A. STOCK ASSESSMENT OF SILVER HAKE FOR 2010

Terms of Reference:

1. Estimate catch from all sources including landings, discards, and effort. Characterize the uncertainty in these sources of data, and estimate LPUE. Analyze and correct for any species mis-identification in these data.

2. Present the survey data being used in the assessment (e.g., regional indices of abundance, recruitment, state surveys, age-length data, etc.). Characterize the uncertainty and any bias in these sources of data.

3. Evaluate the validity of the current stock definition, and determine whether it should be changed. Take into account what is known about migration among stock areas.

4. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series (integrating results from Silver hake TOR-5), and estimate their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results.
5. Evaluate the amount of silver hake consumed by other species as well as the amount due to cannibalism. Include estimates of uncertainty. Relate findings to the stock assessment model.

6. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; estimates or proxies for BMSY, BTHRESHOLD, and FMSY; and estimates of their uncertainty). If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

7. Evaluate stock status (overfished and overfishing) with respect to the existing BRPs, as well as with respect to the "new" BRPs (from Silver hake TOR 6).

8. Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).

    a. Provide numerical short-term projections (3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (e.g., terminal year abundance, variability in recruitment).

b. Comment on which projections seem most realistic, taking into consideration uncertainties in the assessment.
c. Describe this stock's vulnerability to becoming overfished, and how this could affect the choice of ABC

9. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.

Executive Summary

A new assessment model for silver hake (ASAP, Legault and Restrepo 1998) was attempted based on a "combined" (i.e. North + South) assessment area including estimates of fishery landings, discards, and predator consumption, by age class. While the SARC-51 Review Panel felt that the ASAP model represented an advance for the stock assessment, the ASAP results were not accepted due to difficulties in reconciling the inconsistent interpretations from the steep age profiles in the fishery and survey data. An Index Model (AIM) was also explored; however, the diagnostics were not adequate for stock status determination. Therefore, this assessment is based on trends in the three year moving averages for the age-aggregated, fall survey biomass indices (1973-1982) using the arithmetic means rather than the previous delta approach and the three year averages of exploitation indices (total catch/fall survey biomass index). These form the basis for the updated reference points for both the northern and southern management areas.

Based on the reference points in the existing FMP, silver hake is not overfished and overfishing is not occurring in both the northern or southern management areas. For the northern area, the three year delta mean biomass index from the NEFSC fall bottom trawl survey in Albatross units during 2007-2009 (6.79 kg/tow) was above the biomass threshold (3.31 kg/tow) and slightly above the biomass target (6.63 kg/tow). The three year average exploitation index (landings divided by survey biomass index for 2007-2009 (0.13) in the north was less than the exploitation threshold and target (2.57). In the southern area, the three year survey biomass index in Albatross units (1.39 kg/tow) was greater than the biomass threshold (0.89 kg/tow) but below the biomass target (1.78 kg/tow). The three year exploitation index for 2007-2009 (4.33) in the south was below the overfishing threshold (34.39) and target (20.63) .

Based on the updated and accepted reference points from SAW/SARC-51 in 2010, the northern stock of silver hake is not overfished and overfishing is not occurring. The three year arithmetic mean fall biomass index for 2007-2009 in Albatross units (6.20 kg/tow), was above the management threshold (3.21 kg/tow) but below the target (6.42 kg/tow). The three year average exploitation index for 2007-2009 (0.20 kt/kg) was below the management threshold (2.78 kt/kg). In the south, silver hake is also not overfished and overfishing is not occurring. The three year average arithmetic mean biomass, also based on the NESFC fall bottom trawl survey data for 2007-2009 in Albatross units (1.11 kg/tow), was above the biomass threshold (0.83 kg/tow) but below the target (1.65

kg/tow). The three year average exploitation index, for 2007-2009 (5.87 kt/kg) (Figure A9) was below the overfishing threshold (34.19 kt/kg)

Given that the ASAP model was not accepted as a basis for providing management advice, ASAP-based multiyear projections are not provided.

The scientific information available on silver stock structure (morphometrics, tagging, discontinuous larva distribution, homogeneous growth and maturity) is equivocal. Therefore, it was concluded that there was no strong biological evidence to support either a separate or combined silver hake assessment. The role of silver hake in the ecosystem was assessed using diet data. It was apparent that silver hake constitute an important link in the food web. Estimates of silver hake removals from the system from predatory based consumption suggest that consumption can be approximately 10 times higher than total catch. These consumption estimates were useful to inform both scaling of biomass estimates and the magnitude of mortalities for silver hake in the system.

Introduction

Hake Working Group Meetings

Three meetings were held in preparation of the 2010 silver hake assessment

1. Hake fishermen's/stakeholder's meeting – August 6, 2010 – UMASS School of Marine Science and Technology (SMAST), Fairhaven, MA. Participants include fishermen Dan Farnham and Bill Phoel. Also in attendance were David Goethel (Oversight Committee chair), Andrew Applegate (staff) Steve Cadrin (SSC and WG chair, SMAST), Pingguo He, Klondike Jonas, Yuying Zhang, Tony Wood, and Daniel Goethel (SMAST), Loretta O'Brien, Michele Traver, Katherine Sosebee and Larry Alade (NEFSC), and Dick Allen (advisor at large). A summary of the discussions is in Appendix A1.

2. Data Meeting – September 7-10, 2010, NEFSC Woods Hole MA. Participants included Steve Cadrin (WG Chair), Assessment leads (Larry Alade, Kathy Sosebee , Michele Traver), Rapporteurs (Jessica Blaylock and Julie Nieland), Mark Showell (DFO), Andy Applegate (NEFMC Staff), NEFSC (Loretta O'Brien, Mark Terceiro, Chris Legault, Tim Miller, Dave Richardson, Ayeisha Brinson, Jiashen Tang, Janet Nye, Mike Palmer, Paul Rago, Josef Idoine, Jon Hare), Moira Kelly (NERO), SMAST(Tony Wood, Yuying Zhang, Saang-Yoon Hyun)

3. Model Meeting – October 25-29, 2010, NEFSC, Woods Hole, MA. Participants included Steve Cadrin (WG chair), Assessment leads ((Larry Alade, Kathy Sosebee , Michele Traver), Rapporteurs (Jessica Blaylock and Julie Nieland), Mark Showell (DFO), Andy Applegate (NEFMC Staff), Dan Farnham (Fisherman and Industry Advisor), NEFSC (Loretta O'Brien, Paul Nitschke, Mark Terceiro, Jay Burnett, Chris Legault, Liz Brooks, Tim Miller, Jon Deroba, Rich McBride, Jim Weinberg, Paul Rago, Josef Idoine, Jon Hare, Janet Nye, Dave Richardson, Laurel Col, Jason Link), SMAST(Tony Wood, Yuying Zhang, Dan

Goethel). The groups met by correspondence after the meetings, including a WebEx meeting on November 5, 2010 to report updates on silver hake analyses, provide guidance on reference points and discuss plans for report development.

This Working Group (WG) report includes products from all three meetings and contributions from all participants. It also has edits which reflect the outcome of the SAW/SARC51 peer review.

Biology

Silver hake also known as whiting, *Merluccius bilinearis* range from Newfoundland to South Carolina. In U.S. waters, silver hake are managed as two separate stocks (Almeida 1987a). The northern silver hake stock inhabits Gulf of Maine - Northern Georges Bank waters, and the southern silver hake stock inhabits Southern Georges Bank - Middle Atlantic Bight waters (Figure A1). Silver hake migrate in response to seasonal changes in water temperatures, moving toward shallow, warmer waters in the spring. They spawn in these shallow waters during late spring and early summer and then return to deeper waters in the autumn (Brodziak et al. 2001). The older, larger silver hake especially prefer deeper waters. During the summer, portions of both stocks can be found on Georges Bank, whereas during the winter, fish in the northern stock move to deep basins in the Gulf of Maine, while fish in the southern stock move to outer continental shelf and slope waters. Silver hake are widely distributed, and have been observed at temperature ranges of 2-17° C (36-63° F) and depth ranges of 11-500 m (36-1,640 ft). However, they are most commonly found between 7-10º C (45-50º F) (Lock and Packer 2004).

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

Fishery Regulations

The following briefly outlines the current small mesh multispecies regulations (based on the small mesh exemption program) for the New England whiting fishery to provide context for interpreting the fishery and model results.

1. 1994 & 2000 - Exempted fisheries allows vessels to fish for specific species such as whiting or northern shrimp in designated areas using mesh sizes smaller than the minimum mesh size allowed (Gulf of Maine, Georges Bank, Southern New England, Mid-Atlantic : 6.5-inch square or diamond) under the Regulated Mesh Area (RMA) regulations .
2. Permits

    a. Open access Category K Multispecies
    b. Limited Access Category A-F (non Days-at-Sea fishing)
3. No Size Limits
4. 500 lbs at sea transfer limit.
5. 2003 - Possession limits vary by exemption area
    a. 3,500 lbs if mesh < 2.5 inches (63.5mm)
    b. 7,500 lbs if mesh <=3.0 inches (76.2mm)
    c. 30,000 lbs if mesh > 3.0 inches (76.2mm)
    d. No Red Hake possession limit

TOR 1. Estimate catch from all sources including landings, discards, and effort. Characterize the uncertainty in these sources of data, and estimate LPUE. Analyze and correct for any species mis-identification in these data.

Commercial Landings

Silver hake landings (Tables A1, Figures A2-A4) increased substantially during the 1960's due to direct fishing by distant water fleets (DWF) operating in the U.S. waters. Nominal landings of silver hake from the northern stock were significantly higher than those from the southern stock during the mid-1950's through the mid-1960's and fell below the southern stock starting in the late 1960's due to the expansion of the DWF in the southern region. Landings in the north peaked to over 94,000 mt in 1964 and have steadily declined substantially since 1975. Despite the departure of the DWF in 1976, landings continue to further decline and have been less than 10,000mt per year after 2002 (Table A1, Figure A3).

Nominal domestic landings from the southern silver hake stock have varied between 5,000-27,000 mt, (Table A1, Figure A4). However, between 1960 and 1980, distant-water fleet landings of southern silver hake were very high, peaking at about 280,000 mt in 1965 and around 100,000 mt in 1974. Distant-water fleet landings diminished in the mid-1980s, and total landings have since continued to gradually decrease. In 2009, total landings were near a historic low at 7,000 mt.

Maine and Massachusetts have been the primary states in which silver hake from the northern stock have been landed (Table A2). Rhode Island became important in the 1980s and Connecticut in the 1990s. For landings of the southern stock, Rhode Island and Massachusetts were historically important, with New York, New Jersey and Connecticut increasing in importance (Table A3).

The otter trawl has been the principal gear used in the both stocks with some landings in the northern stock coming from the shrimp trawl fishery until the early 1990s with the use of the Nordmore grate (Tables A4-A5, Figures A5-A6). In recent years, sink gill net has increased slightly in importance, although there are significant landings from the other category, which includes unknown gears.

The seasonality of landings from the two stocks is different, with most of the northern stock landings occurring in the second half of the year and the first half of the year accounting for a approximately less than 20% of the annual. Landings from the southern stock appear to be landed more consistently throughout the year than in the north (Tables A6-A8, Figures A7-A8).

Silver hake are landed in seven commercial categories: unclassified round, medium, small, dressed, juvenile, king and large. The vast majorities of landings are reported as round or dressed market category, with other market categories appearing sporadically over time (Tables A9-A10, Figures A9-A10). King silver hake were separated starting in 1981, with smalls appearing in 1982. Large silver hake were further separated in 2004. A juvenile market category appeared in 1994 and was a larger component of the southern stock landings (Tables A9-A10, Figures A11-A12).

A sympatric species of hake, offshore hake, is often landed as silver hake (Garcia-Vazquez et al 2009). In 1991, landings of offshore hake began to be separated, although the extent to which this is actually occurring is still unknown. The geographical distribution of offshore hake is limited to the southern stock of silver hake. Therefore, landings from the northern stock are considered to be silver hake while southern landings are potentially a mixture of silver and offshore hake. In order to estimate landings of silver hake from the southern region, two alternative methods were developed.

Length-based species composition

The first method used the port length samples directly. Length samples of silver and offshore hake were combined by stock (Tables A11-A13). In examining the silver hake length samples by market category, it appeared that most of the market categories were similar in length composition to the round category (Figures A11-A12). Therefore, only three market categories were used for stratification: round, king, and large. Even with the reduction of market categories, pooling over years was required to get an adequate number of fish (Table A14). The length-weight equations by season from Wigley et al 2003 were applied to the samples and used to estimate the landings numbers at length for each market category.

For the southern stock, length compositions for each species were estimated for the spring and fall surveys from 1968-2009. The species length-weight equations were then applied to determine weight-at-length by species. The proportions at length by species for both number and weight were applied to the commercial landings-at-length to estimate landings-at-length by species (Figures A13-A14). The lengths had to be grouped into intervals to avoid zero cells in the survey. To hind-cast the species proportions back to 1955, the average proportion of silver hake for the time series was used and applied to the total silver hake landings.

Depth-based species composition

This method relates survey catch composition to Vessel Monitoring System (VMS) derived commercial landings from 2004-2009 using survey depth as an explanatory factor to develop a model that predicts the hake species landings composition. Offshore and silver hake composition (R_{23}) in the trawl survey tows were modeled as a two parameter logistic function of average depth. Only survey tows with silver hake, offshore hake or both were fitted and mean depth was the dependent variable.

$$R_{23} = \frac{e^{a+b*depth}}{1+e^{a+b*depth}}$$

For each stratum group, survey (winter, spring, and fall), and sets of time series, the catch and depth data were fitted by a non-linear least squares, weighted by the number of positive tows in a stratum, using the Marquardt method (Marquardt 1963) to aide convergence. R^2 and Wald 95% confidence intervals (Cook and Weisberg 1990) were calculated for parameters a, b, D50, and the range to evaluate goodness of fit. Fitting the data with the a two parameter logistic non-linear regression using maximum likelihood estimation and iteratively reweighted least squares approaches was attempted, but did not improve the results.

The parameter estimates for 1985-2009 were applied to the depth association with the VMS-derived commercial landings at depth (Applegate 2010). The model ratio of offshore to silver hake were assigned to landings from each group depth zone, survey season, and survey stratum group and summed for the calendar year (Applegate 2010). The final landings from this method were greater than 90% of the total landings reported by dealers in 2004-2009.

Annual model estimates of silver hake landings for the southern stock area ranged from 4,207 – 6566 mt in 2003-2009, representing 88-95% of the total hake landings **(Table A15)**. Although the depth based landings were derived from VMS effort distribution, hindcast estimates were used for 2003 because the model based estimates appeared to be biased due to small vessels (i.e. fished inshore and catch silver hake) were underrepresented when multispecies VMS requirements first became effective.

Estimates of offshore hake landings ranged between 290 – 893 mt and 5 – 12% of total hake landings **(Table A15)**. These estimates are considerably higher than those reported by either dealers or by fishermen on Vessel Trip Reports (VTR).

Given that VMS data for 2004 – 2009 were deemed acceptable for direct estimation of silver and offshore hake landings composition, landings prior to 2004 (1955 – 2003) were hindcasted to generate longer time series of removal for assessments and for developing biological reference points. Although the hindcast procedure allowed the distribution of catch to vary between statistical areas, the distribution of catch within these intermediate depth statistical areas was assumed to be constant, equal to the average depth distribution observed by VMS during 2004-2009. Details of the hindcasting methodology can be found in Applegate (2010).

The estimated silver hake landings from the depth based logistic model, including the hindcasting, rose from a low of 12,891 mt in 1955 (93% of the total) to over 282,000 mt in 1990 (92% of the total), then declined to 4207 mt in 2006 (90% of the total). Recent landings totaled 5,006-6,406 mt (93 - 95%). Silver hake as a proportion of total hake landings ranged from 87% in 1971, 1976, 1978-1980 to 98% in 1988 and 1996 (Table A16).

Hindcast and model based estimates of offshore hake landings were an order of magnitude greater than that reported by dealers. Landings rose from 951 mt in 1955 (7.0% of the total) to 24,198 mt in 1965 (8% of the total). Offshore hake as a proportion of total hake landings ranged from 2% in 1971, 1976, 1978-1980 to 13% in 1988 and 1996 (Table A16).

The resulting silver hake landings for the two methods are given in Table A15. On average, the two methods gave similar results, with the length-based model averaging 96% silver hake while the depth-based method averaged 94% silver hake. Conversely, there were some differences in the offshore hake estimates with the depth based method averaging approximately 7% and 4% for the length-based method (Table A16, Figure A15).

Given the similarity between both models, the SARC Panel agreed that the results from both methods will have undetectable differences in the assessment results. For the purpose of this assessment, the length-based estimator was considered more suitable primarily due to the number of years hindcasted (1955-1967) relative to the depth-based approach (1955-2003). It was also recognized that the length based approach provided an advantage of estimating fishery age composition which was not readily available in the depth-based method. .

Sampling Intensity

The level of port sampling has generally been strong since the mid-1990's with higher sampling in the south relative to the north. In 2007, over 17,000 length measurements were taken in the southern area resulting in peak sampling intensity of 326 lengths per 100 mt. In the north sampling intensity increases substantially in 2006 and 2007 (115 and 107 lengths per mt respectively). In the recent years, sampling intensity has somewhat declined in both stock areas but more substantially in the north due to very low observed landings (Table A17). Overall, sampling intensity for the silver hake fishery has certainly improved compared to pre-1994 period, particularly in the south.

Commercial Discards

Discard estimates were re-calculated in this assessment. The ratio-estimator used in this assessment is based on the methodology described in Rago et al. (2005) and updated in Wigley et al (2007). It relies on a d/k ratio where the kept component is defined as the total landings of all species within a "fishery". A fishery is defined as a homogeneous group of vessels with respect to gear type (longline, otter trawl, shrimp trawl, sink gill net, and scallop dredge), quarter, and area fished (GOM-NGBK, SGBk-MA), and for otter trawls, mesh size (<= 5.49", > = 5.5 "). All trips were included if they occurred within this stratification regardless of whether or not they caught hakes.

The discard ratio for hakes in stratum h is the sum of discard weight over all trips divided by sum of kept weights over all trips:

$$\hat{R}_h = \frac{\sum_{i=1}^{n_h} d_{ih}}{\sum_{i=1}^{n_h} k_{ih}} \quad (1)$$

Where d_{ih} is the discards for hakes within trip i in stratum h and k_{ih} is the kept component of the catch for all species. R_h is the discard rate in stratum h. The stratum weighted discard to kept ratio is obtained by weighted sum of discard ratios over all strata:

$$\hat{R} = \sum_{h=1}^{H} \left(\frac{N_h}{\sum_{h=1}^{H} N_h} \right) \hat{R}_h \quad (2)$$

The total discard within a strata is simply the product of the estimate discard ratio R and the total landings for the fishery defined as stratum h, i.e., $D_h = R_h K_h$. Cells with < three trips were imputed using annual averages by gear type and region. To hind-cast the discards to 1981 (the first year in which there was no industrial fishery), discards/total landings by half year for the first three years (1989-1991 for otter trawl, sink gill net, and shrimp trawl; 1992-1994 for longline and scallop dredge) were averaged and the rate applied to the total landings from the dealer database. For the otter trawl fisheries, the mesh sizes were combined for the hind-cast.

Discards from the longline and sink gill net fishery were minimal for silver and offshore hake in both stock areas (Table A18-A21). Discards from the otter trawl fisheries have been significant and variable.

The same problem with species identification that exists in the landings was found in the Fisheries Observer Program (FOP) data. There are discards of offshore hake estimated for the north. The geographical distribution of offshore hake is limited to the southern stock of silver hake and therefore, any discards from the northern stock are considered to be silver hake. In order to estimate discards of silver hake from the southern region, only the length-based estimator was employed.

The observer discard length samples of silver and offshore hake were combined by stock (Tables A22-A25). Enough length samples were available for large and small mesh otter trawls in both regions and sink gill net and shrimp trawl in the north. Pooling over years was still required to get an adequate number of fish (Tables A26-A27). The length-weight equations by season from Wigley et al 2003 were applied to the samples and used to estimate the landings numbers at length for each market category. The discards-at-length were raised to the total discards including all the gear types to account for as much of the removals as possible.

For the southern stock, length compositions for each species were estimated for the spring and fall surveys from 1968-2009. The species length-weight equations were then applied to determine weight-at-length by species. The proportions at length by species for both number and weight were applied to the commercial discards-at-length to estimate discards-at-length by species. The lengths had to be grouped into intervals to avoid zero cells in the survey. To hind-cast the species proportions back to 1981, the average proportion of silver hake for the time series was used and applied to the total silver hake discards.

Silver hake discards in the north were approximately 23% of the total catch in years 1981-2009 (Tables A28-A30). Total discards peaked to over 2,900mt in 1982, declined substantially in 1993 to a low of 37mt in 2006 and increased 14% from 2008 (167mt) to 2009 (190mt). In the south, the proportion of discards to total catch in years 1981-2009 was similar to the north (22%), peaked in 1989 (~6500mt), declined substantially in the mid 1990's with a brief increase in 1999 to levels observed in the early 1980's (3500mt). Total discards of silver hake in the south decreased 19% from 2008 (1033mt) to 2009 (839mt).

Catch at age

Due to the lack of commercial age data from the commercial fishery, age compositions for landings and discards were derived from the NEFSC bottom trawl survey age-length keys (ALK) from 1973-2009. Commercial length for both landings and discards frequencies were estimated by half years from the length-based estimator as described above. The silver hake age-length keys were then calculated for both the fall and spring then applied to the length-based landings (1973-2009, Tables A31-A33) and discards (1981-2009, Tables A34-36) by half years (i.e. spring ALK for the half 1 and fall ALK for half2) to capture seasonal differences in the fishery. The fall age-length keys were not available for fall 1974. Therefore adjacent age-length key from 1973 were borrowed to impute commercial landings at ages for half 2 based on minimal differences observed in the mean size at age in the fall survey during the early 1970's.

The catch at age composition of silver hake catches in the fishery has shown a general truncation in the age structure since the late 1980's with fewer availability of fish older than age-6 in the population (Tables A37-A39, Figures A16-A18). In the north, vast majority of the catches were dominated by ages 2-4 in the 1970's, partly supported by the strong 1972 year class. By the early 1980's, ages 2 and 3 declined severely but remained stable through the late 1980's. There were a few strong year classes around the 1990's contributing to moderate expansions in ages 2 and 3. Age-4 continues to decline with further reductions in age-5 in the fishery. However, it appears that there was a 2006 year class which appears to have contributed to the increase in age 3 in 2009 (Table A37, Figure A16).

Similarly in the south, majority of the catches were also dominated by ages 2-4 in the 1970's, supported by the 1972 year class but declined drastically around the early 1980's with moderate expansions in ages 2 and 3 during the 1990's. The age-4 group continues to decline with further truncation in the age structure. However, there have been increased catches of age-1 during the early 1990's probably and recently in the last five years. This is probably due to increased demand for small hake in the Spanish market (comm. Andy Applegate) in the 1990's and more recently, probably related to over the side bait sales (Table A38, Figure A17).

Summary of the combined stock area catches are summarized in Table A39 and in Figure A18. The perception of the age structure does not change relative to the north and south. Similar properties such observed in the north and southern areas such as the truncation of older fish and the dominance of ages 2 and 3 in the recent years still persists.

Mean Weights at age

The overall fishery weights at age were calculated from the landings and discards weighted by the respective catch at age for the north, south and combined area stock. (Tables A40-A42, Figures A19-A21). The mean weight at age (kg) were quite similar but variable between for fish greater than age-4 particularly since the mid 1980's. Only slight variations in mean weights at age were apparent during the mid 1990's - mid 2000's which are likely related to variations in year class strength as they become recruited to the fishery.

Commercial Fishing Effort

There are currently no estimates of CPUE or effort for this species. Given the uncertainties given with species identification above and the major changes in management noted in the introduction, CPUE is not likely to be a good indicator of stock status. In particular, the fishery in the north has been limited in areas they can fish with small mesh. These are not necessarily to good silver hake fishing areas. Over time, the fishery has also changed from one dominated by a distant water fleet that took substantial quantities of everything to a much smaller fishery that may be driven more by prices and regulation than abundance.

TOR 2. Present the survey data being used in the assessment (e.g., regional indices of abundance, recruitment, state surveys, age-length data, etc.). Characterize the uncertainty and any bias in these sources of data.

Data Source: The primary sources of biological information for silver hake are based on the annual fishery independent surveys conducted by the Northeast Fisheries Science Center (NEFSC). The surveys were conducted using a random stratified sampling design which allocates samples relative to the size of the strata, defined by depth. The surveys extend from the Gulf of Maine to Cape Hatteras, in offshore waters at depths 27-365 meters, and have been conducted in the fall since 1963 and in the spring since 1968. The winter bottom trawl survey began in 1992 and was specifically designed for flatfish, however, the deeper survey strata were not sampled until 1998 (Figure A22). The winter trawl survey does not cover the Georges Bank area because the survey was designed specifically for flatfish in the southern region. Details on the stratified random survey design and biological sampling methodology may be found in Grosslein (1969), Azarovitz (1981) and Sosebee and Cadrin (2006). Other surveys used in the analysis of silver hake are NEFSC shrimp survey (1985-2009), Massachusetts Division of Marine Fisheries (1978-2009) fall and spring surveys and Rhode Island (1979-2010), Connecticut (1984-2009), and Maine-New Hampshire (2000-2009) state surveys.

Transform: Survey estimates were computed using both delta transformation and arithmetic means for numbers and weight. The Whiting Plan Development Team (PDT) has used the delta mean for assessing stock status. The delta transformation uses only the positive tows for log transformation given the following equation (syrjala 2000):

$$\hat{M}_\delta = \begin{cases} \frac{m}{n} e^{\bar{y}} \psi_m\left(\frac{1}{2}s_y^2\right) & m > 1, \\ \frac{1}{n} x_1 & m = 1, \\ 0 & m = 0 \end{cases}$$

m = number of non - zero tows

n = total number of tows

$$\hat{V}_\delta = \begin{cases} \frac{m}{n} e^{2\bar{y}} \left[\psi(2s_y^2) - \frac{m-1}{n-1}\psi_m\left(\frac{m-2}{m-1}s_y^2\right)\right] & m > 1, \\ \frac{1}{n} x_1^2 & m = 1, \\ 0 & m = 0 \end{cases}$$

Examination of the differences between the delta and arithmetic means revealed that use of the delta transformation did not reduce the variability of the survey and may have increased interannual variability (See offshore Hake assessment). If a survey has a high variance, the back-transformation may be biased high. The delta transformation was also more sensitive to the handling of missing weights. Prior to 2001, the data for weights were recorded to the nearest 0.1 kg and if a tow contained only a single small fish, the weight was entered into the data as zero. Since the delta transform uses the positive tow, how this is handled has an impact on the result. There were three options: taking out the zeros, leaving in the zeros, and filling in zeros using a length-weight equation. Since these options did not affect the arithmetic as much as the delta mean, the decision was made to use the arithmetic and length-weight options for any new analyses.

Several surveys were explored to provide indices of relative abundance. The properties of each survey are summarized in Table A43. Based on the stock definition provided in TOR 3, survey indices for the assessment was based on data from all strata that have been sampled consistently (NEFSC fall and spring survey). However, future work will explore other surveys as sensitivity analyses in the assessment.

The NEFSC strata set used for the northern area are: 20-30 and 36-40. The NEFSC strata used for the southern management area are: 1-19 and 61-76. The combined strata set are: 1-30, 36-40, and 61-76 (Figure A22). Survey age composition were estimated for the north, south and combined areas from 1973-2009 for when survey ages were available. Of special note, fall 1974 was never aged for both the north and south regions, and therefore age-length key from 1973 was borrowed to impute ages for 1974. As discussed earlier, the mean size at age for both years were similar. The 2009 and 2010 survey values were calibrated to the Albatross IV by using seasonal length-based calibration coefficients. Details on the estimation of the calibration coefficients may be found in Miller et al. 2010. The strata set for the shrimp survey is 1-12, with no calibration needed for 2009. The strata set for the winter surveys are: 1-3, 5-7, 9-11, 13-14, 61-63, 65-67, 69-71, and 73-75. No calibration was also needed for the winter survey, as it was discontinued in 2007. Massachusetts Division of Marine Fisheries data was separated into northern and southern areas. The northern strata set used were 18-36 and the southern strata set used were 11-17 (Figure A23).

Minimum swept area abundance and biomass were calculated by using swept area conversions of 0.0112 for the NEFSC fall and spring surveys, 0.004 for NEFSC shrimp survey, 0.0131 for the NEFSC winter survey, and 0.003846208 for Massachusetts Division of Marine Fisheries (MADMF) fall and spring surveys. Swept area estimates were not calculated for the other state surveys. Swept area estimates at age were also calculated for the NEFSC fall and spring surveys, in the northern, southern, and combined management areas.

Silver hake survey distribution suggests that most of the higher catches for silver hake are in the Gulf of Maine and on Georges Bank in the fall, whereas they are along the shelf edge in the spring. In the spring of the 1970s, most of the silver hake seemed to be in the Gulf of Maine and southern New England, with few on Georges Bank. However, even though the areas did not change through the 1980s and 1990s, the density did. It seems a bit scarcer during this time period. In the fall, there seems to be more silver hake on Georges Bank than in the spring, though most of the catch weight is in the Gulf of Maine (Figures A24-A35).

Calibration: In 2009 the *NOAA* ship *Henry B. Bigelow* replaced the *R/V Albatross IV* as the primary vessel for conducting spring and fall annual bottom trawl surveys for the Northeast Fisheries Science Center (NEFSC). There are many differences in the vessel operation, gear, and towing procedures between the new and old research platforms

(NEFSC Vessel Calibration Working Group 2007). To merge survey information collected in 2009 onward with that collected previously, we need to be able to transform indices (perhaps at size and age) of abundance from the *Henry B. Bigelow* into those that would have been observed had the *Albatross IV* still been in service. The general method for merging information from these two time series is to calibrate the new information to that of the old (Pelletier 1998).

Specifically we need to predict the relative abundance that would have been observed by the *Albatross IV* ($\hat{R}_A$) using the relative abundance from the *Henry B. Bigelow* (R_B) and a "calibration factor" (ρ),

$$\hat{R}_A = \rho R_B . \qquad (1)$$

To provide information from which to estimate calibration factors for a broad range of species, 636 paired tows were conducted with the two vessels during 2008. Paired tows occurred at many stations in both the spring and fall surveys. Paired tows were also conducted during the summer and fall at non-random stations to improve the number of non-zero observations for some species. Protocols for the paired tows are described in NEFSC Vessel Calibration Working Group (2007).

The methodology for estimating the calibration factors was proposed by the NEFSC and reviewed by a panel of independent scientists in 2009. The reviewers considered calibration factors that could potentially be specific to either the spring or fall survey (Miller et al. 2010). They recommended using a calibration factor estimator based on a beta-binomial model for the data collected at each station for most species, but also recommended using a ratio-type estimator under certain circumstances and not attempting to estimate calibration factors for species that were not well sampled. In the case of offshore hake, using silver hake calibration factors as a proxy was better than not using any calibration factors.

Since the review, it has become apparent that accounting for size of individuals can be necessary for many species. When there are different selectivity patterns for the two vessels, the fraction of available fish of a given size taken by the two gears is different. Therefore, the ratio of the mean catches by the two vessels will change with size. Under these circumstances, the estimated calibration factor that ignores size reflects an average ratio weighted across sizes where the weights of each size class are at least in part related to the number of individuals at that size and the number of stations where individuals at that size were caught. Applying calibration factors that ignore size effects to surveys conducted in subsequent years when the size composition is unchanged should not produce biased predictions (eq. 1). However, when the size composition changes, the frequency of individuals and number of stations where individuals are observed at each size changes and the implicit weighting across size classes used to obtain the estimated calibration factor will not apply to the new data. Consequently, the predicted numbers per tow that would have been caught by the *Albatross IV* will be biased.

For silver hake, we fit a suite of beta-binomial models that made different assumptions on the relationship of the calibration factor to length. The models ranged from those that were constant with respect to length to logistic and double-logistic functions of length. A season-specific model was chosen based on AIC_c for silver hake where a logistic functional form for the spring and a double-logistic form for the fall provided the best fit (Table A44, Figure A36). To estimate weight per tow for the 2009 and 2010 surveys, the length-weight equations by season from Wigley et al. 2003 were applied to the length frequencies.

North Survey trends:
The NEFSC fall survey biomass steadily increased continuously through the 1970s, peaked in 1998 at 40,462 metric tons and then declined to 3,672 metric tons in 2005, lowest in the time series. Biomass has increased in the last few years and is currently at 14,748 metric tons, a 31% increase from 2008 (11,285 mt; Table A45, Figure A37).

The NEFSC spring survey has been quite variable. There was a large peak in 2001, with 22,309 mt and then considerably declined until 2006, with 915 mt. Since then,the biomass has increased and estimated at 5,673 mt in 2009 (Table A46, Figure A38).

The NEFSC shrimp survey swept area biomass was at its highest early in the time series, in 1987 with 149,508 metric tons. It dropped substantially to 16,302 metric tons in 1988. The survey continued to vary until thereafter, then declined to an all time low of 9,501 metric tons in 2006. Biomass in 2009 was 16,239 mt, a 42% decrease from 2008 (27,980 mt) (Table A47, Figure A39).

The MADMF fall surveys indicate two large spikes in silver hake swept area biomass, 1986 and 2000, with over 2,000 mt. The most recent years have seen a decrease, with 2009 only catching 651 mt (Table A48, Figure A40).

The MADMF spring surveys have much lower values than the fall. Only in 1987 and 2000 were there over 1,000 mt caught. In 2004, the spring survey saw its lowest catch of silver hake in the time series, with only 47 mt. It has since increased to 225 mt in 2009 (Table A49, Figure A41).

The MENH fall survey has been variable without trend but the spring survey peaked in 2002 at approximately 12 kg/tow, declined sharply in 2006 to 1.6 kg/tow and has steadily increased in the last three years (Table A50, Figures A42-A43).

North Age Composition: Fall survey age composition shows a general truncation of older age fish with less availability of fish older than age 6. Ages-1 and 2 are the abundant in the survey. The strongest year class over the time series was in 1997 with over 400,000 fish. In 2006, there was a moderate size year class which contributed to the expansion of age-3 in 2009. Since the late 1980's and early 1990's, Age 4 and 5 has declined significantly consisting of only 1% of the survey catch (Table A45, Figure A44).

Similar to the fall survey, majority of the spring survey catches consist of ages 1 and 2's and very few fish older than age-5. There has been several strong year classes since the mid-1980's contributing to significant expansion of age 2's and moderately for age-3. A marginal increase was noted for age-4 in the early 2000, but has declined in the recent years (Table A46, Figure A45).

South Survey Trends
The NEFSC fall survey swept area biomass was higher during the 1970's and 1980's than any other part of the time series. Biomass peaked in 1985 at 11,760 metric tons then steadily declined the 1990's to approximately 2,600mt in 1994 then briefly increased in 2001 to over 6,700 metric tons. Biomass has as averaged around 4,000mt in the last 10year and approximately around 3,600 metric tons, a and currently at 3,600 metric tons in 2009, a 20% decrease since 2008 (4,513 metric tons; Table A51, Figure A46).

The NEFSC spring survey had considerably higher biomass than the fall survey. It was fairly high in the 1970s, averaging over 11,000 metric tons. It then decreased through the 1980s and 1990s, with a large spike in 1996 at 20,553 metric tons. In 1997, it fell to 2,142 metric tons. In 2010, it has increased to 3,783 metric tons (Table A52, Figure A47).

The NEFSC winter survey has a very short time series, 1992-2007. The swept area biomass was fairly stable throughout the time series. The largest biomass was in 1993 with almost 8,000 metric tons. It stayed considerably lower than that until it was discontinued in 2007 (Table A53, Figure A48).

The MADMF fall surveys indicate very low swept area biomass. There were only three years in the time series where the catch was over 50 metric tons. In 2007, the biomass plummeted from 25 metric tons down to 0.04 metric tons. The most recent years have increased moderately, with 2009 catching 0.22 metric tons (Table A54, Figure A49).
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The MADMF spring survey has much higher values than the fall, but has generally declined over time. In 1987, there was over 2,000 metric tons caught. In 2003, the spring survey saw its lowest catch of silver hake in the time series, with only 2 metric tons. It has recently increased to 26 metric tons in 2009 (Table A55, Figure A50).

Survey trends for Rhode Island state survey has been variable without trend. The Connecticut survey on the other hand was highest early in the time series but has been low ever since (Table A56, Figures A51-A52).

South Age Composition: Similar to the north, the south has also experienced a general truncation in the age structure with fewer older fish than age-6 in both the fall and the spring survey. Despite the consistent appearance of strong year classes in the last decade, there has been a substantial decline of age 4 and 5 in the surveys. However, the spring survey showed an unusual increase of age-3 in 1989 with approximately 260,000 fish. It is unclear for the sudden increase in age-3. This is likely due to aggregation of this size class during the survey (Tables A51-A52, Figures A53-A54).

Combined North and South
The NEFSC combined area fall survey is driven by the northern region peaking in 1998,

with 42,353 metric tons and was extremely low in 2005 at 6,773 metric tons. It has increased recently with biomass at approximately 18,000 metric tons in 2009 (Table A57, Figure A55). In 1975, the spring survey had its highest biomass in the time series, at 37,136 metric tons. Then it hit an extremely low point at 4,725 metric tons in 1997. The survey had smaller spikes in 2000 and 2001 where the catch was over 20,000 metric tons. In 2009, the swept area biomass increased to 13,278 metric tons (Table A58, Figure A56). Similar pattern in the age structure was also observed in the combined stock areas as in the northern region (Tables A57-A58, Figures A57-A58).

TOR 3. Evaluate the validity of the current stock definition, and determine whether it should be changed. Take into account what is known about migration among stock areas.

Two subpopulations of silver hake are assumed to exist within the U.S. EEZ (Almeida 1987a). Analyses of morphometrics (Conover et al. 1961, Almeida 1987a) are the primary basis for this delineation further supported by otolith microconstituent (Bolles and Begg 2000). However, genetic analyses of the population structure have been inconclusive (Schenk 1981). The northern silver hake stock inhabits the Gulf of Maine - Northern Georges Bank waters, and the southern silver hake stock inhabits Southern Georges Bank - Middle Atlantic Bight waters (Figure A22). These boundaries were established at SAW 11(Brodziak et al. 2005).

While it is likely that the northern and the southern stocks mix on Georges Bank, the degree of mixing and movement among the management areas are unknown (Almeida 1987a, Helser et al. 1995, Helser 1996). Silver hake are known to spawn in the Gulf of Maine, southern New England, and on the southern flank of Georges Bank. Therefore, it is likely that silver hake larvae are entrained in the clockwise gyre on Georges Bank leading to larvae settlement in either management areas. Recent analyses of an icthyoplankton survey suggest the southern stock is larger (>90% of the larvae density) than the northern stock (Richardson et al. 2010). This is also consistent with Nye et al. 2009, suggesting a northern shift in the center of biomass for southern stock of silver hake. This is in contrast with the NEFSC trawl survey, which suggests a much larger stock in the northern area (Figure A59). Additionally, in the Gulf of Maine, there were no larvae observed, although adult spawners were present. This further suggests that there is probable transport of silver hake larvae from north to south and adults are migrating across the traditional stock boundaries which also implies that reproductive isolation between the two stock areas is unlikely.

NEFSC trawl surveys indicate a generally continuous distribution of silver hake from the Gulf of Maine to the southern New England/Mid-Atlantic Bight (Figures A24 and A30). However, the relative density of silver hake has varied through time between the northern and southern management areas. Population density as measured by the NEFSC fall bottom trawl survey increased in northern area during the mid-1980's, declined in 2000's and has continue to increase in the recent years. In contrast, density in the southern area showed decreases in the 1990's with a temporary increase in 2000 and declined in the last few years (Figure A60). Relative to the fall survey, the spring survey trends are highly variable and difficult to interpret the trends (Figure A60). This indicates that it is likely that mixing is occurring during the adult life stage. However, the degree of mixing cannot be determined.

Analyses of silver hake size at age data have shown that growth tends to vary in time and among areas (Helser 1996). Particularly, there were consistent differences between growth in the Gulf of Maine and southern New England/Mid Atlantic Bight areas. However, Helser showed that growth patterns on Georges Bank and in the Gulf of Maine were indistinguishable in the 1980's and 1990's and that growth rate changes dynamically on Georges Bank. In the last assessment, Brodziak et al. (2005) reported that there were negligible differences in growth between the northern and southern stock areas. For the purpose of this assessment, a decadal analyses on silver mean size at age from 1973-2009 for the fall and spring by sex was conducted. Results suggest that not only does silver hake exhibit sexually dimorphism but also very little differences were observed in the growth patterns between the northern and the southern stock areas (Figures A61 – A64).

Patterns in silver hake median age at maturity from the spring NEFSC bottom trawl survey (1980-2009) were estimated for both the northern and southern management areas in this assessment. The observed proportion of fish mature at age was fitted a logistic model using a nonlinear least square estimator. Model results in Figure A61 shows that there is no meaningful geographic variation in age at maturity. Annual trends in median age at maturity were also consistently similar between the north and the south management areas with synchronous increases around the early 1990's from 1.6yrs to approximately of 2.3yrs through late 1990's and early parts of 2000 and declined in the recent years to levels estimated in the early 1980's (A50 = 1.6yrs, Figure A65).

In summary, based on the scientific information available on silver stock structure (morphometrics, tagging, discontinuous larva distribution, homogeneous growth and maturity), it was concluded that there were no strong biological evidences to support either a separate or a single stock structure for silver hake. For the purpose of this assessment, a separate north-south and a combined stock model formulation was explored.

TOR 4. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series (integrating results from Silver hake TOR-5), and estimate their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results.

Assessment History

Stock assessments of the silver hake resources were conducted as early as 1968 using catch curves on catch at age data, with more formal assessment methods using Virtual Population Analysis (VPA) during the next two decades. During the next two decades, VPAs were enhanced in various ways using tuning methods with auxiliary research survey data using age-aggregated *ad hoc* techniques. During the early 1990s both Laurec-Shepherd and ADAPT tuning methods based on statistical fitting were attempted and assessment results were accepted with reservation. However, subsequent VPA assessments were rejected due to high degree of uncertainty and instability in parameter estimates (Brodziak et al 2001). Due to these difficulties of the population assessments, the southern and northern stock of silver hake are based on an index of exploitation and biomass derived from NEFSC resource assessment surveys.

In this assessment, two models were attempted, An Index Method (AIM) and the Age Structure Assessment Program (ASAP). While the ASAP model provided major advancement in the assessments, the results were not accepted due difficulties reconciling the inconsistent interpretations of the steep age profiles. The AIM model was also not accepted because it did not provide adequate diagnostics for stock status determination. Thus, this assessments was based on trends in the three year moving averages for the age-aggregated, fall survey biomass indices (1973-1982) using the arithmetic means rather than the previous delta approach (SAFE2003) and the three year averages of exploitation indices (total catch/fall survey biomass index) for both the northern and southern management areas.

A bridge between the current and last assessment

The NEFSC fall Survey biomass (delta mean kg/tow) and the relative exploitation index (landings/delta mean kg/tow) were computed for both the northern and southern stock areas. Survey biomass for the north declined recently and near the target levels used for management while the southern survey biomass has generally increased in recent years and also near the management target. The exploitation rate index for the southern stock is higher than for the northern stock throughout the time series. The exploitation index show high values during 1963-1977 followed by a period of low values during 1978-1993. Since 1994, the northern exploitation continues to decline and the southern values have varied without trend. Overall, the exploitation rate indices suggest that exploitation rates in recent years are much lower than during the 1960’s and 1970’s when foreign distant water fleets intensively harvested silver hake (Table A59, Figures A66-A67).

For this assessment, the “delta” estimators were replaced with the arithmetic means (i.e. no log transform was applied) because the delta transformation tends to inflate the survey variances and were sensitive to treatment of tows with no catch. Also, the previous exploitation index based on the ratio of landings to the fall delta survey biomass was also updated to include discards to better characterize removals from the commercial catch (landings + discards) relative to the fall survey biomass. Since discards are reliably estimated since 1989, relative exploitation index is now defined as the ratio of the commercial total catch to the arithmetic fall biomass survey (Table 60, Figure A68-69). It is noted that historical discarding, particularly in the Distant Water Fleet, has likely been very small. Therefore, comparison of relative exploitation index based on catch/biomass with reference points based on landings over biomass is justified.

Revised Assessment Method

An Index Method (AIM)

The AIM model is a simple approach for examining the relationship between survey data and catch in data poor stock assessments. AIM is designed to address the question of whether a given rate of fishing mortality is likely to increase or decrease the population size. Survey data are used to define a relative rate of increase and the ratio of catch to survey indices provides a measure of relative fishing mortality. Theoretically the model can identify a stable point about which the stock will neither increase nor decrease in response to a fixed harvest rate. The model assumes that the resource dynamics are approximately linear with relatively minor influence of density dependent effects or variable environmental or ecological factors. Such conditions often typify stocks that have been historically harvested at high fishing rates and are therefore at low population sizes. AIM is both an analytic and graphing approach. The analytical methods can be used to define relative Fs for replacement and the graphical methods can be used to identify transient conditions that are relevant to implementation of any model. The details of the methodology are described below.

- ✓ Population biomass at time t can be written as a linear combination of historical population biomasses
- ✓ Recruitment is proportional to population biomass
- ✓ Fishing mortality is proportional to catch divided by an index of population size (relative F).
- ✓ The rate of change in population biomass is a monotonically decreasing function of relative F.
- ✓ Smoothing methods can be used to identify underlying trends.
- ✓ Randomization methods can be used to develop sampling distributions of test statistics
- ✓ Graphical methods can help identify linkages among variables

Relative F is defined as the ratio of catch to an index of population abundance. A three-year centered average of the abundance index is chosen as the measure of average stock size.

$$relF_{j,s,t} = \left(\frac{C_{s,t}}{\frac{I_{j,s,t-1} + I_{j,s,t} + I_{j,s,t+1}}{3}} \right) \qquad (1)$$

Where $relF_{j,s,t}$ = relative F for relative index j for stock s at time t

$C_{s,t}$ = catch or landings of stock s at time t (in units of weight)
$I_{j,s,t}$= Index of abundance j for stock s at time t expressed in terms of average weight per tow

The population size at any given time can be viewed as a weighted sum of previous recruitment events. For a population with a maximum age of A years, the population in year t consists of the recruits from year t-1, t-2, …t-A. At high levels of total mortality, the contributions from the earliest recruitments, say t-k-1 to t-A will diminish in importance such that the population can be viewed as the sum of recruitments from t-1 to t-k years.

Using the linearity assumption defined above, we can employ basic life history theory to write abundance at time t as a function of the biomasses in previous time periods. The number of recruits at time t (R_t) is assumed to be proportional to the biomass at time t (B_t). More formally,

$$R_t = S_o \, Egg \; B_t \qquad (2)$$

where **Egg** is the number of eggs produced per unit of biomass, and $\mathbf{S_o}$ is the survival rate between the egg and recruit stages. Survival for recruited age groups at age a and time t ($S_{a,t}$) is defined as

$$S_{a,t} = e^{-F_{a,t} - M_{a,t}} \qquad (3)$$

where F and M refer to the instantaneous rates of fishing and natural mortality, respectively. We also need to consider the weight at age a and time t ($W_{a,t}$) and the average longevity (A) of the species.

Using these standard concepts we now write the biomass at time t as a linear combination of the A previous years. Without loss of generality, we can drop the subscripts on the survival terms and assume that average weight at age is invariant with respect to time. Further, set the product S_o Egg equal to the coefficient α. The biomass at time t can now be written as

$$B_t = R_{t-1} S^1 W_1 + R_{t-2} S^2 W_2 + R_{t-3} S^3 W_3 + .. + . R_{t-(A-1)} S^{A-1} W_{A-1} + R_{t-A} S^A W_A \quad (4)$$

Substituting Eq. (2) into Eq. (4) leads to

$$B_t = \alpha B_{t-1} S^1 W_1 + \alpha B_{t-2} S^2 W_2 + \alpha B_{t-3} S^3 W_3 + .. + .\alpha B_{t-(A-1)} S^{A-1} W_{A-1} + \alpha B_{t-A} S^A W_A \, (5)$$

If the population is replacing itself, then the left hand side of Eq. 5 will equal the right hand side. The replacement ratio can then be defined as

$$\Psi_t = \frac{B_t}{\alpha B_{t-1} S^1 W_1 + \alpha B_{t-2} S^2 W_2 + \alpha B_{t-3} S^3 W_3 + .. + .alphaB_{t-(A-1)} S^{A-1} W_{A-1} + \alpha B_{t-A} S^A W_A} \quad (6)$$

Substituting observed values of abundance indices into Eq 6 leads to

$$\Psi_t = \frac{\frac{I_t}{q}}{\alpha \frac{I_{t-1}}{q} S^1 W_1 + \alpha \frac{I_{t-2}}{q} S^2 W_2 + \alpha \frac{I_{t-3}}{q} S^3 W_3 + .. + \alpha \frac{I_{t-(A-1)}}{q} S^{A-1} W_{A-1} + \alpha \frac{I_{t-A}}{q} S^A W_A} \quad (7)$$

By noting that the q's cancel out, and letting $\varphi_j = \alpha S^j W_j$, Eq. 6 simplifies to

$$\Psi_t = \frac{I_t}{\sum_{j=1}^{A} \phi_j \quad I_{t-j}} \qquad (8)$$

All of the I_t and φ_j are positive, and at equilibrium $I_t=I_{t+1}$ and $I_t= \sum\varphi_j I_{t-j}$ both hold. Therefore $\sum\varphi_j =1$. When the population is not at equilibrium the parameter Ψ becomes a measure of the non equilibrium state of the population and a measure of whether the population is increasing or decreasing relative to prevailing fishery and ecosystem conditions.

It would be desirable to express the parameters of φ_j weighting terms as function of the underlying parameters. Analyses of other stocks with more detailed information, such as Georges Bank haddock, has suggested that setting the φ_j to 1/A is a reasonable approximation. Equations 2 to 8 are a long way of justifying that the ratio of current stock size to a moving average of the previous A years of stock size can be used as a measure of population growth rate. This ratio embeds some life history theory into the basis for the ratio and simultaneously provides a way of damping the variations in abundance owing to measurement error. A ratio defined as I_t/I_{t-1} has been found, as expected to be much more noisy measure of population change.
Further details on the AIM methodology may be found in Working Group (2002) and the NOAA Fisheries Toolbox (NFT) 3.1 (2010a) software package http://nft.nefsc.noaa.gov/AIM.html. The relationship between $\mathbf{\Psi_t}$ and $\mathbf{relF_t}$ can be expressed as

$$\ln(\Psi_t) = a + b\ln(relF_t) \quad (9)$$

The usual tests of statistical significance do not apply for the model described in Eq. 9. The relation between $\mathbf{\Psi_t}$ and $\mathbf{relF_t}$ is of the general form of Y/X vs X where X and Y are random variables. The expected correlation between Y/X and X is less than zero and is the basis for the oft stated criticism of spurious correlation. To test for spurious correlation we developed a sampling distribution of the correlation statistic using a randomization test. The randomization test is based on the null hypothesis that the catch and survey time series represent a random ordering of observations with no underlying association. The randomization test was developed as follows:

1. Create a random time series of length $\mathbf{T}$ of $\mathbf{C_{r,t}}$ from the set $\{\mathbf{C_t}\}$ and $\mathbf{I_{r,t}}$ from the set $\{\mathbf{I_t}\}$ by sampling with replacement.

2. Compute a random time series of relative F ($\mathbf{relF_{r,t}}$) and replacement ratios ($\mathbf{\Psi_{r,t}}$)
3. Compute the r-th correlation coefficient; say $\boldsymbol{\rho_r}$ between ln($\mathbf{relF_{r,t}}$) and ln($\mathbf{\Psi_{r,t}}$).
4. Repeat steps 1 to 3 K times.
5. Compare the observed correlation coefficient $\mathbf{r_{obs}}$ with the sorted set of $\boldsymbol{\rho_r}$
6. The approximate significance level of the observed correlation coefficient $\mathbf{r_{obs}}$ is the fraction of values of $\boldsymbol{\rho_r}$ less than $\mathbf{r_{obs}}$

It should be emphasized that relF is not necessarily an adequate proxy for Fmsy, since this parameter only estimates the average mortality rate at which the stock was capable of replacing itself. Thus, while relF defined as average replacement fishing mortality is a necessary condition for an F_{msy} proxy, it is not sufficient, since the stock could theoretically be brought to the stable point under an infinite array of biomass states. The relF at replacement does however provide some guidance on the contemporary rate of harvesting and its potential impact on future stock abundance.

Application of AIM to Silver Hake
AIM was applied to the combined stock of silver hake using catches and the NEFSC fall and spring bottom trawl survey indices (Table A61). Relative F was defined as the ratio of catch to a centered 3-year average of survey abundance (Eq. 1) and the replacement ratio was defined as a 5-year moving average of previous stock sizes (Eq. 8). The relationship between catch, survey, relative F and the replacement ratio for the fall and spring survey indices are depicted in Figures A70 and A71, respectively. Neither of the randomization tests resulted in significant statistical relationship between the replacement ratio and relative F (Table A61). Bootstrap estimation of the relative F at replacement were imprecise (Table A62, Figure A72) and are not appropriate measures of Fmsy proxies. Graphical results suggest some underlying causes for the absence of a strong statistical relationship. Relative F has been declining continuously for both the fall (Figure A70) and spring (Figure A71) survey indices but the population indices do not suggest any significant rate of change over time. The relationship between replacement ratio is barely negative despite a nearly 60-fold range in catches and a 27-fold range in relative F. The relationship between relative F and survey abundance is instructive (the

left center plot in Figures A70-A71). It suggest three temporal stanzas in which the population abundance has declined by comparable amounts from about 8 to 3 kg/tow, when relative F has varied by 30,000 to 70,000 mt/kg/tow between 1968 and 1977 and when relative F varied from 5,000 to 15,000 mt/kg/tow between 1978 and 2000. In the third stanza, from 2001 to 2009 the surveys have fluctuated from 4.0 kg/tow to about 1kg/tow even though relative F has not exceeded 7108 mt/kg/tow for the fall survey and 12,099 mt/kg/tow in the spring survey. At a minimum these stanzas suggest major changes in the population abundance indices and exploitation rates. It is not possible from these data alone to identify causal factors but it does suggest that more advanced modeling will need to account for these changes in apparent productivity and/or natural mortality.

Age Structure Assessment Program (ASAP)

> **[SAW51 Editor's Note: The SARC-51 peer review panel concluded that no single silver hake ASAP model run provided a suitable basis for providing management advice. The silver hake ASAP model and results, which are described here and in Appendices A2-A6, are included in this report mainly to document the ASAP modeling runs that the Hake Working Group provided to the SARC for peer review.]**

Silver hake has been assessed based on survey index of relative exploitation and the 3 year moving average from the survey biomass since 1994(NEFSC 2006). Given some of the changes that have occurred in the fishery (gear, selectivity, targeting, and management), and the change to a new survey vessel (for which a calibration cannot be estimated), the importance of age structure (maturity and growth), and the limited projection capability of the index method, alternative assessment methods were considered for this benchmark. The new assessment model is ASAP (Age Structured Assessment Program v2.0.20, Legault and Restrepo 1998), which can be obtained from the NOAA Fisheries Toolbox (http://nft.nefsc.noaa.gov/). As described at the NFT software website, ASAP is an age-structured model that uses forward computations assuming separability of fishing mortality into year and age components to estimate population sizes given observed catches, catch-at-age, and indices of abundance. Discards can be treated explicitly. The separability assumption is partially relaxed by allowing for fleet-specific computations and by allowing the selectivity at age to change in blocks of years. Weights are input for different components of the objective function which allows for configurations ranging from relatively simple age-structured production models to fully parameterized statistical catch at age models.

The objective function is the sum of the negative log-likelihood of the fit to various model components. Catch at age and survey age composition are modeled assuming a multinomial distribution, while most other model components are assumed to have lognormal error. Specifically, lognormal error is assumed for: total catch in weight by fleet, survey indices, stock recruit relationship, and annual deviations in fishing mortality. Recruitment deviations are also assumed to follow a lognormal distribution, with annual deviations estimated as a bounded vector to force them to sum to zero (this centers the predictions on the expected stock recruit relationship). For more technical details, the reader is referred to the technical manual (Legault 2008).

Model Formulations
The assessment model formulations were structured to consider sensitivity to a number of model inputs. To deal with stock structure, separate North and South stock assessments were considered as well as a single combined stock treatment. These models will subsequently be referred to as North, South, and Combined for brevity. Natural mortality was thought to have a large component due to predation. This was dealt with explicitly by including estimates of consumption in the model as a separate "fishery" fleet (referred to as Consumption model hereafter), or implicitly by considering a single value for natural mortality (referred to as the No-Consumption model hereafter). In the Consumption model formulation, a value of M=0.15 was specified for all ages and all years to comprise all sources of natural mortality *other than* consumption. In the No-Consumption model, a single value of M=0.4 was specified for all ages and all years. The value of M=0.4 was justified by consideration of a maximum observed age of 14. Given M=0.4, the expected cumulative survival to age 14 would be about 0.5%.

Model Inputs
All models considered included catch by a directed fleet beginning in year 1973. Although total landings estimates exist before 1973, there was no age composition, and initial modeling suggested poor identifiability of initial conditions when the model runs started earlier than 1973. All models considered also included estimated discards beginning in 1981. Structurally, discards were included as a separate "fleet" in the model. Treating discards as a separate fleet allowed more flexibility for including total discards in 1981-1988 without any corresponding age composition in addition to years 1989 where estimates of total discards and age composition are both available. These two fleets were the only removals that were modeled for the No Consumption models. For the Consumption models, an additional fleet was modeled to represent removals from predation. The estimated mortality from the "fleet" of predators was then considered to be an additional source of natural mortality (generally termed "M2"). Estimates of total annual natural mortality at age from the Consumption models was then calculated as 0.15+M2 (age, year), and cumulative survival to age 14 could then be compared to the M=0.4 model.

All models included the NEFSC spring and fall bottom trawl surveys. Minimum swept area abundances, annual estimated CV, as well as the age composition for each survey were used in the model.

The model assumed a plus group at age 6. Initial model model runs dealt with the stock as a single unit (Combined runs). An exhausting, albeit not exhaustive, number of model specifications were explored for the Combined run. Exploratory runs examined model sensitivity to estimating a stock recruit function versus estimating an average recruitment with annual deviations; estimating age-specific selectivity for the surveys versus forcing the survey to have a flat-topped selectivity; "breaking" the survey time series into two separate series or maintaining a continuous time series; and adding or removing selectivity "blocks" to the directed and bycatch fleets. In considering these various model iterations, diagnostics were examined to determine if the fit improved. Specifically, the pattern of residuals in age composition for catch and indices, residuals in the fit to total catch and annual index values, components of the objective function in addition to total objective function and number of estimated parameters, as well as the "believability" of the estimated selectivity patterns. With regard to the last criterion ("believability" of estimated selectivity), this was somewhat subjective, however the models tended towards solutions with sharply domed selectivities for both the directed fleet and the surveys (it was also sharply domed for the discard fleet, but that was a sensible result). As there was nothing biological to suggest that fish at ages 5 and beyond would have very low catchability (i.e., no known behavioral aspects, no strong swimming capabilities), nothing gear related that would suggest lower catchability (no outswimming otter trawls, no other known gear interactions), and no known market conditions that would favor smaller fish, the group found it hard to reconcile selectivities of 0.10 on the 6+ group, when fish in the plus group had been estimated in the catch age composition early in the time series.

Model Results—Combined model

Model formulations for both the Consumption and No Consumption model were run in tandem. Although objective function values were not directly comparable between these two model treatments, owing to differences in the underlying data, residual diagnostics, overall fits, and retrospective patterns were compared. After much deliberation, the group agreed to the following base configuration: Consumption model that did not split the survey indices and forced a selectivity=1 for ages 2 and older; two selectivity blocks for the directed fleet (the break occurred between 1988 and 1989) and one single selectivity block for the bycatch fleet. With all models considered, there was a strong correlation between the selectivity estimated for the directed fleet and the selectivity of the surveys. Forcing the flat-top for the survey indices caused the selectivity estimates for the directed fleet to also be flat-topped. For this selectivity pattern, the age composition residuals were acceptable, although the residuals from fits to the total catch and overall index values showed strong time trends. This was a fairly consistent trade-off seen in many of the model diagnostics, wherein improvements in the fit to age composition data were accompanied by a deteriorated fit to the total data (either total catch or total index values). Thus, selecting the 'best' model depended to some extent on the amount of confidence that one had in the age composition data relative to the data streams of total catch and the indices. Complete model diagnostics can be found in the **Appendix A2**. ("Base_model_diagnostics_Consumption_Flat-top Survey").

Retrospective pattern of Base Combined model

A retrospective analysis on the base model using a seven year peel was conducted to examine the stability of the model estimates for fishing mortality, recruitment and spawning stock biomass. Due to the change in selectivity block beginning in 1989, it was difficult to interpret the earliest peels because there was an imbalance in the number of parameters being estimated versus number of years with additional data. However, it was noted that the Consumption models had the lowest retrospective bias (Figures A73-A74, Table A63).

Sensitivity analyses to Base Combined model
For completeness, sensitivity to the model decisions adopted in the base model are summarized in Table A63 and in Figures A75-A77. Eight additional runs are described in this table. Only one run for the No Consumption model is described. While this model offered good diagnostics, and good retrospective analysis results, two of the parameters for selectivity at age were estimated at the upper bound of 1.0. When those parameters were subsequently fixed at 1.0, instead of attempting to estimate them, no hessian was obtained for the model. Because of this instability, the model was not explored further. As an intermediate to the Consumption and No Consumption runs, a model was explored where the natural mortality at age was calculated as 0.15 + $M2_{age,year}$. This model is directly comparable to the No Consumption model as it has exactly the same data, the only difference being the fixed value specified for $M_{age,year}$. Compared to the model with M=0.4 for all years and all ages, the total objective function was 71 points greater, and therefore did not provide a better fit to the data.

The remaining six sensitivity runs were all Consumption models with different numbers of selectivity blocks for the directed and bycatch fleet, and with survey selectivity at age estimated or fixed for ages 2 and older. Model diagnostics and the objective function value favored models that had 2 selectivity blocks for the directed fleet (with the break in 1988/1989) and one selectivity block for the bycatch fleet over the alternatives of 1 selectivity block for each, or 3 selectivity blocks for the directed fleet and 2 selectivity blocks for the bycatch fleet. The motivation for introducing selectivity blocks, and the year that they were introduced, was an attempt to account for changes in the fishery composition (disappearance of foreign fleets) and pertinent regulations (mesh size and trip limits). After the number of selectivity blocks was decided, comparisons were made between a flat-topped survey selectivity (the proposed base model) and a formulation that estimated selectivity at age for the surveys (with only age 2 selectivity fixed at 1.0). The overall objective function for the base model was 4526, while for the model that estimated survey selectivity it was 4491. Thus, the model that estimated survey selectivity improved the objective function by 35 at the cost of adding 8 parameters to the model. And, as mentioned previously, there is the trade-off between fitting age composition data or fitting the total data series better. The other comparison between these two models is the retrospective diagnostics: the Combined base model had relative biases ranging from 26-41% while the sensitivity model that estimated survey selectivity at age had relative biases ranging from 32-62%. Finally, when estimating survey selectivity at age, the model estimated very steep domes with <10% selectivity in the plus group for the directed fleet and both surveys. These two models were considered the best contenders of the models explored, and the working group selected the base model (described above) based on the disbelief of such severe domes and the better retrospective diagnostics.

In general, the No Consumption models had lower retrospective analysis diagnostics compared to the Consumption models. Within the Consumption models, decreasing the selectivity blocks improved the retrospective diagnostics while enforcing a flat-top selectivity worsened the retrospective diagnostics (Table A63).

The intensive examination of model formulations was first explored for the Combined runs, as the likelihood of 'stock' mixing was thought to be high. If stock mixing were occurring, it would result in catch being attributed disproportionately among stocks, and the potential for the survey indices to be more reflective of the seasonal magnitude of mixing rather than any particular stocks' trend in abundance. This was the motivation for the group spending nearly all of the available time on the Combined models. In order to address the terms of reference to explore sensitivity to assumptions of stock structure, some North and South models were explored, but they were simple sensitivities on the structure that had been selected as the base model for the Combined model.

Silver Hake ASAP Results
Attempts were made to assess silver hake by separating the northern and southern data. However, none of the runs examined had assessment diagnostics which were deemed suitable. The working group recommended a combined analysis of data from both areas, meaning a single stock, as the best performing model, but this was ultimately not accepted by the SARC-51 Review Panel as a basis for management advice. Issues encountered in the northern and southern stock assessments are briefly described below, followed by a more detailed description of the recommended model formulation assuming a single stock.

Northern Silver Hake
Four runs were examined for the northern silver hake data. Two of the runs included consumption data while the others did not. Of the set of runs which included consumption forced a flat-topped selectivity patterns in the survey indices while the other allowed domed selectivity. The same selectivity patterns were also assumed for the runs without consumption. All four runs assumed time invariant selectivity patterns for each fleet and assumed recruitment deviations occurred relative to a constant mean, as opposed to being relative to a stock-recruitment relationship (Appendices A3-A6).

The run which did not include consumption estimates set natural mortality to 0.4 for all years and ages. The predicted commercial landings are well below the observed values at the start of the time series when the foreign fleets were operating, but then well above the observed values near the end of the time series. These are large deviations in both absolute and relative terms and are a strong indication that the model is not fitting the data well. However, when a domed selectivity is allowed, the fit the landings show an improvement in the absolute and relative magnitude of the residuals. The fit to the discards also exhibits a pattern of underestimating the observed values early in the time series and overestimating them recently. However, these deviations are small in both absolute and relative terms and so are less of a concern. The opposite is true early in the time series when domed selectivity is allowed in the survey with a good fit to the time series in the recent years. The landings and discards at age both have patterns in the residuals, especially at ages one and two. The input effective sample size appears to be a bit high for the commercial landings, where only approximately 20% of the output effective sample sizes are greater than the input values. The input and output effective sample sizes for the discards are better matched. Neither of the survey indices are fit well, with patterns in the residuals and large magnitudes for the standardized residuals, but to a lesser degree when domed selectivity is allowed in the survey. The observed magnitude and patterning of the residuals is an indication that the input CV for the surveys is too small relative to the ability to fit the indices. The age composition for both indices is not fit well, with long periods of the same sign of residuals for ages one and two especially. The input effective sample sizes for both indices are too high relative to the output effective sample sizes. The catchability coefficients for both indices are above one, indicating that the estimated population is smaller than the minimum swept area biomass estimated from the surveys. This can occur if the assumed swept area of a tow is too small, for example due to herding of fish, but is generally an indication that there may be a problem in the run. In contrast, when domed selectivity is allowed the catchabilities estimates were well below one which agrees with the very strong dome estimated in the survey with less than 5% of ages 5 and 6 selected in the survey. The implication of such selectivity pattern resulted in unrealistic estimate of spawning stock biomass reaching approximately 6million metric tons in the recent years and an expansion of age 6+ in the population which is contradictory to the both the fishery and the survey. Thus, these runs were not considered acceptable by the working group.

The two runs which did include consumption set the base natural mortality to 0.15 and then entered the consumption time series as an additional fleet. The main difference between these two runs is the selectivity pattern for the two indices where the run which allowed a dome did in fact estimate a strong dome for both indices. However, qualitatively the results from the two runs were still quite similar and are described together here. These runs fit the commercial landings and discards much better than the runs which did not include consumption. The fit to the consumption time series was not fit as well and the landing or discards. The absolute magnitude of the lack of fit to the consumption time series is quite high, but the relatively small standardized deviations indicate that the uncertainty in the consumption values is being appropriately modeled. The age composition for the commercial landings and discards still exhibit patterns in the residuals, especially at ages one and two. There are no age composition residuals for the consumption fleet, meaning that the selectivity patterns should not be estimated. However, the two runs did in fact estimate selectivity patterns based on a double logistic form. These parameters could be estimated because priors were set on the values. However, the resulting selectivity patterns do not make intuitive sense with low selectivity at age one, the age which typically has the highest consumption selectivity. The input effective sample size for the commercial landings is slightly high relative to the output effective sample size, but more closely matched for the commercial discards. The survey indices are fit better than the runs without consumption in terms of there not being a strong pattern in the residuals. However, the magnitude of the standardized residuals is still quite large, indicating that the input CV for the indices is too small relative to how closely the indices can be modeled. The age composition for index 1 is fit reasonably well while index two shows patterns in the residuals for ages one and two. The input effective sample size for both the indices is too high relative to the output effective sample size. The catchability coefficients are more reasonable than the runs without consumption, indicating a relative efficiency of the net around 0.5. The catch due to the consumption fleet appears to be quite small in five of the first six years in the time series, which is due to low sampling of predators during this time period instead of a true change in consumption. The mortality rate due to consumption is generally greater than one after the first six years in the time series, with some years above two. This high mortality contrasts with the fishing mortality rates of less than 0.3 for most years. Note that the plot showing the relative spawners (SSB/S0) is treating consumption as a mortality that is not included when computing S0, which it typically would be since it is a form of natural mortality. If this plot was made including consumption mortality as a natural mortality, then the relative spawners would be much closer to one than currently shown.

Southern Silver Hake Stock
For the southern region, similar model runs were conducted as in the northern region. However, the models in the south had convergence problem which is likely attributed to model mis-specification (i.e. inaccurate definition of stock boundaries). One possible hypothesis is that the model is having difficulties resolving the lack of coherence between the removals from the fishery and the trends in the survey due to possible migration patterns of silver hake to the northern region. The shift in the population density over time will then reflect seasonal distribution in the survey rather than stock specific trend of abundance as explained above.

Combined Silver Hake Stock
A number of the issues seen in the northern silver hake runs are also apparent in this combined run. Specifically, commercial landings are not fit well at the start of the time series, consumption landings are mostly underestimated, strong patterns are seen in the age composition residuals for all three fleets, the indices are not well fit in terms of either trends in residuals or the magnitude of the standardized residuals, strong patterns are seen in the age composition residuals for index, the relative spawners plot has the same issue as the northern silver hake assessment with consumption, and consumption in the early years appears low. The inclusion of age composition data for the consumption fleet is an improvement relative to the northern silver hake runs, as now there is information to estimate selectivity for this fleet. The estimated selectivity pattern for the consumption fleet is more traditional than the northern silver hake runs, with highest selectivity at age one and decreasing selectivity at older ages. This means that the effect of consumption will be mainly to increase recruitment to account for this additional mortality, but it will not have a large impact on the adult population. However, there is an indirect impact caused by this selectivity pattern because the base natural mortality is 0.15 compared to 0.4 when consumption is not included. Since there is essentially no consumption mortality at old ages, the net effect is to reduce natural mortality on the old fish, which means fishing mortality must be high to prevent old fish from appearing in the age composition.

Given the series of model exploration for North, South and the combined management area formulation, the working group recommended the Consumption model with 2 selectivity block in the directed fleet with a single selectivity in the bycatch fleet. However, this was not accepted by the SARC-51 Review Panel as a basis for management advice.

Fishing Mortality
Fishing mortality on ages 3+ varied between 0.5 and 1.0 from 1973 to 1995 then increased and varied between 1.0 and 2.0 from 1996 to 2008. The fishing mortality rate in 2009 is estimated to be 0.77 (80% confidence interval 0.58 – 0.95). Note that the variance estimates include some consumption based mortality estimates. Given the very low mortality on older ages in the population, the influence of consumption on the variance is minimal to negligible (Appendix A2, Table A64).

Recruitment
Recruitment at age-1 was relatively low in the early part of the time series, which may be an artifact of consumption mortality being underestimated during this time period. Since then, recruitment has varied without trend between 400 million and 1.1 billion fish annually. The number of age-1 fish in 2009 is estimated to be 742 million fish (80% confidence interval 616 – 867 million fish (Appendix A2, Table A65).

Spawning Stock Biomass
Spawning stock biomass varied around 70 thousand mt during the early part of the time series, but this again could be an artifact due to the low consumption mortality during this time. Spawning stock biomass decreased to approximately 33 thousand mt in 1978 and slowly declined to 55 thousand mt in 2006, but has since increased. Spawning stock biomass in 2009 is estimated to be 23 thousand mt (80% confidence interval 19.5-26.8 thousand mt (Appendix A2, Table A65).

Natural Mortality
Estimate of Natural mortality (M1+M2) was highest and most variable for age-1 ranging between 0.2 and 1.5 from 1973-1995. Natural mortality declined substantially in 1997 by approximately 70% resulting in natural mortality estimate of 0.5. This was also when consumption was relatively low due to very low recruitment. The natural mortality rate in 2009 is estimated to be 1.2 (Appendix 2 and Table A66).

TOR 5. Evaluate the amount of silver hake consumed by other species as well as the amount due to cannibalism. Include estimates of uncertainty. Relate findings to the stock assessment model.

Food habits were evaluated for a wide range (14) of fish predators that eat silver hake and commonly occur in NEFSC bottom trawl surveys. The amount of food eaten and the type of food eaten were the primary food habits data examined. From these data, per capita consumption, total consumption of silver hake, and an estimate of the amount of silver hake removed by these fish predators were calculated. Combined with abundance estimates of these predators, an amount of silver hake removed by these predators was then calculated. Consumption estimates of silver hake were presented as an estimate that is biased towards conservative values because consumption by birds, marine mammals, large pelagic fish and organisms outside of the survey area were not included. Moreover, swept-area biomass estimates for many of predators were based on bottom trawl survey data (without adjustments for bottom trawl catchability), although stock assessment results were used for some predators, such that predator abundance estimates and associated silver hake consumption would be mostly underestimates as well.

Methods

Every predator that contained silver hake was identified from the NEFSC FHDBS. From that original list, a subset of predators (Table A67) was examined to elucidate which predators consistently ate silver hake, determined by "rules of thumb" that include having a diet composition of >1% for any five year block, and with >5tows for each two year block and > 10 stomachs for each three year block.

Annual consumption estimates were calculated on a seasonal basis (two 6 month periods) based on spring and fall bottom trawl surveys and for each predator species. Although the food habits data collections started quantitatively in 1973, not all species of silver hake predators were sampled during the full extent of this sampling program, thus we start our time series here in 1977 (Link and Almeida (2000). This sampling program was a part of the NEFSC bottom trawl survey program (Azarovitz 1981; NEFC 1988). There are various ways to integrate seasonally, but we took the simple sum of the two seasonal estimates in this analysis. We have also done the analyses for various size classes of predators in other instances, but here we have integrated across all predator size classes to come up with a total consumption of silver hake for each predator.

This approach followed previously established and described methods for estimating consumption, using an evacuation rate model methodology. For further details, see Durbin et al. (1983), Ursin et al. (1985), Pennington (1985), Overholtz et al. (1991, 1999, 2000, 2008), Tsou & Collie (2001a, 2001b), Link & Garrison (2002), Link et al. (2006, 2008, 2009), Methratta & Link (2006), Link & Sosebee (2008), Overholtz & Link (2007, 2009), Tyrrell et al. (2007, 2008), Link and Idoine (2009), Moustahfid et al. (2009a, 2009b), and NEFSC (e.g., 2006, 2007a, 2007b, 2008, 2010a, 2010b). The main data inputs are mean stomach contents (S_i) for each silver hake predator i, diet composition (D_{ij}) where the subscript j refers to silver hake as a prey item, and T is the bottom temperature taken from the bottom trawl surveys (Taylor et al. 2005). Units for stomach estimates are in g. We note that we estimated S and D for two-year time blocks to ensure data-density sufficiency for all predators in both seasons and for both stocks; temperature (T) was estimated annually for both seasons and both stock areas.

As noted, to estimate per capita consumption, the gastric evacuation rate method was used (Eggers 1977, Elliott and Persson 1978). There has been copious experience in this region using these models (see references listed above). The two main parameters, α and β, were set to 0.004 and 0.115 respectively based upon prior studies and sensitivity analyses (NEFSC 2007a, 2007b). The exception is that α was set to 0.002 for elasmobranch predators consistent with and to reflect their slightly lower metabolism than teleost fishes.

Using the evacuation rate model to calculate consumption requires two variables and two parameters. The per capita consumption rate, C_{it} is calculated as:

$$C_{it} = 24 \cdot E_{it} \cdot \overline{S_{it}}^{\gamma}$$

where 24 is the number of hours in a day and the evacuation rate E_{it} is:

$$E_{it} = \alpha e^{\beta T} \qquad ;$$

and is formulated such that estimates of mean stomach contents (S_{it}) and ambient temperature (T; here used as bottom temperature from the NEFSC bottom trawl surveys for either season (Taylor & Bascuñán 2000, Taylor et al. 2005)) are the only data required. This was done for each predator i (species) for each time period t (season and year). The parameters α and β are set as values chosen noted above. The parameter γ is a shape function is almost always set to 1 (Gerking 1994).

Once daily per capita consumption rates were estimated for each silver hake predator, those estimates were then scaled up to a seasonal estimate. This was done by multiplying the number days in each half year, which were then multiplied by the diet composition D_{ij} that was silver hake, to estimate the seasonal per capita consumption of silver hake. That is, once per capita consumption rates were estimated for each silver hake predator in a temporal period (t), those estimates were then scaled up to a seasonal estimate ($C'_{it} = C_{fall}$ or C_{spr}) by multiplying the number days in each half year:

$$C'_{it} = C_{it} \cdot 182.5$$

These were then multiplied by the diet composition D_{ijt} that was silver hake, to estimate the seasonal per capita consumption of this fish C_{ijt}:

$$C_{ijt} = C'_{it} \cdot D_{ijt}$$

These were then summed to provide an annual estimate, C'_{ij}:

$$C'_{ij} = C_{ij,fall} + C_{ij,spring}$$

Once these were summed to provide an annual estimate (or the following could be done seasonally and the summed), they were then scaled by the total stock abundance of each predator to estimate the amount of silver hake removed by any of the predators included in the study. We used a swept area estimate of abundance from bottom trawl survey estimates for most predators and recent stock assessment estimates for five of the fourteen (Table A57). Those predators that had stock assessment values were used directly. These consumption estimates were then scaled by the total stock abundance to estimate a total amount of silver hake *(j)* removed by any predator i, C_{ij}:

$$C_{ij} = C'_{ij} \cdot N_i \qquad ,$$

where N_i is the estimate of abundance for each predator for each year.

We note that there are several ways to combine variance estimators in these consumption approaches. Estimates of variance for each variable and data type were calculated, namely about *S*, *DC*, and *N*. Further particulars of these estimators for the stomach contents and diet composition can be found in Link and Almeida (2000). There are three main ways to present variance about the estimates of consumption. One is to calculate a triple variance estimator that scales to the mean of each parameter (*S*, *DC*, and *N*). Another is to evaluate the maximal CV across all three parameters, across both seasons, and across all species of predator and then carry the largest value for each annual estimate of consumption. Finally, since from prior studies we know that the largest source of variance is associated with the estimates of abundance (scaled to the number), one can take the maximal CV across all predators and seasons for abundance and use that as a proxy for the variance about the consumption estimate. Here we adopted a modification of the third option, using the maximal CVs (associated with abundance estimates) and adopted mild adjustments for D_{ij} and S_i on a percentage basis (again, those CVs and means usually are minimized by the scale of the abundance means). The maximum from all predator sets were then used to portray variance for the total amount of silver hake consumed by these fishes. These range from 0.1 to 1.0 and in practice most were on the order of 0.35-0.50.

These predator species-specific consumptions were then summed across all *i* predators to estimate a total amount of silver hake removed by the predators included in this study. Upon further inspection by season, stock area, and predator species, it was determined that pollock *DC* were excessively variable, resulting in some notably anomalous and indefensible outputs; thus we removed pollock as a predator from the final estimates of consumption. Thus, these C_{ij} were then summed across all *i* predators (excluding pollock) to obtain an estimate a total amount of silver hake removed by these silver hake predators, C_j:

$$C_j = \sum_i C_{ij} \quad .$$

We show both the total consumption, total by species, and total by stock area. We also contrast these estimates with silver hake landings to provide a sense of contrast and magnitude. We also present these consumption estimates as 3 year moving averages to smooth the high degree of inter-annual variability common for these food habits data.

Sizes of silver hake in predators were also calculated as proportions by length in 5 cm bins for each year (combined across predators) across the time series. These can be used to inform the allocation of consumption to those size classes of fish overlapping with the fishery (or survey estimates). In this assessment, the consumption estimates were rescaled to conform with the current model formulation (i.e. age 1-6+). Survey age length keys were used to derive the proportion at length for Age-0 to adjust the consumption at length for each year. This makes the assumption that the survey length distribution within a given age is similar to consumption. For simplicity purposes, a constant probability was used based on an aggregated age-length key across seasons and geographical areas for the combined assessment. Table A68 summarizes the probability used in the analyses. On average, this resulted in a 40% decrease from the original consumption estimates (Figure A78).

Total consumption was modeled as a separate fleet in the Age Structured Assessment Program (Legault, 2008) to provide estimate of natural mortality based consumption (M2). Detail on the model structure and assumption regarding natural mortality and selectivity are provided in TOR4.

Results

Total consumptive removals by all consistent silver hake predators, using swept area abundance estimates of the predators, has varied through time ranging between peaking at 4,000 mt in 1975 and peaking at 165,000mt in 1985. This was followed by a brief decline during the early to mid 1990s and increased substantially in 1999 to approximately 135,000 mt. In the last decade, consumption has declined and averaged approximately 70,000 mt in the last five years (Figure A79, Table A69).

Spatially the consumption was approximately equally distributed between the northern and southern stocks (Figure A80), with higher peak values observed in the northern stock.

Although the consumption of silver hake occurred in thirteen predators, the majority of the consumption was attributable to goosefish (Figures A81-A82). For predators with swept area estimated abundance, these were generally lower than those stocks with abundance estimates obtained from stock assessments (summer flounder, goosefish, bluefish, cod), but were dominated by spiny dogfish (Figure A81-A82). These findings were consistent for both the northern and southern stocks combined (Figure A81)

The size of most of the silver hake consumed was <20 cm (Figure A83), yet some large fishes were also eaten. Over 50% of the silver hake eaten in most years were < 15 cm. We note that this loosely corresponds to the age 0 size class. The proportions also varied by size over the years (Table A70, Figure A81).

These estimates of silver hake consumed by the consistent fish predators in this study were compared to total catch (Figures A79-A80). Silver hake catches and consumption estimates were distinct for much of the time series, with landings higher earlier in the time series (1970s), but with consumption the dominant source of removal since the 1980s. Given this caveat, we note that consumption is approximately 10 times higher than catch in the 2000s.

TOR 6. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; estimates or proxies for BMSY, BTHRESHOLD, and FMSY; and estimates of their uncertainty). If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

Existing Reference Points

The northern silver hake stock overfishing definition (NEFMC 2003) uses a relative exploitation index (total landings divided by NEFSC autumn survey biomass index) as a proxy for fishing mortality. The northern stock is considered ***overfished*** *when the 3-year average biomass is less than ½ the B_{MSY} proxy (B_{MSY} proxy = 6.63 kg/tow).* ***Overfishing*** *occurs when the 3-year average exploitation index is greater than 2.57, the F_{MSY} proxy (the average exploitation index during 1973-1982), and is used as both a target and threshold value for fishing mortality for the northern stock (NEFSC 2006)*

The southern silver hake stock is considered to be ***overfished*** *when the three-year moving average of the NMFS autumn survey weight per tow index is less than half of the B_{MSY} proxy (B_{MSY} proxy = 1.78 kg/tow) (NEFMC 2003).* ***Overfishing*** *is considered to be occurring in the silver hake southern stock when the exploitation index (landings divided by the three-year moving average of the delta-distributed fall survey biomass index) exceeds the F_{MSY} threshold proxy of 34.39 (NEFMC 2002).*

There are currently no BRPs for a combined (i.e., north + south) stock.

New Reference Points

In the absence of an agreed ASAP model run, the newly accepted reference points (in kg/tow in Albatross units) for both the northern and southern silver hake stocks are as follows:

> *Silver hake is overfished when the three-year moving average of the fall survey weight per tow (i.e. the biomass threshold) is less than one half the B_{MSY} proxy, where the B_{MSY} proxy is defined as the average observed from 1973-1982. The most recent estimates of the biomass thresholds are 3.21 kg/tow for the northern stock and 0.83 kg/tow for the southern stock.*
>
> *Overfishing occurs when the ratio between the catch and the arithmetic fall survey biomass index from the most recent three years exceeds the overfishing threshold. The most recent estimates of the overfishing threshold, are 2.78 kt/kg for the northern stock and 34.19 kt/kg for the southern stock of silver hake.*

Overfishing threshold estimates were based on annual exploitation ratios (catch divided by arithmetic fall survey biomass) averaged from 1973-1982. Catch per tow is in "Albatross" units.

TOR7. Evaluate stock status (overfished and overfishing) with respect to the existing BRPs, as well as with respect to the "new" BRPs (from Silver hake TOR 6).

Based on the biological reference points in the existing FMP, the northern stock of silver hake is not overfished and overfishing is not occurring. The three year delta mean biomass index (Figure A66), based on NEFSC fall bottom trawl survey data for 2007-2009 (6.79 kg/tow), was above the management threshold level (3.31 kg/tow) and slightly above the target level (6.63 kg/tow). The three year average exploitation index (landings divided by biomass index, Figure A66) for 2007-2009 (0.15) was below the single management threshold/target (2.57).

Similarly, based on the existing BRPs the southern stock of silver hake is not overfished and overfishing is not occurring. The three year delta mean biomass index (Figure A67) based on NEFSC fall bottom trawl survey data for 2007-2009 (1.39 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 (Figure A67) for 2007-2009 (4.33) was below both the management threshold (34.39) and the management target level (20.63).

Based on new biological reference points from SARC 51, the northern stock of silver hake is not overfished and overfishing is not occurring. The three year arithmetic mean biomass index (Figure A68), based on NEFSC fall bottom trawl survey data in Albatross units for 2007-2009 (6.20 kg/tow), was above the management threshold (3.21 kg/tow) and below the target (6.42 kg/tow). The three year average exploitation index (catch divided by biomass index, Figure A68) for 2007-2009 (0.20 kt/kg) was below the overfishing threshold (2.78 kt/kg).

Based on new biological reference points from SARC 51, the southern stock of silver hake is not overfished and overfishing is not occurring. The three year arithmetic mean biomass index (Figure A69), based on NEFSC fall bottom trawl survey data in Albatross units for 2007-2009 (1.11 kg/tow), was above the management threshold (0.83 kg/tow) and below the target (1.65 kg/tow). The three year average exploitation index (catch divided by biomass index, Figure A69) for 2007-2009 (5.87 kt/kg) was below the overfishing threshold (34.19 kt/kg).

TOR 8. Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).

> *a. Provide numerical short-term projections (3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (e.g., terminal year abundance, variability in recruitment).*
>
> *b. Comment on which projections seem most realistic, taking into consideration uncertainties in the assessment.*
>
> *c. Describe this stock's vulnerability to becoming overfished, and how this could affect the choice of ABC.*

Stock projections were not carried out because the results from the ASAP model were not accepted for stock determination. However, with recent increases in stock biomass in the north, relatively stable biomass in the south and average recruitments in both areas, with low fishing mortality rates; qualitative analyses suggest that it is unlikely that the northern and southern stocks of silver hake will decline significantly in the short-term. Despite this assertion, uncertainties in the assessment exist due to the unknown cause of age truncation in the age-structure and the unknown magnitude of species mixing in the catch.

Summary

The population dynamics of silver hake in the northwest Atlantic have changed through time. In particular, patterns in growth and spatial distribution have changed substantially over the last 40years. Age structure, fish growth and spatial distribution reflect stock productivity. The current age structure indicates very little rebuilding of age-6 and older has occurred. It is likely that the lack of rebuilding of the age structure may have resulted from the continued high fishing mortality rates following the cessation of the distant water fleet.

Survey trends indicate that biomass in the northern area is high and low for the southern stock area. The incoherence of the survey trends relative to the levels of removals in the southern area is likely due to movement and therefore the survey trend may reflect seasonal abundances rather that trends for the southern stock. Although the evidence for silver hake stock structure is equivocal, a combined area model formulation appears to be more robust and stable relative to the north-south split.

Silver hake population constitutes an important link in the food web. Estimates of consumption of silver hake is on the same order of magnitude as estimates of silver hake stock landings, but consistently higher than landings. This is true for the combined evaluation and for both stocks. Estimates of predatory removal of silver hake via consumption are likely conservative given nature of these consumption estimates. These consumption estimates should be useful to inform both the scaling of biomass estimates and the magnitude of mortalities for silver hake. These estimates are likely to be quite informative to the dynamics of silver hake, as they represent a major source of removals and internal dynamics (cannibalism) that is being accounted for.

Silver hake are cannibalistic. Over 870 occurrences occurred out of over 49,000 silver hake stomachs sampled and recorded in the Food Habits Database, or roughly 2% of every hake caught consumed hake. For perspective, another species thought to be highly cannibalistic, the goosefish (*Lophius americanus*), only had 0.1% incidence of cannibalism. On average, silver hake comprised 12% of the silver hake diet composition (by weight), a significant, consistent and important prey item. This poses some potential tautologies of estimating silver hake abundance to then estimate silver hake cannibalism, which in turn can inform assessment models to estimate silver hake abundance. To accommodate this, we used swept area abundance estimates for silver hake as a predator of silver hake to help scale the total silver hake consumed by silver hake. Cannibalism has implications for recruitment as well, and we are exploring alternative models of stock-recruit relationships to ascertain how much cannibalism can influence those dynamics.

The accepted catch and survey index-based BRPs do not incorporate age structure and do not provide any measures of uncertainty. No age-based analytical model formulations (ASAP) were accepted, nonetheless, the model results were informative. Based on the collective knowledge of the fishery and the surveys, the most likely model (Run 6) did provide indications of trend that were in agreement with the declining age 3+ spawning numbers from the autumn NEFSC survey. Status quo BRPs are not considered appropriate to set ABC. Recent catches have been considerably less than historical ones, however, 3+ numbers in the autumn surveys have been declining since the early 1990s under such catches possibly for reasons other than only fishing (Figures A86-A87).

Research to address fishery selectivity and stock composition (mixing of northern and southern components) and the extent of stock distribution is needed to reconcile the issues regarding selectivity in the current ASAP model formulation.

TOR 9. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.

SAW1 (1985)

- Re-analysis of VPA incorporating new stock definitions is currently underway
- By-catch and discard of young silver hake in the shrimp fishery a potential source of significant juvenile mortality
- CPUE indices for southern-and northern stocks need to be reconstructed with different standard fleets
- Consistency of surveys and analytical assessments for tracking cohorts will be examined
- Predatory impact of silver hake is likely significant

SAW17 (1994)

- The subcommittee strongly recommends that the stock structure of this resource be closely examined in order to determine the most appropriate aggregation of landings at age and survey data.
- The subcommittee recommends that the survey series be evaluated to 1) determine appropriate strata sets to account for possible differences in distribution between years, 2) determine evidence of mixing between stocks, 3) determine effect of transformations (e.g., logarithmic or delta) in reducing the impact of unusually high tows.
- The subcommittee recommends that the adequacy of the statistical design of the sea sampling program for estimating discards of silver hake be evaluated. The subcommittee notes that this evaluation should be done across several species and that sampling designs need to reflect the priorities given to each species.
- Sea sampling is not yet substitutable for port sampling. Thus, port samples for length composition are essential to estimate landings at age. Since age-structures collected in the survey do not adequately cover commercially caught fish, the

subcommittee recommends that age structures be collected from either the port sampling or sea sampling programs.

- The subcommittee recommends that the spring and summer Canadian surveys be evaluated for use as tuning indices and as indicators of silver hake geographical distribution.
- The developing fishery for juvenile silver hake should be carefully monitored to establish whether it is targeting concentrations of small fish or sampling landing catches that otherwise would have been discarded. From a scientific basis it would be beneficial to take observers aboard that target silver hake, optimally when participating in an experimental fisheries program. This data collection effort is needed to accumulate catch statistics, measure the length composition of landings and discards, and provide adequate sea sampling to determine discard rate.
- There is a need for a market category designation and adequate sampling for small silver hake (<18cm) to properly quantify the magnitude of the landings of these juvenile fish.
- MARMAP data should be examined to gain information on egg and larval silver hake distribution with respect to aggregation of spawning adults.

SAW32 (2001) and SAW42 (2006)

- Develop survey information that covers the offshore range of the population.
- Conduct surveys of spawning aggregations on the southern flank of Georges Bank.
- Investigate bathymetric demography of population.
- 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.
- Quantify age-specific fecundity of silver hake.

New Research Recommendations (from data and model meetings)

- Studies to estimate discard mortality should be conducted.
- Investigate silver and offshore hake data in deepwater surveys (e.g., monkfish survey).
- Consider hydrographic information in conjunction with the larval indices. This is not currently available, but work is in progress to be able to back-calculate spawning areas.
- Information on consumption by more predators (including mammals, highly migratory species (HMS)) needs to be included.
- Examine diel (day/night) variation in consumption of hakes.
- Validation of the ageing method for silver hake via tagging, radiocarbon, or tetracyclin research needs to be conducted.
- More comprehensive analysis of silver hake stock structure based on DNA (expanded genetic analysis) needs to be conducted.

- Investigate stock identification questions for silver hake by using samples from Tom Helser and Bill Phoel.
- Take M matrix from consumption model and put into model without consumption.

Sources of Uncertainty

1. The mis-reporting of silver hake in thee landings as offshore hale and vice-versa introduces considerable uncertainty in removals. Landings of silver hake may be over-reported and landings of offshore hake may be under-reported.
2. Survey data indicate relatively large silver hake may move around Georges Bank from South stock area to the northern. Uncertainty about north-south movements of adult silver hake is important because of uncertainty about linkages between the northern and southern stock areas.
3. The decreasing trend in abundance of relatively old and larger individuals. These reductions have occurred despite normal growth patterns, low fishing mortality rates and relative high biomass. This possibility of increased natural mortality due to predation is likely which was explored in this assessment.
4. Consumption
   a. Minimum swept area estimates for some predator abundance does not account for q for all predators; these are likely lower estimates of predator abundance and thus these consumption estimates should be viewed as conservative estimates. Although stock assessment estimates of abundance were used for some predators, using a full range of abundance estimates from stock assessments for more predators would also likely increase the estimates noted here.
   b. Is the α too low compared to literature? These too may be somewhat conservative, but are within the range of those generally reported. Again, these should be viewed as conservative estimates.
   c. Some fish predators that did not consistently eat silver hake (e.g. pollock, some of the skates) were not included in the analysis.
   d. Also, these estimates did not include a wide range of other (non-fish) predators known to consume silver hake (e.g., seabirds, squids, marine mammals), nor did they include silver hake cannibalism, which is suspected to be significant. Collectively this relatively limited set of predators thus may result in these being fairly conservative estimates of overall predatory removals of silver hake.
   e. Spatio-temporal overlap considerations between predators and silver hake were assumed.
   f. The degree of tautology due to silver hake cannibalism (i.e. estimating consumption based upon silver hake abundance, to better estimate silver hake abundance) is worth noting and addressing in further detail at some point in the future.

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Table A1. Nominal landings of silver hake by stock from 1955-2009.

	Northern Stock			Southern Stock			Combined Stock		
Year	US	DWF	Total	US	DWF	Total	US	DWF	Total
1955	53,361		53,361	13,842		13,842	67,203		67,203
1956	42,150		42,150	14,871		14,871	57,021		57,021
1957	62,750		62,750	17,153		17,153	79,903		79,903
1958	49,903		49,903	13,473		13,473	63,376		63,376
1959	50,608		50,608	17,112		17,112	67,720		67,720
1960	45,543		45,543	9,206		9,206	54,749		54,749
1961	39,688		39,688	13,209		13,209	52,897		52,897
1962	42,427	36,575	79,002	13,408	5,325	18,733	55,835	41,900	97,735
1963	36,399	37,525	73,924	19,359	74,023	93,382	55,758	111,548	167,306
1964	37,222	57,240	94,462	26,518	127,036	153,554	63,740	184,276	248,016
1965	29,512	15,793	45,305	23,765	283,366	307,131	53,278	299,159	352,437
1966	33,569	14,239	47,808	11,212	200,058	211,270	44,781	214,297	259,078
1967	26,489	6,882	33,371	9,500	81,749	91,249	35,989	88,631	124,620
1968	30,873	10,506	41,379	9,074	49,422	58,496	39,947	59,928	99,875
1969	16,008	8,047	24,055	8,165	67,396	75,561	24,173	75,443	99,616
1970	15,223	12,305	27,528	6,879	20,633	27,512	22,102	32,938	55,040
1971	11,158	25,243	36,401	5,546	66,344	71,890	16,704	91,587	108,291
1972	6,440	18,784	25,224	5,973	88,381	94,354	12,413	107,165	119,578
1973	14,005	18,086	32,091	6,604	97,989	104,593	20,609	116,075	136,684
1974	6,907	13,775	20,682	7,751	102,112	109,863	14,658	115,887	130,545
1975	12,566	27,308	39,874	8,441	65,812	74,253	21,007	93,120	114,127
1976	13,483	151	13,634	10,434	58,307	68,741	23,917	58,458	82,375
1977	12,455	2	12,457	11,458	47,850	59,308	23,913	47,852	71,765
1978	12,609		12,609	12,779	14,353	27,132	25,388	14,353	39,741
1979	3,415		3,415	13,498	4,877	18,375	16,913	4,877	21,790
1980	4,730		4,730	11,848	1,698	13,546	16,578	1,698	18,276
1981	4,416		4,416	11,783	3,043	14,826	16,199	3,043	19,242
1982	4,664		4,664	12,164	2,397	14,561	16,828	2,397	19,225
1983	5,312		5,312	11,520	620	12,140	16,832	620	17,452
1984	8,289		8,289	12,731	412	13,143	21,020	412	21,432
1985	8,297		8,297	11,843	1,321	13,164	20,140	1,321	21,461
1986	8,502		8,502	9,573	550	10,123	18,075	550	18,625
1987	5,658		5,658	10,121	2	10,123	15,779	2	15,781
1988	6,789		6,789	9,195		9,195	15,984		15,984
1989	4,648		4,648	13,428		13,428	18,076		18,076
1990	6,377		6,377	13,610		13,610	19,987		19,987
1991	6,055		6,055	10,492		10,492	16,547		16,547
1992	5,306		5,306	10,873		10,873	16,179		16,179
1993	4,364		4,364	12,942		12,942	17,306		17,306
1994	3,899		3,899	12,159		12,159	16,058		16,058
1995	2,594		2,594	12,102		12,102	14,696		14,696
1996	3,619		3,619	12,561		12,561	16,180		16,180
1997	2,802		2,802	12,763		12,763	15,565		15,565
1998	2,045		2,045	12,828		12,828	14,873		14,873
1999	3,444		3,444	10,577		10,577	14,021		14,021
2000	2,592		2,592	9,769		9,769	12,361		12,361
2001	3,391		3,391	9,517		9,517	12,908		12,908
2002	2,593		2,593	5,344		5,344	7,937		7,937
2003	1,808		1,808	6,835		6,835	8,643		8,643
2004	1,049		1,049	7,436		7,436	8,485		8,485
2005	827		827	6,670		6,670	7,497		7,497
2006	903		903	4,629		4,629	5,532		5,532
2007	1,014		1,014	5,345		5,345	6,359		6,359
2008	620		620	5,638		5,638	6,258		6,258
2009	1,038		1,038	6,720		6,720	7,755		7,758

Table A2. Landings of silver hake in metric tons from the northern region by state.

Year	CT	ME	MD	MA	NH	NJ	NY	RI	VA	Unknown	Total
1964		11499		24722				<1		1000	37,222
1965		12625		16887							29,512
1966		13357		20212							33,569
1967		9368		16855				1		265	26,489
1968		13068		17789				<1		16	30,873
1969		8115		7893							16,008
1970		6730		8489				<1		4	15,223
1971		4491		6659				1		7	11,158
1972		1857		4568				1		14	6,440
1973		2503		11502				<1			14,005
1974		1301		5604				1			6,907
1975		544		12022				<1			12,566
1976		185		13284				1		14	13,483
1977		116		12324				<1		15	12,455
1978		527		12054				<1		28	12,609
1979		65		3334				4		12	3,415
1980		245		4448				3		34	4,730
1981		1280		2994	7	2		80		53	4,416
1982		871		3747	16	17		13			4,664
1983		1051		4209	48			4			5,312
1984		1644		6388	64			193			8,289
1985		1131		6691	99			371		5	8,297
1986		876		7496	85			45			8,502
1987		580		4885	72			119		2	5,658
1988		972		4075	69	<1		1673			6,789
1989		342		2794	57			1455			4,648
1990		120		3747	103	<1		2408			6,377
1991		57		3561	78			2359			6,055
1992		46		3165	84			2010			5,306
1993		28		2247	64			2025			4,364
1994		875		2045	92			887			3,899
1995	243	896	<1	1211	80	10	19	135	<1		2,594
1996	318	1452		1144	110		137	459			3,619
1997	131	558		1258	148	5	116	585			2,802
1998	118	76		1153	49	<1	332	317			2,045
1999	540	64		1804	111		380	546			3,444
2000	240	9		1953	163		1	227			2,592
2001	438	14		2199	136		105	499			3,391
2002	251	6		1701	79		106	450			2,593
2003	67	1		1205	83		141	311			1,808
2004	173	1		753	71		31	20			1,049
2005	54	1		644	39		17	71			827
2006	148	<1		538	44		34	140			903
2007	1	<1	3	665	93		24	228			1,014
2008	<1	<1		444	83		<1	21	72		620
2009	10	<1		882	144	<1		1			1,038

Table A3 Landings of silver hake in metric tons from the southern region by state.

	CT	ME	MD	MA	NH	NJ	NY	NC	PA	RI	VA	Unknown	Total
1964				709						1677		24132	26,518
1965				3481						1077		19207	23,765
1966		23		3139						1080		6970	11,212
1967		12		296						552		8640	9,500
1968				579						976		7519	9,074
1969				435						1274		6456	8,165
1970				1304						1629		3946	6,879
1971				179						1318		4049	5,546
1972				525						1219		4229	5,973
1973				53						1397		5154	6,604
1974				6						2337		5408	7,751
1975				52						2400		5989	8,441
1976				70						3249		7115	10,434
1977				4						2469		8985	11,458
1978				298		5021				2981		4479	12,779
1979				62		5356				3776		4304	13,498
1980		2		12		5362				3132		3340	11,848
1981		<1		11		4113				4520		3138	11,783
1982		<1	5	92		3204				6811	80	1971	12,164
1983			15	157		3000				6101	36	2211	11,520
1984			12	2		3720				6620	76	2300	12,731
1985			4	8		4087				5653	25	2066	11,843
1986			1	13		2676	1072			5633	12	165	9,573
1987		1	<1	1		1897	2052			5926	30	214	10,121
1988		<1	3	<1		2765	1900			4483	9	35	9,195
1989	351	1	6	2		3719	4109			5220	20		13,428
1990	238		10	236		3913	3354			5833	26		13,610
1991	385	<1	7	397		1976	2769			4945	14		10,492
1992	572	<1	1	436		943	2693			6226	3		10,873
1993	1088	<1	6	228		1098	5534			4982	5		12,942
1994	857	3	1	86		1214	5055			4918	5	20	12,159
1995	1352	2	2	70	<1	1229	5118			4325	4		12,102
1996	2242	2	1	89	<1	816	5633			3773	5		12,561
1997	1757	7	1	35	<1	981	5319			4661	2		12,763
1998	1643	4	<1	39		701	6081	<1		4353	6		12,828
1999	2404	<1	1	120	<1	336	3879			3836	1		10,577
2000	2573	1	1	307		299	2048	2		4540	<1		9,770
2001	1926	1	1	290	1	361	3248	1		3686	3		9,517
2002	898	14	<1	458	<1	425	1693	2		1855	<1		5,345
2003	1046	<1	<1	1518		68	1891	1		2310	<1		6,835
2004	1207	<1	<1	1917	<1	116	2098	<1	<1	2097	1		7,436
2005	1493	1	<1	1865		140	1100			2073			6,671
2006	1049	1		1132		90	761			1596			4,629
2007	824		<1	796		491	1119			2114			5,345
2008	607	<1	<1	1104		432	1188			2265	42		5,638
2009	302			1579		1070	1233			2535	1		6,720

Table A4. Landings of silver hake in metric tons from the northern region by gear.

Year	LL	OTF	OTS	SGN	OTH	Total
1964	<1	37215		<1	7	37,222
1965		29512		<1	<1	29,512
1966	<1	33551		<1	18	33,569
1967		26488			1	26,489
1968		30871			2	30,873
1969	<1	16008				16,008
1970		15223		<1	<1	15,223
1971	1	11157		<1	<1	11,158
1972	<1	6439		1	<1	6,440
1973	<1	13976		1	28	14,005
1974	<1	6890		11	5	6,907
1975	1	12270	282	13		12,566
1976	3	13405	24	48	3	13,483
1977	3	12368	26	54	4	12,455
1978	1	12471		64	73	12,609
1979	1	3386	1	19	8	3,415
1980	1	4666	5	50	8	4,730
1981	1	4187	175	50	3	4,416
1982	<1	4503	124	27	8	4,664
1983	1	5000	254	29	28	5,312
1984	<1	8035	133	39	81	8,289
1985	<1	7697	464	30	106	8,297
1986	<1	7585	736	49	133	8,502
1987	<1	5008	423	60	167	5,658
1988	<1	6211	395	24	158	6,789
1989	<1	4322	240	38	48	4,648
1990	1	6041	258	73	3	6,377
1991	<1	5756	170	55	73	6,055
1992	1	5078	100	44	82	5,306
1993	2	4195	4	42	121	4,364
1994	<1	3723	21	72	82	3,899
1995	<1	2257	20	56	260	2,594
1996	<1	3516	45	56	2	3,619
1997	<1	2599	131	45	26	2,802
1998	5	1998	9	30	3	2,045
1999	1	3389	16	22	16	3,444
2000	<1	2457	22	41	72	2,592
2001	<1	3293	1	24	73	3,391
2002	<1	2565	<1	20	7	2,593
2003	<1	1753		15	40	1,808
2004	<1	969	<1	26	54	1,049
2005	<1	733	<1	37	57	827
2006		883	1	17	2	903
2007	<1	1005	1	8		1,014
2008	<1	575	3	41	1	620
2009	<1	820	8	200	10	1,038

Table A5. Landings of silver hake in metric tons from the southern region by gear.

Year	LL	OTF	SGN	OTH	Total
1964		26518		<1	26,518
1965		23765		<1	23,765
1966		11212			11,212
1967		9499		01	9,500
1968		9073		1	9,074
1969		8165		<1	8,165
1970		6879			6,879
1971		5546		<1	5,546
1972		5862	1	109	5,973
1973		6593		11	6,604
1974		7747		4	7,751
1975		8440	<1	1	8,441
1976		10430	<1	4	10,434
1977		11457		1	11,458
1978	<1	12746	4	29	12,779
1979		13459	6	33	13,498
1980	<1	11828	6	14	11,848
1981	<1	11772	6	5	11,783
1982		12147	3	14	12,164
1983		11500	14	6	11,520
1984		12689	18	24	12,731
1985		11828	8	6	11,843
1986		9564	3	6	9,573
1987	1	10113	2	5	10,121
1988	<1	9191	1	3	9,195
1989		13422	1	5	13,428
1990		13605	1	4	13,610
1991	<1	10484	2	6	10,492
1992	<1	10872	1	<1	10,873
1993	<1	12927	1	14	12,942
1994	3	11288	1	867	12,159
1995	<1	10731	1	1371	12,102
1996	<1	12543	1	12.81	12,561
1997		12741	1	21	12,763
1998		12786	10	32	12,828
1999	3	10557	2	15	10,577
2000	<1	9755	8	6	9,769
2001	<1	9509	2	6	9,517
2002		5330	3	12	5,345
2003		6818	13	4	6,835
2004	<1	7146	49	241	7,436
2005	60	6211	30	370	6,671
2006	30	4273	68	258	4,629
2007		5053	78	214	5,345
2008	17	4998	143	480	5,638
2009	<1	4735	168	1817	6,720

Table A6. Landings of silver hake in metric tons from the northern region by month.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	Total
1964	1000	4	<1		<1	360	5168	15031	7953	3999	2405	1202	99	37,222
1965		1	1		12	7	2614	12088	7411	5084	1603	649	41	29,512
1966				<1	<1	60	3868	9305	13307	4237	2185	577	30	33,569
1967	265	<1	1			<1	1179	11176	8279	2813	2183	582	12	26,489
1968	15			<1	1	279	3076	11202	9609	4498	2047	140	6	30,873
1969		<1				24	2308	6563	3701	1677	1278	367	91	16,008
1970	3	5	4	21	21	287	1737	4657	5050	1898	901	554	85	15,223
1971	8	2	1	11	7	7	596	4759	2541	607	1016	1447	156	11,158
1972	14	10	1	1	3	225	240	1332	1231	670	1231	1018	464	6,440
1973		9	9	17	54	138	1078	3478	3326	2356	2188	823	529	14,005
1974		18	2	3	8	140	481	1128	1949	1029	711	1139	299	6,907
1975		43	42	24	37	1487	1092	3521	1875	1137	1921	1117	274	12,566
1976	15	99	693	1091	314	302	520	2517	2832	2820	1303	757	220	13,483
1977	15	46	16	87	1404	544	434	1299	3707	2096	1809	601	397	12,455
1978	27	46	356	53	343	625	358	2630	4846	1364	1066	754	141	12,609
1979	12	21	3	21	81	32	87	679	520	510	539	807	103	3,415
1980	34	29	14	16	17	30	229	519	561	1085	1691	392	113	4,730
1981	53	40	46	73	200	108	221	463	803	693	1037	525	154	4,416
1982		57	24	78	42	81	94	318	1251	984	805	598	332	4,664
1983		98	18	62	199	54	288	709	1205	669	652	729	629	5,312
1984	1	72	22	78	74	40	116	582	1869	1431	1580	1549	875	8,289
1985	5	165	96	290	74	161	347	800	1471	1476	1221	1293	898	8,297
1986	2	324	383	223	124	172	317	1274	1278	1054	1414	1261	676	8,502
1987	1	148	75	103	94	180	235	535	457	1062	948	1289	531	5,658
1988		272	148	158	67	182	388	963	1436	1131	957	751	336	6,789
1989		169	31	29	61	94	210	552	1755	611	651	359	127	4,648
1990		90	46	37	47	46	51	1113	1839	853	921	922	413	6,377
1991		110	52	17	16	22	191	2271	1109	694	802	567	204	6,055
1992	2	123	32	11	1	8	71	1227	1301	856	860	688	126	5,306
1993	3	55	7	19	<1	43	127	1476	1086	495	475	443	135	4,364
1994		52	8	20	30	26	199	758	778	884	614	416	114	3,899
1995	2	9	1	1	1	24	49	387	859	595	441	202	23	2,594
1996		4	1	4	2	48	55	415	1071	965	807	214	33	3,619
1997	1	16	14	31	52	94	73	442	683	686	485	208	16	2,802
1998		4	1	2	26	1	29	371	601	413	232	333	33	2,045
1999		8	1	24	6	1	74	659	926	634	520	507	85	3,444
2000		51	57	117	5	4	85	430	451	372	608	368	43	2,592
2001		70	67	65	3	9	37	450	842	804	461	428	156	3,391
2002		32	21	2	2	1	59	472	630	663	472	197	42	2,593
2003		11	1	<1	<1	9	35	410	668	331	178	153	12	1,808
2004		3	<1	<1	2	16	22	70	263	491	120	43	20	1,049
2005		<1	1	<1	<1	44	38	139	396	151	44	9	4	827
2006		2	12	1	<1	<1	<1	42	456	368	7	11	4	903
2007		<1	<1	8	<1	<1	1	94	310	318	247	22	12	1,014
2008		<1	2	1	7	13	7	108	115	81	107	157	22	620
2009		22	<1	2	2	11	8	251	165	167	50	298	63	1,038

Table A7. Landings of silver hake in metric tons from the southern region by month.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	Total
1964	24,133	15	10	4	105	308	876	183	177	118	266	183	140	26,518
1965	19,208	22	4	15	481	1670	1768	196	111	38	90	86	76	23,765
1966	6,961	24	40	22	484	1329	782	394	741	78	201	94	62	11,212
1967	8,637	15	6	15	69	77	393	48	47	32	47	64	50	9,500
1968	7,519	22	27	53	36	170	650	136	118	85	120	75	63	9,074
1969	6,455	21	13	20	103	413	434	160	124	187	90	88	57	8,165
1970	3,947	13	23	25	29	1055	750	285	365	201	78	60	48	6,879
1971	4,050	9	11	50	35	101	358	364	245	109	46	36	132	5,546
1972	4,230	78	9	15	20	412	562	145	275	81	6	69	71	5,973
1973	5,154	59	14	18	23	261	322	156	120	75	84	138	180	6,604
1974	5,406	172	186	160	205	366	363	273	42	46	51	77	404	7,751
1975	5,988	313	89	119	169	324	280	158	161	96	132	131	481	8,441
1976	7,117	298	185	129	362	338	399	298	221	329	103	358	297	10,434
1977	8,986	56	36	49	36	270	465	270	297	231	103	170	489	11,458
1978	4,478	871	1018	1124	848	1153	786	134	111	164	264	642	1186	12,779
1979	4,303	1492	779	991	741	798	496	438	357	383	508	839	1373	13,498
1980	3,340	1131	896	737	1095	968	456	300	285	373	443	608	1216	11,848
1981	3,138	1193	382	673	842	1071	1118	533	429	330	340	854	880	11,783
1982	1,972	953	729	1074	590	1359	1642	715	613	505	546	577	889	12,164
1983	2,212	1145	753	599	721	856	979	871	734	743	493	564	850	11,520
1984	2,301	1214	780	1388	976	1153	1258	1300	356	298	493	381	833	12,731
1985	2,067	1318	1079	840	1209	1391	1077	959	465	214	451	269	504	11,843
1986	165	895	429	828	1567	1351	1133	484	452	603	383	350	933	9,573
1987	213	919	815	1219	1199	1359	938	704	877	505	307	246	820	10,121
1988	35	920	1292	1449	1229	1197	1165	395	70	69	242	432	700	9,195
1989	11	1315	1160	1180	1430	1651	1355	1322	390	564	826	998	1226	13,428
1990		1807	1035	1293	1350	1828	1486	881	591	827	584	743	1185	13,610
1991	11	953	1190	974	1498	1675	1240	172	539	591	355	562	732	10,492
1992	104	953	761	1037	1474	1089	1942	780	350	595	660	491	637	10,873
1993	3	598	986	1397	1380	1510	1194	372	604	1181	1437	1356	924	12,942
1994		1154	1041	1237	1156	1170	1294	913	611	1002	1090	720	771	12,159
1995	4	940	1065	1350	1178	1316	1139	1078	780	884	739	816	813	12,102
1996	2	1194	1340	1250	1320	1433	1278	935	402	637	605	1072	1093	12,561
1997	10	1228	1025	1196	1558	1527	1385	899	526	808	772	827	1002	12,763
1998	1	1058	1145	1393	1243	1255	1487	1036	583	1094	858	835	840	12,828
1999		1071	1034	1365	1469	1474	1149	519	467	406	561	452	610	10,577
2000		1032	992	991	910	923	893	749	878	879	486	386	651	9,769
2001	27	1203	955	1088	911	1208	1209	831	632	280	410	362	401	9,517
2002	22	489	845	683	496	823	556	281	135	144	172	323	376	5,345
2003		524	478	560	361	543	766	668	384	901	601	437	613	6,835
2004		528	780	960	681	684	758	753	665	449	397	491	290	7,436
2005		444	409	822	604	635	850	787	512	657	340	282	328	6,671
2006		318	403	595	393	550	559	530	215	192	313	249	313	4,629
2007		339	342	454	373	556	654	469	615	521	330	316	374	5,338
2008		526	389	626	455	530	401	364	516	585	379	493	373	5,638
2009		420	517	619	488	868	677	613	547	627	604	379	362	6,720

Table A8. Nominal landings of silver hake by region and half year.

	North				South			
Year	1	2	Unknown	Total	1	2	Unknown	Total
1964	5532	30689	1000	37,222	1318	1067	24,133	26,518
1965	2635	26876		29,512	3960	597	19,208	23,765
1966	3928	29641		33,569	2681	1570	6,961	11,212
1967	1180	25045	265	26,489	575	288	8,637	9,500
1968	3356	27502	15	30,873	958	597	7,519	9,074
1969	2332	13677		16,008	1004	706	6,455	8,165
1970	2075	13145	3	15,223	1895	1037	3,947	6,879
1971	624	10526	8	11,158	564	932	4,050	5,546
1972	480	5946	14	6,440	1096	647	4,230	5,973
1973	1305	12700		14,005	697	753	5,154	6,604
1974	652	6255		6,907	1452	893	5,406	7,751
1975	2724	9843		12,566	1294	1159	5,988	8,441
1976	3019	10449	15	13,483	1711	1606	7,117	10,434
1977	2531	9909	15	12,455	912	1560	8,986	11,458
1978	1781	10801	27	12,609	5800	2501	4,478	12,779
1979	245	3158	12	3,415	5297	3898	4,303	13,498
1980	335	4361	34	4,730	5283	3225	3,340	11,848
1981	688	3675	53	4,416	5279	3366	3,138	11,783
1982	376	4288		4,664	6347	3845	1,972	12,164
1983	719	4593		5,312	5053	4255	2,212	11,520
1984	402	7886	1	8,289	6769	3661	2,301	12,731
1985	1133	7159	5	8,297	6914	2862	2,067	11,843
1986	1543	6957	2	8,502	6203	3205	165	9,573
1987	835	4822	1	5,658	6449	3459	213	10,121
1988	1215	5574		6,789	7252	1908	35	9,195
1989	594	4055		4,648	8091	5326	11	13,428
1990	317	6061		6,377	8799	4811		13,610
1991	408	5647		6,055	7530	2951	11	10,492
1992	246	5058	2	5,306	7256	3513	104	10,873
1993	251	4110	3	4,364	7065	5874	3	12,942
1994	335	3564		3,899	7052	5107		12,159
1995	85	2507	2	2,594	6988	5110	4	12,102
1996	114	3505		3,619	7815	4744	2	12,561
1997	280	2520	1	2,802	7919	4834	10	12,763
1998	63	1983		2,045	7581	5246	1	12,828
1999	114	3331		3,444	7562	3015		10,577
2000	319	2272		2,592	5741	4029		9,769
2001	251	3141		3,391	6574	2916	27	9,517
2002	117	2476		2,593	3892	1431	22	5,345
2003	56	1752		1,808	3232	3604		6,835
2004	43	1007		1,049	4391	3045		7,436
2005	83	743		827	3764	2906		6,671
2006	15	888		903	2818	1812		4,629
2007	9	1003		1,014	2718	2625		5,338
2008	30	590		620	2927	2710		5,638
2009	45	994		1,038	3589	3132		6,720

Table A9. Landings of silver hake by market category from the northern region.

	Half 1							Half 2						
Year	Round	Med	Small	Dressed	Juv	King	Large	Round	Med	Small	Dressed	Juv	King	Large
1964	5350			183				30023			666			
1965	2633			2				26626			225			
1966	3916			11				29510			131			
1967	1179			1				24410			634			
1968	3300			55				26867			634			
1969	2331			<1				13314			362			
1970	2052			23				13095			50			
1971	581			43				10415			113			
1972	471			8				5917			29			
1973	1292			13				12600			99			
1974	648			4				6222			33			
1975	2691			28				9678			168			
1976	3010			8				10447			3			
1977	2530			<1				9847			49			
1978	1779			1				10739			62			
1979	241			4				3125			33			
1980	333			4				4341			19			
1981	667			20		1		3591			28		53	
1982	366			6		3		3986		163	63		74	
1983	414		241	18		46		4047		348	16		183	
1984	199		121	2		81		6436		1234	10		206	
1985	788		232	<1		113		5995		606	61		496	
1986	1147		280	2		114		5826		360	355		418	
1987	680		118	1		35		4234		323	6		260	
1988	1027		167	1		19		5030		344	<1		201	
1989	520		51	<1		22		3818		51	16		166	
1990	258		53	<1		6		5776		17	1		263	
1991	394		5	<1		7		5373		9	<1		263	
1992	236		8			3		4692		40			323	
1993	250		1			1		3913		47			148	
1994	275		49		6	4		2774		521		143	113	
1995	73		5	<1		1		1954		162			36	
1996	84		27			1		2755		442			87	
1997	191		87			2		1825		548			148	
1998	54		3			6		1489		188	16	73	212	
1999	79		35			5		2545		289		236	255	
2000	279		8	<1		31		1890		189			193	
2001	206		5			39		2405		416			302	
2002	94		15			5		1801		501			146	
2003	20		34			2		1177		481			93	
2004	13		8	21		1	<1	359		76	362	24	20	100
2005	71		<1	1		<1	1	363		20	303	<1	4	17
2006	10		1	<1	3	<1	<1	291		110	329	41	12	67
2007	9		<1	1		<1	<1	525	72	169	57	50	20	67
2008	17	<1	2	3	<1	1	3	337	48	18	93	3	13	27
2009	1	<1	<1	4		<1	<1	436	43	3	6		9	35

Table A10. Landings of silver hake by market category from the southern region.

	Half 1							Half 2						
Year	Round	Med	Small	Dressed	Juv	King	Large	Round	Med	Small	Dressed	Juv	King	Large
1964	1243			76				548			519			
1965	3934			26				540			59			
1966	2449			223				1374			196			
1967	557			17				259			28			
1968	909			48				560			37			
1969	980			24				701			4			
1970	1864			32				1028			10			
1971	536			29				925			7			
1972	1037			59				644			4			
1973	676			20				743			11			
1974	1388			63				879			13			
1975	1265			28				1121			38			
1976	1674			38				1574			32			
1977	907			5				1561			<1			
1978	5791			8				2496			5			
1979	5294			3				3897			1			
1980	5282			<1				3225			1			
1981	5028			107		145		3253			1		112	
1982	6153			35		160		3718		<1	8		120	
1983	4928			3		122		3994			36		225	
1984	6491		1	12		265		3407		1	1		252	
1985	6662			19		232		2667		10	<1		185	
1986	6005		50	<1		147		3094		1			110	
1987	6291		22			137		3387		<1			72	
1988	7135		<1			117		1853		1	<1		54	
1989	7922		<1			61		4763			4		71	
1990	8564			4		110		4542		1	<1		127	
1991	7168		3	2		154		2643		4	<1		121	
1992	6856		12	<1		155		3187		14	<1		65	
1993	6897		<1			124		3447		1197	1	75	114	
1994	3606		2533	1	361	229		2529		1672	<1	277	75	
1995	5142		1375	<1	33	385		4091		680	<1		328	
1996	5999		1474	<1	2	335		3070		1369	1	23	283	
1997	4620		2583		61	606		3210		1369	<1		251	
1998	5411		1542		75	552		3159		1756		45	282	
1999	4817		1989		338	418		2108		767		4	128	
2000	3793		1571	2	44	299		2438		1187		<1	403	
2001	4335		1214		6	908		1905		602			355	
2002	2355		1059	<1	178	228		916		413			88	
2003	1917		1064			248		1959		1524			118	
2004	2403	<1	1101	406	54	206	63	1203		566	410	267	162	150
2005	1587		640	746	293	85	109	1303		443	551	344	38	49
2006	1103		701	445	209	86	92	739	<1	405	260	143	53	43
2007	1153	128	582		163	128	218	996	101	759	228	53	126	153
2008	864	240	652	318	14	127	198	731	378	367	288	3	179	132
2009	955	592	472	144		160	228	684	338	730	75	20	117	166

Table A11. Summary of number of silver hake measured by port samplers by market category and half in the northern region.

	Round		Small		Dressed		King		Large	
Year	1	2	1	2	1	2	1	2	1	2
1969	202	2135								
1970	218	1838								
1971	243	2481				218				
1972		1221								
1973	320	3572			614					
1974	191	1409			84					
1975	799	855								
1976	1789	2126								
1977	878	3795								
1978	1217	1808								
1979	103	1362								
1980		775								
1981	98	1577								
1982		2007		117						
1983	210	3003		200						
1984	433	1829		519						
1985	221	1946	515	1130			125	338		
1986	974	3183	290	586						
1987	367	2717		839				324		
1988	691	2400	300	728			201	519		
1989	763	1146	106					100		
1990	466	1467								
1991	634	1232					114	129		
1992	215							262		
1993		886								
1995	348	344	202							
1997		207		209						
1998		514								
1999	100	45						113		
2000	269	407						102		
2001	1255	800	218				263	217		
2002	103		98				76	106		
2003	19	426						95		
2004	134	488		201				93		
2005		100		100				4		
2006	110	521						9	108	293
2007		547						189		344
2008		200						12		
2009	87	100								

Table A12. Summary of number of silver hake measured by port samplers by market category and half in the southern region.

	Round		Small		Dressed		Juv		King		Large	
Year	1	2	1	2	1	2	1	2	1	2	1	2
1969	50											
1970	316											
1971	98	311										
1972	216											
1975		793										
1976	200	1268			61							
1977	1418	685										
1978	1039	378										
1979	882	1321										
1980	2128	1995										
1981	1270	2570								154		
1982	3159	2699							472	190		
1983	4246	2067							256	541		
1984	3302	1716							323	306		
1985	5048	2025		110					344	186		
1986	3565	3118							201	468		
1987	5004	2539							167	182		
1988	4778	2922							87			
1989	3643	2594							167	104		
1990	5147	4069							201	100		
1991	3004	2397							95	198		
1992	2610	1023							96			
1993	1414	900		212					41	100		
1994	1003		303									
1995	1489		308						236			
1997	2535	236	1396	317					1475	157		
1998	2877	1585	411	32			104		781	410		
1999	2563	603	102	536			413		526	396		
2000	919	542	526	410					223	182		
2001	3598	2131	1178	555					2201	1021		
2002	3243	1274	1139	221			121		958	98		
2003	3088	1536	981	1309					713	618		
2004	1888	2129	1177	319					515	1163		
2005	2646	4512	539	517					1980	526		696
2006	5634	3341							632	461	1503	1256
2007	7499	3575		102					1209	614	1833	2585
2008	5432	3828	109						997	964	2376	1331
2009	4013	2890					100		1498	683	1339	1340

Table A13. Summary of number of offshore hake measured by port samplers by market category, half and region.

	North	South		
	Round	Round		King
Year	Half 1	Half 1	Half 2	Half 1
1993			103	
1994				
1997		135		
2003				31
2004				337
2005	1			
2006		29		

Table A14. Pooling of silver/offshore hake port length samples to estimate length and species composition of the commercial landings by region and market category.

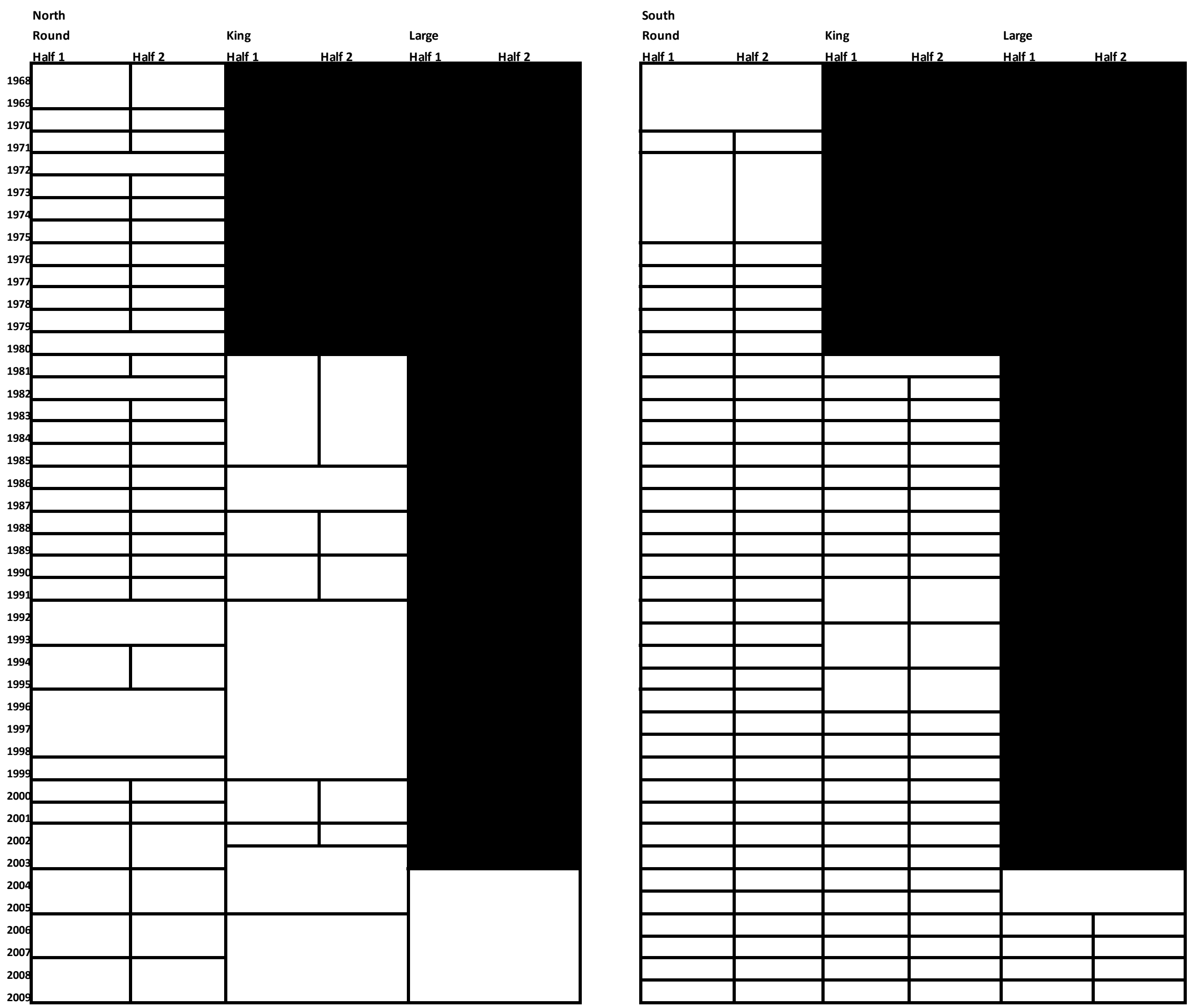

Table A15: Comparison of estimated and reported offshore and silver hake landings, 2004-2009. Red values reflect revisions from the original working paper. Differences are less than 1%.

	Model based estimate			Dealer reported landings			VTR hail weights			
	Offshore hake	Silver hake	Percent offshore	Offshore hake	Silver hake	Percent offshore	Reporting vessels	Offshore hake	Silver hake	Percent offshore
2004	894	6,566	12.00%	18	6,096	0.30%	371	169	6,124	2.70%
2005	819	5,865	12.20%	9	5,886	0.10%	321	213	6,439	3.20%
2006	459	4,207	9.80%	35	3,973	0.90%	405	121	4,170	2.80%
2007	350	5,006	6.50%	11	4,316	0.30%	384	180	4,677	3.70%
2008	290	5,376	5.10%	19	4,127	0.50%	370	194	4,544	4.10%
2009	331	6,406	4.90%	13	4,328	0.30%	382	139	5,363	2.50%

Table A16. Comparison of alternative methods of landings estimation for silver hake. Bold values reflect hindcasted estimates (bold black fonts are hindecast values using historical landings while the bold red fonts are based on dealer landings).

Year	Nominal	Length-Based	Depth-Based
1955	13842	**13255**	**12891**
1956	14871	**14241**	**13849**
1957	17153	**16426**	**15974**
1958	13473	**12902**	**12547**
1959	17112	**16387**	**15936**
1960	9206	**8816**	**8573**
1961	13209	**12649**	**12301**
1962	18733	**17939**	**17446**
1963	93382	**89425**	**86966**
1964	153554	**147048**	**148312**
1965	307131	**294117**	**282942**
1966	211270	**202318**	**193000**
1967	91249	**87383**	**86163**
1968	58496	58157	**56120**
1969	75561	74891	**72817**
1970	27512	26832	**25642**
1971	71890	70506	**70459**
1972	94354	88178	**89047**
1973	104593	102078	**100176**
1974	109863	102396	**105904**
1975	74253	72164	**71706**
1976	68741	64608	**67395**
1977	59308	57160	**57550**
1978	27132	25834	**26655**
1979	18375	16398	**18052**
1980	13546	11684	**13295**
1981	14826	13429	**14316**
1982	14561	14152	**13634**
1983	12140	11860	**11499**
1984	13143	12955	**12531**
1985	13164	12820	**12468**
1986	10123	9697	**9500**
1987	10123	9552	**9219**
1988	9195	8950	**8017**
1989	13428	12995	**12656**
1990	13610	13020	**12784**
1991	10492	9740	**9731**
1992	10873	10531	**9912**
1993	12942	12487	**11517**
1994	12159	12181	**10851**
1995	12102	11992	**10810**
1996	12561	12134	**10925**
1997	12763	12548	**11413**
1998	12828	12558	**11499**
1999	10577	10417	**9667**
2000	9769	9472	**8918**
2001	9517	8884	**8585**
2002	5344	4888	**4773**
2003	6835	6281	**6363**
2004	7436	6965	6566
2005	6670	6395	5865
2006	4629	4584	4207
2007	5345	5067	5006
2008	5638	5582	5376
2009	6720	6595	6406

Table A17. Port Samples (sampling intensity) for Silver hake in the northern and southern regions

NORTH				SOUTH		
Year	Number of Lengths	Commercial Landings (mt)	Lengths per 100mt	Number of Lengths	Commercial Landings (mt)	Lengths per 100mt
1969	2337	24055	10	50	75561	0
1970	2056	27528	7	316	27512	1
1971	2942	36401	8	409	71890	1
1972	1221	25224	5	216	94354	0
1973	4506	32091	14	0	104593	0
1974	1684	20682	8	0	109863	0
1975	1654	39874	4	793	74253	1
1976	3915	13634	29	1529	68741	2
1977	4673	12457	38	2103	59308	4
1978	3025	12609	24	1417	27132	5
1979	1465	3415	43	2203	18375	12
1980	775	4730	16	4123	13546	30
1981	1675	4416	38	3994	14826	27
1982	2124	4664	46	6520	14561	45
1983	3413	5312	64	7110	12140	59
1984	2781	8289	34	5647	13143	43
1985	4275	8297	52	7713	13164	59
1986	5033	8502	59	7352	10123	73
1987	4247	5658	75	7892	10123	78
1988	4839	6789	71	7787	9195	85
1989	2115	4648	46	6508	13428	48
1990	1933	6377	30	9517	13610	70
1991	2109	6055	35	5694	10492	54
1992	477	5306	9	3729	10873	34
1993	886	4364	20	2667	12942	21
1994	0	3899	0	1306	12159	11
1995	894	2594	34	2033	12102	17
1996	0	3619	0	0	12561	0
1997	416	2802	15	6116	12763	48
1998	514	2045	25	6200	12828	48
1999	258	3444	7	5139	10577	49
2000	778	2592	30	2802	9769	29
2001	2753	3391	81	10684	9517	112
2002	383	2593	15	7054	5344	132
2003	540	1808	30	8245	6835	121
2004	916	1049	87	7191	7436	97
2005	204	827	25	11416	6670	171
2006	1041	903	115	12827	4629	277
2007	1080	1014	107	17417	5345	326
2008	212	620	34	15037	5638	267
2009	187	1038	18	11863	6720	177

Table A18. Silver hake discards from the northern region by gear and half. The discards from 1981-1988 (91 for scallop dredge and longline) are hind-cast using the first three years of available data. The otter trawl discards are hind-cast combining mesh-sizes.

	Longline			Large Mesh Otter Trawl			Small Mesh Otter Trawl			Sink Gill Net			Scallop Dredge			Shrimp Trawl		
	1	2	Total	1	2	Total	1	2	Total	1	2	Total	1	2	Total	1	2	Total
1981	0	0	0	417.9	1898.6	2316.4	Na			13.4	53.2	66.6	2.7	28.4	31.1	223.4	0.6	224.0
1982	0	0	0	411.8	2116.1	2527.9	Na			5.9	47.9	53.7	1.6	21.9	23.6	282.0	17.7	299.7
1983	0	0	0	453.9	1783.5	2237.4	Na			6.2	39.8	46.0	1.4	17.2	18.6	285.6	54.1	339.7
1984	0	0	0	379.2	1640.3	2019.4	Na			5.9	52.4	58.3	0.8	10.3	11.1	372.6	130.1	502.7
1985	0	0	0	331.3	1476.8	1808.2	Na			6.4	44.8	51.2	0.6	9.9	10.5	520.1	171.7	691.8
1986	0	0	0	289.6	1159.9	1449.5	Na			7.8	46.9	54.7	1.0	10.6	11.6	634.7	203.5	838.1
1987	0	0	0	243.7	1031.4	1275.1	Na			7.0	47.7	54.6	1.2	20.4	21.6	642.8	112.5	755.4
1988	0	0	0	227.0	982.0	1209.0	Na			7.8	48.6	56.4	1.5	26.0	27.5	379.9	111.7	491.6
1989	0	0	0	56.2	241.6	297.8	183.2	1005.1	1188.3	17.9	34.5	52.4	1.7	29.9	31.6	612.7	159.0	771.7
1990	0	0	0	271.4	415.8	687.2	18.8	611.2	630.0	6.2	81.8	88.0	0.6	31.9	32.5	420.0	130.9	551.0
1991	0	0	0	19.4	372.9	392.3	28.0	486.5	514.5	3.6	40.1	43.8	2.7	3.5	6.2	262.6	31.6	294.2
1992	0	0	0	99.8	271.9	371.8	28.1	555.0	583.0	5.1	37.4	42.4	0.0	5.2	5.2	378.4	48.7	427.1
1993	0	0	0	94.7	165.3	260.1	9.7	179.2	189.0	5.2	55.2	60.4	1.5	58.5	60.0	62.2	108.4	170.6
1994	0	0	0	29.0	15.6	44.7	3.8	63.0	66.8	2.8	41.0	43.8	0.6	0.5	1.1	25.5	58.3	83.8
1995	0.008	0.010	0.019	56.5	64.2	120.7	2.7	17.6	20.2	5.6	23.5	29.1	1.9	5.7	7.6	216.7	239.5	456.1
1996	0.008	0.008	0.016	55.7	9.3	65.1	1.2	19.5	20.7	3.6	52.9	56.5	0.0	2.1	2.1	576.3	105.0	681.3
1997	0.008	0.008	0.017	28.1	28.8	56.8	1.8	14.3	16.1	14.1	13.3	27.4	0.5	6.9	7.4	126.4	15.1	141.5
1998	0.006	0.010	0.016	116.8	21.5	138.3	23.0	269.3	292.3	4.6	4.4	9.0	19.2	17.3	36.6	206.2	11.2	217.4
1999	0.006	0.008	0.015	26.9	143.1	170.0	20.4	395.6	415.9	8.9	9.3	18.2	8.9	10.6	19.5	93.6	2.2	95.8
2000	0.004	0.009	0.013	102.2	83.3	185.5	0.1	0.7	0.9	9.3	15.1	24.4	1.4	2.7	4.1	137.8	2.3	140.1
2001	0.005	0.006	0.011	182.7	221.2	404.0	3.5	14.3	17.7	3.7	8.9	12.6	1.8	1.4	3.2	39.4		39.4
2002	0	0	0	291.6	95.8	387.4	0	103.0	103.0	3.5	5.7	9.2	1.7	2.2	3.9	9.7		9.7
2003	0	0	0	40.5	34.7	75.2	0.3	90.3	90.6	7.3	2.9	10.2	0	4.4	4.4	22.0		22.0
2004	0	0	0	22.1	44.5	66.5	0.1	29.6	29.6	1.2	1.8	2.9	0.1	0.0	0.1	13.4	0.6	13.9
2005	0	0.019	0.019	5.2	35.4	40.6	0.2	9.1	9.3	0.1	0.9	1.0	0.0	0.6	0.6	10.3	0.5	10.7
2006	0	0	0	3.7	17.3	21.1	0	4.9	5.0	0.7	0.4	1.1	0	1.1	1.1	2.5	7.3	9.8
2007	0.002	0	0.002	4.1	14.9	18.9	42.3	669.7	712.0	0.8	0.6	1.5	0.2	1.9	2.1	11.7	2.8	14.5
2008	0	0.002	0.002	12.6	32.2	44.8	8.1	63.6	71.7	1.4	4.7	6.2	0.2	0.1	0.3	35.1	9.0	44.1
2009	0	0	0	13.9	54.5	68.4	11.9	83.7	95.6	2.0	4.3	6.4	0.1	2.7	2.8	14.6	28.3	42.9

Table A19. Silver hake discards from the southern region by gear and half. The discards from 1981-1988 (91 for scallop dredge and longline) are hind-cast using the first three years of available data. The otter trawl discards are hind-cast combining mesh-sizes.

	Longline				Large Mesh Otter Trawl				Small Mesh Otter Trawl				Sink Gill Net				Scallop Dredge		
	1	2	Total		1	2	Total		1	2	Total		1	2	Total		1	2	Total
1981	0	0	0		2332.4	1176.2	3508.5		Na				0.0	0.1	0.1		6.1	87.9	94.0
1982	0	0	0		2646.2	2069.8	4716.0		Na				0.0	0.1	0.1		3.6	67.9	71.6
1983	0	0	0		2869.3	2026.3	4895.7		Na				0.0	0.1	0.1		3.1	53.3	56.4
1984	0	0	0		3124.7	1864.3	4989.1		Na				0.0	0.2	0.2		1.8	31.9	33.7
1985	0	0	0		2580.7	1369.7	3950.3		Na				0.0	0.1	0.1		1.2	30.7	31.9
1986	0	0	0		2598.7	1822.2	4420.9		Na				0.0	0.2	0.2		2.3	32.9	35.2
1987	0	0	0		2664.5	1643.3	4307.8		Na				0.0	0.2	0.2		2.7	63.2	65.9
1988	0	0	0		2971.7	1570.4	4542.1		Na				0.0	0.2	0.2		3.4	80.5	83.9
1989	0	0	0		31.1	81.0	112.1		5295.8	1085.1	6380.9		0	0	0		12.5	136.8	149.3
1990	0	0	0		2342.0	420.7	2762.6		1211.4	1961.3	3172.7		0	0	0		20.5	237.5	258.0
1991	0	0	0		201.0	993.0	1194.0		539.8	1480.5	2020.3		0	0.1	0.1		12.8	6.8	19.6
1992	0	0	0		443.9	211.2	655.1		244.7	2559.4	2804.1		0.6	2.7	3.3		9.8	7.4	17.2
1993	0	0	0		250.5	15.7	266.2		3144.5	1475.9	4620.4		1.4	3.4	4.8		6.9	346.2	353.1
1994	0	0	0		549.7	11.0	560.7		3067.1	2335.5	5402.7		0.4	0.3	0.7		15.0	12.4	27.4
1995	0	0	0		136.9	5.8	142.7		83.1	1087.9	1171.0		0.2	0.3	0.4		64.5	60.5	125.0
1996	0.058	0.041	0.099		9.2	10.4	19.6		386.0	52.6	438.6		0.2	0	0.2		19.7	12.7	32.4
1997	0.066	0.057	0.123		26.7	341.4	368.2		220.7	0.1	220.8		1.7	0.4	2.1		33.6	14.5	48.1
1998	0.064	0.044	0.108		2.0	0	2.0		322.0	14.2	336.2		0.3	0.2	0.5		2.5	12.5	15.0
1999	0.049	0.023	0.072		0	18.9	18.9		3461.8	29.5	3491.4		0.9	0	0.9		22.1	18.5	40.6
2000	0.033	0.028	0.061		7.4	1.9	9.4		29.7	161.2	190.9		7.6	0	7.6		80.2	44.7	124.9
2001	0.046	0.046	0.092		2.9	0.3	3.2		25.3	152.0	177.4		0	0	0		6.1	5.7	11.8
2002	0	0	0		5.9	1.3	7.2		160.5	96.8	257.3		0.4	0	0.4		11.4	3.6	14.9
2003	0	0	0		3.8	11.0	14.8		137.2	515.7	652.9		1.2	0.0	1.3		1.7	5.2	7.0
2004	0	0	0		25.2	63.9	89.1		380.4	760.5	1141.0		0.4	0	0.4		4.5	9.0	13.5
2005	0	0	0		19.5	31.2	50.7		825.6	685.9	1511.5		0.1	0.2	0.2		3.4	8.4	11.8
2006	0.045	0.028	0.073		8.9	15.7	24.5		95.7	28.0	123.7		0.0	0	0.0		1.0	11.2	12.2
2007	0.140	0.190	0.331		8.0	13.5	21.5		47.5	53.8	101.3		0	0	0		5.3	3.5	8.8
2008	0.165	0.160	0.325		12.6	12.1	24.7		713.7	299.3	1013.1		0.0	0	0.0		3.7	3.5	7.2
2009	0.121	0.209	0.330		33.2	24.9	58.2		185.9	562.2	748.1		0.1	0.0	0.1		14.5	6.3	20.8

Table A20. Offshore hake discards from the northern region by gear and half. The hind-cast discards for offshore hake are zero.

	Large Mesh Otter Trawl				Small Mesh Otter Trawl				Sink Gill Net				Scallop Dredge		
	1	2	Total		1	2	Total		1	2	Total		1	2	Total
1989	0	0	0		0	0	0		0	0	0		0	0	0
1990	0	0	0		0	0	0		0	0	0		0	0	0
1991	0	0	0		0	0	0		0	0	0		0	0	0
1992	0	0	0		0	0	0		0	0	0		0	0	0
1993	0	0	0		0	0	0		0	0.023	0.023		0	0	0
1994	0	0	0		0	0	0		0	0	0		0	0	0
1995	0	0	0		0	0	0		0	0	0		0	0	0
1996	0	0	0		0	0	0		0	0	0		0	0	0
1997	0	0	0		0	0	0		0	0	0		0	0	0
1998	0	0	0		0	0	0		0	0	0		0	0	0
1999	0	0	0		0	0	0		0	0	0		0	0	0
2000	0	6.544	6.544		0	0	0		0	0	0		0	0	0
2001	0	0.065	0.065		0	0	0		0	0	0		0	0	0
2002	0.428	0.028	0.457		0	0	0		0.272	0	0.272		0.016	0.021	0.038
2003	0.028	0	0.028		0	0	0		0	0.085	0.085		0	0.339	0.339
2004	2.169	0.023	2.192		0	0	0		0	0	0		0	0	0
2005	0.168	0.025	0.192		0	0	0		0	0.032	0.032		0	0	0
2006	0	0.520	0.520		0	0	0		0	0	0		0	0	0
2007	0.089	0.630	0.719		0	0	0		0	0.004	0.004		0	0.027	0.027
2008	0.079	0.007	0.086		0	0	0		0	0	0		0	0	0
2009	0.915	4.311	5.226		0.013	0.089	0.102		0	0	0		0	0	0

Table A21. Offshore hake discards from the southern region by gear and half. The hind-cast discards for offshore hake are zero.

	Large Mesh Otter Trawl				Small Mesh Otter Trawl				Sink Gill Net				Scallop Dredge		
	1	2	Total		1	2	Total		1	2	Total		1	2	Total
1989	0	0	0		0	0	0		0	0	0		0	0	0
1990	0	0	0		0	0	0		0	0	0		0	0	0
1991	0	0	0		0	0	0		0	0	0		0	0	0
1992	0	0	0		0	0	0		0	0	0		0	0	0
1993	0	0	0		0	0	0		0	0	0		0	0	0
1994	0	0	0		0	0	0		0	0	0		0	0	0
1995	0	0	0		0	0	0		0	0	0		0.064	0.001	0.064
1996	0	0	0		0	0	0		0	0	0		0	0	0
1997	0	0	0		0.019	1.810	1.828		0.028	0	0.028		1.028	0.435	1.463
1998	0	0	0		170.494	0	170.494		0	0	0		3.386	0	3.386
1999	0	0	0		0	1.168	1.168		0	0	0		0	0.571	0.571
2000	0	0.619	0.619		0.183	0.239	0.422		0	0	0		0	0.056	0.056
2001	0	0.065	0.065		0	9.685	9.685		0	0	0		0	0	0
2002	0	0	0		143.674	0	143.674		0	0	0		0	2.563	2.563
2003	0	0	0		0	0	0		0	0	0		2.183	0.015	2.199
2004	0.036	0.030	0.066		2.131	0.909	3.040		0	0	0		1.618	0.219	1.837
2005	0	0	0		0	6.384	6.384		0	0	0		0	0	0
2006	0	0.416	0.416		0	4.109	4.109		0	0	0		0	0.012	0.012
2007	0.510	0.685	1.195		19.386	0	19.386		0	0	0		0	0.036	0.036
2008	0.926	0.176	1.102		0.006	0	0.006		0	0	0		0.001	0.035	0.035
2009	0.440	4.941	5.381		0.025	20.262	20.287		0.050	0	0.050		0	0	0

Table A22. Number of discarded silver hake sampled from the FOP in the northern region by gear type.

	Large Mesh					Small Mesh					Sink Gill Net					Scallop Dredge					Shrimp Trawl			
	Half 1		Half 2			Half 1		Half 2			Half 1		Half 2			Half 1		Half 2			Half 1		Half 2	
	trips	len	trips	len		trips	len	trips	len		trips	len	trips	len		trips	len	trips	len		trips	len	trips	len
1989	2	213	10	779		3	1543	23	6445		-	-	-	-		-	-	-	-		16	3590	4	546
1990	-	-	5	362		1	84	7	1130		1	4	-	-		-	-	-	-		8	1221	-	-
1991	1	31	1	150		-	-	27	8063		2	5	4	10		-	-	-	-		8	1055	-	-
1992	1	1	-	-		1	100	19	3888		4	24	5	22		-	-	-	-		-	-	-	-
1993	2	222	1	70		-	-	2	371		2	19	2	7		-	-	-	-		13	2383	2	224
1994	-	-	1	11		-	-	-	-		-	-	6	63		-	-	1	1		9	446	2	459
1995	3	32	1	48		-	-	1	81		1	1	-	-		-	-	-	-		4	404	5	728
1996	1	1	-	-		-	-	4	343		1	3	3	31		-	-	-	-		9	470	1	149
1997	1	1	2	66		1	20	-	-		-	-	-	-		-	-	1	1		9	739	-	-
1998	-	-	-	-		-	-	-	-		1	1	-	-		-	-	-	-		-	-	-	-
1999	-	-	-	-		-	-	9	218		1	2	6	85		-	-	-	-		-	-	-	-
2000	-	-	-	-		-	-	-	-		6	60	2	22		-	-	-	-		-	-	-	-
2001	-	-	1	14		-	-	-	-		2	2	2	3		-	-	-	-		-	-	-	-
2002	-	-	11	265		-	-	9	542		3	4	3	7		-	-	-	-		-	-	-	-
2003	13	565	13	255		-	-	5	241		11	229	12	39		-	-	1	113		5	372	-	-
2004	4	9	23	749		1	5	9	325		6	12	22	65		-	-	-	-		3	284	-	-
2005	13	105	17	259		2	5	9	97		1	1	10	66		-	-	1	2		2	66	-	-
2006	9	69	5	30		-	-	4	1028		1	1	1	1		-	-	-	-		-	-	-	-
2007	9	127	15	195		-	-	2	733		3	14	3	4		-	-	-	-		4	444	-	-
2008	5	155	16	255		-	-	1	144		6	7	6	62		1	3	-	-		6	206	-	-
2009	7	34	16	260		-	-	3	180		3	15	1	1		-	-	-	-		-	-	-	-

Table A23. Number of discarded silver hake sampled from the FOP in the southern region by gear type.

	Large Mesh					Small Mesh					Sink Gill Net					Scallop Dredge			
	Half 1		Half 2			Half 1		Half 2			Half 1		Half 2			Half 1		Half 2	
Year	trips	len	trips	len		trips	len	trips	len		trips	len	trips	len		trips	len	trips	len
1989	2	40	1	150		12	2265	10	1659		-	-	-	-		-	-	-	-
1990	2	399	-	-		8	2090	2	95		-	-	-	-		-	-	-	-
1991	-	-	2	29		5	657	7	860		-	-	-	-		-	-	-	-
1992	-	-	-	-		1	20	5	459		1	1	-	-		-	-	-	-
1993	1	127	-	-		-	-	-	-		1	12	-	-		1	2	-	-
1994	2	49	-	-		1	20	5	239		-	-	-	-		2	5	2	6
1995	1	3	1	11		2	73	-	-		-	-	1	3		4	50	-	-
1996	-	-	-	-		4	290	8	494		2	2	-	-		2	31	3	17
1997	-	-	1	216		7	371	1	2		7	69	1	4		2	112	1	1
1998	-	-	-	-		3	656	-	-		-	-	-	-		-	-	-	-
1999	-	-	-	-		2	309	4	97		-	-	-	-		1	2	-	-
2000	-	-	1	19		1	198	3	88		-	-	-	-		3	456	1	1
2001	-	-	-	-		2	160	3	13		-	-	-	-		-	-	-	-
2002	-	-	-	-		3	139	-	-		-	-	-	-		-	-	-	-
2003	-	-	2	2		3	76	3	40		1	2	-	-		2	3	4	140
2004	6	150	16	359		6	293	24	2007		2	4	-	-		1	17	15	224
2005	9	118	12	471		15	1191	11	1346		-	-	-	-		-	-	5	53
2006	7	48	4	24		10	762	15	764		-	-	-	-		-	-	1	1
2007	3	13	7	106		7	130	14	479		-	-	-	-		4	13	2	10
2008	6	38	10	110		6	580	12	626		-	-	-	-		4	31	7	36
2009	2	19	1	1		10	832	30	1998		1	1	-	-		12	91	6	37

Table A24. Number of kept and discarded offshore hake sampled in all gears from the FOP in the northern region.

	Large Mesh Trawl			Sink Gill Net			
	Half 2			Half 1		Half 2	
	Discards			Discards		Discards	
Year	ntrips	numlen		ntrips	numlen	ntrips	numlen
2002				1	19		
2004	1	1					
2005	2	3				1	1
2006	1	9					
2009	1	1					

Table A25. Number of kept and discarded offshore hake sampled in all gears from the FOP in the southern region.

