C: ASSESSMENT OF THE NORTHERN STOCK OF BLACK SEA BASS

Report of the Southern Demersal Working Group

1.0 EXECUTIVE SUMMARY

The status of the northern stock of black sea bass was evaluated. (EDITOR'S NOTE: TEXT FROM THIS PARAGRAPH HAS BEEN OMITTED BECAUSE THE REVIEW PANEL DID NOT ACCEPT THE F ESTIMATES OR THE EXISTING BIOMASS REFERENCE POINT.)

Total landings declined in 2004 and 2005 due primarily to reduced recreational landings. Commercial landings are controlled by quota and have remained relatively stable for the past decade. Discards in the recreational fishery are substantial, however only 15% of the discards are expected to be lost due to mortality. Commercial discards, based on logbook information, range from 5% to 13% of landed weight.

The NEFSC spring bottom trawl survey of offshore strata is the basis for evaluating black sea bass biomass status. Adult biomass ($\geq$ 22cm) peaked in 2002 but has since declined to the long term average. A similar pattern in biomass decline has been evident in the NEFSC winter survey. Strong juvenile abundance indices ($\leq$ 14 cm) appeared in 2000 and 2002 winter and spring surveys. However, these strong cohorts have not produced an expected increase in the adult biomass indices. State surveys index local recruitment and also suggest the 2002 year class was above average.

A tagging program for black sea bass between Massachusetts and North Carolina was initiated in September 2002. The recaptures of tagged adult sea bass show seasonal offshore migrations to the edge of the continental shelf and a return migration inshore during spring. Fish in the north (MA and RI) move south as far Virginia before returning in spring. In contrast, fish in the southern end of the range follow a simple inshore/ offshore movement of 50 to 100 miles. Site fidelity is quite strong although straying does occur, particularly for fish traveling the farthest distances.

The tag release/recapture data formed the basis for estimating exploitation rate. Two model types were used; a modified Petersen (R/M) model for exploitation that uses annual recaptures as a ratio of released tags and a Brownie band recovery model which uses the full tag recovery matrix. The WG concluded that the Brownie models as configured did not provide accurate estimates of survival. The R/M model, modified for reporting rates and tag losses, produced the best estimate of exploitation. A Monte-Carlo approach to the R/M model characterized the uncertainty in the estimates. (EDITOR'S NOTE: TEXT FROM THIS PARAGRAPH HAS BEEN OMITTED BECAUSE. THE MODEL RESULTS WERE NOT ACCEPTED BY THE REVIEW PANEL.)

Overfishing in black sea bass is defined by an F_{max} value of 0.33 which serves as a proxy for F_{msy}. The stock biomass threshold is based on a three point moving average of the NEFSC spring adult biomass index from 1977 to 1979. (EDITOR'S NOTE: TEXT HAS BEEN OMITTED BECAUSE THE REVIEW PANEL REJECTED THE F ESTIMATES AND BIOMASS REFERENCE POINT.)

A recent review of the MRFSS program prompted examination of the effect uncertainty in recreational catch data has on stock assessments. Since catch was not used in determination of black sea bass stock status, any error in the MRFSS estimates remains inconsequential to status determination at this time.

2.0 TERMS OF REFERENCE

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

2. Describe temporal trends in abundance and size-structure based on data from NEFSC surveys. When possible, characterize the uncertainty of point estimates. Describe data from other surveys, as appropriate.

3. Based on the recent tagging study, estimate annual rates of mortality due to fishing and overall. Characterize the uncertainty of those estimates.

4. Based on the recent tagging study, describe migration patterns with respect to depth, season, latitude and longitude.

5. Evaluate current stock status with respect to the existing BRPs.

6. Perform sensitivity analyses to determine the impact of uncertainty in the recreational data on the assessment results.

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

3.0 INTRODUCTION

Black sea bass (*Centropristis striata*) range from the Gulf of Maine to the Gulf of Mexico and the population is partitioned into two stocks north and south of Cape Hatteras, NC (Musick and Mercer 1977, Shepherd 1991). The management unit of the Black Sea Bass FMP includes all black sea bass in U.S. waters in the western Atlantic Ocean from Cape Hatteras, North Carolina north to the Canadian border. The initial joint ASMFC (Commission) and MAFMC (Council) Black Sea Bass FMP was completed and approved in 1996. The objectives of the FMP were to reduce fishing mortality to assure overfishing does not occur, reduce fishing mortality on immature black sea bass to increase spawning stock biomass, improve yield from the fishery, promote compatible regulations among states and between federal and state jurisdictions, promote uniform and effective enforcement, and to minimize regulations necessary to achieve the stated objectives. The original FMP defined overfishing as fishing in excess of F_{max}, or F=0.29, which represented an annual exploitation rate of 23%. The FMP was intended to reduce fishing mortality over an eight-year period starting in 1996 implementing coastwide commercial size limits and quota allocated on a quarterly basis, and a recreational harvest limit constrained through the use of minimum size, possession limit (maximum of 25 fish), and seasonal closures. The specifications were minimum requirements and states, such as Massachusetts, chose to implement more conservative measures.

	Minimum sizes	
	commercial	recreational
1996	9"	9"
1997	9"	9"
1998	10"	10"
1999	10"	10"
2000	10"	10"
2001	10"	11"
2002	11"	11.5"
2003	11"	12"
2004	11"	12"
2005	11"	12"
2006	11"	12"

Amendment 12 to the Summer Flounder, Scup, and Black Sea Bass FMP was approved by the Commission and Council in October 1998 and established revised overfishing definitions, identification and description of essential fish habitat, and defined the framework adjustment process. The updated overfishing definition defined F_{max} as a proxy for F_{msy} with F_{max} = 0.32.

Amendment 13, approved by the Commission in May 2002 and Council in June 2002, implemented increases in minimum size for commercial and recreational fisheries as well as a federal, coastwide annual quota that is managed by the Commission using a state-by-state allocation system. F_{max} was re-estimated to account for changes in minimum sizes and currently equals 0.33.

The stock status was reviewed in SARC 39 (NEFSC 2004) which concluded that the assessment, based on tagging results, was suitable for management purposes. The assessment concluded that exploitation was below the management target and biomass indices were at or above the biomass threshold, which is the three-year moving average of the NEFSC spring survey catch per tow from 1977-1979 (0.98 kg/tow)

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

Commercial sea bass landings have remained relatively stable since the mid-1960s, ranging from a low of 566 mt (1,249 thousand lbs) in 1971 to a high of 1,985 mt (4,377 thousand lbs) in 1977 (Table C1, Figure C2). Prior to 1962, landings of the northern stock from North Carolina are not reported. The 2005 quota (1,823 mt) restricted landings of 1,310 mt, which is slightly above the average for 1994-2004 (1,268 mt). Recent landings are all substantially below the peak landings of 9,883 mt estimated for 1952 (Figure C2).

Commercial black sea bass landings in 2005 were primarily from sea bass pots (32%), otter trawl (33%), hook and line (11%) and the remainder from other gear (14% from unreported gear) Figure C3. The pot and hook fisheries begin in coastal waters in May and continue until late October in MA to December in southern areas (Shepherd and Terceiro 1994) (Figure C4). Otter trawl landings generally occur offshore during the winter months in the summer flounder, scup and squid fisheries (Shepherd and Terceiro 1994). New Jersey, Massachusetts, Virginia, North Carolina, Maryland and Rhode Island accounted for 89% of commercial landings in 2005.

Biological samples collected by NMFS and North Carolina DMF were used to expand length frequencies of dealer reported commercial landings. Samples were partitioned by quarter and market category (unclassified, small, medium, large and jumbo). Jumbos accounted for 30% of landings in 2004 and 33% in 2005, while large (31% and 29%) and mediums (27% and 25%) were also a significant part of landings in both 2004 and 2005 respectively (Figure C5).

Expansion of length frequencies to total landing were based on 12,132 measurements in 2005 and 9,557 in 2004 (Table C2). Sample intensity has steadily increased from the 1998-2000 period, which averaged only 4,329 samples per year. Quarter/market categories with no length samples were expanded using samples from adjacent quarters within the same year, market category combination.

Length to weight conversions were based on length-weight equations in the form ln Wt (kg) = ln a + b ln Len (cm) derived from 1995-2005 NEFSC survey data.

	ln a	b
spring	-11.537	3.103
autumn	-11.251	3.033
winter	-11.477	3.077

Expanded length distributions are shown in figure 6. Average lengths in the commercial fisheries have increased steadily since 1996. Increasing minimum sizes have largely contributed to the increase from a 25.3 cm mean length in 1996 to the 2005 average of 35.4 cm (Table C3, Figure C7). Total estimated landings were 2.3 million fish in 2004 and 2.0 million in 2005 (Note: 2002 and 2003 preliminary numbers estimated for commercial landings in SARC 39 report are updated).

Commercial discards were estimated from commercial vessel logbook information which provides coverage of all fishermen holding federal sea bass permits. Total discards were estimated as the ratio of the sum of the reported pounds discarded per trip to weight of reported pounds kept (Table C4). The average ratio by year and gear type was expanded to total pounds discarded. Discard mortality is unknown, although hook mortality is likely similar to recreational fisheries, estimated at 15%. In addition, the fishing methods used in the pot fishery likely results in relatively low discard mortalities. Total discarded pounds peaked in 2002 at 201 mt (443,000 pounds) but declined to 63 mt (140,000 lbs) by 2005. Observer data does not adequately cover pot or hook and line trips which constitute a substantial proportion of landings and was not considered representative of discarding practices. Therefore the observer data was not used for discard estimates.

The proportion of the recreational landings has fluctuated around 50% of total black sea bass landings over the past decade (Table C1). The recreational fishery generally takes place in coastal areas from May until November and is subject to a 12" (30 cm) minimum size and a 25 fish bag limit. Landings ranged from a low of 518 mt (1.1 million pounds) in 1998 to a high of 5,621 mt (12.4 million pounds) in 1986 (Table C1, Figure C8). MRFSS estimates of black sea bass recreational landings (A + B1) in 2004 were 760 mt (1675 thousand lbs) and 787 mt (1735 thousand lbs) in 2005. The average for 1981-2005 was 1,674 mt (3690 thousand lbs.). In 2004-2005, 64.6% of the recreational landings were from the state of New Jersey. The next highest percentages per state were 10.8% from Delaware and 8.6% from Maryland. Length distributions from the recreational landings are shown in Figure C9. Average length in landings has increased from 26.5 cm in 1995 to 34.2 cm in 2005 (Figure C10). Recreational discards (B2) amounted to 5.7 million and 5.8 million fish in 2004 and 2005, respectively (Table C5). As with landings, New Jersey accounted for the largest percent with 45% of total B2 discards. A discard mortality estimate of 5% (Bugley and Shepherd 1991) was based on cage experiments conducted in relatively shallow water. However, an estimate of 15% may be more representative of conditions in deeper water fisheries such as New Jersey. A mortality rate of 15% would result in total discard losses of 851,000 and 860,000 fish in 2004 and 2005 respectively. In 2005, the MRFSS program initiated at sea sampling of party/charter vessels which resulted in 3,883 length measurements of discarded sea bass. Sea bass discards lengths had a knife edge distribution at the legal size limit of 30 cm (Figure C11). The average length of discards in 2005 was 23.2 cm.

5.0 TOR 2. Describe temporal trends in abundance and size-structure based on data from NEFSC surveys. When possible, characterize the uncertainty of point estimates. Describe data from other surveys, as appropriate.

NEFSC surveys

The NEFSC spring bottom trawl survey in offshore strata is used to represent the abundance of adult black sea bass (defined as fish $\geq$ 22 cm). The highest abundance index (log re-transformed stratified mean number per tow) occurred in 2003 (1.614 per tow with a 95% CI of 1.181 to 2.134) and was the highest value since 1974 (Table C6, Figure C12). A slight rise in abundance was evident in the late 1980s but was followed by a decade of fluctuations around low levels of abundance. Since 1999 there was a noticeable increase in the index values which peaked in 2003, followed by a steady decline in the 2006 index (preliminary) of 0.456 fish per tow (95% CI of 0.331 to 0.594), which is equal to the long-term average of 0.461 fish per tow.

The NEFSC winter survey, initiated in 1992, follows a similar pattern with a peak in the index value for 2002 (3.44 fish/tow with a 95% CI of 2.82 to 4.16) followed by declining indices to 1.06 fish/tow in 2006 (95% CI of 0.82 to 1.33) (Table C6, Figure C12). The autumn survey has also had relatively large indices in recent years but has not been considered reliable as an index of adult abundance due to potential catchability issues during sea bass residency in coastal waters.

During development of the FMP, exploitable biomass from survey results was defined as fish greater or equal to 22 cm. The working group decided to maintain this definition for evaluation of trends over the time series to maintain consistency with the definition of the biological reference point (minimum biomass threshold). Total biomass indices from the spring and winter trawl surveys indicate a significant increase between 2000 and 2003 followed by a decline. Spring survey biomass per tow peaked in 2003 at 2.151 kg/tow (95% CI of 0 to 5.00), well above the long term average of 0.435 kg/tow (Table C7, Figure C13). The preliminary 2006 index declined to 0.548 kg/tow (95% CI of 0 to 1.12). The log re-transformed biomass indices show a similar pattern although the index peaked in 2002 (0.6.17 kg/tow, 95% CI of 0.505 to 0.743) and declined to a 2006 index of 0.288 kg/tow (95% CI of 0.199 to 0.358). The winter survey peaked in 2003 at 3.123 kg/tow (95% CI of 0.430 to 5.814), well above the time series average of 0.878 kg/tow (Table C7, Figure C13). The index decreased steadily thereafter to a preliminary 2006 index of 0.568 kg/tow (95% CI of 0.282 to 0.855). Log re-transformed indices had a similar pattern although the indices peak in both 2002 and 2003 (1.327 and 1.300 kg/tow, respectively), followed by a decline to 0.378 kg/tow (95% CI of 0.282 to 0.855) in 2006.

Juvenile indices of black sea bass from the winter, spring and autumn surveys provide some insight into the cohort strength (Table C8). The juveniles appear as clearly defined modes at sizes $\leq$ 14 cm in the autumn surveys. There appears to be little growth during the winter, as the same distinct size mode appears in the winter and spring survey length frequencies. In the spring, fish $\leq$ 14 cm would be considered one year old. Log re-transformed mean #/tow of juvenile sea bass in both the winter and spring surveys suggest large 1999 and 2001 cohorts (peaks in the 2000 and 2002 surveys) (Figure C14). Both of these modes in the length frequency appear the following year as increases in a mode above 20 cm, which is consistent with known growth rates (Figures C15 and C16). The winter survey shows an above average 2002 year class, however this is not apparent in the spring survey and the spring survey shows a strong 1998 cohort that was below average in the winter survey. The autumn surveys show above average 1998-2000 year classes. In all three surveys, the 2005 cohort appears below average.

Massachusetts Division of Marine Fisheries

The Massachusetts spring bottom trawl survey, initiated in 1978, showed a recent increase in sea bass with a peak stratified mean number per tow of 4.0 in 2000 (Table C9, Figure C17). However the indices have since declined and have been at or below the time series average (1.21/tow). The 2005 index was 1.1 fish/tow. The index of spawning stock biomass also peaked in 2000 at 1.93 kg/tow and has steadily declined in 2003 to 0.93 kg/tow in 2005. The SSB index still remains well above the levels experienced in the 1990s. The MA juvenile sea bass index from the autumn survey indicated a series of strong cohorts during the early 1980s, followed by a decade and half of low values. Juvenile indices have increased steadily since 2000 and the 2005 index of 432.5 fish/tow is the series maximum (Figure C17).

Rhode Island Trawl Survey

Catches in the RI autumn bottom trawl survey, which began in 1981, are predominated by juveniles. The mean number per tow shows several strong cohorts in the early 1980s, with 1981 the largest value in the time series (Table C10). Similar to Massachusetts, the late 1980s and 1990s were below average with increased year-class strength beginning in 2000 and a very large 2005 year class.

Connecticut Long Island Sound Trawl survey

The time series of geometric mean number per tow from the CT trawl survey begins in 1984 and this survey catches very few black sea bass. The juvenile indices from the fall survey show a similar trend to the NMFS, MA and RI surveys with low abundance in the 1990s and an increased in abundance over the past several years, beginning in Long Island Sound in 2001 (Table C10) .

New Jersey Coastal Ocean Survey

The New Jersey trawl survey is conducted during January, April, June, August, and October. Mean number per tow peaked in 2002 (2.7/tow) and has since steadily declined (Table C10). Indices of juvenile abundance (<= 14 cm) were unusually large in 1997 (as well as adults that year) and also showed a strong cohort in 2002. The 2004 and 2005 year classes are below time series average.

Chesapeake Bay and Lower James River

A trawl survey conducted by the VA Institute of Marine Science provides indices of age 1 sea bass abundance within Chesapeake Bay. The indices show increasing cohort strength beginning in 1997 (1996 cohort) and peaking in 2002 (2001 cohort), followed by a steady decline to 2005 (Table C10). The 2002 index was 1.29 fish per tow compared to the 2005 index of 0.06 per tow.

The juvenile indices from all sources were standardized as a percent of the maximum value within each series, and averaged across all values (assumed equal weighting among programs). Age 0 fish in fall survey indices were advanced to the next calendar year to coincide with age 1 sea bass in spring indices. The results, presented in Figure C18, show an overall trend of good recruitment in the 1980s, low recruitment in the 1990s and improved recruitment in since 2001.

6.0 TOR 3. Describe migration patterns based on data from the recent tagging study.

The northern stock of black sea bass has distinctive seasonal movement patterns. Timing and directionality of these movements are not the same throughout the region but they experience a common offshore residence area during the winter/spring (Jan-Jun) and then return to a seasonal separation during the summer/fall (Jul-Dec) inshore residence. Movement patterns were examined on a sub-regional basis (area of release) (New England (NE) = MA, RI, CT) (Mid Atlantic Bight (MAB) = NY, NJ, DE) (Maryland/Virginia (MV) = MD, VA). Distinctive patterns emerged among the groups based on recapture data.

Maps and migration descriptions are based on the 2,415 tag recaptures reported as of 15 April 2006. Fish tagged and released in late summer or fall moved to the edge of the continental shelf for the winter months and almost always returned to the same area the following summer (Figure C19). During summer and fall months, recapture data show relatively little mixing among adjacent areas whereas winter and spring recaptures show a thorough mix of all three sub-regions along the edge of the continental shelf (Figure C20).

Timing of fish movements begin in the New England (MA, RI, CT) region during late October and progress southward as water temperature decreases. It is clear that fish released in the New England area travel much greater distances to reach the offshore area (Table C11). Mean distance traveled is twice as high during summer/fall months for the New England released fish (when compared to Mid-Atlantic Bight and the Maryland/Virginia releases) and more than 3½ times the mean distance traveled during winter/spring months. The NE releases move south-southwest, MAB fish tend to move southeast and MV fish move eastward to reach their offshore grounds.

The seasonality of movement and mixing of tag recaptures is further supported by Table C12; a matrix of recaptures by region and month, based on the region of release. During December through April, New England released fish were primarily caught in the MAB region (33 of 49 tags), approximately half as many were caught within the MV region (15 of 49) and only two tags were recaptured within that same region during that time period. Conversely, from May through November, the majority of recaptured tags were recovered within the New England region. When the Mid Atlantic Bight released tags are examined, there is much less movement to the MV region and only a single tag moved into the NE region (consequently, this tag was released near the NE/MAB boundary). Maryland and Virginia released fish showed a more random pattern of movement. Eight tags moved into North Carolina water (south of the MV boundary region) and 36 of the 1024 recaptured tags moved into the MAB region. The majority of the MV released tags were recaptured within the MV region.

A matrix of movement among the States of release is shown on Table C13. The grey boxes represent no net movement or recapture within the State of release (State fidelity). Values within the same row but outside the grey box demonstrate net movement to the north and south of the release State. Proportions of net movements are presented in the last three columns. In most States the recaptures primarily occur within the State of release (‘No net Move’) which suggests that the fish return to the same State in which they were originally tagged. The exception is Connecticut where all recaptures (2) occurred to the south. Fish generally moved more southward than northward, the two exception being RI → MA (the states are at equal latitude, movements are actually eastward) and DE → NJ (where tag data shows a common exchange of fish between underwater structures located off Lewes, DE and Cape May, NJ).

Archival tag (data storage tag – DST) information suggests that fish movements are cued by decreasing temperatures in late fall. Figure C21 shows the depth and temperature profiles of a tag released off RI and recovered along the edge of the continental shelf near the tip of Hudson canyon. The data show decreases in temperature related to fish movement to deeper water, apparently in search of warmer water (abrupt depth changes suggest movement perpendicular to depth contours). Once a warmer body of water is found (usually at greater depth), the fish settles at depth and remains until the temperature falls and once again the fish moves. By late January the temperature readings leveled out and the movement patterns cease.

7.0 TOR 4. Estimate annual rates of fishing mortality and total mortality, based on the recent tagging study. Characterize the uncertainty of those estimates.

The black sea bass tagging program was initiated in September of 2002, with subsequent release periods in May 2003, September 2003 and September 2004. An analysis of tag recaptures were reviewed in SARC 39 and judged to be adequate for management. At that point, tag returns were limited to one year and consequently analysis was limited to a simple R/M estimate of exploitation. Since then, we have completed three years of tag recaptures which allows us to complete a more rigorous analysis of the data. Two basic modeling approaches are presented; a modified R/M estimate with a Monte Carlo method of examining uncertainty and Brownie models under a variety of configurations.

Modified R/M Method

Tag releases were limited to fish greater than 28 cm (11 in) which were considered to be subject to full exploitation by both commercial and recreational fisheries. Subsequent tag recaptures were tallied by release cohort and year of recapture. Year of recapture was a one year period beginning with time of release (e.g. September to September) and not a calendar year. A recapture matrix is provided in Table C14.
Tag recaptures (and the associated release record) that occurred within 7 days by the same fisherman involved with the release program were discounted. Tag releases and recaptures are influenced by several external factors. The number of released tags can be reduced by tag loss and tagging induced mortality. The number of tag recaptures are a function of reporting rate, exploitation, fishery selectivity and emigration from the system. There is no indication from the geographic distribution of tag recaptures that the tagged sea bass left the tag recovery area, since there are active commercial and recreational fisheries in surrounding areas with no reported recaptures. Tag retention experiments (Table C15) have provided an estimate of tag loss (8%) and mortality (2%), as well as a range of values from the three experiments (Table 16). Reporting rate was estimated for each tagging period using the ratio of regular tag returns to returns from $100 tags. We are assuming that $100 tags are reported at close to 100% although there is evidence that the rate may be slightly less than 100%. Reporting rates for the four release periods were estimated as 65.8% (fall 2002-2003); 60.9% (spring 2003-2004); 68.6% (fall 2003-2004); and 55.3% (fall 2004-2005). Length frequency of tag recaptures

and fishery length frequencies are comparable, suggesting that the selectivity of the tags is representative of the fisheries (Figure C22).

The modified R/M estimate was based on the expression:

$$u = \frac{\text{\# tags recaptured /reporting rate)}}{\text{(\# tags release - \# tags lost - \# tags lost due to tag induced mortality)}}$$

Since the estimated reporting rates, tag loss and tag induced mortalities were all measured with error, possible variation around the exploitation rate was estimated using a Monte Carlo approach. A normal distribution around mean tag loss and tag induced mortality was generated with standard deviations that produced a comparable range of values as the empirical data. A normal distribution around the mean annual reporting rates was generated to produce a distribution ranging from 40% to 95% (Figure C23). A thousand values from each distribution were randomly selected to produce 1000 combinations of tag loss, tag induced mortality and reporting rate. Exploitation rates were generated for each of the 1000 combinations to produce a distribution of *u* for each tag release group. (EDITOR'S NOTE: TEXT FROM THIS PARAGRAPH HAS BEEN OMITTED. THE REVIEW PANEL DID NOT ACCEPT THE F ESTIMATES. THE PANEL CONCLUDED THAT INCOMPLETE MIXING AND MIGRATION NEED TO BE INVESTIGATED FURTHER.)

The R/M approach was further modified in an attempt to directly estimate natural mortality. The method is based on a variation of an approach described by Pollock et al. (1991). The tag release and recoveries were arranged as follows:

		Recapture year		
	M_1	$\mathbf{R_{11}}$	R_{12}	R_{13}
Release	M_2		$\mathbf{R_{21}}$	R_{22}
Year	M_3			$\mathbf{R_{31}}$

The diagonal of the recaptures represent the exploitation for the first recapture year following release of that tag cohort. The second year of recoveries ($R_{12,}$ R_{22}) should also be a function of same exploitation rate and tag reporting rate within that recapture year, except the number of tags available for recapture has been reduced by the removals in the first year (R_{i1}) and natural mortality. Since the number of tags removed the first year is known, and we assume tags recovered in the diagonal row properly estimate exploitation for that year, the difference between R_{21} and R_{12} should be equal to tags lost from natural annual mortality. Therefore:

[(R_{21} / reporting rate) / (M_2-initial tag loss)] - [(R_{12}/reporting rate) / (M_1- initial tag loss - (R_{11}/reporting rate))] = # tags removed by natural annual mortality

The natural loss percentage was translated into instantaneous natural mortality as described above using 1000 combinations of initial tag loss, tag induced mortality and reporting rates. For M in years not estimable with this approach, values were randomly selected from a uniform distribution ranging from 0.17 to 0.27. (EDITOR'S NOTE: TEXT FROM THIS PARAGRAPH HAS BEEN OMITTED. THE REVIEW PANEL DID NOT ACCEPT THE MORTALITY ESTIMATES. THEY CONCLUDED THAT INCOMPLETE MIXING AND MIGRATION NEED TO BE INVESTIGATED FURTHER.)

Brownie Method

A second modeling approach used was a class of band recovery models commonly referred to as Brownie models (Brownie et al. 1985). Survival estimates are based on the tag release-recovery matrix and the estimates of model parameters S (survival) and f (recovery rate) were developed using maximum log-likelihood estimation. A spreadsheet version of the model was developed (see appendices) and tested against known model results. Two series of models were examined; the first series used the fall annual recapture matrix of regular tags while a second series divided release and recoveries into seasonal components (June-November and December-May), which included the spring release cohort and combined regular with high reward tags to increase sample size. The spreadsheet model included parameters to allow adjustments in the recovery matrix for reporting rate (which is subsumed in the f parameter) and a term labeled dispersal rate which allowed adjustment of the first year recoveries to examine the sensitivity to the assumption of tag dispersal. The numbers of released tags in the recovery matrix were adjusted by 8% to account for initial tag loss and annual models adjusted recoveries for annual reporting rates. The seasonal tag model included 0 tags released or recovered in the second spring period and therefore no likelihood estimates were included for that row. QAIC values were calculated for each model for comparison within each series. Pearson goodness-of-fit tests were also made for each model to test for significance between observed and predicted recoveries (degrees of freedom were calculated as # cells - # of model parameters).

The first annual recapture model was a fully parameterized model:

N_1f_1	$N_1S_1f_2$	$N_1S_1S_2f_3$
	N_2f_2	$N_2S_2f_3$
		N_3f_3

The second annual model assumed constant survival and tag recovery over the 3 years and had the structure:

N_1f	N_1Sf	N_1SSf
	N_2f	N_2Sf
		N_3f

Model results are listed in Table C17. (EDITOR'S NOTE: THIS TABLE OF THE WORKING GROUP REPORT HAS BEEN OMITTED. THE ESTIMATES WERE NOT ACCEPTED BY THE REVIEW PANEL. THEY CONCLUDED THAT INCOMPLETE MIXING AND MIGRATION NEED TO BE INVESTIGATED FURTHER.)

The seasonal model increased the model structure to 5 release periods (which included the 0 releases in the 2nd spring period) and 8 recovery periods. The fully parameterized model was structured as:

N_1f_1	$N_1S_1f_2$	$N_1S_1S_2f_3$	$N_1S_1S_2S_3f_4$	$N_1S_1S_2S_3S_4f_5$	$N_1S_1S_2S_3S_4S_5f_6$	$N_1S_1S_2S_3S_4S_5S_6f_7$	$N_1S_1S_2S_3S_4S_5S_6S_7f_8$
	N_2f_2	$N_2S_2f_3$	$N_2S_2S_3f_4$	$N_2S_2S_3S_4f_5$	$N_2S_2S_3S_4S_5f_6$	$N_2S_2S_3S_4S_5S_6f_7$	$N_2S_2S_3S_4S_5S_6S_7f_8$
		N_3f_3	$N_3S_3f_4$	$N_3S_3S_4f_5$	$N_3S_3S_4S_5f_6$	$N_3S_3S_4S_5S_6f_7$	$N_3S_3S_4S_5S_6S_7f_8$
			N_4f_4	$N_4S_4f_5$	$N_4S_4S_5f_7$	$N_4S_4S_5S_6f_7$	$N_4S_4S_5S_6S_7f_8$
				N_5f_5	$N_5S_5f_7$	$N_5S_5S_6f_7$	$N_5S_5S_6S_7f_8$

Other seasonal models examined were: an assumption of constant survival within each period (S_1, S_2 and f_1, f_2) and an assumption of constant survival across periods (S and f). These model results are listed in Table C17. (EDITOR'S NOTE: THIS TABLE HAS BEEN OMITTED BECAUSE THE RESULTS WERE NOT ACCEPTED BY THE REVIEW PANEL. THEY CONCLUDED THAT INCOMPLETE MIXING AND MIGRATION NEED TO BE INVESTIGATED FURTHER.)

An alternative length tuned model (LTM) was compared to the tagging models (Appendix). The length model was able to capture the dynamics of the population with the exception of the last few years. A decrease in biomass observed in the surveys following several large cohorts since 2002 could not be explained by reported landings.

Consequently the model predicted a significant rise in biomass over the most recent 5 years. The WG concluded that there may be underestimates of removals from discarding, the recruitment index may be overestimating the strength of recent year classes, the survey biomass index was not correct or combinations of all three. The group also concluded that further model runs should be conducted to explore the sensitivity of the input data.

8.0 TOR 5. Evaluate current stock status with respect to the existing BRPs.

The present BRP for black sea bass is F_{max} as a proxy for F_{msy}. F_{max} as currently defined is equal to 0.33 based on Thompson-Bell yield per recruit model. The Working Group did not recommend any changes to the estimate. (EDITOR'S NOTE: F ESTIMATES THAT WERE IN THIS PARAGRAPH HAVE BEEN REMOVED BECAUSE THEY WERE NOT ACCEPTED BY THE REVIEW PANEL.)

