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Silver Hake

by

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Distribution, Biology, and Management

Silver hake, also known as whiting, *Merluccius bilinearis*, range primarily from Newfoundland to South Carolina. Silver hake are fast swimmers with sharp teeth, and are important fish predators that also feed heavily on crustaceans and squid (Lock and Packer 2004). Although they do not swim in definitive schools, silver hake tend to aggregate in large numbers (Collette and Klein-MacPhee eds. 2002). In U.S. waters, two stocks have been identified based on differences of head and fin lengths (Almeida 1987), otolith morphometrics (Bolles and Begg 2000), otolith growth differences, and seasonal distribution patterns (Lock and Packer 2004). The northern silver hake stock inhabits Gulf of Maine - Northern Georges Bank waters, and the southern silver hake stock inhabits Southern Georges Bank - Middle Atlantic Bight waters (Figure 4.1).

As nocturnal, semi-pelagic predators, silver hake move up in the water column to feed at night, primarily between dusk and midnight, and return to rest on the bottom during the day, preferring sandy, muddy or pebbly substrate (Collette and Klein-MacPhee eds. 2002). There is some difference in diet between the two stocks. Northern silver hake primarily feed on euphausiids, Atlantic herring, silver hake and other fish, while southern silver hake primarily feed on crangonid shrimp, squids, cephalopods, and sand lance. Diet varies depending on size, sex, season, migration, spawning, and age (Lock and Packer 2004). Small silver hake prey on euphausiids, while larger, especially older females prey primarily on fish. Silver hake tend to prey more heavily on fish during the spring and autumn, whereas during the summer months, their diets often include a mixture of fish, crustaceans, and mollusks (Lock and Packer 2004).

Silver hake migrate in response to seasonal changes in water temperatures, moving towards shallow, warmer waters in the spring. They spawn in late spring and early summer and return to deeper waters in the autumn (Brodziak et al. 2001). In general, older, larger silver hake tend to prefer deeper waters. During the summer, portions of both stocks can be found on Georges Bank, whereas during the winter, fish in the northern stock move to deep basins in the Gulf of

Maine, while fish in the southern stock move to outer continental shelf and slope waters. Silver hake are widely distributed, and have been observed at temperature ranges of 2-17° C (36-63° F) and depth ranges of 11-500 m (36-1,640 ft). However, they are most commonly found between 7-10° C (45-50° F) (Lock and Parker 2004).

Female silver hake are serial spawners, producing and releasing up to three batches of eggs in a single spawning season (Collette and Klein-MacPhee eds. 2002). Major spawning areas include the coastal region of the Gulf of Maine from Cape Cod to Grand Manan Island, southern and southeastern Georges Bank, and the southern New England area south of Martha's Vineyard. Peak spawning occurs earlier in the south (May to June) than in the north (July to August). Over one-half of age-2 fish (20 to 30 cm, 8 to 12 in.) and virtually all age-3 fish (25 to 35 cm, 10 to 14 in.) are sexually mature. Silver hake grow to a maximum length of over 70 cm (28 in.) and ages up to 14 years have been observed in U.S. waters, although few fish older than age 6 have been observed in recent years (Brodziak et al. 2001).

Due to their abundance and availability, silver hake have supported important U.S. and Canadian fisheries as well as distant-water fleets. Following the entrance of distant-water fleets in 1962, nominal catches from both stocks increased rapidly, peaking at more than 350,000 mt in 1965, but declined to 55,000 mt by 1970. Landings increased to 137,000 mt in 1973 and then declined sharply with increased restrictions on distant-water fleet effort and implementation of the Magnuson Fishery Conservation and Management Act (MFCMA) in 1977. Prior to MFCMA, distant-water fleets accounted for about 49% and 87% of the total landings of the northern and southern stocks, respectively. Fishing activity by distant-water fleets ceased after 1977 for the northern stock, but distant-water fleet exploitation of the southern stock continued until 1987, primarily as a bycatch in the squid fishery. U.S. landings during 1987-1996 were relatively stable, averaging 16,000 mt per year, but have gradually declined to a historic low of 6,800 mt in 2005 (Figure 4.2).

The otter trawl remains the principal gear used in the U.S. fishery, and recreational catches have been low since 1985. Silver hake are managed under the New England Fishery Management Council's Northeast Multispecies Fishery Management Plan ("nonregulated multispecies" category). In 2000, the New England Fishery Management Council implemented Amendment 12 to this FMP, and placed silver hake into the "small mesh multispecies" management unit, along with red hake and offshore hake. This amendment established retention limits based on net mesh size, adopted overfishing definitions for northern and southern stocks, identified essential fish habitat for all life stages, and set requirements for fishing gear (NEFMC 2000).

NORTHERN STOCK SILVER HAKE

The Fishery

Commercial landings of silver hake from the northern stock were significantly lower than those from the southern stock during the mid and late 1960s and throughout the 1970s (Figure 4.2). In 1975, commercial landings peaked at 40,000 mt but have since progressively declined. After

1976, landings declined due to the departure of the distant water fleets. Commercial landings attained a historical low of 240 mt in 2005 (Figure 4.3, Table 4.1).

Substantial quantities of juvenile silver hake are discarded in the large mesh and small mesh otter trawl fisheries and in the northern shrimp fishery. Discard estimates during 1989-1992 range from 1,700 mt to 7,200 mt (17 million to 76 million fish) per year. High juvenile discards can diminish future yields and spawning potential (Brodziak et al. 2001).

Research Vessel Survey Indices

The NEFSC autumn bottom-trawl survey biomass index declined during the mid-1960s, reaching a minimum in 1967-68 (Figure 4.4). With the appearance of the strong 1973 and 1974 year classes, biomass indices increased during the mid-1970s, but declined during the late 1970s. Biomass indices were higher in the 1980s and early 1990s, peaking in 1998 at 22.0 kg/tow. Subsequently, biomass indices have markedly declined to a low of 1.95 kg/tow in 2005. Age structure of the northern stock was more uniform through the early 1980s, with fish up to age 8. However, the current age structure shows few fish older than age 4 (Figure 4.5).

