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Atlantic Herring

by

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Distribution, Biology and Management

The Atlantic herring, *Clupea harengus*, is widely distributed in continental shelf waters of the Northeast Atlantic, from Labrador to Cape Hatteras. Important commercial fisheries for juvenile herring (ages 1 to 3) exist along the coasts of Maine and New Brunswick. Development of large-scale fisheries for adult herring is comparatively recent, primarily occurring in the western Gulf of Maine, on Georges Bank, and on the Scotian Shelf. Gulf of Maine herring migrate from summer feeding grounds along the Maine coast and on Georges Bank to southern New England and Mid-Atlantic areas during winter, with larger individuals tending to migrate farther distances. Tagging experiments provide evidence of intermixing of Gulf of Maine, Georges Bank, and Scotian Shelf herring during different phases of the annual migration.

Spawning in the Gulf of Maine occurs during late August-October, beginning in northern locations and progressing southward. Atlantic herring are not fully mature until age 4. Age at maturity varies annually and appears to change in response to density dependent effects. Herring eggs are demersal and are typically deposited on gravel substrates. Primary spawning locations off the northeastern United States are located on the Maine coast, Jeffreys Ledge, Nantucket Shoals, and Georges Bank. Incubation is temperature dependent, but usually occurs for 7 to 10 days. Larvae metamorphose by late spring into juvenile brit herring that may form large aggregations in coastal waters during summer. By age 2, juvenile herring are fully vulnerable to fixed and mobile gear coastal fisheries.

In the past, the herring resource along the East Coast of the United States was divided into the Gulf of Maine and Georges Bank stocks. There is currently no genetic evidence to suggest that these two components are separate stocks. However, morphometric analyses suggest that discernable phenotypic differences exist among herring from the Gulf of Maine, Georges Bank, and the Scotian shelf. However, fishery-independent measures of abundance for herring include fish originating from all spawning areas. As a consequence, herring from the Gulf of Maine and Georges Bank components are combined for assessment purposes into a single coastal stock

complex (Figure 22.1). This approach has many advantages over the separate stock approach, but also poses a number of technical and management challenges, particularly for the management of the smaller inshore component.

An interstate fishery management plan has been adopted by the Atlantic States Marine Fisheries Commission (ASMFC), and a Fishery Management Plan has been developed by the New England Fishery Management Council (NEFMC) in collaboration with the ASMFC. Management measures include spawning area closures, an area management scheme (three areas), catch controls on the entire complex, and a TAC on the near shore (1A) Gulf of Maine fishery. The information provided herein reflects the results of the most recent peer-reviewed assessment for the Gulf of Maine-Georges Bank herring complex (TRAC 2006).

The Fishery

Total landings for the coastal stock complex have declined from 470,000 mt in 1968 to 36,000 mt in 1983. (Table 22.1, Figure 22.2). After the large offshore fishery collapsed in 1977, the fishery focused on near shore waters of the Gulf of Maine. Landings gradually increased from the mid 1980s through the 1990s and peaked at 133,000 mt in 2001. Landings declined slightly during 2002-2005, averaging 109,000 mt. The USA has accounted for about 72% of landings since 1978, but during the last decade has accounted for 85% of the total herring.

The fishery in the Gulf of Maine consists of fixed and mobile gear fisheries in coastal waters. Landings from the New Brunswick weir fishery ranged from 9,000 to over 44,000 mt during 1980-1998, while the mobile gear (purse seine and mid-water trawl) fisheries landed between 27,000-81,000 mt during the same period. There has been a great deal of annual variability in the landings, but little evidence of any long-term trend. However, changes have occurred in the distribution of landings between mobile and fixed gear fleets. Over the past five years, greater than 90 percent of Maine herring landings have been taken by U.S. mobile gear fisheries compared with less than 50 percent during the 1970s. This shift reflects reduced availability of herring to the fixed-gear fisheries and also less emphasis on this type of fishing. Current mobile gear landings are dominated by single and paired mid-water trawlers.

The Georges Bank herring fishery was initiated in 1961 by distant-water fleets. Landings peaked in 1968 at 373,600 mt and subsequently declined to 43,500 mt in 1976 as the fishery collapsed. Mid-water trawling by both USA and Canada herring fleets began in 1994, with landings peaking at 35,000 mt in 2001 and averaging about 13,000 mt during 1994-2005. The majority of Georges Bank herring landings are by USA mid-water vessels, with the balance taken by Canada.

Historically many age groups of herring (age 2-7) have been represented in the commercial landings (Figure 22.3), as the inshore fisheries by the USA and Canada focused on younger fish while the offshore distant water fisheries targeted all age groups. After the offshore component had collapsed in the late 1970s and early 1980s, and the inshore component had been heavily fished, only age groups 2-3 were well represented in the landings. As the herring complex recovered in the late 1980s and the offshore fishery resumed, the age distribution of the landings

expanded and ages 2-7 were prevalent. The recent fishery has been dominated by the strong 1994 and 1998 year classes, but many other recent cohorts have been moderate size or larger.