A proxy for the minimum biomass threshold is based on a three point moving average of exploitable biomass ($\geq$ 22 cm) from the NEFSC spring survey 1977-1979 indices. No alternative biomass estimates are currently available. The average biomass ($\geq$22 cm) index for 2004-2006 (0.80) was below the biomass threshold proxy of 0.98 kg/tow. (EDITOR'S NOTE: TEXT ABOUT STOCK STATUS HAS BEEN OMITTED BECAUSE THE REVIEW PANEL DID NOT ACCEPT THE EXISTING BIOMASS REFERENCE POINT.)

9.0 TOR 6. Perform sensitivity analyses to determine the impact of uncertainty in the recreational data on the assessment results.

The impact of uncertainty in the recreational data was not explicitly evaluated since this assessment model does not incorporate fishery landings. Recreational landings and discards $\pm$ 2 PSE are presented in Table C19. The length based model (LTM) was run using MRFSS estimates $\pm$ 2 PSE. The changes did not affect the results.

10.0 TOR 7. Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in the previous SARC-reviewed assessment.

SARC 39 Recommendations, followed by update in italics:

- More comprehensive evaluation of regional survey data is required to give more integrated indices of recruitment. *The WG did not make progress on this research recommendation.*

- Adequate sampling of both commercial and recreational catches should be implemented with a view to improving knowledge of discarding and what affects it, so reducing one of the uncertainties inherent in the catch series. *Commercial and recreational length sampling intensity has improved since the last assessment. However, in light of recent overall reductions in commercial observer coverage, discard sampling is expected to decline.*

- Both accuracy and completeness of catch data, particularly recreational catch, should be investigated to explain unusual inter-annual variability. *No further information was available to investigate the variability in recreational catch estimates. In the preliminary LTM model, the average of adjacent years was used to replace the aberrant 1982 and 1986 recreational landing estimates.*

- Attempts should be made to extract as much information as possible from all time-series considered appropriate using, for example, a GLM or GAM approach to combine the various surveys and gear types into a standardized index. *The Working Group made no progress on this recommendation.*

- Confidence limits for survey-based estimates of recreational catch should be derived and presented. *Estimates of proportional standard error are included with the recreational catch estimates.*

- Ageing of samples of black sea bass should be initiated as soon as possible, and survey indices need to be disaggregated by age to identify the impact of year-class variation in the biomass index and to investigate the magnitude of year effects. *No progress was made in aging the back log of age samples.*

- A standard assessment based on a population model should be developed for the stock. A catch-at-age model would seem to be the most appropriate. *A length tuned model (LTM) was applied to the fishery and survey catch information to derive preliminary estimates of population biomass and fishing mortality.*

- Clarification is needed whether the bias introduced on back-transforming from length-weight relationship has been corrected for in the assessment. If not, it should be. *No progress made on this recommendation*.

- If financially feasible, tagging studies should continue (at least sporadically), to permit return rates over longer periods and the stability of estimates of exploitation rate to be established. Further, long-term data on rates of tag loss need to be collected through the tagging program. *The tag release program for black sea bass has been completed. Recoveries continue to be collected and included in analysis. Current assessment includes recoveries through April 2006.*

- A more sophisticated analytical model such as the Brownie with a migration extension should be applied to the tagging data. *The Working Group completed analysis of tagging data with a Brownie model however a migration extension was not included due to limited data. Work continues on defining migration patterns for inclusion in the Brownie model.*

- Improved education and awareness programs should be initiated in an attempt to improve tag return rates. *The tag release program for black sea bass has been completed and no funds are available for continued outreach programs.*

- The relationship between offshore distribution patterns and environmental variables such as temperature and frontal systems should be investigated, to ensure that catchability effects are not driving trends in the spring surveys. *No further progress has been completed on this recommendation.*

Working Group Research Recommendations:

- If a new analytical assessment is available, update biological reference points as part of the assessment. The Working Group notes that a new age-based analytical assessment will be contingent on aging the backlog of age structures in storage and developing reliable estimates of fishery discards.

- Continue work on development of the length based model, or another analytical model as the basis for the assessment. The WG notes that progress is contingent on development of updated growth estimates and improved estimates of fishery discards.

- Continue work on defining migration pathways and identifying migration groups of black sea bass for use in analyzing tagging data.

- Funding should be provided for continued management of tag recoveries and outreach programs (tag rewards).

- Recommend examination of population structure of black sea bass using genetic techniques.

11.0 SUMMARY

(EDITOR'S NOTE: TEXT ABOUT STOCK STATUS HAS BEEN OMITTED BECAUSE THE REVIEW PANEL DID NOT ACCEPT THE EXISTING BIOMASS REFERENCE POINT.) Following a peak in 2002, the spring and winter indices have both followed a similar pattern of decline. The WG expressed concern about the use of biomass index for fish greater or equal to 22 cm as a proxy for exploitable biomass. When the index was developed, the minimum size for the commercial and recreational fisheries was equivalent to 22 cm but has since increased such that exploitable biomass is closer to 29 cm. The WG decided that the current definition was a reasonable compromise for use as a biomass reference point. The WG also discussed the shortcomings of a biomass reference point where the status determination can be heavily influenced by one large data point in the index. However at this time there do not appear to be any better alternatives.

The tag model using a modified tag recapture to release ratio was chosen as the best estimate of current exploitation. (EDITOR'S NOTE: TEXT ON F RATES AND OVERFISHING HAS BEEN OMITTED BECAUSE THE F ESTIMATES WERE NOT ACCEPTED BY THE REVIEW PANEL. THEY CONCLUDED THAT INCOMPLETE MIXING AND MIGRATION NEED TO BE INVESTIGATED FURTHER.)

Various configurations of the Brownie model produced a wide range of survival estimates. Sensitivity tests implied that the Brownie model results were less robust than the R/M approach. The WG also noted that since the f parameter in the model was the probability of tag recovery, adjustments of the observed tag recoveries to account for estimated reporting rate (f /reporting rate) should be equivalent to exploitation rate. Also with a year, the survival estimate and exploitation rate should be comparable. However, in all the Brownie model results, the two parameters were not comparable implying the model fit was not adequate.

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BLACK SEA BASS TABLES

Table C1. Black sea bass commercial and recreational landings, ME-NC.

Year	Commercial landings 000s lbs	Commercial landings (mt)	Recreational landings (000 lbs)	Recreational landings (mt)	Total landings (mt)
1950	12,645	5,736			
1951	18,432	8,361			
1952	21,788	9,883			
1953	14,375	6,521			
1954	11,334	5,141			
1955	11,310	5,130			
1956	11,569	5,247			
1957	9,521	4,319			
1958	11,554	5,241			
1959	8,056	3,654			
1960	6,836	3,101			
1961	5,422	2,459			
1962	8,123	3,554			
1963	8,372	3,705			
1964	7,051	3,143			
1965	7,948	3,481			
1966	3,606	1,537			
1967	2,803	1,154			
1968	2,482	1,079			
1969	2,489	1,097			
1970	2,214	970			
1971	1,349	566			
1972	1,989	727			
1973	2,746	1,115			
1974	3,320	1,023			
1975	4,650	1,680			
1976	4,135	1,557			
1977	5,014	1,985			
1978	4,267	1,662			
1979	3,152	1,241			
1980	2,325	977			
1981	2,548	868	1,245	565	2,678
1982	2,960	1,004	9,898	4,490	15,392
1983	3,692	1,437	4,106	1,862	7,405
1984	3,786	1,641	1,294	587	3,522
1985	3,341	1,178	2,116	960	4,254
1986	3,984	1,594	12,391	5,621	19,606
1987	4,263	1,729	1,942	881	4,551
1988	3,466	1,473	2,864	1,299	5,636
1989	2,758	1,105	3,292	1,493	5,890
1990	3,178	1,334	2,770	1,257	5,361
1991	2,433	1,104	4,162	1,888	7,154
1992	2,594	1,177	2,620	1,189	4,985
1993	2,896	1,314	4,835	2,193	8,341
1994	2,094	950	2,940	1,333	5,223
1995	2,069	938	6,204	2,814	9,957
1996	3,458	1,569	3,986	1,808	7,363
1997	2,642	1,198	4,262	1,933	7,394
1998	2,583	1,171	1,143	518	2,833
1999	2,881	1,307	1,651	749	3,707
2000	2,658	1,206	4,006	1,817	7,028
2001	2,862	1,298	3,429	1,556	6,283
2002	3,499	1,587	4,380	1,987	7,955
2003	2,996	1,359	3,314	1,503	6,177
2004	3,002	1,362	1,675	760	3,796
2005	2,888	1,310	1,735	787	3,833

Table C2. Summary of number of black sea bass length measurements from commercial fisheries, 1998-2005.

1998

	1	2	3	4
Unclassified		69		
Small	750	475	494	174
Medium	990	587	260	102
Large	590	111	9	
Jumbo	104	28		
				4,743

1999

	1	2	3	4
Unclassified		221		
Small	627	530	377	375
Medium	924	344	261	351
Large	278			275
Jumbo	103			
				4,666

2000

	1	2	3	4
Unclassified				
Small	252	312	513	108
Medium	809	318	64	121
Large	722	67		
Jumbo	269	24		
				3,579

2001

	1	2	3	4
Unclassified	89	80		
Small	953	178	300	200
Medium	1370	206	209	100
Large	622	310	100	27
Jumbo	3678	89	103	147
				8,761

2002

	1	2	3	4
Unclassified	906			
Small	274	199		300
Medium	1310	49		417
Large	1693	103	104	263
Jumbo	278	87	100	169
				6,252

2003

	1	2	3	4
Unclassified	103	128	50	
Small		200	99	
Medium	2552	343	204	408
Large	2625	264	101	463
Jumbo	2071	215	134	231
				10,191

2004

	1	2	3	4
Unclassified		54	168	41
Small	219		104	
Medium	2446	939	303	106
Large	1872	817	101	131
Jumbo	1322	686	18	230
				9,557

2005

	1	2	3	4
Unclassified	33	100	58	
Small	278	100		
Medium	2454	1061	399	354
Large	2885	931	419	219
Jumbo	1903	502	25	411
				12,132

Table C3. Summary of total number, total weight, mean weight and mean lengths by year and market category of commercial black sea bass, 1998-2005.

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
	number	*number*	*number*	*number*	*number*	*number*	*number*	*number*
uncl	323,967	173,127	164,069	157,495	373,279	64,935	139,376	180,419
large	360,523	488,271	519,377	545,703	640,400	873,903	752,321	693,492
jumbo	70,841	105,361	186,302	220,932	429,998	268,934	290,911	258,768
med	1,049,440	962,946	623,481	926,165	988,376	892,235	833,155	739,007
small	1,297,322	995,057	763,540	706,149	344,846	225,718	241,028	152,660
total	3,102,093	2,724,762	2,256,770	2,556,445	2,776,898	2,325,726	2,256,792	2,024,346
	wt kg	*wt kg*	*wt kg*	*wt kg*	*wt kg*	*wt kg*	*wt kg*	*wt kg*
uncl	118,204	119,993	92,564	83,264	136,135	56,228	70,286	99,727
large	249,420	364,936	372,206	379,265	518,184	436,463	420,716	380,501
jumbo	88,119	143,652	226,116	192,660	366,878	377,954	410,063	417,214
med	364,681	387,143	286,839	422,354	446,842	409,077	366,690	321,047
small	350,997	290,876	227,814	220,816	119,283	79,450	92,030	56,890
mean wt	0.38	0.48	0.53	0.51	0.57	0.58	0.60	0.63
	x wt	*x wt*	*x wt*	*x wt*	*x wt*	*x wt*	*x wt*	*x wt*
uncl	0.36	0.69	0.56	0.53	0.36	0.87	0.50	0.55
large	0.69	0.75	0.72	0.70	0.81	0.50	0.56	0.55
jumbo	1.24	1.36	1.21	0.87	0.85	1.41	1.41	1.61
med	0.35	0.40	0.46	0.46	0.45	0.46	0.44	0.43
small	0.27	0.29	0.30	0.31	0.35	0.35	0.38	0.37
	x len	*x len*	*x len*	*x len*	*x len*	*x len*	*x len*	*x len*
uncl		35.5		32.9	29.5	40.6	34.7	28.3
large	36.3	37.2	36.7	36.4	38.1	36.3	37.6	37.3
jumbo	44.0	45.2	43.7	38.6	38.3	45.6	45.5	47.5
med	28.9	30.4	31.8	31.8	31.7	31.7	31.3	31.1
small	26.8	27.4	27.7	28.1	29.1	29.2	29.8	29.6
mean length	29.3	31.4	32.6	32.4	33.6	35.1	35.3	34.9

Table C4. Summary of commercial black sea bass discards from vessel log books, prorated to total landings.

	lbs kept	lbs disc	% discard	total landings	% in VTR	total discard lbs	total discard mt
2005	2,424,560	117,439	5%	2,888,223	84%	139,898	63
2004	2,633,329	173,804	7%	3,001,888	88%	198,129	90
2003	2,484,244	209,349	8%	2,996,458	83%	252,514	115
2002	2,629,970	333,106	13%	3,499,448	75%	443,232	201
2001	2,297,375	268,104	12%	2,862,243	80%	334,024	152
2000	2,307,036	250,255	11%	2,657,944	87%	288,320	131
1999	2,521,161	205,336	8%	2,880,556	88%	234,607	106
1998	2,335,566	178,172	8%	2,582,541	90%	197,013	89
1997	2,315,661	64,185	3%	2,641,595	88%	73,219	33

Table C5. Recreational discards (B2) (000s) from 1981 to 2005 as estimated from MRFSS.

	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	Total
1981	-	-	79	3	11	79	142	12	144	1,249	41	1,760
1982	-	-	2	3	-	127	364	14	135	671	23	1,339
1983	-	-	9	-	-	166	800	26	170	1,481	370	3,023
1984	-	1	24	4	8	199	136	10	389	723	117	1,610
1985	-	-	8	1	41	227	929	26	172	1,151	96	2,651
1986	-	2	110	49	204	713	3,265	66	518	2,164	84	7,175
1987	-	-	119	42	2	247	280	62	425	879	388	2,444
1988	-	-	60	11	7	244	201	104	2,492	1,632	264	5,014
1989	-	1	18	18	20	184	584	148	442	714	107	2,235
1990	1	-	11	5	1	56	616	124	1,461	2,889	91	5,254
1991	1	-	8	5	39	230	2,019	277	1,280	1,622	131	5,610
1992	-	-	3	9	2	114	1,065	219	1,096	1,541	257	4,304
1993	-	-	9	9	2	30	956	178	546	1,256	239	3,223
1994	-	-	6	1	1	326	1,317	206	381	1,379	352	3,970
1995	-	0	16	41	10	343	2,570	314	1,832	2,012	418	7,556
1996	-	-	21	82	19	311	1,405	119	582	1,936	77	4,553
1997	-	0	29	36	18	523	2,811	272	586	1,533	207	6,015
1998	-	-	42	26	15	79	1,235	284	754	1,332	134	3,900
1999	-	0	26	121	174	731	1,728	213	1,487	1,242	29	5,751
2000	-	0	268	401	89	1,222	5,545	820	3,224	1,570	66	13,207
2001	-	0	143	151	17	641	4,371	1,003	2,324	2,180	56	10,886
2002	-	-	268	241	291	1,411	4,318	1,233	925	2,441	177	11,304
2003	-	-	197	205	55	739	4,295	832	773	1,742	38	8,877
2004	-	0	58	38	11	491	2,559	439	671	1,322	83	5,672
2005	-	-	68	50	42	967	2,536	286	767	962	89	5,767

Table C6a. Spring offshore survey mean number per tow and 95% confidence intervals of black sea bass ≥ 22 cm, 1968-2006.

Year	Spring offshore stratified mean #/tow (≥22 cm)	std. error	95% CI High	95% CI Low	ln re-transform mean #/tow	95% CI Low	95% CI High
1968	0.269	0.233	0.725	-0.187	0.070	0.045	0.096
1969	0.937	0.854	2.611	-0.737	0.103	0.076	0.13
1970	0.118	0.032	0.180	0.056	0.111	0.073	0.15
1971	0.182	0.134	0.445	-0.081	0.105	0.059	0.154
1972	0.358	0.141	0.633	0.083	0.250	0.169	0.337
1973	0.696	0.351	1.383	0.009	0.337	0.212	0.475
1974	2.332	0.941	4.176	0.488	1.229	0.786	1.78
1975	1.83	1.251	4.283	-0.623	0.513	0.42	0.612
1976	1.223	0.420	2.046	0.400	0.688	0.525	0.867
1977	4.54	4.073	12.522	-3.442	0.604	0.458	0.765
1978	2.261	1.002	4.225	0.297	0.598	0.444	0.768
1979	4.634	4.114	12.697	-3.429	0.446	0.342	0.558
1980	1.006	0.441	1.871	0.141	0.462	0.326	0.611
1981	0.686	0.196	1.070	0.302	0.360	0.288	0.436
1982	0.102	0.049	0.197	0.007	0.073	0.045	0.102
1983	0.607	0.315	1.225	-0.011	0.339	0.221	0.469
1984	0.23	0.084	0.394	0.066	0.186	0.123	0.252
1985	0.376	0.111	0.594	0.158	0.268	0.193	0.347
1986	1.981	1.148	4.230	-0.268	0.755	0.515	1.032
1987	0.959	0.274	1.496	0.422	0.514	0.389	0.65
1988	1.229	0.413	2.038	0.420	0.602	0.457	0.76
1989	0.397	0.105	0.602	0.192	0.245	0.18	0.315
1990	0.458	0.197	0.844	0.072	0.270	0.177	0.37
1991	0.221	0.109	0.434	0.008	0.186	0.101	0.277
1992	1.154	0.427	1.992	0.316	0.665	0.505	0.842
1993	0.697	0.416	1.512	-0.118	0.201	0.137	0.268
1994	0.257	0.126	0.504	0.010	0.175	0.109	0.244
1995	0.431	0.159	0.742	0.120	0.314	0.221	0.413
1996	0.317	0.131	0.573	0.061	0.203	0.149	0.258
1997	1.201	0.659	2.492	-0.090	0.542	0.396	0.702
1998	0.401	0.249	0.889	-0.087	0.189	0.137	0.244
1999	1.026	0.708	2.413	-0.361	0.537	0.344	0.759
2000	0.343	0.095	0.528	0.158	0.301	0.202	0.407
2001	1.581	0.582	2.722	0.440	0.792	0.598	1.009
2002	2.274	0.478	3.210	1.338	1.253	1.024	1.508
2003	6.885	4.569	15.839	-2.069	1.614	1.181	2.134
2004	2.081	0.837	3.721	0.441	0.711	0.561	0.874
2005	1.803	0.965	3.695	-0.089	0.727	0.571	0.898
2006	0.913	0.478	1.849	-0.023	0.456	0.331	0.594

Table C6b. Winter survey mean number per tow and 95% confidence intervals of black sea bass ≥ 22 cm, 1992-2006.

Year	Winter stratified mean #/tow (>22 cm)	std. error	95% CI Low	95% CI High	ln re-transform mean #/tow	95% CI Low	95% CI High
1968							
1969							
1970							
1971							
1972							
1973							
1974							
1975							
1976							
1977							
1978							
1979							
1980							
1981							
1982							
1983							
1984							
1985							
1986							
1987							
1988							
1989							
1990							
1991							
1992	1.913	0.496	0.941	2.885	0.991	0.808	1.193
1993	2.521	0.916	0.725	4.317	0.951	0.755	1.169
1994	0.517	0.146	0.231	0.803	0.405	0.294	0.525
1995	1.247	0.347	0.566	1.928	0.847	0.639	1.081
1996	2.036	0.550	0.957	3.115	1.058	0.819	1.330
1997	0.809	0.384	0.057	1.561	0.422	0.325	0.527
1998	2.299	0.500	1.319	3.279	0.351	0.297	0.408
1999	0.805	0.149	0.514	1.096	0.612	0.495	0.738
2000	1.790	0.547	0.717	2.863	1.082	0.843	1.352
2001	4.869	1.825	1.291	8.447	1.866	1.487	2.302
2002	5.893	1.516	2.922	8.864	3.436	2.817	4.156
2003	7.591	3.339	1.046	14.136	3.160	2.351	4.164
2004	3.207	1.090	1.070	5.344	1.213	1.007	1.440
2005	2.182	0.759	0.695	3.669	0.558	0.450	0.674
2006	1.595	0.410	0.792	2.398	1.061	0.819	1.334

Table C7a. Spring offshore survey mean weight per tow and 95% confidence intervals of black sea bass ≥ 22 cm, 1968-2006.

Year	Spring offshore stratified mean kg/tow (≥22 cm)	95% CI High	Low	ln re-transform mean kg/tow	95% CI Low	High
1968	0.152	-0.113	0.417	0.040	0.026	0.055
1969	0.217	-0.178	0.613	0.024	0.018	0.030
1970	0.066	0.030	0.102	0.062	0.041	0.084
1971	0.063	-0.030	0.155	0.036	0.020	0.053
1972	0.155	0.034	0.277	0.108	0.073	0.146
1973	0.272	-0.001	0.545	0.131	0.083	0.185
1974	0.964	0.185	1.744	0.509	0.325	0.737
1975	0.846	-0.310	2.002	0.237	0.194	0.283
1976	0.631	0.198	1.064	0.355	0.271	0.447
1977	1.120	-0.891	3.130	0.149	0.113	0.189
1978	0.730	0.083	1.378	0.193	0.143	0.248
1979	1.078	-0.835	2.990	0.104	0.080	0.130
1980	0.292	0.036	0.547	0.134	0.094	0.177
1981	0.311	0.133	0.489	0.164	0.131	0.198
1982	0.027	0.001	0.053	0.019	0.012	0.027
1983	0.145	-0.005	0.296	0.081	0.053	0.112
1984	0.122	0.034	0.209	0.097	0.064	0.132
1985	0.164	0.068	0.260	0.116	0.084	0.150
1986	0.559	-0.088	1.206	0.213	0.145	0.291
1987	0.380	0.163	0.597	0.204	0.154	0.258
1988	0.407	0.133	0.680	0.199	0.151	0.251
1989	0.138	0.066	0.211	0.085	0.062	0.109
1990	0.144	0.021	0.268	0.085	0.055	0.116
1991	0.057	0.001	0.113	0.048	0.026	0.072
1992	0.362	0.094	0.629	0.208	0.158	0.263
1993	0.141	-0.027	0.309	0.041	0.028	0.054
1994	0.086	0.002	0.171	0.059	0.037	0.082
1995	0.148	0.040	0.256	0.107	0.075	0.141
1996	0.143	0.026	0.260	0.091	0.067	0.116
1997	0.300	-0.029	0.629	0.135	0.099	0.175
1998	0.111	-0.026	0.247	0.052	0.038	0.067
1999	0.424	-0.160	1.008	0.222	0.142	0.313
2000	0.156	0.070	0.242	0.137	0.092	0.185
2001	0.470	0.124	0.815	0.235	0.178	0.300
2002	1.121	0.650	1.591	0.617	0.505	0.743
2003	2.151	-0.703	5.004	0.504	0.369	0.666
2004	0.938	0.183	1.693	0.321	0.253	0.394
2005	0.927	-0.066	1.919	0.374	0.293	0.461
2006	0.548	-0.027	1.123	0.288	0.199	0.358

Table C7b. Winter survey mean weight per tow and 95% confidence intervals of black sea bass ≥ 22 cm, 1992-2006.

Year	Winter stratified mean kg/tow (≥22 cm)	95% CI Low	High	ln re-transform mean kg/tow	95% CI Low	High
1968						
1969						
1970						
1971						
1972						
1973						
1974						
1975						
1976						
1977						
1978						
1979						
1980						
1981						
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990						
1991						
1992	0.455	0.224	0.686	0.236	0.192	0.284
1993	0.764	0.220	1.308	0.288	0.229	0.354
1994	0.139	0.062	0.217	0.109	0.079	0.142
1995	0.335	0.152	0.518	0.228	0.172	0.290
1996	0.539	0.253	0.824	0.280	0.217	0.352
1997	0.252	0.018	0.485	0.131	0.101	0.164
1998	0.602	0.346	0.859	0.092	0.078	0.107
1999	0.288	0.184	0.392	0.219	0.177	0.264
2000	0.488	0.196	0.781	0.295	0.230	0.369
2001	1.507	0.400	2.614	0.577	0.460	0.712
2002	2.276	1.128	3.423	1.327	1.088	1.605
2003	3.123	0.430	5.814	1.300	0.967	1.713
2004	1.184	0.395	1.973	0.448	0.372	0.532
2005	0.643	0.205	1.081	0.164	0.133	0.199
2006	0.568	0.282	0.855	0.378	0.292	0.476

Table C8. NEFSC Spring , Autumn and Winter survey indices of juvenile (<14 cm) black sea bass.

	Spring JI		Spring JI			Fall JI		Fall JI			Winter JI	≤ 14 cm			
	≤ 14 cm		ln re- trans	95% CI		≤ 14 cm		ln re-transform	95% CI		mean		ln re-transform	95% CI	
	#/tow	SE	mean #/tow	Low	High	#/tow	SE	mean #/tow	Low	High	#/tow	SE	mean #/tow	Low	High
1968	0.408	0.408	0.085	0.040	0.133										
1969	0.000	0.000	0.000	0.000	0.000										
1970	0.000	0.000	0.000	0.000	0.000										
1971	0.000	0.000	0.000	0.000	0.000										
1972	0.243	0.200	0.143	0.062	0.231	0.033	0.020	0.034	0.007	0.061					
1973	0.000	0.000	0.000	0.000	0.000	0.624	0.294	0.482	0.316	0.668					
1974	0.000	0.000	0.000	0.000	0.000	0.525	0.189	0.493	0.320	0.688					
1975	0.069	0.069	0.061	-0.003	0.129	4.094	3.477	1.334	0.841	1.958					
1976	0.944	0.396	0.557	0.397	0.735	2.074	1.163	1.740	1.086	2.598					
1977	0.184	0.066	0.163	0.099	0.231	15.998	5.813	1.661	1.420	1.925					
1978	0.384	0.261	0.148	0.088	0.211	0.080	0.027	0.079	0.040	0.119					
1979	0.017	0.016	0.017	-0.004	0.039	0.463	0.095	0.386	0.299	0.479					
1980	1.018	0.538	0.482	0.304	0.685	0.856	0.416	0.646	0.407	0.925					
1981	0.045	0.021	0.045	0.016	0.074	0.302	0.267	0.252	0.082	0.448					
1982	0.003	0.003	0.003	0.000	0.006	0.381	0.092	0.387	0.263	0.523					
1983	0.009	0.007	0.009	-0.001	0.018	1.425	0.263	0.724	0.612	0.844					
1984	0.007	0.007	0.007	-0.002	0.016	0.542	0.504	0.257	0.131	0.398					
1985	0.097	0.058	0.085	0.034	0.138	3.464	0.113	1.035	0.866	1.220					
1986	0.182	0.116	0.149	0.068	0.237	7.910	4.634	2.337	1.641	3.216					
1987	0.031	0.020	0.030	0.004	0.055	0.453	0.236	0.363	0.232	0.508					
1988	0.497	0.420	0.232	0.109	0.370	3.011	0.438	2.210	1.528	3.076					
1989	0.079	0.063	0.070	0.016	0.126	0.378	0.177	0.383	0.204	0.589					
1990	0.396	0.373	0.171	0.065	0.288	0.961	0.474	0.845	0.499	1.271					
1991	0.761	0.413	0.499	0.322	0.699	1.062	0.366	0.889	0.607	1.220					
1992	0.382	0.362	0.164	0.060	0.279	0.501	0.158	0.505	0.314	0.724	0.705	0.258	0.538	0.373	0.723
1993	0.007	0.007	0.007	-0.002	0.016	0.079	0.033	0.081	0.041	0.123	0.174	0.074	0.146	0.083	0.214
1994	0.011	0.008	0.011	0.000	0.022	6.488	5.869	1.058	0.818	1.329	0.223	0.109	0.199	0.098	0.309
1995	0.181	0.055	0.162	0.107	0.219	1.239	0.468	1.207	0.790	1.720	0.480	0.124	0.420	0.315	0.533
1996	0.068	0.036	0.063	0.024	0.103	0.741	0.541	0.314	0.226	0.408	1.909	0.617	1.244	0.975	1.548
1997	0.025	0.013	0.024	0.006	0.043	0.841	0.461	0.631	0.434	0.856	0.192	0.093	0.156	0.094	0.220
1998	0.000	0.000	0.000	0.000	0.000	2.888	1.312	1.974	1.400	2.685	0.261	0.062	0.247	0.171	0.328
1999	0.700	0.553	0.347	0.191	0.523	2.489	1.535	1.723	1.009	2.690	0.545	0.179	0.462	0.328	0.610
2000	2.782	2.394	0.661	0.417	0.948	9.977	2.766	2.401	1.721	3.250	3.820	1.285	2.422	1.840	3.123
2001	0.087	0.052	0.078	0.026	0.132	0.325	0.166	0.296	0.167	0.438	1.026	0.250	0.801	0.623	0.999
2002	0.718	0.264	0.554	0.397	0.729	4.394	3.980	1.233	0.801	1.770	3.954	1.072	1.998	1.636	2.411
2003	0.156	0.050	0.154	0.085	0.227	5.960	5.284	1.131	0.757	1.583	2.889	0.943	1.876	1.346	2.526
2004	0.101	0.014	0.080	0.059	0.102	1.326	0.790	0.853	0.572	1.184	0.478	0.214	0.320	0.230	0.416
2005	0.535	0.437	0.219	0.116	0.331	2.793	1.953	0.775	0.600	0.969	1.617	0.691	0.692	0.534	0.866
2006	0.057	0.026	0.054	0.022	0.087						0.896	0.307	0.647	0.465	0.851

Table C9. Massachusetts Division of Marine Fisheries autumn trawl survey stratified mean number per tow and spawning stock biomass per tow of black sea bass, 1978-2005.

