A. ASSESSMENT OF SILVER HAKE

EXECUTIVE SUMMARY

1) Overfishing definitions and biological reference points used in this assessment for the northern and southern stocks of silver hake are based on trends in three-year moving averages of fall survey biomass indices (delta mean kg/tow) and three-year averages of exploitation indices (landings / fall survey biomass index).

2) The biological reference points based on exploitation indices are new since the last assessment. They were developed during the interim by the New England Council's Whiting Monitoring Committee because fishing mortality estimates were not estimated for whiting in the last assessment and because it was not possible to use the original fishing mortality based reference points ($F_{0.1}$) in Amendment 12. The Whiting Monitoring Committee's proposal is a typical approach that was based on the original reference points to the extent possible. The new biological reference points were reviewed for this assessment and used because fishing mortality rates could not be estimated in this assessment either.

3) The northern stock of silver hake is not overfished and overfishing is not occurring. In particular, the three year average biomass index for 2002-2004 (6.72 kg/tow) was above the management threshold level (3.31 kg/tow) and near the target level (6.63 kg/tow). The three year average exploitation index for 2002-2004 (0.24) was below the management threshold and target level (2.57). The target and threshold reference points for defining overfishing in the northern stock are identical. The northern stock of silver hake was not overfished based on results from the last assessment (NEFSC 2001). Overfishing was not evaluated in the last assessment because fishing mortality rates were not estimated.

4) Based on current reference points, the southern stock of silver hake is not overfished and overfishing is not occurring. In particular, the three year average biomass index for 2002-2004 (1.37 kg/tow) was above the management threshold level (0.89 kg/tow) but below the target level (1.78 kg/tow). The three year average exploitation index for 2002-2004 (4.85) was below the management threshold level (34.39) and below the management target level (20.63). The southern stock of silver hake was overfished based on results from the last assessment (NEFSC 2001). Overfishing was not evaluated in the last assessment because fishing mortality rates were not estimated. The change in status is due to increases in stock biomass indices for the southern stock of silver hake.

5) The southern stock of silver hake was overfished based on results from the last assessment (NEFSC 2001). The change in status is due to increases in stock biomass indices for the southern stock of silver hake.

6) (EDITOR'S NOTE: THIS PART OF THE WORKING GROUP REPORT HAS BEEN OMITTED. IT WAS NOT ACCEPTED BY THE REVIEW PANEL.)

7) Fall survey recruitment indices show variable but generally increasing trends in the northern stock area since 1967. In the southern stock area, recruit and fishable biomass during fall surveys varied without trend.

8) Coast wide silver hake landings were less than 10 thousand mt per annually after 2002. During 2001-2004, coast wide silver hake discards averaged about 4000 mt y^{-1} (CV 17%) with at least 1,600 mt y^{-1} in the north and 2000 mt y^{-1} in the south on average during 2001-2004.

9) The most important uncertainties in management stem from clearly decreasing trends in abundance of relatively old and large individuals, despite low fishing mortality rates and relatively high biomass levels during recent years. Declines in abundance and occurrence of relatively old silver hake appear real and not due entirely to age reader errors, misidentification of offshore hake in surveys, or slower somatic growth. There is evidence of northward and offshore shifts in average location that may make relatively old and large silver hake less available to bottom trawl surveys. The possibility of increased natural mortality rates due to predation is a key area for future research.

10) Total allowable landings (TAL) for 2005 were calculated based on fall survey data through 2004 and exploitation index reference points. For the northern stock area during 2005, where the target and threshold reference points are the same, TAL < 17.3 mt. For the southern stock area during 2005 and based on the target reference point, TAL=28.3 mt. For comparison, annual landings averaged 1.71 thousand mt in the north and 6.65 thousand mt in the south during 2002-2004.

11) Stock projections were not carried out but stock biomass levels are relatively high. Fishing mortality rates are very low in the north and probably low in the south also. Recent recruitments have been roughly average. Significant declines in stock biomass due to fishing are unlikely in the short term.

1.0 TERMS OF REFERENCE:

1. Characterize the commercial and recreational catch including landings and discards.

Recreational landings of silver hake were not estimated in this assessment but are minor based on estimates in the last assessment (Brodziak et al. 2001).

Discards were estimated in this assessment.

2. Estimate fishing mortality, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates. If possible, also include estimates for earlier years.

(EDITOR'S NOTE: THIS PART OF THE WORKING GROUP REPORT HAS BEEN OMITTED. IT WAS NOT ACCEPTED BY THE REVIEW PANEL.)

3. Evaluate and either update or re-estimate biological reference points, as appropriate.

Reference points proposed by the New England Fishery Management Council's Whiting Monitoring Committee and used in overfishing definitions for silver hake during recent years were reviewed and used in this assessment.

4. As needed by management, estimate a single-year or multi-year TAC and/or TAL by calendar year or fishing year, based on stock biomass and target mortality rate.

TAL levels were calculated based on fall survey data through 2004 and exploitation index reference points.

5. If possible,
   a. provide short term projections (2-3 years) of biomass and fishing mortality rate, and characterize their uncertainty, under various TAC/F strategies and
   b. evaluate current and projected stock status against existing rebuilding or recovery schedules, as appropriate.

Based on a qualitative analysis, significant declines in stock biomass due to fishing are unlikely in the short term. It was not possible to carry out quantitative projection analyses.

6. Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in previous SARC-reviewed assessments.

This information is provided at the end of the stock assessment report.

2.0 INTRODUCTION

Silver hake (*Merluccius bilinearis* or "whiting") range from Newfoundland to South Carolina and are most abundant between Nova Scotia to New Jersey (Figure A1; Collette and Klein-MacPhee 2002). Silver hake are found over a broad range of depths ranging from shallow coastal areas to the continental slope. The offshore limit of habitat of silver hake habitat on the continental slope is uncertain but the species ranges to at least 400 m depth (Collette and Klein-MacPhee 2002). Silver hake are found in midwater as well as on the bottom but the extent to which they use the water column as habitat is unknown because most of the available information comes from bottom trawl gear.

As shown below, adult silver hake (age $\geq$ 2 y and TL $\geq$ 20 cm TL) tend to be distributed further offshore and further north than younger, smaller individuals. The size and age at which the offshore and northern shift in distribution occurs are approximately the same as the size and age at sexual maturity. Distribution patterns change seasonally as the adult population moves inshore with warmer water temperatures during the spring and summer to spawn near coastal juvenile habitat areas. Depth appears more important than temperature or season in determining distribution patterns because small individuals remain in shallow coastal areas despite substantial seasonal changes in water temperatures (warm during summer-fall and cool during winter-spring). Similarly, larger individuals remain primarily in deeper water that is relatively warm during winter-spring and cool during summer-fall.

Silver hake are important as predators and prey in the food web of the northeast continental shelf ecosystem (Sissenwine and Cohen 1991). They feed mainly at night (Collette and Klein-MacPhee 2002). Small silver hake (< 20 cm TL) eat euphausids, shrimp, amphipods and decapods. Larger silver hake eat fish (including other silver hake), crustaceans and squid. The shift in diet coincides with the onset of sexual maturity and offshore/north shift in distribution and cannibalism is common.

Two stocks of silver hake are currently assumed in managing the fishery and in stock assessments for silver hake in US waters (Figure A1). The northern stock area includes northern Georges Bank and the Gulf of Maine. The southern stock area includes southern Georges Bank, southern New England, and the Mid-Atlantic Bight. The two stock areas are based on differences in morphology (Almeida 1987), otolith shape (Bolles and Begg 2000), abundance trends, fishery patterns and the apparent break in silver hake habitat at Georges Bank.

Although management and stock assessments have been based on two stocks, silver hake along the northeast coast are likely one population with incomplete mixing between northern and southern areas (Brodziak et al. 2001). Larvae are pelagic and remain in the water column where they circulate freely for 1-5 months before metamorphosing to juvenile form and presumably settling to the bottom at about 1.7-2.0 cm TL (Lock and Packer 2004). North-south movement patterns are not well understood but it is likely, based on results from this assessment, that adults move around Georges Bank seasonally and depending on environmental conditions. The northern and southern stocks of silver hake are probably best viewed as management units.

Silver hake in Canadian waters are abundant enough to support a fishery.[1] The US and Canadian stocks of silver hake are probably linked to some degree and this is an important topic for future research.

The proportion of silver hake minimum swept area biomass in the northern area has varied substantially over time from less than 40% to more than 90% with proportions in the north generally increasing until recently (Figure A2). One of the key questions regarding silver hake is whether the shifts in distribution between the northern and southern areas are due to environmental effects on distribution or relatively high mortality in the southern area (Brodziak et al. 2001).

Silver hake grow rapidly (Figure A3). Growth rates vary over time and among areas but in an inconsistent fashion (Helser 1996; Brodziak et al. 2001). Based on Brodziak et al. (2001), growth has been rapid and almost linear in silver hake during recent years based on Brodziak et al. (2001). However, scarcity of older fish makes growth curves estimated from recent data difficult to compare to growth curves estimated from historic data (Brodziak et al. 2001). Growth and maturity rates may depend on stock biomass (Helser and Brodziak 1998).

[1] http://www.frcc.ca/2004/SF2004.pdf

Based on data from Canadian waters, growth of males and females is similar up to about 22 cm TL (Collette and Klein-MacPhee 2002), which coincides with the onset of sexual maturity (Figure A4). After sexual maturity, females grow more rapidly and to larger maximum sizes.

Survey age data for silver hake collected during 1973-2005 are from thin sectioned otoliths. Age data for earlier years are from whole otoliths and less reliable. Age reader experiments described in this assessment show that criteria used to age silver age changed during 1973-2005. Historical age estimates are one or two years higher than estimates made recently from the same otoliths. The precision of age estimates decreases for older silver hake. Age data for silver hake are currently being re-audited to remove duplicate records discovered during this assessment.

There is considerable uncertainty about the potential longevity and underlying natural mortality rates silver hake. Brodziak et al. (2001) report that maximum ages observed in NEFSC fall and spring surveys declined from 14 y (corresponding to a natural mortality rate M of about 0.3 y^{-1}, Hoenig 1983) during the mid-1970's to 6 y recently (corresponding to a natural mortality rate of about 0.8 y^{-1}, Figure A5). One of the key questions regarding the stock is whether changes in maximum ages are due to environmental effects on availability of older fish to surveys, increased mortality, age estimation errors, or mis-identification of offshore hake (*M. albidus*).

3.0 THE FISHERY

Silver hake landings (Table 1) increased substantially during the 1960s due to directed fishing for silver hake by distant water fleets operating in US waters (Figure A6). During the 1990s, total silver hake landings were relatively low in comparison to historic values. Silver hake landings declined further to less than 10 thousand mt per year after 2002 (Figure A7).

Landings were almost entirely from the northern area prior to 1964 (Table A1 and Figures A8). After 1964, silver hake landings were mostly from the southern stock area.

Recreational Fishery

Silver hake once supported a recreational fishery in the Mid-Atlantic Bight (Fritz 1960) with annual landings of around 1,000 mt (2.2 million pounds) in the southern stock area. Recreational fishery landings decreased substantially in the 1970s and 1980s and are currently very low. Recreational landings of silver hake averaged only 18,000 fish per year during 1995-1999 (Brodziak et al. 2001).

Commercial Fishery

Directed commercial fishing for silver hake began in the 1920s. The fishery evolved over time from an inshore fishery using pound and trap nets to the modern otter trawl fishery (Fritz 1960; Table A2). The bulk of silver hake landings during recent years were from the southern stock area. In the northern stock area, landings are mostly from the Cultivator shoals, Gulf of Maine and the rest of Georges Bank (Table A2 and Figure A9). In the southern stock area landings are mostly from Southern New England and the Mid-Atlantic Bight (Table A2 and Figure A9). Landings data for years after 1994 are prorated to area of catch based on Vessel Trip Report (VTR) logbook data. Area of catch is identified in records for earlier years based on interviews by port samplers.

Silver hake were landed in six commercial market categories during 1995-2004 including the category "5095 (Large round)" that was new in 2004 (Table A2). Intensity of sampling was measured as number of length measurements divided by metric tons landed (Table A3). Sampling was highest (intensity > 1.5) for the hook & line gear group, gillnet gear group, and for the 5091 (King round) market category.
Length composition data for commercial landings indicate that the fishery has taken smaller silver hake since 1997 and that recruitment to the fishery begins to occur at about 20 cm TL (Figure A10). The shift in commercial length frequencies may be due to management measures, other changes in the fishery, or a change in the silver hake population.

Age composition data for commercial landings from Brodziak et al. (2001) show declines in proportions of older silver hake. Age data are not collected from the commercial fishery but commercial age composition can be inferred based on survey age data and commercial length composition data. Commercial and survey age composition data were not updated for silver hake in this assessment. Survey age data for silver hake used to construct age-length keys are currently being audited and should be ready for use in the next assessment.

Bycatch and Discards

Sea sampling data for 1989-1999 collected by observers on fishing vessels and reviewed by Brodziak et al. (2001) showed that discarding of silver hake captured by otter trawls occurred throughout the northern and southern stock areas. Discarding of silver hake by scallop dredges occurred in both northern and southern stock areas but discarding by sink gill nets occurred primarily in the northern stock area. Discard to kept (DK) ratios by weight (weight of silver hake discarded / weight of species landed) varied through time, ranging from 0% to over 100% for the directed silver hake fishery (small mesh otter trawl, cod end mesh 3" or less) and for the non-directed fisheries (large mesh otter trawl, shrimp trawl, sink gill net, and scallop dredge). Variability in discard ratios may have been due to non-random coverage of the fleet, small sample sizes, or inherent variation in discard rates and practices.

New discard estimates for recent years (2001-2004) in this assessment were based on observer data and a ratio estimator first used for spiny dogfish (*Squalus acanthias*, NEFSC 2003). Estimates in this assessment were for recent years only because observer data coverage has increased in recent years and because recent discards were most important in evaluating the status of the silver hake resource.

The ratio estimator approach has several potential advantages including well defined statistical properties, relative simplicity and objective stratification based on landings data (i.e. it is not necessary to determine target species for tows or trips based criteria that are possibly arbitrary). However, ratio estimators are biased (see below) and the relative merits of discard estimators used in the Northeast (Rago et al. 2005) have not been fully evaluated.

Species groups and gear groups were used to tabulate and stratify observer and "landings" data (landings and hail weights in this analysis were hail weights for individual tows recorded by observers) at the trip level (Tables A4-A6). The species groups and gear groups used for silver hake were similar to the groups used for spiny dogfish (NEFSC 2003) with some modifications. All species potentially landed were assigned to a species group and all potential gear types are assigned to a gear group.

In the first step, kept (and presumably landed) weight $K_{G,S,T}$ is tabulated for each trip (T) in the observer database by species group (S) and gear group (G). Information about total silver hake discards on each trip ($D_{G,S,T}$) is retained but information about discard of other species is not. At the end of the first step, there is one record for each observed trip. The record contains total silver hake discards (which may be zero) and landings in each of the species groups. The sum of landings for all species groups equals total landings for the trip.

In the second step, the primary species group is determined based on the species group with highest landings. The secondary species group with second highest landings is used for diagnostic plots and identified as well (Rago et al. 2005). At the end of the second step, there is one record for each trip that contains the total silver hake discard, variables that identify the primary and secondary species group, a variable that identifies the gear group, and landings in the primary and secondary species groups.

The third step is to calculate DK ratios for each species group and gear group using the ratio estimator:

$$R_{G,S} = \frac{\sum_T D_{G,S,T}}{\sum_T K_{G,S,T}}$$

where $R_{G,S}$ is the DK ratio. The variance of the ratio estimator (Cochran 1977) is approximately:

$$Var(R_{G,S}) = \frac{Var(D_{G,S}) + R_{G,S}{}^2 Var(K_{G,S}) - 2R_{G,S}Cov(D_{G,S}, K_{G,S})}{n\overline{K}^2_{G,S}}$$

As shown in Cochran (1977) the ratio estimator is biased with:

$$bias = -\frac{Cov(R,\overline{K})}{\overline{k}} = -\frac{\rho\sigma_R\sigma_{\overline{L}}}{\overline{k}}$$

where $\overline{K}$ is average landed weight estimated from observer data and $\overline{k}$ is the true (unknown) value. Note that the absolute value of the bias increases with the variance and correlation in R and $\overline{K}$. It is therefore advantageous, in terms of minimizing both bias and variance, to pool data and choose primary species groups and gear groups that minimize the variance in these quantities.

In the final step, total landings in weight ($L_{G,S}$, based on dealer records) is calculated for each species gear and gear group. Total discard (Λ) is:

$$\Delta = \sum_G \sum_S L_{G,S} R_{G,S}$$

Assuming that landings are measured without error, the variance is:

$$Var(\Delta) = \sum_G \sum_S L_{G,S}^2 Var\left(R_{G,S}\right)$$

For silver hake in this assessment, observer data for 2001-2004 were pooled to estimate one set of DK ratios and average annual discard estimates for 2001-2004. Pooling observer data for adjacent years, and use of relatively broad species groups and gear groups increased sample size and decreased variance. However, bias may have increases as well because of non-representative sampling and discard rates that probably varied among years, gear groups and primary species groups. The potential importance of these potential problems was not evaluated. However, the statistical (not sampling related) bias of ratio estimators is proportional to their CV (Cocharan 1977) and it seemed reasonable to pool data sufficiently to reduce CVs.

Results

Mean annual discards during 2001-2004 are presented for gear and species groups with DK ratios > 0.0001 (Table A7). During 2001-2004, silver hake discards averaged about 3,820 mt y^{-1} (CV 17%). Trips with hakes and ocean pout as the primary species group in the other/unknown and bottom trawl gear groups had the highest DK ratios. The highest level of average annual silver hake discards were for crab/shrimps in shrimp trawls, and hakes and ocean pout in bottom trawls. See Appendix A4 for diagnostic plots (NEFSC 2003) presented to reviewers but not originally included in this assessment.

Discards were not estimated separately for northern and southern stock areas but it was possible to prorate estimates approximately for the most important primary species and gear groups with discards of at least 70 mt y^{-1} based on general knowledge about the fisheries (Table A7). On this basis, discards of silver hake in the northern stock area averaged at least 1,580 mt y^{-1} and discards in the southern stock area averaged at least 1998 mt y^{-1} during 2001-2004. For comparison, silver hake landings during the same period averaged 2,142 mt y^{-1} in the north and 7,153 mt y^{-1} in the south (Table A1).

4.0 SURVEY INFORMATION

Trends in survey biomass indices for the two silver hake stocks are evaluated in a subsequent section under the heading “Biomass And Fishing Mortality”. Analyses in this section are confined to trends in recruitment and related factors. Survey recruitment trends show that recruitment to the fishery (silver hake ≥ 20 cm TL) was at least average in the north during recent years. In the south, recruitment to the fishable stock fluctuated around average levels in recent years. Despite average or better recruitment, survey trends show reductions in abundance of relatively large silver hake and reduction in mean weight of individual fish that are analogous to reductions in abundance of old fish mentioned above.

A number of analyses were carried out to measure environmental effects on silver hake catches in NEFSC surveys, by size group, age, and stock area. Results suggest an ontogenetic shift at about the size and age of sexual maturity. In particular, relatively large and old fish are found further north and in deeper water (further offshore). Survey catches are highest at night, contrary to expectations, suggesting that silver hake have a reverse diel migration pattern. Depth seems to be more important than temperature in determining the distribution of silver hake. Small/young silver hake inhabit relatively shallow waters and larger/older silver hake inhabit deeper waters year around, despite large seasonal fluctuations in bottom temperatures.

Survey data are used to track the average position of silver hake in both stock areas and to test for trends in average position over time that might explain recent reductions in abundance of larger and older silver hake. Results generally suggest a shift in the distribution of larger fish to the north and offshore over time.

North-south movements of silver hake between stock areas is likely because the center of distribution for large fish n the northern area during the spring and small fish in the southern area during the fall is close to the boundary between the two stocks. It seems unlikely that silver hake in the north and south are separate populations but, depending on management goals, differences between the two areas are clear enough to justify use of the northern and southern regions as separate management areas.

Survey age data were examined to determine if relatively old silver hake observed historically might have been mis-aged or mis-identified offshore hake. Results indicate some imprecision in age estimation and a positive bias in historical ages (age reading criteria used historically result in ages 1-2 y higher than criteria used recently). The factors do not, however, completely explain the absence of older fish during recent years.

Spatial patterns in NEFSC survey catches

Maps showing locations and size of survey catches for all inshore and offshore strata sampled since 1979 (when inshore strata were first sampled consistently during spring and fall, Figures A11-A13) show how ubiquitous and widely distributed silver hake are in all seasons. Nearshore areas at 35^{o}-38^{o} N Lat. have a relatively high proportion of zero tows during fall and winter but not during spring. In addition, the southern flank of Georges Bank north of 40^{o} N Lat. has a relatively high proportion of zero tows in winter, but not during spring or fall. Silver hake were distributed in an apparently normal fashion during the most recent NEFSC surveys (Figures A14-A16).

None of the NEFSC bottom trawl surveys appear to cover the entire range of the silver hake stocks (Figures A11-A13). Catches were relatively high in deep water during winter, spring and fall along the 100-fathom contour and eastern edge of the area surveyed. In addition, catches from coastal areas north of 38^o N Lat. were relatively high during spring and fall (inshore strata were not sampled during winter).

"Traditional" and "Special" strata sets for survey data

In this assessment, "traditional" strata sets are those used in previous assessments to describe trends in silver hake stock biomass (Brodziak et al. 2001). In particular, trends in abundance and biomass of silver hake for the northern stock area are traditionally measured using NEFSC fall and spring survey data from offshore strata 01200-01300 and 01360-01400 (NEFSC 2001). Strata 01610-01760 were not sampled during 1963-1966 so the survey biomass for sampled strata during 1963-1966 was increased by 1.8% in Brodziak et al. (2001), the long-term average proportion of silver hake biomass in strata 01610-01760. In this assessment, data for 1963-1966 were usually ignored. Previous assessments did not typically use inshore survey strata for silver hake, although inshore habitats are used by young and small silver hake, because inshore strata were not sampled consistently until 1979.

Different "special" strata sets were used for survey data in this assessment for environmental and trend analyses described below. Special strata sets for each survey and season were considered carefully with the goals of: 1) using as much information over the widest range of environmental conditions as possible; 2) using as many inshore strata as possible (small silver hake are most common in relatively shallow water; and 3) avoiding spurious results due to lack of sampling in some years. The primary criterion for choosing strata was consistency of sampling (i.e., was the stratum sampled during all years?). Winter and spring survey data were available through 2005. Fall survey data were available only through 2004.

Beginning in 1979, offshore and inshore strata were sampled consistently in the northern and southern stock areas (Tables A8-A11). The winter survey is carried out in offshore strata and in the southern stock area exclusively (Table A12). Based on this information, stock-specific strata sets were derived for the fall and spring surveys beginning in 1979 and for the winter survey beginning in 1992 (Table A13). In this assessment, special strata sets are consistently sampled inshore and offshore strata starting in 1979 (fall and spring surveys) or 1992 (winter surveys).

Mean weight and recruitment trends

Using the special strata sets, mean body weight of silver hake in NEFSC spring and fall surveys and north and south stock areas combined declined steadily during 1979 to 2005 (Figure A17). There were similar trends using the traditional strata sets for individual stock areas (results not shown). Mean weights were usually highest in the northern stock area because larger fish tend to be found further north than smaller individuals. Survey length composition data show progressive reductions in abundance of large individuals (Figure A18).

Fall survey biomass indices (delta mean kg/tow) for recruit (< 20 cm TL) and fishable (≥ 20 cm TL) silver hake in the northern stock show variable but generally increasing trends in abundance since 1967 (Figures A19-A20). In the southern stock area, recruit and fishable abundance during fall surveys varied without trend (Figures A19-A20).

Based on spring survey data, recruit and fishable biomass peaked in both the north and south during 1973-1974 and then declined to relatively low levels by 1980 (Figures A19-A20). In the north, recruit and fishable biomass indices show noisy but generally increasing trends since the early 1980s. In the south, recruit biomass was low during 1982-1998 but may have increased somewhat during 1999-2005. Fishable biomass, in contrast, showed a variable but declining trend during the same period (Figures A19-A20).

Environmental effects on silver hake density and occurrence

Environmental effects on catchability of large or small silver hake may contribute to issues in interpreting survey data trends. The special set of survey strata were used in these analyses. A few tows in anomalously deep water (> 400 m), and tows with missing temperature, depth or time of day data were omitted. Analyses were carried out for the southern and northern stocks independently and combined.

Models were developed for the probability of occurrence of at least one silver hake in survey bottom trawl tows, and for numbers of silver hake caught in tows where at least one silver hake was caught. The first type of model measures probability of occurrence. The second measures density in areas where silver hake occur. Both types of models were fit to tow-by-tow data for individual length groups. Based on preliminary analyses, five cm length groups (1-5.9, 6-10.9, 11-15. 9, 16-20.9, 21-25.9 and 26+ cm) were used in modeling. Very few small silver hake (1-5.9 cm TL) were captured during the spring survey in the northern stock areas. Therefore, the smallest size group was excluded from analyses for the northern stock area and for the northern and southern stock areas combined.

Relationships between environmental variables and the probability of occurrence were evaluated using step-wise logistic regression and generalized additive models (GAMs). Relationships between environmental variables and catch in positive tows were evaluated in a similar manner using step-wise log-linear regression and GAM models. The step-wise procedure used in both cases (step.gam in Splus) minimized the AIC statistic for a set of models.

The most complicated model considered for probability of occurrence was:

```
        gam(P ~ as.factor(Y) + lo(T) + lo(D) + lo(L),
family=binomial)
```

where the dependent variable *P* was either one (if at least one silver hake of appropriate size was caught in the tow) or zero (if no silver hake of appropriate size were caught). The most complicated model for density in positive tows was similar:

```
          gam(log(d) ~ as.factor(Y) + lo(T) + lo(D) +
lo(L))
```

where the dependent variable was the logarithm of the number of silver hake of appropriate size taken in the tow. In both models, the independent variables were year (*Y*), bottom temperature (*T*), average depth of the tow (*D*) and time of day (*L*, decimal EST time; e.g. 23.5 for 11:30 pm). The term lo(x) is the loess locally linear scatter plot smoother fit with a span of 0.5 (Hastie and Tibshirani 1990).

Year (*Y*) was a categorical variable that was "forced" in each model (i.e. the step-wise procedure could not eliminate it). Other independent variables could enter the model either as a loess term, quadratic polynomial, linear term or could be omitted completely. Latitude and longitude were omitted in modeling because they were highly correlated with depth and bottom temperature and because the purpose was to understand environmental effects. Latitudinal and longitudinal patterns are explored in subsequent analyses (see below).

Results - probability of occurrence

Based on GAM model results (Table A14 and Figures A21-A25), small silver hake were most likely to be found in relatively shallow waters that tend to be relatively warm during autumn surveys and cool during spring and winter surveys. Depth and temperature distributions for positive tows confirm GAM results (Figures A26 to A28). Patterns related to depth and temperature were strongest for the southern stock probably because of the wider area sampled in the south.

Depth seemed more important than bottom temperature in predicting occurrence of silver hake because small individuals were found in relatively shallow water for both stocks during all surveys. Relationships between probability of occurrence for silver hake size and temperature differed in the winter, spring and fall surveys.

The probability of a positive tow for small silver hake was generally highest at night with the northern stock and fall survey being the notable exception (Table A14). This "reverse" diel pattern was first noted by Bowman and Bowman (1980) and is unexpected because most mesopelagic organisms migrate off bottom during the night time so that catch rates are highest during the day. Bowman and Bowman (1980) attributed low catch rates during the day to behavior of silver hake. They hypothesized that silver hake were very close to the bottom during the day and not efficiently captured by survey bottom trawls with roller gear, which might roll over them. Reverse diel migration patterns are not as strong for silver hake in winter surveys which use bottom trawls that have cables, rather than rollers, as ground gear (Tables A14-A15).

Results-catch in positive tows

GAM results for catches of silver hake in positive survey tows were generally similar to results for probability of occurrence although patterns were clearer for density with more significant loess terms in models (Table A15). In particular, density of small silver hake was highest in relatively shallow waters. The highest catches of large silver hake (> 21 cm) were at depths of at least 150 m at or near the offshore edge of the bottom trawl surveys. Bottom temperature, depth and time of day were significant in 30, 31 and 27 out of 31 total cases. All models with significant time of day effects predicted highest catch rates at night.

Temporal patterns in stock distribution

Mean depth, latitude, longitude and bottom temperature for silver hake of different sizes in the northern and southern stock areas were computed as catch weighted averages so that the latitude of a tow with a large catch received a higher weight than the latitude of a tow with a small catch (special strata set). Tows with zero catches were, in effect, omitted from the analysis because they received zero weight. Murawski (1993) and Overholtz and Friedland (2002) carried out similar analyses for latitude and longitude in a variety of species but used unweighted means. The weighted means used here should more accurately measure average position and environmental variables encountered by silver hake stocks. Linear regression analyses with year as the independent variable and mean latitude or longitude as the dependent variable were used to test for trends in location of silver hake. Both linear and loess regression lines were plotted to help visualize trends.

Results

Results (not shown) for trends in average temperature and depth supported results from the GAM model analysis because larger fish were found in deeper water that was relatively cold during fall surveys and relatively warm during spring and winter surveys. Variation in average temperature and depth was irregular and inconsistent. It did not indicate steady unidirectional trends or abrupt shifts in average depth or temperature of silver hake in any size group.

Results for trends in average location (latitude and longitude, Figures A29-A35) show that small silver hake (< 6 cm) in the northern stock area during the fall and southern stock area during the spring are located further south (lower mean latitude) than larger individuals. Larger individuals were located further offshore (at lower mean longitude) during the spring and winter surveys in the southern stock area.

Differences between location and size were clearest when the northern and southern stock areas combined (Figure A31 and A34). In particular, small silver hake tend to occur over inshore regions in the south while larger individuals are further north and offshore. As pointed out by reviewers, trends towards the north and offshore might be spurious and due to increasing abundance in the north of the northern and southern stocks are, in fact, independent populations.

Average latitude results indicate that substantial interchange of silver hake is likely between the northern and southern stock areas. The northern and southern stock areas are divided at approximately 41-42^{o} N (Figure A1). Average locations of silver hake in the northern stock were generally close to the northern boundary of the southern stock area (Figures A29 and A32). Similarly, average locations of silver hake in the southern stock area during fall when water temperatures are warm were generally close to the southern boundary of the northern stock area (Figures A30).

Trends in mean bottom temperature over time were statistically significant (Table A16) in only two out of 40 possible cases. In particular, there were negative trends for two size groups in the fall survey with north and south stock areas combined. Trends in mean depth were statistically significant and positive in 12 out of 40 possible cases, most often for combined north and south stock areas during the fall.). Two apparently significant trends would be expected under the null hypothesis of no trends in bottom temperature using *p*-value 0.05.

Trends in latitude and longitude (Table A16 and Figures A29 to A35) indicate a general shift in the distribution of silver hake to the north and offshore. In particular, trends in mean latitude were statistically significant in 16 out of 40 cases. Trends in mean longitude were statistically significant in eight out of 40 cases (significant trends were positive in two cases and negative in eight cases). Two apparently significant trends would be expected under the null hypothesis of no trends in bottom temperature using *p*-value 0.05.

Trends in distribution may be confounded with changes in relative abundance of the north and south stocks because higher abundance in the north would result in a positive shift in mean latitude and a negative shift in mean longitude. Omitting cases with the southern and northern stocks combined, there were significant positive trends in mean latitude in ten cases and significant trends in mean longitude in six out of 30 cases (four negative trends and two positive trends, Table A16). One or two apparently significant trends would be expected under the null hypothesis of no trends in bottom temperature using *p*-value 0.05.

What happened to the old fish?

NEFSC survey age composition data for silver hake are currently being audited to remove some duplicate records. The provisional survey age data used here were corrected for obvious errors by the assessment authors and are meant only for use in this assessment.

Survey age composition data were not updated for silver hake in this assessment but age-specific abundance indices for silver hake from Brodziak et al (2001) show the declining trends in abundance of old fish despite trends for young fish that increased in recent years (Figure A36). Trends for relatively old silver hake are similar to results for relatively large fish (Figures A18-A20).

Several analyses indicate that normal variability in age reader data may exaggerate the apparent decline old silver hake in survey catches (see below). However, age data errors do not appear to be sufficient to completely explain the decline of old silver hake. As shown above, relatively abundance of relatively large silver hake have declined in abundance as well.

Accounting for changes in criteria used to age silver hake (see below), the small number of old fish observed, and age estimation errors (see below), it appears likely that the apparent decline in maximum age from 14 to 6 years represents an actual decline from perhaps 10 to 6 years (see below). Based on the provisional survey data and original age estimates (Table A17), only sixteen "old" individuals (originally aged 11-14 years) have been observed out of roughly 100,000 age estimates for silver hake taken in NEFSC fall and spring surveys during 1973-2005. Sixteen age estimation errors of at least +2 y are plausible given experimental results shown below.

It is unlikely that old silver hake observed in surveys were all or mostly offshore hake, although the two species are similar in appearance (Collette and Klein-MacPhee 2002). Plots (not shown) of length versus age for all silver hake in the NEFSC survey database indicate that lengths at age for relatively old individuals were not anomalous. Geographic distributions of silver hake ages 8+ and offshore hake overlap (Figures A11-A12 and A37-A38). However, survey staffs are aware of potential misidentification problems with silver hake and are generally alert to the possibility of misidentification in areas where both species occur. Moreover, otoliths from the two species differ in shape (Figure A39) and age readers are able to distinguish otoliths from the two species.

An environmental change that shifted large silver hake into deeper water might explain the apparent decline in abundance (Brodziak et al. 2001). Relatively old and large silver hake are most common in deep water at the limit of depths sampled in NEFSC surveys (Figure A40-A41). Trends in the mean locations of large and presumably old silver hake have been noted (see above). However, despite a range of potential candidates (Brodziak et al 2001), no environmental factor with a definitive mechanism that might cause a shift to the north or offshore has been clearly identified.

Distribution plots for relatively old silver hake may indicate a north-south seasonal migration pattern (prepared after this assessment was completed and presented to reviewers, Appendix A4). During spring surveys, silver hake ages 8+ were found south of Georges Bank. During fall surveys, in contrast, silver hake ages 8+ were almost entirely north of Georges Bank.

Age reader experiments

Three experiments were undertaken to determine the precision of current and historic age estimates for silver hake in NEFSC surveys. In the first experiment, the primary age reader who estimated ages for silver hake in the 2001-2005 surveys re-aged a sample of 99 fish originally aged 1-5 y. The sample size at ages 3 y and older was small but percent agreement declines for older silver hake (Table A18).

In the second experiment, an alternate age reader who was experienced in ageing silver hake re-aged the 99 specimens used in the first experiment. Percent agreement between readings was generally lower than in the first experiment. As in the first experiment, the sample size was small for ages 3 y and older but percent agreement appears to have declined with age (Table A19).

In the third experiment, a sample of 17 fish from fall and spring surveys during 1973-1975, 1979 and 1982 originally aged 7-14 y were re-aged by the primary reader. Although sample size was small, it appears that current criteria for ageing silver hake would result in age estimates that would be 1-2 y lower than originally (Table A20).

Relationships between age and depth

Cumulative distributions for silver hake of different ages in fall and spring surveys (all strata and tows) show older fish in deeper water with an apparent shift to deep water during fall between ages 2-3 y (Figure A42). Cumulative distributions for age and temperature show older fish in relatively warm water during the fall and relatively cool water during the spring. Patterns for old fish are similar to those described above for large fish. In particular, depth seems to be more important than temperature in determining habitat for silver hake of different size.

Supplemental "Transect" bottom trawl survey

Bottom trawl data from the Supplemental Finfish Survey Targeting Mid-Atlantic Migratory Species were used in this assessment to estimate lower bounds for catchability in NEFSC bottom trawl surveys and to better characterize the distribution of silver hake in deep water along the shelf break (Tables A21-A22). The survey is described in general terms below and in Appendix A2. See HSRL (2005) for a more complete description.

Supplemental survey data for silver hake in this assessment were collected during March of 2004-2005 following transects along the northern flank of Baltimore and Hudson canyons (transects and tow locations were the same in all years, Figure A43). Data for 2003 were not used because silver hake and offshore hake were not distinguished in survey catch records. Baltimore canyon stations included in this analysis were in NEFSC survey strata 01020-01040. Hudson canyon stations were in NEFSC survey strata 01700-01720 (Figure A1). For simplicity in this analysis, "fixed" stations along transects are treated like random samples from NEFSC survey strata. Supplemental survey data used in the analysis were from fixed stations at target depths of 73, 91, 110, 146, 183, 229 and 274 m (40, 50, 60, 80, 100, 125 and 150 fathoms) that were occupied during the daytime. Deeper stations were occupied at night and omitted from this analysis except in estimating survey length composition.

The F/V Jason and Danielle (96 ft and 1080 hp) was used in 2003-2004 Supplemental surveys and the F/V Luke & Sarah (120 ft and 1500 hp) was used during 2005. The captain, bottom trawl gear and sampling protocols were the same in all surveys.

The commercial 4 seam box net bottom trawl used in supplemental surveys was the same in each year. The wingspread averaged about 67 m and head rope height averaged about 5.5 m. In contrast, the Yankee #36 standard bottom trawl currently used in NEFSC fall and spring surveys is smaller with a wingspread of about 12 m and head rope height of about 2 m. The commercial bottom trawl has a larger liner in the cod end (6 cm vs. 1.27 cm). The sweep of the commercial net is covered with 3 inch rubber cookies. The Yankee #36 bottom trawl has a combination of 5 and 15 inch rollers. The Yankee #36 bottom trawl used in NEFSC surveys catches more small whiting (< 20 cm TL, Figure A44).

Supplemental survey tows were made at 3 knots in a direction perpendicular to the slope and transect. NEFSC survey tows were made at 3.8 knots in the direction of the next station. The amount of wire let out was constant for all tows at the same depth. Distance towed in the Supplemental survey was determined based on a depth data from a depth sensor on the trawl.

Twenty cm is a reasonable lower bound for defining the fishable stock of silver hake. Silver hake captured by the commercial bottom trawl used in Supplemental surveys are seldom < 20 cm TL (Figure A45). Small silver hake are more common in NEFSC surveys but not often encountered in the areas of interest during the spring (Figure A44). In analyses that follow, catch was in kg per tow for silver hake ≥ 20 cm TL in NEFSC surveys and total catch for Supplemental surveys. Densities of silver hake (kg/km^2) were calculated for each tow by dividing catch by area swept (Table A22).

Relationships between density and depth were generally similar for the two surveys (Figures A45-A47). Densities measured by the Supplemental Survey were substantially higher and less variable.

5.0 BIOMASS AND MORTALITY ESTIMATES

Three methods were used to characterize biomass and fishing mortality for silver hake in the northern and southern stock areas, and for the stocks combined. The first method is based on trends in biomass and exploitation indices that are calculated from landings and NEFSC fall survey data. The first method is the current standard and used by managers to specify management targets and thresholds and to define overfishing and overfished stock conditions. The second and third methods provide lower bound estimates for stock biomass and upper bound estimates for fishing mortality based on NEFSC survey, landings, discard and Supplemental survey data. The later two methods are new and have not been used previously. They are not intended to displace the standard method. Rather, they provide information about the scale (magnitude) of biomass and fishing mortality for silver hake.

Silver hake appear to be at relatively high biomass levels in both the northern and southern stock areas. Fishing mortality rates were low during recent years and much higher historically.

Trends in biomass and exploitation indices

Survey biomass trends for both the northern and southern stock areas (delta mean kg/tow for fall surveys during 1967-2004, calculated for "traditional" offshore strata) indicate that stock biomass is relatively high and near target levels used in management (Tables A22-A23 and Figures A48-A49). Relative exploitation indices (landings divided by the survey stock biomass index) indicate that fishing mortality rates are low in both stock areas and less than threshold levels used in management (Tables A22-A23 and Figures A48-A49).

A conventional age-structured stock assessment model was not used in this assessment for silver hake due to lack of time, uncertainty about stock structure, uncertainty about natural mortality stemming from trends in maximum age, ongoing audit of silver hake age data, low levels of fishing mortality during recent years (particularly in the north) which may complicate modeling, lack of a hypothesis regarding old fish to test in modeling, uncertainty about the magnitude of discards, a new stock assessment author, and the apparently misleading results from previous modeling efforts. In lieu of an age-structured stock assessment model, two approaches were used to estimate lower bounds for silver hake biomass and upper bounds for fishing mortality rates.

Bounds for fishable biomass and fishing mortality

(EDITOR'S NOTE: THIS PART OF THE WORKING GROUP REPORT HAS BEEN OMITTED. IT WAS NOT ACCEPTED BY THE REVIEW PANEL.)

Bounds based on NEFSC and Supplemental surveys

(EDITOR'S NOTE: THIS PART OF THE WORKING GROUP REPORT HAS BEEN OMITTED. IT WAS NOT ACCEPTED BY THE REVIEW PANEL.)

Bounds based on historical landings and concurrent survey data

(EDITOR'S NOTE: THIS PART OF THE WORKING GROUP REPORT HAS BEEN OMITTED. IT WAS NOT ACCEPTED BY THE REVIEW PANEL.)

A bridge between the current and last assessment

Trends in biomass and exploitation indices suggest that results from a virtual population analysis for silver hake in the previous assessment were overly pessimistic (NEFSC 2001). It appears that the virtual population analysis (VPA) used in the last assessment mistakenly interpreted trends in abundance of old silver hake as evidence of low abundance and high fishing mortality. A Bayesian surplus production model in the last assessment appears to have given more plausible results with generally increasing biomass trends for the stock as a whole.

6.0 OVERFISHING DEFINITIONS AND STATUS

Overfishing definitions and biological reference points used by managers for the northern and southern stocks of silver hake are summarized below and in NEFMC (2002).

Summary of biolgical reference points used in overfishing definitions for silver hake. The new exploitation based target for silver hake in the southern stock area is 60% of the threshold, F_{MSY} proxy level. The biomass based reference points include an adjustment made in NEFSC (2001) to accommodate recalculation of survey biomass indices.

Stock	Biomass target (B_{MSY} proxy, average delta mean kg tow for NEFSC fall survey during 1973-1982)	Biomass threshold (1/2 BMSY proxy, delta mean kg tow in NEFSC fall survey)	New exploitation index reference points (landings / biomass index)		Original fishing mortality (F) based reference points in Ammendment 12 (y^{-1})	
			Target	Threshold (F_{MSY} proxy)	Target	Threshold (F_{MSY} proxy)
North	6.63	3.31	2.57	2.57	$F < F_{0.1}$	$F_{0.1} = 0.41$
South	1.78	0.89	20.63	34.39	$F < F_{0.1}$	$F_{0.1} = 0.39$

The B_{MSY} proxies and biomass reference points used for both stocks of silver hake in this assessment and in NEFSC (2002) are based on average catch rates in the NEFSC fall survey (delta mean kg/tow) during 1973-1982, a period of relative stability in the fishery (Figure A48-A49). The biomass reference points for silver hake are compared to the most recent three-year averages of fall survey biomass (delta mean kg/tow) to determine if either stock is overfished.

The F_{MSY} proxies and associated reference points used for silver hake in this assessment and in NEFSC (2002) are based on exploitation indices (landings / fall survey delta mean kg/tow), are new since the last assessment (NEFSC 2001), and differ from the reference points in Amendment 12 of the Northeast Multispecies Fishery Management Plan. In particular, the F_{MSY} proxies and fishing mortality reference points used for silver hake in this assessment are based on exploitation indices (landings / fall survey delta mean kg/tow) during 1973-1982, a period of relative stability in the fisheries that is already used to define biomass reference points (Figure A48-A49). The new reference points for silver hake are compared to the most recent three-year averages of the exploitation rates indices (landings over delta mean kg/tow) to determine if overfishing is occurring in either stock.

The new reference points based on exploitation indices were developed since the last assessment and used annually by the New England Council's Whiting Monitoring Committee because fishing mortality rates were not estimated for whiting in the last assessment (NEFSC 2001) and because it was not possible to use the original fishing mortality based reference points ($F_{0.1}$) in Amendment 12.

The Whiting Monitoring Committee's new reference points were reviewed and used in this assessment because fishing mortality rates were not estimated. The exploitation index approach is common in northeast fisheries when fishing mortality cannot be estimated, and it was based on the original reference points to the extent possible. The exploitation based target for the southern stock is set at 60% of the F_{MSY} proxy and is more risk averse than the original approach in Amendment 12. The target and threshold reference points for defining overfishing in the northern stock are identical.

Northern stock

The northern stock of silver hake is not overfished and overfishing is not occurring (Table A22 and Figure A48). In particular, the three-year average biomass index for 2002-2004 (6.72 kg/tow) was above the management threshold level (3.31 kg/tow) and near the target level (6.63 kg/tow). The three-year average exploitation index for 2002-2004 (0.24) was below the management threshold and target level (2.57).

The northern stock of silver hake was not overfished based on results from the last assessment (NEFSC 2001). Overfishing was not evaluated in the last assessment because fishing mortality rates were not estimated.

Southern stock

Based on current reference points, the southern stock of silver hake is not overfished and overfishing is not occurring (Table A23 and Figure A49). In particular, the three year average biomass index for 2002-2004 (1.37 kg/tow) was above the management threshold level (0.89 kg/tow) and near the target level (1.78 kg/tow). The three year average exploitation index for 2002-2004 (4.85) was below the management threshold level (34.39) and below the management target level (20.63).

The southern stock of silver hake was overfished based on results from the last assessment (NEFSC 2001). Overfishing was not evaluated in the last assessment because fishing mortality rates were not estimated. The change in status is due to increases in stock biomass indices for the southern stock of silver hake.

7.0 STOCK PROJECTIONS

Stock projections were not carried out because current age structure, abundance and were not estimated biomass in absolute terms. However, stock biomass levels are relatively high and current fishing mortality rates are very low in the north and probably low in the south also. Recent recruitments have been roughly average. Uncertainties exist because old fish are still absent and the cause is unknown. Given these factors, a qualitative analysis suggests that significant declines in stock biomass due to fishing are unlikely in the short term.

8.0 TOTAL ALLOWABLE LANDINGS (TAL)

Total allowable landings (TAL) for 2005 were calculated based on fall survey data through 2004 and exploitation index reference points (Table A27). In particular, target exploitation indices (landings / three year average survey) were multiplied by the most recent three-year average survey abundance index to estimate landings at the target exploitation level. Assuming that the reference points are exact, CVs measuring uncertainty in TAL calculations are the same as the CV for the three year average survey.

For the northern stock area during 2005, where the target and threshold reference points are the same, TAL < 17.3 mt. For the southern stock area during 2005 based on the target reference point, TAL=28.3 mt. For comparison, annual landings averaged 1.71 thousand mt in the north and 6.65 thousand mt in the south during 2002-2004.

9.0 SOURCES OF UNCERTAINTY AND NEW RESEARCH RECOMMENDATIONS

The most important uncertainties stem from clearly decreasing trends in abundance of relatively old and large individuals. These reductions have occurred despite apparently normal growth patterns, low fishing mortality rates and relatively high biomass levels during recent years. The possibility of increased natural mortality rates due to predation or other ecosystem level effect is a key area for future research.

Survey data indicate that relatively large silver hake may move around Georges Bank from the southern stock area to the northern. Uncertainty about north-south movements of adult silver is important because of uncertainty about linkages between the northern and southern stock areas.

Considerable amounts of silver hake biomass may occur midwater and on the bottom at depths that are not effectively sampled by NEFSC bottom trawl surveys. Stock biomass would be better estimated if more information about use of midwater habitat information was available and if the lower depth distribution of silver hake was determined.

