R. Gulf of Maine haddock
by Michael Palmer

Additional details and supporting information can be found in the Appendix of the GARM-III Report (NEFSC 2008).

1.0 Background

The Gulf of Maine haddock stock was last assessed at the Groundfish Assessment Review Meeting (GARM) in 2005 (NEFSC 2005). That assessment compared survey biomass and exploitation rate indices to biological reference points (BRPs) generated in 2002 using the index-based model, An Index Method (AIM[4], NEFSC 2002). The proxy F_{MSY} (exploitation rate index) and $B_{Threshold}$ (1/2 B_{MSY}) were estimated at 0.23 and 11.09 kg/tow, respectively (NEFSC 2002). Based on the 2005 assessment, the terminal year (2004) exploitation rate index was 0.18 and the 3-year survey biomass index was 5.79 kg/tow. Stock status was overfished but overfishing was not occurring. The 2005 assessment did not include estimates of recreational catch or commercial discards in the exploitation rate.

The 2005 GARM Review Panel recommended that future assessments include recreational catches in estimates of fishery removals and that an age-structured assessment be attempted. Past assessments have not utilized age-structured models because biological data (length frequencies, age and maturity sampling) were sparse during the late 80s and early- to mid-90s (NEFSC 2001). The 2008 GARM Models Meeting Review Panel (O'Boyle 2008a) also encouraged the exploration of age-structured models but supported the AIM model as a fall-back method for the determination of BRPs.

For the 2008 GARM BRP Meeting a virtual population analysis (VPA) assessment was performed and the model was accepted by the Panel as a basis for BRP determination (O'Boyle 2008b). The current assessment updates fishery catch estimates (including recreational landings and commercial discards), research survey abundance indices and analytical models (i.e., VPA) through 2007/08 analyzed by VPA. Additionally, BRPs are recalculated using the updated VPA results.

2.0 Fishery

Commercial landings

For the purposes of describing fishery removals, the Gulf of Maine region is defined as statistical areas 510 – 515 (NAFO area 5Y; Fig. R.1). The commercial fishery has been largely dominated by the United States (US) domestic fleet (Table R.1; Fig.R.2). There were two periods of significant Canadian landings, the first from 1965 to 1968 and the second from 1978 to 1986. Domestic landings remained above 4,500 mt until 1967, subsequently dropping below 600 mt in 1973 before rising back above 6000 mt by 1980. Subsequent to 1980 landings began to decrease, reaching a historic low of 120 mt in 1994. Landings gradually increased after 1994 and remained relatively constant at approximately 1000 mt from 2003 to 2005. Landings have dropped off in the most recent two years and remain below 700 mt. The US commercial fishery is primarily composed of otter trawl, sink gillnet and benthic longline vessels which account for on average,

[4] *NOAA Fisheries http://nft.nefsc.noaa.gov/Toolbox Version 3.0, 2008. An Index Method (AIM) Version 2.0. [Internet address: http://nft.nefsc.noaa.gov].*

99% of total landings (Table R.2). Handline, beam trawl, pot and scallop dredge gear account for the remaining landings.

Length and age samples of US commercial landings were collected through the Northeast Region port sampling program. Sampling of landings are stratified by market category (scrod and large) and quarter. To the extent possible catches-at-age were estimated using the same stratification used to collect the port samples (i.e., by quarter and market category), however in some years where available length/age data were insufficient to characterize the catch, quarters were grouped to achieve full length frequency distributions. Prior to 1977 port sampling intensity was low (Table R.3). From 1977 on, sampling remained relatively high until the late-1980s when landings began to decline. Sampling remained low until 1997 when haddock trip limit restrictions were relaxed and landings increased. Age-length keys were supplemented with survey age data to the extent possible when the number of ages per year was less than 100. Commercial landings at age were estimated from 1977 to the present using the Commercial Data Biostatistical Analysis Program (BioStat v 5.10[5]) software (Table R.4). Length-weight relationships were calculated using the Northeast Fisheries Science Center (NEFSC) bottom trawl survey data from 1992 to 2007 [autumn] / 2008 [spring]. Before 1992, individual weights were not recorded in the bottom trawl survey. Spring survey data were used to represent the relationship during the first two quarters of the calendar year, and the autumn survey for quarters three and four. Regression equations were calculated using non-linear least squares regression. The representative equations for each half year block are:

$$\text{Spring: } W_{\text{live (kg)}} = 0.00000769 \cdot L_{(\text{fork cm})}^{3.0622} \quad (p < 0.0001, n=2502)$$

$$\text{Autumn: } W_{\text{live (kg)}} = 0.00000987 \cdot L_{(\text{fork cm})}^{3.0987} \quad (p < 0.0001, n=4890)$$

Uncertainty in the catch at age was determined using the BioStat bootstrap option (1000 realizations; Legault et al. 2007). The catch at age coefficient of variation (CV) were generally less than 30% (Table R.5). CVs are large for the youngest and oldest age classes. Catch at age uncertainty could only be determined back to 1984; prior to 1984 individual sampling events can not be identified in the data.

Commercial discards

Commercial discards were estimated for five commercial fleets: the large mesh bottom otter trawl (≥ 5.5”), small mesh bottom otter trawl (< 5.5”), benthic longline, sink gillnet, midwater-paired otter trawl, and midwater otter trawl fleets. These five fleets constitute the majority of total Gulf of Maine haddock discards (Table R.6). For years where direct observations of commercial discards were made by at-sea observers (1989 – present) estimates of commercial discards were calculated using the combined-ratio method (Wigley et al. 2007). Discards prior to 1989 were estimated using the survey-scaling method (Palmer et al. 2008). Prior to 1982, the large mesh otter trawl fishery did not exist.

With the exception of the period from 1994 to 1997 when possession limits ranged from 500 to 1,000 lb/day, Gulf of Maine haddock are primarily discarded because of minimum size limits (Table R.7). Federal size limits were first imposed in 1977 and have ranged from 16” to 19” for the commercial fishery (Table R.8). It was assumed that the primary reason for discards in the period before 1994 was similar to the most recent period, i.e., below minimum size. It is

[5] *NOAA Fisheries Toolbox Version 3.0 2008. Commercial Data Biostatistical Analysis Program 5.10. [Internet address: http://nft.nefsc.noaa.gov].*

unknown whether groundfish quotas in place in the late 1970's to early 1980's resulted in significant discarding of legal sized fish.

Commercial discards average less than 100 mt per year (Table R.9). There are two predominant peaks in discards, the first between 1964 to 1966 when there was an abundance of undersized fish and a second from 1994 to 1997 when restrictive trip limits were in place. Discards constitute a minor fraction of total fishery removals with the exception of the 1994 to 1997 period (Fig. R.2).

Length and age samples of commercial discards are collected by the Northeast Fisheries Observer Program. The number of individual lengths sampled annually has varied from zero in 1990 to over 900 in 2005 (Table R.10). Because of the relative sparseness of discard sampling, a non-fleet specific annual discard length frequency was used to characterize the length distribution of the discarded catch. In years where the total number of sampled fish was less than 100, discard length frequencies were supplemented by the length frequency distribution of fish from the NEFSC surveys that were below the minimum size (or 5th percentile observed in commercial landings for those years where no minimum size restrictions existed). Age-length keys were supplemented with survey age data in all years. Discards at age were estimated from 1977 to the present using the BioStat software (Table R.11). Because of the combined nature of the discard biosampling sources (i.e., discards and survey) analyses of the uncertainty in the discards at age could not be assessed.

Recreational landings

Gulf of Maine haddock recreational landings (types A and B1 catch) were obtained from the Marine Recreational Fisheries Statistics Survey (MRFSS). There was assumed 100% survival of recreational live releases (type B2 catch). Landings were partitioned among stock complexes using a standard algorithm (S. Steinback pers. comm.). MRFSS data are available from 1981 onward. Historically, recreational landings have been a minor component of overall fishery removals, though over the past five years recreational landings have averaged less than 500 mt (Table R.12; Fig. R.2).

Recreational length samples were extremely limited prior to 2002 (Table R.13). The size distribution of haddock landed by the recreational fishery is similar to those of the commercial longline fishery and from those fish captured in the bottom trawl survey above the recreational minimum size (Table R.8; Fig. R.3). Length samples before 2002 were supplemented with length frequency data from these sources. Because no ages were sampled from the recreational fishery, age-length keys were obtained from survey age data for all years. Recreational landings at age were estimated from 1981 to the present using the BioStat software (Table R.14). Because of the combined nature of the recreational landings biosampling sources (i.e., MRFSS survey, commercial longline and survey) analyses of the uncertainty in the recreational catch at age could not be assessed.

Total fishery catch at age are presented in Table R.15. The mean catch weight at age has exhibited declines in the last ten years, particularly among the older age classes (Table R.16).

3.0 Research surveys

Survey indices of abundance (stratified mean number per tow) and biomass (stratified mean kg per tow) were estimated from both the NEFSC spring and autumn bottom trawl surveys

from 1963 to 2007 (spring survey commenced in 1968). The indices include catch data from stations within the NEFSC offshore survey strata 01260 – 01280 and 01360 – 01400 (Fig. R.4). The survey indices were adjusted for differences between the fishing power of the Albatross IV and Delaware II and for differences in the catchability of the BMV trawl doors used prior to 1985 (Forrester et al. 1997; Table R.17). Spring and autumn survey indices exhibit similar trends over the time series (Table R.18; Fig. R.5).

Indices declined from highs in the mid-1960's to lows in the early 1970's before again increasing during the late 1970's and early 1980's. The period from 1987 to 1992 experienced historically low indices. Increases have been observed since 1997 with current indices equal to those observed during the late 1970's and early 1980's. The increases in both abundance and biomass observed throughout the time series have been largely driven by moderate to strong year classes observed in 1963, 1975, 1998, and 2003 (Fig. R.6 and R.7) that track strongly through the survey abundance at age matrices (Tables R.19 and R.20). Survey biological sampling (lengths, ages) was sparse during the late 1980s and early to mid-1990s during the periods of low stock abundance (Table R.21).

4.0 Assessment

Model Selection

A VPA assessment was accepted by the GARM 2008 BRP Panel for the purpose of calculating BRPs. The accepted VPA configuration included catch, survey and biological data for years 1977 through 2006 with a maximum age of 9^+ calibrated using the ADAPT VPA version 2.8.0[6]. The decision to start the VPA at 1977 and plus the ages at 9+ was made based on the availability of biological sampling and high CVs in the catch at age estimates for the older age classes, respectively. For the BRP meeting, several calibration runs were undertaken to assess the sensitivity of the VPA results to inclusion/exclusion of the survey indices at age. The BRP-selected model configuration, BRP1 (Table R.22), included catch at age estimates of ages 1 to 9^+ and survey abundance at age (age 1 and above), however, the spring survey and autumn surveys plus groups began at age-6 and age-8 respectively because of the predominance of zero values in the survey indices of the older age classes (Tables R.19 and R.20). The ALT1 model examined survey index ages from 1 to 9+ for both the spring and autumn surveys.

For the NEFSC spring and autumn survey series trawl effective area swept estimates were available to calculate swept area abundance indices. These calculations assume 100% trawl efficiency. Swept area abundance indices were used as calibration indices in both the BASE and ALT1 runs. BASE run survey catchability coefficients (*q's)* were < 1.0 for all but the autumn 7 and $8{:}9^+$ indices (Fig. R.8a). ALT1 survey *q's* were comparable for the spring indices (< 0.4), however they were considerably higher for the older autumn age classes (Fig. R.8b). Mohn's rho (Mohn 1999) statistic was used to quantify the relative retrospective pattern in terminal year estimates of fishing mortality (F), spawning stock biomass (SSB) and recruitment (R) for both the BASE and ALT1 configurations:

$$\rho = \frac{\left(\sum_{y}^{n} \frac{x_{y,tip} - x_{y,ref}}{x_{y,ref}} \right)}{n} \qquad (1)$$

[6] *NOAA Fisheries Toolbox Version 3.0 2008. Virtual Population Analysis Model VPA/ADAPT version 2.8.0. [Internet address: http://nft.nefsc.noaa.gov].*

Mohn's rho values were calculated using a seven year peel (n=7); rho values for both the BASE and ALT1 configurations are presented in Table R.22. With the exception of the Mohn's rho value for SSB, the BASE run exhibited lower retrospective pattern. However, the recent relative differences in the terminal year SSB estimates were lower in the BASE run compared to ALT1. Based on the GARM 2008 BRP Panel acceptance of the BRP1 configuration (which is identical to the BASE configuration), survey *q* patterns and retrospective pattern statistics, the GARM 2008 Panel selected the BASE run as the final model configuration with which to use for calculation of BRPs, and stock status determination.

Diagnostics

Age-specific survey residual plots for the BASE run do not exhibit any evidence of systematic patterning (Fig. R.9 and R.10).

There is a moderate retrospective pattern observable in the terminal year F estimates of the BASE model configuration (Fig. R.11 and R.12), however there is no separation of the bootstrap distributions (1000 iterations; Fig. R.13) suggesting absence of a strong retrospective pattern (Legault 2008). There is no retrospective pattern evident in the terminal year estimates of recruitment (Fig. R.14); however, there are large relative differences (Fig. R.15), though no patterning is observed.

There are minor retrospective patterns in the SSB terminal year estimates (Fig. R.16), though these difference are < 10% in the most recent year "peels" (Table R.22; Fig. R.17). There is no separation of the bootstrapped distributions in the recent year peels, suggesting this is not a strong retrospective pattern (Fig. R.18).

The precision of the 2008 (terminal year + 1) stock size at age, SSB in 2007, and F at age in 2007 was evaluated by resampling errors from 1000 bootstrap realizations. Bootstrapped estimates of stock size at age indicate low bias (< 15%) in ages 2 – 7 (Table R.23). Bootstrapped CVs range from 0.33 at age 7 to 201% at age 1. The SSB CV = 19% with an 80% probability of the SSB being between 4,690 mt and 7,520 mt (Table R.24; Fig. R.18). Bootstrapped CVs of F at age ranged from 0.26 at age 0 to 500% at age 7 (2000 year class; Table R.25). The 2000 year class is a weak year class that has experienced high fishing mortality. Excluding age 7 F CVs, the highest CV is 71% at age 1. There is an 80% probability that fully recruited unweighted average F for ages 6-8 in 2007 was between 0.31 and 1.40. The 80% confidence intervals for the N-weighted average $F_{6\text{-}8}$ range from 0.26 to 0.55 (Fig. R.20). Because of the presence of a weak year class with a high degree of uncertainty in the estimated unweighted average F, it is more appropriate to use an N-weighted average F as the basis for stock status determination. The N-weighted F has tracked very closely with the unweighted average F over time with the exception of periods where the unweighted average F was influenced by high mortality on weak year classes (Fig. R.21; Table R.26).

Results

The BASE VPA assessment results indicate the stock numbers were around 29 million fish during the late 1970s and declined to 1.8 million fish by 1990 (Table R.27). The high abundances in the late 1970s were driven by the strong year class of 1975 and moderate year classes of 1978 and 1979 (Fig. R.22). Two back-to-back moderate strength year classes in 1993 and 1994 contributed to an increase in population numbers following the low of 1990. A very strong year class developed in 1998. The 1998 year class increased stock numbers above 20 million for the first time since 1980. Several moderate year classes have been observed since

1998, sustaining a current population size of approximately 10 million fish. There is some evidence of a moderately strong year class in 2003, but not of the relative magnitude as observed on Georges Bank (NEFSC 2005). Median and mean age 1 recruitment from 1977 to 2006 is estimated at 1.4 and 2.3 million fish respectively (Fig, R.22).

SSB was estimated at approximately 15,000 mt during the early 1980s, declining to a low of 550 mt by 1989 (Table R.28). Moderate recruitment during the mid-1990s combined with the strong 1998 year class led to a recent peak in the SSB in 2002 at around 13,700 mt (Fig. R.22). SSB has since declined as the 1998 year class is removed from the population. The 2003 year class should have reached near 100% maturity in 2007. Low recruitment and high F ($F_{6-8} > 0.5$) during the period from 1983 to 1991 reduced the biomass of the older age classes. With low F in the recent period combined with strong to moderate recruitment, the current population age structure has expanded to levels similar to those observed in the early 1980's. F among the younger age classes (< age 4) has declined in the last ten years in response to decreases in the fishery selectivity brought about by increases in mesh size (Fig. R.23) and the greater contribution of the recreational fishery to total catch (Fig. R.2). The 2007 SSB is estimated at 5,850 mt and the N-weighted fully-recruited F, F_{6-8}, is estimated at 0.35.

5.0 Biological Reference Points

The 2008 GARM BRP Review Panel supported the use of BRPs calculated from yield per recruit (YPR) and SSB per recruit (SSBPR) analyses based on mean weight and partial recruitment patterns calculated from an unweighted average of the most recent five years in the assessment (2003 – 2007; O'Boyle 2008b). Given the observed declined in haddock size at age, applying averages of the recent values for the purposes of yield projections could be cause for concern when used for long-term projection. However, without better understanding the underlying cause(s), the current biological parameters are the best indicator of future parameters. Input vectors are presented in Table R.29.

In general, mean weights of the commercial catch have declined in recent years (Table R.16). A similar trend has been observed in survey weights at age and lengths at age over time (Fig. R.24; O'Brien et al. 2008). It is notable that the recent observed weights at age are similar to those observed in the 1960s when the stock was abundant. The fishery and stock weights at age were less than those estimated for Georges Bank haddock (Brooks et al. 2008). It is not clear why stock weights at age differ; spring survey weights at age between the two stocks are similar in recent years (O'Brien et al. 2008). Differences in fishery weights-at-age may be partly explained because the Gulf of Maine fishery tends to occur earlier in the year relative to the Georges Bank fishery.

There is some evidence of declining maturity at age in recent years (Fig. R.25), however this trend is not apparent in the age at 50% maturity (Fig. R.26). The VPA assessment used a time series averaged maturity at age. This is held consistent for BRP calculations.

There are appreciable differences in the partial recruitment vectors between Gulf of Maine and Georges Bank haddock stocks. This may be explained in part because of the large fraction of the Gulf of Maine landings contributed by the recreational fishery; it's expected that the selectivity of the hook and line recreational fishery is low for smaller/younger fish. Additionally, anecdotal evidence suggests that Gulf of Maine trawlers use a 6.5" square body mesh size to target flatfish in the Gulf of Maine, with haddock constituting non-targeted catch.

The larger mesh size (compared to 6.0" inch diamond body mesh) could allow for greater escapement of the smaller/younger haddock. Currently the codend mesh size must be 6.5" for both diamond and square hung nets in both the Gulf of Maine and on Georges Bank.

Natural mortality estimates have not been considered in previous assessments of Gulf of Maine haddock. The longevity of Gulf of Maine haddock is similar to that of Georges Bank haddock (e.g., 15 years), thus an assumption of 0.2 was used consistent with previous Georges Bank assessments and those of other groundfish (NEFSC 2005).

F estimates from the yield per recruit analysis were $F_{0.1} = 0.32$, $F_{40\%} = 0.43$ and $F_{max} = 1.66$ (all fully recruited Fs; Table R.30). The 2008 GARM BRP Panel recommend $F_{40\%}$ as the appropriate proxy for F_{MSY}. The SSBPR and YPR at $F_{40\%}$ were estimated at 2.15 and 0.50 kg/recruit respectively.

Maximum sustainable yield and SSB_{MSY} were derived from the median values of long-term projections (100 years) of the Age Structured Model Projections (AGEPRO[7]) model run at a constant harvest of $F_{40\%} = 0.43$ (Brodziak and Rago 1994; Brodziak et al. 1998). Input vectors for the AGEPRO runs are the same as those used for the YPR/SSBR analyses (Table R.29). Projected recruitment was determined using the cumulative density function (CDF) of a recruitment series that included both VPA-estimated age-1 recruitment and hindcasted recruitment estimates. A linear regression was fit to VPA estimates of age 1 recruitment and NEFSC autumn bottom trawl survey indices of abundance of age 1 fish (Fig. R.27a). Using the regression relationship, recruitment was estimated back to the 1962 year class (Fig. R.27b). The 2008 GARM BRP Panel recommended a recruitment series that includes VPA estimated recruitment excluding recruitment estimates for years when SSB was less than 3,000 mt in addition to hindcasted recruitment from 1962 to 1976 with the large 1962 year class removed (considered a "bonanza" outlier). As the current SSB is above 3,000 mt, it was not necessary to include recruitment estimates below 3,000 mt in the projection. The resulting BRP estimates were: SSB_{MSY} = 5,900 mt (80% confidence interval of 3,200 – 10,300 mt), and MSY = 1,360 mt (80% confidence interval of 730 – 2,450 mt).

6.0 Projections

Projections of SSB and MSY in 2009 were conducted using the same recruitment series and input vectors used in BRP determinations. Catch in 2008 was assumed equivalent to 2007 (1,368 mt). Two projections were conducted assuming different levels of $F_{6\text{-}8}$ in 2009: $F_{40\%}$, and N-weighted average $F_{6\text{-}8,2007}$. Under both assumptions of F, 2009 SSB will exceed SSB_{MSY} and catch will remain ± 17% of MSY (Table R.31).

7.0 Summary

Stock Status

Based on the current assessment, Gulf of Maine haddock is not overfished and overfishing is not occurring (Fig. R.28). This stock status determination is based on the use of the N-weighted average of $F_{6\text{-}8}$ in this unique situation. The high mortality on a weak year class results in large

[7] *NOAA Fisheries http://nft.nefsc.noaa.gov/Toolbox Version 3.0, 2008. Age Structured Model Projections (AGEPRO). Version3.1.3. [Internet address: http://nft.nefsc.noaa.gov].*

uncertainty of the unweighted average F_{6-8}. Using the N-weighted average F_{6-8} reduces the uncertainty, but it is a departure from other current age-based groundfish assessments.

The previous assessment of this stock in 2005 compared survey biomass and exploitation rate indices to BRPs generated in 2002 using the index-based model, AIM. Based on the 2005 assessment, the stock status was overfished but overfishing was not occurring. That assessment did not include estimates of recreational catch or commercial discards in the exploitation rate. The results of this current assessment are not comparable to the previous assessment due to the major shift in assessment methods (i.e., index-based to age-based assessment).

Sources of Uncertainty

Sources of uncertainty in the current assessment include: 1) assumption of 100% survival in the recreational released live catch (type B2); and, 2) use of the size at age from the recent five years for long term projections. The exclusion of recreational fishery discards of live releases (type B2 catch) assumes 100% survival of this component of the recreational catch. Over the last ten years, the average number of recreational releases is approximately equal to the number of fish landed. Other GARM assessments have applied mortality rates to the live releases (e.g., southern New England/mid-Atlantic winter flounder); however there is little information on the survival rates of haddock caught in hook and line fisheries. The use of the recent size at age for long term projections introduces additional uncertainty. However, without better understanding the underlying cause(s) of the observed declines in size at age, the current conditions are the best indicator of future conditions.

8.0 Panel discussion/comments

Conclusions

This stock was assessed using a VPA model which is an improvement over the GARM II Relative Index. The Panel accepted as Final and sufficient for management purposes this VPA and also concluded that an adjustment for the small retrospective pattern was unnecessary.

The large difference between Gulf of Maine and Georges Bank haddock BRPs was questioned. The Gulf of Maine fishery does not target haddock and is directed mostly at flatfish for which the fleet uses large square (6.5 in) mesh gear, which leads to reduced selectivity on haddock. It was noted that the current analysis indicates that Gulf of Maine haddock have lower weights at age than the Georges Bank stock. As well, the age at 50% maturity was also lower for Gulf of Maine as compared to Georges Bank haddock.

Uncertainty of the estimated fishing mortality on the weak 2000 year – class in 2007 raised the issue on how best to compute the current year's age 6 – 8 fishing mortality. Variability in the year-class specific Fs of small year-classes is to be expected. Reflecting the 2007 fishing mortality as the weighted (by population numbers) average of ages 6 to 8 was considered a more robust approach than using the unweighted average. It was noted that the use of the unweighted versus weighted average needs to be considered on a case by case basis.