Year	spring index mean # / tow	spring index mean kg / tow	fall juv index index mean # / tow	mean weight (kg) per fish	SSB index
1978	1.96	1.40	79.3	0.72	1.40
1979	0.99	0.73	73.2	0.74	0.73
1980	1.00	0.79	93.1	0.79	0.79
1981	2.23	1.26	62.9	0.56	1.26
1982	2.16	0.90	397.2	0.42	0.90
1983	4.53	1.42	185.7	0.31	1.42
1984	1.60	0.69	201.3	0.43	0.69
1985	1.21	0.57	198.5	0.47	0.57
1986	1.58	0.74	80.4	0.47	0.74
1987	0.71	0.20	35.3	0.29	0.20
1988	0.42	0.20	60.4	0.48	0.20
1989	0.55	0.23	6.5	0.42	0.23
1990	0.70	0.45	4.3	0.64	0.45
1991	0.38	0.43	9.5	1.12	0.43
1992	0.09	0.04	10.8	0.43	0.04
1993	0.11	0.08	1.1	0.72	0.08
1994	0.22	0.19	45.0	0.87	0.19
1995	0.47	0.15	32.6	0.33	0.15
1996	0.15	0.09	23.6	0.58	0.09
1997	0.45	0.18	5.3	0.40	0.18
1998	0.22	0.08	9.9	0.35	0.08
1999	1.26	0.78	22.1	0.62	0.78
2000	4.00	1.93	195.5	0.48	1.93
2001	1.75	1.04	87.9	0.59	1.04
2002	1.88	1.14	118.9	0.61	1.14
2003	0.83	0.72	178.2	0.87	0.72
2004	1.25	0.68	241.0	0.54	0.68
2005	1.10	0.93	432.5	0.85	0.93
Avg.	1.21	0.64	103.29	0.57	0.64

Table C10. Juvenile black sea bass indices from state agencies, MA to VA.

Year	MA Fall Mean #/tow age 0	RI Fall Mean #/tow age 0	CT Spring total catch age 1	CT Fall total catch age 0	NJ Fall Mean #/tow age 0	VIMS May-July Mean #/tow age 1	Lower CL	Upper CL
1978	79.3							
1979	73.2							
1980	93.1							
1981	62.9	29.15						
1982	397.2	0.20						
1983	185.7	1.38						
1984	201.3	8.68						
1985	198.5	7.97						
1986	80.4	11.72						
1987	35.3	0.41	0	2				
1988	60.4	1.50	1	0		1.58	1.08	2.20
1989	6.5	0.33	0	1	0.10	0.84	0.59	1.13
1990	4.3	0.76	1	2	0.06	2.36	1.70	3.17
1991	9.5	0.33	4	15	0.57	1.12	0.78	1.53
1992	10.8	1.14	0	0	0.50	1.28	0.91	1.72
1993	1.1	0.03	0	7	0.18	0.22	0.13	0.32
1994	45.0	0.17	0	9	0.18	1.05	0.74	1.42
1995	32.6	1.19	0	0	0.28	1.06	0.74	1.45
1996	23.6	1.15	0	2	0.44	0.50	0.33	0.69
1997	5.3	4.24	0	0	38.00	0.36	0.22	0.52
1998	9.9	0.07	0	1	3.77	0.46	0.31	0.63
1999	22.1	0.90	1	4	1.01	0.57	0.35	0.82
2000	195.5	9.40	17	1	0.98	0.58	0.41	0.77
2001	87.9	3.71	0	22	0.86	0.74	0.50	1.02
2002	118.9	2.38	48	32	4.41	1.29	0.85	1.84
2003	178.2	6.67	0	0	0.54	0.64	0.41	0.90
2004	241.0	1.74	0	67	1.34	0.12	0.06	0.18
2005	432.5	15.51	0	11	0.37	0.06	0.02	0.1

Table C11. Distance traveled for tagged black sea bass recovered since 2002. “DAL”: days at large.

Region	Time	Months	Max Dist(nm)	Mean Dist(nm)	Max DAL	Mean DAL
MA, RI, CT	Sum/Fall	7-12	354	16	1088	139
	Win/Spr	1-6	387	76	1000	338
NY, NJ, DE	Sum/Fall	7-12	146	7	1144	121
	Win/Spr	1-6	212	17	1028	174
MD, VA	Sum/Fall	7-12	90	7	1079	210
	Win/Spr	1-6	180	18	1269	269

Table C12. Black sea bass movements among areas based on region of release and recaptures by region and month.

Release Area	Recapture Area	Recapture Month											
		10	11	12	1	2	3	4	5	6	7	8	9
New England (NE)													
- MA, RI, CT	NE	227	32	1	-	-	-	1	38	69	20	44	33
	MAB	1	1	5	10	3	7	8	-	7	3	2	-
	MV	-	-	-	6	3	5	1	-	-	1	-	-
Mid Atl. Bight (MAB)													
- NY, NJ, DE	NE	-	-	-	-	-	-	-	-	-	1	-	-
	MAB	274	100	9	1	5	7	7	77	150	55	64	94
	MV	1	1	1	1	3	5	-	-	4	1	-	1
Maryland/Virginia (MV)													
- MD, VA	NE	-	-	-	-	-	-	-	-	-	-	-	-
	MAB	7	5	3	-	-	1	4	4	2	7	2	1
	MV	199	200	46	23	35	16	14	122	108	82	83	52

Table C13. Site fidelity of tagged sea bass as indicated by frequency of tagged fish returning to area of release. Recapture limited to inshore residency period.

Release State	# Released	May 15-Sept 30 Recaptures MA	RI	CT	NY	NJ	DE	MD	VA	NC	Total Recaps	Recap North	No net Move	Recap South
MA	2607	145	10	6	9	1	-	-	1	-	172	0.0%	84.3%	15.7%
RI	963	11	31	1	3	-	-	-	-	-	46	23.9%	67.4%	8.7%
CT	31	-	-	-	2	-	-	-	-	-	2	0.0%	0.0%	100.0%
NY	532	-	1	-	16	2	-	-	-	-	19	5.3%	84.2%	10.5%
NJ	2398	-	-	-	6	265	61	4	-	-	336	1.8%	78.9%	19.3%
DE	453	-	-	-	-	12	68	1	3	-	84	14.3%	81.0%	4.8%
MD	3549	-	-	-	-	4	14	176	57	-	251	7.2%	70.1%	22.7%
VA	3155	-	-	-	-	-	-	-	165	8	173	0.0%	95.4%	4.6%

Table C14. Tag release/recapture matrix of black sea bass recaptured between September 2002 and April 2006.

Regular Reward tags

	releases	fall 2002- fall 2003	spr 2003 - spr 2004	fall 2003 - fall 2004	spr 2004 - spr 2005	fall 2004- fall 2005	spr 2005 - spr 2006
fall 2002	**3143**	289		63		23	
spr 2003	**2199**		256	60	60		18
fall 2003	**2449**			355		46	
fall 2004	**2854**					346	

High Reward tags

	releases	fall 2002- fall 2003	spr 2003 - spr 2004	fall 2003 - fall 2004	spr 2004 - spr 2005	fall 2004- fall 2005	spr 2005 - spr 2006
fall 2002	**279**	39		9		5	
spr 2003	**68**		13		4		1
fall 2003	**232**			49		3	
fall 2004	**178**					39	

Table C15. Tag retention results from experiments in MA, RI, NJ and VA.

Study Site	# Tagged	# Shed	Initial Tag Shedding	Tag induced Mortality
Sandy Hook	30	3	10%	0%
RI DEP	30	4	13%	0%
VIMS	33	1	3%	0%
Woods Hole	7	0	0%	0%
	100	8	8%	0%

Table C16. Estimates of exploitation rates by year $\pm$ 80% confidence intervals, instantaneous fishing mortalities and natural mortalities from tagging data.

(EDITOR'S NOTE: TABLE OMITTED. RESULTS NOT ACCEPTED BY THE REVIEW PANEL. PANEL FELT THAT INCOMPLETE MIXING AND MIGRATION REQUIRE FURTHER INVESTIGATION)

Table C17. Results of Brownie model estimates of survival with annual and seasonal recoveries.

(EDITOR'S NOTE: TABLE OMITTED. RESULTS NOT ACCEPTED BY THE REVIEW PANEL. PANEL FELT THAT INCOMPLETE MIXING AND MIGRATION REQUIRE FURTHER INVESTIGATION.)

Table C18. Sensitivity of the full annual Brownie model to variation in the tag release and recovery matrix. Dispersion coefficient is an adjustment in recaptures in first year, with number recaptured reduced by the coefficient. Dispersion and reporting rate apply to recoveries, tag loss rate to releases.

(EDITOR'S NOTE: TABLE OMITTED. RESULTS NOT ACCEPTED BY THE REVIEW PANEL. PANEL FELT THAT INCOMPLETE MIXING AND MIGRATION REQUIRE FURTHER INVESTIGATION.)

Table C19. MRFSS estimated of recreational landings (AB1) and discards (B2) from Maine to Virginia, with ± 2 PSE.

	Total #	Confidence Intervals		Total #	Confidence Intervals	
	AB1 (000s)	lower 95%	upper 95%	B2 (000s)	lower 95%	upper 95%
1981	1,808	1,252	2,363	1,719	739	2,699
1982	10,030	3,046	17,013	1,316	856	1,777
1983	4,457	2,925	5,989	2,653	1,577	3,729
1984	1,592	1,189	1,996	1,493	888	2,099
1985	3,336	2,567	4,105	2,555	1,975	3,136
1986	21,723	12,531	30,915	7,091	5,300	8,881
1987	2,841	2,068	3,614	2,056	1,508	2,605
1988	3,048	2,136	3,959	4,750	3,759	5,741
1989	4,221	3,679	4,763	2,129	1,824	2,433
1990	3,853	3,221	4,486	5,165	4,378	5,951
1991	5,200	4,385	6,016	5,479	4,812	6,145
1992	3,507	2,987	4,027	4,048	3,354	4,741
1993	5,981	3,697	8,265	2,984	2,331	3,637
1994	3,409	2,622	4,196	3,618	3,111	4,126
1995	6,726	4,809	8,644	7,138	6,120	8,157
1996	3,610	2,840	4,379	4,476	3,749	5,202
1997	4,721	3,849	5,594	5,808	4,927	6,689
1998	1,126	850	1,402	3,766	3,125	4,407
1999	1,323	928	1,719	5,721	4,835	6,607
2000	3,608	2,853	4,363	13,142	11,573	14,711
2001	2,830	2,430	3,230	10,830	9,924	11,736
2002	3,337	2,879	3,795	11,128	9,899	12,356
2003	3,226	2,875	3,577	8,838	8,021	9,656
2004	1,637	1,344	1,930	5,589	4,836	6,343

BLACK SEA BASS FIGURES

Figure C1. Map of the east coast of the United States.

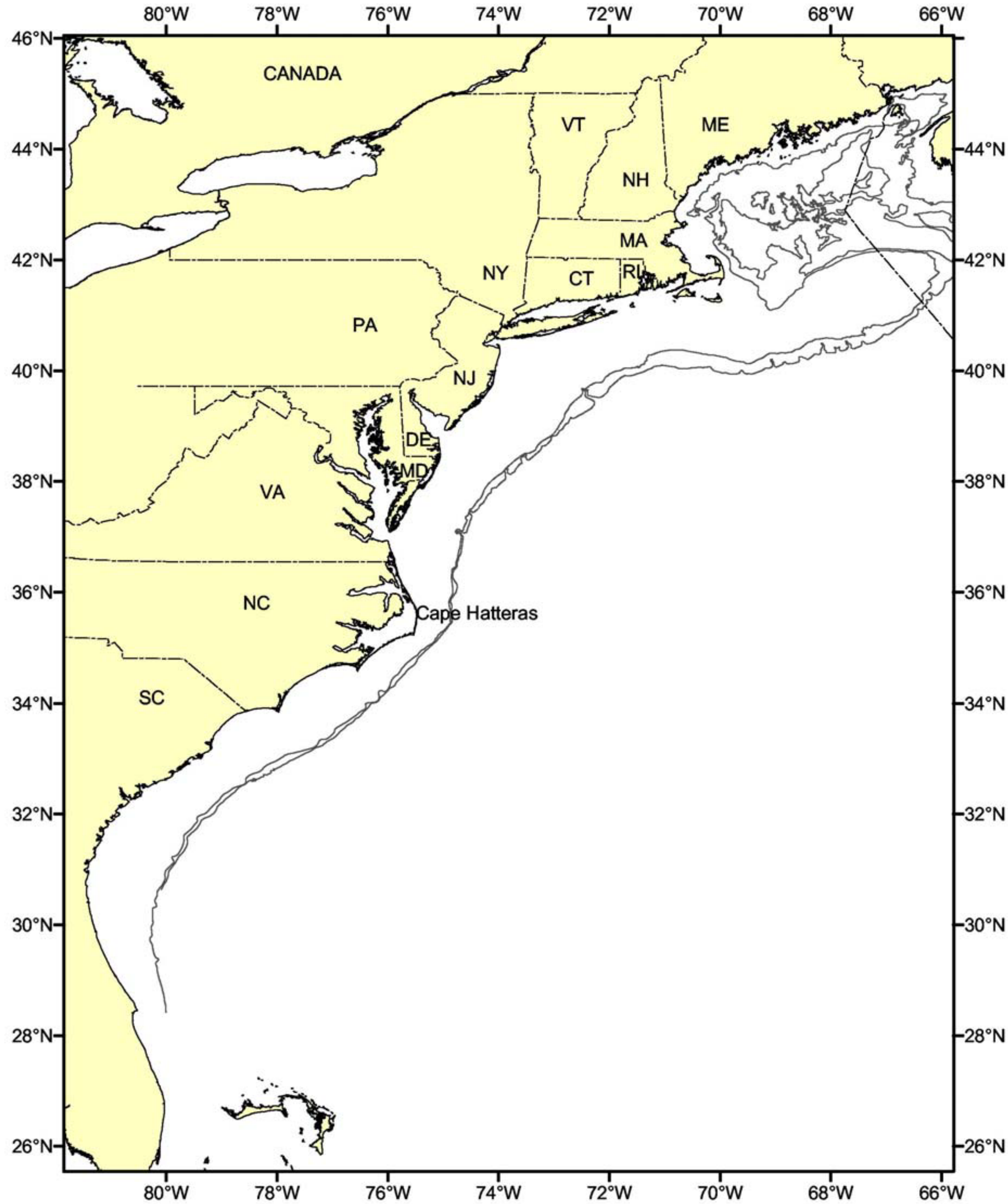


Figure C2. Time series of commercial black sea bass landings ME- Cape Hatteras, NC (note: 1950 – 1961 does not include NC landings).

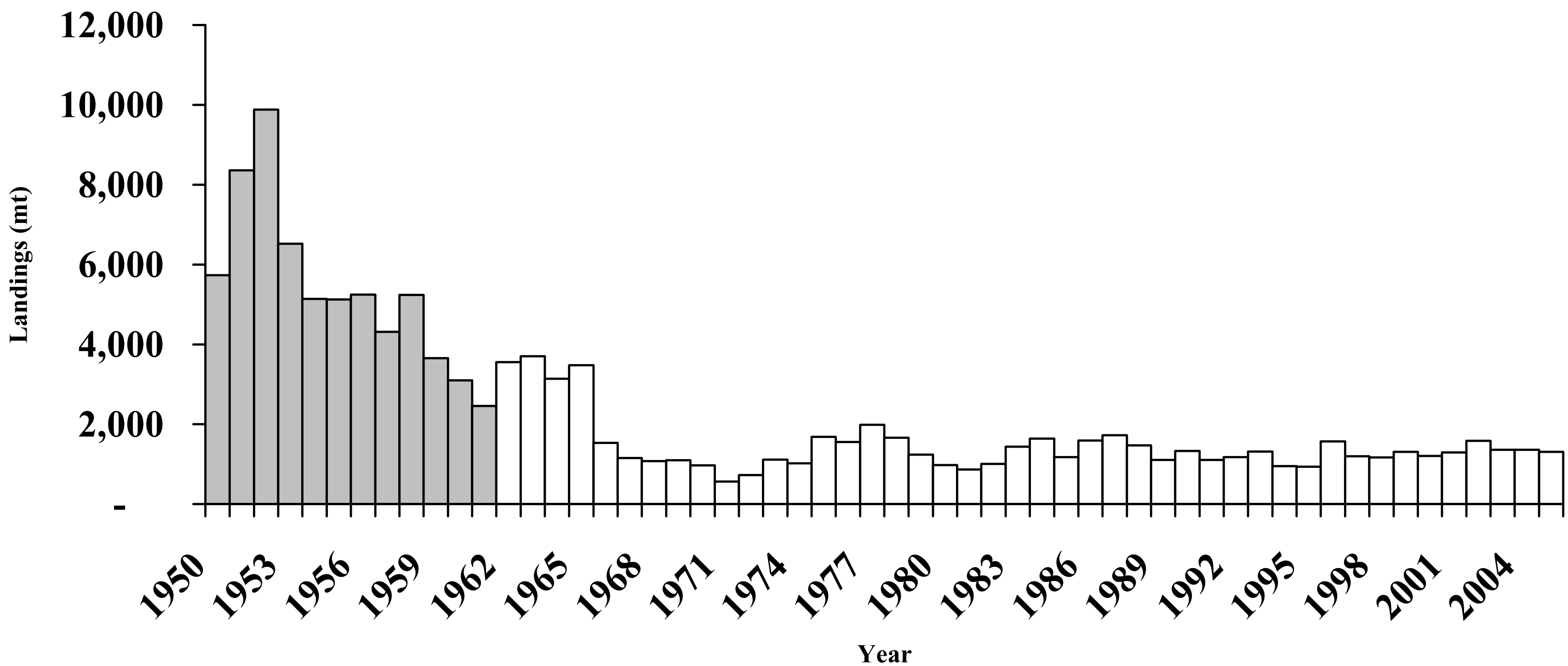


Figure C3. Percent of average black sea bass commercial landings by major gear type, 2000-2005.

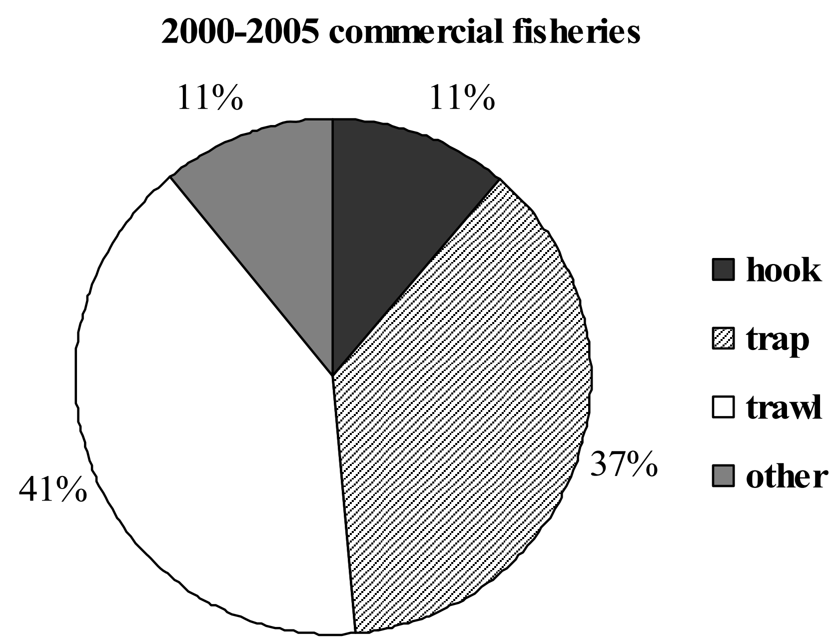


Figure C4. Average percent landings of commercial black sea bass by quarter and gear type 2000-2005.

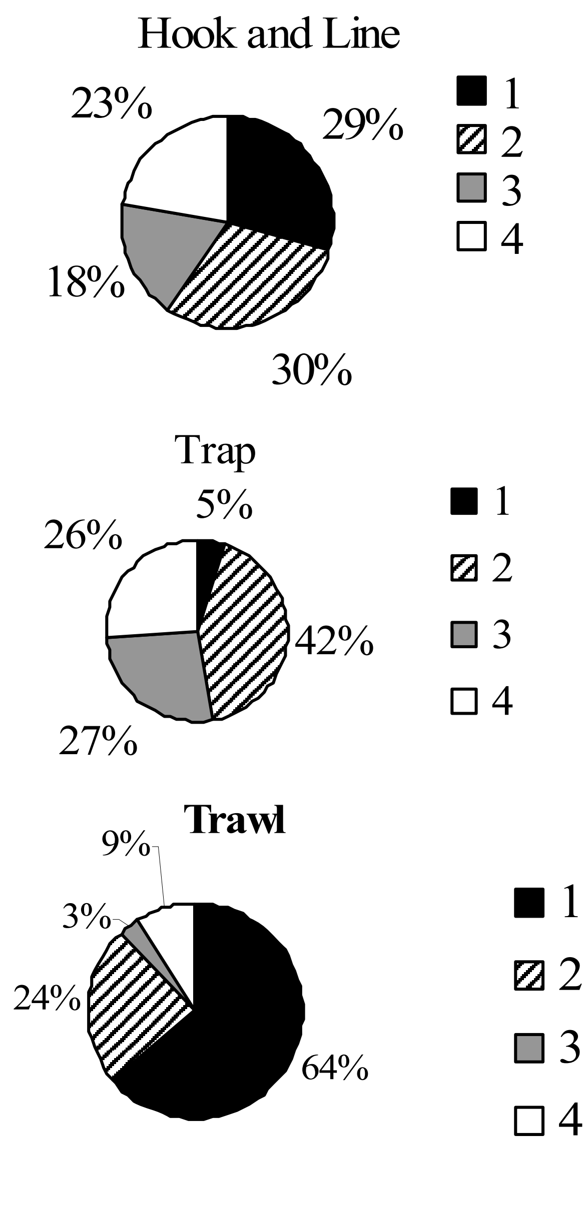
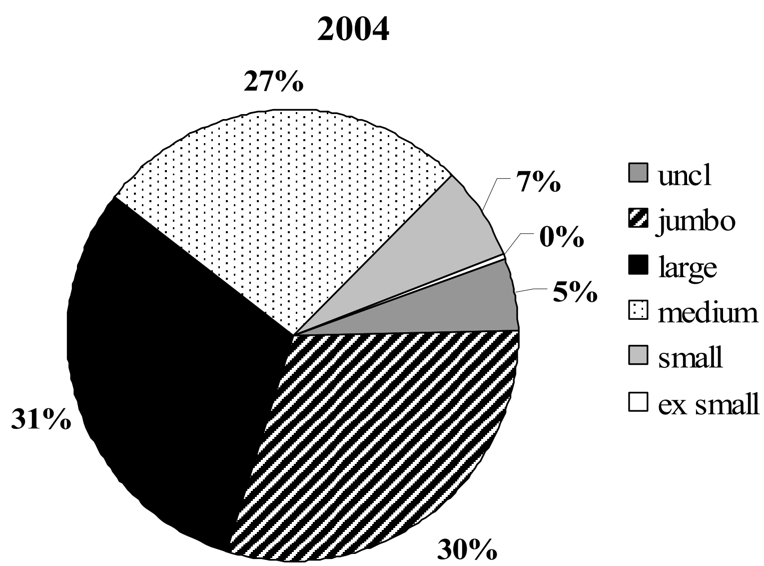


Figure C5. Landings of commercial black sea bass by market category, 2004 and 2005.



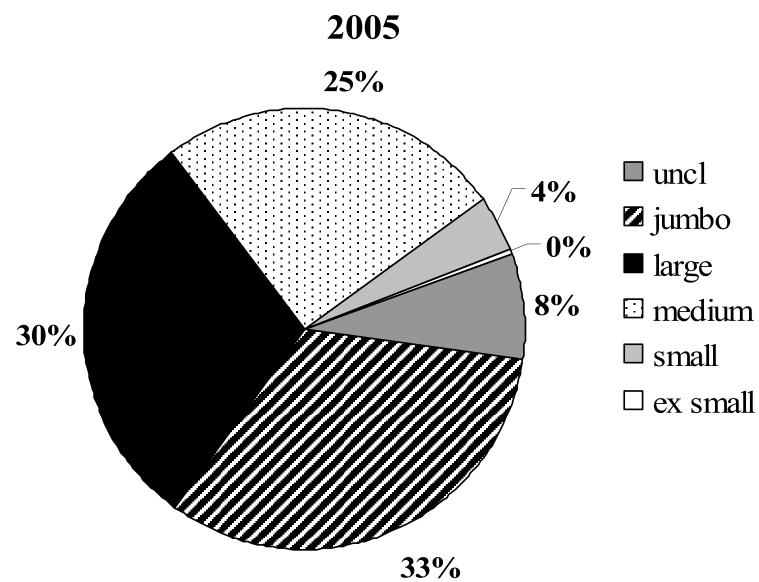


Figure C6. Expanded length frequencies of commercial landings, 1998-2005.

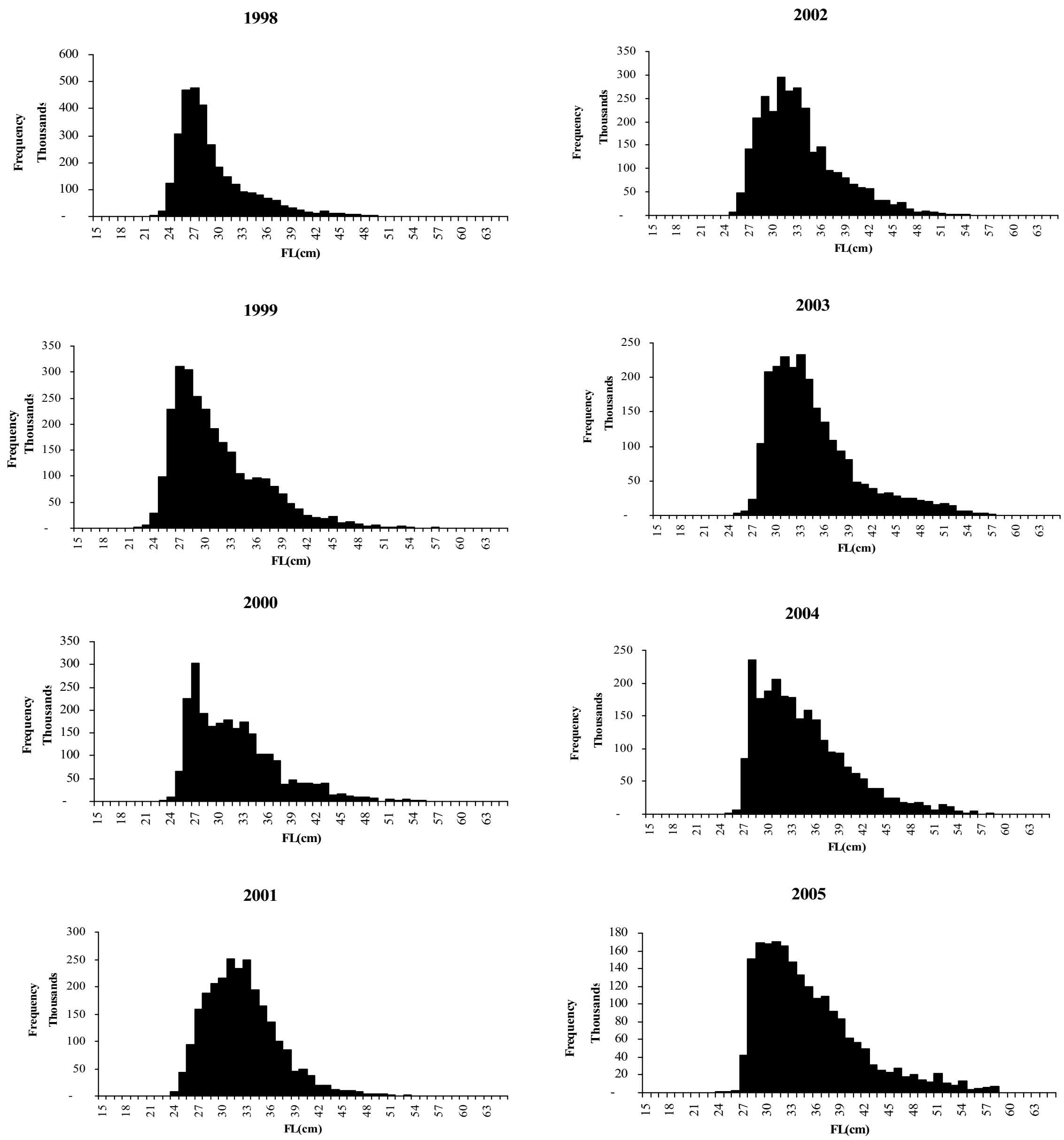


Figure C7. Average length (cm) of black sea bass in commercial landings, 1984-2005.

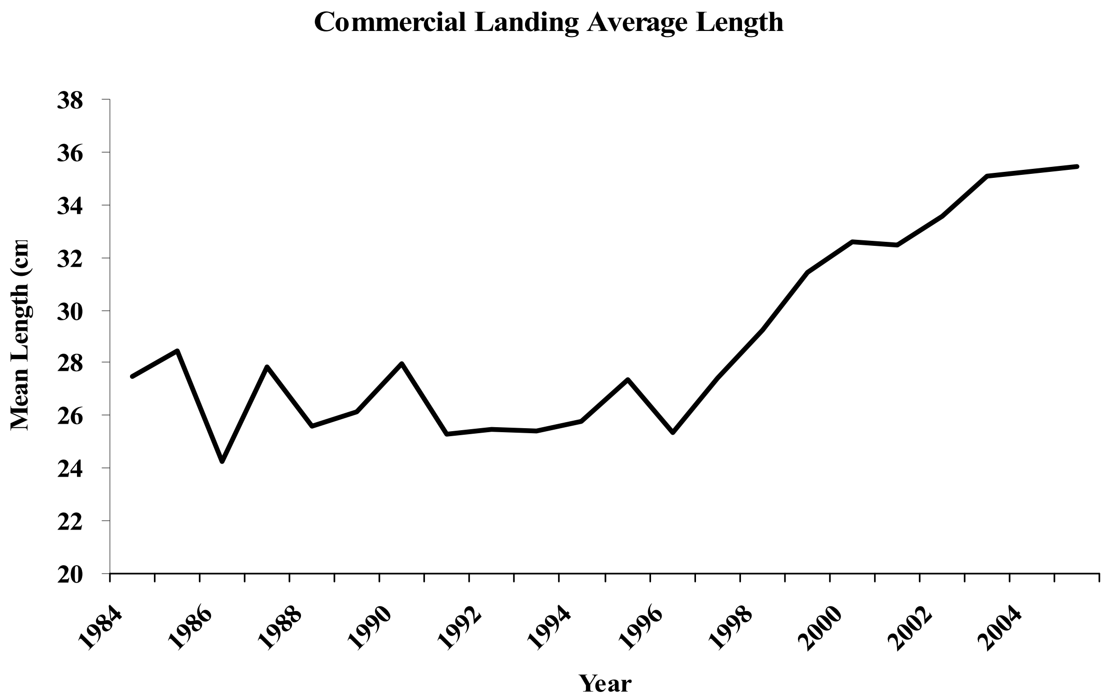


Figure C8. Recreational black sea bass landings from the northern stock, 1981-2005.