10.0 RESEARCH RECOMMENDATIONS FROM PREVIOUS ASSESSMENTS

1) Develop survey information that covers the offshore range of the population. *The Supplemental ("Transect") survey during 2003-2005 sampled relatively deep water along several transects.*

2) Conduct surveys of spawning aggregations on the southern flank of Georges Bank. *This research recommendation was not addressed.*

3) Investigate bathymetric demography of population. *The current assessment includes extensive analysis of relationships between location, depth, size and age based on bottom trawl survey data.*

4) Investigate spatial distribution, stock structure and movements of silver hake within Georges Bank, the Gulf of Maine, and the Scotian shelf in relation to physical oceanography. *The current assessment includes extensive analysis of survey data to determine trends in locations of highest silver hake density (catch*

weighted mean latitude and longitude) and to determine environmental factors that affect density of silver hake of different sizes and at different times of the year.

5) Quantify age-specific fecundity of silver hake. *This research recommendation was not addressed.*

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SILVER HAKE TABLES

Table A1. Silver hake landings (mt) by stock area during 1955-2004 for foreign and domestic fishing fleets.

Year	Northern stock area			Southern stock area			North plus south stock areas		
	Foreign	Domestic	Total	Foreign	Domestic	Total	Foreign	Domestic	Foreign + domestic
1955		53,361	53,361		13,842	13,842	0	67,203	67,203
1956		42,150	42,150		14,871	14,871	0	57,021	57,021
1957		62,750	62,750		17,153	17,153	0	79,903	79,903
1958		49,903	49,903		13,473	13,473	0	63,376	63,376
1959		50,608	50,608		17,112	17,112	0	67,720	67,720
1960		45,543	45,543		9,206	9,206	0	54,749	54,749
1961		39,688	39,688		13,209	13,209	0	52,897	52,897
1962	36,575	42,427	79,002	5,325	13,408	18,733	41,900	55,835	97,735
1963	37,525	36,399	73,924	74,023	19,359	93,382	111,548	55,758	167,306
1964	57,240	37,222	94,462	127,036	26,518	153,554	184,276	63,740	248,016
1965	15,793	29,449	45,242	283,366	23,765	307,131	299,159	53,214	352,373
1966	14,239	33,477	47,716	200,058	11,212	211,270	214,297	44,689	258,986
1967	6,882	26,489	33,371	81,749	9,500	91,249	88,631	35,989	124,620
1968	10,506	30,873	41,379	49,422	9,074	58,496	59,928	39,947	99,875
1969	8,047	15,917	23,964	67,396	8,165	75,561	75,443	24,082	99,525
1970	12,305	15,223	27,528	20,633	6,879	27,512	32,938	22,102	55,040
1971	25,243	11,158	36,401	66,344	5,546	71,890	91,587	16,704	108,291
1972	18,784	6,440	25,224	88,381	5,973	94,354	107,165	12,413	119,578
1973	18,086	13,997	32,083	97,989	6,604	104,593	116,075	20,601	136,676
1974	13,775	6,905	20,680	102,112	7,751	109,863	115,887	14,656	130,543
1975	27,308	12,566	39,874	65,812	8,441	74,253	93,120	21,007	114,127
1976	151	13,483	13,634	58,307	10,434	68,741	58,458	23,917	82,375
1977	2	12,455	12,457	47,850	11,458	59,308	47,852	23,913	71,765
1978		12,609	12,609	14,353	12,779	27,132	14,353	25,388	39,741
1979		3,415	3,415	4,877	13,498	18,375	4,877	16,913	21,790
1980		4,730	4,730	1,698	11,848	13,546	1,698	16,578	18,276
1981		4,416	4,416	3,043	11,783	14,826	3,043	16,199	19,242
1982		4,656	4,656	2,397	12,164	14,561	2,397	16,820	19,217
1983		5,310	5,310	620	11,520	12,140	620	16,830	17,450
1984		8,289	8,289	412	12,731	13,143	412	21,020	21,432
1985		8,297	8,297	1,321	11,843	13,164	1,321	20,140	21,461
1986		8,502	8,502	550	9,573	10,123	550	18,075	18,625
1987		5,658	5,658	2	10,121	10,123	2	15,779	15,781
1988		6,767	6,767		9,195	9,195	0	15,962	15,962
1989		4,646	4,646		13,169	13,169	0	17,815	17,815
1990		6,379	6,379		13,615	13,615	0	19,994	19,994
1991		6,053	6,053		10,093	10,093	0	16,146	16,146
1992		5,302	5,302		10,288	10,288	0	15,590	15,590
1993		4,360	4,360		12,912	12,912	0	17,272	17,272
1994		5,724	5,724		10,334	10,334	0	16,058	16,058
1995		3,033	3,033		11,694	11,694	0	14,727	14,727
1996		3,200	3,200		12,999	12,999	0	16,199	16,199
1997		2,591	2,591		12,994	12,994	0	15,585	15,585
1998		2,258	2,258		12,701	12,701	0	14,959	14,959
1999		4,042	4,042		9,970	9,970	0	14,012	14,012

2000	2,418	2,418	9,760	9,760	0	12,178	12,178
2001	3,446	3,446	8,694	8,694	0	12,140	12,140
2002	2,839	2,839	5,153	5,153	0	7,992	7,992
2003	1,727	1,727	6,916	6,916	0	8,643	8,643
2004	557	557	7,889	7,889	0	8,445	8,445

Table A1. (cont.)

Table A2. Proportion of total landings (mt) by market category and gear group during 1995-2004.

Market Category	Gillnets	Hook&Line	OtherGear	OtterTrawl	UnkGear	Grand Total
5090 (Round)	0.15%	0.04%	0.32%	65.84%	1.56%	67.91%
5091 (King round)	0.06%	0.00%	0.05%	6.36%	0.06%	6.54%
5092 (Small round)	0.18%	0.02%	0.04%	22.73%	0.10%	23.07%
5093 (Dressed)	0.01%	0.00%	0.95%	0.02%	0.00%	0.97%
5094 (Juvenile)	0.00%	0.00%	0.00%	1.09%	0.19%	1.28%
5095 (Large round)	0.00%	0.00%	0.09%	0.12%	0.02%	0.23%
Grand Total	0.39%	0.06%	1.45%	96.16%	1.93%	100.00%

Table A3. Sampling intensity (length measurements / mt landed) for commercial landings during 1995-2004.

Market Category	Landings (mt)	Gear Groups					
		Gillnets	Hook&Line	OtherGear	OtterTrawl	UnkGear	All
5090 (Round)	85,316	3.91	0	0.34	0.48	0	0.47
5091 (King round)	8,220	0.50	0	0	1.63	0	1.59
5092 (Small round)	28,981	0	9.26	0	0.48	0	0.48
5093 (Dressed)	1,219	0	0	0	0	0	0
5094 (Juvenile)	1,608	No landings	0	0	0.47	0	0.40
5095 (Large round)	289	No landings	0	0	0	0	0
All	125,633	1.54	2.61	0.07	0.55	0	0.54

Table A4. Names, database codes (NESPP3) and groups for species used to estimate discard for silver hake.

Species Group	Species Code (NESPP3)	Species Name	Species Group	Species Code (NESPP3)	Species Name
Monkfish	12	ANGLER	Crabs/Shrimps	711	CRAB
Squid/ButterFish	51	BUTTERFISH	Crabs/Shrimps	712	CRAB
Squid/ButterFish	801	SQUID (LOLIGO)	Crabs/Shrimps	713	CRAB
Squid/ButterFish	802	SQUID (ILLEX)	Crabs/Shrimps	714	CRAB
Squid/ButterFish	803	SQUIDS (NS)	Crabs/Shrimps	715	CRAB
Principal Grndfsh	81	COD	Crabs/Shrimps	718	CRAB
Principal Grndfsh	147	HADDOCK	Crabs/Shrimps	724	CRAB
Principal Grndfsh	153	HAKE	Crabs/Shrimps	727	LOBSTER
Principal Grndfsh	155	HAKE MIX RED & WHITE	Crabs/Shrimps	735	SHRIMP (NK)
Principal Grndfsh	240	REDFISH	Crabs/Shrimps	736	SHRIMP (PANDALID)
Principal Grndfsh	269	POLLOCK	Crabs/Shrimps	737	SHRIMP (MANTIS)
Herring/Shad/Other/Pelagics	112	HERRING	Crabs/Shrimps	738	SHRIMP (PENAEID)
Herring/Shad/Other/Pelagics	347	SHAD	Mollusks	748	QUAHOG
Flatfish	120	FLOUNDER	Mollusks	754	QUAHOG
Flatfish	122	FLOUNDER	Mollusks	764	CLAM NK
Flatfish	123	FLOUNDER	Mollusks	769	CLAM
Flatfish	124	FLOUNDER	Mollusks	775	CONCHS
Flatfish	125	FLOUNDER	Mollusks	776	WHELK
Flatfish	126	FLOUNDERS (NK)	Mollusks	777	WHELK
Flatfish	128	HOGCHOCKER	Mollusks	781	MUSSELS
Flatfish	158	HALIBUT	Mollusks	786	OCTOPUS
Flatfish	159	HALIBUT	Mollusks	799	SCALLOP
Fluke/Fourspot	121	FLOUNDER	Scallops	800	SCALLOP
Fluke/Fourspot	127	FLOUNDER	Urchins/Cumcumbers/Shellfish	805	SEA URCHINS
Hakes+OceanPout	152	HAKE	Urchins/Cumcumbers/Shellfish	806	SEA CUCUMBERS
Hakes+OceanPout	250	POUT	Urchins/Cumcumbers/Shellfish	828	STARFISH
Hakes+OceanPout	508	HAKE	Other Species	1	ALEWIFE
Hakes+OceanPout	509	HAKE	Other Species	23	BLUEFISH
Atlantic herring	167	HERRING (NK)	Other Species	24	SQUIRRELFISH
Atlantic herring	168	HERRING	Other Species	33	BONITO
Atllantic mackerel	212	MACKEREL	Other Species	87	CREVALLE
Menhaden	221	MENHADEN	Other Species	90	CROAKER
Scup/Seabass	329	SCUP	Other Species	93	CUNNER
Scup/Seabass	335	SEA BASS	Other Species	96	CUSK
Dogfishes	350	DOGFISH (NK)	Other Species	106	DRUM
Dogfishes	351	DOGFISH SMOOTH	Other Species	107	DRUM
Dogfishes	352	DOGFISH SPINY	Other Species	115	EEL
Other sharks	353	SHARK	Other Species	116	EEL
Other sharks	357	SHARK	Other Species	117	EEL
Other sharks	359	SHARK	Other Species	130	FLOUNDER
Other sharks	478	SHARK	Other Species	133	GARFISH
Other sharks	482	SHARK	Other Species	134	GIZZARD SHAD
Skates/Rays	365	SKATES	Other Species	150	HAGFISH
Skates/Rays	366	SKATE	Other Species	165	HARVEST FISH
Skates/Rays	367	SKATE	Other Species	173	SHAD
Skates/Rays	368	SKATE	Other Species	188	JOHN DORY
Skates/Rays	369	SKATE	Other Species	189	DORY
Skates/Rays	370	SKATE	Other Species	194	MACKEREL
Skates/Rays	372	SKATE	Other Species	197	WHITING
Striped Bass	418	BASS	Other Species	210	LUMPFISH
Large Pelagics	466	TUNA	Other Species	213	BLUE RUNNER
Large Pelagics	468	TUNA	Other Species	215	MACKEREL
Crabs/Shrimps	700	CRAB	Other Species	234	MULLETS
Crabs/Shrimps	710	CRAB	Other Species	235	STRIPED MULLET

Table A4 (cont.)

Species Group	Species Code (NESPP3)	Species Name
Other Species	242	ROSEFISH
Other Species	258	PIGFISH
Other Species	267	PINFISH
Other Species	268	LADYFISH
Other Species	272	POMPANO
Other Species	326	SCULPINS
Other Species	327	SEA RAVEN
Other Species	333	SEA BASS
Other Species	334	SEATROUT
Other Species	340	SEA ROBIN
Other Species	341	SEA ROBINS
Other Species	342	SEA ROBIN
Other Species	343	SEA ROBIN
Other Species	344	WEAKFISH
Other Species	345	WEAKFISH
Other Species	356	SHEEPSHEAD
Other Species	364	SKATE
Other Species	371	SMELT
Other Species	381	SPADEFISH
Other Species	384	MACKEREL
Other Species	406	SPOT
Other Species	429	PUFFER
Other Species	430	PUFFER
Other Species	438	TAUTOG
Other Species	444	TILEFISH
Other Species	446	TILEFISH
Other Species	447	TILEFISH (NK)
Other Species	456	TRIGGERFISH
Other Species	512	WOLFFISHES
Other Species	526	OTHER FISH
Other Species	660	OTHER FISH
Other Species	661	OTHER FISH
Other Species	662	OTHER FISH
Other Species	664	OTHER FISH
Other Species	667	OTHER FISH
Other Species	668	OTHER FISH
Other Species	678	OTHER FISH
Other Species	679	OTHER FISH
Other Species	681	OTHER FISH
Other Species	686	OTHER FISH
Other Species	687	OTHER FISH
Other Species	688	OTHER FISH
Other Species	733	SHRIMP ROYAL RED
Other Species	778	WHELK
Other Species	796	SCALLOPS NK
Other Species	804	MOLLUSKS NK

Table A5. Names, database codes (NEGEAR) and groups for fishing gear used to estimate discard for silver hake. “Total Hail Weight” is the total hail weight for landings by the gear group in observer data for 2001-2004 (a measure of potential importance for each gear group).

Gear Group	Gear Code (NEGEAR)	Gear Name	Total Hail Weight (mt)
Dredges	132	DREDGE, SCALLOP,SEA	8,172
Gill/set nets	100	GILL NET, FIXED OR ANCHORED,SINK, OTHER/NK SPECIES	2,999
Gill/set nets	105	GILL NET, ANCHORED-FLOATING, FISH	13
Gill/set nets	116	GILL NET, DRIFT-FLOATING, FISH	50
Hook & line	10	LONGLINE, BOTTOM	265
Shrimp trawls	58	TRAWL,OTTER,BOTTOM,SHRIMP	18
Trawls	50	TRAWL,OTTER,BOTTOM,FISH	14,823
Trawls	52	TRAWL,OTTER,BOTTOM,SCALLOP	39
Other/unknown gear	20	HANDLINE	0.21
Other/unknown gear	60	TROLL LINE, OTHER/NK SPECIES	0.01
Other/unknown gear	117	GILL NET, DRIFT-SINK, FISH	554
Other/unknown gear	120	PURSE SEINE, OTHER/NK SPECIES	217
Other/unknown gear	121	PURSE SEINE, HERRING	2,324
Other/unknown gear	170	TRAWL,OTTER,MIDWATER PAIRED	15,685
Other/unknown gear	181	POTS + TRAPS,FISH	2
Other/unknown gear	200	POT/TRAP, LOBSTER OFFSH NK	0.19
Other/unknown gear	360	SCOTTISH SEINE	25
Other/unknown gear	370	TRAWL,OTTER,MIDWATER	2,848

Table A6. Number of trips with observers during 2001-2004 used to estimate discard rates and discard for silver hake, by primary species group and gear group.

Species Group	Gear Groups								Total
	Dredges	Gill/set nets	Hook & line	Shrimp trawls	Bottom Trawls	Purse seines	Midwater trawls	Other/ unknown gear	
Atlantic herring	0	5	0	0	12	27	27	82	153
Atllantic mackerel	0	10	0	0	8	0	2	15	35
Bonito	0	3	0	0	0	0	0	1	4
Crabs/Shrimps	0	6	0	31	66	0	0	5	108
Dogfishes	0	242	2	0	16	0	0	0	260
Flatfish	0	229	0	0	722	0	0	13	964
Fluke/Fourspot	0	54	1	0	358	0	0	4	417
Hakes+OceanPout	0	2	0	0	93	0	3	6	104
Herring/Shad/Other	0	16	0	0	3	0	0	0	19
Large Pelagics	0	9	1	0	0	0	0	0	10
Menhaden	0	75	0	0	0	2	0	0	77
Mollusks	0	0	0	0	1	0	0	0	1
Monkfish	0	865	0	0	147	0	0	0	1012
Other Species	0	928	3	0	51	0	0	1	983
Principal Grndfs	0	1595	146	0	559	0	0	5	2305
Scallops	285	0	0	0	37	0	0	0	322
Scup/Seabass	0	1	0	0	67	0	0	9	77
Skates/Rays	0	218	0	0	102	0	0	0	320
Squid/ButterFish	0	5	0	0	233	0	12	0	250
Striped Bass	0	90	3	0	5	0	0	0	98
Total	285	4353	156	31	2480	29	44	141	7519

Table A7. Discard to kept (DK) ratios and mean annual discard (mt y^{-1}) for silver hake from ratio estimators, by primary species group and primary gear group, based on observer data for 2001-2004. Results are sorted in descending order by DK ratio. Primary species group and gear group combinations not shown had DK ratios < 0.00001. The CV for the DK ratio is the same as the CV for discard because landings were assumed measured without error. The "Assumed stock area" for cases with mean annual discard > 70 mt per year is the principle silver hake stock area for landings and discards based on the primary geographical location of the fishery. Landings for crabs/shrimps in shrimp trawls also include landings for crabs/shrimps in other/unknown gear.

Species Group	Gear Group	N trips	DK ratio	CV	Mean 2001 - 2004 landings (mt y^{-1})	Mean discard 2001-2004 (mt y^{-1})	Assumed stock area
Hakes+OceanPout	Other/unknown gear	6	0.24082	1.46	297	72	South
Hakes+OceanPout	Bottom trawls	93	0.12455	0.20	9,822	1,223	South
Squid/ButterFish	Bottom trawls	233	0.02423	0.24	24,673	598	South
Crabs/Shrimps	Shrimp trawls	31	0.02150	0.32	73,479	1,580	North
Dogfishes	Bottom trawls	16	0.00946	0.39	232	2.2	
Monkfish	Bottom trawls	147	0.00830	0.14	12,672	105	South
Principal Grndfsh	Other/unknown gear	5	0.00458	0.91	415	1.9	
Flatfish	Bottom trawls	722	0.00437	0.15	17,133	75	
Principal Grndfsh	Bottom trawls	559	0.00434	0.14	19,112	83	
Flatfish	Other/unknown gear	13	0.00406	0.84	651	2.6	
Atlantic herring	Bottom trawls	12	0.00371	1.04	7,678	28	
Scup/Seabass	Bottom trawls	67	0.00189	0.41	2,775	5.2	
Flatfish	Gill/set nets	229	0.00166	0.41	648	1.1	
Fluke/Fourspot	Bottom trawls	358	0.00085	0.28	5,831	5.0	
Squid/ButterFish	Midwater trawls	12	0.00080	0.90	176	0.1	
Principal Grndfsh	Gill/set nets	1595	0.00045	0.13	5,892	2.7	
Scallops	Bottom trawls	37	0.00028	0.73	14,540	4.1	
Atlantic herring	Other/unknown gear	82	0.00020	0.63	38,263	7.7	
Skates/Rays	Bottom trawls	102	0.00020	0.35	9,897	2.0	
Dogfishes	Gill/set nets	242	0.00011	0.27	1,156	0.1	
Other Species	Bottom trawls	51	0.00011	0.81	5,612	0.6	
Scallops	Dredges	285	0.00010	0.37	191,675	19.2	
Monkfish	Gill/set nets	865	0.00006	0.25	8,428	0.5	
Atlantic herring	Midwater trawls	27	0.00005	0.73	26,953	1.3	
Skates/Rays	Gill/set nets	218	0.00003	0.72	3,292	0.1	
Crabs/Shrimps	Bottom trawls	66	0.00002	0.60	1,057	0.0	
All	All	6073		0.17	482,358	3,820	na

Table A8. Number of successful random tows (SHG code <= 136) for offshore strata during fall NEFSC bottom trawl surveys during 1963-2004. Cells with zero tows are black. Strata are assigned to stock ("S" for southern and "N" for northern).

		Year of Survey																																									
Stratum	Stock	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04
1010	S	5	4	4	4	9	9	7	9	8	7	8	6	8	8	7	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
1020	S	5	4	4	4	8	7	10	7	7	7	7	7	7	8	7	7	7	7	7	7	7	7	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
1030	S	5	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2
1040	S	2	3	4	4	3	3	3	3	3	3	3	3	2	3	3	1	3	3	3	3	2	3	2	3	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1
1050	S	4	5	3	5	4	5	7	5	8	7	5	6	6	6	5	10	10	4	5	5	5	5	4	5	5	5	5	5	5	5	5	6	3	5	5	5	5	5	5	4	5	5
1060	S	7	5	5	5	9	7	11	8	11	11	8	8	9	8	7	17	16	8	8	8	8	6	8	8	8	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
1070	S	5	4	4	5	5	4	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1080	S	2	3	4	3	3	3	3	3	3	3	3	3	2	3	2	3	3	2	2	3	2	3	2	3	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
1090	S	4	5	5	5	6	7	5	7	8	5	5	5	5	5	5	10	15	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
1100	S	4	5	5	5	6	9	8	9	11	9	8	8	9	8	9	15	16	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
1110	S	2	4	4	4	5	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1120	S		3	4	4	4	2	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1130	S	5	5	7	6	8	8	9	7	9	9	9	9	9	9	10	18	18	9	9	8	9	9	9	9	10	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
1140	S	6	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	3	5	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1150	S	1	3	3	4	3	4	3	4	3	3	3	4	3	3	3	3	2	2	2	3	2	3	2	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1160	S	7	7	7	7	8	8	12	8	11	12	11	12	11	10	17	30	20	20	10	10	9	10	10	10	10	10	10	16	10	10	10	13	11	10	10	10	10	10	10	10	11	10
1170	S	5	6	4	5	3	4	4	4	4	4	4	4	4	4	7	8	4	8	4	3	3	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	4
1180	S	1	2	4	3	3	3	3	3	3	3	3	3	3	3	1	5	3	3	3	1	3	3	4	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
1190	S	4	6	5	6	9	9	9	9	9	9	9	9	9	9	11	18	18	9	9	9	9	9	8	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
1200	N	4	5	5	5	6	6	6	6	6	6	6	6	6	5	7	14	12	6	9	6	6	6	5	5	6	6	6	6	5	5	6	6	6	6	6	6	6	6	6	6	6	6
1210	N	6	4	5	5	4	4	4	4	4	4	4	4	4	3	8	8	8	7	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4
1220	N	2	5	6	6	4	4	4	4	4	4	4	4	4	3	4	10	8	8	5	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	3	4	4	4	4
1230	N	3	6	6	6	6	5	5	6	5	5	5	5	5	5	10	11	14	5	4	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	6	5	5	5	5	5	5	5
1240	N	11	6	6	6	5	6	6	8	7	6	7	6	7	5	12	23	23	6	6	8	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
1250	N	2	4	3	4	4	4	4	3	4	4	4	4	4	4	7	4	11	4	2	4	4	3	4	3	3	4	3	4	3	3	2	4	3	3	4	4	4	3	4	4	4	4
1260	N	7	4	4	4	5	4	5	5	5	5	5	5	15	9	9	15	19	5	6	5	5	4	5	5	5	5	5	5	5	4	4	5	5	5	5	6	9	5	5	3	5	5
1270	N	2	4	4	4	4	4	4	4	4	4	4	4	4	4	9	7	8	4	4	4	4	4	4	4	4	4	4	4	4	5	4	3	4	4	4	5	8	4	4	4	4	4
1280	N	6	5	6	6	7	7	7	7	7	7	7	8	7	6	11	11	15	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
1290	N	15	8	7	5	8	8	8	8	8	9	8	8	8	8	8	16	23	7	8	8	9	8	5	8	8	8	8	8	8	8	8	8	9	7	8	8	7	8	8	8	8	8
1300	N	1	2	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3
1310	N	9	4	5	6	5	6	7	8	6	7	7	7	6	7	6	6	5	6	7	7	5	6	5	7																		
1320	N	6	5	5	5	4	5	5	5	5	5	6	5	5	4	5	4	4	5	5	5	5	6	5	5																		
1330	N	4	4	4	4	3	4	3	4	4	4	3	4	4	4	3	4	4	3	4	3	4	4	2	4	4	3	4	4	4	3	4	5	4	1	4	3	4	4	4	3	4	3
1340	N	5	6	5	5	5	5	5	5	6	6	5	6	7	6	4	6	6	6	6	6	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	6	5	6	6	6
1350	N		4	4	4	4	2	3	3	3	4	3	5	4	1	3	5		4	4	4		4	4	4																		
1351	S																									2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1360	S	9	8	5	6	7	9	8	9	10	9	10	10	9	8	9	9	8	8	8	9	4	8	8	8	8	7	8	8	8	8	8	8	8	8	8	11	9	7	8	8	8	8
1370	S	5	5	5	5	4	5	5	5	6	5	5	6	6	6	7	15	14	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5	5	5	10	5	5	5	5	5
1380	S	7	6	7	5	4	4	5	6	5	5	6	5	5	5	8	19	18	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	7	5	5	8	9	5	5	4	5	4
1390	S	2	3	3	4	2	3	3	3	5	5	3	5	5	4	4	14	11	4	5	5	3	4	5	5	3	5	3	5	5	4	5	4	5	5	4	8	5	5	6	4	4	3
1400	S	3	2	4	4	4	3	3	3	2	3	3	3	3	2	3	11	10	3	2	3	3	3	3	3	3	3	3	2	3	2	3	3	3	3	3	6	3	3	3	3	2	1
1410	S			4	4	6	6	6	15	17	18	15	18	16		18																											
1420	S			2	2	4	4	4	6	6	6	6	6	6		6																											
1490	S								3	3	3	3	3	3		3																											
1610	S					5	5	3	5	3	3	4	4	5	4	5	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1620	S					2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	3	2	2	2
1630	S					2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	2	2		2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	1	2	2	2
1640	S					2	2	2	2	2	2	2	2	2	2	2	2	1		2	2	2	3	2	2	1	1	1	1	1	1		1	1	1	1	1	1	1		1		1
1650	S					7	10	9	9	7	7	7	8	8	10	10	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
1660	S					3	3	3	3	4	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1670	S					3	2	2	2	3	2	2	2	2	2	1	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2
1680	S					2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	1	2	2		1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1
1690	S					8	9	6	8	7	6	6	5	7	10	10	6	6	7	6	6	6	5	7	6	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6	6	6	6
1700	S					3	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4
1710	S					3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	1	2	2	2	3	1
1720	S					3	2	2	2	3	2	2	1	2	2	2	1	2	2	2	1	2	2	2	2	1	1	1		1		1	1	1	1	1	1	1	1	1	1	1	1
1730	S					7	7	5	7	5	5	6	5	5	8	8	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5	5	5	5	5	5	5	5	5	5
1740	S					5	5	4	5	4	4	4	4	5	5	5	4	4	4	4	5	4	4	4	3	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5
1750	S					3	2	3	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1760	S					2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1990																																								2			1

Table A9. Number of successful random tows (SHG code <= 136) for inshore strata during fall NEFSC bottom trawl surveys during 1963-2004. Cells with zero tows are black. Strata are assigned to stock ("S" for southern and "N" for northern).

		Year of Survey																																							
Stratum	Stock	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04
3010	S										2	2		2	1	1	1	1		1	1	1	1	1	1	1	2																
3020	S										2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2
3030	S										2	2		2	1	1	1	1	1	1				1	1				1	1	1	1		1	1	1	1	1	1	1	1		1
3040	S										2	2	2	2	2	2	2	2	2	2	3	3	2	2	2	2	1	3	2	2	2	2	3	2	2	2	2	2	2	2	2	3	2
3050	S										2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3060	S										2	2		1		1		1	1					1	1					1	1	1	1	1	1	1	1	1	1	1		1	1
3070	S										2	2	1	3	3	2	3	2	2	3	2	3	3	2	2	2	1	3	3	2	2	2	2	2	2	2	2	2	2	2	3	2	2
3080	S										2	2	4	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3090	S										2	2		2	1	1	1	1	1	1	1		1	1	1				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3100	S										2	4	2	2	2	2	2	1	2	2	2	3	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3110	S										3	5	3	3	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3120	S										5	6			1	1	1	1	1	1		1	1	1	1			1		1	1	1	1	1	1	1	1	1	1	1	1	1	1
3130	S										4	6	2	3	2	2	2	2	2	2	3	2	2	2	2	2	1	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3140	S										5	14	4	3	2	2	2	2	1	2	2	2	2	2	2	2	2	2	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3150	S										3	2				1	1	1			1	1		1	1				1	1		1	1	1			1	1	1	1		1	
3160	S										3	2	2	3	3	2	2	2	2	3	2	2	3	2	2	2	2	3	2	2	3	2	2	2	2	2	2	2	2	2	2	2	3
3170	S										4	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2
3180	S										2	3		2	1	1	1	1	1	1			1	1	1					1	1	1	1	1	1	1	1		1	1	1	2	1
3190	S										4	3	2	3	2	2	2	2	2	2	3	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3200	S										3	4	4	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3210	S										3	2		2	1		1	1	1	1	1	1	1	1	1			1	1	1	1	1		1						1	1		1
3220	S										3	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3230	S										3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3240	S										3	2		2	1	1	1	1	1	1	1	1	1	1	1			2	2	2	1	2	2	2	2	2	2	1	2	2	2	2	2
3250	S										4	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3260	S										3	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3270	S										1	2		2	1	1	1	1	1	1			1	1				1		1	1	1	1	1	1		1	1			1	1	
3280	S										3	3	3	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	2	2	2
3290	S										3	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3300	S										4	2		2	1	1	1		1	1			1	1	1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
3310	S										3	4	3	3	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3320	S										2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3330	S										2	1		2	1	1	1	1	1	1		1	1	1	1			1	1	1	1	1	1	1		1	1	1		1	1	1	
3340	S										3	3	3	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2
3350	S										2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3360	S										3	2	2	1	1	1	1	1	1	1	1	1	1	1				1	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2
3370	S										4	4	4	3	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3380	S										3	3	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3390	S										2	2		2	1	1	1	1	1	1		1	1	1	2			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
3400	S										3	3	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2
3410	S										4	4	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3420	S										2	2		1	1	1	1	1	1	1	1	1	1	1	1				1	1	1	1	1	1	1	1	1	1	1	1	1		
3430	S										3	2		4	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3440	S										2	4	4	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3450	S										1			2		2	2	1	2	1	2	1	2	1	2	2	1	2	2	2	2	2	2	2	2	2	3	2	2	2	1	2	2
3460	S															2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2
3520	S																							4																			
3550	S																	4	4	3	2	4	4	3	2	4	4	4	5	5	5	5	5	5	4	5	5	5	5	3	5	4	4
3560	N																	1	1				1		1	1	1		1	1	1	1		1	1	1	1	1			1		1
3580	N																	1	1		1	1	1	1		1	1			1	1	1	1		1	1	1	1	1	1	1		1
3590	N																	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1		1
3600	N																	2	2		2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	1	2	2	2
3610	N																	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	3	1	2	2	2	2	2	2	2	2	2
3630	N																									2					1		1		1		1	1					
3640	N																			1	1			1		1				1	1		1		1		1	1	1	1	1	2	
3650	N																	1	1	1	1	1		2	1	1	1		1	1	1	1	1		1	1	1	1	2	2			
3660	N																	2	3	3		2	1	2	2	2	2		2	1	2	2	1	1	2	2	2	2	2	2	3	1	2
3890	N																							1																			
3900	N																							2																			

Table A10. Number of successful random tows (SHG code <= 136) for offshore strata during spring NEFSC bottom trawl surveys during 1968-2005. Cells with zero tows are black. Strata are assigned to stock ("S" for southern and "N" for northern).

		Year of Survey																																								
Stratum	Stock	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05
1010	S						6	7	7	8	7	16	7	6	8	7	8	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	6	7	7
1020	S						5	7	9	7	8	14	6	8	7	7	8	7	7	7	7	7	7	5	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	7	7
1030	S						4	3	8	3	5	6	3	3	3	3	3	2	3	3	3	3	3	3	3	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1040	S						4	3	3	3	4	3	3	3	2	3	1	3	2	1	3	3	3	2	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1050	S						4	5	5	5	5	10	4	6	5	5	7	10	17	3	5	4	4	5	5	5	6	5	5	5	4	4	5	5	4	5	5	5	5	5	5	5	5	5
1060	S						6	8	9	11	9	16	8	9	9	8	10	8	28	8	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
1070	S						4	3	4	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2
1080	S						3	3	3	3	3	3	3	2	3	2	4	3	3	2	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1090	S						4	5	5	6	5	5	4	5	5	6	5	15	18	5	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
1100	S						6	8	10	9	8	8	8	7	10	9	8	8	20	8	8	8	7	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
1110	S						4	3	4	3	4	3	3	3	3	3	3	3	3	3	3	3	3	4	3	3	2	2	2	2	2	2	3	2	2	2	2	2	2	3	2	2	2	2
1120	S						3	3	3	3	4	3	3	3	3	3	2	3	2	3	3	3	2	2	3	3	1	1	1	1				1	1		1	1	1	1	1	1	1	1
1130	S						7	9	9	13	9	9	8	9	9	9	9	18	8	9	9	9	9	9	8	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
1140	S						4	4	4	4	4	4	3	4	4	5	5	4	4	4	4	4	4	5	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1150	S						4	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	2	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1160	S						9	14	10	20	13	10	10	10	10	9	12	20	10	10	10	10	11	10	10	10	10	10	10	10	10	10	10	9	10	10	10	10	10	10	10	10	10	10
1170	S						4	4	4	7	4	4	3	4	3	4	4	4	5	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1180	S						3	3	3	2	3	3	3	3	2	2	3	3	2		3	2	3	2	3	3	1	1		1	1	1	1	1	1	2	1	1	1	1	1	1	1	1
1190	S						8	8	8	14	9	9	9	9	9	8	9	18	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
1200	N						6	6	5	9	6	6	6	6	6	6	6	12	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	4	6	6
1210	N						4	4	4	9	4	4	5	4	4	4	4	8	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4
1220	N						4	4	4	6	5	4	2	4	4	4	5	8	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
1230	N						6	5	5	7	5	5	5	5	6	6	6	10	5	4	5	5	5	4	5	5	4	4	5	5	4	6	4	4	4	5	5	5	5	5	5	5	5	5
1240	N						6	6	6	10	7	6	6	6	6	7	9	12	6	6	6	6	6	5	6	6	6	6	6	6	6	6	6	6	4	6	9	6	6	6	6	6	6	6
1250	N						4	4	4	4	4	4	3	4	3	3	4	7	2	4	5	3	4	2	4	4	4	2	4	3	4	3	3	3	2	3	4	4	4	4	4	3	4	3
1260	N						3	5	5	5	5	5	5	15	14	14	5	9	5	6	7	5	4	5	5	3	5	5	5	4	5	5	5	5	5	5	8	5	5	5	5	5	5	5
1270	N						4	4	4	5	4	2	4	3	3	4	5	8	4	4	4	4	4	4	4	3	4	4	4	4	4	4	5	4	4	4	6	4	4	4	4	4	4	5
1280	N						7	7	7	7	7	7	6	7	8	9	8	7	7	7	7	7	7	6	7	7	7	7	7	7	7	7	6	7	7	7	11	7	7	7	7	7	7	7
1290	N						8	8	9	8	9	7	5	6	8	8	10	8	8	8	8	8	8	7	8	8	9	8	8	8	8	8	8	8	8	8	9	8	7	8	8	8	8	8
1300	N						3	3	3	3	3	4	2	3	3	3	4	3	3	2	3	3	3	3	3	3	3	2	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3
1310	N						6	7	11	10	7	7	6	7	7	7	8	6	7	5	6	7	5	6	4	6																		
1320	N						5	5	5	7	5	4	4	5	5	5	5	5	5	4	3	3	5	3	5	5																		
1330	N						4	2	5	4	4	4	4		4	4	5	4	4	3	4	3	3	3	3	4	3		4	3		3	3	4	2	4	4		3	4	3	4	3	4
1340	N						5	5	6	7	6	5	5	6	4	6	8	6	6	5	5	6	6	6	6	5	6	6	6	6	3	6	6	6	4	6	6	6	6	6	6	6	6	6
1350	N						3	3	4	2	4	5	4		2	4	5	4	2	2	4	3	1	3	3																			
1351	S																									2	2	2	2	2		2	2	2	2	2	2		2	2	2	2	3	2
1360	S						8	8	8	9	9	8	8	7	9	9	10	8	8	7	8	8	7	6	8	8	8	8	8	8	8	8	8	8	8	8	11	8	8	8	8	8	8	8
1370	S						5	5	5	5	5	4	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	8	5	5	5	5	5	5	5
1380	S						6	5	5	6	6	5	5	5	7	7	10	9	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	7	5	5	5	5	5	4	5
1390	S						2	2	3	5	5	4	5		4	5	5	9	3	4	3	5	4	3	5	2	5	5	5	3	4	3	5	5	4	5	7	5	5	4	5	4	3	3
1400	S						2	3	3	4	2	2	2	2	3	3	4	6	2	3	3	3	3	3	2	3	3	3	2	3	3	3	3	3	3	3	5	2	3	3	5	3	3	2
1410	S						6	6	8	15	17	16	13		14		19																											
1420	S						4	4	4	6	6	6	6		6		6																											
1490	S									3	3	3	3		3		3																											
1610	S						3	3	3	4	4	3	1		5	5	4	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3
1620	S						2	2	2	2	2	2	1		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	3	2
1630	S						2	2	2	2	2	2	1		2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	1	2	1	2
1640	S						2	2	2	2	2	2	1		2	1	2	1	2	3	2	1	2	2	2	2	1	1	1	1			1	1	2	1	1	1	1	1	2	1	1	1
1650	S						8	8	6	8	8	7	3	1	9	9	7	6	7	7	7	7	7	7	7	6	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	6	7	7
1660	S						4	3	4	3	3	3	3	3	3	3	4	4	3	3	3	3	3	4	4	3	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3
1670	S						2	2	1	2	2	2	1	2	2	2	2	2	2	1	2	2	2	1	1	2	2	2	2	2	2	2	2	1	3	2	2	2	2	2	2	2	2	2
1680	S						2	2	2	2	2	2	1	2	2	2	2	1	2	2	2	2	2	2	2	2	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1690	S						7	7	7	6	7	6	5	4	9	10	7	6	6	6	6	6	6	7	6	6	6	6	6	6	6	6	6	6	7	6	6	6	6	6	6	5	6	6
1700	S						4	4	5	4	4	4	4	4	4	4	4	6	4	4	4	4	4	4	4	4	4	2	2	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4
1710	S						3	2	3	2	2	2	2	2	3	2	2	2	2	3	2	2	2	2	2	2	3	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
1720	S						3	2	2	2	2	1	2	2	2	2	2	3	2	1	2	2	2	2	2	2		1	1	1	1	1	1	1	2		1	1	1	1	1	1	1	1
1730	S						6	5	6	6	6	9	5	6	7	8	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5	5	5	5	5	5	4	5	5
1740	S						4	4	5	5	4	6	4	4	5	5	4	5	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4
1750	S						3	2	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
1760	S						3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1
1990																																												1

Table A11. Number of successful random tows (SHG code <= 136) for inshore strata during spring NEFSC bottom trawl surveys during 1973-2005. Cells with zero tows are black. Strata are assigned to stock ("S" for southern and "N" for northern).

		Year of Survey																																										
Stratum	Stock	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05
3010	S											2	2		1	1	1		2	1	1	1	1	1	1																			
3020	S											2	2	1	1	2	1	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3030	S											2	2	1	1		1	1	2	1		2	1								1	1	1	1		1	1	1		1		1	1	1
3040	S											2	2		2	2	2	2	4	2	3	2	1	3	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3050	S											2	2		2	3	2	2	4	2	2	1	3	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3060	S											2		1	1		1			1		1			1					1	1		1	1	1	1	1	1	1	1	1	1		1
3070	S											2	4	1	2	2	2	3	3	2	3	2	3	3	1	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	3	2	2	2
3080	S											2	2	3	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
3090	S											3	2		1		1	1	1	1	1	1	1	1	1	1				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3100	S											3	3	3	2	2	3	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2
3110	S											3	9	4	2	2	3	2	1	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
3120	S											5	1	1	1	1	1	1	1	1	1									1		1	1	1		1	1	1	1	1	1	1	1	1
3130	S											9	4	1	2	2	1	1	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3140	S											23	6	3	2	2	1	2	2	2	2	2	3	3	3	2	2	2	2	2	2	2	2	2	3	2	2	1	2	2	2	2	2	2
3150	S											3	2	1	1			1	1	1	1	1	1								1	1	1	1			1	1		1	1		1	1
3160	S											3	3	1	2	3	2	2	2	2	1	2	2	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2
3170	S											4	4	6	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
3180	S											3	2	2	1	1		1	1	1	1	1	1		1					1	1	1	1	1	1	1	1	1		1	1	1		1
3190	S											4	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
3200	S											6	3	4	3	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
3210	S											3			1	1		1		1	1	1	1	1	1					1	1	1	1	1	1	1	1		1		1	1	1	1
3220	S											2	2		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
3230	S											2	2		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3240	S											2	2			1	1	1		1	1	1	1	1	1					2	1	2	2	2	1	2	2	2	2	2	2	1	2	2
3250	S											3	3		2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
3260	S											2	2		2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
3270	S											3	2		1	1	1	1	1		1	1	1		1					1	1		1	1		1	1		1	1	1	1	1	1
3280	S											4	2		2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	3	2	2	3	2	2	3	2	2	2	2	2	2
3290	S											4	2		2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
3300	S											3	2		1	1		1		1	1	1	1		1					1	1	1	1	1	2	1	1	1	1	1	1	1	1	1
3310	S											6	2		2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
3320	S											3	2		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2
3330	S											3	2		1	1		1	1	1	1	1	1		1					1	1	1	1	1	2	1	1	1	1		1	1	1	1
3340	S											4	2		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	3	2	2	2	2
3350	S											2	2		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3360	S											2	2		1	1	1	1	1	1	1	1			1					2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
3370	S											5	2		2	2	3	2	2	2	2	2	2	4	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
3380	S											4	2		2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
3390	S											3	2		1	1		1	1	1	1	1	1		1					1	1	1		1	1	1	1	1	1	1	1	1	1	1
3400	S											4	3		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	3	2	2	2	2	2	2	2	2	2
3410	S											7	4		3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
3420	S											2	2		1	1	1	1	1	1	1	1	1		1					1	1	1		1	1	1	1	1	1	1	1	1	1	1
3430	S											3	2		2	2	2	2	2	2	2	2	2	5	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
3440	S											5	2		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2
3450	S											2					2	4	4	2	2	2	1	1	2	2		2	2	2	2	2	2	1	2	2	2	2	2	2	1	2	2	2
3460	S												7		2		2	3	4	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	1	2	2	2	2
3520	S																	4	4	3	4	4	4	3	5	4	5	5	5	5	1	4	5	4	4	5	5	5	5	5	5	5	5	4
3550	S																					1	1	1			1		1		1	1	1	1					1		1	1		1
3560	N																	1	1	1	1	1	1	1	1				1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1
3580	N																	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1
3590	N																	1	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
3600	N																	2	2	2	2	2	2	2	2	2	2		1	2	1	2	2	2	2	2	3	2	1	2	2	2	2	2
3610	N																			1		1	1							1	1	1	1		1	1		1	1		1	1	1	1
3630	N																	1	1	1	2	1				1	1						1	1	1	1	2	1	1	2		1	1	1
3640	N																		1	1	1	1	1	2	1	1	1			1		1	1	1	1	1	1	1		1	1		1	1
3650	N																	1	3	1		2	2	2	2	2	2		2	1	2	3	1	2	1	2	2	2	1	2	2	3	2	2
3660	N																																											

Table A12. Number of successful random tows (SHG code <= 136) for offshore strata covered by winter NEFSC bottom trawl surveys during 1992-2005. Cells with zero tows are black. Strata are assigned to stock ("S" for southern and "N" for northern). Inshore strata and the northern stock area are not sampled in the winter survey.

		Year of Survey													
STRATUM	Stock	92	93	94	95	96	97	98	99	00	01	02	03	04	05
1010	S	9	8	6	8	8	7	8	8	8	8	8	4	6	5
1020	S	7	7	5	7	8	7	7	7	8	8	8	4	7	5
1030	S	3	2	2	2	3	2	3	3	4	4	4	2	4	3
1040	S				1		1		1	1	2	2	2	1	1
1050	S	7	4	3	5	5	5	4	5	5	7	7	4	4	3
1060	S	9	9	5	9	10	9	9	8	10	12	11	5	11	7
1070	S	2	3	1	2	2	2	3	3	4	4	4	2	4	3
1080	S				1		1	1	1		2	2	1	2	1
1090	S	5	3	4	5	4	6	5	5	3	7	5	3	5	4
1100	S	6	8	8	8	10	8	8	9	7	12	12	6	10	7
1110	S	2	2	2	2	3	2	3	3	4	4	4	2	4	3
1120	S						1	1	1		2	2	2	1	1
1130	S	7	9	7	9	7	9	9	9	4	9	8		4	2
1140	S	1	3	2	3	4	3	4	4	2	4	4		4	
1150	S						1	1	1		2			1	
1160	S	5		1	9	2	5	10	8		6				
1170	S				1	2	1	3	3		2				
1180	S										1				
1190	S	5		4	5				4						
1610	S	4	5	3	4	4	4	4	4	5	6	7	7	7	6
1620	S	1	2	1	2	2	2	2	2	3	2	5	3	3	1
1630	S	1		2	1	2	2	3	3	3	2	3	3	4	2
1640	S							1	1	1	2		2	1	
1650	S	7	9	5	8	9	8	9	9	10	12	12	10	10	8
1660	S	2	3	1	4	4	3	3	3	4	4	4	3	4	3
1670	S	2	1	2	2	3	3	3	3	4	4	4	4	4	3
1680	S							1	1	1	2	2	2	2	1
1690	S	8	10	5	8	9	8	8	8	9	9	9	6	6	7
1700	S	4	5	4	4	5	4	4	4	5	5	5	4	5	4
1710	S	2	2	1	2	3	2	3	3	4	4	4	4	4	3
1720	S						1	1	1	1	3	1	2	2	2
1730	S	5	6	3	5	6	5	5	5	3	5	5	3	4	4
1740	S	4	5	4	4	5	4	4	4	5	5	5	3	5	5
1750	S	2	2	1	2	3	2	3	3	4	5	5	4	4	3
1760	S		1				1	1	1	1	1	1	2	2	2

Table A13. Strata for silver hake survey data used for environmental and trend analyses. Offshore and inshore bottom trawl survey strata in the table were consistently sampled (at least one during each year) in the fall survey during 1979-2004, spring survey during 1979-2005 and winter survey during 1992-2005, by stock area for silver hake. The winter survey does not sample inshore strata or the northern stock area.

Survey	Stock	Offshore	Inshore	N offshore	N inshore	N total
Winter	Southern	1010-1030, 1050-1070, 1090-1110, 1610-1620, 1650-1670, 1690-1710, 1730-1750	NA	20	NA	20
Spring	Northern	1020-1300,1340	None	12	0	12
Spring	Southern	1010-1110, 1130-1170, 1190, 1360-1400	3020, 3040-3050, 3070-3080, 3100-3110, 3130-3140, 3160-3170, 3190-3200, 3220-3230, 3250-3260, 3280-3290, 3310-3320, 3340-3350, 3370-3380, 3400-3410, 3430-3440, 3460, 3520	17	31	48
Fall	Northern	1200-1300,1330-1340, 1360-1400	3610	18	1	19
Fall	Southern	1010-1190, 1610-1620, 1650-1670, 1690-1710, 0173-0176	3020, 3040-3050, 3070-3080, 3100-3110, 3130-3140, 3160-3170, 3190-3200, 3220-3230, 3250-3260, 3280-3290, 3310-3320, 3340-3350, 3370-3380, 3400-3410, 3430-3460, 3550	31	32	63

Table A14. Final generalized additive models (GAMs) for probability of occurrence of silver hake in winter, spring and fall surveys. Final models were selected by a step-wise procedure based on the AIC statistic. Variables included in final models were either loess, quadratic or linear terms. Blank cells indicate variables that were not statistically significant based on AIC. Temperatures, depths and time at highest probability of a positive tow (PPT) were identified subjectively by looking at fitted lines in logit-scale partial residual plots. Time at highest PPT is labeled "noon" for predicted curves that were concave down and "midnight" for curves that were concave up.