	Large Mesh Trawl		Small Mesh Trawl				Scallop Dredge	
	Half 1		Half 1		Half 2		Half 1	
	Discards		Discards		Discards		Discards	
Year	ntrips	numlen	ntrips	numlen	ntrips	numlen	ntrips	numlen
1997					1	7		
2001	1	1						
2002								
2004					1	8	1	3
2007								
2009			1	1	1	1		

Table A26. Pooling of silver/offshore hake observer length samples to estimate length and species composition of the commercial discards by gear from the north.

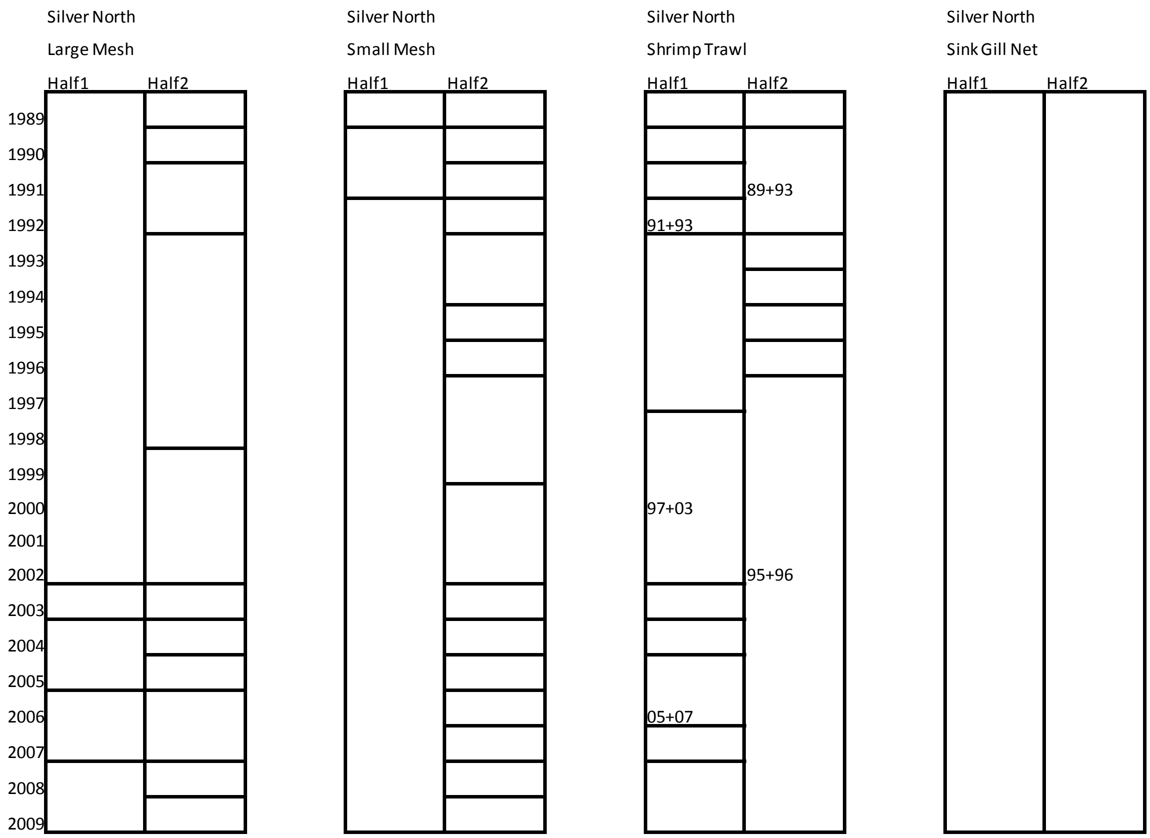

Table A27. Pooling of silver/offshore hake observer length samples to estimate length and species composition of the commercial discards by gear from the south.

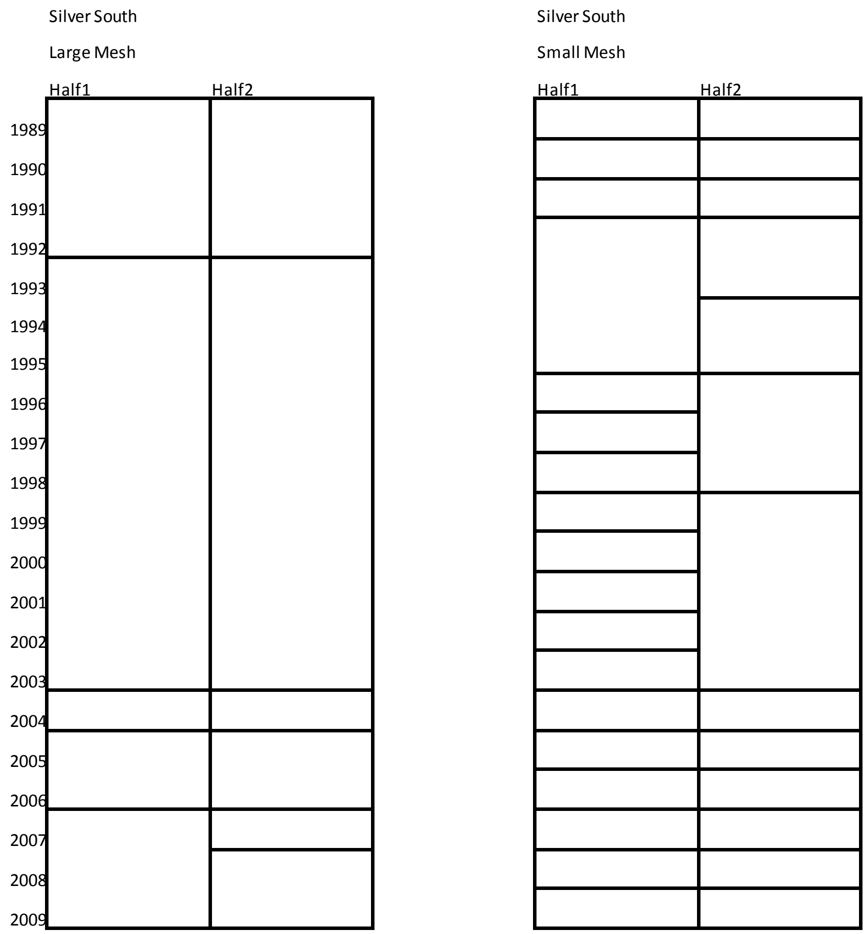

Table A28: Silver hake annual catch in metric tons from the northern stock area.

Year	Domestic	Foreign	Total landings	discards	Total Catch	% discards
1955			53361	0	53361	0%
1956			42150	0	42150	0%
1957			62750	0	62750	0%
1958			49903	0	49903	0%
1959			50608	0	50608	0%
1960			45543	0	45543	0%
1961			39688	0	39688	0%
1962			79002	0	79002	0%
1963			73924	0	73924	0%
1964			94462	0	94462	0%
1965			45279	0	45279	0%
1966			47808	0	47808	0%
1967			33371	0	33371	0%
1968			41379	0	41378.94	0%
1969			24055	0	24054.96	0%
1970			27528	0	27527.97	0%
1971			36398	0	36398.22	0%
1972			25224	0	25223.95	0%
1973	14005	18086	32091	0	32090.95	0%
1974	6,907	13,775	20,682	0	20682	0%
1975	12,566	27,308	39874	0	39874	0%
1976	13,483	151	13634	0	13634	0%
1977	12,455	2	12457	0	12457	0%
1978	12,609	0	12609	0	12609	0%
1979	3415	0	3415	0	3415	0%
1980	4730	0	4730	0	4730	0%
1981	4416	0	4416	2638	7054	37%
1982	4664	0	4664	2905	7569	38%
1983	5312	0	5312	2642	7954	33%
1984	8289	0	8289	2591	10880	24%
1985	8297	0	8297	2562	10859	24%
1986	8502	0	8502	2354	10856	22%
1987	5658	0	5658	2107	7765	27%
1988	6789	0	6789	1785	8574	21%
1989	4648	0	4648	2315	6963	33%
1990	6377	0	6377	1958	8335	23%
1991	6055	0	6055	1256	7311	17%
1992	5306	0	5306	1424	6730	21%
1993	4364	0	4364	686	5050	14%
1994	3899	0	3899	241	4140	6%
1995	2594	0	2594	630	3224	20%
1996	3619	0	3619	824	4443	19%
1997	2802	0	2802	243	3045	8%
1998	2045	0	2045	693	2738	25%
1999	3449	0	3449	742	4190	18%
2000	2592	0	2592	359	2952	12%
2001	3391	0	3391	477	3868	12%
2002	2593	0	2593	513	3106	17%
2003	1808	0	1808	198	2006	10%
2004	1049	0	1049	115	1165	10%
2005	828	0	828	62	890	7%
2006	904	0	904	37	941	4%
2007	1014	0	1014	750	1764	43%
2008	620	0	620	167	788	21%
2009	1042	0	1042	190	1232	15%

Table A29: Silver hake annual catches in metric tons in from the Southern stock area.

Year	Domestic	Foreign	Total landings	discards	Total Catch	% discards
1955			13255	0	13255	0%
1956			14241	0	14241	0%
1957			16426	0	16426	0%
1958			12902	0	12902	0%
1959			16387	0	16387	0%
1960			8816	0	8816	0%
1961			12649	0	12649	0%
1962			17939	0	17939	0%
1963			89425	0	89425	0%
1964			147048	0	147048	0%
1965			294117	0	294117	0%
1966			202318	0	202318	0%
1967			87383	0	87383	0%
1968			58157	0	58157	0%
1969			74891	0	74891	0%
1970			26832	0	26832	0%
1971			70506	0	70506	0%
1972			88179	0	88179	0%
1973	6445	95633	102078	0	102078	0%
1974	7224	95171	102396	0	102396	0%
1975	8204	63961	72164	0	72164	0%
1976	9807	54802	64608	0	64608	0%
1977	11043	46117	57160	0	57160	0%
1978	12168	13666	25834	0	25834	0%
1979	12046	4352	16398	0	16398	0%
1980	10219	1465	11684	0	11684	0%
1981	10672	2756	13429	3502	16931	21%
1982	11822	2330	14152	4654	18806	25%
1983	11254	606	11860	4814	16674	29%
1984	12549	406	12955	4883	17838	27%
1985	11533	1286	12820	3872	16691	23%
1986	9170	527	9697	4332	14029	31%
1987	9550	2	9552	4252	13804	31%
1988	8950	0	8950	4497	13447	33%
1989	12995	0	12995	6573	19568	34%
1990	13020	0	13020	5972	18992	31%
1991	9740	0	9740	3081	12821	24%
1992	10531	0	10531	3446	13977	25%
1993	12487	0	12487	5166	17653	29%
1994	12181	0	12181	5936	18118	33%
1995	11992	0	11992	1402	13394	10%
1996	12134	0	12134	479	12613	4%
1997	12548	0	12548	624	13172	5%
1998	12558	0	12558	526	13084	4%
1999	10417	0	10417	3549	13965	25%
2000	9472	0	9472	329	9800	3%
2001	8884	0	8884	188	9072	2%
2002	4888	0	4888	410	5298	8%
2003	6281	0	6281	604	6884	9%
2004	6965	0	6965	1203	8168	15%
2005	6395	0	6395	1576	7971	20%
2006	4583	0	4583	161	4745	3%
2007	5067	0	5067	146	5212	3%
2008	5582	0	5582	1033	6616	16%
2009	6595	0	6595	839	7434	11%

Table A30 Silver hake annual catch in metric tons for the combined areas.

Year	Domestic	Foreign	Total landings	discards	Total Catch	% discards
1955			66616	0	66616	0%
1956			56391	0	56391	0%
1957			79176	0	79176	0%
1958			62805	0	62805	0%
1959			66995	0	66995	0%
1960			54359	0	54359	0%
1961			52337	0	52337	0%
1962			96941	0	96941	0%
1963			163349	0	163349	0%
1964			241510	0	241510	0%
1965			339396	0	339396	0%
1966			250126	0	250126	0%
1967			120754	0	120754	0%
1968			99536	0	99536	0%
1969			98946	0	98946	0%
1970			54360	0	54360	0%
1971			106905	0	106905	0%
1972			113403	0	113403	0%
1973	20,450	113,719	134,169	0	134169	0%
1974	14,131	108,946	123,078	0	123078	0%
1975	20,770	91,269	112,038	0	112038	0%
1976	23,290	54,953	78,242	0	78242	0%
1977	23,498	46,119	69,617	0	69617	0%
1978	24,777	13,666	38,443	0	38443	0%
1979	15,461	4,352	19,813	0	19813	0%
1980	14,949	1,465	16,414	0	16414	0%
1981	15,088	2,756	17,845	6140.438	23985	26%
1982	16,486	2,330	18,816	7559.343	26375	29%
1983	16,566	606	17,172	7455.982	24628	30%
1984	20,838	406	21,244	7474.685	28718	26%
1985	19,830	1,286	21,117	6433.169	27550	23%
1986	17,672	527	18,199	6686.172	24885	27%
1987	15,208	2	15,210	6359	21569	29%
1988	15739	0	15,739	6282	22021	29%
1989	17643	0	17,643	8888	26530	34%
1990	19397	0	19,397	7930	27327	29%
1991	15794	0	15,794	4337	20131	22%
1992	15837	0	15,837	4870	20707	24%
1993	16851	0	16,851	5852	22703	26%
1994	16080	0	16,080	6178	22258	28%
1995	14586	0	14,586	2032	16618	12%
1996	15753	0	15,753	1302	17055	8%
1997	15350	0	15,350	867	16217	5%
1998	14603	0	14,603	1219	15822	8%
1999	13866	0	13,866	4290	18156	24%
2000	12064	0	12,064	688	12752	5%
2001	12275	0	12,275	665	12941	5%
2002	7481	0	7,481	923	8404	11%
2003	8089	0	8,089	802	8890	9%
2004	8015	0	8,015	1318	9333	14%
2005	7223	0	7,223	1638	8861	18%
2006	5487	0	5,487	199	5686	3%
2007	6081	0	6,081	896	6977	13%
2008	6203	0	6,203	1201	7403	16%
2009	7636	0	7,636	1030	8666	12%

Table A31. Commercial landings at Age (in thousands of fish) of Silver hake in the northern stock.

year	age-1	age-2	age-3	age-4	age-5	age-6	age-7	age-8	age-9	age-10	age-11	age-12	age-13	age-14
1973	37000	96406	27096	3454	1856	899	123	0	0	240	0	22	185	0
1974	12400	40532	25154	4244	2087	937	54	0	0	52	54	0	81	0
1975	4830	57091	77841	23950	8358	2549	430	117	0	0	0	0	0	0
1976	2016	19716	23193	9460	2422	1501	359	20	0	0	0	0	0	0
1977	1027	7540	21532	14176	3152	472	271	25	9	0	0	0	0	0
1978	1593	7550	6950	10922	13525	2465	311	271	0	7	5	0	0	0
1979	532	2599	2233	1441	1759	2262	419	25	0	0	0	0	0	0
1980	1506	11469	10300	1899	532	437	866	348	49	44	0	3	0	0
1981	4366	9008	7668	3937	689	155	231	185	21	0	0	0	0	0
1982	4679	7989	2937	2864	2773	266	71	471	92	1	2	0	0	0
1983	2944	11947	2801	1447	1924	880	180	51	17	0	0	0	0	0
1984	5183	16108	6503	3325	920	817	8	0	51	0	0	0	0	0
1985	8979	5508	12908	3977	531	713	141	0	0	0	0	0	0	0
1986	3905	15321	3927	4907	1382	516	23	38	0	0	0	0	0	0
1987	851	13368	9831	1456	948	71	3	0	0	0	0	0	0	0
1988	1312	6242	20269	3349	521	624	0	0	0	0	0	0	0	0
1989	3184	5770	10242	2758	344	43	0	0	0	0	0	0	0	0
1990	3528	15845	6989	4840	1140	15	0	0	0	0	0	0	0	0
1991	1186	13900	7701	2537	1074	9	0	0	0	0	0	0	0	0
1992	6149	15882	8256	1206	143	11	2	0	0	0	0	0	0	0
1993	4062	14565	5674	2045	187	8	0	0	0	0	0	0	0	0
1994	2053	10017	6551	1898	38	3	0	0	0	0	0	0	0	0
1995	630	1769	910	1912	531	25	0	0	0	0	0	0	0	0
1996	1842	13844	6984	1026	54	16	0	0	0	0	0	0	0	0
1997	2787	13552	3167	205	101	7	0	0	0	0	0	0	0	0
1998	1033	5539	1842	1001	32	77	0	0	0	0	0	0	0	0
1999	63	4212	3875	2126	244	108	0	0	0	0	0	0	0	0
2000	630	4922	4152	814	273	4	3	0	0	0	0	0	0	0
2001	233	1829	1752	1822	978	241	5	0	0	0	0	0	0	0
2002	441	5674	3600	707	60	74	0	0	0	0	0	0	0	0
2003	189	2634	3742	632	63	31	10	0	0	0	0	0	0	0
2004	1168	2838	1975	191	16	1	1	0	0	0	0	0	0	0
2005	1288	1927	1598	209	32	13	3	0	0	0	0	0	0	0
2006	4839	795	482	511	14	14	0	0	0	0	0	0	0	0
2007	4072	2211	214	218	117	0	0	0	0	0	0	0	0	0
2008	2141	2210	130	61	2	7	0	0	0	0	0	0	0	0
2009	584	2370	1510	346	19	0	1	0	0	0	0	0	0	0

Table A32. Silver hake commercial landings at Age (in thousands of fish) for the southern stock.

year	age-1	age-2	age-3	age-4	age-5	age-6	age-7	age-8	age-9	age-10	age-11	age-12	age-13	age-14	Total
1973	3470	164329	134686	55533	13498	3410	1524	0	0	0	0	0	0	0	376669
1974	6213	65952	172266	108329	34225	10484	2576	0	455	0	0	0	0	0	400665
1975	5223	49456	128180	63861	20200	2694	396	0	96	0	0	0	0	0	270243
1976	383	51663	48274	39785	18228	8141	3881	412	0	0	0	0	0	0	170766
1977	2044	16736	62794	35481	14643	5894	5004	1312	0	0	0	0	0	0	143908
1978	1383	20549	18263	26284	11708	3412	458	61	0	0	0	0	0	72	82191
1979	1716	12338	12825	6390	9503	5726	998	197	0	0	0	0	0	0	49693
1980	1793	17101	17433	7962	3778	1793	2257	414	168	1	0	0	0	0	52701
1981	5739	12437	17517	12679	5443	2190	1015	1275	666	0	13	0	0	0	58973
1982	4968	26448	10550	8833	6558	2070	1033	369	299	133	0	0	0	0	61260
1983	7861	19351	11352	5583	2531	1733	816	59	71	273	0	0	0	0	49629
1984	2129	29479	15330	5535	1091	421	346	0	0	0	0	0	0	0	54332
1985	3098	23434	21909	8077	1377	236	311	63	65	0	0	0	0	0	58571
1986	5545	27377	9665	8122	1524	205	21	0	0	0	0	0	0	0	52464
1987	4791	21647	14036	5113	3369	69	0	0	39	0	0	0	0	0	49062
1988	1331	17531	27692	7243	579	27	0	0	0	0	0	0	0	0	54404
1989	1204	20708	38294	10594	1034	182	0	0	0	0	0	0	0	0	72036
1990	716	21207	32891	10819	1793	31	19	0	0	0	0	0	0	0	67475
1991	341	3601	22108	17717	3723	1124	62	0	0	0	0	0	0	0	48677
1992	2318	19170	24496	13147	793	3	0	0	0	0	0	0	0	0	59928
1993	3120	19023	24621	15399	2579	0	0	0	0	0	0	0	0	0	64742
1994	1161	21801	33190	9522	355	0	0	0	0	0	0	0	0	0	66028
1995	1479	17014	27007	16578	436	0	0	0	0	0	0	0	0	0	62513
1996	2220	25222	42727	7537	1229	2	0	0	0	0	0	0	0	0	78937
1997	14558	23930	36763	7045	124	0	0	0	0	0	0	0	0	0	83538
1998	4970	29969	43918	3510	10	0	0	0	0	0	0	0	0	0	84559
1999	2697	32190	37657	3405	94	0	0	0	0	0	0	0	0	0	76042
2000	1089	22309	36529	3064	35	0	0	0	0	0	0	0	0	0	63026
2001	1615	9840	22302	9767	765	36	0	0	0	0	0	0	0	0	44325
2002	832	10883	20010	2696	108	0	0	0	0	0	0	0	0	0	34528
2003	7130	13441	18738	5432	18	0	0	0	0	0	0	0	0	0	45364
2004	2917	11052	27476	5139	21	0	0	0	0	0	0	0	0	0	46611
2005	13692	14352	15447	5051	144	0	0	0	0	0	0	0	0	0	48697
2006	11545	16527	8551	1080	35	1	0	0	0	0	0	0	0	0	37738
2007	10627	17887	5919	1526	171	4	0	0	0	30	0	0	0	0	36167
2008	13215	27207	3266	828	73	0	0	0	0	0	0	0	0	0	44603
2009	6886	31886	8431	807	124	0	0	0	0	0	0	0	0	0	48137

Table A33. Silver hake commercial landings at Age (in thousands of fish) for the combined stock area.

year	age-1	age-2	age-3	age-4	age-5	age-6	age-7	age-8	age-9	age-10	age-11	age-12	age-13	age-14
1973	40470	260734	161782	58987	15354	4310	1647	0	0	240	0	22	185	0
1974	18614	106484	197420	112573	36311	11421	2630	0	455	52	54	0	81	0
1975	10053	106547	206021	87810	28557	5243	826	117	96	0	0	0	0	0
1976	2399	71378	71467	49245	20650	9642	4239	431	0	0	0	0	0	0
1977	3071	24276	84326	49656	17795	6365	5275	1336	9	0	0	0	0	0
1978	2975	28099	25213	37205	25233	5877	769	333	0	7	5	0	0	72
1979	2248	14938	15059	7831	11262	7988	1417	222	0	0	0	0	0	0
1980	3300	28571	27734	9861	4310	2230	3123	761	216	45	0	3	0	0
1981	10105	21445	25185	16616	6132	2344	1246	1459	687	0	13	0	0	0
1982	9647	34437	13487	11697	9331	2336	1104	839	391	134	2	0	0	0
1983	10804	31298	14153	7030	4454	2613	996	110	88	273	0	0	0	0
1984	7312	45587	21833	8860	2011	1238	355	0	51	0	0	0	0	0
1985	12077	28943	34817	12054	1908	950	451	63	65	0	0	0	0	0
1986	9450	42698	13593	13029	2906	720	44	38	0	0	0	0	0	0
1987	5642	35015	23866	6569	4317	140	3	0	39	0	0	0	0	0
1988	2643	23773	47960	10592	1100	651	0	0	0	0	0	0	0	0
1989	4388	26478	48536	13352	1378	225	0	0	0	0	0	0	0	0
1990	4244	37052	39880	15659	2932	46	19	0	0	0	0	0	0	0
1991	1526	17501	29808	20254	4797	1133	62	0	0	0	0	0	0	0
1992	8467	35052	32751	14353	937	14	2	0	0	0	0	0	0	0
1993	7182	33588	30295	17443	2766	8	0	0	0	0	0	0	0	0
1994	3214	31818	39741	11419	393	3	0	0	0	0	0	0	0	0
1995	2109	18783	27917	18490	967	25	0	0	0	0	0	0	0	0
1996	4062	39066	49711	8563	1283	18	0	0	0	0	0	0	0	0
1997	17344	37482	39930	7250	225	7	0	0	0	0	0	0	0	0
1998	6004	35508	45759	4511	41	77	0	0	0	0	0	0	0	0
1999	2760	36401	41532	5531	338	108	0	0	0	0	0	0	0	0
2000	1719	27231	40680	3878	308	4	3	0	0	0	0	0	0	0
2001	1848	11669	24053	11589	1743	277	5	0	0	0	0	0	0	0
2002	1273	16556	23610	3402	168	74	0	0	0	0	0	0	0	0
2003	7318	16074	22480	6064	80	31	10	0	0	0	0	0	0	0
2004	4084	13890	29450	5330	36	1	1	0	0	0	0	0	0	0
2005	14980	16279	17045	5260	176	13	3	0	0	0	0	0	0	0
2006	16384	17321	9033	1591	48	14	0	0	0	0	0	0	0	0
2007	14698	20099	6133	1744	287	4	0	0	0	30	0	0	0	0
2008	15355	29416	3396	889	75	7	0	0	0	0	0	0	0	0
2009	7469	34256	9941	1153	143	0	1	0	0	0	0	0	0	0

Table A34. Silver hake commercial discards at age (in thousands of fish) for the northern stock.

year	age-1	age-2	age-3	age-4	age-5	age-6	age-7	age-8	age-9	age-10	age-11	age-12	age-13	age-14
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	34529	3279	1442	629	44	2	0	0	0	0	0	0	0	0
1990	8113	7223	1550	818	340	23	0	0	0	0	0	0	0	0
1991	7800	4315	1102	277	40	5	0	0	0	0	0	0	0	0
1992	11045	6942	1802	322	48	5	0	0	0	0	0	0	0	0
1993	5725	2262	452	275	79	7	0	0	0	0	0	0	0	0
1994	1894	1067	140	69	11	4	0	0	0	0	0	0	0	0
1995	9688	4188	433	136	25	5	0	0	0	0	0	0	0	0
1996	14927	7047	2159	175	10	4	0	0	0	0	0	0	0	0
1997	2270	2068	242	39	26	8	0	0	0	0	0	0	0	0
1998	4734	4809	1209	245	25	13	0	0	0	0	0	0	0	0
1999	2075	3559	1177	113	25	2	0	0	0	0	0	0	0	0
2000	2610	3434	489	148	40	5	0	0	0	0	0	0	0	0
2001	975	2054	713	304	67	11	0	0	0	0	0	0	0	0
2002	1246	1253	709	479	95	40	0	0	0	0	0	0	0	0
2003	2895	691	142	89	17	4	2	0	0	0	0	0	0	0
2004	536	554	121	39	5	6	0	0	0	0	0	0	0	0
2005	1204	225	76	7	3	2	0	0	0	0	0	0	0	0
2006	542	27	16	23	1	0	0	0	0	0	0	0	0	0
2007	8724	1155	109	66	122	0	0	0	0	0	0	0	0	0
2008	2196	679	26	11	4	1	0	0	0	0	0	0	0	0
2009	2346	348	99	17	4	0	1	0	0	0	0	0	0	0

Table A35. Silver hake commercial discards at age (in thousands of fish) for the southern stock.

year	age-1	age-2	age-3	age-4	age-5	age-6	age-7	age-8	age-9	age-10	age-11	age-12	age-13	age-14
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	4958	16357	19820	5162	407	112	0	0	0	0	0	0	0	0
1990	5688	27591	11822	2303	170	6	3	0	0	0	0	0	0	0
1991	3135	11326	6831	1442	204	34	0	0	0	0	0	0	0	0
1992	17293	14333	3295	724	15	0	0	0	0	0	0	0	0	0
1993	11733	14866	8778	5663	1075	0	0	0	0	0	0	0	0	0
1994	1172	13170	15618	5120	117	0	0	0	0	0	0	0	0	0
1995	986	3789	2401	717	35	0	0	0	0	0	0	0	0	0
1996	384	837	2001	382	48	0	0	0	0	0	0	0	0	0
1997	604	1640	1626	159	12	0	0	0	0	0	0	0	0	0
1998	174	841	3176	65	0	0	0	0	0	0	0	0	0	0
1999	113	18144	17372	32	0	0	0	0	0	0	0	0	0	0
2000	340	1188	856	62	3	0	0	0	0	0	0	0	0	0
2001	827	987	274	15	0	0	0	0	0	0	0	0	0	0
2002	490	2019	1878	65	0	0	0	0	0	0	0	0	0	0
2003	1182	1780	1590	115	1	0	0	0	0	0	0	0	0	0
2004	5936	3506	2209	504	12	0	0	0	0	0	0	0	0	0
2005	5577	6210	4992	142	2	0	0	0	0	0	0	0	0	0
2006	441	588	293	46	0	0	0	0	0	0	0	0	0	0
2007	551	364	181	34	6	0	0	0	0	0	0	0	0	0
2008	2841	6586	494	68	5	0	0	0	0	0	0	0	0	0
2009	5572	3479	511	21	6	0	0	0	0	0	0	0	0	0

Table A36. Silver hake commercial discards at age (in thousands of fish) for the combined stock areas.

year	age-1	age-2	age-3	age-4	age-5	age-6	age-7	age-8	age-9	age-10	age-11	age-12	age-13	age-14
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	39487	19636	21262	5791	451	114	0	0	0	0	0	0	0	0
1990	13801	34814	13372	3121	510	29	3	0	0	0	0	0	0	0
1991	10935	15641	7933	1720	244	40	0	0	0	0	0	0	0	0
1992	28338	21276	5097	1046	63	5	0	0	0	0	0	0	0	0
1993	17458	17128	9230	5938	1154	7	0	0	0	0	0	0	0	0
1994	3067	14236	15758	5189	127	4	0	0	0	0	0	0	0	0
1995	10673	7978	2835	853	61	5	0	0	0	0	0	0	0	0
1996	15311	7884	4160	557	58	4	0	0	0	0	0	0	0	0
1997	2874	3708	1868	197	38	8	0	0	0	0	0	0	0	0
1998	4907	5651	4386	310	25	13	0	0	0	0	0	0	0	0
1999	2188	21703	18548	145	25	2	0	0	0	0	0	0	0	0
2000	2950	4623	1345	210	43	5	0	0	0	0	0	0	0	0
2001	1801	3041	988	319	68	11	0	0	0	0	0	0	0	0
2002	1736	3272	2587	543	95	40	0	0	0	0	0	0	0	0
2003	4077	2471	1732	204	18	4	2	0	0	0	0	0	0	0
2004	6473	4060	2330	543	17	6	0	0	0	0	0	0	0	0
2005	6781	6435	5069	149	5	2	0	0	0	0	0	0	0	0
2006	983	615	309	69	1	0	0	0	0	0	0	0	0	0
2007	9275	1519	291	99	128	0	0	0	0	0	0	0	0	0
2008	5037	7265	519	80	9	1	0	0	0	0	0	0	0	0
2009	7918	3828	611	37	10	0	1	0	0	0	0	0	0	0

Table A37. Silver hake catch at age (in thousands of fish) for the northern stock.

year	age-1	age-2	age-3	age-4	age-5	age-6	age-7	age-8	age-9	age-10	age-11	age-12	age-13	age-14
1973	37000	96406	27096	3454	1856	899	123	0	0	240	0	22	185	0
1974	12400	40532	25154	4244	2087	937	54	0	0	52	54	0	81	0
1975	4830	57091	77841	23950	8358	2549	430	117	0	0	0	0	0	0
1976	2016	19716	23193	9460	2422	1501	359	20	0	0	0	0	0	0
1977	1027	7540	21532	14176	3152	472	271	25	9	0	0	0	0	0
1978	1593	7550	6950	10922	13525	2465	311	271	0	7	5	0	0	0
1979	532	2599	2233	1441	1759	2262	419	25	0	0	0	0	0	0
1980	1506	11469	10300	1899	532	437	866	348	49	44	0	3	0	0
1981	4366	9008	7668	3937	689	155	231	185	21	0	0	0	0	0
1982	4679	7989	2937	2864	2773	266	71	471	92	1	2	0	0	0
1983	2944	11947	2801	1447	1924	880	180	51	17	0	0	0	0	0
1984	5183	16108	6503	3325	920	817	8	0	51	0	0	0	0	0
1985	8979	5508	12908	3977	531	713	141	0	0	0	0	0	0	0
1986	3905	15321	3927	4907	1382	516	23	38	0	0	0	0	0	0
1987	851	13368	9831	1456	948	71	3	0	0	0	0	0	0	0
1988	1312	6242	20269	3349	521	624	0	0	0	0	0	0	0	0
1989	37713	9049	11684	3387	388	45	0	0	0	0	0	0	0	0
1990	11640	23068	8539	5658	1480	37	0	0	0	0	0	0	0	0
1991	8985	18215	8803	2814	1114	14	0	0	0	0	0	0	0	0
1992	17193	22825	10058	1528	191	16	2	0	0	0	0	0	0	0
1993	9787	16827	6126	2320	266	15	0	0	0	0	0	0	0	0
1994	3948	11084	6691	1966	49	7	0	0	0	0	0	0	0	0
1995	10318	5957	1344	2048	556	30	0	0	0	0	0	0	0	0
1996	16769	20891	9143	1202	64	20	0	0	0	0	0	0	0	0
1997	5056	15620	3409	243	127	15	0	0	0	0	0	0	0	0
1998	5767	10348	3051	1246	57	90	0	0	0	0	0	0	0	0
1999	2138	7771	5052	2240	270	110	0	0	0	0	0	0	0	0
2000	3239	8356	4640	962	313	9	3	0	0	0	0	0	0	0
2001	1208	3883	2465	2126	1045	252	5	0	0	0	0	0	0	0
2002	1687	6927	4309	1185	155	114	0	0	0	0	0	0	0	0
2003	3083	3325	3884	721	80	36	12	0	0	0	0	0	0	0
2004	1704	3392	2095	230	21	7	1	0	0	0	0	0	0	0
2005	2492	2151	1674	216	35	15	3	0	0	0	0	0	0	0
2006	5381	821	498	534	15	14	0	0	0	0	0	0	0	0
2007	12796	3366	324	284	239	0	0	0	0	0	0	0	0	0
2008	4337	2889	156	72	6	8	0	0	0	0	0	0	0	0
2009	2930	2718	1609	363	23	0	1	0	0	0	0	0	0	0

Table A38. Silver hake catch at age (in thousands of fish) for the southern stock.

year	age-1	age-2	age-3	age-4	age-5	age-6	age-7	age-8	age-9	age-10	age-11	age-12	age-13	age-14
1973	3470	164329	134686	55533	13498	3410	1524	0	0	0	0	0	0	0
1974	6213	65952	172266	108329	34225	10484	2576	0	455	0	0	0	0	0
1975	5223	49456	128180	63861	20200	2694	396	0	96	0	0	0	0	0
1976	383	51663	48274	39785	18228	8141	3881	412	0	0	0	0	0	0
1977	2044	16736	62794	35481	14643	5894	5004	1312	0	0	0	0	0	0
1978	1383	20549	18263	26284	11708	3412	458	61	0	0	0	0	0	72
1979	1716	12338	12825	6390	9503	5726	998	197	0	0	0	0	0	0
1980	1793	17101	17433	7962	3778	1793	2257	414	168	1	0	0	0	0
1981	5739	12437	17517	12679	5443	2190	1015	1275	666	0	13	0	0	0
1982	4968	26448	10550	8833	6558	2070	1033	369	299	133	0	0	0	0
1983	7861	19351	11352	5583	2531	1733	816	59	71	273	0	0	0	0
1984	2129	29479	15330	5535	1091	421	346	0	0	0	0	0	0	0
1985	3098	23434	21909	8077	1377	236	311	63	65	0	0	0	0	0
1986	5545	27377	9665	8122	1524	205	21	0	0	0	0	0	0	0
1987	4791	21647	14036	5113	3369	69	0	0	39	0	0	0	0	0
1988	1331	17531	27692	7243	579	27	0	0	0	0	0	0	0	0
1989	6162	37065	58113	15756	1441	294	0	0	0	0	0	0	0	0
1990	6404	48799	44712	13122	1962	37	22	0	0	0	0	0	0	0
1991	3476	14927	28939	19159	3927	1159	62	0	0	0	0	0	0	0
1992	19611	33504	27791	13871	809	3	0	0	0	0	0	0	0	0
1993	14853	33889	33400	21062	3654	0	0	0	0	0	0	0	0	0
1994	2333	34970	48808	14642	472	0	0	0	0	0	0	0	0	0
1995	2464	20804	29408	17295	471	0	0	0	0	0	0	0	0	0
1996	2604	26059	44729	7919	1277	2	0	0	0	0	0	0	0	0
1997	15162	25570	38389	7204	136	0	0	0	0	0	0	0	0	0
1998	5144	30811	47094	3576	10	0	0	0	0	0	0	0	0	0
1999	2810	50334	55028	3437	94	0	0	0	0	0	0	0	0	0
2000	1429	23497	37385	3126	38	0	0	0	0	0	0	0	0	0
2001	2442	10827	22576	9782	765	36	0	0	0	0	0	0	0	0
2002	1322	12901	21888	2760	108	0	0	0	0	0	0	0	0	0
2003	8312	15220	20327	5547	18	0	0	0	0	0	0	0	0	0
2004	8853	14559	29685	5643	33	0	0	0	0	0	0	0	0	0
2005	19269	20562	20439	5193	147	0	0	0	0	0	0	0	0	0
2006	11986	17115	8844	1126	35	1	0	0	0	0	0	0	0	0
2007	11178	18252	6100	1559	177	4	0	0	0	31	0	0	0	0
2008	16055	33793	3759	896	78	0	0	0	0	0	0	0	0	0
2009	12458	35366	8942	827	130	0	0	0	0	0	0	0	0	0

Table A39. Silver hake catch at age (in thousands of fish) for the combined stock areas.

year	age-1	age-2	age-3	age-4	age-5	age-6	age-7	age-8	age-9	age-10	age-11	age-12	age-13	age-14
1973	40470	260734	161782	58987	15354	4310	1647	0	0	240	0	22	185	0
1974	18614	106484	197420	112573	36311	11421	2630	0	455	52	54	0	81	0
1975	10053	106547	206021	87810	28557	5243	826	117	96	0	0	0	0	0
1976	2399	71378	71467	49245	20650	9642	4239	431	0	0	0	0	0	0
1977	3071	24276	84326	49656	17795	6365	5275	1336	9	0	0	0	0	0
1978	2975	28099	25213	37205	25233	5877	769	333	0	7	5	0	0	72
1979	2248	14938	15059	7831	11262	7988	1417	222	0	0	0	0	0	0
1980	3300	28571	27734	9861	4310	2230	3123	761	216	45	0	3	0	0
1981	10105	21445	25185	16616	6132	2344	1246	1459	687	0	13	0	0	0
1982	9647	34437	13487	11697	9331	2336	1104	839	391	134	2	0	0	0
1983	10804	31298	14153	7030	4454	2613	996	110	88	273	0	0	0	0
1984	7312	45587	21833	8860	2011	1238	355	0	51	0	0	0	0	0
1985	12077	28943	34817	12054	1908	950	451	63	65	0	0	0	0	0
1986	9450	42698	13593	13029	2906	720	44	38	0	0	0	0	0	0
1987	5642	35015	23866	6569	4317	140	3	0	39	0	0	0	0	0
1988	2643	23773	47960	10592	1100	651	0	0	0	0	0	0	0	0
1989	43875	46114	69798	19143	1829	339	0	0	0	0	0	0	0	0
1990	18045	71866	53252	18780	3442	74	22	0	0	0	0	0	0	0
1991	12461	33142	37742	21973	5041	1172	62	0	0	0	0	0	0	0
1992	36804	56328	37849	15399	1000	19	2	0	0	0	0	0	0	0
1993	24640	50716	39525	23382	3920	15	0	0	0	0	0	0	0	0
1994	6281	46054	55499	16608	521	7	0	0	0	0	0	0	0	0
1995	12782	26761	30752	19343	1027	30	0	0	0	0	0	0	0	0
1996	19373	46950	53871	9120	1341	22	0	0	0	0	0	0	0	0
1997	20218	41190	41798	7447	263	15	0	0	0	0	0	0	0	0
1998	10911	41159	50145	4822	67	90	0	0	0	0	0	0	0	0
1999	4948	58104	60080	5676	364	110	0	0	0	0	0	0	0	0
2000	4668	31853	42025	4087	351	9	3	0	0	0	0	0	0	0
2001	3650	14709	25041	11908	1811	288	5	0	0	0	0	0	0	0
2002	3009	19828	26197	3945	263	114	0	0	0	0	0	0	0	0
2003	11395	18545	24212	6268	98	36	12	0	0	0	0	0	0	0
2004	10557	17950	31780	5873	54	7	1	0	0	0	0	0	0	0
2005	21761	22713	22113	5409	181	15	3	0	0	0	0	0	0	0
2006	17367	17936	9343	1660	49	15	0	0	0	0	0	0	0	0
2007	23974	21618	6424	1843	416	4	0	0	0	31	0	0	0	0
2008	20392	36681	3915	968	84	8	0	0	0	0	0	0	0	0
2009	15388	38084	10552	1190	153	0	1	0	0	0	0	0	0	0

Table A40. Silver hake catch weight at age for the northern stock (kg).

year	age-1	age-2	age-3	age-4	age-5	age-6	age-7	age-8	age-9	age-10	age-11	age-12	age-13	age-14
1973	0.1232	0.1730	0.2557	0.4812	0.5760	0.6304	1.3418	0	0	1.1065	0	1.5049	0.8503	0
1974	0.1086	0.2086	0.2856	0.4209	0.5113	0.6522	0.6635	0	0	0.8537	1.4930	0	0.8479	0
1975	0.0845	0.1426	0.2117	0.3529	0.4732	0.7730	0.8541	0.8503	0	0	0	0	0	0
1976	0.0806	0.1519	0.2129	0.3369	0.4962	0.5890	0.6476	1.7126	0	0	0	0	0	0
1977	0.1227	0.1803	0.2294	0.2859	0.4489	0.6075	0.9102	0.8939	0.9586	0	0	0	0	0
1978	0.1167	0.2110	0.2448	0.2883	0.3236	0.4981	0.5365	0.7281	0	0.9017	0.9586	0	0	0
1979	0.1363	0.2126	0.2817	0.3397	0.3510	0.3655	0.4756	1.0956	0	0	0	0	0	0
1980	0.0960	0.1346	0.1689	0.2160	0.3041	0.3532	0.3083	0.4826	1.0829	1.8496	0	2.4460	0	0
1981	0.1099	0.1383	0.1780	0.2258	0.2935	0.3490	0.4612	0.3617	0.3282	0	0	0	0	0
1982	0.1109	0.1630	0.2068	0.3004	0.3150	0.3347	0.3768	0.6137	0.9944	1.5090	1.6687	2.0320	0	0
1983	0.1293	0.1911	0.2906	0.3329	0.3918	0.5613	0.4510	0.2854	0.5359	0	0	0	0	0
1984	0.1242	0.1925	0.2971	0.4626	0.4736	0.7454	1.5651	0	0.3111	0	0	0	0	0
1985	0.1410	0.2052	0.2619	0.3762	0.4645	0.9337	0.6524	0	0	0	0	0	0	0
1986	0.1257	0.2281	0.3306	0.3757	0.5430	1.0947	2.0009	0.3005	0	0	0	0	0	0
1987	0.0903	0.1539	0.2679	0.3407	0.3579	0.6826	1.7468	0	0	0	0	0	0	0
1988	0.1001	0.1409	0.1930	0.3411	0.4072	0.8203	0	0	0	0	0	0	0	0
1989	0.0474	0.1487	0.2174	0.3043	0.4352	1.2695	0	0	0	0	0	0	0	0
1990	0.0648	0.1417	0.2294	0.2869	0.4627	0.8688	0	0	0	0	0	0	0	0
1991	0.0675	0.1498	0.2149	0.2853	1.1251	0.8025	0	0	0	0	0	0	0	0
1992	0.0576	0.1224	0.2228	0.3462	0.7570	1.2611	3.8648	0	0	0	0	0	0	0
1993	0.0603	0.1300	0.2233	0.3077	0.6194	1.5227	2.9826	0	0	0	0	0	0	0
1994	0.0697	0.1318	0.2435	0.3618	1.0404	1.7938	2.3271	0	0	0	0	0	0	0
1995	0.0354	0.0759	0.2045	0.6955	1.1767	1.7207	0	0	0	0	0	0	0	0
1996	0.0210	0.1009	0.1713	0.2751	0.7922	1.3982	3.3621	0	0	0	0	0	0	0
1997	0.0623	0.1262	0.1681	0.2849	0.7734	1.1201	1.5205	0	0	0	0	0	0	0
1998	0.0250	0.1047	0.2592	0.4631	0.6507	1.1736	2.6742	0	0	0	0	0	0	0
1999	0.0157	0.1443	0.3103	0.5187	0.7310	0.9842	1.5045	0	0	0	0	0	0	0
2000	0.0275	0.1180	0.2511	0.4529	0.8244	1.4221	1.4473	0	0	0	0	0	0	0
2001	0.0324	0.1161	0.3010	0.5716	0.9876	1.5147	1.7181	0	0	0	0	0	0	0
2002	0.0762	0.1576	0.2679	0.4301	0.6001	1.1045	2.1307	0	0	0	0	0	0	0
2003	0.0348	0.1338	0.2434	0.5180	0.9793	1.0626	1.5786	2.1307	0	0	0	0	0	0
2004	0.0620	0.1191	0.2631	0.2836	0.9794	2.0800	1.7304	0	0	0	0	0	0	0
2005	0.0466	0.1386	0.2308	0.3075	0.3634	0.3484	1.7543	0	0	0	0	0	0	0
2006	0.1007	0.1784	0.1847	0.2651	1.0386	0.1753	1.8087	0	0	0	0	0	0	0
2007	0.0717	0.1848	0.2308	0.2906	0.2756	1.8087	0.2359	0	0	0	0	0	0	0
2008	0.0667	0.1451	0.2292	0.4476	0.8437	0.7874	1.8087	0	0	0	0	0	0	0
2009	0.0642	0.1589	0.2403	0.5676	0.5001	2.0215	0.4448	0	0	0	0	0	0	0

Table A41. Silver hake catch weight at age for the southern stock (kg).

year	age-1	age-2	age-3	age-4	age-5	age-6	age-7	age-8	age-9	age-10	age-11	age-12	age-13	age-14
1973	0.1102	0.2002	0.2795	0.3898	0.4967	0.5898	0.5125	0	0	0	0	0	0	0
1974	0.1362	0.1872	0.2263	0.3065	0.3433	0.3767	0.4480	0	0.3271	0	0	0	0	0
1975	0.1363	0.1927	0.2312	0.3531	0.4162	0.4345	0.2943	0	0.4383	0	0	0	0	0
1976	0.1063	0.2132	0.2660	0.4318	0.7257	0.8034	0.8772	0.8802	0	0	0	0	0	0
1977	0.1487	0.2365	0.3146	0.3922	0.5951	0.8713	0.8184	0.9788	0	0	0	0	0	0
1978	0.1434	0.2082	0.2816	0.3553	0.3564	0.6986	0.5444	0.7697	0	0	0	0	0	0.3273
1979	0.1494	0.2159	0.2669	0.3164	0.4980	0.4376	0.6086	0.9545	0	0	0	0	0	0
1980	0.1172	0.1895	0.2163	0.2605	0.2752	0.3078	0.2723	0.3256	0.2761	0.6516	0	0	0	0
1981	0.1187	0.1889	0.2139	0.2490	0.2903	0.3502	0.3504	0.3930	0.4192	0	0.8959	0	0	0
1982	0.1364	0.1902	0.2691	0.2662	0.2856	0.3225	0.3791	0.3954	0.4054	0.4021	0	0	0	0
1983	0.1677	0.2019	0.2752	0.3016	0.3392	0.3186	0.3143	0.2506	0.5700	0.3831	0	0	0	0
1984	0.1522	0.1991	0.2536	0.3985	0.3472	0.4259	0.3178	0	0	0	0	0	0	0
1985	0.1371	0.1749	0.2295	0.3164	0.3773	0.2988	0.2871	0.2739	0.2500	0	0	0	0	0
1986	0.1387	0.1555	0.2190	0.2504	0.2931	0.3239	0.3268	0	0	0	0	0	0	0
1987	0.1338	0.1521	0.2097	0.2763	0.3653	0.3325	0	0	0.2280	0	0	0	0	0
1988	0.0608	0.1476	0.1574	0.2408	0.2785	0.6306	0	0	0	0	0	0	0	0
1989	0.0882	0.1311	0.1716	0.2291	0.3326	0.2510	0	0	0	0	0	0	0	0
1990	0.0742	0.1260	0.1864	0.2558	0.3304	0.4163	0.5621	0	0	0	0	0	0	0
1991	0.0668	0.1196	0.1736	0.2177	0.3123	0.3114	0.3537	0	0	0	0	0	0	0
1992	0.0730	0.1269	0.1761	0.2274	0.2613	1.3141	0	0	0	0	0	0	0	0
1993	0.0688	0.1158	0.1958	0.2369	0.3218	0	0	0	0	0	0	0	0	0
1994	0.0696	0.1472	0.1781	0.2616	0.6066	0	0	0	0	0	0	0	0	0
1995	0.0901	0.1610	0.1869	0.2323	0.6541	0	0	0	0	0	0	0	0	0
1996	0.0822	0.1272	0.1430	0.2696	0.4288	1.5012	0	0	0	0	0	0	0	0
1997	0.0843	0.1312	0.1683	0.2783	0.4143	0	0	0	0	0	0	0	0	0
1998	0.0832	0.1347	0.1533	0.3480	0.8411	0	0	0	0	0	0	0	0	0
1999	0.0699	0.0976	0.1399	0.3240	0.4891	0	0	0	0	0	0	0	0	0
2000	0.0935	0.1388	0.1483	0.2680	0.5868	0	0	0	0	0	0	0	0	0
2001	0.0722	0.1350	0.1717	0.3047	0.6768	1.6357	0	0	0	0	0	0	0	0
2002	0.0773	0.1172	0.1274	0.2928	0.8062	0	0	0	0	0	0	0	0	0
2003	0.0762	0.1333	0.1501	0.2077	0.6676	0	0	0	0	0	0	0	0	0
2004	0.0674	0.1069	0.1529	0.2558	1.0052	0	0	0	0	0	0	0	0	0
2005	0.0991	0.1045	0.1189	0.2738	0.4053	0	0	0	0	0	0	0	0	0
2006	0.0961	0.1252	0.1352	0.2019	0.7299	1.3809	0	0	0	0	0	0	0	0
2007	0.0959	0.1393	0.1884	0.2224	0.5065	1.1264	0	0	0	0.2369	0	0	0	0
2008	0.0907	0.1173	0.2107	0.4058	0.5134	0	0	0	0	0	0	0	0	0
2009	0.0920	0.1242	0.1629	0.4140	0.7106	0	0	0	0	0	0	0	0	0

Table A42 Silver hake catch weight at age for the combined stock areas (kg).

year	age-1	age-2	age-3	age-4	age-5	age-6	age-7	age-8	age-9	age-10	age-11	age-12	age-13	age-14
1973	0.1221	0.1902	0.2755	0.3952	0.5063	0.5983	0.5745	0	0	1.1065	0	1.5049	0.8503	0
1974	0.1178	0.1954	0.2339	0.3108	0.3530	0.3993	0.4525	0	0.3271	0.8537	1.4930	0	0.8479	0
1975	0.1114	0.1659	0.2238	0.3530	0.4329	0.5991	0.5859	0.8503	0.4383	0	0	0	0	0
1976	0.0847	0.1962	0.2488	0.4136	0.6988	0.7700	0.8578	0.9179	0	0	0	0	0	0
1977	0.1400	0.2190	0.2928	0.3619	0.5692	0.8518	0.8231	0.9772	0.9586	0	0	0	0	0
1978	0.1291	0.2089	0.2715	0.3356	0.3388	0.6145	0.5412	0.7358	0	0.9017	0.9586	0	0	0.3273
1979	0.1463	0.2153	0.2691	0.3206	0.4751	0.4172	0.5693	0.9706	0	0	0	0	0	0
1980	0.1075	0.1675	0.1987	0.2519	0.2788	0.3167	0.2823	0.3973	0.4580	1.8180	0	2.4460	0	0
1981	0.1149	0.1676	0.2030	0.2435	0.2906	0.3501	0.3710	0.3890	0.4164	0	0.8959	0	0	0
1982	0.1240	0.1839	0.2556	0.2746	0.2944	0.3239	0.3789	0.5178	0.5435	0.4109	1.6687	2.0320	0	0
1983	0.1572	0.1978	0.2782	0.3081	0.3619	0.4004	0.3391	0.2666	0.5634	0.3831	0	0	0	0
1984	0.1323	0.1968	0.2666	0.4226	0.4050	0.6367	0.3476	0	0.3111	0	0	0	0	0
1985	0.1400	0.1807	0.2415	0.3361	0.4016	0.7757	0.4009	0.2739	0.2500	0	0	0	0	0
1986	0.1334	0.1816	0.2512	0.2976	0.4120	0.8756	1.2022	0.3005	0	0	0	0	0	0
1987	0.1272	0.1528	0.2337	0.2906	0.3637	0.5107	1.7468	0	0.2280	0	0	0	0	0
1988	0.0803	0.1458	0.1724	0.2725	0.3395	0.8123	0	0	0	0	0	0	0	0
1989	0.0531	0.1346	0.1792	0.2424	0.3544	0.3861	0	0	0	0	0	0	0	0
1990	0.0681	0.1310	0.1933	0.2652	0.3873	0.6436	0.5621	0	0	0	0	0	0	0
1991	0.0673	0.1362	0.1832	0.2264	0.4918	0.3172	0.3537	0	0	0	0	0	0	0
1992	0.0658	0.1250	0.1885	0.2392	0.3562	1.2704	3.8648	0	0	0	0	0	0	0
1993	0.0654	0.1205	0.2001	0.2440	0.3420	1.5227	2.9826	0	0	0	0	0	0	0
1994	0.0697	0.1435	0.1859	0.2735	0.6470	1.7938	2.3271	0	0	0	0	0	0	0
1995	0.0459	0.1421	0.1877	0.2813	0.9371	1.7207	0	0	0	0	0	0	0	0
1996	0.0292	0.1155	0.1478	0.2704	0.4462	1.4061	3.3621	0	0	0	0	0	0	0
1997	0.0788	0.1293	0.1683	0.2785	0.5876	1.1201	1.5205	0	0	0	0	0	0	0
1998	0.0524	0.1272	0.1597	0.3778	0.6780	1.1736	2.6742	0	0	0	0	0	0	0
1999	0.0465	0.1038	0.1542	0.4008	0.6685	0.9842	1.5045	0	0	0	0	0	0	0
2000	0.0477	0.1333	0.1597	0.3115	0.7990	1.4221	1.4473	0	0	0	0	0	0	0
2001	0.0591	0.1300	0.1844	0.3523	0.8562	1.5298	1.7181	0	0	0	0	0	0	0
2002	0.0767	0.1313	0.1505	0.3341	0.6847	1.1045	2.1307	0	0	0	0	0	0	0
2003	0.0650	0.1334	0.1651	0.2434	0.9217	1.0626	1.5786	2.1307	0	0	0	0	0	0
2004	0.0665	0.1092	0.1601	0.2569	0.9951	2.0800	1.7304	0	0	0	0	0	0	0
2005	0.0930	0.1077	0.1274	0.2752	0.3973	0.3484	1.7543	0	0	0	0	0	0	0
2006	0.0976	0.1276	0.1379	0.2222	0.8232	0.2517	1.8087	0	0	0	0	0	0	0
2007	0.0830	0.1464	0.1906	0.2329	0.3737	1.1763	0.2359	0	0	0.2369	0	0	0	0
2008	0.0856	0.1194	0.2115	0.4089	0.5376	0.7874	1.8087	0	0	0	0	0	0	0
2009	0.0867	0.1267	0.1747	0.4608	0.6791	2.0215	0.4448	0	0	0	0	0	0	0

Table A43. Survey attributes. The years where age structure is available pertains to silver hake specifically (Some age information is available earlier in the time series for other stocks).

Survey	Index	Years	Precision	Area	depth(m)	Speed (kn)	duration (min)	Height (m)	Changes	Comments
Fall	abundance	1973-2009		GOM, SGB, NGB, SNE, MA	>30	3.8	30	1-2	D85, V~	
	age Structure	1973-2009								
Spring	abundance	1973-2009		GOM, SGB, NGB, SNE, MA	>30	3.8	30	1-2	5, V~, N73-81, V~	
	age Structure	1973-2009								
Shrimp	abundance	1985-2009	?	W.GOM	?	2	15	3	none	no ages
Larval	SSB	1977-2008	IQR~?	SW.GOM-GB	>30	NA		NA	mesh93	
ME-NH	Recruitment	2000-2009	?	Inshore ME	<30	2.5	20	3	none	no ages
Maspring	Recruitment	(1978)1982-2009	?	Inshore MA			15	3	V82	Intermittent ages
Mafall	Recruitment	(1978)1982-2009	?	Inshore MA	<100~	2	15	3		intermittent ages

Table A44. negative log-likelihood, number of model parameters, AIC_c measures for beta-binomial models with the specified relationship of the calibration factor to length fit to silver hake catch data from the 2008 *Albatross IV*/*Henry B. Bigelow* calibration experiment.

Model	Model	-LL	# parameters	AIC_c	Δ (AIC_c)	AIC_c Weights
1	**All stations, constant (no length effect)**	9341.745	2	18687.49	494.4465	0
2	**Survey, S-S, constant**	9322.744	4	18653.49	460.4489	0
3	**S,F,S-S, constant model**	9305.244	6	18622.5	429.4549	0
4	**All stations, logistic model**	9186.488	5	18382.99	189.9405	0
5	**Survey, S-S logistic**	9163.663	10	18347.36	154.3148	0
6	**S, F, S-S, logistic**	9146.738	15	18323.55	130.5072	0
7	**All stations, double logistic model**	9115.248	8	18246.52	53.4731	0
8	**Survey, S-S, double-logistic model**	9089.773	16	18211.63	18.5858	1.00E-04
9	**S,F,S-S, double-logistic model**	9073.961	24	18196.11	3.0675	0.1774
10	**Spring logistic model**	9076.506	21	18195.16	2.1138	NA
11	**No minimum of ascending logistic for Fall**	9073.981	23	18194.14	1.0926	NA
12	**No minima for ascending or descending logistic for Fall**	9074.917	22	18194	0.9499	NA
13	**Spring logistic, no minima for ascending or descending logistic for Fall**	9076.527	19	18193.05	0	0.8225

Table A45: NEFSC fall survey indices of minimum swept area abundance for northern silver hake stock in thousands of fish and thousand of metric tons (Note that 2009a are raw Bigelow Values and 2009b are converted Bigelow values to Albatross units)

Year	CV	Age1	Age2	Age3	Age4	Age5	Age6+	B(000mt)
1973	12%	14436.5	17065.9	6506.6	956.3	640.4	384.7	8.818
1974	16%	0.0	0.0	0.0	0.0	0.0	0.0	7.374
1975	17%	35678.7	65288.3	15495.3	4861.7	1785.7	1324.1	17.312
1976	15%	15459.1	33747.8	35380.2	13317.2	2055.5	2303.5	24.070
1977	21%	11894.0	11472.0	19658.5	12447.3	2127.2	519.8	14.381
1978	10%	22603.4	7793.0	4901.3	7013.1	9481.1	2681.8	13.527
1979	14%	54164.4	35852.5	4038.5	1873.8	2241.7	3455.2	13.222
1980	21%	8020.5	27275.0	26790.4	6152.2	2286.6	6611.8	15.460
1981	24%	16369.2	10221.9	11695.4	9707.7	1530.8	2594.7	9.667
1982	38%	32671.9	18255.7	6595.6	6801.4	6221.3	1512.4	13.443
1983	20%	85804.5	59343.2	2440.3	1256.5	1284.5	820.2	18.735
1984	16%	12838.7	15684.7	4775.2	1077.8	396.1	248.0	7.185
1985	12%	84813.3	7705.9	14376.6	2885.3	210.8	51.6	17.718
1986	11%	171009.8	46817.8	6360.4	6077.7	742.5	0.0	27.902
1987	13%	7056.1	88792.7	21521.0	2330.5	1818.8	229.0	20.949
1988	13%	8381.9	13019.5	37131.3	2667.3	319.7	79.6	12.939
1989	14%	115415.1	26960.7	28799.9	2886.6	141.0	17.1	22.539
1990	21%	45324.0	116639.3	29578.5	13340.3	1629.7	0.0	33.397
1991	19%	76098.0	61390.6	21634.0	4048.5	230.2	0.0	22.515
1992	13%	79017.2	80694.6	25106.3	840.5	0.0	0.0	21.925
1993	15%	103221.8	62864.1	9868.4	1885.8	112.1	0.0	16.051
1994	12%	41373.7	78996.9	7439.5	226.2	0.0	0.0	14.644
1995	14%	174259.8	75106.4	18922.2	772.3	0.0	0.0	27.592
1996	14%	30675.8	75793.5	19831.7	1861.6	119.4	39.6	16.191
1997	17%	24796.9	39185.3	11025.0	855.9	53.9	17.8	12.108
1998	20%	437056.4	85750.8	10686.5	1411.6	45.2	86.0	40.462
1999	13%	82209.2	124230.5	3951.8	837.5	106.8	20.1	23.853
2000	13%	216280.5	92445.2	14006.8	860.2	55.4	0.0	28.903
2001	13%	26200.2	111742.1	7411.1	1307.6	224.5	0.0	17.820
2002	12%	55376.4	64790.2	4901.0	628.7	38.3	0.0	17.093
2003	13%	135899.8	34640.5	15642.5	537.1	55.8	0.0	17.745
2004	17%	39525.1	28282.0	3761.0	390.3	36.2	0.0	7.014
2005	16%	8989.2	15479.3	4467.7	170.5	88.6	55.6	3.672
2006	39%	56340.2	4048.3	3011.8	2338.8	0.0	65.1	7.903
2007	12%	163771.4	6655.9	818.1	500.7	444.0	0.0	13.786
2008	13%	73158.4	32141.6	1132.8	208.0	0.0	0.0	11.285
2009a	13%	349370.4	132034.0	55391.2	932.5	1458.7	32.7	67.300
2009b	NA	71712.5	30640.6	13550.5	285.8	357.7	11.9	14.748

Table A46: NEFSC spring survey indices of minimum swept area abundance for northern silver hake stock in thousands of fish and thousands of metric tons (Note that 2009a are raw Bigelow Values and 2009b are converted Bigelow values to Albatross units).

Year	CV	Age1	Age2	Age3	Age4	Age5	Age6+	B(000mt)
1973	17%	11417.2	25745.9	2586.8	336.2	113.2	40.7	5.760
1974	21%	80728.8	8416.8	4048.8	1116.6	218.9	153.0	5.789
1975	24%	103639.2	163802.8	17115.2	2873.8	937.9	119.7	18.268
1976	13%	25532.1	57159.3	30964.7	3593.2	1243.0	833.2	17.952
1977	14%	12742.4	12445.0	10823.9	4368.0	873.5	719.0	7.796
1978	26%	10279.1	4439.9	840.5	449.6	448.3	164.6	1.720
1979	23%	20114.1	30356.8	1037.8	288.7	147.6	304.7	3.693
1980	14%	9743.9	44268.4	15180.1	1065.2	305.4	615.4	8.565
1981	15%	24465.0	12678.4	8566.6	2805.3	348.4	144.4	4.607
1982	15%	23899.0	12213.5	3437.4	1493.6	1156.8	286.3	3.047
1983	16%	23320.0	17971.3	1880.7	546.5	766.9	266.6	3.273
1984	22%	8586.5	12281.1	1891.8	403.1	107.6	133.1	2.370
1985	29%	70390.3	7367.8	4209.5	1578.5	456.2	313.3	5.004
1986	20%	162634.1	12302.0	1595.9	1455.1	311.3	182.3	6.321
1987	19%	6462.3	72239.3	7050.9	961.0	460.9	96.7	7.906
1988	16%	1956.9	3583.3	10439.5	1317.5	218.5	97.4	2.641
1989	21%	236852.6	7336.2	1499.6	3118.6	250.1	0.0	7.353
1990	18%	30459.7	19804.3	3243.8	736.5	413.6	41.9	3.363
1991	12%	85192.9	10244.0	2636.3	1228.0	89.9	46.9	2.850
1992	26%	237761.6	91109.7	12132.1	3703.4	189.4	16.0	11.639
1993	25%	80010.3	49913.7	6632.8	2830.6	281.8	0.0	5.513
1994	31%	15457.9	139351.6	22783.5	2405.6	25.3	33.4	11.254
1995	19%	92548.6	113790.1	14160.7	2347.8	125.0	37.0	6.998
1996	19%	7746.6	43529.7	29157.0	2431.9	37.7	45.4	6.436
1997	14%	5291.4	13944.4	7595.3	579.5	172.5	37.7	2.583
1998	12%	156694.2	212364.9	4923.3	1076.5	190.0	47.3	8.357
1999	16%	24723.9	123620.3	11145.9	1487.2	461.6	16.0	8.751
2000	17%	38275.9	357605.0	49393.7	5192.7	557.6	126.7	20.285
2001	13%	8371.0	261511.6	72584.2	6256.4	614.6	65.3	22.309
2002	15%	14365.3	79166.5	30560.5	3707.2	350.3	240.3	7.457
2003	19%	104133.8	160288.7	13610.3	2901.2	166.9	73.6	7.496
2004	19%	10608.0	111844.0	7763.1	2773.9	236.0	33.0	6.541
2005	16%	5128.1	21365.7	7241.4	555.5	36.2	0.0	2.436
2006	13%	18462.6	2344.0	630.8	1038.0	59.5	36.2	0.915
2007	19%	160220.6	12298.6	1249.9	384.1	338.5	43.7	4.716
2008	18%	23538.5	64374.8	1957.3	282.0	28.5	161.6	6.290
2009a	14%	458004.4	131703.7	65939.2	1601.0	304.9	958.9	75.190
2009b	NA	52960.0	27848.6	13993.6	339.8	64.7	203.5	5.673

Table A47: Swept area abundance and biomass for silver hake from the Shrimp survey

Year	Swept Area (nm)	Swept Area Abundance (millions)	Swept Area Upper CI	Swept Area Lower CI	Swept Area Biomass (mt)	Swept Area Upper CI	Swept Area Lower CI
1985	9675	775.78	1218.38	333.18	68474.09	107632.44	29315.49
1986	12022	2242.04	2740.04	1744.04	105899.39	130566.43	81232.65
1987	11595	1151.27	1439.34	863.19	149508.25	187774.65	111241.56
1988	6574	95.94	117.43	74.45	16302.04	19623.88	12980.20
1989	9167	1452.78	1981.00	924.56	82533.48	121208.59	43858.37
1990	9167	761.40	851.82	670.98	92028.43	102836.78	81220.08
1991	10401	852.50	955.33	749.67	62591.40	72070.35	53112.45
1992	8983	1542.04	1827.99	1256.09	82456.75	94660.16	70253.12
1993	10629	1964.33	2160.56	1768.11	85261.32	91638.99	78883.65
1994	6574	399.06	533.46	264.66	32765.14	46107.41	19423.05
1995	6147	554.31	691.27	417.35	30770.35	38115.24	23425.29
1996	6574	506.71	654.17	359.25	34179.38	43632.79	24726.13
1997	6147	154.76	200.29	109.23	10644.45	13005.05	8283.85
1998	7241	2060.04	2831.16	1288.92	72296.68	98166.24	46427.12
1999	8195	741.92	875.53	608.31	46540.63	56341.44	36739.62
2000	8195	1892.18	2206.53	1577.83	81988.72	93634.84	70342.81
2001	7749	617.70	730.27	505.14	46869.83	55068.85	38670.80
2002	8500	1063.57	1149.30	977.84	66092.60	71205.56	60979.64
2003	9167	2324.57	2974.95	1674.18	81179.51	108300.31	54058.72
2004	10788	875.95	1053.75	698.15	42106.37	50668.00	33544.75
2005	10788	244.07	295.65	192.50	17895.40	20879.63	14911.17
2006	7241	136.78	177.41	96.15	9501.46	12106.05	6896.87
2007	9370	773.15	950.45	595.84	32559.34	40137.80	24980.65
2008	9370	575.56	668.92	482.21	27980.69	33357.67	22603.95
2009	9370	286.63	343.30	229.97	16239.62	20030.72	12448.51

Table A48. Fall survey Swept area abundance and biomass with 95% Confidence interval for silver from the Massachusetts Division of Fisheries Fall North Survey

Year	Swept Area (nm)	Swept Area Abundance (millions)	Swept Area Upper CI	Swept Area Lower CI	Swept Area Biomass (mt)	Swept Area Upper CI	Swept Area Lower CI
1978	948	16.03	23.30	8.77	767.75	1373.74	161.79
1979	969	18.10	20.35	15.84	1327.45	1548.98	1105.90
1980	969	15.11	23.96	6.26	1522.93	3150.82	-104.96
1981	969	11.05	13.71	8.38	1450.37	1821.45	1079.30
1982	969	14.38	17.12	11.64	794.94	924.46	665.39
1983	969	8.72	10.10	7.33	845.40	979.33	711.47
1984	969	3.74	4.33	3.15	595.07	723.94	466.18
1985	948	13.93	16.01	11.85	1477.26	1797.31	1157.18
1986	969	32.75	36.69	28.81	2115.96	2435.27	1796.68
1987	933	3.47	4.59	2.35	274.01	328.50	219.51
1988	933	3.57	4.26	2.88	552.66	718.88	386.45
1989	875	9.75	11.30	8.21	695.98	802.75	589.24
1990	969	4.37	5.21	3.52	483.49	610.52	356.44
1991	914	20.69	24.40	16.98	1399.73	1635.34	1164.13
1992	969	59.66	68.32	51.00	1657.29	1974.05	1340.50
1993	969	8.27	9.91	6.64	549.88	656.52	443.21
1994	969	11.89	14.74	9.05	1099.07	1376.58	821.54
1995	969	14.41	17.89	10.93	1041.30	1299.77	782.84
1996	969	10.82	12.89	8.74	1111.37	1274.32	948.41
1997	969	7.99	11.02	4.96	507.48	677.86	337.07
1998	969	12.70	15.58	9.83	666.70	820.48	512.92
1999	969	14.15	19.27	9.02	1210.00	1590.30	829.73
2000	969	21.69	25.38	18.01	2231.55	2596.94	1866.14
2001	969	4.94	6.64	3.24	759.74	1147.77	371.71
2002	969	13.74	15.65	11.82	1018.45	1133.66	903.27
2003	969	10.69	13.45	7.94	718.47	996.69	440.26
2004	969	7.39	10.58	4.20	434.49	527.73	341.27
2005	969	1.77	2.12	1.42	171.75	207.57	135.92
2006	969	5.92	7.16	4.68	508.06	643.22	372.92
2007	948	4.27	4.93	3.60	412.63	500.96	324.29
2008	969	6.09	7.20	4.98	481.80	576.23	387.35
2009	948	7.74	10.18	5.30	651.17	892.02	410.28

Table A49: Spring survey swept area abundance and biomass with 95% Confidence interval for silver from the Massachusetts Division of Fisheries in the northern management area

Year	Swept Area (nm)	Swept Area Abundance (millions)	Swept Area Upper CI	Swept Area Lower CI	Swept Area Biomass (mt)	Swept Area Upper CI	Swept Area Lower CI
1978	930	1.15	1.75	0.55	227.17	357.30	97.03
1979	969	1.76	2.43	1.10	79.41	142.42	16.40
1980	969	2.11	2.87	1.36	268.44	375.11	161.77
1981	969	4.47	6.14	2.81	560.31	1114.59	6.02
1982	969	0.64	0.78	0.51	80.39	100.85	59.94
1983	969	4.73	5.69	3.76	677.13	833.78	520.50
1984	969	1.97	2.46	1.48	299.96	392.84	207.07
1985	969	5.65	7.06	4.24	322.13	469.99	174.26
1986	969	10.12	11.73	8.52	753.77	1069.50	438.04
1987	969	11.83	39.84	-16.17	1470.43	4825.34	-1884.51
1988	969	1.24	1.55	0.94	198.78	244.81	152.75
1989	969	4.00	5.32	2.68	204.22	282.52	125.92
1990	969	1.25	2.90	-0.40	112.26	238.94	-14.41
1991	969	1.56	2.12	1.00	112.19	160.91	63.44
1992	969	3.99	5.62	2.37	386.24	676.58	95.91
1993	969	0.84	1.60	0.07	32.22	44.52	19.93
1994	969	1.96	4.30	-0.38	73.87	117.88	29.85
1995	969	5.44	6.91	3.96	273.60	324.29	222.91
1996	969	1.88	2.36	1.41	70.27	94.60	45.95
1997	969	6.34	10.92	1.76	644.38	1191.00	97.73
1998	969	2.24	3.03	1.45	124.83	191.85	57.84
1999	969	4.91	6.63	3.20	231.43	373.14	89.74
2000	969	13.12	17.61	8.62	1031.18	1478.87	583.48
2001	969	2.86	3.67	2.05	314.19	410.05	218.35
2002	969	4.53	5.68	3.37	406.30	498.86	313.74
2003	969	3.67	4.46	2.88	149.90	182.30	117.50
2004	969	0.95	1.21	0.68	47.19	73.09	21.26
2005	969	1.00	1.26	0.74	52.76	65.98	39.53
2006	969	3.90	5.09	2.72	186.03	313.33	58.73
2007	969	2.36	2.87	1.85	162.57	198.80	126.35
2008	969	2.08	2.61	1.55	138.44	182.98	93.87
2009	969	4.80	6.14	3.45	225.05	256.62	193.51

Table A50: Stratified mean number and weight per tow (kg) for silver hake from the fall and spring Maine_New Hampshire State surveys, 2000-2009

Year	MENH Fall Stratified Mean Number/Tow	MENH Fall Stratified Mean Weight/Tow (Kg)	MENH Spring Stratified Mean Number/Tow	MENH Spring Stratified Mean Weight/Tow (Kg)
2000	786.49	34.77		
2001	687.67	52.88	97.74	3.68
2002	476.28	13.47	302.44	13.34
2003	1046.25	49.97	503.71	11.63
2004	413.66	24.85	131.82	5.25
2005	44.93	3.77	43.34	1.91
2006	82.59	7.13	40.47	1.58
2007	605.57	37.14	223.16	5.68
2008	467.93	30.66	145.21	4.67
2009	498.48	25.73	277.21	8.54

Table A51: NEFSC fall survey indices of minimum swept area abundance for southern silver hake stock in thousands of fish and thousand of metric tons (Note that 2009a are raw Bigelow Values and 2009b are converted Bigelow values to Albatross units)

Year	CV	Age1	Age2	Age3	Age4	Age5	Age6+	B(000mt)
1973	20%	10253.2	10947.8	4677.8	1335.2	664.1	61.6	5.622
1974	28%	0.0	0.0	0.0	0.0	0.0	0.0	2.813
1975	27%	13223.3	7848.6	4759.3	1939.8	670.4	340.7	5.912
1976	34%	6303.8	12596.9	6726.9	2316.6	600.6	720.4	6.600
1977	25%	8336.3	3369.7	6678.9	2286.1	520.8	387.0	5.546
1978	19%	20398.5	8995.1	5934.6	5397.9	2441.4	533.0	8.272
1979	16%	6862.6	6226.6	4536.8	2209.3	1604.1	1555.7	5.575
1980	21%	8781.9	3224.5	7869.9	2438.1	1357.2	1344.7	5.386
1981	35%	22241.3	2260.9	3415.8	2392.1	557.5	218.2	3.720
1982	28%	9618.2	7750.3	3109.5	1301.1	589.3	329.1	5.178
1983	32%	25684.2	11599.1	5732.0	1143.2	593.3	345.3	8.510
1984	25%	16431.4	7743.5	3112.5	888.5	52.9	0.0	4.611
1985	26%	53270.5	11520.9	8872.3	4211.0	394.0	0.0	11.760
1986	28%	19161.6	8618.4	1948.4	642.3	216.5	0.0	4.788
1987	36%	17745.5	24635.5	1873.3	559.1	173.9	0.0	6.454
1988	26%	12656.9	28969.2	3205.2	237.7	26.5	0.0	5.903
1989	21%	9082.5	22022.5	7874.4	681.4	124.2	0.0	6.177
1990	33%	4143.3	19925.8	4208.3	1185.5	262.5	0.0	5.004
1991	49%	2058.3	8055.8	3870.3	722.1	26.5	0.0	2.808
1992	31%	12976.8	11667.0	1663.2	150.0	0.0	0.0	3.277
1993	16%	22742.5	18502.6	1894.0	367.9	0.0	0.0	4.215
1994	22%	4162.7	14601.6	1315.1	227.8	0.0	0.0	2.629
1995	41%	36320.2	13168.4	1984.8	109.9	24.2	0.0	5.270
1996	21%	4640.1	6595.1	1365.0	90.1	0.0	0.0	1.480
1997	21%	13166.7	9125.2	1010.5	79.1	0.0	0.0	2.755
1998	36%	4748.0	7988.6	725.1	238.4	0.0	0.0	1.891
1999	30%	21293.8	10837.6	1007.5	84.8	0.0	0.0	2.716
2000	62%	1978.5	10553.8	1038.9	216.2	27.1	0.0	2.395
2001	41%	65534.4	19651.2	991.0	345.7	26.4	0.0	6.743
2002	21%	10754.8	21521.5	609.5	60.9	0.0	0.0	3.893
2003	37%	35866.4	11142.0	1595.5	113.7	0.0	0.0	4.704
2004	18%	65266.9	4749.3	997.2	76.8	0.0	0.0	4.102
2005	20%	21784.7	6852.2	1074.5	54.4	0.0	0.0	3.101
2006	20%	37081.2	5964.6	3335.6	232.1	0.0	0.0	4.680
2007	26%	26012.3	3766.4	512.5	433.1	28.5	45.4	2.895
2008	18%	43819.5	8795.8	1065.7	126.5	0.0	0.0	4.513
2009a	27%	79099.4	50105.0	7161.3	210.2	0.0	0.0	15.826
2009b	NA	16273.2	11362.2	1685.5	54.9	0.0	0.0	3.626

Table A52: NEFSC spring survey indices of minimum swept area abundance for southern silver hake stock in thousands of fish and thousands of metric tons (Note that 2009a are raw Bigelow Values and 2009b are converted Bigelow values to Albatross units)

Year	CV	Age1	Age2	Age3	Age4	Age5	Age6+	B(000mt)
1973	10%	23216.7	28594.1	13686.5	4411.0	461.5	444.3	15.290
1974	19%	104382.4	8053.2	13057.8	7587.7	2534.4	1179.3	11.809
1975	19%	58454.3	17071.7	32399.7	9237.4	2545.3	262.8	18.868
1976	21%	42942.4	20578.0	13881.5	6775.9	1484.6	485.0	14.811
1977	15%	6986.5	6084.6	17959.1	9840.0	1990.1	1401.8	14.036
1978	17%	17383.0	14294.7	7623.8	11028.3	5194.0	1786.2	17.842
1979	17%	17435.4	6898.7	3638.6	1658.1	2540.0	1894.4	7.136
1980	19%	16115.3	13853.7	8564.7	2655.6	845.6	1982.2	9.117
1981	13%	15333.7	8390.5	10064.3	6951.4	3366.6	3090.1	11.434
1982	14%	4534.8	10927.0	3547.2	3527.3	3133.3	2111.3	6.569
1983	15%	9440.1	14156.3	3170.8	2046.4	844.9	1260.4	4.289
1984	21%	8799.5	21514.3	8743.2	2175.9	563.8	582.4	7.559
1985	16%	31074.2	13642.2	14057.3	5059.9	1196.9	579.4	8.800
1986	18%	12520.1	36261.6	8422.4	7110.0	1040.3	181.1	9.055
1987	25%	12185.7	51033.7	19782.4	4940.7	2512.2	175.1	11.658
1988	24%	17296.8	9247.0	21241.4	3235.1	204.0	16.8	5.564
1989	12%	22894.9	17626.4	25833.9	4946.7	240.4	68.9	7.348
1990	33%	11031.5	46469.4	21782.2	3927.5	632.4	72.2	9.685
1991	13%	10555.2	3100.6	14473.5	8034.0	1713.3	465.8	4.755
1992	20%	21388.9	4697.7	5565.6	2077.1	102.6	0.0	1.864
1993	39%	21848.8	39640.3	12190.1	2698.9	505.0	0.0	5.153
1994	22%	2224.8	22240.5	37090.5	1827.8	116.0	0.0	6.089
1995	26%	23867.3	6953.7	14572.8	4287.2	56.3	0.0	3.346
1996	1%	6805.4	44641.9	146495.8	4756.3	163.2	0.0	20.553
1997	13%	6915.1	3822.6	8567.2	1338.3	24.0	0.0	2.142
1998	29%	13695.1	6767.6	11494.4	383.8	0.0	0.0	2.305
1999	21%	41367.2	27313.8	17347.3	890.6	90.7	0.0	5.026
2000	12%	4618.2	5012.6	22022.1	851.5	79.5	0.0	3.443
2001	21%	36543.7	9513.9	16918.2	3099.2	200.3	0.0	3.840
2002	16%	6964.3	14237.4	16791.1	686.3	0.0	0.0	3.074
2003	14%	3226.7	6534.5	4954.0	1134.9	15.2	0.0	1.131
2004	24%	63875.7	11964.3	3883.6	794.6	0.0	0.0	1.547
2005	12%	8959.0	11265.3	15589.3	779.7	58.6	0.0	2.910
2006	39%	37114.2	5765.0	2969.3	414.5	28.4	0.0	1.635
2007	22%	15693.2	12443.0	4701.3	612.2	51.3	0.0	2.759
2008	28%	68912.7	26971.5	1734.5	425.8	41.4	0.0	4.185
2009a	13%	86549.1	202485.5	46310.8	1633.4	82.2	0.0	28.47
2009b	NA	11177.5	42971.2	9828.0	346.6	17.4	0.0	5.975

Table A53: Swept area abundance and biomass with 95% confidence intervals for silver hake from NEFSC winter surveys in the southern management region

Year	Swept Area (nm)	Swept Area Abundance (millions)	Swept Area Upper CI	Swept Area Lower CI	Swept Area Biomass (mt)	Swept Area Upper CI	Swept Area Lower CI
1992	30014	48.76	58.55	38.96	3066.24	3686.45	2445.80
1993	29928	137.05	182.72	91.39	7947.14	11916.37	3977.68
1994	30014	39.13	52.01	26.24	3450.01	4532.11	2367.90
1995	30014	35.74	45.25	26.23	3594.12	4395.56	2792.45
1996	30014	41.20	49.10	33.30	2811.92	3353.32	2270.30
1997	30014	71.73	89.77	53.70	3879.14	5264.59	2493.91
1998	30014	41.50	61.28	21.71	2260.44	2633.90	1886.99
1999	30014	71.04	92.95	49.13	4532.57	5779.64	3285.50
2000	30014	52.49	65.05	39.94	4512.64	5622.70	3402.58
2001	30014	222.80	289.34	156.27	4947.04	5999.59	3894.49
2002	30014	49.52	60.22	38.81	3606.03	4317.89	2894.17
2003	26984	41.11	58.14	24.07	1434.89	1887.44	982.55
2004	30014	215.98	298.19	133.77	4742.90	6318.75	3167.05
2005	29358	39.69	50.62	28.75	1053.75	1301.61	805.89
2006	30014	40.01	52.39	27.62	1467.48	1691.32	1243.40
2007	26984	79.29	152.22	6.35	2066.44	2786.97	1345.90

Table A54: Fall survey swept area abundance and biomass with 95% confidence intervals for silver hake from the Massachusetts Division of Marine Fisheries state survey in the southern management area.

Year	Swept Area (nm)	Swept Area Abundance (millions)	Swept Area Upper CI	Swept Area Lower CI	Swept Area Biomass (mt)	Swept Area Upper CI	Swept Area Lower CI
1978	864	0.07	0.19	-0.05	3.68	14.89	-7.50
1979	864	0.23	0.46	-0.01	6.02	8.83	3.21
1980	864	0.19	0.42	-0.03	3.91	5.68	2.13
1981	864	0.89	1.99	-0.22	9.50	21.68	-2.67
1982	864	4.90	9.40	0.40	51.35	94.30	8.38
1983	864	0.04	0.15	-0.06	2.61	10.60	-5.39
1984	864	0.15	0.29	0.00	0.94	1.71	0.18
1985	864	1.04	2.00	0.09	3.26	5.98	0.54
1986	864	12.92	23.81	2.02	126.74	206.35	47.13
1987	864	0.01	0.02	0.00	0.52	2.13	-1.08
1988	864	0.07	0.12	0.01	0.83	1.89	-0.22
1989	864	0.37	0.61	0.13	0.67	1.24	0.11
1990	864	0.22	0.50	-0.05	1.44	3.01	-0.16
1991	864	3.15	6.35	-0.05	8.02	16.29	-0.25
1992	864	0.97	2.45	-0.51	5.84	14.35	-2.67
1993	864	1.47	3.85	-0.92	5.89	15.46	-3.71
1994	864	4.13	9.88	-1.62	38.73	111.94	-34.48
1995	864	6.06	9.59	2.54	50.75	85.90	15.61
1996	864	0.17	0.30	0.04	15.34	26.46	4.20
1997	864	0.43	0.77	0.10	0.61	1.19	0.02
1998	864	0.04	0.07	0.02	0.18	0.31	0.04
1999	864	1.15	2.28	0.02	4.56	9.23	-0.13
2000	864	0.05	0.09	0.02	2.36	4.76	-0.04
2001	864	0.02	0.04	-0.01	0.27	1.06	-0.54
2002	864	0.05	0.09	0.01	0.36	1.08	-0.34
2003	864	1.44	3.51	-0.64	4.40	10.96	-2.16
2004	864	0.12	0.21	0.02	0.25	0.45	0.04
2005	864	0.09	0.19	-0.01	1.19	2.61	-0.25
2006	864	3.95	6.79	1.11	24.64	38.75	10.54
2007	864	0.03	0.10	-0.03	0.04	0.13	-0.04
2008	864	0.02	0.04	0.00	0.34	1.08	-0.43
2009	864	0.05	0.09	0.01	0.22	0.43	0.04

Table A55: Spring survey swept area abundance and biomass with 95% confidence intervals for silver hake from the Massachusetts Division of Marine Fisheries state survey in the southern management area

Year	Swept Area (nm)	Swept Area Abundance (millions)	Swept Area Upper CI	Swept Area Lower CI	Swept Area Biomass (mt)	Swept Area Upper CI	Swept Area Lower CI
1978	864	1.21	1.70	0.73	76.74	122.02	31.45
1979	864	2.03	3.68	0.38	865.62	1653.35	77.90
1980	864	2.76	7.65	-2.14	519.65	2020.38	-981.08
1981	864	0.53	1.11	-0.05	117.60	241.73	-6.56
1982	864	1.04	1.49	0.59	63.41	182.83	-56.02
1983	864	5.26	9.34	1.17	508.33	930.60	86.06
1984	864	8.43	14.06	2.80	1641.33	2646.33	636.33
1985	864	1.54	2.29	0.78	229.06	289.87	168.25
1986	864	1.93	2.35	1.50	157.00	204.44	109.58
1987	864	19.64	34.79	4.49	2106.26	3692.45	520.10
1988	864	2.28	3.92	0.64	138.29	240.07	36.50
1989	864	3.48	4.63	2.33	470.70	633.36	308.07
1990	864	4.40	8.37	0.44	847.82	1743.52	-47.89
1991	864	1.37	5.30	-2.57	312.07	1224.88	-600.75
1992	864	7.45	15.04	-0.15	75.37	133.68	17.05
1993	864	2.84	4.83	0.84	57.64	117.33	-2.07
1994	864	1.02	1.26	0.79	89.00	116.86	61.12
1995	864	0.82	1.92	-0.28	27.34	80.44	-25.79
1996	864	0.91	1.72	0.10	39.33	125.93	-47.26
1997	864	0.36	0.60	0.12	26.42	46.45	6.40
1998	864	1.94	6.80	-2.91	202.02	794.11	-390.08
1999	864	0.95	3.41	-1.50	34.30	123.62	-55.01
2000	864	2.01	7.31	-3.28	93.18	288.39	-102.03
2001	864	0.96	1.20	0.72	23.83	58.14	-10.47
2002	864	0.92	1.10	0.74	113.31	167.85	58.74
2003	864	0.14	0.24	0.03	2.04	4.52	-0.43
2004	864	1.88	6.12	-2.37	17.41	55.89	-21.07
2005	864	0.56	1.52	-0.40	12.62	33.38	-8.13
2006	864	0.78	1.53	0.03	14.15	26.71	1.57
2007	864	6.97	21.75	-7.81	128.69	367.69	-110.30
2008	864	1.45	3.89	-1.00	20.08	55.51	-15.32
2009	864	0.37	1.11	-0.36	26.37	104.73	-51.96

Table A56: Stratified mean number and weight per tow for silver hake from Rhode Island and Connecticut state surveys in the southern management area for both fall and spring

	RI Fall	RI Fall	RI Spring	RI Spring	CT Fall	CT Fall	CT Spring	CT Spring
Year	Stratified Mean Number/Tow	Stratified Mean Weight/Tow (Kg)	Stratified Mean Number/Tow	Stratified Mean Weight/Tow (Kg)	Stratified Mean Number/Tow	Stratified Mean Weight/Tow (Kg)	Stratified Mean Number/Tow	Stratified Mean Weight/Tow (Kg)
1979	3.77	0.20	3.05	0.34				
1980	0.48	0.04	13.73	0.33				
1981	4.10	0.40	1.52	0.28				
1982	1.85	0.03	0.45	0.06				
1983	0.13	0.01	11.65	0.59				
1984	10.14	0.10	8.01	1.20	0.55		7.53	
1985	9.71	0.05	3.24	0.98	0.23		1.83	
1986	29.15	0.29	5.59	0.86	1.65		1.19	
1987	1.63	0.17	3.89	0.53	0.01		2.48	
1988	55.36	0.22	0.00	0.00	0.30		2.25	
1989	0.47	0.04	2.56	0.18	0.60		4.86	
1990	0.12	0.01	2.24	0.33	0.96		5.53	
1991	0.09	0.00	2.54	0.19	0.32		3.87	
1992	0.38	0.03	0.26	0.01	0.48	0.04	2.67	0.20
1993	0.38	0.03	0.38	0.04	0.20	0.02	1.56	0.14
1994	2.28	0.04	0.27	0.03	3.34	0.28	1.73	0.40
1995	1.88	0.02	2.69	0.06	0.22	0.02	4.88	0.36
1996	0.18	0.01	2.11	0.20	0.06	0.01	1.15	0.12
1997	8.25	0.18	28.98	0.84	0.80	0.06	4.32	0.39
1998	0.02	0.00	6.48	0.27	0.07	0.01	4.64	0.48
1999	0.65	0.04	8.91	0.14	0.16	0.03	12.57	0.56
2000	2.02	0.01	4.86	0.20	0.09	0.01	2.28	0.19
2001	0.47	0.02	2.96	0.03	0.07	0.01	7.64	0.54
2002	0.21	0.00	11.19	1.08	0.07	0.01	5.92	0.52
2003	13.09	0.15	0.86	0.01	0.18	0.02	0.76	0.06
2004	2.21	0.05	31.04	0.19	0.18	0.02	2.63	0.16
2005	0.48	0.00	0.16	0.00	0.09	0.01	0.57	0.05
2006	8.05	0.08	8.67	0.43	0.64	0.08	4.75	0.33
2007	0.04	0.00	1.06	0.04	0.04	0.01	0.98	0.10
2008	0.02	0.00	140.13	1.38	0.28	0.03	19.08	1.02
2009	0.90	0.01	0.37	0.01	0.18	0.02	2.30	0.27
2010			11.84	0.15				

Table A57: NEFSC fall survey indices of minimum swept area abundance for combined north and south silver hake stocks in thousands of fish and thousand of metric tons (Note that 2009a are raw Bigelow Values and 2009b are converted Bigelow values to Albatross units)

Year	CV	Age1	Age2	Age3	Age4	Age5	Age6+	B(000mt)
1973	16%	24689.7	28013.8	11184.4	2291.5	1304.6	446.3	14.4
1974	22%	0.0	0.0	0.0	0.0	0.0	0.0	10.2
1975	22%	48902.1	73136.9	20254.6	6801.5	2456.1	1664.8	23.2
1976	25%	21762.9	46344.7	42107.1	15633.7	2656.1	3023.9	30.7
1977	23%	20230.3	14841.7	26337.4	14733.5	2648.0	906.8	19.9
1978	15%	43001.9	16788.1	10835.9	12411.0	11922.5	3214.9	21.8
1979	15%	61027.1	42079.1	8575.3	4083.1	3845.8	5010.9	18.8
1980	21%	16802.4	30499.5	34660.3	8590.3	3643.8	7956.5	20.8
1981	29%	38610.5	12482.9	15111.2	12099.8	2088.4	2812.9	13.4
1982	33%	42290.1	26005.9	9705.1	8102.6	6810.6	1841.5	18.6
1983	26%	111488.7	70942.3	8172.2	2399.7	1877.8	1165.5	27.2
1984	20%	29270.1	23428.2	7887.8	1966.4	448.9	248.0	11.8
1985	19%	138083.8	19226.9	23248.9	7096.3	604.8	51.6	29.5
1986	19%	190171.4	55436.1	8308.8	6720.0	959.0	0.0	32.7
1987	24%	24801.5	113428.3	23394.3	2889.6	1992.8	229.0	27.4
1988	19%	21038.8	41988.7	40336.4	2905.0	346.2	79.6	18.8
1989	17%	124497.6	48983.2	36674.3	3568.0	265.2	17.1	28.7
1990	27%	49467.3	136565.1	33786.9	14525.8	1892.2	0.0	38.4
1991	34%	78156.4	69446.5	25504.4	4770.6	256.7	0.0	25.3
1992	22%	91994.0	92361.6	26769.5	990.5	0.0	0.0	25.2
1993	15%	125964.2	81366.7	11762.4	2253.7	112.1	0.0	20.3
1994	17%	45536.3	93598.5	8754.6	454.0	0.0	0.0	17.3
1995	27%	210580.0	88274.8	20907.1	882.2	24.2	0.0	32.9
1996	18%	35315.9	82388.7	21196.7	1951.7	119.4	39.6	17.7
1997	19%	37963.6	48310.5	12035.5	935.1	53.9	17.8	14.9
1998	28%	441804.4	93739.4	11411.5	1650.0	45.2	86.0	42.4
1999	22%	103502.9	135068.1	4959.3	922.3	106.8	20.1	26.6
2000	37%	218259.1	102999.1	15045.8	1076.4	82.6	0.0	31.3
2001	27%	91734.6	131393.3	8402.0	1653.4	250.9	0.0	24.6
2002	17%	66131.3	86311.7	5510.6	689.6	38.3	0.0	21.0
2003	25%	171766.3	45782.5	17238.1	650.8	55.8	0.0	22.4
2004	18%	104791.9	33031.4	4758.2	467.1	36.2	0.0	11.1
2005	18%	30773.9	22331.5	5542.3	224.9	88.6	55.6	6.8
2006	30%	93421.5	10013.0	6347.4	2570.9	0.0	65.1	12.6
2007	19%	189783.8	10422.3	1330.6	933.8	472.5	45.4	16.7
2008	16%	116977.8	40937.4	2198.6	334.5	0.0	0.0	15.8
2009a	20%	428469.8	182139.1	62552.5	1142.8	1458.7	32.7	83.1
2009b	NA	87985.7	42002.8	15236.1	340.7	357.7	11.9	18.4

Table A58: NEFSC spring survey indices of minimum swept area abundance for combined silver hake stocks in thousands of fish and thousands of metric tons (Note that 2009a are raw Bigelow Values and 2009b are converted Bigelow values to Albatross units)

Year	CV	Age1	Age2	Age3	Age4	Age5	Age6+	B(000mt)
1973	14%	34633.9	54340.0	16273.4	4747.2	574.7	485.0	21.1
1974	20%	185111.2	16470.0	17106.6	8704.3	2753.3	1332.3	17.6
1975	21%	162093.5	180874.5	49514.9	12111.1	3483.3	382.5	37.1
1976	17%	68474.6	77737.3	44846.3	10369.1	2727.6	1318.2	32.8
1977	15%	19728.9	18529.6	28783.0	14208.1	2863.6	2120.8	21.8
1978	21%	27662.1	18734.6	8464.3	11477.9	5642.3	1950.8	19.6
1979	20%	37549.5	37255.5	4676.4	1946.7	2687.7	2199.1	10.8
1980	17%	25859.2	58122.1	23744.8	3720.8	1150.9	2597.6	17.7
1981	14%	39798.7	21069.0	18630.9	9756.7	3715.0	3234.5	16.0
1982	15%	28433.8	23140.4	6984.6	5020.9	4290.1	2397.6	9.6
1983	16%	32760.1	32127.6	5051.4	2592.9	1611.8	1527.0	7.6
1984	21%	17385.9	33795.3	10635.0	2579.0	671.5	715.5	9.9
1985	22%	101464.5	21010.0	18266.8	6638.4	1653.1	892.7	13.8
1986	19%	175154.3	48563.6	10018.2	8565.0	1351.6	363.4	15.4
1987	22%	18648.0	123273.0	26833.3	5901.7	2973.2	271.8	19.6
1988	20%	19253.7	12830.3	31680.9	4552.6	422.5	114.2	8.2
1989	17%	259747.4	24962.6	27333.5	8065.2	490.5	68.9	14.7
1990	26%	41491.2	66273.7	25026.0	4664.0	1046.0	114.1	13.0
1991	13%	95748.1	13344.5	17109.8	9262.0	1803.2	512.7	7.6
1992	23%	259150.4	95807.5	17697.7	5780.5	292.0	16.0	13.5
1993	32%	101859.0	89554.0	18822.9	5529.5	786.8	0.0	10.7
1994	27%	17682.7	161592.1	59874.0	4233.4	141.2	33.4	17.3
1995	22%	116415.8	120743.8	28733.5	6635.0	181.3	37.0	10.3
1996	10%	14551.9	88171.6	175652.8	7188.2	200.9	45.4	27.0
1997	13%	12206.5	17767.0	16162.5	1917.7	196.5	37.7	4.7
1998	20%	170389.3	219132.4	16417.7	1460.3	190.0	47.3	10.7
1999	19%	66091.1	150934.1	28493.2	2377.8	552.3	16.0	13.8
2000	14%	42894.1	362617.6	71415.9	6044.2	637.1	126.7	23.7
2001	17%	44914.7	271025.6	89502.4	9355.7	814.9	65.3	26.1
2002	15%	21329.5	93404.0	47351.6	4393.6	350.3	240.3	10.5
2003	16%	107360.5	166823.2	18564.3	4036.1	182.1	73.6	8.6
2004	21%	74483.6	123808.2	11646.6	3568.4	236.0	33.0	8.1
2005	14%	14087.1	32631.0	22830.6	1335.2	94.8	0.0	5.3
2006	26%	55576.8	8109.0	3600.1	1452.5	87.9	36.2	2.6
2007	20%	175913.8	24741.6	5951.2	996.3	389.8	43.7	7.5
2008	23%	92451.2	91346.3	3691.8	707.8	69.8	161.6	10.5
2009a	14%	544553.5	334189.2	112250.0	3234.4	387.2	958.9	103.7
2009b	NA	64137.5	70819.8	23821.6	686.4	82.1	203.5	11.6

Table A59: Northern silver hake arithmetic fall biomass survey, total catch and relative exploitation index

	Fall SV	Fall SV - Bmass	Northern Landings	Northern Discards	Total Catch	Relative Exploitation Index	Relative Exploitation Index
Year	arithmetic mean kg/tow	3-yr avg	000's mt	000's mt	000's mt	Catch/Fall_SV ~F	3-yr avg ~F
1955			53.36		53.36		
1956			42.15		42.15		
1957			62.75		62.75		
1958			49.90		49.90		
1959			50.61		50.61		
1960			45.54		45.54		
1961			39.69		39.69		
1962			79.00		79.00		
1963	23.10		73.92		73.92	3.20	
1964	4.34		94.46		94.46	21.77	
1965	7.06	11.50	45.28		45.28	6.41	10.46
1966	4.19	5.20	47.81		47.81	11.41	13.20
1967	2.27	4.51	33.37		33.37	14.70	10.84
1968	2.28	2.91	41.38		41.38	18.15	14.75
1969	2.41	2.32	24.06		24.06	9.98	14.28
1970	3.03	2.57	27.53		27.53	9.09	12.41
1971	2.67	2.70	36.40		36.40	13.63	10.90
1972	5.78	3.83	25.22		25.22	4.36	9.03
1973	4.12	4.19	32.09		32.09	7.79	8.60
1974	3.45	4.45	20.68		20.68	5.99	6.05
1975	8.09	5.22	39.87		39.87	4.93	6.24
1976	11.25	7.60	13.63		13.63	1.21	4.05
1977	6.72	8.69	12.46		12.46	1.85	2.66
1978	6.32	8.10	12.61		12.61	2.00	1.69
1979	6.18	6.41	3.42		3.42	0.55	1.47
1980	7.23	6.58	4.73		4.73	0.65	1.07
1981	4.52	5.98	4.42	2.64	7.05	1.56	0.92
1982	6.28	6.01	4.66	2.91	7.57	1.21	1.14
1983	8.76	6.52	5.31	2.64	7.95	0.91	1.22
1984	3.36	6.13	8.29	2.59	10.88	3.24	1.78
1985	8.28	6.80	8.30	2.56	10.86	1.31	1.82
1986	13.04	8.23	8.50	2.35	10.86	0.83	1.79
1987	9.79	10.37	5.66	2.11	7.77	0.79	0.98
1988	6.05	9.63	6.79	1.79	8.57	1.42	1.01
1989	10.53	8.79	4.65	2.32	6.96	0.66	0.96
1990	15.61	10.73	6.38	1.96	8.34	0.53	0.87
1991	10.52	12.22	6.06	1.26	7.31	0.69	0.63
1992	10.25	12.13	5.31	1.42	6.73	0.66	0.63
1993	7.50	9.42	4.36	0.69	5.05	0.67	0.67
1994	6.84	8.20	3.90	0.24	4.14	0.61	0.65
1995	12.89	9.08	2.59	0.63	3.22	0.25	0.51
1996	7.57	9.10	3.62	0.82	4.44	0.59	0.48
1997	5.66	8.71	2.80	0.24	3.05	0.54	0.46
1998	18.91	10.71	2.05	0.69	2.74	0.14	0.42
1999	11.15	11.91	3.45	0.74	4.19	0.38	0.35
2000	13.51	14.52	2.59	0.36	2.95	0.22	0.25
2001	8.33	11.00	3.39	0.48	3.87	0.46	0.35
2002	7.99	9.94	2.59	0.51	3.11	0.39	0.36
2003	8.29	8.20	1.81	0.20	2.01	0.24	0.37
2004	3.28	6.52	1.05	0.12	1.16	0.35	0.33
2005	1.72	4.43	0.83	0.06	0.89	0.52	0.37
2006	3.69	2.90	0.90	0.04	0.94	0.26	0.38
2007	6.44	3.95	1.01	0.75	1.76	0.27	0.35
2008	5.27	5.13	0.62	0.17	0.79	0.15	0.23
2009	6.89	6.20	1.04	0.19	1.23	0.18	0.20

Table A60: Southern silver hake arithmetic fall biomass survey, total catch and relative exploitation index

	Fall SV	Fall SV	Southern Landings	Southern Discards	Total Catch	Relative Exploitation Index	Relative Exploitation Index
Year	Arithmetic mean kg/tow	3-yr avg	000's mt	000's mt	000's mt	Catch/Fall_SV ~F	3-yr avg ~F
1955			13.26		13.26		
1956			14.24		14.24		
1957			16.43		16.43		
1958			12.90		12.90		
1959			16.39		16.39		
1960			8.82		8.82		
1961			12.65		12.65		
1962			17.94		17.94		
1963	4.66		89.43		89.43	19.19	
1964	4.06		147.05		147.05	36.22	
1965	5.28	4.67	294.12		294.12	55.70	37.04
1966	2.64	3.99	202.32		202.32	76.64	56.19
1967	2.44	3.45	87.38		87.38	35.81	56.05
1968	2.73	2.60	58.16		58.16	21.30	44.58
1969	1.26	2.14	74.89		74.89	59.44	38.85
1970	1.35	1.78	26.83		26.83	19.88	33.54
1971	2.21	1.61	70.51		70.51	31.90	37.07
1972	2.13	1.90	88.18		88.18	41.40	31.06
1973	1.70	2.01	102.08		102.08	60.05	44.45
1974	0.85	1.56	102.40		102.40	120.47	73.97
1975	1.79	1.45	72.16		72.16	40.32	73.61
1976	1.99	1.54	64.61		64.61	32.47	64.42
1977	1.68	1.82	57.16		57.16	34.02	35.60
1978	2.50	2.06	25.83		25.83	10.33	25.61
1979	1.68	1.95	16.40		16.40	9.76	18.04
1980	1.63	1.94	11.68		11.68	7.17	9.09
1981	1.12	1.48	13.43	3.50	16.93	15.12	10.68
1982	1.56	1.44	14.15	4.65	18.81	12.06	11.45
1983	2.57	1.75	11.86	4.81	16.67	6.49	11.22
1984	1.40	1.84	12.96	4.88	17.84	12.74	10.43
1985	3.55	2.51	12.82	3.87	16.69	4.70	7.98
1986	1.45	2.13	9.70	4.33	14.03	9.68	9.04
1987	1.95	2.32	9.55	4.25	13.80	7.08	7.15
1988	1.78	1.73	8.95	4.50	13.45	7.55	8.10
1989	1.87	1.87	13.00	6.57	19.57	10.46	8.37
1990	1.52	1.72	13.02	5.97	18.99	12.49	10.17
1991	0.85	1.41	9.74	3.08	12.82	15.08	12.68
1992	0.99	1.12	10.53	3.45	13.98	14.12	13.90
1993	1.28	1.04	12.49	5.17	17.65	13.79	14.33
1994	0.79	1.02	12.18	5.94	18.12	22.93	16.95
1995	1.59	1.22	11.99	1.40	13.39	8.42	15.05
1996	0.45	0.94	12.13	0.48	12.61	28.03	19.80
1997	0.83	0.96	12.55	0.62	13.17	15.87	17.44
1998	0.57	0.62	12.56	0.53	13.08	22.95	22.28
1999	0.82	0.74	10.42	3.55	13.97	17.03	18.62
2000	0.72	0.70	9.47	0.33	9.80	13.61	17.87
2001	2.04	1.19	8.88	0.19	9.07	4.45	11.70
2002	1.18	1.31	4.89	0.41	5.30	4.49	7.52
2003	1.42	1.55	6.28	0.60	6.89	4.85	4.60
2004	1.24	1.28	6.97	1.20	8.17	6.59	5.31
2005	0.94	1.20	6.40	1.58	7.97	8.48	6.64
2006	1.42	1.20	4.58	0.16	4.74	3.34	6.14
2007	0.87	1.08	5.07	0.15	5.21	5.99	5.94
2008	1.36	1.22	5.58	1.03	6.62	4.86	4.73
2009	1.10	1.11	6.60	0.84	7.43	6.76	5.87

Table A61. Summary of catch, NEFSC fall and spring bottom trawl survey indices, replacement ratios and relative fishing mortality rates for silver hake. Catch is based on length-based estimator. Northern and southern stocks are combined.

		NEFSC Survey		Replacement Ratio		Relative Fishing Mortality	
Year	Catch(mt)	Fall (kg/tow)	Spring (kg/tow)	Fall	Spring	Relative F Fall (mt/kg)	Relative F Spring (mt/kg)
1963	163349.2	-999	-999				
1964	241509.6	-999	-999				
1965	339396.2	-999	-999				
1966	250126.1	-999	-999				
1967	120753.6	2.37	-999			50950.9	
1968	99535.6	2.55	2.27			39033.6	43848.3
1969	98946.0	1.71	1.38			57863.2	71700.0
1970	54359.9	2.01	3.07			27044.7	17706.8
1971	106904.6	2.39	1.57			44729.9	68092.1
1972	113402.6	3.57	1.5	1.6183		31765.4	75601.7
1973	134169.2	2.65	3.86	1.0834	1.9714	50629.9	34758.8
1974	123077.9	1.87	3.23	0.7583	1.4192	65817.1	38104.6
1975	112038.5	4.26	7.1	1.7054	2.6833	26300.1	15780.1
1976	78242.5	5.63	6.01	1.9098	1.7410	13897.4	13018.7
1977	69617.0	3.66	4.01	1.0178	0.9240	19021.0	17360.9
1978	38443.1	4	3.59	1.1068	0.7414	9610.8	10708.4
1979	19813.2	3.45	1.99	0.8883	0.4156	5742.9	9956.4
1980	16413.6	3.83	3.24	0.9119	0.7137	4285.5	5065.9
1981	23985.2	2.46	2.95	0.5980	0.7829	9750.1	8130.6
1982	26375.5	3.42	1.76	0.9828	0.5577	7712.1	14986.1
1983	24628.1	5	1.39	1.4569	0.5137	4925.6	17718.1
1984	28718.5	2.17	1.82	0.5975	0.8032	13234.3	15779.4
1985	27549.9	5.41	2.53	1.6025	1.1335	5092.4	10889.3
1986	24885.4	6	2.82	1.6251	1.3493	4147.6	8824.6
1987	21569.2	5.03	3.59	1.1432	1.7393	4288.1	6008.1
1988	22020.8	3.46	1.51	0.7327	0.6214	6364.4	14583.3
1989	26530.4	5.27	2.7	1.1939	1.1002	5034.2	9826.1
1990	27327.0	7.06	2.4	1.4025	0.9125	3870.7	11386.3
1991	20131.4	4.65	1.4	0.8669	0.5376	4329.3	14379.6
1992	20707.1	4.64	2.49	0.9109	1.0733	4462.7	8316.1
1993	22703.3	3.72	1.96	0.7416	0.9333	6103.0	11583.3
1994	22257.7	3.17	3.19	0.6255	1.4566	7021.4	6977.3
1995	16618.0	6.03	1.9	1.2973	0.8304	2755.9	8746.3
1996	17055.2	3.24	4.95	0.7294	2.2623	5264.0	3445.5
1997	16216.6	2.73	0.87	0.6563	0.3002	5940.1	18639.8
1998	15822.4	7.77	1.96	2.0566	0.7615	2036.3	8072.6
1999	18155.6	4.87	2.53	1.0615	0.9829	3728.1	7176.1
2000	12752.0	5.74	4.35	1.1648	1.7813	2221.6	2931.5
2001	12940.6	4.51	4.8	0.9261	1.6371	2869.3	2696.0
2002	8403.7	3.85	1.93	0.7514	0.6651	2182.8	4354.3
2003	8890.3	4.12	1.58	0.7704	0.5074	2157.8	5626.8
2004	9332.8	2.04	1.48	0.4418	0.4872	4574.9	6306.0
2005	8885.7	1.25	0.98	0.3085	0.3465	7108.5	9067.0
2006	5686.9	2.31	0.47	0.7324	0.2182	2461.8	12099.7
2007	6979.7	3.06	1.37	1.1275	1.0637	2281.0	5094.7
2008	7403.4	2.9	1.92	1.1346	1.6327	2552.9	3855.9
2009	8666.0	3.37	2.14	1.4576	1.7203	2571.5	4049.5

Table A62. Summary of AIM results silver hake, both stocks combined, for NEFSC fall and spring bottom trawl surveys and catch estimates based on Sosebee method.

Silver Hake	***Fall Survey***	***Spring Survey***
Critical value (observed correlation between replacement ratio and relative F	-0.019413	-0.214283
Probability of observing correlation < Critical Value	0.97750	0.9200
Relative F at Replacement (mt/kg)	492.9	5651.1
90% Confidence Interval for RelF at replacement	(4.6, 647745)	(483.8, 14560.5)

Table A63.Summary results of Silver hake ASAP model runs.

Model #	1	2	3	4	5	6	7	8	9
Converge	N	Y	Y	Y	Y	Y	Y	Y	Y
Num Est Params	p*	p	p*-8	p-8	p-10	p-18	p-15	p-23	p*
Model	No Split M = 0.4	No Split M=0.15	No Split M = 0.4_Surv_Flat-top_IndexSel	No Split M = 0.15_Surv_Flat-top_Index Sel	Run 2 (3 block Fishery Selectivity)	Run 4 (3 block Fishery Selectivity)	Run5 (2 block Fishery Selectivity)	Run6 (2 Block Fishery Selectivity)	Run 2 (Apply Time and Age variant M from Run 6 to Run1)
Fishery Slectivity	5 blocks (fleet1: 73-88; 89-99; 00-09) (Fleet2: 73-99; 00-09)	5 blocks (fleet1: 73-88; 89-99; 00-09) (Fleet2: 73-99; 00-09)	5 blocks (fleet1: 73-88; 89-99; 00-09) (Fleet2: 73-99; 00-09)	5 blocks (fleet1: 73-88; 89-99; 00-09) (Fleet2: 73-99; 00-09)	3 blocks (fleet1: 73-88; 89-09) (Fleet2: 73-09)	3 blocks (fleet1: 73-88; 89-09) (Fleet2: 73-09)	2 blocks (fleet1: 73-09) (Fleet2: 73-09)	2 blocks (fleet1: 73-09) (Fleet2: 73-09)	5 blocks (fleet1: 73-88; 89-99; 00-09) (Fleet2: 73-99; 00-09)
Overall Objective Fxn	3899	4524	4083	4601	4491	4526	4532	4511	3970
Total Index	1053	1022	1248	1180	1028	1173	1032	1194	1068
Index Age Comp	846	839	786	741	832	735	822	752	815
Total Catch	506	918	627	1025	918	1015	921	1032	511
Catch Age Comp	617	783	606	768	777	762	834	742	630
q_fall	0.13	0.23	0.48	0.62	0.25	0.62	0.17	0.61	0.49
q_spr	0.13	0.23	0.42	0.48	0.24	0.48	0.18	0.47	0.41
Fleet 1 Sel	Strong Dome in the Recent Years	Strong Dome in the Recent Years	Flat Top (1973-1999), Strong Dome (2000-2009)	Flat Top (1973-1999), Moderate Dome (2000-2009)	Strong Dome in the Recent Years	Flat Top Selectivity	Srong Dome	Flat Top Selectivity	Strong Dome
Fleet2 Sel	Dome	Dome	Dome	Dome	Dome	Dome	Dome	Dome	Dome
Fleet3 Sel	NA	Exponential	NA	Exponential	Exponential	Exponential	Exponential	Exponential	NA
Fall_Surv_Sel	Strong Dome	Strong Dome	Fixed- Flat top (Estimated Age1)	Fixed- Flat top (Estimated Age1)	Strong Dome	Fixed- Flat top (Estimated Age1)	Strong Dome	Fixed- Flat top (Estimated Age1)	Strong Dome
Spr_Surv_Sel	Strong Dome	Strong Dome	Fixed- Flat top, (Estimated Age 1)	Fixed- Flat top, (Estimated Age 1)	Strong Dome	Fixed- Flat top, (Estimated Age 1)	Strong Dome	Fixed- Flat top, (Estimated Age 1)	Strong Dome
Retro_SSB (Rel. Diff)	6-13%	9-44%	49-320%	51-160%	15-72%	44-82%	11-39%	48-70%	7-13%
Retro_Rec (rel Diff)	7-90%	5-14%	19-230%	2-6%	5-16%	1-5%	7-18%	<1 - 4 %	7-90%
Retro_F (Rel Diff)	8-17%	23-53%	40-82%	36-64%	32-62%	26-41%	29-57%	35-46%	8-18%
Comments	4 year Peel. Model did not converge initially but now it is??? Unsure about the inconsistent estimation process	4 year Peel. Strong Dome . Very High SSB (Cryptic Biomass???)	4 Year Peel. Relative to model 4, better overall model fit. Better fit to the to the catch but poorer fit to the index with stronger retro. Patterns	4 Year Peel. Relative to model 2, less improvement in overall fit, but better fit to the index and catch at age comp. Less improvement to the total catch fit, better retro for Rec, Similar retro for F, and stronger retro for SSB. Less doming in the fishery and SSB estimates appears reasonable in the model	Retro2 (4yr peel). Relative to Model 2, Stronger retro for SSB and F rellative to model. Improved overall model fit, less improvement to total index fit but better fit to index age comp. Similar fit to total catch. Better fit to catch at age comp. Q's are similar and strong dome persists	Relative to Model 4, Improved fit in the overall model as well as in the index and catch. Improved Retro Patterns. No Dome in the Fishery	4 year Peel. Relative to Model 2 and 5, less improvement in overall model fit, total catch and total index , but some improvement in the index catch at age. Stromg dome, lower q's . Better retro patterns for SSB. Slightly stronger for Rec, but better retro for F relative to Model 5.	4 year Peel. Relative to model 4 and 6, Less improvement in model likelihood with the exception of slight improvement in the firt to the catch at age. Flat top selectivity. Q's are similar to model 4 and 6. Retro Pttaerns improve in Rec and SSB and slighlty improved reative to model 4.	Relative to 1, No improvement in Retro. Less Improvement in likelihood components except for index age comp.

Table A64 Silver hake estimated Fishing Mortality at Age for the Combined Areas

Year	age-1	age-2	age-3	age-4	age-5	age-6
1973	0.069	0.621	1.168	1.168	1.168	1.168
1974	0.063	0.564	1.062	1.062	1.062	1.062
1975	0.062	0.551	1.037	1.037	1.037	1.037
1976	0.044	0.393	0.739	0.739	0.739	0.739
1977	0.050	0.444	0.835	0.835	0.835	0.835
1978	0.055	0.488	0.918	0.918	0.918	0.918
1979	0.031	0.275	0.518	0.518	0.518	0.518
1980	0.030	0.266	0.500	0.500	0.500	0.500
1981	0.076	0.526	0.839	0.818	0.735	0.685
1982	0.100	0.689	1.097	1.069	0.958	0.892
1983	0.082	0.570	0.918	0.896	0.811	0.760
1984	0.080	0.569	0.927	0.908	0.829	0.782
1985	0.089	0.646	1.071	1.051	0.972	0.925
1986	0.075	0.535	0.874	0.855	0.782	0.738
1987	0.058	0.394	0.622	0.605	0.539	0.500
1988	0.063	0.429	0.677	0.659	0.587	0.544
1989	0.070	0.429	1.069	1.039	0.920	0.849
1990	0.067	0.429	1.149	1.122	1.013	0.949
1991	0.058	0.408	1.261	1.241	1.161	1.114
1992	0.057	0.395	1.202	1.182	1.102	1.055
1993	0.065	0.451	1.374	1.352	1.261	1.207
1994	0.066	0.444	1.294	1.270	1.172	1.114
1995	0.034	0.286	1.064	1.056	1.025	1.006
1996	0.040	0.360	1.438	1.431	1.406	1.392
1997	0.047	0.440	1.817	1.812	1.789	1.776
1998	0.043	0.400	1.619	1.613	1.588	1.574
1999	0.071	0.531	1.773	1.752	1.666	1.615
2000	0.034	0.330	1.394	1.390	1.378	1.370
2001	0.042	0.409	1.743	1.740	1.726	1.718
2002	0.035	0.311	1.228	1.222	1.199	1.185
2003	0.035	0.318	1.283	1.278	1.258	1.246
2004	0.039	0.323	1.195	1.186	1.150	1.129
2005	0.067	0.526	1.863	1.846	1.775	1.734
2006	0.045	0.450	1.952	1.949	1.939	1.933
2007	0.060	0.562	2.302	2.294	2.263	2.244
2008	0.041	0.364	1.434	1.427	1.398	1.381
2009	0.023	0.200	0.777	0.773	0.756	0.746

Table A65: Silver hake estimates SSB in mt and Rec in 000's of fish for the Combined Areas. Note that age-1 recruits are based o year class

Year	Rec	SSB
1973	501,582	81,836
1974	724,312	62,112
1975	512,547	66,245
1976	524,166	82,865
1977	298,756	62,461
1978	295,999	33,981
1979	412,695	35,678
1980	402,731	39,748
1981	477,966	31,930
1982	448,965	28,607
1983	469,867	27,387
1984	457,895	34,466
1985	750,780	27,876
1986	952,229	41,447
1987	533,575	48,047
1988	426,136	35,024
1989	964,751	26,931
1990	614,801	24,745
1991	597,209	16,527
1992	920,823	15,306
1993	789,319	15,793
1994	531,306	17,249
1995	719,677	15,949
1996	819,880	12,748
1997	311,817	9,728
1998	775,926	10,233
1999	691,649	10,731
2000	879,755	11,485
2001	661,829	10,873
2002	496,505	8,177
2003	839,234	8,372
2004	782,181	8,349
2005	496,877	6,515
2006	653,558	5,545
2007	1,061,500	6,684
2008	856,253	13,472
2009	742,192	23,117

Table A66 Silver hake natural mortality estimates based on predatory consumption (M2) and other sources (M1 = 0.15)

Year	age-1	age-2	age-3	age-4	age-5	age-6
1973	0.394	0.242	0.172	0.154	0.151	0.150
1974	0.417	0.250	0.174	0.155	0.151	0.150
1975	0.209	0.172	0.155	0.151	0.150	0.150
1976	1.575	0.686	0.277	0.176	0.155	0.151
1977	1.233	0.558	0.246	0.169	0.154	0.151
1978	0.594	0.317	0.190	0.158	0.152	0.150
1979	0.860	0.417	0.213	0.163	0.152	0.150
1980	1.549	0.676	0.275	0.175	0.155	0.151
1981	1.424	0.629	0.263	0.173	0.154	0.151
1982	1.119	0.515	0.236	0.167	0.153	0.151
1983	0.862	0.418	0.213	0.163	0.152	0.150
1984	1.488	0.654	0.269	0.174	0.155	0.151
1985	1.296	0.581	0.252	0.171	0.154	0.151
1986	1.053	0.490	0.230	0.166	0.153	0.151
1987	1.281	0.576	0.251	0.170	0.154	0.151
1988	0.826	0.405	0.210	0.162	0.152	0.150
1989	1.239	0.560	0.247	0.170	0.154	0.151
1990	1.563	0.682	0.276	0.175	0.155	0.151
1991	1.099	0.507	0.235	0.167	0.153	0.151
1992	1.344	0.600	0.256	0.171	0.154	0.151
1993	1.369	0.609	0.259	0.172	0.154	0.151
1994	1.086	0.502	0.233	0.167	0.153	0.151
1995	1.086	0.502	0.233	0.167	0.153	0.151
1996	2.169	0.910	0.330	0.186	0.157	0.151
1997	0.571	0.308	0.188	0.158	0.151	0.150
1998	1.082	0.501	0.233	0.167	0.153	0.151
1999	1.307	0.586	0.253	0.171	0.154	0.151
2000	1.636	0.709	0.282	0.177	0.155	0.151
2001	1.722	0.742	0.290	0.178	0.155	0.151
2002	1.484	0.652	0.269	0.174	0.155	0.151
2003	1.763	0.757	0.294	0.179	0.156	0.151
2004	2.141	0.899	0.327	0.186	0.157	0.151
2005	2.444	1.013	0.354	0.191	0.158	0.151
2006	2.328	0.970	0.344	0.189	0.157	0.151
2007	1.879	0.801	0.304	0.181	0.156	0.151
2008	1.579	0.688	0.277	0.176	0.155	0.151
2009	1.174	0.535	0.241	0.168	0.154	0.151

Table A67. Species of consistent silver hake predators. Whether abundances were estimated from recent stock assessments (SA) or swept area (SWA) from surveys are noted, as is the resolution of the diet data (all predators were presented as two year averages). *Pollock was ultimately excluded from the analyses due to an excessive degree of variability in diet composition comprised of silver hake.

Common Name	**Species Name**	**Assessment or Swept Area**	**Diet Resolution**
Spiny dogfish	*Squalusa canthias*	SWA	2yr
Little skate	*Raja ocellata*	SWA	2yr
Winter skate	*Raja erinacea*	SWA	2yr
Thorny skate	*Raja radiata*	SWA	2yr
Silver Hake	*Merluccius bilinearis*	SWA	2yr
Atlantic cod	*Gadus morhua*	SA	2yr
Pollock*	*Pollachius virens*	SA	2yr
Red hake	*Urophycis chuss*	SWA	2yr
White hake	*Urophycis tenuis*	SWA	2yr
Fourspot flounder	*Paralichthys oblongus*	SWA	2yr
Summer Flounder	*Paralichthys dentatus*	SA	2yr
Windowpane	*Scophthalmus aquosus*	SWA	2yr
Bluefish	*Pomatomuss altatrix*	SA	2yr
Goosefish	*Lophius americanus*	SA	2yr

Table A68: Age-0 proportion at length derived from the survey age-length keys to adjust consumption estimates for the ASAP model.

Length	North	South	Combined
<5	0.97	0.97	0.97
5-10	0.86	0.66	0.75
11-15	0.32	0.19	0.29
16-20	0.02	0.02	0.02
21-25	0.00	0.00	0.00
26-30	0.00	0.00	0.00
31-35	0.00	0.00	0.00
36-40	0.00	0.00	0.00
41-45	0.00	0.00	0.00

Table A69. Total Consumption and CV of silver hake for both stocks. Consumption units in 000s MT.

Year	Combined	CV
1973	25.8	NA
1974	31.9	NA
1975	4.0	NA
1976	18.7	NA
1977	8.1	0.35
1978	7.1	0.35
1979	30.3	0.35
1980	53.0	0.35
1981	67.0	0.35
1982	77.9	0.68
1983	95.8	0.63
1984	116.9	0.6
1985	142.1	0.75
1986	167.7	0.81
1987	151.6	0.42
1988	54.2	0.47
1989	51.0	0.58
1990	48.2	0.47
1991	38.3	0.48
1992	60.2	0.37
1993	88.2	0.38
1994	66.4	0.61
1995	62.6	0.37
1996	31.5	0.58
1997	12.8	0.5
1998	68.3	0.45
1999	131.3	0.69
2000	129.8	0.39
2001	107.1	0.63
2002	93.3	0.35
2003	101.6	0.35
2004	98.0	0.66
2005	65.0	0.46
2006	52.6	0.43
2007	83.8	0.43
2008	88.0	0.45
2009	71.0	0.45

Table A70 Proportion of all silver hake lengths in all predators of silver hake at size, in 5 cm size classes.

Year	<5	5-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45
1973	0.053	0.263	0.316	0.211	0.053	0	0.105	0	0
1974	0	0.067	0.467	0.2	0.067	0.2	0	0	0
1975	0.667	0.333	0	0	0	0	0	0	0
1976	0.231	0.308	0.231	0.154	0	0.077	0	0	0
1977	0.759	0.034	0	0.034	0.103	0.034	0.034	0	0
1978	0.776	0.096	0.032	0.032	0.016	0.016	0.032	0	0
1979	0.053	0.105	0.316	0.263	0.105	0.053	0.053	0.053	0
1980	0	0.071	0.143	0.214	0.143	0.214	0	0.143	0.071
1981	0.143	0	0	0.143	0.571	0.143	0	0	0
1982	0.094	0.156	0.156	0.125	0.188	0.094	0.156	0.031	0
1983	0	0.054	0.405	0.189	0.216	0.081	0.054	0	0
1984	0.216	0.081	0.054	0.135	0.297	0.162	0.027	0.027	0
1985	0.106	0.187	0.211	0.154	0.203	0.098	0.024	0.008	0.008
1986	0.055	0.097	0.29	0.255	0.166	0.103	0.028	0.007	0
1987	0.06	0.048	0.048	0.145	0.434	0.241	0.024	0	0
1988	0.143	0.446	0.286	0.012	0.042	0.036	0.024	0.006	0
1989	0.08	0.492	0.174	0.148	0.061	0.035	0.01	0	0
1990	0.227	0.241	0.124	0.149	0.188	0.057	0.007	0.007	0
1991	0.157	0.442	0.235	0.078	0.041	0.046	0	0	0
1992	0.129	0.3	0.229	0.194	0.077	0.06	0.011	0	0
1993	0.176	0.127	0.337	0.173	0.15	0.037	0	0	0
1994	0.159	0.37	0.077	0.159	0.183	0.053	0	0	0
1995	0.056	0.222	0.268	0.193	0.18	0.072	0.007	0	0.003
1996	0.09	0.244	0.167	0.141	0.256	0.103	0	0	0
1997	0.183	0.639	0.063	0.042	0.037	0.021	0.005	0	0
1998	0.106	0.229	0.402	0.162	0.067	0.022	0.006	0	0.006
1999	0.047	0.253	0.24	0.197	0.219	0.039	0.004	0	0
2000	0.246	0.192	0.069	0.277	0.177	0.038	0	0	0
2001	0.099	0.441	0.053	0.138	0.211	0.039	0.007	0.013	0
2002	0.108	0.313	0.325	0.06	0.12	0.06	0	0	0
2003	0.095	0.23	0.459	0.135	0.041	0.034	0	0.007	0
2004	0.013	0.227	0.16	0.213	0.28	0.107	0	0	0
2005	0.133	0.167	0.1	0.3	0.267	0.033	0	0	0
2006	0.115	0.462	0.115	0.038	0.192	0.038	0.038	0	0
2007	0.186	0.116	0.209	0.163	0.186	0.093	0.047	0	0
2008	0.075	0.275	0.1	0.125	0.325	0.1	0	0	0
2009	0.036	0.384	0.268	0.08	0.125	0.08	0.027	0	0

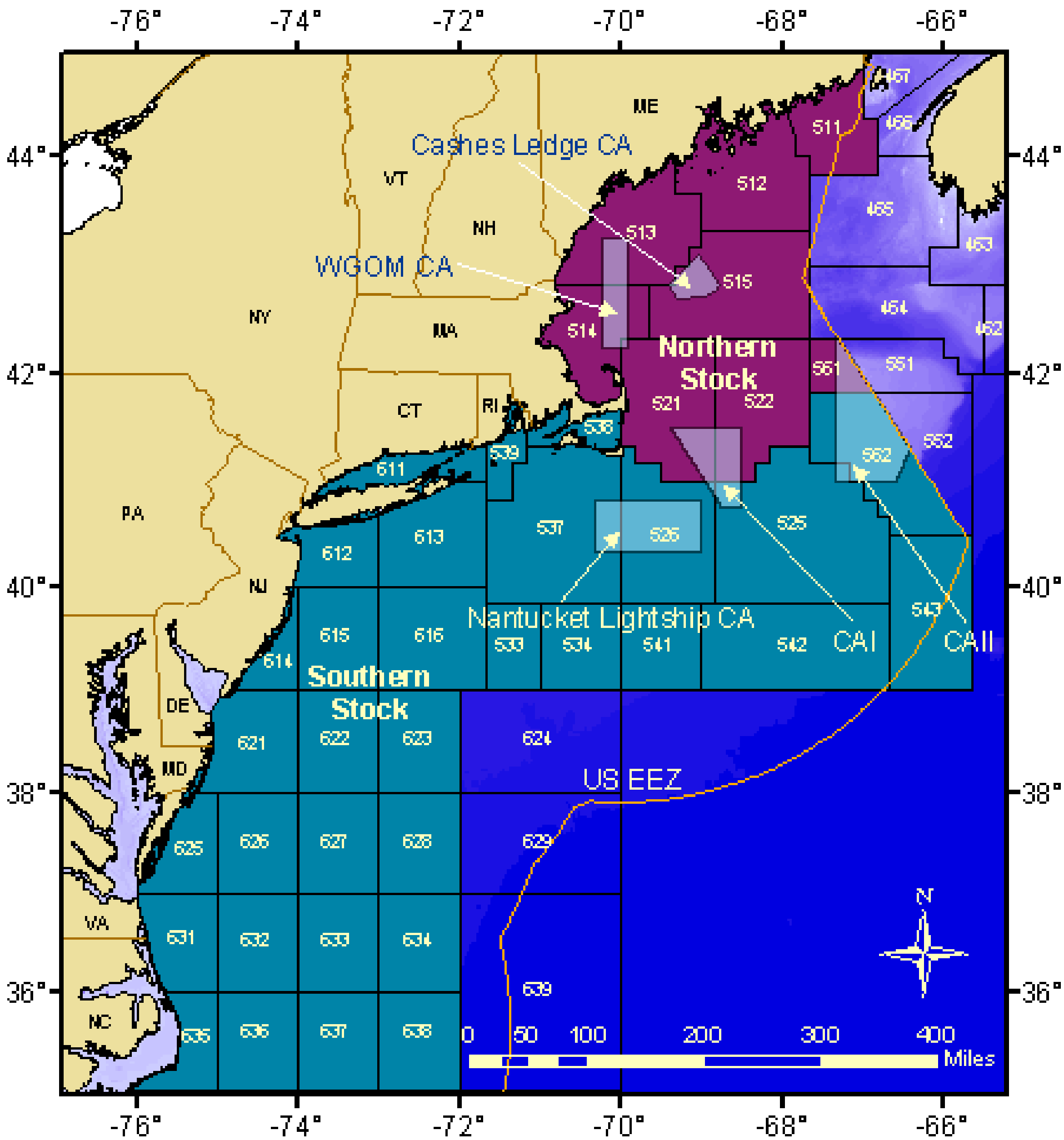

Figure A1. Commercial fishery statistical areas for northern (SA 511-515, 521, 522, 551, and 561) and southern (SA 525, 526, 533-539, 541-543, 552, 562, 611-639) silver hake in the northwest Atlantic.

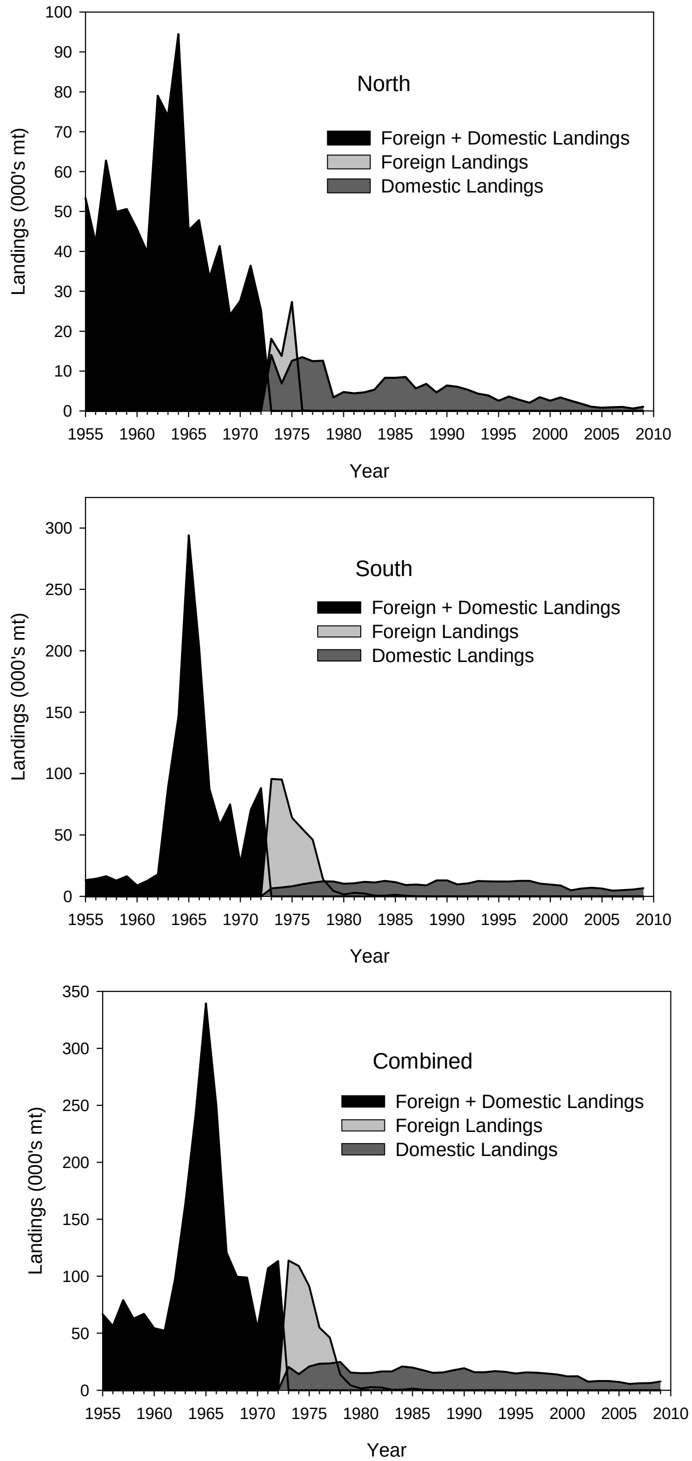

Figure A2: Silver hake catch in thousands of metric tons for the north (Top), south (middle) and combined stock areas (bottom).

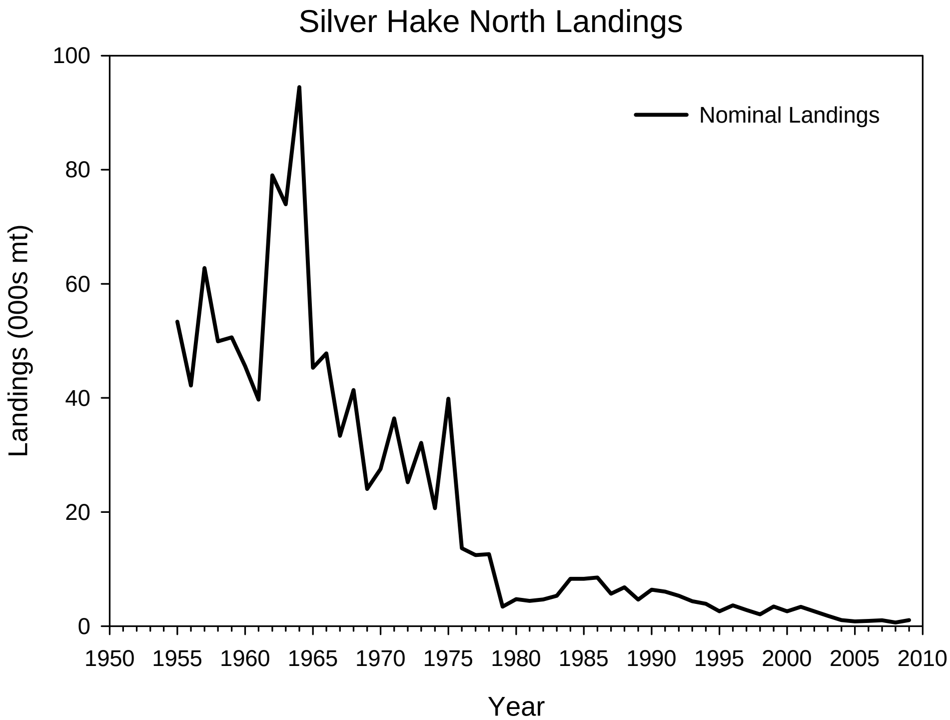

Figure A3. Nominal landings of silver hake (mt) from the northern stock.

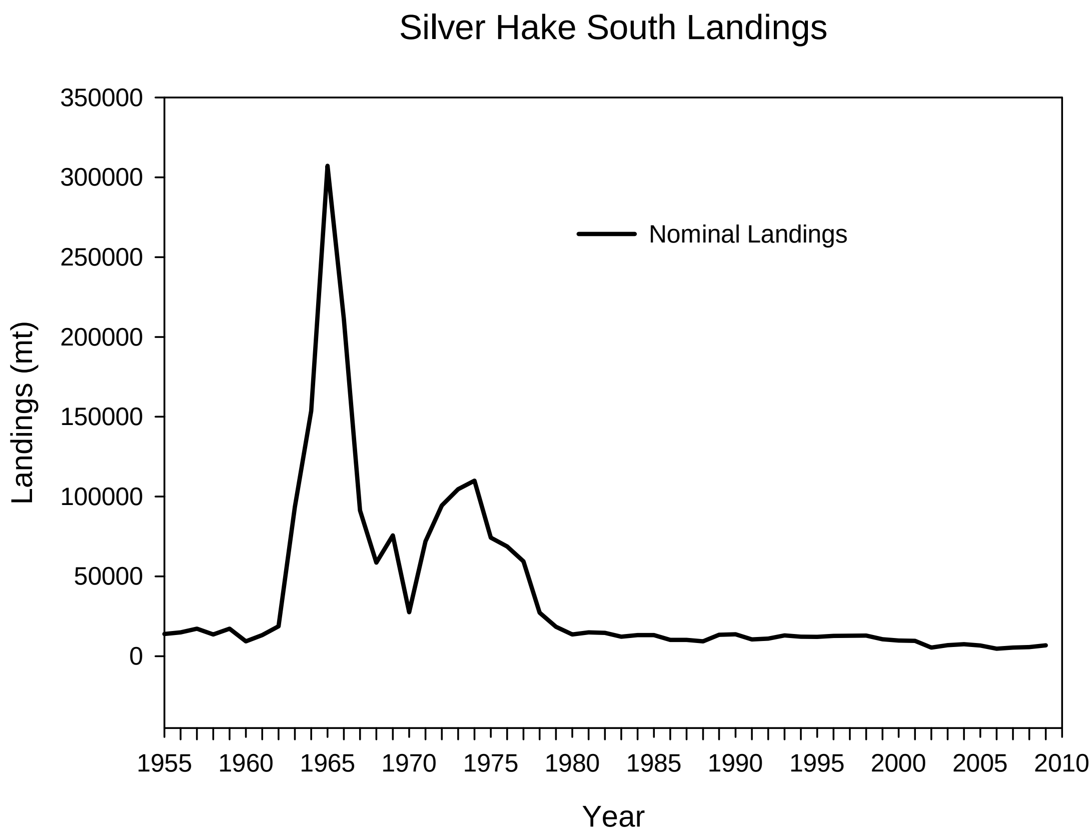

Figure A4. Comparison of nominal landings with the two model-based estimates for silver hake from the southern stock.

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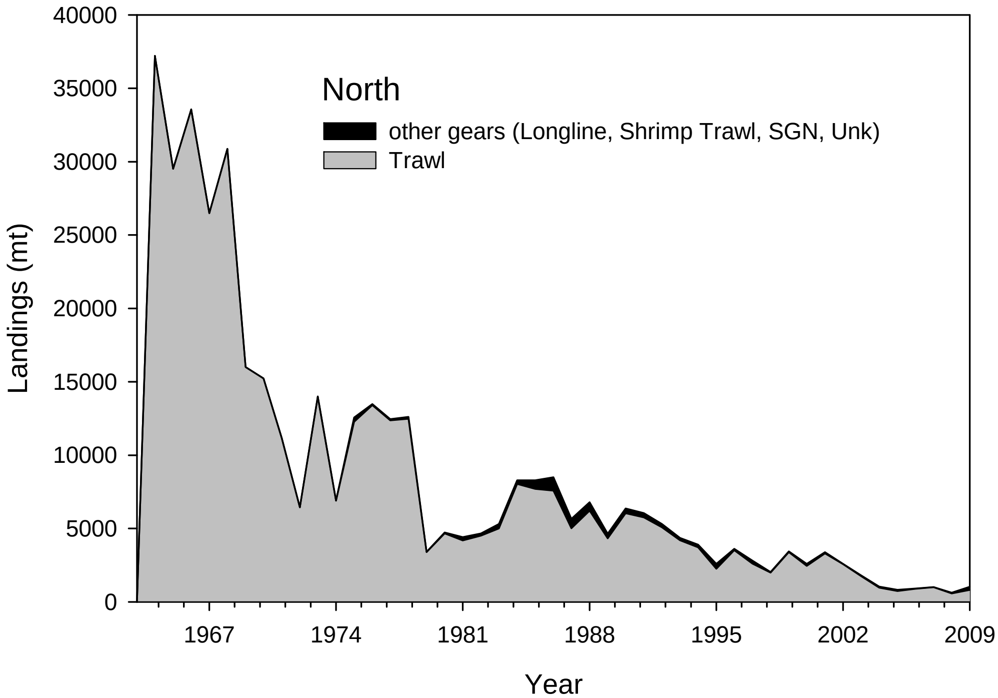


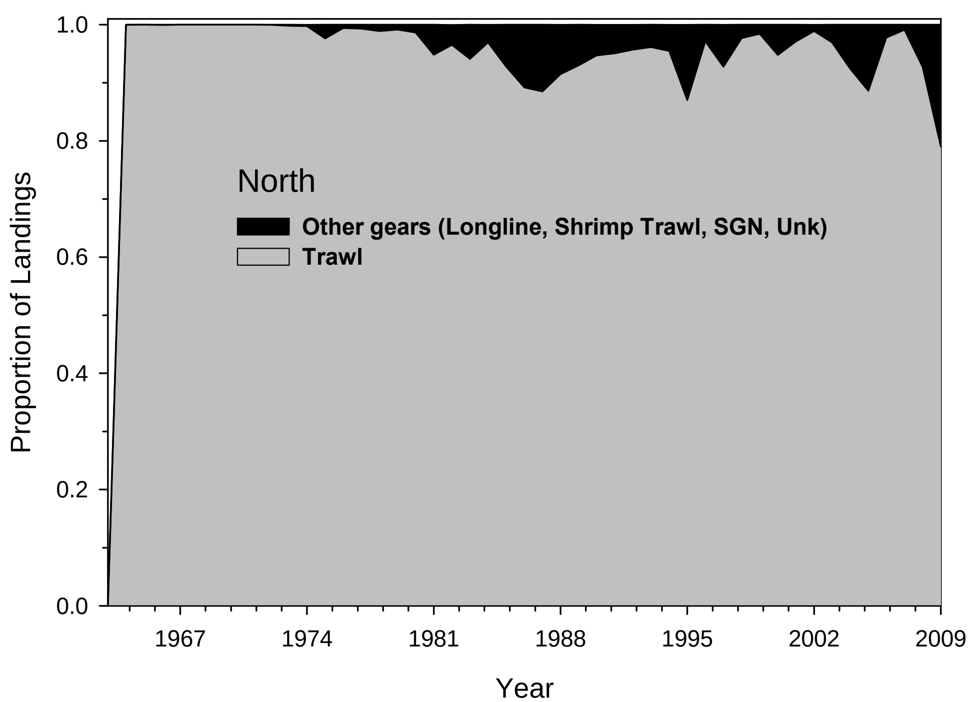
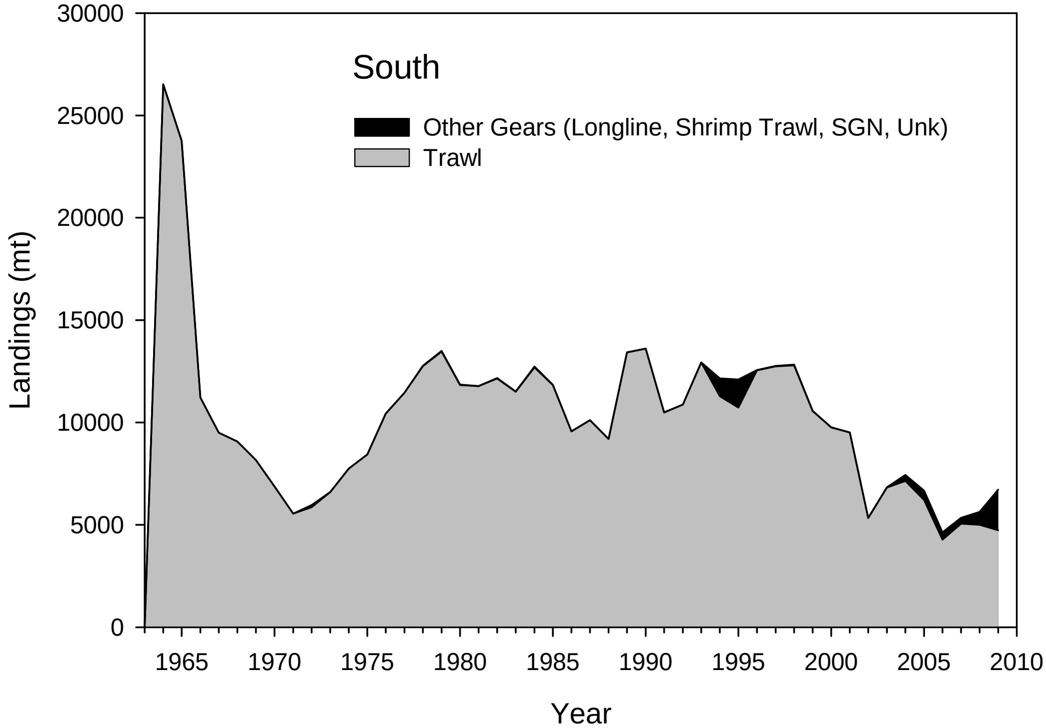


Figure A5. Landings of Silver hake (mt) by gear from the northern stock.



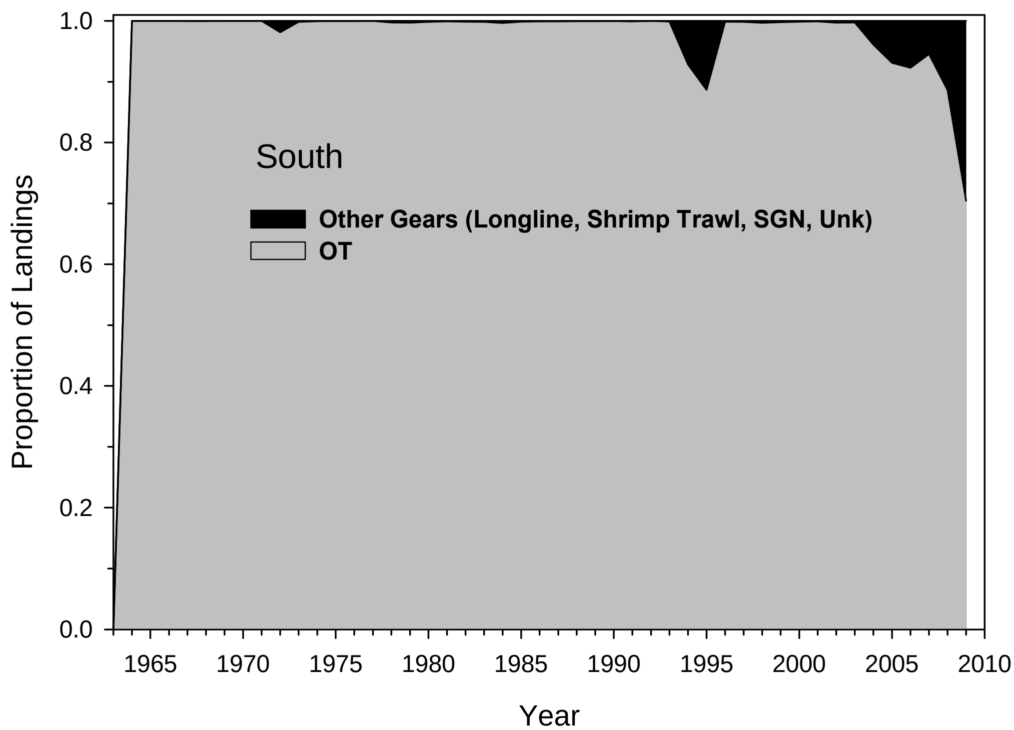


Figure A6. Landings of Silver hake (mt) by gear from the southern stock.

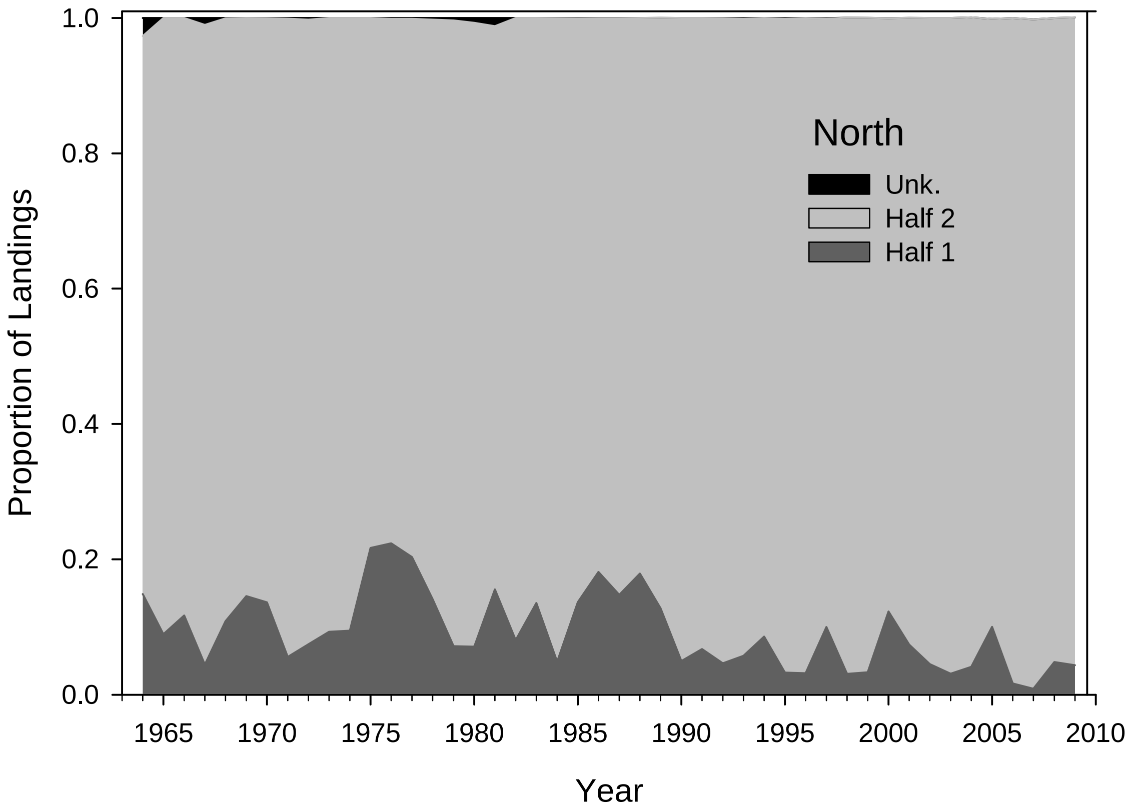


Figure A7. Landings of Silver hake by half year in the northern stock.