Regarding uncertainties, the recreational fishery commenced in the late 1990s and in recent years represents about 50% of the annual catch, with about 20 – 60 of this being live releases. The assumption has been made that 100% of these releases survive. There is very little information of the survival of haddock after their release.

Research Recommendations

Inverse variance weighting should be investigated as a means to compute the current year's fishing mortality as it has superior statistical characteristics than either the unweighted or weighted (by population) numbers.

Research should be undertaken on the estimation of the survivorship of haddock released in the recreational fishery.

9.0 References

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10.0 Tables

Table R1. Gulf of Maine haddock commercial landings by country, 1956 to 2007. The Gulf of Maine stock comprises Northwest Atlantic Fisheries Organization division 5Y and United States statistical areas 511 – 515.

Year	United States landings (mt)	Canada landings (mt)	USSR landings (mt)	Other landings (mt)	Total (mt)
1956	7,278	29	0	0	7,307
1957	6,141	25	0	0	6,166
1958	7,082	285	0	0	7,367
1959	4,497	163	0	0	4,660
1960	4,541	383	0	0	4,924
1961	5,297	56	0	0	5,353
1962	5,003	107	0	0	5,110
1963	4,742	3	44	0	4,789
1964	5,379	70	0	0	5,449
1965	4,155	159	0	0	4,314
1966	4,524	1,125	0	0	5,649
1967	4,852	589	0	0	5,441
1968	3,417	120	0	0	3,537
1969	2,405	59	0	231	2,695
1970	1,436	38	0	67	1,541
1971	1,190	85	0	27	1,302
1972	912	23	4	0	939
1973	526	49	0	0	575
1974	629	198	0	9	836
1975	1,180	79	0	4	1,263
1976	1,835	91	0	0	1,926
1977	3,230	26	0	0	3,256
1978	4,382	641	0	0	5,023
1979	4,131	257	0	0	4,388
1980	6,318	203	0	0	6,521
1981	5,720	513	0	0	6,233
1982	5,637	1,278	0	0	6,915
1983	5,593	2,003	0	0	7,596
1984	2,793	1,245	0	0	4,038
1985	2,234	791	0	0	3,025
1986	1,590	225	0	0	1,815
1987	829	0	0	0	829
1988	416	0	0	0	416
1989	264	0	0	0	264
1990	433	0	0	0	433
1991	431	0	0	0	431
1992	312	0	0	0	312
1993	193	0	0	0	193
1994	120	0	0	0	120
1995	173	0	0	0	173
1996	247	0	0	0	247
1997	589	0	0	0	589
1998	885	0	0	0	885
1999	543	0	0	0	543
2000	738	0	0	0	738
2001	929	0	0	0	929
2002	977	0	0	0	977
2003	1,023	0	0	0	1,023
2004	946	0	0	0	946
2005	962	0	0	0	962
2006	618	0	0	0	618
2007	694	0	0	0	694

Table R2. Gulf of Maine haddock landings by gear type from the United States commercial fishery, 1964 to 2007.

Year	Longline, benthic (mt)	Otter trawl, bottom (mt)	Gillnet, sink (mt)	Otter trawl, paired midwater (mt)	Otter trawl, midwater (mt)	Other (mt)	Total (mt)
1964	527.6	4689.5	155.5	0.0	0.0	6.0	5378.8
1965	686.8	3308.5	147.2	0.0	0.0	12.1	4154.7
1966	335.3	4107.2	78.7	0.0	0.0	2.9	4524.0
1967	160.6	4621.5	64.4	0.0	0.0	5.6	4852.2
1968	93.9	3285.5	32.7	0.0	0.0	5.2	3417.3
1969	103.8	2226.7	73.6	0.0	0.0	0.6	2404.6
1970	210.8	1155.4	68.0	0.0	0.0	1.7	1435.8
1971	260.0	850.1	76.6	0.0	0.0	3.5	1190.2
1972	374.9	440.0	95.4	0.0	0.0	2.1	912.3
1973	205.0	235.1	84.7	0.0	0.0	1.1	526.0
1974	126.9	456.1	45.1	0.0	0.0	0.7	628.8
1975	89.7	1016.3	73.8	0.0	0.0	0.4	1180.2
1976	37.9	1551.8	244.0	0.8	0.0	0.1	1834.5
1977	101.8	2576.1	551.7	0.1	0.0	0.5	3230.1
1978	84.1	3563.8	733.9	0.0	0.0	0.7	4382.5
1979	51.7	3362.5	715.0	0.0	0.0	1.4	4130.6
1980	72.0	4835.5	1387.5	0.6	0.0	22.1	6317.6
1981	74.5	4560.3	1085.2	0.0	0.0	0.4	5720.4
1982	6.7	5293.2	332.1	0.0	0.0	5.0	5637.0
1983	15.9	4905.7	654.3	0.0	0.0	17.4	5593.4
1984	11.9	2359.6	410.3	0.0	0.0	11.1	2792.8
1985	8.6	1885.2	247.4	0.0	0.0	93.1	2234.3
1986	8.7	1361.0	183.6	0.0	0.0	37.1	1590.4
1987	11.2	653.1	159.0	0.0	0.0	5.9	829.2
1988	14.0	252.2	145.4	0.0	0.0	4.6	416.2
1989	2.5	150.2	101.0	0.0	0.0	10.2	263.8
1990	10.4	332.5	84.9	0.0	0.0	5.5	433.3
1991	7.4	356.9	62.3	0.0	0.0	4.3	430.9
1992	13.5	256.7	40.1	0.0	0.0	1.5	311.8
1993	6.3	160.1	26.4	0.0	0.0	0.1	193.0
1994	9.4	83.7	26.9	0.0	0.0	0.1	120.1
1995	37.1	92.6	38.1	0.0	0.0	5.3	173.0
1996	42.7	162.3	38.7	0.0	0.0	2.9	246.6
1997	68.9	463.6	54.7	0.0	0.6	0.8	588.6
1998	81.3	705.3	67.8	0.0	25.7	5.0	885.2
1999	21.8	437.5	78.7	0.0	1.2	3.3	542.5
2000	20.9	587.7	122.8	0.0	0.0	6.5	737.9
2001	8.4	813.4	104.4	0.0	0.0	2.9	929.2
2002	29.9	689.6	242.2	0.0	0.0	15.2	976.9
2003	86.8	809.6	82.2	0.0	0.0	44.5	1023.0
2004	81.5	707.3	127.9	0.0	0.0	29.8	946.5
2005	143.9	592.3	93.4	0.0	14.9	117.0	961.5
2006	137.5	384.5	78.6	0.0	0.0	17.7	618.2
2007	153.0	432.7	82.9	0.0	0.0	27.7	696.4
Average	105.4	1631.2	213.6	0.0	1.0	12.3	1963.5

Table R3. Summary of United States (US) Gulf of Maine haddock number of fish lengths measured from the commercial fishery by market category and quarter, 1965 – 2007.

Year	Large				Scrod				Unclassified				Total lengths (numbers)	US commercial landings (mt)	Metric tons per 100 lengths
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4			
1969		93	59				282	92					526	2,405	457
1970													0	1,436	
1971	86			101				82					269	1,190	442
1972			74	115									189	912	483
1973	99		627					205					931	526	56
1974					207	47							254	629	248
1975					64	100							164	1,180	720
1976	30						74	108					212	1,835	865
1977		197	358		382	511	481	569					2,498	3,230	129
1978	149	35	200		223	322	179	203					1,311	4,382	334
1979	195		124	100	114			66					599	4,131	690
1980		319	102		51	175	257	201					1,105	6,318	572
1981		52	257	638	53	358	514	381					2,253	5,720	254
1982	103		1,361	104	473	53	273	154				87	2,608	5,637	216
1983	249	868	1,317	496	312	308	340	203			102		4,195	5,593	133
1984		79	828	391	187	94	139	113					1,831	2,793	153
1985	347	597	573	536	353	202	298	84					2,990	2,234	75
1986	283	234	789	271	181	242	207	204					2,411	1,590	66
1987	214	102	515	405	162	79	75	136					1,688	829	49
1988	91		100	202	261	50	42						746	416	56
1989			65	118	99			129					411	264	64
1990	34			100	41	50		50					275	433	158
1991		146	216	213	57		179	212					1,023	431	42
1992	121			19	107		53	111					411	312	76
1993					103	56	125			54			338	193	57
1994		100	52	297				219					668	120	18
1995	62				194								256	173	68
1996	77			427		92		100					696	247	35
1997	120	255	497	355		124	358	147					1,856	589	32
1998	309	111	78	313	689	49	156	35					1,740	885	51

Table R3 continued. Summary of United States (US) Gulf of Maine haddock number of fish lengths measured from the commercial fishery by market category and quarter, 1965 – 2007.

Year	Large				Scrod				Unclassified				Total lengths (numbers)	US commercial landings (mt)	Metric tons per 100 lengths
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4			
1999	117		300	211			214	102					944	543	57
2000	488	313	339	107	414	259	105	287					2,312	738	32
2001	528	93	207	579	353	108	66	847					2,781	929	33
2002	729	210		262	348	143	247	161					2,100	977	47
2003	792	348	1,282	1,043	485	216	716	513					5,395	1,023	19
2004	1,898	942	101	601	1,021	1,085	262	451					6,361	946	15
2005	1,313	325	573	752	661	449	733	769					5,575	962	17
2006	1,193	687	453	617	928	535	569	514					5,496	618	11
2007	385	266	539	480	324	357	415	426					3,192	694	22

Table R4. Commercial landings (000's) at age of Gulf of Maine haddock, 1977 to 2007.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Total
1977	0.0	43.8	1747.2	51.1	365.0	215.0	143.6	4.8	1.6	6.3	2578.4
1978	0.0	0.0	337.7	1958.4	181.2	320.3	154.6	32.0	0.0	4.6	2988.8
1979	0.0	7.5	81.4	613.5	1348.8	200.5	105.5	32.4	23.8	0.0	2413.4
1980	0.0	0.0	861.6	109.8	754.9	1235.8	165.4	134.1	11.5	25.3	3298.4
1981	0.0	0.0	1458.3	641.3	266.8	356.8	498.2	69.1	96.8	12.1	3399.4
1982	0.0	67.0	440.7	1245.1	510.4	80.5	225.1	400.0	89.6	59.6	3118.0
1983	0.0	0.0	6.4	595.4	712.7	588.9	109.1	184.0	251.0	86.8	2534.3
1984	0.0	0.0	44.7	32.0	409.8	173.1	247.3	43.1	48.9	99.7	1098.8
1985	0.0	0.0	16.6	236.1	62.2	267.1	107.9	173.4	34.7	37.6	935.4
1986	0.0	0.0	0.0	153.7	287.7	63.4	97.5	73.8	88.0	11.4	775.4
1987	0.0	0.0	2.3	16.2	90.4	48.9	33.1	51.9	37.5	17.1	297.4
1988	0.0	0.0	0.0	12.7	9.8	52.9	38.2	9.0	20.5	4.3	147.5
1989	0.0	0.0	15.7	3.4	48.5	16.5	21.2	16.1	1.7	0.8	124.0
1990	0.0	0.0	1.9	133.3	1.8	24.1	17.7	28.2	3.4	0.0	210.4
1991	0.0	0.0	26.6	47.7	61.6	17.7	19.2	13.0	2.7	2.2	190.7
1992	0.0	0.0	7.4	88.9	36.3	23.3	2.4	2.3	0.0	1.1	161.8
1993	0.0	0.0	11.7	25.4	29.8	17.6	5.9	6.4	0.0	0.0	96.7
1994	0.0	0.0	5.3	29.5	9.4	1.7	6.9	4.5	1.0	0.6	58.9
1995	0.0	0.0	1.8	5.7	30.8	9.4	5.0	5.0	3.0	2.8	63.5
1996	0.0	0.0	2.4	53.3	53.0	14.0	4.3	6.1	5.3	0.8	139.2
1997	0.0	0.0	2.4	82.7	104.6	53.4	12.7	4.2	1.0	1.2	262.3
1998	0.0	0.0	11.8	20.0	111.3	171.5	50.3	16.4	7.3	7.2	395.7
1999	0.0	0.0	0.3	41.4	60.5	89.8	60.5	30.6	6.7	6.0	295.8
2000	0.0	0.0	3.6	27.9	84.2	53.3	114.7	49.8	26.3	13.9	373.7
2001	0.0	0.0	7.8	148.0	101.3	72.4	67.6	64.4	31.8	20.7	513.9
2002	0.0	0.0	0.0	11.0	176.5	89.9	90.8	28.5	53.3	56.7	506.8
2003	0.0	0.0	0.0	2.3	29.8	344.9	70.2	51.5	18.0	60.4	577.1
2004	0.0	0.0	0.0	2.1	19.8	42.9	344.7	52.6	24.6	40.9	527.6
2005	0.0	0.0	0.0	1.4	18.3	41.9	68.7	310.7	35.8	53.8	530.6
2006	0.0	0.0	0.0	8.0	0.3	20.5	35.4	39.7	200.7	40.9	345.5
2007	0.0	0.0	0.2	1.7	102.8	5.5	27.4	22.6	49.3	222.0	431.5

Table R5. Coefficients of variation (CV) at age for Gulf of Maine haddock commercial landings, 1984 to 2007. **Note: CVs can not be determined for landings before 1984 because individual biological samples can not be identified in the database.*

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15
1984	0.23	0.09	0.09	0.11	0.03	0.09	0.12	0.09	0.27	0.53	0.17	0.25		
1985	0.18	0.10	0.16	0.08	0.11	0.05	0.11	0.16	0.18	1.28	0.79			
1986		0.07	0.06	0.05	0.04	0.04	0.08	0.17	0.24					
1987	0.41	0.19	0.07	0.05	0.07	0.05	0.08	0.10	0.19	0.46				
1988		0.34	0.23	0.31	0.46	0.31	0.45	0.55	0.65					
1989	0.79	1.02	0.43	0.41	0.38	0.32	0.93	1.13						
1990	0.85	0.24	1.07	0.50	0.48	0.52	1.04							
1991	0.54	0.26	0.13	0.25	0.23	0.24	0.52	0.85						
1992	0.89	0.19	0.40	0.57	0.73	1.01		1.43						
1993	0.18	0.18	0.19	0.25	0.28	0.49								
1994	0.17	0.10	0.27	0.38	0.31	0.23	0.47	1.09	1.13	0.88				
1995		0.74	0.14	0.44	0.42	0.35	0.44	8.11	0.99	0.61				
1996	0.85	0.26	0.24	0.34	0.31	0.45	0.76	1.06						
1997	0.99	0.12	0.14	0.13	0.26	0.24	0.37	0.35	0.77	1.15				
1998	0.83	0.30	0.14	0.11	0.19	0.36	0.37	0.61	1.24	1.38				
1999		0.28	0.21	0.20	0.23	0.22	0.37	0.55		1.12	0.97	1.43		
2000	0.54	0.24	0.16	0.12	0.11	0.17	0.26	0.52	0.65		0.87	0.70	0.77	
2001	0.45	0.10	0.10	0.16	0.11	0.15	0.22	0.37	0.53	0.92				1.10
2002		0.44	0.08	0.15	0.13	0.24	0.17	0.21	0.28	0.48	1.36			
2003		0.81	0.19	0.05	0.11	0.14	0.19	0.15	0.18	0.46	0.40	0.75	1.28	
2004		0.68	0.47	0.17	0.04	0.12	0.19	0.26	0.28	0.31	0.46	0.99		
2005		0.73	0.27	0.15	0.10	0.03	0.15	0.17	0.27	0.29	0.27	0.73	1.21	
2006		0.25	0.76	0.16	0.13	0.09	0.04	0.12	0.18	0.30	0.22	0.33	0.55	1.34
2007	1.39	0.59	0.08	0.37	0.14	0.15	0.10	0.05	0.19	0.26	0.52	0.57	0.61	1.36

Table R6. Fleet-specific discards (kg) of Gulf of Maine haddock observed by the Northeast Fisheries Observer Program (NEFOP), 1989 to 2007.

Year	Otter trawl, bottom, large mesh (≥ 5.5") (kg)	Otter trawl, bottom, small mesh (< 5.5") (kg)	Otter trawl, paired-midwater (kg)	Otter trawl, midwater (kg)	Longline, benthic (kg)	Gillnet, sink (kg)	Other (kg)	Percent of total discards by other fleets (%) (kg)
1989	12.7	0.5	0.0	0.0	0.0	16.8	0.9	2.9
1990	0.9	0.0	0.0	0.0	0.0	12.7	4.1	23.2
1991	11.8	0.0	0.0	0.0	2.7	87.5	1.8	1.7
1992	66.2	0.0	0.0	0.0	0.0	54.9	10.0	7.6
1993	70.3	0.0	0.0	0.0	0.0	73.0	21.3	12.9
1994	67.6	0.0	0.0	0.0	0.0	30.4	21.3	17.9
1995	773.2	13.2	0.0	0.0	0.0	27.2	16.8	2.0
1996	319.3	44.0	0.0	0.0	0.0	92.5	6.8	1.5
1997	1214.9	0.0	0.0	0.0	0.0	0.9	1.8	0.1
1998	12.7	0.0	0.0	0.0	0.0	25.4	0.0	0.0
1999	1.4	3.6	0.0	0.0	0.0	31.7	0.0	0.0
2000	161.0	0.0	0.0	0.0	0.0	63.5	0.0	0.0
2001	110.7	112.9	0.0	0.0	0.0	25.4	0.0	0.0
2002	118.4	41.7	0.0	0.0	0.0	83.9	0.0	0.0
2003	441.7	15.0	0.0	0.0	68.9	157.8	0.0	0.0
2004	343.8	166.4	154.2	119.3	5.4	268.0	0.9	0.1
2005	799.1	57.6	497.9	110.2	542.4	375.5	0.5	0.0
2006	868.9	24.0	0.0	2.7	345.1	70.7	9.5	0.7
2007	375.0	25.4	127.4	0.0	318.8	528.8	4.1	0.3
Annual average	303.7	26.5	41.0	12.2	67.5	106.7	5.3	0.9

Table R7. Discard reasons by year described as a percent occurrence from Northeast Fisheries Observer Program (NEFOP), 1989 to 2007.

Year	Discard reason by percent of total weight					Total weight of discards with discard reason available (lb)	Count of observed hauls with discard reasons available
	Other / unknown	Quota filled / retention prohibited	Upgraded	Poor quality	Below minimum size		
1989	49.3	0.0	0.0	50.7	0.0	69	6
1990	66.7	0.0	0.0	33.3	0.0	30	2
1991	71.1	0.0	0.0	28.9	0.0	225	7
1992	79.8	0.0	0.0	20.2	0.0	297	8
1993	72.2	13.6	0.0	14.2	0.0	316	8
1994	47.8	42.7	0.0	0.0	9.5	216	23
1995	22.5	46.9	0.0	0.5	30.1	1,794	127
1996	1.0	29.6	13.1	5.6	50.7	1,095	120
1997	4.8	34.5	0.0	50.5	10.2	4,173	56
1998	44.2	0.0	0.0	4.4	51.4	91	15
1999	9.9	0.0	0.0	76.5	13.6	81	17
2000	0.2	0.0	0.0	22.6	77.3	532	42
2001	2.6	0.0	0.0	3.9	93.5	696	72
2002	4.9	0.0	0.0	16.0	79.1	614	85
2003	1.9	0.0	0.0	7.7	90.3	1,544	250
2004	48.6	0.0	0.0	9.0	42.5	2,876	296
2005	24.8	0.6	0.0	13.3	61.3	5,178	558
2006	0.9	0.0	0.0	2.7	96.4	2,854	183
2007	12.2	0.0	0.0	34.5	53.2	3,006	160

Table R8. Gulf of Maine haddock minimum size limits for commercial and recreational landings, 1977 to 2008. Prior to 1977 there were no federal minimum size limits for either fishery. Values in italics are assumed pending clarification of regulations.

Year	Commercial minimum size limit (total length, inches)	Recreational minimum size limit (total length, inches)	Management action
1977	16	*15*	Groundfish Fishery Management Plan
1978	16	*15*	
1979	16	*15*	
1980	16	*15*	
1981	16	*15*	
1982	16	*15*	
1983	17	15	Large-mesh multispecies Fishery Management Plan
1984	17	15	
1985	17	15	
1986	17	15	
1987	19	17	Amendment 1
1988	19	17	
1989	19	19	
1990	19	19	
1991	19	19	
1992	19	19	
1993	19	19	
1994	19	19	Amendment 5
1995	19	19	
1996	19	19	
1997	19	19	
1998	19	19	
1999	19	19	
2000	19	19	
2001	19	19	
2002	19	23	Framework 33
2003	19	21	Framework 22
2004	19	19	Amendment 13
2005	19	19	
2006	19	19	
2007	18	19	Emergency action (August 10, 2007 through August 10, 2008)
2008	18	19	

Table R9. Fleet-specific discards (kg) of Gulf of Maine haddock observed by the Northeast Fisheries Observer Program, 1989 to 2007.

Year	Large mesh otter trawl (≥ 5.5" mesh)			Small mesh otter trawl (< 5.5" mesh)			Sink gillnet			Benthic longline		
	discards (mt)	number of observed trips	CV	discards (mt)	number of observed trips	CV	discards (mt)	number of observed trips	CV	discards (mt)	number of observed trips	CV
1964				232.5			8.3			163.7		
1965				126.1			5.8			208.3		
1966				101.3			7.4			112.2		
1967				36.3			2.6			21.8		
1968				13.5			1.1			5.5		
1969				2.1			0.1			0.7		
1970				1.6			0.1			0.6		
1971				9.4			0.4			4.3		
1972				8.6						7.1		
1973				15.7			1.8			16.8		
1974				16.6			3.6			22.3		
1975				24.5			6.7			48.0		
1976				38.3			12.9			36.2		
1977				39.0			14.3			25.3		
1978				25.8			11.8			9.9		
1979				11.2			3.3			3.4		
1980				14.5			4.4			2.8		
1981				11.9			4.7			2.9		
1982	8.5			3.1			2.7			1.0		
1983	10.4			3.5			3.1			0.9		
1984	12.4			3.7			4.7			0.6		
1985	10.9			2.5			3.3			0.7		
1986	4.7			1.0			1.8			0.5		
1987	0.7			0.1			0.3			0.1		
1988	0.8			0.1			0.5			0.1		

Table R9 (cont.). Fleet-specific discards (kg) of Gulf of Maine haddock observed by the Northeast Fisheries Observer Program, 1989 to 2007.

Year	Paired-midwater trawl			Midwater trawl			Total	
	discards (mt)	number of observed trips	CV	discards (mt)	number of observed trips	CV	discards (mt)	CV
1964	0.0			0.0			404.5	
1965	0.0			0.0			340.3	
1966	0.0			0.0			220.9	
1967	0.0			0.0			60.8	
1968	0.0			0.0			20.1	
1969	0.0			0.0			2.8	
1970	0.0			0.0			2.3	
1971	0.0			0.0			14.1	
1972	0.0			0.0			15.7	
1973	0.0			0.0			34.3	
1974	0.0			0.0			42.5	
1975	0.1			0.0			79.3	
1976	0.1			0.0			87.4	
1977	0.1			0.0			78.7	
1978	0.0			0.0			47.6	
1979	0.0			0.0			18.0	
1980	0.0			0.0			21.7	
1981	0.0			0.0			19.4	
1982	0.0			0.0			15.3	
1983	0.0			0.0			17.9	
1984	0.0			0.0			21.4	
1985	0.0			0.0			17.3	
1986	0.0			0.0			8.0	
1987	0.0			0.0			1.2	
1988	0.0			0.0			1.5	

Table R9 (cont.). Fleet-specific discards (kg) of Gulf of Maine haddock observed by the Northeast Fisheries Observer Program, 1989 to 2007.