Biological Reference Points

The northern silver hake stock overfishing definition (NEFMC 2003) uses a relative exploitation index (total landings divided by NEFSC autumn survey biomass index) as a proxy for fishing mortality. The northern stock is considered overfished when the 3-year average biomass is less than $\frac{1}{2}$ the B_{MSY} proxy (6.63 kg/tow). The 3-year average biomass has been above the $\frac{1}{2} B_{MSY}$ proxy (> 3.31 kg/tow) since 1971, although the 2005 survey biomass index is below this value (Figure 4.6). Overfishing occurs when the 3-year average exploitation index is below 2.57, the F_{MSY} proxy (the average exploitation index during 1973-1982), and is used as both a target and threshold value for fishing mortality for the northern stock (NEFSC 2006). Exploitation indices have been below the F_{MSY} proxy since 1978 (Figure 4.7).

Summary

Northern silver hake landings have decreased substantially since 1977, and are presently at a historical low. The autumn survey biomass index has fluctuated over the years, but has continuously declined since 1998, and is at a low of 1.95 kg/tow in 2005. In 2005, the 3-year average exploitation index for 2003-2005 was below the F_{MSY} proxy and the 3-year average biomass index remained above the $\frac{1}{2} B_{MSY}$ proxy, indicating that the stock is not overfished and overfishing is not occurring.

Table 4.1 Recreational and commercial landings for the northern silver hake stock (thousand metric tons).

Category	1986-95 Average	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
U. S. Recreational	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Commercial											
United States	5.6	3.2	2.6	2.3	4.0	2.4	3.4	2.8	1.7	0.6	0.2
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total Nominal Catch	5.6	3.2	2.6	2.3	4.0	2.4	3.4	2.8	1.7	0.6	0.2

Table 4.2. MSY- based reference points for the northern silver hake stock.

F_{MSY} Threshold Proxy	=	2.57
F_{MSY} Target Proxy	=	2.57
B_{MSY} Proxy	=	6.63 kg/tow
$1/2 B_{MSY}$	=	3.31 kg/tow

SOUTHERN STOCK SILVER HAKE

The Fishery

Domestic landings from the southern silver hake stock have varied between 5,000-30,000 mt, reaching a peak of about 27,000 mt in 1964. However, between 1960 and 1980, distant-water fleet landings of southern silver hake were very high, peaking at about 280,000 mt in 1965 and around 100,000 mt in 1974. Distant-water fleet landings tapered off in the mid-1980s, and total landings have since continued to gradually decrease. In 2005, total landings were near a historic low at 7,000 mt (Figure 4.8).

As in the northern stock, significant quantities of juvenile southern silver hake are discarded in both large mesh and small mesh otter trawl fisheries. Annual discard estimates during 1989-1992 range from 1,300 mt to 10,000 mt (10 million to 81 million fish) per year. High discarding of juveniles may severely limit opportunities to rebuild the southern silver hake stock (Brodziak et al. 2001).

Research Vessel Survey Indices

The NEFSC autumn bottom trawl survey biomass index declined sharply from a high of 5.52 kg/tow in 1965 to 0.86 kg/tow in 1974. The survey biomass index recovered slightly during the early 1980s as distant-water fleet fishing effort diminished. However, between 1985 and 2000, the biomass index decreased by more than 50%. Since 2001, the biomass index has fluctuated between 1.1 and 2.4 kg/tow (Figure 4.9). The NEFSC autumn survey shows a progressive truncation of the southern silver hake age composition throughout the time series, with no fish older than age 4 after 2002 (Figure 4.10).

Biological Reference Points

The southern silver hake stock is considered to be overfished when the three-year moving average of the NMFS autumn survey weight per tow index is less than half of the B_{MSY} proxy (1.78 kg/tow) (NEFMC 2003). The three-year average of the survey biomass during 2003-2005 was 1.41 kg/tow, which was above $1/2 B_{MSY}$ (0.89 kg/tow) but below the B_{MSY} target of 1.78 kg/tow (Figure 4.11).

Overfishing is considered to be occurring in the silver hake stock when the exploitation index (landings divided by the three-year moving average of the delta-distributed fall survey biomass index) exceeds the F_{MSY} threshold proxy of 34.39 (NEFMC 2002). The 2003-2005 average exploitation index of 4.67 is below the F_{MSY} threshold proxy as well as the F_{MSY} target proxy of 20.63 (Figure 4.12).

Summary

The southern silver hake stock is not overfished and overfishing is not occurring. However, the 2005 biomass index is less than half of the indices observed in the early 1960s, and except for 2001, the biomass index has remained below the B_{MSY} proxy since 1989 (Figure 4.9). Another source of concern is that the age structure of the southern silver hake stock is severely truncated in recent years, with few fish older than age 4 (Figure 4.10).

Table 4.3 Recreational and commercial landings for the southern silver hake stock (thousand metric tons).

Category	1986-95 Average	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
U. S. Recreational	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Commercial											
United States	11.2	13.0	13.0	12.7	10.0	9.8	8.7	5.2	6.9	7.9	6.6
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total Nominal Catch	11.2	13.0	13.0	12.7	10.0	9.8	8.7	5.2	6.9	7.9	6.6

Table 4.4. MSY- based reference points for the southern silver hake stock.

F_{MSY} Threshold Proxy	=	34.39
F_{MSY} Target Proxy	=	20.63
B_{MSY} Proxy	=	1.78 kg/tow
$1/2 B_{MSY}$	=	0.89 kg/tow

