Fisheries and Oceans Canada   Pêches et Océans Canada

NOAA FISHERIES
NATIONAL MARINE FISHERIES SERVICE

CERT

**Comité d'évaluation des
ressources transfrontalières**

Document de référence 2009/04

Ne pas citer sans
autorisation des auteurs

TRAC

**Transboundary Resources
Assessment Committee**

Reference Document 2009/04

Not to be cited without
permission of the authors

**Transboundary Resources Assessment Committee
Gulf of Maine/Georges Bank Atlantic Herring Stock Assessment Update**

G.Shepherd[1], M. Cieri[2], M. Power[3], and W. Overholtz[1]

National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, MA USA

Maine Dept. of Marine Resources
Boothbay Harbor Lab
West Boothbay Harbor, ME, USA

Fisheries and Oceans Canada
St. Andrews Biological Station
St. Andrews, NB Canada

National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, MA USA

Canada

ABSTRACT

The Gulf of Maine/Georges Bank Atlantic herring stock assessment previously conducted in 2006 was updated through 2008. A forward projecting age structured model was used to estimate abundance, spawning biomass, total age 2+ biomass and fishing mortality. A revised landings at age time series and updated survey indices at age (NMFS spring and autumn survey indices) were employed in a similar model formulation as accepted at the 2006 benchmark assessment.

Combined Canada and USA herring landings increased from 106,000 mt in 2005 to 116,000 mt in 2006, then declined to 90,000 mt in 2008. Total biomass (age 2+, January 1st) increased steadily from about 111,600 mt in 1982 to almost 830,000 mt in 1997 and has since fluctuated without trend. Total biomass was estimated to be 652,000 mt at the beginning of 2008 which is below B_{MSY} (670,600 mt). Recruitment at age 2 from the 2004 and 2006 year classes appear weaker than the long-term (1967-2005) average of 2.3 billion fish. The 2005 year class abundance estimate is above average abundance at 3.3 billion fish. Fishing mortality (age 2+) declined to 0.14 in 1993 and has remained stable at about 0.16 from 2002 onwards. Estimated fishing mortality in 2008 was 0.14 which is below F_{MSY} (0.27). Model results indicate that overfishing is not occurring and that Gulf of Maine/Georges Bank Atlantic herring are not overfished.

RÉSUMÉ

L'évaluation du stock de hareng du golfe du Maine et du banc Georges effectuée en 2006 a été mise à jour jusqu'à 2008. On s'est servi d'un modèle à projection prospective fondé sur l'âge pour estimer l'abondance, la biomasse du stock de reproducteurs, la biomasse des harengs des âges 2 + et la mortalité par pêche. Une série chronologique révisée des débarquements selon l'âge et des indices d'abondance selon l'âge (d'après les relevés de printemps et d'automne du NMFS) mis à jour ont été utilisés pour une élaboration de modèle semblable qui avait été acceptée lors de l'évaluation des points de référence de 2006.

Les débarquements combinés de hareng du Canada et des États-Unis ont augmenté de 2005 à 2006, passant de 106 000 tm à 116 000 tm, puis ils sont tombés à 90 000 tm en 2008. La biomasse totale (harengs des âges 2 + au 1er janvier) a augmenté constamment, passant d'environ 111 600 tm en 1982 à près de 830 000 tm en 1997. Elle a depuis fluctué sans présenter de tendance. Elle était estimée à 652 000 tm au début de 2008, ce qui est inférieur à la biomasse au rendement maximal durable (BRMD), qui est de 670 600 tm. Le recrutement à l'âge 2 des harengs des classes d'âge de 2004 et 2006 semble inférieur à la moyenne à long terme (1967-2005) qui est de 2,3 milliards de poissons. L'estimation de l'abondance de la classe d'âge de 2005 est supérieure à l'abondance moyenne (3,3 milliards de poissons). La mortalité par pêche (parmi les âges 2 +) est tombée à 0,14 en 1993 et elle est restée stable, à environ 0,16 à partir de 2002. En 2008, la mortalité par pêche a été estimée à 0,14, ce qui est inférieur à la FRMD (0,27). Les résultats du modèle indiquent qu'il n'y a pas de surpêche et que le hareng du golfe du Maine et du banc Georges n'est pas surexploité.

INTRODUCTION

Gulf of Maine/Georges Bank Atlantic herring were last assessed in a benchmark assessment conducted in May 2006 (O'Boyle and Overholtz 2006). The meeting participants agreed on an assessment model structure and input data. However, there remained unresolved several outstanding issues such as a significant retrospective pattern. An update of that assessment was requested for the 2009 TRAC meeting and terms of reference developed. Among the TORs addressed at this meeting were:

- Update results with the latest information from fisheries, including discards if appropriate, and research surveys.
- Apply the benchmark formulation to update the status of Gulf of Maine/Georges Bank Atlantic herring through 2008 and characterize the uncertainty of estimates.
- Review the retrospective pattern and consider alternative model formulations to address uncertainty in status determination and harvest forecast.
- Using the established harvest strategy biological reference points, review projections to meet the requirements of both countries.

The Gulf of Maine/Georges Bank Atlantic herring are comprised of multiple spawning stocks which intermix throughout the year and are exposed to seasonal fisheries from southern New England to New Brunswick, Canada. Since it is not currently possible to identify stock of origin within the mixed stock fishery, the Gulf of Maine/Georges Bank herring are treated as a single fishery management unit (Overholtz et al., 2004)

LANDINGS

The May 2006 assessment used landings data from 1967 to 2005. In 2006 and 2007 commercial landings of Atlantic herring in the Gulf of Maine/Georges Bank increased slightly to 116,000 mt and 112,600 mt, respectively (Table 1). Landings in 2008 declined to 90,000 mt. Landings from Georges Bank, between 2005 and 2008, showed a slight decline from 16,700 mt to 13,100 mt, and Gulf of Maine landings decreased from 67,800 mt to 47,900 mt. In southern New England, landings increased from 18,500 mt in 2005 to 22,500 mt in 2008. The largest variation in recent landings has occurred in the New Brunswick weir fishery where landings have ranged from 12,900 mt in 2006 to 30,900 mt in 2007, followed by a decline to only 6,500 mt in 2008. The proportion of the total annual landings (in weight) from the New Brunswick weir fisheries ranged from 7 to 27% during 2005 to 2008.

During 1978-1982, USA landings were about equally split between the weir fisheries and purse seines. During 1983-1992, most USA landings were taken by purse seines but subsequently single mid-water and paired mid-water trawling have dominated the landings, with purse seining accounting for only about 10-15% of the total USA landings during 2000-2005. Since 2005, purse seining has increased while pair and single midwater trawling has decreased with pair trawling accounting for 56%, single midwater trawling 12% and purse seine 26%.

As discussed in the 2006 TRAC Proceedings (O'Boyle and Overholtz, 2006), commercial landings information since 1960 was reviewed and modified by Maine DMR. These adjusted landings served as the basis for development of a new landings at age time series (Figures 1-2). Adjustments to USA landings from 1960-1963 resulted in a decrease in estimated landings of 15 to 22%. Adjustments to USA landings from 1964 to 2002 were

all positive and resulted in increases on the order of 30%, ranging from 4% to 61%. No adjustments were made to the New Brunswick weir landings (Figure 3). As in the 2005 assessment, commercial discards of Atlantic herring were not estimated, therefore landings were considered equivalent to catch.

LANDINGS AT AGE

Annual age data were applied to the new USA landings data to produce a landings at age series from 1967 to 2008 (Tables 2-4). Comparable landings at age from New Brunswick weir fisheries were provided by DFO. Per the recommendation of the 2006 TRAC, the landings at age matrix was truncated with an age 6+ category.

In the USA fishery (Table 1), total landings during 2006 and 2008 ranged between 81,700 mt and 103,100 mt.   The number of herring landed in the USA fishery declined from 922 million in 2006 to 634 million in 2008 (Table 2). In 2006, the landings were dominated by age 3 and 4 fish, while in 2007 age 2 fish were slightly more dominant than age 3, 4, or 5 fish. In 2008, age 3 fish and age 6+ fish dominated the USA harvest.

The New Brunswick weir fishery targets primarily small fish, therefore the total number of herring landed has varied annually depending on the abundance of age 1 herring. In 2005, the weir fishery landed 1.1 million age 1 herring, however, in 2006 the number of age 1 herring landed increased to 231.3 million fish (Table 3). This large 2005 cohort was again evident in the 2007 weir fishery as age 2 (546 million fish) and was also seen as age 2 in the 2007 USA fishery (Table 2; Figure 4). The contribution in number of weir landings to the total landings ranged from 18% in 2005 to 45% in 2007.

For the total USA and Canadian harvest, age 3 and 4 fish dominated the landings in 2006 while age 2 and 3 fish dominated landings in 2007 and 2008, respectively (Table 4; Figure 4). The proportion of landings in the 6+ category increased since 2006 from 9% to 29% in 2008. Weights at age have remained relatively stable since the early 1990s after several decades of annual fluctuations (Tables 5-6).

INDICES OF ABUNDANCE

Overall indices of abundance were updated through the 2008 surveys (Figure 5). Indices include the NMFS winter, spring and fall bottom trawl survey as well as the NMFS fall acoustic survey. The NMFS winter survey series was terminated after 2007. Data from the winter 2003 cruise were revised resulting in a new survey index for that year. Trends in total indices (all ages included) show stable, albeit variable, number and weight per tow in the winter survey values through 2007, but a general declining trend in spring number and weight per tow since peaking in 1999. Fall survey indices show a decline between 2003 and 2005 but stable thereafter.

Survey indices disaggregated by age group identify recent large year classes beginning with the 1994 cohort as age 2 in the 1996 winter, spring, and fall surveys (Tables 7-9, Figure 6). Additionally, the 1998 and 2002 year classes appear in several indices as well above average. Most recently the 2005 cohort appeared strong in the fall 2007 survey at age 2 and also in the fall 2008 survey at age 3 (Table 9). This cohort also appeared as a dominant year class in 2006-2008 commercial landings (Table 4). Examination of the NMFS fall survey age 1 indices (age data not immediately available prior to 1987) show

significant year classes in 1994 and 2002 but do not indicate large 1998 or 2005 cohorts (Table 10).

The NMFS fall acoustic survey indices for herring were updated from the previous assessment. In the 2006 assessment the acoustic survey data was converted to absolute biomass estimates. In the most recent iteration, the acoustic survey data were not expanded to total biomass but rather used as an index of relative abundance (Table 11).

The inshore USA area in the Gulf of Maine is managed as a subset of the total stock complex. NMFS spring and fall survey mean number and weight per tow (kg) from the inshore Gulf of Maine survey strata are presented in Table 12. The inshore indices during the 2005-2008 spring surveys are among the lowest in the past two decades, while the recent fall indices are about average for the last 20 years.

ASAP MODEL

The 2006 TRAC recommended a model formulation for Gulf of Maine/Georges Bank Atlantic herring as follows (page 22, O'Boyle and Overholtz 2006):

"An ASAP is to be used using the annual landings at age, $C_{a,t}$ for ages $a = 2$ to 5, 6+ and time $t = 1967$ to the terminal year, where t represents the beginning of the time interval during which the landings was taken.

The ASAP is calibrated to the following survey indices:

NMFS spring, ages $a = 2$ to 5, 6+, time $t = 1968$ to 1984

NMFS spring, ages $a = 2$ to 5, 6+, time $t = 1985$ to terminal time

NMFS fall, ages $a = 2$ to 5, 6+, time $t = 1967.5$ to 1984.5

NMFS fall, ages $a = 2$ to 5, 6+, time $t = 1985.5$ to terminal time

NMFS winter, ages $a = 2$ to 5, 6+, time $t = 1992$ to terminal time

NMFS Acoustic, $a=2$ to 5, 6+, time $t= 1999$ to terminal time.

The lognormal errors in the indices are assumed independent and identically distributed. The relationship between the indices and population abundance is assumed proportional. The tuning indices' observations are all equally weighted. The stock/recruitment relationship is turned off by estimating a mean level of recruitment and deviations about the mean level. The numbers at age in the first year, 1967, are freely estimated.

Fishery selectivity is set to 1.0 for ages 2+.

Natural mortality is assumed to be 0.2 for all ages and years. Maturity at age for all years is set to 0.21, 0.86, 0.93, 0.98, and 1.00 for ages 2 through 6+, respectively. Spawning stock biomass is calculated as the sum of mid-year numbers at age times maturity at age times weight at age. Total

> *biomass is calculated outside the model using weights at age for the start of the year times numbers at age at the start of the year. "*

Since the 2006 assessment, the NOAA Fisheries Toolbox (NFT http://nft.nefsc.noaa.gov/) software for the Age Structured Assessment Program (ASAP) (Legault and Restrepo 1999) forward catch at age model has been upgraded to the current version 2.0.1.9. Consequently, in the 2009 assessment there were some changes required for the input parameters. The initial phase of the assessment update was to create an input file for the new ASAP version that produced results similar to the 2006 model (Figures 7-10). The input file that recreated the 2006 results served as the basis for updating the new ASAP file. A number of variations of the update of the original model were undertaken to evaluate the influence of the newest information.

The initial update involved adding the 2006 through 2008 age 2+ landings at age data to the original 1967 through 2005 series, as well as using revised acoustic survey indices and modified 2003 winter survey indices. The model followed the same formulation as the 2006 assessment with the exception that Rivard weights were calculated for Jan 1 weights at age and the timing of spawning was moved to the fall rather than mid-year. The initial update resulted in an increase in F and decrease in biomass since 2005 (Table 13). The effects of retrospective bias were evident in that the 2005 F estimate changed from 0.11 to 0.20 and the 2005 total age 2+ biomass declined from 1,121,000 mt to 551,000 mt. The 2008 estimate of F was 0.22 and total age 2+ biomass declined to 436,000 mt (Table 13). Retrospective bias also persisted in estimates of spawning stock biomass (SSB).

The original ASAP model formulation from the 2006 assessment was re-run with the revised 1967-2005 landings at age time series (Figure 7-10; Table 13). The resulting fishing mortality estimate for 2005 was 0.08, compared to 0.11 with the original LAA. The estimated total age 2+ biomass for 2005 increased from 1,121,000 to 1,439,000 mt and the 2005 SSB increased from 781,000 mt to 1,170,000 mt. The value of the penalized likelihood for the model with updated LAA was 3287.1 compared to the original value of 3196.9.

The new landings time series (age 2+) was then updated with the 2006 to 2008 landings at age and survey indices at age. Otherwise the model formulation remained the same as the 2006 assessment. The model (2009 Base) estimated 2008 fishing mortality as 0.18, total biomass as 523,000 mt and SSB as 400,000 mt. Additionally the model estimated F_{2005} as 0.18 (compared to the original estimate of 0.11) and the 2005 total age 2+ biomass as 626,000 mt (compared to the original 2005 value of 1,121,000 mt) (Figures 7-14). The retrospective pattern persisted and the Mohn's rho value (Mohn 1999) for F (using 6 peels) was -3.63, compared to -2.31 in the 2006 assessment, and Mohn's rho for SSB increased to 9.34 from the 2006 assessment value of 4.19 (Table 13).

Several variations to the Base model were examined by including age 1 landings with the NMFS age 1 fall index; including age 1 landings and survey index and removing or downweighting the acoustic survey index series; the Base model without the acoustic survey index; the Base model without the acoustic or winter survey indices; the Base model with time varying natural mortality estimates using annual values developed by Overholtz and Link (2007); and a run partitioning the landings at age into USA and Canadian fleets. Results from the updated 2005 model, the 2009 initial update and the model excluding the acoustic and winter survey indices [*i.e.* the 2009 TRAC preferred model] are presented in Tables 14-19.

MODEL SELECTION

The selection of a preferred model in the ASAP framework based on any single quantitative criterion can be somewhat problematic. Changes in the model formulation change the penalized likelihood values and consequently the alternative models cannot be compared directly. The preferred model selected by the TRAC was the Base model excluding both the acoustic and winter survey indices. The rationale to eliminate the acoustic survey indices was that recent declines in the indices appear to reflect changes in the distribution of herring during the survey period rather than changes in stock abundance. It is believed that the acoustic survey has not been consistently indexing the entire stock, resulting in biased indices. The elimination of the winter survey indices was based on the recent upward trends in the winter indices, which conflicted with the trends in the spring and fall survey indices, as well as concerns about changes in spatial coverage during the survey time series and shifts in temporal/spatial distribution of herring. In addition, inclusion of the winter survey indices resulted in a questionable increase in age 6+ abundance estimates.

MODEL RESULTS

Based on the preferred model output, F in 2008 equaled 0.14 (Table 18; Figure 11) which decreased slightly from F estimates between 2002 to 2007 (0.16 to 0.17). Fishing mortality has remained relatively constant since the early 1990s averaging 0.17 since 1993. Estimates of total age 2+ biomass increased from the time series low of 111,600 mt in 1982 to 827,300 mt in 1997, and have since remained relatively stable, averaging 732,000 mt (Table 19; Figure 12). Since 2005, biomass decreased slightly from 684,000 mt to 652,000 mt in 2008. SSB followed a similar pattern and increased from the time series low of 50,900 mt in 1982 to 596,400 mt in 1997 (Table 19; Figure 13). SSB in 2008 was estimated as 515,600 mt, nearly equal to the 1998 to 2007 average (515,200 mt). Recruitment (at age 2) improved markedly in the late 1980s (Table 18; Figure 14) with several recent year classes above the time series average of 2.3 billion fish. Strong year classes were produced in 1998 (3.8 billion fish at age 2), 2002 (3. 8 billion fish at age 2) and most recently in 2005 (3.25 billion fish at age 2). The 2005 cohort was dominant in the Canadian weir fishery in 2006 and 2007 as well as the United States fishery in 2007 and 2008. The 2003 and 2004 year classes were below average and the 2006 cohort appears to be the lowest on record (265 million fish).

An MCMC option was run for the preferred model to estimate uncertainty in the parameter estimates (Figures 15-19). One thousand iterations were performed which provided distributions around the estimates of fishing mortality, total age 2+ biomass and SSB.

