FINAL REPORT
Northeast Fisheries Science Center

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PROJECT SUMMARY

This project is designed to be a fishery independent black sea bass survey of hard bottom sites in Southern New England (SNE) and Mid-Atlantic waters. Black sea bass were collected from four general zones along the coast utilizing black sea bass pots (43½" long, 23" wide, and 16" high) made with 1½ x 1½ inch coated wire mesh, single mesh entry head, and single mesh inverted parlor nozzle. Pots were unvented and therefore have the capability to retain all size classes of black sea bass. The four general zones will include one in Massachusetts, one south of Rhode Island, one south of New Jersey, and one south of Virginia (Figures 1-5). In each of these general zones, four individual sampling sites were selected, each of which is one square mile in size. For example, there were four sampling sites in Massachusetts waters, each of which was approximately 1 square mile in size. Each of the individual sampling sites was separated by at least four miles in order to provide adequate spatial coverage. This sampling design dispersed the sampling effort over a larger area, since it is not cost effective to sample along the entire coast at this time.

The sampling protocol required that a commercial vessel take 30 pots (3 ten pot trawls) to each of the randomly selected hard bottom sampling sites. This procedure continued each month during the sampling season for five months. Sampling was conducted between April and August in VA, in New Jersey from May to August, and from May to September in MA and RI. Four stations were sampled monthly in VA, but monthly sampling intensity was more variable in the other zones.

Pots were un-baited and allowed to remain in place for a minimum of four days. The date, area, depth, set over days, and catch was recorded and fish measured utilizing the standard NMFS sea sampling protocols. Each black sea bass was measured to the nearest cm (excluding the tendril), and the total catch of black sea bass at each size class was recorded for each unvented pot. The data were aggregated by zone, station and month to allow for analysis.

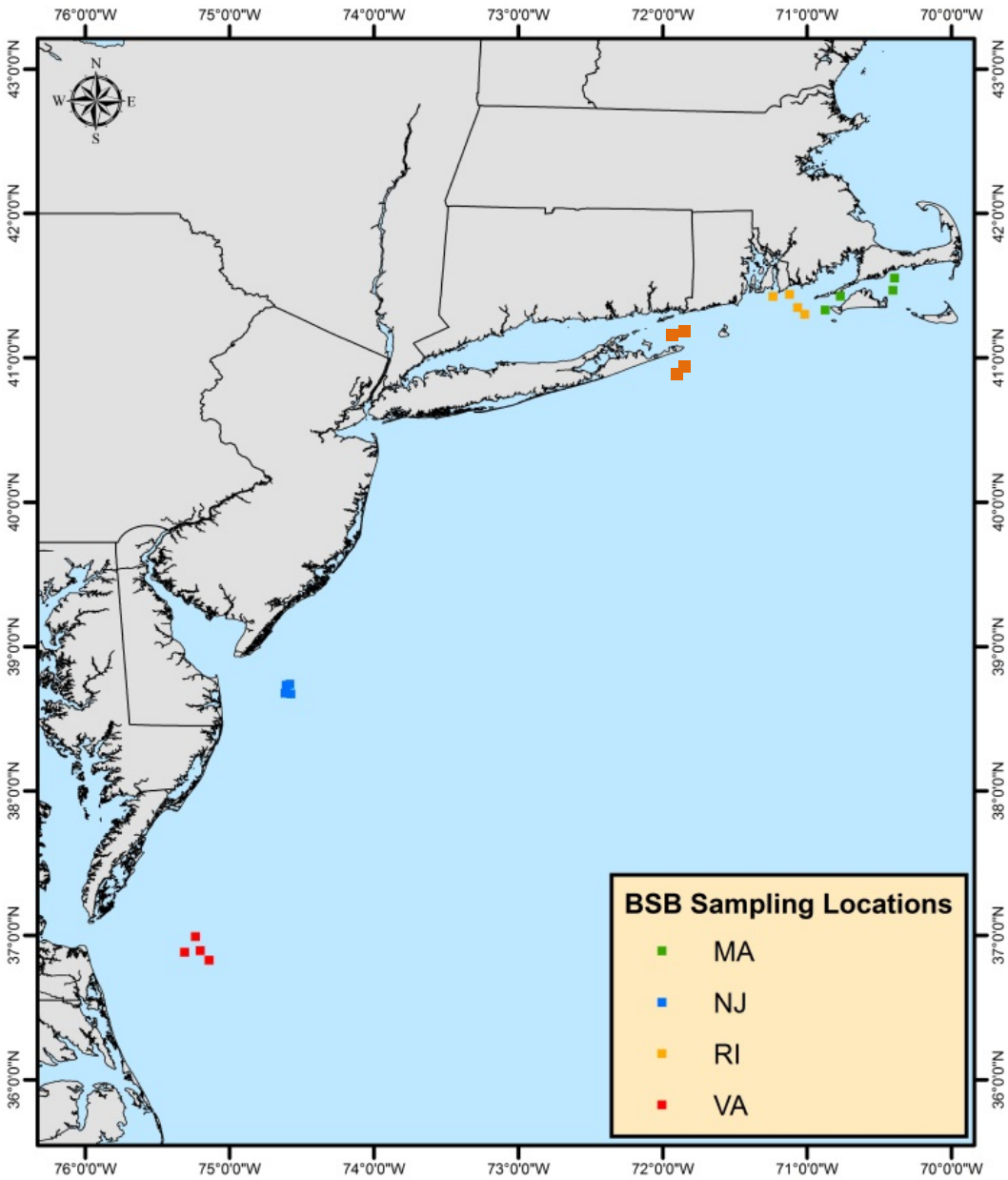

Figure 1. Map showing all 20 sampling sites, 4 in each location: Virginia, New Jersey, New York, Rhode Island, and Massachusetts.

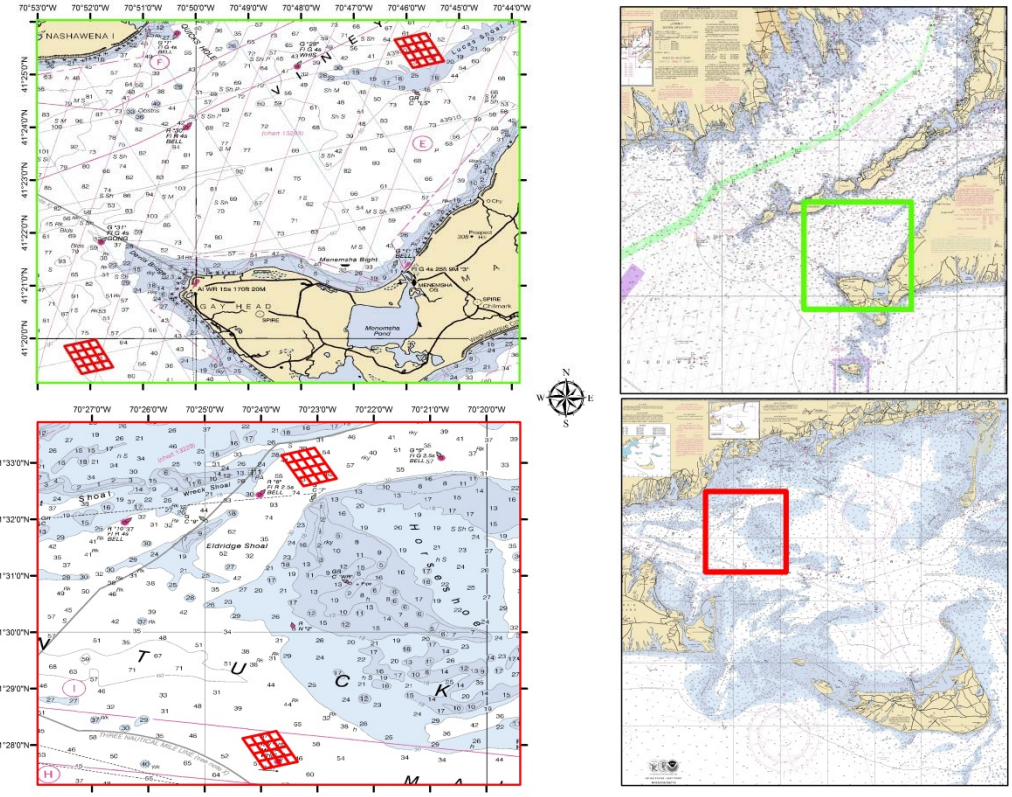

Figure 2. Four sampling sites in Massachusetts showing 16 sub-blocks in each site.

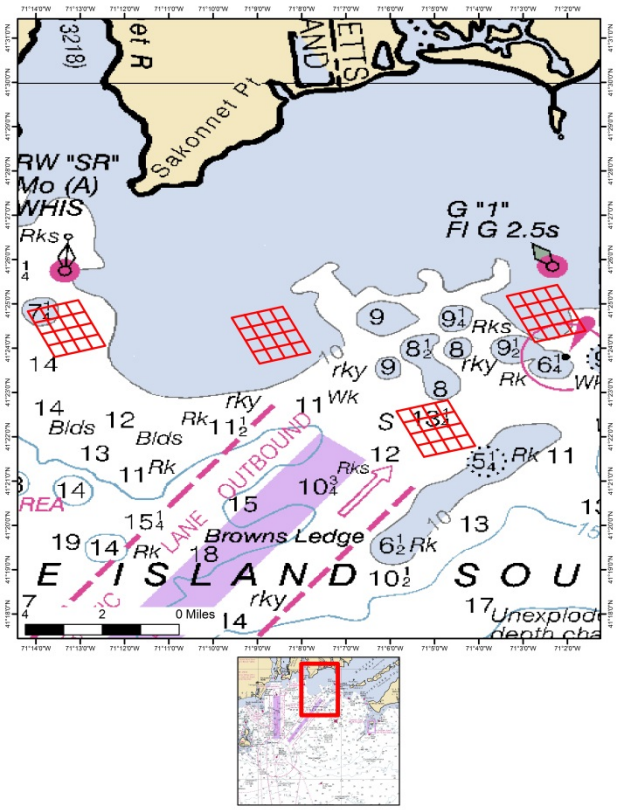

Figure 3. Four sampling sites in Rhode Island showing 16 sub-blocks in each site.

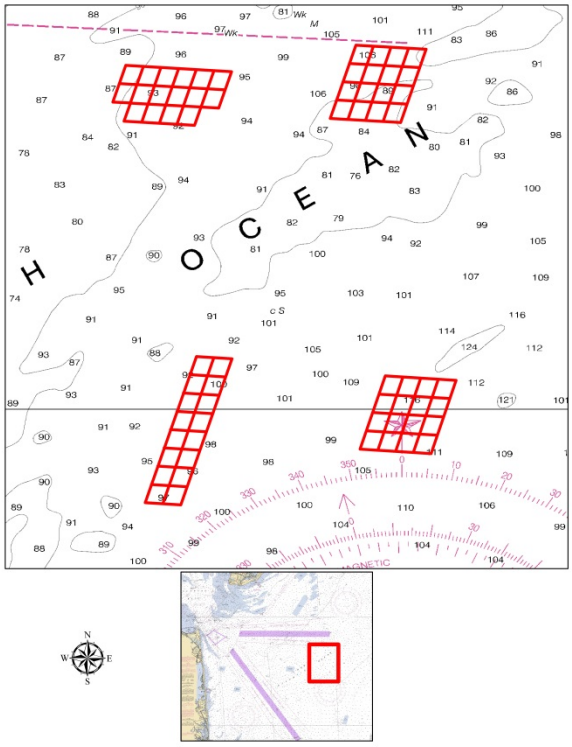

Figure 4. Four sampling sites in New Jersey showing 16 sub-blocks in each site.

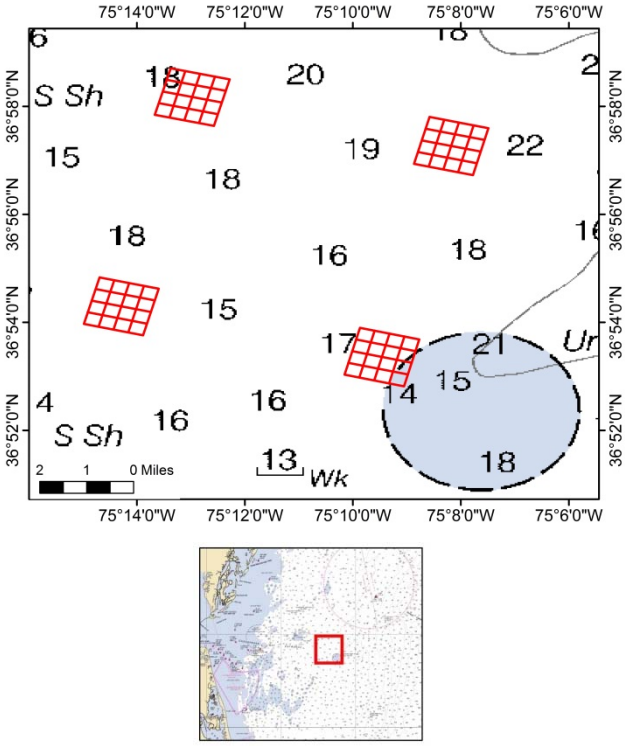

Figure 5. Four sampling sites in Virginia showing 16 sub-blocks in each site.

