

Table K5. Numbers of Georges Bank winter flounder sampled for length, by year and market category, and sampling intensity (mt landed per 100 lengths) during 1982-2007.

Year	N lengths by market category					Sampling intensity (mt landed per 100 lengths)
	Unclassified (1200)	Lemon/XL (1201, 1204)	Large/Lg mix (1202, 1205)	Med/small (1203, 1206, 1207)	Total	
1982	350	724	1,019	807	2,900	101
1983		625	1,768	2,100	4,493	86
1984		518	1,435	902	2,855	137
1985	68	728	1,675	1,456	3,927	55
1986	124	389	1,125	1,184	2,822	61
1987		603	1,068	1,437	3,108	82
1988		478	1,034	1,447	2,959	91
1989		167	566	737	1,470	120
1990	399	27	1,285	1,758	3,469	51
1991	103	136	1,603	1,295	3,137	53
1992		131	1,420	1,483	3,034	56
1993		336	509	590	1,435	108
1994		183	632	556	1,371	66
1995		103	279	469	851	85
1996		370	484	138	992	138
1997		43	518	443	1,004	121
1998			79	403	482	269
1999	94		121	274	489	190
2000		486	160	697	1,343	118
2001	102	670	990	804	2,566	65
2002	274	699	1,458	424	2,855	74
2003	268	1,589	2,863	625	5,345	53
2004		1,579	4,643	188	6,410	41
2005	161	1,987	3,790	576	6,514	29
2006	100	1,978	3,196	293	5,567	14
2007		1,164	1,256	61	2,481	31

Table K6. Port sampling of U.S. winter flounder landings from Georges Bank (Statistical Areas 522-525, 551-562), for length and age compositions, during 1982-2007. Total number of samples does not include unclassified market category samples collected in: 1980 (1), 1981 (2), 1982 (4), 1985 (1), 1986 (1), 1990 (4), 1991 (1), 1999 (1), 2001 (1), 2002 (3), 2003 (4), 2005 (3), and 2006 (1).

				Number of Samples by Market Category and Quarter														Annual Sampling Intensity (mt landed/sample)		
				Lemon Sole Lemon Sole (1201) Extra-Large (1204)					Large Large (1202) Large/Mixed (1205)					Small Small (1203) Medium (1206) Pee-Wee (1207)					1201 1204	1202 1205	1203 1206 1207
Year	N Samples	N Lengths	N Ages	Q1	Q2	Q3	Q4	Tot	Q1	Q2	Q3	Q4	Tot	Q1	Q2	Q3	Q4	Tot	Lemon	Large	Small
1982	26	2,900	739	0	1	6	2	**9**	0	1	6	3	**10**	0	1	5	1	**7**	26	71	190
1983	36	4,493	874	0	3	2	1	**6**	2	5	6	2	**15**	2	3	9	1	**15**	37	42	84
1984	24	2,855	593	0	1	3	1	**5**	3	3	4	3	**13**	1	2	0	3	**6**	135	111	48
1985	38	3,927	827	1	2	5	1	**9**	2	4	9	1	**16**	2	3	7	1	**13**	50	28	75
1986	29	2,822	563	1	1	0	3	**5**	2	3	3	2	**10**	1	6	3	4	**14**	178	67	144
1987	33	3,108	618	2	1	1	2	**6**	4	3	3	1	**11**	5	3	4	4	**16**	87	51	131
1988	34	2,959	693	2	2	1	2	**7**	4	3	3	1	**11**	4	4	4	4	**16**	86	61	111
1989	16	1.470	280	1	1	0	0	**2**	3	2	0	1	**6**	1	3	3	1	**8**	412	124	282
1990	34	3,469	737	0	0	0	1	**1**	3	3	4	3	**13**	6	7	3	4	**20**	902	58	116
1991	35	3,137	698	1	1	1	1	**4**	6	6	2	2	**16**	6	3	3	3	**15**	129	37	114
1992	35	3,034	688	1	2	1	1	**5**	5	4	3	3	**15**	6	5	3	1	**15**	301	36	118
1993	16	1,435	338	1	2	0	1	**4**	3	2	0	0	**5**	1	5	0	1	**7**	93	408	195
1994	14	1,371	276	0	2	1	0	**4**	1	2	2	1	**6**	1	2	1	1	**5**	15	62	92
1995	9	851	215	1	0	0	1	**2**	1	0	0	2	**3**	2	1	0	1	**4**	22	86	91
1996	10	992	218	0	2	1	1	**4**	0	2	1	1	**4**	0	0	1	1	**2**	16	111	315
1997	13	1,004	232	0	0	0	1	**1**	1	2	1	1	**5**	2	2	0	3	**7**	44	87	51

Table K6 (cont.).

Year	N Samples	N Lengths	N Ages	Number of Samples by Market Category and Quarter: Lemon Sole — Lemon Sole (1201) Extra-Large (1204) Q1	Q2	Q3	Q4	Tot	Large — Large (1202) Large/Mixed (1205) Q1	Q2	Q3	Q4	Tot	Small — Small (1203) Medium (1206) Pee-Wee (1207) Q1	Q2	Q3	Q4	Tot	Annual Sampling Intensity (mt landed/sample) 1201 1204	1202 1205	1203 1206 1207
																			Lemon	Large	Small
1998	6	482	70	0	0	0	0	**0**	0	1	0	0	**1**	0	1	1	3	**5**	-----	493	148
1999	6	395	78	0	0	0	0	**0**	0	0	0	1	**1**	2	0	0	3	**5**	-----	379	97
2000	17	1,343	283	0	0	1	4	**5**	0	0	0	2	**2**	2	4	1	3	**10**	23	329	77
2001	27	2.464	606	2	2	1	3	**8**	1	5	3	1	**10**	1	0	2	6	**9**	24	82	65
2002	33	2,485	753	2	4	3	2	**11**	0	9	5	3	**17**	1	1	0	3	**5**	34	70	83
2003	60	4,864	1,396	2	7	4	5	**18**	5	17	8	5	**35**	1	1	0	5	**7**	56	40	47
2004	78	6,343	1,862	1	5	6	5	**17**	6	15	22	13	**56**	1	2	1	1	**5**	35	32	46
2005	75	6,353	1,561	3	9	8	4	**24**	4	17	13	6	**40**	1	4	4	2	**11**	17	33	24
2006	68	5,467	1,458	5	13	4	6	**28**	4	17	9	5	**35**	0	3	1	1	**5**	1	14	20
2007	35	2,481	736	4	6	2	4	**16**	7	6	3	0	**16**	3	0	0	0	**3**	8	30	44

Table K7. Percentage of U.S. landings, during 1982-2007, by market category group.

	% of U.S. Landings by Market Category Group			
	Lemon	Large	Small	Unclassified
Year	1201	1202	1203	1200
1982	18.6	57.9	18.9	4.7
1983	9.3	45.5	43.4	1.8
1984	9.6	51.7	34.8	3.9
1985	12.4	50.1	33.9	3.5
1986	10.1	42.0	37.5	10.4
1987	9.2	38.9	47.4	4.5
1988	5.9	35.5	53.3	5.3
1989	5.9	38.1	49.2	6.7
1990	3.8	33.1	57.3	5.9
1991	3.0	37.5	51.2	8.3
1992	3.6	36.9	51.2	8.3
1993	5.3	38.2	49.3	7.1
1994	6.5	40.3	49.4	3.8
1995	6.1	35.4	50.3	8.2
1996	4.8	32.6	46.1	16.6
1997	3.6	35.5	29.2	31.7
1998	4.0	37.7	56.4	1.9
1999	4.8	40.4	51.8	2.9
2000	7.3	41.1	48.4	3.3
2001	11.4	48.7	34.9	4.9
2002	17.6	56.5	19.8	6.0
2003	35.9	49.3	11.6	3.2
2004	22.3	67.9	8.7	1.2
2005	20.0	65.6	13.4	1.0
2006	25.3	59.4	12.3	3.0
2007	17.1	61.2	17.1	4.7

Table K8. Data pooling procedures used to apply length frequency samples to landings by market category to estimate catch (numbers) at age of Georges Bank winter flounder, 1982-2007. An "X" indicates that the time bin applies to all market categories unless otherwise noted.

<table>
<tr><th>Year</th><th>Quarter 1</th><th>Quarter 2</th><th>Quarter 3</th><th>Quarter 4</th><th>Market Category Comments</th></tr>
<tr><td>1982</td><td colspan="2">Pooled each mkt cat</td><td>X</td><td>X</td><td rowspan="11">1204 (Extra Large) pooled with 1201 Lemon Sole

1205 (Large/Mixed) pooled with 1202 (Large)

1206 (Medium) and 1207 (Peewee) pooled with 1203 (Small)</td></tr>
<tr><td>1983</td><td colspan="2">Pooled each mkt cat</td><td>X</td><td>X</td></tr>
<tr><td>1984</td><td colspan="2">Pooled each mkt cat</td><td colspan="2">Pooled each mkt cat</td></tr>
<tr><td>1985</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1986</td><td>X</td><td>X</td><td colspan="2">Pooled each mkt cat</td></tr>
<tr><td>1987</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1988</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1989</td><td>X</td><td>X</td><td colspan="2">Pooled each mkt cat</td></tr>
<tr><td>1990</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1991</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1992</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>1993</td><td>X</td><td colspan="3">Pooled each mkt category</td></tr>
<tr><td rowspan="2">1994</td><td colspan="2">Pooled Lemon/Lg</td><td colspan="2">Pooled Lemon/Lg</td><td rowspan="7">1201 (Lemon Sole) and 1204 (Extra Large) pooled with 1202 (Large) and 1205 (Large/Mixed)

1206 (Medium) and 1207 (Peewee) pooled with 1203 (Small)</td></tr>
<tr><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td rowspan="2">1995</td><td colspan="2">Pooled Lemon/Lg</td><td colspan="2">Pooled Lemon/Lg</td></tr>
<tr><td>X</td><td>X</td><td colspan="2">Pooled Med/Sm</td></tr>
<tr><td rowspan="2">1996</td><td colspan="2">Pooled Lemon/Lg</td><td>X</td><td>X</td></tr>
<tr><td colspan="4">Pooled Med/Sm</td></tr>
<tr><td>1997</td><td>X</td><td>X</td><td colspan="2">Pooled Lemon/Lg
Pooled Med/Sm</td></tr>
<tr><td>1998</td><td colspan="4">Pooled all mkt categories</td><td rowspan="2">Pooled all market categories and included all kept lengths from otter trawl observer trips</td></tr>
<tr><td>1999</td><td colspan="4">Pooled all mkt categories</td></tr>
<tr><td>2000</td><td colspan="2">Pooled all mkt categories</td><td colspan="2">Pooled Lemon/Lg
Pooled Med/Sm</td><td>Pooled market categories as in 1994-1997 and included kept lengths from otter trawl observer trips (months 1-6)</td></tr>
</table>

Table K8 (cont.).

Year	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Market Category Comments
2001	Pooled Med/Sm		X	X	1204 (Extra Large) pooled with 1201 Lemon Sole 1205 (Large/Mixed) pooled with 1202 (Large) 1206 (Medium) and 1207 (Peewee) pooled with 1203 (Small)
2002	X	X	Pooled Med/Sm		
2003	X	X	Pooled Med/Sm		
2004	X	X	X	X	
2005	X	X	X	X	
2006	Pooled Med/Sm		X	X	
2007	Pooled Med/Sm				
	X	X	Pooled Lg		
	X	X	X	X	

Table K9. Landings (numbers, in thousands) at age for Georges Bank winter flounder during 1982-2007.

	Age							
Year	1	2	3	4	5	6	7+	Total
1982	0	353	1,707	1,048	511	258	281	4,157
1983	10	787	2,902	1,454	551	206	528	6,438
1984	0	282	570	1,371	1,408	635	920	5,186
1985	20	805	693	812	491	112	100	3,031
1986	0	665	1,328	235	229	131	88	2,675
1987	0	1,294	1,681	899	133	89	121	4,217
1988	0	835	2,774	843	197	90	93	4,832
1989	0	1,381	1,222	509	147	107	61	3,427
1990	0	295	2,032	668	185	46	17	3,241
1991	0	593	1,270	951	136	38	60	3,047
1992	0	796	756	727	468	92	61	2,902
1993	37	301	1,143	451	320	163	47	2,461
1994	0	367	635	360	97	50	45	1,554
1995	371	701	172	142	105	32	41	1,563
1996	0	1,319	423	185	95	98	88	2,208
1997	0	355	993	444	176	79	87	2,135
1998	0	10	1,426	826	131	43	12	2,447
1999	0	296	786	521	147	20	20	1,790
2000	0	646	1,108	369	254	186	160	2,723
2001	11	372	1,280	801	586	158	99	3,307
2002	0	121	927	757	445	236	189	2,675
2003	0	259	694	925	455	252	400	2,987
2004	0	62	579	844	520	234	367	2,606
2005	0	224	529	752	362	142	217	2,227
2006	0	25	283	278	122	55	113	876
2007	0	0	143	125	223	77	96	864

Table K10. Number of Georges Bank winter flounder lengths sampled from the discards of the bottom trawl and scallop dredge fisheries by fisheries observers during 1989-2007.