RETROSPECTIVE BIAS

Significant retrospective patterns persisted in all the model variations examined. Generally, retrospective biases in fishing mortality estimates were less than those for biomass which sometimes had relative differences greater than 50%. Mohn's rho values for F equaled -2.89 (Table 13) whereas rho values for SSB equaled 5.92 (based on 7 peels). Examination of the final model shows moderate retrospective bias in the estimates of fishing mortality (Figure 20) and abundance at age 2 (recruits) (Figure 21) through 5 but a consistently large retrospective bias in abundance at age 6+ (Figure 22). The bias in the

plus category in turn imparts large biases in SSB estimates (Figure 23). Additional model formulations used to examine retrospective bias included a run with increasing weights at age in the 6 +group, a run with increased M in the 6+ group as well as a run with increased M in age groups 1 and 2. The only formulation which noticeably reduced retrospective patterns in SSB was one with natural mortality (M) in the 6+ group increased since 1995 to 0.6 (from 0.2).

PROJECTIONS

Short-term stochastic projections (2 year per the recommendation of the 2006 TRAC) were conducted (using NFT software AGEPRO 3.3.5) to examine the consequences to abundance, biomass and landings if fishing continued at the status quo F=0.14. Additional projections at different fishing mortality levels of potential interest to management were not examined. Model inputs included full selectivity for ages 2 and greater, weights at age averaged for the last three years and recruitment from the last 10 years (average of 2,013 million fish at age 2). No adjustments were made for the retrospective patterns.

Projections at an F=0.14 generate a mean total biomass in 2009 of 694,300 mt which declines to 683,800 mt in 2010, followed by an increase in 2011 to 696,200 mt. SSB was projected to decline from 460,300 mt in 2009 to 444,500 mt in 2011 (Table 20; Figures 24-26). Associated landings would decline to 82,403 mt in 2009 ($\pm$ 1 std deviation ranged from 71,684 to 93, 122 mt) and 81,154 mt in 2010 (70,099 mt to 92,209 mt), followed by an increase to 82,625 mt in 2011 (69,342 to 95,908 mt) (Table 20).

BIOLOGICAL REFERENCE POINTS

Biological reference points were updated as the landings time series had been revised and fishing mortality and biomass were re-estimated for all years using the preferred TRAC ASAP model formulation. A Fox surplus production model, which was used at the 2006 TRAC, provided the basis for the update. The new values for B_{MSY} equaled 670,600 mt (629,000 mt in 2006) and F_{MSY} equaled 0.27 (previously equal to 0.31). The current status of Gulf of Maine/Georges Bank Atlantic herring remains unchanged with current fishing mortality below F_{MSY} and total age 2+ biomass slightly lower than B_{MSY}.

CONCLUSION

The results of the updated assessment for Gulf of Maine/Georges Bank Atlantic herring are highly influenced by revisions in the landings-at-age time series as well as the ASAP model formulation. Changes to the 1967-2005 landings-at-age applied to the original 2006 TRAC assessment model formulation resulted in a higher biomass estimate and a lower fishing mortality than estimated in the last assessment. However, with the addition of the 2006-2008 landings to the revised LAA, the 2005 estimate of fishing mortality increased above that estimated in 2006 (0.18) and the 2005 total age 2+ biomass decreased by nearly 50%.

In addition to the effects of the revised landings data, the assessment results were also sensitive to the formulation of the ASAP model (Figures 27-28). The acoustic survey indices suggested a sharp decline in herring biomass, therefore removal of this survey

index series from the model generated higher estimates of biomass. In contrast, the winter survey index series implied a recent sharp increase in biomass and thus removal of the indices produced lower model estimates of biomass. Removing the NMFS acoustic survey indices was justified based on evidence that the entire stock complex was not available in the survey area during the survey period. Elimination of the NMFS winter survey time series was based on a similar rationale. As the two survey series produced conflicting signals, removal of both indices tended to neutralize one another with the effect that the final model results were similar to the 'Base run' that included all of the indices (including the acoustic and winter survey indices) used in the 2006 assessment.

The uncertainty due to model configuration is dwarfed by the uncertainty associated with retrospective bias (Figures 29-30). The problem appears to be related to bias in the estimate of age 6+ abundance. Despite the model uncertainty, it can be stated with reasonable certainty that overfishing ($F_{2008} < F_{MSY}$) is not occurring on Gulf of Maine/Georges Bank Atlantic herring (Figure 17) and that the stock complex is not overfished ($B_{2008} > 1/2\ B_{MSY}$) (Figure 19).

Given the persistence of a retrospective bias in the estimates of fishing mortality and biomass, as well as the influence of data revisions on model estimates, it is recommended that the next assessment undertake a benchmark re-examination of the data and model, with a primary objective of reducing the retrospective biases.

LITERATURE CITED

Legault, C.M., and V.R. Restrepo. 1999. A Flexible Forward Age-Structured Assessment Program. Int. Comm. Cons. Atl. Tunas, Coll. Vol. Sci. Pap. 49(2): 246-253.

Mohn, R. 1999. The Retrospective Problem in Sequential Population Analysis: An Investigation Using Cod Fishery and Simulated Data. ICES J. Mar. Sci. 56: 473-488.

O'Boyle, R., and W. Overholtz. 2006. Proceedings of the Transboundary Resources Assessment Committee (TRAC): Benchmark Review of Stock Assessment Models for Gulf of Maine and Georges Bank Herring; 2-5 May 2006. TRAC Proc. Doc. 2006/01: 35 pp.
(http://www.mar.dfo-mpo.gc.ca/science/TRAC/proceedings/TRAC_pro_2006_01.pdf)

Overholtz, W.J., and J.S. Link. 2007. Consumption Impacts by Marine Mammals, Fish and Seabirds on the Gulf of Maine-Georges Bank Atlantic Herring (*Clupea harengus*) Complex During the Years 1977-2002. ICES J. Mar. Sci. 64:83-96.

Overholtz, W.J., L.D. Jacobson, G.D. Melvin, M. Cieri, M. Power, D. Libby, and K. Clark. 2004. Stock Assessment of the Gulf of Maine - Georges Bank Atlantic Herring Complex, 2003. NEFSC Ref. Doc. 04-06: 290 pp.

Table 1. Atlantic herring landings (mt) - with revised 1960-2005 USA landings.

YEAR	FOR GB	USA GB	CAN GB	FOR GoM	USA GoM	FOR SNE/MA	USA SNE/MA	NB	TOTAL CAN	TOTAL USA	TOTAL
1960	105				49,169	10		34,304	34,304	49,169	83,473
1961	67,653				21,954	2	25	8,054	8,054	21,979	30,033
1962	151,522			144	59,258			20,698	20,698	59,258	79,956
1963	97,307			227	53,245	661		29,366	29,366	53,245	82,611
1964	130,954	160		636	41,304	484	101	29,432	29,432	41,565	70,997
1965	40,452	217		30	51,340	2,430	131	33,460	33,460	51,688	85,148
1966	136,670	12		47	42,047	6,034	390	35,805	35,805	42,449	78,254
1967	213,976	22		5,226	51,518	4,768	254	30,032	30,032	51,794	81,826
1968	304,173	9		21,497	50,359	69,426	192	33,145	33,145	50,560	83,705
1969	208,099	794		26,088	32,724	101,428	2,022	26,539	26,539	35,540	62,079
1970	196,679	272		13,716	43,789	50,615	1,352	15,840	15,840	45,413	61,253
1971	213,427	1,210		19,498	44,098	53,947	1,512	12,660	12,660	46,820	59,480
1972	149,708	12		24,220	47,310	24,482	2,793	32,699	32,699	50,116	82,815
1973	169,834	162		10,725	34,461	32,501	6,817	19,935	19,935	41,440	61,375
1974	129,037	173		7,865	48,154	20,473	4,800	20,602	20,602	53,127	73,729
1975	135,626	2		5,249	44,070	10,470	7,226	30,819	30,819	51,298	82,117
1976	41,950	508		921	69,947	1,552	459	29,206	29,206	70,915	100,121
1977	106			382	79,542	2,031	1,552	23,487	23,487	81,093	104,580
1978	2	1		582	65,272	2,102	4,773	38,842	38,842	70,046	108,888
1979	5	5			78,687	1,231	1,120	37,828	37,828	79,812	117,640
1980	166	166			96,477	1,365	1,271	13,525	13,525	97,914	111,439
1981	22	21			83,845	850	884	19,080	19,080	84,750	103,830
1982		1			42,922		1,525	25,963	25,963	44,448	70,411
1983		3			33,160		67	11,383	11,383	33,230	44,613
1984		10			46,584		66	8,698	8,698	46,660	55,358
1985		162			33,024		166	27,863	27,863	33,352	61,215
1986		3			39,604		612	27,883	27,883	40,219	68,102
1987		12			49,502		443	27,320	27,320	49,957	77,277
1988		9			52,852		756	33,421	33,421	53,617	87,038
1989		4			55,533		305	44,112	44,112	55,842	99,954
1990		20	91		54,688		698	38,778	38,869	55,406	94,275
1991		613	64		68,331		11,222	24,576	24,640	80,165	104,805
1992		10			82,013		10,726	31,968	31,968	92,749	124,717
1993		135			70,235		6,510	31,572	31,572	76,880	108,452
1994			266		60,825		2,876	22,241	22,507	63,701	86,208
1995					83,184		23,001	18,248	18,248	106,185	124,433
1996		2,232	2,491		82,524		30,242	15,913	18,404	114,998	133,402
1997		7,016	79		90,433		26,159	20,552	20,631	123,608	144,239
1998		28,686			53,774		24,073	20,092	20,092	106,534	126,626
1999		7,070			78,190		25,293	18,592	18,592	110,553	129,145
2000		15,321	275		66,573		26,923	16,830	17,105	108,818	125,923
2001	1,241	43,813	3,317		60,716		15,496	20,210	23,527	120,025	143,552
2002		18,040	1,605		63,905		11,237	11,807	13,412	93,183	106,595
2003		23,495			62,287		15,054	9,003	9,003	100,836	109,839
2004		18,194			64,663		11,570	20,620	20,620	94,427	115,047
2005		16,672			61,998		14,589	12,639	12,639	93,259	105,898
2006		16,769			67,848		18,510	12,863	12,863	103,128	115,991
2007		10,271			51,212		20,178	30,943	30,943	81,661	112,604
2008		13,144			47,941		22,495	6,448	6,448	83,580	90,029

Table 2. USA landings at age, 1967-2008 (millions of fish) of Gulf of Maine/Georges Bank Atlantic herring

AGE

Year	1	2	3	4	5	6+	total
1967	36.5	389.4	312.5	230.3	158.8	750.3	1878
1968	118.0	2596.1	919.3	215.9	317.8	847.4	5014
1969	38.3	2565.4	483.4	249.2	241.3	681.8	4259
1970	62.8	301.7	124.0	328.1	238.7	572.5	1628
1971	636.7	202.4	454.1	326.4	317.5	476.9	2414
1972	13.7	837.0	109.2	177.9	202.3	392.8	1733
1973	27.9	355.9	914.3	198.3	90.5	225.1	1812
1974	33.4	232.2	178.3	780.6	94.1	69.4	1388
1975	53.6	288.6	113.1	122.3	581.4	116.7	1276
1976	53.8	545.4	250.4	42.8	49.3	214.7	1156
1977	113.0	613.4	95.1	103.0	33.8	152.2	1111
1978	61.4	503.0	127.8	45.7	61.2	74.3	873
1979	5.6	1112.6	253.6	61.2	18.3	38.5	1490
1980	96.3	297.9	433.7	215.9	25.9	22.9	1093
1981	20.7	1260.9	30.7	88.1	61.1	11.2	1473
1982	34.2	394.3	55.4	5.3	44.4	31.4	565
1983	55.9	198.0	58.0	34.8	2.1	21.8	371
1984	6.8	233.7	170.8	46.0	31.1	10.6	499
1985	12.9	211.8	41.7	59.8	24.0	16.0	366
1986	30.0	144.0	158.1	32.9	29.3	19.2	413
1987	31.0	152.0	110.5	156.5	25.0	20.8	496
1988	0.6	174.4	86.4	66.1	114.1	44.1	486
1989	0.2	184.7	62.6	65.4	52.0	112.8	478
1990	0.0	111.5	142.1	49.8	26.4	113.5	443
1991	0.0	207.4	291.4	100.5	81.1	117.1	797
1992	0.1	219.0	214.2	113.1	115.4	199.7	862
1993	0.0	175.6	155.8	110.4	102.5	142.3	687
1994	0.0	158.0	151.6	66.8	84.8	153.7	615
1995	2.4	234.3	121.5	54.7	55.2	435.7	904
1996	0.5	328.0	170.4	78.9	94.2	356.6	1029
1997	0.1	106.6	644.6	118.8	73.2	223.3	1167
1998	0.0	178.8	175.7	454.6	92.8	126.3	1028
1999	0.9	111.3	347.1	108.5	268.5	181.4	1018
2000	0.0	191.8	50.6	142.2	171.1	283.6	839
2001	0.1	66.2	409.1	62.9	110.9	321.7	971
2002	14.3	94.2	110.4	263.9	98.1	190.9	772
2003	0.9	225.3	161.9	66.7	206.6	185.2	847
2004	0.6	156.6	396.5	100.2	76.6	143.4	874
2005	0.0	65.9	382.6	234.9	66.3	109.8	859
2006	0.0	83.0	295.4	335.4	124.2	84.3	922
2007	0.1	192.7	145.9	150.5	148.1	108.3	746
2008	0.0	12.3	272.7	85.6	76.4	186.7	634

Table 3. New Brunswick, Canada weir landings at age 1967-2008 (millions of fish) of Atlantic herring.

	Age						
Year	1	2	3	4	5	6+	total
1967	129.8	160.3	55.7	105.8	12.4	0.0	464
1968	2.2	694.0	47.5	23.6	29.0	0.0	796
1969	61.5	350.9	94.9	4.4	9.5	0.0	521
1970	4.0	312.5	9.3	11.8	5.4	0.0	343
1971	81.0	164.6	33.3	7.4	3.6	0.0	290
1972	7.6	615.2	6.3	9.9	4.2	0.0	643
1973	26.0	197.4	178.3	20.4	1.2	0.0	423
1974	3.2	245.8	43.6	30.7	1.6	0.0	325
1975	16.8	463.1	57.5	9.5	16.0	3.0	566
1976	51.8	199.0	104.3	19.7	14.5	11.8	401
1977	515.0	124.0	10.0	21.4	7.3	12.4	690
1978	213.8	894.4	52.1	3.7	0.8	1.5	1166
1979	2.4	423.7	247.4	12.2	0.8	2.5	689
1980	258.0	5.3	62.1	21.6	0.9	0.4	348
1981	53.3	294.7	18.8	10.2	5.4	0.4	383
1982	30.2	395.4	73.2	3.2	1.8	1.9	506
1983	2.5	135.3	21.7	7.5	0.4	0.6	168
1984	14.4	82.9	17.3	5.7	4.3	1.0	126
1985	20.3	385.4	45.9	17.9	7.4	4.0	481
1986	3.2	136.3	119.7	24.1	10.6	7.4	301
1987	35.7	129.3	48.0	53.2	22.9	10.4	300
1988	76.1	347.8	45.1	22.4	38.8	16.3	546
1989	26.9	331.0	81.4	21.4	22.7	58.8	542
1990	12.6	454.8	69.0	30.7	6.4	29.1	603
1991	5.5	338.3	44.5	23.6	9.5	11.1	432
1992	0.8	375.8	97.7	36.4	10.4	7.8	529
1993	1.7	244.1	106.1	37.2	23.2	20.4	433
1994	2.0	292.0	63.9	10.0	16.3	16.7	401
1995	57.8	259.7	40.1	14.8	1.8	3.1	377
1996	5.4	269.4	22.4	9.3	4.3	2.9	314
1997	9.3	216.2	113.2	11.3	3.6	0.8	354
1998	0.4	387.7	36.1	9.6	3.4	2.2	439
1999	0.1	78.6	102.4	36.8	12.1	3.5	233
2000	3.9	250.0	12.8	7.6	6.0	1.4	282
2001	1.1	119.1	114.8	8.3	4.7	2.0	250
2002	33.2	178.7	15.6	13.2	2.3	0.4	243
2003	10.6	161.6	17.5	3.0	1.6	0.2	195
2004	6.0	182.6	102.1	22.9	4.6	0.5	319
2005	1.1	102.2	76.1	21.3	1.2	0.1	202
2006	231.3	109.9	26.0	5.7	2.3	0.2	375
2007	33.4	545.9	31.8	1.0	1.2	0.4	614
2008	24.7	121.6	23.7	0.2	0.1	0.2	170

Table 4. Combined USA and Canadian landings at age 1967-2008 (millions of fish) of Gulf of Maine/Georges Bank Atlantic herring.

Year	Age 1	2	3	4	5	6+	total
1967	166.3	549.6	368.2	336.1	171.2	750.3	2,342
1968	120.2	3290.1	966.8	239.5	346.8	847.4	5,811
1969	99.8	2916.3	578.3	253.6	250.8	681.8	4,781
1970	66.8	614.2	133.3	339.8	244.1	572.5	1,971
1971	717.6	367.0	487.4	333.8	321.1	476.9	2,704
1972	21.3	1452.1	115.4	187.8	206.5	392.8	2,376
1973	53.9	553.4	1092.5	218.7	91.6	225.1	2,235
1974	36.7	478.0	221.9	811.3	95.7	69.4	1,713
1975	70.4	751.7	170.6	131.7	597.4	119.6	1,841
1976	105.6	744.5	354.7	62.5	63.8	226.5	1,558
1977	628.0	737.4	105.2	124.4	41.1	164.7	1,801
1978	275.2	1397.4	179.9	49.3	62.0	75.8	2,040
1979	8.0	1536.4	501.0	73.5	19.2	41.0	2,179
1980	354.3	303.2	495.8	237.5	26.8	23.3	1,441
1981	74.0	1555.6	49.5	98.3	66.4	11.6	1,855
1982	64.4	789.7	128.6	8.5	46.2	33.3	1,071
1983	58.4	333.3	79.7	42.4	2.6	22.4	539
1984	21.1	316.6	188.1	51.6	35.4	11.6	624
1985	33.1	597.2	87.5	77.7	31.4	20.0	847
1986	33.2	280.3	277.9	57.0	39.9	26.7	715
1987	66.7	281.4	158.5	209.6	47.9	31.2	795
1988	76.6	522.2	131.5	88.5	152.9	60.4	1,032
1989	27.0	515.8	144.0	86.8	74.8	171.7	1,020
1990	12.6	566.3	211.1	80.5	32.7	142.6	1,046
1991	5.6	545.7	335.8	124.1	90.6	128.2	1,230
1992	0.9	594.8	311.9	149.6	125.8	207.5	1,390
1993	1.7	419.7	261.9	147.6	125.8	162.7	1,119
1994	2.0	450.0	215.5	76.8	101.1	170.4	1,016
1995	60.2	494.0	161.7	69.5	57.0	438.8	1,281
1996	5.8	597.4	192.8	88.3	98.5	359.5	1,342
1997	9.4	322.8	757.7	130.2	76.8	224.1	1,521
1998	0.4	566.5	211.8	464.2	96.2	128.5	1,468
1999	1.0	189.9	449.5	145.3	280.6	184.9	1,251
2000	3.9	441.9	63.4	149.8	177.2	285.0	1,121
2001	1.2	185.3	524.0	71.2	115.6	323.7	1,221
2002	47.5	272.9	126.0	277.1	100.4	191.4	1,015
2003	11.6	386.9	179.4	69.7	208.2	185.5	1,041
2004	6.7	339.2	498.5	123.1	81.1	143.9	1,193
2005	1.1	168.1	458.7	256.2	67.5	109.8	1,061
2006	231.3	192.9	321.4	341.1	126.5	84.6	1,298
2007	33.5	738.6	177.7	151.6	149.3	108.7	1,360
2008	24.7	133.8	296.4	85.7	76.6	186.9	804

Table 5. USA and Canadian landings weights (in kg) at age, 1967-2008 of Gulf of Maine/Georges Bank Atlantic herring.