Year	Large mesh otter trawl (≥ 5.5" mesh)			Small mesh otter trawl (< 5.5" mesh)			Sink gillnet			Benthic longline		
	discards (mt)	number of observed trips	CV	discards (mt)	number of observed trips	CV	discards (mt)	number of observed trips	CV	discards (mt)	number of observed trips	CV
1989	5.8	37	0.91	0.0	23	0.97	2.9	84	0.50			
1990	0.5	26	1.10	0.0	8		1.9	120	0.43			
1991	2.3	48	0.62	0.0	29		1.4	801	0.31	0.4	2	1.20
1992	18.0	44	0.66	0.0	15		1.0	896	0.25	0.0	9	
1993	26.3	17	0.53	0.0	6		3.4	560	0.34	0.0	2	
1994	85.8	6	0.56				7.6	85	0.44			
1995	121.4	25	0.37	0.5	30	0.34	5.7	69	0.39			
1996	85.9	11	0.69	2.4	40	0.19	18.3	46	0.50			
1997	368.0	5	1.65	0.0	3		0.3	33	1.08			
1998	20.9	6	0.42				3.2	78	0.64			
1999	1.3	21	1.47	0.2	11	0.47	1.3	73	0.53			
2000	30.0	79	0.59				7.9	81	0.44			
2001	13.1	113	0.51	8.3	4	0.71	5.7	47	0.31			
2002	11.1	149	0.32	0.8	35	0.53	11.8	80	0.36	0.0	1	
2003	11.2	253	0.20	0.3	19	0.56	5.8	295	0.19	5.3	14	0.46
2004	20.1	258	0.30	0.7	67	0.89	3.9	775	0.20	0.5	8	0.37
2005	14.5	498	0.21	0.1	69	0.54	4.5	651	0.14	17.0	58	0.26
2006	38.8	206	0.50	0.2	24	0.43	3.2	128	0.23	7.1	36	0.35
2007	4.9	224	0.34	0.5	16	0.40	25.2	118	0.87	15.1	36	0.40

Table R9 (cont.). Fleet-specific discards (kg) of Gulf of Maine haddock observed by the Northeast Fisheries Observer Program, 1989 to 2007.

Year	Paired-midwater trawl			Midwater trawl			Total	
	discards (mt)	number of observed trips	CV	discards (mt)	number of observed trips	CV	discards (mt)	CV
1989							8.7	0.62
1990							2.4	0.41
1991							4.1	0.38
1992							19.1	0.62
1993							29.7	0.47
1994							93.5	0.52
1995				0.0	4		127.6	0.36
1996							106.5	0.57
1997							368.2	1.65
1998							24.1	0.37
1999	0.0	2					2.9	0.70
2000				0.0	3		37.9	0.47
2001							27.1	0.34
2002				0.0	1		23.6	0.24
2003	0.0	8		0.0	20		22.6	0.16
2004	0.0	41	0.09	1.5	27	0.95	26.6	0.23
2005	0.6	63	0.14	0.6	7	1.16	37.4	0.15
2006	0.0	7		0.0	3	1.51	49.4	0.40
2007	0.0	4	4.41	0.0	4		45.7	0.50

Table R10. Summary of Gulf of Maine haddock length and age measurements taken of United States commercial discards by quarter, 1989 – 2007.

Year	Commercial discards (mt)	Total lengths (numbers)	Metric tons per 100 lengths
1989	8.7	10	87
1990	2.4	0	
1991	4.1	1	410
1992	19.1	41	47
1993	29.7	104	29
1994	93.5	163	57
1995	127.6	550	23
1996	106.5	190	56
1997	368.2	808	46
1998	24.1	14	172
1999	2.9	29	10
2000	37.9	17	223
2001	27.1	48	56
2002	23.6	129	18
2003	22.6	426	5
2004	26.6	569	5
2005	37.4	950	4
2006	49.4	600	8
2007	45.7	558	8

Table R11. Commercial discards (000's) at age of Gulf of Maine haddock, 1977 to 2007.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Total
1977	8.2	504.6	44.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	557.0
1978	9.9	3.1	95.8	1.2	0.0	0.0	0.0	0.0	0.0	1.0	110.9
1979	46.5	62.0	6.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	115.7
1980	76.6	121.9	3.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	202.4
1981	3.8	164.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	170.7
1982	178.9	10.8	15.5	0.8	0.0	0.0	0.0	0.0	0.0	0.0	206.0
1983	2.5	76.1	10.0	7.3	0.1	0.0	0.0	0.0	0.0	0.0	96.0
1984	0.0	11.4	43.2	1.0	1.9	0.0	0.0	0.0	0.0	0.0	57.4
1985	0.2	3.1	8.3	21.4	0.0	0.0	0.0	0.0	0.0	0.0	33.0
1986	10.0	19.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.9
1987	14.6	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.8
1988	0.0	18.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5
1989	0.0	3.4	7.1	0.8	1.7	0.0	0.0	0.0	0.0	0.0	13.0
1990	4.5	4.5	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	10.8
1991	9.2	7.9	2.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	19.8
1992	4.8	20.4	11.0	4.8	0.1	0.0	0.0	0.0	0.0	0.0	41.0
1993	15.7	12.4	17.8	3.1	1.8	0.2	0.6	0.1	0.4	0.6	52.7
1994	60.4	89.9	17.8	21.4	3.9	1.5	3.2	2.0	0.3	0.4	200.8
1995	0.9	50.1	58.5	42.0	14.5	1.6	0.9	0.6	0.0	0.0	169.1
1996	47.7	9.9	32.4	85.8	10.3	1.7	0.4	0.4	0.2	0.0	189.0
1997	0.2	2.9	5.7	87.4	123.1	23.9	4.4	1.5	0.5	0.2	249.8
1998	107.6	13.3	13.8	1.5	4.7	5.0	0.0	0.0	0.0	0.0	145.9
1999	1.1	8.4	0.7	0.2	0.1	0.1	0.1	0.0	0.0	0.0	10.8
2000	1.1	5.4	47.0	14.2	1.7	0.2	0.4	0.1	0.0	0.0	70.1
2001	1.2	1.6	11.2	21.1	2.3	0.4	0.4	0.3	0.0	0.0	38.6
2002	0.0	2.1	1.3	6.6	17.3	1.8	0.3	0.0	0.1	0.1	29.5
2003	0.0	0.1	3.9	1.0	3.6	14.3	1.5	0.3	0.2	0.1	25.0
2004	0.3	7.8	0.4	4.9	1.1	2.9	12.1	1.0	0.4	0.5	31.4
2005	0.0	0.3	15.6	1.0	5.1	4.3	4.1	10.1	0.6	0.5	41.5
2006	5.2	9.4	1.6	35.9	3.8	3.7	1.6	2.8	9.2	0.4	73.6
2007	0.0	1.7	12.7	4.1	27.8	0.3	1.8	0.5	1.4	4.8	55.1

Table R12. Recreational landings and releases of Gulf of Maine haddock, 1981 – 2007. The weight of recreational landings from 1981 to 2001 were estimated from the total numbers multiplied by the average weight of individually sampled fish from 1981 to 2001.

Year	Estimated recreational landings, A + B1 (numbers)	Estimated recreational live releases, B2 (numbers)	Estimated recreational landings (mt)
1981	22,990	0	36.3
1982	19,531	122	30.9
1983	36,455	0	57.6
1984	31,277	1,687	49.4
1985	19,417	92	30.7
1986	34,777	432	55.0
1987	18,765	0	29.7
1988	7,630	2,970	12.1
1989	5,995	5,134	9.5
1990	1,836	278	2.9
1991	242	0	0.4
1992	0	0	0.0
1993	336	0	0.5
1994	2,385	1,720	3.8
1995	110,818	43,469	175.1
1996	4,190	8,597	6.6
1997	20,022	15,733	31.6
1998	28,161	9,550	44.5
1999	12,128	16,673	19.2
2000	80,735	101,016	127.6
2001	120,422	112,326	190.3
2002	83,283	171,955	165.9
2003	119,788	260,881	191.8
2004	278,497	142,426	429.6
2005	444,739	116,168	717.1
2006	277,858	164,196	503.9
2007	398,229	105,432	627.9

Table R13. Summary of Gulf of Maine haddock length and age measurements taken of United States recreational fishery by quarter, 1981 – 2007.

Year	Recreational landings (mt)	Total lengths (numbers)	Metric tons per 100 lengths
1981	36.3	13	279
1982	30.9	2	1545
1983	57.6	10	576
1984	49.4	16	309
1985	30.7	7	439
1986	55.0	0	
1987	29.7	6	495
1988	12.1	2	605
1989	9.5	3	317
1990	2.9	0	
1991	0.4	0	
1992	0.0	0	
1993	0.5	0	
1994	3.8	4	95
1995	175.1	153	114
1996	6.6	25	26
1997	31.6	21	150
1998	44.5	62	72
1999	19.2	32	60
2000	127.6	34	375
2001	190.3	25	761
2002	165.9	119	139
2003	191.8	210	91
2004	429.6	928	46
2005	717.1	1,711	42
2006	503.9	1,171	43
2007	627.9	1,068	59

Table R14. Recreational landings (000's) at age of Gulf of Maine haddock, 1977 to 2007.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Total
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1978	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1979	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1981	0.0	0.0	5.3	4.2	2.1	3.2	5.0	1.0	1.6	0.6	23.0
1982	0.0	0.0	2.4	10.6	3.5	0.6	0.6	1.3	0.2	0.3	19.5
1983	0.0	0.0	0.6	9.8	11.4	7.5	1.2	1.7	3.1	1.2	36.5
1984	0.0	0.0	8.4	1.2	8.3	3.1	6.4	0.9	0.8	2.3	31.3
1985	0.0	0.0	0.7	8.8	1.1	3.4	1.4	2.6	0.7	0.8	19.4
1986	0.0	1.2	0.0	5.9	16.3	2.8	4.2	1.9	2.0	0.4	34.8
1987	0.0	0.0	1.3	1.9	6.3	2.6	1.9	2.2	1.2	1.3	18.8
1988	0.0	0.0	0.0	0.3	0.3	2.1	1.8	0.4	2.1	0.5	7.6
1989	0.0	0.0	1.1	0.3	1.0	1.2	1.2	1.1	0.1	0.1	6.0
1990	0.0	0.0	0.0	0.9	0.0	0.2	0.1	0.4	0.3	0.0	1.8
1991	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.2
1992	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.3
1994	0.0	0.0	0.3	1.3	0.2	0.2	0.2	0.1	0.0	0.0	2.4
1995	0.0	0.0	18.3	51.7	37.9	1.1	0.7	0.5	0.3	0.3	110.8
1996	0.0	0.0	0.1	1.8	1.5	0.3	0.1	0.2	0.1	0.0	4.2
1997	0.0	0.0	0.1	6.9	8.3	2.8	1.0	0.4	0.2	0.3	20.0
1998	0.0	0.0	1.1	2.2	10.0	11.5	2.1	0.5	0.3	0.4	28.2
1999	0.0	0.0	0.0	1.7	1.9	3.6	3.0	1.5	0.3	0.2	12.1
2000	0.0	0.0	0.6	5.8	20.7	12.8	23.5	11.3	4.6	1.4	80.7
2001	0.0	0.0	4.4	44.4	26.4	15.8	10.9	10.0	5.5	3.0	120.4
2002	0.0	0.0	0.0	0.4	23.6	16.4	16.4	4.5	10.2	11.8	83.3
2003	0.0	0.0	0.0	0.2	5.2	71.6	16.2	10.3	3.9	12.2	119.8
2004	0.0	0.3	0.1	1.4	14.1	33.5	189.1	15.5	11.4	13.1	278.5
2005	0.0	0.3	1.2	1.7	25.6	40.8	74.5	248.2	23.7	28.7	444.7
2006	0.0	0.0	0.0	25.9	0.8	21.0	33.5	34.8	141.6	20.2	277.9
2007	0.0	0.0	0.3	2.7	159.4	4.8	25.1	21.1	37.4	147.6	398.2

Table R15. Total catch (000's) at age of Gulf of Maine haddock, 1977 to 2007.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Total
1977	8.2	548.4	1791.5	51.1	365.0	215.0	143.6	4.8	1.6	6.3	3135.4
1978	9.9	3.1	433.5	1959.5	181.2	320.3	154.6	32.0	0.0	5.6	3099.8
1979	46.5	69.5	87.4	614.6	1348.8	200.5	105.5	32.4	23.8	0.0	2529.0
1980	76.6	121.9	865.2	110.0	754.9	1235.8	165.4	134.1	11.5	25.3	3500.8
1981	3.8	164.0	1466.5	645.6	268.9	360.0	503.2	70.1	98.3	12.7	3593.0
1982	178.9	77.9	458.6	1256.6	513.9	81.2	225.7	401.3	89.8	59.8	3343.6
1983	2.5	76.1	17.0	612.5	724.2	596.3	110.3	185.7	254.1	88.0	2666.8
1984	0.0	11.4	96.4	34.1	420.0	176.2	253.7	44.0	49.8	102.1	1187.5
1985	0.2	3.1	25.5	266.2	63.3	270.5	109.3	176.0	35.3	38.3	987.7
1986	10.0	21.1	0.0	159.6	304.0	66.2	101.7	75.8	90.0	11.8	840.1
1987	14.6	8.1	3.6	18.1	96.7	51.5	35.0	54.2	38.7	18.4	339.0
1988	0.0	18.5	0.0	13.0	10.1	55.0	40.1	9.4	22.7	4.8	173.6
1989	0.0	3.4	23.9	4.4	51.2	17.7	22.4	17.2	1.8	0.9	142.9
1990	4.5	4.5	1.9	136.0	1.8	24.2	17.8	28.6	3.7	0.0	223.0
1991	9.2	7.9	28.9	48.3	61.7	17.7	19.2	13.0	2.7	2.2	210.7
1992	4.8	20.4	18.3	93.7	36.4	23.3	2.4	2.3	0.0	1.1	202.8
1993	15.7	12.4	29.6	28.7	31.7	17.8	6.5	6.4	0.4	0.6	149.8
1994	60.4	89.9	23.4	52.2	13.5	3.4	10.3	6.7	1.3	1.0	262.1
1995	0.9	50.1	78.5	99.4	83.2	12.1	6.5	6.1	3.4	3.1	343.4
1996	47.7	9.9	35.0	141.0	64.8	16.1	4.8	6.6	5.6	0.8	332.3
1997	0.2	2.9	8.3	177.0	235.9	80.1	18.1	6.1	1.8	1.8	532.1
1998	107.6	13.3	26.6	23.7	126.1	188.0	52.4	16.9	7.6	7.6	569.8
1999	1.1	8.4	0.9	43.4	62.4	93.5	63.6	32.1	7.1	6.2	318.7
2000	1.1	5.4	51.2	47.8	106.6	66.3	138.6	61.2	31.0	15.3	524.6
2001	1.2	1.6	23.4	213.5	130.0	88.5	79.0	74.7	37.3	23.7	672.9
2002	0.0	2.1	1.3	18.0	217.4	108.0	107.5	33.1	63.5	68.6	619.6
2003	0.0	0.1	3.9	3.6	38.6	430.8	87.9	62.1	22.2	72.7	721.9
2004	0.3	8.1	0.5	8.4	34.9	79.3	546.0	69.1	36.4	54.5	837.5
2005	0.0	0.6	16.7	4.1	49.0	87.0	147.4	569.0	60.1	83.1	1016.9
2006	5.2	9.4	1.6	69.9	4.9	45.2	70.5	77.3	351.5	61.5	697.0
2007	0.0	1.7	13.2	8.5	290.0	10.6	54.3	44.1	88.0	374.4	884.8

Table R16. Mean catch weight at age (kg) of Gulf of Maine haddock, 1977 to 2007. Catch weights at age do not include biological samples from the recreational landings due to low sampling of this fishery prior to 2002.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age9+
1977	0.02	0.14	0.74	1.14	2.01	2.62	3.30	4.66	5.98	5.70
1978	0.02	0.12	0.72	1.22	1.78	2.42	2.95	4.14	4.64	5.00
1979	0.02	0.25	0.79	1.22	1.80	2.25	2.54	2.83	3.29	4.48
1980	0.02	0.15	0.76	1.25	1.87	2.39	3.29	3.38	3.99	4.36
1981	0.03	0.11	0.68	1.49	1.97	2.52	3.28	3.84	4.19	3.79
1982	0.04	0.33	0.64	1.00	2.14	2.56	3.10	3.65	4.26	4.09
1983	0.03	0.12	0.57	1.19	1.73	2.38	2.96	3.38	3.72	4.23
1984	0.04	0.24	0.68	1.22	1.80	2.30	3.16	3.95	4.41	4.09
1985	0.05	0.33	0.91	1.06	1.91	2.36	2.66	3.57	4.12	4.21
1986	0.07	0.37	0.98	1.22	1.46	2.28	2.50	3.05	3.63	4.51
1987	0.03	0.10	1.06	1.30	2.00	2.43	2.62	3.36	4.19	5.18
1988	0.03	0.08	1.15	1.23	1.49	2.65	2.34	3.65	4.89	5.35
1989	0.03	0.25	1.12	1.67	1.64	2.51	2.30	3.38	4.47	4.33
1990	0.03	0.23	0.80	1.51	3.36	2.36	2.96	3.63	3.51	3.85
1991	0.01	0.24	1.30	1.48	2.49	2.96	2.96	3.31	4.25	3.37
1992	0.04	0.21	1.09	1.68	1.91	2.68	2.94	2.92	4.21	2.80
1993	0.03	0.19	0.86	1.36	1.92	2.52	3.29	3.89	4.17	4.60
1994	0.03	0.07	0.85	1.65	2.23	2.93	2.98	3.80	3.53	3.99
1995	0.02	0.07	0.78	1.19	1.93	2.64	3.63	4.45	5.15	5.56
1996	0.07	0.24	0.56	1.00	1.75	2.21	3.07	2.37	2.12	3.19
1997	0.07	0.15	0.93	1.80	1.68	2.33	2.98	3.21	3.82	3.74
1998	0.02	0.22	0.95	1.48	1.85	2.21	2.86	3.38	3.12	3.00
1999	0.05	0.17	0.62	1.32	1.70	1.72	1.94	2.35	3.11	3.34
2000	0.04	0.19	0.59	1.02	1.53	1.84	2.07	2.38	2.61	3.39
2001	0.02	0.20	0.84	1.31	1.50	1.81	2.24	2.27	2.46	2.58
2002	0.07	0.18	0.37	1.04	1.37	1.67	2.20	2.67	2.46	2.75
2003	0.05	0.13	0.52	0.95	1.30	1.53	1.85	2.19	2.52	2.57
2004	0.02	0.16	0.58	0.83	1.38	1.42	1.72	2.10	2.16	2.24
2005	0.10	0.15	0.50	0.92	1.16	1.53	1.53	1.80	2.02	2.38
2006	0.04	0.09	0.45	0.81	0.69	1.41	1.75	1.60	1.78	2.12
2007	0.04	0.22	0.60	0.81	1.05	1.23	1.59	1.63	1.71	1.83

Table R17. Vessel and door types used in the Northeast Fisheries Science Center's spring and autumn bottom trawl surveys where Gulf of Maine haddock were caught and the types of conversion factors applied to the annual indices, 1963 – 2008. Coefficients of 0.82 (Delaware II) and 1.49 (BMV trawl door) were applied to abundance indices and 0.79 (Delaware II) and 1.51 (BMV trawl door) wee applied to biomass indices.

Year	Door	Spring survey vessel	Spring conversion factor	Autumn survey vessel	Autumn conversion factor
1963	BMV			Albatross IV	door
1964	BMV			Albatross IV	door
1965	BMV			Albatross IV	door
1966	BMV			Albatross IV	door
1967	BMV			Albatross IV	door
1968	BMV	Albatross IV	door	Albatross IV	door
1969	BMV	Albatross IV	door	Albatross IV	door
1970	BMV	Albatross IV	door	Albatross IV	door
1971	BMV	Albatross IV	door	Albatross IV	door
1972	BMV	Albatross IV	door	Albatross IV	door
1973	BMV	Albatross IV	door	Albatross IV	door
1974	BMV	Albatross IV	door	Albatross IV	door
1975	BMV	Albatross IV	door	Albatross IV	door
1976	BMV	Albatross IV	door	Albatross IV	door
1977	BMV	Albatross IV	door	Delaware II	door
1978	BMV	Albatross IV	door	Delaware II	door
1979	BMV	Albatross IV/Delaware II	door, vessel	Albatross IV/Delaware II	door, vessel
1980	BMV	Delaware II	door, vessel	Delaware II	door
1981	BMV	Delaware II	door, vessel	Albatross IV/Delaware II	door, vessel
1981	BMV	Delaware II	door, vessel	Delaware II	door
1982	BMV	Albatross IV	door	Albatross IV	door
1983	BMV	Albatross IV	door	Albatross IV	door
1984	BMV	Albatross IV	door	Albatross IV	door
1985	Polyvalent	Albatross IV		Albatross IV	
1986	Polyvalent	Delaware II	vessel	Albatross IV	
1987	Polyvalent	Albatross IV		Albatross IV	
1988	Polyvalent	Delaware II	vessel	Albatross IV	
1989	Polyvalent	Delaware II	vessel	Delaware II	vessel
1990	Polyvalent	Delaware II	vessel	Delaware II	vessel
1991	Polyvalent	Albatross IV		Delaware II	vessel
1992	Polyvalent	Albatross IV		Albatross IV	
1993	Polyvalent	Delaware II	vessel	Delaware II	vessel
1994	Polyvalent	Albatross IV		Albatross IV	
1995	Polyvalent	Albatross IV		Albatross IV	
1996	Polyvalent	Albatross IV		Albatross IV	
1997	Polyvalent	Albatross IV		Albatross IV	
1998	Polyvalent	Albatross IV		Albatross IV	
1999	Polyvalent	Albatross IV		Albatross IV	
2000	Polyvalent	Albatross IV		Albatross IV	
2001	Polyvalent	Albatross IV		Albatross IV	
2002	Polyvalent	Delaware II	vessel	Albatross IV	
2003	Polyvalent	Albatross IV		Albatross IV	
2004	Polyvalent	Albatross IV		Albatross IV	
2005	Polyvalent	Albatross IV		Albatross IV	
2006	Polyvalent	Albatross IV		Albatross IV	
2007	Polyvalent	Albatross IV		Albatross IV	
2008	Polyvalent	Albatross IV		N/A	

Table R18. Northeast Fisheries Science Center (NEFSC) spring and autumn survey indices of abundance (stratified mean numbers/tow) and biomass (stratified mean kg/tow) for Gulf of Maine haddock with, 1968 – 2008. *Note Spring 2008 data are preliminary.

