FINAL REPORT
Northeast Fisheries Science Center

A. NOAA Grant Number: NA13NMF4540008

B. Grantee: Captain Charles Borden

C. Principal Investigators

Laura Skrobe
University of Rhode Island
Fisheries Center
East Farm – Building 83
Kingston, RI 02881

Captain Charles R. Borden
Cockeast Fisheries, Inc.
F/V *Drake*
38 D Mullin Hill Rd.
Little Compton, RI 02837

Dr. Stephen Cadrin
Department of Fisheries and Oceanography
School of Marine Science and Technology
200 Mill Rd, Suite 325
Fairhaven, MA 02719

Additional Fishing Industry Collaborators

Captain Eric S. Rodegast
F/V *Evangeline*
PO Box 2685
Oak Bluffs, MA 02557

Eric and Rob Burcaw
10 Crestview Drive
Seaville, NJ 08230

Captain Mark Hodges
2456 Bullock Trail
Virginia Beach, VA 23454

State Agency Collaborators

Rob O'Reilly
Deputy Chief of Fisheries
Virginia Marine Resources Commission
2600 Washington Avenue, 3rd Floor
Newport News, VA 23607

Dr. David Pierce
Deputy Director
MA Division of Marine Fisheries
251 Causeway Street
Boston, MA 02114

Brandon Muffley
Chief, Bureau of Marine Fisheries
NJ DEP Division of Fish and Wildlife
Nacote Creek Station
PO Box 418
Port Republic, NJ 08241

Mark Gibson
Deputy Chief, Division of Fish and Wildlife
RI Department of Environmental Management
Division of Fish and Wildlife
3 Ft. Wetherill Road
Jamestown, RI 02835

D. Project Title: Industry Based Survey on Black Sea Bass Utilizing Ventless Traps

E. Amount of Grant: $230,802.00

F. Award Start Date: 01/01/2013

G. Period Covered by Report: 07/01/2013 - 12/31/2013

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.

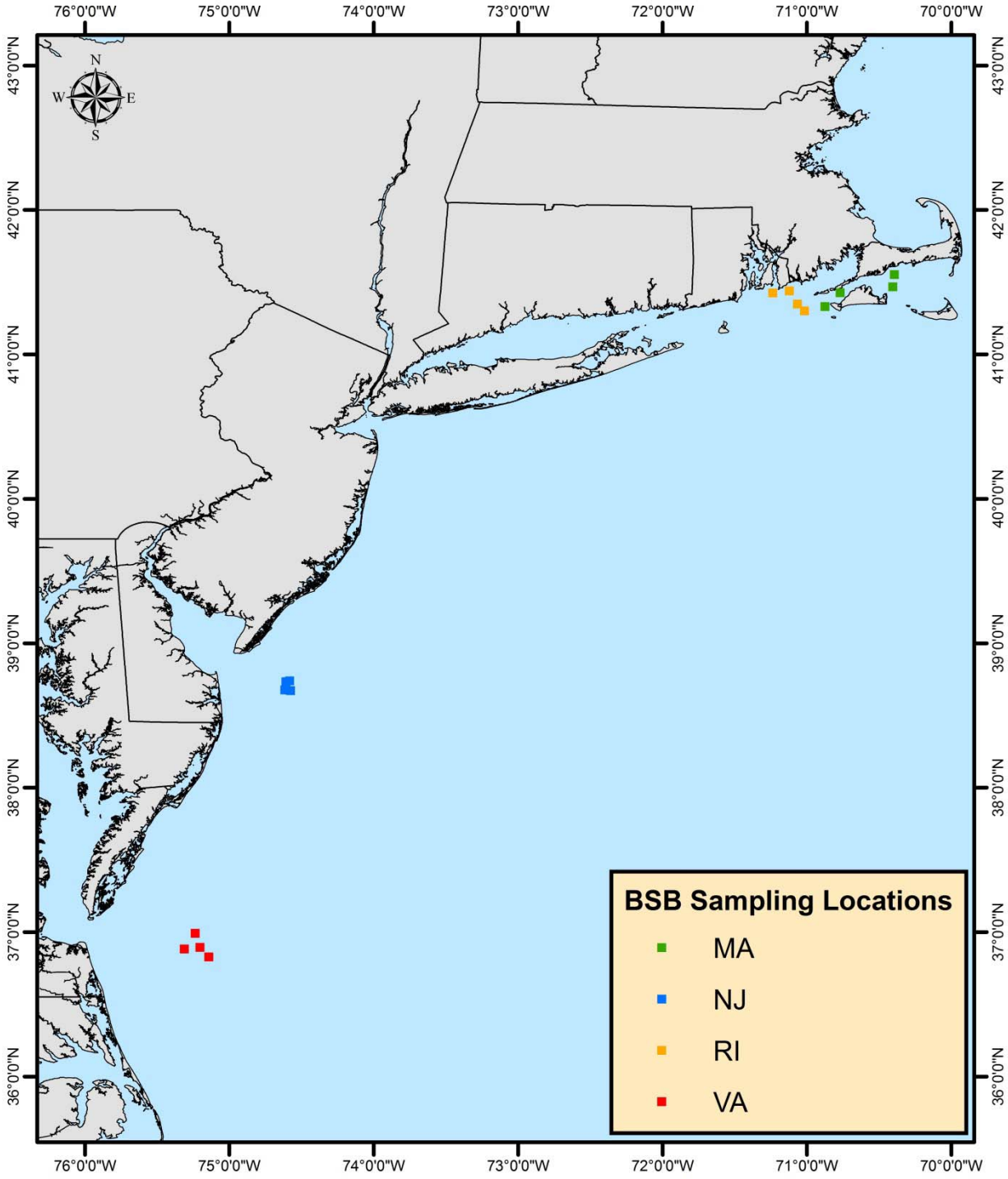


Figure 1. Map showing all 16 sampling sites, 4in each location: Virginia, New Jersey, Rhode Island, and Massachusetts.

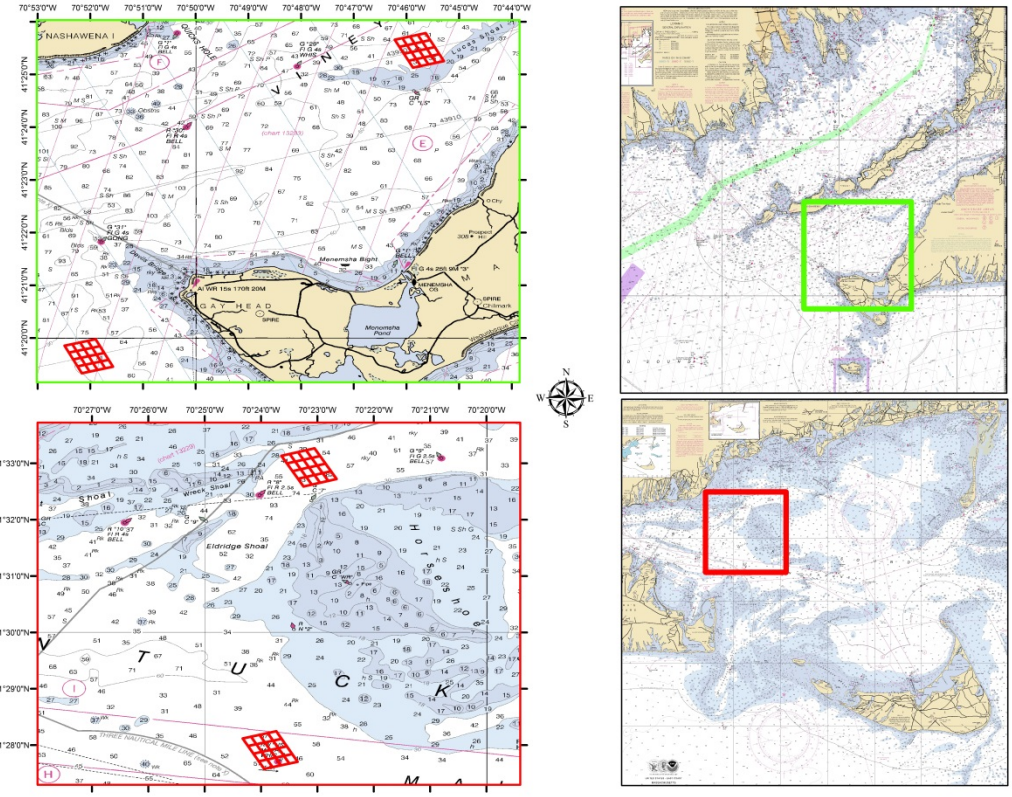


Figure 2. Four sampling sites in Massachusetts showing 16 sub-blocks in each site.

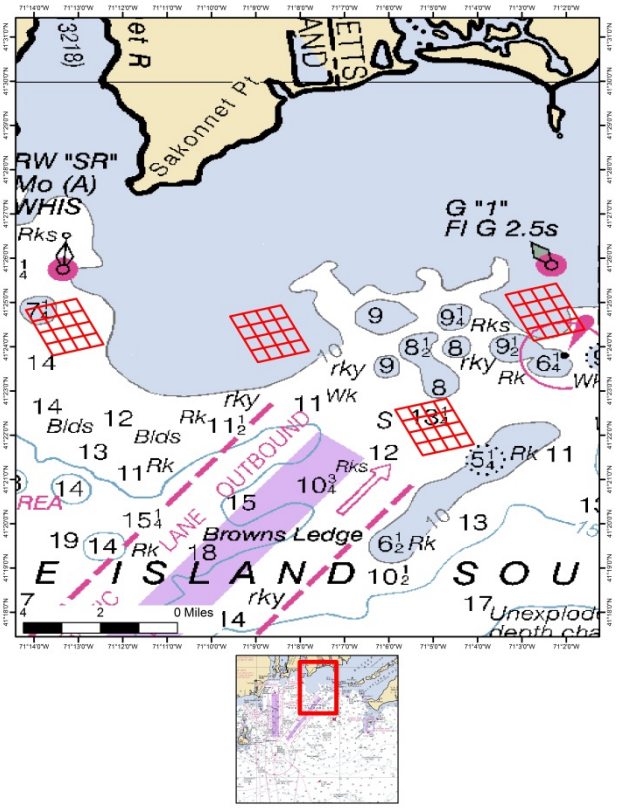


Figure 3. Four sampling sites in Rhode Island showing 16 sub-blocks in each site.

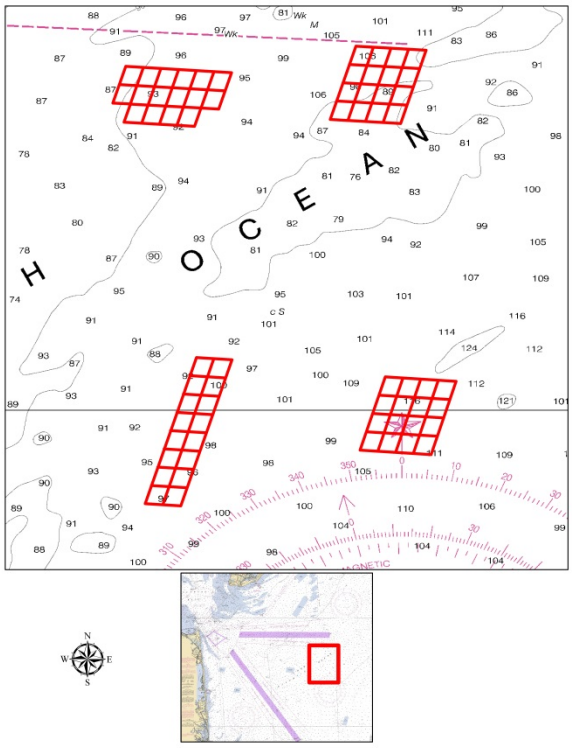


Figure 4. Four sampling sites in New Jersey showing 16 sub-blocks in each site.