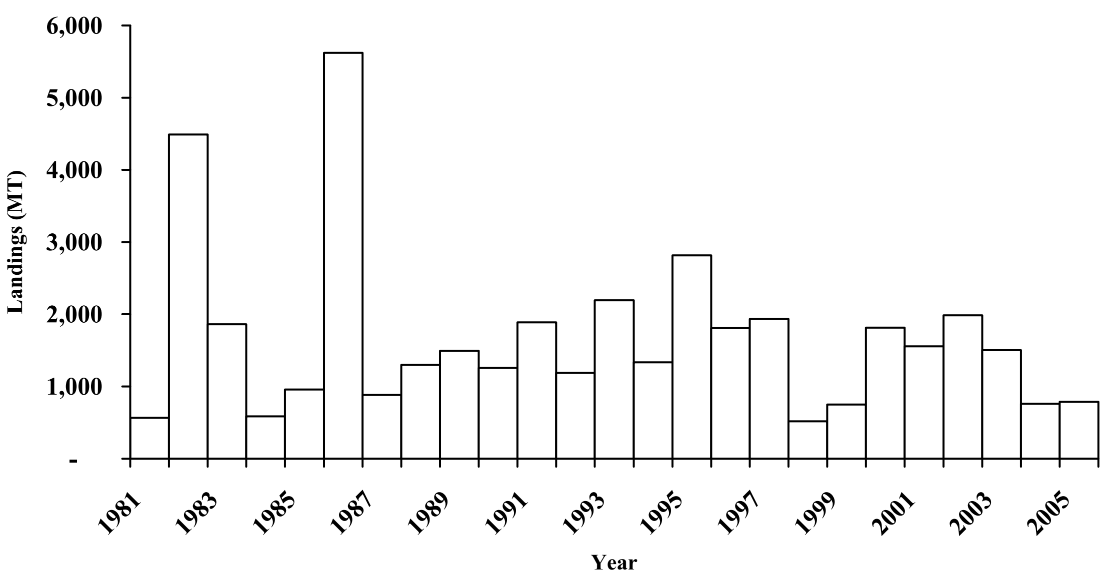


Figure C9. Expanded length distribution of recreational black sea bass landings, 1981-2005.

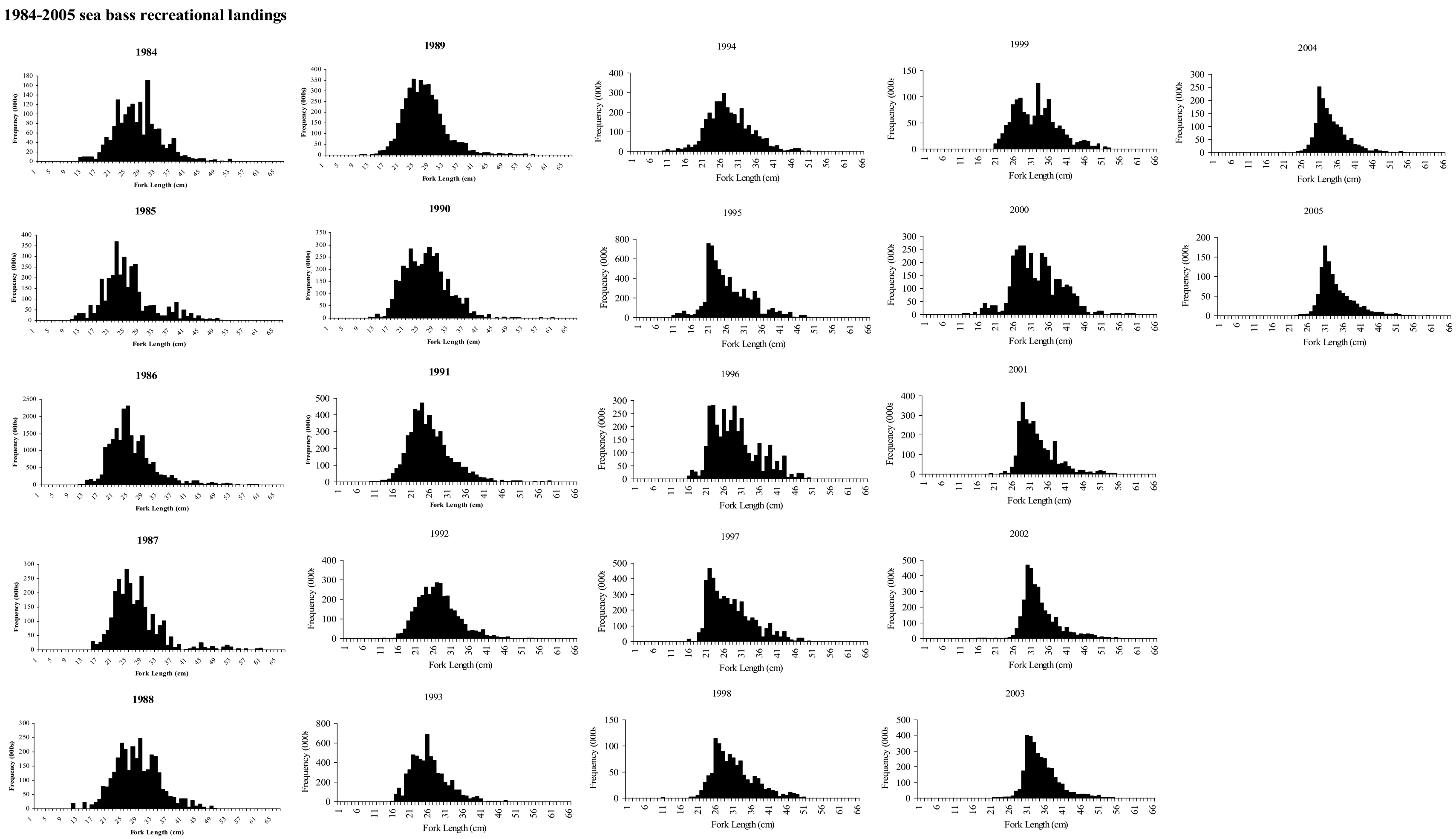


Figure C10. Average length (cm) of black sea bass recreational landings, 1981-2005.

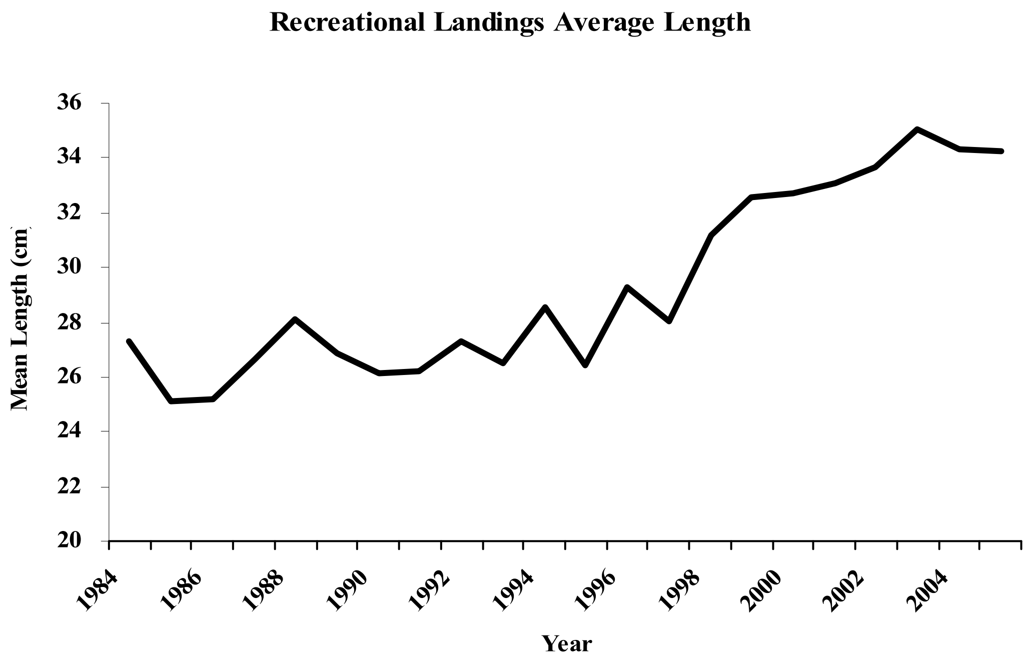


Figure C11. Length distribution of recreationally discarded black sea bass (B2) for 2005 party and charter boats. “FL”: fork length.

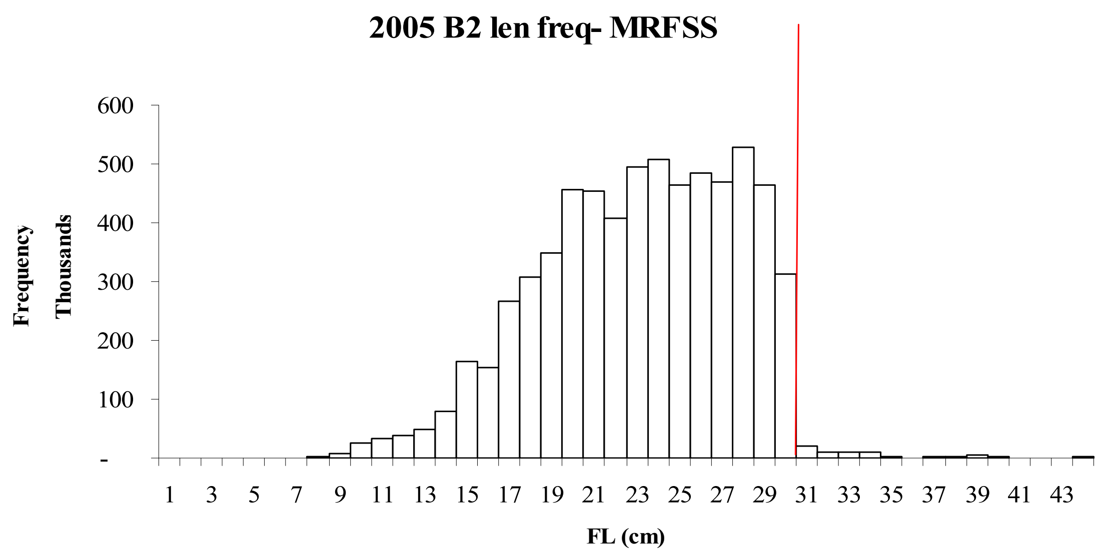
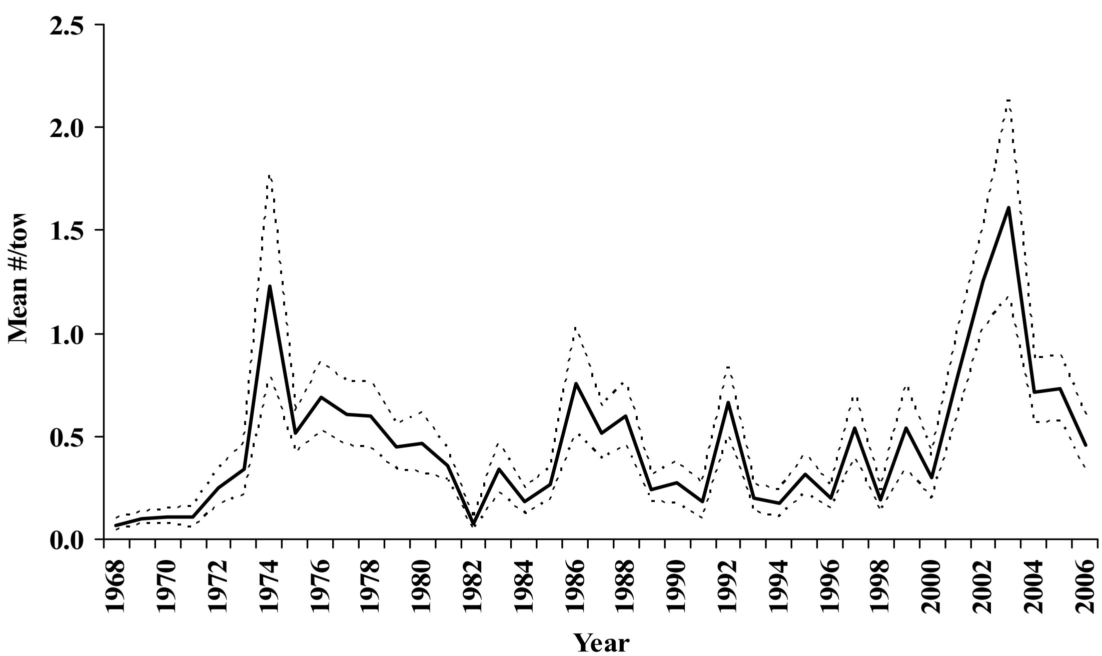


Figure C12. Adult black sea bass ≥ 22 cm ln re-transformed stratified mean #/tow ± 95% CI from NEFSC spring and winter bottom trawl surveys.



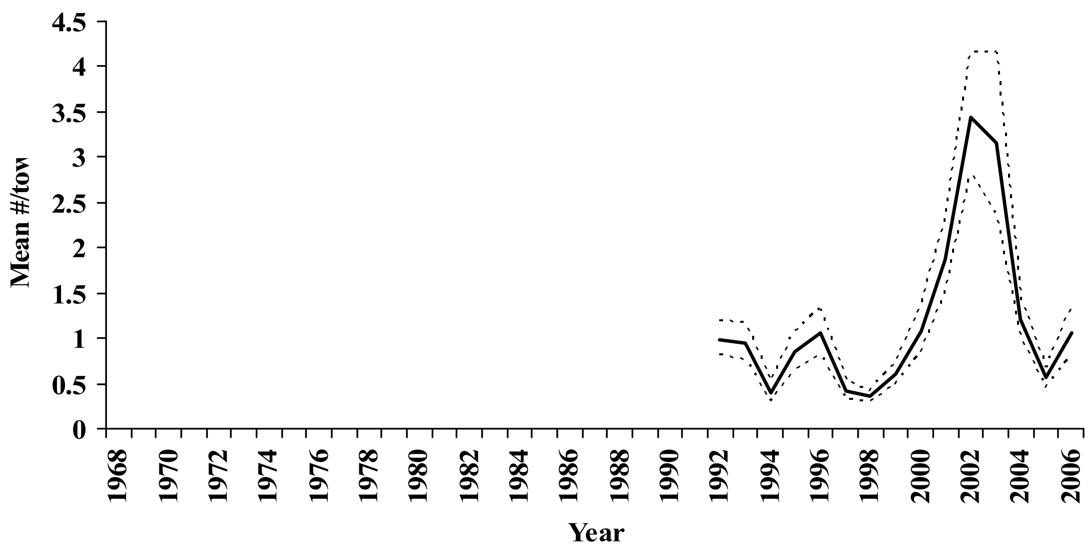
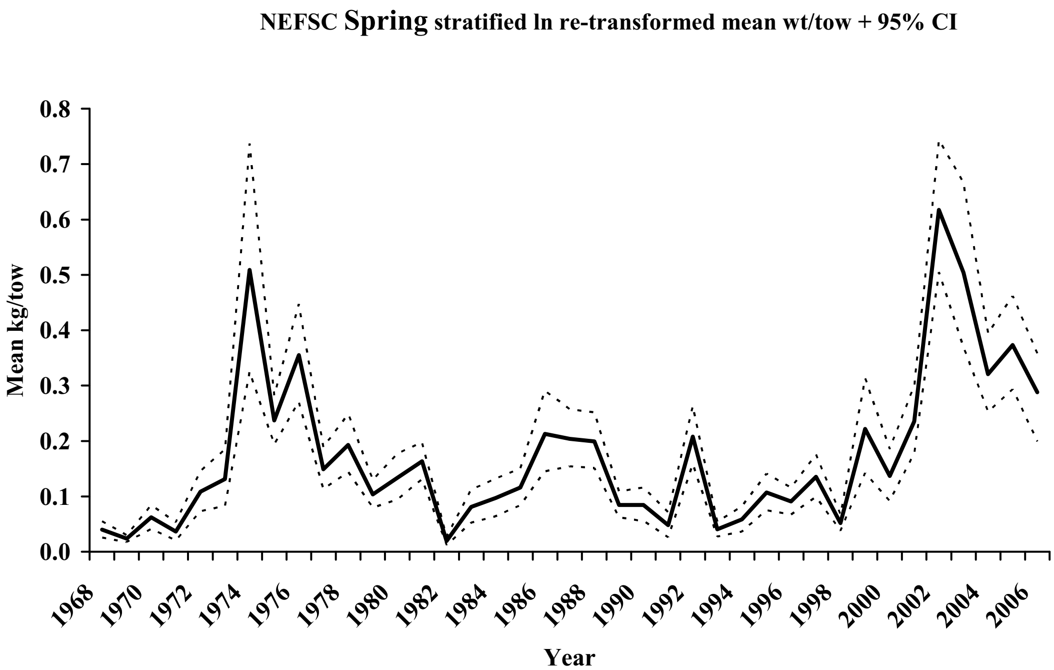


Figure C13. Adult black sea bass ≥ 22 cm stratified mean biomass per tow and 95% CI for spring and winter NEFSC bottom trawl surveys.



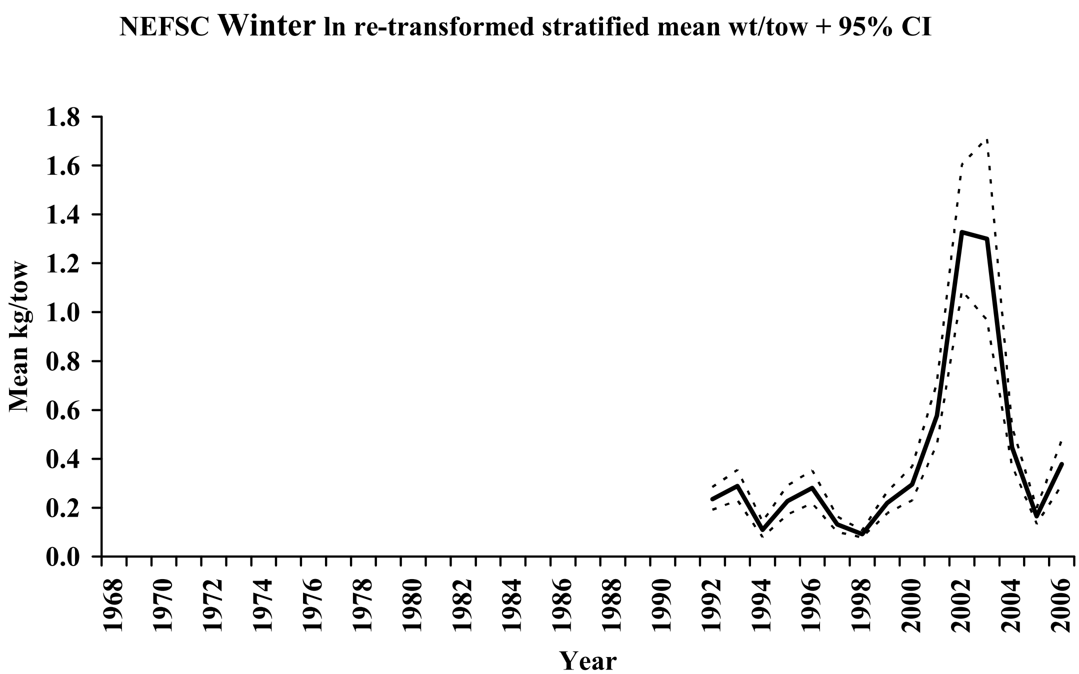
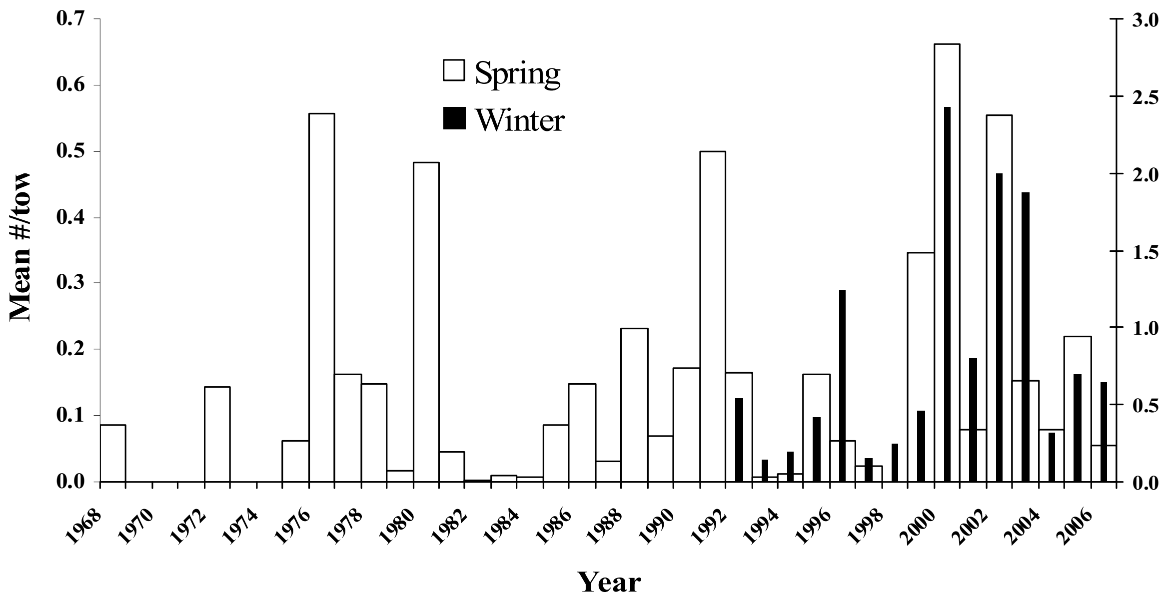


Figure C14. NEFSC black sea bass juvenile indices (≤ 14 cm) from winter, spring and autumn surveys.



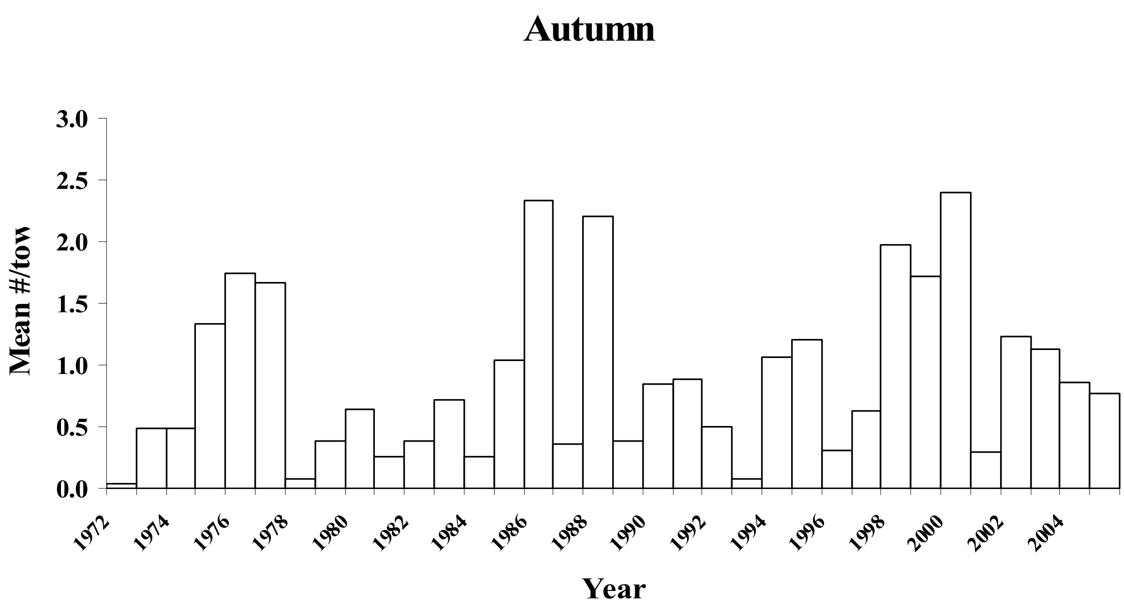


Figure C15. Length frequencies of black sea bass from NEFSC spring offshore surveys, 1981-2006.

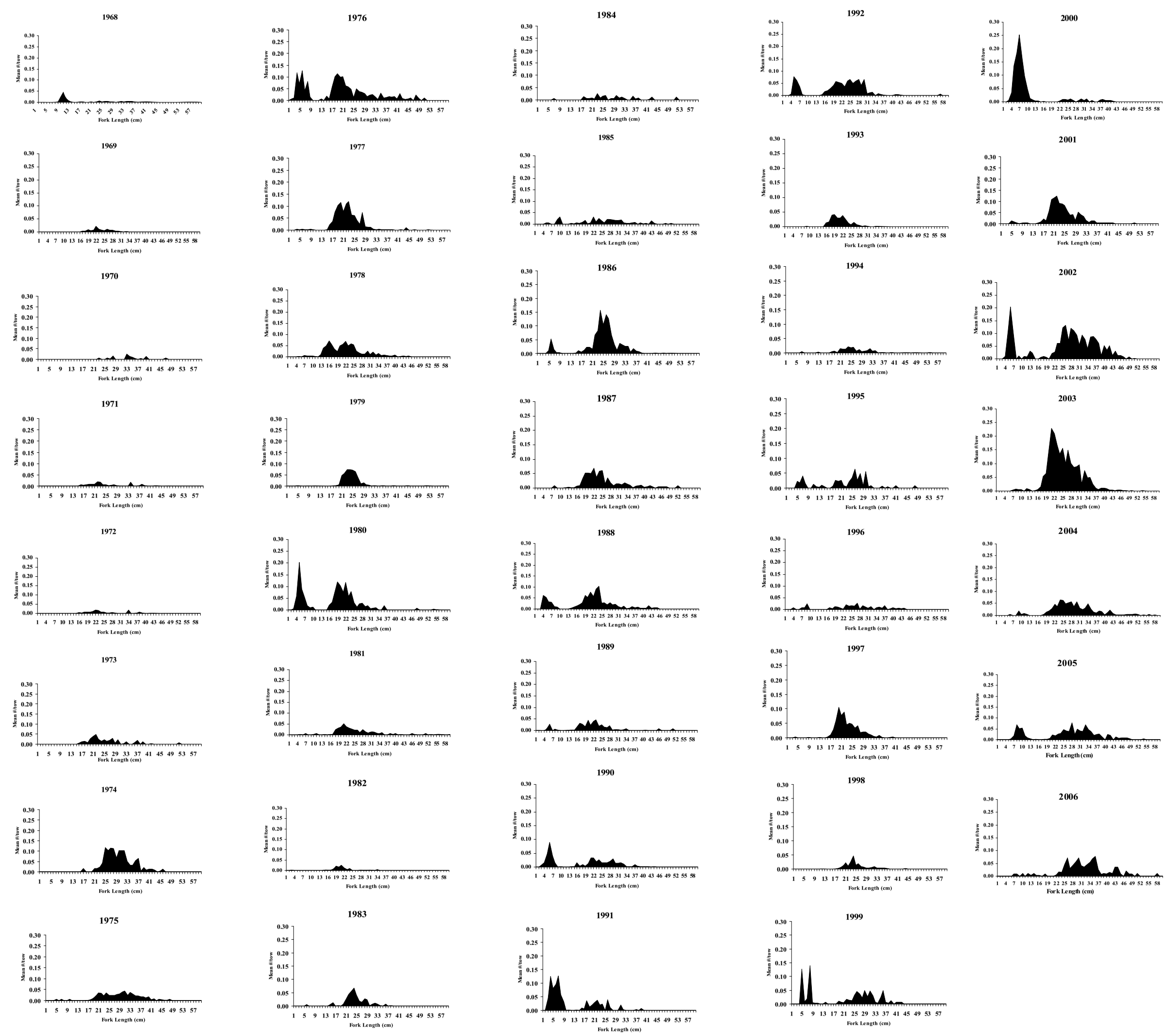


Figure C16. Length frequencies of black sea bass from NEFSC winter offshore survey, 1992-2006.

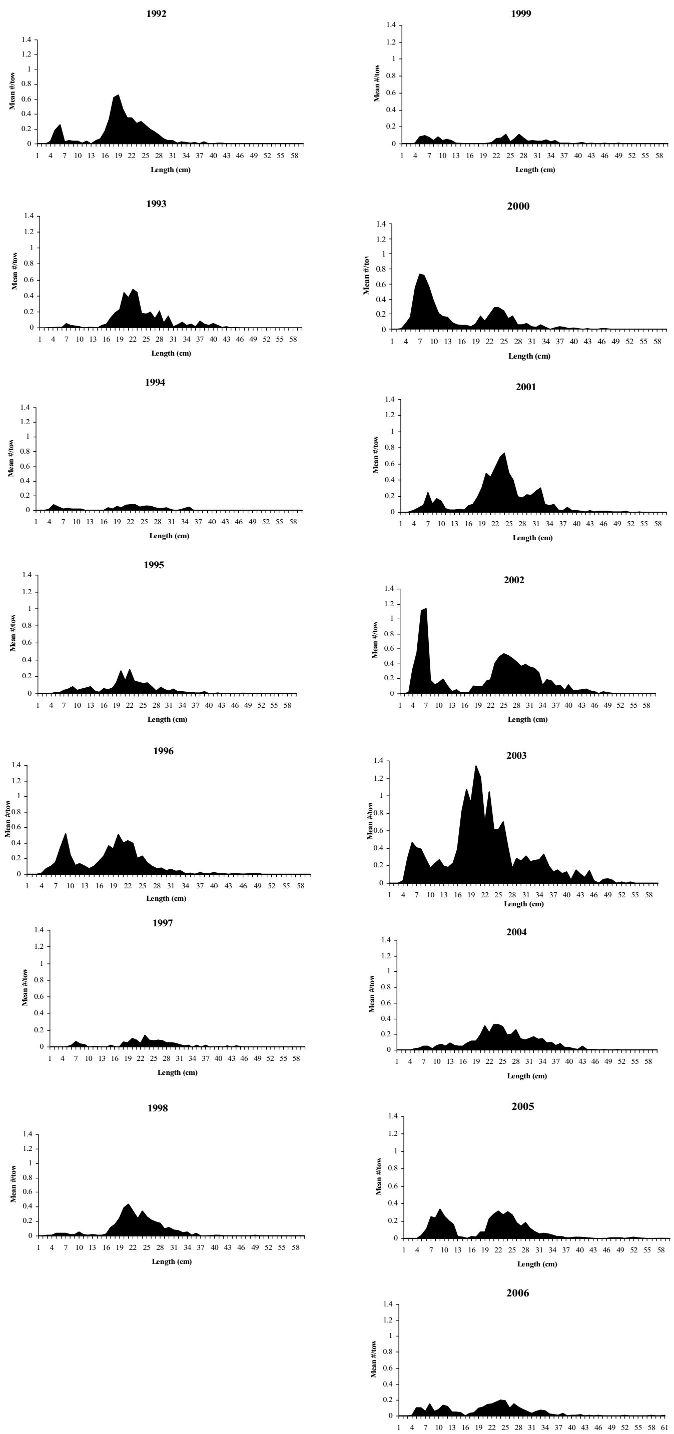


Figure C17. Massachusetts Division of Marine Fisheries spring trawl survey stratified mean number per tow and autumn juvenile number per tow of black sea bass, 1978-2005. "JI": juvenile index.