	Age				
	2	**3**	**4**	**5**	**6+**
1967	0.025	0.059	0.142	0.194	0.236
1968	0.025	0.059	0.142	0.194	0.244
1969	0.039	0.079	0.051	0.252	0.289
1970	0.063	0.106	0.167	0.210	0.283
1971	0.049	0.115	0.180	0.234	0.313
1972	0.051	0.120	0.187	0.234	0.296
1973	0.054	0.108	0.170	0.233	0.284
1974	0.053	0.108	0.169	0.204	0.247
1975	0.051	0.096	0.169	0.192	0.251
1976	0.042	0.114	0.179	0.206	0.216
1977	0.042	0.103	0.161	0.189	0.228
1978	0.040	0.120	0.186	0.226	0.281
1979	0.032	0.089	0.198	0.255	0.281
1980	0.041	0.103	0.169	0.268	0.339
1981	0.045	0.114	0.190	0.232	0.303
1982	0.049	0.130	0.194	0.250	0.273
1983	0.055	0.138	0.216	0.223	0.329
1984	0.039	0.122	0.170	0.217	0.299
1985	0.040	0.129	0.183	0.213	0.242
1986	0.049	0.106	0.165	0.211	0.242
1987	0.049	0.096	0.146	0.195	0.236
1988	0.038	0.107	0.143	0.172	0.222
1989	0.044	0.100	0.146	0.175	0.213
1990	0.043	0.093	0.144	0.186	0.226
1991	0.041	0.070	0.134	0.164	0.216
1992	0.040	0.080	0.123	0.146	0.188
1993	0.036	0.089	0.130	0.150	0.196
1994	0.036	0.081	0.118	0.138	0.172
1995	0.046	0.092	0.118	0.131	0.160
1996	0.048	0.084	0.120	0.144	0.171
1997	0.045	0.085	0.116	0.143	0.175
1998	0.041	0.079	0.112	0.133	0.172
1999	0.053	0.082	0.114	0.129	0.159
2000	0.060	0.102	0.128	0.148	0.167
2001	0.055	0.095	0.128	0.149	0.170
2002	0.046	0.095	0.121	0.139	0.168
2003	0.051	0.090	0.133	0.149	0.180
2004	0.042	0.093	0.129	0.157	0.180
2005	0.042	0.084	0.123	0.147	0.177
2006	0.053	0.081	0.121	0.151	0.187
2007	0.053	0.091	0.116	0.139	0.168
2008	0.040	0.098	0.127	0.151	0.175

Table 6. USA and Canadian Jan 1 weights (in kg) at age for Gulf of Maine/Georges Bank Atlantic herring.

	Age				
	2	**3**	**4**	**5**	**6+**
1967	0.016	0.038	0.122	0.166	0.236
1968	0.014	0.038	0.092	0.166	0.244
1969	0.024	0.044	0.055	0.189	0.289
1970	0.047	0.064	0.115	0.104	0.283
1971	0.031	0.085	0.138	0.198	0.313
1972	0.035	0.077	0.147	0.205	0.296
1973	0.038	0.074	0.143	0.209	0.284
1974	0.039	0.076	0.135	0.186	0.247
1975	0.034	0.071	0.135	0.180	0.251
1976	0.027	0.076	0.131	0.187	0.216
1977	0.025	0.066	0.136	0.184	0.228
1978	0.027	0.071	0.138	0.191	0.281
1979	0.018	0.060	0.154	0.218	0.281
1980	0.025	0.057	0.123	0.230	0.339
1981	0.027	0.068	0.140	0.198	0.303
1982	0.029	0.077	0.149	0.218	0.273
1983	0.037	0.082	0.168	0.208	0.329
1984	0.021	0.082	0.153	0.217	0.299
1985	0.025	0.071	0.149	0.190	0.242
1986	0.035	0.065	0.146	0.197	0.242
1987	0.033	0.069	0.124	0.179	0.236
1988	0.023	0.072	0.117	0.159	0.222
1989	0.030	0.062	0.125	0.158	0.213
1990	0.034	0.064	0.120	0.165	0.226
1991	0.029	0.055	0.112	0.154	0.216
1992	0.027	0.057	0.093	0.140	0.188
1993	0.024	0.060	0.102	0.136	0.196
1994	0.023	0.054	0.103	0.134	0.172
1995	0.034	0.058	0.098	0.124	0.160
1996	0.036	0.062	0.105	0.130	0.171
1997	0.034	0.064	0.099	0.131	0.175
1998	0.029	0.060	0.098	0.124	0.172
1999	0.038	0.058	0.095	0.120	0.159
2000	0.048	0.074	0.102	0.130	0.167
2001	0.042	0.076	0.114	0.138	0.170
2002	0.033	0.072	0.107	0.133	0.168
2003	0.038	0.064	0.112	0.134	0.180
2004	0.030	0.069	0.108	0.145	0.180
2005	0.030	0.059	0.107	0.138	0.177
2006	0.040	0.058	0.101	0.136	0.187
2007	0.039	0.069	0.097	0.130	0.168
2008	0.022	0.072	0.108	0.132	0.175

Table 7. NEFSC winter survey indices of Atlantic herring mean number per tow at age (offshore strata 1-3, 5-7, 9-11, 13-14, 16, 61-63, 65-67, 69-71, 73-75).

| | Age | | | | | |
	2	3	4	5	6+	total
1963						
1964						
1965						
1966						
1967						
1968						
1969						
1970						
1971						
1972						
1973						
1974						
1975						
1976						
1977						
1978						
1979						
1980						
1981						
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990						
1991						
1992	7.705	13.229	8.194	4.398	1.889	35.415
1993	0.319	16.174	17.004	9.784	6.489	49.769
1994	0.137	0.883	1.959	2.107	2.350	7.436
1995	0.073	0.840	0.987	4.887	10.817	17.604
1996	74.732	6.574	3.602	4.110	23.232	112.251
1997	0.870	7.615	1.384	6.337	38.326	54.532
1998	0.916	11.962	31.021	7.348	6.009	57.256
1999	0.019	5.260	12.385	23.977	14.030	55.671
2000	47.819	2.828	5.499	5.101	4.847	66.094
2001	5.515	36.870	3.914	11.360	16.393	74.052
2002	0.992	2.089	40.388	8.498	19.468	71.435
2003	14.140	7.423	5.034	24.971	20.844	72.411
2004	13.068	15.757	1.954	0.599	2.865	34.244
2005	1.416	46.227	25.290	10.275	14.690	97.898
2006	0.342	16.371	19.065	8.883	6.205	50.867
2007	0.470	5.789	16.262	22.311	10.424	55.255
2008						

Table 8. NEFSC spring survey indices of Atlantic herring mean number per tow at age. (offshore strata 1-30, 36-40, 61-76)

	Age					
	2	**3**	**4**	**5**	**6+**	**total**
1963						
1964						
1965						
1966						
1967						
1968	1.541	8.701	3.445	3.571	9.636	26.893
1969	0.119	1.323	0.497	1.004	8.211	11.154
1970	3.850	1.475	1.036	0.833	1.026	8.220
1971	0.201	0.451	0.504	0.209	0.451	1.816
1972	0.471	0.943	0.477	0.568	0.380	2.838
1973	0.067	2.268	3.456	0.569	1.906	8.265
1974	0.026	0.104	4.436	0.764	0.330	5.660
1975	0.038	0.096	0.041	0.833	0.145	1.152
1976	0.044	0.226	0.056	0.116	0.580	1.021
1977	0.059	0.119	0.385	0.134	0.321	1.018
1978	0.122	1.994	0.331	0.301	0.312	3.061
1979	4.532	0.371	1.120	0.807	0.600	7.429
1980	0.113	1.463	3.708	0.685	0.263	6.232
1981	0.019	0.012	0.508	1.345	0.306	2.190
1982	0.404	0.052	0.048	0.049	0.052	0.604
1983	0.153	0.027	0.064	0.009	0.147	0.399
1984	1.932	0.408	0.304	0.143	0.043	2.830
1985	1.953	0.940	0.421	0.482	0.169	3.965
1986	1.692	27.167	3.365	1.169	0.994	34.388
1987	1.176	2.133	3.831	0.228	0.141	7.509
1988	3.222	3.970	3.494	3.295	0.327	14.307
1989	1.655	1.659	2.888	1.990	1.503	9.695
1990	2.826	2.381	2.666	1.161	0.158	9.192
1991	3.792	6.810	10.905	0.959	0.359	22.824
1992	11.002	15.991	6.505	2.053	0.769	36.320
1993	7.225	32.696	25.610	5.719	0.981	72.231
1994	4.347	3.385	12.108	10.999	3.857	34.696
1995	6.064	3.771	3.233	11.660	3.372	28.100
1996	40.913	8.480	5.059	2.801	7.668	64.921
1997	10.133	34.303	5.909	2.714	3.978	57.037
1998	4.750	11.739	27.430	5.022	2.749	51.690
1999	2.175	19.043	10.987	43.983	10.729	86.917
2000	15.103	4.040	4.471	4.540	5.115	33.269
2001	5.383	19.405	1.827	1.891	6.568	35.073
2002	5.864	2.482	13.435	2.068	3.417	27.266
2003	2.919	2.003	1.556	6.305	5.069	17.852
2004	31.162	11.211	1.161	0.664	3.677	47.874
2005	1.003	13.514	2.475	0.723	1.964	19.679
2006	1.099	5.150	8.302	8.132	4.469	27.153
2007	2.705	3.304	3.664	3.870	3.573	17.116
2008	0.060	4.102	5.304	1.595	5.599	16.660

Table 9. NEFSC fall survey indices of Atlantic herring mean number per tow at age (offshore strata 1-30, 36-40).

	age					
	2	**3**	**4**	**5**	**6+**	**total**
1963	0.0285	0.9269	1.0119	1.0692	1.0614	4.0979
1964	0.0255	0.0278	0.2641	0.1138	0.1082	0.5394
1965	0.0003	0.0487	1.8260	0.2174	0.3127	2.4051
1966	0.0038	0.0060	0.3311	0.3574	4.5374	5.2357
1967	0.0685	0.1298	0.3607	0.1914	0.9999	1.7503
1968	0.0223	0.0605	0.0553	0.0544	0.4882	0.6807
1969	0.0232	0.0360	0.0641	0.0386	0.1626	0.3245
1970	0.0308	0.0332	0.0721	0.0616	0.1207	0.3184
1971	0.0152	0.3079	0.2571	0.5787	0.3560	1.5149
1972	0.1267	0.0591	0.0755	0.0628	0.1248	0.4489
1973	0.0007	0.0432	0.0043	0.0021	0.0041	0.0544
1974	0.0002	0.0025	0.0627	0.0094	0.0201	0.0949
1975	0.0075	0.0018	0.0150	0.1047	0.1475	0.2765
1976		0.0002	0.0121	0.0137	0.0810	0.1070
1977	0.0061	0.0010	0.0071	0.0023	0.0127	0.0292
1978	0.0107	0.0634	0.0810	0.1565	0.1272	0.4388
1979	0.0119	0.0223	0.0016	0.0026		0.0384
1980	0.0062		0.0035	0.0131		0.0228
1981	0.0023	0.0002	0.0365	0.0394	0.0011	0.0795
1982	0.0062	0.0295	0.0092	0.1195	0.0331	0.1975
1983	0.0222	0.0015			0.0373	0.0610
1984	0.1477	0.1534			0.4637	0.7648
1985	0.0342	0.0529	0.9885	0.3097	0.5368	1.9221
1986	0.0226	0.4321	0.2301	0.1850	0.0634	0.9332
1987	2.0223	3.8322	3.0066	0.3867	0.2634	9.5112
1988	1.0161	3.5625	4.5386	1.7661	0.2523	11.1356
1989	1.3981	4.3239	4.0157	2.0076	2.4494	14.1947
1990	2.5992	8.9160	1.9033	0.4249	0.1380	13.9814
1991	2.7028	11.5474	5.4394	0.8597	0.1895	20.7388
1992	2.2444	25.4372	16.5611	9.9948	2.2378	56.4753
1993	0.3543	1.7973	6.7920	6.0910	1.7704	16.8050
1994	0.6347	1.0301	4.1131	3.6280	4.1524	13.5583
1995	0.5846	7.7999	8.8095	23.5985	28.9690	69.7615
1996	10.8050	6.7177	6.7524	2.8344	10.4169	37.5264
1997	1.8240	17.3812	4.6547	4.1584	8.8404	36.8587
1998	1.5964	2.8441	8.3574	2.8197	5.0106	20.6282
1999	0.2229	2.8610	2.8138	5.2207	2.3579	13.4763
2000	1.1009	1.0114	4.1913	6.7870	7.5564	20.6470
2001	0.3009	8.4976	1.6134	2.5742	12.2832	25.2693
2002	2.1576	5.4579	28.4389	14.3080	26.7865	77.1489
2003	3.1217	3.3908	3.6520	12.2406	11.9167	34.3218
2004	8.4860	12.0203	3.0558	2.2518	14.8635	40.6774
2005	1.3730	8.4563	5.4708	3.3091	6.9988	25.6080
2006	0.7523	11.0649	8.7365	4.2377	3.3399	28.1313
2007	5.1162	3.4145	4.6066	5.4548	4.3219	22.9140
2008	0.1789	9.5363	4.9419	2.3624	5.7907	22.8102

Table 10. NEFSC fall survey age 1 indices of abundance (mean number/tow) of Atlantic herring.

	age 1
1963	
1964	
1965	
1966	
1967	
1968	
1969	
1970	
1971	
1972	
1973	
1974	
1975	
1976	
1977	
1978	
1979	
1980	
1981	
1982	
1983	
1984	
1985	
1986	
1987	0.03
1988	0.41
1989	0.05
1990	0.00
1991	0.00
1992	0.02
1993	0.00
1994	0.06
1995	55.98
1996	0.13
1997	0.20
1998	0.00
1999	0.04
2000	0.00
2001	0.05
2002	0.76
2003	60.45
2004	0.01
2005	0.09
2006	0.02
2007	0.05
2008	0.02

Table 11. NEFSC fall acoustic survey indices (Sa, herring backscatter) of Atlantic herring.

	age					
	2	**3**	**4**	**5**	**6+**	**total**
1963						
1964						
1965						
1966						
1967						
1968						
1969						
1970						
1971						
1972						
1973						
1974						
1975						
1976						
1977						
1978						
1979						
1980						
1981						
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990						
1991						
1992						
1993						
1994						
1995						
1996						
1997						
1998						
1999	45.45	180.22	362.81	326.61	249.60	1164.69
2000	126.64	201.21	597.39	578.90	628.35	2132.48
2001	0.00	173.28	495.53	365.01	964.10	1997.91
2002	2.56	12.18	121.11	204.66	287.01	627.52
2003	0.00	45.85	50.47	80.14	225.47	401.94
2004	0.00	44.43	58.64	54.61	209.04	366.72
2005	0.00	2.87	34.19	34.18	198.14	269.38
2006	0.13	119.53	327.13	176.24	199.45	822.48
2007	81.19	36.53	31.34	28.63	16.86	194.54
2008	2.42	79.97	21.78	35.26	59.45	198.89

Table 12. Atlantic herring survey indices from NMFS spring and fall bottom trawl surveys for inshore Gulf of Maine strata (01260-01270, 01380-01400).

YEAR	Number per tow		Weight per tow (kg)	
	Spring	Fall	Spring	Fall
1963		4.82		1.176
1964		0.55		0.090
1965		1.18		0.242
1966		3.59		0.905
1967		0.88		0.207
1968	0.45	0.00	0.065	0.000
1969	0.47	0.30	0.084	0.000
1970	0.29	0.19	0.033	0.000
1971	0.90	9.02	0.000	1.969
1972	1.11	1.01	0.033	0.107
1973	22.42	0.14	5.268	0.035
1974	0.42	0.12	0.050	0.031
1975	2.72	3.10	0.491	0.731
1976	2.55	0.77	0.456	0.167
1977	1.77	0.30	0.365	0.031
1978	0.89	0.81	0.182	0.150
1979	30.54	0.19	0.371	0.012
1980	24.55	0.05	2.288	0.010
1981	0.62	0.00	0.083	0.000
1982	4.96	0.24	0.157	0.054
1983	1.97	0.73	0.157	0.132
1984	21.61	6.76	0.559	1.691
1985	11.89	16.33	0.217	3.470
1986	5.42	2.55	0.583	0.503
1987	15.81	16.71	0.639	2.318
1988	31.31	4.70	1.850	0.674
1989	43.88	106.04	7.238	18.865
1990	35.20	16.45	2.512	2.583
1991	34.08	7.14	1.102	1.085
1992	32.60	101.18	1.950	16.585
1993	63.18	37.68	5.698	5.936
1994	27.72	15.90	0.824	2.364
1995	68.44	95.75	1.850	14.487
1996	36.79	27.08	0.621	3.801
1997	209.88	66.95	2.712	8.881
1998	24.16	39.24	0.817	4.867
1999	18.35	35.12	0.607	4.668
2000	83.02	56.52	9.428	8.323
2001	63.28	28.40	4.579	4.061
2002	91.04	440.44	3.698	57.882
2003	13.86	41.04	0.305	5.470
2004	258.35	24.10	5.995	2.139
2005	2.34	18.72	0.078	2.299
2006	3.63	159.98	0.170	17.048
2007	16.62	46.33	0.382	5.067
2008	2.94	18.88	0.392	2.329

Table 13. Gulf of Maine/Georges Bank Atlantic herring alternative ASAP model runs.

	penalized Likelihood	F 2005	F 2008	2+ Biomass 2005	2+ Biomass 2008	SSB 2005	SSB 2008	Mohn's rho F	SSB
Final 2005	3196.9	0.11		1,121		781		-2.31	4.19
2009 initial update	3326.3	0.20	0.22	551	436	394	323	-2.65	9.62
Final 2005 - revised LAA	3287.1	0.08		1,439		1,170			
2009 Base	3570.2	0.18	0.18	626	523	457	400	-3.63	9.34
Base w/o AC	2963.3	0.11	0.10	1,117	995	759	734	-3.22	7.21
2009 Base age1 added	3801.6	0.14	0.15	610	653	607	507	-3.56	7.93
2009 Base age1 added no AC	3242.5	0.09	0.09	1,202	1,120	977	908	-2.89	5.23
2009 Base age1, AC downwt'd	3295.3	0.09	0.09	1,167	1,075	944	870	-2.91	5.30
2 fleet, age 1, no AC	3820.7	0.09	0.08	1,455	1,177	997	933	-3.77	8.52
FINAL 2009 TRAC	2501.8	0.16	0.14	684	652	512	516	-2.89	5.92
Base increase M	3595.7	0.08	0.10	1,679	1,013	1,077	699	-2.65	9.62

Table 14. Final 2005 Gulf of Maine/Georges Bank Atlantic herring age 2+ F, landings and abundance based on revised LAA.

