

## B. STOCK ASSESSMENT OF BLACK SEA BASS FOR 2011

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

### Executive Summary

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

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

**SDWG-data meeting participants:**

BSB WG Data meeting September 19-September 20, 2011

BSB WG Model meeting October 18-October 20, 2011

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

## **Introduction**

### Life History

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

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

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

Spawning in the Middle Atlantic peaks during spring (May and June) when the fish reside in coastal waters (Drohan et al. 2007). The social structure of the spawning aggregations is poorly known although some observations suggest that large dominant males gather a harem of females and

aggressively defend territory during spawning season (Nelson et al. 2003). The bright coloration of males during spawning season suggests that visual cues may be important in structuring of the social hierarchy.

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

### Fisheries

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

### Stock assessment history summary

Black sea bass stock assessments have been reviewed in the SARC/SAW process (SAWs 1, 9, 11, 20, 25, 27, 39 and 43) beginning with an index based assessment in 1991. In 1995 a VPA model was approved and the results generally showed fishing mortalities exceeding 1.0 (estimated using an  $M=0.2$ ). The VPA was reviewed again in 1997 and at this time was considered too uncertain to determine stock status but indicative of general trends. In 1998, another review was conducted and both VPA and production models were rejected as either too uncertain or inappropriate for use with an hermaphroditic species. A suggestion was made to use an alternative method such as a tag/recapture approach. The NEFSC survey remained the main source of information regarding relative abundance and stock status. A tagging program was initiated in 2002 and the first year results were presented for peer review in 2004. The review panel concluded that a simple tag model using the proportion recovered in the first year at large, as well as an analysis of survey indices, produced acceptable results to determine exploitation rate

and stock status. The release of tags continued through 2004 and results of tag models as well as indices were presented for SARC review in 2006. Their findings were that the tag model did not meet the necessary assumptions and the variability in the survey indices created uncertainty which prevented determination of stock status. The panel did not recommend any alternative reference points, however they did recommend continued work on length based analytical models. Black sea bass were once again considered at the NDPSWG in December 2008. The review panel considered a statistical catch-at-length model (SCALE) and a variety of natural mortality options. That panel concluded that the length-based model was suitable for evaluating stock status and recommended a constant natural mortality option of 0.4. Although the stock was considered not overfished or experiencing overfishing, the uncertainty in the results prompted the reviewers to recommend caution in applying the results for management.

### **SAW/SARC 53 Terms of Reference**

#### **B. Black sea bass**

1. Estimate catch from all sources including landings and discards. Characterize the uncertainty in these sources of data. Evaluate available information on discard mortality and, if appropriate, update mortality rates applied to discard components of the catch. Describe the spatial and temporal distribution of fishing effort.
2. Present the survey data being used in the assessment (e.g., indices of abundance, recruitment, state surveys, age-length data, etc.). Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.
3. Consider known aspects of seasonal migration and availability of black sea bass, and investigate ways to incorporate these into the stock assessment. Based on the known aspects, evaluate whether more than one management unit should be used for black sea bass from Cape Hatteras north and, if so, propose unit delineations that could be considered by the Mid-Atlantic Fishery Management Council and for use in future stock assessments.
4. Investigate estimates of natural mortality rate,  $M$ , and if possible incorporate the results into TOR-5. Consider including sex- and age-specific rate estimates, if they can be supported by the data.
5. Estimate annual fishing mortality, recruitment and appropriate measures of stock biomass (both total and spawning stock) for the time series (integrating results from TOR-4), and estimate their uncertainty. Include a historical retrospective analysis to allow a comparison with most recent

assessment results.