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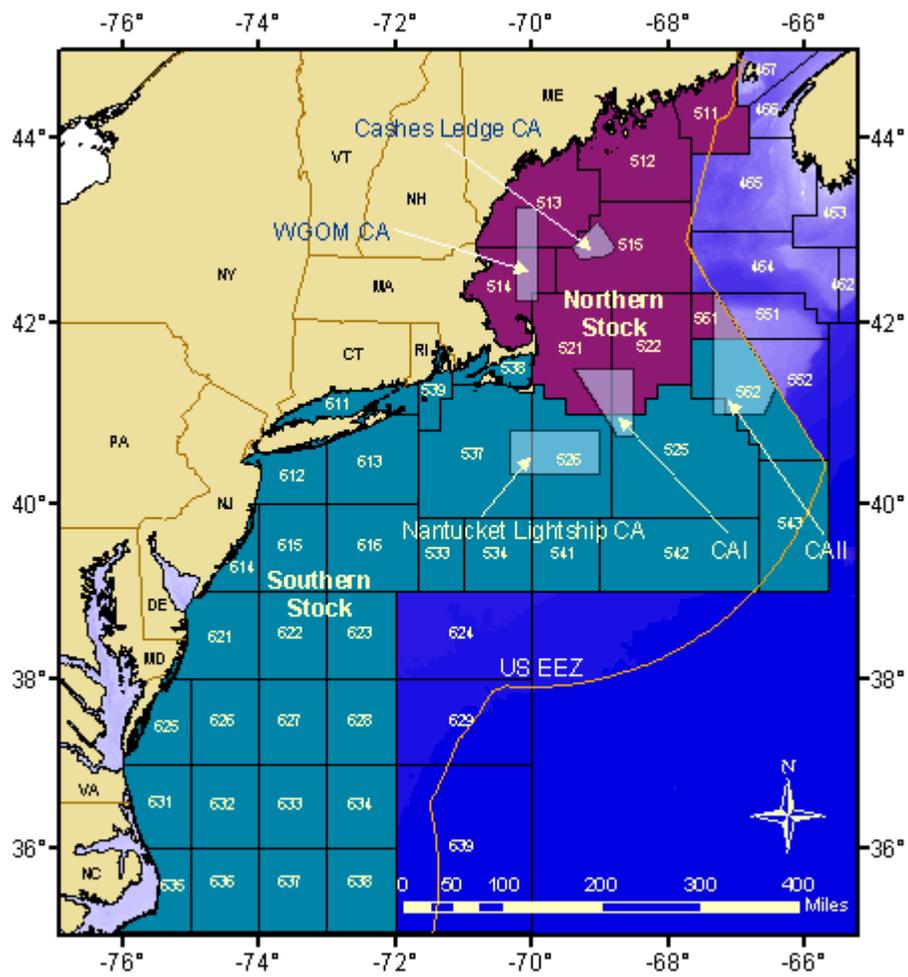


Figure 4.1. Statistical areas used to define the northern and southern silver hake stocks.

Northern and Southern Silver Hake Total Commercial Landings

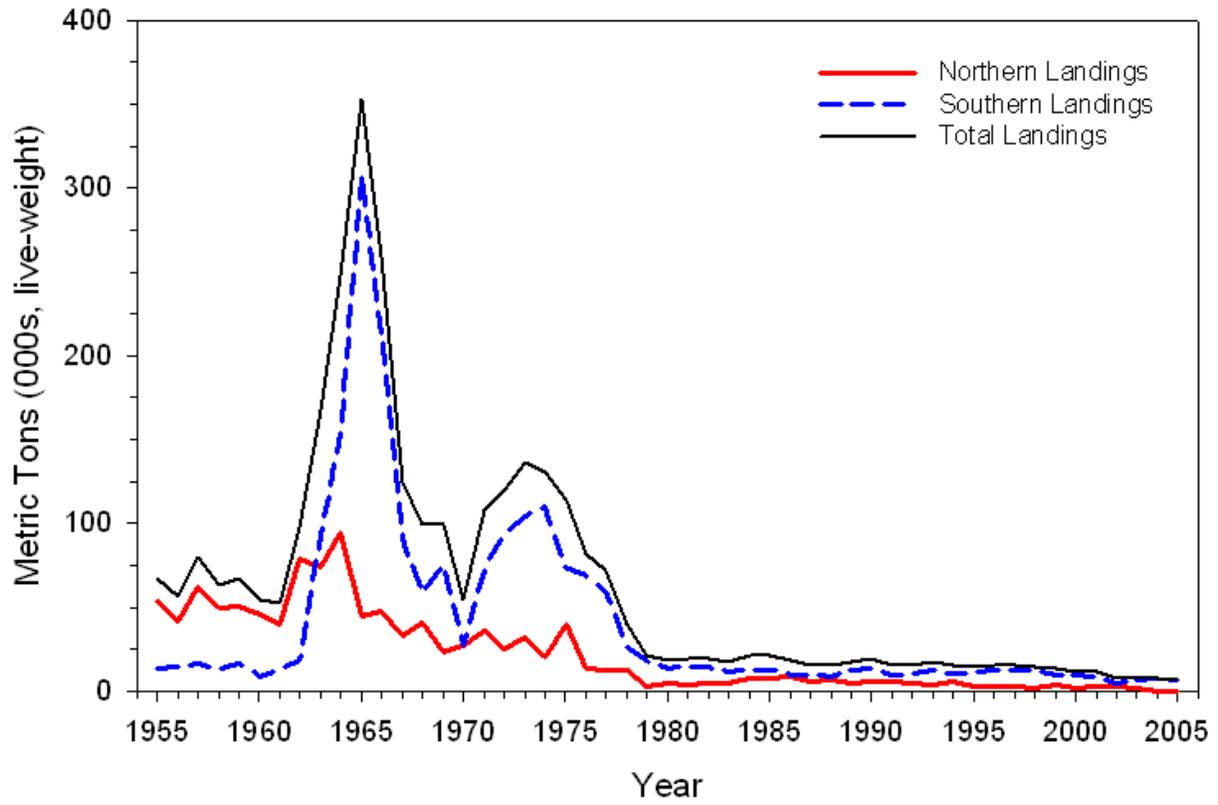


Figure 4.2. Total commercial landings of northern and southern silver hake, 1955-2005.