	F	Obs CATCH	Pred CATCH		Jan 1 abundance (000s)					
					2	3	4	5	6+	total
1967	0.27	302.7	302.7	1967	3625	1687	1421	826	3638	11,197
1968	0.53	474.0	474.7	1968	4881	2269	1055	889	2794	11,888
1969	0.55	393.7	393.8	1969	3424	2350	1092	508	1773	9,147
1970	0.46	319.0	319.2	1970	2884	1615	1108	515	1076	7,197
1971	0.62	342.9	343.1	1971	2070	1493	836	573	823	5,795
1972	0.39	278.4	278.7	1972	8812	916	660	370	618	11,376
1973	0.41	271.7	271.8	1973	573	4900	509	367	549	6,898
1974	0.45	228.8	228.3	1974	411	312	2667	277	499	4,166
1975	0.70	231.1	229.9	1975	1572	214	162	1388	404	3,739
1976	0.68	143.1	142.5	1976	1328	636	87	66	725	2,841
1977	0.66	106.0	105.6	1977	1401	549	263	36	327	2,575
1978	0.58	110.5	110.4	1978	2257	594	232	111	154	3,347
1979	0.63	117.7	118.0	1979	2147	1031	271	106	121	3,677
1980	0.65	111.8	112.2	1980	471	935	449	118	99	2,072
1981	0.76	103.7	103.6	1981	888	202	400	192	93	1,775
1982	0.61	69.7	69.6	1982	787	340	77	153	109	1,466
1983	0.30	44.2	44.2	1983	1065	349	150	34	116	1,715
1984	0.33	55.1	55.2	1984	861	644	211	91	91	1,897
1985	0.27	60.8	60.9	1985	1906	507	379	124	107	3,024
1986	0.25	67.5	67.5	1986	1220	1193	317	237	145	3,112
1987	0.28	75.7	75.6	1987	1552	781	764	203	245	3,545
1988	0.32	86.2	86.2	1988	1836	960	483	472	277	4,028
1989	0.27	99.5	99.6	1989	3078	1089	569	286	444	5,467
1990	0.17	93.8	93.8	1990	4514	1930	683	357	458	7,942
1991	0.13	104.7	104.6	1991	5147	3111	1331	471	562	10,621
1992	0.13	124.7	124.7	1992	4384	3685	2227	953	739	11,989
1993	0.10	108.4	108.4	1993	1521	3145	2644	1598	1214	10,122
1994	0.09	85.9	85.9	1994	1885	1124	2323	1953	2077	9,361
1995	0.13	123.6	123.5	1995	2269	1411	841	1740	3017	9,278
1996	0.10	130.8	130.8	1996	9094	1636	1018	607	3430	15,784
1997	0.11	144.0	144.0	1997	3836	6724	1209	752	2985	15,507
1998	0.09	126.6	126.7	1998	3550	2824	4951	891	2752	14,967
1999	0.10	129.2	129.2	1999	2172	2653	2110	3700	2722	13,357
2000	0.07	125.6	125.6	2000	6941	1616	1974	1570	4777	16,878
2001	0.09	141.5	141.6	2001	1368	5282	1230	1502	4831	14,213
2002	0.07	104.1	104.2	2002	1851	1027	3966	923	4754	12,521
2003	0.08	109.7	109.8	2003	2809	1406	780	3014	4315	12,325
2004	0.08	115.0	115.1	2004	6157	2128	1066	591	5553	15,495
2005	0.08	106.3	106.3	2005	1759	4668	1613	808	4658	13,506

Table 15. Final 2005 estimates of Gulf of Maine/Georges Bank Atlantic herring SSB and total age 2+ biomass based on revised LAA.

	SSB	Biomass at age			000 mt		
	000 mt	2	3	4	5	6+	Total
1967	878.2	59.1	64.1	172.7	137.1	858.7	1291.7
1968	607.5	68.8	87.1	96.6	147.6	681.7	1081.8
1969	463.1	81.2	104.3	60.0	96.1	512.4	854.0
1970	438.6	134.4	103.8	127.3	53.3	304.4	723.2
1971	349.0	64.8	127.0	115.4	113.4	257.7	678.2
1972	347.0	308.4	70.2	96.8	75.9	182.9	734.2
1973	466.2	21.9	363.6	72.7	76.6	156.0	690.8
1974	362.3	16.2	23.8	360.3	51.6	123.2	575.1
1975	195.8	53.6	15.3	21.9	249.9	101.3	442.0
1976	121.9	35.6	48.5	11.4	12.2	156.6	264.2
1977	87.4	34.7	36.1	35.6	6.6	74.5	187.5
1978	96.7	60.5	42.1	32.2	21.2	43.1	199.2
1979	100.6	38.2	61.6	41.8	23.1	34.0	198.7
1980	108.0	11.6	53.7	55.1	27.2	33.6	181.1
1981	75.4	23.5	13.8	56.0	38.1	28.2	159.6
1982	63.7	23.0	26.0	11.5	33.3	29.8	123.5
1983	84.5	39.3	28.7	25.2	7.1	38.2	138.5
1984	106.2	18.4	52.7	32.3	19.7	27.2	150.3
1985	130.6	46.9	36.0	56.7	23.6	25.9	189.1
1986	182.1	42.7	77.6	46.3	46.7	35.0	248.3
1987	177.3	51.5	53.6	95.0	36.5	57.8	294.4
1988	177.1	43.0	69.5	56.6	74.9	61.5	305.4
1989	224.5	93.3	67.1	71.1	45.3	94.7	371.5
1990	335.9	152.1	123.5	82.0	58.8	103.6	520.0
1991	489.6	151.3	170.8	148.5	72.4	121.4	664.4
1992	663.9	117.5	211.1	206.7	133.3	139.0	807.6
1993	847.0	36.5	187.8	269.6	217.0	237.9	948.9
1994	780.0	42.4	60.7	238.1	261.4	357.2	959.9
1995	762.9	77.1	81.1	82.3	216.2	482.8	939.6
1996	825.9	328.3	101.7	106.9	79.1	586.5	1202.6
1997	1033.6	130.4	429.7	119.4	98.6	522.3	1300.4
1998	1098.5	102.9	168.3	483.2	110.6	473.3	1338.4
1999	1095.1	83.0	153.9	200.3	444.7	432.7	1314.6
2000	1255.5	331.1	118.8	202.1	204.0	797.8	1653.7
2001	1349.9	57.2	398.8	140.6	207.4	821.2	1625.2
2002	1163.4	60.9	74.2	425.1	123.2	798.7	1482.2
2003	1150.2	106.2	90.4	87.7	404.7	776.7	1465.8
2004	1142.2	182.9	146.6	114.8	85.4	999.5	1529.2
2005	1169.7	53.1	277.3	172.6	111.2	824.4	1438.7

Table 16. Gulf of Maine/Georges Bank Atlantic herring age 2+ F, landings and abundance
from the initial 2009 update (Base).

		000 mt							
		Obs	**Pred**	**Jan 1 abundance (000s)**					
	F	**CATCH**	**CATCH**	**2**	**3**	**4**	**5**	**6+**	
1967	0.27	302.7	302.7	3406	1707	1393	833	3675	11,014
1968	0.53	474.0	474.6	4722	2132	1068	872	2822	11,617
1969	0.56	393.7	393.6	3335	2265	1023	513	1772	8,908
1970	0.47	319.0	319.1	2860	1559	1059	478	1068	7,023
1971	0.65	342.9	342.9	2006	1457	794	539	788	5,584
1972	0.41	278.4	278.6	8798	856	622	339	566	11,180
1973	0.43	271.7	271.7	535	4799	467	339	493	6,632
1974	0.49	228.8	228.2	402	284	2546	248	442	3,921
1975	0.71	231.1	229.8	2293	201	142	1274	345	4,254
1976	0.68	143.1	142.6	1022	920	81	57	649	2,729
1977	0.66	106.0	105.7	1468	422	380	33	292	2,596
1978	0.61	110.5	110.4	2061	622	179	161	138	3,161
1979	0.63	117.7	117.9	2502	921	278	80	134	3,915
1980	0.64	111.8	112.1	395	1090	401	121	93	2,100
1981	0.80	103.7	103.7	593	171	473	174	93	1,503
1982	0.75	69.7	69.7	684	217	63	173	98	1,235
1983	0.40	44.2	44.2	934	264	84	24	105	1,412
1984	0.52	55.1	55.2	777	511	145	46	71	1,550
1985	0.42	60.8	60.9	1748	377	248	70	57	2,500
1986	0.39	67.5	67.5	1037	936	202	133	68	2,376
1987	0.42	75.7	75.6	1310	573	517	112	111	2,624
1988	0.47	86.2	86.2	1525	707	309	279	120	2,941
1989	0.43	99.5	99.5	2520	782	363	159	205	4,028
1990	0.28	93.8	93.8	3601	1345	418	194	194	5,751
1991	0.24	104.7	104.6	4132	2225	831	258	239	7,686
1992	0.23	124.7	124.6	3481	2651	1427	533	319	8,411
1993	0.18	108.4	108.4	1148	2263	1723	928	554	6,615
1994	0.16	85.9	85.8	1431	783	1543	1175	1011	5,943
1995	0.25	123.6	123.3	1684	997	545	1075	1523	5,823
1996	0.19	130.8	130.8	6873	1076	637	349	1660	10,595
1997	0.19	144.0	144.0	2622	4653	729	431	1360	9,795
1998	0.18	126.6	126.6	2394	1768	3137	491	1208	8,999
1999	0.20	129.2	129.2	1198	1644	1214	2154	1166	7,375
2000	0.16	125.6	125.6	4031	807	1107	817	2235	8,997
2001	0.20	141.5	141.6	898	2825	565	776	2140	7,204
2002	0.17	104.1	104.3	1086	604	1899	380	1959	5,927
2003	0.18	109.7	109.9	2514	747	415	1306	1609	6,592
2004	0.18	115.0	115.3	3169	1720	511	284	1995	7,679
2005	0.18	106.3	106.4	1615	2163	1174	349	1555	6,857
2006	0.20	112.4	112.5	784	1107	1483	805	1306	5,485
2007	0.21	111.8	111.8	2801	524	741	992	1412	6,470
2008	0.18	89.7	89.7	266	1864	349	493	1600	4,572

Table 17. Estimates of Gulf of Maine/Georges Bank Atlantic herring SSB and total age 2+
biomass from the initial 2009 update.

	000 mt	Biomass at age		000 mt			
	SSB	2	3	4	5	6+	Total
1967	882.6	55.5	64.9	169.3	138.3	867.3	1295.3
1968	604.5	66.6	81.9	97.8	144.8	688.7	1079.6
1969	454.9	79.0	100.6	56.2	97.0	512.2	844.9
1970	419.9	133.3	100.2	121.6	49.5	302.2	706.8
1971	323.7	62.8	124.0	109.7	106.6	246.5	649.6
1972	320.1	307.9	65.6	91.1	69.5	167.5	701.7
1973	433.6	20.4	356.1	66.7	70.8	140.1	654.0
1974	327.2	15.9	21.7	344.0	46.1	109.1	536.7
1975	179.3	78.2	14.3	19.2	229.4	86.6	427.6
1976	124.8	27.4	70.1	10.6	10.6	140.2	258.9
1977	86.8	36.4	27.8	51.5	6.1	66.6	188.4
1978	94.3	55.2	44.2	24.8	30.8	38.8	193.7
1979	96.8	44.5	55.0	42.9	17.4	37.6	197.4
1980	111.3	9.7	62.6	49.2	27.9	31.6	180.9
1981	74.0	15.7	11.7	66.1	34.4	28.2	156.1
1982	49.8	20.0	16.6	9.3	37.8	26.7	110.4
1983	59.2	34.5	21.7	14.1	5.0	34.5	109.8
1984	61.6	16.6	41.9	22.2	9.9	21.1	111.7
1985	74.8	43.0	26.8	37.1	13.4	13.7	133.9
1986	103.3	36.3	60.9	29.5	26.1	16.4	169.3
1987	105.7	43.5	39.3	64.4	20.0	26.2	193.4
1988	108.9	35.7	51.2	36.3	44.2	26.7	194.0
1989	123.5	76.3	48.2	45.3	25.1	43.6	238.6
1990	182.8	121.3	86.1	50.1	31.9	43.9	333.3
1991	251.2	121.5	122.2	92.8	39.7	51.7	427.8
1992	354.4	93.3	151.9	132.5	74.6	60.0	512.2
1993	458.8	27.5	135.1	175.7	126.0	108.6	572.9
1994	417.3	32.2	42.3	158.2	157.4	173.8	563.8
1995	366.8	57.2	57.3	53.3	133.6	243.6	545.1
1996	395.7	248.1	66.9	67.0	45.5	283.9	711.4
1997	530.7	89.2	297.3	71.9	56.5	238.0	752.9
1998	537.0	69.4	105.4	306.2	61.0	207.8	749.8
1999	511.3	45.8	95.3	115.2	258.9	185.5	700.6
2000	550.9	192.3	59.3	113.3	106.2	373.3	844.4
2001	560.3	37.6	213.3	64.6	107.1	363.7	786.3
2002	476.2	35.7	43.6	203.5	50.7	329.1	662.7
2003	446.5	95.0	48.0	46.7	175.4	289.7	654.9
2004	455.0	94.1	118.5	55.0	41.1	359.0	667.7
2005	457.4	48.8	128.5	125.6	48.0	275.3	626.2
2006	437.7	31.7	64.6	149.5	109.7	244.2	599.6
2007	371.1	109.2	36.4	71.8	128.7	237.2	583.3
2008	400.0	5.9	134.4	37.5	65.2	280.0	523.1

Table 18. Gulf of Maine/Georges Bank Atlantic herring age 2+ F, landings and abundance
from 2009 TRAC preferred model.

| | | 000 mt | | Jan 1 abundance (millions) | | | | | |
	F	**Obs CATCH**	**Pred CATCH**	**2**	**3**	**4**	**5**	**6+**	**Total**
1967	0.27	302.7	302.7	3424	1712	1397	832	3668	11033
1968	0.53	474.0	474.6	4735	2143	1072	874	2817	11641
1969	0.56	393.7	393.6	3342	2272	1028	514	1771	8929
1970	0.47	319.0	319.1	2865	1563	1063	481	1069	7041
1971	0.65	342.9	342.9	2012	1462	798	542	791	5605
1972	0.41	278.4	278.6	8758	862	626	342	571	11159
1973	0.43	271.7	271.7	539	4781	470	342	498	6630
1974	0.49	228.8	228.2	405	286	2538	250	446	3925
1975	0.71	231.1	229.8	2290	203	143	1270	348	4254
1976	0.68	143.1	142.6	1024	919	81	57	650	2732
1977	0.66	106.0	105.7	1468	424	381	34	293	2599
1978	0.60	110.5	110.4	2060	624	180	162	139	3163
1979	0.63	117.7	117.9	2499	922	279	81	134	3916
1980	0.63	111.8	112.1	395	1091	402	122	94	2104
1981	0.80	103.7	103.7	596	172	474	175	94	1510
1982	0.74	69.7	69.7	695	220	63	175	99	1252
1983	0.39	44.2	44.2	957	272	86	25	107	1446
1984	0.50	55.1	55.2	798	530	151	48	73	1599
1985	0.40	60.8	60.9	1767	396	263	75	60	2562
1986	0.37	67.5	67.5	1060	965	217	144	74	2459
1987	0.39	75.7	75.6	1330	598	545	122	123	2717
1988	0.44	86.2	86.2	1555	735	331	301	135	3057
1989	0.40	99.5	99.6	2556	823	389	175	231	4173
1990	0.26	93.8	93.8	3707	1403	452	213	223	5998
1991	0.23	104.7	104.6	4236	2332	883	284	274	8010
1992	0.22	124.7	124.6	3447	2758	1518	575	364	8661
1993	0.17	108.4	108.4	1552	2267	1814	999	617	7250
1994	0.14	85.9	85.9	1896	1072	1567	1254	1117	6905
1995	0.21	123.6	123.6	2184	1344	760	1111	1680	7079
1996	0.17	130.8	130.8	6305	1454	895	506	1859	11019
1997	0.18	144.0	144.1	2431	4357	1005	619	1634	10046
1998	0.17	126.6	126.7	2245	1665	2985	688	1543	9127
1999	0.19	129.2	129.3	1032	1558	1156	2071	1549	7366
2000	0.16	125.6	125.6	3828	700	1057	784	2455	8823
2001	0.20	141.5	141.5	1033	2684	491	741	2271	7219
2002	0.17	104.1	104.2	1275	694	1805	330	2025	6129
2003	0.17	109.7	109.8	2739	880	479	1245	1625	6968
2004	0.17	115.0	115.1	3775	1887	606	330	1977	8575
2005	0.16	106.3	106.3	1616	2613	1306	419	1597	7552
2006	0.17	112.4	112.5	1318	1128	1824	911	1407	6588
2007	0.17	111.8	111.8	3252	909	777	1257	1598	7793
2008	0.14	89.7	89.6	265	2247	628	537	1973	5650