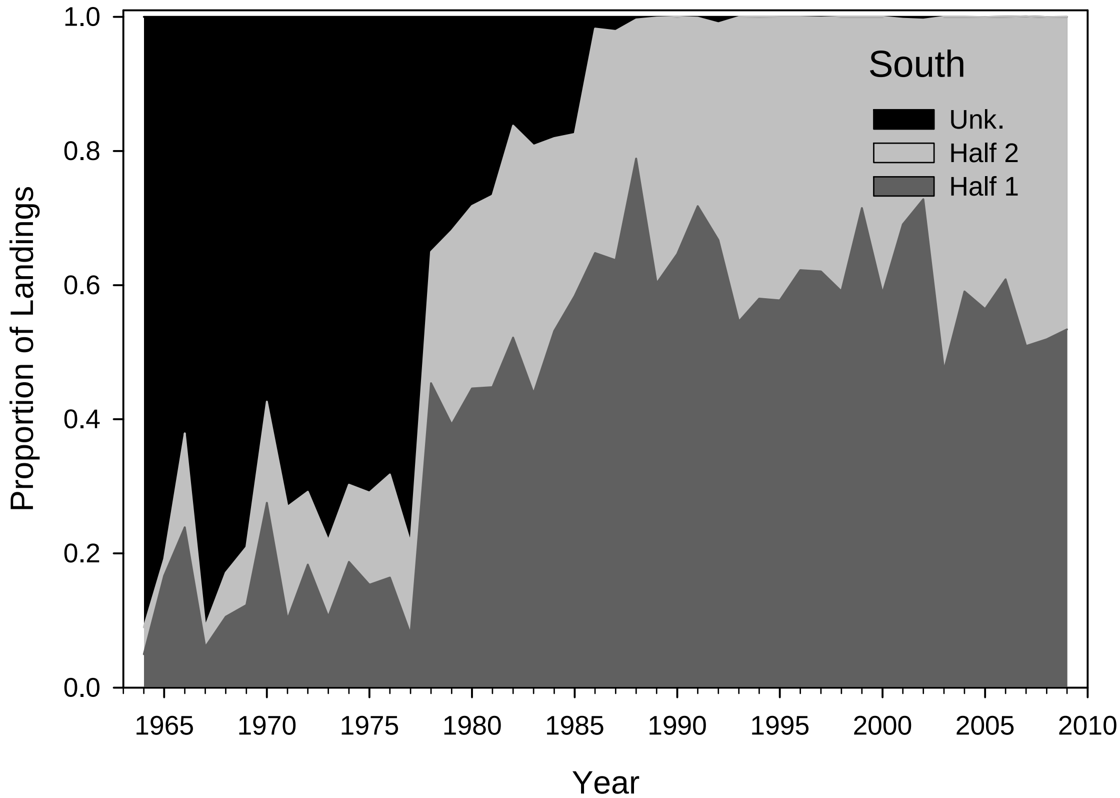


Figure A8. Landings of silver hake by half year in the southern stock.

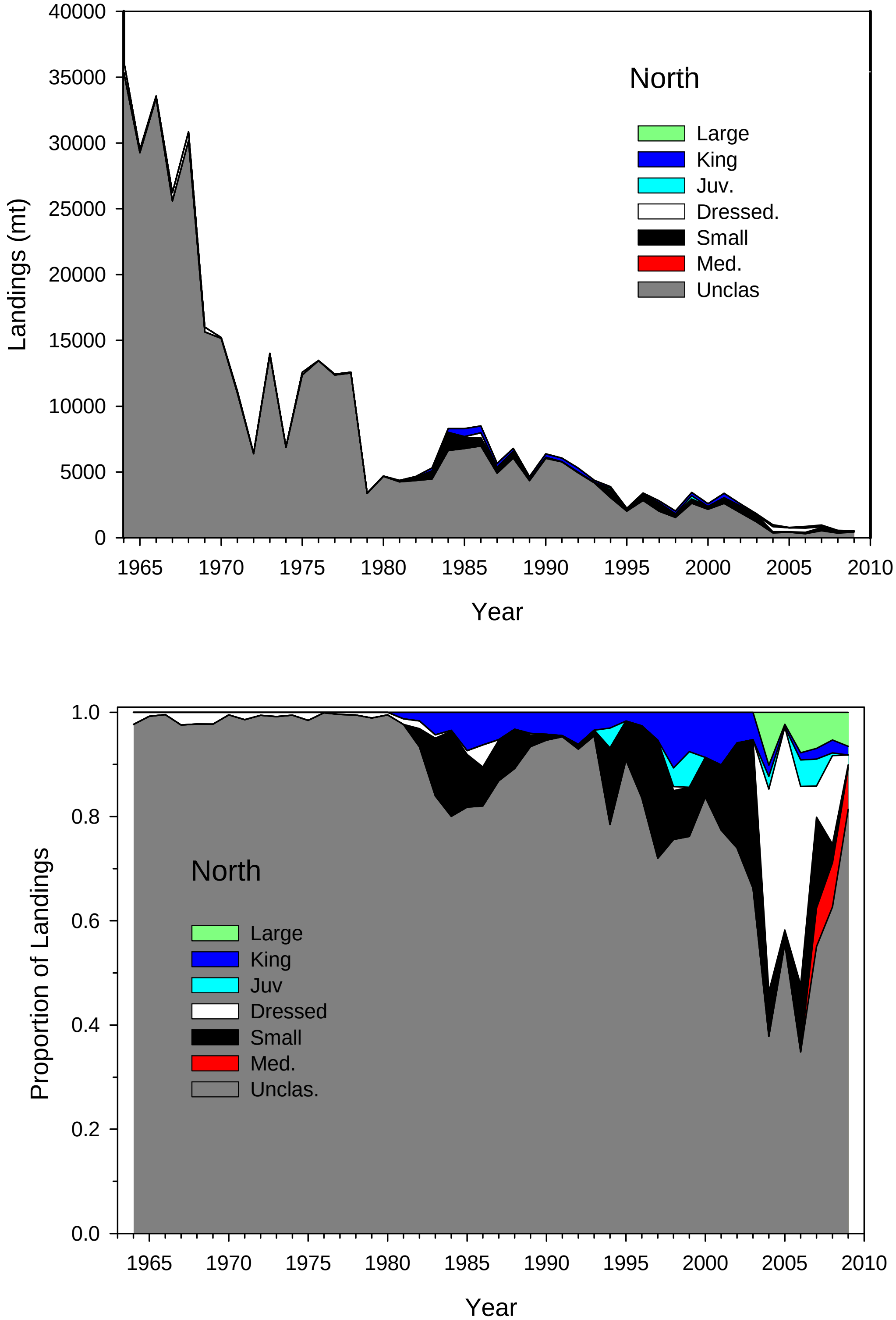


Figure A9. Landings of silver hake (mt) by market category from the northern stock.

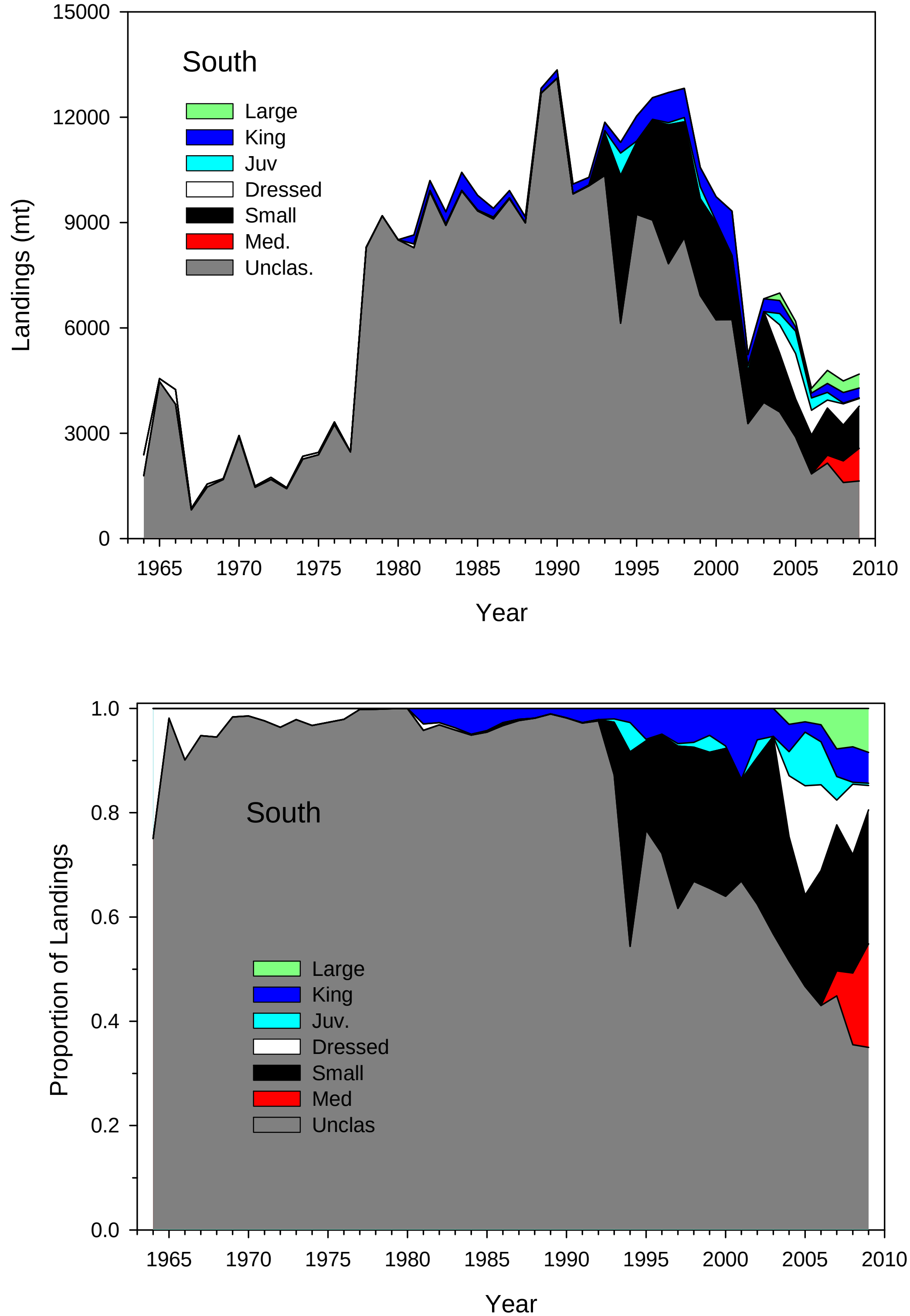


Figure A10. Landings of silver hake (mt) by market category from the southern stock.

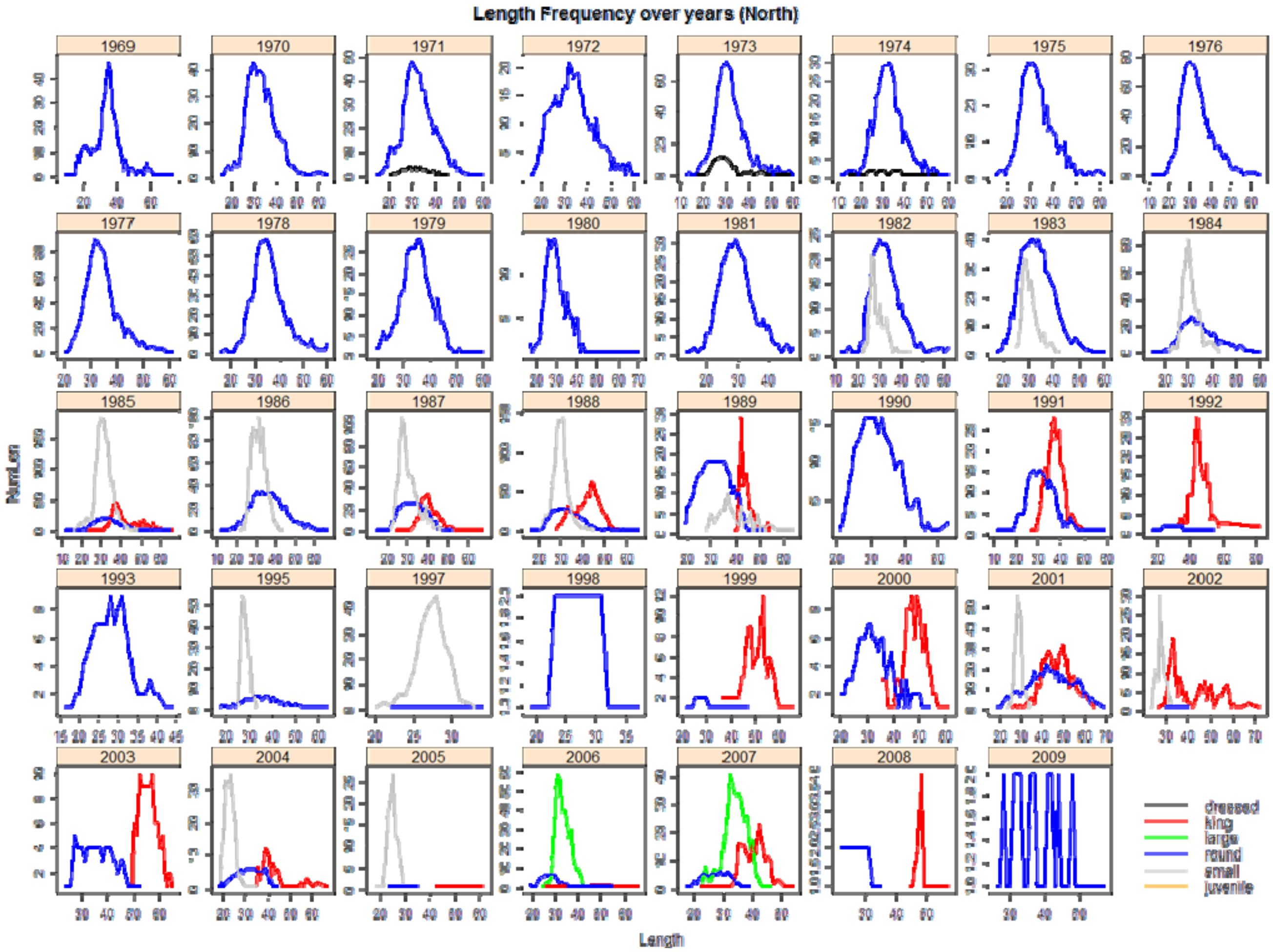


Figure A11: Silver hake length samples by market category in the northern region.

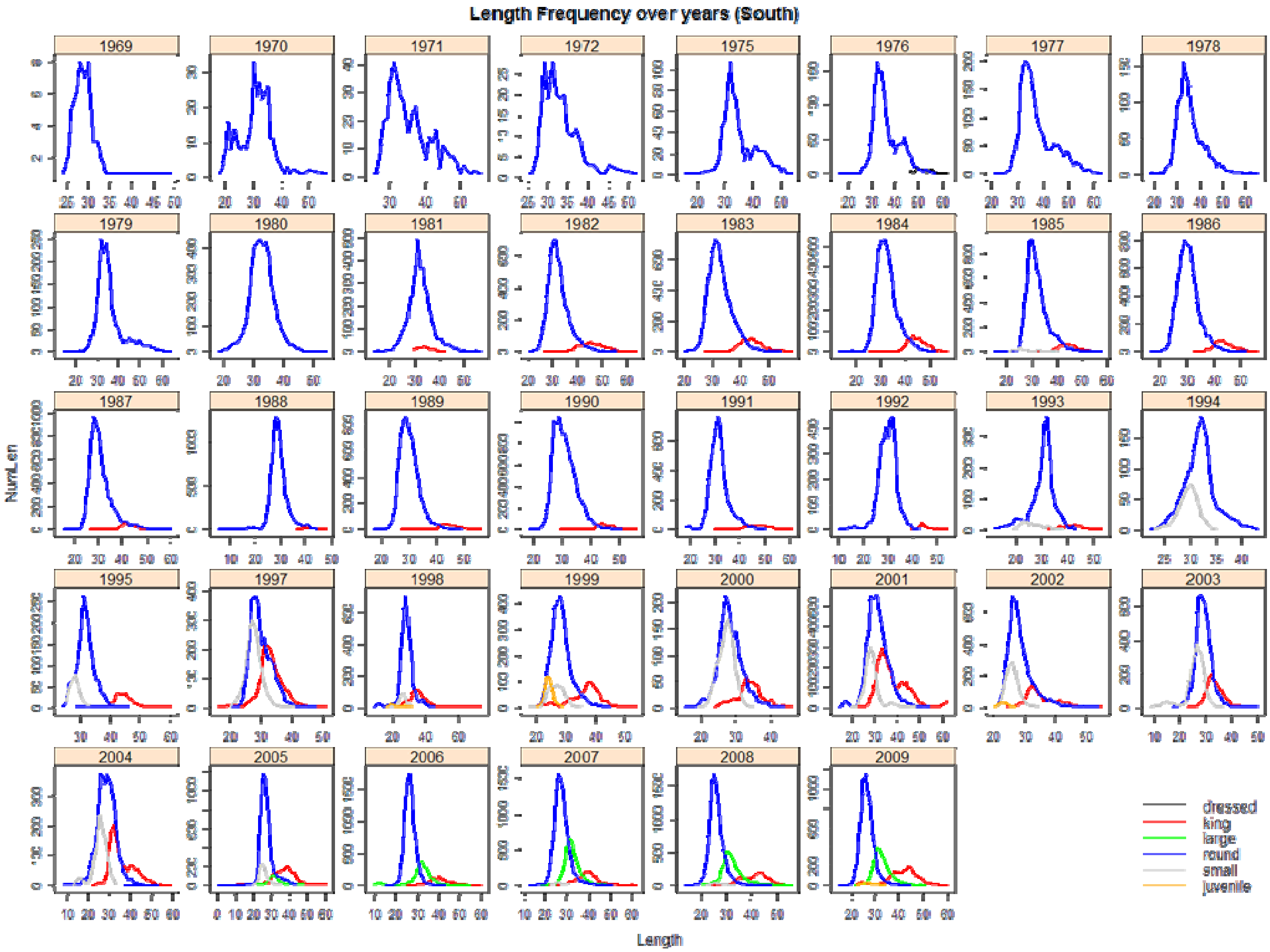


Figure A12: Silver hake length samples by market category in the southern region.

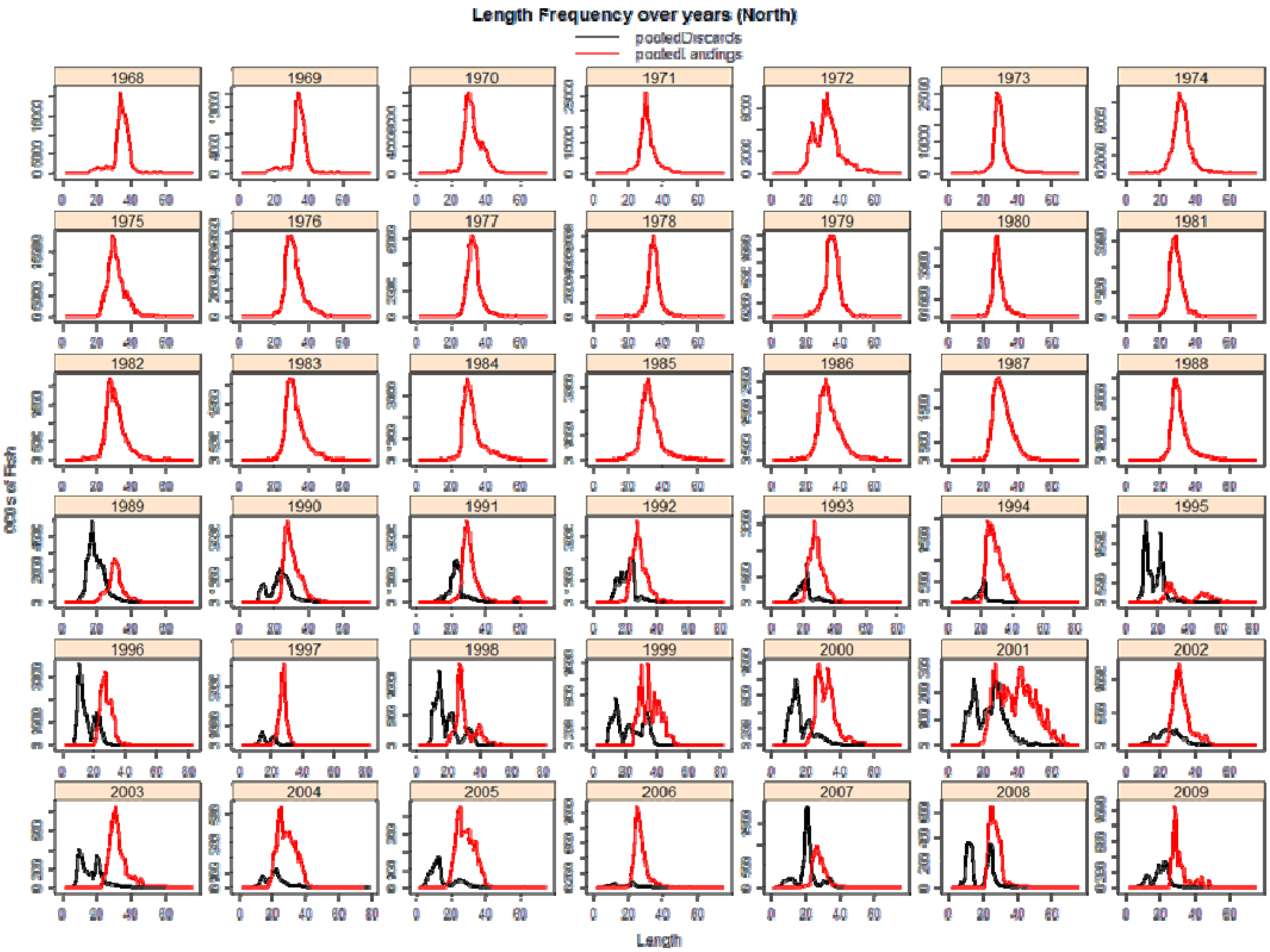


Figure A13. Silver hake length in thousands of fish frequencies from the northern region.

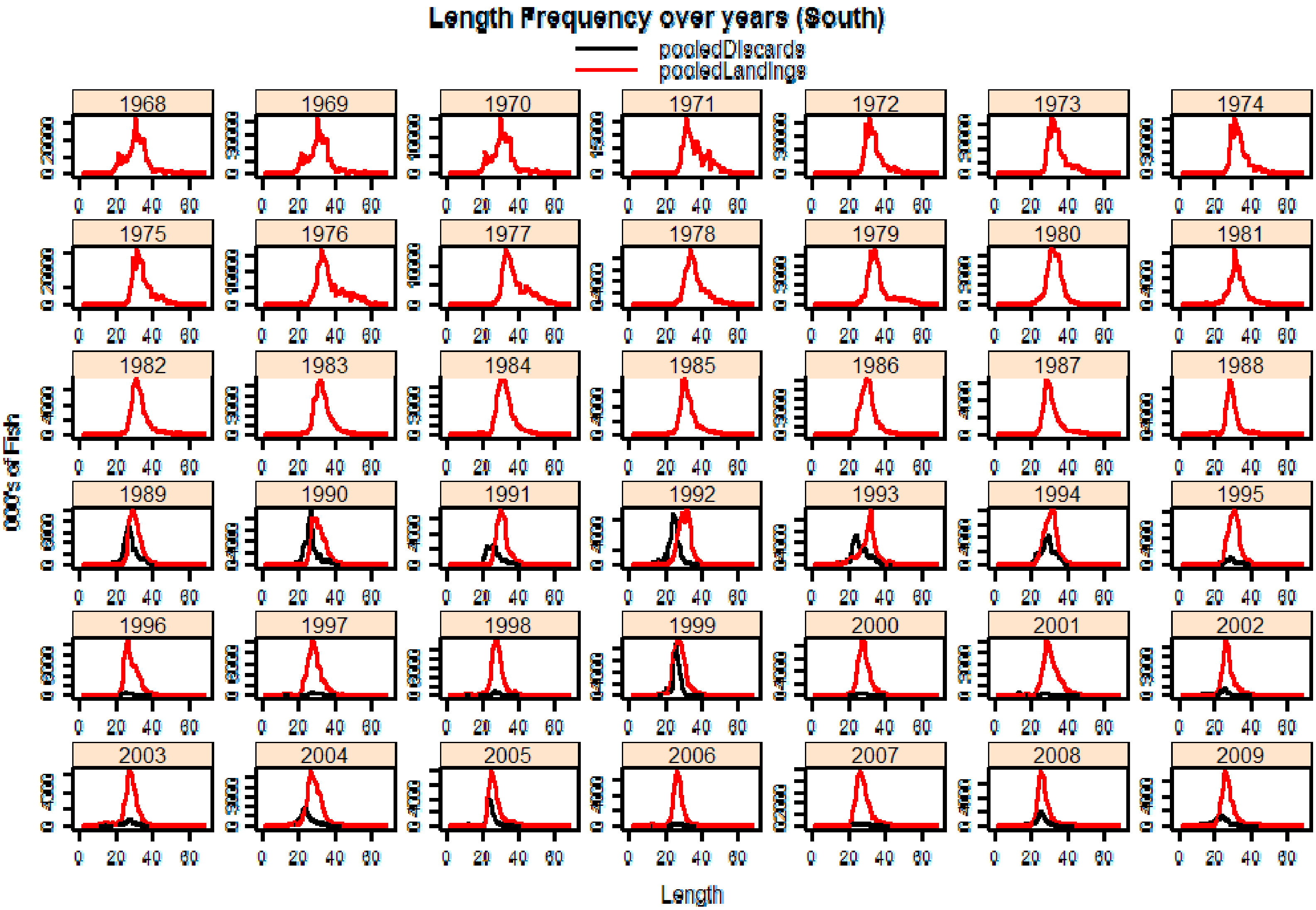
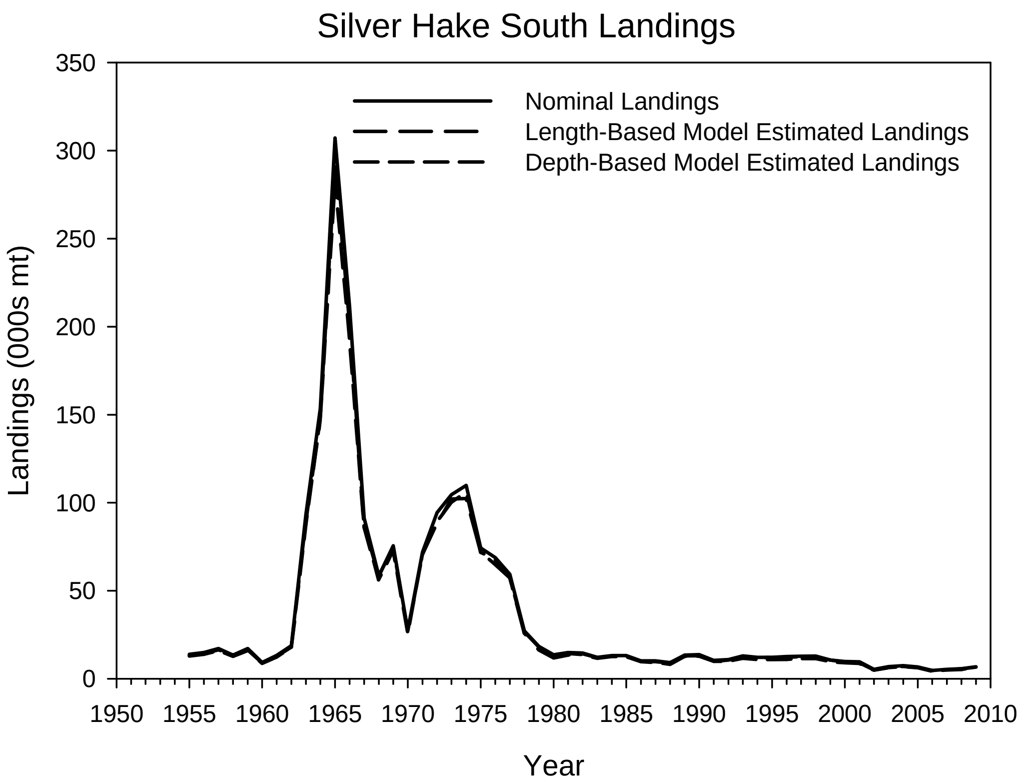


Figure A14. Silver hake length in thousands of fish frequencies from the southern region.



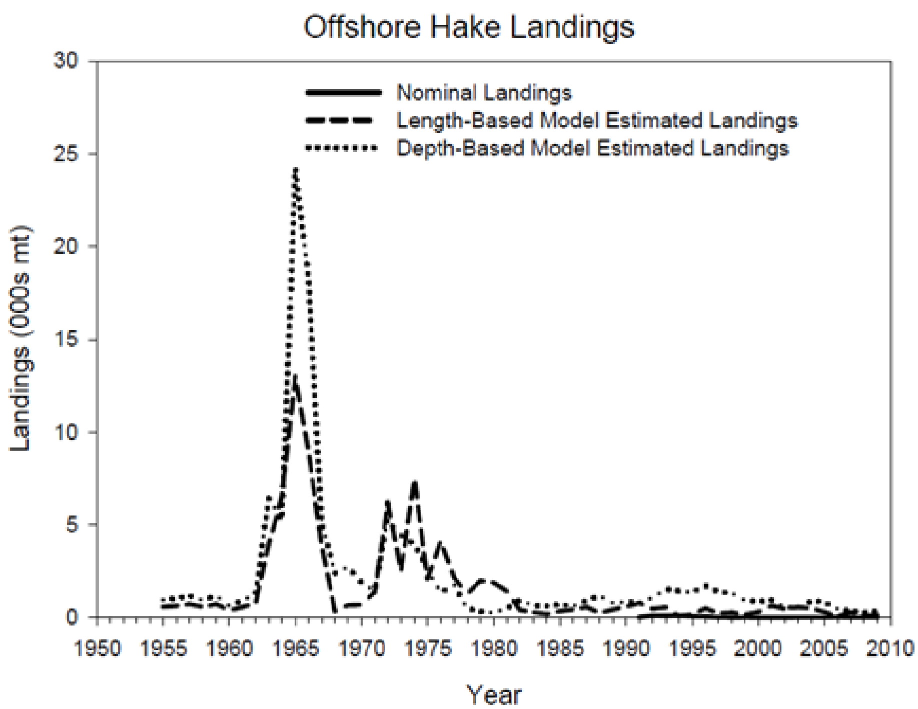


Figure A15. Comparison of nominal landings with the two model-based estimates for silver hake and offshore hake in the southern region.

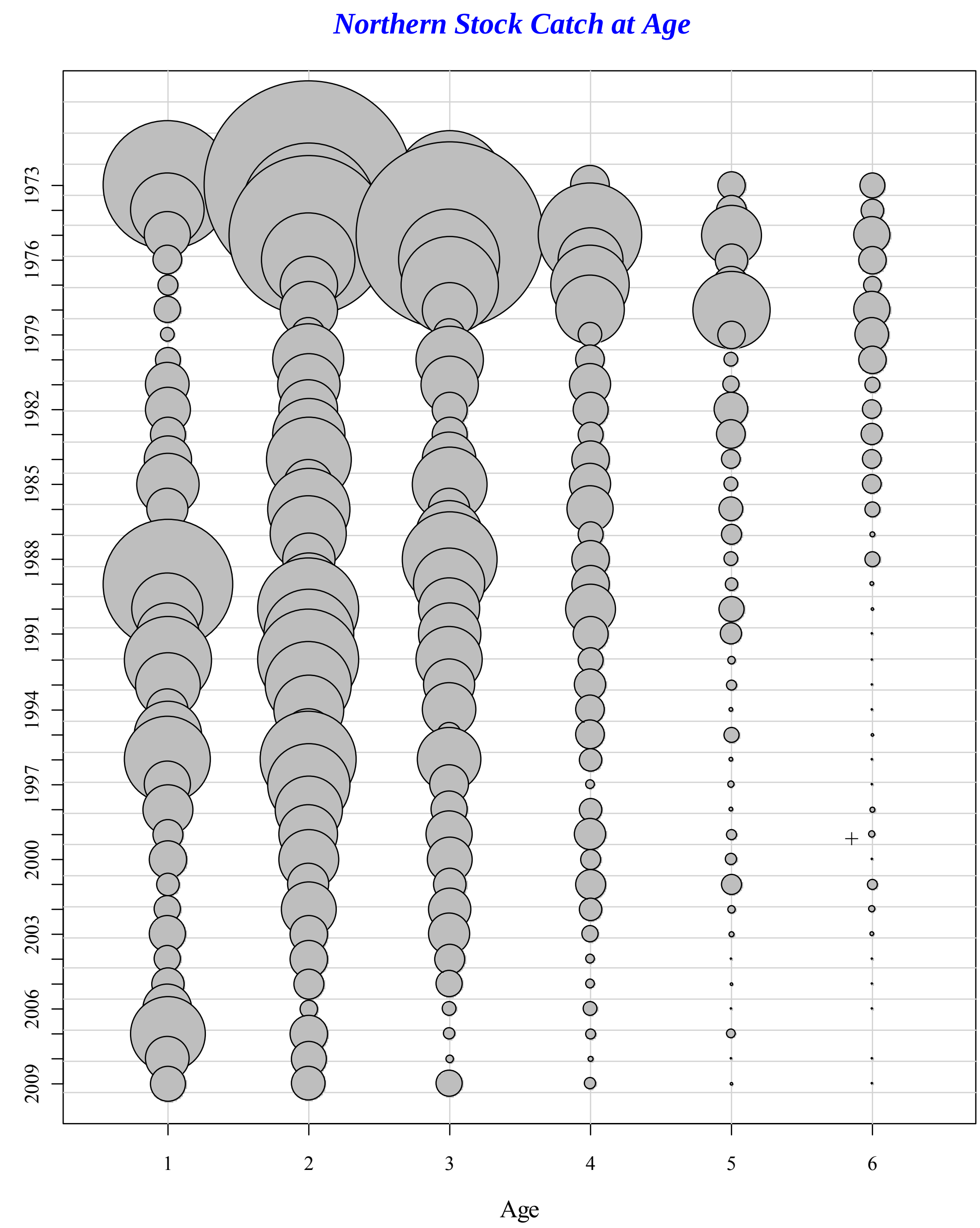


Figure A16. Catch at age of silver hake in the northern stock. (The area of the bubble is proportional to the magnitude of the catch).

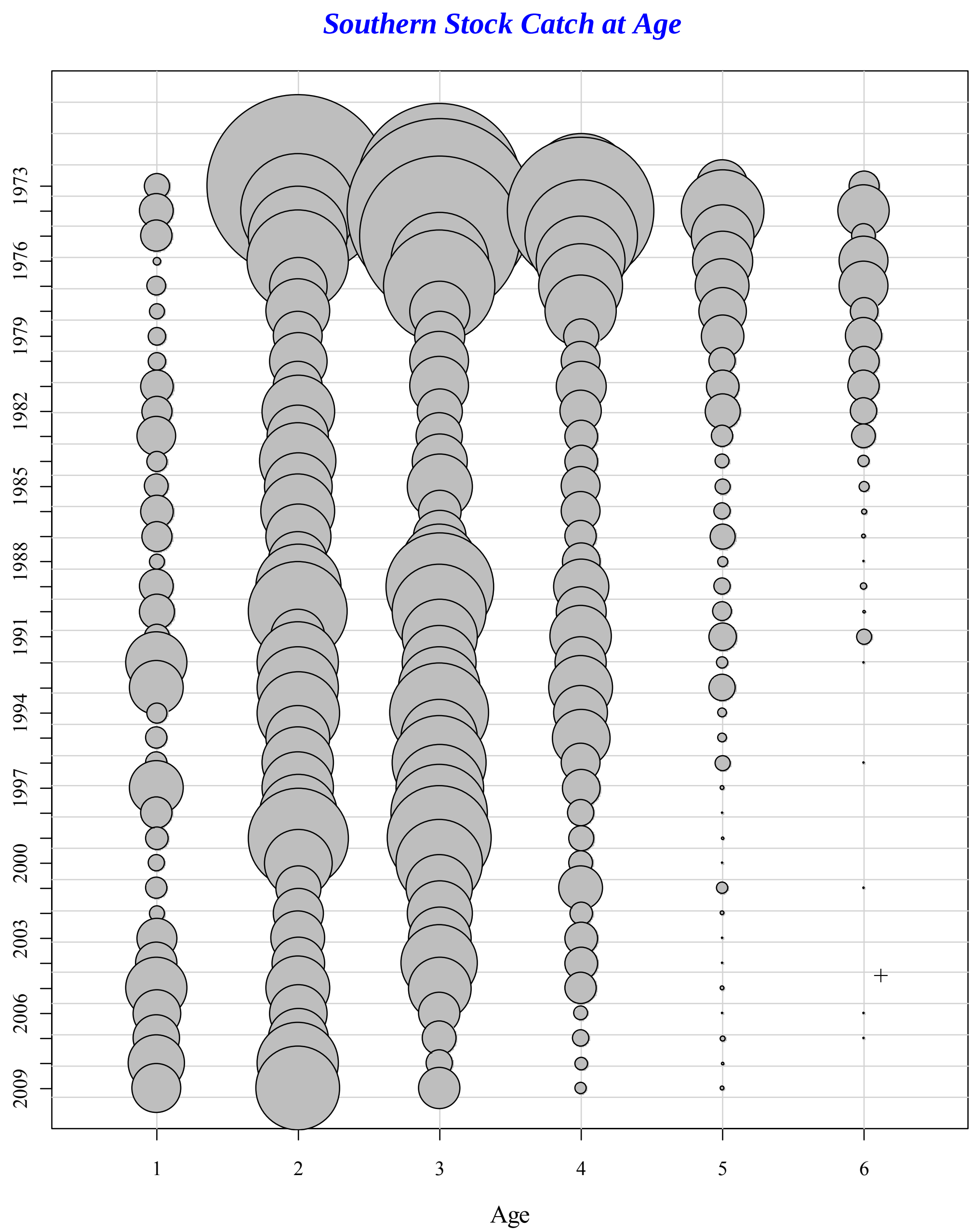


Figure A17. Catch at age of silver hake in the southern stock. (The area of the bubble is proportional to the magnitude of the catch).

Combined Stock Area Catch at Age

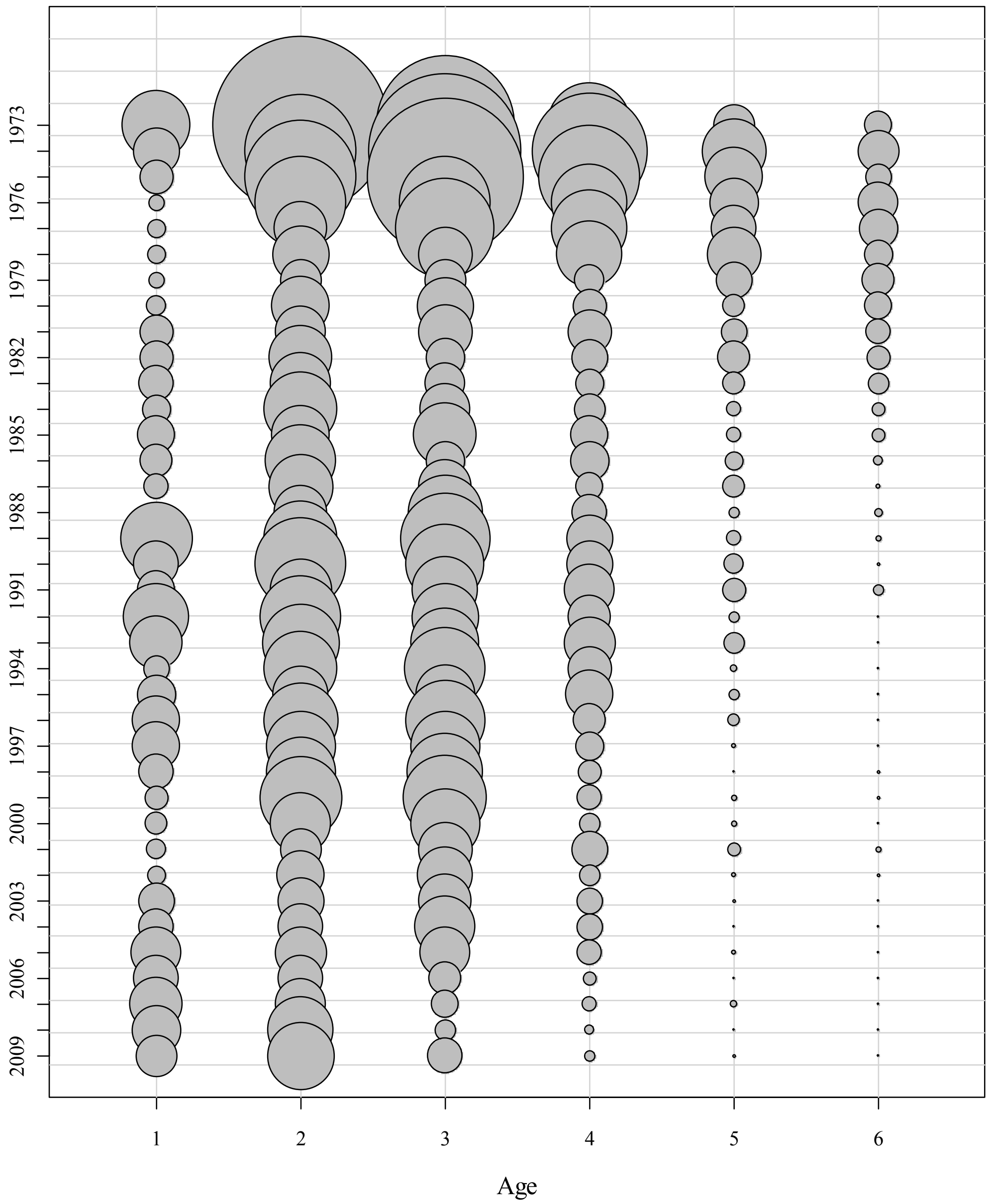


Figure A18. Catch at age of silver hake for the combined stock area. (The area of the bubble is proportional to the magnitude of the catch).

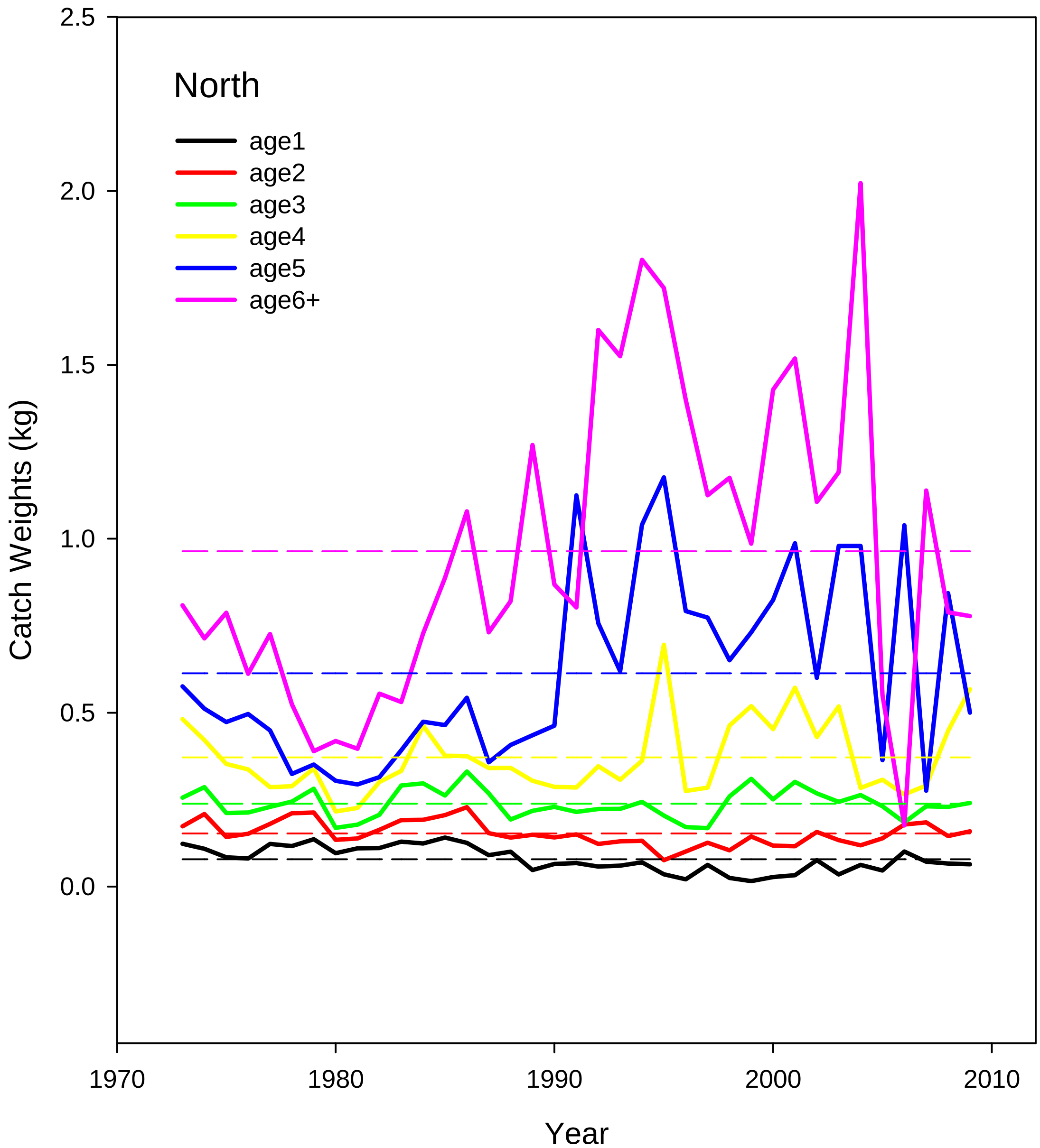


Figure A19. Trends in mean weight at age of silver hake from the northern stock. Dash lines denote the time series average.

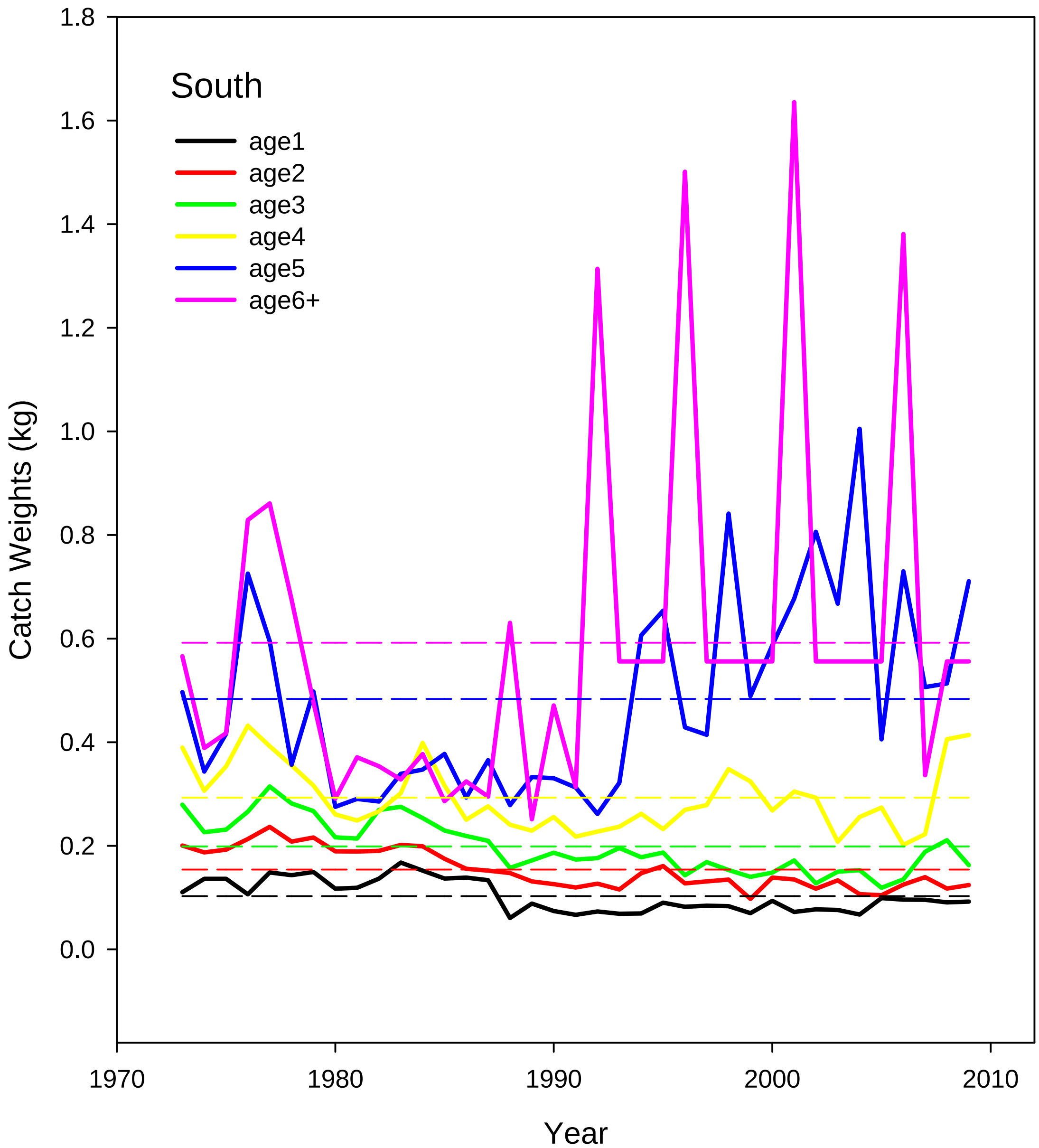


Figure A20. Trends in mean weight at age of silver hake from the southern stock. Dash lines denote the time series average.

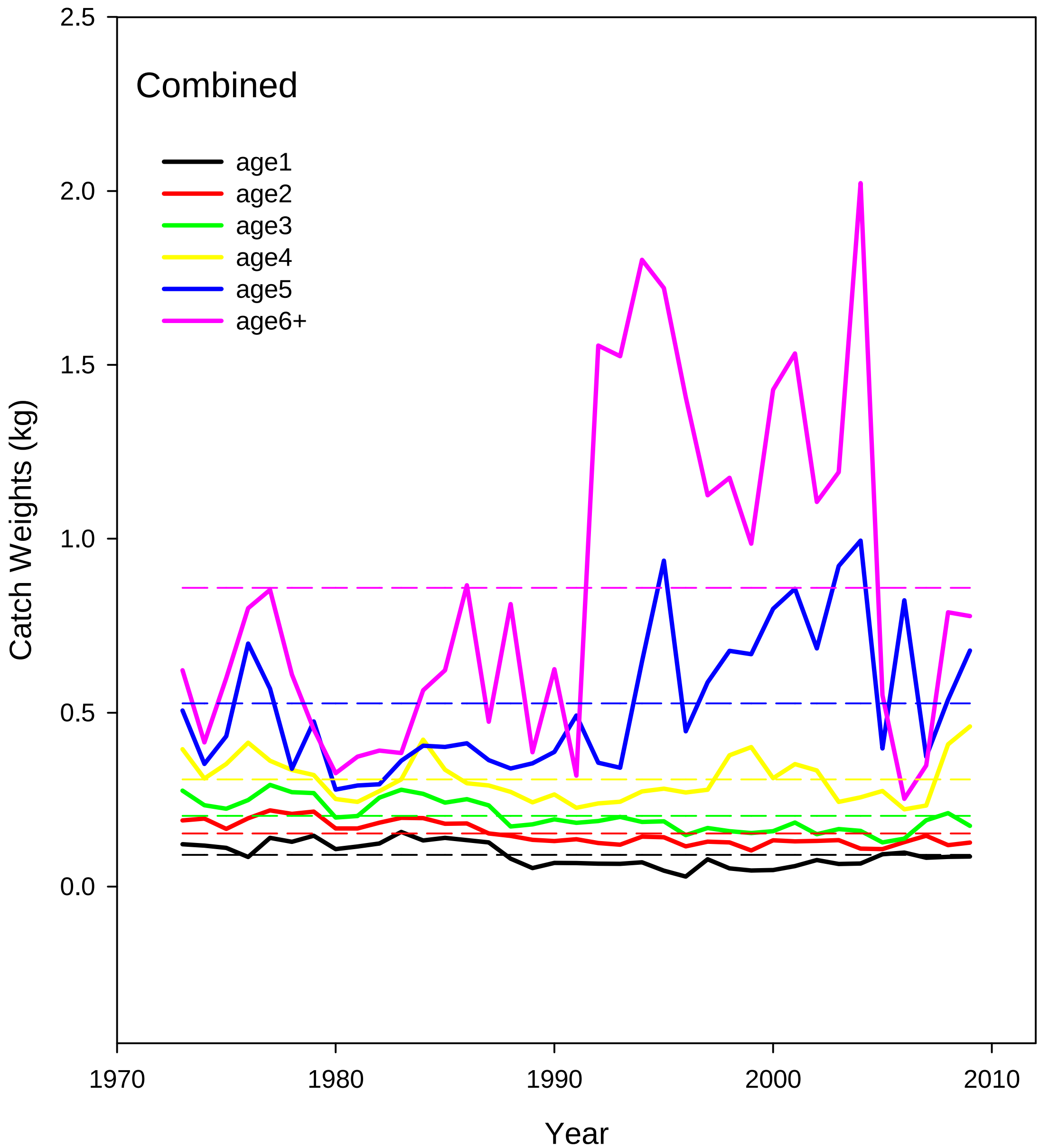


Figure A21. Trends in mean weight at age of silver hake for the combined stock areas. Dash lines denote the time series average.

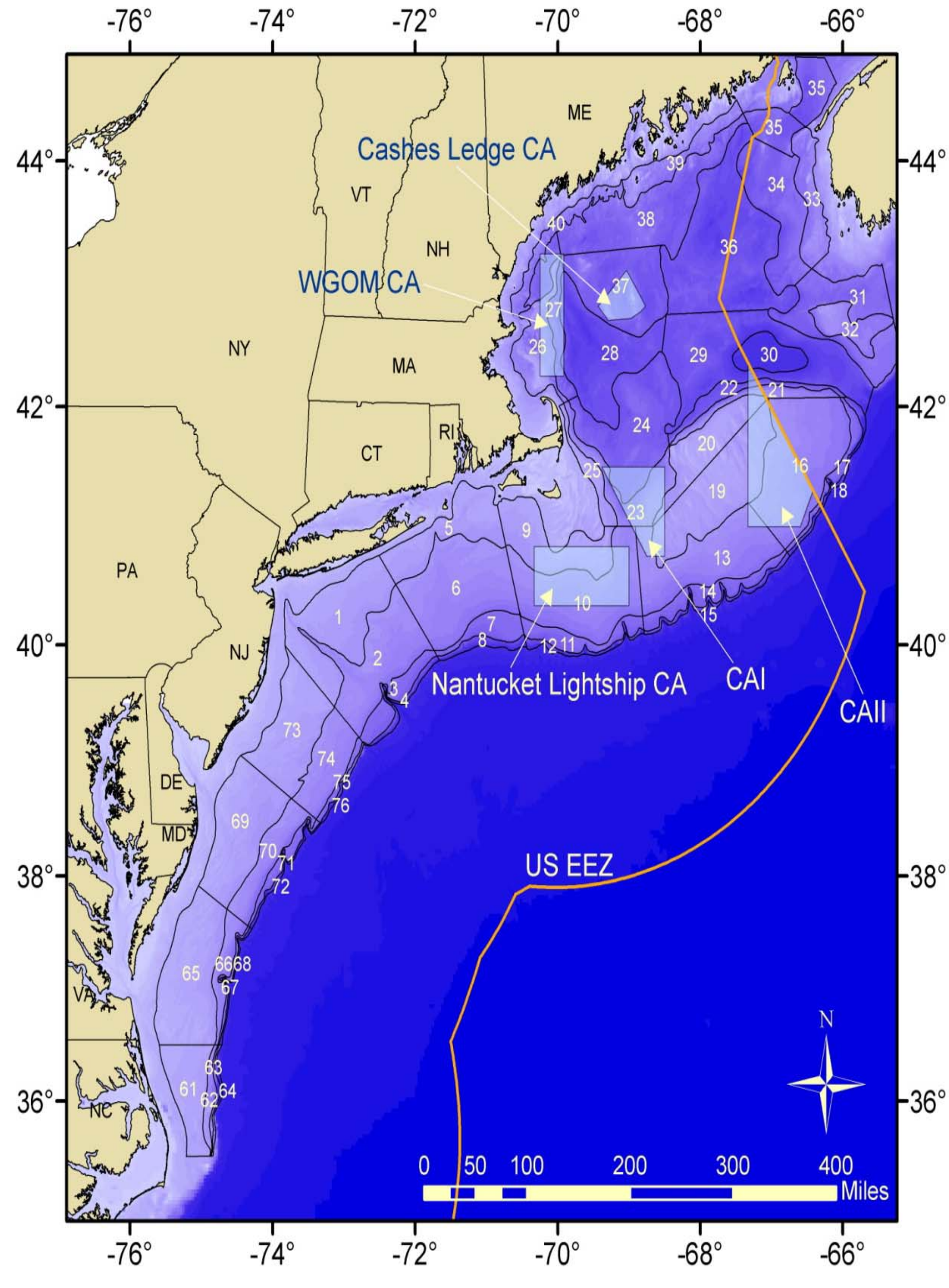


Figure A22. NEFSC bottom trawl survey strata for the northern (offshore strata 20-30 and 36-40) and southern (offshore strata 1-19 and 61-76) silver hake in the northwest Atlantic.

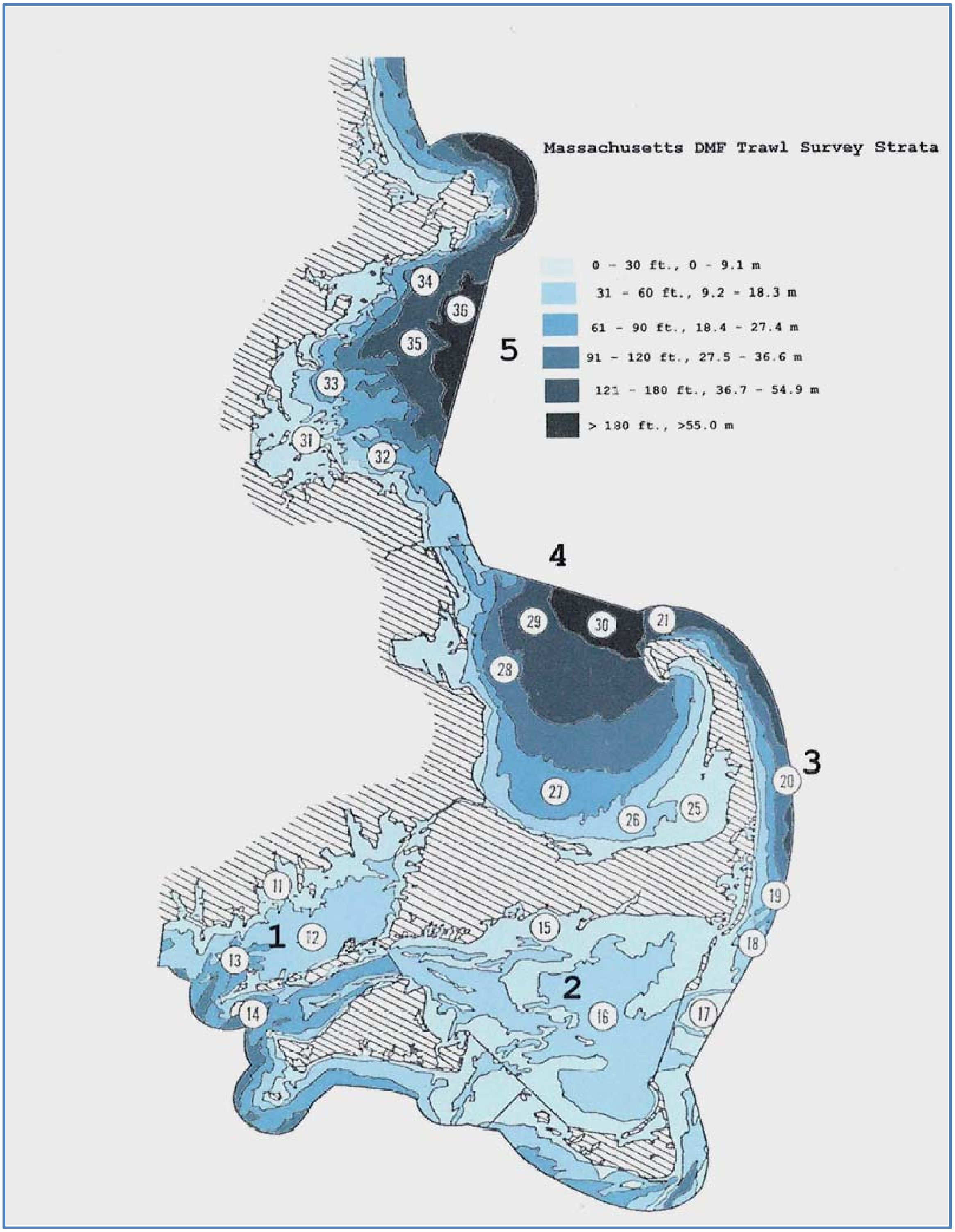
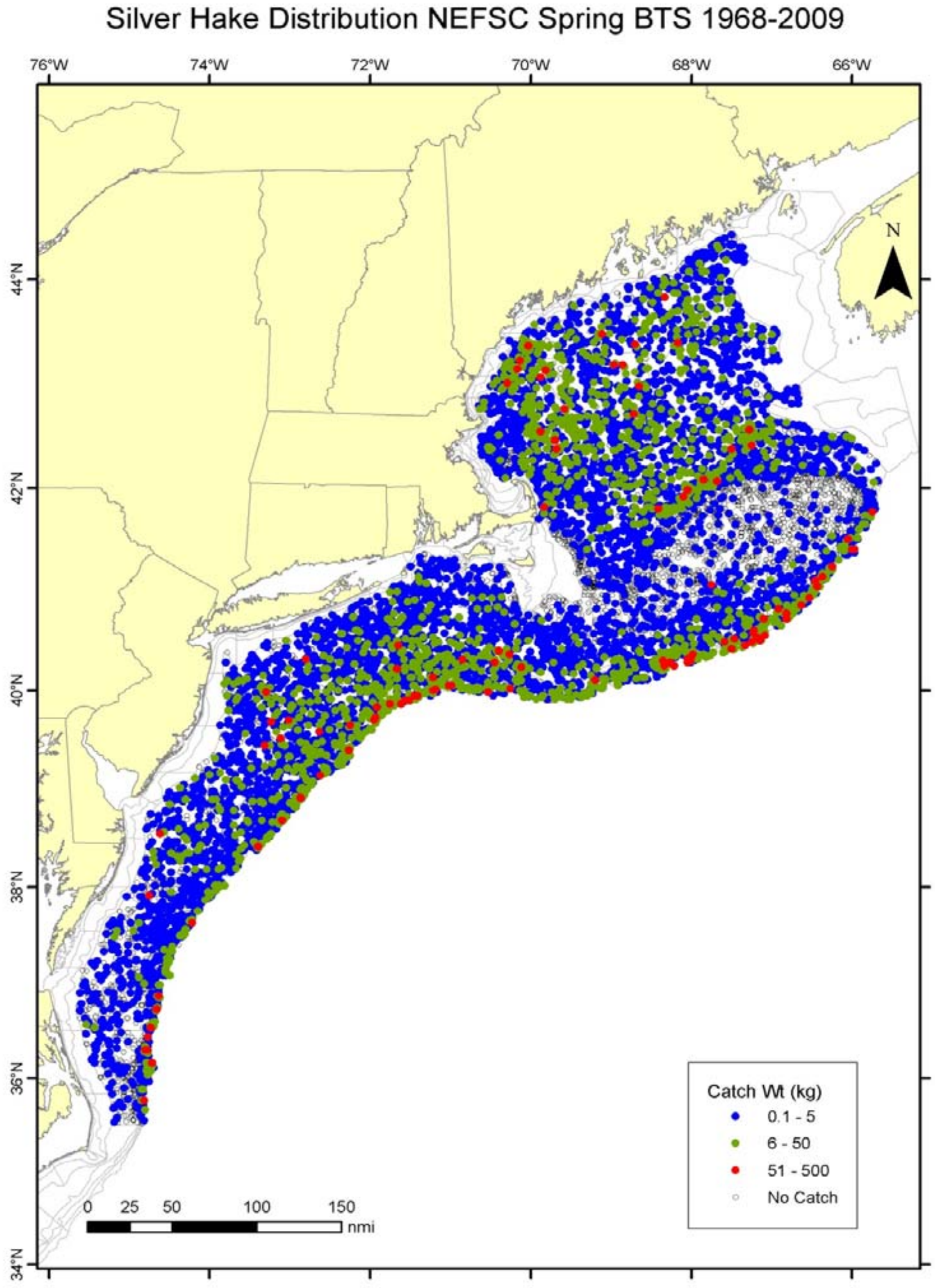


Figure A23. Massachusetts Division of Marine Fisheries (MADMF) survey strata.



A24. Spring survey distribution of silver hake from the NEFSC bottom trawl surveys, 1968-2009.

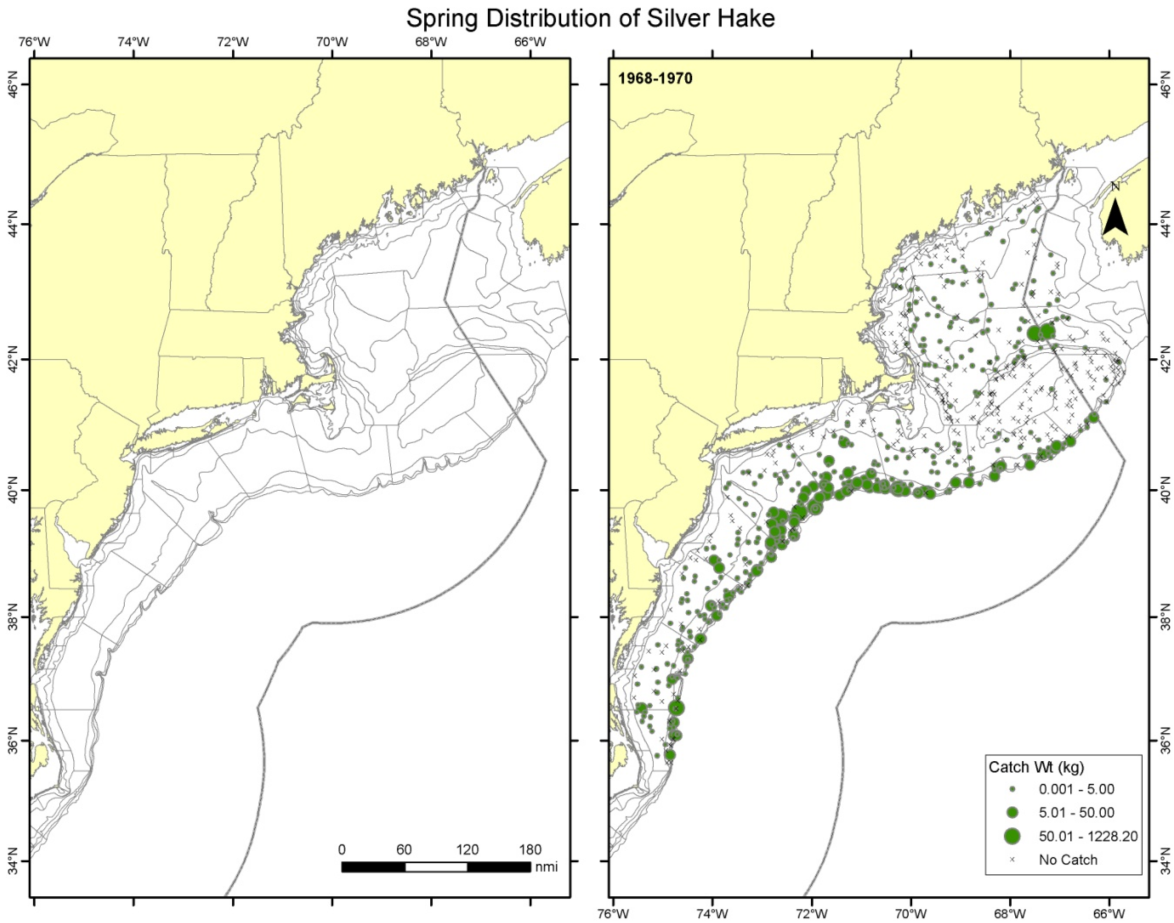


Figure A25. NEFSC distribution maps for silver hake during the spring bottom trawl surveys, 1968-1970.

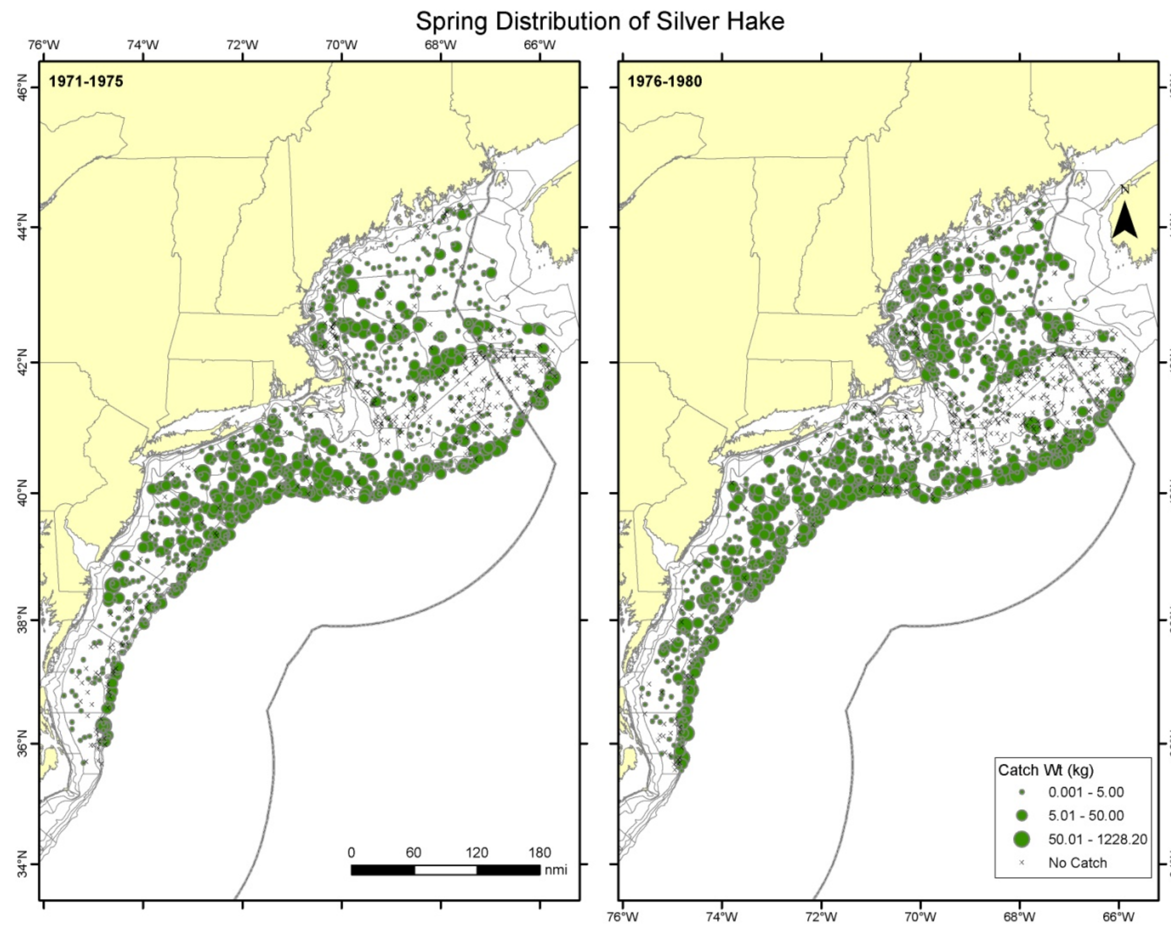


Figure A26. NEFSC distribution maps for silver hake during the spring bottom trawl surveys, 1971-1980.

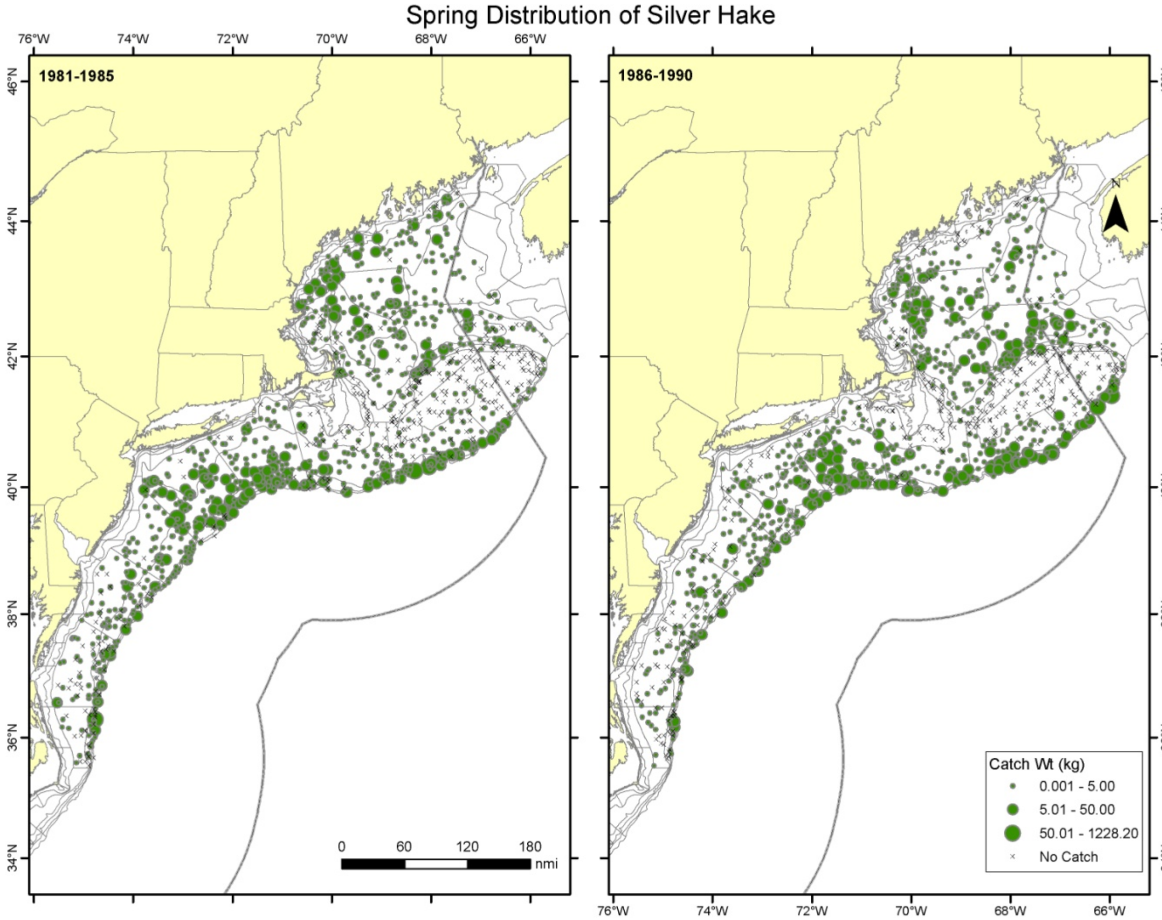


Figure A27. NEFSC distribution maps for silver hake during the spring bottom trawl surveys, 1981-1990.

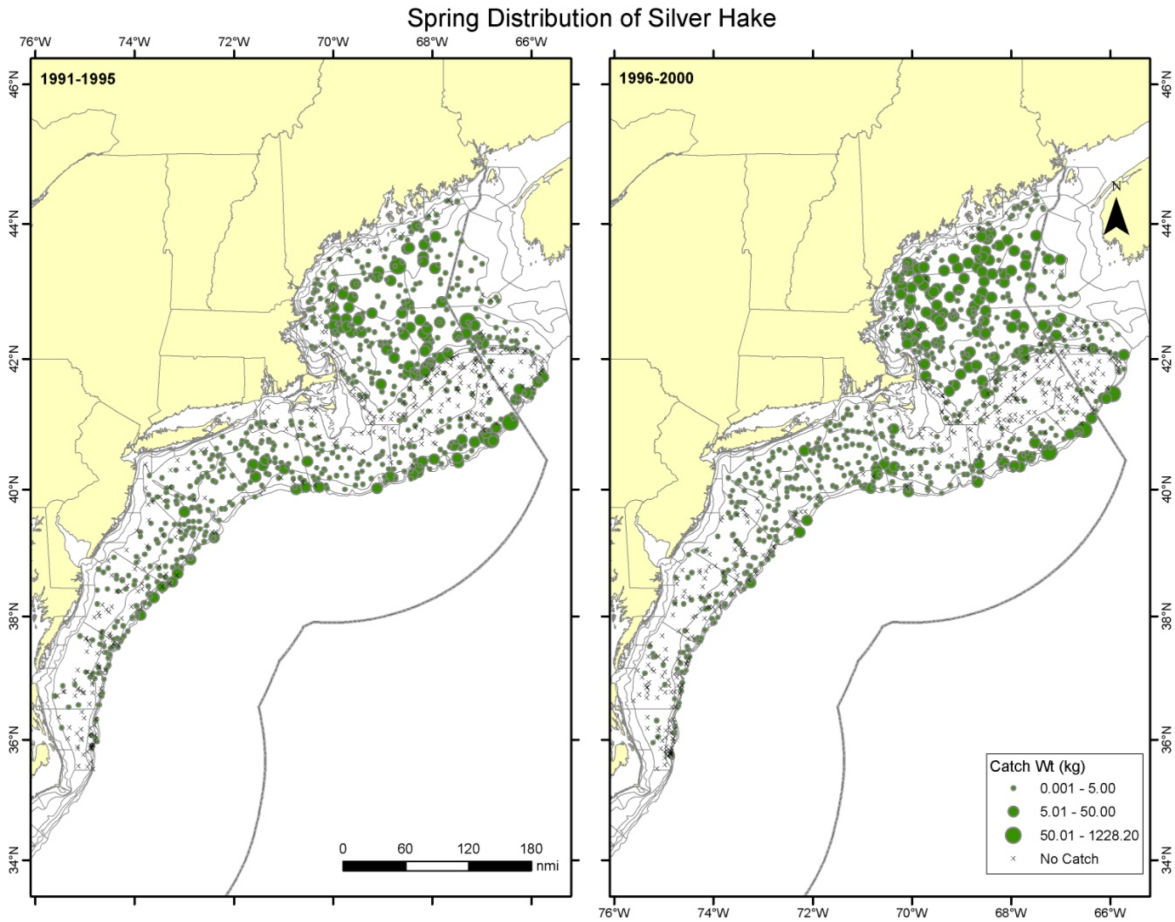


Figure A28. NEFSC distribution maps for silver hake during the spring bottom trawl surveys, 1991-2000.

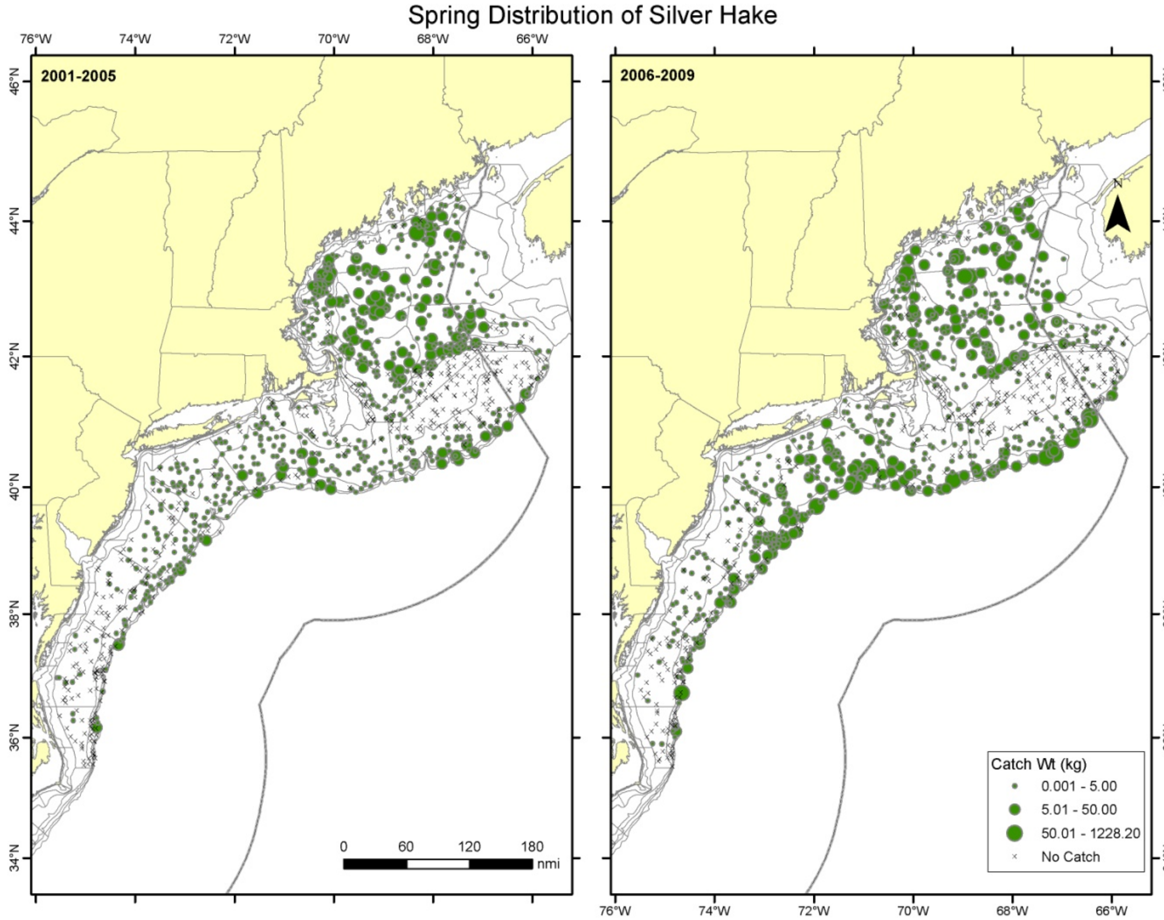


Figure A29. NEFSC distribution maps for silver hake during the spring bottom trawl surveys, 2001-2009.

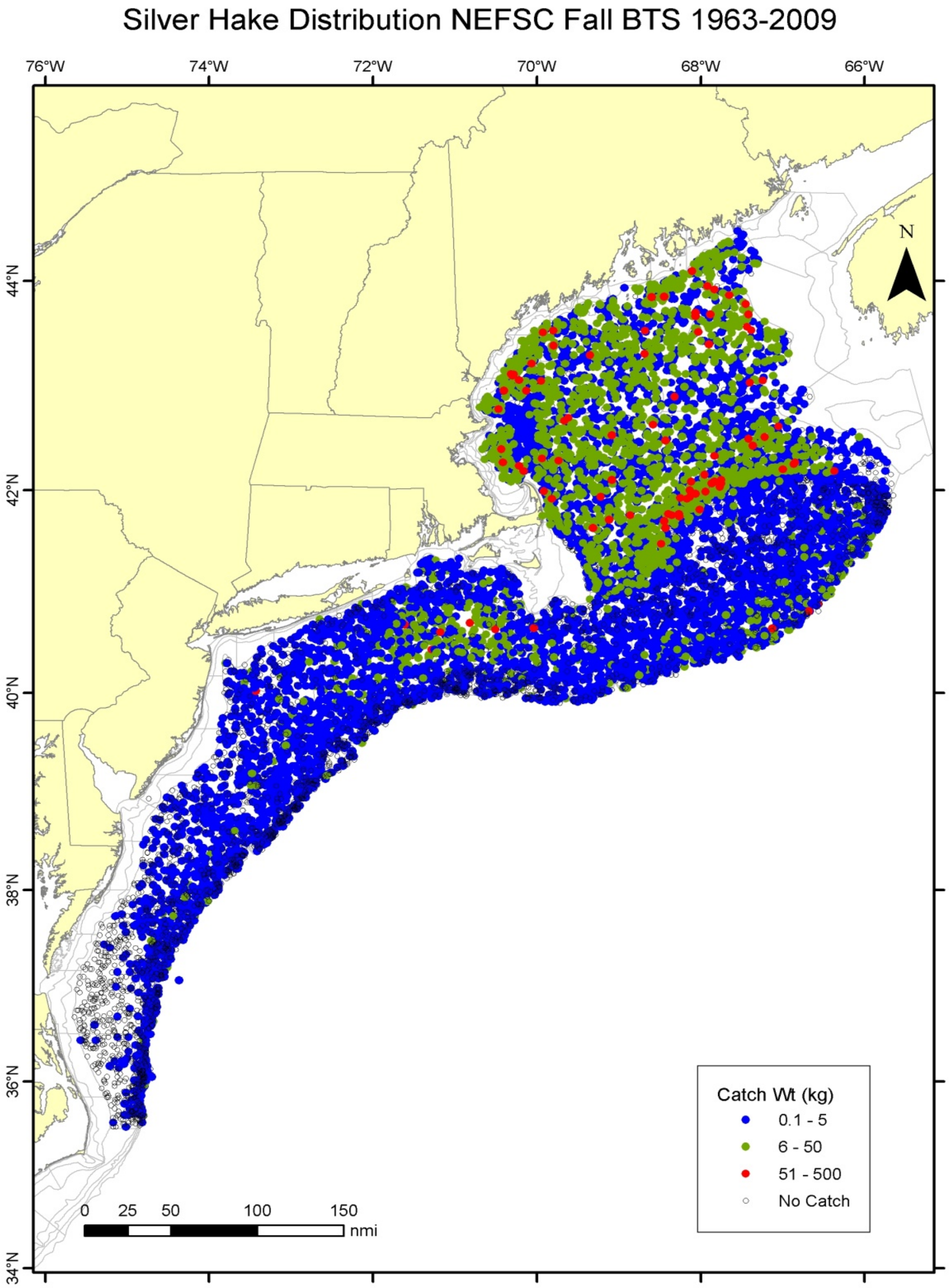


Figure A30. Fall survey distribution of silver hake from the NEFSC bottom trawl surveys, 1963-2009.

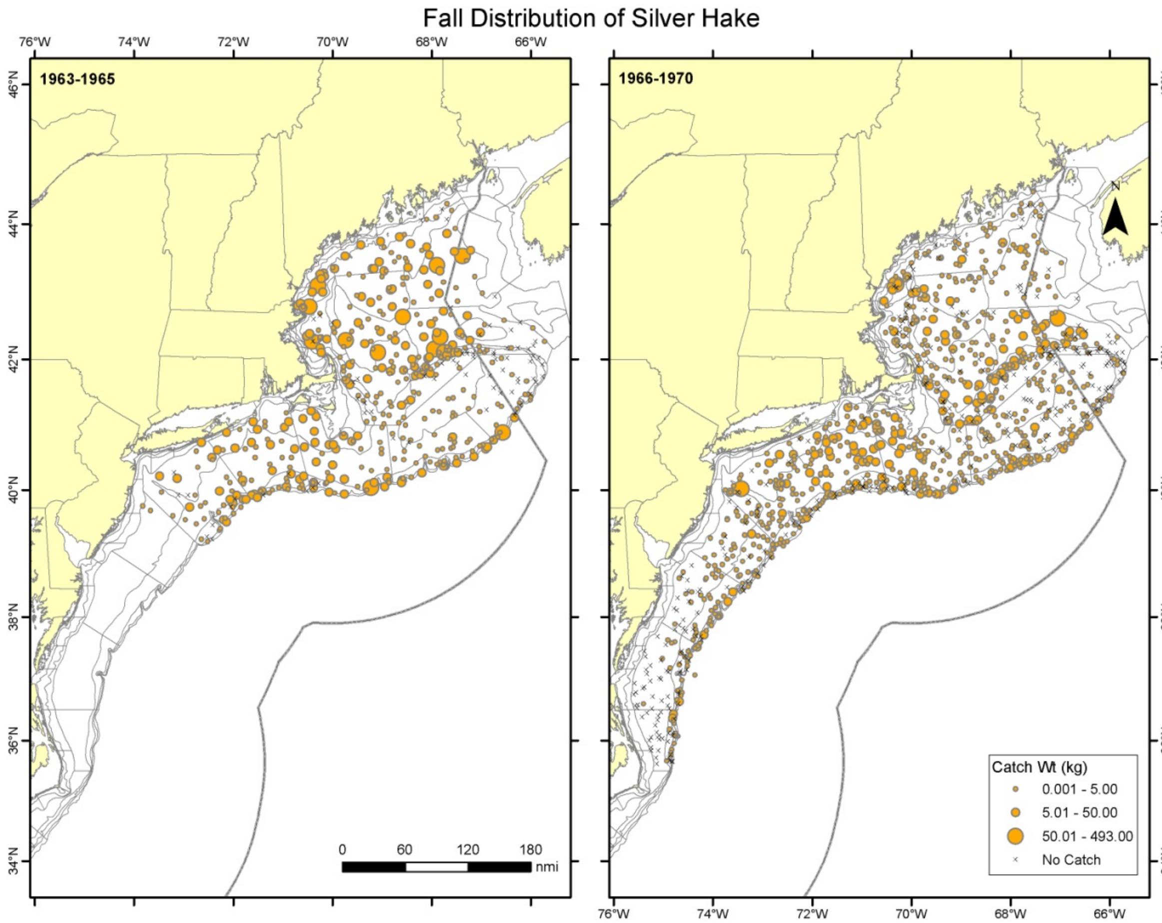


Figure A31. NEFSC distribution maps for silver hake during the fall bottom trawl surveys, 1963-1970.

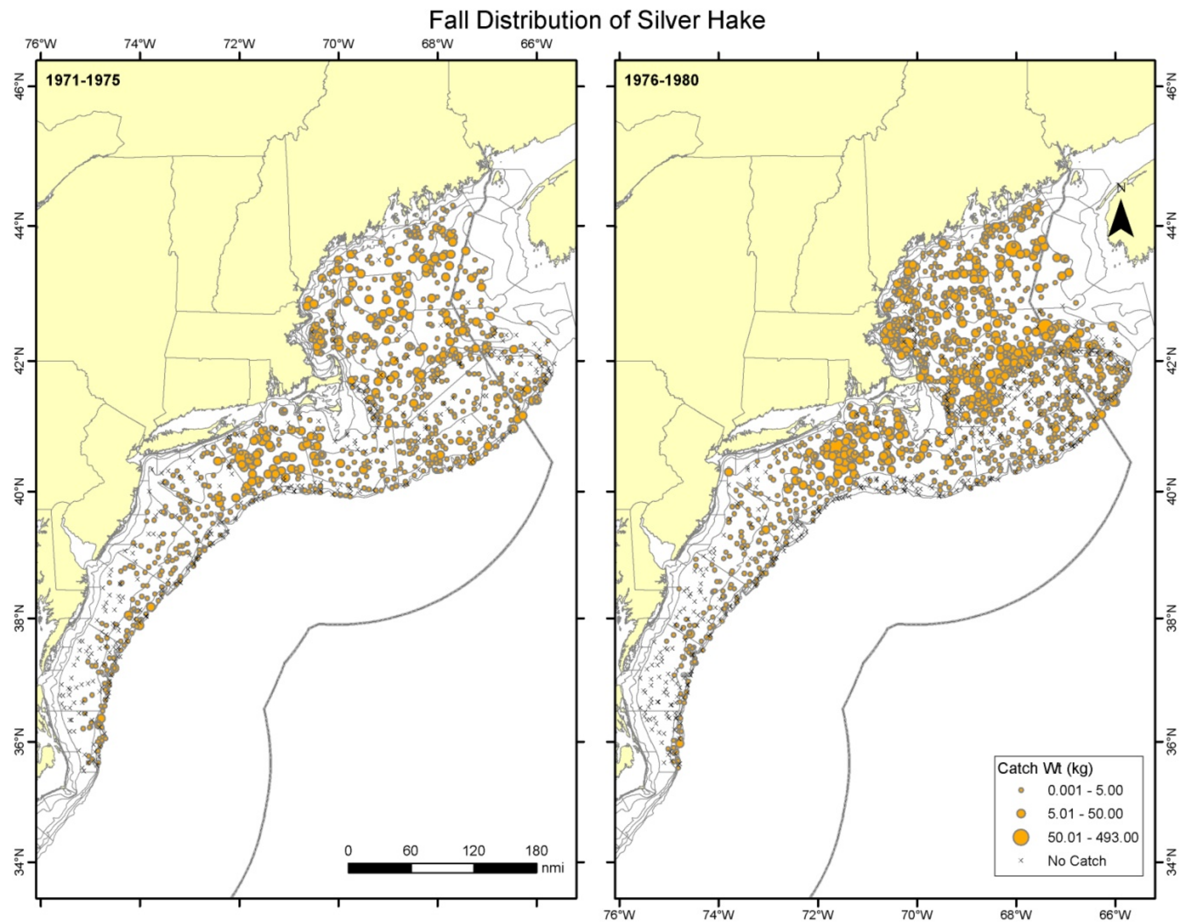


Figure A32. NEFSC distribution maps for silver hake during the fall bottom trawl surveys, 1971-1980.

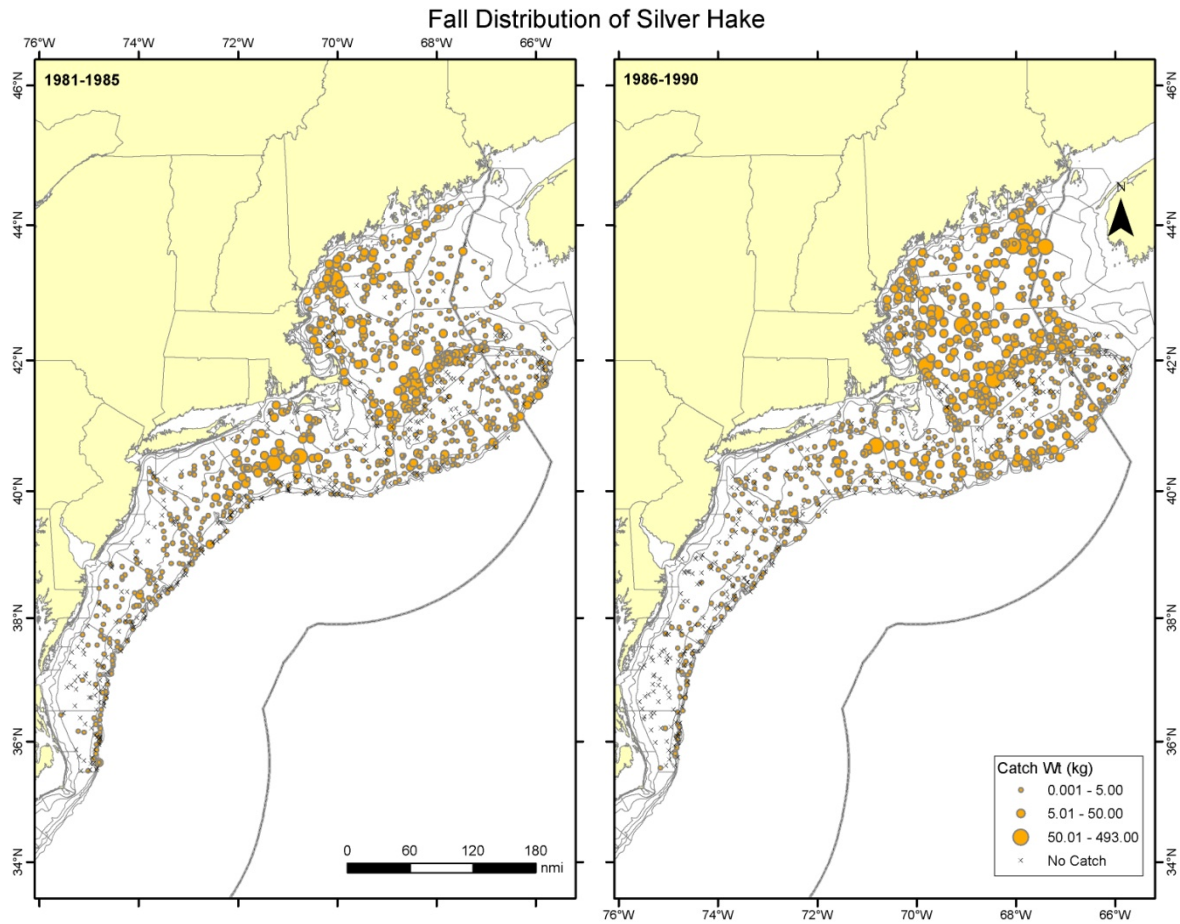


Figure A33. NEFSC distribution maps for silver hake during the fall bottom trawl surveys, 1981-1990.

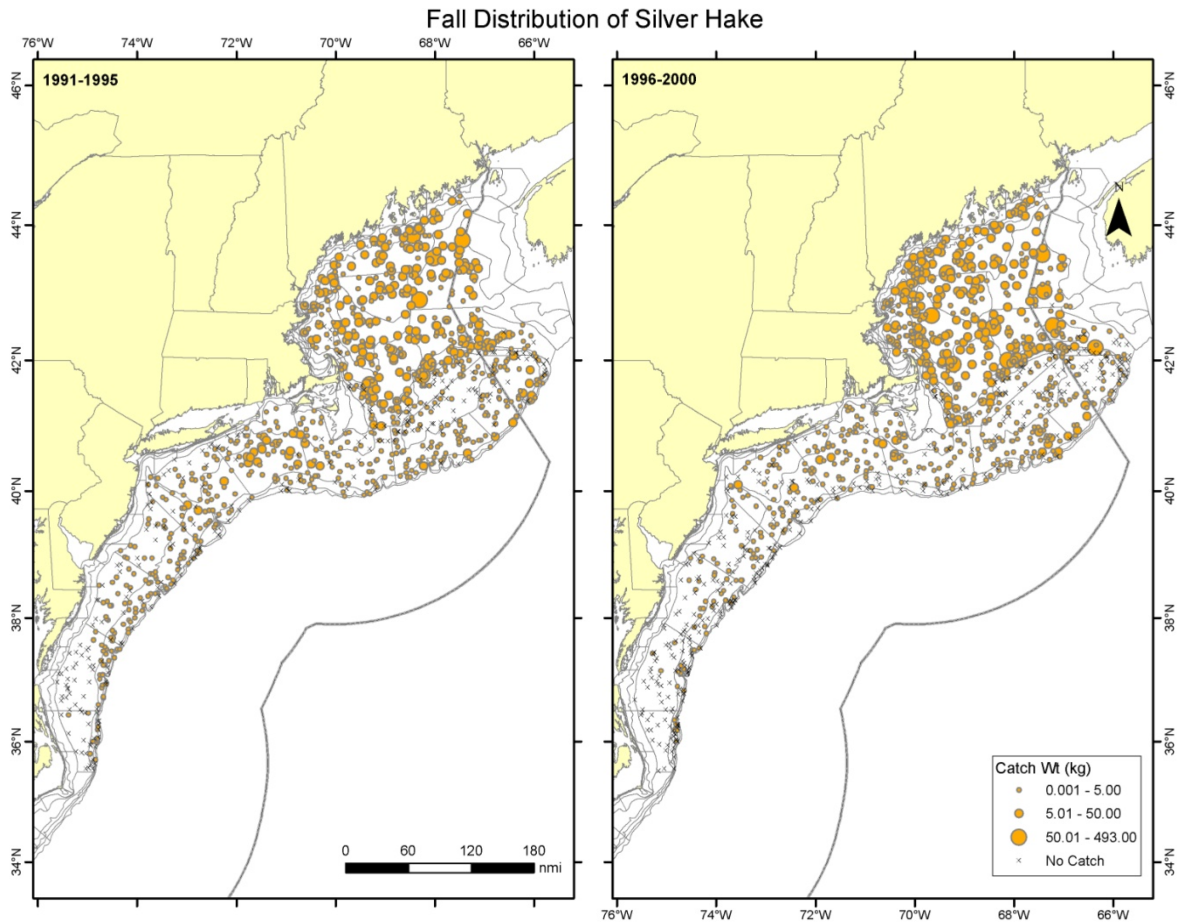


Figure A34. NEFSC distribution maps for silver hake during the fall bottom trawl surveys, 1991-2000.

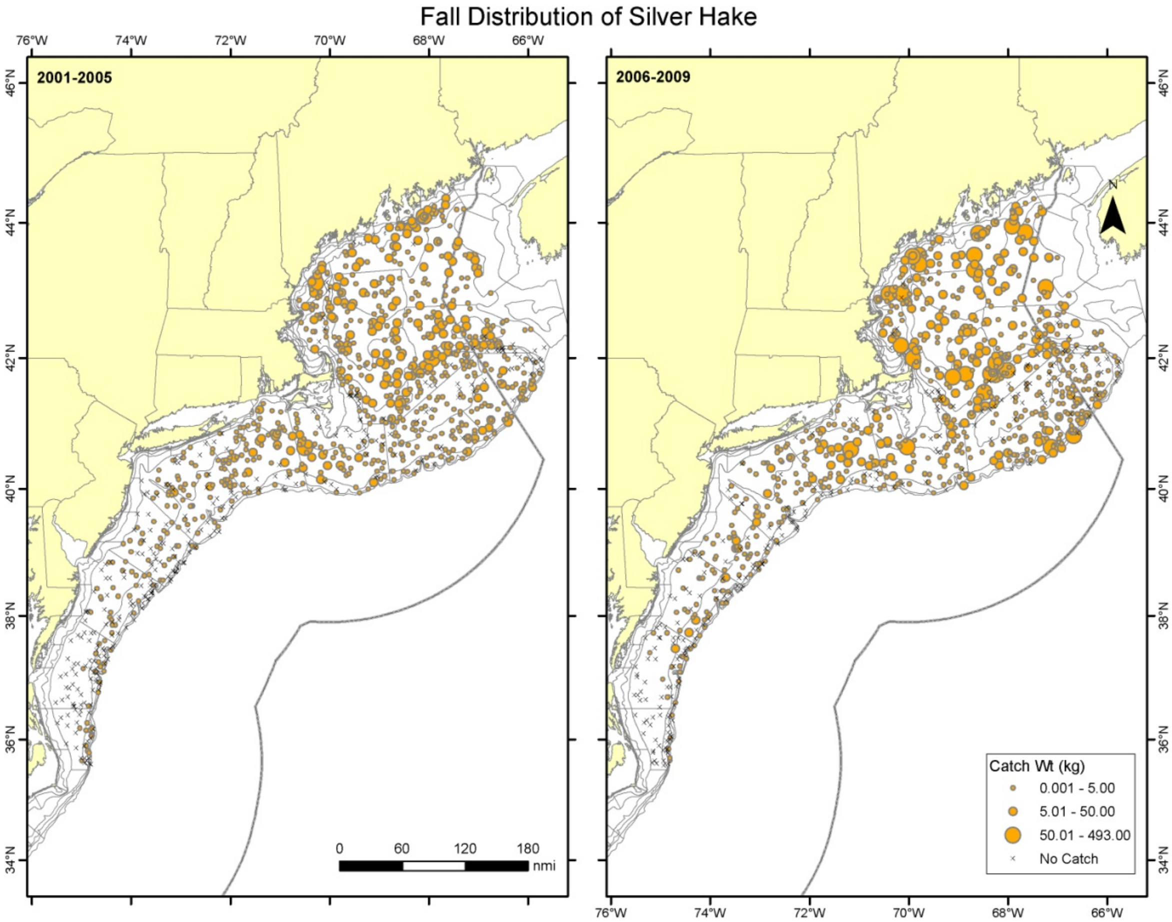


Figure A35. NEFSC distribution maps for silver hake during the fall bottom trawl surveys, 2001-2009.

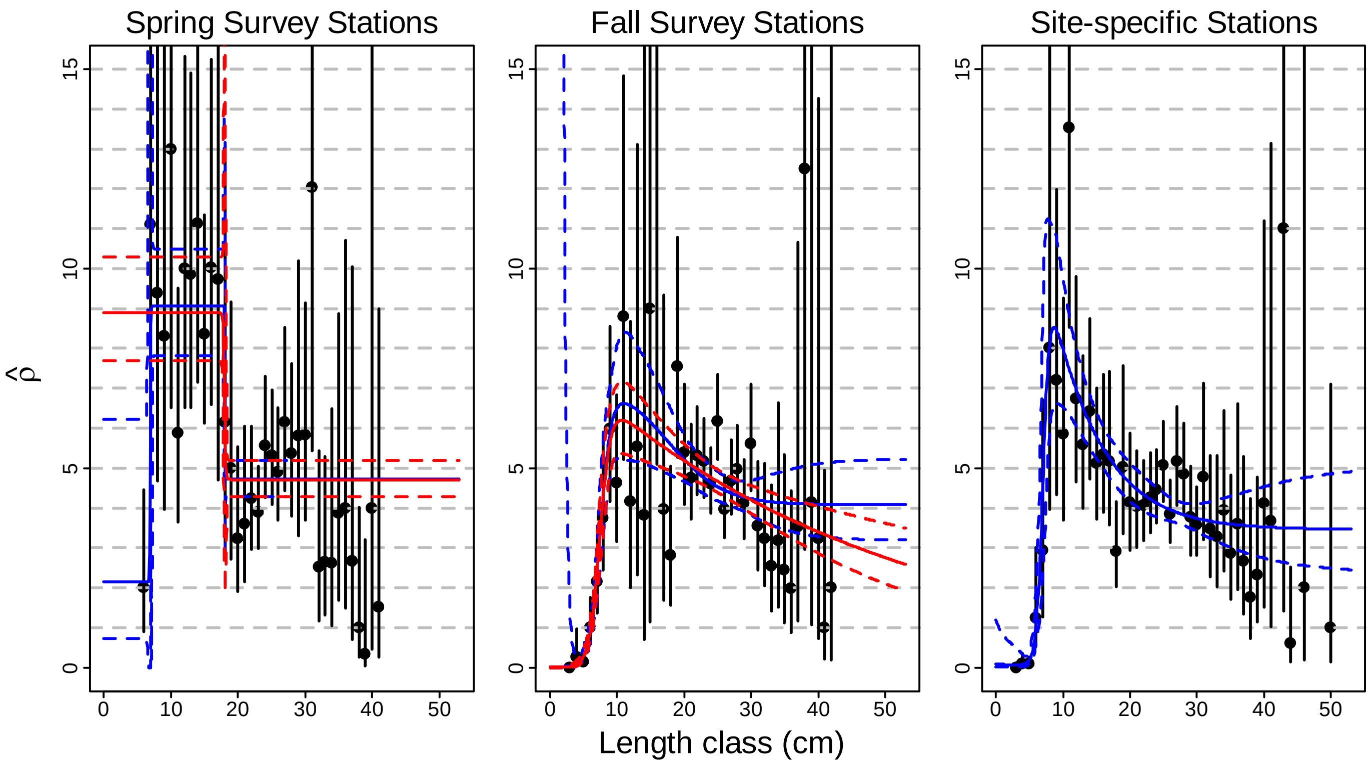
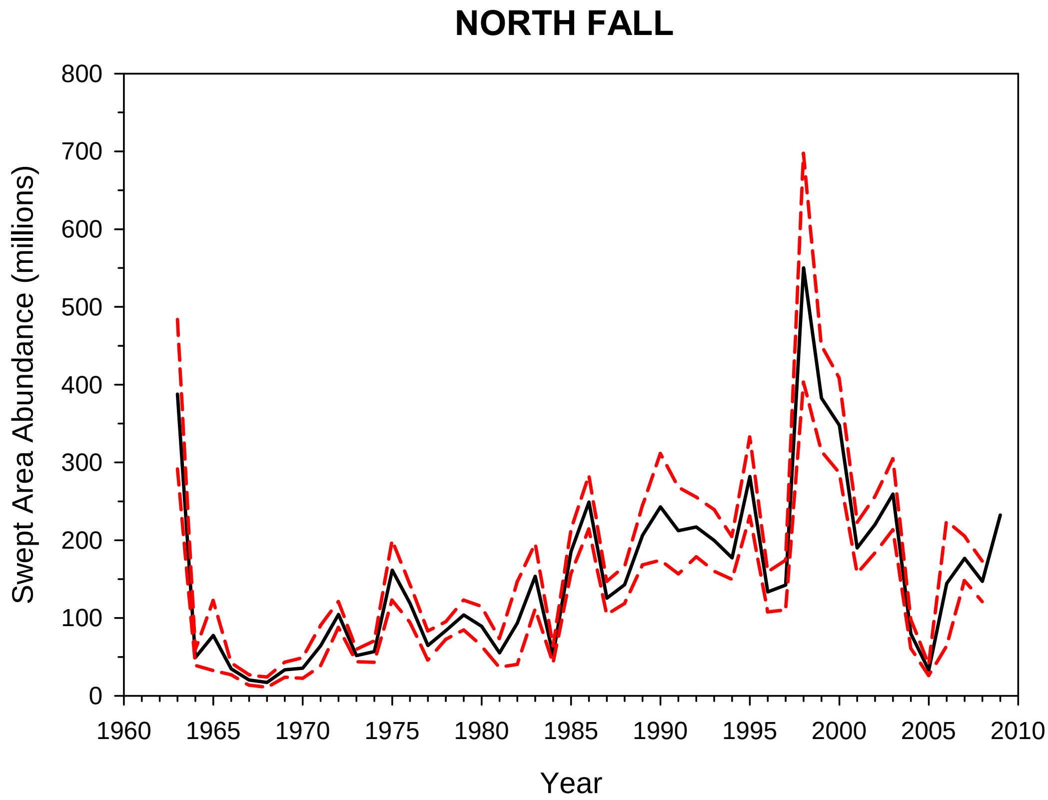


Figure A36: Beta-binomial based estimates of calibration factors and corresponding 95% confidence intervals by length class (1 cm bins) for **silver hake**. The black points and vertical bars represent results where different calibration factors are estimated for each length class. The blue lines represent results from fully parameterized double-logistic models. For the spring, the red lines represent results for a (single) logistic model whereas they represent results for a double logistic model with no minima for the ascending or descending logistic function for the fall.



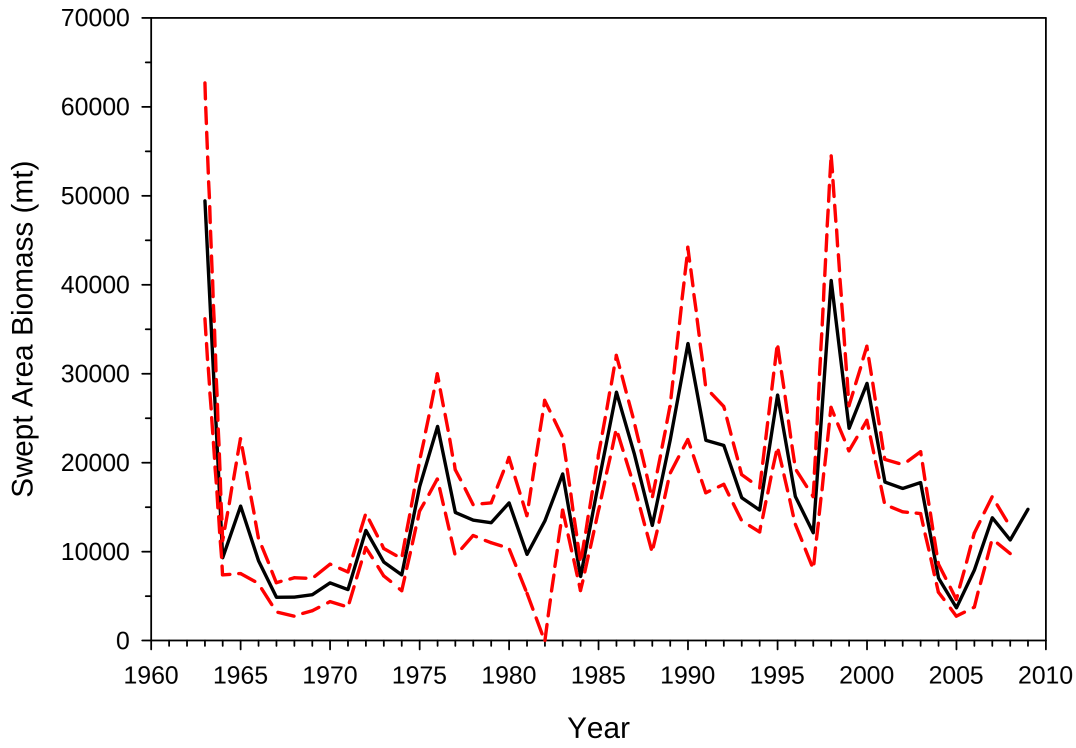


Figure A37. Trends in fall Survey abundances (top) and biomass (bottom) estimates for Silver hake in the northern stock expressed as minimum swept area estimates. Solid lines represent point estimates while the dash lines are the confidence intervals.

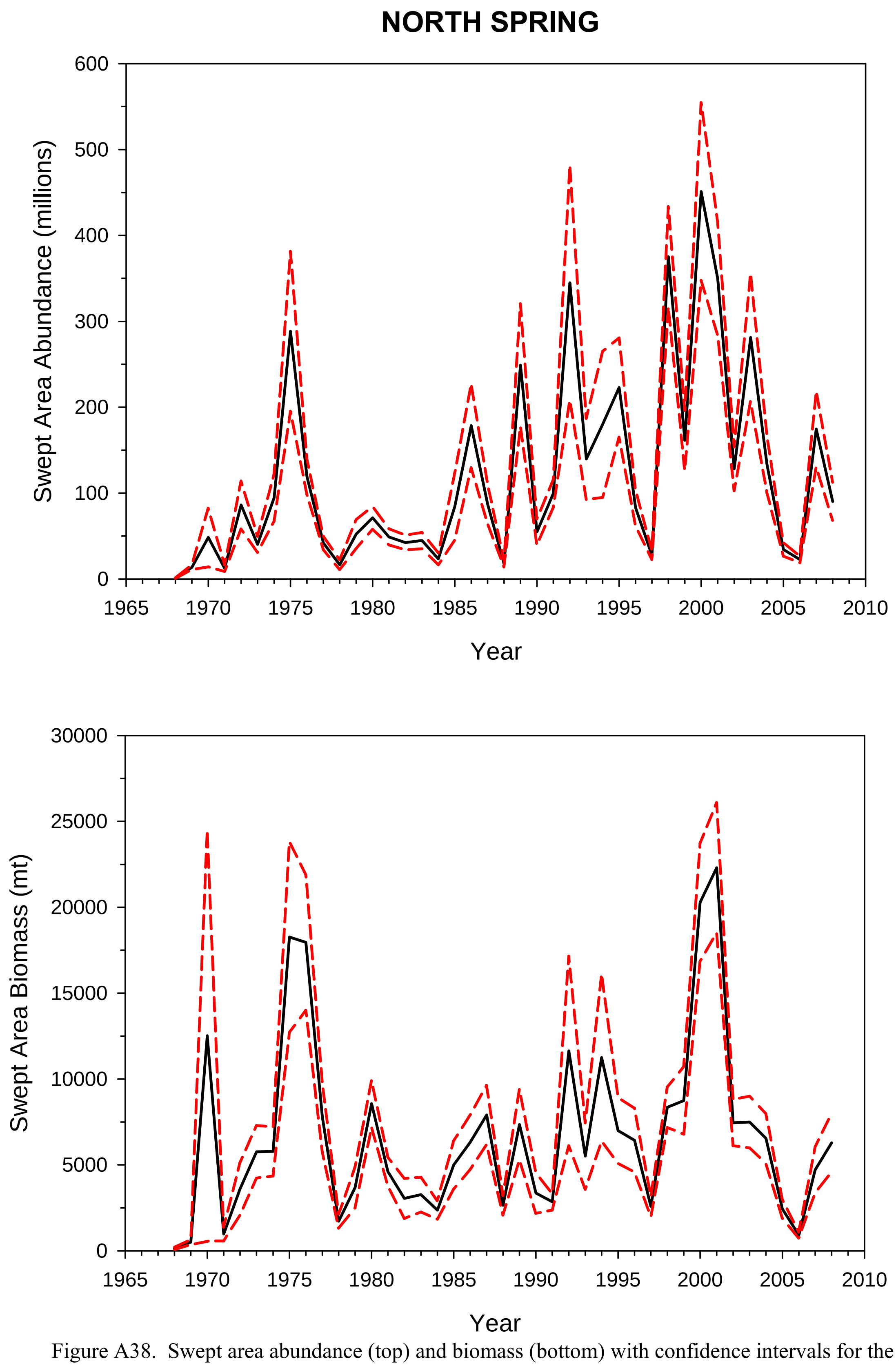
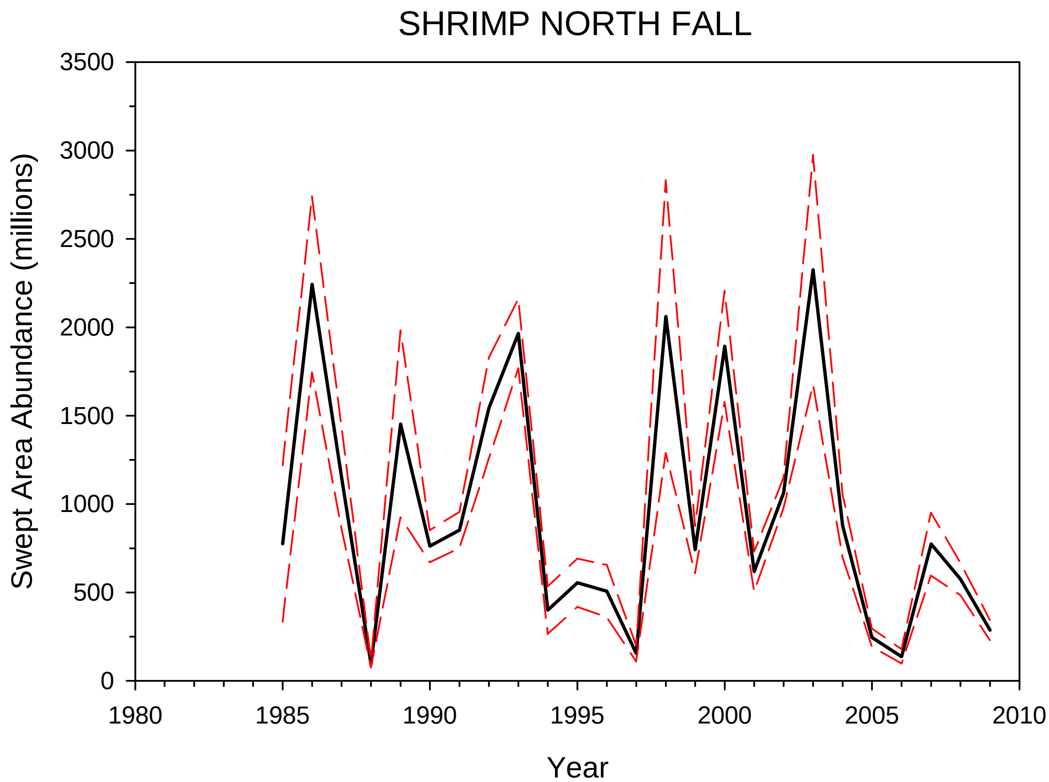


Figure A38. Swept area abundance (top) and biomass (bottom) with confidence intervals for the NEFSC spring survey in the northern management region.



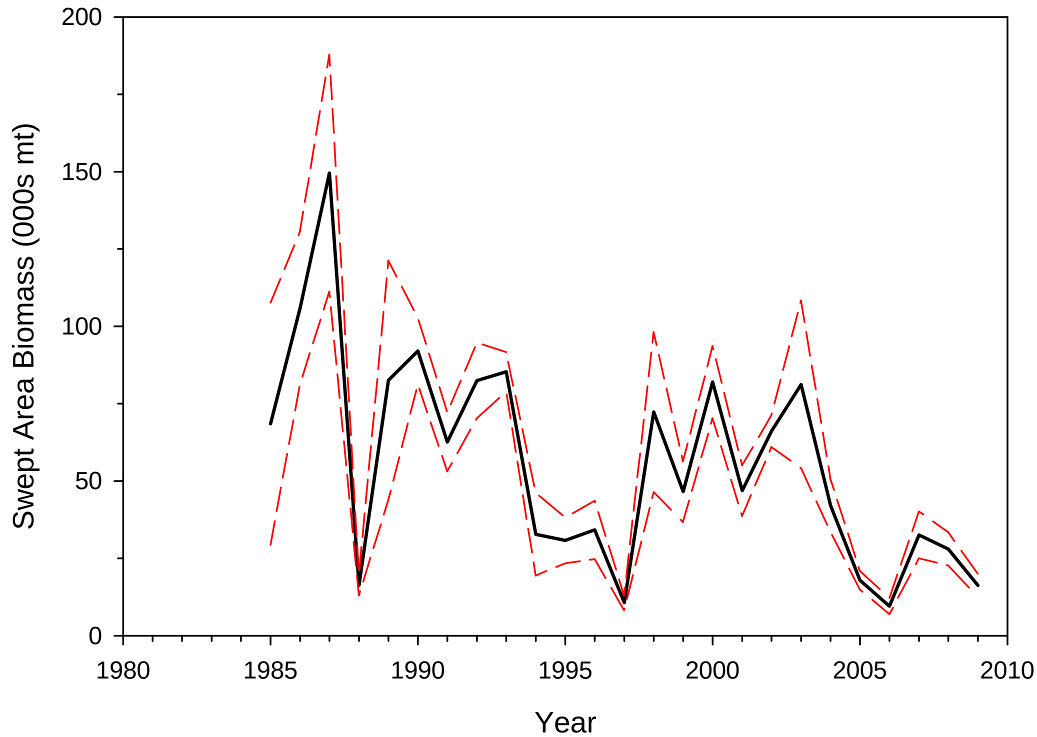


Figure A39. Swept area abundance (top) and biomass (bottom) with confidence intervals for the NEFSC shrimp survey.

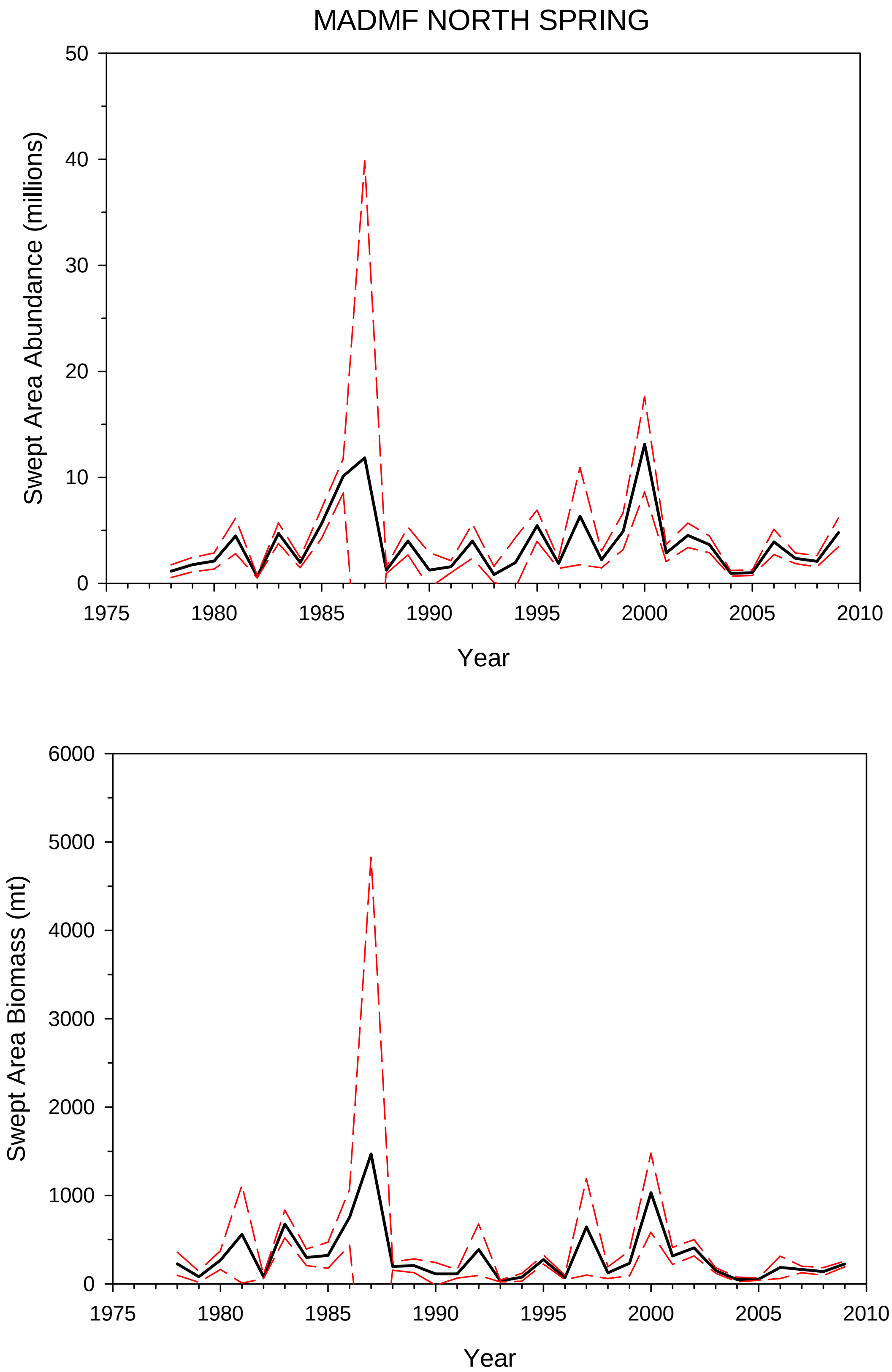
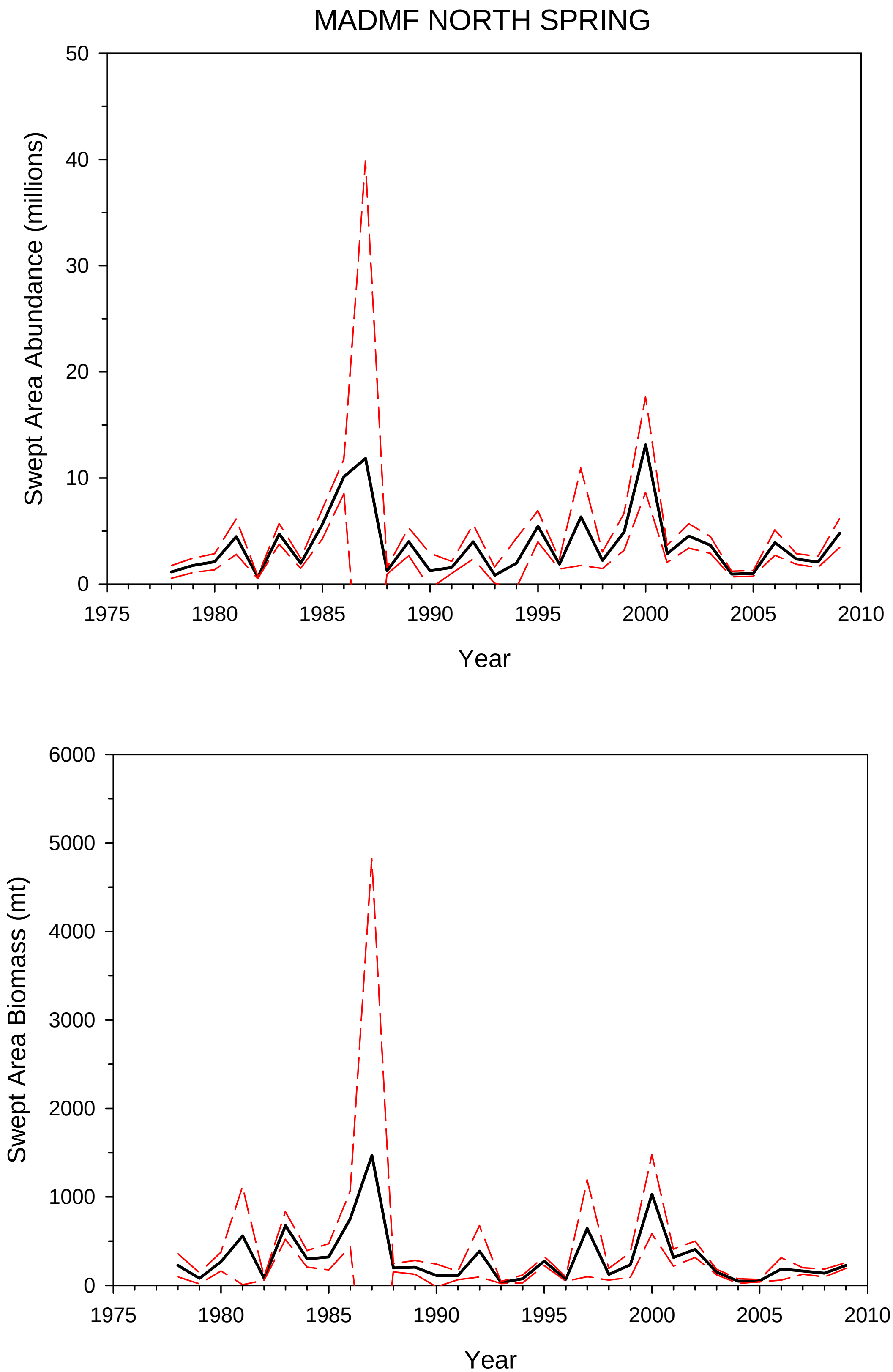
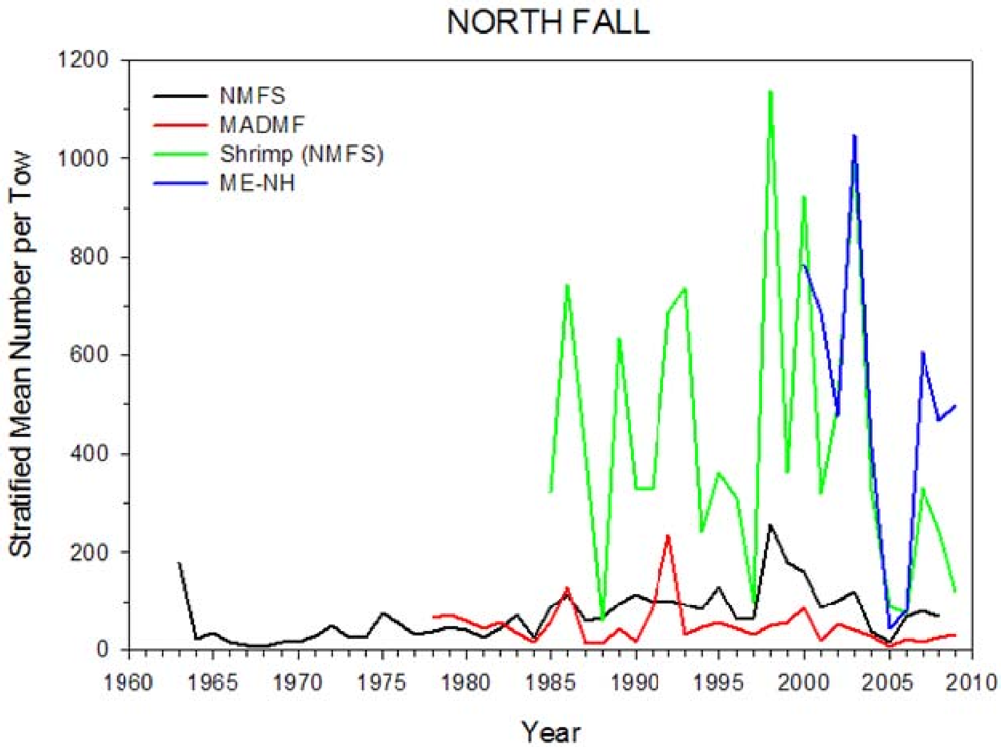


Figure A40. Swept area abundance (top) and biomass (bottom) with confidence intervals for silver hake from the Massachusetts Division of Marine Fisheries fall north survey (strata 18-36).



A41. Swept area abundance (top) and biomass (bottom) with confidence intervals for silver hake from the Massachusetts Division of Marine Fisheries spring north survey (strata 18-36).



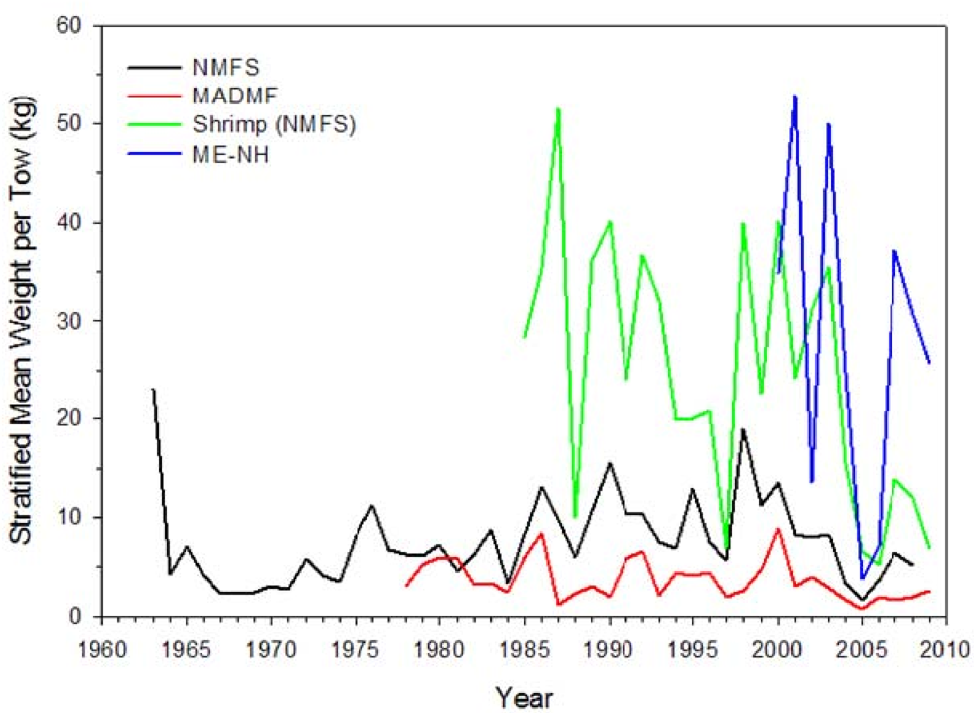
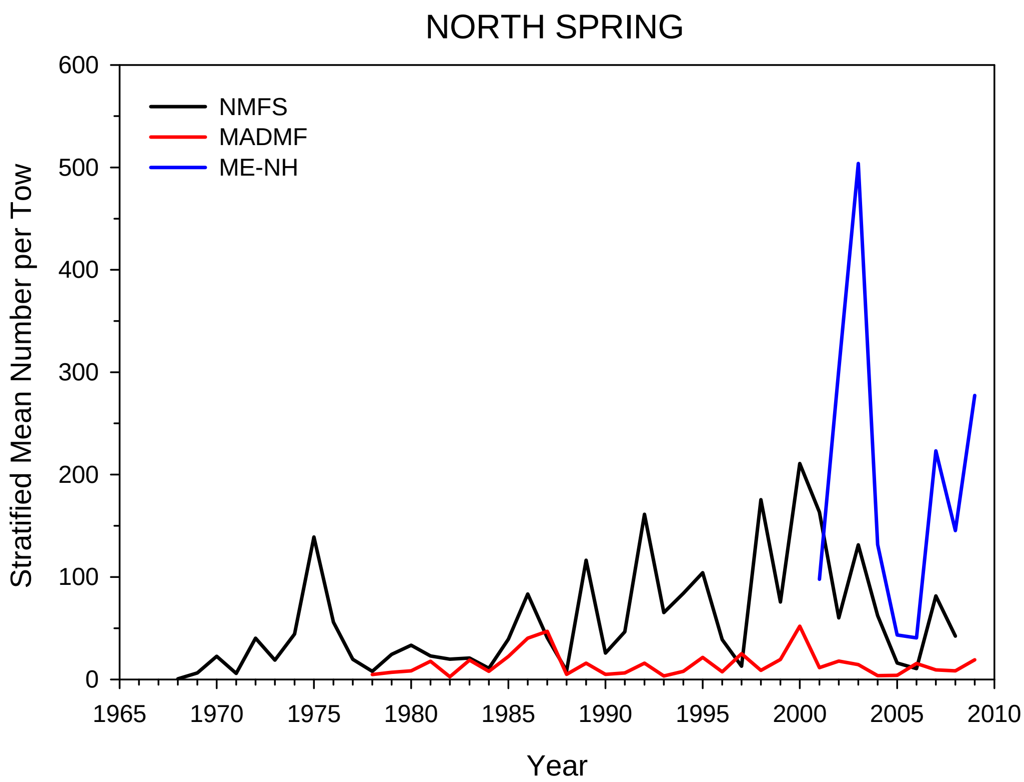


Figure A42. Survey abundances (millions of fish) and biomass (mt) for silver hake from the fall NEFSC, MADMF, and shrimp surveys.



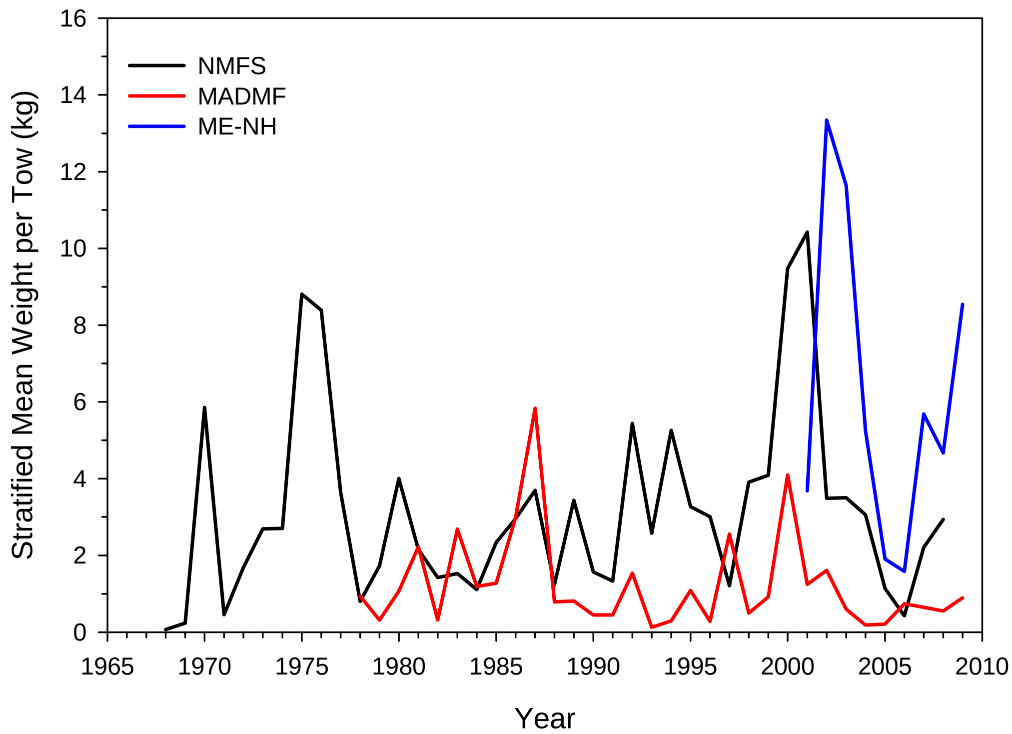


Figure A43. Survey abundances (millions of fish) and biomass (mt) for silver hake from the spring NEFSC, MADMF, and Maine-New Hampshire state surveys.

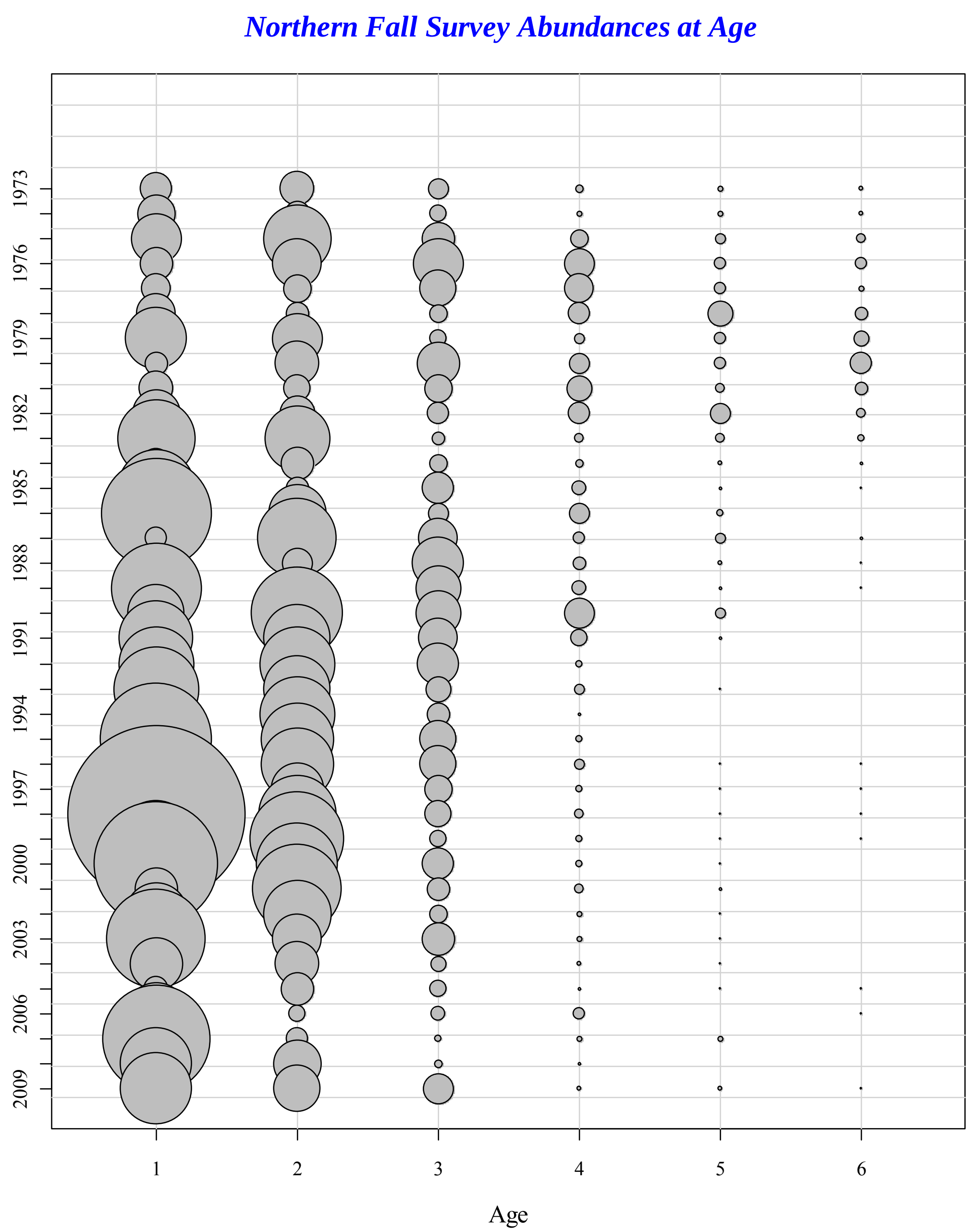


Figure A44. Silver hake age specific indices of abundance for the fall survey in the northern stock area. The area of the bubble plot is proportional to the magnitude.

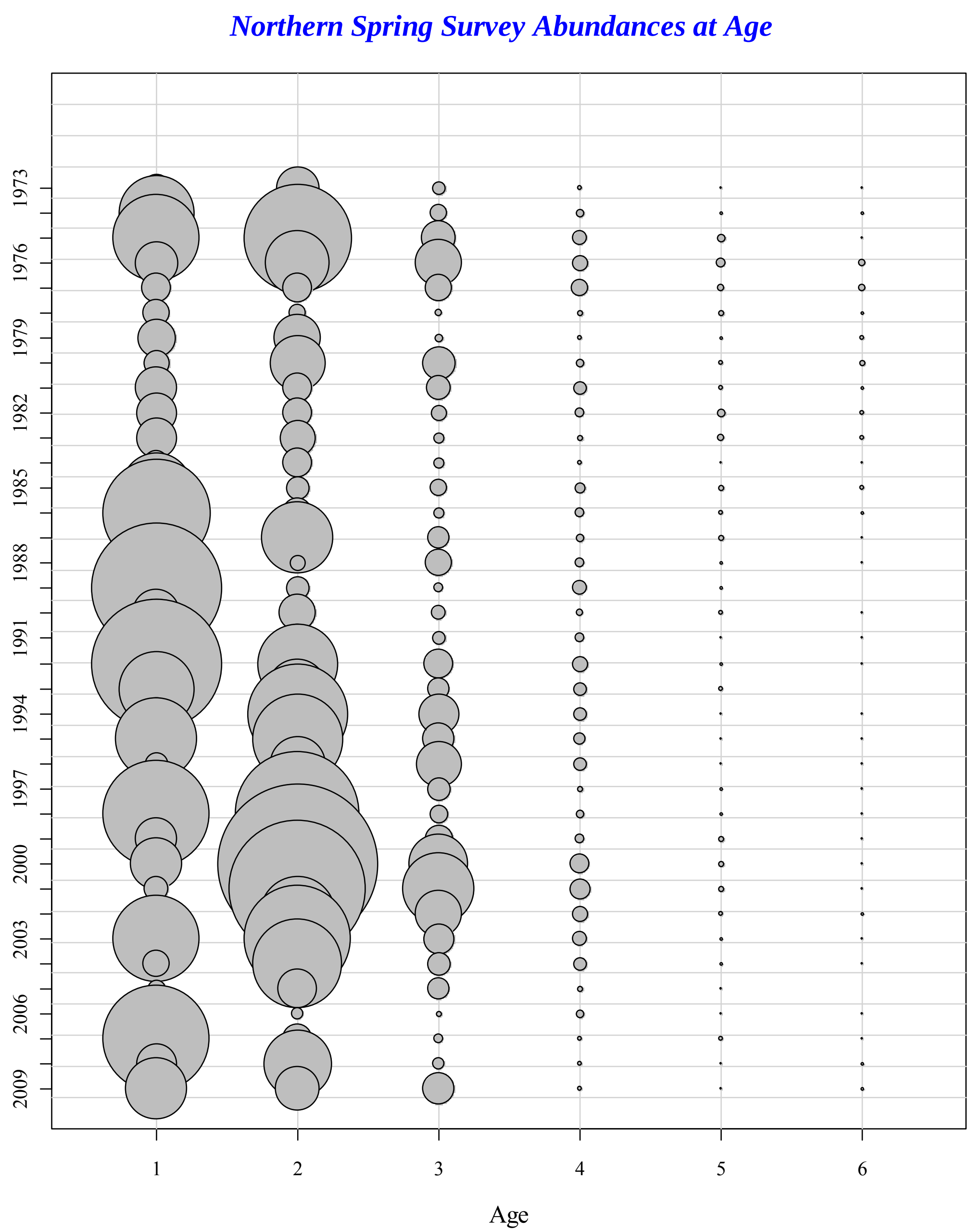


Figure A45. Silver hake age specific indices of abundance for the spring survey in the northern stock area. The area of the bubble plot is proportional to the magnitude.

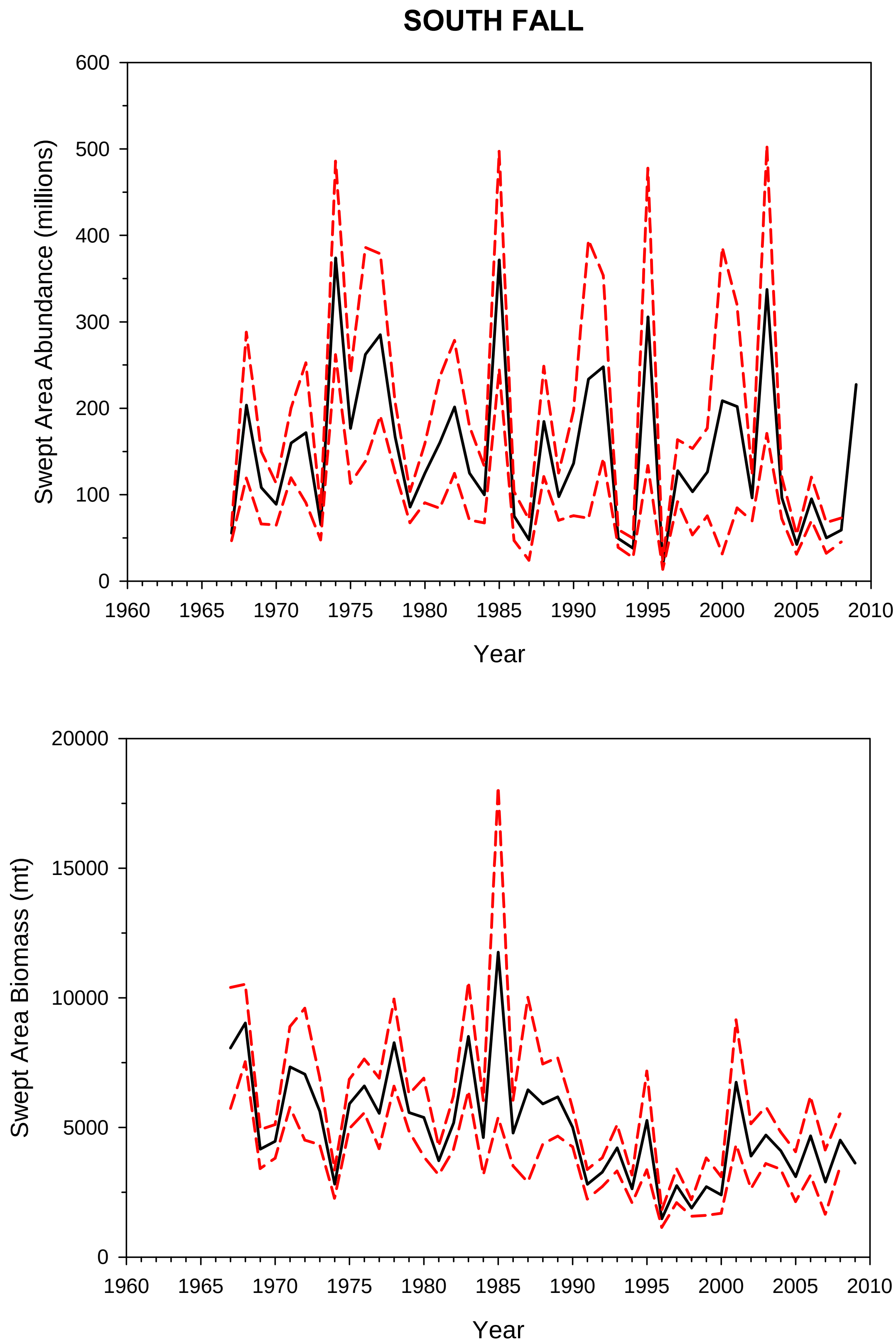


Figure A46. Swept area abundance (top) and biomass (bottom) with confidence intervals for the NEFSC fall survey in the southern management region.

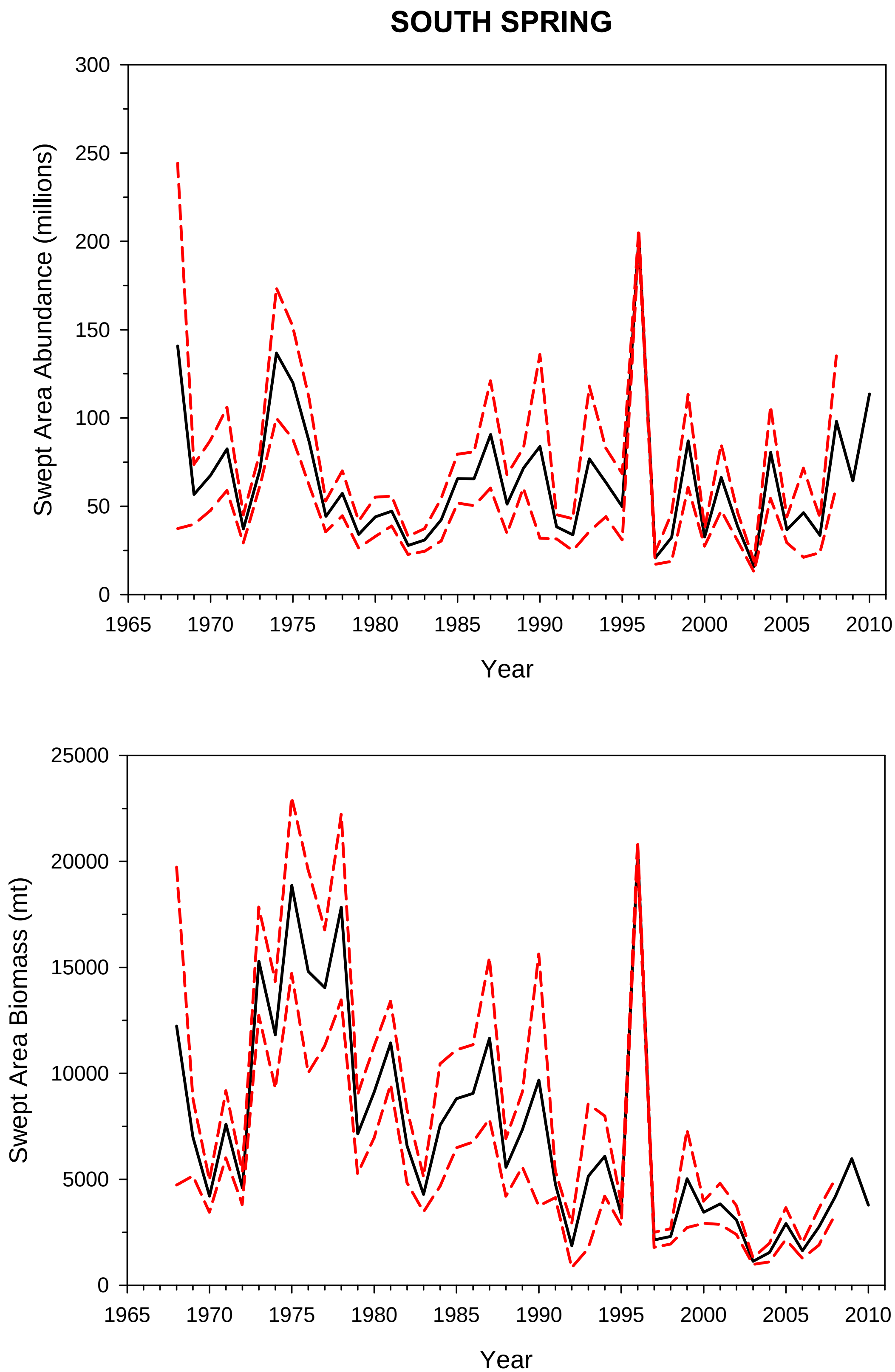


Figure A47. Swept area abundance (top) and biomass (bottom) with confidence intervals for the NEFSC spring survey in the southern management region.