Survey	Stock	Lengths	Length Group Label in Plots	Bottom Temperature (*T*)	Depth (*D*)	Time of Day (*L*)	Temperature range highest PPT (°C)	Depth range highest PPT (m)	Time at highest PPT
Fall	Northern	1.0 - 5.9	2.5	loess	loess	quadratic	> 15	< 150	noon
		6.0 - 10.9	7.5	loess		quadratic	> 15		noon
		11.0 - 15.9	12.5	quadratic		loess	8		noon
		16.0 - 20.9	17.5	quadratic	loess		8	< 150	
		21.0 - 25.9	22.5	loess	loess		11	190	
		26+	27.5	loess	loess		< 15	> 200	
	Southern	1.0 - 5.9	2.5	loess	loess	loess	10 -17	< 150	midnight
		6.0 - 10.9	7.5	loess	loess	loess	> 15	< 150	midnight
		11.0 - 15.9	12.5	loess	loess	loess	> 15	not clear	not clear
		16.0 - 20.9	17.5	quadratic	loess	linear	10	< 150	not clear
		21.0 - 25.9	22.5	loess	loess	loess	< 15	< 150	not clear
		26+	27.5	quadratic	loess		14	> 90	not clear
	Both	1.0 - 5.9	2.5	loess	loess	loess	15	< 100	midnight
		6.0 - 10.9	7.5	loess	loess	loess	> 15	< 100	midnight
		11.0 - 15.9	12.5	loess	loess	quadratic	< 10	> 100	noon
		16.0 - 20.9	17.5	loess	quadratic		< 10	150	
		21.0 - 25.9	22.5	loess	loess	loess	< 10	200	not clear
		26+	27.5	loess	loess		< 15	> 100	not clear
Spring	Northern	1.0 - 5.9	2.5	NA	NA	NA	NA	NA	NA
		6.0 - 10.9	7.5		loess	loess		100 - 250	midnight
		11.0 - 15.9	12.5	loess	loess	loess	< 9	200	midnight
		16.0 - 20.9	17.5	quadratic	loess	quadratic	6	200	midnight
		21.0 - 25.9	22.5	loess	quadratic		< 10	250	
		26+	27.5	quadratic	quadratic		< 6	300	
	Southern	1.0 - 5.9	2.5		loess	loess		< 200	midnight
		6.0 - 10.9	7.5	quadratic	loess	loess	9	< 100	midnight
		11.0 - 15.9	12.5		loess	quadratic		< 100	midnight
		16.0 - 20.9	17.5	loess	loess	loess	6	< 250	midnight
		21.0 - 25.9	22.5	loess	loess		7	> 100	
		26+	27.5	quadratic	loess		not clear	not clear	
	Both	1.0 - 5.9	2.5	NA	NA	NA	NA	NA	NA
		6.0 - 10.9	7.5	quadratic	loess	loess	< 6	not clear	midnight
		11.0 - 15.9	12.5	loess	loess	loess	< 6	220	midnight
		16.0 - 20.9	17.5	loess	loess	quadratic	5	200	midnight
		21.0 - 25.9	22.5	quadratic	loess	loess	8	> 100	not clear
		26+	27.5	loess	loess	loess	> 8	>80	not clear
Winter	Southern	1.0 - 5.9	2.5	loess	loess	quadratic	> 8	< 150	midnight
		6.0 - 10.9	7.5	loess	quadratic		< 8	150	
		11.0 - 15.9	12.5	loess	loess		< 8	> 150	
		16.0 - 20.9	17.5	loess	loess		5	> 100	
		21.0 - 25.9	22.5	loess	loess		6	> 100	
		26+	27.5	loess	loess		7	> 75	

Table A15. Final generalized additive models (GAMs) for catches of silver hake in winter, spring and fall survey tows where at least one silver hake was taken. Final models were selected by a step-wise procedure based on the AIC statistic. Variables included in final models were either loess, quadratic or linear terms. Blank cells indicate variables that were not statistically significant based on AIC. Temperatures, depths and time at highest density were identified subjectively by looking at fitted lines in log-scale partial residual plots. Time at highest density is labeled "noon" for predicted curves that were concave down and "midnight" for curves that were concave up.

Survey	Stock	Lengths	Length Group Label in Plots	Bottom Temperature (*T*)	Depth (*D*)	Time of Day (*L*)	Temperature range highest PPT (°C)	Depth range highest PPT (m)	Time at highest PPT
Fall	Northern	1.0 - 5.9	2.5	loess	loess	loess	10 - 17	< 100	midnight
		6.0 - 10.9	7.5	loess	loess	loess	10 - 17	< 100	midnight?
		11.0 - 15.9	12.5	quadratic	quadratic		12	100 - 200	
		16.0 - 20.9	17.5	loess	loess		10	100	
		21.0 - 25.9	22.5	loess	loess	loess	8	125 - 225	midnight
		26+	27.5	loess	loess	loess	8	200	midnight
	Southern	1.0 - 5.9	2.5	loess	loess	loess	10 - 16	< 100	midnight
		6.0 - 10.9	7.5	loess	loess	loess	10 - 18	< 100	midnight
		11.0 - 15.9	12.5	quadratic	quadratic		12	100 - 200	
		16.0 - 20.9	17.5	loess	loess		8 - 10	100 - 150	
		21.0 - 25.9	22.5	loess	loess	loess	9	150 - 250	midnight
		26+	27.5	loess	loess	loess	< 10	200	midnight
	Both	1.0 - 5.9	2.5	loess	loess	loess	8 - 17	< 100	midnight
		6.0 - 10.9	7.5	loess	loess	loess	10 - 17	< 100	midnight?
		11.0 - 15.9	12.5	quadratic	quadratic		12	125	
		16.0 - 20.9	17.5	loess	loess		7 - 10	100	
		21.0 - 25.9	22.5	loess	loess	loess	9	150 - 220	midnight
		26+	27.5	loess	loess	loess	< 10	> 200	midnight
Spring	Northern	1.0 - 5.9	2.5	NA	NA	NA	NA	NA	NA
		6.0 - 10.9	7.5	loess	loess	loess	< 8	< 100	midnight
		11.0 - 15.9	12.5	loess	loess	quadratic	< 8	200 - 250	midnight
		16.0 - 20.9	17.5	loess	loess	quadratic	8	> 150	midnight
		21.0 - 25.9	22.5	loess	loess		< 12	> 150	
		26+	27.5	loess	loess	quadratic	12	> 250	midnight
	Southern	1.0 - 5.9	2.5	NA	NA	NA	NA	NA	NA
		6.0 - 10.9	7.5	loess	loess	loess	< 10	< 100	midnight
		11.0 - 15.9	12.5	loess	loess	quadratic	< 10	200 - 250	midnight
		16.0 - 20.9	17.5	loess	loess	quadratic	6 - 8	> 150	midnight
		21.0 - 25.9	22.5	loess	loess		< 12	> 150	
		26+	27.5	loess	loess	quadratic	> 9	> 250	midnight
	Both	1.0 - 5.9	2.5	NA	NA	NA	NA	NA	NA
		6.0 - 10.9	7.5	loess	loess	loess	< 10	< 100	midnight
		11.0 - 15.9	12.5	loess	loess	quadratic	< 10	200 - 250	midnight
		16.0 - 20.9	17.5	loess	loess	quadratic	6 - 9	> 150	midnight
		21.0 - 25.9	22.5	loess	loess		< 12	> 150	
		26+	27.5	loess	loess	quadratic	> 9	> 250	midnight
Winter	Southern	1.0 - 5.9	2.5		linear	quadratic		< 100	midnight
		6.0 - 10.9	7.5	loess	loess	quadratic	< 6	< 100	midnight
		11.0 - 15.9	12.5	loess	loess	loess	< 6	70	not clear
		16.0 - 20.9	17.5	linear	quadratic		< 6	150 - 200	
		21.0 - 25.9	22.5	loess	loess		6- 8	> 150	
		26+	27.5	loess	loess		8	> 150	

Table A16. Direction and statistical significance of estimated trends (linear regression models) in abundance weighted mean bottom temperatures, depths, latitudes and longitudes for silver hake taken during fall (1979-2004), spring (1978-2005) and winter (1992-2005) bottom trawl surveys. Symbols are "+" for increasing trends and "-" for decreasing trends. Variables with statistically significant regressions on time are identified by single ("*" for 0.1≥ p-values > 0.05) or double ("**" for 0.05 ≥ p-value) asterisks.

	Length Group	Fall			Spring			Winter
Lengths	Label in Plots	North	South	Both	North	South	Both	South
Mean Bottom Temperature								
1.0 - 5.9	2.5				NA		NA	
6.0 - 10.9	7.5							
11.0 - 15.9	12.5			- * *				
16.0 - 20.9	17.5							
21.0 - 25.9	22.5							
26+	27.5			- *				
Mean Depth								
1.0 - 5.9	2.5							
6.0 - 10.9	7.5	+ *		+ * *				
11.0 - 15.9	12.5			+ *		+ *		
16.0 - 20.9	17.5	+ *						
21.0 - 25.9	22.5	+ *		+ *		+ * *		+ *
26+	27.5			+ * *			+ * *	+ *
Mean Latitude								
1.0 - 5.9	2.5		+ *	+ *			NA	+ * *
6.0 - 10.9	7.5	+ *		+ * *				
11.0 - 15.9	12.5	+ *		+ * *		+ * *		
16.0 - 20.9	17.5				+ * *	+ *	+ *	
21.0 - 25.9	22.5		+ * *					
26+	27.5		+ * *	+ * *		+ * *	+ * *	
Mean Longitude								
1.0 - 5.9	2.5				NA		NA	- * *
6.0 - 10.9	7.5			- *				
11.0 - 15.9	12.5				+ * *			
16.0 - 20.9	17.5				+ *			
21.0 - 25.9	22.5		- * *	- *				
26+	27.5		- * *	- *		- * *	- * *	

Table A17. Number of relatively old individual fish in provisional survey age data for silver hake, by season and year. Duplicate records were removed manually.

Count of AGE		AGE							
Season	year	8	9	10	11	12	13	14	Grand Total
Fall	1973			3	2		1		6
	1975	2	1	1					4
	1976	1		1					2
	1977	3	2	1					6
	1978	14		1					15
	1979	6	4			1			11
	1980	21	3	2	1				27
	1981	23	2	1					26
	1982	6	3						9
	1983	1	2						3
	1984		1						1
	1985	1							1
	1989					1			1
Fall Total		78	18	10	3	2	1		112
Spring	1973	1	2	1		1		1	6
	1974	1	5		1			1	8
	1975		1						1
	1976	11	2	1					14
	1977	10	3	1					14
	1978	12		3	1			1	17
	1979	4	1						5
	1980	22	7	4		1			34
	1981	33	21		1				55
	1982	6	7	5		2			20
	1983	1	2	4					7
	1985	1	1						2
	1986	2							2
	1987	1	2						3
Spring Total		105	54	19	3	4		3	188
Grand Total		183	72	29	6	6	1	3	300

Table A18. Age reader precision experiment using 99 silver hake ototliths collected during the NEFSC spring 2004 bottom trawl survey. The sample of otoliths were aged a second time by the original technician without knowledge of the original ages.

Production Age	N	N agreed	% Agreement	Mean Age	SD
0					
1	9	9	100%	1.00	0.00
2	41	38	93%	2.07	0.26
3	23	21	91%	3.09	0.29
4	23	20	87%	3.96	0.37
5	3	3	100%	5.00	0.00
Total	99	91	92%		

Second age->

First age	0	1	2	3	4	5
0						
1		9				
2			38	3		
3				21	2	
4				2	20	1
5						3
					Total	99

Table A19. Age reader precision experiment using 99 silver hake ototliths collected during the NEFSC spring 2004 bottom trawl survey. The sample of otoliths were aged a second technician without knowledge of the ages estimated by the original technician.

Secondary reader reages a sample from 200402 cruise.

Production Age	N	N agreed	% Agreement	Mean Age	SD
0					
1	9	8	89%	1.11	0.33
2	41	39	95%	2.00	0.22
3	23	21	91%	2.95	0.21
4	23	7	30%	3.38	0.58
5	3	1	33%	5.67	0.58
Total	99	76	77%		

Second age ->

First age	0	1	2	3	4	5	6
0							
1		8	1				
2		1	39	1			
3			1	21			
4				16	7	1	
						1	2
5							
						Total	99

Table A20. Otoliths from a sample of 15 fish taken in NEFSC surveys during 1973-1982 and originally estimated to be at least age 7 y by several technicians were reaged by the current technician. New ages were all from sectioned otoliths. In some cases, original ages were from "baked" otoliths. All of the original age estimates were made prior to 1983.

ID	Cruise	Station	Length	Preparation for original age	Original age	Preparation for new age	New age
1	73-3	112	46	Section	7	Section	6
2	73-3	112	59	Section	7	Section	6
3	73-3	197	54	Section	10	Section	9
4	73-8	179	51	Section	10	Section	9
5	73-8	196	50	Section	10	Section	10
6	74-4	64	53	Section	9	Section	7
7	74-4	98	59	Section	9	Section	7
8	74-4	223	60	Section	9	Section	7
9	74-4	226	61	Section	14	Section	12
10	75-12	275	50	Baked	8	Section	5
11	75-12	321	63	Baked	6	Section	5
12	75-12	321	61	Baked	8	Section	6
13	79-12	616	68	Section	12	Section	11
14	82-02	348	64	Section	12	Section	11
15	82-02	420	66	Section	12	Section	9

Count of Cruise	New age								
Original age	5	6	7	9	10	11	12	13	14	Grand Total
5										
6	1									1
7		2								2
8	1	1								2
9			3							3
10				2	1					3
12				1		2				3
13										0
14							1			1
Grand Total	2	3	3	3	1	2	1	0	0	15

Table A21. Number of tows, mean catch per tow and mean densities of silver hake by stratum and transect canyon area for the NEFSC spring and Supplemental surveys during March, 2004-2005.

				NEFSC Survey (averages for all tows)						Supplemental Survey (averages for all tows)						
Year	Season	Canyon Area	NEFSC Stratum	N Random Stations	Bottom Temp. (°C)	Depth (m)	Catch (kg)	Swept Area (km^2)	Density (kg/km^2)	N Fixed Stations	Bottom Temp. (°C)	Depth (m)	Catch (kg)	Swept Area (km^2)	Density (kg/km^2)	Ratio NEFSC / Supplemental Density
2004	Spring	Hudson	1020	7	3.5	69	0.274	0.041	6.7	3	5.5	89	202.4	0.269	739.7	0.0090
2005	Spring	Hudson	1020	7	8.0	79	0.764	0.041	18.6	2	8.7	81	109.1	0.145	770.3	0.0242
2004	Spring	Hudson	1030	2	7.7	16	2.268	0.041	55.3	1	10.7	144	691.6	0.293	2358.1	0.0235
2005	Spring	Hudson	1030	2	10.6	81	0.286	0.041	7.0	2	11.5	127	141.0	0.130	1074.2	0.0065
2004	Spring	Hudson	1040	1	11.3	216	0.553	0.041	13.5	3	10.6	224	394.2	0.294	1366.5	0.0099
2005	Spring	Hudson	1040	1	6.5	289	26.142	0.041	637.8	3	10.6	227	1283.2	0.130	10078.4	0.0633
2004	Spring	Baltimore	1700	4	6.7	73	0.057	0.041	1.4	3	2.3	91	18.5	0.246	77.1	0.0181
2005	Spring	Baltimore	1700	4	7.8	67	0.112	0.041	2.7	2	9.9	82	35.0	0.144	238.2	0.0114
2004	Spring	Baltimore	1710	4	6.7	73	0.057	0.041	1.4	2	5.7	162	36.6	0.270	132.0	0.0106
2005	Spring	Baltimore	1710	4	7.8	67	0.112	0.041	2.7	3	10.9	149	143.7	0.149	950.7	0.0029
2004	Spring	Baltimore	1720	1	5.8	375	0.000	0.041	0.0	2	10.1	244	257.1	0.265	968.1	0.0000
2005	Spring	Baltimore	1720	1	6.8	355	1.042	0.041	25.4	2	8.3	256	2000.1	0.142	13932.3	0.0018
													Average Hudson Canyon			0.0227
													Median Hudson Canyon			0.0167
				38						28			Average Baltimore Canyon			0.0075
													Median Baltimore Canyon			0.0067
													Average 2004			0.0118
													Median 2004			0.0102
													Average 2005			0.0184
													Median 2005			0.0090

Table A22. NEFSC fall survey biomass index (delta mean kg/tow, all size groups), landings data, and exploitation index (landings / survey biomass index) for silver hake in the nothern stock area. Survey data are for traditional NEFSC survey strata that have been consistently occupied since 1964. Three year averages show trends and are used in overfishing definitions.

Year	Fall Survey (delta mean kg/tow, all sizes)	CV	3-Year Average	Landings (L_t, 1000 mt)	Landings / Survey (all sizes)	3-Year Average
1964	4.42	0.20		94.46	21.40	
1965	6.48	0.28		45.24	6.99	
1966	4.12	0.19	5.00	47.72	11.57	13.32
1967	2.16	0.27	4.25	33.37	15.46	11.34
1968	2.05	0.27	2.78	41.38	20.20	15.75
1969	2.64	0.22	2.28	23.96	9.09	14.92
1970	3.03	0.26	2.57	27.53	9.07	12.79
1971	2.47	0.20	2.71	36.40	14.76	10.98
1972	6.09	0.16	3.86	25.22	4.15	9.33
1973	4.15	0.14	4.23	32.08	7.73	8.88
1974	3.76	0.28	4.67	20.68	5.49	5.79
1975	8.23	0.14	5.38	39.87	4.84	6.02
1976	12.63	0.22	8.21	13.63	1.08	3.81
1977	7.59	0.33	9.49	12.46	1.64	2.52
1978	7.07	0.14	9.10	12.61	1.78	1.50
1979	6.65	0.15	7.11	3.42	0.51	1.31
1980	6.66	0.18	6.79	4.73	0.71	1.00
1981	4.06	0.25	5.79	4.42	1.09	0.77
1982	5.45	0.56	5.39	4.66	0.85	0.88
1983	9.21	0.21	6.24	5.31	0.58	0.84
1984	3.62	0.22	6.09	8.29	2.29	1.24
1985	8.58	0.16	7.14	8.30	0.97	1.28
1986	14.19	0.16	8.80	8.50	0.60	1.28
1987	9.84	0.14	10.87	5.66	0.58	0.71
1988	6.31	0.20	10.11	6.77	1.07	0.75
1989	12.55	0.26	9.57	4.65	0.37	0.67
1990	15.25	0.25	11.37	6.38	0.42	0.62
1991	11.89	0.29	13.23	6.05	0.51	0.43
1992	14.25	0.38	13.79	5.30	0.37	0.43
1993	8.12	0.19	11.42	4.36	0.54	0.47
1994	6.93	0.14	9.76	5.72	0.83	0.58
1995	13.16	0.15	9.40	3.03	0.23	0.53
1996	7.89	0.16	9.32	3.20	0.41	0.49
1997	5.64	0.20	8.90	2.59	0.46	0.37
1998	21.97	0.31	11.83	2.26	0.10	0.32
1999	11.64	0.10	13.08	4.04	0.35	0.30
2000	13.79	0.13	15.80	2.42	0.18	0.21
2001	9.53	0.20	11.65	3.45	0.36	0.29
2002	8.00	0.11	10.44	2.84	0.35	0.30
2003	8.77	0.18	8.77	1.73	0.20	0.30
2004	3.40	0.22	6.72	0.56	0.16	0.24

Table A23. NEFSC fall survey biomass index (delta mean kg/tow, all size groups), landings data, and exploitation index (landings / survey biomass index) for silver hake in the southern stock area. Survey data are for traditional NEFSC survey strata that have been consistently occupied since 1964. Three year averages show trends and are used in overfishing definitions.

Year	Fall Survey (delta mean kg/tow, all sizes)	CV	3-Year Average	Landings (L_t, 1000 mt)	Landings / Survey (all sizes)	3-Year Average
1967	2.19	0.14	2.19	91.25	41.74	41.74
1968	2.69	0.13	2.44	58.50	21.72	31.73
1969	1.26	0.14	2.05	75.56	60.16	41.21
1970	1.33	0.13	1.76	27.51	20.65	34.18
1971	2.21	0.16	1.60	71.89	32.53	37.78
1972	2.00	0.22	1.85	94.35	47.18	33.45
1973	1.70	0.18	1.97	104.59	61.56	47.09
1974	0.86	0.21	1.52	109.86	127.45	78.73
1975	1.84	0.16	1.47	74.25	40.35	76.46
1976	2.06	0.14	1.59	68.74	33.34	67.05
1977	1.77	0.24	1.89	59.31	33.45	35.71
1978	2.93	0.24	2.26	27.13	9.26	25.35
1979	1.74	0.12	2.15	18.38	10.55	17.75
1980	2.12	0.35	2.26	13.55	6.38	8.73
1981	1.17	0.14	1.68	14.83	12.72	9.88
1982	1.65	0.20	1.65	14.56	8.82	9.31
1983	3.20	0.35	2.01	12.14	3.79	8.44
1984	1.56	0.30	2.14	13.14	8.44	7.02
1985	3.91	0.49	2.89	13.16	3.37	5.20
1986	1.39	0.17	2.28	10.12	7.29	6.37
1987	1.62	0.24	2.30	10.12	6.25	5.64
1988	1.83	0.23	1.61	9.20	5.02	6.19
1989	2.12	0.26	1.86	13.17	6.21	5.83
1990	1.65	0.17	1.87	13.62	8.28	6.50
1991	0.91	0.22	1.56	10.09	11.13	8.54
1992	0.98	0.14	1.18	10.29	10.52	9.97
1993	1.33	0.19	1.07	12.91	9.72	10.45
1994	0.80	0.16	1.04	10.33	12.93	11.06
1995	1.64	0.34	1.26	11.69	7.13	9.92
1996	0.43	0.16	0.96	13.00	30.16	16.74
1997	0.84	0.19	0.97	12.99	15.43	17.57
1998	0.62	0.18	0.63	12.70	20.49	22.03
1999	0.87	0.40	0.78	9.97	11.46	15.79
2000	0.72	0.22	0.74	9.76	13.50	15.15
2001	2.23	0.28	1.27	8.69	3.90	9.62
2002	1.18	0.22	1.38	5.15	4.35	7.25
2003	1.56	0.22	1.66	6.92	4.44	4.23
2004	1.37	0.21	1.37	7.89	5.76	4.85

Table A24. Lower bound estimates for silver hake (southern stock) fishable biomass and upper bound estimates for fishing mortality based on relative efficiency of NEFSC and Supplemental survey bottom trawls and NEFSC fall survey data.

(EDITOR'S NOTE: THIS PART OF THE WORKING GROUP REPORT HAS BEEN OMITTED. IT WAS NOT ACCEPTED BY THE REVIEW PANEL.)

Table A25. Lower bounds for fishable biomass and upper bounds for fishing mortality in the northern silver hake during 1964-2004 based on historical landings and fall survey data.

(EDITOR'S NOTE: THIS PART OF THE WORKING GROUP REPORT HAS BEEN OMITTED. IT WAS NOT ACCEPTED BY THE REVIEW PANEL.)

Table A26. Lower bounds for fishable biomass and upper bounds for fishing mortality in the southern silver hake during 1964-2004 based on historical landings and fall survey data.

(EDITOR'S NOTE: THIS TABLE FROM THE WORKING GROUP REPORT HAS BEEN OMITTED. IT WAS NOT ACCEPTED BY THE REVIEW PANEL.)

Table A27. Total allowable landings (TAL, thousand mt) for silver hake during 2005 based on exploitation index (landings / fall survey biomass index) reference points and average fall survey biomass index during 2002-2004. For comparison, landings averaged 1.71 thousand mt in the north and 6.65 thousand mt in the south during 2002-2004. The CV is for the 2002-2004 mean biomass index and measures uncertainty in the TAL calculation assuming that the reference points are exact.

Stock Area	Exploitation Index Reference Points Type	Value	2002-2004 Mean Biomass Index	TAL (1000 mt)	CV
Northern	Both	2.57	6.72	17.27	0.10
Southern	Target	20.63	1.37	28.26	0.13
Southern	Threshold	34.39		47.11	0.13

SILVER HAKE FIGURES

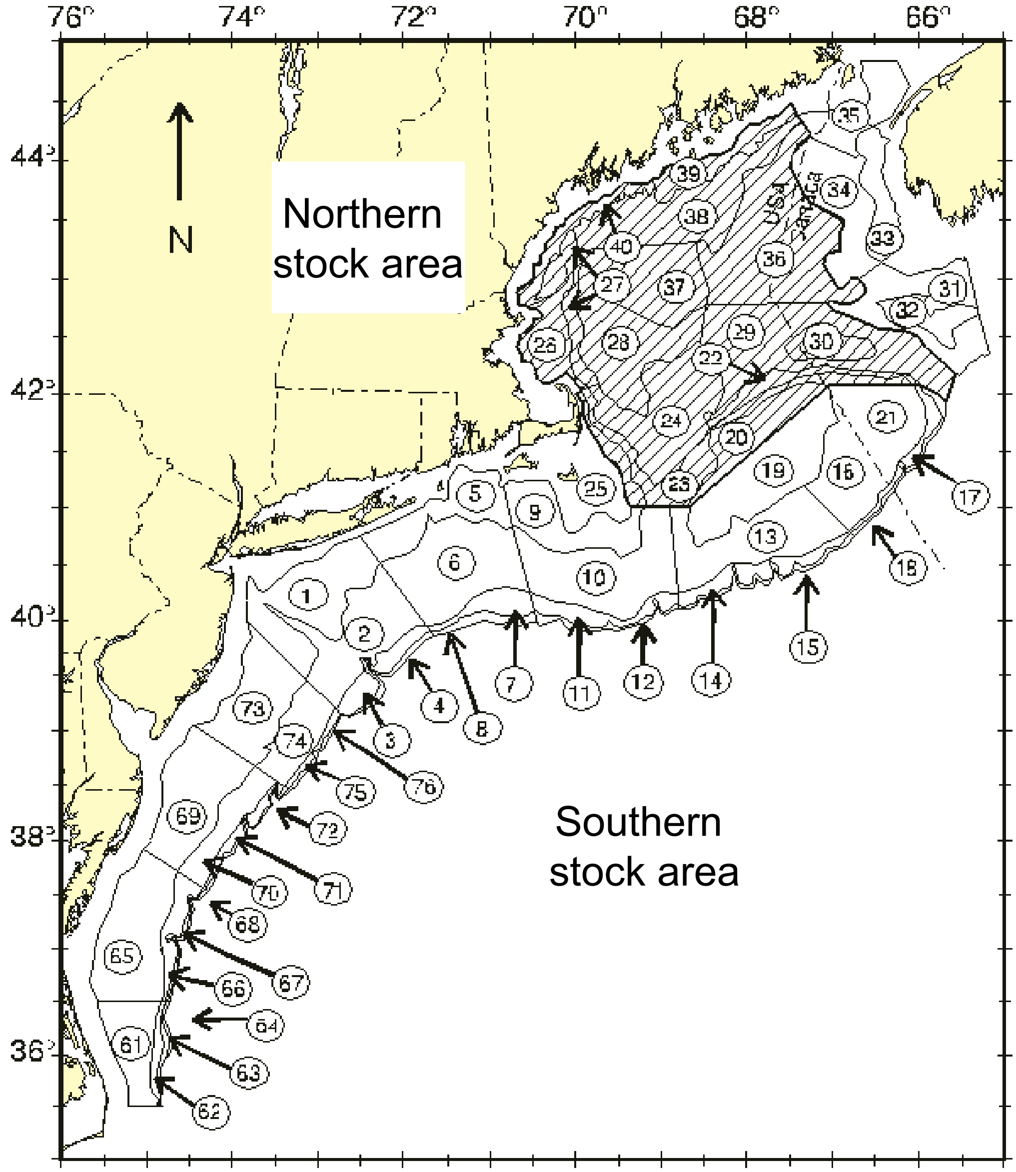
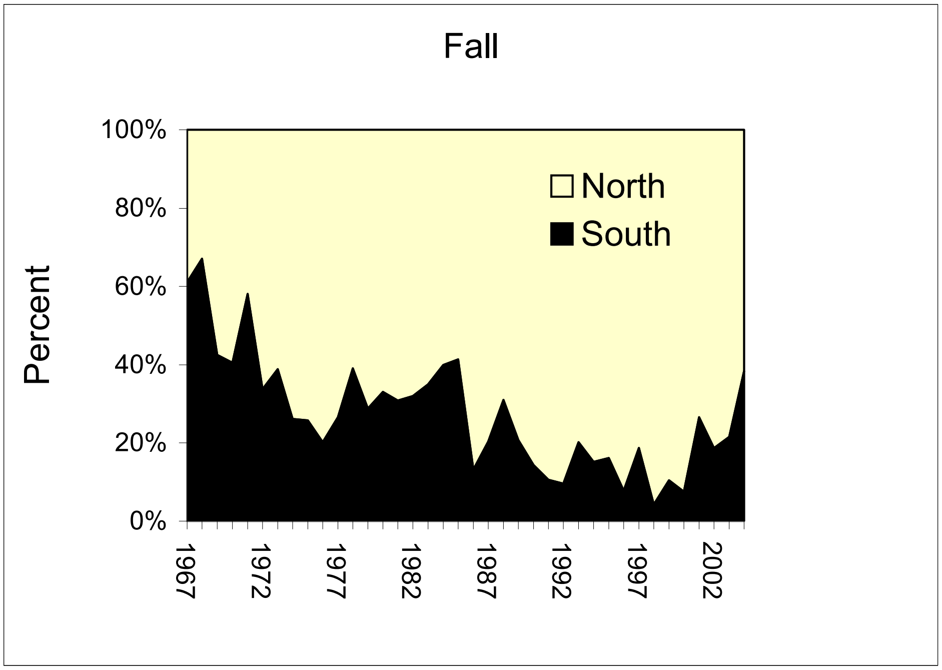


Figure A1. Silver hake stock areas in US waters with NEFSC offshore survey strata. The straum labeled “73” is, for example, stratum 01730. Numerous inshore survey strata, where silver hake also occur, are not shown. The northern stock area is shown by diagonal lines.



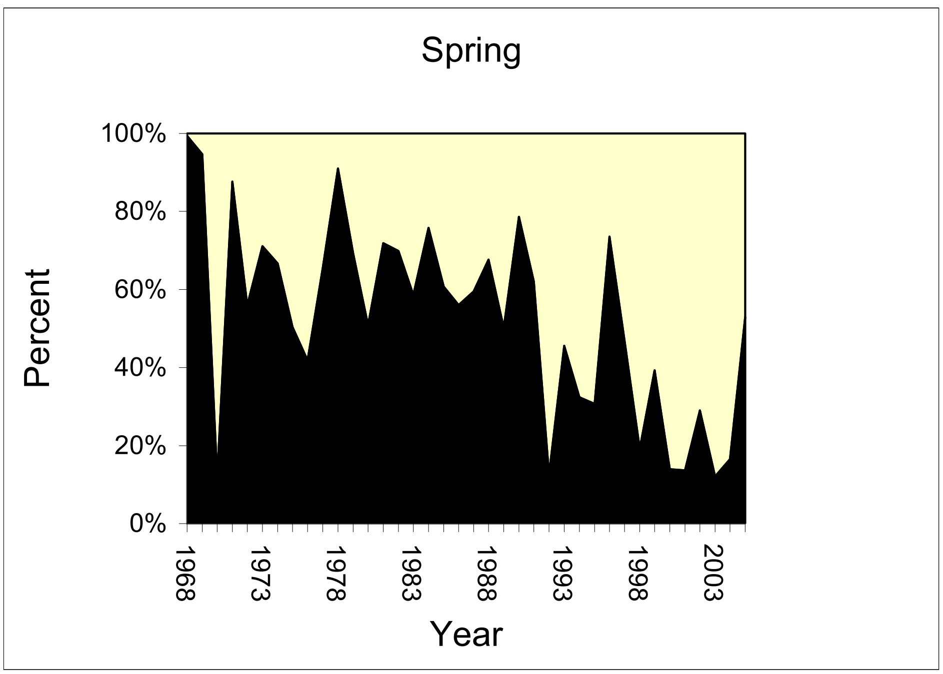


Figure A2. Percent of minimum swept area biomass in the northern and southern stock areas based on NEFSC fall surveys during 1967-2004 and NEFSC spring surveys during 1968-2005. Traditional (consistently occupied offshore strata) were used for survey data.

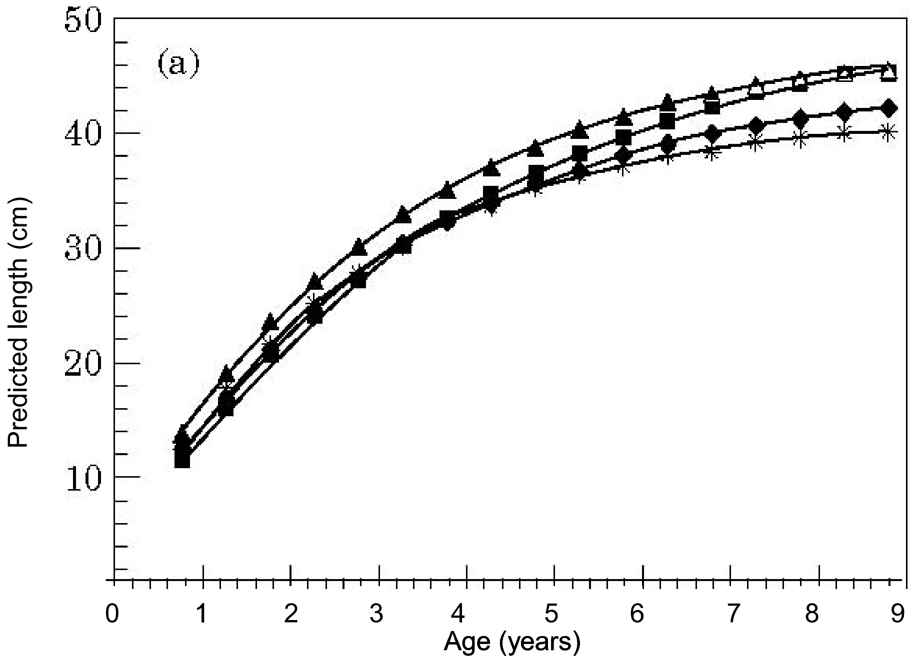


Figure A3. “Typical” growth curves for silver hake from NEFSC fall surveys along the northeast coast between the Gulf of Maine and Mid-Atlantic during 1975-1980 (from Helser 1996).

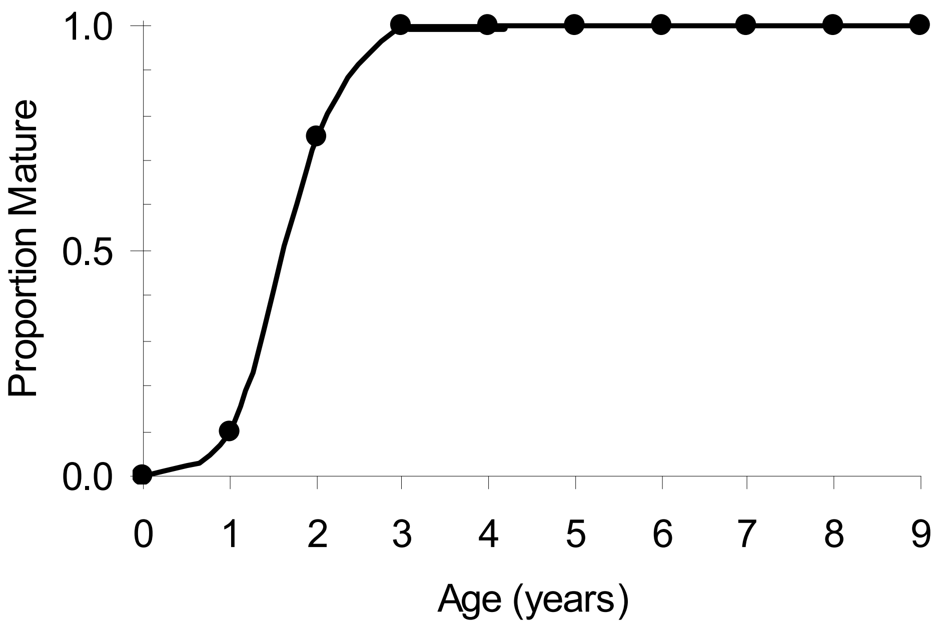


Figure A4. Maturity at age for silver hake from Brodziak et al. (2001).

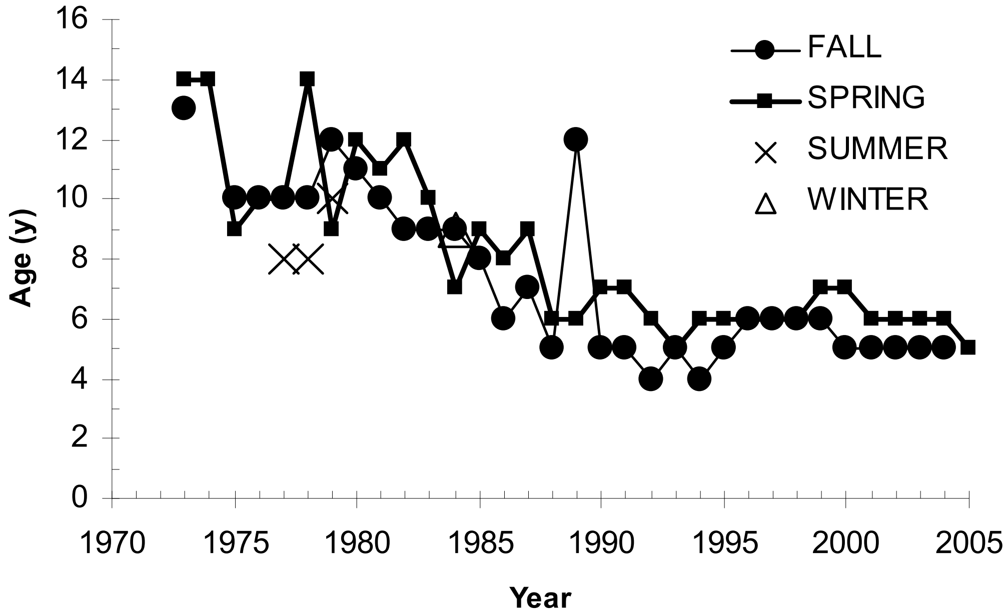


Figure A5. Maximum observed ages by year in NEFSC fall, spring, summer, and winter bottom trawl surveys. Silver hake in summer and winter surveys are not routinely aged. Silver hake age data are currently being audited and are preliminary.

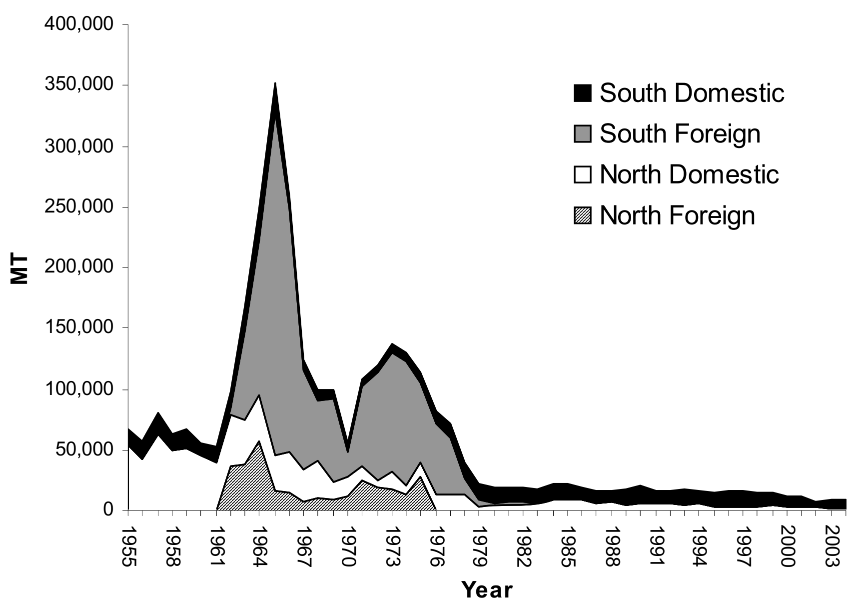


Figure A6. Silver hake landings (mt) by stock area during 1955-2004 for foreign and domestic fishing fleets.

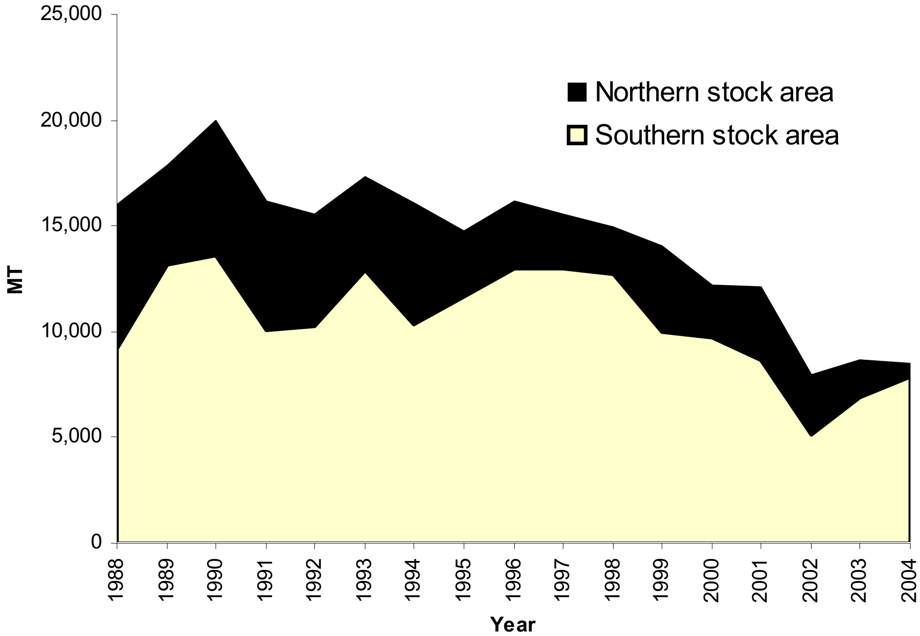


Figure A7. Silver hake landings (mt) in the US domestic fishery by stock area during 1988-2004.

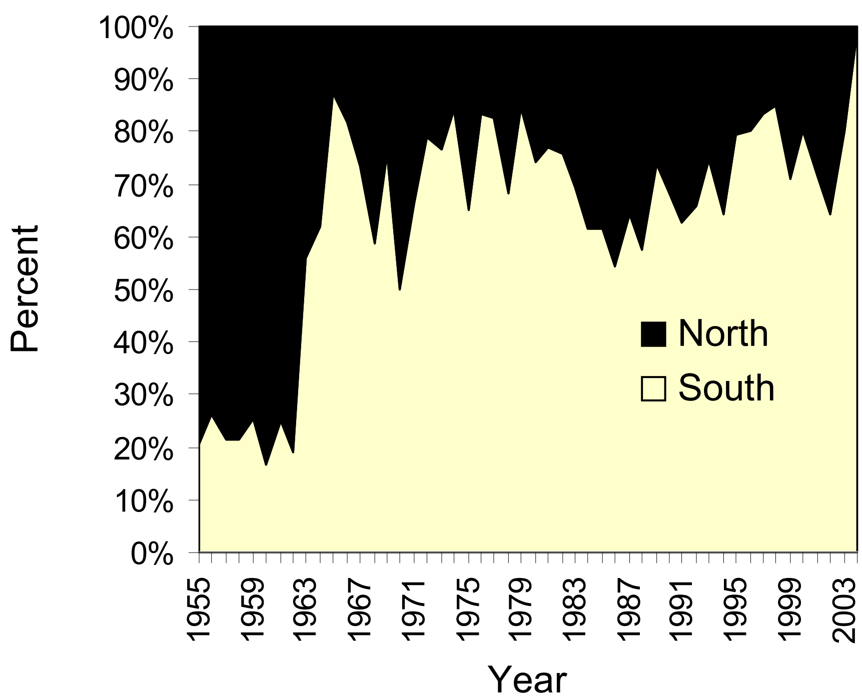


Figure A8. Percent of total silver hake landings (domestic + foreign) from the northern and southern stock areas during 1955-2004.

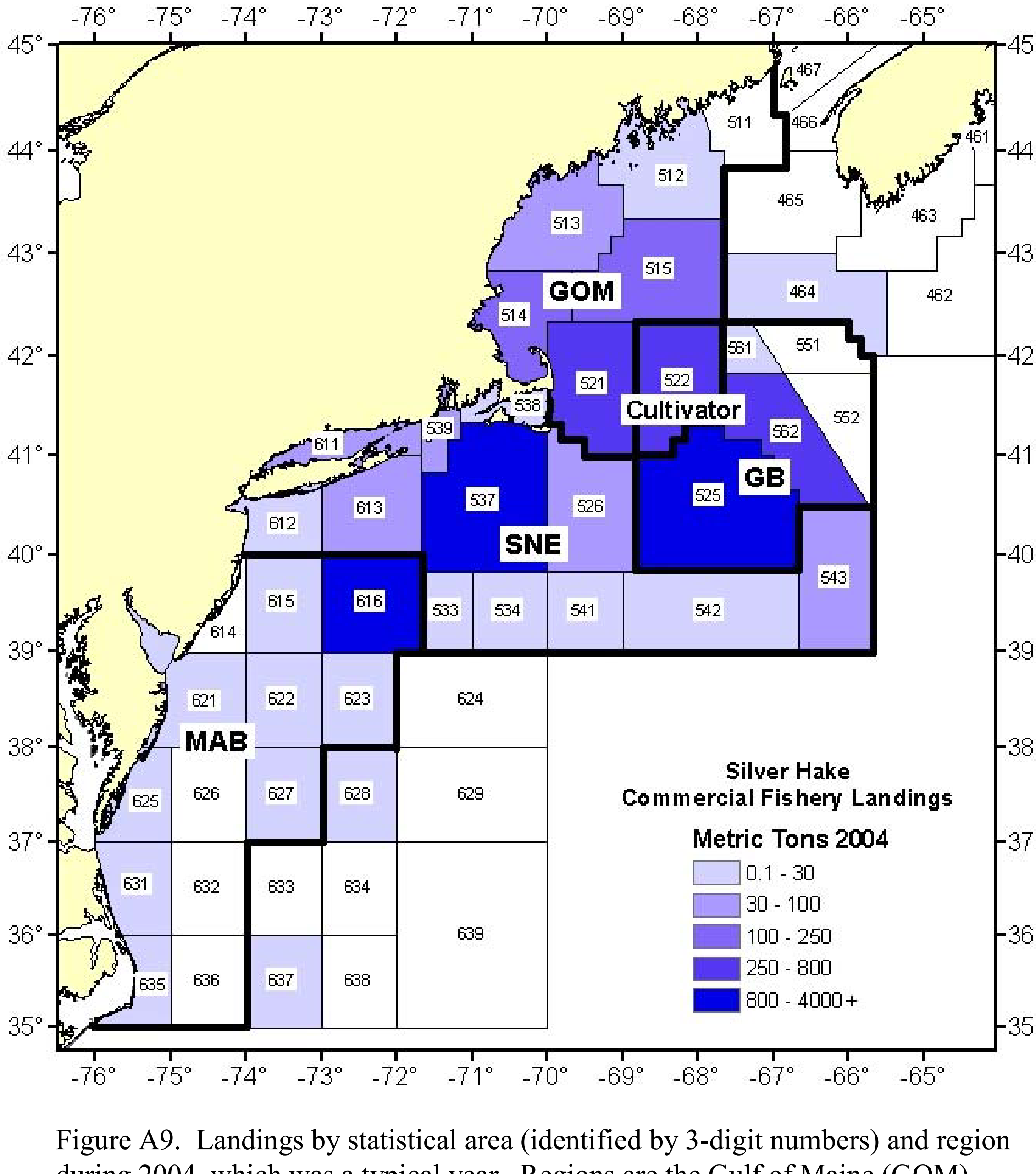


Figure A9. Landings by statistical area (identified by 3-digit numbers) and region during 2004, which was a typical year. Regions are the Gulf of Maine (GOM), Cultivator Shoals, Georges Bank (GB), Southern New England (SNE), and the Mid-Atlantic Bight (MAB).