	N lengths sampled from discards	
Year	Bottom trawl	Scallop dredge
1989	70	0
1990	22	0
1991	5	0
1992	15	1
1993	5	3
1994	6	35
1995	11	0
1996	39	2
1997	1	417
1998	1	84
1999	2	17
2000	4	15
2001	1	0
2002	95	1
2003	92	1
2004	299	125
2005	420	807
2006	438	421
2007	730	887

Table K11. Discards (numbers, in thousands) at age for Georges Bank winter flounder during 1982-2007.

	Age							
Year	1	2	3	4	5	6	7+	Total
1982	116	692	1,776	1,090	531	268	292	4,776
1983	137	1,037	3,000	1,503	570	213	546	7,007
1984	138	427	587	1,412	1,450	654	947	5,616
1985	66	946	733	858	519	118	106	3,346
1986	38	763	1,416	251	244	139	94	2,945
1987	99	1,461	1,789	956	142	94	129	4,670
1988	72	1,013	2,925	889	208	95	98	5,300
1989	34	1,556	1,340	559	161	117	66	3,833
1990	36	370	2,248	739	204	50	18	3,667
1991	2	656	1,389	1,040	149	41	66	3,343
1992	23	764	704	678	436	86	57	2,748
1993	39	285	1,062	419	297	152	44	2,296
1994	8	353	598	339	92	47	43	1,478
1995	365	688	168	138	103	31	40	1,534
1996	35	1,336	424	185	95	98	88	2,261
1997	2	52	27	12	2	1	1	96
1998	0	10	1,445	837	132	44	12	2,480
1999	70	395	808	536	151	20	21	2,001
2000	52	676	1,100	366	253	185	159	2,791
2001	15	376	1,276	799	584	157	99	3,306
2002	0	117	890	728	427	227	182	2,571
2003	0	257	689	918	452	251	398	2,968
2004	3	25	15	17	5	4	8	76
2005	4	41	18	19	11	18	12	123
2006	4	12	23	24	24	6	9	102
2007	11	34	32	35	47	13	14	186

Table K12. Mean weights at age (kg) in the catches of Georges Bank winter flounder during 1982-2007.

				Age				All
Year	1	2	3	4	5	6	7+	Ages
1982	0.216	0.234	0.444	0.779	1.041	1.228	1.615	0.647
1983	0.149	0.260	0.451	0.668	0.899	0.991	1.340	0.576
1984	0.110	0.281	0.467	0.585	0.744	0.891	1.266	0.719
1985	0.191	0.386	0.522	0.782	1.050	1.366	1.720	0.683
1986	0.197	0.392	0.617	0.778	1.029	1.194	1.589	0.650
1987	0.081	0.375	0.549	0.868	1.107	1.217	1.724	0.606
1988	0.145	0.327	0.510	0.760	1.149	1.323	1.761	0.567
1989	0.123	0.355	0.459	0.826	1.076	1.332	1.742	0.538
1990	0.110	0.432	0.510	0.757	0.992	1.339	2.021	0.588
1991	0.190	0.415	0.479	0.702	0.985	1.438	1.751	0.594
1992	0.137	0.386	0.494	0.744	0.906	1.185	1.465	0.627
1993	0.246	0.382	0.537	0.758	0.941	1.294	1.900	0.680
1994	0.200	0.413	0.543	0.803	0.954	1.380	1.618	0.651
1995	0.285	0.387	0.590	0.666	0.999	1.267	1.652	0.501
1996	0.120	0.444	0.649	0.892	1.223	1.467	1.763	0.639
1997	0.140	0.429	0.540	0.696	0.981	1.233	1.439	0.648
1998	0.178	0.244	0.486	0.631	0.809	1.322	1.829	0.572
1999	0.215	0.337	0.452	0.703	1.040	1.569	1.778	0.534
2000	0.119	0.416	0.478	0.568	1.003	1.277	1.627	0.628
2001	0.238	0.306	0.488	0.750	0.827	1.241	1.821	0.664
2002	0.137	0.481	0.554	0.845	1.071	1.340	1.812	0.878
2003	0.124	0.404	0.608	0.968	1.254	1.540	1.893	1.052
2004	0.095	0.471	0.703	0.962	1.216	1.435	1.753	1.090
2005	0.157	0.378	0.592	0.929	1.157	1.435	1.740	0.936
2006	0.131	0.428	0.639	0.919	1.232	1.528	1.874	1.013
2007	0.153	0.465	0.579	0.755	1.036	1.348	1.722	0.935

Table K13. Catch (numbers, in thousands) at age for Georges Bank winter flounder during 1982-2007.

	Age							
Year	1	2	3	4	5	6	7+	Total
1982	116	1,045	3,483	2,138	1,042	526	573	8,924
1983	147	1,824	5,902	2,957	1,121	419	1,075	13,445
1984	138	709	1,157	2,783	2,859	1,289	1,867	10,802
1985	86	1,751	1,426	1,670	1,010	229	206	6,378
1986	38	1,428	2,744	486	472	270	182	5,621
1987	99	2,755	3,470	1,855	275	183	250	8,887
1988	72	1,848	5,699	1,731	405	184	192	10,131
1989	34	2,936	2,562	1,068	309	224	127	7,260
1990	36	665	4,280	1,408	389	96	35	6,908
1991	2	1,248	2,659	1,990	284	79	126	6,390
1992	23	1,560	1,460	1,405	904	178	118	5,649
1993	76	585	2,205	870	617	315	90	4,757
1994	8	720	1,232	699	189	96	88	3,032
1995	736	1,388	340	280	209	63	80	3,097
1996	35	2,655	846	370	190	196	176	4,469
1997	2	407	1,020	456	179	80	87	2,231
1998	0	20	2,870	1,662	263	87	25	4,927
1999	70	691	1,595	1,057	298	40	41	3,790
2000	52	1,322	2,208	735	507	371	319	5,514
2001	26	748	2,556	1,600	1,170	315	198	6,613
2002	0	238	1,816	1,485	872	463	371	5,245
2003	0	517	1,383	1,843	908	504	797	5,954
2004	1	69	584	861	525	237	374	2,682
2005	2	260	545	771	373	160	229	2,350
2006	0	32	301	300	146	61	120	978
2007	11	34	174	360	271	90	110	1,050

Table K14. Relative abundance (stratified mean number per tow) and biomass (stratified mean kg per tow) indices for Georges Bank winter flounder caught in the U.S. spring and autumn (strata 13-23) and Canada spring (strata 5Z1-5Z4) research vessel bottom trawl surveys. Standardization coefficients for trawl door changes (numbers = 1.46 and weight = 1.39) and gear changes (numbers = 2.02 and weight = 1.86) were applied to NEFSC survey indices.

Year	U.S. Spring Survey		U.S. Autumn Survey		Canada Spring Survey	
	Number/tow	Kg/tow	Number/tow	Kg/tow	Number/tow	Kg/tow
1963			1.94	3.02		
1964			1.75	2.77		
1965			2.70	3.03		
1966			4.79	5.26		
1967			1.78	2.11		
1968	2.66	2.99	1.92	1.83		
1969	2.95	4.02	2.59	2.53		
1970	1.81	2.20	7.02	7.73		
1971	1.71	2.04	1.53	1.32		
1972	4.71	4.90	1.64	1.56		
1973	1.34	1.73	2.56	2.30		
1974	3.19	3.16	1.36	1.55		
1975	0.92	0.72	3.74	2.09		
1976	2.23	1.57	5.52	3.63		
1977	1.95	0.90	4.81	3.97		
1978	3.25	2.52	4.22	3.47		
1979	0.79	1.09	5.06	4.08		
1980	1.63	1.45	2.03	2.32		
1981	1.92	2.00	5.50	4.41		
1982	2.42	1.57	5.61	3.32		
1983	8.29	6.93	3.03	2.89		
1984	5.12	5.22	4.90	3.28		
1985	3.54	2.44	1.98	1.18		
1986	2.10	1.26	3.31	2.00		
1987	2.61	1.16	0.96	1.03	1.24	1.74
1988	2.68	1.51	3.90	1.29	4.31	2.75
1989	1.25	0.73	1.43	0.96	4.05	1.95
1990	2.65	1.48	0.51	0.34	4.93	2.64
1991	2.21	1.21	0.31	0.24	1.98	1.38
1992	1.34	0.83	0.69	0.38	0.51	0.59
1993	1.00	0.58	1.22	0.78	3.53	1.76
1994	1.25	0.56	0.85	0.56	5.10	2.01
1995	2.42	1.38	2.74	1.62	5.63	1.96
1996	2.12	1.38	1.48	1.68	4.12	2.30

Table K14 (cont.)

Year	U.S. Spring Survey		U.S. Autumn Survey		Canada Spring Survey	
	Number/tow	Kg/tow	Number/tow	Kg/tow	Number/tow	Kg/tow
1997	1.48	1.09	1.78	1.55	4.58	3.09
1998	0.78	0.71	3.50	3.40	1.14	1.21
1999	3.56	3.21	2.45	2.47	1.25	1.89
2000	4.25	3.55	4.60	4.82	1.48	2.22
2001	1.25	1.16	6.08	4.85	2.28	2.54
2002	4.73	4.82	4.67	5.60	3.17	3.85
2003	1.22	1.30	2.36	2.96	1.09	1.31
2004	0.42	0.51	5.01	4.06	2.10	1.79
2005	1.00	0.80	1.94	2.11	1.19	1.23
2006	0.58	0.49	1.36	1.42	0.09	0.17
2007	0.75	0.68	2.13	2.00	[1]0.18	0.27
2008	7.35	5.42			1.07	0.65
Grand Mean	2.42	2.03	2.92	2.57	2.50	1.79

[1] No tows conducted in the northwest portion of stratum 5Z3 due to adverse weather conditions.

Table K15. NEFSC fall survey minimum population sizes at age (000's) for Georges Bank winter flounder (offshore strata 13-23). Numbers at age include data for 1981-2007 lagged forward one year and age.

Year	1	2	3	4	5	6	7	8	9	10+	Total
1982	0	2,396	674	814	1,082	504	135	244	147	63	6,059
1983	284	2,094	2,178	583	542	283	184	0	33	0	6,181
1984	27	70	568	1,347	619	236	264	95	57	57	3,339
1985	239	654	1,189	1,391	1,408	368	113	26	12	0	5,401
1986	110	341	885	550	80	190	27	0	0	0	2,182
1987	145	1,160	1,627	370	205	48	24	23	0	48	3,652
1988	36	53	239	256	208	99	80	62	27	0	1,061
1989	49	2,958	620	468	139	9	25	25	0	0	4,293
1990	24	97	1,072	73	143	74	58	9	27	0	1,577
1991	24	61	44	376	0	52	0	0	0	0	557
1992	109	46	0	81	53	18	36	0	0	0	344
1993	0	53	509	158	9	27	0	0	0	0	757
1994	0	592	192	283	213	27	0	18	0	18	1,343
1995	0	167	424	224	86	33	0	0	0	0	934
1996	18	937	1,115	685	187	57	0	0	18	0	3,018
1997	0	124	344	614	259	131	94	63	0	0	1,628
1998	18	79	648	758	344	79	30	3	0	0	1,960
1999	91	273	386	1,713	1,109	190	66	27	0	0	3,854
2000	18	388	796	381	367	608	88	27	24	0	2,697
2001	18	53	1,286	1,666	753	902	270	56	69	0	5,073
2002	18	599	1,536	2,442	1,276	322	332	100	53	25	6,703
2003	0	206	496	1,053	1,309	1,148	410	477	23	23	5,146
2004	309	176	27	352	770	652	209	80	21	0	2,597
2005	231	326	1,353	1,377	1,328	282	349	230	44	0	5,520
2006	97	55	167	493	464	297	358	132	18	58	2,139
2007	0	101	179	307	380	422	72	42	0	0	1,502
2008	231	313	317	307	428	613	91	34	18	0	2,351

Table K16. NEFSC spring survey minimum population sizes at age for Georges Bank winter flounder (offshore strata 13-23) during 1982-2008.