Year	NEFSC spring numbers per tow	NEFSC spring numbers per tow standard error	NEFSC spring weight (kg) per tow	NEFSC spring weight (kg) per tow standard error	NEFSC autumn numbers per tow	NEFSC autumn numbers per tow standard error	NEFSC autumn weight (kg) per tow	NEFSC autumn weight (kg) per tow standard error
1963					69.549	20.456	50.697	8.362
1964					14.176	5.432	18.386	3.533
1965					17.434	6.342	17.731	3.991
1966					10.742	3.786	13.103	3.962
1967					12.186	3.092	16.871	4.444
1968	6.066	1.907	8.107	2.194	8.564	1.430	17.307	2.900
1969	3.719	0.802	6.607	1.523	5.451	1.373	12.721	3.055
1970	0.906	0.232	1.784	0.482	2.918	0.672	7.354	1.663
1971	0.878	0.436	2.523	1.203	2.880	1.010	8.159	2.863
1972	0.862	0.329	0.867	0.555	1.984	0.504	3.036	1.101
1973	1.312	0.347	1.598	0.651	4.165	0.905	8.583	2.905
1974	1.437	0.611	1.059	0.472	2.687	1.642	3.347	1.131
1975	2.770	0.815	3.482	1.650	5.533	1.517	8.616	2.856
1976	8.326	3.015	6.350	2.487	6.035	1.496	8.040	2.365
1977	6.799	2.299	6.725	2.797	8.296	2.878	8.752	2.624
1978	1.356	0.621	1.434	0.454	9.775	1.773	21.658	4.299
1979	2.890	0.691	3.948	0.926	6.174	1.300	15.567	3.523
1980	2.212	0.975	2.673	1.351	7.152	2.666	9.835	2.543
1981	3.613	0.958	3.545	0.846	4.456	0.878	10.874	2.645
1982	2.047	0.732	2.555	0.967	2.627	1.000	4.164	1.301
1983	3.678	1.684	3.567	1.721	2.598	0.820	5.219	1.613
1984	1.095	0.502	1.144	0.532	1.697	0.513	3.893	1.164
1985	1.773	0.739	1.882	0.618	4.079	1.780	6.149	1.994
1986	0.707	0.362	1.284	0.696	0.623	0.285	1.392	0.585
1987	0.092	0.038	0.063	0.036	1.035	0.354	2.645	0.755
1988	0.187	0.108	0.301	0.199	0.335	0.233	1.476	1.126
1989	0.083	0.069	0.125	0.115	0.283	0.119	0.631	0.335
1990	0.024	0.015	0.000	0.000	0.145	0.059	0.432	0.168
1991	0.074	0.044	0.066	0.046	0.142	0.092	0.120	0.091
1992	0.193	0.125	0.271	0.268	0.211	0.128	0.091	0.062
1993	0.450	0.229	0.200	0.158	0.866	0.709	0.472	0.453
1994	0.402	0.151	0.253	0.105	0.325	0.150	0.217	0.207
1995	0.806	0.414	0.350	0.172	0.977	0.598	1.099	0.501
1996	0.305	0.105	0.338	0.129	2.407	0.970	3.543	1.632
1997	1.935	0.848	1.222	0.691	2.688	1.071	2.424	0.752
1998	0.197	0.085	0.112	0.054	3.130	1.735	2.917	1.321
1999	4.267	1.873	1.108	0.438	6.730	2.116	4.910	1.254
2000	3.610	1.620	1.815	0.833	16.589	8.290	14.032	6.095
2001	2.364	1.547	3.205	2.306	9.960	2.918	11.981	3.326
2002	5.704	3.222	2.793	0.991	3.920	1.491	4.835	1.746
2003	3.191	0.871	3.908	1.196	4.733	1.147	5.359	1.367
2004	1.061	0.404	1.199	0.530	5.704	1.636	7.171	2.278
2005	0.862	0.383	0.971	0.508	4.132	0.886	3.932	0.692
2006	3.151	1.536	2.661	1.188	3.910	1.073	3.945	0.881
2007	0.771	0.315	0.675	0.262	5.153	1.669	4.393	1.175
2008	1.848	0.773	1.510	0.437				
Average	2.049	0.801	2.056	0.800	6.337	2.022	7.957	2.081

Table R19. Stratified mean numbers-at-age per tow of Gulf of Maine haddock from the Northeast Fisheries Science Center (NEFSC) spring survey, 1968 – 2008. Indices have been corrected to account for changes in catchability due to changes in research vessels and doors. *Note 2008 data are preliminary.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9^+
1968	0.000	0.000	0.000	0.051	0.301	4.433	0.893	0.134	0.112	0.142
1969	0.000	0.000	0.000	0.054	0.019	0.263	2.526	0.785	0.029	0.043
1970	0.000	0.000	0.000	0.000	0.000	0.000	0.143	0.612	0.092	0.059
1971	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.026	0.637	0.189
1972	0.000	0.584	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.278
1973	0.000	0.129	0.784	0.000	0.054	0.000	0.000	0.000	0.000	0.345
1974	0.000	0.900	0.088	0.333	0.000	0.000	0.000	0.000	0.016	0.101
1975	0.000	0.030	1.958	0.152	0.380	0.000	0.203	0.000	0.000	0.048
1976	0.000	5.114	0.124	1.734	0.176	0.942	0.067	0.033	0.000	0.136
1977	0.000	1.158	3.268	0.049	1.339	0.407	0.578	0.000	0.000	0.000
1978	0.000	0.085	0.716	0.333	0.030	0.192	0.000	0.000	0.000	0.000
1979	0.000	0.371	0.314	0.400	1.379	0.233	0.194	0.000	0.000	0.000
1980	0.000	1.053	0.152	0.171	0.455	0.318	0.025	0.000	0.000	0.037
1981	0.000	1.181	0.993	0.607	0.213	0.356	0.160	0.025	0.038	0.038
1982	0.000	0.045	0.433	0.892	0.465	0.147	0.066	0.000	0.000	0.000
1983	0.143	1.352	0.137	1.236	0.319	0.306	0.000	0.163	0.000	0.022
1984	0.000	0.019	0.570	0.054	0.299	0.108	0.000	0.000	0.045	0.000
1985	0.000	0.042	0.280	1.095	0.058	0.170	0.059	0.050	0.020	0.000
1986	0.000	0.051	0.000	0.121	0.403	0.000	0.036	0.073	0.023	0.000
1987	0.000	0.036	0.025	0.031	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.000	0.043	0.000	0.000	0.015	0.119	0.010	0.000	0.000	0.000
1989	0.000	0.000	0.036	0.012	0.000	0.012	0.012	0.012	0.000	0.000
1990	0.012	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.000	0.014	0.007	0.052	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.000	0.085	0.000	0.000	0.109	0.000	0.000	0.000	0.000	0.000
1993	0.000	0.261	0.146	0.000	0.000	0.029	0.015	0.000	0.000	0.000
1994	0.000	0.074	0.182	0.122	0.024	0.000	0.000	0.000	0.000	0.000
1995	0.000	0.441	0.240	0.073	0.030	0.000	0.000	0.000	0.023	0.000
1996	0.000	0.000	0.037	0.146	0.123	0.000	0.000	0.000	0.000	0.000
1997	0.000	0.775	0.231	0.239	0.592	0.076	0.022	0.000	0.000	0.000
1998	0.000	0.080	0.046	0.000	0.062	0.009	0.000	0.000	0.000	0.000
1999	0.000	3.724	0.087	0.162	0.029	0.227	0.039	0.000	0.000	0.000
2000	0.000	1.037	1.188	0.968	0.145	0.084	0.053	0.136	0.000	0.000
2001	0.000	0.073	0.131	1.040	0.525	0.167	0.227	0.065	0.048	0.090
2002	0.000	3.299	0.207	0.605	1.418	0.081	0.036	0.022	0.036	0.000
2003	0.000	0.359	0.203	0.093	0.109	1.990	0.204	0.144	0.036	0.054
2004	0.000	0.115	0.000	0.154	0.033	0.095	0.621	0.029	0.000	0.015
2005	0.000	0.010	0.172	0.000	0.070	0.083	0.225	0.274	0.000	0.029
2006	0.000	0.179	0.092	1.678	0.272	0.104	0.022	0.211	0.548	0.047
2007	0.000	0.156	0.085	0.028	0.252	0.000	0.028	0.029	0.034	0.159
2008	0.000	0.036	0.659	0.411	0.000	0.334	0.000	0.028	0.057	0.324

Table R20. Stratified mean numbers-at-age per tow of Gulf of Maine haddock from the Northeast Fisheries Science Center (NEFSC) autumn survey, 1963 – 2007. Indices have been corrected to account for changes in catchability due to changes in research vessels and doors.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9^+
1963	35.602	12.183	1.704	3.012	6.942	4.938	1.669	1.318	1.041	1.142
1964	0.081	5.904	1.848	0.706	0.975	1.820	1.754	0.984	0.000	0.103
1965	0.054	0.367	7.991	5.064	0.253	1.450	1.205	0.663	0.333	0.054
1966	0.019	0.000	0.525	6.597	2.181	0.284	0.616	0.403	0.083	0.034
1967	0.000	0.000	0.000	1.542	7.995	1.801	0.528	0.125	0.149	0.046
1968	0.000	0.000	0.000	0.000	0.193	6.265	1.452	0.217	0.319	0.117
1969	0.000	0.000	0.000	0.037	0.028	0.037	4.119	0.931	0.138	0.161
1970	0.000	0.048	0.000	0.000	0.000	0.126	0.136	1.946	0.606	0.057
1971	0.268	0.000	0.000	0.000	0.016	0.000	0.122	0.169	2.029	0.276
1972	0.000	1.190	0.000	0.024	0.000	0.000	0.000	0.000	0.000	0.770
1973	1.129	0.022	0.960	0.000	0.356	0.026	0.022	0.038	0.022	1.592
1974	0.022	1.660	0.209	0.429	0.000	0.000	0.000	0.000	0.000	0.368
1975	0.888	0.227	1.916	0.558	1.388	0.000	0.045	0.045	0.000	0.466
1976	1.633	1.794	0.077	1.275	0.149	0.902	0.000	0.189	0.000	0.016
1977	0.104	3.085	3.401	0.137	1.028	0.192	0.255	0.000	0.000	0.094
1978	0.174	0.087	1.716	5.523	0.201	0.640	1.204	0.126	0.000	0.104
1979	0.781	0.421	0.084	1.123	2.854	0.509	0.326	0.063	0.000	0.013
1980	3.953	0.509	0.320	0.000	0.298	1.068	0.650	0.157	0.105	0.093
1981	0.000	0.614	0.562	1.013	0.314	0.855	0.681	0.170	0.183	0.064
1982	0.386	0.056	0.682	0.855	0.306	0.055	0.000	0.112	0.048	0.128
1983	0.000	0.557	0.053	0.638	0.603	0.312	0.172	0.068	0.161	0.034
1984	0.000	0.202	0.541	0.000	0.282	0.000	0.408	0.000	0.034	0.228
1985	0.000	0.089	0.471	2.725	0.017	0.182	0.150	0.395	0.000	0.051
1986	0.000	0.015	0.000	0.069	0.351	0.085	0.018	0.025	0.059	0.000
1987	0.029	0.000	0.127	0.114	0.190	0.061	0.238	0.146	0.000	0.130
1988	0.000	0.000	0.000	0.032	0.023	0.101	0.000	0.041	0.137	0.000
1989	0.000	0.059	0.059	0.019	0.012	0.031	0.052	0.052	0.000	0.000
1990	0.009	0.024	0.000	0.056	0.000	0.000	0.000	0.038	0.019	0.000
1991	0.053	0.047	0.000	0.000	0.042	0.000	0.000	0.000	0.000	0.000
1992	0.043	0.145	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.099	0.467	0.219	0.037	0.030	0.015	0.000	0.000	0.000	0.000
1994	0.206	0.047	0.000	0.000	0.000	0.000	0.000	0.036	0.000	0.036
1995	0.000	0.094	0.604	0.185	0.036	0.036	0.000	0.000	0.000	0.023
1996	0.043	0.115	0.227	1.043	0.618	0.068	0.114	0.070	0.036	0.073
1997	0.214	1.328	0.025	0.378	0.584	0.083	0.075	0.000	0.000	0.000
1998	1.466	0.241	0.431	0.131	0.423	0.297	0.070	0.048	0.025	0.000
1999	0.542	3.231	0.620	0.817	0.278	0.477	0.525	0.131	0.051	0.058
2000	0.333	0.806	11.209	1.604	1.265	0.446	0.618	0.222	0.088	0.000
2001	0.196	0.240	2.288	4.821	0.756	0.866	0.287	0.192	0.271	0.045
2002	0.014	0.121	0.014	0.482	2.521	0.365	0.135	0.000	0.205	0.065
2003	0.853	0.000	0.280	0.073	0.486	2.494	0.350	0.048	0.000	0.150
2004	0.073	0.348	0.029	0.559	0.262	0.812	3.215	0.124	0.168	0.116
2005	0.188	0.110	1.579	0.088	0.143	0.314	0.427	1.117	0.076	0.091
2006	0.230	0.282	0.088	1.762	0.028	0.219	0.107	0.285	0.841	0.068
2007	0.015	1.042	0.850	0.221	2.157	0.066	0.014	0.162	0.122	0.504

Table R21. Summary of the number of individual length and age measurements taken during the Northeast Fisheries Science Center spring and autumn bottom trawl surveys, 1963 – 2008.

Year	Lengths		Ages	
	Spring	Autumn	Spring	Autumn
1963		2347		320
1964		412		140
1965		609		142
1966		356		140
1967		316		162
1968	189	260	108	232
1969	134	161	94	148
1970	36	74	36	69
1971	39	72	38	50
1972	37	53	34	51
1973	50	142	44	112
1974	61	114	26	58
1975	280	365	132	175
1976	919	363	154	164
1977	498	660	150	181
1978	68	887	29	78
1979	219	603	19	145
1980	105	331	59	117
1981	199	151	115	28
1982	106	101	76	64
1983	159	102	64	99
1984	35	59	34	59
1985	92	194	65	137
1986	27	29	26	29
1987	5	35	5	27
1988	10	13	9	12
1989	10	22	10	21
1990	2	9	1	9
1991	4	9	4	6
1992	9	11	9	8
1993	25	64	19	34
1994	24	16	20	10
1995	31	55	21	33
1996	10	91	10	66
1997	98	115	60	74
1998	11	225	11	90
1999	278	517	77	216
2000	207	809	83	157
2001	209	468	72	184
2002	333	151	119	98
2003	236	233	118	130
2004	56	312	41	113
2005	49	197	33	117
2006	232	288	95	167
2007	48	251	38	125
2008	126		57	

Table R22. Summary of virtual population analysis (VPA) configuration runs for Gulf of Maine haddock. The BRP1 configuration was accepted by the Biological Reference Point Panel.

VPA run description	BRP1	BASE	ALT1
Survey indices			
1977 - 2008 NEFSC Spring ages	1-6+	1-6+	1-9+
1976 - 2007 NEFSC Autumn ages (projected +1)	1-8+	1-8+	1-9+
Discards			
1977 - 1988 hindcast	Yes	Yes	Yes
1989 - 2007 estimated from observer	Yes	Yes	Yes
Recreational catch			
1981 - 2007 MRFSS	Yes	Yes	Yes
Diagnostics			
Sum of squares	316.5	327.6	474.7
Mean squared residuals	0.978	0.905	1.141
Retrospective calculations			
Recruitment (age 1, T+1) relative difference			
2000		1.06	0.85
2001		7.12	9.85
2002		0.58	0.62
2003		-0.40	-0.41
2004		-0.49	-0.50
2005		-0.19	-0.21
2006		-0.51	-0.52
Average (Mohn's rho)		1.02	1.38
Avg F (6-8) relative difference			
2000		1.11	0.98
2001		1.05	0.94
2002		1.03	0.93
2003		0.93	1.55
2004		0.32	0.76
2005		0.11	0.43
2006		0.01	0.37
Average (Mohn's rho)		0.65	0.85
SSB relative difference			
2000		-0.09	-0.05
2001		0.27	0.31
2002		0.31	0.35
2003		0.21	0.17
2004		-0.04	-0.21
2005		-0.06	-0.21
2006		-0.01	-0.13
Average (Mohn's rho)		0.08	0.03

Table R23. Virtual population analysis (VPA) uncertainty measures in terminal year + 1 (2008) numbers at age estimates for Gulf of Maine haddock.

Output variable	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8
NLLS Estimate	219	2924	1411	251	1793	142	196	29
Bootstrap mean	299	3312	1510	270	1904	155	200	34
Bootstrap std. error	279	1820	680	107	628	60	65	31
C.V. for NLLS soln.	0.93	0.55	0.45	0.40	0.33	0.39	0.32	0.93
Bias estimate	80	389	98	19	111	13	3	5
Bias std. error	9	59	22	3	20	2	2	1
Percent bias	36.7	13.3	7.0	7.6	6.2	9.1	1.6	16.4
NLLS estimate corrected for bias	139	2535	1313	232	1682	129	193	24
CV for corrected estimate	2.01	0.72	0.52	0.46	0.37	0.47	0.33	1.29
Lower 80% CI	74	1495	796	154	1165	90	121	1
Upper 80% CI	594	5670	2407	405	2711	232	290	77

Table R24. Virtual population analysis (VPA) uncertainty measures in terminal year (2007) biomass estimates for Gulf of Maine haddock.

Output variable	Jan-1 biomass	Mean biomass	Spawning stock biomass
NLLS Estimate	7350	7340	5850
Bootstrap mean	7817	7755	6089
Bootstrap std. error	1470	1355	1084
C.V. for NLLS soln.	0.19	0.17	0.18
Bias estimate	466	420	244
Bias std. error	49	45	35
Percent bias	6.3	5.7	4.2
NLLS estimate corrected for bias	6885	6915	5602
CV for corrected estimate	0.21	0.20	0.19
Lower 80% CI	5970	6080	4690
Upper 80% CI	9710	9460	7520

Table R25. Virtual population analysis (VPA) uncertainty measures in terminal year (2007) fishing mortality estimates for Gulf of Maine haddock.

Output variable	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Avg F_{6-8}	N-weighted F_{6-8}
NLLS Estimate	0.00	0.00	0.01	0.03	0.14	0.07	0.22	0.86	0.33	0.33	0.47	0.35
Bootstrap mean	0.00	0.00	0.01	0.03	0.14	0.07	0.24	1.47	0.34	0.34	0.68	0.39
Bootstrap std. error	0.00	0.00	0.00	0.01	0.05	0.03	0.08	1.22	0.09	0.09	0.41	0.12
C.V. for NLLS soln.	0.25	0.53	0.42	0.40	0.32	0.39	0.33	0.83	0.26	0.26	0.60	0.31
Bias estimate	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.61	0.01	0.01	0.21	0.04
Bias std. error	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.01	0.00
Percent bias	0.80	14.42	11.21	7.47	3.99	5.41	7.99	71.49	3.07	3.07	45.47	12.87
NLLS estimate corrected for bias	0.00	0.00	0.01	0.03	0.13	0.06	0.20	0.24	0.32	0.32	0.26	0.30
CV for corrected estimate	0.26	0.71	0.53	0.47	0.35	0.43	0.39	5.00	0.28	0.28	1.61	0.41
Lower 80% CI	0.00	0.00	0.00	0.02	0.09	0.04	0.16	0.42	0.24	0.24	0.31	0.26
Upper 80% CI	0.00	0.00	0.01	0.05	0.20	0.10	0.34	3.66	0.45	0.45	1.40	0.55

Table R26. Gulf of Maine haddock fishing mortality (F) at age estimated from the virtual population analysis (VPA), 1977 to 2007.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Avg F_{6-8}	N-weighted F_{6-8}
1977	0.00	0.10	0.15	0.03	0.20	0.51	0.42	5.00	0.42	0.42	1.94	0.42
1978	0.00	0.00	0.10	0.25	0.14	0.27	0.87	0.15	0.47	0.47	0.50	0.54
1979	0.01	0.01	0.06	0.21	0.28	0.23	0.13	0.45	0.16	0.16	0.25	0.16
1980	0.02	0.02	0.18	0.11	0.42	0.44	0.30	0.25	0.28	0.28	0.28	0.28
1981	0.01	0.05	0.34	0.20	0.40	0.36	0.32	0.20	0.30	0.30	0.27	0.30
1982	0.10	0.15	0.18	0.56	0.25	0.20	0.41	0.45	0.44	0.44	0.43	0.44
1983	0.00	0.05	0.05	0.38	0.74	0.50	0.47	0.69	0.59	0.59	0.58	0.59
1984	0.00	0.02	0.09	0.12	0.49	0.39	0.41	0.34	0.40	0.40	0.38	0.40
1985	0.00	0.02	0.04	0.39	0.34	0.69	0.45	0.56	0.51	0.51	0.51	0.52
1986	0.06	0.09	0.00	0.41	1.05	0.72	0.61	0.67	0.63	0.63	0.64	0.63
1987	0.02	0.07	0.02	0.22	0.47	0.49	1.11	0.79	0.89	0.89	0.93	0.89
1988	0.00	0.03	0.00	0.09	0.19	0.55	0.91	1.10	0.94	0.94	0.98	0.94
1989	0.00	0.01	0.06	0.06	0.57	0.57	0.45	1.48	0.64	0.64	0.86	0.72
1990	0.01	0.01	0.01	0.50	0.03	0.58	2.57	2.02	2.19	2.19	2.26	2.22
1991	0.01	0.02	0.11	0.19	0.44	0.45	1.40	5.00	1.44	1.44	2.62	1.56
1992	0.00	0.03	0.07	0.64	0.21	0.30	0.10	0.60	0.17	0.17	0.30	0.19
1993	0.01	0.01	0.06	0.15	0.46	0.15	0.13	0.42	0.19	0.19	0.25	0.20
1994	0.02	0.04	0.02	0.15	0.10	0.08	0.12	0.19	0.14	0.14	0.15	0.14
1995	0.00	0.02	0.04	0.12	0.37	0.12	0.22	0.10	0.14	0.14	0.15	0.14
1996	0.02	0.01	0.02	0.10	0.11	0.11	0.06	0.35	0.12	0.12	0.18	0.13
1997	0.00	0.00	0.01	0.11	0.24	0.18	0.18	0.11	0.15	0.15	0.15	0.15
1998	0.01	0.01	0.02	0.03	0.10	0.31	0.18	0.25	0.19	0.19	0.21	0.19
1999	0.00	0.00	0.00	0.04	0.11	0.10	0.16	0.16	0.16	0.16	0.16	0.16
2000	0.00	0.00	0.01	0.04	0.11	0.16	0.22	0.23	0.22	0.22	0.22	0.22
2001	0.00	0.00	0.01	0.03	0.13	0.13	0.29	0.17	0.22	0.22	0.23	0.22
2002	0.00	0.00	0.00	0.01	0.04	0.15	0.23	0.19	0.22	0.22	0.21	0.22
2003	0.00	0.00	0.01	0.01	0.03	0.10	0.17	0.20	0.18	0.18	0.19	0.18
2004	0.00	0.00	0.00	0.01	0.10	0.09	0.17	0.20	0.18	0.18	0.18	0.18
2005	0.00	0.00	0.00	0.02	0.10	0.36	0.23	0.27	0.26	0.26	0.26	0.26
2006	0.00	0.00	0.00	0.02	0.02	0.13	0.56	0.18	0.27	0.27	0.34	0.27
2007	0.00	0.00	0.01	0.03	0.14	0.07	0.22	0.86	0.33	0.33	0.47	0.35