Northern Silver Hake Total Commercial Landings

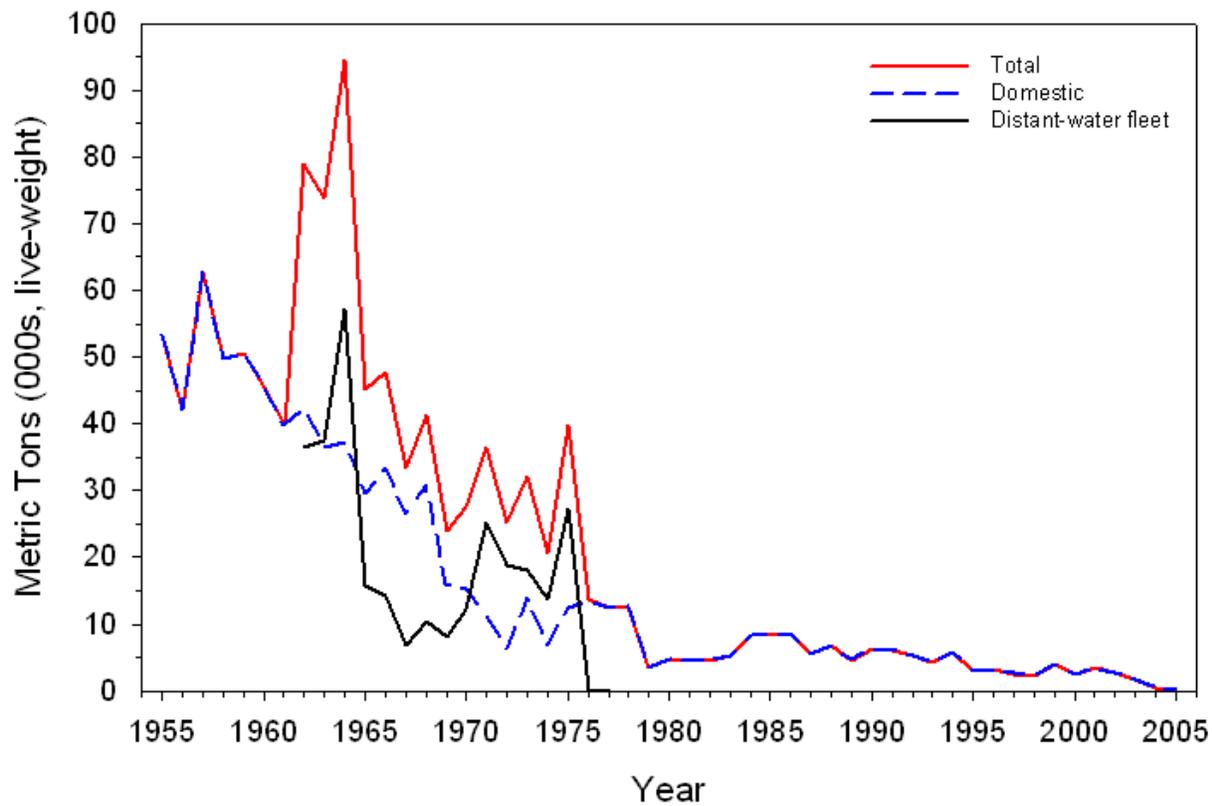


Figure 4.3. Total commercial landings of northern silver hake from the Gulf of Maine-Georges Bank region, 1955-2005.

Northern Silver Hake NEFSC Autumn Biomass Index

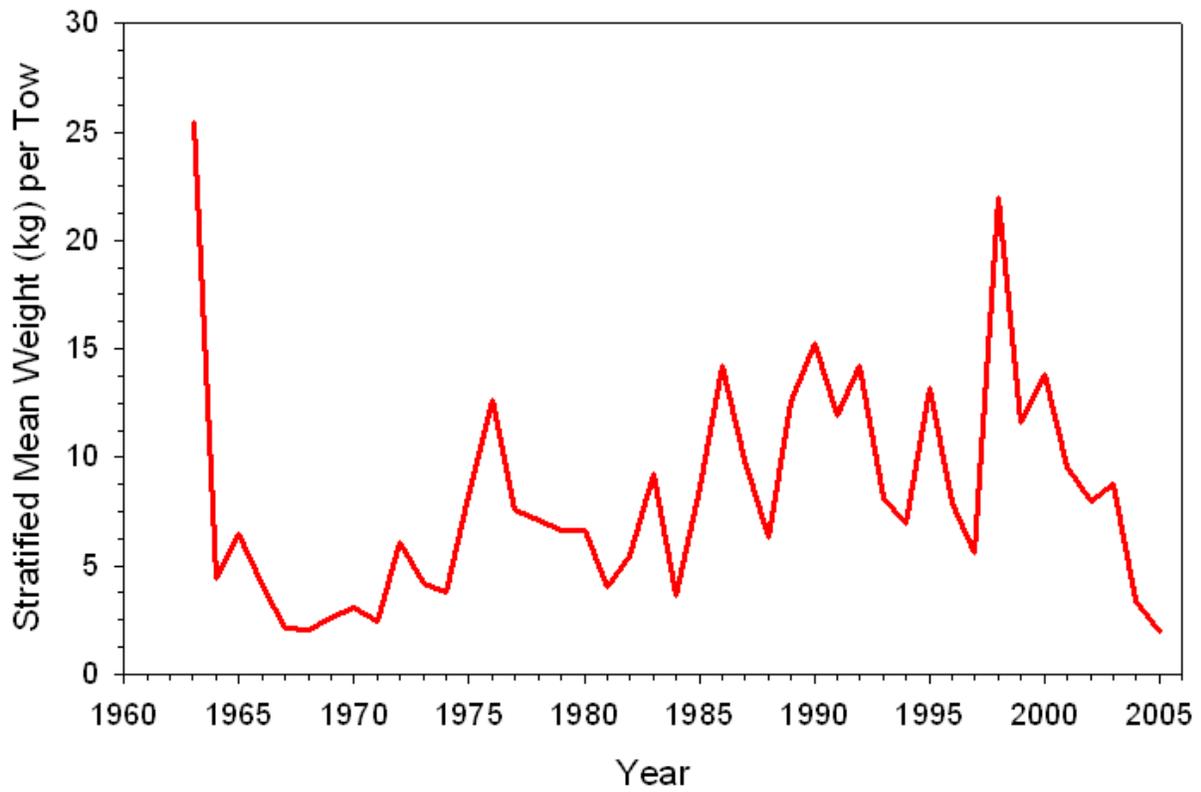


Figure 4.4. Biomass index (stratified mean weight per tow) for northern silver hake from the NEFSC autumn research vessel survey.