Research Vessel Survey Indices

Biomass indices of herring in NEFSC spring and autumn research vessel surveys were relatively low during the 1960s and 1970s (Figure 22.4), and declined even further in the late 1970s and early 1980s after the offshore component collapsed and the inshore component was greatly reduced. The survey indices markedly increased in the mid 1980s and early 1990s as recovery commenced, and have since remained relatively high although variable.

NMFS surveys have shown a progressively expanding age structure of herring in the Gulf of Maine-Georges Bank region since the early 1990s (Figure 22.5).

Assessment Results

Estimates of total stock biomass for the coastal stock complex exceeded 1 million mt before the collapse of the Georges Bank fishery. After the collapse in the early 1980s, stock size estimates declined to about 100,000 mt. Stock biomass has since increased substantially primarily due to improved recruits. The offshore spawning component, which was the largest historic component of the stock complex, is now fully recovered.

Fishing mortality (2+) for herring declined from about 0.7 during 1970s to an average of 0.3 during the mid-late 1980s (Figure 22.6). Thereafter, fishing mortality declined 0.1 in 1998 and has since remained at this level. Total biomass (2+) increased from about 105,000 mt in 1982 to about 1.3 million mt in 2000 but declined to 1.0 million mt in 2005 (Figure 22.7). The increase in biomass the late 1990's was primarily due to generally improved recruitment and two extremely large year classes, the 1994 and 1998 cohorts (Figure 22.7). The 1994 year-class was the largest at about 7.2 billion, followed by the 1998 year class at about 5.5 billion and the 2002 year class at about 4.8 billion. Recruitment from the 1999-2000 and 2003 year classes is weaker than average.

Biological Reference Points

Yield per recruit reference points were estimated as: $F_{0.1}=0.21$ and $F_{40\%}=0.20$ (Table 22.2).

The relationship between spawning biomass (SSB) and recruitment for the Gulf of Maine-Georges Bank herring complex during 1967-2003 and the geometric mean recruitment (horizontal line) are shown in (Figure 22.8). Near average or better than average recruitment appear to occur at SSBs greater than about 700,000 mt. Recruit per spawner ratios were relatively high during the 1980s. Recent ratios have been greater than 1.0 (Figure 22.9).

MSY reference points for the herring complex were re-estimated during the most recent (2006) assessment (TRAC Status Report 2006/01) (Table 22.2). Results from a Fox surplus production model were $F_{msy} = 0.31$, $MSY = 194,000$ mt, and $B_{msy} = 629,000$ mt.

Summary

The Gulf of Maine-Georges Bank herring complex began to recover during the late 1980s and current total biomass (age 2+) is now comparable to the 1960s. Biomass increased from a low of about 105,000 mt in 1982 to near 1.3 million mt in 2001, and declined slightly to about 1.0 million mt in 2005, but is still substantially above the B_{MSY} (629,000 mt). Fishing mortality has remained low since the early 1990s and has averaged 0.1 since 2002 far below F_{MSY} (0.31). The stock complex is not overfished and overfishing is not occurring.

Table 22.1. Commercial landings of Atlantic herring (thousand mt) during 1996-2005.

Category	1986-95 Average	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
U. S. Recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	53	109	99	106	106	109	108	93	101	94	92
Canada	30	18	21	20	19	17	24	13	11	21	13
Other	-	-	-	-	-	-	-	-	-	-	-
Total Nominal Catch	83	127	120	126	125	126	132	106	112	115	105

Table 22.2. Yield and MSY (SSB based) reference points for Atlantic herring.

Yield and SSB per Recruit-based Reference Points

$$F_{0.1} = 0.21$$

$$F_{40\%} = 0.20$$

MSY-based Reference Points

$$MSY = 194,000 \text{ mt}$$

$$B_{msy} = 629,000 \text{ mt.}$$

$$F_{msy} = 0.31$$

For further information

Anthony, V. C., and G. Waring. 1980. The assessment and management of the Georges Bank herring fishery. Rapp. P.-V. Reun. Cons. Int. Explor. Mer 177:72-111.

Fogarty, M. J., and S. H. Clark. 1983. Status of herring stocks in the Gulf of Maine region for 1983. Northeast Fish. Sci. Cent. Ref. Doc. 83-46. 33 p.

Overholtz, W.J., and K.D. Friedland. 2002. Recovery of the Gulf of Maine-Georges Bank Atlantic herring (*Clupea harengus*) complex: perspectives based on bottom trawl survey data. Fishery Bulletin, 100: 593-608.