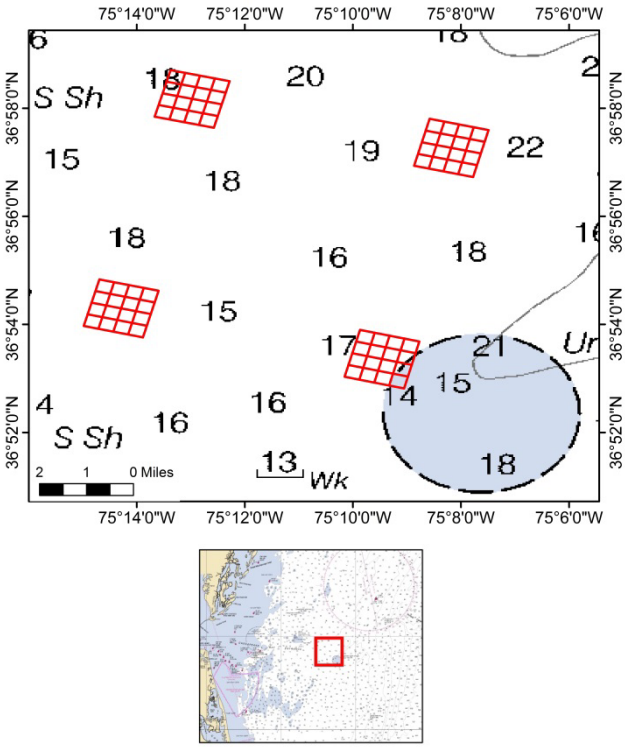


Figure 5. Four sampling sites in Virginia showing 16 sub-blocks in each site.

In the Mid-Atlantic a total of 15965 black sea bass were measured (10022 in Virginia waters and 5943 in New Jersey waters) (Figure 6). Mean size was 25.3 cm. A total of 18394 black sea bass were measured in the Southern New England sites with 6019 measured in Rhode Island and 12375 in Massachusetts. Mean size in New England was slightly larger than in the Mid-Atlantic at 27.3 cm.

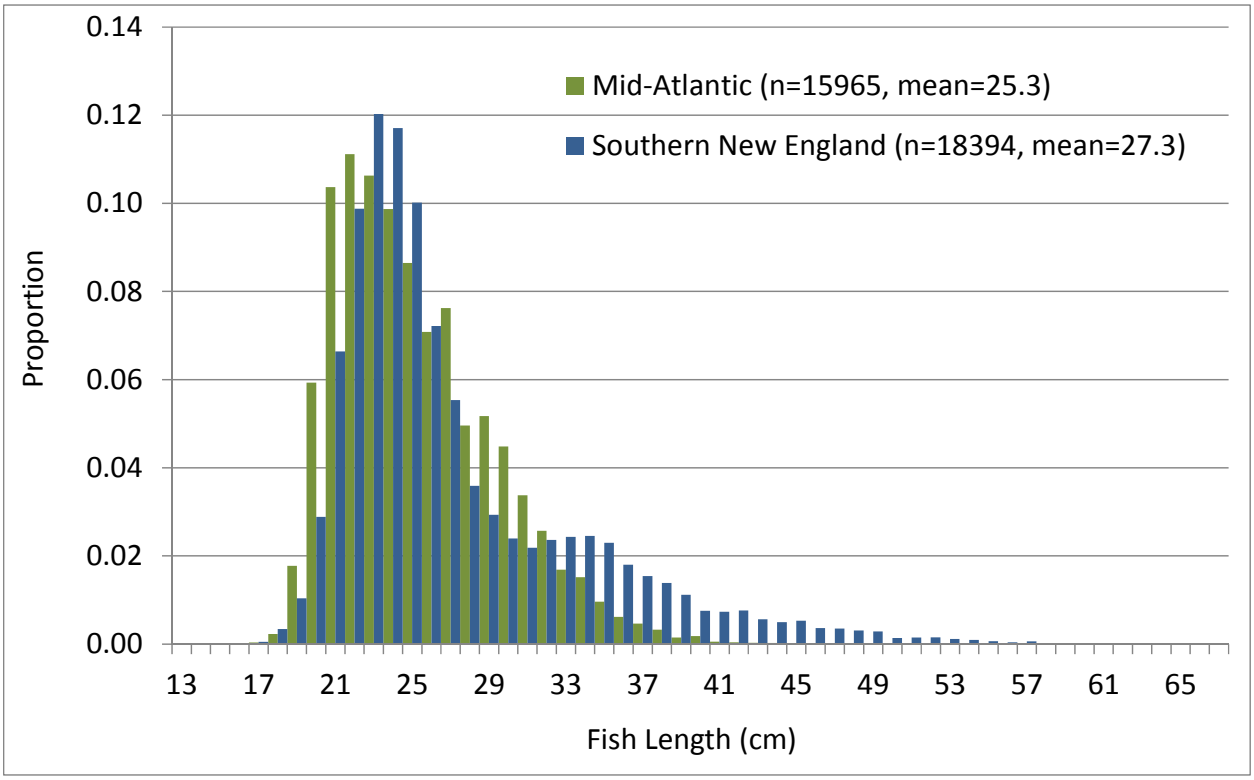


Figure 6. Length frequency distribution of black sea bass in the Mid-Atlantic and New England sites.

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

Greg DeCelles and Steve Cadrin

University of Massachusetts, Dartmouth

Department of Fisheries Oceanography

School for Marine Science & Technology

200 Mill Road, Suite 325

Fairhaven, MA 02719 U.S.A.

Background

The 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). The assessment indicated that the sea bass stock was not overfished and that overfishing was not occurring. However, the assessment has substantial uncertainty and the peer review panel concluded that "a pot survey for black sea bass should be considered" (NEFSC 2011).

An industry-based, fishery independent survey of black sea bass was initiated to develop a new index of abundance, which could be used to improve the quality of the stock assessment for black sea bass. The survey was conducted between Virginia and Massachusetts, at the core of the species range. Unvented fish pots were sampled on hard-bottom substrates, which are not currently sampled by other fishery independent surveys. Unvented pots were sampled over the course of six months; from April through August in Virginia, from May to August off New Jersey, and from May to September in New England waters. Five commercial fishing vessels served as industry partners during the research.

Methods

Four zones (MA, RI, NJ, and VA) were sampled during the 2013 unvented trap 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 2013 was conducted monthly between April and August in VA (Table 1). Sampling occurred monthly in New Jersey from May to August, and from May to September in MA and RI. Four stations were sampled monthly in VA, but the monthly sampling intensity was more variable in the other zones (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 traps were deployed in trawls, with each trawl

containing ten ventless fish traps, and three trawls were set at each station (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. 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.

Exploratory analyses were used to investigate patterns of variation in the survey data. Catch data from the 2013 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 four survey zones (MA, RI, NJ and VA). Secondly, we tested for significant differences in catch rates among stations within each survey zone. The catch data were grouped by study area, month, station and trawl to perform the Nested ANOVA analysis. GT2 tests (Sokal and Rohlf, 2001) were used to test for significant differences in the catch rates of black sea bass sampled between the six pairs of survey zones. 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).

A single factor ANOVA was used to test for significant differences in mean of black sea bass sampled at the four survey zones in the fixed gear survey (MA, RI, NJ and VA). GT2 tests were used to test for significant differences in the mean length of black sea bass sampled between the six 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 four zones during the ventless trap survey. The Kolmogorov-Smirnov test is highly sensitive to differences, and 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 three of the survey zones in 2013 (Table 1).

Size distributions from the ventless trap survey were compared to other sources of information to examine what demographic portion of the stock is being sampled by the ventless trap survey. The length frequency distributions of black sea bass caught in the four zones that were sampled during the ventless trap survey were combined to form a single aggregated length frequency distribution. A Kolmogorov-Smirnov test was used to test whether the aggregated 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 (2013 Massachusetts Division of Marine Fisheries Spring

Trawl Survey, the 2013 Northeast Fisheries Science Center Spring trawl survey, the 2013 NEAMAP spring and fall trawl surveys, and the 2013 Rhode Island Department of Environmental Management spring and fall trawl surveys). The length frequency distribution data from the NEFSC and MADMF spring 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 surveys and the 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 four zones of the ventless trap survey during the spring (defined here as April-June) was compared to the length frequency distribution of black sea bass captured during the 2013 NEFSC spring bottom trawl survey, and the 2013 NEAMAP spring bottom trawl survey. Similarly, the proportional length frequency distribution of black sea bass sampled in all four zones of the ventless trap survey during the fall (defined here as July-September) was compared to the length frequency distribution of black sea bass captured during the 2013 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-June) was compared to the length frequency distribution observed during the 2013 spring MADMF bottom trawl survey. The proportional length frequency distribution of black sea bass observed in the RI zone was compared to the length frequency distribution of black sea bass captured during the 2013 Rhode Island Department of Environmental Management 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 was compared to the 2013 New Jersey Department of Environmental Protection trawl survey, which sampled in April, June, August, and October.

The length frequency distributions of black sea bass that were measured by scientific samplers on board recreational party vessels in the 2013 Massachusetts, Rhode Island, and New Jersey recreational fisheries was obtained through the NOAA Marine Resource Information Program website (http://www.st.nmfs.noaa.gov/st1/recreational/MRIP_Survey_Data/CSV/). 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 and New Jersey were compared to the length distribution of black sea bass from the ventless trap survey in that state. Kolmogorov-Smirnov 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 three states, and 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.

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 two northernmost (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 and RI 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 four survey zones in 2013, 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 four survey zones:

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

Where L_λ is the maximum length in the catch. We used the recreational length frequency data (Figure 7) to inform our estimates of L_λ. L_λ was assumed to be 50cm for the NJ and VA survey zones, 56cm for the MA zone, and 58cm for the RI survey zone. L_c was assumed to be 30cm in all four survey zones.

Results

A total of 34,359 black sea bass were measured during the 2013 fixed gear survey. The greatest catch rates (black sea bass/trawl) were observed in NJ, while the lowest catch rates were observed in RI (Table 2). The results of the nested ANOVA indicated that catch rates (number of sea bass/trawl) differed significantly among the four survey zones ($p=0.002$), but significant differences were not detected in catch rates among the stations within each survey zone ($p=0.20$).

RI had the lowest catch rates of black sea bass, and the catch rates in RI significantly differed from those observed in the three other survey zones (Table 3). The GT2 test did not detect any significant differences in the catch rates of black sea bass between MA, VA, and NJ.

In the southern survey zones (VA and NJ), the greatest mean sea bass catches were observed in May and June (Figure 1). In the MA survey zone, the greatest mean catches were observed in May, and catches generally declined from June through August, before increasing again in September. In Rhode Island, the greatest average catches were observed in May, and mean black sea bass catches declined slightly over the remainder of the sampling period.

The length frequency distributions of black sea bass caught in the four survey zones are show that larger fish were generally observed more often in the northernmost survey areas (MA and RI), while smaller black sea bass are sampled more frequently in the southern range of the survey (NJ and VA) (Figures 2 and 3, and Tables 4 and Table 5). In all zones, the highest proportions of black sea bass observed in the survey were between 20 to 24 cm. Results of the ANOVA indicated that the mean length of black sea bass varied significantly between the four study zones ($p<0.001$).

The results of the GT2 tests for differences in the mean length among areas are shown in Table 6. The mean length of black sea bass was found to differ significantly between all six pairs of survey zones that were tested.

When the proportional length frequency distributions of black sea bass observed in each zone of the ventless trap survey were examined using a K-S test, no significant differences were observed between pairs of survey zones (Table 7).