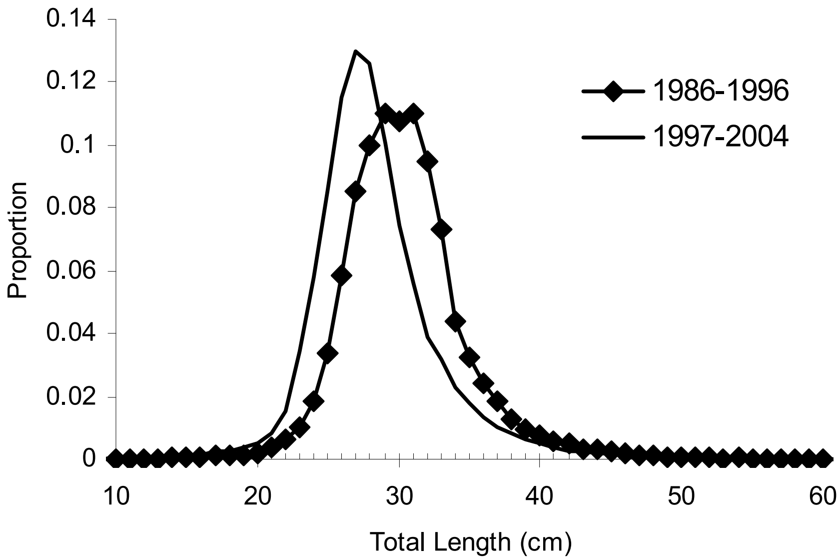


Figure A10. Commercial length composition data for silver hake during 1986-1996 and 1997-2004.

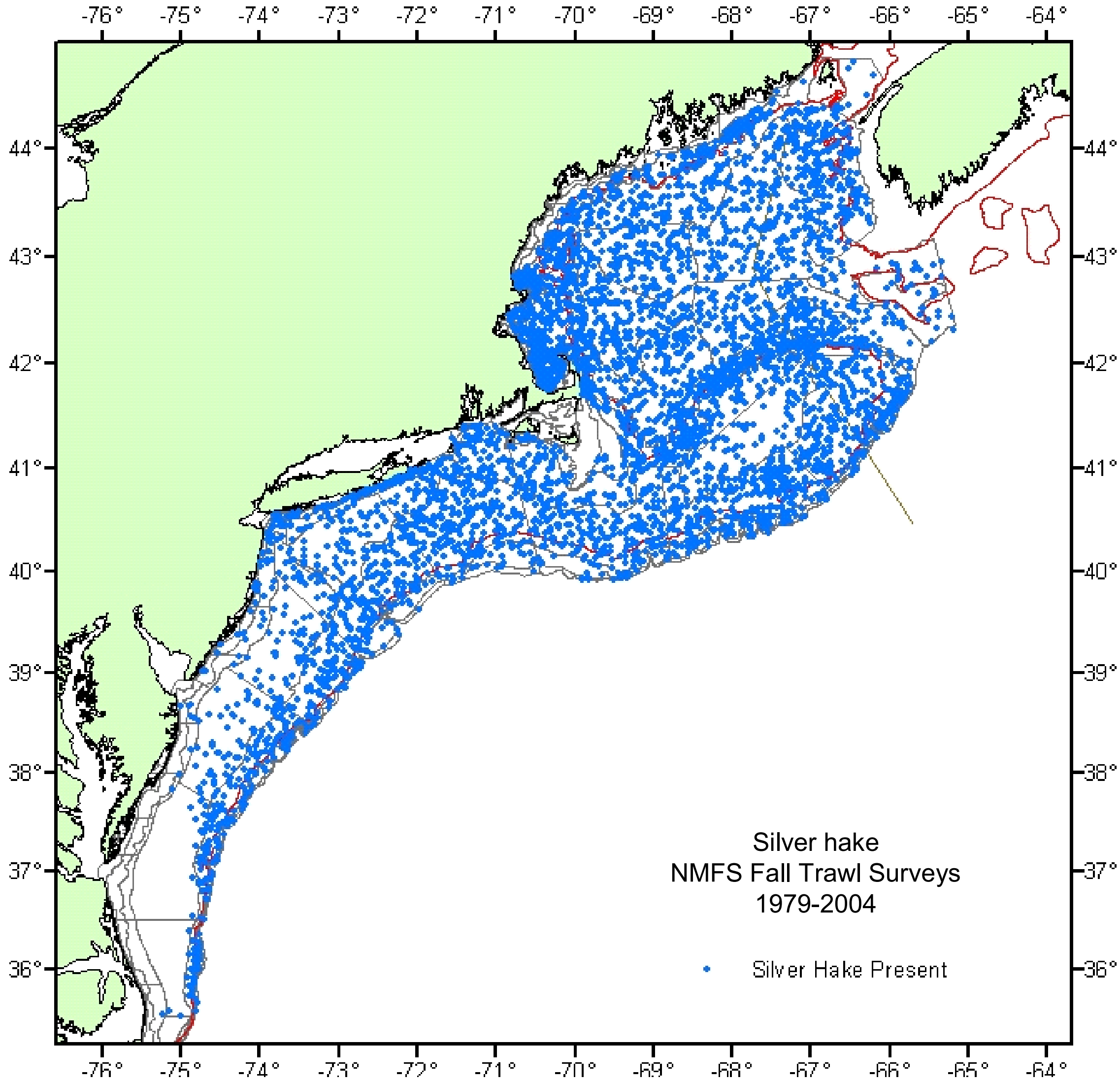


Figure A11. Locations of NEFSC fall bottom trawl survey tows that caught at least one silver hake during 1979-2004, based on all inshore and offshore strata that were sampled.

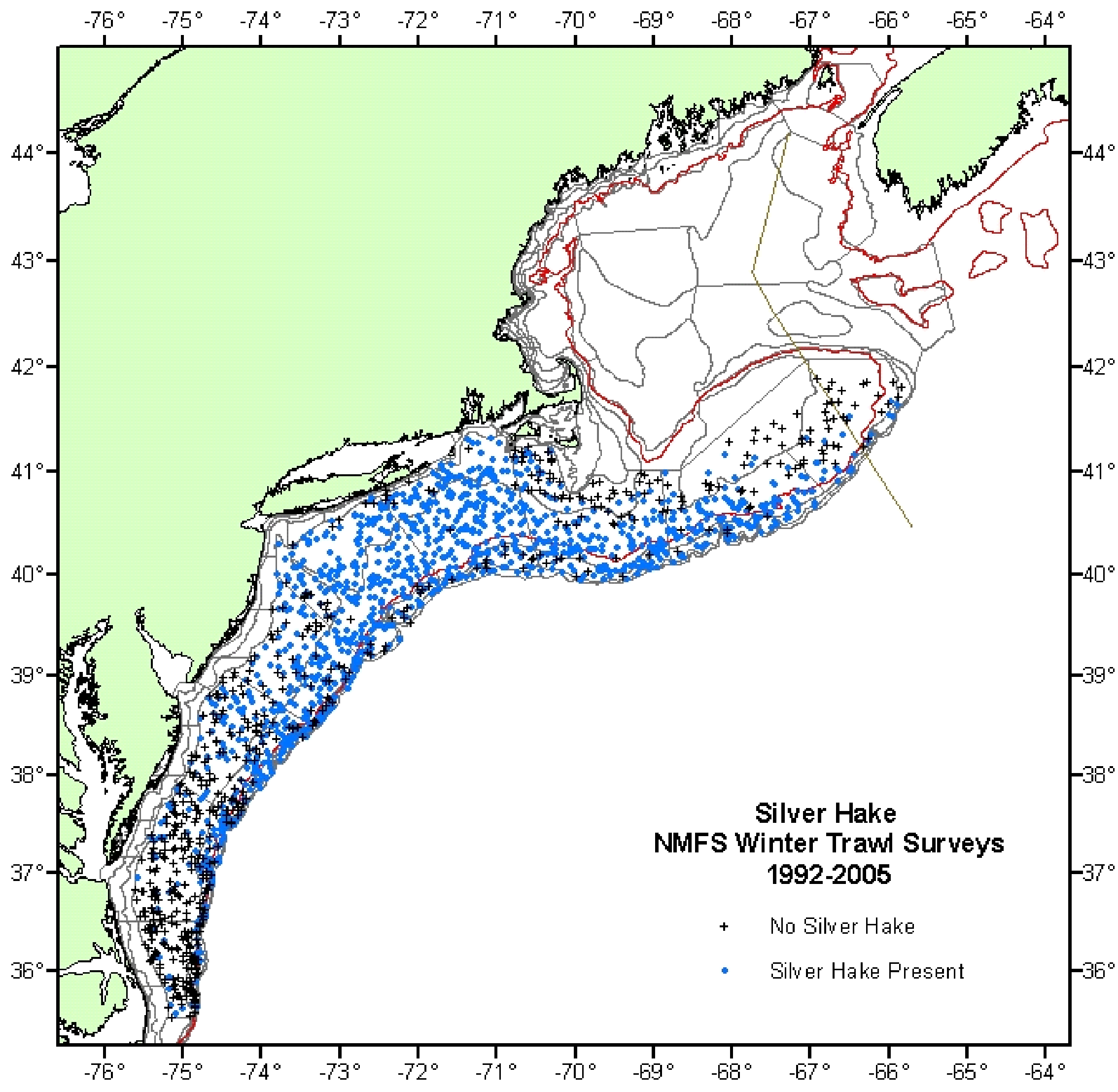


Figure A12. Locations of NEFSC winter bottom trawl survey tows with and without silver hake during 1992-2002, based on all offshore strata that were sampled. The winter survey does not cover strata above southern Georges Bank or inshore strata.

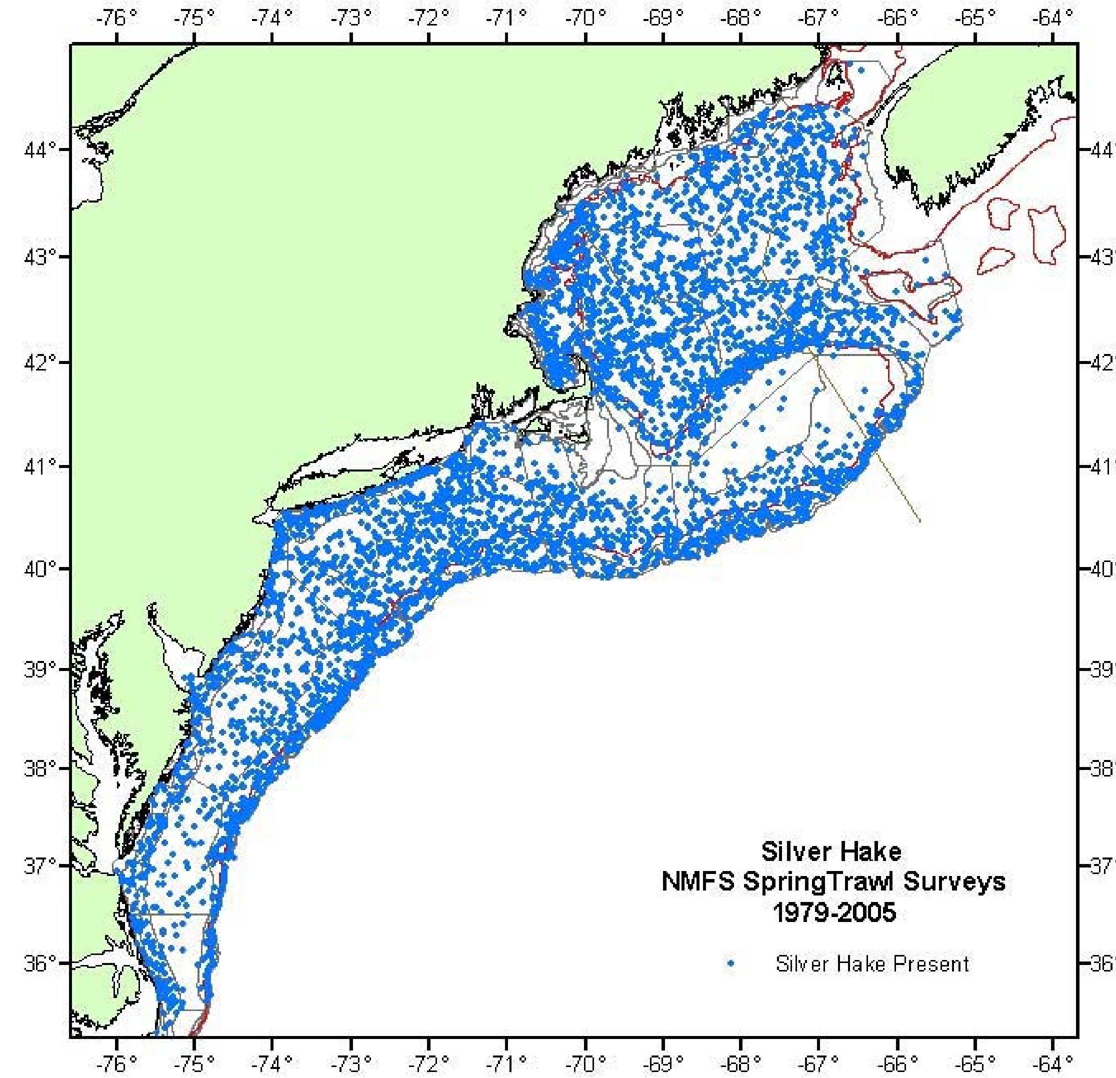


Figure A13. Locations of NEFSC spring bottom trawl survey tows that caught at least one silver hake during 1979-2004, based on all inshore and offshore strata that were sampled.

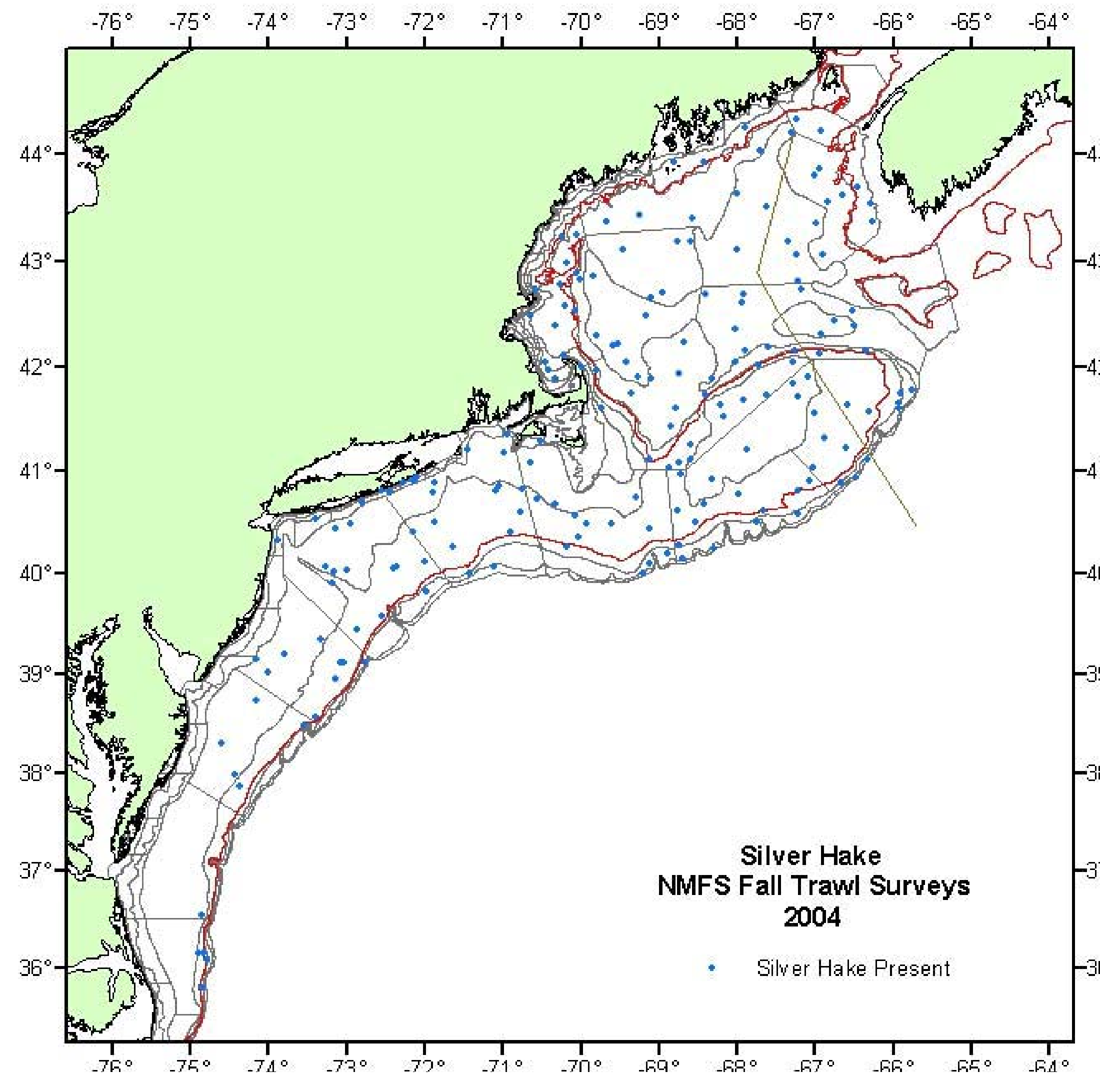


Figure A14. Locations of NEFSC fall bottom trawl survey tows that caught at least one silver hake during 2004, based on all inshore and offshore strata that were sampled.

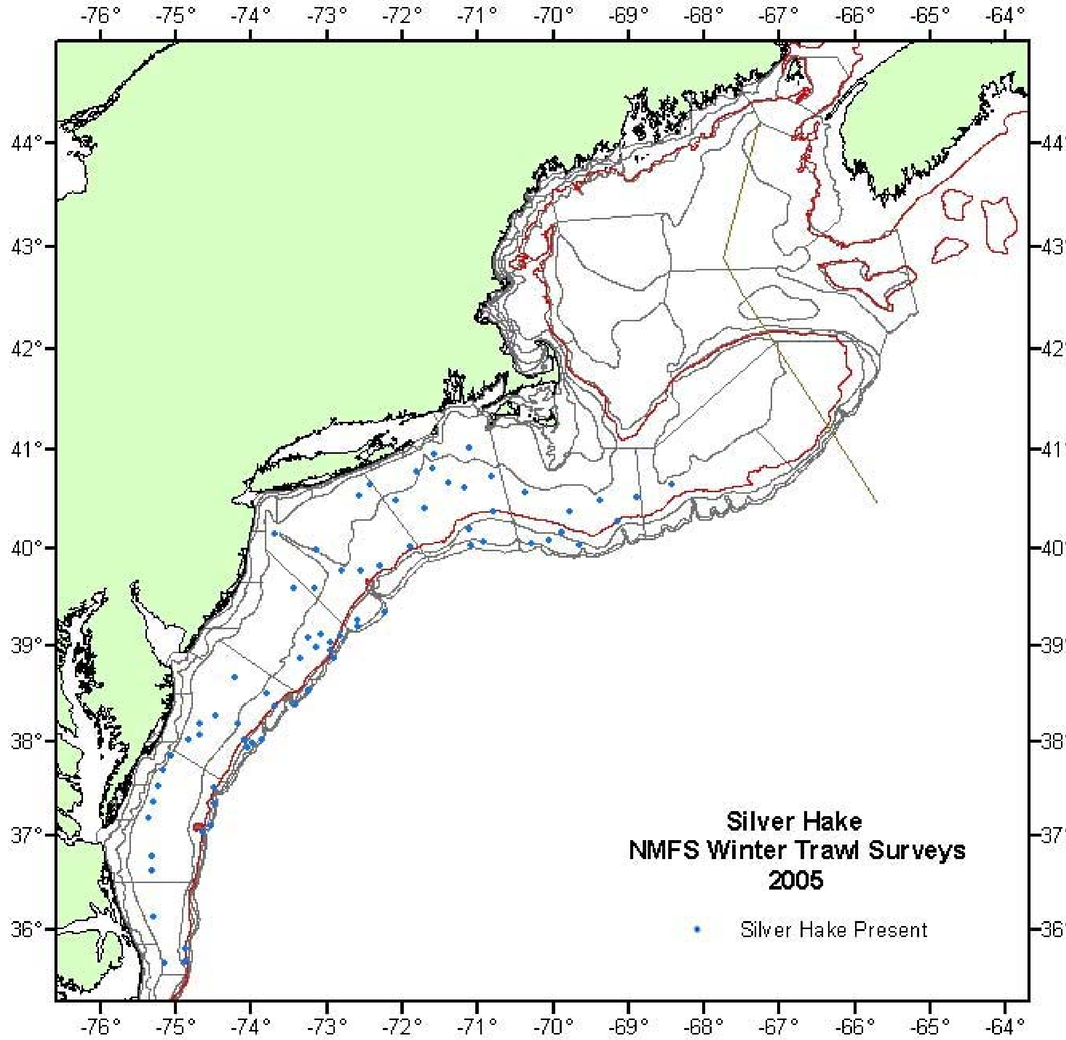


Figure A15. Locations of NEFSC winter bottom trawl survey tows that caught at least one silver hake during 2005, based on all offshore strata that were sampled. The winter survey does not cover strata above southern Georges Bank or inshore strata.

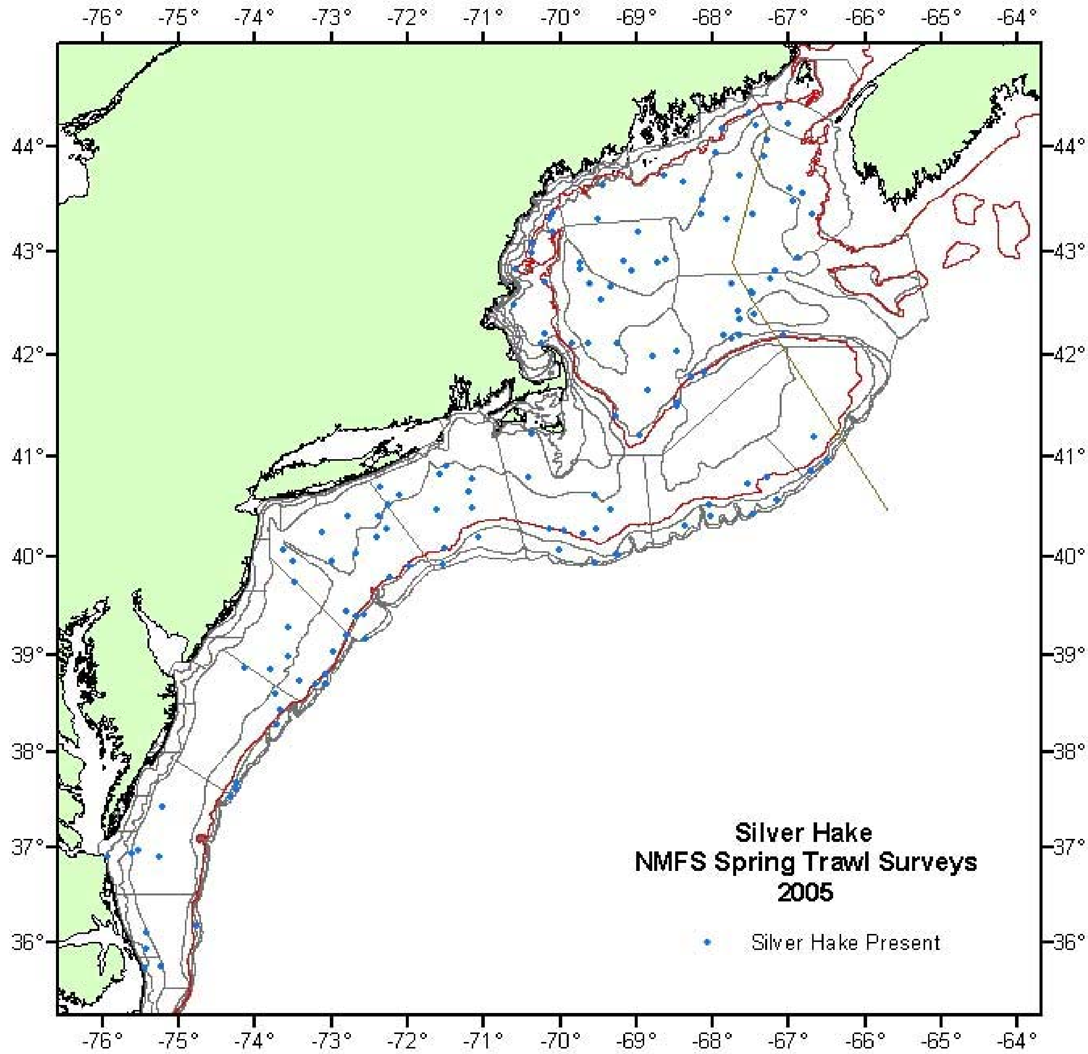


Figure A16. Locations of NEFSC spring bottom trawl survey tows that caught at least one silver hake during 1979-2004, based on all inshore and offshore strata that were sampled.

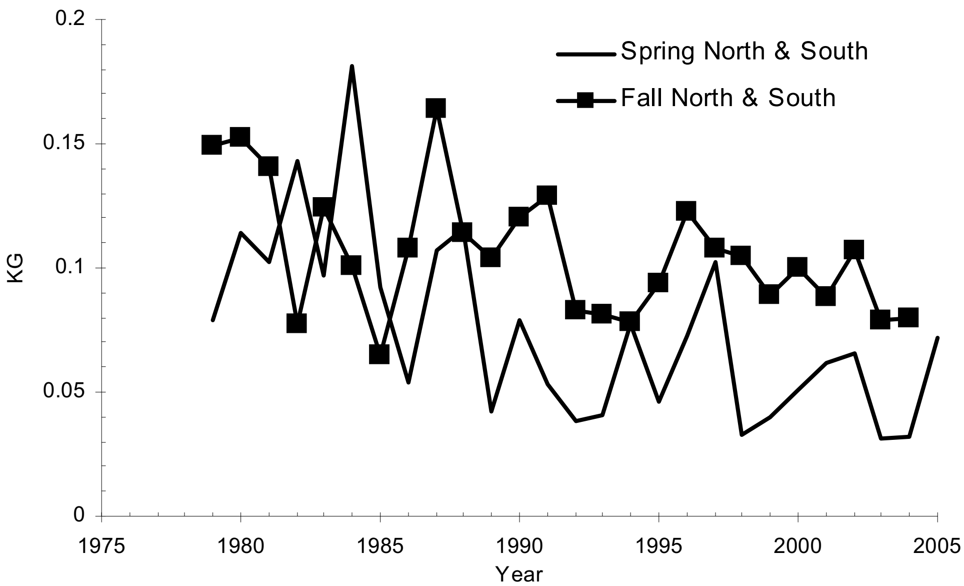


Figure A17. Trends in mean body weight for silver hake in NEFSC surveys during 1979-2005 (special strata set, north and south stock areas combined).

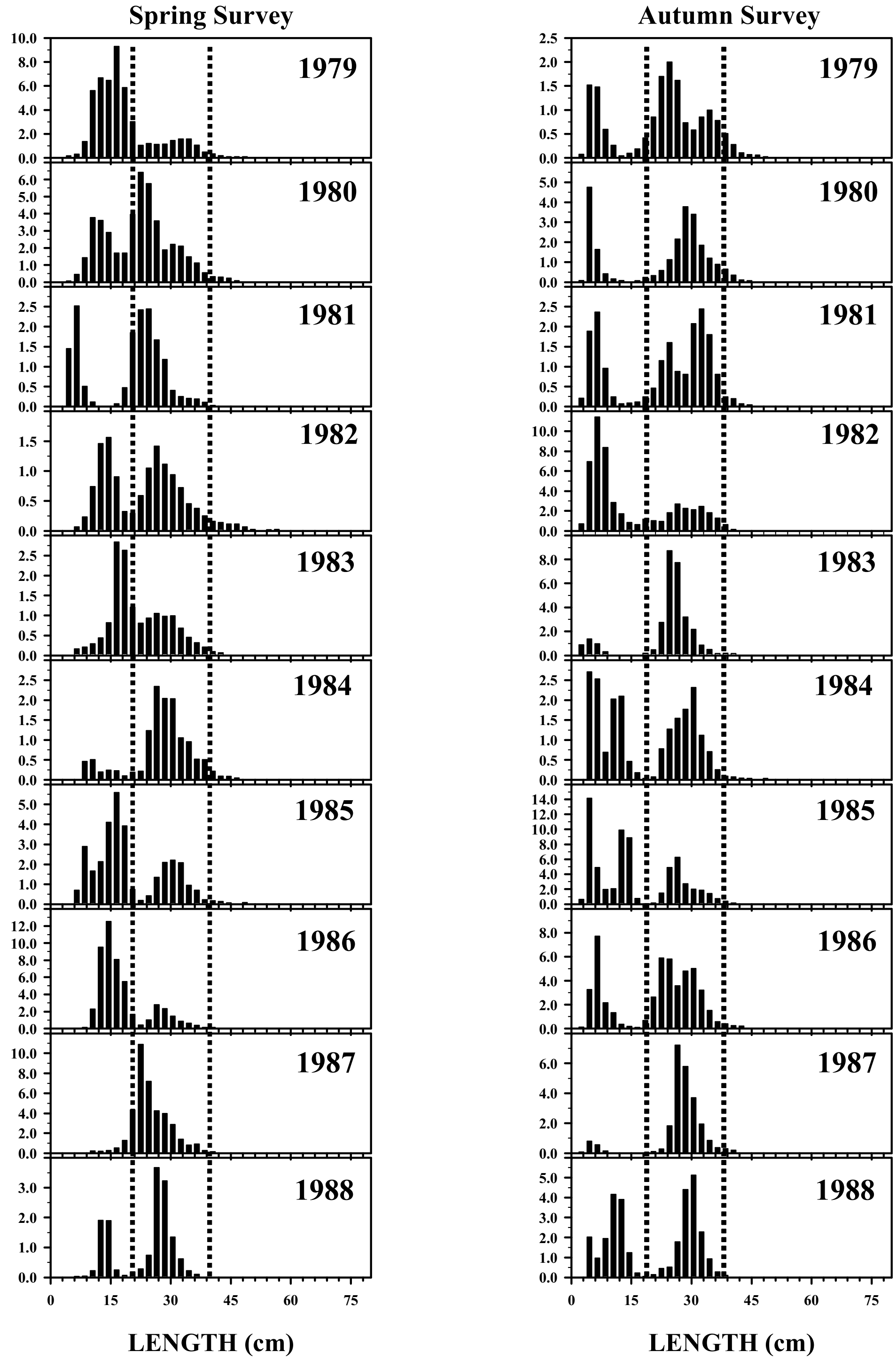


Figure A18. Silver hake length composition from the NEFSC spring and autumn bottom trawl surveys in the combined inshore and offshore regions, 1979-1988 (special strata set). Vertical lines are at approximately 20 cm and 40 cm TL.

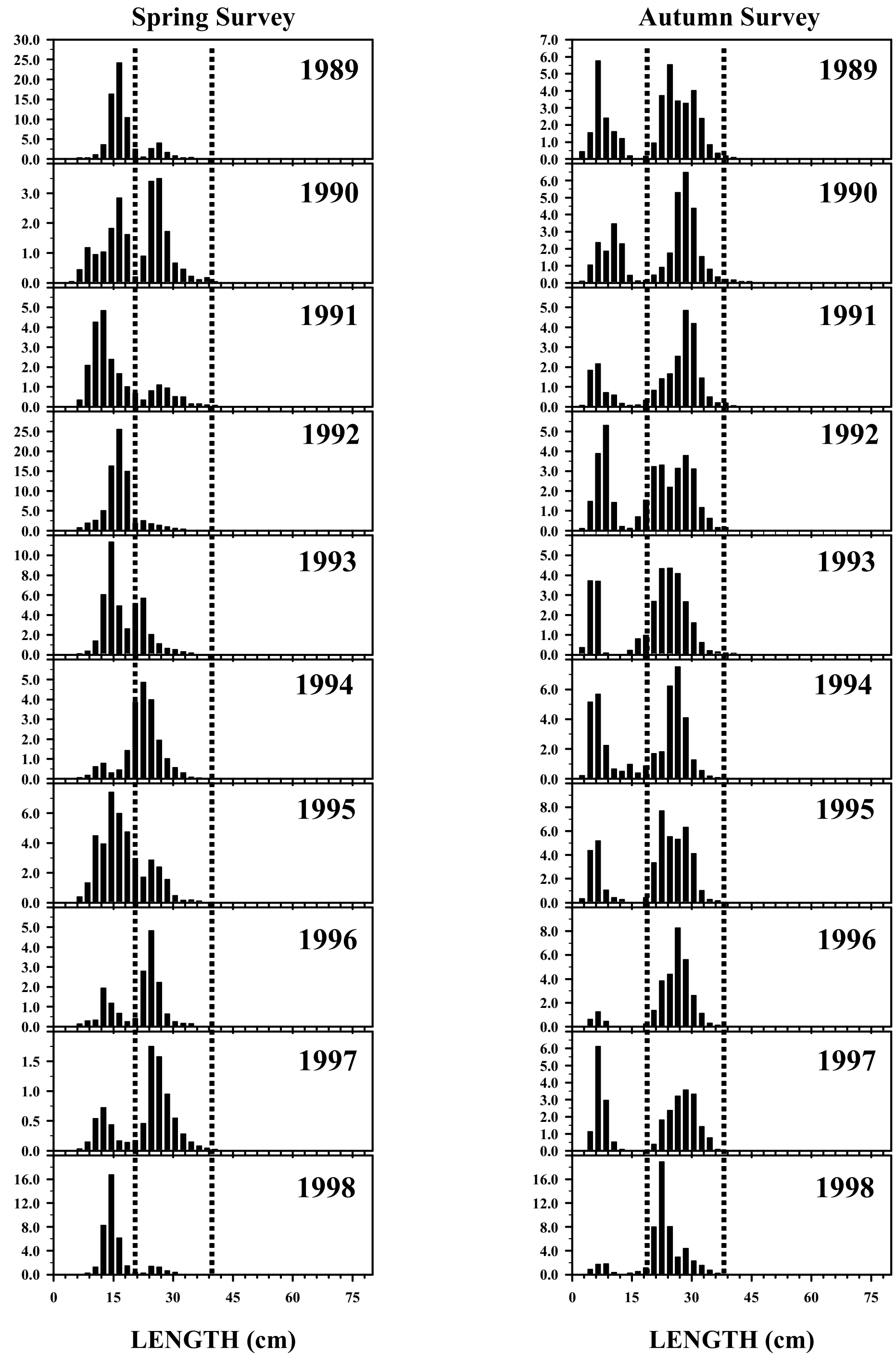


Figure A18. (cont.)

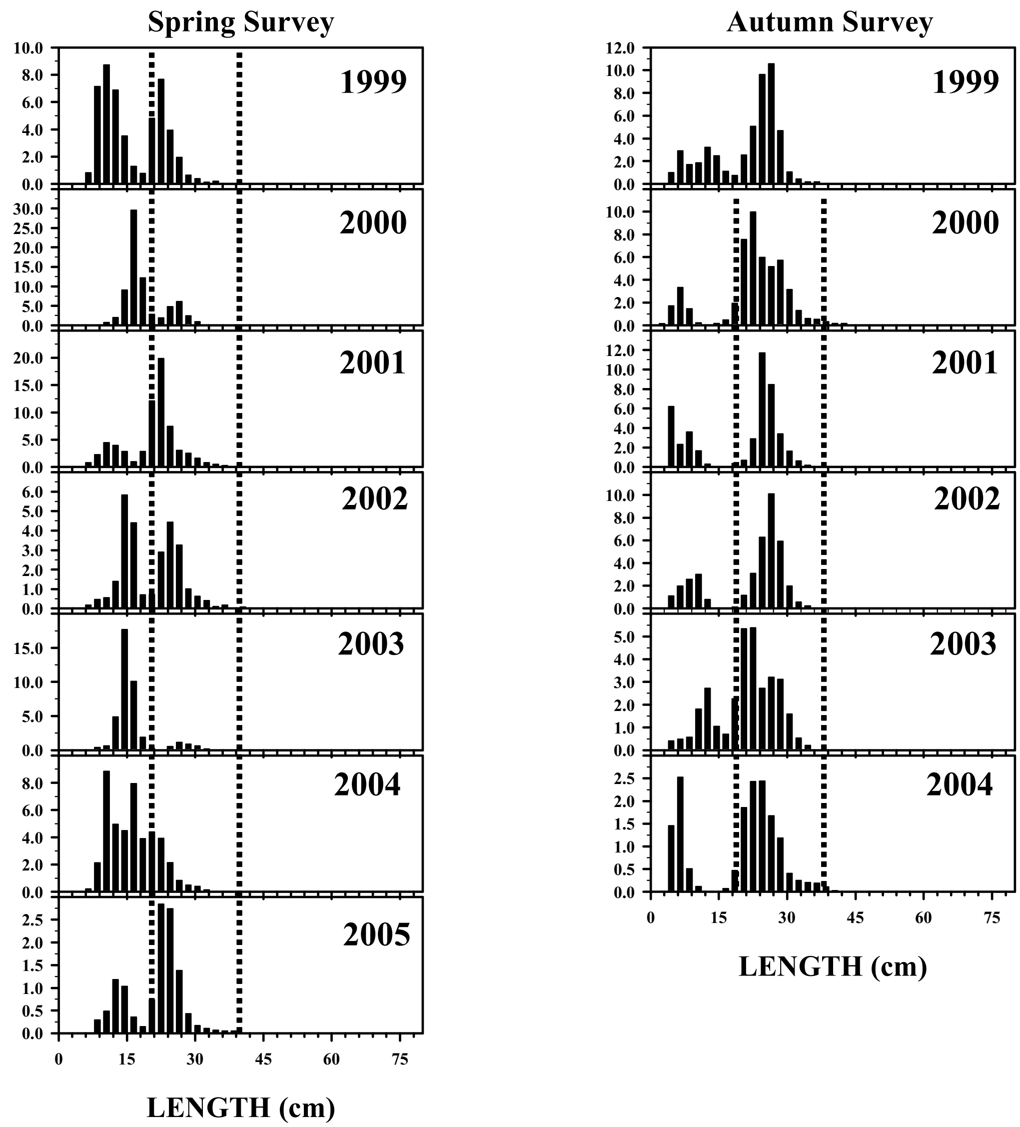


Figure A18. (cont.)

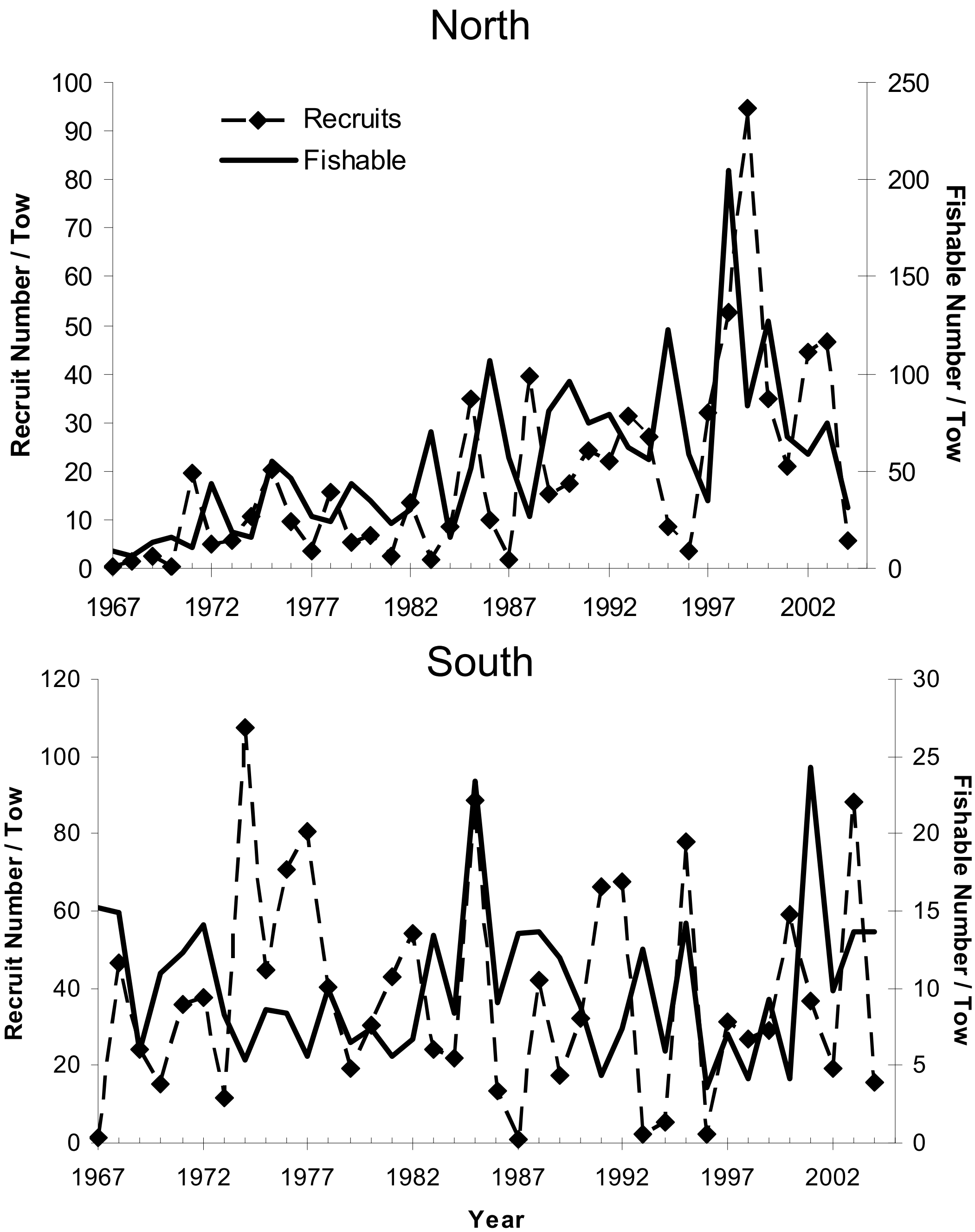


Figure A19. Trends in abundance for recruit (< 20 cm TL) and fishable (= 20 cm TL) silver hake in NEFSC fall surveys.

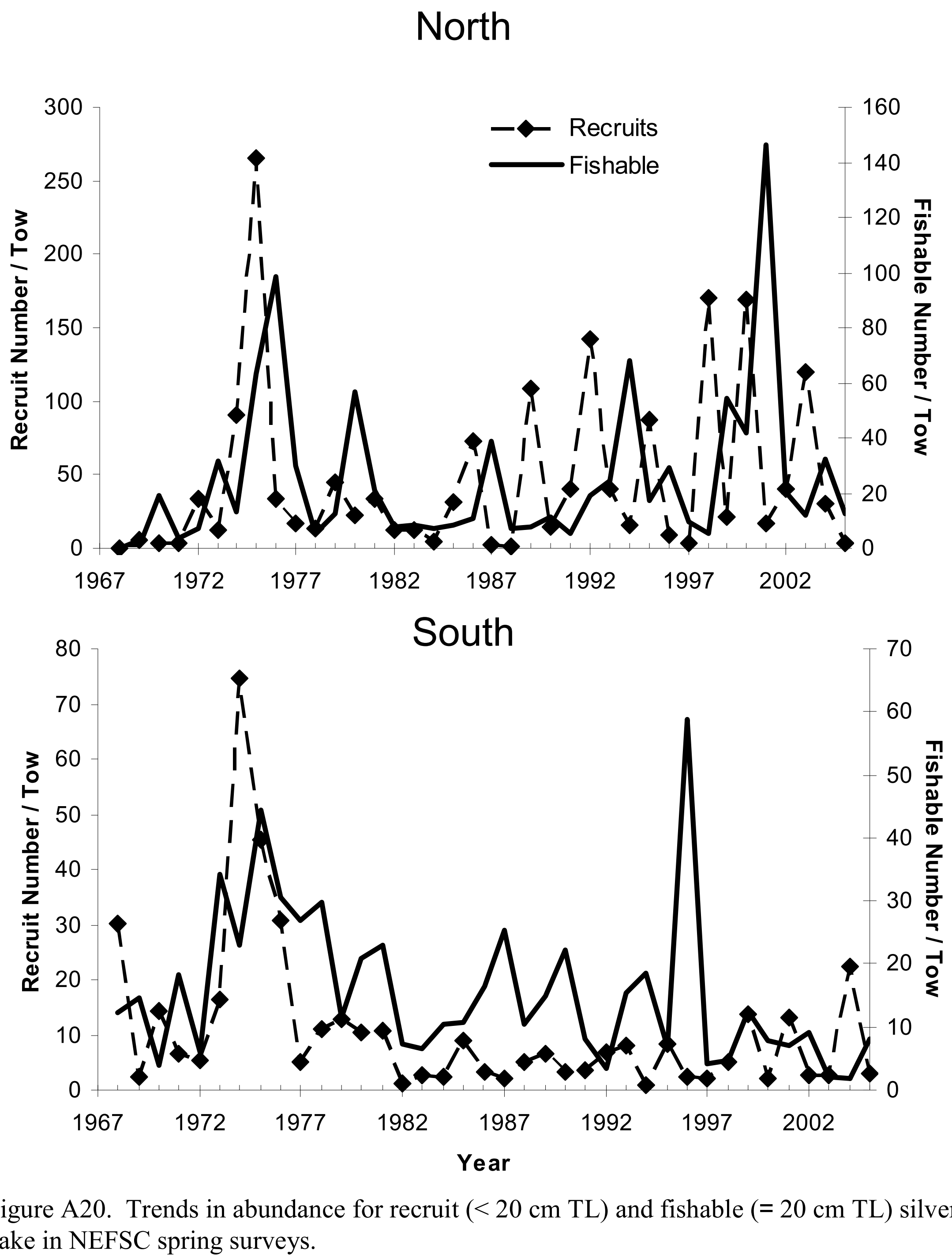


Figure A20. Trends in abundance for recruit (< 20 cm TL) and fishable (= 20 cm TL) silver hake in NEFSC spring surveys.

