B. STOCK ASSESSMENT OF BLACK SEA BASS FOR 2011

[SAW-53 Editor's Note: The SARC-53 review panel accepted the work done on TORs 1-4, but rejected the results of all new work done on TOR 5, on stock status and on stock projections. The SARC concluded that the results from the new black sea bass ASAP model developed in Fall 2011 for SAW/SARC-53 should NOT be used at this time to determine stock status or for management advice. The ASAP model and results are included in the body of this report just to show the work that was done by the SAW Working Group for the December 2011 peer review.]

Executive Summary

The principal gears used in commercial fishing for black sea bass are fish pots, otter trawl and hand-line. Commercial landings peaked in 1952 at 9,900 mt then declined markedly during the 1960s until commercial landings during the late 1980s and 1990s averaged 1,300 mt. Commercial fishery quotas were implemented in 1998 but landings remained stable between 1,300 mt and 1,600 mt until 2007. Recent quota restrictions resulted in declining commercial landings of 523 and 751 mt in 2009 and 2010, respectively. The recreational rod-and-reel fishery for black sea bass harvests a significant proportion of the total catch. After peaking in 1986, recreational landings averaged 1,700 mt annually until 1997. Recreational fishery harvest limits were implemented in 1998 and landings have since ranged between 500 mt and 2,000 mt. Landings in 2010 were 1,350 mt. Commercial fishery discard losses, although poorly estimated, appear to be a minor part of the total fishery removals from the stock, generally less than 200 mt per year. Recreational discard losses assuming 15% hook and release mortality are similar, ranging from 30 to 390 mt per year.

The 2008 Northeast Data Poor Stocks Working Group (NEDPSWG) Review Panel (NEFSC 2009a) recommended $F_{40\%}$ be used as a proxy for F_{MSY} and spawning stock biomass at $F_{40\%}$ ($SSB_{40\%}$) be used as the proxy for the stock biomass target reference point. The SCALE model, which was accepted (NEFSC 2009a,b), was most recently used in June and July 2011 (MAFMC 2011; NEFSC 2011) to estimate the status of the stock compared to previously accepted reference points. Based on that analysis, a comparison of 2010 estimates of the spawning stock biomass and fishing mortality rate to existing biological reference points (SSB_{MSY} proxy estimate = 12,537 mt and F_{MSY} proxy estimate = 0.42) indicated that black sea bass was not overfished and overfishing was not occurring. SSB in 2010 was estimated to be 13,926 mt (30.7 million lbs) and the fully selected F was estimated to be 0.41. The 2010 stock was at 111% of the SSB_{MSY} proxy. Based on deterministic projections for 2012 at the F_{MSY} proxy (0.42), the resulting catch would be 3,551 mt (7.8 million lbs) with landings equal to 2,841 mt (6.3 million lbs) (assuming the release mortality rate that was used in June 2011).

SDWG-data meeting participants:

BSB WG Data meeting September 19-September 20, 2011

BSB WG Model meeting October 18-October 20, 2011

Name	Affiliation	Data Mtg.	Model Mtg.
Mark Terceiro (chair)	NEFSC	x	x
Gary Shepherd	NEFSC	x	x
Chris Batsavage	NC DMF	x	
Toni Kerns	ASMFC	x	x
Jason McNamee	RI DFW	x	x
Jeff Brust	NJ DFW	x	x
Allison Watts	VA MRC	x	
Steve Doctor	MD DNR	x	x
Tony Wood	NEFSC	x	
Paul Caruso	MA DMF	x	x
Julie Nieland	NEFSC	x	x
Paul Nitschke	NEFSC	x	x
Jessica Coakley	MAFMC	x	x
Rich McBride	NEFSC	x	
Mark Wuenschel	NEFSC	x	
Jason Morsen	Rutgers	x	
Greg Wojcik	CT DEP	x	x
Eric Powell	Rutgers	x	x
Jon Deroba	NEFSC	x	
David McElroy	NEFSC		x
Chad Keith	NEFSC		x
Rob O'Reilly	VA MRC		x
Rich Wong	DE DEP		x
Kiersten Curti	NEFSC		x
Jim Weinberg	NEFSC		x
Ray Kane	Fisherman		x
Dorwine Allen	Fisherman		x
Al Keller	Fisherman		x
Rick Rozen	Fisherman		x
Joe Huckemeyer	Fisherman		x

Introduction

Life History

Black sea bass (*Centropristis striata*) are distributed from the Gulf of Maine to the Gulf of Mexico, however, fish north of Cape Hatteras, NC are considered part of a single fishery management unit. Sea bass are generally considered structure oriented, preferring live-bottom and reef habitats. Within the stock area, distribution changes on a seasonal basis and the extent of the seasonal change varies by location. In the northern end of the range (New York to Massachusetts), sea bass move offshore crossing the continental shelf, then south along the edge of the shelf (Moser and Shepherd 2009). By late winter, northern fish may travel as far south as Virginia, however most return to the northern inshore areas by May. Sea bass originating inshore along the Mid-Atlantic coast (New Jersey to Maryland) head offshore to the shelf edge during late autumn, travelling in a southeasterly direction. They return inshore in spring to the general area from which they originated. Black sea bass in the southern end of the stock (Virginia and North Carolina) move offshore in late autumn/early winter. Given the proximity of the shelf edge, they transit a relatively short distance, due east, to reach over-wintering areas (Figure B1).

Fisheries also change seasonally with changes in distribution. Inshore commercial fisheries are prosecuted primarily with fish pots (baited and unbaited) and handlines. Recreational fisheries generally occur during the period that sea bass are inshore. Once fish move offshore in the winter, they are caught in a trawl fishery targeting summer flounder, scup and *Loligo* squid (Shepherd and Terceiro, 1994). Handline and pot fisheries in the southern areas may still operate during this offshore period. Additionally a small sector of the NJ charter fleet target sea bass offshore during the winter.

Black sea bass are protogynous hermaphrodites and can be categorized as temperate reef fishes (Steimle et al. 1999, Drohan et al. 2007). Transition from female to male generally occurs between the ages of two and five (Lavenda 1949, Mercer 1978). Based on sex ratio at length from NMFS surveys, males constitute approximately 35% of the population by 15 cm, with increasing proportions of males with size (Figure B2). Following transition from female to male, sea bass can follow one of two behavioral pathways; either becoming a dominant male, characterized by a larger size and a bright blue nuccal hump during spawning season, or subordinate males which have few distinguishing features. The initiation of sexual transition appears to be based on visual rather than chemical cues (Dr. David Berlinsky, UNH, Personal communication). In studies of protogny, among several coral reef fish species, transition of the largest female to male may occur quickly if the dominate male is removed from the reef, however, similar studies have not been published for black sea bass.

Spawning in the Middle Atlantic peaks during spring (May and June) when the fish reside in coastal waters (Drohan et al. 2007). The social structure of the spawning aggregations is poorly known although some observations suggest that large dominant males gather a harem of females and aggressively defend territory during spawning season (Nelson et al. 2003). The bright coloration of males during spawning season suggests that visual cues may be important in structuring of the social hierarchy.

Black sea bass attain a maximum size around 60 cm and 4 kg. Growth curves are available from only one published study as well as several unpublished studies. Lavenda (1949) suggested a maximum age for females of 8 and age 12 for males. However he noted the presence of large males (>45 cm) in deeper water that may have been older. A working paper considering recent maturity and sex ratio data by Wuenschel et al. is provided in Appendix 1.

Fisheries

In the Northwest Atlantic, black sea bass support commercial and recreational fisheries. Prior to WWII in 1939 and 1940, 46-48% of the commercial landings were in New England, primarily in Massachusetts. After 1940, the center of the fishery shifted south to New York, New Jersey and Virginia. Landings increased to a peak in 1952 at 9,883 MT with the bulk of the commercial landings from otter trawls, then declined steadily reaching a low point in 1971 of 566 MT. Historically, trawl fisheries for sea bass have focused on the over-wintering areas near the shelf edge. Inshore pot fisheries, which were primarily in New Jersey, showed a similar downward trend in landings between the peak in 1952 and the late 1960s. The large increase in landings during the 1950's appears to be the result of increased landings from otter trawlers, particularly from New York, New Jersey and Virginia. During the same period, a large increase in fish pot effort, and subsequent landings, occurred in New Jersey. In recent years, fish pots and otter trawls account for the majority of commercial landings with increasing contributions from hand-line fisheries. The species affinity for bottom structure and reefs during its seasonal period of inshore residency increases the availability to hook and line or trap fisheries while decreasing susceptibility to bottom trawl gear.

Stock assessment history summary

Black sea bass stock assessments have been reviewed in the SARC/SAW process (SAWs 1, 9, 11, 20, 25, 27, 39 and 43) beginning with an index based assessment in 1991. In 1995 a VPA model was approved and the results generally showed fishing mortalities exceeding 1.0 (estimated using an M=0.2). The VPA was reviewed again in 1997 and at this time was considered too uncertain to determine stock status but indicative of general trends. In 1998, another review was conducted and both VPA and production models were rejected as either too uncertain or inappropriate for use with an hermaphroditic species. A suggestion was made to use an alternative method such as a tag/recapture approach. The NEFSC survey remained the main source of information regarding relative abundance and stock status. A tagging program was initiated in 2002 and the first year results were presented for peer review in 2004. The review panel concluded that a simple tag model using the proportion recovered in the first year at large, as well as an analysis of survey indices, produced acceptable results to determine exploitation rate and stock status. The release of tags continued through 2004 and results of tag models as well as indices were presented for SARC review in 2006. Their findings were that the tag model did not meet the necessary assumptions and the variability in the survey indices created uncertainty which prevented determination of stock status. The panel did not recommend any alternative reference points, however they did recommend continued work on length based analytical models. Black sea bass were once again considered at the NDPSWG in December 2008. The review panel considered a statistical catch-at-length model (SCALE) and a variety of natural mortality options. That panel concluded that the length-based model was suitable for evaluating stock status and recommended a constant natural mortality option of 0.4. Although the stock was considered not overfished or experiencing overfishing, the uncertainty in the results prompted the reviewers to recommend caution in applying the results for management.

SAW/SARC 53 Terms of Reference

B. Black sea bass

1. Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data. Evaluate available information on discard mortality and, if appropriate, update mortality rates applied to discard components of the catch. Describe the spatial and temporal distribution of fishing effort.

2. Present the survey data being used in the assessment (e.g., indices of abundance, recruitment, state surveys, age-length data, etc.). Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.

3. Consider known aspects of seasonal migration and availability of black sea bass, and investigate ways to incorporate these into the stock assessment. Based on the known aspects, evaluate whether more than one management unit should be used for black sea bass from Cape Hatteras north and, if so, propose unit delineations that could be considered by the Mid-Atlantic Fishery Management Council and for use in future stock assessments.

4. Investigate estimates of natural mortality rate, M, and if possible incorporate the results into TOR-5. Consider including sex- and age-specific rate estimates, if they can be supported by the data.

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

assessment results.

6. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, F_{MSY}, and MSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the appropriateness of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

7. Evaluate stock status with respect to the existing model (from the most recent accepted peer reviewed assessment) and with respect to a new model developed for this peer review.
   a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.
   b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs (from black sea bass TOR 6).
8. Develop and apply analytical approaches to conduct single and multi-year stock projections to compute the PDF (probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).
   a. Provide numerical annual projections (3-5 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment, and definition of BRPs for black sea bass).
   b. Comment on which projections seem most realistic. Consider major uncertainties in the assessment as well as the sensitivity of the projections to various assumptions.
   c. Describe this stock's vulnerability (see "Appendix to the SAW TORs") 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.

TOR 1. Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data. Evaluate available information on discard mortality and, if appropriate, update mortality rates applied to discard components of the catch. Describe the spatial and temporal distribution of fishing effort.

Commercial fishery

The commercial fishery on the northern black sea bass stock (Maine to Cape Hatteras, NC) is prosecuted primarily with fish pots, otter trawls and hand lines (Figure B3). Fish pots and hand lines are generally fished in inshore waters and target black sea bass (with the exception of some lobster and sea bass targets in NY). Trawls are generally offshore in the winter months in conjunction with summer flounder and scup fisheries (Shepherd and Terceiro 1994). Fish pots have accounted for 46% of landings since 1998, followed by otter trawls at 38% and hand lines at 10%. Other gears account for 6%. The majority of the landings occur in January through June (Figure B4). Total landings by NMFS statistical areas are presented for 2008-2010 in Figures B5-B7.

Trends in landings were relatively stable at around 1,300 MT until 2007 (Table B1, Figures B8, B9). State and Federal management plans were implemented in 1998 which included minimum size restrictions and commercial quotas. In 2008, additional quota regulations were enacted which decreased landings to an average of 720 MT between 2008 and 2010. The commercial sea bass fishery is prosecuted in all states between Massachusetts and North Carolina however Massachusetts, New Jersey and Virginia account for 50-60% of total commercial landings (Figure B10)

Length measurements (cm) of sea bass in the commercial landings are sampled by NMFS in ports from Maine to North Carolina. Samples are collected from boxes of fish available from dealers and sorted by market category. Market categories are extra small, small, medium, large and jumbo. Length frequencies by market category and half year were expanded to total catch beginning with 1984, the first year associated age data were available. NMFS samples were supplemented with similar information collected by the state of North Carolina between 1984 and 1998. The NC lengths measurements were combined with NMFS data by market category and half year. Sample sizes and total number of fish measured from NMFS and NC data are provided in Tables B2-B6. Expansion requires weight at length information which was available from NMFS spring and autumn survey data since 1992. The equations applied to all length samples by season were:

Spring: 1.0428e-5 *len^3.072
Autumn: 1.2924e-5*len^3.027

In the expansion process, missing cells were replaced with lengths from the same market category and the closest year or years containing measurements. The extra small category in years 2000 to 2010 were minimal and the few lengths available matched the smalls. Therefore in those years, extra smalls were combined with smalls. Changes in the length distributions resulting from changes in regulations are shown in Figure B11. Recent length distributions (2005-2010) are displayed in Figure B12.

The total number of black sea bass landed has declined since 1996 (5.1 million) to a low of 926,000 in 2009. Landings in 2010 increased slightly to 1.3 million. Mean length in the landings were relatively stable between 1984 and 1996 around 26 cm (Table B7, Figure B13). Mean length rose steadily from 28 cm in 1997 to 34 cm in 2004 where it has remained on average until 2010 (Figure B14). The small market category averaged 59% of landings between 1984 and 1996 before steadily declining and by 2010 the small category comprised only 9% of landings (Figure B15). Mediums were replaced as the dominant market category with 45% of landings in 2010. The large category also showed a proportional increase from 9% between 1984 and 1996 to 25% by 2010.

Commercial discards

Estimated discards were calculated for the three primary gear types. Otter trawl discards were calculated using the Standard By-catch Reporting Methodology (SBRM) (Wigley et al 2008). SBRM relies on information collected by NMFS observers on a sub-sample of commercial trips as part of a program begun in 1989. Discards per year and quarter are estimated as the ratio of recorded discards for the species in question to recorded kept of all species landed, multiplied by the total reported landings of all species in that time strata. The associated CV for the estimate is also calculated (Table B8). The observer program does not regularly monitor hand-line or pot trips, therefore the SBRM estimates were only made for otter trawls trips. Prior to observer coverage in 1989, discards were estimated using landings of sea bass, scup and summer flounder which are the principle targeted species in the sea bass winter trawl fishery. For the period 1989 to 1992, a ratio was calculated between sea bass discards and total sea bass, summer flounder and scup landings targeted by the trawl fleet. This ratio was then applied to sea bass, flounder and scup landings between 1984 and 1988 as an estimate of sea bass discards.

Pot and hand-line discards from 1994-2010 were estimated from self-reported vessel trip logs (VTR), adjusted to total landings by gear. VTR logs were not required prior to 1994, therefore the 1984 to 1993 discard estimates were based on the discard to landing ratio for 1994-1996, by half year. This ratio was applied to sea bass landings by gear type.

Discards from the trawl fishery were assumed to suffer 100% mortality because of depths fished and length of tow time. Discard mortalities of 15% were applied to pot and hand-line discards. The rational was that depths fished generally resulted in minimal barotrauma and the volume of fish in a pot catch would result in minimal damage to released fish. Hand-line discard mortality was assumed equivalent to recreational discard mortalities.

Discards prior to 1984 were not estimated by fishery. A ratio of 0.06 (std. dev among annual ratios = 0.011) was developed from the median discard to landings ratio from 1984 to 1996. This ratio was applied to total landings (commercial plus recreational) for the period 1968 to 1983 to produce estimates of total discards. Discards by fishery reported in Table B1 were calculated from the proportion of commercial to recreational discards in 1984-1996 and applied to total discards for that period. The stock assessment model does not incorporate the landings and discards by fishery but instead uses total catch as a single fleet.

The time series of commercial discard length frequencies available for age expansion was limited (Table B9). Length samples from observer trawl trips were available from 1989 and 1995-2010 in the spring and 1994-1997 and 2000-2010 in the fall. There were few observations from fish pot trips (none from hand-line) vessels (Table B9), therefore the samples were combined with otter trawl discards lengths. Annual commercial discard length distributions show a shift in the size composition over time (Figure B16). Prior to the FMP, discards were composed primarily of sizes below 30 cm. As minimum sizes and quotas went into effect the size distribution increased (likely due to gear changes) and included larger individuals of legal size.

Recreational Landings and Discards

Information from the NMFS Marine Recreational Fishery Statistical Survey (MRFSS) was downloaded from the website (http://www.st.nmfs.noaa.gov/st1/recreational/queries/index.html) for Mid-Atlantic and North Atlantic AB1 fish (fish kept or fish filleted, released dead, disposed in some other way) (Table B1, B10) and B2 fish (released alive) (Table B11). Estimates are provided for waves (two month period) 2 to 6. Wave 1 (Jan/Feb) is not sampled in the Northeast/ however since 2004, wave 1 estimates have been produced for North Carolina. Catch estimates by wave and year include a value for proportional standard error (PSE).

Since North Carolina catch may occur from either stock (partitioned at Cape Hatteras, NC) annual MRFSS catches are split north and south of Hatteras based on intercept sites. MRFSS estimates are provided as number of fish for AB1, B2 and weight (kg) of AB1 catches. Total weight of discards was derived by applying a length-weight equation to the expanded discard length frequencies. In the time series of catch in numbers, 1982 and 1986 appear as anomalies. The 1982 increase can be attributed to outliers in MD and VA estimates since it is unreasonable to assume that landings increased by a factor of 3 or 4 in a single year. For purposes of the analysis, the MRFSS value in 1982 (which was not expanded by age in the model) was replaced with an average of 1981 and 1983. The high 1986 MRFSS estimate was influenced by an unusually large estimate in NJ wave 5. The NJ wave 5 value was replaced with the average AB1 of waves 4 and 6, then re-summed.

Stockwide recreational landings averaged 1700 MT between 2000 and 2003 then declined to an average of 950 MT thereafter (Table B1, Figure B17). Some of the decline could be attributed to changes in the regulations, particularly minimum size and bag limits beginning in 2008. The majority of sea bass landings (53%) since 2000 are taken in New Jersey (Figure B18). The next closest states, by percentage, are New York (13.4%), Massachusetts (7.8%) and Delaware (7.3%). Since 2000, from MA to VA, 77% of landings have occurred in waves 4 and 5 (July to October), although in 2009 and 2010 this proportion was influenced by seasonal closures. Mean length in the recreational landings averaged 27 cm between 1984 and 1996, then steadily increased to 35 cm by 2003 and has remained at that average length through 2010 (Figure B19).

Previous sea bass assessments assumed a 25% discard mortality in the recreational fishery. That rate was re-evaluated and the WG determined that a15% mortality was more appropriate. This conclusion was based on information from published studies showing mortalities of 5% (Bugley and Shepherd 1991) and 12% (Rudershausen and Buckel 2007), potential barotraumas in the range of depths fished (generally less than 40 m), and published studies for other species (summer flounder, striped bass, snapper, etc.).

Recreational landings for years between 1968 and 1980, prior to the implementation of the MRFSS program, were based on the ratio of commercial to recreational landings between 1981 and 1997 (1982, 1986 and 1995 excluded). The ratio of 1.03 (std. dev among annual ratios=0.441) was applied to commercial landings for that time period to estimate recreational landings. Discard (B2) values for the pre-1981 period were estimated similarly to commercial discards (total discards estimated then divided into commercial and recreational) (Table B11, Figure B20).

Length frequencies of the recreational catch were sampled by MRFSS personnel during dockside interviews. Sample sizes in Table B10 are based on number of annual intercepts. Lengths were expanded to total landings by half year then summed to annual totals (Figure B21). Discard lengths were compiled from a variety of sources. Since the majority of the recreational fishery occurs from July to October, the limited discard data were assumed equivalent to the annual discard totals. The American Littoral Society is a conservation group that promotes fish tagging of recreationally caught fish to follow their movement. Therefore they are by definition B2s (caught and released alive). The lengths of the fish tagged between 1984 and 2010 were available, but measured in inches. Consequently, the length frequencies of all discard measurements were converted to inches. Additional information came from a tagging program conducted by NJDEP from 1995 to 2003 involving hook and line gear. Released fish below the minimum size were classified as discards. NJ also operates a Volunteer Angler Survey program to collect information, including lengths of discarded fish. This information was available for 2008 to 2010. New York DEP provided discard length information collected from party/charter boats between 1995 and 1999. Finally, the MRFSS program began at-sea sampling of party/charter boats in 2005. The total number of discard lengths expanded to total discards, and subsequently discards at age, are shown in Table B12.

Since the last benchmark assessment, age-length data is available from the spring and fall NMFS surveys between 1984 and 2010. No data were available for 1997, so we created an average age key from surrounding years. In 2008-2010 the survey age key was supplemented with commercial age samples. Overall, 8,262 ages were used to develop age-length keys, with an average of 107 and 124 ages in spring and fall, respectively, prior to 2008. The addition of the commercial samples in 2008-2010, increased the average to 668 and 315 ages for spring and fall, respectively. These age keys were applied to all indices and fishery lengths. Missing ages were interpolated with information from surrounding years.

The maximum age in the time series was 12, but that was represented by only 1 fish among the 8,262 ages; a total of 21 fish of the 8,262 were age 10 or greater. We truncated the catch at age to a plus group of 7+. In the final CAA, the plus group represented 1% or less with the exception of 2007 at 4% (from spring 2007 recreational catch) (Tables B13-B16; Figures B22-B26). Catch weight at age was developed from the expanded length frequencies at age by half year period, then combined into an overall mean, weighted by half-year catch (Table B18). A CV around the mean weight was developed for the last five years for input to a stochastic yield per recruit model (Table B19).

TOR 2. Present the survey data being used in the assessment (e.g., indices of abundance, recruitment, state surveys, age-length data, etc.). Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.

Survey data available included NMFS winter, spring and fall surveys and state survey data from MA, RI, CT, NY, NJ, MD, VA and the CHESMAP program in Chesapeake Bay.

<u>State Surveys:</u>

The Virginia Institute of Marine Science (VIMS) conducts a monthly trawl survey targeting juvenile fish within Virginia tributaries of the Chesapeake Bay and provided a random stratified index of black sea bass abundance (Figure B27). The index is for black sea bass sampled in May, June, and July since 1989 and contains fish that are less than 110, 150, and 175 mm total length, respectively. All are age-1 fish, assuming a Jan 1 birthdate. Thus, the mean number per tow index for 2010 represents the 2009 year class (spawned in 2009). The results show a declining trend in abundance with above average year classes in 1989, 2001 and 2007. The 2010 index (0.32 fish/tow) was below the series average (0.71 fish/tow).

The CHESMAP program is a trawl survey also conducted by VIMS which targets fish in the Chesapeake Bay (Figure B28). About 80 stations are sampled in March, May, July, September and November beginning in 2002. The age classes sampled include ages 0 to age 2. The results (delta-lognormal mean number per tow) show an increasing abundance of age 1 fish since 2006, with above average indices in 2007 and 2009 (Figure B29).

The Maryland Dept. of Natural Resources conducts surveys from April through October in coastal bays using a 16ft trawl. Twenty sites have been sampled monthly since 1989. Black sea bass collected in the survey are all less than 21 cm and age 1 or less. The index (geometric mean) has not shown any trends and the 2010 index (1.70 fish per tow) was close to the series average of 1.14 fish per tow (Figure B30).

The Northeast Monitoring Program (NEMAP) is a trawl survey conducted between New York and Virginia within the NMFS inshore strata. The series began in 2008 when the Bigelow dropped sampling of those strata. The time series (4 years) is not yet indicative of trends in abundance (Figures B31, B32). No calibration factor is available to convert the NEMAP indices to ALB IV indices.

The New Jersey Department of Environmental Protection conducts a stratified random trawl survey in state waters during January, April, June (Figure B33), August, and October (Figure B34). The index in June shows a large degree of inter-annual variability, likely due to the difficulty sampling inshore near structured habitat. The index in 2010 (1.17 fish/tow) was below the series average (3.3 fish/tow), however the std. deviation of the series average was 4.69. The October survey was primarily age 0 sea bass (Figure B35). The mean number per tow shows high age 0 abundance in 1998 with above average indices in 1999 and 2007.

New York Department of Environmental Conservation has conducted a small mesh trawl survey in Peconic Bay (eastern Long Island) from August to November since 1987 (excluding 2006). Mean CPUE has shown a variable but increasing trend in age 0 black sea bass with the highest index in 2002 followed by 2009. However the 2010 index was among the lowest in the series (Figure B36).

Connecticut Department of Energy and Environmental Protection conducts monthly trawl surveys in Long Island Sound between April and November since 1984 (Figure B37). The sampling intensity is generally 40 stations per month. The survey results were partitioned into spring and fall with the fall index being primarily age 0 and 1 fish (Figures B38 and B39). Both seasonal indices show a variable but increasing trend, with a large age 0 index in 2002 and age 1 in 2008. The state also conducts a seine survey within coastal CT during the fall (Figure B40). The mean number per tow in this survey shows an increasing trend in age 0 sea bass, with peaks occurring in 2001 and 2009. The 2010 value (0.40 fish/tow) exceeded the series average (0.25 fish/tow, std. dev =0.310).

Rhode Island Department of Environmental Management conducts several surveys which catch black sea bass. A seasonal trawl survey in Narragansett Bay and along the coast since 1979 employs a stratified random design as well as several fixed stations (Figure B41). The indices have been highly variable over time, although the spring index includes several above average years since 1999 (Figure B42). The fall index, dominated by age 0 and 1, includes several high values in the mid-1980s and a large age 0 index in 2005 (Figures B43- B44). The 2010 overall index (1.429 fish/tow) was below the series average (4.14 fish/tow, std dev = 6.721). The Department also conducts a coastal pond seine survey

(Figure B45). Although the mean catches per tow are small, it does show an increasing trend, peaking in 2009 at 2.04 fish per tow. The 2010 value (0.06 fish/tow) is well below the series average (0.40 fish/tow, std dev =0.575).

Massachusetts Division of Marine Fisheries has conducted a spring and fall bottom trawl survey in coastal waters of Massachusetts since 1978 (Figures B46-B49). The spring index declined during the 1990s, peaked briefly in 2000, then again in 2008 and 2010. The spring 2011 mean number per tow (0.51) was below the series average (1.40 fish/tow, std dev. 1.226). The fall survey is primarily age 0 sea bass. The trends are similar to spring, with peaks in the early 1980s, a low period in the 1990s with an increasing index through 2005, followed a several years of average indices. The fall 2010 age 0 index was 113.7 which remains above the series average (103.9 fish/tow, std dev = 108.3).

NMFS surveys

The NEFSC winter bottom trawl survey was conducted with stratified random tows in offshore strata between Georges Bank and Virginia between 1992 and 2007. The trawl gear was modified with a chain sweep rather than roller gear used on the spring and autumn surveys. The stratified mean number per tow increased to a peak in 2003 of 3.86 fish/tow before declining to average values by 2007 of 0.5 fish per tow (Figures B50-B52).

The NEFSC spring bottom trawl survey is conducted between Nova Scotia and North Carolina, beginning in 1968. The indices (stratified mean number per tow) for black sea bass were developed using offshore strata containing at least one positive tow in the time series. In addition, the NEFSC autumn bottom trawl survey, which included inshore strata prior to 2009, is dominated by age 0 sea bass. Consequently that survey was included as a young of year index of abundance. Previous assessments using the NMFS data considered a log transformation of catch per tow to reduce the influence of high catches. The WG reconsidered the use of the transformation and concluded that it was unnecessary. The survey is designed to account for variation and the transformation can violate the underlying assumption of the designed survey (T. Miller, NEFSC, pers. comm.). Therefore the indices in the NMFS surveys were the arithmetic mean number or mean weight per tow. In 2008 the NMFS acquired a new ship, the FSV *Henry B. Bigelow*, to conduct the survey. Field work was done to develop calibration factors to convert *Bigelow* indices into equivalent FRV *Albatross IV* units. Previous assessments used a constant value of 3.41 across all sizes, however new model results allow calibration by length categories (Figure B53). The length calibration factors in sea bass produced a bi-modal sequence of values described by a polynomial equation. The working group considered the calibration results and concluded that the tails of the distribution with few samples (Figure B54) was not appropriate for calibration (small calibration values had large influence on small indices). Therefore the calibration factor was held constant for lengths beyond 40 cm. The factor for the smallest fish sizes, less than 5 cm, was also held constant at 1.0, which implies no difference in catchability between the ships. The calibration at length was applied to the NEFSC spring and fall survey data series.

The NEFSC spring mean number per tow followed a pattern of an increasing index during the late 1970s, followed by a decline during the 1980s and 1990s (Figure B55-B57). An increase in the index occurred beginning in 1998, peaking in 2003, followed by a decline. The calibrated 2010 index (1.687 fish/tow) was near the series average of 1.707 fish/tow (std dev = 1.691).

An additional abundance index was developed using the recreational catch per angler trip. The MRFSS program has collected information since 1981 (Figure B58). CPUE was developed following the procedure outlined in Terceiro (2003), using a GLM with a negative binomial error structure. The index shows an increasing trend through 2000, followed by a decline until 2005. With the exception of a spike in 2006, the index has remained stable through 2010. On a regional basis, the catch per angler index shows an increase in the northern states and a stable or decreasing trend in the south.

The only surveys that integrate across all areas are the NEFSC winter, spring and fall surveys and the REC CPA. Past reviews have expressed concern that the NEFSC fall inshore survey does not tow in areas of sea bass habitat (structure), thus cannot be representative of abundance. In addition, the 2 most inshore strata are no longer sampled by the Bigelow. However, the age 0 fish (lt 14 cm) do not require the same structure (a clam shell is enough), so that age group was included as an index (Figure B59). The spring and winter surveys use the offshore strata set. Those surveys were conducted during the period sea bass are resident on the over-wintering ground of the continental shelf or are moving across the shelf. Therefore the habitat requirements during that time should be minimal. To examine potential biases in the offshore spring survey, an analysis was done to examine the frequency of tear ups in the tows, the idea being that tear ups would represent tows in structured habitat. Results are detailed in Appendix II. The analysis concluded that there is no evidence to imply a bias in sea bass catches in the offshore strata resulting from structured habitat. In addition, the presence of a commercial otter trawl fishery in the offshore area implies some degree of towable bottom.

NEFSC survey data was also used to develop maturity at age information. On-going work to verify black sea bass maturity stages and the characteristics of transforming gonads is described in Appendix I. Information collected on surveys was used to develop a maturity ogives. Male and female maturities were divided into mature or immature categories. Logistic maturity at length ogives were first developed for each sex (Figure B60). The resulting parameters were:

Male: alpha = -6.638, beta=0.359; Female: alpha = -5.720, beta=0.282

A maturity at age ogive was also developed, using the SAS Proc Logistic function. A model was developed for females as well as both sexes combined. The resulting model showed an A50 for females at age 1.15 and for both sexes of 1.57. In both scenarios, the fish were fully mature by age 5. Results are shown in Figure B61 and Table B20.

TOR 3. Consider known aspects of seasonal migration and availability of black sea bass, and investigate ways to incorporate these into the stock assessment. Based on the known aspects, evaluate whether more than one management unit should be used for black sea bass from Cape Hatteras north and, if so, propose unit delineations that could be considered by the Mid-Atlantic Fishery Management Council and for use in future stock assessments.

Black sea bass undergo seasonal migrations between coastal and shelf waters (Moser and Shepherd 2009). The general over-wintering areas are on the continental shelf south of the Hudson Canyon. The distance of the migration varies depending on the starting point in the fall, with fish from the northern end of the stock (Massachusetts) travelling the furthest distance. The tagging study documented the movement and showed that the further the distance travelled, the higher the chance of returning to an area other than the point of origin (Figure B62). Consequently there is a higher likelihood of mixing among adjacent areas at the northern end of the stock (e.g. greater chance of fish leaving MA and returning to RI than fish leaving VA and returning to MD or NC).

A preliminary genetics study to examine mixing around Cape Hatteras, NC (the demarcation between the northern and southern stocks) also examined the genetic characteristics within the Middle Atlantic (McCartney and Burton, 2011). The study concluded that there were no distinct sub-stocks with the northern group with the possible exception of fish from Massachusetts. The MA fish had some unique genetic characteristics however further work is required to determine if these differences are robust. A published study examining meristics and morphometrics in black sea bass also concluded that there was likely a clinal gradient rather than distinct sub-units (Shepherd 1991).

Local variations in black sea bass abundances became an issue following the 2010 fishing season when states in the northern end of the stock (NY-MA) exceeded their recreational quota. Examination of the relationship in CPA among states shows a clinal gradient in black sea bass CPUE. States are most similar to adjacent states and more dissimilar the further the distance (Figure B63).

The recent NMFS age data were fit to growth curves north and south of the Hudson Canyon, a possible geographic boundary seen in tag results. The fitted von Bertalanffy curves show slower growth north of the Canyon but not significantly different between the areas based on the overlap in the confidence intervals (Figure B64). The growth curve parameters are presented in Table B21.

After examining tagging data, growth curves, meristic and morphometric analyses, and genetic studies, the Working Group concluded that the northern stock of black sea bass (north of Cape Hatteras, NC) shows a clinal gradient north to south but there is not enough evidence to further divide the northern stock into sub-units. Preliminary genetic studies show some unique characteristics between MA fish and the rest of the stock which should be explored with additional analysis.

In addition, the current data is inadequate to conduct an assessment accounting for spatial differences. The stock mixes in the offshore winter areas such that offshore catch cannot be accurately assigned to area of origin. In addition, mixing between areas may vary by year which creates problems in a spatial assessment model. While acknowledging differences among states, it may be possible to consider these differences in the context of management rather than within an analytical assessment.

TOR 4. Investigate estimates of natural mortality rate, M, and if possible incorporate the results into TOR-5. Consider including sex- and age-specific rate estimates, if they can be supported by the data.

The issue of natural mortality in sea bass was examined at the Northeast Data Poor Stocks Working Group meeting (NDPSWG 2008). Preliminary results (Shepherd and Moser 2008) from an analysis of tag returns using the Instantaneous Rates Model (Hoenig et al. 1998) had shown that M was likely much greater than the 0.2 used in earlier assessment. However, the tag model estimates greater than 1.0 were considered unrealistic (note that the M in the tagging model is a function of unseen tags which includes the effect of unaccounted for non-reporting, tag loss, etc.). The NDPSWG considered estimates of M using the rule of thumb approach ($3/t_{max}$) and the Hewitt and Hoenig (2005) approach ($4.22/t_{max}$), both with a maximum age of 9. The review group adopted the average of the two models (0.4) as an appropriate value of M.

Estimates of M were reconsidered using several different approaches (Table B22), including the Lorenzen (1996) model for age-specific estimates of natural mortality and two constant M models with an alternative maximum age of 12 (Appendix III). The WG concluded that sex specific rate estimates were not appropriate at this time since complimentary catch by sex was unavailable. The WG adopted an age-specific, time invariant estimate of M based on the Lorenzen curve re-scaled to an average M equal to 0.4 (Table B22). Since the model includes age 0, the Lorenzen model was fitted to a power curve:

$$M = 0.694\ \text{age}^{-0.417}$$

and extrapolated to age 0.5. The fitted values were used in the model and the plus category set at M=0.29. Sensitivities to the assessment model results were conducted using the alternative of a constant 0.4 at all ages.

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

Updated age information has not been available for recent black sea bass assessments, consequently the working model has been SCALE, a statistical catch at length model (NDPSWG 2008). An update to the assessment was completed in June 2011 and provided to managers for quota setting in 2012 (Figure B65). That update followed the previous approach which incorporated NEFSC $\log_e$ transformed indices from the winter and spring surveys and assumed a recreational discard mortality of 25%. The resulting estimate of F_{2010} equaled 0.41, an increase from 2009 of 0.32 and the 2010 SSB equaled 13,926 MT (Figure B66).

[SAW53 Editor's Note: The SARC-53 review panel did not accept new models or results (described below) that were done for TOR 5. Text about TOR 5 that describes those new models is included below to demonstrate the work that was done by the SAW Working Group for the December 2011 peer review. Those results are not intended to be used for management at this time.]

The availability of age data beginning with 1984 allowed for development of an age based assessment as recommended in the NDPSWG review (2008). A statistical catch at age model (ASAP) served as the basis for the new analytical assessment (which was then rejected by the SARC53 peer review panel in December 2011). A catch at age matrix was developed for 1984 to 2010, while NEFSC spring survey indices were available since 1968. Total commercial landings recorded since 1939 provided a basis for estimating historic total catch using ratios. Initial model configurations began with 1939 catch partitioned into four separate fleets; commercial landings, commercial discards, recreational landings and recreational discards. Models starting in 1939 or 1950 (prior to the peak catch in 1952) did not properly converge despite numerous variations in model configuration.

The ASAP model was simplified and ultimately configured with catch beginning in 1968 and one fleet. Natural mortality was based on a Lorenzen curve for M at age, scaled to a constant of 0.4. Maturity was constant within the time series and equaled the average maturity at age from the survey results. Catch weights at age were estimated from 1984 to 2010 using expanded length frequencies of the catch. In several years, the weights at age for ages 6 or 7+ decreased due to limited sample sizes. This was not considered biologically feasible, therefore those values were replaced with calculated weights at age using the relation between weight and age from earlier ages within the same year. Weights at age prior to 1984 were based on the average of the last three years (1984-1986) (Table B18). Black sea bass spawning stock weights (Table B23) for ages 1 to 4 were set equal to NEFSC spring survey weights at age, as recommended by SARC53 reviewers, while ages 5 to 7+ remained equal to catch weights. Age 0 weights were fixed at 0.001 kg but have no bearing on SSB calculation since percent mature is 0. Rivard weights were calculated for use as January 1 stock weights.

Selectivity at age was divided into two periods, with a split between 1997 and 1998. A fishery management plan was implemented in 1998 which set minimum sizes in both the commercial and recreational fisheries. Prior to the plan few size restrictions were in place. Since both the recreational and commercial fleets target large fish using a variety of gear types, selectivity was assumed flat-topped and fixed at 1.0 beginning with age 4. Selectivity at younger ages was freely estimated, using a lambda value of 1.0 and CV of 0.5. Fishing mortality was fixed at 0.3 for the initial year (1968) in the final model although a variety of options for the initial F were explored.

Prior to 1981 recreational landings and total discards were estimated based on a ratio to commercial landings. Therefore in the modeling process the predicted catch was allowed to vary to a greater degree pre-1981 by increasing the CV settings.

In a protogynous hermaphrodite such as black sea bass, defining spawning stock biomass has been the subject of debate. We followed the recommendation of Brooks et al. (2008) and defined SSB as combined male and female, although the SSB is not used in a stock-recruitment model. In the ASAP model we have limited the influence of the stock recruit curve in defining recruitment. The model software assumes recruits are age 1 and consequently adjusts the time series to correspond to the correct SSB. Since our input includes age 0 as the first age, the recruits using the S/R curve would be incorrectly estimated. Consequently, we have fixed the steepness in the curve to 1.0 to essentially disregard the stock-recruitment relationship. The CV in years with age information (1984-2010) was set to 0.6 with a lambda of 1.0, which keeps the recruitment near the mean in years prior to 1984 when there is limited information about cohort strength.

Abundance indices used in the model included the recreational catch per angler trip, Virginia spring trawl survey age 1 index, New Jersey autumn trawl survey age 0 index, Massachusetts autumn trawl survey age 0 index, NMFS autumn bottom trawl survey age 0 index, NMFS spring bottom trawl survey number per tow and age composition for ages 1 to 7+, and NMFS winter bottom trawl survey number per tow and age composition for ages 1 to 7+ indices. NMFS winter and spring indices incorporated empirical CVs estimated from survey data whereas the CVs for the other surveys were set equal to 0.6. Survey selectivity for surveys other than the spring and winter were set equal to 1.0. Following numerous models runs and the ratio of qs of indices at age, the winter and spring index selectivities were fixed at 1.0 for age 2 and at 0.5 for age 7+. The remaining ages were freely estimated using a lambda value of 1.0 and a CV equal to 0.3.

Base model results

The index fit total was the largest component of the objective function, followed by recruitment deviations and the catch at age comps (Table B24, Figure B67). The catch age composition (Figures B68a-68f) and associated residuals (Figures B69-B70) showed the largest residuals in ages 2 and 3 in the 1980s and also the late 1990s, implying an underestimate of the predicted values. The effective sample size of the fleet was set equal to 50, which corresponded to the mean age trends (Figures B70-B71). Catch selectivities pre- and post-1998 (Figure B72) reflect a greater A_{50} post-1998, indicative of the shift in the selectivity patterns in the fishery due to regulations. Quantile plots of the model results are shown in figure B73.

The standardized residuals in the indices were generally centered near 0 as shown in the distribution of the probability density (Figures B74-B89). The exception was the Massachusetts age 0 index which tended to be under-estimated in recent years (Figure B77). The residual patterns in the age composition for the NMFS winter and spring indices did not display any large positive or negative residuals (Figures B79-B80). The selectivity at age for the NMFS winter and spring survey indices showed a declining selectivity beyond age four. The spring selectivity declined to 78% at age 5 and 74% at age 6 (age 7+ fixed at 0.5). Similarly, the winter survey was dome shaped with selectivity at 65% for age 5 (Figure B90).

Average spawning stock biomass increased between 1997 (2,701 MT) and 2005 (9,654 MT), remained stable until 2008 (9,587 MT) then increased to the 2010 estimate of 10,843 MT (± 1 std. dev of 1,226 MT) (Figure B91). Total January 1 biomass followed a similar trend, peaking in 2006 at 10,353 MT, declining briefly in 2007 to 9,877 MT before increasing through 2010, reaching 11,616 MT (Figure B91). Trends in exploitable biomass were similar to SSB with 2010 biomass being one of the largest in the series at 11,022 MT (Figure B91). Posterior distributions of SSB were developed from an MCMC simulation. The MCMC process was completed with 1000 iterations and a thinning factor of 200. The range of values in the 2010 SSB distribution ranged from 8,100 MT to 15,600 MT, with a median value of 11,456 MT (Figure B92). The 80% confidence interval was between 10,012 MT and 13,082 MT (Figure B93).

With the exception of the 2007 year class, recruitment since 2001 has been below the time series average (72 million (1984-2010)) (Figure B94). The 2010 cohort was estimated at 40.7 million (with ±1 std. dev of 7.8 million) and the 2009 cohort at only 35.3 million (± 1 std dev of 11.6 million). Total stock numbers follows the same decline since 1999 owing to the dominance of the age 0 fish in the total number. Biomass has increased in recent years (Figure B91) with the growth of the 2007 year class contributing to the biomass already accumulated since a large 1999 cohort.

Fishing mortality, estimated as F on fully recruited ages, has decreased since reaching the time series maximum of 0.97 in 1996. The trend continued downward until reaching an F of 0.16 in 2008

(Figure B95). The most recent value in 2010 equaled 0.18. Posterior distributions of fishing mortality were developed from an MCMC simulation. The MCMC process was completed with 1000 iterations and a thinning factor of 200. The range of values in the distribution ranged from 0.12 to 0.23, with a median value of 0.17. The 80% confidence interval ranged from 0.149 to 0.195 (Figure B96). The model selectivity also showed a change in the age at 50% selectivity between the two periods, with an increase from 1.6 in 1968-1987 to 2.1 in 1998 to 2010 (Figure B74).

Retrospective patterns were explored for F and SSB beginning with 2003. Fishing mortality had a retrospective pattern showing consistent under-estimation (Figure B97-B98). The pattern for fishing mortality was considered reasonable a maximum range in 2006 of 0.15 to 0.22 and a relative difference of 33%. However, the relative difference between 2009 and 2010 was only 1.4%. The retrospective pattern for SSB was a consistent over-estimation (Figure B99-B100). The maximum in 2006 ranged from 14,070 MT decreasing to 9,368 MT and a maximum relative difference of 50%. The last three years in the SSB varied considerably less, ranging from 10,302 MT in the 2008 terminal year to 10,843 MT in 2010. The relative difference in 2009 was 0.2%. The WG concluded that the large index pulse around 2002 produced the retrospective pattern and as the influence of that index group passed, the retrospective problems subsided.

The WG explored a variety of model configurations before choosing the base model (Figure B101-B105). The examination of the models showed that retrospective effects could be reduced by increasing the influence of the catch in the model while reducing the weight on the indices. However, the resulting estimates of fishing mortality were thought to be unrealistically low throughout the time series. In addition, the WG felt that the indices provided information on abundance and should not be completely down-weighted. The chosen model provided a compromise between the retrospective pattern, fishing mortalities that were not comparable to a previous tag based estimates of F and convergence properties that would allow execution of the MCMC function.

Comparison of the base model run to previous F estimates is presented in Table B25, Figure B106. The previous estimates of F using length based models were all higher, particularly during the 1984 to 2004 period. However, the differences are a matter of scale and the trends among all models are very similar.

(NOTE: The SARC53 panel concluded that the ASAP and revised SCALE results shown here should not be used at this time as a basis for developing management advice or for determining stock status. The methods and results are included here to show the work that was done by the SAW Working Group and reviewed for SARC53.)

TOR 6. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, F_{MSY}, and MSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the appropriateness of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

The most recent biological reference points (BRP) were developed and approved at the NDPSWG review (2008). Since no age data were available for BRP development, results from a length based yield per recruit model were adopted. An $F_{40\%}$ equal to 0.42 was chosen as a proxy for F_{MSY} and the associated SSB_{MSY} was estimated using the average recruitment derived from the SCALE model applied to the SSB/R ratio at $F_{40\%}$. The SCALE model and the YPR model both used constant M equal to 0.4.

[SAW53 Editor's Note: Because the SARC-53 review panel rejected the ASAP model, no new reference points were considered. The text below about TOR 6 is included to show the work that was done by the SAW Working Group for the December 2011 peer review, and should not be used for management.]

A new stochastic yield per recruit model was developed to derive new age-based biological reference points. The model was developed with an age 7 plus group but a maximum age of 12. In order to develop the probability distribution around the reference points the model required CVs for stock weights, catch weights, SSB weights, fishery selectivity, natural mortality and maturity at age (Table B26). Mean weights at age developed from both fishery and survey data suggest CVs in the order of 30%. The age specific values from the fishery mean weights were input for all three weight input data. Fishery selectivity CVs were fixed at 20%, M CVs at 30% and the maturity CVs were resulting from the variance around the fitted survey values at age. The model was run with 1000 realizations and the results summarized in Table B27. Similarly, an optional stochastic model was run with a constant M=0.4 and also in deterministic mode for both cases. The proxy for F_{MSY} remained at $F_{40\%.}$ SSB_{MSY} was determined as the median estimate of SSB following a stochastic projection of 100 years under F_{MSY}, with recruitment based on the 1984 to 2010 empirical recruitment estimates.

The preferred model was the stochastic YPR with age varying M. Median fishing mortality at F_{MSY} equaled 0.275 (80% CI between 0.230 and 0.337). The corresponding deterministic estimate at F_{MSY} equaled 0.252. SSB_{MSY} generated from 100 year projections with age variable M resulted in a median SSB of 9,467 MT with an 80% CI between 8,004 and 11,184 MT. The comparable BRP estimate using a constant M=0.4 produced a median F_{MSY} equaled 0.316 and the associated SSBMSY of 8,128 MT with an 80% CI between 6,734 and 9,870 MT (Table B27). Maximum sustainable yield (MSY) was calculated for both the variable and constant M model. With an age varying M, median MSY equaled 3,087 MT (80%

CI between 2,593 MT and 3,675 MT), whereas the MSY under a constant M at age assumption equaled 3,197 MT (80% CI between 2,628 MT and 3,905 MT).

The appropriateness of $F_{40\%}$ as a proxy for F_{MSY} and the associated SSB_{MSY} is dependent on the assumption that black sea bass populations respond to changes in F in a similar fashion as gonochoristic species. Without empirical evidence that sustainability differs, the WG felt that the recommended BRPs were appropriate.

TOR 7. Evaluate stock status with respect to the existing model (from the most recent accepted peer reviewed assessment) and with respect to a new model developed for this peer review.

a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.

b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs (from black sea bass TOR 6).

The existing model (SCALE) estimates of F_{2010} equaled 0.41 and SSB_{2010} of 13,926 MT. The corresponding BRPs were F_{MSY} =0.42 and SSB_{MSY}=12,537 MT. The results of the SCALE model indicates that the stock is 98% of F_{MSY} and 111% of SSB_{MSY}. Therefore, based on previous work presented in the summer of 2011 (MAFMC 2011; NEFSC 2011), the stock is not overfished or experiencing overfishing.

[SAW53 Editor's Note: Because the SARC-53 review panel rejected the ASAP model, the default was to fall back on using the previously accepted BRPs and SCALE model fit from the summer of 2011, which indicated that the stock was not overfished and overfishing was not occurring. The TOR 7 text below is included to show the work that was done by the SAW53 Working Group for the December 2011 peer review and is not intended for use by managers at this time.]

The 2010 estimate of average F from the ASAP model equaled 0.18 with corresponding SSB of 10,843 MT. Comparison of the 2010 ASAP results to the BRPs generated from the stochastic YPR show that the stock is not overfished or experiencing overfishing (Figure B107, Table B28). The 90% confidence bound of the median F_{2010} (0.171) remains below the 10% confidence bound of F_{MSY} (0.230). The 2010 F is 62% of F_{MSY}. The same conclusion is reached in comparison with the deterministic BRP estimate. Alternative stochastic and deterministic BRPs were calculated using a constant M=0.4. The deterministic $F_{40\%}$ = 0.292, while the median value in the stochastic model equaled 0.316. In either case the comparison with average F_{2010} (0.17 with M=0.4) shows that the stock is not experiencing overfishing.

Similarly, the median SSB_{2010} (11,456 MT) with age variable M shows the stock is not overfished when compared to the stochastic estimate of SSB_{MSY} (9,467 MT) (Figure B108). The lower bound of the 80% CI of median SSB_{2010} (10,012 MT) is below the upper bound of the SSB_{MSY} 80% CI (11,184 MT). The median SSB_{2010} estimated with constant M=0.4 equal to 11,863 MT is greater than the associated SSB_{MSY} of 8,128 MT, consequently the stock would not be considered overfished.

TOR 8. Develop and apply analytical approaches to conduct single and multi-year stock projections to compute the pdf (probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).

Provide numerical annual projections (3-5 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment, and definition of BRPs for black sea bass).

[SAW53 Editor's Note: Because the SARC-53 review panel rejected the ASAP model, no projections were considered. The text below is included to show the work that was done by the SAW Working Group for the December 2011 peer review.]

Short term (5 year) projections of catch were computed using the stochastic methods available in AGEPRO software (Table B29-B32). For the harvest scenario, the projection assumed the 2011quota of 2,041 MT would be taken and thereafter fished at a target F. Recruitment estimates for 2011 were developed under two scenarios; using the last 5 years of the ASAP model (2006-2010) or the full series since 1984 (27 years). Recruitment for the years 2012 to 2015 were randomly chosen in the bootstrap process from the 27 year time series (Figure B107).

Four scenarios were evaluated; 2006-2010 recruits w/variable M, 2006-2010 recruits with constant M, 1984-2010 recruits w/variable M and 1984-2010 recruits w/constant M. The median SSB projections using the 1984-2010 series declined over the five years from 11,160 MT to 8,550 MT (variable M) or 11,177 MT to 7,651 MT (constant M), and in both case declined below the median of SSB_{MSY}. In projections using the shorter recruitment time series, SSB also declined below the median SSB_{MSY} by 2015 using either variable M or constant M. In all cases, the projected 2012 catch would exceed the current 2011 quota of 2,041 MT (Table B33). The 2012 OFL using the recent recruitment scenario and variable M would equal 3,093 MT. Comparable values for constant M equaled 3,444 MT; with long-term recruitment estimate and variable M, OFL in 2012 = 3,103 MT and similarly with constant M = 3,451 MT.

The SARC53 panel concluded that the ASAP and revised SCALE results shown here should not be used at this time as a basis for developing management advice or for determining stock status. The methods and results are included here to show the work that was done by the SAW Working Group and reviewed for SARC53.

Comment on which projections seem most realistic. Consider major uncertainties in the assessment as well as the sensitivity of the projections to various assumptions.

Depending on the amount of risk that is acceptable to managers, each scenario could be considered realistic. The trend in recent recruitment and the preferred model incorporating variable M would imply that the scenario with 2006-2010 recruitment and variable M is most realistic.

The major uncertainties in the assessment were considered to be the choice of natural mortality, the impact of fishing on the life history and behavior as well as the local variability in population dynamics. The choice of M has been examined under two scenarios and the conclusion on stock status remains the same. The uncertainties associated with the other issues were not examined in this assessment. It should be noted that the recreational catch estimates were generated from the MRFSS program. Beginning in 2011 changes to the estimation procedures may result in new recreational catch estimates. The sensitivity to potential changes was not examined at this time since there is no available information on the potential magnitude of those changes.

Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.

Explanation of "Vulnerability" (DOC Natl. Standard Guidelines, Fed. Reg., vol. 74, no. 11, 1/16/2009): *"Vulnerability.* A stock's vulnerability is a combination of its productivity, which depends upon its life history characteristics, and its susceptibility to the fishery. Productivity refers to the capacity of the stock to produce MSY and to recover if the population is depleted, and susceptibility is the potential for the stock to be impacted by the fishery, which includes direct captures, as well as indirect impacts to the fishery (e.g., loss of habitat quality)." (p. 3205)

Like most members of the family Serranidae, black sea bass are protogynous hermaphrodites. Generally speaking, black sea bass are relatively short-lived, highly fecund, and mature relatively early. These life history characteristics could make black sea bass inherently resilient to fishing pressure. However, the vulnerability of the stock to fishing pressure while aggregated on structured habitat in coastal areas and the potential impacts on productivity from being fished while spawning (May-July), make this stock more susceptible to impacts from the fishery when compared to species with other reproductive strategies (i.e., gonochoritic species). In many species with territorial spawning behavior controlled by a dominant male, the smaller precocious males may play some role in spawning. During spawning season, the large dominant males are targeted by fisheries. It is unknown if this has a severe negative impact on spawning success or if the precocious males fill the void left by removal of the larger male. Given the uncertainties in the influence of fishing on spawning behavior and subsequent recruitment success, black sea bass is moderately vulnerable to becoming overfished. On this basis, an ABC should be selected that considers these sources of uncertainty relative to life history/reproductive characteristics for this stock.

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.

<u>NDPSWG Panel Recommendations:</u>

a) On-going ageing studies should be continued to provide a foundation for an age-based assessment.

- Aging has been completed for 1984-2010 survey data and 2008-2010 commercial.

b) A pot survey for black sea bass should be considered.

- A pilot project is ongoing and proposals are being considered for funding to expand the program throughout the range of the management unit (MA-NC).

c) At-sea samples need to be taken to improve understanding of the timing of sex change over years in order to study the potential influence of population size on sex switching. This may have implications of overfishing BRPs.

- Work is being conducted at NEFSC and UMass-Dartmouth on the northern stock and UNC-Wilmington on the South Atlantic stock.

d) Ageing validation studies should be undertaken to examine the implications of sex change as well as temperature and salinity changes associated with movement onshore and offshore on ageing reliability.

- The issue will be discussed at a future workshop. Also see literature from SEDAR 2011 BSB assessment. (http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=25).

e) Meta-analysis of patterns of natural mortality in protogynous fishes should be undertaken.

- This recommendation is not yet addressed. It is to be discussed at a future workshop on modeling hermaphroditic species.

f) Exploration of management approaches used on species with protogynous life histories would be helpful.

- This is addressed in Brooks et al. (2008) as well as Heppel et al. (2006).

g) Research is needed to understand the implication of the removal of large males on population dynamics. These could be field studies or large scale mesocosm experiments. This could involve collaboration with industry and recreational sectors.

- This has not been addressed.

h) Efforts to quantify discard mortality are needed.

- This work is still needed and has not been addressed.

i) Exploration of model behavior, including retrospective analysis, is required.

- This exploratory work was conducted in this assessment.

j) Non-compliance may be an alternate explanation for high assumed rates of natural mortality. It would be useful to estimate whether or not there are sufficient amounts of non-reported catch to account of the assumed high rates of M.

- This has not been addressed.

k) The sensitivity of the SCALE model results to alternative data weightings should be explored.

- The assessment model advanced to a statistical catch at age model and alternative model settings were explored.

<u>New WG research recommendations.</u>

- In addition to recommendation "e" above: more simulation work should be done to better understand the implications of alternative natural mortality schemes.
- Research the source of the retrospective pattern, especially when survey data and fisheries catch data are weighted equally in the model (i.e., why is the survey data unreliable).
- Comparison of scale vs. otolith ages.
- Encourage the continuation of genetics work for stock identification (i.e., do multiple BSB stocks exist from Cape Cod to Cape Hatteras).

<u>Acknowledgments</u>

Age data was provided by Joshua Dayton of the NEFSC Population Biology Branch.

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Tables

[SAW53 Editor's Note:
The SARC-53 review panel did accept the work presented on TORs 1-4 (which primarily gives an update on fishing patterns, landings and survey data. Tables B1-B23 and Figures B1-B66 are associated with TORs 1-4.

The SARC-53 review panel did not accept new assessment models (or results from those new models) that were prepared by the SAW53 Working Group. Tables B24-B33 and Figures B67-B110 are associated with the new models and results. They are included in this report to demonstrate the work that was done by the SAW Working Group for the December 2011 peer review. However, those Tables and Figures are not intended to be used for management at this time.]

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Table B1. Black sea bass northern stock commercial and recreational landings (MT) and commercial and recreational discard losses, 1968-2010. (*1982 and 1986 rec landings adjusted*)

	Landings		Discard losses		
Year	Com	Rec	Com	Rec	Total MT
1968	1,079.0	1,108.5	64.3	66.0	2,317.8
1969	1,097.0	1,127.0	65.3	67.1	2,356.5
1970	970.0	996.5	57.8	59.4	2,083.6
1971	566.0	581.5	33.7	34.6	1,215.8
1972	727.0	746.9	43.3	44.5	1,561.7
1973	1,115.0	1,145.5	66.4	68.2	2,395.1
1974	1,023.0	1,051.0	60.9	62.6	2,197.5
1975	1,680.0	1,725.9	100.1	102.8	3,608.8
1976	1,557.0	1,599.5	92.7	95.3	3,344.5
1977	1,985.0	2,039.2	118.2	121.5	4,263.9
1978	1,662.0	1,707.4	99.0	101.7	3,570.1
1979	1,241.0	1,274.9	73.9	75.9	2,665.8
1980	977.0	1,003.7	58.2	59.8	2,098.7
1981	1,129.0	558.2	67.2	33.3	1,787.7
1982	1,177.1	*1,213.4*	70.1	268.0	2,728.6
1983	1,513.2	1,868.6	90.1	111.3	3,583.2
1984	1,519.4	601.5	104.5	33.0	2,258.4
1985	1,074.8	957.6	88.9	43.9	2,165.1
1986	1,508.5	*1,829.5*	100.7	98.6	3,537.3
1987	1,635.3	880.4	97.7	34.3	2,647.7
1988	1,424.0	1,299.2	101.8	92.3	2,917.4
1989	1,104.5	1,487.8	82.1	37.6	2,712.1
1990	1,401.6	1,255.9	52.8	94.4	2,804.6
1991	1,189.6	1,885.1	19.1	94.2	3,188.0
1992	1,264.3	1,187.9	91.2	83.4	2,626.9
1993	1,352.6	2,193.8	179.2	63.2	3,788.9
1994	848.4	1,332.7	33.8	80.7	2,295.5
1995	889.1	2,815.4	35.7	129.2	3,869.3
1996	1,448.4	1,809.0	482.7	92.0	3,832.0
1997	1,197.9	1,931.8	31.2	115.2	3,276.1
1998	1,171.2	519.0	135.8	86.6	1,912.6
1999	1,305.1	745.5	36.2	115.2	2,202.0
2000	1,205.5	1,804.3	41.7	277.4	3,328.8
2001	1,298.5	1,545.3	187.3	309.0	3,340.1
2002	1,587.4	1,982.9	24.3	390.7	3,985.2
2003	1,359.2	1,498.5	58.3	313.9	3,229.9
2004	1,405.5	761.6	369.9	142.3	2,679.3
2005	1,298.0	852.2	29.4	149.9	2,329.5
2006	1,285.4	897.7	16.1	173.2	2,372.4
2007	1,036.9	1,011.2	57.3	220.3	2,325.7
2008	875.1	712.7	36.7	252.0	1,876.6
2009	523.2	1,049.2	164.8	228.2	1,965.4
2010	751.4	1,351.1	110.1	231.4	2,444.0

Table B2. Black sea bass length measurements from Jan-June (spring) and July to December (fall) commercial sampling.

Lengths measured

Spring

	Unclass.	Jumbo	Large	Medium	Small	Ex-small
1984	669	592	3326	2777	2209	0
1985	157	710	3143	1471	1921	1062
1986	113	672	3551	2509	2507	231
1987	310	170	3211	1168	898	389
1988	799	341	2389	1449	1293	0
1989	202	132	2066	1341	1604	161
1990	181	260	2798	2537	3075	194
1991	226	0	2106	452	568	0
1992	33	89	786	827	894	99
1993	75	74	1534	1816	1927	0
1994	188	0	1307	1150	1471	0
1995	482	98	938	906	562	0
1996	24	107	1175	984	905	163
1997	384	0	1454	1432	1485	0
1998	0	152	1491	1559	1217	0
1999	221	103	949	1268	1157	0
2000	0	198	628	610	632	0
2001	169	0	1037	1278	956	0
2002	101	365	1384	648	285	0
2003	231	603	1153	537	200	0
2004	56	240	942	845	0	0

Fall

	Unclass.	Jumbo	Large	Medium	Small	Ex-small
1984	329		182	0	200	
1985	164		0	156	567	
1986	108	95	175	131	300	100
1987	216	43	200	53	41	51
1988	106	0	20	13	52	
1989	38	13	48	39	84	
1990	168	0	10	0	328	
1991	117	67	105	12	130	4
1992	37	0	31	142	280	
1993	0	0	37	0	56	
1994	0	3	42	38	67	
1995	0	0	151	215	476	
1996	495	10	491	408	1099	
1997	0	17	183	325	355	
1998	69	15	18	362	668	
1999	0	35	275	612	752	
2000	0	0	0	185	621	
2001	0	0	127	309	500	
2002	0	243	281	401	300	
2003	50	350	544	613	99	
2004	209	207	184	409	104	

Table B3. Number of black sea bass commercial samples from otter trawls and by half-year from NMFS samples.

Otter Trawl Jan-June	ex-small	small	medium	large	ex-large	unclass	total
1984		4	10	5	2	4	25
1985	2	3	4	5	3	1	18
1986		5	5	4	1	2	17
1987		2	2	4		2	10
1988		1	2	2		5	10
1989		2	2	2		2	8
1990		4	3	2			9
1991							
1992	1	1	2	1			5
1993			2	1			3
1994			2	1			3
1995			2	1			3
1996		3	5	1			9
1997		7	6	4		3	20
1998		7	8	6	2		23
1999		9	11	3	1		24
2000		3	4	4	1		12
2001		8	14	6		2	30
2002		1	7	6	4	1	19
2003		1	4	3	2	5	15
2004			7	4	1	2	14
2005		2	9	9	8	2	30
2006		1	3	8	8	3	23
2007		4	14	12	5	1	36
2008		5	13	12	8	2	40
2009	2	3	8	10	5	3	31
2010	2	2	9	6	5	2	26
							463

Otter Trawl July-Dec	ex-small	small	medium	large	ex-large	unclass	total
1984				2		1	3
1985		1					1
1986	1		1	2	1	1	6
1987				1		1	2
1988						1	1
1989							
1990		1	1				2
1991							
1992							
1993							
1994							
1995		1	1	1			3
1996		2		1		5	8
1997			1	1			2
1998							
1999				3	2		5
2000							
2001			1				1
2002							
2003			1	3	5	1	10
2004				1	4	3	8
2005			2	5	8	1	16
2006			4	1	8		13
2007		1	1	1	4	1	8
2008				2	6	3	11
2009			3	3	4	2	12
2010			1	2	7		10
							122

Table B4. Number of black sea bass commercial samples from fish pots and by half-year from NMFS samples.

Fish Pot Jan-June	ex-small	small	medium	large	ex-large	unclass	total
1984		4	2				6
1985							
1986		3					3
1987			1			1	2
1988						2	2
1989							
1990							
1991		2	2	2			6
1992				1			1
1993							
1994							
1995						3	3
1996		3	3	3	1		10
1997		6	7	5	1		19
1998		5	5	3	2		15
1999		3	2				5
2000		3	4	1	1		9
2001		2		1			3
2002		1					1
2003		1	2				3
2004				1	1		2
2005		1	2				3
2006		1	6	5	3	2	17
2007		1	9	7	4		21
2008		4	12	8	2	2	28
2009		1	8	1	2	1	13
2010		1	8	2			11
							183

Fish Pot July-Dec	ex-small	small	medium	large	ex-large	unclass	total
1984		2					2
1985		5	1			1	7
1986		3					3
1987						1	1
1988							
1989							
1990							
1991		1					1
1992							
1993							
1994							
1995		2	2	2			6
1996		7	5	5	1		18
1997		3	3	1	1		8
1998		7	5	1			13
1999		8	10	3			21
2000		6	2				8
2001		5	2	2			9
2002		3	3	2	2		10
2003		1	5	2	1	1	10
2004		1	4		1	3	9
2005			6	4		1	11
2006		2	15	7	2	1	27
2007		1	15	11	6	1	34
2008		9	9	4	4	3	29
2009		4	4	2	1	1	12
2010		3	2	1	1		7
							246

Table B5. Number of black sea bass commercial samples for other gears and by half-year from NMFS samples.

Other gear Jan-June	ex-small	small	medium	large	ex-large	unclass	total
1984							
1985							
1986			1	1			2
1987							
1988							
1989							
1990							
1991							
1992							
1993							
1994							
1995							
1996							
1997							
1998							
1999						2	2
2000		1			1		2
2001				1			1
2002		1		1			2
2003				2	5		7
2004			1		1		2
2005					1		1
2006					4	1	5
2007			2	1	2	4	9
2008							
2009			2	2	1		5
2010			1		1		2
							40

Other Gear Jul-Dec	ex-small	small	medium	large	ex-large	unclass	total
1984							
1985							
1986							
1987							
1988							
1989							
1990							
1991							
1992							
1993							
1994							
1995							
1996		1					1
1997							
1998							
1999							
2000			1				1
2001							
2002			1	1	1		3
2003				1			1
2004				1			1
2005			1	2		1	4
2006		2	1	4	4	1	12
2007		3	3	3	3	4	16
2008			2	1	1		4
2009		1	2	3	3	2	11
2010			1				1
							55

Table B6. Number of black sea bass commercial samples from otter trawl by half-year from NCDMF samples.

NC Otter trawl
1st half

	3356	3355	3353	3351	3352	3350	
1984	3	14	1			3	21
1985	11	10		1		8	30
1986	9	16		1		4	30
1987	10	7				1	18
1988	4	21	3			4	32
1989	5	29				2	36
1990	1	33	2	2		5	43
1991	2	14	5	1		8	30
1992	2	10		1		2	15
1993	2	29	2			2	35
1994	3	30	2	1		5	41
1995		18	3	1		4	26
1996	2	16	5	1		2	26
1997		3	1				4
1998		6	4	1		1	12
1999		2	3	2	1	7	15
							414

NC Otter trawl
2nd half

	3356	3355	3353	3351	3352	3350	
1984	1	4	2			7	14
1985	2	5	3			10	20
1986	2	14	1	1		7	25
1987	9	8	1	1		3	22
1988	1	12	3			2	18
1989	4	7	2	1		4	18
1990	1	11	2	2		11	27
1991	1	19	4			7	31
1992	1	6	7	1		2	17
1993		11	5	2			18
1994	1	11	4	2		1	19
1995	2	2	2	1			7
1996						1	1
1997	1	2					3
1998		1	1	1		8	11
1999		2	2	2	1		7
							258

Table B7. Black sea bass commercial landings mean length (cm), 1984-2010.

	Mean Length	CV
1984	27.05	0.20
1985	27.56	0.22
1986	25.47	0.24
1987	26.24	0.21
1988	25.57	0.22
1989	26.99	0.22
1990	26.40	0.19
1991	25.18	0.20
1992	25.39	0.18
1993	25.69	0.18
1994	25.59	0.18
1995	27.20	0.17
1996	26.59	0.19
1997	27.84	0.17
1998	29.74	0.16
1999	31.43	0.17
2000	32.47	0.18
2001	32.79	0.15
2002	33.92	0.15
2003	33.33	0.22
2004	34.15	0.16
2005	35.24	0.19
2006	34.99	0.19
2007	34.24	0.18
2008	32.98	0.16
2009	33.65	0.16
2010	34.04	0.17

Table B8. Black sea bass commercial discard estimates (MT) (prior to discard mortality). Trawl data based on SBRM method (1989-2010) includes CV.

	Otter trawl	CV	Fish Pot	Hand line	Total
1984	103.9		4.3	0.3	108.4
1985	88.1		3.3	1.5	92.9
1986	99.5		6.9	0.9	107.3
1987	96.5		7.4	0.6	104.5
1988	100.4		7.8	1.2	109.5
1989	80.9	0.37	6.9	1.1	88.9
1990	51.0	0.38	10.3	1.5	62.7
1991	17.1	0.28	11.8	1.8	30.7
1992	89.4	0.40	10.5	1.5	101.5
1993	177.9	0.94	7.9	1.1	186.9
1994	33.1	0.52	4.3	0.5	37.8
1995	34.2	0.44	8.2	1.3	43.7
1996	480.8	0.87	8.3	4.3	493.4
1997	27.2	1.93	25.2	1.7	54.1
1998	124.2	0.39	74.8	2.5	201.6
1999	22.6	0.30	83.6	7.5	113.6
2000	24.9	0.29	104.3	7.2	136.5
2001	170.1	0.30	108.7	5.9	284.6
2002	10.0	0.51	89.9	5.5	105.4
2003	46.6	0.49	70.0	8.1	124.7
2004	359.5	0.26	65.1	4.4	429.0
2005	22.3	0.28	43.8	3.5	69.6
2006	10.5	0.39	32.2	5.2	47.8
2007	51.7	0.36	31.6	5.8	89.1
2008	32.2	0.31	25.8	4.2	62.3
2009	160.7	0.36	23.0	4.2	187.9
2010	105.4	0.17	27.7	3.6	136.7

Table B9. Sample size (number of black sea bass measured) from otter trawl trips and fish pot trips.

	Otter Trawls	Fish Pots
1989	477	
1990		
1991		
1992		
1993		46
1994	26	158
1995	89	
1996	514	
1997	304	
1998	509	
1999	13	
2000	116	
2001	297	
2002	156	
2003	1200	64
2004	2349	254
2005	1051	14
2006	605	
2007	903	172
2008	982	320
2009	2154	
2010	2092	1084

Table B10. Black sea bass recreational landings (AB1), proportional standard error and sample sizes. Note that the 1982 and 1986 landings are unadjusted values.

	Total Num (000s)	PSE	Number fish Inspected
1981	1886.7	15.7	744
1982	*10045.9*	35.5	1153
1983	4968.4	17.5	1330
1984	1700.1	12.9	1354
1985	3377.1	11.8	1863
1986	*21732.6*	21.6	2913
1987	2875.6	13.9	1759
1988	3058.8	15.3	2033
1989	4221.1	6.6	4202
1990	3879.8	8.4	3109
1991	5226.3	8.0	3569
1992	3535.3	7.6	4011
1993	5994.4	19.5	2470
1994	3422.2	11.8	2989
1995	6742.8	14.5	2535
1996	3619.4	10.9	2734
1997	4736.2	9.4	2690
1998	1147.0	12.5	2353
1999	1361.6	15.3	2102
2000	3631.5	10.7	3022
2001	2845.8	7.2	3651
2002	3372.1	7.0	3456
2003	3258.7	5.5	4137
2004	1750.7	9.2	3609
2005	1255.1	11.6	4057
2006	1484.9	11.5	3244
2007	1738.0	13.7	3691
2008	1107.8	10.9	3566
2009	1603.2	11.2	3223
2010	1897.3	13.0	4113

Table B11. Black sea bass recreational discards (B2) totals, ME to northern NC, 1981-2010.

	Total Num(000s)	PSE
1981	1,760	29.08
1982	1,338	17.85
1983	2,653	20.69
1984	1,610	20.69
1985	2,651	11.59
1986	7,175	12.88
1987	2,117	13.61
1988	5,014	10.64
1989	2,129	7.31
1990	5,246	7.77
1991	5,610	6.21
1992	4,304	8.74
1993	3,223	11.16
1994	3,970	7.16
1995	7,565	7.28
1996	4,549	8.28
1997	6,010	7.74
1998	3,900	8.68
1999	5,751	7.90
2000	13,208	6.09
2001	10,886	4.27
2002	11,304	5.63
2003	8,877	4.72
2004	5,853	6.78
2005	5,667	7.51
2006	6,895	7.50
2007	8,576	6.41
2008	9,730	7.27
2009	7,753	7.32
2010	7,327	9.08

Table B12. Lengths measurements of discarded black sea bass.

	ALS tags	NJ Tags	NJ Volunteers	MRFSS Party/Charter	New York Party/Charter	Total
1984	9					9
1985	59					59
1986	41					41
1987	23					23
1988	45					45
1989	20					20
1990	22					22
1991	98					98
1992	43					43
1993	45					45
1994	39					39
1995	35	253			232	520
1996	14	8			175	197
1997	40	528			325	893
1998	52	492			63	607
1999	125	17			224	366
2000	194					194
2001	392	1265				1657
2002	337	482				819
2003	248	184				432
2004	308					308
2005	263			4348		4611
2006	230			5255		5485
2007	202			7799		8001
2008	988		413	7614		9015
2009	967		315	8332		9614
2010	680		242	8963		9885

Table B13. Black sea bass commercial landings at age, 1984-2010.

000s

	0	1	2	3	4	5	6	7	8	9
1984	0.0	84.5	1327.0	2255.8	1249.8	87.9	36.0	5.1	7.9	0.0
1985	0.0	17.2	862.5	1386.4	863.3	94.4	39.3	16.5	10.2	0.3
1986	0.0	185.8	3896.5	1098.7	258.9	50.6	78.5	5.4	19.6	15.3
1987	0.0	26.3	3194.0	2131.5	345.3	74.3	56.6	4.4	9.0	0.0
1988	0.0	108.9	2363.7	2228.5	563.1	166.9	39.2	0.0	10.3	1.7
1989	0.0	9.7	1892.1	1146.6	424.5	44.1	56.8	3.3	9.8	1.6
1990	0.0	67.4	2297.3	2252.7	261.3	59.4	27.6	23.5	1.9	0.7
1991	0.0	56.7	3273.4	922.1	403.0	123.1	15.8	3.2	0.0	0.0
1992	0.0	28.6	2749.6	1958.4	281.9	48.5	13.1	2.2	1.3	0.0
1993	0.0	57.4	1814.7	2957.6	399.2	48.7	21.8	5.8	1.0	0.0
1994	0.0	44.5	1149.7	1425.1	655.4	80.4	17.5	4.2	0.4	0.2
1995	0.0	203.3	1794.0	770.1	128.9	39.0	11.3	1.4	0.0	0.0
1996	0.0	296.7	2470.1	1717.2	347.5	189.1	49.6	11.9	1.3	0.3
1997	0.0	65.8	1508.2	1561.0	458.1	64.9	24.2	7.3	1.2	0.3
1998	0.0	63.3	1080.8	1173.3	596.2	41.9	32.9	6.7	6.3	0.7
1999	0.0	27.1	664.4	1215.6	614.7	187.9	71.5	20.6	3.5	1.2
2000	0.0	140.3	466.1	796.2	610.5	264.3	42.9	6.7	2.7	2.8
2001	0.0	3.8	411.8	1522.9	443.4	85.1	36.9	2.4	9.9	2.7
2002	0.0	14.2	239.1	1512.9	895.3	51.4	21.1	7.9	1.2	12.0
2003	0.0	5.1	218.4	805.3	654.0	366.5	91.6	13.1	0.0	0.0
2004	0.0	0.0	207.7	969.6	501.1	573.7	49.5	5.2	7.9	0.0
2005	0.0	0.0	316.4	375.2	760.3	196.5	232.7	18.1	3.3	0.0
2006	0.0	1.3	349.3	373.6	591.3	419.3	139.9	13.8	3.6	1.8
2007	0.0	27.3	239.0	613.2	446.2	125.5	113.5	86.2	7.0	1.3
2008	0.0	0.3	183.2	1028.9	260.3	93.0	38.8	10.8	5.5	1.0
2009	0.0	0.3	101.7	408.7	305.3	56.2	38.4	8.1	6.1	1.4
2010	0.0	0.0	41.8	529.3	444.6	209.8	60.6	10.9	3.8	2.0

Table B14. Black sea bass commercial discards at age, 1989, 1994-2010.

000s	0	1	2	3	4	5	6	7	8	9
1984	0.0	0.0	0.0	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	0.0	0.0	0.0
1986	0.0	0.0	0.0	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	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1989	0.0	422.2	737.8	74.0	1.5	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	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	0.0	0.0	0.0	0.0
1992	0.0	0.0	0.0	0.0	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	0.0	0.0	0.0	0.0
1994	31.5	243.8	134.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	43.1	115.0	100.9	22.8	0.0	0.0	0.0	0.0	0.0	0.0
1996	207.1	2217.5	1817.5	55.8	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	25.3	149.1	11.8	0.3	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.1	698.5	27.0	20.3	1.7	0.0	1.5	0.0	1.5
1999	0.0	0.0	69.1	83.1	34.2	0.0	0.0	0.0	0.0	0.0
2000	0.0	50.0	117.4	32.7	8.3	0.4	0.0	0.0	0.0	0.0
2001	1.9	170.7	625.2	161.1	40.3	4.8	3.8	0.0	0.8	0.0
2002	86.8	28.3	101.8	9.3	5.7	0.0	0.6	0.6	0.0	0.0
2003	1.9	34.9	43.1	21.1	19.7	6.7	6.6	1.3	0.0	0.0
2004	4.2	127.3	181.5	218.8	103.4	91.9	27.6	3.4	1.1	0.0
2005	3.1	0.8	22.2	9.1	21.2	4.3	4.8	0.3	0.0	0.0
2006	0.0	3.4	7.5	3.3	5.1	3.7	2.3	0.2	0.0	0.0
2007	0.0	33.4	113.4	31.2	10.7	5.0	6.7	0.5	0.0	0.0
2008	2.2	30.2	54.0	21.8	4.4	1.0	1.4	2.3	0.2	0.0
2009	3.8	81.9	230.5	118.7	56.3	12.4	15.5	3.5	1.3	0.6
2010	0.3	8.9	55.5	90.7	51.2	24.0	12.7	1.3	1.8	0.0

Table B15. Black sea bass recreational landings at age, 1984-2010.

000s

	0	1	2	3	4	5	6	7	8	9
1984	0.0	269.7	588.0	552.3	126.8	30.4	23.6	0.5	0.9	0.0
1985	10.4	515.3	1623.7	735.3	340.0	67.1	36.9	5.9	1.3	0.0
1986	0.0	790.4	4437.6	1235.6	259.2	56.6	86.9	8.9	11.3	16.9
1987	0.0	158.4	1489.6	946.0	96.0	33.9	91.1	11.2	15.0	0.0
1988	0.0	237.5	1097.7	1064.6	417.6	110.7	36.6	0.0	12.8	0.0
1989	2.8	139.9	2499.9	1254.0	259.1	15.4	44.8	2.0	3.2	0.0
1990	0.0	535.4	1499.5	1474.3	259.3	57.0	17.7	10.0	0.0	0.0
1991	2.5	208.1	3152.7	1196.4	474.2	109.5	32.1	17.7	2.4	4.9
1992	0.0	124.7	1699.8	1168.4	379.6	86.9	37.7	7.9	1.8	0.0
1993	1.3	359.4	3502.0	1447.2	536.7	61.7	59.2	12.2	7.6	0.0
1994	10.7	418.6	1494.9	859.4	430.4	147.1	37.5	10.2	0.0	0.0
1995	90.1	2100.8	2895.2	1067.2	231.2	179.4	31.3	8.0	0.0	0.0
1996	8.5	562.4	1841.0	509.4	481.5	152.3	47.2	5.3	0.0	2.1
1997	0.4	168.1	2117.6	1486.4	670.3	182.7	68.1	27.8	0.0	0.0
1998	0.0	29.3	339.5	399.2	279.9	32.3	28.6	11.2	6.0	0.0
1999	0.0	37.8	303.0	525.2	306.9	115.6	33.8	1.1	0.0	0.0
2000	0.4	464.4	786.1	1161.6	795.3	309.6	60.3	14.3	9.9	5.9
2001	0.0	5.9	740.4	1617.1	331.3	63.8	58.5	7.8	4.7	0.9
2002	0.0	29.4	287.0	1989.0	924.0	50.4	38.1	14.9	0.8	3.4
2003	0.0	10.7	311.5	1359.1	962.7	490.1	79.4	11.9	0.6	0.0
2004	0.0	1.2	139.9	878.5	245.9	346.5	18.8	3.4	2.7	0.0
2005	0.0	0.3	289.6	327.3	423.3	125.4	68.2	6.3	1.2	0.0
2006	0.0	3.6	106.1	401.9	483.5	393.5	63.5	3.7	3.2	0.3
2007	0.0	4.6	58.9	733.4	565.9	126.2	128.3	105.0	6.5	1.5
2008	0.0	11.6	138.5	561.0	223.5	88.7	43.7	14.1	6.2	0.5
2009	0.0	4.5	165.6	733.4	489.5	138.3	37.7	10.4	8.7	1.9
2010	0.6	10.9	172.6	873.1	555.4	213.0	38.6	6.8	0.0	0.2

Table B16. Black sea bass recreational discards at age, 1984-2010.

000s

	0	1	2	3	4	5	6
1984	24.8	142.4	33.4	40.9	0.0	0.0	0.0
1985	4.7	221.0	156.5	6.1	0.0	0.0	0.0
1986	40.6	731.0	284.3	0.0	0.0	0.0	0.0
1987	21.2	160.3	131.6	4.4	0.0	0.0	0.0
1988	12.5	494.4	234.3	0.0	0.0	0.0	0.0
1989	0.0	158.2	154.7	6.3	0.0	0.0	0.0
1990	67.3	446.6	220.5	52.5	0.0	0.0	0.0
1991	46.7	325.9	441.3	21.1	0.0	0.0	0.0
1992	9.0	268.1	356.1	12.6	0.0	0.0	0.0
1993	28.0	246.5	208.1	0.9	0.0	0.0	0.0
1994	3.6	376.0	68.8	147.2	0.0	0.0	0.0
1995	2.2	1,085.9	46.7	0.0	0.0	0.0	0.0
1996	7.0	405.7	269.7	0.0	0.0	0.0	0.0
1997	0.0	328.8	572.1	0.7	0.0	0.0	0.0
1998	0.5	323.2	261.2	0.0	0.0	0.0	0.0
1999	0.7	803.5	58.4	0.0	0.0	0.0	0.0
2000	21.5	1,636.3	303.5	20.0	0.0	0.0	0.0
2001	1.2	776.5	768.6	86.6	0.0	0.0	0.0
2002	0.8	562.6	916.4	215.8	3.7	0.0	0.0
2003	0.5	439.4	655.8	229.7	6.0	0.0	0.0
2004	8.3	612.5	203.9	50.2	2.8	0.4	0.0
2005	35.2	477.0	258.9	77.4	1.1	0.0	0.0
2006	29.7	632.3	291.7	60.9	18.5	1.1	0.0
2007	44.9	594.3	613.5	31.7	1.3	0.7	0.0
2008	144.0	871.0	417.0	27.4	0.0	0.0	0.0
2009	50.2	517.0	514.0	76.2	4.8	0.8	0.0
2010	69.9	450.1	378.5	183.9	16.2	0.5	0.0

Table B17. Black sea bass total catch at age, 1984-2010.

