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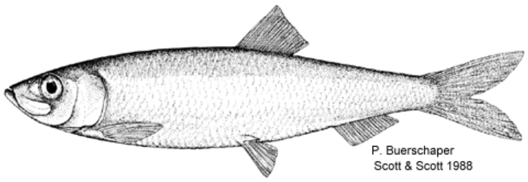


Atlantic Herring: Georges Bank, Nantucket Shoals, Gulf of Maine Stock Complex

Stock Complex and Management Units

Atlantic herring spawn in discrete locations to which they are presumed to return. In the Gulf of Maine and Georges Bank there are major herring spawning grounds on the northern edge of Georges Bank, on Nantucket shoals and in the coastal waters of Cape Cod through Maine. Herring from these spawning areas migrate and mix outside of the spawning season, and are mixed in most fisheries and in research surveys. As a result, the herring of the Gulf of Maine and Georges Bank are considered to be a complex made up of three major distinct but seasonally intermixing components (Georges Bank, Nantucket Shoals and the coastal Gulf of Maine).

While it would normally be considered desirable to treat components separately in assessment and management, intermixing of components in the fishery and in surveys preclude separate assessment and management. It was therefore deemed necessary (as has been done in recent years) to undertake an evaluation of the entire complex with subsequent consideration of the individual components.

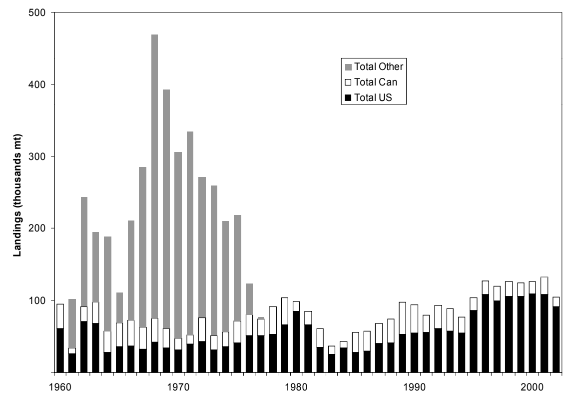
Management boundaries in the US Federal-Atlantic States Marine Fisheries Commission (ASMFC) fisheries management plan for herring were based on the current distribution of seasonal fisheries during the summer in the Gulf of Maine (GOM), on Georges Bank and in southern New England (SNE) during the winter. These boundary lines correspond to a rough demarcation between the coastal and Georges Bank/Nantucket Shoals components and to the spatial/seasonal components of the fisheries on the stock complex. The GOM, Georges Bank and the area south of Cape Cod were divided into three major management areas (areas 1-3) for the purpose of allocation of catch from the various seasonal components of the fishery.

In previous assessments the relative proportions between the inshore GOM and Georges Bank were determined from an analysis of the National Marine Fisheries Service (NMFS) autumn bottom trawl survey indices allocated to inshore and offshore strata. Since 1996 these relative proportions from the autumn survey became more variable and gave results that were contrary to other information suggesting that the Georges Bank component is currently much larger than the inshore component. An analysis of comparisons between the relative size of the two components using hydroacoustics results from both the inshore and offshore areas and previous assessments (Stevenson 1998) suggest that the current proportion in the GOM is much smaller. A summary of these results suggested that the percentage of the total stock in the inshore GOM is currently somewhere near 10-15% in contrast to the 25% that was used in recent years. These reflect available results at the present time, but require confirmation from subsequent calibrations of NMFS and inshore surveys.

Fisheries and Landings

The coastal herring fisheries of Division 5Y are among the oldest in the western Atlantic, dating back over a century. These fisheries have evolved from traps (weirs and shutoffs) through gillnet to purse seine and midwater trawl. Landings in these fisheries peaked at 94,200t in 1950 and have averaged about 50,000t since 1951. Landings in the contiguous New Brunswick weir fishery, which has historically been considered to take fish from this stock complex, have averaged 26,000t over the same period.

Herring landings increased dramatically in the early 1960’s with the development of a predominantly foreign fleet fishery, first using gillnets then trawls and purse seines, in the (then) international waters of Georges Bank and southern New England. Landings in this fishery increased from 68,000t in 1961 to at least 373,000t in 1968, but then decreased rapidly as the stock collapsed and as management measures were introduced in the early 1970’s. Limited directed fishing for herring occurred on Georges Bank between 1979 and 1995. Since 1996 landings have increased to almost 40,000t in 2001 and were about 17,000 in 2002.