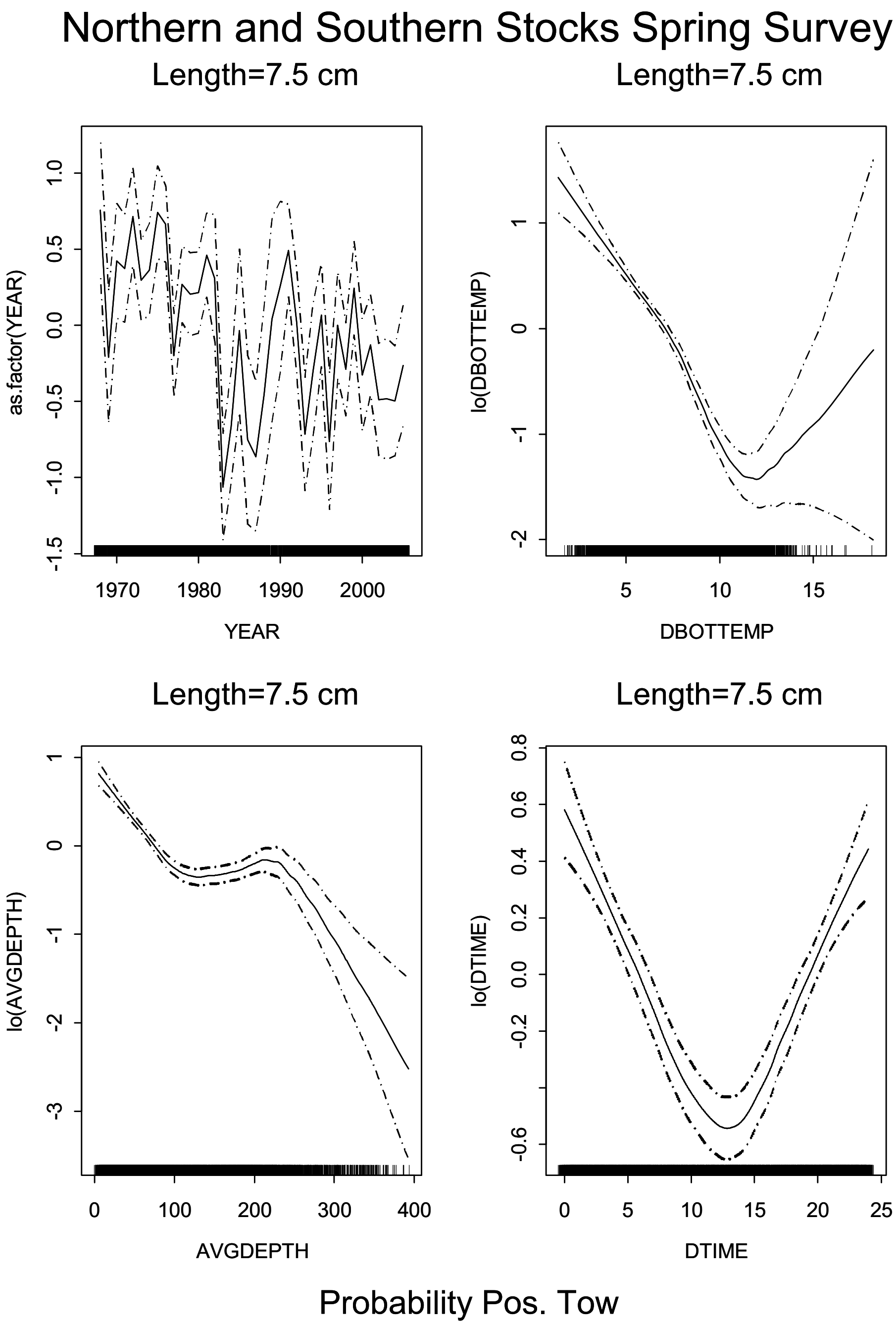


Figure A21. GAM results (partial residual plots for the probability of a positive tow) for silver hake 5-9.9 cm TL in the NEFSC spring survey during 1979-2005 (north and south stock areas combined). The y-axis gives standardized logit-scale residuals. Trends are shown for all terms that were statistically significant based on the AIC criteria.

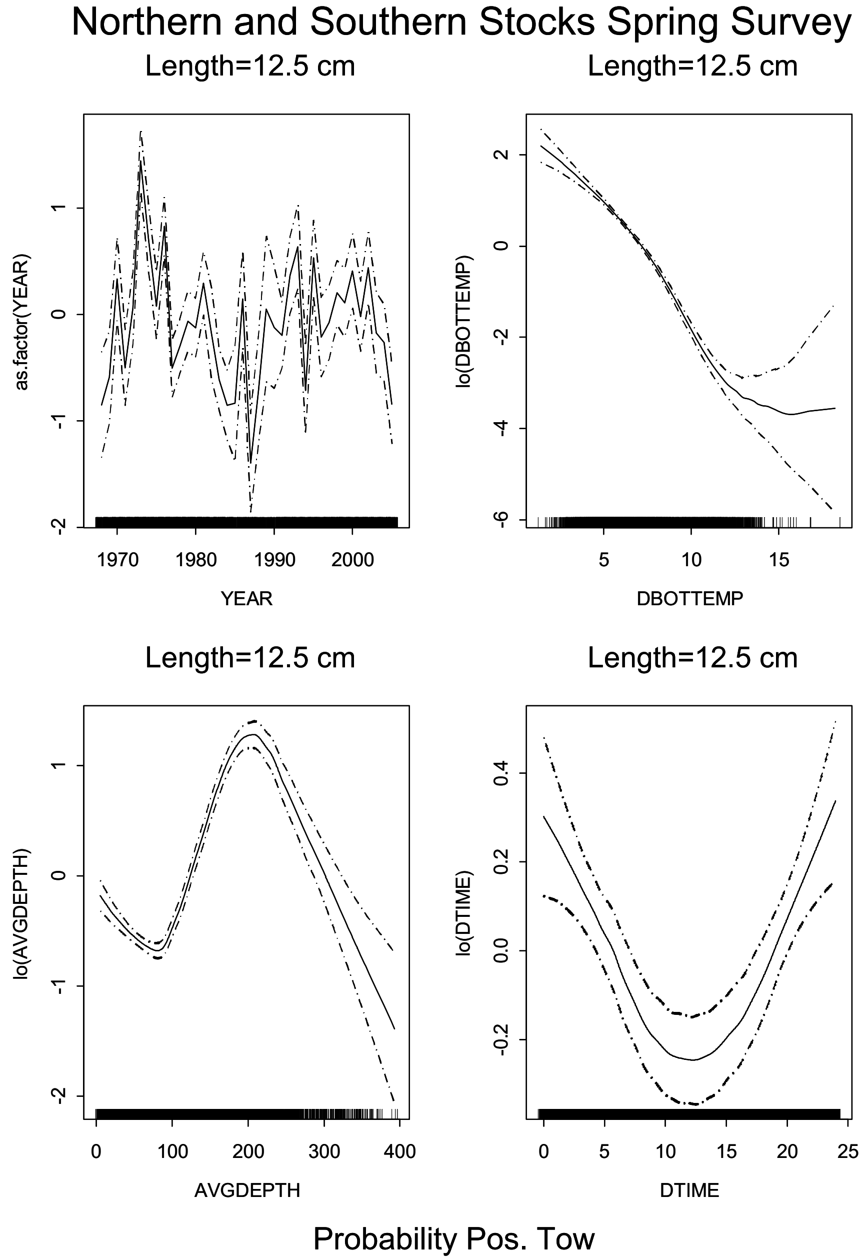


Figure A22. GAM results (partial residual plots for the probability of a positive tow) for silver hake 10-14.9 cm TL in the NEFSC spring survey during 1979-2005 (north and south stock areas combined). The y-axis gives standardized logit-scale residuals. Trends are shown for all terms that were statistically significant based on the AIC criteria.

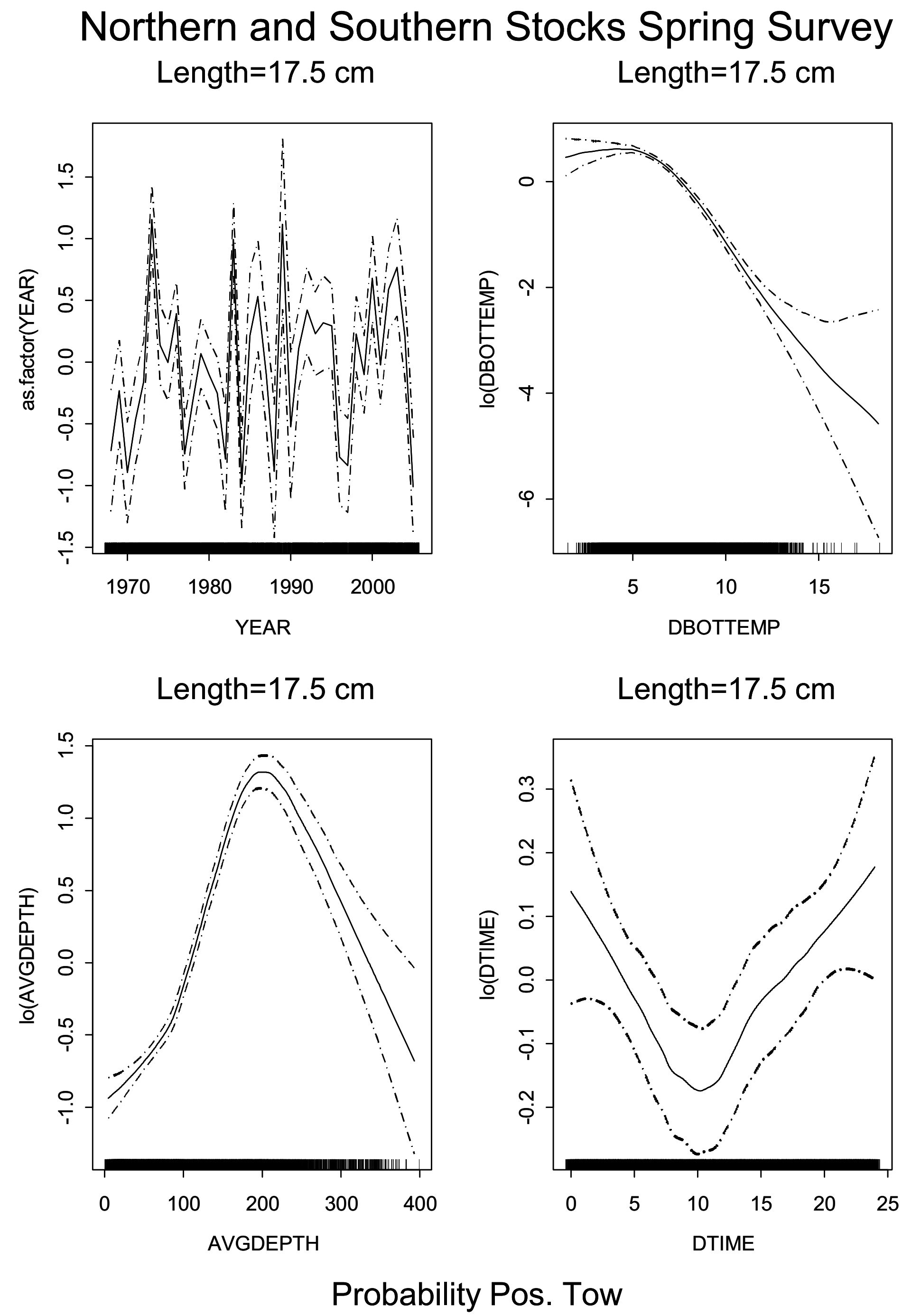


Figure A23. GAM results (partial residual plots for the probability of a positive tow) for silver hake 15-19.9 cm TL in the NEFSC spring survey during 1979-2005 (north and south stock areas combined). The y-axis gives standardized logit-scale residuals. Trends are shown for all terms that were statistically significant based on the AIC criteria.

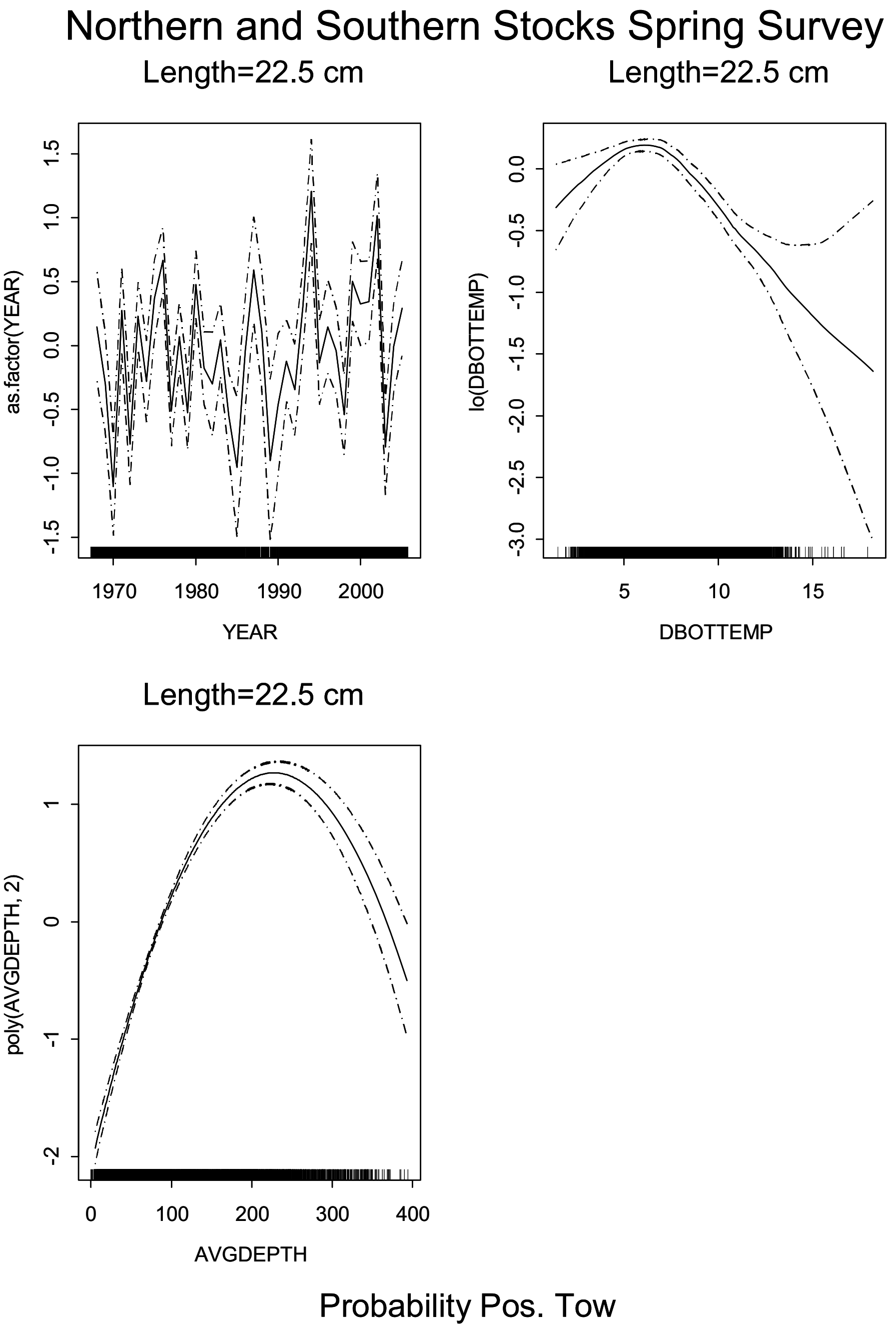


Figure A24. GAM results (partial residual plots for the probability of a positive tow) for silver hake 20-24.9 cm TL in the NEFSC spring survey during 1979-2005 (north and south stock areas combined). The y-axis gives standardized logit-scale residuals. Trends are shown for all terms that were statistically significant based on the AIC criteria.

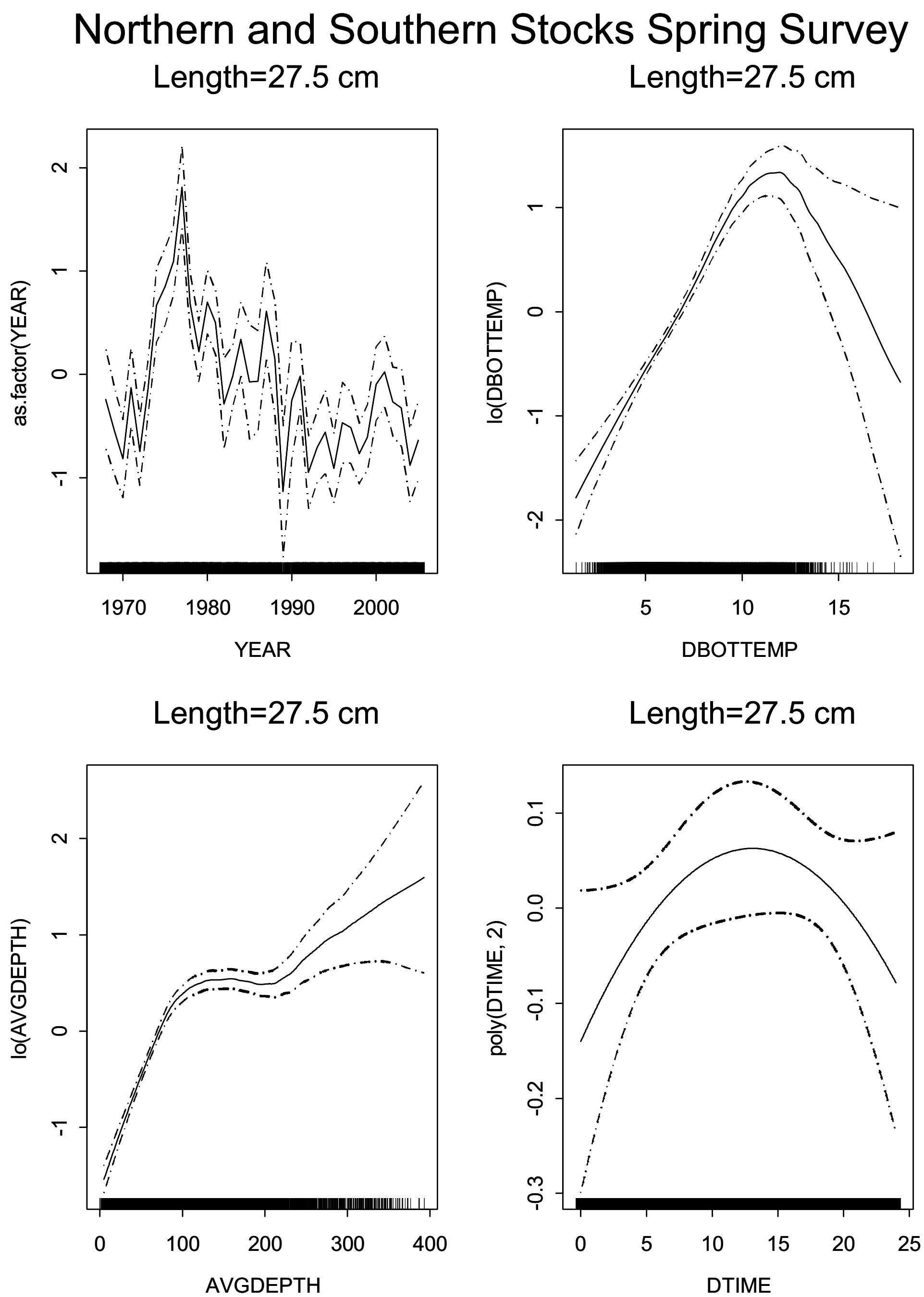


Figure A25. GAM results (partial residual plots for the probability of a positive tow) for silver hake 25+ cm TL in the NEFSC spring survey during 1979-2005 (north and south stock areas combined). The y-axis gives standardized logit-scale residuals. Trends are shown for all terms that were statistically significant based on the AIC criteria.

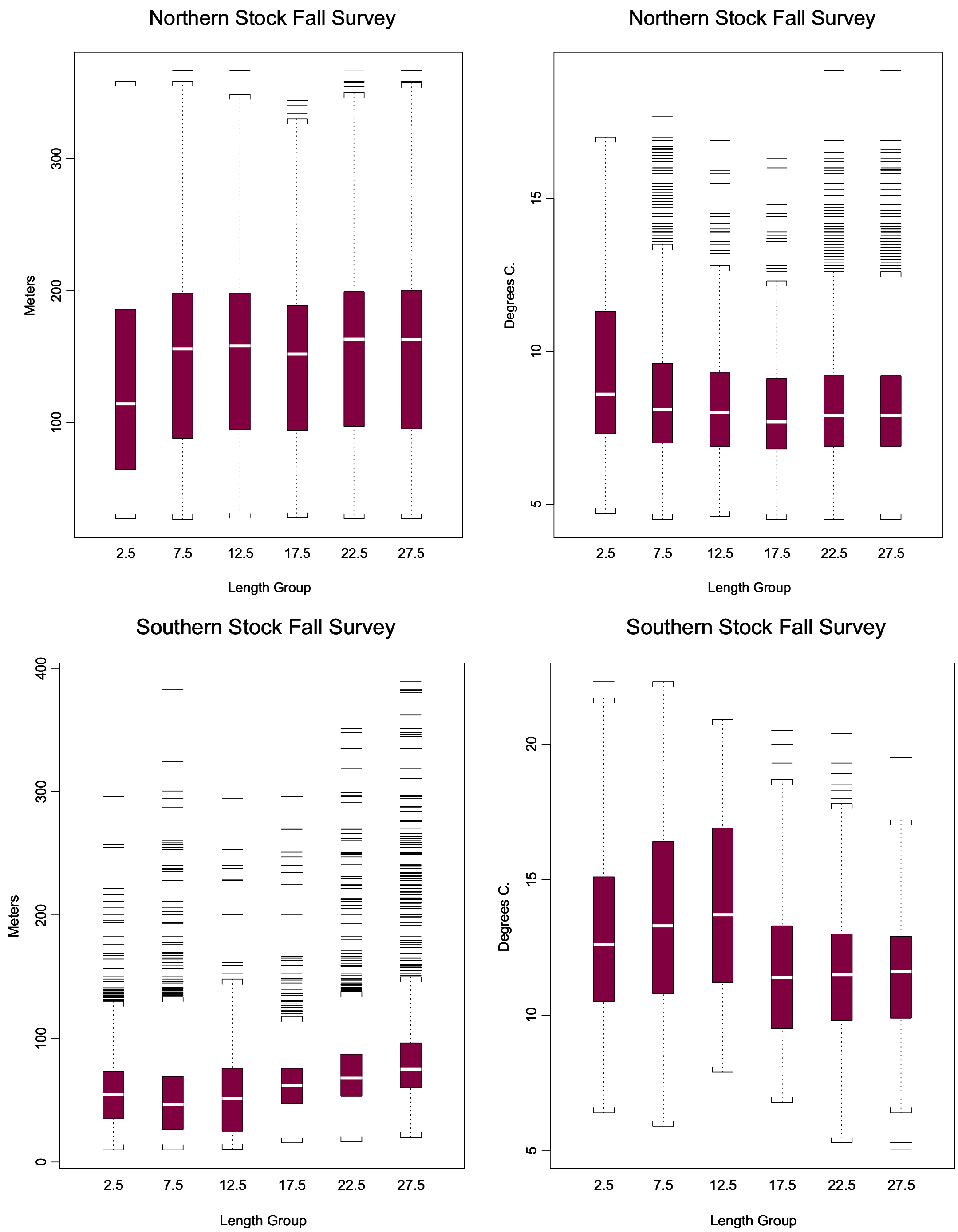


Figure A26. Distributions of depths and bottom temperatures by size and stock for tows that took silver hake in NEFSC fall bottom trawl surveys.

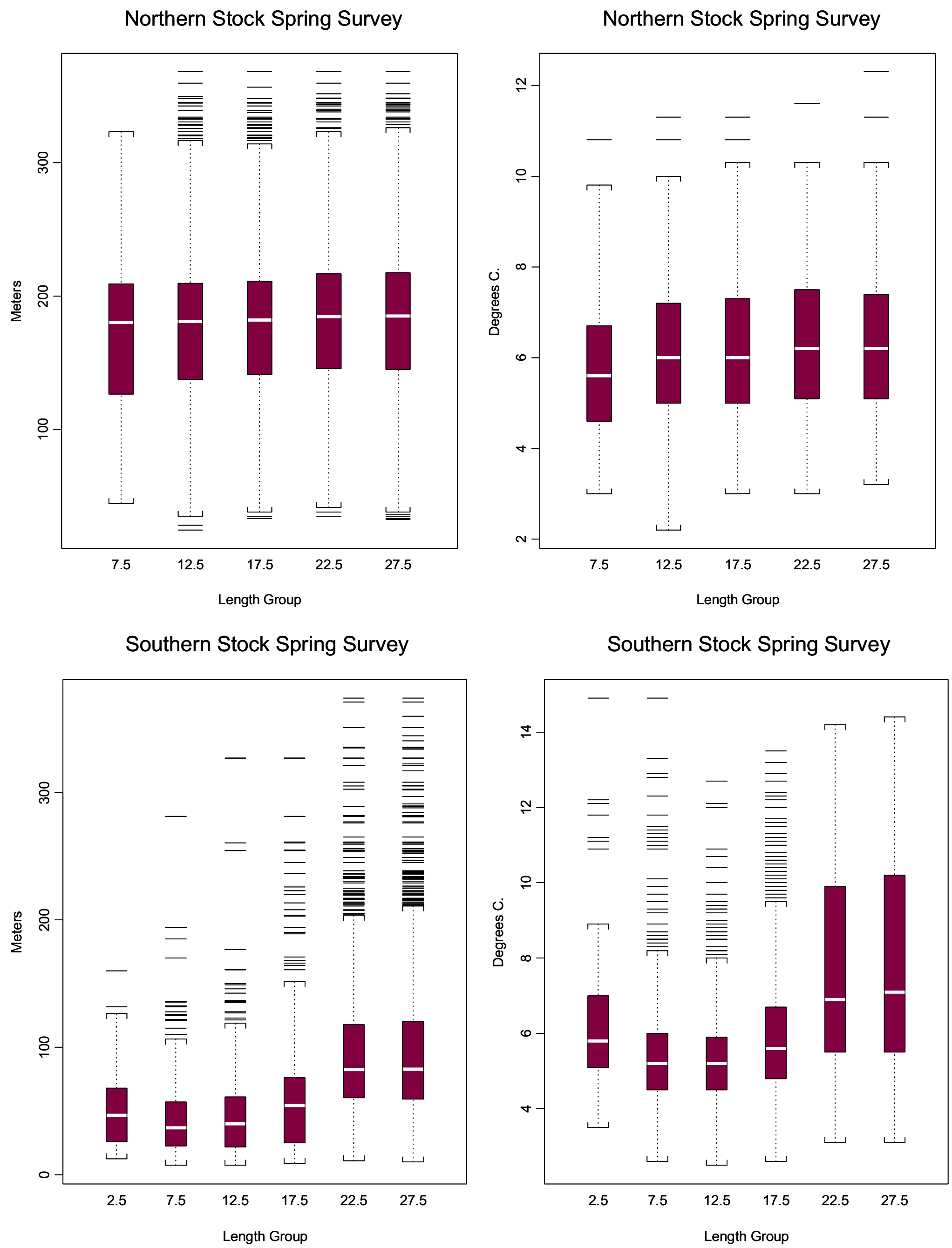


Figure A27. Distributions of depths and bottom temperatures by size and stock for tows that took silver hake in NEFSC spring bottom trawl surveys.

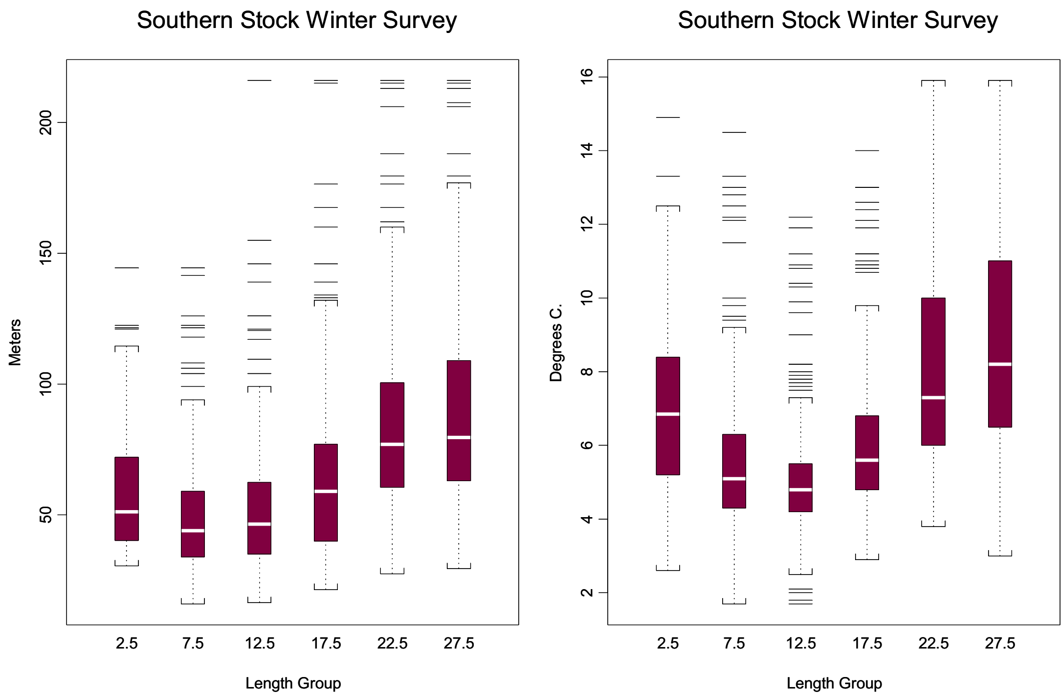
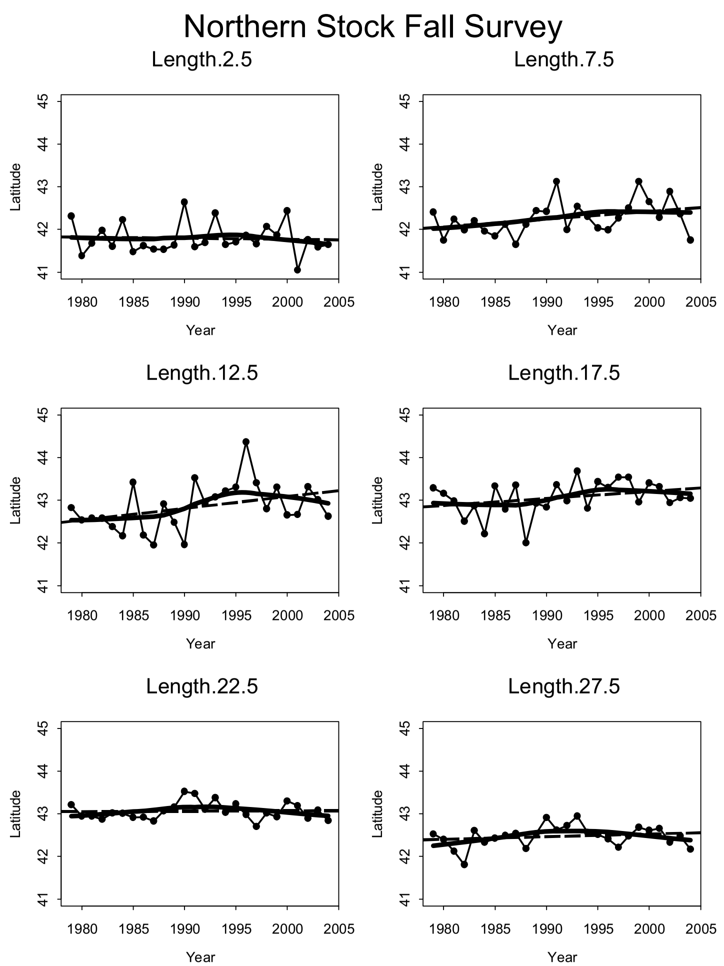


Figure A28. Distributions of depths and bottom temperatures by size and stock for tows that took silver hake in NEFSC winter bottom trawl surveys.

Figure A29. Average position (latitude in left panel and longitude in right) for silver hake in fall bottom trawl surveys in the northern stock area, by size group. Averages are for tows, weighted by catch of the appropriate size group.



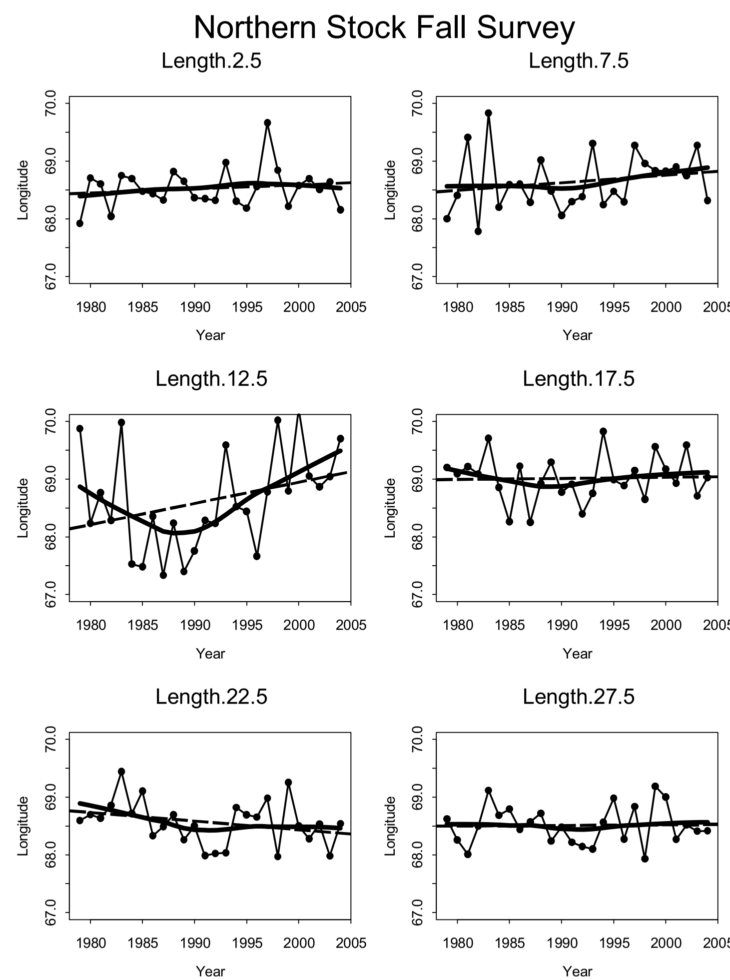


Figure A30. Average position (latitude in left panel and longitude in right) for silver hake in fall bottom trawl surveys in the southern stock area, by size group. Averages are for tows, weighted by catch of the appropriate size group.

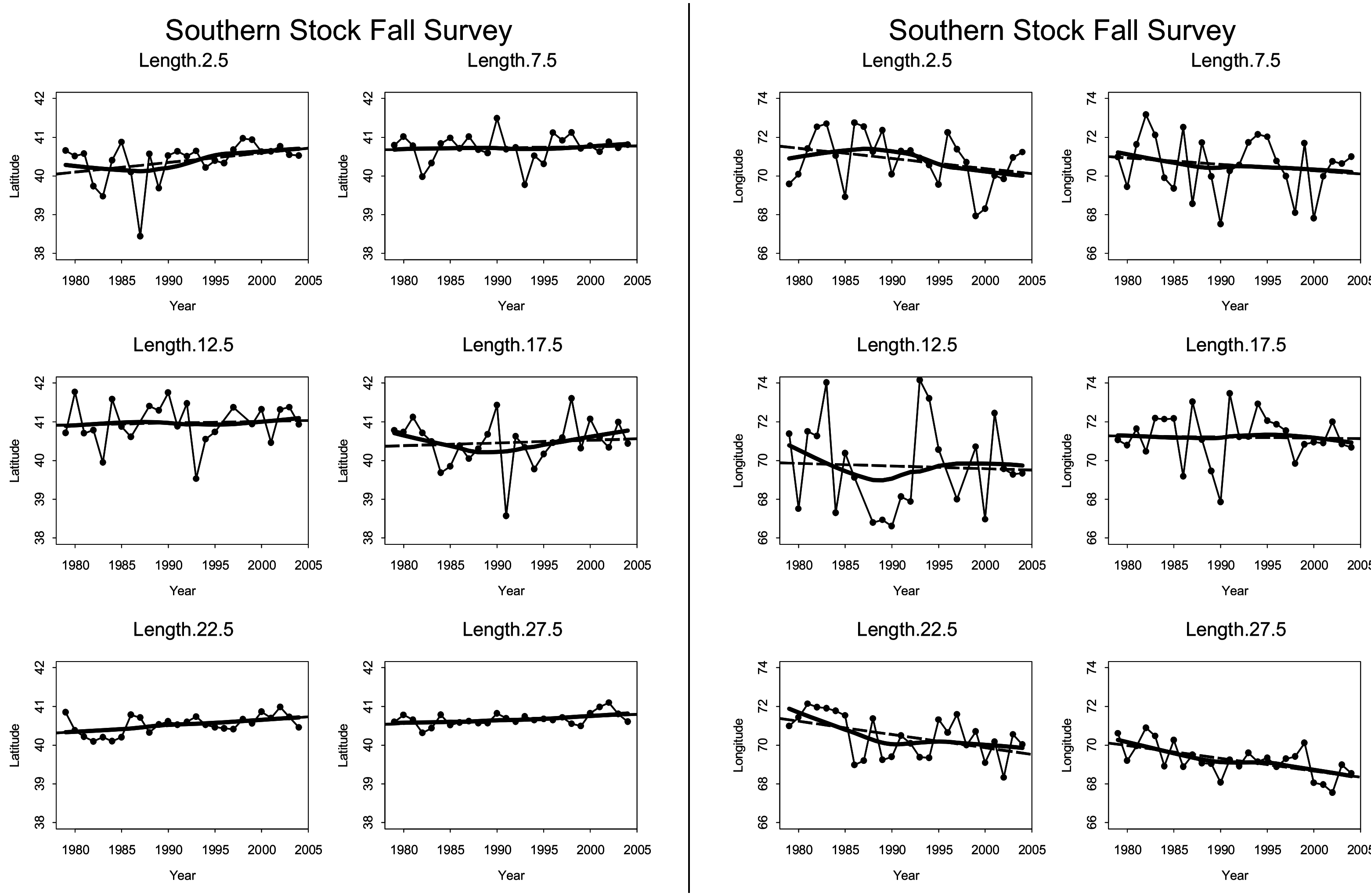
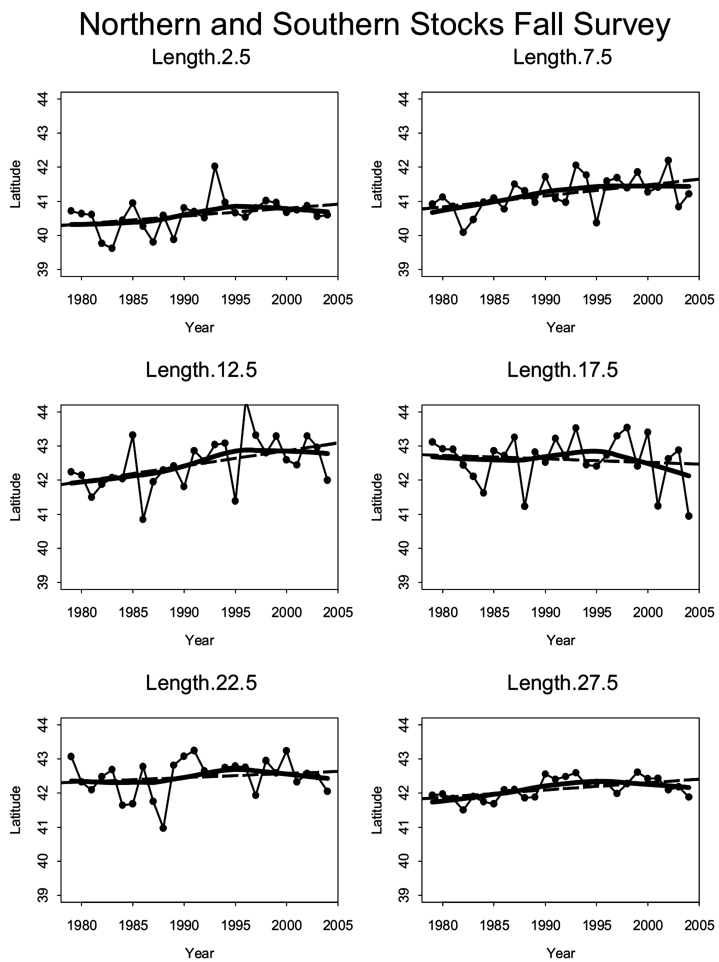


Figure A31. Average position (latitude in left panel and longitude in right) for silver hake in fall bottom trawl surveys in the combined northern and southern stock areas, by size group. Averages are for tows, weighted by catch of the appropriate size group.



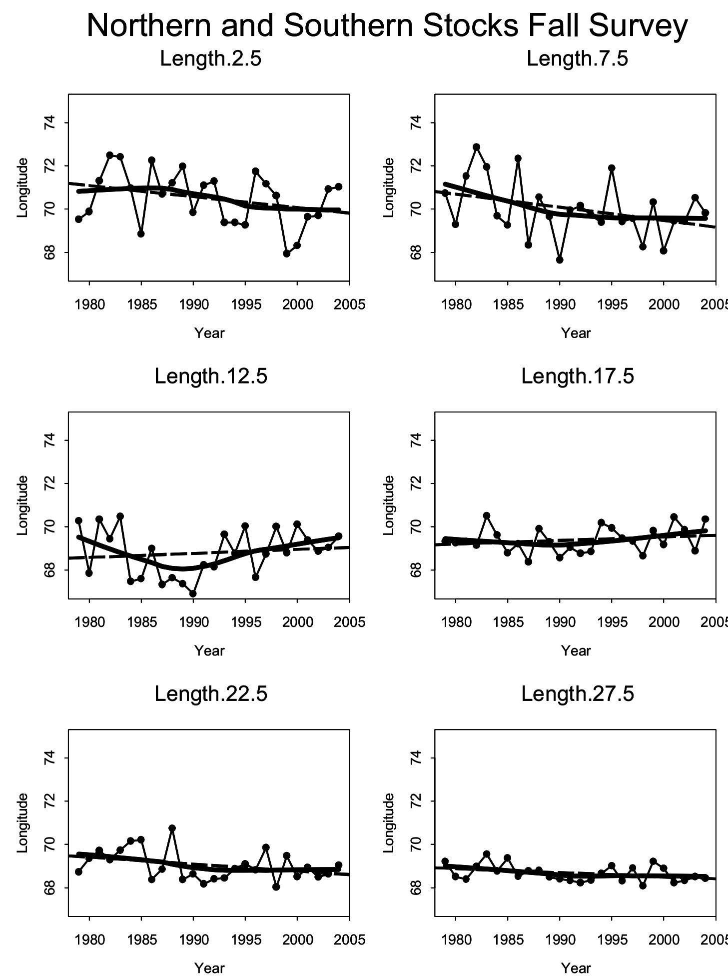
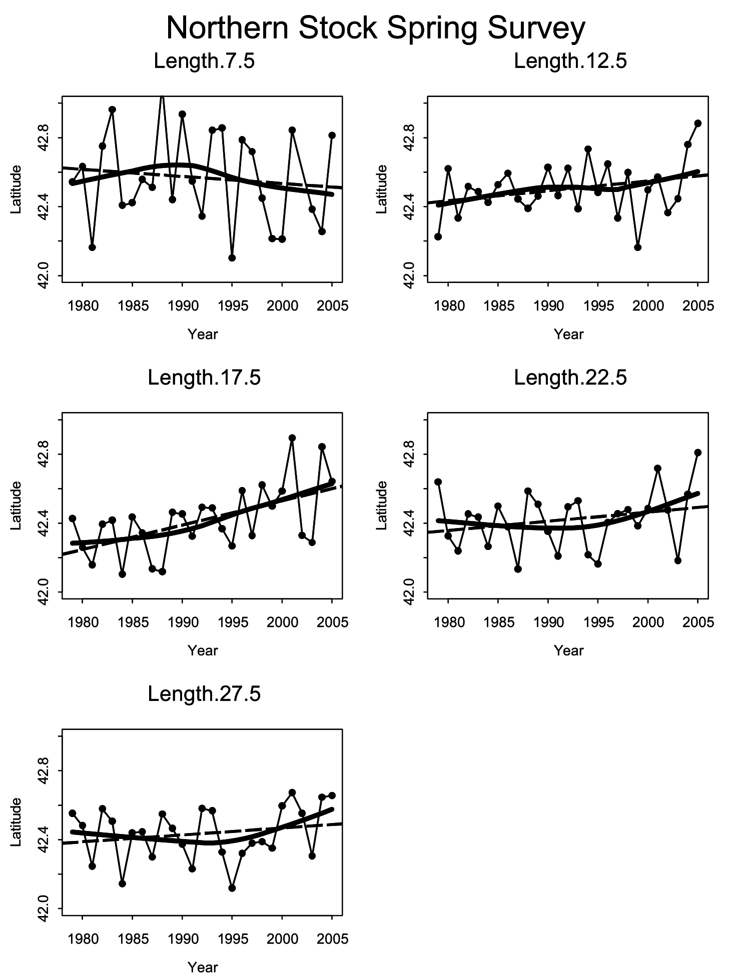


Figure A32. Average position (latitude in left panel and longitude in right) for silver hake in spring bottom trawl surveys in the northern stock area, by size group. Averages are for tows, weighted by catch of the appropriate size group.



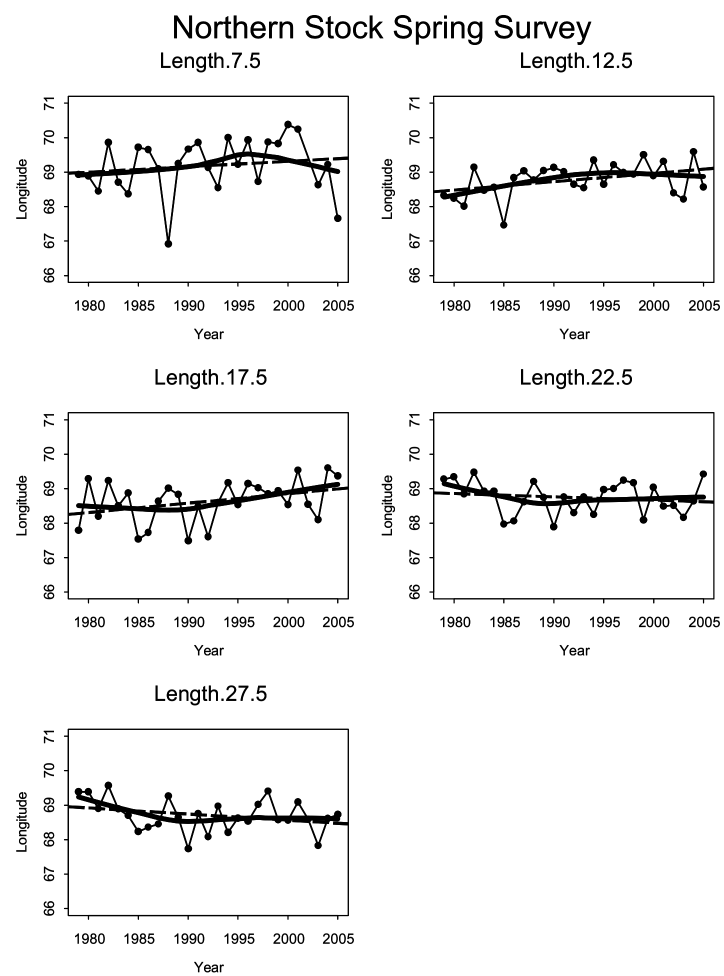
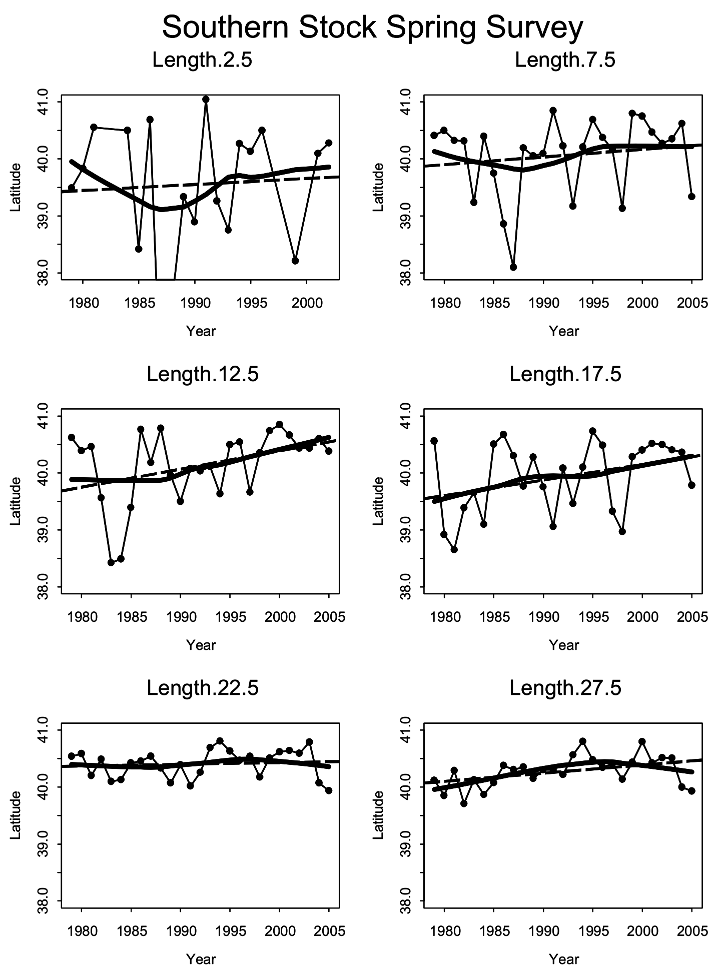


Figure A33. Average position (latitude in left panel and longitude in right) for silver hake in spring bottom trawl surveys in the southern stock area, by size group. Averages are for tows, weighted by catch of the appropriate size group.