Smith, W. G. and W. W. Morse. 1993. Larval distribution patterns: early signals for the collapse/recovery of Atlantic herring, *Clupea harengus*, in the Georges Bank area. Fish. Bull., U.S. 91:338-347.

Transboundary Resource Assessment Committee (TRAC). 2006. Gulf of Maine-Georges Bank Herring Stock complex. TRAC Status Report 2006/01, 7p.
http://www.mar.dfo-mpo.gc.ca/science/trac/TSRs%5CTSR_2006_01_E.pdf

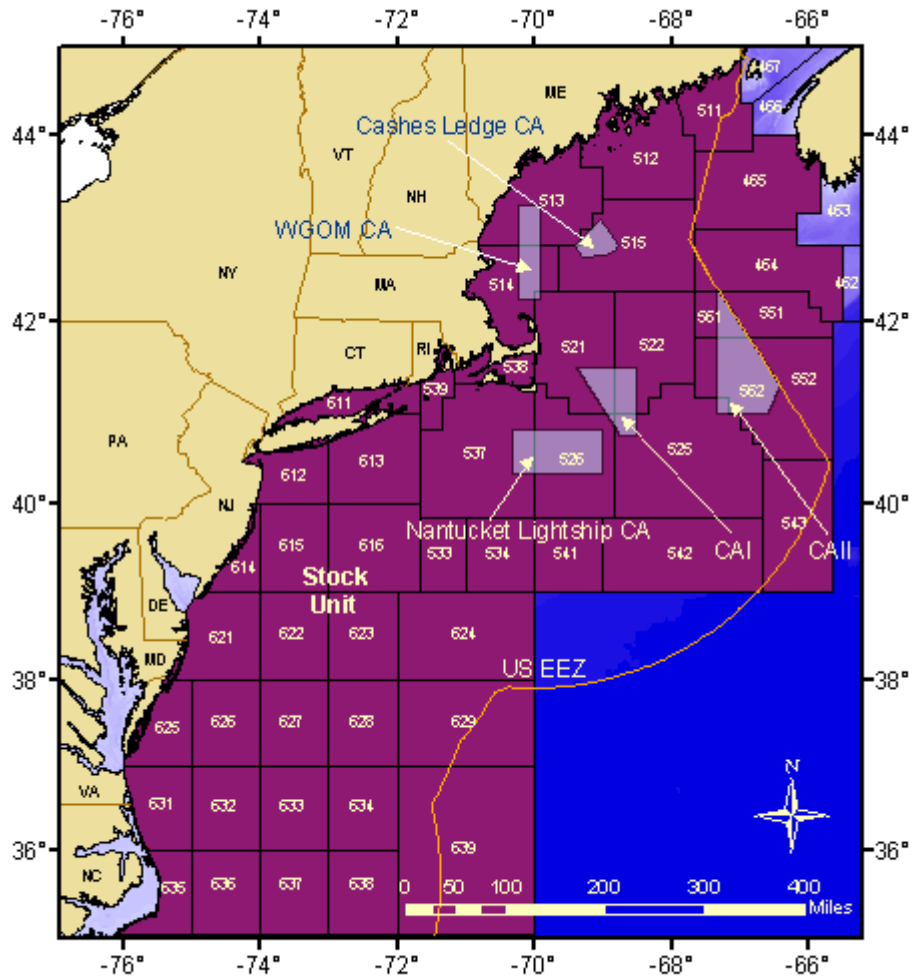


Figure 22.1. Statistical areas used to define the Gulf of Maine-Georges Bank Atlantic herring stock complex.