Year	1	2	3	4	5	6	7	8	9	10+	Total
1980	92	444	506	268	292	97	7	73	18	0	1,796
1981	53	128	829	579	133	119	247	13	12	0	2,113
1982	74	903	555	660	191	151	41	18	36	36	2,665
1983	27	1,037	3,704	1,555	692	796	608	424	125	169	9,135
1984	36	168	2,107	1,635	390	379	477	280	27	146	5,644
1985	0	1,701	821	636	402	223	47	24	49	0	3,902
1986	255	752	857	192	170	85	0	0	0	0	2,310
1987	163	1,647	670	275	91	0	24	0	0	0	2,871
1988	73	556	1,433	692	117	42	18	0	27	0	2,958
1989	49	560	293	251	157	18	0	53	0	0	1,381
1990	129	653	1,611	357	99	74	0	0	0	0	2,923
1991	273	349	834	587	278	36	24	0	49	0	2,430
1992	73	652	302	141	148	111	0	24	27	0	1,477
1993	172	291	362	175	0	47	33	24	0	0	1,105
1994	127	604	436	96	66	45	0	0	0	0	1,374
1995	150	790	1,295	297	103	30	0	0	0	0	2,664
1996	38	1,233	436	494	70	27	43	0	0	0	2,339
1997	24	194	542	677	115	24	27	0	24	0	1,627
1998	0	24	218	468	125	0	27	0	0	0	861
1999	225	548	675	1,313	896	200	53	18	0	0	3,927
2000	18	620	1,069	697	1,155	734	200	120	71	0	4,685
2001	0	73	335	314	197	193	268	0	0	0	1,380
2002	113	167	245	1,935	772	784	701	312	159	26	5,215
2003	52	27	163	231	367	320	154	27	0	0	1,341
2004	0	36	27	63	215	73	24	28	0	0	465
2005	98	188	130	315	212	132	0	27	0	0	1,101
2006	43	0	188	210	88	81	0	24	0	0	634
2007	91	128	67	159	180	100	56	23	19	0	822
2008	945	1,280	1,513	1,945	1,427	386	94	504	0	0	8,094

Table K17. Canada spring (February) survey minimum population sizes at age for Georges Bank winter flounder (strata 5Z1-5Z4) during 1987-2008.

Year	1	2	3	4	5	6	7	8	9	10+	Total
1987	0	68	153	202	255	102	0	0	0	0	780
1988	102	386	1,396	653	101	46	0	23	0	0	2,708
1989	54	1,244	623	448	141	27	7	6	0	0	2,550
1990	0	88	683	1,991	262	42	25	3	0	0	3,094
1991	44	57	412	577	129	29	0	0	0	0	1,247
1992	0	17	38	131	48	86	0	3	0	0	323
1993	746	419	595	282	85	48	41	3	0	0	2,219
1994	10	2,083	705	155	234	1	11	10	0	0	3,207
1995	992	1,544	799	134	57	8	2	0	0	0	3,534
1996	562	792	589	408	136	50	48	2	3	4	2,594
1997	11	609	990	1,102	120	23	9	17	0	0	2,880
1998	11	19	100	382	180	21	0	0	0	0	714
1999	32	154	146	252	145	36	12	4	4	0	784
2000	6	0	7	87	82	227	227	120	121	54	932
2001	150	49	121	147	276	92	232	348	10	11	1,437
2002	0	58	136	51	729	256	270	284	126	83	1,993
2003	29	135	37	53	80	131	86	126	7	2	686
2004	331	113	59	138	136	327	101	96	17	0	1,319
2005	55	100	55	104	107	107	102	63	37	17	748
2006	0	3	3	36	36	33	68	2	3	1	186
2007	0	0	3	0	8	39	24	21	8	9	112
2008	260	123	48	54	75	26	32	54	0	0	671

Table K18. Annual and average values of Mohn's rho statistic for average F (ages 4-6), spawning stock biomass, and age 1 recruits for Georges Bank winter flounder.

	Relative difference (Year *t*-2007)		
	Avg Fages 4-6	SSB	Age 1 Recruits
2000	-0.01	-0.03	-0.83
2001	-0.27	0.13	0.12
2002	-0.30	0.10	-0.16
2003	-0.11	0.04	-0.07
2004	-0.28	0.16	2.06
2005	-0.20	0.13	0.47
2006	0.09	-0.10	-0.11
Total	-1.08	0.43	1.48
Average	-0.15	0.06	0.21

Table K19. VPA estimates of Jan. 1 population size (numbers, 000's) for Georges Bank winter flounder, 1982-2008.

AGE	1982	1983	1984	1985	1986
1	9809.	5883.	12716.	12242.	16440.
2	16950.	7926.	4684.	10287.	9945.
3	13084.	12935.	4850.	3196.	6846.
4	6882.	7584.	5319.	2930.	1343.
5	2556.	3716.	3562.	1875.	914.
6	1563.	1161.	2036.	411.	637.
7	1702.	2978.	2950.	370.	430.
Total	52546.	42183.	36117.	31312.	36555.

AGE	1987	1988	1989	1990	1991
1	11146.	18565.	10206.	6873.	8955.
2	13426.	9036.	15135.	8325.	5595.
3	6856.	8514.	5735.	9749.	6216.
4	3150.	2520.	1928.	2407.	4157.
5	664.	931.	533.	628.	720.
6	328.	298.	400.	162.	170.
7	447.	310.	227.	59.	271.
Total	36017.	40174.	34164.	28204.	26083.

AGE	1992	1993	1994	1995	1996
1	4365.	3412.	5220.	14569.	10724.
2	7329.	3553.	2725.	4267.	11264.
3	3458.	4598.	2382.	1585.	2248.
4	2712.	1526.	1796.	852.	991.
5	1628.	968.	476.	845.	447.
6	335.	528.	246.	220.	505.
7	223.	152.	226.	279.	452.
Total	20050.	14737.	13072.	22617.	26631.

AGE	1997	1998	1999	2000	2001
1	9940.	12243.	12524.	9900.	6060.
2	8748.	8136.	10022.	10191.	8058.
3	6835.	6795.	6643.	7582.	7152.
4	1083.	4678.	2997.	4006.	4226.
5	480.	479.	2340.	1506.	2618.
6	196.	233.	158.	1648.	779.
7	215.	66.	161.	1417.	489.
Total	27497.	32629.	34846.	36250.	29382.

AGE	2002	2003	2004	2005	2006
1	4807.	3788.	4829.	2584.	5580.
2	4937.	3935.	3101.	3951.	2112.
3	5923.	3827.	2755.	2460.	2995.
4	3566.	3220.	1894.	1721.	1522.
5	2027.	1591.	997.	782.	721.
6	1098.	881.	496.	349.	307.
7	880.	1396.	781.	500.	609.
Total	23239.	18638.	14854.	12348.	13845.

AGE	2007	2008
1	12033.	5122.
2	4565.	9842.
3	1696.	3706.
4	2176.	1231.
5	975.	1457.
6	458.	555.
7	491.	586.
Total	22393.	22500.

Table K20. VPA estimates of fishing mortality rates, by year and age, for Georges Bank winter flounder, 1982-2007.

AGE	1982	1983	1984	1985	1986
1	0.0131	0.0279	0.0120	0.0078	0.0026
2	0.0703	0.2913	0.1821	0.2072	0.1719
3	0.3454	0.6886	0.3037	0.6671	0.5763
4	0.4162	0.5556	0.8424	0.9647	0.5042
5	0.5892	0.4015	1.9583	0.8806	0.8265
6	0.4602	0.5023	1.1567	0.9310	0.6225
7	0.4602	0.5023	1.1567	0.9310	0.6225
Average Ages 4-6	0.4885	0.4865	1.3192	0.9254	0.6511

AGE	1987	1988	1989	1990	1991
1	0.0099	0.0043	0.0037	0.0058	0.0003
2	0.2555	0.2546	0.2398	0.0922	0.2811
3	0.8009	1.2851	0.6684	0.6523	0.6294
4	1.0192	1.3537	0.9210	1.0073	0.7378
5	0.6018	0.6444	0.9909	1.1093	0.5655
6	0.9329	1.1080	0.9357	1.0276	0.7104
7	0.9329	1.1080	0.9357	1.0276	0.7104
Average	0.8513	1.0354	0.9492	1.0480	0.6712

AGE	1992	1993	1994	1995	1996
1	0.0058	0.0248	0.0016	0.0573	0.0036
2	0.2664	0.1998	0.3423	0.4407	0.2995
3	0.6184	0.7399	0.8279	0.2690	0.5305
4	0.8299	0.9652	0.5538	0.4458	0.5246
5	0.9257	1.1690	0.5698	0.3158	0.6245
6	0.8648	1.0395	0.5571	0.3790	0.5546
7	0.8648	1.0395	0.5571	0.3790	0.5546
Average	0.8734	1.0579	0.5602	0.3802	0.5679

AGE	1997	1998	1999	2000	2001
1	0.0002	0.0001	0.0062	0.0059	0.0048
2	0.0527	0.0027	0.0790	0.1541	0.1078
3	0.1793	0.6187	0.3058	0.3845	0.4960
4	0.6156	0.4926	0.4878	0.2252	0.5346
5	0.5228	0.9079	0.1507	0.4596	0.6687
6	0.5862	0.5247	0.3259	0.2840	0.5838
7	0.5862	0.5247	0.3259	0.2840	0.5838
Average	0.5749	0.6417	0.3215	0.3229	0.5957

AGE	2002	2003	2004	2005	2006
1	0.0001	0.0001	0.0006	0.0019	0.0008
2	0.0547	0.1564	0.0315	0.0769	0.0196
3	0.4095	0.5032	0.2703	0.2804	0.1195
4	0.6069	0.9721	0.6850	0.6709	0.2455
5	0.6339	0.9663	0.8499	0.7350	0.2524
6	0.6166	0.9702	0.7389	0.6905	0.2477
7	0.6166	0.9702	0.7389	0.6905	0.2477
Average	0.6191	0.9695	0.7579	0.6988	0.2485

AGE	2007
1	0.0010
2	0.0084
3	0.1199
4	0.2009
5	0.3634
6	0.2821
7	0.2821
Average	0.2821

Table K21. VPA estimates of spawning stock biomass (mt) for Georges Bank winter flounder, 1982-2007.

AGE	1982	1983	1984	1985	1986
1	148.	49.	57.	125.	180.
2	1462.	919.	479.	1055.	1364.
3	3992.	3307.	1436.	968.	2689.
4	4411.	3551.	2218.	1403.	743.
5	2329.	2757.	1631.	1184.	668.
6	1548.	1025.	1389.	331.	605.
7	2409.	3468.	2847.	507.	579.
Total	16300.	15077.	10058.	5573.	6828.

AGE	1987	1988	1989	1990	1991
1	34.	132.	51.	30.	92.
2	1799.	725.	1698.	977.	586.
3	2447.	2600.	1756.	3288.	2252.
4	1806.	1193.	1000.	1114.	2062.
5	525.	785.	380.	438.	533.
6	292.	277.	394.	152.	169.
7	615.	420.	315.	94.	396.
Total	7519.	6133.	5594.	6094.	6090.

AGE	1992	1993	1994	1995	1996
1	27.	50.	58.	253.	52.
2	976.	405.	421.	564.	1958.
3	1250.	1630.	830.	669.	915.
4	1318.	739.	1014.	450.	622.
5	1036.	616.	347.	683.	342.
6	292.	446.	241.	216.	525.
7	263.	225.	314.	410.	686.
Total	5163.	4112.	3226.	3245.	5101.

AGE	1997	1998	1999	2000	2001
1	81.	122.	149.	56.	78.
2	1019.	780.	1253.	1533.	781.
3	2917.	2476.	1874.	2545.	2636.
4	618.	2377.	1526.	1864.	2185.
5	389.	288.	1767.	1109.	1508.
6	206.	230.	160.	1724.	743.
7	265.	104.	258.	2093.	761.
Total	5494.	6376.	6988.	10924.	8691.

AGE	2002	2003	2004	2005	2006
1	29.	19.	18.	19.	30.
2	857.	466.	386.	383.	283.
3	2029.	1690.	1256.	1109.	1298.
4	1949.	1865.	1214.	1169.	1027.
5	1538.	1297.	877.	684.	704.
6	982.	895.	551.	386.	373.
7	1354.	2091.	1135.	729.	1044.
Total	8739.	8323.	5437.	4478.	4759.

AGE	2007
1	88.
2	584.
3	744.
4	1395.
5	850.
6	536.
7	767.
Total	4964.

Table K22. Bootstrapped estimates of the 2008 stock sizes-at-age (numbers, 000's) and 80% confidence intervals for Georges Bank winter flounder.

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
N 2	9842.	11820.	7544.	0.6383
N 3	3706.	4048.	1839.	0.4542
N 4	1231.	1336.	572.	0.4281
N 5	1457.	1507.	496.	0.3290
N 6	555.	590.	205.	0.3481

	Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
N 2	1978.	247.	20.0933	7865.	0.9593
N 3	342.	59.	9.2163	3365.	0.5464
N 4	105.	18.	8.5084	1127.	0.5077
N 5	49.	16.	3.3877	1408.	0.3520
N 6	35.	7.	6.2893	520.	0.3949

	LOWER 80. % CI	UPPER 80. % CI
N 2	4493.	21106.
N 3	2126.	6413.
N 4	727.	2094.
N 5	930.	2164.
N 6	352.	849.

Table K23. Bootstrapped estimates of the 2007 fishing mortality rates-at-age and 80% confidence intervals for Georges Bank winter flounder.

		NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. For NLLS Soln.
AGE	1	0.0010	0.0012	0.000850	0.7071
AGE	2	0.0084	0.0092	0.004312	0.4663
AGE	3	0.1199	0.1291	0.050977	0.3948
AGE	4	0.2009	0.2129	0.065914	0.3096
AGE	5	0.3634	0.3756	0.111159	0.2959
AGE	6	0.2821	0.2943	0.059064	0.2007
AGE	7	0.2821	0.2943	0.059064	0.2007

		Bias Estimate	Bias Std. Error	Per Cent Bias	NLLS Estimate Corrected For Bias	C.V. For Corrected Estimate
AGE	1	0.000199	0.000028	19.8822	0.0008	1.0580
AGE	2	0.000877	0.000139	10.4812	0.0075	0.5755
AGE	3	0.009190	0.001638	7.6622	0.1108	0.4603
AGE	4	0.012055	0.002119	6.0015	0.1888	0.3491
AGE	5	0.012208	0.003536	3.3592	0.3512	0.3165
AGE	6	0.012131	0.001907	4.2998	0.2700	0.2187
AGE	7	0.012131	0.001907	4.2998	0.2700	0.2187

		LOWER 80. % CI	UPPER 80. % CI
AGE	1	0.000468	0.002192
AGE	2	0.004822	0.014537
AGE	3	0.072221	0.194724
AGE	4	0.139716	0.298322
AGE	5	0.252005	0.524366
AGE	6	0.225821	0.371011
AGE	7	0.225821	0.371011

Table K24. Input data, based on 2003-2007 average values from the VPA, for the Georges Bank winter flounder SSB- and yield-per-recruit model (M = 0.2) and stochastic projections.

Age	Selectivity on F	Selectivity on M	Mean stock weights	Mean catch weights	Spawning stock weights	Proportion mature
1	0.001	1	0.074	0.132	0.074	0.08
2	0.10	1	0.235	0.429	0.235	0.54
3	0.43	1	0.518	0.624	0.518	0.94
4	1.00	1	0.747	0.907	0.747	1.00
5	1.00	1	1.043	1.179	1.043	1.00
6	1.00	1	1.313	1.457	1.313	1.00
7+	1.00	1	1.796	1.796	1.796	1.00

Table K25. Current and re-estimated biological reference points for Georges Bank winter flounder and 2007 VPA estimates of fishing mortality rate and spawning stock biomass (mt).

Input data	**$F_{40\%MSP}$**	**F 2007** (80% CI)	**SSB_{MSY}**	**SSB 2007** (80% CI)	**MSY**
1982-2007	0.26	0.28 (0.22,0.37)	16,000	4,964 (4,204, 6,249)	3,500
	F_{MSY}		**B_{MSY}**		**MSY**
Current[1]	0.32		9,400		3,000

[1] Derived from an ASPIC model that included landings data for 1964-2000 and NEFSC spring and fall survey indices for strata 13-22.

Table K26. Stochastic projections of catch (mt) and spawning stock biomass (mt) in 2009 for Georges Bank winter flounder, assuming that the 2008 catch is the same as in 2007, for F_{sq} (status quo), F_{MSY} proxy (= $F_{40\%MSP}$), and F rebuild by 2018.

2008			2009	
Catch (mt)	**SSB (mt)**	**F 2009**	**Catch (mt)**	**SSB (mt)**
980	4,964	F_{sq} (= 0.28)	2,084	9,792
		F_{MSY} ($F_{40\%MSP}$ = 0.26)	1,948	9,822
		$F_{REBUILD}$ (= 0.254)	1,907	9,831

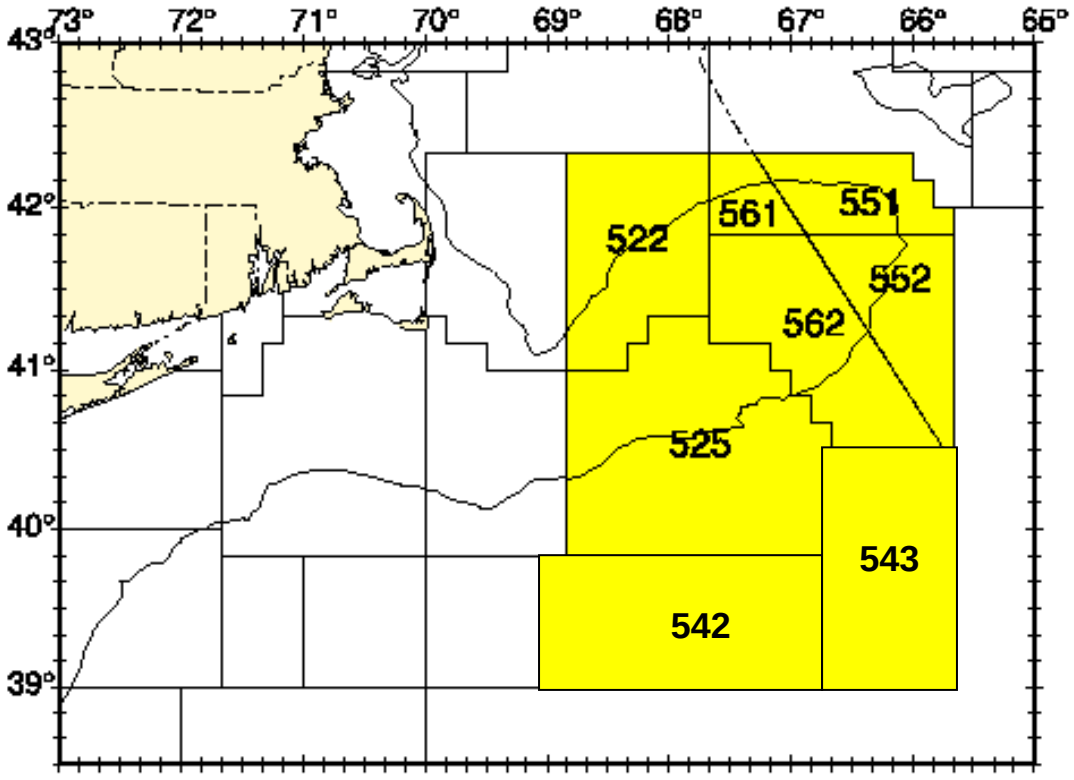

Figure K1. Statistical Areas included in the assessment of the Georges Bank winter flounder stock.

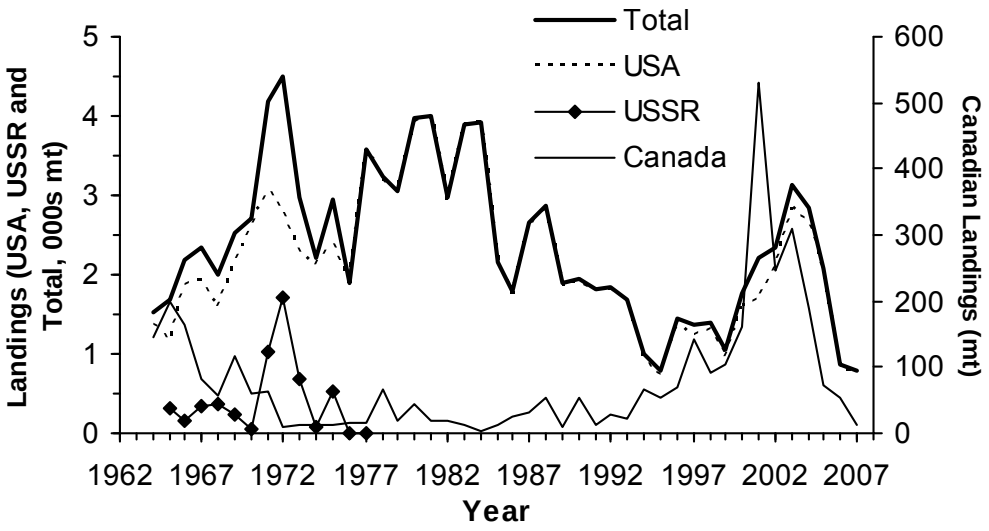

Figure K2. Landings of Georges Bank winter flounder during 1964-2007.

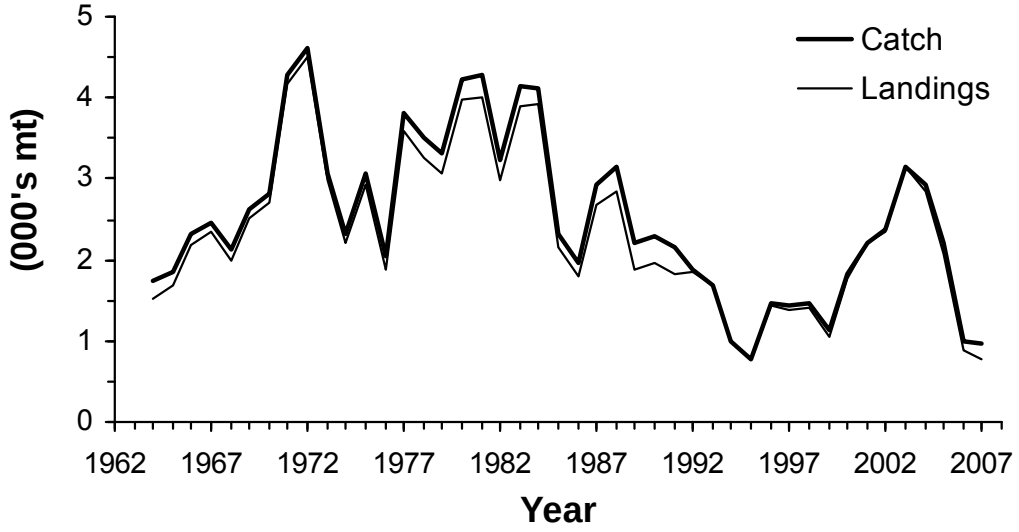

Figure K3. Landings and catches of Georges Bank winter flounder during 1964-2007.

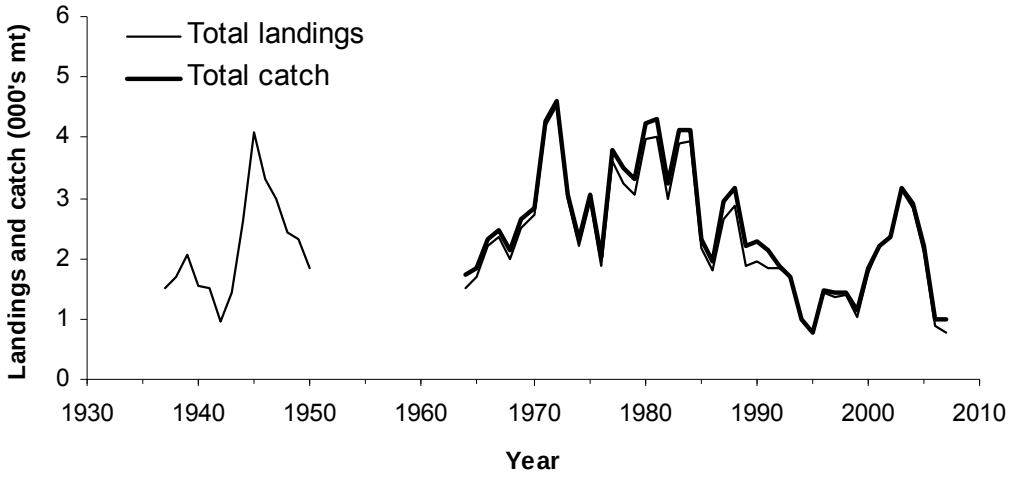

Figure K4. Historical total landings of winter flounder from Georges Bank, during 1937-1950, in relation to total landings and catches during 1964-2007.