Northern Silver Hake Autumn Survey Indices by Age

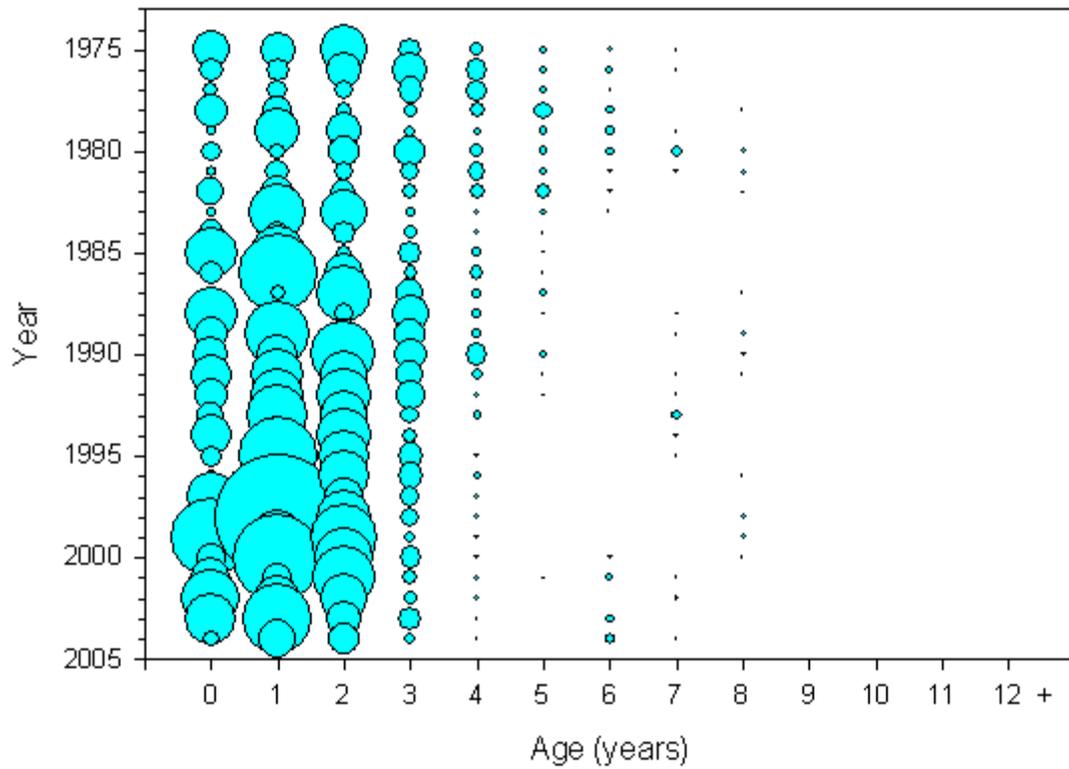


Figure 4.5. Age structure of the northern silver hake stock, 1975-2004.

Northern Silver Hake Survey Biomass v. B_{MSY} Proxy

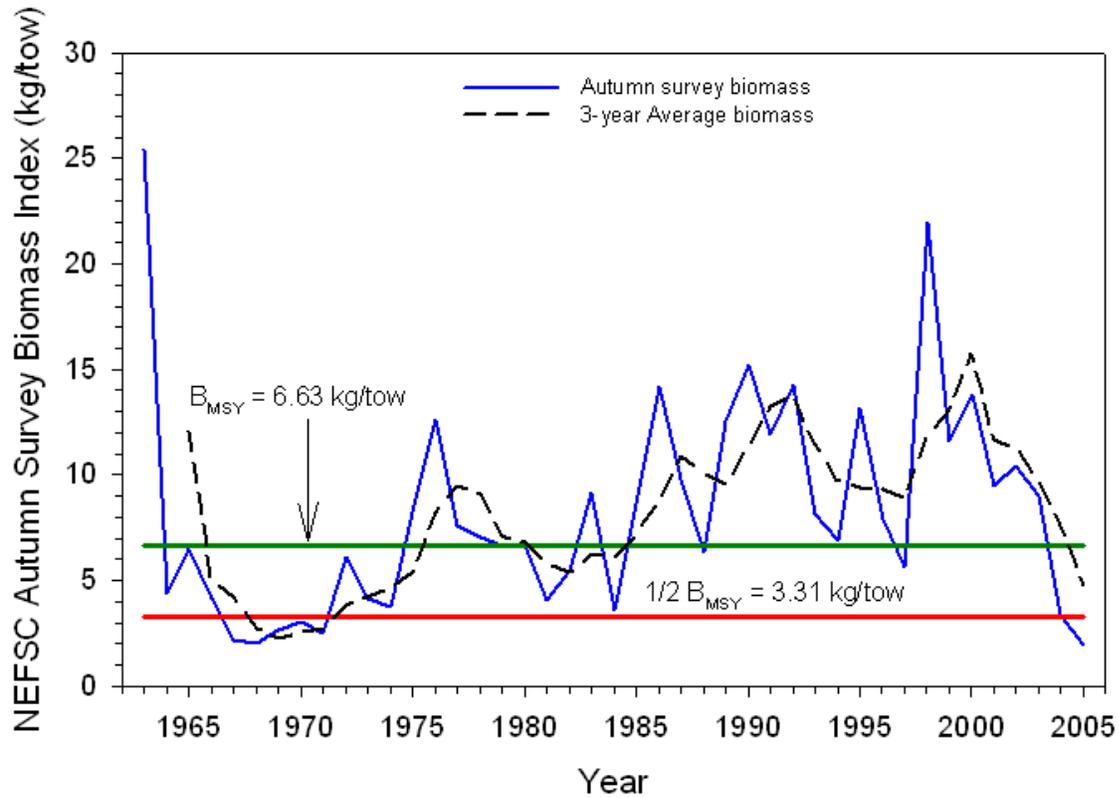


Figure 4.6. Trends in biomass indices (mean kg/tow) of northern silver hake from NEFSC autumn bottom trawl surveys in relation to the B_{MSY} proxy (6.63 kg/tow) and $1/2 B_{MSY}$ proxy (3.31 kg/tow).