The results of the K-S test indicate that the length frequency of black sea bass observed during the ventless trap survey differed significantly from the length frequency of sea bass observed in the NEAMAP spring survey and the NEFSC spring survey, with the trap survey catching a larger distribution of sea bass (Table 7: Figures 4 and 7). There was also a significant difference in the length frequency distribution of black sea bass in the ventless trap survey and the MADMF spring trawl survey ($p = 0.048$). However, when the proportional length frequency distribution of black sea bass captured in MA zone of the ventless trap survey during the spring months (May-June) was compared to the MADMF spring trawl survey, no significant difference was observed (Table 7; Figure 6). There was no significant difference in the proportional length frequency distributions of black sea bass from the ventless trap survey and the 2013 NEAMAP fall survey (Table 7; Figure 5). The length frequency distributions observed in the RI zone of the ventless trap survey and the 2013 spring and fall RIDEM trawl surveys differed significantly, with more small sea bass (<10cm) in the RIDEM survey (Table 7; Figure 8). 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 2013 NJDEP bottom trawl survey, with more small sea bass (<15cm) in the NJDEP survey (Table 7; Figure 9).

The greatest proportion of sea bass sampled in the ventless trap survey was observed at 24cm, and the majority of sea bass ranged in size from 20 to 30cm (Figure 2). In each survey zone, the largest proportions of black sea bass were observed between 22 and 26cm, suggesting that each survey is capable of capturing intermediate size sea bass effectively. The 2013 NEAMAP spring survey captured more black sea bass at the smallest sizes than the ventless trap survey (Figure 4). Young-of-the-year black sea bass (<10cm) were somewhat common in the 2013 fall NEAMAP survey, but these fish were relatively rare in the other surveys (Figure 5). The smallest sea bass captured in the ventless traps were 13cm, and sea bass <18cm were uncommon in the ventless trap survey. The results of the K-S test indicated that there was no significant difference in the length frequency distribution of black sea bass observed in the 2013 fall NEAMAP survey, and in the ventless trap survey during the fall months (July-September; Table 7.)

The majority of black sea bass sampled in the New Jersey recreational fishery were between 30 and 40cm (Figures 10 and 10a). In the Rhode Island and Massachusetts recreational fisheries a broader size range of black sea bass were observed, with most individuals ranging from 30 to 53cm. Intermediate sized sea bass (20 to 27cm) were sampled more often in the Massachusetts recreational fishery than in Rhode Island or New Jersey.

The length frequency distributions of black sea bass captured in the ventless trap survey were compared to the recreational fisheries for three of the survey zones; MA, RI, and NJ (Figures 11-13). In all three regions, 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 results of the Kolmogorov-Smirnov tests indicated that the length frequency distributions sampled in the recreational catch and the ventless trap survey differed significantly in each of the three survey zones that were examined (Table 8).

Estimates of total mortality that were derived independently for the four survey zones ranged from 0.74 to 2.22 using the Beverton and Holt (1956) length-based total mortality model (Table 9). Total mortality estimates from the two northern zones (MA and RI) were lower than those calculated for the two southern survey zones (VA and NJ; Table 9). When the survey data were aggregated across all four zones, the total mortality estimates ranged from 0.85 to 0.92, which were generally comparable with the total mortality estimate from the most recent stock assessment. Total mortality rates were also estimated for each survey zone using the Erhardt and Ault (1992) method, and the estimates of total mortality were nearly identical to those derived using the Beverton and Holt (1956) model (Table 9).

Discussion

During the 2013 ventless trap survey the catch rates of black sea bass varied significantly between the sampling zones (MA, RI, NJ, VA), but not within zones, supporting the stratified design. The GT2 test for pairwise comparisons found that catch rates in Rhode Island were significantly less than catch rates in the three other zones that were sampled. The variability in catch rates suggest that the productivity and abundance of black sea bass vary spatially, and that these differences should be accounted for in survey design and resource monitoring.

The size structure of black sea bass appeared to vary throughout the range of the ventless trap survey. The largest black sea bass were typically sampled in the northern range of the survey (MA and RI), but these large individuals were less common in the southern survey zones (NJ and VA).

None of the available surveys appear to be effective at sampling black sea bass throughout their entire size range. In particular, the hard bottom, complex habitat that is preferentially occupied

by black sea bass is typically undersampled during trawl surveys (Drohan et al., 2007). There were significant differences in the length frequency distributions of black sea bass observed in the ventless trap survey and those sampled on the NEFSC spring trawl survey, and the MADMF spring trawl survey. The ventless trap survey samples intermediate sized black sea bass effectively, but does not typically capture the smallest sea bass in the population. The preponderance of small sea bass (<10cm) captured during the NEAMAP Fall survey (Figure 5) suggests that this index may be most appropriate to monitor young-of-the-year abundance in the black sea bass stock. The substantially larger size distributions in the recreational fishery also suggest that the ventless trap survey may be a valuable index of recruitment (i.e., monitoring relative abundance of fish that are smaller than the size that is vulnerable to the recreational fishery). In addition, the relatively high proportion of large black sea bass in the recreational catch and MADMF spring survey suggests that these indices may be good candidates for monitoring the relative abundance of older year classes in the black sea bass population. These analyses demonstrate the importance of the fixed gear survey due to the differences in length distribution.

The estimates of total mortality derived from the ventless trap survey suggest that survival may vary throughout the range of the stock. Mortality estimates were greater for the southern survey zones, while mortality rates in the northern zones were generally in agreement with 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). Under the assumption that M = 0.4, and is constant throughout the range of the stock, the results of this analysis suggest that F is low in RI (0.1 – 0.13), moderate in MA (0.34 – 0.47), and higher in NJ and VA (1.44 – 1.82). When the data are aggregated across all four survey zones, the stock wide estimates of F derived from the ventless trap survey are slightly higher (0.45 – 0.52) than the estimate of 0.41 that was calculated by the most recent stock assessment (NEFSC, 2011). Nearly identical estimates of total mortality were obtained using the Ehrhardt and Ault (1992) method, 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.

Large sea bass (>50cm) were not captured in the NJ zone during the ventless trap survey, and were also not sampled in the 2013 NJ recreational fishery (Figure 7). Similarly, only one black sea bass was observed > 50cm in the VA zone of the ventless trap survey in 2013. The paucity of older, larger fish in the southern survey zones could result from higher exploitation rates in these regions, greater rates of M, emigration of the larger fish to more northern areas, slower growth, gear selectivity, or some combination of these factors.

The Beverton and Holt (1956) length based total mortality model is 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 available data suggest that L_∞ is actually 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.

Assumptions of the relatively simple Beverton Holt mortality estimator should be considered in interpretations and comparisons to stock assessment models. The Beverton Holt model assumes 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).

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 addition, the 2014 survey will expand to include a fifth sampling zone off of New York. The addition of this sampling zone should help to further elucidate the regional differences in growth, size structure, and mortality within the stock.

Acknowledgements

Gary Shepherd provided many helpful comments and suggestions during the data analysis, and his insights were valuable to this report. 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 and fall bottom trawl surveys 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 2013 Rhode Island Department of Environmental Management semi-annual 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.

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.

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

Tables

Table 1. Summary of monthly sampling intensity at each survey zone during the 2013 ventless trap survey for black sea bass. The number of stations sampled each month is provided in the table. 30 ventless traps (3 trawls of 10 traps each) were deployed at each station during the 2013 survey.

Survey Zone	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
VA	4	4	4	4	4	-	20
NJ	-	2	2	4	1	-	9
RI	-	1	5	5	5	4	20
MA	-	2	3	4	6	5	20

Table 2. Summary of black sea bass catches (black sea bass/trawl) at each of the four zones that were sampled during the 2013 ventless trap survey.

Zone	Stations	Number of black sea bass	mean catch/trawl	median catch/trawl	min. catch	max. catch
MA	60	12375	206.3	185.5	58	494
VA	60	10022	167.0	123.5	19	589
RI	60	6019	100.3	91.5	23	243
NJ	27	5943	220.1	218	43	529

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 is shown, and significant results are denoted with an *.

	NJ	MA	VA	RI
NJ	-	-	-	-
MA	13.86	-	-	-
VA	53.08	39.21	-	-
RI	119.79*	105.93*	66.72*	-

Table 4. Observed length frequency distribution of black sea bass in the four survey zones during the 2013 ventless trap survey, and the aggregated length frequency for black sea bass observed in all four survey zones.

Length	VA	NJ	RI	MA	Total
13	0	0	0	1	1
14	0	0	0	0	0
15	0	0	0	0	0
16	0	1	1	1	3
17	0	6	5	5	16
18	8	29	42	21	100
19	68	216	81	110	475
20	463	484	249	282	1478
21	824	831	486	735	2876
22	1052	723	666	1151	3592
23	1050	647	831	1381	3909
24	1065	511	755	1399	3730
25	901	480	614	1229	3224
26	869	262	363	964	2458
27	648	569	270	748	2235
28	467	325	141	520	1453
29	602	224	111	429	1366
30	517	199	82	359	1157
31	421	118	99	303	941
32	300	111	101	334	846
33	209	61	96	352	718
34	180	62	94	358	694
35	126	28	109	314	577
36	79	20	93	239	431
37	60	15	94	190	359
38	41	11	89	166	307
39	21	3	76	130	230
40	24	5	62	77	168
41	9	0	49	87	145
42	6	1	58	82	147
43	5	0	41	63	109
44	3	1	43	49	96
45	1	0	29	69	99
46	1	0	27	40	68
47	0	0	18	47	65
48	1	0	23	34	58
49	0	0	17	36	53
50	0	0	14	12	26
51	0	0	9	19	28
52	0	0	12	17	29
53	1	0	11	11	23
54	0	0	10	8	18
55	0	0	12	1	13
56	0	0	7	1	8
57	0	0	11	1	12
58	0	0	3	0	3
59	0	0	1	0	1
60	0	0	3	0	3
61	0	0	3	0	3
62	0	0	0	0	0
63	0	0	1	0	1
64	0	0	3	0	3
65	0	0	1	0	1
66	0	0	3	0	3
Sum	10022	5943	6019	12375	34359

Table 5. Summary of the length frequency distribution of black sea bass sampled in each of the four survey zones during the 2013 ventless trap survey.

Zone	Number of sea bass	mean length (cm)	median length (cm)	min. length (cm)	max. length (cm)
MA	12375	27.4	25	13	57
VA	10022	25.86	25	18	53
RI	6019	26.99	24	16	66
NJ	5943	24.41	24	16	44

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. Differences in the mean length (cm) between pairs of survey zones are shown, and significant results are denoted with an *.

	NJ	MA	VA	RI
NJ	-	-	-	-
MA	2.99*	-	-	-
VA	1.45*	1.54*	-	-
RI	2.58*	0.41*	1.13*	-

Table 7. Kolmogorov-Smirnov test results. The factors MA, RI, NJ and VA are zones that were surveyed during the ventless trap survey. Ventless Traps is the aggregate length frequency distribution of all black sea bass that were sampled in the 2013 ventless trap survey. NEFSC Spring is the 2013 Northeast Fisheries Science Center spring bottom trawl survey. MADMF Spring is the 2013 Massachusetts Division of Marine Fisheries Spring bottom trawl survey. NEAMAP Spring and NEAMAP Fall refers to the 2013 Northeast Area Monitoring and Assessment Program spring and fall trawl surveys. RIDEM refers to the 2013 spring and fall Rhode Island Department of Environmental Management bottom trawl surveys.

Factors	D	p-value
MA-RI	0.195	0.39
MA-NJ	0.199	0.3
MA-VA	0.054	1
RI-NJ	0.126	0.85
RI-VA	0.206	0.29
NJ-VA	0.163	0.51
Ventless Traps (All zones) - MADMF Spring	0.207	0.05
Ventless Traps (MA only from May-June) - MADMF Spring	0.172	0.16
Ventless Traps - NEFSC Spring	0.302	0.0009
Ventless Traps (May-June) - NEFSC Spring	0.281	0.002
Ventless Traps - NEAMAP Spring	0.358	<0.0001
Ventless Traps (April-June) - NEAMAP Spring	0.336	0.0001
Ventless Traps-NEAMAP Fall	0.137	0.414
Ventless Traps (July-September) - NEAMAP Fall	0.136	0.428
Ventless Traps (RI only) - RIDEM trawl survey	0.398	<0.0001
Ventless Traps (NJ only) - NJDEP trawl survey	0.507	<0.0001

Table 8. Kolmogorov-Smirnov test results. The length frequency distributions observed in three survey zones during the 2013 ventless trap survey were tested against the length frequency distributions of black sea bass observed in the recreational fishery in that zone.