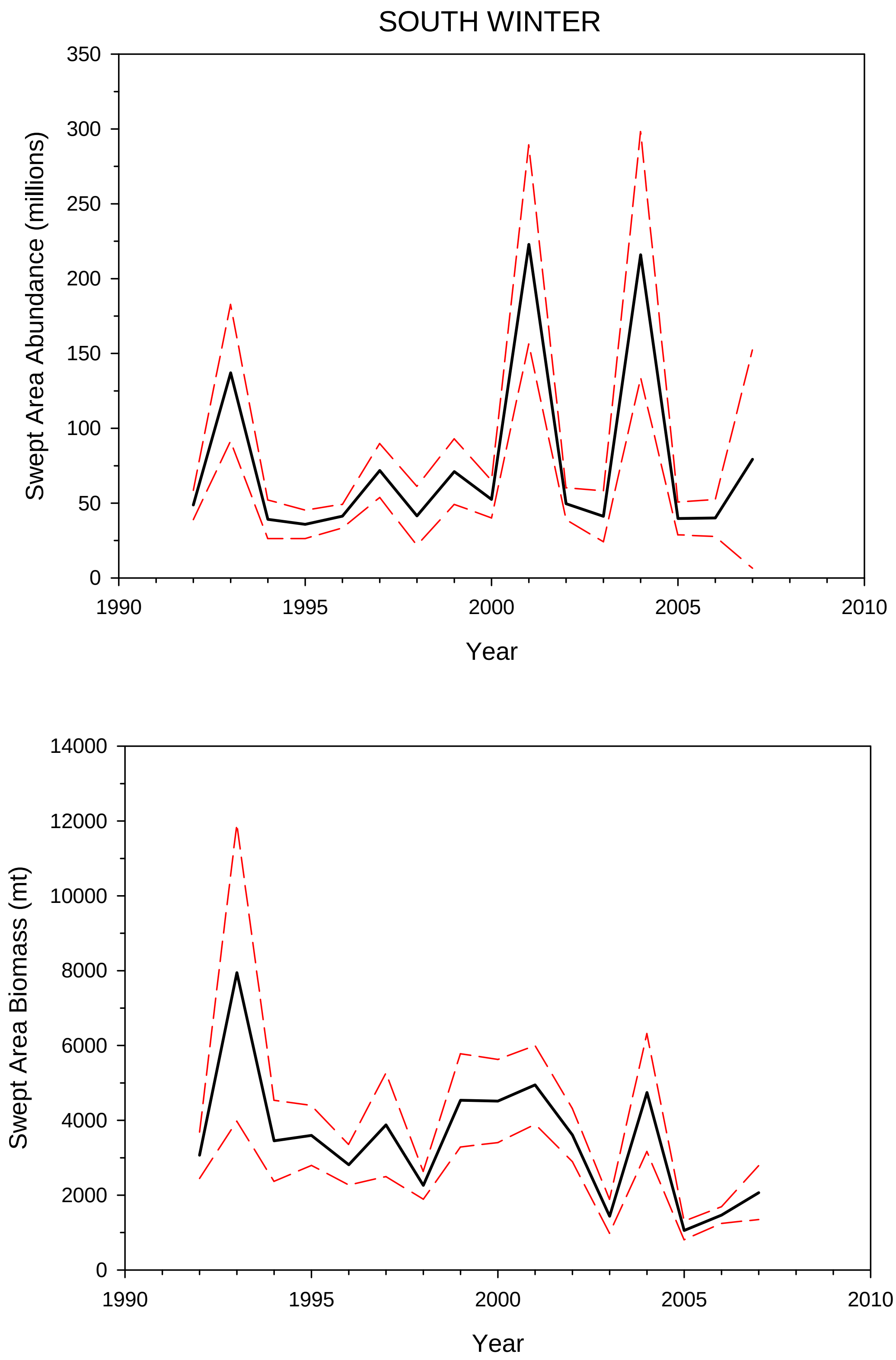
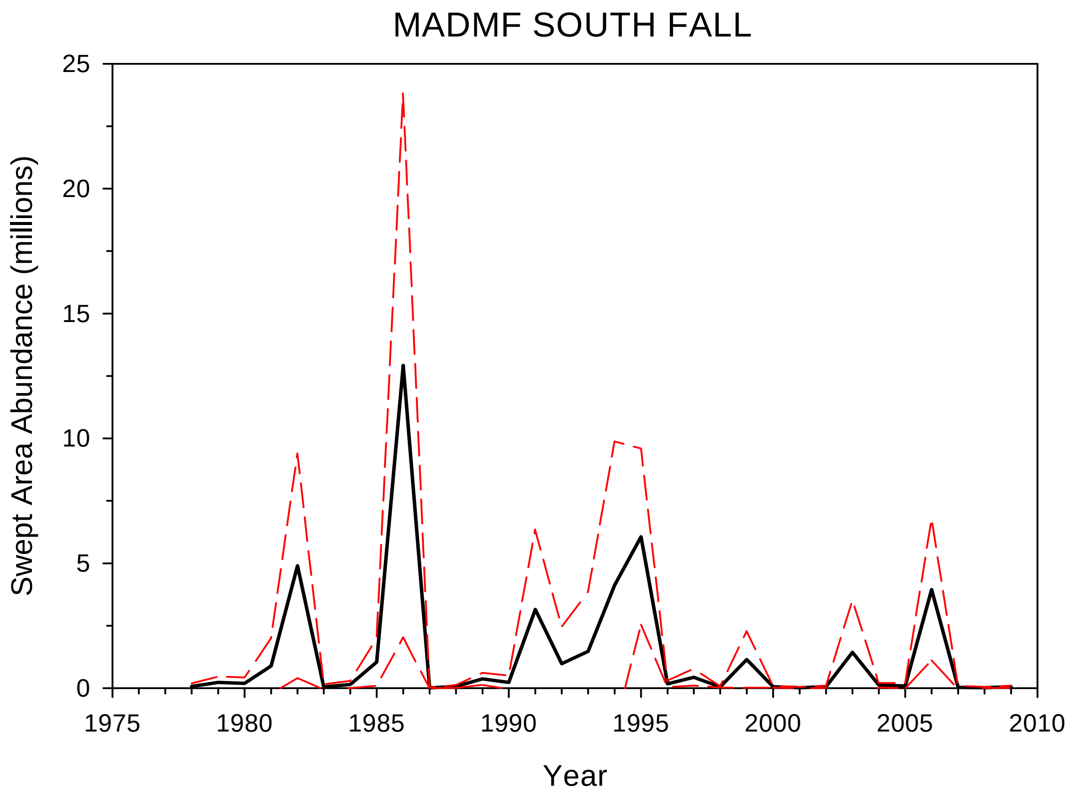


Figure A48. Swept area abundance and biomass with upper and lower confidence intervals for silver hake from the NEFSC winter survey in the southern management region.



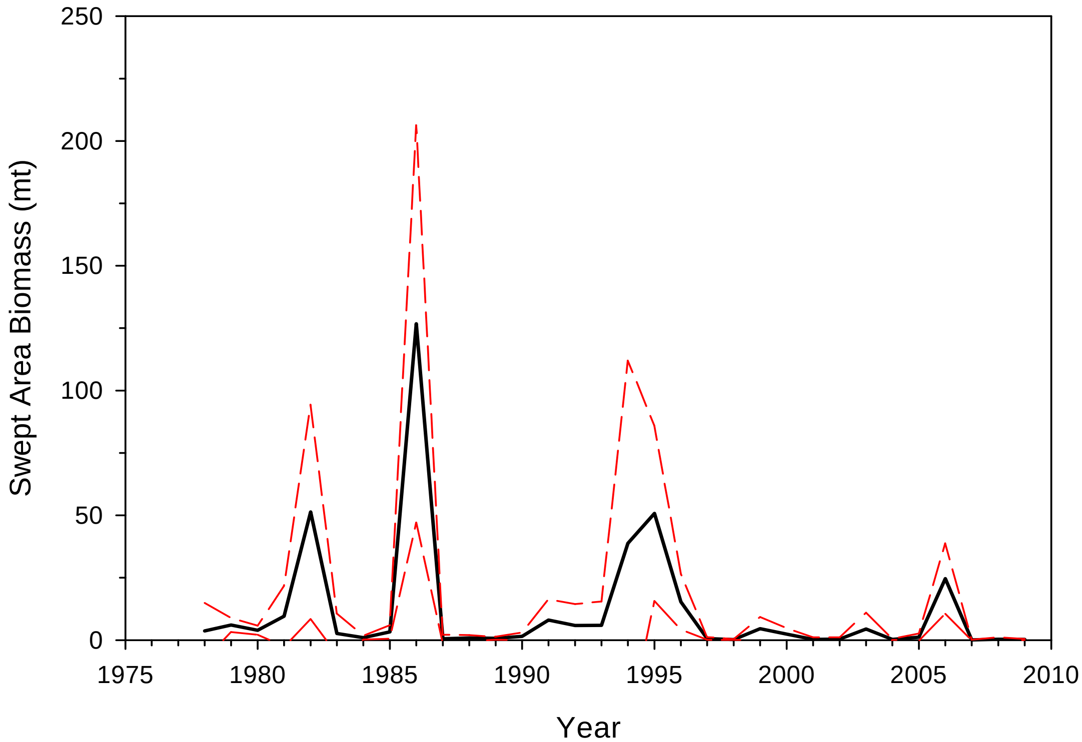
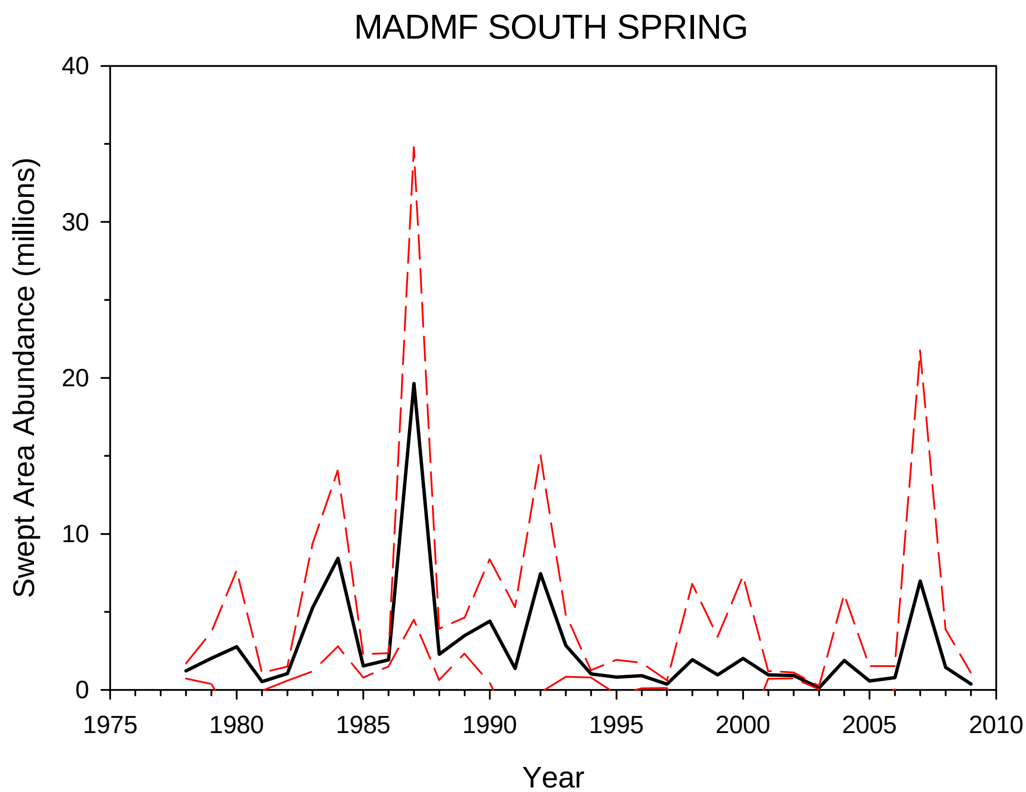


Figure A49. Swept area abundance (top) and biomass (bottom) with confidence intervals for silver hake from the Massachusetts Division of Marine Fisheries fall south survey (strata 11-17).



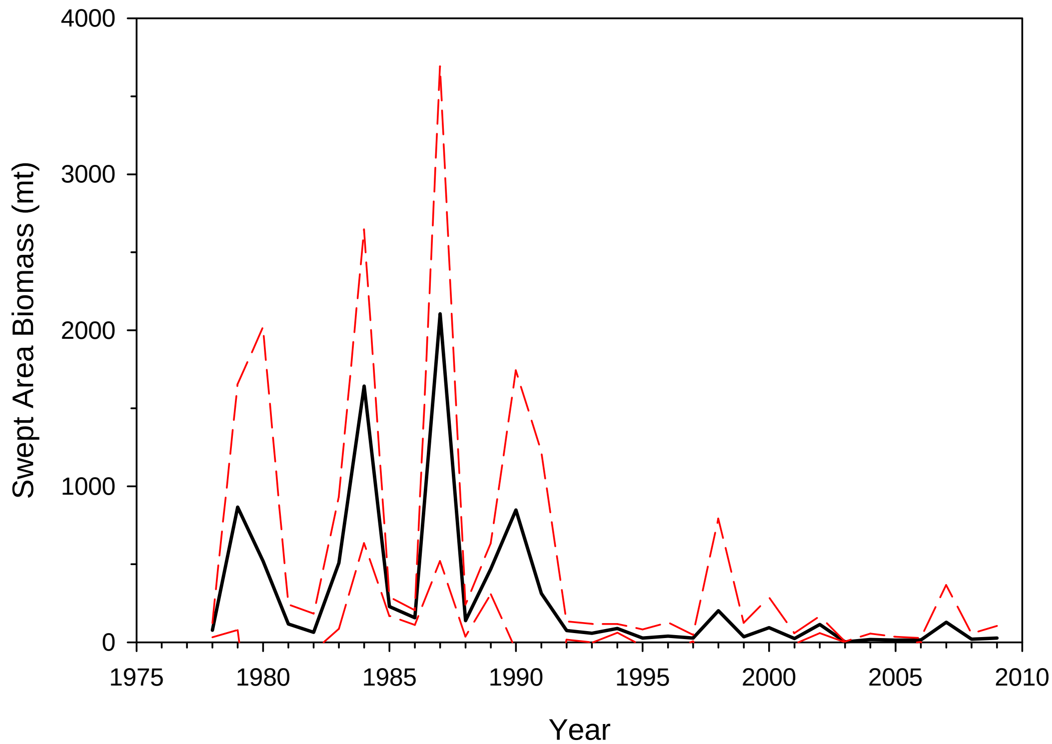


Figure A50. Swept area abundance (top) and biomass (bottom) with confidence intervals for silver hake from the Massachusetts Division of Marine Fisheries spring south survey (strata 11-17).

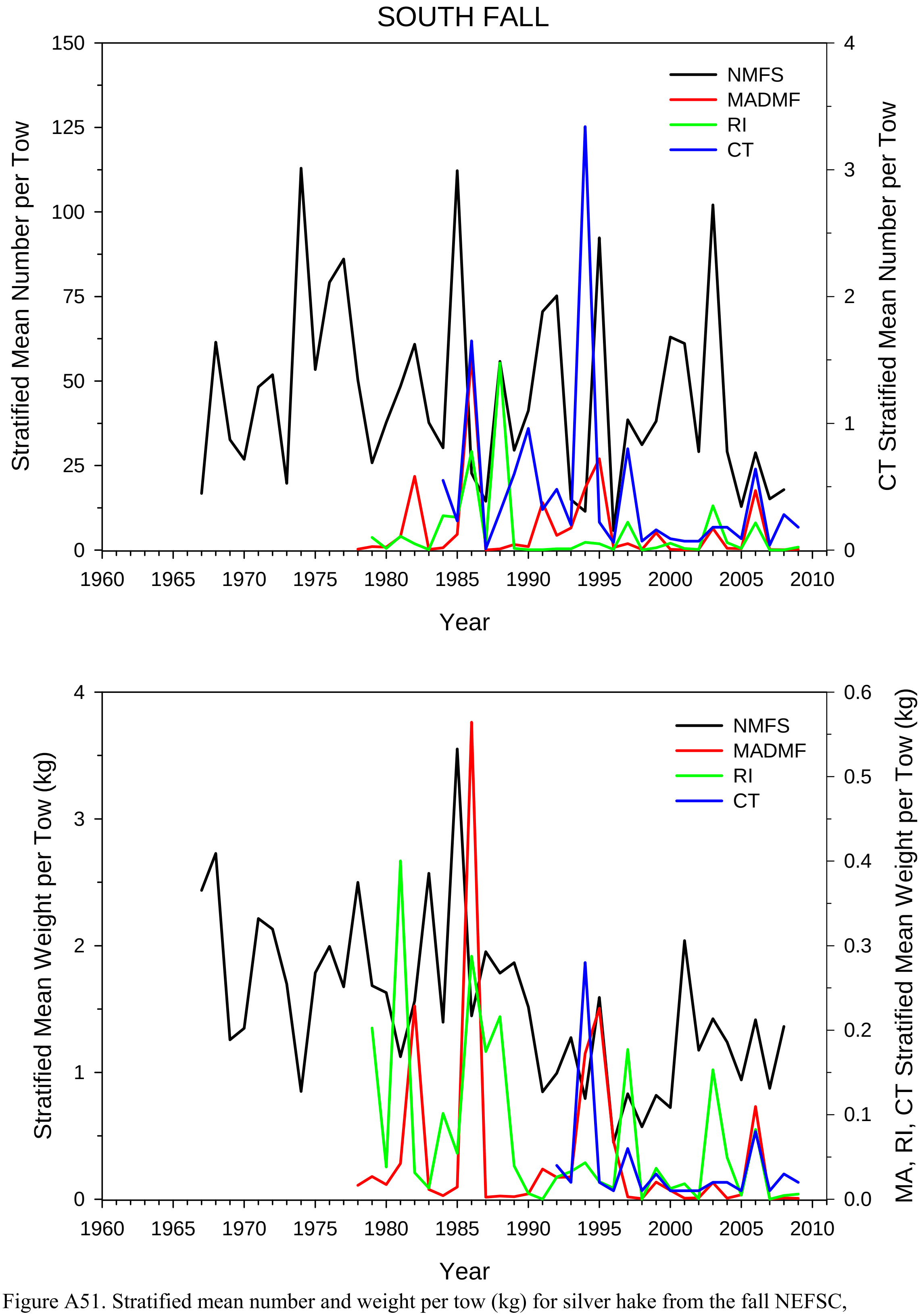
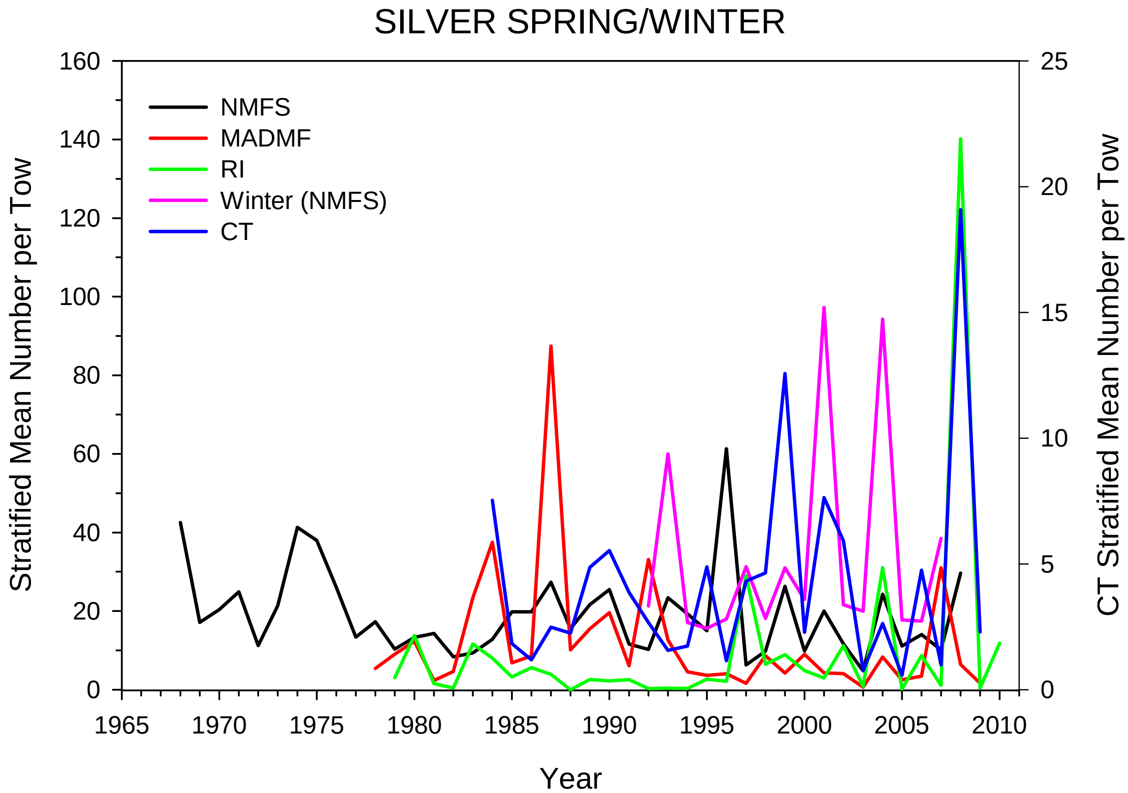


Figure A51. Stratified mean number and weight per tow (kg) for silver hake from the fall NEFSC, MADMF, Rhode Island and Connecticut state surveys.



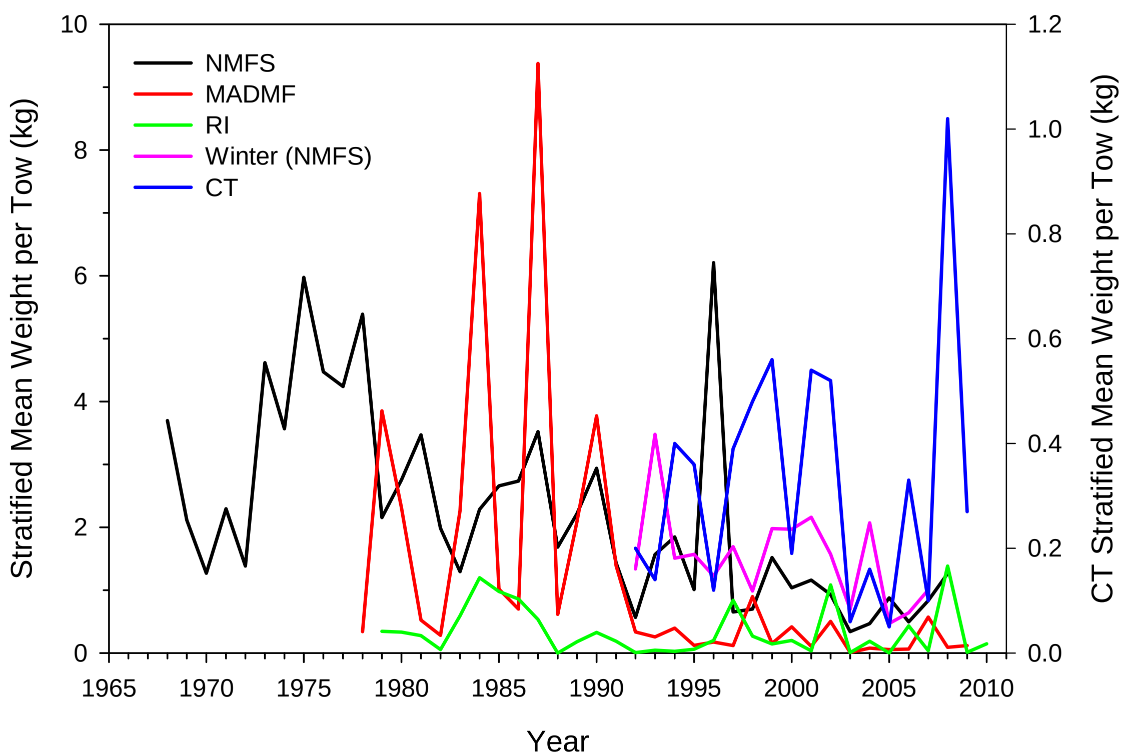


Figure A52. Stratified mean number and weight per tow (kg) for silver hake from the spring and winter NEFSC, MADMF, Rhode Island and Connecticut state surveys.

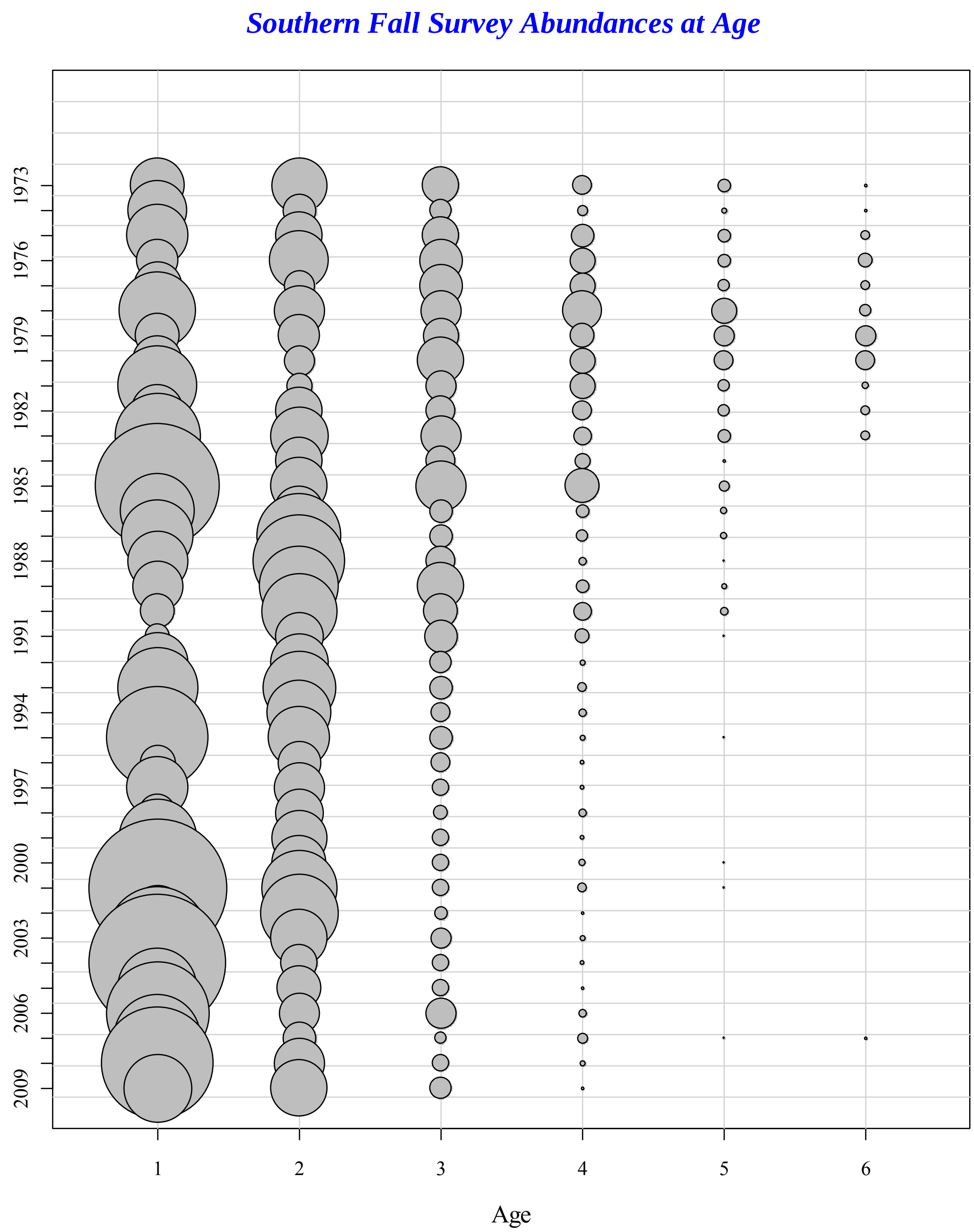


Figure A53. Silver hake age specific indices of abundance for the fall survey in the southern stock area. The area of the bubble plot is proportional to the magnitude.

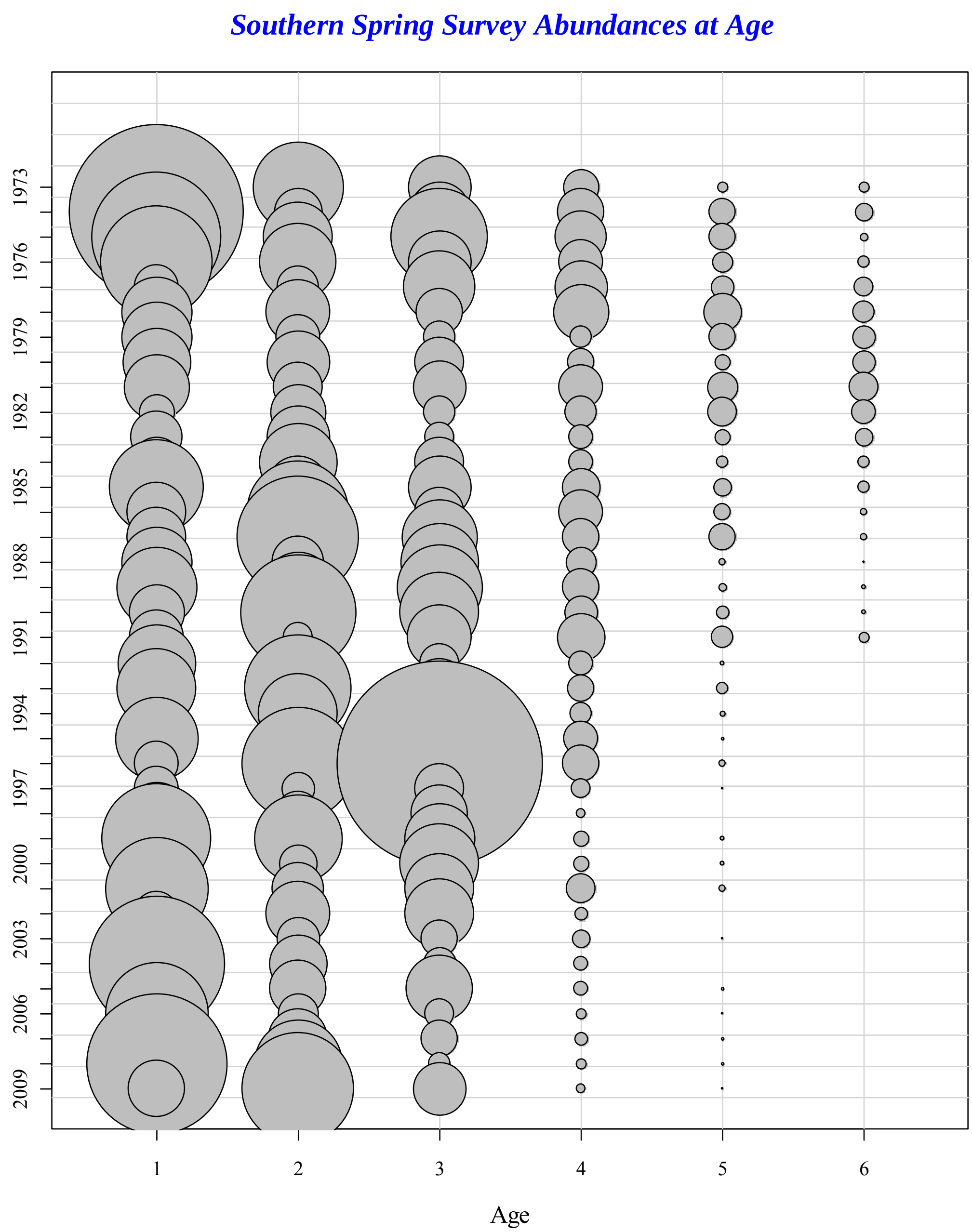
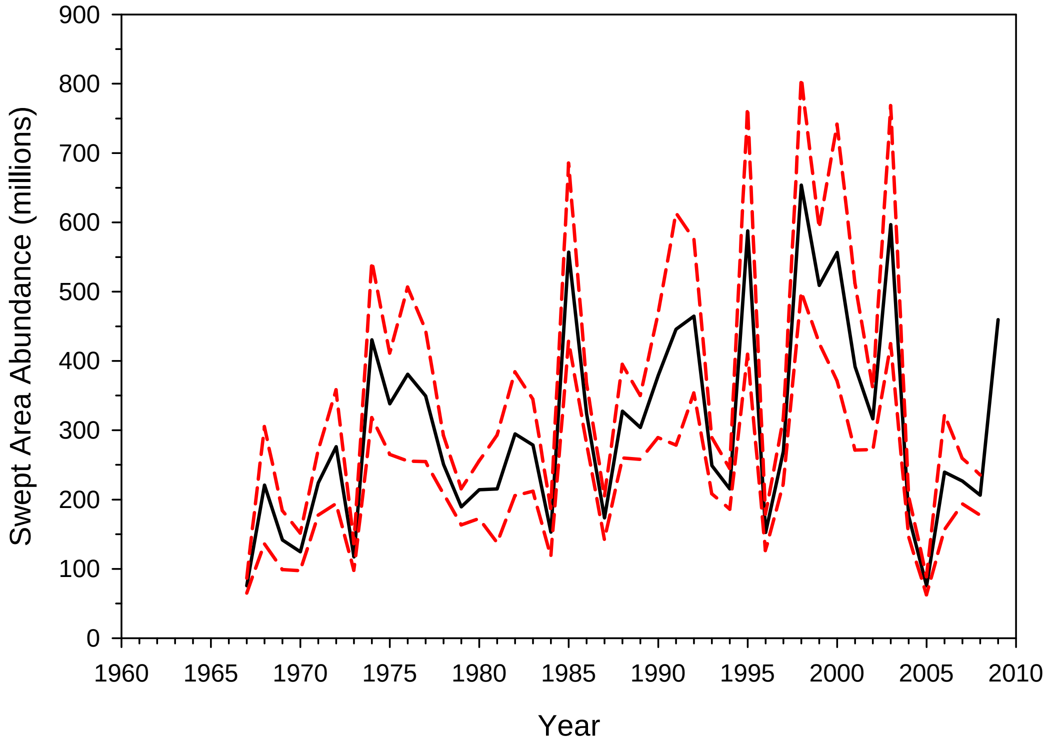


Figure A54. Silver hake age specific indices of abundance for the spring survey in the southern stock area. The area of the bubble plot is proportional to the magnitude.

COMBINED FALL



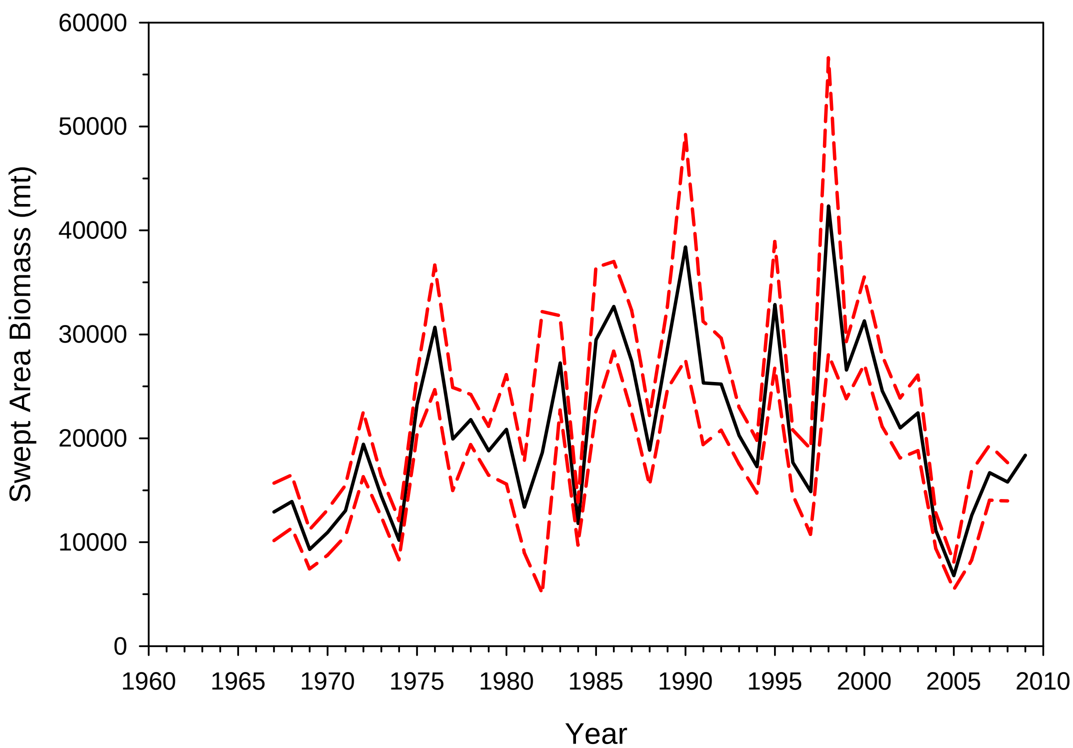


Figure A55. Swept area abundance and biomass and upper and lower confidence intervals for silver hake from the NEFSC fall bottom trawl surveys in the northern and southern management regions combined.

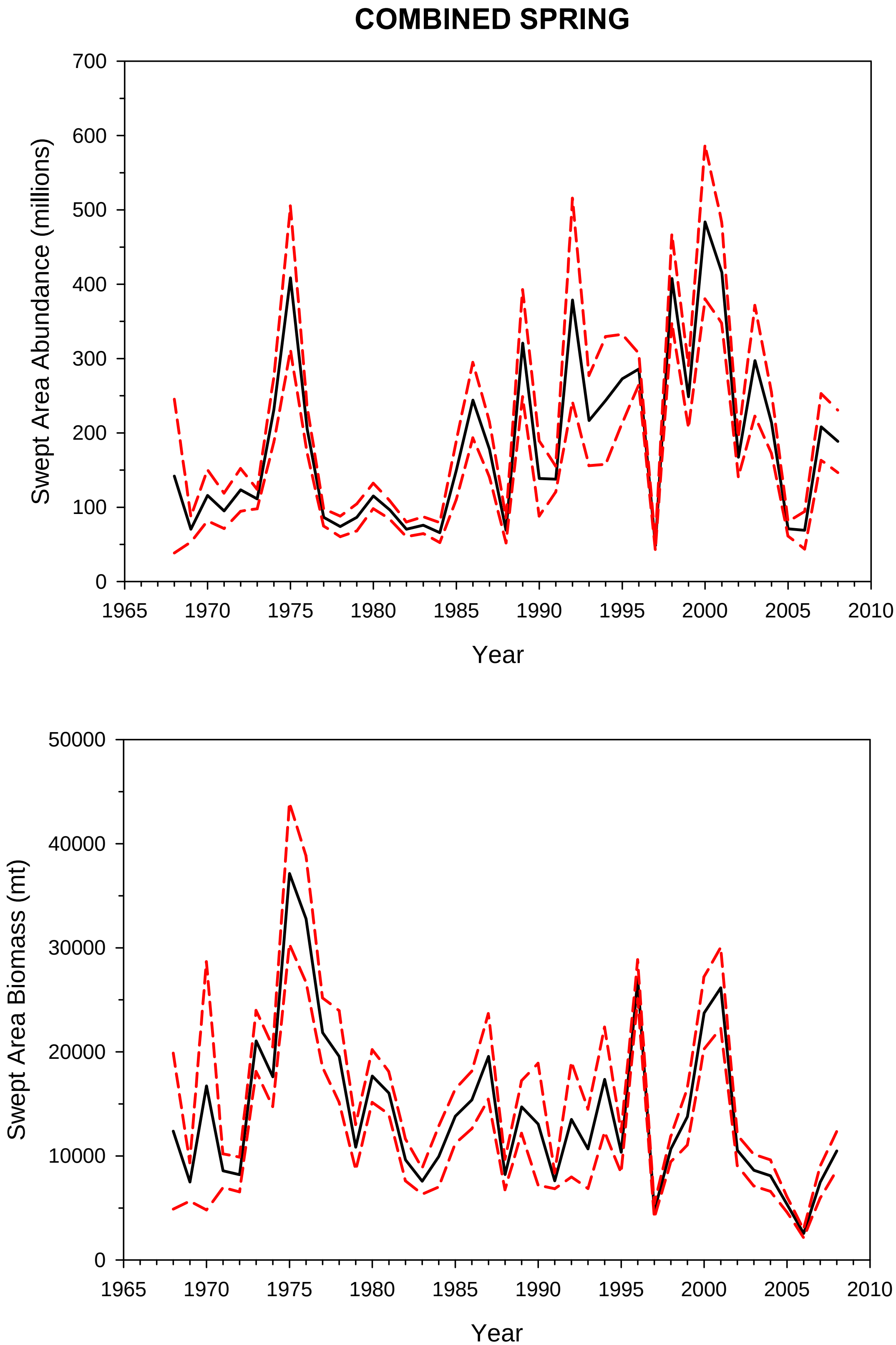


Figure A56. Swept area abundance and biomass and upper and lower confidence intervals for silver hake from the NEFSC spring bottom trawl surveys in the northern and southern management regions combined.

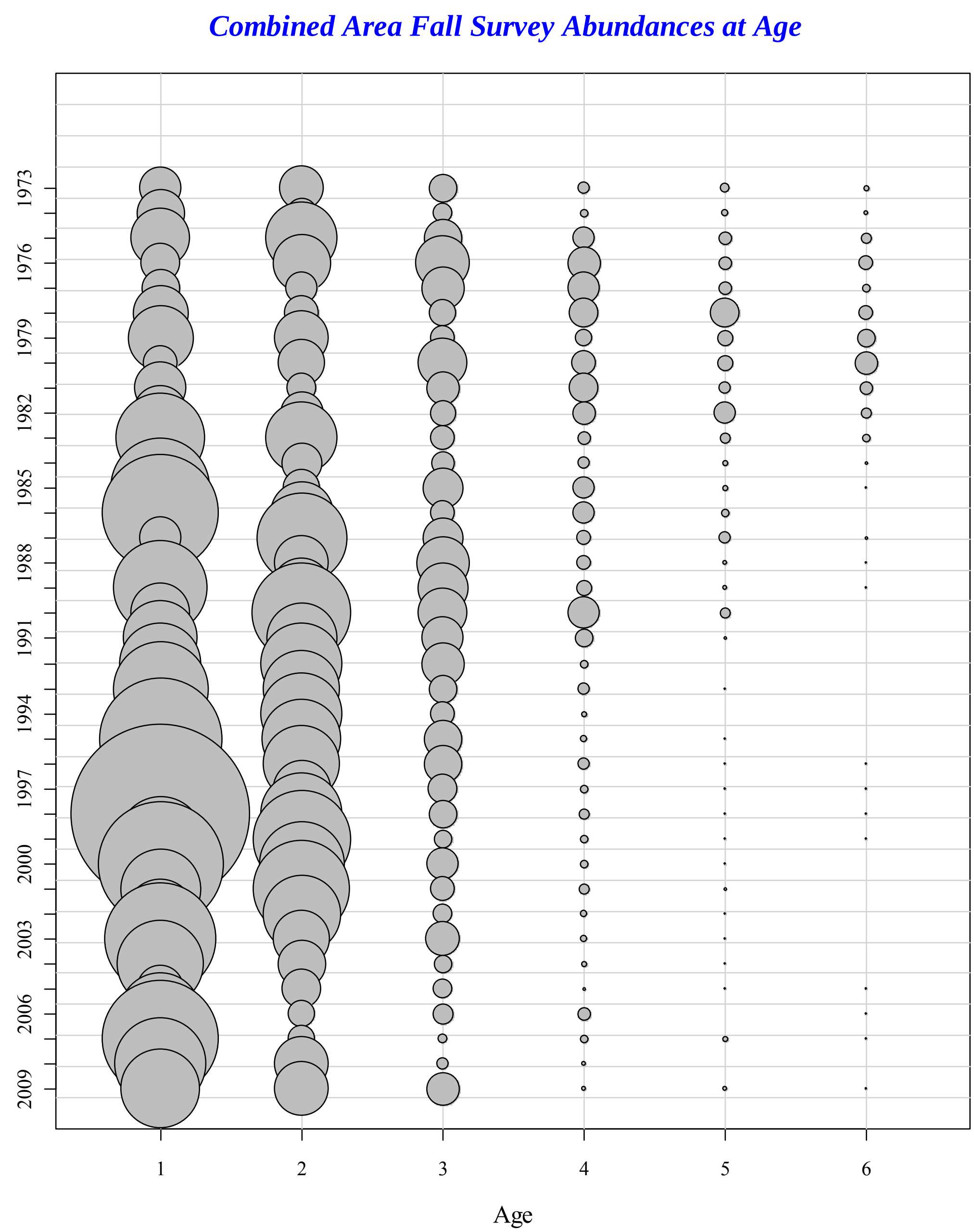


Figure A57 Silver hake age specific fall survey indices of abundance for the combined stock areas. The area of the bubble plot is proportional to the magnitude.

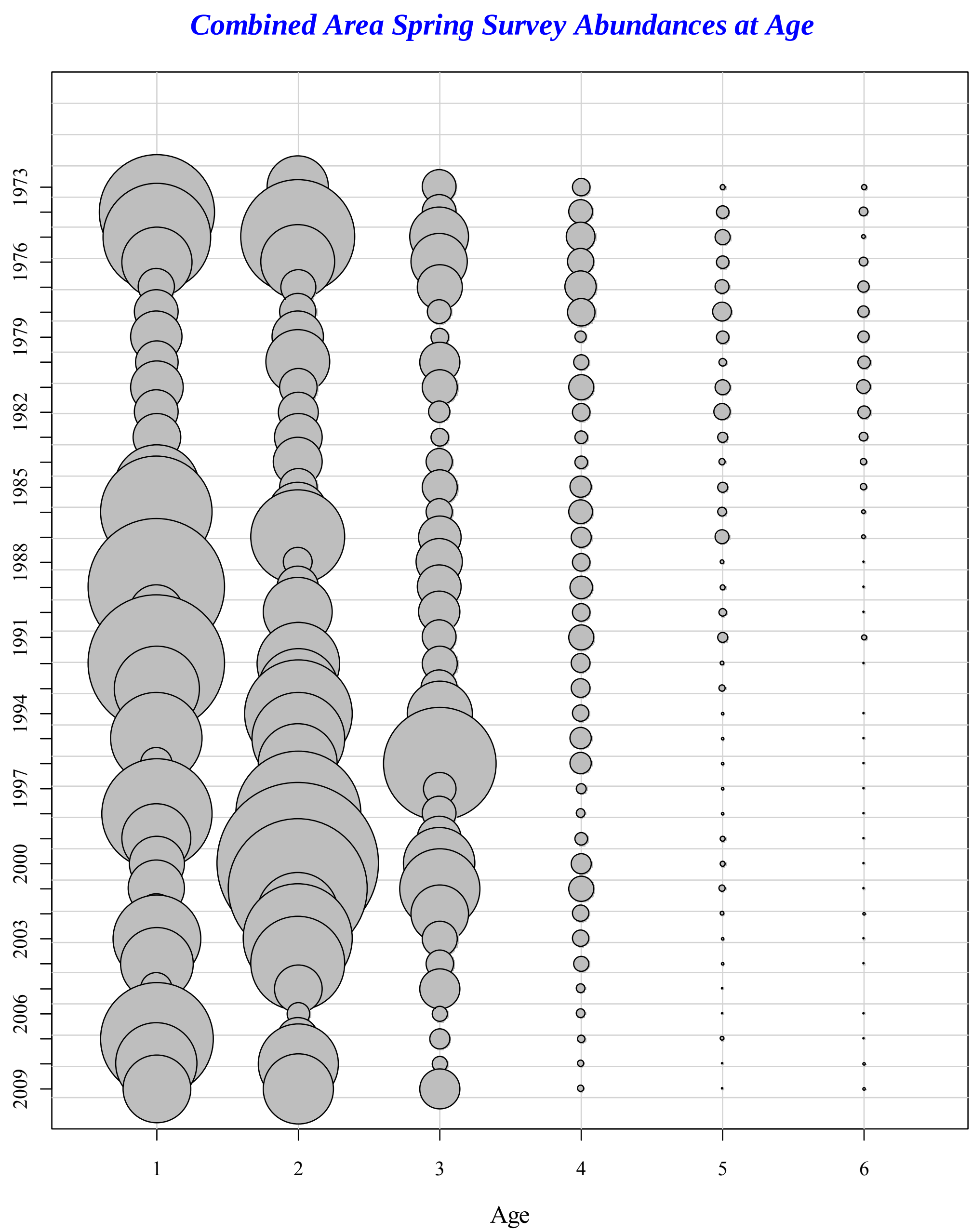


Figure A58. Silver hake age specific spring survey indices of abundance for the combined stock areas. The area of the bubble plot is proportional to the magnitude.

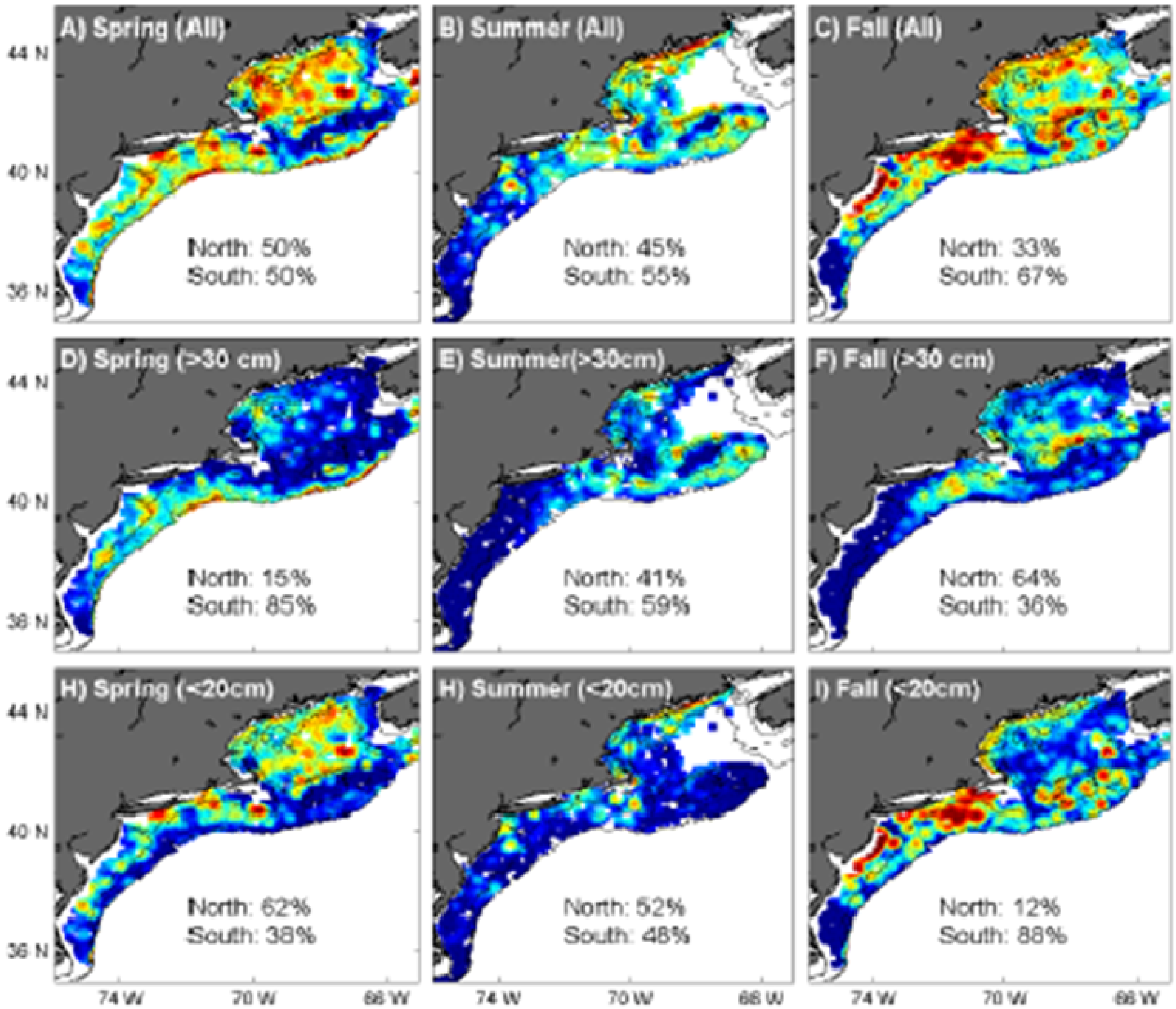
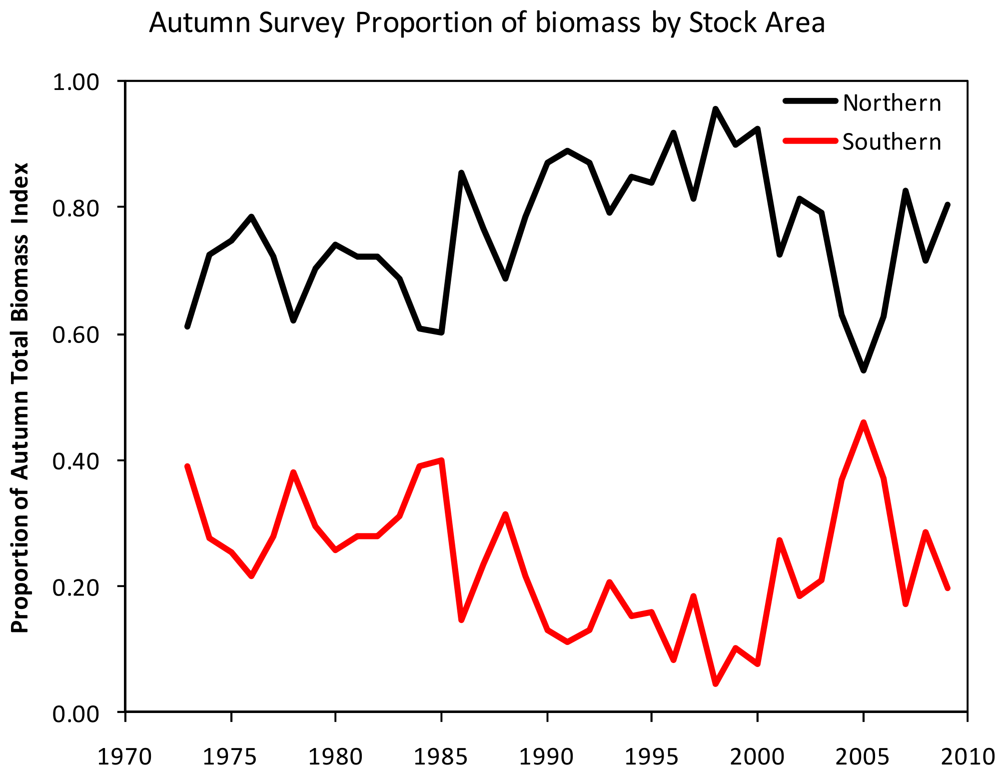


Figure A59: Distribution of silver hake during the NEFSC trawl surveys in the spring, summer and fall of 1977-1981. The summer >30 cm size class should correspond to the spawning distribution of silver hake.



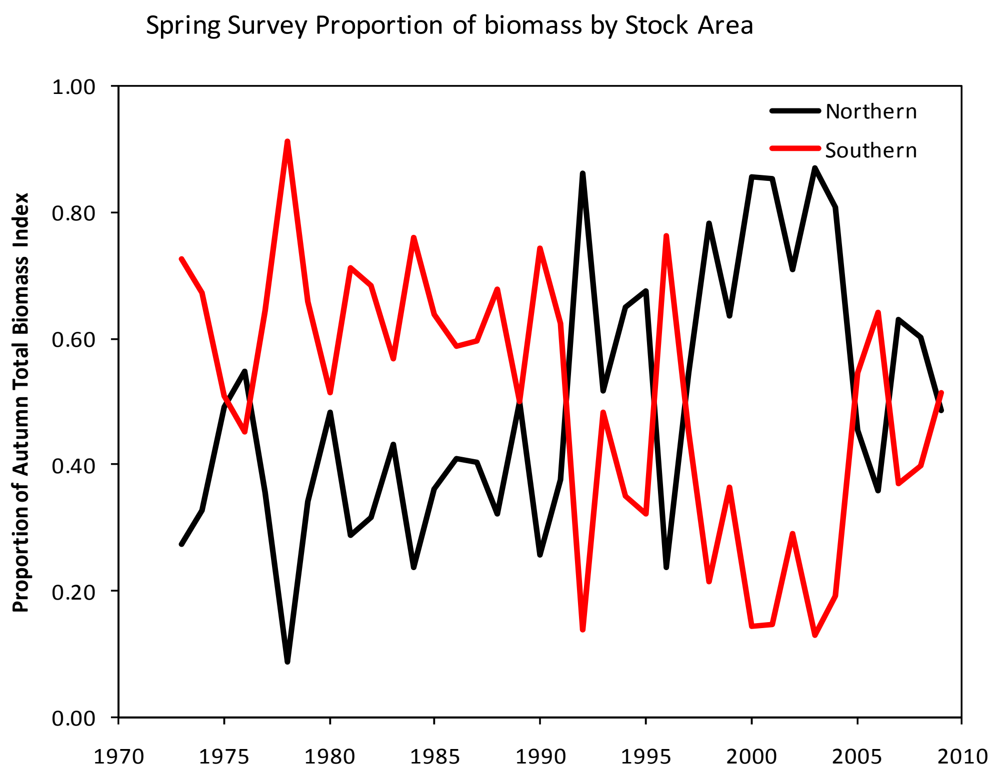


Figure A60: Autumn (top) and spring (bottom) survey distribution of silver hake by area.

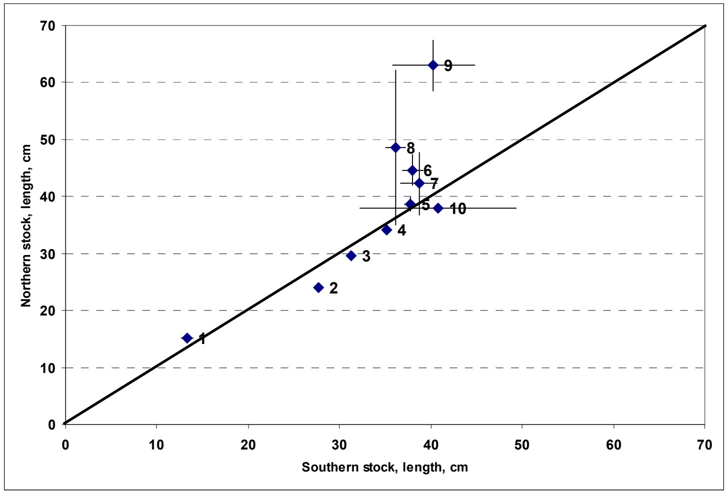
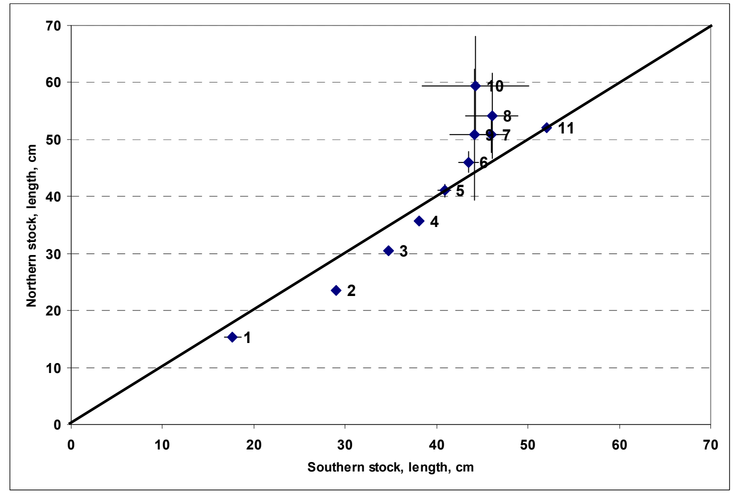
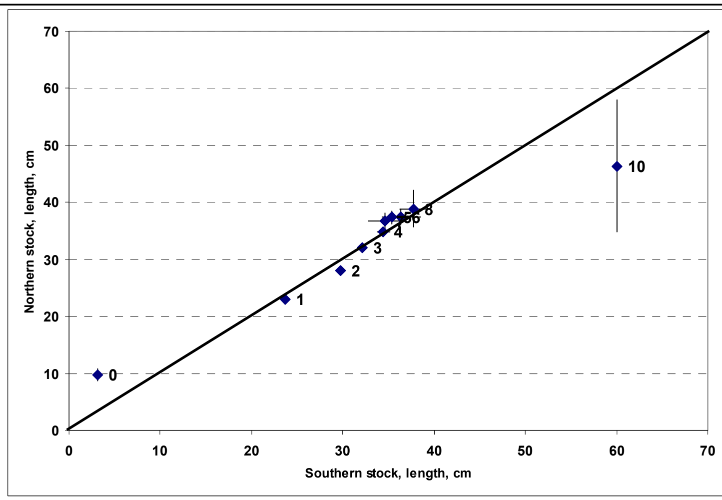
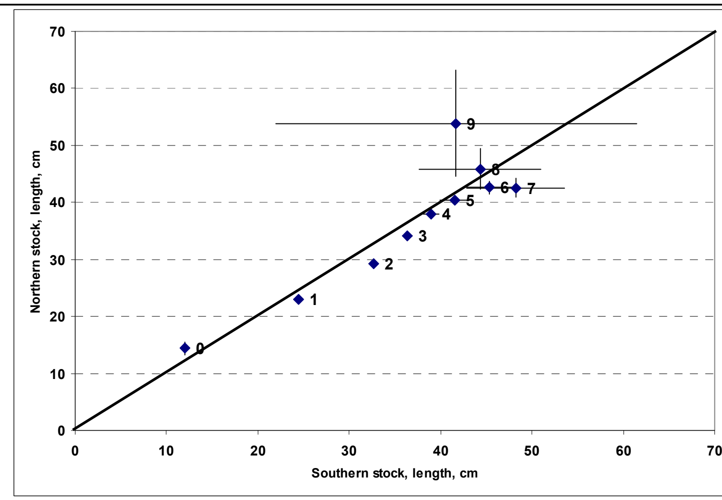
Silver hake	Males	Females
Spring		
Fall		

Figure A61. Size (cm total length) at age comparison between silver hake caught in strata 1-19, 61-76 (Southern stock) and strata 20-40 (Northern stock) for 1962-1979 cohorts.

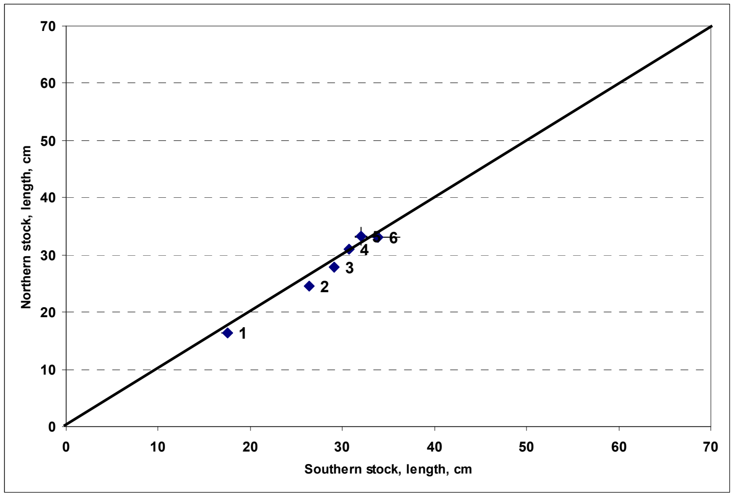
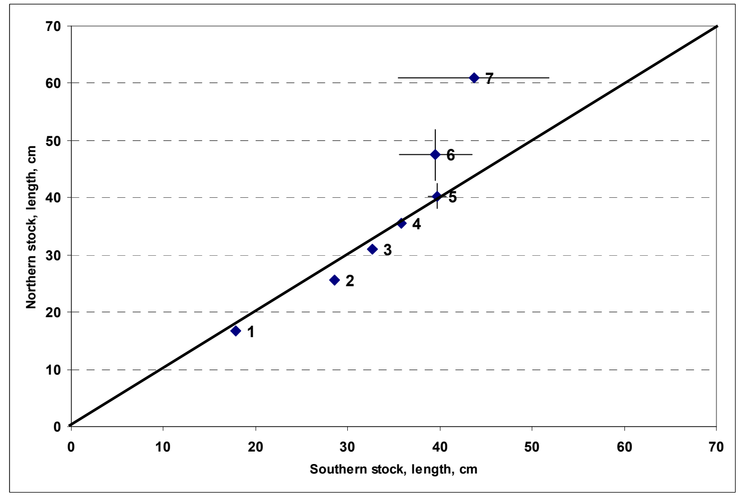
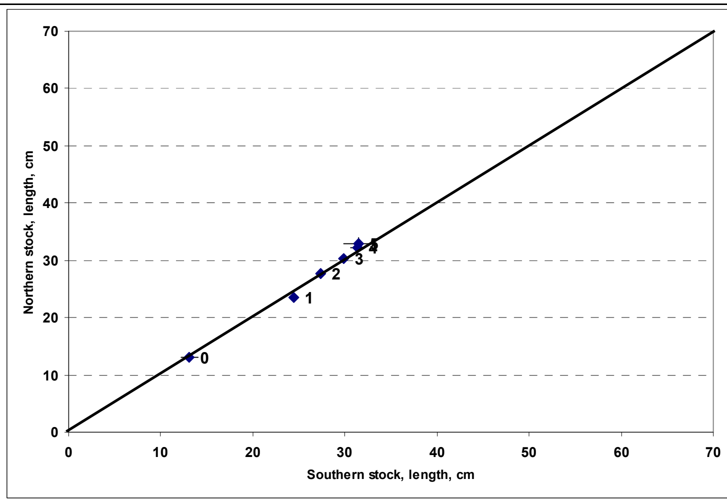
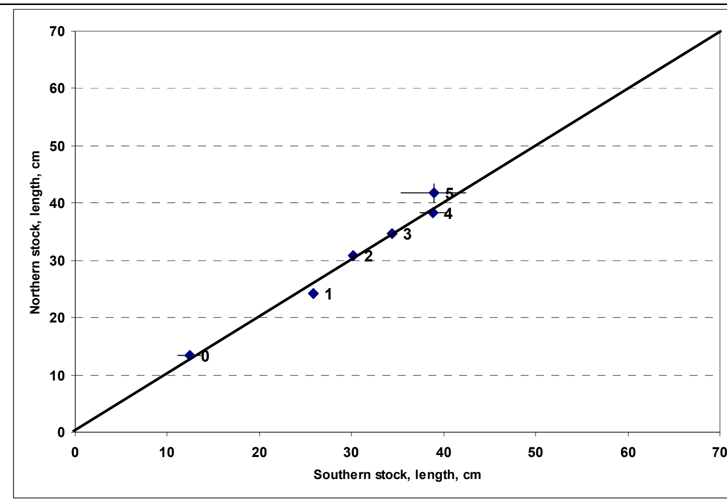
Silver hake	Males	Females
Spring		
Fall		

Figure A62. Size (cm total length) at age comparison between silver hake caught in strata 1-19, 61-76 (Southern stock) and strata 20-40 (Northern stock) for 1980-1989 cohorts.

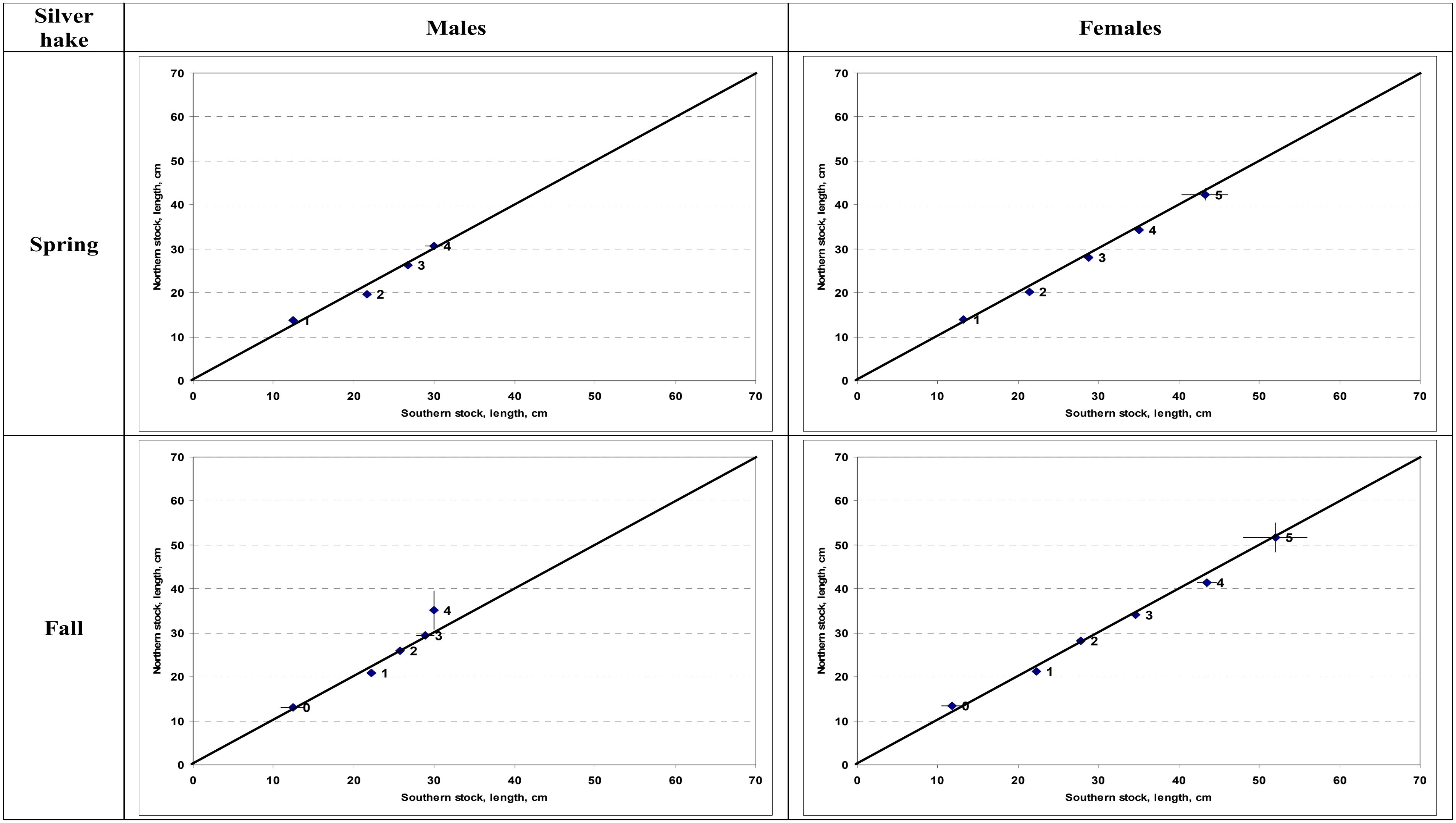


Figure A63. Size (cm total length) at age comparison between red hake caught in strata 1-19, 61-76 (Southern stock) and strata 20-40 (Northern stock) for 1990-1999 cohorts.

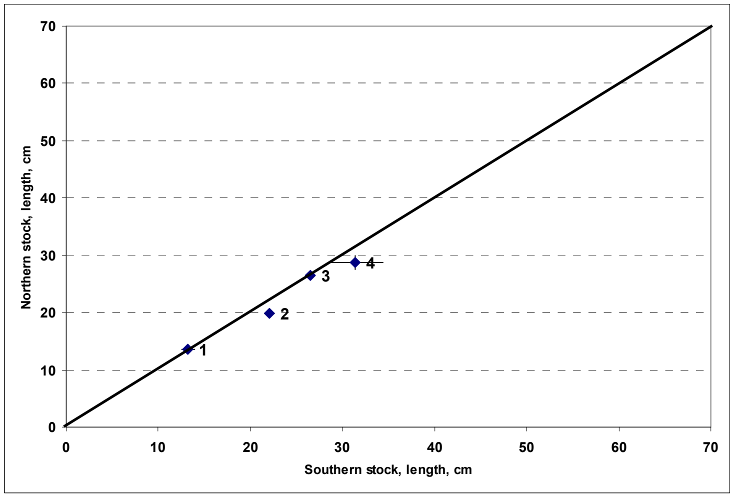
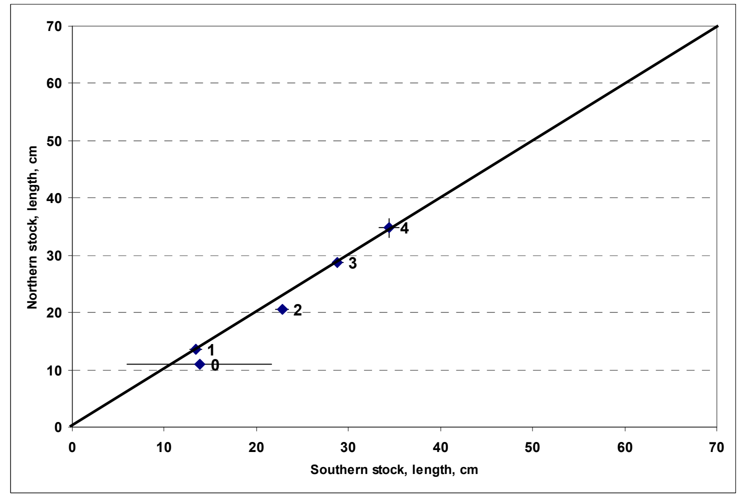
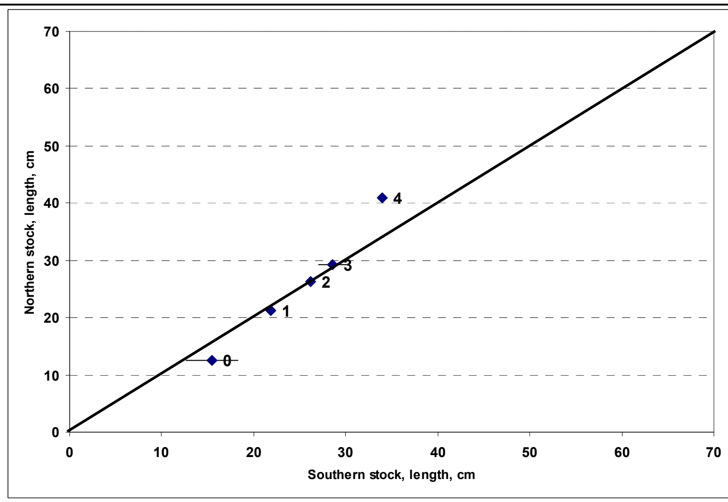
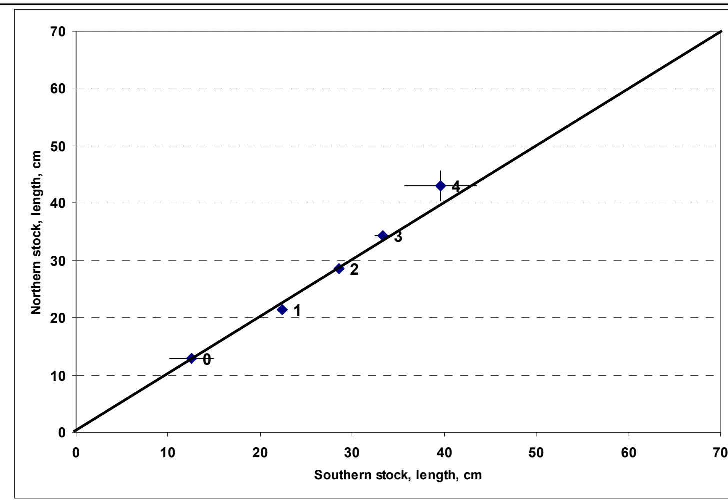
<table>
<tr><th>Silver hake</th><th>Males</th><th>Females</th></tr>
<tr><td>Spring</td><td>
</td><td>
</td></tr>
<tr><td>Fall</td><td>
</td><td>
</td></tr>
</table>

Figure A64. Size (cm total length) at age comparison between red hake caught in strata 1-19, 61-76 (Southern stock) and strata 20-40 (Northern stock) for 2000-2009 cohorts.

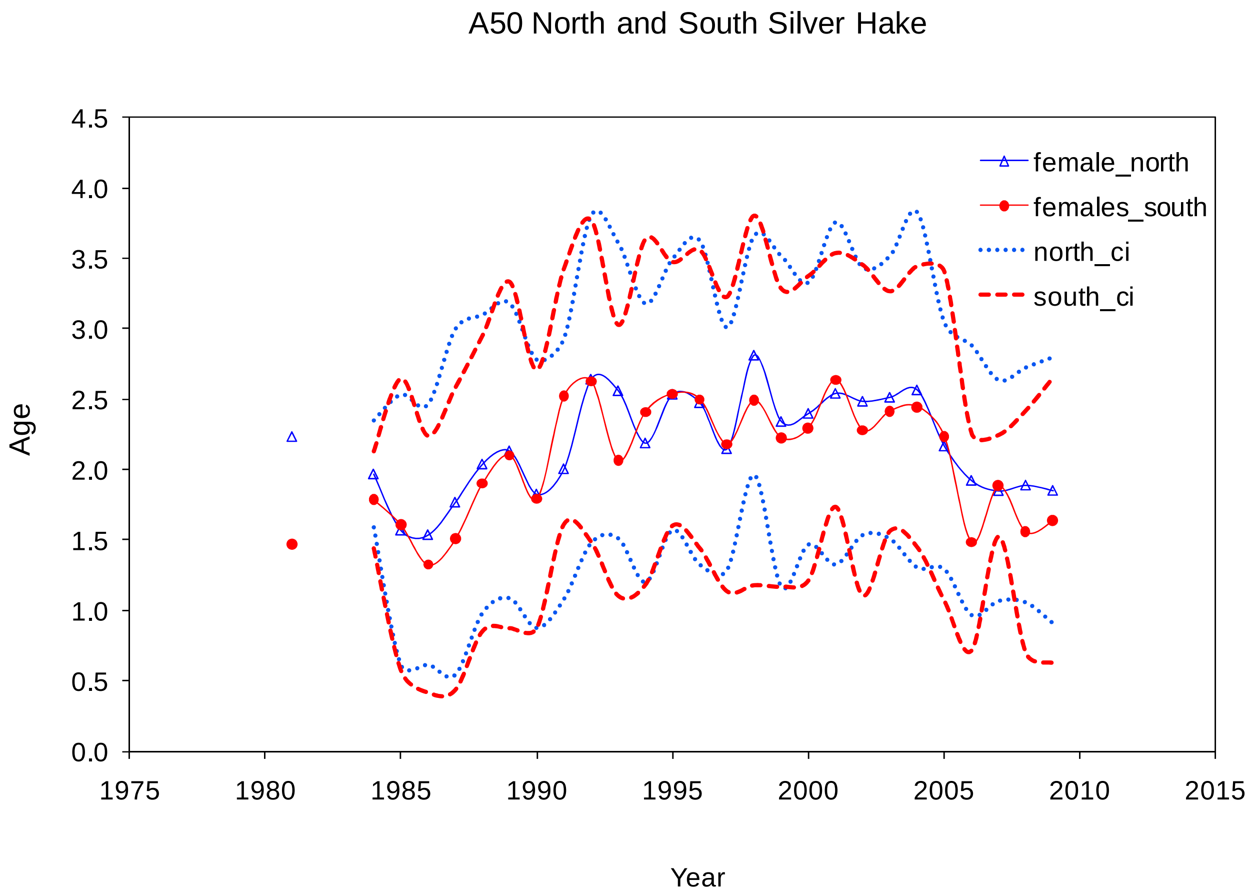
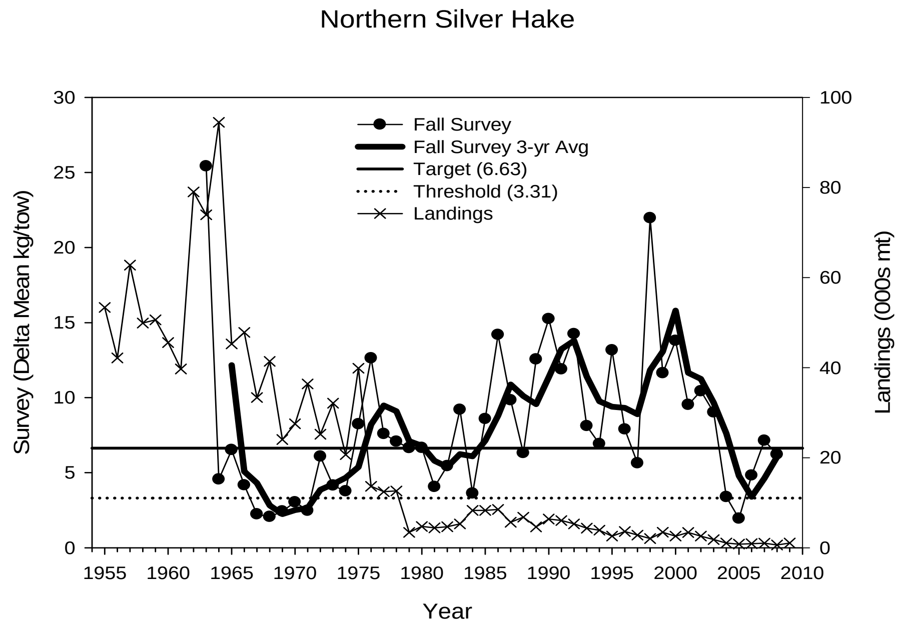


Figure A65: Time series of median size at maturity (A50) and 95% confidence interval for silver hake in the northern and southern management area



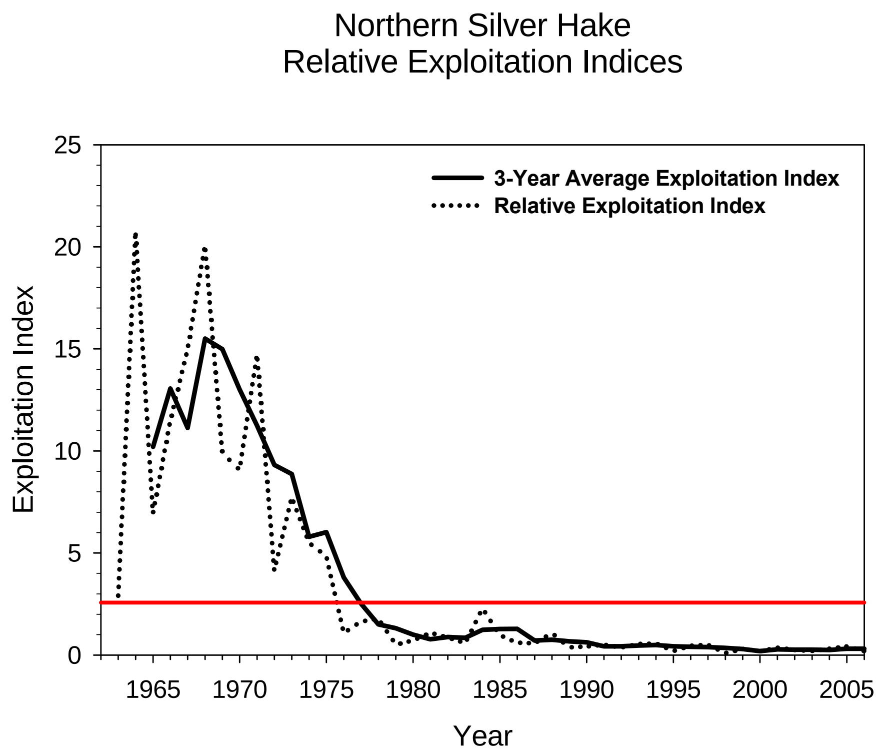
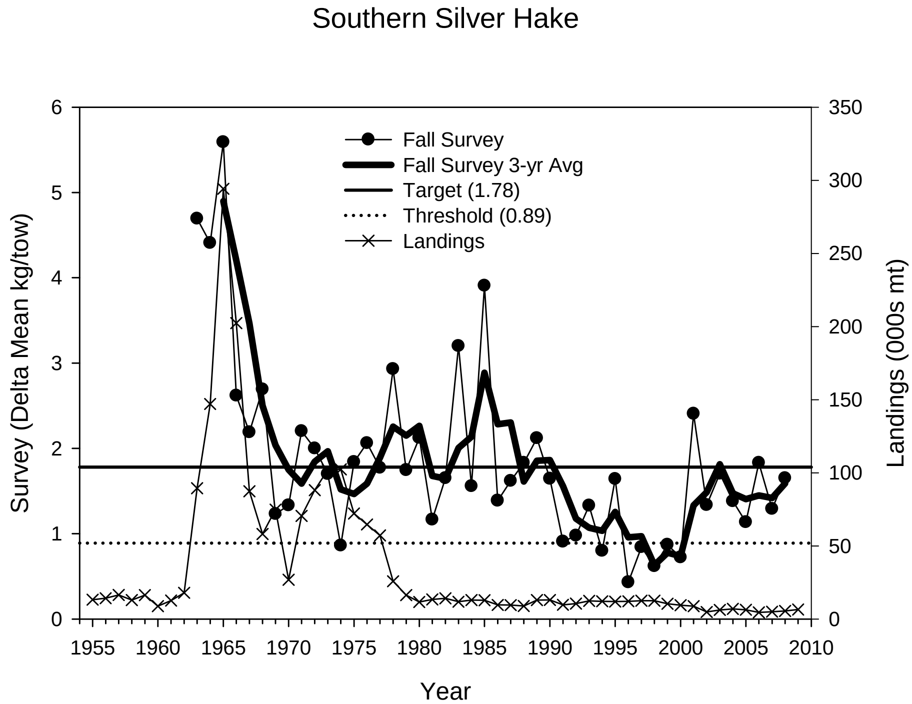


Figure A66. Abundance and exploitation indices for the northern stock of silver hake. Top: Fall abundance index (delta mean/tow) with 3 yr running average and current reference points for biomass. Bottom: landings/delta fall survey biomass (exploitation index)



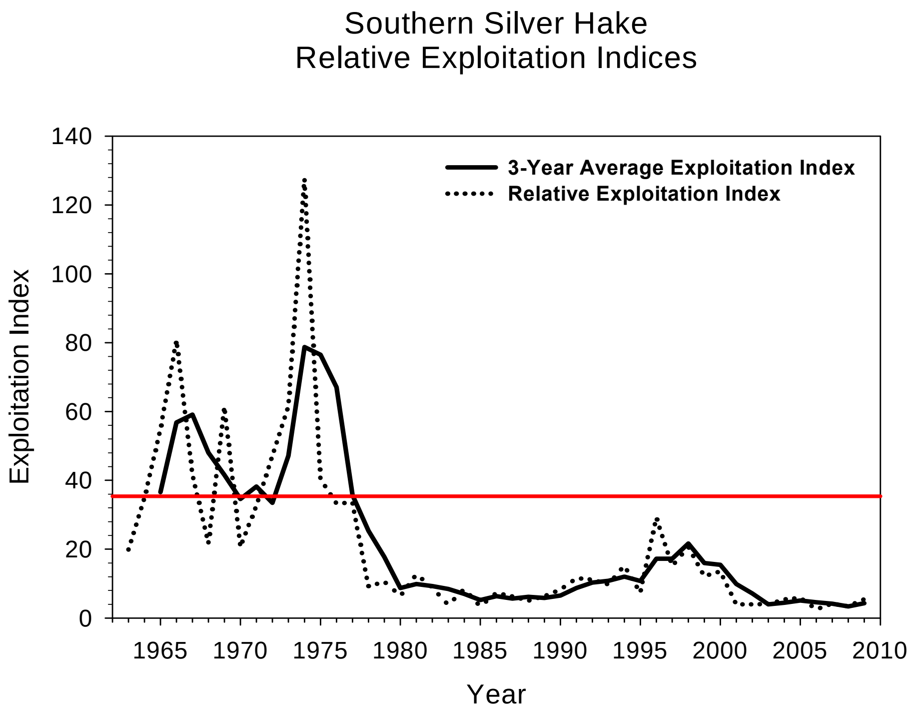
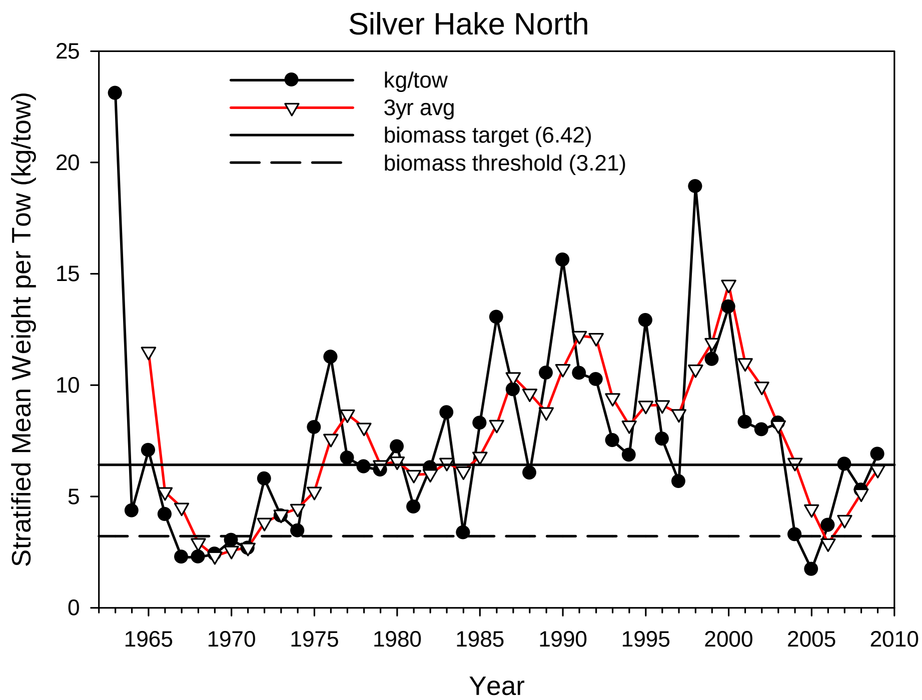


Figure A67. Abundance and exploitation indices for the southern stock of silver hake. Top: Fall abundance index (delta mean/tow) with 3 yr running average and current reference points for biomass. Bottom: landings/delta fall survey biomass (exploitation index)



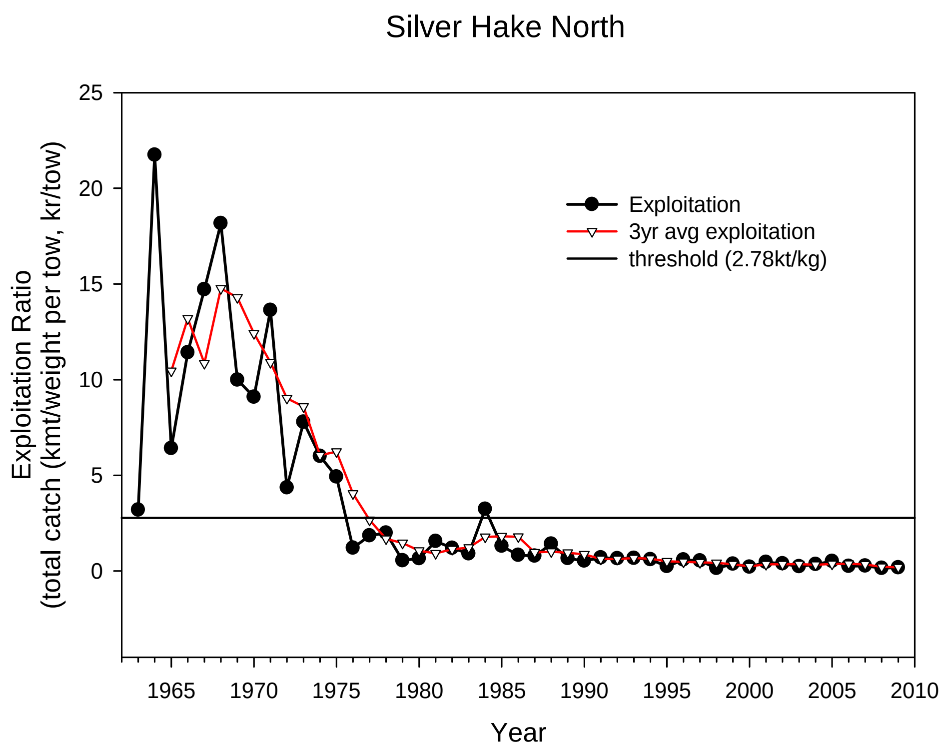
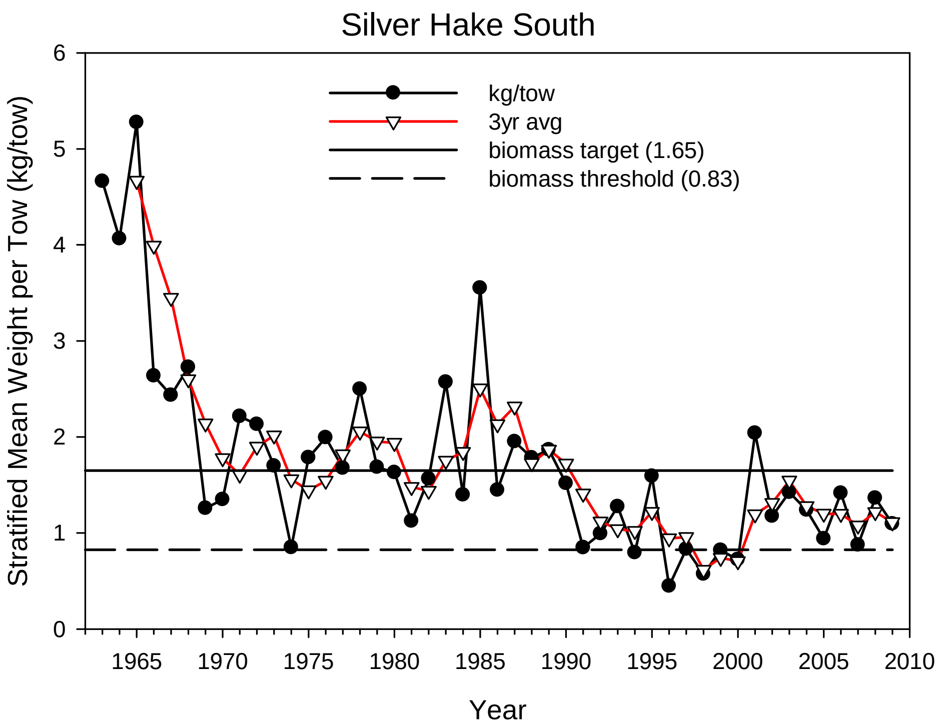


Figure A68. Abundance and exploitation indices for the northern stock of silver hake. Top: Fall abundance index (arithmetic mean/tow) with 3 yr running average and current reference points for biomass. Bottom: catch/arithmetic fall survey biomass (exploitation index)



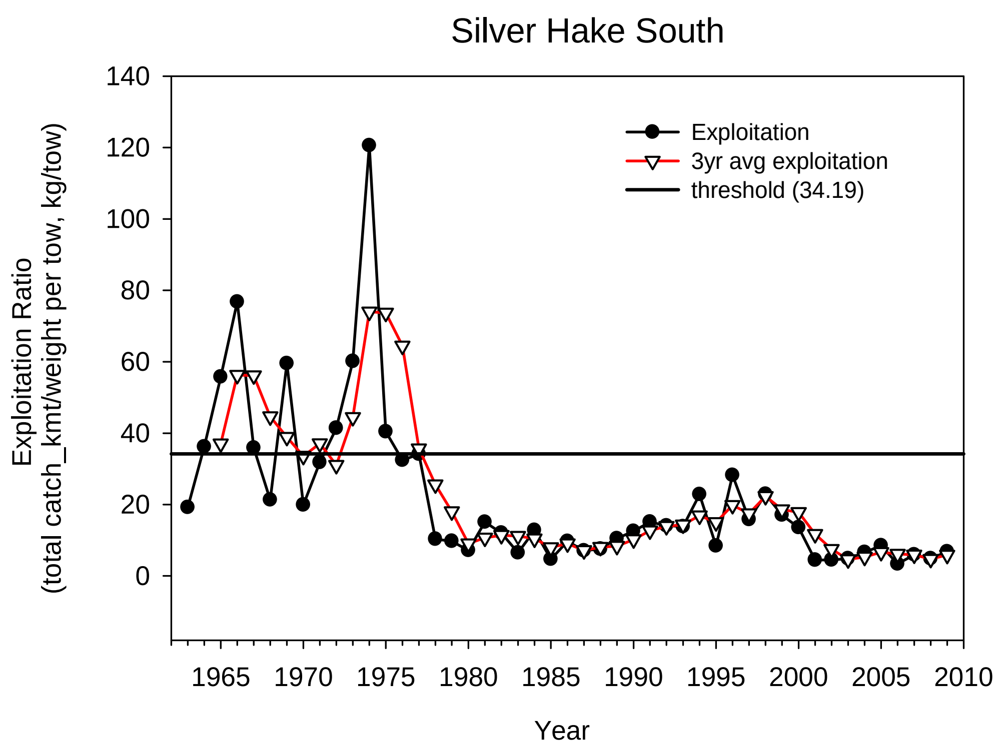


Figure A69. Abundance and exploitation indices for the southern stock of silver hake. Top: Fall abundance index (arithmetic mean/tow) with 3 yr running average and current reference points for biomass. Bottom: catch/arithmetic fall survey biomass (exploitation index)

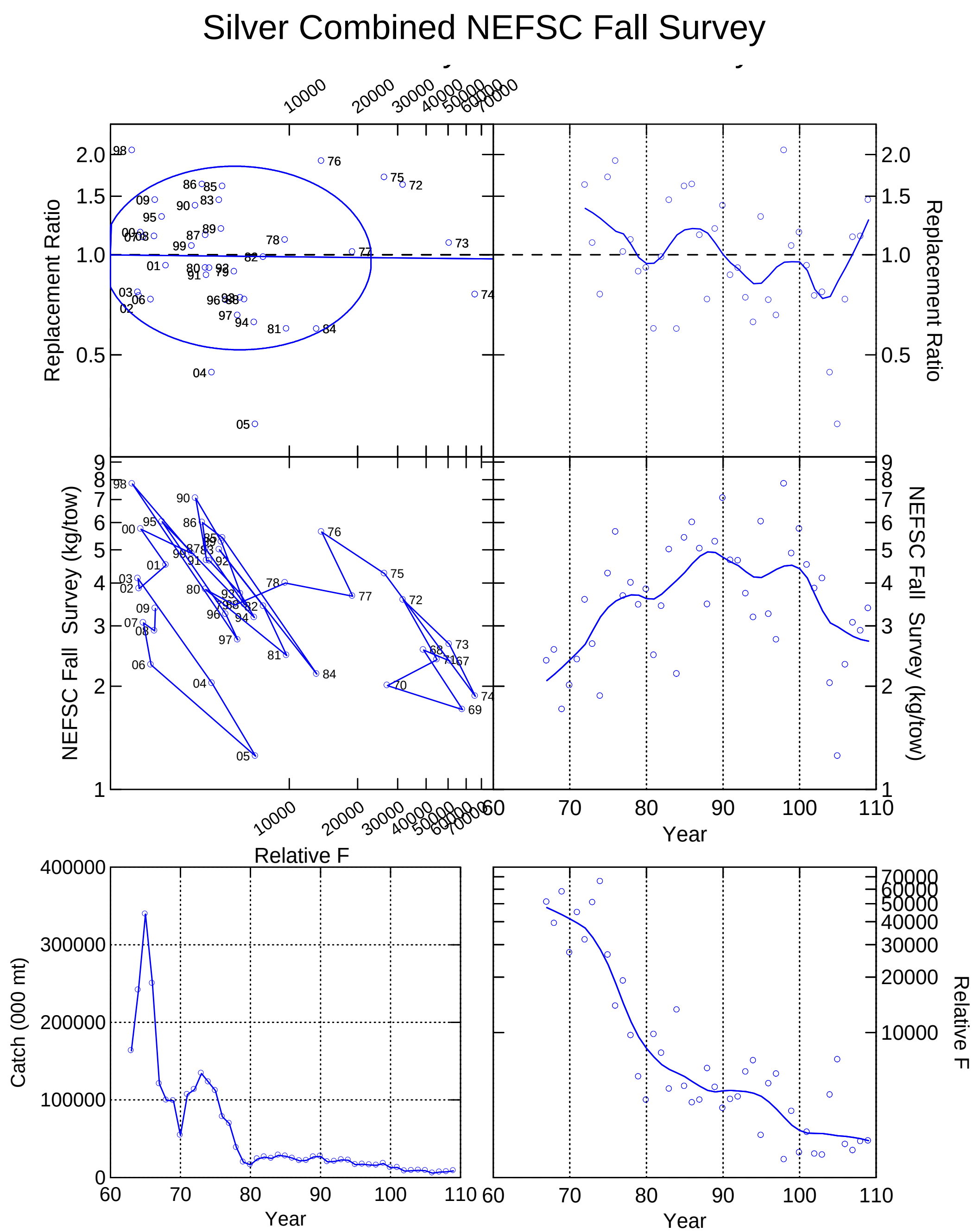


Figure. A70. Six panel plot for silver hake depicting trends in relative biomass, landings, relative fishing mortality and replacement ratios for the NEFSC Fall bottom trawl survey index and landings based on the Sosebee method. Horizontal dashed lines (---) represent replacement ratios in the top two panels and the replacement F in the lower right panel. Smooth lines represent Lowess smooths (tension =0.3). The confidence ellipse in the top left panel has a nominal probability level of 0.68. The regression line in the top left panel is a robust regression using bisquare downweighting of residuals.

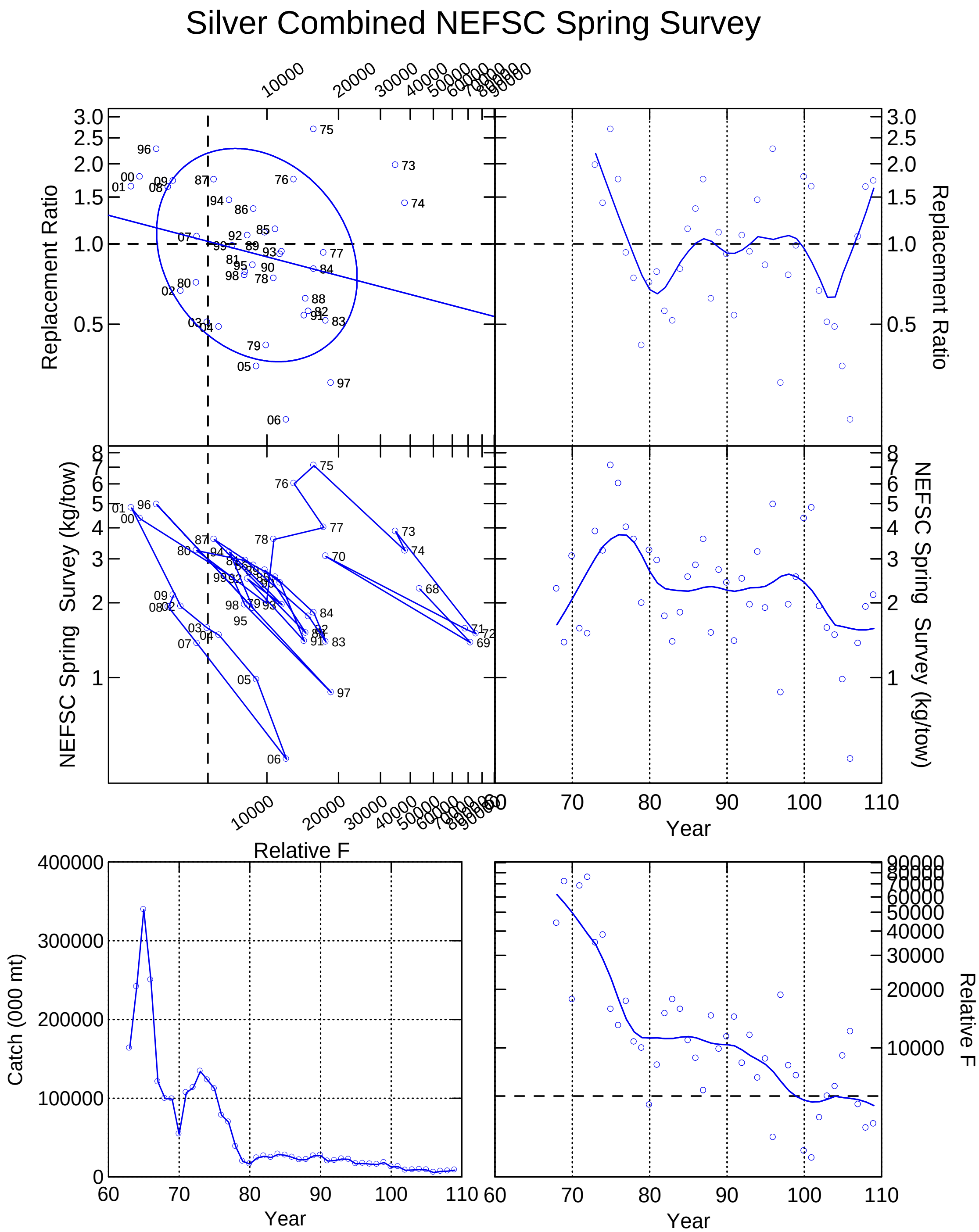


Figure. A71. Six panel plot for silver hake depicting trends in relative biomass, landings, relative fishing mortality and replacement ratios for the NEFSC spring bottom trawl survey index and landings based on the Sosebee method . Horizontal dashed lines (---) represent replacement ratios in the top two panels and the replacement F in the lower right panel. Smooth lines represent Lowess smooths (tension =0.3). The confidence ellipse in the top left panel has a nominal probability level of 0.68. The regression line in the top left panel is a robust regression using bisquare downweighting of residuals.

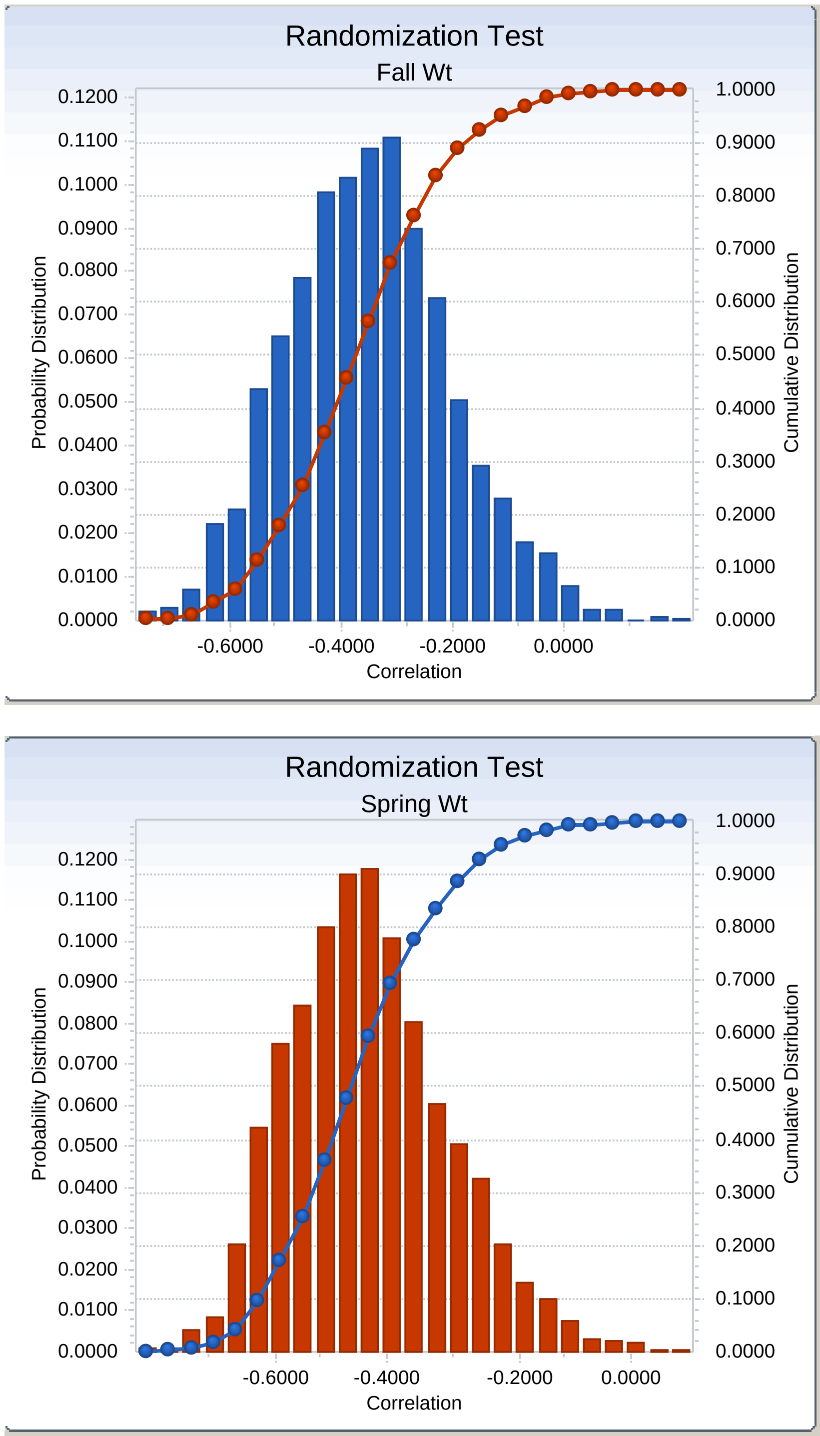


Figure A72 Randomization tests summary of sampling distribution of correlation coefficient between replacement ratio and relative F for fall(top) and spring (bottom) survey indices.

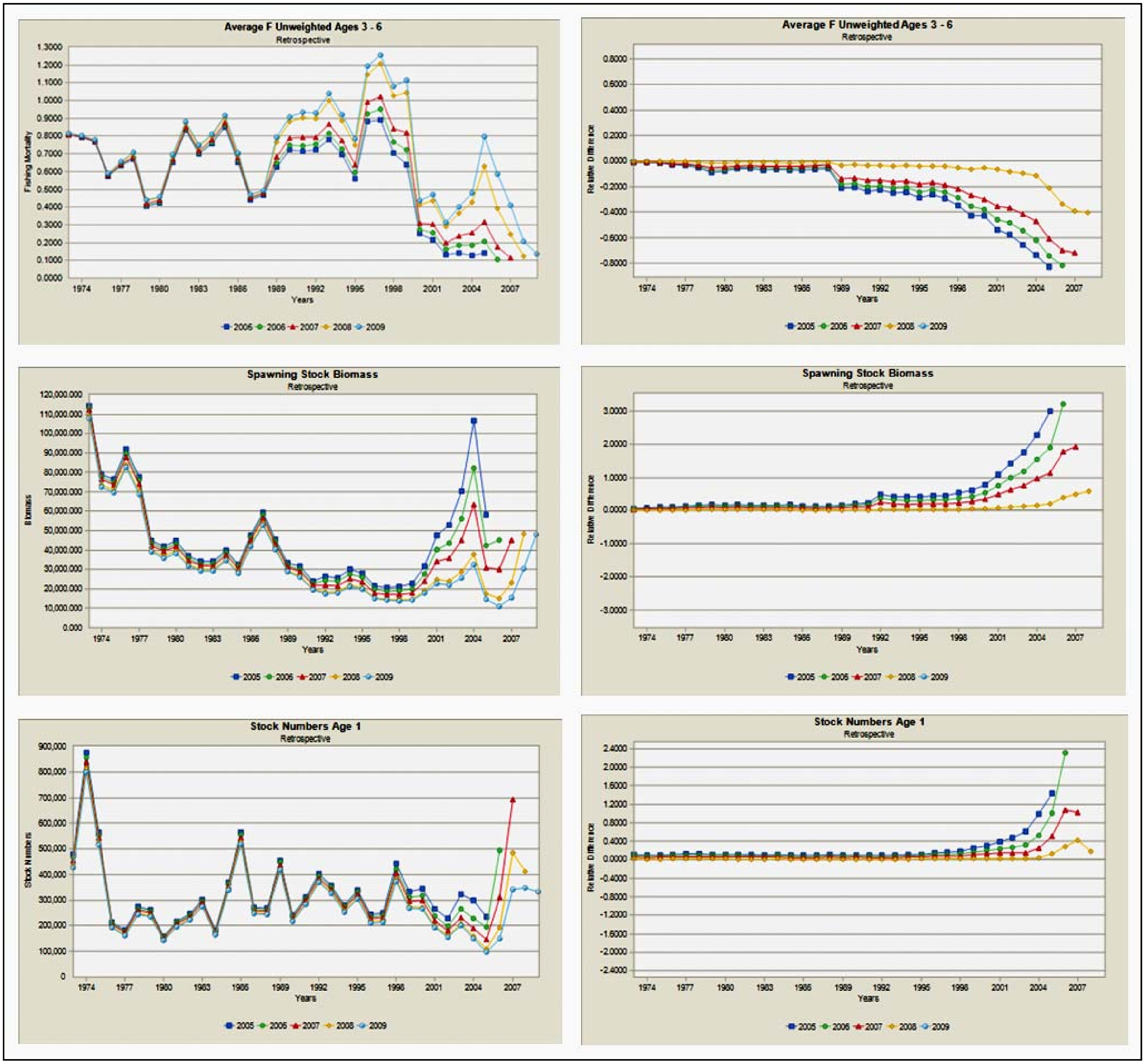


Figure A73: Age 6+ ASAP formulation (M = 0.4 model with NO consumption) - Retrospective plots of fully selected F, SSB and Recruitment.

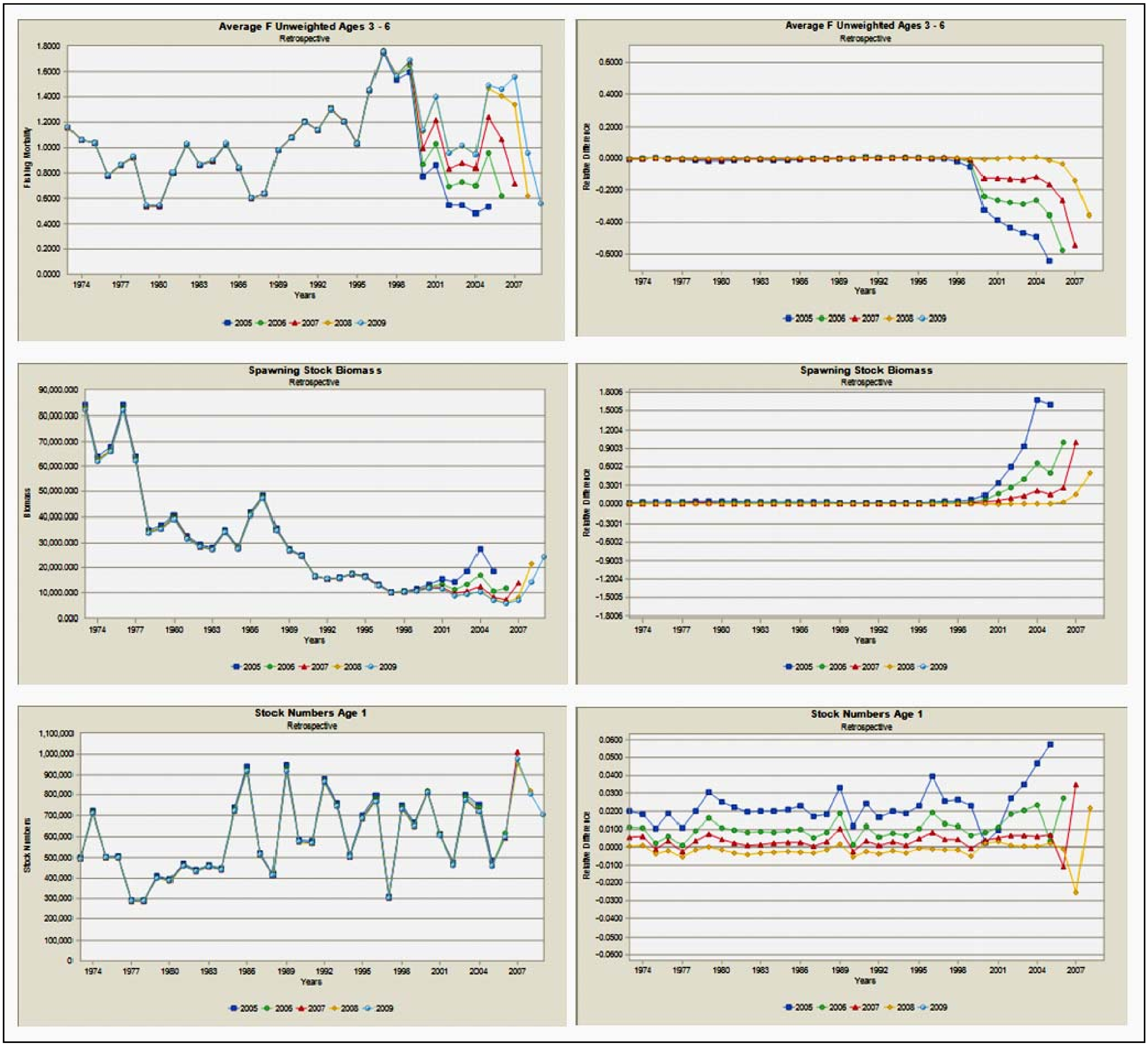


Figure A74 Age 6+ ASAP formulation (M = 0.15 model WITH consumption) - Retrospective plots of fully selected F, SSB and Recruitment.

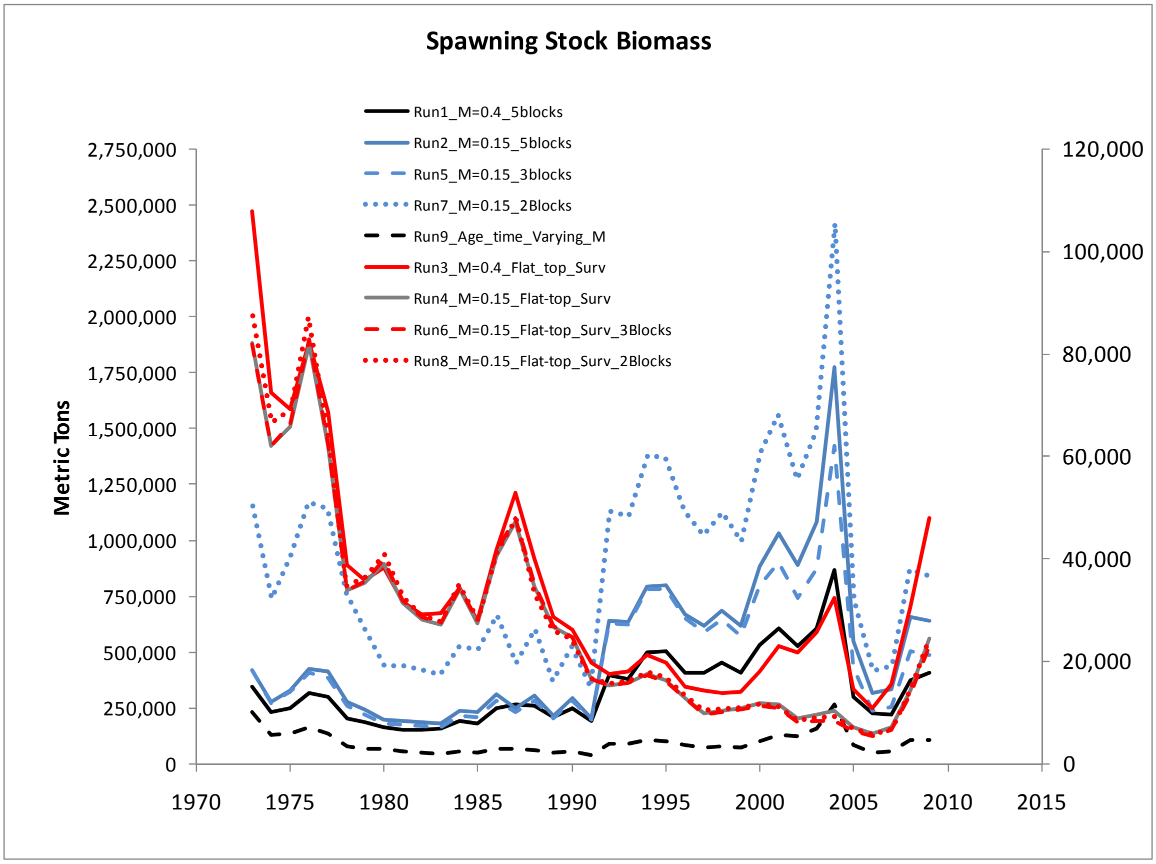


Figure A75: Silver hake SSB sensitivity analyses to the base combined ASAP model.

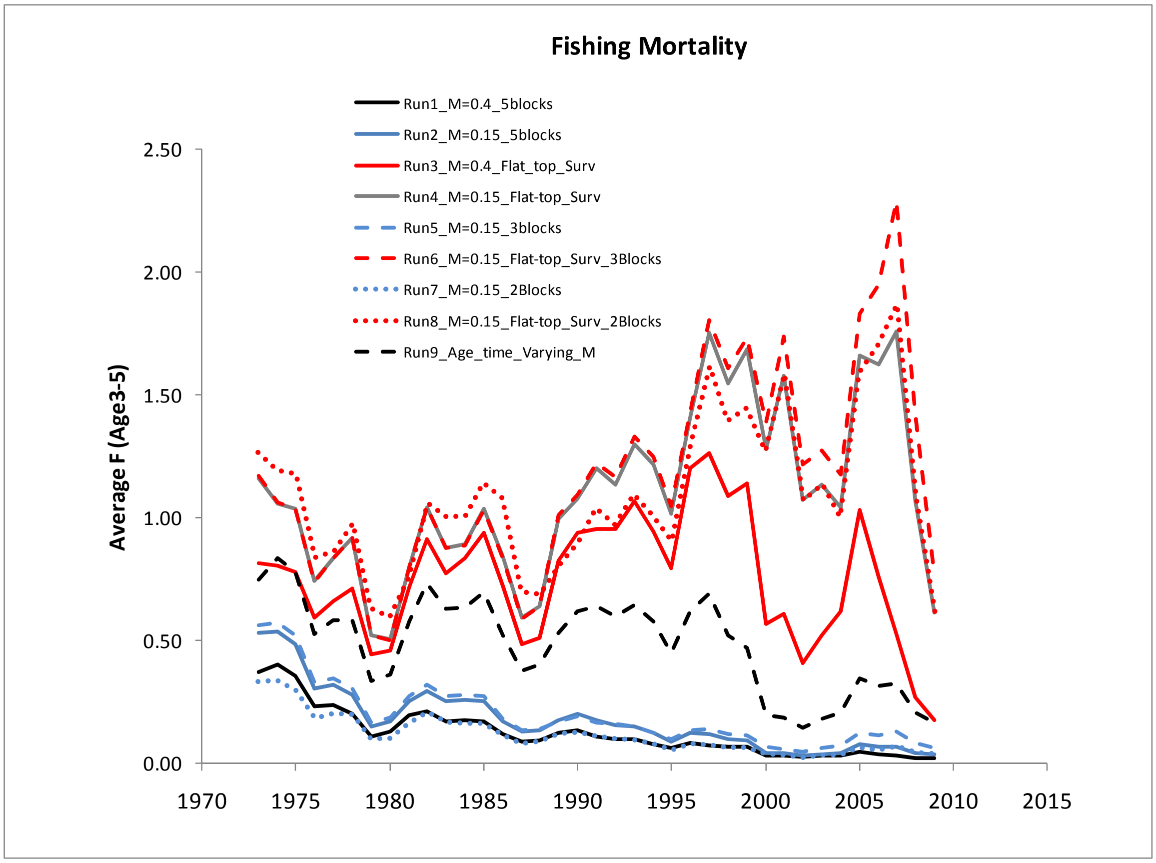


Figure A76: Silver hake SSB sensitivity analyses to the base combined ASAP model.

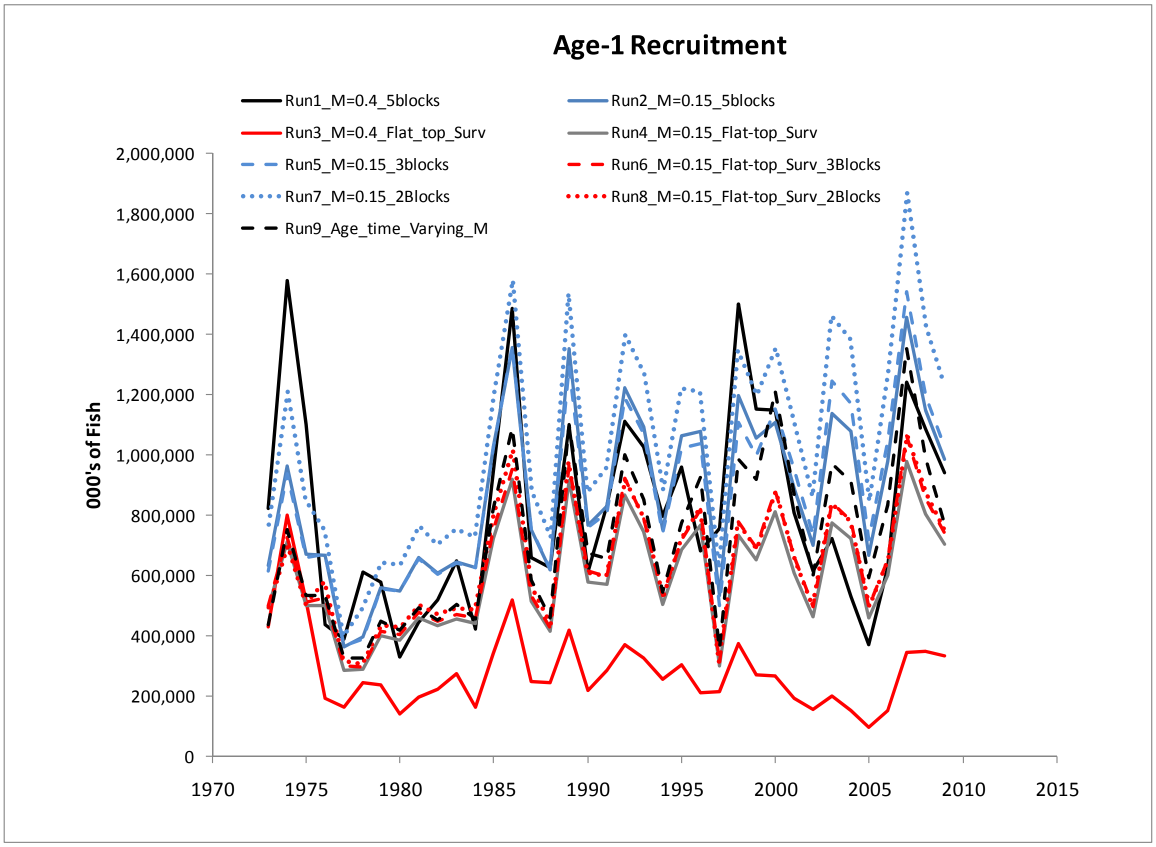


Figure A77: Silver hake SSB sensitivity analyses to the base combined ASAP model.

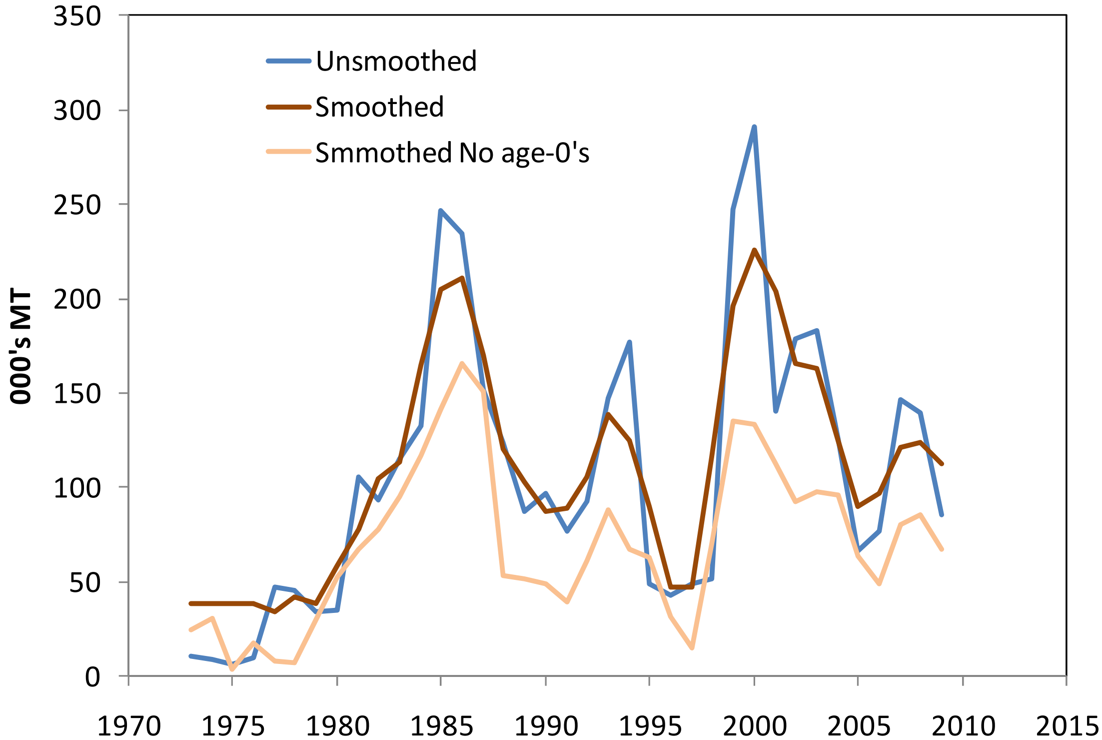


Figure A78. A comparison of silver hake consumption trends with and without the 3 year moving average including the adjustment for age-0.

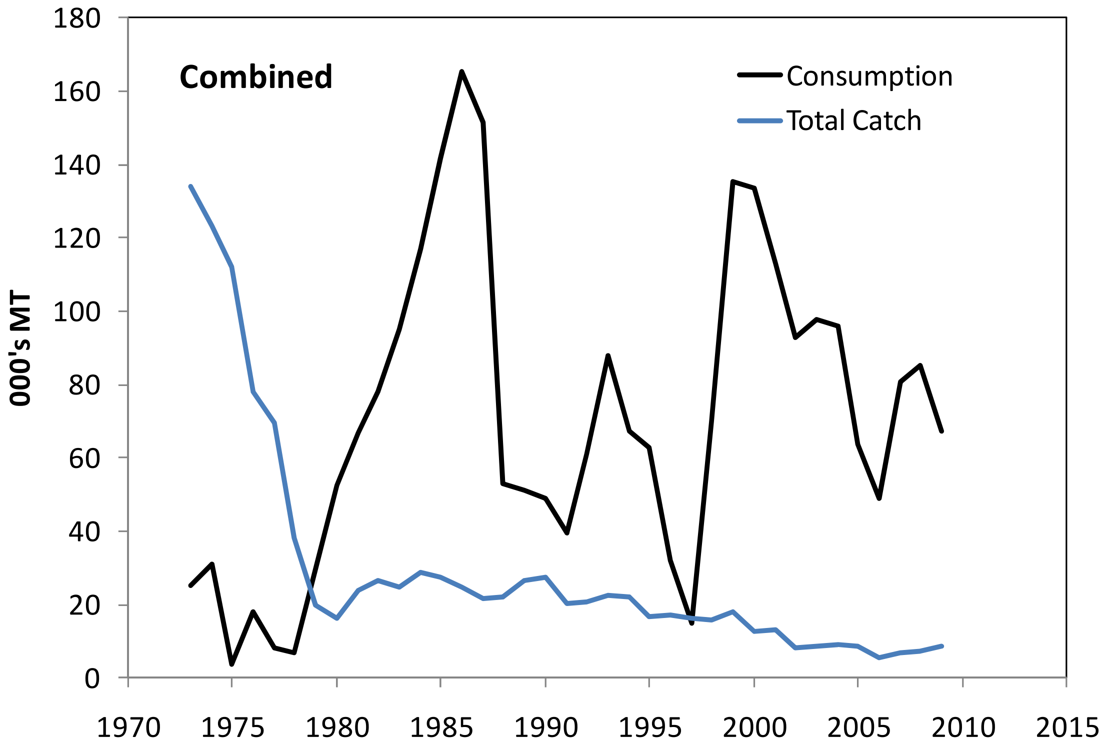


Figure A79. Estimates of total silver hake biomass removed, as that consumed by major fish predators and total catch in the fishery. A three year smoothed estimate of consumption is also shown.

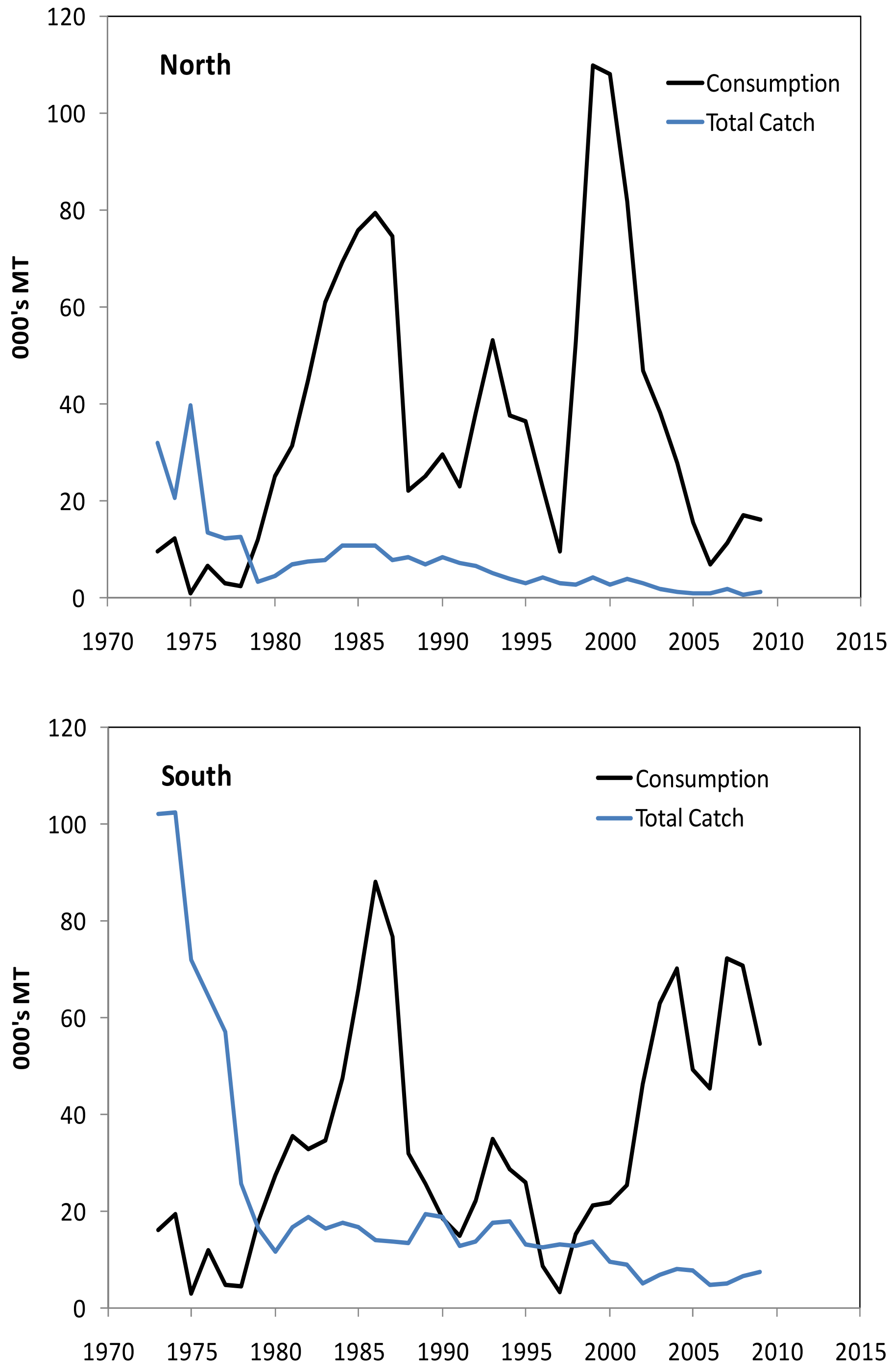


Figure A80. Estimates of total silver hake biomass removed, as that consumed by major fish predators and total catch in the fishery for the north (top) and south (bottom). A three year smoothed estimate of consumption is also shown.

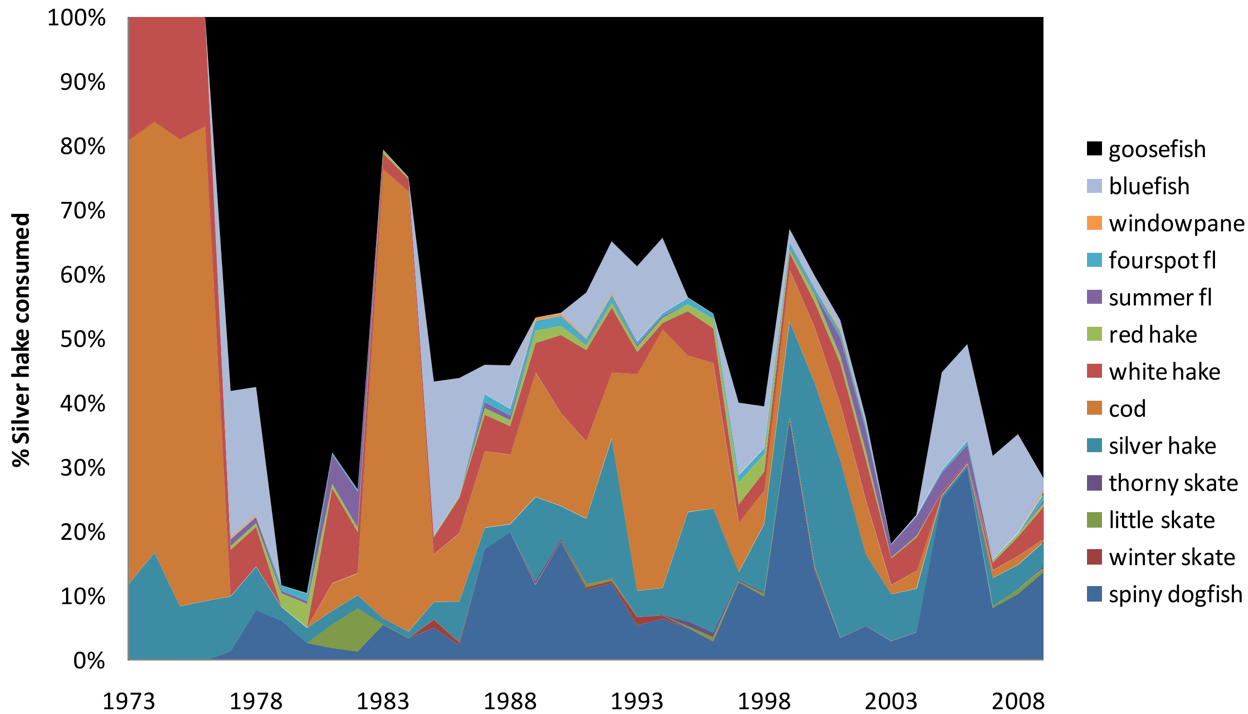
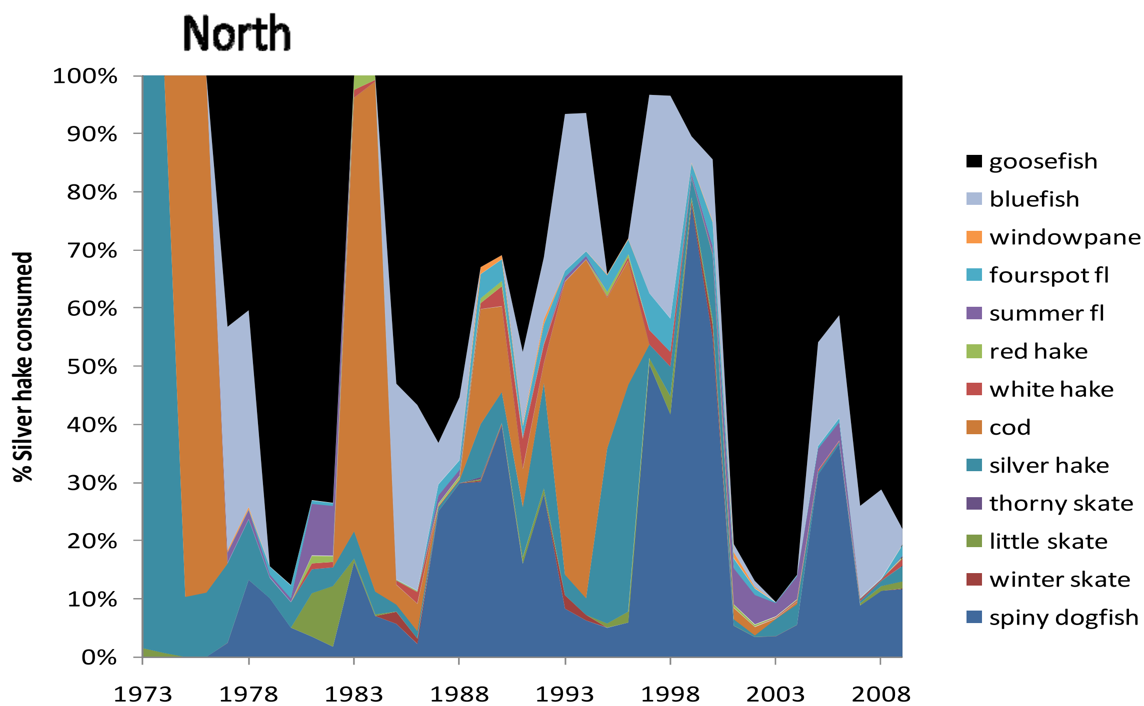


Figure A81. Consumption of silver hake by predator, for all predators, in both areas.



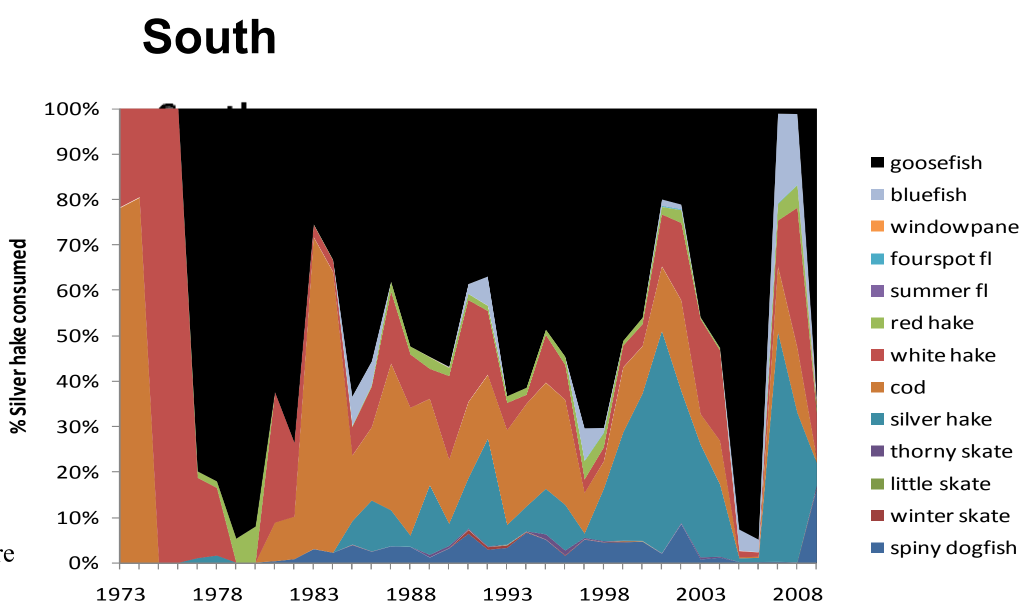


Figure A82. Consumption of silver hake by predator, for all predators, for north (top) and south (bottom)

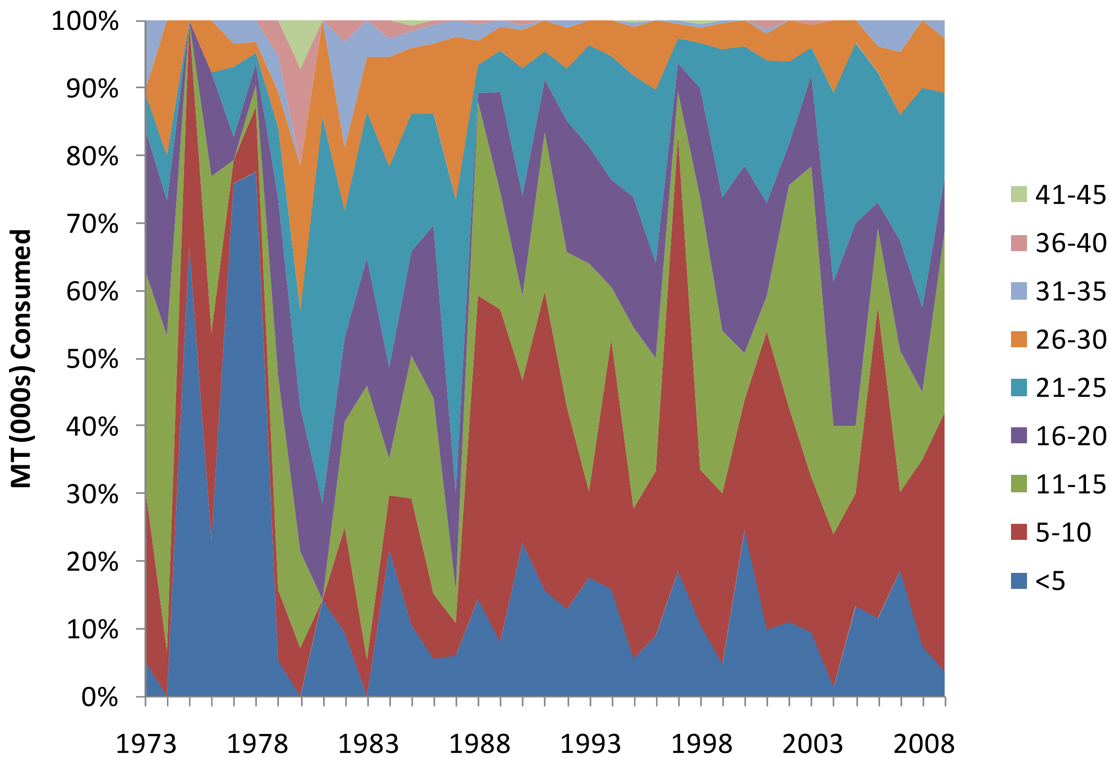


Figure A83. Proportion of total consumption by size classes of silver hake eaten by the predators in this study.

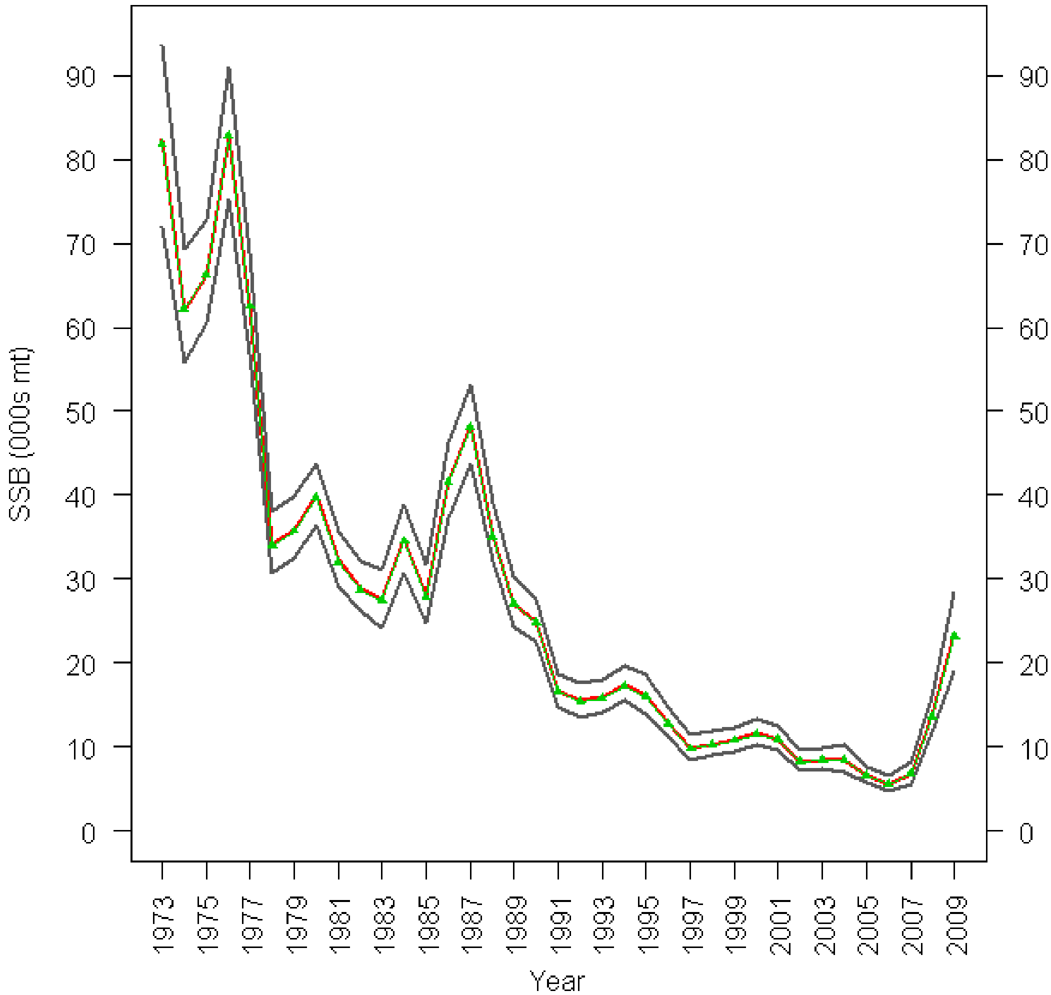


Figure A84**.** A 90% probability interval for silver hake spawning stock biomass (SSB) in thousands of mt is plotted for the entire time series. The median value is in red, while the 5th and 95th percentiles are in dark grey. The point estimate from the base model (joint posterior modes) is shown in the thin green lined with filled triangles. (ASAP base model).

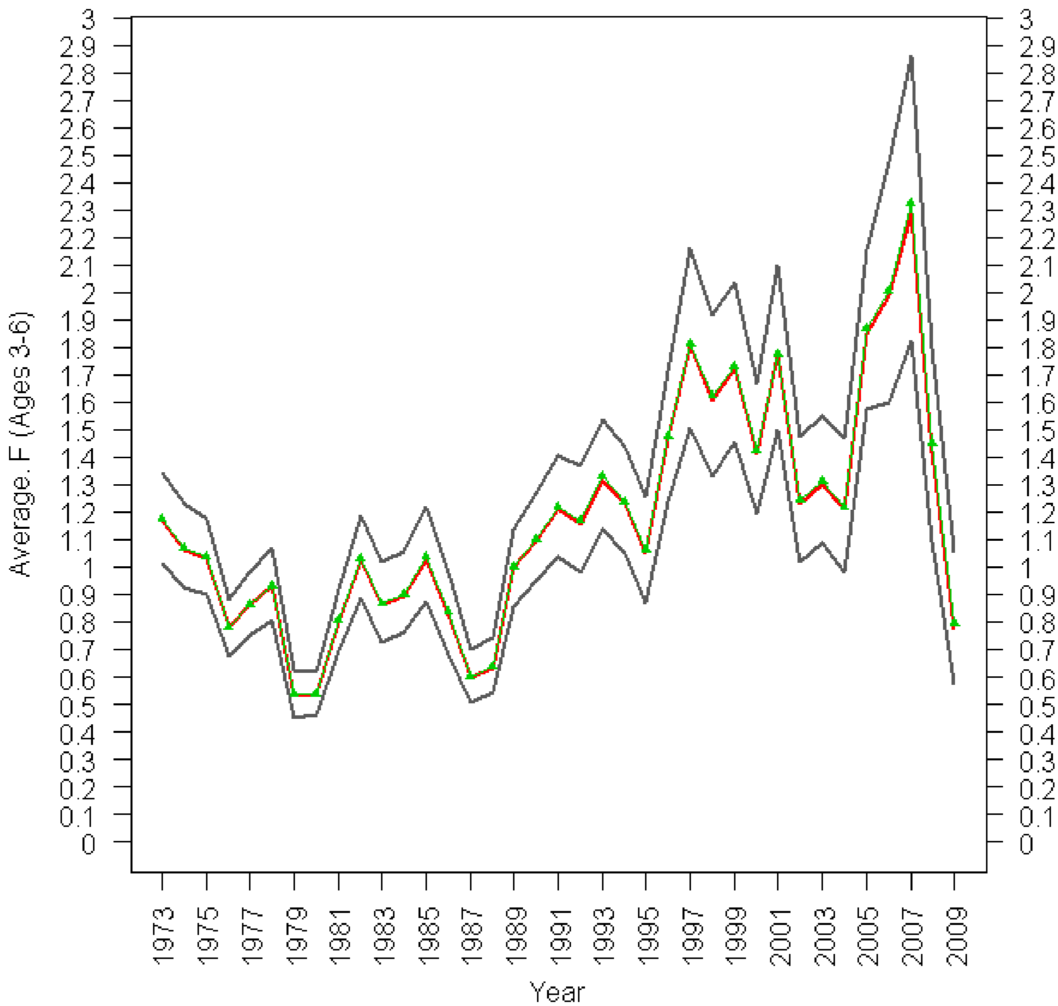
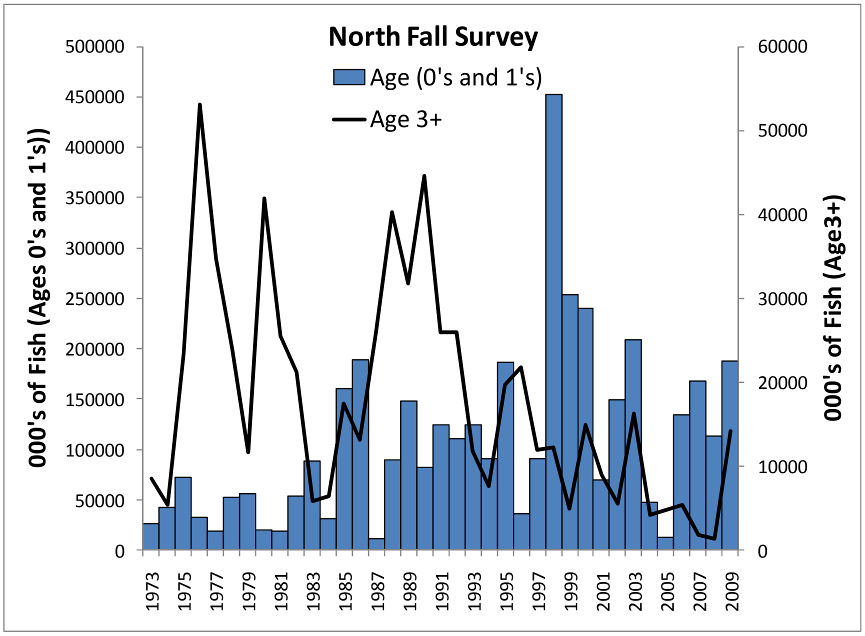


Figure A85. A 90% probability interval for the average F on ages 5-7 (F5-7) for silver hake is plotted for the entire time series. The median value is in red, while the 5th and 95th percentiles are in dark grey. The point estimate from the base model (joint posterior modes) is shown in the thin green lined with filled triangles. (ASAP base model).