000s

	0	1	2	3	4	5	6	7	8	9
1984	24.8	496.7	1948.4	2849.0	1376.7	118.3	59.6	5.7	8.7	0.0
1985	15.1	753.5	2642.7	2127.8	1203.4	161.5	76.2	22.4	11.5	0.3
1986	40.6	1707.2	8618.4	2334.2	518.0	107.3	165.4	14.3	30.9	32.2
1987	21.2	345.0	4815.2	3081.9	441.3	108.1	147.7	15.6	24.0	0.0
1988	12.5	840.8	3695.7	3293.0	980.6	277.6	75.8	0.0	23.0	1.7
1989	2.8	730.0	5284.5	2481.0	685.1	59.5	101.6	5.3	13.0	1.6
1990	67.3	1049.5	4017.3	3779.4	520.6	116.4	45.3	33.5	1.9	0.7
1991	49.2	590.8	6867.4	2139.7	877.2	232.6	47.9	20.8	2.4	4.9
1992	9.0	421.3	4805.5	3139.3	661.4	135.3	50.8	10.1	3.1	0.0
1993	29.3	663.3	5524.8	4405.7	935.9	110.4	81.0	17.9	8.6	0.0
1994	45.8	1082.9	2847.8	2431.6	1085.8	227.5	55.0	14.4	0.4	0.2
1995	135.4	3505.2	4836.8	1860.1	360.1	218.4	42.6	9.3	0.0	0.0
1996	222.5	3482.2	6398.3	2282.4	829.0	341.4	96.7	17.1	1.3	2.4
1997	0.4	588.0	4346.9	3059.9	1128.7	247.6	92.3	35.1	1.2	0.3
1998	0.5	416.0	2380.0	1599.6	896.4	76.0	61.4	19.4	12.3	2.1
1999	0.7	868.3	1094.9	1823.9	955.8	303.5	105.2	21.7	3.5	1.2
2000	21.8	2291.1	1673.1	2010.5	1414.1	574.3	103.2	21.0	12.6	8.7
2001	3.0	956.9	2545.9	3387.7	815.1	153.7	99.2	10.3	15.4	3.6
2002	87.7	634.6	1544.3	3727.1	1828.8	101.8	59.7	23.4	2.1	15.4
2003	2.4	490.0	1228.8	2415.3	1642.4	863.2	177.6	26.3	0.6	0.0
2004	12.4	741.0	732.9	2117.2	853.2	1012.5	95.9	11.9	11.8	0.0
2005	38.2	478.2	887.0	789.0	1205.9	326.1	305.7	24.7	4.5	0.0
2006	29.7	640.7	754.6	839.7	1098.4	817.6	205.7	17.7	6.8	2.1
2007	44.9	659.7	1024.7	1409.5	1024.0	257.5	248.4	191.7	13.5	2.8
2008	146.3	913.0	792.7	1639.1	488.3	182.7	83.9	27.2	11.9	1.6
2009	54.0	603.8	1011.8	1337.1	855.9	207.6	91.6	22.0	16.1	3.9
2010	70.8	470.0	648.4	1677.0	1067.4	447.4	111.9	19.0	5.6	2.3

Table B18. Black sea bass mean catch weights at age (kg), 1968-2010. 1968-1983 weights at age the average of 1984-1986.

year	0	1	2	3	4	5	6	7+
1968	0.01	0.08	0.17	0.32	0.54	0.89	1.34	2.43
1969	0.01	0.08	0.17	0.32	0.54	0.89	1.34	2.43
1970	0.01	0.08	0.17	0.32	0.54	0.89	1.34	2.43
1971	0.01	0.08	0.17	0.32	0.54	0.89	1.34	2.43
1972	0.01	0.08	0.17	0.32	0.54	0.89	1.34	2.43
1973	0.01	0.08	0.17	0.32	0.54	0.89	1.34	2.43
1974	0.01	0.08	0.17	0.32	0.54	0.89	1.34	2.43
1975	0.01	0.08	0.17	0.32	0.54	0.89	1.34	2.43
1976	0.01	0.08	0.17	0.32	0.54	0.89	1.34	2.43
1977	0.01	0.08	0.17	0.32	0.54	0.89	1.34	2.43
1978	0.01	0.08	0.17	0.32	0.54	0.89	1.34	2.43
1979	0.01	0.08	0.17	0.32	0.54	0.89	1.34	2.43
1980	0.01	0.08	0.17	0.32	0.54	0.89	1.34	2.43
1981	0.01	0.08	0.17	0.32	0.54	0.89	1.34	2.43
1982	0.01	0.08	0.17	0.32	0.54	0.89	1.34	2.43
1983	0.01	0.08	0.17	0.32	0.54	0.89	1.34	2.43
1984	0.01	0.10	0.17	0.30	0.45	0.82	1.33	2.29
1985	0.01	0.07	0.16	0.27	0.51	0.84	1.37	2.10
1986	0.01	0.08	0.18	0.40	0.66	1.00	1.34	2.89
1987	0.03	0.08	0.17	0.34	0.57	0.92	1.58	2.02
1988	0.01	0.10	0.18	0.32	0.49	0.62	1.38	1.93
1989	0.01	0.03	0.18	0.35	0.58	0.86	1.37	2.54
1990	0.02	0.09	0.17	0.33	0.60	0.81	1.20	2.22
1991	0.03	0.08	0.17	0.36	0.54	0.66	1.16	1.84
1992	0.01	0.08	0.18	0.31	0.58	0.90	1.05	2.02
1993	0.02	0.11	0.21	0.29	0.59	0.88	1.15	1.94
1994	0.02	0.08	0.20	0.28	0.40	0.86	0.99	1.77
1995	0.05	0.12	0.24	0.45	0.76	1.01	1.21	1.69
1996	0.05	0.11	0.19	0.34	0.66	0.70	1.08	1.61
1997	0.06	0.15	0.23	0.37	0.61	0.84	0.94	1.37
1998	0.03	0.18	0.21	0.40	0.54	1.09	1.13	1.94
1999	0.03	0.14	0.28	0.41	0.59	0.85	0.92	1.78
2000	0.05	0.18	0.30	0.47	0.68	0.82	1.60	2.08
2001	0.02	0.08	0.26	0.48	0.67	1.12	1.47	1.94
2002	0.01	0.16	0.31	0.44	0.75	1.25	1.44	2.40
2003	0.03	0.14	0.36	0.49	0.63	0.84	1.40	2.13
2004	0.03	0.11	0.32	0.47	0.67	0.73	1.72	2.18
2005	0.02	0.12	0.35	0.47	0.60	0.85	1.29	2.17
2006	0.04	0.12	0.32	0.49	0.61	0.70	1.38	1.92
2007	0.04	0.15	0.27	0.48	0.64	0.88	1.06	1.79
2008	0.04	0.14	0.32	0.45	0.70	0.82	1.11	1.78
2009	0.04	0.11	0.27	0.47	0.66	0.83	1.20	1.83
2010	0.05	0.14	0.35	0.46	0.60	0.79	1.33	1.83

Table B19. Black sea bass mean catch weights at age (kg) 2006-2010, variance and CV

	Age								
	0	1	2	3	4	5	6	7	8
2006									
mean wt		0.15	0.34	0.57	0.65	0.66	1.61	1.89	
var		0.006	0.002	0.028	0.096	0.108	0.178	0.477	
CV		0.52	0.13	0.29	0.48	0.50	0.26	0.37	
2007									
mean wt		0.28	0.33	0.50	0.78	0.90	1.66	2.16	
var		0.00	0.01	0.02	0.11	0.07	0.24	0.41	
CV		0.19	0.30	0.29	0.44	0.30	0.29	0.30	
2008									
mean wt		0.14	0.39	0.49	1.00	1.54	1.99	1.96	2.98
var		0.001	0.008	0.025	0.016	0.036	0.068	0.184	0.008
CV		0.18	0.23	0.32	0.12	0.12	0.13	0.22	0.03
2009									
mean wt		0.15	0.37	0.52	0.60	0.73	1.19	1.40	
var		0.001	0.010	0.020	0.038	0.093	0.082	0.344	
CV		0.25	0.26	0.27	0.33	0.42	0.24	0.42	
2010									
mean wt	0.02	0.09	0.25	0.46	0.58	0.79	1.26	1.45	1.88
var	0.000	0.001	0.002	0.011	0.034	0.121	0.121	0.270	0.036
CV	0.00	0.36	0.18	0.23	0.32	0.44	0.28	0.36	0.10

Table B20. Model results for black sea bass maturity at age, female and sexes combined.

Female at age

	estimate	SE	L95	U95
intercept	-1.372	0.121	-1.614	-1.130
age	1.150	0.054	1.042	1.258

All at age

	estimate	SE	L95	U95
intercept	-2.578	0.101	-2.780	-2.376
age	1.572	0.048	1.476	1.668

Table B21. Black sea bass von Bertalanffy growth curves for all areas, north and south of Hudson Canyon.

All areas	n=5484	SE	lower 95%CI	upper 95%CI
Linf	65.12	1.44	62.30	67.93
K	0.181	0.006	0.168	0.193
to	0.146	0.017	0.112	0.180

North	n=4215	SE	lower 95%CI	upper 95%CI
Linf	63.64	1.71	60.29	66.98
K	0.183	0.008	0.167	0.199
to	0.150	0.026	0.099	0.201

South	n=1269	SE	lower 95%CI	upper 95%CI
Linf	65.19	2.30	60.69	69.70
K	0.202	0.011	0.180	0.224
to	0.190	0.019	0.154	0.227

Table B22. Models and associated values for natural mortality evaluated for black sea bass. Lorenzen M scaled to constant used in model. M in assessment model extrapolated to age 0.5 = 0.87.

Age	Constant	Rule of Thumb[1]	Rule of Thumb[2]	Hewitt & Hoenig[1]	Hewitt & Hoenig[2]	Lorenzen	Lorenzen Scaled to Constant	Lorenzen Scaled to Rule of Thumb[1]	Lorenzen Scaled to Hewitt & Hoenig[1]	Lorenzen Scaled to Rule of Thumb[2]	Lorenzen Scaled to Hewitt & Hoenig[2]
1	0.40	0.33	0.25	0.47	0.35	0.87	0.65	0.56	0.78	0.50	0.62
2	0.40	0.33	0.25	0.47	0.35	0.69	0.49	0.44	0.62	0.36	0.46
3	0.40	0.33	0.25	0.47	0.35	0.60	0.41	0.38	0.53	0.29	0.38
4	0.40	0.33	0.25	0.47	0.35	0.52	0.36	0.33	0.47	0.24	0.33
5	0.40	0.33	0.25	0.47	0.35	0.47	0.33	0.30	0.42	0.21	0.29
6	0.40	0.33	0.25	0.47	0.35	0.42	0.31	0.27	0.37	0.18	0.25
7	0.40	0.33	0.25	0.47	0.35	0.39	0.29	0.25	0.35	0.16	0.23
8	0.40	0.33	0.25	0.47	0.35	0.37	0.27	0.24	0.34	0.15	0.21
9	0.40	0.33	0.25	0.47	0.35	0.36	0.26	0.23	0.33	0.15	0.21
10	0.40		0.25		0.35	0.33	0.25			0.13	0.19
11	0.40		0.25		0.35	0.32	0.24			0.12	0.17
12	0.40		0.25		0.35	0.30	0.23			0.11	0.16

[1]Maximum age = 9

[2]Maximum age = 12

Table B23. Black sea bass mean stock weights at age (kg), 1968-2010. 1968-1983 weights at age the average of 1984-1986.

year	0	1	2	3	4	5	6	7+
1968	0.001	0.01	0.13	0.29	0.51	0.89	1.34	2.43
1969	0.001	0.01	0.13	0.29	0.51	0.89	1.34	2.43
1970	0.001	0.01	0.13	0.29	0.51	0.89	1.34	2.43
1971	0.001	0.01	0.13	0.29	0.51	0.89	1.34	2.43
1972	0.001	0.01	0.13	0.29	0.51	0.89	1.34	2.43
1973	0.001	0.01	0.13	0.29	0.51	0.89	1.34	2.43
1974	0.001	0.01	0.13	0.29	0.51	0.89	1.34	2.43
1975	0.001	0.01	0.13	0.29	0.51	0.89	1.34	2.43
1976	0.001	0.01	0.13	0.29	0.51	0.89	1.34	2.43
1977	0.001	0.01	0.13	0.29	0.51	0.89	1.34	2.43
1978	0.001	0.01	0.13	0.29	0.51	0.89	1.34	2.43
1979	0.001	0.01	0.13	0.29	0.51	0.89	1.34	2.43
1980	0.001	0.01	0.13	0.29	0.51	0.89	1.34	2.43
1981	0.001	0.01	0.13	0.29	0.51	0.89	1.34	2.43
1982	0.001	0.01	0.13	0.29	0.51	0.89	1.34	2.43
1983	0.001	0.01	0.13	0.29	0.51	0.89	1.34	2.43
1984	0.001	0.01	0.13	0.29	0.51	0.82	1.33	2.29
1985	0.001	0.01	0.14	0.28	0.46	0.84	1.37	2.10
1986	0.001	0.01	0.14	0.32	0.54	1.00	1.34	2.89
1987	0.001	0.01	0.15	0.32	0.54	0.92	1.58	2.02
1988	0.001	0.01	0.13	0.27	0.53	0.62	1.38	1.93
1989	0.001	0.01	0.13	0.25	0.46	0.86	1.37	2.54
1990	0.001	0.01	0.12	0.25	0.46	0.81	1.20	2.22
1991	0.001	0.01	0.12	0.27	0.46	0.66	1.16	1.84
1992	0.001	0.01	0.11	0.23	0.44	0.90	1.05	2.02
1993	0.001	0.01	0.12	0.23	0.39	0.88	1.15	1.94
1994	0.001	0.01	0.15	0.26	0.58	0.86	0.99	1.77
1995	0.001	0.01	0.17	0.32	0.64	1.01	1.21	1.69
1996	0.001	0.02	0.16	0.31	0.67	0.70	1.08	1.61
1997	0.001	0.02	0.15	0.32	0.50	0.84	0.94	1.37
1998	0.001	0.01	0.16	0.34	0.47	1.09	1.13	1.94
1999	0.001	0.01	0.18	0.37	0.55	0.85	0.92	1.78
2000	0.001	0.01	0.17	0.37	0.60	0.82	1.60	2.08
2001	0.001	0.01	0.18	0.36	0.68	1.12	1.47	1.94
2002	0.001	0.01	0.16	0.35	0.61	1.25	1.44	2.40
2003	0.001	0.01	0.17	0.33	0.58	0.84	1.40	2.13
2004	0.001	0.01	0.16	0.32	0.47	0.73	1.72	2.18
2005	0.001	0.01	0.17	0.35	0.52	0.85	1.29	2.17
2006	0.001	0.01	0.17	0.33	0.52	0.70	1.38	1.92
2007	0.001	0.01	0.17	0.34	0.60	0.88	1.06	1.79
2008	0.001	0.01	0.16	0.33	0.58	0.82	1.11	1.78
2009	0.001	0.01	0.15	0.33	0.55	0.83	1.20	1.83
2010	0.001	0.01	0.14	0.31	0.49	0.79	1.33	1.83

Table B24. Components, number of residuals and residual mean square errors of ASAP model objective function.

Component	Num.resids	RMSE
_Catch_Fleet_1	43	0.364
Catch_Fleet_Total	43	0.364
_Discard_Fleet_1	0	0
Discard_Fleet_Total	0	0
_Index_1	30	0.428
_Index_2	22	1.27
_Index_3	22	2.94
_Index_4	27	2.67
_Index_5	27	2.63
_Index_6	43	2.34
_Index_7	16	2.3
Index_Total	187	2.23
Nyear1	7	0.341
Fmult_Year1	0	0
_Fmult_devs_Fleet_1	0	0
Fmult_devs_Total	0	0
Recruit_devs	43	0.542
Fleet_Sel_params	16	1.66
Index_Sel_params	16	0.383
q_year1	2	5.62
q_devs	0	0
SRR_steepness	0	0
SRR_unexpl_S	0	0

Table B25. Historic retrospective estimates of black sea bass fishing mortality.

	SCALE M=0.4 DPWG (model avg)	SCALE M=0.4 2008 (model avg)	SCALE M=0.4 2009 (model avg)	SCALE M=0.4 June update	M=0.4 Revised SCALE	M=0.4 ASAP	Lorenzen M ASAP
1968	0.62	0.59	0.58	0.57	0.46	0.30	0.30
1969	0.48	0.46	0.45	0.45	0.38	0.29	0.30
1970	0.46	0.44	0.43	0.43	0.37	0.25	0.25
1971	0.21	0.20	0.20	0.20	0.18	0.13	0.13
1972	0.24	0.23	0.23	0.23	0.21	0.15	0.15
1973	0.29	0.29	0.29	0.28	0.27	0.21	0.21
1974	0.28	0.28	0.28	0.28	0.24	0.19	0.19
1975	0.43	0.43	0.43	0.42	0.35	0.33	0.32
1976	0.50	0.50	0.51	0.48	0.34	0.34	0.34
1977	0.72	0.72	0.74	0.70	0.44	0.54	0.52
1978	0.66	0.64	0.65	0.62	0.31	0.57	0.55
1979	0.35	0.33	0.34	0.34	0.16	0.49	0.48
1980	0.36	0.33	0.34	0.34	0.17	0.39	0.38
1981	0.28	0.26	0.26	0.26	0.15	0.29	0.28
1982	0.83	0.79	0.79	0.79	0.54	0.41	0.41
1983	0.65	0.63	0.62	0.63	0.44	0.58	0.58
1984	0.49	0.48	0.48	0.48	0.37	0.41	0.41
1985	0.42	0.41	0.40	0.41	0.36	0.39	0.40
1986	1.21	1.27	1.26	1.25	1.34	0.49	0.50
1987	0.66	0.68	0.67	0.67	0.71	0.40	0.41
1988	0.91	0.92	0.90	0.90	0.93	0.49	0.50
1989	0.95	0.88	0.89	0.89	0.93	0.43	0.43
1990	1.02	0.94	0.96	0.95	1.03	0.47	0.47
1991	1.01	1.00	1.00	1.01	1.15	0.55	0.55
1992	0.78	0.73	0.75	0.75	0.75	0.40	0.40
1993	0.95	0.87	0.90	0.88	0.91	0.60	0.60
1994	0.52	0.51	0.52	0.51	0.53	0.52	0.52
1995	0.86	0.90	0.89	0.88	0.90	0.76	0.76
1996	1.19	1.07	1.15	1.14	1.10	0.96	0.97
1997	1.01	0.99	1.02	1.02	0.92	0.76	0.80
1998	0.62	0.58	0.62	0.61	0.56	0.52	0.57
1999	0.60	0.59	0.62	0.62	0.59	0.49	0.56
2000	0.93	0.93	0.97	0.98	1.01	0.56	0.65
2001	1.16	1.09	1.17	1.21	1.24	0.43	0.51
2002	1.02	0.98	1.03	1.03	0.72	0.34	0.41
2003	0.86	0.81	0.87	0.84	0.48	0.25	0.31
2004	0.80	0.56	0.68	0.65	0.35	0.19	0.24
2005	0.54	0.40	0.46	0.46	0.26	0.17	0.21
2006	0.50	0.39	0.45	0.46	0.26	0.19	0.22
2007	0.48	0.37	0.43	0.46	0.27	0.20	0.22
2008		0.28	0.35	0.39	0.24	0.15	0.17
2009			0.29	0.32	0.22	0.15	0.16
2010				0.41	0.30	0.17	0.18

Table B26. Black sea bass CVs used in stochastic biological reference points.

Catch, SSB, Jan 1 Mean Weights

	True Age							
	0	1	2	3	4	5	6	7+
Input CV	0.301	0.301	0.222	0.281	0.336	0.356	0.214	0.332

Fishery Selectivity

	True Age							
	0	1	2	3	4	5	6	7+
Input CV	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200

Maturity at age

	True Age							
	0	1	2	3	4	5	6	7+
Input CV	0.190	0.220	0.150	0.050	0.020	0.010	0.010	0.010

Natural Mortality

	True Age							
	0	1	2	3	4	5	6	7+
Input CV	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300

Table B27. Black sea bass biological reference points and 2010 catch.

Biological Reference Points	F40%	SSB40%	MSY	F2010	SSB2010	Catch2011
Existing BRPs and July 2011 Scale update	0.42	12,537 MT	3,903 MT	0.41	13,926 MT	2,960 MT
LOR M=0.40 from final base run (median SSB 2010)	DET: **0.252** AVG: **0.279** SD: 0.041 CV: 0.147 **50%: 0.275** 10%: 0.230 90%: 0.337	50%: 9,467 MT 10%: 8,004 MT 90%: 11,184 MT	50%: 3,087MT 10%: 2,593 MT 90%: 3,675 MT	avg 0.18 50%: 0.171 10%: 0.134 90%: 0.216	avg 10,843 MT 50%: 11,456MT 10%: 10,012 MT 90%: 13,082 MT	2,444 MT
Const M = 0.4. from alternate run	DET: **0.292** AVG: **0.323** SD: 0.050 CV: 0.155 **50%: 0.316** 10%: 0.262 90%: 0.390	50%: 8,128 MT 10%: 6,734 MT 90%: 9,870 MT	50%: 3,197 MT 10%: 2,628 MT 90%: 3,905 MT	avg 0.17 50%: 0.161 10%: 0.143 90%: 0.182	avg. 11,412 MT 50%: 11,863 MT 10%: 10,521 MT 90%: 13,369 MT	2,444 MT

Table B28. Black sea bass stock status (2010) compared to biological reference points.

Biological Reference Points	Status 2010	2010 % BRP
Existing BRPs and July 2011 Scale update	Not overfished No overfishing	111% of SSB40% 98% of F40%
LOR M=0.40 from final base run	Not overfished No overfishing	121% of SSB40% 62% of F40%
Const M = 0.4. from alternate run	Not overfished No overfishing	146% of SSB40% 59% of F40%

Table B29. Black sea bass projected catch (000s MT) for 2012-2015, under age varying M and 2011 recruitment from 2006-2010 average, at $F_{40\%}$.

Variable M

recruitment 2006-2010

SSB

	10% CI	Median	90% CI
2011	9.849	11.160	12.596
2012	8.883	9.905	10.960
2013	8.150	9.029	9.909
2014	7.843	8.712	9.663
2015	7.527	8.550	9.741

Catch	10% CI	Median	90% CI
2011	3.204	3.628	4.076
2012	2.783	3.093	3.401
2013	2.535	2.799	3.087
2014	2.509	2.779	3.075
2015	2.434	2.806	3.229

Total biomass	10% CI	Median	90% CI
2011	11.219	12.802	14.554
2012	10.170	11.363	12.653
2013	9.207	10.202	11.181
2014	8.851	9.766	10.722
2015	8.451	9.519	10.732

Mean biomass	10% CI	Median	90% CI
2011	10.796	12.162	13.643
2012	9.744	10.847	11.92
2013	9.086	10.028	11.009
2014	8.823	9.863	11.038
2015	8.529	9.767	11.246

Table B30. Black sea bass projected catch (000s MT) for 2012-2015, under constant M=0.4 and 2011 recruitment from 2006-2010 average at $F_{40\%}$.

Constant M
recruitment 2006-2010

SSB

	10% CI	Median	90% CI
2011	9.950	11.177	12.499
2012	8.402	9.325	10.357
2013	7.409	8.184	9.070
2014	6.953	7.762	8.707
2015	6.574	7.588	8.831

Catch	10% CI	Median	90% CI
2011	3.839	4.292	4.800
2012	3.109	3.444	3.827
2013	2.743	3.032	3.371
2014	2.701	3.003	3.351
2015	2.562	3.007	3.534

Total Biomass	10% CI	Median	90% CI
2011	11.747	13.318	14.982
2012	9.981	11.101	12.369
2013	8.560	9.462	10.501
2014	8.049	8.881	9.818
2015	7.499	8.564	9.808

Mean Biomass	10% CI	Median	90% CI
2011	10.961	12.266	13.719
2012	9.300	10.282	11.423
2013	8.402	9.253	10.251
2014	7.931	8.943	10.114
2015	7.553	8.798	10.370

Table B31. Black sea bass projected catch (000s MT) for 2012-2015, under age varying M and 2011 recruitment from 1984-2010 average at $F_{40\%}$.

Variable M

recruitment 1984-2010

SSB

	10% CI	Median	90% CI
2011	9.849	11.160	12.596
2012	8.893	9.910	10.960
2013	8.355	9.171	9.991
2014	8.141	8.931	9.804
2015	7.784	8.754	9.899

Catch	10% CI	Median	90% CI
2011	3.205	3.628	4.076
2012	2.797	3.103	3.409
2013	2.591	2.840	3.109
2014	2.638	2.873	3.133
2015	2.520	2.878	3.286

Total biomass	10% CI	Median	90% CI
2011	11.220	12.802	14.555
2012	10.184	11.372	12.659
2013	9.312	10.281	11.223
2014	9.196	10.011	10.865
2015	8.743	9.749	10.890

Mean Biomass	10% CI	Median	90% CI
2011	10.802	12.165	13.646
2012	9.778	10.868	11.942
2013	9.397	10.256	11.134
2014	9.150	10.116	11.208
2015	8.792	9.982	11.422

Table B32. Black sea bass projected catch (000s MT) for 2012-2015, under constant M and 2011 recruitment from 1984-2010 average at $F_{40\%}$.

Constant M
recruitment 1984-2010

SSB

	10% CI	Median	90% CI
2011	9.950	11.177	12.499
2012	8.407	9.328	10.356
2013	7.523	8.228	9.057
2014	7.105	7.841	8.702
2015	6.678	7.651	8.854

Catch	10% CI	Median	90% CI
2011	3.839	4.292	4.800
2012	3.119	3.451	3.824
2013	2.775	3.048	3.365
2014	2.777	3.040	3.351
2015	2.600	3.033	3.547

Total Biomass	10% CI	Median	90% CI
2011	11.748	13.318	14.982
2012	9.988	11.102	12.364
2013	8.620	9.488	10.485
2014	8.241	8.966	9.787
2015	7.630	8.638	9.820

Mean Biomass	10% CI	Median	90% CI
2011	10.962	12.270	13.718
2012	9.316	10.288	11.419
2013	8.564	9.327	10.223
2014	8.091	9.026	10.112
2015	7.659	8.865	10.409

Table B33. 2012 OFL (median and 80% CI) under two M options and two recruit series. 2011 catch assumed equal to ABC (2,041 MT).

	2012 OFL R=2006-2010	2012 OFL R=1984-2010
LOR M = 0.40 from final base run	50%: 3,093 MT 10%: 2,783 MT 90%: 3,401 MT	50%: 3,103 MT 10%: 2,797 MT 90%: 3,409 MT
Const M = 0.4. from alternate run	50%: 3,444 MT 10%: 3,109 MT 90%: 3,827 MT	50%: 3,451 MT 10%: 3,119MT 90%: 3,824 MT

Figures

[SAW53 Editor's Note:
The SARC-53 review panel did accept the work presented on TORs 1-4 (which primarily gives an update on fishing patterns, landings and survey data. Tables B1-B23 and Figures B1-B66 are associated with TORs 1-4.

The SARC-53 review panel <u>did not accept</u> new assessment models (or results from those new models) that were prepared by the SAW53 Working Group. Tables B24-B33 and Figures B67-B110 are associated with the new models and results. They are included in this report to demonstrate the work that was done by the SAW Working Group for the December 2011 peer review. However, those Tables and Figures are not intended to be used for management at this time.]

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Figure B110. Relationship between time series spawning stock biomass and fishing mortality for black sea bass. Lines represent biological reference points and the red diamond is the 2010 value.

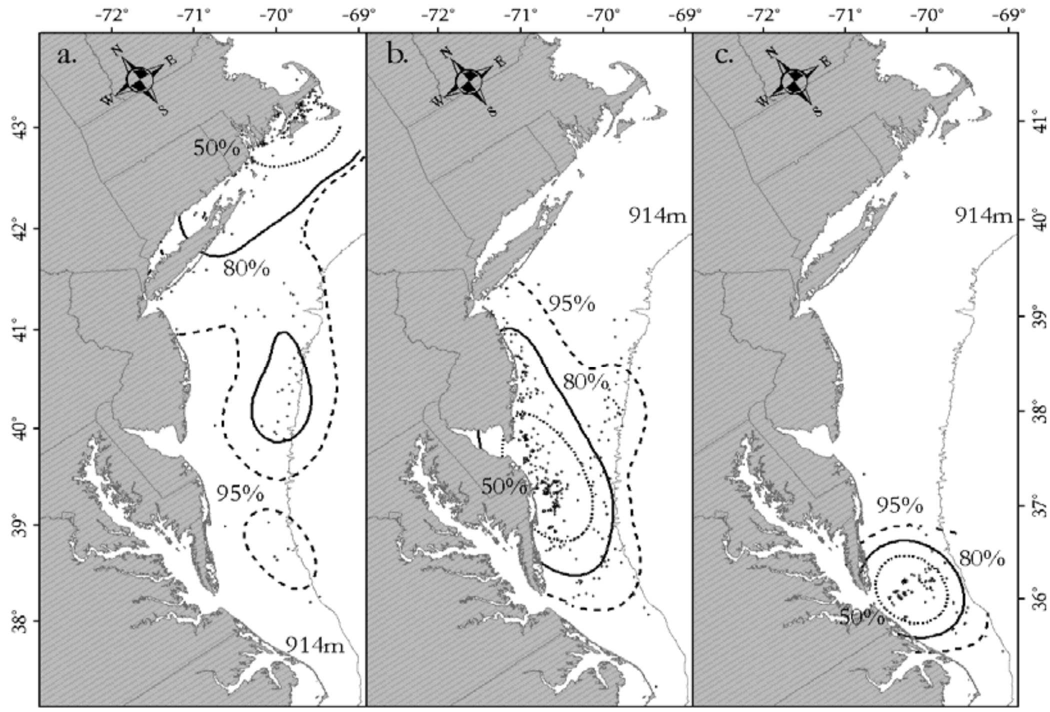
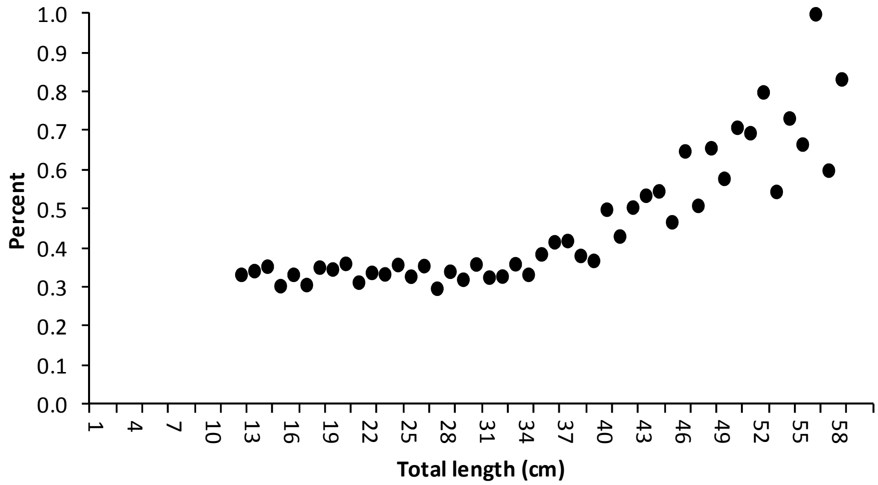


Figure B1. Percent volume contours of black sea bass tag recaptures released from a) the Northern area, b) the Central area, and c) the Southern area. The area within the dashed line contains 95% of tag recaptures, the solid line contains 80% of tag recaptures and the dotted line contains 50% of the recaptured tags from the respective area. Small circles indicate the respective tag recapture locations for tags released in that area. (*from* Moser and Shepherd 2009)



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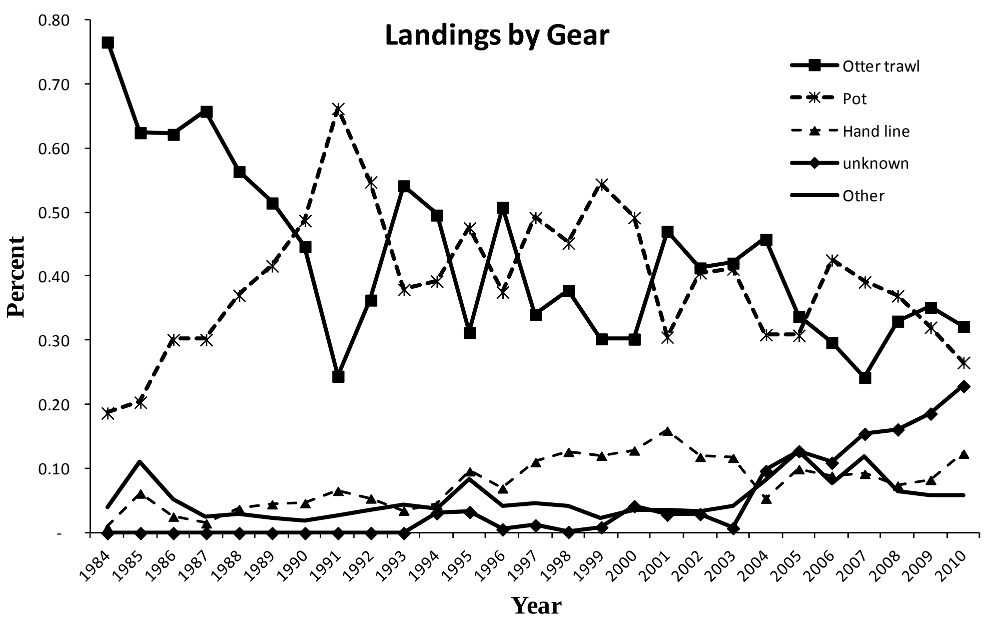

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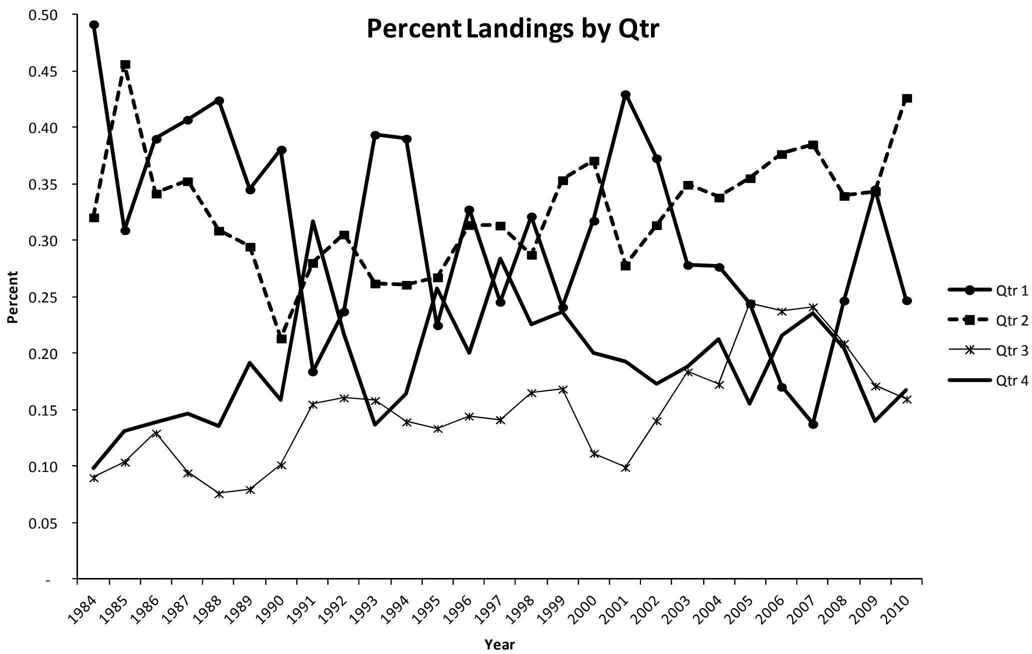

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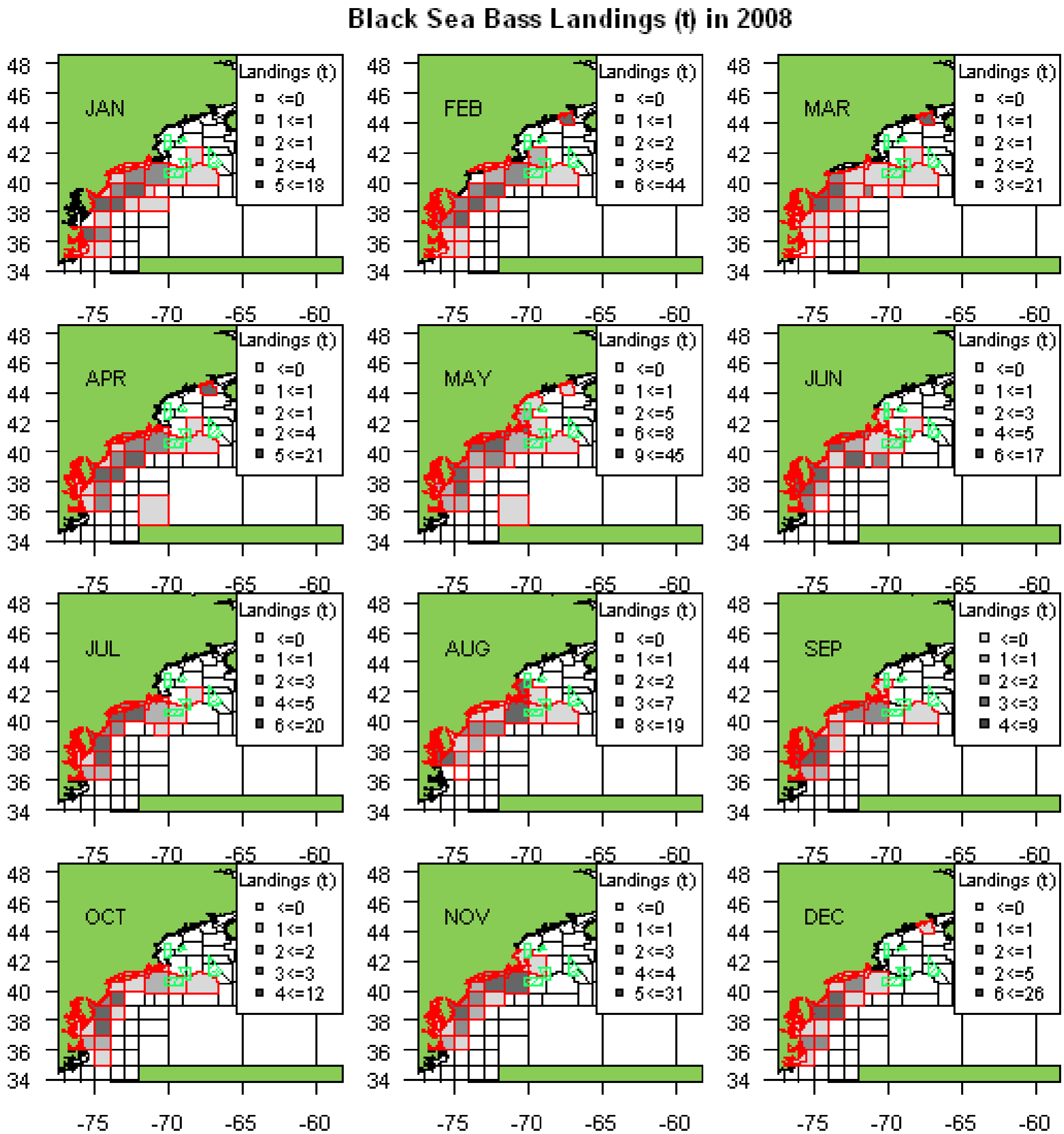

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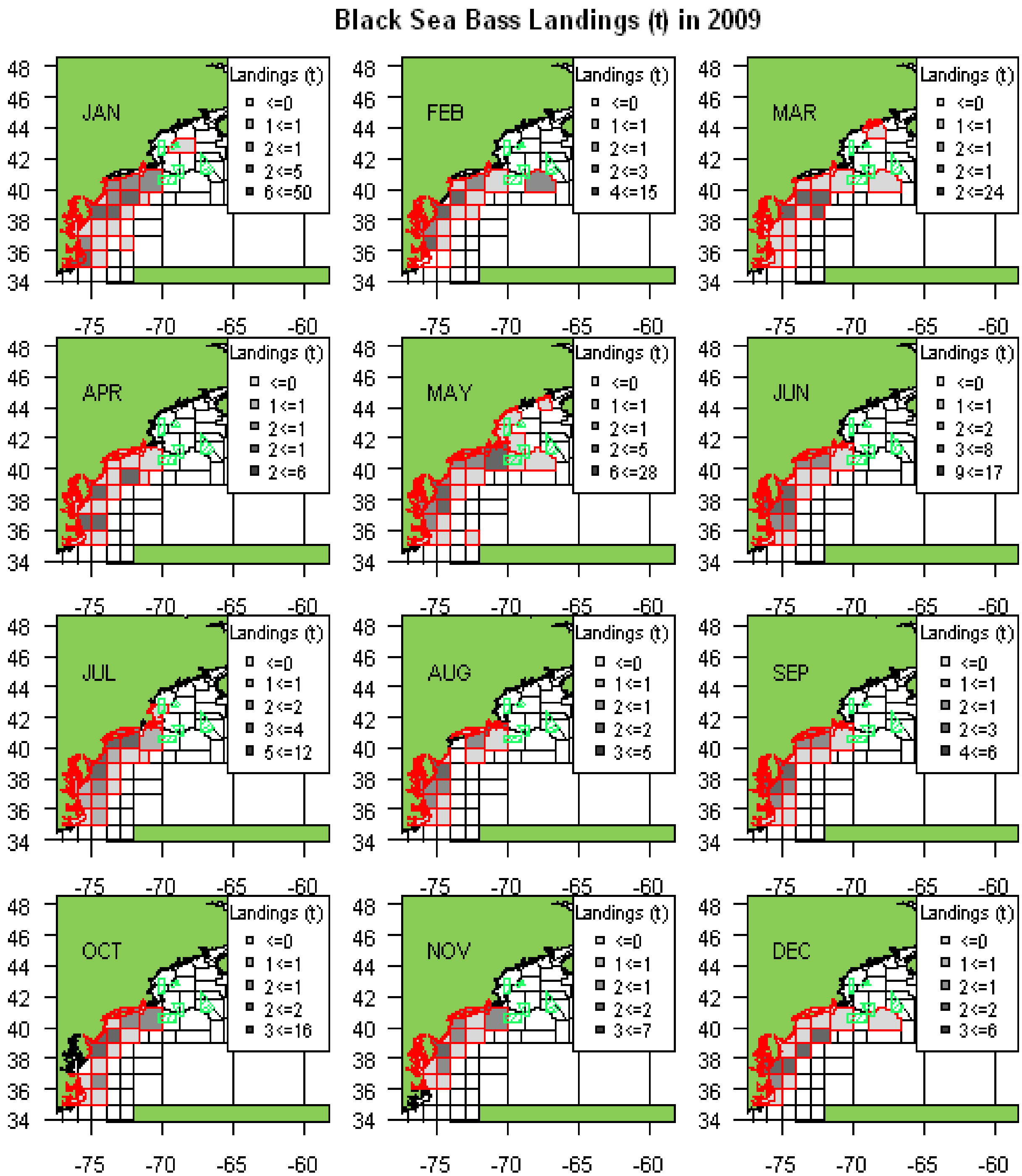

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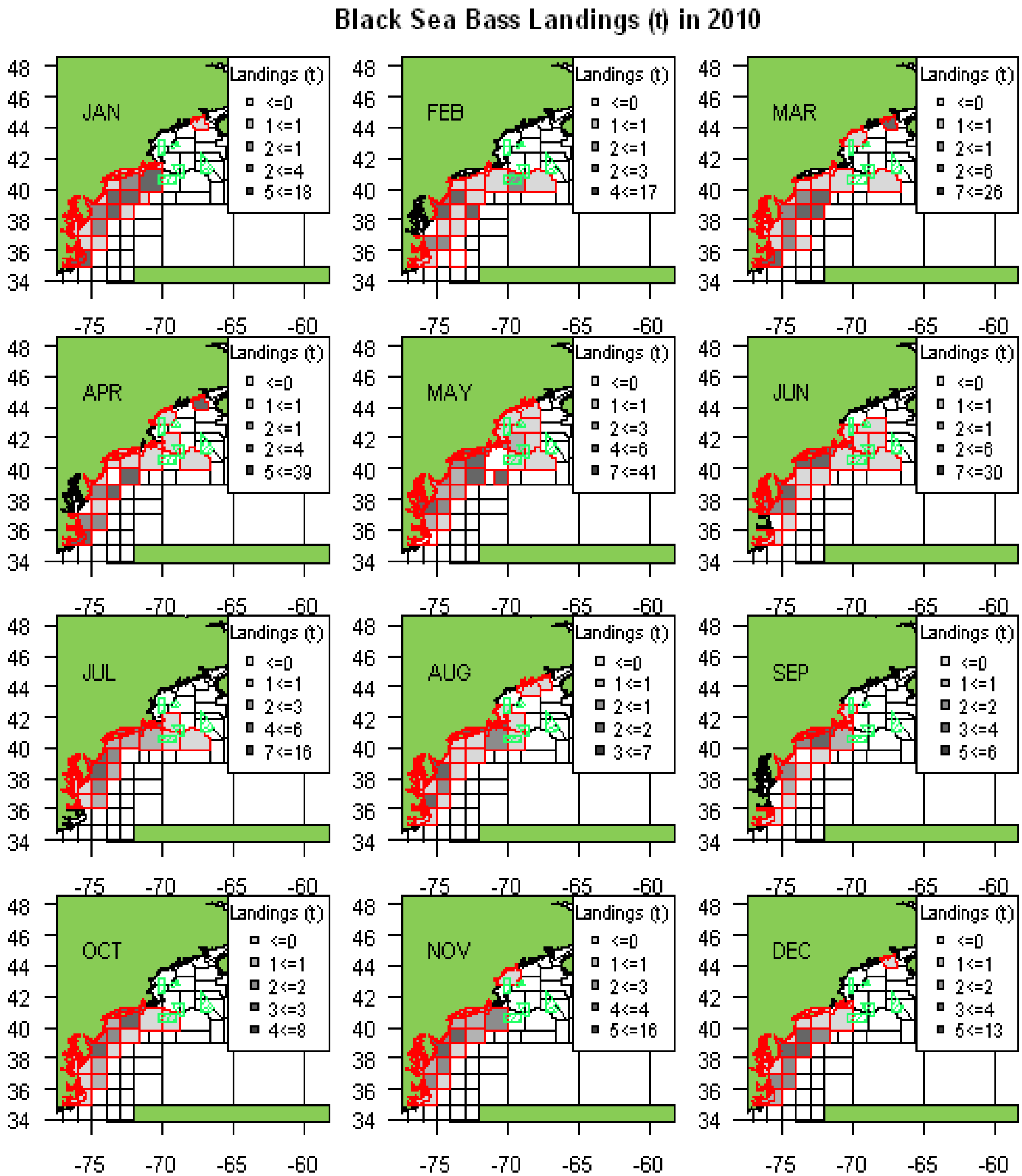

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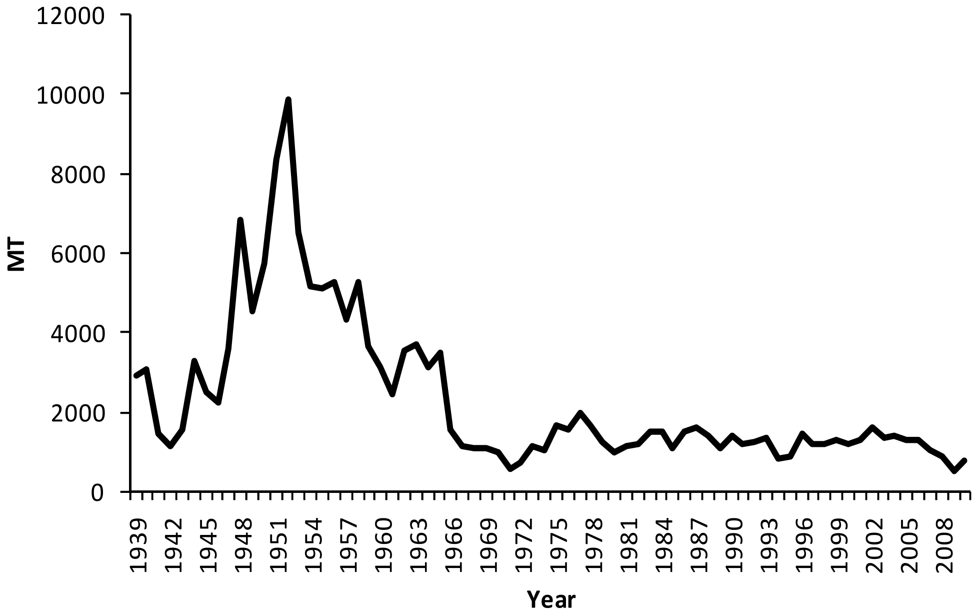

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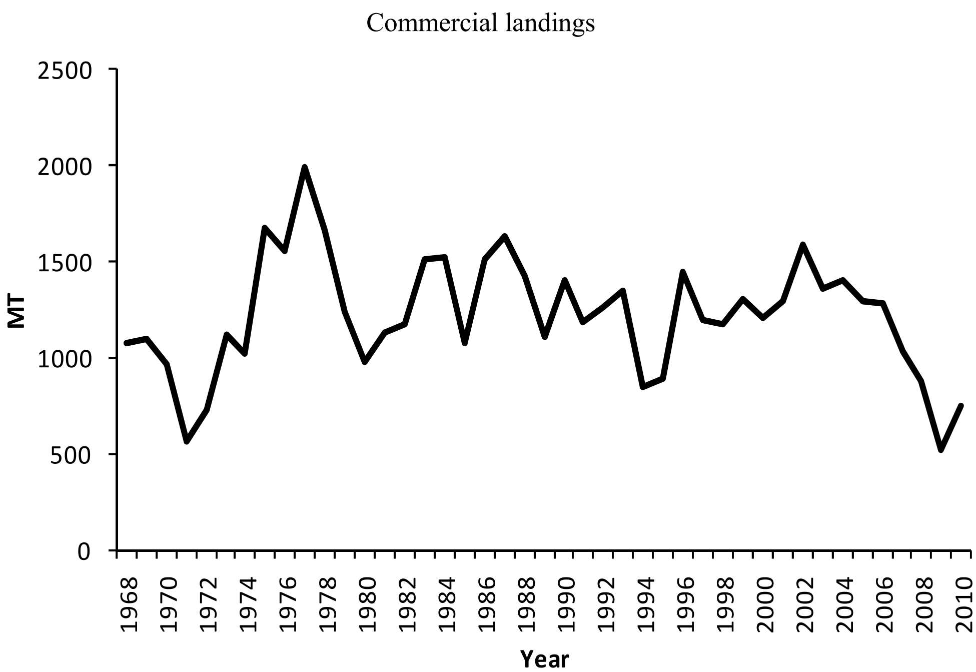

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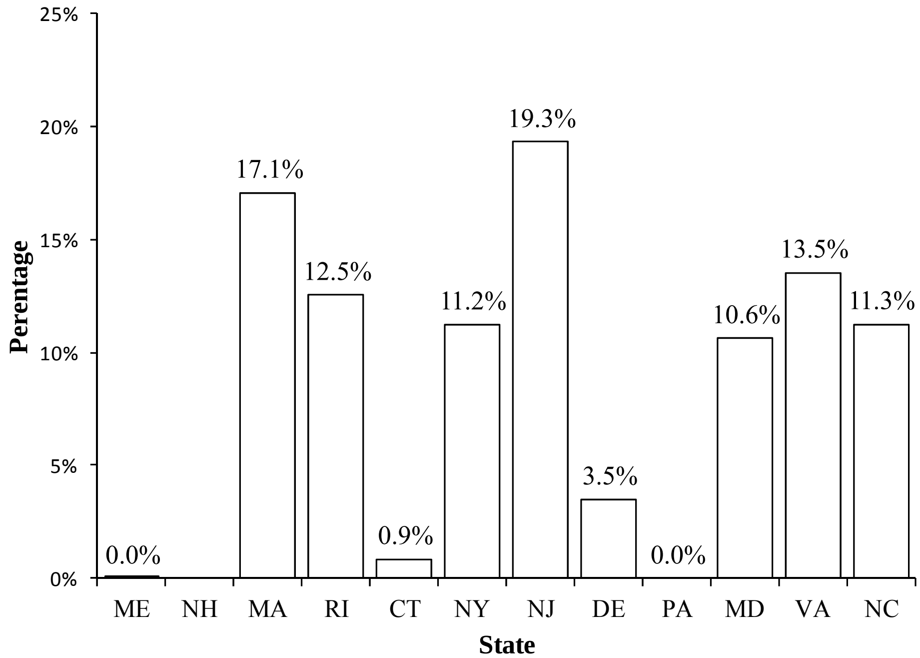

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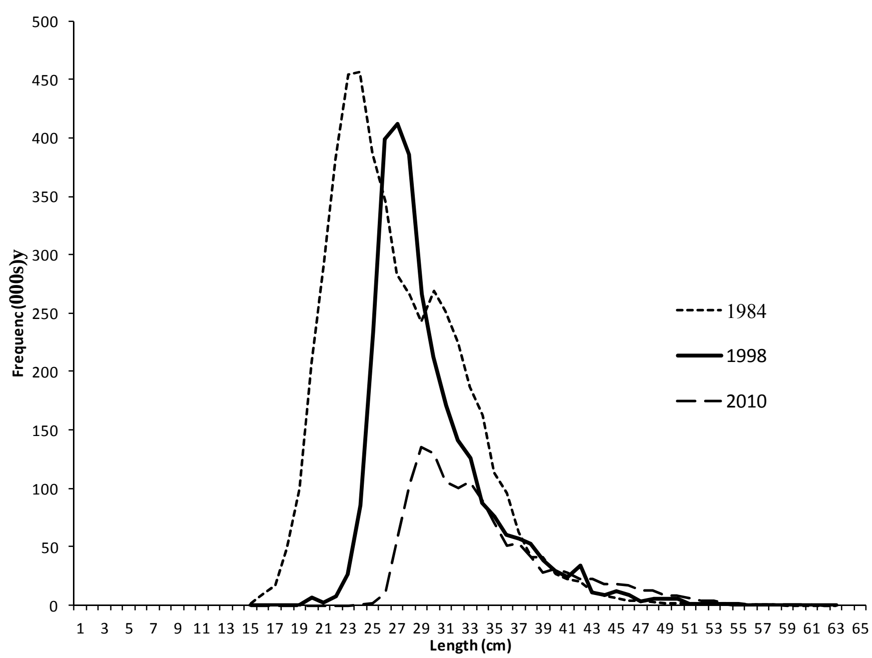

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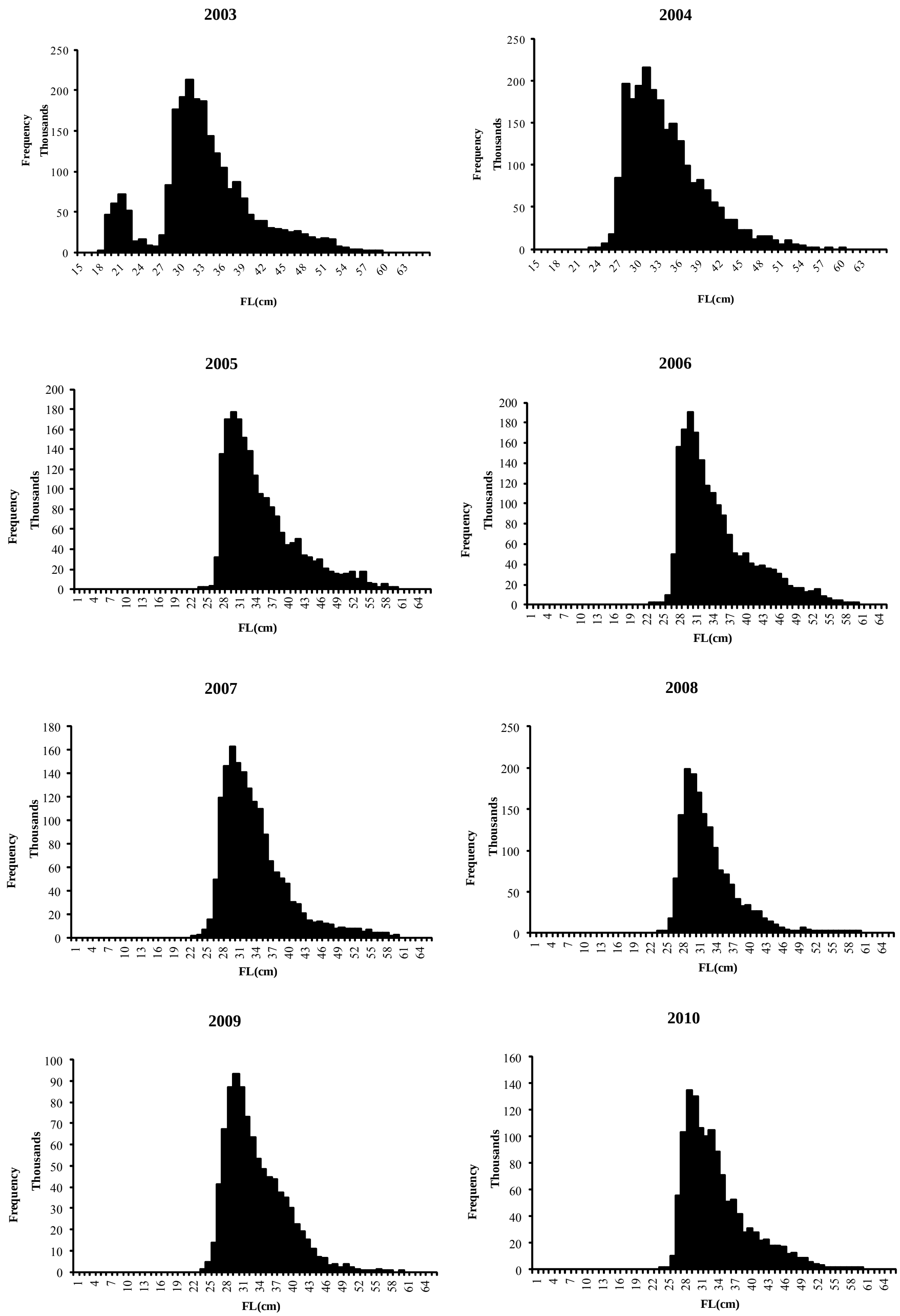

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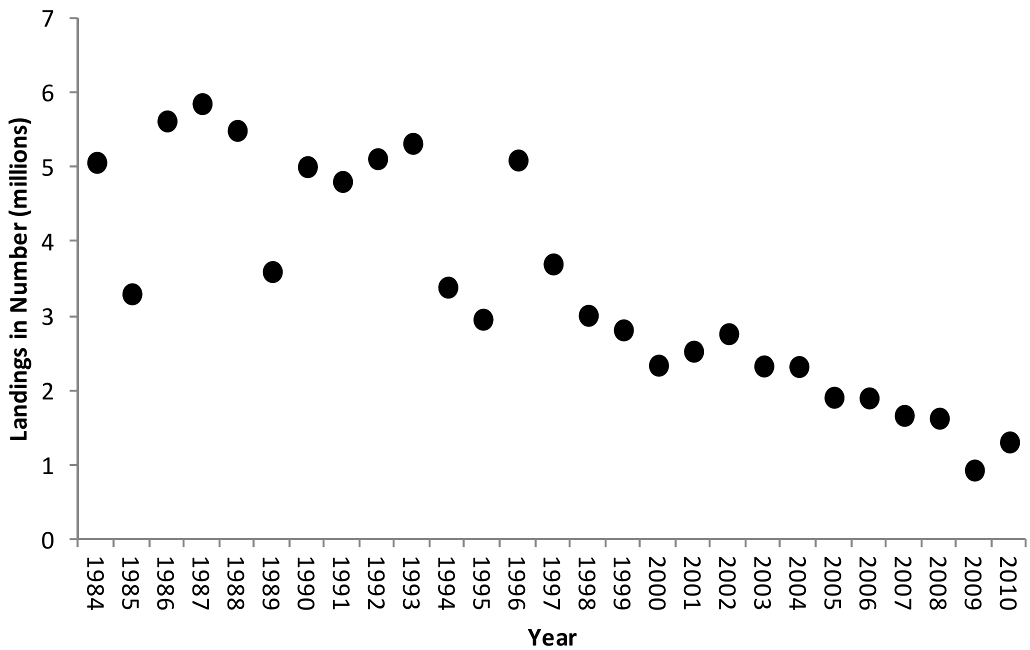

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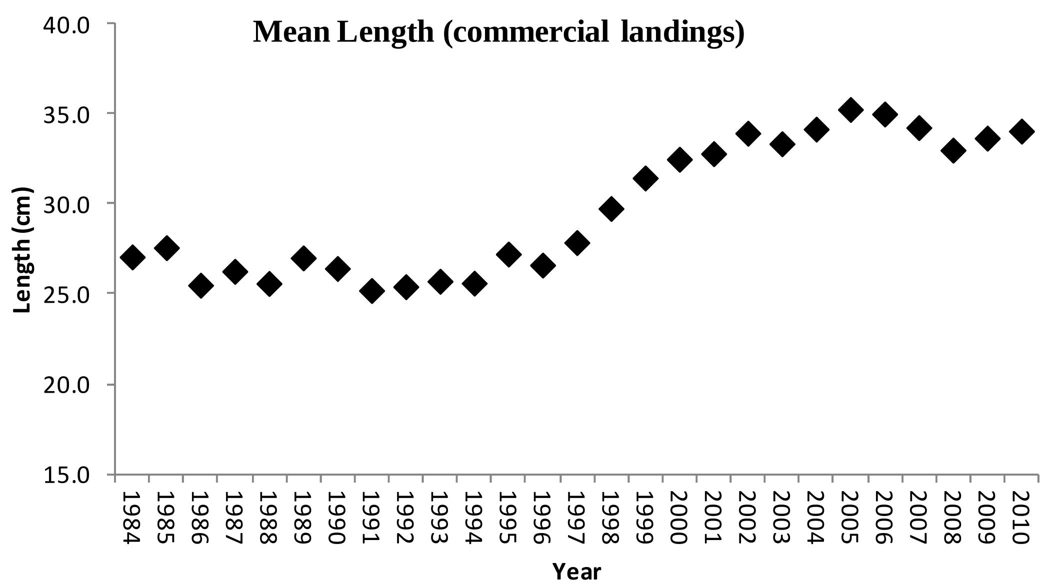

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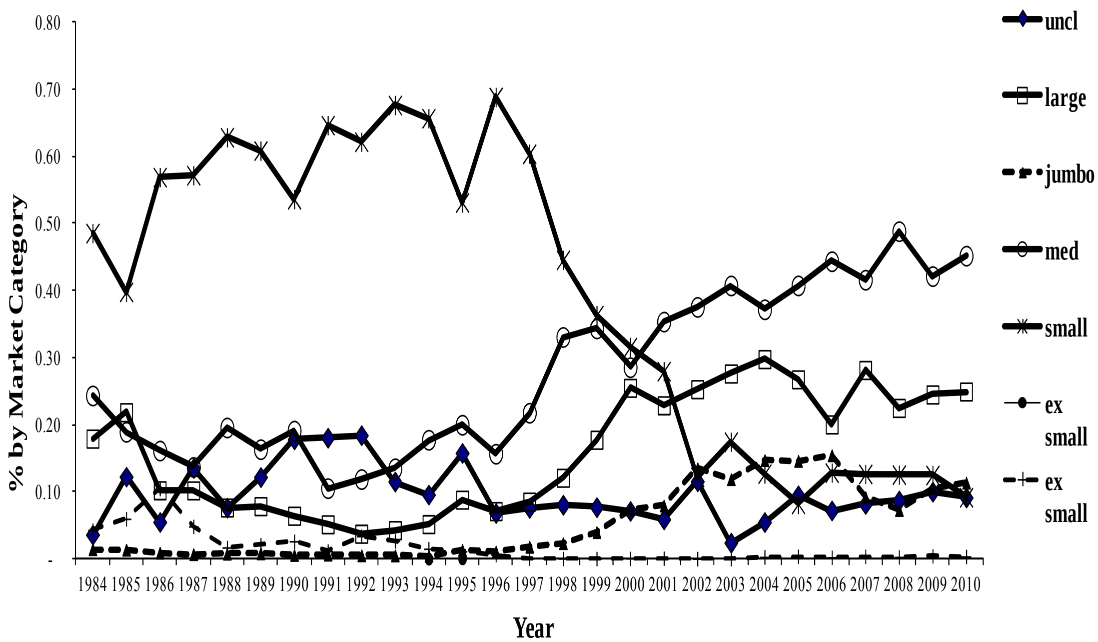

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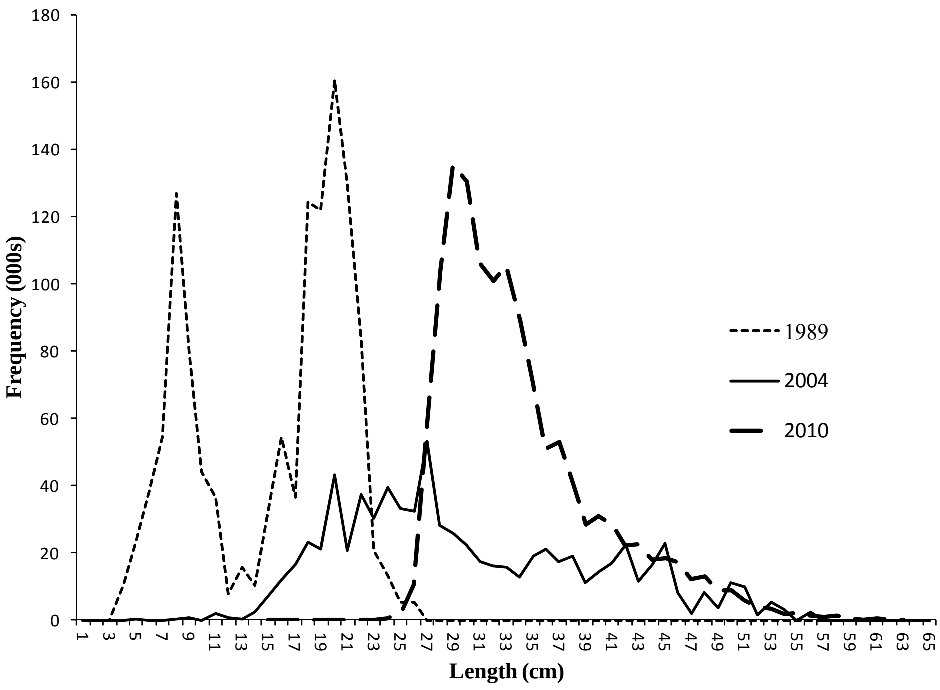

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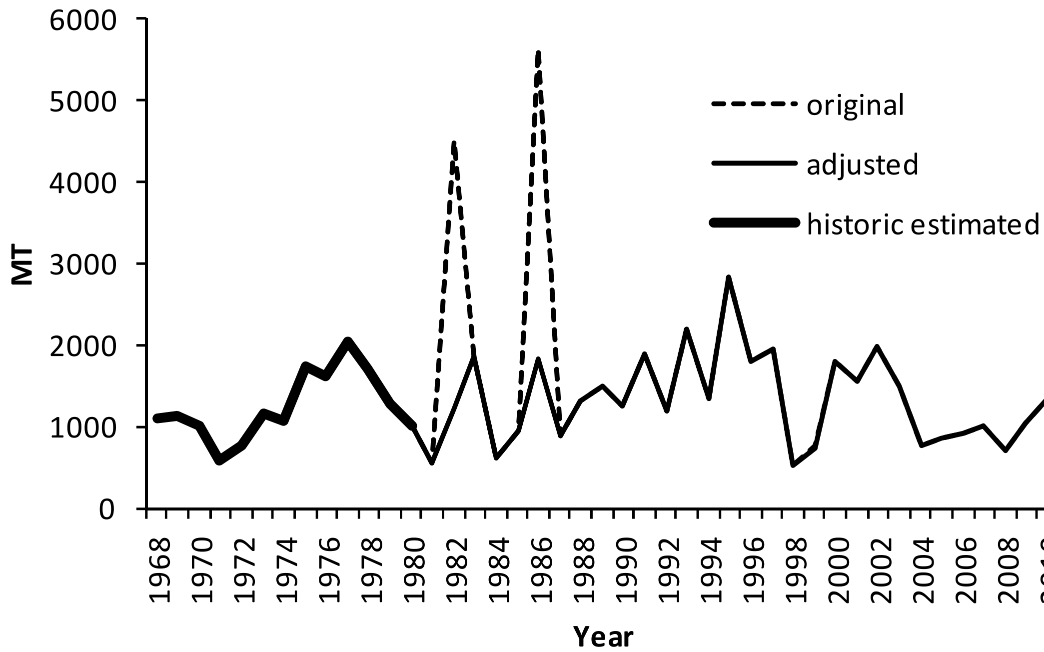

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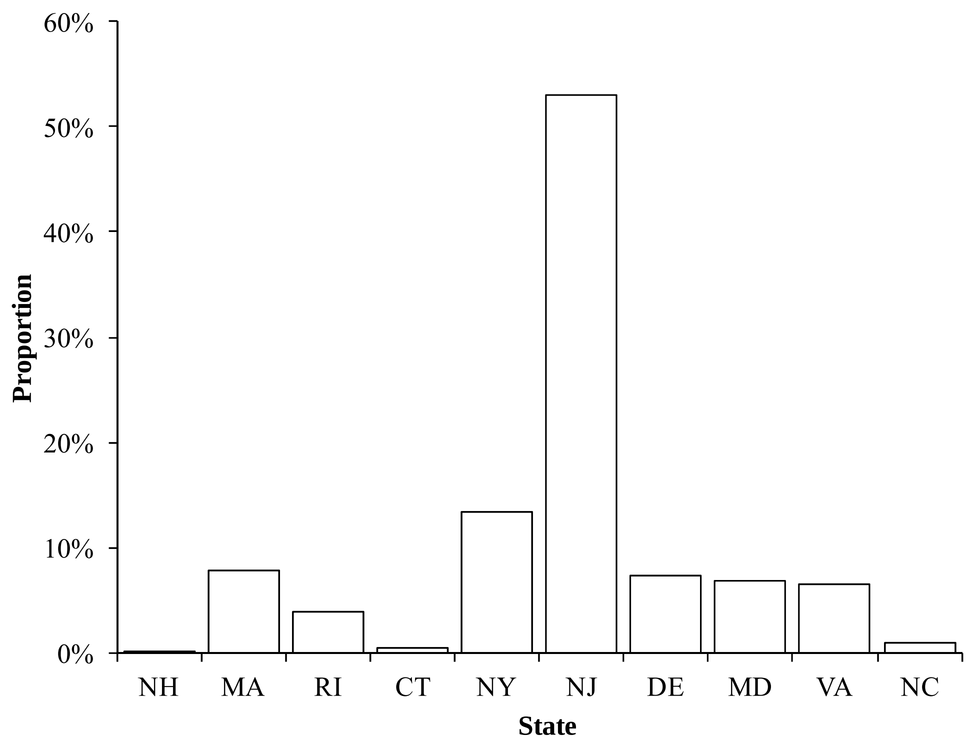

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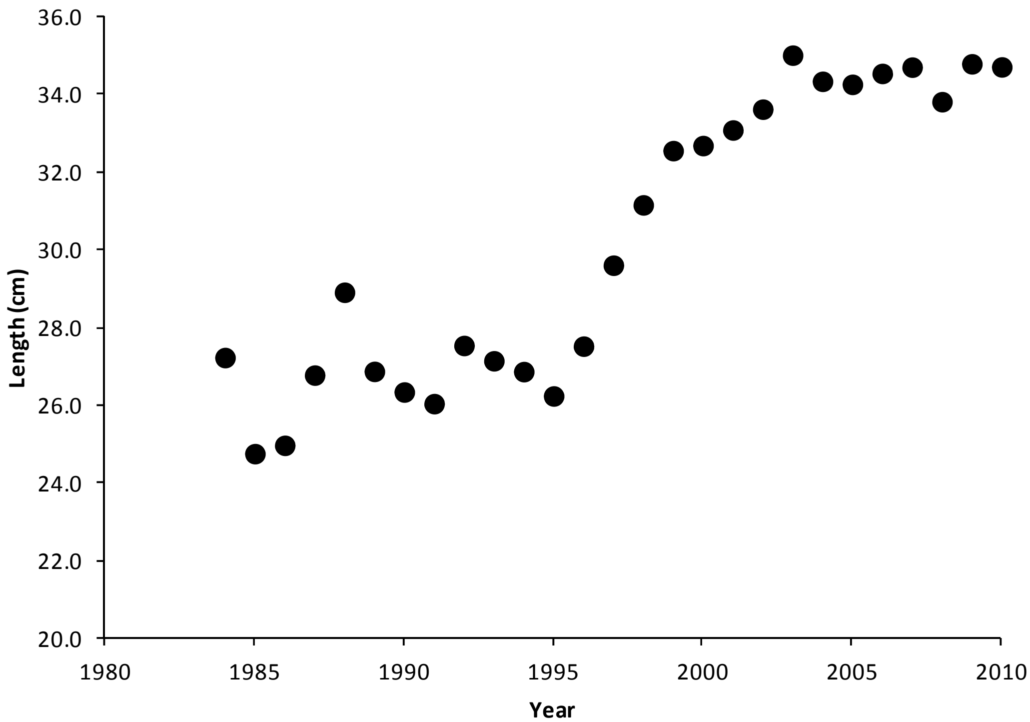

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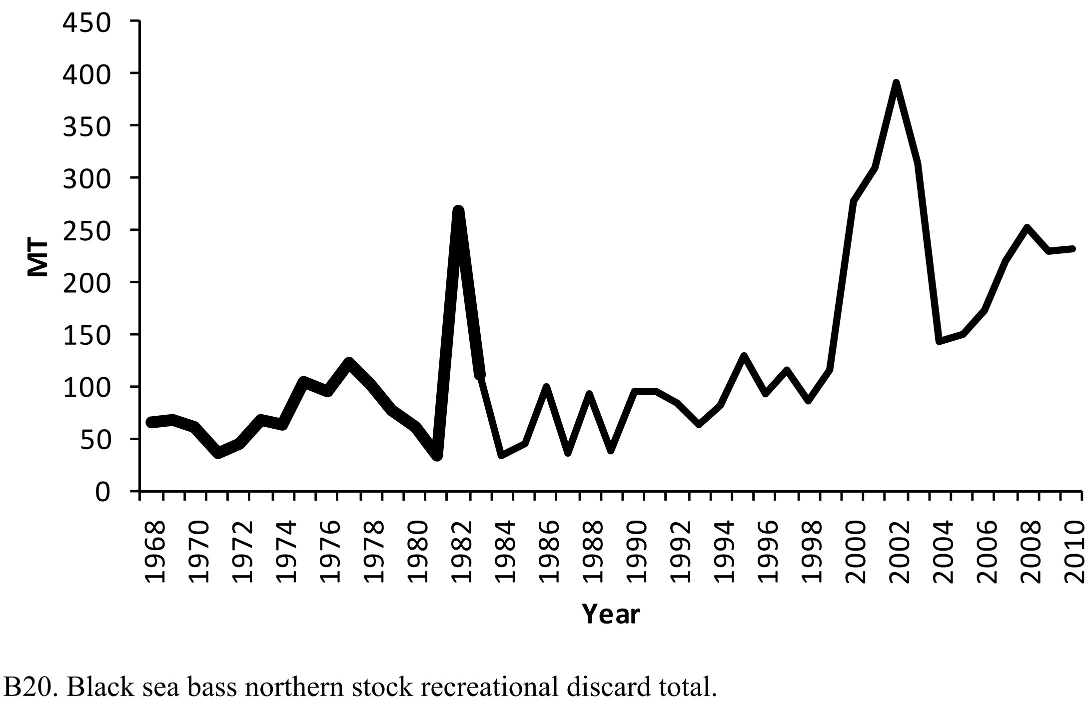

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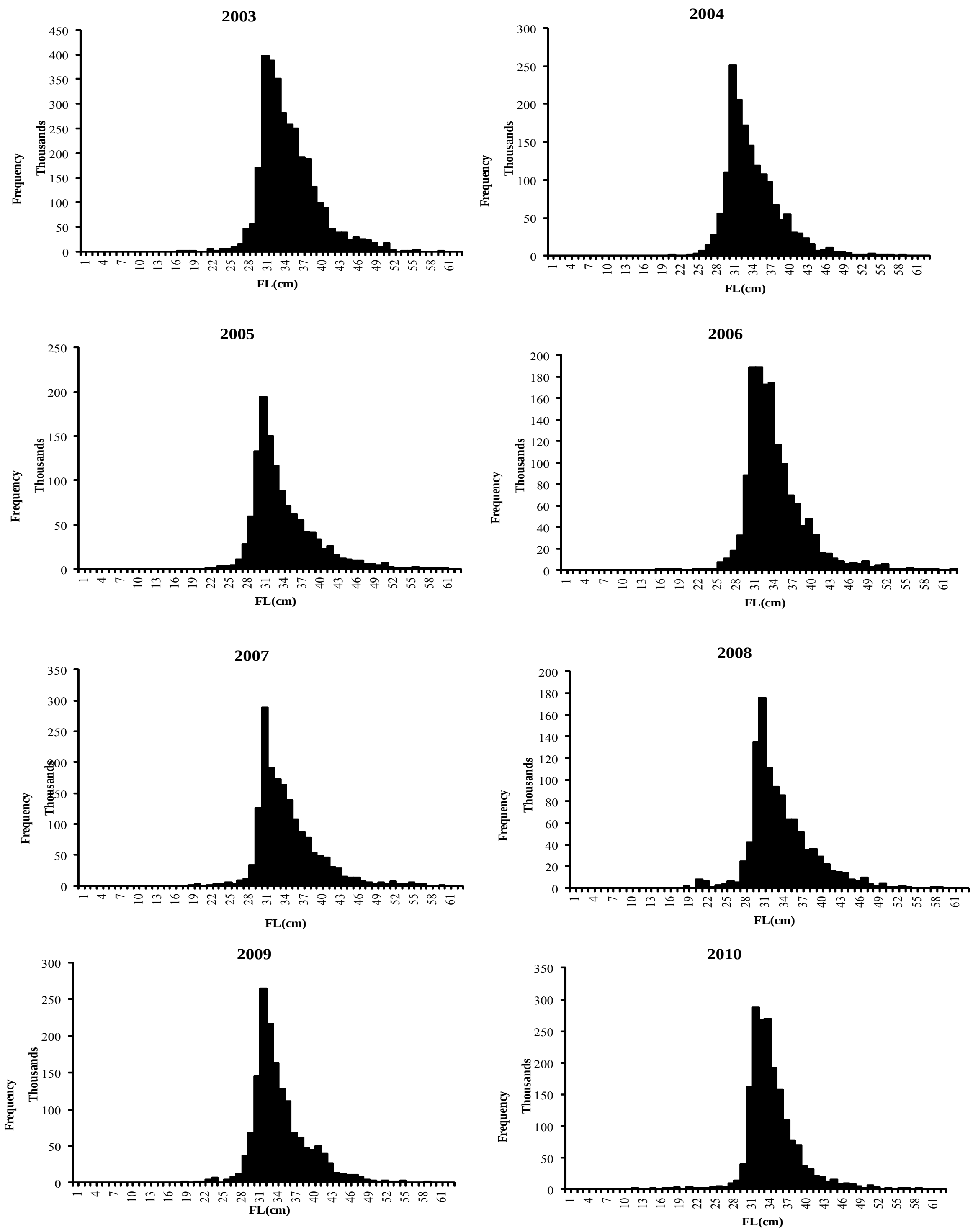

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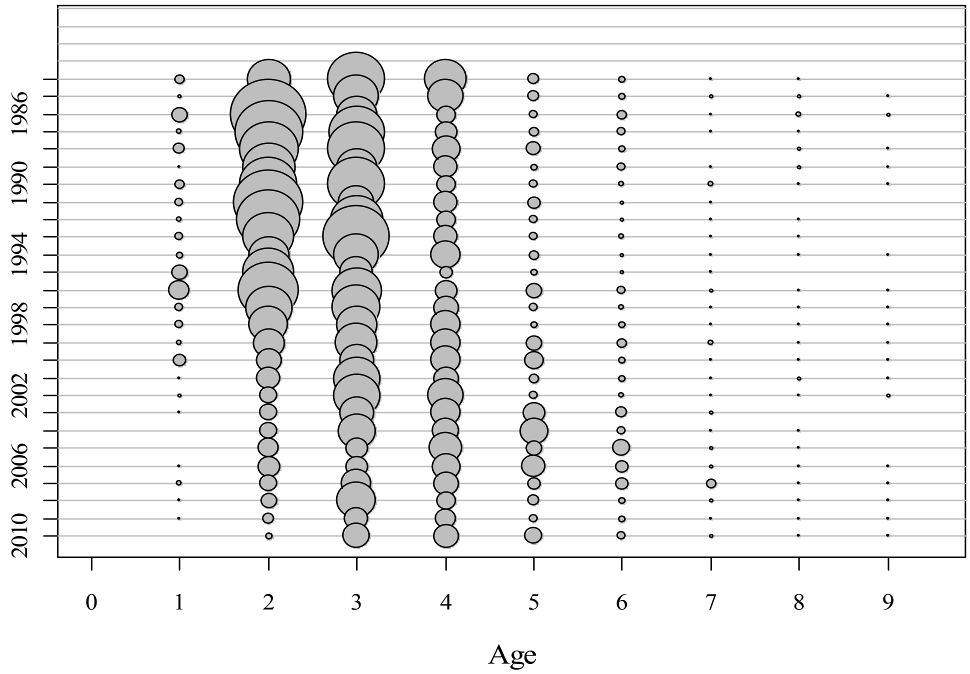
Commercial Landings at Age



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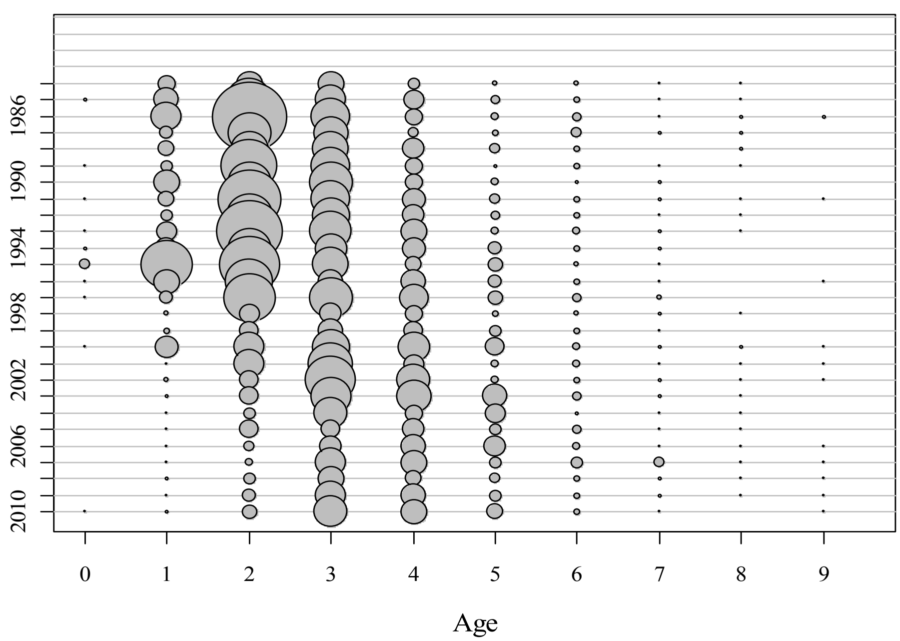