A total of 45,469 black sea bass were captured and measured. In the Mid-Atlantic (NJ, VA) a total of 18,328 black sea bass were measured (10591 in Virginia waters and 7737 in New Jersey waters) (Figure 6). Mean size was 25.0 cm. A total of 27141 black sea bass were measured in the Southern New England (SNE) sites. New York was included in the SNE data because the length frequency distribution matched more appropriately with RI and MA. A total of 7145 were measured in New York, 8332 in Rhode Island, and 11664 in Massachusetts. Mean size in New England was larger than in the Mid-Atlantic at 29.4 cm.

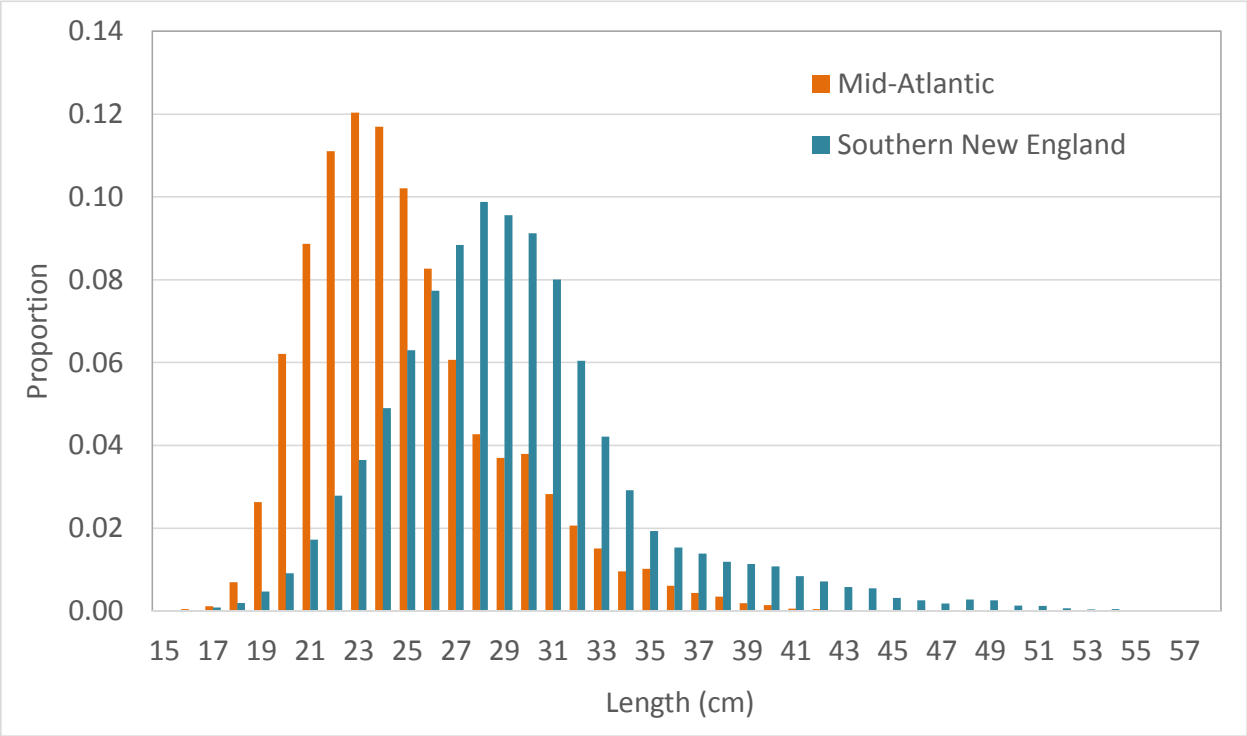

Figure 6. Length frequency distribution of black sea bass in the Mid-Atlantic and New England sites.

Data analysis was conducted by Greg DeCelles and Dr. Steve Cadrin from the University of Massachusetts, School for Marine Science & Technology. Catch data and length frequency distribution were compared between areas as well as between other surveys. This final report is based almost entirely on their analysis which is included below.

Mid-Atlantic Research Set-Aside (RSA) Report

Industry Based Survey on Black Sea Bass Utilizing Ventless Traps

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Background

Black sea bass (*Centropristis striata)* are a warm-temperate species that occurs along the entire US Atlantic coast from the Gulf of Mexico to the Gulf of Maine (Steimle et al. 1998; Shepherd 2000). Three stocks have been recognized; Gulf of Mexico, south Atlantic Bight, and the mid-Atlantic Bight (Roy et al. 2012). The mid-Atlantic stock is considered art of a single fishery management unit that includes that coastal waters north of Cape Hatteras, and this stock is the focus of the ventless trap survey. Black sea bass are generally found associated with structured bottom habitats such as reefs, oyster beds, and wrecks (Steimle et al. 1998; Shepherd 2000). Their affinity to these hard-bottom habitats makes this species difficult to survey using trawl gear. Black sea bass are managed by the Mid-Atlantic Fishery Management Council (MAFMC) and Atlantic State Marine Fisheries Commission (ASMFC) under the Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan (FMP).

The distribution of black sea bass in the mid-Atlantic Bight changes seasonally depending on location. Black sea bass in the northern end of the range, between New York and Massachusetts, travel offshore, cross the continental shelf, then head south following the edge of the shelf with most returning north by May (Moser and Shepherd, 2009). Along the Mid-Atlantic coast from New Jersey to Maryland, black sea bass move offshore during late autumn to the shelf edge and travel in a southeasterly direction returning in spring to their origin of location. In the southern end of this stock, from Virginia to North Carolina, fish undergo an offshore migration in late autumn/early winter. The timing of these migrations is mediated, at least in part, by changes in water temperature and perhaps photoperiod (Moser and Shepherd, 2009, Fabrizio et al., 2013). When black sea bass are abundant nearshore during the summer months they are typically targeted by commercial fishermen using fish pots, which can be baited or unbaited. In the winter when the black sea bass move offshore, they are primarily caught in the trawl fishery targeting summer flounder, scup, and Loligo squid (Shepherd and Terceiro 1994).

The Statistical Catch at Length (SCALE) stock assessment model for black sea bass was developed by the Data Poor Working Group meeting in December 2008 (NEFSC 2009) and was updated in 2011 (NEFSC 2011). At the 2011 stock assessment, a statistical catch at age model (ASAP) was presented, but the results of the ASAP model were rejected by the peer-review panel. The assessment indicated that the sea bass stock was not overfished and that overfishing was not occurring. However, the SCALE assessment model had substantial uncertainty and the peer review panel concluded that "a pot survey for black sea bass should be considered" (NEFSC 2011). Fabrizio et al., (2013) noted that in order to derive an index of relative abundance for black sea bass during the summer months when the fish are distributed inshore, the sampling gear must be capable of capturing sea bass in structurally complex habitats, and recommended using fish traps or visual surveys.

An industry-based, fishery independent survey of black sea bass was initiated in 2012 to develop a new index of abundance, and to collect additional information on the biological characteristics of black sea bass. The survey was conducted between Virginia and Massachusetts, covering nearly the entire geographic range of the mid-Atlantic Bight stock. Unvented fish pots were deployed on hard-bottom substrates, which are not currently well sampled by fishery independent trawl surveys.

Methods

Survey Coverage

Five geographic zones (MA, RI, NJ, NY, and VA) were sampled during the 2014 ventless trap survey, and six commercial fishing vessels served as our industry partners during the research. The NY zone was added to the sampling plan in 2014 to improve the geographic coverage of the survey. Four stations were sampled in each zone, and each sampling station had an area of 1nm^2. The four stations within each zone were spaced at least four miles apart, to achieve an adequate distribution of sampling coverage within each zone. Sampling in 2014 was conducted monthly between April and September in the VA survey zone, and from May through September in all other zones (Table 1). Four stations were sampled each month in NY and RI, but the monthly sampling intensity was more variable in the other zones due to weather conditions and logistical issues (Table 1). At each station, 30 unbaited ventless fish traps were deployed at a random location, and each trap was fished for a minimum of four days. The ventless traps were deployed in a series of trawls, with three trawls set at each station, and each trawl containing ten traps (for a total of 30 traps per station). The ventless traps were constructed with 1.5" coated wire mesh, and each trap measured 43.5" long, 23" wide, and 16" high. After the traps were retrieved, each black sea bass was measured to the nearest cm (excluding the tendril), and the total catch of black sea bass at each size class was recorded for each trap. The data were aggregated by trawl, zone, station and month to allow for analysis.

Analysis of Catch Rates

Exploratory analyses were used to investigate patterns of variation in the catch data. Catch data from the 2014 black sea bass unvented pot survey was examined using a Nested Analysis of Variance (ANOVA). The Nested ANOVA was used for two tests. First, we tested for significant differences in catch rates (sea bass/trawl) among the five survey zones (MA, RI, NJ, NY and VA). Secondly, we tested for significant differences in catch rates among the four stations within each survey zone. The catch data were grouped by study area, month, station and trawl to perform the Nested ANOVA analysis. A Two-Way Analysis of Variance was performed to test for significant differences in catch rates among survey zones, among the different months that were sampled during the course of the survey, and to examine whether there was a significant interaction between sampling location and time in the survey.

GT2 tests (Sokal and Rohlf, 2001) were used to test for significant differences in sea bass catches (number of sea bass/trawl) between the ten pairs of survey zones that were sampled. The GT2 test is a slight modification of the Tukey's Honestly Significant Difference method, and the GT2 test allows for unequal sample sizes between treatment groups (Sokal and Rohlf, 2001).

Analysis of Length Frequency Data

A single factor ANOVA was used to test for significant differences in the mean length of black sea bass among the five survey zones that were sampled in 2014. GT2 tests were used to test for significant differences in the mean length of black sea bass sampled between the ten pairs of survey zones.

A Kolmogorov-Smirnov two sample ($\alpha = 0.05$) test was used to test for significant differences in the length frequency distributions of black sea bass sampled in the five zones during the ventless trap survey. The Kolmogorov-Smirnov test is highly sensitive to differences, and samples are clustered in space and time. So, using the number of observed fish to approximate the sample size may overestimate the number of independent observations. Therefore, we used the proportional length frequency distributions that were observed in each zone, assuming a sample size of 60. The assumed sample size of 60 was chosen to reflect the number of trawls that were sampled in four of the five of the survey zones in 2014 (Table 1).

Size distributions from the ventless trap survey were compared to other sources of information to examine what demographic portion of the population is being sampled by the ventless trap survey. Kolmogorov-Smirnov tests were used to test whether the length frequency distribution of black sea bass observed in the ventless trap survey differed significantly from the length frequency distributions of black sea bass that were observed in other fisheries-independent surveys:

- 2014 Massachusetts Division of Marine Fisheries (MADMF) spring trawl survey
- 2014 Northeast Fisheries Science Center (NEFSC) spring trawl survey
- 2014 North East Area Assessment and Monitoring Program (NEAMAP) spring and fall trawl surveys
- 2014 Rhode Island Department of Environmental Management (RIDEM) spring and fall trawl surveys
- 2014 New Jersey Department of Environmental Protection (NJDEP) trawl survey in April, June, August and October

The length frequency distribution data from the NEFSC and MADMF spring trawl surveys were provided to SMAST as the mean number of black sea bass per tow at each length category. The length frequency distribution data from the NEAMAP spring and fall trawl surveys and the NJDEP and RIDEM trawl surveys were provided to SMAST as the total number of black sea bass observed at each length category. The proportional length frequency distributions were examined, because sample sizes differed substantially between the different indices, and the number of observed fish overestimates the number of independent observations of the cluster samples. Therefore, the number of black sea bass in each size class was approximated for the survey indices by multiplying the proportion of sea bass in each size class by 100 to reflect the number of stations that are typically sampled during the MADMF spring survey.

The proportional length frequency distribution of black sea bass sampled in all five zones of the ventless trap survey during the spring (defined as April and May for the VA zone, and May for all other zones) was compared to the length frequency distribution of black sea bass captured during the 2014 NEFSC spring bottom trawl survey, and the 2014 NEAMAP spring bottom trawl survey. Similarly, the proportional length frequency distribution of black sea bass sampled in all five zones of the ventless trap survey during the fall (defined as September) was compared to the length frequency distribution of black sea bass captured during the 2014 NEAMAP fall bottom trawl survey. In addition, the proportional length frequency distribution of black sea bass captured in the MA zone during the ventless trap survey in the spring (May) was compared to the length frequency distribution observed during the 2014 spring MADMF bottom trawl survey. The proportional length frequency distribution of black sea bass observed in the RI zone (May-September) was compared to the length frequency distribution of black sea bass captured during the 2014 RIDEM spring and fall bottom trawl surveys. Finally, the proportional length frequency distribution of black sea bass observed in the NJ zone of the ventless trap survey (May–September) was compared to the 2014 NJDEP trawl survey.

The length frequency distributions of black sea bass that were measured by scientific samplers on board recreational party vessels in the Massachusetts, Rhode Island, New York, and New Jersey recreational fisheries (waves 2-5) was obtained through the NOAA Marine Resource Information Program website

(http://www.st.nmfs.noaa.gov/st1/recreational/MRIP_Survey_Data/CSV/). Length frequency data was also obtained for the recreational fishery in Virginia, but the low sample size (n=22) precluded further analysis. The at-sea samplers measured both kept and discarded black sea bass that were captured on the party vessels, so the length frequency data is assumed to be representative of the catches of the recreational fleet (David Martins, Massachusetts Division of Marine Fisheries, personal communication).

The length frequency distribution observed in the party boat recreational fisheries of Massachusetts, Rhode Island, New York, and New Jersey were compared to the length distribution of black sea bass from the ventless trap survey in that state. Kolmogorov-Smirnov two-sample tests were used to test for significant differences in the proportional length frequency distribution of black sea bass captured in the recreational fishery and the ventless trap survey in that zone. The sample size in the recreational fishery differed between the four states, and far fewer fish were sampled in the recreational fishery than in the ventless trap survey. Therefore, the proportion of sea bass at each length was calculated for each index, and the proportion at each length was multiplied by 100 to complete the Kolmogorov-Smirnov test.