6. State the existing stock status definitions for “overfished” and “overfishing”. Then update or redefine biological reference points (BRPs; point estimates or proxies for  $B_{MSY}$ ,  $B_{THRESHOLD}$ ,  $F_{MSY}$ , and  $MSY$ ) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the appropriateness of existing BRPs and the “new” (i.e., updated, redefined, or alternative) BRPs.
7. Evaluate stock status with respect to the existing model (from the most recent accepted peer reviewed assessment) and with respect to a new model developed for this peer review.
  - a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.
  - b. Then use the newly proposed model and evaluate stock status with respect to “new” BRPs (from black sea bass TOR 6).
8. Develop and apply analytical approaches to conduct single and multi-year stock projections to compute the PDF (probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).
  - a. Provide numerical annual projections (3-5 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for  $F$ , and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment, and definition of BRPs for black sea bass).
  - b. Comment on which projections seem most realistic. Consider major uncertainties in the assessment as well as the sensitivity of the projections to various assumptions.
  - c. Describe this stock’s vulnerability (see “Appendix to the SAW TORs”) to becoming overfished, and how this could affect the choice of ABC.
9. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.

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

Commercial fishery

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

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

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

$$\text{Spring: } 1.0428e-5 * \text{len}^{3.072}$$

$$\text{Autumn: } 1.2924e-5 * \text{len}^{3.027}$$

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

shown in Figure B11. Recent length distributions (2005-2010) are displayed in Figure B12.

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

### Commercial discards

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

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

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

Discards prior to 1984 were not estimated by fishery. A ratio of 0.06 (std. dev among annual ratios = 0.011) was developed from the median discard to landings ratio from 1984 to 1996. This ratio was applied to total landings (commercial plus recreational) for the period 1968 to 1983 to produce



estimates of total discards. Discards by fishery reported in Table B1 were calculated from the proportion of commercial to recreational discards in 1984-1996 and applied to total discards for that period. The stock assessment model does not incorporate the landings and discards by fishery but instead uses total catch as a single fleet.

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

#### Recreational Landings and Discards

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

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

Stockwide recreational landings averaged 1700 MT between 2000 and 2003 then declined to an average of 950 MT thereafter (Table B1, Figure B17). Some of the decline could be attributed to changes in the regulations, particularly minimum size and bag limits beginning in 2008. The majority of sea bass landings (53%) since 2000 are taken in New Jersey (Figure B18). The next closest states, by percentage,

are New York (13.4%), Massachusetts (7.8%) and Delaware (7.3%). Since 2000, from MA to VA, 77% of landings have occurred in waves 4 and 5 (July to October), although in 2009 and 2010 this proportion was influenced by seasonal closures. Mean length in the recreational landings averaged 27 cm between 1984 and 1996, then steadily increased to 35 cm by 2003 and has remained at that average length through 2010 (Figure B19).

Previous sea bass assessments assumed a 25% discard mortality in the recreational fishery. That rate was re-evaluated and the WG determined that a 15% mortality was more appropriate. This conclusion was based on information from published studies showing mortalities of 5% (Bugley and Shepherd 1991) and 12% (Rudershausen and Buckel 2007), potential barotraumas in the range of depths fished (generally less than 40 m), and published studies for other species (summer flounder, striped bass, snapper, etc.).

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

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

Since the last benchmark assessment, age-length data is available from the spring and fall NMFS surveys between 1984 and 2010. No data were available for 1997, so we created an average age key from

surrounding years. In 2008-2010 the survey age key was supplemented with commercial age samples. Overall, 8,262 ages were used to develop age-length keys, with an average of 107 and 124 ages in spring and fall, respectively, prior to 2008. The addition of the commercial samples in 2008-2010, increased the average to 668 and 315 ages for spring and fall, respectively. These age keys were applied to all indices and fishery lengths. Missing ages were interpolated with information from surrounding years.