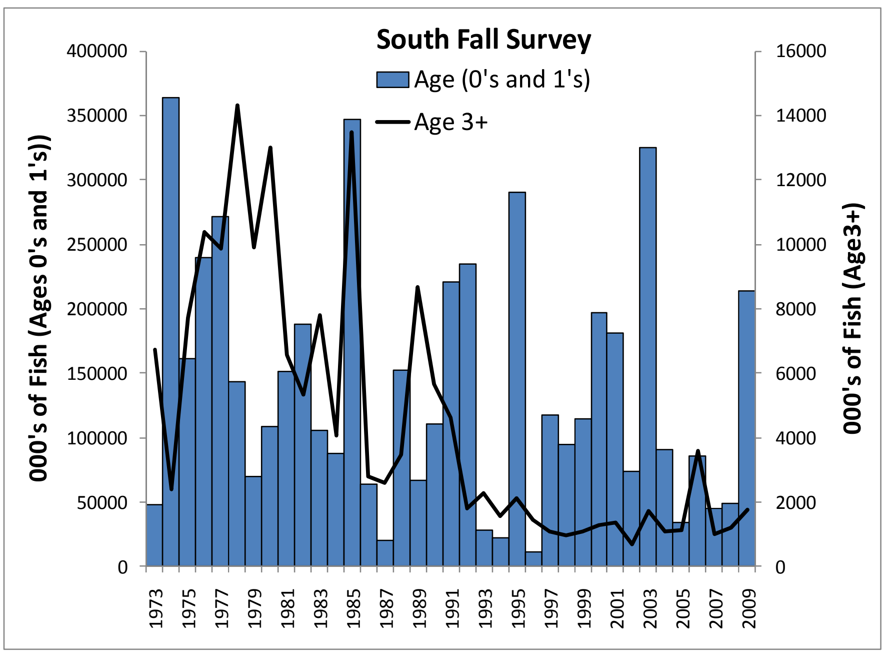


Figure A86: Recruitment (ages 0's and 1's) and adult abundances (ages 3+) derived from the NEFSC Fall bottom trawl Survey in the northern (TOP) and southern (BOTTOM) management areas

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Appendix A1

New England Fishery Management Council
Whiting Advisory Panel Meeting
SMAST – Fairhaven, MA

DRAFT Meeting Summary
August 6, 2010

Purpose of meeting: The advisory panel meeting served as an initial hake assessment meeting for stakeholders and fishermen to provide input on fishery and survey data.

Attendance: Advisors: Dan Farnham and Bill Phoel. Also in attendance were David Goethel (Oversight Committee chair), Andrew Applegate (staff) Steve Cadrin (SSC and WG chair, SMAST), Pingguo He, Klondike Jonas, Yuying Zhang, Tony Wood, and Daniel Goethel (SMAST), Loretta O'Brien, Michele Traver, Katherine Sosebee and Larry Alade (NEFSC), and Dick Allen (advisor at large).

Motions: No motions were made.

Summary

Steve Cadrin gave a presentation outlining the benchmark assessment Terms of Reference and known issues from previous assessments for the three hake species: silver, offshore, and red. He emphasized that besides simply assessing the status of the stocks with new data and models, it was important that the stock assessment produced sufficient projections for 2011-2013 to set ACLs and specifications within the planned FMP amendment for small mesh multispecies.

All five stocks (northern and southern silver hake, offshore hake, and northern and southern red hake) have existing proxy MSY reference points developed in 2002 during the last amendment, but these may be inconsistent with new estimates of MSY. Dr. Cadrin stressed the importance of making a status determination against the existing reference points as well as against any reference point recommendations that would be estimated and developed. Meeting participants also noted that another benchmark assessment may be a long way off, so that this benchmark assessment needed to identify how future update assessments should be conducted, either by the PDT or another group.

Dr. Cadrin also reviewed the calendar of related meetings, including a data meeting in early September, followed by a models/analysis meeting in late October, and the SAW review in early December.

Larry Alade, Michele Travers, and Kathy Sosebee gave an overview of the assessment data for silver, offshore, and red hakes, respectively. Data for all three species exhibited problems with mis-identification and reporting, uncertain stock structure (north and south stocks for silver and red hake), and difficult to estimate stock dynamics. Particularly for silver hake, it was noted that landings have been at relatively low levels since 1980, yet the survey biomass indices have not increased very much. The low landings may have been a result of the 5% groundfish catch limit for small mesh fisheries.

During the presentations, several issues were raised and there was some discussion of possible approaches and analyses to address these issues.

Silver hake

For silver hake, these issues included mis-reporting of species (silver and offshore hake mixed), stock structure (separate north/south stocks or combined), potential aging errors (mis-interpretation of annuli), difficulty in following strong and weak cohorts beyond age 2, and the effects of cannibalism on biological reference points and productivity. The work group was given a term of reference and had plans to develop model-based estimates of the species composition in landings and discard.

Species composition may be resolved through a variety of means. Although the dealer data is considered to be the more accurate estimate of landings volume, in this case, the vessel trip reports may be the more accurate estimate of species composition. Although sampling frequency in the observer data may be too low to estimate species composition, the VMS data may be useful because silver and offshore hake stratify by depth.

Some suggested that the dealer reports may also be subject to some underreporting, either via sales as bait or via sales to dealers in other states via truck. Some states, particularly CT, obtain these landings and make an aggregate report at the end of the year. Nonetheless, one of the advisors suggested that silver hake reported landings may be as much as 2 million pounds too low. Some discussion also occurred about industrial, or 'trash' fish, landings in the 1960s and 1970s, particularly at the Point Judith fish meal plant. Someone would investigate whether there was more information about those landings. Some fishermen thought that there might have been an increase in CPUE around 1975, when larger vessels began to fish offshore, which also may have lead to an increase in landings of offshore hake. Advisors reported that the hake fishery was market driven, controlled by what can be landed for a price, rather than what can be caught.

Some discussion also occurred about the apparent absence of larger 3+ fish in the survey data, without high landings. It was decided that the working group would inquire about growth ring validation. Fishermen reported that the larger silver hake move more seasonally than the smaller silver hake and can be found in deeper water (> 40 fathoms). Periodic or ad hoc offshore surveys, like the cooperative monkfish survey, should be investigated for presence of silver hake in deep water, the working group decided. Some wondered whether the larger fish in the southern portion of the range end up in the northern portion, but there is no tagging data suggesting that this is the case. Hake are difficult to tag due to their delicate nature and high discard mortality.

Red hake

It has been 20 years since the last red hake assessment and aging data is only available up to

1985. It was noted that there is significant over the side bait sales (supposedly reported on vessel trip reports), but that there were few red hake in the groundfish catch, suggesting low discards by vessels using large groundfish mesh. There were also industrial fish landings that included red hake, potentially recoverable data in the ICNAF data.

Although previous assessments analyzed a northern and southern stock separately, there was little evidence for such a separation. The group decided that a combined assessment would be appropriate, but that separate north/south assessments would also be needed for status determinations using the existing reference points and overfishing definitions.

Offshore hake

Besides the species composition of the commercial catch discussed in the context of silver hake, the offshore range and what proportion of the stock was sampled by the NMFS trawl survey was an issue. And like silver hake, periodic offshore surveys like the cooperative monkfish survey might be informative. The length of the derived catch series was questioned and it might be difficult to complete an analytical assessment. A catch/biomass exploitation rate might be possible, but its utility as a measure of population trend and mortality would be questionable due to noise caused by availability to the survey and to the fishery. It was suggested that the relationship between the survey index (or number of positive tows) might be related to the NAO and Gulf Stream positioning. The working group thought that this could be a productive avenue for analysis.

Depending on the amount of catch and the range of the stock relative to the commercial fishery, it seemed that offshore hake might be re-classified as an ecosystem fishery component by a new amendment. This would mean that there would be monitoring, but no overfishing definition.

Other issues; Management and amendment schedule

For both red and silver hake, discards would be estimated and hindcasted, using sea sampling data, most recently collected using standard bycatch reporting methodology (SBRM). Dr. He indicated that there were some experiments planned to estimate discard mortality, but not enough data would be available for this assessment. In the absence of more data, the group thought that 100% discard mortality was the most reasonable assumption for trawls and especially dredges. Non-catch mortality was discussed, but not having any data, it would be assumed that there was no non-catch mortality of hakes, although some is likely, particularly in scallop dredges and might occur in large mesh trawls.

Andy Applegate gave a brief summary of the amendment timeline and process going forward. He indicated that except for the structure of accountability measures, it was difficult to make much progress on the amendment until the stock assessment was completed because the assessment might change the biological reference points and stock status. He said that the January Council meeting would be the earliest that the Council could approve draft amendment alternatives, which then would be analyzed and taken to public hearing. The Council could consider final alternatives in April, but he thought that June would be much more likely. In this case, the Council would submit the final amendment in June or July, and the final rule could be published in late 2011, with an ACL that applied to the 2011 fishing year beginning in May 2011. He thought that unless the assessment changed the status, the specification cycle would be for three years, or 2011-2013.

Appendix A2-A6 Silver Hake ASAP Model Results

[SAW51 Editor's Note: The SARC-51 peer review panel concluded that no single silver hake ASAP model run provided a suitable basis for providing management advice. The silver hake ASAP model results, which are described in Appendices A2-A6, are included in this report mainly to document the ASAP modeling runs that the Hake Working Group provided to the SARC for peer review.]

A. **Appendix 2:** Combined Area Consumption ASAP model results (Also summarizes as Run 6 in Table A52). Two block selectivity in the directed fleet and assumes Flat-top selectivity in the survey.

B. **Appendix A3:** North Model ASAP results M=0.4 Base run

C. **Appendix A4:** North Model ASAP results M=0.4 assuming Flat-top selectivity in the survey

D. **Appendix A5:** North Model Consumption ASAP model results M=0.15 _Base run

E. **Appendix A6:** North Model ASAP results M=0.15. Assuming Flat-top selectivity in survey

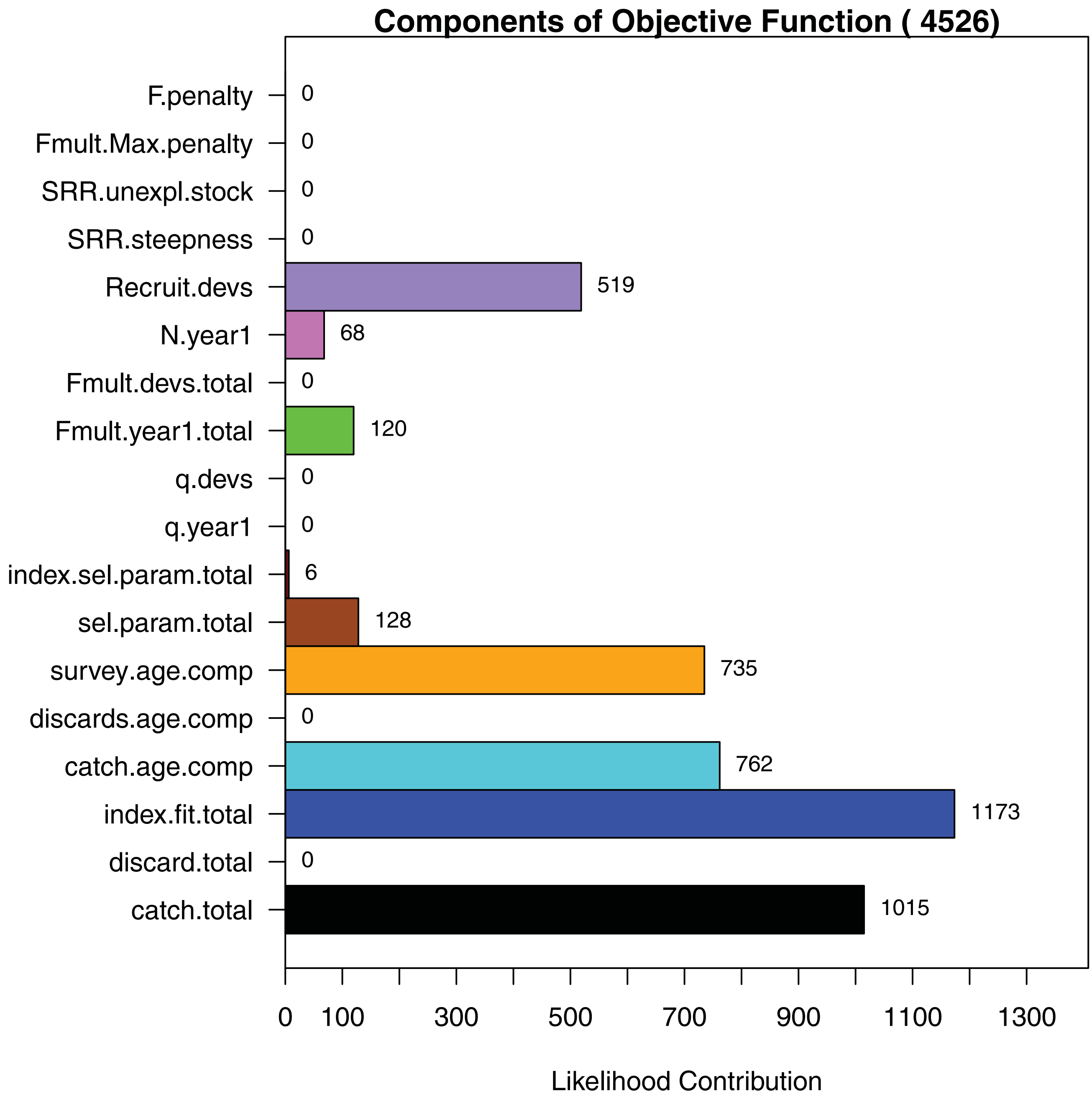
Appendix A2: Combined Area Consumption ASAP Model Results (Also summarized as Run 6 in Table A52)

Model Attributes:

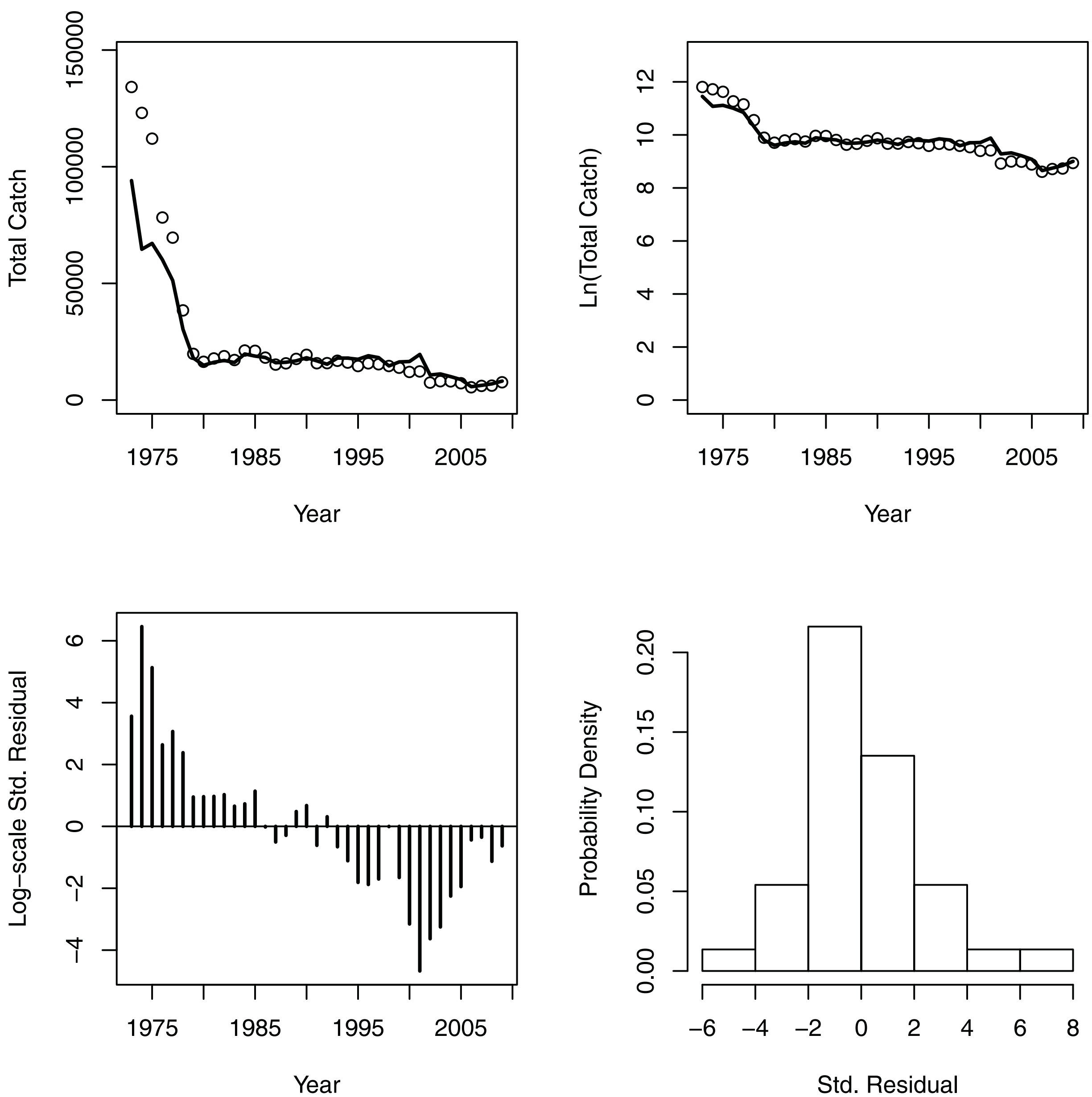
1. 3 Fleet Model
   a. Catch : 1973-2009
   b. Discards: 1981 – 2009
   c. Consumption – 1973-2009

2. Fishery Selectivity (3 Block Selectivity)
   a. Landings (2 Blocks: 1973-1988; 1989-2009)
   b. Discards (1 Block: 1981-2009)
   c. Consumption (Double Logistic Functional Form)

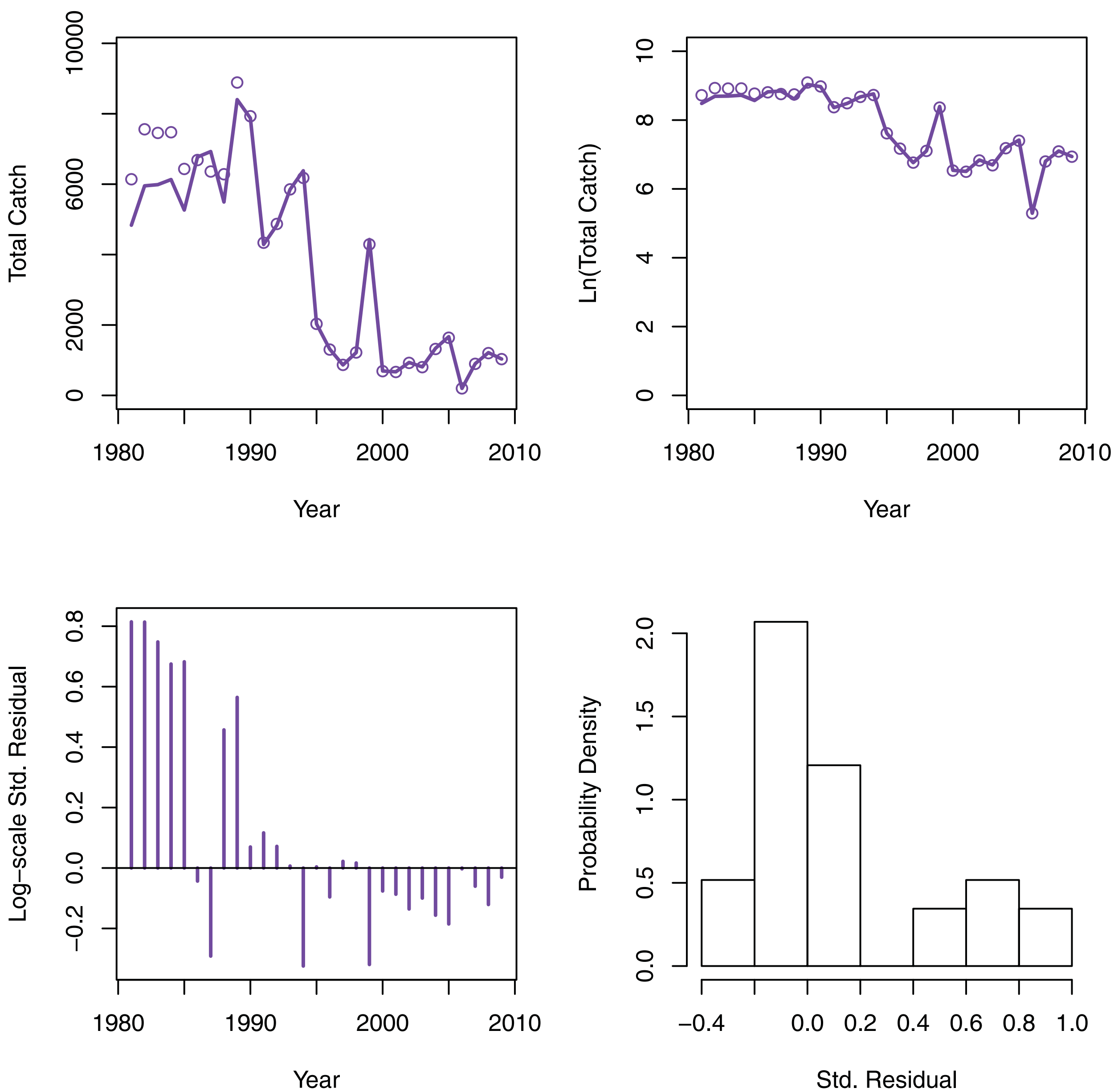
3. Survey Selectivity (Fixed 100% at age 2 – 6+) i.e. Flat-top

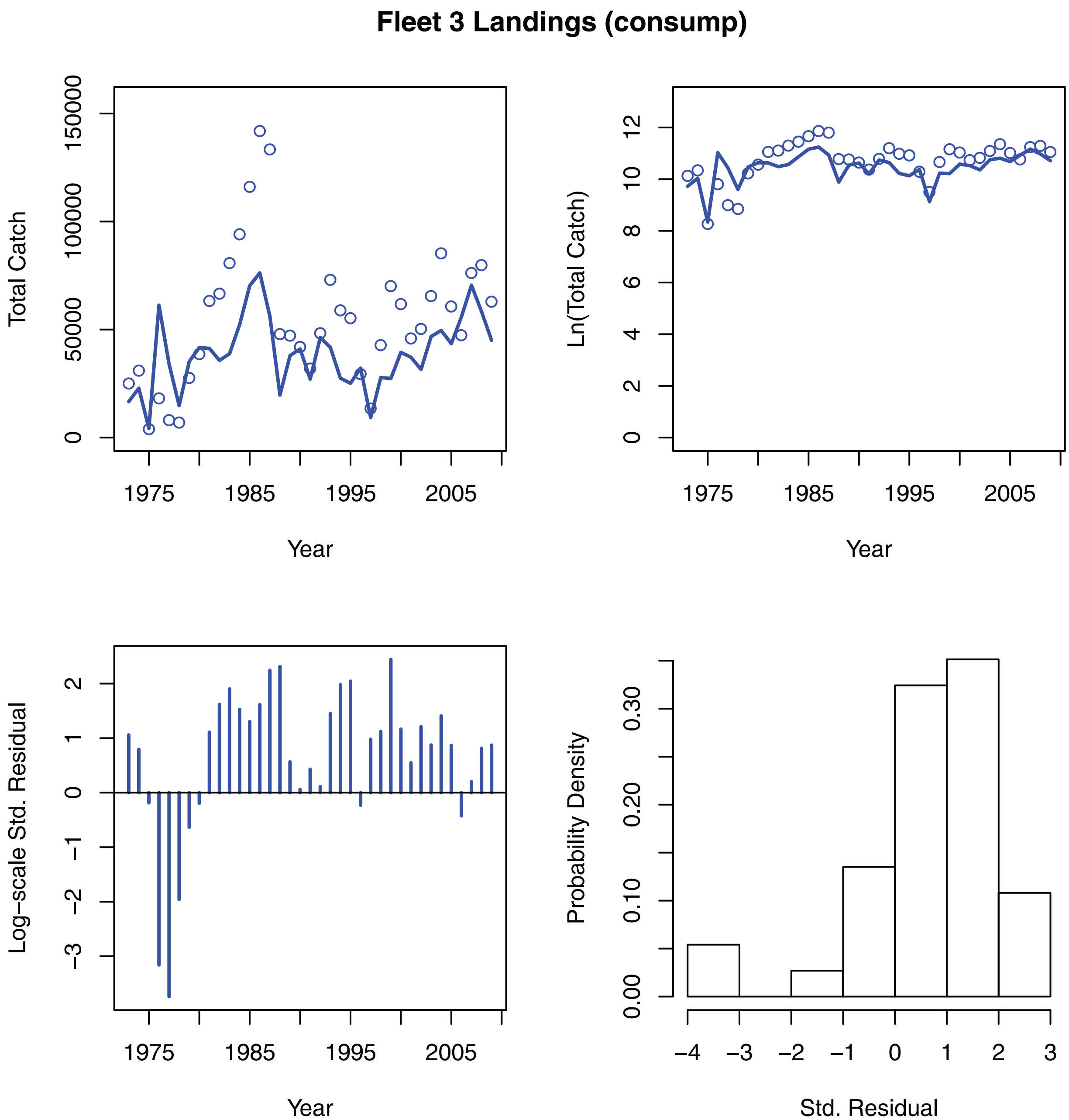

Components of Objective Function (4526)
F.penalty
Fmult.Max.penalty
SRR.unexpl.stock
SRR.steepness
Recruit.devs
N.year1
Fmult.devs.total
Fmult.year1.total
q.devs
q.year1
index.sel.param.total
sel.param.total
survey.age.comp
discards.age.comp
catch.age.comp
index.fit.total
discard.total
catch.total
0
0
0
0
519
68
0
120
0
0
6
128
735
0
762
1173
0
1015
0
100
300
500
700
900
1100
1300
Likelihood Contribution

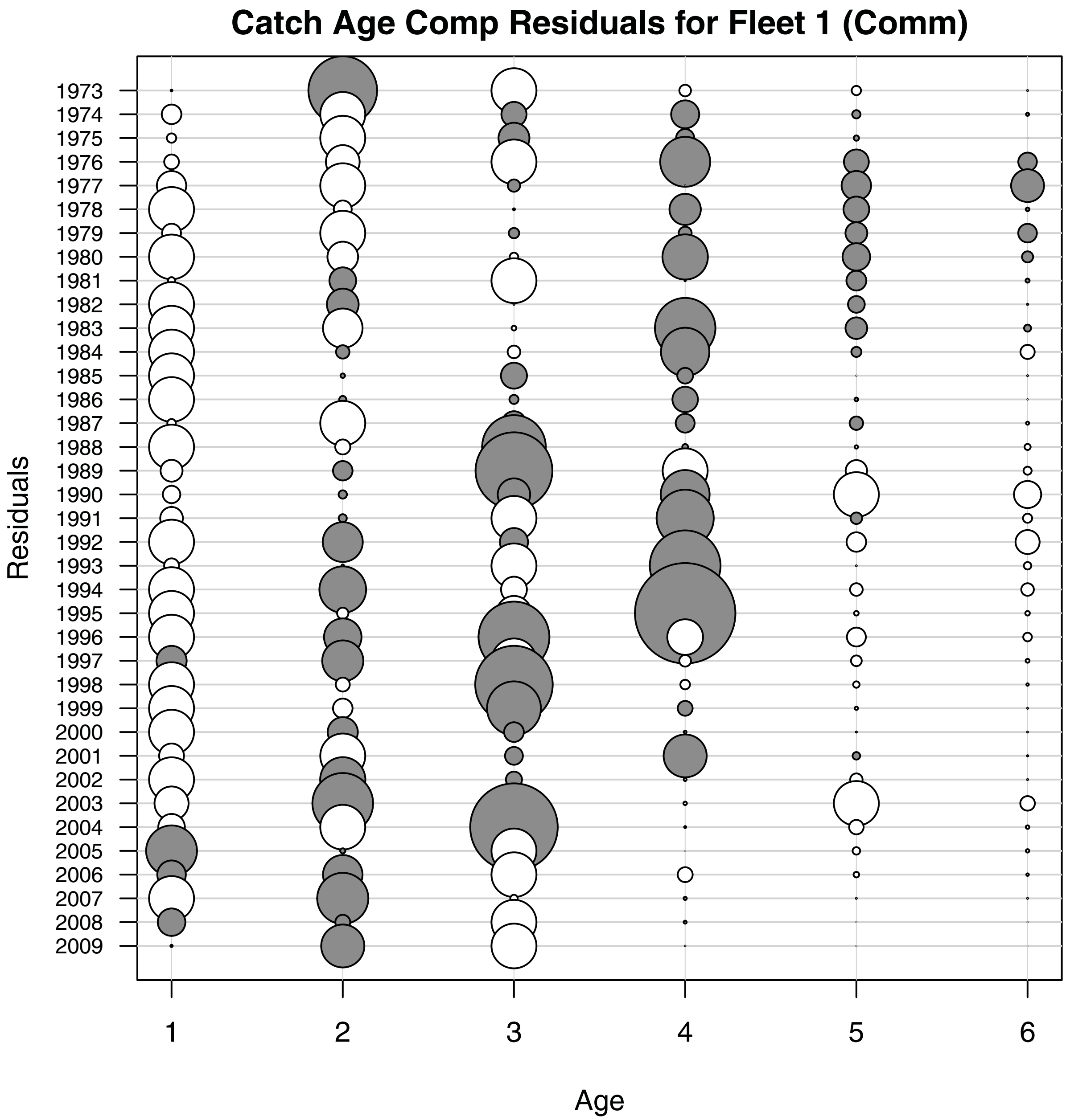
Fleet 1 Landings (Comm)

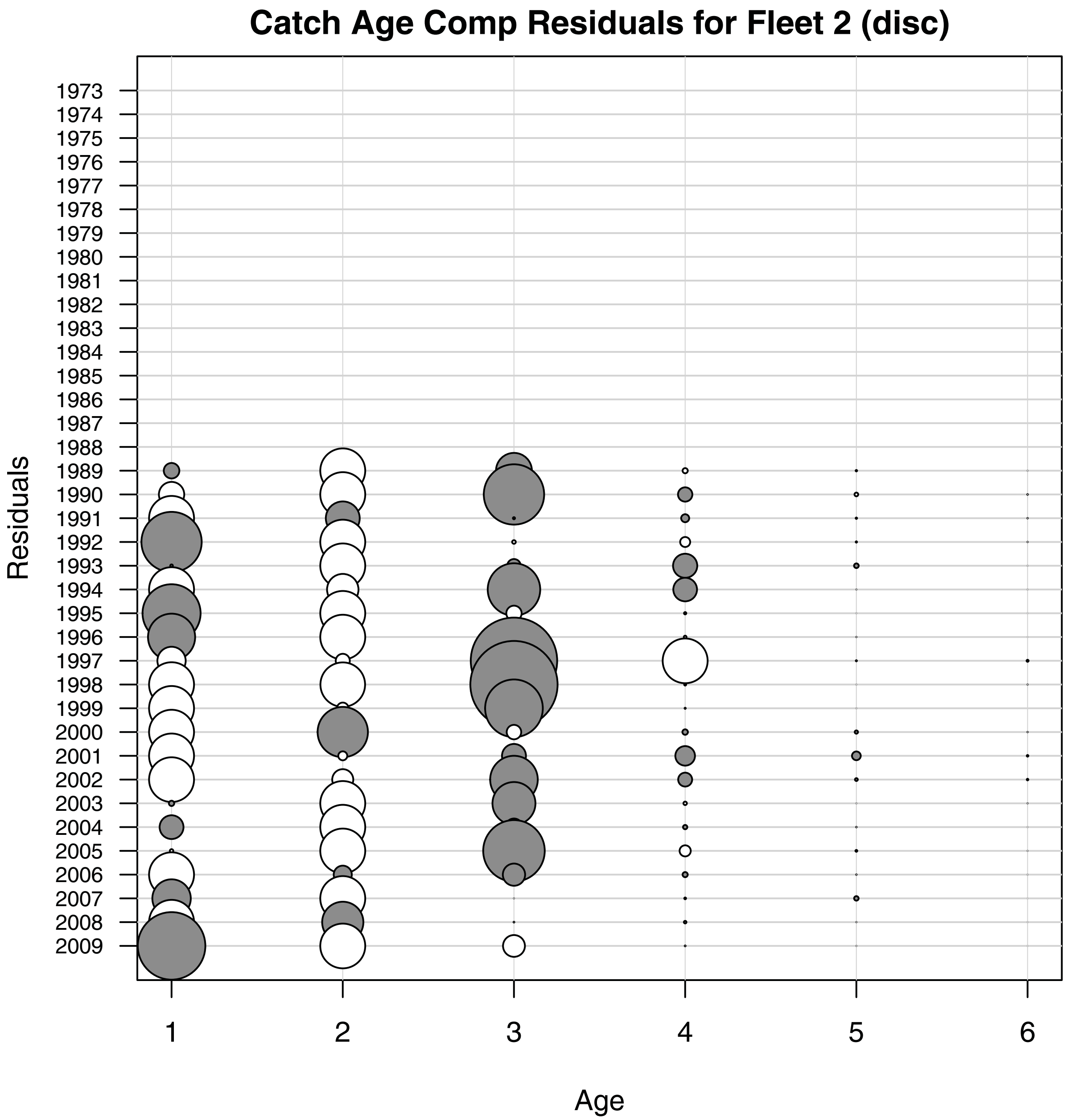


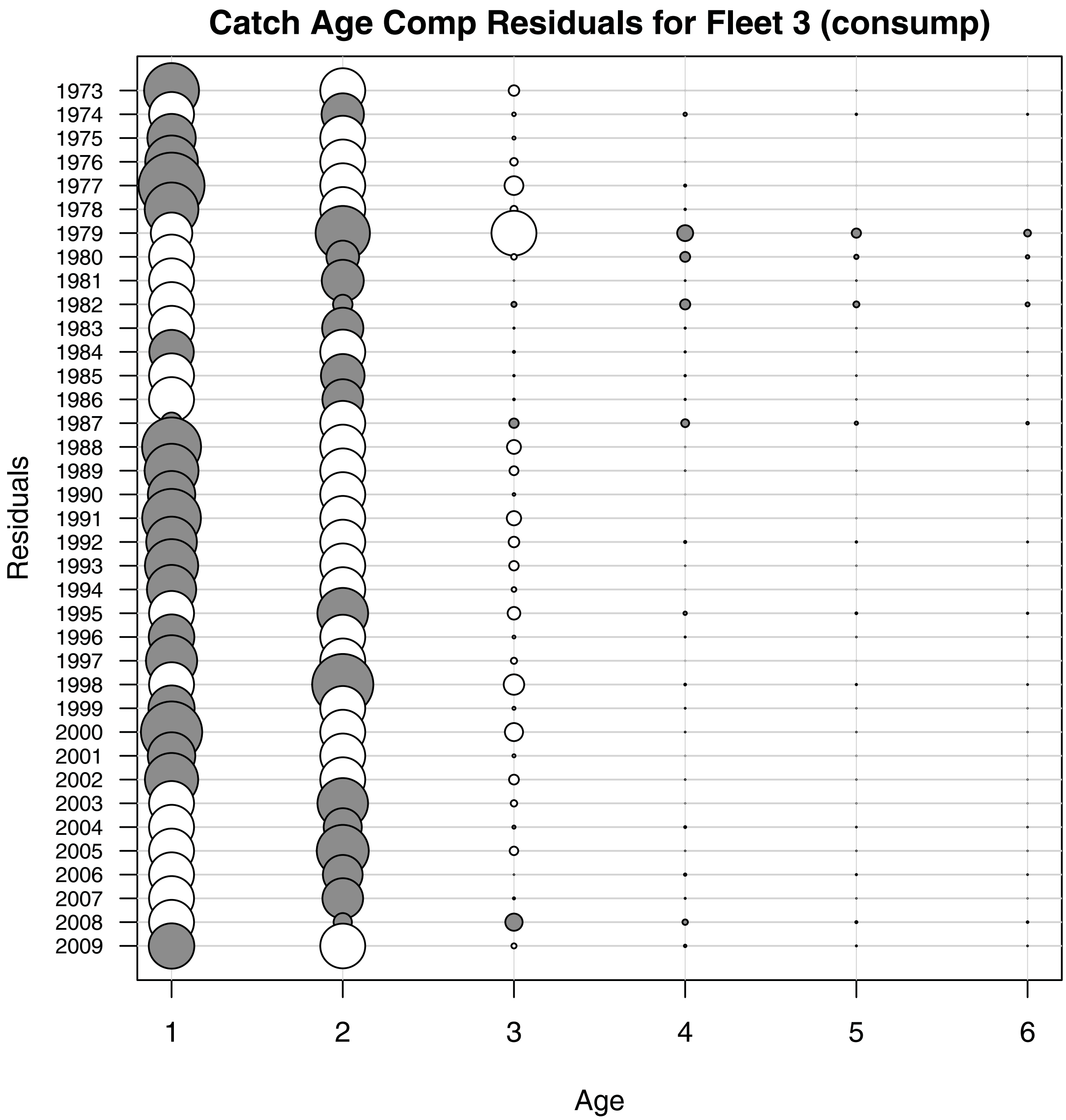
Fleet 2 Landings (disc)

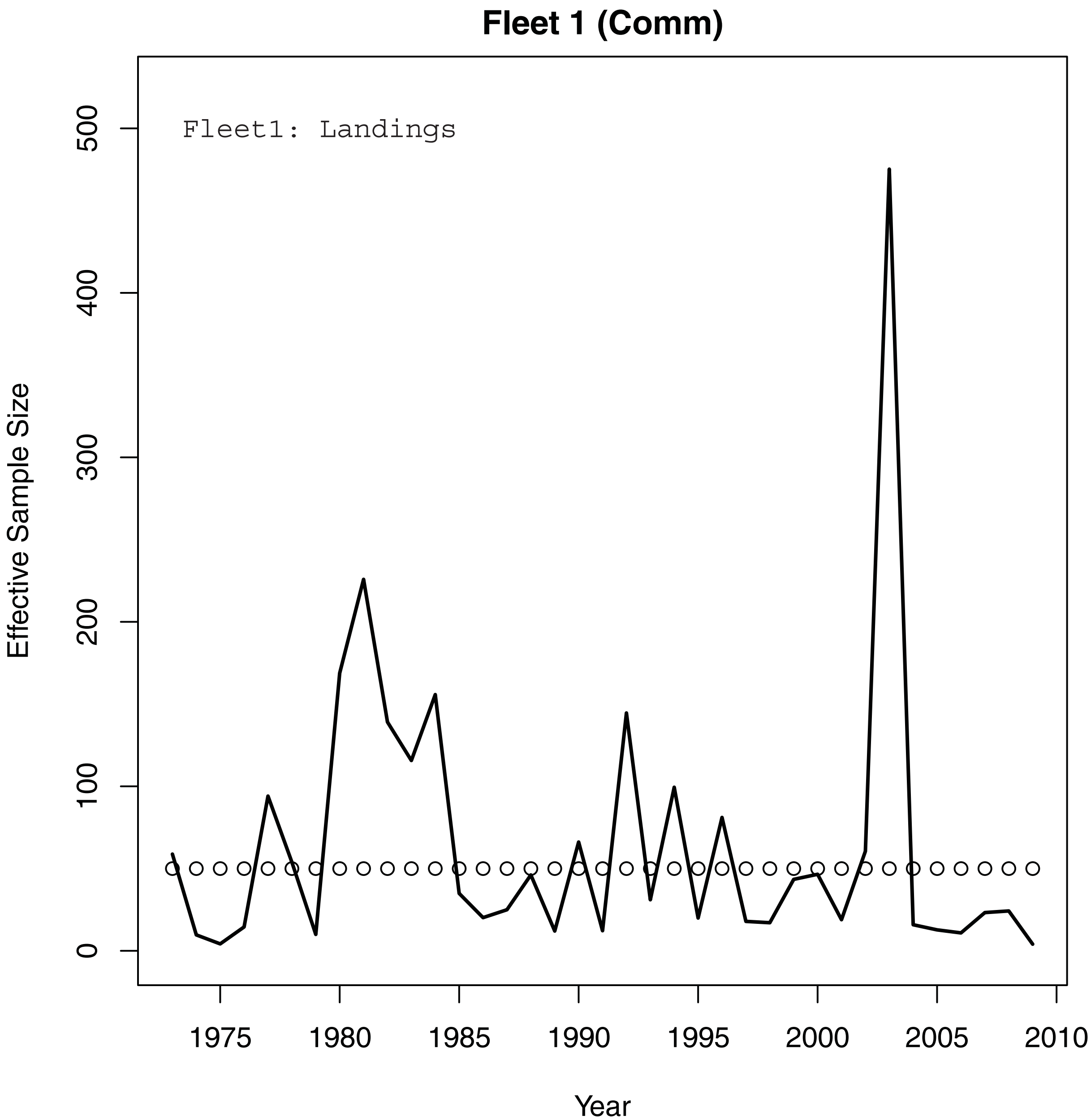


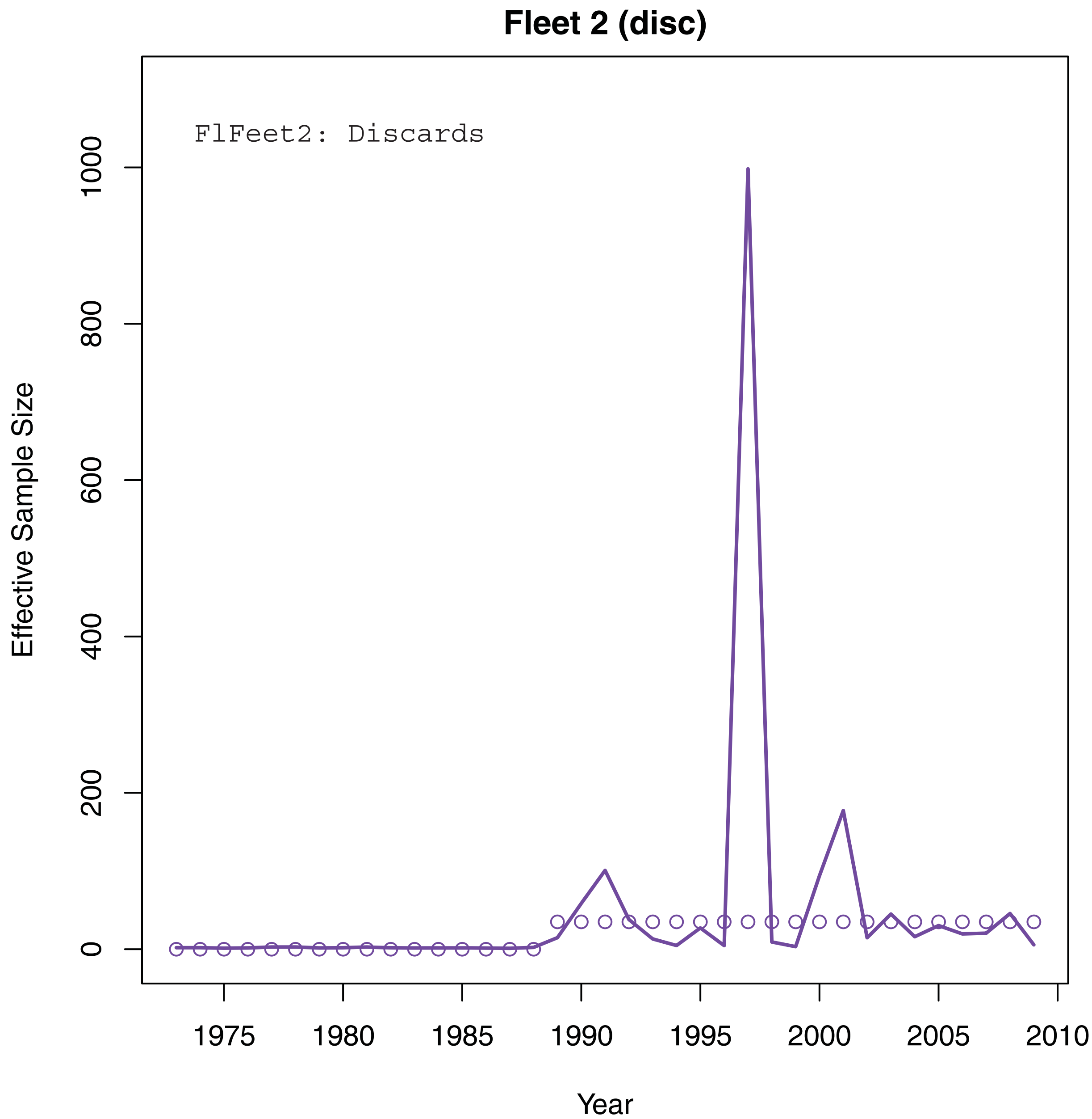

Fleet 3 Landings (consump)
Total Catch
0
50000
100000
150000
1975
1985
1995
2005
Year
Ln(Total Catch)
0
2
4
6
8
10
12
Log−scale Std. Residual
−3
−2
−1
0
1
2
Probability Density
0.00
0.10
0.20
0.30
−4
−3
−2
−1
0
1
2
3
Std. Residual

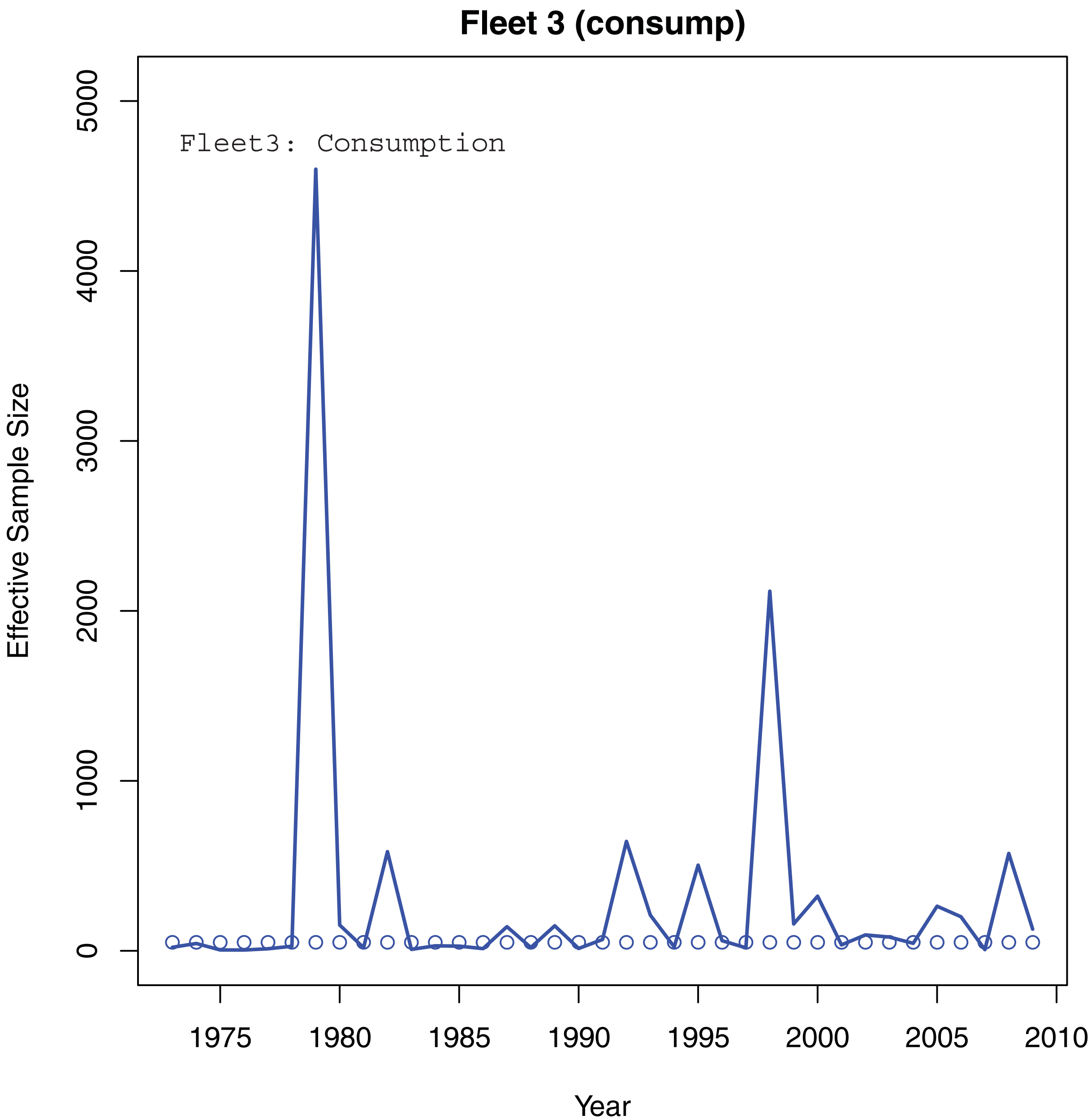

Catch Age Comp Residuals for Fleet 1 (Comm)
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age

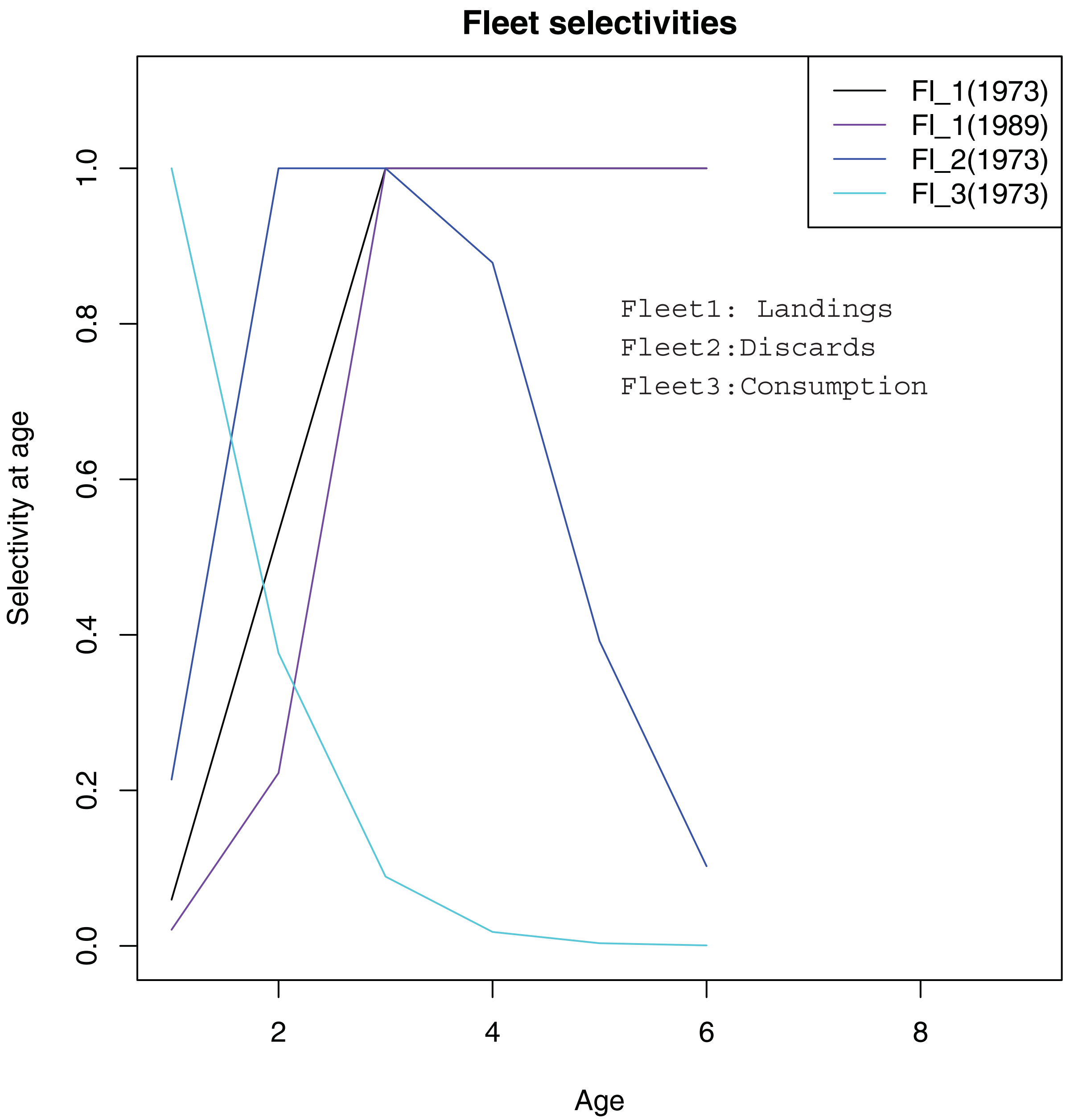

Catch Age Comp Residuals for Fleet 2 (disc)
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age


Catch Age Comp Residuals for Fleet 3 (consump)
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age


Fleet 1 (Comm)
Fleet1: Landings
Effective Sample Size
0
100
200
300
400
500
1975
1980
1985
1990
1995
2000
2005
2010
Year

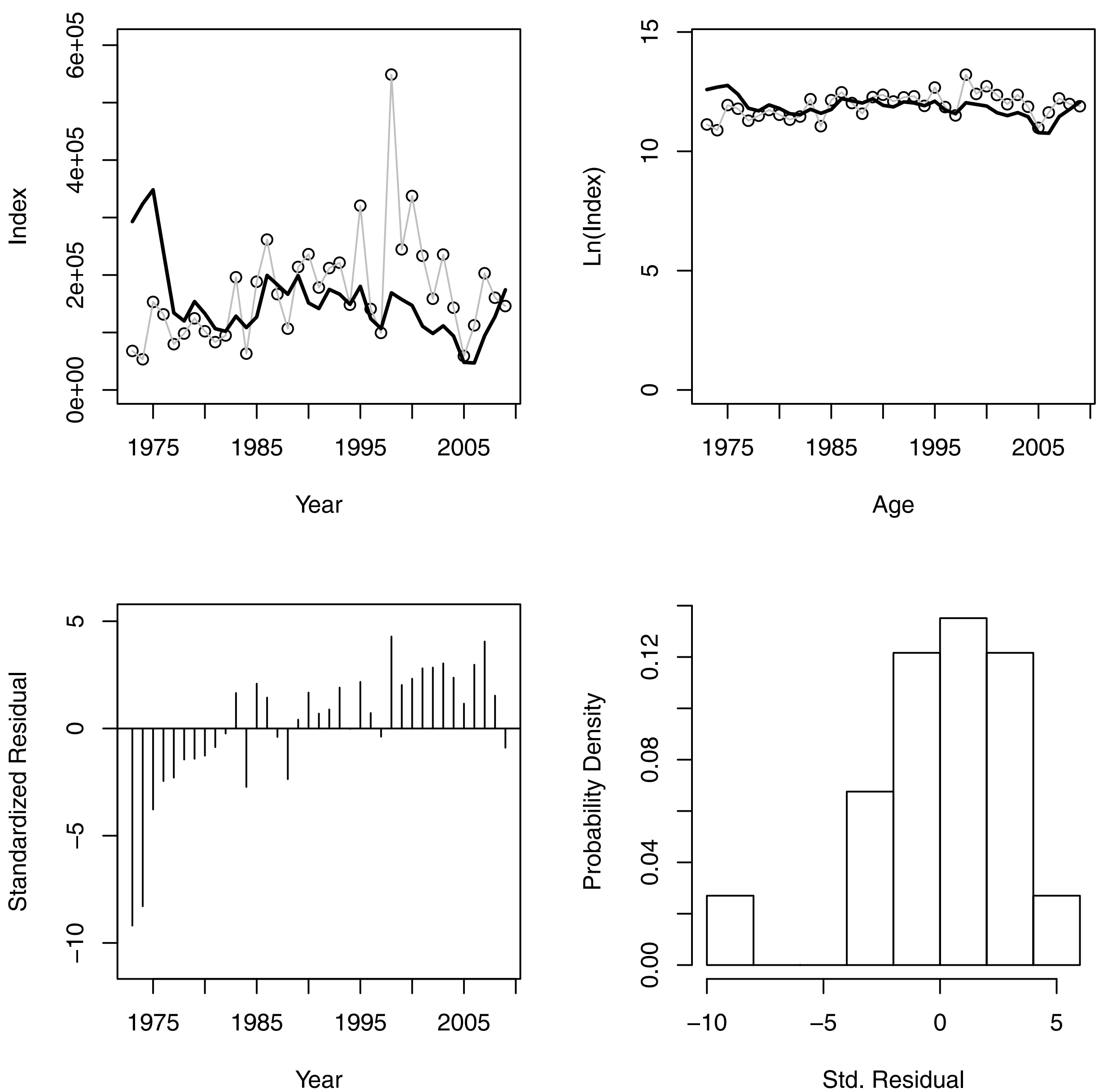

Fleet 2 (disc)
FlFeet2: Discards
Effective Sample Size
0
200
400
600
800
1000
1975
1980
1985
1990
1995
2000
2005
2010
Year


Fleet 3 (consump)
Fleet3: Consumption
Effective Sample Size
0
1000
2000
3000
4000
5000
1975
1980
1985
1990
1995
2000
2005
2010
Year


Fleet selectivities
Selectivity at age
Age
Fl_1(1973)
Fl_1(1989)
Fl_2(1973)
Fl_3(1973)
Fleet1: Landings
Fleet2:Discards
Fleet3:Consumption
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8

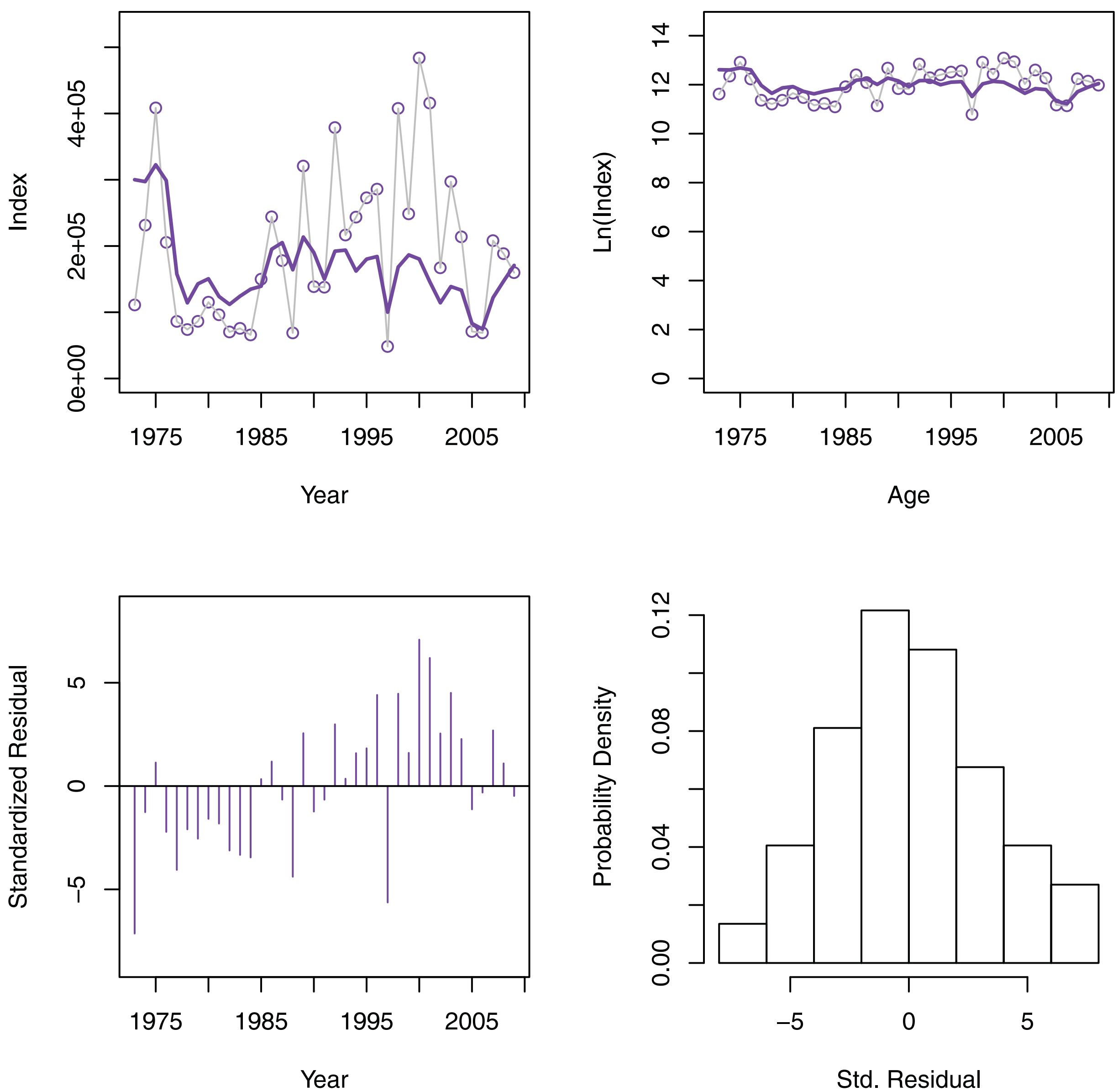
Index 1

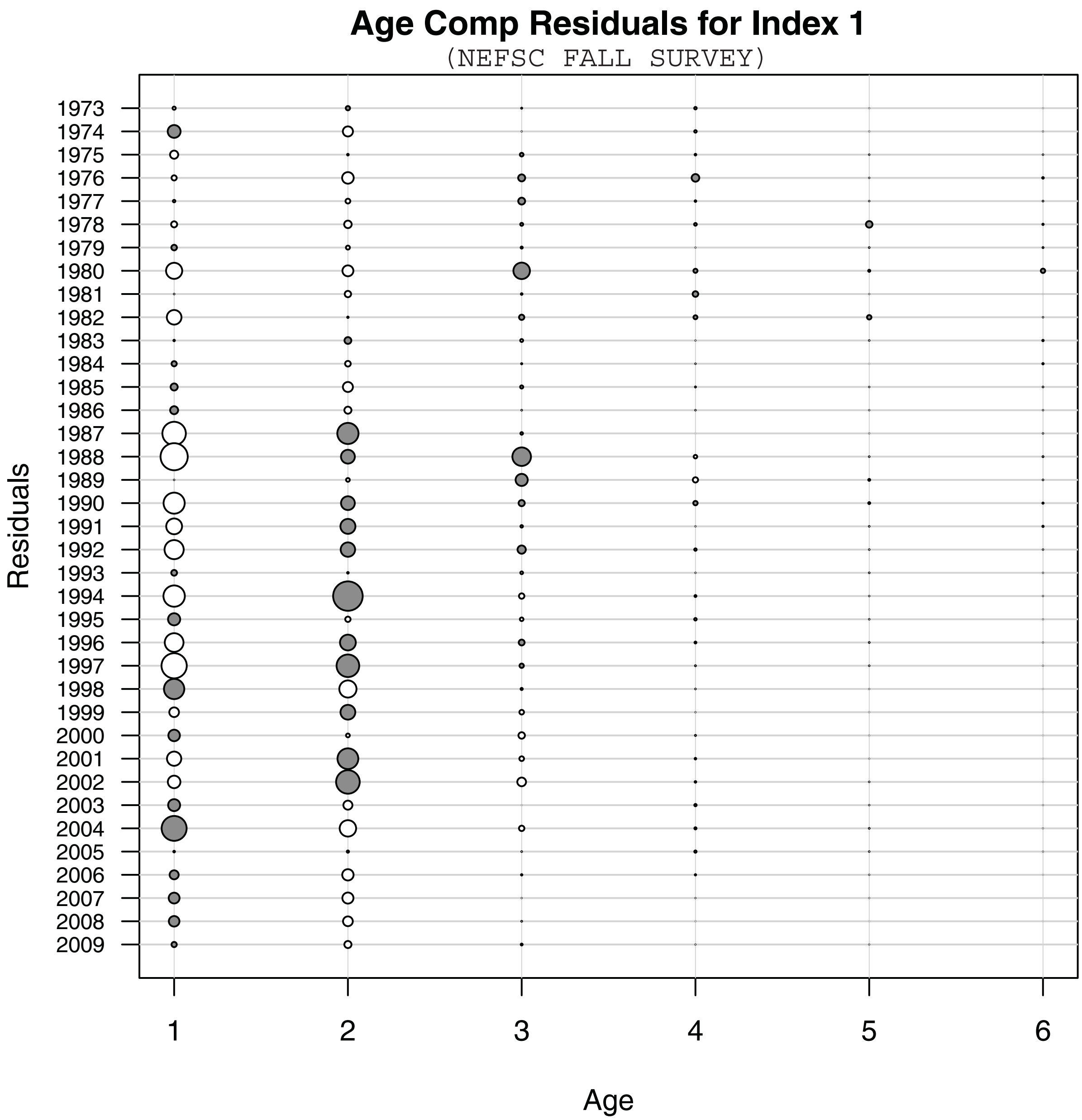
NEFSC FALL SURVEY



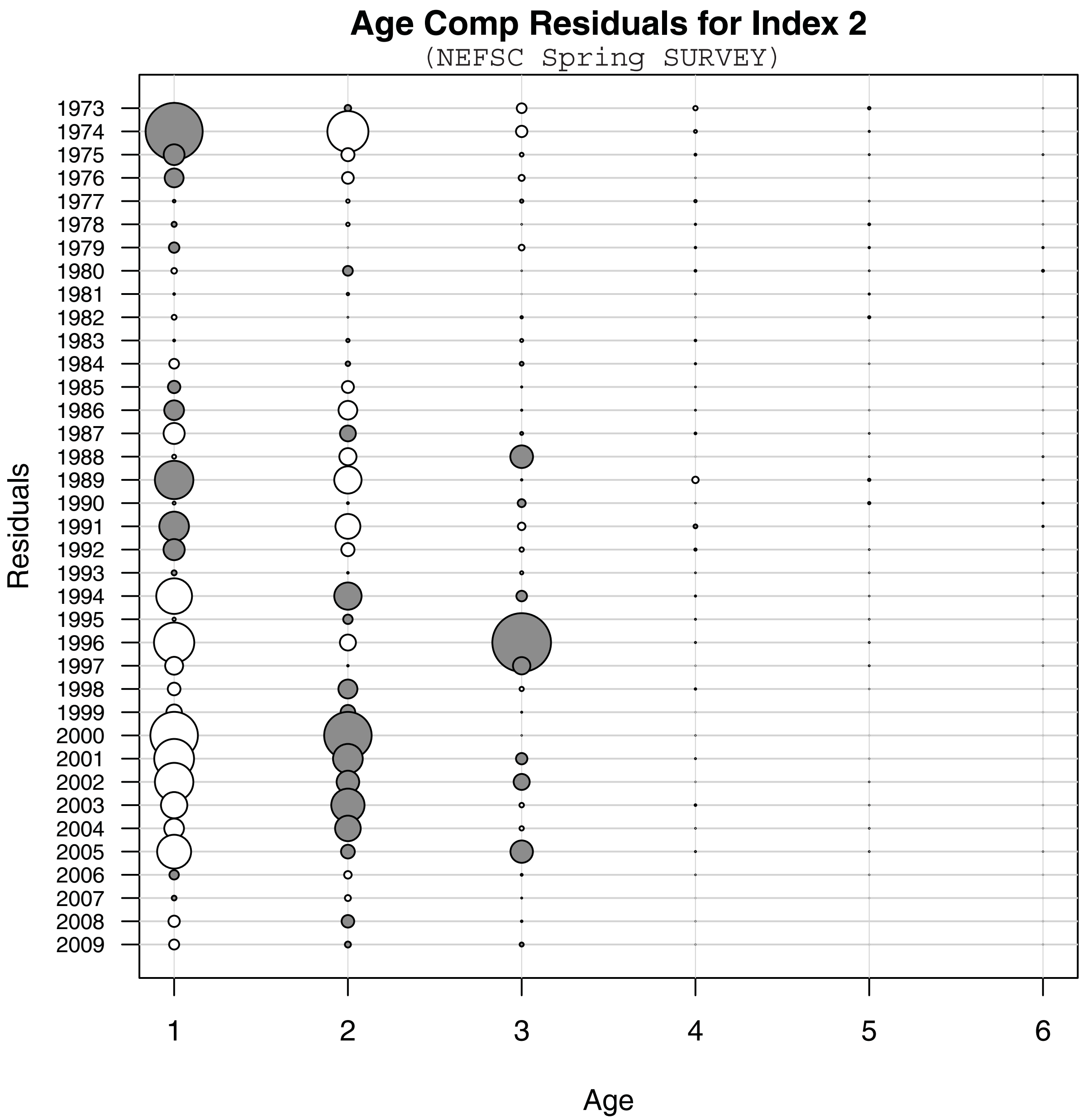
Index 2

NEFSC Spring Survey





Age Comp Residuals for Index 1
(NEFSC FALL SURVEY)
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age



Age Comp Residuals for Index 2
(NEFSC Spring SURVEY)
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
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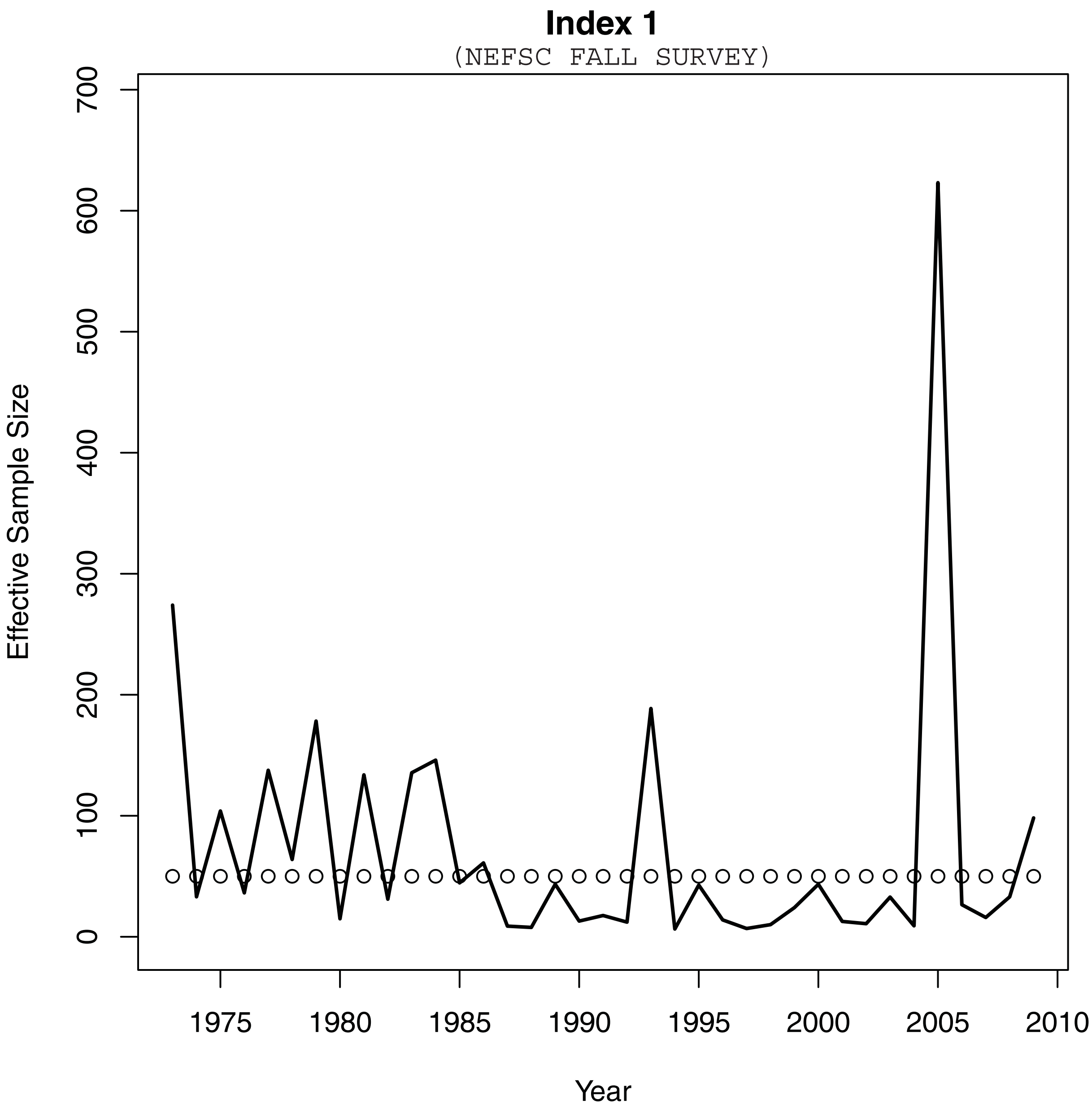
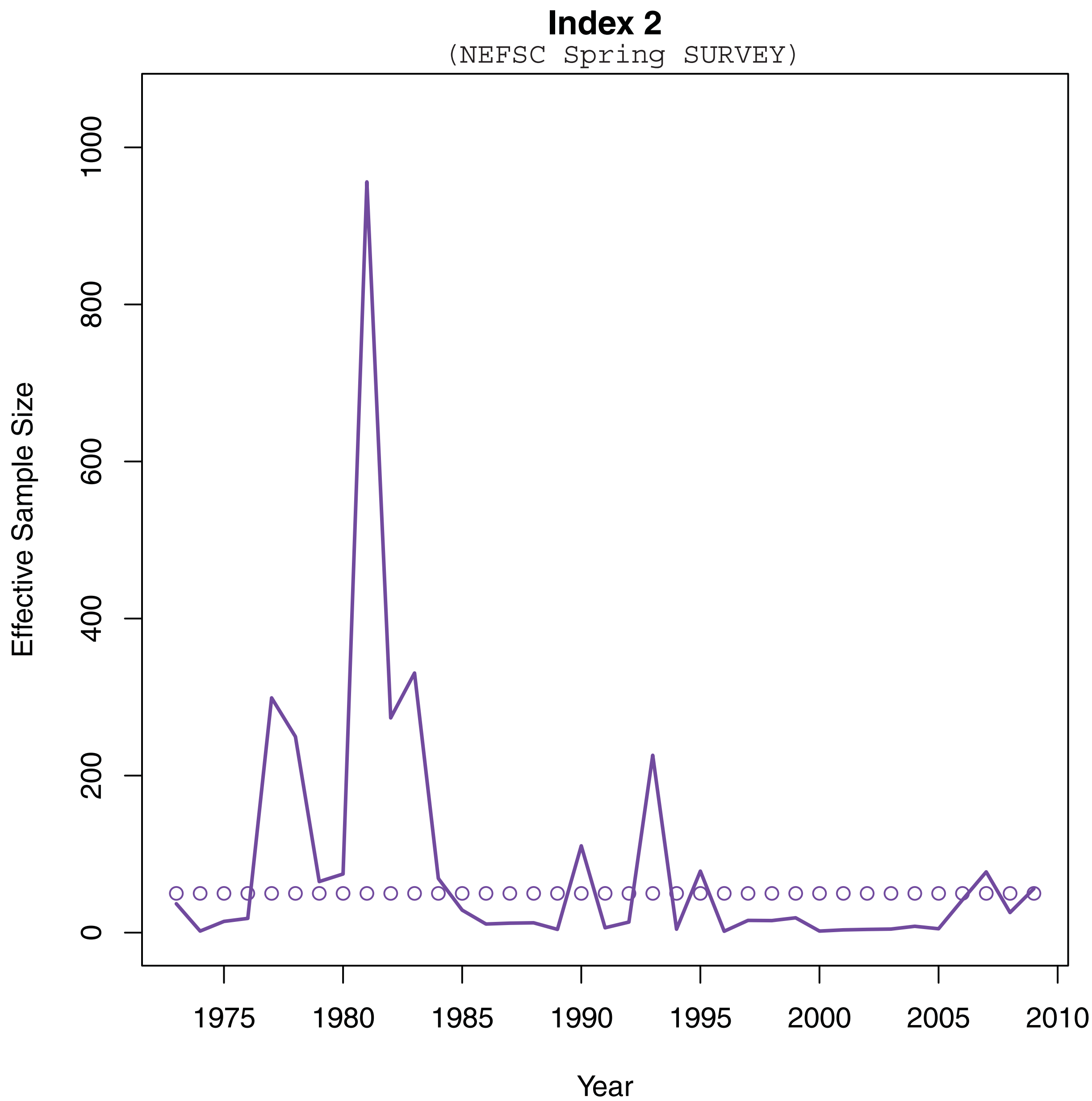
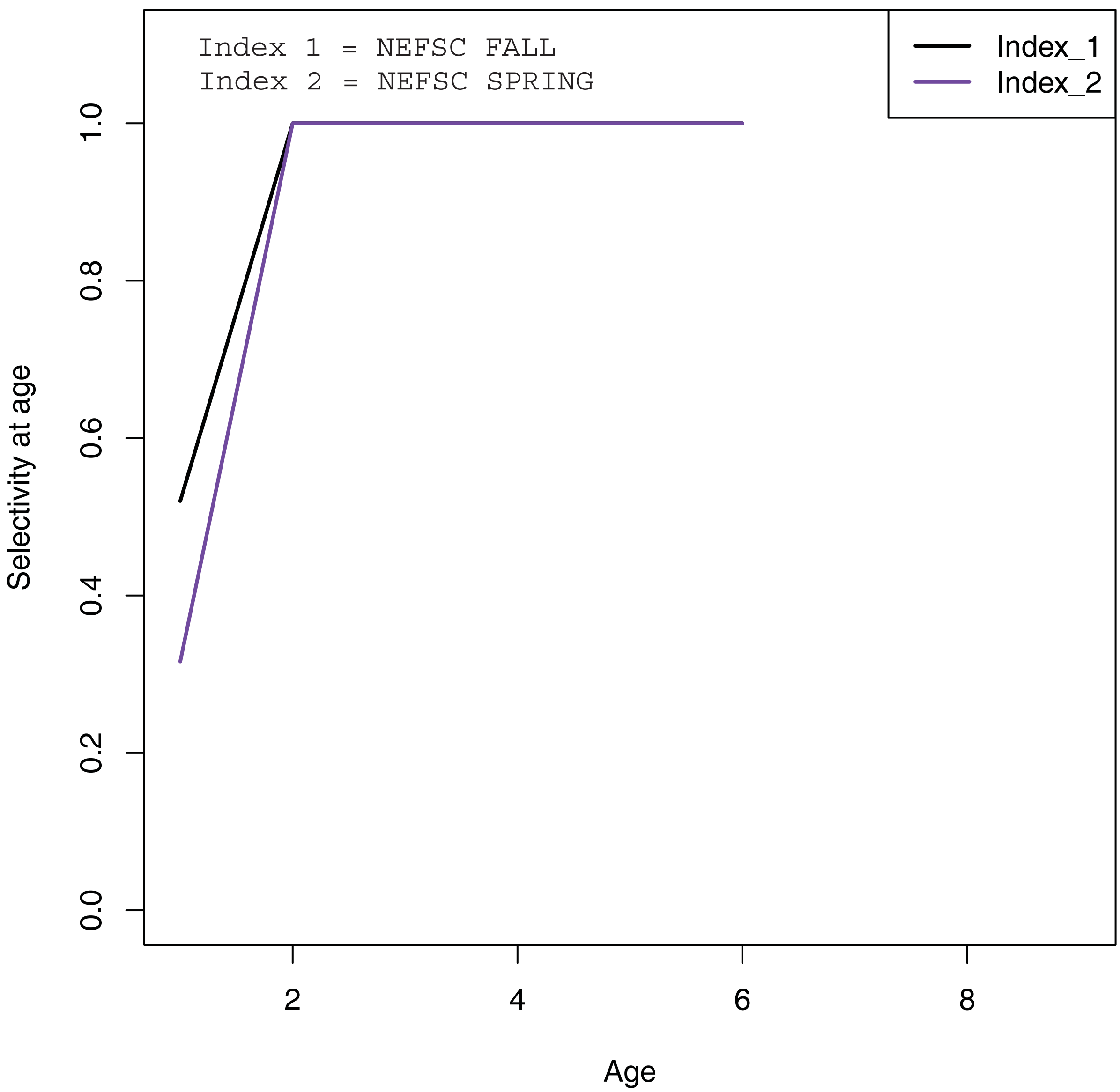
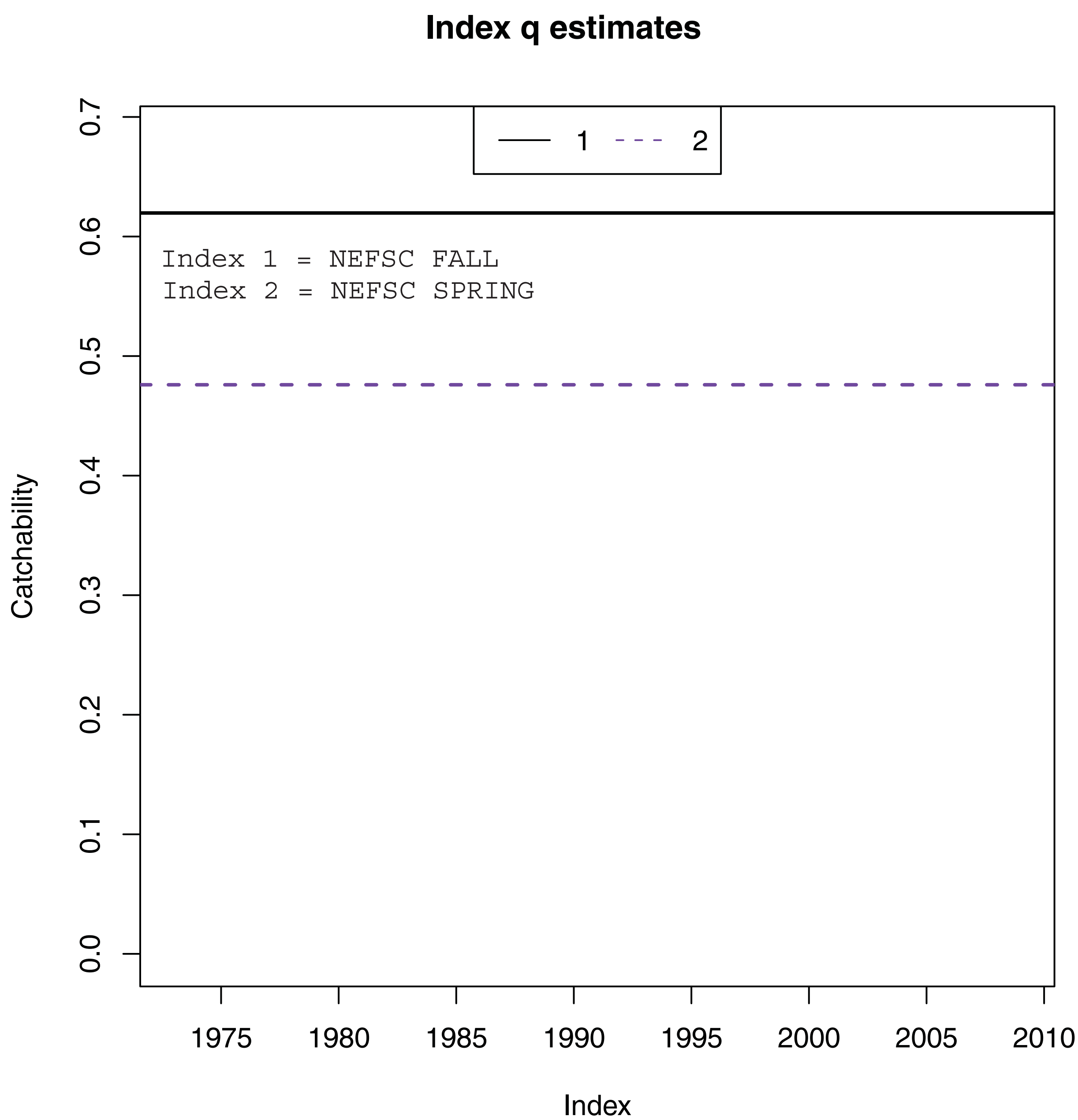
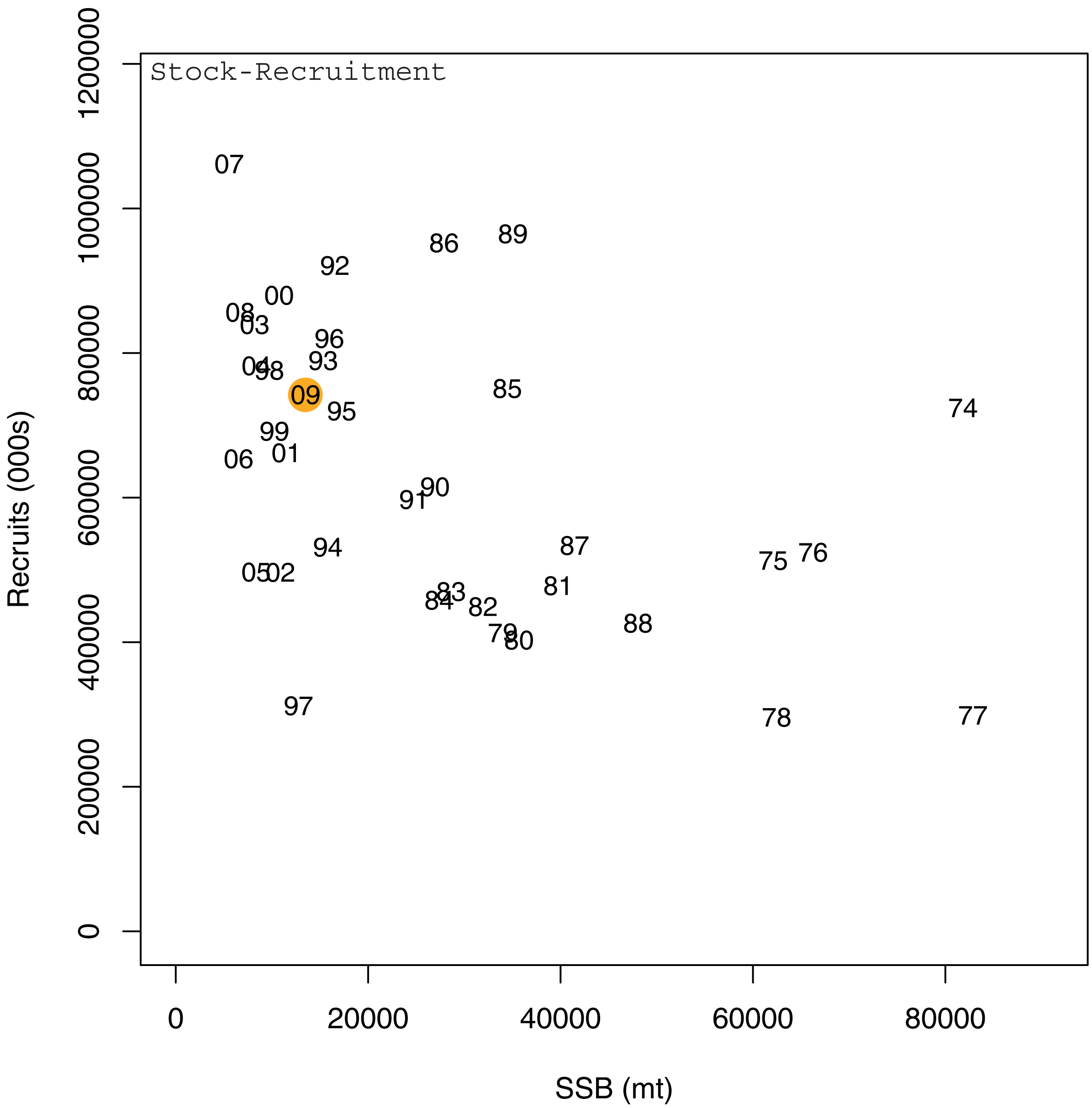
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age

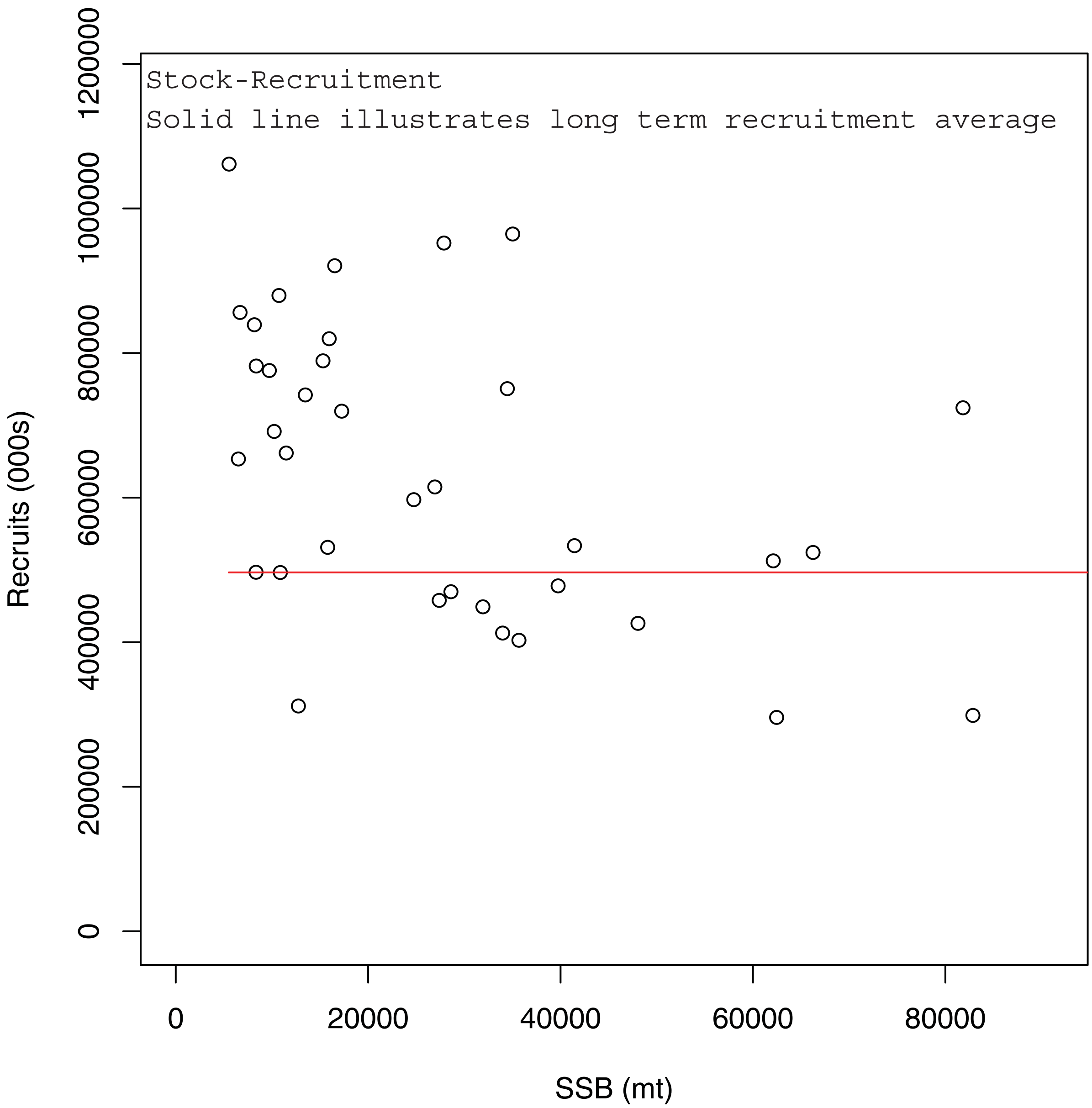

Index 1
(NEFSC FALL SURVEY)
Effective Sample Size
0
100
200
300
400
500
600
700
1975
1980
1985
1990
1995
2000
2005
2010
Year

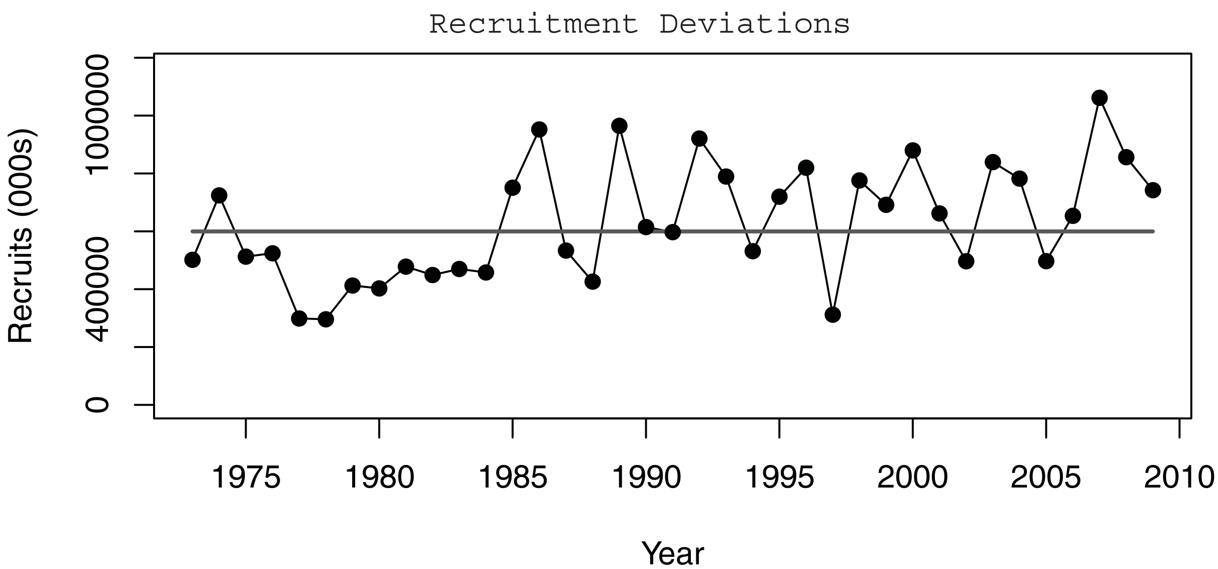

Index 2
(NEFSC Spring SURVEY)
Effective Sample Size
0
200
400
600
800
1000
1975
1980
1985
1990
1995
2000
2005
2010
Year

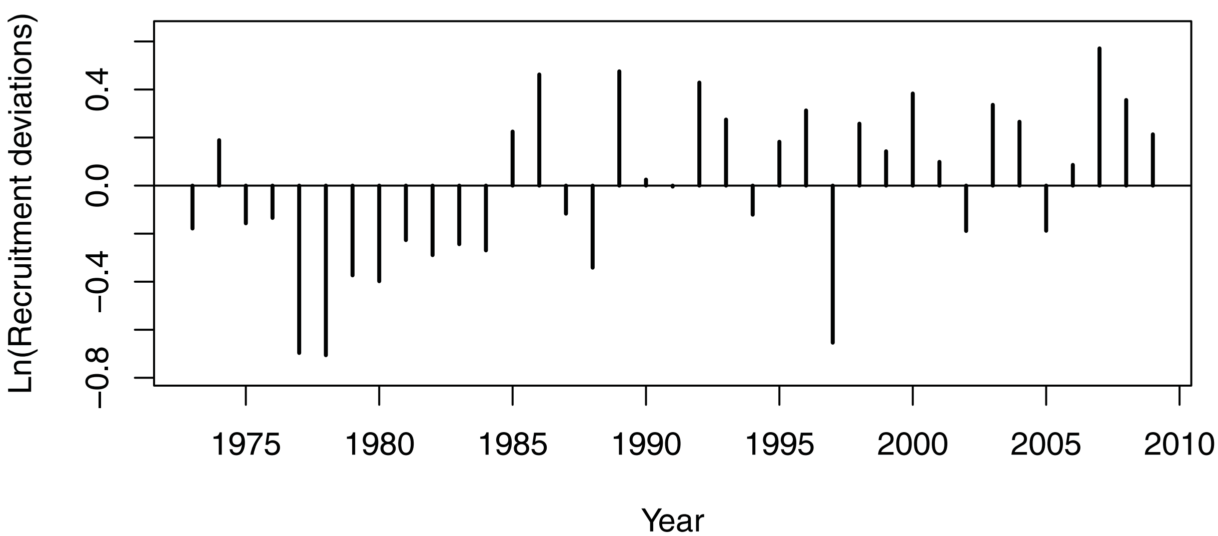

Index 1 = NEFSC FALL
Index 2 = NEFSC SPRING
Index_1
Index_2
Selectivity at age
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
Age

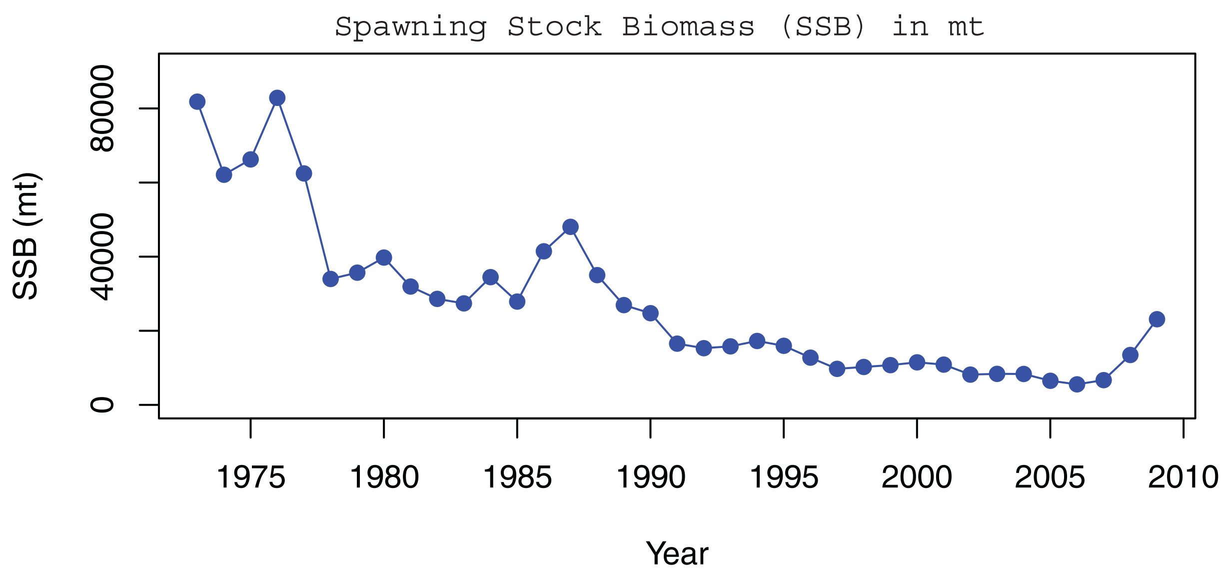

Index q estimates
1
2
Index 1 = NEFSC FALL
Index 2 = NEFSC SPRING
Catchability
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
1975
1980
1985
1990
1995
2000
2005
2010
Index

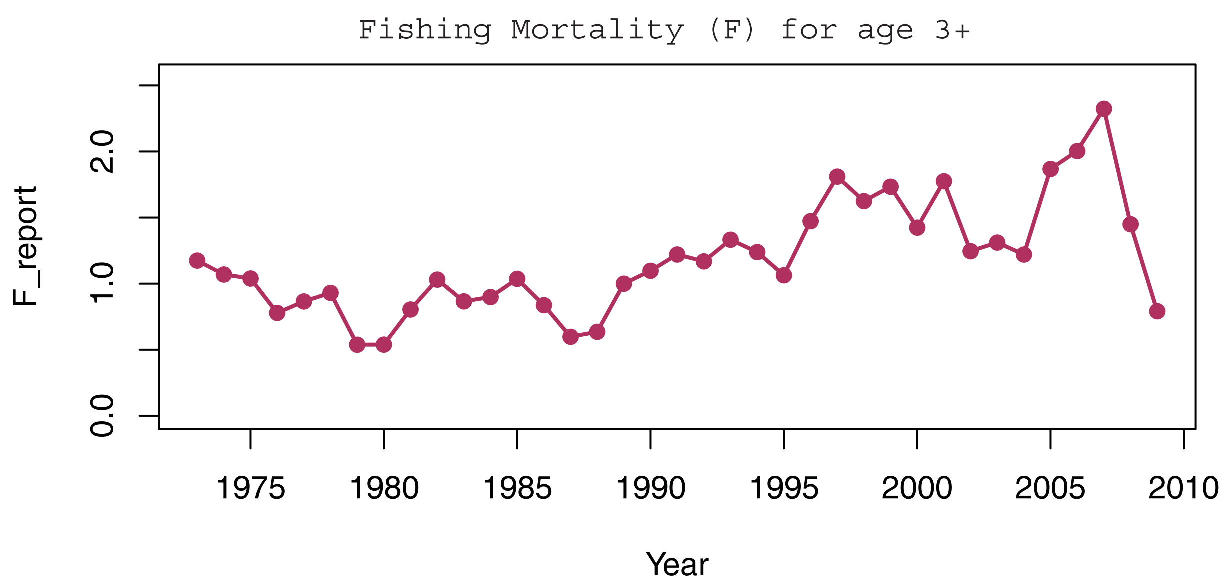

Stock-Recruitment
Recruits (000s)
SSB (mt)
0
200000
400000
600000
800000
1000000
1200000
0
20000
40000
60000
80000
07
86
89
92
00
08
03
96
93
04
98
09
85
74
95
99
01
06
91
90
94
87
75
76
05
02
81
83
84
82
88
79
80
97
78
77

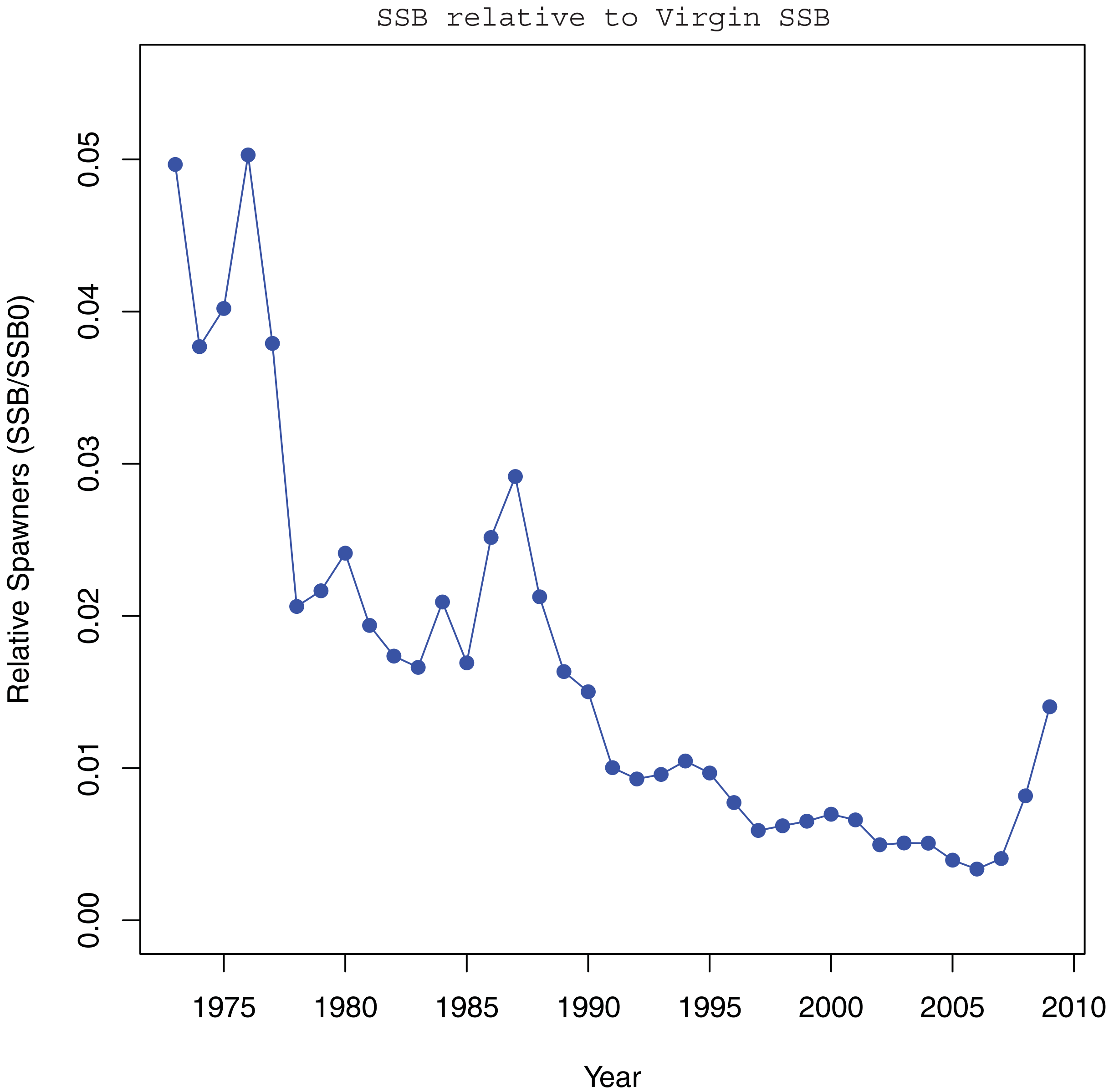

Stock-Recruitment
Solid line illustrates long term recruitment average
Recruits (000s)
0
200000
400000
600000
800000
1000000
1200000
0
20000
40000
60000
80000
SSB (mt)

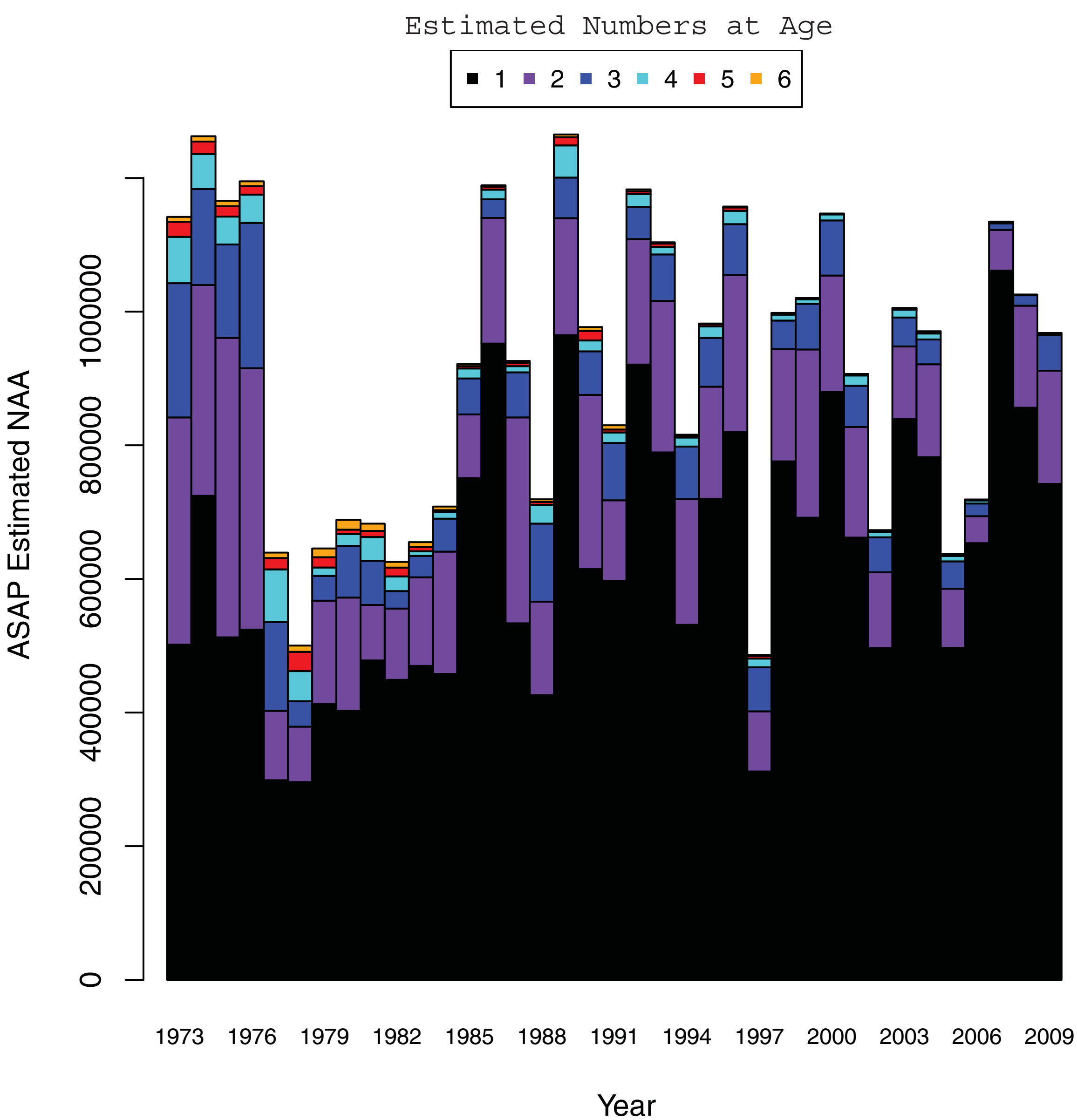

Recruitment Deviations
Recruits (000s)
0
400000
1000000
1975
1980
1985
1990
1995
2000
2005
2010
Year

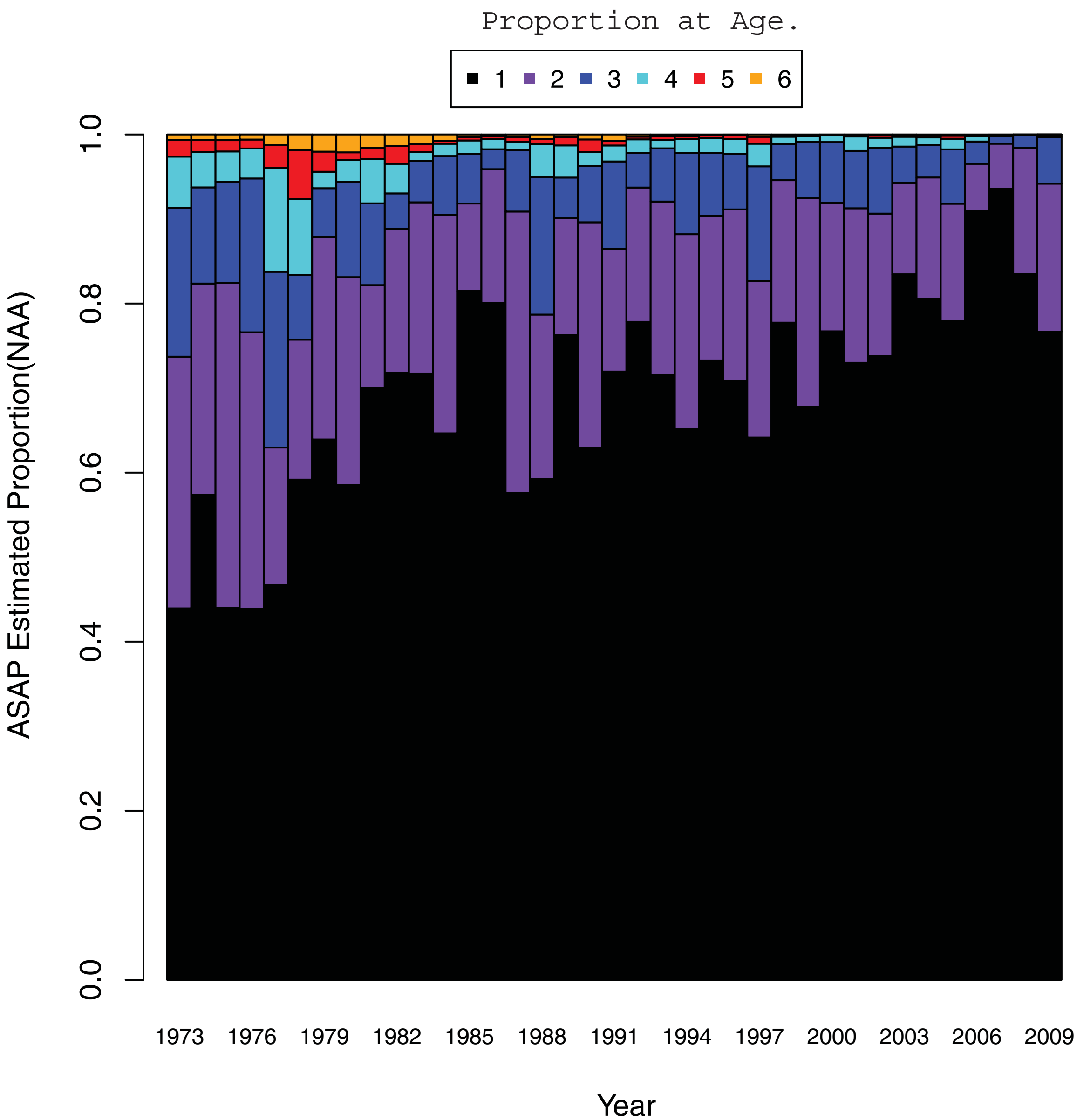

Ln(Recruitment deviations)
−0.8
−0.4
0.0
0.4
1975
1980
1985
1990
1995
2000
2005
2010
Year


Spawning Stock Biomass (SSB) in mt
SSB (mt)
0
40000
80000
1975
1980
1985
1990
1995
2000
2005
2010
Year

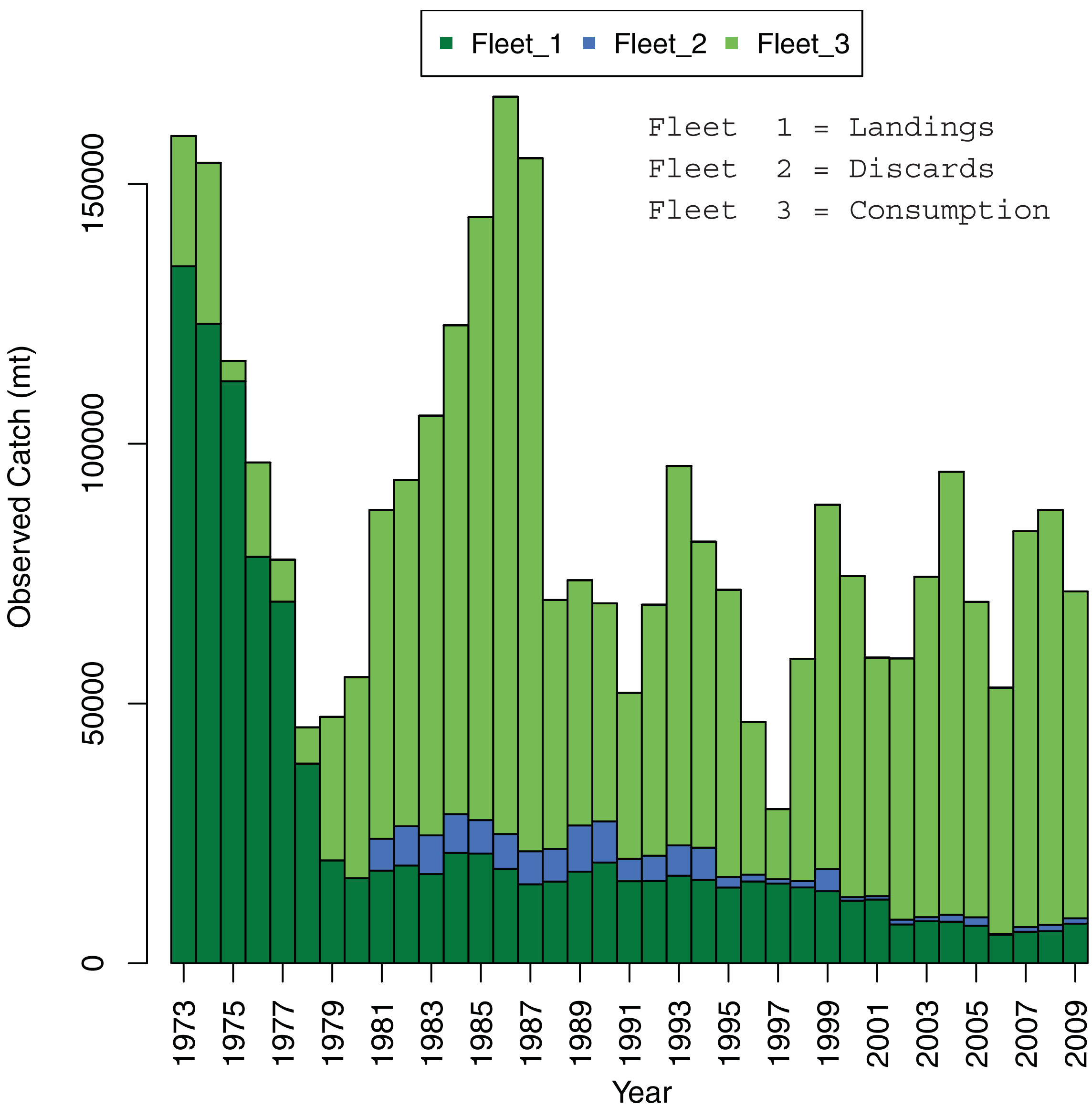

Fishing Mortality (F) for age 3+
F_report
0.0
1.0
2.0
1975
1980
1985
1990
1995
2000
2005
2010
Year

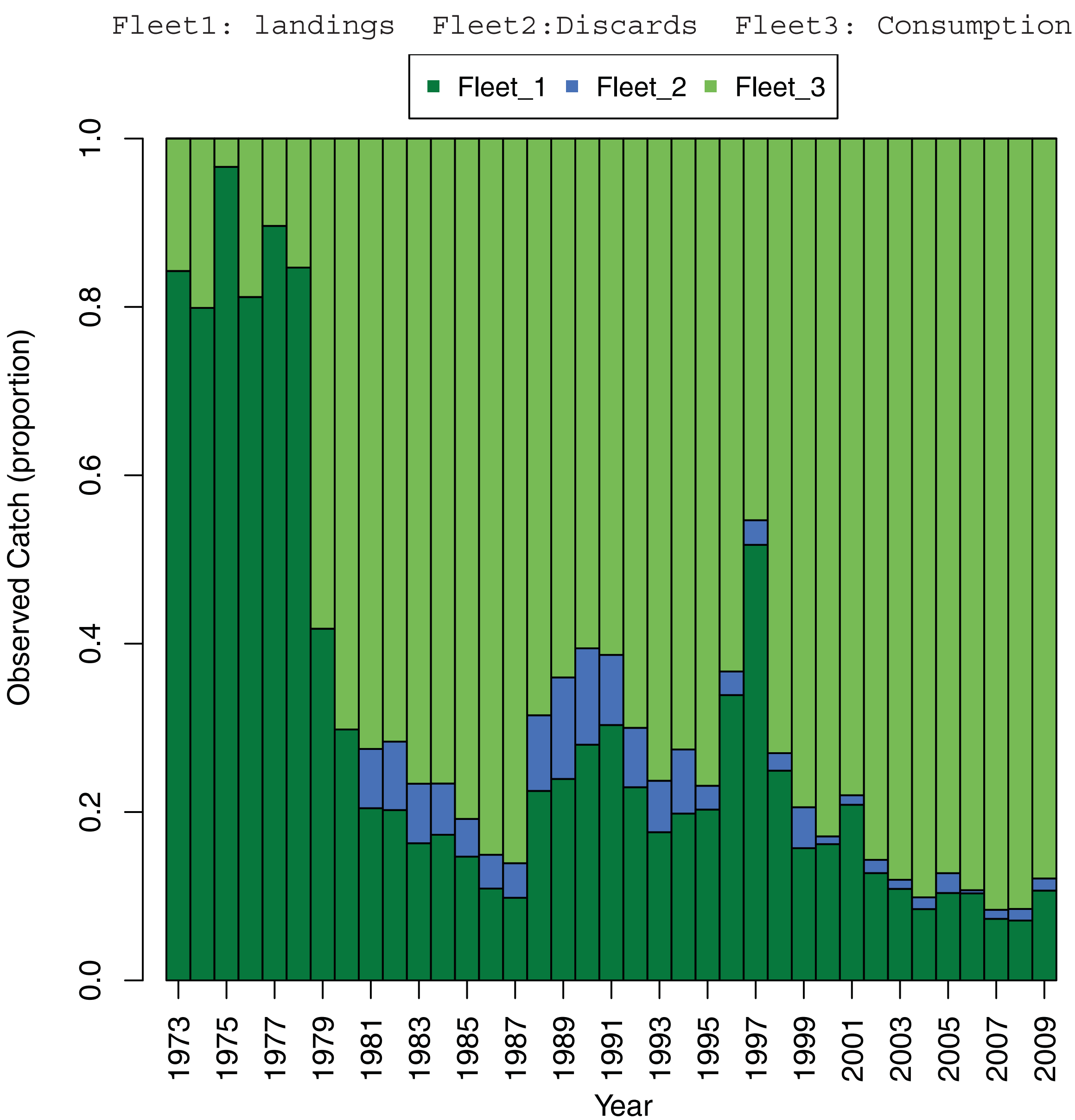

SSB relative to Virgin SSB
Relative Spawners (SSB/SSB0)
0.00
0.01
0.02
0.03
0.04
0.05
1975
1980
1985
1990
1995
2000
2005
2010
Year

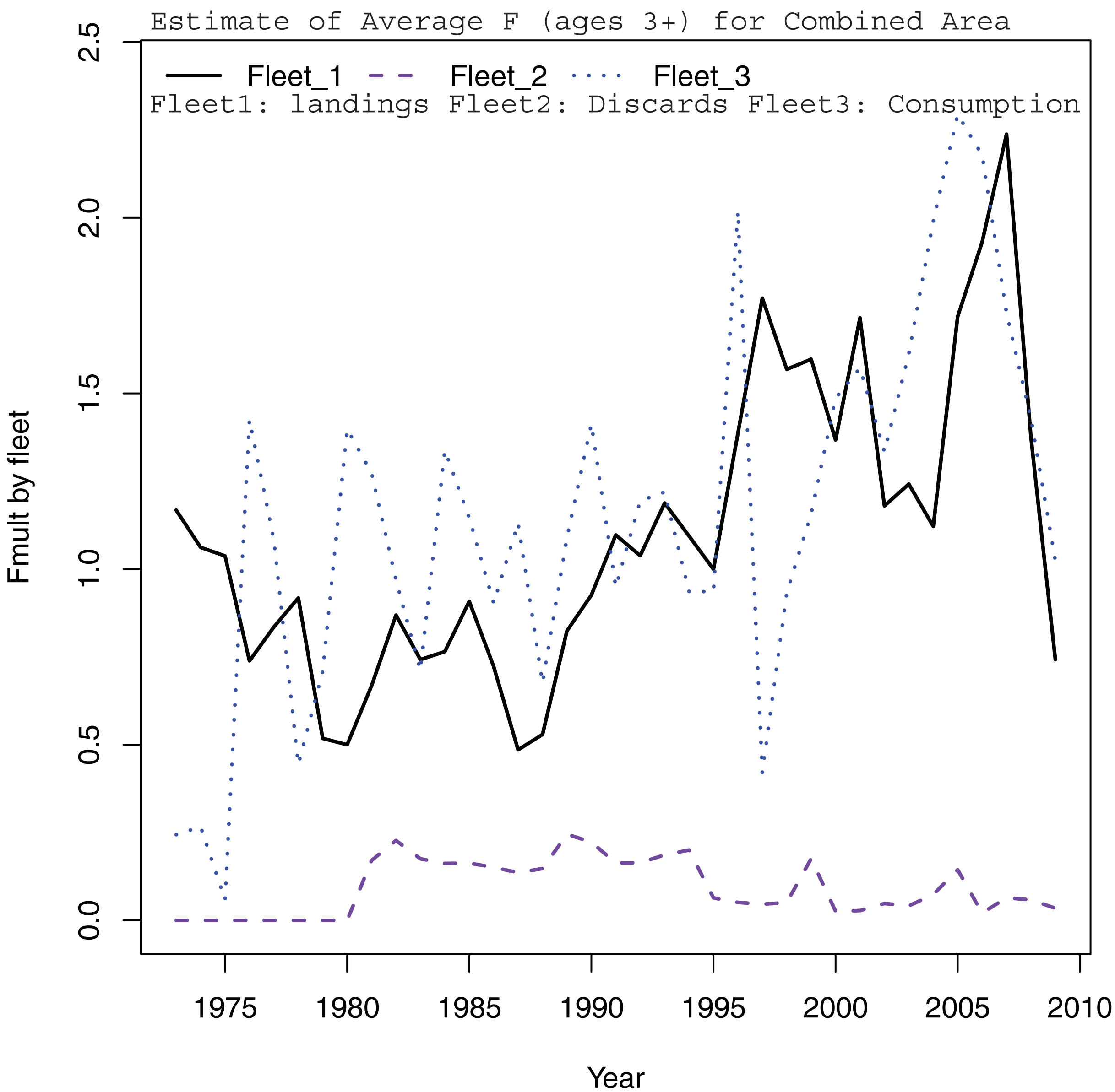

Estimated Numbers at Age
1
2
3
4
5
6
ASAP Estimated NAA
0
200000
400000
600000
800000
1000000
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
Year



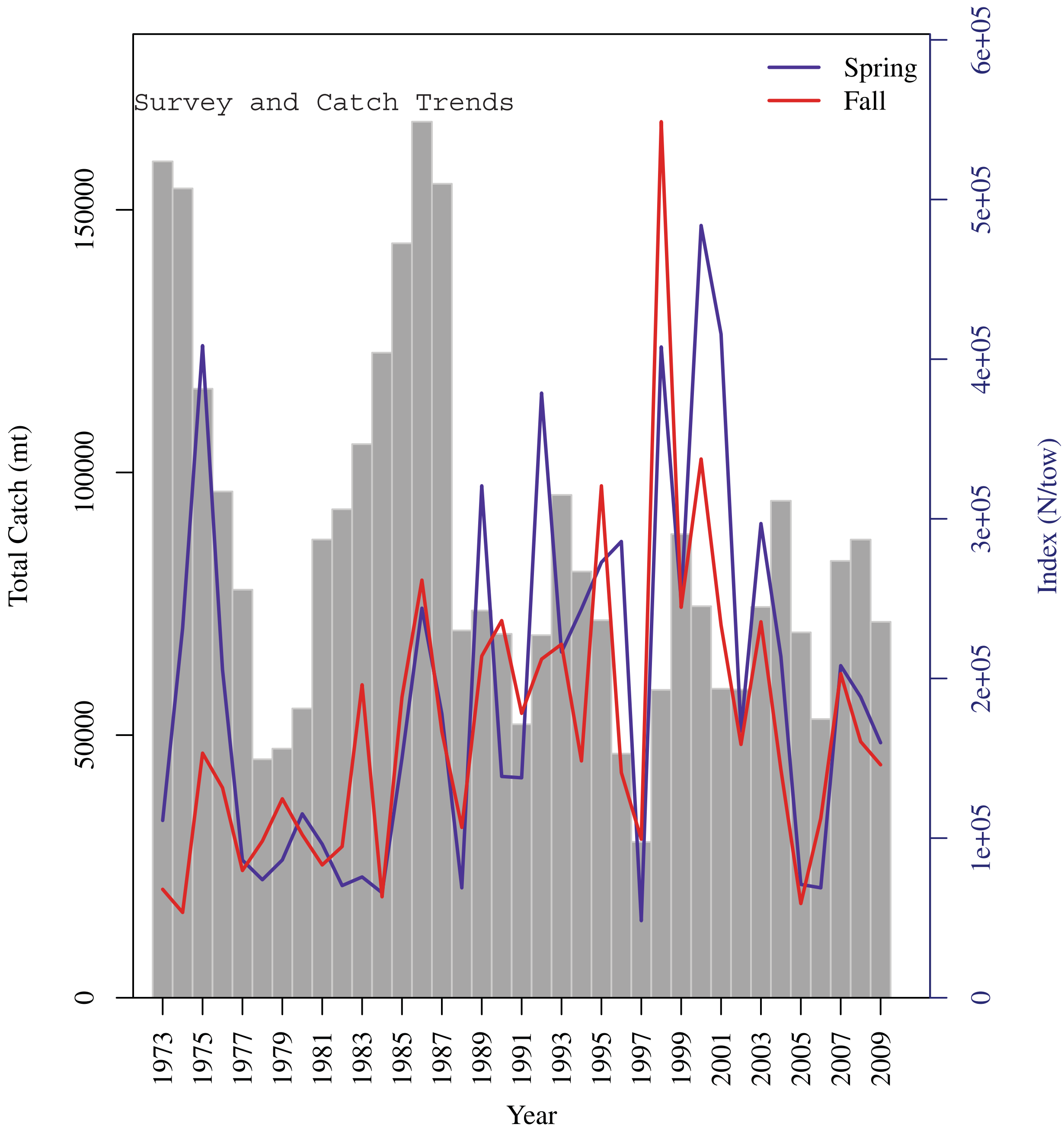
Proportion at Age.
1
2
3
4
5
6
ASAP Estimated Proportion(NAA)
0.0
0.2
0.4
0.6
0.8
1.0
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
Year

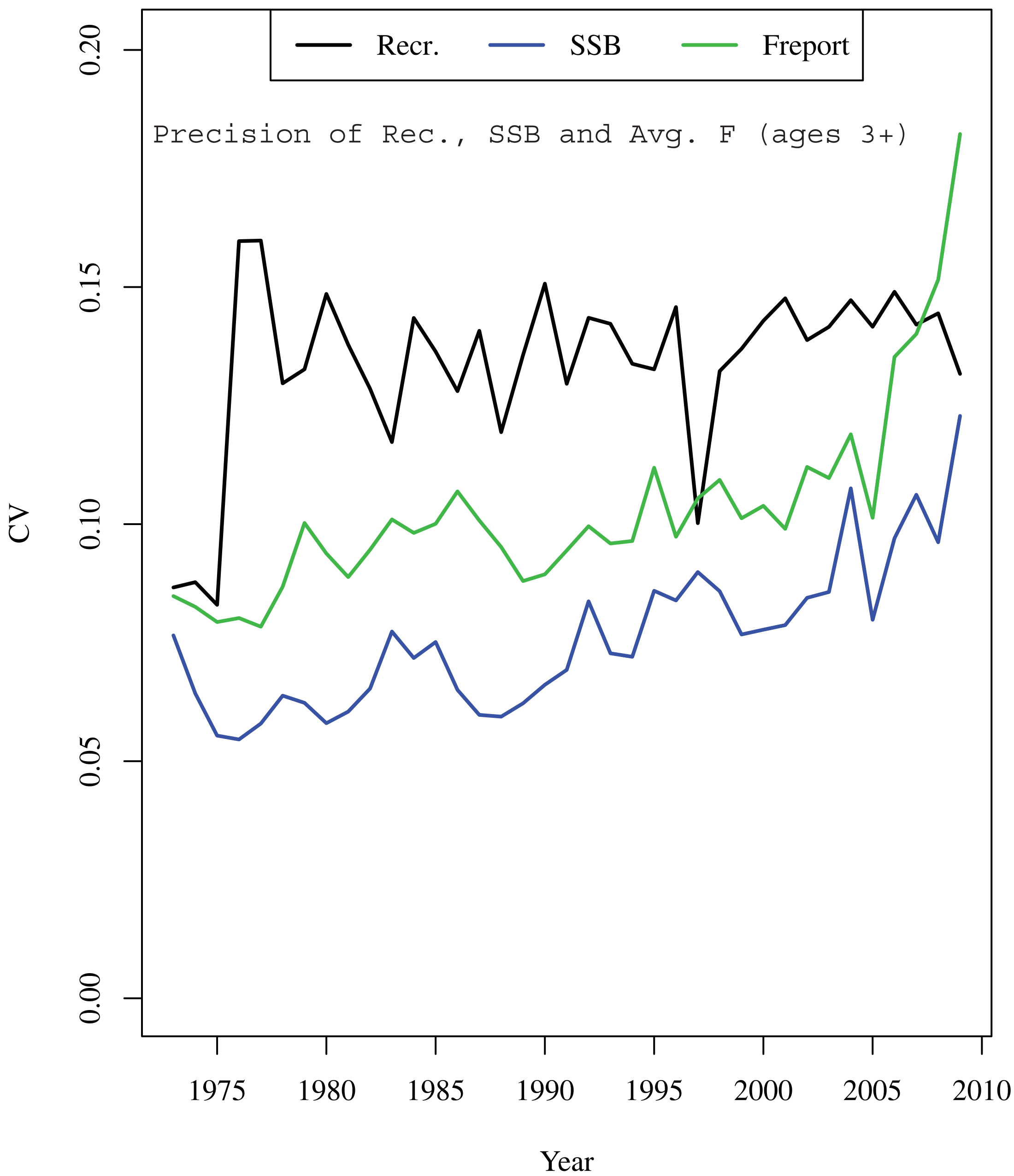

Fleet_1
Fleet_2
Fleet_3
Fleet 1 = Landings
Fleet 2 = Discards
Fleet 3 = Consumption
Observed Catch (mt)
0
50000
100000
150000
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year

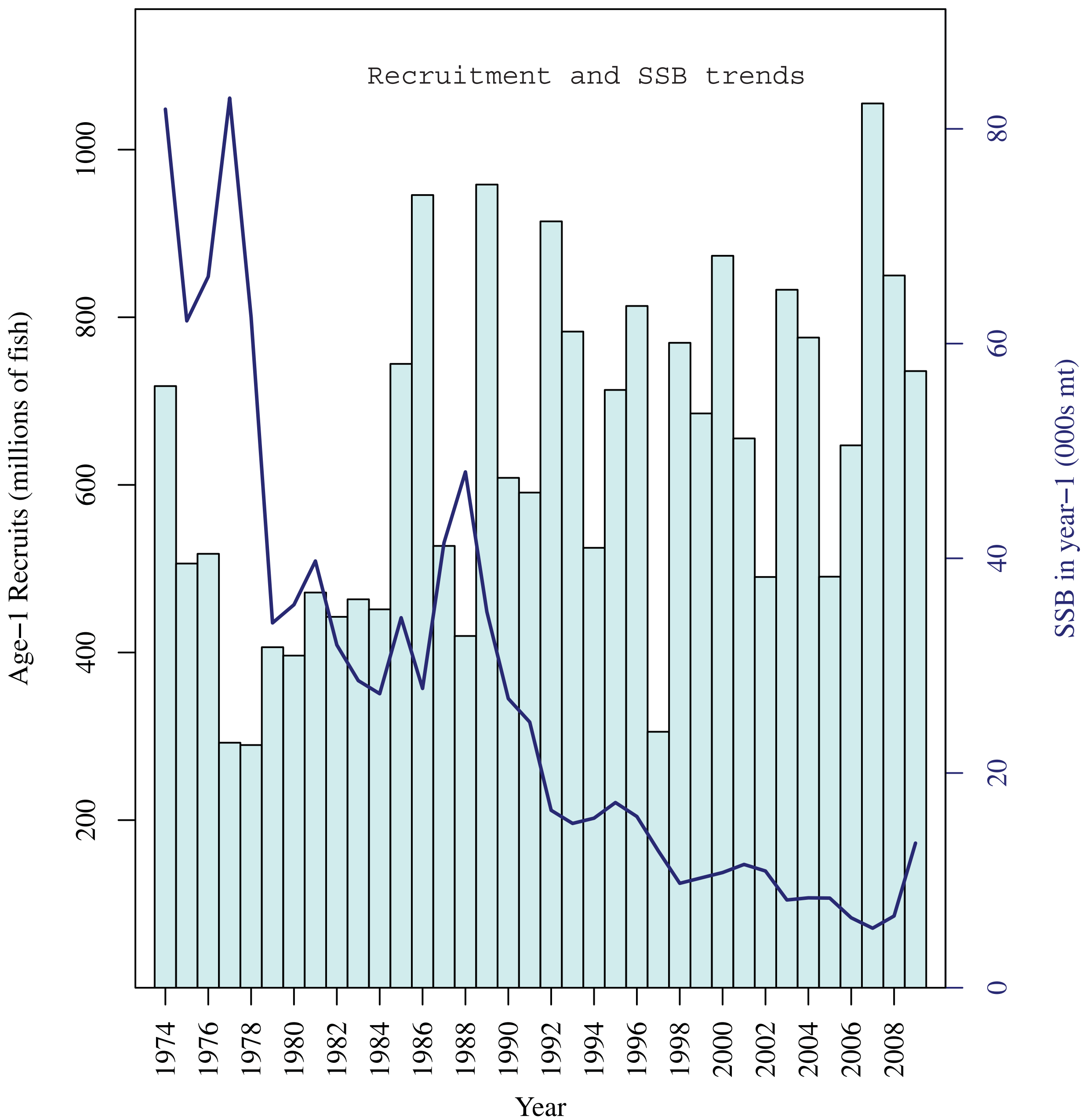

Fleet1: landings Fleet2:Discards Fleet3: Consumption
Fleet_1
Fleet_2
Fleet_3
Observed Catch (proportion)
0.0
0.2
0.4
0.6
0.8
1.0
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year



Estimate of Average F (ages 3+) for Combined Area
Fleet_1
Fleet_2
Fleet_3
Fleet1: landings Fleet2: Discards Fleet3: Consumption
Fmult by fleet
0.0
0.5
1.0
1.5
2.0
2.5
1975
1980
1985
1990
1995
2000
2005
2010
Year


Survey and Catch Trends
Spring
Fall
Total Catch (mt)
0
50000
100000
150000
Index (N/tow)
0
1e+05
2e+05
3e+05
4e+05
5e+05
6e+05
Year
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009


Recr.
SSB
Freport
Precision of Rec., SSB and Avg. F (ages 3+)
CV
0.00
0.05
0.10
0.15
0.20
1975
1980
1985
1990
1995
2000
2005
2010
Year


Recruitment and SSB trends
Age−1 Recruits (millions of fish)
SSB in year−1 (000s mt)
Year
200
400
600
800
1000
0
20
40
60
80
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008

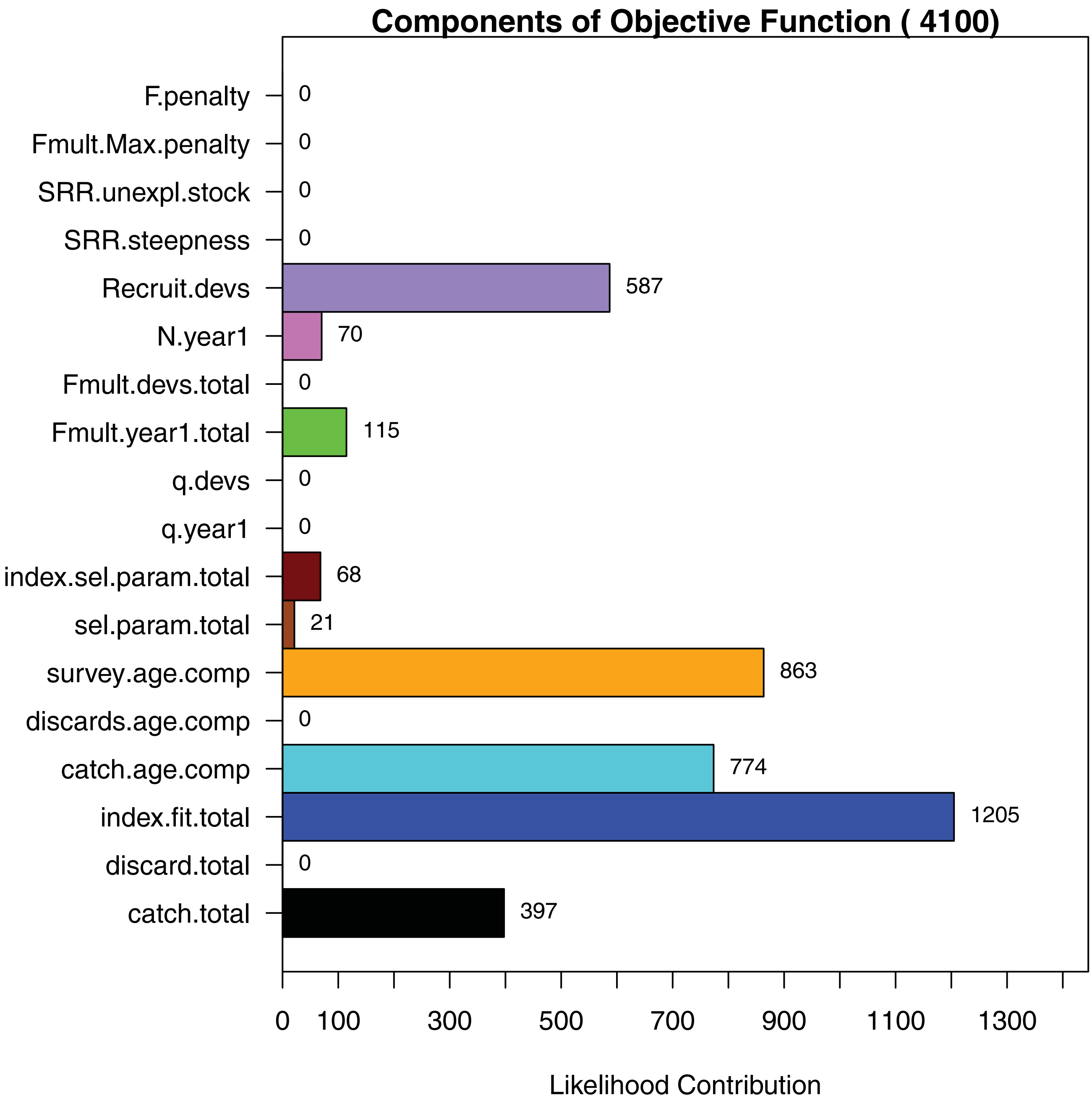
Appendix A3: North Model ASAP results M = 0.4 Base run

Model Attributes:

1. 3 Fleet Model
    a. Catch : 1973-2009
    b. Discards: 1981 – 2009
    c. Consumption – 1973-2009

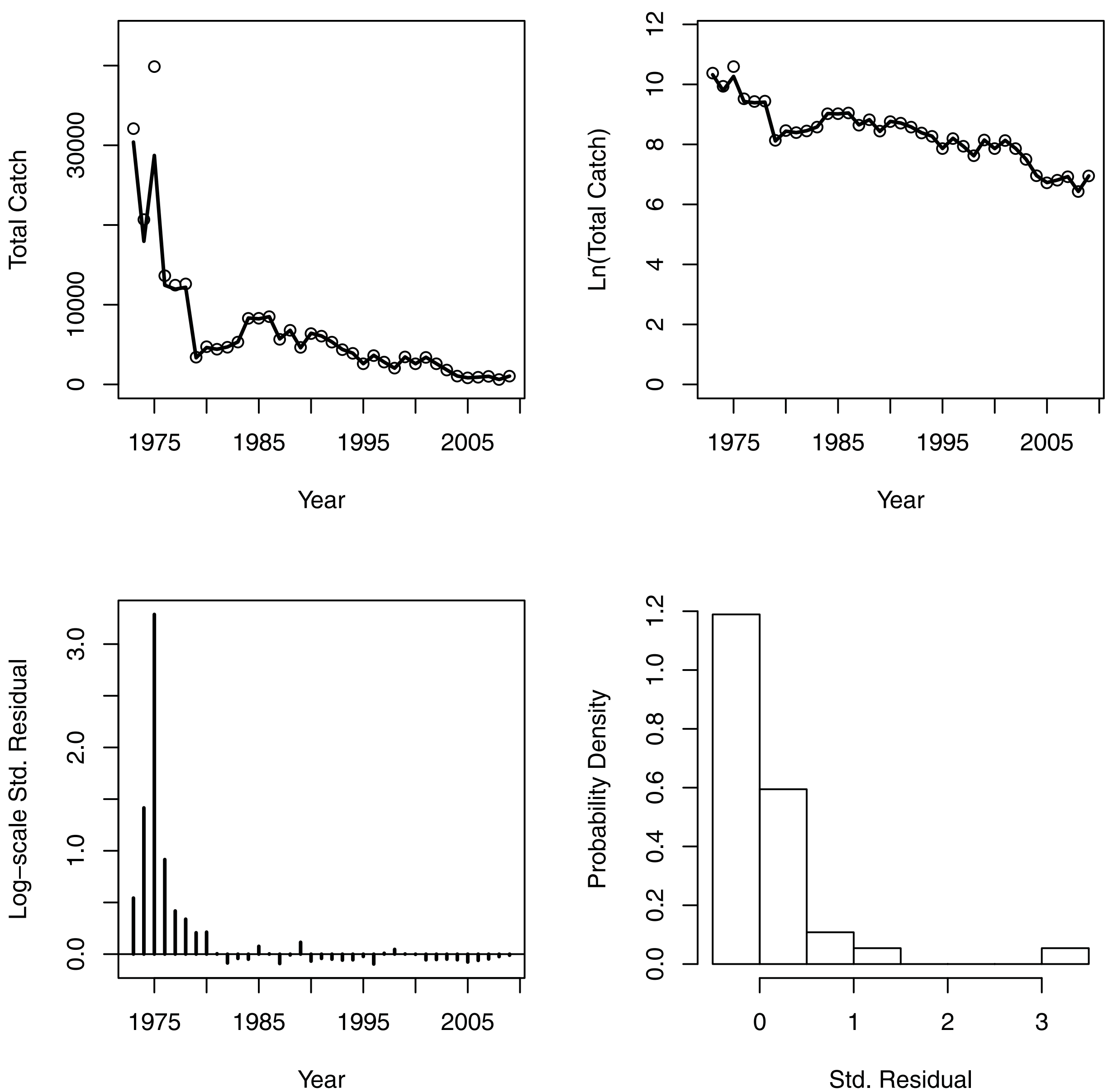
2. Fishery Selectivity (3 Block Selectivity)
    a. Landings (1 Blocks: 1973-2009)
    b. Discards (1 Block: 1981-2009)
    c. Consumption (Double Logistic Functional Form)

3. Survey Selectivity (Fixed 100% at age 2 and freely estimated older aged (3+)

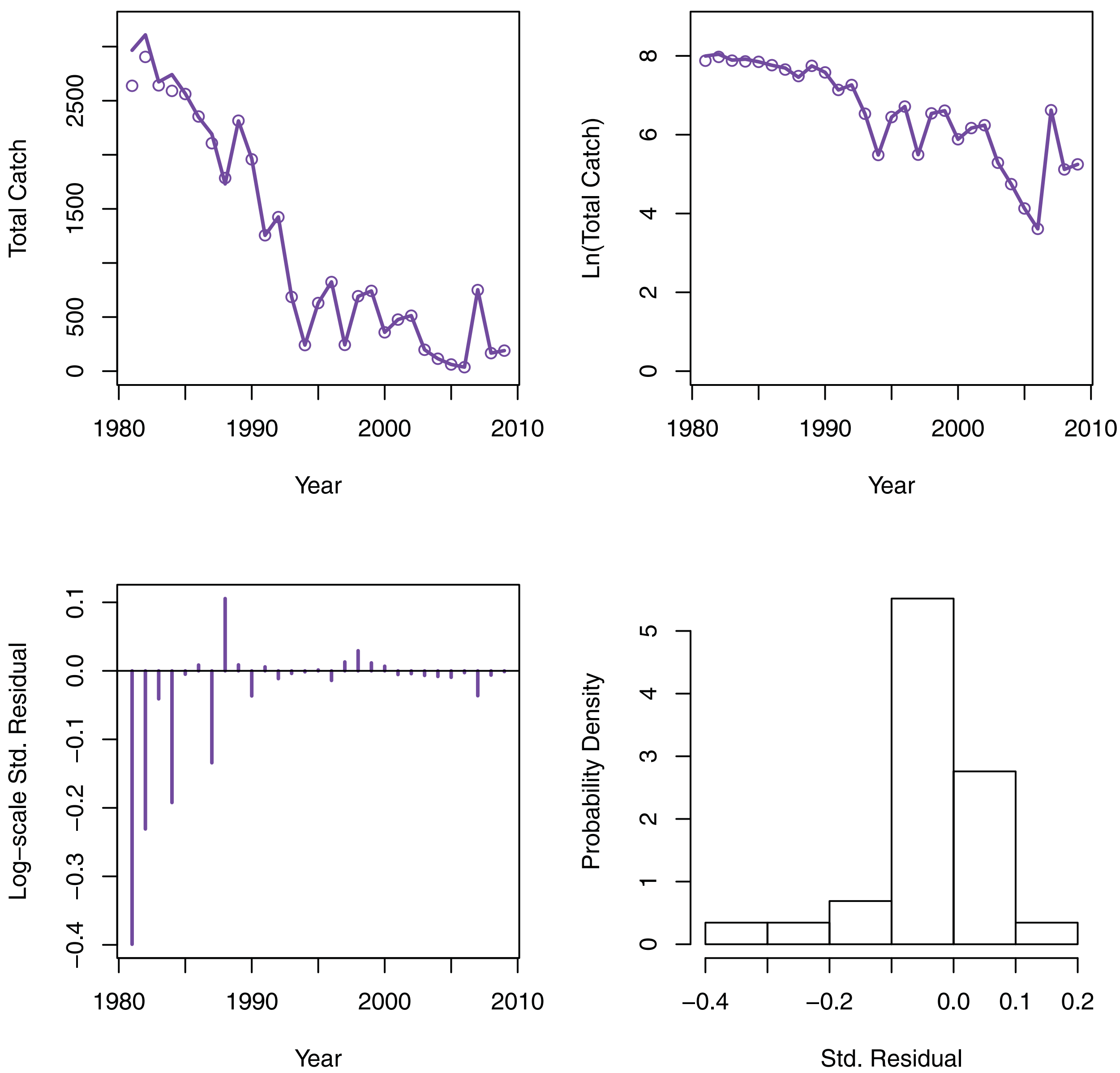


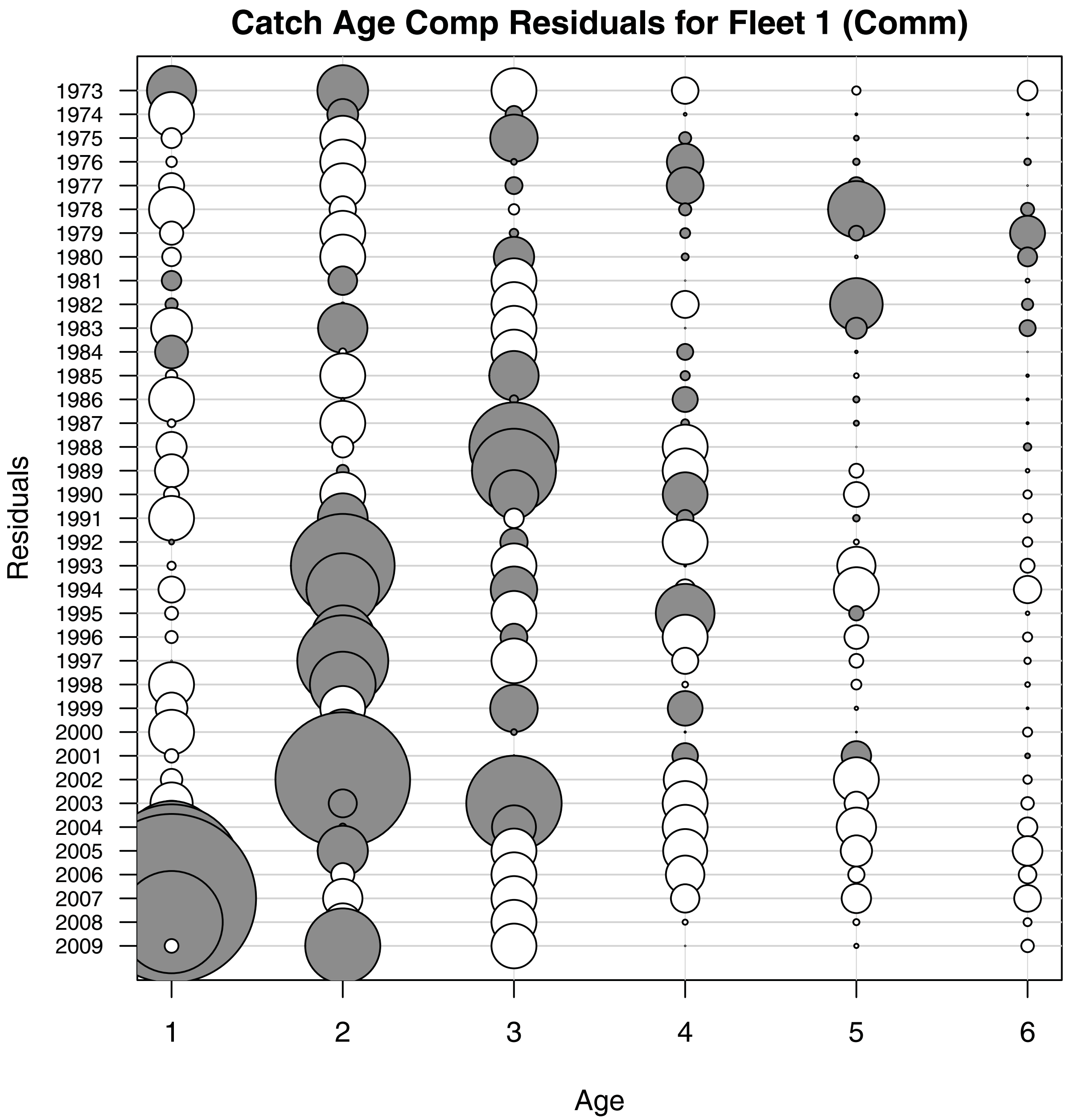
Components of Objective Function (4100)
F.penalty
Fmult.Max.penalty
SRR.unexpl.stock
SRR.steepness
Recruit.devs
N.year1
Fmult.devs.total
Fmult.year1.total
q.devs
q.year1
index.sel.param.total
sel.param.total
survey.age.comp
discards.age.comp
catch.age.comp
index.fit.total
discard.total
catch.total
0
0
0
0
587
70
0
115
0
0
68
21
863
0
774
1205
0
397
0
100
300
500
700
900
1100
1300
Likelihood Contribution

