

## **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 ( $\geq 22$ cm) 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  $F_{\text{msy}}$ . 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
<b>1996</b>	9"	9"
<b>1997</b>	9"	9"
<b>1998</b>	10"	10"
<b>1999</b>	10"	10"
<b>2000</b>	10"	10"
<b>2001</b>	10"	11"
<b>2002</b>	11"	11.5"
<b>2003</b>	11"	12"
<b>2004</b>	11"	12"
<b>2005</b>	11"	12"
<b>2006</b>	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  $F_{\text{msy}}$  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  $\ln Wt \text{ (kg)} = \ln a + b \ln Len \text{ (cm)}$  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 ( $\leq 14$  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:

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

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 <sub>1</sub>	<b>R<sub>11</sub></b>	R <sub>12</sub>	R <sub>13</sub>
Release	M <sub>2</sub>		<b>R<sub>21</sub></b>	R <sub>22</sub>
Year	M <sub>3</sub>			<b>R<sub>31</sub></b>

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<sub>12</sub>, R<sub>22</sub>) 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<sub>11</sub>) 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<sub>21</sub> and R<sub>12</sub> should be equal to tags lost from natural annual mortality. Therefore:

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

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 2<sup>nd</sup> 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  $F_{\text{msy}}$ .  $F_{\max}$  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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