Northern Silver Hake Exploitation and Autumn Survey Biomass Indices

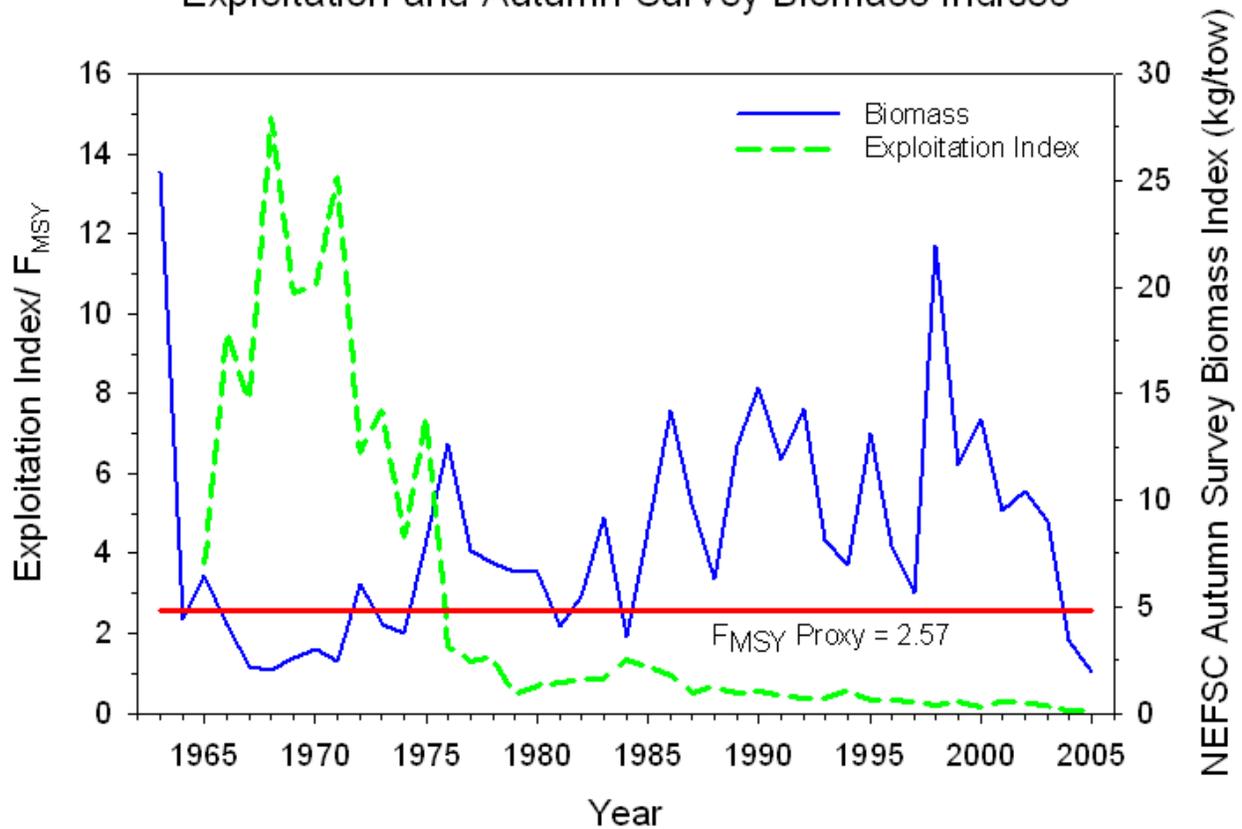


Figure 4.7. Trends in northern silver hake autumn survey biomass and exploitation indices (calculated as annual landings divided by the autumn survey biomass index). The solid red line represents the F_{MSY} proxy (2.57).

Southern Silver Hake Total Commercial Landings

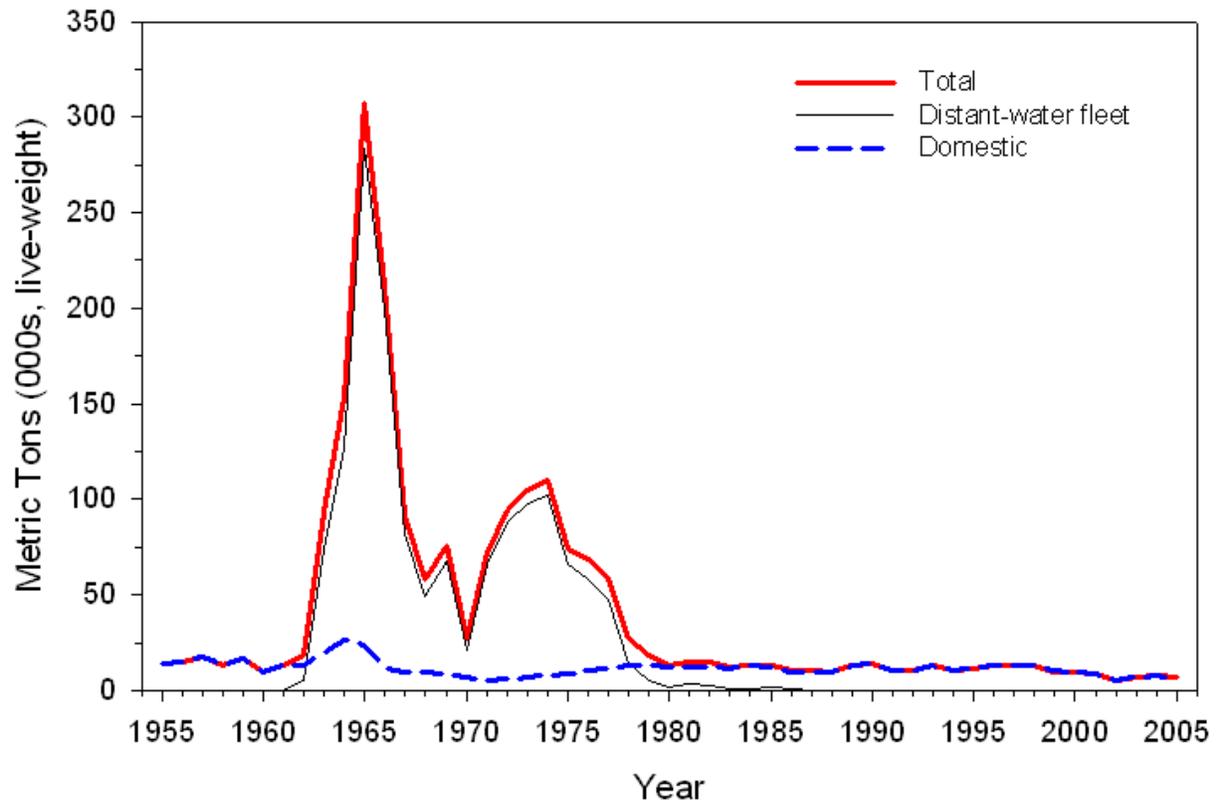


Figure 4.8. Total commercial landings of southern silver hake from the Southern Georges Bank-Middle Atlantic Bight region, 1955-2005.