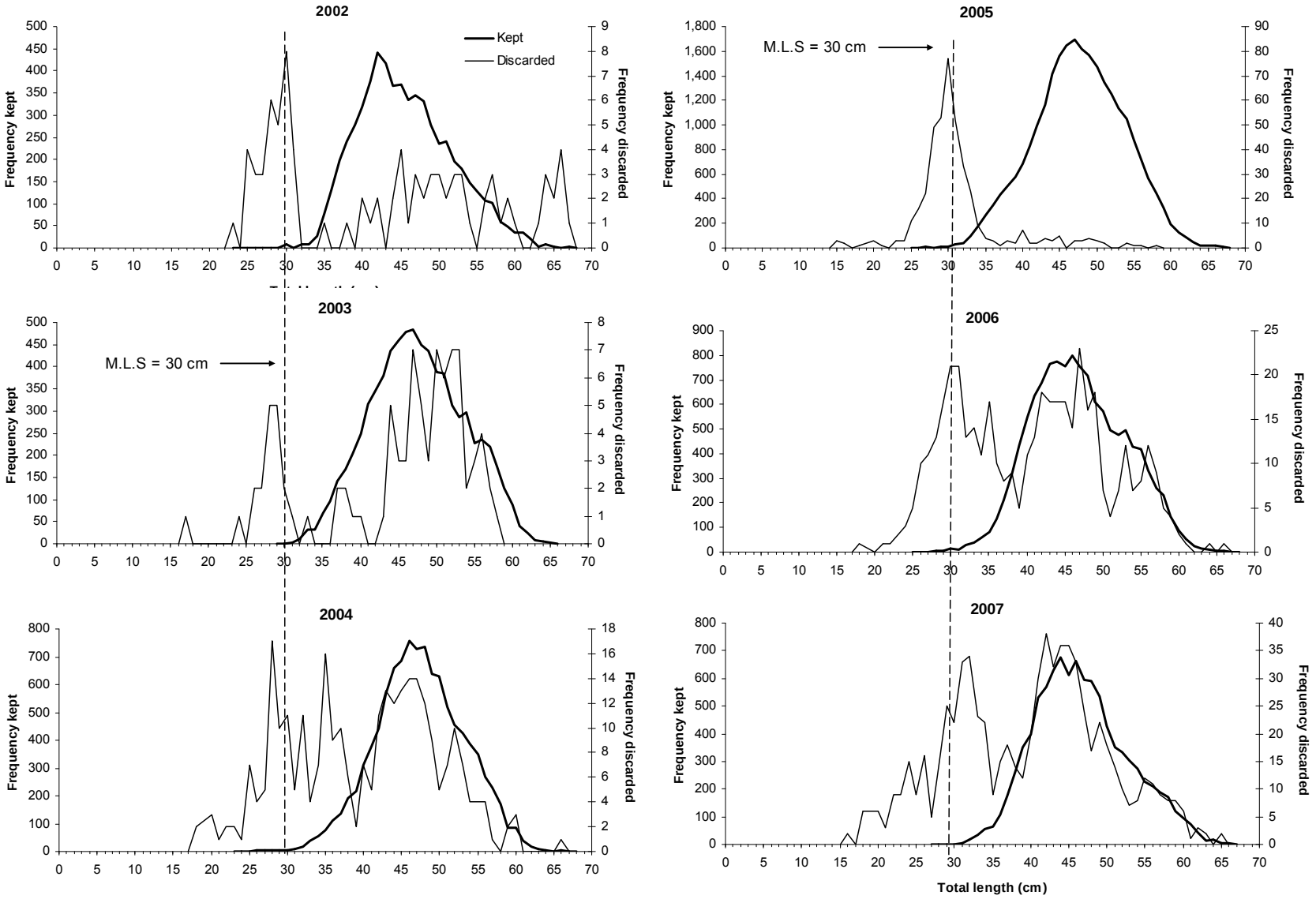

Figure K5. Length frequency distributions of Georges Bank winter flounder kept and discarded portions of bottom trawl catches during 2002-2007.

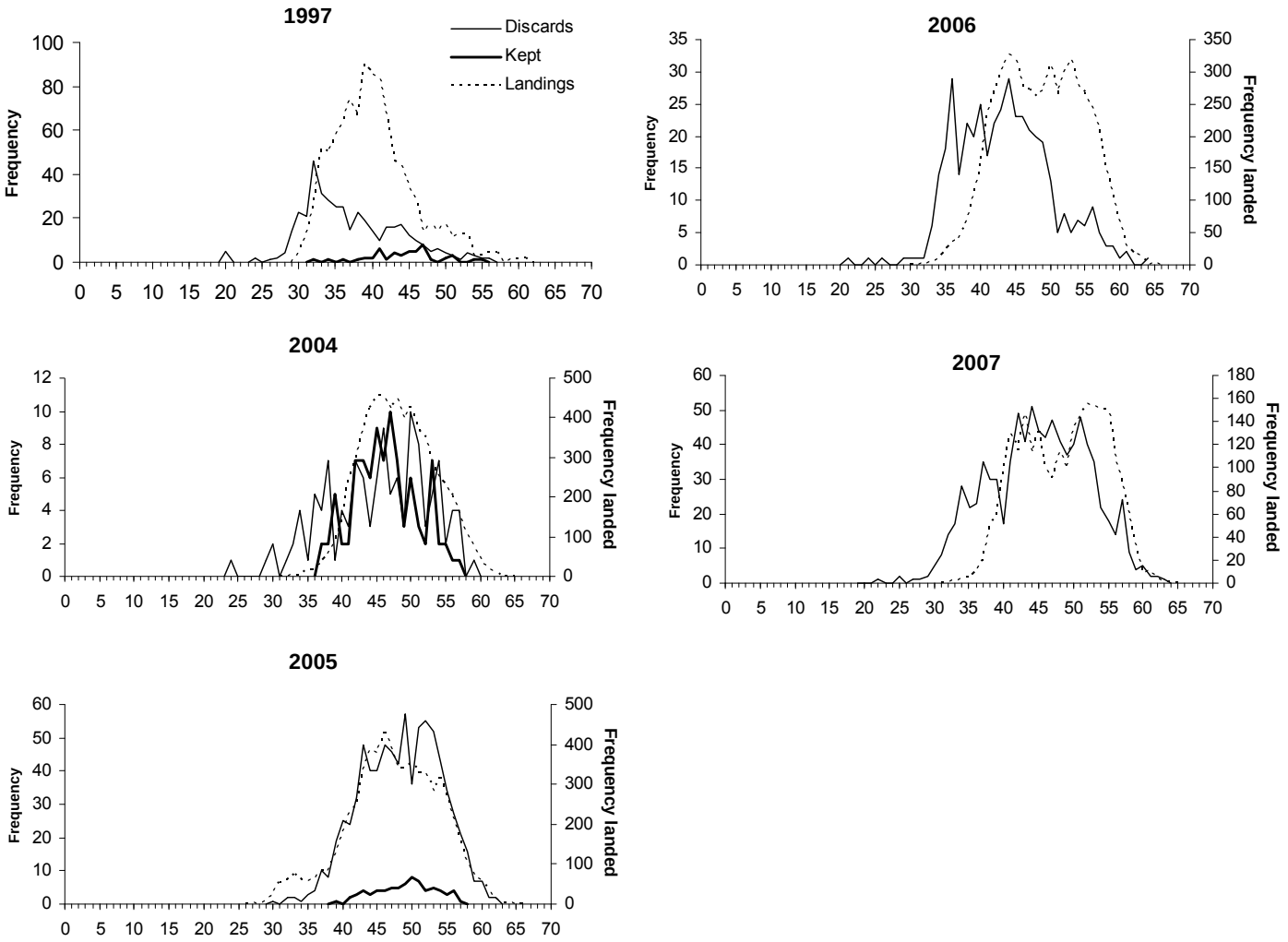

Figure K6. Length frequency distributions of Georges Bank winter flounder kept and discarded portions of scallop dredge catches and landings during 1997 and 2004-2007.

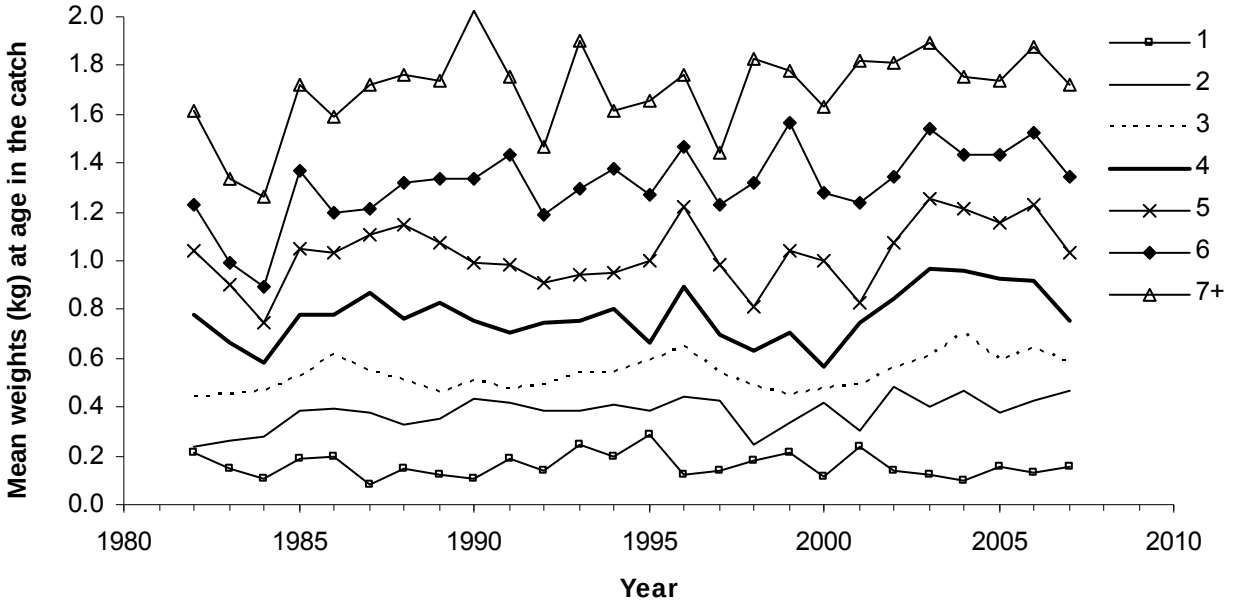

Figure K7. Trends in mean weights (kg) at age for the total catch of GB winter flounder, 1982-2007.

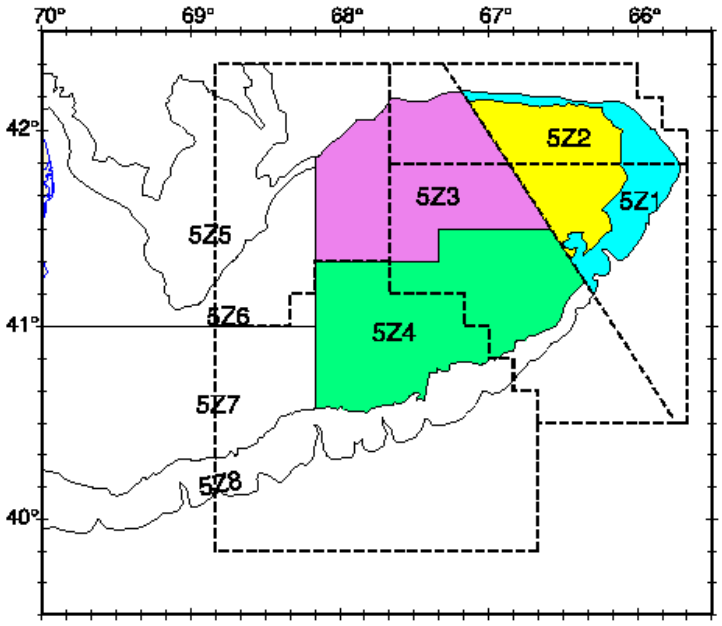

Figure K8 NEFSC survey strata (13-23) included in the assessment of Georges Bank winter flounder in relation to fishery Statistical Areas for the stock.

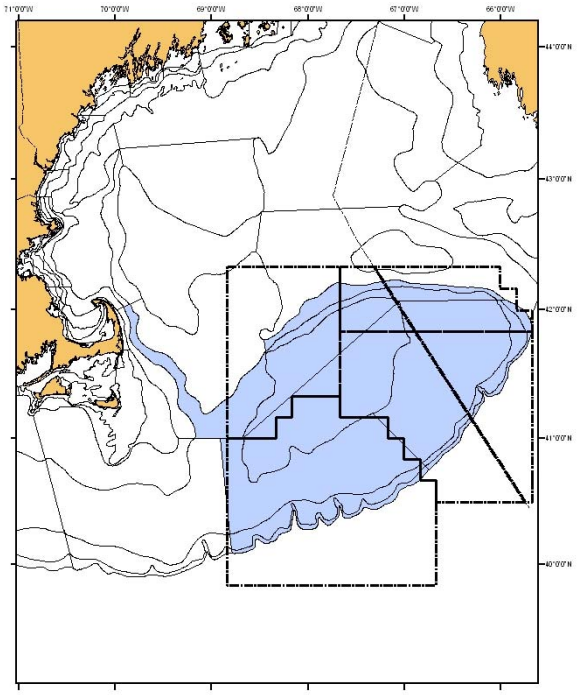

Figure K9. Canadian spring survey strata (5Z1-5Z4) included in the assessment of Georges Bank winter flounder in relation to fishery Statistical Areas for the stock.