Gulf of Maine-Georges Bank Atlantic Herring Total Commercial Landings

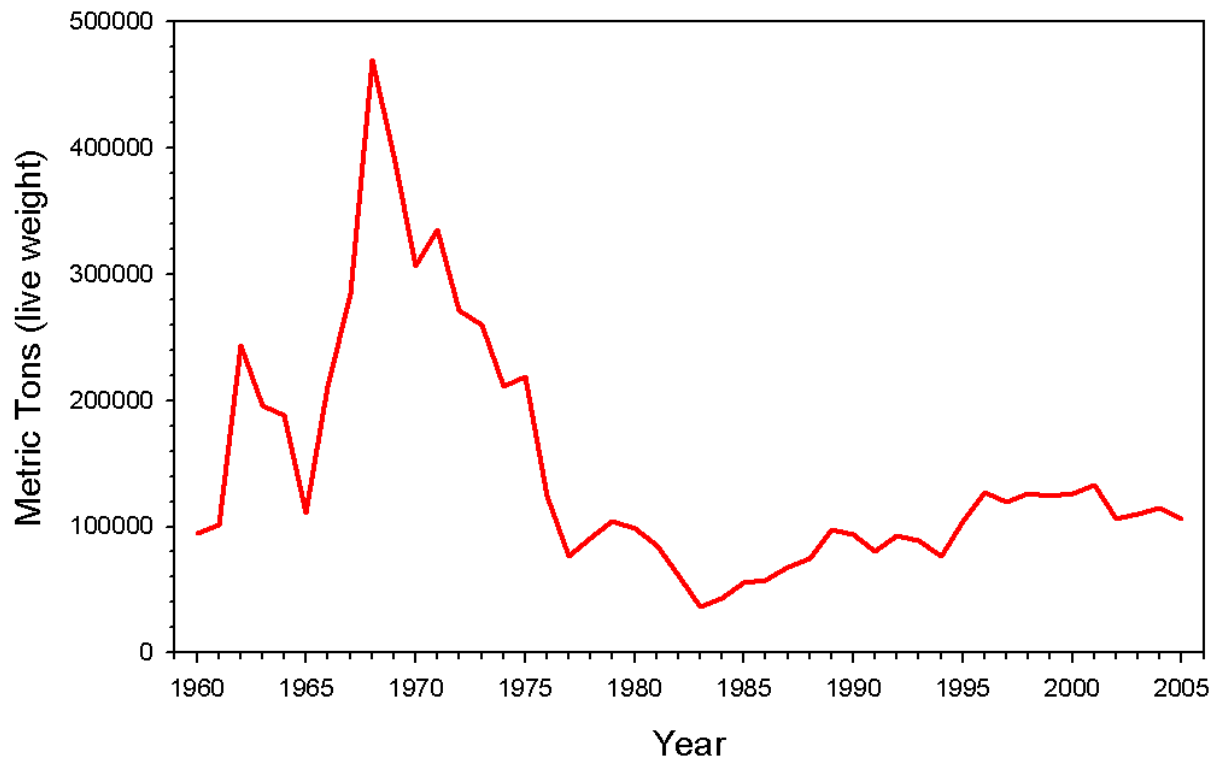


Figure 22.2. Total commercial landings of Gulf of Maine-Georges Bank Atlantic herring (NAFO Div. 5Y and 5Z), 1960-2005.

Gulf of Maine-Georges Bank Atlantic Herring Commercial Landings by Age

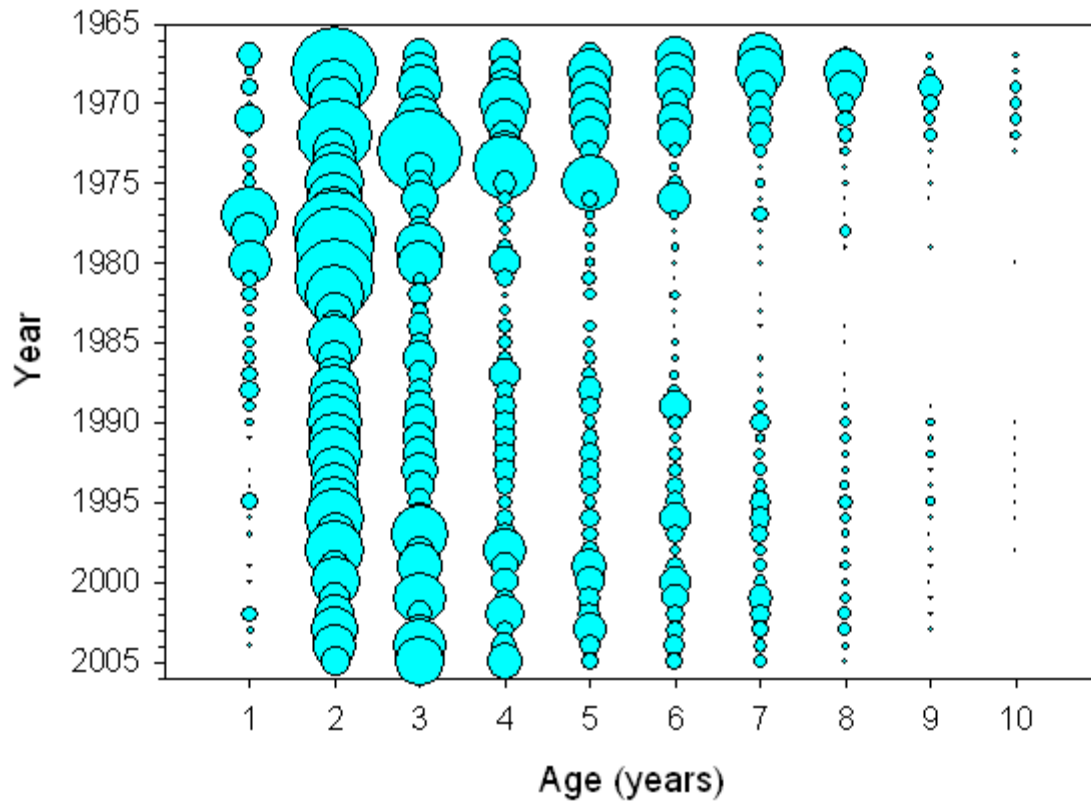


Figure 22.3. Age structure of total Gulf of Maine-Georges Bank Atlantic herring landings, 1967-2005.