25

Table 19. Gulf of Maine/Georges Bank Atlantic herring SSB and total Jan 1 age 2+ biomass from 2009 TRAC preferred model.

| | 000 mt | Jan 1 Biomass at age | | | 000s mt | | age 2+ |
	SSB	2	3	4	5	6+	Total
1967	881.9	55.8	65.1	169.7	138.1	865.8	1294.5
1968	604.7	66.8	82.3	98.0	145.1	687.4	1079.6
1969	455.8	79.2	100.9	56.5	97.3	511.9	845.8
1970	421.7	133.5	100.5	122.1	49.8	302.6	708.5
1971	326.2	63.0	124.4	110.2	107.2	247.6	652.4
1972	322.2	306.5	66.1	91.8	70.1	169.0	703.5
1973	434.4	20.6	354.8	67.2	71.3	141.5	655.3
1974	327.6	16.0	21.8	342.9	46.5	110.1	537.4
1975	179.6	78.1	14.5	19.3	228.8	87.4	428.0
1976	125.1	27.4	70.1	10.7	10.7	140.4	259.3
1977	87.2	36.4	27.9	51.6	6.2	66.7	188.8
1978	94.7	55.2	44.3	24.9	30.8	39.0	194.2
1979	97.2	44.5	55.1	43.0	17.6	37.8	197.9
1980	111.8	9.7	62.6	49.3	28.1	31.8	181.5
1981	74.7	15.8	11.7	66.3	34.6	28.4	156.9
1982	50.9	20.3	16.8	9.4	38.1	27.0	111.6
1983	61.2	35.3	22.4	14.4	5.2	35.2	112.5
1984	65.0	17.1	43.4	23.1	10.3	21.8	115.7
1985	80.0	43.5	28.1	39.3	14.2	14.5	139.6
1986	110.4	37.1	62.8	31.6	28.2	17.8	177.6
1987	114.3	44.2	41.0	67.8	21.9	28.9	203.8
1988	119.2	36.4	53.2	38.7	47.7	30.0	206.1
1989	135.9	77.4	50.7	48.6	27.7	49.2	253.5
1990	199.2	124.9	89.8	54.2	35.2	50.3	354.4
1991	272.0	124.5	128.0	98.5	43.7	59.3	454.0
1992	380.4	92.4	158.0	140.9	80.4	68.4	540.0
1993	491.1	37.2	135.4	185.1	135.7	121.0	614.3
1994	464.7	42.7	57.9	160.6	167.9	192.1	621.1
1995	440.5	74.2	77.3	74.3	138.1	268.9	632.8
1996	480.5	227.6	90.5	94.1	66.0	317.8	796.0
1997	596.4	82.7	278.4	99.2	81.0	286.0	827.3
1998	585.4	65.1	99.3	291.3	85.5	265.4	806.6
1999	540.5	39.4	90.4	109.7	249.0	246.2	734.7
2000	561.3	182.6	51.4	108.2	101.8	409.9	853.9
2001	559.4	43.2	202.6	56.1	102.3	386.0	790.2
2002	479.5	41.9	50.2	193.5	44.0	340.2	669.8
2003	459.6	103.5	56.6	53.9	167.3	292.5	673.7
2004	485.3	112.1	130.0	65.3	47.7	355.8	710.9
2005	512.3	48.8	155.2	139.7	57.8	282.7	684.2
2006	507.6	53.3	65.8	183.8	124.2	263.1	690.2
2007	460.8	126.8	63.1	75.3	163.0	268.5	696.7
2008	515.6	5.9	162.0	67.5	71.1	345.3	651.7

Table 20. Projected landings (mt), total age 2+ biomass (mt) and SSB (mt) for the Gulf of Maine/Georges Bank Atlantic herring under a status quo F=0.14.

Landings (mt)

	- 1 STD DEV	Average	+ 1 STD DEV
2009	71,684	82,403	93,122
2010	70,099	81,154	92,209
2011	69,342	82,625	95,908

Total Biomass (mt)

	- 1 STD DEV	Average	+ 1 STD DEV
2009	544,107	627,849	711,591
2010	528,730	608,473	688,216
2011	526,997	616,614	706,231

SSB (mt)

	- 1 STD DEV	Average	+ 1 STD DEV
2009	396,727	460,343	523,959
2010	385,888	439,952	494,016
2011	378,994	444,532	510,070
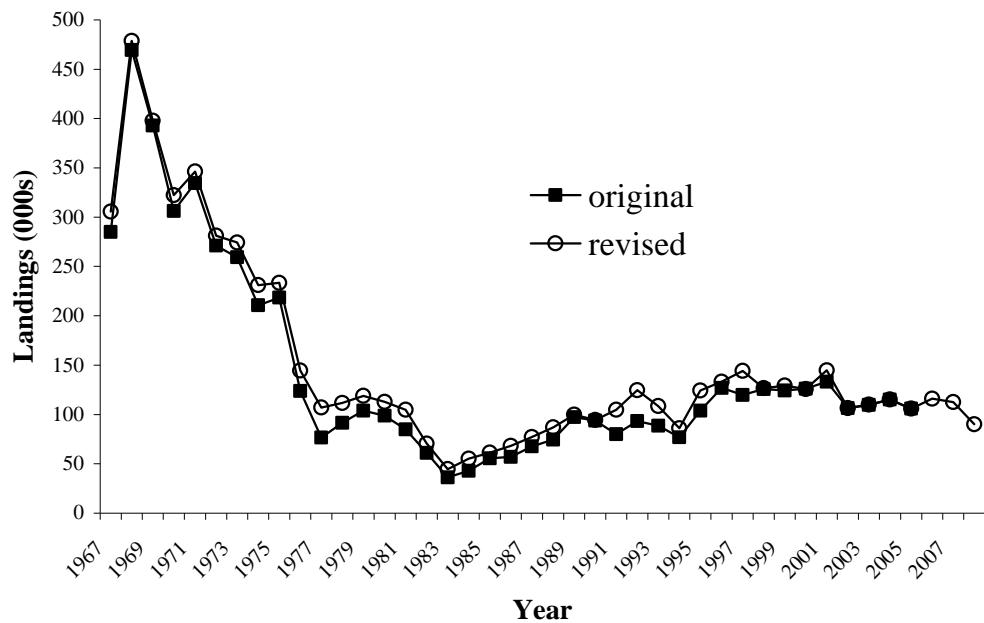
Figure 1. Atlantic herring total landings (000s mt) from the Gulf of Maine/Georges Bank - original from 2005 assessment and revised estimates.
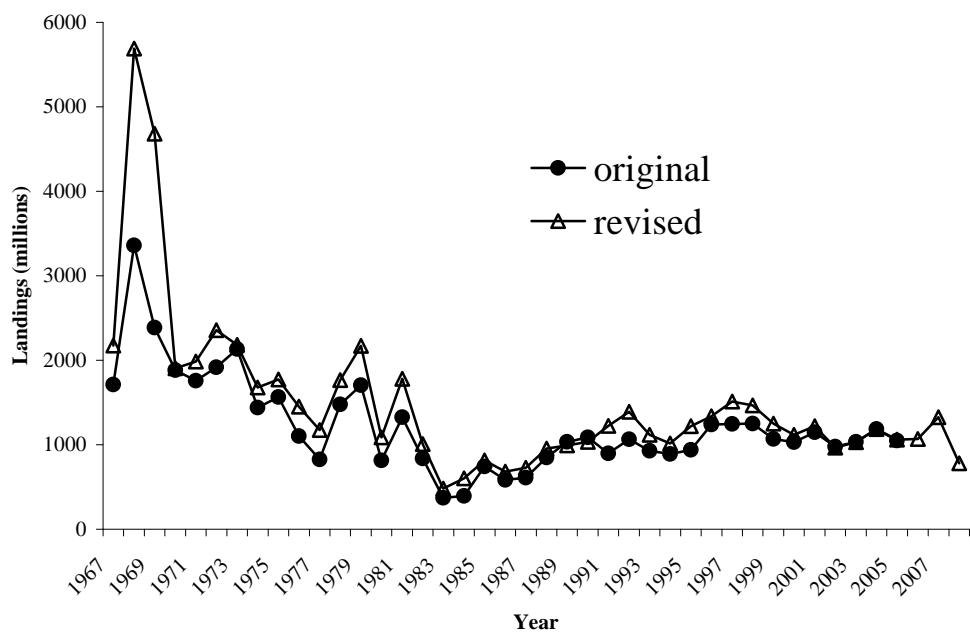
Figure 2. Atlantic herring age 2+ landing (millions of fish) from the Gulf of Maine/Georges Bank; original from 2005 assessment and revised CAA estimates.

28
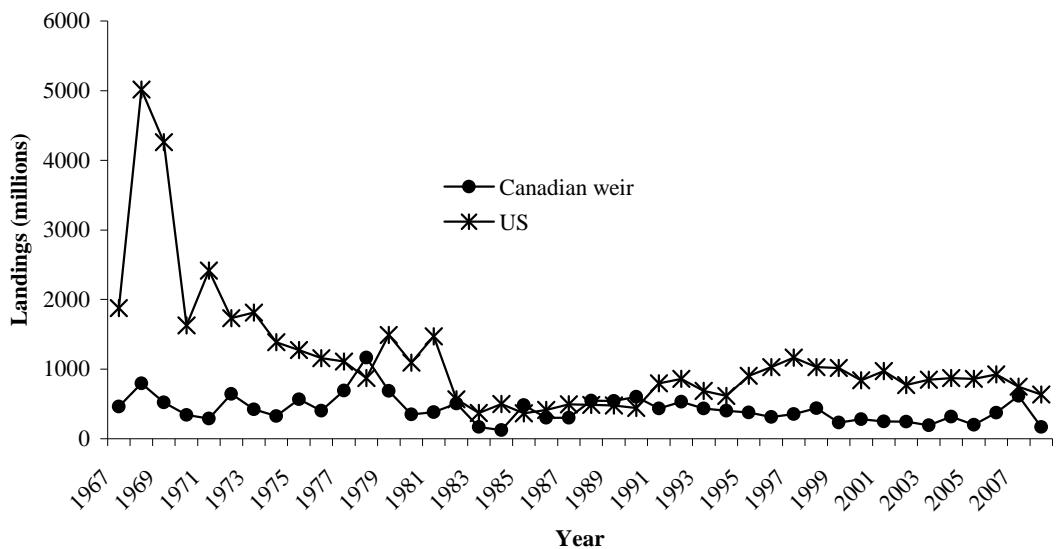
Figure 3. USA and Canadian landings (millions of fish) of Atlantic herring from the Gulf of Maine/Georges Bank.
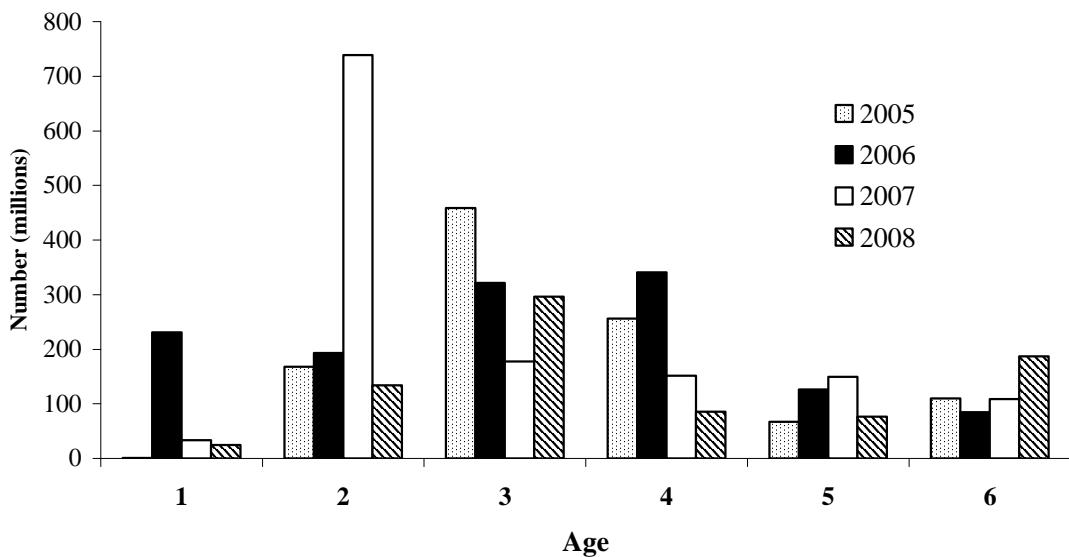
Figure 4. Gulf of Maine/Georges Bank Atlantic herring landings at age 2005-2008.
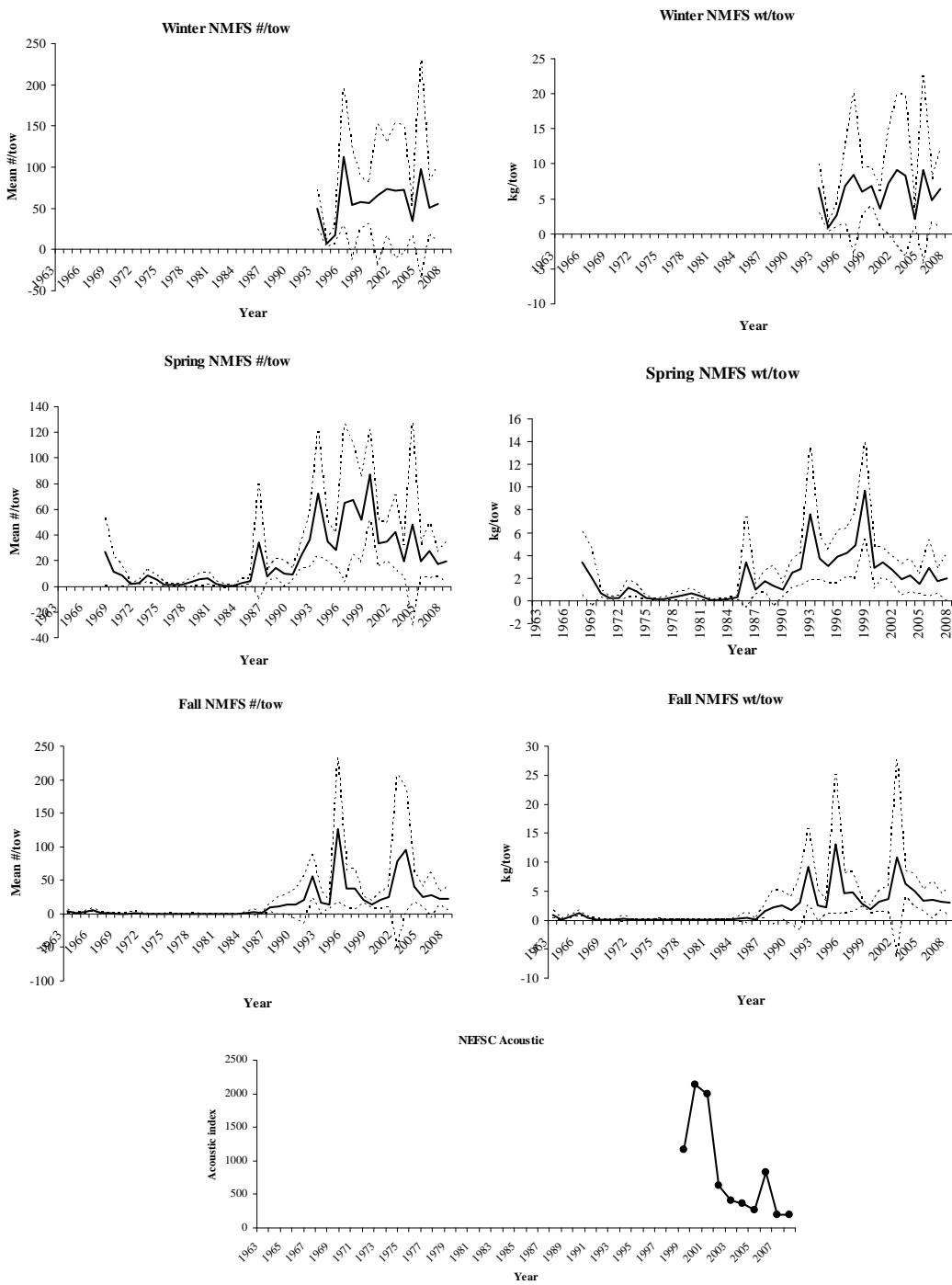
Figure 5. NMFS survey indices of abundance (stratified mean #/tow and kg/tow, $\pm$ 95% CI) for Atlantic herring in winter, spring, fall and acoustic surveys.
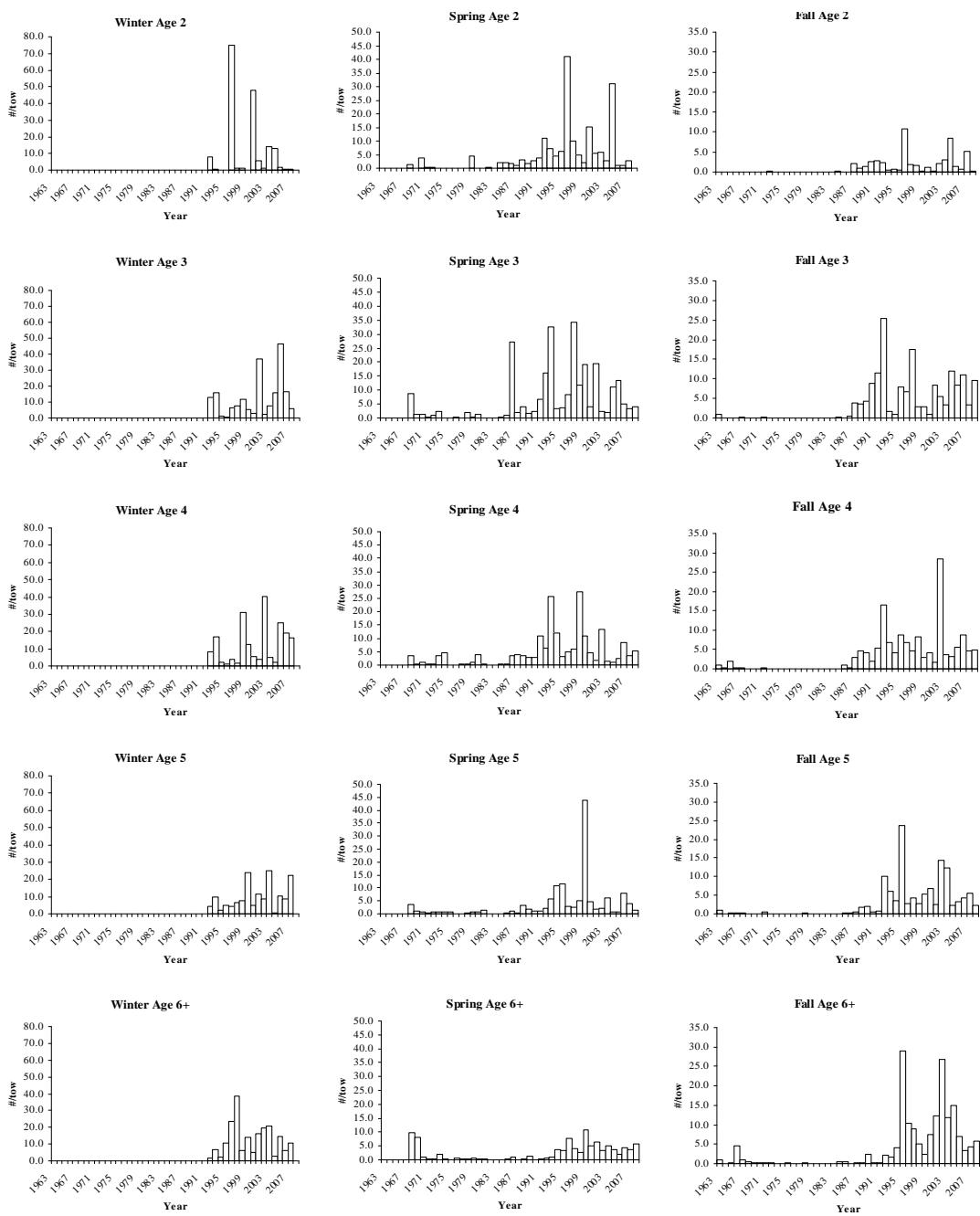
Figure 6. NMFS winter, spring and fall survey indices of abundance at age (mean #/tow) for
Gulf of Maine/Georges Bank Atlantic herring.