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

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

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

State Surveys:

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

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

The Maryland Dept. of Natural Resources conducts surveys from April through October in

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

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

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

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

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

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

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

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

#### NMFS surveys

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

The NEFSC spring bottom trawl survey is conducted between Nova Scotia and North Carolina, beginning in 1968. The indices (stratified mean number per tow) for black sea bass were developed using offshore strata containing at least one positive tow in the time series. In addition, the NEFSC autumn bottom trawl survey, which included inshore strata prior to 2009, is dominated by age 0 sea bass. Consequently that survey was included as a young of year index of abundance. Previous assessments using the NMFS data considered a log transformation of catch per tow to reduce the influence of high catches. The WG reconsidered the use of the transformation and concluded that it was unnecessary. The survey is designed to account for variation and the transformation can violate the underlying assumption of the designed survey (T. Miller, NEFSC, pers. comm.). Therefore the indices in the NMFS surveys were the arithmetic mean number or mean weight per tow. In 2008 the NMFS acquired a new ship, the FSV *Henry B. Bigelow*, to conduct the survey. Field work was done to develop calibration factors to convert *Bigelow* indices into equivalent FRV *Albatross IV* units. Previous assessments used a constant value of 3.41 across all sizes, however new model results allow calibration by length categories (Figure B53). The length calibration factors in sea bass produced a bi-modal sequence of values described by a polynomial equation. The working group considered the calibration results and concluded that the tails of the distribution with few samples (Figure B54) was not appropriate for calibration (small calibration values had large influence on small indices). Therefore the calibration factor was held constant for lengths beyond 40 cm. The factor for the smallest fish sizes, less than 5 cm, was also held constant at 1.0, which

implies no difference in catchability between the ships. The calibration at length was applied to the NEFSC spring and fall survey data series.

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

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

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

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

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

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

shown in Figure B61 and Table B20.

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

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

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

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

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

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

the rest of the stock which should be explored with additional analysis.

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

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

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

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

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

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

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

Updated age information has not been available for recent black sea bass assessments,



consequently the working model has been SCALE, a statistical catch at length model (NDPSWG 2008). An update to the assessment was completed in June 2011 and provided to managers for quota setting in 2012 (Figure B65). That update followed the previous approach which incorporated NEFSC log<sub>e</sub> transformed indices from the winter and spring surveys and assumed a recreational discard mortality of 25%. The resulting estimate of  $F_{2010}$  equaled 0.41, an increase from 2009 of 0.32 and the 2010 SSB equaled 13,926 MT (Figure B66).

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

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

The ASAP model was simplified and ultimately configured with catch beginning in 1968 and one fleet. Natural mortality was based on a Lorenzen curve for  $M$  at age, scaled to a constant of 0.4. Maturity was constant within the time series and equaled the average maturity at age from the survey results. Catch weights at age were estimated from 1984 to 2010 using expanded length frequencies of the catch. In several years, the weights at age for ages 6 or 7+ decreased due to limited sample sizes. This was not considered biologically feasible, therefore those values were replaced with calculated weights at age using the relation between weight and age from earlier ages within the same year. Weights at age prior to 1984 were based on the average of the last three years (1984-1986) (Table B18). Black sea bass spawning stock weights (Table B23) for ages 1 to 4 were set equal to NEFSC spring survey weights at age, as

recommended by SARC53 reviewers, while ages 5 to 7+ remained equal to catch weights. Age 0 weights were fixed at 0.001 kg but have no bearing on SSB calculation since percent mature is 0. Rivard weights were calculated for use as January 1 stock weights.

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

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

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

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

#### Base model results

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The 2010 estimate of average F from the ASAP model equaled 0.18 with corresponding SSB of 10,843 MT. Comparison of the 2010 ASAP results to the BRPs generated from the stochastic YPR show that the stock is not overfished or experiencing overfishing (Figure B107, Table B28). The 90% confidence bound of the median  $F_{2010}$  (0.171) remains below the 10% confidence bound of  $F_{MSY}$  (0.230). The 2010 F is 62% of  $F_{MSY}$ . The same conclusion is reached in comparison with the deterministic BRP

estimate. Alternative stochastic and deterministic BRPs were calculated using a constant  $M=0.4$ . The deterministic  $F_{40\%} = 0.292$ , while the median value in the stochastic model equaled 0.316. In either case the comparison with average  $F_{2010}$  (0.17 with  $M=0.4$ ) shows that the stock is not experiencing overfishing.