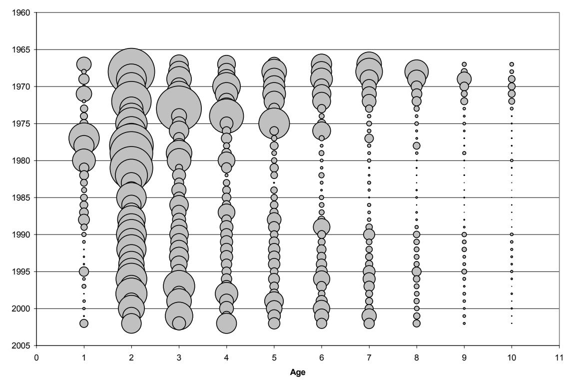


State of the Stock

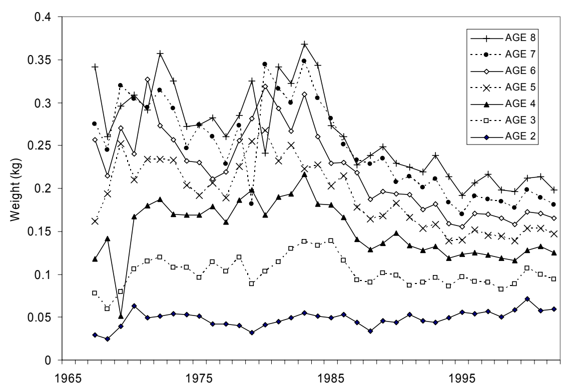
Commercial Fishery Information

Commercial landings compiled for the period since 1959 from Maine Department of Marine Resources (DMR), Fisheries and Oceans Canada (DFO) and the International Commission for Northwest Atlantic Fisheries (ICNAF) sources (1961-1978), are considered to be reliable in recent years but may represent a minimum catch in the early period.

Age composition of the commercial catch is available since 1967. A comparison of age determinations by NMFS and DFO readers showed consistency in age determination to age 5, but reduced agreement on older ages. Examination of the catch at age indicated some misallocation to adjacent ages. The size of the bubbles in the accompanying graph corresponds to the magnitude of the catch at age.

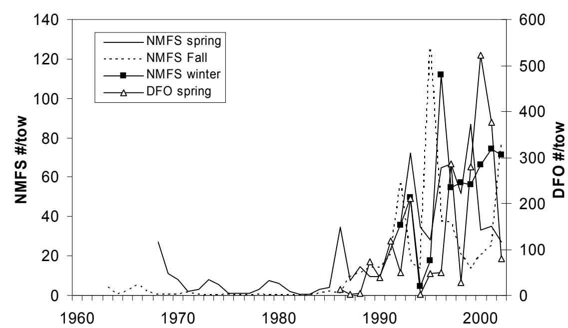


The growth rate of herring in the Georges Bank/Gulf of Maine complex has changed. Size at age of mature herring has decreased coincident with expansion of the population since about 1982.

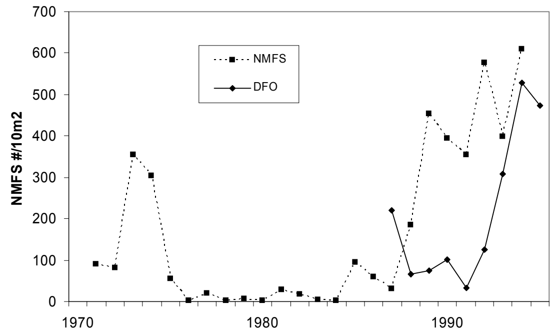


Research Surveys

Several bottom trawl surveys have been undertaken by both NMFS and DFO in this area. While designed primarily for groundfish, these surveys also take herring, and provide some of the longest time series of survey information. These differ in season and length of time series and there is uncertainty regarding the consistency of herring catchability. The NMFS spring (1968-2002) and NMFS autumn (1963-2002) surveys cover the complete distribution of herring, while the NMFS winter includes mostly the over-wintering area in Southern New England. The DFO spring survey covers only Georges Bank and represents a small portion of the northern distribution during that time of year. Timing of the surveys is relatively constant for each of the time series, except for the fall survey where the mean survey date has changed by about one month becoming progressively earlier. Indices of abundance were developed using the strata defined in the 27th NMFS Stock Assessment Workshop. Both the NMFS spring and autumn surveys imply that a change in catchability occurred around 1985, coincident with a bottom trawl door change. The surveys indices were subsequently divided into two time periods pre-1985 and 1985- present.