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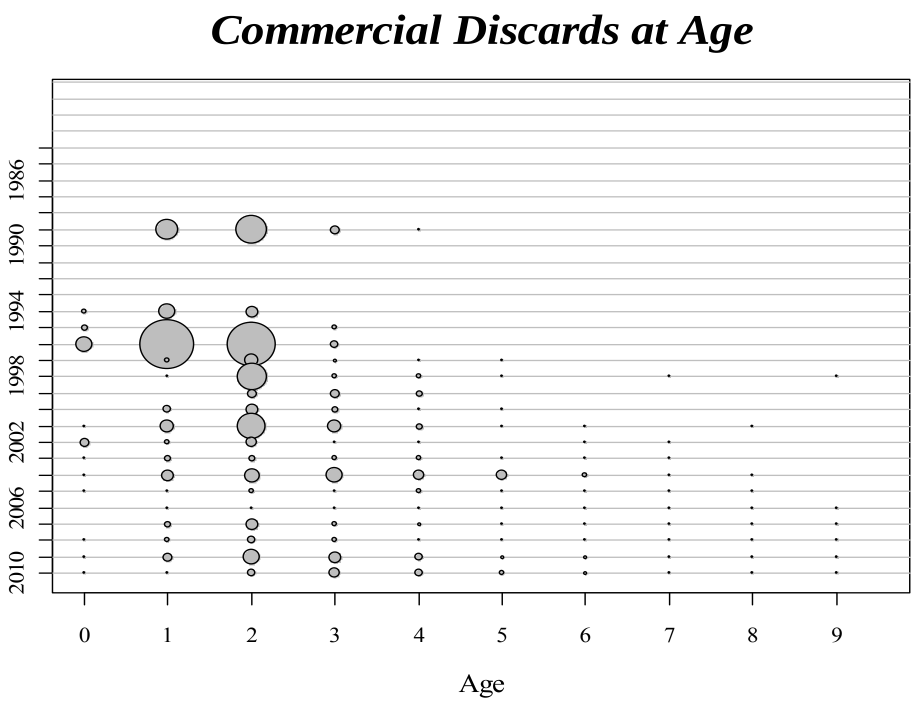

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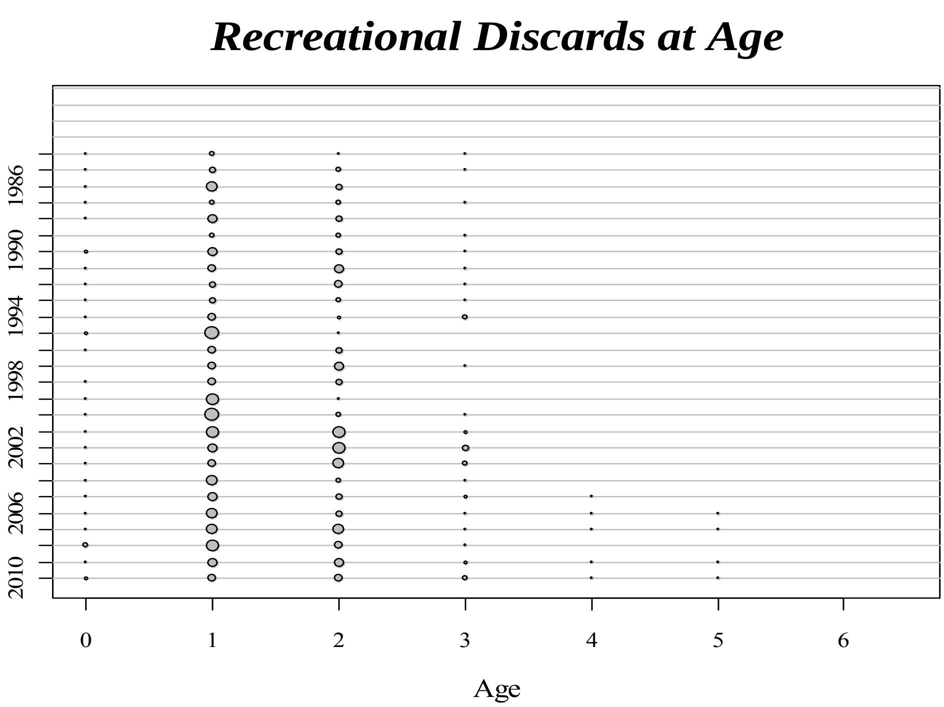

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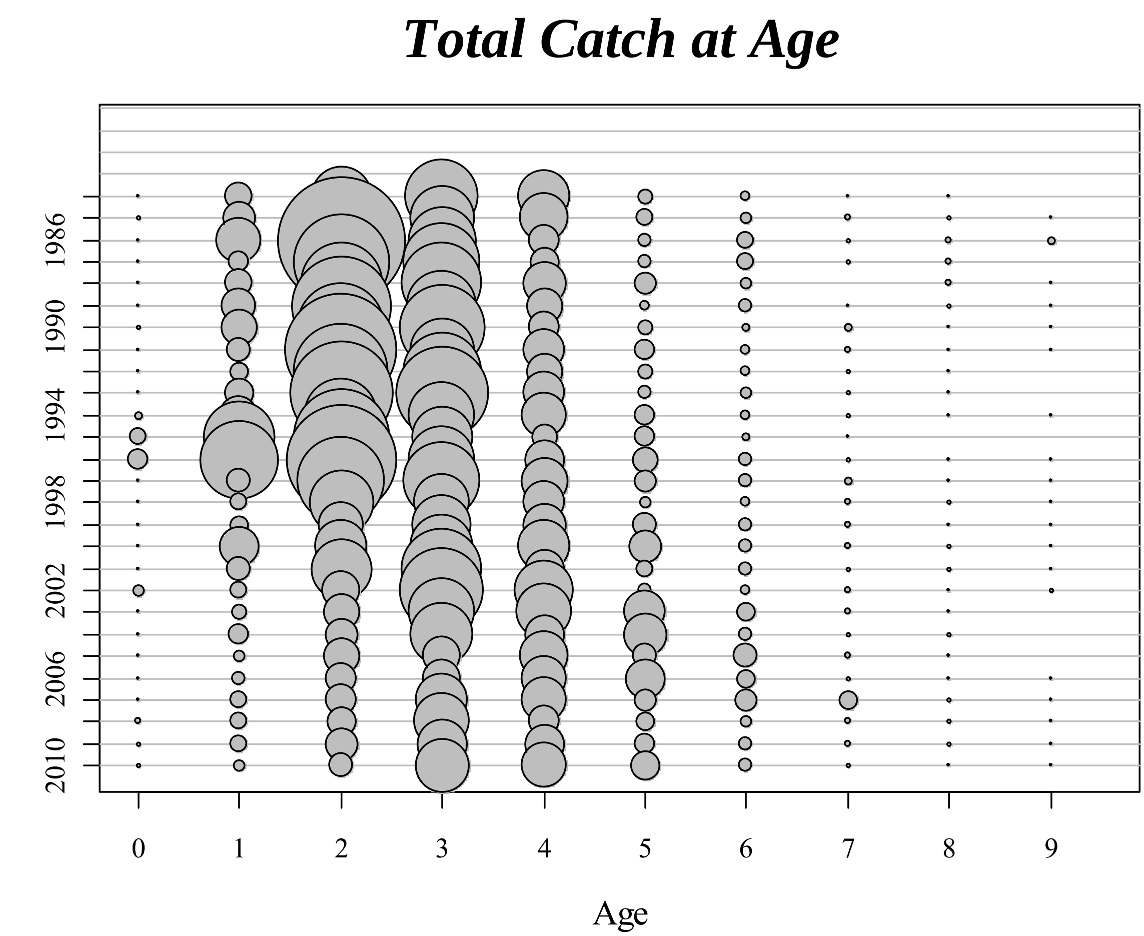

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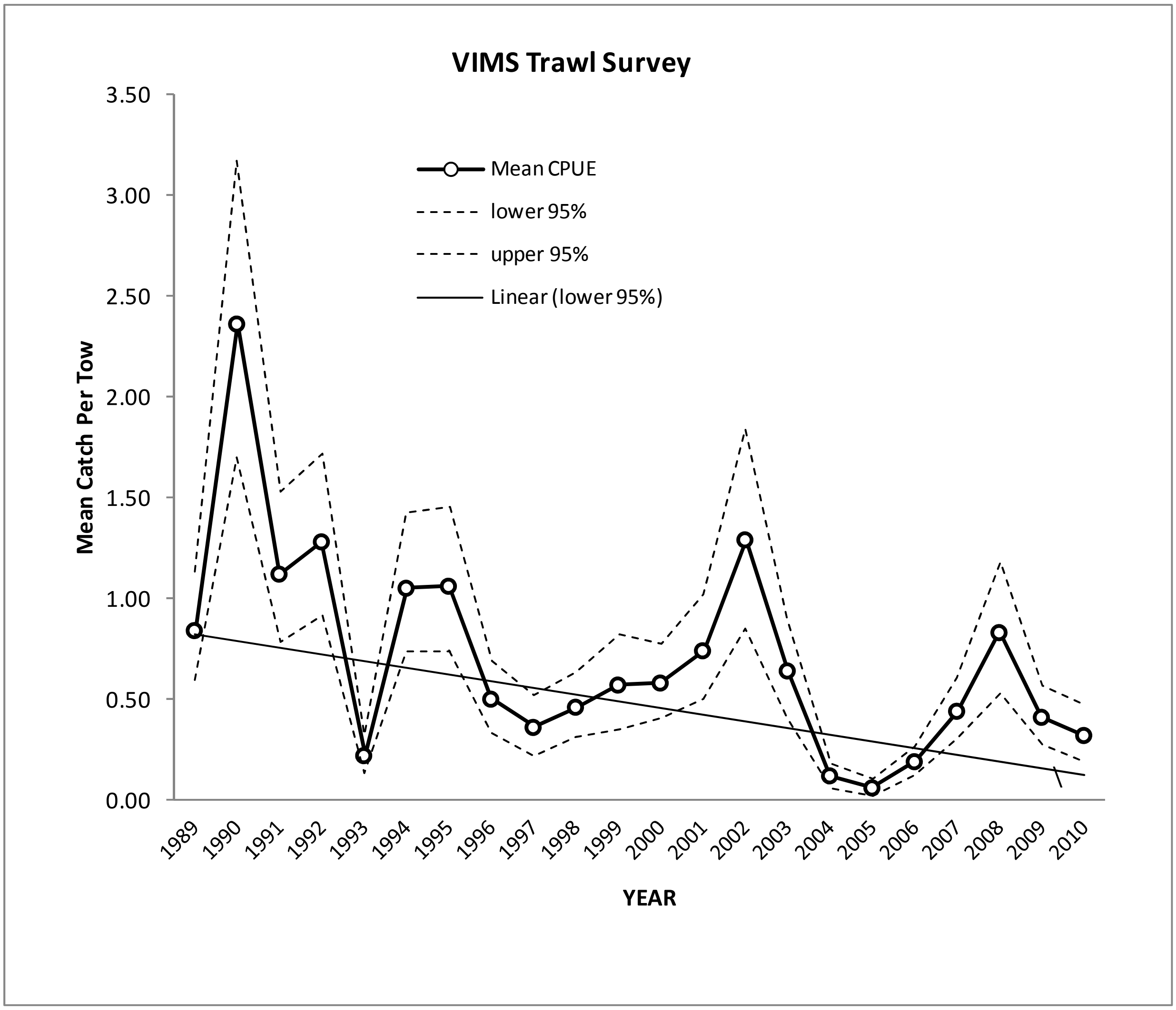

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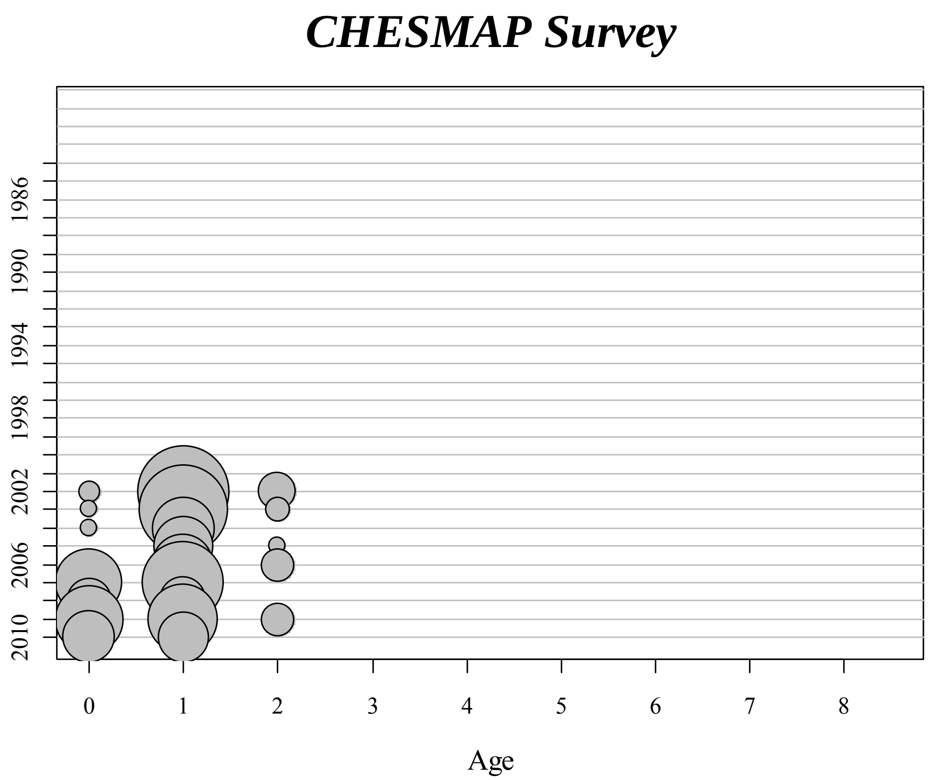

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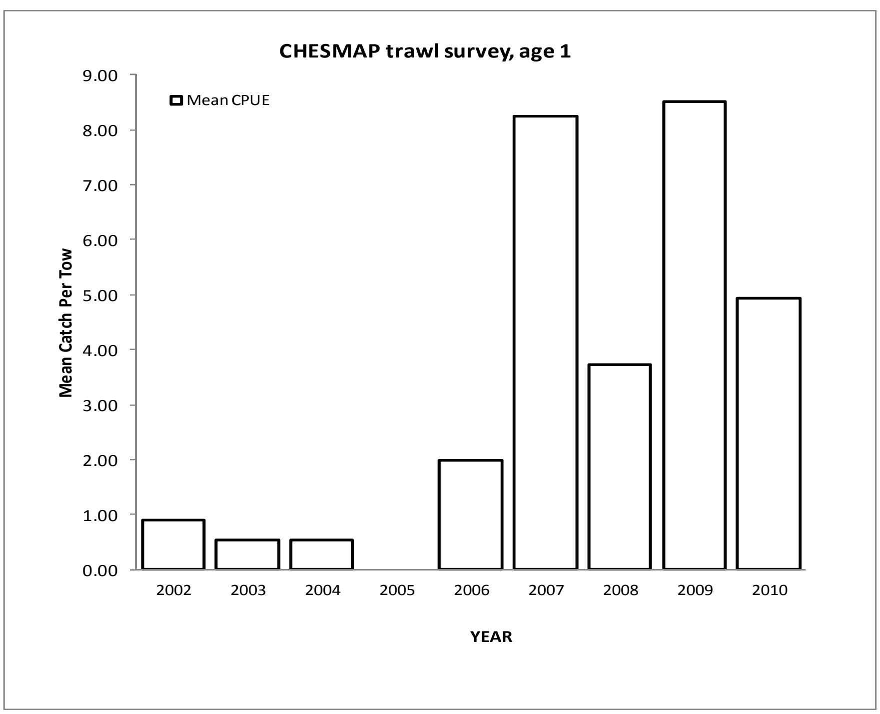

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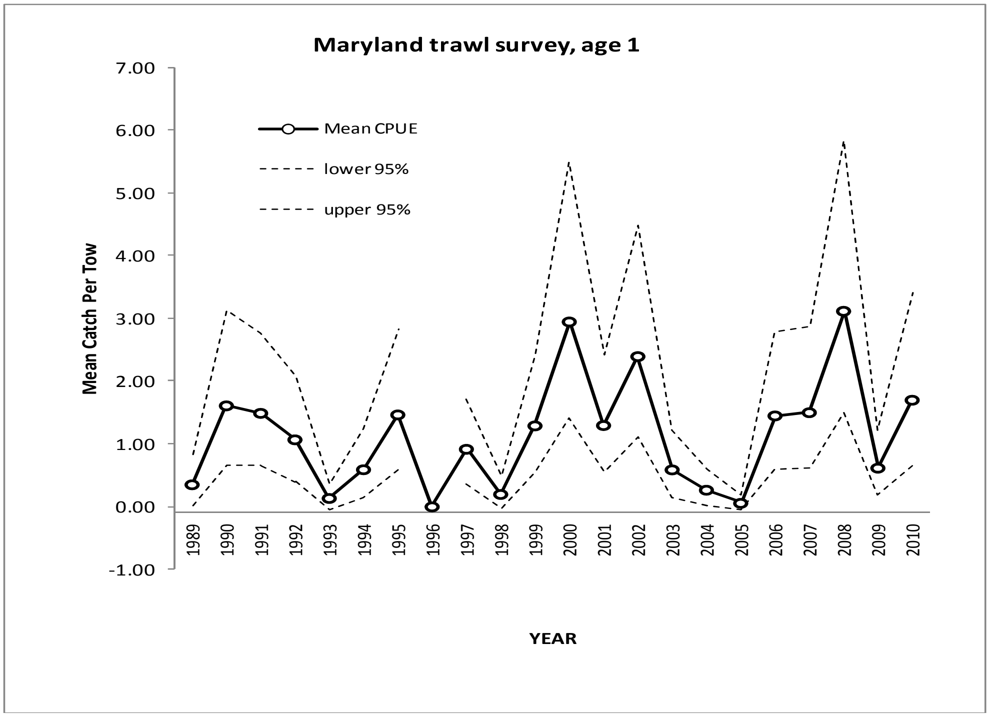

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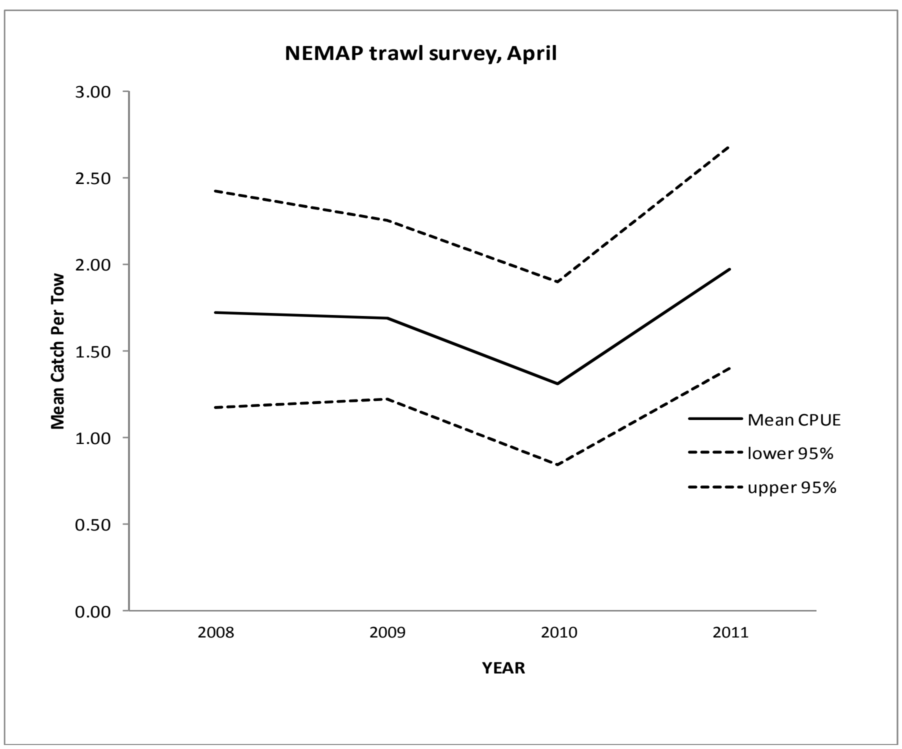

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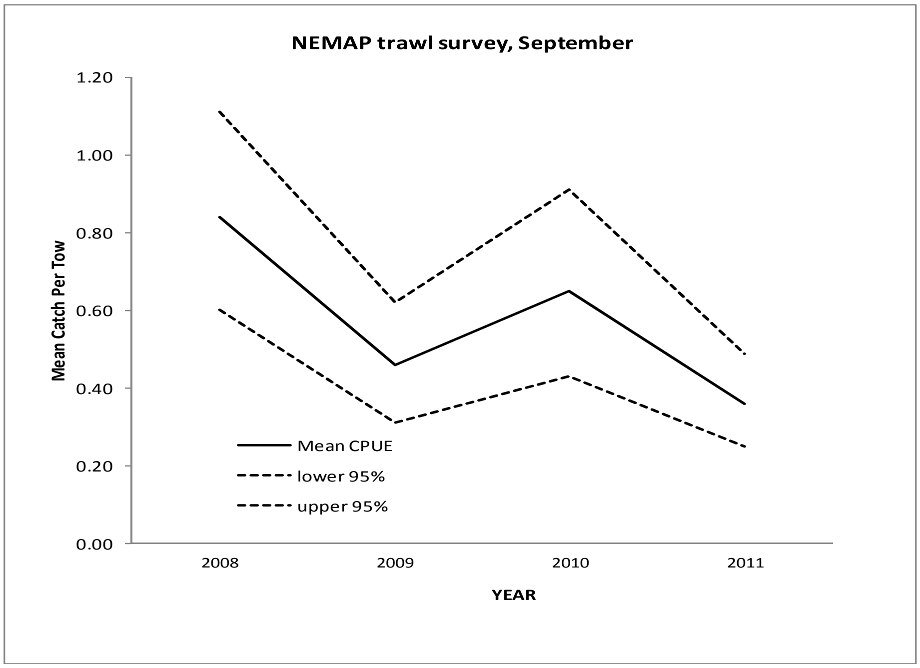

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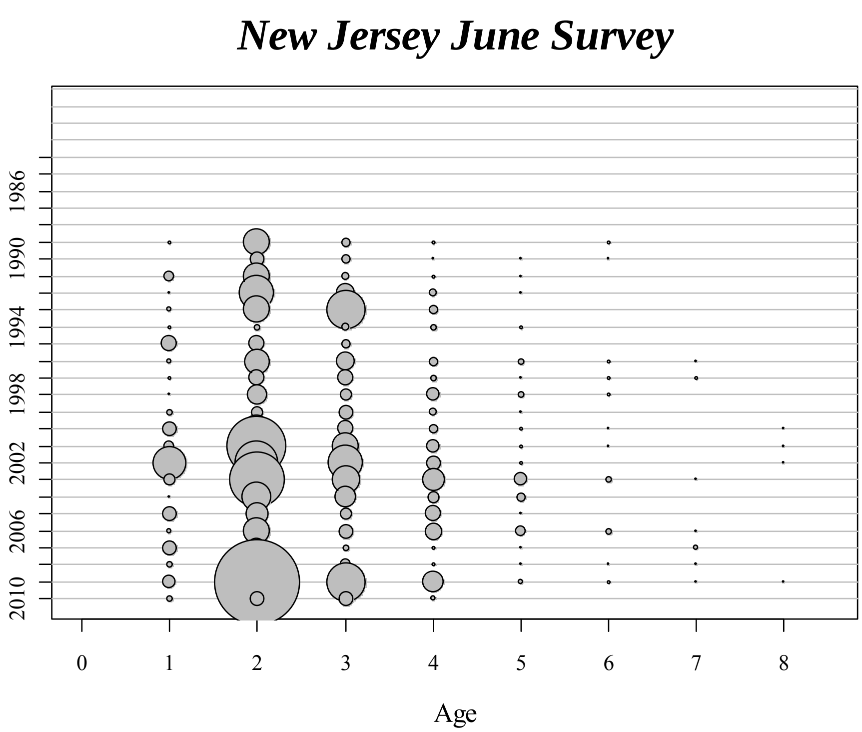

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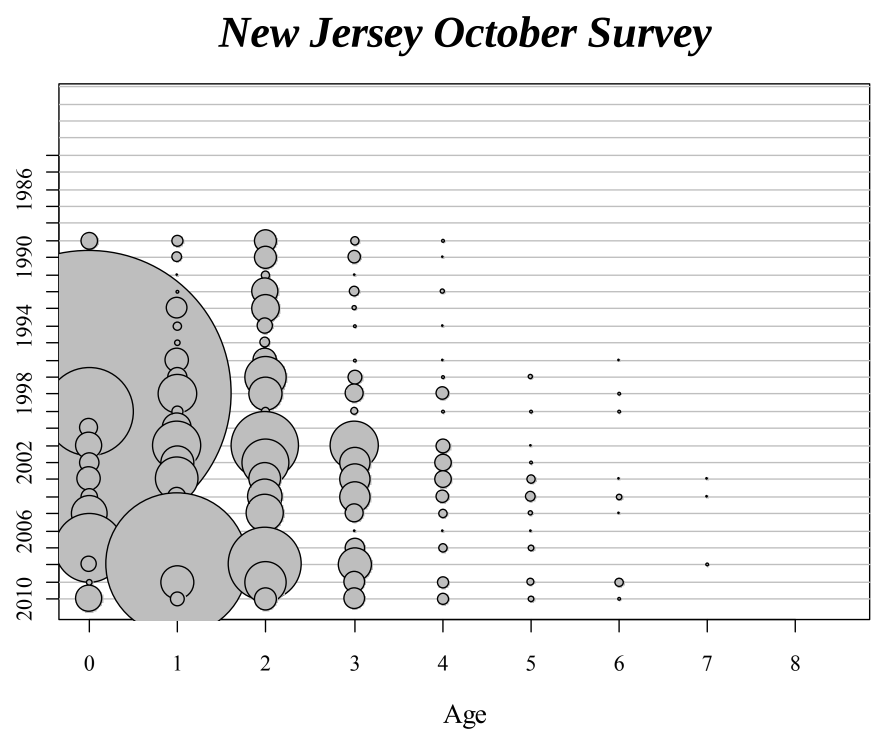

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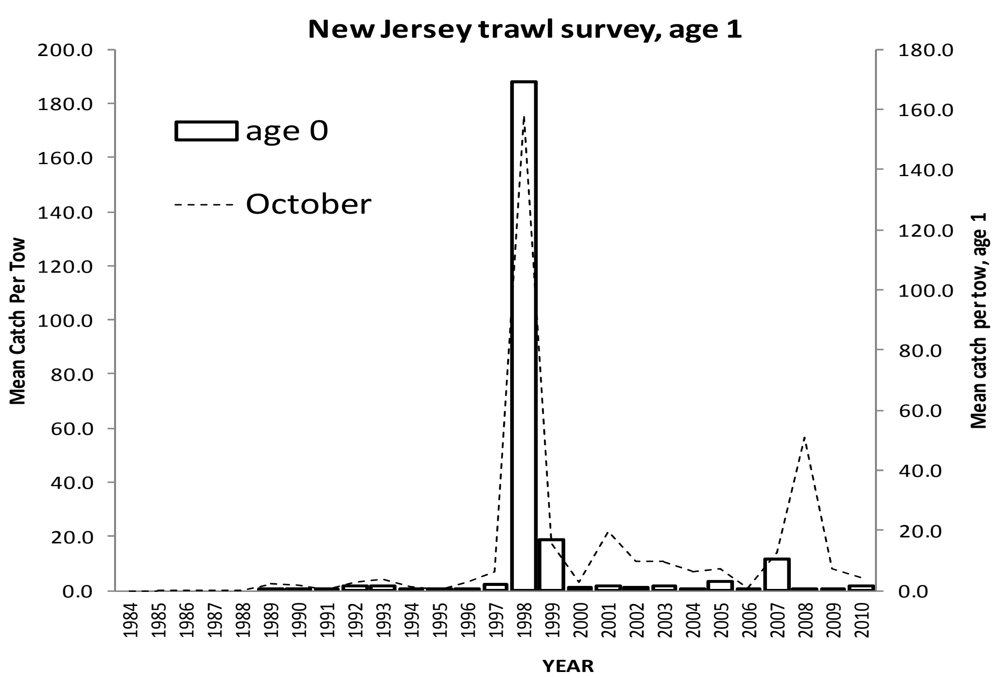

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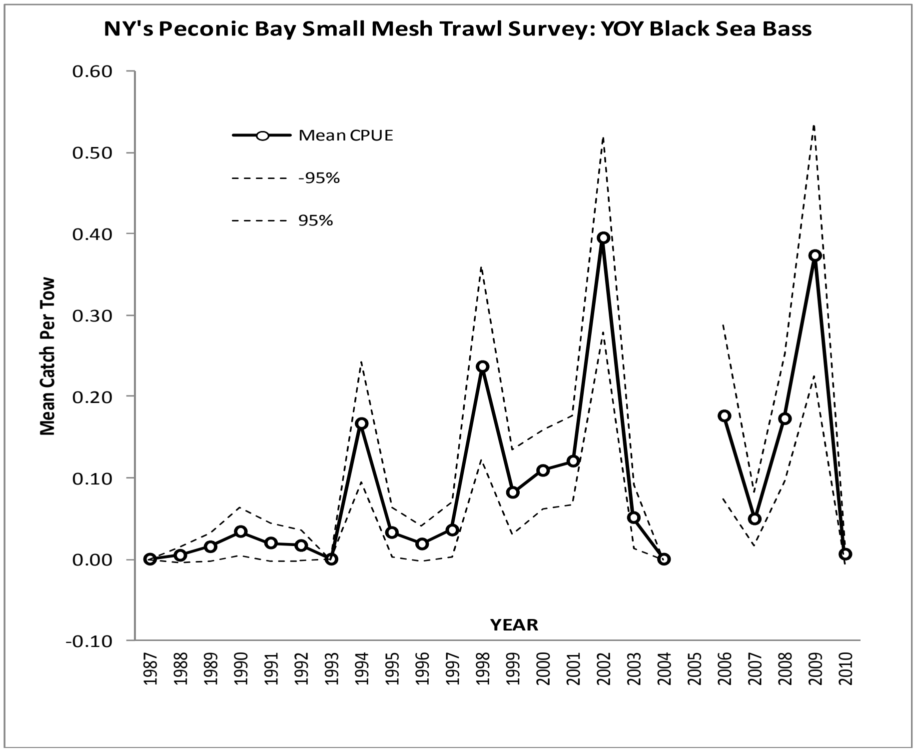

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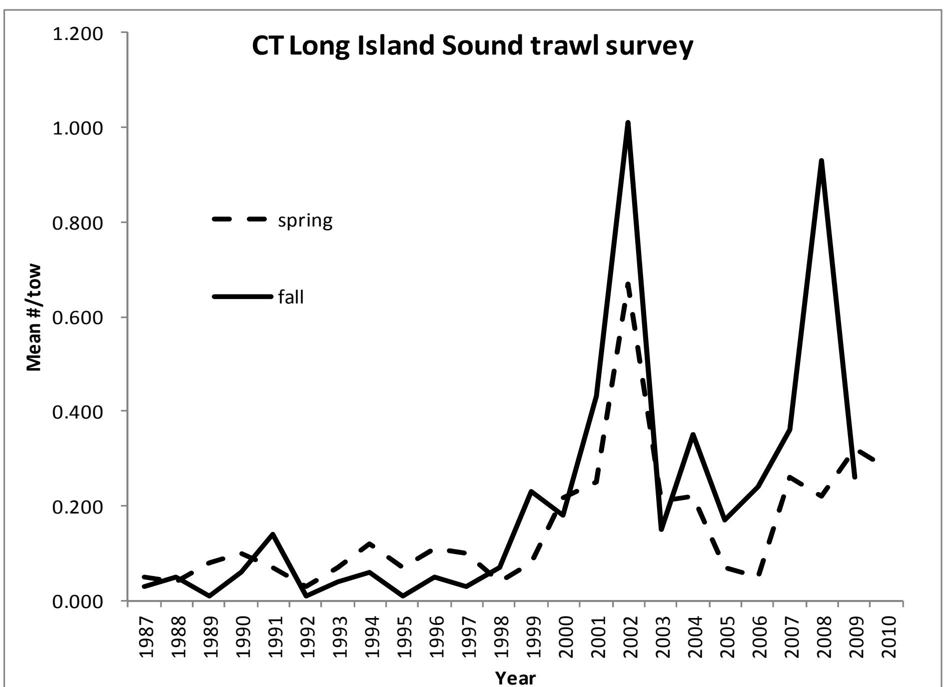

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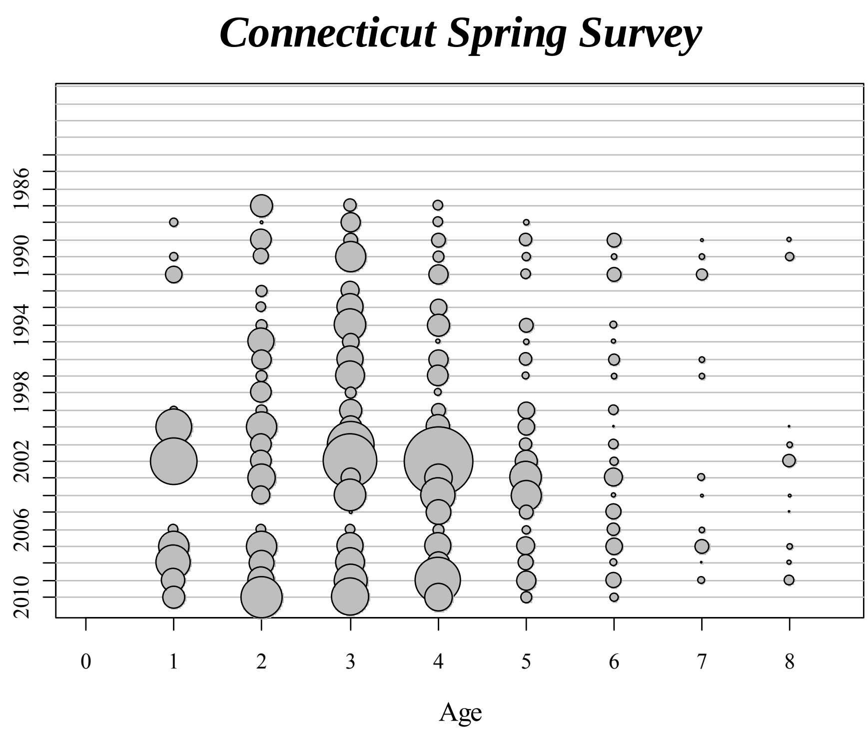

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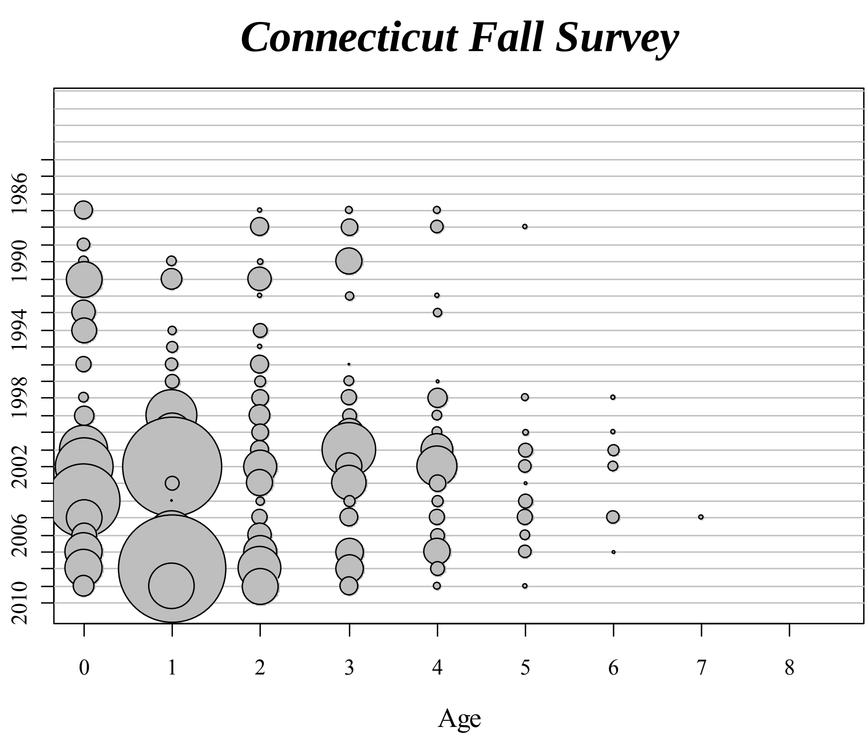

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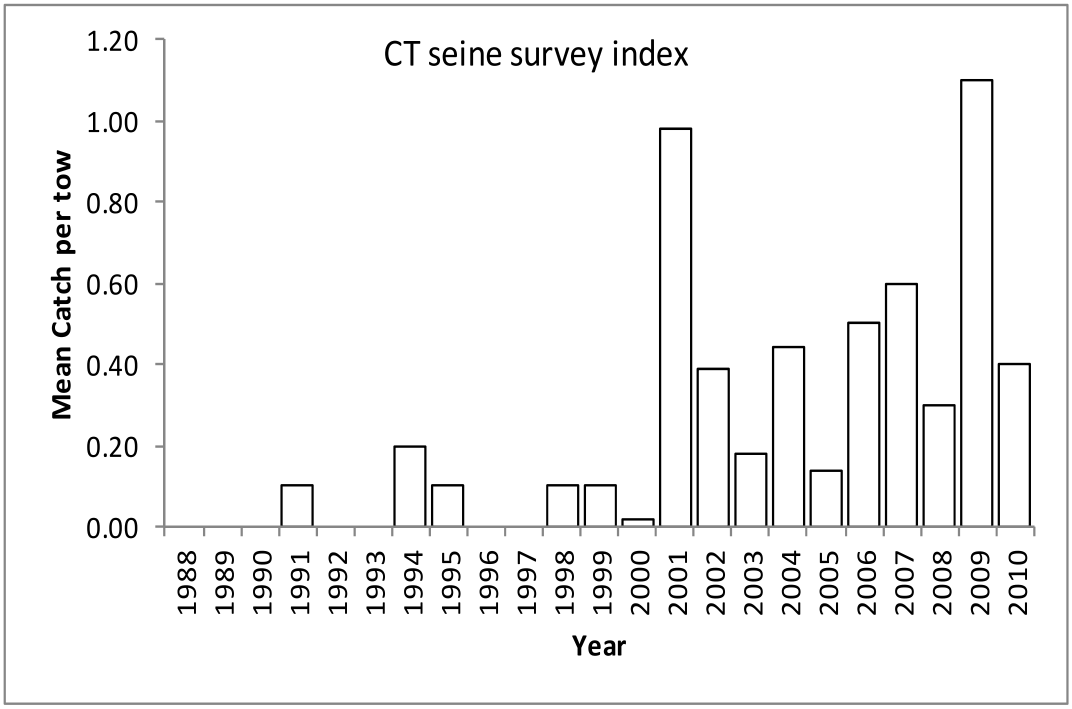

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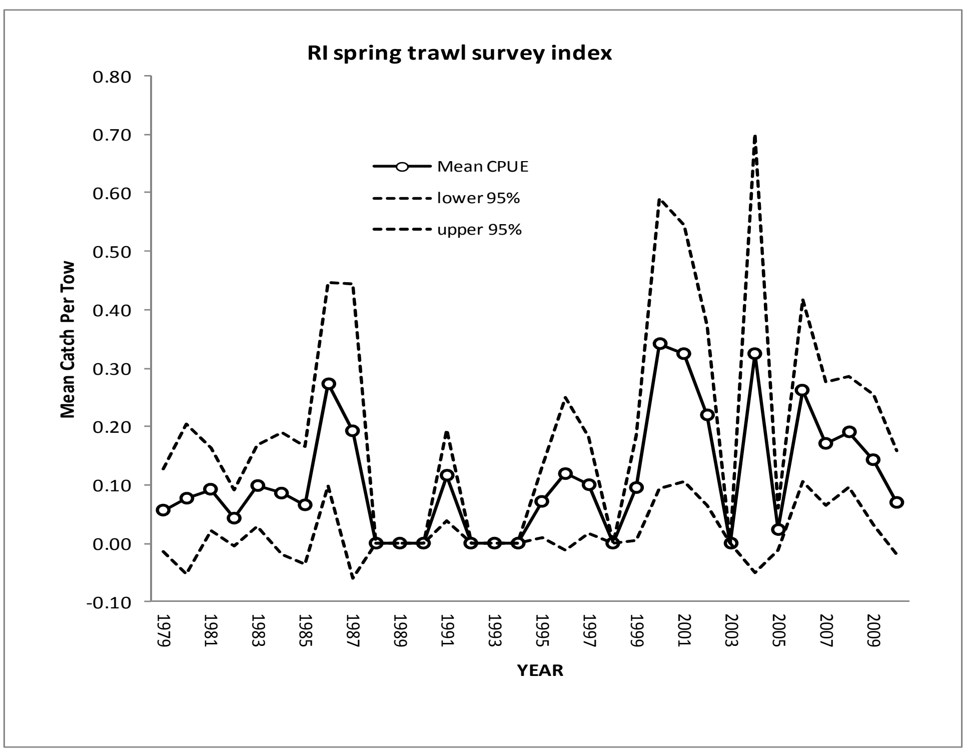

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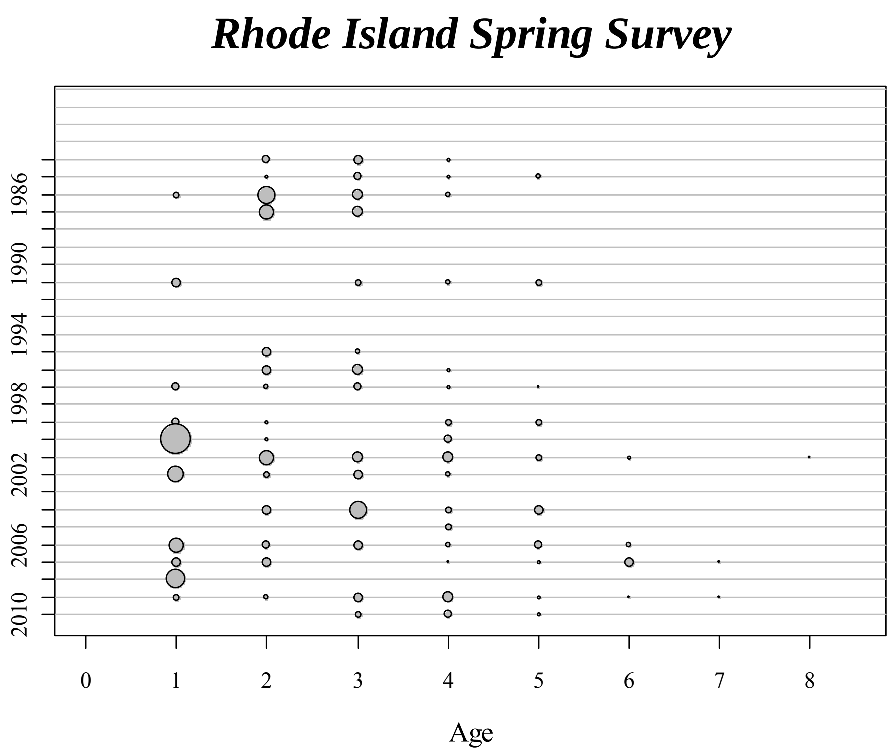

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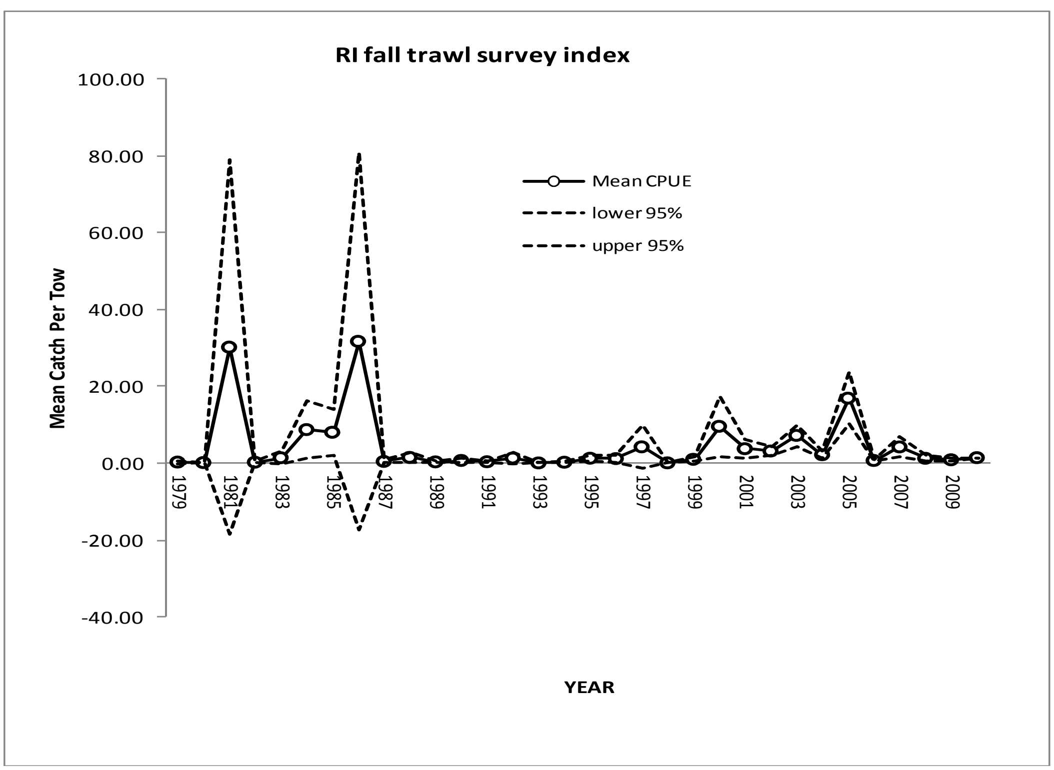

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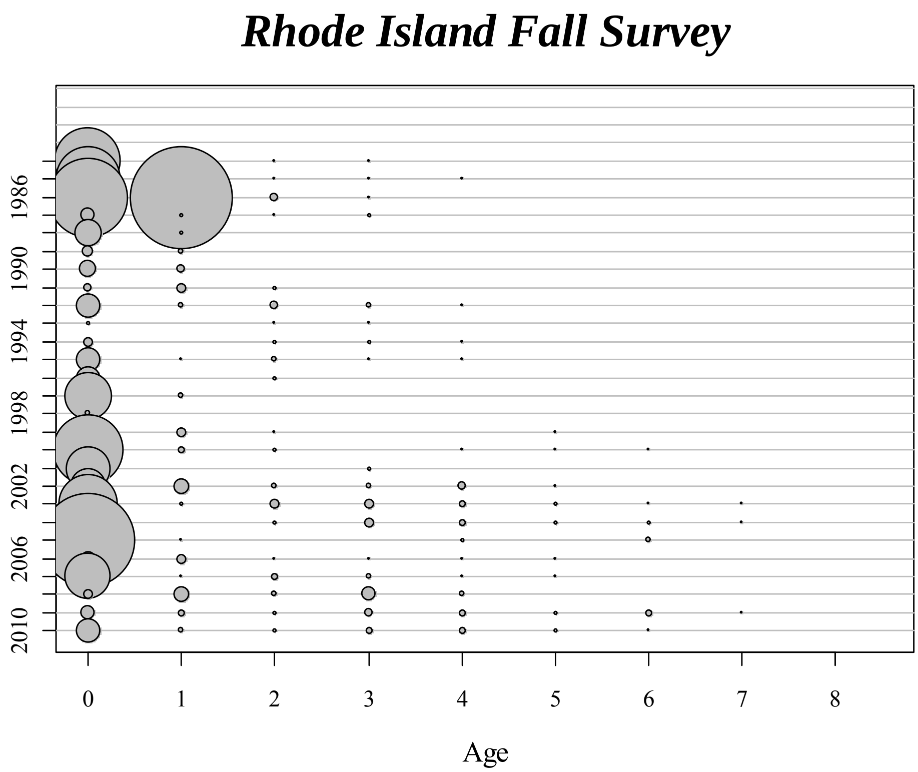

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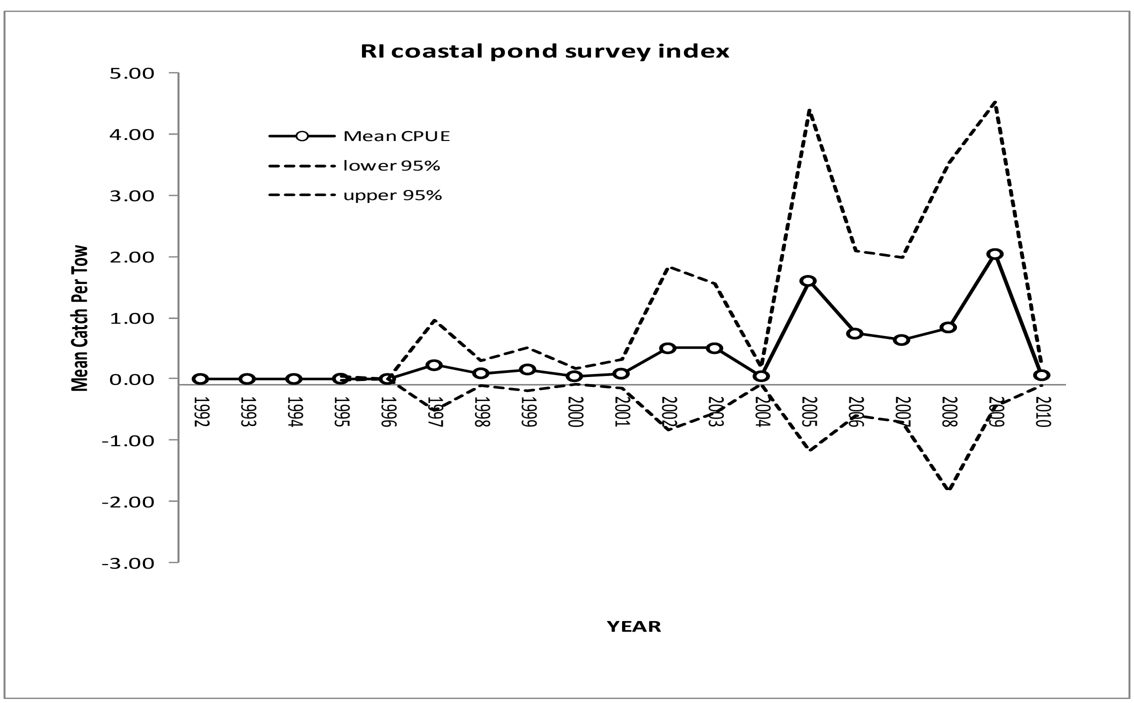

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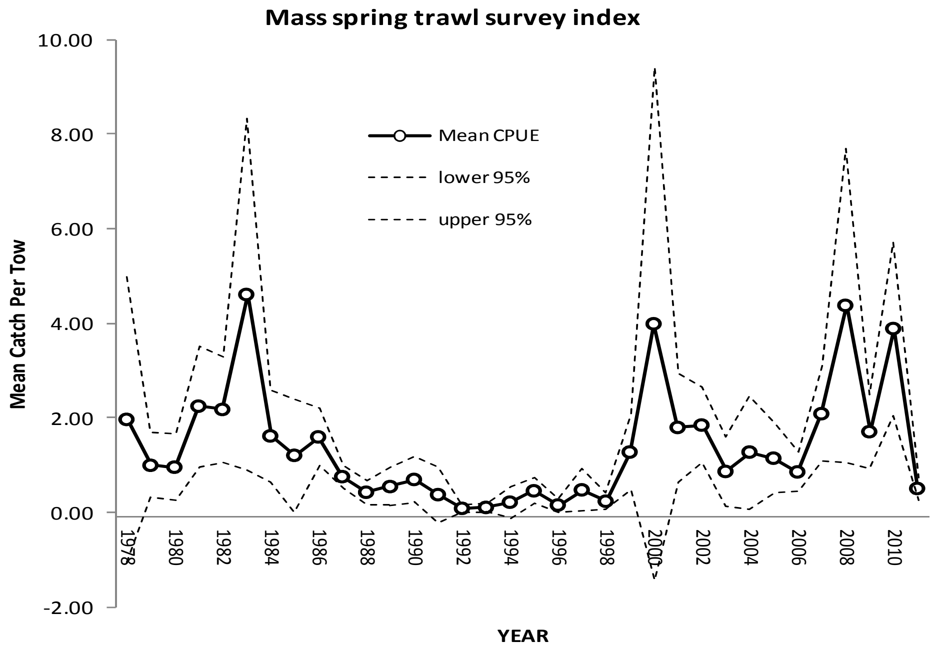

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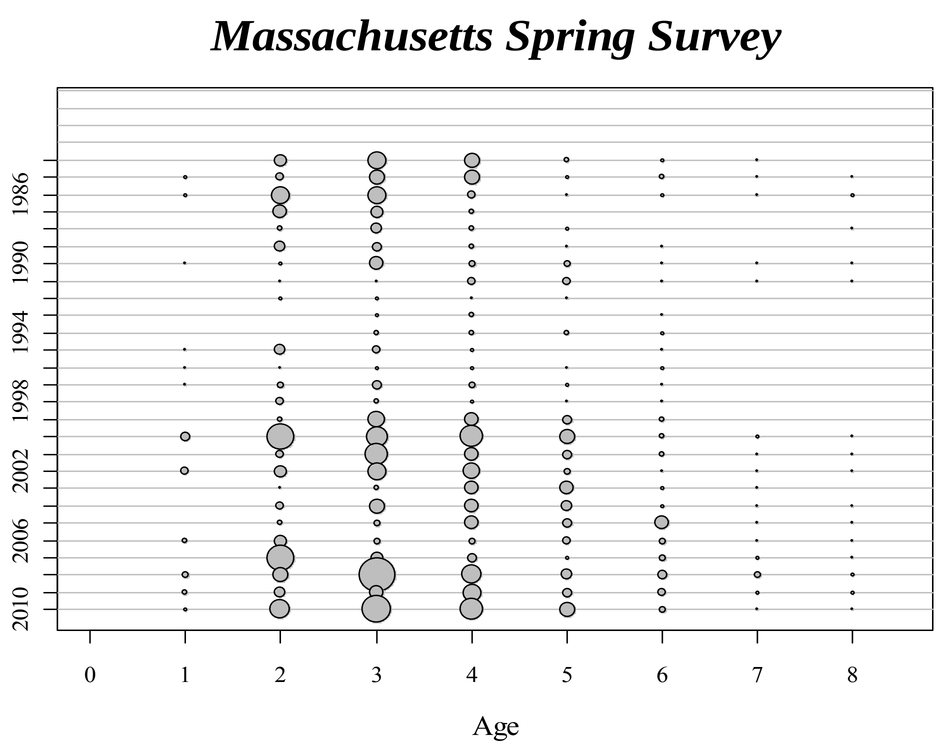

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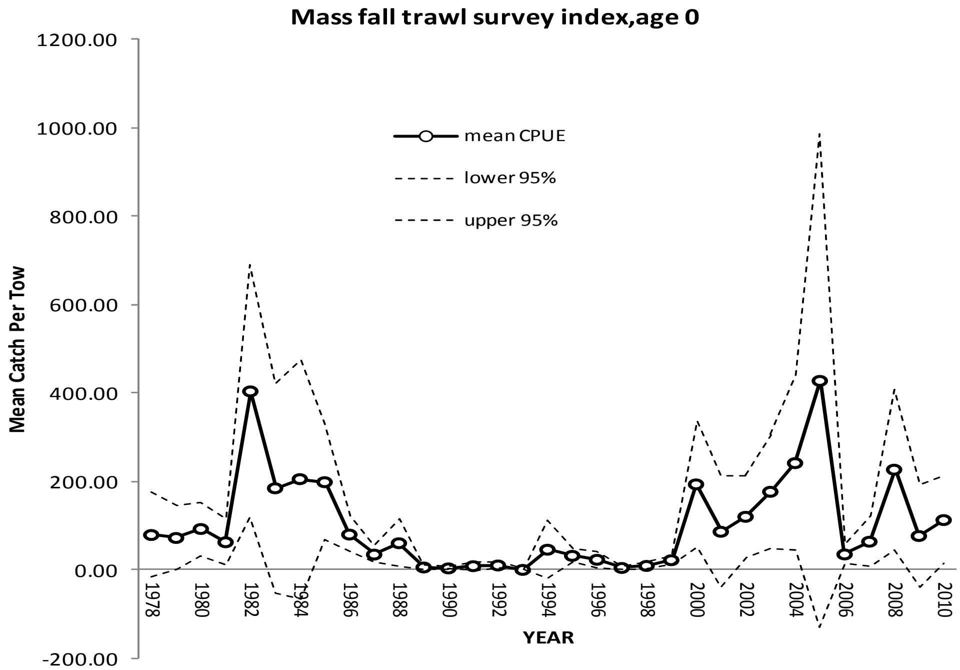

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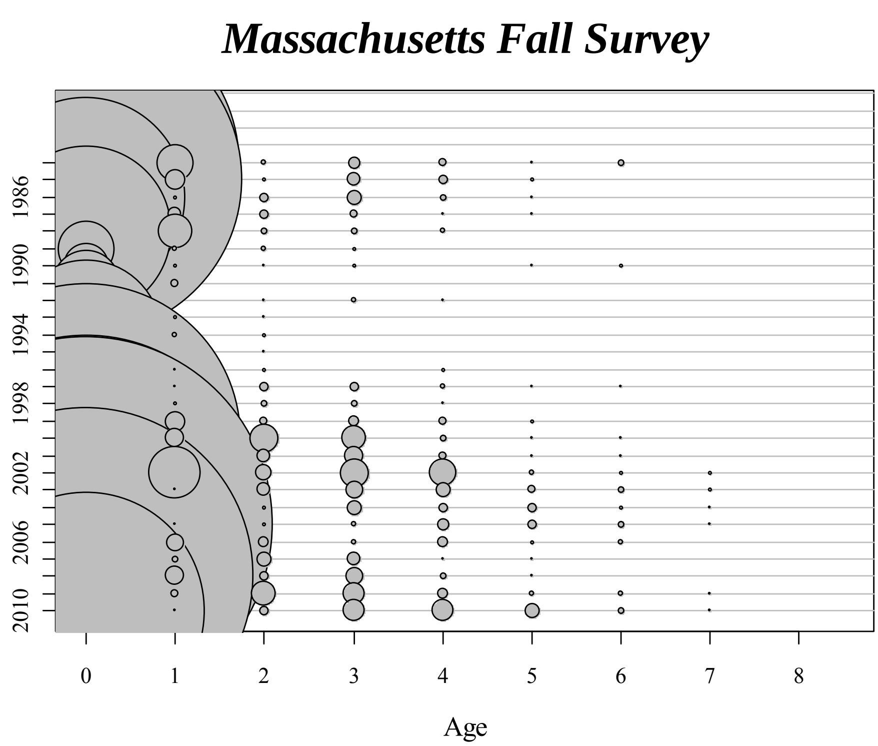

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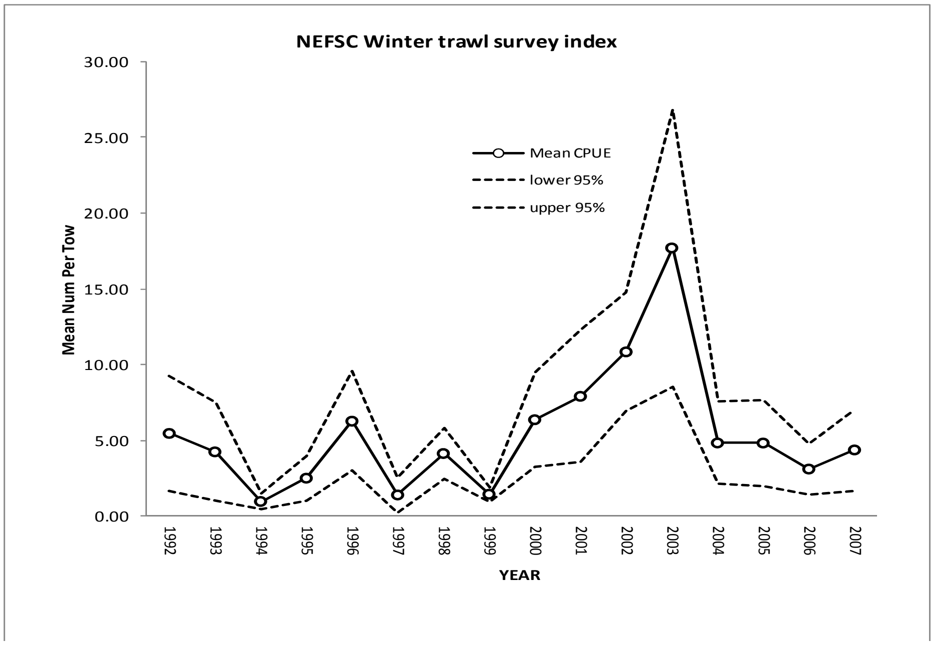

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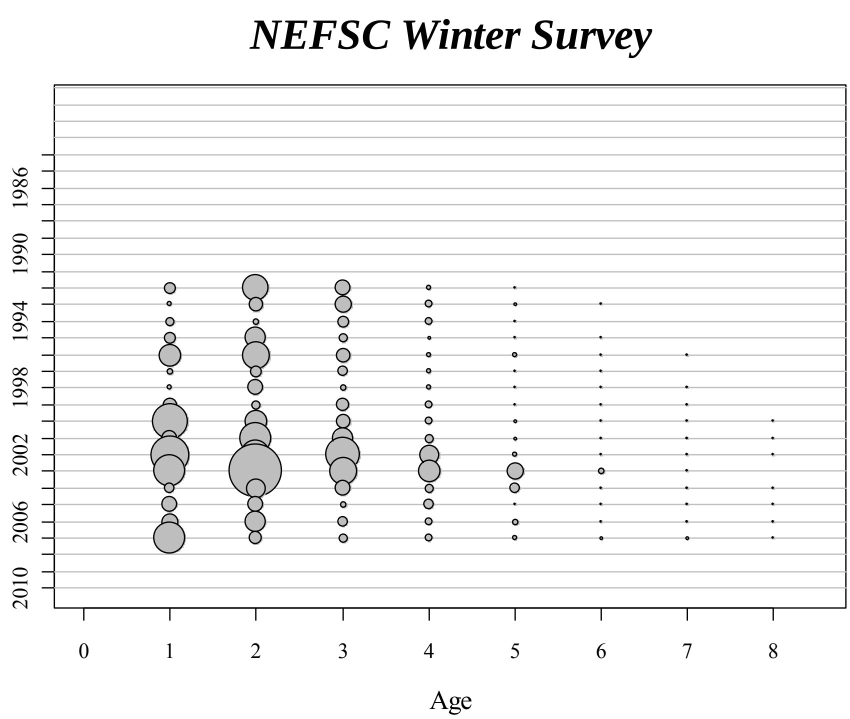

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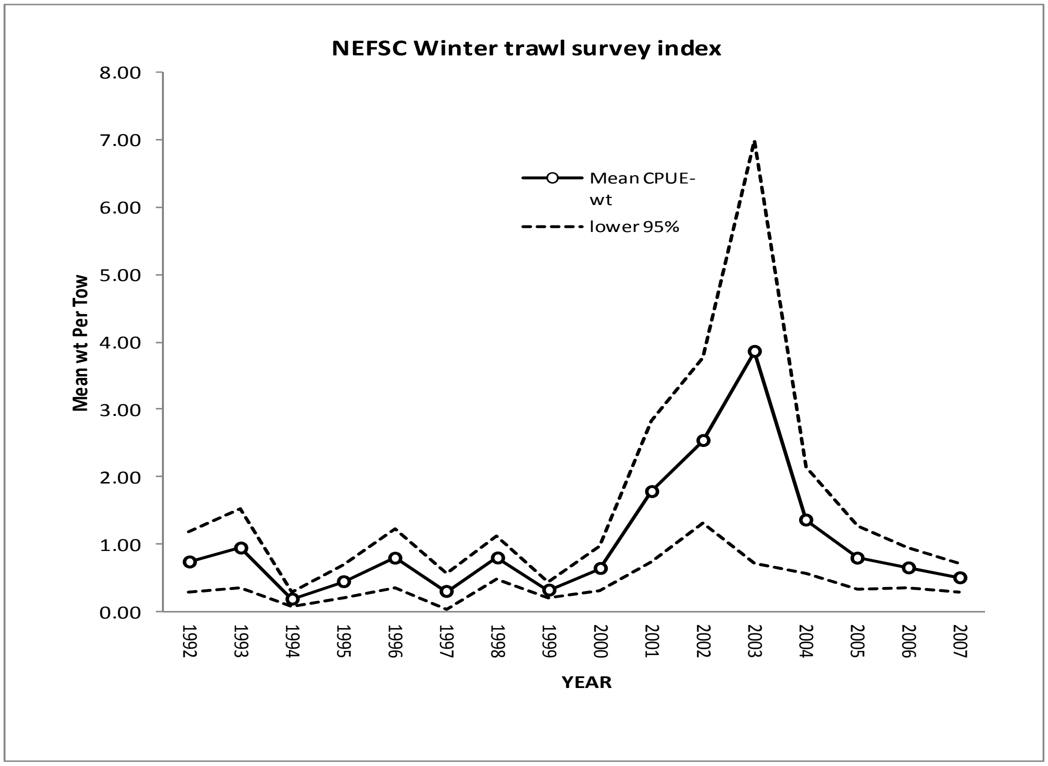

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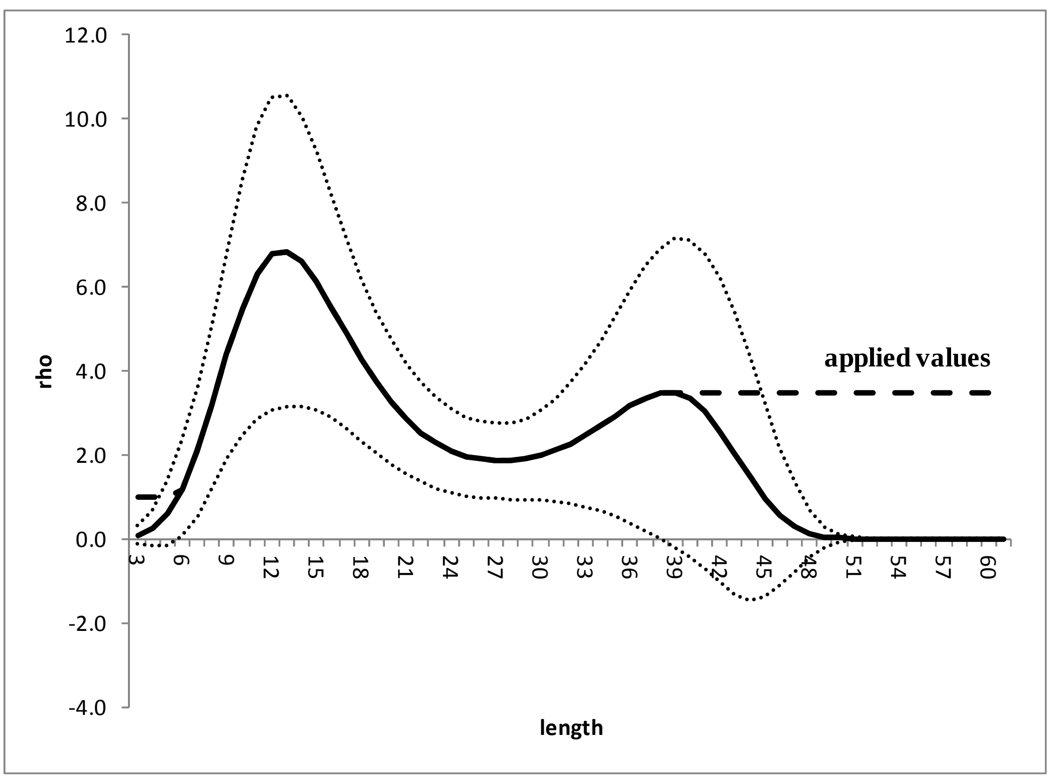

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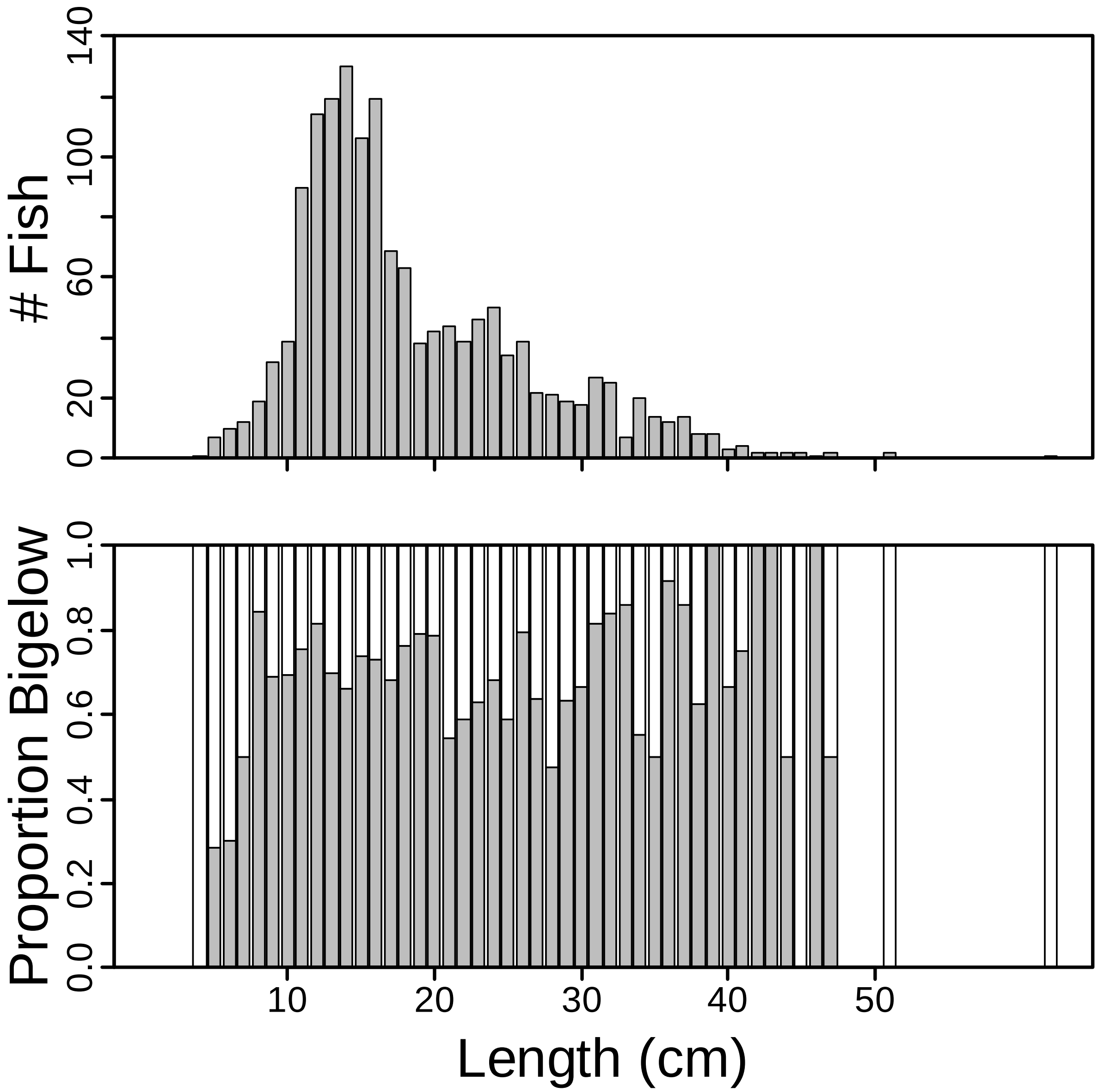

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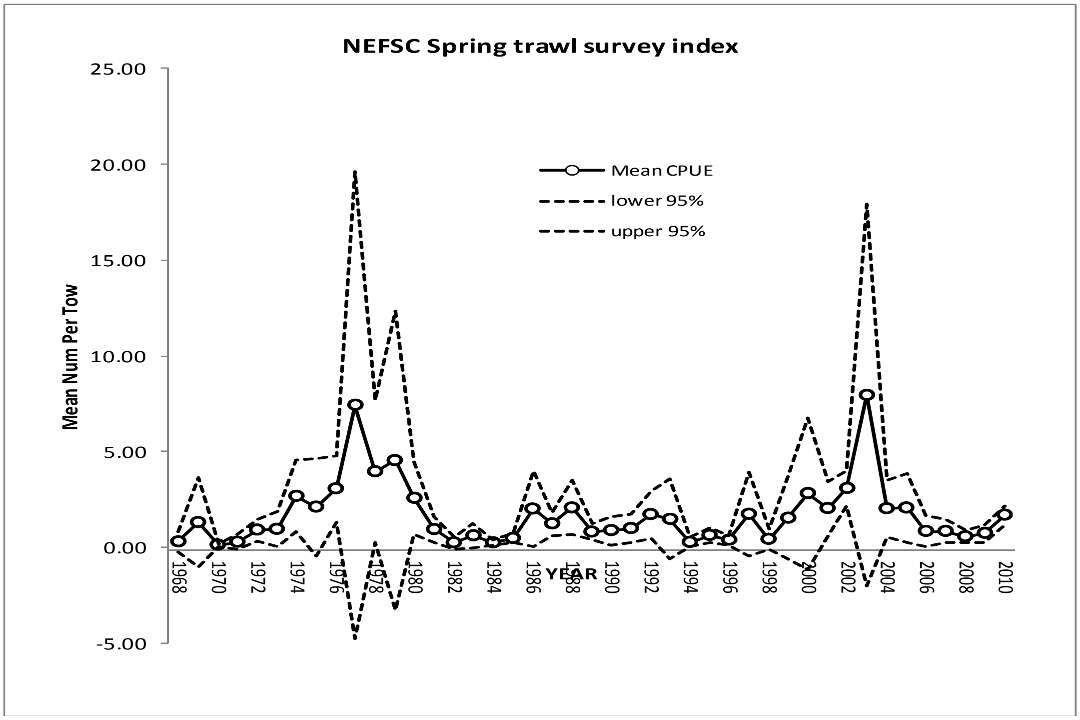

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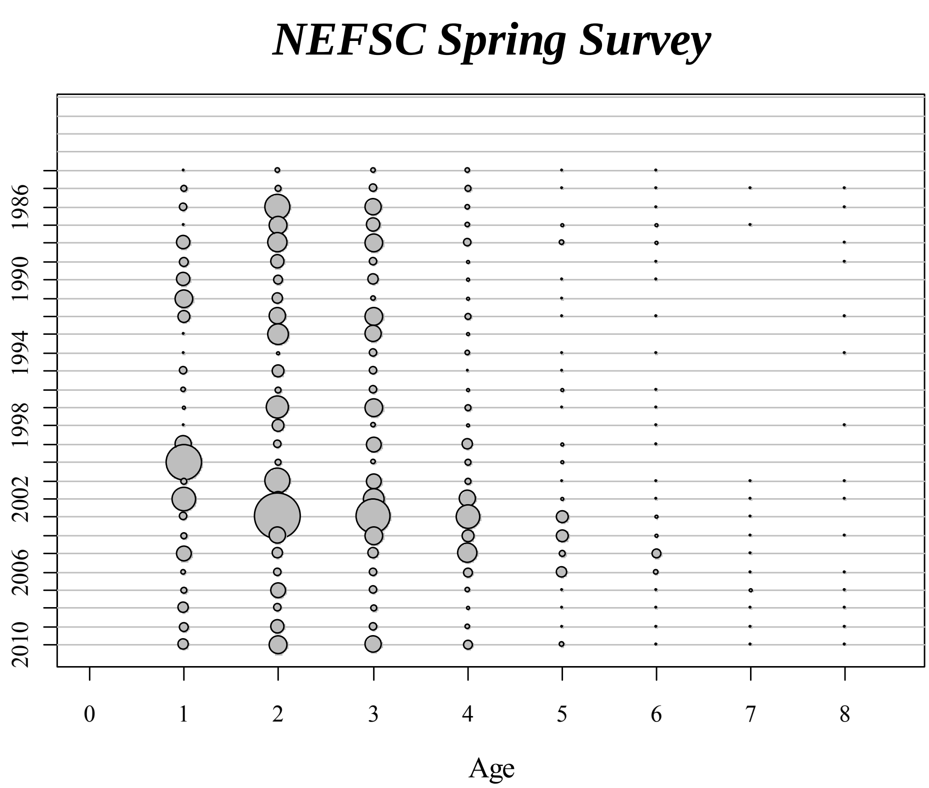

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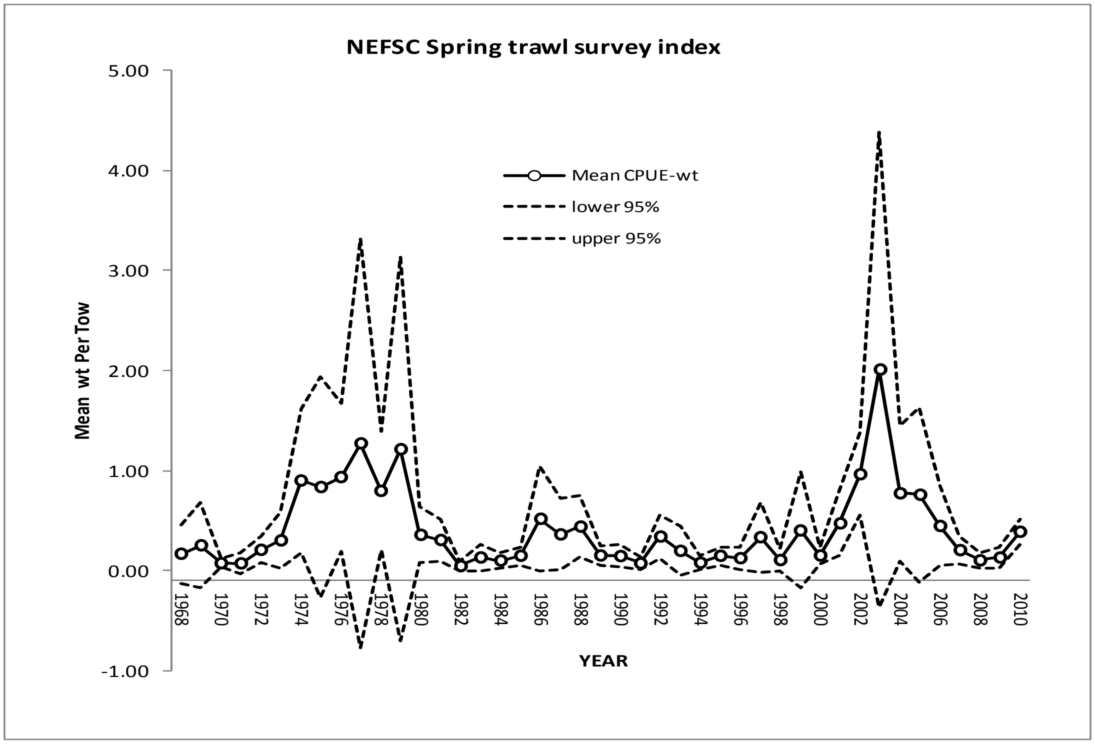

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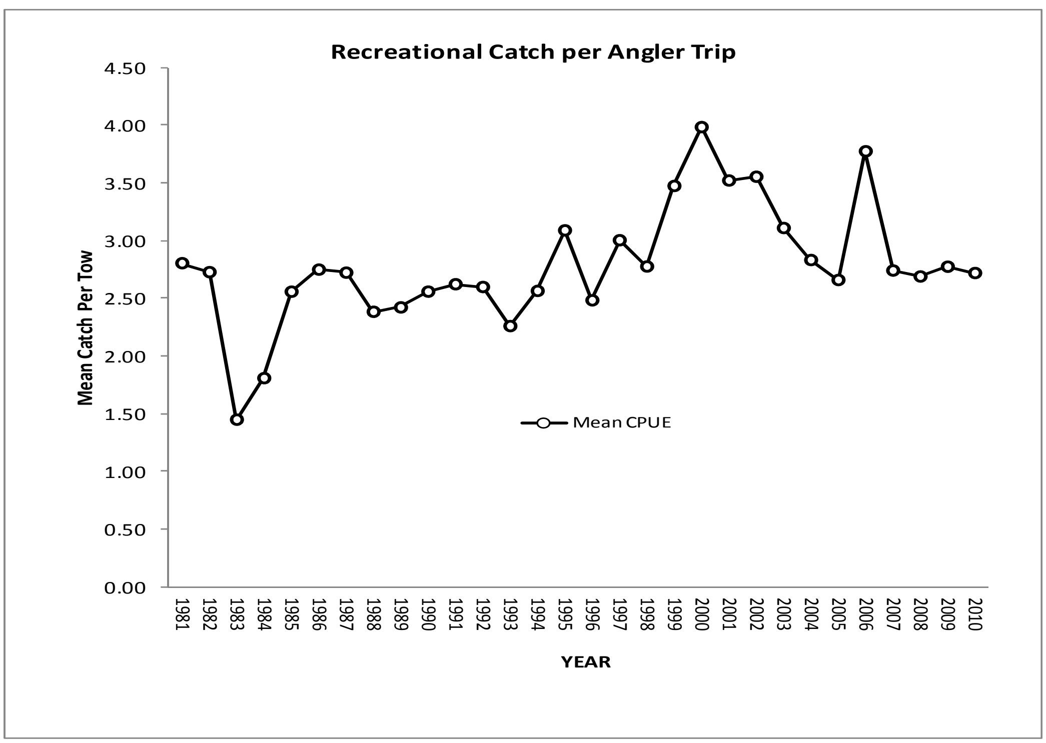

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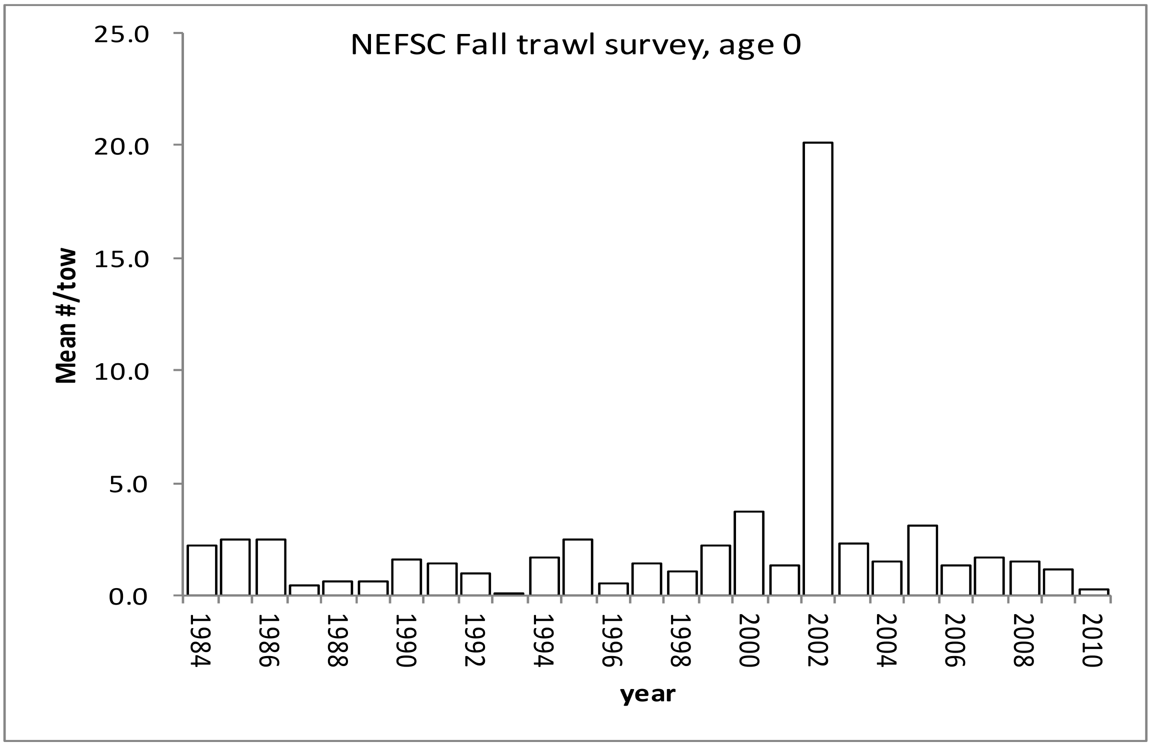


Figure B59. Black sea bass indices of age 0 abundance from NMFS fall trawl survey.