Factors	D	p-value
Venless Traps in MA - MA Recreational	0.766	< 0.001
Ventless Traps in RI - RI Recreational	0.867	< 0.001
Ventless Traps in NJ - NJ Recreational	0.922	< 0.001

Table 9. 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	35.1	35.8	37.8
RI	37.6	38.8	40.1
NJ	31.3	33.0	34.8
VA	31.7	33.4	35.2
MA and RI	35.8	37.2	38.6
NJ and VA	31.6	33.3	35.1
MA, RI, NJ and VA	34.1	36.0	37.8

Z estimates (Beverton and Holt 1956)

Survey Zone	Lc = 28	Lc = 30	Lc = 32
MA	0.74	0.87	0.81
RI	0.50	0.52	0.53
NJ	2.09	2.13	2.22
VA	1.84	1.91	1.90
MA and RI	0.66	0.67	0.70
NJ and VA	1.89	1.96	1.96
MA, RI, NJ and VA	0.92	0.88	0.85

Z estimates (Erhardt and Ault 1992)

Survey Zone	Lc = 30
MA	0.87
RI	0.49
NJ	2.13
VA	1.91

Figures

Figure 1. Average monthly catch/trawl of black sea bass observed in all four zones in 2013.

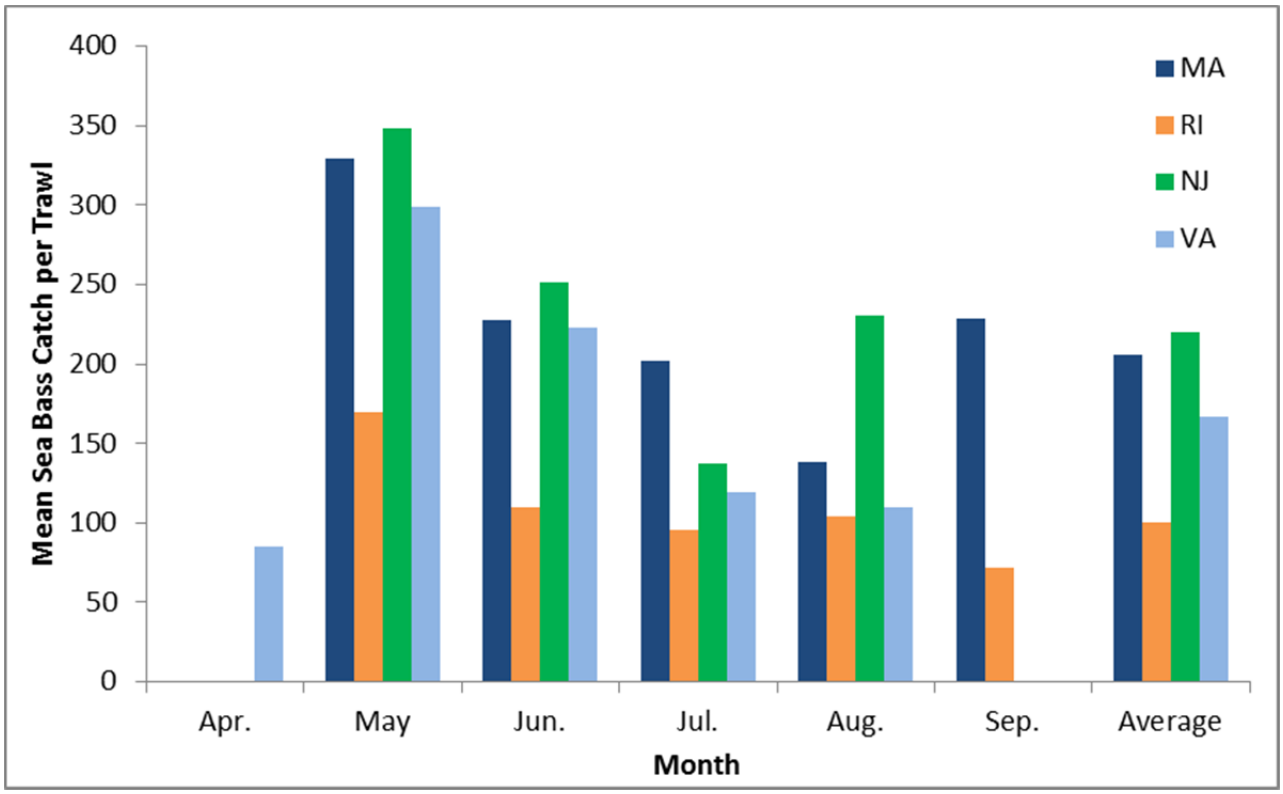


Figure 2. Proportional length-frequency distribution of black sea bass sampled at the four survey zones during the 2013 ventless trap survey.

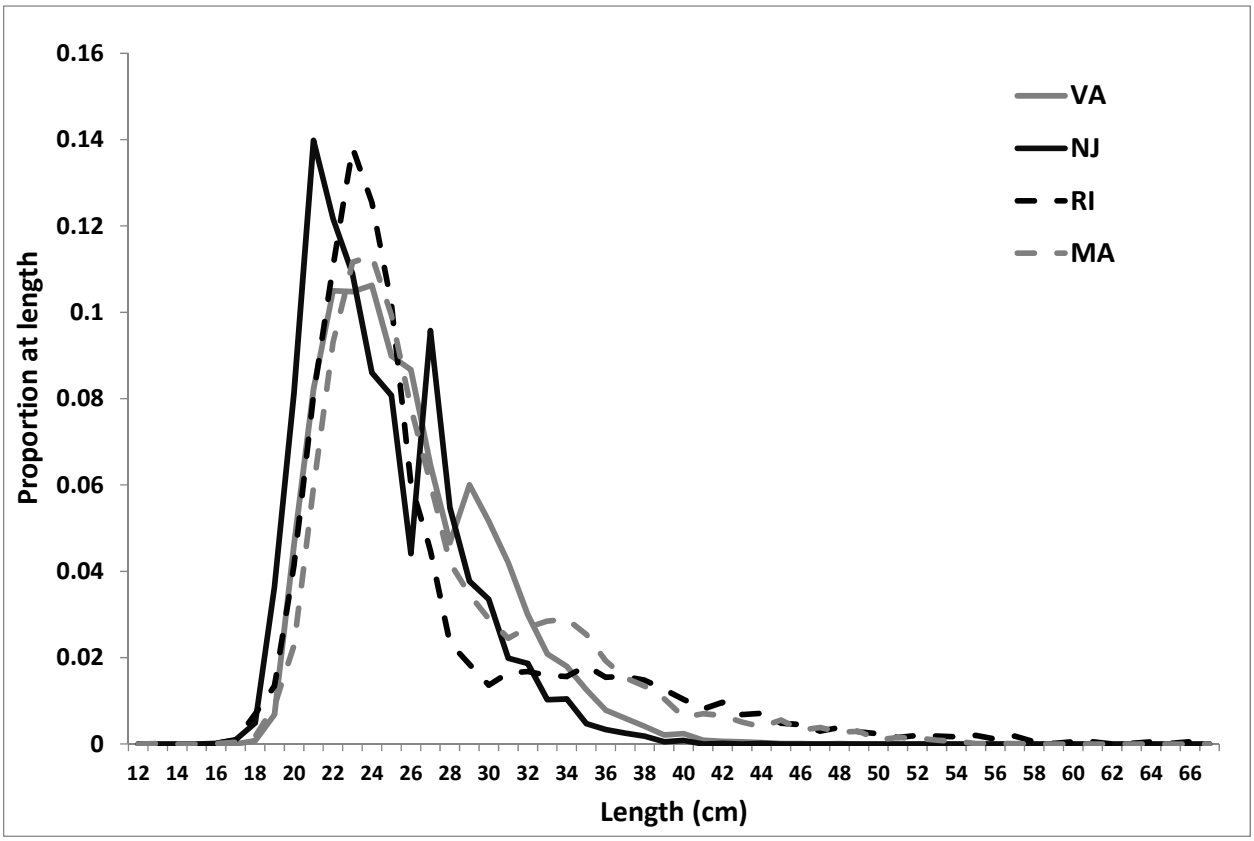


Figure 3. Proportional length-frequency distribution of black sea bass sampled at the two northern survey zones (MA and RI) and at the two southern survey zones (NJ and VA) during the 2013 ventless trap survey.

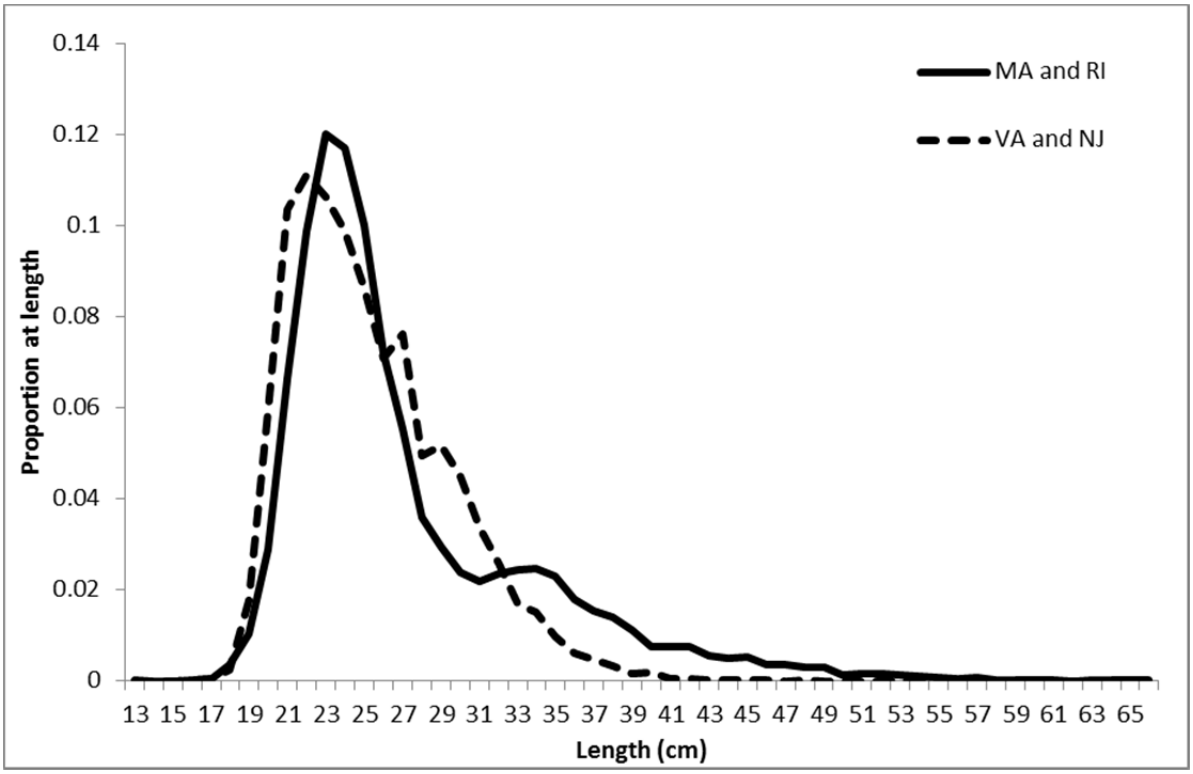
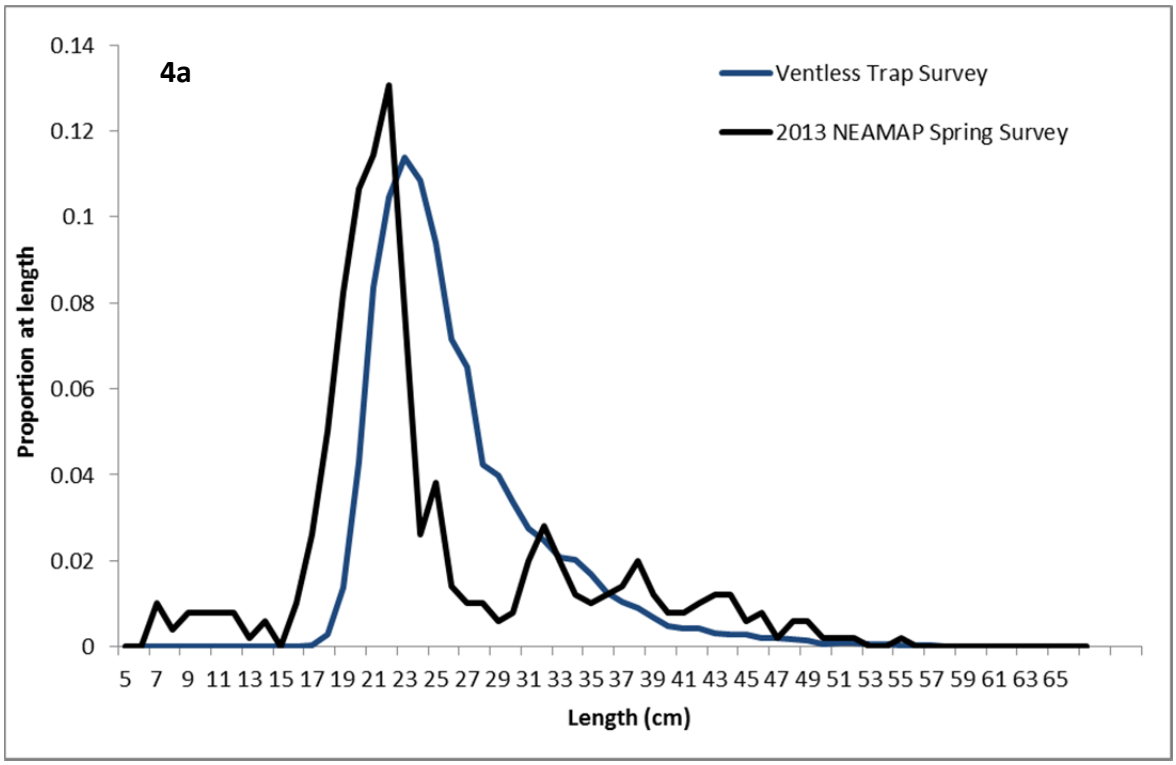