Estimation of Total Mortality

The growth rates of black sea bass were described using a von Bertalanffy growth equation during (NEFSC, 2011) with the following form:

$$L_t = L_\infty(1 - e^{-k(t-to)})$$

where L_t is the length of the individual at time t, L_∞ is the asymptotic length at which growth equals zero, k is the asymptotic growth rate, and t_0 is the length of the fish at age 0. Von Bertalanffy growth parameters were estimated independently for black sea bass north and south of Hudson Canyon at the stock assessment workshop, and combined parameters were estimated for the black sea bass stock between Cape Hatteras and Massachusetts (NEFSC, 2011).

The Beverton and Holt (1956) length based mortality model was applied to the data collected from the ventless trap survey to derive total mortality estimates. Mortality estimates were calculated independently for each survey zone. We also estimated mortality rates for the three northernmost (NY, RI and MA combined) and the two southernmost survey zones (VA and NH combined). In these regional analyses, the von Bertalanffy parameters estimated for black sea bass north of Hudson Canyon were applied to sea bass sampled in the MA, RI, and NY zones, and the von Bertalanffy parameters estimated for black sea bass south of Hudson Canyon were applied to sea bass sampled in the VA and NJ zones. Finally, stock wide mortality rates were estimated using the aggregated length frequency distribution observed at all five survey zones in 2014, and the stock-wide von Bertalanffy growth parameters that were derived in 2011 (NEFSC, 2011).

$$Z = \frac{k(L_\infty - \bar{L})}{(\bar{L} - L_c)}$$

where Z is the total mortality rate, L_c is the smallest length at which individuals are fully selected to the fishery and $\bar{L}$ is the mean of fish in the sample > L_c. Because the mortality estimates are sensitive to the assumption of L_c, a range of values for L_c between 28 and 32cm were explored. This range was chosen after an examination of the commercial and recreation length frequency data (NEFSC, 2011).

Erhardt and Ault (1992) found that the Beverton and Holt (1956) length based mortality model can be positively biased under certain conditions. Erhardt and Ault (1992) modified the Beverton and Holt model to be applicable to fisheries in which the largest individuals sampled in the catch (L_λ) are smaller than L_∞. Following the methods of Erhardt and Ault (1992), the following equation was used to iteratively solve for Z in each of the five survey zones:

$$\left[\frac{(L_\infty - L_\lambda)}{(L_\infty - L_c)}\right]^{Z/K} = \frac{Z(L_c - \bar{L}) + K(L_\infty - \bar{L})}{Z(L_\lambda - \bar{L}) + K(L_\infty - \bar{L})}$$

Where L_λ is the maximum length in the catch. We used the recreational length frequency data from MRIP (Figure 12) to inform our estimates of L_λ. L_λ was assumed to be 54 cm in VA, 52cm in NJ, 55cm in NY, 58cm in RI, and 60cm in MA. L_c was assumed to be 30cm in all five survey zones.

Combined (spring and fall) age-length keys were used to estimate the age composition of black sea bass using the length frequency distributions that were sampled in each survey zone in 2014 (April-September). Season specific age-length keys were used to estimate the age structure of sea bass that were sampled in each zone during the spring (April and May) and fall (September).

Total mortality rates (Z) were estimated for the 2014 ventless trap survey data using static catch curves. The static catch curves assume that the initial abundance of each cohort was the same. The catch curve method also assumes that each cohort experienced the same rate of mortality during its' lifetime. Visual analysis of the abundance at age indices suggested that age 1 sea bass were not fully selected to the ventless traps. Age 2 black sea bass appeared to be partially recruited to the survey gear in most seasons and survey zones, although age 2 sea bass represented the greatest catch per trawl in some zones. It most cases, using age 2 as the first age in the regression would have resulted in estimates of Z that were biased low by the partial selectivity of age 2 fish to the ventless traps. Therefore, age 3 was used as the starting age in the regressions for each zone and season. Z was calculated as the negative slope of the relationship between the abundance of sea bass (ln(abundance+1)) and age. Total mortality was estimated seasonally (spring and fall) in each zone by using the abundance at each age class estimated from

the spring and fall age-length keys. In addition, the average mortality was estimated by calculating the average abundance at each age that was observed in the spring and fall months.

Generalized Linear Models

Generalized Linear Models (GLMs) were used to better understand the distribution and abundance of black sea bass that were sampled in the ventless trap survey between 2012 and 2014. In general, the form of a GLM is shown in the equation below:

$$Y = B_0 + B_1x_1 + B_2x_2 + B_3x_3 + \ldots + B_kx_k$$

Where Y is the response variable, B_0 is the intercept term, and the B_i values are the regression coefficients for variables 1 through k that are computed from the survey data. Catch rates of black sea bass (number/trawl) were chosen as the response variable. A number of explanatory variables were available from the data collected during the survey. Ultimately five explanatory variables were considered during model development. The explanatory variables included in the models were: year, month, zone, station, and soak time (number of days the ventless trap was fished).

Explanatory factors influencing catch rates were identified using backward model selection. The full model was tested first, and explanatory terms were removed from the full model based on the results of an ANOVA that tested for significant differences in the deviance explained between the full and reduced models. Explanatory terms were removed from the model if they did not significantly improve the model fit. Initial models that were fit using Poisson and quasipoisson error structures had substantial problems with overdispersion. The problems with overdispersion were resolved using a Negative Binomial error structure and a log link function. A Generalized Additive Model (GAM) that treated soak time as a non-linear factor was also explored, but it did not improve the model fit.

Results

A total of 45,469 black sea bass were captured and measured during the 2014 ventless trap survey. The greatest catch rates (black sea bass/trawl) were observed in the MA survey zone, while the lowest catch rates were observed in the NY survey zone (Table 2, Figure 1). The results of the nested ANOVA indicated that catch rates (number of sea bass/trawl) differed significantly among the five geographic survey zones ($p<0.01$), but significant differences were not detected in catch rates among the stations within each survey zone ($p=0.11$; Figure 2).

The results of the GT2 test indicated significant differences in catch rates between four pairs of the ten pairs of survey zones that were examined (Table 3). Catch rates were significantly different between VA and RI, VA and NY, MA and NY, and MA and RI.

There was a strong seasonal component to the catch rates that were observed in each of the survey zones. The results of the Two-Way ANOVA indicated that catch rates differed significantly among zones ($p<0.01$), and among the different months that were sampled ($p<0.01$). A significant interaction was also detected between the survey location and month ($p<0.01$). In the VA survey zone the greatest mean sea bass catches were observed in May and June, and the same monthly trend in catch rates was also observed in 2013 (Figure 3). In the NJ survey zone, the lowest mean catches were observed in June and July, while catch rates were greater at the beginning and end of the survey. The greatest catch rates in the NY zone were observed in July and September. In the RI zone, catches generally declined over the course of the year, and the greatest mean catches were observed in May. In the MA survey zone catch rates were comparable between May, June, and July, and declined to lower levels in August and September.

Similar to last year's results, the length frequency distributions of black sea bass caught in the 2014 survey indicate that larger fish were more common in the northernmost survey areas (MA, RI, and NY), while smaller black sea bass were sampled more frequently in the southern range of the survey (NJ and VA) (Figures 4 and 5, and Tables 4 and Table 5). Results of the ANOVA indicated that the mean length of black sea bass varied significantly among the five survey zones ($p<0.001$). The results of the GT2 tests indicated that the mean length of black sea bass differed significantly between all ten pairs of survey zones that were tested (Table 6).

Results of the K-S test indicated that there were no significant differences in the length frequency distributions of black sea bass in the three northern (NY, RI, and MA) survey zones (Table 7). However, the length frequency distributions observed in the NJ and VA zones differed significantly from those observed in all other zones.

The results of the K-S test indicate that the length frequency of black sea bass observed during the ventless trap survey in April and May did not differ significantly ($p=0.11$) from the length frequency observed during the NEAMAP spring survey (Table 8, Figure 6). However, a significant difference in length frequency distributions was observed between the 2014 NEAMAP fall survey and the ventless trap survey in September (Table 8; Figure 6). In particular, the NEAMAP survey caught more sea bass at the smallest sizes, and the modal length in the NEAMAP survey (32cm) was greater than observed in the ventless trap survey (26cm). A comparison of the two indices suggests that the ventless traps have low selectivity for young-of-the-year black sea bass.

The K-S test results indicated that the length frequency distribution of sea bass differed significantly ($p<0.01$) between the NEFSC spring trawl survey and the ventless trap survey in April and May (Table 8; Figure 7). The model length observed in the NEFSC survey (29cm) was larger than the modal length in the ventless trap survey (24cm), and intermediate size sea bass (20-25cm) were more common in the ventless trap survey than in the NEFSC spring survey.

There was also a significant difference ($p<0.01$) in the length frequency distribution observed in the ventless traps in the MA zone in May, and those observed on the MADMF 2014 spring trawl survey (Table 8; Figure 8). The model lengths were similar in both surveys, but large (≥35cm) sea bass were captured more frequently in the MADMF spring trawl survey, while intermediate size sea bass were more common in the ventless trap survey.

The length frequency distributions of black sea bass differed significantly ($p=0.04$) between the ventless trap survey in the RI zone and the RIDEM trawl survey (Table 8; Figure 9). The modal lengths were substantially different between the two different indices. Small sea bass (<15cm) were observed in the RIDEM trawl survey, but not in the ventless traps. Intermediate size sea bass (20-25cm) were sampled in higher proportion in the ventless trap survey, while large sea bass (>25cm) were relatively more common in RIDEM trawl survey.

Finally, a significant difference was detected in the proportional length frequency distributions of black sea bass sampled in the NJ zone during the ventless trap survey and those observed in the 2014 New Jersey Department of Environmental Protection (NJDEP) trawl survey. Small sea bass (<15cm) were far more common in the NJDEP survey than in the ventless traps (Table 8; Figure 10). Large sea bass (≥ 35cm) were uncommon in both the trawl and ventless taps surveys in the NJ zone.

The length frequency distribution of black sea bass observed in the recreational fishery and the ventless trap survey were compared for four states (MA, RI, NY, and NJ) (Tables 9 and 10; Figures 11-13). The majority of the black sea bass sampled in the ventless traps were an intermediate size, while the recreational fisheries typically targeted and captured the largest individuals in the population. The K-S tests indicated significant differences ($p<0.01$) in the length frequency distribution of black sea bass in the recreational fishery and the ventless trap survey for all four states. In general, a higher proportion of large sea bass (≥30cm) were captured in the recreational fishery than in the ventless trap survey. Very large sea bass (≥40cm) were relatively common in the recreational fisheries of RI and MA, but sea bass ≥40cm were rarely observed in the recreational fishery in NJ (Figure 13). A similar trend that was observed in the ventless trap survey, where large sea bass were uncommon in the NJ zone.

The length frequency distributions of black sea bass in the recreational fishery and the ventless trap survey were truncated to include black sea bass ≥30cm. Using a K-S test, significant

differences ($p<0.01$) in the length frequency indices were found between the two indices, for all four survey zones. These results suggest that the ventless traps may not be fully selective for sampling the largest sea bass that are present in the population.

Estimation of Total Mortality

Estimates of total mortality that were derived independently for the five survey zones ranged from 0.82 to 2.32 using the Beverton and Holt (1956) length-based total mortality model (Table 11). Total mortality estimates from the northern zones (MA, RI) were substantially lower than those calculated for the two southern survey zones (VA and NJ; Table 11). A similar clinal gradient in mortality was estimated from 2013 survey data. Mortality estimates from the NY survey zone were of a similar magnitude to those observed in MA and RI. When the survey data were aggregated across all survey zones, the total mortality estimates ranged from 0.99 to 1.22, depending upon the value of L_c that is chosen. The most recent stock assessment for black sea bass (NEFSC, 2011), estimated that F=0.41, and assumed that M=0.4, which sum to produce a stock-wide estimate of total mortality (Z) = 0.81. Therefore, length-based total mortality estimates from the ventless trap survey were greater than those estimated in the assessment. Total mortality rates estimated using the Erhardt and Ault (1992) method were nearly identical to those derived using the Beverton and Holt (1956) method (Table 11).

Total mortality estimates were also calculated using static catch curves that were applied to the ventless trap survey catches in 2014 (Table 12; Figure 14). The stock-wide mortality estimate derived using a catch curve (1.28) was similar to the stock wide total mortality estimate from the Beverton Holt approach (Z = 1.17 assuming L_c = 30cm). However, when a catch curve is used instead of the Beverton Holt estimator, the regional differences in total mortality were less pronounced. Again, the total mortality estimates derived from the survey are greater than estimates from the most recent stock assessment (NEFSC, 2011).

Generalized Linear Model

A number of models were fit to the data, and model fits were compared using AIC. The most parsimonious model included four explanatory variables (year, zone, month, and soak time). The model results indicate that survey year (2012, 2013, or 2014) had a significant effect on black sea bass catch rates (Table 13). Catch rates in 2013 were significantly higher than catch rates in 2012, and catch rates in 2014 were slightly higher than catch rates in 2013. Over the three year period, catch rates were highest in the MA and NJ survey zones. The catch rates observed in MA were significantly greater than the catch rates observed in VA, RI, and NY. The highest catch rates were observed in May, and catch rates in May were significantly greater than in the other months that were surveyed. Finally, the model output suggested that catch rates increased linearly as a function of soak time.