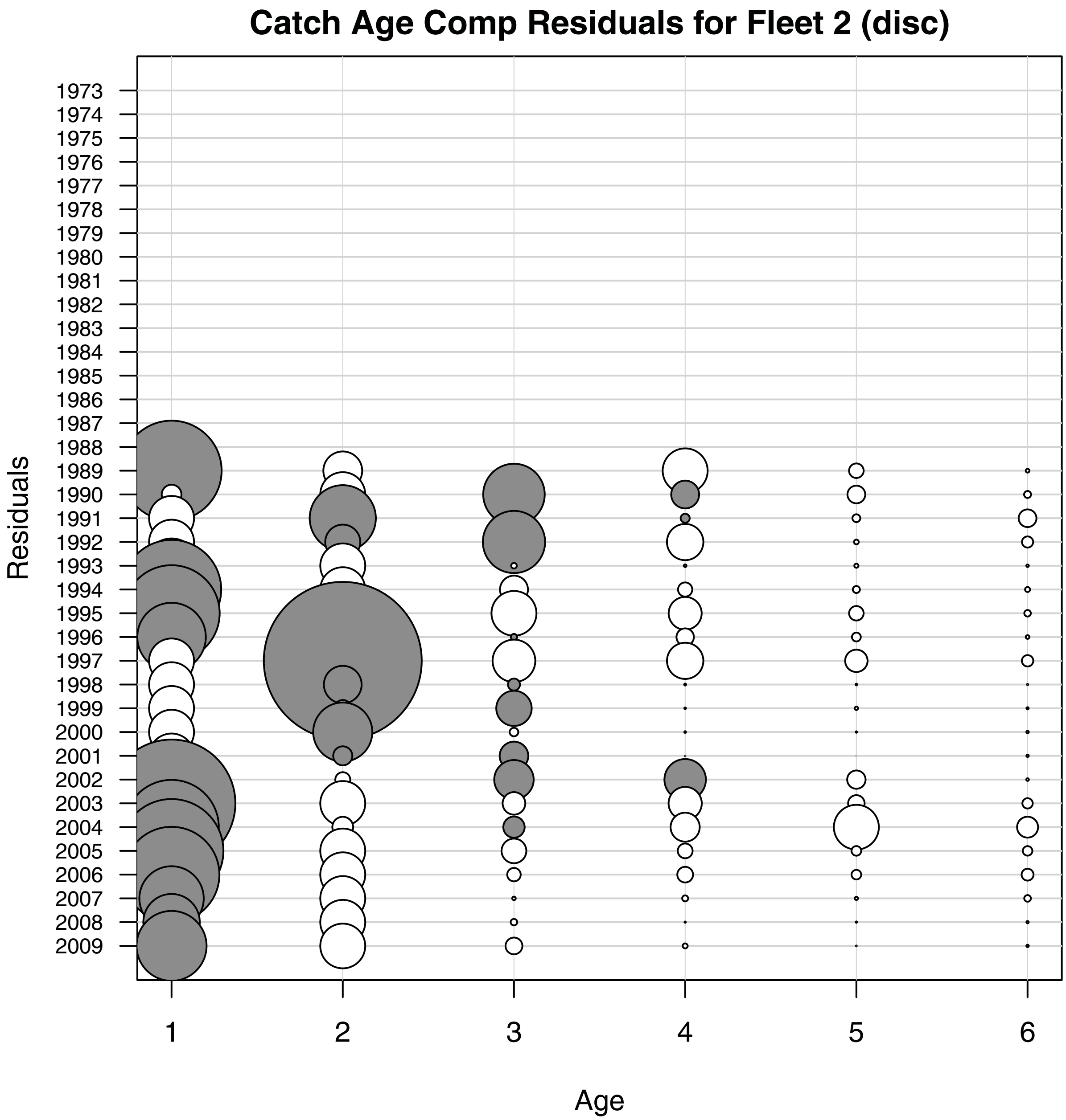
Fleet 1 Landings (Comm)

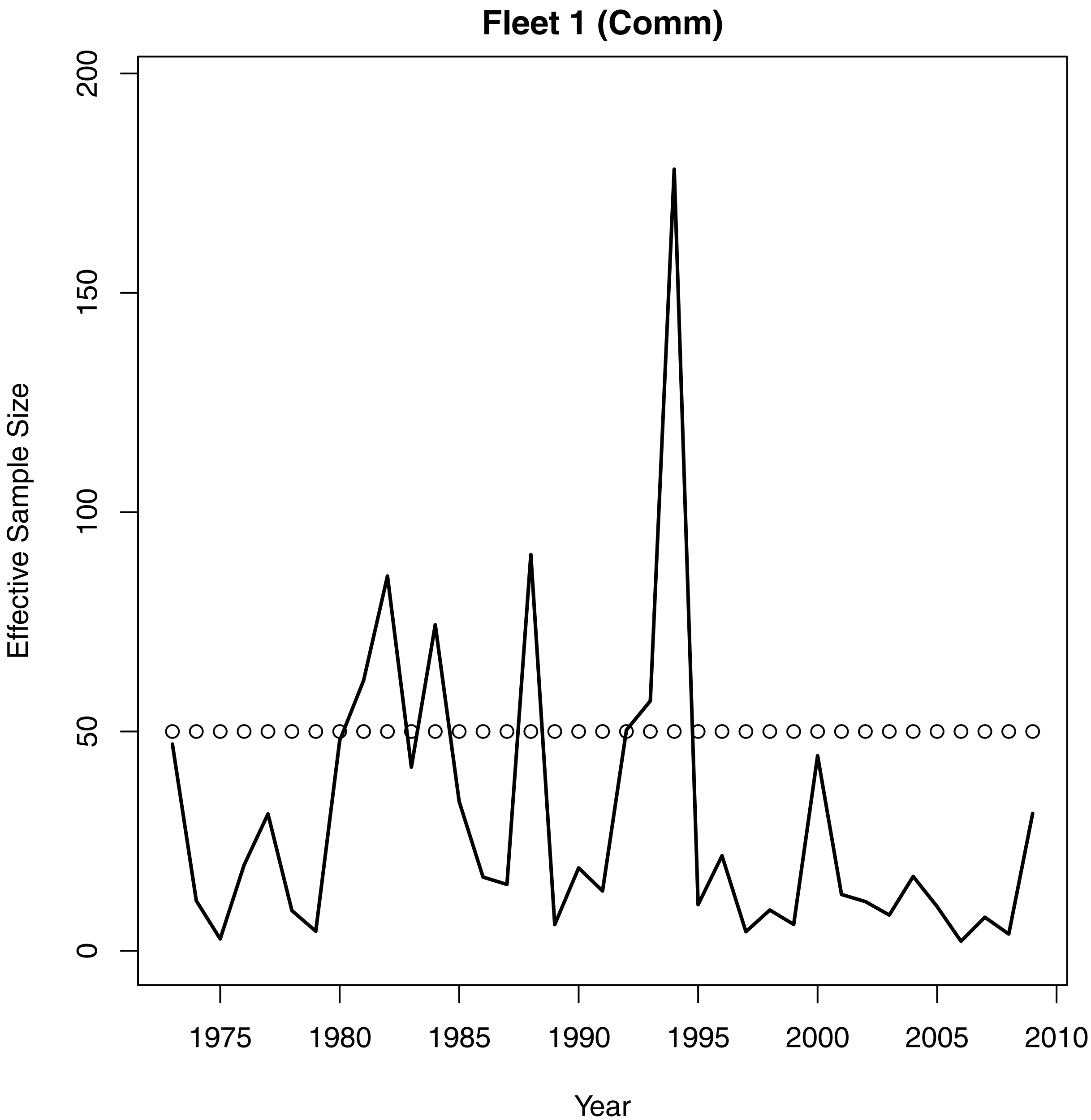


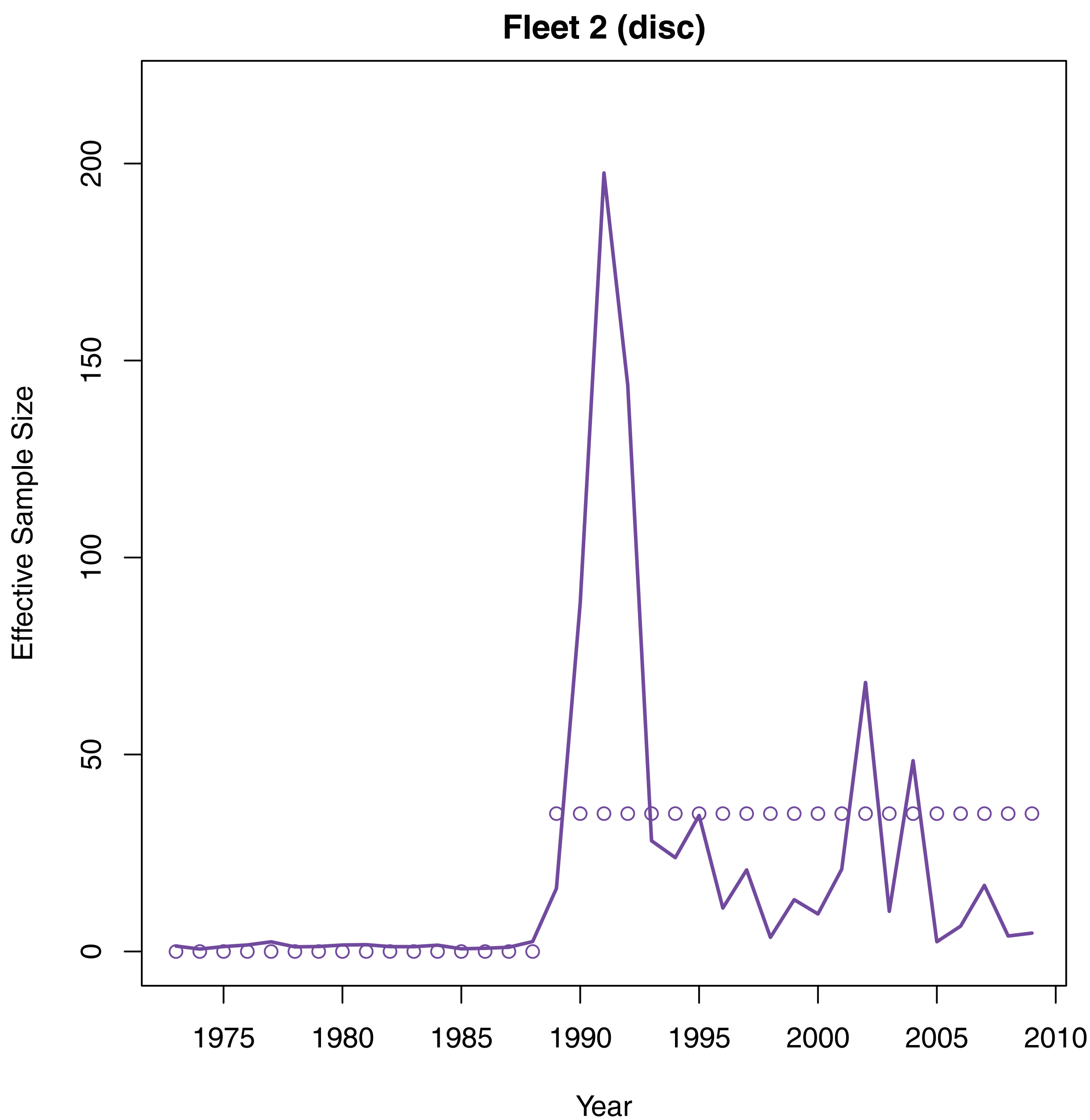
Fleet 2 Landings (disc)

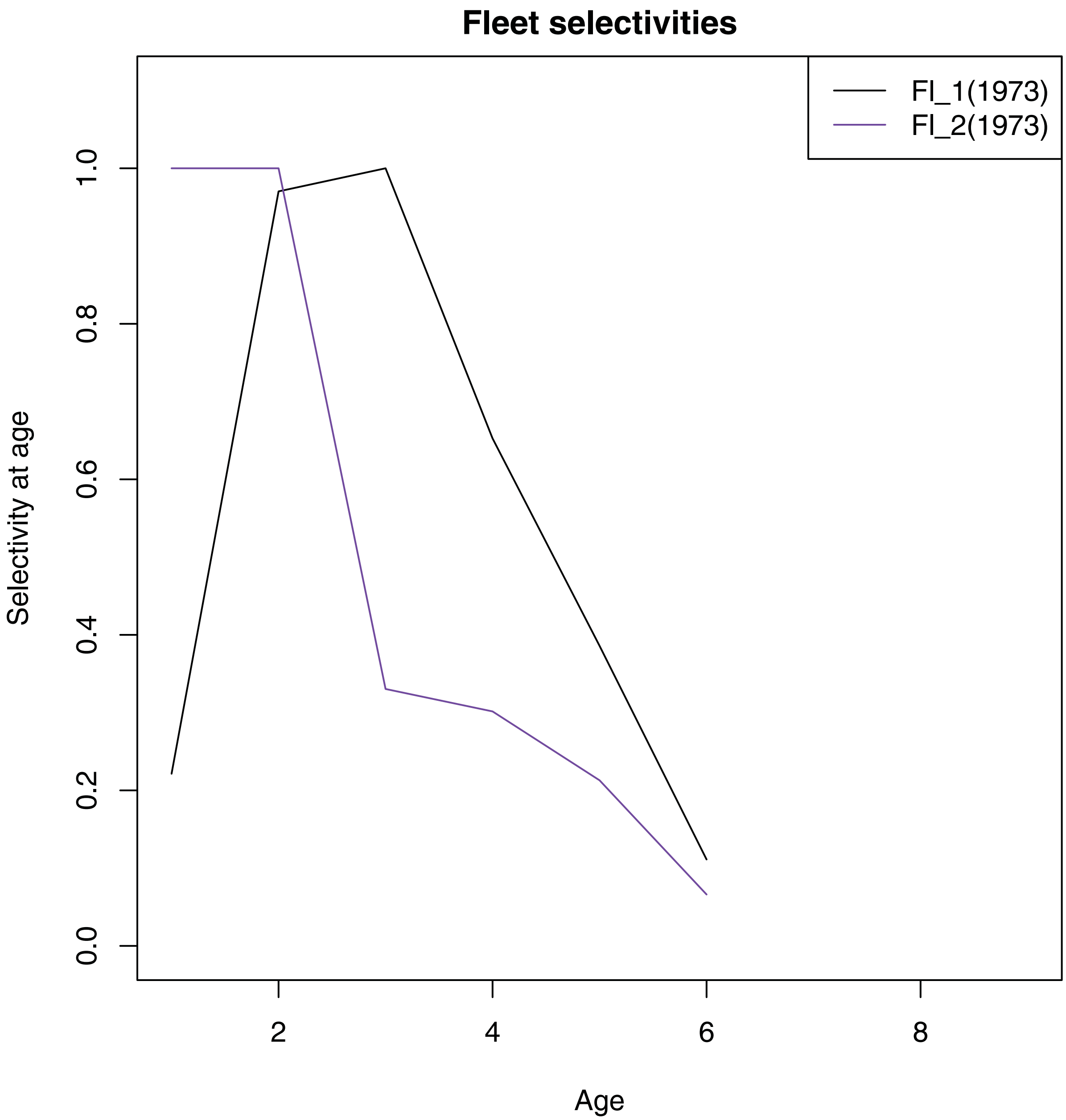


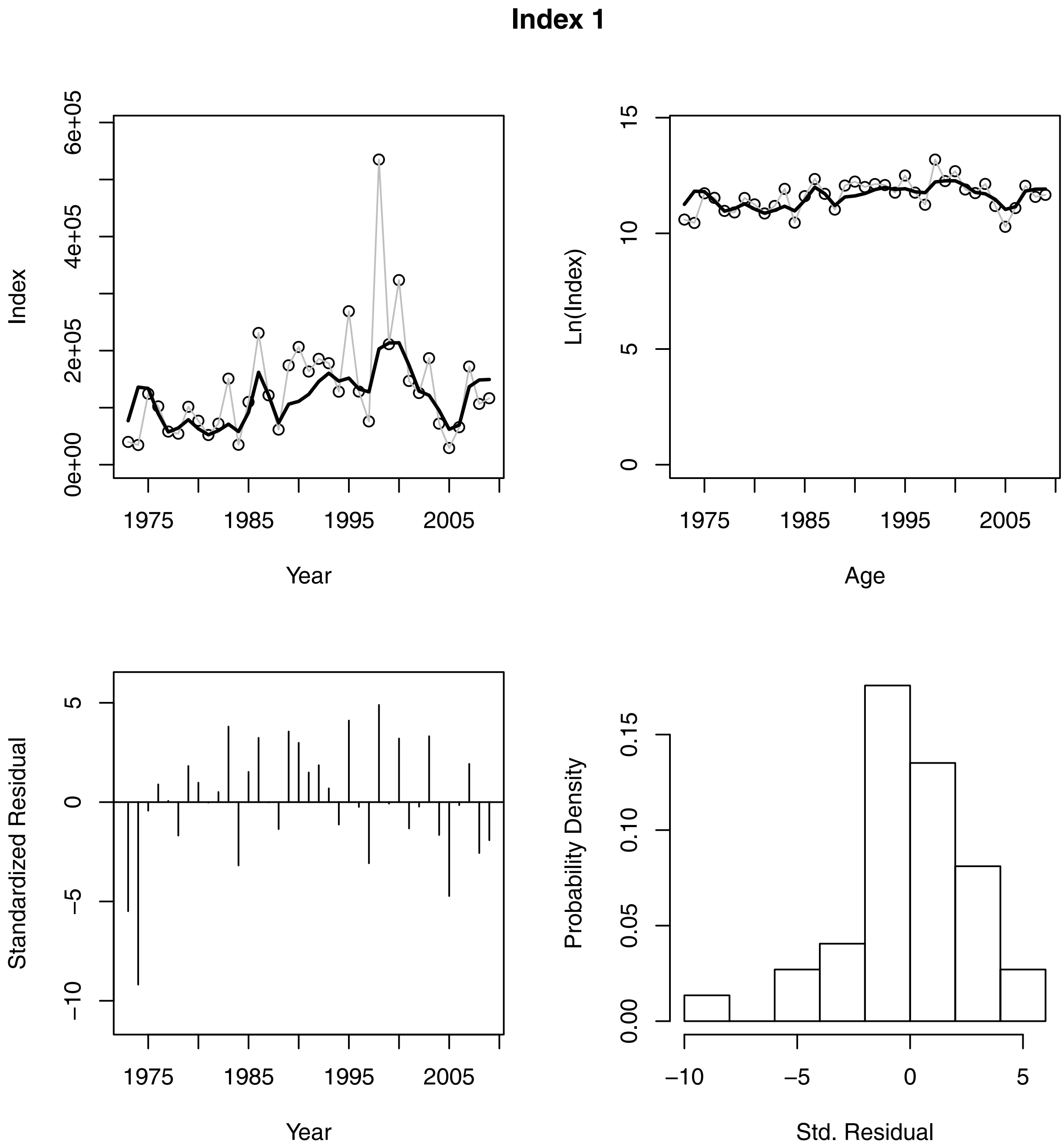

Catch Age Comp Residuals for Fleet 1 (Comm)
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age

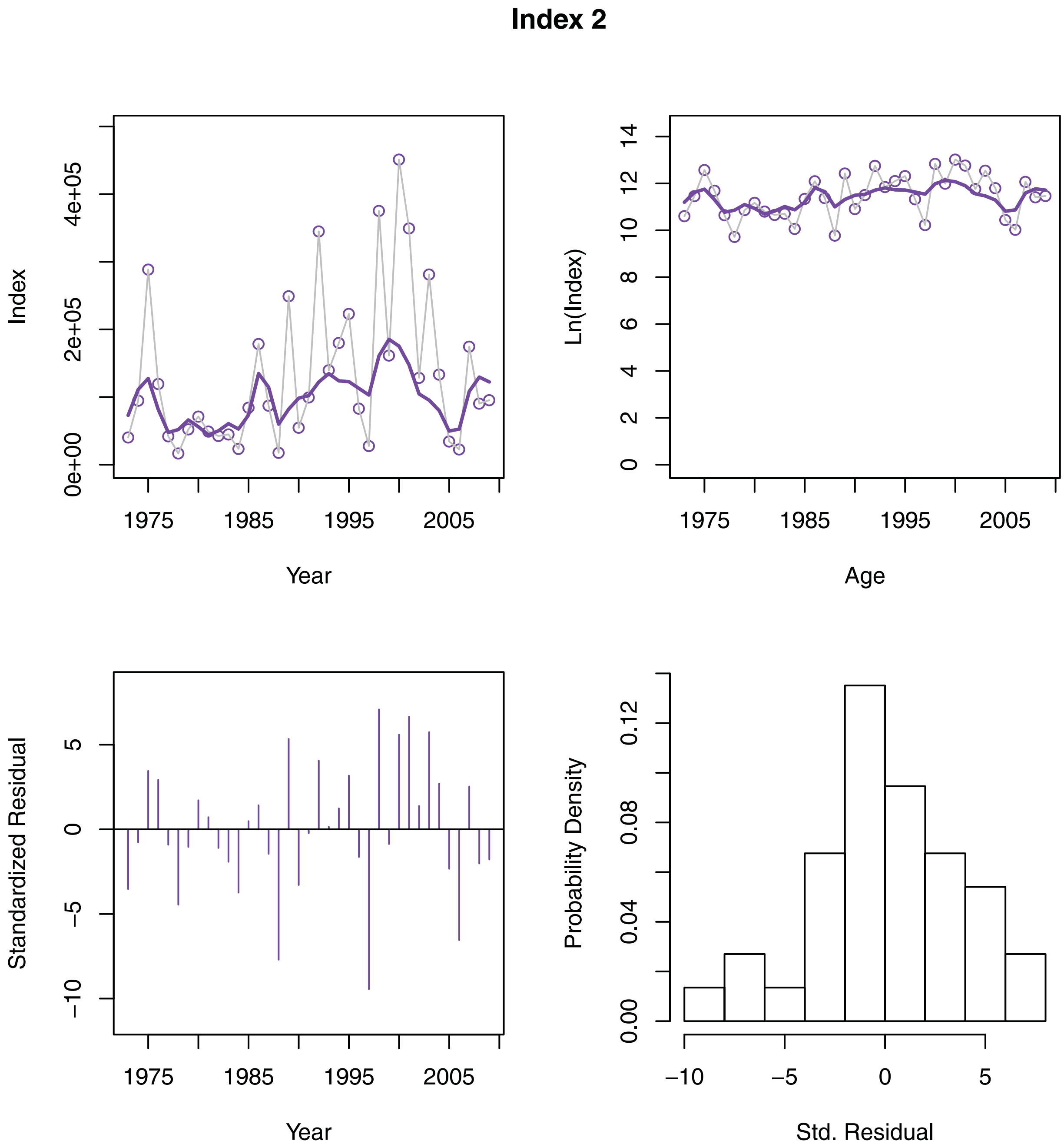

Catch Age Comp Residuals for Fleet 2 (disc)
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age

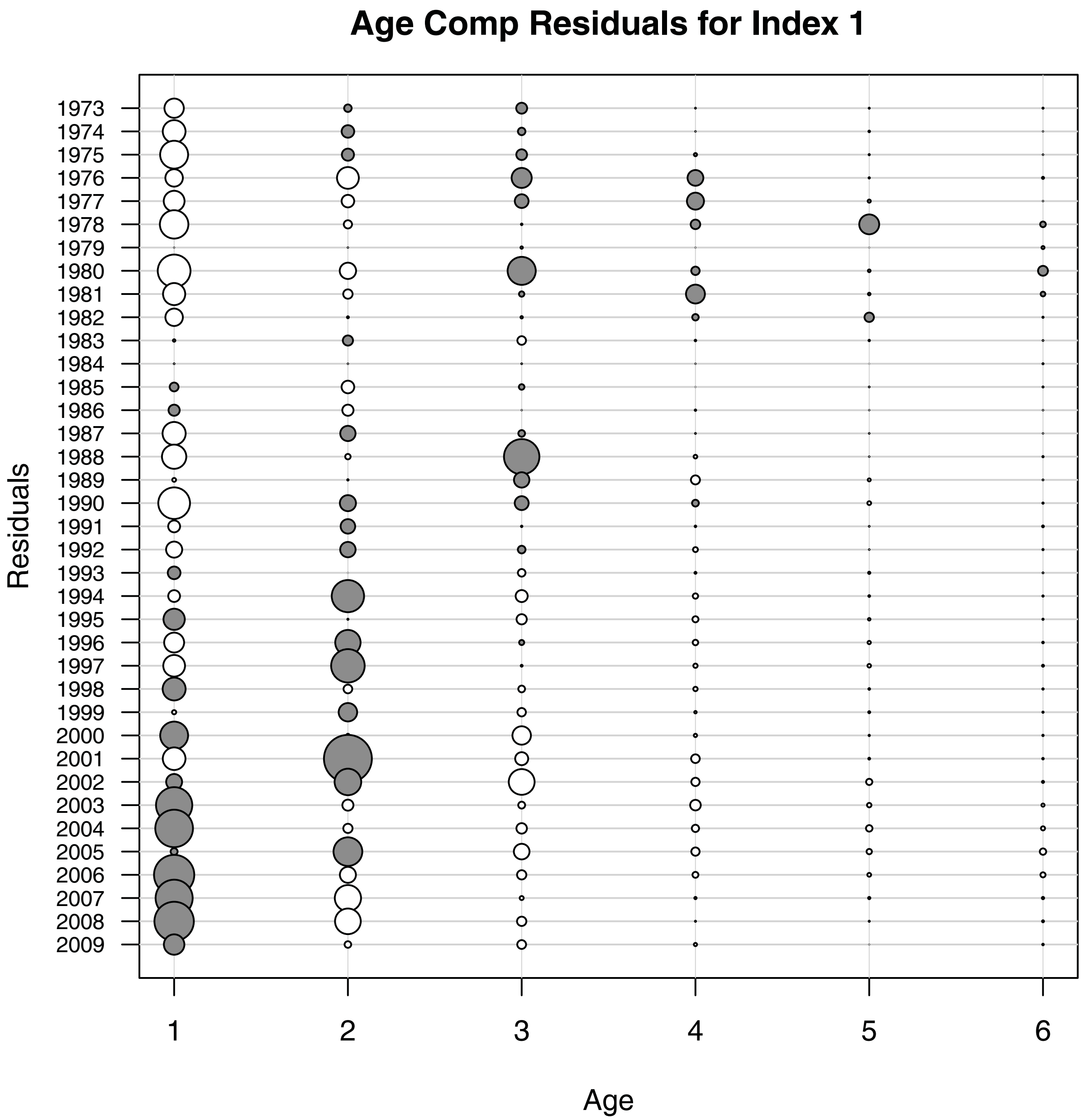

Fleet 1 (Comm)
Effective Sample Size
0
50
100
150
200
1975
1980
1985
1990
1995
2000
2005
2010
Year


Fleet 2 (disc)
Effective Sample Size
0
50
100
150
200
1975
1980
1985
1990
1995
2000
2005
2010
Year

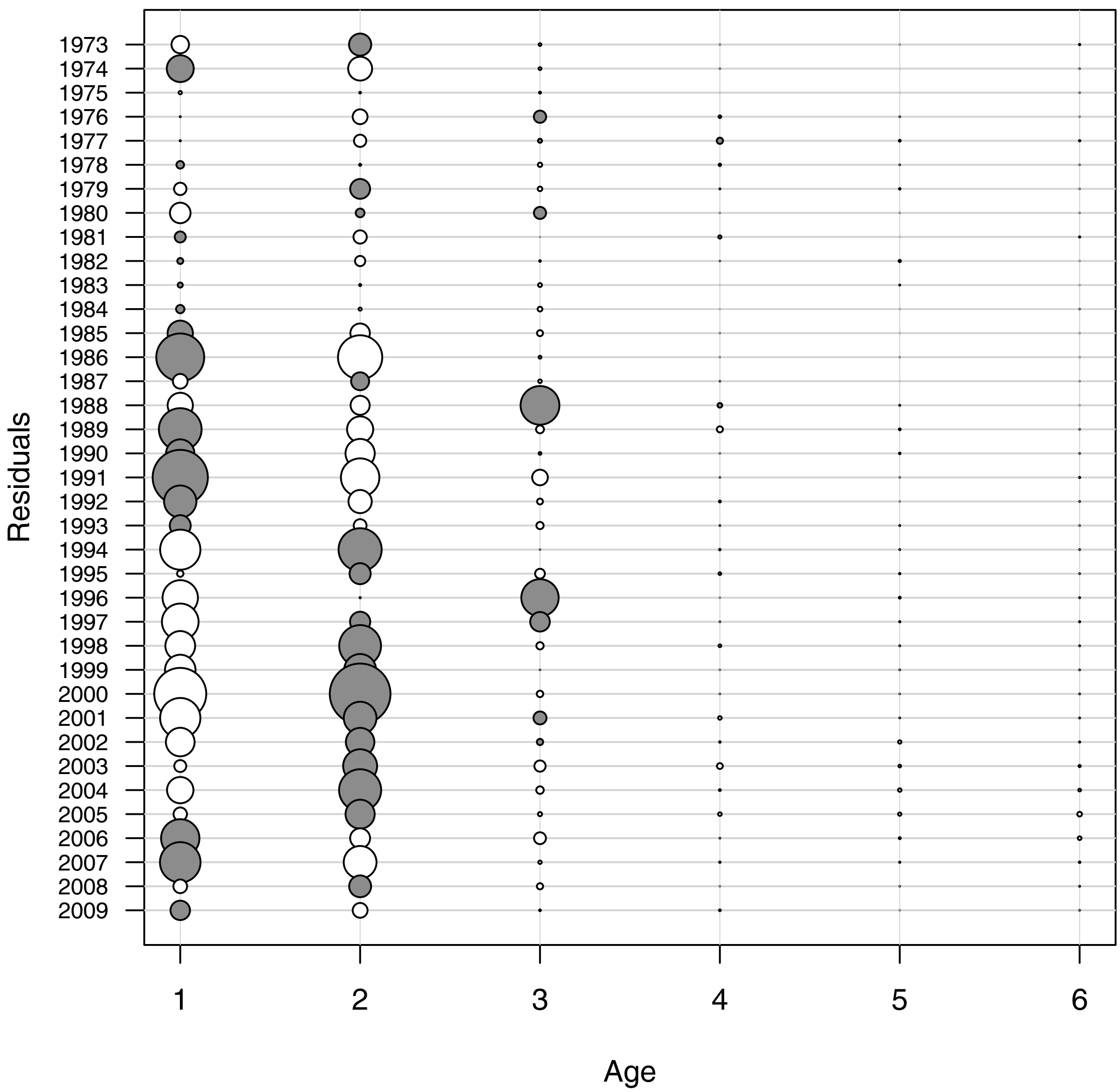

Fleet selectivities
Fl_1(1973)
Fl_2(1973)
Selectivity at age
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
Age

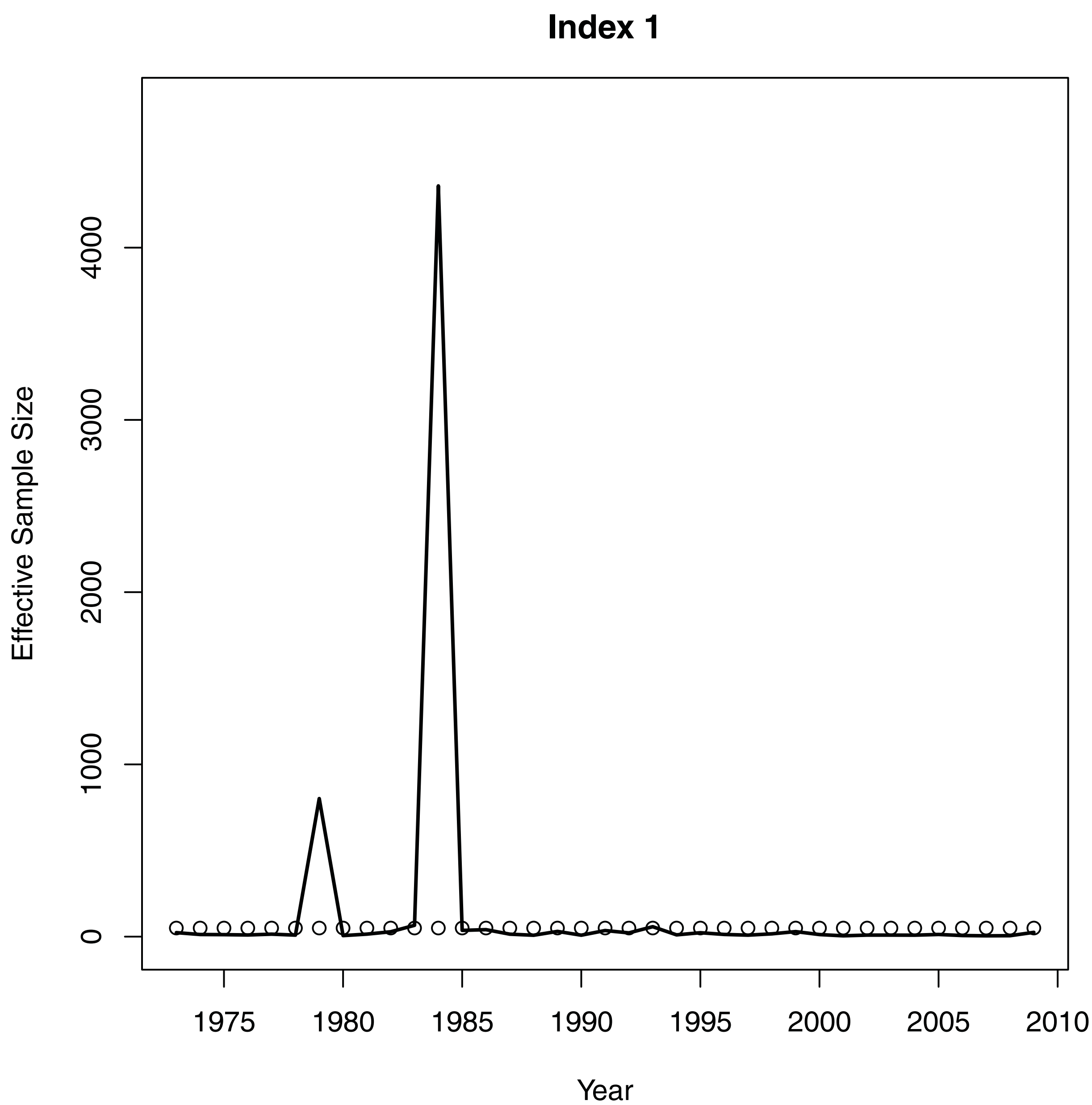

Index 1
Index
0e+00
2e+05
4e+05
6e+05
1975
1985
1995
2005
Year
Ln(Index)
0
5
10
15
Age
Standardized Residual
−10
−5
0
5
Year
Probability Density
0.00
0.05
0.10
0.15
−10
−5
0
5
Std. Residual


Index 2
Index
0e+00
2e+05
4e+05
1975
1985
1995
2005
Year
Ln(Index)
0
2
4
6
8
10
12
14
Age
Standardized Residual
−10
−5
0
5
Year
Probability Density
0.00
0.04
0.08
0.12
−10
−5
0
5
Std. Residual

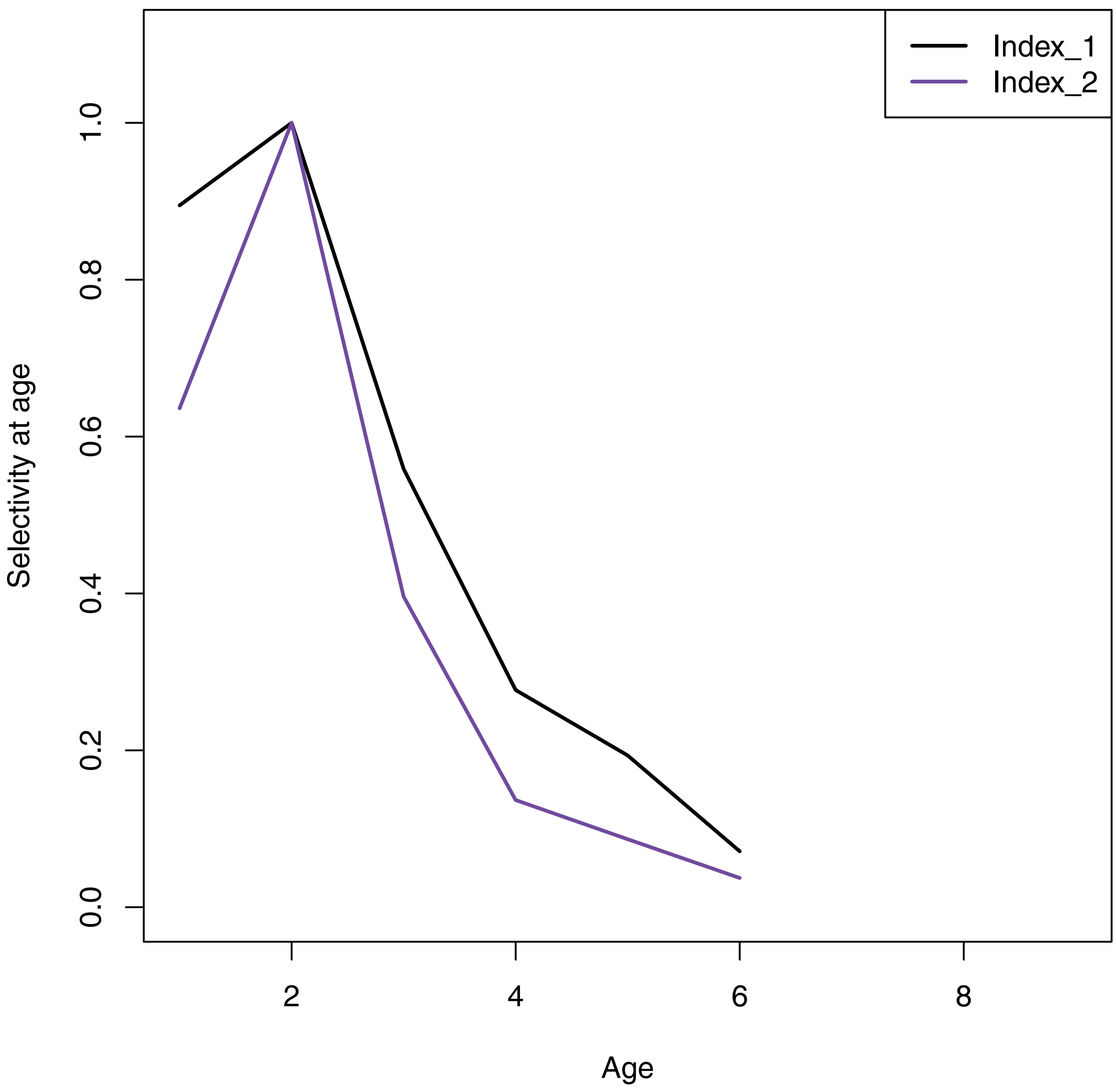

Age Comp Residuals for Index 1
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age

Age Comp Residuals for Index 2

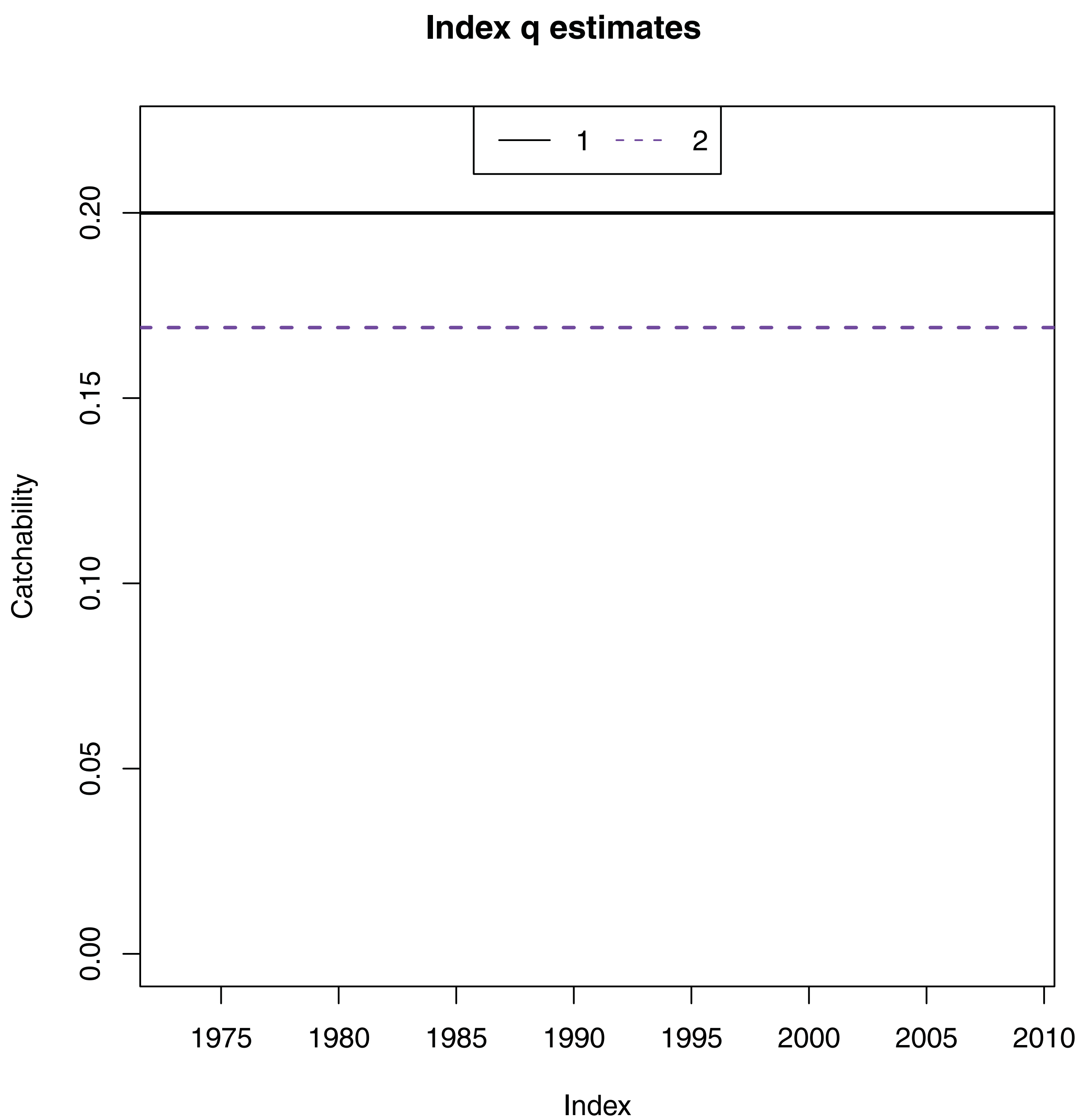


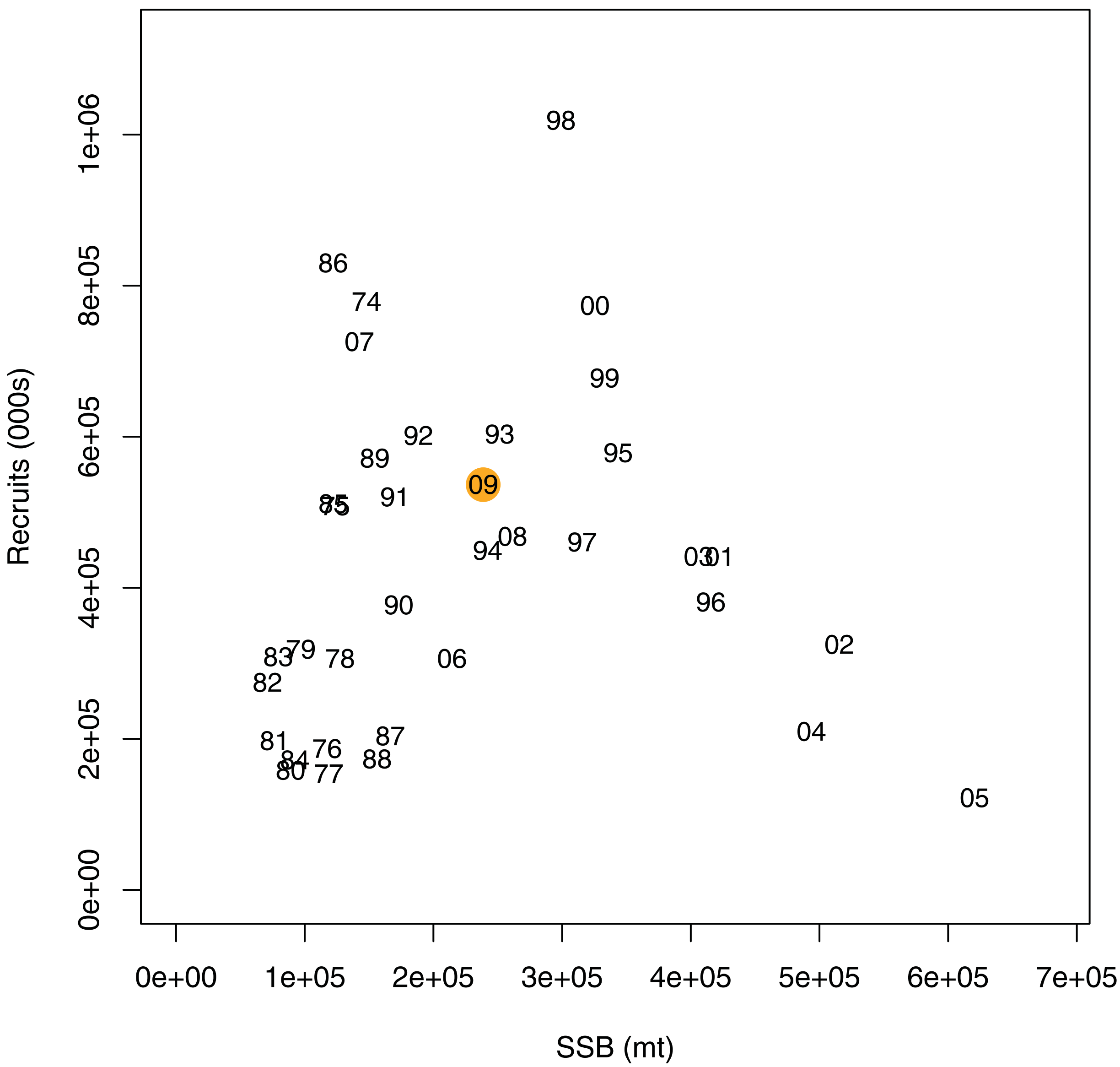

Index 1
Effective Sample Size
0
1000
2000
3000
4000
1975
1980
1985
1990
1995
2000
2005
2010
Year


Index 2
Effective Sample Size
0
200
400
600
1975
1980
1985
1990
1995
2000
2005
2010
Year

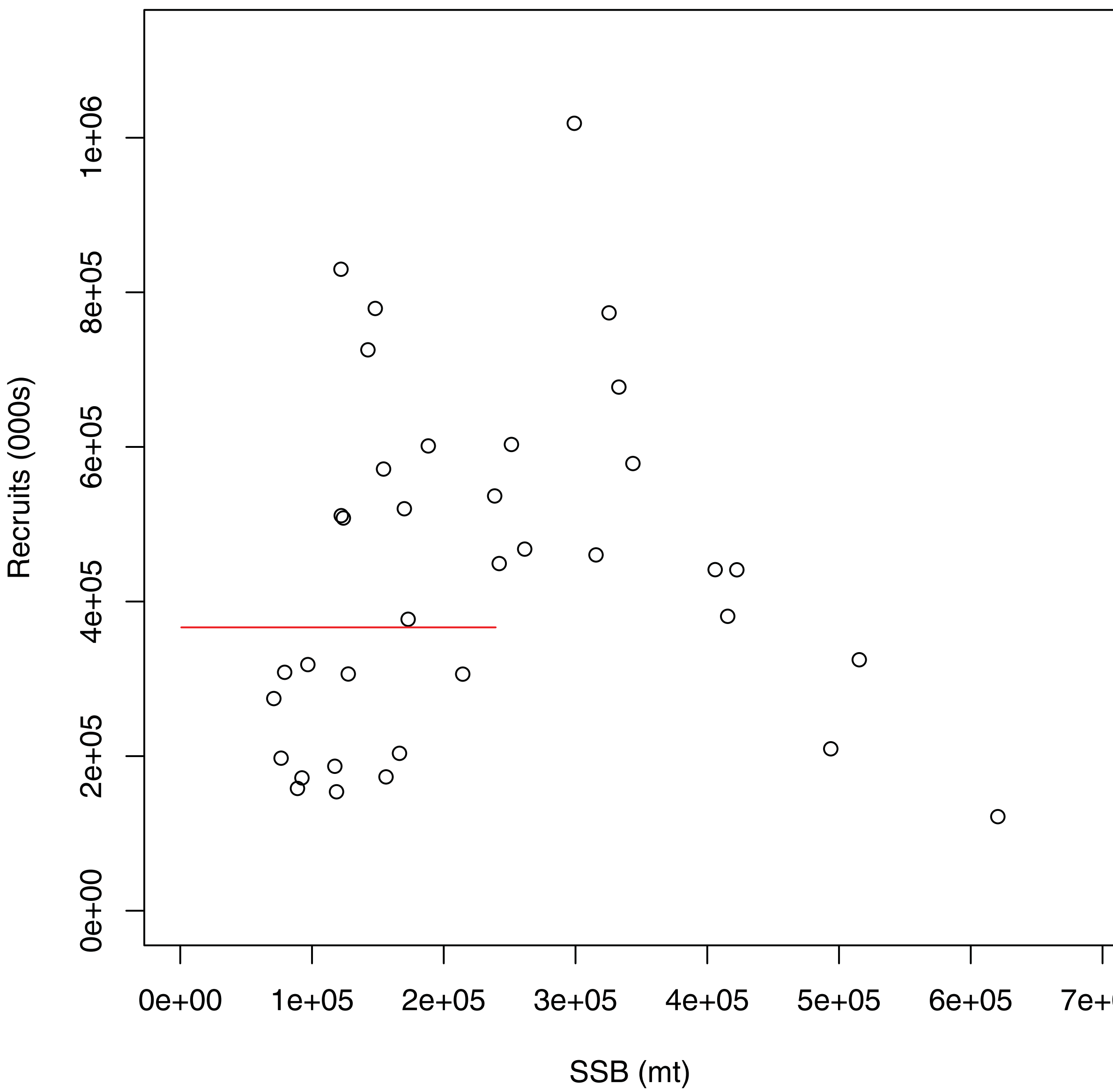


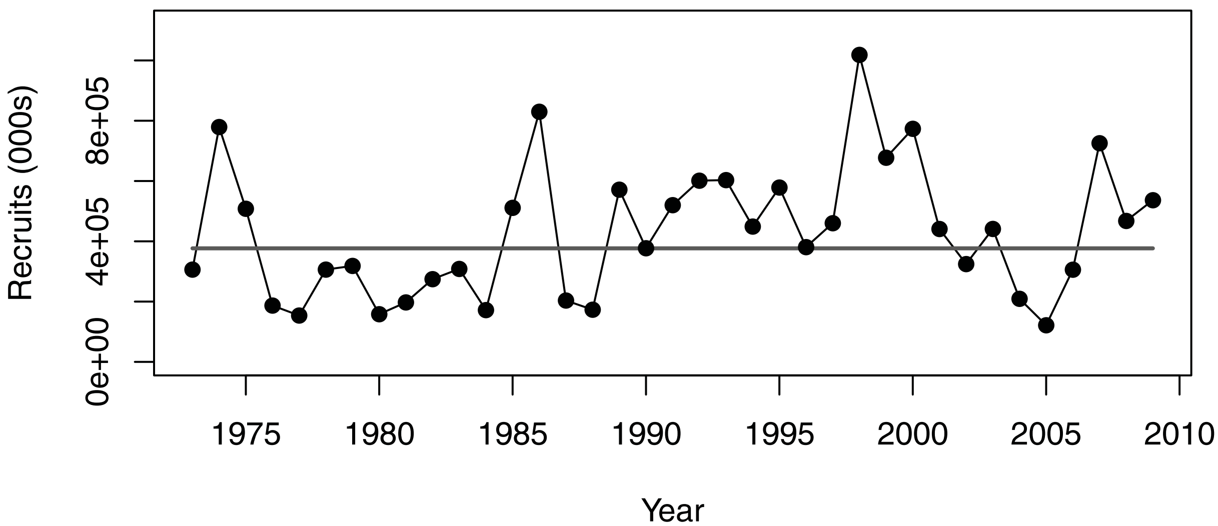
Index_1
Index_2
Selectivity at age
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
Age

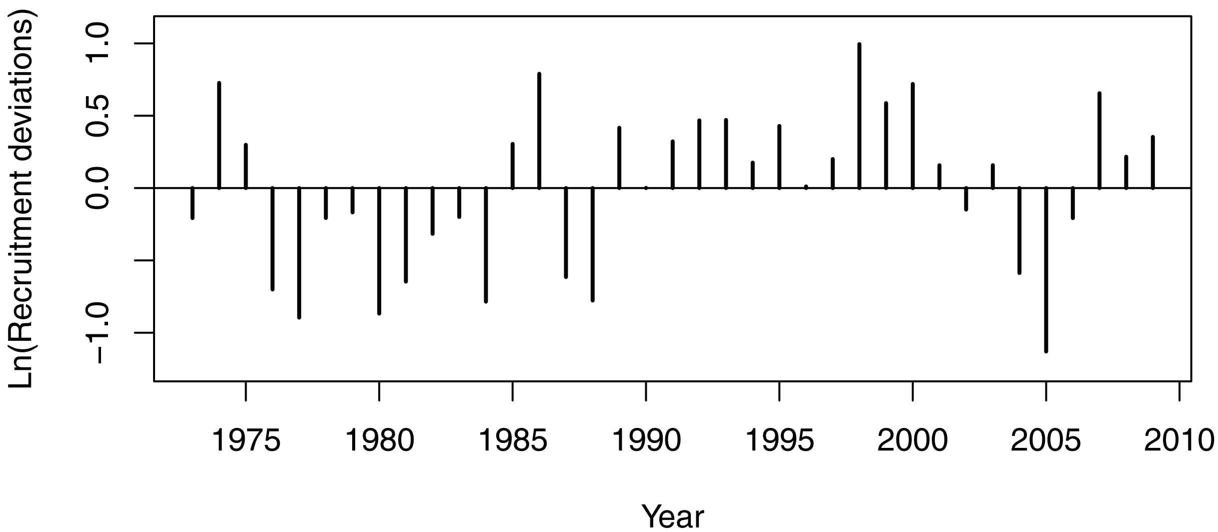

Index q estimates
1
2
0.00
0.05
0.10
0.15
0.20
Catchability
1975
1980
1985
1990
1995
2000
2005
2010
Index

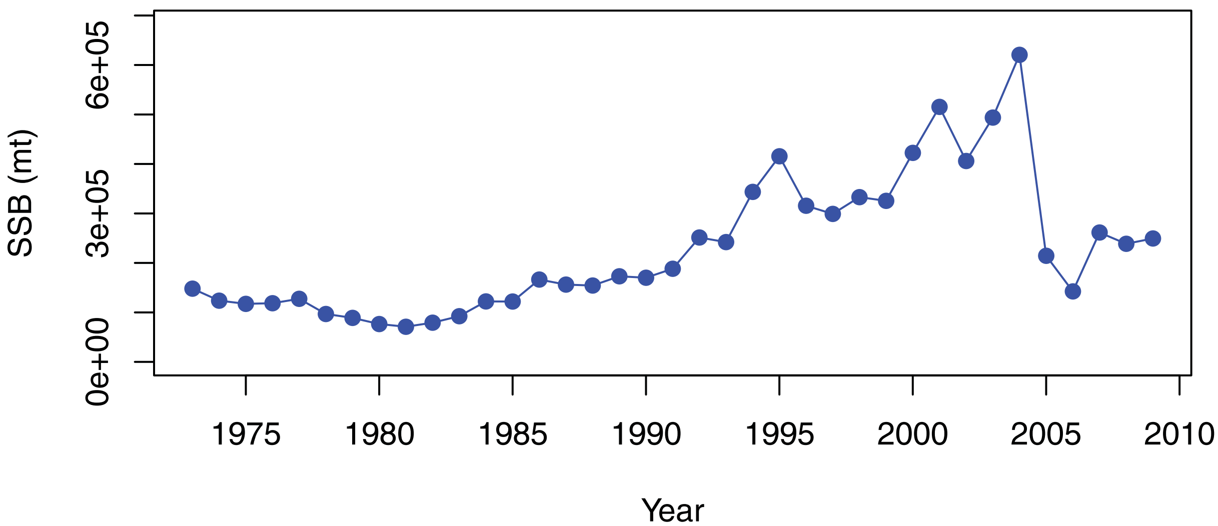


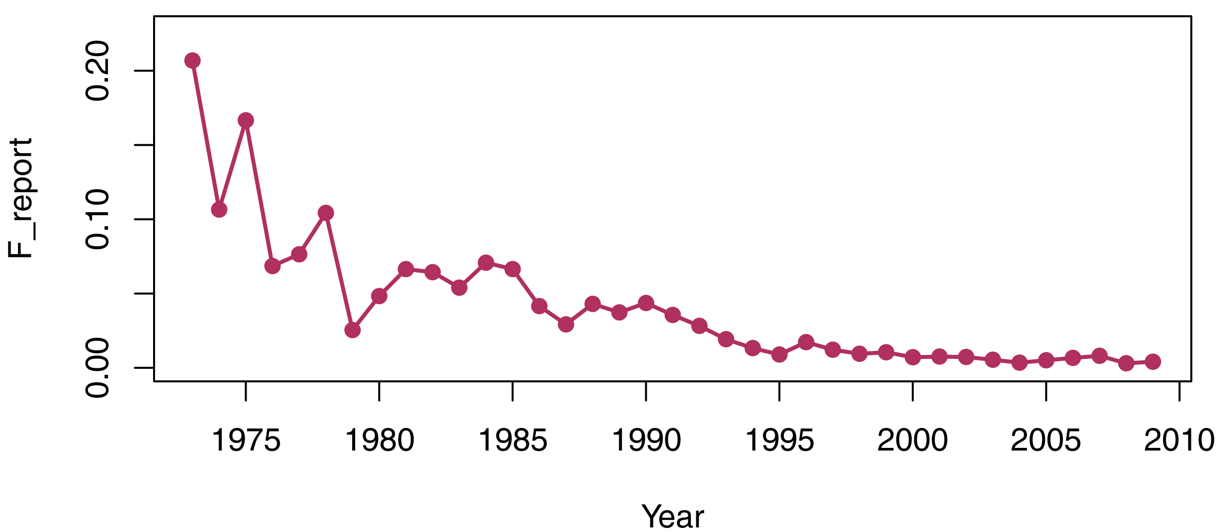
Recruits (000s)
SSB (mt)
0e+00
2e+05
4e+05
6e+05
8e+05
1e+06
0e+00
1e+05
2e+05
3e+05
4e+05
5e+05
6e+05
7e+05
98
86
74
00
07
99
92
93
89
95
09
91
08
94
97
03
01
96
90
02
79
83
78
06
82
87
04
81
76
84
88
80
77
05

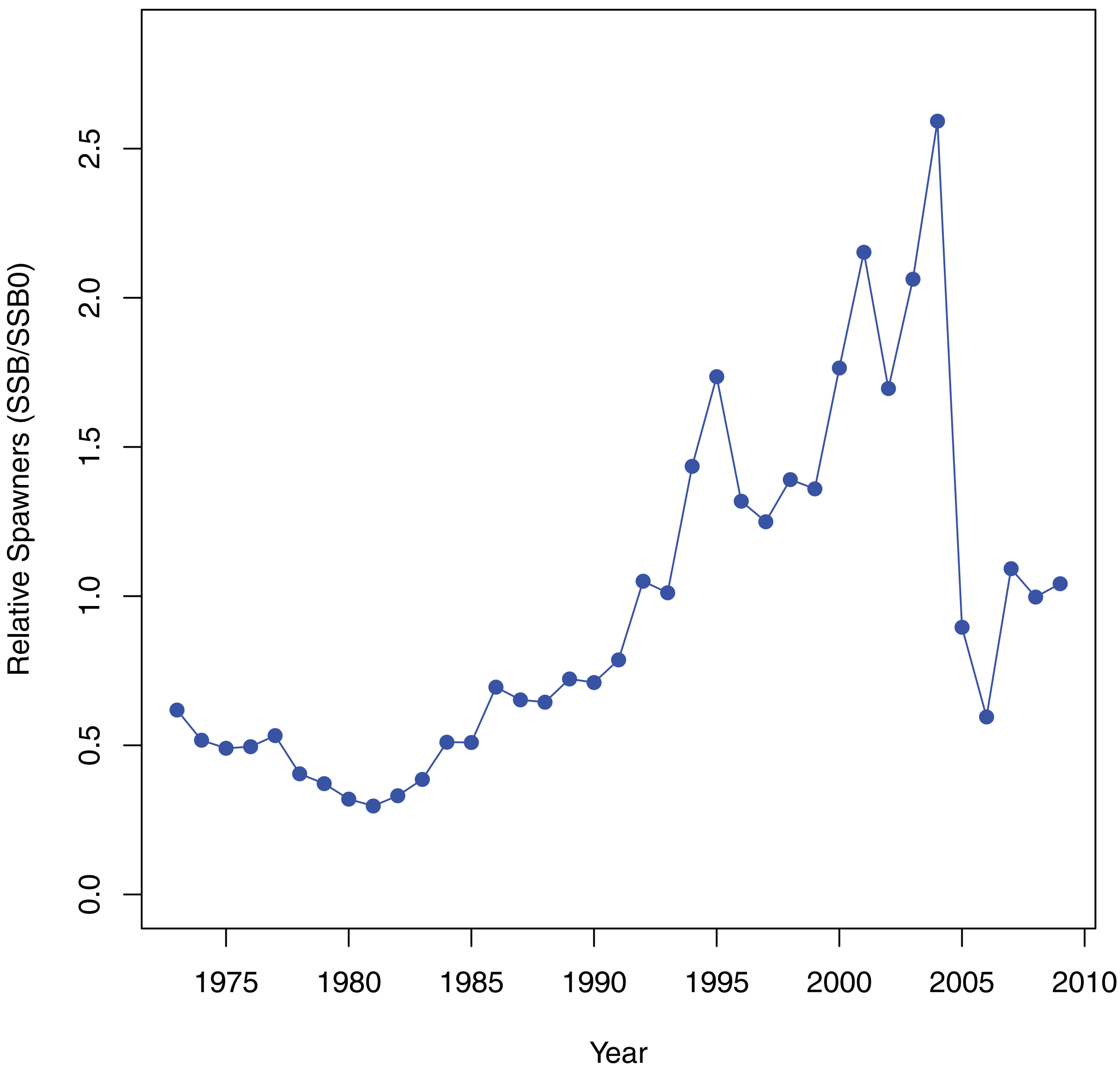

Recruits (000s)
0e+00
2e+05
4e+05
6e+05
8e+05
1e+06
0e+00
1e+05
2e+05
3e+05
4e+05
5e+05
6e+05
7e+05
SSB (mt)

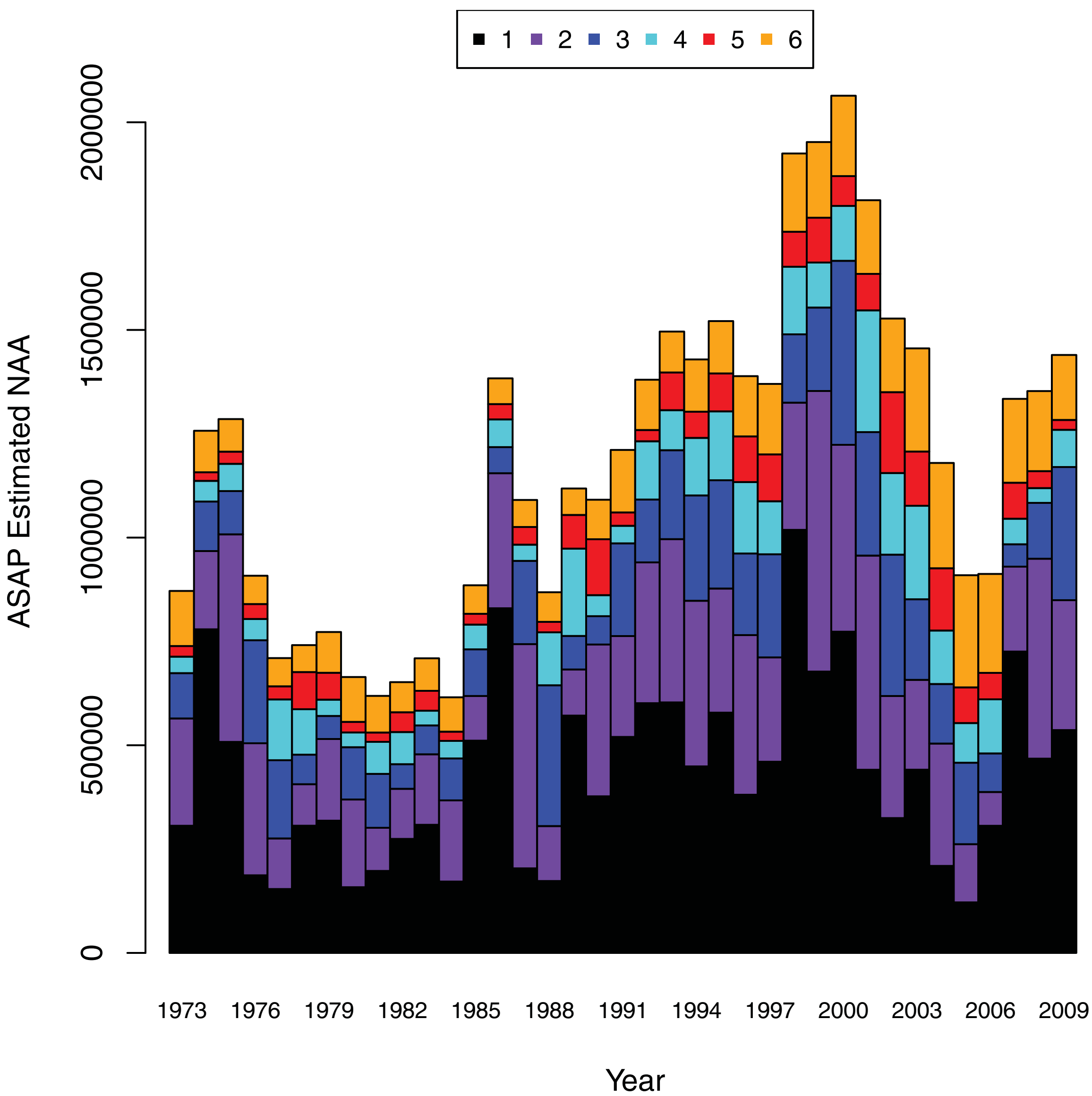

Recruits (000s)
0e+00
4e+05
8e+05
1975
1980
1985
1990
1995
2000
2005
2010
Year

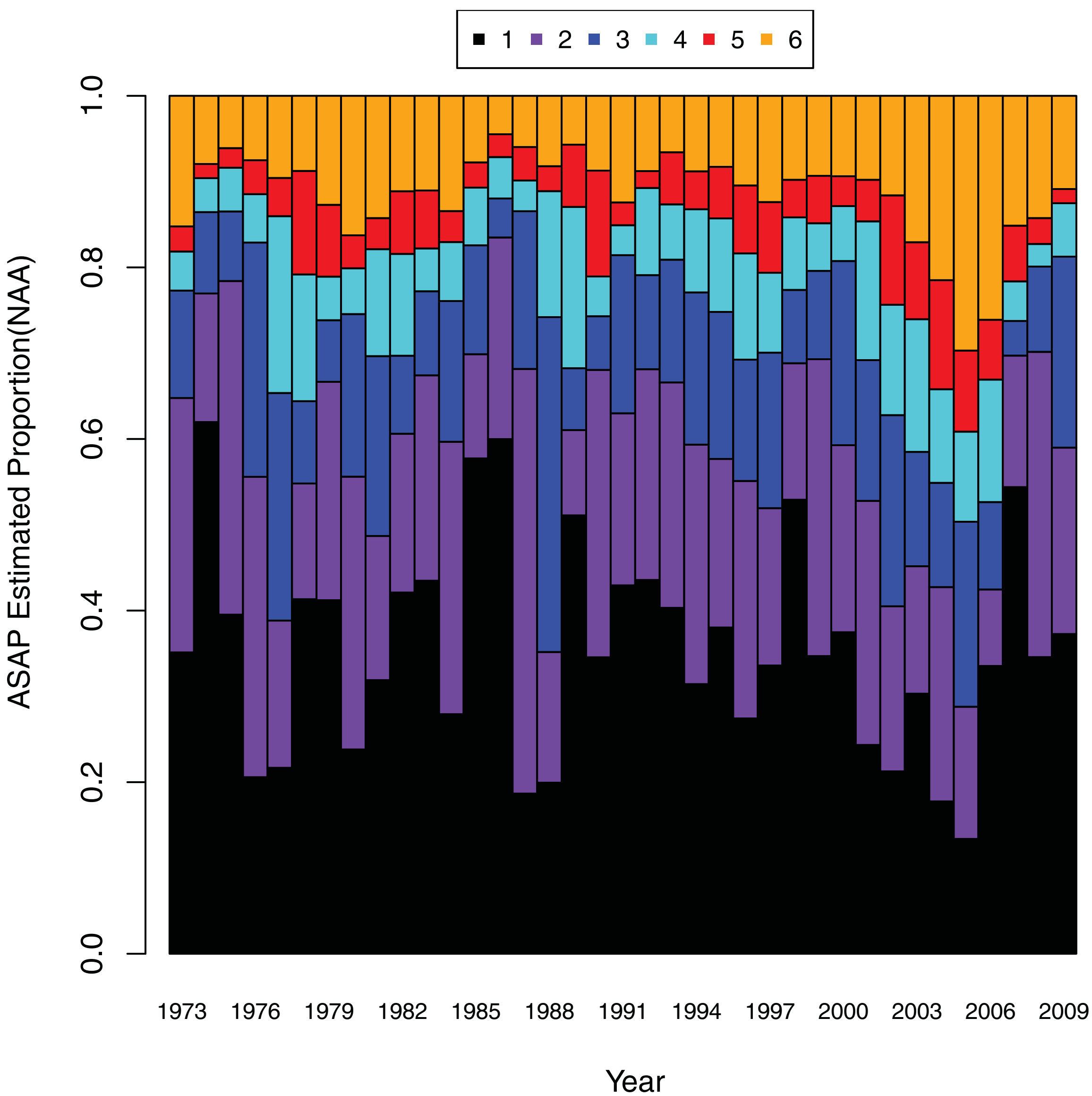

Ln(Recruitment deviations)
−1.0
0.0
0.5
1.0
1975
1980
1985
1990
1995
2000
2005
2010
Year

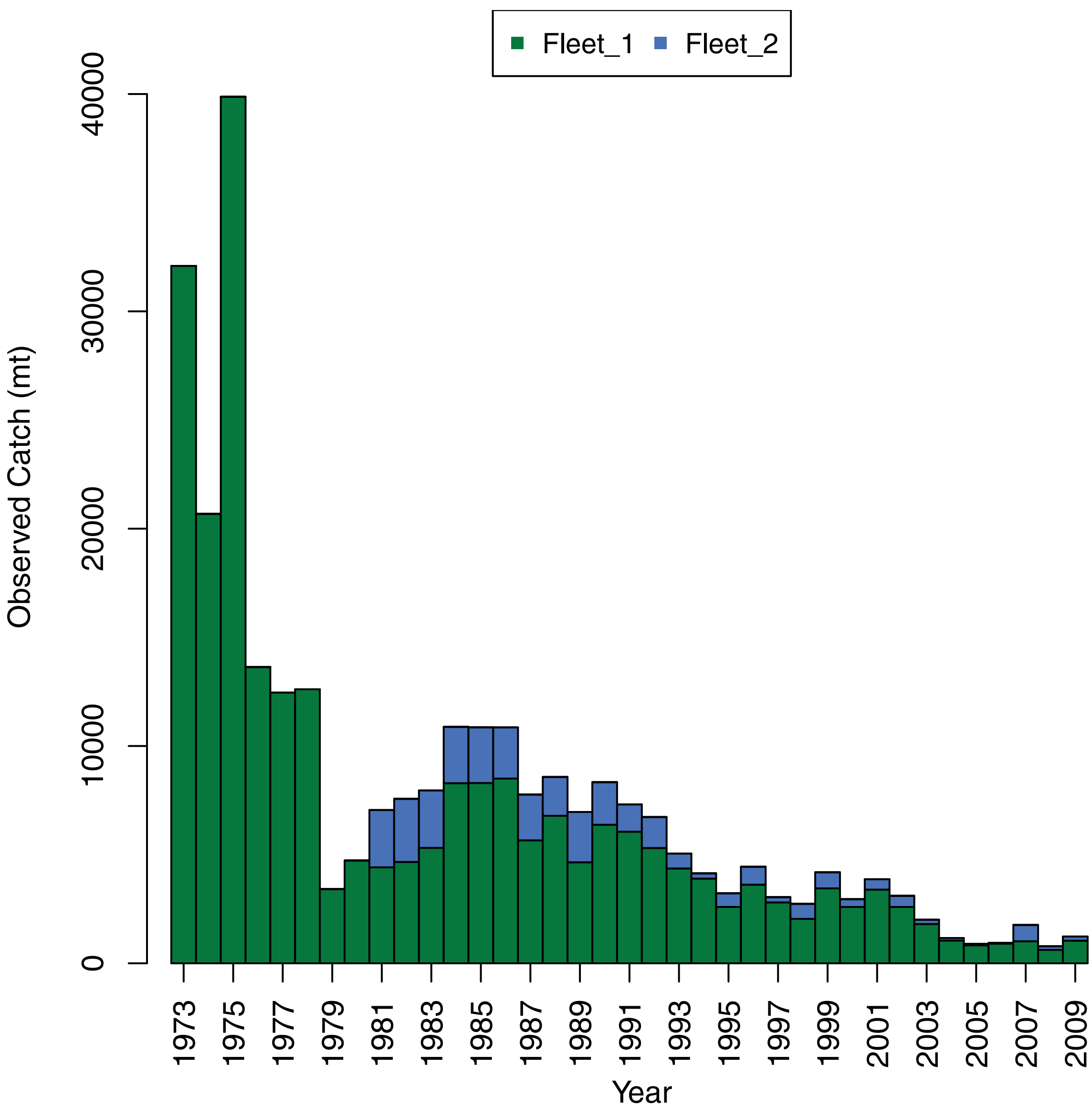

SSB (mt)
0e+00
3e+05
6e+05
1975
1980
1985
1990
1995
2000
2005
2010
Year

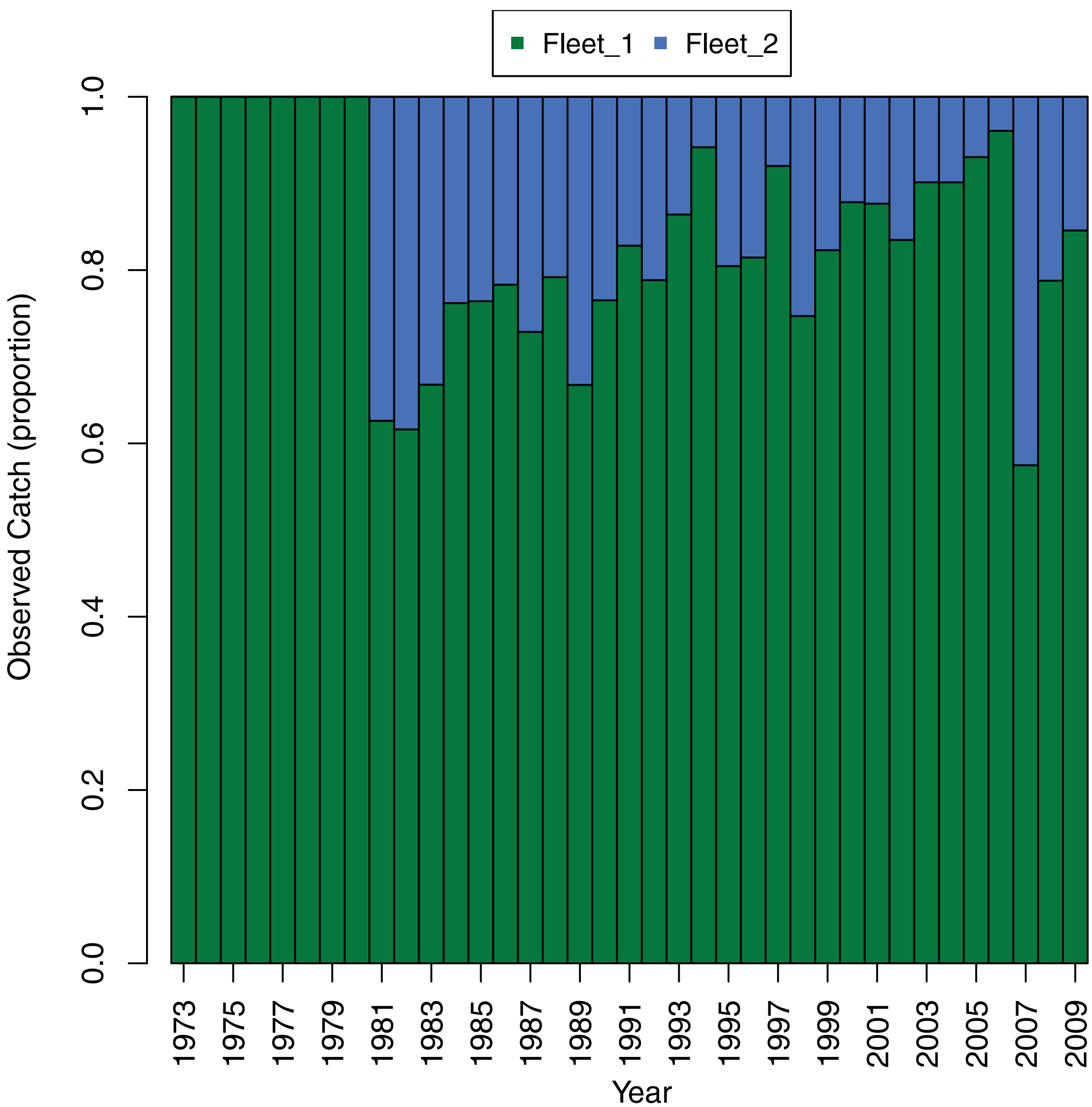

F_report
0.00
0.10
0.20
1975
1980
1985
1990
1995
2000
2005
2010
Year

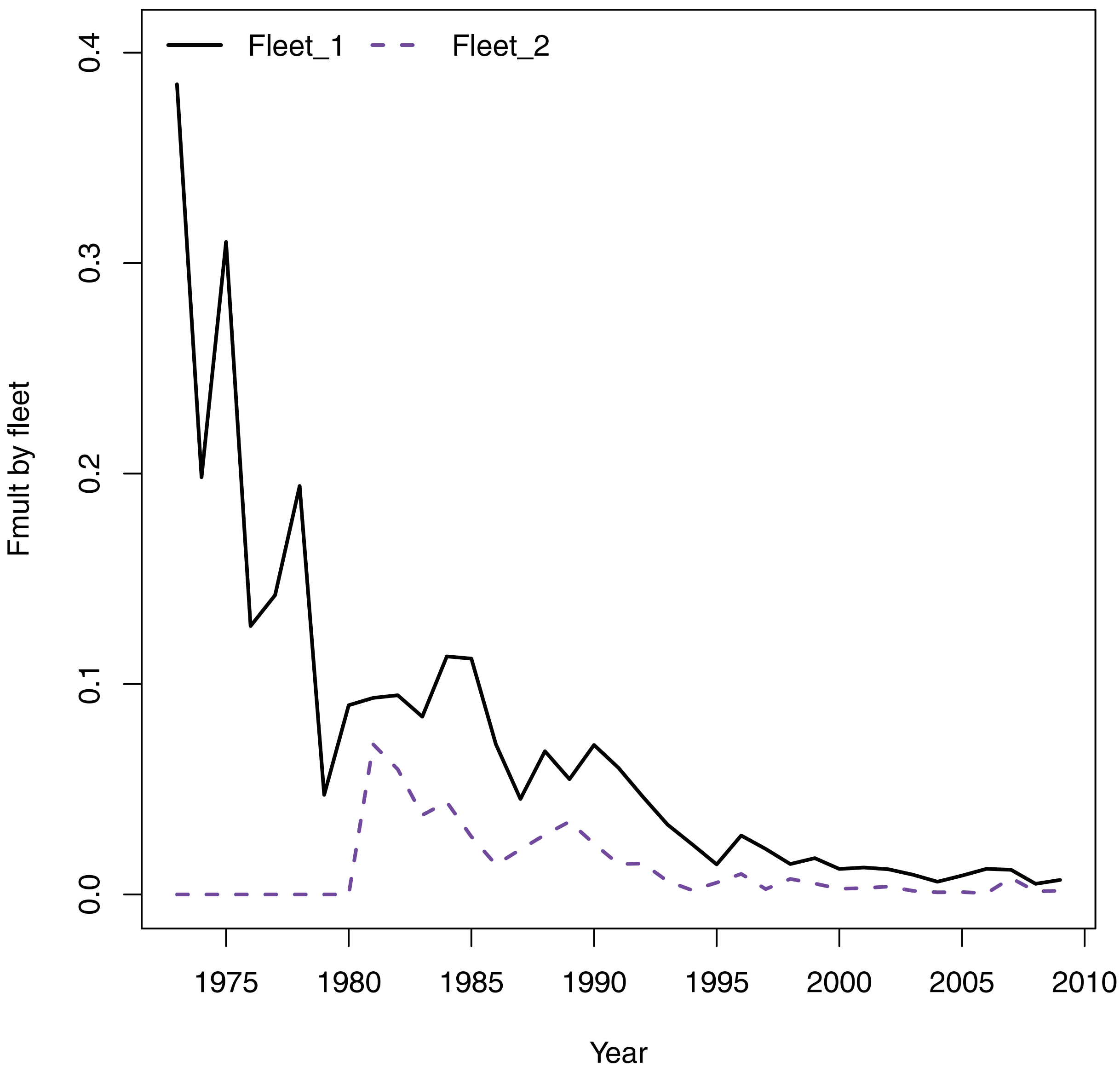

Relative Spawners (SSB/SSB0)
0.0
0.5
1.0
1.5
2.0
2.5
1975
1980
1985
1990
1995
2000
2005
2010
Year

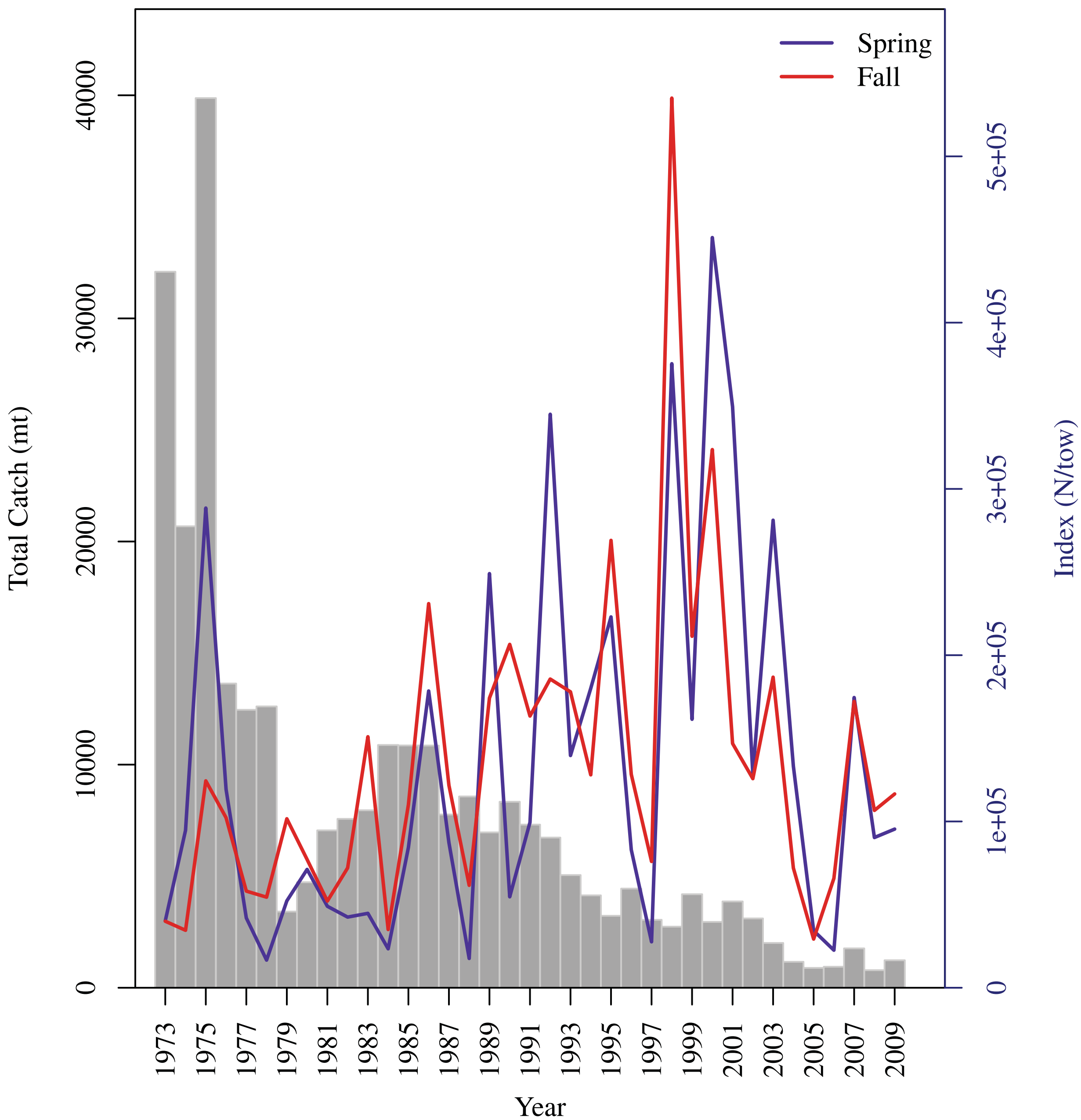

1 2 3 4 5 6
ASAP Estimated NAA
0
500000
1000000
1500000
2000000
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
Year

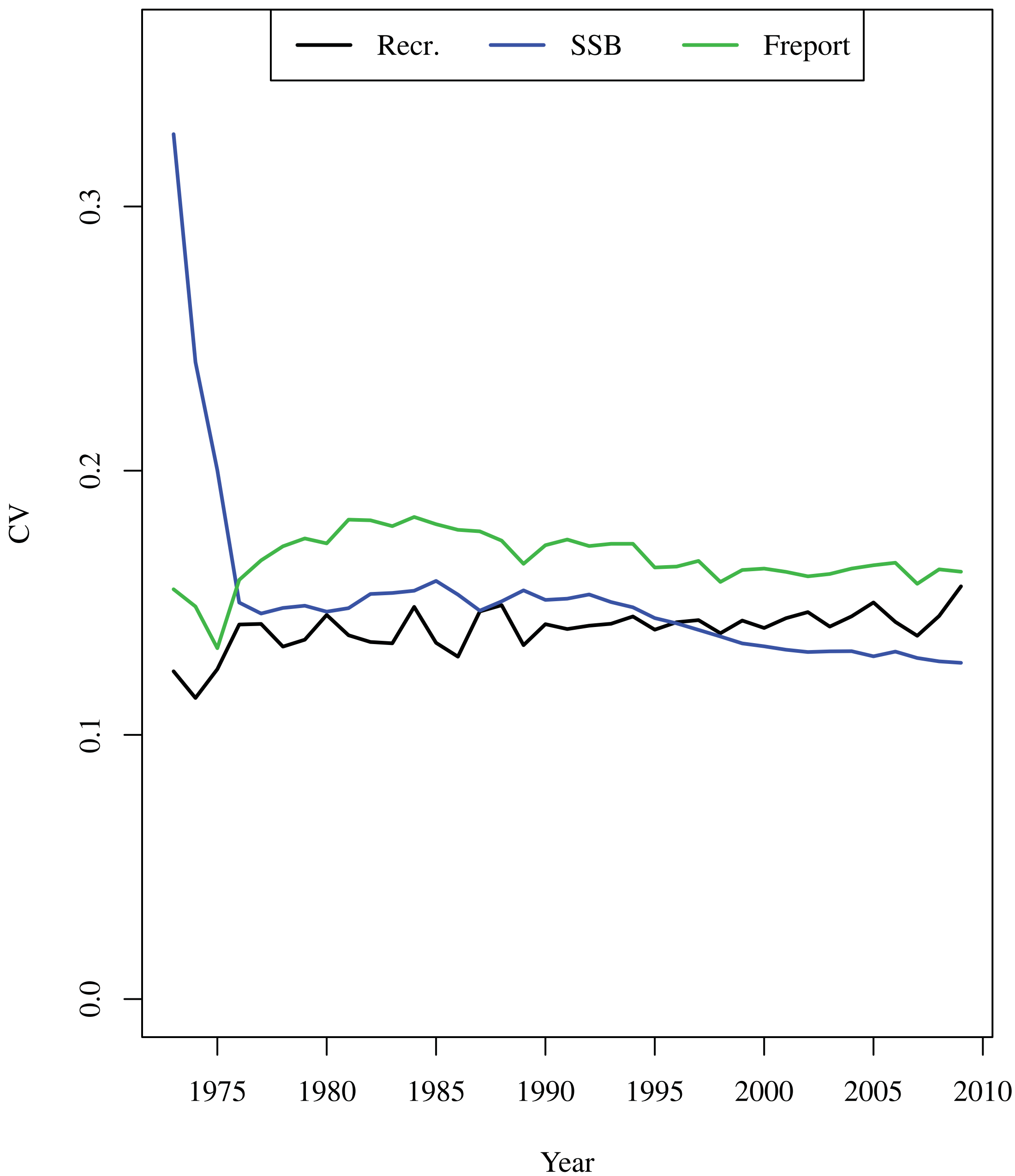

1
2
3
4
5
6
ASAP Estimated Proportion(NAA)
0.0
0.2
0.4
0.6
0.8
1.0
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
Year

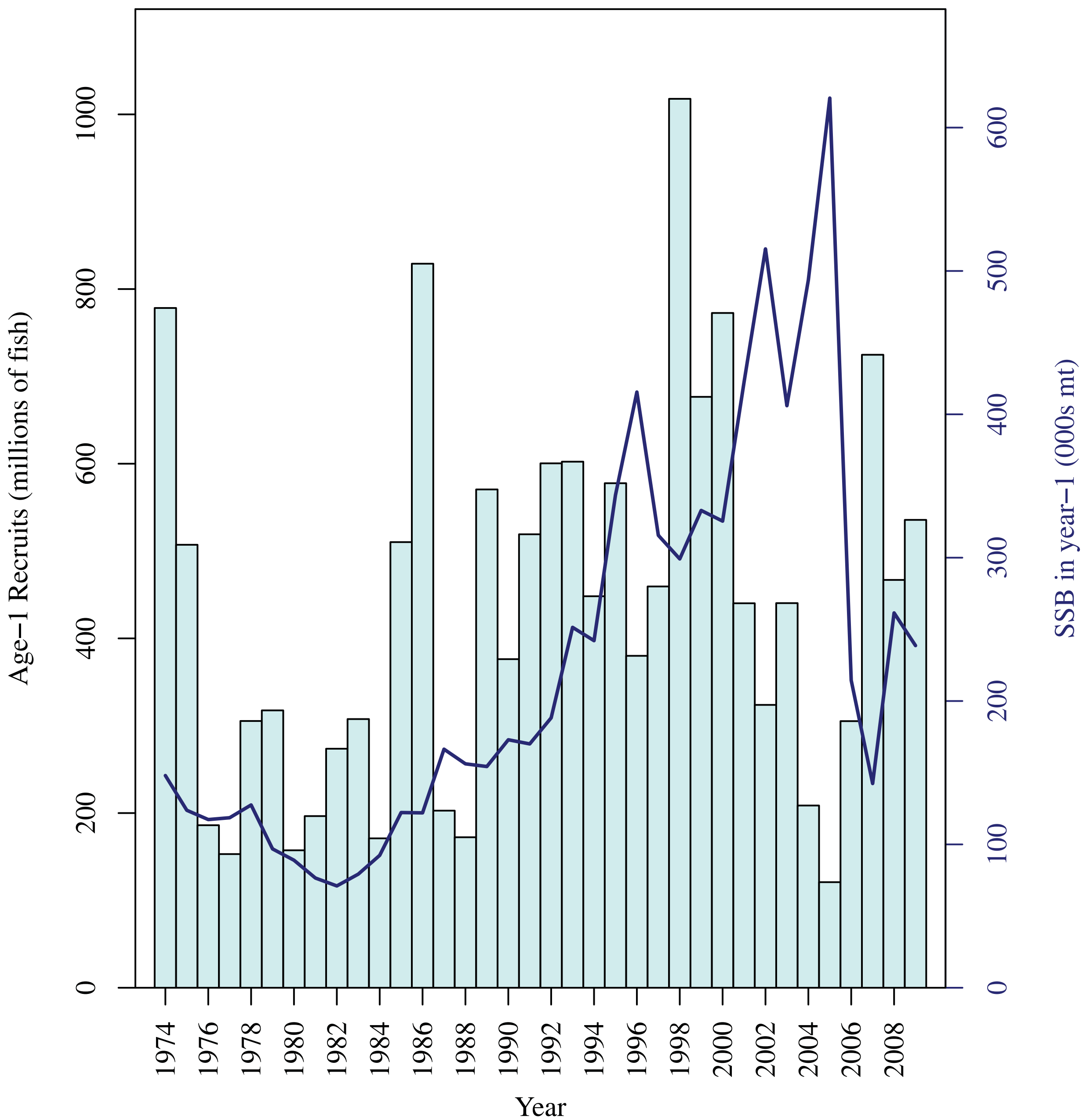

Fleet_1
Fleet_2
Observed Catch (mt)
0
10000
20000
30000
40000
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year


Fleet_1
Fleet_2
Observed Catch (proportion)
0.0
0.2
0.4
0.6
0.8
1.0
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year


Fleet_1
Fleet_2
Fmult by fleet
0.0
0.1
0.2
0.3
0.4
Year
1975
1980
1985
1990
1995
2000
2005
2010


Spring
Fall
Total Catch (mt)
Index (N/tow)
Year
0
10000
20000
30000
40000
1e+05
2e+05
3e+05
4e+05
5e+05
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009


Recr.
SSB
Freport
CV
0.0
0.1
0.2
0.3
1975
1980
1985
1990
1995
2000
2005
2010
Year


Age−1 Recruits (millions of fish)
SSB in year−1 (000s mt)
Year
0
200
400
600
800
1000
0
100
200
300
400
500
600
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008

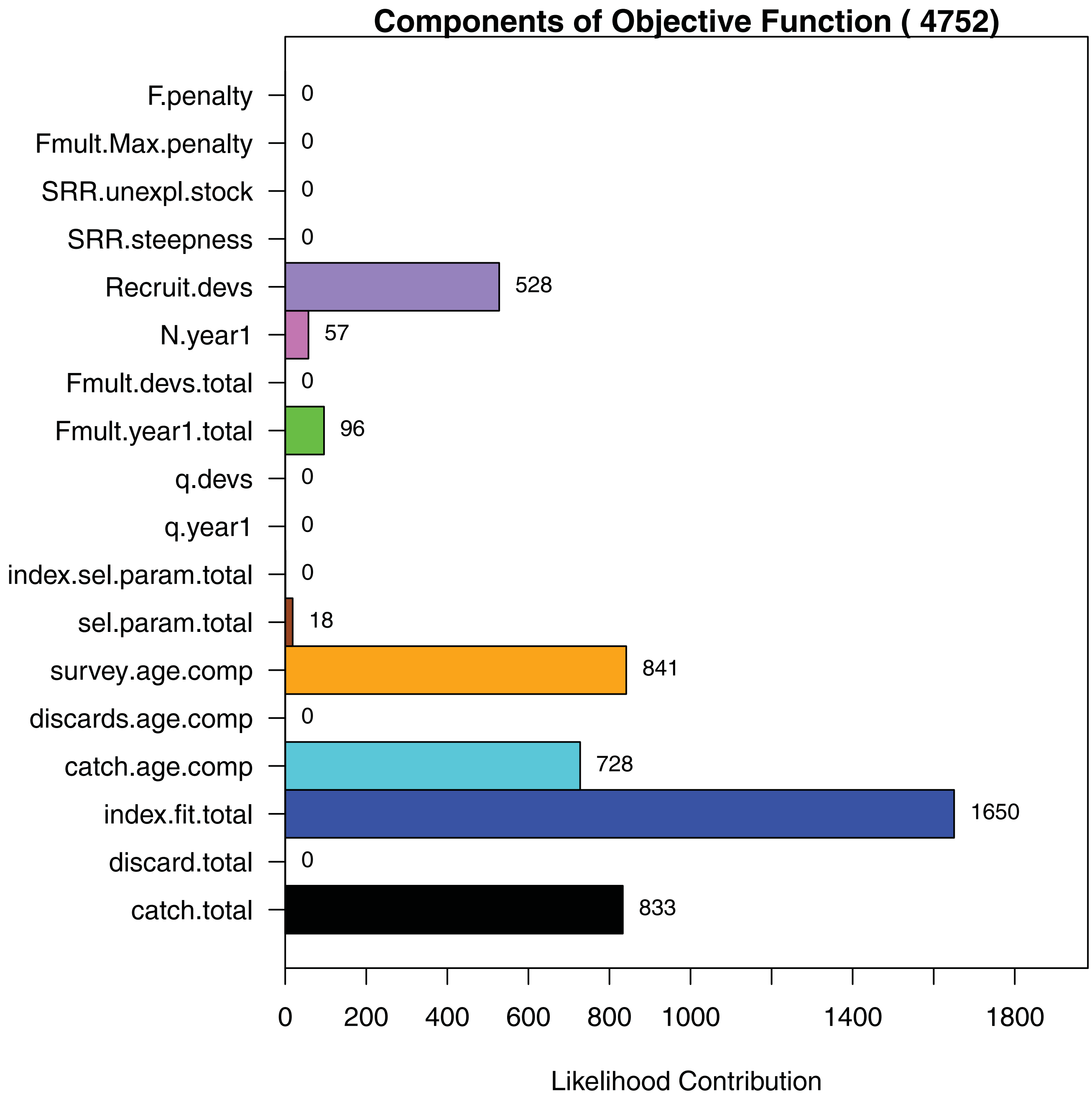
Appendix A4: North Model ASAP results M = 0.4 assuming Flat-top Selectivity in the Survey

Model Attributes:

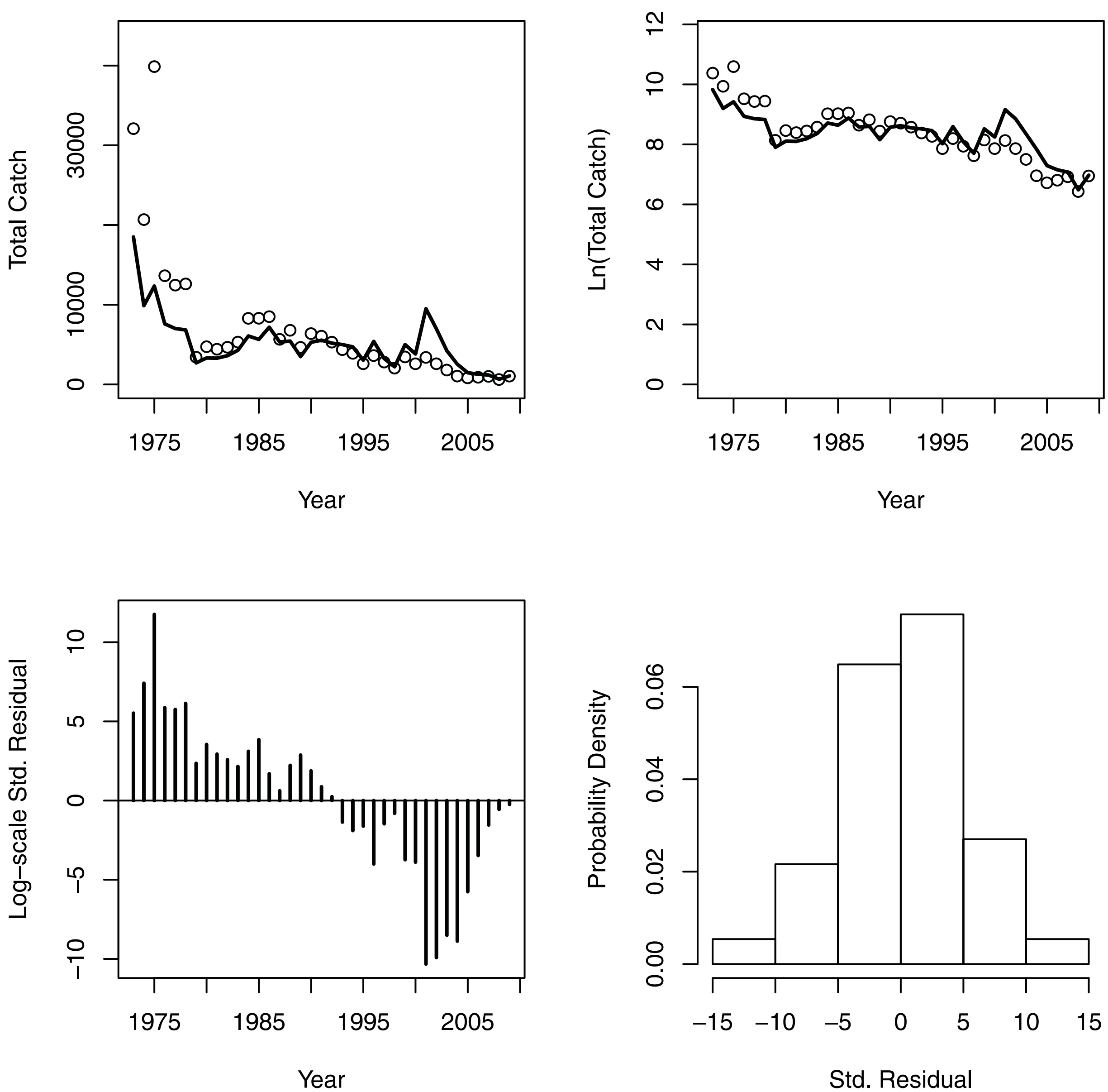
1. 3 Fleet Model
    a. Catch : 1973-2009
    b. Discards: 1981 – 2009
    c. Consumption – 1973-2009

2. Fishery Selectivity (3 Block Selectivity)
    a. Landings (1 Blocks: 1973-2009)
    b. Discards (1 Block: 1981-2009)
    c. Consumption (Double Logistic Functional Form)

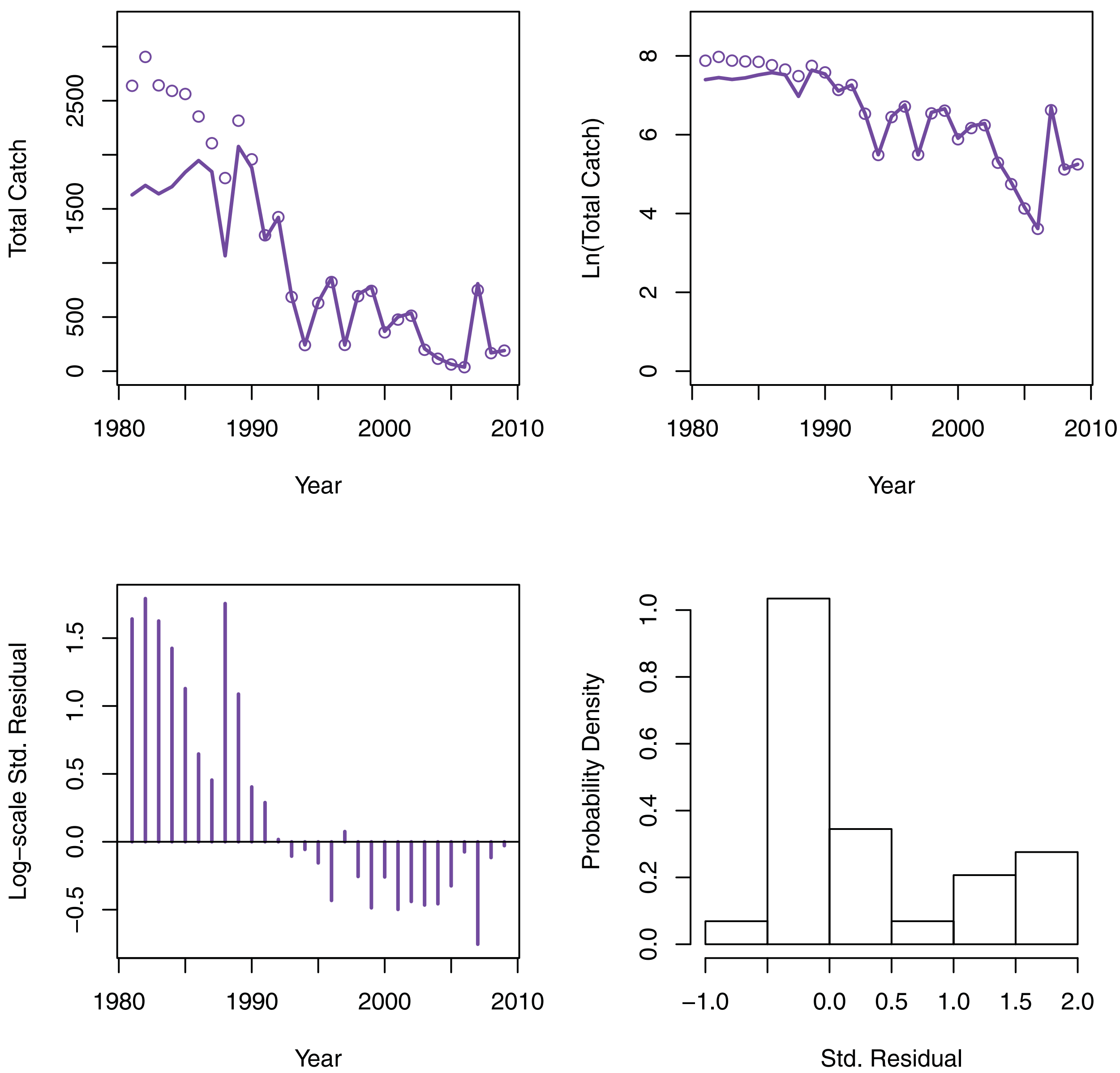
3. Survey Selectivity (Fixed 100% at age 2-6+)

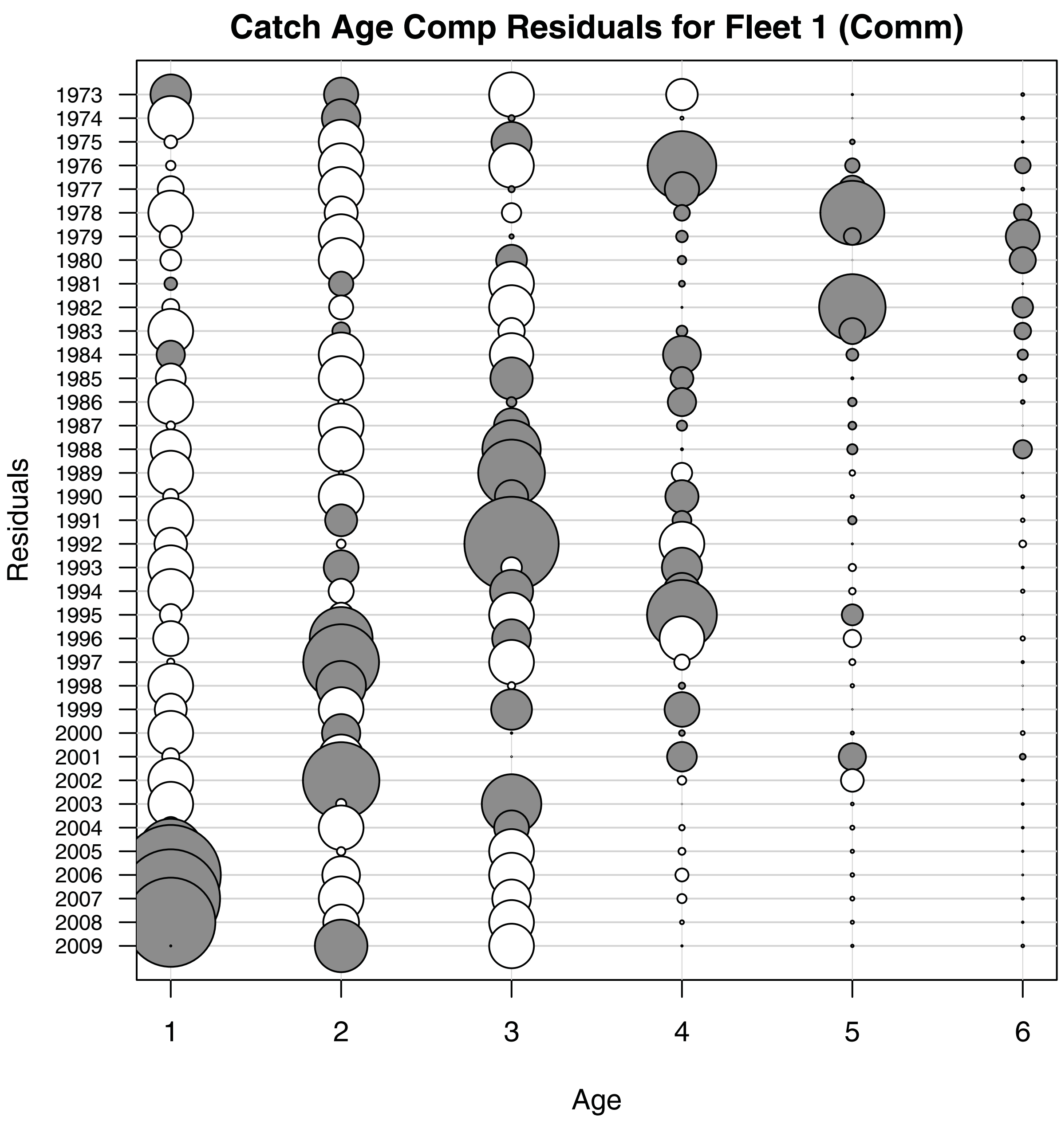

Components of Objective Function (4752)
F.penalty
Fmult.Max.penalty
SRR.unexpl.stock
SRR.steepness
Recruit.devs
N.year1
Fmult.devs.total
Fmult.year1.total
q.devs
q.year1
index.sel.param.total
sel.param.total
survey.age.comp
discards.age.comp
catch.age.comp
index.fit.total
discard.total
catch.total
0
0
0
0
528
57
0
96
0
0
0
18
841
0
728
1650
0
833
0
200
400
600
800
1000
1400
1800
Likelihood Contribution

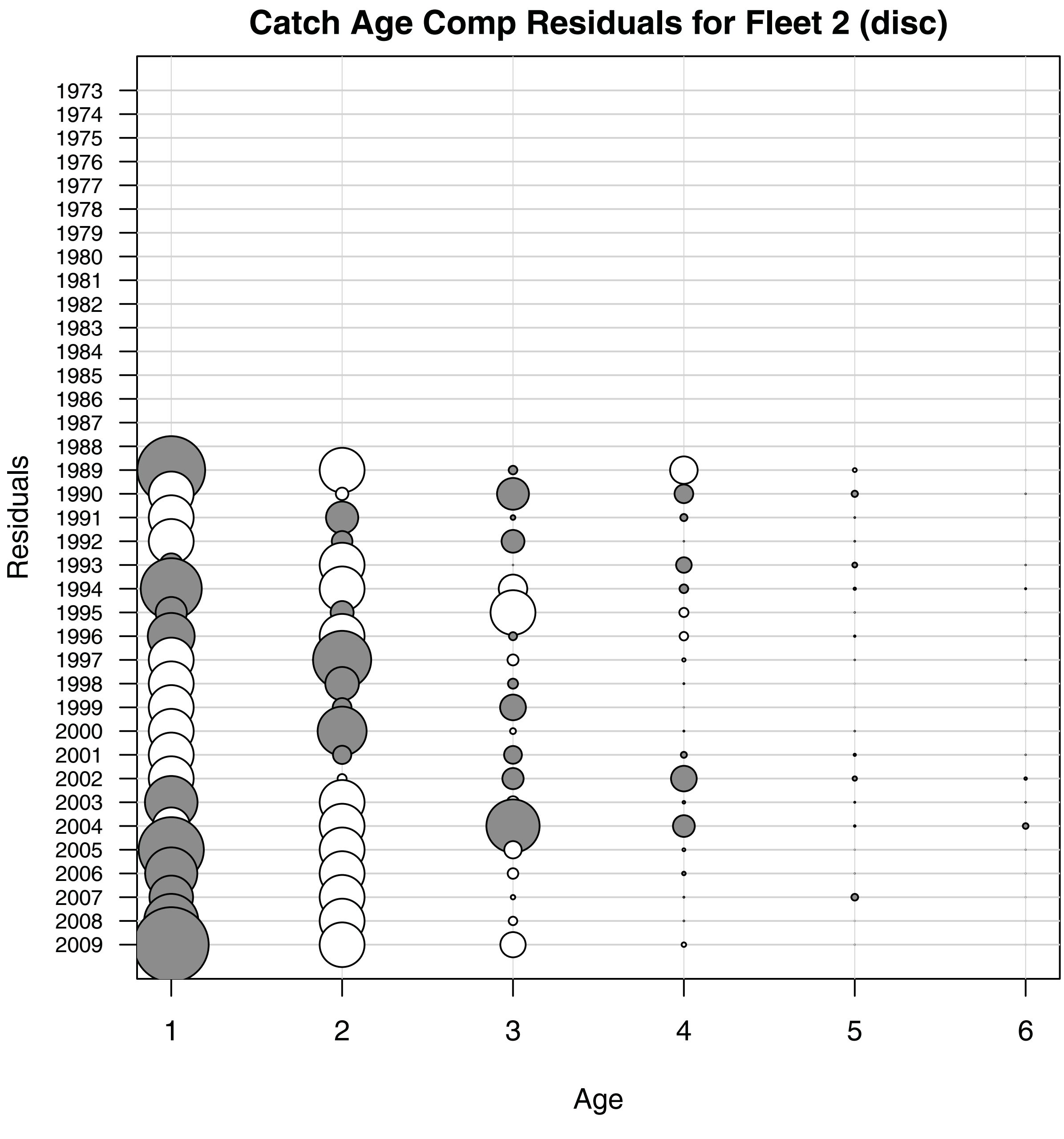
Fleet 1 Landings (Comm)

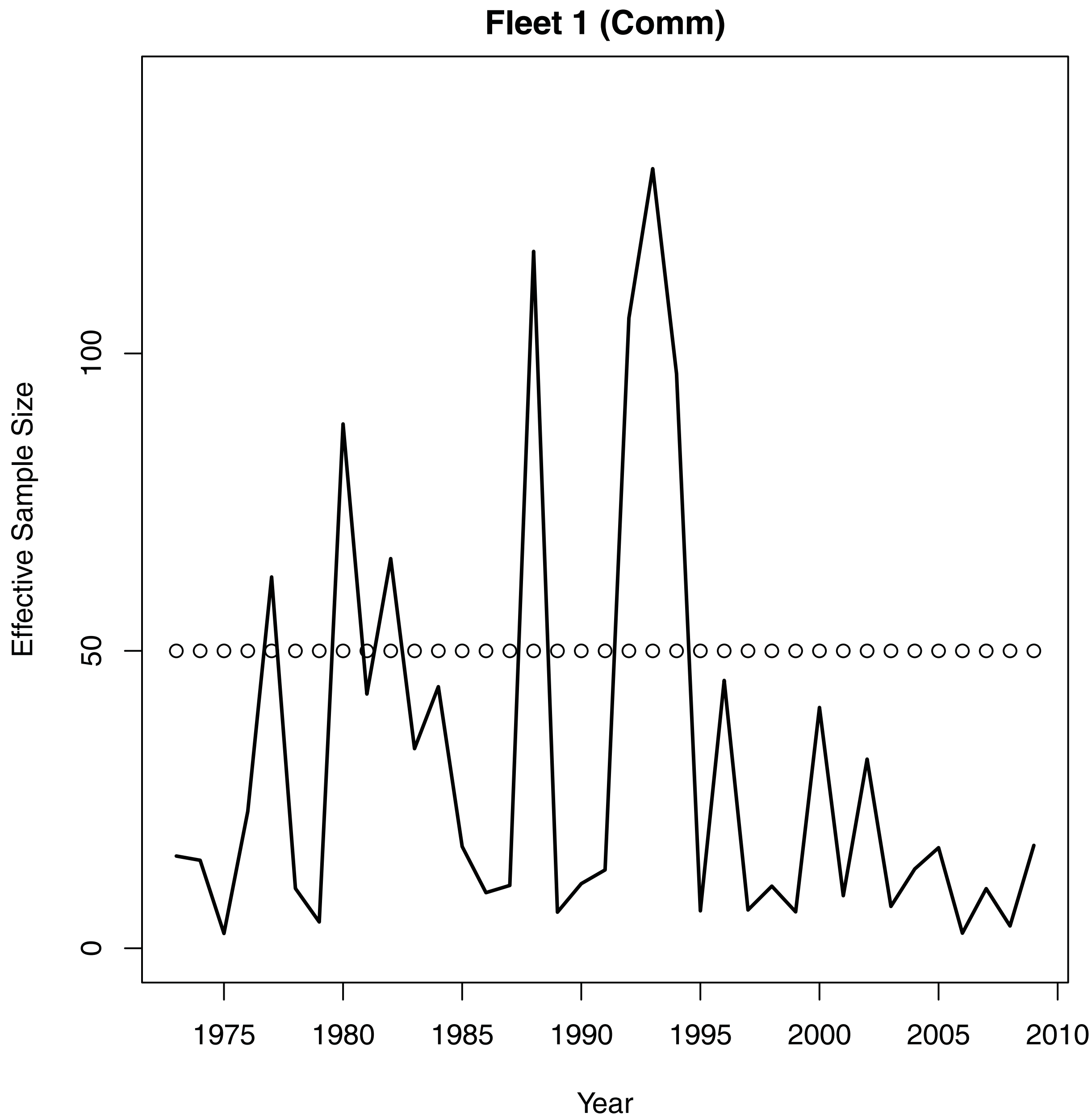


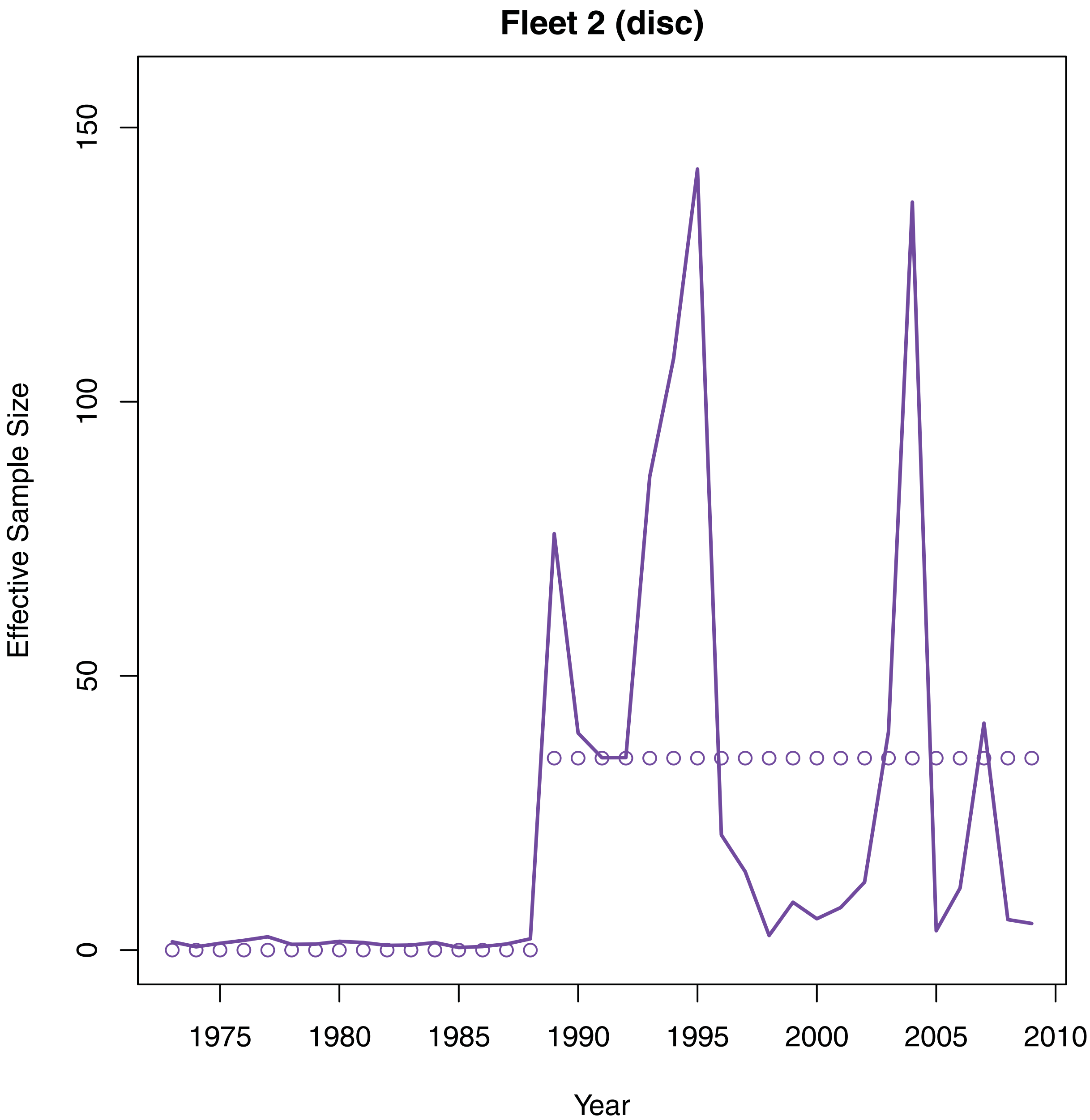
Fleet 2 Landings (disc)

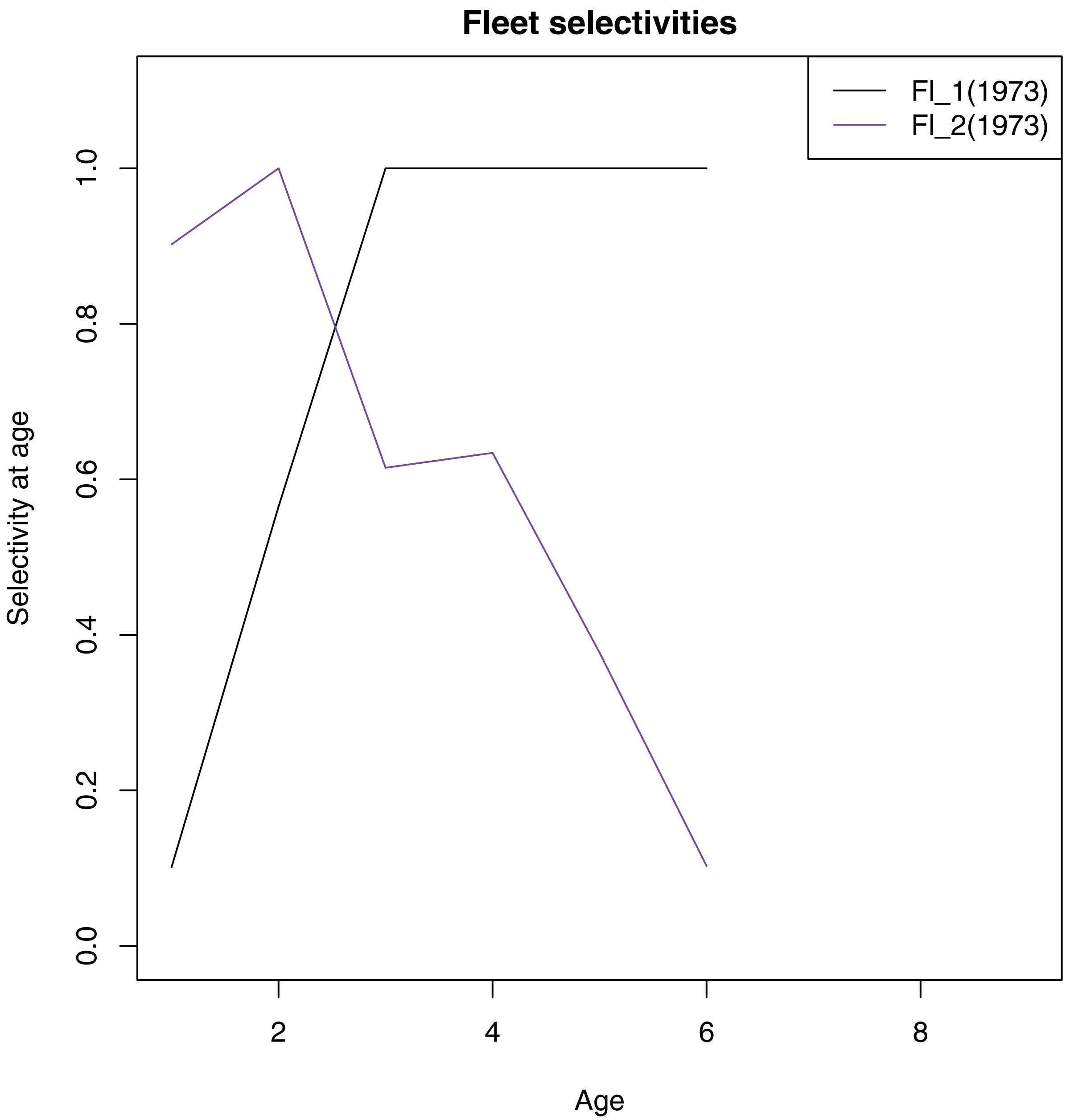



Catch Age Comp Residuals for Fleet 1 (Comm)
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age

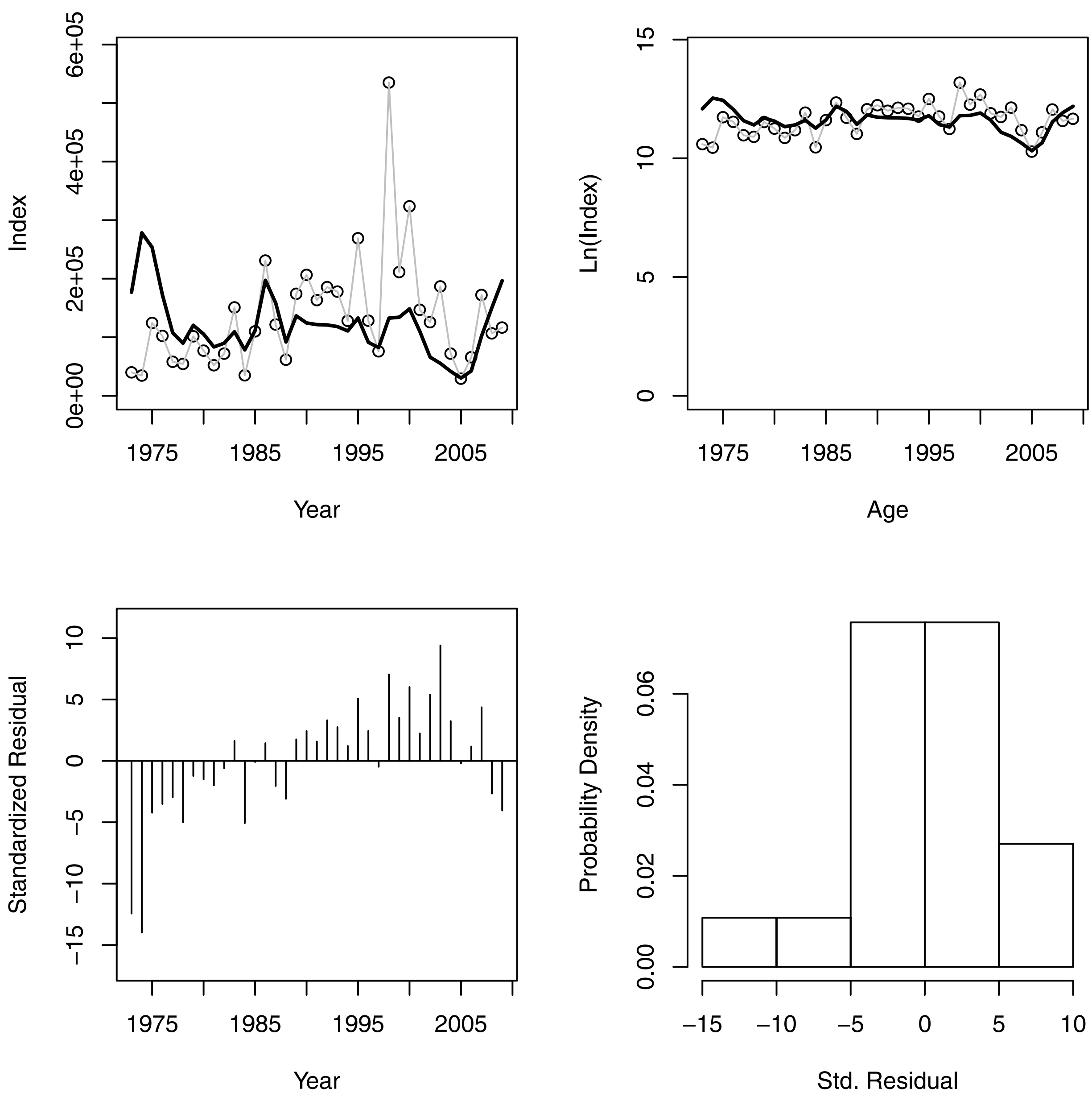

Catch Age Comp Residuals for Fleet 2 (disc)
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age


Fleet 1 (Comm)
Effective Sample Size
0
50
100
1975
1980
1985
1990
1995
2000
2005
2010
Year


Fleet 2 (disc)
Effective Sample Size
0
50
100
150
1975
1980
1985
1990
1995
2000
2005
2010
Year

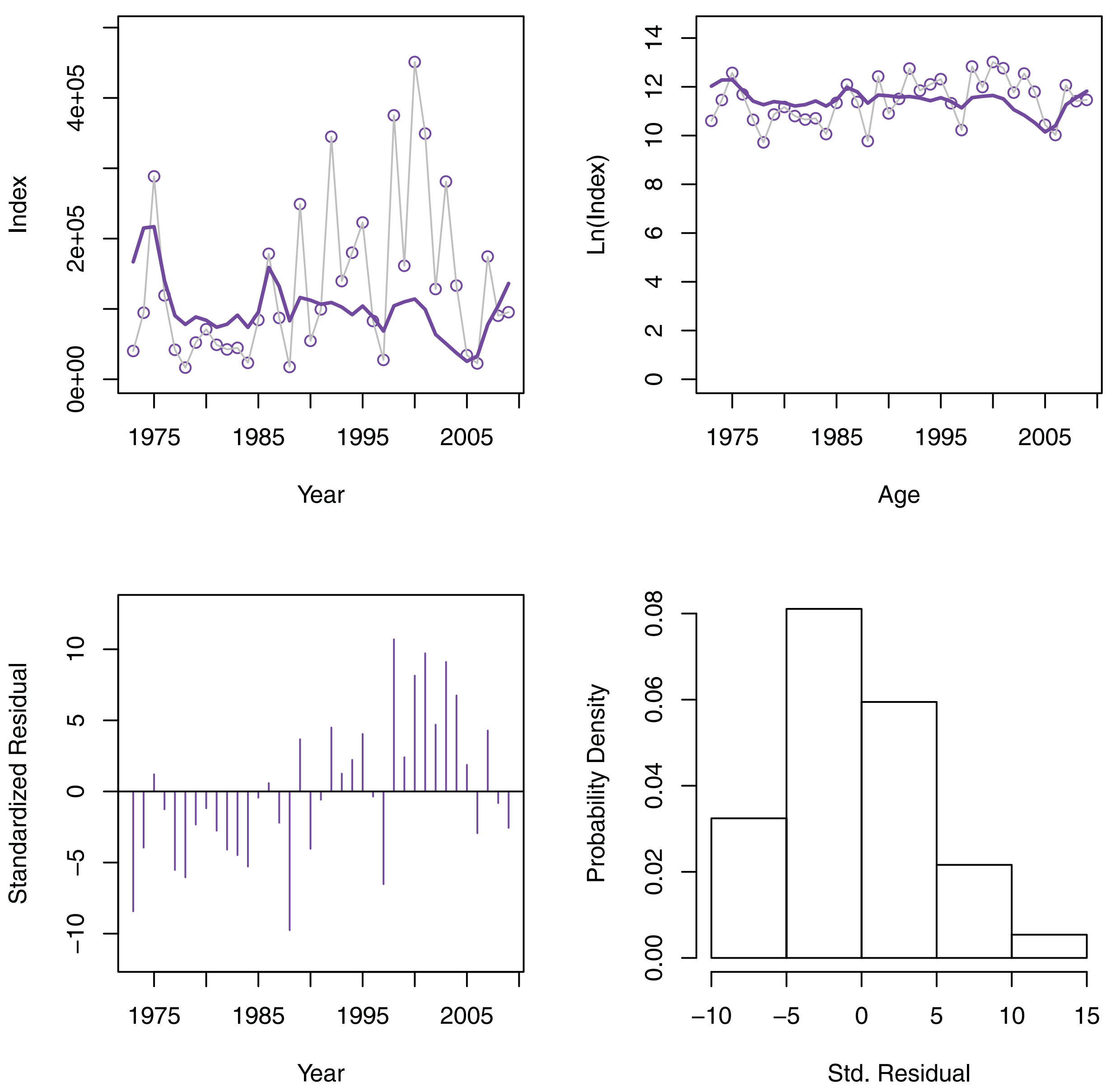

Fleet selectivities
Fl_1(1973)
Fl_2(1973)
Selectivity at age
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
Age

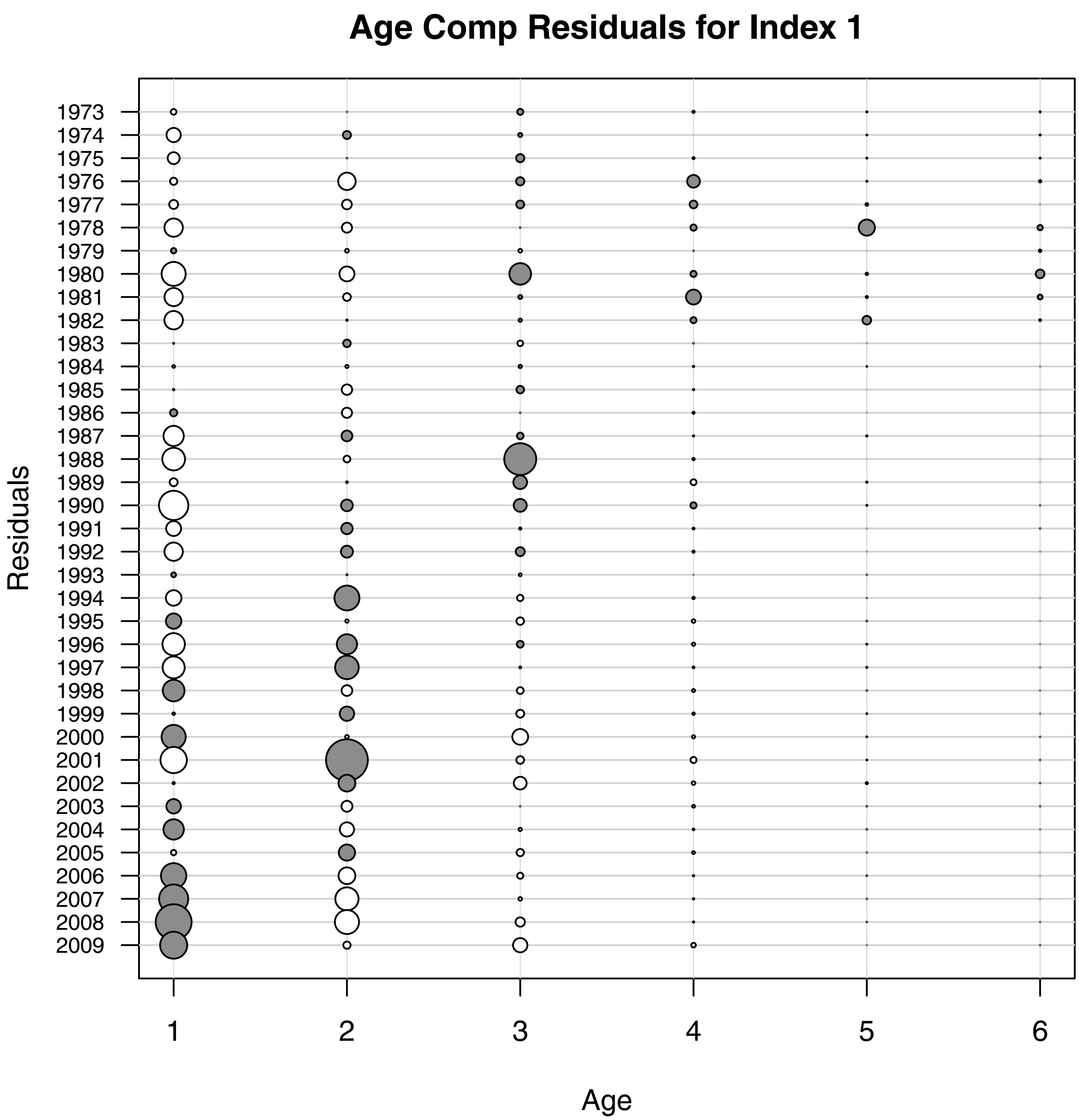
Index 1

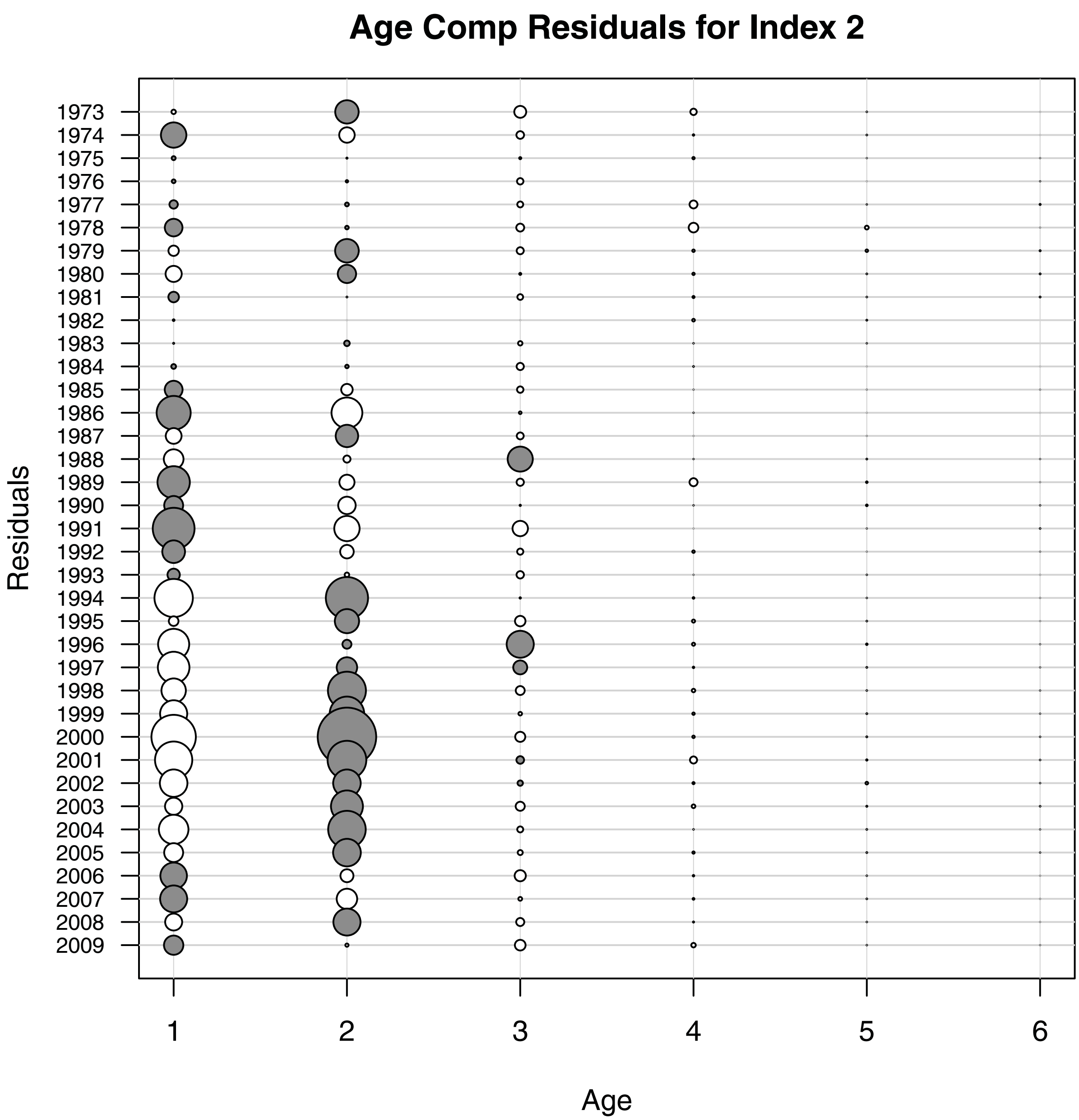


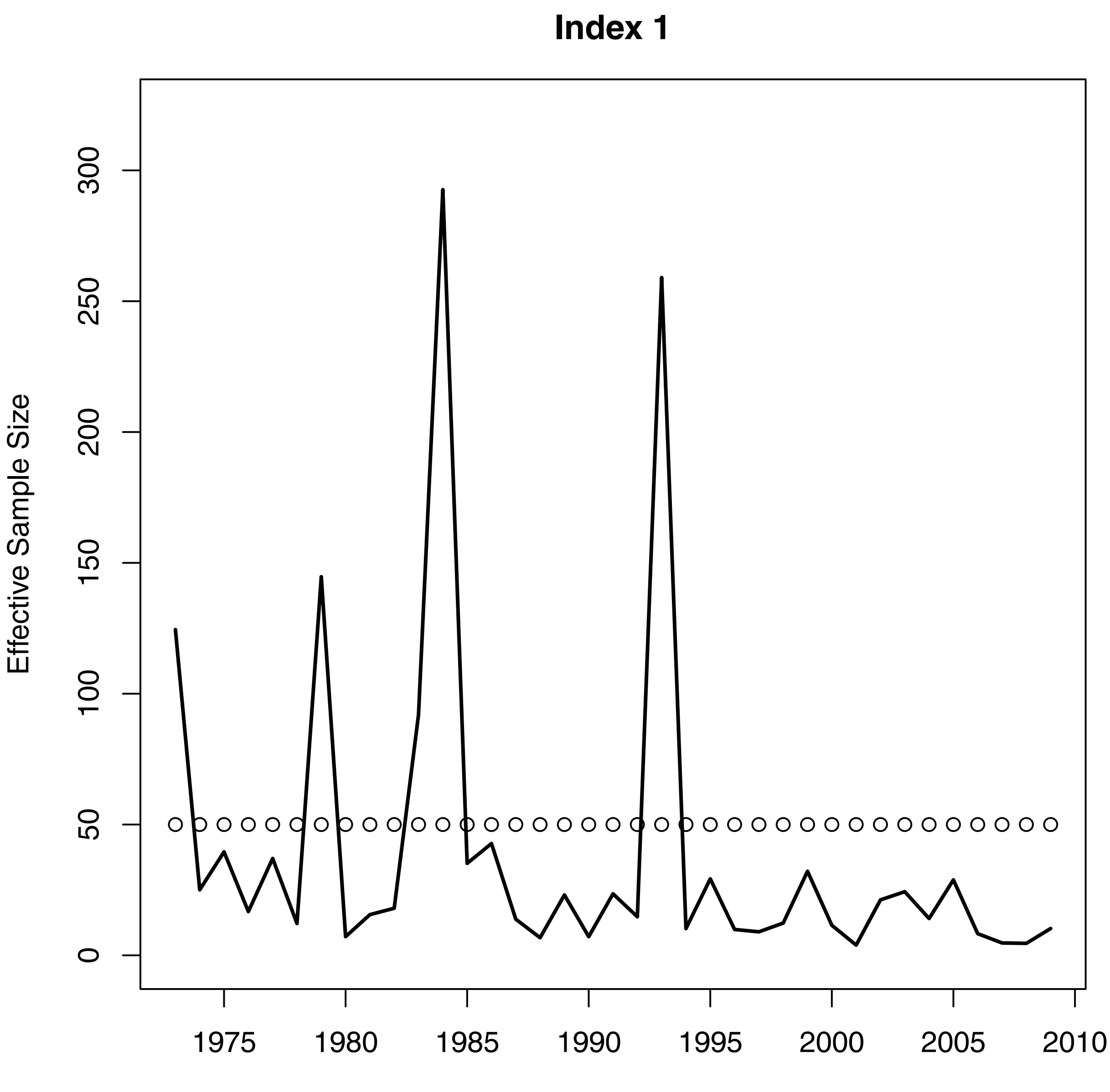
Index
0e+00
2e+05
4e+05
6e+05
1975
1985
1995
2005
Year
Ln(Index)
0
5
10
15
Age
Standardized Residual
−15
−10
−5
0
5
10
Year
Probability Density
0.00
0.02
0.04
0.06
−15
−10
−5
0
5
10
Std. Residual

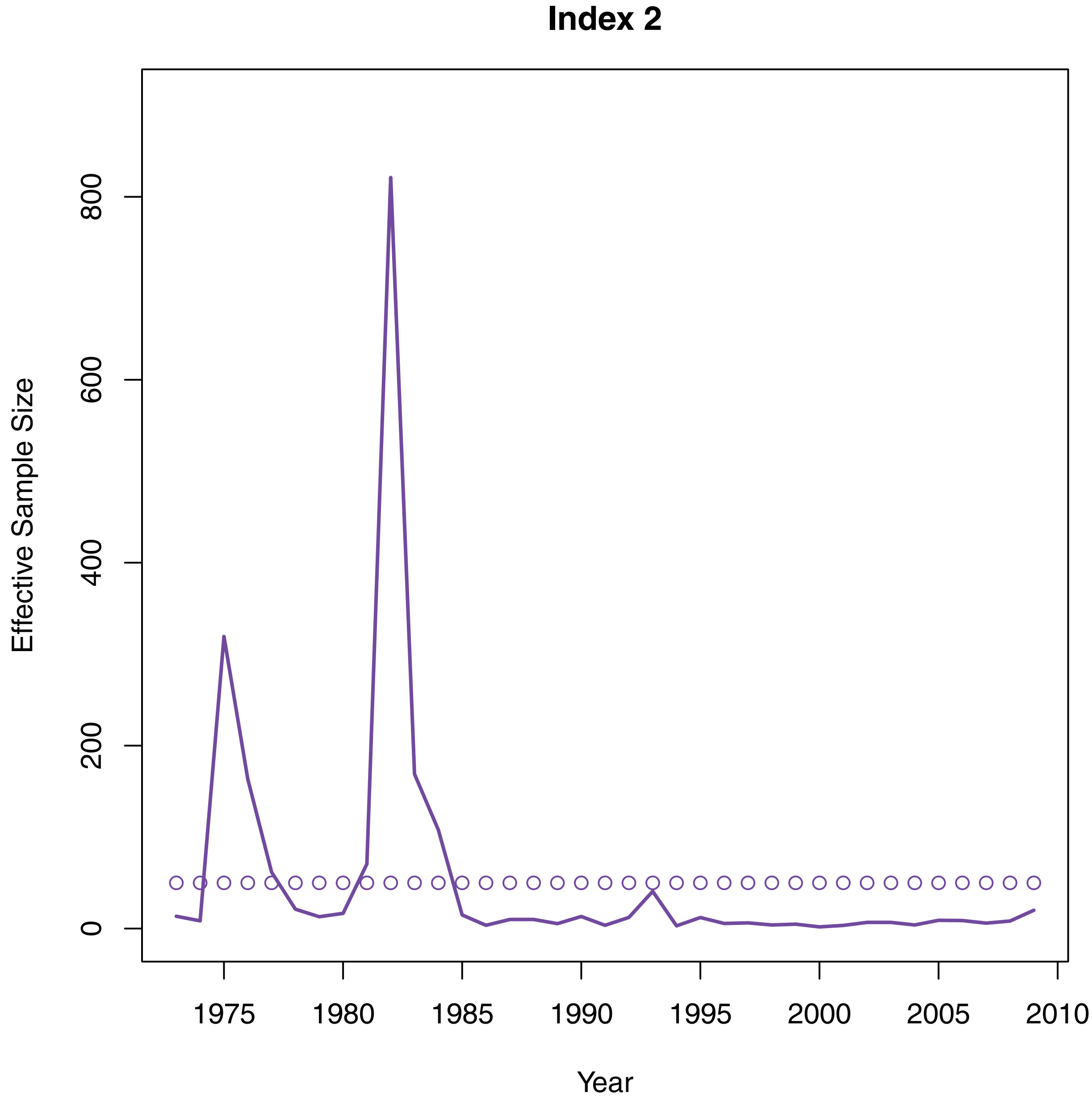
Index 2

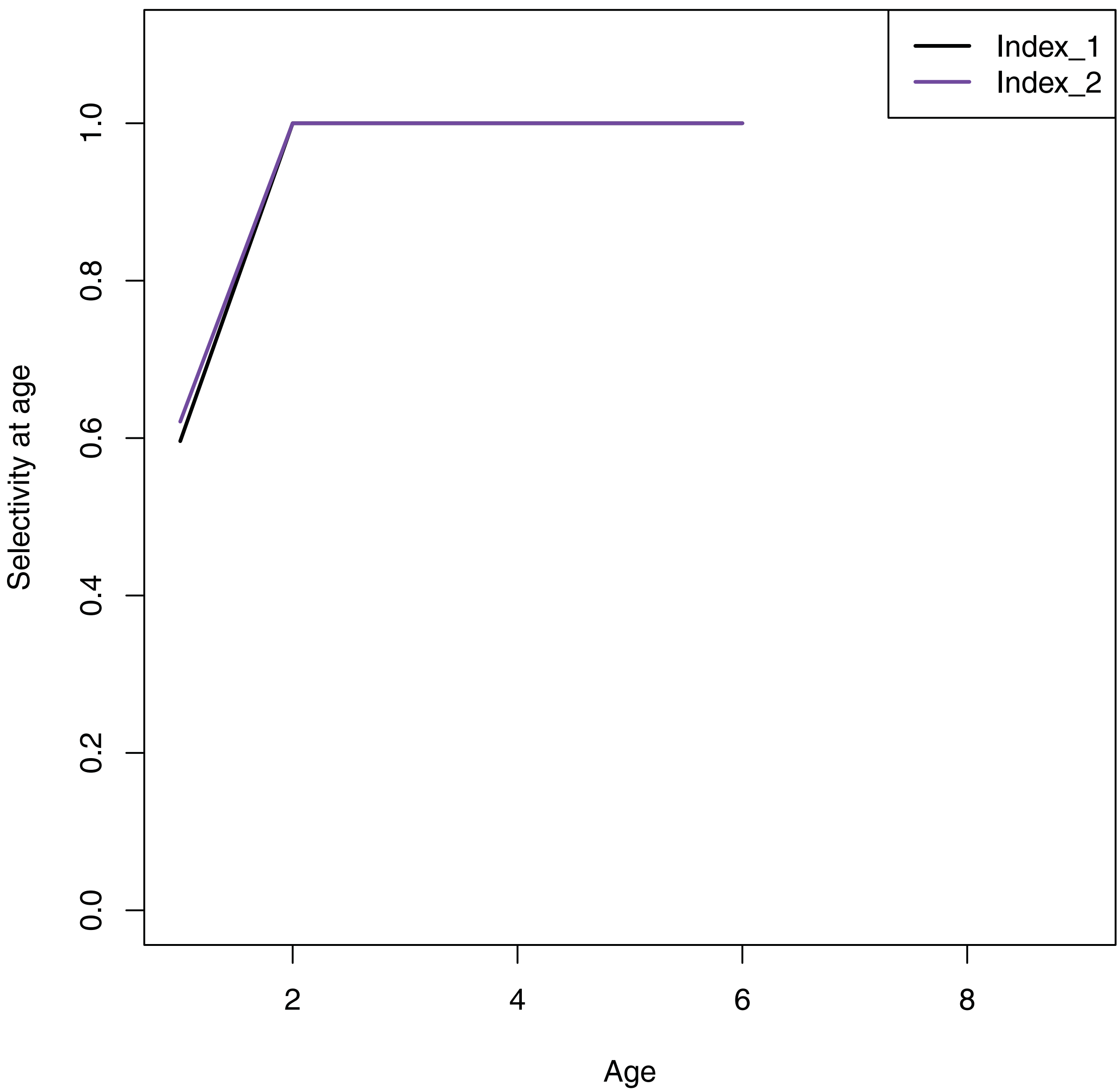

Index
0e+00
2e+05
4e+05
1975
1985
1995
2005
Year
Ln(Index)
0
2
4
6
8
10
12
14
Age
Standardized Residual
−10
−5
0
5
10
Probability Density
0.00
0.02
0.04
0.06
0.08
−10
−5
15
Std. Residual