Figure 4. Proportional length frequencies of black bass sampled in the ventless trap survey between April and September and black sea bass observed in the 2013 NEAMAP spring trawl survey (Figure 4a). Proportional length frequencies of black bass sampled in the ventless trap survey between April and June and black sea bass observed in the 2013 NEAMAP spring trawl survey (Figure 4b).



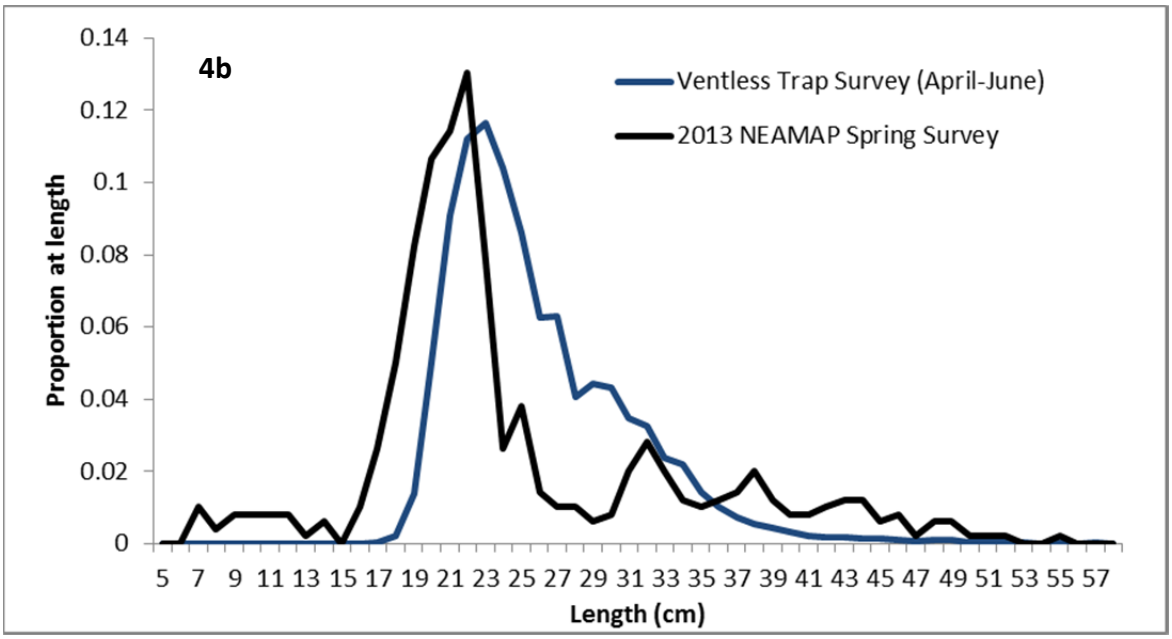
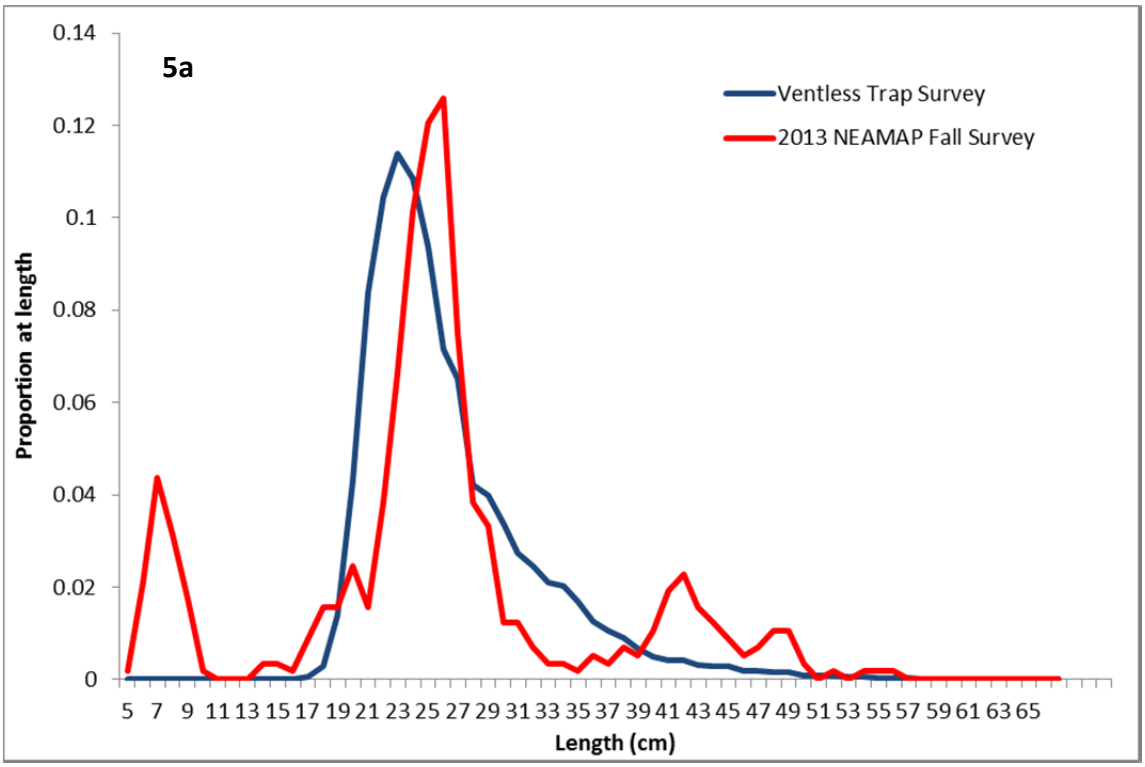


Figure 5. Proportional length frequencies of black bass sampled in the ventless trap survey (April-September) and the 2013 NEAMAP fall trawl survey (Figure 4a). Proportional length frequencies of black bass sampled in the ventless trap survey during the fall months (July-September) and the 2013 NEAMAP fall trawl survey (Figure 4b)