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

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

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

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

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

Four scenarios were evaluated; 2006-2010 recruits w/variable  $M$ , 2006-2010 recruits with constant  $M$ , 1984-2010 recruits w/variable  $M$  and 1984-2010 recruits w/constant  $M$ . The median  $SSB$  projections using the 1984-2010 series declined over the five years from 11,160 MT to 8,550 MT (variable  $M$ ) or 11,177 MT to 7,651 MT (constant  $M$ ), and in both case declined below the median of  $SSB_{MSY}$ . In projections using the shorter recruitment time series,  $SSB$  also declined below the median  $SSB_{MSY}$  by 2015 using either variable  $M$  or constant  $M$ . In all cases, the projected 2012 catch would

exceed the current 2011 quota of 2,041 MT (Table B33). The 2012 OFL using the recent recruitment scenario and variable M would equal 3,093 MT. Comparable values for constant M equaled 3,444 MT; with long-term recruitment estimate and variable M, OFL in 2012 = 3,103 MT and similarly with constant M = 3,451 MT.

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

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

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

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

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

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

Like most members of the family Serranidae, black sea bass are protogynous hermaphrodites. Generally speaking, black sea bass are relatively short-lived, highly fecund, and mature relatively early. These life history characteristics could make black sea bass inherently resilient to fishing pressure. However, the vulnerability of the stock to fishing pressure while aggregated on structured habitat in



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

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

NDPSWG Panel Recommendations:

- a) On-going ageing studies should be continued to provide a foundation for an age-based assessment.
  - Aging has been completed for 1984-2010 survey data and 2008-2010 commercial.
- b) A pot survey for black sea bass should be considered.
  - A pilot project is ongoing and proposals are being considered for funding to expand the program throughout the range of the management unit (MA-NC).
- c) At-sea samples need to be taken to improve understanding of the timing of sex change over years in order to study the potential influence of population size on sex switching. This may have implications of overfishing BRPs.
  - Work is being conducted at NEFSC and UMass-Dartmouth on the northern stock and UNC-Wilmington on the South Atlantic stock.
- d) Ageing validation studies should be undertaken to examine the implications of sex change as well as temperature and salinity changes associated with movement onshore and offshore on ageing reliability.
  - The issue will be discussed at a future workshop. Also see literature from SEDAR 2011 BSB assessment. ([http://www.sefsc.noaa.gov/sedar/Sedar\\_Workshops.jsp?WorkshopNum=25](http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=25)).
- e) Meta-analysis of patterns of natural mortality in protogynous fishes should be undertaken.

- This recommendation is not yet addressed. It is to be discussed at a future workshop on modeling hermaphroditic species.
- f) Exploration of management approaches used on species with protogynous life histories would be helpful.
  - This is addressed in Brooks et al. (2008) as well as Heppel et al. (2006).
- g) Research is needed to understand the implication of the removal of large males on population dynamics. These could be field studies or large scale mesocosm experiments. This could involve collaboration with industry and recreational sectors.
  - This has not been addressed.
- h) Efforts to quantify discard mortality are needed.
  - This work is still needed and has not been addressed.
- i) Exploration of model behavior, including retrospective analysis, is required.
  - This exploratory work was conducted in this assessment.
- j) Non-compliance may be an alternate explanation for high assumed rates of natural mortality. It would be useful to estimate whether or not there are sufficient amounts of non-reported catch to account of the assumed high rates of M.
  - This has not been addressed.
- k) The sensitivity of the SCALE model results to alternative data weightings should be explored.
- The assessment model advanced to a statistical catch at age model and alternative model settings were explored.

#### New WG research recommendations.

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

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