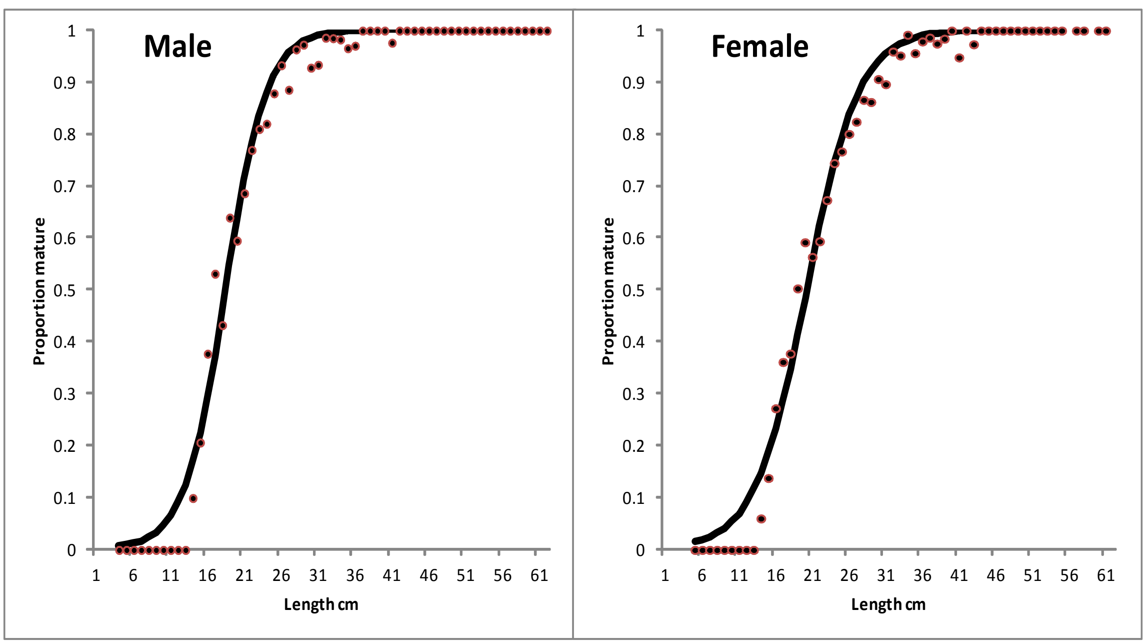


Figure B60. Black sea bass observed and predicted maturity at length for male and female from NMFS survey data.

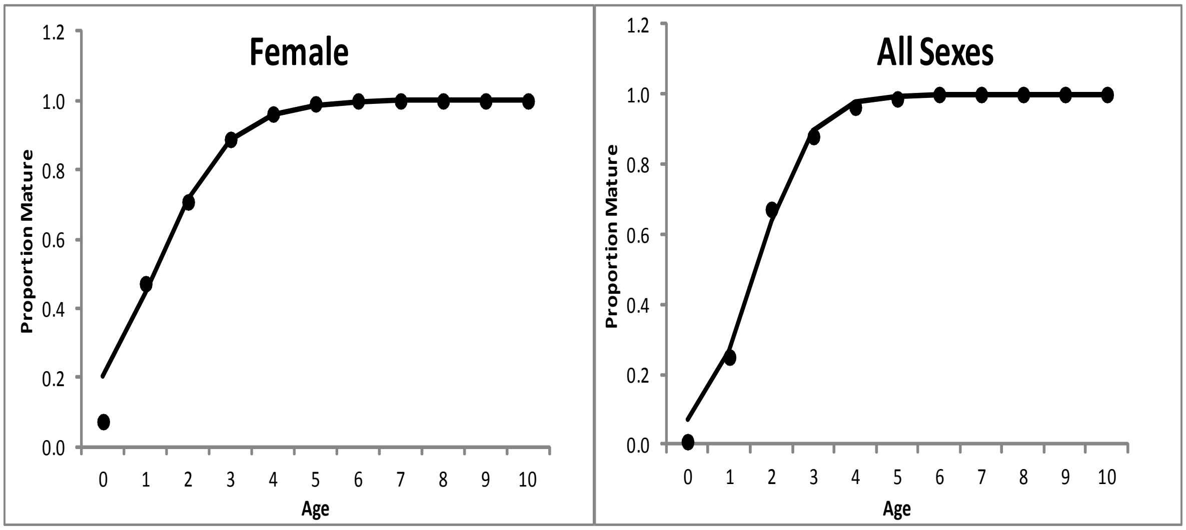


Figure B61. Black sea bass observed and predicted maturity at age for female and male/female combined from NMFS survey data.

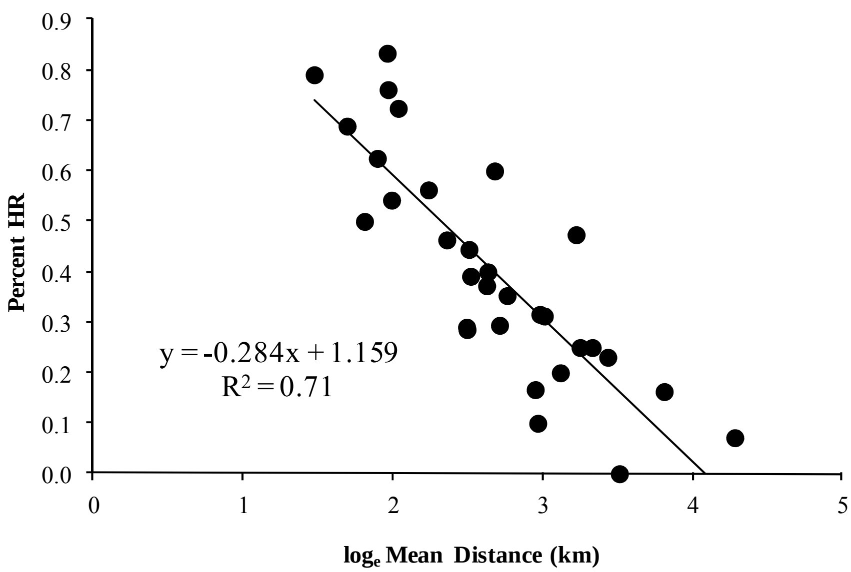


Figure B62. Relationship between distance tagged black sea bass traveled and percent return to within 10 km of release site the following season.

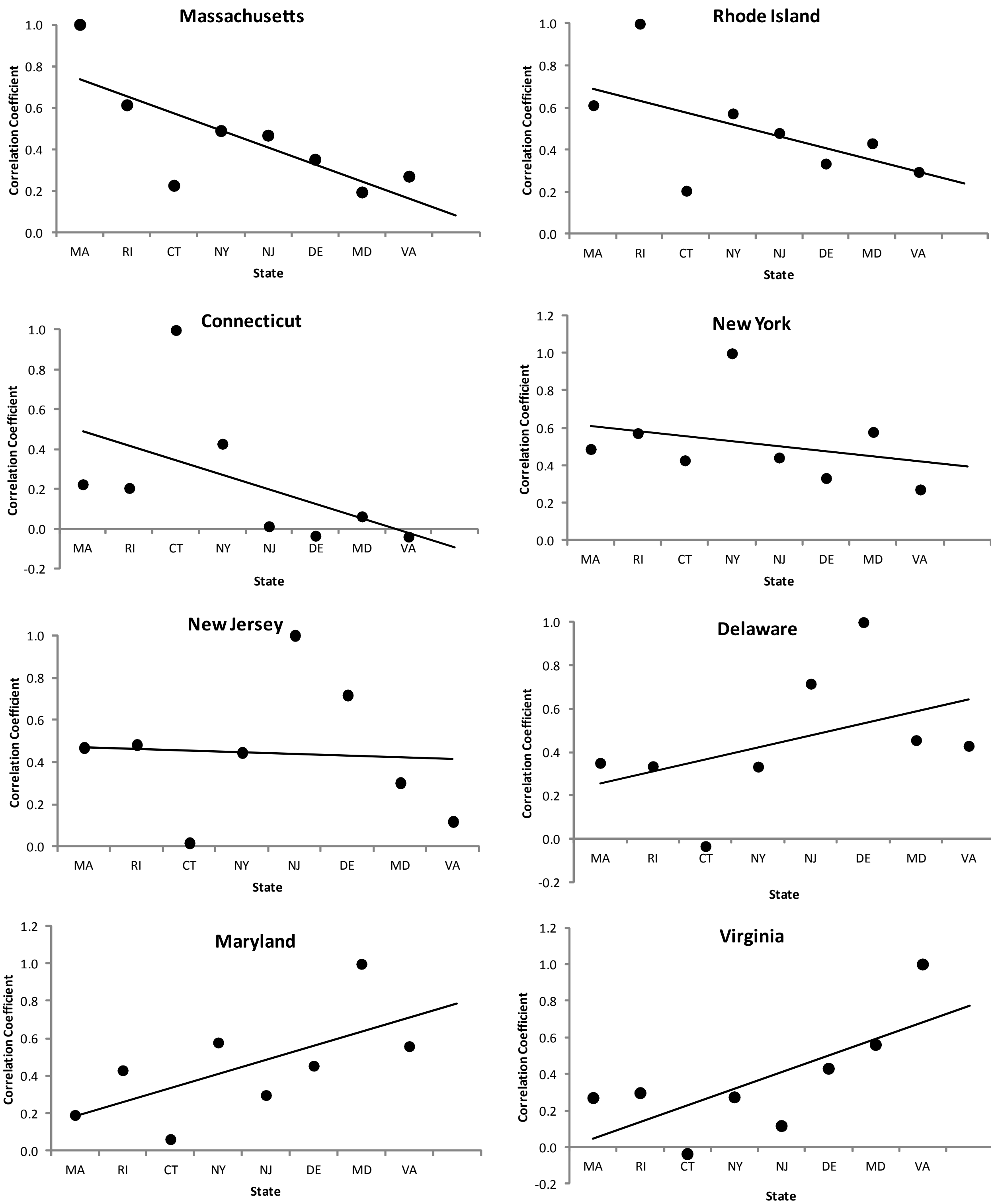


Figure B63. Correlation coefficients and trendline of black sea bass catch per angler trip (1984-2010) among states, MA to VA

.

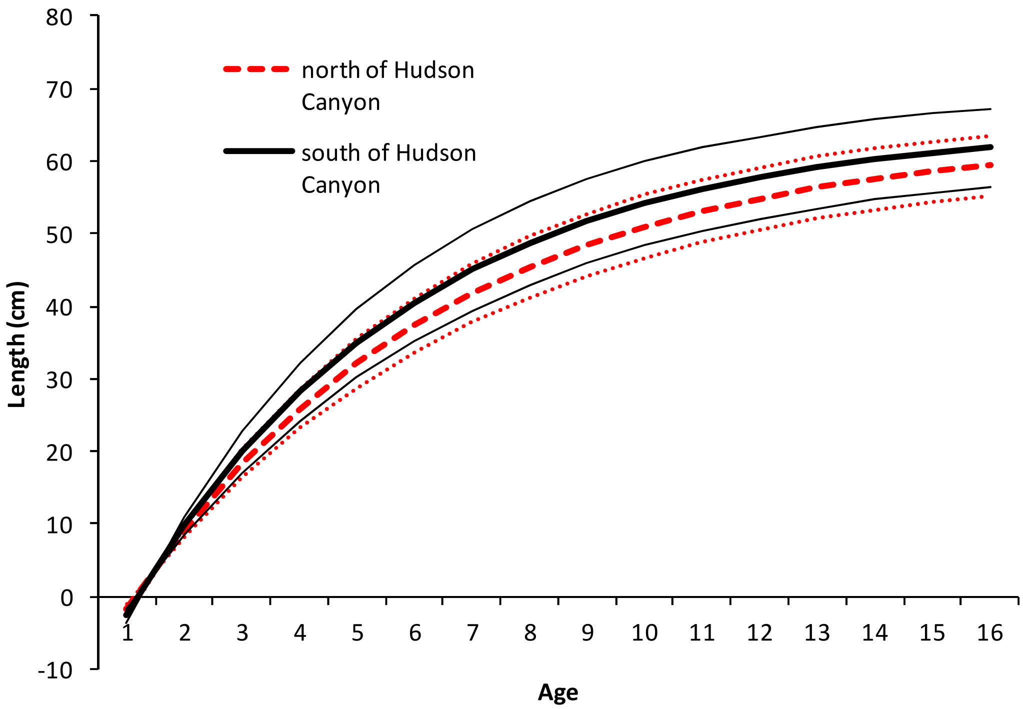


Figure B64. Black sea bass von Bertalanffy growth curves north and south of Hudson Canyon.

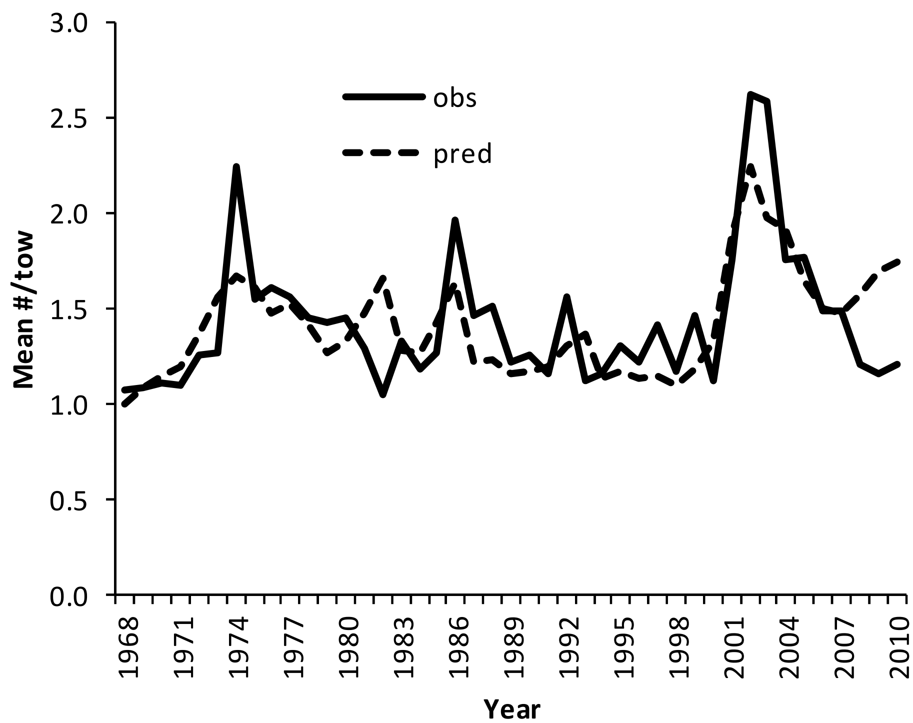


Figure B65. Observed and predicted adult ($\geq$22 cm) black sea bass NMFS spring indices from June SCALE model.

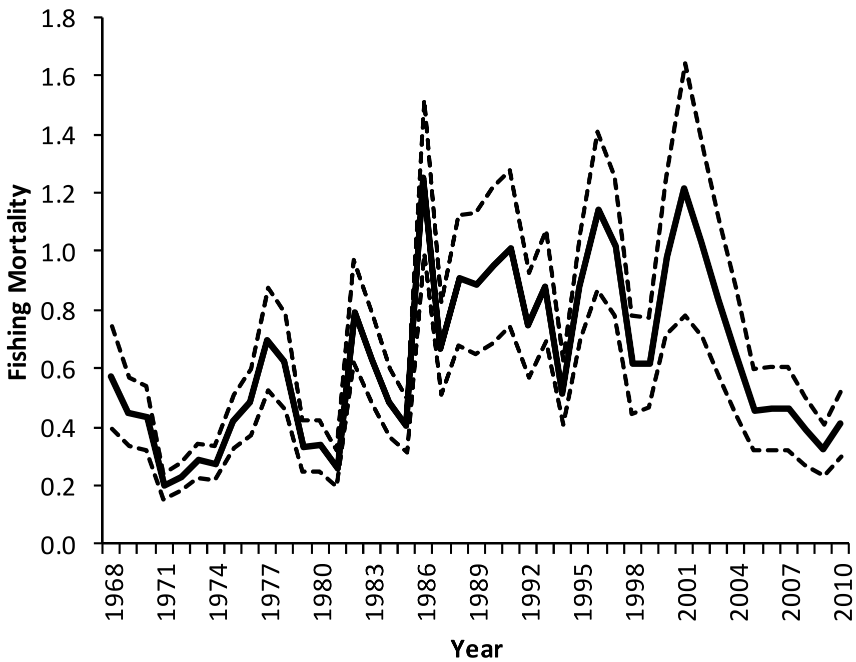


Figure B66. Estimates of black sea bass fishing mortality (± 1 std dev) from June 2011 SCALE model.

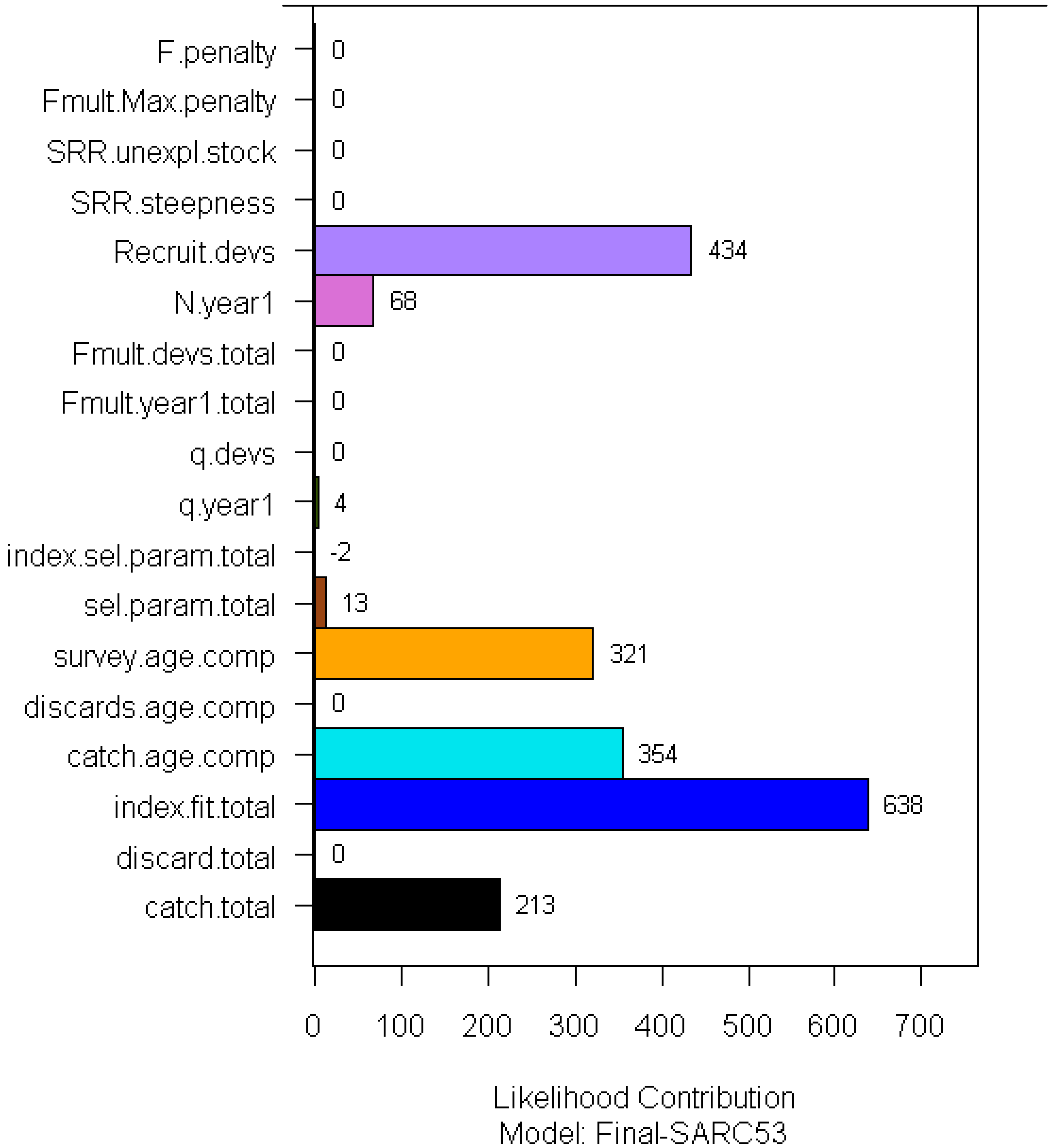


Figure B67. Components of ASAP model objective function.

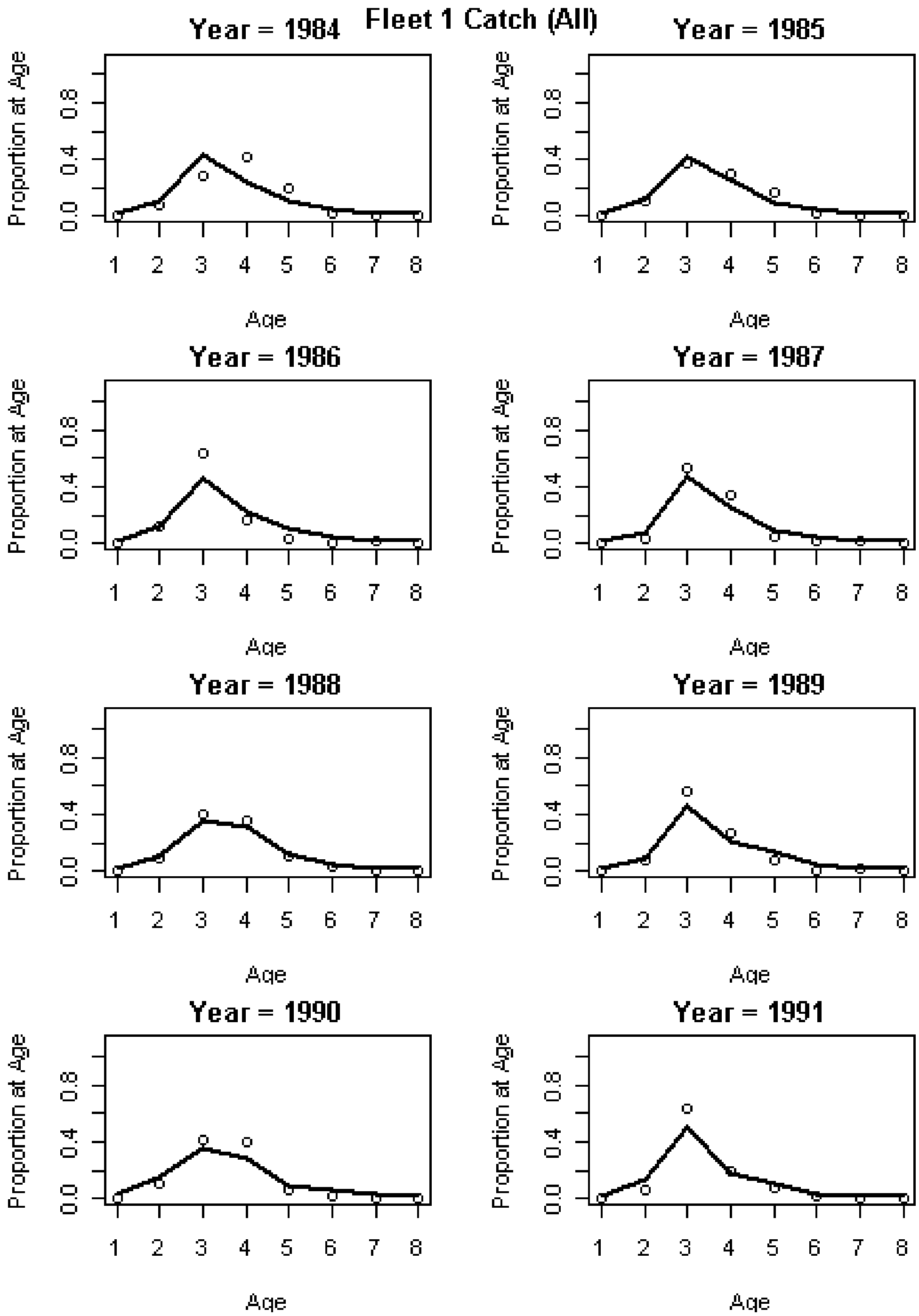


Figure B68a. Observed and predicted age comps of fleet, 1984-2010. (note: ages are shown are a+1).

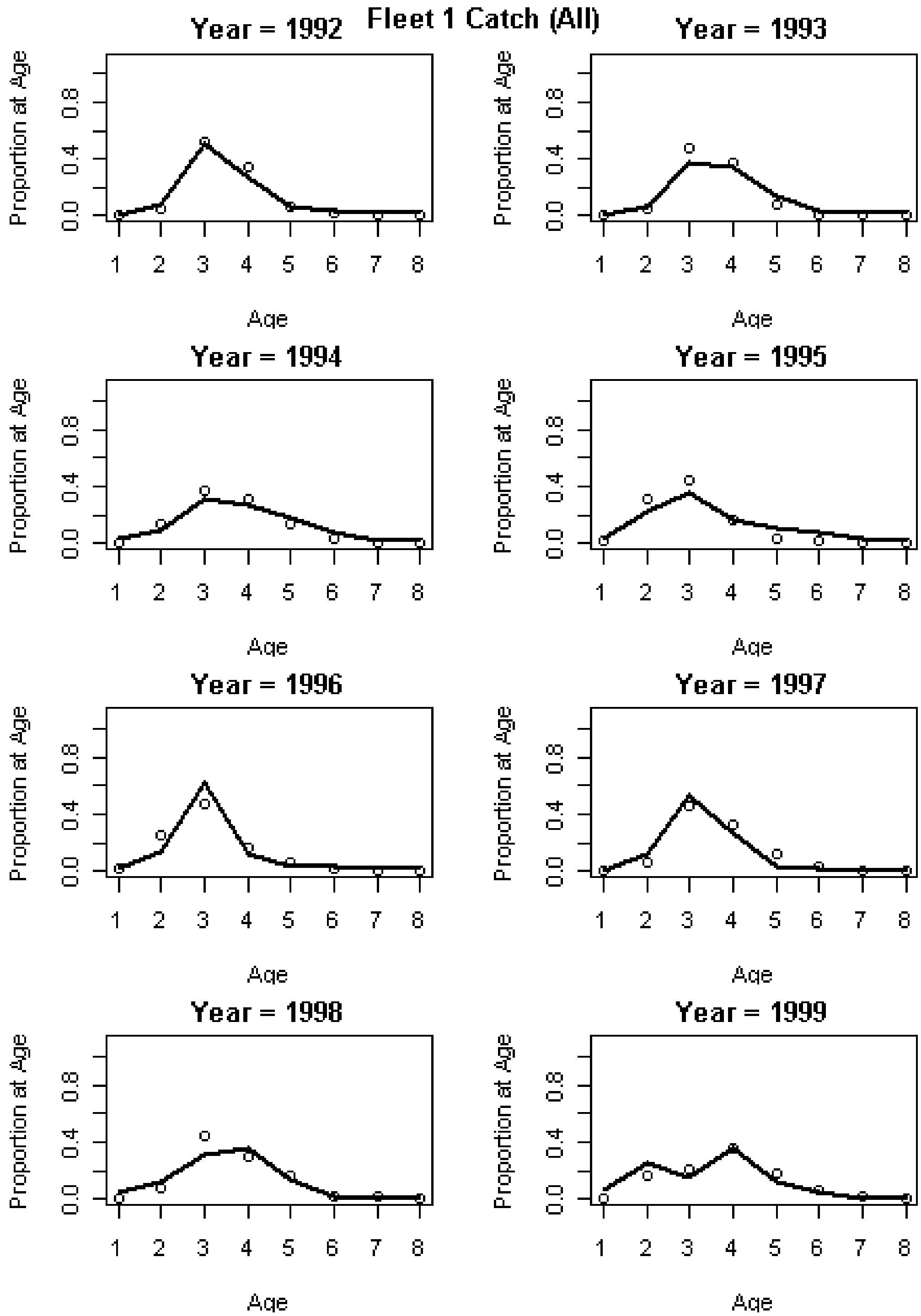


Figure B68b. Observed and predicted age comps of fleet, 1984-2010. (note: ages are shown are a+1).

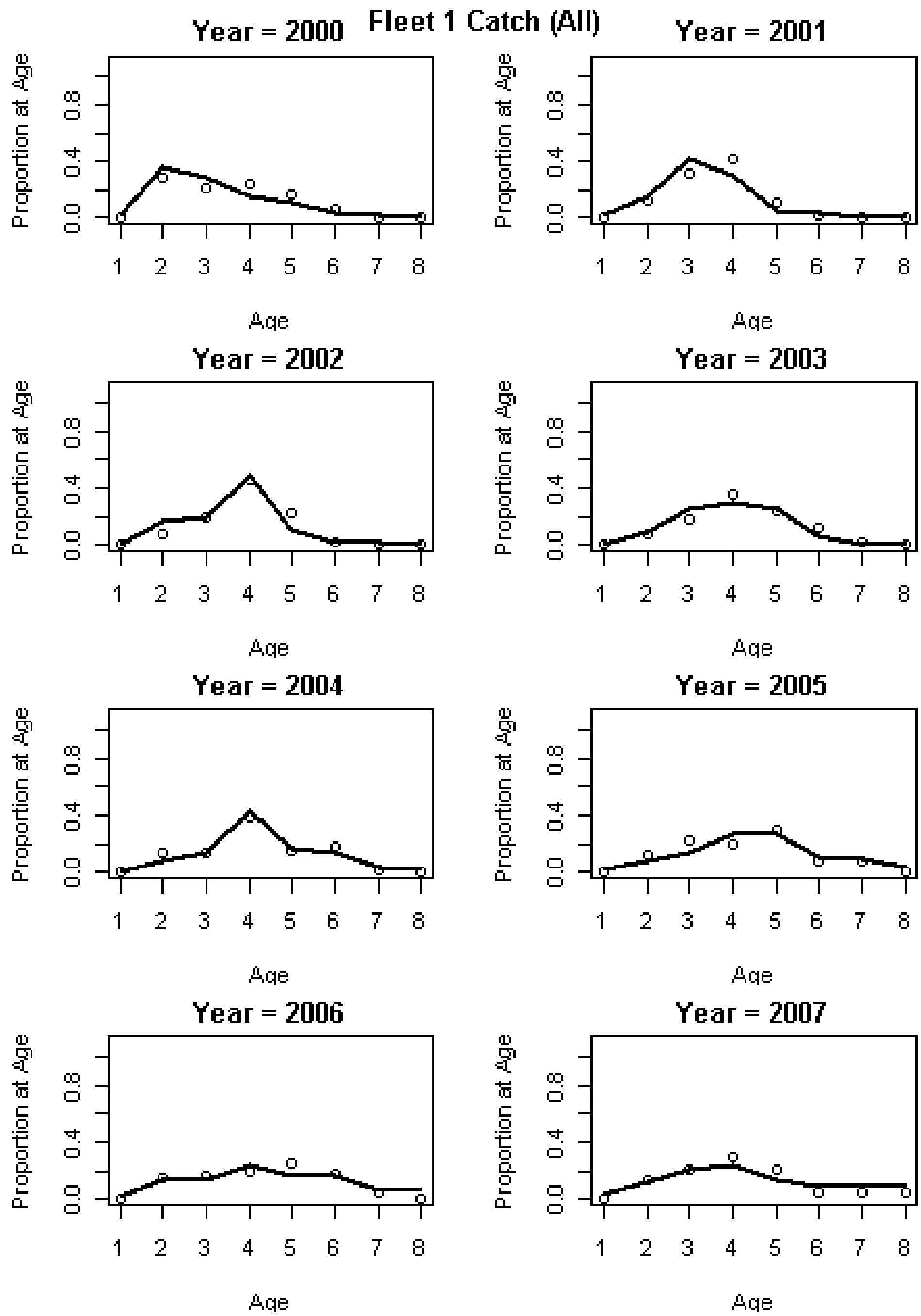


Figure B68c. Observed and predicted age comps of fleet, 1984-2010. (note: ages are shown are a+1).

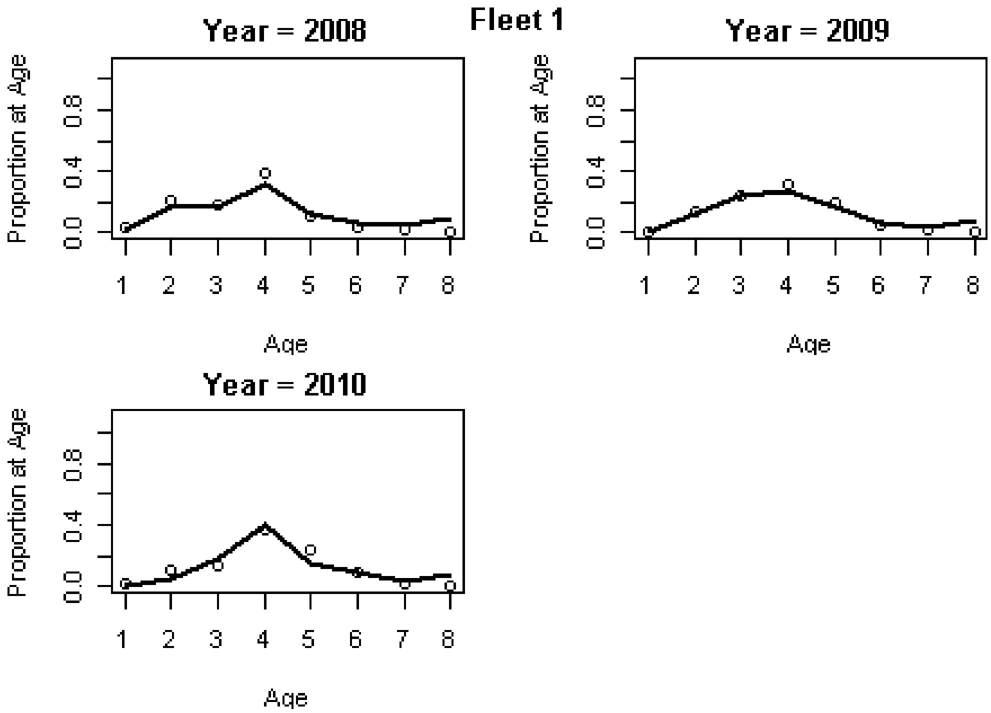


Figure B68d. Observed and predicted age comps of fleet, 1984-2010. (note: ages are shown are a+1).

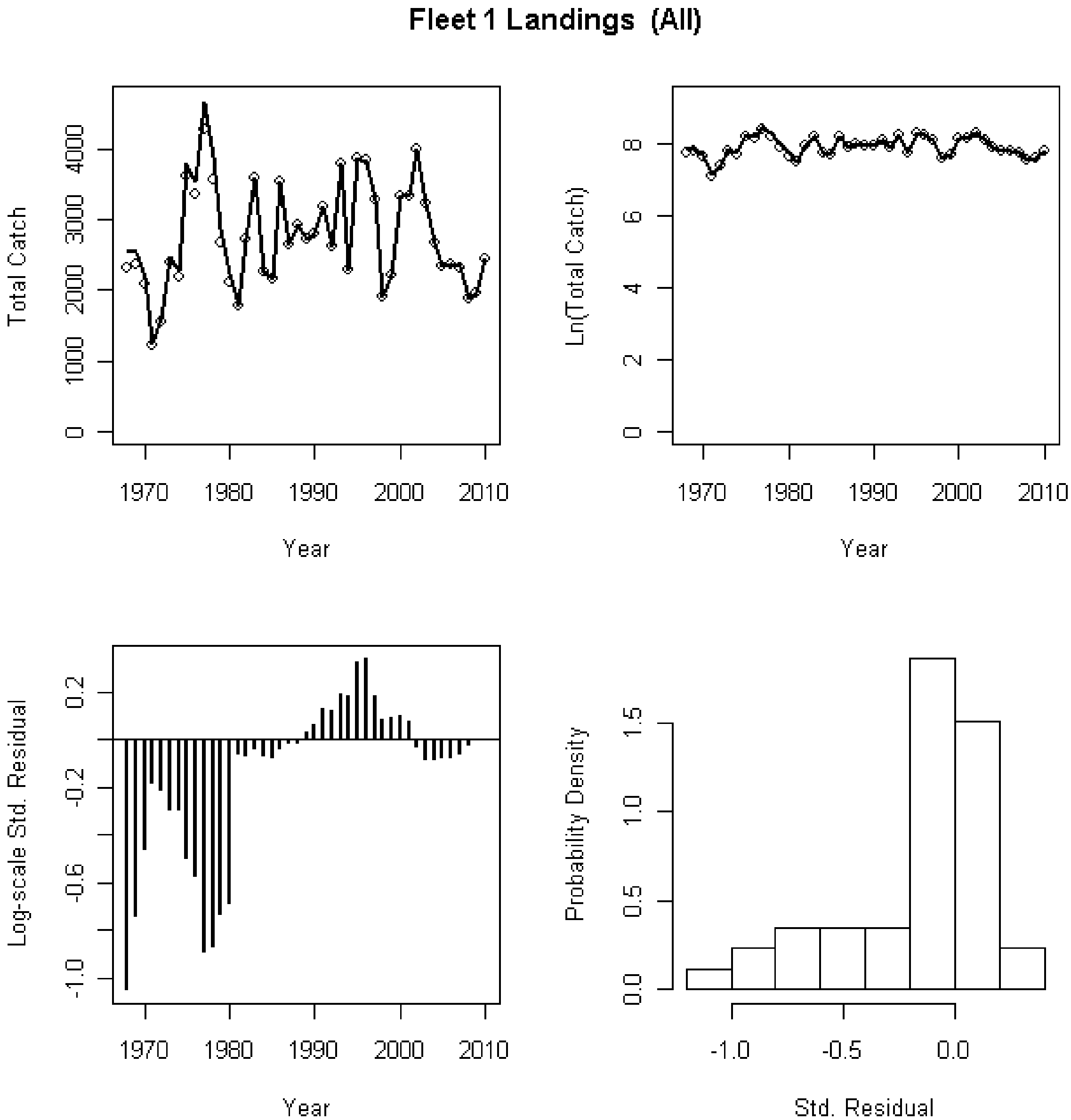


Figure B69. Observed and predicted catch and residual patterns from ASAP model.

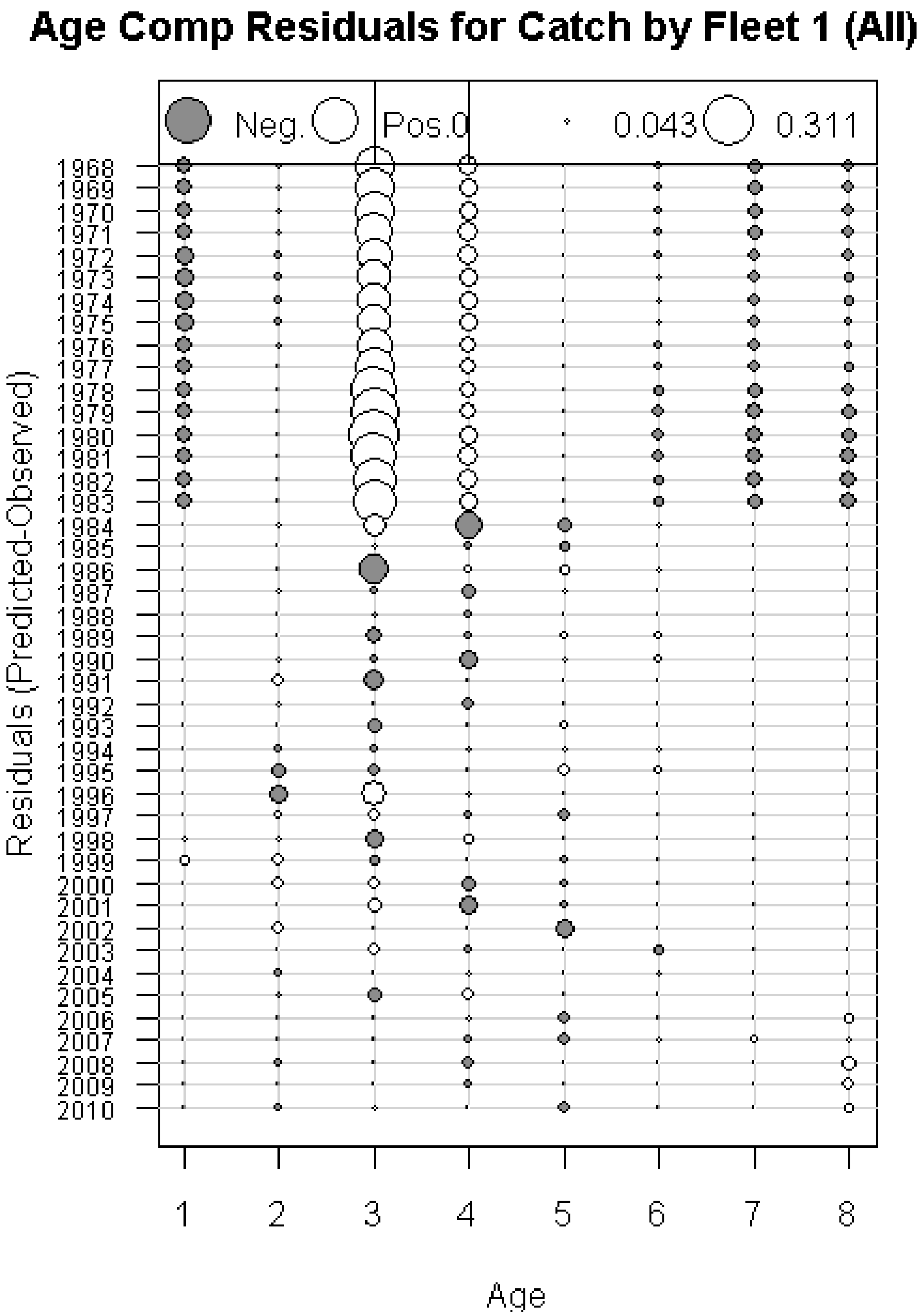


Figure B70. Age composition residuals of catch from ASAP model. (note: ages are shown are a+1).

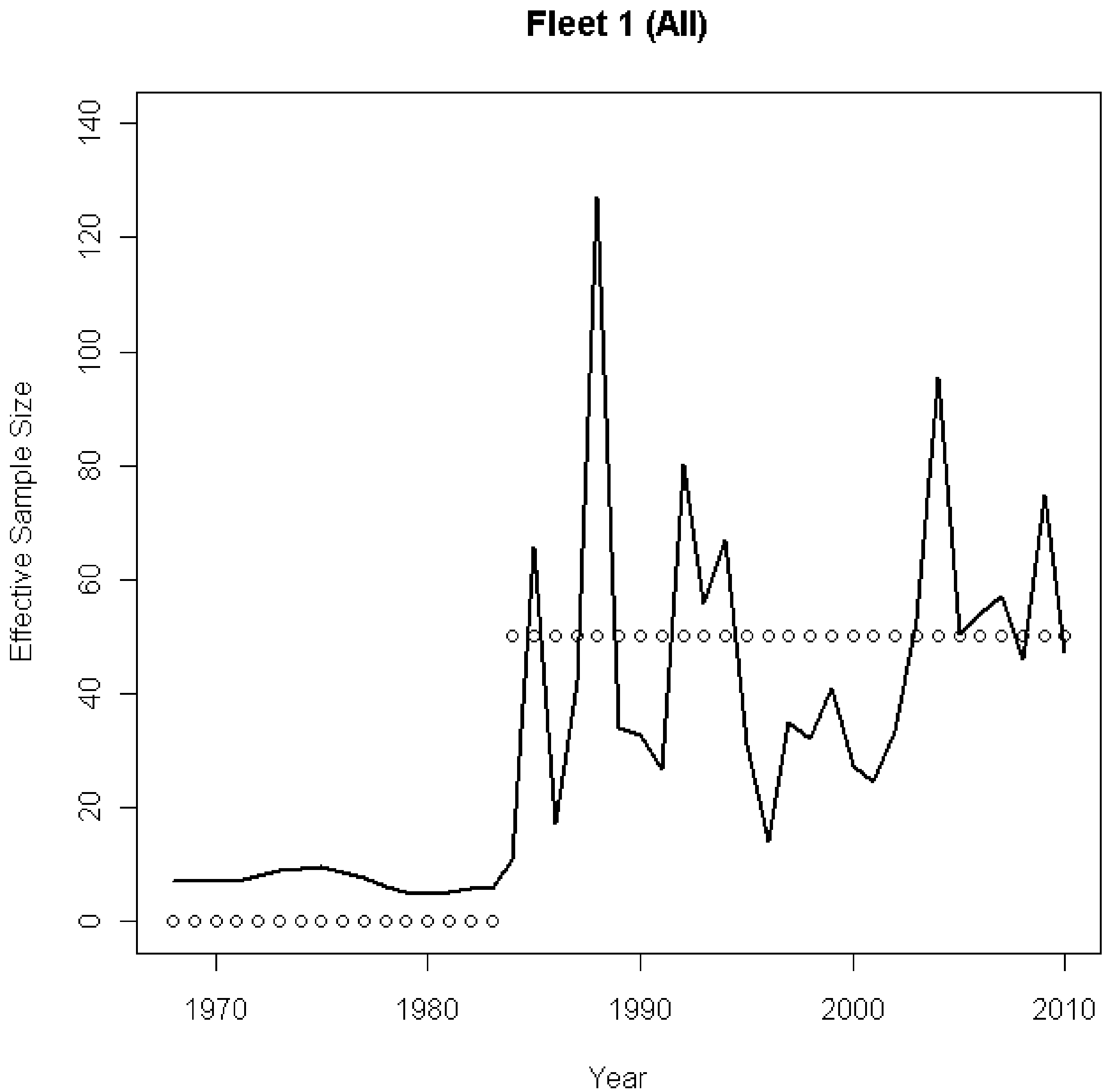


Figure B71. Observed and predicted effective sample size for fleet in ASAP model.

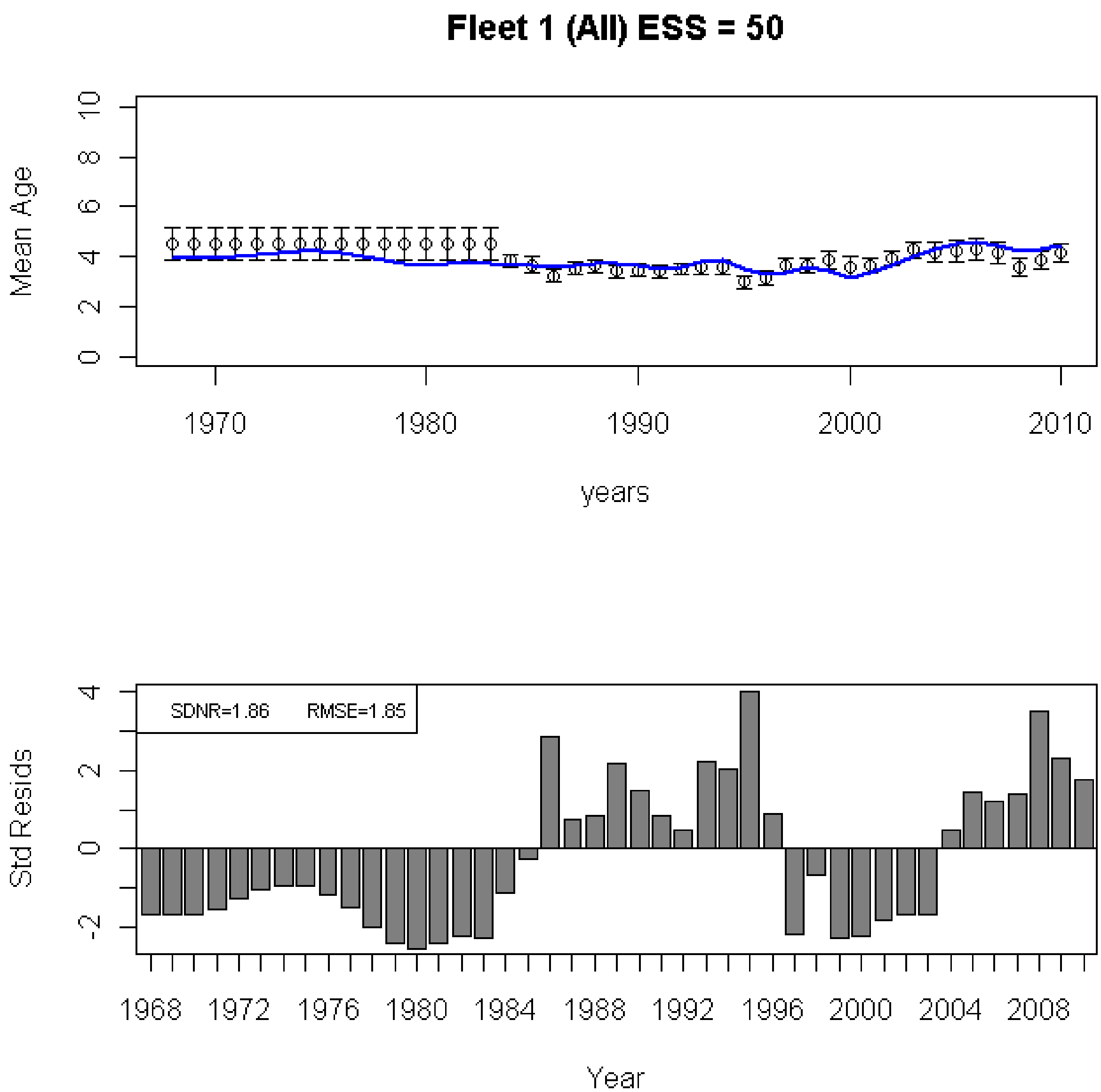


Figure B72. Fleet mean age and effective sample size plus residuals from ASAP model.

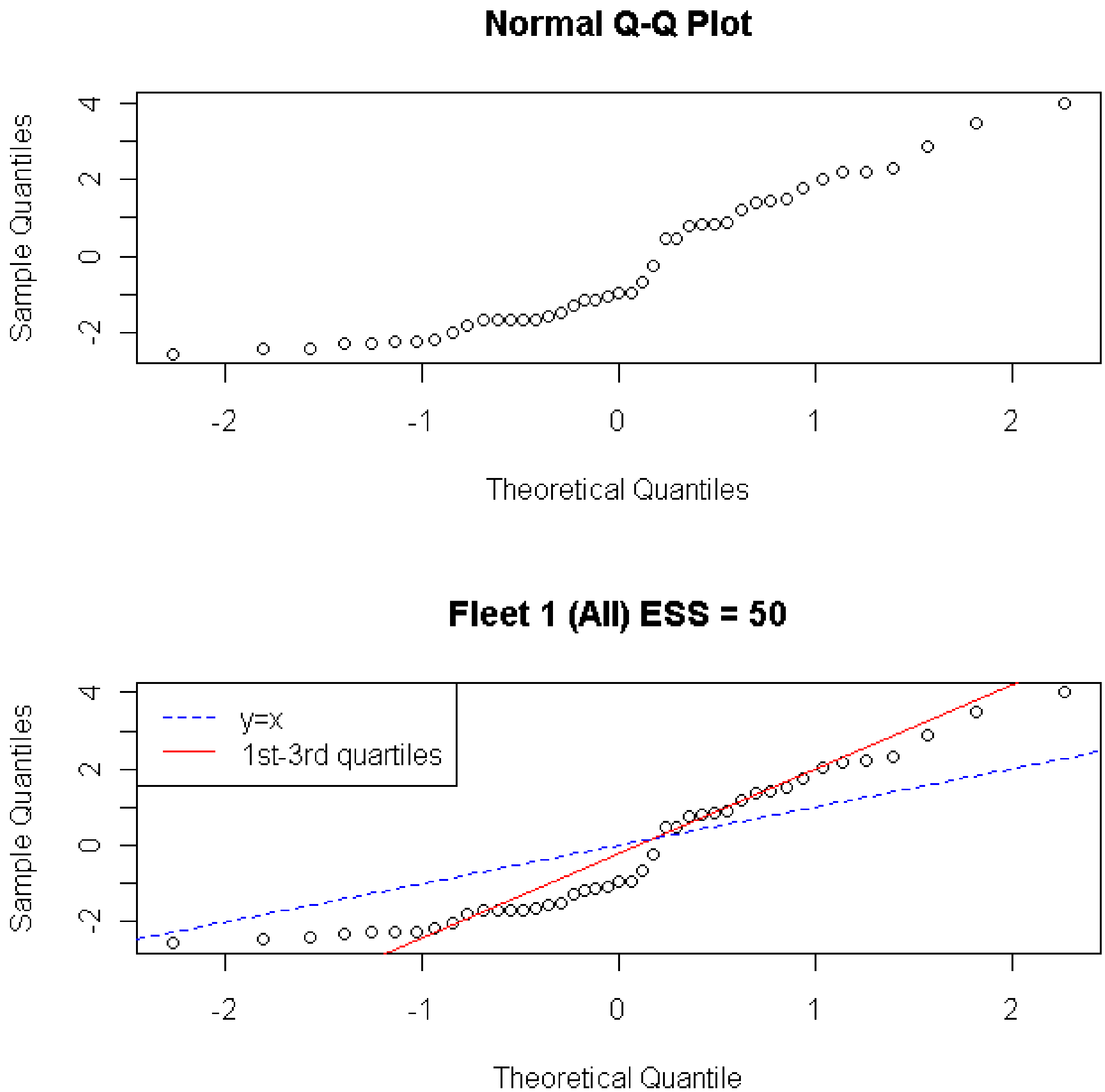


Figure B73. Quantile plots of ASAP model results.

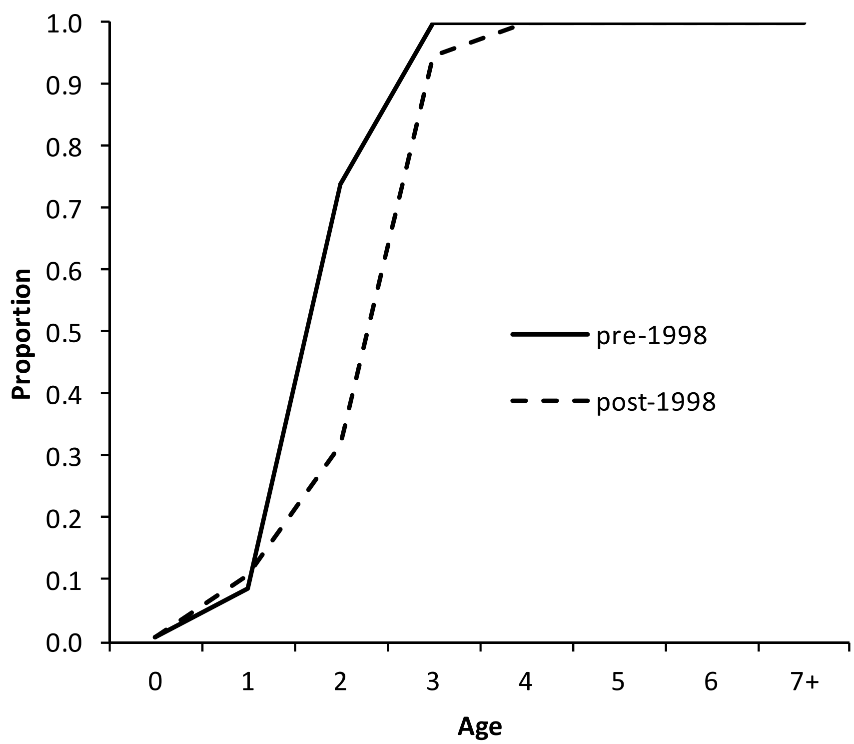


Figure B74. Catch selectivity at age pre- and post 1998 for fleet in ASAP model.

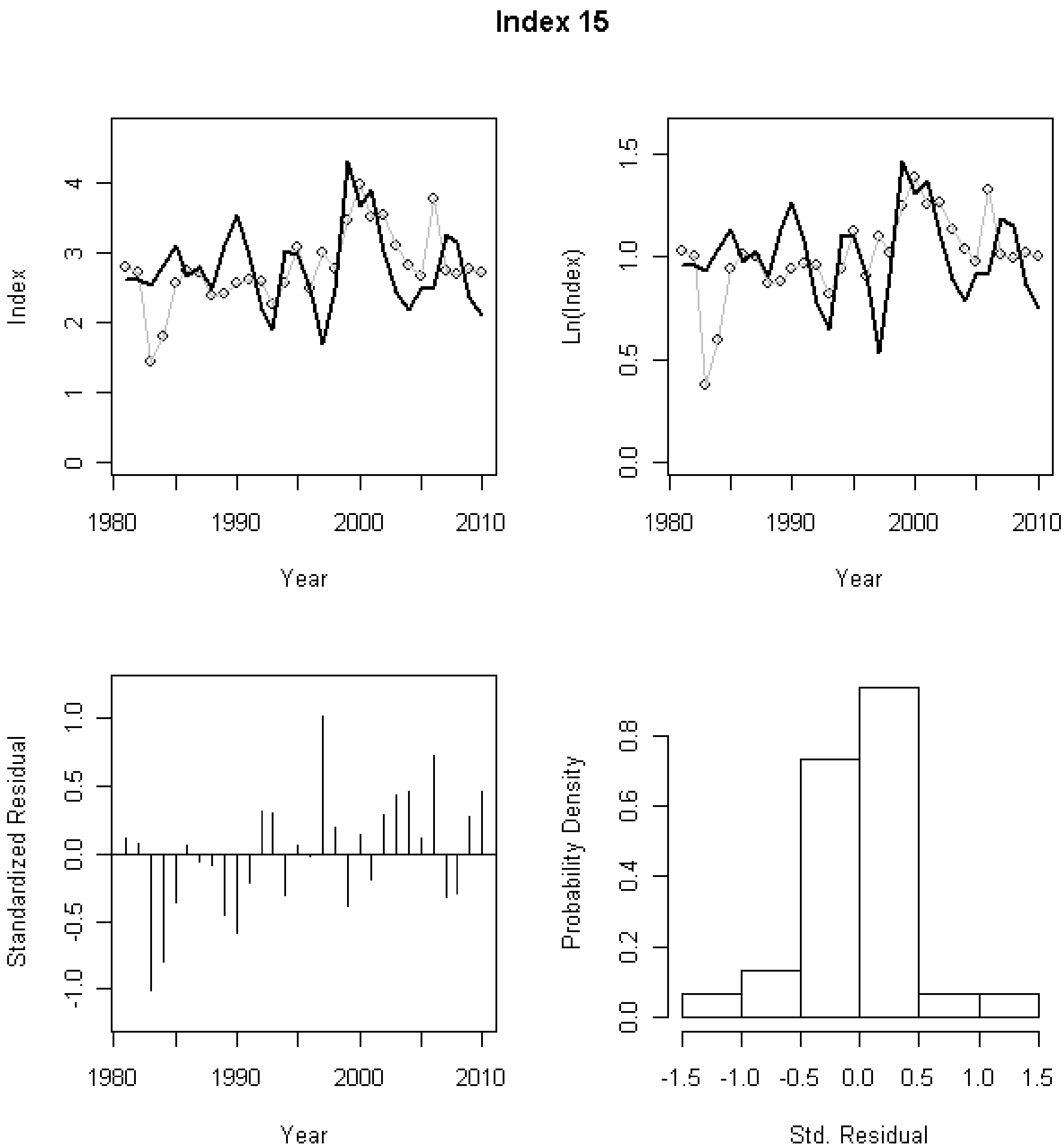


Figure B75. Observed and predicted indices and residual patterns for REC catch per angler index in ASAP model.

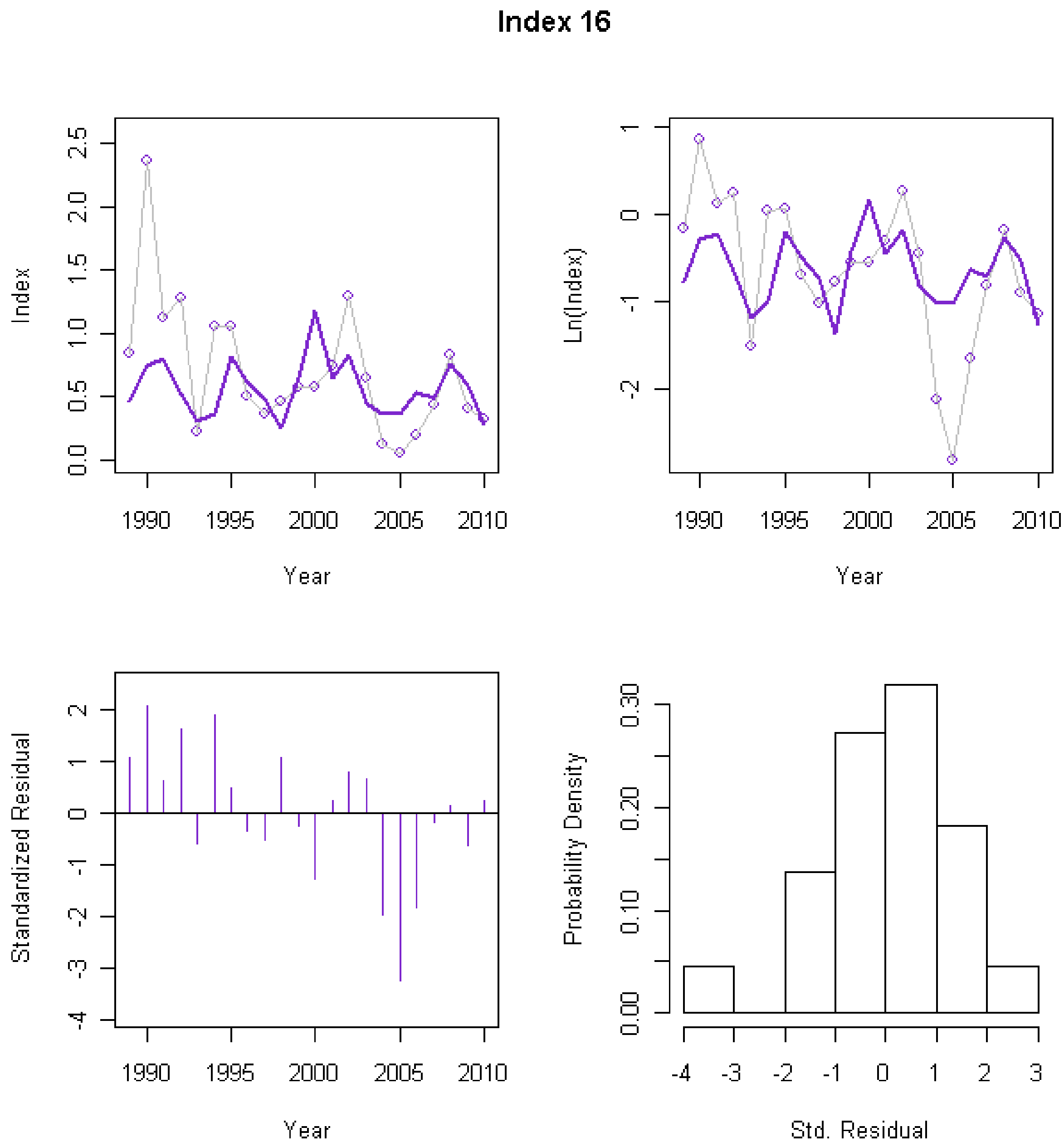


Figure B76. Observed and predicted indices and residual patterns for VA age 1 index (mean number per tow) in ASAP model.

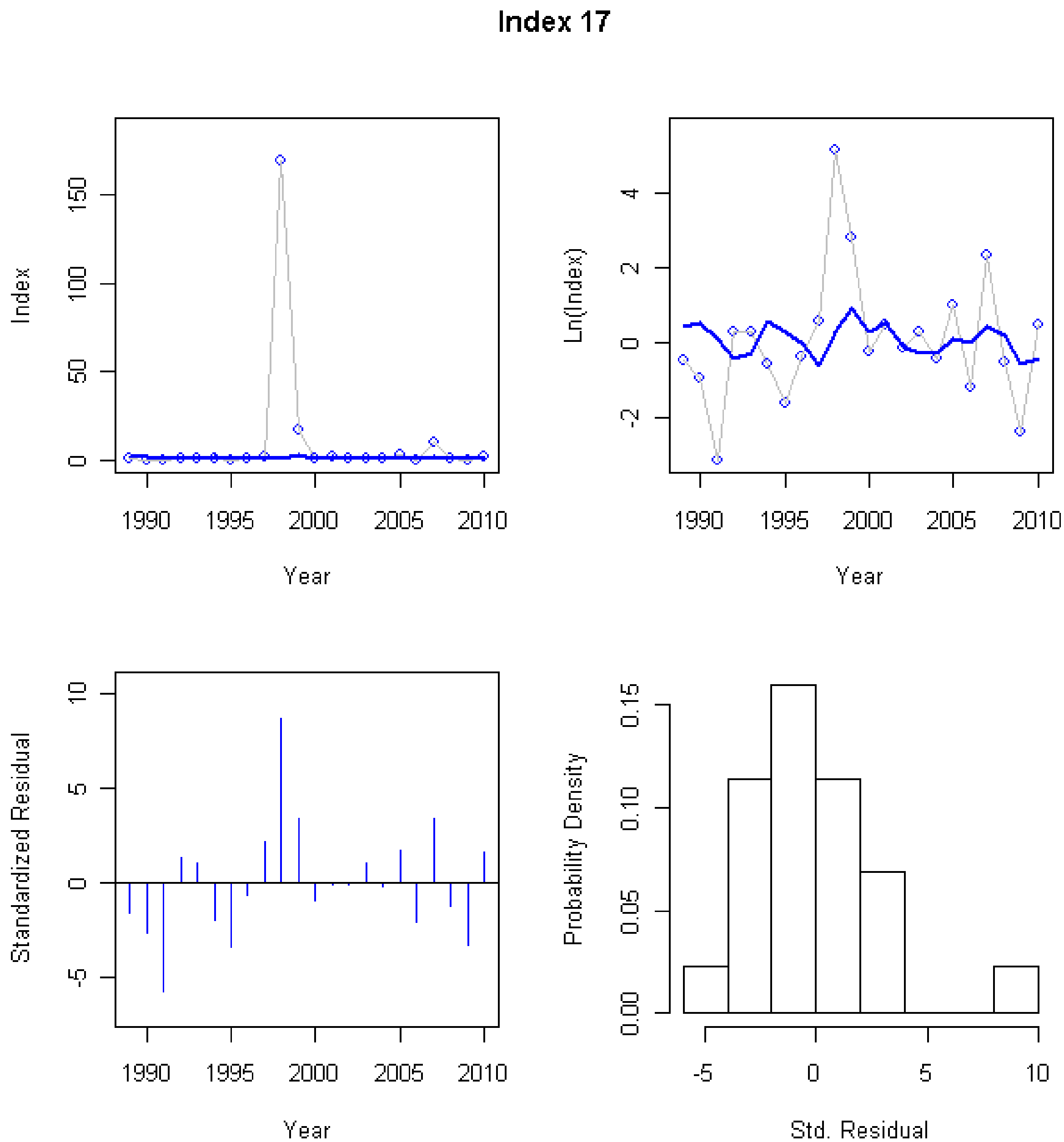


Figure B77. Observed and predicted indices and residual patterns for NJ age 0 index (mean number per tow) in ASAP model.

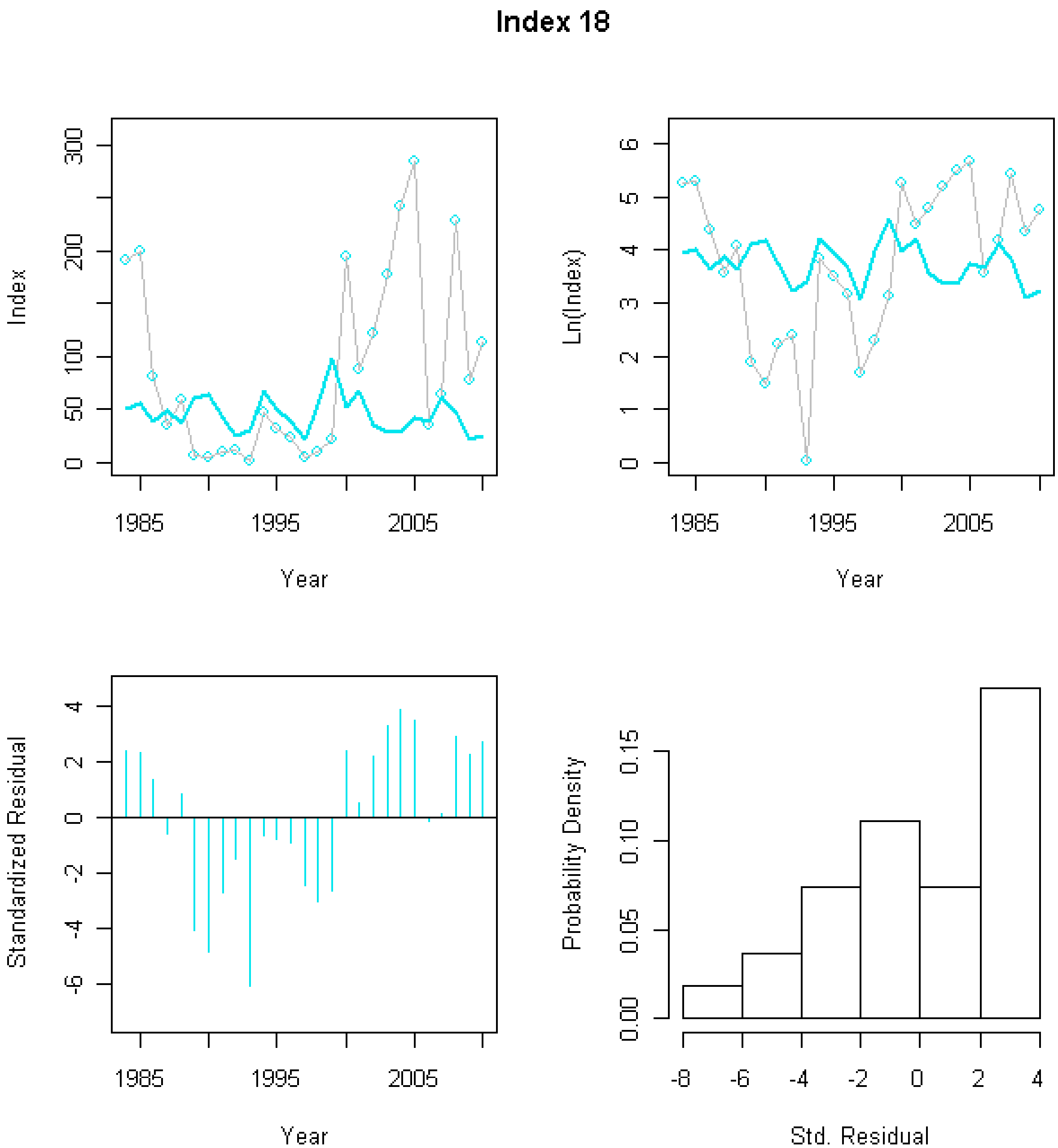


Figure B78. Observed and predicted indices and residual patterns for MA age 0 index (mean number per tow) in ASAP model.

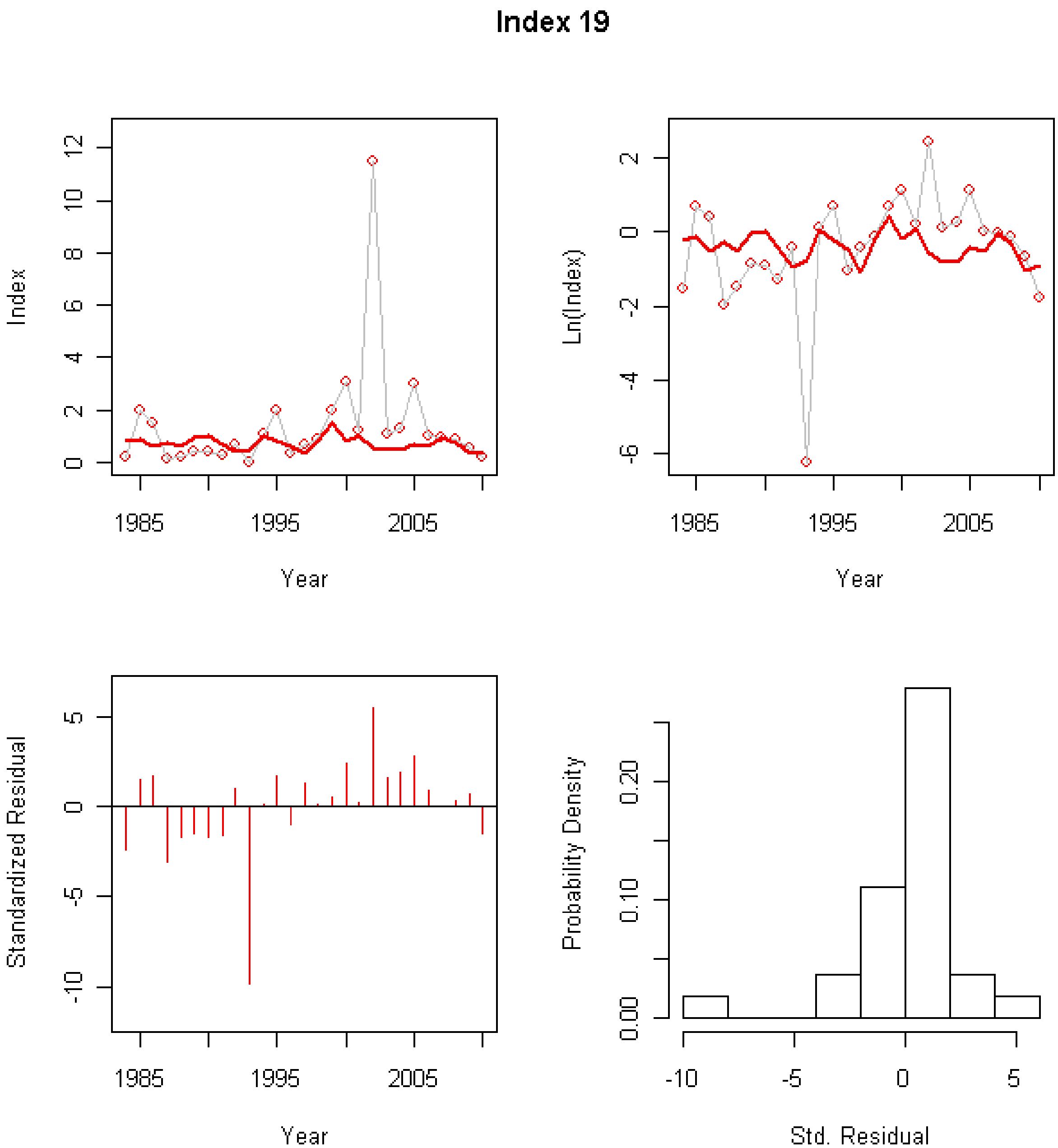


Figure B79. Observed and predicted indices and residual patterns for NEFSC Fall trawl survey age 0 index (mean number per tow) in ASAP model.

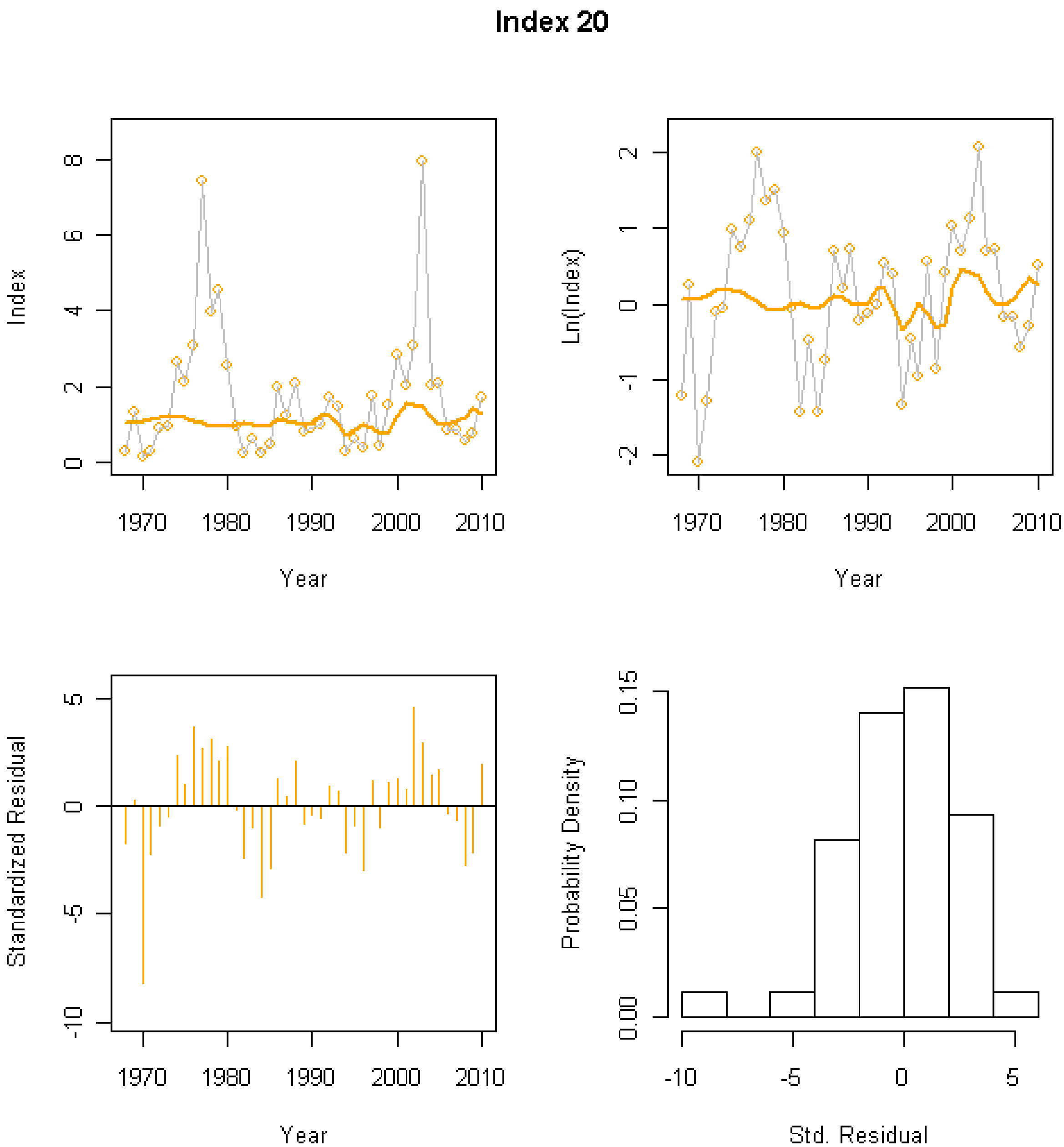


Figure B80. Observed and predicted indices and residual patterns for NEFSC spring trawl survey index (mean number per tow) in ASAP model.

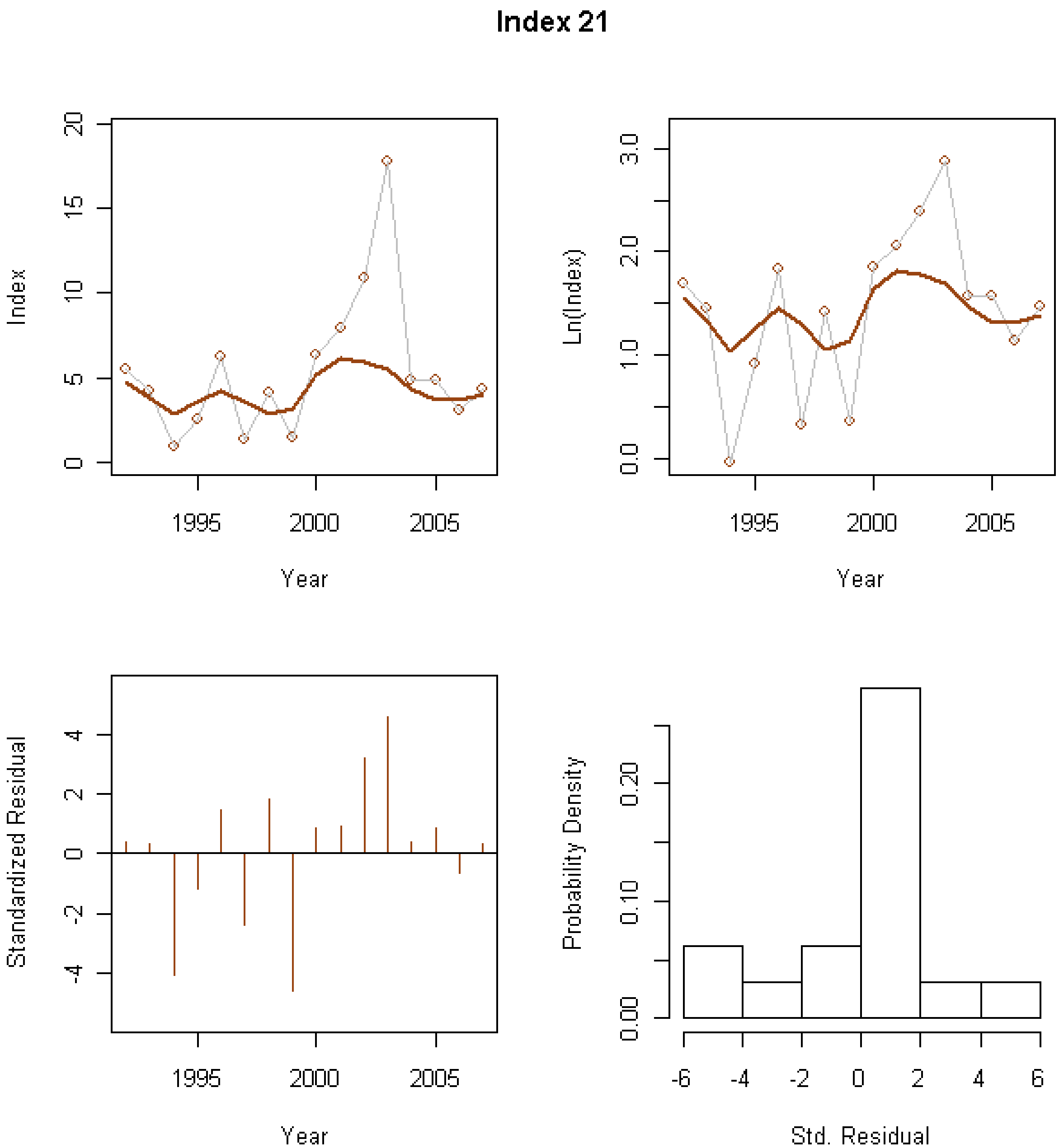


Figure B81. Observed and predicted indices and residual patterns for NEFSC winter trawl survey index (mean biomass per tow) in ASAP model.