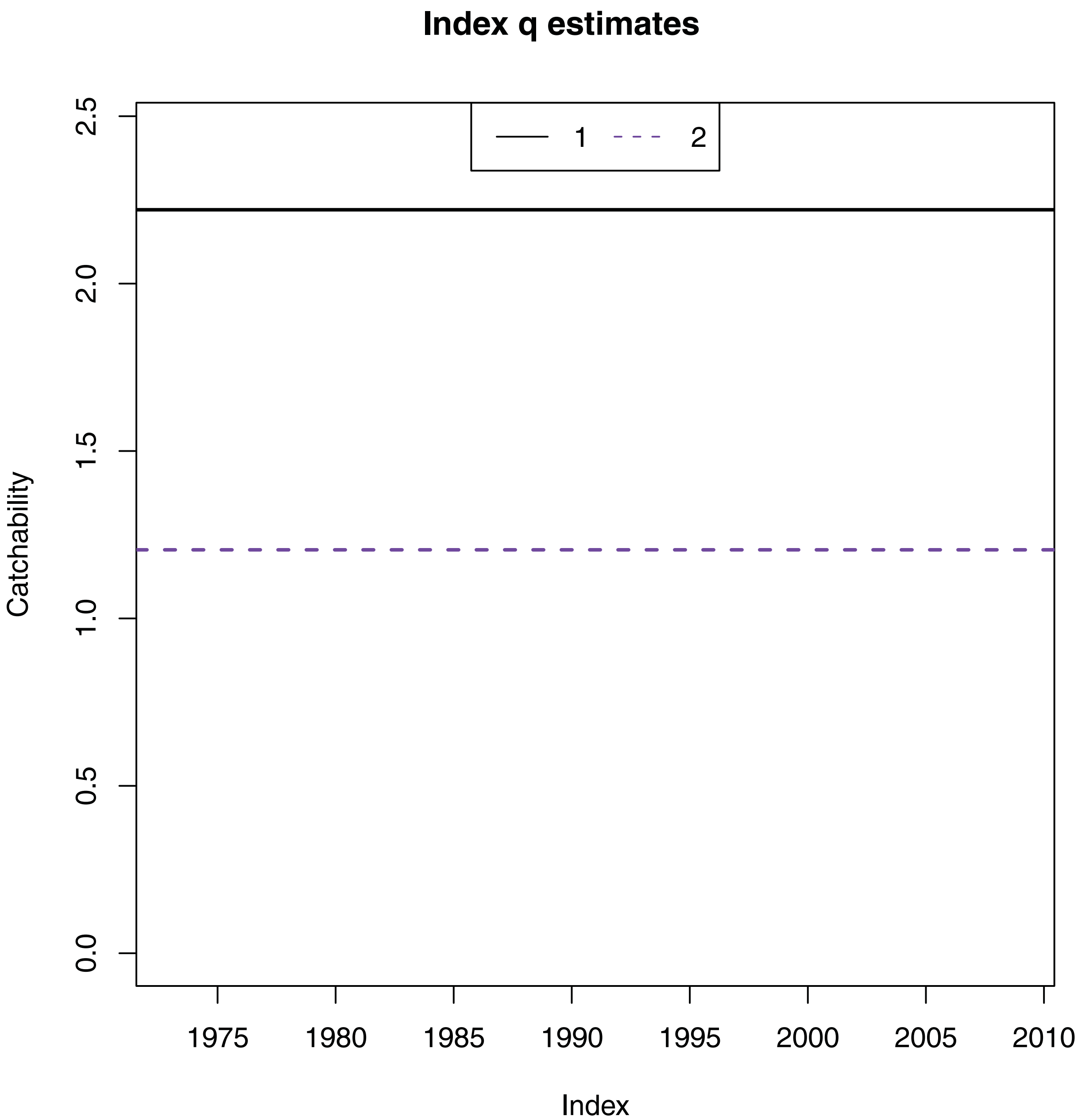

Age Comp Residuals for Index 1
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age

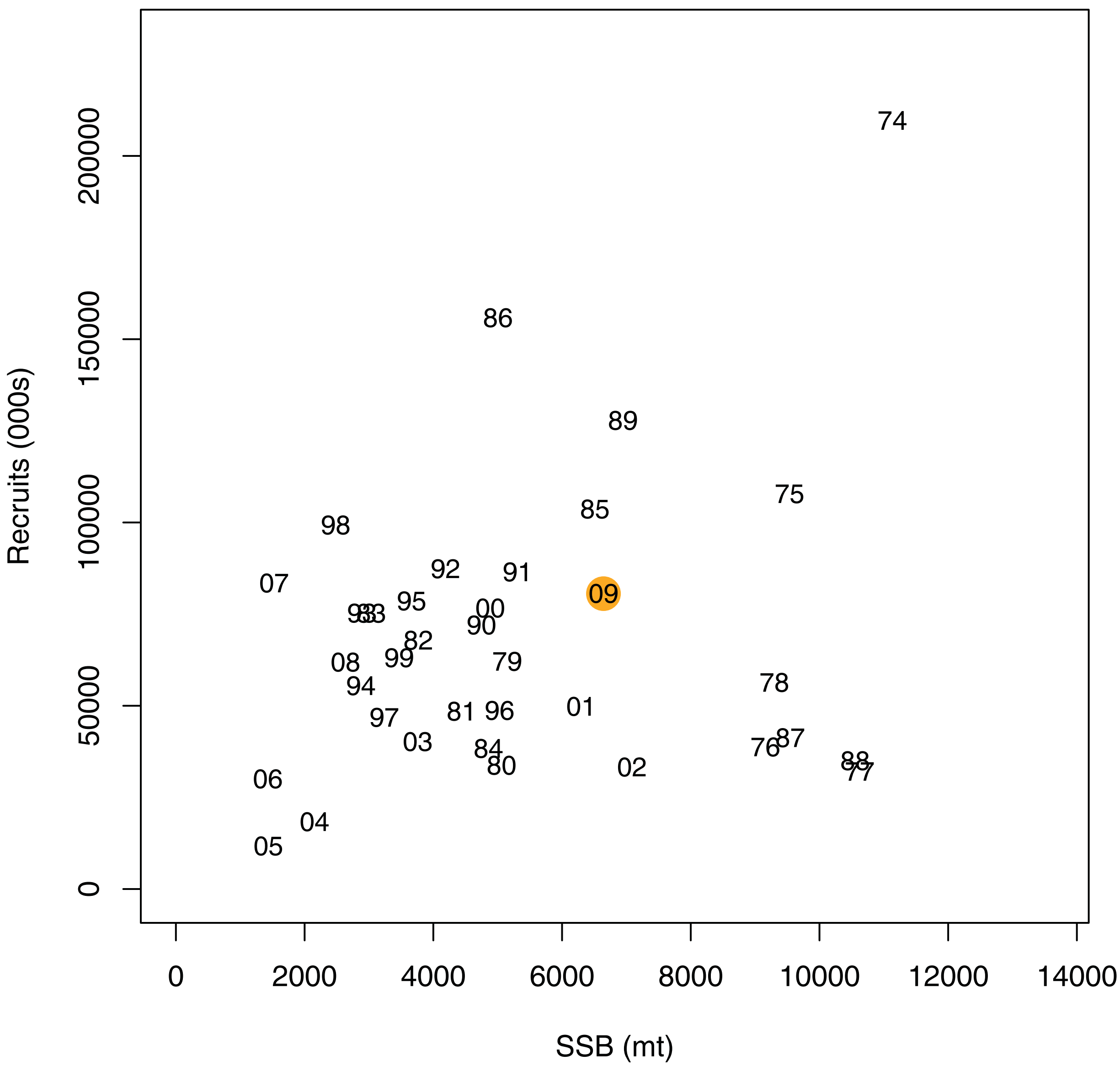

Age Comp Residuals for Index 2
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age

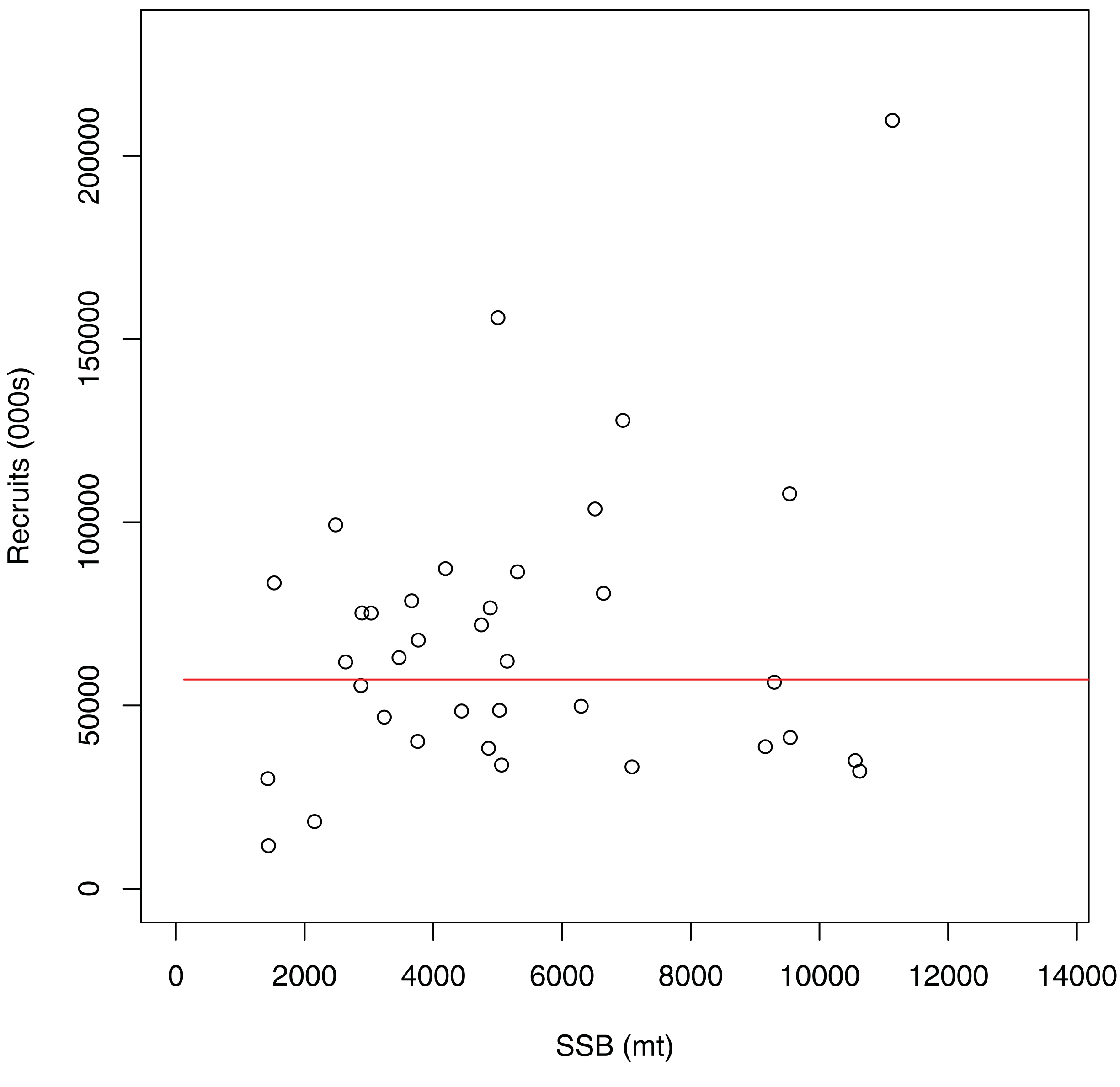

Index 1
Effective Sample Size
0
50
100
150
200
250
300
1975
1980
1985
1990
1995
2000
2005
2010
Year


Index 2
Effective Sample Size
0
200
400
600
800
1975
1980
1985
1990
1995
2000
2005
2010
Year

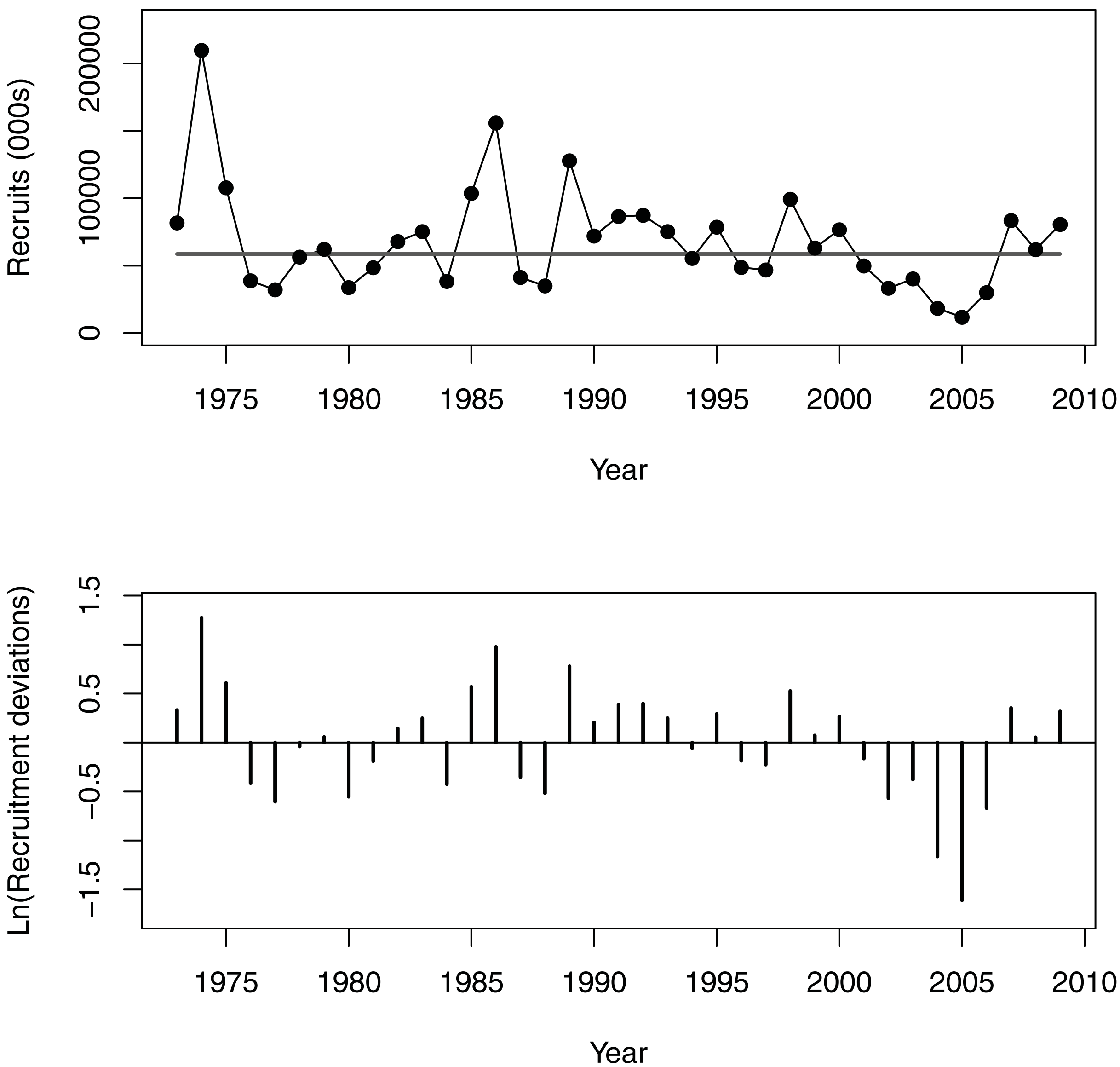

Index_1
Index_2
Selectivity at age
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
Age

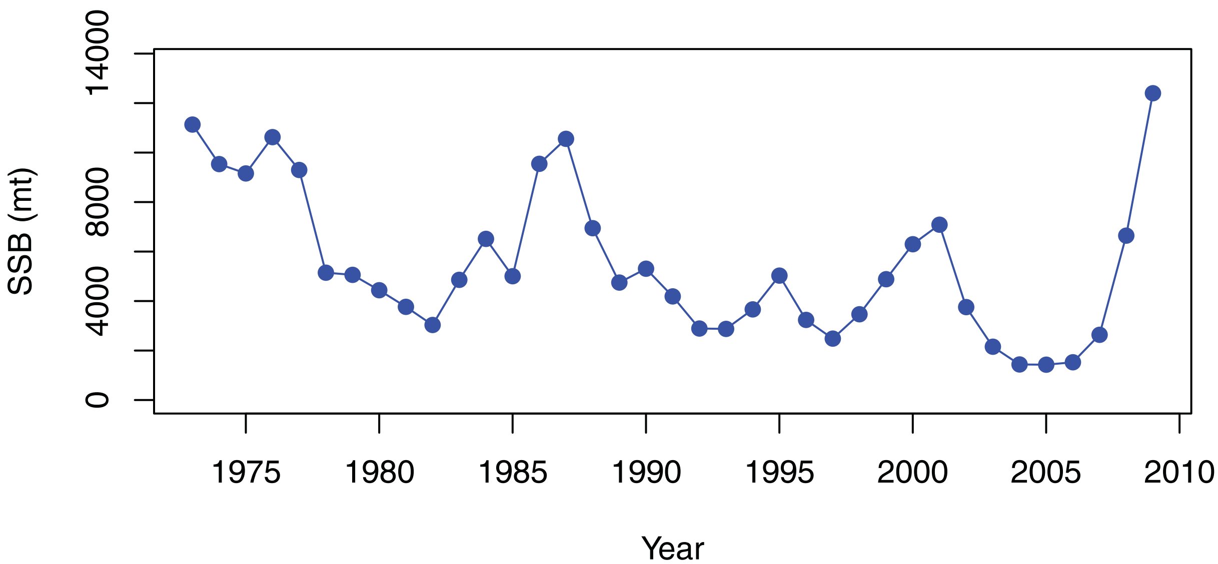

Index q estimates
1
2
Catchability
0.0
0.5
1.0
1.5
2.0
2.5
1975
1980
1985
1990
1995
2000
2005
2010
Index

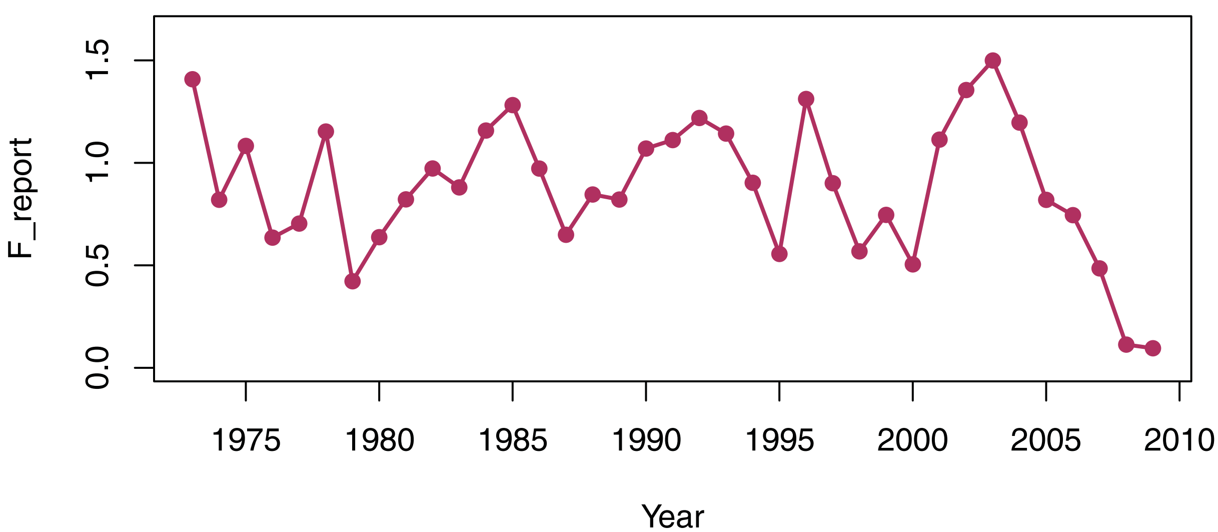

Recruits (000s)
0
50000
100000
150000
200000
0
2000
4000
6000
8000
10000
12000
14000
SSB (mt)
74
86
89
75
85
98
07
92
91
09
95
00
93
83
90
82
08
99
79
94
78
97
81
96
01
03
84
80
02
76
87
88
77
06
04
05

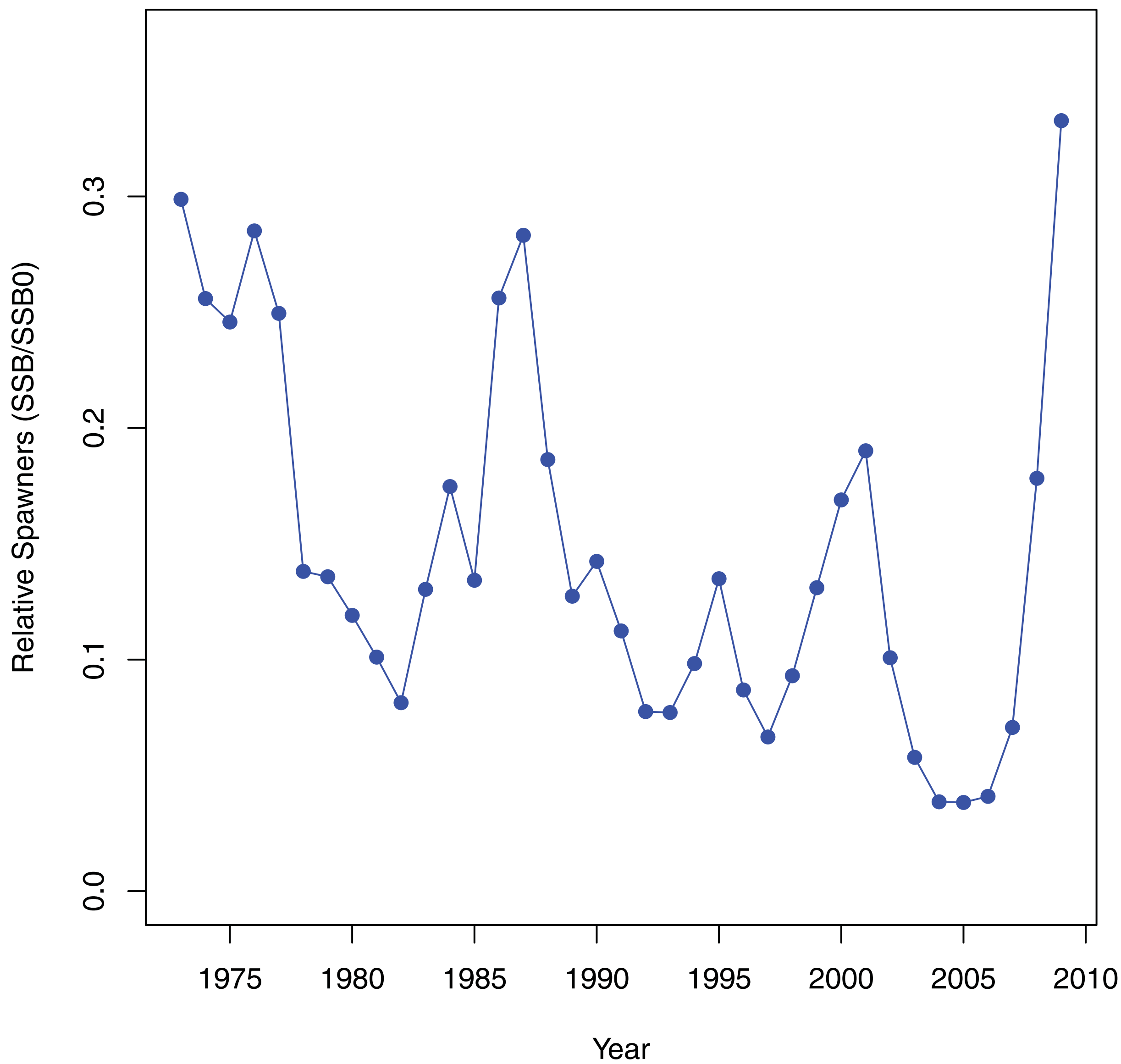


Recruits (000s)
0
50000
100000
150000
200000
0
2000
4000
6000
8000
10000
12000
14000
SSB (mt)

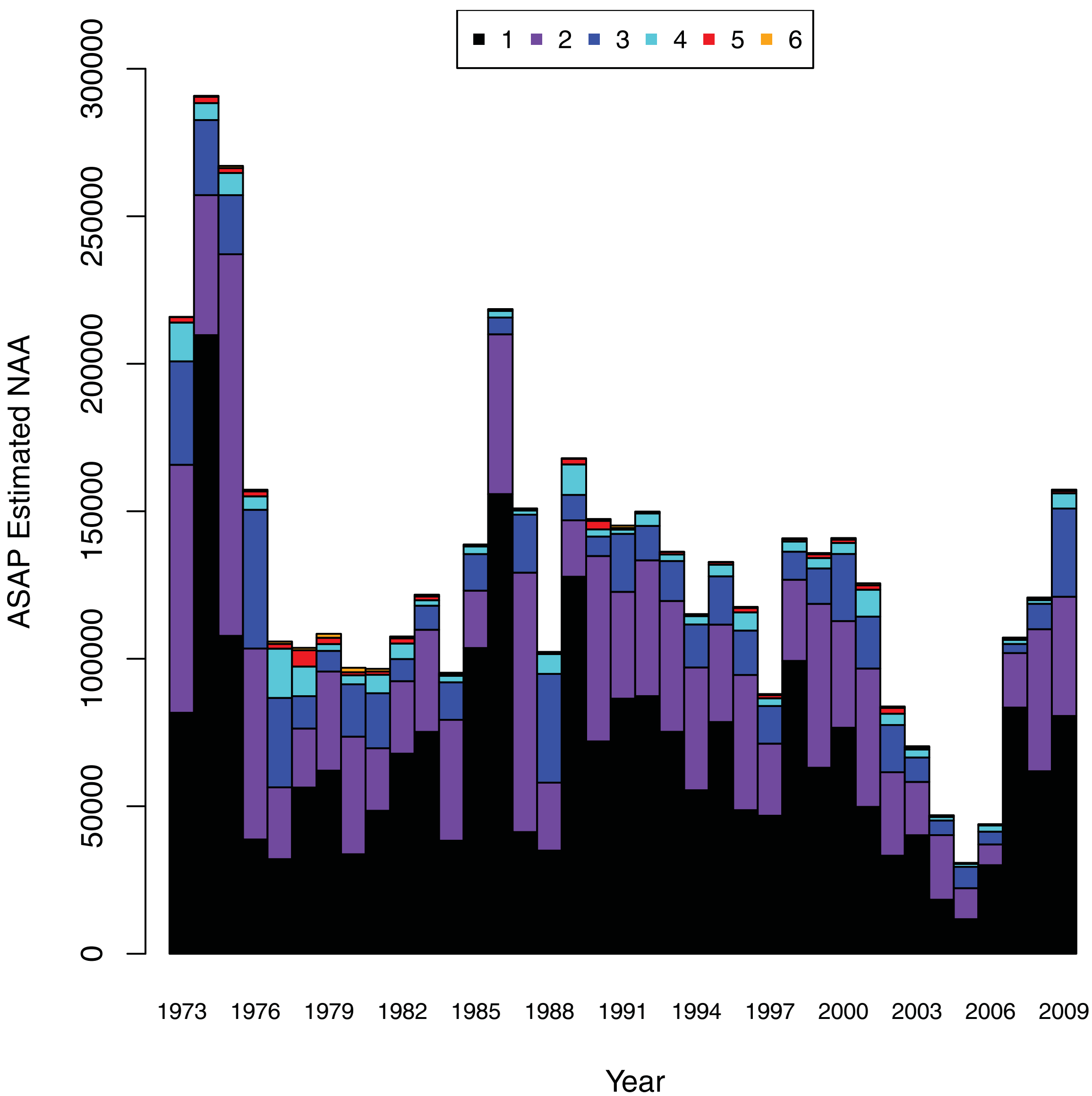

Recruits (000s)
0
100000
200000
1975
1980
1985
1990
1995
2000
2005
2010
Year
Ln(Recruitment deviations)
1.5
0.5
−0.5
−1.5
1975
1980
1985
1990
1995
2000
2005
2010
Year


SSB (mt)
0
4000
8000
14000
1975
1980
1985
1990
1995
2000
2005
2010
Year

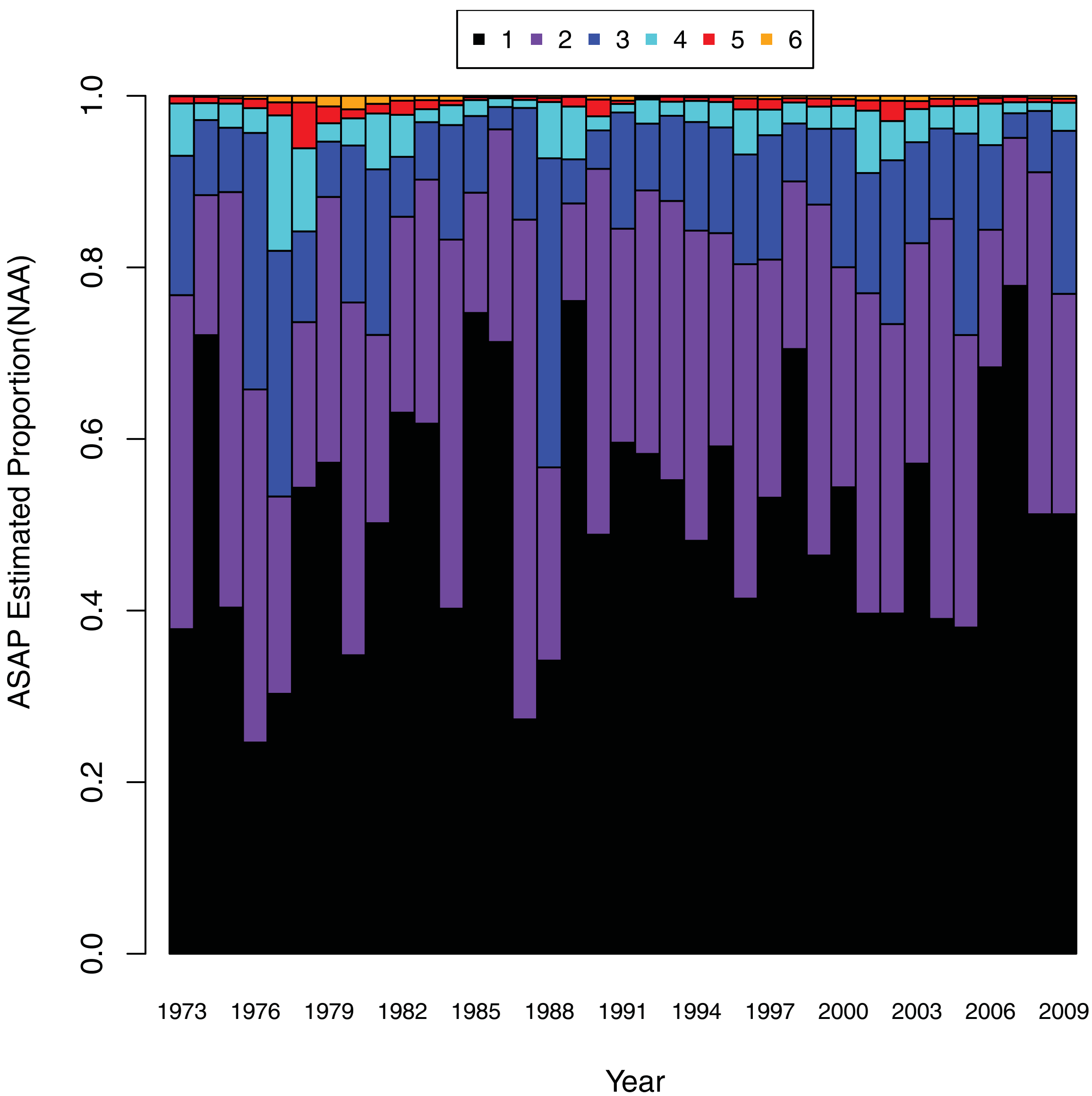

F_report
0.0
0.5
1.0
1.5
1975
1980
1985
1990
1995
2000
2005
2010
Year

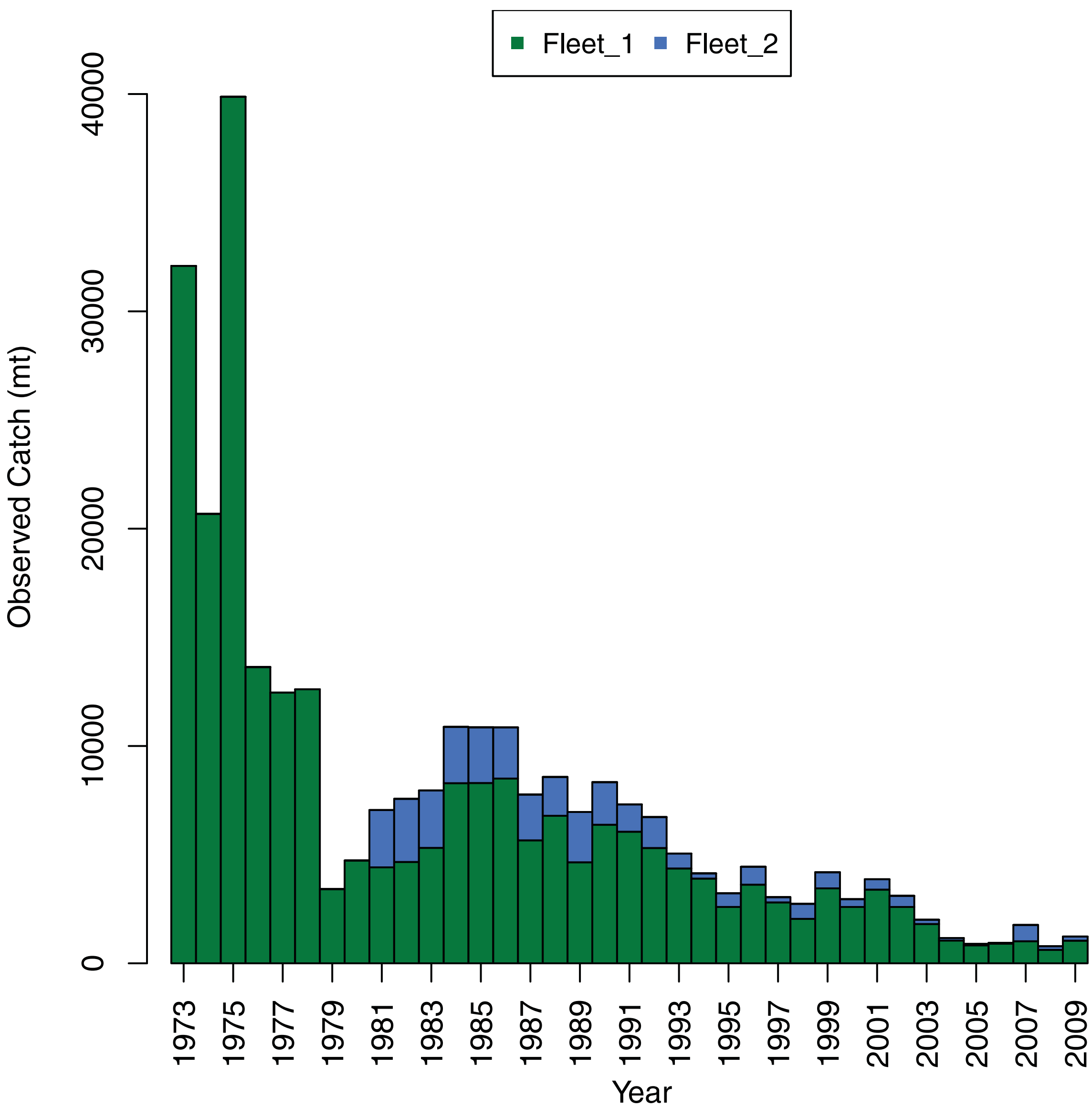


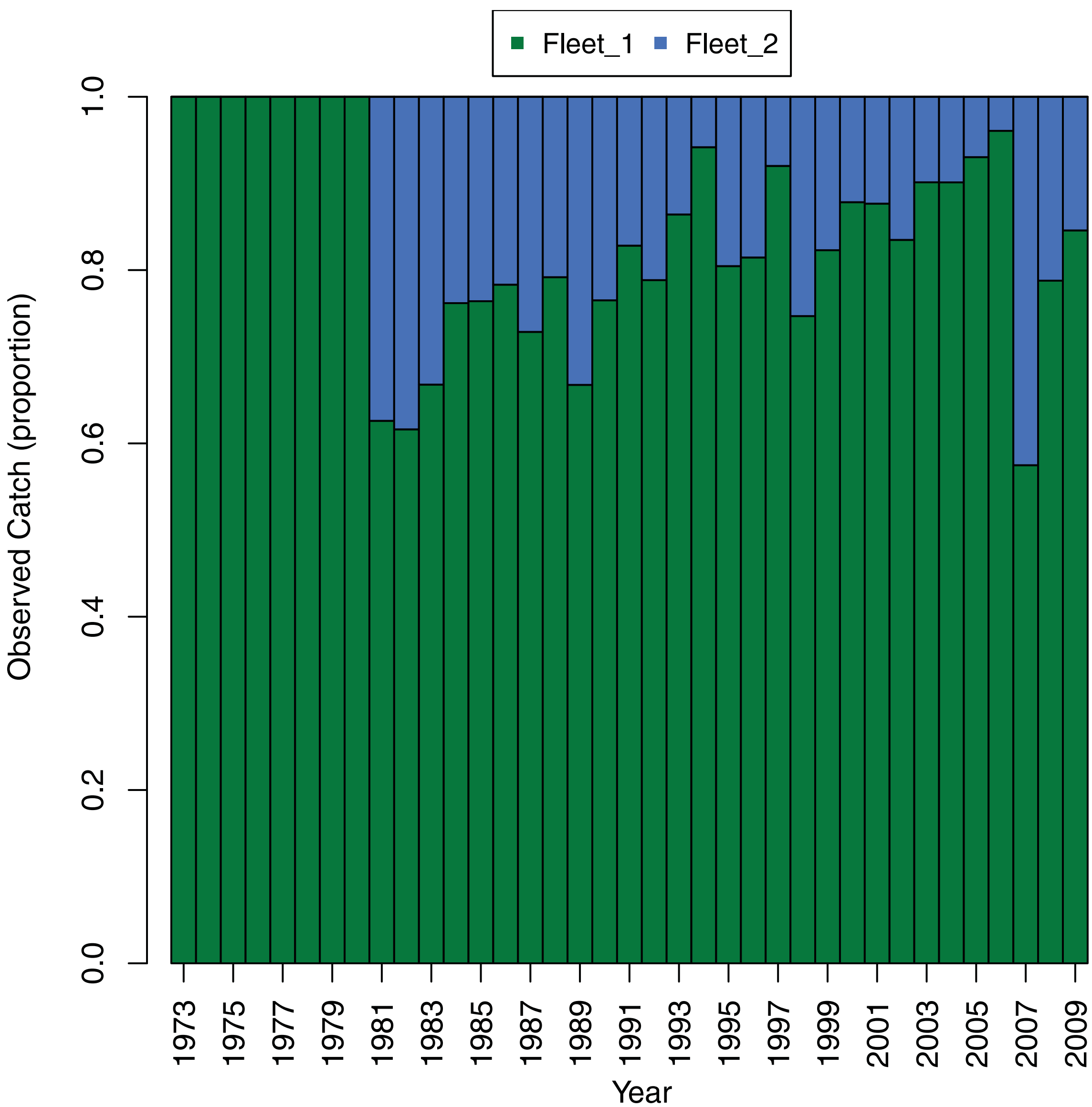
Relative Spawners (SSB/SSB0)
0.0
0.1
0.2
0.3
1975
1980
1985
1990
1995
2000
2005
2010
Year

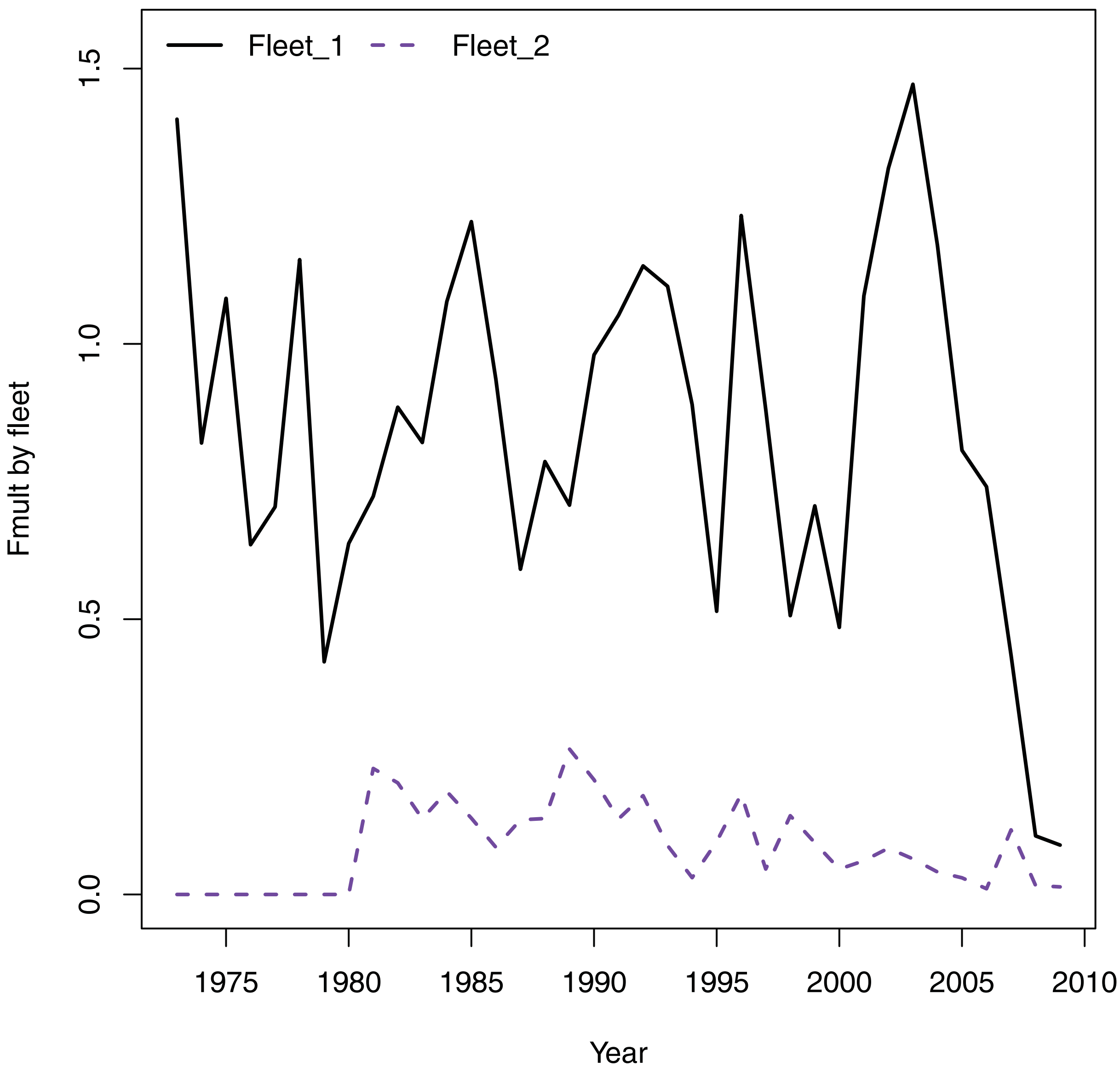


1 2 3 4 5 6
ASAP Estimated NAA
0
50000
100000
150000
200000
250000
300000
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
Year

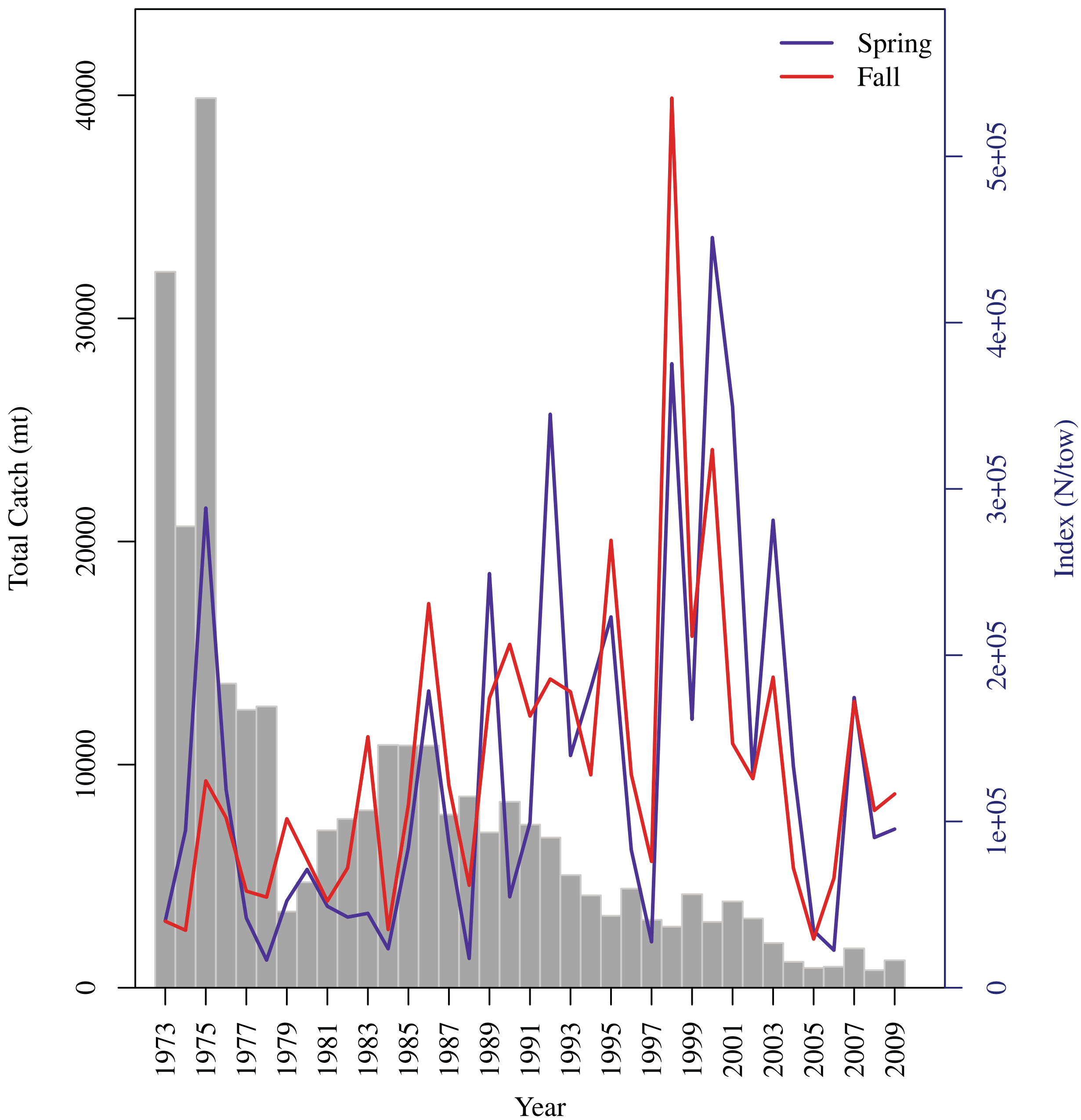

1
2
3
4
5
6
ASAP Estimated Proportion(NAA)
0.0
0.2
0.4
0.6
0.8
1.0
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
Year


Fleet_1
Fleet_2
Observed Catch (mt)
0
10000
20000
30000
40000
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year

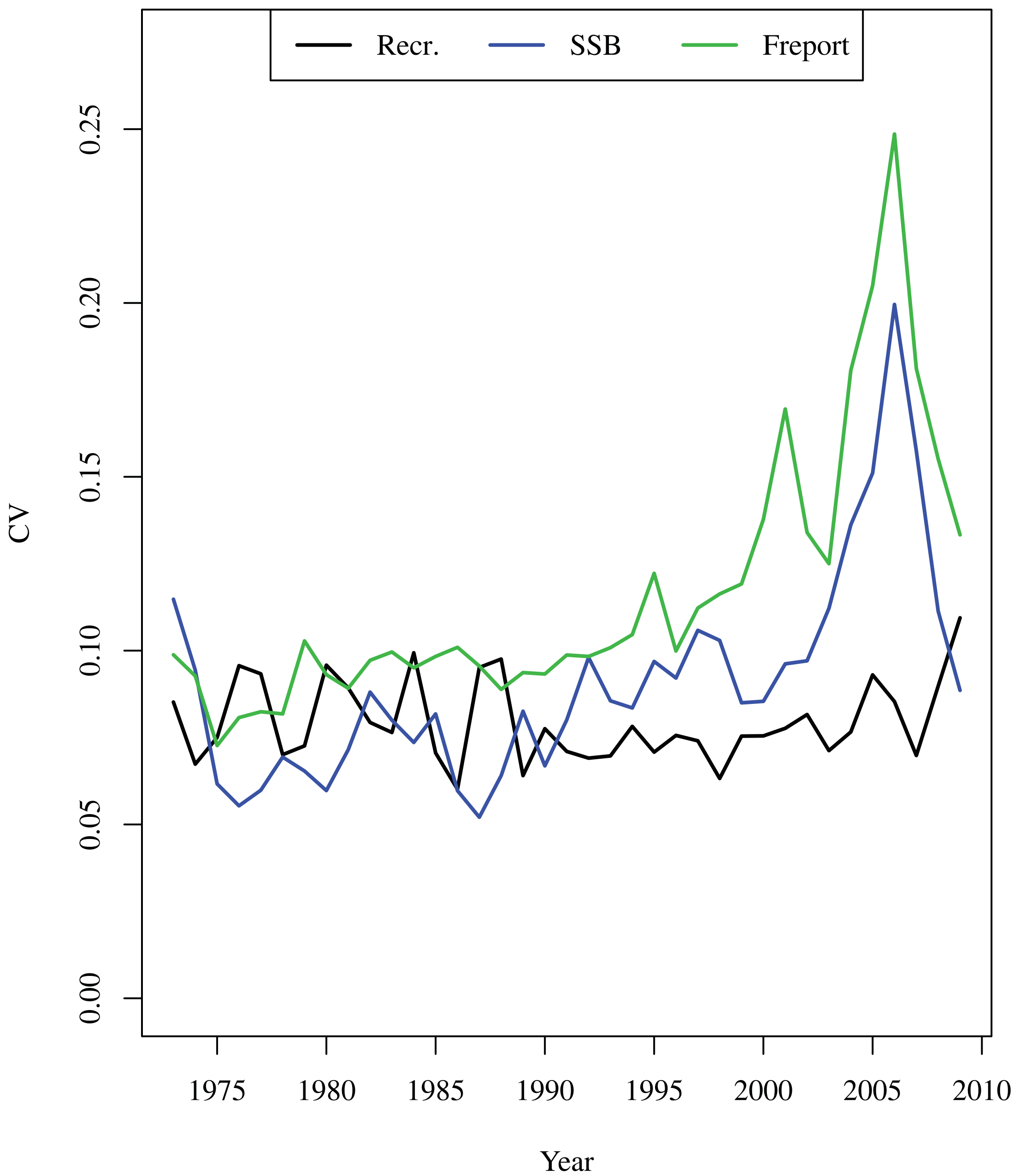

Fleet_1
Fleet_2
Observed Catch (proportion)
0.0
0.2
0.4
0.6
0.8
1.0
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year

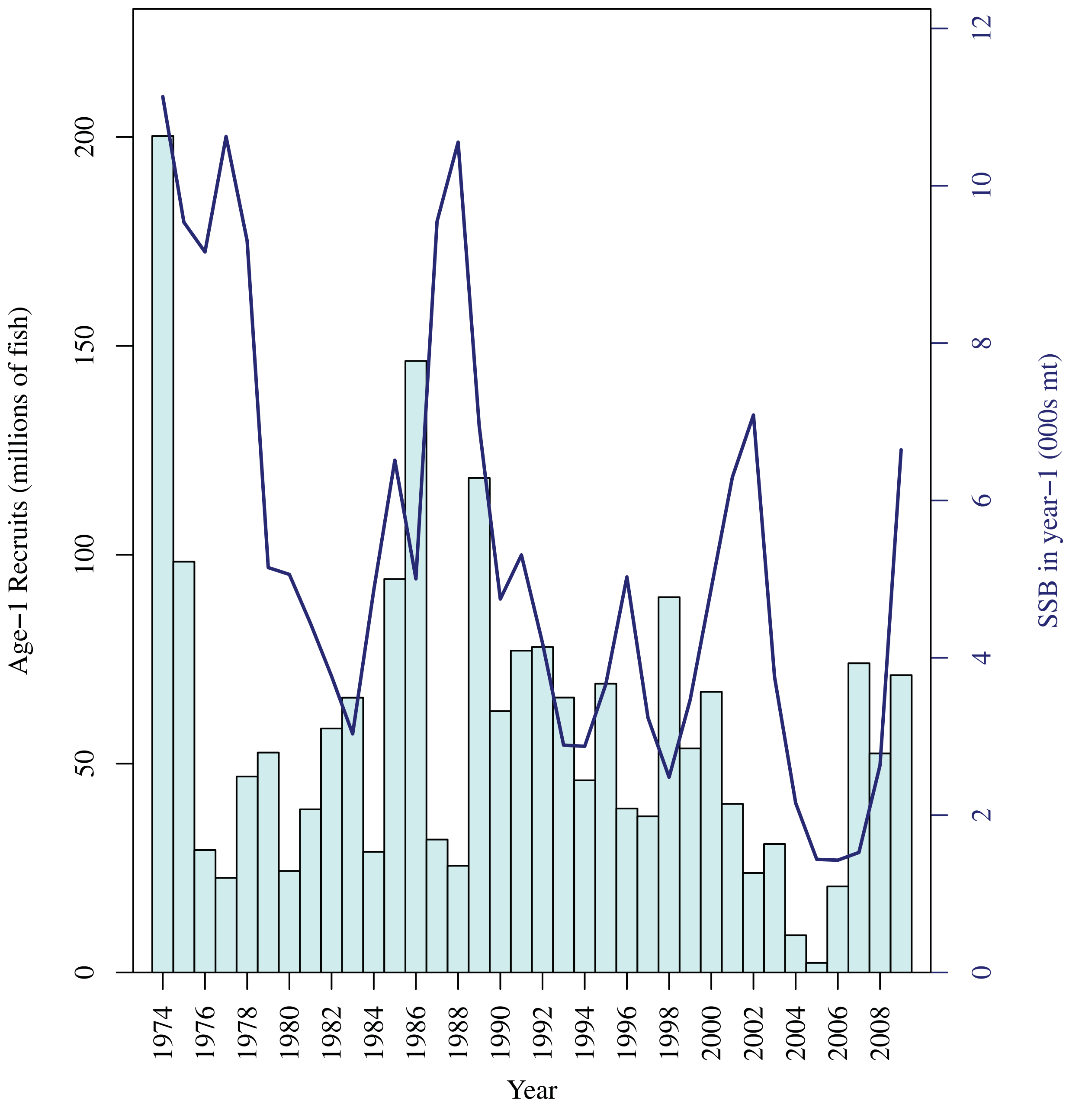


Fleet_1
Fleet_2
Fmult by fleet
0.0
0.5
1.0
1.5
1975
1980
1985
1990
1995
2000
2005
2010
Year



Spring
Fall
Total Catch (mt)
Index (N/tow)
Year
0
10000
20000
30000
40000
1e+05
2e+05
3e+05
4e+05
5e+05
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009


Recr.
SSB
Freport
CV
0.00
0.05
0.10
0.15
0.20
0.25
1975
1980
1985
1990
1995
2000
2005
2010
Year


Age−1 Recruits (millions of fish)
SSB in year−1 (000s mt)
Year
0
50
100
150
200
0
2
4
6
8
10
12
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008

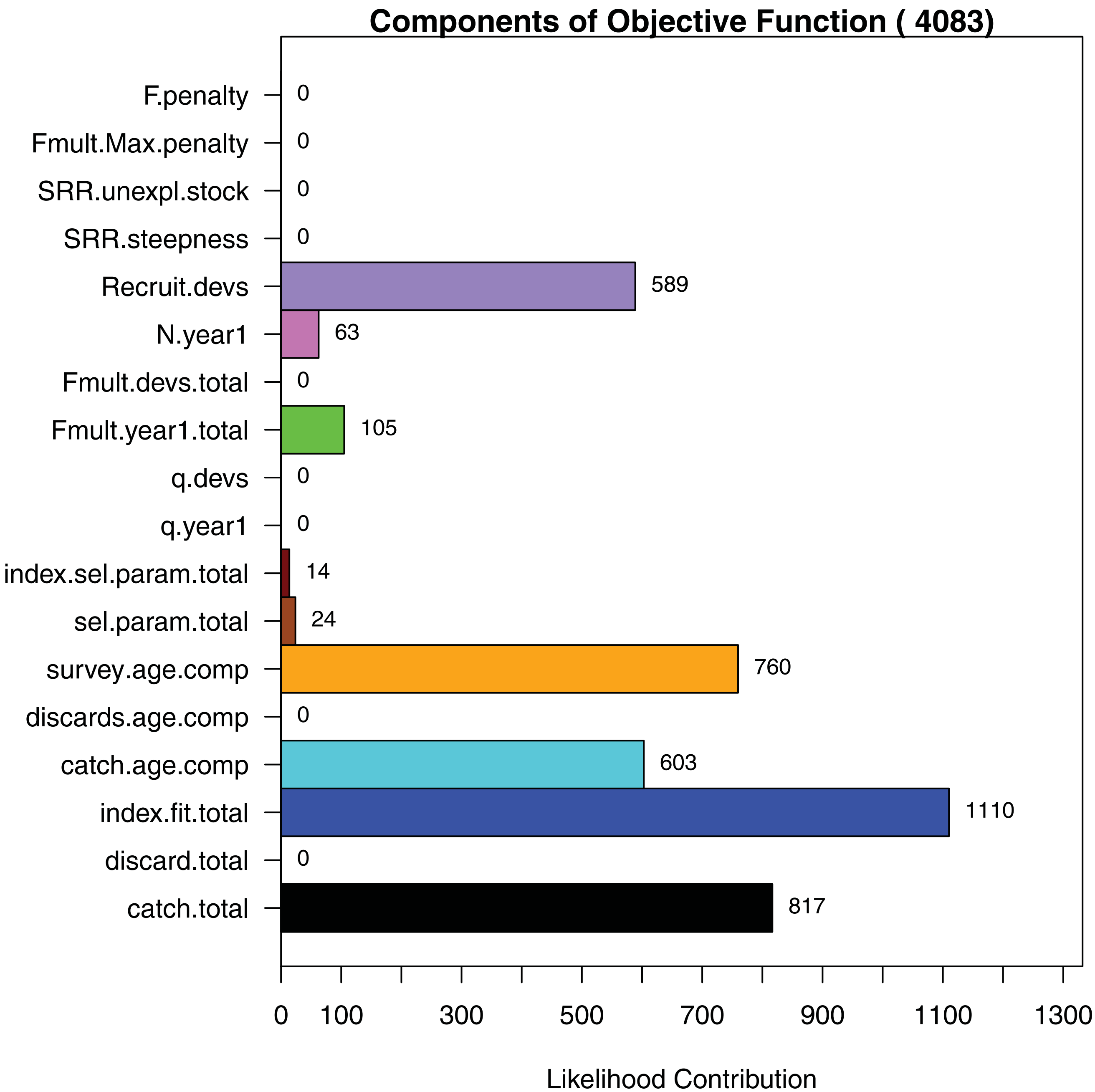
Appendix A5: North Model Consumption ASAP results M = 0.15_Base run

Model Attributes:

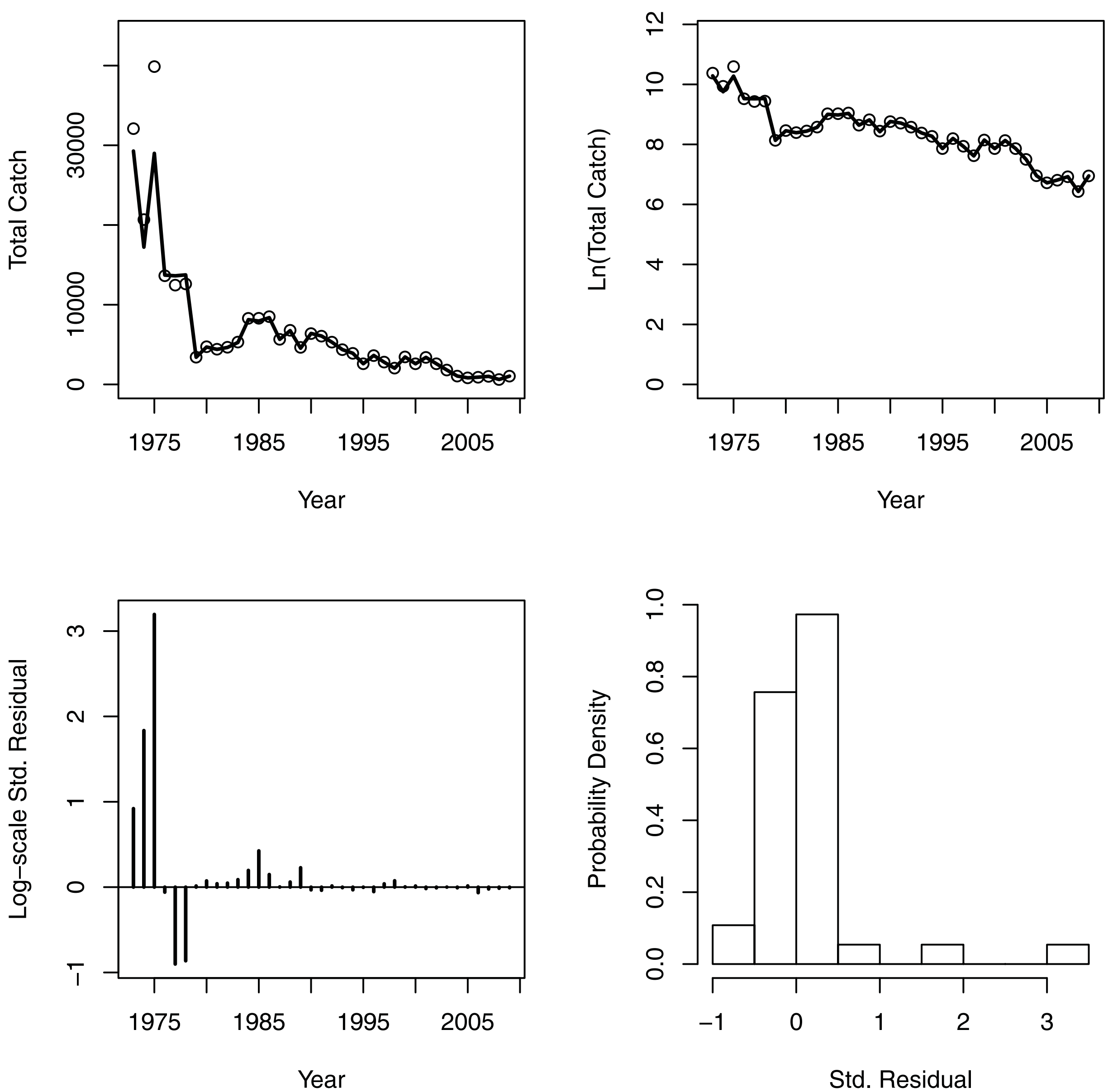
1. 3 Fleet Model
    a. Catch : 1973-2009
    b. Discards: 1981 – 2009
    c. Consumption – 1973-2009

2. Fishery Selectivity (3 Block Selectivity)
    a. Landings (1 Blocks: 1973-2009)
    b. Discards (1 Block: 1981-2009)
    c. Consumption (Double Logistic Functional Form)

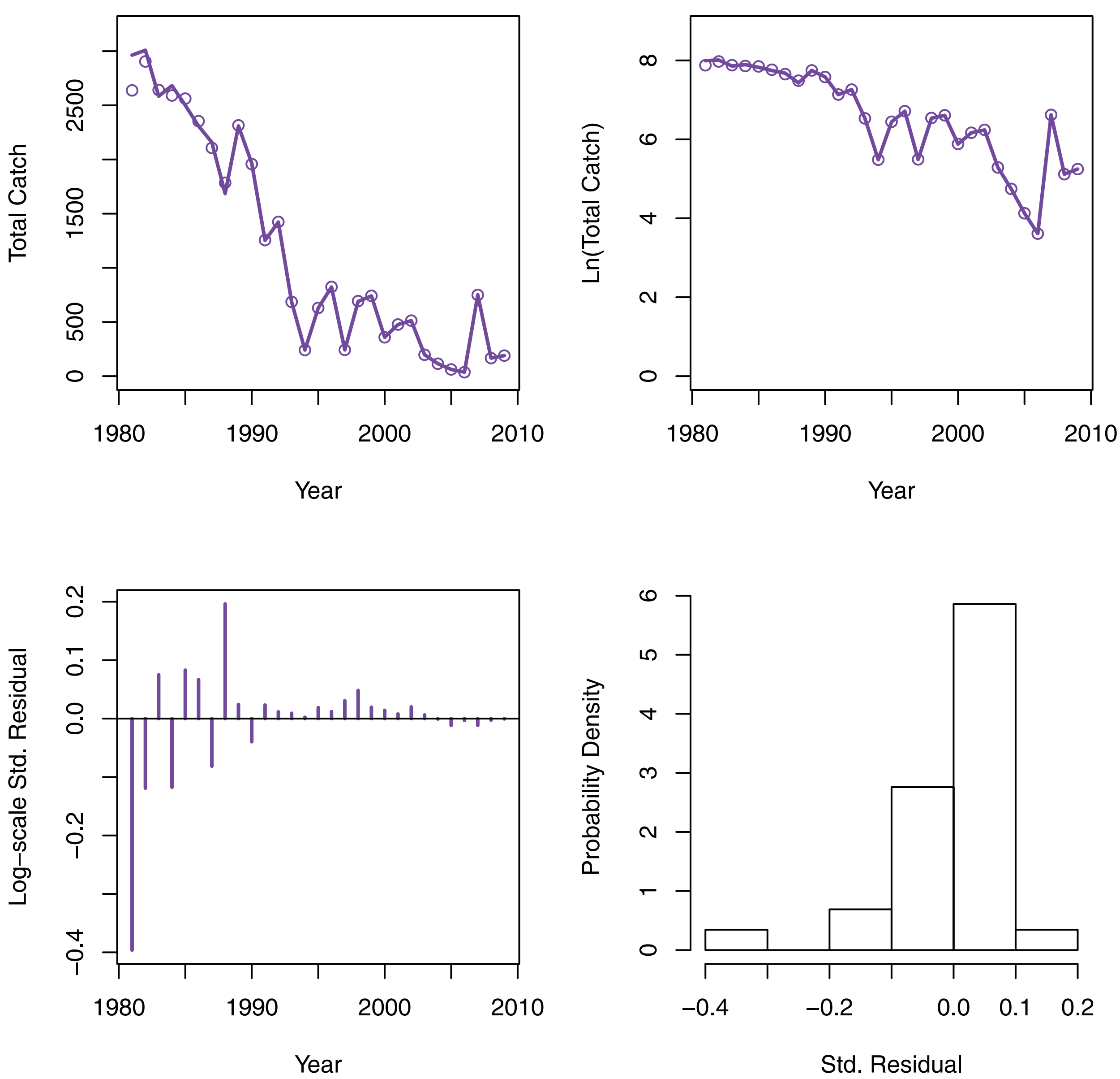
3. Survey Selectivity (Fixed 100% at age 2 and freely estimating older ages (3+)


Components of Objective Function (4083)
F.penalty
Fmult.Max.penalty
SRR.unexpl.stock
SRR.steepness
Recruit.devs
N.year1
Fmult.devs.total
Fmult.year1.total
q.devs
q.year1
index.sel.param.total
sel.param.total
survey.age.comp
discards.age.comp
catch.age.comp
index.fit.total
discard.total
catch.total
0
0
0
0
589
63
0
105
0
0
14
24
760
0
603
1110
0
817
0
100
300
500
700
900
1100
1300
Likelihood Contribution

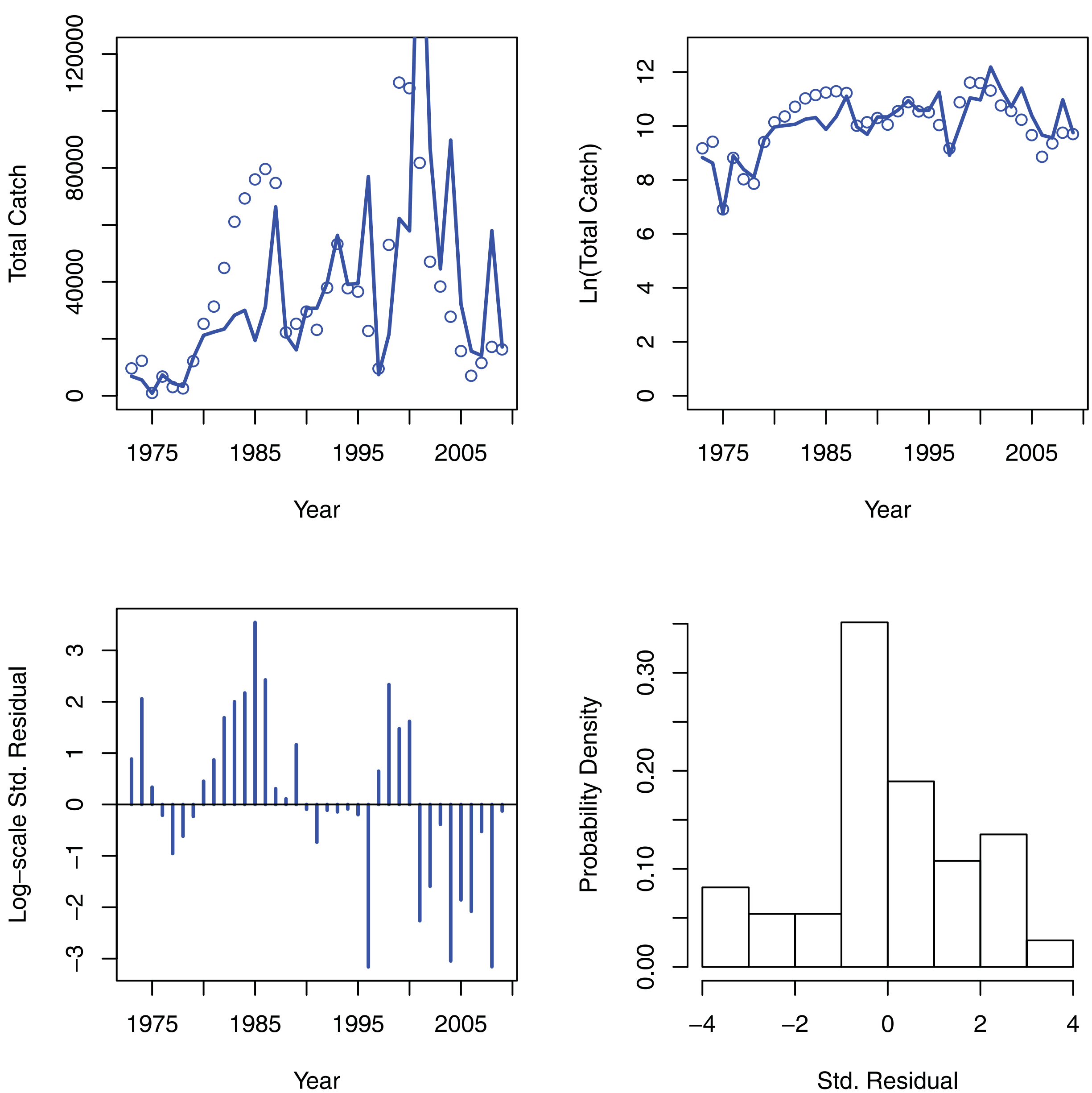
Fleet 1 Landings (Comm)

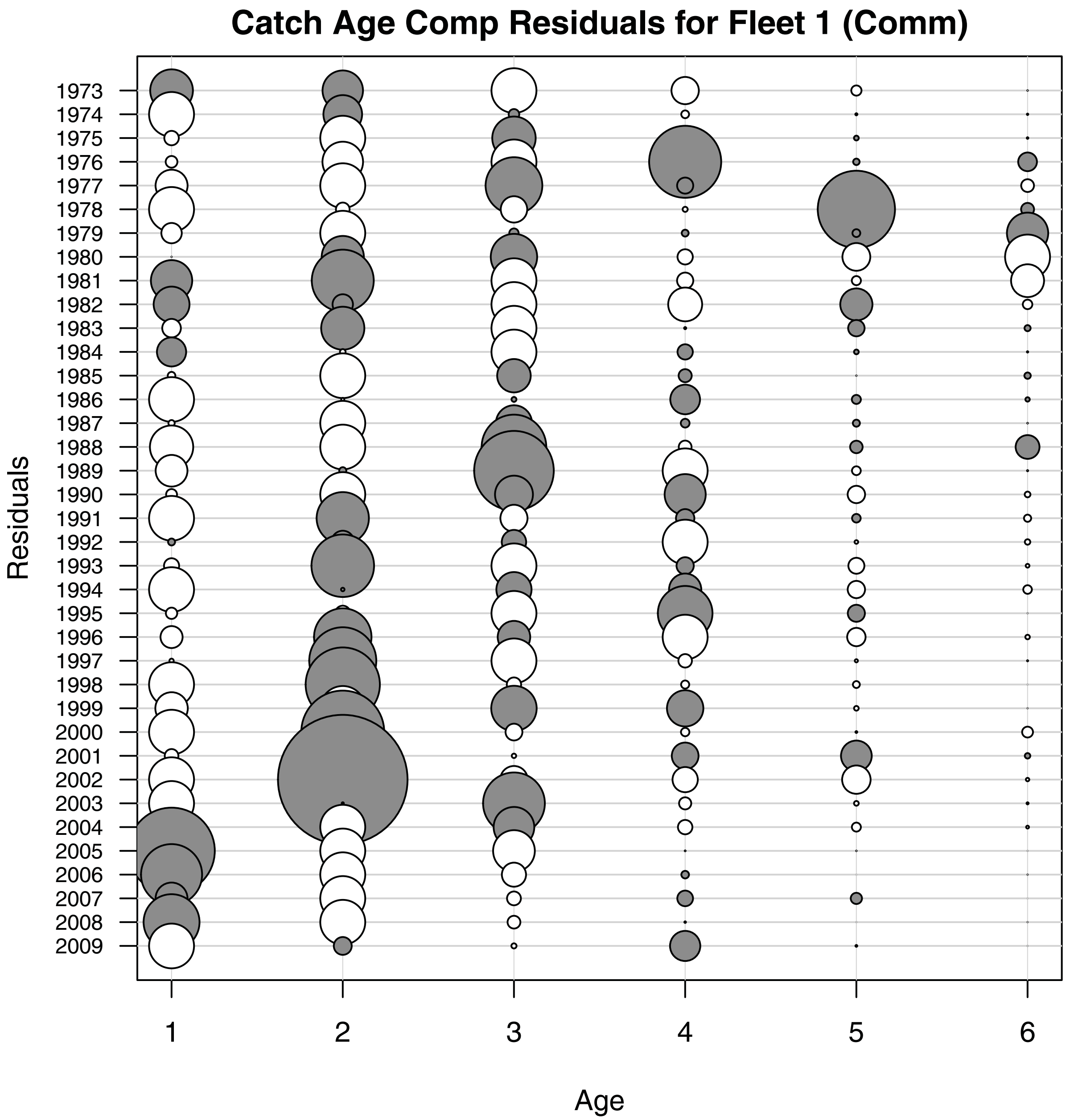


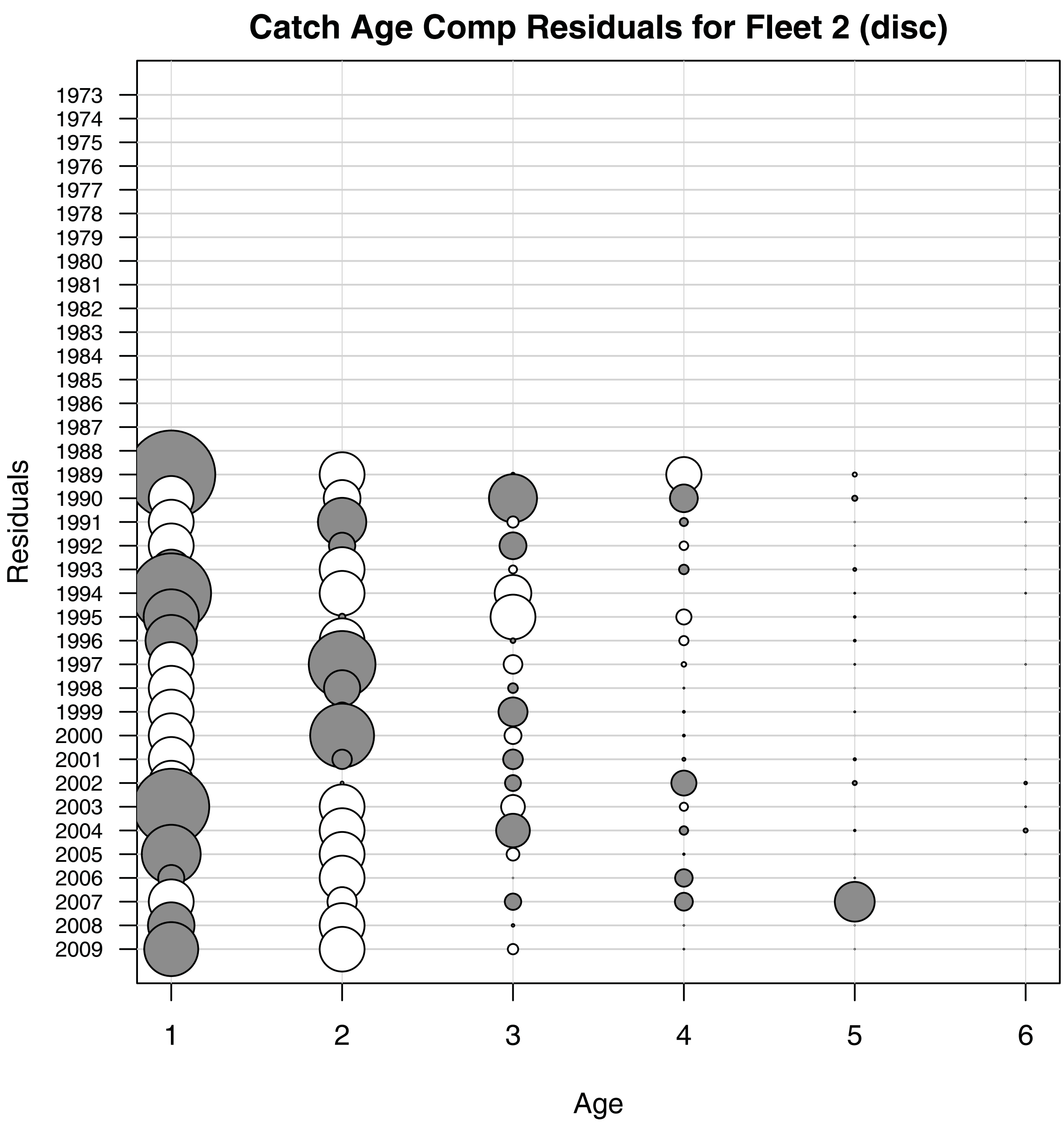
Fleet 2 Landings (disc)

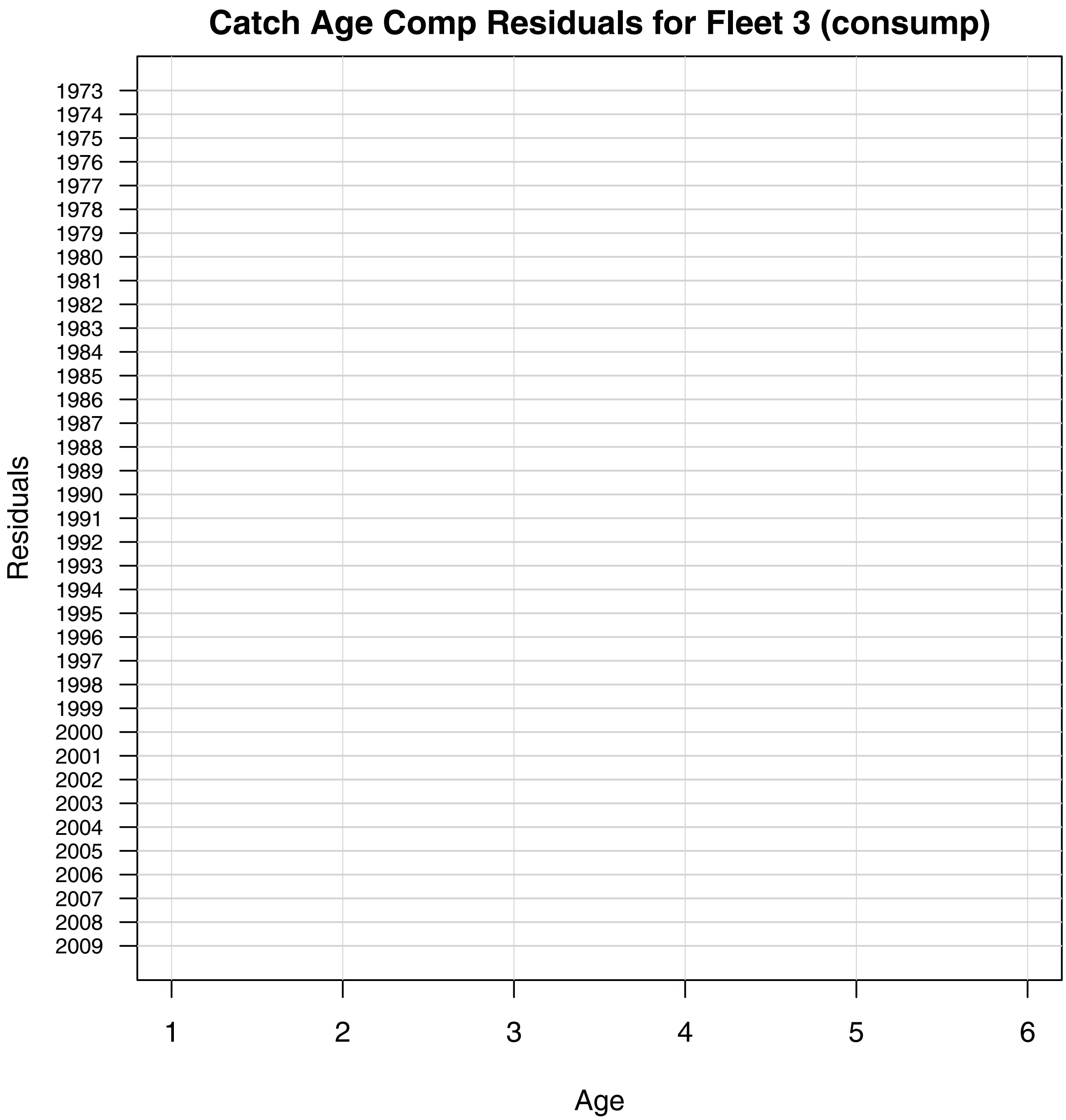


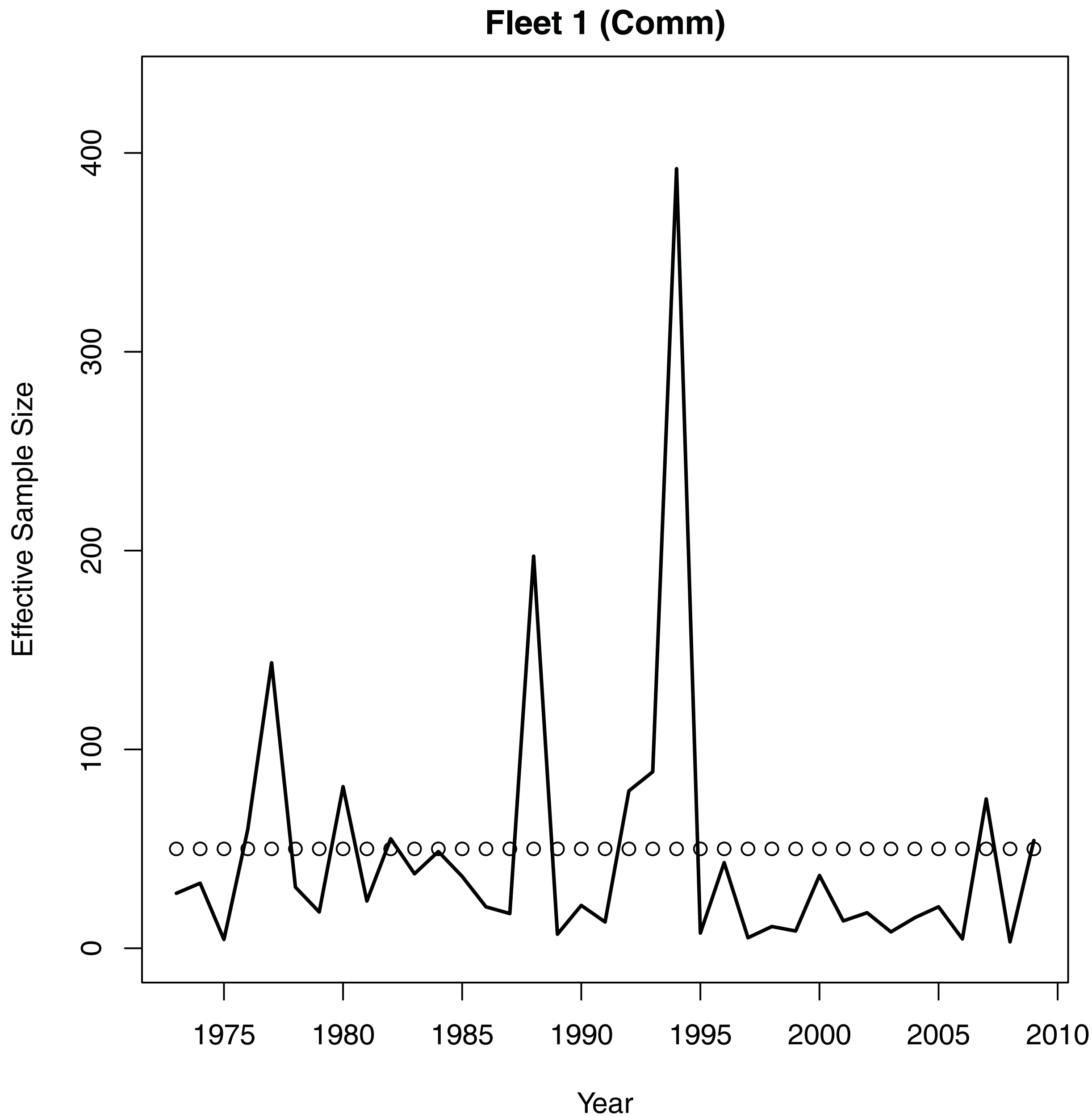
Fleet 3 Landings (consump)



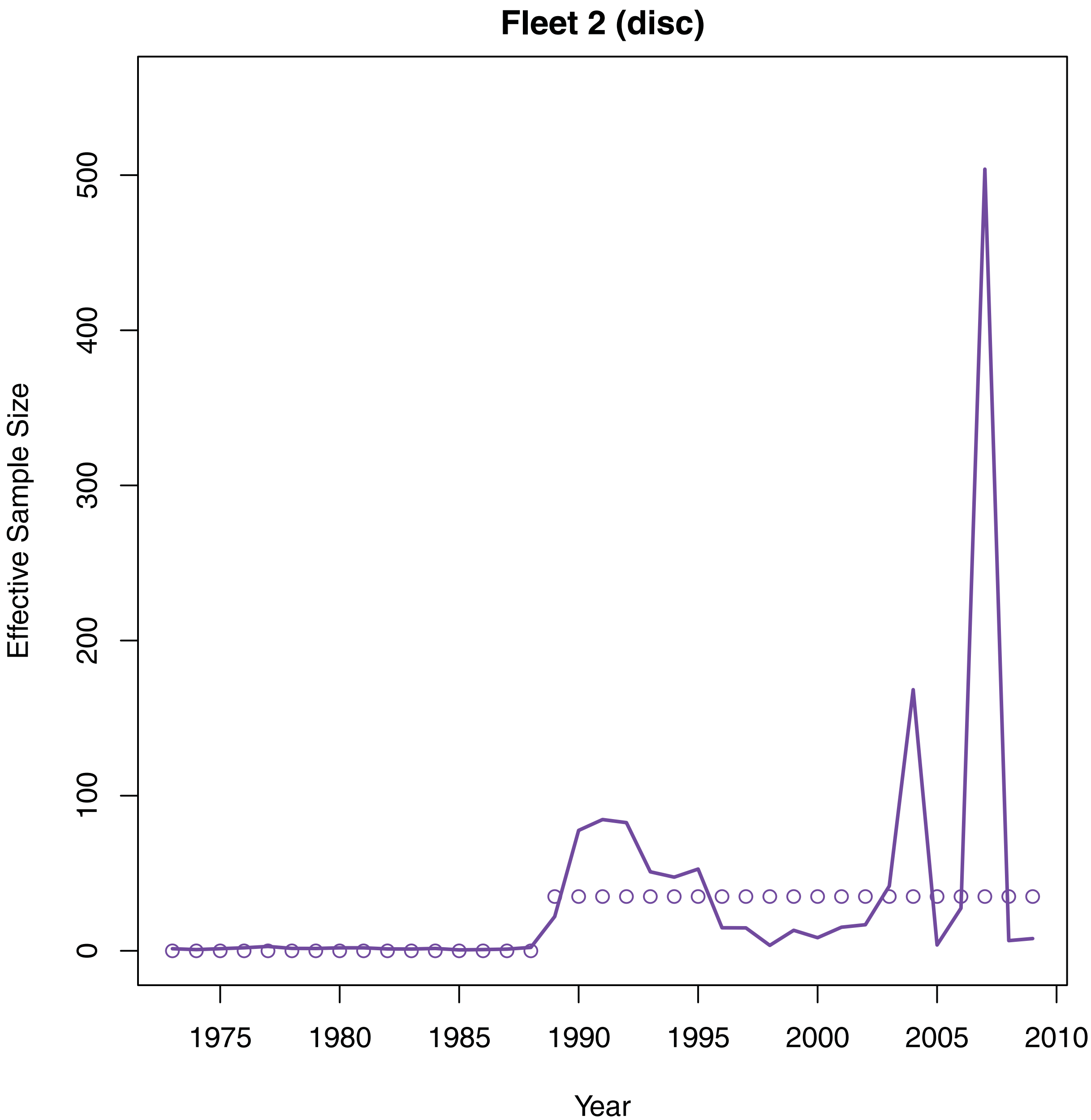

Catch Age Comp Residuals for Fleet 1 (Comm)
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age

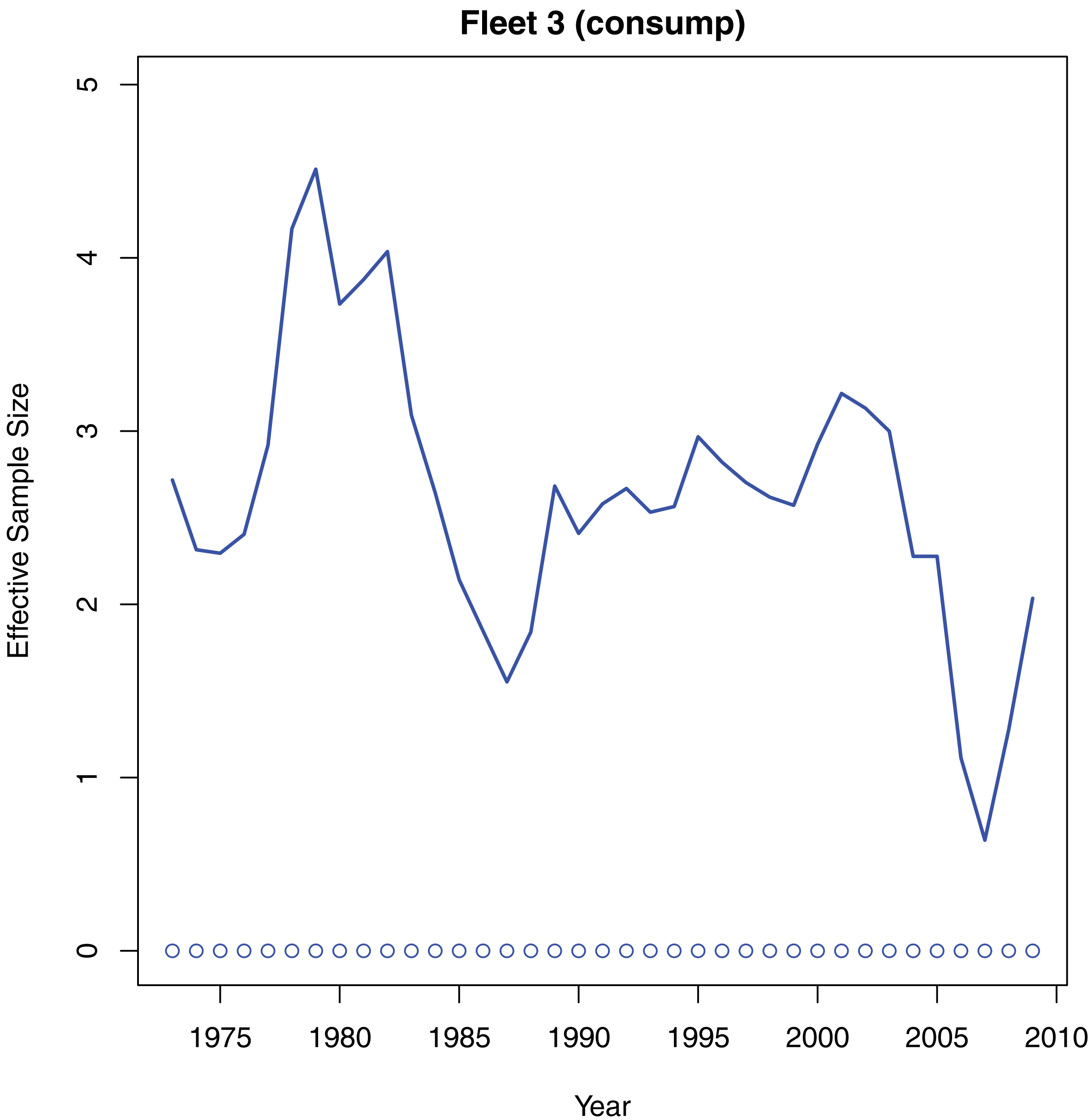

Catch Age Comp Residuals for Fleet 2 (disc)
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age

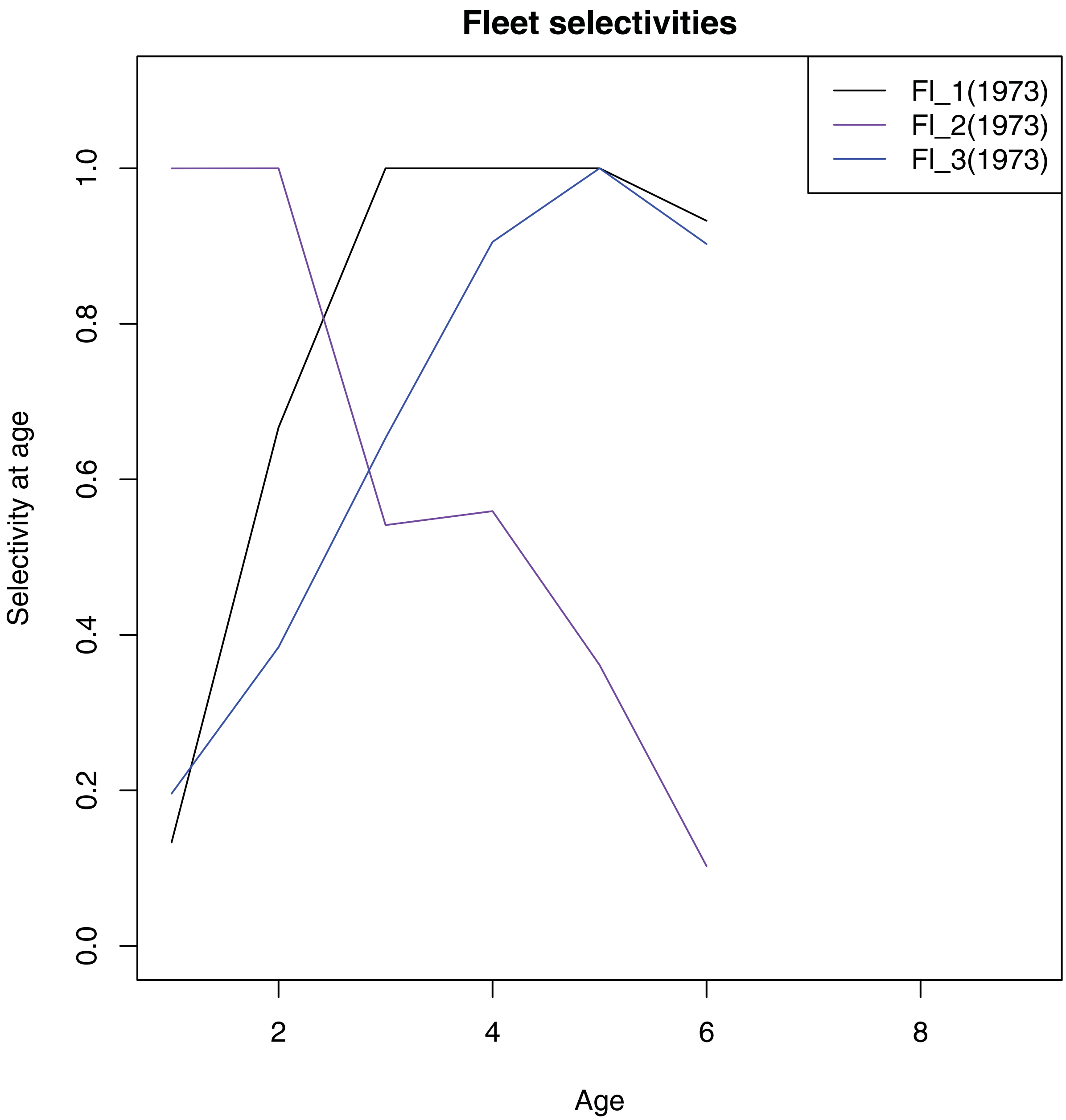

Catch Age Comp Residuals for Fleet 3 (consump)
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age

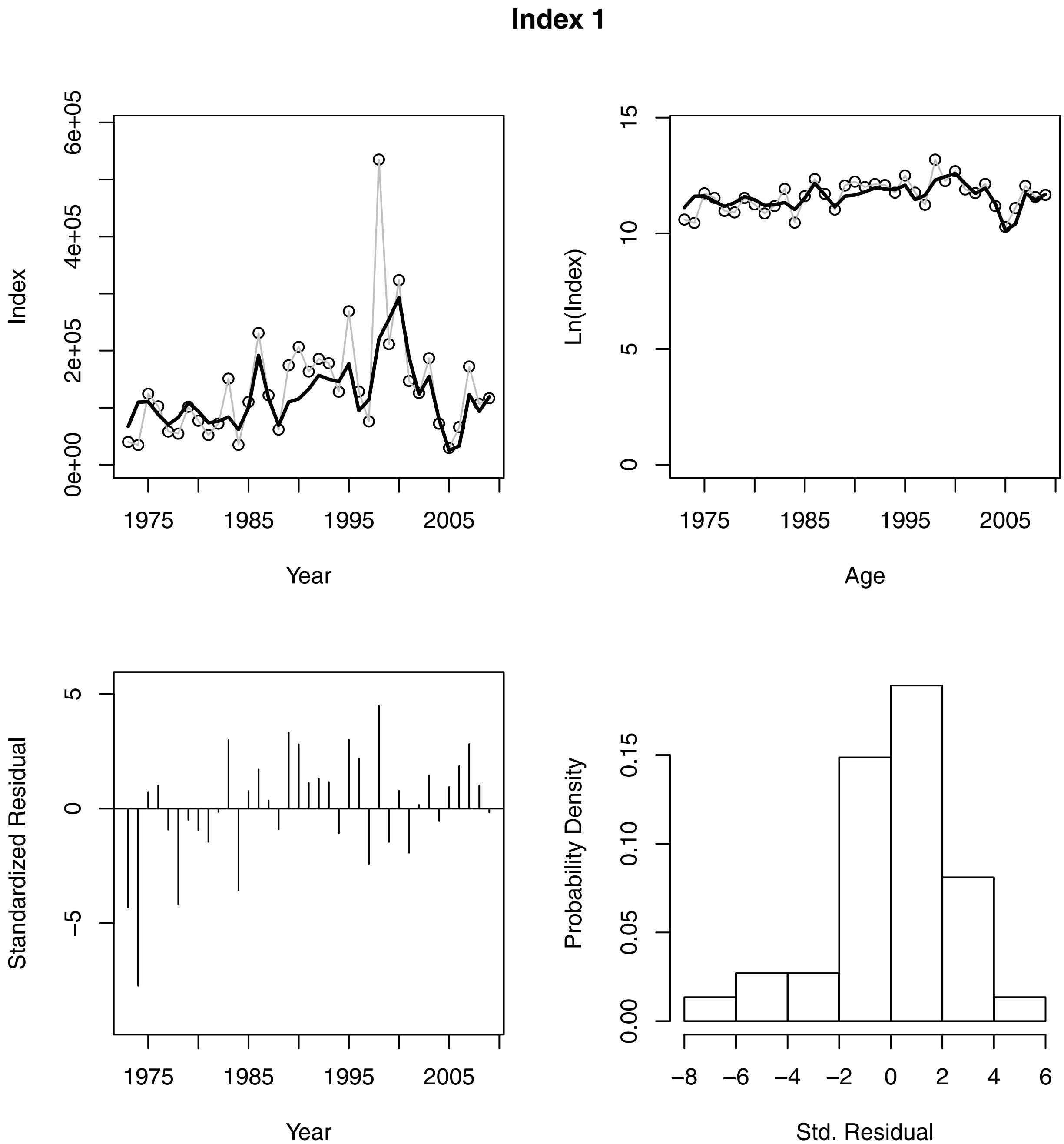


Fleet 1 (Comm)
Effective Sample Size
0
100
200
300
400
1975
1980
1985
1990
1995
2000
2005
2010
Year

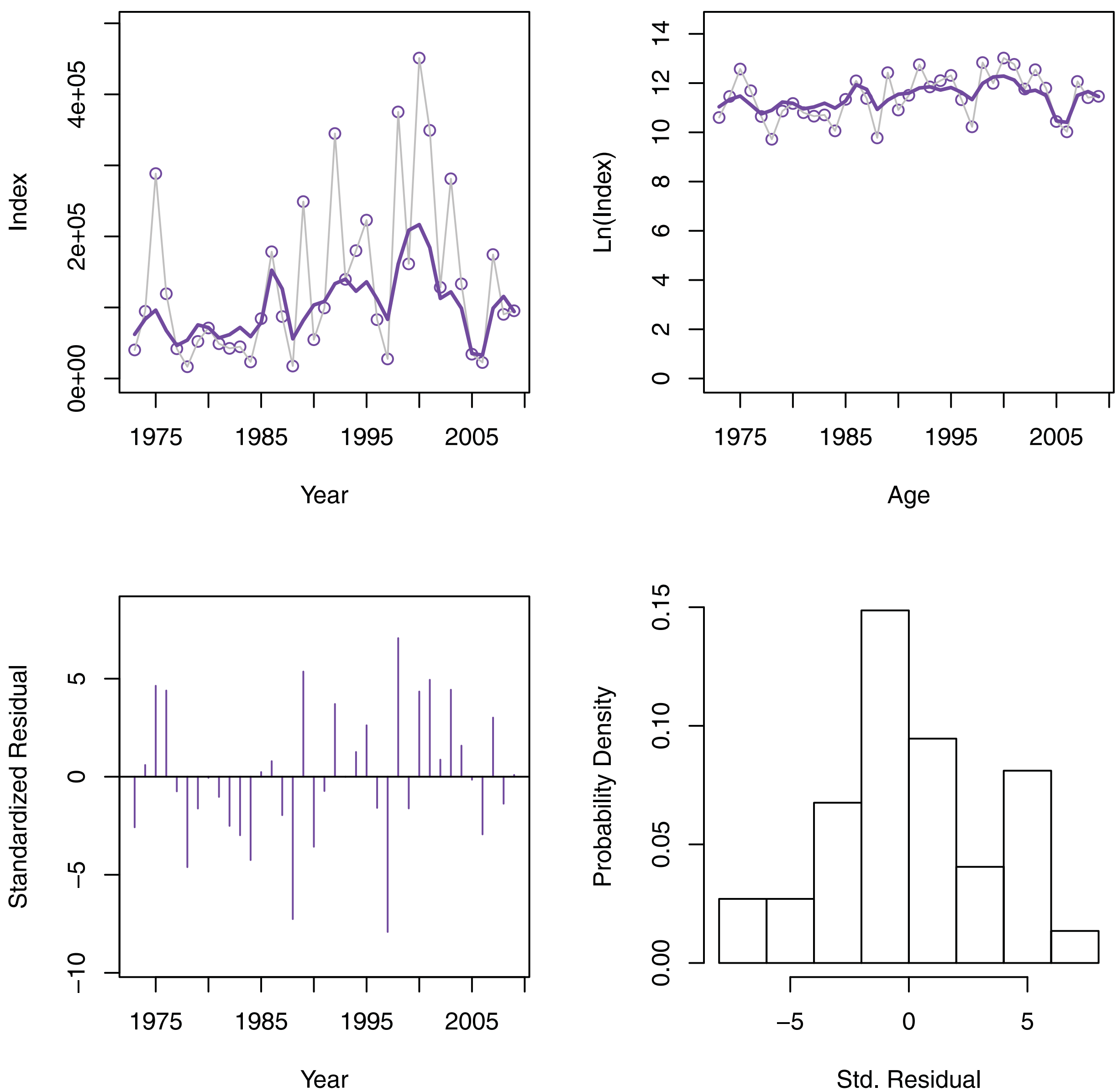

Fleet 2 (disc)
Effective Sample Size
0
100
200
300
400
500
1975
1980
1985
1990
1995
2000
2005
2010
Year


Fleet 3 (consump)
Effective Sample Size
0
1
2
3
4
5
1975
1980
1985
1990
1995
2000
2005
2010
Year

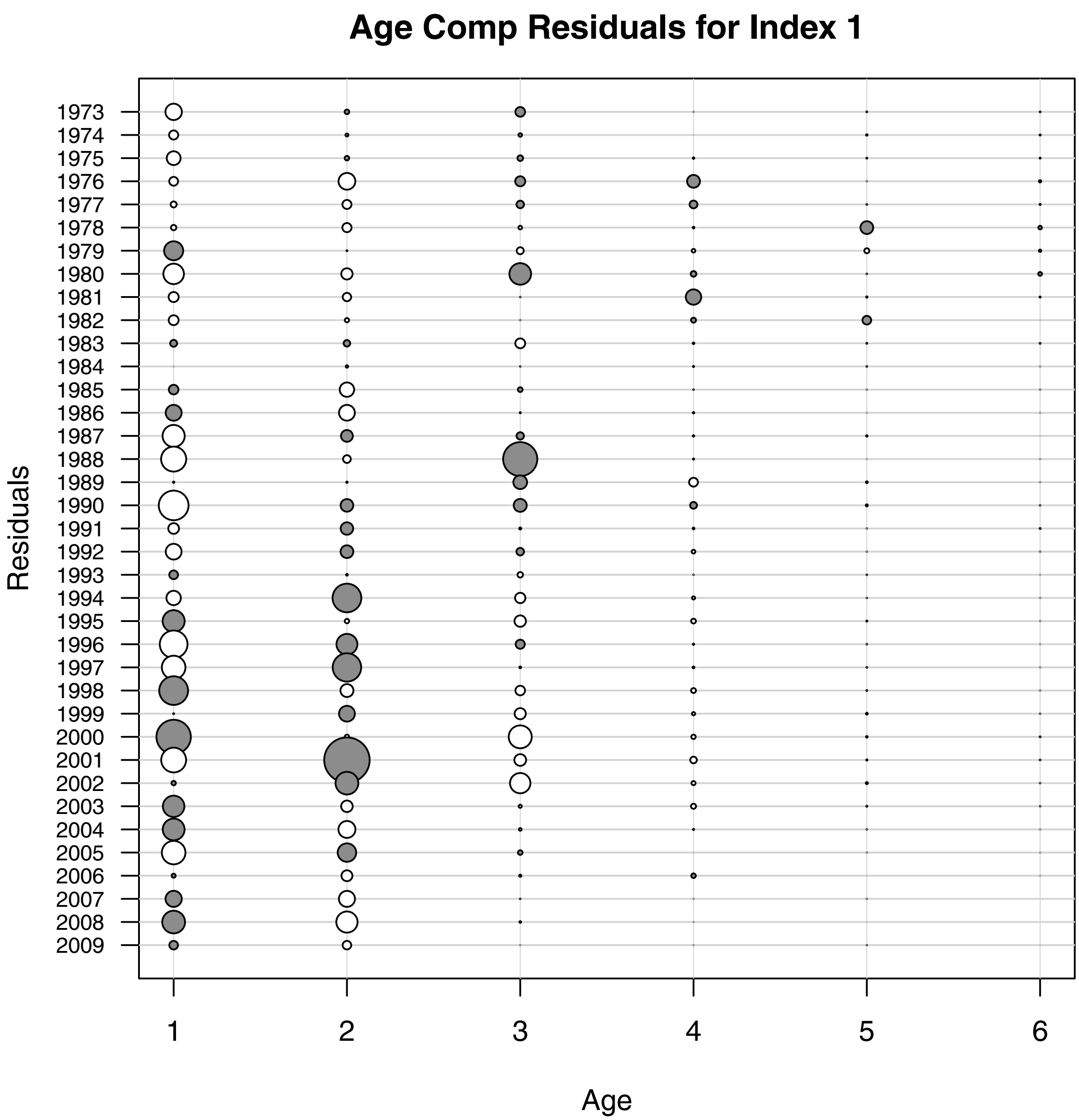

Fleet selectivities
Fl_1(1973)
Fl_2(1973)
Fl_3(1973)
Selectivity at age
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
Age


Index 1
Index
0e+00
2e+05
4e+05
6e+05
1975
1985
1995
2005
Year
Ln(Index)
0
5
10
15
Age
Standardized Residual
−5
0
5
Year
Probability Density
0.00
0.05
0.10
0.15
−8
−6
−4
−2
0
2
4
6
Std. Residual

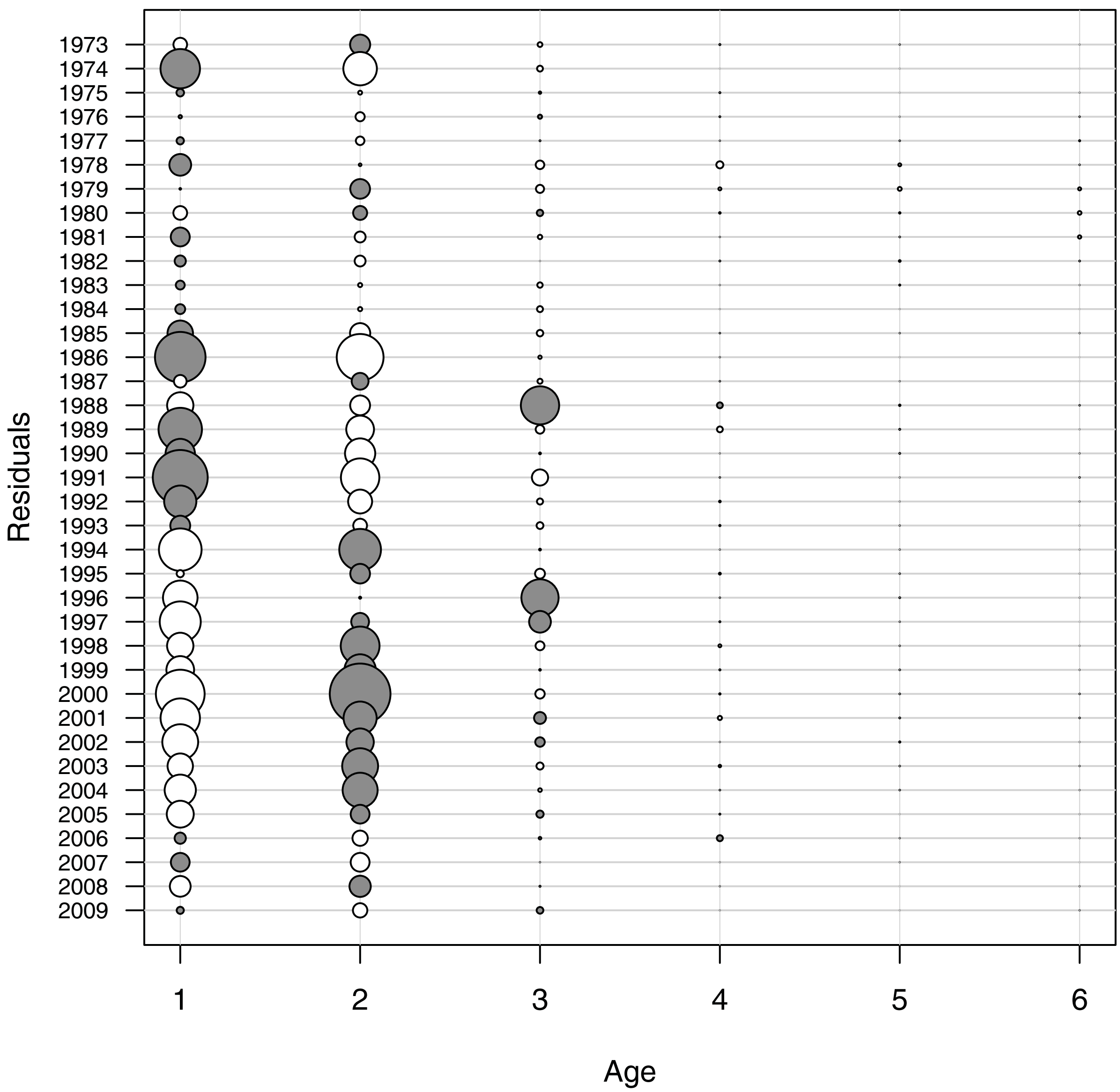
Index 2

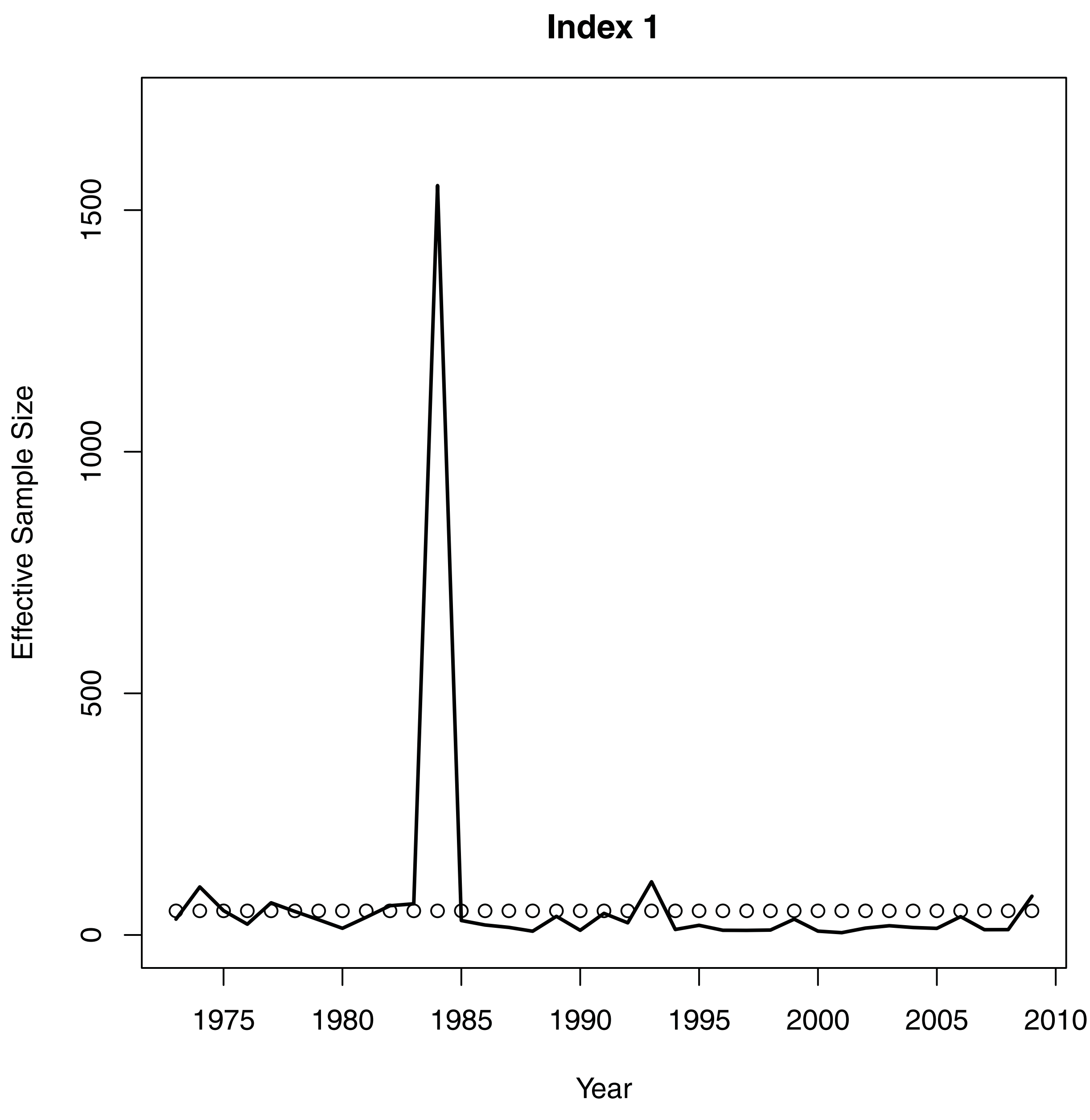


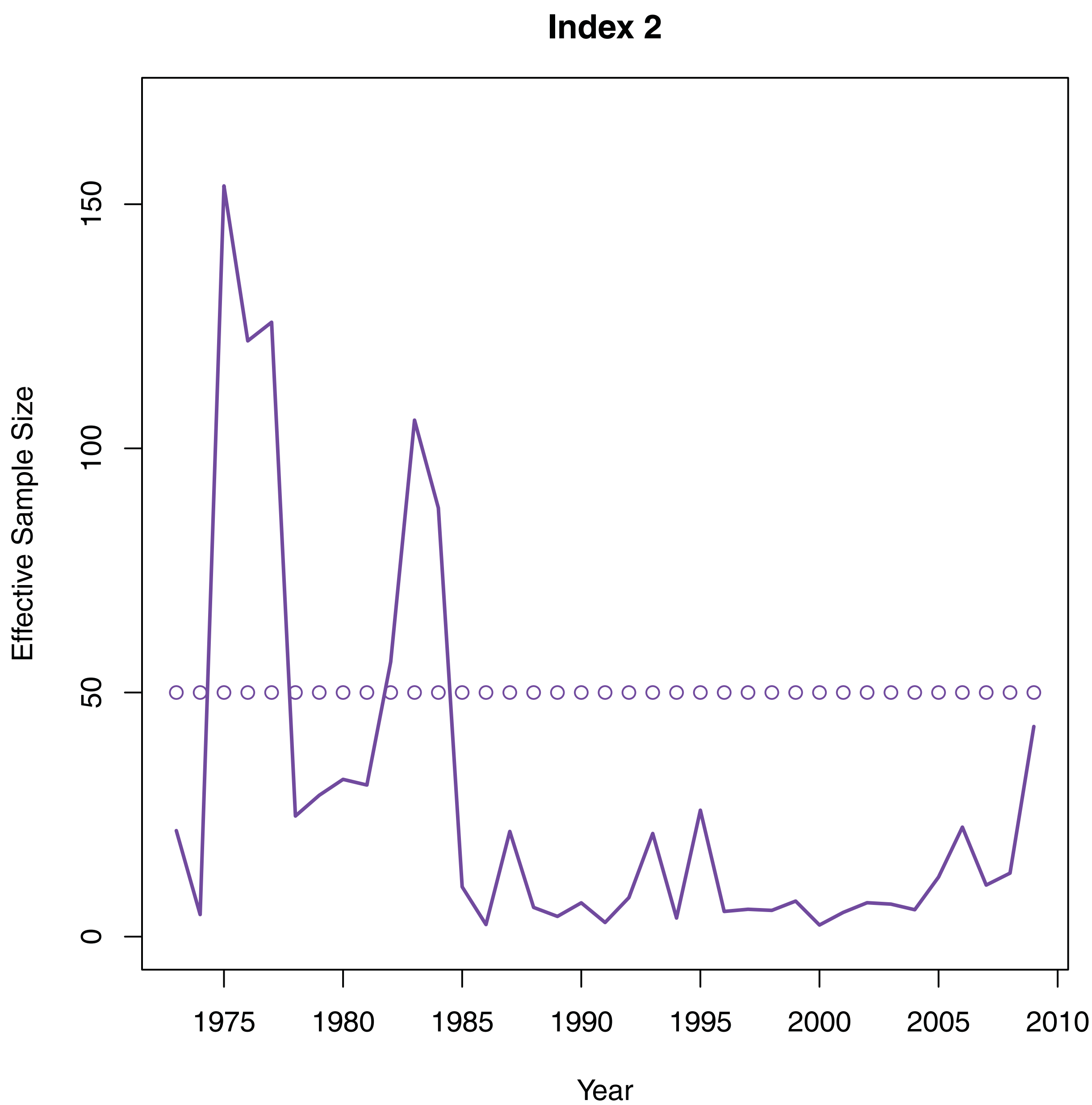
Index
0e+00
2e+05
4e+05
1975
1985
1995
2005
Year
Ln(Index)
0
2
4
6
8
10
12
14
Age
Standardized Residual
−10
−5
0
5
Probability Density
0.00
0.05
0.10
0.15
−5
Std. Residual

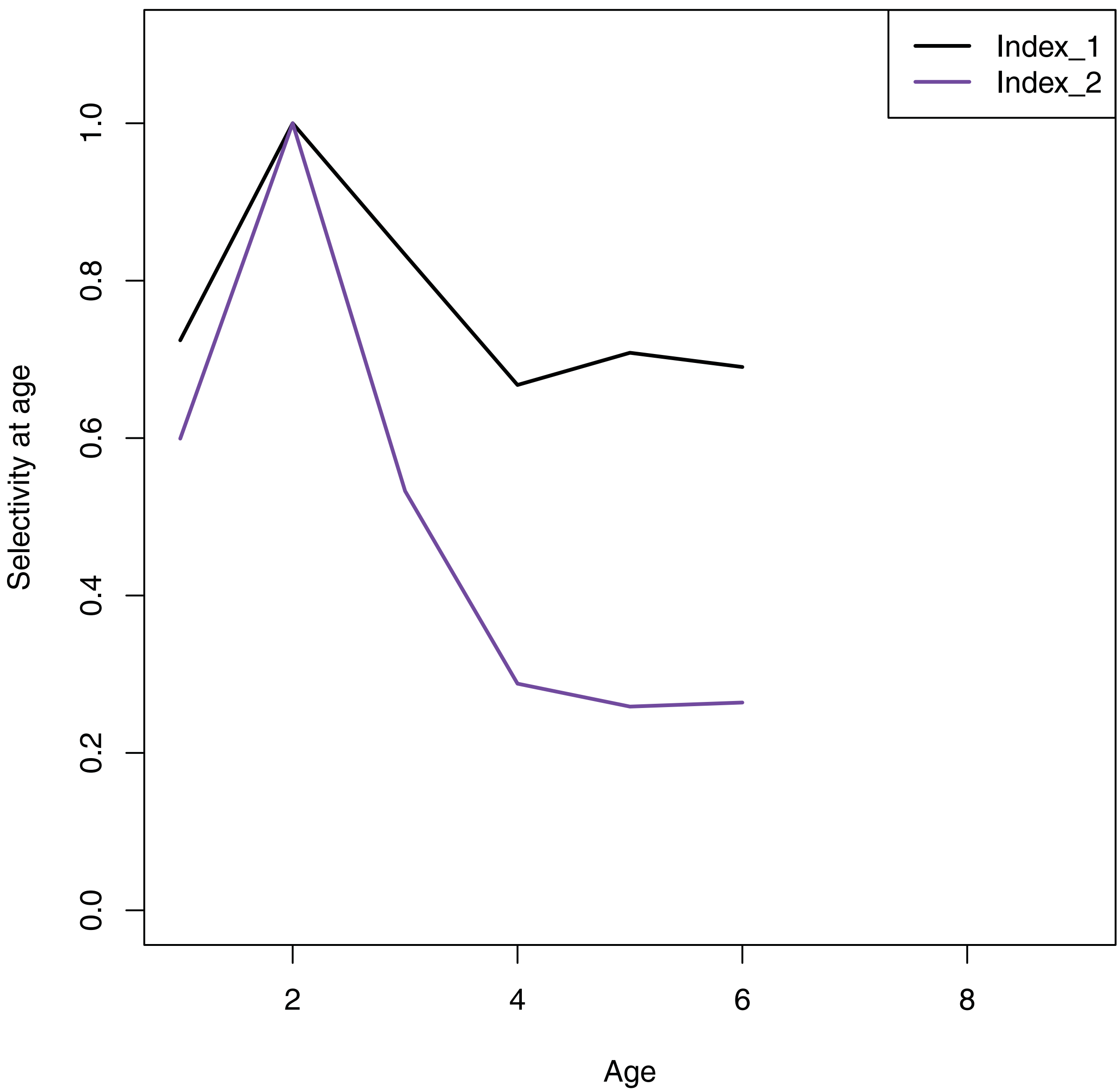

Age Comp Residuals for Index 1
Residuals
Age
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6

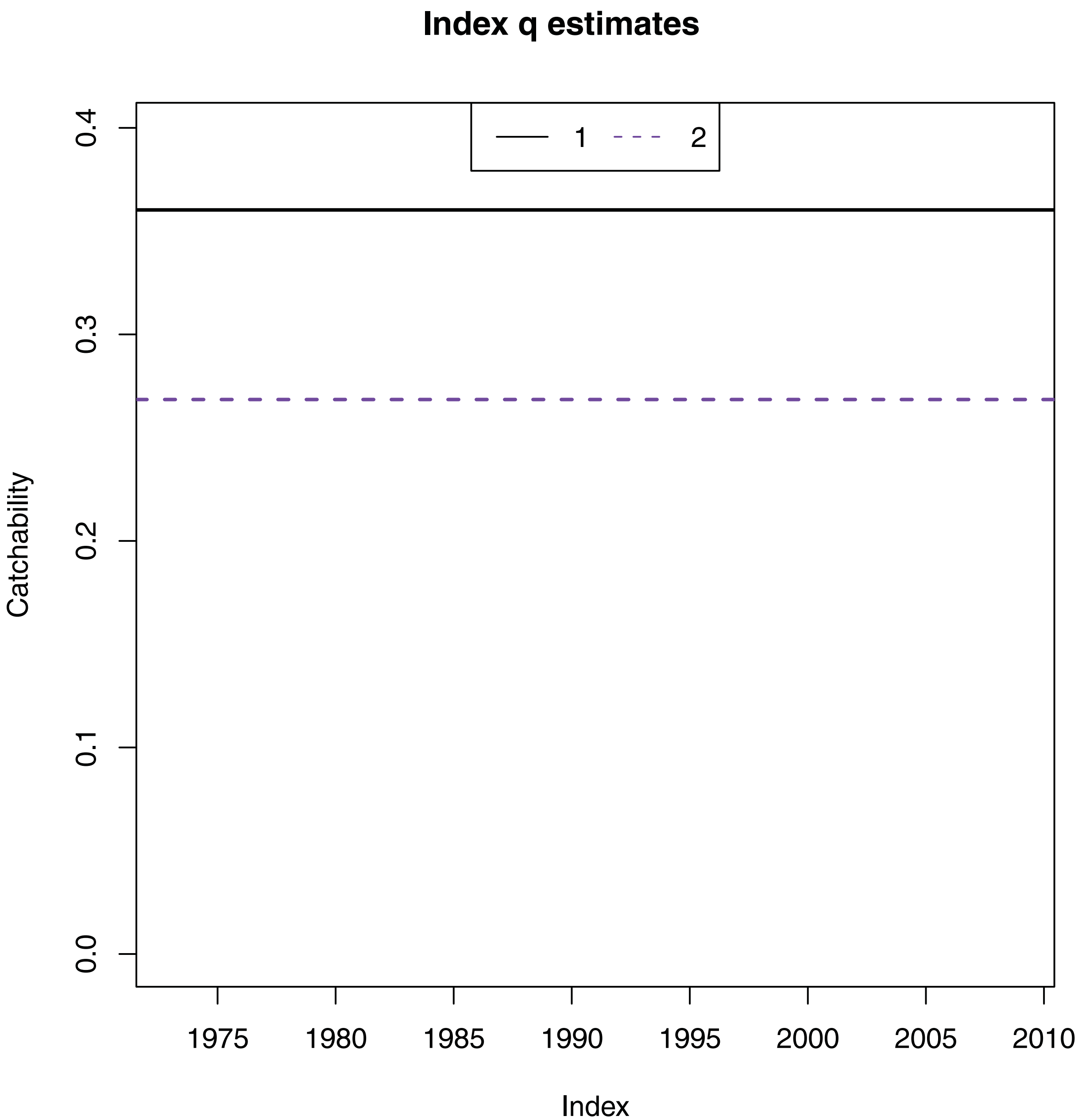
Age Comp Residuals for Index 2

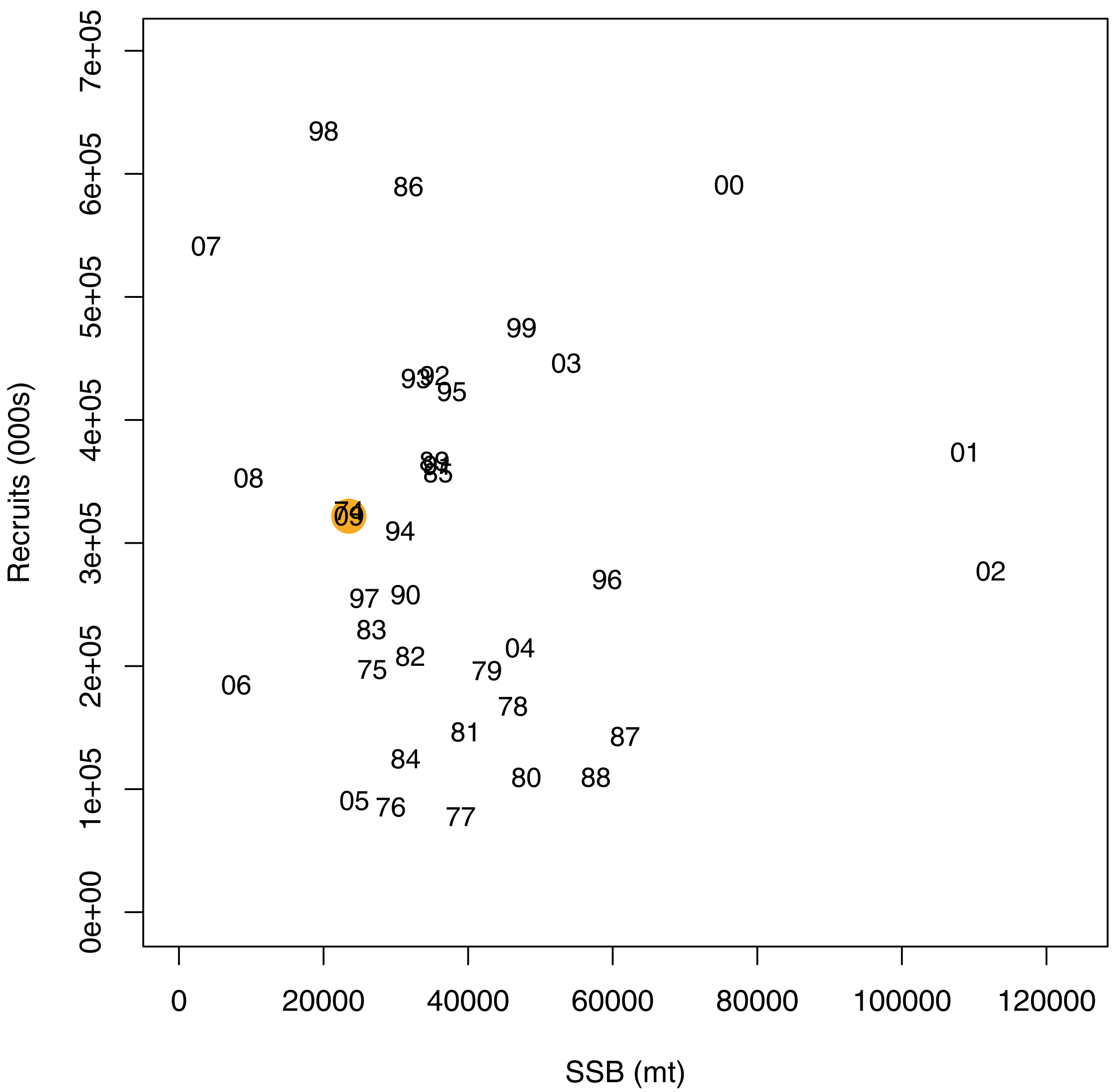


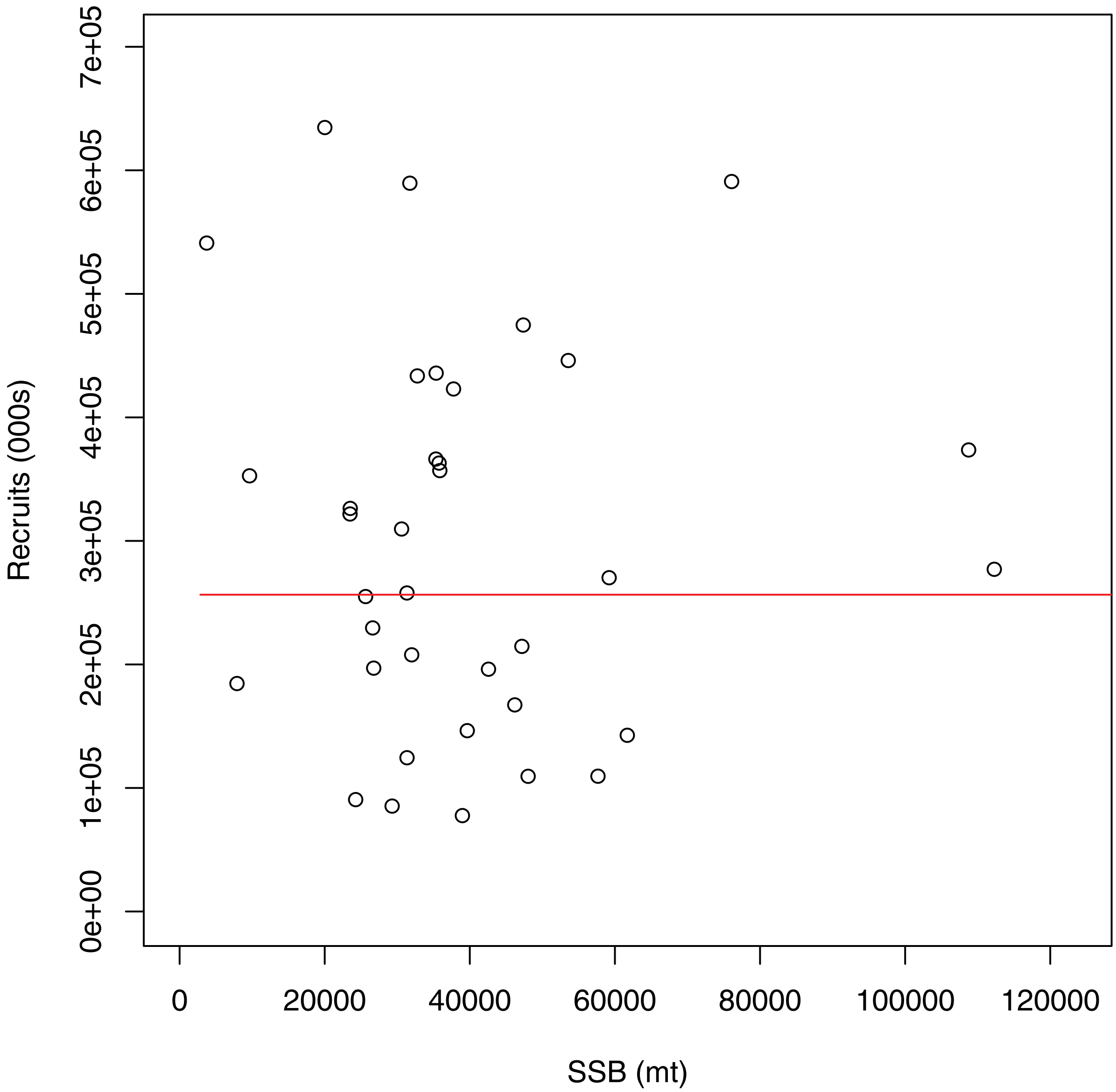

Index 1
Effective Sample Size
0
500
1000
1500
Year
1975
1980
1985
1990
1995
2000
2005
2010

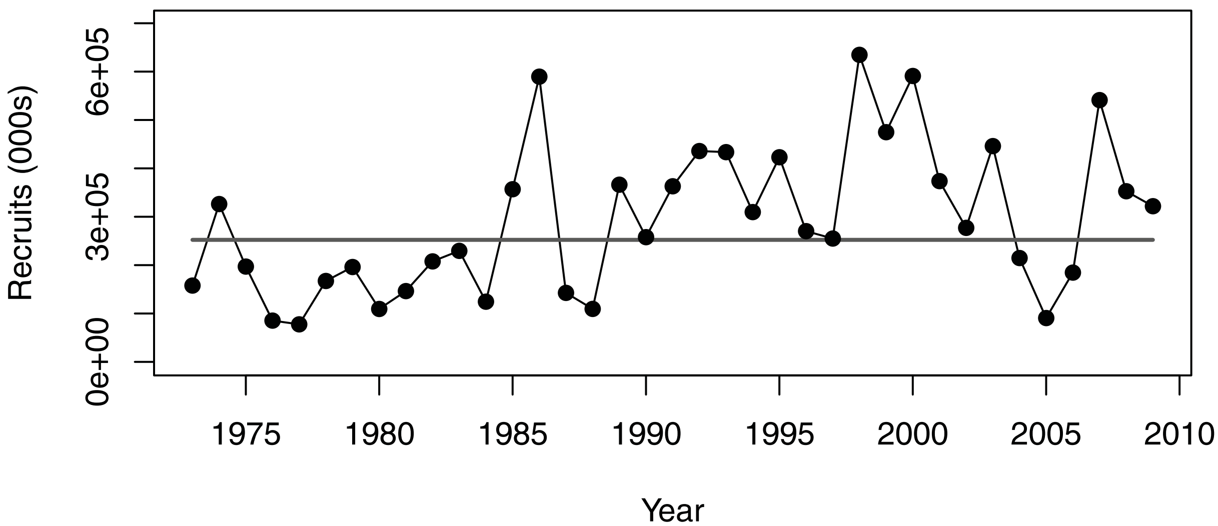

Index 2
Effective Sample Size
0
50
100
150
1975
1980
1985
1990
1995
2000
2005
2010
Year

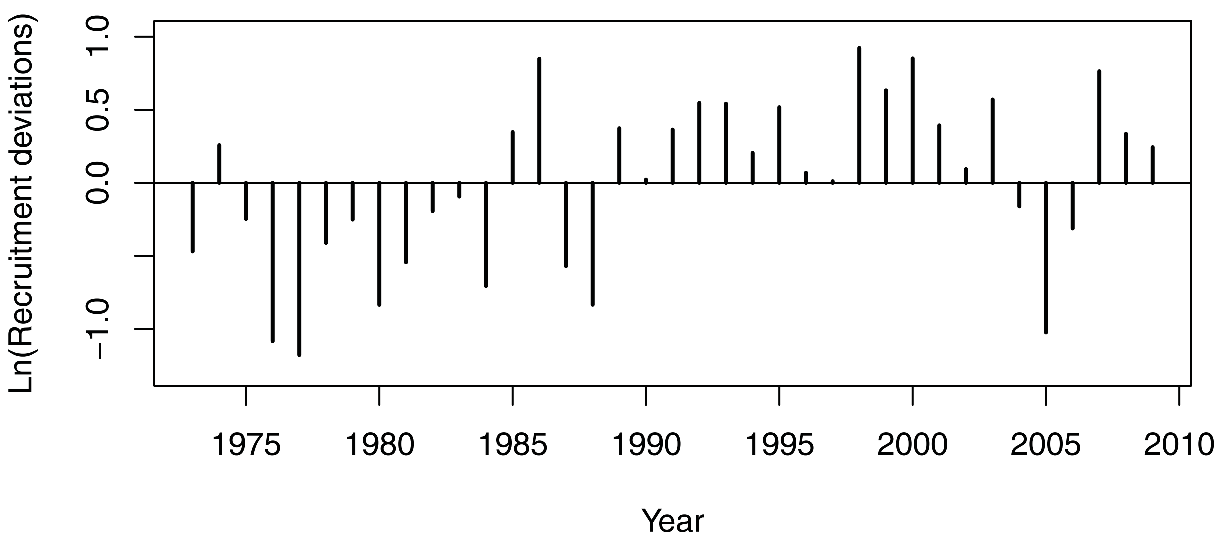

Index_1
Index_2
Selectivity at age
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
Age

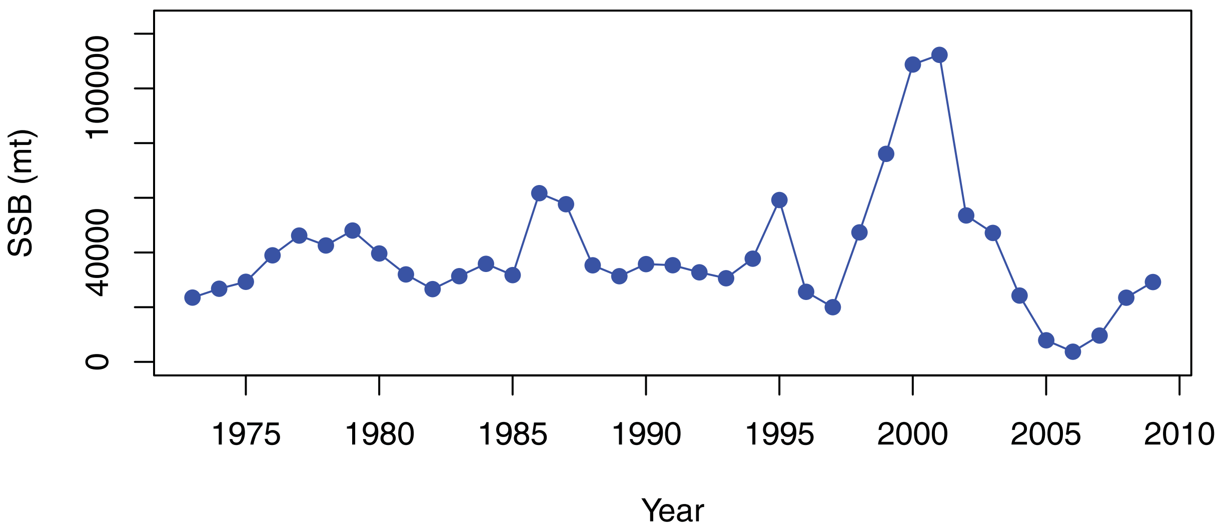

Index q estimates
1
2
Catchability
0.0
0.1
0.2
0.3
0.4
1975
1980
1985
1990
1995
2000
2005
2010
Index

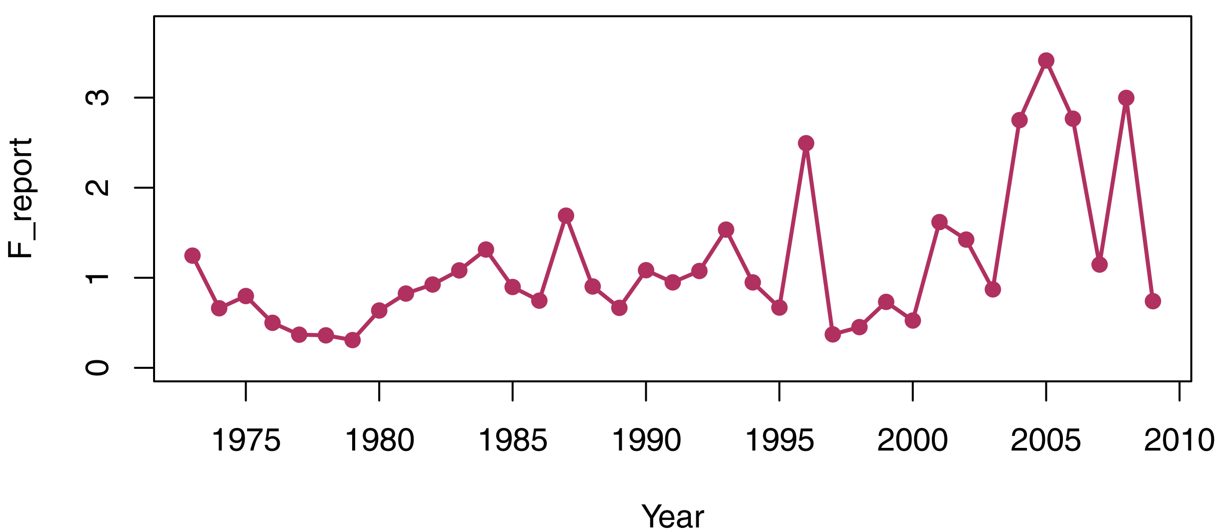

Recruits (000s)
SSB (mt)
0e+00
1e+05
2e+05
3e+05
4e+05
5e+05
6e+05
7e+05
0
20000
40000
60000
80000
100000
120000
98
86
00
07
99
03
93
92
95
01
08
94
02
96
97
90
83
04
82
75
79
06
78
81
87
84
80
88
05
76
77

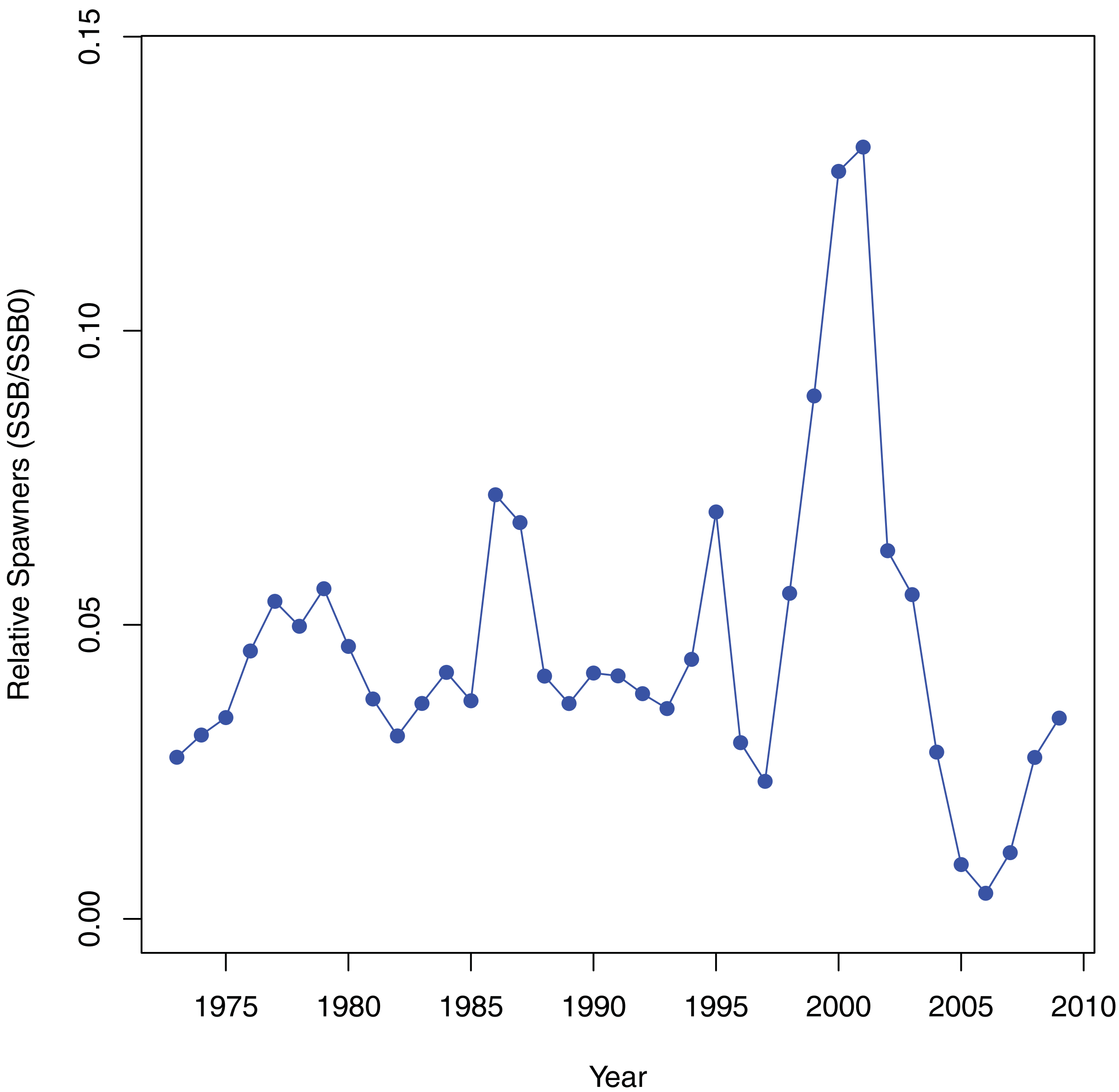

Recruits (000s)
0e+00
1e+05
2e+05
3e+05
4e+05
5e+05
6e+05
7e+05
0
20000
40000
60000
80000
100000
120000
SSB (mt)

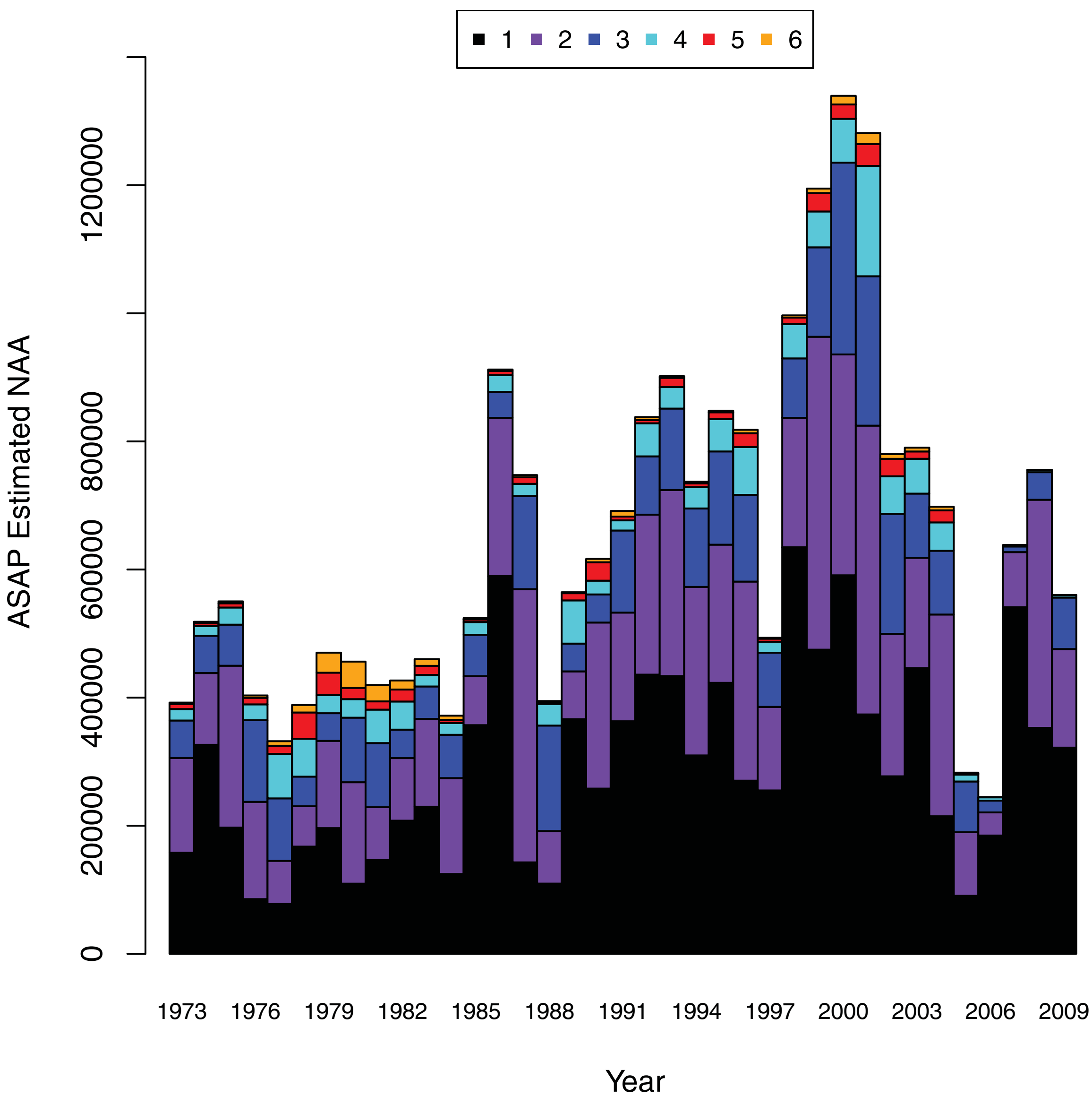

Recruits (000s)
0e+00
3e+05
6e+05
1975
1980
1985
1990
1995
2000
2005
2010
Year

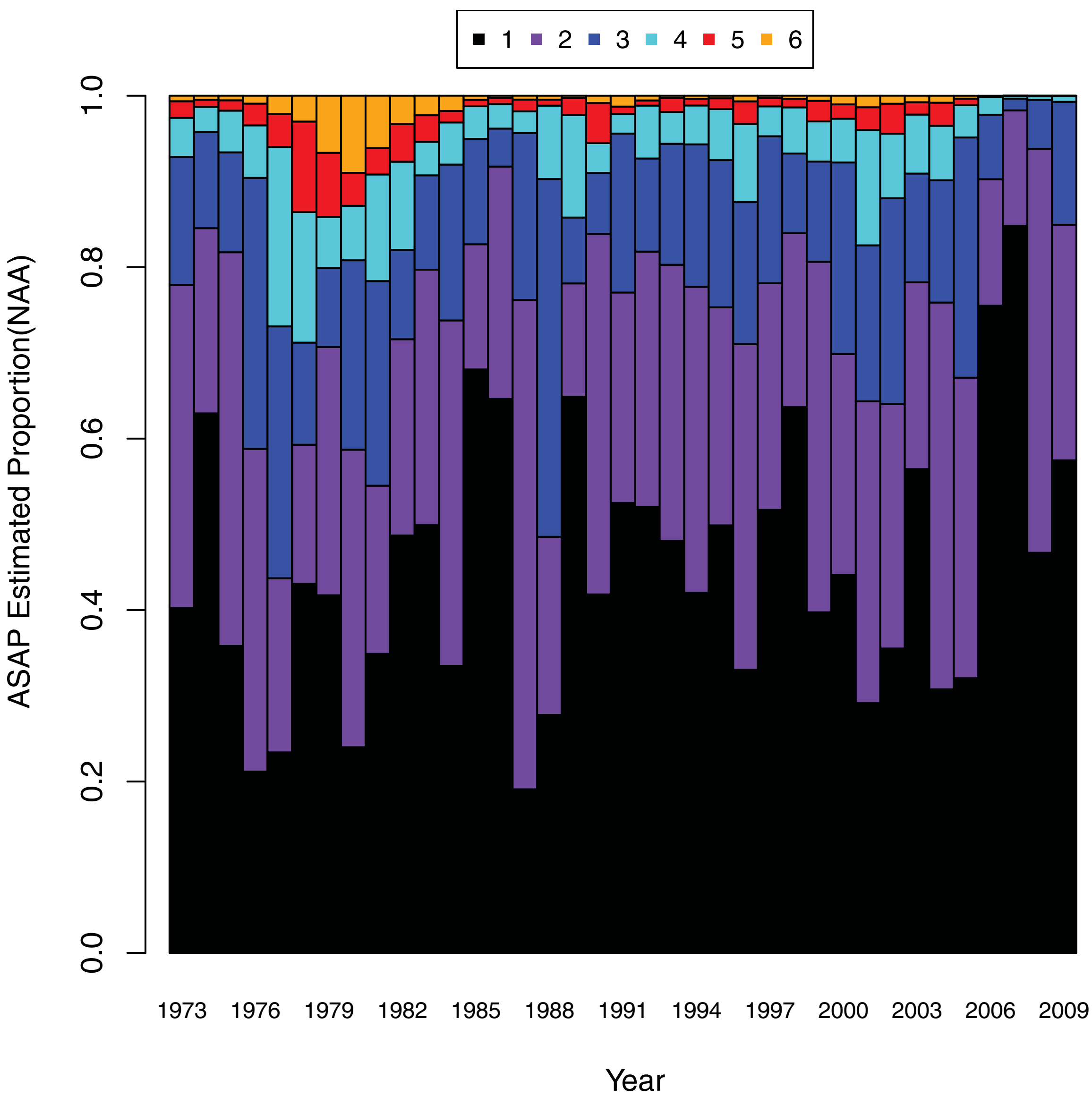

Ln(Recruitment deviations)
−1.0
0.0
0.5
1.0
1975
1980
1985
1990
1995
2000
2005
2010
Year