Discussion

The results of the 2014 ventless trap survey suggest that there may be substantial variation in the productivity, abundance, and mortality of black sea bass throughout the range of the stock. Such differences in productivity should be accounted for in survey design and resource monitoring. Similar to the trends that were observed in 2012 and 2013, the size structure of black sea bass varied throughout the range of the stock in 2014. Sea bass in the northern range of the survey (MA, RI and NY), were larger on average, and reached greater maximum sizes, than sea bass sampled in the southern survey zones. The explanation for these size differences is not clear, but the smaller mean sizes observed in the VA and NJ survey zones could be due to increased mortality rates, a lack of suitable habitat in the survey area for the largest individuals, migration of large fish from the survey area, or some combination of these factors.

The size structure of sea bass captured in the ventless trap survey differed from the size structure observed in trawl surveys and the recreational fisheries. Some fishery independent surveys conducted in the fall (e.g., NEAMAP fall survey and the RIDEM fall survey) capture young-of-the-year sea bass, which are not commonly captured in the ventless trap survey. Thus, the ventless trap survey does not appear to be an appropriate index for monitoring the abundance of age-0 black sea bass. However, the ventless trap survey appears to be well-suited for monitoring the abundance and distribution of sea bass at intermediate sizes and ages, which may allow the ventless trap survey to serve as a useful index of recruitment into the recreational fishery. Proportionally, the ventless trap survey does not capture as many large (>40cm) sea bass as the recreational fisheries, or some trawl surveys (e.g., MADMF spring survey). Thus, there is some indication that the largest sea bass in the population may not be fully selected to the ventless traps that are used in the survey. These analyses demonstrate the importance of the fixed gear survey due to the differences in length distribution.

Due to the sampling design and the high catch rates of sea bass, the abundance indices derived from the ventless trap survey can be used to estimate spatially specific mortality rates for this stock. While there are a number of other fisheries independent surveys which provide relative abundance indices for black sea bass, none appear to be capable of providing spatially-specific estimates of mortality. Some of these trawl surveys (e.g., NEAMAP Fall survey and NJDEP trawl surveys) catch sea bass across all size (and age) classes, and appear to provide the information needed to understand the size structure of the resource. However, a closer examination of these indices as described in the most recent stock assessment (NEFSC, 2011; Figures B27-B57) suggest that the catch rates of black sea bass in these surveys are typically relatively low (mean catch < 5 individuals/tow). Further, an examination of the survey catch at age distributions from these indices suggests that none of the trawl survey indices appear to be capable of reliably tracking cohorts over time. The time series associated with the ventless trap

survey is currently too short to track sea bass cohorts. However, the high catch rates and age distributions observed to date suggest that this index would likely be capable of tracking cohorts if the survey were continued into the future. Such data could be very informative for the stock assessment for black sea bass.

The estimates of total mortality derived from the ventless trap survey suggest that mortality rates are currently higher than those estimated during the most recent stock assessment. The 2011 stock assessment assumed that the natural mortality rate (M) = 0.4, although there was some uncertainty surrounding the magnitude of M (NEFSC, 2011). The results of the SCALE model estimated that the fishing mortality rate (F) in 2011 was 0.41 (NEFSC, 2011). The stock wide estimates of total mortality estimated using the Beverton and Holt (1956) length based approach (Z = 1.17), and estimated using static catch curves (Z = 1.28), were relatively consistent, and much greater than indicated in the most recent assessment. Further, our analyses suggest that mortality rates vary throughout the range of the stock, as greater mortality rates were observed in the southern survey zones (Tables 11 and 12; Figure 14), indicating that fishing pressure, natural mortality, or both factors vary across the range of the stock. Nearly identical estimates of total mortality were obtained using the Beverton and Holt (1956) and the Ehrhardt and Ault (1992) methods, suggesting that the mortality estimates obtained using the Beverton and Holt method were not positively biased due to short exploitable life spans in the black sea bass population.

Assumptions of the relatively simple Beverton Holt mortality estimator and the static catch curves should be considered in interpretations and comparisons to stock assessment models. Both approaches assume equilibrium recruitment (i.e., all year classes in the sample had the same initial abundance) and constant mortality (i.e., all fish larger than L_c experience the same mortality rate). The regional estimates of Z also assume closed populations. Therefore, estimates of Z may be biased from movement of sea bass among regions (e.g., the high estimates of Z in NJ may be result from some emigration of sea bass).

The Beverton and Holt (1956) length based total mortality model is also sensitive to the parameters that are chosen to represent the growth of the population, and any errors in the von Bertalanffy growth parameters may result in inaccurate estimates of total mortality. The von Bertalanffy growth parameters from the most recent stock assessment assume that black sea bass in the southern portion of the stock grow faster and attain a larger L_∞ than black sea bass in the northern range of the stock, but the data available from the ventless trap survey suggests that L_∞ may be greater in RI and MA. Therefore, we suggest that it may be worthwhile to revise the growth parameters for black sea bass in the future.

A number of studies have shown that black sea bass aggregate in areas where the bottom is structurally complex, and where hard-bottom structures like rock outcroppings and wrecks are present (Steimle and Zetlin, 2000; Fabrizio et al., 2013). To date, the structure and rugosity of

the habitats that are sampled in each zone of the ventless trap survey has not been evaluated. Quantifying the habitat characteristics at each survey station may help to interpret the patterns of abundance and size structure that have been observed in the ventless trap survey. The use of underwater video cameras or side-scan sonar may be informative for describing and quantifying the habitat characteristics at each site. Obtaining such data may also allow habitat rugosity to be used as an explanatory variable in the Generalized Linear Modeling approach.

We expect that the continuation of the time-series for this survey will increase the utility of this data set for future use in the stock assessment for black sea bass. In particular, extending the length of the time series will enable cohort tracking, and will allow us to determine if the regional differences in mortality persist into the future.

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Gary Shepherd provided many helpful comments and suggestions during the data analysis, and his insights were valuable to this report. Gary also supplied us with the age-length keys needed to perform the catch curve analysis. A number of people supplied the data that was needed to facilitate this analysis. David Martins assisted with gathering recreational catch data from the MRIP website. Jeremy King provided data from the Massachusetts Division of Marine Fisheries bottom trawl survey. NEAMAP trawl survey data was provided by Chris Bonzek. Data from the NEFSC spring bottom trawl survey was supplied by Gary Shepherd. Linda Barry provided data from the New Jersey Department of Environmental Protection bottom trawl survey. Jason McNamee provided data from the Rhode Island Department of Environmental Management bottom trawl survey.

References

Beverton, R.J.H., and Holt, S.J. 1956. A review of methods for estimating mortality rates in exploited fish populations, with special reference to sources of bias in catch sampling. Rapports et Proces-Verbaux des Reunions, Conseil International pour l'Exploration de la Mer. 140: 67-83.

Drohan, A.F., Manderson, J.P., and Packer, D.B. 2007. Black sea bass, *Centropristis striata*, life history and habitat characteristics. Second Edition. NOAA Tech. Memo. NMFS-NE-200.

Ehrhardt, N.M., and Ault, J.S. 1992. Analysis of two length-based mortality models applied to bounded length frequencies. Transactions of the American Fisheries Society. 121: 115-122.

Fabrizio, M.C., Manderson, J.P., and Pessutti, J.P. 2013. Habitat associations and dispersal of black sea bass from a mid-Atlantic reef. Marine Ecology Progress Series, 482: 241-253.

Moser, J., and Shepherd, G.R. 2009. Seasonal distribution and movement of black sea bass (Centropristis striata) in the Northwest Atlantic as determined from a mark-recapture experiment. Journal of Northwest Atlantic Fisheries Science. 40: 17-28.

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

Northeast Fisheries Science Center (NEFSC) 2011. 53rd Northeast Regional Stock Assessment Workshop (53rd SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 12-05; 559 p.

Roy, E.M., Quattro, J.M., and Greig, T.W. 2012. Genetic management of black sea bass: influence of biogeographic barriers on population structure. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 4(1): 391-402.

Shepherd, G. 2000. Black Sea Bass. In S. H. Clark, editor. Status of Fishery Resources off the Northeastern United States for 1998. NOAA Tech. Memo. NMFS-NE-115, on-line version, http://www.nefsc.nmfs.gov/sos/spsyn/og/seabass/html.

Shepherd, G. R., and M. Tercerio. 1994. The summer flounder, scup, and black sea bass fishery of the Middle Atlantic Bight and southern New England waters. NOAA Tech. Rep. NMFS, No. 122, 18 p. http://spo.nwr.noaa.gov/tr122.pdf

Sokal, R.R., and Rohlf, F.J. 2001. Biometry. Third Edition. W.H. Freeman and Company, USA. 850 p.

Steimle, F., C. Zetlin, P. Berrien, D. Johnson, S. Chang, and the EFH Information Team. 1998. FMP EFH Source Document: Black Sea Bass, *Centroprista striata* (Linnaeus), Life History and Habitat Use in the Mid-Atlantic Bight. USDC, NMFS, Highlands, NJ.

Steimle, F.W., and Zetlin, C. 2000. Reef habitats in the middle Atlatic Bight: abundance, distribution, associated biological communities, and fishery resource use. Marine Fisheries Reviews 62: 24-42.

Tables

Table 1. Summary of monthly sampling intensity (number of trawls fished) at each survey zone during the 2014 ventless trap survey for black sea bass. Ten ventless traps were deployed in each trawl, and three trawls were fished at each station. *Twelve trawls were deployed in the MA zone in July, but one of the trawls was cut and several of the traps were not recovered, so the data from this trawl were omitted from the analysis.

Survey Zone	April	May	June	July	Aug.	Sept.	Total
VA	6	18	12	12	6	6	60
NJ		12	12	12	6	3	45
NY		12	12	12	12	12	60
RI		12	12	12	12	12	60
MA		6	15	11*	12	15	59
Total	6	60	63	59	48	48	**284**

Table 2. Summary of black sea bass catches (black sea bass/trawl) at each of the five zones that were sampled during the 2014 ventless trap survey.

Zone	Stations Sampled	Number of black sea bass	mean catch/trawl	standard error	median catch/trawl	min. catch	max. catch
VA	60	10591	176.5	18.9	128	8	572
NJ	45	7737	171.9	14.2	179	22	394
NY	60	7145	119.1	7.1	104	41	295
RI	60	8332	138.9	10.3	128.5	12	323
MA	59	11664	197.7	12.8	195	13	499

Table 3. Results of the GT2 test that was used to investigate whether the catch rates of sea bass varied significantly between survey zones. The differences in mean catch rates (black sea bass/trawl) between survey zones are shown, and significant results are denoted with an *.

	VA	NJ	NY	RI
VA	-	-	-	-
NJ	4.58	-	-	-
NY	57.43*	52.85	-	-
RI	37.65*	33.07	19.78	-
MA	18.73	23.32	76.17*	56.38*

Table 4. Observed length frequency distribution of black sea bass from the 2014 ventless trap survey, and the aggregated length frequency distribution across all five survey zones.

Length	VA	NJ	NY	RI	MA	Total
15	0	1	1	0	0	2
16	0	8	3	0	0	11
17	0	22	23	0	0	45
18	1	126	45	6	2	180
19	45	438	84	33	10	610
20	302	836	144	56	48	1386
21	636	989	214	140	113	2092
22	927	1108	216	308	232	2791
23	1146	1060	250	378	362	3196
24	1222	922	263	515	552	3474
25	1164	707	370	636	703	3580
26	1056	459	423	770	906	3614
27	816	296	465	884	1050	3511
28	490	292	560	936	1185	3463
29	523	155	599	847	1148	3272
30	585	111	647	763	1065	3171
31	448	70	715	587	870	2690
32	328	50	564	401	674	2017
33	254	23	330	288	525	1420
34	160	16	289	150	352	967
35	171	16	161	122	242	712
36	97	15	141	72	203	528
37	71	9	94	70	212	456
38	63	1	93	42	187	386
39	33	2	87	42	179	343
40	23	3	89	33	172	320
41	11	0	54	28	147	240
42	6	2	48	33	113	202
43	4	0	36	25	97	162
44	4	0	39	18	92	153
45	0	0	24	20	41	85
46	0	0	24	23	23	70
47	1	0	17	17	15	50
48	0	0	11	16	49	76
49	0	0	13	20	37	70
50	2	0	1	14	20	37
51	1	0	6	12	15	34
52	0	0	1	5	12	18
53	0	0	1	7	3	11
54	1	0	0	7	6	14
55	0	0	0	2	1	3
56	0	0	0	1	0	1
57	0	0	0	4	0	4
58	0	0	0	1	1	2
Total	10591	7737	7145	8332	11664	45469

Table 5. Summary of the size structure of black sea bass sampled in each of the five survey zones during the 2014 ventless trap survey.

Zone	number of sea bass	mean length (cm)	median length (cm)	min. length (cm)	max. length (cm)
VA	10591	26.2	25	18	54
NJ	7737	23.3	23	15	42
NY	7145	29.4	29	15	53
RI	8332	28.5	28	18	58
MA	11664	30	28	18	58

Table 6. Results of the GT2 test to test for significant differences in the mean length of black sea bass observed at the pairs of zones that were sampled during the ventless trap survey in 2014. Differences in the mean length (cm) between pairs of survey zones are shown, and significant results are denoted with an *.