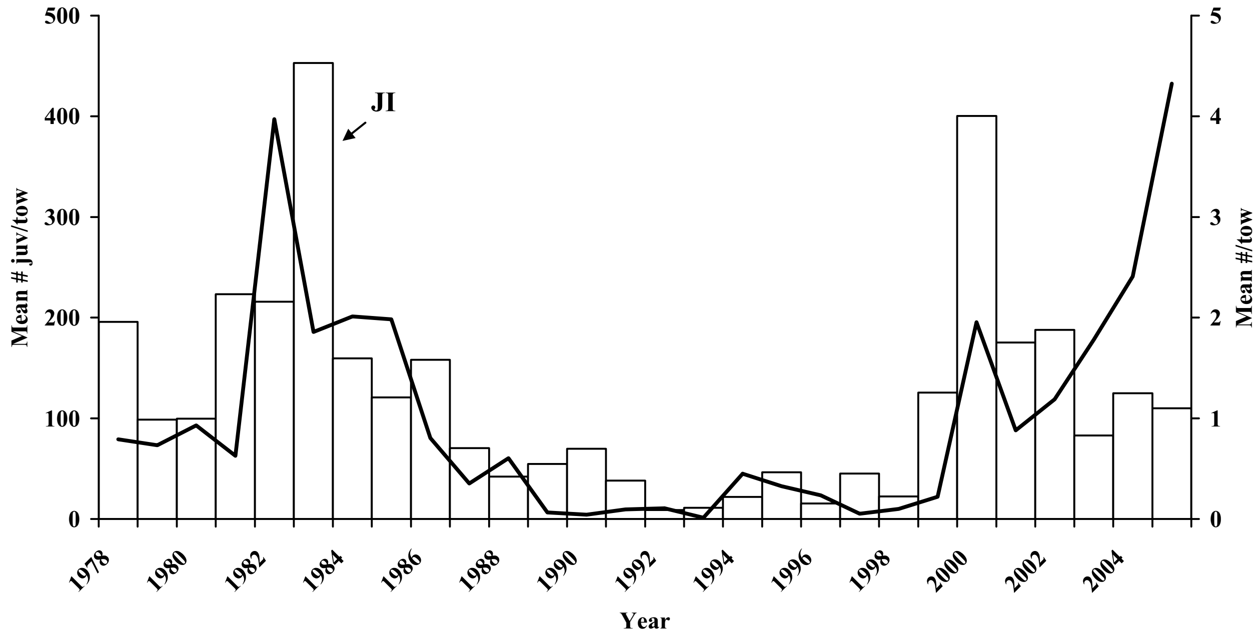


Figure C18. Sum of state survey rank indices of juvenile abundance. Age 0 fish in fall survey indices were advanced to the next calendar year to coincide with age 1 sea bass in spring indices. "JI": juvenile index.

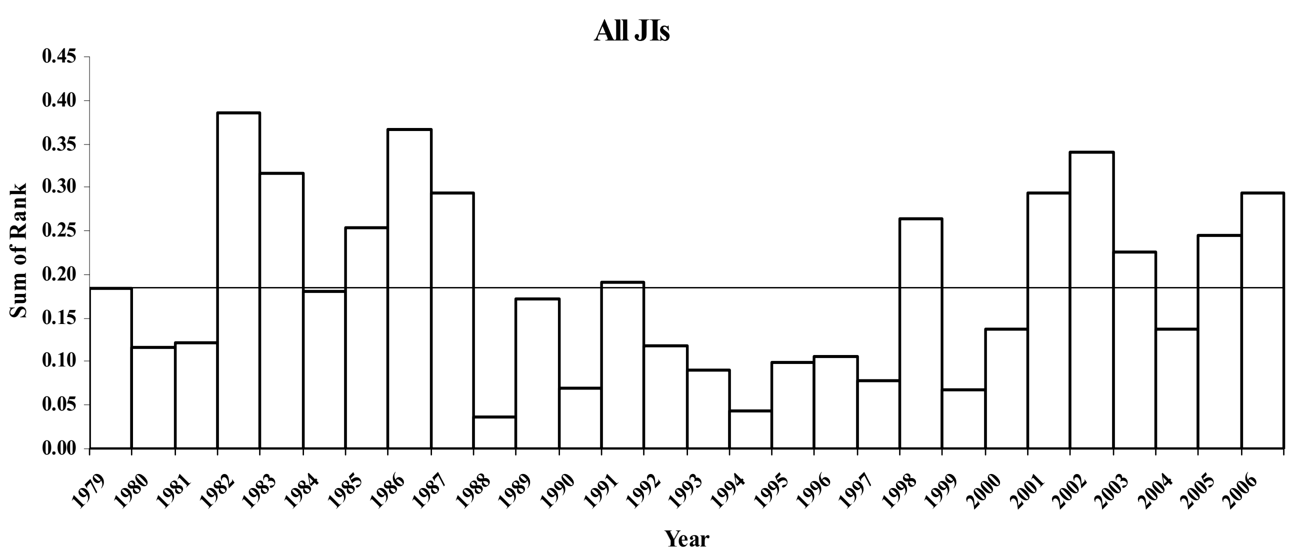


Figure C19. Tag recoveries relative to location of commercial fisheries.

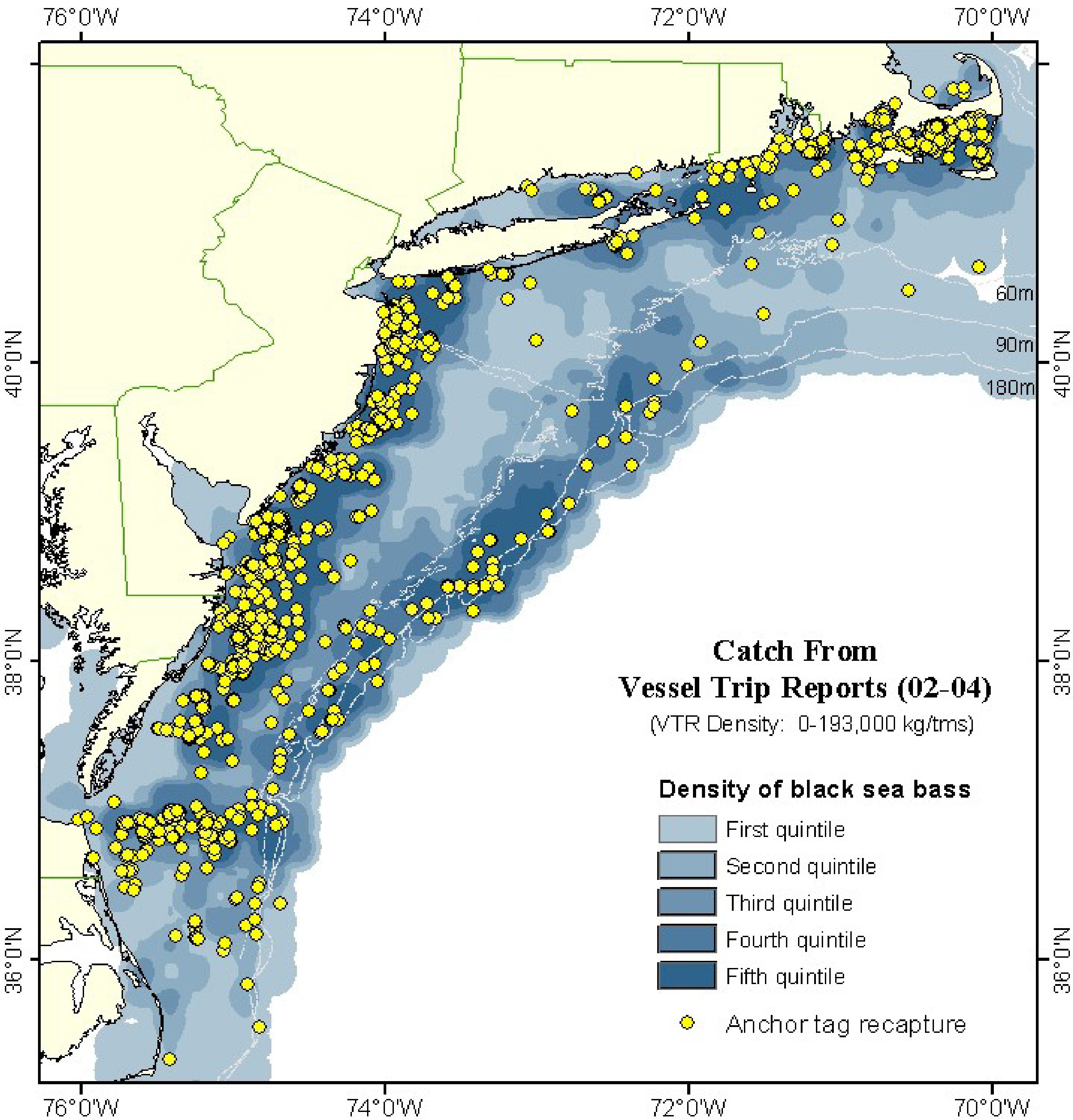


Figure C20. Tag recoveries by area of release and season.

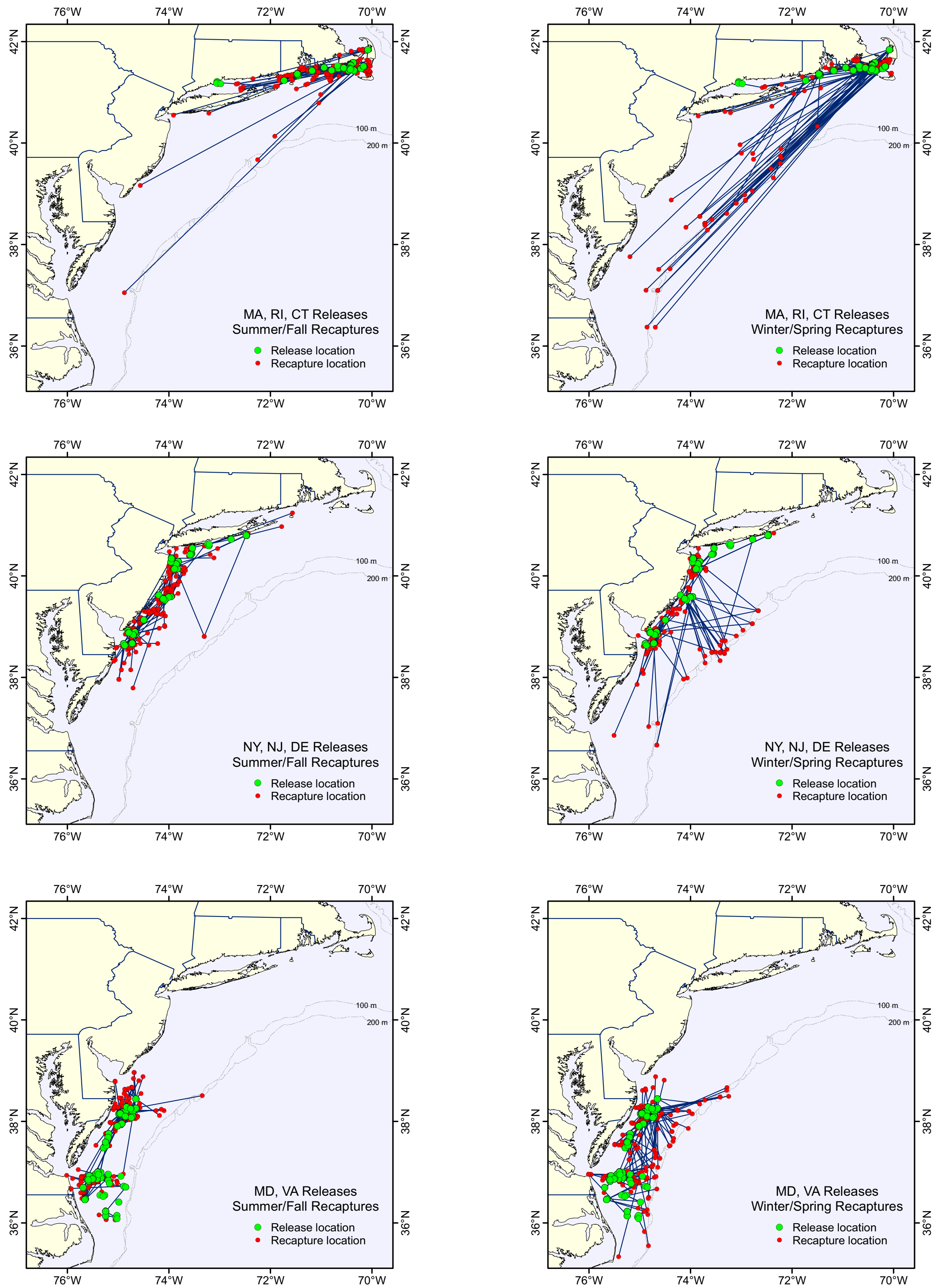


Figure C21. Data Storage Tag (DST) results of depth and temperature for black sea bass released in RI and recovered in Hudson Canyon.

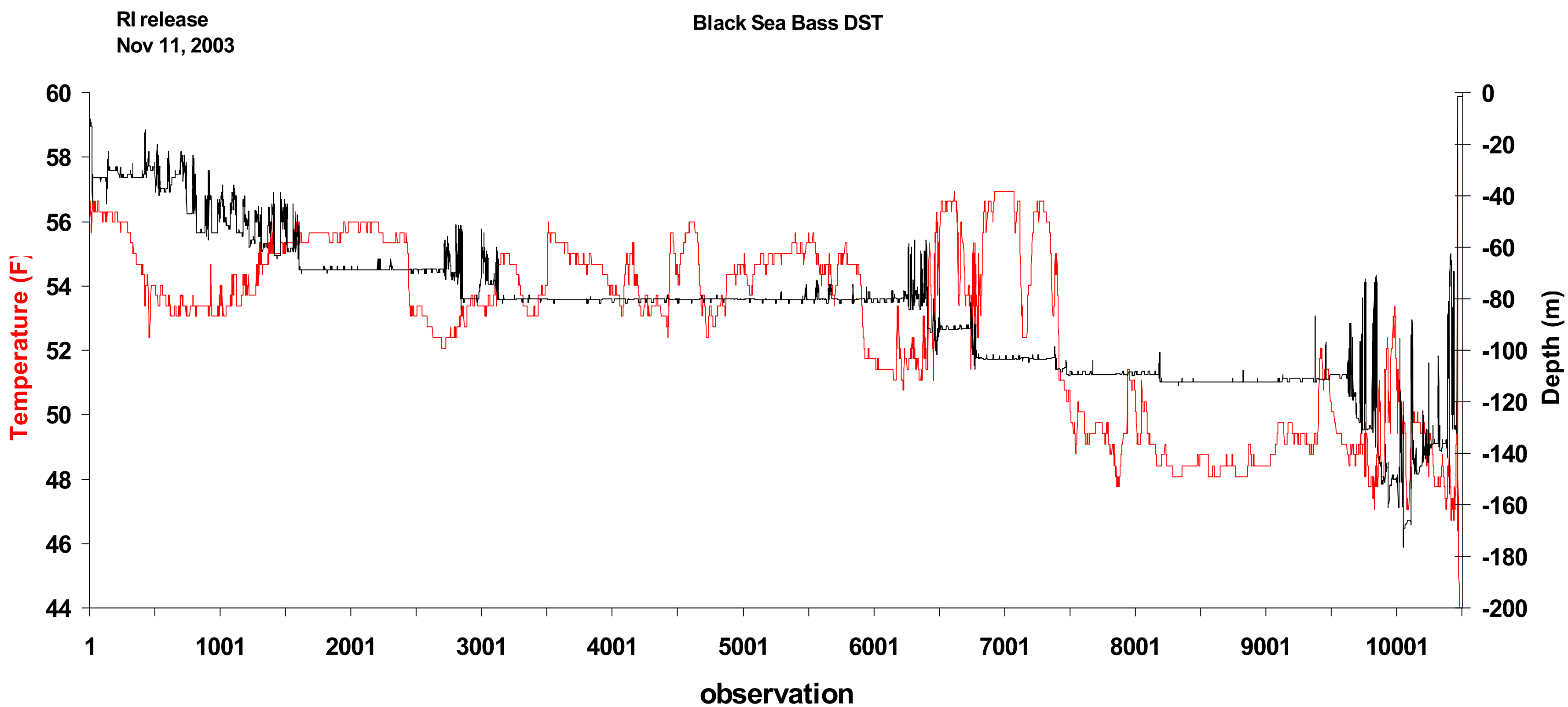
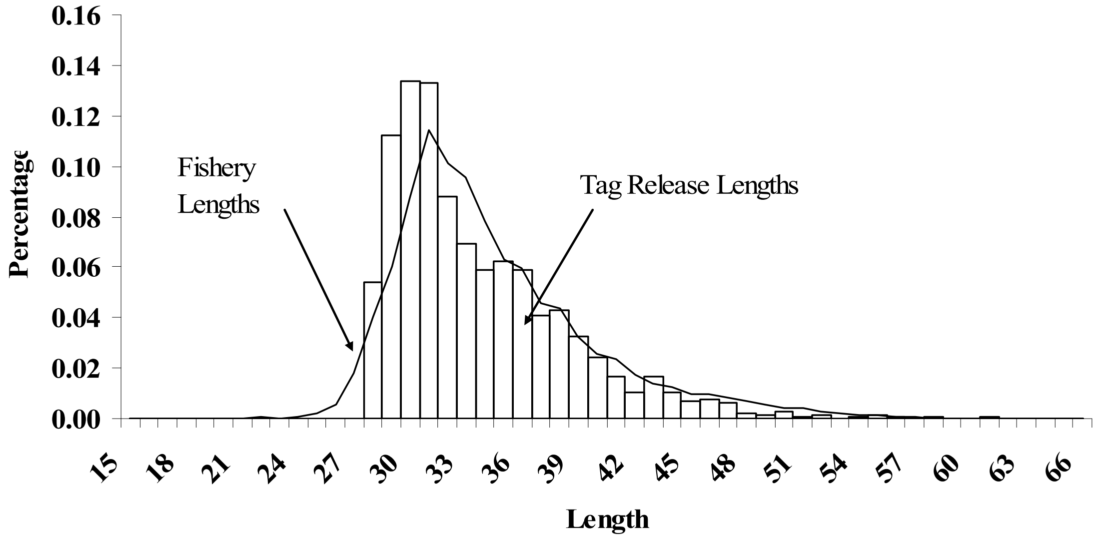


Figure C22. Tag releases and recoveries compared to average length frequency of fisheries between 2002 and 2004.



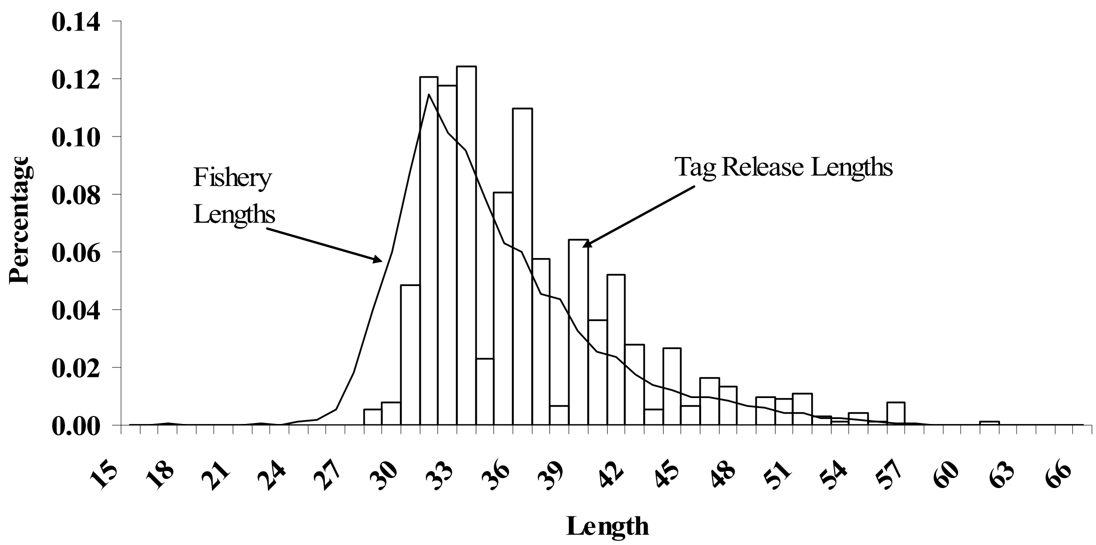
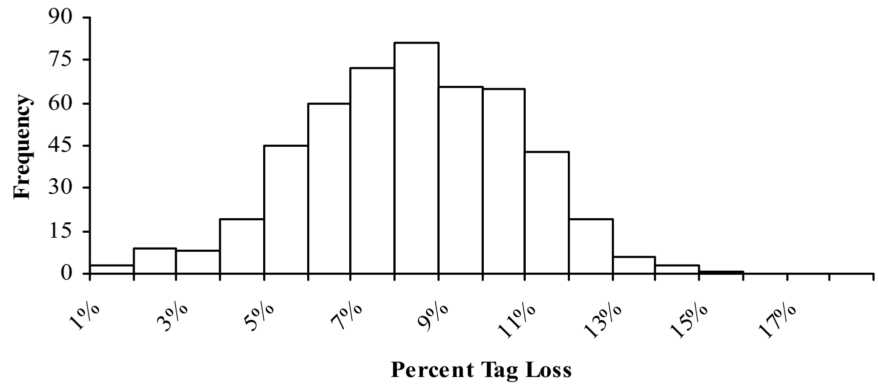
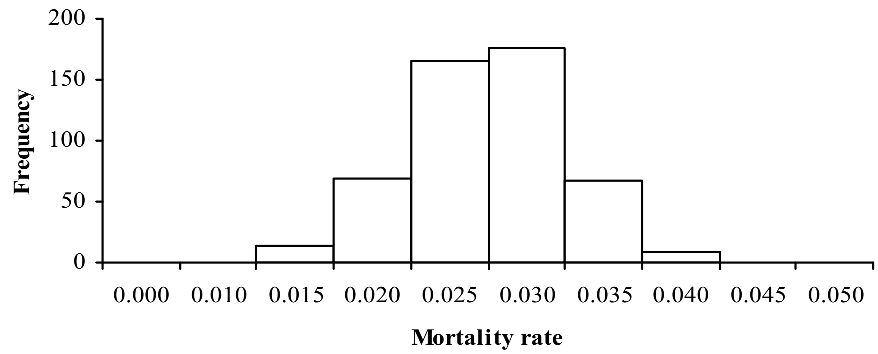


Figure C23. Distribution of tag loss, tag induced mortality and reporting rates used in estimation of exploitation rate.

Tag loss



Tag mortality



Reporting rate

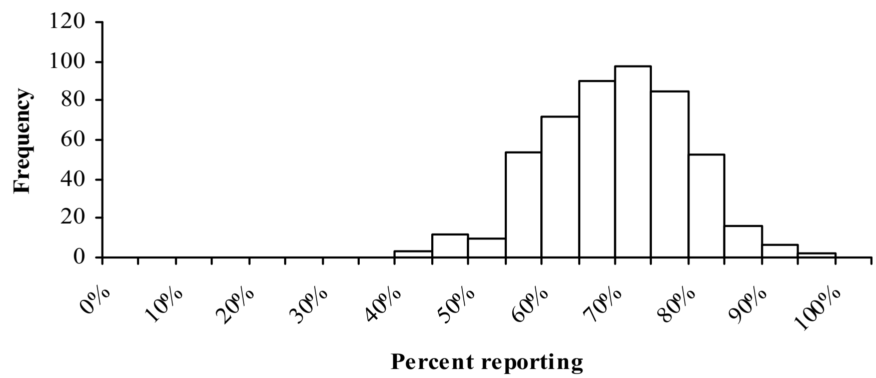


Figure C24. Frequency distribution of exploitation rate estimates and cumulative frequency based on Monte Carlo approach.

(EDITOR'S NOTE: THIS FIGURE OF THE WORKING GROUP REPORT HAS BEEN OMITTED. THE MORTALITY ESTIMATES WERE NOT ACCEPTED BY THE REVIEW PANEL.)

Figure C25. Frequency distribution and cumulative frequency of instantaneous fishing mortality rates assuming a constant M of 0.2.

(EDITOR'S NOTE: THIS FIGURE OF THE WORKING GROUP REPORT HAS BEEN OMITTED. THE MORTALITY ESTIMATES WERE NOT ACCEPTED BY THE REVIEW PANEL.)

Figure C26. Distribution of estimated natural mortalities for 2003-2004 and 2004-2005.

(EDITOR'S NOTE: THIS FIGURE OF THE WORKING GROUP REPORT HAS BEEN OMITTED. THE ESTIMATES WERE NOT ACCEPTED BY THE REVIEW PANEL.)

Figure C27. Distribution of estimated F using calculated M for 2003-2004 and 2004-2005.

(EDITOR'S NOTE: THIS FIGURE OF THE WORKING GROUP REPORT HAS BEEN OMITTED. THE ESTIMATES WERE NOT ACCEPTED BY THE REVIEW PANEL.)

APPENDIX C1: Black sea bass Length Tuned Model (LTM)

Introduction

Incomplete age information on catch and survey indices, often limits the application of full age-structured assessment models tuned with age specific data (e.g. Virtual Population Analysis). Knowledge of a species growth and lifespan, along with total catch data, size composition of the removals, recruitment indices and indices on numbers and size composition of the large fish in a survey can provide insights on population status using a simple model framework.

Herein we used a simple forward projecting age-based model tuned with total catch, catch at length, age-1 recruitment (estimated from first length mode in the survey), and survey numbers and length frequency of the larger fish sizes. The Length Tuned Model (LTM) was developed in the AD model builder framework. The model estimates fishing mortality and recruitment in each year, fishing mortality to produce the initial population (Fstart), and Qs for each survey index.

Methods

Model configuration

The LTM model assumes growth follows the mean input length at age with predetermined input error in length at age. Therefore a growth model or estimates of the average mean lengths at age is essential for reliable results. The LTM model uses an input partial recruitment (pr) vector at length in each year for the calculation of population and catch age-length matrices. A starting population is computed for year one in the model. First the estimated populations numbers at age starting with age-1 recruitment get normally distributed at one cm length intervals using the mean length at age with the assumed standard deviation. Next the initial population numbers at age are calculated from the previous age at length abundance using the survival equation. An estimated fishing mortality (Fstart) is also used to produce the initial population. This F can be thought of as the average fishing mortality that occurred before the first year in the model. Now the process repeats itself with the total of the estimated abundance at age getting redistributed according to the mean length at age and standard deviation in the next age (age+1).

This two step process is used to incorporate the effects of length specific selectivities and fishing mortality. The initial population length and age distribution is constructed by assuming that the population is at equilibrium with an initial value of F, say F_{start}. Length specific mortality is estimated as a two step process in which the population is first decremented for the length specific effects of mortality as follows:

$$N^*_{a,len,y_1} = N_{a-1,len,y_1} e^{-\left(PR_{len}F_{start}+M\right)}$$

In the second step, the total population of survivors is then redistributed over the lengths at age *a* by assuming that the proportions of numbers at length at age *a* follow a normal distribution with a mean length derived from the von Bertalanffy growth function.

$$N_{a,len,y_1} = \pi_{len,a} \sum_{len=0}^{L_\infty} N^*_{a,len,y_1}$$

where

$$\pi_{len,a} = \Phi\left(len + 1 \mid \mu_a, \sigma_a^2\right) - \Phi\left(len \mid \mu_a, \sigma_a^2\right)$$

where

$$\mu_a = L_\infty\left(1 - e^{-K(a-t_0)}\right)$$

For black sea bass the variance of length at age a = σ_s^2 was estimated from the NEFSC survey age data (standard deviation of 4.2 from ages 4+).

This model formulation does not explicitly track the dynamics of length groups across age because the consequences of differential survival at length at age a do not alter the mean length of fish at age a+1. However, it does more realistically account for the variations in age specific partial recruitment patterns by incorporating the expected distribution of lengths at age.

In the next step the population numbers at age and length for years after the calculation of the initial population use the previous age and year for the estimate of abundance. Here the calculations are done on a cohort basis. Like in the previous initial population survival equation the partial recruitment is taken from the input length vector.

$$N^*_{a,len,y} = N_{a-1,len,y-1} e^{-\left(PR_{len} F_{start} + M\right)}$$

second stage

$$N_{a,len,y} = \pi_{len,a} \sum_{len=0}^{L_\infty} N^*_{a,len,y}$$

Constant M is assumed along with an estimated length-weight relationship to convert estimated catch in numbers to landings in weight. The best available estimate of partial recruitment at length is used as input to the model from knowledge of landings size distribution, fishing practice, regulations, and discarding. The standard Baranov's catch equation is used to remove the catch from the population in estimating fishing mortality.

$$C_{y,a,len} = \frac{N_{y,a,len} F_y \left(1 - e^{-\left(F_y PR_{len} + M\right)}\right)}{(F_y \quad PR_{len}) + M}$$

Catch is converted to yield by assuming a time invariant average weight at length

$$Y_{y,a,len} = C_{y,a,len} W_{len}$$

The LTM model results in the calculation of population and catch age-length matrices for the starting population and then for each year thereafter. The model is programmed to estimate recruitment in year 1 and estimate variation in recruitment relative to recruitment in year 1 for each year thereafter. Estimated recruitment in year one can be thought of as the estimated average long term recruitment in the population since it produces the initial population. The residual sum of squares of the variation in recruitment $\sum(\mathrm{Vrec})^2$ is than used as a component of the total objective junction. The weight on the recruitment variation component of the objective junction (Vrec) can be used to penalize the model for estimating large changes in recruitment relative to estimated recruitment in year one.