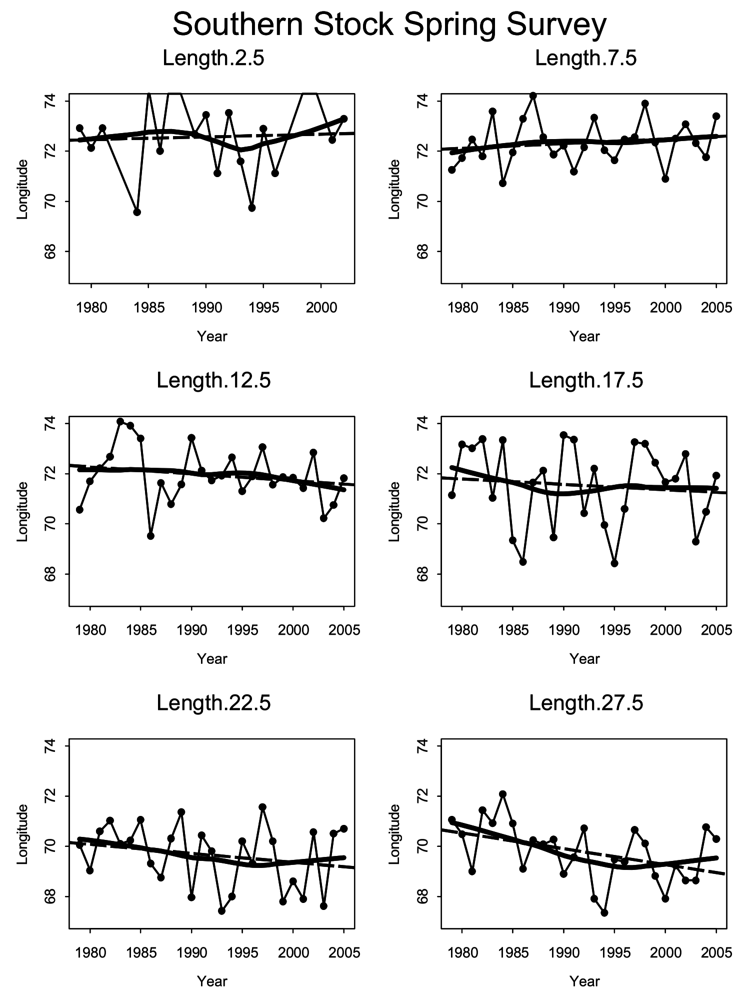
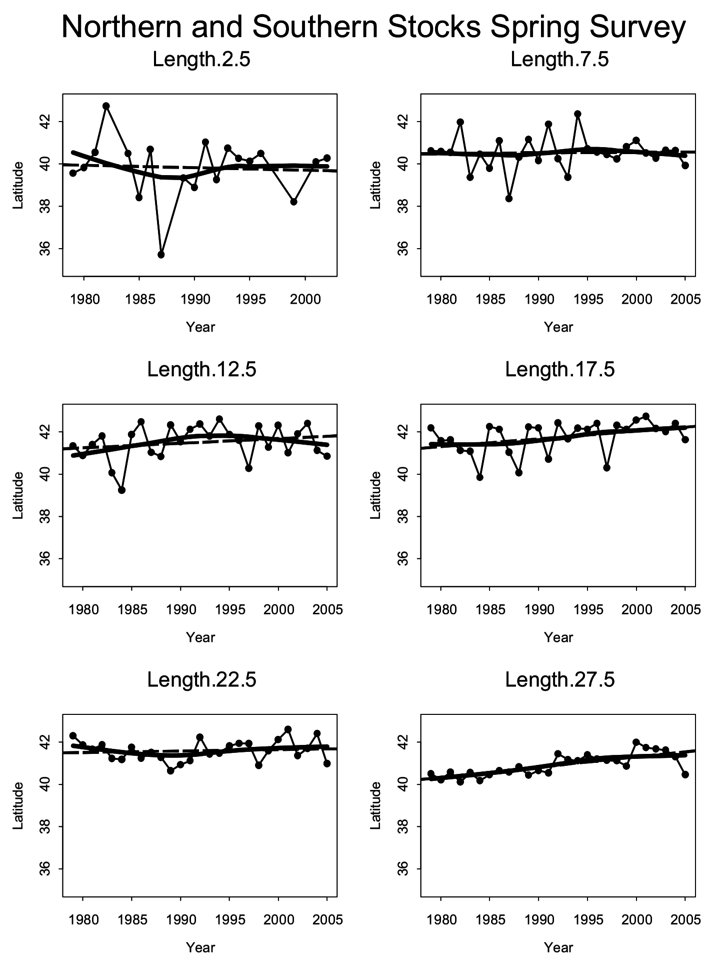


Figure A34. Average position (latitude in left panel and longitude in right) for silver hake in spring bottom trawl surveys in the combined northern and southern stock areas, by size group. Averages are for tows, weighted by catch of the appropriate size group.



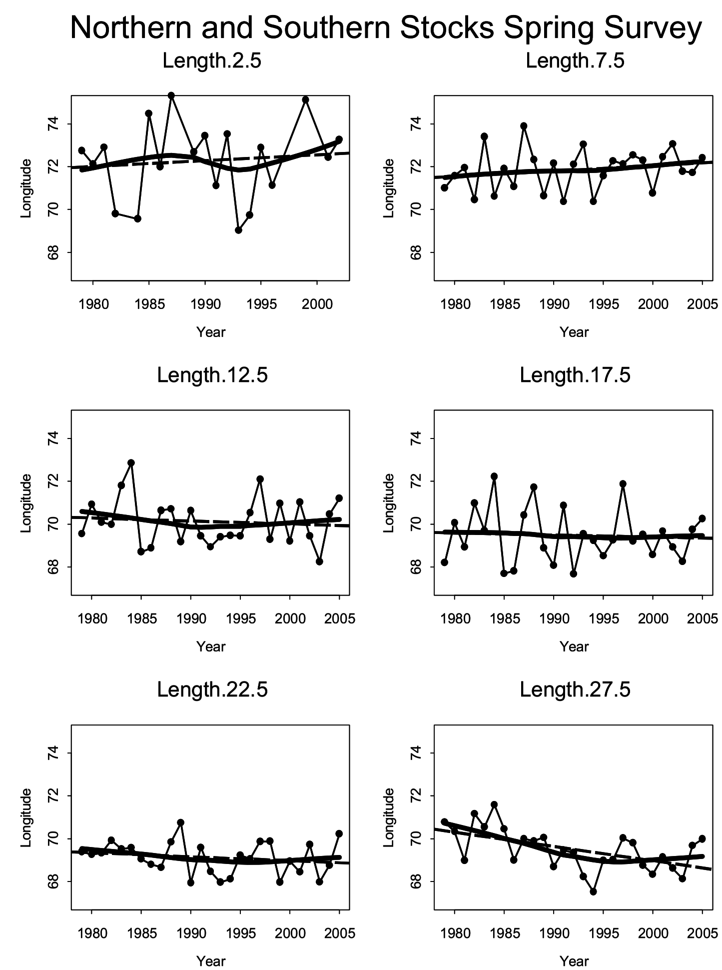
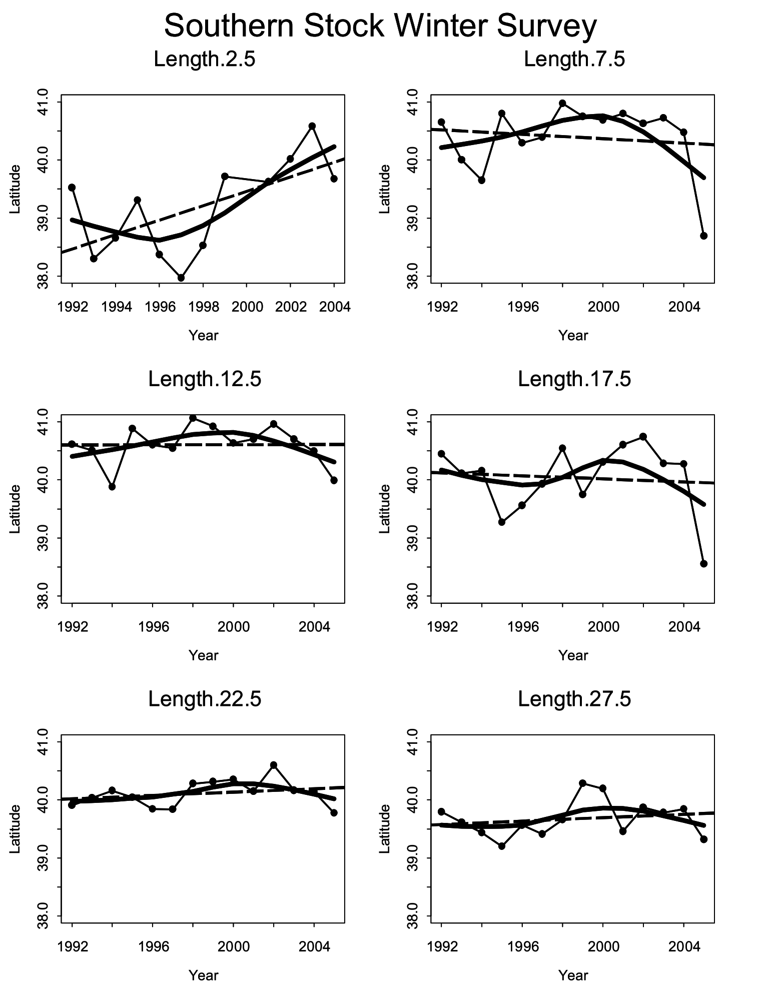
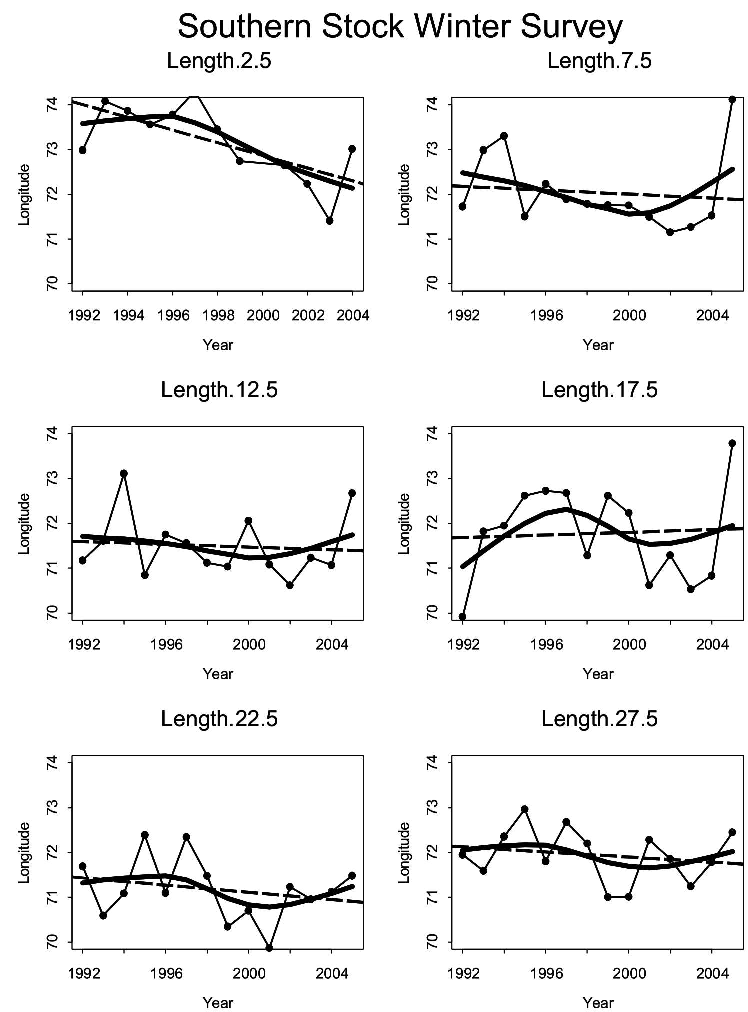


Figure A35. Average position (latitude in left panel and longitude in right) for silver hake in winter bottom trawl surveys in the southern stock area, by size group. Averages are for tows, weighted by catch of the appropriate size group.





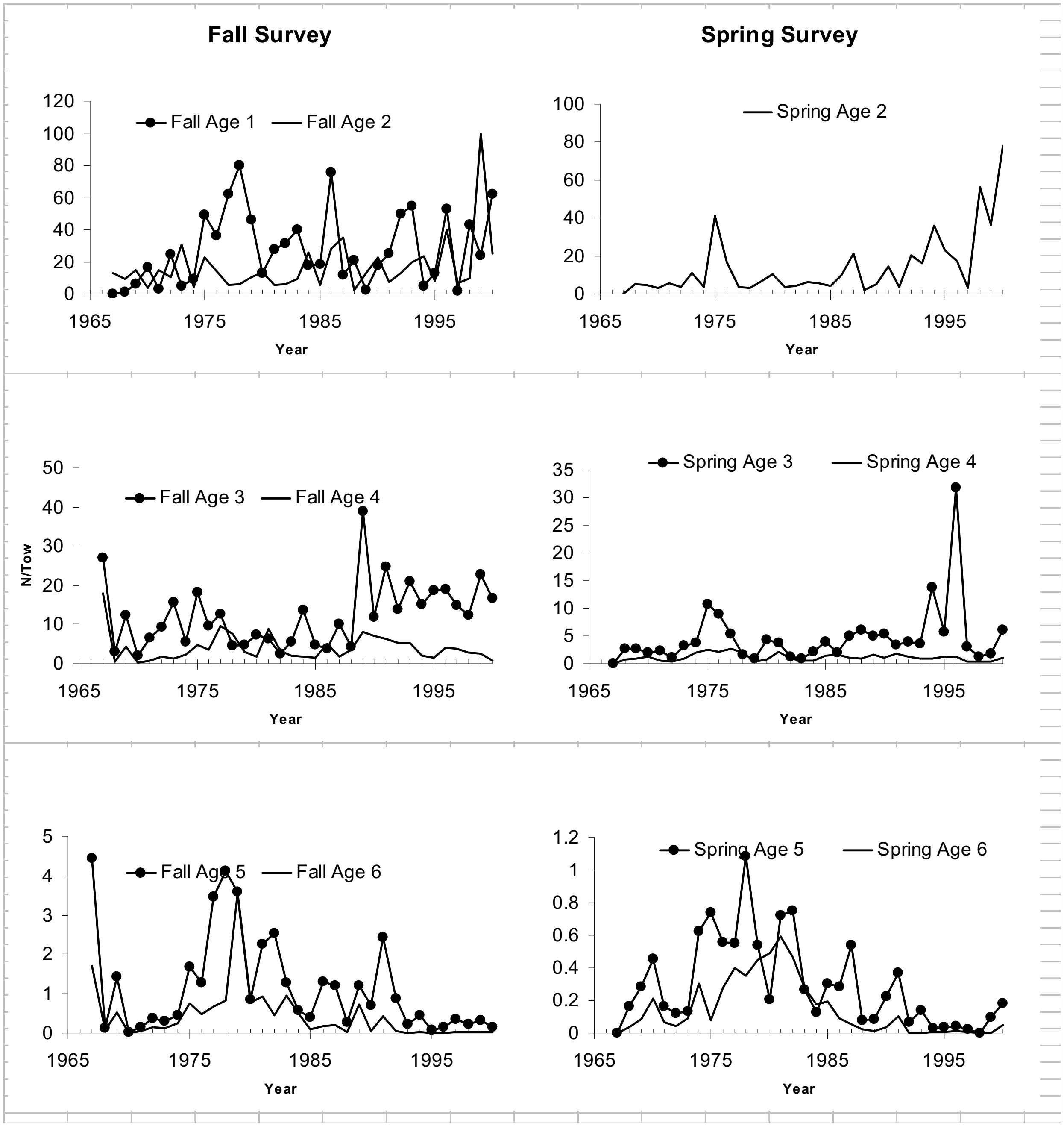


Figure A36. Relative abundance data from Brodziak et al. (2001) for silver hake ages 1-6+ in NEFSC fall and spring surveys. Data for years prior to 1973 were calculated using average age-length keys for spring and fall surveys during 1973-1975.

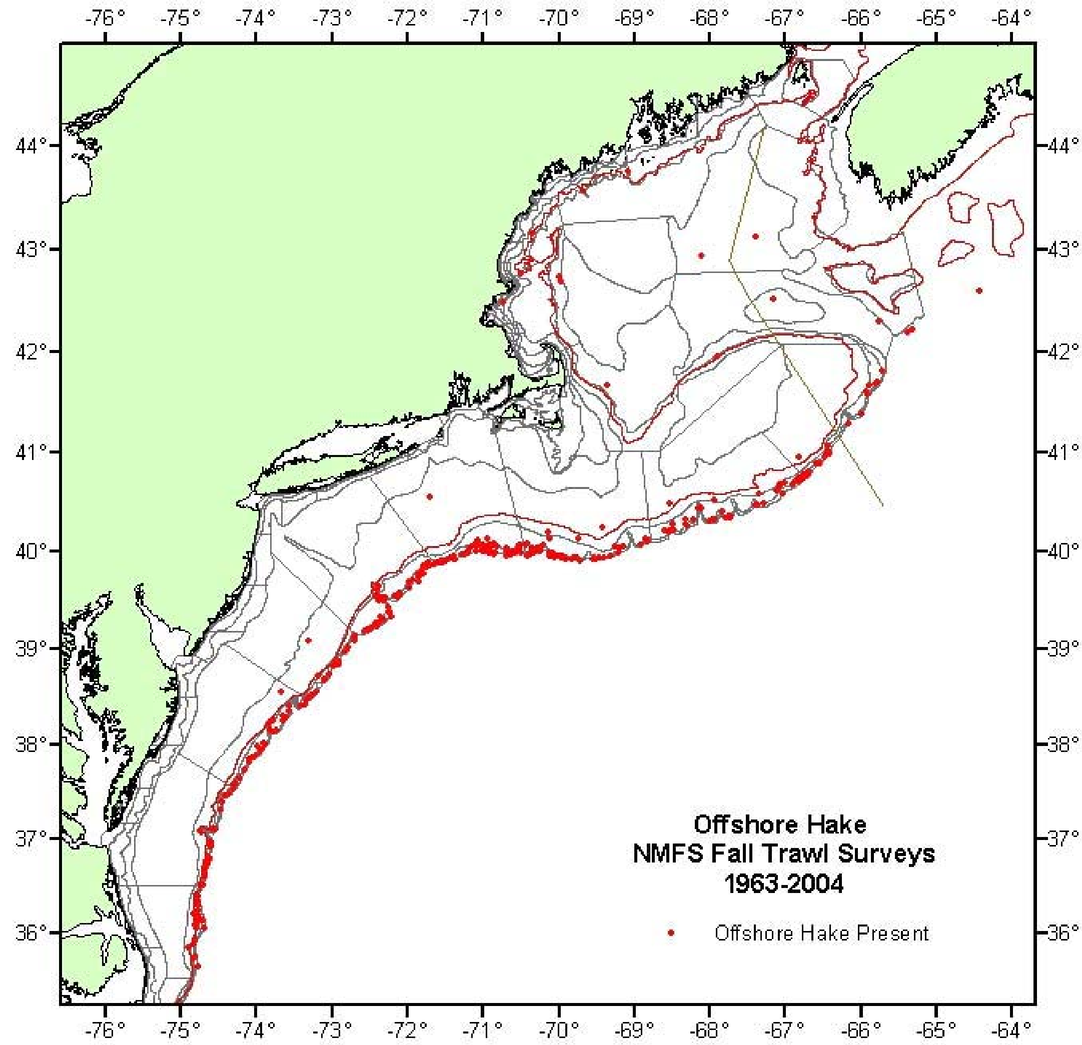


Figure A37. Locations of NEFSC fall bottom trawl survey tows that caught at least one offshore hake during 1963-2004, based all strata that were sampled.

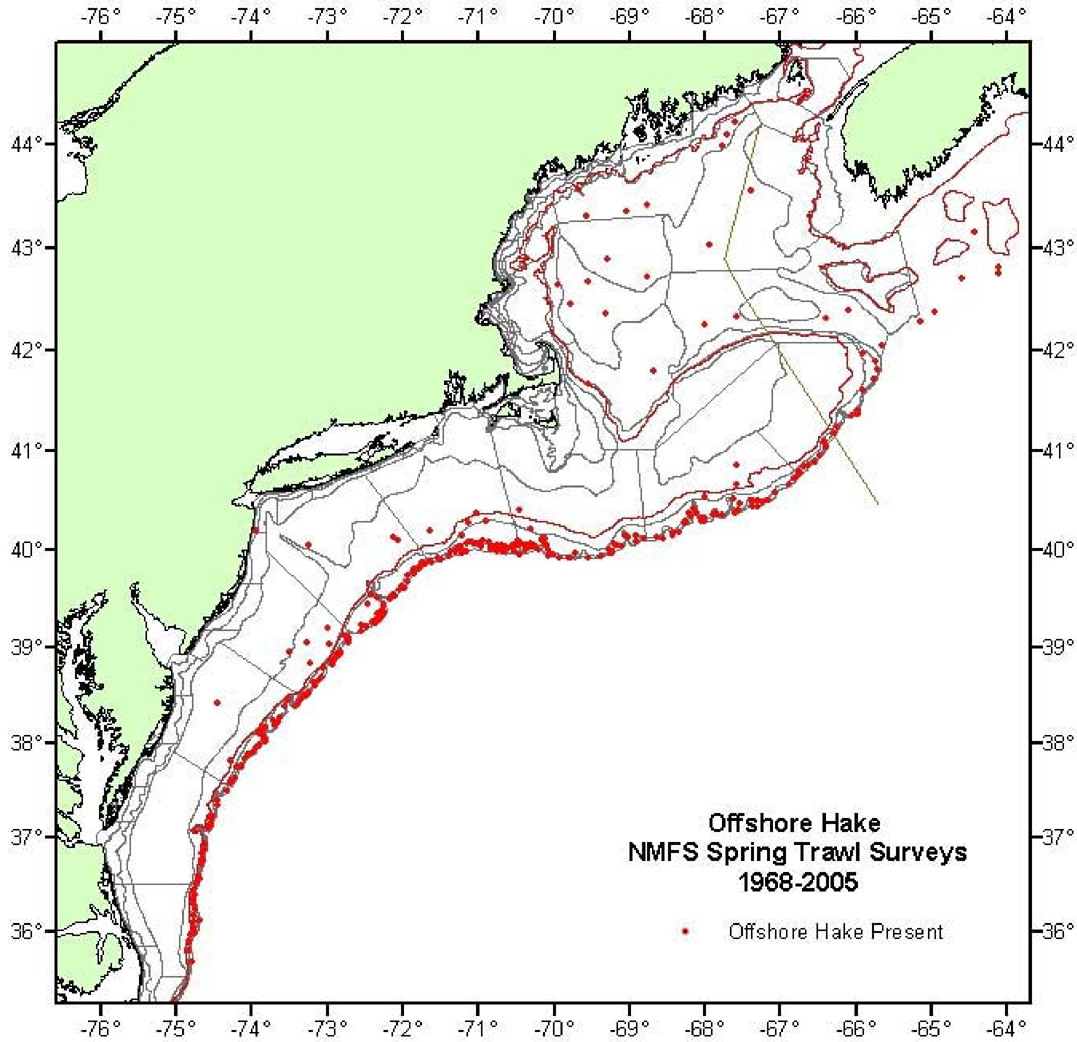


Figure A38. Locations of NEFSC spring bottom trawl survey tows that caught at least one offshore hake during 1963-2004, based all strata that were sampled.

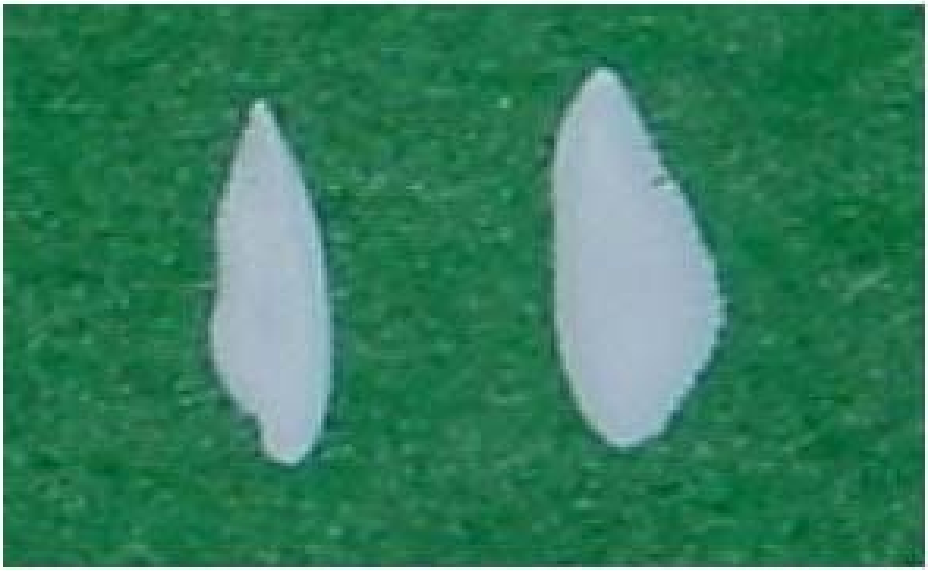


Figure A39. Otoliths from a silver hake (left) and an offshore hake (right). Both specimens were 35 cm TL.

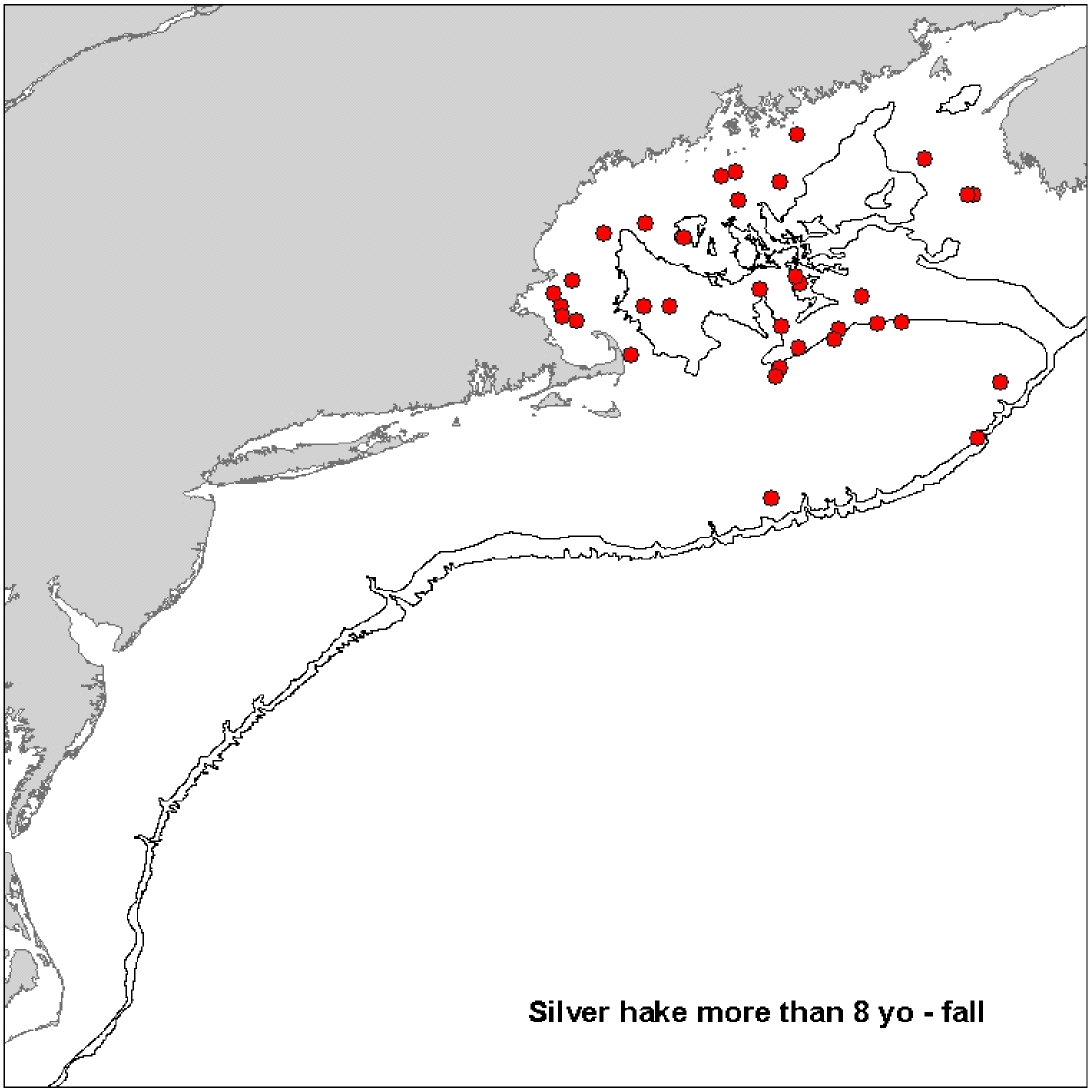


Figure A40. Catch locations for silver hake 8+ y captured during NEFSC fall surveys since 1973.

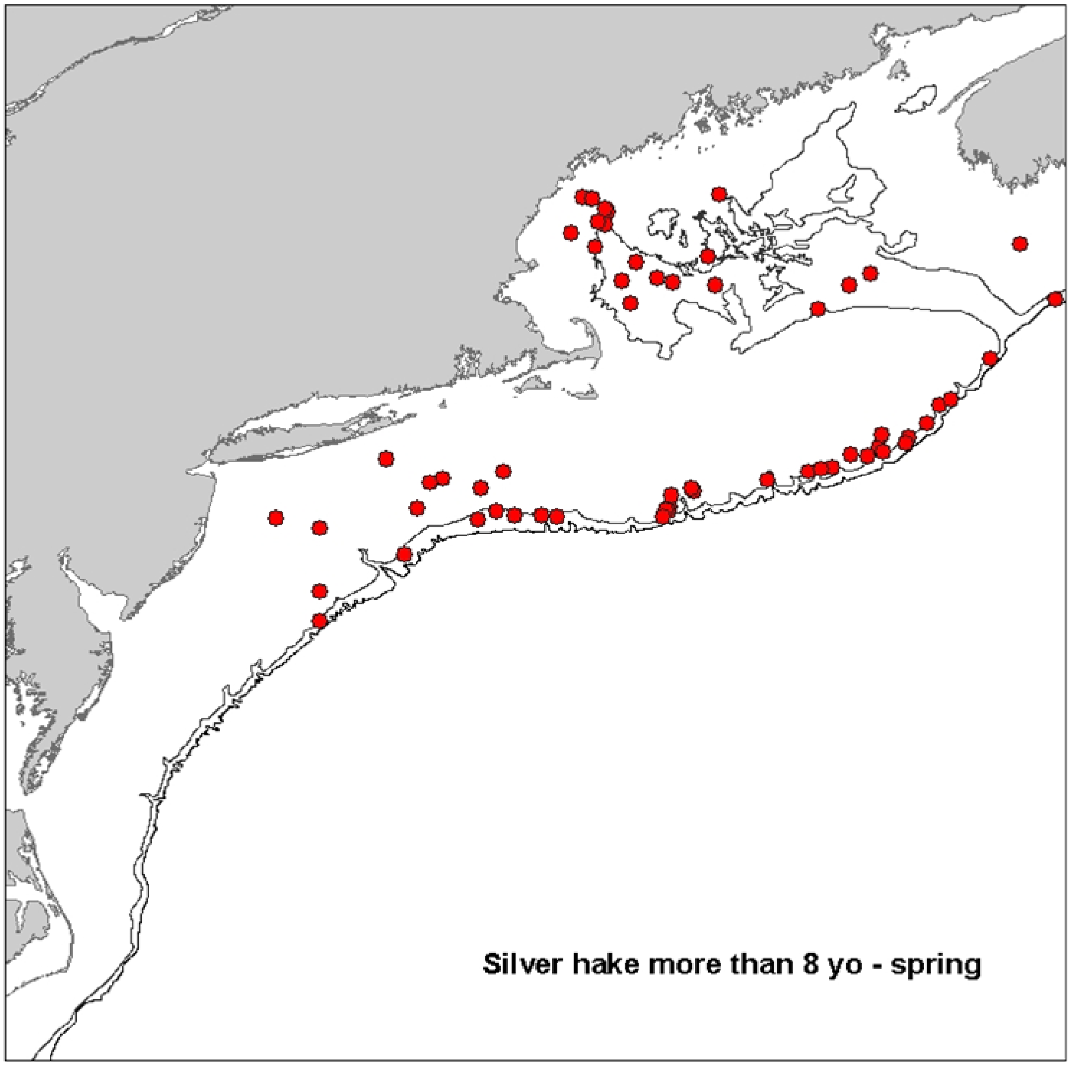


Figure A41. Catch locations for silver hake 8+ y captured during NEFSC spring surveys since 1973.

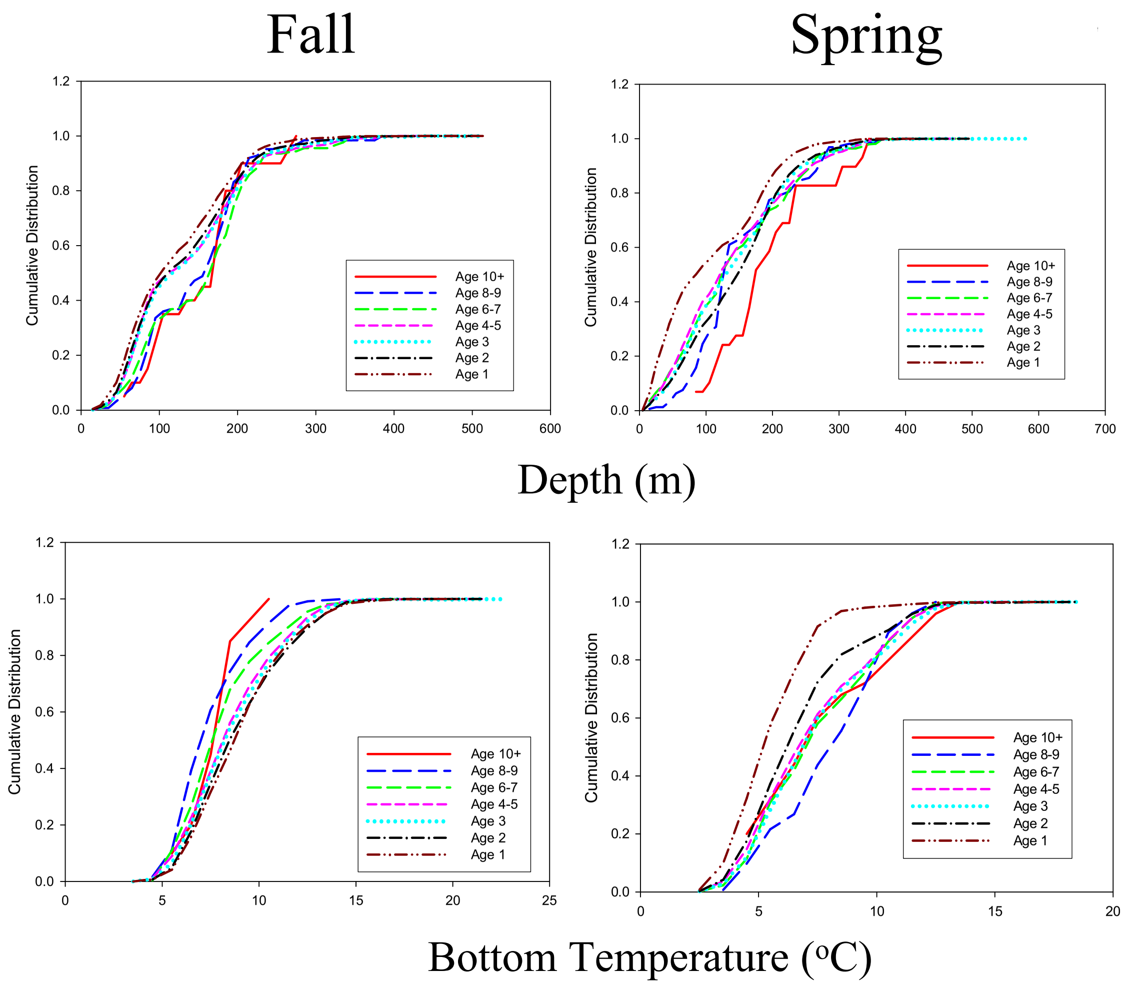


Figure A42. Cumulative depth and bottom temperature distributions for silver hake ages 1-10+ in NEFSC fall and spring bottom trawl surveys.

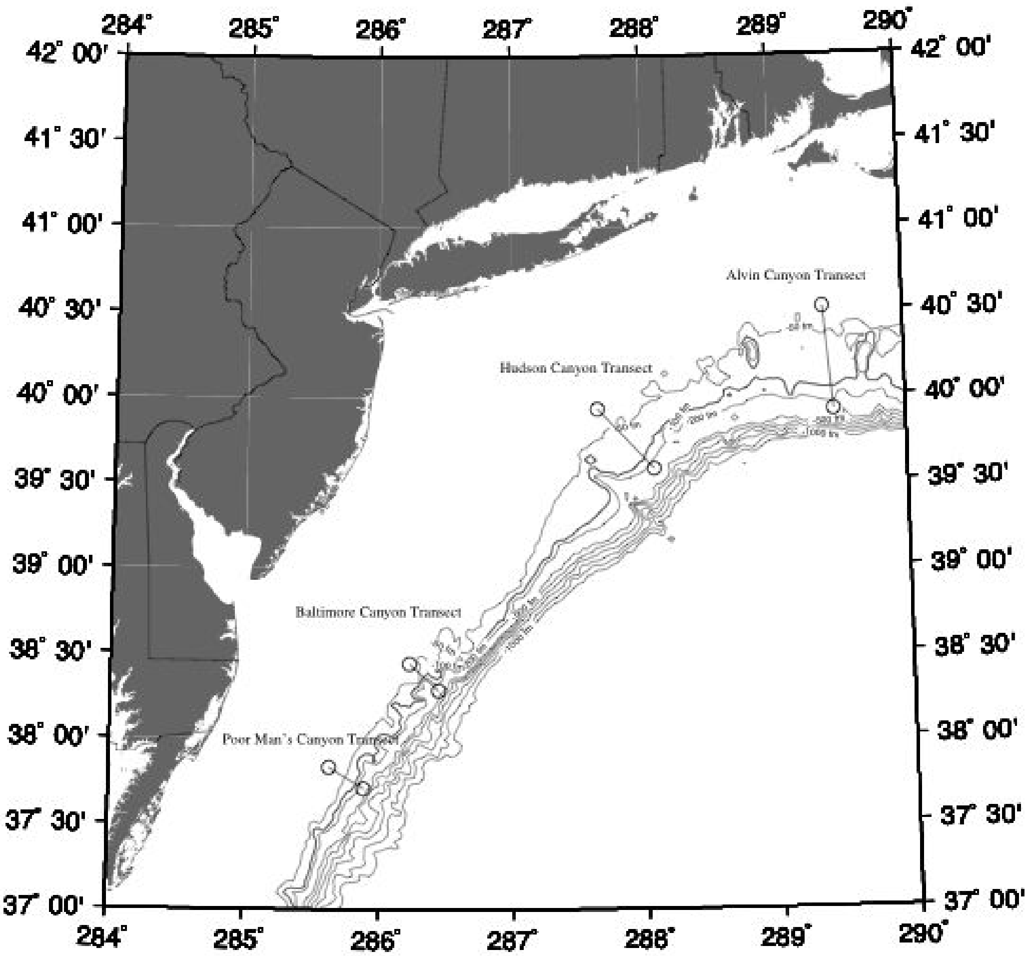


Figure A43. Location of transects for Supplemental Survey sampling. Data from the Baltimore and Hudson canyon transects at depths ≤ 274 m (150 fathoms) were used for silver hake.

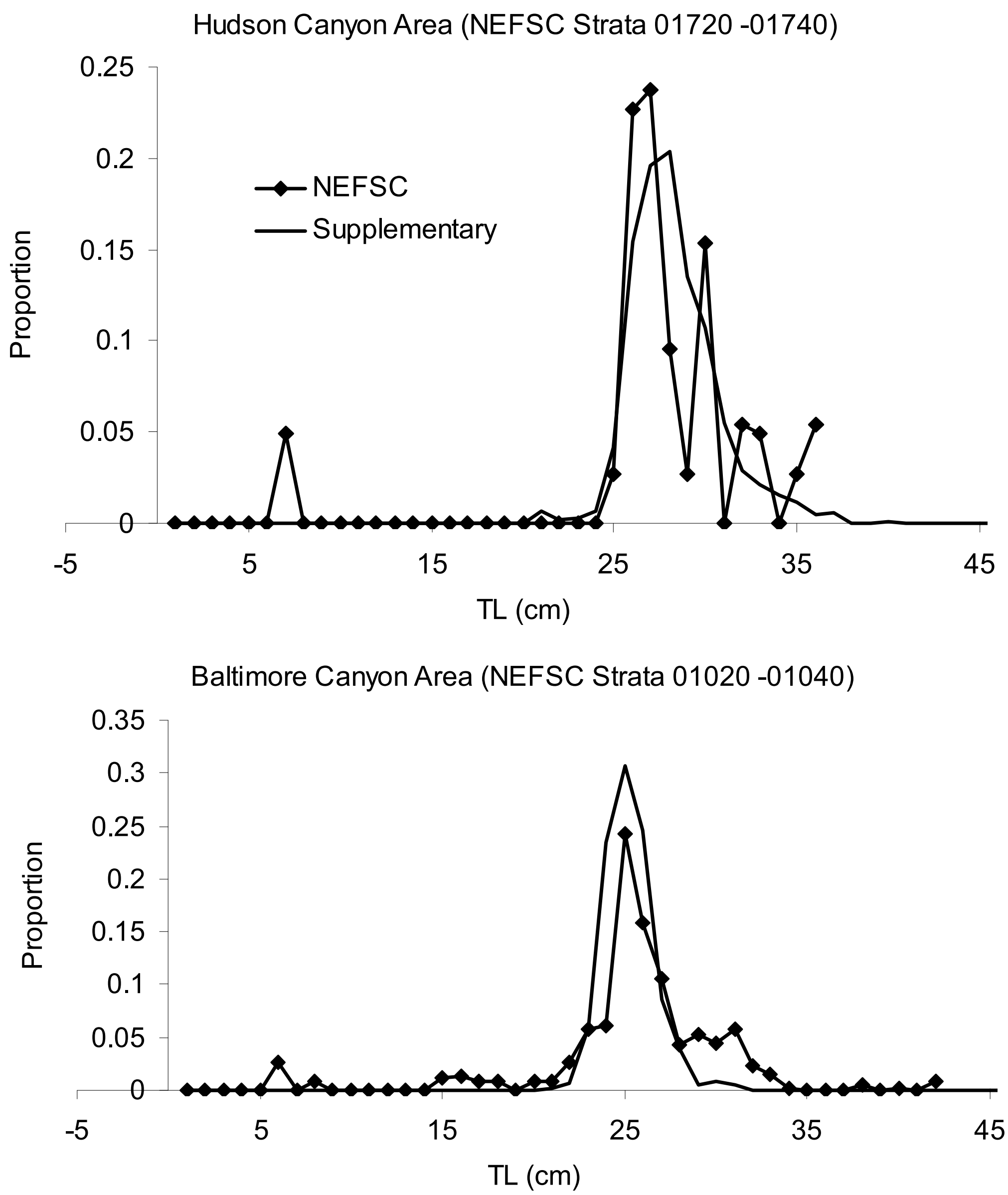


Figure A44. Length composition data for NEFSC and Supplemental surveys during 2004-2005 in the Hudson and Baltimore canyon areas. Data are for 12 tows in each area for the Supplemental survey (both fixed and adaptive stations during day or night were used). NEFSC data are for 14 tows in the Baltimore canyon area and 20 tows in the Hudson canyon area.

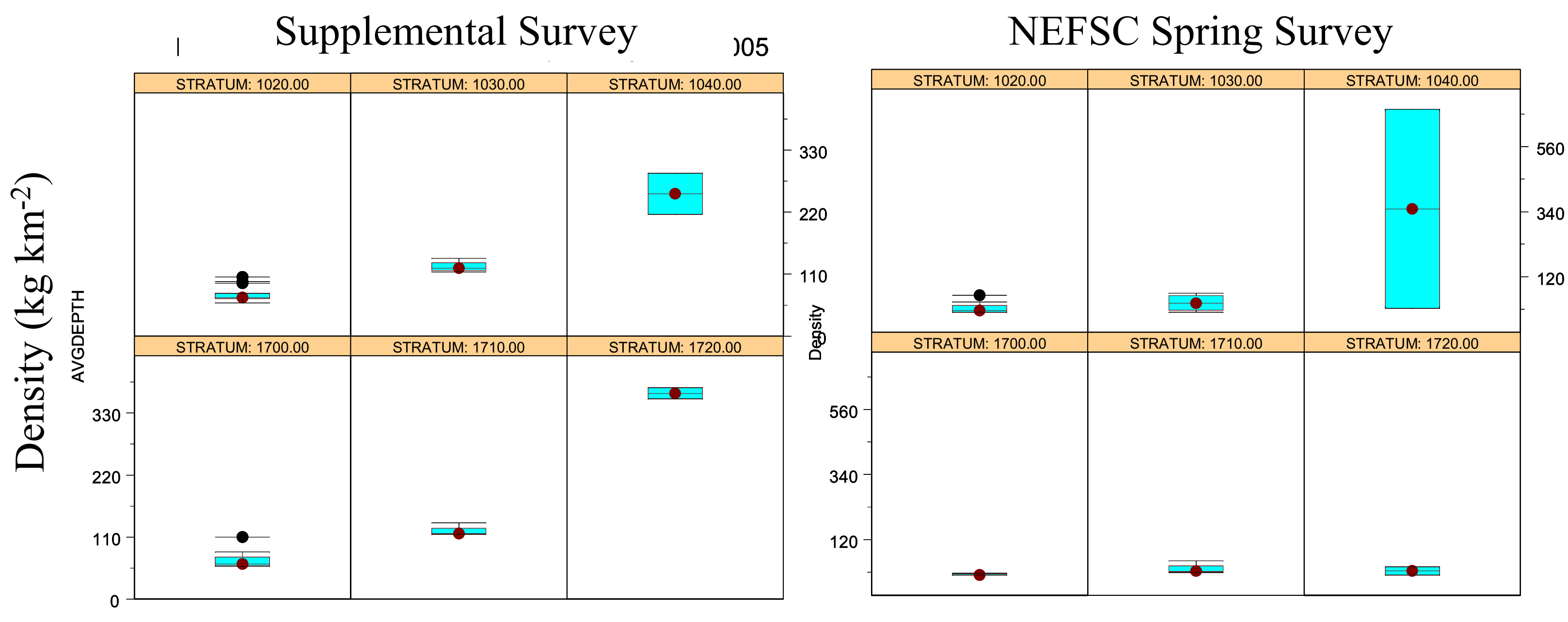


Figure A45. Densities of silver hake measured by the Supplemental and NEFSC spring bottom trawl surveys during March, 2004-2005. Y-axis are the same in all panels.