	VA	NJ	NY	RI
VA	-	-	-	-
NJ	2.96*	-	-	-
NY	3.18*	6.14*	-	-
RI	2.28*	5.23*	0.9*	-
MA	3.82*	6.78*	0.64*	1.54*

Table 7. Results of the Kolmogorov-Smirnov tests (p-values) that were used to test for significant differences in the proportional length frequency distributions of black sea bass between pairs of survey zones. The tests were performed using an assumed sample size of 60 in each survey zone. The factors MA, RI, NY, NJ and VA are geographic zones that were sampled during the ventless trap survey.

	VA	NJ	NY	RI
VA	-	-	-	-
NJ	0.02	-	-	-
NY	<0.01	<0.01	-	-
RI	0.01	<0.01	0.49	-
MA	<0.01	<0.01	1	0.92

Table 8. Kolmogorov-Smirnov test results to compare the length frequency distribution of black sea bass observed in the ventless trap survey and other fishery-independent indices. NEAMAP Spring and NEAMAP Fall refers to the 2014 Northeast Area Monitoring and Assessment Program spring and fall trawl surveys. NEFSC Spring is the 2014 Northeast Fisheries Science Center spring bottom trawl survey. MADMF Spring is the 2014 Massachusetts Division of Marine Fisheries Spring bottom trawl survey. RIDEM refers to the 2014 spring and fall Rhode Island Department of Environmental Management bottom trawl surveys. NJ D.E.P. trawl survey refers to the New Jersey Department of Environmental Protection bottom trawl survey.

Factors	D	p-value
NEAMAP spring survey - Ventless Traps (All zones April and May)	0.18	**0.11**
NEAMAP fall survey - Ventless Traps (All zones September)	0.23	**0.03**
NEFSC spring survey - Ventless Traps (All zones April and May)	0.31	**<0.01**
MADMF spring survey - Ventless traps (MA zone in May)	0.33	**<0.01**
RIDEM survey - Ventless traps (RI zone from May to September)	0.22	**0.04**
NJ D.E.P. Trawl Survey - Ventless traps (NJ zone from May to September)	0.65	**<0.01**

Table 9. Kolmogorov-Smirnov test results. The proportional length frequency distributions observed in four survey zones during the 2014 ventless trap survey were tested against the length frequency distributions of black sea bass (kept and discard) observed in the recreational fishery in that zone. An assumed sample size of 100 was used for both the ventless trap survey and the recreational fishery.

Factors	D	p-value
NJ Ventless Traps - NJ rec.	0.99	<0.01
NY Ventless Traps - NY rec.	0.68	<0.01
RI Ventless Traps - RI rec.	0.91	<0.01
MA Ventless Traps - MA rec.	0.69	<0.01

Table 10. Kolmogorov-Smirnov test results. The proportional length frequency distributions of black sea bass ≥30cm observed in four geographic survey zones during the 2014 ventless trap survey were tested against the length frequency distributions of black sea bass ≥30cm (kept and discard) observed in the recreational fishery in that zone. An assumed sample size of 100 was used for both the ventless trap survey and the recreational fishery.

Factors	D	p-value
NJ Ventless Traps - NJ rec.	0.54	<0.01
NY Ventless Traps - NY rec.	0.47	<0.01
RI Ventless Traps - RI rec.	0.74	<0.01
MA Ventless Traps - MA rec.	0.48	<0.01

Table 11. Estimates of total mortality derived using the Beverton and Holt (1956) length-based mortality model and the Ekhardt and Ault (1992) length based mortality model. The von Bertalanffy growth parameters estimated by NEFSC (2011) are given. The mean length in the samples ($\bar{L}$) was calculated using a range of assumptions for the length at which black sea bass are first fully recruited to the fishery L_c.

von Bertalanffy growth parameters

	Linf	K	to
North	63.64	0.183	0.15
South	65.19	0.202	0.19
Combined	65.12	0.181	0.146

mean length $\bar{L}$

Survey Zone	Lc = 28	Lc = 30	Lc = 32
MA	33.44	35.49	37.77
RI	32.36	34.62	37.58
NY	32.93	34.43	36.88
NJ	30.97	32.98	35.13
VA	31.92	33.50	35.29
NY, RI and MA	33.02	34.97	37.47
NJ and VA	31.78	33.44	35.27
MA, RI, NY, NJ and VA	32.79	34.71	37.13

Z estimates (Beverton and Holt 1956)

Survey Zone	Lc = 28	Lc = 30	Lc = 32
MA	1.02	0.94	0.82
RI	1.31	1.15	0.85
NY	1.14	1.21	1.00
NJ	2.32	2.19	1.94
VA	1.71	1.83	1.84
NY, RI and MA	1.12	1.06	0.87
NJ and VA	1.78	1.86	1.85
MA, RI, NY, NJ and VA	1.22	1.17	0.99

Z estimates (Erhardt and Ault 1992)

Survey Zone	Lc = 30
MA	0.94
RI	1.15
NY	1.21
NJ	2.17
VA	1.83

Tables 12a-12f. Abundance (ln(abundance + 1)) at age of black sea bass observed in each zone of the ventless trap survey during the spring and the fall, and the average abundance observed between the spring and fall. Estimates of total mortality (Z) were derived separately for the spring and fall, and using the average abundance observed in the spring and fall. The catch curves associated with these estimates are shown in Figures 14a-14e.

Table 12a. Abundance and total mortality estimates observed across all five survey zones in 2014.

LN(Abundance + 1)				Z Estimate		
Age	May	Sept.	Mean	Month(s)	Ages	Z
1	0.130	6.551	3.341	May	3 to 10	1.38
2	8.714	7.984	8.349	Sept.	3 to 8	1.41
3	8.802	7.438	8.120	Mean	3 to 10	**1.28**
4	7.733	6.254	6.994			
5	5.953	4.983	5.468			
6	4.083	3.942	4.012			
7	1.219	2.527	1.873			
8	1.006	0	0.503			
9	0.405	0	0.203			
10	0	0	0			

Table 12b. Abundance and total mortality estimates observed in the VA survey zone in 2014.

LN(Abundance + 1)				Z Estimate		
Age	Apr. & May	Sept.	Mean	Month(s)	Ages	Z
1	0	4.539	2.270	Apr. & May	3 to 8	1.74
2	8.034	6.010	7.022	Sept.	3 to 7	1.23
3	8.001	4.758	6.379	**Mean**	**3 to 8**	**1.36**
4	6.872	2.978	4.925			
5	5.122	1.524	3.323			
6	3.082	0.199	1.641			
7	0.615	0	0.308			
8	0	0	0			
9	0.223	0	0.112			
10	0.000	0	0			

Table 12c. Abundance and total mortality estimates observed in the NJ survey zone in 2014.

LN(Abundance + 1)				Z Estimate		
Age	May	Sept.	Mean	Month	Ages	Z
1	0.105	5.578	2.841	May	3 to 7	1.73
2	7.376	6.024	6.700	Sept.	3 to 6	1.19
3	6.626	3.703	5.164	**Mean**	**3 to 7**	**1.28**
4	5.023	0.836	2.930			
5	2.876	0.080	1.478			
6	0.947	0	0.473			
7	0	0	0			
8	0	0	0			
9	0	0	0			
10	0	0	0			

Table 12d. Abundance and total mortality estimates observed in the NY survey zone in 2014.

LN(Abundance + 1)				Z Estimate		
Age	May	Sept.	Mean	Month	Ages	Z
1	0.216	5.598	2.907	May	3 to 9	1.19
2	6.114	6.606	6.360	Sept.	3 to 8	1.32
3	6.864	6.482	6.673	**Mean**	**3 to 9**	**1.18**
4	6.282	5.288	5.785			
5	4.978	3.882	4.430			
6	3.904	2.540	3.222			
7	1.380	1.170	1.275			
8	1.683	0	0.842			
9	0	0	0			
10	0	0	0			

Table 12e. Abundance and total mortality estimates observed in the RI survey zone in 2014.

LN(Abundance + 1)				Z Estimate		
Age	May	Sept.	Mean	Month	Ages	Z
1	0	4.482	2.241	May	3 to 10	1.13
2	6.718	6.378	6.548	Sept.	3 to 8	1.05
3	7.297	5.457	6.377	**Mean**	**3 to 10**	**0.97**
4	6.251	3.990	5.120			
5	4.345	2.809	3.577			
6	2.659	2.300	2.480			
7	0.670	1.007	0.838			
8	0.511	0	0.255			
9	0.223	0	0.112			
10	0	0	0			

Table 12f. Abundance and total mortality estimates observed in the MA survey zone in 2014.

LN(Abundance + 1)				Z Estimate		
Age	May	Sept.	Mean	Month	Ages	Z
1	0	4.185	2.093	May	3 to 7	1.74
2	5.983	7.000	6.491	Sept.	3 to 8	1.26
3	6.842	6.602	6.722	**Mean**	**3 to 9**	**1.24**
4	5.957	5.567	5.762			
5	4.180	4.394	4.287			
6	2.238	3.425	2.832			
7	0	2.147	1.073			
8	0.080	0	0.040			
9	0	0	0			
10	0	0	0			

Table 13. Output from the Generalized Linear Model that was used to explore variation in catch rates as a function of survey year, zone, month, and soak time.

	Estimate	Std Error	Z Value	P Value	
(Intercept)	4.228	0.142	29.8	<2e-16	***
YearB	0.676	0.071	9.56	<2e-16	***
YearC	0.751	0.068	11	<2e-16	***
AreaNJ	-0.045	0.092	-0.49	0.6262	
AreaNY	-0.552	0.109	-5.08	3.78E-07	***
AreaRI	-0.880	0.074	-11.9	<2e-16	***
AreaVA	-0.602	0.091	-6.58	4.61E-11	***
MonthAugust	-0.081	0.146	-0.55	0.5799	
MonthJuly	0.033	0.143	0.234	0.8151	
MonthJune	0.254	0.143	1.775	0.0759	
MonthMay	0.709	0.141	5.04	4.66E-07	***
MonthSeptember	-0.014	0.154	-0.09	0.9253	
Soak_Time	0.036	0.007	5.481	4.23E-08	***

Figures

Figure 1. Boxplots of black sea bass catch rates (number/trawl) observed in each survey zone in 2014.

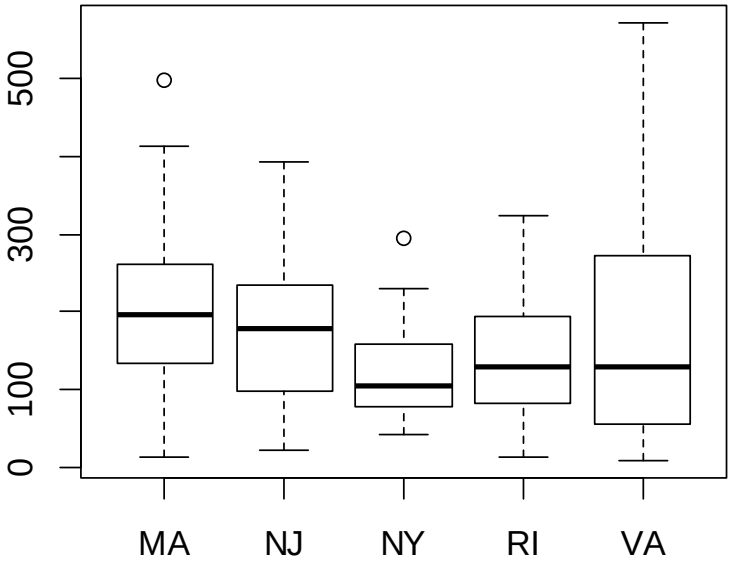


Figure 2. Boxplots of catch rates (number/trawl) at the four stations within each zone observed during the 2014 ventless trap survey.

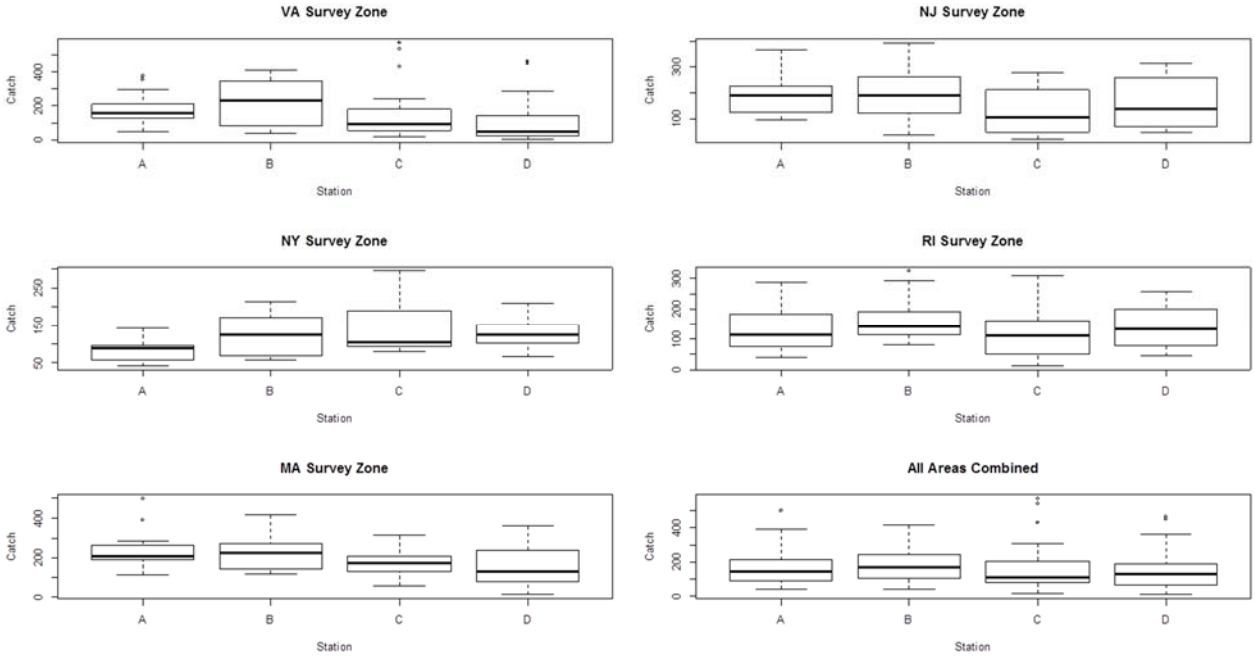


Figure 3. Boxplots of monthly black sea bass catches (number/trawl) observed in each survey zone in 2014.