Larval surveys undertaken by both the NMFS (1971-1994) and by DFO (1987-1995) which covered Georges Bank and Nantucket, were terminated in the mid 1990’s. Statistical analysis of the NMFS survey suggested a difference in catchability between two time periods, 1971-1988 and 1989-1994.



The NMFS hydroacoustic program began in 1998 with a series of surveys on inshore locations and a broad scale survey of the entirety of the GOM. Surveys on Georges Bank in 1998 were of a pilot nature and were useful in pinpointing the location of spawning fish. During subsequent years (1999-2002) larger scale surveys were conducted on Georges Bank with the intent of covering the entire spawning distribution of herring. Three surveys in each year (1999-2001) were completed on Georges Bank, utilizing systematic zigzag, parallel and stratified random designs. One parallel design survey was completed in 2002. An analysis of acoustic information was completed using 11 available TS equations for herring stocks in the North Atlantic. Results suggest that the average 2+ biomass increased from about 1.2 million mt in 1999 to about 1.8 million mt in 2001 on Georges Bank. The survey during 2002 suggested a 2+ biomass of 0.8 million mt, but other information suggests that the peak spawning time on Georges Bank may have occurred prior to the survey.

The hydroacoustic program in the inshore area of the GOM has been conducted by the DMR-Gulf of Maine Aquarium during 1999-2002. Surveys from this program were conducted at frequent intervals during September-November, utilizing a systematic zigzag design. Results suggest that the spawning biomass during this period increased from 200,000t in 1999 to 350,000t in 2001, and decreased to 200,000t in 2002.

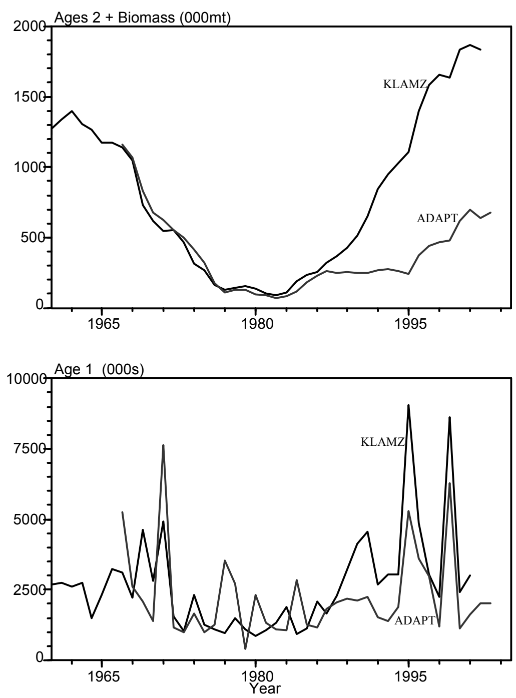
Assessments

Two approaches, a delay-difference model (KLAMZ) and a calibrated VPA model (ADAPT) were used to evaluate stock status. Both models assumed that the natural mortality rate was equal to 0.2 and constant over time for all ages. The total catch was assumed known without error in both models and all available indices were used, though given different weightings according to their variability.

KLAMZ partitions the herring stock into two age groups (age 2 and age 3+). All delay-difference calculations for herring were in units of biomass assuming von Bertalanffy growth. The delay-difference model is “foreward-casting” and simulates the herring stock starting with the first year in the analysis. Model parameters, biomass, recruitment biomass and fishing mortality rates are estimated from survey data and other information including hydroacoustic biomass estimates and a spawner-recruit constraint.

For ADAPT, the survey indices were used to calibrate a VPA with the following further assumptions; error in the catch at age is negligible and the fishing mortality on age 10 is equal to the weighted average for ages 7-9. This approach places greater emphasis on the catch at age observations, particularly in earlier years. Inconsistencies between the catch at age information and trends in the survey indices can give rise to retrospective patterns (systematic positive or negative differences in estimates as additional years of data are used) and this assessment displays a marked retrospective pattern.