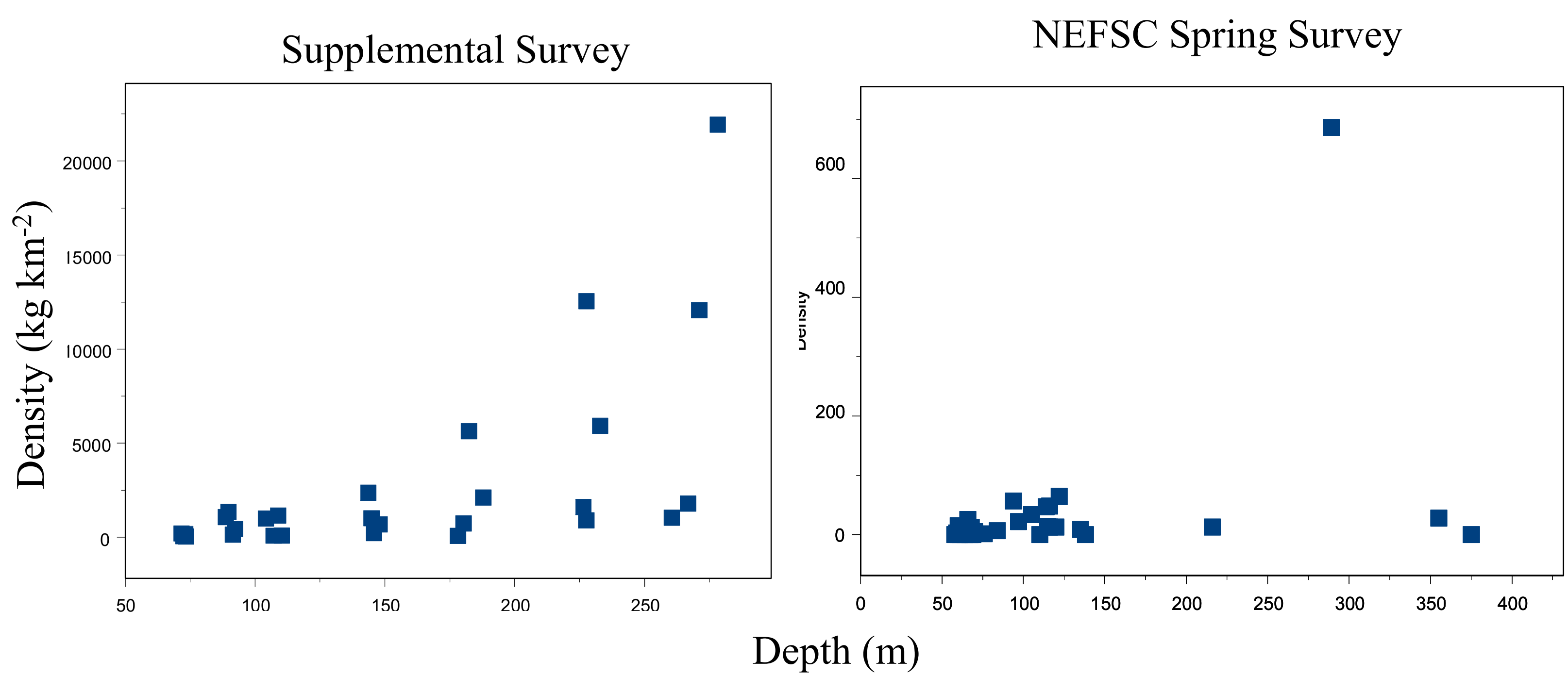


Figure A46. Densities of silver hake measured by the Supplemental and NEFSC spring bottom trawl surveys during March, 2004-2005.

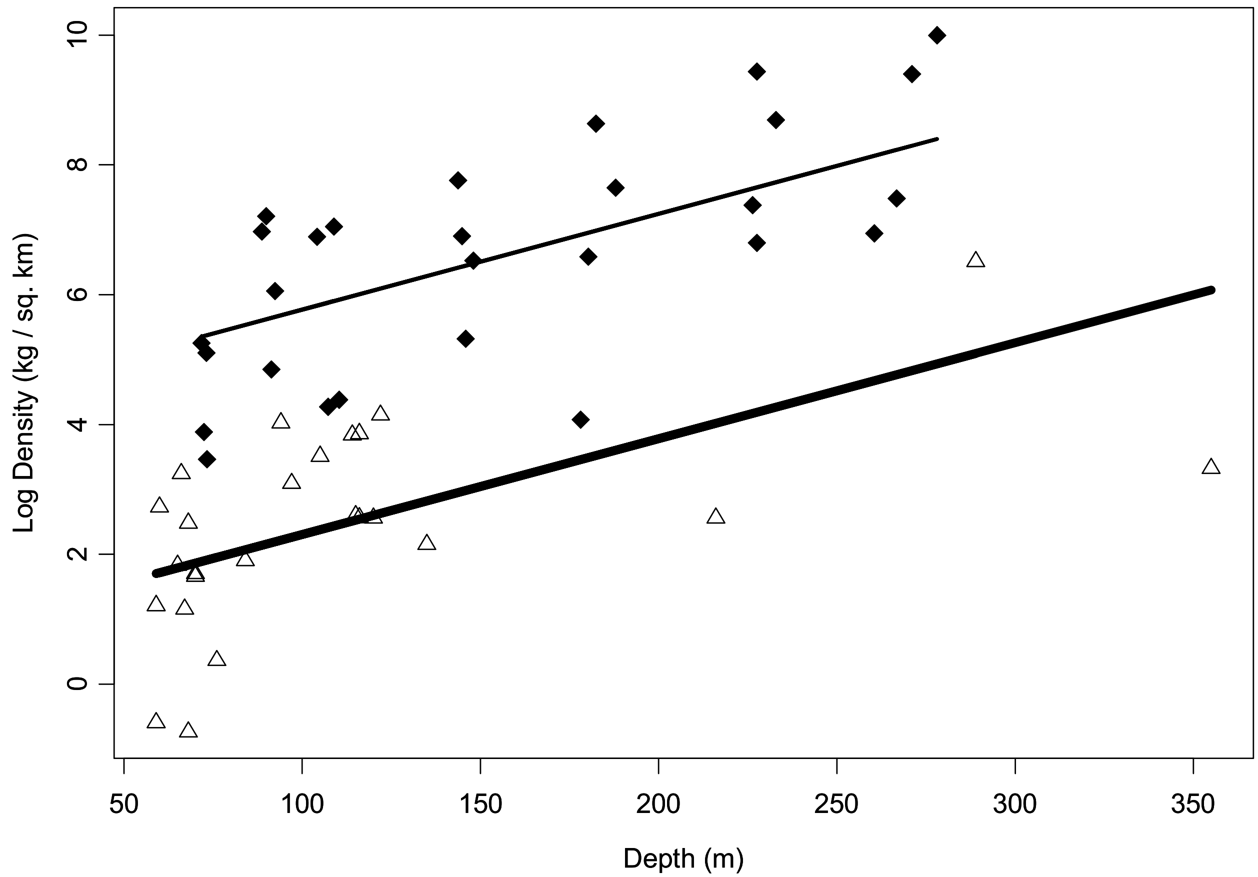
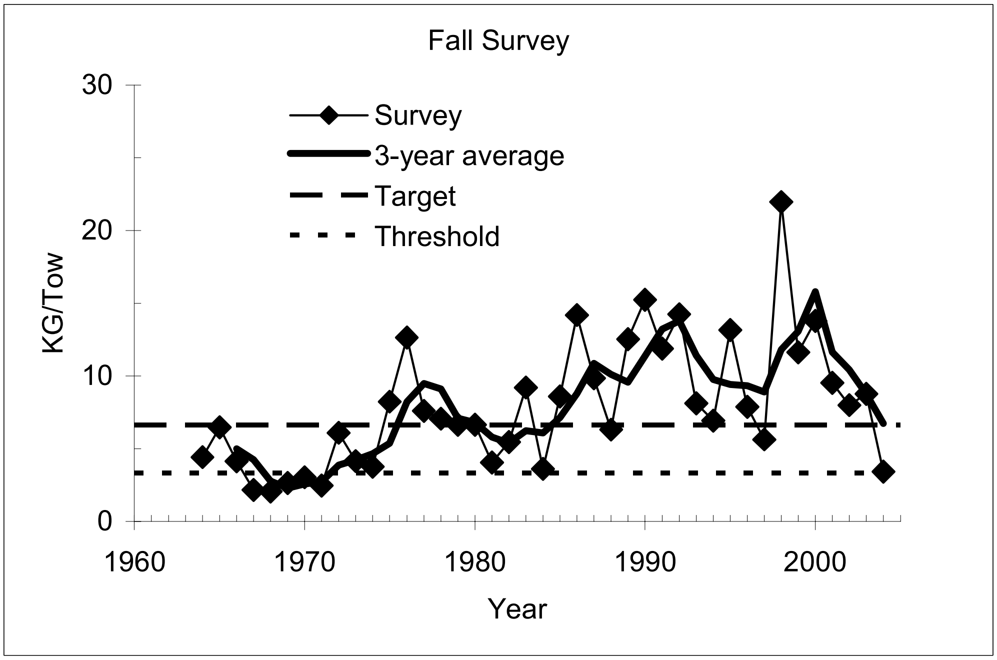


Figure A47. Densities of silver hake measured by the Supplemental (solid diamonds) and NEFSC (open triangles) spring bottom trawl surveys during March, 2004-2005. Lines from the best analysis of covariance model are also shown.



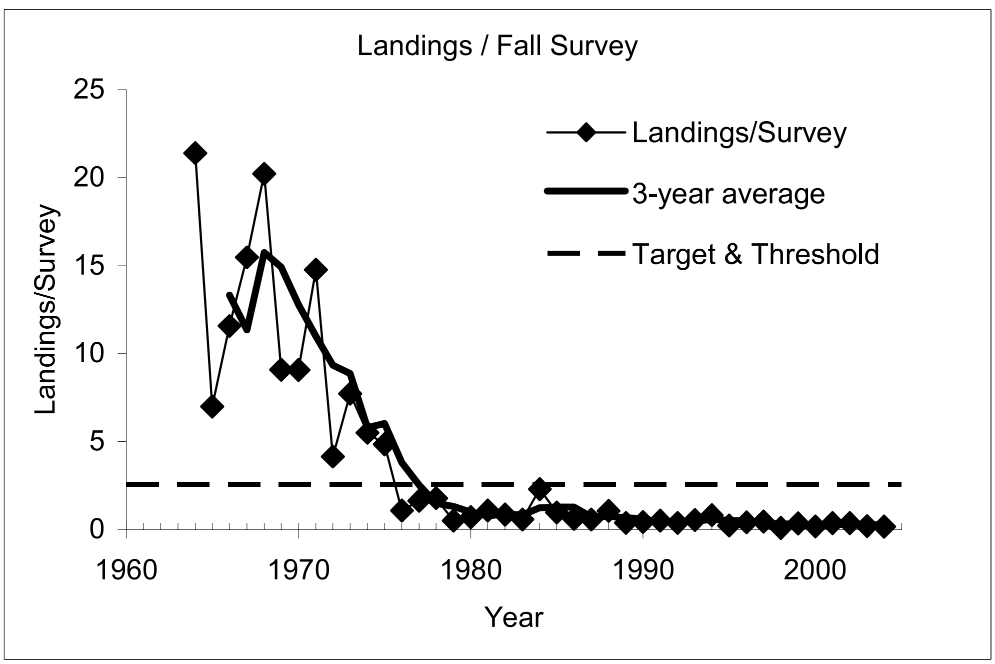
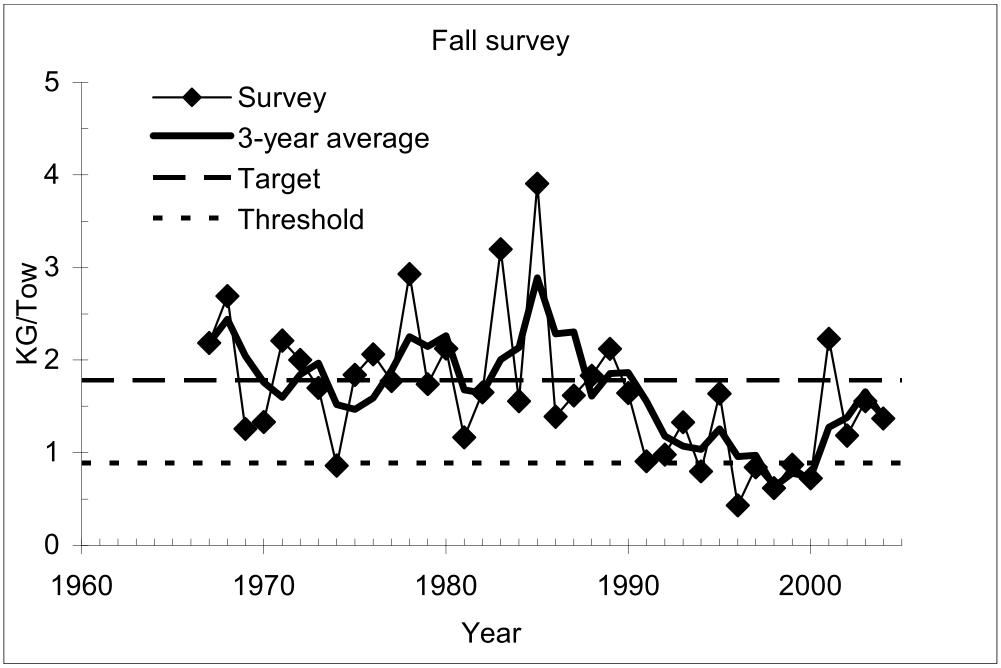


Figure A48. Abundance and exploitation indices for the northern stock of silver hake. Top: fall survey abundance index (delta mean kg/tow, based on consistently occupied offshore strata starting in 1964) with 3-year running average and current reference points for biomass. Bottom: landings/survey (exploitation index) and current reference points.



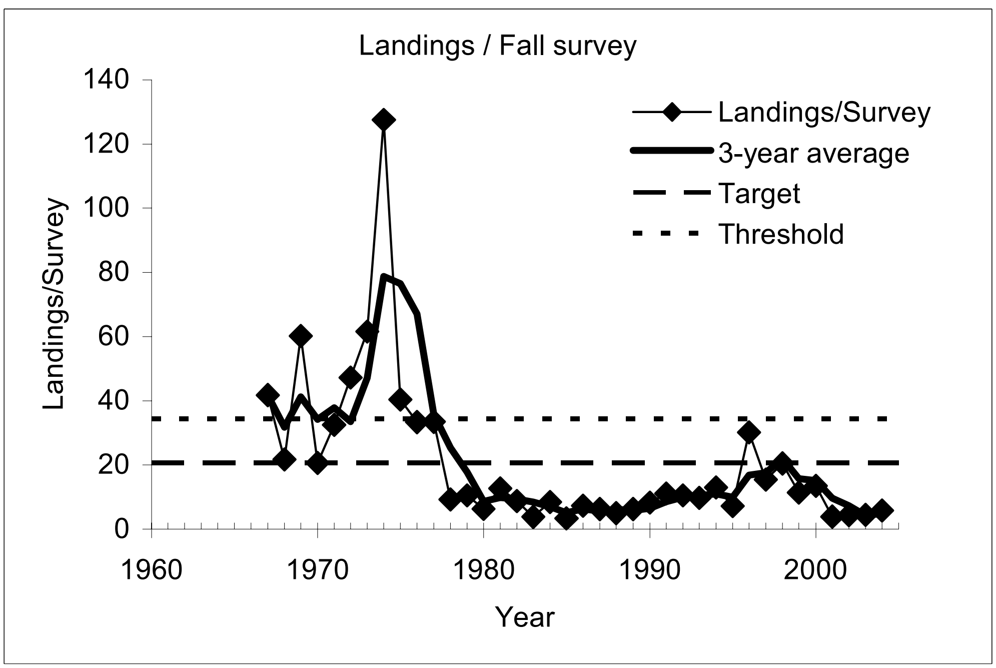


Figure A49. Abundance and exploitation indices for the southern stock of silver hake. Top: fall survey abundance index (delta mean kg/tow, based on consistently occupied offshore strata starting in 1967) with 3-year running average and current reference points for biomass. Bottom: landings/survey (exploitation index) and current reference points.

Figure A50. Lower bounds for fishable biomass and upper bounds for fishing mortality in the northern stock of silver hake during 1964-2004 based on historical landings and fall survey data.

(EDITOR'S NOTE: THIS FIGURE FROM THE WORKING GROUP REPORT HAS BEEN OMITTED. IT WAS NOT ACCEPTED BY THE REVIEW PANEL.)

Figure A51. Lower bounds for fishable biomass and upper bounds for fishing mortality in the northern stock of silver hake during 1964-2004 based on historical landings and fall survey data.

(EDITOR'S NOTE: THIS FIGURE FROM THE WORKING GROUP REPORT HAS BEEN OMITTED. IT WAS NOT ACCEPTED BY THE REVIEW PANEL.)

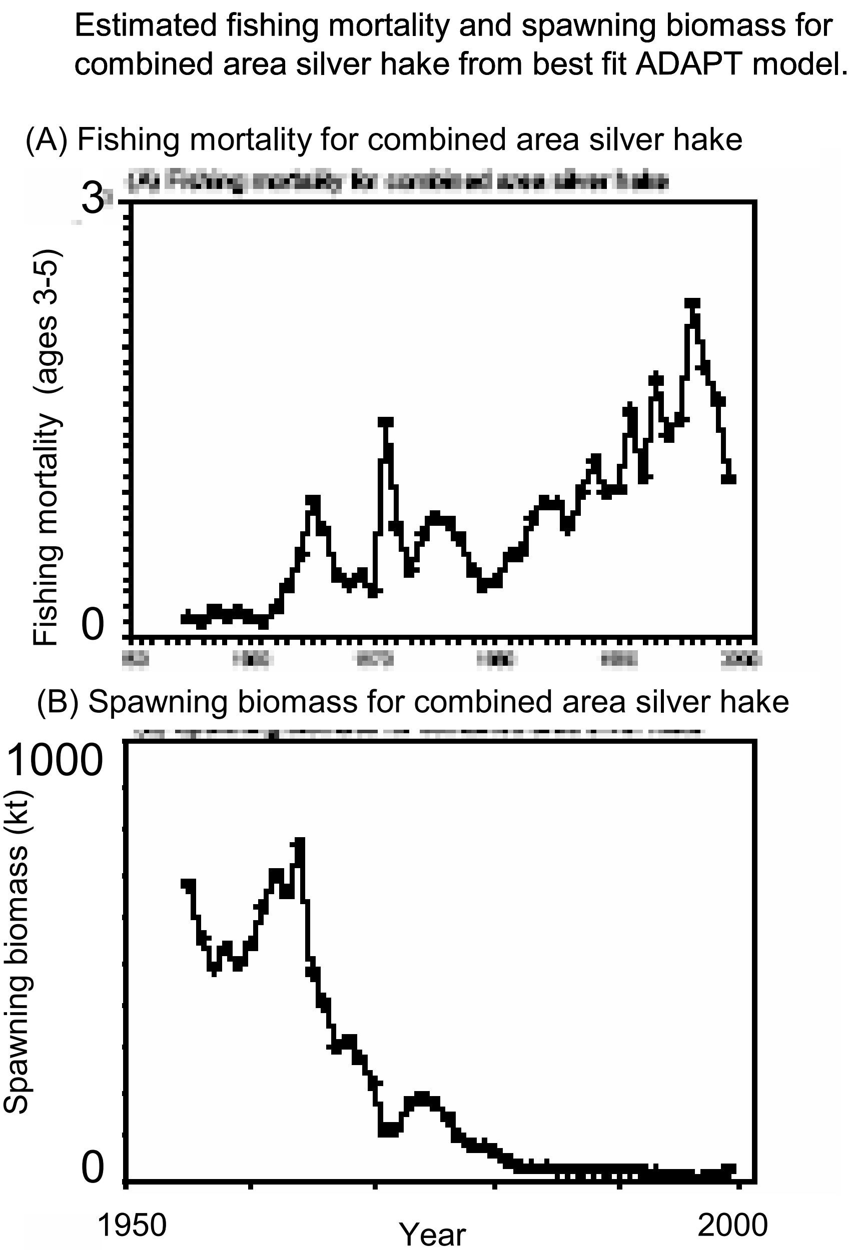


Figure 52. Fishing mortality and spawning biomass estimates for silver hake (northern and southern stock area) from the age structured stock assessment mode in NEFSC (2001).

APPENDIX A1: Stock assessment team members and persons who contributed to the silver hake assessment. "NMFS/NEFSC" stands for the National Marine Fisheries Service / Northeast Fisheries Science Center in Woods Hole, MA.

Name	Organization
F. Almeida	NMFS/NEFSC
J. Brodziak	NMFS/NEFSC
J. Burnett	NMFS/NEFSC
T. Chute	NMFS/NEFSC
L. Col	NMFS/NEFSC
P. Jones	NMFS/NEFSC
L. Jacobson (lead)	NMFS/NEFSC
S. King	Rutgers University (Haskins Shellfish Research Laboratory)
K. Lang	NMFS/NEFSC
J. Link	NMFS/NEFSC
P. Rago	NMFS/NEFSC
K. Sosebee	NMFS/NEFSC
M. Traver	NMFS/NEFSC
S. Wigley	NMFS/NEFSC

APPENDIX A2: Supplemental "Transect" Survey. General information regarding silver hake in the Supplemental "Transect" Survey carried out cooperatively by Industry and the Haskin Shellfish Research Laboratory in Bivalve, NJ. Some calculations (e.g. for "swath areas") were not discussed by the Joint Working Group or used in the assessment for silver hake.

Summary of results for whiting from the Supplemental Finfish Survey Targeting Mid-Atlantic Migratory Species: March 2003 – May 2005

Sarah King
Haskin Shellfish Research Laboratory
Rutgers University
Port Norris, NJ

To date, nine Supplemental Finfish Surveys have been completed. Surveys took place on the F/V Jason & Danielle during the weeks of March 8-12, 2003, May 25-31, 2003, January 24-February 2, 2004, March 4-17, 2004, and May 19-23, 2004. During the weeks of November 15-21, 2004, January 10-22, March 13-23, and May 4-10, 2005 the survey was conducted on the F/V Luke & Sarah. Two transects located near Hudson and Baltimore Canyon were sampled during every survey effort. A transect near Poor Man's Canyon was sampled during March of 2004 and 2005 and in March of 2005, a transect was sampled near Alvin Canyon (Figure 1). The survey gear, including net, sweep and doors were transferred from the original survey vessel and have remained constant throughout the survey. In November 2004, two new codends were built by the same company and to the same specifications as those used during previous surveys.

To obtain a relative index of silver hake, *Merluccius bilinearis*, from the Supplemental Finfish Surveys Targeting Mid-Atlantic Migratory Species, all calculations have been adjusted to swath area. Swath area measures the relative importance of each sampled depth according to its contribution to total distance along the transect line set perpendicular to the depth contour. Figure 2 shows an example of how the distance along the transect line was allocated to each tow for the calculation of swath area. The calculation projects the swept area of the tow had the net been towed continuously down slope along the transect line, from the shallowest to deepest station, for the distance allocated to each sample depth. This distance is established by the midpoints between perpendiculars dropped to the transect line from the midpoints of each tow (Figure 2).

During the March 2003 survey, silver and offshore hake were not separated and thus, the March 2003 data were excluded from this synopsis. Since the Poor Man's and Alvin Canyon transects were not sampled during every survey effort, data from these transects were also excluded.

Cross-Shelf Biomass By Transect and Survey

The highest overall cross-shelf projected biomasses were observed during March of 2005 along the Hudson and Baltimore Canyon transects. The survey consistently caught, in biomass and abundance, more whiting along Hudson Canyon transect than Baltimore Canyon transect (Tables 1 & 2 and Figure 3).

Swath Projected Biomass By Depth

In order to understand how whiting are distributed both spatially and temporally, the data are broken down by transect, by survey, and by depth. A comparison of depth changes for the 20th, 50th, and 80th percentiles of cumulative catch on each transect is plotted in Figure 4. The 50th percentile, for example, is the depth where the cumulative catch curve reached 50% of the total catch and the 20th and 80th percentiles are confidence interval bands, where cumulative catch reached 20% and 80% of the total catch. Observations show that silver hake are widely distributed across the shelf but are caught most frequently at depths ranging from 80 to 350 m on the Hudson and Baltimore Canyon transects. Whiting are caught as deep as 457 m, the deepest station, though catches tend to be smaller and less frequent at these depths (Table 3 and Figure 4). It is likely that the survey misses a small percentage of the inshore portion of the stock during some surveys. Instances include all of the surveys, but most notably May 2003 (Baltimore), May 2004 (Hudson and Baltimore) (Table 3). Also noteworthy, is the fact that the whiting catches occurred in deeper water more frequently in 2005 than in 2003 and 2004, and it is likely that the survey also misses a small percentage of the offshore portion of the stock.

Silver hake appear to make seasonal inshore/offshore migrations and the population tends to be situated further offshore on the Baltimore Canyon transect than the Hudson Canyon transect (Figure 4). Generally, silver hake are narrowly distributed inshore during the spring surveys (May 2003, 2004, 2005) and migrate further offshore, spreading out over the shelf, during the winter months (March and November 2004 and January 2005). Along the Hudson and Baltimore Canyon transects during the May 2003 and 2004 surveys, silver hake tended to be most abundant at depths ranging 80-130 m. They spread out over the shelf and move into deeper water during the winter surveys. For example, 60% of the whiting caught along the Hudson Canyon transect occurred at depths of 90-180 m during March 2004, and 210-325 m, in January 2005. Along Baltimore Canyon transect, 60% of the whiting caught occurred at depths ranging from 110-260 m, in March 2004 and 270-360 m, in January 2005 (Figure 4).

Cross Shelf Numbers Per Size Class By Transect and Survey

The size of silver hake caught ranged from 19-52 cm during the March 2004 and 2005 supplemental surveys (Table 4 and Figure 5). More than 95% of the whiting measured during the March surveys ranged from 21-34 cm.

Length-Weight Relationship By Transect and Survey

The von Bertalanffy equation for isometric growth is: $W = a\sum L^b$, where W=weight, L=length, b=3, and a is a constant. The length-weight relationships observed for whiting are consistent with this equation and the growth exponent, b, ranged from 3.23-3.30, and R^2 values fell between 68-85% (Figure 6).

Median Size Class Per Depth By Transect and Survey

The 50th percentile size class was determined for each depth sampled for tows with 20 or more measured individuals (Table 5). Within a given survey, the median size of whiting does not appear to vary with depth. In a given survey, the median size of whiting caught on the Baltimore Canyon transect is, on average, 1-2 cm larger than whiting captured on Hudson Canyon transect (Table 5 and Figure 7).

Table 1 (APPENDIX A2). Swath area whiting catch (kg) per tow summed across all tows per transect. This is a theoretical number caught if the net had been towed continuously down slope from the shallowest to the deepest station along each transect.

	Hudson Canyon Transect	Baltimore Canyon Transect
May 2003	240,209.7	17,214.3
January 2004	966,929.5	96,870.9
March 2004	3,057,810.4	256,876.6
May 2004	1,184,289.6	187,153.3
November 2004	5,218,371.8	799,376.9
January 2005	3,041,186.9	499,071.9
March 2005	9,445,397.0	1,130,256.1
May 2005	5,215,401.3	625,998.6

Table 2 (APPENDIX A2). Swath area projected total abundance of measured whiting across all tows for each survey. The multiplication of these numbers and the percentages in Table 4, provide the reader with the project number of whiting per size class (March 2004 and 2005, only).

	Hudson Canyon Transect	Baltimore Canyon Transect
May 2003	1,171,783.4	76,713.8
January 2004	68,783,310.9	815,642.1
March 2004	646,675,951.2	12,803,011.3
May 2004	24,839,510.8	1,111,541.7
November 2004	4,176,326,937.9	1,211,781,610.3
January 2005	3,332,306,046.2	235,738,849.4
March 2005	14,076,324,593.3	894,659,210.2
May 2005	1,663,613,791.5	41,528,449.4

Table 3 (APPENDIX A2). Percentage of total whiting catch (kg) at each depth. Dashes represent stations that were not sampled. For each transect, the depth with highest percentage of whiting caught per transect is highlighted. H=Hudson Canyon transect, B=Baltimore Canyon transect.

Target	**Mar-04**		**Mar-05**	
Depth (m)	**H**	**B**	**H**	**B**
73.15	3.38	2.00	1.47	0.32
82.30	-	-	-	5.96
91.44	26.14	13.73	12.08	5.30
100.58	1.28	-	1.09	2.56
109.73	9.23	11.15	3.42	2.63
128.02	10.75	-	2.22	-
146.30	17.88	24.47	2.64	18.64
164.59	8.94	3.00	-	-
182.88	3.61	0.66	11.75	10.98
204.83	-	6.10	8.29	-
228.60	7.51	4.45	14.62	16.59
250.55	2.01	11.11	14.22	3.23
274.32	9.15	19.67	12.68	25.48
320.04	-	2.35	13.93	5.80
365.76	0.12	1.30	0.69	2.33
387.71	-	-	-	-
411.48	0.00	0.02	0.88	0.19
457.20	0.00	-	0.02	-

Table 4 (APPENDIX A2). Cumulative size-frequency distribution of whiting across all tows, reported as a percentage of total abundance. For each transect, the size with highest percentage of whiting caught per survey is highlighted. H=Hudson Canyon transect, B=Baltimore Canyon transect.

Length	**Mar-04**		**Mar-05**	
(cm)	**H**	**B**	**H**	**B**
18	0	0	0	0
19	0	0.001	0	0
20	0	0	0.32	0
21	0.03	0.77	3.30	0.12
22	0.64	0.41	17.47	0.90
23	1.59	0.15	29.53	4.82
24	7.62	0.76	22.59	21.85
25	15.55	3.28	14.55	30.54
26	18.76	15.52	5.82	26.77
27	14.83	19.71	4.15	7.57
28	15.41	22.51	0.85	5.02
29	8.16	13.32	0.41	0.75
30	8.29	11.52	0.15	0.85
31	3.89	3.95	0.03	0.74
32	1.09	2.42	0.02	0.01
33	1.68	2.29	0.01	0.01
34	0.80	1.20	0.13	0.0004
35	0.60	1.18	0.003	0.003
36	0.48	0.33	0.01	0.01
37	0.15	0.56	0.02	0.01
38	0.32	0.03	0.45	0.02
39	0	0.07	0.0003	0
40	0.10	0.03	0	0.001
41	0.002	0	0	0
42	0	0	0.01	0
43	0.002	0	0.17	0
44	0	0	0.01	0
45	0	0.01	0.001	0
46	0	0	0	0
47	0	0	0	0
48	0	0	0	0
49	0	0	0	0
50	0	0	0	0
51	0	0	0	0
52	0	0	0.001	0
53	0	0	0	0

Table 5 (APPENDIX A2). Dashes represent tows where less than 20 whiting were measured or station was not sampled.

Target Depth (m)	Mar-04 H	Mar-04 B	Mar-05 H	Mar-05 B
73.15	26.7	28.1	24.9	26.1
82.30	-	-	-	24.9
91.44	27.0	28.9	25.0	25.3
100.58	26.9	-	25.1	24.8
109.73	26.3	-	25.2	25.0
128.02	-	-	26.8	-
146.30	27.1	28.1	23.9	24.2
164.59	25.6	28.6	-	-
182.88	25.5	-	22.5	24.1
204.83	-	27.2	23.0	-
228.60	25.6	26.5	22.6	24.4
250.55	25.0	27.7	23.3	24.4
274.32	27.8	27.3	23.1	24.8
320.04	-	28.8	23.5	24.9
365.76	-	27.9	25.6	25.0
387.71	-	-	-	-
411.48	-	-	24.5	24.8
457.20	-	-	-	-
Overall	**26.4**	**27.4**	**23.0**	**24.7**

Figure 1 (APPENDIX A2). Location of transects sampled during Supplemental Survey cruises.

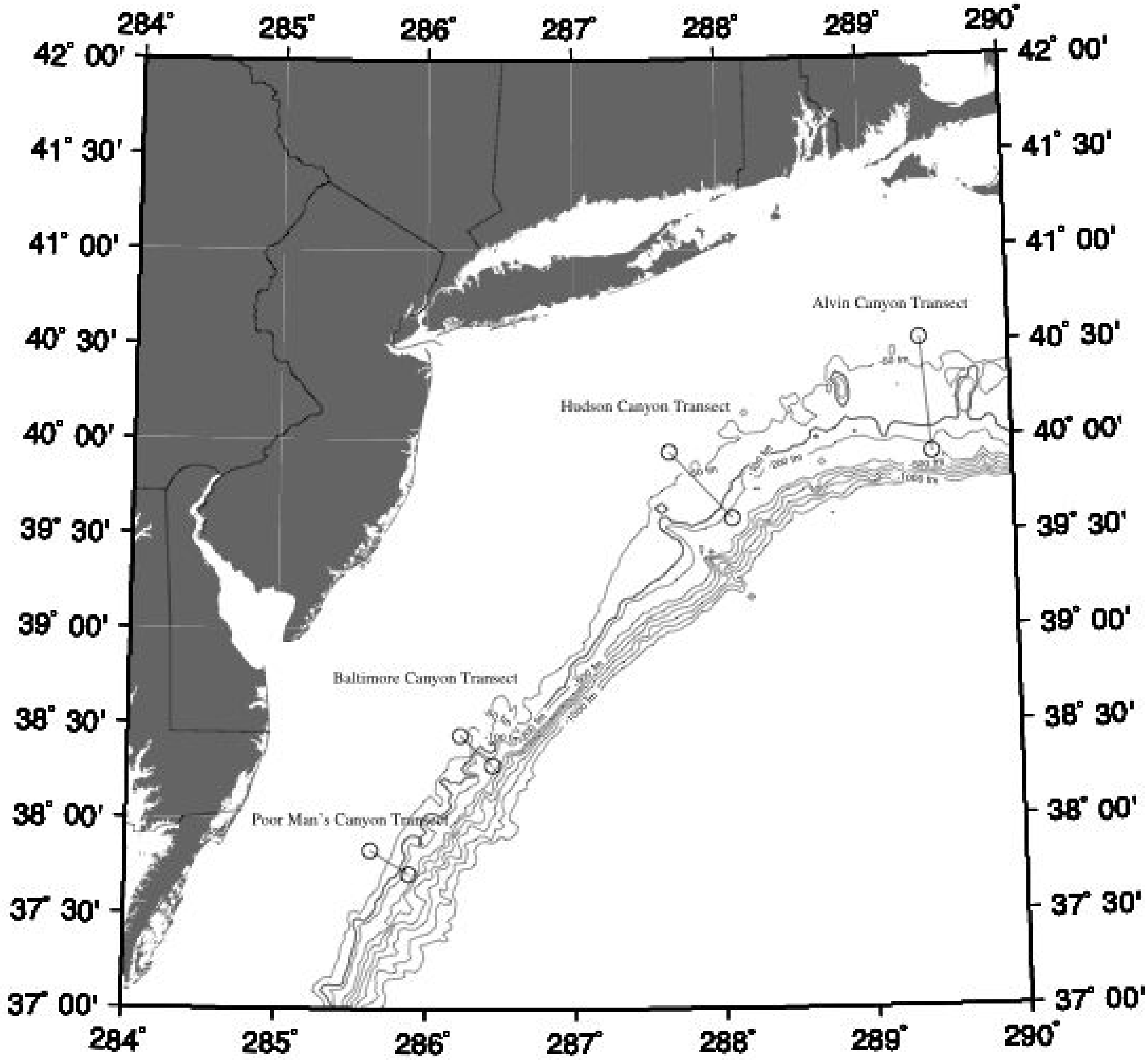


Figure 2 (APPENDIX A2). Swath distance for tows 1, 2, and 3, taken near a transect, showing the distance allotted to each tow had it actually been taken along the transect line.

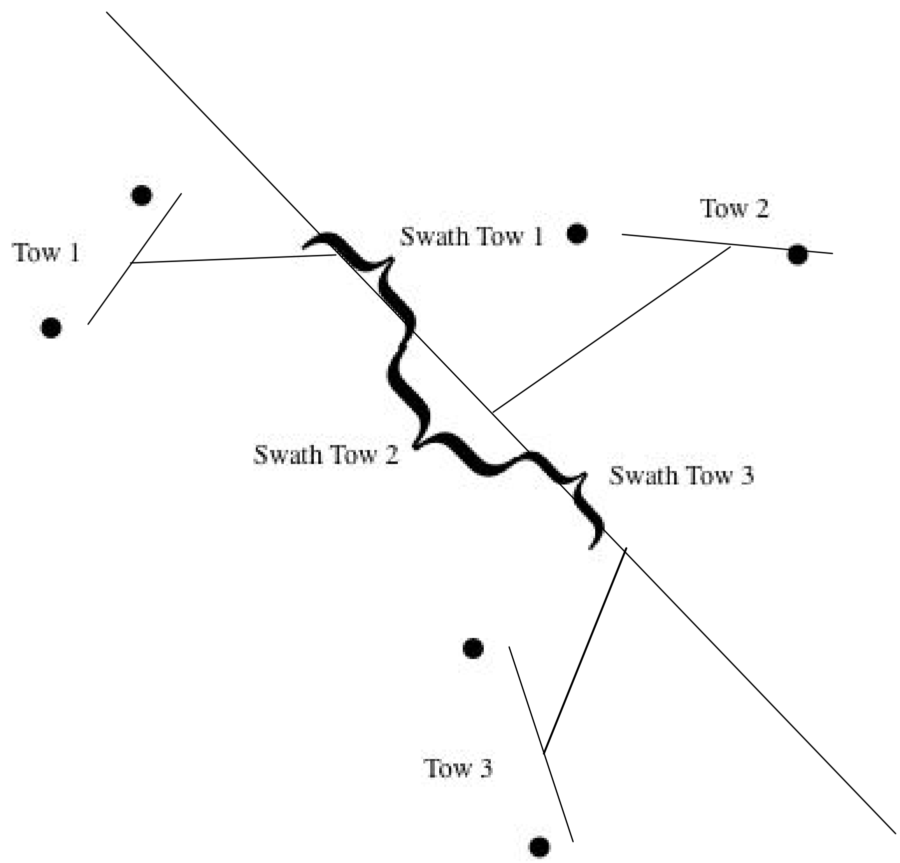
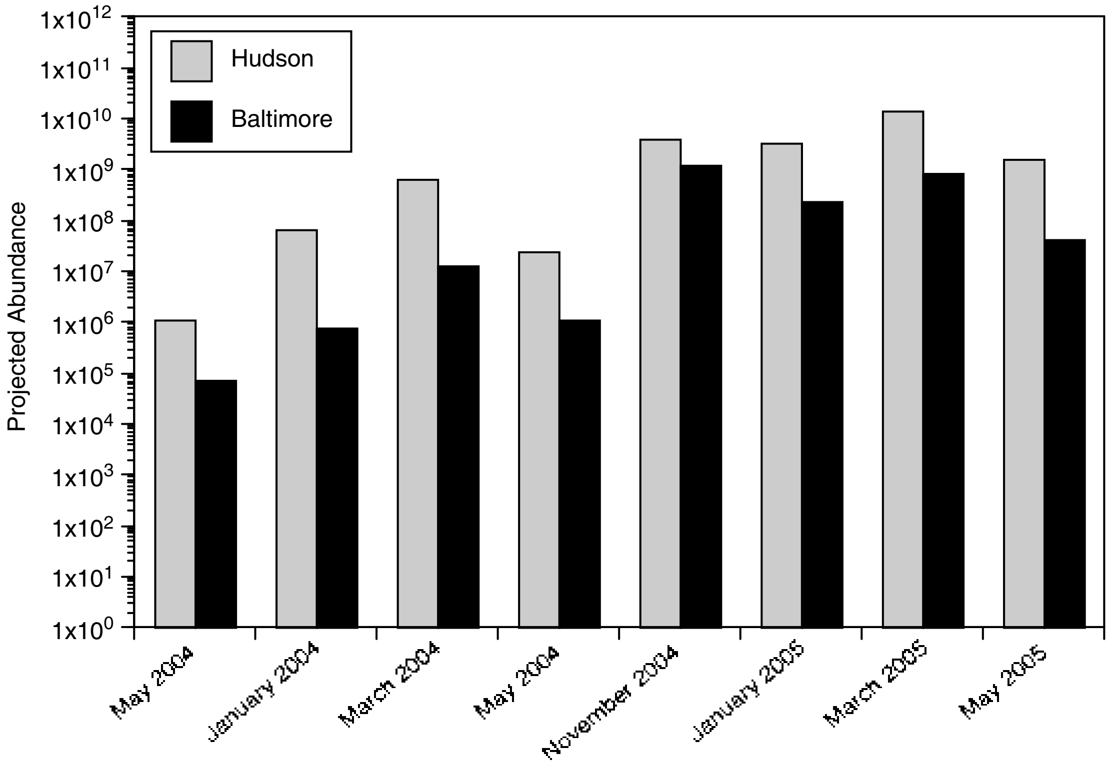


Figure 3 (APPENDIX A2). Projected biomass and abundance of whiting along each transect for each survey. In order to display all of the data on the same figure, there is an axis break in projected biomass. Logarithmic axis scaling was necessary in order to plot the projected abundances from all of the surveys on one figure.



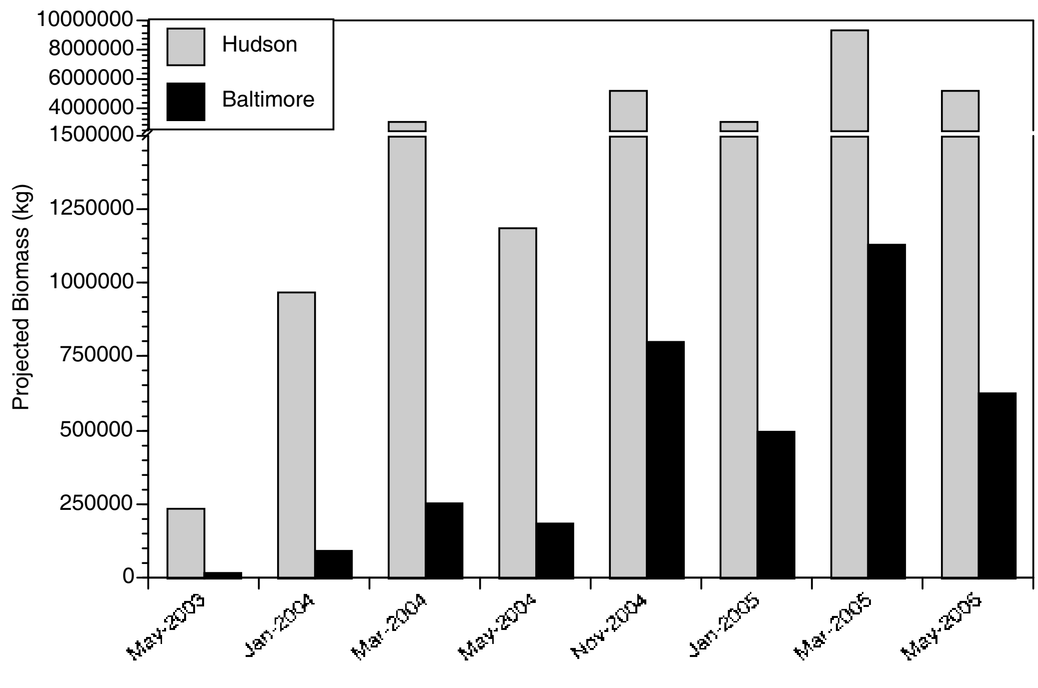


Figure 4 (APPENDIX A2). Comparison of changes in depth for the 20th, 50th, and 80th percentiles of cumulative catch during all surveys completed through May 2005. To calculate the percentiles, swath area catch (Table 2) was cumulated from the shallowest to the deepest station on each transect. The 20th percentile, for example, is the depth where the cumulative catch curve reached 20% of the total catch.

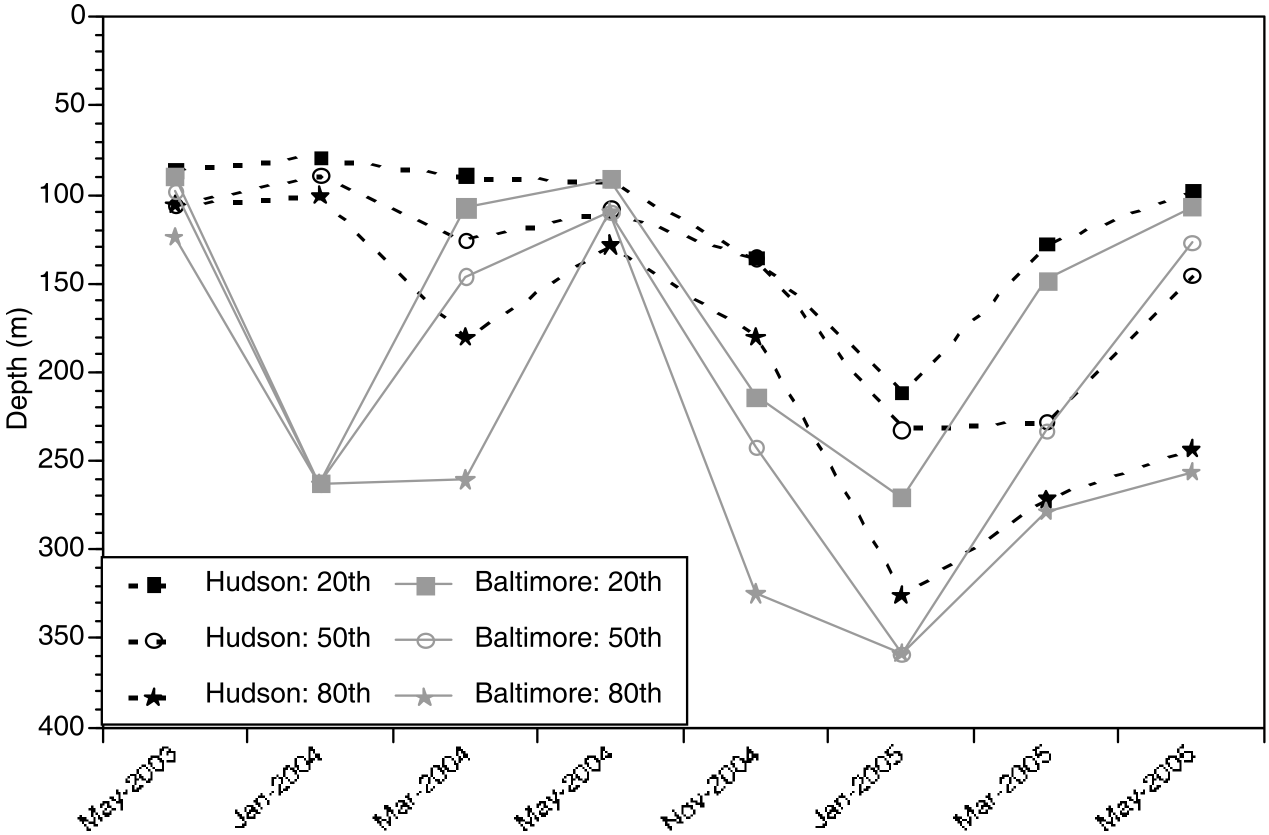


Figure 5 (APPENDIX A2). Projected number of whiting per size class across all tows for the March 2004 and 2005 surveys. Tow size frequencies were corrected to the number caught per km^2 swept area. Tows were then normalized to swath distance along the transect and the abundances were summed across all tows for each transect. Logarithmic axis scaling was necessary in order to plot data from all surveys on one figure. Note: zeros were not plotted.