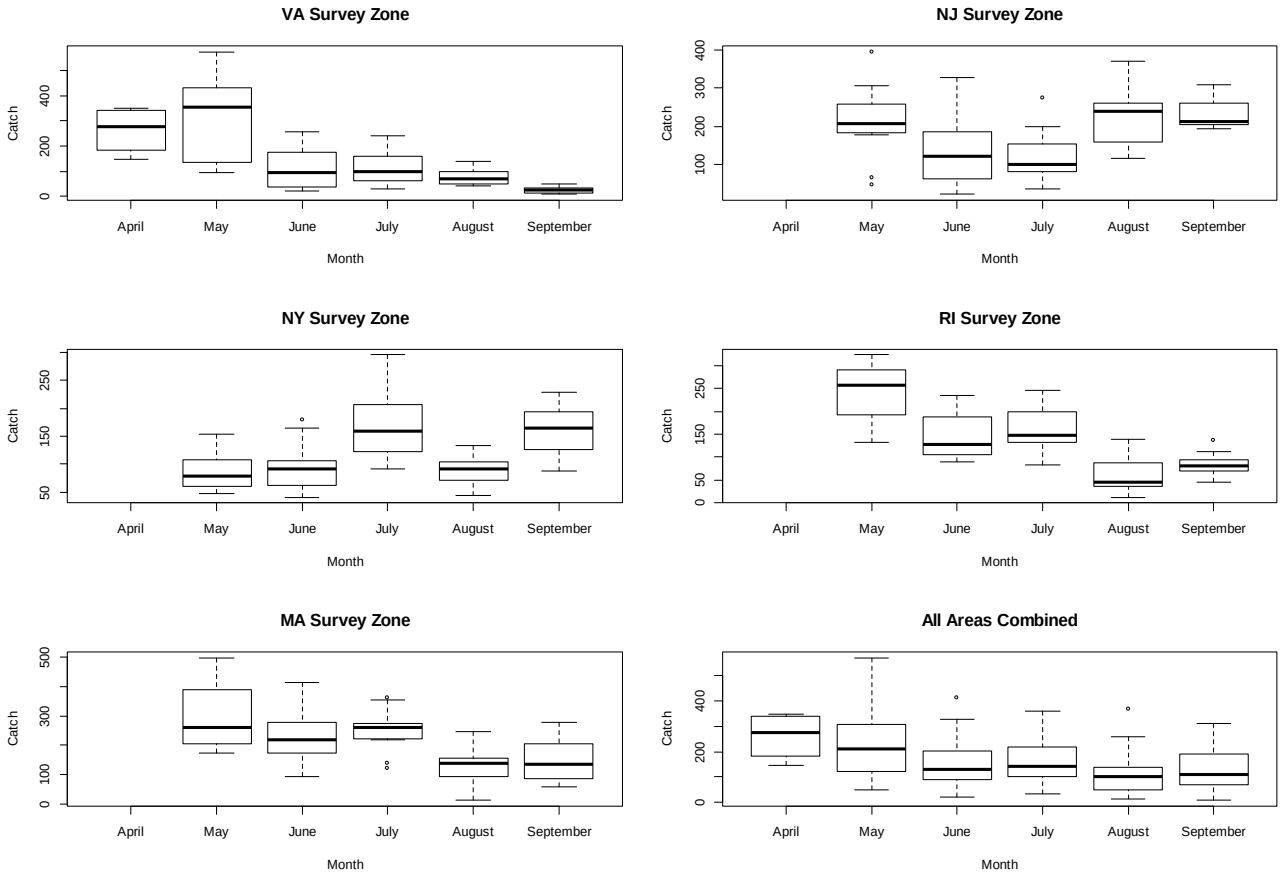


Figure 4. Proportional length-frequency distribution of black sea bass sampled at the five survey zones during the 2014 ventless trap survey.

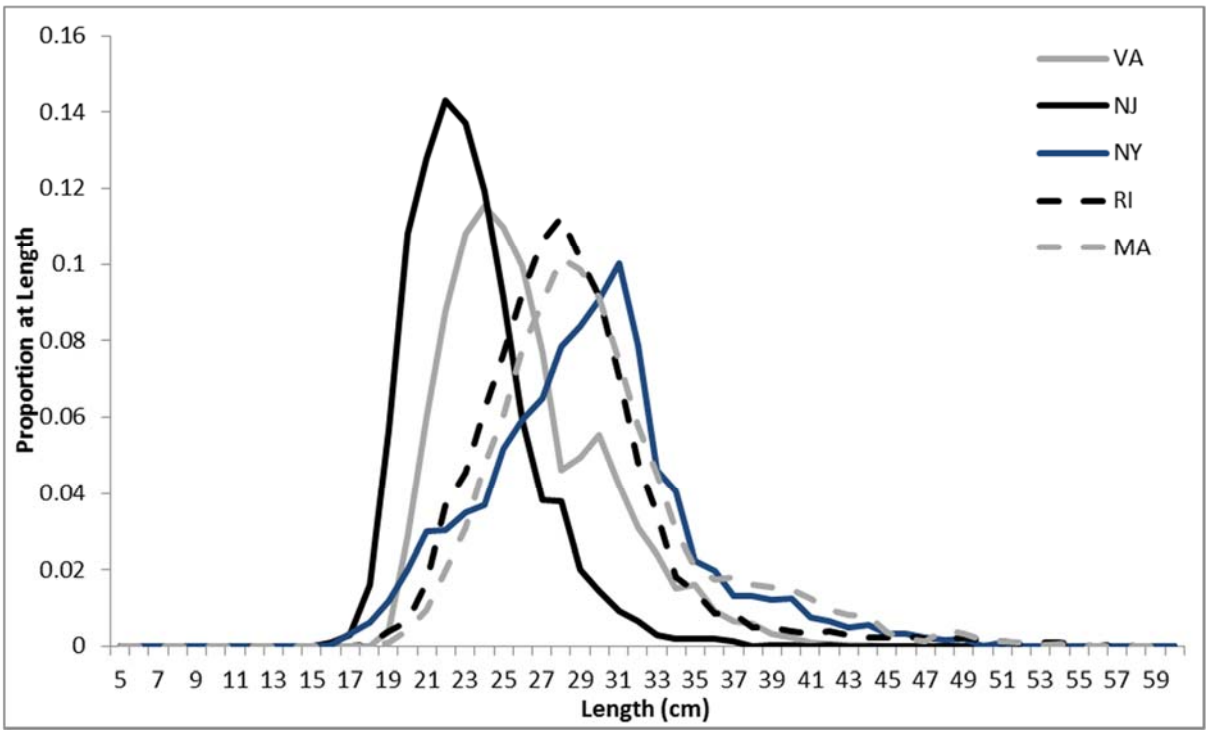


Figure 5. Proportional length-frequency distribution of black sea bass sampled at the two northern survey zones (MA, and RI) at the two southern survey zones (NJ and VA), and in the "transitional" survey zone (NY) during the 2014 ventless trap survey.

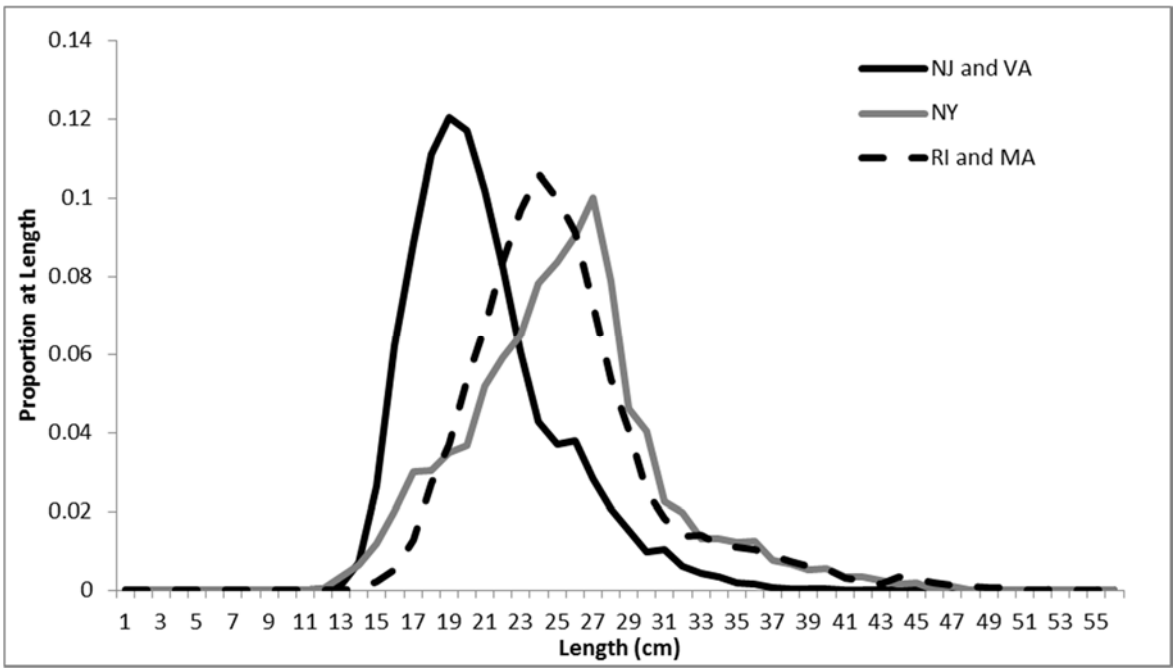
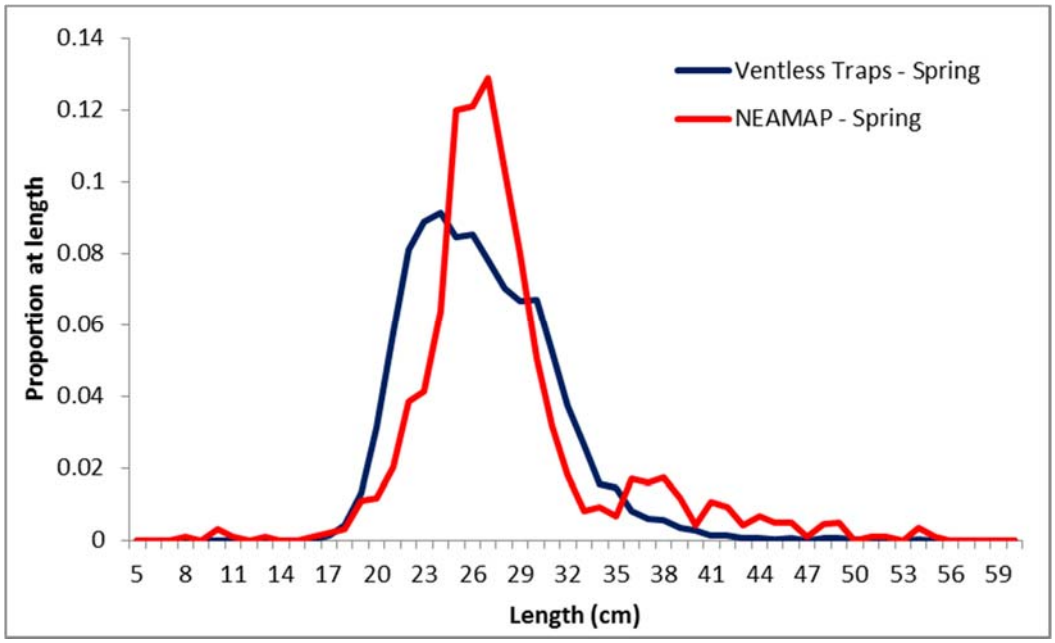


Figure 6. Proportional length frequencies of black bass sampled in the ventless trap survey in April and May and during the 2014 NEAMAP spring trawl survey (top figure). Proportional length frequencies of black bass sampled in the ventless trap survey in September and the 2014 NEAMAP fall trawl survey (bottom figure).