The model requires an age-1 recruitment index for tuning or the user can assume relatively constant recruitment over time by putting a high weight on Vrec. Usually there is little overlap in ages at length for fish that are one and/or two years of age in a survey of abundance. The first mode in a survey can generally index age-1 recruitment using length slicing. In addition numbers and the length frequency of the larger fish in a survey where overlap in ages at a particular length occurs can be used for tuning population abundance. The model tunes to the catch and survey length frequency data using a multinomial distribution. The user specifies the minimum size (cm) for the model to fit. Different minimum sizes can be fit for the catch and survey data length frequency.

The number of parameters estimated is equal to the number of years in estimating F and recruitment plus one for the F to produce the initial population (Fstart) and for each survey Q. The total likelihood function to be minimized is made up of 10 likelihood components:

$$\mathrm{L}_1 = \sum_{years} \left(l\,\mathrm{n}(Y_{\mathrm{obs,y}} + 1) - \ln\left(\sum_{a} \sum_{len} \mathrm{Y}_{\mathrm{pred,len,a,y}} + 1 \right) \right)^2$$

$$L_2 = -N_{eff} \sum_{y} \left(\sum_{len=30}^{L_\infty} \left(\left(C_{y,len} + 1\right) \ln\left(1 + \sum_{a} C_{pred,y,a,len} \right) - \ln\left(C_{y,len} + 1\right) \right) \right)$$

$$L_3 = \sum_{y=2}^{Nyears} \left(Vrec_y\right)^2 = \sum_{y=2}^{Nyears} \left(R_1 - R_y\right)^2$$

$$L_4 = \sum_{y}^{Nyears} \left(\ln\left(I_{FALL,1,y} + 1\right) - \ln\left(1 + \sum_{len}^{L_\infty} N_{y,1,len}\right) q_{FALL} \right)^2$$

$$L_5 = \sum_{y=1992}^{Nyears} \left(\ln\left(I_{WINTER,1,y} + 1\right) - \ln\left(1 + \sum_{len}^{L_\infty} N_{y,1,len}\right) q_{WINTER} \right)^2$$

$$L_6 = \sum_{y}^{Nyears} \left(\ln\left(I_{SPRING,1,y} + 1\right) - \ln\left(1 + \sum_{len}^{L_\infty} N_{y,1,len}\right) q_{SPRING} \right)^2$$

$$L_7 = \sum_{y=1992}^{Nyears} \left(\ln\left(I_{WINTER,22+,y} + 1\right) - \ln\left(\sum_{a} \sum_{len=22}^{L_\infty} \ln\left(N_{pred,y,a,len} + 1\right) q_{WINTER,22+} \right)\right)^2$$

$$L_8 = -N_{eff} \sum_{y=1992}^{Nyears} \left(\sum_{len=22}^{L_\infty} \left(\left(I_{WINTER,y,len} + 1\right) \ln\left(1 + \sum_{a} N_{pred,y,a,len}\right) - \ln\left(I_{WINTER,y,len} + 1\right) \right) \right)$$

$$L_9 = \sum_{y}^{Nyears} \left(\ln\left(I_{SPRING,22+,y} + 1\right) - \ln\left(\sum_{a} \sum_{len=22}^{L_\infty} \ln\left(N_{pred,y,a,len} + 1\right) q_{SPRING,22+} \right)\right)^2$$

$$L_{10} = -N_{eff} \sum_{y} \left(\sum_{len=22}^{L_\infty} \left(\left(I_{SPRING,y,len} + 1\right) \ln\left(1 + \sum_{a} N_{pred,y,a,len}\right) - \ln\left(I_{SPRING,y,len} + 1\right) \right) \right)$$

In equation L_2 calculations of the sum of length is made from the user input catch length to the maximum length for fitting the catch. In equation L_7 through L_{10} the survey length up to the maximum length is used in the calculation.

$$Obj\ \ fcn = \sum_{i=1}^{10} \lambda_i L_i$$

Lambdas represent the weights to be set by the user for each likelihood component in the total objective function.

Black Sea Bass LTM Model Results

Black sea bass natural mortality was assumed to be 0.2 with a fifteen year lifespan. Estimates of commercial discard were not available. B2 estimates were relatively small when reduced by a 15 % mortality rate and are not used in the model. The catch length frequency were fit to 30+ cm fish and the survey numbers and survey length frequency were fit to 22+ cm fish. Surveys were standardized by dividing each survey by its mean and multiplying by 1 million. An approximation of the partial recruitment vector at length was developed by shifting the partial recruitment curve to larger fish as minimum size limits and mesh size increases occurred in the recreational and commercial fisheries (Fig 1). The shift to larger fish can be observed in the landings length frequency.

All black sea bass LTM model runs estimated high F start values. The model predicts a truncated distribution at the beginning of the model in 1981. The fishery landings history supports the presence of an exploited population before 1981.

The working group reviewed the effects of using different growth estimates in runs 1 to 3 (Fig 2 and 3). The three different growth estimates tend to produce changes in the fishing mortality estimates in the past with the terminal year estimates being very similar among the runs. However the changes in growth resulted in a shift in the recruitment/biomass estimates among the three runs. The survey growth model was used for all subsequent model runs and comparisons.

In general all three recruitment indices showed increases in recruitment between 2000 and 2002. The recreational B2 estimates were also higher during the early 2000s which suggests higher recruitment. Runs with different assumptions on the variation in recruitment (Vrec = 1, 1000, 0.1) showed different trends in F and biomass depending on how closely the model is allowed to fit the increases in recruitment in the surveys from 2000-2002 (Table 1, Fig 4). However all the black sea bass LTM model runs could not match the decrease in the 22+ index. Given that the catch has decreased and strong recruitment occurred during the early 2000s, the effect should be reflected in both the adult index (22+) and the exploitable length frequency in the terminal year of the model. Both the winter and spring survey show a substantial decrease in numbers of 22+ fish from 2004 to 2006. The model predicts a greater amount of larger fish than observed in the catch and surveys for the terminal year especially as the model is allowed to fit the high recruitment in the surveys. The working group was not confident in the LTM model results for stock status determination given the differences in trends between the predicted and observed 22+ cm indices in the last three years. The working group could not determine if this mismatch was due to a survey availability event and/or an unaccounted source of mortality such as commercial and recreational discards.

The working group questioned the large increases in recreational catch in 1982 and 1986. These large increases were not realistic and the average of adjacent years was used for the recreational catch estimate in these two years. Results did not change greatly when the actual reported recreational landings were used in run 7 (Fig 5). All of the resulting output graphs are shown for run 3 which uses the survey growth curve and a Vrec weight of 5 in figures 6-11. Using the Lower or Upper 95% confidence intervals for the MRFSS catch did not produce different trends in the LTM model results (Table 3, Fig 12).

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Table 1. Black Sea Bass LTM runs of residual sum of squares, input weights, estimated Qs, estimated Fstart, and age 1 recruitment in year 1.

run number	1	2	3	4	5	6	7
Landings makeup	avg rec 82 & 86	avg rec 82 & 86	avg rec 82 & 86	avg rec 82 & 86	avg rec 82 & 86	avg rec 82 & 86	MRFSS landings
growth	Shepherd	Caruso	NEFSC survey	NEFSC survey	NEFSC survey	NEFSC survey	NEFSC survey
total objective function	181.00	206.14	184.28	165.93	172.80	202.53	187.24
total catch	0.04	0.23	0.14	0.14	0.13	0.17	0.18
catch len freq 80+	10.31	17.51	9.17	10.39	9.98	9.96	10.13
Vrec	1.98	1.60	1.62	12.07	5.46	0.0002	1.61
Fall age 1	11.62	13.11	13.41	12.94	12.67	16.77	13.61
Spring age 1	40.16	41.78	42.32	33.47	36.26	52.86	43.22
Winter age 1	16.75	16.45	15.83	10.00	11.84	22.35	15.55
Winter 80+ len freq	17.81	21.94	18.84	20.73	20.13	19.07	18.96
Winter 80+ numbers	6.46	6.06	5.95	5.67	5.55	7.06	5.81
Spring 80+ len freq	58.19	69.93	60.57	61.94	61.49	62.37	61.10
Spring 80+ numbers	9.37	9.04	8.69	8.22	8.08	10.17	9.04
wt total catch	10	10	10	10	10	10	10
effective sample size wt catch len freq 80+	200	200	200	200	200	200	200
wt Vrec	5	5	5	0.1	1	1000	5
wt Fall age 1	1	1	1	1	1	1	1
wt Spring age 1	1	1	1	1	1	1	1
wt Winter age 1	1	1	1	1	1	1	1
effective sample size wt Winter 80+ len freq	200	200	200	200	200	200	200
wt Winter 80+ numbers	1	1	1	1	1	1	1
effective sample size Spring 80+ len freq	200	200	200	200	200	200	200
wt Spring 80+ numbers	1	1	1	1	1	1	1
Q Fall age 1	0.80	0.83	0.82	0.81	0.82	0.82	0.82
Q Spring age 1	0.77	0.80	0.79	0.78	0.79	0.79	0.79
Q Winter age 1	0.77	0.80	0.79	0.77	0.78	0.80	0.79
Q Winter 80+ numbers	0.77	0.81	0.80	0.78	0.79	0.81	0.80
Q Spring 80+ numbers	0.79	0.82	0.81	0.80	0.81	0.82	0.81
Fstart	0.75	1.72	1.40	1.08	1.43	1.36	0.89
recruitment year 1	21.9	12.0	14.0	12.4	14.5	13.6	15.4

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Table 2. Black Sea Bass LTM run 3 F-mult, age 1 recruitment and 22+ population biomass.

year	F Fmult	age 1 recruitment millions	population 22+ biomass metric tons
1981	0.83	14.0	3,520
1982	0.78	12.4	4,589
1983	0.93	10.2	5,230
1984	0.78	10.7	4,753
1985	0.79	13.1	4,725
1986	0.96	15.1	4,885
1987	1.24	12.2	4,909
1988	1.54	18.3	4,881
1989	1.39	10.8	4,575
1990	1.23	15.0	4,846
1991	1.56	15.1	4,707
1992	1.35	16.6	4,553
1993	1.45	9.9	5,024
1994	0.77	11.8	4,650
1995	1.17	14.3	5,293
1996	1.32	13.4	4,954
1997	1.34	11.9	4,795
1998	0.57	9.8	4,492
1999	0.60	16.4	5,821
2000	0.82	24.6	7,199
2001	0.72	13.3	8,879
2002	0.80	25.2	11,567
2003	0.42	21.6	13,601
2004	0.20	15.4	17,882
2005	0.13	16.6	23,359

Table 3. Black Sea Bass LTM runs 8 and 9 which used the MRFSS 95% upper and lower CI bounds. The residual sum of squares, input weights, estimated Qs, estimated Fstart, and age 1 recruitment in year 1 are shown.

run number	8	9
Landings makeup	MRFSS lower CI landings	MRFSS upper CI landings
growth	NEFSC survey	NEFSC survey
total objective function	183.00	185.81
total catch	0.12	0.16
catch len freq 80+	8.98	9.20
Vrec	1.66	1.72
Fall age 1	13.32	13.61
Spring age 1	41.92	41.94
Winter age 1	15.74	15.93
Winter 80+ len freq	18.65	19.01
Winter 80+ numbers	5.88	6.05
Spring 80+ len freq	60.33	60.99
Spring 80+ numbers	8.67	8.90
wt total catch	10	10
effective sample size wt catch len freq 80+	200	200
wt Vrec	5	5
wt Fall age 1	1	1
wt Spring age 1	1	1
wt Winter age 1	1	1
effective sample size wt Winter 80+ len freq	200	200
wt Winter 80+ numbers	1	1
effective sample size Spring 80+ len freq	200	200
wt Spring 80+ numbers	1	1
Q Fall age 1	0.82	0.81
Q Spring age 1	0.79	0.78
Q Winter age 1	0.79	0.78
Q Winter 80+ numbers	0.80	0.79
Q Spring 80+ numbers	0.82	0.80
Fstart	1.51	1.40
recruitment year 1	13.3	17.1

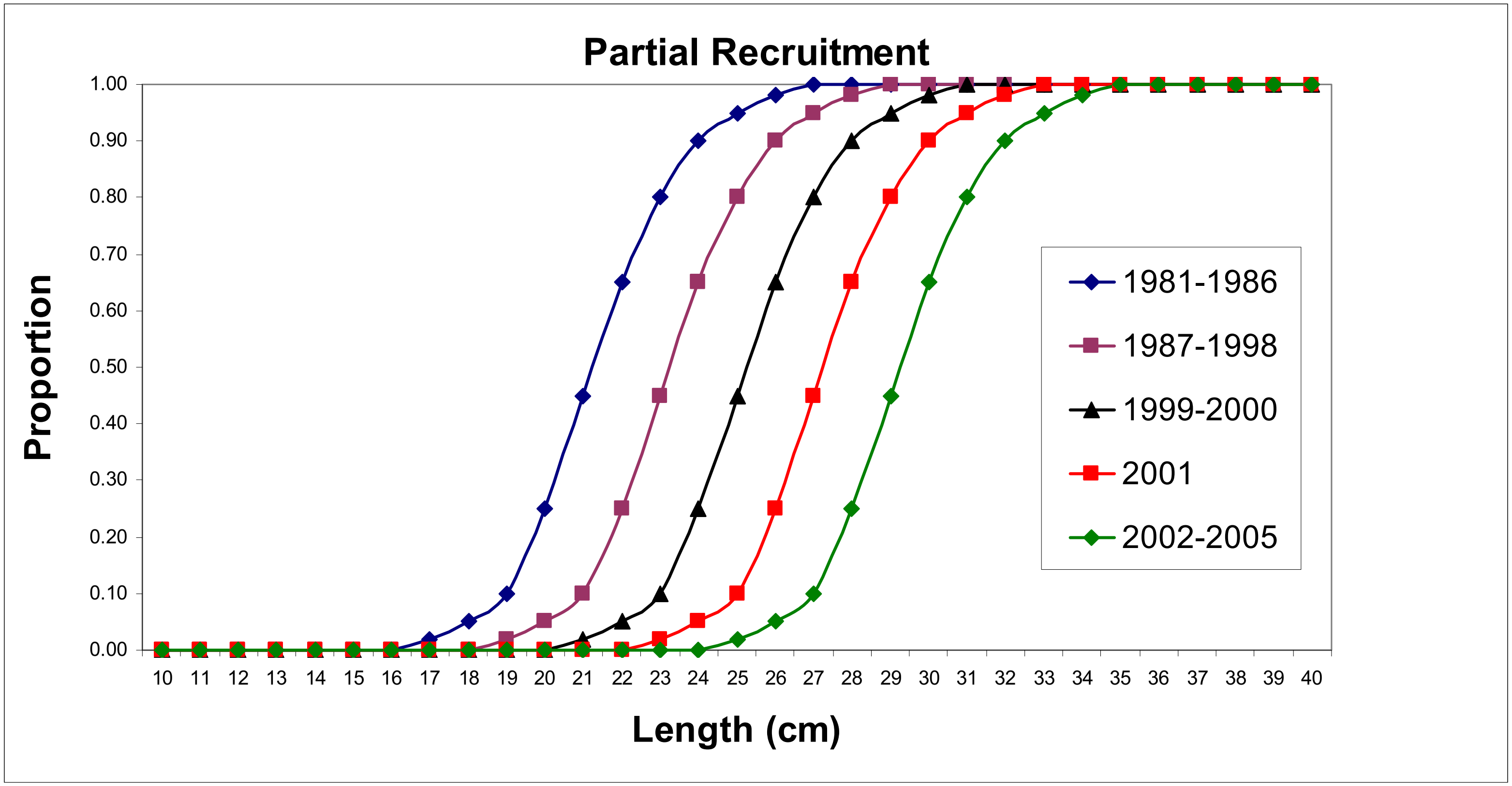

Figure 1 (Appendix C1). Input partial recruitment vector at length used in the black sea bass LTM model.

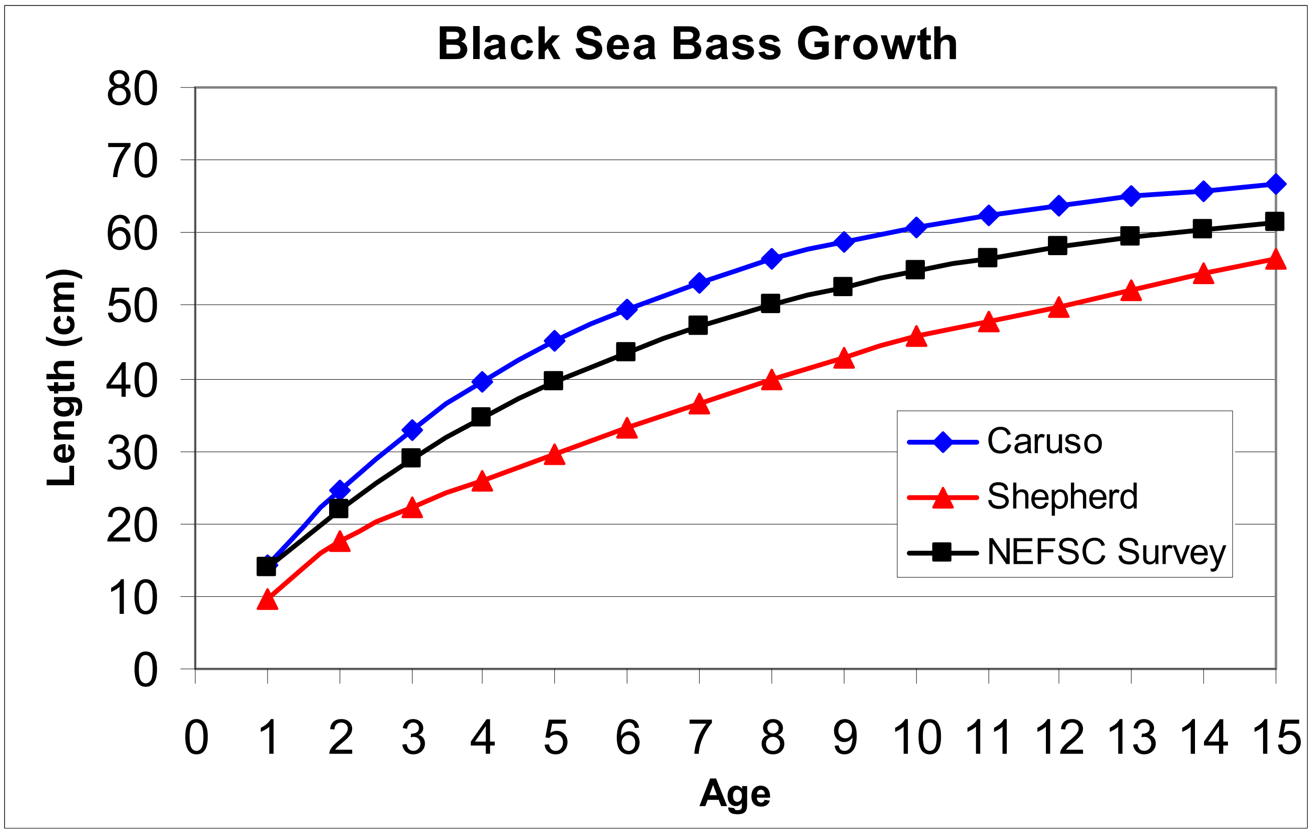

Figure 2 (Appendix C1). Three different growth models used in Black Sea Bass LTM runs 1 to 3.

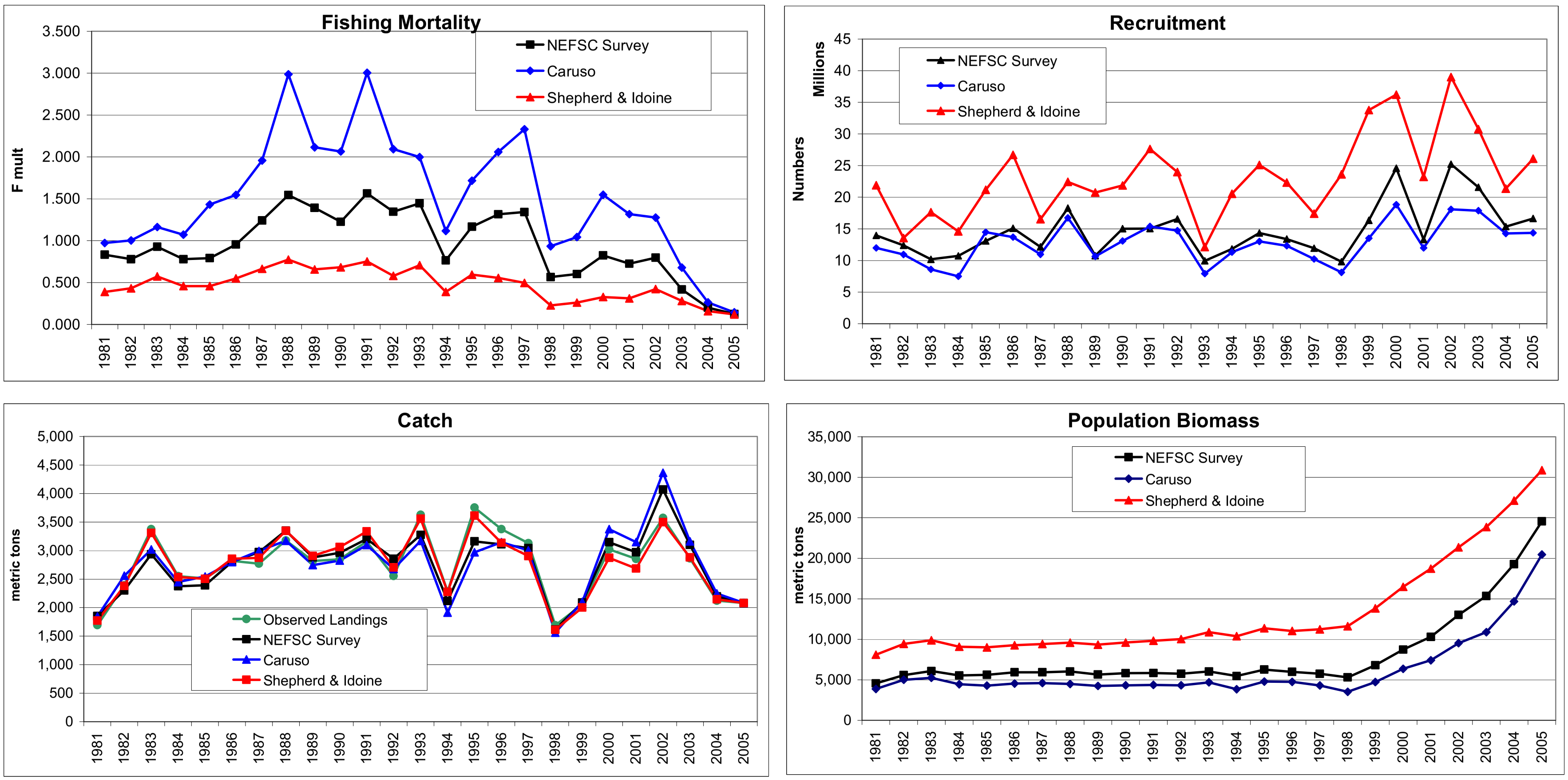

Figure 3 (Appendix C1). Black Sea Bass LTM runs 1 to 3 using three different growth models with a Vrec weight of 5 and average 82 and 86 recreational landings.

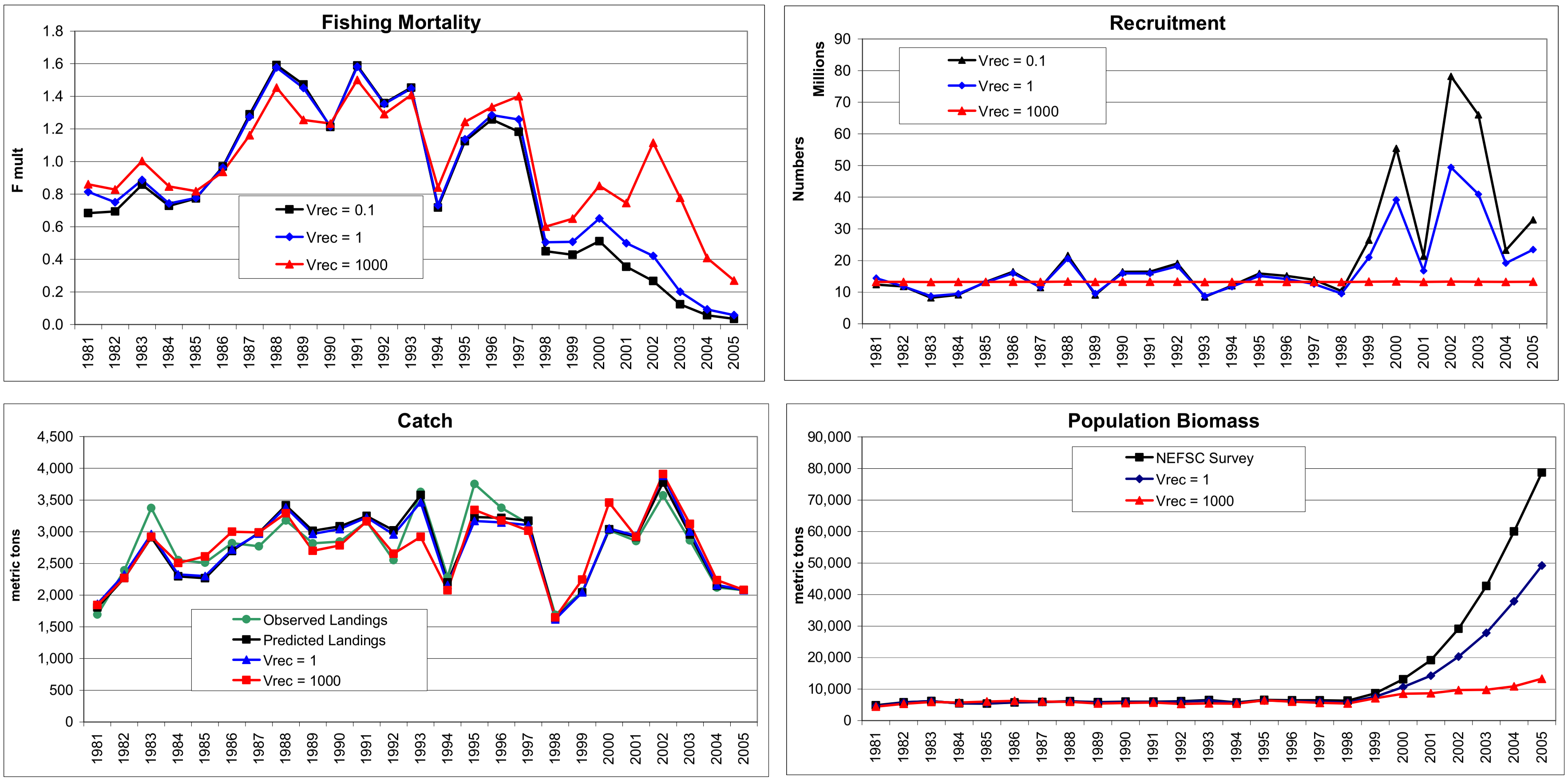

Figure 4 (Appendix C1). Black Sea Bass LTM runs 4 to 6 using three different Vrec weights (0.1,1,1000) and average 82 and 86 recreational landings.