Table R27. Gulf of Maine haddock January 1 numbers (000's) at age estimated from the virtual population analysis (VPA), 1977 to 2008.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9^{+}	Total
1977	2,349	6,599	13,777	1,888	2,204	588	463	1	5	20	27,894
1978	8,591	1,916	4,908	9,666	1,500	1,476	289	250	0	16	28,611
1979	8,488	7,024	1,565	3,627	6,151	1,065	920	99	176	0	29,116
1980	4,915	6,908	5,688	1,203	2,417	3,823	691	658	52	114	26,469
1981	744	3,955	5,545	3,878	886	1,301	2,022	417	418	54	19,221
1982	2,119	606	3,090	3,223	2,594	484	742	1,203	279	186	14,524
1983	1,002	1,573	426	2,117	1,514	1,661	323	405	625	217	9,863
1984	186	818	1,219	333	1,183	593	826	166	166	340	5,831
1985	348	152	660	911	242	592	328	449	96	104	3,882
1986	179	285	122	517	507	141	243	170	210	28	2,403
1987	771	138	214	100	280	145	57	108	72	34	1,919
1988	579	618	106	172	65	143	73	15	40	9	1,821
1989	449	474	490	86	129	44	68	24	4	2	1,771
1990	457	368	385	379	67	60	20	35	4	0	1,776
1991	845	370	297	314	189	53	28	1	4	3	2,103
1992	1,845	683	296	217	213	99	28	6	0	8	3,394
1993	3,235	1,506	541	225	94	142	60	20	3	4	5,830
1994	3,739	2,634	1,222	416	159	49	100	43	11	8	8,382
1995	1,586	3,007	2,076	979	294	118	37	73	30	27	8,225
1996	2,618	1,298	2,417	1,629	712	166	86	24	54	8	9,011
1997	2,796	2,101	1,054	1,947	1,206	525	121	66	14	14	9,843
1998	15,057	2,289	1,717	855	1,434	775	357	83	48	48	22,665
1999	2,999	12,230	1,862	1,382	679	1,061	466	245	53	46	21,022
2000	951	2,454	10,006	1,524	1,092	499	784	324	172	85	17,891
2001	1,278	778	2,004	8,146	1,204	798	349	517	210	134	15,418
2002	524	1,045	635	1,620	6,476	869	574	215	356	385	12,699
2003	5,764	429	854	519	1,310	5,106	614	373	146	478	15,594
2004	579	4,719	351	695	422	1,038	3,792	423	249	374	12,642
2005	2,606	474	3,856	287	562	314	778	2,613	285	393	12,167
2006	4,369	2,134	387	3,142	231	416	179	504	1,628	285	13,275
2007	267	3,573	1,738	316	2,509	185	300	83	343	1,461	10,776
2008	1,445	219	2,924	1,411	251	1,793	142	196	29	1,062	9,472

Table R28. Gulf of Maine haddock spawning stock biomass (mt) at age estimated from the virtual population analysis (VPA), 1977 to 2007.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9^{+}	Total (mt)
1977	0	12	1,905	1,290	3,587	1,218	1,171	1	23	99	9,306
1978	0	3	379	6,497	1,922	2,897	614	847	0	69	13,228
1979	0	15	116	2,423	7,925	1,909	2,097	243	593	0	15,321
1980	0	10	584	876	3,069	6,755	1,657	1,719	154	441	15,265
1981	0	5	406	2,943	1,171	2,457	4,971	1,341	1,389	181	14,864
1982	0	2	197	1,736	4,061	982	1,784	3,534	961	647	13,904
1983	0	3	45	1,260	1,543	3,146	753	1,049	1,892	752	10,443
1984	0	2	85	202	1,429	1,021	1,942	494	551	1,198	6,924
1985	0	1	75	529	316	976	688	1,246	324	367	4,522
1986	0	1	17	370	452	235	482	390	614	101	2,662
1987	0	0	33	80	362	230	100	245	195	134	1,379
1988	0	1	9	145	81	272	132	34	123	34	831
1989	0	1	36	89	149	71	142	44	14	7	553
1990	0	1	43	327	146	97	28	58	8	0	708
1991	0	1	39	245	305	142	49	1	10	7	799
1992	0	1	36	206	318	226	75	13	0	20	895
1993	0	3	55	198	140	285	165	59	8	16	929
1994	0	3	119	359	252	107	253	139	37	31	1,300
1995	0	4	115	717	445	264	108	246	120	138	2,157
1996	0	2	116	1,055	932	316	228	62	153	23	2,887
1997	0	6	122	1,427	1,371	961	283	191	38	48	4,447
1998	0	8	159	747	2,377	1,317	838	235	139	132	5,952
1999	0	22	171	1,153	977	1,751	881	582	156	141	5,834
2000	0	7	775	906	1,407	809	1,331	624	383	259	6,501
2001	0	2	198	5,330	1,348	1,223	628	1,020	458	310	10,517
2002	0	2	43	1,135	8,009	1,262	1,028	477	757	954	13,667
2003	0	1	64	231	1,410	6,857	984	741	344	1,115	11,747
2004	0	12	24	341	438	1,313	5,603	755	494	763	9,743
2005	0	1	274	157	500	396	1,029	4,077	521	834	7,789
2006	0	6	25	1,502	171	490	242	717	2,585	537	6,275
2007	0	9	97	142	2,090	160	404	108	498	2,338	5,846

Table R29. Input values for Gulf of Maine haddock biological reference point calculations based on 2002 to 2006 average values from the VPA base run.

Age	Fishery selectivity	Natural mortality	Stock weights (kg)	Catch weights (kg)	Spawning stock weights (kg)	Proportion mature (%)
1	0.007	1.0	0.086	0.151	0.086	0.032
2	0.016	1.0	0.271	0.531	0.271	0.259
3	0.063	1.0	0.645	0.863	0.645	0.787
4	0.258	1.0	1.002	1.117	1.002	0.975
5	0.536	1.0	1.292	1.424	1.292	0.998
6	1.000	1.0	1.598	1.688	1.598	1.000
7	1.000	1.0	1.836	1.863	1.836	1.000
8	1.000	1.0	2.053	2.037	2.053	1.000
9	1.000	1.0	2.228	2.228	2.228	1.000

Table R30. Output from yield and biomass per recruit analyses of Gulf of Maine haddock.

Reference point	F	Yield per recruit	SSB per recruit	Total biomass per recruit	Mean age	Mean generation time	Expected spawnings
F_0	0.00	0.00	5.37	6.00	5.52	9.07	2.35
$F_{0.1}$	0.32	0.46	2.47	3.08	3.40	5.77	1.65
F_{max}	1.66	0.56	1.11	1.69	2.54	4.18	0.92
$F_{40\%\ MSP}$	**0.43**	**0.50**	**2.15**	**2.75**	**3.19**	**5.39**	**1.51**

Table R31. Gulf of Maine haddock spawning stock biomass (SSB) and catch projections for 2009 under assumptions of $F_{40\%}$ and N-weighted $F_{6\text{-}8,2007}$. Catch in 2008 is assumed to be equal to 2007 catch (1,368 mt).

Scenario	F	SSB (mt)	$\%SSB_{MSY}$	Catch (mt)	% MSY
$F_{40\%}$	0.43	6,000	1.02	1,450	1.07
$F_{2007\ N\text{-}weighted}$	0.35	6,090	1.03	1,200	0.88

11.0 Figures

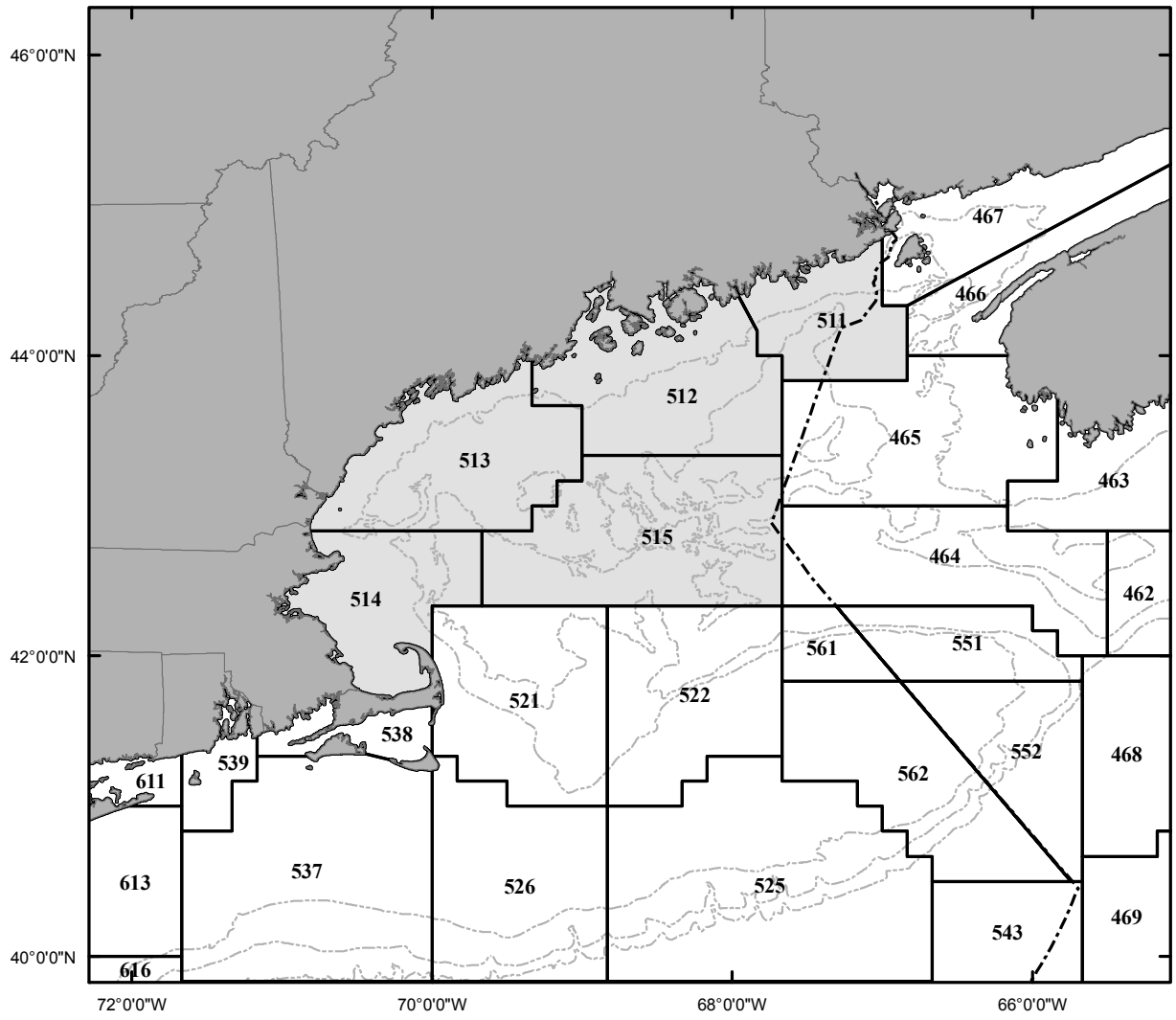

Figure R1. Statistical areas included in the Gulf of Maine haddock management unit (light grey). Northeast Atlantic Fisheries Organization (NAFO) division 5Y is composed of United States statistical areas 511 – 515. Bathymetric contours corresponding to the 50, 100, and 500 fa contour lines are shown in light grey. Dashed line represents the United Sates Exclusive Economic Zone.

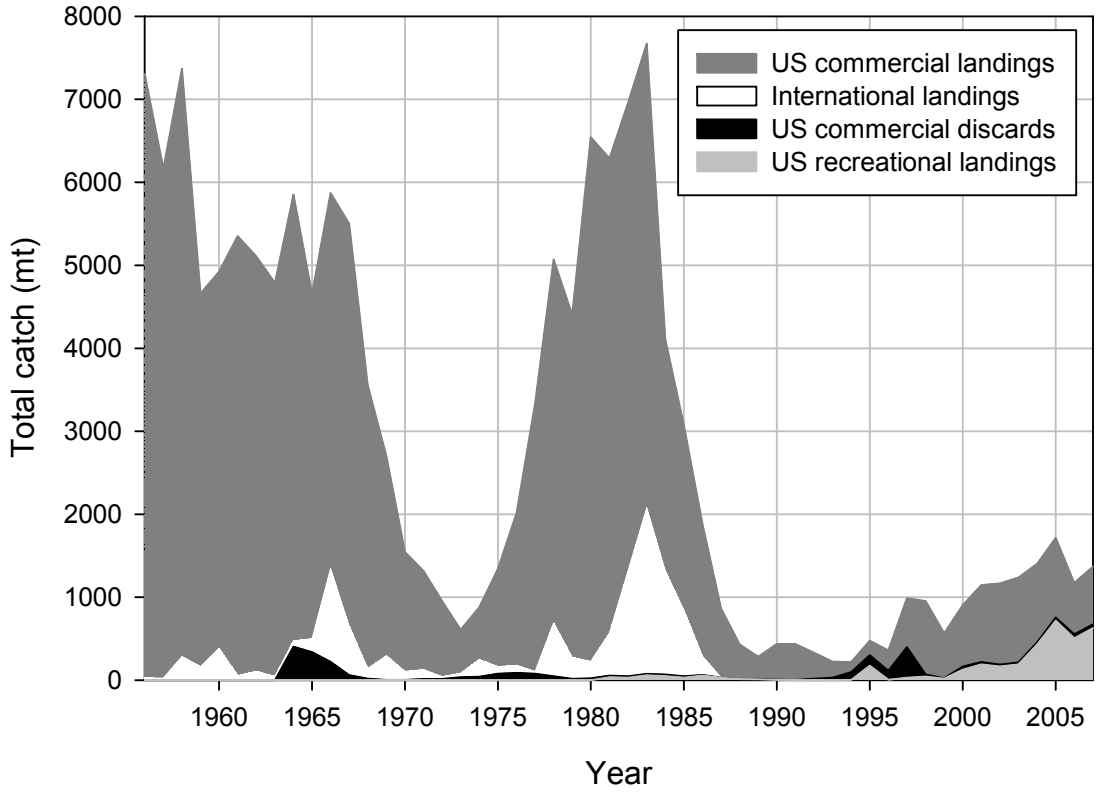

Figure R2. Total catch (mt) of Gulf of Maine haddock, 1956 – 2007.

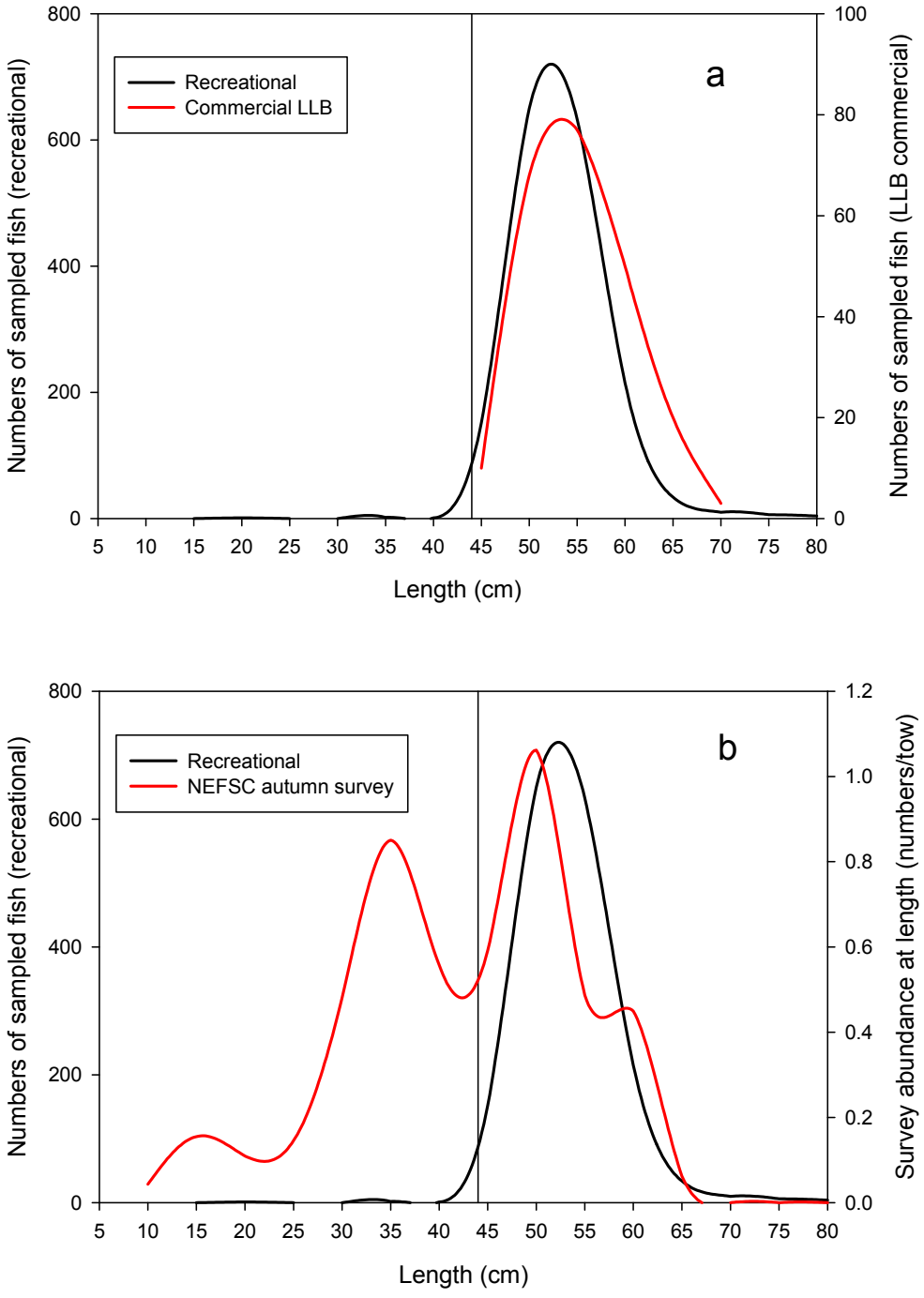

Figure R3. Selectivity of the recreational fishery relative to the commercial longline fishery (a) and Northeast Fisheries Science Center bottom trawl survey (b). Solid vertical lines indicate minimum legal size for recreational fishery. Data shown are from 2005.

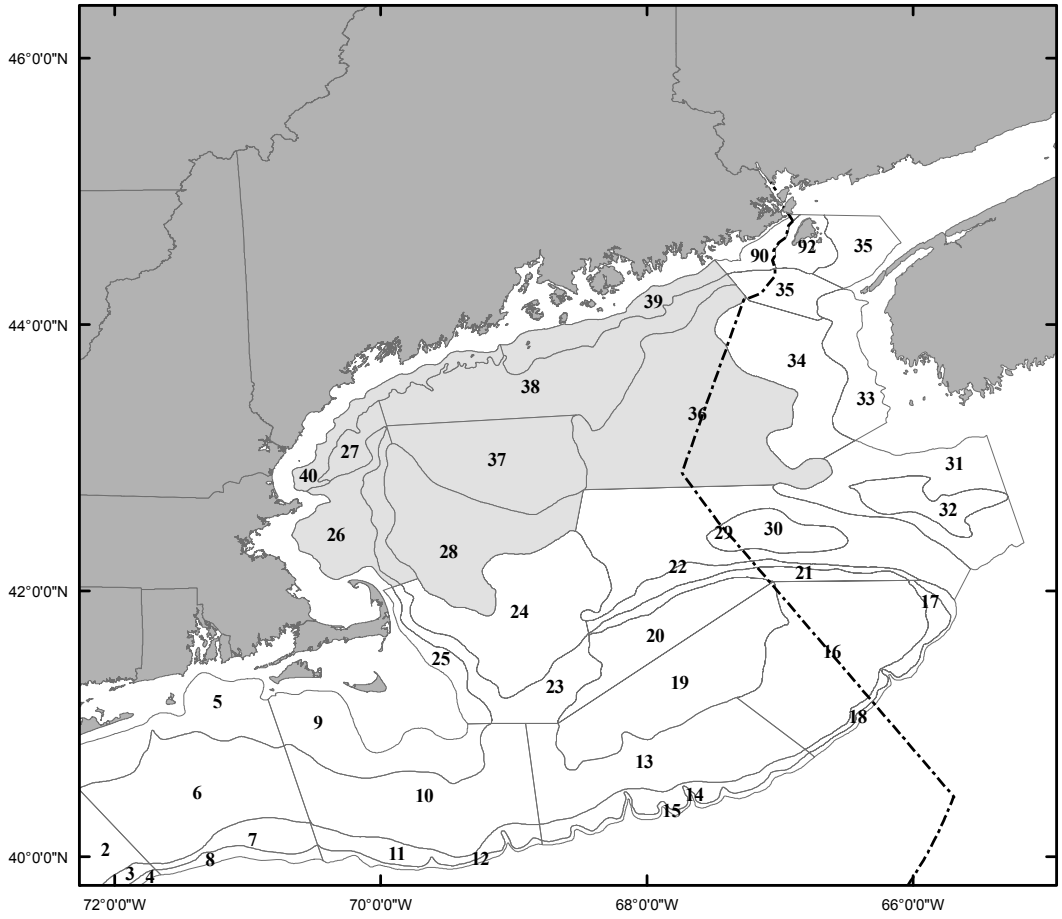

Figure R4. Northeast Fisheries Science Center (NEFSC) bottom trawl survey strata used to calculate the Gulf of Maine survey indices. Dashed line represents the United Sates Exclusive Economic Zone.

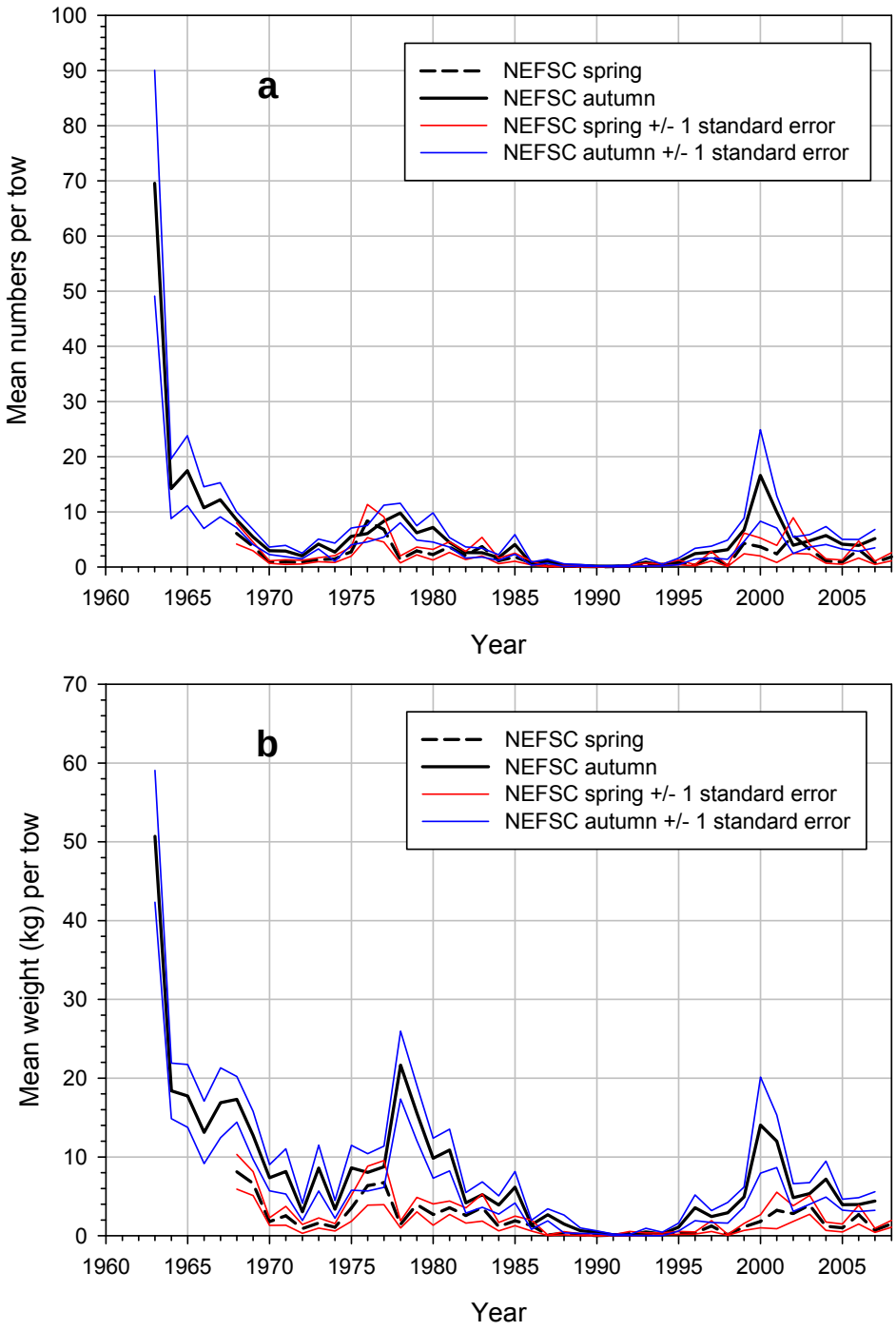

Figure R5. Northeast Fisheries Science Center (NEFSC) bottom trawl survey abundance (stratified mean numbers per tow) (a), and biomass (stratified mean weight (kg) per tow) (b) for Gulf of Maine haddock, 1963 – 2008 (autumn 2008 survey has not been conducted). Indices have been corrected to account for changes in catchability due to changes in research vessels and doors.