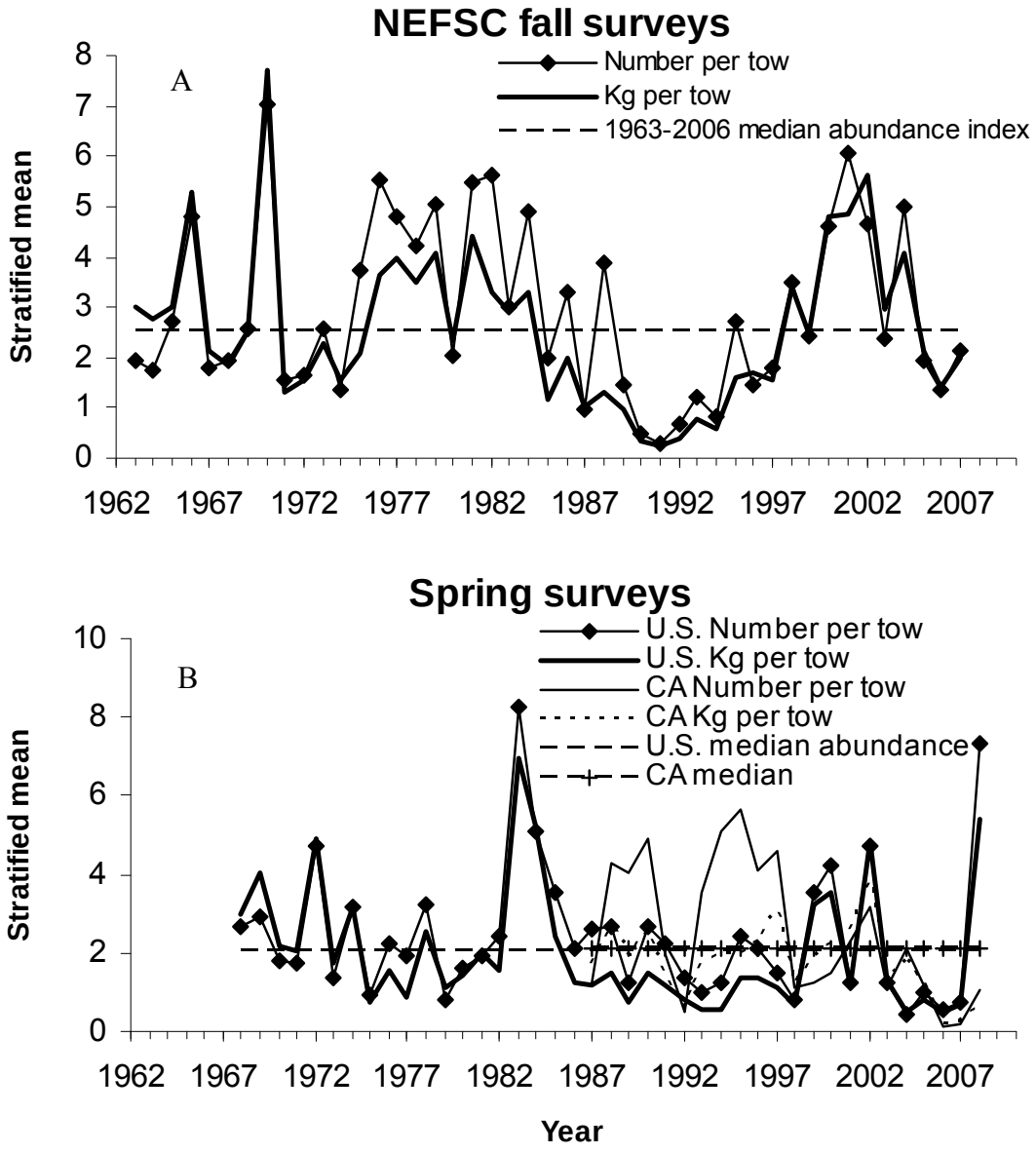

Figure K10. Relative biomass (stratified mean kg per tow) and abundance (stratified mean numbers per tow) indices for Georges Bank winter flounder caught during (A) NEFSC fall (1963-2007) bottom trawl surveys and (B) NEFSC spring (1968-2008) and Canadian spring (1987-2008 strata 5Z1-5Z4) bottom trawl surveys. NEFSC survey indices include strata 13-23 and were standardized for gear changes (weight = 1.86 and numbers = 2.02) and trawl door changes (weight = 1.39 and numbers = 1.46) prior to 1985.

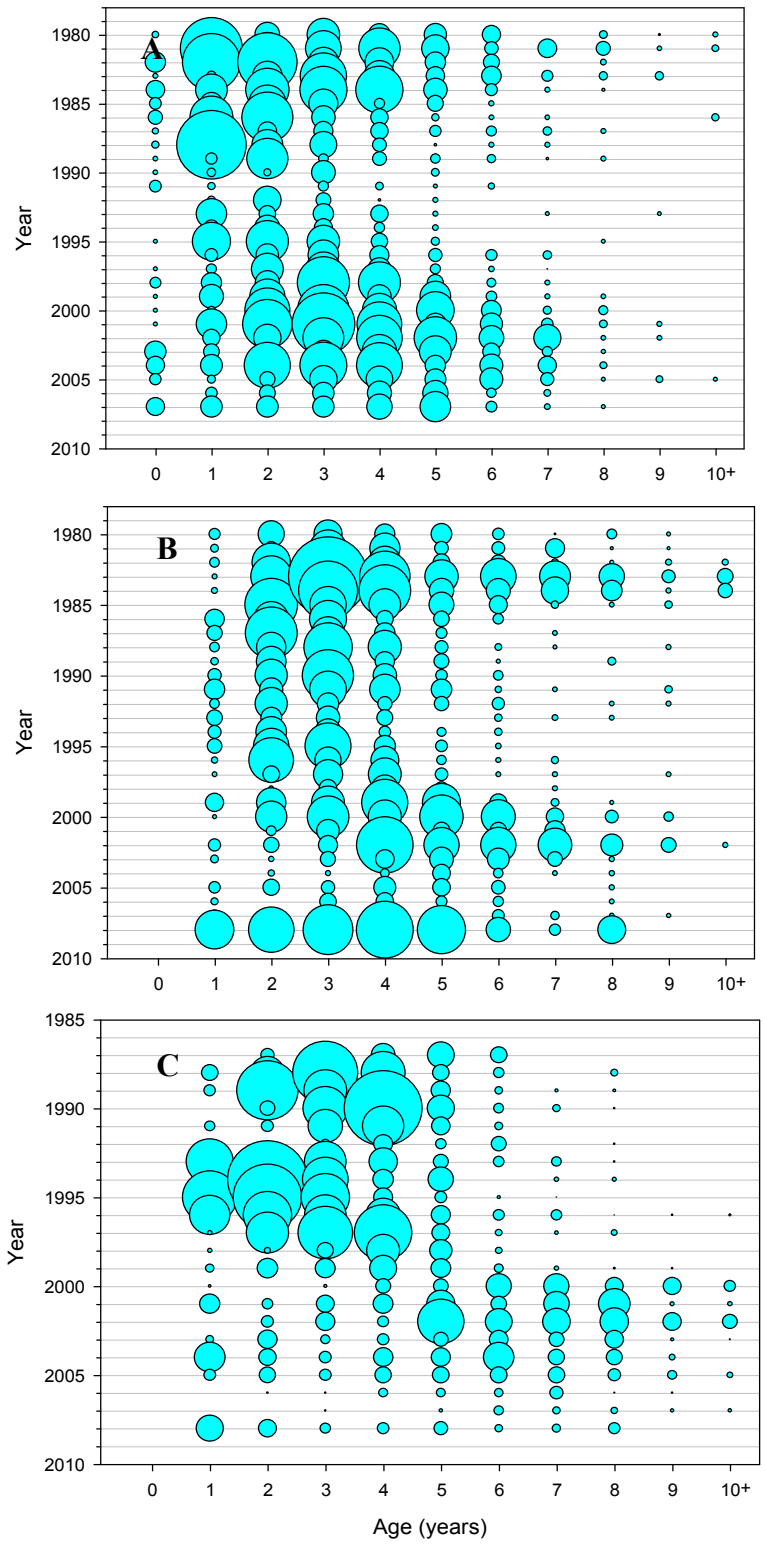

Figure K11. Stratified mean number per tow at age indices for (A) NEFSC fall bottom trawl surveys (1963-2007), (B) NEFSC spring surveys (1968-2008) and (C) CA spring surveys (1987-2008). NEFSC survey indices include offshore strata 13-23 and CA spring surveys include strata 5Z1-5Z4.

Figure K12. Residual patterns NEFSC spring bottom trawl survey indices (ages 1-7, 1982-2008) used to calibrate the VPA for Georges Bank winter flounder.

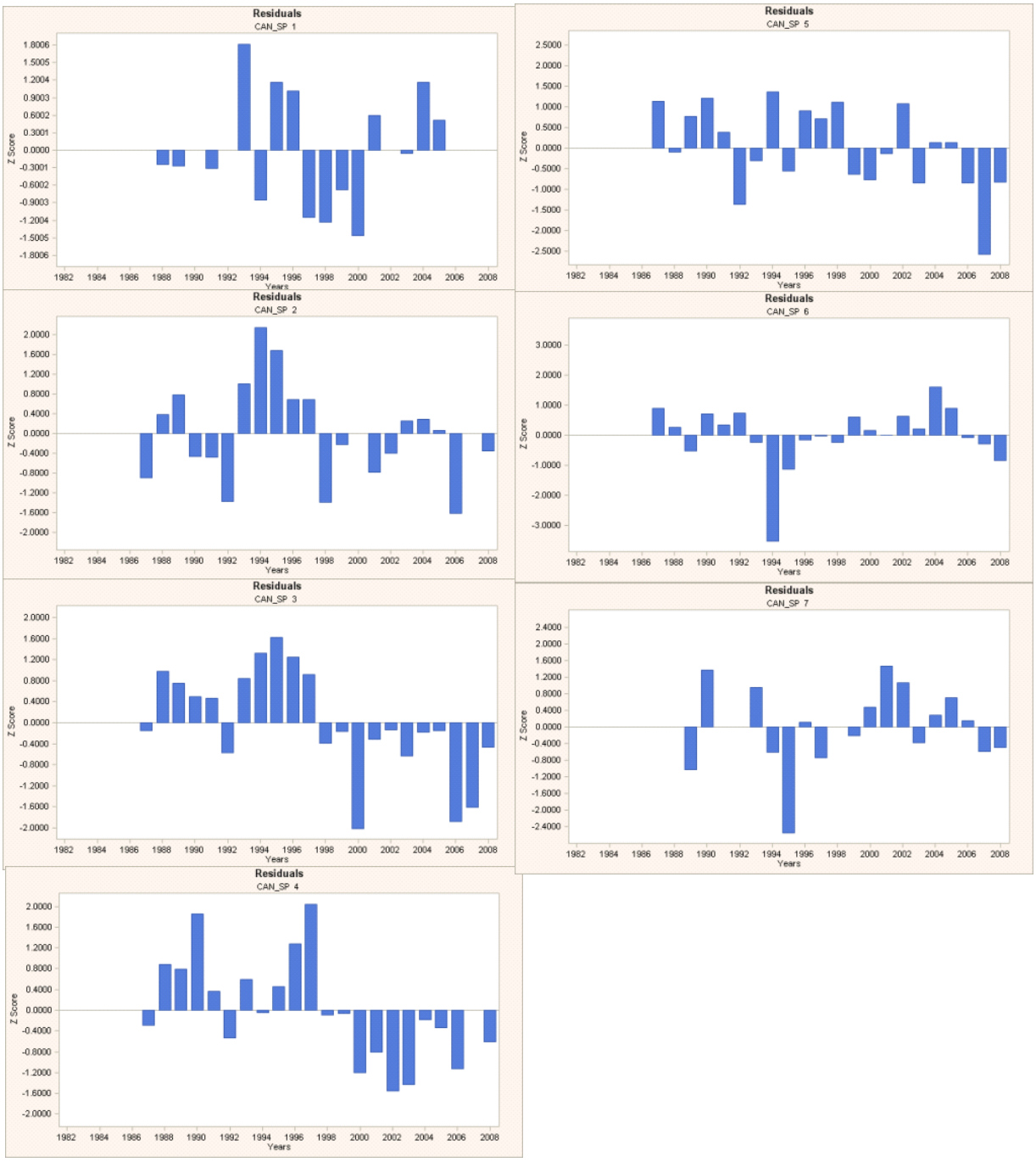

Figure K13. Residual patterns Canadian spring bottom trawl survey indices (ages 1-7, 1982-2008) used to calibrate the VPA for Georges Bank winter flounder.