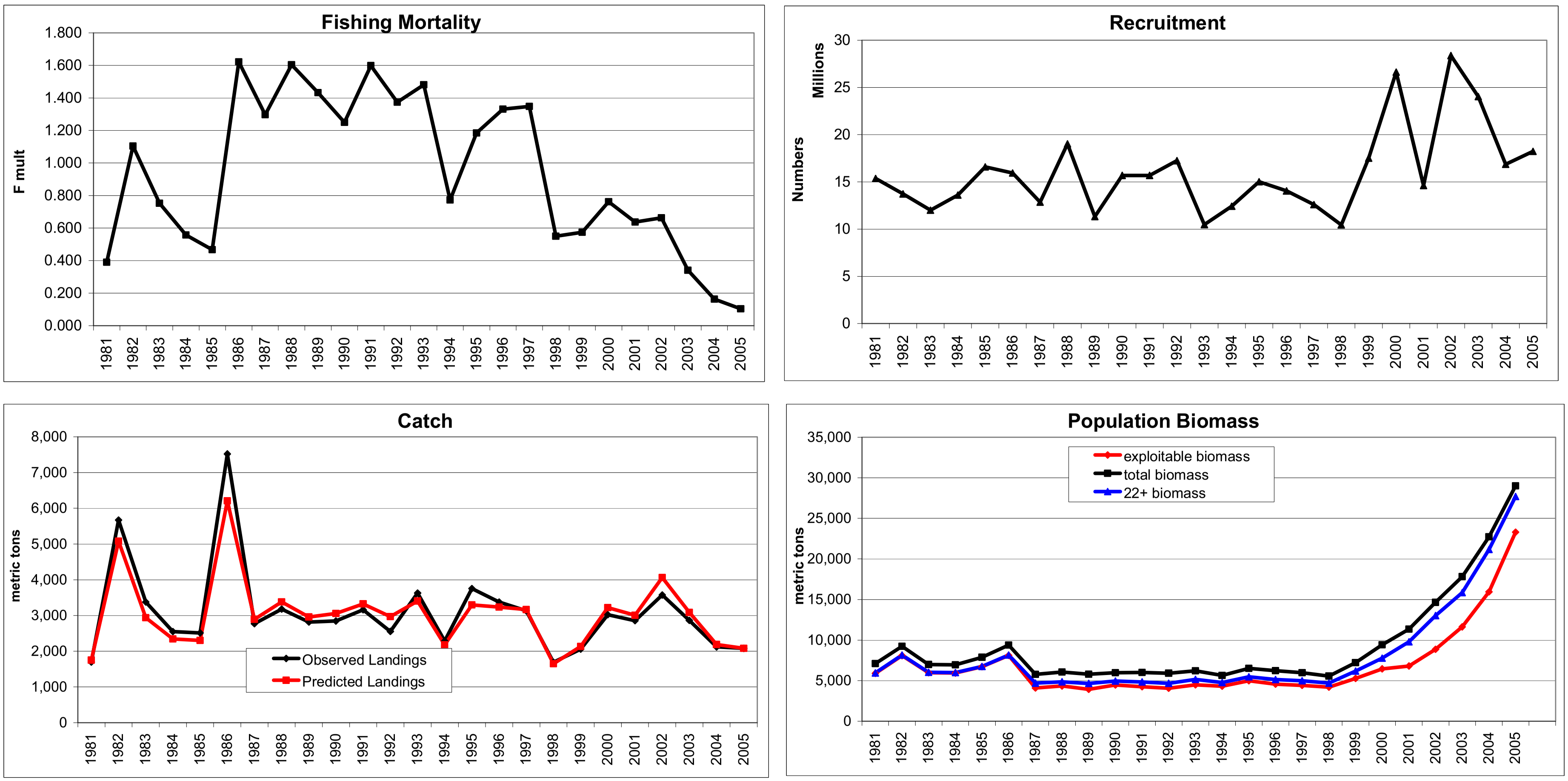

Figure 5 (Appendix C1). Black Sea Bass LTM run 7 using Vrec weight of 5 and the reported recreational landings for 1982 and 1986

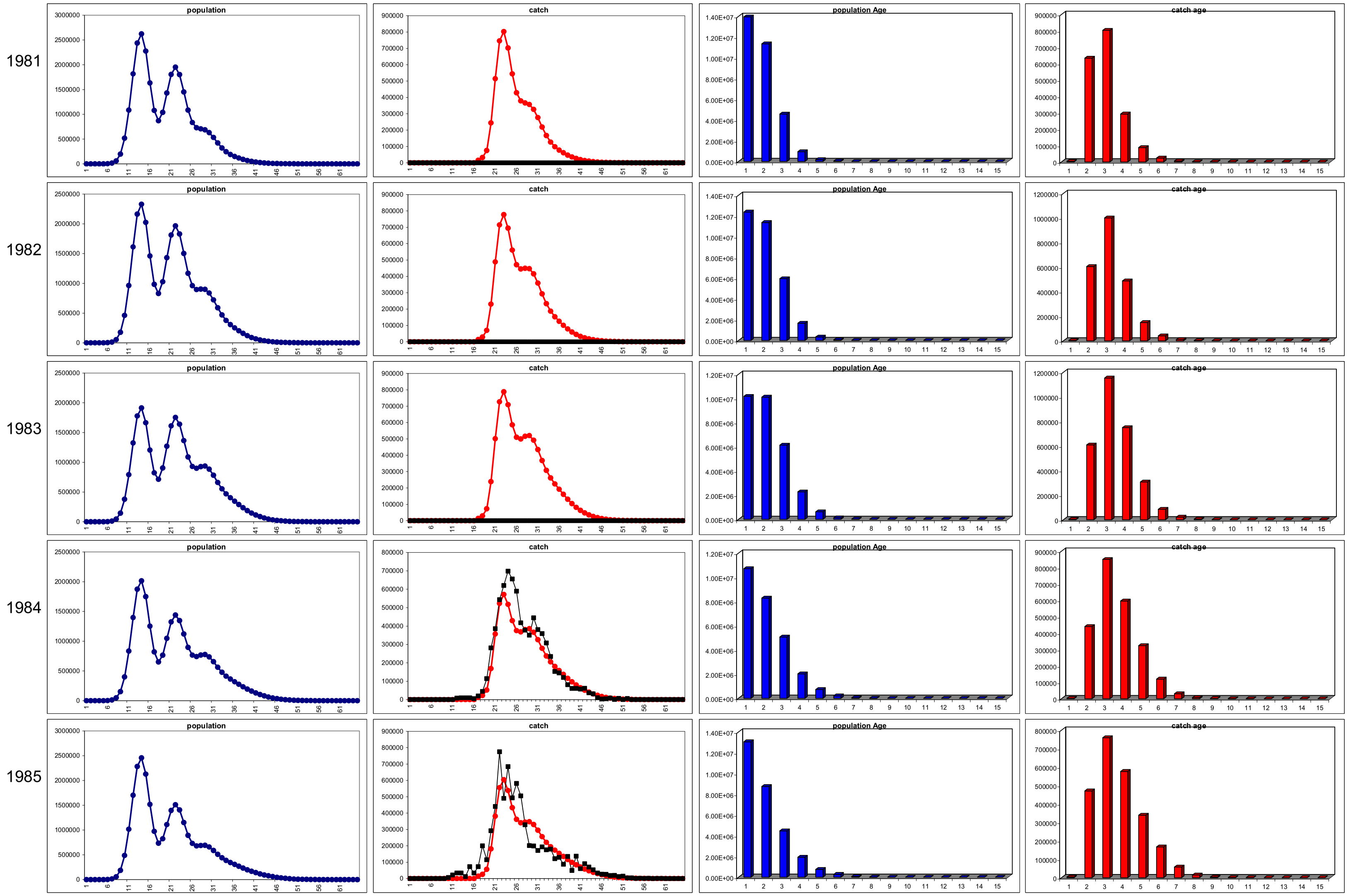

Figure 6 (Appendix C1). Black Sea Bass LTM run 3 population length frequency, observed (squares) and predicted (dots) catch length frequency, population age frequency and catch frequency from 1981-2005.

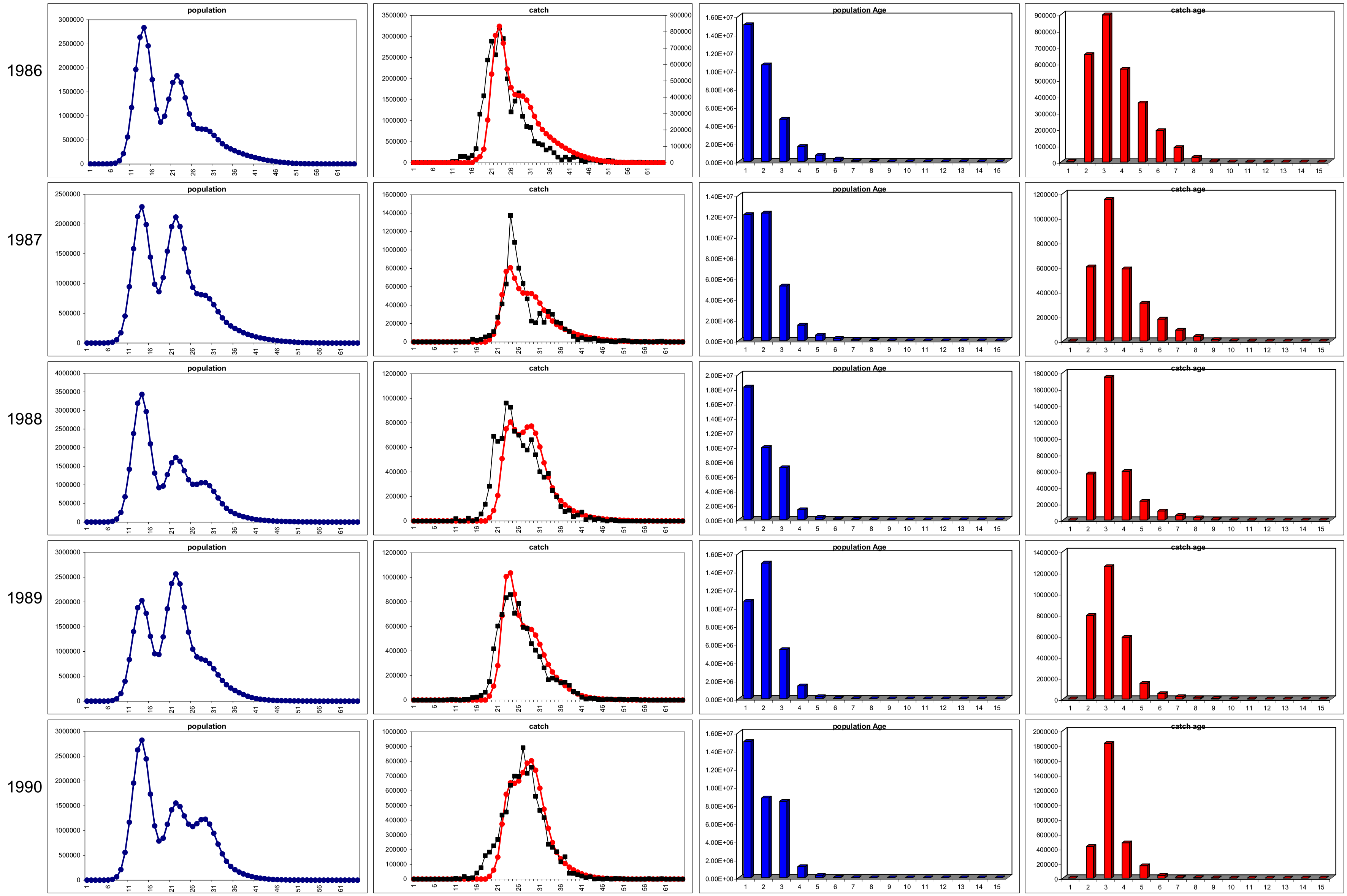
1986
1987
1988
1989
1990
population
catch
population Age
catch age

Fig. 6. cont.

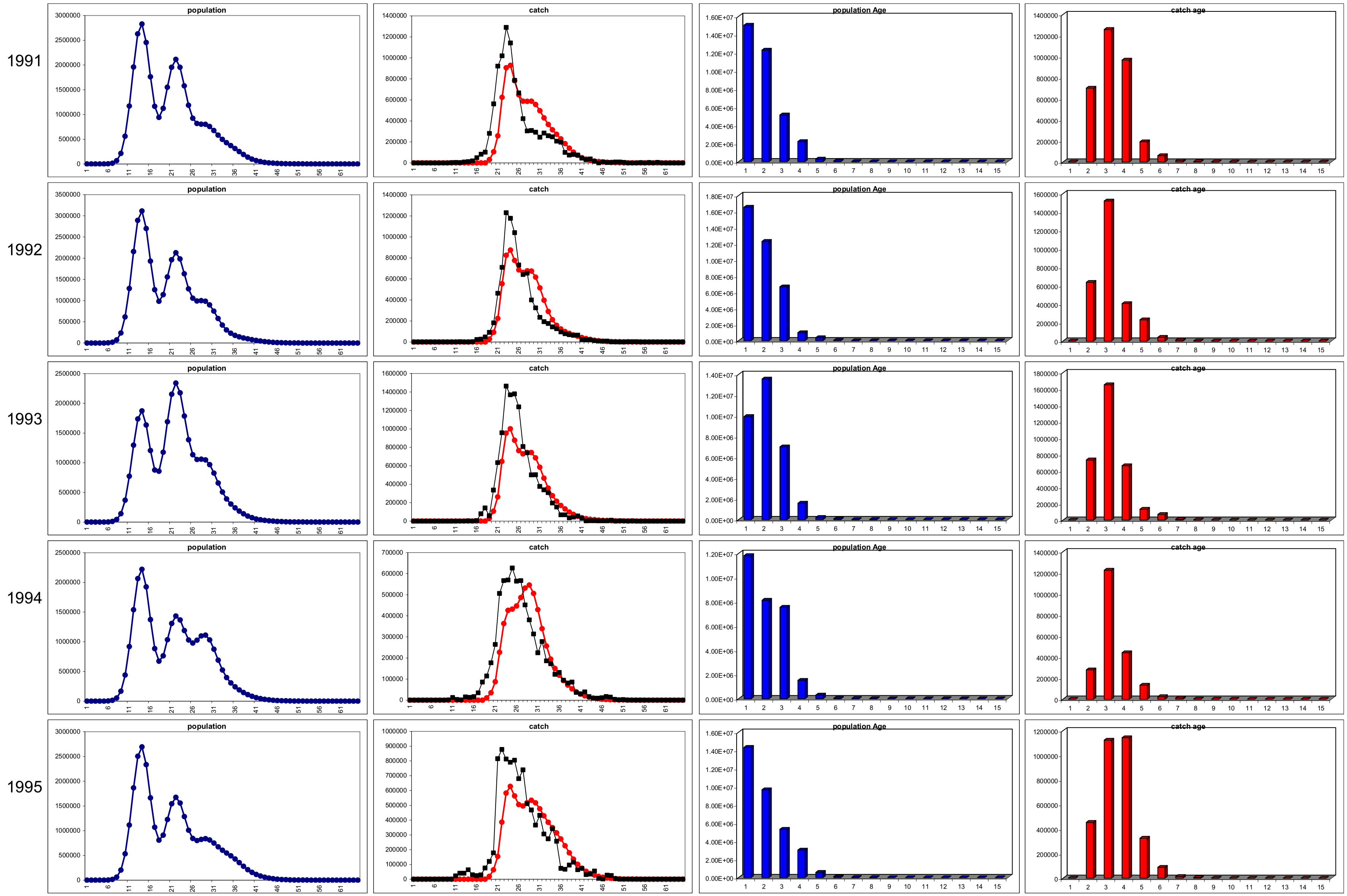
1991
1992
1993
1994
1995
population
catch
population Age
catch age

Fig. 6. cont.

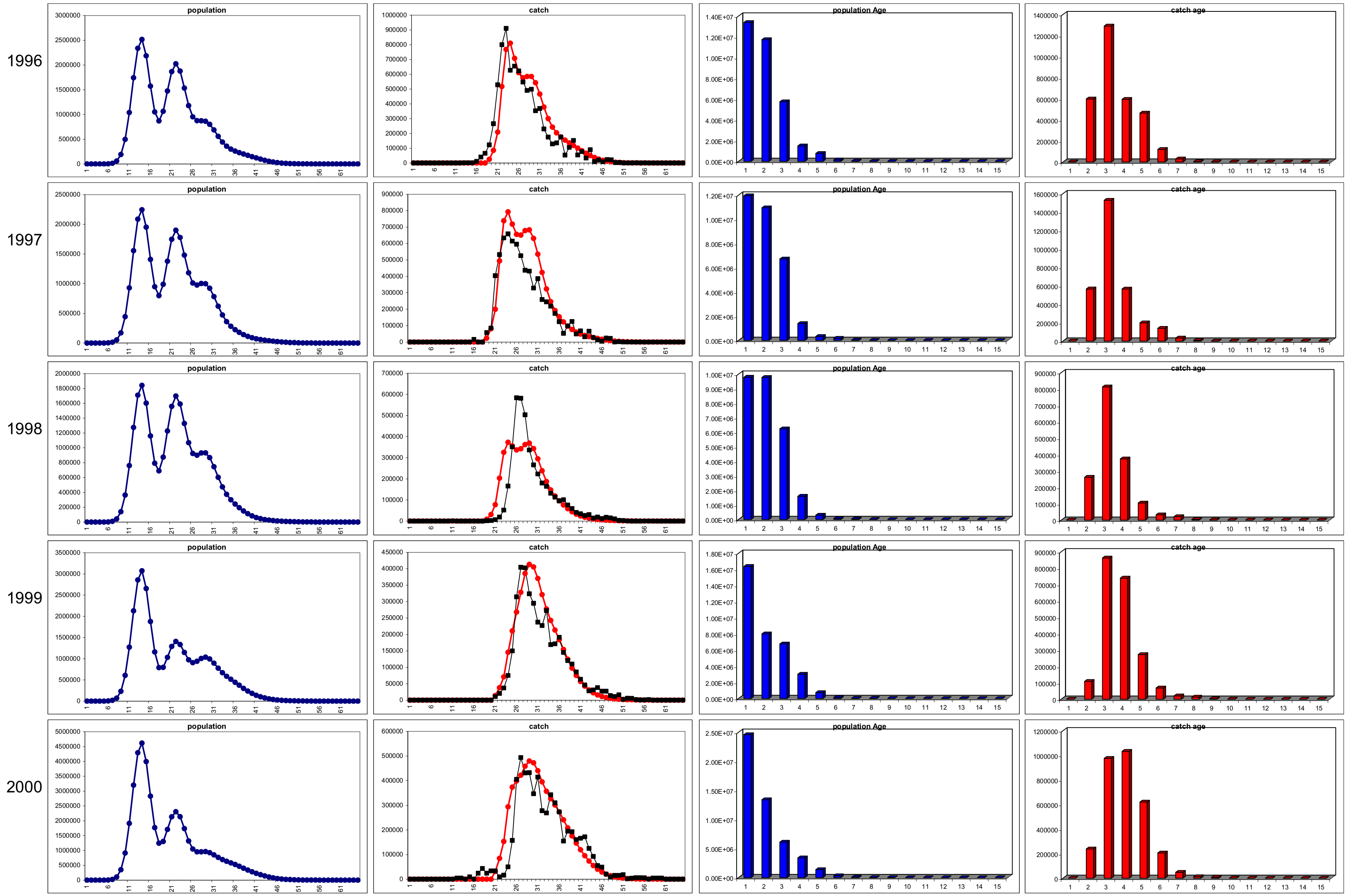
1996
1997
1998
1999
2000
population
catch
population Age
catch age

Fig. 6. cont.

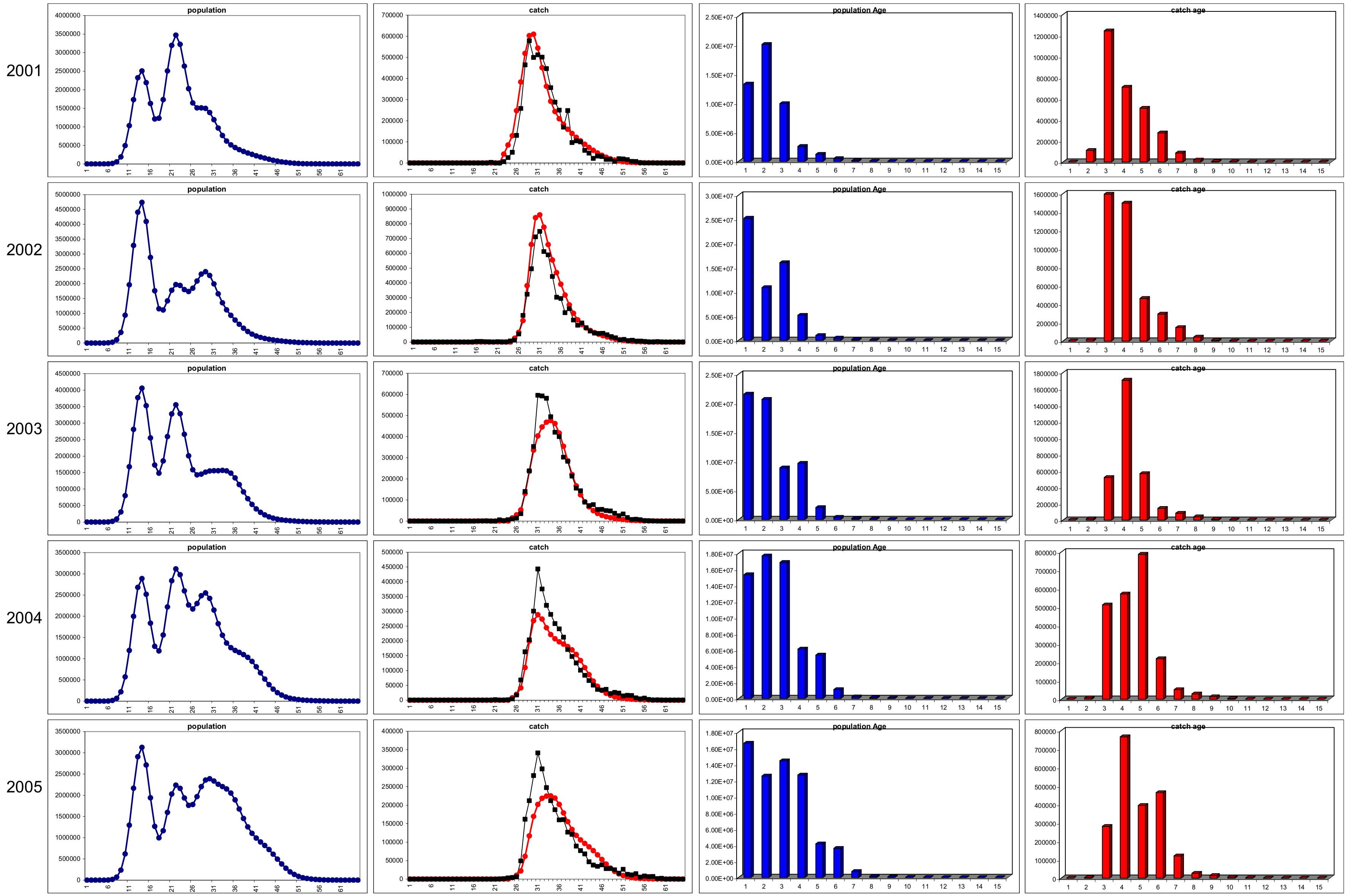
2001
2002
2003
2004
2005
population
catch
population Age
catch age

Fig. 6. cont.

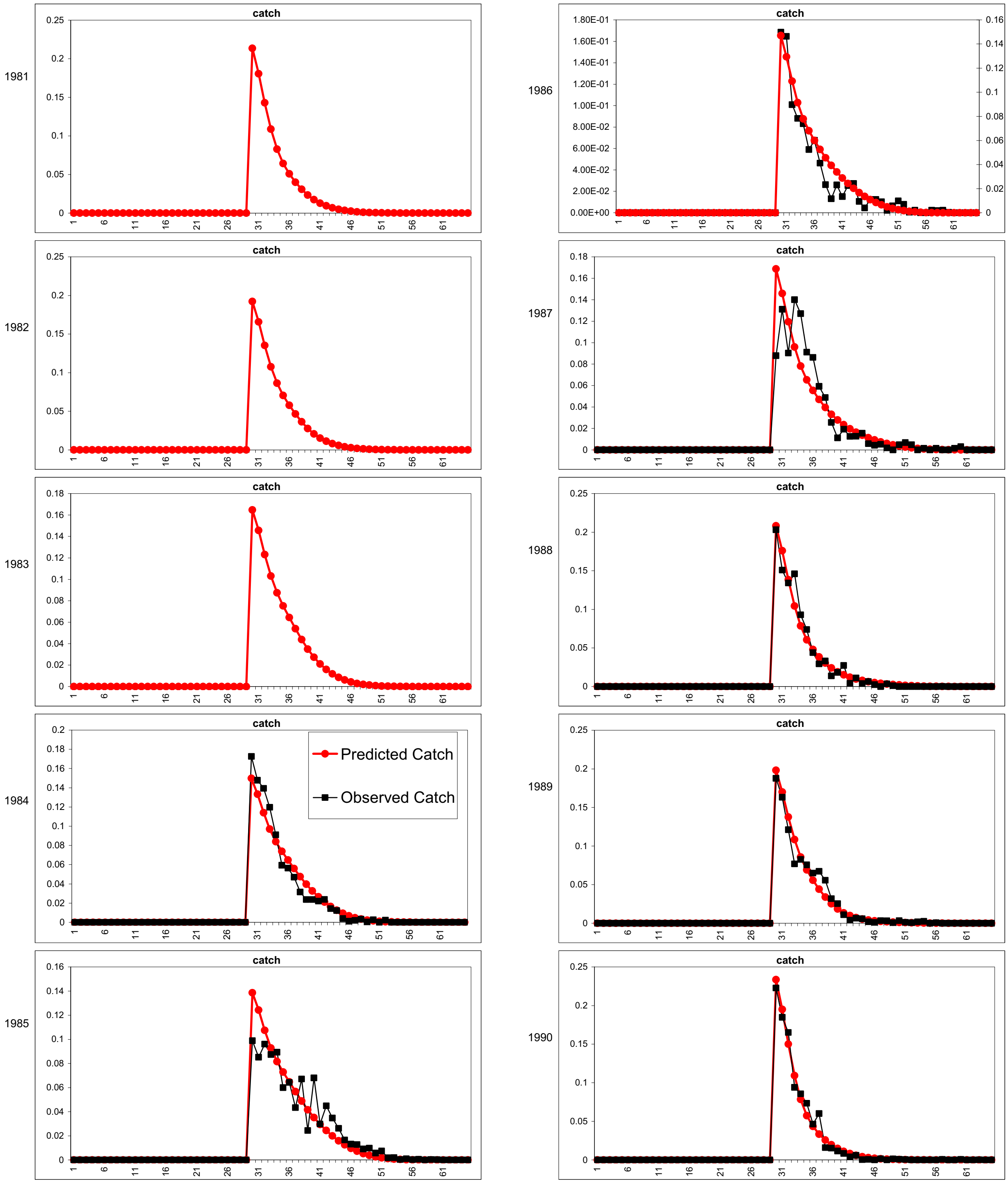

Figure 7 (Appendix C1). Black sea bass LTM run 3 observed and predicted fitted catch length frequency for 22+ cm fish from 1981-2005.

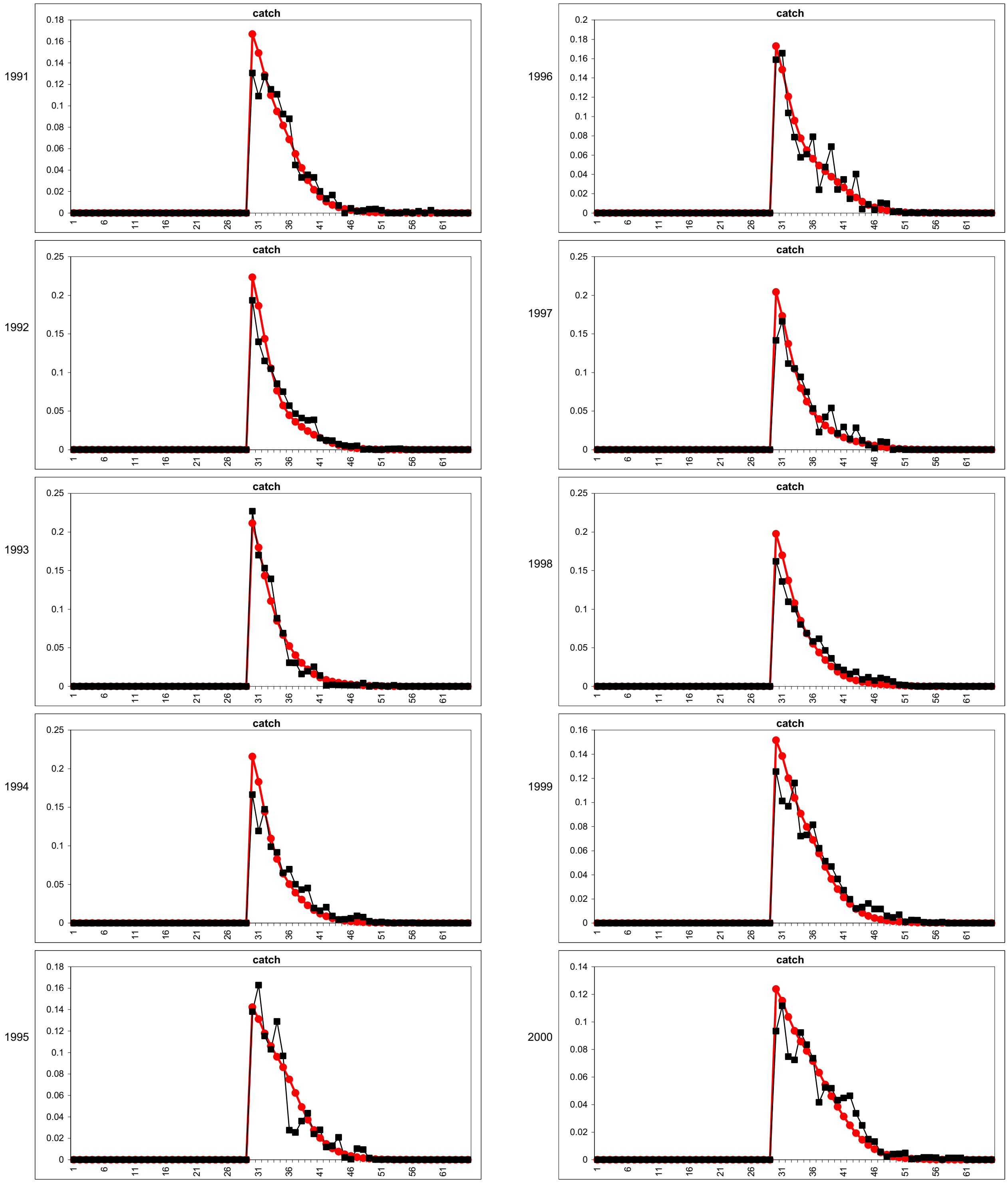
1991
catch
1992
catch
1993
catch
1994
catch
1995
catch
1996
catch
1997
catch
1998
catch
1999
catch
2000
catch

Fig 7. cont.

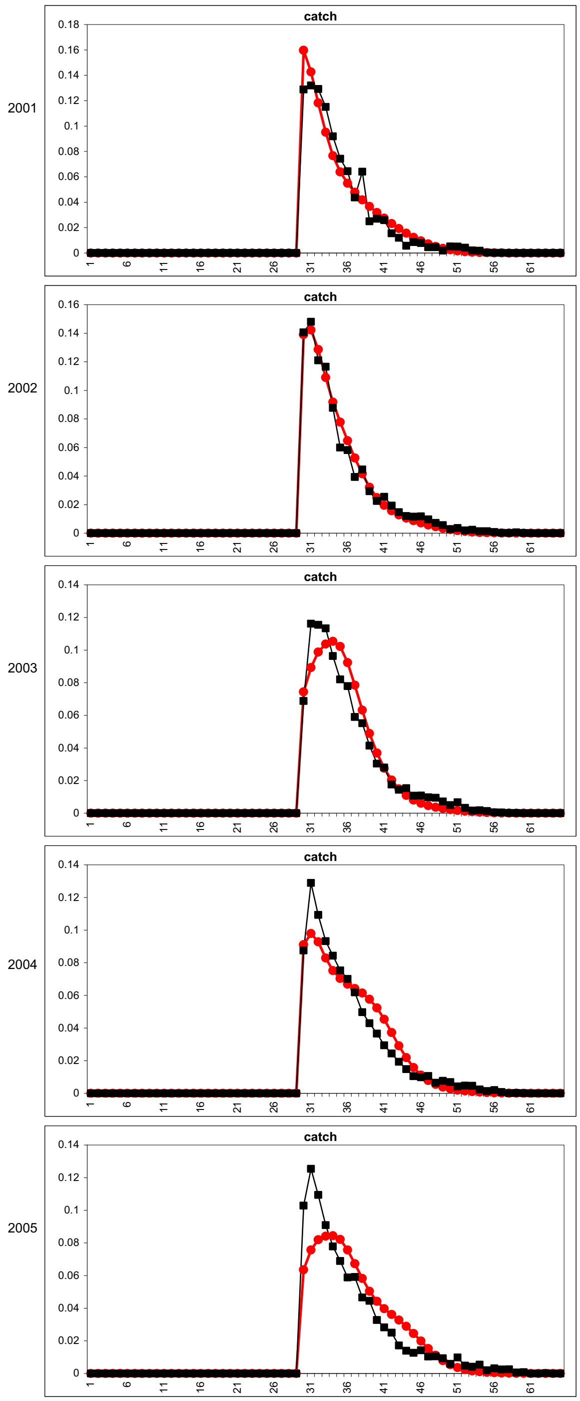
2001
catch
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1 6 11 16 21 26 31 36 41 46 51 56 61
2002
catch
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1 6 11 16 21 26 31 36 41 46 51 56 61
2003
catch
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1 6 11 16 21 26 31 36 41 46 51 56 61
2004
catch
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1 6 11 16 21 26 31 36 41 46 51 56 61
2005
catch
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1 6 11 16 21 26 31 36 41 46 51 56 61

Fig 7. cont.