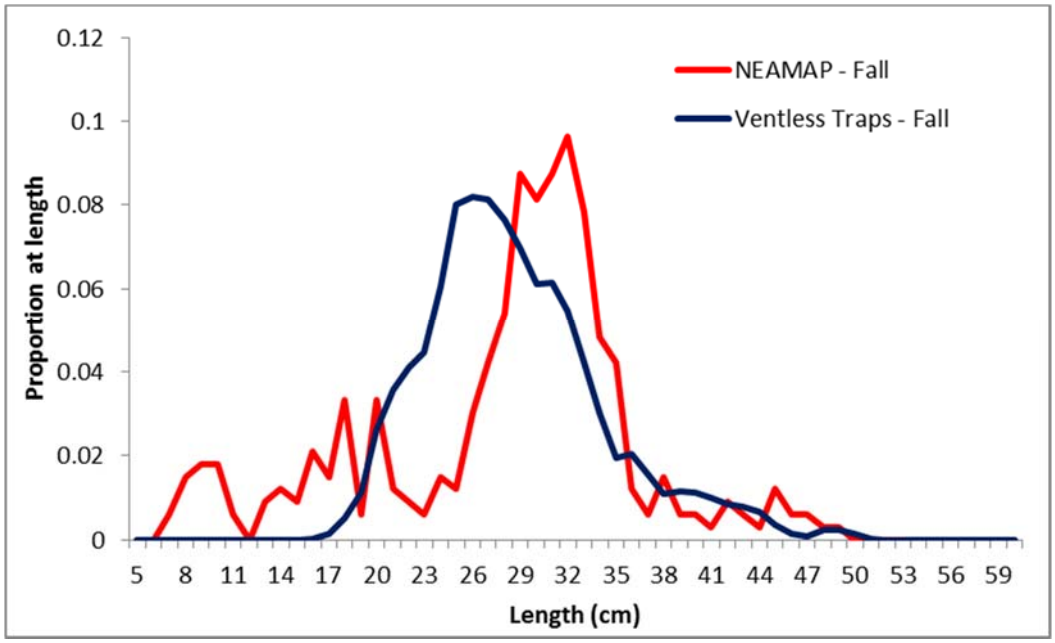


Figure 7. Proportional length frequencies of black bass sampled in April and May during the ventless trap survey and the 2014 NEFSC spring trawl survey. It should be noted that the NEFSC spring survey did not sample south of 38º in 2014.

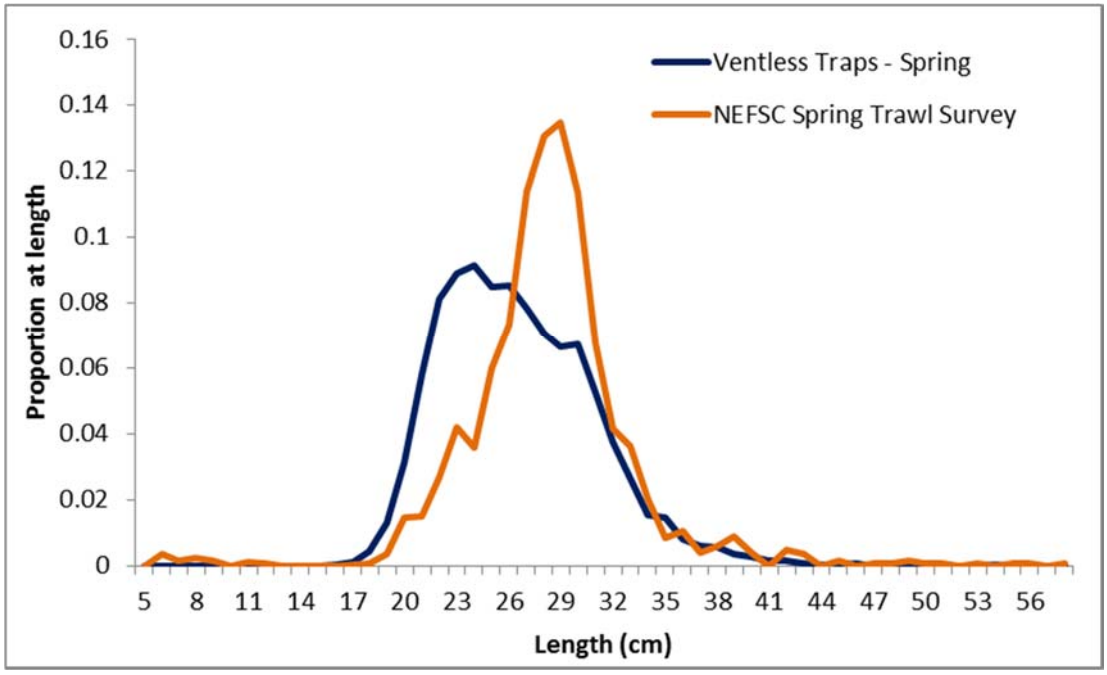


Figure 8. Proportional length frequencies of black sea bass sampled in the 2014 MADMF spring trawl survey and in the MA zone of the ventless trap survey during the month of May.

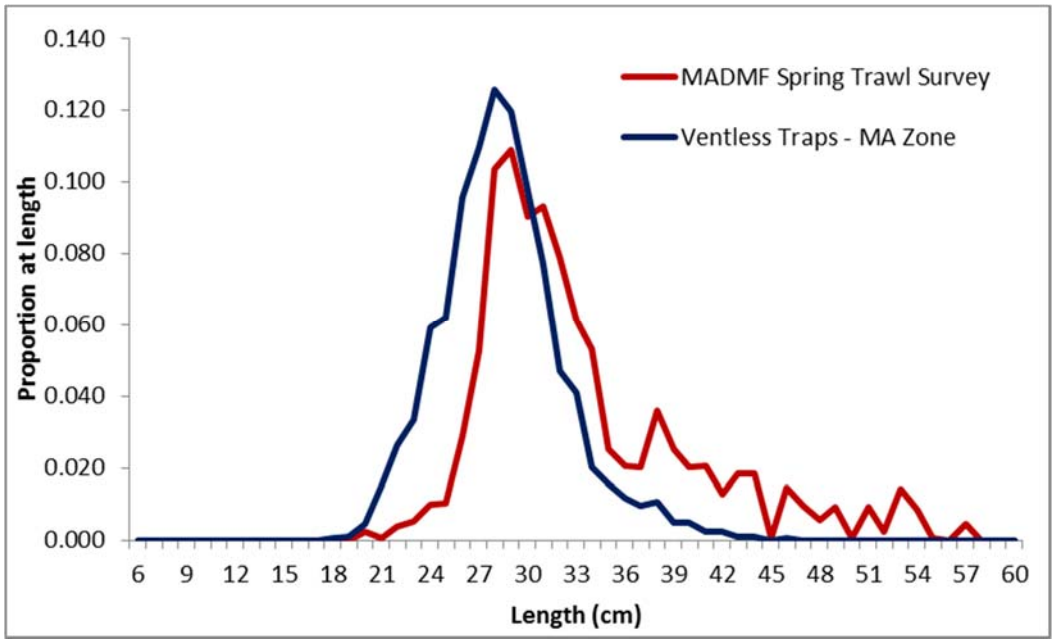


Figure 9. Proportional length frequencies of black bass sampled in the RI zone during the ventless trap survey and the 2014 Rhode Island Department of Environmental Management spring and fall trawl survey.

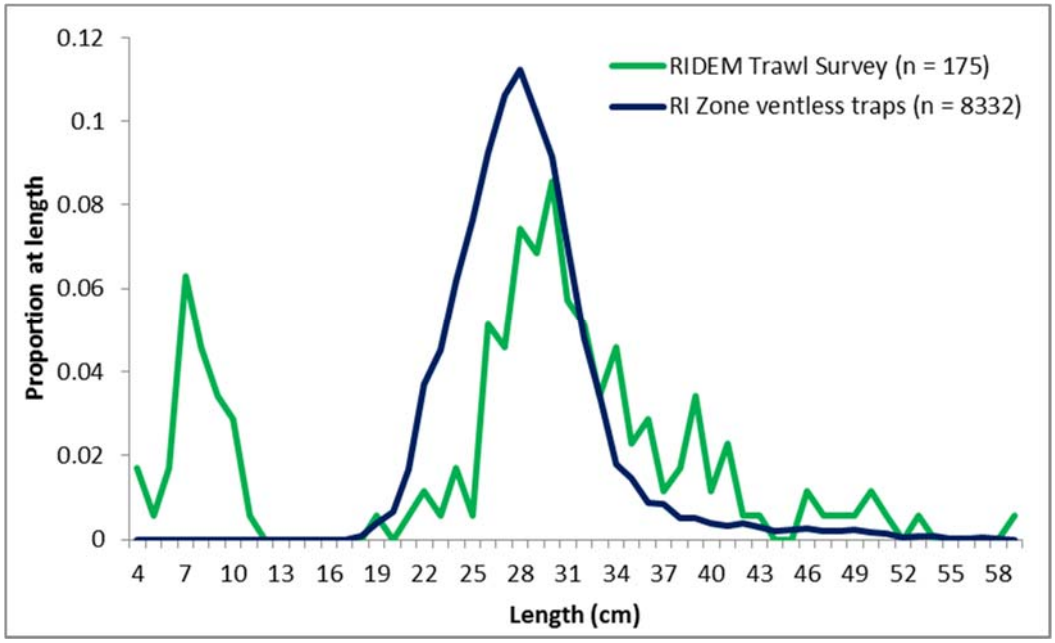
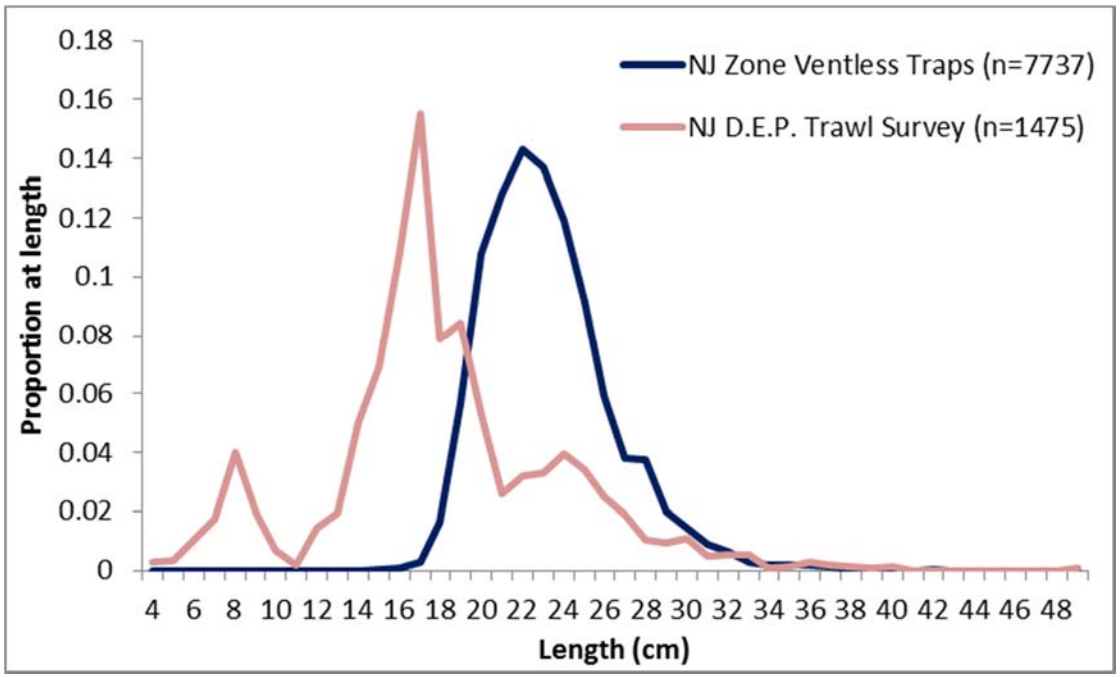
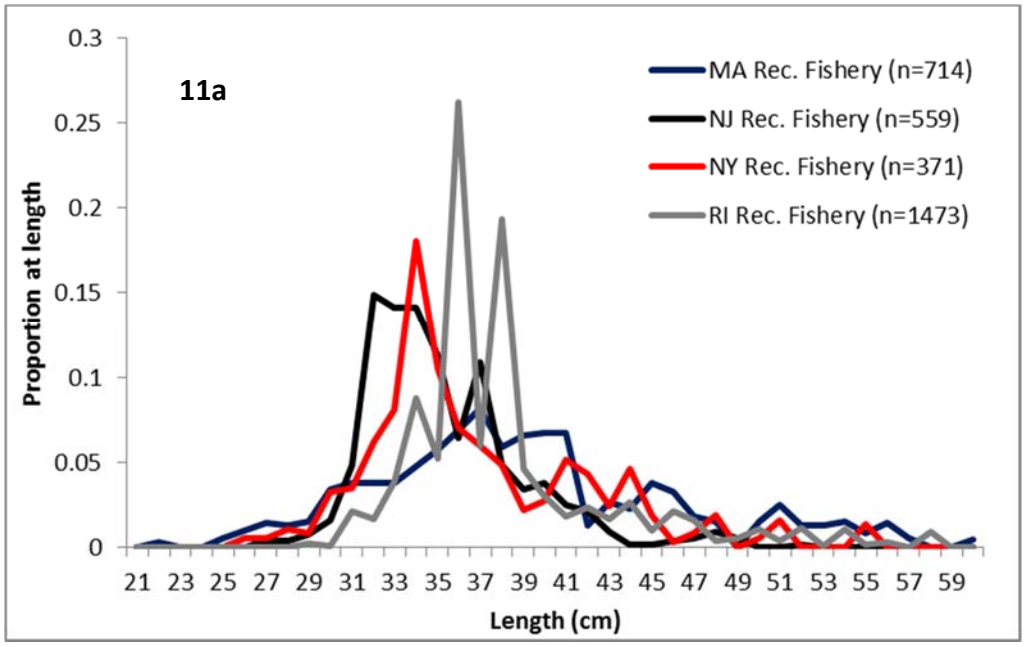


Figure 10. Proportional length frequencies of black bass sampled in the NJ zone during the ventless trap survey and the 2014 New Jersey Department of Environmental Protection trawl survey.