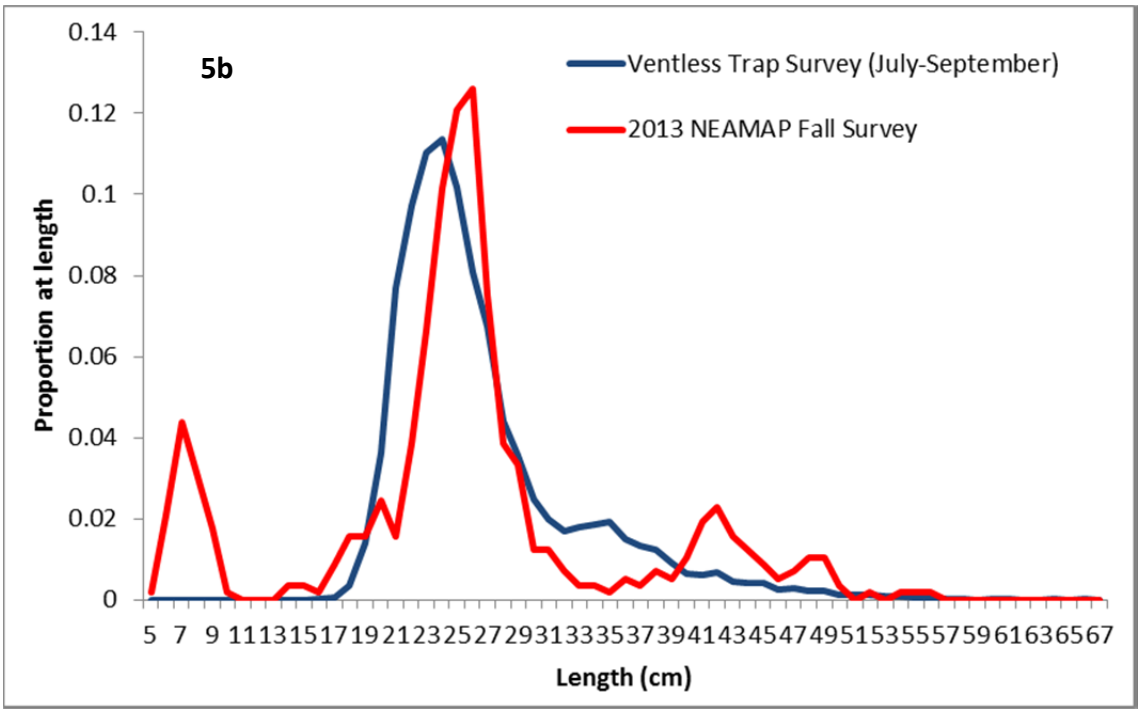
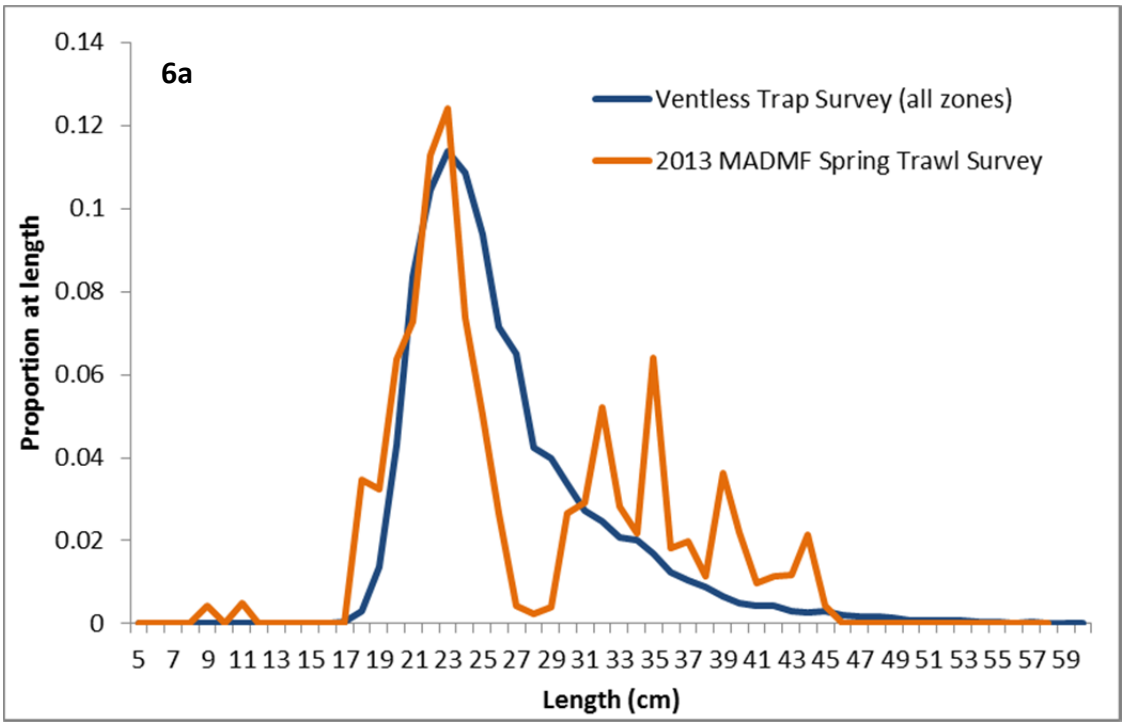
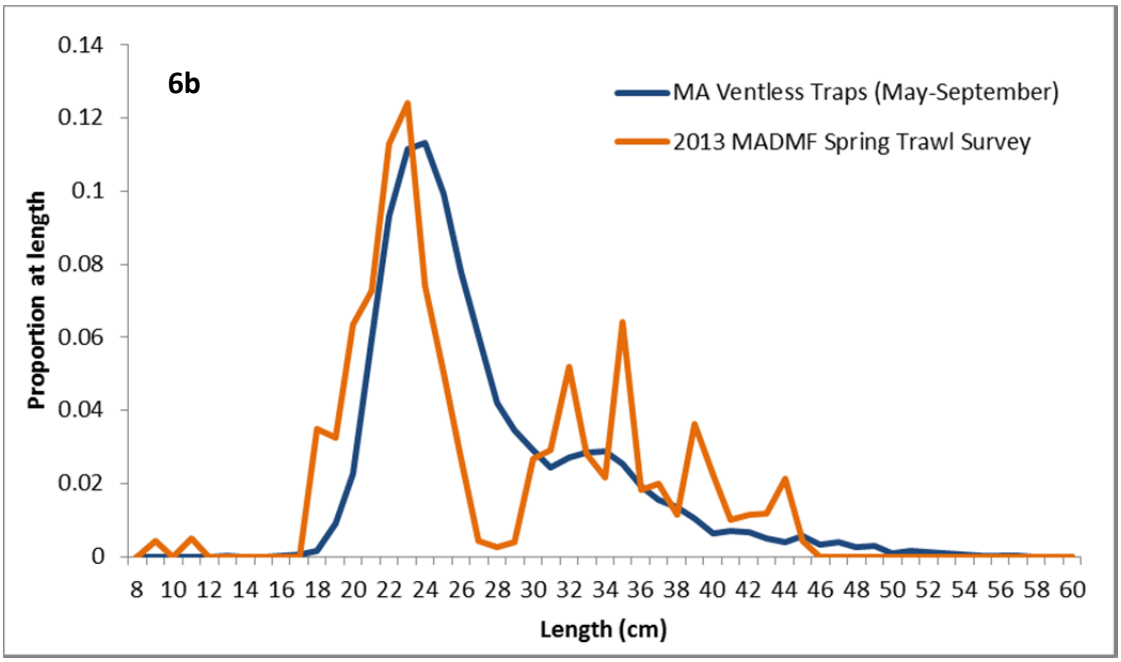


Figure 6a, 6b, and 6c. Proportional length frequencies of black bass sampled in the 2013 MADMF spring trawl survey and the ventless trap survey (all four zones combined; Figure 5a). Proportional length frequencies of black sea bass samples in the 2013 MADMF spring trawl survey and the ventless trap survey (MA zone only from May from September; Figure 5b). Proportional length frequencies of black sea bass samples in the 2013 MADMF spring trawl survey and the ventless trap survey (MA zone only in May and June; Figure 5c).





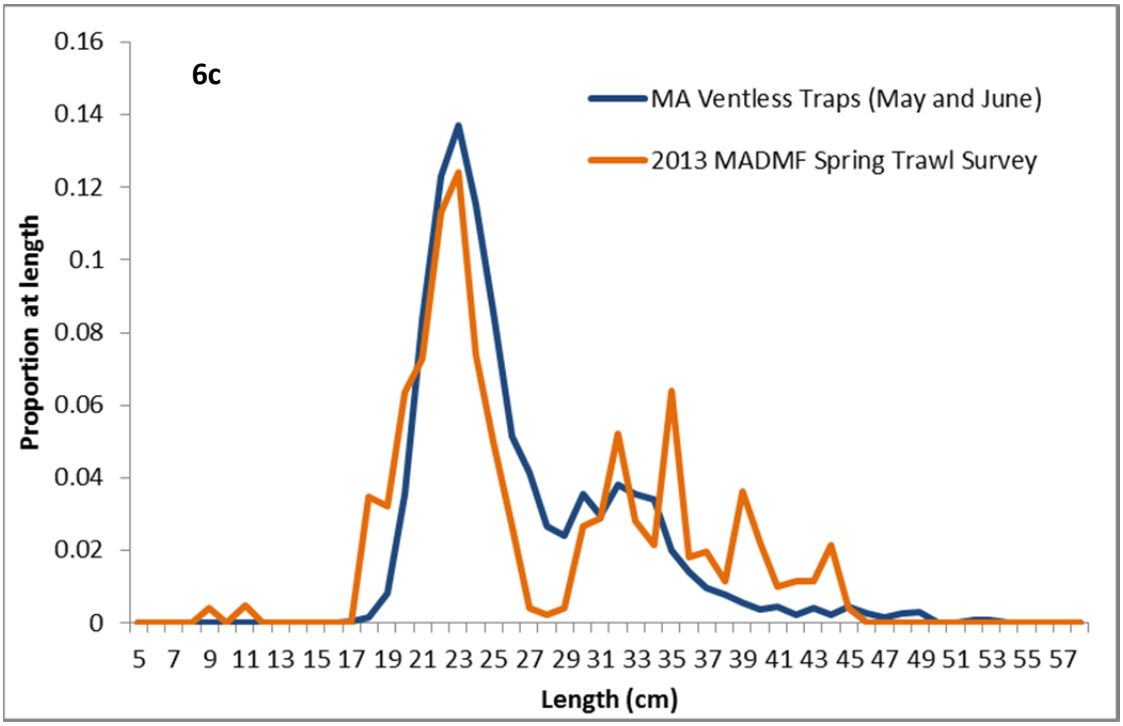
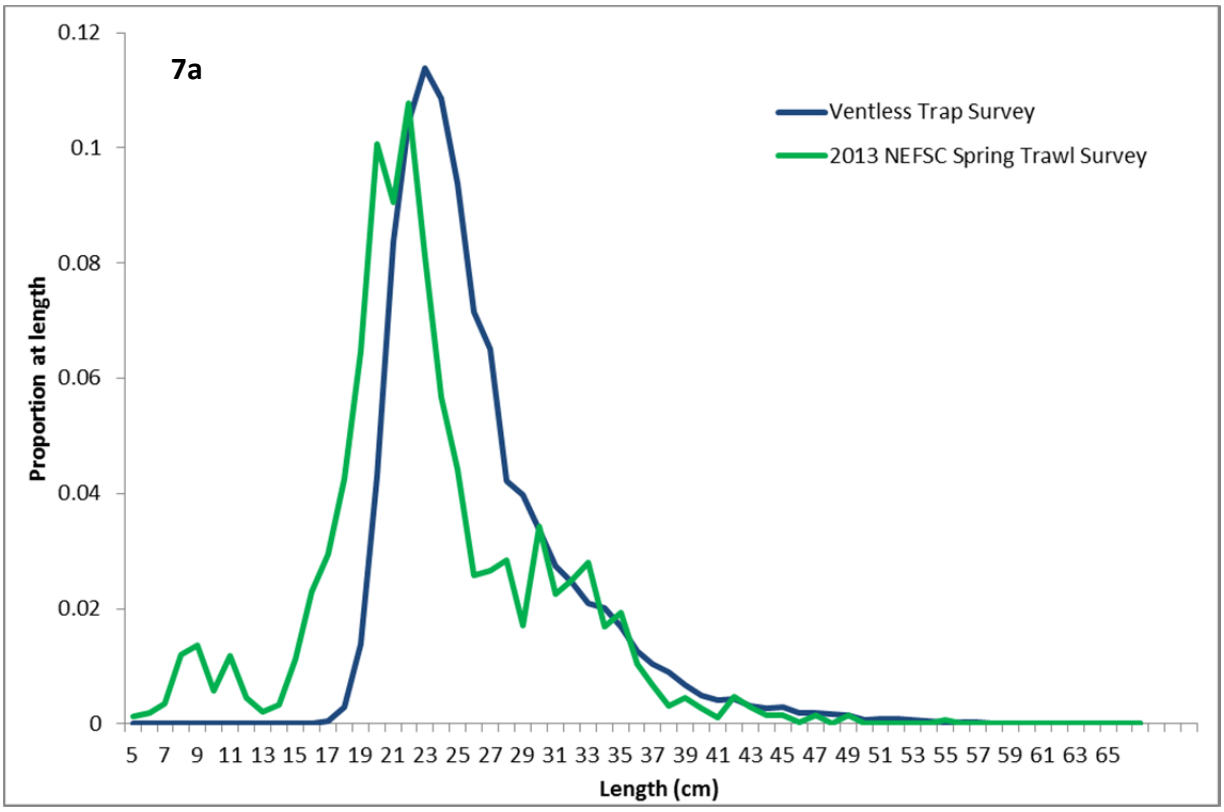

6c
MA Ventless Traps (May and June)
2013 MADMF Spring Trawl Survey
Proportion at length
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57
Length (cm)

Figure 7a and 7b. Proportional length frequencies of black bass sampled between April and September in the ventless trap survey and the 2013 NEFSC spring trawl survey (Figure 6a). Proportional length frequencies of black bass sampled between April and June in the ventless trap survey and the 2013 NEFSC spring trawl survey (Figure 6b).