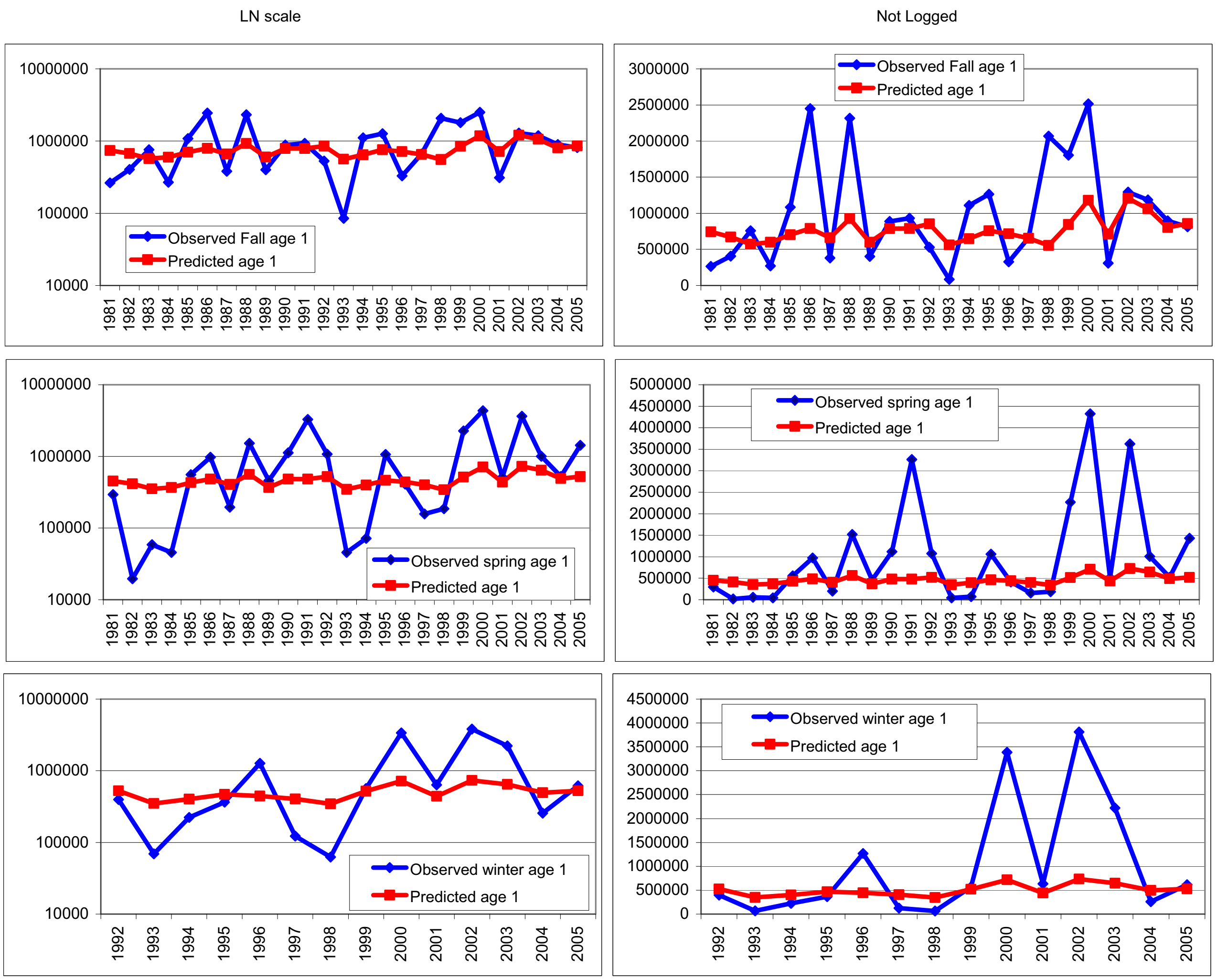

Figure 8 (Appendix C1). Black sea bass run 3 ln and nominal observed and predicted age 1 recruitment indices for the Fall, Spring, and winter NEFSC surveys.

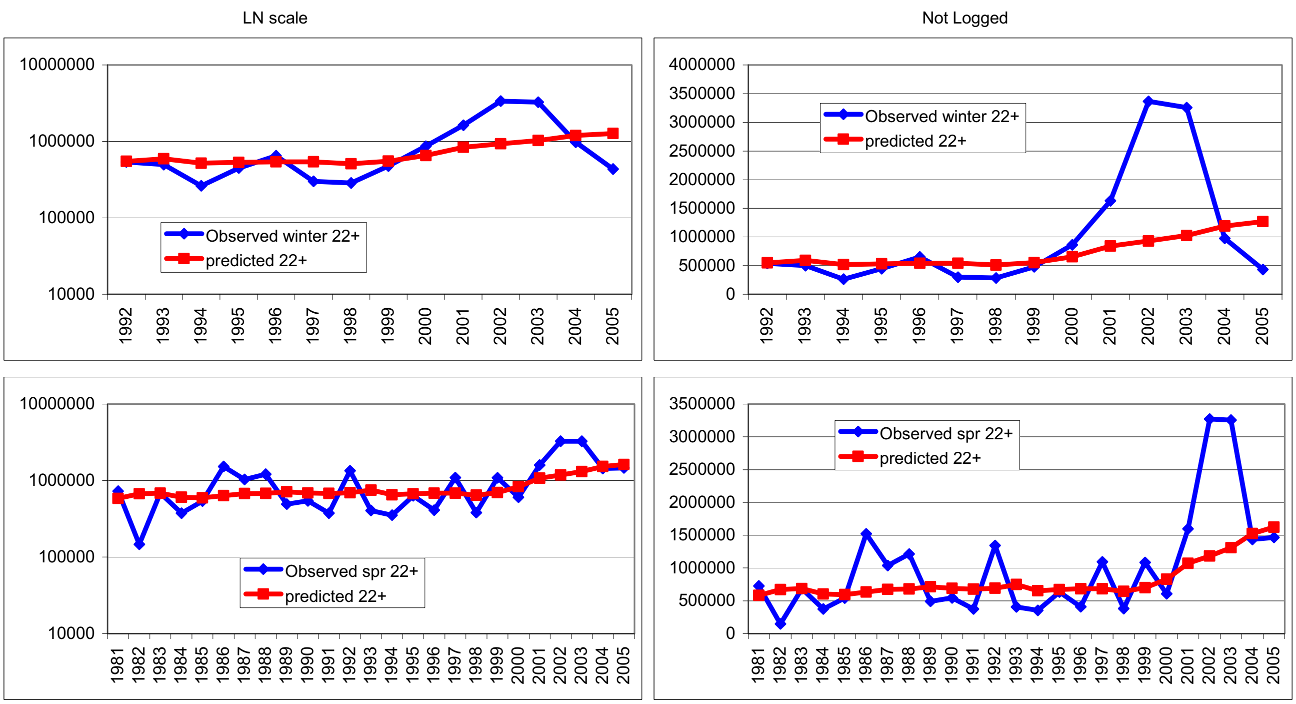

Figure 9 (Appendix C1). Black sea bass run 3 ln and nominal observed and predicted 22+ cm number indices for the NEFSC winter and spring surveys.

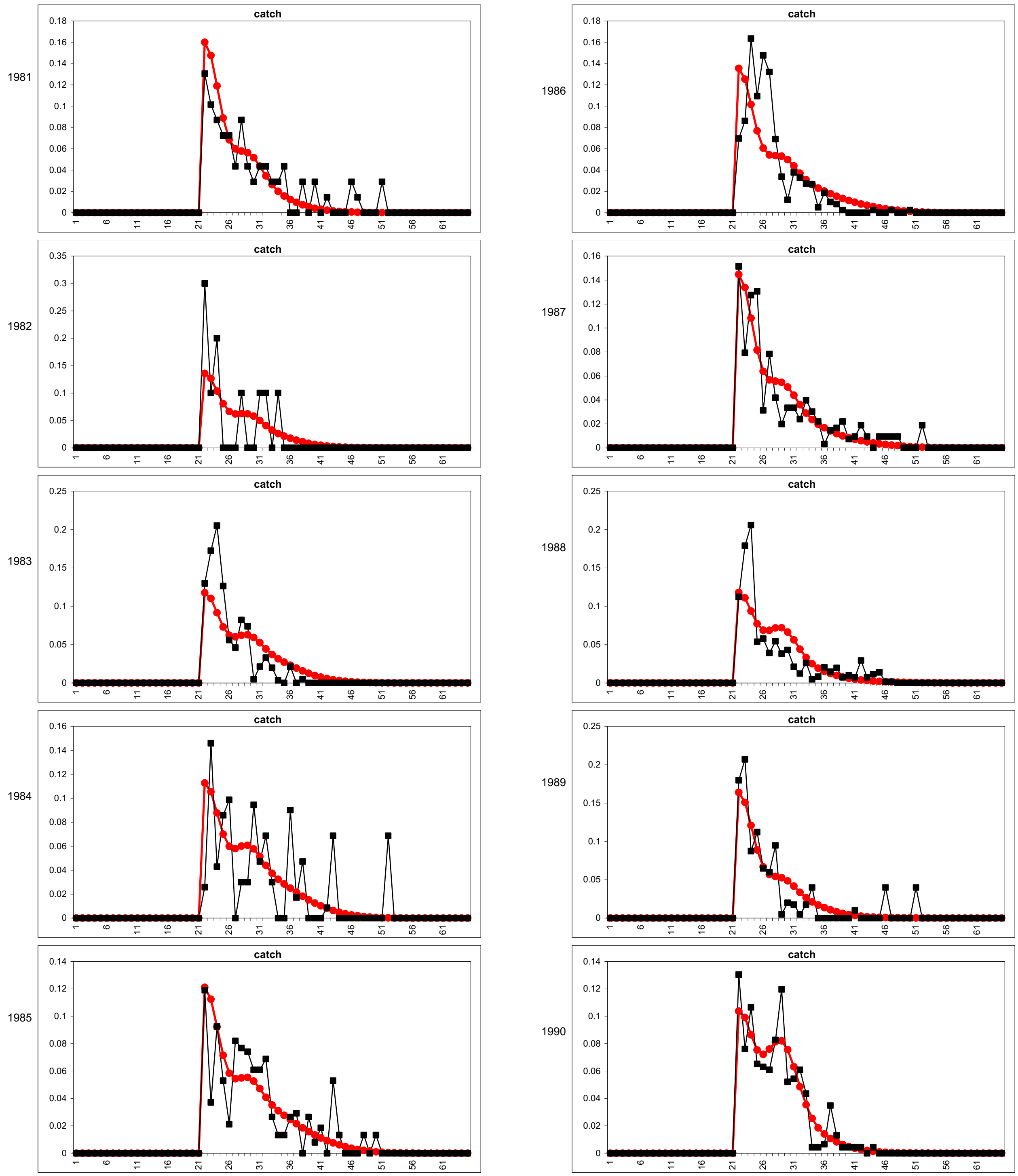

Figure 10 (Appendix C1). Black sea bass LTM run 3 observed (squares) and predicted (dots) fitted length frequency for 22+ cm fish for the NEFSC Spring survey from 1981-2005.

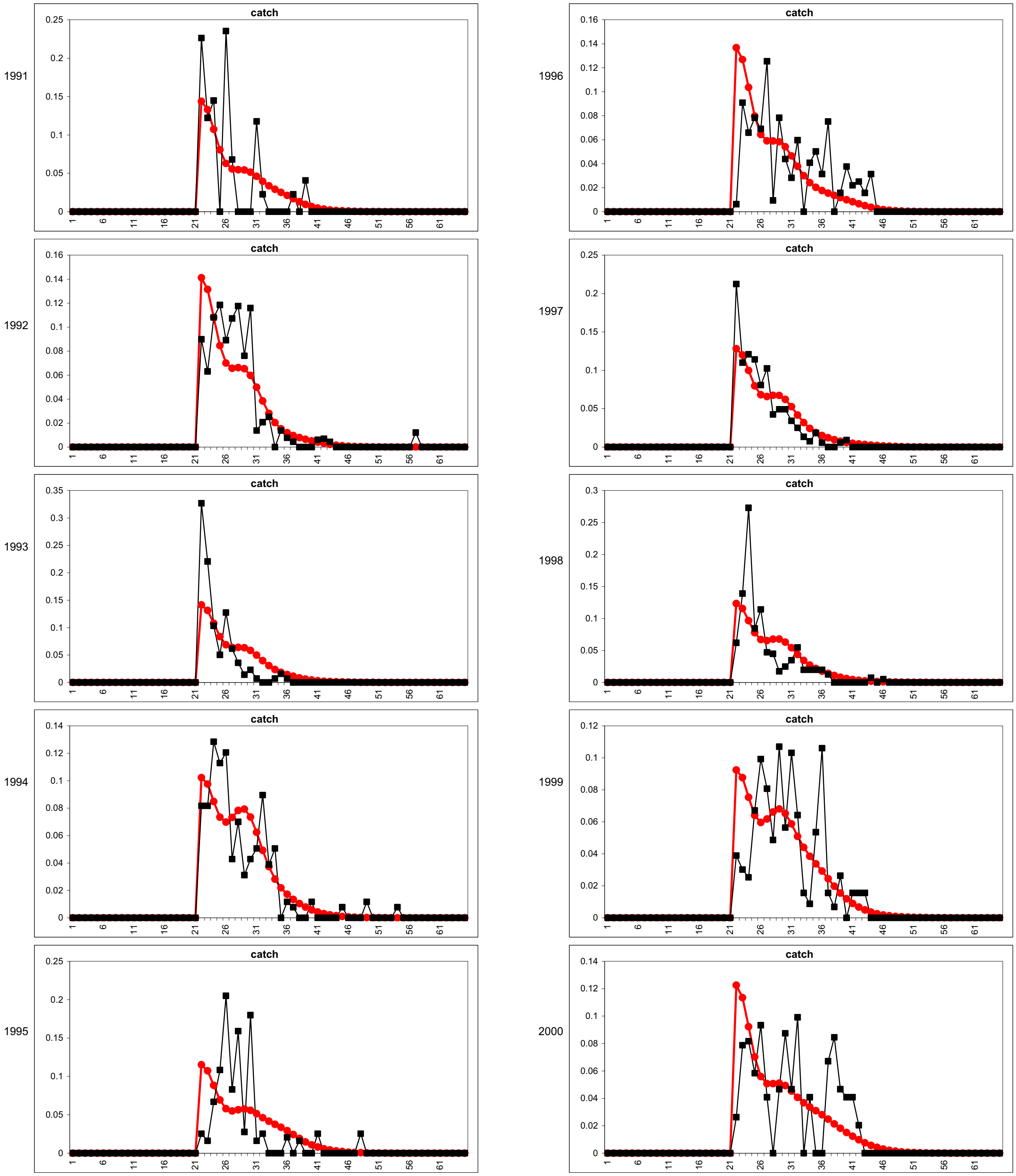
1991
catch
1992
catch
1993
catch
1994
catch
1995
catch
1996
catch
1997
catch
1998
catch
1999
catch
2000
catch

Fig 10. cont.

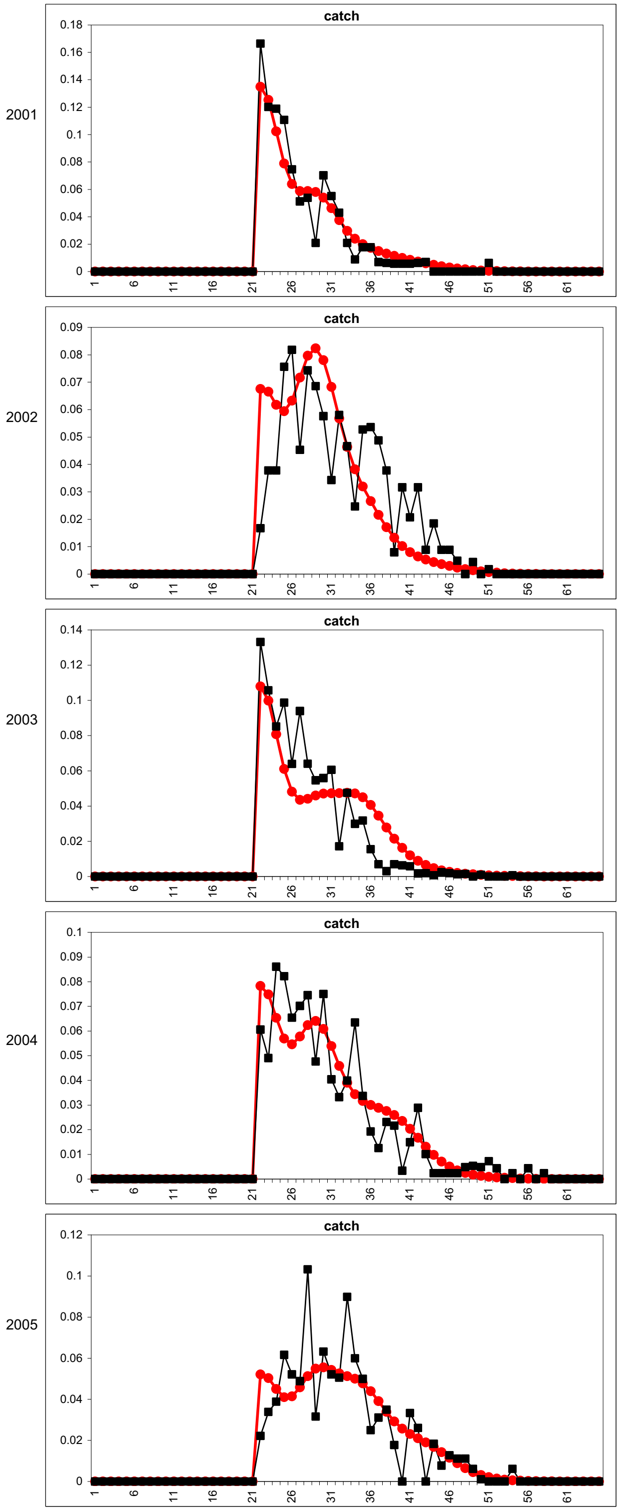

Fig 10. cont.

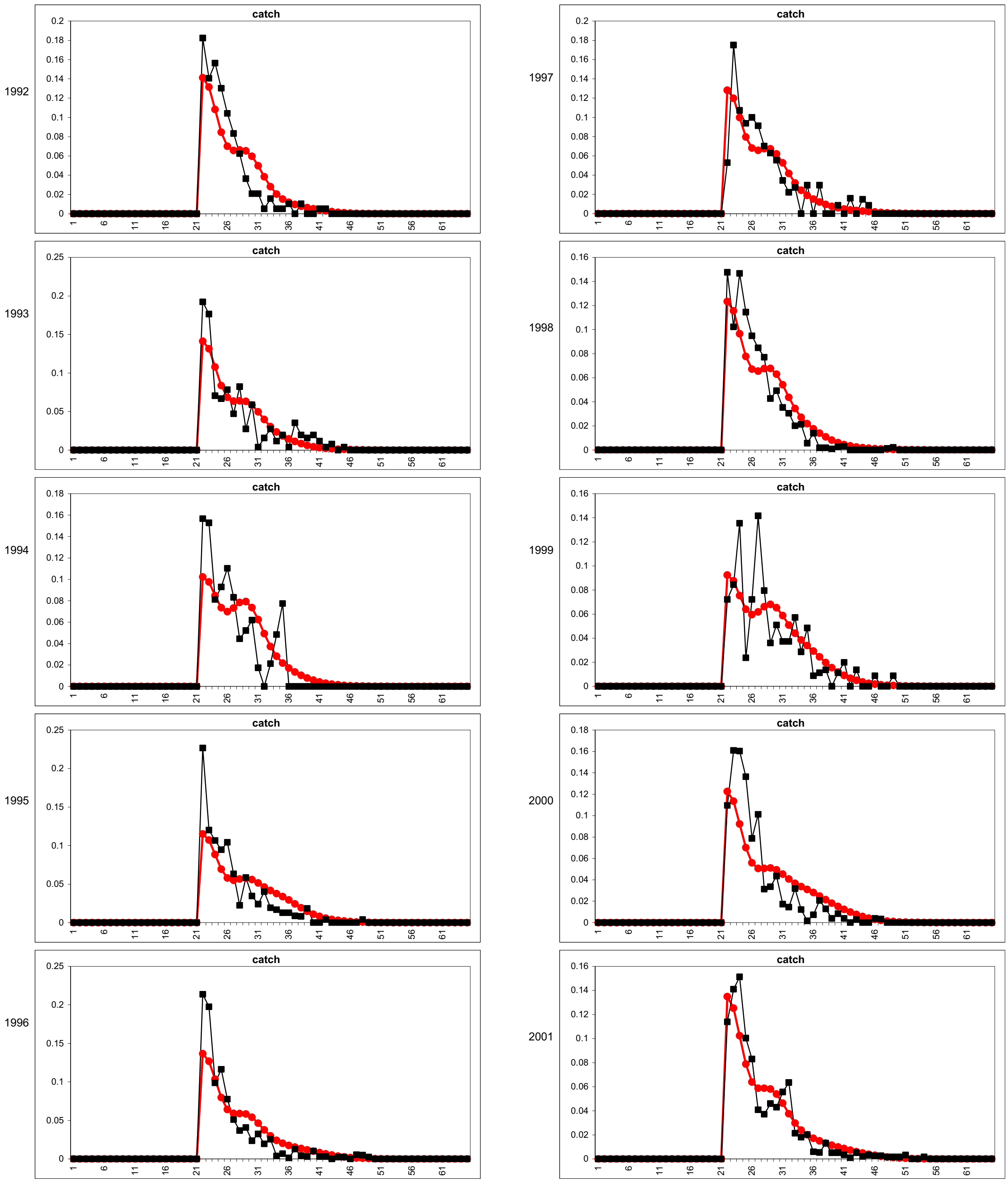

Figure 11 (Appendix C1). Black sea bass LTM run 3 observed (squares) and predicted (dots) fitted length frequency for 22+ cm fish for the NEFSC Winter survey from 1992-2005.

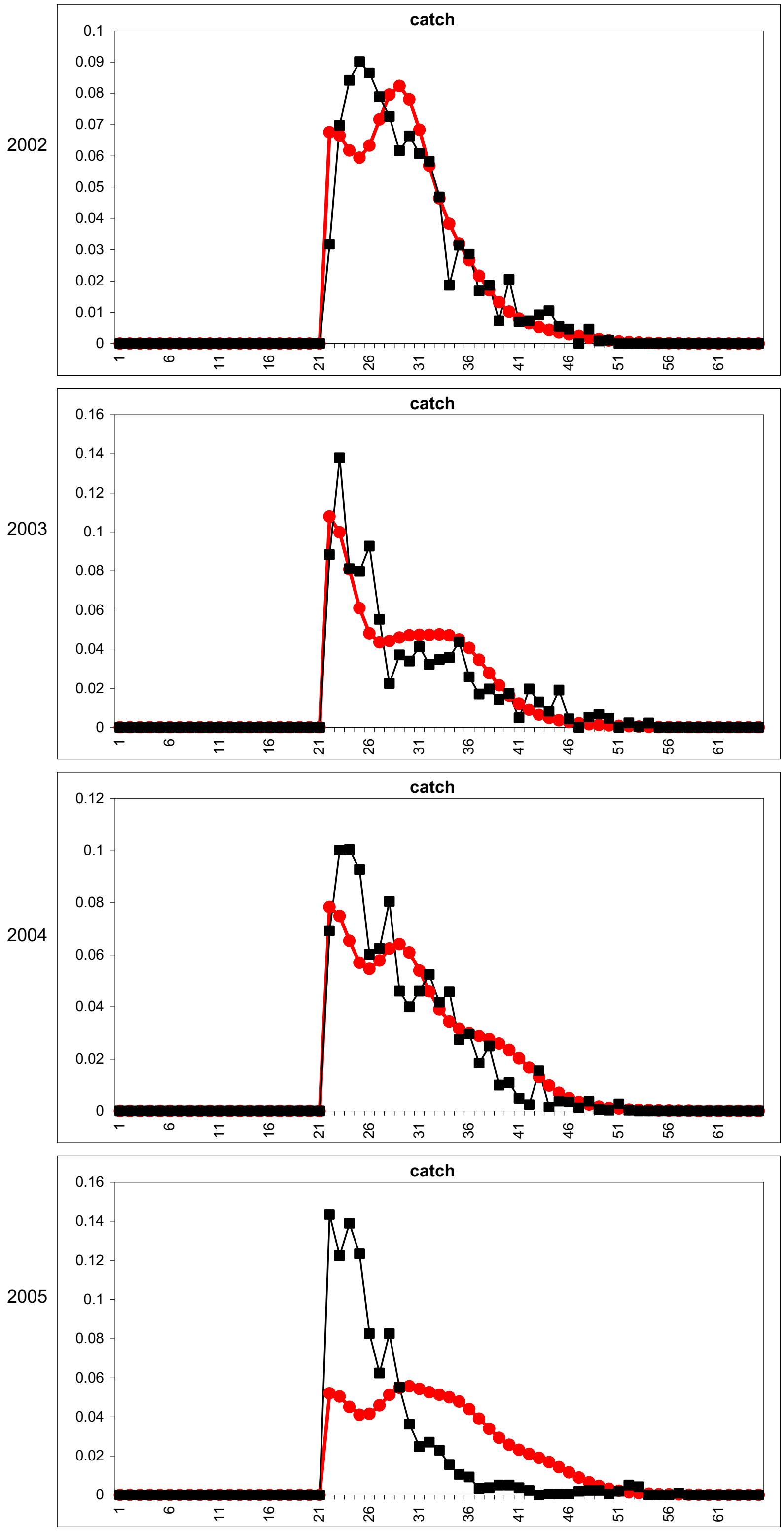

Fig 11. cont.

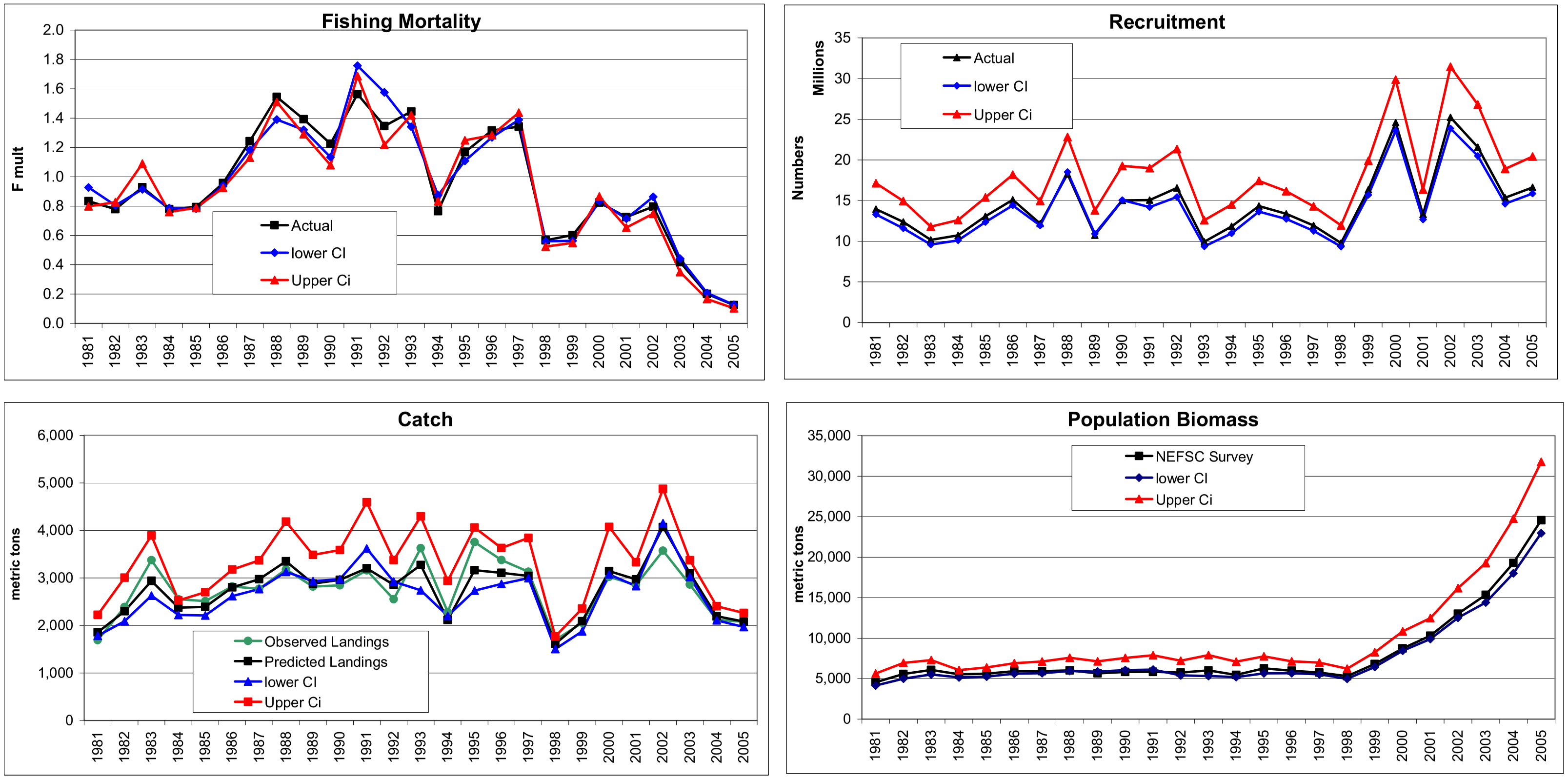

Figure 12 (Appendix C1). Black Sea Bass LTM runs 3, 8, and 9 using MRFSS median, 95% lower and upper confidence interval as the catch with a Vrec weight of 5 and average 82 and 86 recreational landings.