Figures 11a and 11b. Proportional length frequency distributions of black sea bass observed in the recreational catches in Massachusetts, Rhode Island, New York and New Jersey in 2014 (11a), and proportional length frequency distribution of black sea bass ≥40cm observed in the recreational catches in each state (11b).



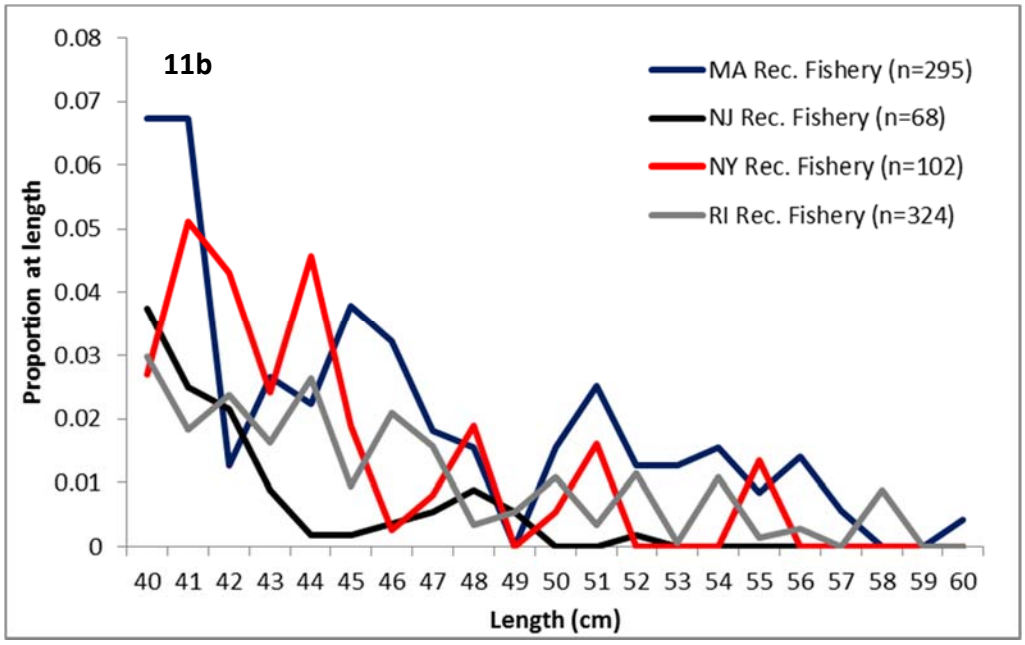


Figure 12A-12D. Proportional length frequency distributions of black sea bass (all lengths) observed in the 2014 ventless trap survey and the 2014 recreational fishery for four zones (MA, RI, NY and NJ).

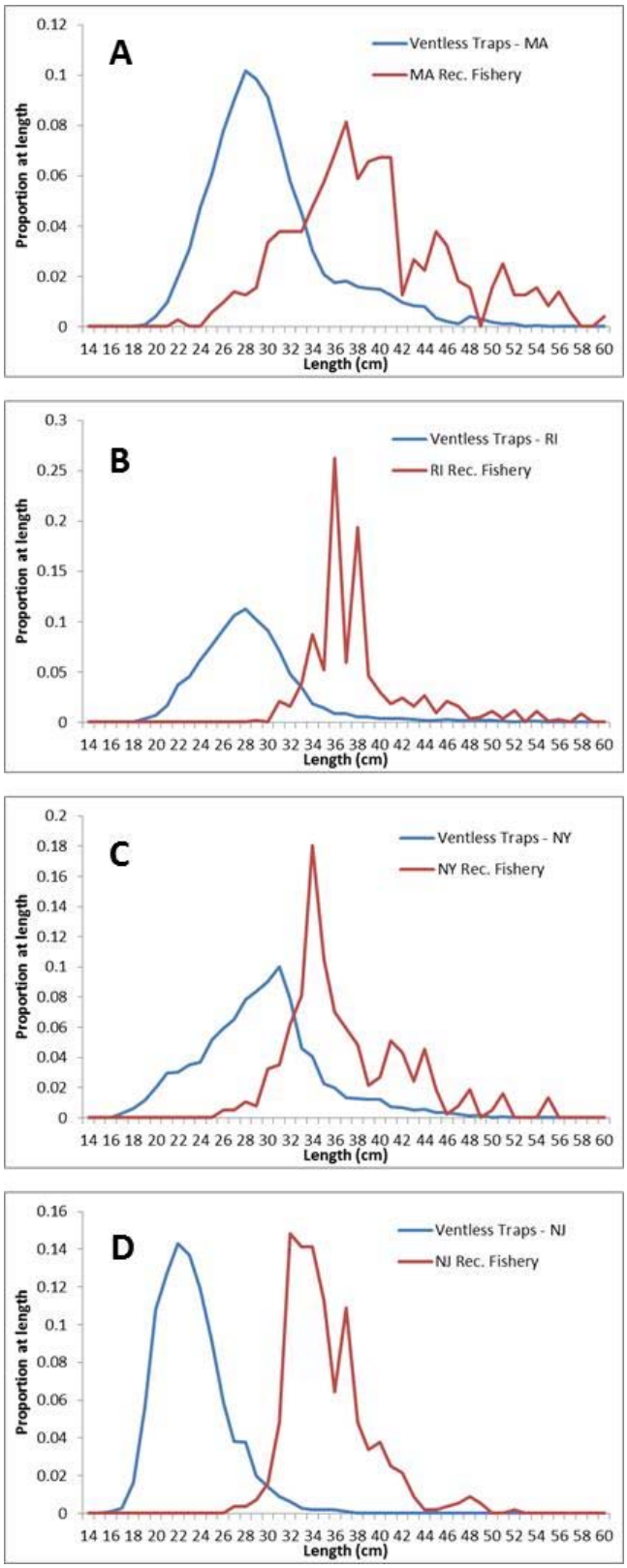
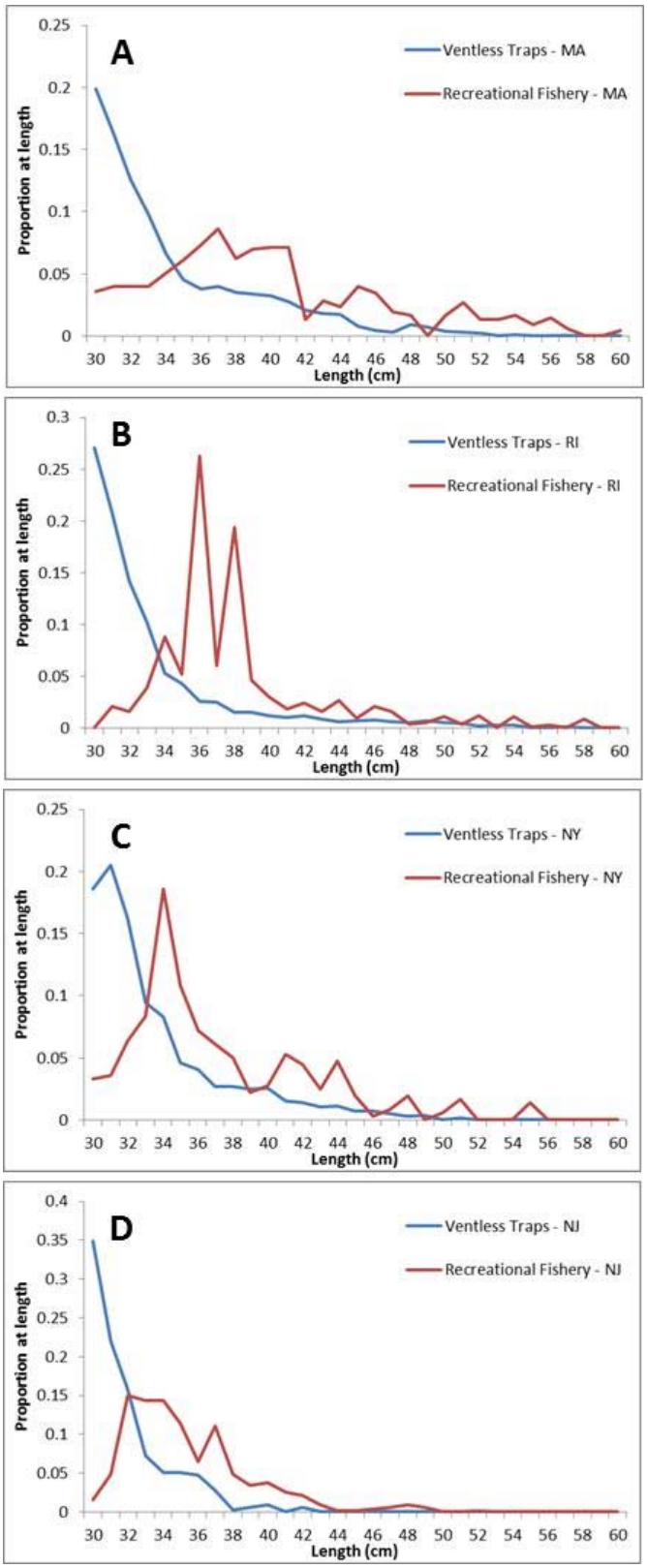
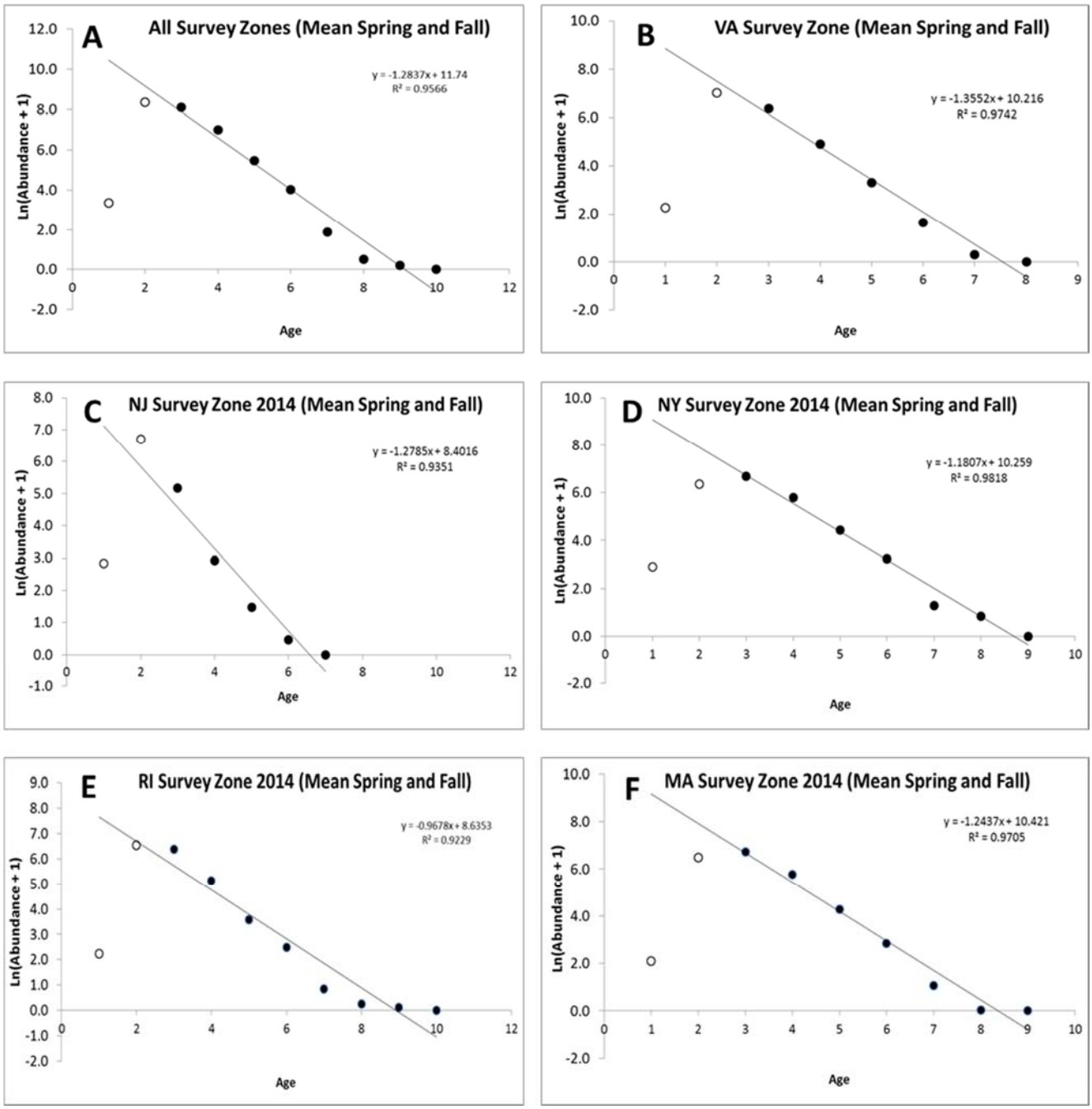


Figure 13A – 13D. Proportional length frequency distributions of black sea bass (>30cm) observed in the 2014 ventless trap survey the 2014 recreational fishery for four zones (MA, RI, NY and NJ).



Figures 14A – 14F. Catch curves depicting the mean abundance of black sea bass ((ln(Abundance + 1)) at each age class that was observed in the ventless trap survey during the spring and the fall months. Partially recruited age classes are denoted using an open circle, while fully recruited age classes are represented with closed circles. The abundance indices and associated Z estimates are also provided for each survey zone in Tables 12A – 12F.