Gulf of Maine-Georges Bank Atlantic Herring NEFSC Spring and Autumn Biomass Indices

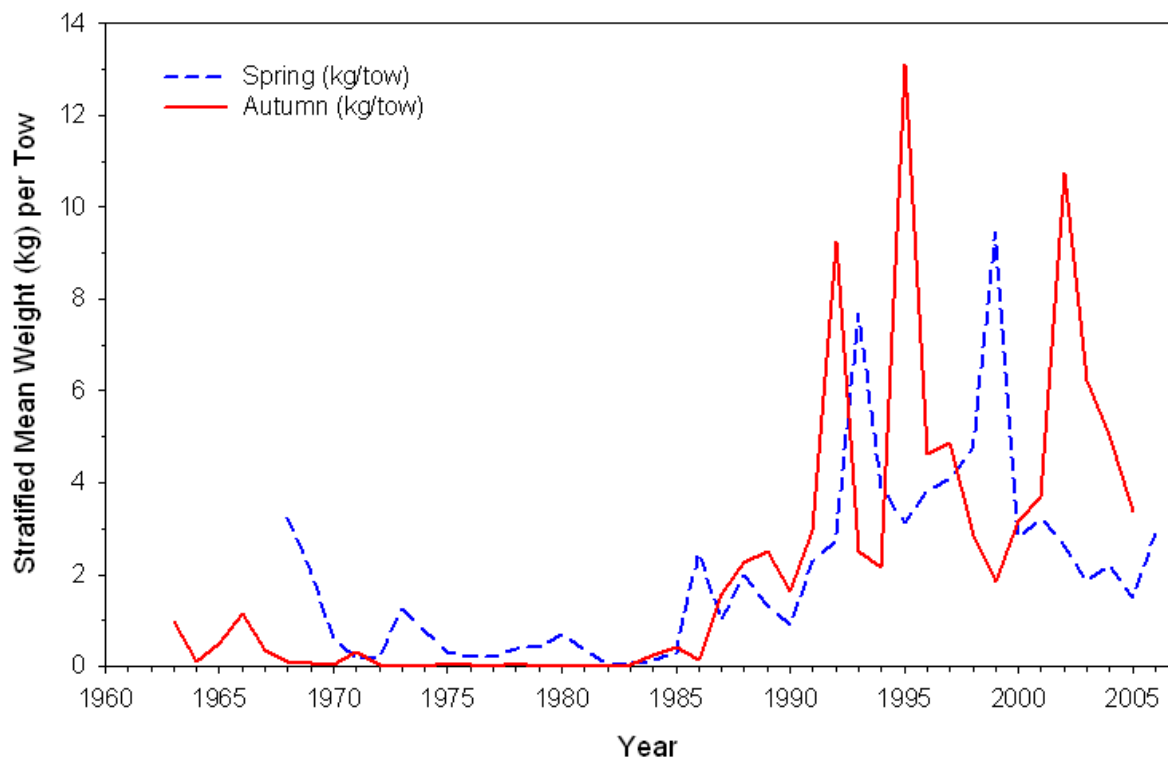


Figure 22.4. Biomass indices (stratified mean weight per tow) for Gulf of Maine-Georges Bank Atlantic herring from NEFSC spring and autumn research vessel surveys.