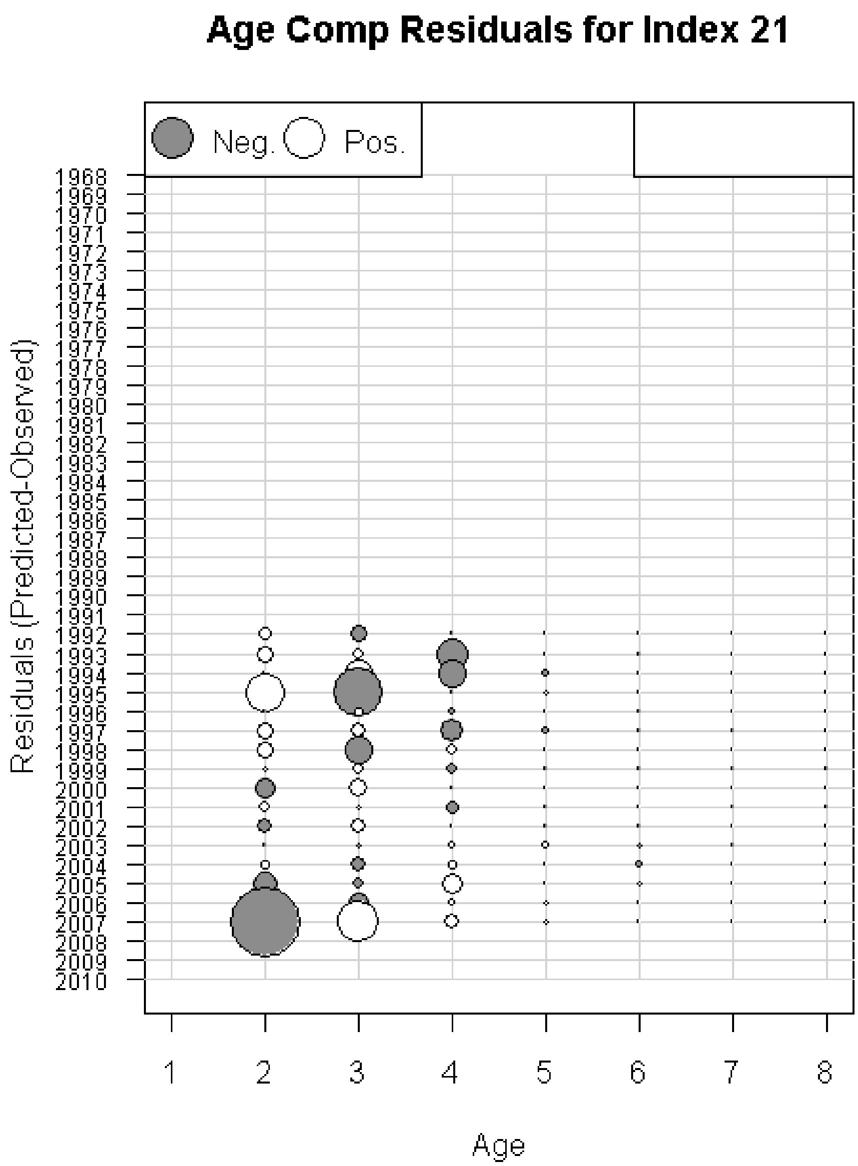


Figure B82. Age composition of NMFS winter trawl survey in ASAP model. (note: ages are shown are a+1).

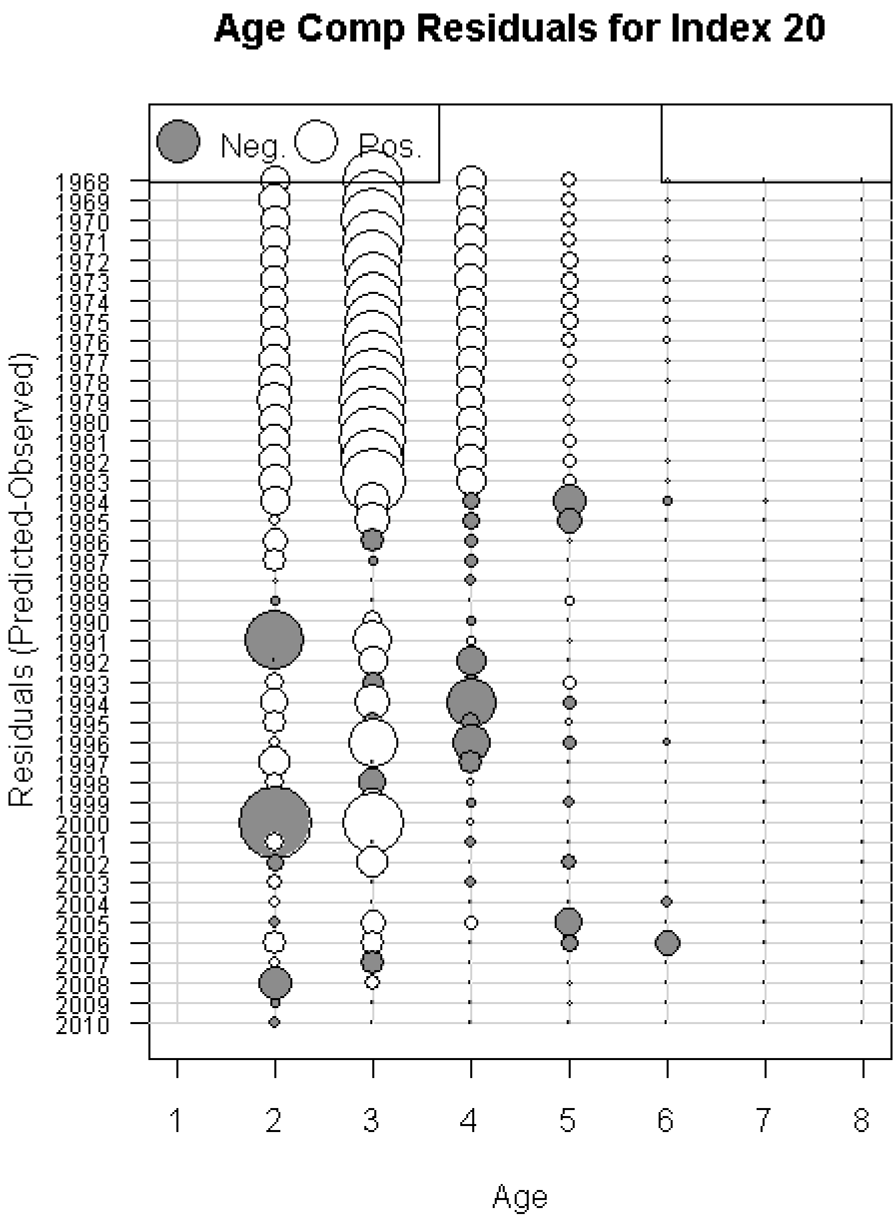


Figure B83. Age composition of NMFS spring trawl survey in ASAP model. (note: ages are shown are a+1).

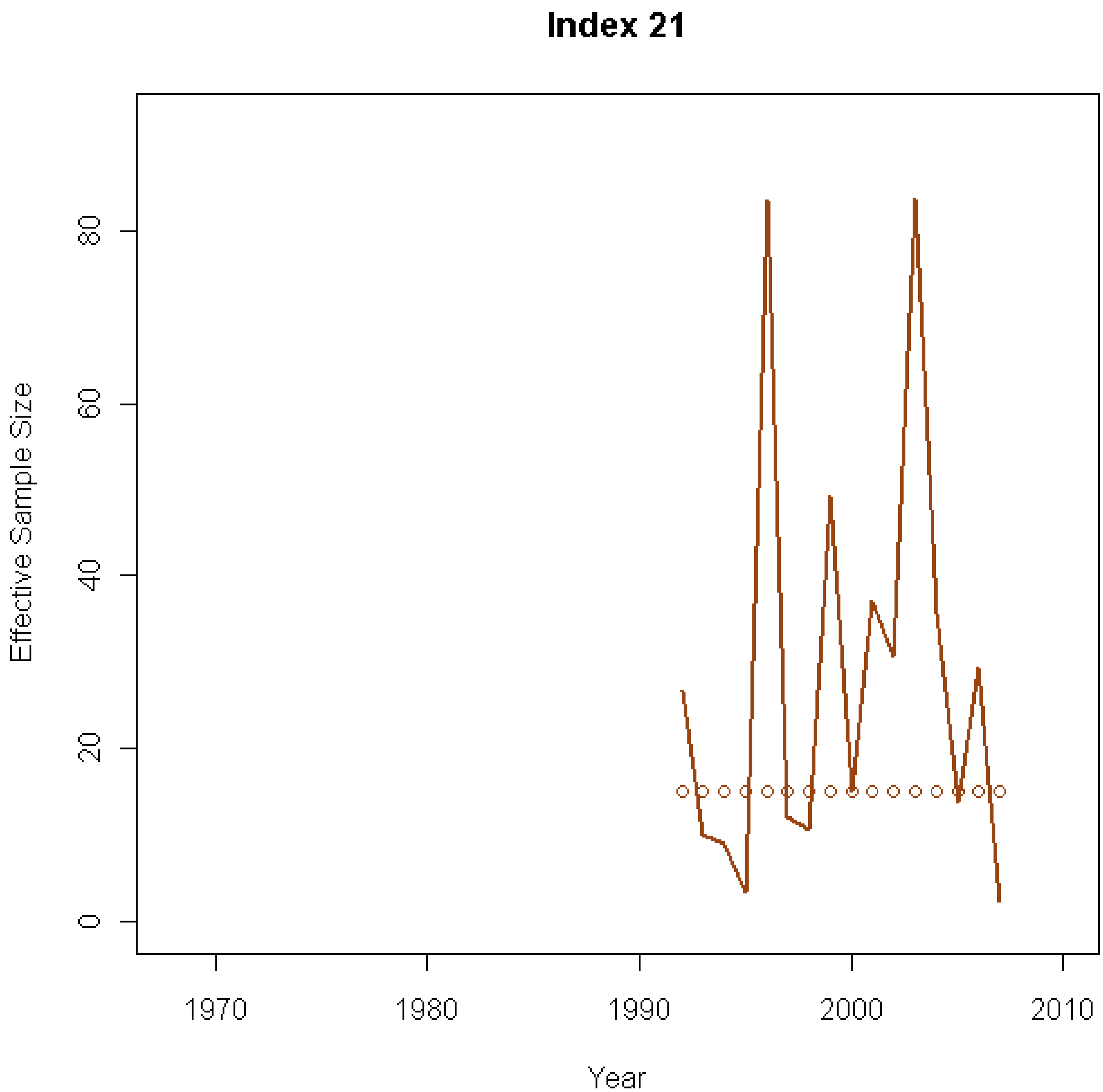


Figure B84. Observed and predicted effective sample size for NEFSC winter trawl survey index.

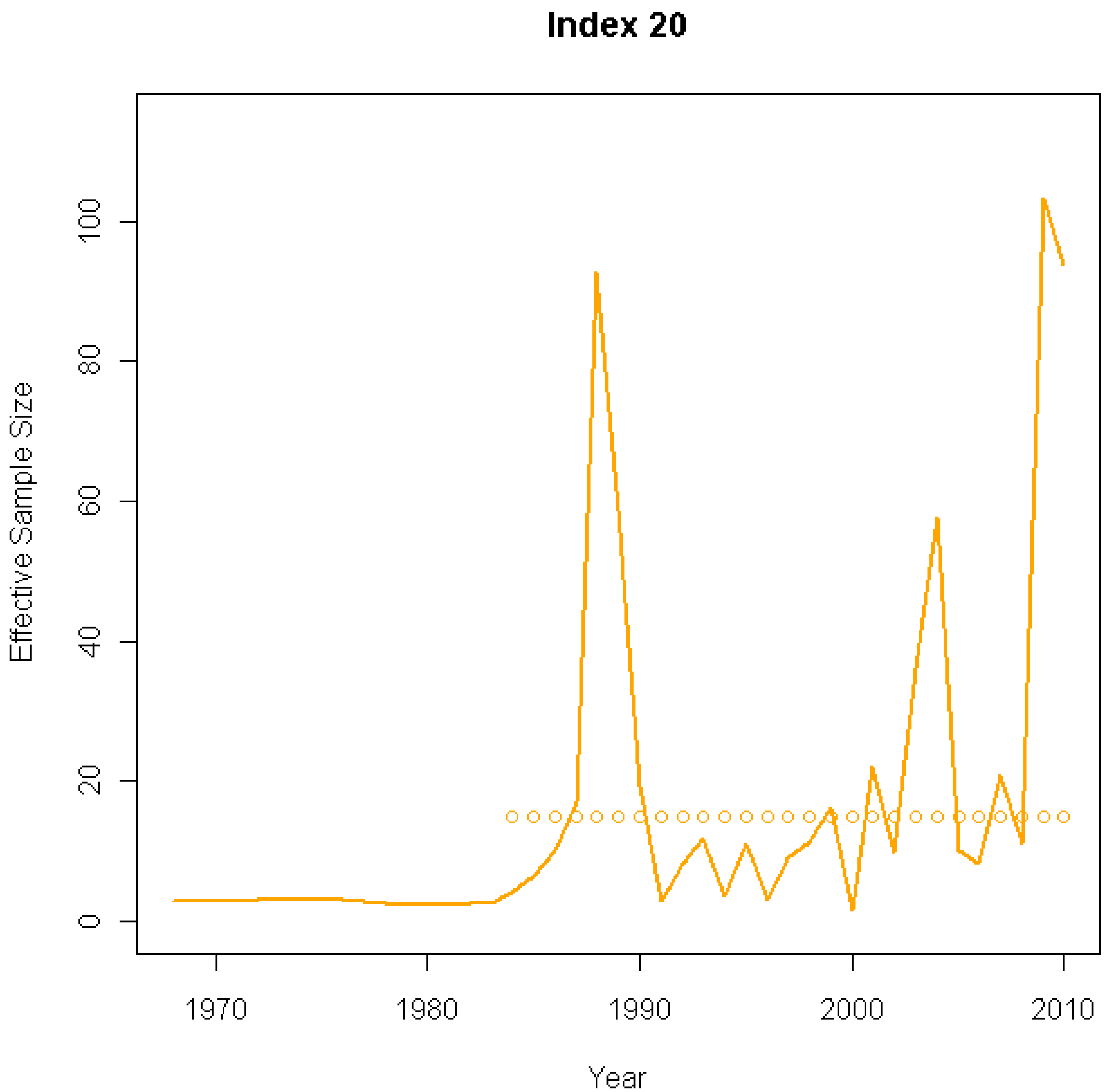


Figure B85. Observed and predicted effective sample size for NEFSC spring trawl survey index.

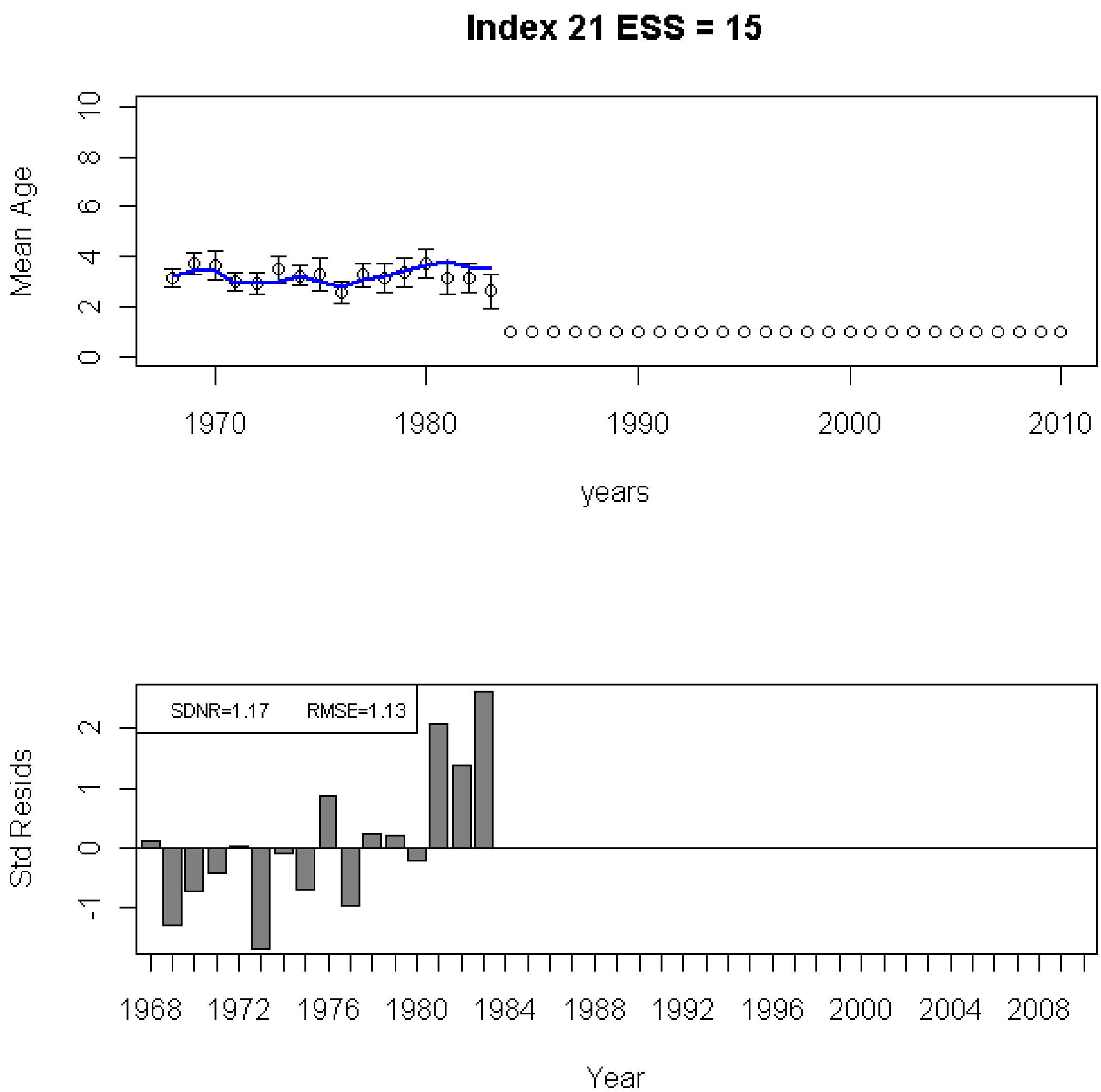


Figure B86. Mean age and effective sample size for NEFSC winter trawl survey in ASAP model.

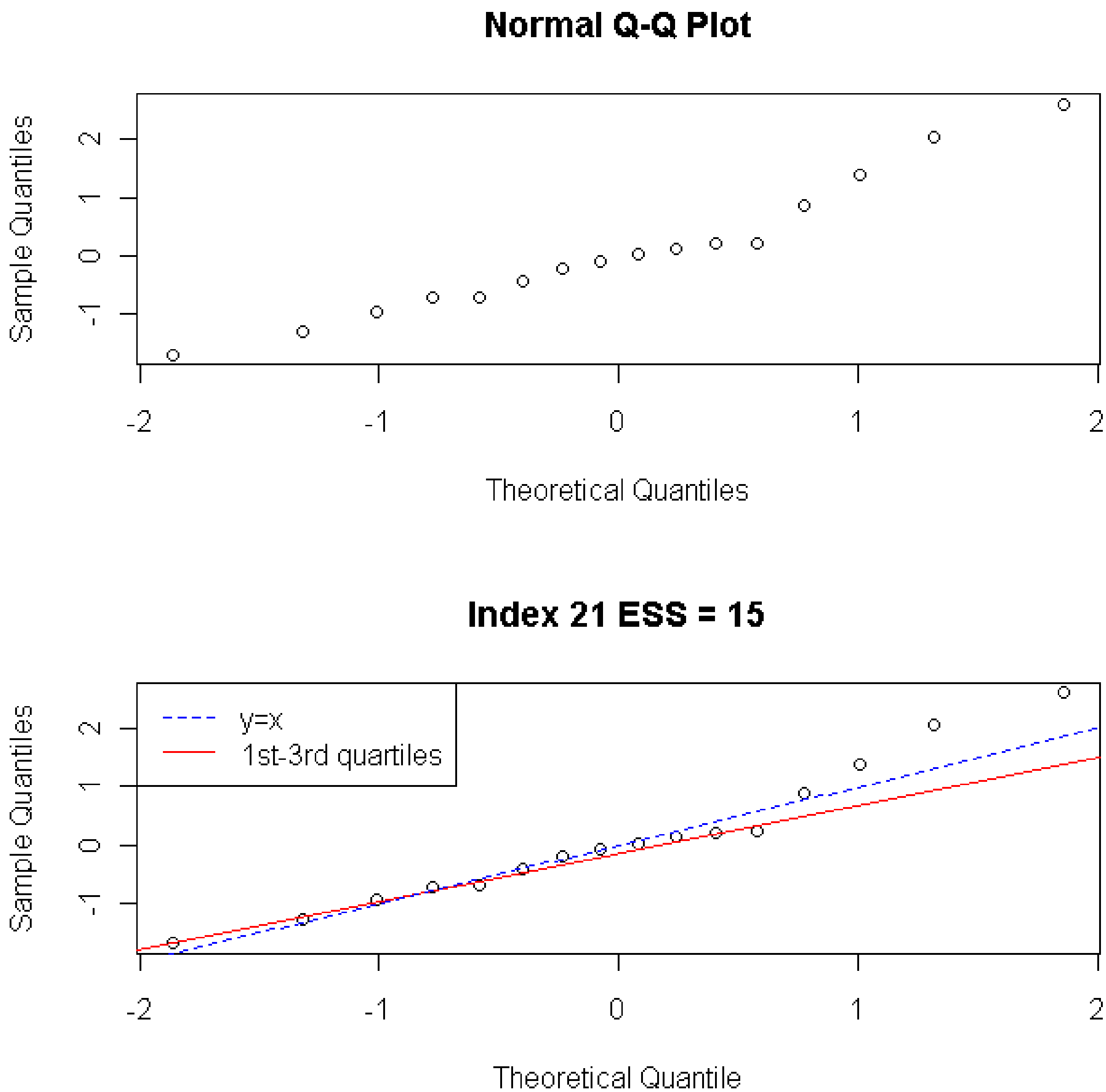


Figure B87. Quantiles from NEFSC winter trawl survey indices.

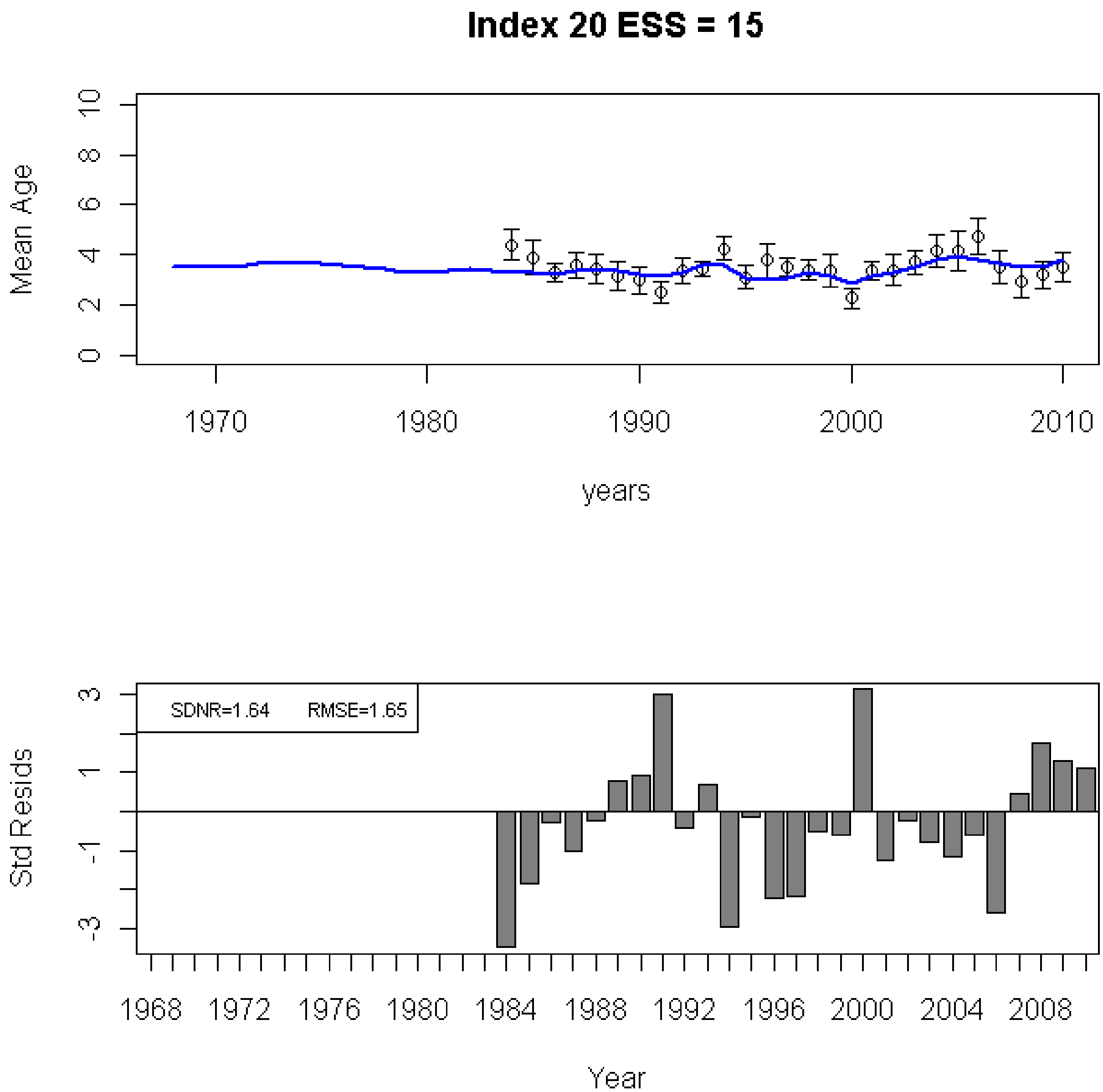
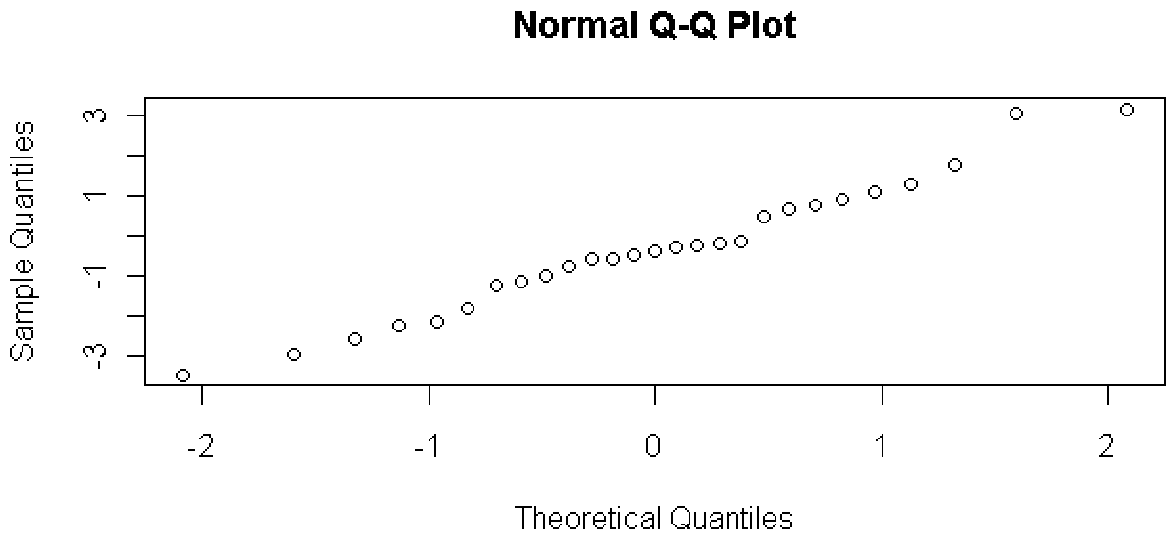


Figure B88. Mean age and effective sample size for NEFSC spring trawl survey in ASAP model.



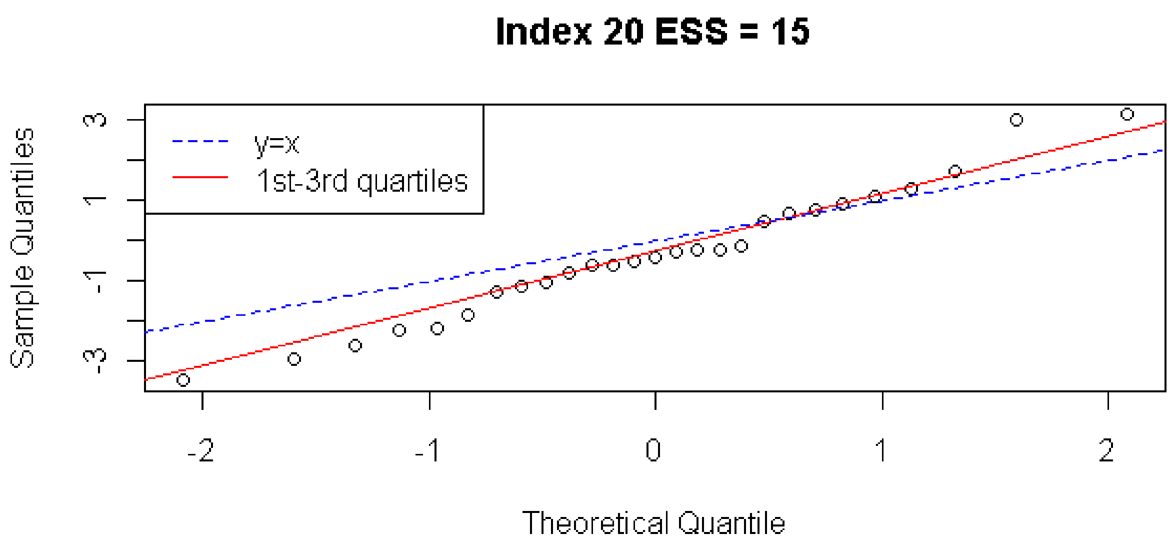


Figure B89. Quantiles from NEFSC spring trawl survey indices

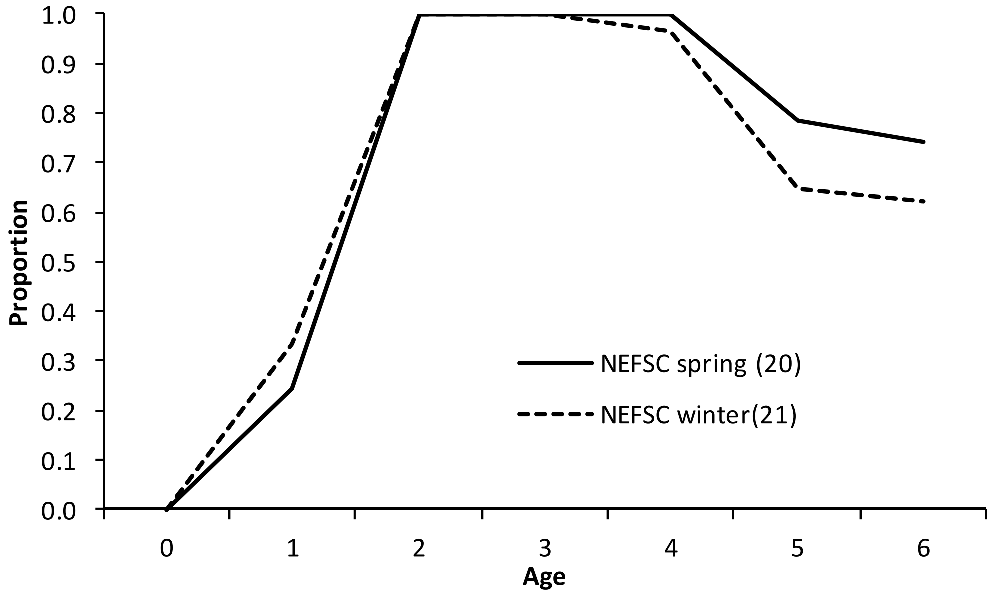


Figure B90. Selectivity at age from ASAP model for NEFSC winter and spring survey indices.

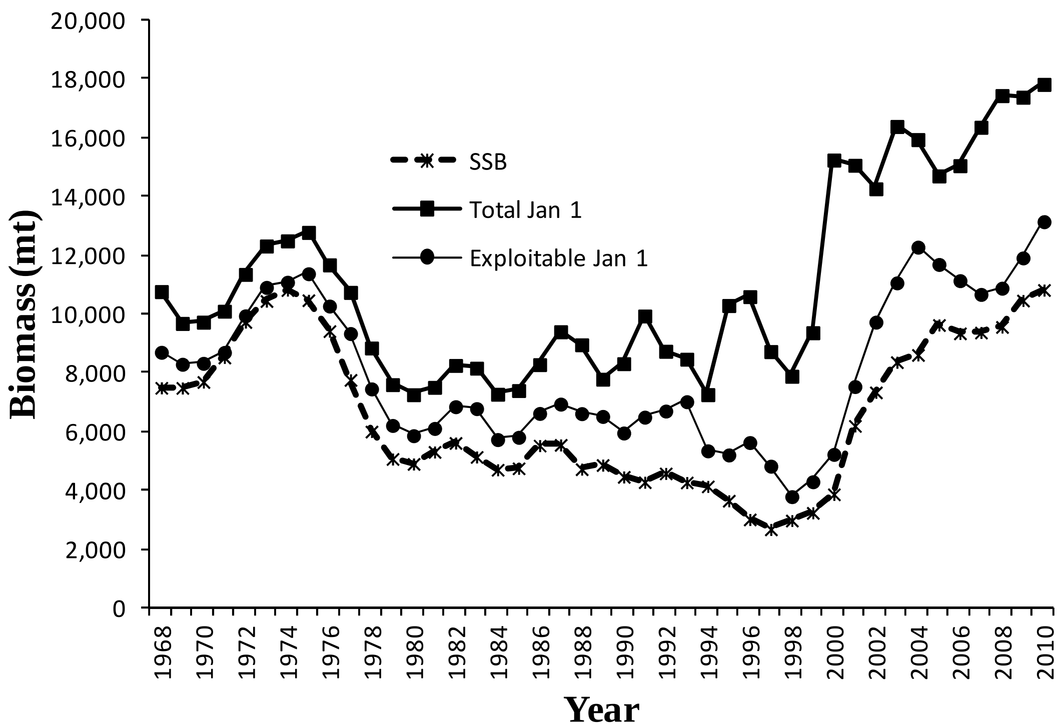


Figure B91. Predicted black sea bass spawning stock biomass, exploitable biomass and January 1 biomass from ASAP model results.

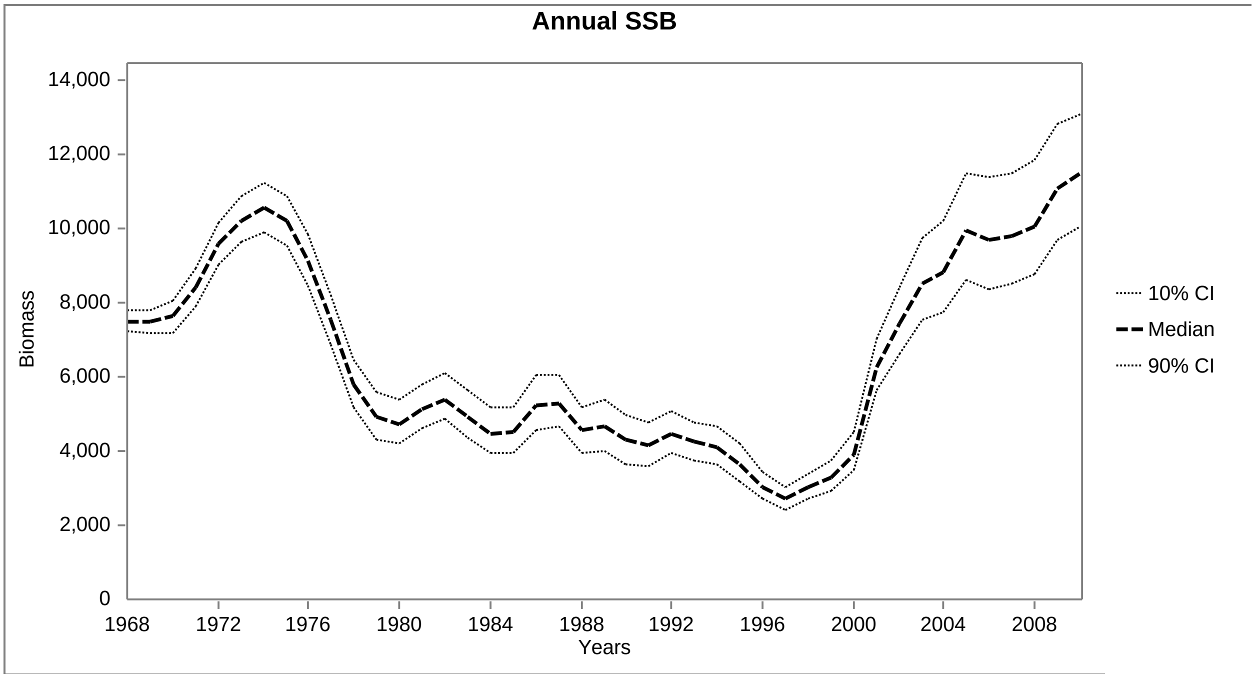


Figure B92. Results of MCMC run for black sea bass spawning stock biomass.

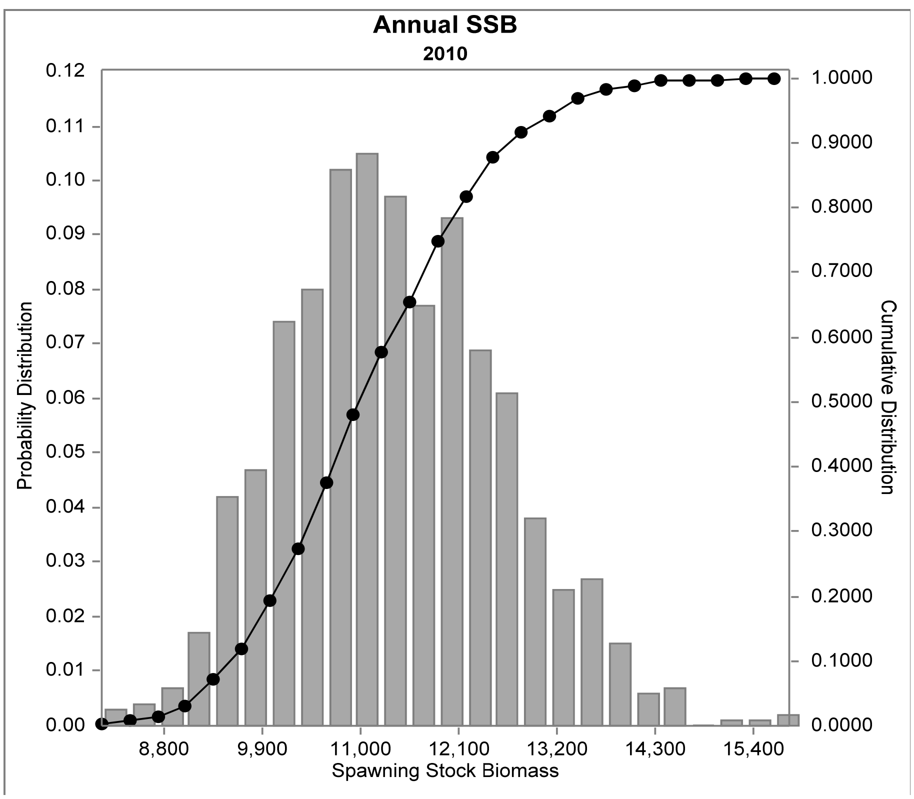


Figure B93. Distribution of 2010 black sea bass SSB from MCMC run.

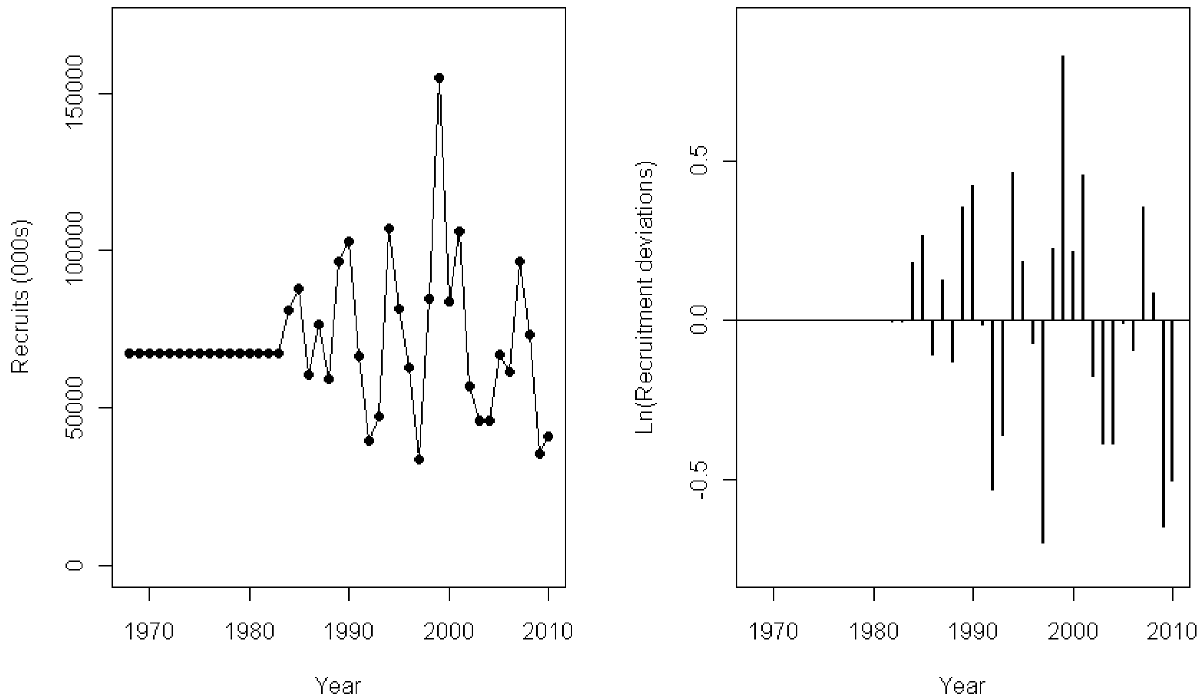


Figure B94. Predicted black sea bass age 0 recruits and associated residuals from ASAP model.

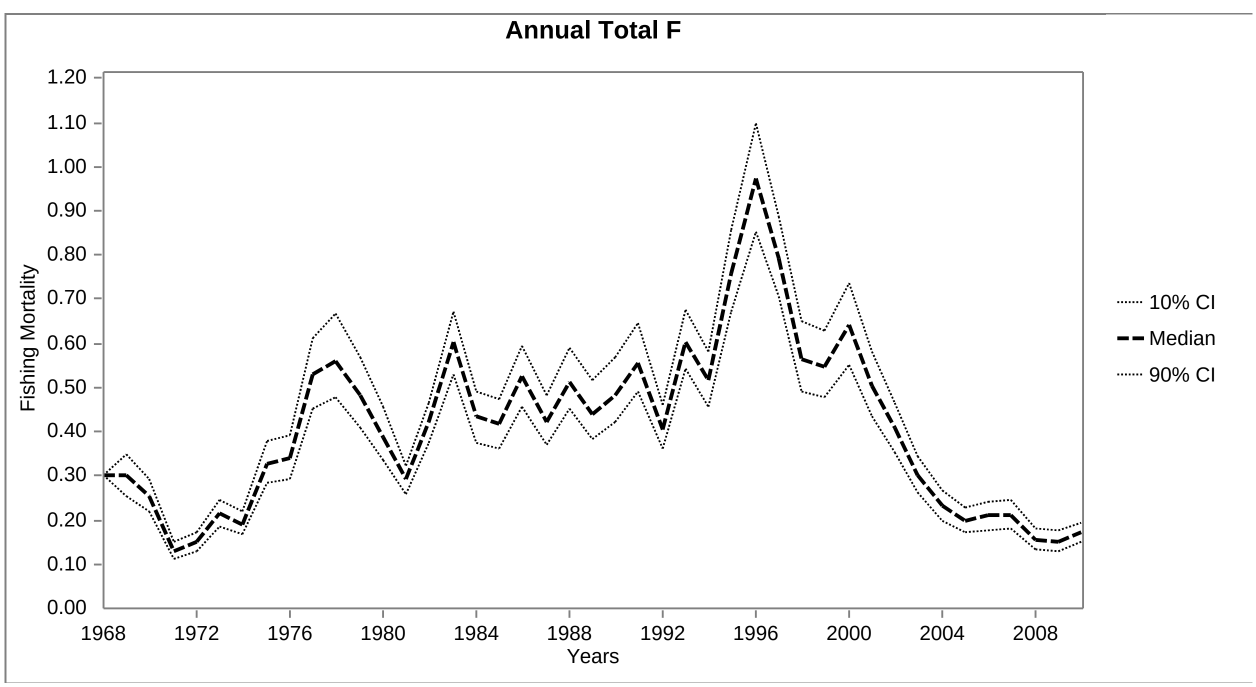


Figure B95. Results of MCMC run for black sea bass fishing mortality.

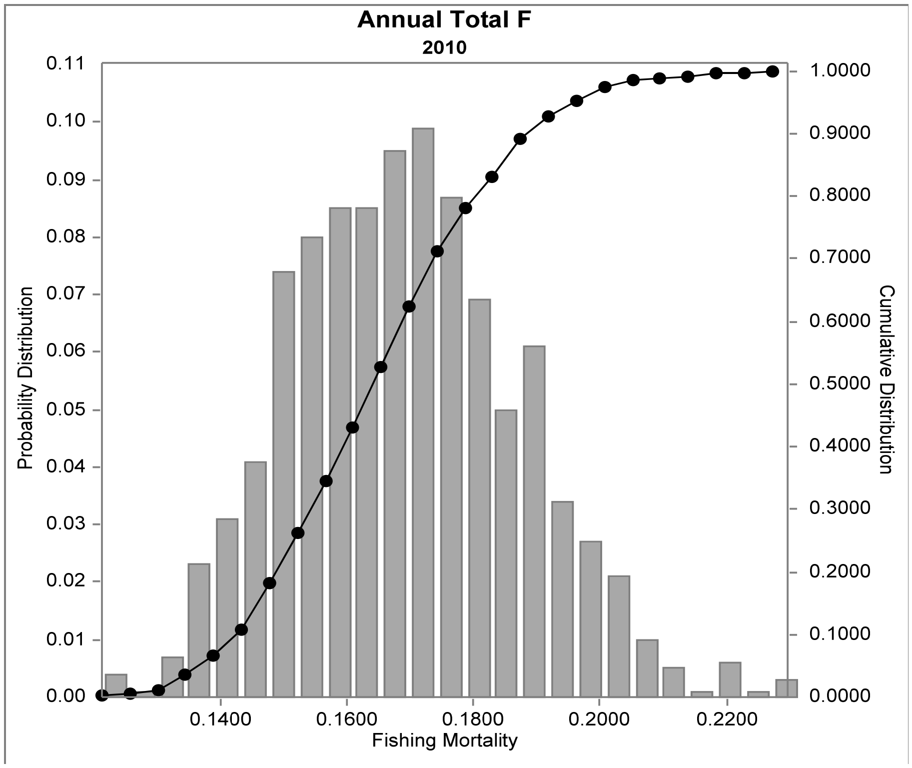


Figure B96. Distribution of 2010 black sea bass fishing mortality from MCMC run.

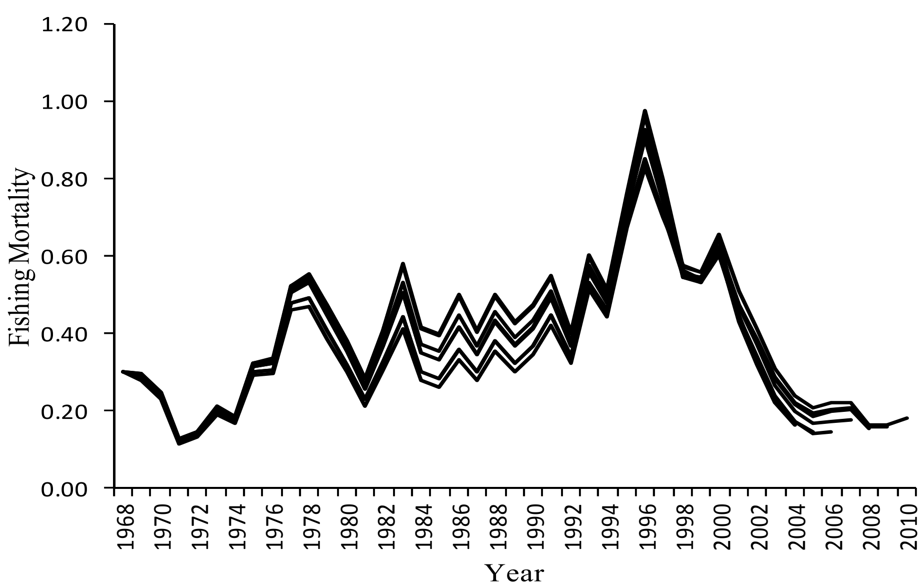


Figure B97. Retrospective pattern of fishing mortality, 2003-2010, from ASAP model results.

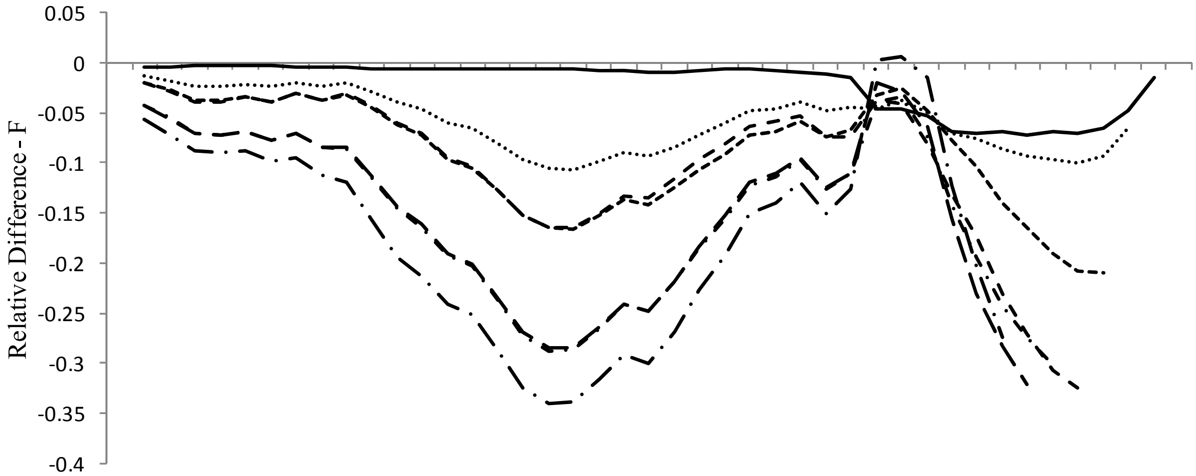


Figure B98 . Relative difference of fishing mortality, 2003-2010, from ASAP model results.

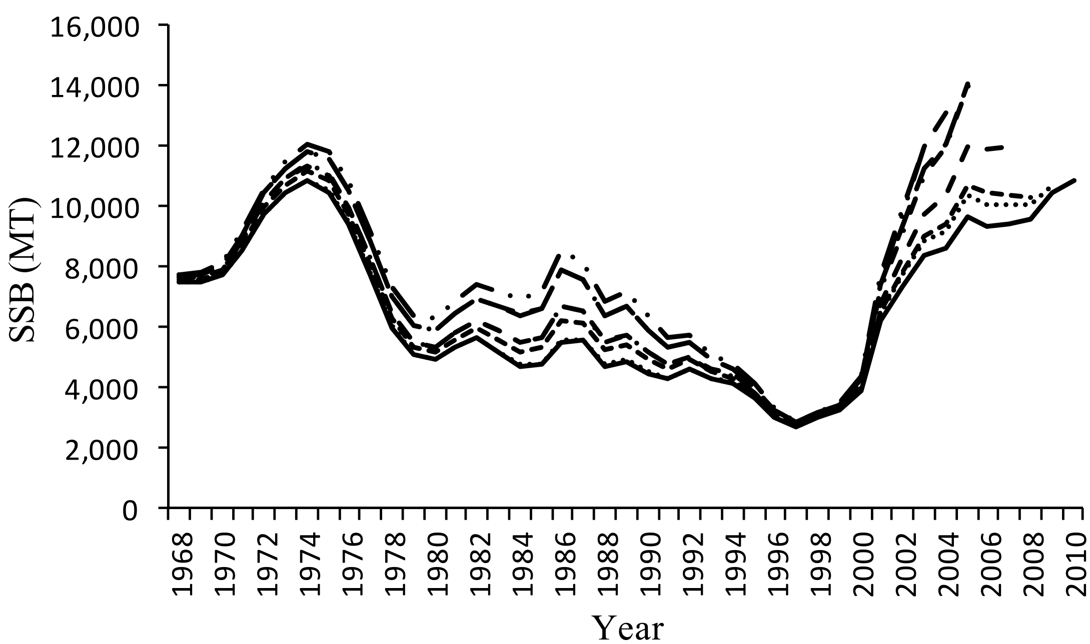


Figure B99. Retrospective pattern of spawning biomass, 2003-2010, from ASAP model results.

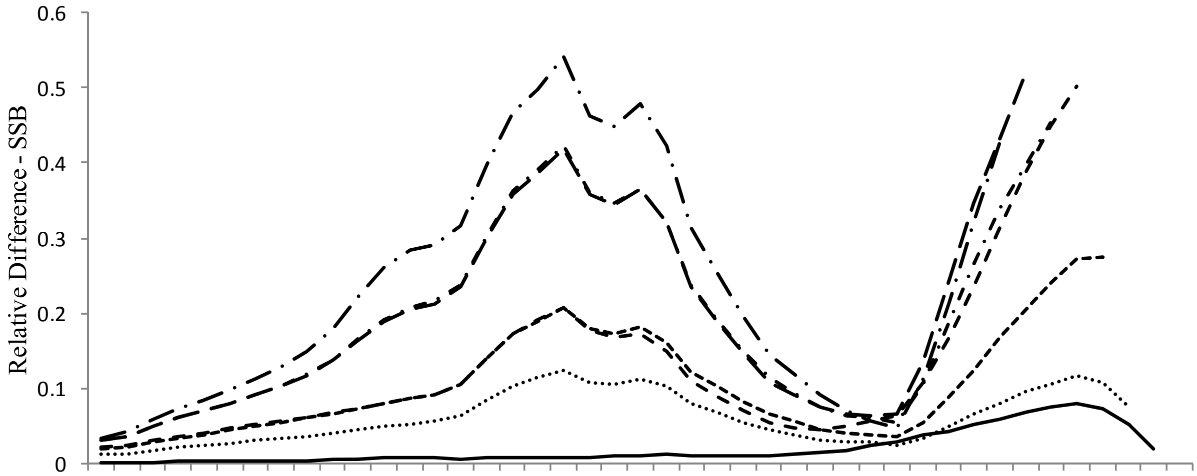


Figure B100. Relative difference of spawning biomass, 2003-2010, from ASAP model results.

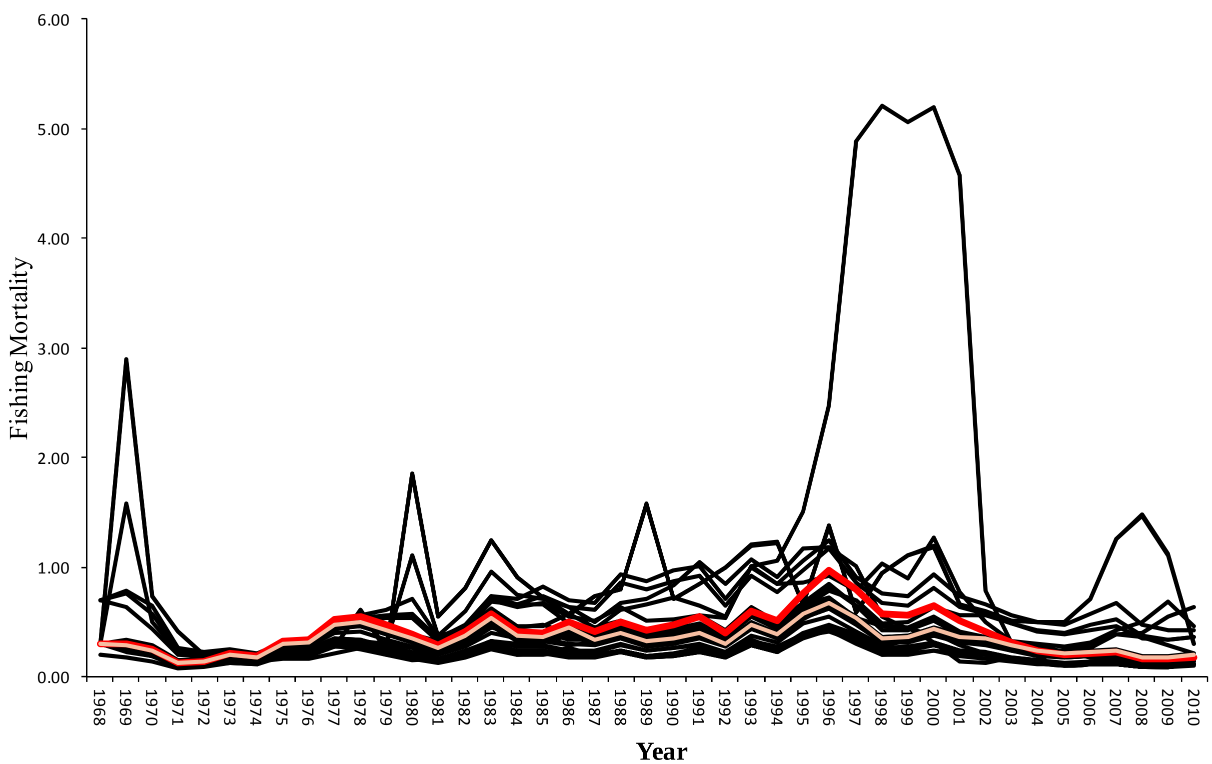


Figure B101. Fishing mortality estimates from the various ASAP and SCALE models considered by the WG. Red line represents final model.

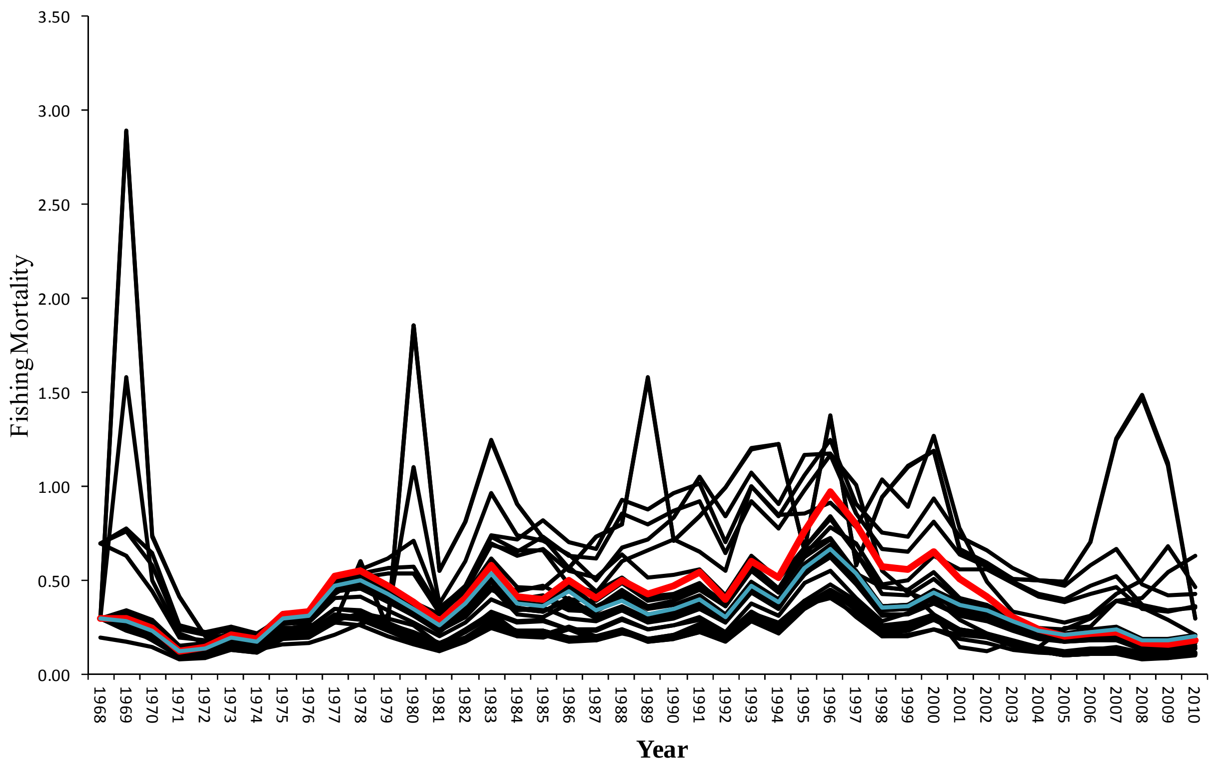


Figure B102. Fishing mortality estimates from the various ASAP and SCALE models considered by the WG, with the maximum value not included. Red line represents final model.

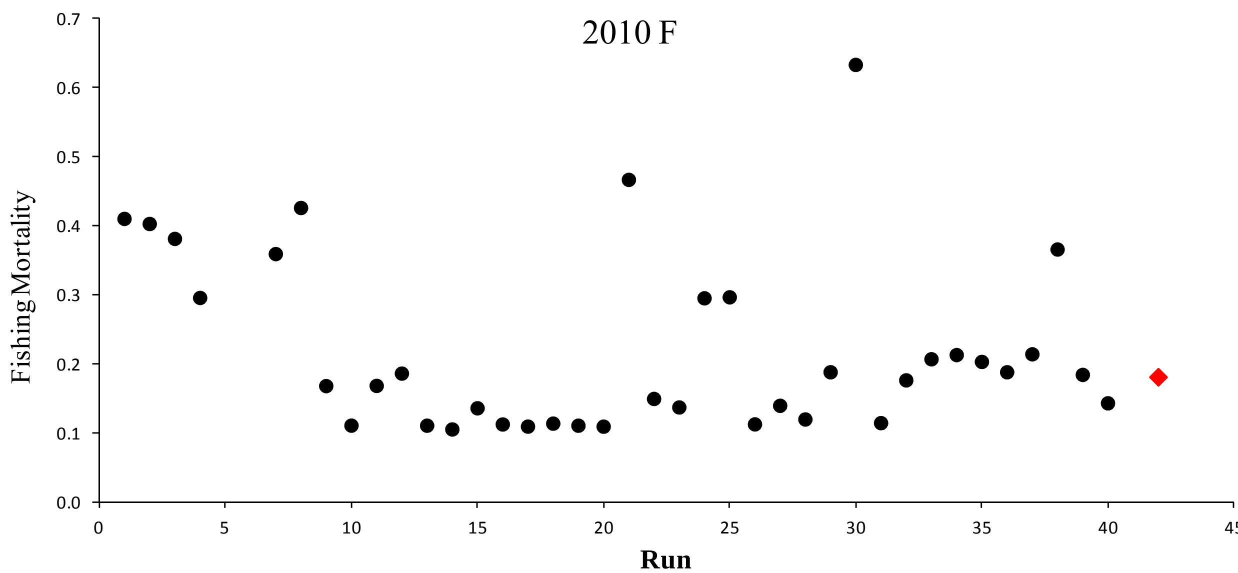


Figure B103. 2010 estimates of fishing mortality from among the models considered by the WG. Red diamond represents the final model results.

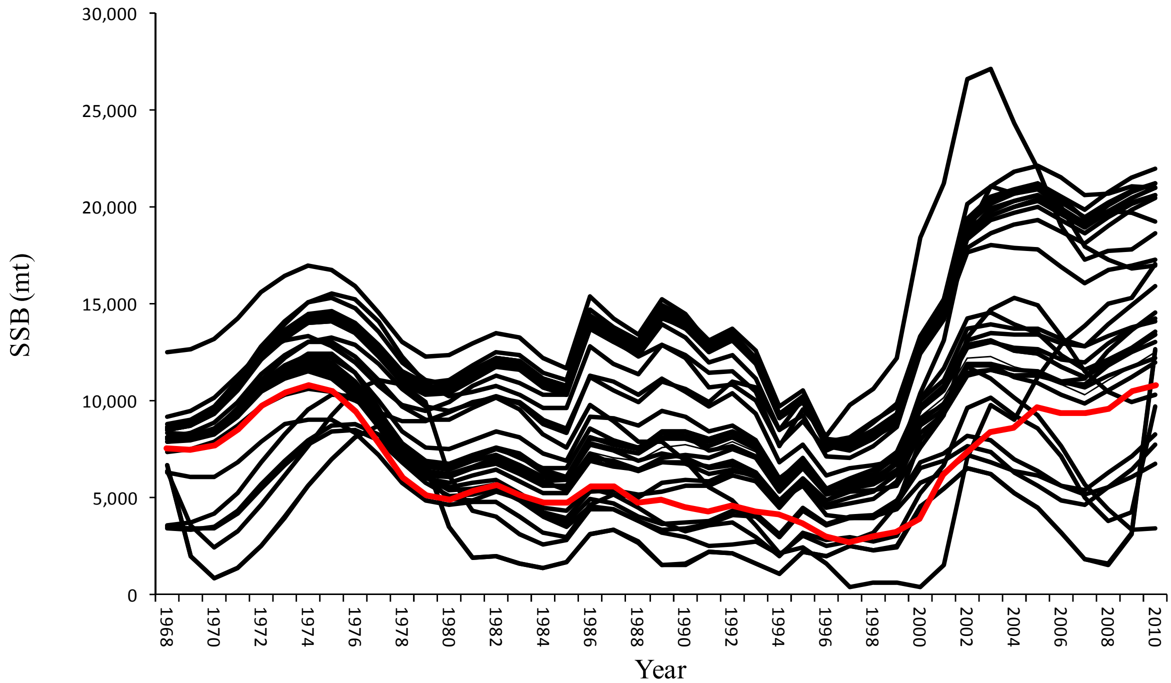


Figure B104. Spawning stock biomass estimates from the various ASAP and SCALE models considered by the WG. Red line represents final model.

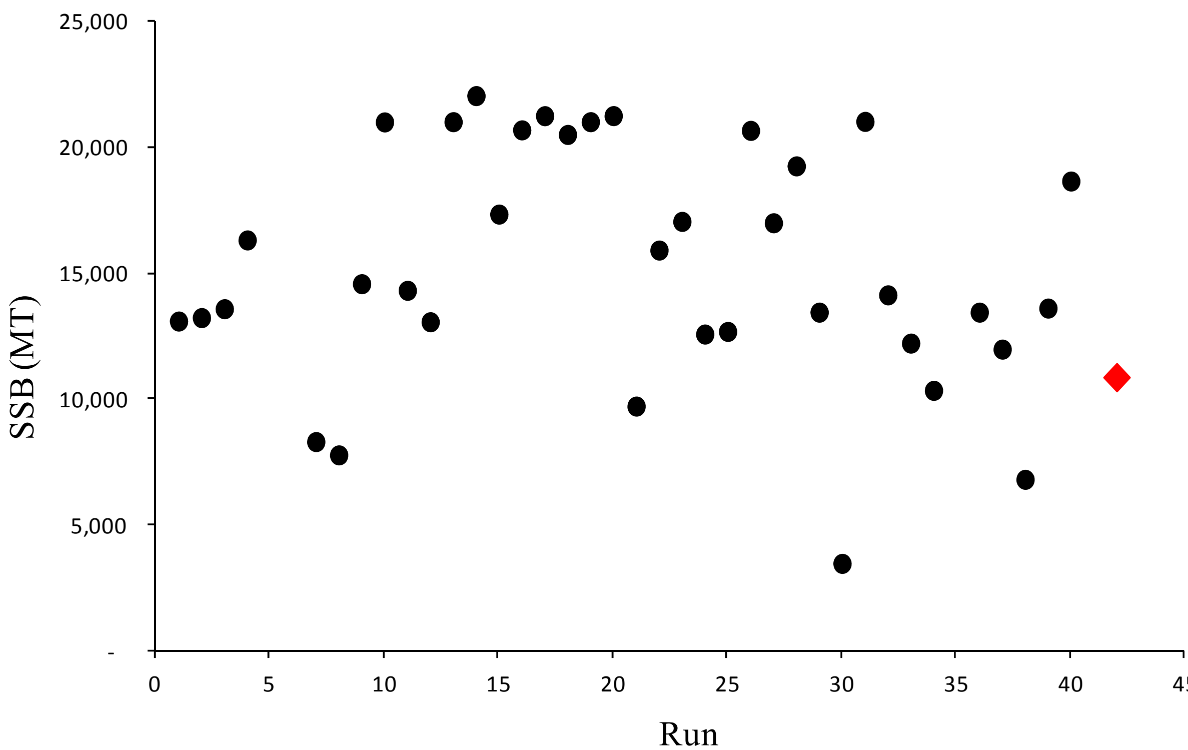
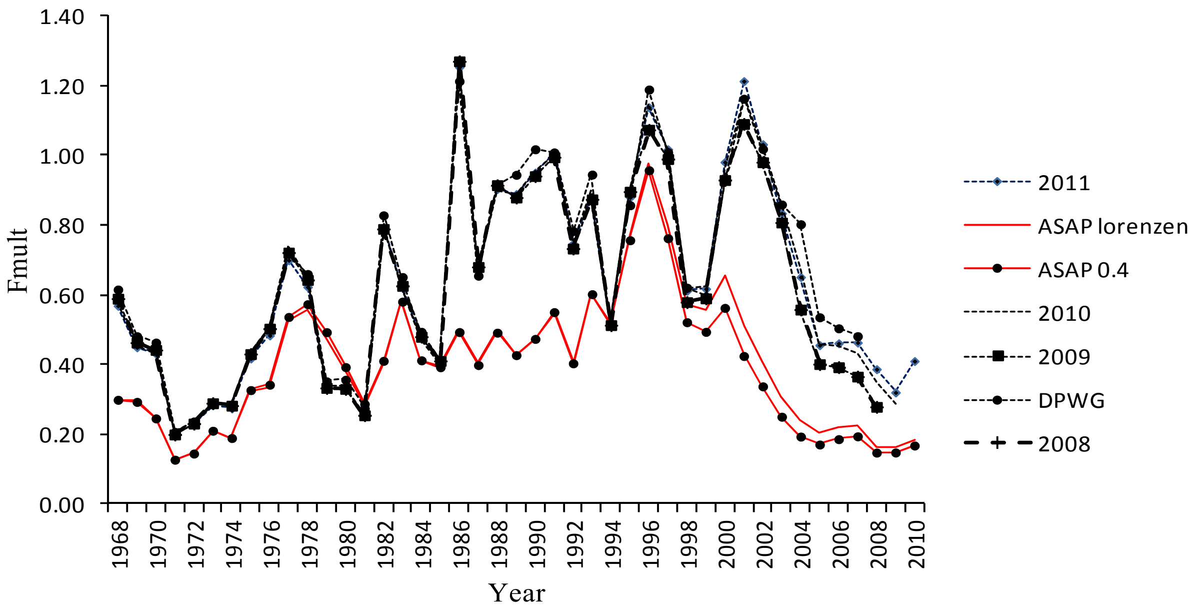


Figure B105. 2010 estimates of spawning stock biomass from among the models considered by the WG. Red diamond represents the final model results.



Fishing

Figure B106. Historical retrospective of black sea bass fishing mortality estimates. ASAP models are the recommendation of the WG.

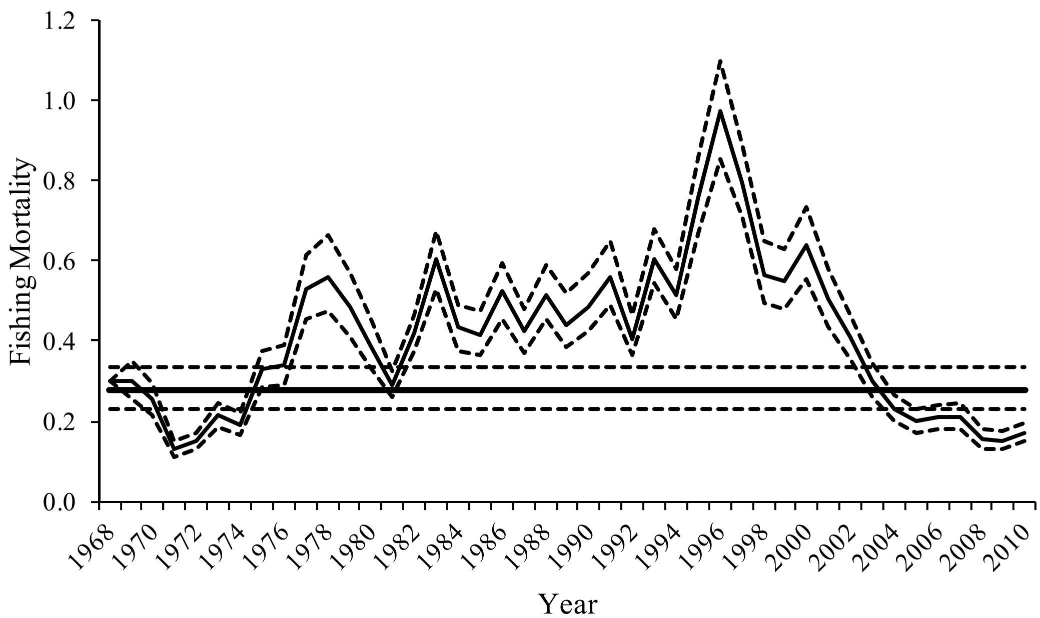


Figure B107. Fishing mortality time series and associated biological reference point (median from stochastic yield per recruit).

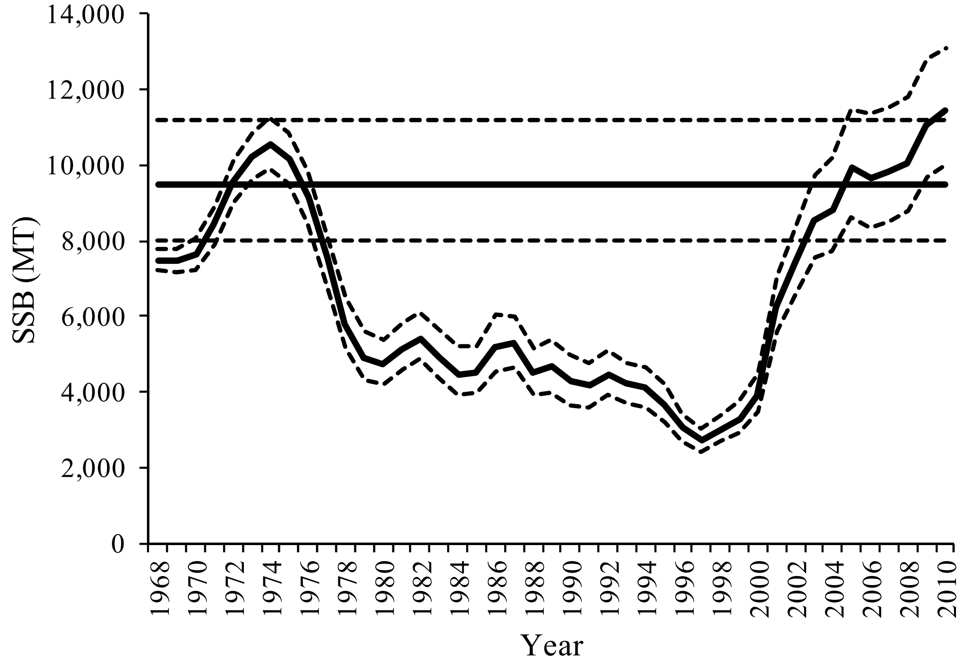


Figure B108. Spawning stock biomass time series and associated biological reference point (median from stochastic yield per recruit).

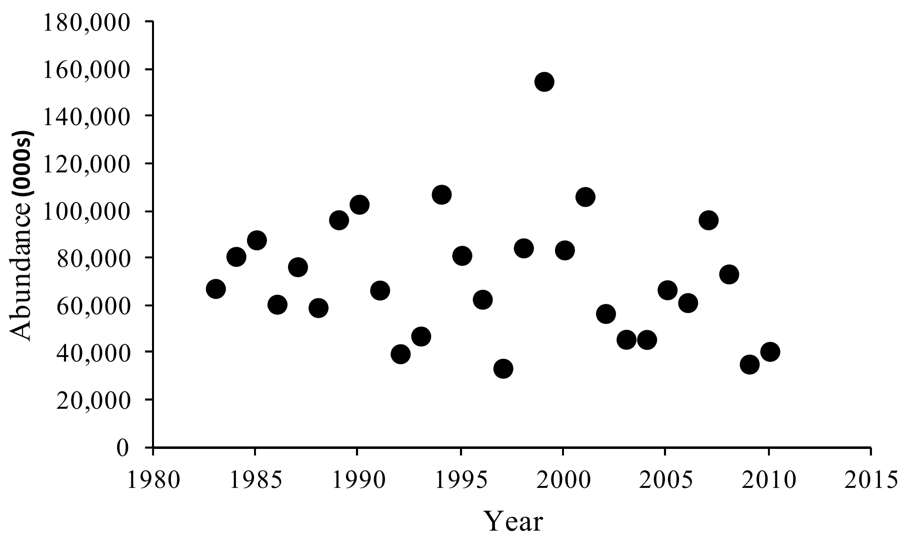


Figure B109. Estimated recruitment from final ASAP model used in projections.

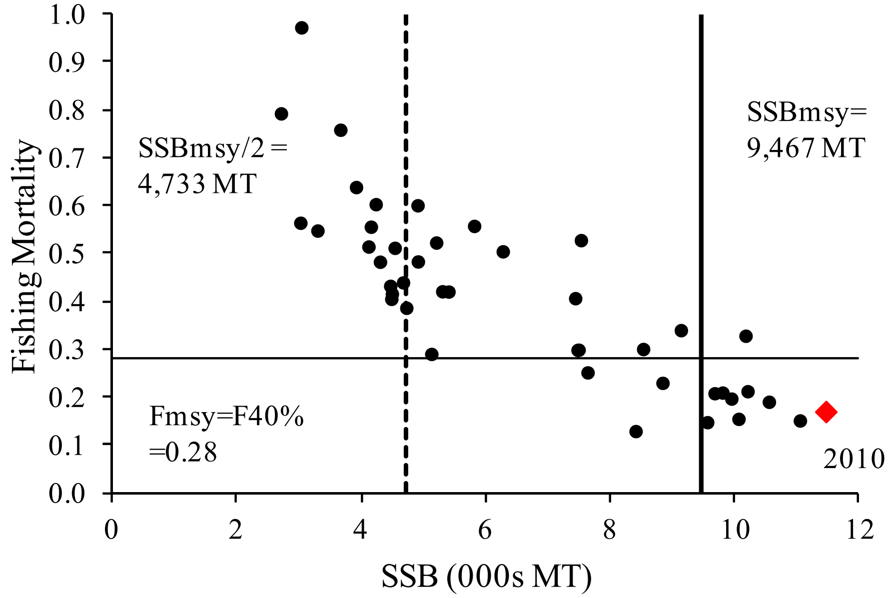


Figure B110. Relationship between time series spawning stock biomass and fishing mortality for black sea bass. Lines represent biological reference points and the red diamond is the 2010 value.

Sex and maturity of black sea bass collected in Massachusetts and Rhode Island waters; preliminary results based on macroscopic staging of gonads with a comparison to survey data

A working paper for SARC 53- Black Sea Bass Data Meeting

September 2011

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Introduction

Black sea bass (*Centropristis striata*) are protogynous hermaphrodites, with most individuals maturing first as a female before changing sex to male later in life (Wenner et al 1986). This life history characteristic poses unique challenges for management of the species (Shepherd and Nieland 2010), and requires accurate information/understanding of the sex ratios and the size at which sex changes. Several studies have described salient aspects of black sea bass life history, however these have largely been limited to populations in the South Atlantic Bight (SAB) and Gulf of Mexico (Mercer 1978, Wenner et al. 1986, Hood et al. 1994, McGovern et al 2002). Although black sea bass north of Cape Hatteras, NC are considered part of a single fishery management unit, focused life history studies on more northern portions of the population are lacking. Given greater migration distances and larger sizes attained by the northern stock component 'borrowing' of data from southern populations may be inappropriate. To reduce uncertainties in management of this population requires accurate estimate of sex ratios and size at sexual transition for this population. The need for more current and detailed (histology based) life history information for the northern component of the stock is currently being addressed in a cooperative research funded project ('A histology- and otolith-based study of black sea bass (Serranidae: *Centropristis striata*) life history in southern New England', Dr. K. Oliveira, R. Jorgensen UMASS Dartmouth). However, the scheduling of SARC53 necessitates reporting preliminary data to address questions about sex ratios of black sea bass in the northern management unit. Specifically, there is an apparent conflict of this species characterized as a protogynous hermaphrodite but that small and young males are evident in the NEFSC groundfish survey database. Namely, how likely are these small males misspecified by macroscopic methods used in routine survey operations? This working paper documents in detail the macroscopic method of identifying sex and maturity class of black sea bass, and although it does note that criteria for identifying active sex change needs further clarification, it also confirms that small males in survey data are real and should be accounted for in modeling of sex ratios.

Methods

Fish were obtained from two sources; the Massachusetts Division of Marine Fisheries (MA-DMF) inshore trawl survey (spring, May; and fall, September) and Research Set Aside (RSA) funded fishery independent scup survey of hard bottom areas in southern New England waters (MA and RI; June, August and October). Subsamples of fish from both sources were selected to cover the size range encountered, kept on ice, transported to the Woods Hole laboratory and processed the same or following day. A total of 217 black sea bass were processed from May to October, 2010 (Table 1). Fish were measured (total length in mm, total weight in grams, gonad and liver weight) photographed, and the gonads were dissected and photographed on a copy stand. A gonadosomatic index (GSI) was calculated as 100*(gonad weight/gonad free body weight). Gonadal tissue samples were preserved for histological analysis but these aspects of the research are ongoing and not presented here. Scales and otoliths were removed from fish for age determination following procedures outlined in Penttila and Dery (1988).

This working paper describes only the macroscopic maturity staging of these samples. Although the macroscopic staging may be less accurate and/or precise than histology-based determinations, individuals experienced in macroscopic assignment of fish maturity processed these samples in the laboratory. In addition, the authors convened to review the high-resolution photographs taken of each fish. Images were projected on a large screen, examined at higher magnification if necessary, discussed and consensus sex and maturity classifications were assigned. This approach may be considered intermediate to at-sea staging on resource surveys (that cannot be reviewed or revisited) and the more definitive gonad histology based approach currently underway. To accommodate sex change in this protogynous hermaphrodite, we included transitional and unknown classifications for individuals whose sex was ambiguous (Table 2). In the present analysis, transitional and unknown fish are combined into a single sex category, as there are no clear macroscopic criteria for the transitional stage yet. The histological analysis may help resolve the classification of transitional fish; however, this preliminary analysis of macroscopic criteria is applicable during and immediately following the late spring to summer spawning season when sex is more apparent and less likely to be in transition.

The sex ratio (percent male) was modeled as a function of length (or age) using a four parameter logistic regression model.

$$f(Length) = c + \frac{d - c}{\left(1 + \exp\left(b(Length - e)\right)\right)}$$

Where *Length* is fish total length (or age) and the parameter *e* is the length (or age) halfway between the upper (*d*) and lower (*c*) asymptotes, and *b* denotes the slope around *e*. In this model both the upper and lower asymptotes are fitted (not fixed) allowing for estimation of non zero lower asymptote as well as upper asymptote different than 100 percent. All models were fitted using the 'drm' function in the 'drc' add-on package for the language and environment R (R Development Core Team 2004). To evaluate the potential influence of data density and variability, models were fitted to sex ratios binned by 1, 2, 3, and 5 cm length categories. Age classes were not binned beyond annual age.