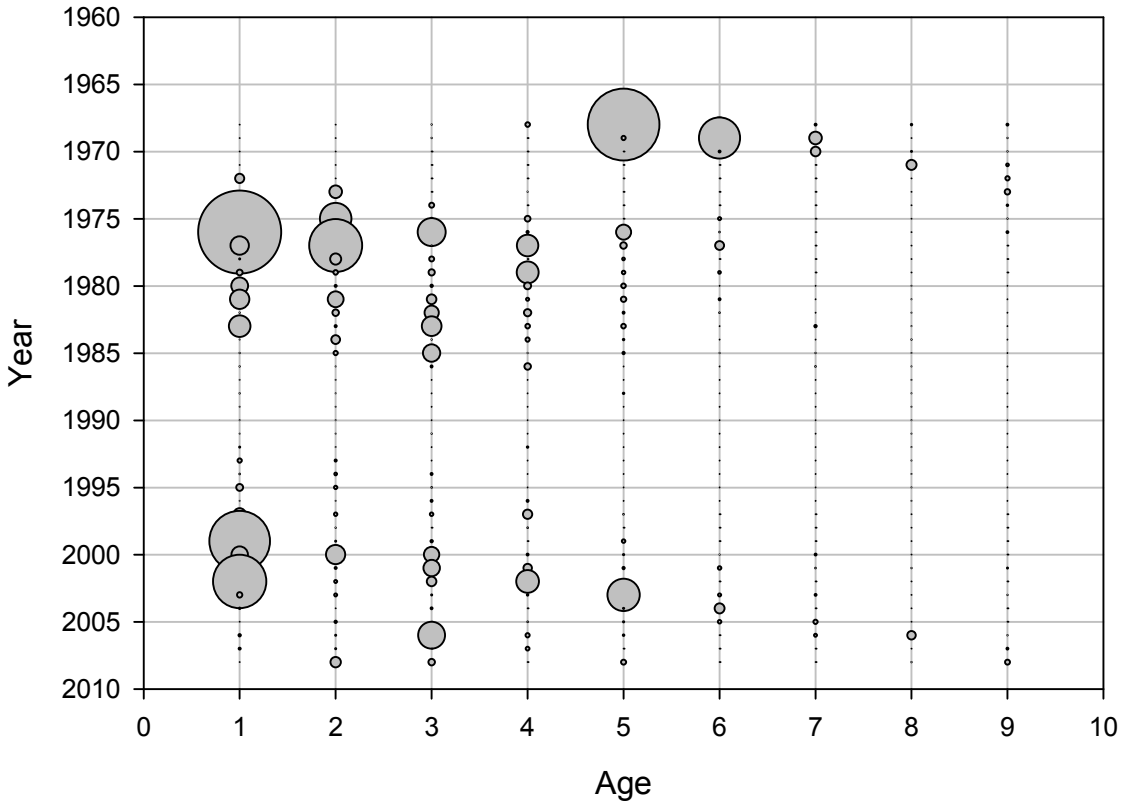

Figure R6. Age structure of the Gulf of Maine haddock population as indicated by the NEFSC spring bottom trawl survey indices of abundance, 1968 – 2008.

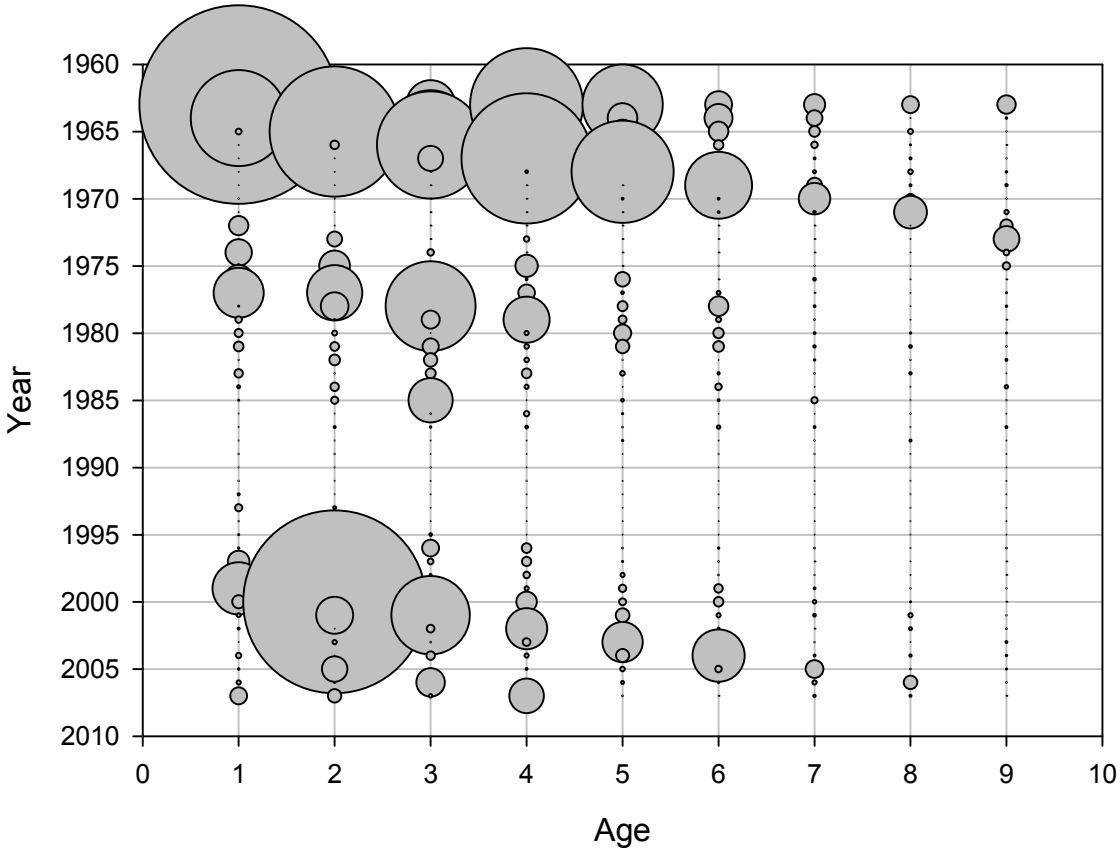

Figure R7. Age structure of the Gulf of Maine haddock population as indicated by the NEFSC autumn bottom trawl survey indices of abundance, 1963 – 2007.

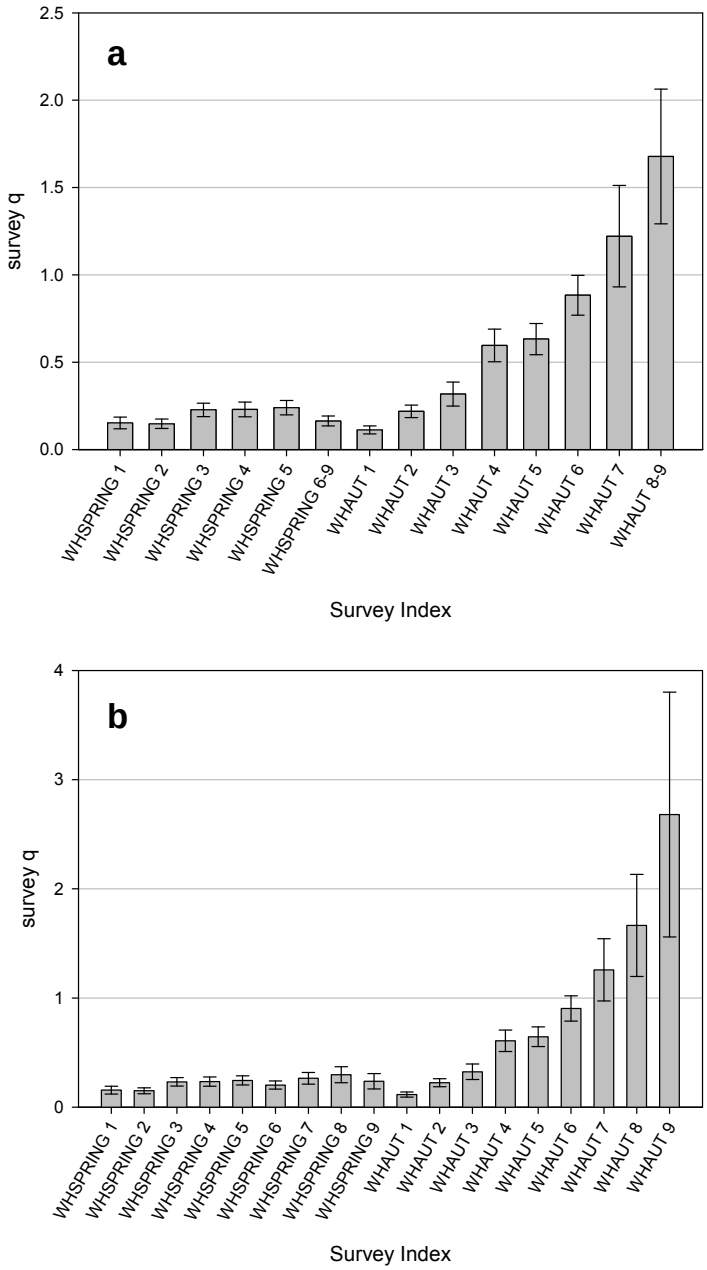

Figure R8. Comparison of swept area (absolute N) survey index catchability coefficients (q) fo the BASE (a) and ALT1 (b) virtual population analysis (VPA) run configurations; error bars are +/- 1 standard error.

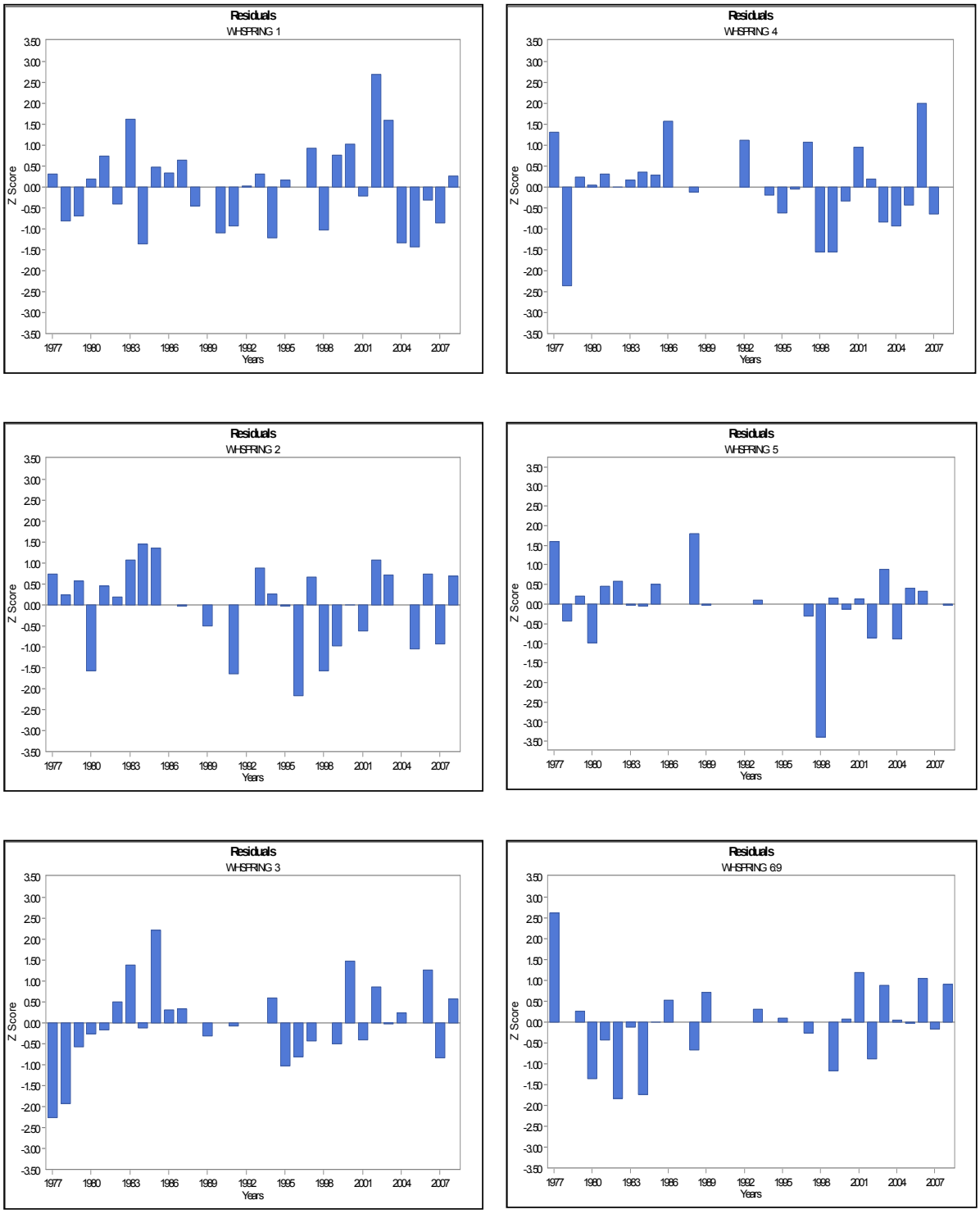

Figure R9. Standardized residuals for the age 1 through 6:9^{+} spring survey indices used to tune the BASE virtual population analysis run for Gulf of Maine haddock.

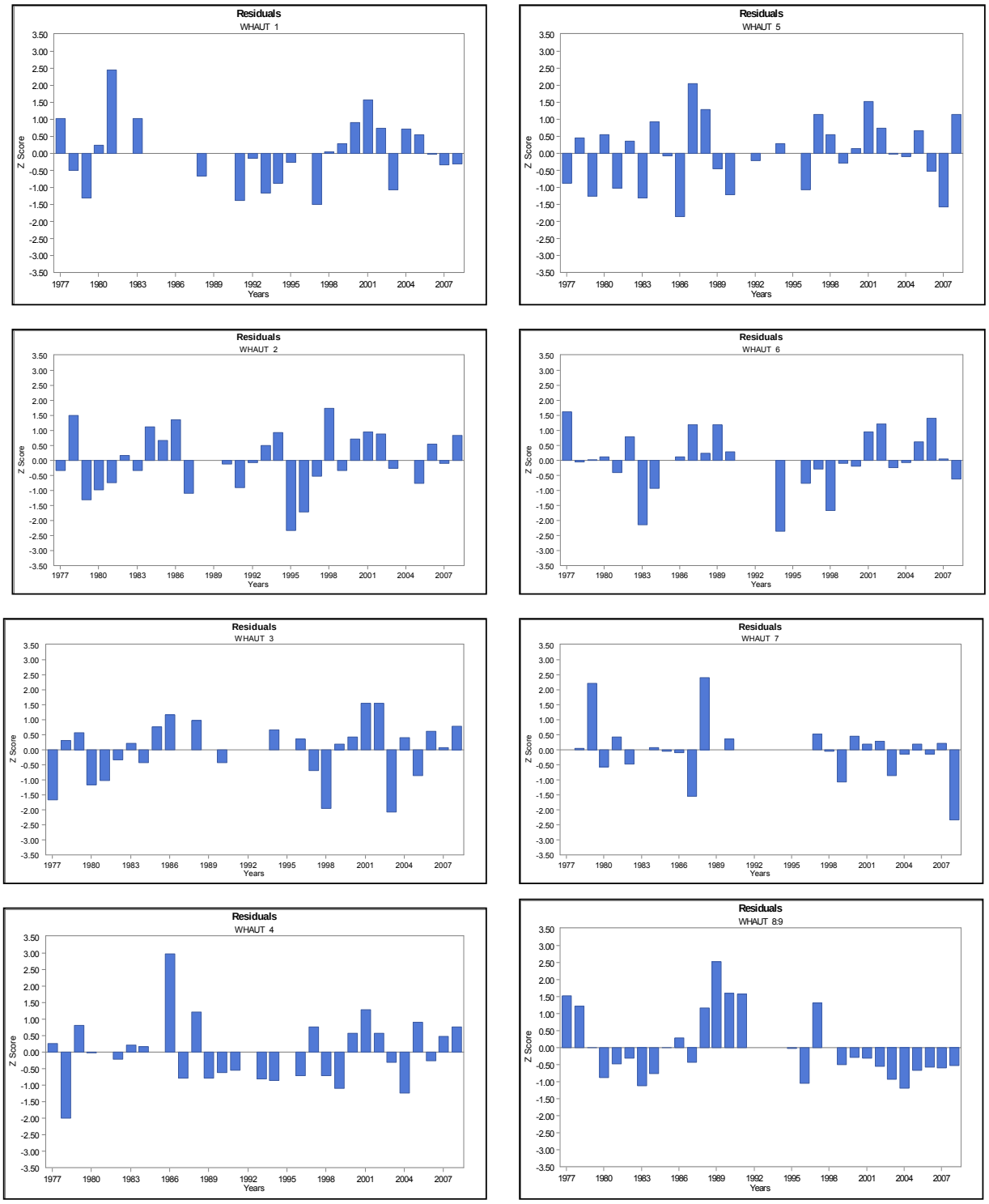

Figure R10. Standardized residuals for the age 1 through 8:9^{+} autumn survey indices used to tune the BASE virtual population analysis run for Gulf of Maine haddock.

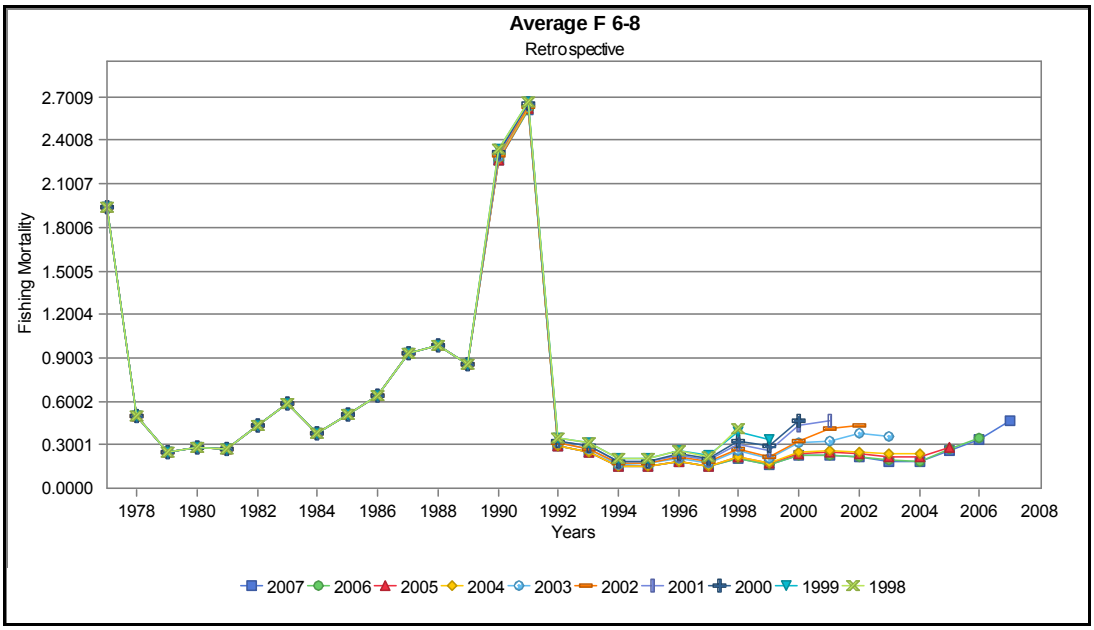

Figure R11. Retrospective plot of the virtual population analysis (VPA) estimates of fully recruited F for Gulf of Maine haddock ($F_{6\text{-}8}$).

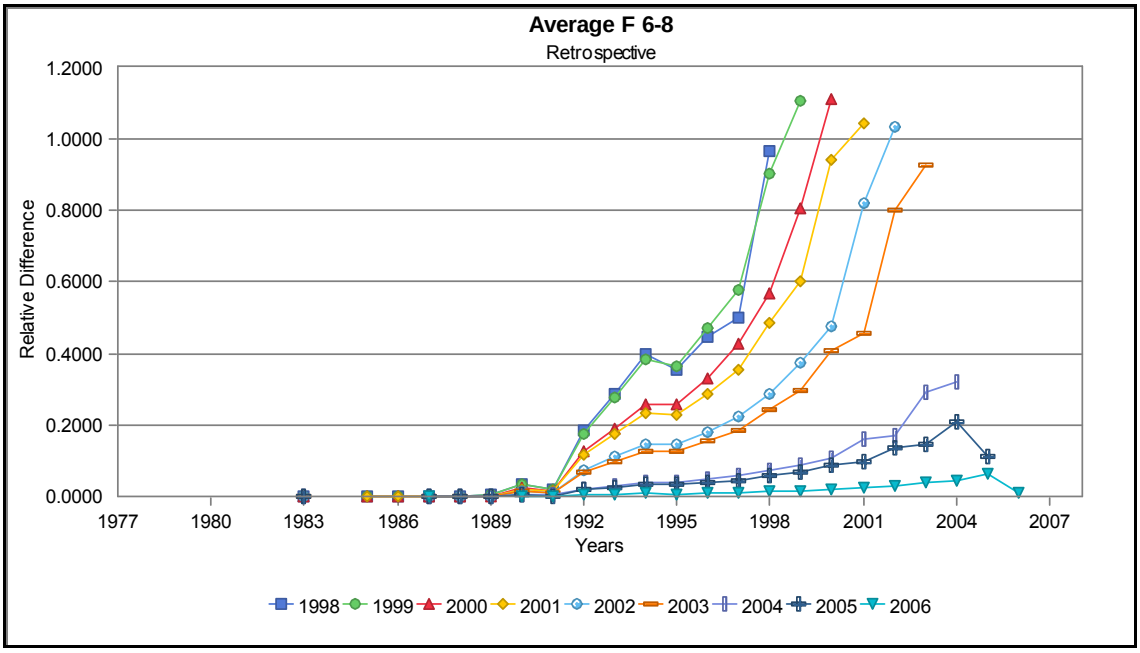

Figure R12. Relative difference of annual virtual population analysis (VPA) "peels" compared to the 2007 base run estimates of fully recruited F for Gulf of Maine haddock ($F_{6\text{-}8}$).