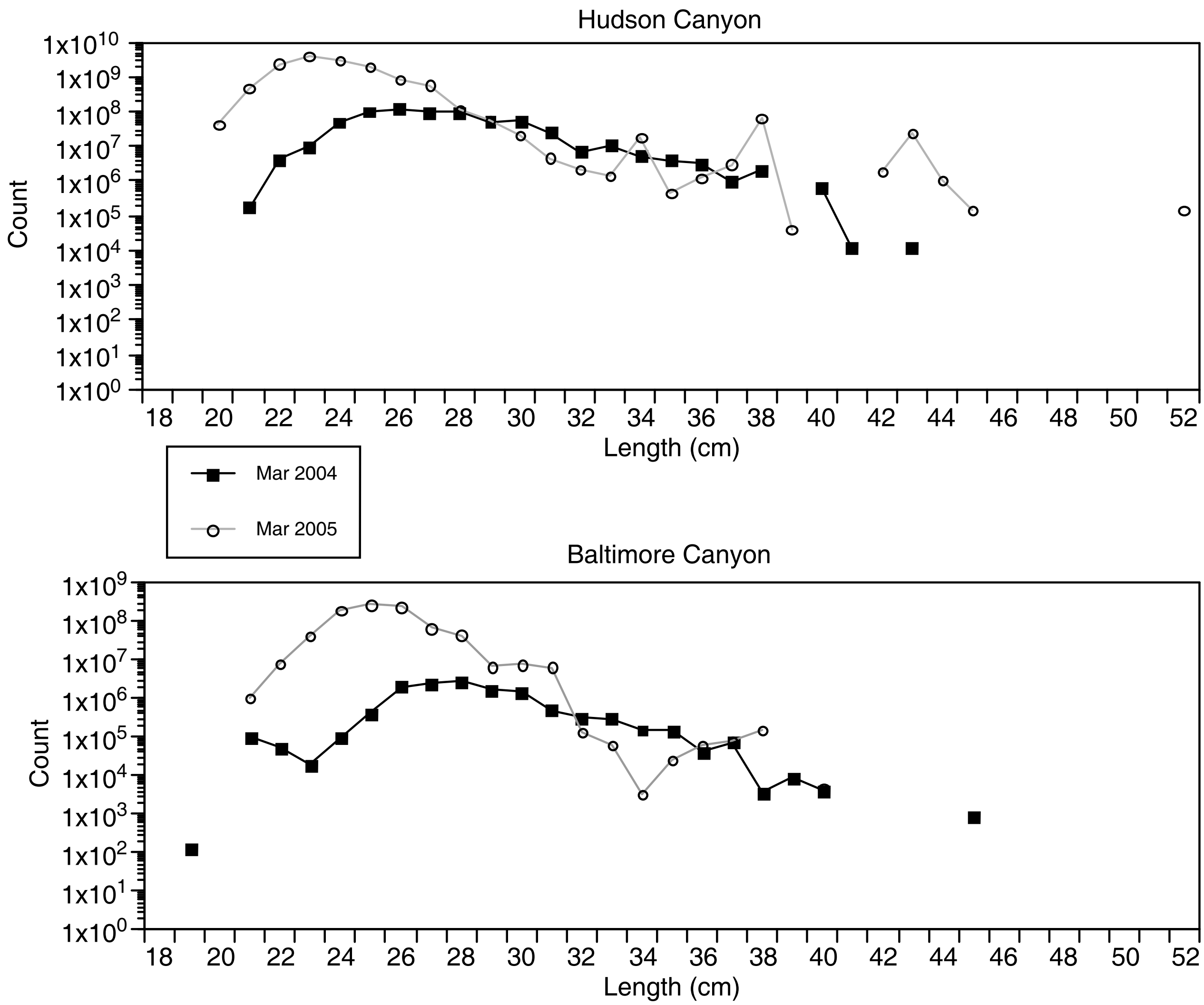


Figure 6 (APPENDIX A2). Relationship between length and weight for silver hake measured in March 2004 and 2005. f(x)=weight, x=length.

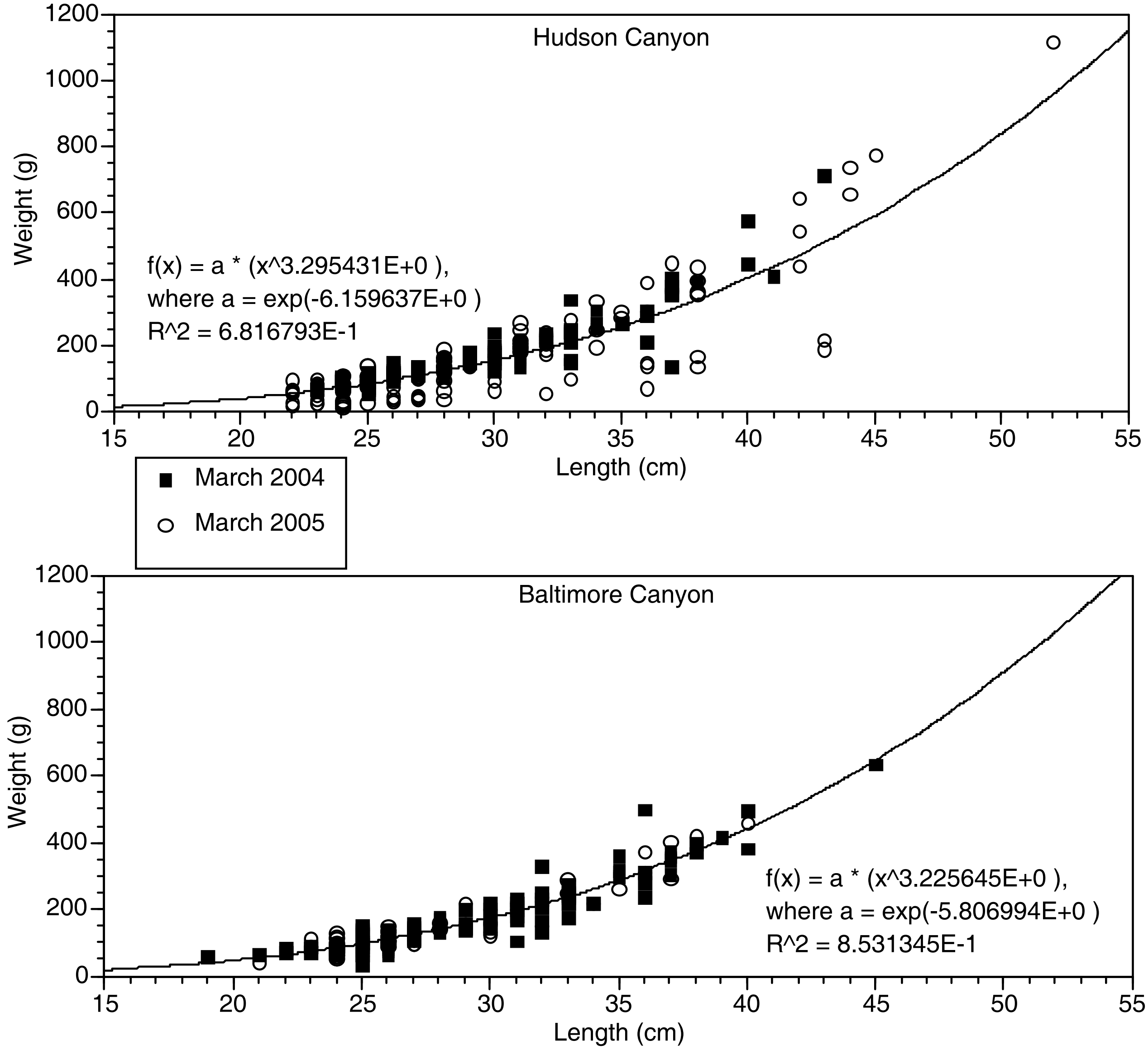
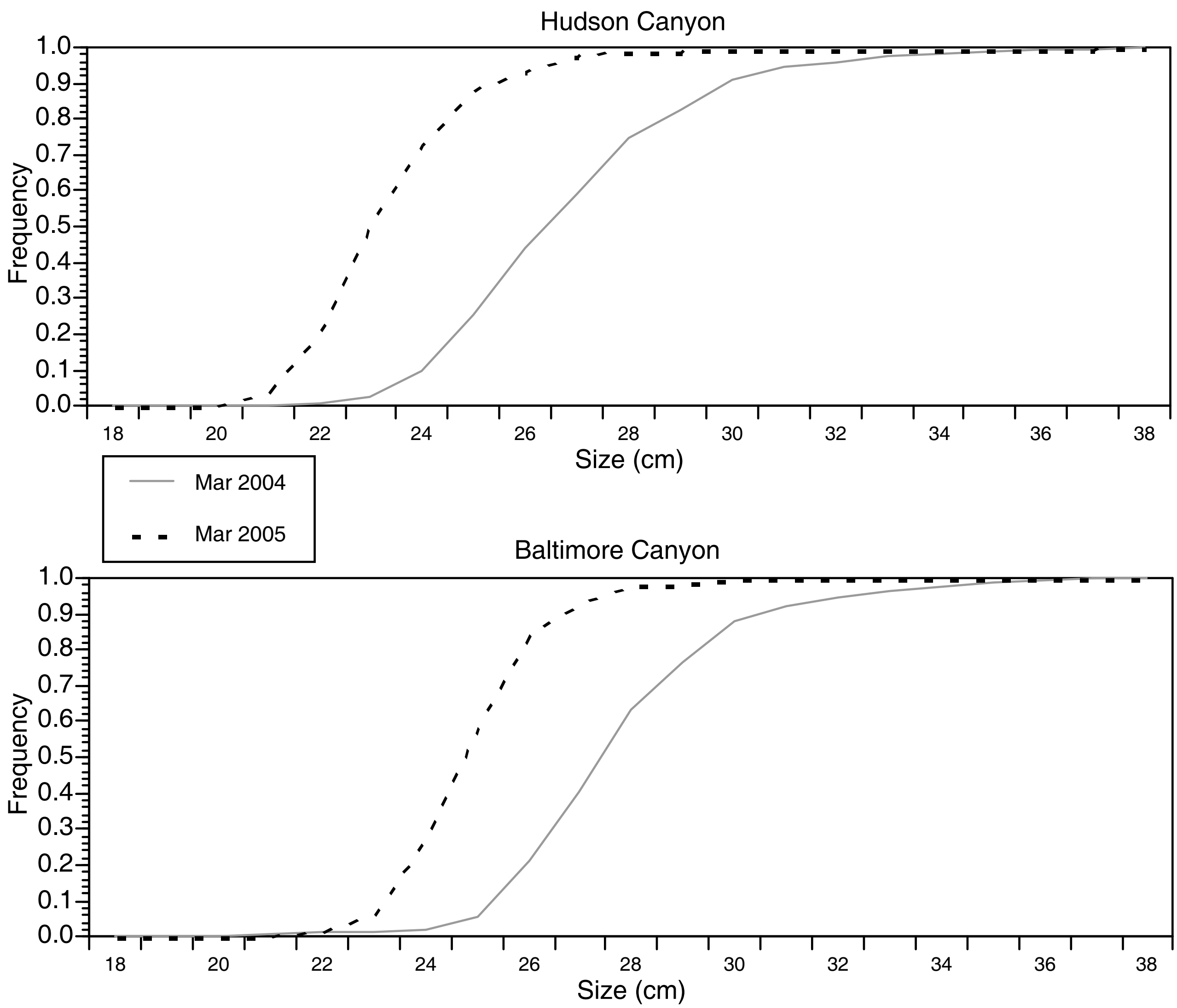


Figure 7 (APPENDIX A2). Cumulative size frequency for whiting from the March 2004 and 2005 surveys.



APPENDIX A3: Chairman and Rapporteur's Report from Working Group Meeting.

Silver Hake WG Meeting, Oct. 24-28, 2005.

Truncation of Older Fish

A concern was raised that the relatively high spawning stock biomass and low fishing mortality estimates for silver hake are inconsistent with the recent truncation of older, larger fish in the commercial and NMFS survey data. The Working Group also noted that the change in total mortality needed to account for the observed decline in age structure seems unrealistic. The intense fishing effort by foreign fleets during the 1960s and 1970s may have caused such a decline in age structure, but it was noted that recently the age structure does not show expansion despite decades of lower fishing effort. It was observed that the truncation of the older silver hake started in the mid 1980s when survey doors changed, and it was recommended that gear comparisons be reexamined by length.

Ageing error was discussed as one possibility for the recent lack of older silver hake, since sectioning methods and age readers have changed. Attempts to re-age old fish from archived otoliths show that new ages average one to two years younger than original ageing. However, these slight biases do not seem to explain the age truncation seen in the survey, and the older fish in the earlier part of the survey time series also correspond to larger fish than are currently being observed.

The Working Group also discussed the possibility that the older fish in the historical NMFS data could have been miss-identified as offshore hake. In the NMFS spring survey, the distributions of older silver hake roughly corresponded to offshore hake distributions. However, it is not likely that the aged fish are mis-identified since the otoliths are distinct between the two species, and no mis-identified otoliths have been found in recent years. The older fish also seem to fall on the same age-length growth curve as the young silver hake, indicating that they are most likely not offshore hake, although growth curves for offshore hake were not examined. The commercial sample data are not aged. The commercial catch is not sorted by species and may include offshore hake, especially from the area along the shelf edge where offshore hake are often found.

The decrease of large silver hake in commercial landings was discussed by the Working Group, and it was noted that the closure of areas for lobster pot fisheries could be affecting catch composition since large fish were historically caught in these areas. The recent decrease in silver hake landings can be attributed to catch limits implemented in 2001.

Stock Structure

A question was raised about whether the northern and southern silver hake stocks are in fact distinct. The two stocks are within close proximity to each other, and it is thought that some exchange exists between the two areas. However, there is currently no new evidence to refute the current stock structure assumed in management.

The Working Group noted that silver hake recruitment seemed strong in both stocks. Concern was expressed that estimates of fishable biomass of silver hake in the NMFS surveys is far less in the southern stock than in the northern stock. Several potential explanations were discussed including greater fishing efforts in the south, less thorough coverage of silver hake habitat by NMFS surveys in the south, especially in deep waters, and possible exchange between the Scotian Shelf and the northern stock.

Survey and Commercial Data Uncertainty

Concern was expressed that the catchability of silver hake in the NMFS survey could be variable since silver hake are known to come off the bottom during the day. The point was also made that the decreased catchability during the day could be a net avoidance issue, since the species is a visual feeder. However, the NMFS survey design assumes that strata are sampled randomly during day and night, and catchability is not biased over the time series.

Commercial discard estimates were calculated on a trip basis, but the Working Group discussed examining changing target species between tows. Due to variability between years, small sample sizes, and the belief that target species during a trip would not frequently change, discards were estimated on a trip basis. A recommendation was made to also include catches that are entirely discarded, as well as some fisheries with low discard rates but large landings such as large mesh groundfish. Despite the low discard ratio of silver hake in the groundfish fishery, these discard estimates should be included due to the substantial catch volume.

Depth was found to be a more significant predictor of large silver hake distribution than temperature, and concern was expressed that the NMFS survey does not thoroughly cover deeper habitat. The Working Group noted that interactions should be tested between temperature and depth in GAM models.

Population Density Estimation

The Working Group discussed possible issues for using supplemental survey data to calibrate NMFS survey data. These issues include uncertainty of area swept, diel migration of fish, tow duration, and availability of tow-specific sensor data. These concerns merit further research. The analysis would benefit from controlled side-by-side tows involving both vessels. Estimates were only applied in the southern region where the surveys overlapped.

Three methods were presented to calculate an expansion factor of silver hake density between NMFS and supplemental surveys, and the viability of each method was discussed. Small sample sizes were a concern for all of these models. The first method estimated a median density by year and strata in order to obtain a ratio of relative fishing power, but was inefficient in utilizing the available data. The second method was to use a conventional ratio estimator. The bootstrap estimates of precision for this method show substantial bias due to small sample size. A third regression method using density by tow was performed in order to use the survey data most efficiently and account for depth and other effects. The regression method had the narrowest confidence intervals, and was agreed to be the best model using the supplemental survey data.

Finally, a catch-survey ratio method was applied to both stock areas. This method gives a reasonable minimum biomass estimate since the catch in the years of greatest fishing effort cannot exceed the total biomass. Concerns were expressed that the bootstrap results from this method do not reflect all of the uncertainty since a constant catchability is assumed, and a minimum estimate of biomass is not comparable between years. Do to the difficulty in comparing this assessment to previous years and the potential to ignore missing older fish, it was recommended that future assessments be based on model-based assessments.

Research Recommendations:

- A study be conducted to verify silver hake species identification with port agents, and to take additional age samples of larger commercial silver hake.

-The presence of silver hake in stratum 99 of NMFS surveys as well as in special deepwater surveys needs to be examined in order to determine if the NMFS survey is missing silver hake in deeper waters, and if additional tows in existing NMFS deep water stations would be beneficial. All available surveys that cover depths in excess of NMFS surveys should be examined for the distribution of silver hake.

-Acoustics data could be examined to augment silver hake distributions.

-Review effects of gear changes in NMFS survey on catchability of silver hake by size.

-Devise a method to cast the current survey based reference points into a form that is compatible with abundance indices derived from the new vessel.

-A study needs to be conducted to determine the extent of movement along the coast, especially around Georges Bank.

-The next assessment be based on an age-structure model, and reference points be derived from model results.

Sources of Uncertainty:

-There is uncertainty in the aging precision of silver hake from NMFS surveys due to changes in sectioning methods and age readers.

-Offshore hake could be incorrectly identified as silver hake, especially in commercial data.

-Gear changes in NMFS survey could affect catchability of silver hake over time.

-There is uncertainty as to whether silver hake is appropriately divided into two stocks.
-The NMFS surveys may have reduced catchability and coverage in deep water, and may not capture a good representation of the larger silver hake.

APPENDIX A4: Supporting information. Information in this appendix was presented and discussed during the SARC review meeting but not presented in the original assessment document. In most cases, the information was not presented in the original document because it was requested by the reviewers or prepared during discussions. This information was not discussed to the Working Group that prepared the assessment.

Figure 1 (APPENDIX A4) . Silver hake discards and landings (hail weights) for all trips (all gear and primary species groups) with observers during 2001-2004.

```
 Plot of Discard*TargetGrpMT.  Legend: A = 1 obs, B = 2 obs, etc.

Discard |
 7.4180 +    A
        |
        |
        |                                Correlations:
 5.5635 +      A                          Pearson = 0.03 (ns)
        |                                 Spearman =  0.26 (p < 0.0001)
        |   AB                            Kendall Tau = 0.20 (p < 0.0001)
        |   A
 3.7090 +   A
        |
        |  BAB
        |  ADBA
 1.8545 +  DA
        |  BCB       A
        |  DDCB A         A
        |  ZSFD  A
 0.0000 +  ZZZZZZXUNIGGMHGFHEBDFDAAA C BADBD  ABA AAA  AA       A  A   A    B
        ---+----------+----------+----------+----------+----------+----------+--
           0         100        200        300        400        500        600

                                       TargetGrpMT
```

Figure 2 (APPENDIX A4). Same as previous figure except that trips with zero discards are omitted and both axes are log scale.

```
 Plot of LnDiscard*LnGroupMT.  Legend: A = 1 obs, B = 2 obs, etc.

              Correlations:
LnDiscard |    Pearson = 0.37 (p < 0.0001)
        5 +    Spearman =  0.39 (p < 0.0001)
          |    Kendall Tau = 0.27 (p < 0.0001)
          |
          |                                               A  C   A
          |                              A  AA A   AB   CAACBAB
        0 +                              A   AA  A CAAAACAAC BC A A   A A
          |                          A   B A ABAAGBDCBCAEBDDEABC   A
          |                             AACBAEABBAAABDCCIEGGGBB  A  A A    A
          |                    A   AAAC  AEFBCDACBFAGDKFKIDRID B A          A
          | A               A    BEBGCHAFJFGDCC DFJFLHHIQJGHFGD CBC    C    CA
       -5 +                   ACACFAHMKHJGIFGGFBGGCEGFHHMGEFAEF BBBAA   A AAA
          |                A AAACCJGFPJMNLMGAFGEDBGFCHBGDBFEDBECCEDB E  A  A
          |             AB AACBHCJGHURQNMNFKJHEDF DDGCDCCCBCCAABACFBAAA A
          |         A  A   CBBDCDGJCMPXSQGKJMHDCB DBFCCCACBCFCBCEDCAC A   A A A
          |        A   A    A  A AC AADCA CAB  B A     CA  A A   A    A   A  A
      -10 +                      AA  A   A  A        A AA     A    A  A
          |
          --+----------+----------+----------+----------+----------+----------+-
           -6         -4         -2          0          2          4          6

                                         LnGroupMT
```

Figure 3 (APPENDIX A4). *Top*: Silver hake discards and landings (hail weights) for the Trawls gear group and all primary species groups based on trips with observers during 2001-2004. *Bottom*: Same as top but records with zero discard are omitted and both axes are log scale.

```
------------------------------- GearGroup=Trawls -------------------------------

        Plot of Discard*TargetGrpMT.  Legend: A = 1 obs, B = 2 obs, etc.
Discard
 7.3881 +      A
        |
 6.3326 +
        |
 5.2772 +          A
        |    A B
 4.2217 +   A
        |    A
 3.1663 +       A
        |   ABA
 2.1109 +  ABABBA
        |  BB BAA             A
 1.0554 +  CBBA A A  A
        |  NRHHCD
 0.0000 +  ZZZZZUKECFB  BB A      A  AA             A   A A           AAA  B
        ---+----------+----------+----------+----------+----------+----------+--
           0         50         100        150        200        250        300

                                       TargetGrpMT

        Plot of Discard*TargetGrpMT.  Legend: A = 1 obs, B = 2 obs, etc.
          (NOTE: 50 obs hidden.  1429 obs out of range.)
 Discard |
         |
   10000 +
    1000 +
     100 +
      10 +                                            A
       1 +                               AA BB BGBAKCIFEAB A
     0.1 +                            ACABFCHFIIHNOZPZKE  A
    0.01 +             A           DALJOIPSPLHNWUZZZRZKEBB   A AC
   0.001 +                     BAADLMQZZUZKNRJLFRLQNMGLFAA
  0.0001 +                  B B  CDCEKHNMHBCFCCBDCGAAFB        A
         |                          AA A         AAA   A  A
         ---+-------+-------+-------+-------+-------+-------+-------+-------+--
         0.0001   0.001   0.01     0.1      1      10       100    1000    10000
```

Figure 4 (APPENDIX A4). *Top*: Silver hake discards and landings (hail weights) for the Squid and Butterfish primary species group and all gear groups based on trips with observers during 2001-2004. *Bottom*: Same as top but records with zero discard are omitted and both axes are log scale.

```
------------------------- TargetGrpID=Squid/ButterFish -------------------------

        Plot of Discard*TargetGrpMT.  Legend: A = 1 obs, B = 2 obs, etc.
Discard
 7.3881 +      A
        |
 6.3326 +
        |
 5.2772 +          A
        |    A B
 4.2217 +
        |    A
 3.1663 +       A
        |    B
 2.1109 +   BAABA
        |  AB BAA             A
 1.0554 +  AAA  A A  A
        |  CCAECD
 0.0000 +  ZUQHGGJDDDB   B A A    A  A                                  AA   B
        ---+----------+----------+----------+----------+----------+----------+--
           0         50         100        150        200        250        300

                                       TargetGrpMT
```

```
        Plot of Discard*TargetGrpMT.  Legend: A = 1 obs, B = 2 obs, etc.
Discard
   1000 +
        |
    100 +
        |
     10 +                                          A
        |                                   A  ABBACAB A
      1 +                               B A C A B CABBA A A
        |                                 CAAB  A DCAC
    0.1 +                            B   A     A  B  A   A
        |                               A  B BB BA   A  A    A
   0.01 +                     A AB A  A  AA B   AAA    A        BB
        |                       AA   A    A         BA A
  0.001 +                   A     A B AC          A ABA
        |             A         B AA   A          A A B
 0.0001 +          A           AA   B
        -+---------+---------+---------+---------+---------+---------+---------+
       0.00      0.01      0.10      1.00      10.00    100.00  1000.00 10000.00

                                       TargetGrpMT
```

Figure 5 (APPENDIX A4). *Top*: Silver hake discards and landings (hail weights) for the Hakes and Ocean Pout primary species group and Trawls gear group based on trips with observers during 2001-2004. *Bottom*: Same as top but records with zero discard are omitted and both axes are log scale.

```
----------------- TargetGrpID=Hakes+OceanPout GearGroup=Trawls -----------------

        Plot of Discard*TargetGrpMT.  Legend: A = 1 obs, B = 2 obs, etc.

      4 +                                  A
        |
        |
Discard |
        |               A                                                      A
        |
        |                                                               A
      2 +  A
        |     A
        |
        |                                  A
        |  A  A
        |  AAA    AA  AB  A A  A           A                                 A
        | A A CBA AAA  A    A B     A      A  A                      A
      0 +DLCCFADBAC  A  AAA        AAB    A A    A         A          A
        -+---------+---------+---------+---------+---------+---------+---------+
         0         2         4         6         8        10        12        14

                                       TargetGrpMT

        Plot of Discard*TargetGrpMT.  Legend: A = 1 obs, B = 2 obs, etc.
Discard
   1000 +
        |
    100 +
        |
     10 +
        |                                   A  A  B
      1 +                           B  B    AA A
        |                       A   B AACACBBBAAA B
    0.1 +                           BAADAA   BAA
        |                   A        B  A        AA
   0.01 +                             A
        |                   A    CB           A
  0.001 +                       A
        |
 0.0001 +
        -+---------+---------+---------+---------+---------+---------+---------+
       0.00      0.01      0.10      1.00      10.00    100.00  1000.00 10000.00

                                       TargetGrpMT
```

Figure 6 (APPENDIX A4). *Top*: Silver hake discards and landings (hail weights) for the Squid and Butterfish primary species group and Trawld gear group based on trips with observers during 2001-2004. *Bottom*: Same as top but records with zero discard are omitted and both axes are log scale.

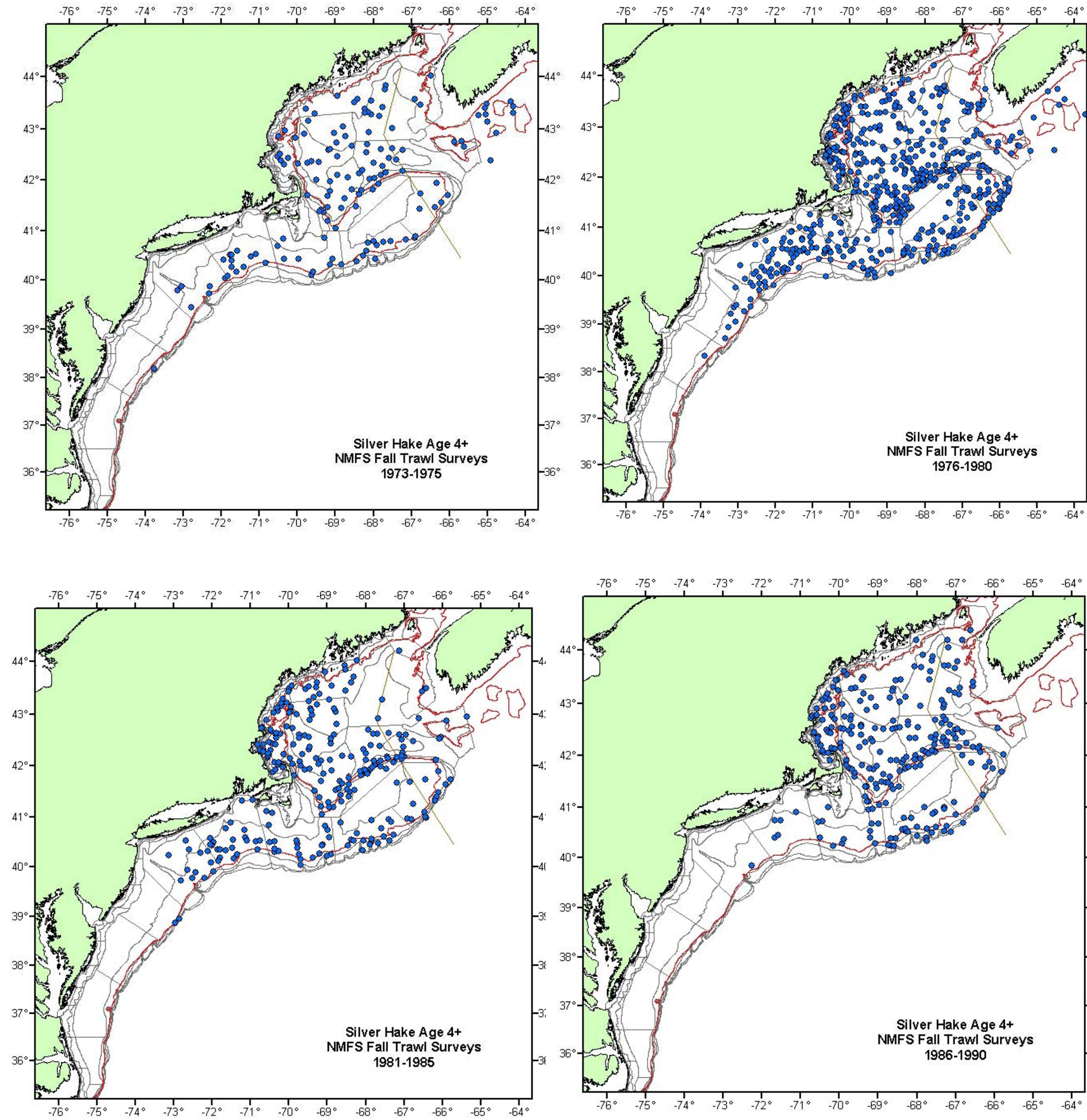
```
---------------- TargetGrpID=Squid/ButterFish GearGroup=Trawls -----------------

        Plot of Discard*TargetGrpMT.  Legend: A = 1 obs, B = 2 obs, etc.
Discard
 7.3881 +      A
        |
 6.3326 +
        |
 5.2772 +          A
        |    A B
 4.2217 +
        |    A
 3.1663 +       A
        |    B
 2.1109 +   BAABA
        |  AB BAA             A
 1.0554 +  AAA  A A  A
        |  CCAECD
 0.0000 +  ZUNHGFIBCDB   B        A  A                                 AA  B
        ---+----------+----------+----------+----------+----------+----------+--
           0          50         100        150        200        250        300

                                       TargetGrpMT

Plot of Discard*TargetGrpMT.  Legend: A = 1 obs, B = 2 obs, etc.
Discard
   1000 +
        |
    100 +
        |
     10 +                                          A
        |                                   A  ABBACAB A
      1 +                               B A C A B CABBA A A
        |                                 BAAB  A DCAC
    0.1 +                            B   A     A  B  A   A
        |                               A  B BB B   A  A    A
   0.01 +                     A AB A  A   AA B   AAA    A       BB
        |                       AA   A    A         BA A
  0.001 +                   A     A B AC          A AB
        |             A         B AA   A          A A
 0.0001 +          A            AA   B
        -+---------+---------+---------+---------+---------+---------+---------+
       0.00      0.01      0.10      1.00      10.00     100.00  1000.00 10000.00

                                       TargetGrpMT
```

Figure 7 (APPENDIX A4). *Top*: Silver hake discards and landings (hail weights) for the Hakes and Ocean Pout primary species group and Other/unknown gear group based on trips with observers during 2001-2004. *Bottom*: Same as top but records with zero discard are omitted and both axes are log scale.

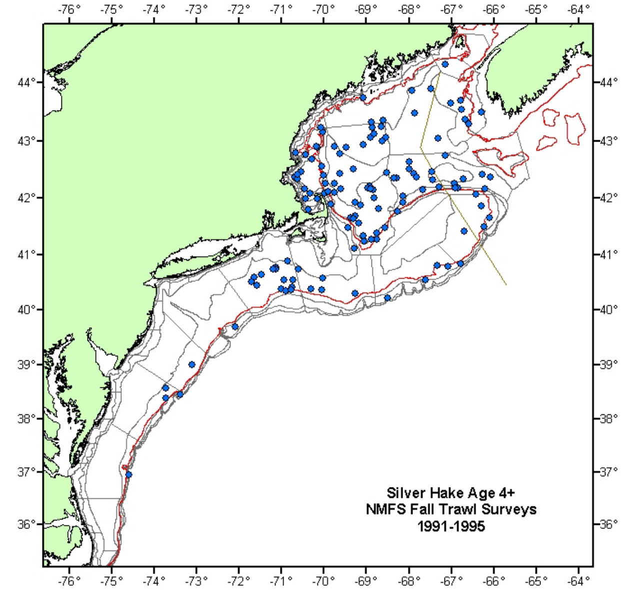
```
----------- TargetGrpID=Hakes+OceanPout GearGroup=Other/unknown gear -----------

        Plot of Discard*TargetGrpMT.  Legend: A = 1 obs, B = 2 obs, etc.

     Discard |
           3 +
             |
             |           A
             |
           2 +
             |
             |
             |
           1 +
             |
             |
             |
           0 +  A     A     A   A      A       A      A            A
             |
             ---+-------------+-------------+-------------+-------------+--
                0             1             2             3             4

                                       TargetGrpMT
```

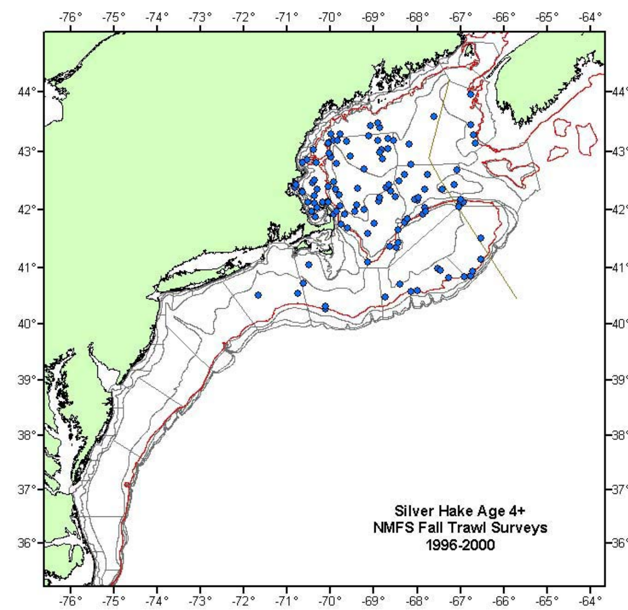
```
        Plot of Discard*TargetGrpMT.  Legend: A = 1 obs, B = 2 obs, etc.
Discard
   1000 +
        |
    100 +
        |
     10 +
        |                             A
      1 +
        |
    0.1 +
        |
   0.01 +                               A
        |                                 AA
  0.001 +
        |
 0.0001 +
        -+---------+---------+---------+---------+---------+---------+---------+
       0.00      0.01      0.10      1.00     10.00    100.00  1000.00 10000.00

                                       TargetGrpMT
```

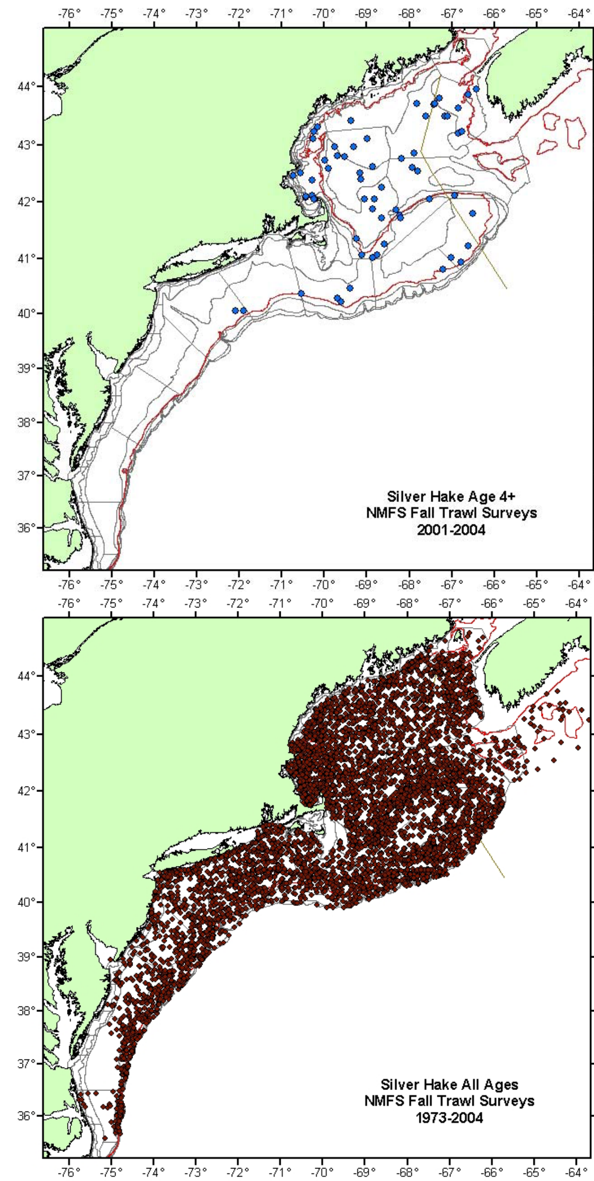
Figure 8 (APPENDIX A4). Location of tows with silver hake ages 4+ for NEFSC fall bottom trawl surveys during 1979-2004. The plots show the successive reduction in abundance of silver hake ages 4+ in the southern area over time. The last panel shows the location of all tows with silver hake of all ages during all years and, in comparison to other panels, shows the tendency for relatively young (ages 1-3) silver hake to use southern and nearshore habitats.



Appendix 5 Figure 8 (cont.)







Appendix 5 Figure 8 (cont.)

Figure 9 (APPENDIX A4). Location of random NEFSC spring bottom trawl survey tows (blue dots) and fixed Supplemental (Transect) bottom trawl survey tows (red dots) in the Hudson Canyon area during 2004-2005 that were used to estimate relative fishing power. Red lines show the 50, 100 and 200 m depth contours. Dark lines show NEFSC bottom trawl survey strata.

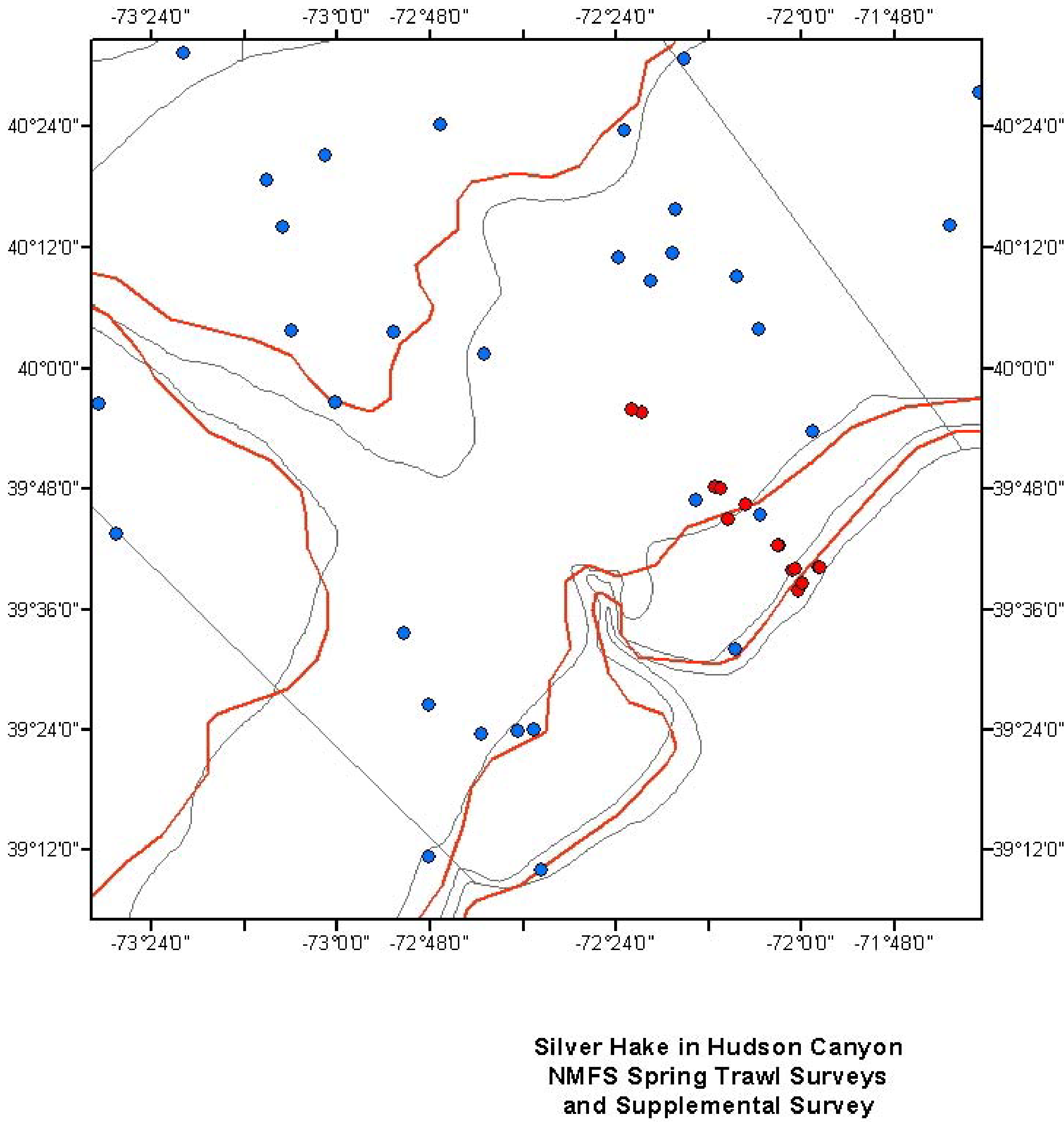


Figure 10 (APPENDIX A4). Location of random NEFSC spring bottom trawl survey tows (blue dots) and fixed Supplemental (Transect) bottom trawl survey tows (red dots) in the Baltimore Canyon area during 2004-2005 that were used to estimate relative fishing power. Red lines show the 50, 100 and 200 m depth contours. Dark lines show NEFSC bottom trawl survey strata.

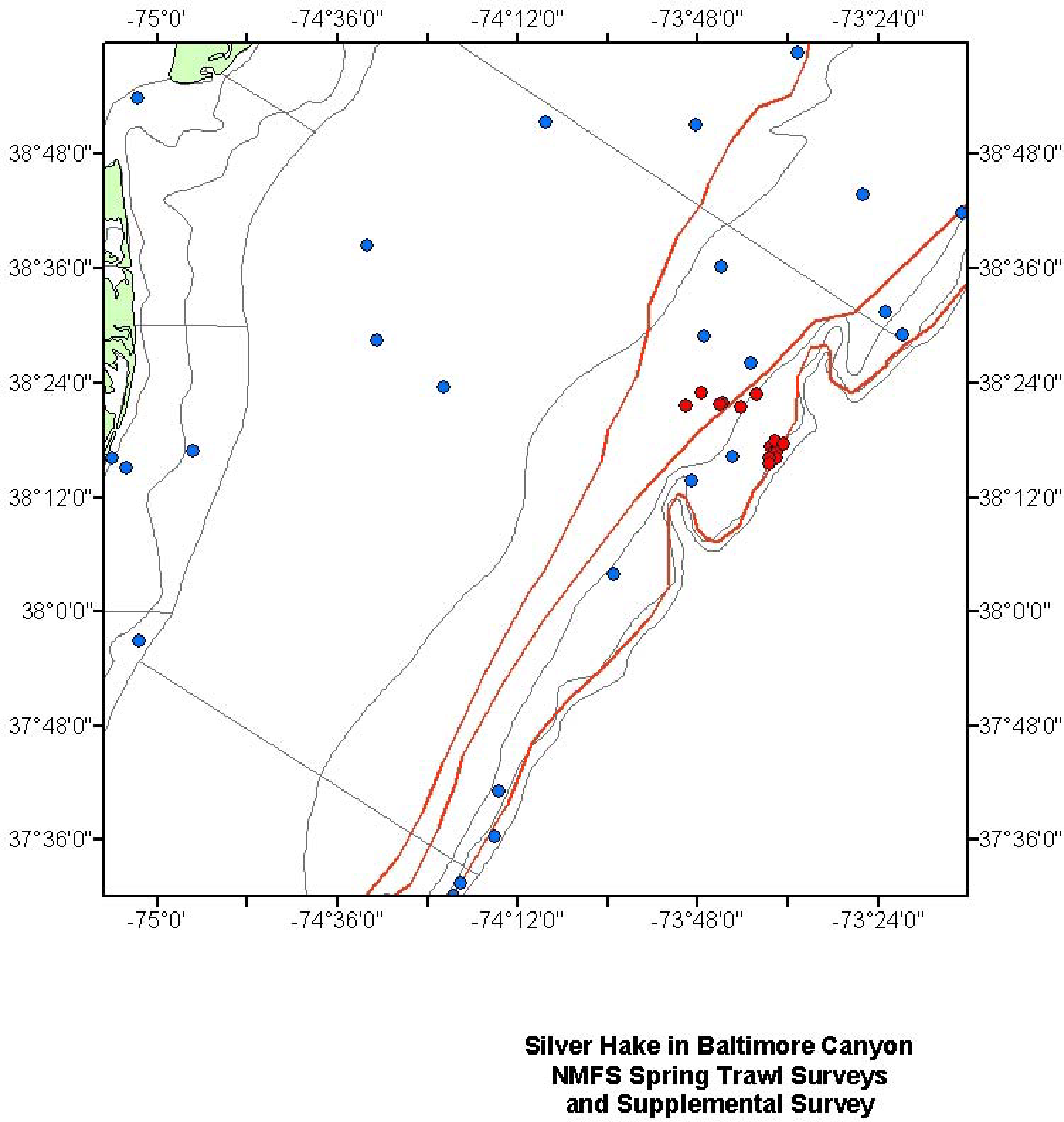


Figure 11 (APPENDIX A4). Text slides with information about Supplemental survey transects and stations that were requested by reviewers.

Map points

- Stations at 40, 50, 60, 80, 100 and 150 fathoms
  - Fixed locations only (same each year)
- Transects not on edge of canyons where fish may “pile up”
- Only two transects
  - Don’t know how representative

Randomizer’s

- Multispecies survey (like NEFSC)
  - None given higher importance
- Seasonal variation in migration patterns
- Tides
- Migratory patterns not pronounced in March
  - Winter hiatus?
- Away from canyons where fish can mix and don’t pile up

Transects

- Survey meant to answer questions about the timing of fish migrations (time at which fish cross the transect)
  - Away from canyons where fish might pile up
- Same transects for multiple target species at various times of year
- On steep grounds to minimize distance over transect
- Maximize trawable ground
  - Minimize gear damage
  - Same as NEFSC
- Proximity to other transects
  - Reduce steaming time
- Away from the “bend” north of Hudson canyon
- Away from really poor fishing grounds (i.e. not trawlable)
- Selected by a panel of different backgrounds

Bottom line

- Not a side-by-side gear experiment
- Only two transects
- Transects on towable ground where catch can be expected
- Not designed (on purpose or inadvertently) to maximize catch of silver hake

Figure 12 (APPENDIX A4). Minimum swept-area biomass (mt) for silver hake and offshore hake in the northern and southern stock areas based on NEFSC fall survey data and the special survey strata set.