Southern Silver Hake NEFSC Autumn Biomass Index

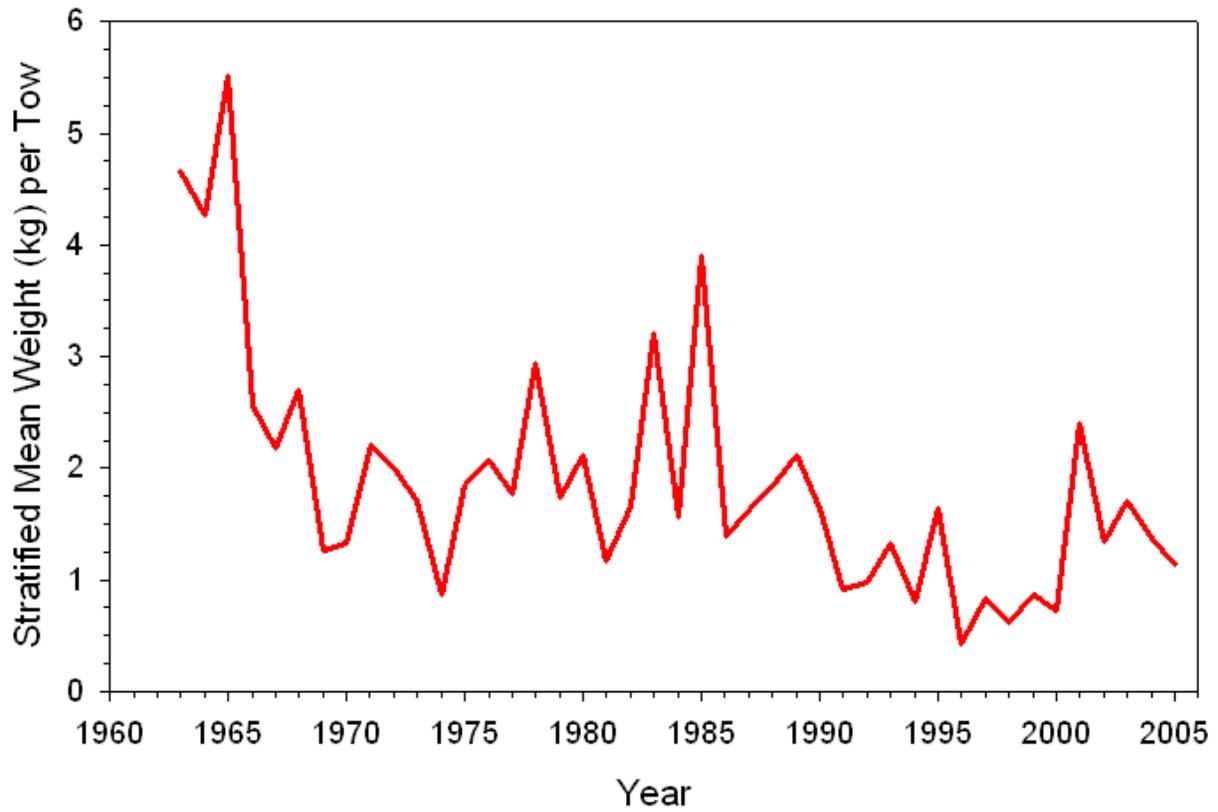


Figure 4.9. Biomass index (stratified mean weight per tow) for southern silver hake from the NEFSC autumn research vessel survey.

Southern Silver Hake Autumn Survey Indices by Age

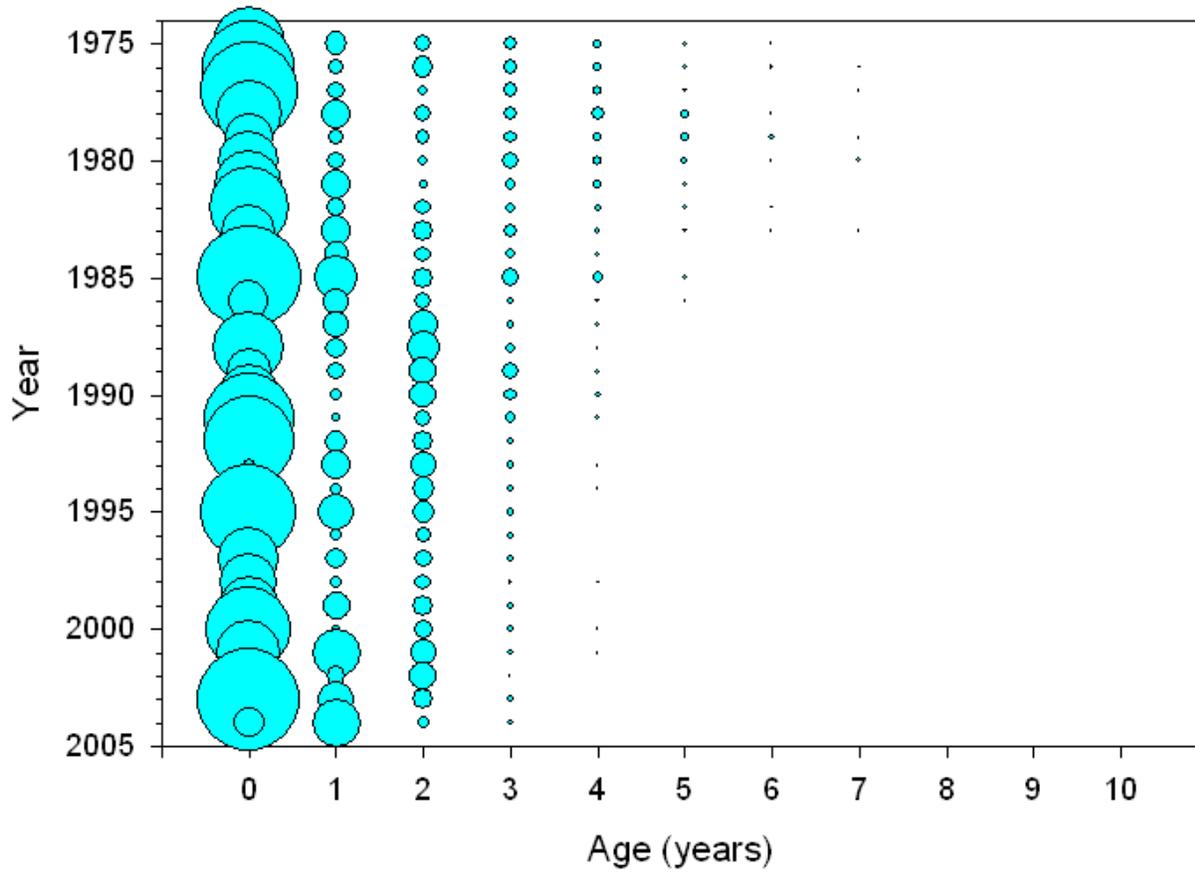


Figure 4.10. Age structure of the Southern silver hake stock, 1975-2004.