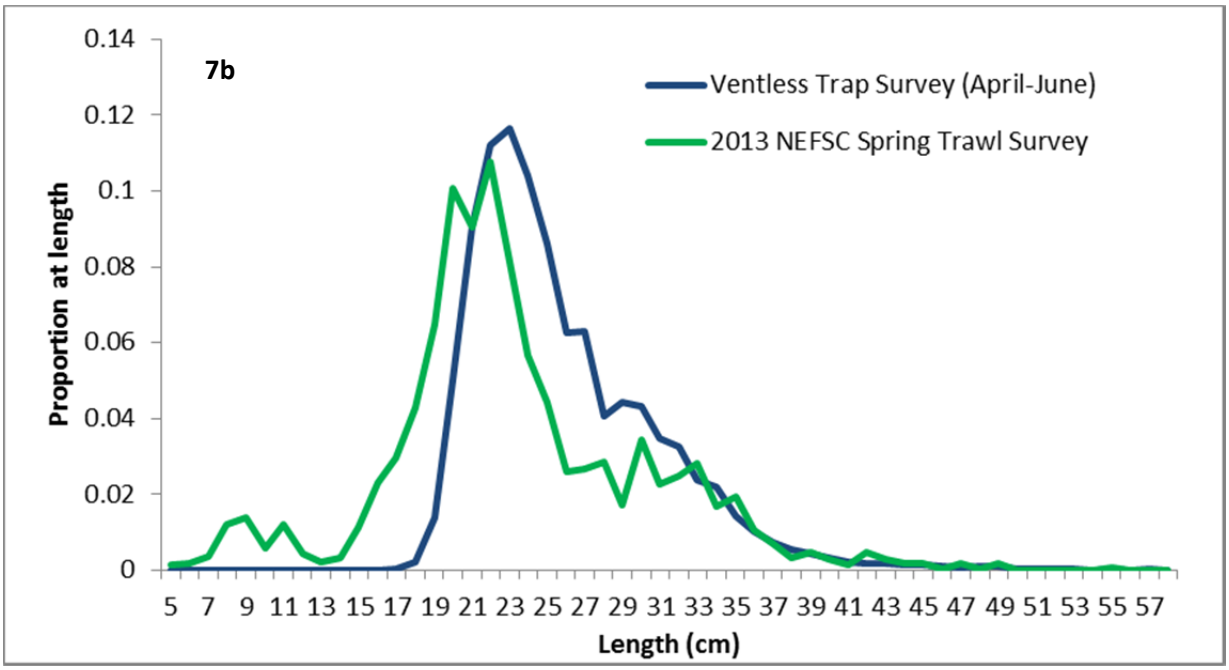


Figure 8. Proportional length frequencies of black bass sampled in the RI zone during the ventless trap survey and the 2013 Rhode Island Department of Environmental Management spring and fall trawl survey.

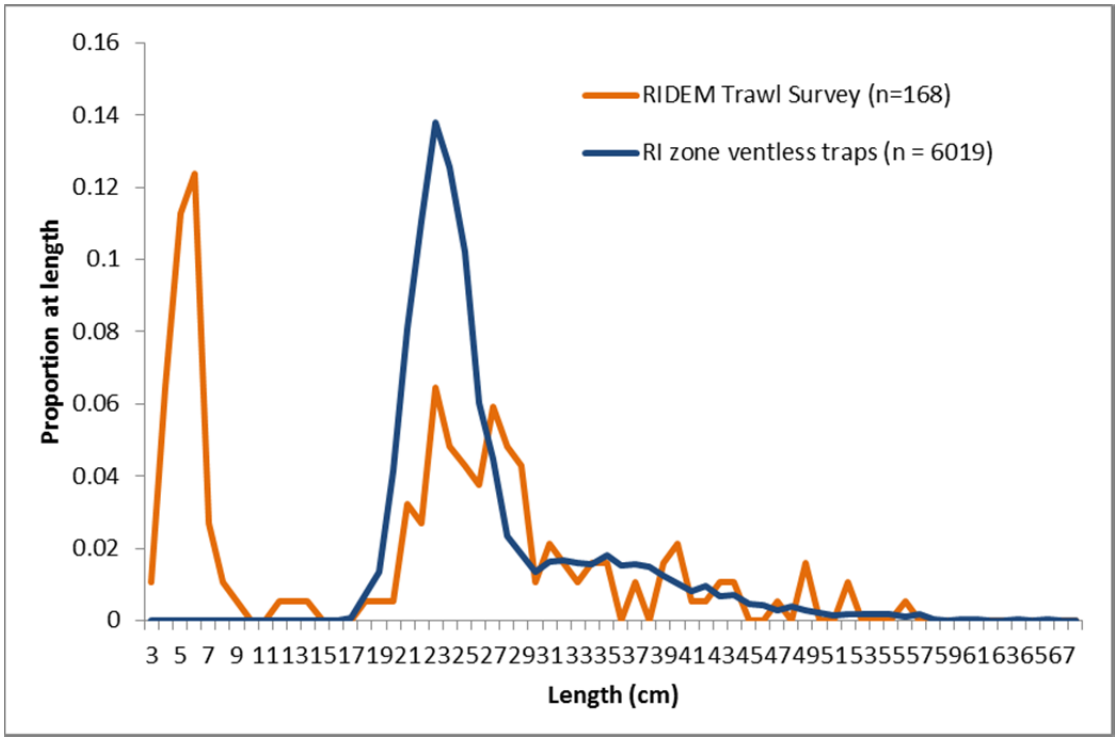
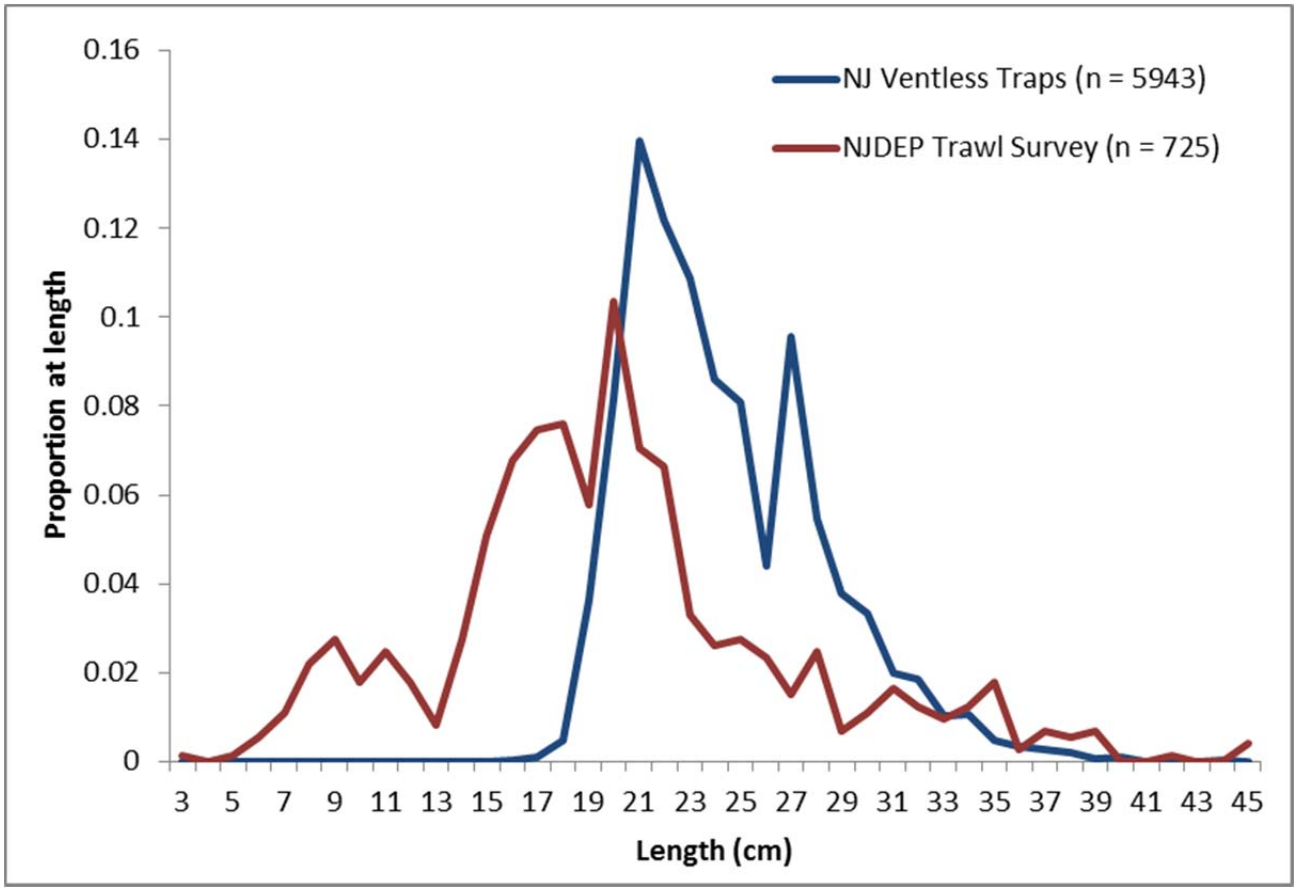
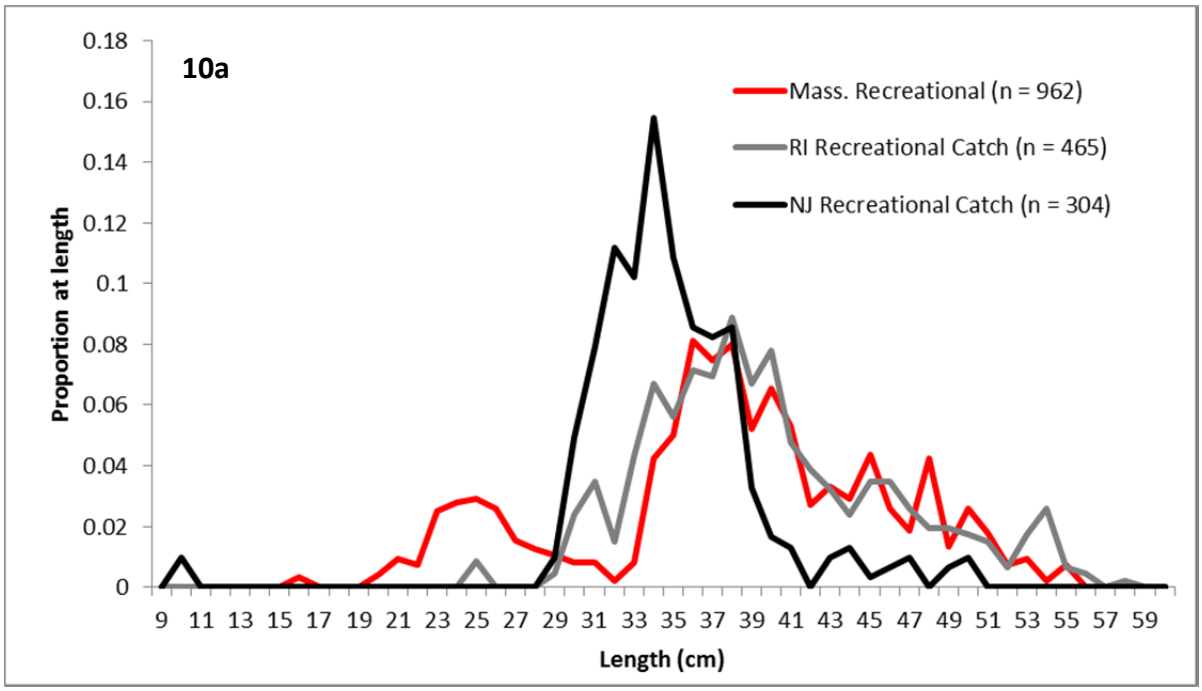


Figure 9. Proportional length frequencies of black bass sampled in the NJ zone during the ventless trap survey and the 2013 Ney Jersey Department of Environmental Protection trawl survey.



Figures 10a and 10b. Proportional length frequency distributions of black sea bass observed in the recreational catches in Massachusetts, Rhode Island, and New Jersey in 2013 (10a), and proportional length frequency distribution of black sea bass ≥40cm observed in the recreational catches in each state (10b).