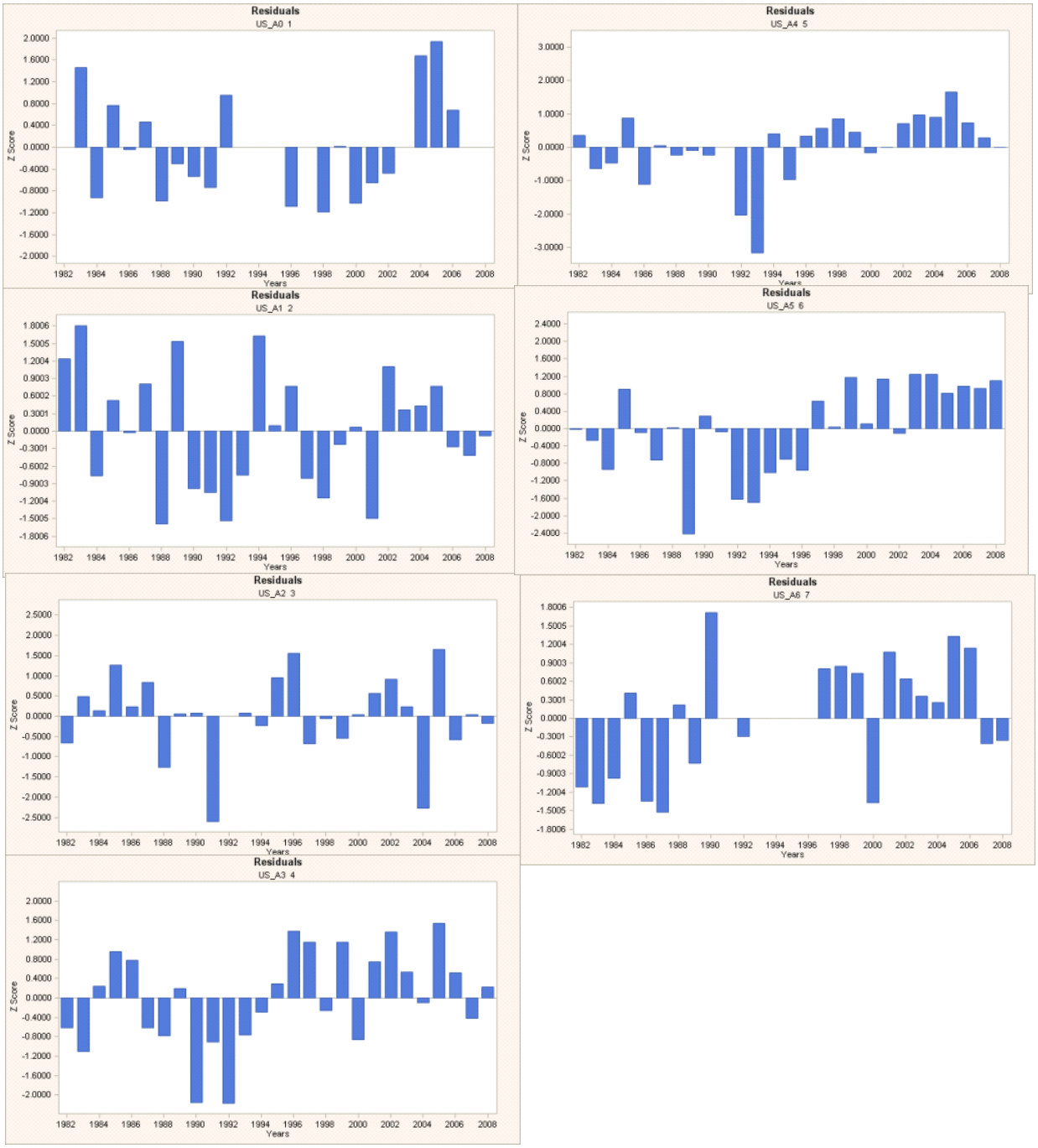

Figure K14. Residual patterns NEFSC autumn bottom trawl survey indices (ages 1-7, 1982-2006 lagged forward one year and age) used to calibrate the VPA for Georges Bank winter flounder.

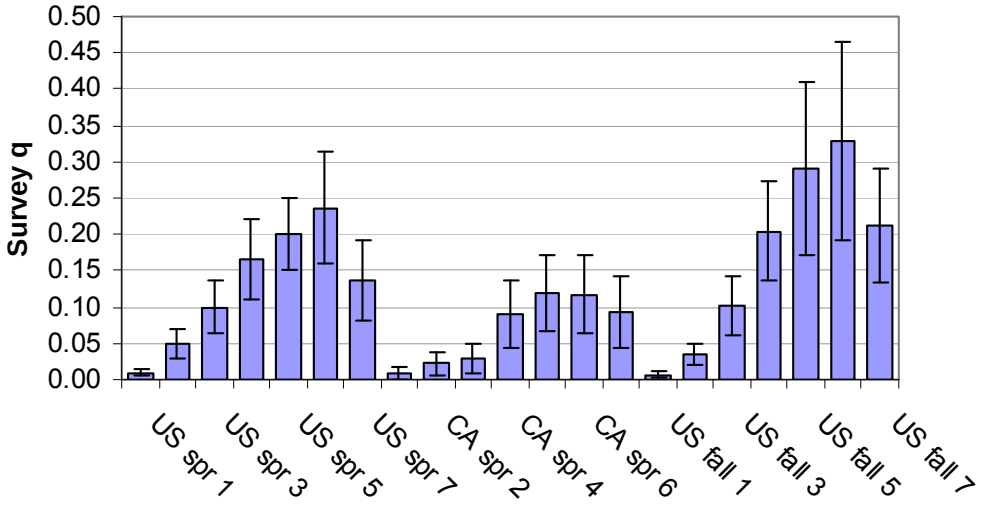

Figure K15. VPA estimates of catchability coefficients, by age, for Georges Bank winter flounder caught during the US spring (1982-2008), Canadian spring (1987-2008), and US fall bottom trawl surveys (1982-2007, lagged forward one year and age). Error bars represent 2 SE.

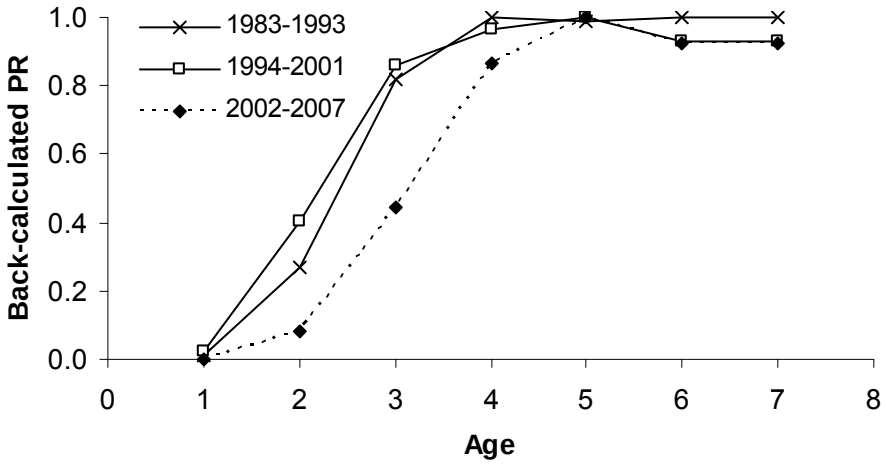

Figure K16. Back-calculated partial recruitment of Georges Bank winter flounder during management periods with major changes in codend minimum mesh sizes.

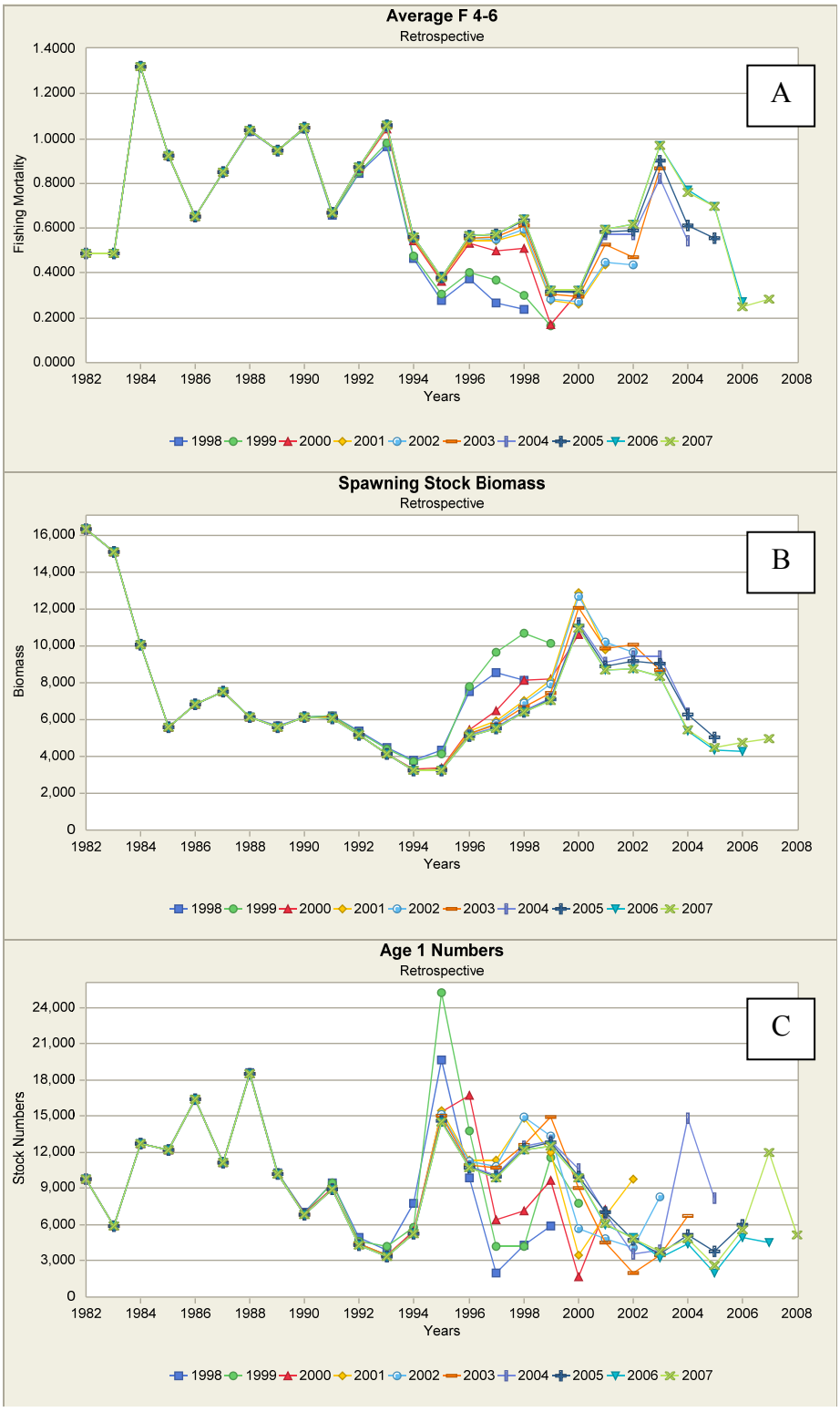

Figure K17. Retrospective analysis of (A) average F (ages 4-6), (B) spawning stock biomass (mt), and (C) Age 1 recruitment (numbers, 000's) during 1993-2007 for the Georges Bank winter flounder VPA (1982-2007).

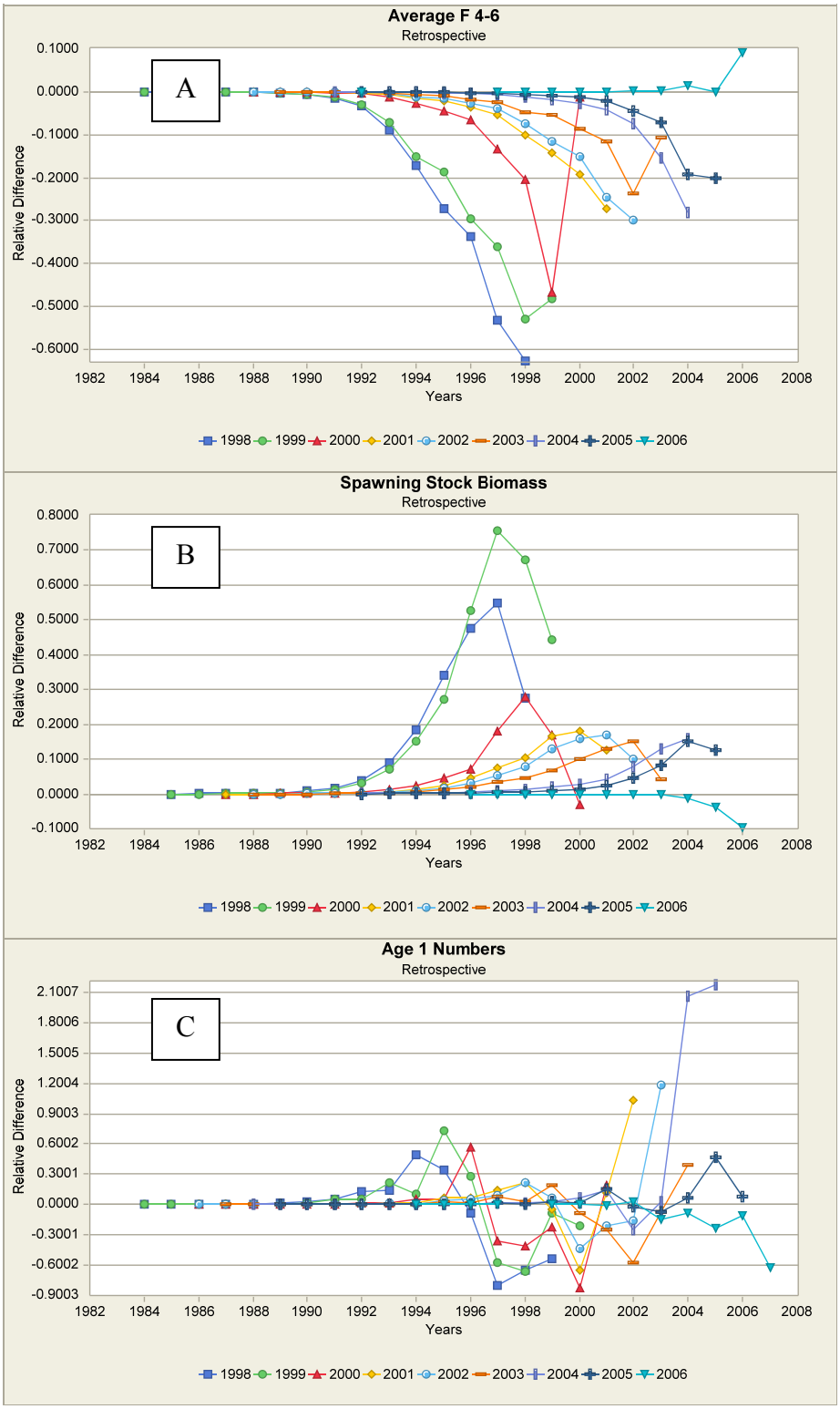

Figure K18. Relative differences between (A) average F (ages 4-6), (B) spawning stock biomass (mt), and (C) Age 1 recruitment estimates (numbers, 000's) in year t and 2007 (1993-2006) from the Georges bank winter flounder VPA (1982-2007).