Sex at length data were summarized for the period 1984-2010 from NEFSC and MADMF trawl surveys. Results of the monthly sampling (below) indicated some uncertainty in determining sex in the fall, therefore we limited our analysis to spring surveys. This survey data was modeled using the same approach as above (four parameter logistic model). Macroscopic determination of sex in small fish is difficult, therefore we limited our analysis to fish > 15 cm. Two models were fit; with percent male binned by either 1 or 2 cm length categories.

Results

A wide range of fish sizes (19-59 cm total length) and maturity stages (developing, ripe, running ripe, spent and resting) were sampled over the six month period (Figs. 1-3). Four individuals analyzed were considered to be immature (19.4, 20.0, 20.6, 27.5 cm TL), and these were all classified as females. Mature male and female black sea bass were easily distinguished macroscopically during the spawning season, when ovaries and testes were developing or ripe and GSI was high (Figs. 1 and 4). Review of the high resolution photographs resulted in changing the sex classification for 10 of the 217 fish examined (4.6%), all associated with changing to or from the transitional class. Nine were initially classified as transitional/unknown but during the review and discussion process we were able to assign an agreed upon sex (4 female, 5 male). One individual was classified as a female during the initial workup, but upon review was changed to transitional/unknown. During the consensus review process, no fish sex classifications were changed from the May and June samples, three individuals collected in August were changed, two in September, and 5 were changed in October. Individuals classified as transitional/unknown had low GSI and occurred from August- October, well after the peak spawning season (Fig. 2).

Across all months, the size distribution of males was greater than that for females, with a large region of overlap (Fig. 3). Small males (<40cm) occurred in all months sampled. Fits of the four parameter logistic model indicated a significant non-zero (c = 19.7-22.9; Appendix 1) percentage male at smaller size classes. The different binning approaches resulted in similar fits, however only the 1 cm bin model had a significant slope parameter (b), possibly due to the abrupt change predicted in the other models. All models had similar estimates for the inflection point (e = 43.4-44.0) and upper limit (d = 100.1-101.2).

Female ages ranged from 1 to 7 years while male ages ranged from 2 to 12 years (Fig. 6). Thus, age classes 2 to 7 were comprised of both sexes, with an increasing percentage male after age 6 or 7. Fits of the four parameter logistic model indicated a significant non-zero (c = 19.9; Appendix 2) percentage male at younger age classes. This model indicated a significant inflection at about age 7 (e = 6.96) and an upper asymptote near 100 percent (d = 104.6).

The spring survey data (NEFSC and MADMF; 1984-2010) showed similar patterns in percentage male vs. length (Fig 7). Although sample size was large for this dataset (1061 males and 2386 females) sample sizes were generally small at for length bins greater than 50 cm. Two models were fit with length data binned at 1 and 2 cm intervals. Fits of the four parameter logistic models indicated a significant non-zero (c = 24.6, 22.8; Appendix 3) percentage male at smaller size classes. The different binning approaches resulted in similar fits, however only the 2 cm bin model had a significant slope parameter (b). Both models had similar estimates for the inflection point (e = 42.8, 45.6). The estimates for the upper limit were variable (d = 81.0, 95.1), influenced by the low data density at larger sizes.

Discussion

Despite being regarded as sequential hermaphrodites, in most cases the sex of black sea bass was readily identifiable macroscopically, and few individuals were reclassified (10 of 217) after reviewing images and consulting others experienced with this and other hermaphroditic species. Of these ‘reclassified’ fish, most (9 of 10) were initially identified as transitional/unknown, therefore they should not be considered misclassifications. Difficulty in determining sex increased after the spawning season (August – October), when fish had low GSI and sexual transition is thought to occur (Mercer 1978, Wenner 1986).

As in other studies on black sea bass elsewhere, we observed males across the full length range of mature fish analyzed. In the Gulf of Mexico, Hood et al. (1994) estimated close to 20% percent males at smallest mature sizes. Similarly, Wenner et al. (1986) reported the presence of ~3% mature males at small sizes. Both of these populations (GOMEX and SAB) mature at smaller sizes than the northern population studied here that attains greater sizes (Gulf of Mexico, Hood et al. 1994; South Atlantic Bight, Wenner et al. 1986, McGovern et al. 2002). Only four individuals analyzed were considered to be immature (19.4, 20.0, 20.6, 27.5 cm TL), and these were among the smallest individuals analyzed in the present study. The low number of small and immature fish precluded more detailed analysis of size at maturity.

The approach we used to confirm macroscopic classification of sex, reviewing high resolution images, is intermediate to the more definitive classification possible via gonad histology and the macroscopic classifications made at sea by scientists of varying experience levels whose classifications cannot be reviewed (the fish go overboard and no images are taken). While pictures are less ideal than evaluating the fresh specimen, they provide the opportunity to consult others who may not have been present during the initial processing of samples. Thus, data resulting from a consensus review may be considered to be more precise and accurate than routine macroscopic classifications. The images were of high enough quality to allow us to zoom in on specific regions of the gonad and when reviewed by the entire group we agreed with nearly all of the initial classifications. In addition, we were able to classify difficult samples that were initially classified as unknown. The images also provide a permanent record that can be revisited in the future as needed (if new macroscopic classification schemes are developed). More detailed histological analyses of gonad samples from these and other collections is needed to verify the preliminary conclusions presented here.

Analysis of spring survey data from both NEFSC and MADMF surveys for the period 1984-2010, collected over a broad geographical region showed similar patterns of percentage males at length we estimated from a more localized region in 2010. Models fit to these datasets both indicated about 20 percent male at smaller sizes, and an inflection near 42-45 cm. The slope of the survey time series is more gradual, possibly influenced by differences in size at transition occurring over time. Additionally, this more gradual pattern may be the result of averaging of data over a large region, where transition points differ regionally. Similarly, the estimate of the upper asymptote is likely influenced by averaging across broad geographic scales, since the presence of larger sized females in some portion of the range will pull down the percentage male at large sizes across the entire range.

The results from these datasets of macroscopic sex classifications, one determined by a 'panel' of experienced biologists and the other larger dataset determined by many individuals with varying experience levels (novice-expert) both indicate approximately 20 percent males throughout most of the mature size and age distribution. Similar estimates have been determined from the NEFSC and MADMF spring surveys (Shepherd and Nieland 2010) however, the accuracy of the sex classifications on the surveys was not evaluated. We did not observe any indication of sexual transition in individuals collected during the spawning season. Several caveats should be considered with respect to the estimates of the size at transition (and the estimated inflection point *e*). First, samples were pooled over a six month period, during which time significant growth occurs. Secondly, the parameter *e*, represents the halfway point between the two modeled asymptotes and not 50% (i.e. for the 1 cm bin model, the length 43.8 has a percent male halfway between 22.9 and 101.2). The present study provides supporting evidence for the presence of significant numbers of males at small sizes, and demonstrates that sex determination of mature black sea bass by macroscopic examination during the spring is reliable.

Research recommendations

1. Very few immature and age 1 fish were collected in the sampling done in 2010, precluding detailed evaluation of first maturity. A detailed characterization of these sizes and ages, both macroscopically and microscopically (histological) is needed to determine developmental pathways and functionality (or viability) of small males.

2. Although the percentage male appears relatively constant at small sizes and young ages, it is not known whether the rates of transitioning fish and sex-specific mortality rates are constant. A better understanding of the criteria to identify transitioning fish, and an evaluation of when and which individuals change sex is needed to evaluate the proportions transitioning at length and age.

3. Given the latitudinal differences in maximum size attained by black sea bass, the size and age at transition is likely to also differ with latitude. More regional evaluation of sex ratios and the inflection in percent male is warranted.

4. Similarly, given the potential effect of selective fishing on size and age structure, the percentage of small males and the size at transition should be evaluated through time in conjunction with fishing mortality and size regulations.

Acknowledgements

We are grateful for the cooperation by MADMF (especially Jeremy King), and the fishery independent scup survey (especially Dave Borden) who both provided fresh samples in 2010 for this analysis. We thank the many individuals who participated in NEFSC and MADMF surveys over the years and collected some of the data analyzed here. We also thank the Northeast Cooperative Research Program for funding continuing work on life history of black sea bass (Grant # NFFM7230-11-06444).

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Table 1. Summary of black sea bass biological samples collected processed from various sources May-Oct 2010. Sources are; Massachusetts Division of Marine Fisheries (MA-DMF) inshore trawl surveys, Research Set Aside funded fishery independent scup survey (RSA-scup survey).

Date	**Source**	***n***	**Length range (cm)**
5/16/2010	MA-DMF	55	20-42
6/29/2010	RSA-Scup survey	65	30-56
8/2/2010	RSA-Scup survey	50	22-51
9/19/2010	MA-DMF	16	27-38
10/15/2010	RSA-Scup survey	31	19-59

Table 2. Macroscopic maturity staging criteria applied to images of black sea bass gonads; modified from Burnett et al. (1989), and Lyon et al. (2008). TR* not previously used on NEFSC bottom trawl surveys.

Sex/Class	**Code**	**Description**
Female		
Immature	I	Ovary paired, tube-like organ, small relative to body cavity; thin, transparent outer membrane; contains colorless to pink jell-like tissue with no visible eggs
Developing	D	Ovaries enlarge; if blood vessels present, they become prominent; ovary has granular appearance as yellow to orange yolked eggs develop
Ripe	R	Enlarged ovary; mixture of yellow to orange yolked eggs and hydrated or "clear" eggs present
Ripe & Running	U	Ripe female with eggs flowing from vent with little or no pressure to abdomen
Spent	S	Ovaries flaccid, sac-like, similar in size to ripe ovary; color red to purple; ovary wall thickening, becoming cloudy and translucent vs. transparent as in ripe ovary; some eggs, either clear or yolked, may still be present, however most adhere to ovary wall; therefore, CUT OPEN OVARY to make sure there is no mass of eggs in center of ovary (as in stages D and R)
Resting	T	Gonad reduced in size relative to ripe ovary, but larger than an immature; interior jell-like with no visible eggs
Transitional	TR*	Gonad contains both female and male tissue; inactive or regressing ovarian tissue with concurrent testicular proliferation
Unknown	UNK	Sex is uncertain
Male		
Immature	I	Testes paired, tube-like organ, small relative to body cavity; thin, translucent, colorless to gray or pinkish
Developing	D	Testes enlarge; color is gray to off-white, outer texture appears smooth; firm with little or no milt
Ripe	R	Enlarged testes; color chalk white, milt (spermatozoa) flows easily when testes is cut
Ripe & Running	U	Before cutting open fish, milt flows easily from vent with little or no pressure on abdomen; once cut open milt flows easily and color is chalk white
Spent	S	Testes flaccid, not as full of milt and robust as in Ripe stage; may contain residual milt; edges or parts of testes starting to turn gray and milt recedes
Resting	T	Testes shrunken in size relative to Ripe stage; color off-white-gray with little or no milt

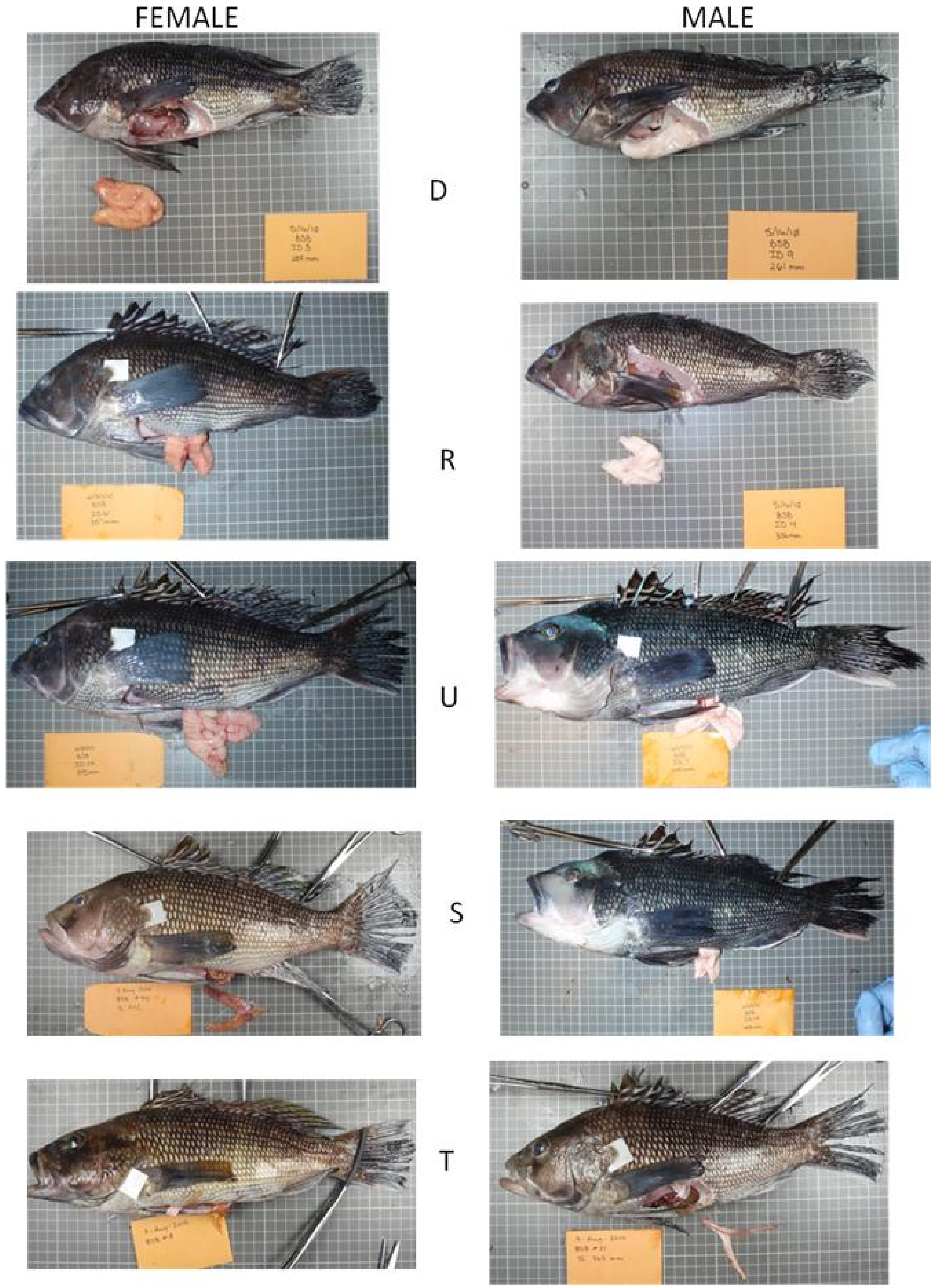

Figure 1. Representative images of black sea bass maturity stages observed in collections over the six month study. D-Developing, R-Ripe, U-Running ripe, S-Spent, T-Resting.

TRANS/UNK – Aug

TRANS/UNK – Aug

TRANS/UNK – Sept

Figure 2. Three individual black sea bass collected in August and September that were classified as transitional/unknown.

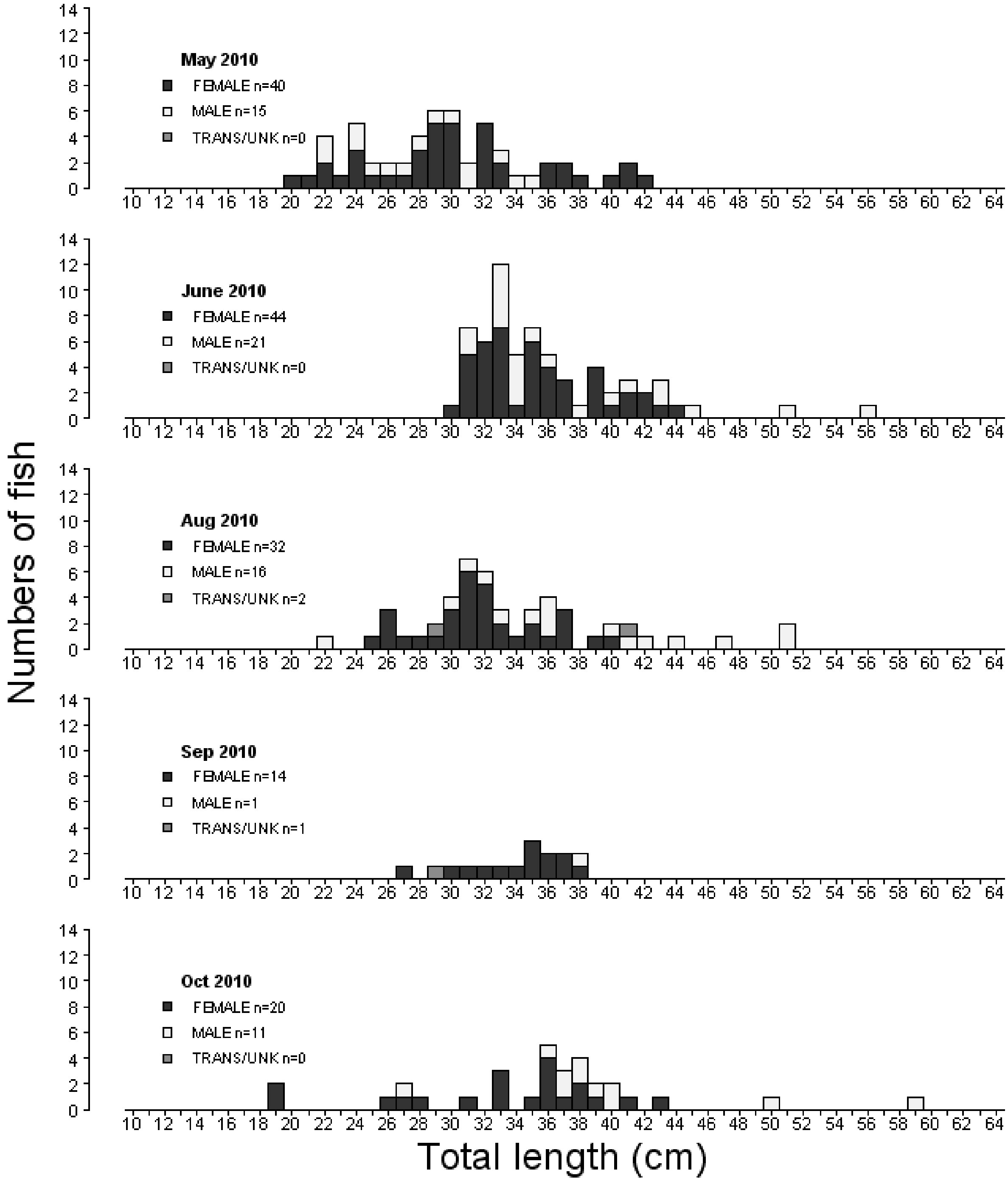

Fig. 3. Size distribution (length frequency) of male, female and transitional black sea bass collected in each month sampled in 2010.

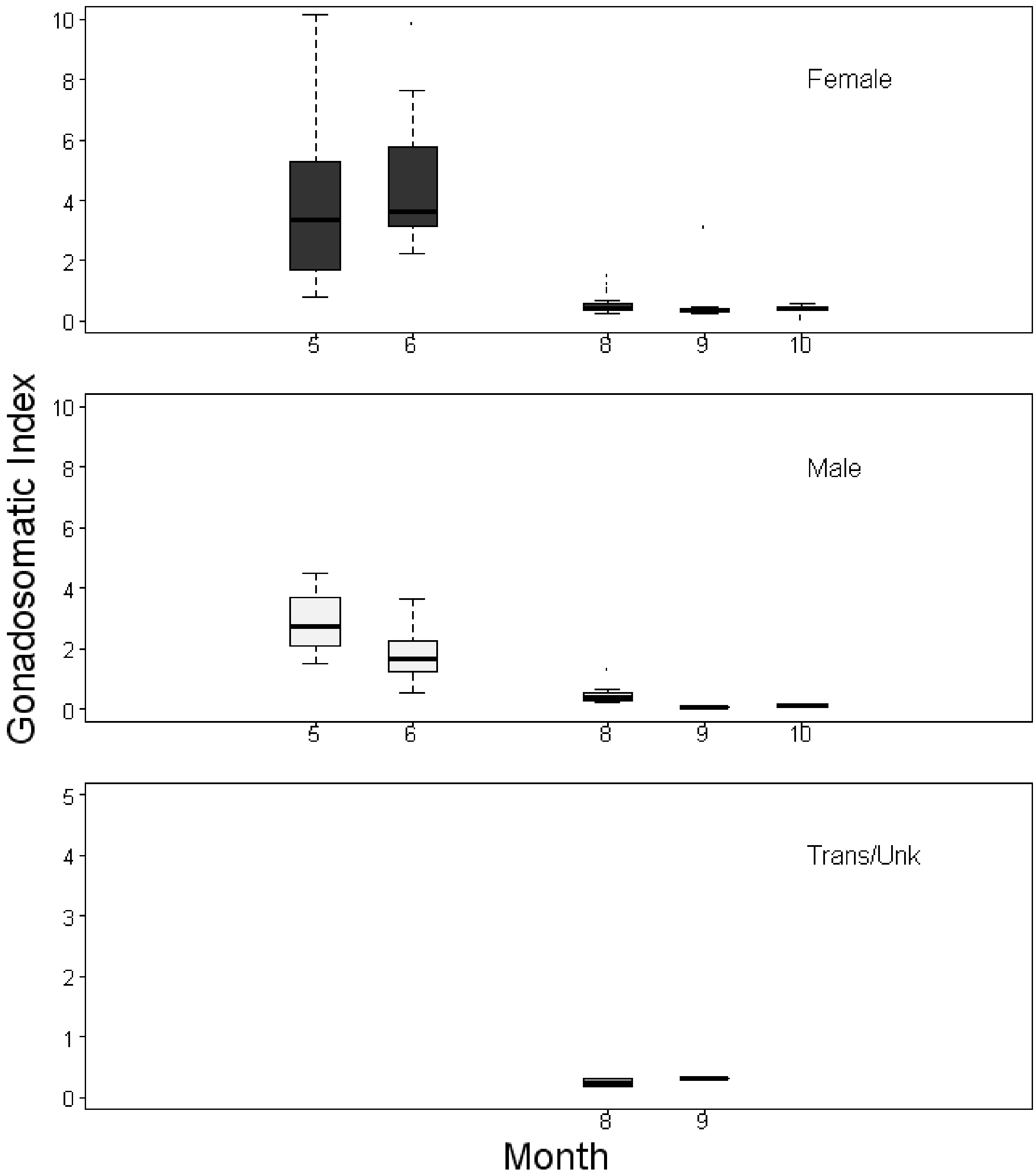

Fig. 4. Gonadosomatic index by month to indicate spawning seasonality. Note different y-axis scales.

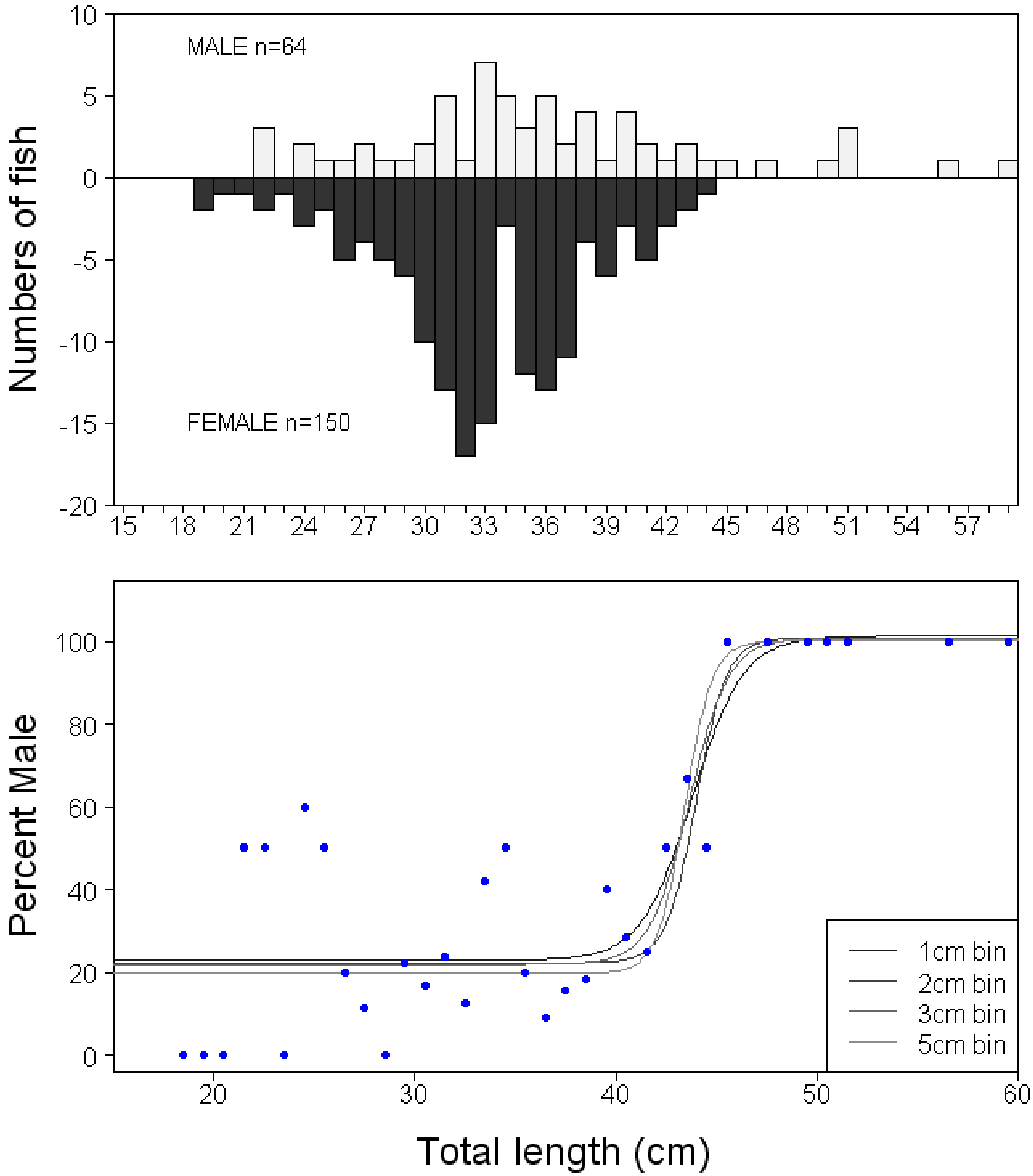

Figure 5. Percent male for black sea bass sampled in 2010 as a function of length. Points represent percentages in each 1 cm length bin. Lines represent the fits of the four parameter logistic model with data binned by 1, 2, 3, and 5cm.

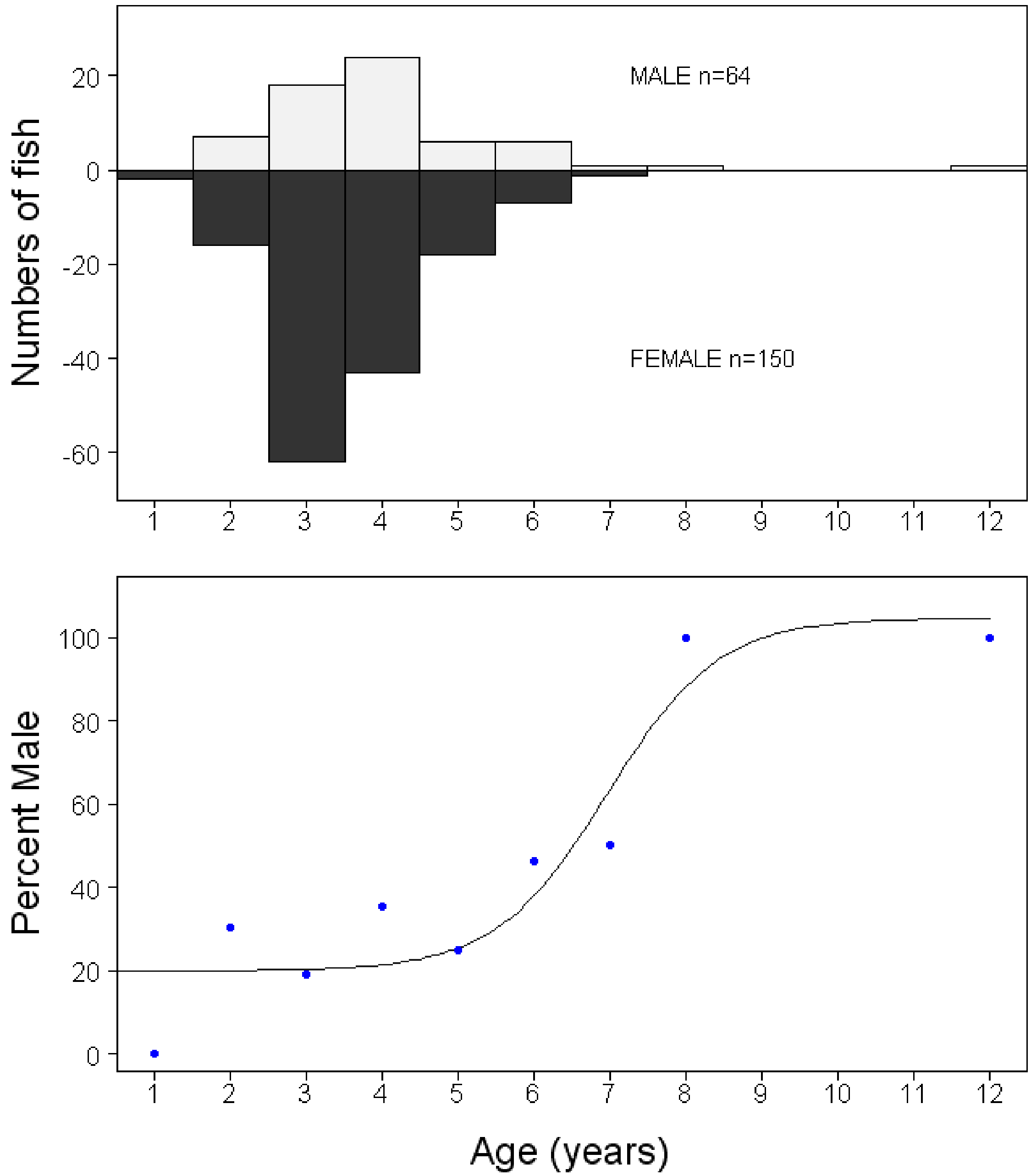

Figure 6. Percent male for black sea bass sampled in 2010 as a function of age. Points represent percentages in each 1 year age bin. Lines represent the fit of the four parameter logistic model.

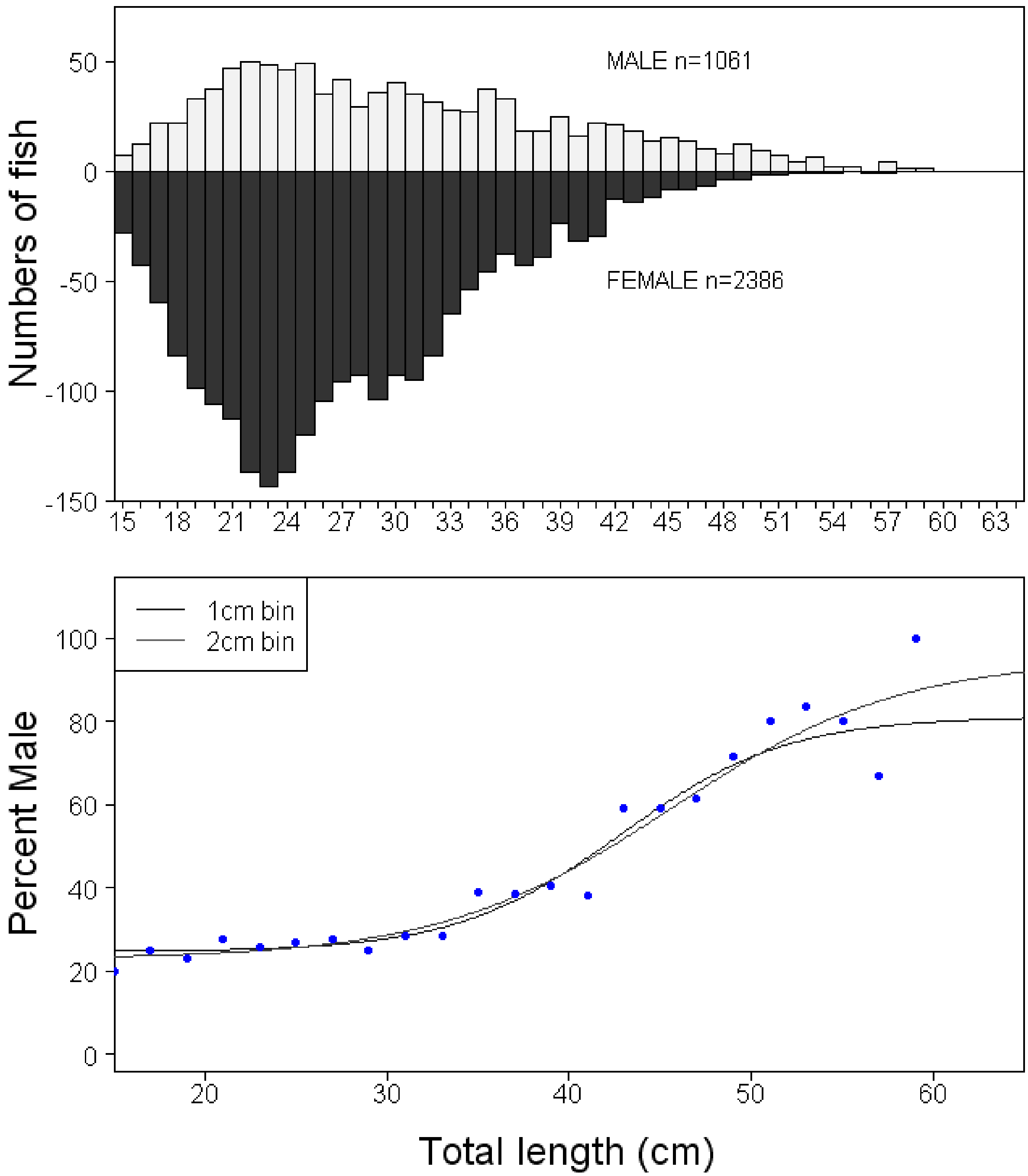

Figure 7. Percent male for black sea bass sampled on NEFSC SBTS and MADMF SBTS (1984-2010) as a function of length. Points represent percentages in each 2 cm length bin. Lines represent the fits of the four parameter logistic model with data binned by 1 and 2 cm.

Appendix 1. Summary of four parameter logistic model fits to the percentage male at length for black sea bass collected in 2010 from various sources (Table 1). See text for model formula and explanation. Four models were fit, with variable size length bins.

Model 1- 1cm binned Length data

Model fitted: Logistic (ED50 as parameter) (4 parms)

Parameter estimates:

	Estimate	Std. Error	t-value	p-value
b:(Intercept)	-0.78981	0.37082	-2.12993	0.0415
c:(Intercept)	22.87569	3.80002	6.01989	1.319e-06
d:(Intercept)	101.23089	7.55191	13.40467	3.349e-14
e:(Intercept)	43.79021	0.73120	59.88786	4.394e-33

Residual standard error:

17.38728 (30 degrees of freedom)

Model 2- 2cm binned Length data

Model fitted: Logistic (ED50 as parameter) (4 parms)

Parameter estimates:

	Estimate	Std. Error	t-value	p-value
b:(Intercept)	-1.3346	1.2352	-1.0805	0.296
c:(Intercept)	22.3124	3.9912	5.5904	4.062e-05
d:(Intercept)	100.7394	5.9271	16.9964	1.157e-11
e:(Intercept)	43.9883	0.5388	81.6416	1.063e-22

Residual standard error:

13.50645 (16 degrees of freedom)

Model 3- 3cm binned Length data

Model fitted: Logistic (ED50 as parameter) (4 parms)

Parameter estimates:

	Estimate	Std. Error	t-value	p-value
b:(Intercept)	-1.01834	0.86342	-1.17943	0.2655
c:(Intercept)	21.95482	4.30140	5.10411	0.0005
d:(Intercept)	100.73393	5.52513	18.23196	5.294e-09
e:(Intercept)	43.64280	0.59727	73.07078	5.587e-15

Residual standard error:

11.41578 (10 degrees of freedom)

Model 4- 5cm binned Length data

Model fitted: Logistic (ED50 as parameter) (4 parms)

Parameter estimates:

	Estimate	Std. Error	t-value	p-value
b:(Intercept)	-1.47008	9.16190	-0.16046	0.8788
c:(Intercept)	19.71305	5.62585	3.50401	0.0172
d:(Intercept)	100.06556	7.86294	12.72623	0.0001
e:(Intercept)	43.41306	5.74844	7.55215	0.0006

Residual standard error:

12.57344 (5 degrees of freedom)

Appendix 2. Summary of four parameter logistic model fits to the percentage male at age for black sea bass collected in 2010 from various sources (Table 1). See text for model formula and explanation. A single model was fit, no age groups were binned.

Model 1- 1 year binned Age data

Model fitted: Logistic (ED50 as parameter) (4 parms)

Parameter estimates:

	Estimate	Std. Error	t-value	p-value
b:(Intercept)	-1.36333	1.03397	-1.31853	0.2445
c:(Intercept)	19.87582	9.30625	2.13575	0.0858
d:(Intercept)	104.61013	13.40348	7.80470	0.0006
e:(Intercept)	6.95768	0.56333	12.35091	0.0001

Residual standard error:
14.62701 (5 degrees of freedom)

Appendix 3. Summary of four parameter logistic model fits to the percentage male at length for black sea bass collected on NEFSC SBTS and MADMF SBTS (1984-2010). See text for model formula and explanation. Two models were fit with different size length bins (1 and 2 cm).

Model 1- 1cm binned Length data

Model fitted: Logistic (ED50 as parameter) (4 parms)

Parameter estimates:

	Estimate	Std. Error	t-value	p-value
b:(Intercept)	-0.22023	0.11726	-1.87813	0.0675
c:(Intercept)	24.58665	4.86670	5.05202	9.486e-06
d:(Intercept)	81.04034	9.06859	8.93638	3.574e-11
e:(Intercept)	42.84653	2.32888	18.39792	1.009e-21

Residual standard error:
14.64586 (41 degrees of freedom)

Model 2- 2cm binned Length data

Model fitted: Logistic (ED50 as parameter) (4 parms)

Parameter estimates:

	Estimate	Std. Error	t-value	p-value
b:(Intercept)	-0.157158	0.054259	-2.896457	0.0093
c:(Intercept)	22.842641	3.720414	6.139811	6.682e-06
d:(Intercept)	95.094550	12.142503	7.831544	2.296e-07
e:(Intercept)	45.576677	2.541987	17.929550	2.299e-13

Residual standard error:
6.162665 (19 degrees of freedom)

Comparing Black Sea Bass Catch and Presence Between Smooth and Structured Habitat in Northeast Fisheries Science Center Spring Bottom Trawl Surveys

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September 2011

Introduction
The northern stock of black sea bass (*Centropristis striata*) ranges from the southern Gulf of Maine to Cape Hatteras, North Carolina. Black sea bass in this stock are generally located in inshore areas from late spring to autumn and move to offshore areas for overwintering (Kendall 1977; Musick and Mercer 1977; Able et al. 1995; Collette and Klein-MacPhee 2002; Drohan et al. 2007).

The National Marine Fisheries Service (NMFS) Northeast Fisheries Science Center (NEFSC) spring bottom trawl survey (hereafter called the spring bottom trawl survey) is used to assess black sea bass abundance. Black sea bass may congregate in structured bottom (e.g., near rocks or other substrate), which may not be adequately sampled by the bottom trawls. Consequently, the accuracy of black sea bass abundance estimates from bottom trawl surveys is in question.

The objective of this research is to determine if black sea bass catches or presence in spring bottom trawl surveys is greater in areas with structured bottom than with smooth bottom. To address this objective, we will compare characteristics of black sea bass catches in the spring bottom trawl survey between tows conducted over structured bottom and smooth bottom. We used tows with problems due to hangups, tears, or obstructions as a proxy for having occurred over structured bottom (hereafter called structured tows) and tows without any damage or entanglement as a proxy for having occurred over smooth bottom (hereafter called smooth tows).

Methods
The National Oceanic and Atmospheric Administration (NOAA) Fisheries Toolbox (NFT) program SAGA was used to compile black sea bass catch data from the spring bottom trawl survey during 1968 – 2010. Only data from strata 1 – 12, 25, and 61 – 76 were used, as these are strata where black sea bass are typically located (Figure 1). Strata 8, 9, 12, and 25 were later removed because no black sea bass were caught in these areas. Only data from the following station, haul, and gear (SHG) codes were used: 111, 121, 122, 123, 135, and 136. Other SHG codes were not used because the tow was not from survey trips, the tow was not considered representative, the problem with the tow was caused by a malfunction in the gear instead of structured bottom, or no black sea bass were caught. SHG codes 111 and 121 represent tows without any damage or entanglement and were used as proxies for smooth tows and the other codes were used as proxies for structured tows (Table 1).

The Mann-Whitney test, a special case of the Wilcoxon rank test, was used to compare the catches of black sea bass (in number and weight) between smooth and structured tows ($\alpha = 0.05$). This non-parametric test was used because the data were distributed in a manner that violated the assumptions of alternative parametric tests (i.e., unequal sample sizes, unequal variances, and non-normal distribution), such as a two-sample t-test. A Mann-Whitney test was also used to compare the proportion of the total catch (of all species) comprised of black sea bass (in number and weight) between smooth and structured tows ($\alpha = 0.05$). If black sea bass congregate near structured bottom, the catches of black sea bass and the proportion of the total catch comprised of black sea bass may be larger in structured tows than smooth tows.

Furthermore, the proportion of smooth tows that caught black sea bass was calculated as the number of smooth tows that caught black sea bass divided by the total number of smooth tows. The proportion of structured tows that caught black sea bass was calculated as the number of structured tows that caught black sea bass divided by the total number of structured tows. If black sea bass congregate near structured bottom, the proportion of structured tows that caught black sea bass may be greater than the proportion of smooth tows that caught black sea bass.

Results

The number of black sea bass caught in smooth tows was significantly greater than the number of black sea bass caught in structured tows (mean smooth = 4.2872; mean structured = 1.4448; W = 575576, P = 0.0243). Similarly, the weight of black sea bass caught in smooth tows was significantly greater than the weight of black sea bass caught in structured tows (mean smooth = 0.9881; mean structured = 0.4635; W = 576742.5, P = 0.0232).

The proportion of the total catch in numbers comprised of black sea bass in smooth tows was significantly greater than the proportion of the total catch in numbers comprised of black sea bass in structured tows (smooth = 0.0046; structured = 0.0022; W = 576465.5, P = 0.0409). Likewise, the proportion of the total catch in weight comprised of black sea bass in smooth tows was significantly greater than the proportion of the total catch in weight comprised of black sea bass in structured tows (smooth = 0.0080; structured = 0.0058; W = 572181, P = 0.0292).

The proportion of smooth tows that caught black sea bass was 0.1922 (Figure 2), and the proportion of structured tows that caught black sea bass was 0.1420 (Figure 3).

Conclusions

More black sea bass (in number and weight) were caught in survey areas with smooth bottom than with structured bottom, which contradicts the assumption that black sea bass congregate in structure while on the continental shelf. This result, however, could be due to our use of entangled or damaged tows as having occurred over structured habitat. If the gear was entangled or damaged, then we would expect fewer black sea bass to have been caught over structure, which would obscure any effect of congregating behavior.

None the less, assuming that any entanglement or damage to the gear affects the catchability of all species equally, if black sea bass do congregate around structured habitat then the proportion of black sea bass caught in structured bottom areas should still be greater than the proportion of black sea bass caught in smooth bottom areas. We found, however, that a greater proportion of the total catch comprised of black sea bass (in number and weight) were caught in survey areas with smooth bottom than with structured bottom. Hence, we found no evidence for black sea bass congregating in structured habitat in a way that would invalidate the use of the spring bottom trawl survey as a method to assess black sea bass abundance.

Acknowledgements

We thank Jon Deroba and Dan Hennen for their input on this research.

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Figure 1. NMFS NEFSC spring bottom trawl survey strata. (Figure courtesy of Elizabeth Holmes.)

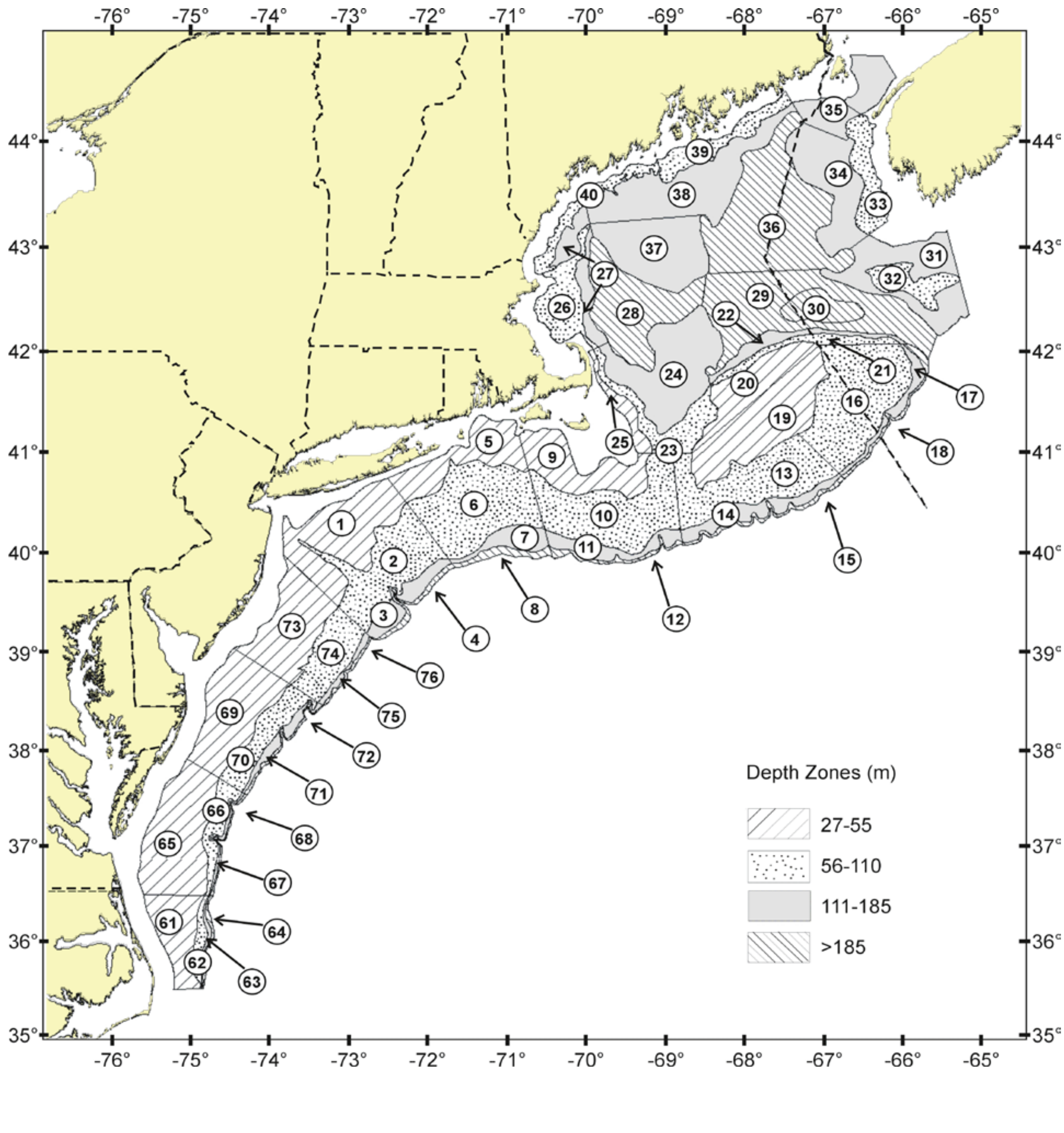

Figure 2. Locations of smooth tows where black sea bass were caught (black circles) and not caught (red circles).

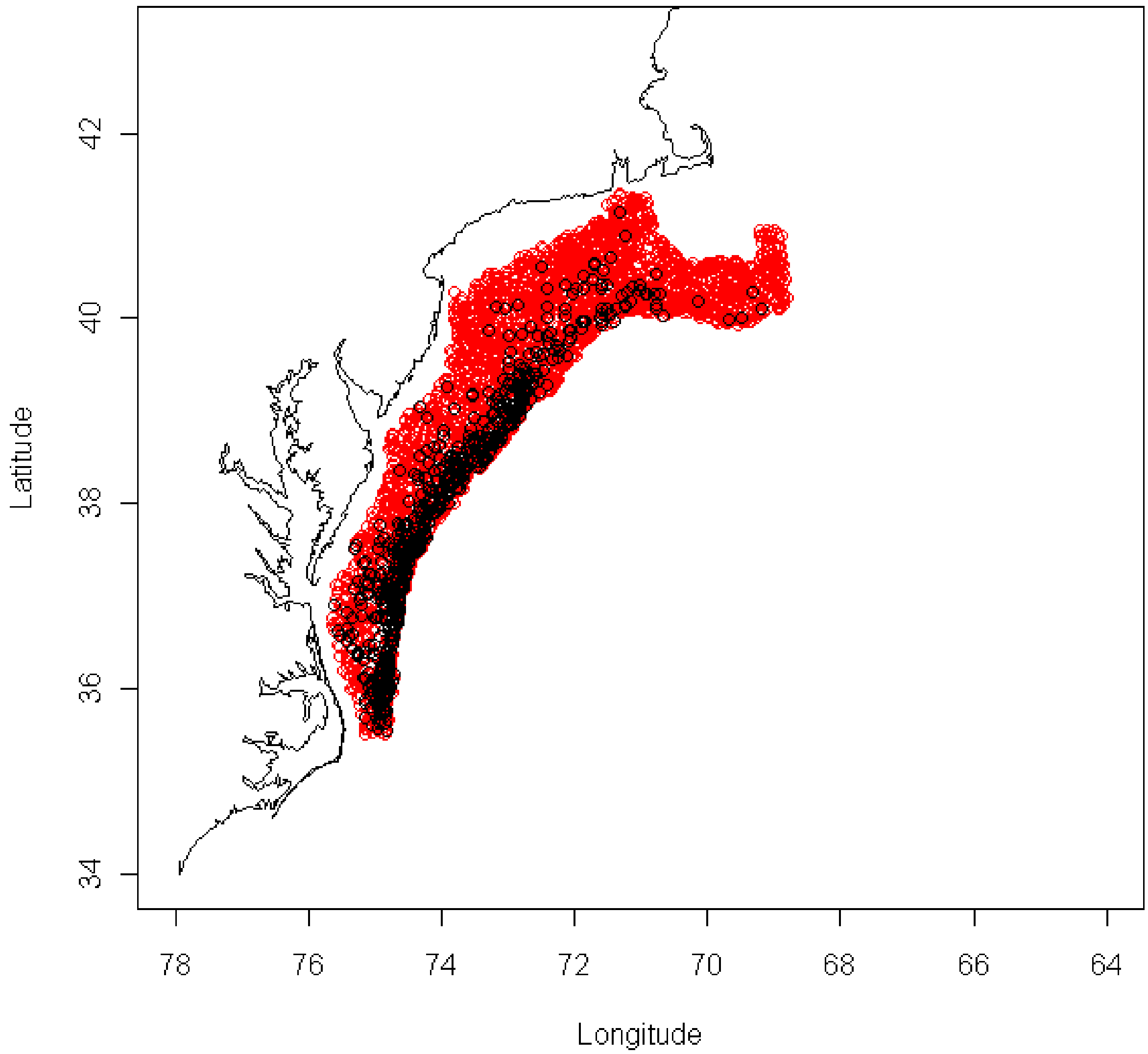

Figure 3. Locations of structured tows where black sea bass were caught (black circles) and not caught (red circles).

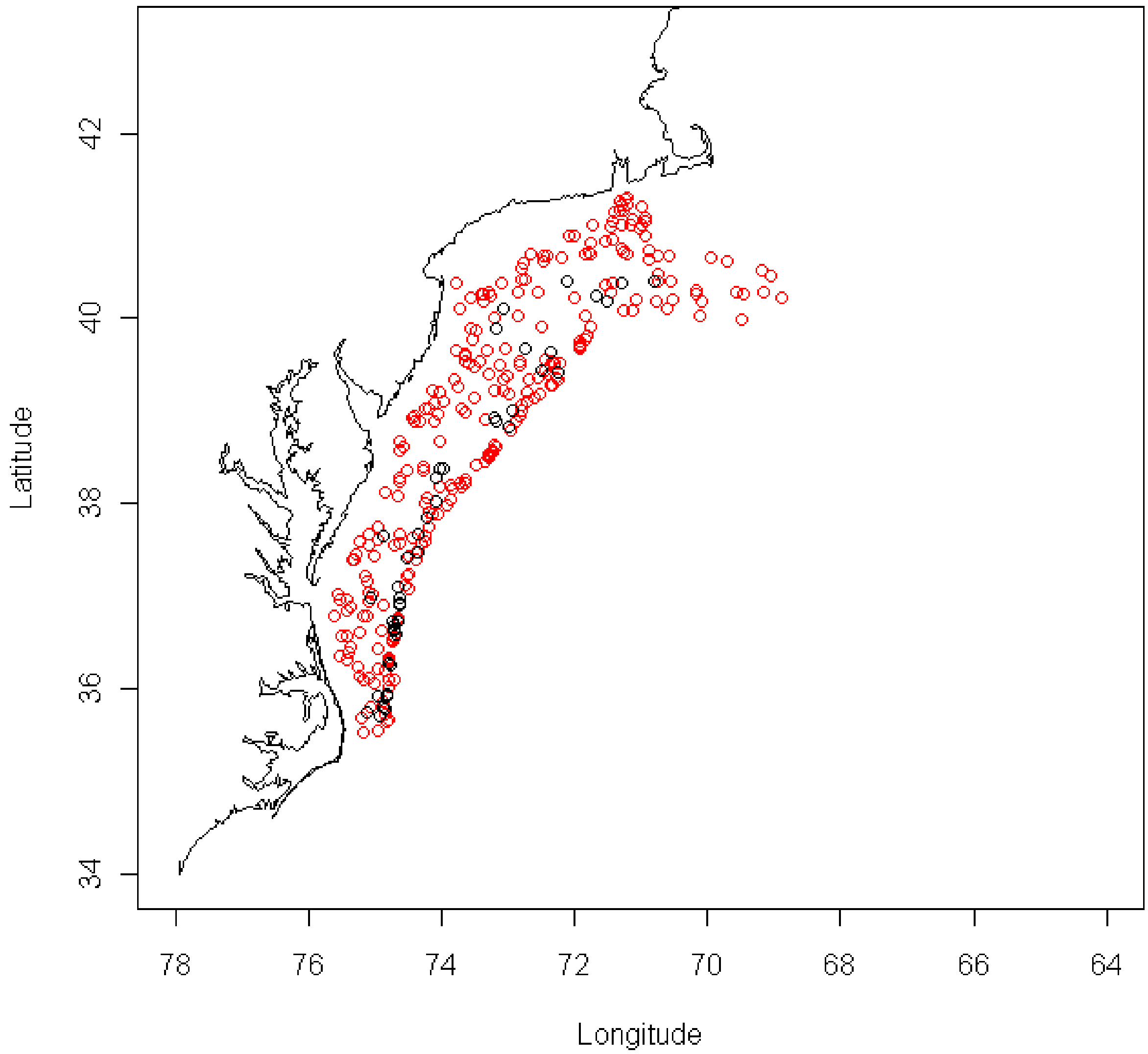

Table 1. Relevant station, haul, and gear (SHG) codes.

Station, Haul, or Gear Code	Description
Station Type	
1	Survey tows.
Haul Type	
1	Good tow. No gear or tow duration problem.
2	Representative, but some problem encountered due to gear or tow duration.
3	Problem tow. May or may not be representative due to gear or tow duration.
Gear Condition	
1	No damage to insignificant damage.
2	Wing twisted or tears in upper or lower wings not exceeding 10 feet; tear in square not exceeding 5 feet; tears not exceeding 3 feet in upper belly, or 6 feet in lower belly; codend or liner with tears not exceeding 2 feet; parted idler; liner hanging out of codend.
3	Hung up with minor damage.
5	Tearup exceeding limits for code 2, but not total.
6	Significant obstruction in trawl, such as fixed gear, rocks, old anchors, timbers, etc. Problem with third wire; unmatched doors; strong current.

Estimating Black Sea Bass Natural Mortality Using Several Methods

Julie L. Nieland and Gary R. Shepherd
October 2011

The natural mortality rate, M , of black sea bass was estimated using several methods. The rule-of thumb approach, M_R, was estimated by dividing a constant by the maximum age observed in the stock, $t_{\max}$:

$$M_R = \frac{3}{t_{\max}}.$$

The 3 in this equation implied that 5% of the stock remains alive at $t_{\max}$, and this value was selected arbitrarily (Hewitt and Hoenig 2005). If $t_{\max}$ was selected based on data from an exploited stock, M could also be biased. The Hewitt and Hoenig (2005) approach, M_H , was based on a regression equation rearranged for consistency with the rule-of thumb approach:

$$M_H = \frac{4.22}{t_{\max}}.$$

The 4.22 in this equation implied that 1.5% of the stock remains alive at $t_{\max}$, and this value was estimated based on a meta-analysis of fish stocks. Maximum age, $t_{\max}$, equaled 9 or 12 in both the rule-of-thumb and Hewitt and Hoenig approaches. The Lorenzen (1996) approach modeled natural mortality as a power function of weight (in grams), or in our application, mean weight at age, W_a , to produce natural mortality at age, $M_{L,a}$:

$$M_{L,a} = \alpha W_a^{\beta},$$

where α was the natural mortality rate at unit weight and β was the allometric scaling factor. The values of α and β were set to the estimates for marine species in Lorenzen (1996) and were 3.69 and -0.305, respectively. Mean weight at age was calculated as the average weight during 1984–2010 for ages 1–9 (Table 1). Mean weight for ages 10-12 were predicted from the fitted wt for ages 1 to 9 (wt=4.7155*age^0.2233). A constant value, M_c , was used in the last assessment and was carried forward as an option for the natural mortality rate in this assessment:

$$M_c = 0.4$$

(Figure 1). This value was based on estimates from tagging studies and meta-analyses of mortality rates in other fishes (Miller et al. 2009).

The $M_{L,a}$ values from the Lorenzen approach were also scaled, $\widetilde{M}_{L,a}$, so that the average among ages equaled each of the other methods (i.e., M_R , M_H , and M_c) for calculating natural mortality, M_i :

$$\widetilde{M}_{L,a} = M_{L,a} \frac{M_i}{\overline{M}_{L,a}},$$

where $\overline{M}_{L,a}$ was the average of $M_{L,a}$ over all ages considered (Table 2; Figure 2).

Acknowledgements
We thank Jon Deroba and Amy Schueller for their input on this research.

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Table 1. Black sea bass mean weight at age (in grams).

Age	WAA (g)
1	112.92
2	243.19
3	395.48
4	604.69
5	861.95
6	1279.68
7	1542.01
8	1821.36
9	1974.56
10	2658.4
11	3149.8
12	3689.1
Average	

Table 2. Black sea bass natural mortality estimates at age using a constant, the rule-of-thumb approach, the Hewitt and Hoenig approach, the Lorenzen approach, and the Lorenzen approach scaled to each of the other three methods.

Natural Mortality											
Age	**Constant**	**Rule of Thumb[1]**	**Rule of Thumb[2]**	**Hewitt & Hoenig[1]**	**Hewitt & Hoenig[2]**	**Lorenzen**	**Lorenzen Scaled to Constant**	**Lorenzen Scaled to Rule of Thumb[1]**	**Lorenzen Scaled to Hewitt & Hoenig[1]**	**Lorenzen Scaled to Rule of Thumb[2]**	**Lorenzen Scaled to Hewitt & Hoenig[2]**
1	0.40	0.33	0.25	0.47	0.35	0.87	0.67	0.56	0.78	0.50	0.62
2	0.40	0.33	0.25	0.47	0.35	0.69	0.53	0.44	0.62	0.36	0.46
3	0.40	0.33	0.25	0.47	0.35	0.60	0.46	0.38	0.53	0.29	0.38
4	0.40	0.33	0.25	0.47	0.35	0.52	0.40	0.33	0.47	0.24	0.33
5	0.40	0.33	0.25	0.47	0.35	0.47	0.36	0.30	0.42	0.21	0.29
6	0.40	0.33	0.25	0.47	0.35	0.42	0.32	0.27	0.37	0.18	0.25
7	0.40	0.33	0.25	0.47	0.35	0.39	0.30	0.25	0.35	0.16	0.23
8	0.40	0.33	0.25	0.47	0.35	0.37	0.29	0.24	0.34	0.15	0.21
9	0.40	0.33	0.25	0.47	0.35	0.36	0.28	0.23	0.33	0.15	0.21
10	0.40		0.25		0.35	0.33	0.24			0.13	0.19
11	0.40		0.25		0.35	0.32	0.22			0.12	0.17
12	0.40		0.25		0.35	0.30	0.21			0.11	0.16

[1]Maximum age = 9

[2]Maximum age = 12

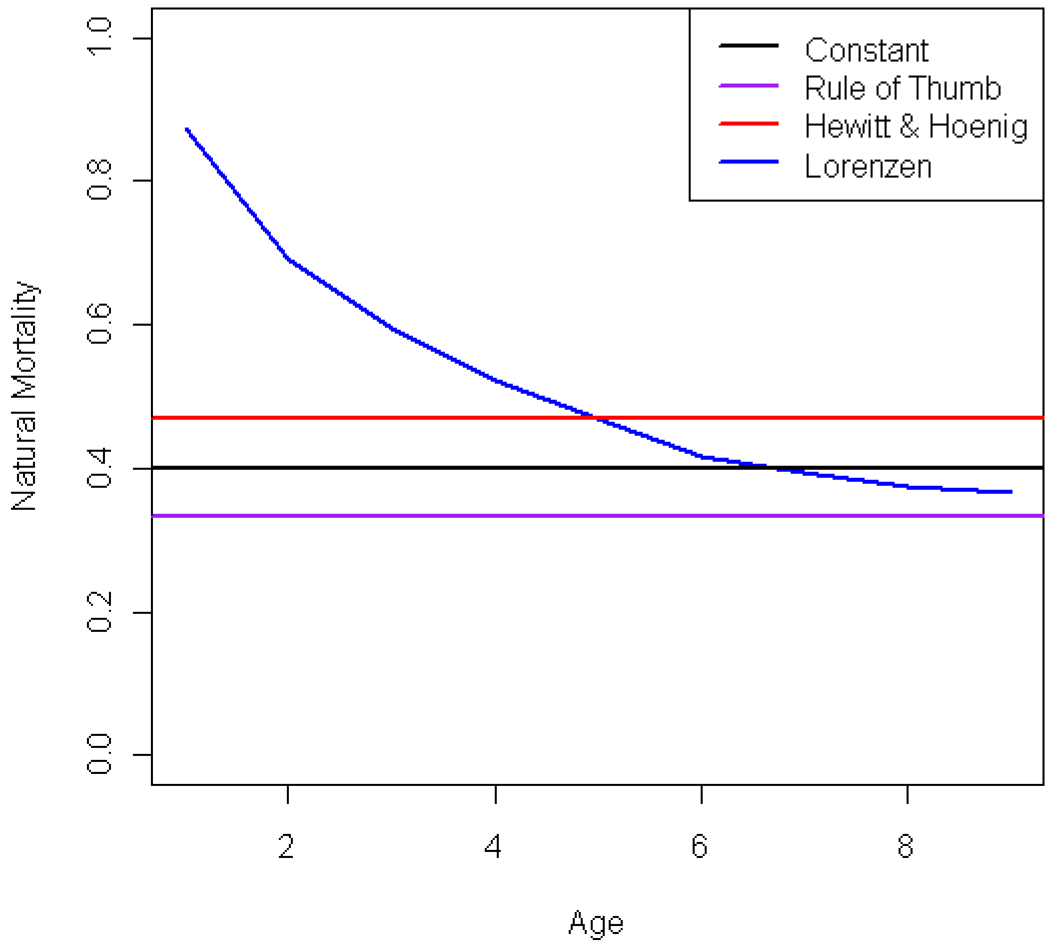

Figure 1. Black sea bass natural mortality estimates at age using a constant, the rule-of thumb approach, the Hewitt and Hoenig approach, and the Lorenzen approach.

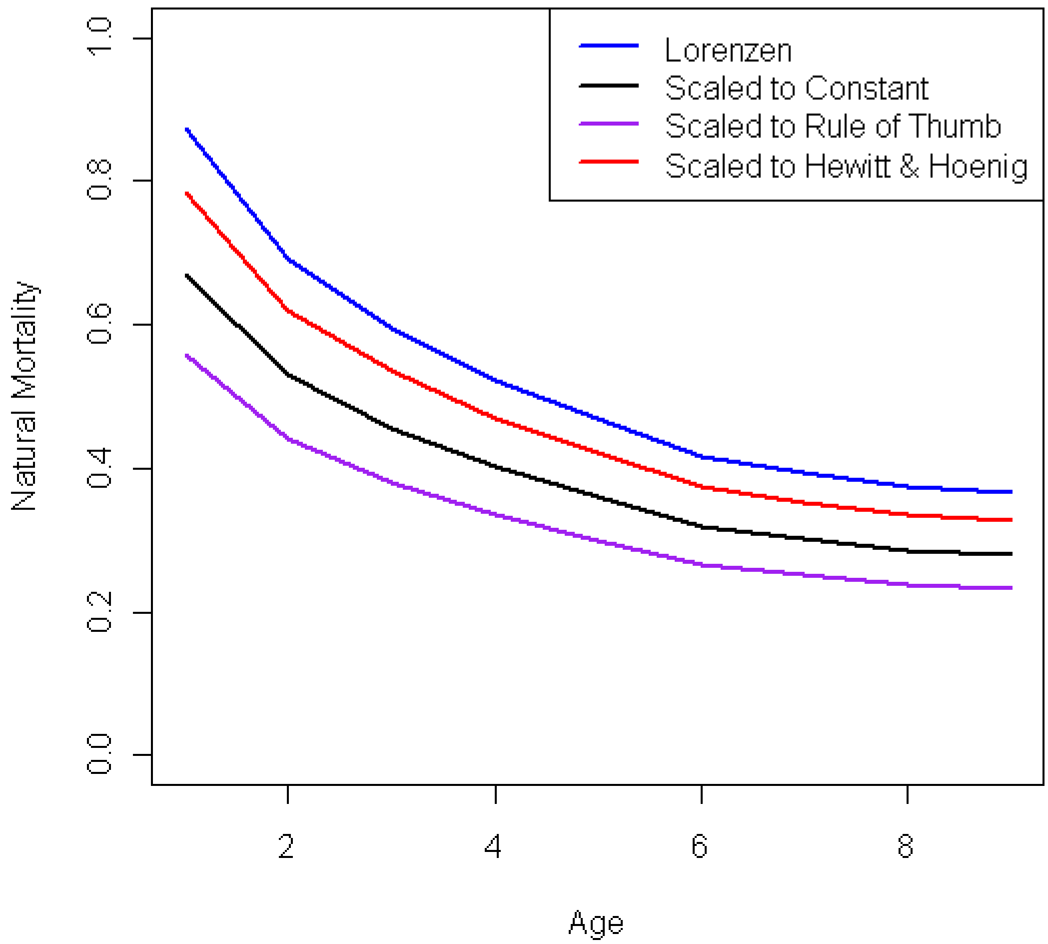

Figure 2. Black sea bass natural mortality estimates at age using the Lorenzen approach, and the Lorenzen approach scaled to the constant, rule-of thumb, and Hewitt and Hoenig approaches.

53rd Northeast Regional Stock Assessment Review Committee

November 29 – December 2, 2011

Northeast Fisheries Science Center

Woods Hole, MA

SARC 53

SUMMARY REPORT

December 16, 2011

Review Committee

Thomas J. Miller (Chair, MAFMC SSC & University of Maryland Center for Environmental Science, Solomons, MD)
Ewen Bell (CIE Reviewer, CEFAS, Lowestoft, Suffolk, UK
Kenneth Patterson (CIE Reviewer, Brussels, Belgium)
Kurtis Trzcinski (DFO, Bedford, NS, Canada)

INTRODUCTION

Background

The 53rd Stock Assessment Review Committee (hereafter referred to as the Review Committee) convened at the Northeast Fisheries Science Center (NEFSC), Woods Hole, MA from November 29th – December 2nd, 2011 to review the stock assessments of Gulf of Maine cod (*Gadus morhua*) and black sea bass (*Centropristis striata*).

The Review Panel (hereafter referred to as the Panel) comprised of Dr. Thomas J. Miller (Chair of the panel and Vice-Chair of the Mid-Atlantic Fisheries Management Council's Scientific and Statistical Committee) and three scientists appointed by the Center for Independent Experts: Dr. Ewen D. Bell (CEFAS, Lowestoft, Suffolk, UK), Dr. Kenneth Patterson (Brussels, Belgium) and Dr. M. Kurt Trzcinski (DFO, Bedford, Nova Scotia, Canada).

The SARC was supported and assisted by Dr. Jim Weinberg, (SAW Chairman), Dr. Paul Rago, (Branch Chief of the NEFSC's Population Dynamics Branch) and analysts from the NEFSC. The assessment document for the Gulf of Maine cod assessment was prepared by the Northern Demersal Working Group (NDWG). This assessment was presented by Mr. Mike Palmer with support from Drs. Liz Brooks and Chris Legault. The assessment document for black sea bass was prepared by the Southern Demersal Working Group (SDWG). The sea bass assessment was presented by Dr. Gary Shepherd with support from Dr. Mark Terceiro. The support of all of these scientists to the SARC process is gratefully acknowledged.

Review Activities

About two weeks before the meeting, assessment documents and supporting materials were made available to the Panel via an ftp server. On the morning of the meeting, the Panel met with Drs. Weinberg and Rago to discuss the meeting agenda, reporting requirements, and meeting logistics. At that meeting the Panel was made aware of an important error in the assessment model input parameters for black sea bass reported in the document that the Panel had been provided. The specifics of the error are documented later in this summary. After careful discussion, the Panel agreed to review black sea bass as although the error changed specific details of the assessment, the data stream used in the model and the structure of the model itself had not changed. The Panel did not feel that the nature of the error negated all of the previous work the Panel had invested in reviewing the original draft.

The panel also discussed whether to review any late arriving submissions that had not been through the full SAW process. The Panel did not consider such material.

The SARC meeting started on Tuesday morning (December 29th) with a welcome and introductions by Drs. Weinberg and Miller (See page 34 for detailed agenda). The Gulf of Maine cod assessment was presented for the remainder of this first day. At the end of the SARC discussions on Day 1, the Panel requested additional model diagnostics for subsequent review. The black sea bass assessment was presented on December 30th (Day 2). As with the cod assessment, the SARC Panel requested additional model diagnostics be provided. The supplementary information for both species was discussed on December 1st (Day 3). All meetings of the SARC on Days 1-3 were held in open session. On December 2nd, (Day 4), the SARC prepared Assessment Summary Reports for both species in open session. Rapporteurs provided detailed records of all open sessions. For the second half of Day 4, the Panel met in closed session to work on its consensus report.

SARC Process and General Conclusions

The Review Committee agreed unanimously on all the Terms of Reference it was charged to address for both Gulf of Maine cod and black sea bass. It acknowledges the significant work that both the NEFSC assessment analysts and the Northern and Southern Demersal Working Groups had undertaken in preparing and presenting the assessments. It also appreciates the professionalism and cooperation of NEFSC staff at the SARC meeting which significantly assisted the peer review. Here we identify some overall conclusions pertinent to the SARC process for both assessments and highlight the principal conclusions for each assessment. We expand on the principal conclusions for each assessment in the subsequent sections.

General Conclusions

- **Details of the fisheries management framework and policies should be provided**

  Given its composition, this SARC panel was less familiar with the former and current framework that guides the management of both species. The Panel recommends that a short document be prepared for reviewers that documents the history of management regimes in reviewed stocks. The Panel believes such a document is important because it would help inform reviewers of changes in policy that might affect the interpretation of input data, model performance and stock dynamics. Currently, each assessment provides some detail on management, but the SARC lacked a general overview.

- **Internal review of assessments should be improved before documents are released to reviewers**

  The error that was found in the black sea bass assessment immediately prior to the assessment was unfortunate and the analysts must be credited for bringing it to the Panel's attention as expeditiously as they did. However, the Panel suggests the circumstances of this review may highlight the need for improved internal review of assessments prior to the release of documents.

- **The format of assessment should be more standardized**

  The Panel acknowledges that formatting of assessments cannot be so restrictive as to limit the analyst's creativity and individuality, but the Panel recommends that increased attention be paid to the uniformity of assessment documents, and in particular in those sections that link the existing assessment framework to that developed and presented in the document.

  Evaluating the details of the equations used in the assessment is an important part of the review activity. The Panel also recommends that every assessment document should, at a minimum, present the structural model equations, the observation error model and (if relevant) process error equations used in the assessment. Although we acknowledge that there are advantages in the familiarity that accrues to the analyst from the repeated application of models in the NEFSC Fisheries Toolbox to multiple stocks, the reviewers do not have this local familiarity and they should not have to rely on software manuals and interpretation of software input file to determine the fundamental assumptions each assessment makes. The assessment documents should be "stand alone" documents that contain the information needed to reproduce the assessment. It is expected that the Fisheries Toolbox will evolve which may make it difficult to reproduce previous assessments in the future if the specific details of the assessment are not adequately documented.

The Panel also recommends that the assessment document text should be consistent with the model inputs used. There were several instances in both assessments where the description of the input data in the document differed from that in the input files provided. For example, in one case a survey index was rescaled to transform an index value to an area-swept abundance estimate.

- **Pre-analysis of catch at age and survey data should be improved**

  The Panel felt that for both Gulf of Maine cod and black sea bass more information could have been derived from the catch at age and survey had additional "screening" analyses been undertaken prior to their use in assessment models. The internal consistency of age-structured data should be routinely evaluated prior to use in a model. For example, correlation plots of abundance of fish of age (a) in year t against abundance of fish of age (a+1) in year t+1 should be evaluated to determine the ability of catch streams and surveys to track year classes. We also suggest that general linear models of survey data may help identify changes in the relative weighting of individual survey strata to the overall abundance index that could indicate changes in distribution or the presence of anomalous survey catches.

- **Responsibility for preparation of the Assessment Summary document**

  The Panel recommends that the preparation and finalization of the Assessment Summary documents should not be a part of the SARC review process. The Assessment Summary documents are important management products and it is critical that the people preparing and editing these documents are fully conversant with local protocols – something which the SARC Panel cannot be expected to understand.

Summary of Gulf of Maine Cod

The Panel unanimously recommends that the results of the Gulf of Maine cod assessment be used for management of this stock. All terms of reference for this stock had been fully met. Both catch and survey data have been fully and adequately summarized. The statistical catch at age model (ASAP) was appropriately applied to the data and that the time series of abundance and fishing mortality estimated from the model represent the best scientific estimates available for this stock. In particular, the Panel agrees that the 2005 cod year class in the Gulf of Maine was less strong than suggested by analyses conducted for a prior assessment. The Panel did not accept the revision of the reference points from $F_{40\%}$ to $F_{35\%}$ recommended in the assessment, but rather recommended the continued use of $F_{40\%}$ as the basis for biological reference point proxies. However, regardless of which reference point is selected, results indicate that the Gulf of Maine cod stock is overfished and is experiencing overfishing. Stock projections provided at the SARC indicate that the stock will not be rebuilt by 2014.

Summary of black sea bass

The Panel unanimously rejected the assessment for black sea bass as a basis for management of this species. The Panel identified substantial concerns over the potential for spatial structure and incomplete mixing within the stock area that compromised the ability of the forward projecting catch at age model to index abundance and fishing mortality reliably based on the data available. Based on the biological reference points and assessment as approved at the Data Poor Species Workshop in 2007, black sea bass is not overfished and overfishing is not occurring.

It was suggested that the assessment team continue to consider alternative methods for assessing black sea bass stock status, perhaps continuing with age-based methods, although achieving a new framework should not be expected in the short term.

GULF OF MAINE COD

The SARC invested considerable time and effort in evaluating the assessment of Gulf of Maine cod, allowing for considerable public input during our open sessions. The Panel concludes it has a good understanding of the important sources of uncertainty relating to this stock. The Panel unanimously recommends that the assessment be accepted as providing the best scientific information for management of Gulf of Maine cod. In the sections that follow, the Panel details its principal findings and recommendations regarding each term of reference identified in the charge to the Panel.

Background Information

- The application of the new length-weight relationships derived in this assessment was appropriate.

  The change in the length-weight relationship represents an important improvement to the assessment. Prior assessments had used a relationship that, although having been widely used previously, could not be documented. Accordingly, there is no basis for its continued use. The new relationship is well documented and is based on a large sample of cod collected in NEFSC survey activity between 1992-2010. Separate, seasonal relationships were accepted for spring and fall. The panel notes that the adoption of these new relationships has a substantial impact on the assessment results, because the change in length-weight relationships implies fish are heavier at length than previously estimated.

- The assumed level of M (=0.2) was deemed appropriate.

  The Panel accepted the continued use of M=0.2 as the best available scientific information for this stock. The reliability of this estimate is important and we recommend continued efforts to refine the estimate of M used in future assessments.

TOR1: Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data. Evaluate available information on discard mortality and, if appropriate, update mortality rates applied to discard components of the catch.

- A general assumption was made that the control systems to monitor catches were adequate and no concerns were raised either by the analysts or by the members of the public attending the meeting that led the review panel to question the validity of the catch reports.

- There was no indication that important sources of catches were not accounted for.

- While the change to a management system based on sector-based ACLs could possibly have motivated over-reporting of catches, there was no evidence for this and, in any event, it would have made little difference to the perception of the state of the stock (which is heavily driven by the surveys).

- **Thus, the Panel concludes that this term of reference was addressed adequately for the purpose of assessment.**

  However, the Panel notes that the level of precision of the total commercial and recreational catches should be better documented and the level of uncertainty characterized better. We suggest that this be an increasing issue given the implementation of ABCs and the expansion recreational catches. This documentation is also important as the uncertainty inherent in catch should be used as the foundation for the weighting of these data in the final assessment model. The Panel believes more information could have been obtained from these data relative to uncertainty.

The Panel viewed the recreational catches in recent years as uncertain because of apparently anomalously high catches in MRFSS Wave 2 in 2010. Substantial concern on this topic was expressed from the floor, but the sensitivity of the overall assessment conclusions to these data has been evaluated and appears to be low.

- The Panel commends the analysts for the full inclusion of and improved estimation of the commercial and recreational discards.

  The Panel believes that the inclusion of all sources of discards is an important enhancement to the input data and to the assessment overall. Estimation of discards separately by length-group is a clear methodological improvement. The assumption of 100% discard mortality was appropriate given the nature of the principal fisheries.

  The incorporation of the full discard time series is one of the most significant changes to the prior GARM III implementation. It is recommended that future assessments continue to incorporate discard estimates for the commercial and recreational sectors.

TOR 2: Present the survey data being used in the assessment (e.g., indices of abundance, recruitment, state surveys, age-length data, etc.). Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.

- **The Panel concluded that this term of reference was addressed adequately for the purpose of assessment.**

- The Panel recommends that increased inspection and analysis of survey data be conducted in future prior to inclusion of these data in the model. Examples of such analyses include:

  - Inspection of the distribution of catches within strata to ensure that single catches are not driving survey estimates. In particular, we recommend application of GLMs to check of consistency of survey strata estimates.
  - Routine internal estimates of variance of annual survey estimates.
  - Inspection of relationships between age i and age i+1 within individual surveys to ensure cohorts are tracked – such analyses may help identify appropriate designation of plus groups.
  - Inspection of correlations among different surveys to examine information content of individual surveys.
- The Panel notes that the Albatross IV – Henry B. Bigelow conversion factors have important consequences for the interpretation of survey data and for the assessment model. Given the high uncertainty in these conversions, we recommend that methods that do not rely on these conversion factors be implemented as soon as the length of the Bigelow time series permits.

- The latest survey data (Spring 2011 NEFSC survey) were not used in the assessment, but these data do not contradict the model fit.

TO3: Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results. Review the performance of historical projections with respect to stock size, catch recruitment and fishing mortality.

- **The Panel concluded that this term of reference was addressed adequately for the purpose of assessment.**
- The careful and systematic fashion in which a bridge from the existing GARM III assessment to the final ASAP model was built developed a high degree of "comfort" in showing that the change in perception of stock status is data-driven and not model-driven.

  The Panel commends the analysts on their work in this area. The sequential introduction of alternative assumptions and data streams into the VPA and ASAP models was very thorough. This approach greatly assisted the Panel in developing an understanding and appreciation of the importance of each alternative. We also note that this careful development of alternatives would have provided intermediate assessment points that could have been accepted had the final ASAP model not been accepted. We suggest that this approach be implemented, where possible in other assessments.

- The performance of the model under a plausible range of different structural assumptions was thoroughly evaluated. We consider that these afford a high level of confidence in the results.
- The Panel examined the scaling of the model results compared to swept-area estimates of biomass, and concluded that these didn't invalidate the use of the assessment for management purposes.
- **As a result, the Panel accepts the base ASAP model as providing the best scientific foundation for providing management advice.**
- The perception of the stock biomass has changed markedly as a result of changes in the weights at age (resulting from inclusion of complete discard time series) and reductions in the estimated strength of the 2005 year (resulting from observations of this year class recruiting to the surveys and the fishery). These have combined to reduce estimates of current stock size. We view these changes are being well documented and appropriate.

  The change in the perceived strength of this year class is central to the revision of the status of this stock. This change highlights the need for increased attention to survey data that as recommended under TOR 2 above. Analysts and managers often have to make decisions based on information from very recent data. Presumably, we should have most confidence in these data. Yet, by their very nature these data cannot be validated by the sequential observations of the year class in catch and survey time series. Thus, every effort must be made to evaluate the reliability of these data from first principles which we believe demands increased attention to the statistical properties of the survey data themselves.

- Model diagnostics were adequate. The Panel appreciated the range of model diagnostics that were presented and evaluated by the analysts. However, we note that three commonly used diagnostics were not presented:
  - Observed vs. predicted scatter plots of survey fits should be routinely provided because they provide a direct test of the precision and accuracy of model estimates.

- o Quantile-quantile plots should be presented based on individual observations for the proportions in the catches-at-age and in the surveys, rather than means across ages or years.

- o Single index runs should be routinely conducted.

  For models, such as GOM cod with multiple survey indices, we believe that runs of the assessment model with single indices input should be routinely conducted. We believe that such runs help to identify the relative importance of different indices and provide a check on the reliability of the overall model estimates. While the assessment program used reports the "weighting" of the objective function by different components, this can be misleading in assessing the contribution of each source of information to the final result, as some likelihood components (typically, catches at age) may be very flat with respect to the parameters of interest near the solution.

- Retrospective patterns were persistent across a wide range of different models. This indicates that there is some degree of model misspecification, but the source of the errors could not be identified.

  The Panel cautions managers that they should be cognizant of the additional uncertainty that this pattern introduces into estimation of current stock sizes and in projections.

  Considerable concern was shown from the floor that the fishing mortality could not be as high as evidenced by the model fit because of the management measures that had been put in place. The panel considered these concerns and concluded that such an apparent contradiction can appear if:
  - o The recent decommissioning from the fleet caused an increase in average efficiency as inefficient vessels and operators are withdrawn first.
  - o An increased economic incentive is created to target cod when days at sea become limited
  - o Non-linear relationships develop between commercial fleet catchability and abundance, if (as has been seen in surveys) the stock concentrates in a smaller area and becomes more vulnerable.