Gulf of Maine-Georges Bank Atlantic Herring Autumn Survey Indices by Age

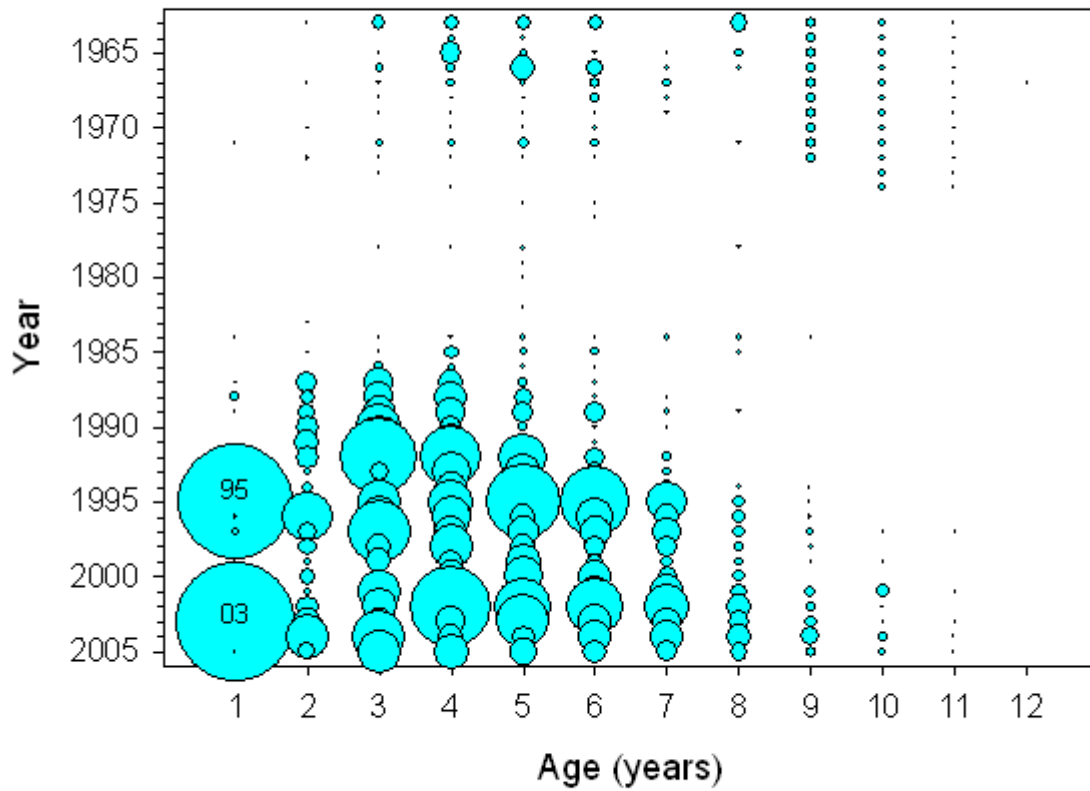


Figure 22.5. Age structure of the Gulf of Maine-Georges Bank Atlantic herring population, 1963-2005.

Gulf of Maine-Georges Bank Atlantic Herring Trends in Landings and Fishing Mortality

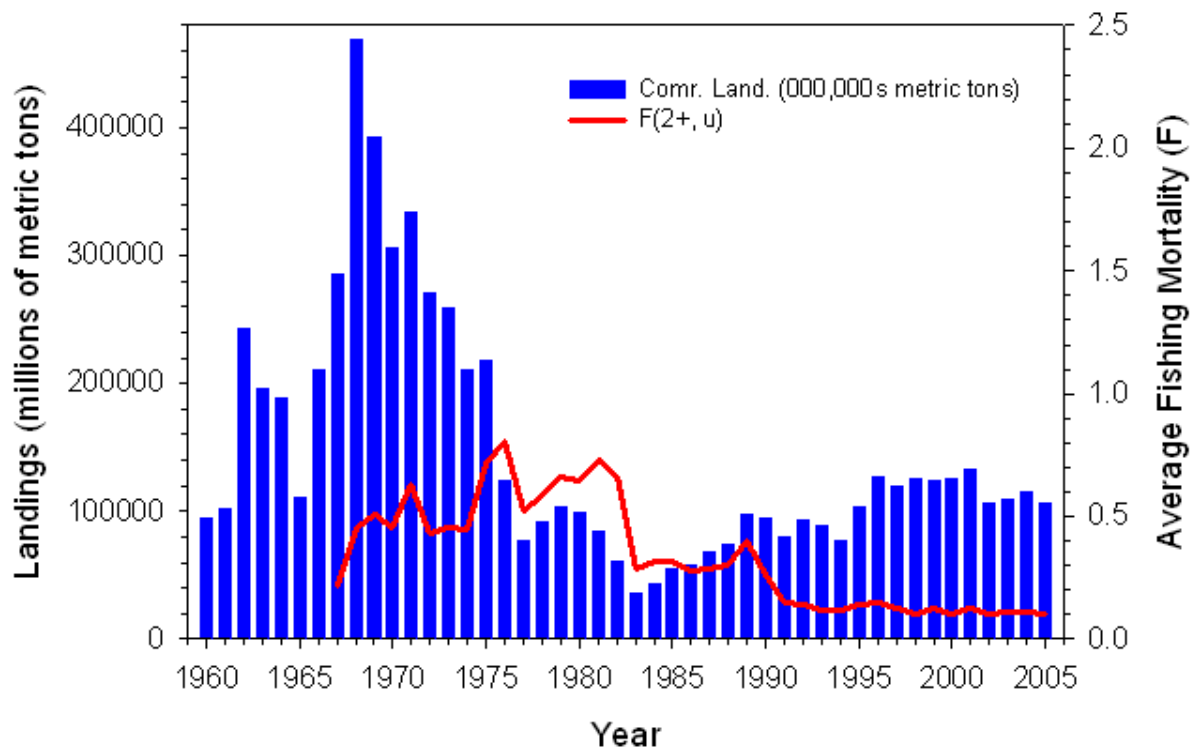


Figure 22.6. Trends in landings and fishing mortality for Gulf of Maine-Georges Bank Atlantic herring.