Results from the primary methods used for the assessment differ considerably in some regards, reflecting uncertainties in input data sets, but several important agreements are also seen. Historical biomass trends until 1985 are very similar. Differences between model estimates appear in the mid-1980s, when the biomass and recruitment estimates diverge. This is due to the combined effects of divergent mortality and recruitment estimates.



Estimates of the current stock biomass are quite dependent on model assumptions and weightings given to data sets. This application of ADAPT, tends to give estimates of mortality rates which correspond to catch at age data (indicating higher mortality rates and lower biomasses). KLAMZ leans towards the scaling implied by the acoustic survey biomass estimates and the stock recruit constraint (indicating higher biomass and lower fishing mortality). The KLAMZ results seemed to track trends in recent survey data more closely than did the ADAPT results, implying more older fish in the population during recent years and a different recent recruitment pattern. Evidence for higher proportions of older fish in the catch at age or surveys is not strong.

To verify and compare models, new and revised data need to be considered. Thus a continuation of the hydroacoustic survey is likely to elucidate trends in biomass when they appear and improved age determinations for older fish should give a better indication of the total mortality in the stock. While results are substantially different, the estimation error internal to each model is considerable, blurring the statistical significance of those differences. This is a reflection of the great variation in the observed survey indices. An additional complicating factor that contributes to this statistical uncertainty is the apparent change in survey catchability before and after 1985, particularly for the NMFS autumn survey. The KLAMZ model estimated the magnitude of this effect to be a factor of 68 times for age 2 and 10 times for ages 3+ while the ADAPT model estimated it to be a factor of about 60 times at age 2 and decrease to about a factor of 10 at age 8.

A possible way to resolve the discrepancy between model results, is to use hydroacoustics to directly estimate abundance (with accompanying target strength verification).

Productivity and Biological Reference Points

Biological reference points (BRP's) based on the KLAMZ assessment were updated from the last assessment and are based on a yield per recruit model (Thompson-Bell) for $F_{40\%}$, $F_{0.1}$ and F_{max}, and a surplus production model for F_{msy}, MSY and B_{msy}. The yield per recruit model results gave an F_{max} =0.40, an $F_{0.1}$ =0.18 and an $F_{40\%}$ =0.15. The new F_{max} is the same and the $F_{0.1}$ is slightly lower than values from the last assessment. Reference points from the production model were also re-estimated, using a formulation that is consistent with the KLAMZ model. The new biological reference points for the herring complex were estimated as F_{msy} =0.25, MSY =222,000 mt and B_{msy} =896,000 mt. These reference points are all less than those from the previous assessment, which used a conditioned ASPIC model to estimate the BRP's.

BRP's were also estimated using a yield/spawner per recruit model with a reproductive component fitted to ADAPT model output. $F_{0.1}$ and $F_{40\%}$ estimates were similar to those estimated in the KLAMZ assessment. $F_{95\%MSY}$, was estimated to be in the range of 0.20 - 0.22 using a parametric and nonparametric stock recruitment relationship.

Although the ADAPT and KLAMZ assessments suggest different levels of production and biomass at MSY, the reference fishing mortality rates produced by the two approaches were similar. There is greater uncertainty about biomass reference points than the fishing mortality reference points.

Projections/Forecast

Projections were conducted from the results of both the KLAMZ and ADAPT models assuming that the catch in 2003 would be 100,000t, approximately equal to that in 2002. Natural mortality was assumed to be 0.2 as in the assessment. Two F scenarios were considered, F = 0.2, approximating the F estimated by the VPA in recent years and corresponding roughly to an F_{MSY} proxy reference points, as well as F = 0.1.

The results from the KLAMZ projections indicated that a catch of about 323,000t in 2004 corresponds to an F = 0.2 and results in a decrease in 2+ biomass from about 1,800,000t in 2004 to about 1,640,000t in 2005. With an F = 0.1, the resulting catch is about 170,000t and the 2+ biomass decreases from about 1,800,000t to about 1,790,000t.

The ADAPT projections were done from the bias adjusted VPA results and assumed that the fishery partial recruitment to be fully recruited for ages 2 and older and 0.01 at age 1. The fishery and population weights at age were taken as the average from 1992 to 2002. The results indicated that a catch of about 100,000t in 2004 corresponds to an F = 0.2 and results in a decrease in 3+ biomass from about 550,000t in 2004 to about 500,000t in 2005. With an F = 0.1, the resulting catch is about 60,000t and the 3+ biomass stays constant at about 550,000t.

For More Information

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