TO4: Perform a sensitivity analysis which examines the impact of allocation of catch to stock areas on model performance (TOR-3).

- **We conclude that this term of reference was adequately addressed.**

- Sensitivity runs of the accepted ASAP model indicated that model was not sensitive to the reallocation of catches taken either side of the "Hague Line".

TO5: If time permits, consider the small-scale distribution of cod (e.g., spawning sites, resource distribution, fishing effort) in the Gulf of Maine and advise on its management implications.

- **We conclude that this term of reference was adequately addressed.**

- The spatial distribution of the catch was compared to the spatial distribution of survey catches, leading to the conclusion that distributions were adequately determined.

There was evidence that the stock is more aggregated in the western part of the Gulf of Maine in recent years. In this situation, commercial catches per unit effort can be maintained even in the face of declining abundances.

We recommend that work be undertaken to assess the potential causes and consequences of the observed aggregation.

- There remain concerns over the loss of local spawning aggregations.

TO6: State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, F_{MSY} , and MSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the appropriateness of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

- The Review Panel did not accept the logic presented within the assessment to justify selection of an F35%SPR reference point. The stock-recruit relationship fitted to justify the change from $F_{40\%\ SPR}$ was not appropriate and the Review Panel found no convincing reason to deviate from the previously established $F_{40\%\ SPR}$ reference points. Reference points were recalculated for $F_{40\%\ SPR}$ as a basis for stock determination. These reference points were accepted by the Review Panel.

The Panel emphasizes that the recommendation to maintain an $F_{40\%}$ basis for reference point determination was based on the lack of a consistent logic to abandon the existing standard. We do not suggest that $F_{40\%}$ is necessarily the best proxy to use, rather there has yet to be compelling reasons to abandon it.

TO7: Evaluate stock status with respect to the existing model (from the most recent accepted peer reviewed assessment) and with respect to a new model developed for this peer review. In both cases, evaluate whether the stock is rebuilt. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs (from Cod TOR-6).

- **Based on the existing reference points, the updated assessment indicates that the Gulf of Maine cod stock is overfished and overfishing is occurring.**

- The Panel determined that there was insufficient reason to abandon an $F_{40\%}$ foundation for reference point determination. Thus, the Panel rejected the revised reference points provided in the assessment that were based on an $F_{35\%}$ proxy. Instead revised FMSY and BMSY proxies based on an $F_{40\%}$ standard were developed. **Using these new reference points, we conclude that, in 2010, the GOM cod stock was overfished and overfishing was occurring.** Further evaluations indicate that this conclusion remains valid even had an $F_{35\%}$ foundation been adopted for reference points, and regardless of whether a variety of VPA or ASAP formulations were used for the assessment.

- The Panel notes a long history of this stock experiencing overfishing.

TO8: Develop and apply analytical approaches to conduct single and multi-year stock projections to compute the pdf (probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs). (a). Provide numerical annual

projections (3-5 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment). (b). Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions. (c). Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.

- The Panel reviewed stock projections. Current projections methods resample from historic recruitment levels independent of stock size. The Review Panel noted that this approach is not consistent with precautionary principles and made the strong recommendation that stock projections be re-calculated to reduce recruitments at low stock sizes.
- This was accepted by the assessment team and new projections were calculated following the SARC.
- The Review Panel also cautions that in cases where managers have attempted to rebuild stocks according to projection scenarios, the outcomes have often performed much worse than the projections, for a variety of reasons including stock depensation poor management implementation. Projections should be used for management purposes as tools to compare the risks of different outcomes and not as forecasts of the future. Regardless of changes recommended to projections, we conclude that the stock will not be rebuilt by 2014.

T09: 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.

1. Stock definition should be re-assessed. The Panel recommends that efforts be undertaken to re-assess the stock definition for Gulf of Maine cod. Cod is a very population-rich species, and matching the scale of the assessment to the spatial scale of the population dynamics is important to achieve reliable, accurate assessments. Several lines of evidence support this recommendation.
    - The assessment under review presents compelling evidence of a change in the distribution of cod within the current stock area. The Panel was not able to determine whether this is solely a demographic response, but comments made during the SARC indicate that it may also relate to a reduction in the diversity of spawning times and locations.
    - There is compelling historical and contemporary evidence from natural history information and tagging studies of movements across stock boundaries that compromises the integrity of existing stock definitions.
    - There is a wealth of historical and more recent genetic information of local stock structure and local adaption in cod and in fish populations general at finer spatial scales than previously admitted.
2. The level, schedule and variability of natural mortality should be evaluated. Currently, the level of fishing mortality, F, estimated in Gulf of Maine cod is substantially higher than the estimated

rate of natural mortality, M. However, as managers begin to regulate harvests more effectively, F will decline and approach M. Under such circumstances the accuracy of the assumed M becomes more important. Accordingly, the Panel recommends that efforts be increased to evaluate size-specific, age-specific and inter-annual variation in M be expanded.

3. Study of the behavior of fishers in response to changes in the distribution of the stock and to changes in management. There was clear evidence presented in the assessment and at the SARC of changes in the distribution of cod within the stock area. The Panel recommends that research and analyses be conducted to:

- Understand and characterize changes in the distribution of the stock.
- Understand and characterize changes in the distribution of fishing effort and to evaluate the impacts of such changes on the pattern and biological characteristics of removals from the stock.
- Evaluate the potential for changes in the distribution of effort to be associated with changes in the distribution of vulnerability of different components of the stock to fishing mortality.

The Panel also reviewed the research recommendations contained in the assessment document itself. We endorse recommendations related to the inclusion of the Maine/NH survey and for the re-evaluation of the maturity condition of fish in local surveys to assess evidence for local spawning aggregations.

BLACK SEA BASS

As with Gulf of Maine cod, the SARC invested considerable time and effort in evaluating the assessment of black sea bass. We note that no industry or Council representatives were present at these discussions and only one independent party attended the meetings for black sea bass. Based on extensive discussions with the analysts who conducted the assessment and NEFSC staff who have considerable insight into this species, the fisheries it supports and the available data to assess it, the Panel concludes it has a thorough understanding of importance sources of uncertainty relating to this stock. The Panel unanimously rejected the assessment brought forward by the Southern Demersal Workgroup as providing a scientific foundation for management.

The effort to complete a revised and age-structured assessment was both important and constructive. The assembly of the age data, the analysis of the regional and broadscale surveys and the attempt to fit a forward projecting statistical catch at age model were all important contributions that will lead to improved black sea bass assessments in the future.

There is substantial information in the age data currently available, and efforts should continue to exploit these data. However, the data in the assessment presented showed significant deviations from the model assumptions. This makes the model presently unsuitable for advisory purposes.

There is also strong evidence of regional stock structure and incomplete mixing within the stock area for black sea bass that may compromise the accuracy and reliability of the current integrated approach.

In the sections that follow, the Panel details its principal findings and recommendations regarding each term of reference identified in the charge to the Panel.

General comments

This assessment represents a reintroduction of age information into the assessment framework for this species. Considerable effort has been expended by NEFSC scientists to develop the required age-based indices and catch data. Despite the Panel's rejection of the assessment overall, age-based assessments offer substantial advantages over the current length-based assessment. However, age-based approaches require confidence in the underlying ageing and resultant age-specific patterns. The assessment would have been strengthened by the provision of supporting information on the reliability of the ageing, the completeness of the age-length keys and resultant growth patterns. We suggest that this information could have been provided in supporting documentation outside of the main assessment document.

The assessment document didn't adequately provide a bridge from the SCALE model to the ASAP model. It would have been desirable to document the point of departure thoroughly and provide more detail on the sequential consequences of assumptions leading from the SCALE model to the final ASAP presented in the assessment document.

A lot of work was done to improve the input data streams to the assessment model.

TOR 1: Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data. Evaluate available information on discard mortality and, if appropriate, update mortality rates applied to discard components of the catch. Describe the spatial and temporal distribution of fishing effort.

- The general assumption was made that the control systems to monitor catches were adequate. No concerns were raised by the analysts that led the review panel to question the validity of the catch reports.
- There was no indication that important sources of catches had not been accounted for.
- **Thus, the Panel concludes that this term of reference was addressed adequately for the purpose of assessment.**

  However, the Panel notes that the level of precision of the total commercial and recreational catches should be better documented and the level of uncertainty characterized better. We suggest that this be an increasing issue given the implementation of ABCs and the expansion recreational catches. This documentation is also important as the uncertainty inherent in catch should be used as the foundation for the weighting of these data in the final assessment model. The Panel believes more information could have been obtained from these data relative to uncertainty.

- The reduction in the discard mortality rate from 25 to 15% was poorly justified. The Panel notes that discard mortality is a difficult parameter to estimate. One approach to address this uncertainty would be to explore the implications of miss-specification would be to evaluate the impact on the assessment model results of alternative values of discard mortality on stock status. Such simulations were not presented at the SARC.

Tor 2: Present the survey data being used in the assessment (e.g., indices of abundance, recruitment, state surveys, age-length data, etc.). Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.

- **The Panel concluded that this term of reference was addressed adequately for the purpose of assessment.**
- The Panel reviewed evidence regarding the presence of stock structure within the stock area.
  - We note that although at the region wide level, no year class structure was apparent in the surveys, evidence was presented that some individual state surveys are better able to track the local abundances of particular year-classes.
  - Tagging data presented at the SARC suggest incomplete mixing among population unit, with homing of the population to specific spawning sites.
  - In combination, we support the conclusion of the assessors that the population is not homogeneously mixed but retains internal population structure, such as a clinal variation from north to south.
- The Panel recommends that increased inspection and analysis of survey data be conducted prior to inclusion in the model as described in the Panel's overview comments. Examples of such analyses include:
  - Inspection of relationships between age I and age i+1 within individual local surveys to ensure cohorts are tracked – such analyses may help identify appropriate designation of plus groups.

- Inspection of correlations among different surveys to examine information content of individual surveys.
- Routine internal estimates of variance of annual survey estimates.

- The Albatross IV – Henry B. Bigelow conversion factors have important consequences for the interpretation of survey data and for the assessment model. Given the high uncertainty in these conversions, the Review Panel recommends that methods that do not rely on these conversion factors be implemented as soon as the length of the Bigelow time series permits.

TOR 3: Consider known aspects of seasonal migration and availability of black sea bass, and investigate ways to incorporate these into the stock assessment. Based on the known aspects, evaluate whether more than one management unit should be used for black sea bass from Cape Hatteras north and, if so, propose unit delineations that could be considered by the Mid-Atlantic Fishery Management Council and for use in future stock assessments. The Panel concludes that this term of reference was addressed adequately.

- The Panel noted that the overlaying of tagging results and the distribution of commercial fishing effort was an attractive feature of the analyses.

TOR 4: Investigate estimates of natural mortality rate, M, and if possible incorporate the results into TOR-5. Consider including sex- and age-specific rate estimates, if they can be supported by the data.

- The Panel felt that the estimate of M used was the best available, but the implications of decisions regarding M require further evaluation.
- **Thus, we conclude that this term of reference was adequately addressed.**
- The implications of assigning M for a protogynous species are not fully understood, and in particular black sea bass' life history response to changes in exploitation rates are equally not fully understood.

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

- The Review Panel rejected the ASAP model for black sea bass on the following basis:
  - The Panel had substantial discomfort with the fit of the model to the data.
  - The lack of contrast in recruitments mean that it is difficult to use surveys to estimate recent stock sizes with any level of precision, or even to validate the principle that the surveyed stock and the exploited stock are the same.
  - Because black sea bass enter the fishery at half L_{∞}, catch provides relative little evidence on stock dynamics.
  - Observed vs. expected plots of surveys gave rise to scatter plots that deviated strongly from linear - the apparent non-zero intercepts in these scatter plots give rise to concerns of structural violation within the model.

- A series retrospective problem arose in the middle of the time series as data were peeled away from the terminal end.
- Structural uncertainties gave rise to very large uncertainties in terminal stock sizes and substantial retrospective issues.

- The Panel requested assessment model runs with single indices as a way of revealing the importance of different data sources on model outcomes. We note a discrepancy in the fits of the model to single indices to ones fit to multiple indices. We were not able to determine the source of the inter-model variability.

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

- Because the Review Panel rejected the ASAP model, no new reference points were considered.

TOR 7 Evaluate stock status with respect to the existing model (from the most recent accepted peer reviewed assessment) and with respect to a new model developed for this peer review. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs (from black sea bass TOR 6).

- The Review Panel observes that the previously accepted BRPS and SCALE model fit imply that the black sea bass stock is not overfished and overfishing is not occurring.

TOR 8 Develop and apply analytical approaches to conduct single and multi-year stock projections to compute the pdf (probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs). Provide numerical annual projections (3-5 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment, and definition of BRPs for black sea bass). Comment on which projections seem most realistic. Consider major uncertainties in the assessment as well as the sensitivity of the projections to various assumptions. Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.

Because the Review Panel rejected the ASAP model, no projections were considered.

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.

1. The panel recommends multiple age-structured models be evaluated for use in a future model. We recommend these models are selected to span a range of structural assumptions that thereby shed light on the importance of processes that caused us to reject the formulation presented at this SARC. Specifically, we recommend:

a. A simple model such as a separable model with smoothing on F among years.

b. A more complex, spatially structured model with 6 month time step within independent stock areas in spring and mixing in winter with natal homing, if the data are adequate to support such a model.

c. Consideration should be given to including tag return data in an age-structured (and possibly spatially-structured) assessment model.

The Panel notes that the three models suggested above are a major research task and may require additional data. We do not anticipate that such models could be produced within an operational assessment framework.

2. The Panel recommends evaluation of a species specific survey, such as a pot survey to provide increased information on abundances and biological characteristics.

3. Continue and expand the tagging program to provide:

a. increased age information.

b. increased resolution on mixing rates among putative populations.

4. Continue and expand genetic studies to evaluate the potential of population structure north of Cape Hatteras.

5. Continued research on rate, timing and occurrence of sex-change in this species. Recent research findings discussed at the SARC lead to the hypothesis that protogyny is not obligate in this species – some individuals may never have been female before maturing as a male.

6. The validity of the age data used in the assessment requires further evaluation, in particular the reliability of scale-based ageing needs to be determined. A scale- otolith intercalibration exercise might be of utility.

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APPENDIX 1
Statement of Work

External Independent Peer Review by the Center for Independent Experts

53rd Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC): Black sea bass and Gulf of Maine cod.

Statement of Work (SOW) for CIE Panelists
(including a description of SARC Chairman's duties)

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: The purpose of this meeting will be to provide an external peer review of stock assessments for black sea bass (*Centropristis striata*) and Gulf of Maine Atlantic cod (*Gadus morhua*). Black sea bass occupy reefs, wrecks and shell bed habitats. They may attain lengths up to 60 cm with maximum age of 10-12 years. Black sea bass change sex from female to male between ages 2 to 5. Black sea bass are jointly managed by the Atlantic States Marine Fisheries Commission (ASMFC) and the Mid-Atlantic Fishery Management Council. The last peer reviewed assessment of black sea bass was in 2008 as part of the Data Poor Stocks Working Group, with annual updates since then. The Atlantic cod is a demersal gadoid species found on both sides of the North Atlantic. Cod may attain lengths up to 130 cm with maximum age in excess of 20 years. Commercial and recreational fisheries for cod are managed by the New England Fishery Management Council. The last peer reviewed assessment of Gulf of Maine cod was in 2008 as part of the GARM III. Results of the 2011 peer review will form the scientific basis for fishery management in the northeast region.

Duties of reviewers are explained below in the "**Requirements for CIE Reviewers**", in the "**Charge to the SARC Panel**" and in the "**Statement of Tasks**". The stock assessment Terms of Reference (ToRs), which are carried out by the SAW Working Groups, are attached in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3**. The SARC Summary Report format is described in **Annex 4.**

The SARC 53 review panel will be composed of three appointed reviewers from the Center of Independent Experts (CIE), and an independent chair from the SSC of the New England or Mid-Atlantic Fishery Management Council. The SARC panel will write the SARC Summary Report and each CIE reviewer will write an individual independent review report.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review of the stock assessments that are provided, and this review should be in accordance with this SoW and stock assessment ToRs herein. CIE reviewers shall have working knowledge and recent experience in fish stock assessments. For sea bass, knowledge of complex life histories and their implications for Biological Reference Points is desirable. For GOM cod, familiarity with forward projecting models and estimation is desirable.

In general, CIE reviewers for SARCs shall have working knowledge and recent experience in the application of modern fishery stock assessment models. Expertise shall include statistical catch-at-age, state-space and index methods. Reviewers shall also have experience in evaluating measures of model fit, identification, uncertainty, and forecasting. Reviewers shall have experience in development of Biological Reference Points that includes an appreciation for the varying quality and quantity of data available to support estimation of BRPs.

Each CIE reviewer's duties shall not exceed a maximum of 15 days to complete all work tasks of the peer review described herein.

Not covered by the CIE, the SARC chair's duties should not exceed a maximum of 15 days (i.e., several days prior to the meeting for document review; the SARC meeting in Woods Hole; several days following the open meeting for SARC Summary Report preparation).

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review during the panel review meeting scheduled in Woods Hole, Massachusetts during November 29 – December 2, 2011.

Charge to SARC panel: During the SARC meeting, the panel is to determine and write down whether each stock assessment Term of Reference of the SAW (see **Annex 2**) was or was not completed successfully. To make this determination, panelists should consider whether the work provides a scientifically credible basis for developing fishery management advice. Criteria to consider include: whether the data were adequate and used properly, the analyses and models were carried out correctly, and the conclusions are correct/reasonable. Where possible, the SARC chair shall identify or facilitate agreement among the reviewers for each stock assessment Term of Reference of the SAW.

If the panel rejects any of the current Biological Reference Points (BRP) or BRP proxies (for B_{MSY} and F_{MSY} and MSY), the panel should explain why those particular BRPs or proxies are not suitable and the panel should recommend suitable alternatives. If such alternatives cannot be identified, then the panel should indicate that the existing BRPs or BRP proxies are the best available at this time.

Statement of Tasks:

1. Prior to the meeting

(SARC chair and CIE reviewers)

Review the reports produced by the Working Groups and read background reports.

Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein:

Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email, and FAX number) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and stock assessment ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, foreign national security clearance, and other information concerning pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

<u>Foreign National Security Clearance</u>: When CIE reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for CIE reviewers who are non-US citizens. For this reason, the CIE reviewers shall provide by FAX the requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/.

<u>Pre-review Background Documents</u>: Approximately two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports (i.e., working papers) for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

2. During the Open meeting

<u>Panel Review Meeting</u>: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and stock assessment ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs shall not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** Each CIE reviewer shall actively participate in a

professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the stock assessment ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

(SARC chair)
Act as chairperson, where duties include control of the meeting, coordination of presentations and discussion, making sure all stock assessment Terms of Reference of the SAW are reviewed, control of document flow, and facilitation of discussion. For each assessment, review both the Assessment Report and the draft Assessment Summary Report.

During the question and answer periods, provide appropriate feedback to the assessment scientists on the sufficiency of their analyses. It is permissible to discuss the stock assessment and to request additional information if it is needed to clarify or correct an existing analysis and if the information can be produced rather quickly.

(SARC CIE reviewers)
For each stock assessment, participate as a peer reviewer in panel discussions on assessment validity, results, recommendations, and conclusions. From a reviewer's point of view, determine whether each stock assessment Term of Reference of the SAW was completed successfully. Terms of Reference that are completed successfully are likely to serve as a basis for providing scientific advice to management. If a reviewer considers any existing Biological Reference Point or BRP proxy to be inappropriate, the reviewer should try to recommend an alternative, should one exist. Review both the Assessment Report and the draft Assessment Summary Report.

During the question and answer periods, provide appropriate feedback to the assessment scientists on the sufficiency of their analyses. It is permissible to request additional information if it is needed to clarify or correct an existing analysis and if the information can be produced rather quickly.

3. After the Open meeting

(SARC CIE reviewers)
Each CIE reviewer shall prepare an Independent CIE Report (see **Annex 1**). This report should explain whether each stock assessment Term of Reference of the SAW was or was not completed successfully during the SARC meeting, using the criteria specified above in the "Charge to SARC panel" statement.

If any existing Biological Reference Points (BRP) or their proxies are considered inappropriate, the Independent CIE Report should include recommendations and justification for suitable alternatives. If such alternatives cannot be identified, then the report should indicate that the existing BRPs are the best available at this time.

During the meeting, additional questions that were not in the Terms of Reference but that are directly related to the assessments may be raised. Comments on these questions should be included in a separate section at the end of the Independent CIE Report produced by each reviewer.

The Independent CIE Report can also be used to provide greater detail than the SARC Summary Report on specific stock assessment Terms of Reference or on additional questions raised during the meeting.

(SARC chair)
The SARC chair shall prepare a document summarizing the background of the work to be conducted as part of the SARC process and summarizing whether the process was adequate to complete the stock assessment Terms of Reference of the SAW. If appropriate, the chair will include suggestions on how to improve the process. This document will constitute the introduction to the SARC Summary Report (see **Annex 4**).

(SARC chair and CIE reviewers)
The SARC Chair, with the assistance from the CIE reviewers, will prepare the SARC Summary Report. Each CIE reviewer and the chair will discuss whether they hold similar views on each stock assessment Term of Reference and whether their opinions can be summarized into a single conclusion for all or only for some of the Terms of Reference of the SAW. For terms where a similar view can be reached, the SARC Summary Report will contain a summary of such opinions. In cases where multiple and/or differing views exist on a given Term of Reference, the SARC Summary Report will note that there is no agreement and will specify - in a summary manner – what the different opinions are and the reason(s) for the difference in opinions.

The chair's objective during this SARC Summary Report development process will be to identify or facilitate the finding of an agreement rather than forcing the panel to reach an agreement. The chair will take the lead in editing and completing this report. The chair may express the chair's opinion on each Term of Reference of the SAW, either as part of the group opinion, or as a separate minority opinion.

The SARC Summary Report (please see **Annex 4** for information on contents) should address whether each stock assessment Term of Reference of the SAW was completed successfully. For each Term of Reference, this report should state why that Term of Reference was or was not completed successfully. The Report should also include recommendations that might improve future assessments.

If any existing Biological Reference Points (BRP) or BRP proxies are considered inappropriate, the SARC Summary Report should include recommendations and justification for suitable alternatives. If such alternatives cannot be identified, then the report should indicate that the existing BRP proxies are the best available at this time.

The contents of the draft SARC Summary Report will be approved by the CIE reviewers by the end of the SARC Summary Report development process. The SARC chair will complete all final editorial and formatting changes prior to approval of the contents of the draft SARC Summary Report by the CIE reviewers. The SARC chair will then submit the approved SARC Summary Report to the NEFSC contact (i.e., SAW Chairman).

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in **Annex 1**. Each CIE reviewer shall complete the independent peer review addressing each stock assessment ToR listed in **Annex 2**.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Participate during the panel review meeting at the Woods Hole, Massachusetts during November 29 – December 2, 2011.
3) Conduct an independent peer review in accordance with this SoW and the assessment ToRs (listed in **Annex 2**).
4) No later than December 16, 2011, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and to David Sampson, CIE Regional Coordinator, via email to david.sampson@oregonstate.edu. Each CIE report shall be written using the format and content requirements specified in **Annex 1**, and address each assessment ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

24 October 2011	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
15 November 2011	NMFS Project Contact will attempt to provide CIE Reviewers the pre-review documents by this date
Nov. 29 – Dec. 2 2011	Each reviewer participates and conducts an independent peer review during the panel review meeting in Woods Hole, MA
1-2 December 2011	SARC Chair and CIE reviewers work at drafting reports during meeting at Woods Hole, MA, USA
16 December 2011	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator

19 December 2011	Draft of SARC Summary Report, reviewed by all CIE reviewers, due to the SARC Chair *
23 December 2011	SARC Chair sends Final SARC Summary Report, approved by CIE reviewers, to NEFSC contact (i.e., SAW Chairman)
30 December 2011	CIE submits CIE independent peer review reports to the COTR
6 January 2012	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

* The SARC Summary Report will not be submitted, reviewed, or approved by the CIE.

The SAW Chairman will assist the SARC chair prior to, during, and after the meeting in ensuring that documents are distributed in a timely fashion.

NEFSC staff and the SAW Chairman will make the final SARC Summary Report available to the public. Staff and the SAW Chairman will also be responsible for production and publication of the collective Working Group papers, which will serve as a SAW Assessment Report.

Modifications to the Statement of Work: Requests to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) each CIE report shall be completed with the format and content in accordance with **Annex 1**,
(2) each CIE report shall address each stock assessment ToR listed in **Annex 2**,
(3) the CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

William Michaels, Program Manager, COTR
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1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
William.Michaels@noaa.gov Phone: 301-713-2363 ext 136

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Key Personnel:

NMFS Project Contact:

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Northeast Fisheries Science Center
166 Water Street, Woods Hole, MA 02543
James.Weinberg@noaa.gov (Phone: 508-495-2352) (FAX: 508-495-2230)

Mr. Frank Almeida, Acting NEFSC Science Director
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Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of whether they accept or reject the work that they reviewed, with an explanation of their decision (strengths, weaknesses of the analyses, etc.).

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Findings of whether they accept or reject the work that they reviewed, and an explanation of their decisions (strengths, weaknesses of the analyses, etc.) for each ToR, and Conclusions and Recommendations in accordance with the ToRs. For each assessment reviewed, the report should address whether each Term of Reference of the SAW was completed successfully. For each Term of Reference, the Independent Review Report should state why that Term of Reference was or was not completed successfully. To make this determination, the SARC chair and CIE reviewers should consider whether the work provides a scientifically credible basis for developing fishery management advice.

   a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including a concise summary of whether they accept or reject the work that they reviewed, and explain their decisions (strengths, weaknesses of the analyses, etc.), conclusions, and recommendations.

   b. Reviewers should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.

   c. Reviewers should elaborate on any points raised in the SARC Summary Report that they feel might require further clarification.

   d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

   e. The CIE independent report shall be a stand-alone document for others to understand the proceedings and findings of the meeting, regardless of whether or not others read the SARC Summary Report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work
   Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2: Stock Assessment Terms of Reference for SAW/SARC53
(to be carried out by SAW Working Groups) (file vers.: 5/20/11)

A. Black sea bass

1. Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data. Evaluate available information on discard mortality and, if appropriate, update mortality rates applied to discard components of the catch. Describe the spatial and temporal distribution of fishing effort.

2. Present the survey data being used in the assessment (e.g., indices of abundance, recruitment, state surveys, age-length data, etc.). Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.

3. Consider known aspects of seasonal migration and availability of black sea bass, and investigate ways to incorporate these into the stock assessment. Based on the known aspects, evaluate whether more than one management unit should be used for black sea bass from Cape Hatteras north and, if so, propose unit delineations that could be considered by the Mid-Atlantic Fishery Management Council and for use in future stock assessments.

4. Investigate estimates of natural mortality rate, M, and if possible incorporate the results into TOR-5. Consider including sex- and age-specific rate estimates, if they can be supported by the data.

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

6. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, F_{MSY}, and MSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the appropriateness of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

7. Evaluate stock status with respect to the existing model (from the most recent accepted peer reviewed assessment) and with respect to a new model developed for this peer review.
   a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.
   b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs (from black sea bass TOR 6).

8. Develop and apply analytical approaches to conduct single and multi-year stock projections to compute the pdf (probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).
   a. Provide numerical annual projections (3-5 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment, and definition of BRPs for black sea bass).
   b. Comment on which projections seem most realistic. Consider major uncertainties in the assessment as well as the sensitivity of the projections to various assumptions.
   c. Describe this stock's vulnerability (see "Appendix to the SAW TORs") 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.

B. Cod (Gulf of Maine Stock)

1. Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data. Evaluate available information on discard mortality and, if appropriate, update mortality rates applied to discard components of the catch.

2. Present the survey data being used in the assessment (e.g., indices of abundance, recruitment, state surveys, age-length data, etc.). Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.

3. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results. Review the performance of historical projections with respect to stock size, catch recruitment and fishing mortality.

4. Perform a sensitivity analysis which examines the impact of allocation of catch to stock areas on model performance (TOR-3).

5. If time permits, consider the small-scale distribution of cod (e.g., spawning sites, resource distribution, fishing effort) in the Gulf of Maine and advise on its management implications.

6. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, F_{MSY} , and MSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the appropriateness of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

7. Evaluate stock status with respect to the existing model (from the most recent accepted peer reviewed assessment) and with respect to a new model developed for this peer review. In both cases, evaluate whether the stock is rebuilt.
    a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.
    b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs (from Cod TOR-6).

8. Develop and apply analytical approaches to conduct single and multi-year stock projections to compute the pdf (probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).
    a. Provide numerical annual projections (3-5 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).
    b. Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.
    c. Describe this stock's vulnerability (see "Appendix to the SAW TORs") 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.

Annex 2 (cont)
Appendix to the Assessment TORs:

Explanation of "Acceptable Biological Catch" (DOC Natl. Standard Guidelines, Fed. Reg., vol. 74, no. 11, 1/16/2009):

> *Acceptable biological catch (ABC)* is a level of a stock or stock complex's annual catch that accounts for the scientific uncertainty in the estimate of [overfishing limit] OFL and any other scientific uncertainty…" *(p. 3208) [In other words, OFL ≥ ABC.]*
>
> *ABC for overfished stocks.* For overfished stocks and stock complexes, a rebuilding ABC must be set to reflect the annual catch that is consistent with the schedule of fishing mortality rates in the rebuilding plan. *(p. 3209)*
>
> NMFS expects that in most cases ABC will be reduced from OFL to reduce the probability that overfishing might occur in a year. (p. 3180)
>
> ABC refers to a level of ''catch'' that is ''acceptable'' given the ''biological'' characteristics of the stock or stock complex. As such, [optimal yield] OY does not equate with ABC. The specification of OY is required to consider a variety of factors, including social and economic factors, and the protection of marine ecosystems, which are not part of the ABC concept. (p. 3189)

Explanation of "Vulnerability" (DOC Natl. Standard Guidelines, Fed. Reg., vol. 74, no. 11, 1/16/2009):

> *''Vulnerability.* A stock's vulnerability is a combination of its productivity, which depends upon its life history characteristics, and its susceptibility to the fishery. Productivity refers to the capacity of the stock to produce MSY and to recover if the population is depleted, and susceptibility is the potential for the stock to be impacted by the fishery, which includes direct captures, as well as indirect impacts to the fishery (e.g., loss of habitat quality)." (p. 3205)

Rules of Engagement among members of a SAW Assessment Working Group:

> Anyone participating in SAW assessment working group meetings that will be running or presenting results from an assessment model is expected to supply the source code, a compiled executable, an input file with the proposed configuration, and a detailed model description in advance of the model meeting. Source code for NOAA Toolbox programs is available on request. These measures allow transparency and a fair evaluation of differences that emerge between models.

Annex 2 (cont)

Appendix to the Assessment TORs (cont.):

ABC Control Rule Methods Proposed by the Mid-Atlantic Fishery Management Council:

A multi-level approach will be used for setting an ABC for each Mid-Atlantic stock, based on the overall level of scientific uncertainty associated with its assessment. The stock assessment will be required to provide estimates of the maximum fishing mortality threshold (MFMT) and future biomass, the probability distributions of these estimates, the probability distribution of the overfishing limit (OFL; level of catch that would achieve MFMT given the current or future biomass), and a description of factors considered and methods used to estimate their distributions. The multi-level approach defines four levels of overall assessment uncertainty defined by characteristics of the stock assessment and determination by the SSC that the uncertainty in the probability distribution of OFL adequately represents best available science. The procedure used to determine ABCs is different in each level of the methods framework. The SSC will determine to which level the assessment for a particular stock belongs when setting single or multi-year ABC specifications and a description of the justification for assignment to a level will be provided with the ABC recommendation. The ABC receommdations should be more precautionary as an assessment moves from level 1 to level 4. Recommendations for ABC may be made for up to 3 years for all of the managed resources except spiny dogfish which may be specified for up to 5 years. The rationale for assigning an assessment to a level will be reviewed each time an ABC determination is made.

Levels of stock assessments, characteristics, and procedures for determining ABCs are defined as follows:

Level 1: Level 1 represents the highest level to which an assessment can be assigned. Assignment of a stock to this level implies that all important sources of uncertainty are fully and formally captured in the stock assessment model and the probability distribution of the OFL calculated within the assessment provides an adequate description of uncertainty of OFL. Accordingly, the OFL distribution will be estimated directly from the stock assessment. In addition, for a stock assessment to be assigned to Level 1, the SSC must determine that the OFL probability distribution represents best available science. Examples of attributes of the stock assessment that would lead to inclusion in Level 1 are:

- Assessment model structure and any treatment of the data prior to inclusion in the model includes appropriate and necessary details of the biology of the stock, the fisheries that exploit the stock, and the data collection methods;
- Estimation of stock status and reference points integrated in the same framework such that the OFL calculations promulgate all uncertainties (stock status and reference points) throughout estimation and forecasting;
- Assessment estimates relevant quantities including F_{MSY}[1], OFL, biomass reference points, stock status, and their respective uncertainties; and
- No substantial retrospective patterns in the estimates of fishing mortality (F), biomass (B), and recruitment (R) are present in the stock assessment estimates.

The important part of Level 1 is that the precision estimated using a purely statistical routine will define the OFL probability distribution. Thus, all of the important sources of uncertainty are formally captured in the stock assessment model. When a Level 1 assessment is achieved, the assessment results are likely unbiased and fully consider uncertainty in the precision of estimates. Under Level 1, the ABC will be determined solely on the basis of an acceptable probability of overfishing (P*), determined by the Council's risk policy (see alternatives in section 5.2.2), and the probability distribution of the OFL.

Level 2: Level 2 indicates that an assessment has greater uncertainty than Level 1. Specifically, the estimation of the probability distribution of the OFL directly from the stock assessment model fails to include some important sources of uncertainty, necessitating expert judgment during the preparation of the stock assessment, and the OFL probability distribution is deemed best available science by the SSC. Examples of attributes of the stock assessment that would lead to inclusion in Level 2 are:

- Key features of the biology of the stock, the fisheries that exploit it, or the data collection methods are missing from the stock assessment;
- Assessment estimates relevant quantities, including reference points (which may be proxies) and stock status, together with their respective uncertainties, but the uncertainty is not fully promulgated through the model or some important sources may be lacking;

[1] With justification, F_{MSY} may be replaced with an alternative maximum fishing mortality threshold to define the OFL.

- Estimates of the precision of biomass, fishing mortality rates, and their respective reference points are provided in the stock assessment; and
- Accuracy of the MFMT and future biomass is estimated in the stock assessment by using *ad hoc* methods.

In this level, ABC will be determined by using the Council's risk policy (see alternatives in section 5.2.2), as with a Level 1 assessment, but with the OFL probability distribution based on the specified distribution in the stock assessment.

Level 3: Attributes of a stock assessment that would lead to inclusion in Level 3 are the same as Level 2, except that

- The assessment does not contain estimates of the probability distribution of the OFL or the probability distribution provided does not, in the opinion of the SSC, adequately reflect uncertainty in the OFL estimate.

Assessments in this level are judged to over- or underestimate the accuracy of the OFL. The SSC will adjust the distribution of the OFL and develop an ABC recommendation by applying the Council's risk policy (see alternatives in section 5.2.2) to the modified OFL probability distribution. The SSC will develop a set of default levels of uncertainty in the OFL probability distribution for this level based on literature review and a planned evaluation of ABC control rules. A control rule of 75 percent of F_{MSY} may be applied as a default if an OFL distribution cannot be developed.

Level 4: Stock assessments in Level 4 are deemed to have reliable estimates of trends in abundance and catch, but absolute abundance, fishing mortality rates, and reference points are suspect or absent. Additionally, there are limited circumstances that may not fit the standard approaches to specification of reference points and management measures set forth in these guidelines (i.e., ABC determination). In these circumstances, the SSC may propose alternative approaches for satisfying the NS1 requirements of the Magnuson-Stevens Act than those set forth in the NS1 guidelines. In particular, stocks in this level do not have point estimates of the OFL or probability distributions of the OFL that are considered best available science. In most cases, stock assessments that fail peer review or are deemed highly uncertain by the SSC will be assigned to this level. Examples of potential attributes for inclusion in this category are:

- Assessment approach is missing essential features of the biology of the stock, characteristics of data collection, and the fisheries that exploit it;
- Stock status and reference points are estimated, but are not considered reliable;
- Assessment may estimate some relevant quantities including biomass, fishing mortality or relative abundance, but only trends are deemed reliable;
- Large retrospective patterns usually present; and
- Uncertainty may or may not be considered, but estimates of uncertainty are probably substantially underestimated.

In this level, a simple control rule will be used based on biomass and catch history and the Council's risk policy.

The SSC will determine, based on the assessment level to which a stock is classified, the specifics of the control rule to specify ABC that would be expected to attain the probability of overfishing specified in the Council's risk policy. The SSC may deviate from the above control rule methods framework or level criteria and recommend an ABC that differs from the result of the ABC control rule calculation, but must provide justification for doing so.

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(END OF ANNEX 2)

APPENDIX 2:
Agenda

53rd Northeast Regional Stock Assessment Workshop (SAW 53)
Stock Assessment Review Committee (SARC) Meeting

Nov. 29 - Dec. 2, 2011

Stephen H. Clark Conference Room – Northeast Fisheries Science Center
Woods Hole, Massachusetts

AGENDA (version: 25 Nov. 2011)

TOPIC	PRESENTER(S)	SARC LEADER	RAPPORTEUR

Tuesday, Nov. 29

9:00 – 9:30 AM			
Welcome	**James Weinberg**, SAW Chair		
Introduction	**Thomas Miller**, SARC Chair		
Agenda			
Conduct of Meeting			
9:30 – 11:45 Assessment Presentation (A. GOM Cod)	**Mike Palmer**	**TBD**	**Tony Wood**
11:45 – 1 Lunch			
1 – 3 SARC Discussion w/ presenters (A. GOM Cod)	**Thomas Miller**, SARC Chair		**Tony Wood**
3 - 3:15 Break			
3:15 - 5:30 Assessment Presentation (B. Black sea bass)	**Gary Shepherd**	**TBD**	**Toni Chute/ Jessica Blaylock**

Wednesday, Nov. 30

9:30 – 11:30	SARC Discussion w/ presenters (B. Black sea bass)		
		Thomas Miller, SARC Chair	**Toni Chute/ Jessica Blaylock**
11:30 - 12:45	Lunch		
12:45 – 3:15	Revisit w/ presenters (A. GOM Cod)		
		Thomas Miller, SARC Chair	**Tony Wood**
3:15 – 3:30	Break		
3:30 – 5:00	Revisit w/ presenters (B. Black sea bass)		
		Thomas Miller, SARC Chair	**Toni Chute/ Jessica Blaylock**

(Evening Social/Dinner – Probably at BBC, Falmouth)

Thursday, Dec. 1

8:45 – 9:45	(cont.) Revisit w/ presenters (B. Black sea bass)		
		Thomas Miller, SARC Chair	**Toni Chute/ Jessica Blaylock**
9:45 - 10	Break		
10 – 12:30	Review/edit Assessment Summary Report (B. Black sea bass.)		
		Thomas Miller, SARC Chair	**Toni Chute/ Jessica Blaylock**
12:30 – 1:45	Lunch		
1:45 – 4:30	Review/edit Assessment Summary Report (A. GOM cod.)		
		Thomas Miller, SARC Chair	**Tony Wood**
4:45 – 5:30	SARC Report writing. (closed meeting)		

Friday, Dec. 2

9:00 - 4 PM (cont.) SARC Report writing. (closed meeting)

*All times are approximate, and may be changed at the discretion of the SARC chair. The meeting is open to the public, except where noted.

Annex 4: Contents of SARC Summary Report

1. The main body of the report shall consist of an introduction prepared by the SARC chair that will include the background, a review of activities and comments on the appropriateness of the process in reaching the goals of the SARC. Following the introduction, for each assessment reviewed, the report should address whether each Term of Reference of the SAW Working Group was completed successfully. For each Term of Reference, the SARC Summary Report should state why that Term of Reference was or was not completed successfully.

   To make this determination, the SARC chair and CIE reviewers should consider whether the work provides a scientifically credible basis for developing fishery management advice. Scientific criteria to consider include: whether the data were adequate and used properly, the analyses and models were carried out correctly, and the conclusions are correct/reasonable.
   If the CIE reviewers and SARC chair do not reach an agreement on a Term of Reference, the report should explain why. It is permissible to express majority as well as minority opinions.

   The report may include recommendations on how to improve future assessments.

2. If any existing Biological Reference Points (BRP) or BRP proxies are considered inappropriate, include recommendations and justification for alternatives. If such alternatives cannot be identified, then indicate that the existing BRPs or BRP proxies are the best
   available at this time.

3. The report shall also include the bibliography of all materials provided during the SAW, and any papers cited in the SARC Summary Report, along with a copy of the CIE Statement of Work.

   The report shall also include as a separate appendix the assessment Terms of Reference used for the SAW, including any changes to the Terms of Reference or specific topics/issues directly related to the assessments and requiring Panel advice.

Northeast Fisheries Science Center Reference Document 12-03

53rd Northeast Regional Stock Assessment Workshop (53rd SAW)

Assessment Summary Report

by the Northeast Fisheries Science Center

January 2012

Northeast Fisheries Science Center Reference Document 12-03

53rd Northeast Regional Stock Assessment Workshop (53rd SAW)

Assessment Summary Report

by the Northeast Fisheries Science Center
NOAA National Marine Fisheries Service
Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543

US DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts

January 2012

Northeast Fisheries Science Center Reference Documents

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Information Quality Act Compliance: In accordance with section 515 of Public Law 106-554, the Northeast Regional Office completed both technical and policy reviews for this report. These predissemination reviews are on file at the Northeast Regional Office.

This document may be cited as:

Northeast Fisheries Science Center. 2012. 53rd Northeast Regional Stock Assessment Workshop (53rd SAW) Assessment Summary Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 12-03; 33 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/nefsc/publications/

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SAW-53 ASSESSMENT SUMMARY REPORT

Introduction

The 53rd SAW Assessment Summary Report contains summary and detailed technical information on two stock assessments reviewed during November 29 to December 2, 2011 at the Stock Assessment Workshop (SAW) by the 53rd Stock Assessment Review Committee (SARC-53): Gulf of Maine Atlantic cod (*Gadus morhua*) and black sea bass (*Centropristis striata*). The SARC-53 consisted of 3 external, independent reviewers appointed by the Center for Independent Experts [CIE], and an external SARC chairman from the MAFMC SSC. The SARC evaluated whether each Term of Reference (listed in the Appendix) was completed successfully based on whether the work provided a scientifically credible basis for developing fishery management advice. The reviewers' reports for SAW/SARC-53 are available at website: http://www.nefsc.noaa.gov/nefsc/saw/ under the heading "SARC 53 Panelist Reports".

An important aspect of any assessment is the determination of current stock status. The status of the stock relates to both the rate of removal of fish from the population – the exploitation rate – and the current stock size. The exploitation rate is the proportion of the stock alive at the beginning of the year that is caught during the year. When that proportion exceeds the amount specified in an overfishing definition, overfishing is occurring. Fishery removal rates are usually expressed in terms of the instantaneous fishing mortality rate, F, and the maximum removal rate is denoted as $F_{THRESHOLD.}$

Another important factor for classifying the status of a resource is the current stock level, for example, spawning stock biomass (SSB) or total stock biomass (TSB). Overfishing definitions, therefore, characteristically include specification of a minimum biomass threshold as well as a maximum fishing threshold. If the biomass of a stock falls below the biomass threshold ($B_{THRESHOLD}$) the stock is in an overfished condition. The Sustainable Fisheries Act mandates that a stock rebuilding plan be developed should this situation arise.

As there are two dimensions to stock status – the rate of removal and the biomass level – it is possible that a stock not currently subject to overfishing in terms of exploitation rates is in an overfished condition, that is, has a biomass level less than the threshold level. This may be due to heavy exploitation in the past, or a result of other factors such as unfavorable environmental conditions. In this case, future recruitment to the stock is very important and the probability of improvement may increase greatly by increasing the stock size. Conversely, fishing down a stock that is at a high biomass level should generally increase the long-term sustainable yield. Stocks under federal jurisdiction are managed on the basis of maximum sustainable yield (MSY). The biomass that produces this yield is called B_{MSY} and the fishing mortality rate that produces MSY is called F_{MSY}.

Given this, federally managed stocks under review are classified with respect to current overfishing definitions. A stock is overfished if its current biomass is below $B_{THRESHOLD}$ and overfishing is occurring if current F is greater than $F_{THRESHOLD.}$ The table below depicts status criteria.

		BIOMASS		
		B < $B_{THRESHOLD}$	$B_{THRESHOLD}$ < B < B_{MSY}	B > B_{MSY}
EXPLOITATION RATE	F>$F_{THRESHOLD}$	Overfished, overfishing is occurring; reduce F, adopt and follow rebuilding plan	Not overfished, overfishing is occurring; reduce F, rebuild stock	F = F_{TARGET} <= F_{MSY}
	F<$F_{THRESHOLD}$	Overfished, overfishing is not occurring; adopt and follow rebuilding plan	Not overfished, overfishing is not occurring; rebuild stock	F = F_{TARGET} <= F_{MSY}

Fisheries management may take into account scientific and management uncertainty and overfishing guidelines often include a control rule in the overfishing definition. Generically, the control rules suggest actions at various levels of stock biomass and incorporate an assessment of risk, in that F targets are set so as to avoid exceeding F thresholds.

Outcome of Stock Assessment Review Meeting

Based on the Review Panel reports (available at http://www.nefsc.noaa.gov/nefsc/saw/ under the heading "SARC 53 Panelist Reports"), the SARC review panel concluded that the results of the **Gulf of Maine cod** assessment can serve as a scientific basis for fishery management of this stock. All terms of reference for this stock assessment were fully met. Both catch and survey data were fully and adequately summarized. The newly developed statistical catch at age model (ASAP) was appropriately applied to the data and the time series of abundance and fishing mortality estimated from the model represent the best scientific estimates available for this stock. In particular, the Panel agrees that the 2005 cod year class in the Gulf of Maine was less strong than suggested by analyses conducted for a prior assessment. The Panel did not accept the proposed revision of the reference points from $F_{40\%}$ to $F_{35\%}$ that were recommended during the assessment review, but rather recommended the continued use of $F_{40\%}$ as the basis for biological reference point proxies. However, regardless of which reference point is selected, results indicate that the Gulf of Maine cod stock is overfished and is experiencing overfishing. Stock projections provided at the SARC-53 meeting indicate that the stock will not be rebuilt by 2014.

The Review Panel unanimously rejected the newly proposed statistical catch at age stock assessment model (ASAP) for **black sea bass** and concluded that it did not provide a suitable scientific basis for management of this stock. The Panel identified substantial concerns over the potential for spatial structure and incomplete mixing within the stock area that compromised the ability of the forward projecting catch at age model to index abundance and fishing mortality reliably based on the data available. Based on the biological reference points and assessment as approved at the Data Poor Species Workshop in 2007, black sea bass is not overfished and overfishing is not occurring. The SARC-53 panel suggested that the assessment team continue to consider alternative methods for assessing the black sea bass stock, perhaps continuing with age-based methods, although achieving a new framework should not be expected in the short term.

Glossary

ADAPT. A commonly used form of computer program used to optimally fit a Virtual Population Assessment (VPA) to abundance data.

ASAP. The Age Structured Assessment Program 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 relaxed by allowing for fleet-specific computations and by allowing the selectivity at age to change smoothly over time or in blocks of years. The software can also allow the catchability associated with each abundance index to vary smoothly with time. The problem's dimensions (number of ages, years, fleets and abundance indices) are defined at input and limited by hardware only. The input is arranged assuming data is available for most years, but missing years are allowed. The model currently does not allow use of length data nor indices of survival rates. Diagnostics include index fits, residuals in catch and catch-at-age, and effective sample size calculations. Weights are input for different components of the objective function and allow for relatively simple age-structured production model type models up to fully parameterized models.

ASPM. Age-structured production models, also known as statistical catch-at-age (SCAA) models, are a technique of stock assessment that integrate fishery catch and fishery-independent sampling information. The procedures are flexible, allowing for uncertainty in the absolute magnitudes of catches as part of the estimation. Unlike virtual population analysis (VPA) that tracks the cumulative catches of various year classes as they age, ASPM is a forward projection simulation of the exploited population. ASPM is similar to the NOAA Fishery Toolbox applications ASAP (Age Structured Assessment Program) and SS2 (Stock Synthesis 2)

Availability. Refers to the distribution of fish of different ages or sizes relative to that taken in the fishery.

Biological reference points. Specific values for the variables that describe the state of a fishery system which are used to evaluate its status. Reference points are most often specified in terms of fishing mortality rate and/or spawning stock biomass. The reference points may indicate 1) a desired state of the fishery, such as a fishing mortality rate that will achieve a high level of sustainable yield, or 2) a state of the fishery that should be avoided, such as a high fishing mortality rate which risks a stock collapse and long-term loss of potential yield. The former type of reference points are referred to as "target reference points" and the latter are referred to as "limit reference points" or "thresholds". Some common examples of reference points are $F_{0.1}$, F_{MAX}, and F_{MSY}, which are defined later in this glossary.

B_0. Virgin stock biomass, i.e., the long-term average biomass value expected in the absence of fishing mortality.

B_{MSY}. Long-term average biomass that would be achieved if fishing at a constant fishing mortality rate equal to F_{MSY}.

Biomass Dynamics Model. A simple stock assessment model that tracks changes in stock using assumptions about growth and can be tuned to abundance data such as commercial catch rates, research survey trends or biomass estimates.

Catchability. Proportion of the stock removed by one unit of effective fishing effort (typically age-specific due to differences in selectivity and availability by age).

Control Rule. Describes a plan for pre-agreed management actions as a function of variables related to the status of the stock. For example, a control rule can specify how F or yield should vary with biomass. In the National Standard Guidelines (NSG), the "MSY control rule" is used to determine the limit fishing mortality, or Maximum Fishing Mortality Threshold (MFMT). Control rules are also known as "decision rules" or "harvest control laws."

Catch per Unit of Effort (CPUE). Measures the relative success of fishing operations, but also can be used as a proxy for relative abundance based on the assumption that CPUE is linearly related to stock size. The use of CPUE that has not been properly standardized for temporal-spatial changes in catchability should be avoided.

Exploitation pattern. The fishing mortality on each age (or group of adjacent ages) of a stock relative to the highest mortality on any age. The exploitation pattern is expressed as a series of values ranging from 0.0 to 1.0. The pattern is referred to as "flat-topped" when the values for all the oldest ages are about 1.0, and "dome-shaped" when the values for some intermediate ages are about 1.0 and those for the oldest ages are significantly lower. This pattern often varies by type of fishing gear, area, and seasonal distribution of fishing, and the growth and migration of the fish. The pattern can be changed by modifications to fishing gear, for example, increasing mesh or hook size, or by changing the proportion of harvest by gear type.

Mortality rates. Populations of animals decline exponentially. This means that the number of animals that die in an "instant" is at all times proportional to the number present. The decline is defined by survival curves such as: $N_{t+1} = N_t e^{-z}$

where N_t is the number of animals in the population at time t and N_{t+1} is the number present in the next time period; Z is the total instantaneous mortality rate which can be separated into deaths due to fishing (fishing mortality or F) and deaths due to all other causes (natural mortality or M) and e is the base of the natural logarithm (2.71828).To better understand the concept of an instantaneous mortality rate, consider the following example. Suppose the instantaneous total mortality rate is 2 (i.e., Z = 2) and we want to know how many animals out of an initial population of 1 million fish will be alive at the end of one year. If the year is apportioned into 365 days (that is, the 'instant' of time is one day), then 2/365 or 0.548% of the population will die each day. On the first day of the year, 5,480 fish will die (1,000,000 x 0.00548), leaving 994,520 alive. On day 2, another 5,450 fish die (994,520 x 0.00548) leaving 989,070 alive. At the end of the year, 134,593 fish [$1,000,000 \times (1 - 0.00548)^{365}$] remain alive. If, we had instead selected a smaller 'instant' of time, say an hour, 0.0228% of the population would have died by the end of the first time interval (an hour), leaving 135,304 fish alive at the end of the year [$1,000,000 \times (1 - 0.00228)^{8760}$]. As the instant of time becomes shorter and shorter, the exact answer to the number of animals surviving is given by the survival curve mentioned above, or, in this example:

$N_{t+1} = 1,000,000e^{-2} = 135,335$ fish

Exploitation rate. The proportion of a population alive at the beginning of the year that is caught during the year. That is, if 1 million fish were alive on January 1 and 200,000 were caught during the year, the exploitation rate is 0.20 (200,000 / 1,000,000) or 20%.

F_{MAX}. The rate of fishing mortality that produces the maximum level of yield per recruit. This is the point beyond which growth overfishing begins.

$F_{0.1}$. The fishing mortality rate where the increase in yield per recruit for an increase in a unit of effort is only 10% of the yield per recruit produced by the first unit of effort on the unexploited stock (i.e., the slope of the yield-per-recruit curve for the $F_{0.1}$ rate is only one-tenth the slope of the curve at its origin).

$F_{10\%}$. The fishing mortality rate which reduces the spawning stock biomass per recruit (SSB/R) to 10% of the amount present in the absence of fishing. More generally, Fx%, is the fishing mortality rate that reduces the SSB/R to x% of the level that would exist in the absence of fishing.

F_{MSY}. The fishing mortality rate that produces the maximum sustainable yield.

Fishery Management Plan (FMP). Plan containing conservation and management measures for fishery resources, and other provisions required by the MSFCMA, developed by Fishery Management Councils or the Secretary of Commerce.

Generation Time. In the context of the National Standard Guidelines, generation time is a measure of the time required for a female to produce a reproductively-active female offspring for use in setting maximum allowable rebuilding time periods.

Growth overfishing. The situation existing when the rate of fishing mortality is above F_{MAX} and when fish are harvested before they reach their growth potential.

Limit Reference Points. Benchmarks used to indicate when harvests should be constrained substantially so that the stock remains within safe biological limits. The probability of exceeding limits should be low. In the National Standard Guidelines, limits are referred to as thresholds. In much of the international literature (e.g., FAO documents), "thresholds" are used as buffer points that signal when a limit is being approached.

Landings per Unit of Effort (LPUE). Analogous to CPUE and measures the relative success of fishing operations, but is also sometimes used a proxy for relative abundance based on the assumption that CPUE is linearly related to stock size.

MSFCMA. (Magnuson-Stevens Fishery Conservation and Management Act). U.S. Public Law 94-265, as amended through October 11, 1996. Available as NOAA Technical Memorandum NMFS-F/SPO-23, 1996.

Maximum Fishing Mortality Threshold (MFMT, $F_{THRESHOLD}$). One of the Status Determination Criteria (SDC) for determining if overfishing is occurring. It will usually be equivalent to the F corresponding to the MSY Control Rule. If current fishing mortality rates are above $F_{THRESHOLD}$, overfishing is occurring.

Minimum Stock Size Threshold (MSST, $B_{THRESHOLD}$). Another of the Status Determination Criteria. The greater of (a) ½B_{MSY}, or (b) the minimum stock size at which rebuilding to B_{MSY} will occur within 10 years of fishing at the MFMT. MSST should be measured in terms of spawning biomass or other appropriate measures of productive capacity. If current stock size is below $B_{THRESHOLD}$, the stock is overfished.

Maximum Spawning Potential (MSP). This type of reference point is used in some fishery management plans to define overfishing. The MSP is the spawning stock biomass per recruit (SSB/ R) when fishing mortality is zero. The degree to which fishing reduces the SSB/R is expressed as a percentage of the MSP (i.e., %MSP). A stock is considered overfished when the fishery reduces the %MSP below the level specified in the overfishing definition. The values of %MSP used to define overfishing can be derived from stock-recruitment data or chosen by analogy using available information on the level required to sustain the stock.

Maximum Sustainable Yield (MSY). The largest average catch that can be taken from a stock under existing environmental conditions.

Overfishing. According to the National Standard Guidelines, "overfishing occurs whenever a stock or stock complex is subjected to a rate or level of fishing mortality that jeopardizes the capacity of a stock or stock complex to produce MSY on a continuing basis." Overfishing is occurring if the MFMT is exceeded for 1 year or more.

Optimum Yield (OY). The amount of fish that will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities and taking into account the protection of marine ecosystems. MSY constitutes a "ceiling" for OY. OY may be lower than MSY, depending on relevant economic, social, or ecological factors. In the case of an overfished fishery, OY should provide for rebuilding to B_{MSY}.

Partial Recruitment. Patterns of relative vulnerability of fish of different sizes or ages due to the combined effects of selectivity and availability.

Rebuilding Plan. A plan that must be designed to recover stocks to the B_{MSY} level within 10 years when they are overfished (i.e. when B < MSST). Normally, the 10 years would refer to an expected time to rebuilding in a probabilistic sense.

Recruitment. This is the number of young fish that survive (from birth) to a specific age or grow to a specific size. The specific age or size at which recruitment is measured may correspond to when the young fish become vulnerable to capture in a fishery or when the number of fish in a cohort can be reliably estimated by a stock assessment.

Recruitment overfishing. The situation existing when the fishing mortality rate is so high as to cause a reduction in spawning stock which causes recruitment to become impaired.

Recruitment per spawning stock biomass (R/SSB). The number of fishery recruits (usually age 1 or 2) produced from a given weight of spawners, usually expressed as numbers of recruits per kilogram of mature fish in the stock. This ratio can be computed for each year class and is often used as an index of pre-recruit survival, since a high R/SSB ratio in one year indicates above-average numbers resulting from a given spawning biomass for a particular year class, and vice versa.

Reference Points. Values of parameters (e.g. B_{MSY}, F_{MSY}, $F_{0.1}$) that are useful benchmarks for guiding management decisions. Biological reference points are typically limits that should not be exceeded with significant probability (e.g., MSST) or targets for management (e.g., OY).

Risk. The probability of an event times the cost associated with the event (loss function). Sometimes "risk" is simply used to denote the probability of an undesirable result (e.g. the risk of biomass falling below MSST).

Status Determination Criteria (SDC). Objective and measurable criteria used to determine if a stock is being overfished or is in an overfished state according to the National Standard Guidelines.

Selectivity. Measures the relative vulnerability of different age (size) classes to the fishing gears(s).

Spawning Stock Biomass (SSB). The total weight of all sexually mature fish in a stock.

Spawning stock biomass per recruit (SSB/R or SBR). The expected lifetime contribution to the spawning stock biomass for each recruit. SSB/R is calculated assuming that F is constant over the life span of a year class. The calculated value is also dependent on the exploitation pattern and rates of growth and natural mortality, all of which are also assumed to be constant.

Stock Synthesis (SS). This application provides a statistical framework for calibration of a population dynamics model using a diversity of fishery and survey data. SS is designed to accommodate both age and size structure and with multiple stock sub-areas. Selectivity can be cast as age specific only, size-specific in the observations only, or size-specific with the ability to capture the major effect of size-specific survivorship. The overall model contains subcomponents which simulate the population dynamics of the stock and fisheries, derive the expected values for the various observed data, and quantify the magnitude of difference between observed and expected data. Parameters are searched for which will maximize the goodness-of-fit. A management layer is also included in the model allowing uncertainty in estimated parameters to be propagated to the management quantities, thus facilitating a description of the risk of various possible management scenarios. The structure of SS allows for building of simple to complex models depending upon the data available.

Survival Ratios. Ratios of recruits to spawners (or spawning biomass) in a stock-recruitment analysis. The same as the recruitment per spawning stock biomass (R/SSB), see above.

TAC. Total allowable catch is the total regulated catch from a stock in a given time period, usually a year.

Target Reference Points. Benchmarks used to guide management objectives for achieving a desirable outcome (e.g., OY). Target reference points should not be exceeded on average.

Uncertainty. Uncertainty results from a lack of perfect knowledge of many factors that affect stock assessments, estimation of reference points, and management. Rosenberg and Restrepo (1994) identify 5 types: measurement error (in observed quantities), process error (or natural population variability), model error (mis-specification of assumed values or model structure), estimation error (in population parameters or reference points, due to any of the preceding types of errors), and implementation error (or the inability to achieve targets exactly for whatever reason)

Virtual population analysis (VPA) (or cohort analysis). A retrospective analysis of the catches from a given year class which provides estimates of fishing mortality and stock size at each age over its life in the fishery. This technique is used extensively in fishery assessments.

Year class (or cohort). Fish born in a given year. For example, the 1987 year class of cod includes all cod born in 1987. This year class would be age 1 in 1988, age 2 in 1989, and so on.

Yield per recruit (Y/R or YPR). The average expected yield in weight from a single recruit. Y/R is calculated assuming that F is constant over the life span of a year class. The calculated value is also dependent on the exploitation pattern, rate of growth, and natural mortality rate, all of which are assumed to be constant.

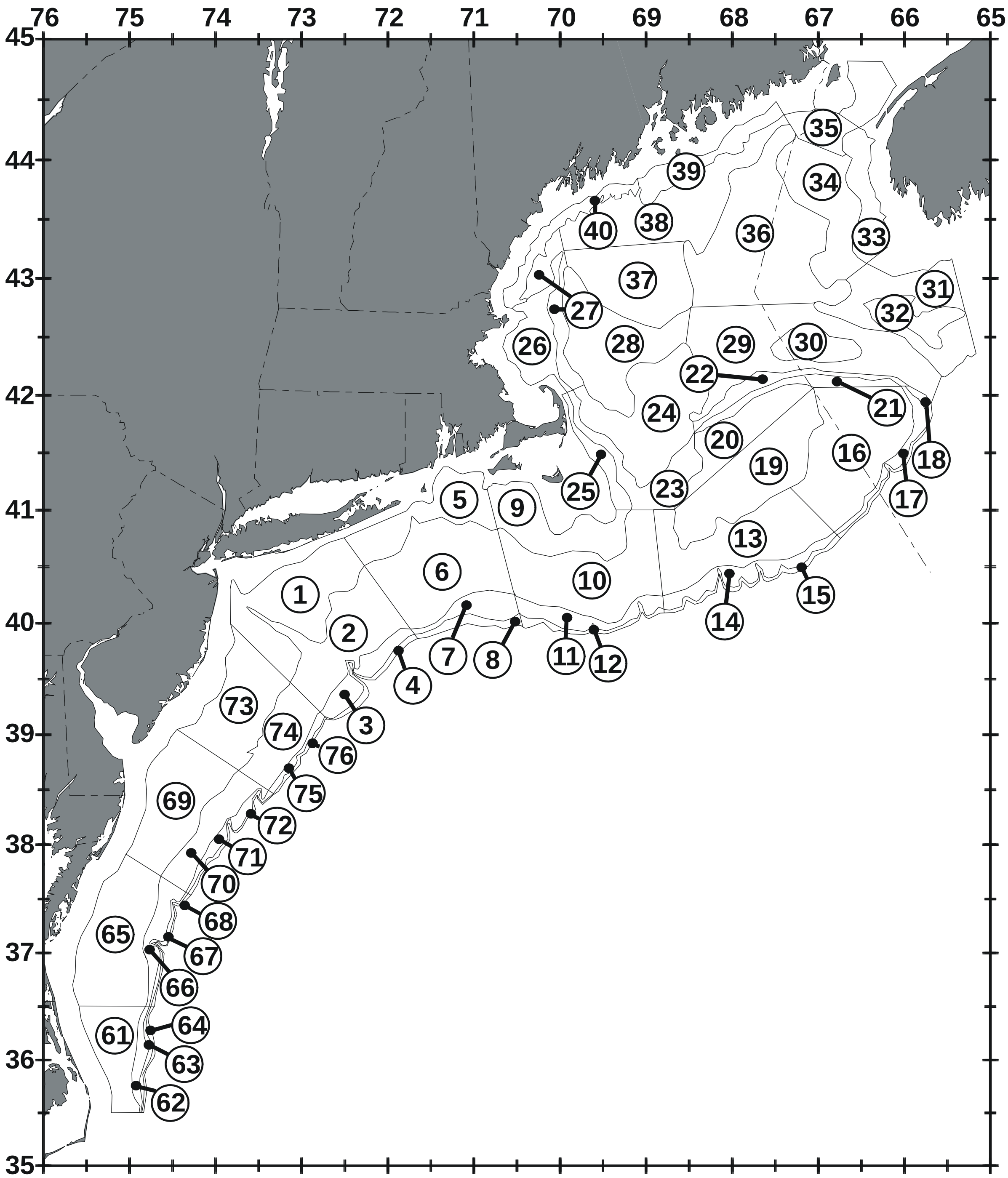


Figure 1. Offshore depth strata that have been sampled during Northeast Fisheries Science Center bottom trawl research surveys. Some of these may not be sampled presently.

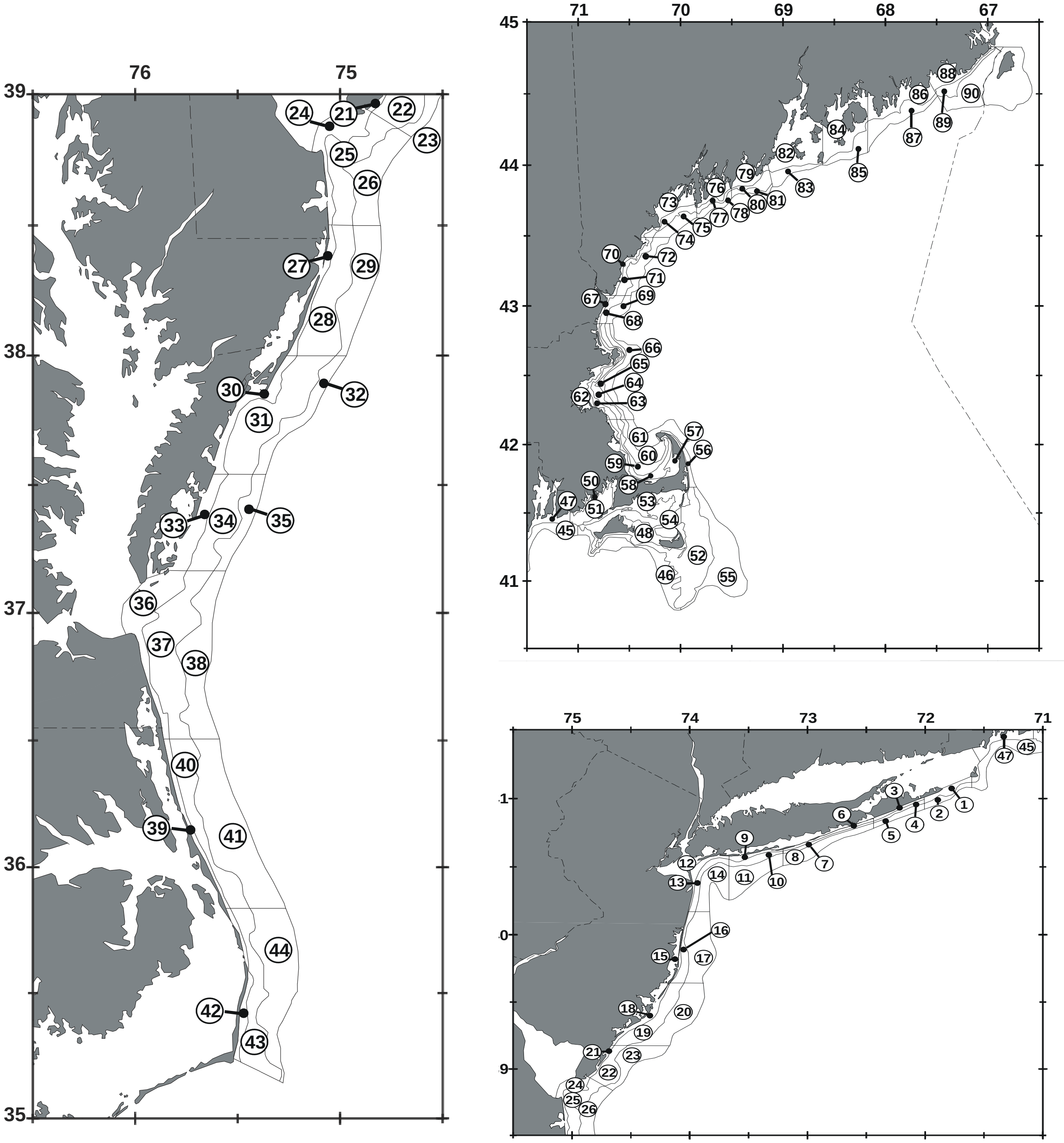
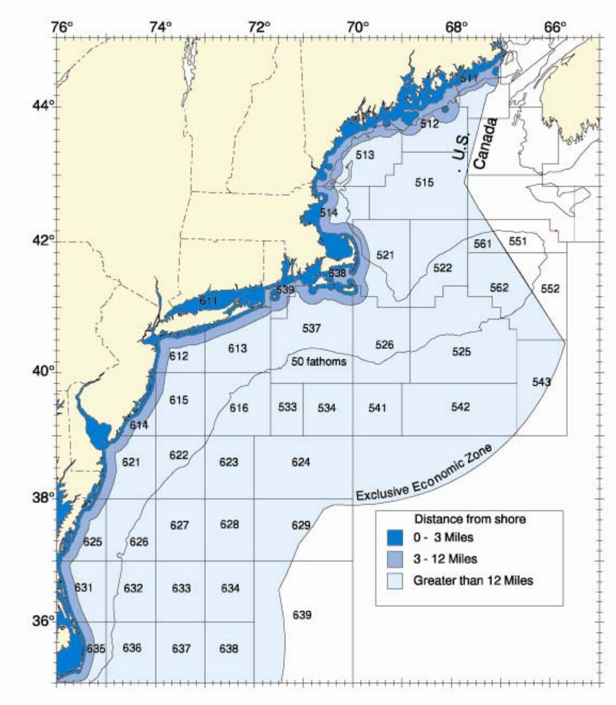


Figure 2. Inshore depth strata that have been sampled during Northeast Fisheries Science Center bottom trawl research surveys. Some of these may not be sampled presently.



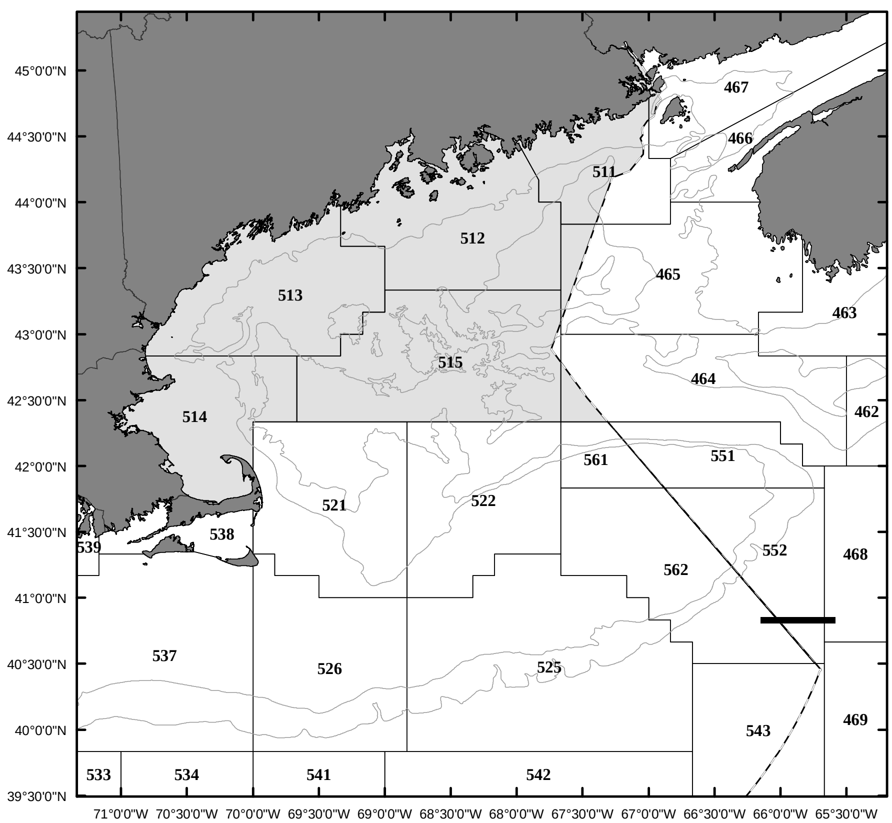


Figure 3. Statistical areas used for reporting commercial catches.

A. GULF OF MAINE COD ASSESSMENT SUMMARY FOR 2011

State of Stock: A new stock assessment model (ASAP) is proposed as the best scientific information available for determining stock status for Gulf of Maine Atlantic cod (*Gadus morhua*). Spawning stock biomass (SSB) in 2010 is estimated to be 11,868 mt and the fully recruited fishing mortality (F_{full}) is estimated to be 1.14 (Figure A1, Figure A2, Figure A3).

An MSY could not be derived directly from the ASAP model; therefore an MSY proxy must be used for reference points. $F_{40\%}$ is recommended as the proxy for F_{MSY} (the overfishing threshold). $F_{40\%}$, estimated on the fully selected age class, is 0.20. SSB_{MSY} (the biomass target) is calculated from projections at $F_{40\%}$ and is estimated to be 61,218 mt.

Comparing the current 2010 ASAP model estimates of SSB and fully recruited F to the newly accepted reference points, the Gulf of Maine cod stock is overfished and overfishing is occurring (Figure A1).

By the convention developed in GARM III, because the point estimate of current stock status with a five-year peel was within the confidence intervals of the base model (Figure A1), no correction for a retrospective pattern was used for stock status determination or applied in the stock projections.

All alternative parameterizations of the ASAP model led to the same conclusions regarding stock status. Moreover, all versions of the previously used VPA model also led to the same conclusions that the stock is overfished and overfishing is occurring.

Projections: The ASAP model results indicate that the stock is overfished and overfishing is occurring (Figure A1), and there was a moderate retrospective pattern. Projections were made for three constant F scenarios: F = 0 (no fishing), $F = 0.75*F_{MSY\ Proxy}$, and $F = F_{MSY\ Proxy}$ (Table A1). Based on the recommendations of the SARC-53 Review Panel, a revised method was used to conduct short term projections relative to the methods used in the previous GARM III assessment. Similar to the previous method, the revised projection model samples from a cumulative density function derived from ASAP estimated age-1 recruitment between 1982 and 2008. Recruitment in 2009 and 2010 was not included due to general uncertainty in terminal estimates of recruitment. Unlike, the previous method, the revised approach adjusts projected recruitment when SSB falls below some specified SSB threshold based on a linear function that declines to zero when SSB = 0 mt. This revised method provides a better representation of the risk associated with alternative management policies. Under all projection scenarios, the stock does not rebuild by the current rebuilding date of 2014.

Catch and Status Table: Gulf of Maine Atlantic cod (weights in 000s mt, recruitment in millions, arithmetic means)

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Max[1]	Min[1]	Mean[1]
Commercial landings	4.3	3.6	3.9	3.8	3.6	3.0	4.0	5.4	6.0	5.4	18.0	1.4	7.5
Commercial discards	2.0	1.8	1.0	0.9	0.4	0.5	0.3	0.5	1.0	0.2	2.2	<0.1	0.9
Recreational landings	2.7	1.7	2.2	1.6	1.8	0.8	1.1	1.6	1.7	3.5	4.8	0.3	1.9
Recreational discards	1.0	1.3	1.2	0.8	1.1	0.6	1.1	1.3	1.2	2.3	2.3	<0.1	0.6
Catch used in assessment	10.0	8.4	8.3	7.1	6.8	5.0	6.4	8.8	9.9	11.4	22.3	3.9	10.9
Spawning stock biomass	14.9	15.1	12.4	10.4	8.9	8.4	10.8	12.6	13.6	11.9	23.7	7.3	12.5
Recruitment (age 1)	1.7	7.4	2.8	8.6	5.4	9.0	6.7	6.7	5.3	4.3	33.1	1.7	8.7
$F_{5\text{-}7}$	0.69	0.59	0.72	0.70	0.84	0.62	0.59	0.74	0.77	1.10	1.44	0.49	0.85
F_{mult}	0.72	0.61	0.75	0.72	0.87	0.64	0.62	0.77	0.80	1.14	1.49	0.51	0.90

[1]Over the period 1982-2010

Stock Distribution and Identification: Within the Gulf of Maine the US EEZ splits statistical areas 464, 465 and 467. Prior to implementation of the Hague line in October 1984, United States (US) landings of fish from these statistical areas could have been either Gulf of Maine or Scotian Shelf cod. The operational definition of the stock area was changed for this assessment to be consistent with the management boundaries. Current management of Gulf of Maine cod includes catch from these areas against the fisheries ACLs. Since 1985, landings from these statistical areas have averaged less than 2% of total commercial landings. While previous assessments have not included these catches, their impact on the updated assessment is negligible.

Catches: Since 1964, catch of Gulf of Maine Atlantic cod has ranged from 3,242 mt to 22,272 mt. Recent catches over the past five years have ranged from approximately 5,000 mt to 11,000 mt. Catch estimates prior to 1981 do not include commercial discards or estimates of recreational removals. Since 1982, commercial landings have been the largest source of fishery removals, comprising 40-90% of the total catch. Commercial discards constituted a large proportion of the catch during the 1998 – 2003 period when trip limits ranged from 30-500 lb/day (13.6 – 226.8 kg/day). In the most recent five years, commercial discards have accounted for <10% of the catch (Figure A4).

Commercial discards were estimated for 1989 to 2010, and were hindcasted from 1988 back to 1982. Discard estimates ranged from 2% to 36% of catch, with an average of 9% for all years. The fleets that account for nearly all cod discards were longline, shrimp otter trawl, small-mesh otter trawl, large-mesh otter trawl, large-mesh gillnet, and extra-large mesh gillnet. Discards could not be estimated for any other commercial gear types.

Recreational catch has varied annually from a low of 574 mt in 1997 to a high of 5,795 mt in 2010. Recreational catches have constituted between 8 and 51% of total annual removals by weight, averaging 25% over the period 1982-2010. In terms of numbers of fish, estimates of recreational discards have increased from approximately 10% of recreational landings at the beginning of the time series to more than 200% of the recreational landings currently.

Discard mortality in all fleets was assumed to be 100%. The determination of stock status was not sensitive to this assumption.

Data and assessment: The previous assessment of Gulf of Maine cod was conducted with a VPA that accounted for total commercial landings, some commercial discards, and recreational landings. A new assessment model (ASAP) was developed that incorporated updated estimates of the length-weight equation, maturity at age, and weights at age. Commercial and recreational discards in all years were also included as inputs to the model.

The commercial fleet catch includes catch by all gear types, though Gulf of Maine cod are primarily caught using otter trawl and gillnet (with minor contributions from hook and line gear). Recreational catch was included for 1982 to 2010. These data were entered as a single time series of catch and catch-at-age.

Abundances (number/tow) from the NEFSC spring and fall surveys, and the MADMF spring survey (1982-2010) were used in the ASAP model along with estimated CV and annual age composition. The MADMF fall survey and the commercial landings per unit effort (LPUE) index were not included in this assessment.

Natural mortality rate was assumed to be 0.2 for all ages and years. Maturity at age was assumed constant for all years.

The assessment model was evaluated across a wide range of alternative assumptions regarding data inputs and was found to be robust to these different assumptions. In this assessment, inclusion of the discard weights at age into the overall weight at age estimates had a substantial impact on estimated model outputs. The estimated 2010 SSB ranged from 9,479 – 16,301 mt and F_{full} from 0.79 – 1.54.

Biological Reference Points: No basis was found to change the foundation of the biological reference points from the previous GARM III Assessment. $F_{40\%}$ is recommended as the proxy for the overfishing threshold (F_{MSY}). A deterministic value of $F_{40\%}$ was estimated from a spawner per recruit analysis using 2008-2010 average SSB weights, catch weights, maturity and selectivity at age. Expressed as a fully recruited fishing mortality, $F_{40\%}$ is 0.20.

Stochastic projections at $F_{40\%}$ were used to determine new recommended biomass-related reference points (SSB_{MSY} and MSY proxies). The projection methodology used to determine SSB_{MSY} and MSY proxies was identical to that used for short-term projections. The proxy for SSB_{MSY}, the B_{TARGET}, is estimated at 61,218 mt, with 5th and 95th percentiles spanning 46,905 - 81,089 mt. One half of SSB_{MSY} is proposed for $B_{THRESHOLD}$ (30,609 mt).

The proxy for MSY is 10,392 mt, with 5th and 95th percentiles spanning 7,825 - 14,146 mt. The median recruitment was 7.4 million age 1 fish, with 5th and 95th percentiles ranging from 2.9 to 17.5 million fish.

The biological reference points that had been used previously were $F_{MSY}=F_{40\%}=0.237$, $SSB_{MSY}=58{,}248$ mt, and MSY=10,014 mt.

Fishing Mortality: In 1982, the fully recruited F was 0.9, and over the next decade fishing mortality (F_{full}, also called F_{mult}) mostly increased, peaking in the early 1990s (1.10-1.49). It subsequently decreased through 1999, but has since increased to 1.14 in 2010 (Figure A5).

Biomass: The ASAP model estimates a 1982 spawning stock biomass (SSB) of 23,675 mt. Spawning biomass decreased to the time series low (7,270 mt) in 1998 (Figure A6). Spawning biomass then increased steadily through 2002, but has been fluctuating around 8,000-14,000 mt for the last eight years. Spawning biomass in 2010 is estimated to be 11,868 mt.

Total population biomass (January 1) follows the same trend as SSB (Figure A6). It has ranged from 41,575 mt in 1982 to a low of 11,885 mt in 1998. The current estimate of total biomass in 2010 is 20,589 mt.

Recruitment: Mean recruitment (age 1) was around 8.7 million fish. Strong year classes were produced in 1982, 1983, 1985, 1986, and 1987 with below average recruitment in recent years (Figure A7). The 2005 year class was believed to be very strong based on survey estimates in 2007 and 2008 (NEFSC 2008). However, as this year class recruited to the fishery and to the fishery-independent surveys, data through 2010 indicate that this year class was not as strong as previously believed, but still above the time series average.

Special Comments:

- The addition of three years of catch and survey data since the last assessment has altered the perception of the 2005 year class. Two anomalously large tows in the spring survey (2007 and 2008) produced an estimate of this year class of 23.9 million fish in the previous assessment. The additional recent observations of this year class in the surveys, and now in the catch, have revised this estimate downwards to 8.9 million fish. This has reduced estimates of stock biomass substantially.

- Previous estimates of fish weights at age were biased high as a result of their being derived only from landed catch. The current assessment re-estimated weights at age based on both the landed and discarded catch, and this has resulted in lower weights at age and lower stock biomasses.

- Based on the previous assessment (NEFSC 2008), the stock was predicted to be rebuilt by 2009-2010. The current re-evaluation of the stock indicates that this expectation was incorrect.