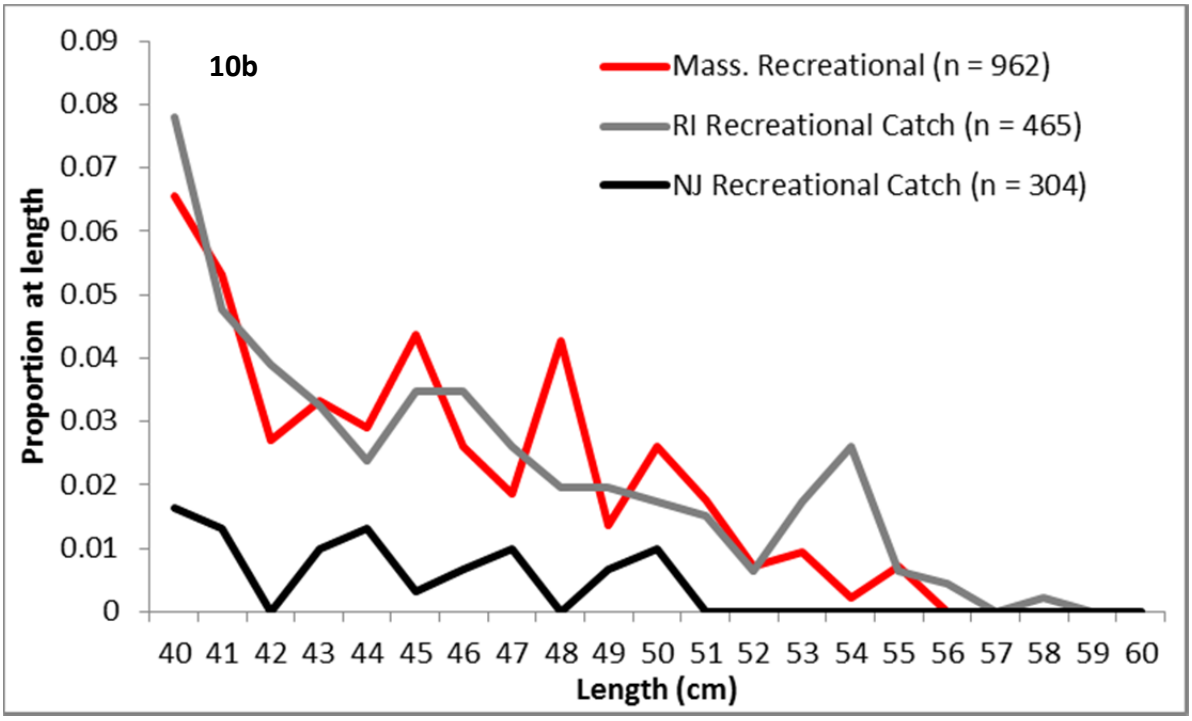


Figure 11. Proportional length frequency distributions of black sea bass observed in the Massachusetts zone during the ventless trap survey in 2013, and black sea bass sampled on board recreational party vessels in Massachusetts.

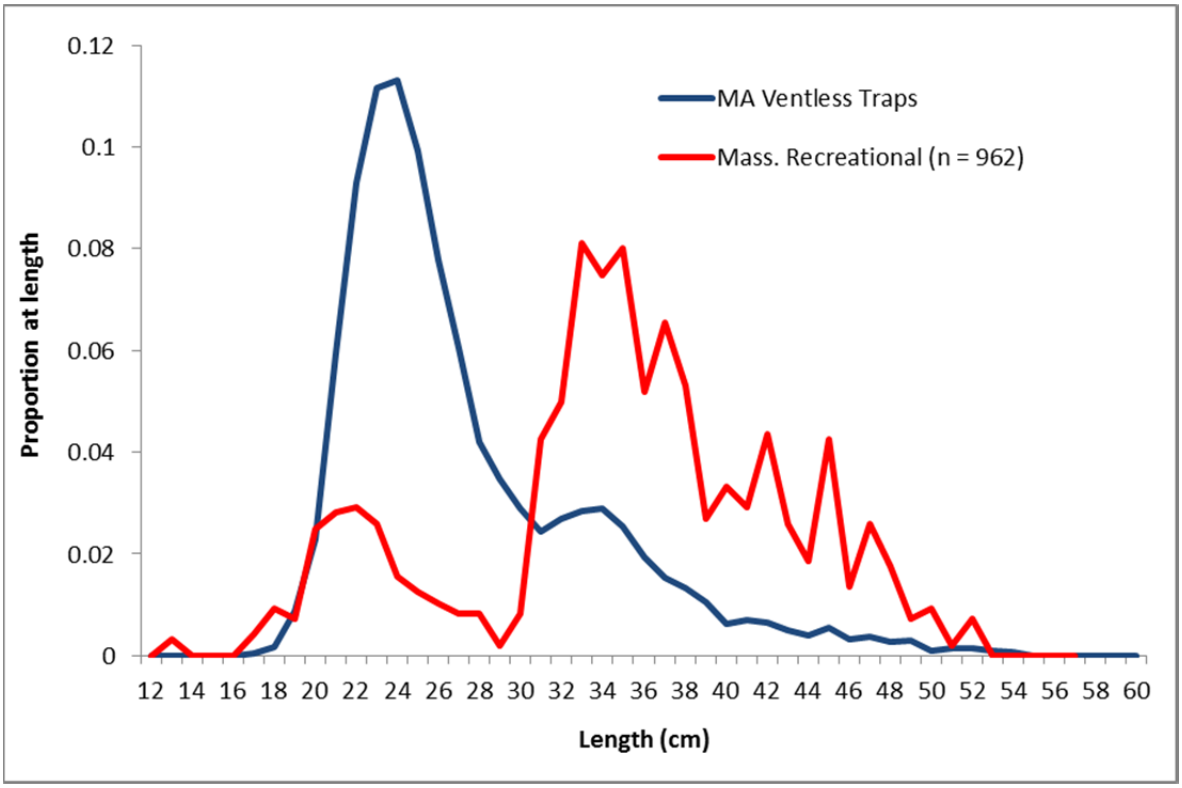


Figure 12. Proportional length frequency distributions of black sea bass observed in the Rhode Island zone during the ventless trap survey in 2013, and black sea bass sampled on board recreational party vessels in Rhode Island.

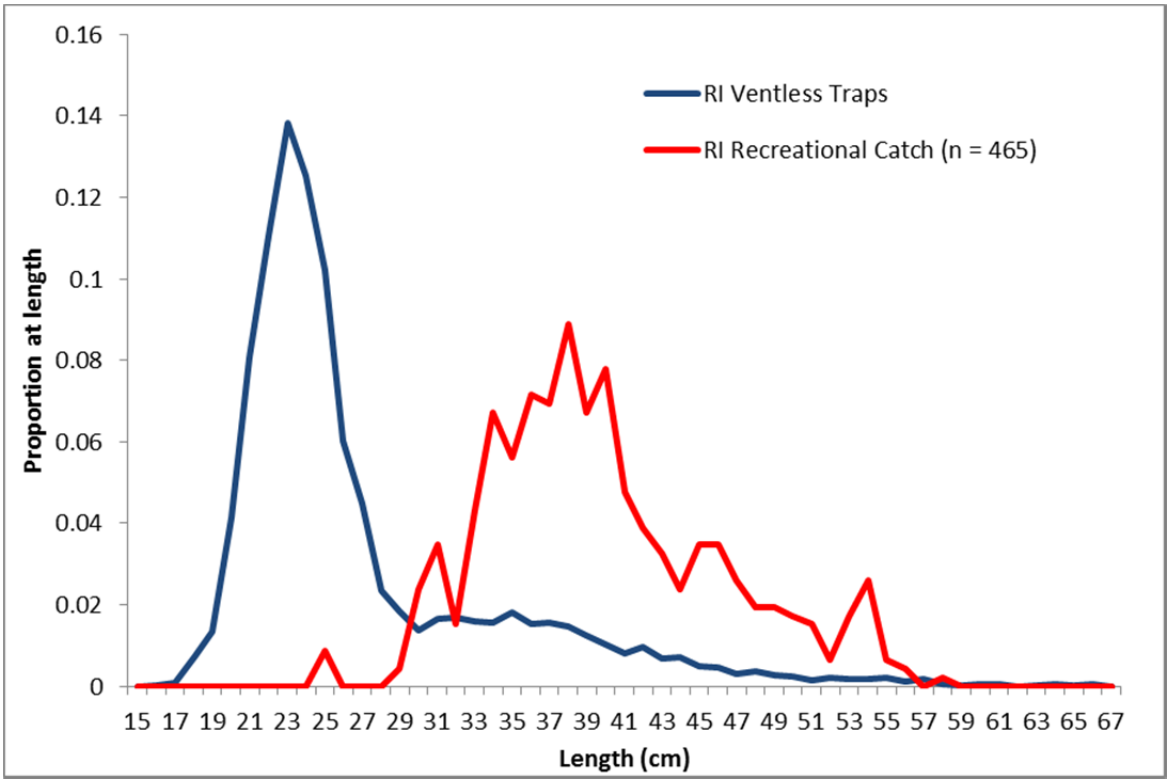
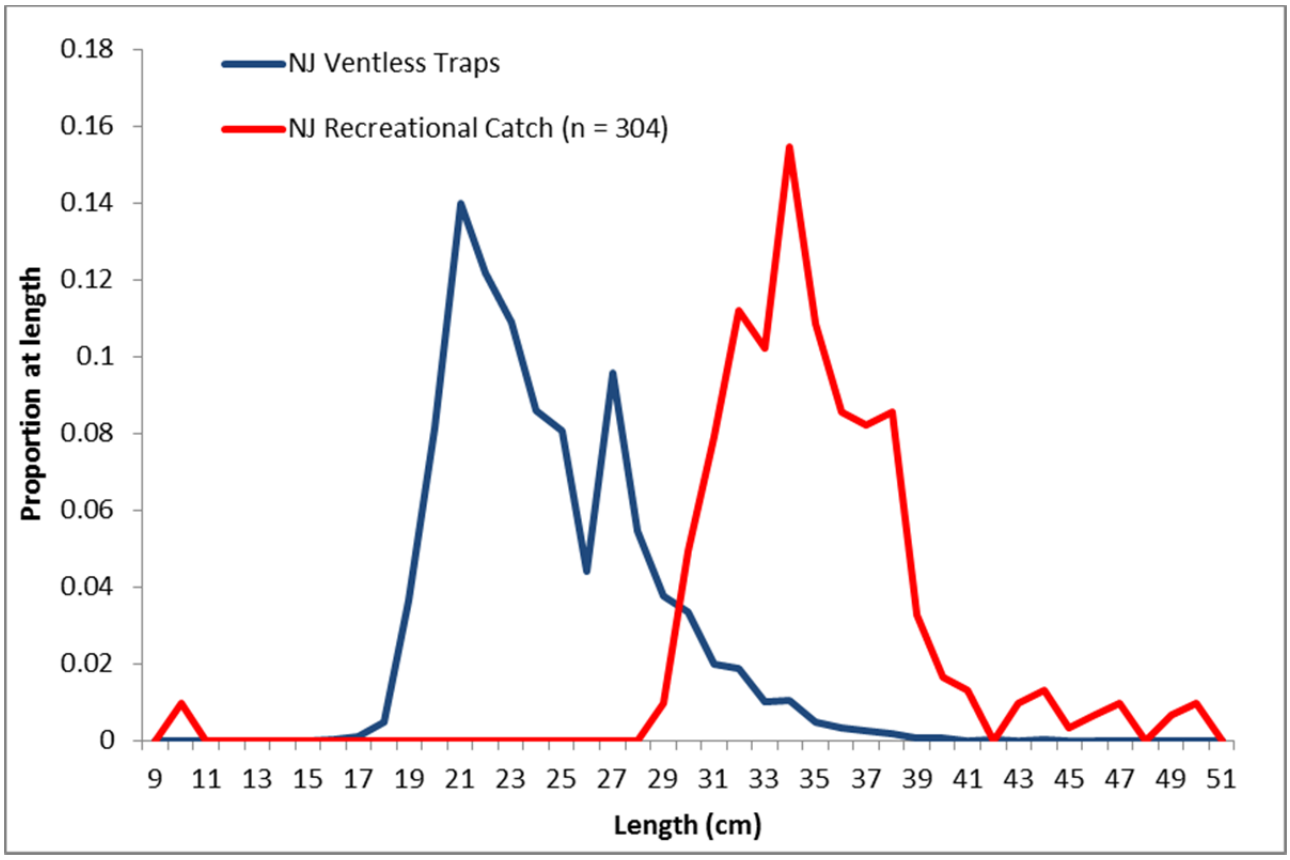



Figure 13. Proportional length frequency distributions of black sea bass observed in the New Jersey zone during the ventless trap survey in 2013, and black sea bass sampled on board recreational party vessels in New Jersey.