Southern Silver Hake Autumn Survey Biomass v. B_{MSY} Proxy

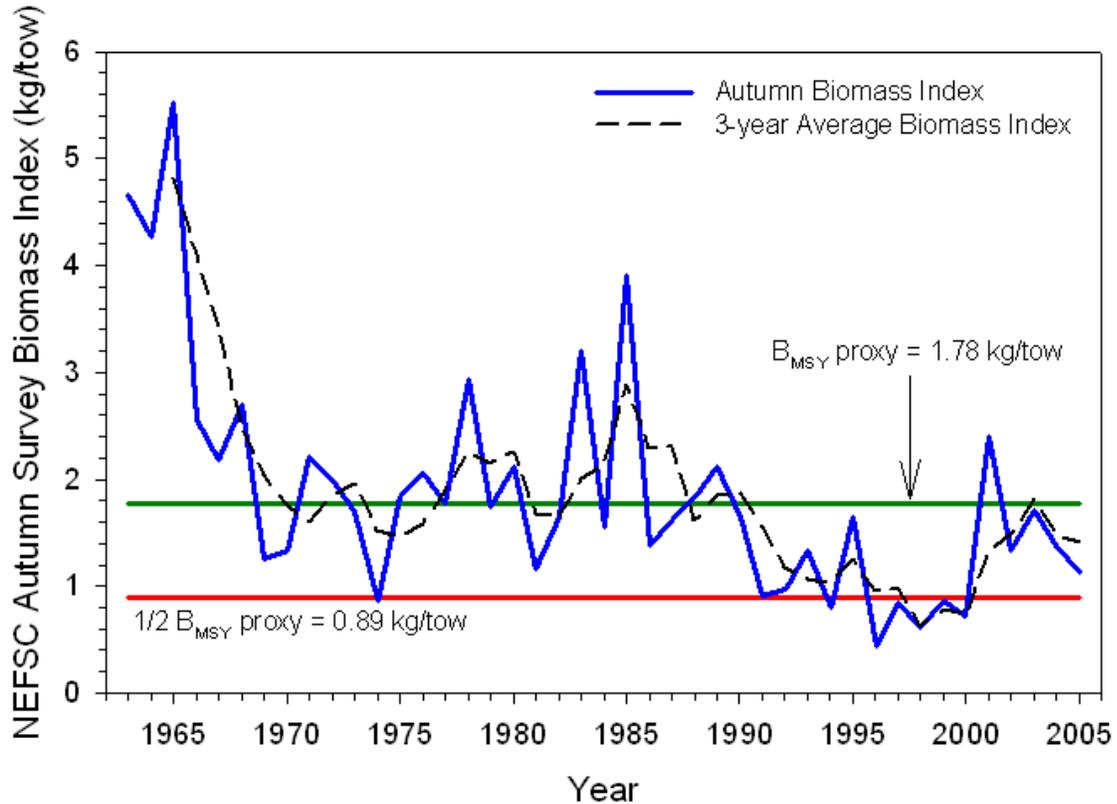


Figure 4.11. Trends in biomass indices (mean kg/tow) of southern silver hake from NEFSC autumn bottom trawl surveys in relation to the B_{MSY} proxy (1.78 kg/tow) and $1/2 B_{MSY}$ proxy (0.89 kg/tow).

Southern Silver Hake Exploitation and Autumn Survey Biomass Indices

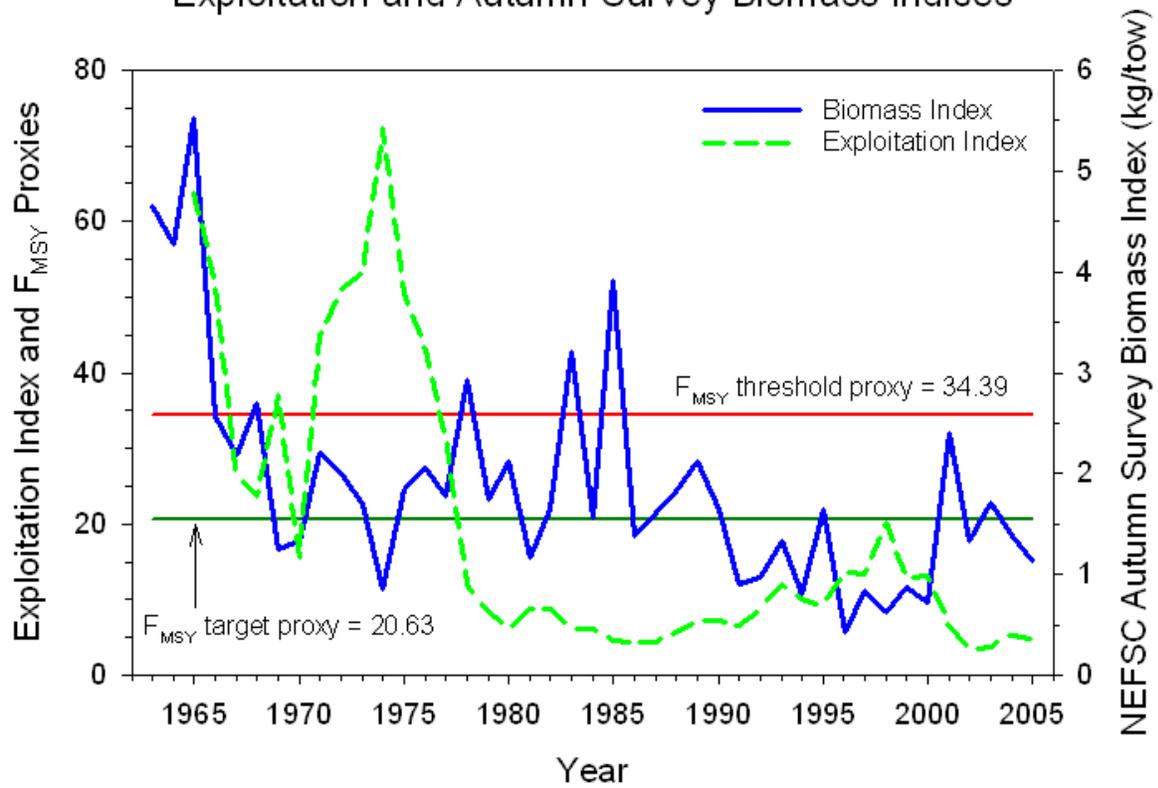


Figure 4.12. Trends in southern silver hake autumn survey biomass and exploitation indices, calculated as annual landings divided by the autumn survey biomass index.