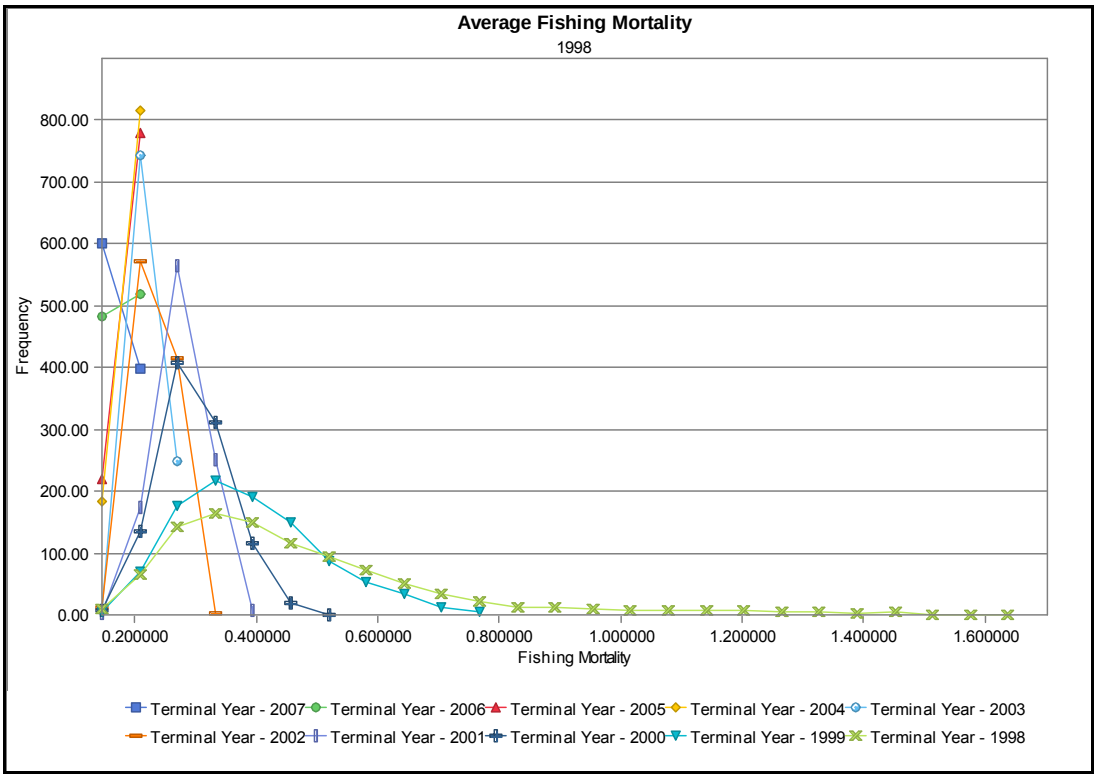

Figure R13. Distributions of terminal year fishing mortality estimates resulting from 1000 bootstrap iterations.

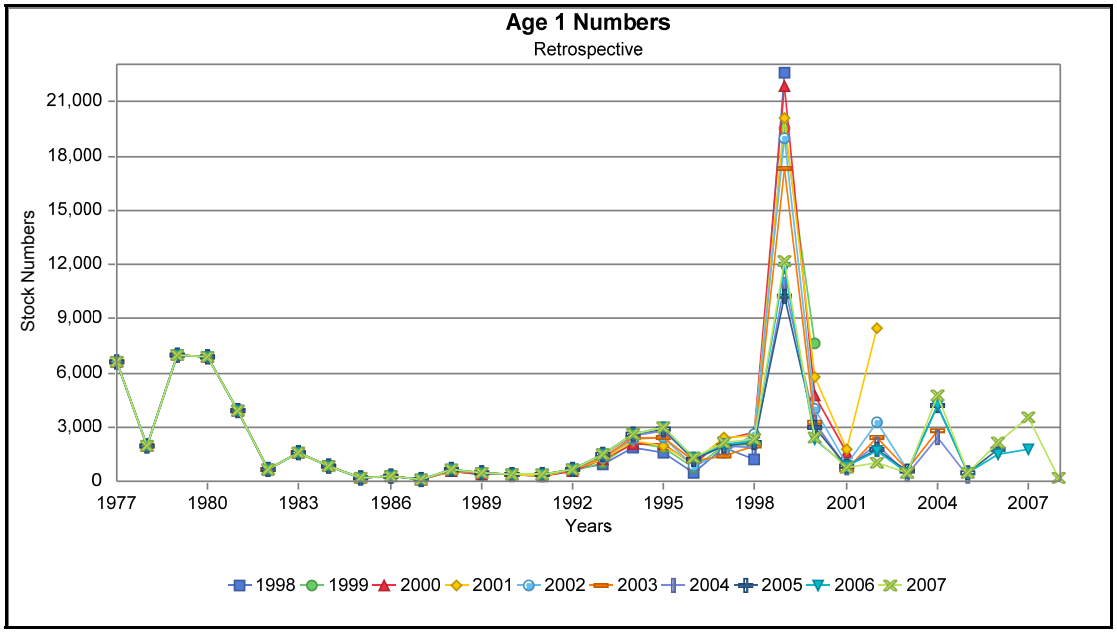

Figure R14. Retrospective plot of the virtual population analysis (VPA) estimates of age 1 recruitment for Gulf of Maine haddock.

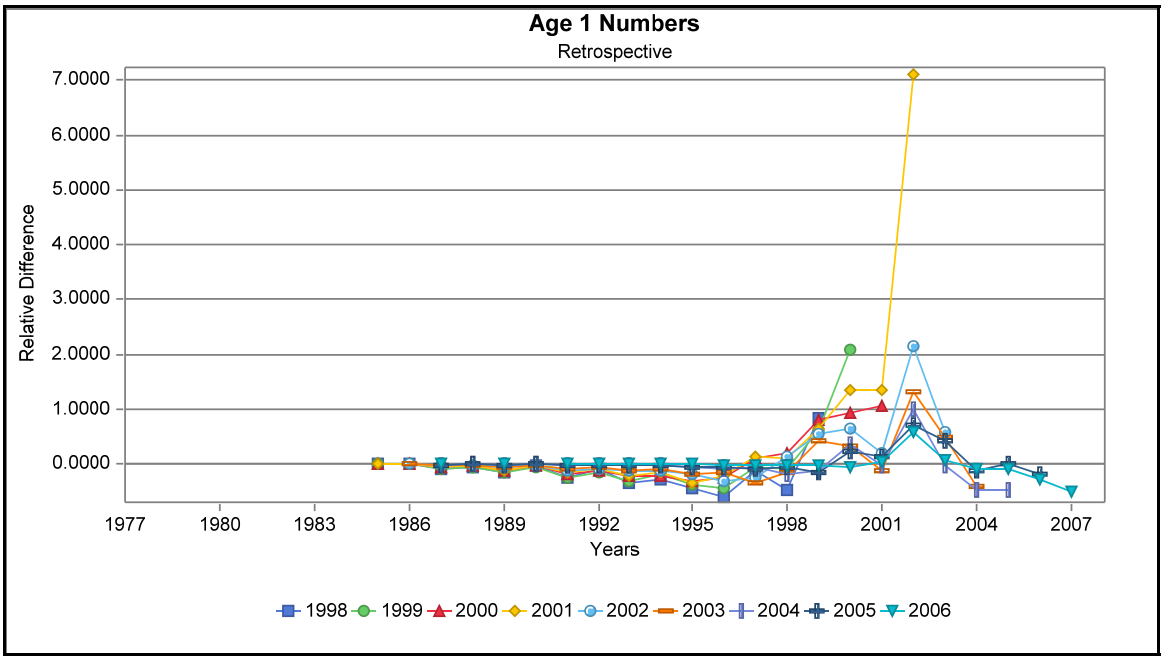

Figure R15. Relative difference of annual virtual population analysis (VPA) "peels" compared to the 2007 base run estimates of age 1 recruitment for Gulf of Maine haddock.

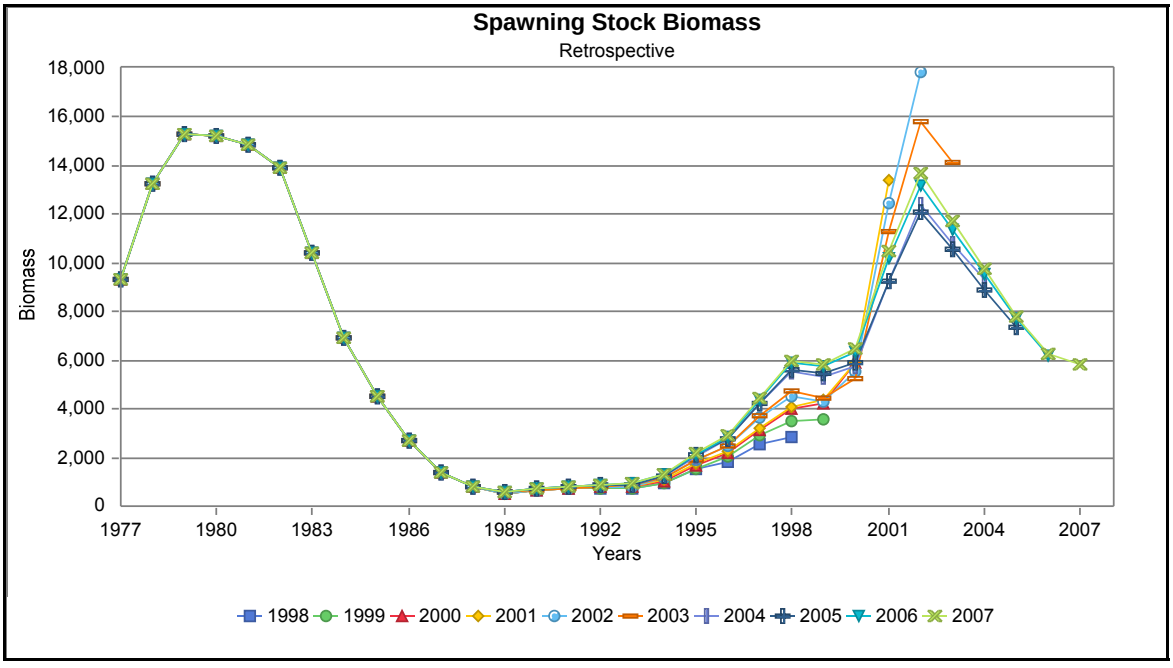

Figure R16. Retrospective plot of the virtual population analysis (VPA) estimates of spawning stock biomass for Gulf of Maine haddock.

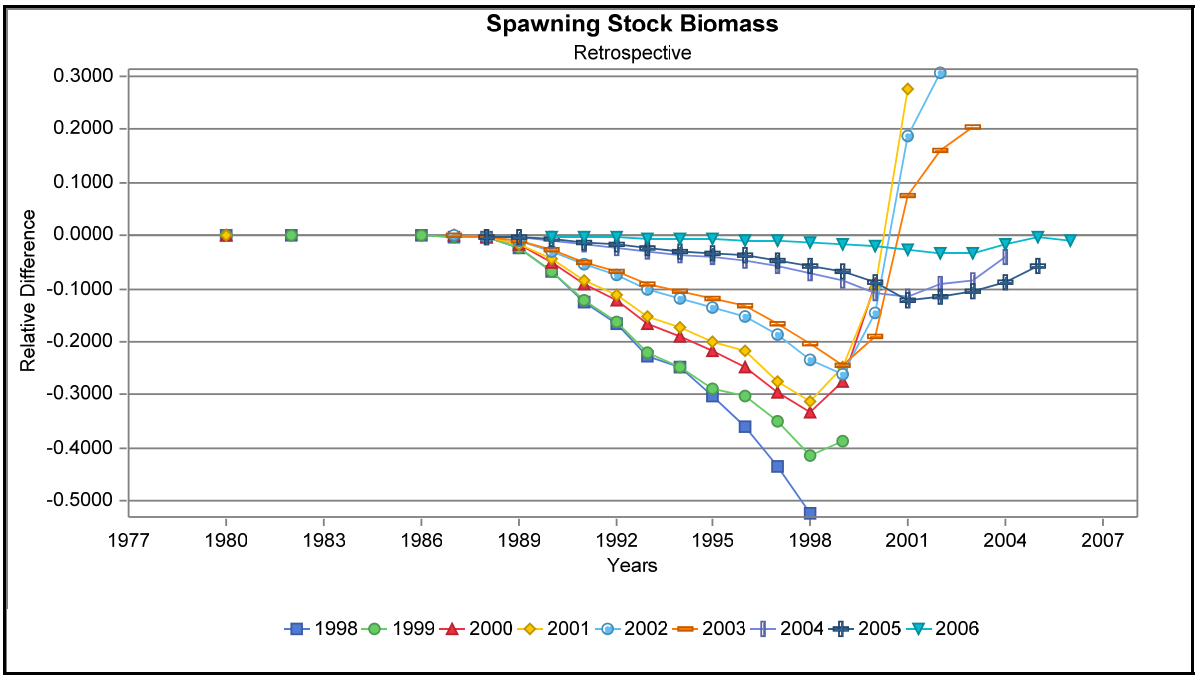

Figure R17. Relative difference of annual virtual population analysis (VPA) "peels" compared to the 2007 base run estimates of spawning stock biomass for Gulf of Maine haddock.

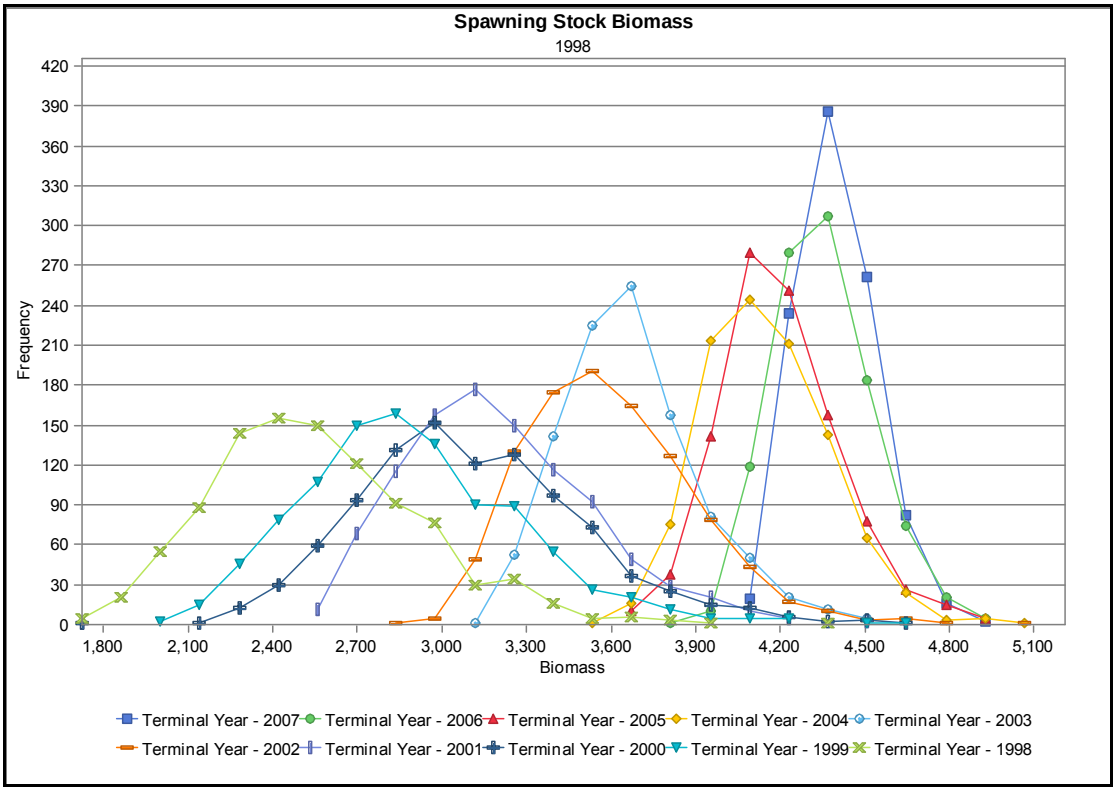

Figure R18. Distributions of terminal year spawning stock biomass estimates resulting from 1000 bootstrap iterations.

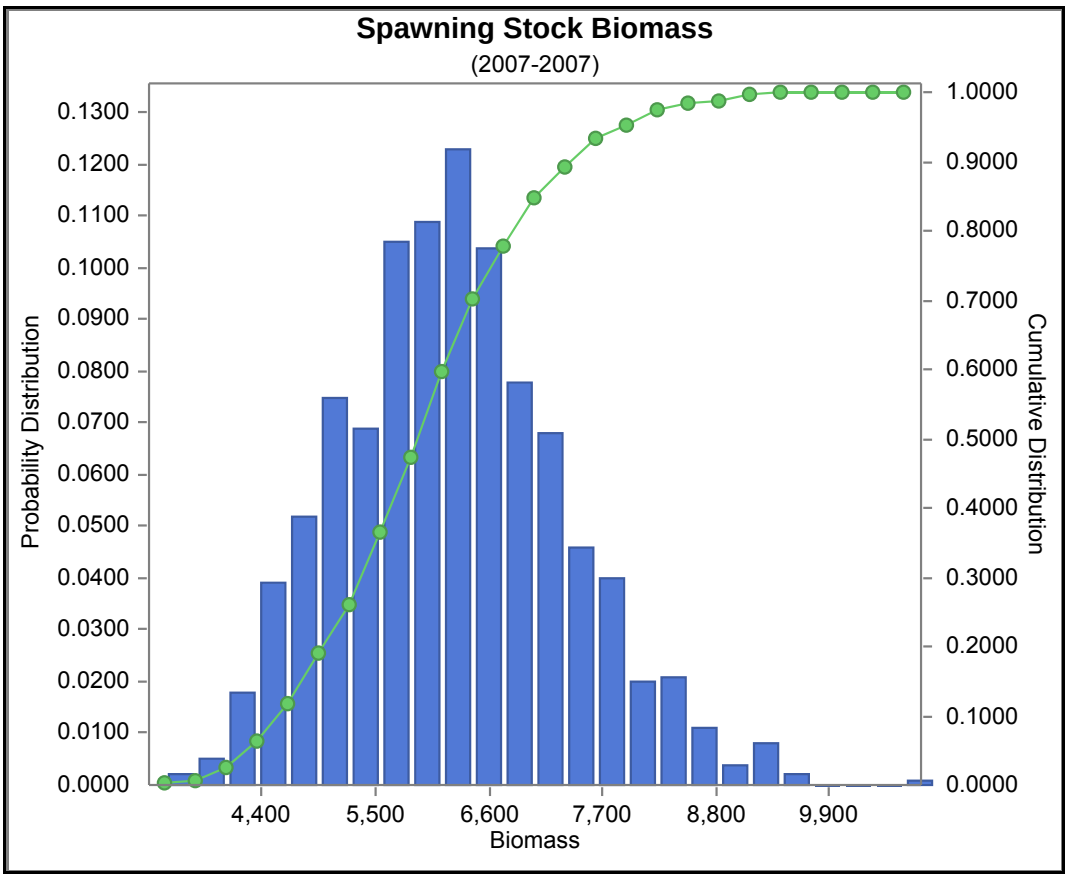

Figure R19. Bootstrap distribution of 2007 fishing mortality; unweighted avg. $F_{6\text{-}8}$ (a), and N-weighted avg. $F_{6\text{-}8}$ (b). The vertical bars provide the probability distribution of values of SSB from 1000 bootstrap realizations of the virtual population analysis (VPA). The solid line tracks the cumulative distribution.

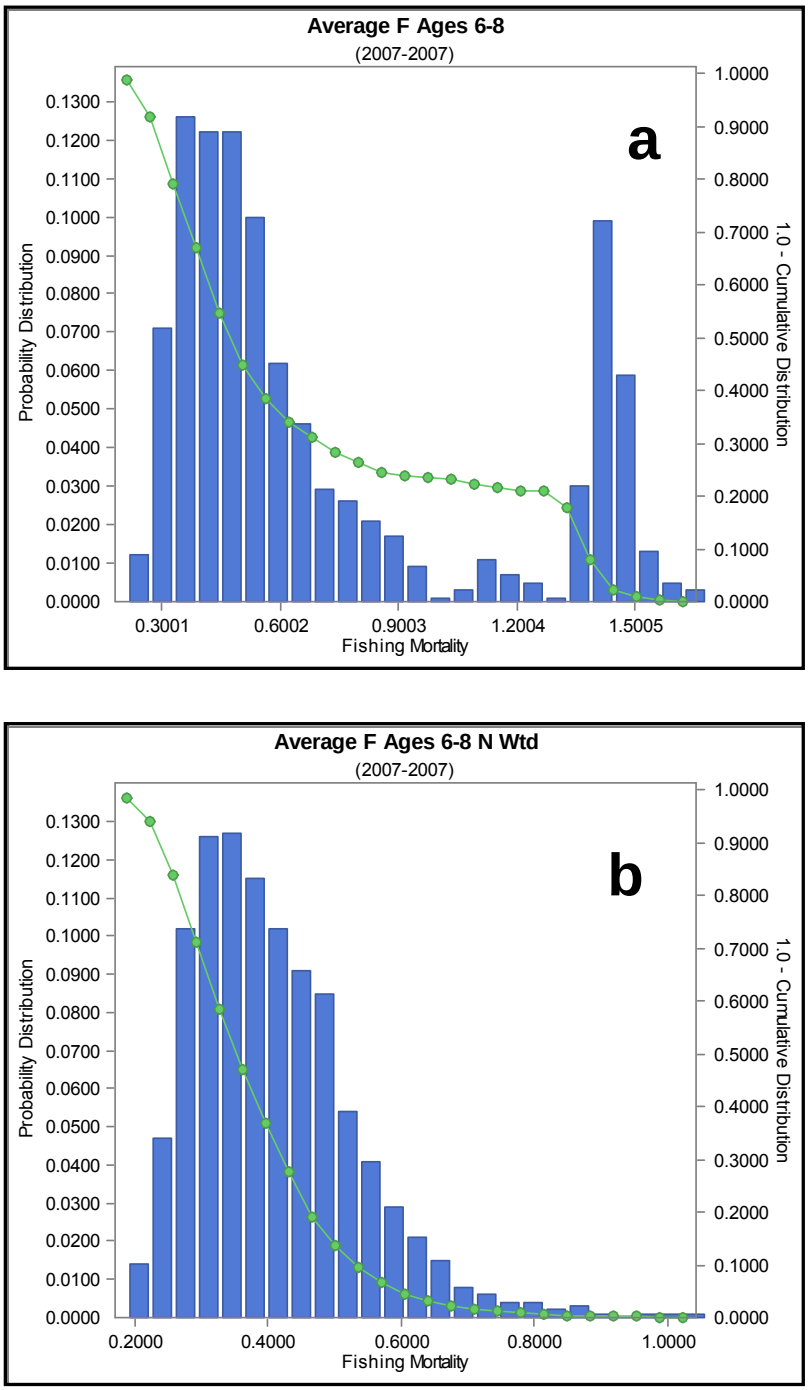

Figure R20. Bootstrap distribution of 2007 fishing mortality; unweighted avg. $F_{6\text{-}8}$ (a), and N-weighted avg. $F_{6\text{-}8}$ (b). The vertical bars provide the probability distribution of values of $F_{6\text{-}8}$ from 1000 bootstrap realizations of the virtual population analysis (VPA). The solid line tracks the cumulative distribution.

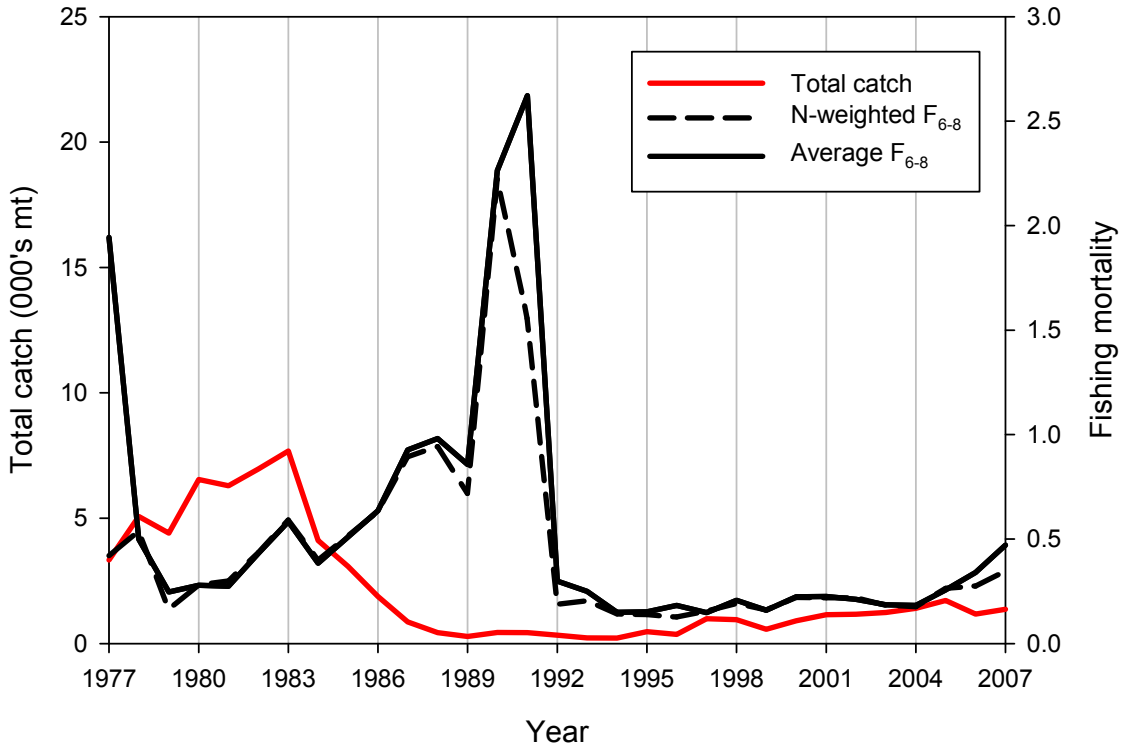

Figure R21. Trends in total catch (commercial landings, discards and recreational landings, 000's mt), fully recruited average F_{6-8} and N-weighted F_{6-8}, 1977 to 2007.