31

Atl. Herring Fishing Mortality
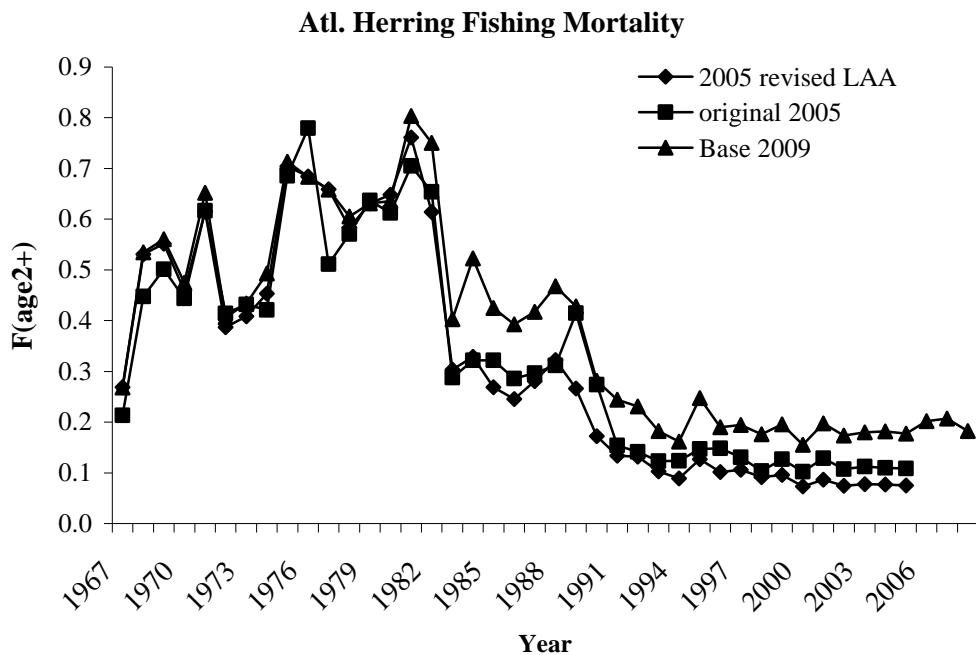
Figure 7. ASAP catch at age model estimates of fully recruited fishing mortality (age 2+) for Gulf of Maine/Georges Bank Atlantic herring from original 2005 assessment, 2005 with updated LAA and initial update through 2008 with revised LAA (Base 2009).

Atl. Herring Total Biomass
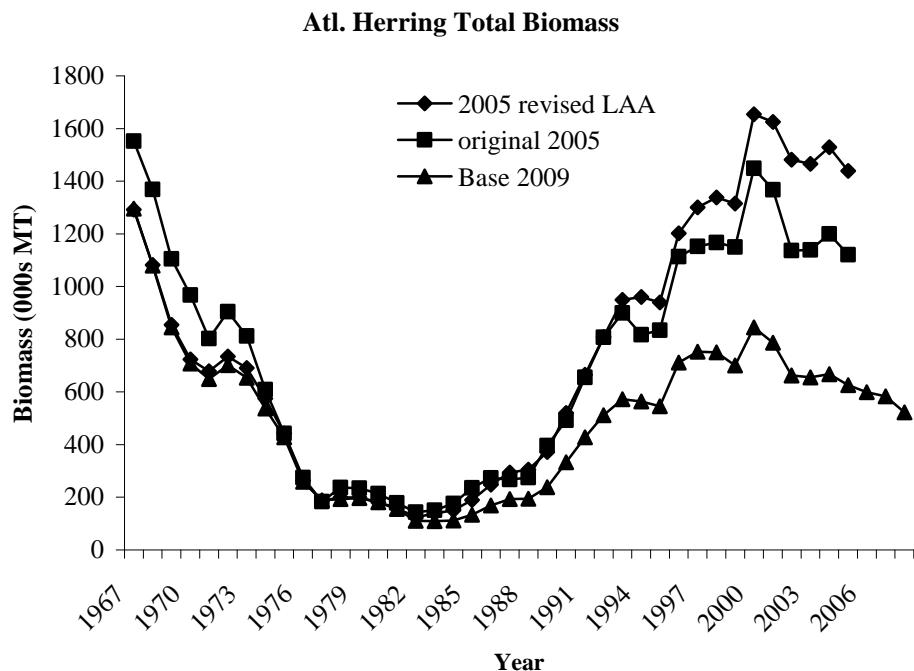
Figure 8. ASAP catch at age model estimates of total stock (age 2+) biomass for Gulf of Maine/Georges Bank Atlantic herring from original 2005 assessment, 2005 with updated LAA and initial update through 2008 with revised LAA (Base 2009).

Atl. Herring Spawning Stock Biomass
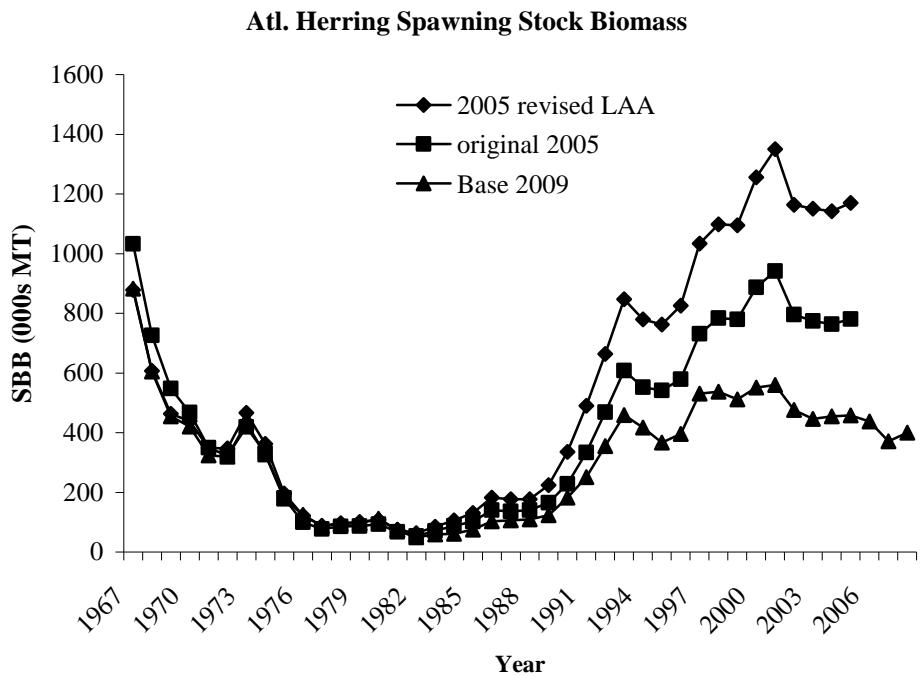
Figure 9. ASAP catch at age model estimates of spawning biomass for Gulf of Maine/Georges Bank Atlantic herring from original 2005 assessment, 2005 with updated LAA and initial update through 2008 with revised LAA.

Atl herring Age 2 Abundance
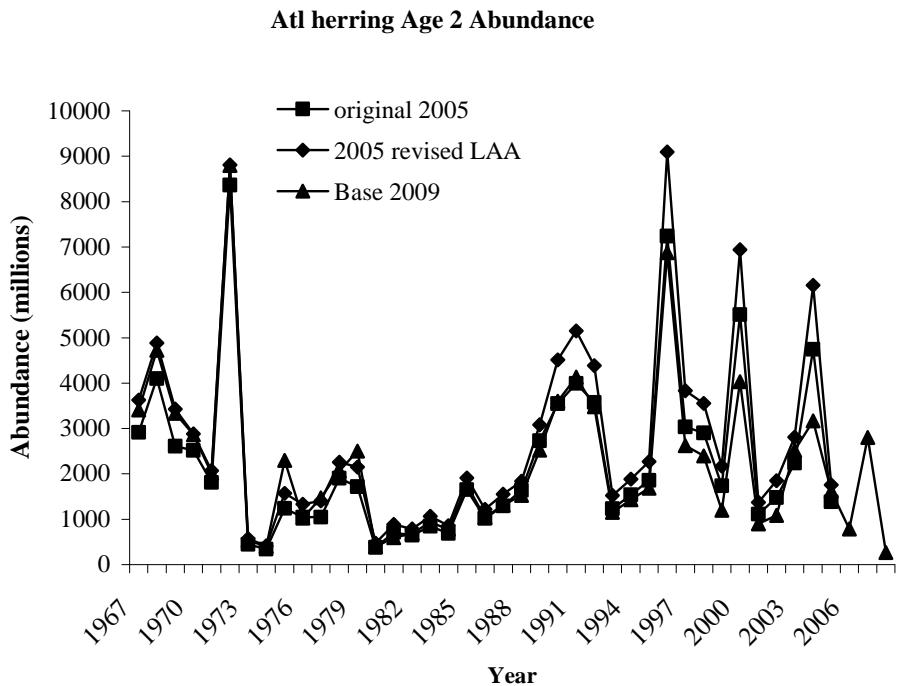
Figure 10. ASAP catch at age model estimates of total age 2+ abundance for Gulf of Maine/Georges Bank Atlantic herring from original 2005 assessment, 2005 with updated LAA and initial update through 2008 with revised LAA (Base 2009).

Atl. Herring Fishing Mortality
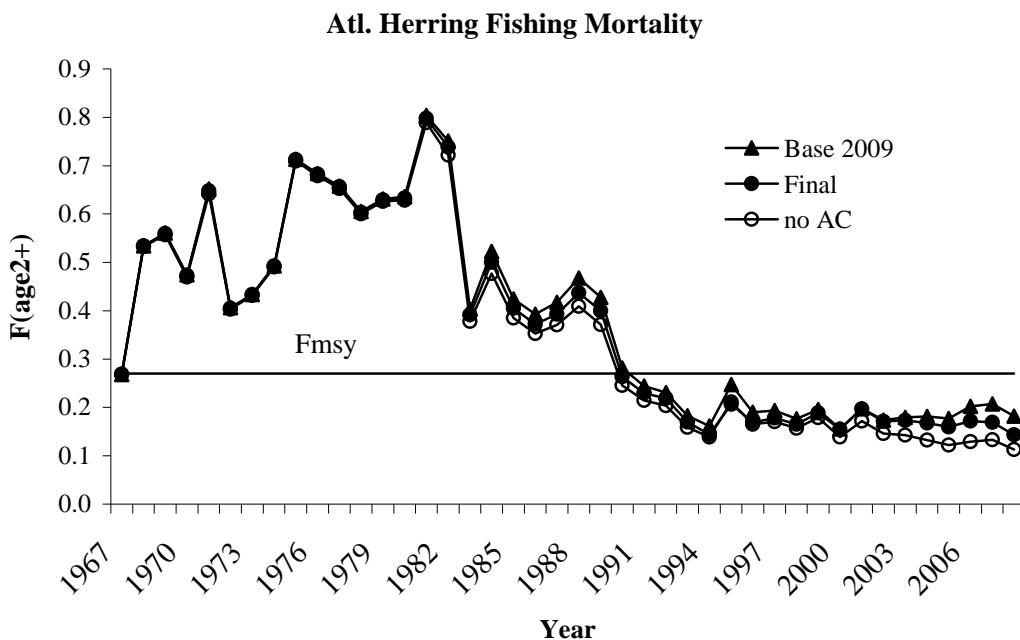
Figure 11. ASAP catch at age model estimates of fully recruited fishing mortality (age 2+) for Gulf of Maine/Georges Bank Atlantic herring for update through 2008 (Base 2009), model without the NMFS acoustic survey indices and the final model without the NMFS acoustic or winter survey indices.

Atl. Herring Total Biomass
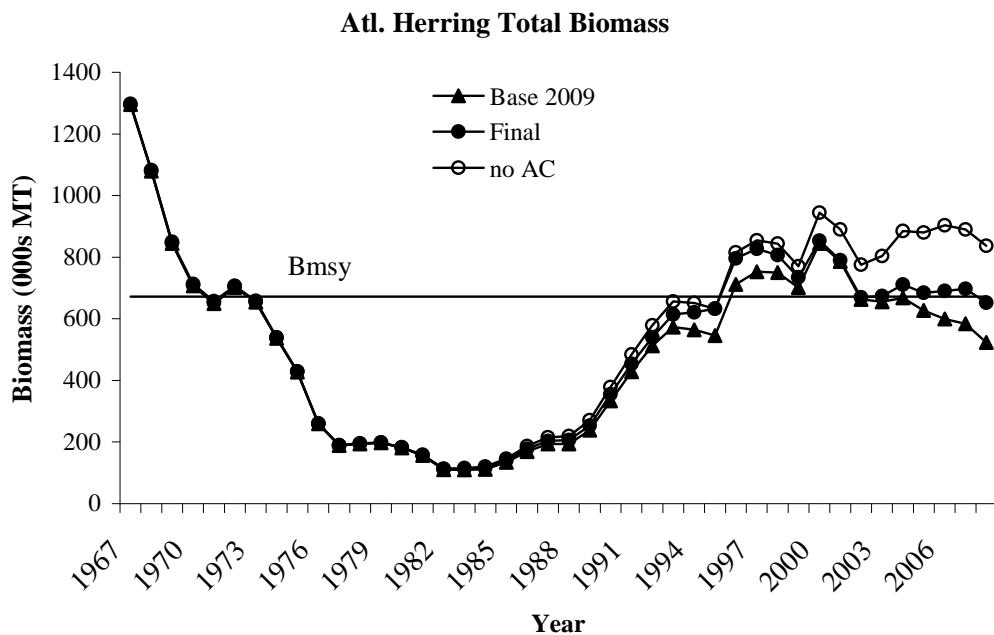
Figure 12. ASAP catch at age model estimates of total age 2+ biomass for Gulf of Maine/Georges Bank Atlantic herring for update through 2008 (Base 2009), model without the NMFS acoustic survey indices and the final model without the NMFS acoustic or winter survey indices.

34

Atl. Herring Spawning Stock Biomass
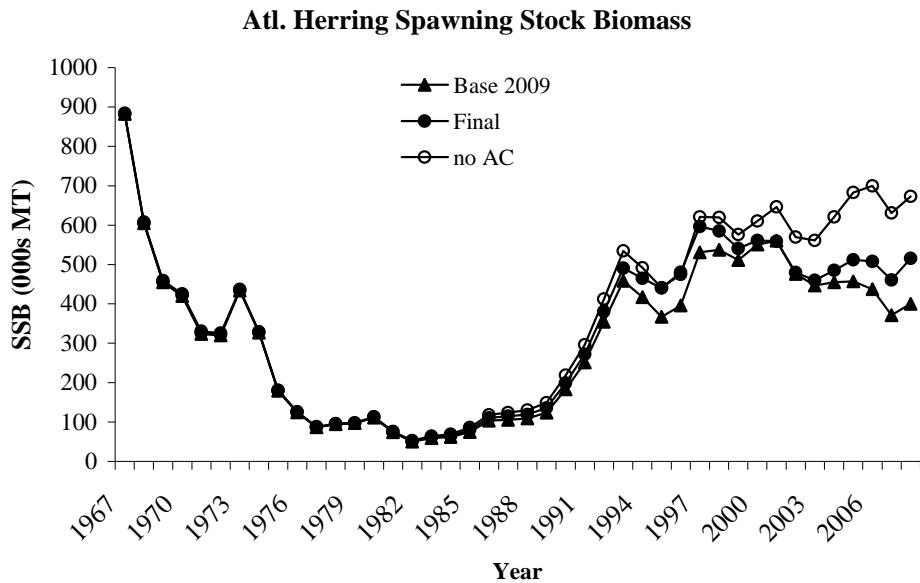
Figure 13. ASAP catch at age model estimates of spawning stock biomass for Gulf of Maine/Georges Bank Atlantic herring for update through 2008 (Base 2009), model without the NMFS acoustic survey indices and the final model without the NMFS acoustic or winter survey indices.