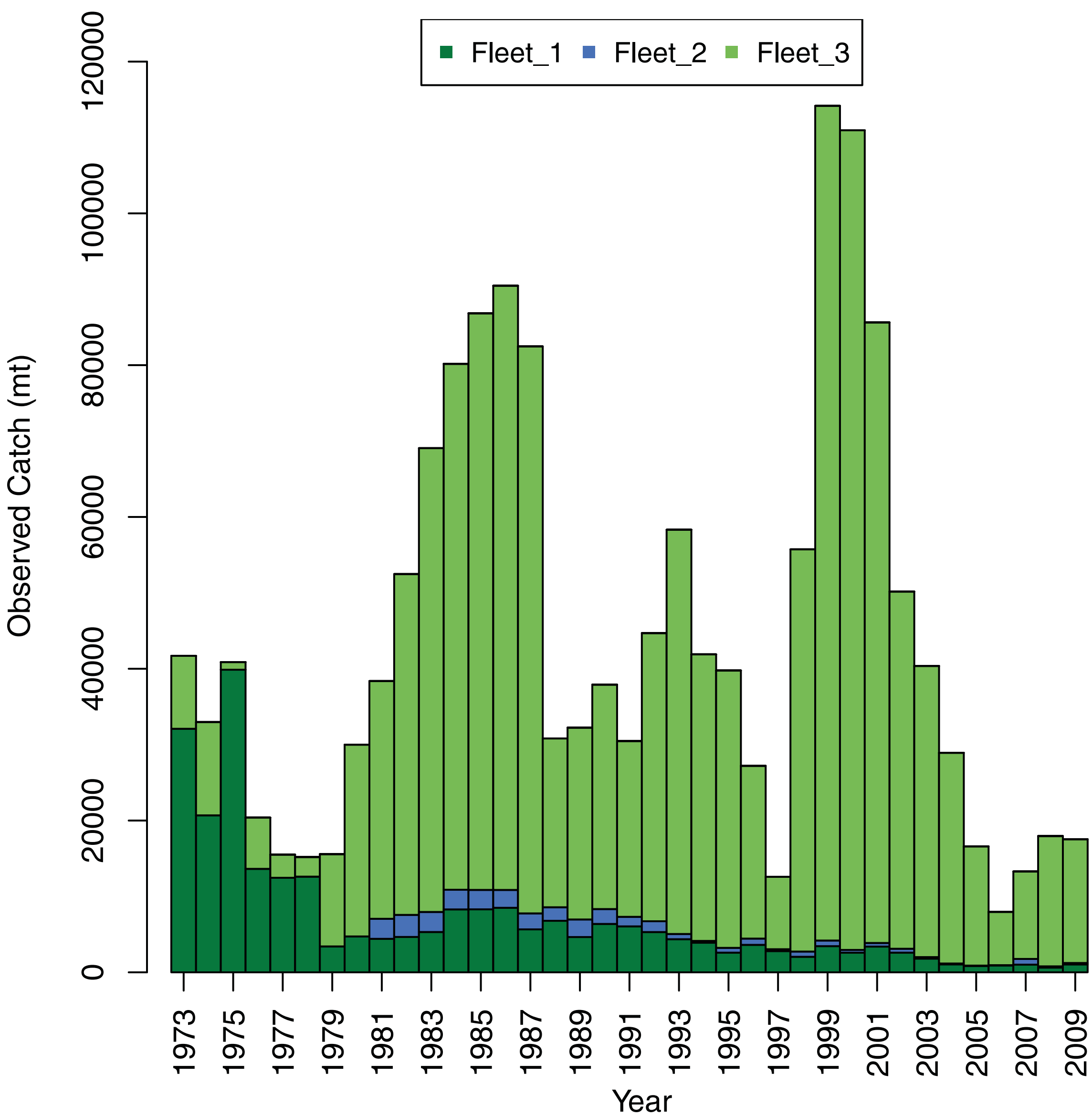

SSB (mt)
0
40000
100000
1975
1980
1985
1990
1995
2000
2005
2010
Year

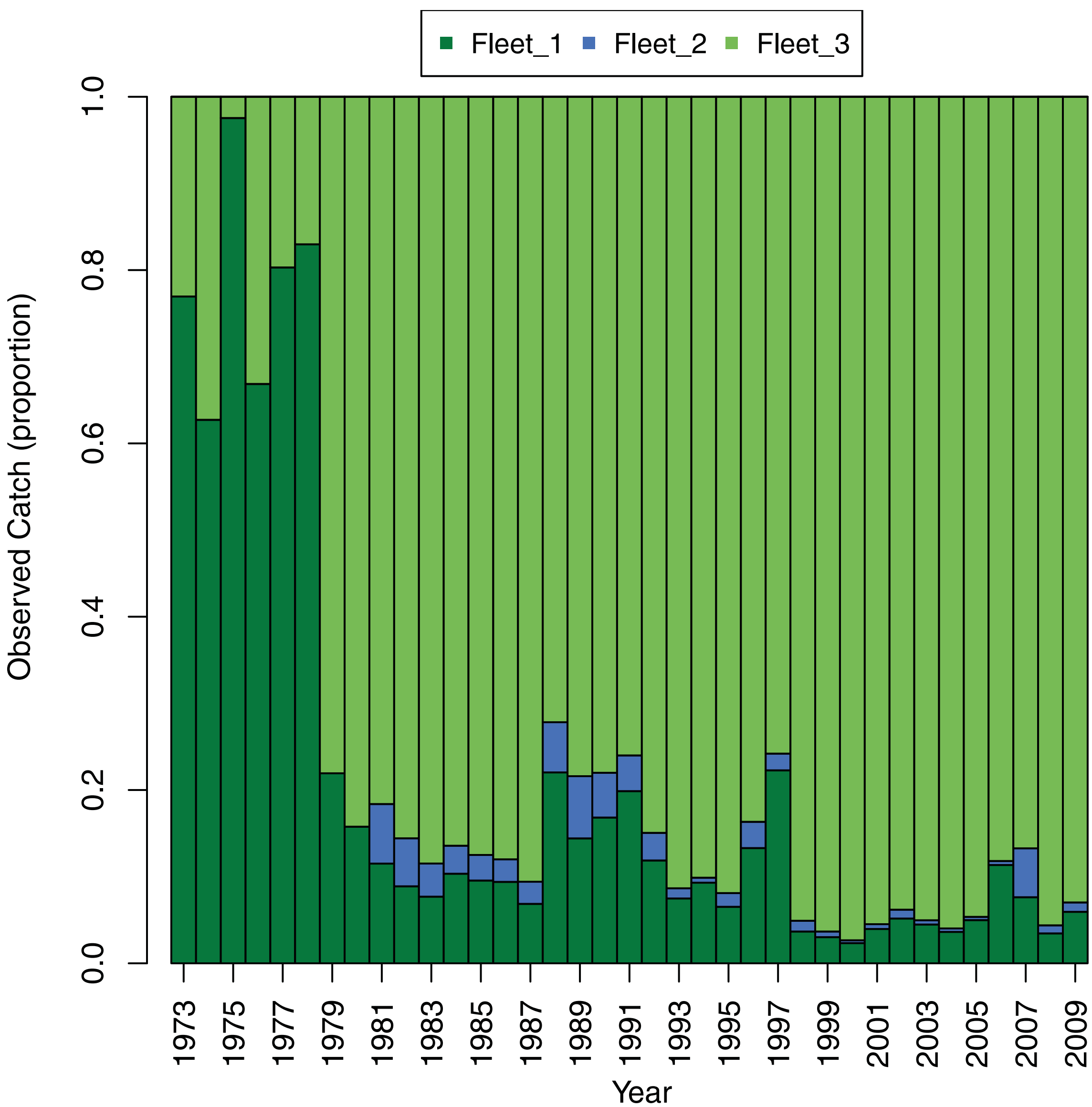

F_report
0
1
2
3
1975
1980
1985
1990
1995
2000
2005
2010
Year

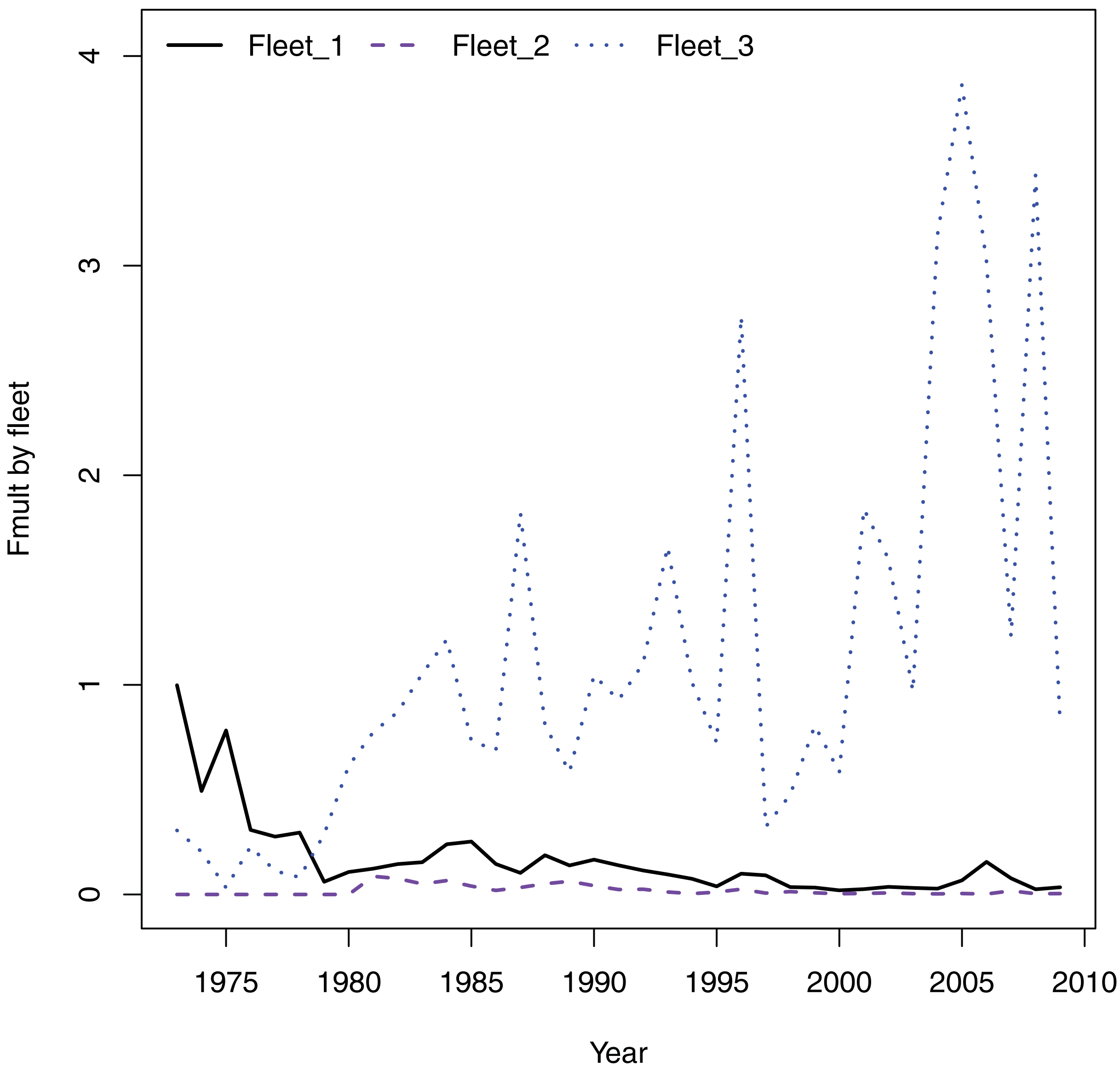

0.00
0.05
0.10
0.15
Relative Spawners (SSB/SSB0)
1975
1980
1985
1990
1995
2000
2005
2010
Year

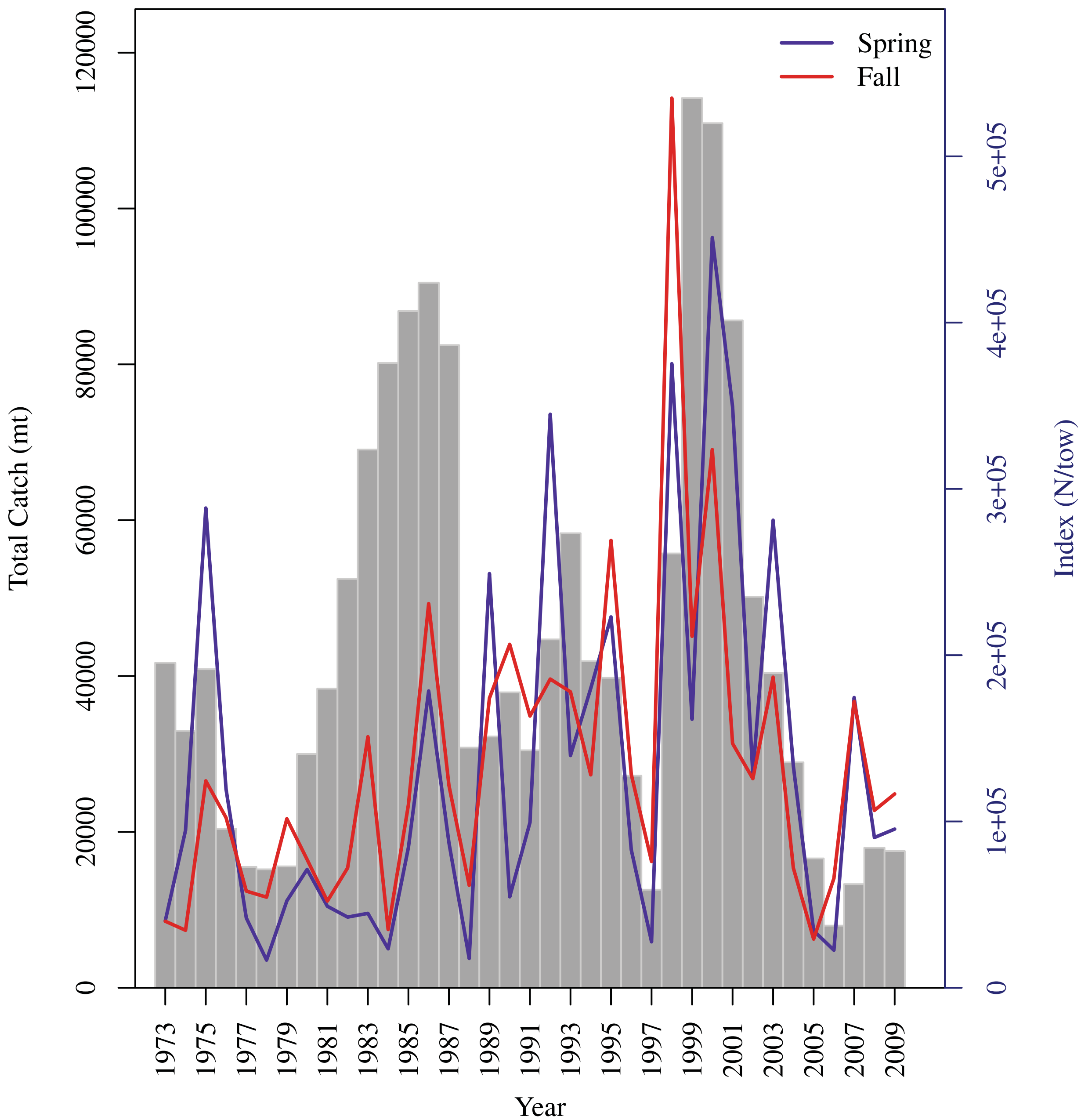

1 2 3 4 5 6
ASAP Estimated NAA
0
200000
400000
600000
800000
1200000
1973 1976 1979 1982 1985 1988 1991 1994 1997 2000 2003 2006 2009
Year

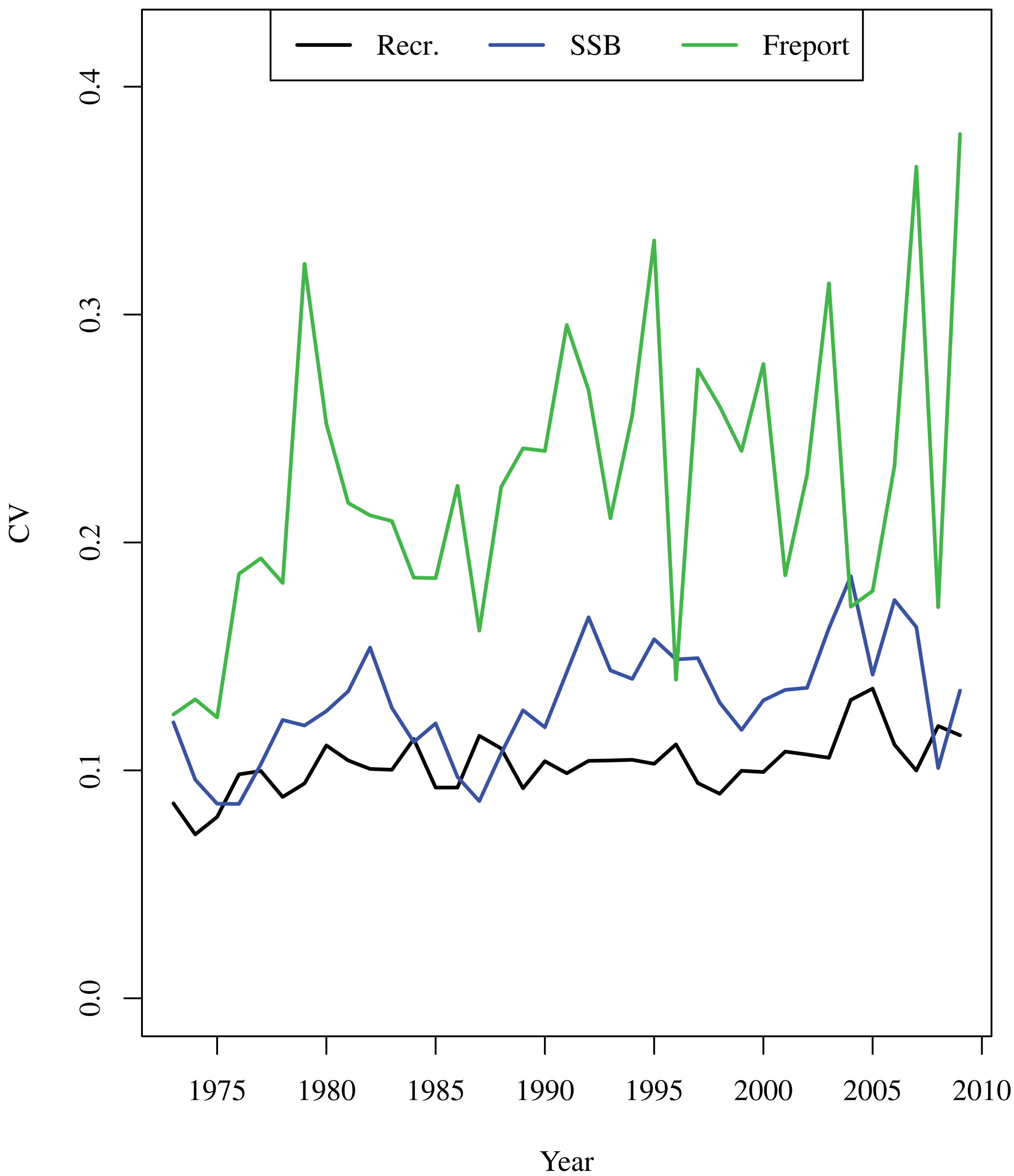

1
2
3
4
5
6
ASAP Estimated Proportion(NAA)
0.0
0.2
0.4
0.6
0.8
1.0
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
Year

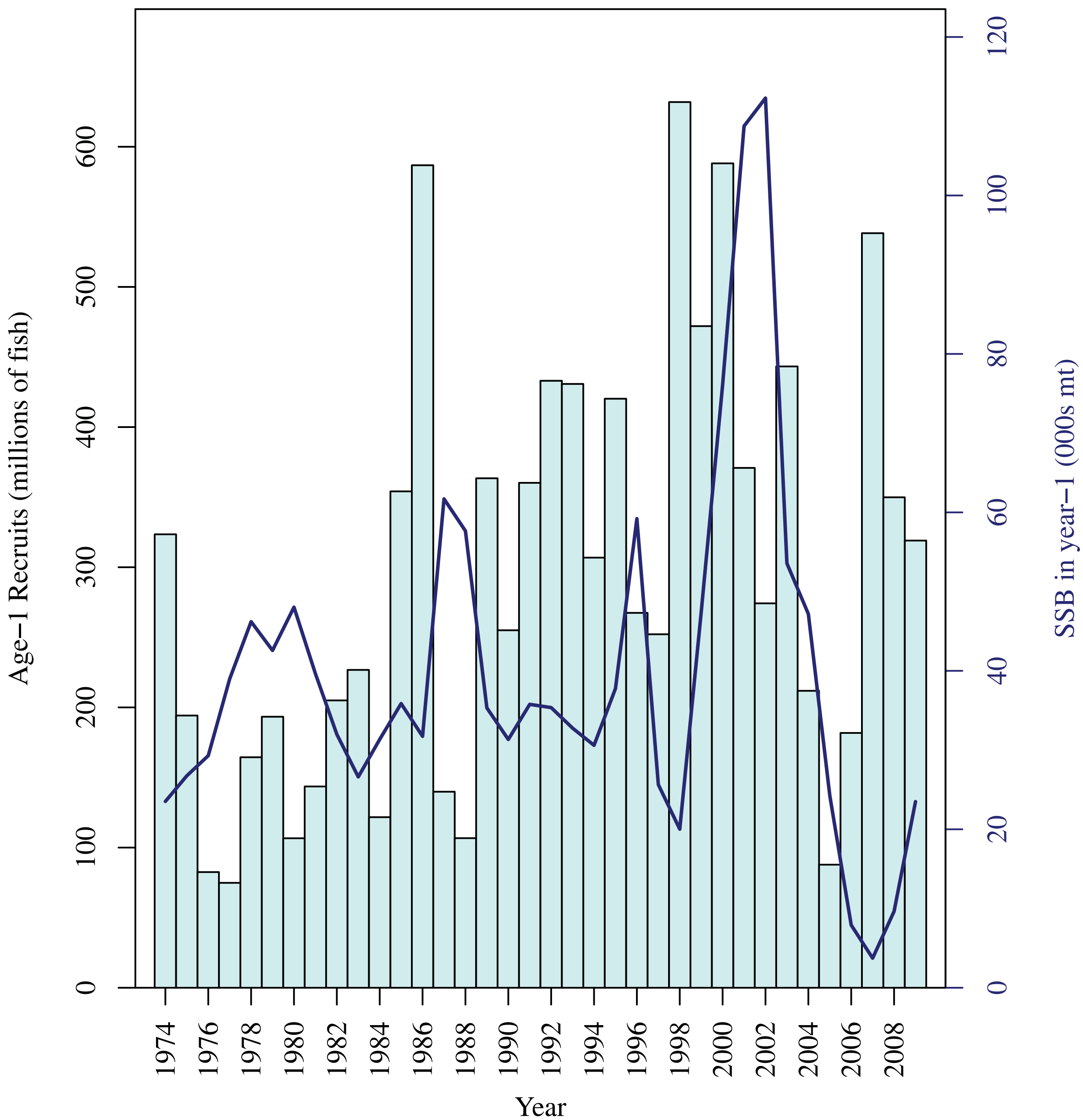

Fleet_1
Fleet_2
Fleet_3
Observed Catch (mt)
0
20000
40000
60000
80000
100000
120000
Year
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009


Fleet_1
Fleet_2
Fleet_3
Observed Catch (proportion)
0.0
0.2
0.4
0.6
0.8
1.0
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year


Fleet_1
Fleet_2
Fleet_3
Fmult by fleet
0
1
2
3
4
1975
1980
1985
1990
1995
2000
2005
2010
Year


Spring
Fall
Total Catch (mt)
0
20000
40000
60000
80000
100000
120000
Index (N/tow)
0
1e+05
2e+05
3e+05
4e+05
5e+05
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year


Recr.
SSB
Freport
CV
0.0
0.1
0.2
0.3
0.4
1975
1980
1985
1990
1995
2000
2005
2010
Year


Age−1 Recruits (millions of fish)
SSB in year−1 (000s mt)
Year
0
100
200
300
400
500
600
20
40
60
80
100
120
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008

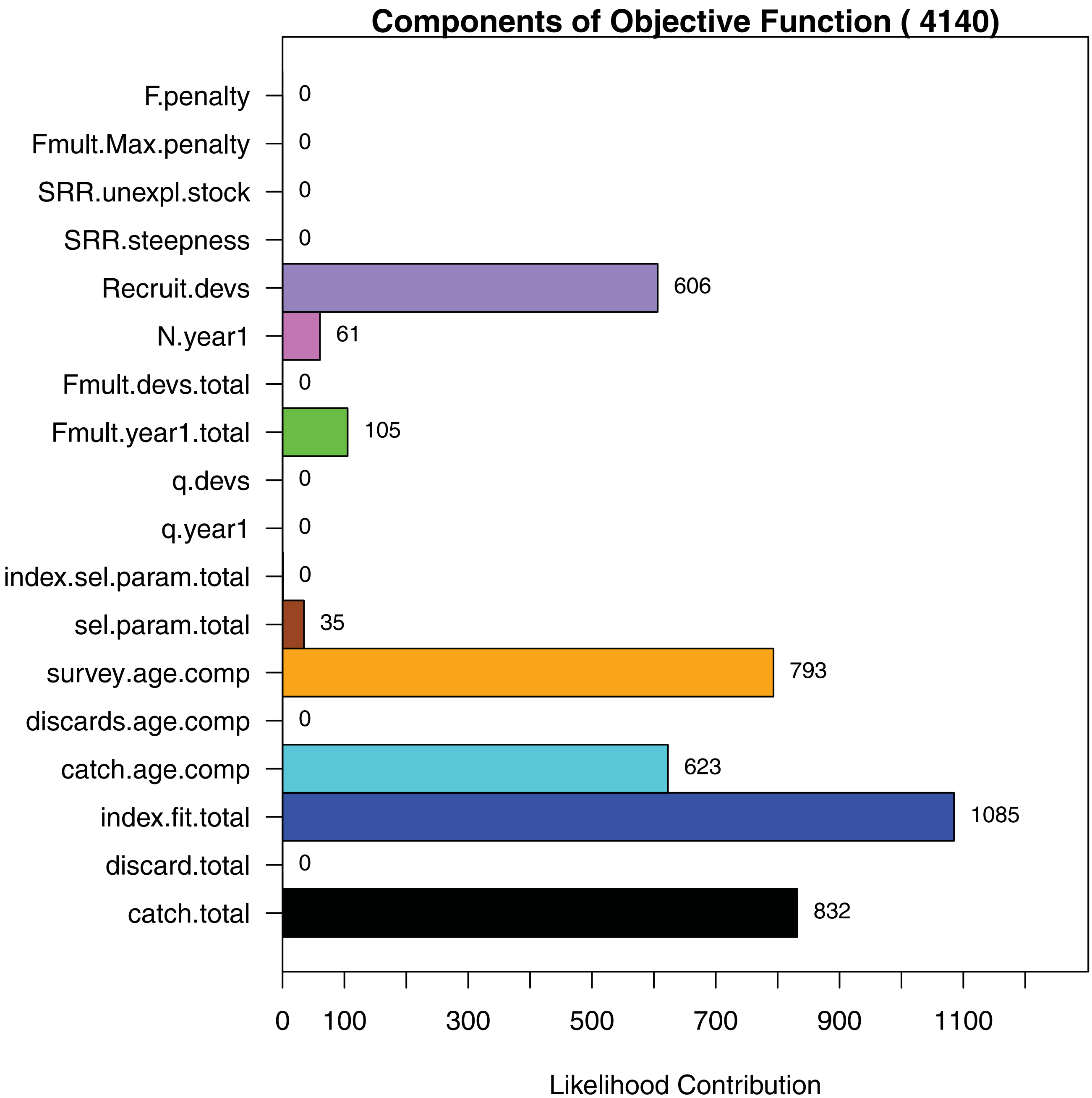
Appendix A6: North Model Consumption ASAP results M = 0.15_Assuming Flat-top Selectivity in the Survey

Model Attributes:

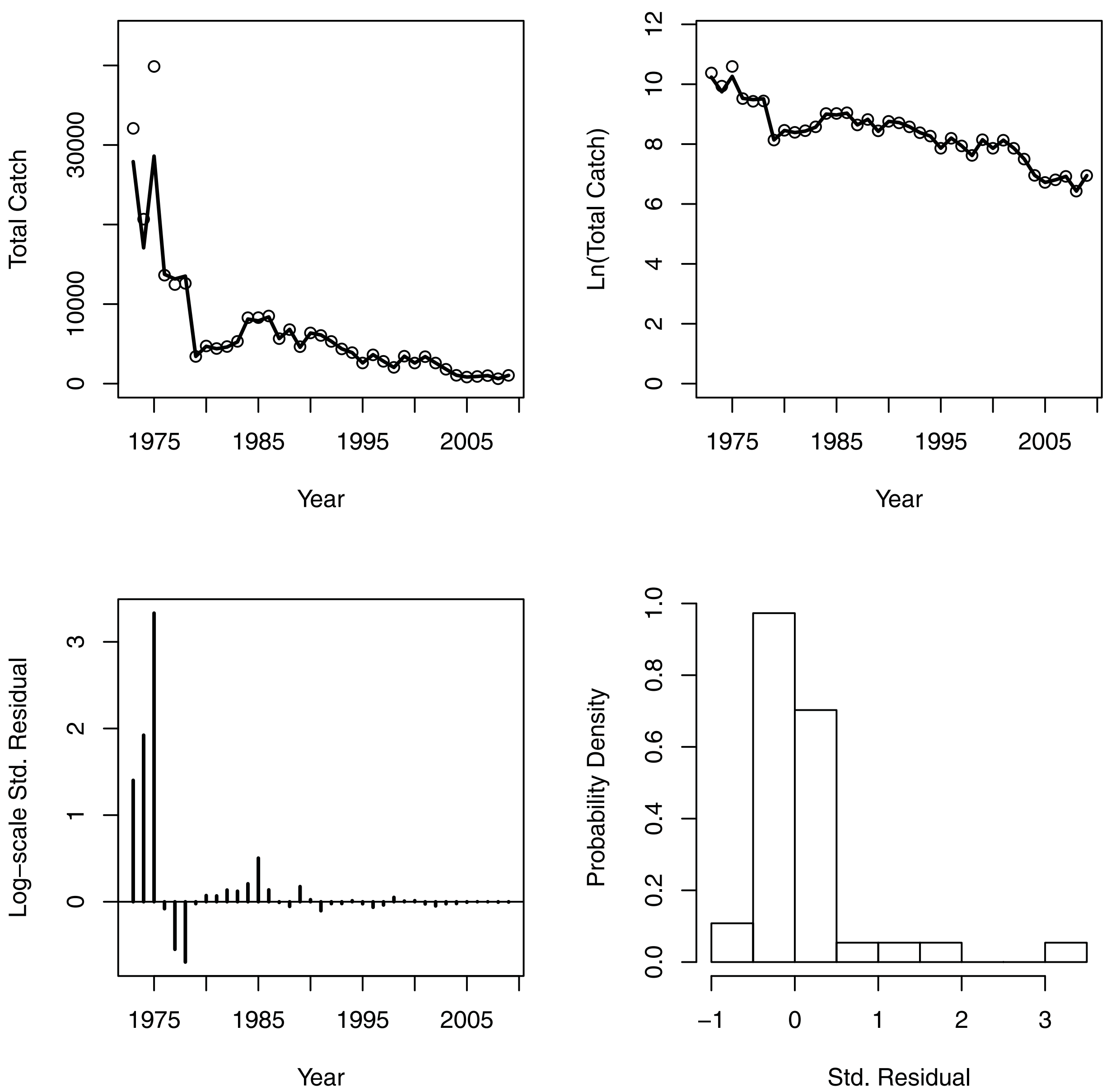
1. 3 Fleet Model
    a. Catch : 1973-2009
    b. Discards: 1981 – 2009
    c. Consumption – 1973-2009

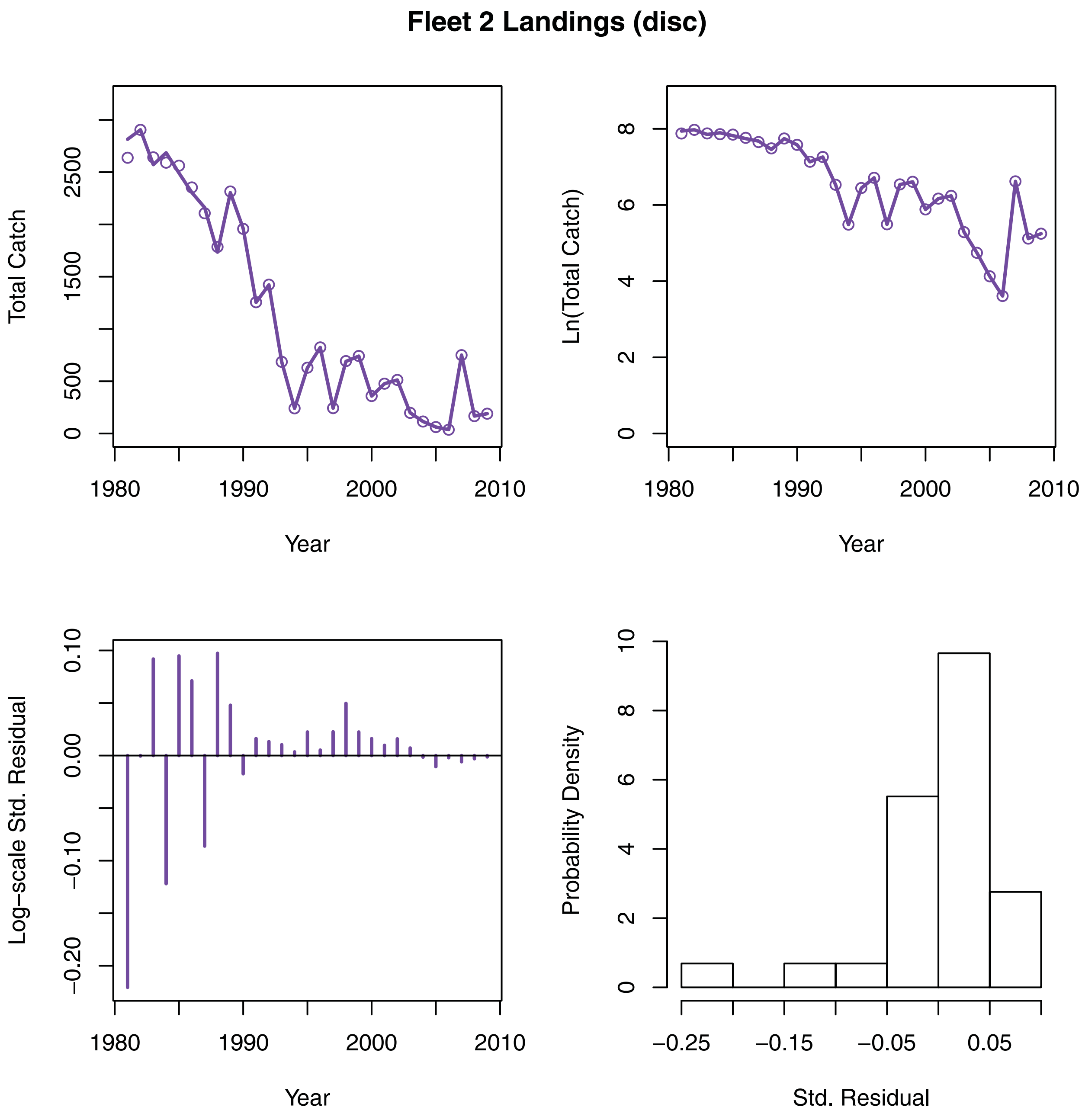
2. Fishery Selectivity (3 Block Selectivity)
    a. Landings (1 Blocks: 1973-2009)
    b. Discards (1 Block: 1981-2009)
    c. Consumption (Double Logistic Functional Form)

3. Survey Selectivity (Fixed 100% at age 2-6)

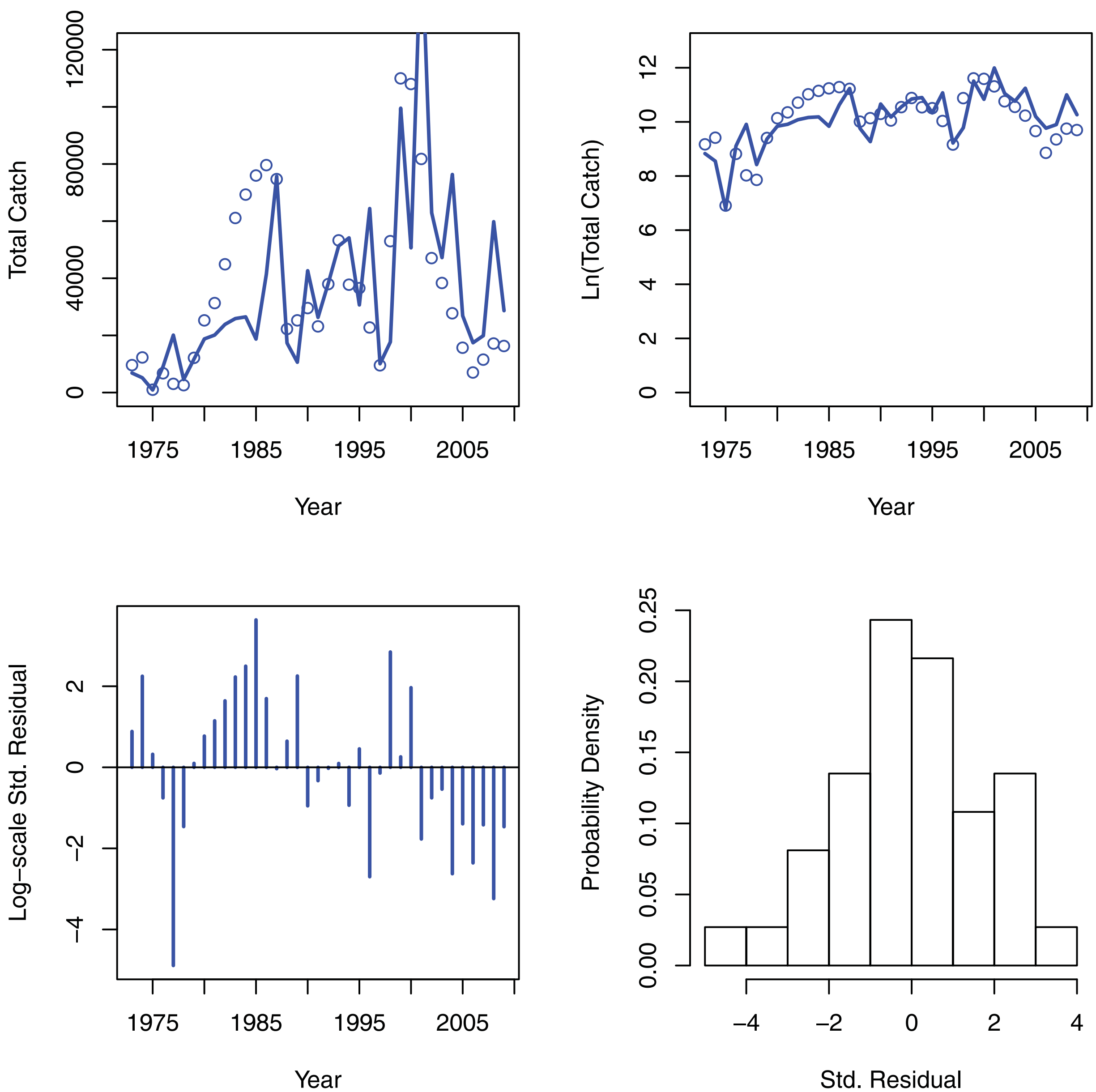

Components of Objective Function (4140)
F.penalty
Fmult.Max.penalty
SRR.unexpl.stock
SRR.steepness
Recruit.devs
N.year1
Fmult.devs.total
Fmult.year1.total
q.devs
q.year1
index.sel.param.total
sel.param.total
survey.age.comp
discards.age.comp
catch.age.comp
index.fit.total
discard.total
catch.total
0
0
0
0
606
61
0
105
0
0
0
35
793
0
623
1085
0
832
0
100
300
500
700
900
1100
Likelihood Contribution

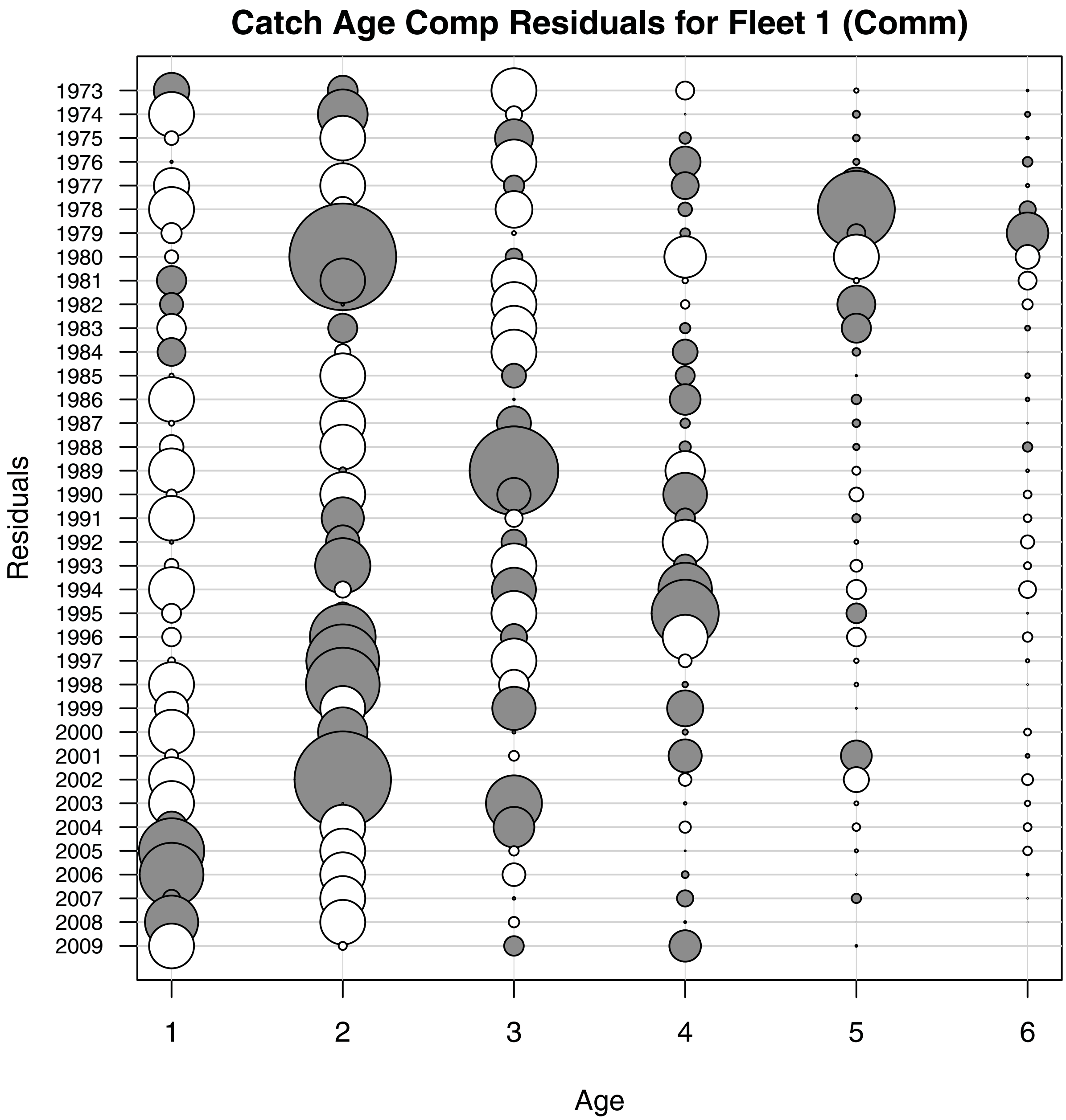
Fleet 1 Landings (Comm)

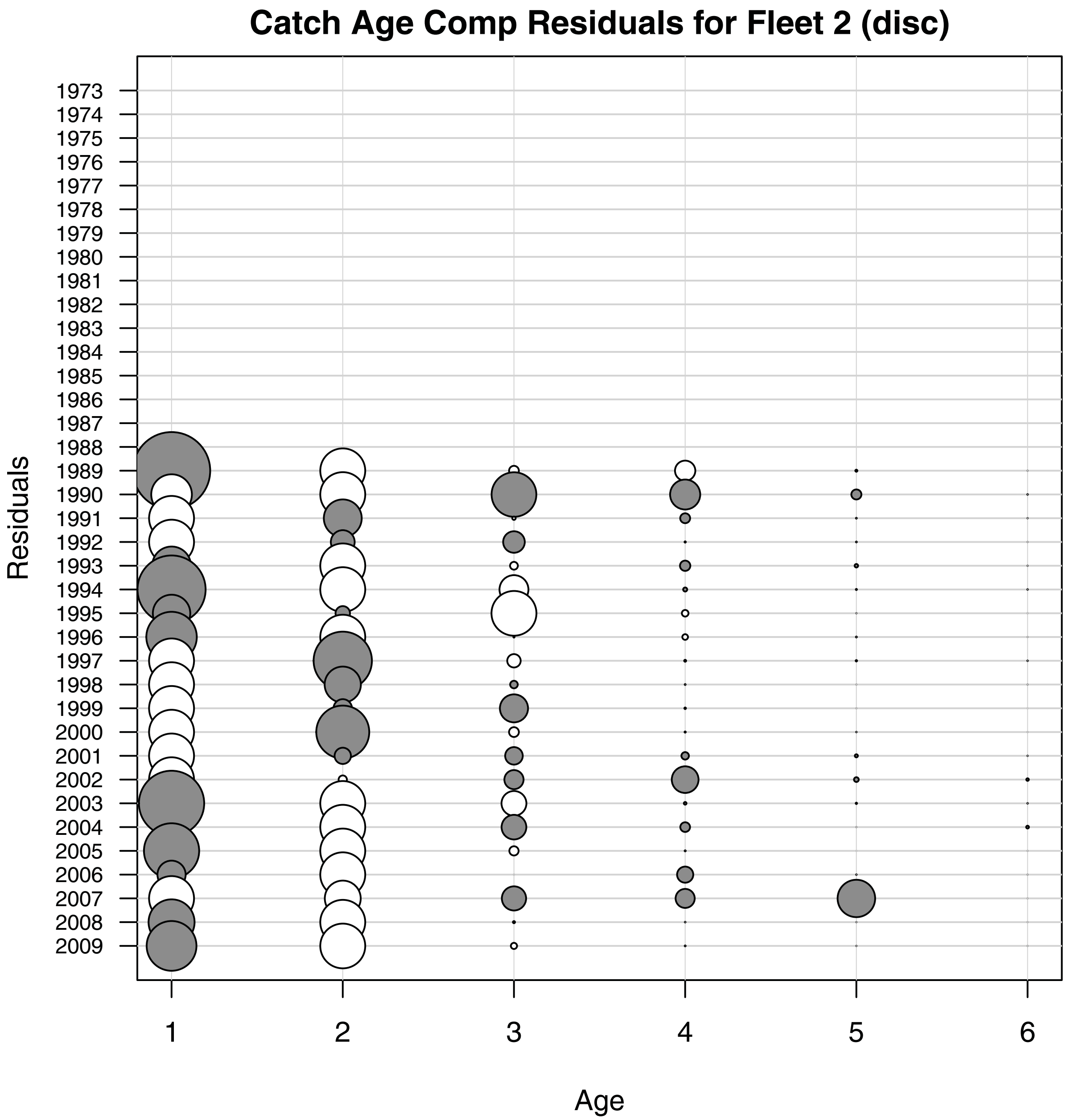


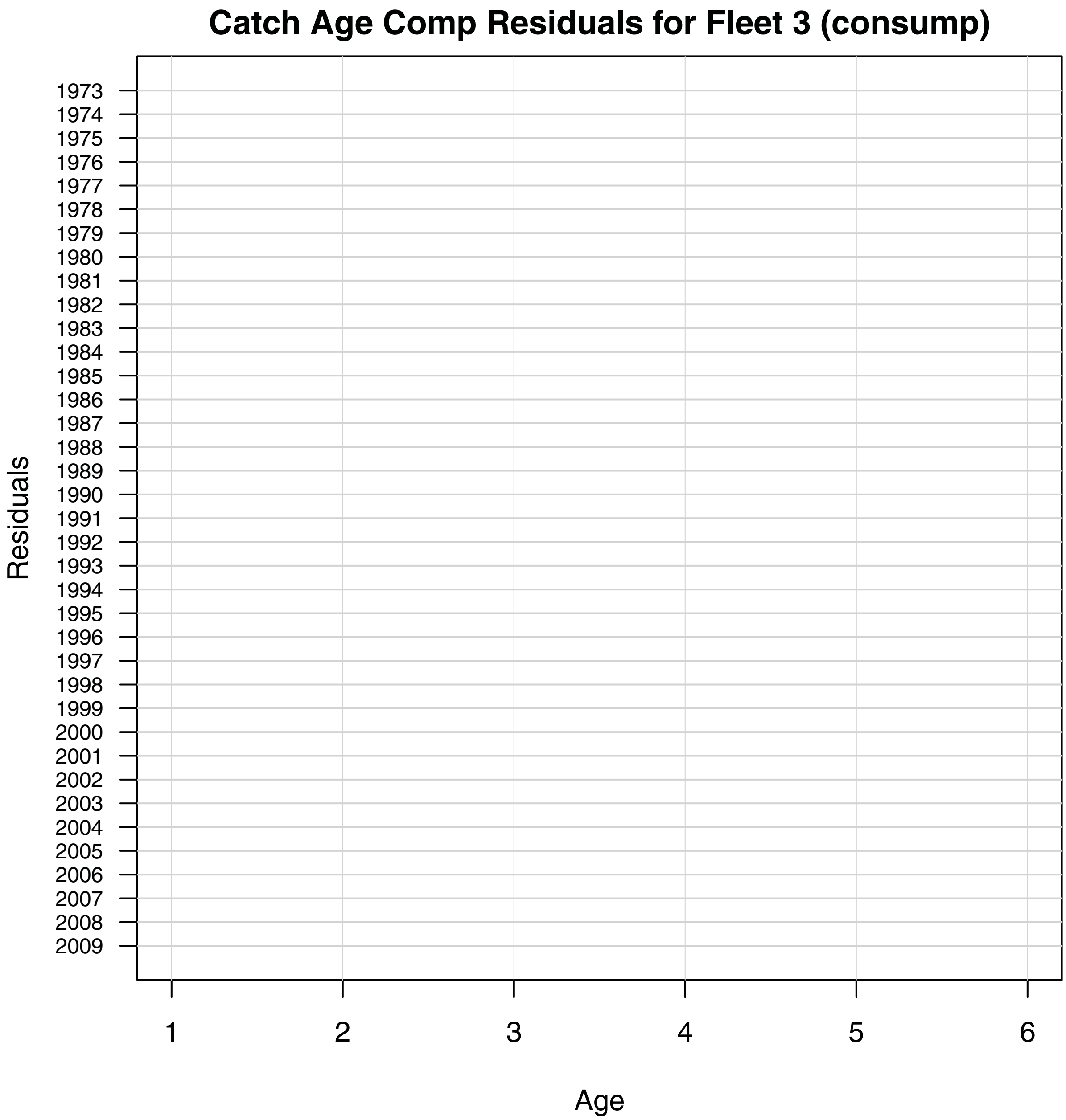

Fleet 2 Landings (disc)
Total Catch
Year
Ln(Total Catch)
Log−scale Std. Residual
Probability Density
Std. Residual

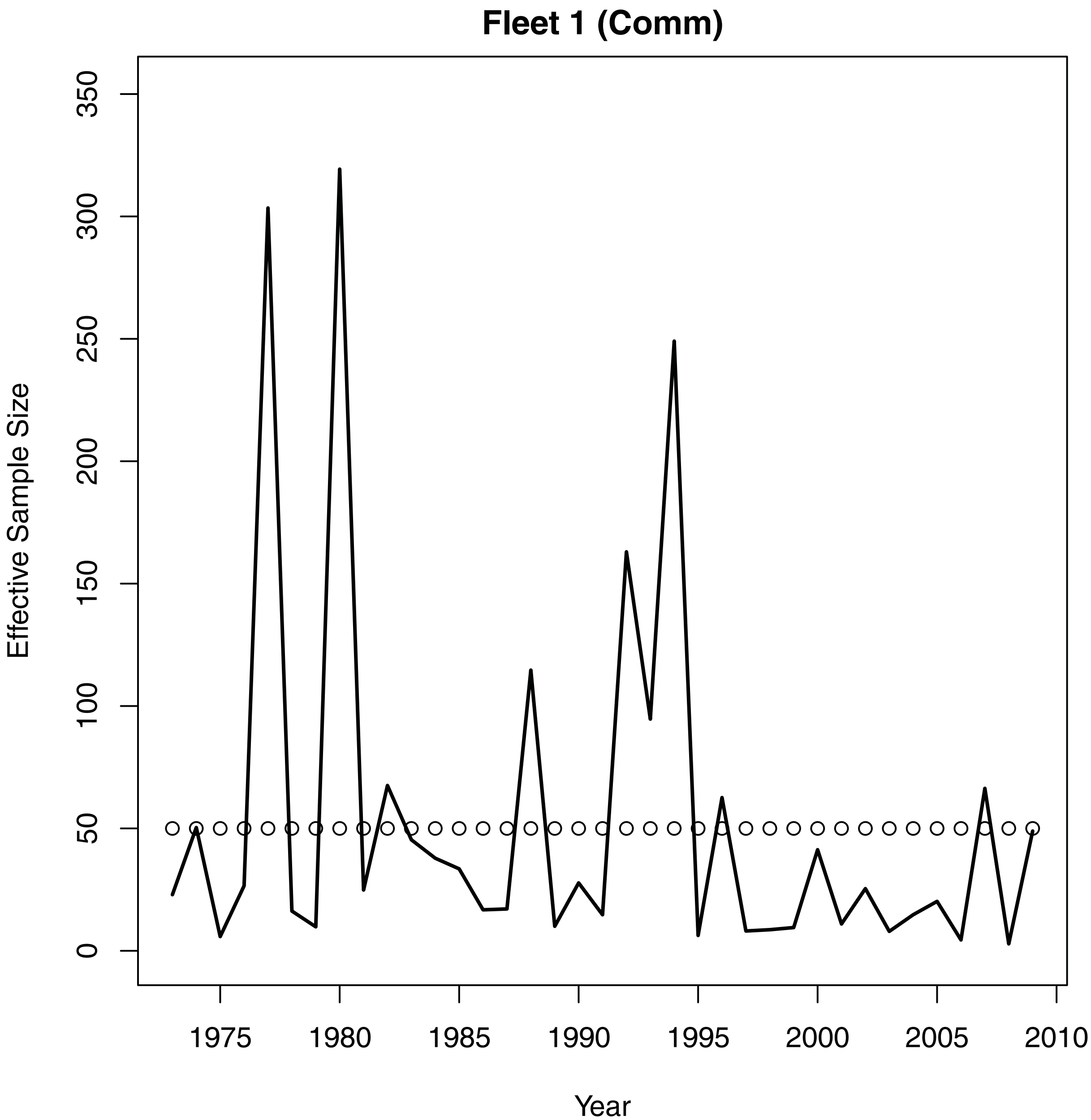
Fleet 3 Landings (consump)

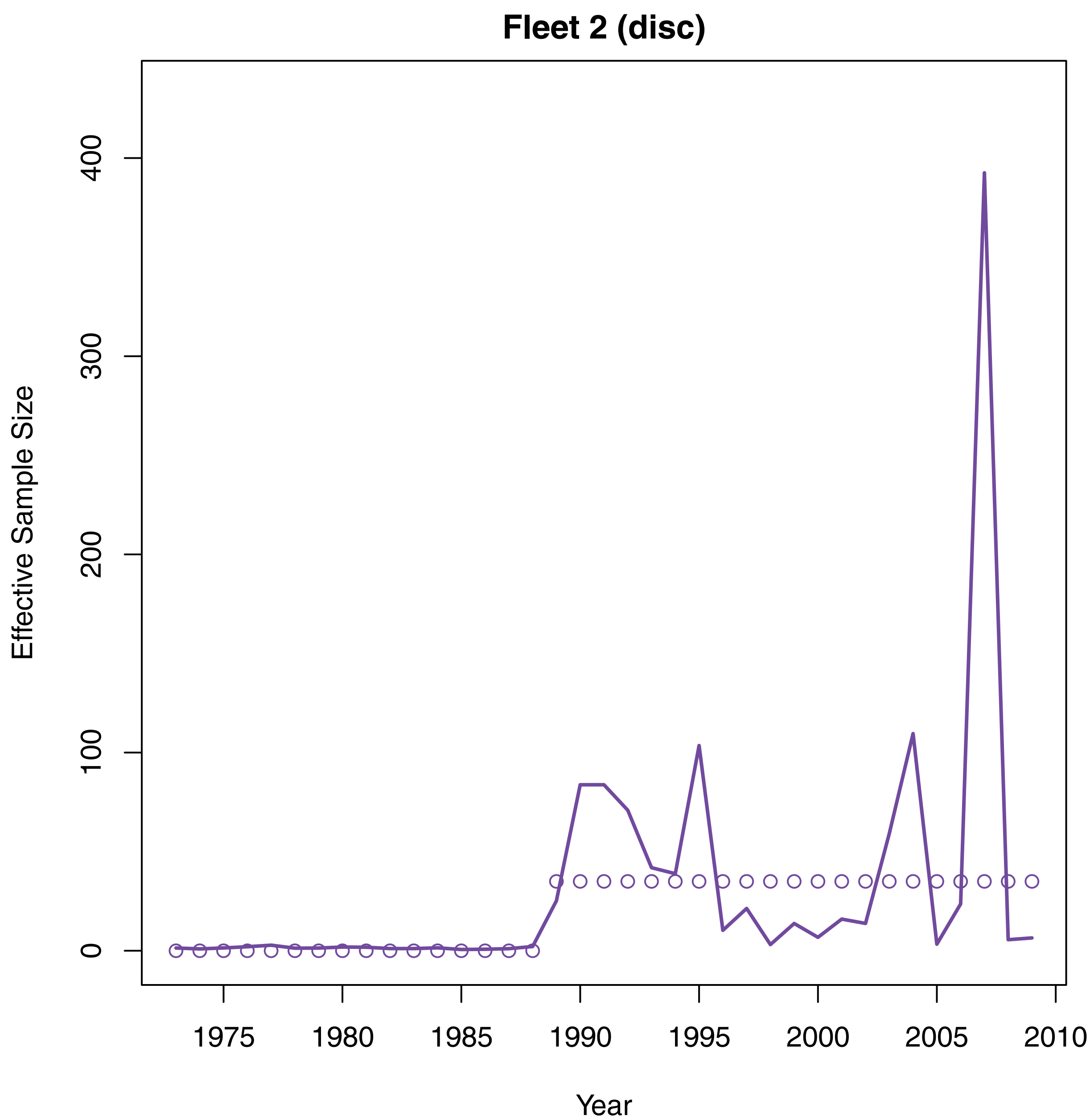


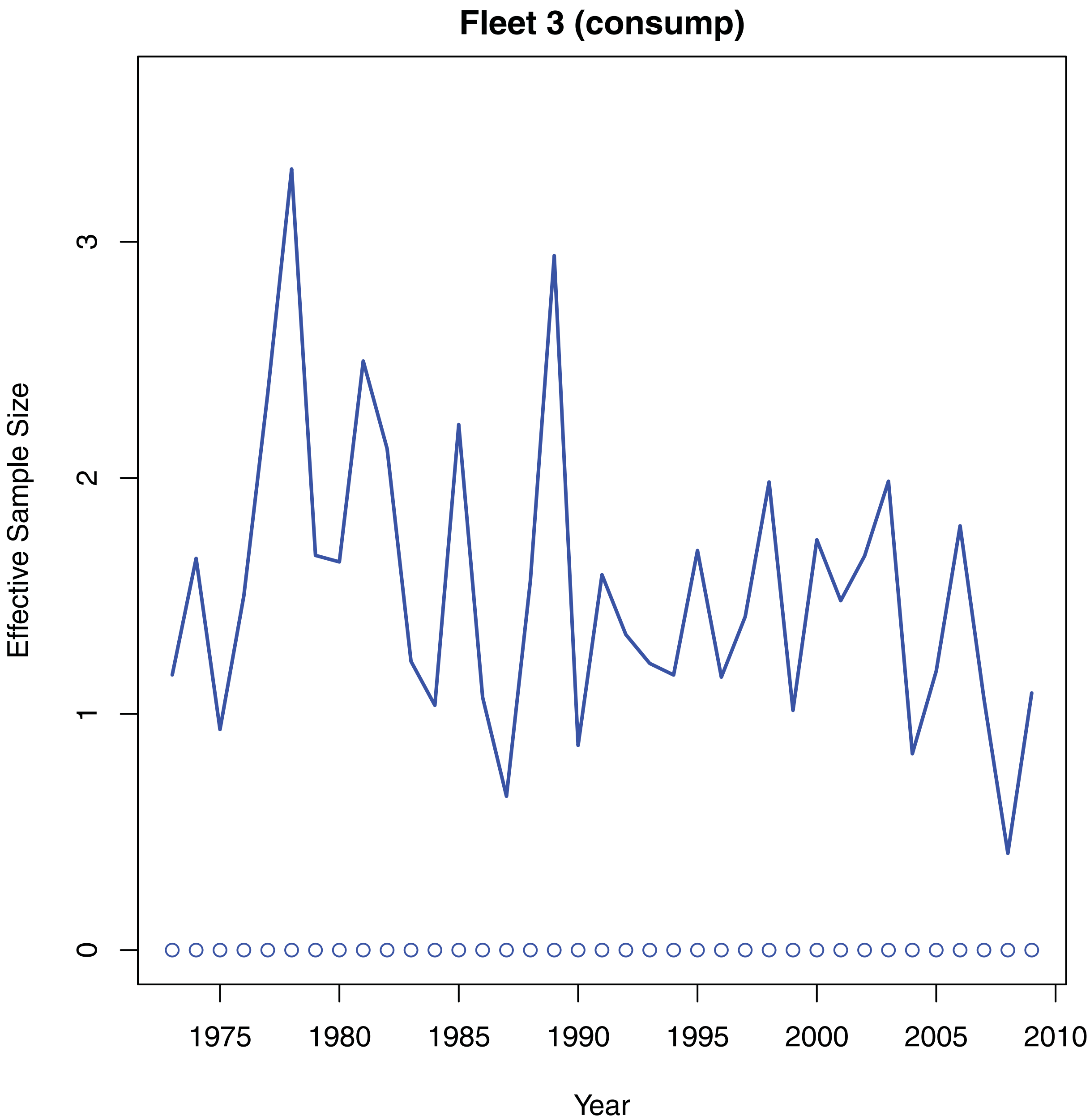

Catch Age Comp Residuals for Fleet 1 (Comm)
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age

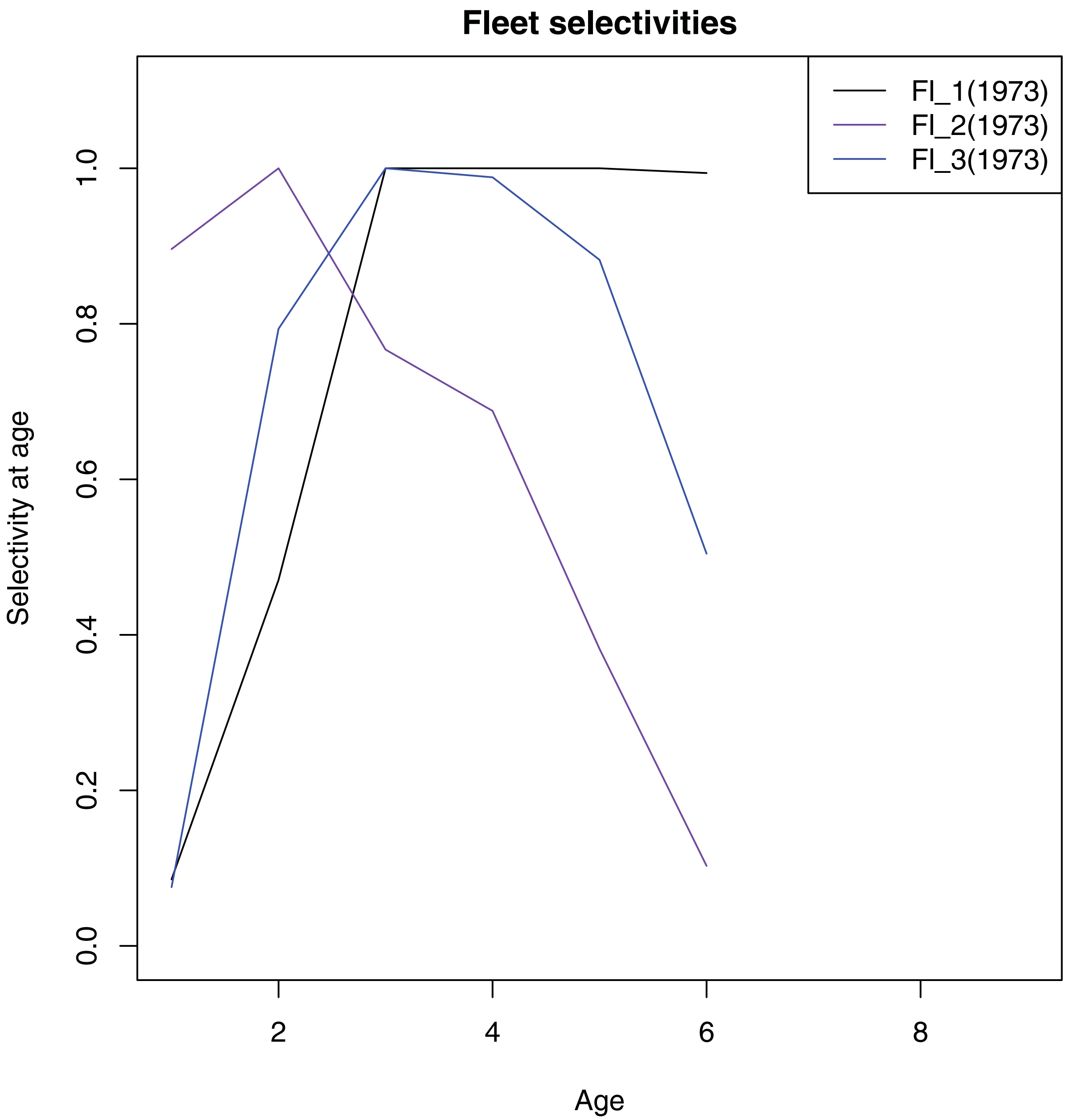

Catch Age Comp Residuals for Fleet 2 (disc)
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age


Catch Age Comp Residuals for Fleet 3 (consump)
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age

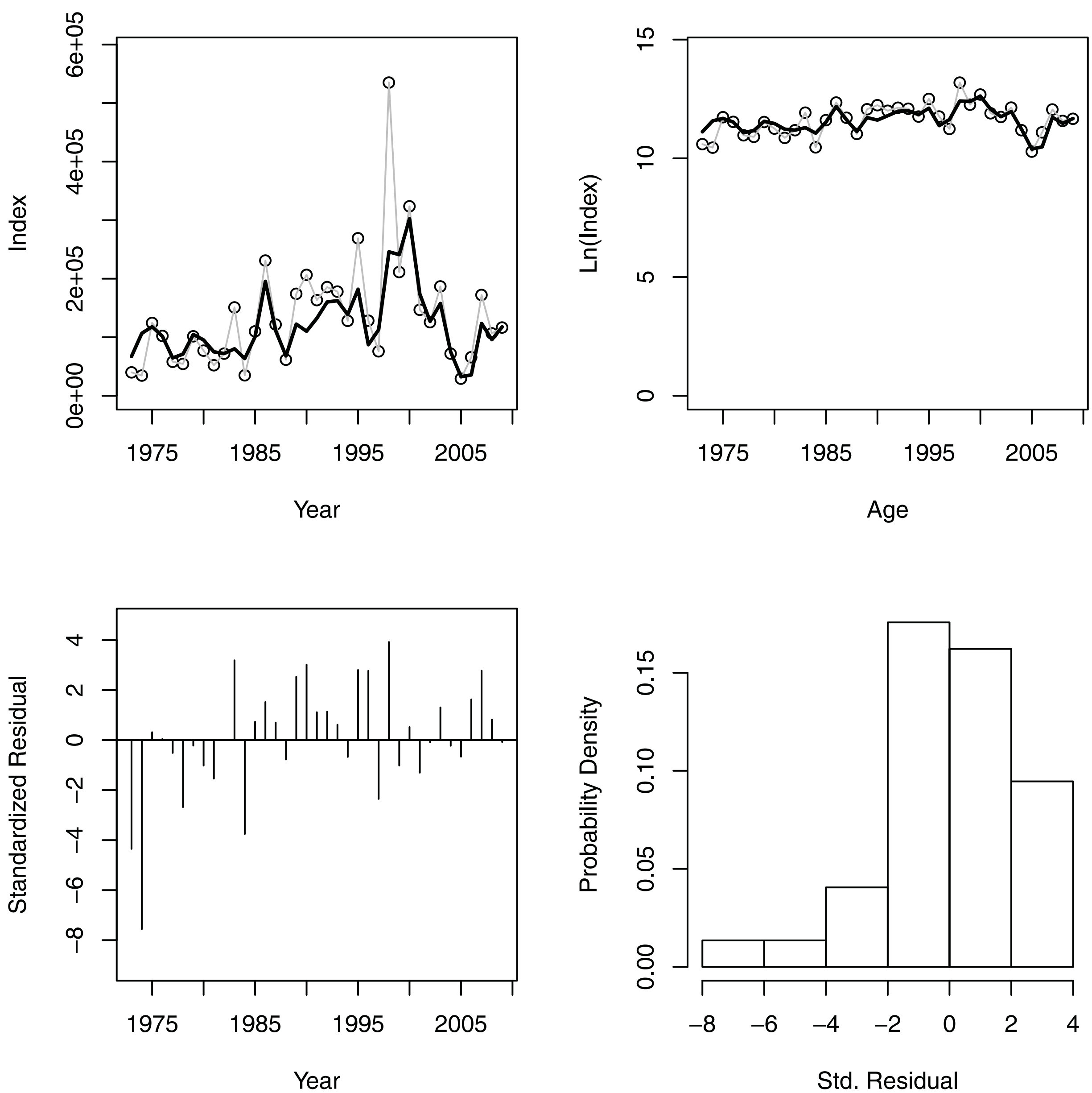

Fleet 1 (Comm)
Effective Sample Size
350
300
250
200
150
100
50
0
1975
1980
1985
1990
1995
2000
2005
2010
Year

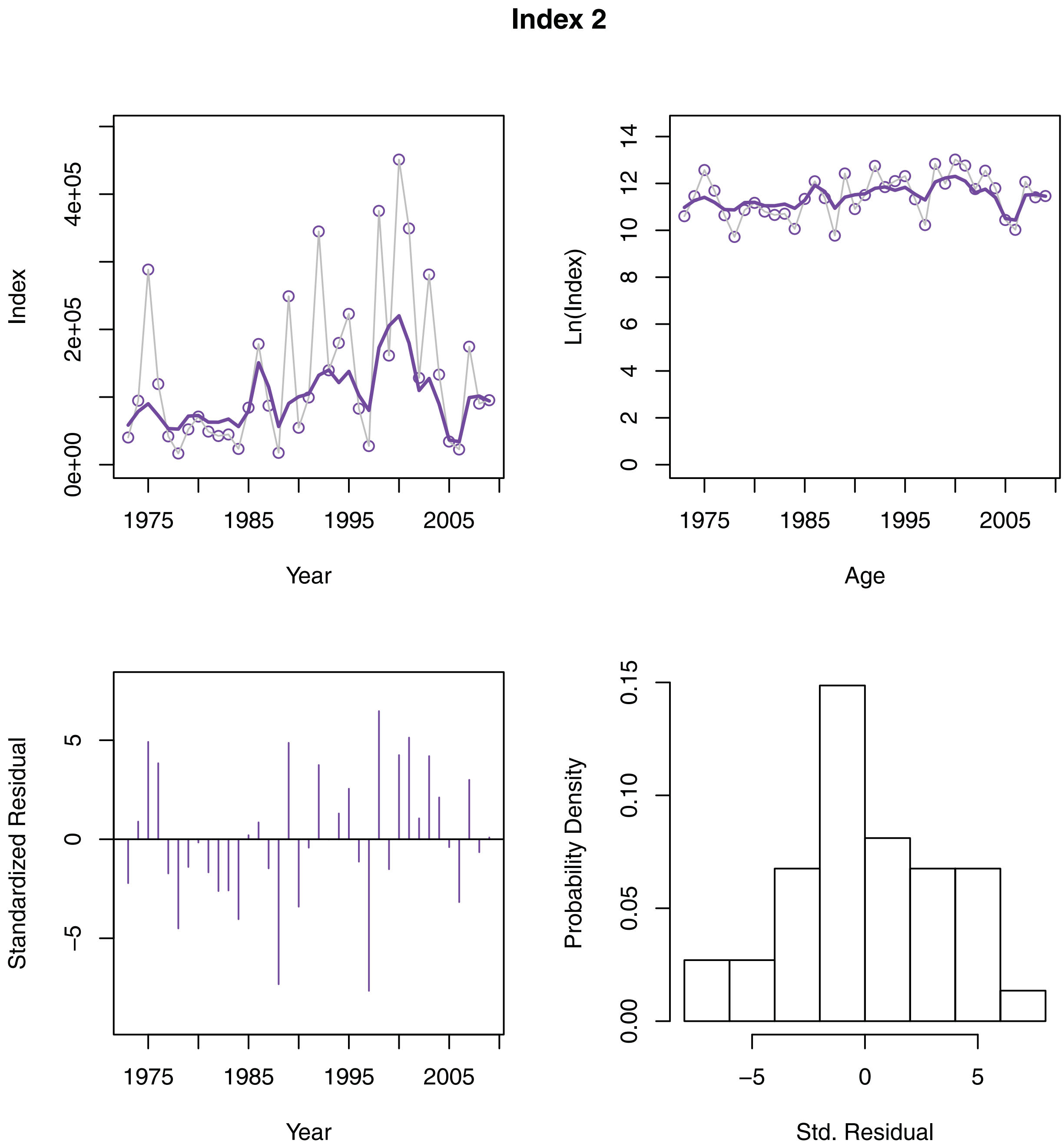

Fleet 2 (disc)
Effective Sample Size
0
100
200
300
400
1975
1980
1985
1990
1995
2000
2005
2010
Year

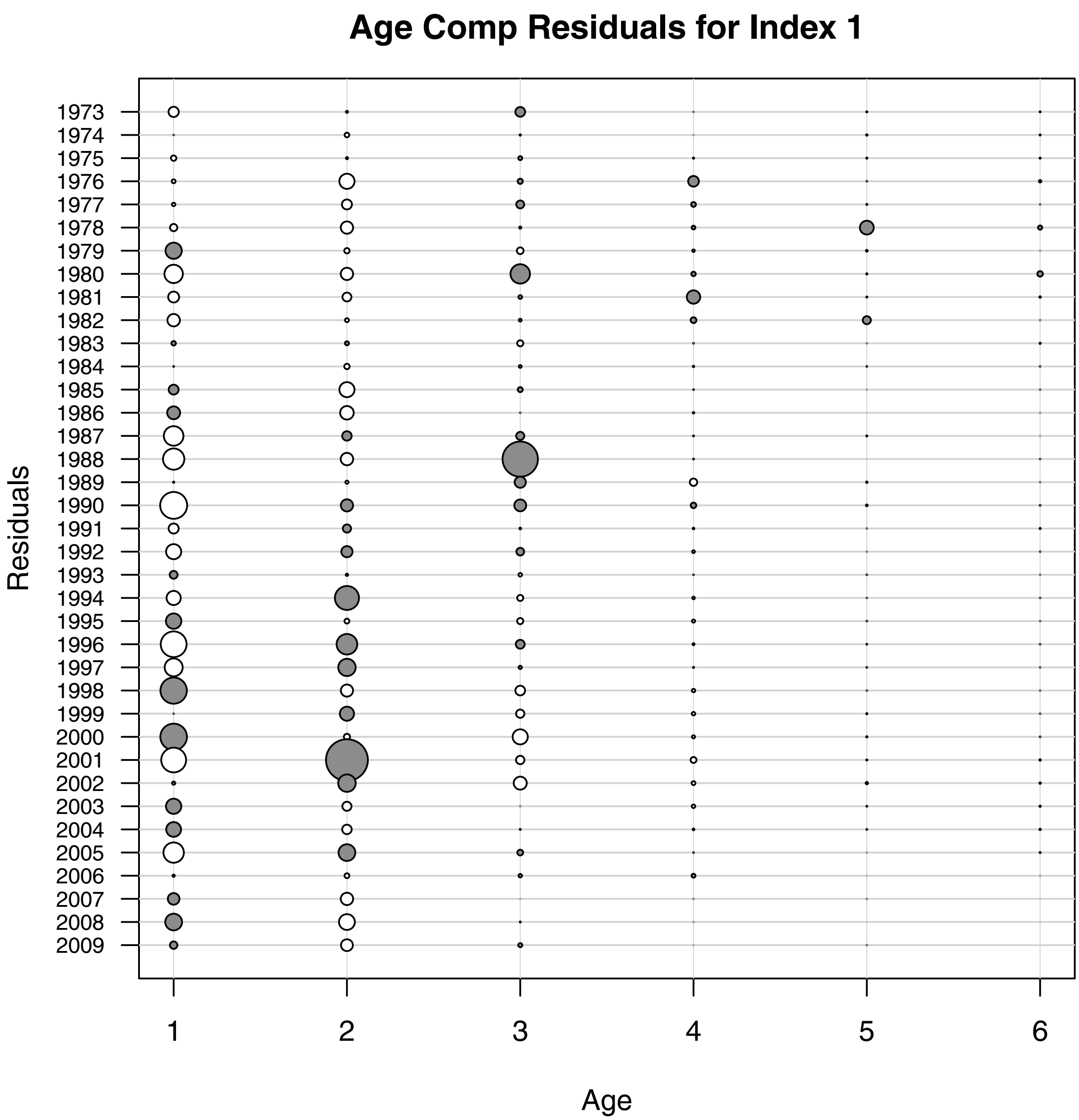

Fleet 3 (consump)
Effective Sample Size
0
1
2
3
1975
1980
1985
1990
1995
2000
2005
2010
Year

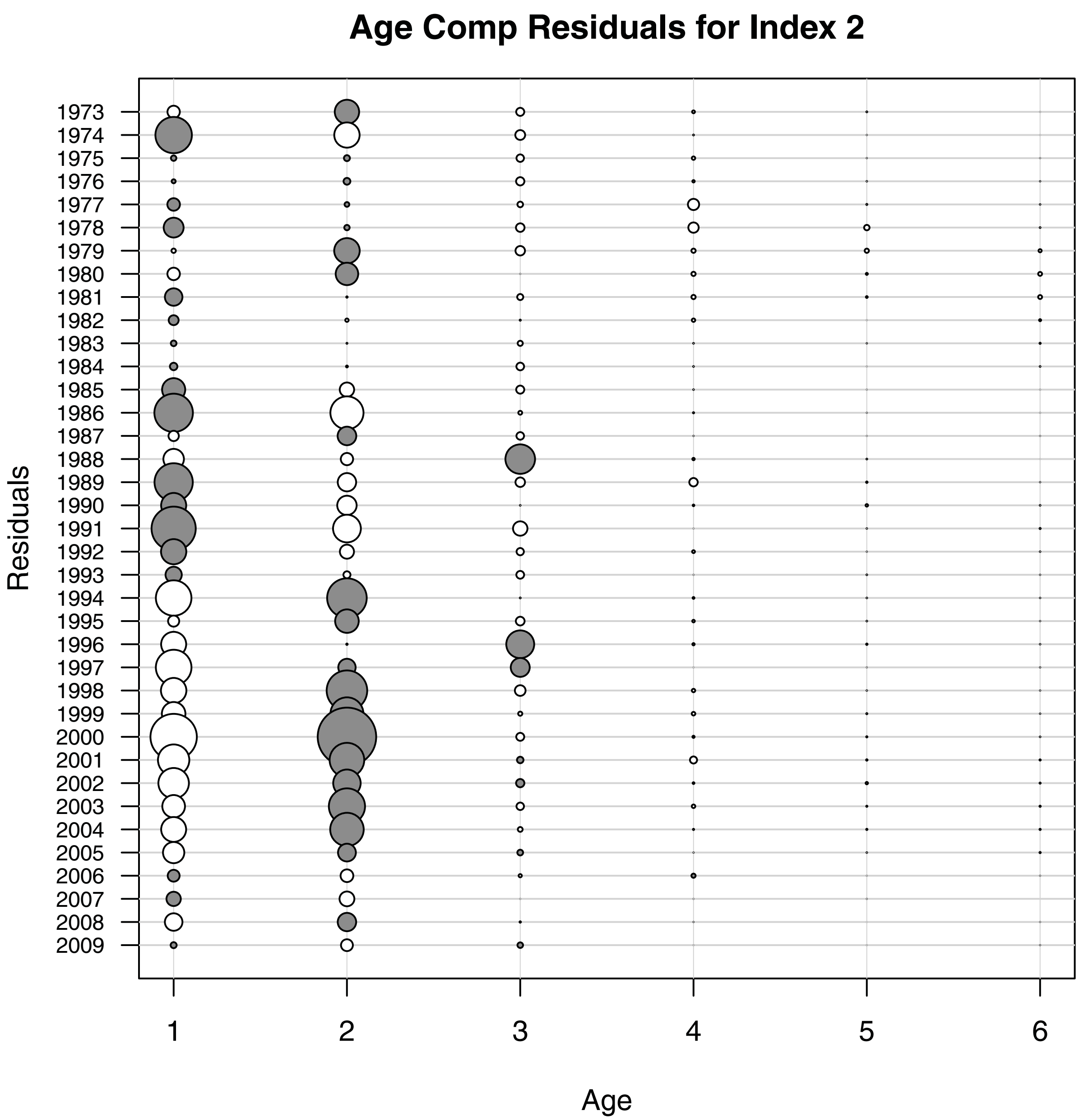

Fleet selectivities
Fl_1(1973)
Fl_2(1973)
Fl_3(1973)
Selectivity at age
0.0
0.2
0.4
0.6
0.8
1.0
Age
2
4
6
8

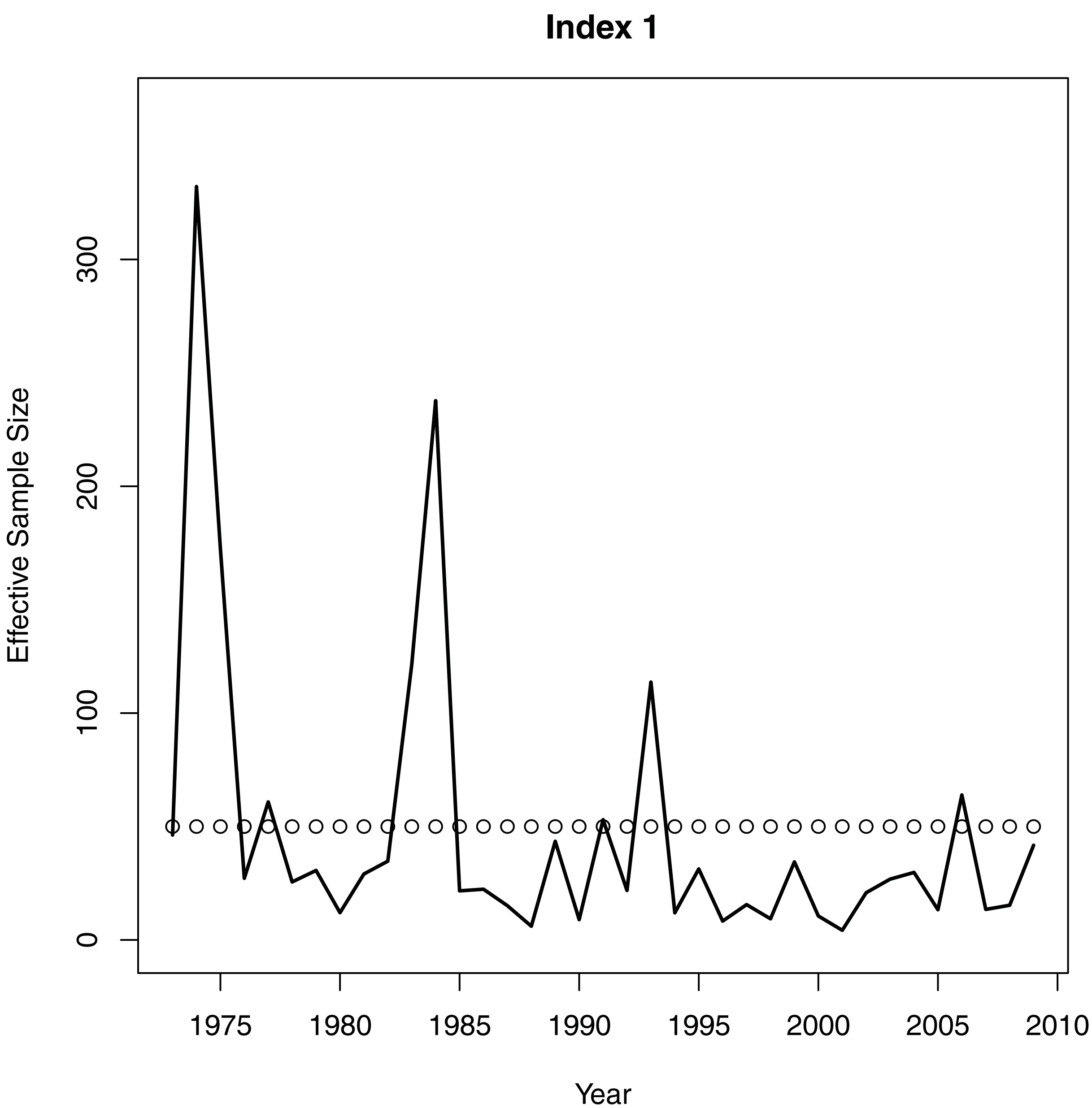
Index 1

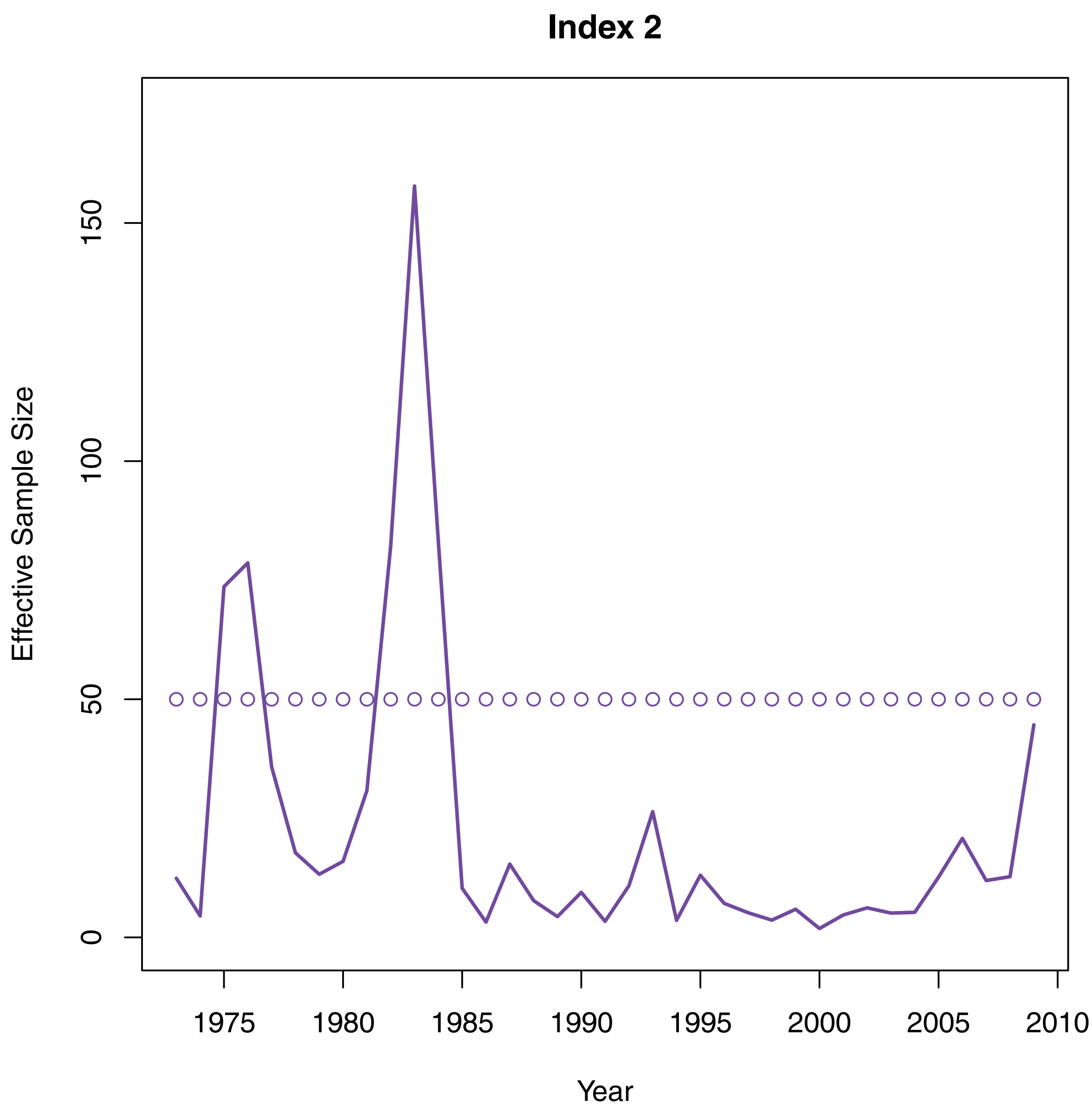

Index
6e+05
4e+05
2e+05
0e+00
1975
1985
1995
2005
Year
Ln(Index)
15
10
5
0
1975
1985
1995
2005
Age
Standardized Residual
4
2
0
−2
−4
−6
−8
1975
1985
1995
2005
Year
Probability Density
0.15
0.10
0.05
0.00
−8
−6
−4
−2
0
2
4
Std. Residual

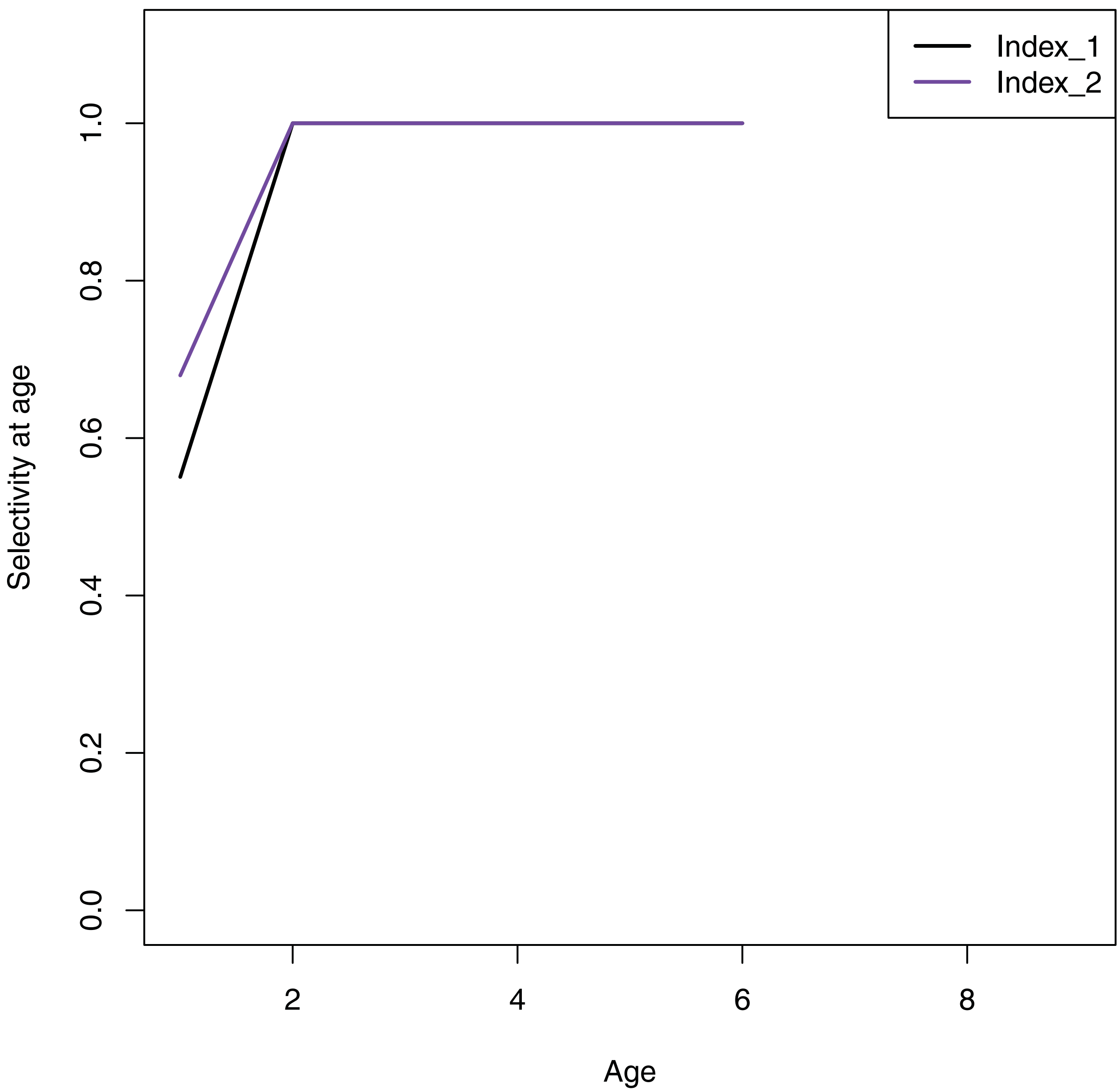

Index 2
Index
0e+00
2e+05
4e+05
1975
1985
1995
2005
Year
Ln(Index)
0
2
4
6
8
10
12
14
Age
Standardized Residual
−5
0
5
Probability Density
0.00
0.05
0.10
0.15
Std. Residual

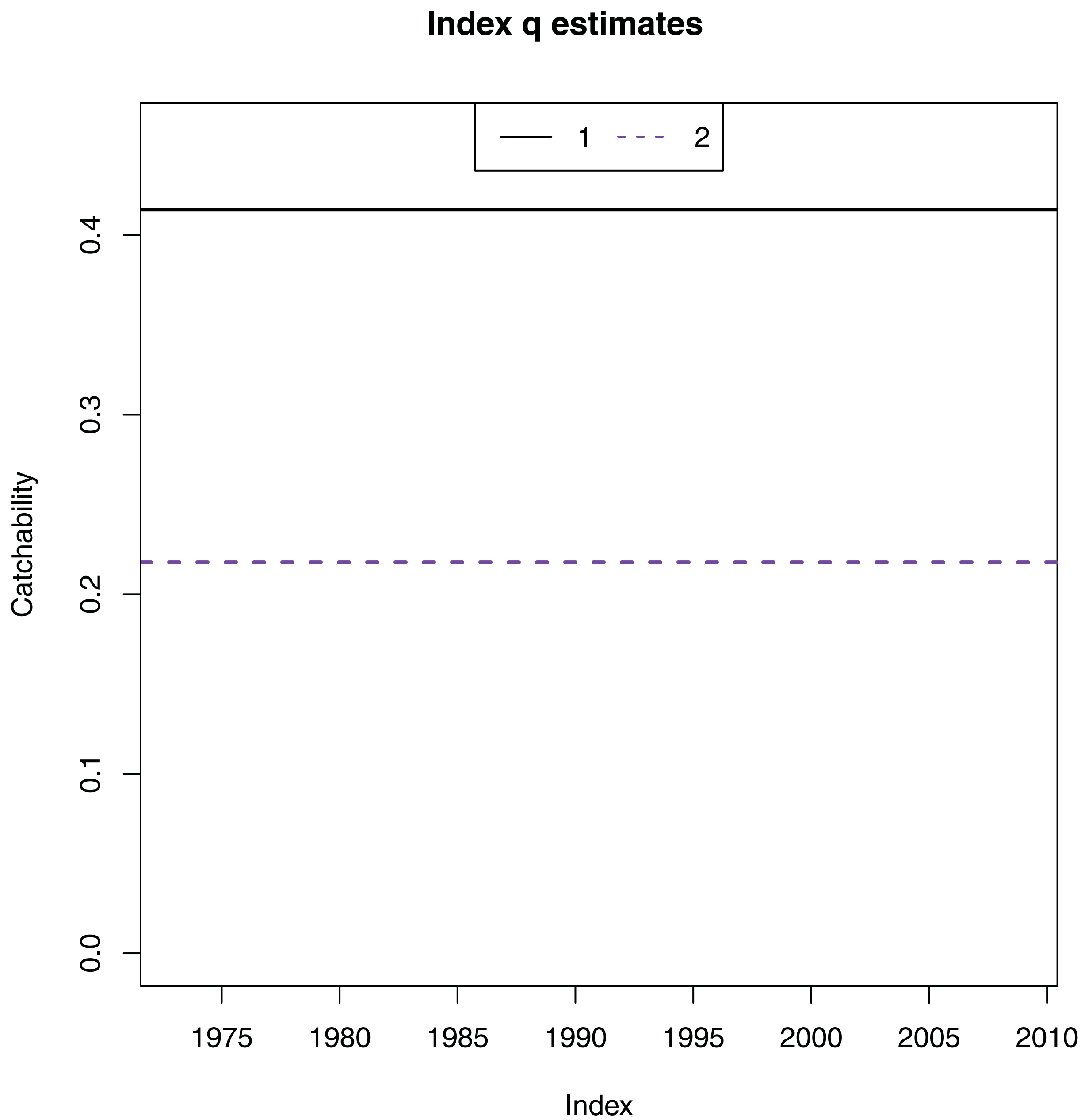

Age Comp Residuals for Index 1
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Residuals
1
2
3
4
5
6
Age

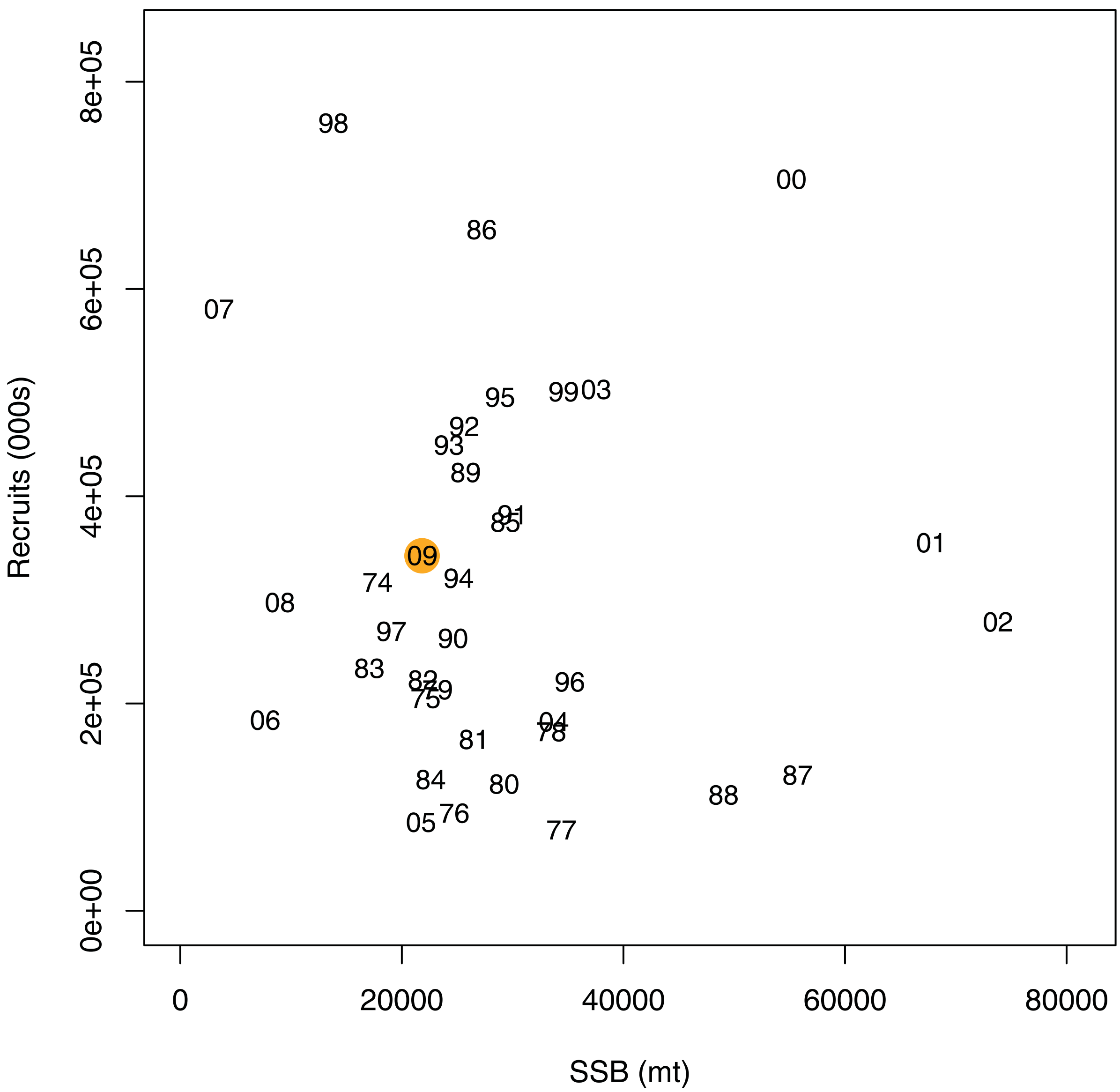

Age Comp Residuals for Index 2
Residuals
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
1
2
3
4
5
6
Age

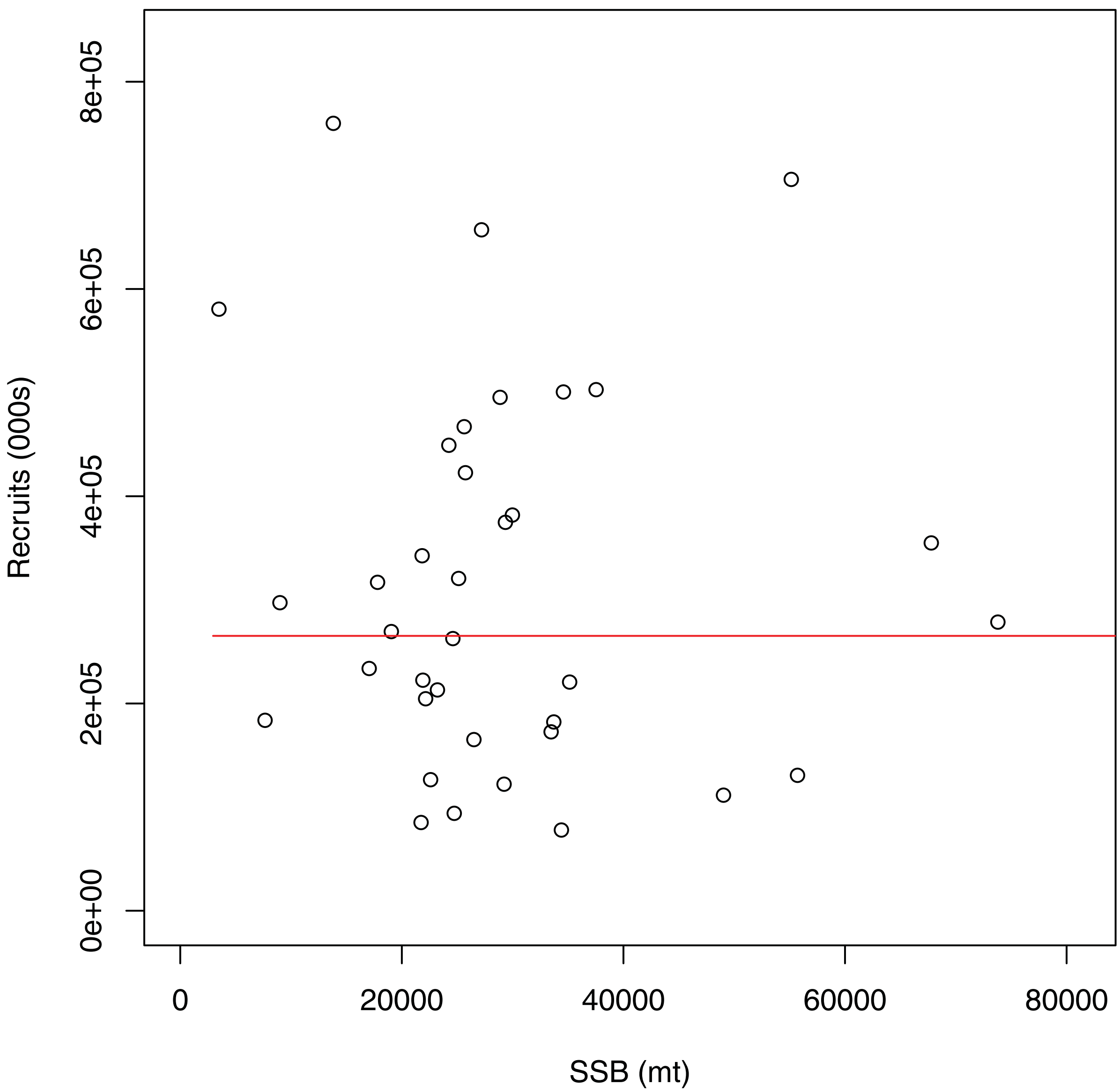

Index 1
Effective Sample Size
0
100
200
300
1975
1980
1985
1990
1995
2000
2005
2010
Year

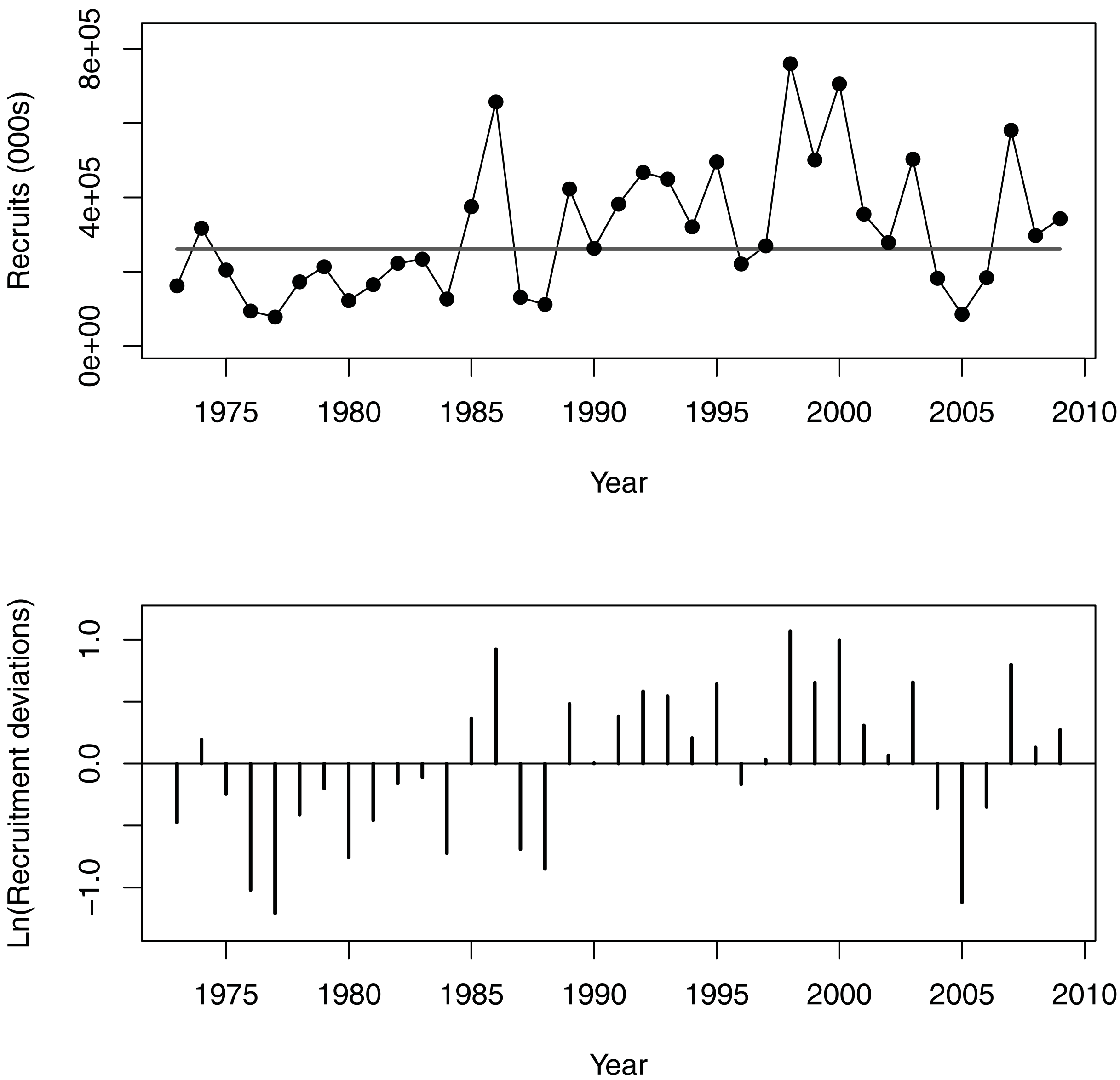

Index 2
Effective Sample Size
0
50
100
150
1975
1980
1985
1990
1995
2000
2005
2010
Year


Index_1
Index_2
Selectivity at age
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
Age

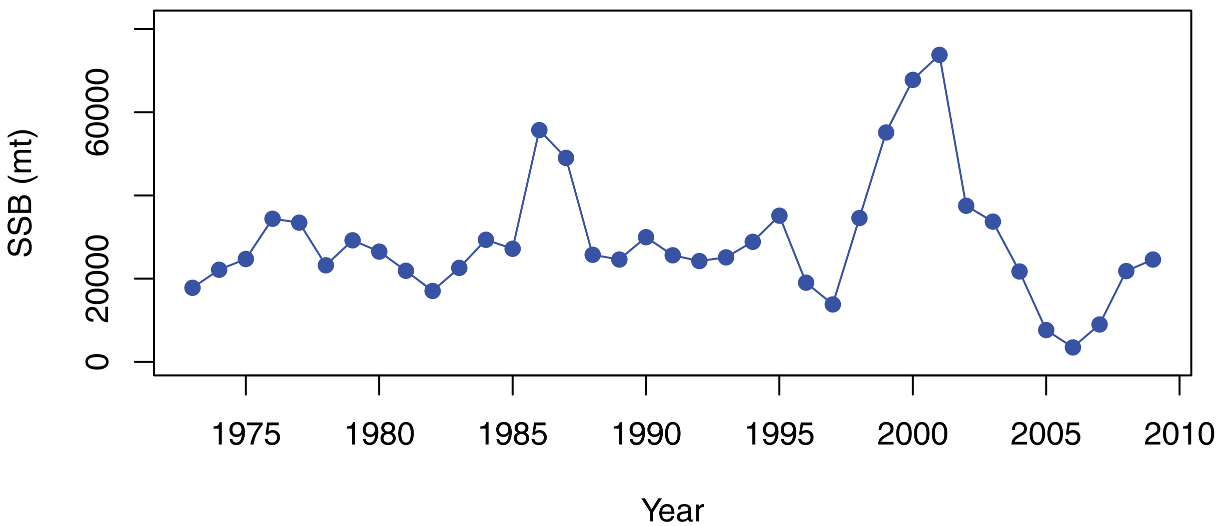

Index q estimates
1
2
Catchability
0.0
0.1
0.2
0.3
0.4
1975
1980
1985
1990
1995
2000
2005
2010
Index

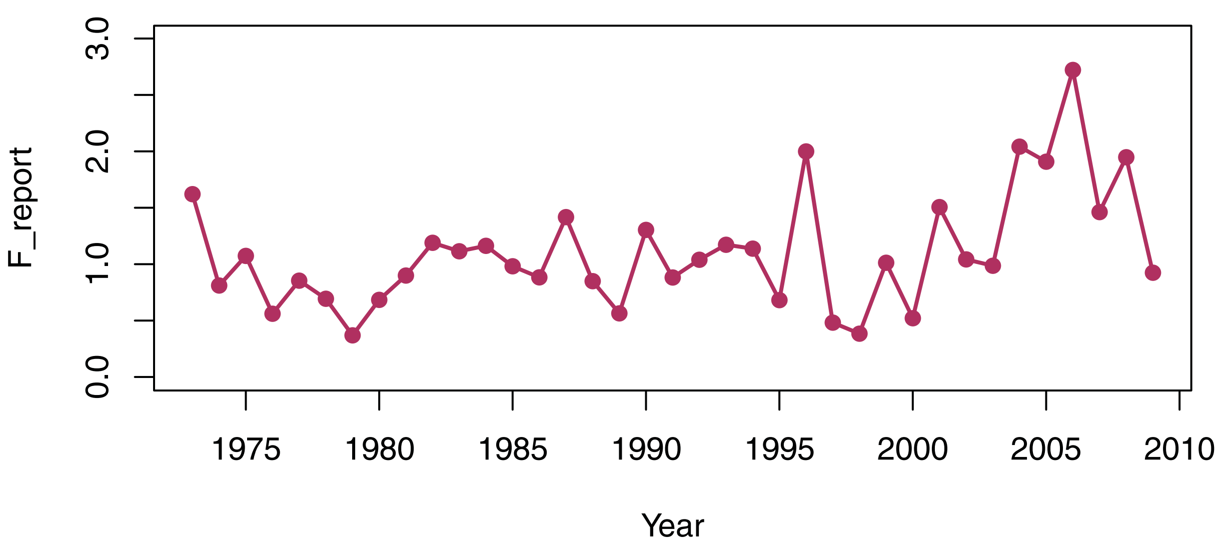

Recruits (000s)
0e+00
2e+05
4e+05
6e+05
8e+05
SSB (mt)
0
20000
40000
60000
80000
98
00
86
07
95
99
03
92
93
89
91
85
01
09
74
94
08
02
97
90
83
82
79
75
96
06
04
78
81
87
84
80
88
05
76
77

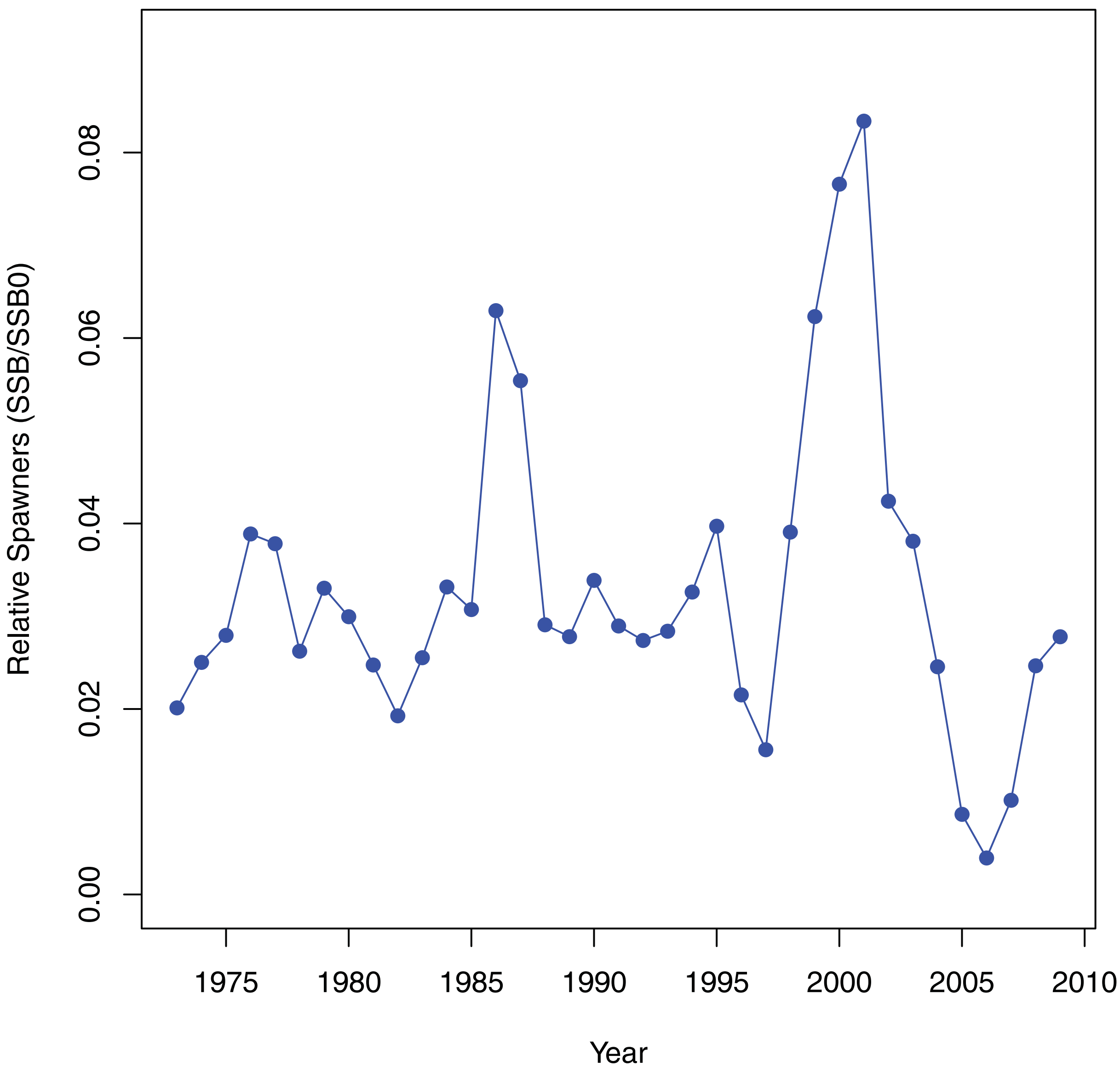

8e+05
6e+05
4e+05
2e+05
0e+00
Recruits (000s)
0
20000
40000
60000
80000
SSB (mt)

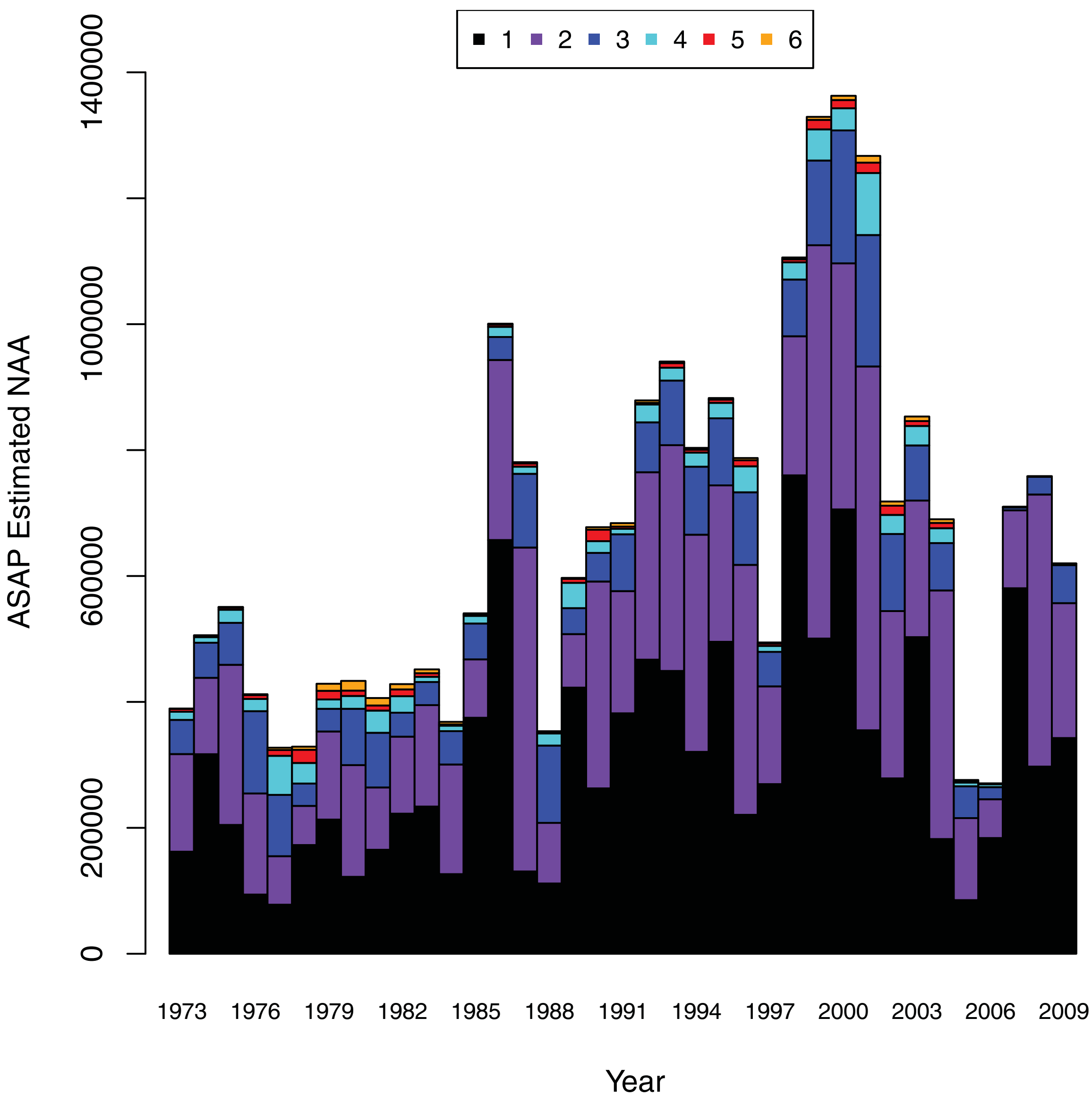


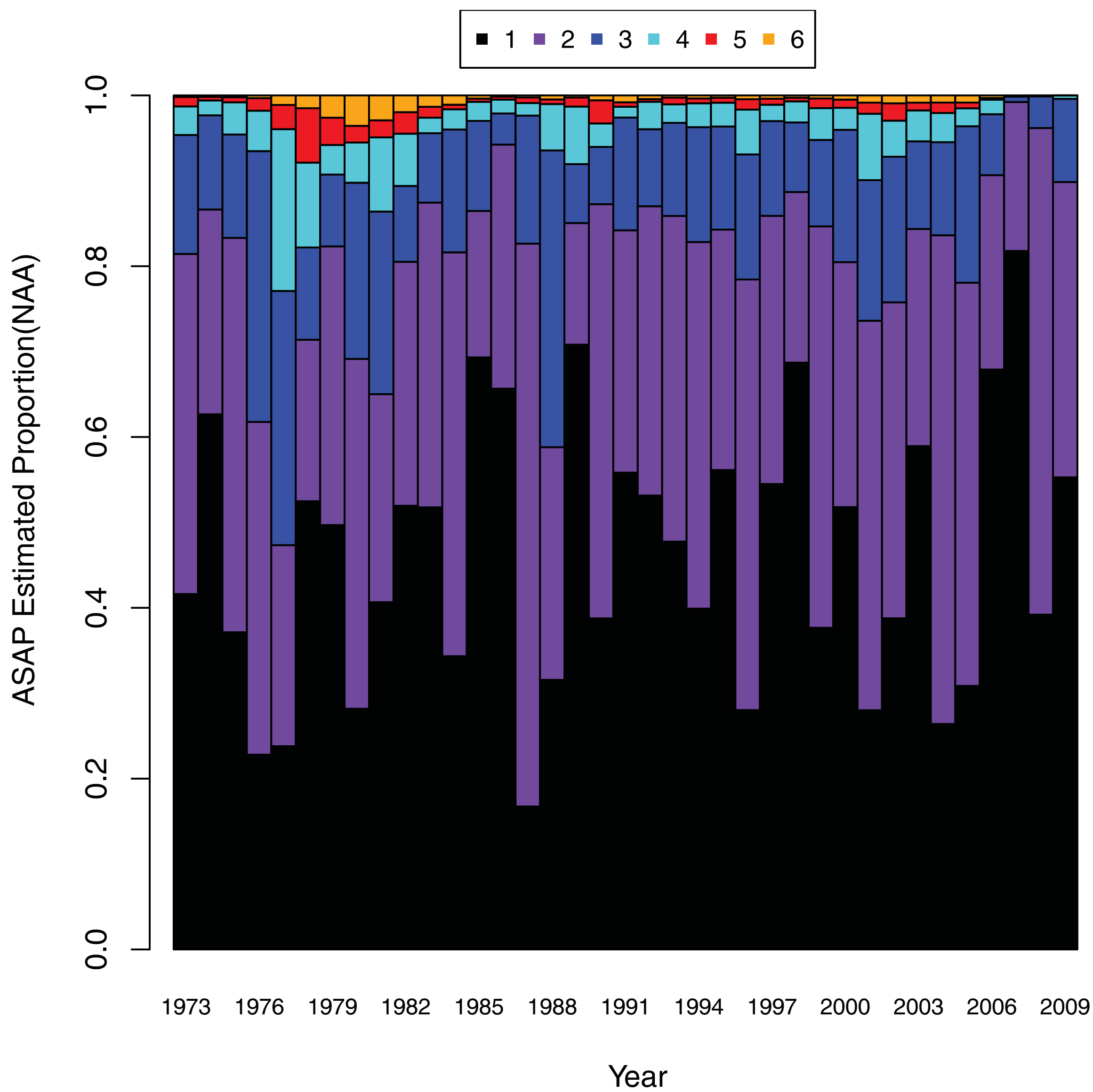
Recruits (000s)
0e+00
4e+05
8e+05
1975
1980
1985
1990
1995
2000
2005
2010
Year
Ln(Recruitment deviations)
−1.0
0.0
1.0
1975
1980
1985
1990
1995
2000
2005
2010
Year

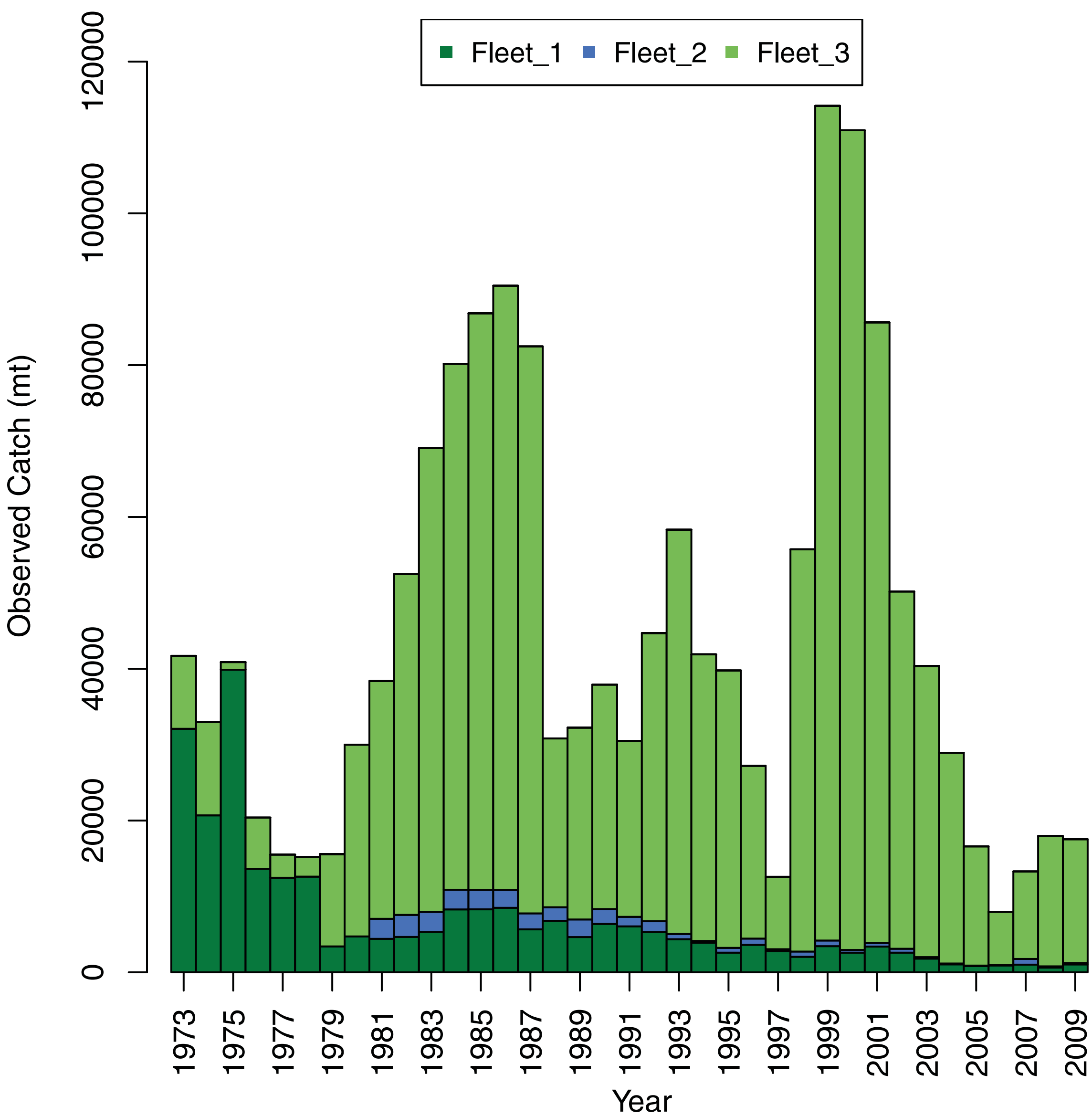

SSB (mt)
0
20000
60000
1975
1980
1985
1990
1995
2000
2005
2010
Year

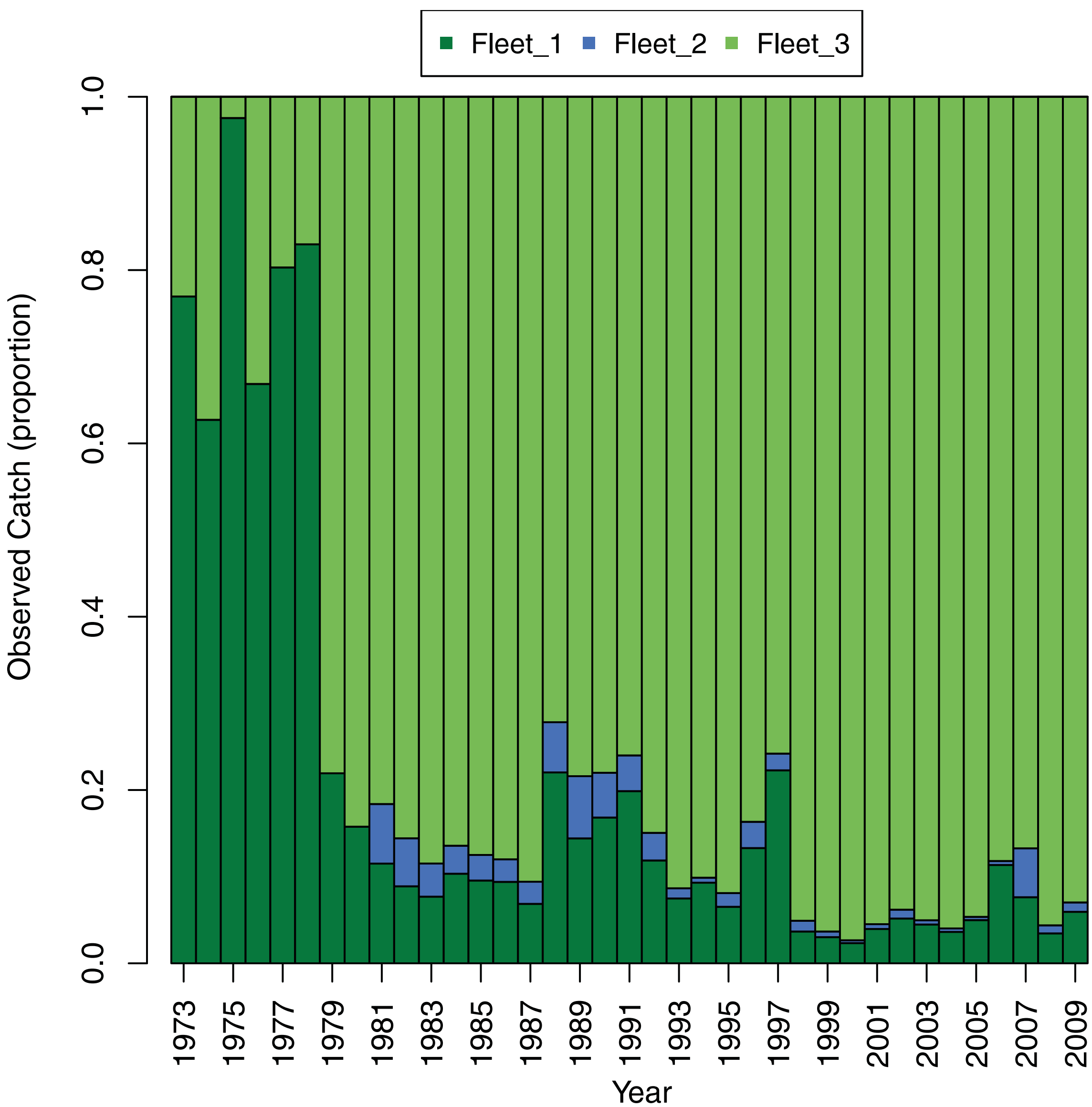

F_report
0.0
1.0
2.0
3.0
1975
1980
1985
1990
1995
2000
2005
2010
Year

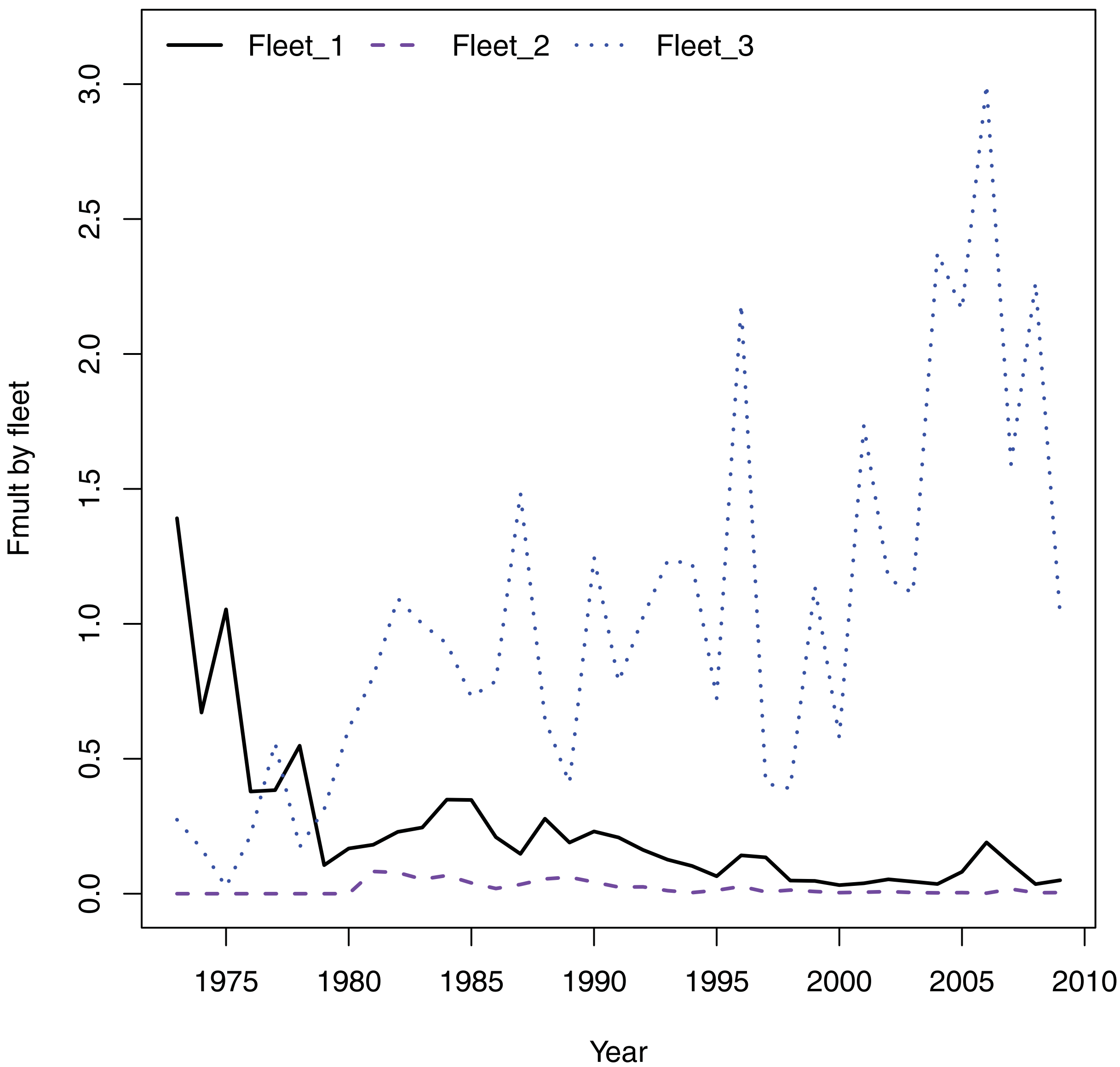

Relative Spawners (SSB/SSB0)
0.00
0.02
0.04
0.06
0.08
1975
1980
1985
1990
1995
2000
2005
2010
Year

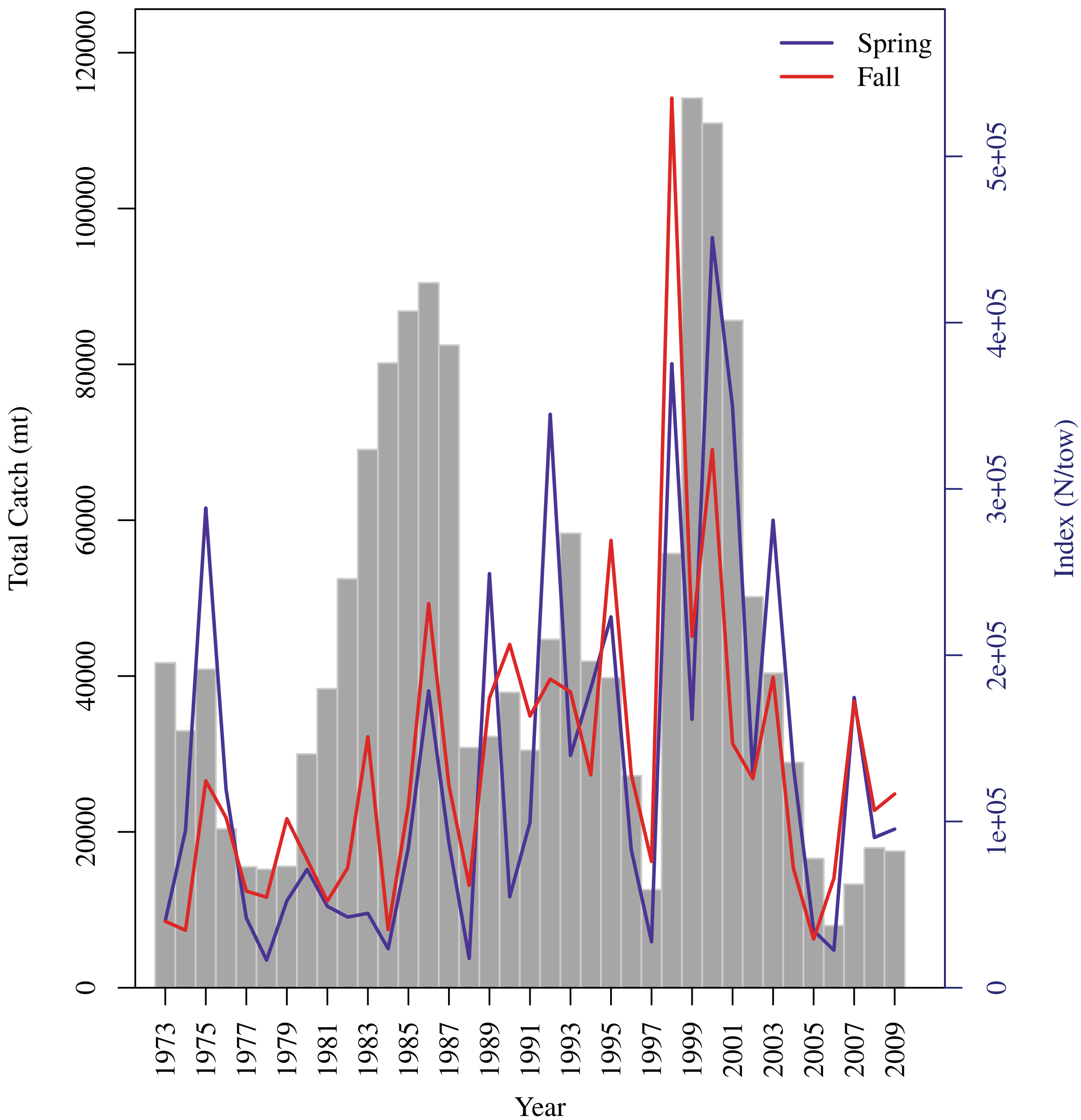

1
2
3
4
5
6
ASAP Estimated NAA
0
200000
600000
1000000
1400000
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
Year

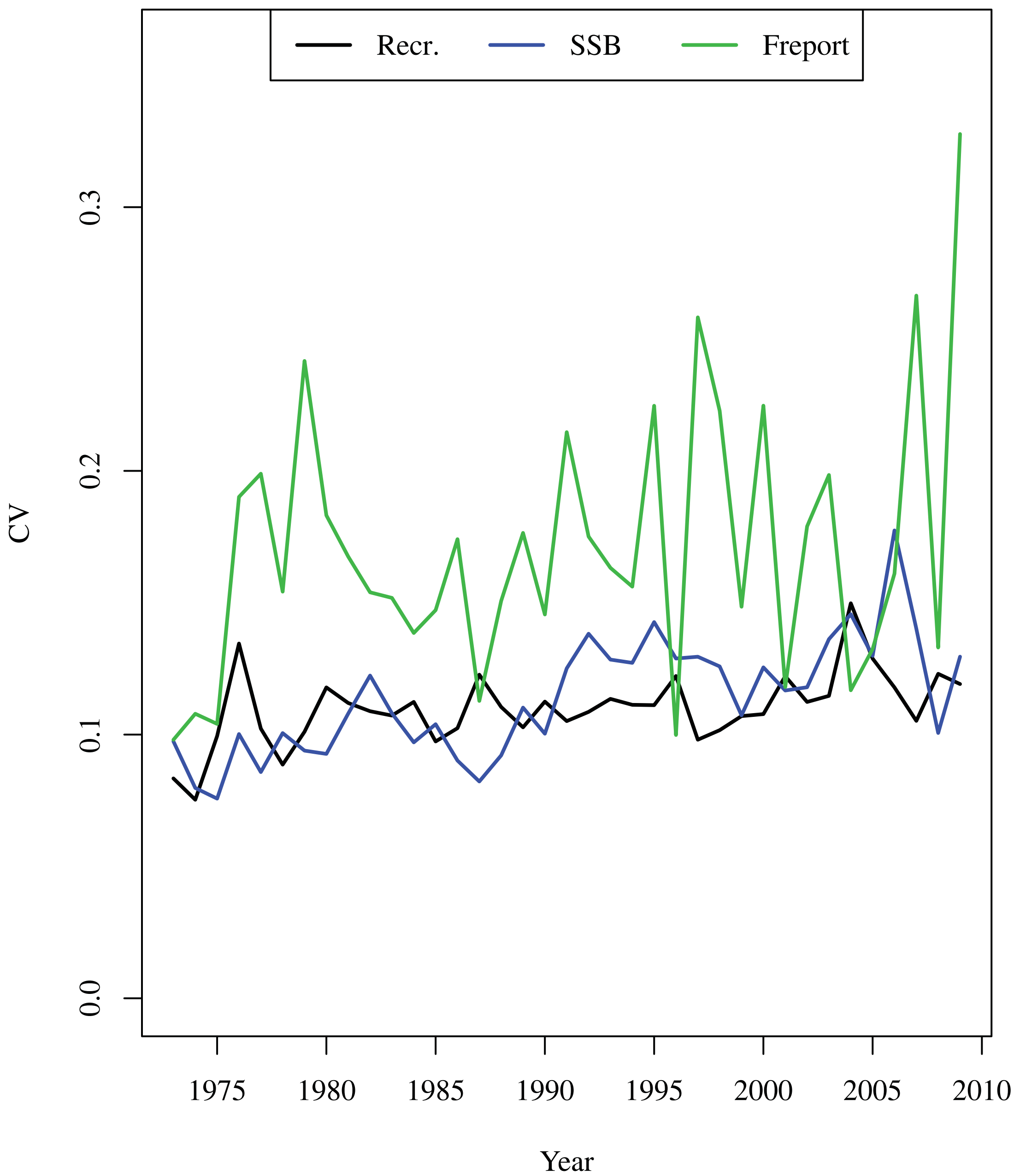

1
2
3
4
5
6
ASAP Estimated Proportion(NAA)
0.0
0.2
0.4
0.6
0.8
1.0
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
Year


Fleet_1
Fleet_2
Fleet_3
Observed Catch (mt)
0
20000
40000
60000
80000
100000
120000
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year

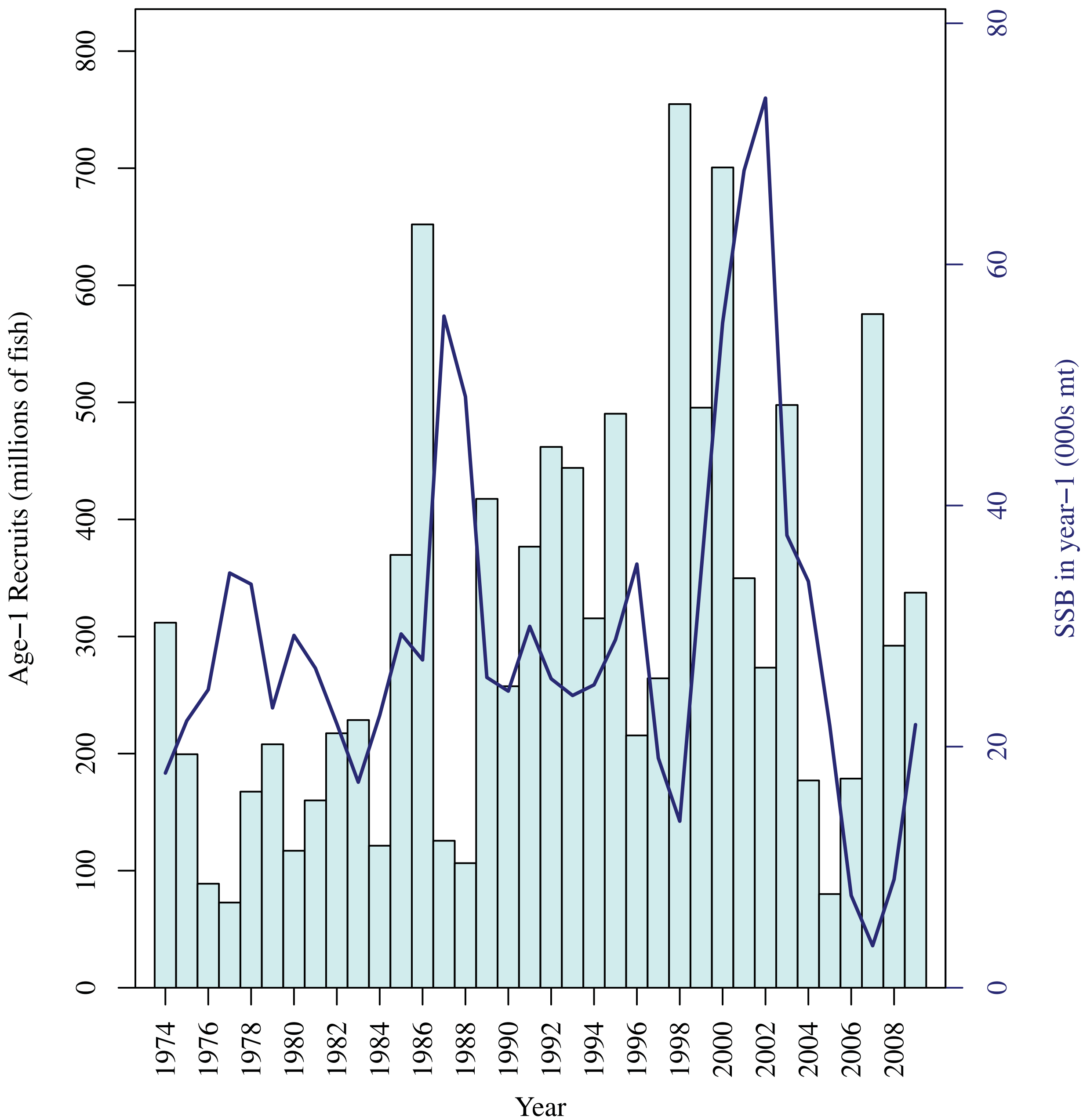

Fleet_1
Fleet_2
Fleet_3
Observed Catch (proportion)
0.0
0.2
0.4
0.6
0.8
1.0
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year


Fleet_1
Fleet_2
Fleet_3
Fmult by fleet
0.0
0.5
1.0
1.5
2.0
2.5
3.0
1975
1980
1985
1990
1995
2000
2005
2010
Year


Spring
Fall
Total Catch (mt)
Index (N/tow)
Year
0
20000
40000
60000
80000
100000
120000
1e+05
2e+05
3e+05
4e+05
5e+05
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009



Recr.
SSB
Freport
CV
0.0
0.1
0.2
0.3
1975
1980
1985
1990
1995
2000
2005
2010
Year


Age−1 Recruits (millions of fish)
SSB in year−1 (000s mt)
Year
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
0
100
200
300
400
500
600
700
800
0
20
40
60
80