References:

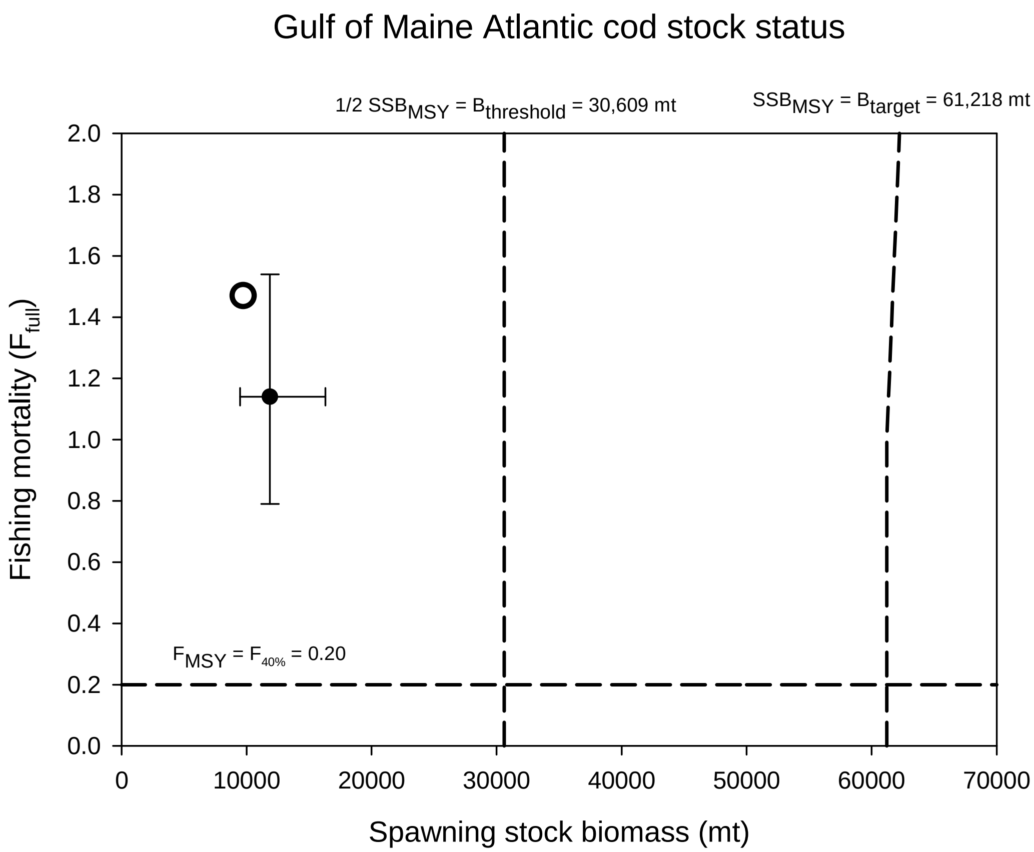
Northeast Fisheries Science Center. 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3rd Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 08-15; 884 p + xvii.

Northeast Fisheries Science Center (NEFSC). (in prep. for 2012.) 53rd Northeast Regional Stock Assessment Workshop (53rd SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc.

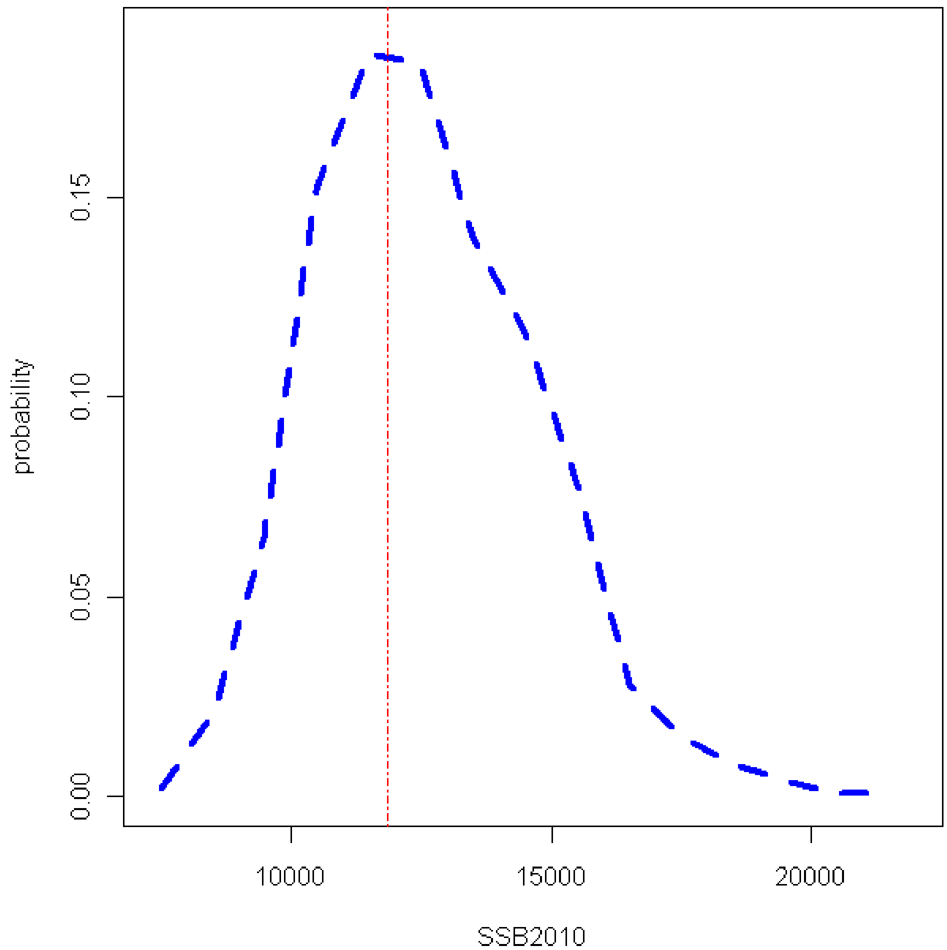
Table A1. Short term projections of total fishery yield and spawning stock biomass for Gulf of Maine Atlantic cod based on three different harvest scenarios: no fishing (F_0), fishing at 75% F_{MSY}, and fishing at F_{MSY}. The 'Unadjusted' notation indicates that these projections have not been adjusted to account for a retrospective pattern.

Total fishery yield (mt)			
	F_0	75% F_{MSY} (0.15)	F_{MSY} ($F_{40\%}$ = 0.20)
Year	*Unadjusted*	*Unadjusted*	*Unadjusted*
2011	11,392	11,392	11,392
2012	0	1,001	1,313
2013	0	1,746	2,232
2014	0	2,780	3,482
2015	0	3,740	4,584
2016	0	4,629	5,562
2017	0	5,526	6,541
2018	0	6,399	7,469
2019	0	7,115	8,213
2020	0	7,682	8,777
2021	0	8,133	9,202
2022	0	8,508	9,560
2023	0	8,781	9,811
2024	0	8,972	9,981
2025	0	9,116	10,100

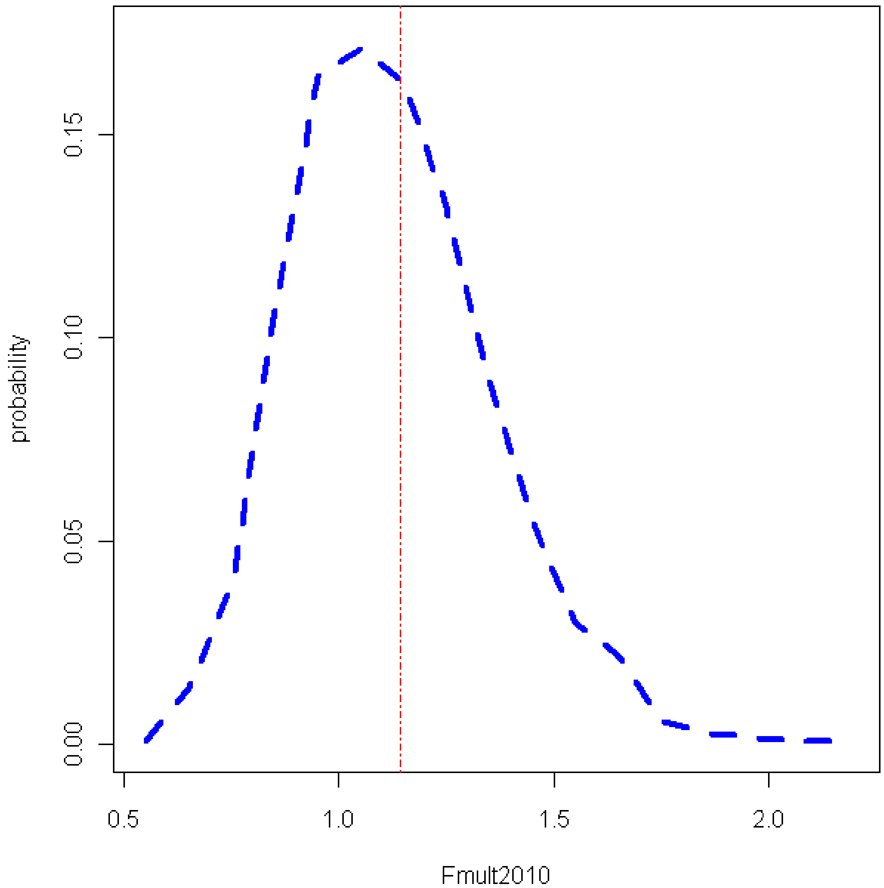
Spawning stock biomass (mt)			
	F_0	75% F_{MSY} (0.15)	F_{MSY} ($F_{40\%}$ = 0.20)
Year	*Unadjusted*	*Unadjusted*	*Unadjusted*
2011	8,178	8,178	8,178
2012	7,069	6,894	6,834
2013	13,073	11,838	11,463
2014	21,656	18,311	17,363
2015	31,565	24,809	23,014
2016	42,701	31,286	28,405
2017	55,765	38,067	33,884
2018	70,054	44,968	39,337
2019	85,801	51,811	44,599
2020	99,450	57,382	48,761
2021	110,811	61,576	51,821
2022	121,689	65,347	54,534
2023	130,611	68,136	56,370
2024	138,032	70,219	57,820
2025	144,000	71,759	58,819



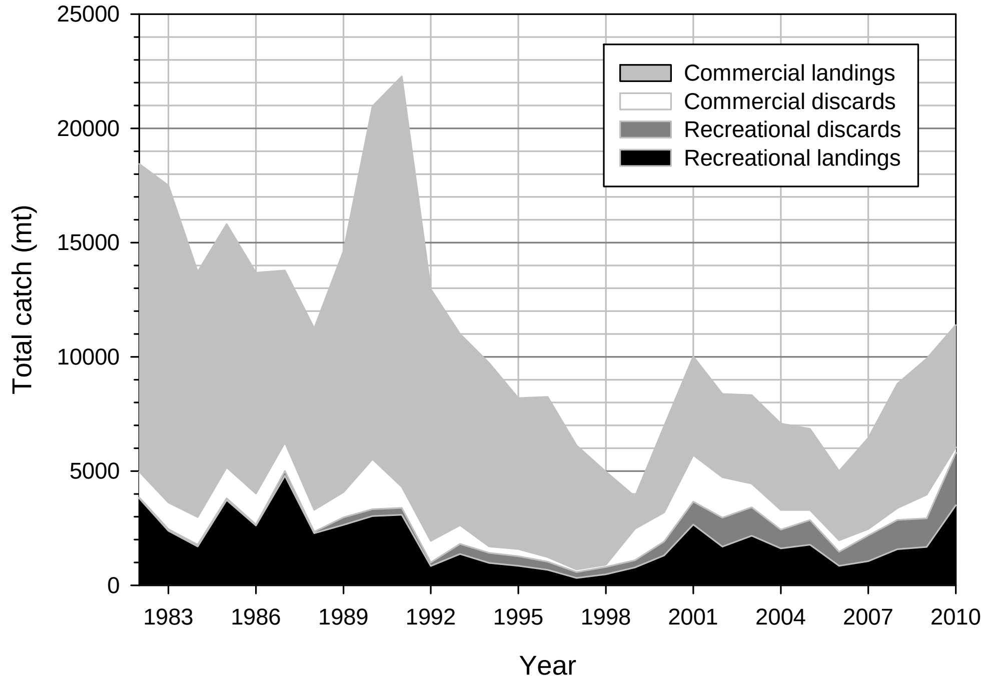
A1. Stock status based on estimates of F and SSB for 2010 for Gulf of Maine Atlantic cod with respect to biological reference points (solid circle); error bars represent 90% confidence intervals. The figure also shows fishing mortality and spawning stock biomass estimates that have been adjusted to account for retrospective pattern (open circle).



A2. MCMC distribution of the estimate of the 2010 spawning stock biomass (SSB2010) for Gulf of Maine Atlantic cod. The final year point estimate is indicated by the dashed vertical red line.

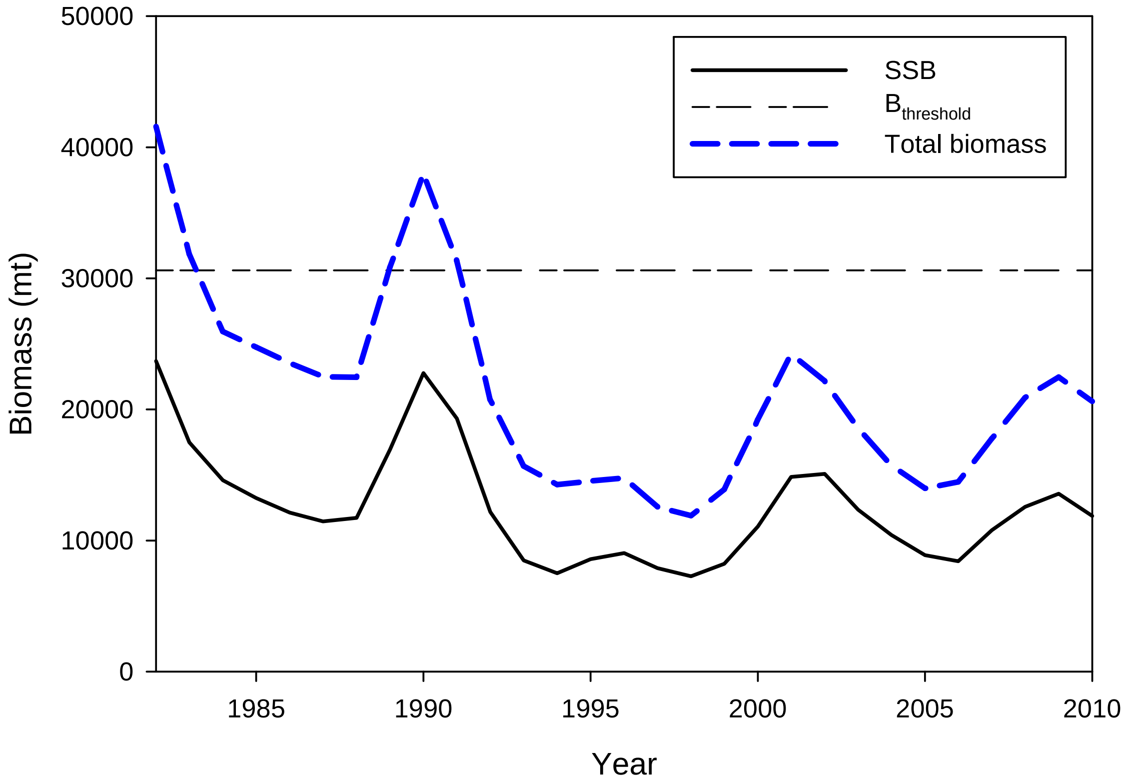


A3. MCMC distribution of the estimate of the 2010 fishing mortality for Gulf of Maine Atlantic cod (Fmult = F_{full}). The final year point estimate is indicated by the dashed vertical red line.

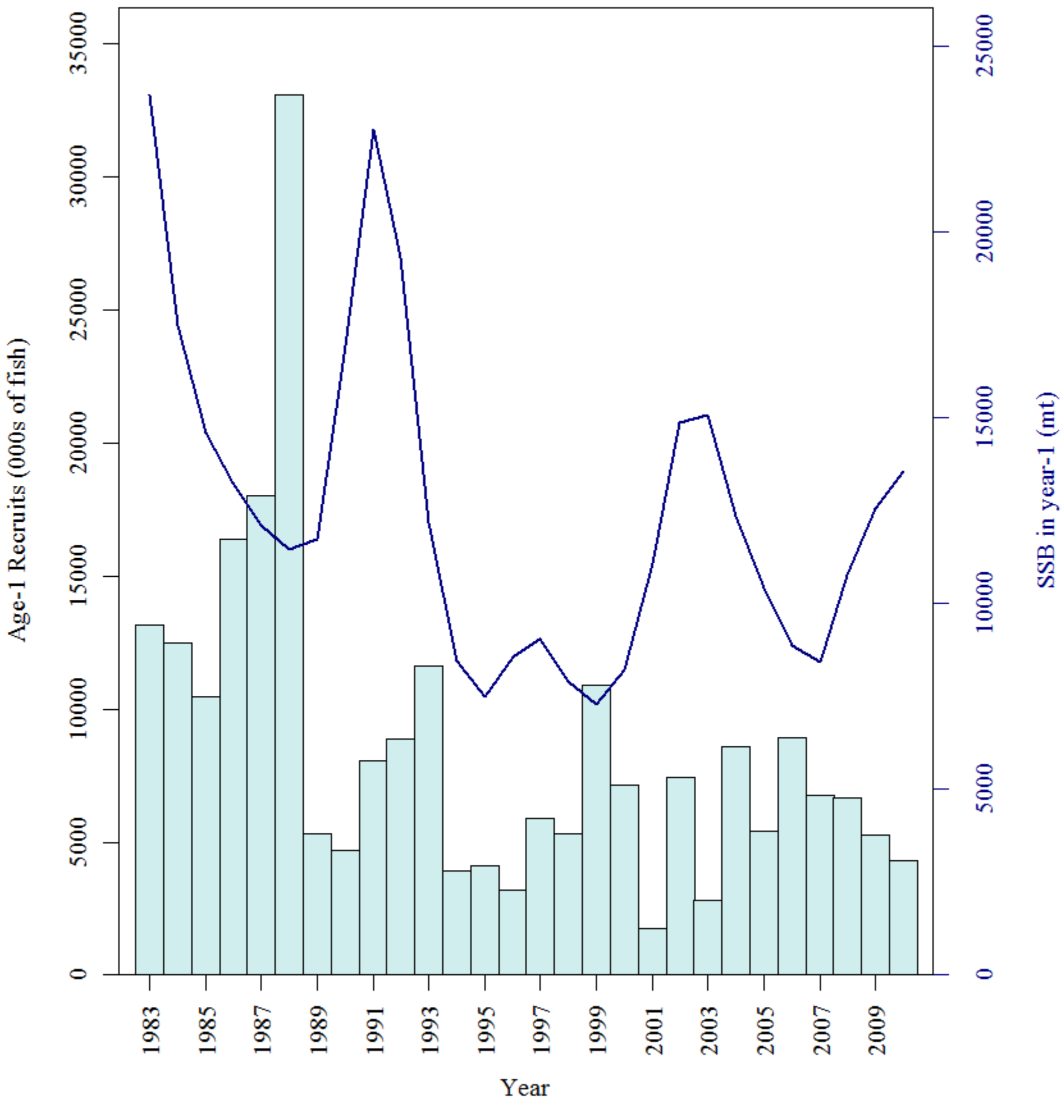


A4. Total catch of the Gulf of Maine Atlantic cod between 1982 and 2010 by fleet (commercial and recreational) and disposition (landings and discards).

A5. Estimated trends in fishing mortality (F_{full}) of Gulf of Maine Atlantic cod and associated overfishing level, $F_{Threshold}$.



A6. Estimated trends in total biomass and spawning stock biomass (SSB) of Gulf of Maine Atlantic cod and the associated overfished level, $SSB_{threshold}$.



A7. Time series plot of Gulf of Maine Atlantic cod spawning stock biomass in year t-1 (SSB, solid line) and recruitment of age-1 fish in year t (solid bars).

B. BLACK SEA BASS ASSESSMENT SUMMARY FOR 2011

State of Stock:

The SARC-53 Review Panel did not believe that the new statistical catch at age model (ASAP) for black sea bass (*Centropristis striata*) brought forward to SARC-53 provided a sound scientific basis for management.

The last approved stock assessment model – a statistical catch at length (SCALE) model was approved at the Data Poor Working Group meeting in December 2008 (NEFSC 2009a, 2009b) and has been updated annually in support of management. The SCALE model was most recently used in June and July 2011 (MAFMC 2011; NEFSC 2011) to estimate the status of the stock compared to previously accepted reference points. Based on that analysis, a comparison of 2010 estimates of the spawning stock biomass and fishing mortality rate to existing biological reference points (SSB_{MSY} proxy estimate = 12,537 mt [27.6 million lbs] and F_{MSY} proxy estimate = 0.42) indicated that black sea bass was not overfished and overfishing was not occurring. SSB in 2010 was estimated to be 13,926 mt (30.7 million lbs) and the fully selected F was estimated to be 0.41. The 2010 stock was at 111% of the SSB_{MSY} proxy. Based on deterministic projections for 2012 at the F_{MSY} proxy (0.42), the resulting catch would be 3,551 mt (7.8 million lbs) with landings equal to 2,841 mt (6.3 million lbs) (assuming the release mortality rate that was used in June 2011).

Catch and Status Table: Black Sea Bass (mt)

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Min	Max	Mean
Commercial landings1	1,299	1,587	1,359	1,405	1,298	1,285	1,037	875	523	751	523	1,635	1,221
Commercial discard1	187	24	58	370	29	16	57	37	165	110	16	483	103
Recreational landings1	1,545	1,983	1,498	762	852	898	1,011	713	1,049	1,351	519	2,815	1,341
Recreational discards1	309	391	314	142	150	173	220	252	228	231	33	391	147
Catch used in assessment1	3,340	3,985	3,230	2,679	2,330	2,372	2,326	1,877	1,965	2,444	1,877	3,985	2,812
Commercial quota (mt)	1,372	1,511	1,511	1,778	1,823	1,778	1,111	938	511	1,066	511	1,823	1,347
Recreational harvest limit (mt)	1,428	1,573	1,573	1,851	1,897	1,851	1,157	975	975	830	830	1,897	1,415

1: Over the period 1984-2010

Stock Distribution and Identification:

The Mid-Atlantic Fishery Management Council (MAFMC) and Atlantic States Marine Fisheries Commission (ASMFC) Fishery Management Plan for black sea bass defines the management unit as all black sea bass from Cape Hatteras, North Carolina northeast to the US-Canada border (MAFMC 1999).

Catch:

The principal gears used in commercial fishing for black sea bass are fish pots, otter trawl and hand-line. After peaking at 9,900 mt (21.8 million lbs) in 1952, commercial landings markedly decreased during the 1960s, and have since ranged between about 600 (1.3 million lbs) and 2,000 mt (4.4 million lbs) (Figure B1). Commercial landings averaged 1,300 mt (2.9 million lbs) annually during 1988-1997. Commercial fishery quotas were implemented in 1998, and landings then ranged between 1,300 mt (2.9 million lbs) and 1,600 mt (3.5 million lbs) during 1998-2007. Recent quota restrictions resulted in declining commercial landings of 523 (1.2 million lbs) and 751 mt (1.7 million lbs) in 2009 and 2010, respectively. The recreational rod-and-reel fishery for black sea bass harvests a significant proportion of the total catch. After peaking in 1986, recreational landings averaged 1,700 mt (3.7 million lbs) annually during

1988-1997. Recreational fishery harvest limits were implemented in 1998, and landings then ranged between 500 mt (1.1 million lbs) and 2,000 mt (4.4 million lbs) during 1998-2010. Landings in 2010 were 1,350 mt (3.0 million lbs). Commercial fishery discards, although poorly estimated, appear to be a minor part of the total fishery removals from the stock, generally less than 200 mt (0.4 million lbs) per year. Recreational discards, assuming 15% hook and release mortality, are similar ranging from 30 (0.01 million lbs) to 390 mt (0.9 million lbs) per year.

Data and Assessment:
The age-structured model presented to the SARC-53 Review Panel was rejected. The last previously approved peer reviewed assessment model was a statistical catch at length model.

Biological Reference Points:
The 2008 DPSWG Peer Review Panel (NEFSC 2009a) recommended that F40% be used as a proxy for the FMSY overfishing threshold reference point and spawning stock biomass at F40% (SSB40%) be used as the proxy for the stock biomass target reference point. Estimates of the BRPs are F40% = 0.42, SSB40% = 12,537 mt (27.6 million lbs), and MSY = 3,903 mt (8.6 million lbs).

Ecosystem Considerations:
Black sea bass are a temperate reef fish utilizing natural habitats such as sponges and other soft bottom habitats, mussel beds, rocky habitats, shipwrecks and artificial reefs. Sea bass prey on small prey fishes and invertebrates and are preyed upon by sharks, skates and other predatory fishes such as weakfish, bluefish and summer flounder.

Special Comments:

The Review Panel endorses a switch to the use of an arithmetic survey index as opposed to a logarithmic survey index for use in future assessments.

Black sea bass is the only known protogynous hermaphroditic species north of Cape Hatteras, NC which is targeted by a fishery. The response of this species, as well as other hermaphroditic species, to exploitation is not fully understood.

The Review Panel notes that the work completed in preparing the ASAP model represents a considerable improvement in summarizing the information in the data.

The Review Panel felt that an age-structured approach has the potential to present a robust assessment approach for this species, even though the model brought forward in SARC-53 was not accepted. In particular, the Panel notes

- Inherent deficiencies in the data collection programs for this species limit the information available for the assessment; these issues include this species' strong association with structure during times when it is distributed in inshore regions
- There seems to be a degree of spatial structure within the managed stock that compromised the ability to fit a single age-structured model throughout the stock area.

The Review Panel recommends continuation and expansion of the current sampling programs that collect data on catch, abundance and biological characteristics of the stock including age.

The Review Panel suggests that new data, such as a species-specific survey, improved information on operational sex-ratios and information on mixing among population sub-units will likely be required to produce an assessment that provides an improved scientific basis for management.

The Review Panel notes that concerns regarding these issues will affect all black sea bass stock assessment approaches.

In considering all of these issues, the Review Panel suggest that development of an effective model is likely to require a considerable investment of additional effort and will not be achieved in the short term.

References:

Mid-Atlantic Fishery Management Council. (MAFMC). 1999. Amendment 12 to the Summer flounder, scup and black sea bass fishery management plan. Dover, DE. 398 p + appendix.

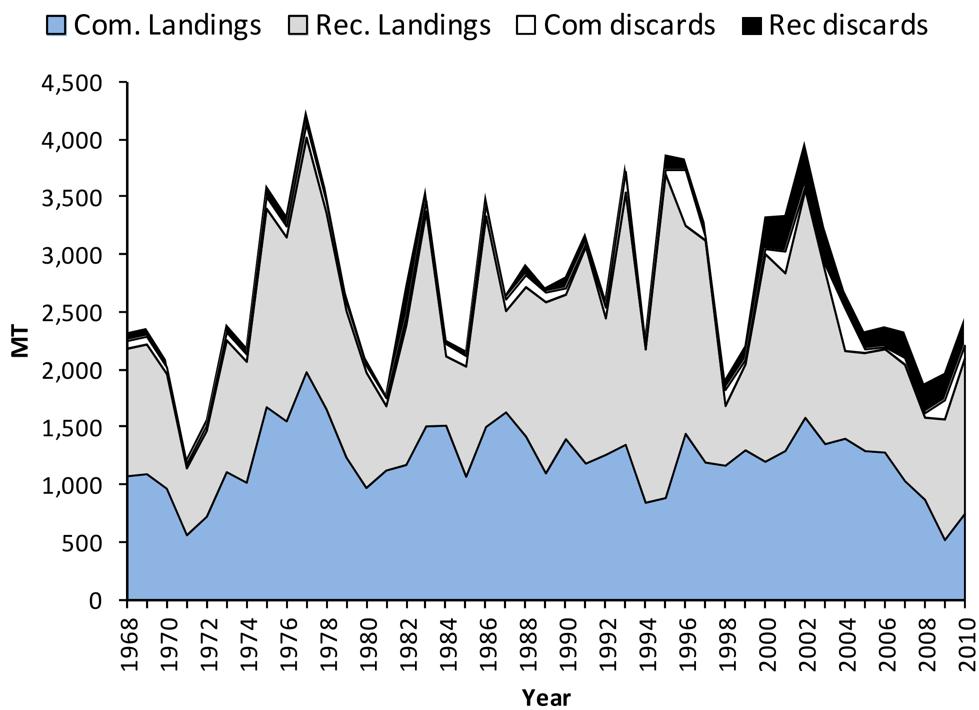
Mid-Atlantic Fishery Management Council. (MAFMC). 2011. Black Sea Bass Management Measures for 2012. MAFMC staff memorandum from Jessica Coakley to Chris Moore, dated 27 June 2011.

Northeast Fisheries Science Center (NEFSC) 2009a. Report by the Peer Review Panel for the Northeast Data Poor Stocks Working Group, 20 January 2009. 34 p.

Northeast Fisheries Science Center (NEFSC) 2009b. The Northeast Data Poor Stocks Working Group Report, December 8-12, 2008 Meeting. Part A. Skate species complex, Deep sea red crab, Atlantic wolfish, and Black sea bass. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 09-02; 496 p.

Northeast Fisheries Science Center (NEFSC) 2011. Black sea bass 2012 projection update. Unpublished manuscript by Gary Shepherd. 12 pp.

Steimle, F.W., C.A. Zetlin, P.L. Berrien and S. Chang. 1999. Essential Fish Habitat Source Document: Black Sea Bass, *Centropristis striata*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-143. 50 pp.



B1. Components of total black sea bass catch (mt) (Commercial and Recreational).

Appendix: Assessment Terms of Reference
TORs for SAW/SARC53 (Nov. 29 – Dec. 2, 2011) (file vers.: 5/20/11-b)

A. Cod (Gulf of Maine Stock)

1. Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data. Evaluate available information on discard mortality and, if appropriate, update mortality rates applied to discard components of the catch.

2. Present the survey data being used in the assessment (e.g., indices of abundance, recruitment, state surveys, age-length data, etc.). Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.

3. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results. Review the performance of historical projections with respect to stock size, catch recruitment and fishing mortality.

4. Perform a sensitivity analysis which examines the impact of allocation of catch to stock areas on model performance (TOR-3).

5. If time permits, consider the small-scale distribution of cod (e.g., spawning sites, resource distribution, fishing effort) in the Gulf of Maine and advise on its management implications.

6. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, F_{MSY} , and MSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the appropriateness of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

7. Evaluate stock status with respect to the existing model (from the most recent accepted peer reviewed assessment) and with respect to a new model developed for this peer review. In both cases, evaluate whether the stock is rebuilt.
    a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.
    b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs (from Cod TOR-6).

8. Develop and apply analytical approaches to conduct single and multi-year stock projections to compute the pdf (probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).
    a. Provide numerical annual projections (3-5 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).
    b. Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.
    c. Describe this stock's vulnerability (see "Appendix to the SAW TORs") 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.

B. Black sea bass

1. Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data. Evaluate available information on discard mortality and, if appropriate, update mortality rates applied to discard components of the catch. Describe the spatial and temporal distribution of fishing effort.

2. Present the survey data being used in the assessment (e.g., indices of abundance, recruitment, state surveys, age-length data, etc.). Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.

3. Consider known aspects of seasonal migration and availability of black sea bass, and investigate ways to incorporate these into the stock assessment. Based on the known aspects, evaluate whether more than one management unit should be used for black sea bass from Cape Hatteras north and, if so, propose unit delineations that could be considered by the Mid-Atlantic Fishery Management Council and for use in future stock assessments.

4. Investigate estimates of natural mortality rate, M, and if possible incorporate the results into TOR-5. Consider including sex- and age-specific rate estimates, if they can be supported by the data.

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

6. State the existing stock status definitions for “overfished” and “overfishing”. Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, F_{MSY}, and MSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the appropriateness of existing BRPs and the “new” (i.e., updated, redefined, or alternative) BRPs.

7. Evaluate stock status with respect to the existing model (from the most recent accepted peer reviewed assessment) and with respect to a new model developed for this peer review.
    a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.
    b. Then use the newly proposed model and evaluate stock status with respect to “new” BRPs (from black sea bass TOR 6).

8. Develop and apply analytical approaches to conduct single and multi-year stock projections to compute the pdf (probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).
    a. Provide numerical annual projections (3-5 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered

(e.g., terminal year abundance, variability in recruitment, and definition of BRPs for black sea bass).

b. Comment on which projections seem most realistic. Consider major uncertainties in the assessment as well as the sensitivity of the projections to various assumptions.
c. Describe this stock's vulnerability (see "Appendix to the SAW TORs") 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.

Appendix to the SAW TORs:

Explanation of "Acceptable Biological Catch" (DOC Natl. Standard Guidelines, Fed. Reg., vol. 74, no. 11, 1/16/2009):

> *Acceptable biological catch (ABC)* is a level of a stock or stock complex's annual catch that accounts for the scientific uncertainty in the estimate of [overfishing limit] OFL and any other scientific uncertainty…" *(p. 3208) [In other words, OFL ≥ ABC.]*
>
> *ABC for overfished stocks.* For overfished stocks and stock complexes, a rebuilding ABC must be set to reflect the annual catch that is consistent with the schedule of fishing mortality rates in the rebuilding plan. *(p. 3209)*
>
> NMFS expects that in most cases ABC will be reduced from OFL to reduce the probability that overfishing might occur in a year. (p. 3180)
>
> ABC refers to a level of ''catch'' that is ''acceptable'' given the ''biological'' characteristics of the stock or stock complex. As such, [optimal yield] OY does not equate with ABC. The specification of OY is required to consider a variety of factors, including social and economic factors, and the protection of marine ecosystems, which are not part of the ABC concept. (p. 3189)

Explanation of "Vulnerability" (DOC Natl. Standard Guidelines, Fed. Reg., vol. 74, no. 11, 1/16/2009):

> *"Vulnerability.* A stock's vulnerability is a combination of its productivity, which depends upon its life history characteristics, and its susceptibility to the fishery. Productivity refers to the capacity of the stock to produce MSY and to recover if the population is depleted, and susceptibility is the potential for the stock to be impacted by the fishery, which includes direct captures, as well as indirect impacts to the fishery (e.g., loss of habitat quality)." (p. 3205)

Rules of Engagement among members of a SAW Assessment Working Group:

> Anyone participating in SAW assessment working group meetings that will be running or presenting results from an assessment model is expected to supply the source code, a compiled executable, an input file with the proposed configuration, and a detailed model description in advance of the model meeting. Source code for NOAA Toolbox programs is available on request. These measures allow transparency and a fair evaluation of differences that emerge between models.

Appendix to the SAW TORs (cont.):

ABC Control Rule Methods Proposed by the Mid-Atlantic Fishery Management Council:

A multi-level approach will be used for setting an ABC for each Mid-Atlantic stock, based on the overall level of scientific uncertainty associated with its assessment. The stock assessment will be required to provide estimates of the maximum fishing mortality threshold (MFMT) and future biomass, the probability distributions of these estimates, the probability distribution of the overfishing limit (OFL; level of catch that would achieve MFMT given the current or future biomass), and a description of factors considered and methods used to estimate their distributions. The multi-level approach defines four levels of overall assessment uncertainty defined by characteristics of the stock assessment and determination by the SSC that the uncertainty in the probability distribution of OFL adequately represents best available science. The procedure used to determine ABCs is different in each level of the methods framework. The SSC will determine to which level the assessment for a particular stock belongs when setting single or multi-year ABC specifications and a description of the justification for assignment to a level will be provided with the ABC recommendation. The ABC recommendations should be more precautionary as an assessment moves from level 1 to level 4. Recommendations for ABC may be made for up to 3 years for all of the managed resources except spiny dogfish which may be specified for up to 5 years. The rationale for assigning an assessment to a level will be reviewed each time an ABC determination is made.

Levels of stock assessments, characteristics, and procedures for determining ABCs are defined as follows:

Level 1: Level 1 represents the highest level to which an assessment can be assigned. Assignment of a stock to this level implies that all important sources of uncertainty are fully and formally captured in the stock assessment model and the probability distribution of the OFL calculated within the assessment provides an adequate description of uncertainty of OFL. Accordingly, the OFL distribution will be estimated directly from the stock assessment. In addition, for a stock assessment to be assigned to Level 1, the SSC must determine that the OFL probability distribution represents best available science. Examples of attributes of the stock assessment that would lead to inclusion in Level 1 are:

- Assessment model structure and any treatment of the data prior to inclusion in the model includes appropriate and necessary details of the biology of the stock, the fisheries that exploit the stock, and the data collection methods;
- Estimation of stock status and reference points integrated in the same framework such that the OFL calculations promulgate all uncertainties (stock status and reference points) throughout estimation and forecasting;
- Assessment estimates relevant quantities including F_{MSY}[1], OFL, biomass reference points, stock status, and their respective uncertainties; and
- No substantial retrospective patterns in the estimates of fishing mortality (F), biomass (B), and recruitment (R) are present in the stock assessment estimates.

1 With justification, F_{MSY} may be replaced with an alternative maximum fishing mortality threshold to define the OFL.

Appendix to the SAW TORs (cont.):

The important part of Level 1 is that the precision estimated using a purely statistical routine will define the OFL probability distribution. Thus, all of the important sources of uncertainty are formally captured in the stock assessment model. When a Level 1 assessment is achieved, the assessment results are likely unbiased and fully consider uncertainty in the precision of estimates. Under Level 1, the ABC will be determined solely on the basis of an acceptable probability of overfishing (P*), determined by the Council's risk policy (see alternatives in section 5.2.2), and the probability distribution of the OFL.

Level 2: Level 2 indicates that an assessment has greater uncertainty than Level 1. Specifically, the estimation of the probability distribution of the OFL directly from the stock assessment model fails to include some important sources of uncertainty, necessitating expert judgment during the preparation of the stock assessment, and the OFL probability distribution is deemed best available science by the SSC. Examples of attributes of the stock assessment that would lead to inclusion in Level 2 are:

- Key features of the biology of the stock, the fisheries that exploit it, or the data collection methods are missing from the stock assessment;
- Assessment estimates relevant quantities, including reference points (which may be proxies) and stock status, together with their respective uncertainties, but the uncertainty is not fully promulgated through the model or some important sources may be lacking;
- Estimates of the precision of biomass, fishing mortality rates, and their respective reference points are provided in the stock assessment; and
- Accuracy of the MFMT and future biomass is estimated in the stock assessment by using *ad hoc* methods.

In this level, ABC will be determined by using the Council's risk policy (see alternatives in section 5.2.2), as with a Level 1 assessment, but with the OFL probability distribution based on the specified distribution in the stock assessment.

Level 3: Attributes of a stock assessment that would lead to inclusion in Level 3 are the same as Level 2, except that

- The assessment does not contain estimates of the probability distribution of the OFL or the probability distribution provided does not, in the opinion of the SSC, adequately reflect uncertainty in the OFL estimate.

Assessments in this level are judged to over- or underestimate the accuracy of the OFL. The SSC will adjust the distribution of the OFL and develop an ABC recommendation by applying the Council's risk policy (see alternatives in section 5.2.2) to the modified OFL probability distribution. The SSC will develop a set of default levels of uncertainty in the OFL probability distribution for this level based on literature review and a planned evaluation of ABC control rules. A control rule of 75 percent of F_{MSY} may be applied as a default if an OFL distribution cannot be developed.

Appendix to the SAW TORs (cont.):

Level 4: Stock assessments in Level 4 are deemed to have reliable estimates of trends in abundance and catch, but absolute abundance, fishing mortality rates, and reference points are suspect or absent. Additionally, there are limited circumstances that may not fit the standard approaches to specification of reference points and management measures set forth in these guidelines (i.e., ABC determination). In these circumstances, the SSC may propose alternative approaches for satisfying the NS1 requirements of the Magnuson-Stevens Act than those set forth in the NS1 guidelines. In particular, stocks in this level do not have point estimates of the OFL or probability distributions of the OFL that are considered best available science. In most cases, stock assessments that fail peer review or are deemed highly uncertain by the SSC will be assigned to this level. Examples of potential attributes for inclusion in this category are:

- Assessment approach is missing essential features of the biology of the stock, characteristics of data collection, and the fisheries that exploit it;
- Stock status and reference points are estimated, but are not considered reliable;
- Assessment may estimate some relevant quantities including biomass, fishing mortality or relative abundance, but only trends are deemed reliable;
- Large retrospective patterns usually present; and
- Uncertainty may or may not be considered, but estimates of uncertainty are probably substantially underestimated.

In this level, a simple control rule will be used based on biomass and catch history and the Council's risk policy.

The SSC will determine, based on the assessment level to which a stock is classified, the specifics of the control rule to specify ABC that would be expected to attain the probability of overfishing specified in the Council's risk policy. The SSC may deviate from the above control rule methods framework or level criteria and recommend an ABC that differs from the result of the ABC control rule calculation, but must provide justification for doing so.

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MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

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Christopher M. Moore, Ph.D.
Executive Director

MEMORANDUM

DATE: January 30, 2013

TO: Richard B. Robins, Jr., Chairman, Mid-Atlantic Fishery Management Council

FROM: Thomas Miller, Ph.D., Vice Chairman, MAFMC Scientific and Statistical Committee

Subject: Report of January 23, 2013 Meeting of the MAFMC Scientific and Statistical Committee

The Scientific and Statistical Committee (SSC) of the Mid-Atlantic Fishery Management Council (MAFMC) met on January 23, to address the request of the Council to reconsider SSCs 2013 ABC recommendation for black sea bass. This request was based on the following motion passed by the Council at its December 2012 meeting:

> *"Move that the SSC develop a 2014 black sea bass ABC recommendation for consideration by the Council at its February meeting. Also move to request that the SSC reconsider the 2013 black sea bass ABC recommendation with respect to the assessment level and Monitoring Committee recommendations for additional data to be considered."*

A total of 12 SSC members were in attendance at the SSC meeting. Two attended via a webinar but were able to hear and participate fully in discussion. One SSC member had to leave shortly after lunch, and thus only 11 members were present for the afternoon session during with we considered the ABC for black sea bass. This represents a quorum as defined by the SSC standard operating procedures (Attachment 2). Also in attendance were representatives of the MAFMC, MAFMC staff, ASMFC staff and state biologists.

Dr. John Boreman sent regrets for not being able to chair the SSC. This was an emergency meeting of the SSC and it was determined that most could attend on this day - regrettably it was one of the few days on which Dr. Boreman could not attend.

Before dealing with the Council motion, the SSC briefly discussed the need to replace Dr. Jason Link (NOAA/NEFSC) who has recently resigned from the SSC owing to his appointment at NOAA's Senior Scientist for Ecosystem Management. The SSC members present made a strong recommendation that Dr. Link's expertise should be replaced on the SSC. Specifically, it would be beneficial if a new member could be appointed with experience working with forage fish or on ecosystem processes. Recommendations will be forwarded to Dr. Boreman and Chairman Robins for consideration by the Council.

Black Sea Bass Reconsideration

The SSC discussed the foundation for the Council motion relative to its remand policy, believing that the Council's motion was effectively a remand request. The SSC found no evidence that (a) the SSC had failed to follow the Council's terms of reference, (b) there had been an error or omission in the material provided to the SSC, (c) there was an error in fact in the SSC's calculations of the recommended ABC or (d) that the SSC failed to follow its own standard operating procedures. Thus the SSC confirmed that the Council's motion was not a remand, but was rather a case of the Council seeking clarification of the foundation of the SSC's previous ABC determination.

The SSC then considered the three terms of reference provided to it by the Council.

ToR 1. Review and evaluate any new information available relative to black sea bass stock abundance and recruitment (i.e., state survey data) and relative to fishery performance (including recent catch data).

The SSC received a briefing from Council staff on the performance of the black sea bass fisheries in 2012. It is clear that the commercial fishery was well managed resulting in its full quota of 1.7 M lbs being landed (Fig 1). Council staff noted that the fishery was opened for only short periods (days) in several waves in order to ensure the quota was not exceeded.

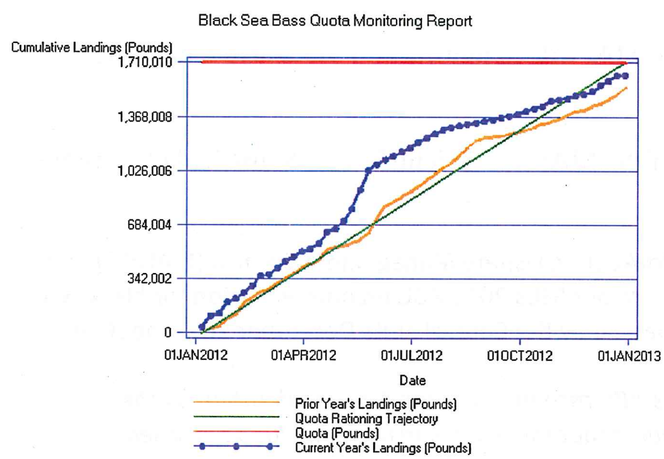

Figure 1. Cumulative commercial catch of black sea bass in the Mid-Atlantic in 2012.

In contrast, the recreational quota was exceeded significantly. The Council enacted a recreational ACT of 1.86 M lbs. After removing the RSA and discards, the recreational black sea bass quota in 2012 was 1.32 M lbs. Data on recreational landings from MRIP presented by MAMFC staff indicate that in waves 1-5, recreational anglers had taken 2.95 M lbs of black sea bass with Massachusetts, New York and New Jersey accounting for approximately 80% of the landings. This provisional figure suggests a recreational overage of 1.63 M lbs – or 123% of the recreational quota.

Insufficient recreational harvest and effort data were available to the SSC at the meeting for the SSC to fully understand or evaluate the excess catch. The SSC evaluated recreational management measures and it is clear that these were liberalized following 2011 when the recreational sector did not meet its full quota. The extent to which this liberalization is responsible for the recreational overage remains unclear: all that is clear is that the management measures in place in 2012 were inadequate to constrain catch to the quota allotted to the recreational fishery.

The SSC did not have access to all of the data it would have liked to evaluate the full range of explanations of the overage. In the time available, the SSC did review recreational data for Massachusetts. These data indicated that recreational black sea bass trips had increased five-fold in 2012 during which time recreational catch per trip increased only modestly from approximately 4.5 - 5.5 fish per trip. However, there remained key concerns in the minds of SSC members of how to interpret recreational effort and catch data that prevented the SSC from reaching a conclusion about black sea bass population status based on the recreational catch data alone.

The SSC also considered fishery-independent survey data collected by state agencies from Virginia to

Massachusetts. These survey data had not previously been examined by the SSC, but components of these data were used in the age-based assessment model that was considered but rejected during the last benchmark assessment. Jason McNamee (RI DFW) presented analyses conducted by the black sea bass technical committee. The goal of these analyses was to present standardized indices of black sea bass. These data and the methods used to analyze them have not undergone formal external review. For all surveys, black sea bass abundances in survey catches were subject to general linear modeling. As is common, survey data exhibited a high incidence of stations with zero catches. To account for this, data were first reviewed to identify stations at which black sea bass were consistently caught over the entire time series and only these stations were retained for further analysis. A general linear model with a negative binomial error structure was fit to catch and environmental data for 7 surveys: the VIMS trawl survey, the New Jersey trawl survey, the NEAMAP survey, the Peconic Bay small mesh trawl survey, the Long Island Sound trawl survey, the Rhode Island trawl survey, and the Massachusetts inshore trawl survey (Fig 2).

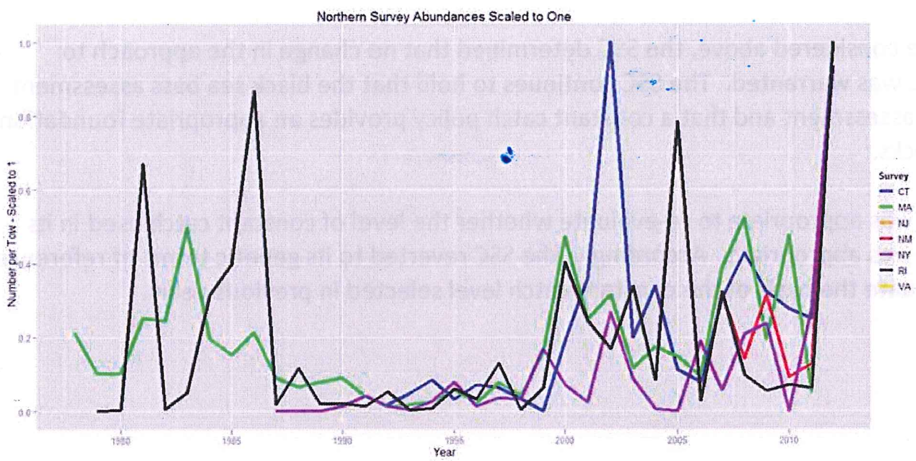

Figure 2. Time series of 7 regional fishery-independent surveys for black sea bass. Note all are scaled such that their peak catch = 1. Indices for 2012 are obscured. The following surveys were at or close to time series highs in 2012: NY, CT and RI. Surveys for other states did not show anomalous increases in 2012.

The SSC welcomed the effort to introduce new data into the consideration of black sea bass stock structure. However, the SSC was uncertain what conclusions could be drawn from these analyses for the following reasons: non-standard analytical methods were used, surveys were mixed in the age-classes indexed, and surveys were conducted at different times of year. Despite this, the SSC was able to conclude that black sea bass populations exhibited a period of relatively low abundance from the late 1980s – the late 1990's. Subsequently abundances have been more variable. Some surveys – e.g., Peconic Bay, Long Island Sound and Rhode Island show signs of large increases in 2012. Two of these surveys (Peconic Bay and Rhode Island) are believed to index juvenile black sea bass – the other (Long Island Sound) may reflect a broader age structure. The increase observed in these surveys was not observed consistently in other surveys nor did there appear to be any latitudinal pattern in the most recent years that might explain the high recreational catches in the northern states (NJ – MA). The SSC also noted that much of these data would not become available until the year after collection.

In summary, the SSC reviewed and evaluated new information available relative to black sea bass stock abundance and recruitment (i.e., state survey data) and relative to fishery performance (including recent catch data). The SSC concluded that there is little information in these data that would lead us to change the 2013 ABC recommendation.

ToR 2. Given the assessment level determinations for other MAFMC-managed species, review and reevaluate the SSC's previous determination that the black sea bass stock assessment qualifies as a level 4 assessment.

In its July meeting, the SSC assigned the black sea bass assessment to a Level 4 tier. In making its recommendation to the Council the SSC noted the following important factors: (i) the absence of important biological information in the assessment (e.g., potential for incomplete mixing in the stock area); (ii) whether reference points are appropriate given the life history; and (iii) that, although point estimates of reference points were provided, the reliability of the OFL point estimate was uncertain.

The SSC was not presented with any new information relative to the three areas of concern noted above at this meeting that would cause us to reconsider our July determination.

The SSC is sensitive to concerns that it has been perceived to be inconsistent in its determination of levels for assessments and commits to undertaking a thorough evaluation of all of its decisions moving forward.

ToR 3. If a revision to the ABC is warranted based on the terms of reference above, provide an updated 2013-2014 ABC recommendation for black sea bass that reflects the current condition of the stock using the generic terms of reference.

Based on the terms of reference considered above, the SSC determined that no change in the approach to determining the 2013-2014 ABC was warranted. The SSC continues to hold that the black sea bass assessment should be classified as a level 4 assessment and that a constant catch policy provides an appropriate foundation for determining ABC in such stocks.

However, the SSC did believe it was appropriate to re-evaluate whether the level of constant catch used in its ABC determinations since 2010 was appropriate. Accordingly, the SSC reverted to its generic terms of reference for determining ABCs to re-evaluate the basis of the constant catch level selected in previous years.

Re-Evaluation of 2013-2014 ABC for Black Sea Bass

Generic ToR 1. The materials considered in reaching its recommendations:

- Shepherd, Gary R. 2012. Black sea bass assessment summary for 2012 . Northeast Fisheries Science Center. 24pp.
- Report of the July 2012 Meeting of the MAFMC Scientific and Statistical Committee, dated July 30, 2012, 12pp.
- Report of the July 2010 Meeting of the MAFMC Scientific and Statistical Committee, dated August 2, 2010, 12 pp.
- Miller, T. J., E. Bell, K. Patterson, and K. Trzcinski. 2011. SARC 53 Summary Report. Dated December 16, 2011, 36 p.

Generic ToR 2. The level (1-4) that the SSC deems most appropriate for the information content of the most recent stock assessment, based on criteria listed in the version of the proposed Omnibus Amendment submitted to the Secretary of Commerce:

The SSC determined again that the black sea bass assessment qualified as a **Level 4**. The determination of Level 4 status involves concerns regarding: (i) the absence of important biological information in the assessment (e.g., potential for incomplete mixing in the stock area); (ii) whether reference points are appropriate given the life history; and (iii) that, although point estimates of reference points were provided, the reliability of the OFL point estimate was uncertain.

The SSC notes that the three concerns above are not trivial to overcome. However, it does not follow that the only way to address them is to bring forward a spatially-specific assessment that includes new reference points. The SSC notes and believes that there are considerable historical data and newly emerging data to enable assessment scientists to address these concerns in a way that may permit a re-designation of the assessment. For example, analyses of the age-structure in surveys, advanced over that included in the assessment rejected at SARC 53 would be useful. Additionally, operational simulation models showing that the assessment model is not sensitive to the spatial structure suggested by tagging data would be helpful. Advances in both areas may help allay concerns regarding the extent of incomplete stock mixing.

Generic ToR 3. If possible, the level of catch (in weight) associated with the overfishing limit (OFL) based on the maximum fishing mortality rate threshold or, if appropriate, an OFL proxy:

The assessment indicates that the catch associated with OFL is **3 175 mt** based on an F_{msy} proxy = $F_{40\%}$ = 0.44. However, the SSC did not endorse these estimates because of concerns about the unresolved uncertainty in the OFL related to stock mixing, life history, and natural mortality that remain unresolved in the assessment.

Generic ToR 4. The level of catch (in weight) associated with the acceptable biological catch (ABC) for the stock:

In its 2010 report, the SSC put forward a constant catch quota as the foundation for determining the ABC for black sea bass. The SSC endorsed this approach again at this meeting (January 23, 2013).

Its original ABC determination in 2010 was based on the 2009 catch. However, this ABC determination was remanded by the Council based on concerns raised by the Monitoring Committee over the impact of conservation measures that were in force in 2009. Accordingly the SSC revised the level of constant catch used for ABC determination based on the 2008 catch. This value, 2 041 metric tonnes (mt, equivalent to 4.5 M lbs) has served as the foundation for its ABC determination since.

The SSC reconsidered the 2008 catch as the foundation for ABC. The SSC noted the following:

- The current constant catch policy has been in place for three years and has led to a relatively constant or potential increasing abundance of black sea bass, such that the 2012 update to the assessment indicated that the black sea bass stock is slightly above B_{MSY}.
- The 2 041 mt catch represents approximately the 16th percentile of cumulative catch distribution and is thus extremely conservative (Fig. 3).

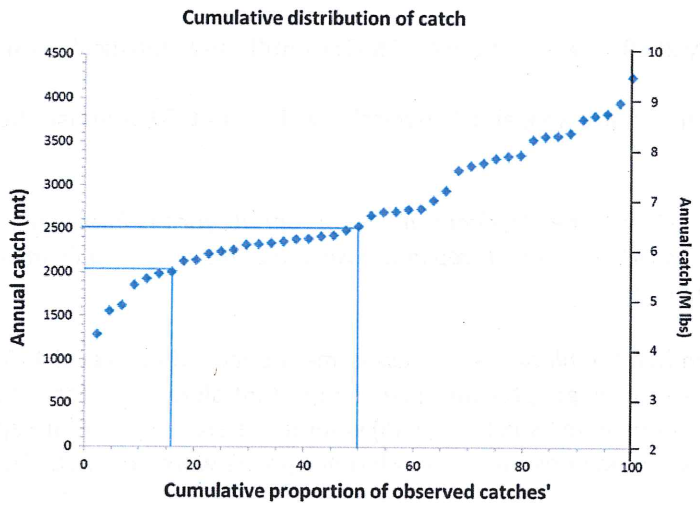

Figure 3. The distribution of observed black sea bass catches (1968 - 2011)

- Other stocks managed by MAFMC that are at or above B_{MSY} are managed with an ABC of approximately 75% of OFL.
- During the period of rebuilding (2000-2009), the black sea bass stock supported catches of 2 721 mt (=6 M lbs).

Based on these observations, **the SSC recommends the 2013-2014 ABC should be based on a constant catch policy of 2 494 mt (=5.5 M lbs).** This revised constant catch level remains less than the 6 M lbs that was taken during rebuilding, is approximately the 50th percentile of the observed cumulative catch distribution, and likely represents approximately 75% of F_{MSY}

The SSC notes in its advice to the Council, that this is a short term, empirical measure. The SSC strongly recommends the Council works to ensure that a revised assessment is completed as soon as possible that may permit the SSC to use a more reliable foundation for ABC determination.

Generic ToR 5. Specify the number of fishing years for which the OFL and/or ABC specification applies and, if possible, identify interim metrics which can be examined to determine if multi-year specifications need adjustment prior to their expiration:

The SSC recommends a two-year specification to be in place through the 2014 fishing year, subject to SSC annual review of fishery-independent surveys and catch information, and in anticipation of a new operational assessment that will be conducted in summer 2013 and a new benchmark assessment, currently scheduled for Spring 2014.

Generic ToR 6. If possible, the probability of overfishing associated with the OFL and ABC catch level recommendations (if not possible, provide a qualitative evaluation):

It is not possible to provide an estimate of the probability of overfishing as the SSC did not endorse the estimate of OFL in the assessment.

Generic ToR 7. The most significant sources of scientific uncertainty associated with determination of OFL and ABC:

- Atypical life history strategy (protogynous hermaphrodite) means that determination of appropriate reference points is difficult;
- Assessment assumes a completely mixed stock, while tagging analyses suggest otherwise;
- Uncertainty exists with respect to M because of the unusual life history strategy the current assumption of a constant M in the model for both sexes may not adequately capture the dynamics in M; and
- Concern about the application of trawl calibration coefficients (ALBATROSS IV vs BIGELOW) and their influence on the selectivity pattern and results of the assessment. There was concern that the pattern of the calibration coefficient across lengths was difficult to justify biologically.

Generic ToR 8. Ecosystem considerations accounted for in the stock assessment, and any additional ecosystem considerations that the SSC took into account in selecting the ABC, including the basis for those additional considerations:

No explicit or specific ecosystem considerations (for example, trophic interactions or habitat) were included in the assessment. No additional information pertinent to ecosystem considerations was included in selecting the ABC.

Generic ToR 9. List high priority research or monitoring recommendations that would reduce the scientific uncertainty in the ABC recommendation:

In order of priority:

- (1) Develop a first principles foundation for establishing reference points and assessment methods to account for black sea bass' life history;
- (2) Explore the utility of a spatially-structured assessment model for black sea bass to address the incomplete mixing in the stock;
- (3) Consider a directed study of the genetic structure in the population north of Cape Hatteras; and
- (4) Evaluate and, if appropriate, continue a fixed gear survey of black sea bass similar to the one used for scup.

Generic ToR 10. A certification that the recommendations provided by the SSC represent the best scientific information available:

To the best of the SSC's knowledge, these recommendations are based on the best available scientific information.

Attachment 1

Mid-Atlantic Fishery Management Council
Scientific and Statistical Committee Meeting
January 23, 2013
Draft Agenda

0900	Welcome and Introductions (Boreman)
0915	Review of SSC ABC recommendation for 2013-2014 and December 2012 Council motion on black sea bass ABC (Seagraves)
0930	Summary of black sea bass assessment/fishery information provided in July 2012 (Dancy/Shepherd)
1000	Address Special TOR relative to reconsideration of 2013-2014 ABC recommendations for black sea bass (Miller)
1200	Lunch
1300	Special BSB TOR cont.
1700	Adjourn

Attachment 2

MAFMC Scientific and Statistical Committee Meeting
Baltimore, MD

January 23, 2013

SSC Members in Attendance

Name	Affiliation
Tom Miller (SSC Vice-Chair)	University of Maryland Center for Environmental Science – CBL
Brian Rothschild	University of Massachusetts
David Tomberlin	NMFS/S&T
Dave Secor	University of Maryland Center for Environmental Science - CBL
Doug Lipton (pm only)	University of Maryland - College Park
Wendy Gabriel	NMFS/NEFSC
Ed Houde	University of Maryland Center for Environmental Science - CBL
Doug Vaughan (left at 2pm)	North Carolina
Mark Holliday	NMFS/HQ
Mike Frisk (via Webinar)	SUNY Stony Brook
Yan Jiao (via Webinar)	Virginia Tech

Others in attendance

Rich Seagraves	MAFMC staff
Kiley Dancy	MAFMC staff
Rick Robins	MAFMC Chair
Toni Kerns	ASMFC staff
Jason McNamee	RI DFW
Jonathan Rountree	NMFS Intern

Black Sea Bass Conference Call

December 17, 2013

10:30- Noon

Participants: Toni Kerns, ASMFC, Rich Seagraves, MAFMC, Kiley Dancy, MAFMC, Genny Nesslage, ASMFC, Kirby Rootes-Murdy, ASMFC, Gary Shepherd, NEFSC, Jessica Blaylock, NEFSC, and Paul Rago, NEFSC.

The meeting opened with a general discussion of management and science priorities, with an emphasis from MAFMC and ASMFC about the importance of black sea bass (BSB) as a primary management concern. We reviewed the conclusions of the April 2013 data review meeting (Attachment #1) and again highlighted the importance of new information before a benchmark assessment is warranted. To that end the group focused on a general review of the work that has been done thus far and what is being planned.

Rich noted that a major proposal to Sea Grant by U. MD on black sea bass was not funded. This would have brought additional resources to address some critical research needs. The group noted that the *NSF Science Center for Marine Fisheries* (SCEMFIS) project, led by Eric Powell, may have an ability to support research on black sea bass. Rich Seagraves noted that the SSC had developed a working group on BSB and might be able to provide limited support for travel.

Gary reviewed recent modeling work that he, Jessica Blaylock and Al Seaver were working on (Attachment #2) . It was noted that the object of the modeling was to examine model behaviors under alternative hypotheses about growth, maturation, migration, and exploitation. The model is a heuristic tool for evaluating population dynamics, identifying priority data collection programs and serving as a possible prototype for improving the assessment model formulation.

Subsequent to the April data meeting, an aging workshop was held with representatives from the Center and states. A report of the meeting is available at *http://www.asmfc.org/uploads/file/529e60e8BSBAgeingWorkshopProceedings_Dec2013.pdfexp*.

Discussion then focused on a number of fixed gear monitoring projects. It was noted that the URI's scup trap project, which also caught BSB, would probably not be useful for BSB monitoring owing to its limited spatial scope. A separate coast-wide project, underway for the past 3 years, may ultimately be useful, but not before an external peer-review of the program was complete. The MAFMC SSC had requested a review of the BSB fixed gear survey in 2014. Rich was going to check on the status of that review. John Hoey would be contacted.

A number of analytical projects were also reviewed, including proposed work on the utility of pooled age length keys. This and some of the recommendations from the April Data meeting might be addressed by the Technical Committee in 2014. Among other projects, some focused consideration of the utility of state survey indices should be conducted in 2014. Preliminary work by Alicia Miller and Gary suggests that year class strength may be determined by oceanographic conditions during the first winter. This could help with interpretation of state indices.

Gary and Jessica gave a brief overview of their modeling project (Attachment #2), particularly as a tool for interpreting field observations and the ability of existing data to support models with greater spatial and temporal resolution.

The group discussed next steps in the process. It was noted that this could be viewed as an implementation of the “Research Track”, a concept endorsed by the NRCC as a way of identifying stocks with critical research needs. A first task would be to develop Terms of Reference that could addressed over the next several years. The TOR would provide managers with some assurance that critical research needs were being addressed. The TOR would also specify a periodic process for reviewing results and communication with the broader scientific community. It was suggested that a review in April 2014 would correspond to the anniversary of the Data Review meeting and might be a suitable occasion to formalize the Research Track process. The group discussed several options for external review, including the SARC and an ASMFC sponsored review. Finally, it was noted that changes in the assessment, particularly the inclusion of spatial components would require changes in management. For MAFMC this would be an Amendment. For ASMFC this would require an Addendum.

The meeting ended at high noon.

Attachment #1

Black Sea Bass Data Workshop Recommendations

A black sea bass data workshop was held April 9-11, 2013, sponsored by the Partnership for the Mid-Atlantic Fisheries Science (PMAFS) and conducted by the Atlantic States Marine Fisheries Commission (ASMFC). The workshop participants included PMAFS scientists, ASMFC staff, MAFMC staff, NEFSC staff, state biologists on the ASMFC Black Sea Bass Technical Committee, University of Rhode Island (URI) and Rutgers University scientists, and Mid-Atlantic Fishery Management Council (MAFMC) Scientific and Statistical Committee (SSC) members. The workshop summarized available state and federal fishery independent and dependent data, as well as any outside (academic) research surveys/projects available for use in the development of indices of relative abundance; evaluated the utility of indices as measures of black sea bass relative abundance; evaluated the spatial heterogeneity of indices among states/regions; and recommended approaches for utilizing indices available within a black sea bass benchmark assessment. The group also developed short and long term research recommendations intended to address both the most recent peer review and SSC highlighted concerns for the black sea bass assessment.

The working group concluded that there are no additional data analyses or data sets that, if taken in conjunction with the existing assessment model, would likely result in an SSC decision to elevate the black sea bass assessment from Level 4 to 3 (based on the ABC control rules the SSC applies). Therefore, based on the information reviewed at the workshop, it is highly unlikely the SSC's perception of uncertainty in the assessment will change with an assessment update. In this case, an assessment update would not be used for management purposes and the SSC would continue to apply catch-based approaches under the Level 4 control rules.

It is the recommendation of the working group to delay the 2014 black sea bass benchmark peer review to 2016 or later, depending on the amount of progress that could be made on interim analyses and modeling approaches. The working group outlined critical areas of analysis, research, and modeling approaches that will need to be addressed for a benchmark to provide meaningful results. This work should be started immediately in preparation for a 2016 peer review. The group recommends that in lieu of an assessment update in 2013 and 2014, the Southern Demersal Working Group should provide a summary of the most recent catch to inform the SSC and Council specifications process. It is recommended the resources that would have be used for a 2014 benchmark and 2013 assessment update go toward the following short and long-term recommendationsto forward the progress of black sea bass modeling:

<u>Short term research to address SSC Concern #2 (uncertainty in the spatial structure of the stock)</u>

Assessment Model Development

- Explore the impact of spatial heterogeneity on the stock assessment results. Conduct sensitivity analyses on this topic. Specifically, if you break the stock north-south do you get qualitatively different stock status results than coastwide stock? [Center resources needed and outside funding possibly needed]
- Explore the use of time-varying catchability to account for changes in density dependent surveys catchability. This was a criticism of use of trawl surveys for a "structure-obligate" species. This will need to be added to the current assessment model (SCALE) code. [Center resources needed and outside funding possibly needed]
- Use paired trawl experiments coefficient/data as prior's when estimating survey selectivities and estimate the change in selectivity instead of specifying it. This will need to be added to the assessment model code. [Center resources needed and outside funding possibly needed]

Supporting Analyses

- Characterize ageing uncertainty: a) Conduct ageing validation study. b) Conduct formal ageing comparison of NEAMAP & NMFS ageing. c) Conduct formal ageing comparison between south and north Atlantic and borrow their ALKs. Conduct aging exchanges for otoliths (no scales). d) Develop ageing error matrices using this comparison study data for informing model inputs. [multiple agency staff required]
- Explore cohort tracking in surveys (formally check that all surveys with multiple age classes show coherence). Determine if the surveys are tracking strong year classes such that age or length structure in the data could inform the assessment model. [Technical Committee]
- Compare the temporal and spatial trends among surveys and report on the evidence of spatial structure of stock among surveys or lack thereof (e.g., spatial autocorrelation of catch and LF, cluster analysis). [Technical Committee]
- Explore the catchability of surveys relative to black sea bass migration (e.g., correlation with temperature cues, etc.). Conduct a comprehensive spatio-temporal comparison of availability (side-by-side mapping and analysis of catch in each survey by date and location). [Technical Committee]
- Conduct paired scup/BSB pot survey and VAS data with NJ trawl comparison using nearby locations. Explore if BSB are truly structure obligate and if trawls are valid for BSB. Compare catch and length frequency on/off structure. [Technical Committee and URI]
- Build an index of relative abundance using Jon Hare's larval survey data. [Center resources]
- Look at the implication of pooling samples in the age-length keys (ALK) versus filling parts of the annual keys that are low on samples. [Center resources]

<u>Long term research to address SSC Concern #2 (uncertainty in the spatial structure of the stock)</u>

Assessment Model Development

- Build a simulation model that incorporates spatial structure for black sea bass as well as other necessary features (e.g., protogynous life history, sex-specific, etc.). Use existing data to simulate/ determine the scale at which management could be implemented. This simulation exercises should be developed at a complex level, but then be used to determine how simple your models need provide management advice. The simulation can be used to identify critical model features (e.g., plasticity of the size/age at transition from female to male, etc.) and data gaps – see protogynous fish workshop report. [likely require outside collaboration]

- Evaluate the ability of the existing data to support a spatially-explicit assessment for management (if needed based on the simulation study above) and implement any necessary data collection protocols to support this approach. [long-term permanent commitment]
- If needed, build a spatially-structured, sex-specific assessment model for management. [long-term research track]

Fieldwork

- Collect additional biological data on all FI surveys
- The collection of nearshore commercial trawl and pot fishery biosamples (i.e., lengths and sex) are needed
- Sex ratio data should be collected from commercial and recreational port/intercept sampling to explore importance of sex information in assessment modeling
- Ages should be collected from nearshore surveys (MA, RI, CT, NJ) for use in development of regional/local ALKs
- Tagging study (natural or artificial) should be conducted to determine mixing/migration [2yr , funding required]

<u>Long term research to address SSC Concern #1(Unusual Life History – priority 2)</u>

Fieldwork

- Studies should be conducted to understand the general reproductive behavior of black sea bass. What is the role of non-dominant males (e.g., sneaker males) in reproductive stock dynamics? Do black sea bass develop spawning harems or leks? [outside funding]
- Studies should be conducted to determine the relationship between fertilization rates and sex ratio so this can be included into population dynamics models. A parentage analysis could be used to determine fecundity. [outside funding required, long-term]
- Work should be conducted to determine the natural mortality by sex; life stage research is needed [ongoing, outside funding]

<u>Attachment #2</u>

Model Development

- Examine the implications of spatial heterogeneity on stock assessment results. Conduct sensitivity to stock status using various north-south splits in distribution.

- Explore use of time-varying catchability to account for possible density dependent survey results.

- Develop new assessment models including
  - A simple separable catch at age model
  - A spatially structured model with seasonal time steps
  - An age-structured model which could include tag return data

Supporting Information

- Evaluate ability of existing data to support a spatially-explicit assessment for management and implement any necessary data collection protocols to support this approach.

- Address ageing uncertainty
  - Conduct ageing validation study.
  - Conduct formal exchange of ageing material among labs.
  - Develop ageing error matrices using comparison study data for informing model.
  -
- Examine feasibility of pooling age length keys across years.

- Examine consistency of size structure within commercial market categories and implications of generalizing to missing information.

- Compare temporal and spatial trends among surveys and examine evidence of spatial structure among surveys (e.g., spatial autocorrelation of catch and LF, cluster analysis).

- Explore catchability of surveys relative to migration (e.g., temperature cues, etc.).

- Conduct comprehensive spatio-temporal comparison of availability to surveys (side-by-side mapping and analysis of catch in each survey by date and location).

- Analyze black sea bass pot survey results and compare information with comparable trawl survey results.

- Build index of spawning stock biomass using NEFSC larval survey data.

- Collect sex ratio information from recreational and commercial fishery catches.

Biological Processes

- Continued research on rate, timing and occurrence of sex-change.
- Examine environmental influences on winter offshore distribution of juveniles and adults.
- Examine influence of overwintering survival on young-of-year in determining year class strength.
- Examine ecological implications of range expansion of black sea bass into the Gulf of Maine.
- Expanded genetics study to evaluate potential of population structure north of Cape Hatteras.

Evaluation

- Develop a length-based simulation model to evaluate critical data and model components that are sensitive to the unique life-history characteristics of black sea bass.
- Develop a management strategy evaluation (MSE) to better understand the implications of a broad range of management strategies.

Sources:

PMAFS and ASMFC Black Sea Bass Data Workshop, April 9-11, 2013, Woods Hole, MA. Black Sea Bass Data Workshop Recommendations. 3 p.

SAW/SARC 53 Panel Summary Report (T. Miller, SARC chair). www.nefsc.noaa.gov/saw/saw53/.

Shepherd,G., K. Shertzer, J. Coakley and M. Caldwell (Editors). 2013. Proceedings from a workshop on modeling protogynous hermaphrodite fishes, Raleigh, NC. 33p.

Black sea bass research –

Life history: A concern in management has been the implication of regulation with a protogynous hermaphrodite like sea bass. The issue is how much fishing will disrupt the spawning behavior and potentially alter the sex ratio. Life history theory and sex allocation models for hermaphrodites have been developed based on reef fishes which are generally stationary within a small reef area. Black sea bass in the South Atlantic tend to follow this pattern where no migratory behavior is exhibited and the fish are aggregated around structure. Consequently social structure within the community, typically a large dominant male surrounded by smaller females, is likely to be the primary influence on the rate of transitioning from female to male. Sex ratio at age shows all females at smaller sizes and all males at larger sizes. Average age when the population reaches a 50:50 sex ratio is 3.8 (Sedar25), with maximum age of 11. In the northern stock, the characteristics of black sea bass are different and tend to be more similar to gonochoristic species. Males are present at smaller sizes and ages and there is not a complete transformation of females to males (e.g. there are large females in the population to the oldest ages). The age at the 50:50 sex ratio is 7.7 years with an average length of 49.5 cm. Sex ratio at the maximum ages in the north is only about 60% male. Average growth is faster in the north with Linf=60 cm compared to 50 cm in the south (k=0.23 in the north and 0.18 in the south). Furthermore, the spawning season in the south is longer; 7 months compared to possibly 4 months in the north with shorter local seasons. Mark Wuenschel and I are working on a review paper to summarize these differences and develop the hypothesis regarding the selective advantage of the northern fish to have an atypical protogynous life history.

Modeling: As noted, a concern of management is the implications of exploitation on the life history of sea bass. Jessica Blaylock and I have developed a simulation model to examine the effects of exploitation on the northern stock. It is our hypothesis that the life history differences highlighted above make the northern stock more robust to exploitation. We have developed a length-based black sea bass population simulation which allows us to re-create a typical or atypical protogynous life history and expose the population to exploitation. The intent is to evaluate how robust the population response is to different degrees of exploitation. The model is currently being tested and the simulation work should begin within the next few weeks.

Recruitment: The northern stock of black sea bass has exhibited a generally stable recruitment pattern since 1982 (the first year in the assessment). There appear to have been exceptions in the early 1980s, 1999 and most recently in 2011. Alicia Miller and I have been examining environmental controls to sea bass recruitment. The very strong 2011 cohort has been apparent in state surveys from CT to MA as well as the NEFSC spring offshore survey. However, it did not appear as a significant cohort in the fall 2011 juvenile indices. The winter that followed was unusually warm due in part to a meandering of the Gulf Stream, resulting in an influx of warm saline water onto the continental shelf. The state and federal spring 2012 indices (as well as numerous reports from local fishermen) showed what must have been high over-wintering survival because that same 2011 cohort was everywhere. Subsequent examination of distributions from the time series of NEFSC spring surveys (biological winter) show that adult fish have a strong affinity to the edge of the continental shelf and in particular to areas of 34-36 ppt salinities. Juvenile sea bass (<=14 cm) generally do not make it all the way to the edge during winter and as a result are at the mercy of winter water conditions across the shelf. We are in the process of working with NEFSC and WHOI oceanographers to quantify the extent of optimal winter water masses and relating that to relative over-wintering survival of juvenile sea bass. Initial results suggest that the fall juvenile indices are not a good indicator of year class strength and that cohort strength is determined by over-winter survival related to oceanographic conditions.

Assessment modeling: The principle roadblock in the black sea bass stock assessment is the potential of spatial heterogeneity in the population dynamics. An assessment as a single stock may miss local conditions which do not align with average abundances, creating possibly local under or over exploitation. Development of a catch at age model for sub-groups requires several steps: identifying where to split the stock geographically, splitting the catch into the appropriate sub-group, identifying appropriate fishery independent indices of abundance for each and developing separate catch at age matrices for each sub-group.

Partitioning the northern stock (shown to be a single genetic entity) into sub-groups can either be done on an ad-hoc approach (by state or based on fisheries) or based on some bio-geographical boundary (or both). Recent work by oceanographers at Rutgers University suggest a mechanism by which the water flow out of the Hudson River across the Hudson Canyon could possibly serve as a physical boundary between southern New England and the Mid-Atlantic states. The aforementioned 2011 year class is dominant in southern New England but not the Mid-Atlantic states giving some credence to the idea that the Hudson Canyon could be used as a split point. Recent management actions have suggested a split at Delaware Bay which could also be a possibility.

With a geographic split, survey indices and catches could be similarly split (the NEFSC offshore spring indices would need some assumptions about origin of the fish). Inshore catches would be assigned to the adjacent state while offshore catches would be an approach to partition into sub-stock. Over the past several decades NOAA Fisheries has collected lengths and ages from landings data. However, sample sizes are limited and to sub-divide further would create significant shortcomings in sample sizes. Michele Traver and I have been working to evaluate if common sea bass age keys and length frequencies could be used to fill the sampling gaps. Preliminary results suggest that size distributions within market categories and among age keys are relatively stable and the information may be suitable for substitutions. If this does not hold up, the best assessment likely to be produced would be an index based model of relative change in biomass and abundance.

State research projects: URI trap based sea bass survey conducted in Rhode Island, Massachusetts, New Jersey and Virginia (scheduled to add New York in 2014) began in 2011 (?). The surveys generate relative abundance indices (CPUE from standard unvented traps fished in a stratified random design) and length frequencies. The program is scheduled for review in 2014.

Massachusetts sea bass project: State funds ($100k) has been allocated to conduct research with the intent of improving the stock assessment. To my knowledge nothing has been finalized for projects.

Northeastern University: Marissa McMahon, a PhD. student under the direction of Jon Grabowski, has begun her dissertation work on sea bass in the Gulf of Maine. Using dive transects she is examining habitat use and the potential impact of predation on lobsters (last we discussed anyway).

State of Maryland: Have raised the possibility of doing experiment on local isolated reef to examine the impact of exploitation on reproduction and age at maturity.

Rutgers University: Olaf Jensen's lab working on identifying rate of sexual transition in sea bass from fish recovered in tag-release program.

Southeastern Massachusetts University: Ken Oliviera's lab working with Mark Wuenschel and Rich McBride on histology of sea bass gonads for at sea guide to maturity stages.

Scheduling Worksheet for Stock Assessments. **date: May 15, 2014**

Basis for entries in Table: April 2014 NRCC meeting

	2013: 1st half	**2013: 2nd half**
1	White hake - SARC 56, Feb 19 -22, 2013	Striped bass - SARC 57, [July 23-26]
2	Atlantic surfclam - SARC 56	Summer flounder - SARC 57
3		
4		
5	(River herring - Extinction Risk Analysis)	(Data Review, August 5-9)
6	(EGB cod benchmark - Ap. 9-11, 2013, TRAC)	
7	(TRAC - EGB cod, EGB haddock, GB YT - June 25-27 Canada)	
8	(Updates: Bluef, Scup [w/ SSC], Dog, skates, monkfish -Ap. 8-9 Op. Assess., Ocean quahog, Mackerel, butterfish, tilefish, squid	

	2014: 1st half	**2014: 2nd half**
1	N. shrimp - SARC 58, Jan. 27-31	Scallops - SARC 59, July 15-18
2	Tilefish - SARC 58	GOM haddock - SARC 59
3	Butterfish - SARC 58	
4		
5	(GB YT Alternative - April 14-19, WH)	(Pollock, GOM winter fl, GB winter fl, Aug 11-13, Oper. Assessment Process)
6	(Model Review - May 19-23)	
7	(TRAC - EGB cod, EGB haddock, GB YT) June 23 -27, WH	
8		
9	(Updates: Bluefish, BlkSeaBass [data update; research report], Scup [rumble], Fluke [rumble strip], Mackerel [data update, research plan]), squids [data update])	(Updates: Dog [rumble], skates, hakes [silver, red, offshore])

	2015: 1st half	**2015: 2nd half**
1	Scup - SARC 60, June 2-5 , to be done with incomplete 2014 data	
2	Bluefish - SARC 60 June 2-5 , to be done with incomplete 2014 data	
3		
4	(ASMFC - Sturgeon -Feb).	(20 Groundfish Stocks, Operational Assessment, Sept. 21-25)
5	(ASMFC - Lobster peer review -Spring 2015)	
6	(Scallop Survey Methods- March 17-19, WH)	
7	(Herring, Operational Assessment, May)	
8	(TRAC - EGB cod, EGB haddock, GB YT - June)	
9	(Protected species: Program Review - DATE in 2015 TBD)	
10	(Updates: BlkSeaBass [data update],Fluke, surfclam [data update], Dog, skates, Mackerel, butterfish, tilefish [data update])	

	2016: 1st half	**2016: 2nd half**
1	*Skates - SARC 61, Month TBD*	*Mackerel, Black sea bass, monkfish -- SARC 62, Nov./Dec.; pick 2; choice dependent on research progress; or possibly schedule NE Groundfish benchmarks*
2	*Ocean quahog - SARC 61*	
3		
4	*(TRAC - EGB cod, EGB haddock, GB YT - June)*	
5	*(Black sea bass - SARC or another process run by ASMFC)*	
6	*(Cumul. Discard Methodology - January)*	
7	*(Ecosystem Applications, Management, Habitat : Program Review - DATE TBD)*	
8	*(Updates: BlkSeaBass [data update],Fluke, surfclam [assessment update], Dog, Mackerel, butterfish, tilefish [data update])*	

Key:

Italics = Under consideration, but not officially scheduled.

"( )" = not in the SARC process.

Cells filled with gray = work completed.

Schedule-worksheet-assessments-2014-05-15

~/sarc/boilerplate/Schedule-worksheet-assessments(date).xls 5/15/2014

Black Sea Bass Research Track Assessment
Terms of reference
First Draft (15 May 2014)

1. Explore assessment models that incorporate spatial structure and life history features for black sea bass (e.g., protogynous life history, sex-specific, etc.)
2. Incorporate ageing uncertainty in stock assessment models
3. Explore the use of time-varying catchability to account for changes in density dependent surveys and explore cohort tracking to verify utility of fishery independent surveys in tracking abundance and/or year class strength

Black Sea Bass Research Track Assessment
Terms of Reference
May 29 2014 Draft

1. Explore cohort tracking to verify utility of fishery independent surveys in tracking abundance and/or year class strength.
2. Examine the spatial timing and coherence of fishery-independent surveys relative to black sea bass distribution and migration.
3. Explore options for developing new age-length keys.
4. Develop new assessment model(s) that address:
    a. ageing uncertainty
    b. the spatial structure and migratory behavior of black sea bass
    c. the unique life history features of black sea bass (e.g., protogynous life history, sex-specificity, etc.)
    d. the incorporation of all available length and age data
    e. the incorporation of time-varying catchability to account for possible density dependent catchability in fishery independent surveys.
5. Develop new biological reference points that take into account the complexities of black sea bass life history.
6. Examine impact of systematic oceanographic changes on abundance and distribution

Black Sea Bass Research Track Assessment

Draft Work Plan (5/28/14)

April 2014	Formally Establish Research Assessment Working Group at Spring NRCC Meeting Membership: NEFSC, ASMFC and MAFMC Staff, MAFMC SSC, ASMFC Technical Committee, Other Tasks: Initiate BSB Research Track Assessment TOR Development
[Summer 2014	ASMFC TC work on age compositions and indices and review Commission aging workshop results]
June 2014	Initiate Peer Review of RSA BSB Trap Survey (MAFMC/ASMFC)
July 2014	Meeting 1 – via conf call BSB RAWG (Develop TORs, NEFSC present recent simulation modeling work - Shepherd/Blaylock/Feaver)
August 2014	Peer Review of BSB Trap Survey
August/Sept 2014	BSB RAWG Progress Report to SSC/Council/ASMFC-approve TOR, BSB RAWG update, and Review BSB Survey Peer Review Meeting 2 – BSB RAWG joint with full TC (Data Meeting, Preliminary Model Discussion) -review BSB survey Peer review -TC report on Age compositions, indices
January 2015	BSB RAWG Meeting 3 (Model development)
May/June 2015	BSB RAWG Meeting 4 (Modeling)
May 2015	BSB RAWG Progress Report to SSC/Council/ASMFC
September 2015	BSB RAWG Meeting 5 (any additional work, draft assessment report)
Dec 2015/Jan 2016	BSB RAWG Meeting 6 with full TC to finalize Assessment Report
Spring 2016	Independent Peer Review of BSB Research Track Assessment Report
July/August 2016	Incorporate BSB Research Track Results in 2017 BSB Specifications