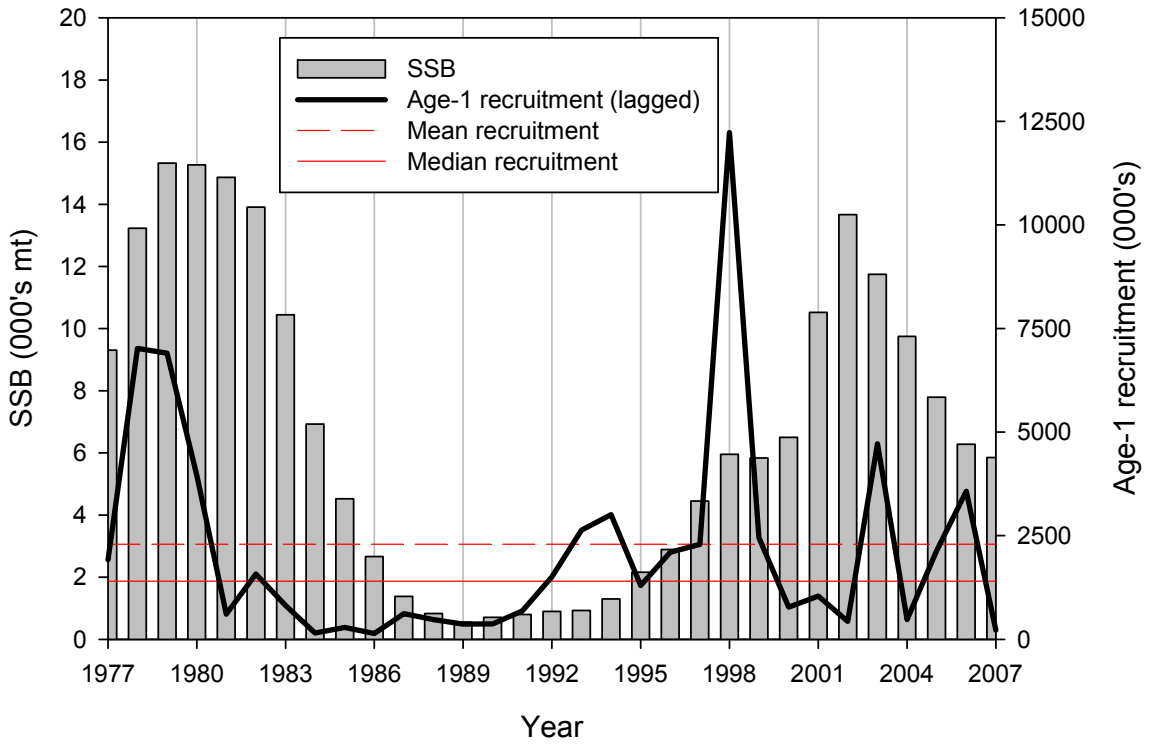

Figure R22. Trends in spawning stock biomass (000's mt) and age-1 recruitment (000's) for Gulf of Maine haddock, 1977 to 2007. The mean (2.3 million fish) and median (1.4 million) age 1 recruitment are indicated by the dashed and solid red lines, respectively.

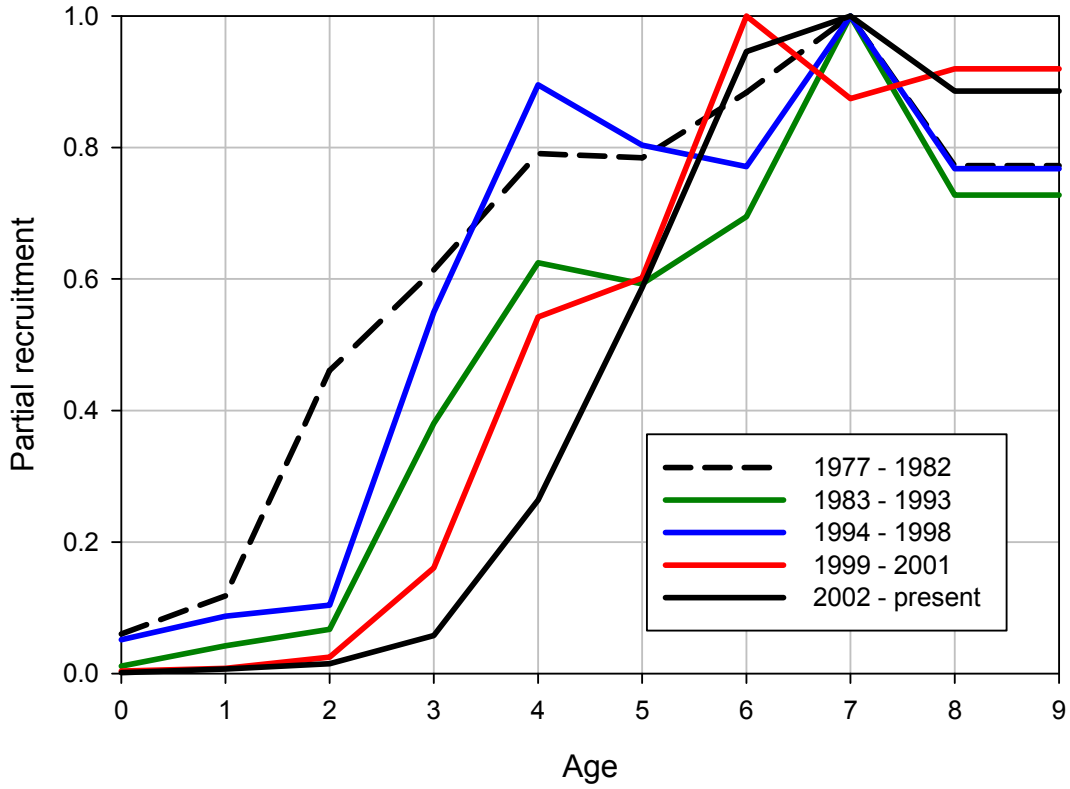

Figure R23. Partial recruitment patterns by age for Gulf of Maine haddock as estimated from the BASE run of the virtual population analysis (VPA) model. Years have been grouped based on changes to minimum mesh size (codend mesh size unless otherwise specified): 1977 – 1982 – 5.125”; 1983 – 1993 – 5.5”; 1994 – 1998 – 6.0”; 1999 – 2001 –6.5” for square nets, 6.0” for diamond nets; 2002 – present – 6.5” for all nets including gillnet (body mesh size can be 6.0” for diamond mesh).

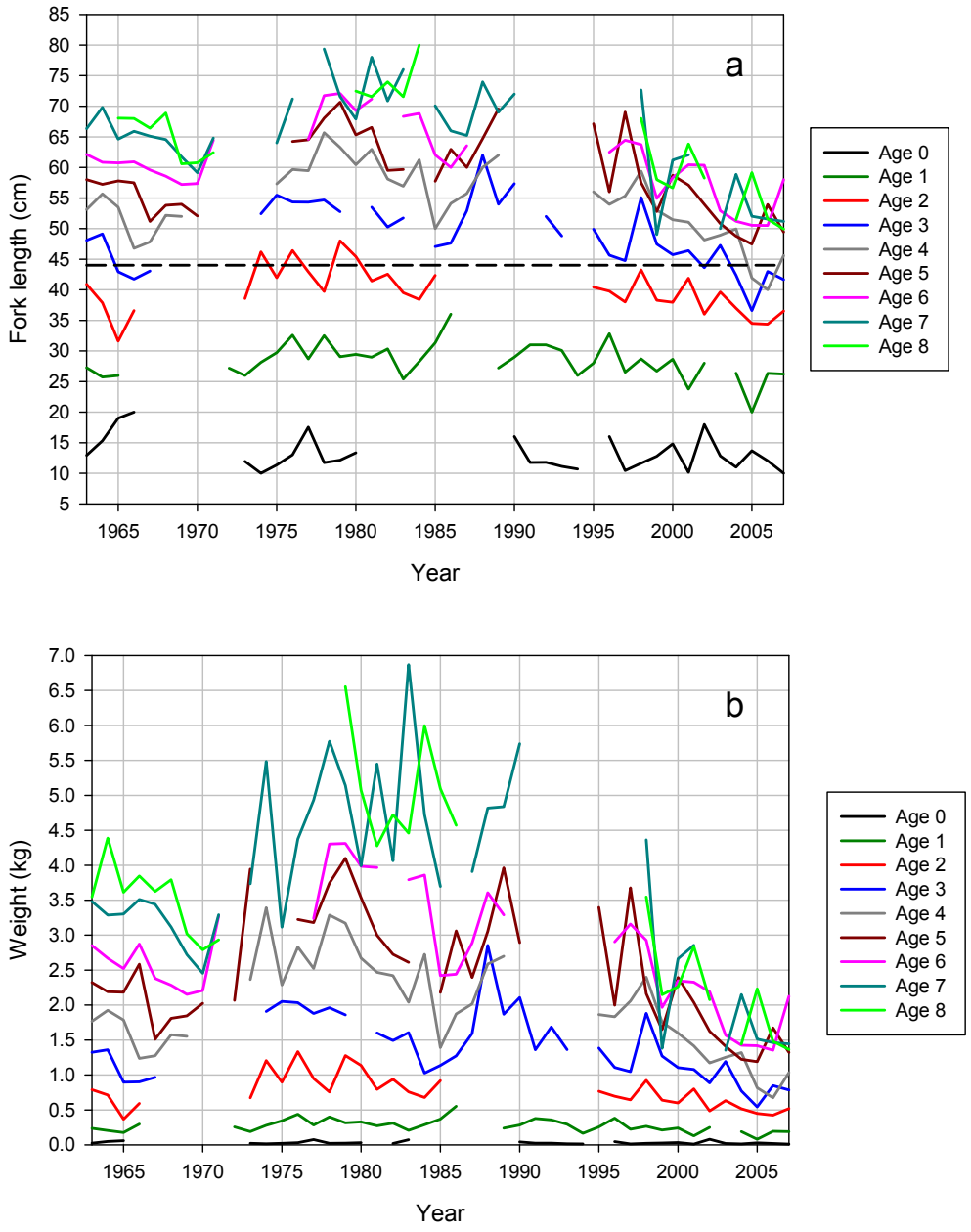

Figure R24. Mean length at age (a) and weight at age (b) of age 0 to 8 Gulf of Maine haddock caught in the Northeast Fisheries Science Center's autumn bottom trawl survey, 1963 to 2007. The dashed line in the length at age plot denotes the fork length equivalent of the current minimum size for both commercial and recreational fisheries of 19 inches.

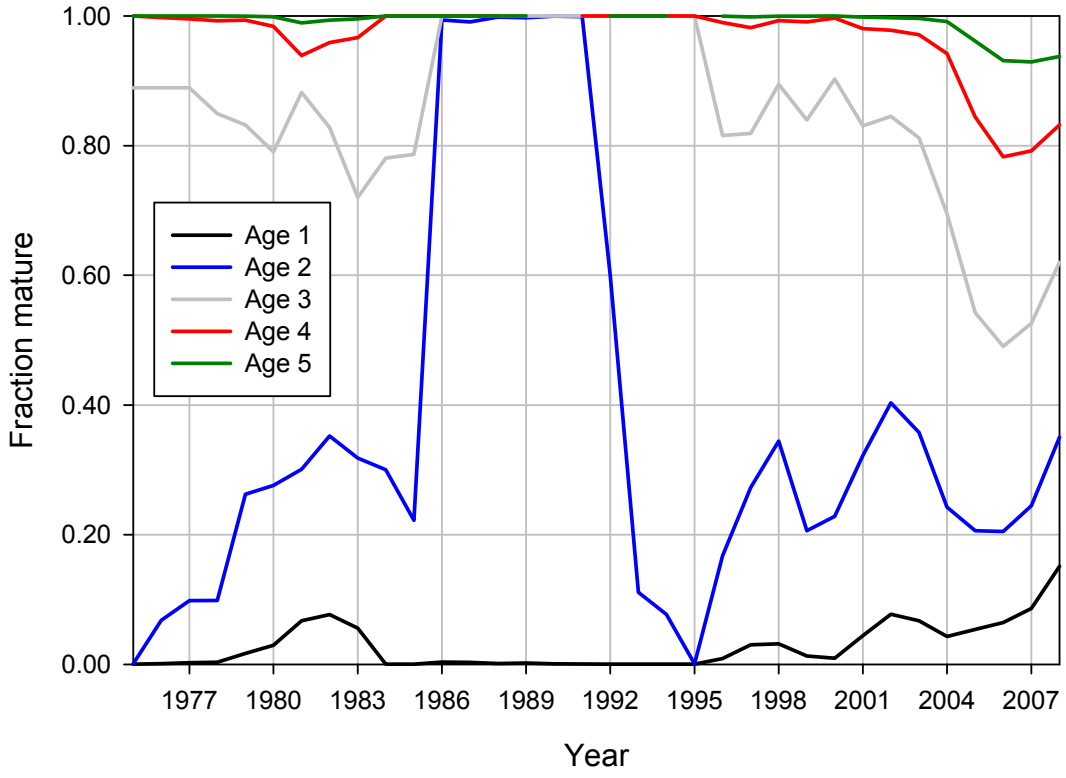

Figure R25. Proportion mature at age of female Gulf of Maine haddock using a 3-year moving window for ages 1-5 (upper panel). Data are from the Northeast Fisheries Science Center spring bottom trawl survey, 1975 to 2008.

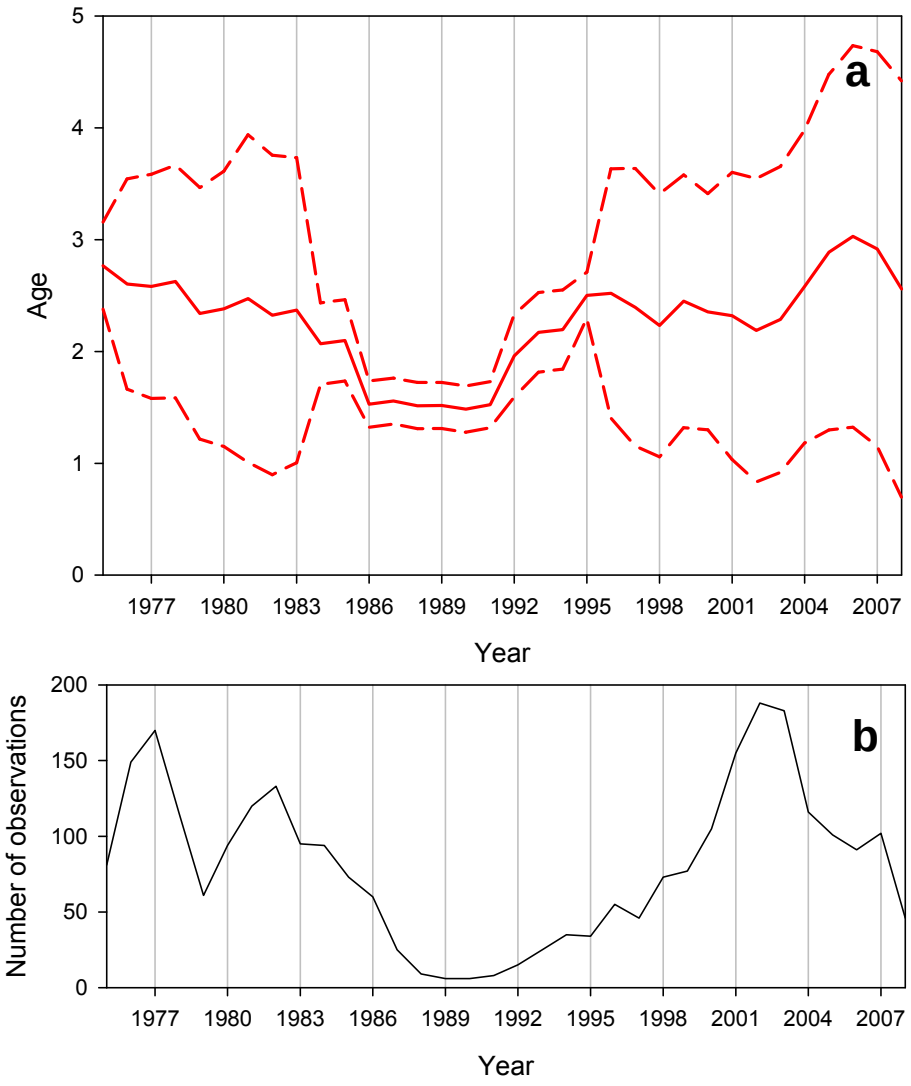

Figure R26. Median age at maturity (A_{50}) of females a) with 95% confidence intervals, and number of samples in the combined 3-year moving average (b). Data are from the Northeast Fisheries Science Center spring bottom trawl survey 1975 to 2008.

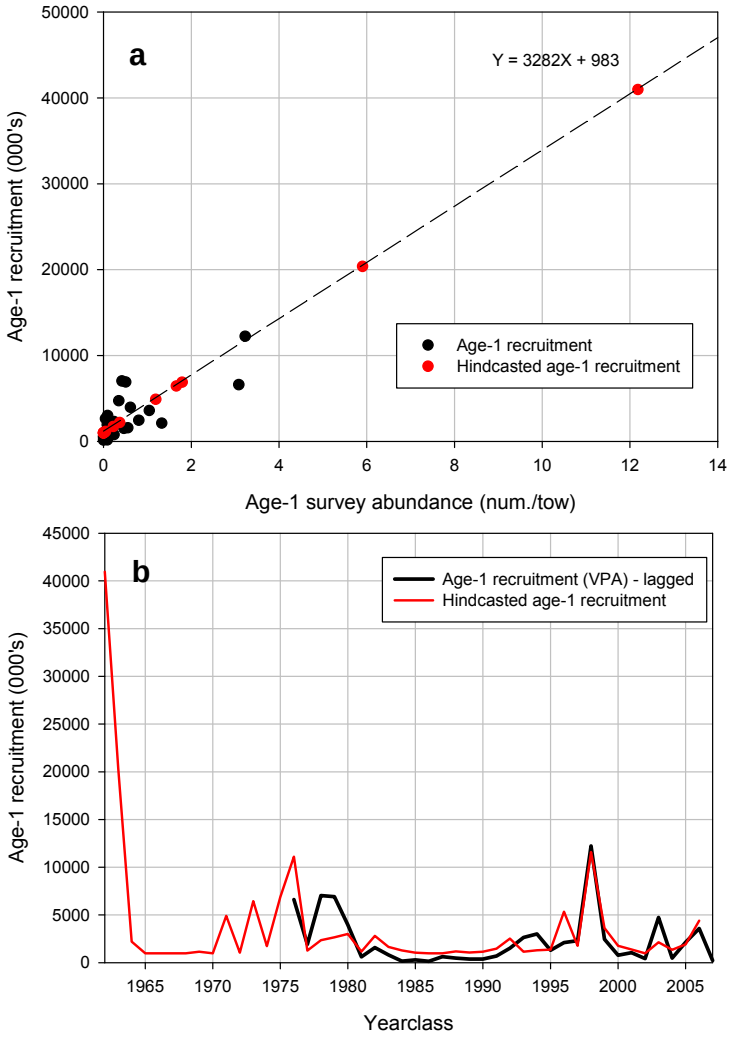

Figure R27. Regression of virtual population analysis (VPA) age 1 numbers on age-1 survey abundance index (a) and hindcasted estimates of age 1 recruitment using the Northeast Fisheries Science Center autumn survey age 1 numbers at age (b).

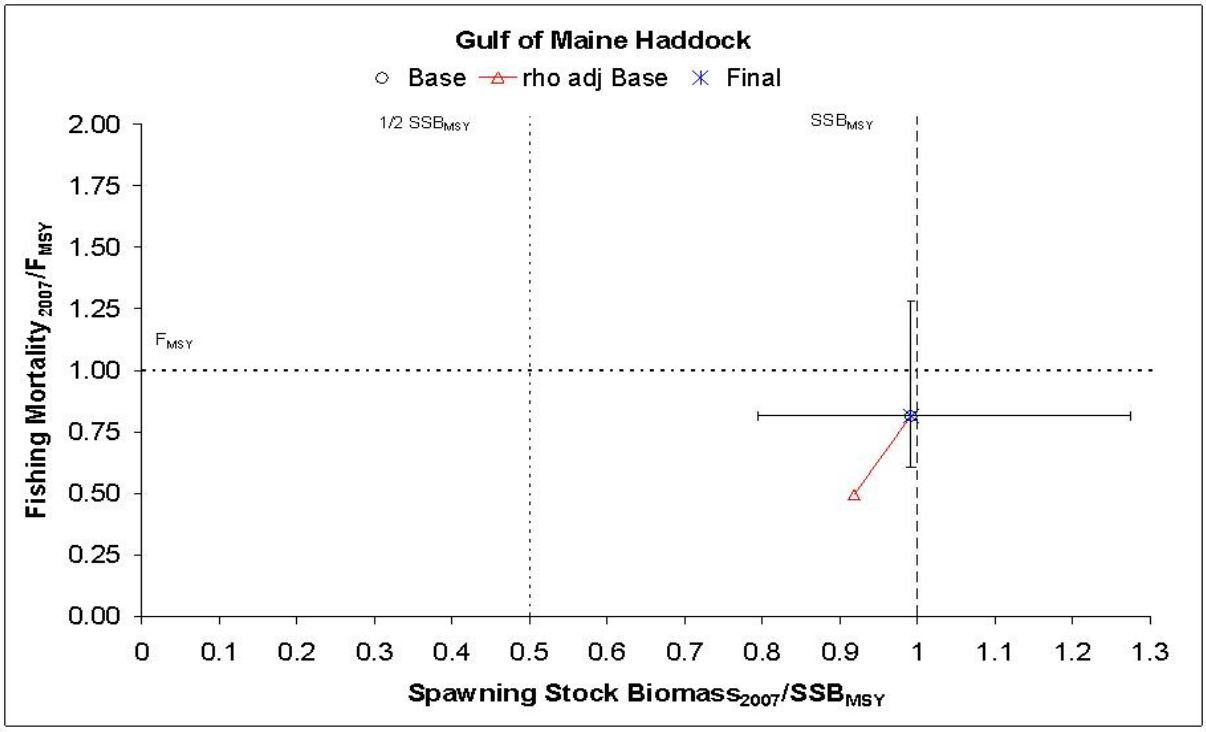

Figure R28. Gulf of Maine haddock stock status in 2007 with respect to GARM 2008 biological reference points; error bars represent the 80% confidence intervals. Stock status is based on the unweighted average $F_{6\text{-}8}$.