Atl herring Age 2 + Abundance
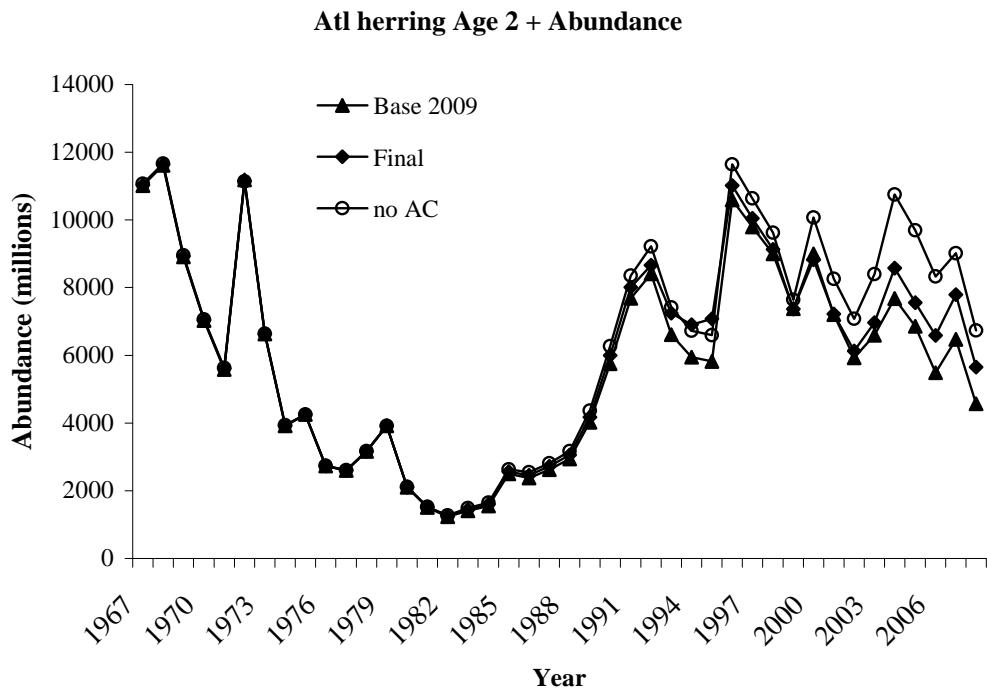
Figure 14. ASAP catch at age model estimates of recruitment (age 2 abundance) for Gulf of Maine/Georges Bank Atlantic herring for update through 2008 (Base 2009), model without the NMFS acoustic indices and the final model without the NMFS acoustic or winter survey indices.
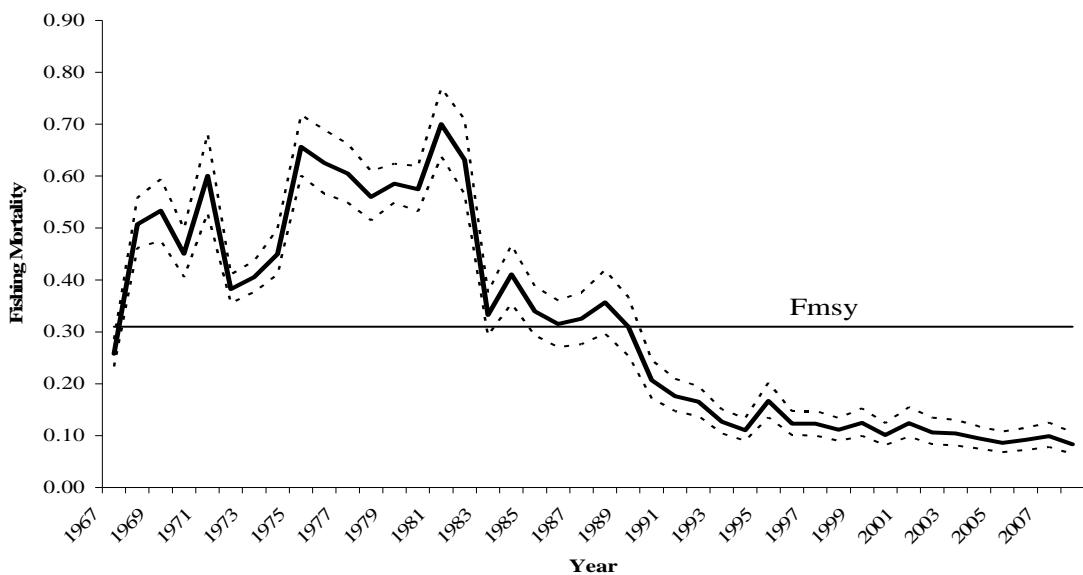
Figure 15. Estimates of median fishing mortality (age 2+) $\pm$ 95% CI for Gulf of Maine/Georges Bank Atlantic herring from ASAP landings at age model without the NMFS acoustic or winter survey indices.
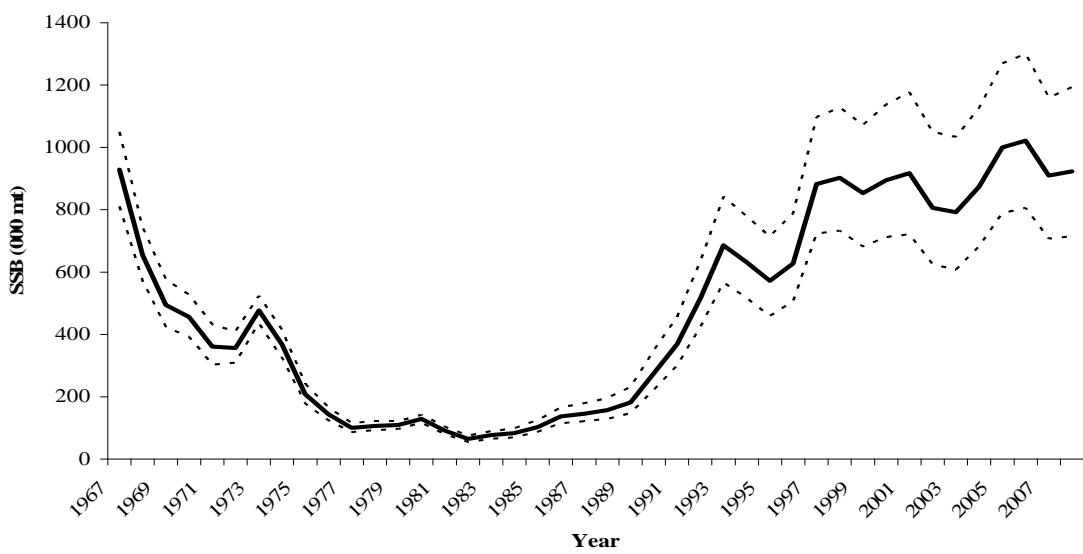
Figure 16. Estimates of median spawning stock biomass (mt) $\pm$ 95% CI for Gulf of Maine/Georges Bank Atlantic herring from ASAP landings at age model without the NMFS acoustic or winter survey indices.

36
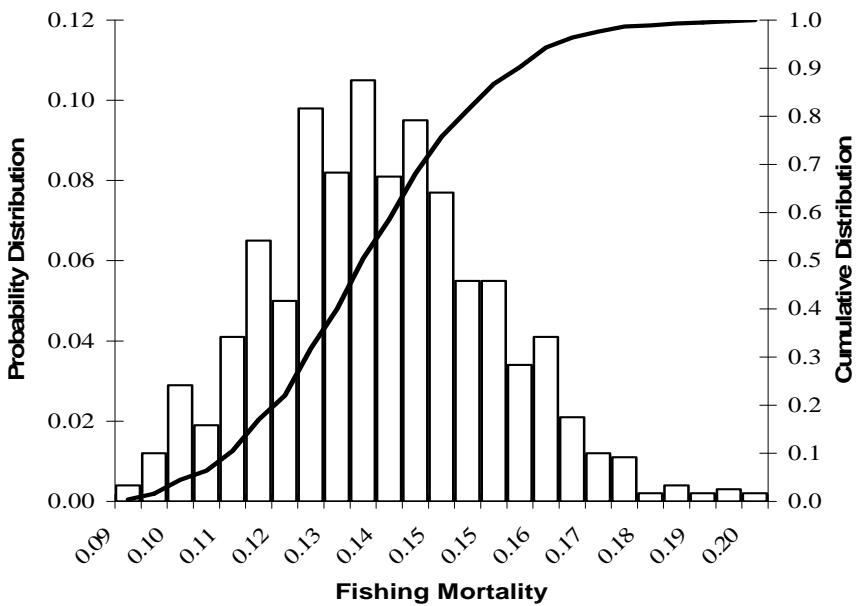
Figure 17. Probability distribution of fully recruited fishing mortality (age 2+) for Gulf of Maine/Georges Bank Atlantic herring from ASAP landings at age model without the NMFS acoustic or winter survey indices. Distribution from bootstrap estimates using MCMC.
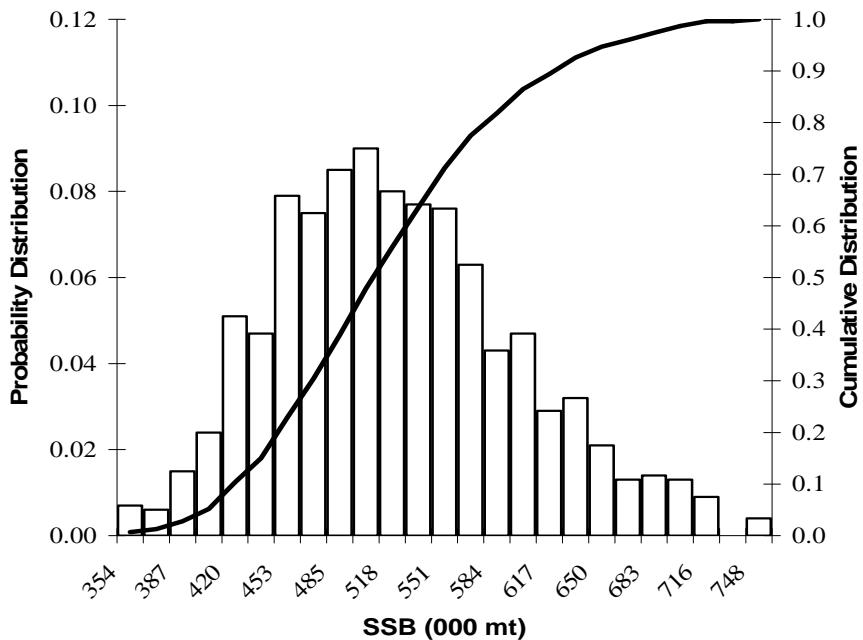
Figure 18. Probability distribution of SSB for Gulf of Maine/Georges Bank Atlantic herring from ASAP landings at age model without the NMFS acoustic or winter survey indices. Distribution from bootstrap estimates using MCMC.

Annual Total Biomass 2008
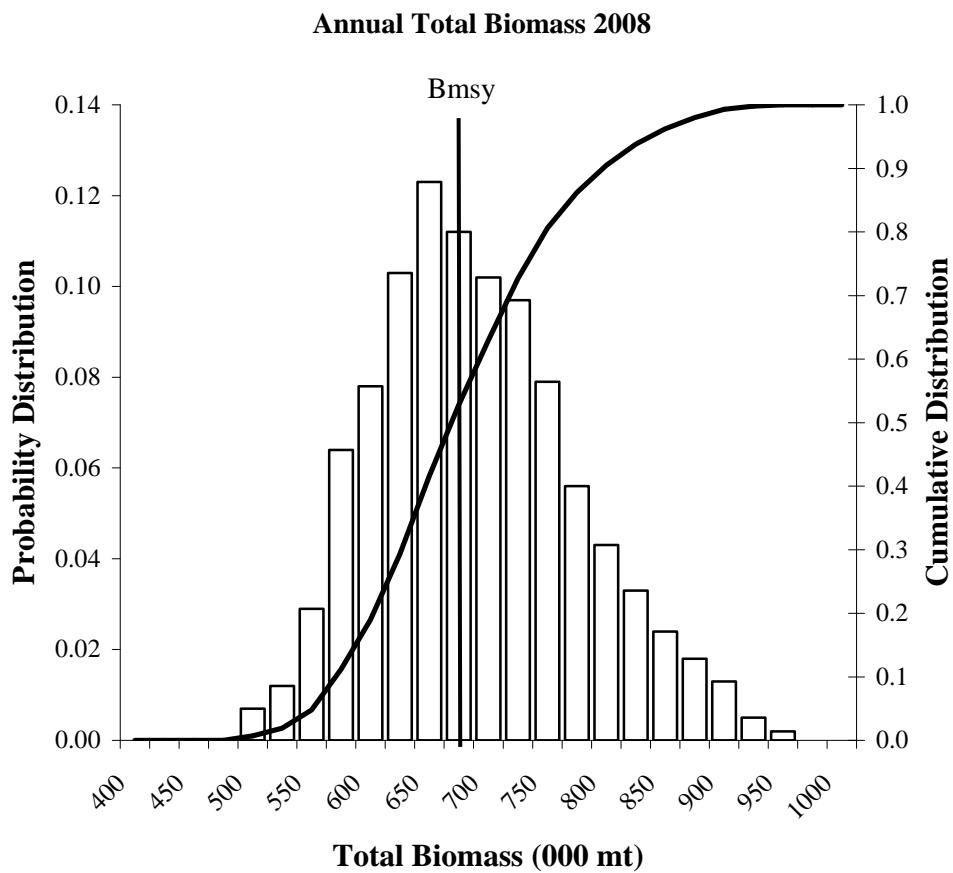
Figure 19. Probability distribution of total age 2+ biomass of Gulf of Maine/Georges Bank Atlantic herring from ASAP landings at age model without the NMFS acoustic or winter survey indices. Distribution from bootstrap estimates using MCMC. B_{MSY} equals 670,600 mt.