Gulf of Maine-Georges Bank Atlantic Herring Trends in Recruitment and Biomass

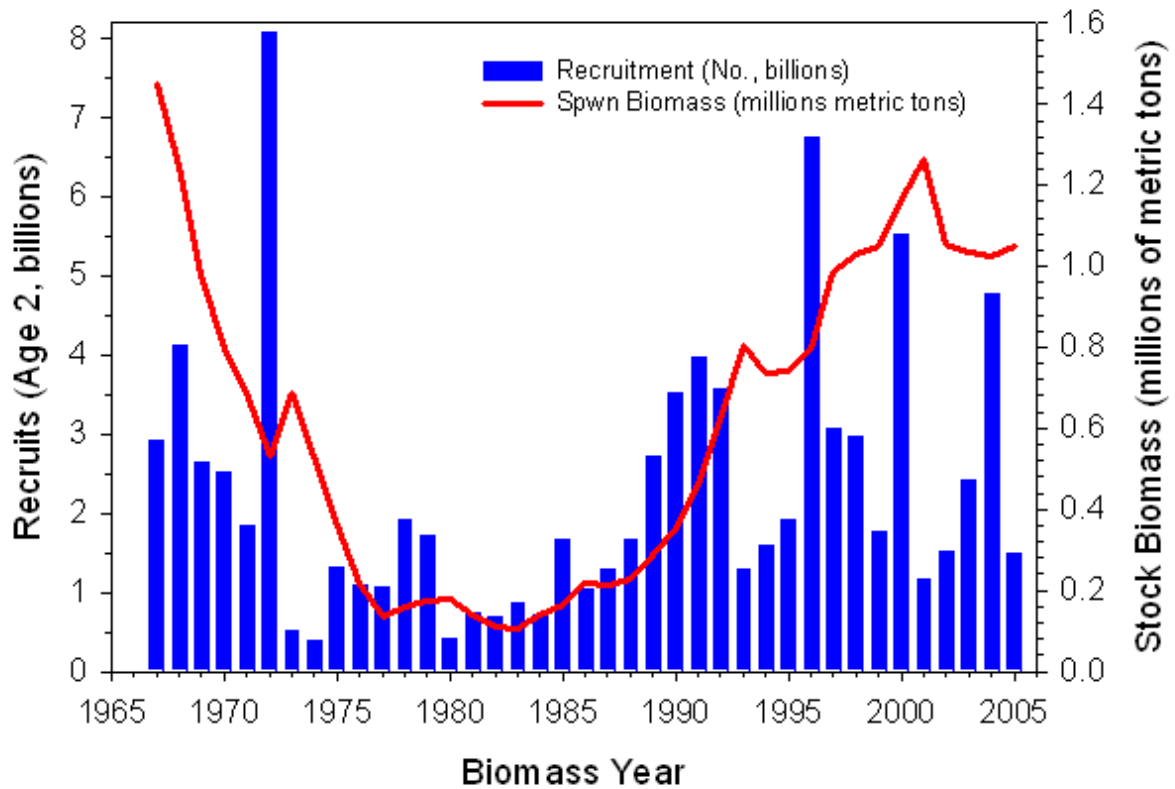


Figure 22.7. Trends in recruitment at age 2 in year and total biomass (age 2+) for Gulf of Maine-Georges Bank Atlantic herring.