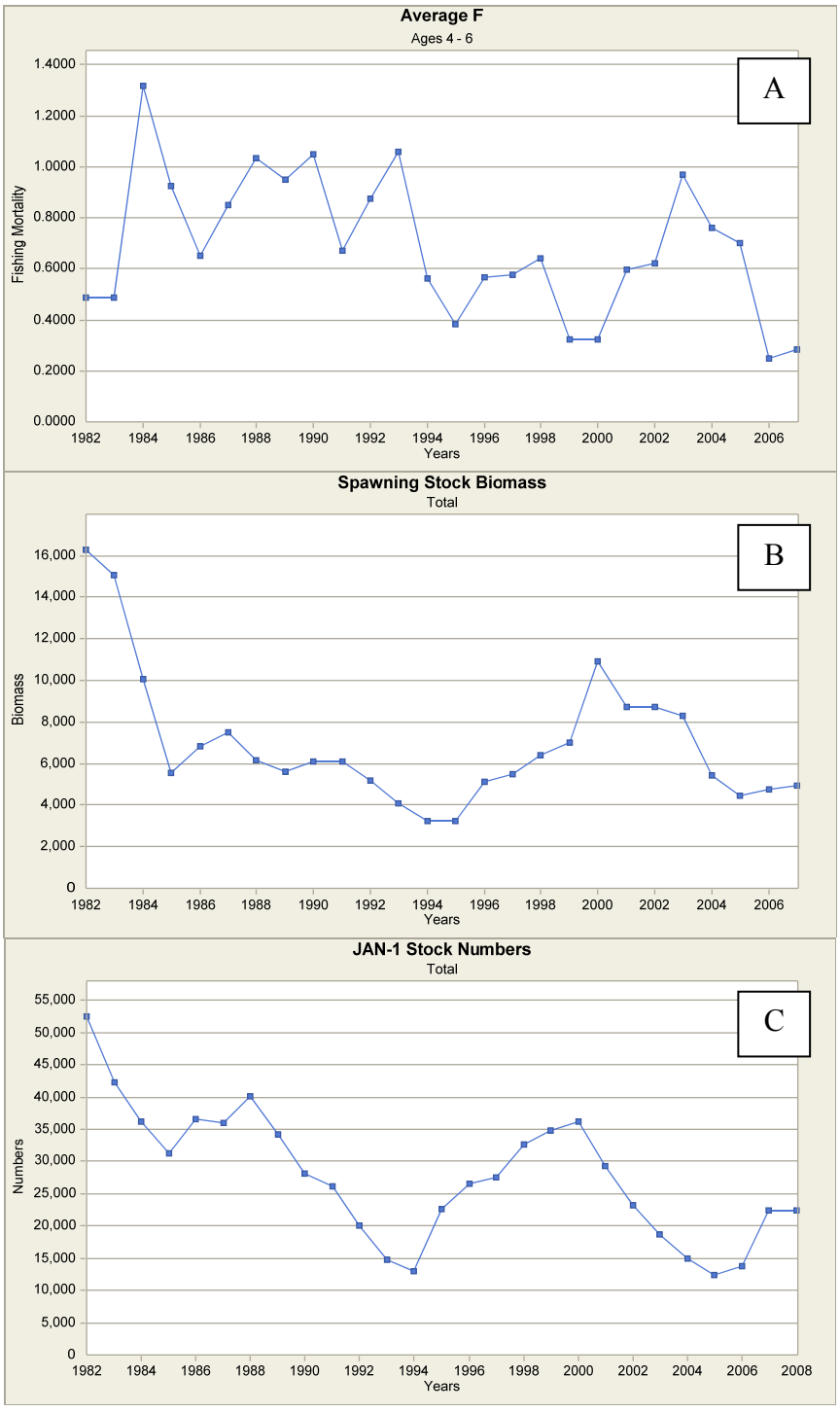

Figure K19. Annual trends in VPA estimates of Georges Bank winter flounder (A) average fishing mortality rates on fully-recruited ages 4-6, (B) spawning stock biomass (mt) and (C) age 1 recruitment (numbers, 000's) during 1982-2007.

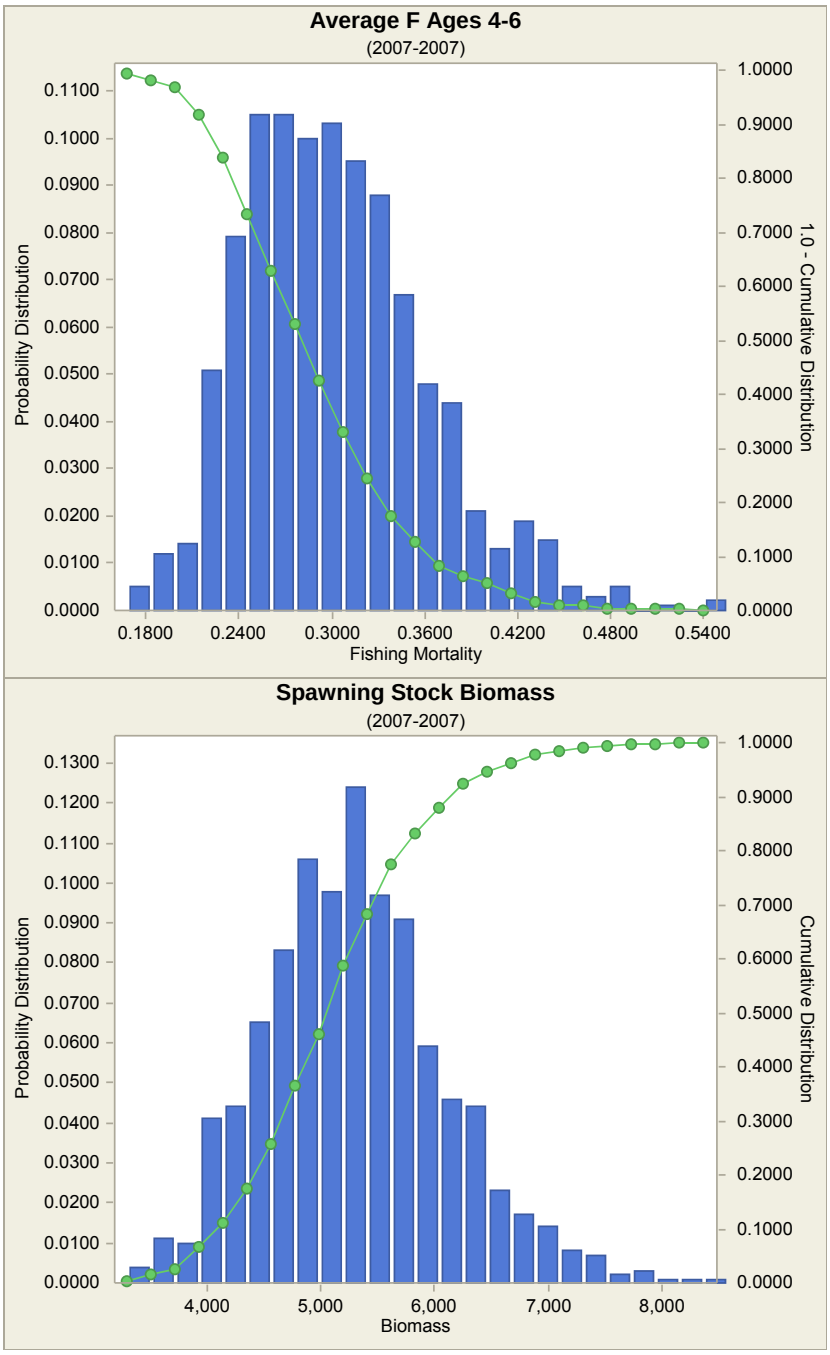

Figure K20. Precision (80% CI) of the terminal year estimates (2007) of average fishing mortality rate on ages 4-6 and spawning stock biomass from the Georges Bank winter flounder VPA.

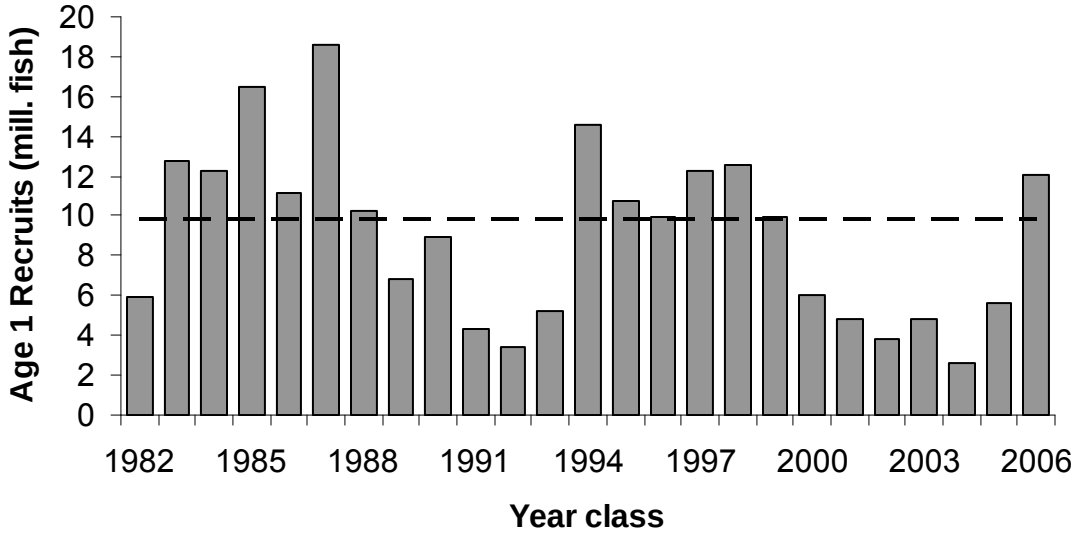

Figure K21. Year class strengths of age 1 recruitment of Georges Bank winter flounder during 1982-2006.

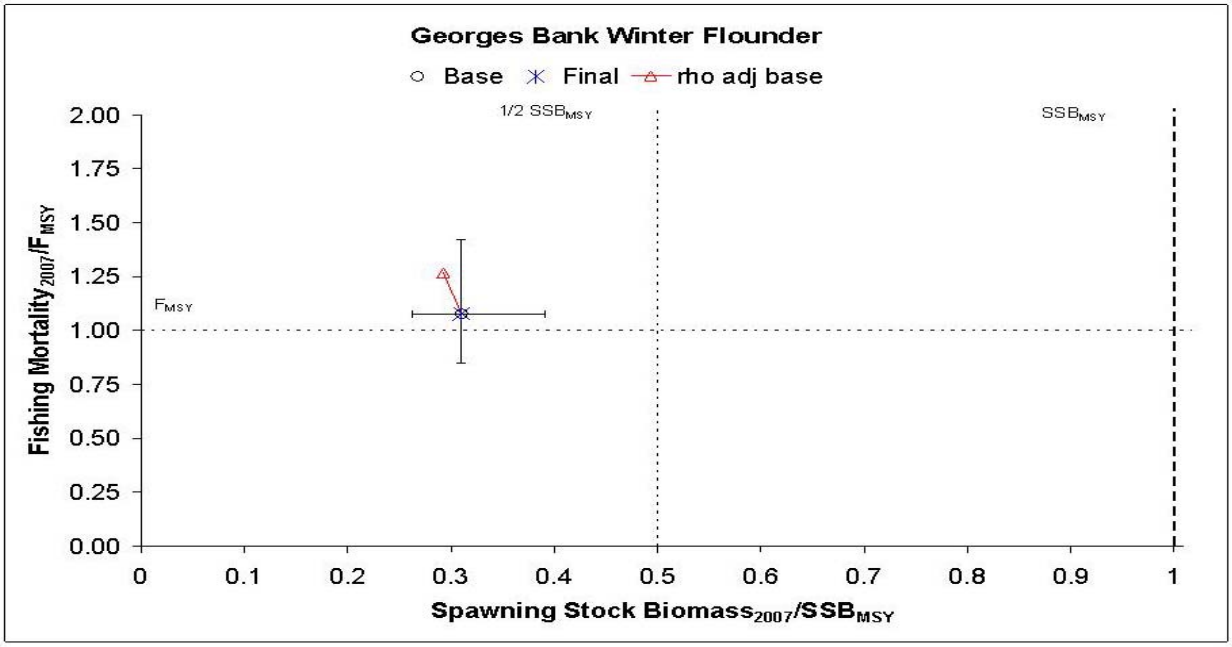

Figure K22. Stock status during 2007 for Georges Bank winter flounder