Figure 20. Retrospective pattern of fishing mortality (age 2+) from final Gulf of Maine/Georges Bank Atlantic herring ASAP model without the NMFS acoustic or winter survey indices.
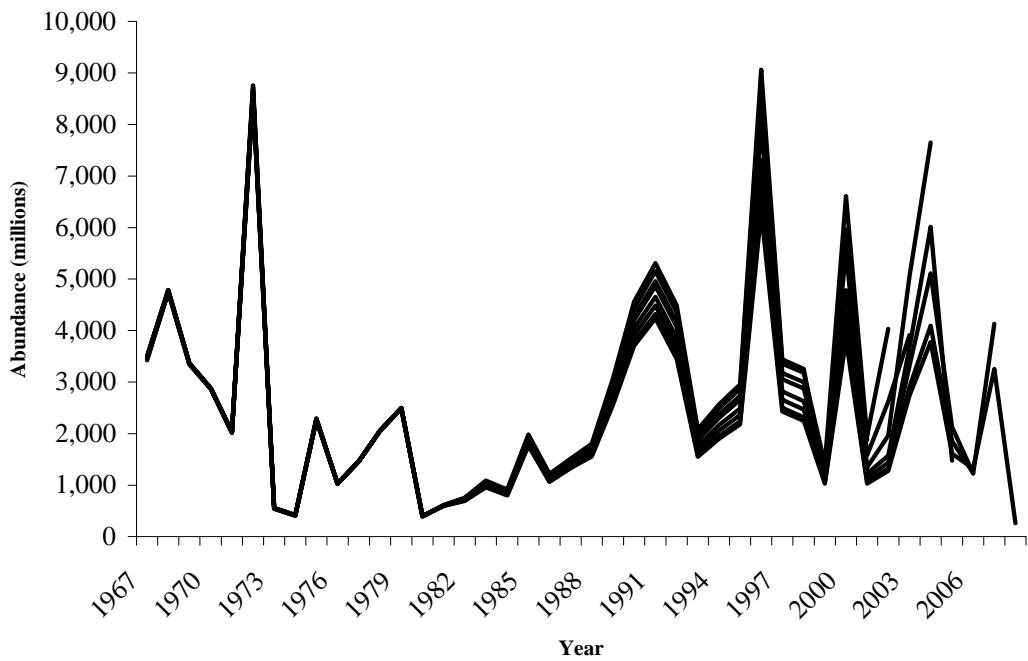
Figure 21. Retrospective pattern of recruitment (age 2 abundance) from final Gulf of Maine/Georges Bank Atlantic herring ASAP model without the NMFS acoustic or winter survey indices.
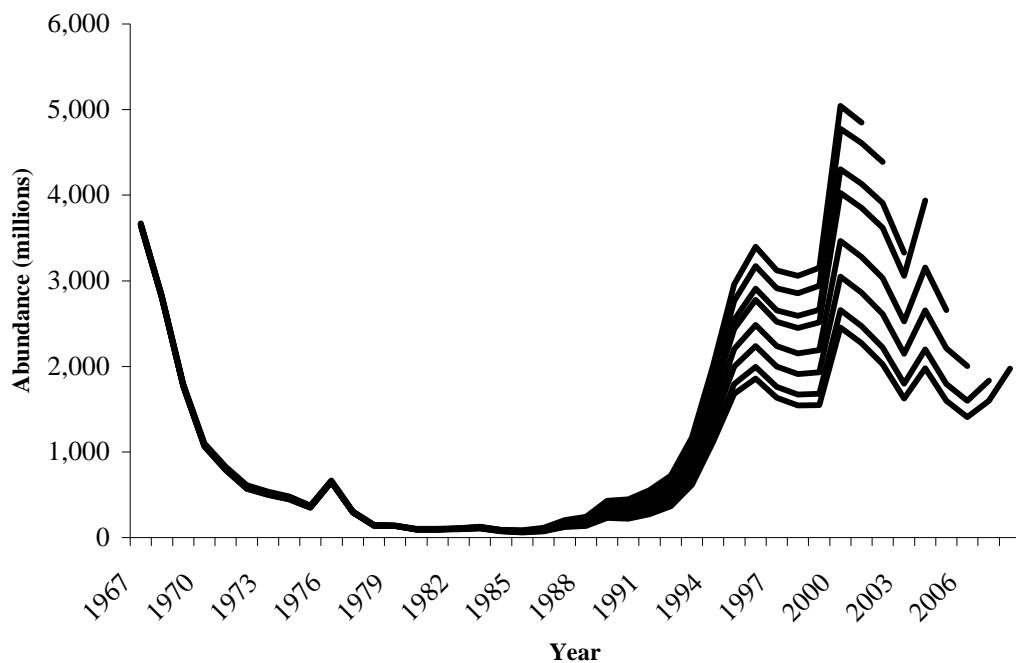
Figure 22. Retrospective pattern of age 6+ abundance from final Gulf of Maine/Georges Bank Atlantic herring ASAP model without the NMFS acoustic or winter survey indices.
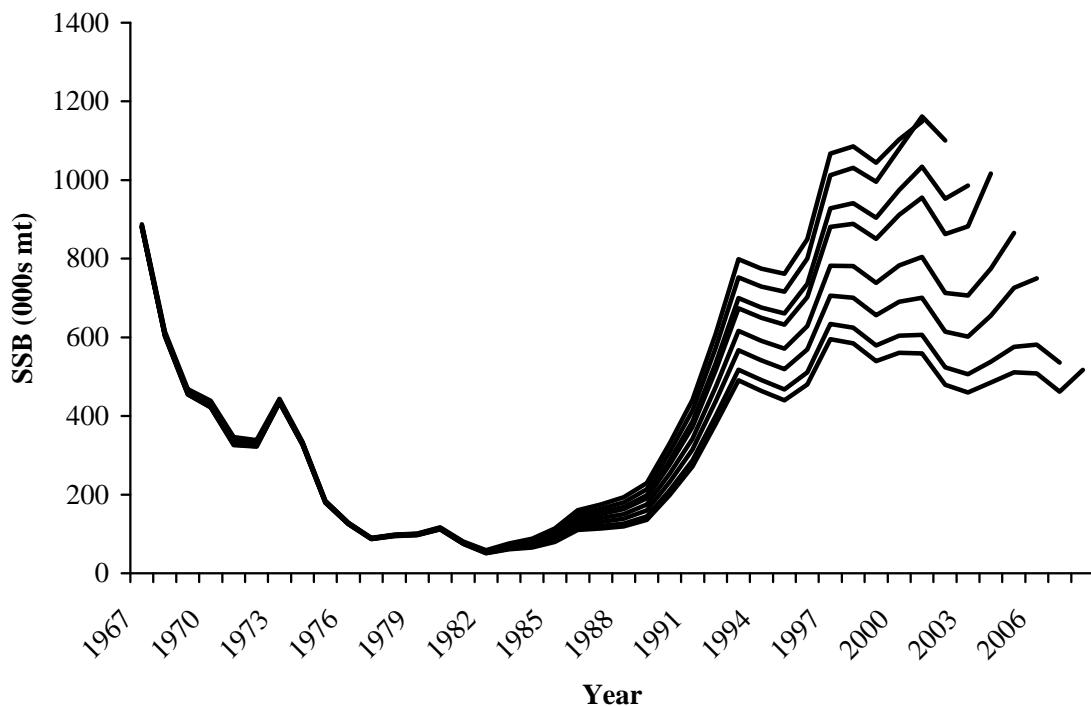
Figure 23. Retrospective pattern of SSB from final Gulf of Maine/Georges Bank Atlantic herring ASAP model without the NMFS acoustic or winter survey indices.
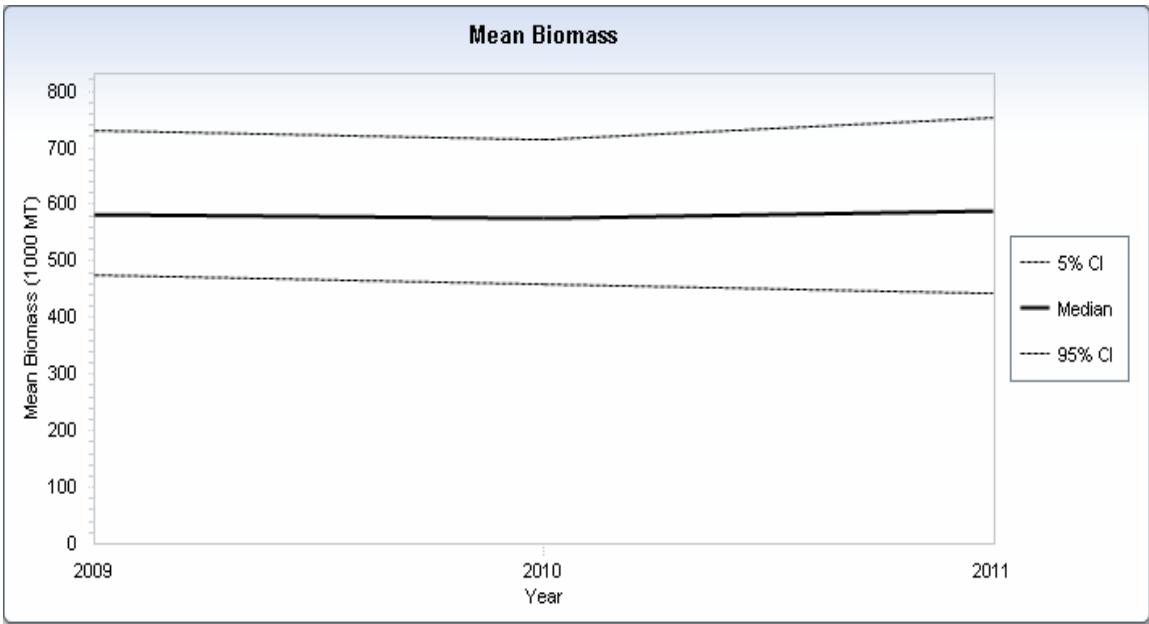
Figure 24. Median of mean age 2+ biomass (mt) with + 95% CI projected through 2011 for status quo F=0.14, based on MCMC results of final ASAP model.
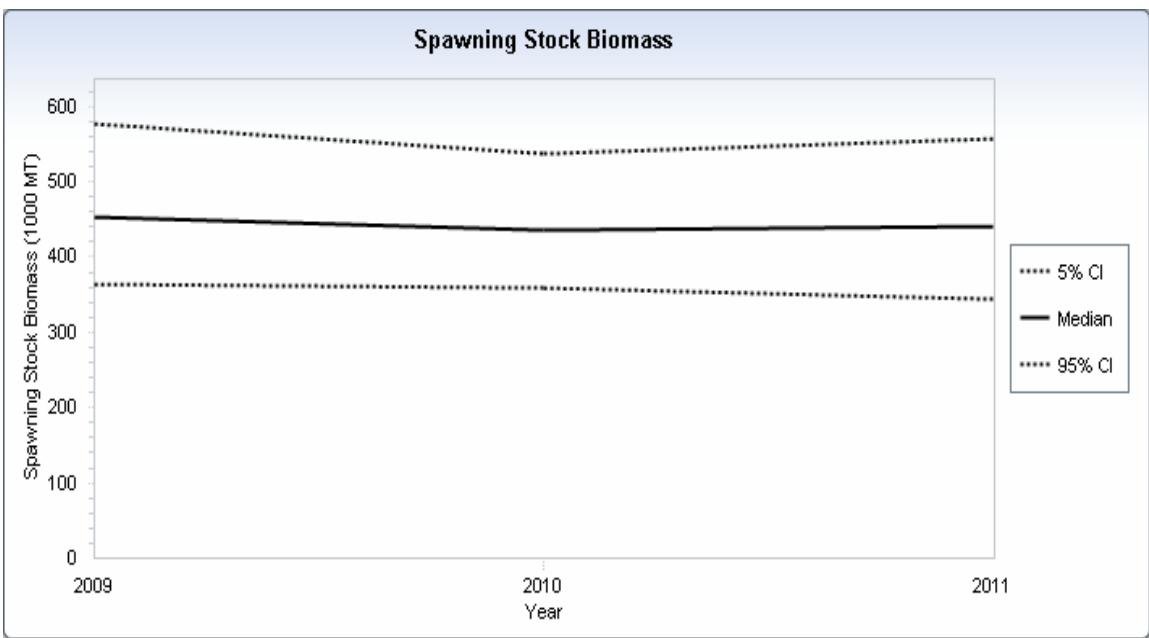
Figure 25. Median of spawning stock biomass (mt) ± 95% CI projected through 2011 for status quo F=0.14, based on MCMC results of final ASAP model.
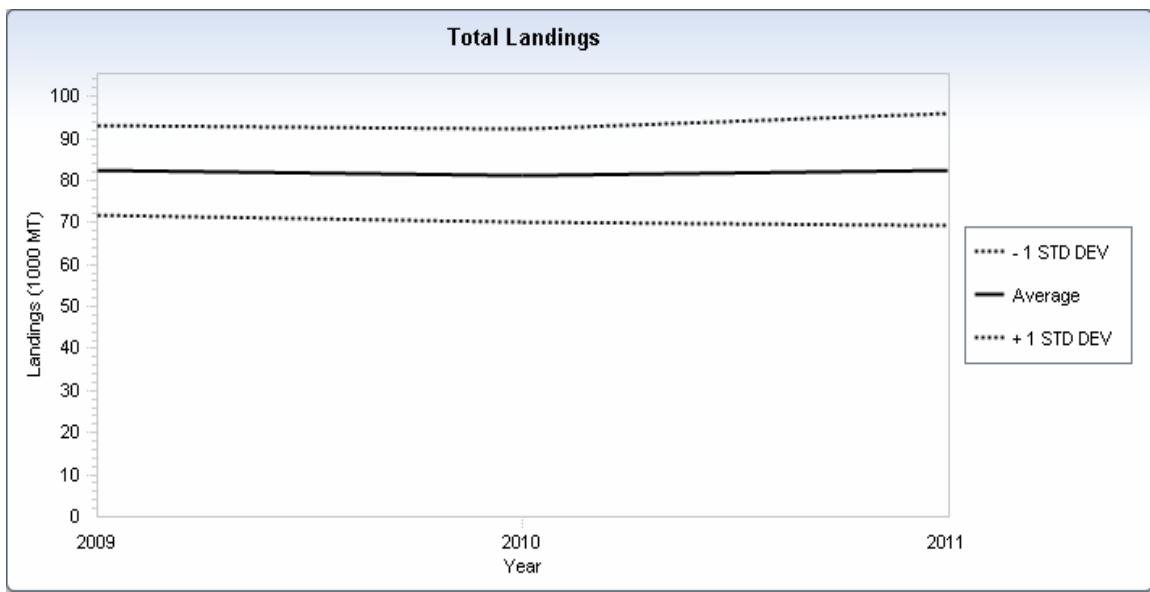
Figure 26. Average landings (mt) +1 std dev projected through 2011 for status quo F=0.14, based on MCMC results of final ASAP model.
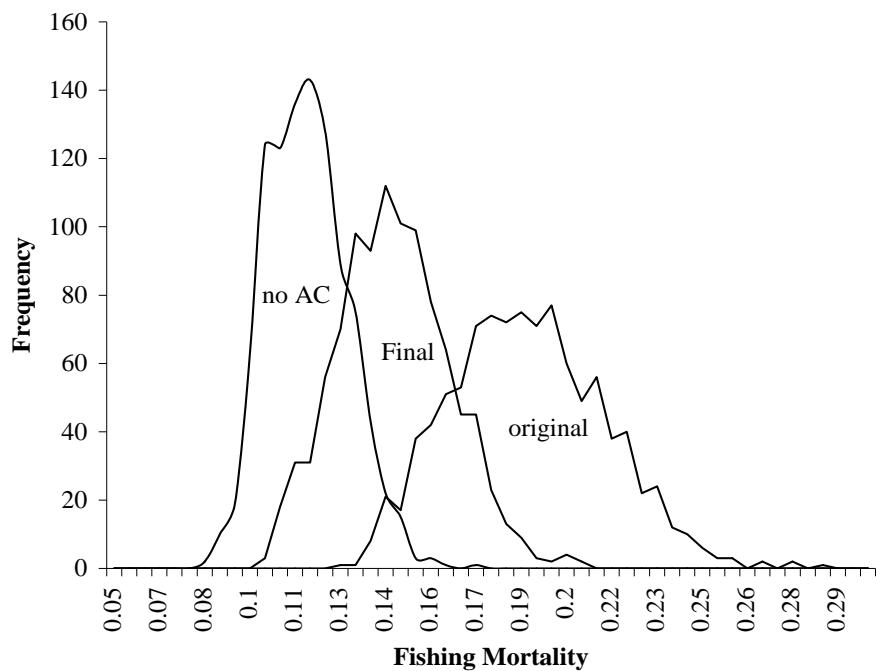
Figure 27. Distribution of fully recruited fishing mortality (age 2+) from MCMC runs for original model update (Base 2009), model without the NMFS acoustic survey indices and the final model without the NMFS acoustic and winter survey indices.
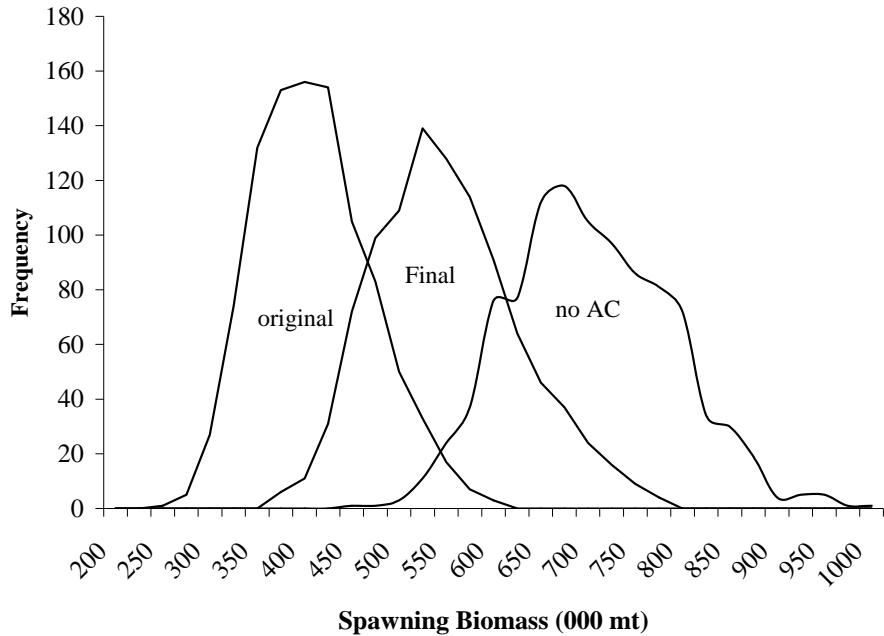
Figure 28. Distribution of spawning biomass from MCMC runs for original model update (Base 2009), model without the NMFS acoustic survey indices and the final model without the NMFS acoustic and winter survey indices.
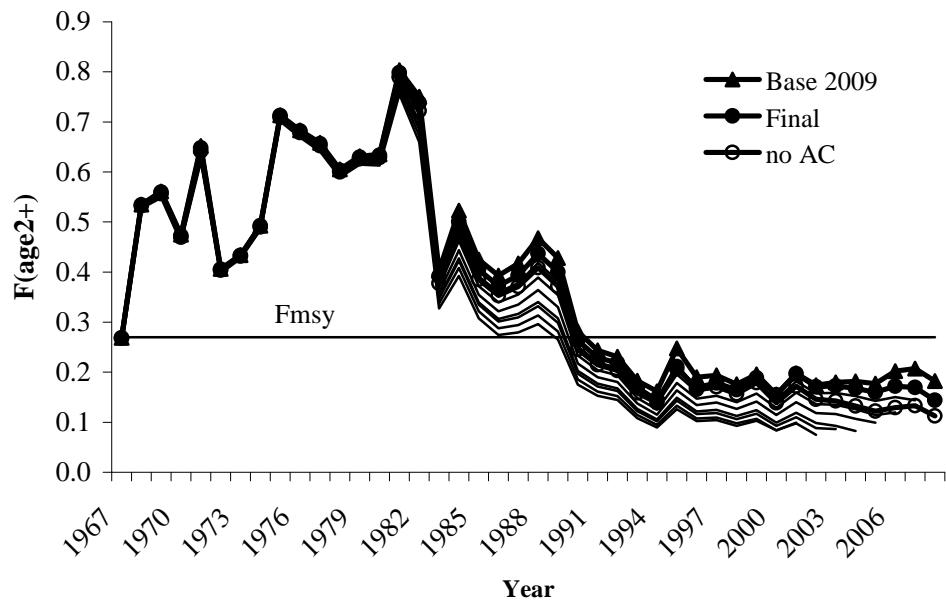

Figure 29. ASAP catch at age model estimates of fully recruited fishing mortality for Gulf of Maine/Georges Bank Atlantic herring for update through 2008 (Base 2009), model without the NMFS acoustic survey indices and the final model without the NMFS acoustic and winter survey indices, relative to the retrospective pattern from the final model.
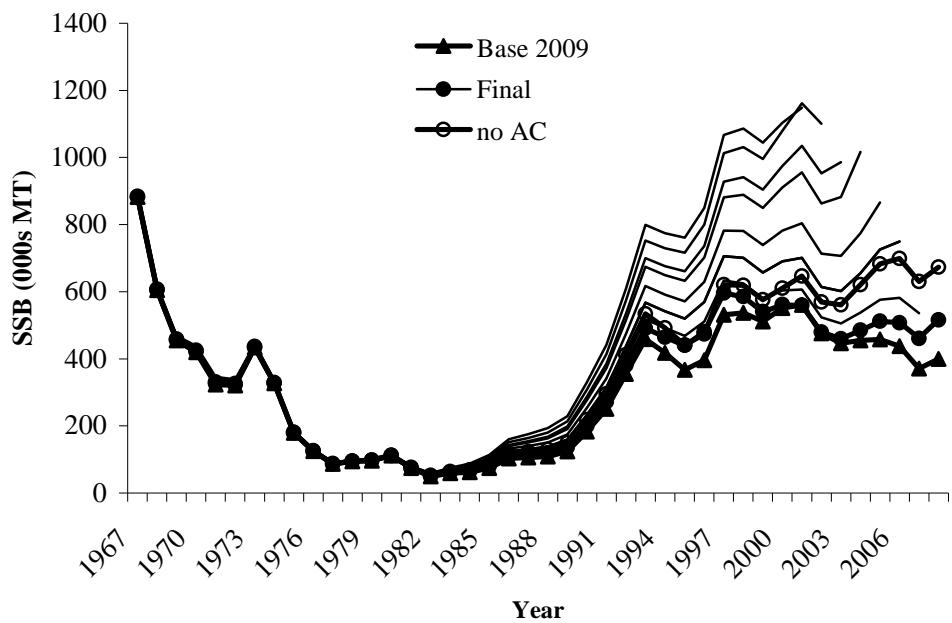
Figure 30. ASAP catch at age model estimates of spawning biomass for Gulf of Maine/Georges Bank Atlantic herring for update through 2008 (Base 2009), model without the NMFS acoustic survey indices and the final model without the NMFS acoustic and winter survey indices, relative to the retrospective pattern from the final model.