Gulf of Maine-Georges Bank Atlantic Herring Stock-Recruitment Plot

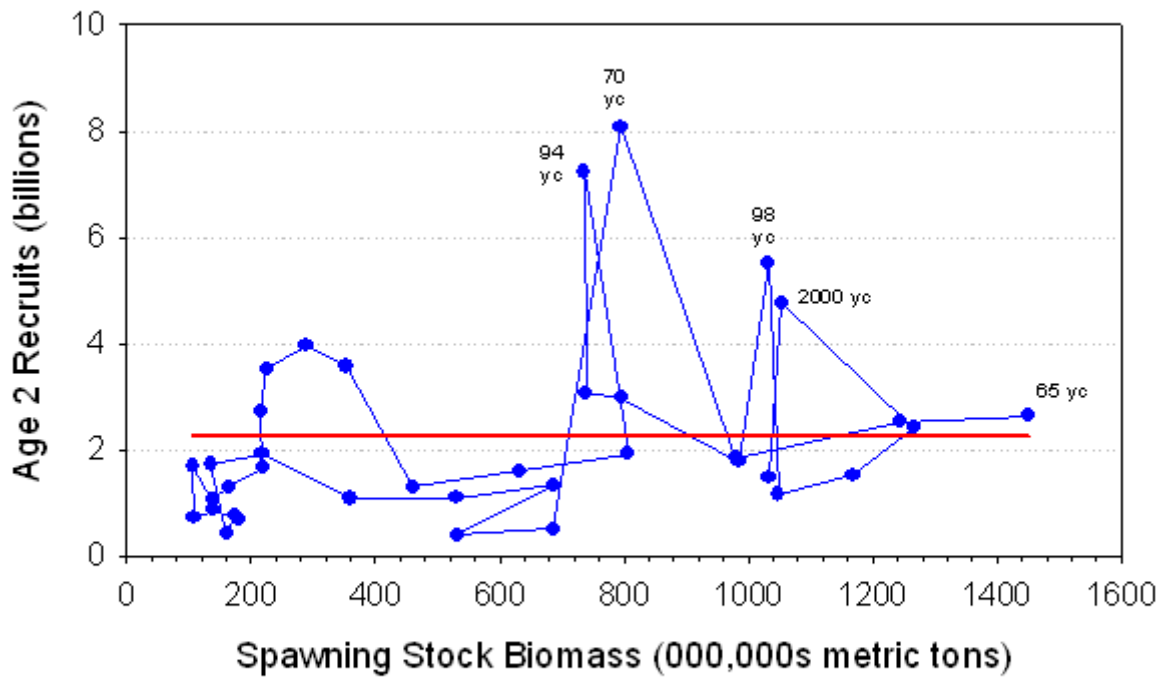


Figure 22.8. Spawning stock-recruitment scatter plot for Gulf of Maine-Georges Bank Atlantic herring. The solid horizontal line represents the geometric mean recruitment.

Gulf of Maine-Georges Bank Atlantic Herring R/SSB Survival Ratios

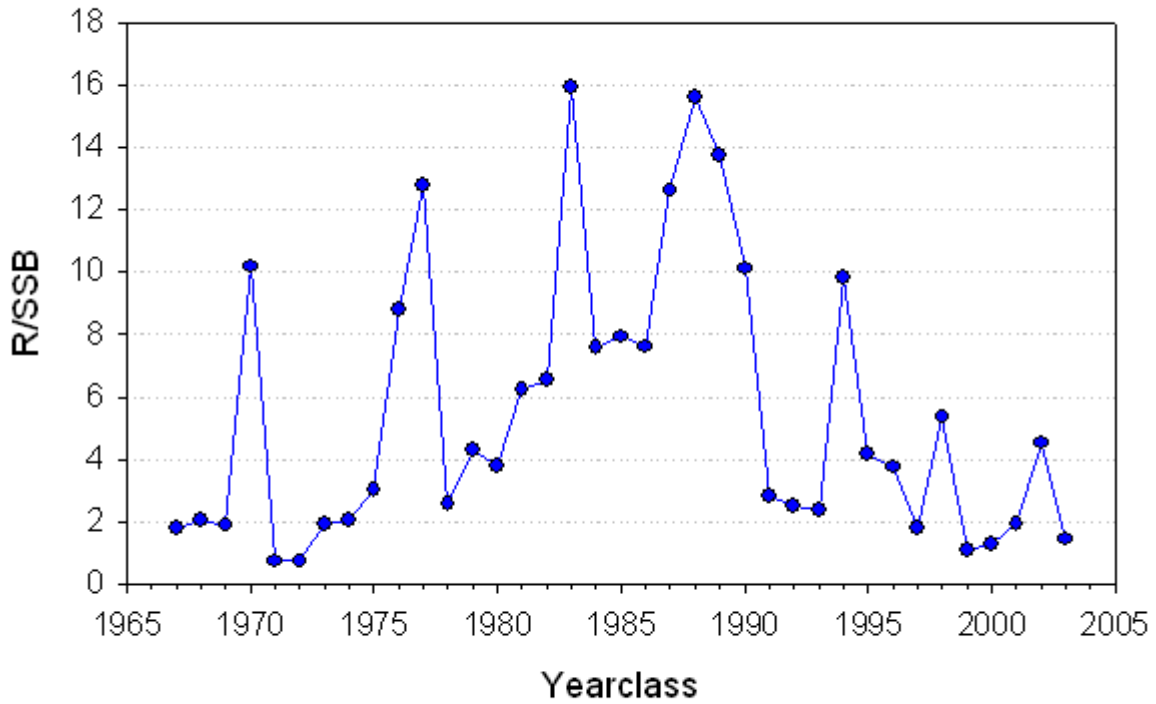


Figure 22.9. Trends in survival ratios (R/SSB) for Gulf of Maine-Georges Bank Atlantic herring.