FINAL REPORT

Northeast Fisheries Science Center

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D. Project Title: 2012 Fishery Independent Scup Survey of Hard Bottom Areas in Southern New England Waters

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PROJECT SUMMARY

This was the 9th year of the Research Set-Aside scup survey project conducted by the University of Rhode Island and participating fishermen to provide an alternative but reliable index of abundance for scup using fixed gear and to provide an annual measure of fishing mortality on scup stock in Southern New England. The use of unvented scup pots was the mean in developing the index of abundance used in areas between Point Judith, RI and Buzzards Bay, MA. Fishing vessels, F/V *Drake, Old Coot,* and *Captain Robert* from Rhode Island and F/V *Evangeline* from Massachusetts sampled from June to October 2012. The Unvented scup pots were fished on fifteen hard bottom areas divided in 3 strata; an Eastern, Mid-Western, and Western Expansion stratum (Table 1; Figure 1). Scup and black sea bass were collected from each site utilizing standard fish pots (2 x 2 x 2 foot) made with 1½ x 1½ inch coated wire mesh. Pots were unvented and therefore have the capability to retain all size classes of scup and black sea bass. All scup and black sea bass were measured from each trap haul. A total of 16,457 scup (Figure 2) and 4,262 black sea bass (Figure 3) were captured in the unvented pots in the three selected areas in Massachusetts and Rhode Island in 2012.

Table 1. Sampling site coordinates.

Eastern Sampling Sites

1	West Chop	41 29 30 N, 70 35 W
2	Cape Pogue	41 25 N, 70 26 W
3	East Chop	41 23 N, 70 27 W
4	Horseshoe Shoals	41 30 N, 70 22 W
5	Nortons Rock	41 26 30 N, 70 41 20 W

Mid-Western Sampling Sites

1	Western End of Buzzards Bay (Old Cock Rock)	41 28 N, 71 01 W
2	Browns Ledge	41 22 N, 71 04 W
3	West or South of Nomans Island	41 26 N, 71 01 W
4	South of Sakonnet Point, RI / Elisha Ledge	41 26 N, 71 01 W
5	South of Newport, RI (Elbow Ledge)	41 26 N, 71 16 W

Far-Western Sampling Sites

1	Narrow River Ledge, Mouth of Narragansett Bay	41 27 N, 71 24 W
2	Point Judith Lighthouse	41 20 N, 71 29 W
3	Southeast Lighthouse, Block Island	41 09 N, 71 33 W
4	Bluff Head Ledge off Block Island	41 10 N, 71 40 W
5	Charlestown Breachway	41 0 N, 71 40 W

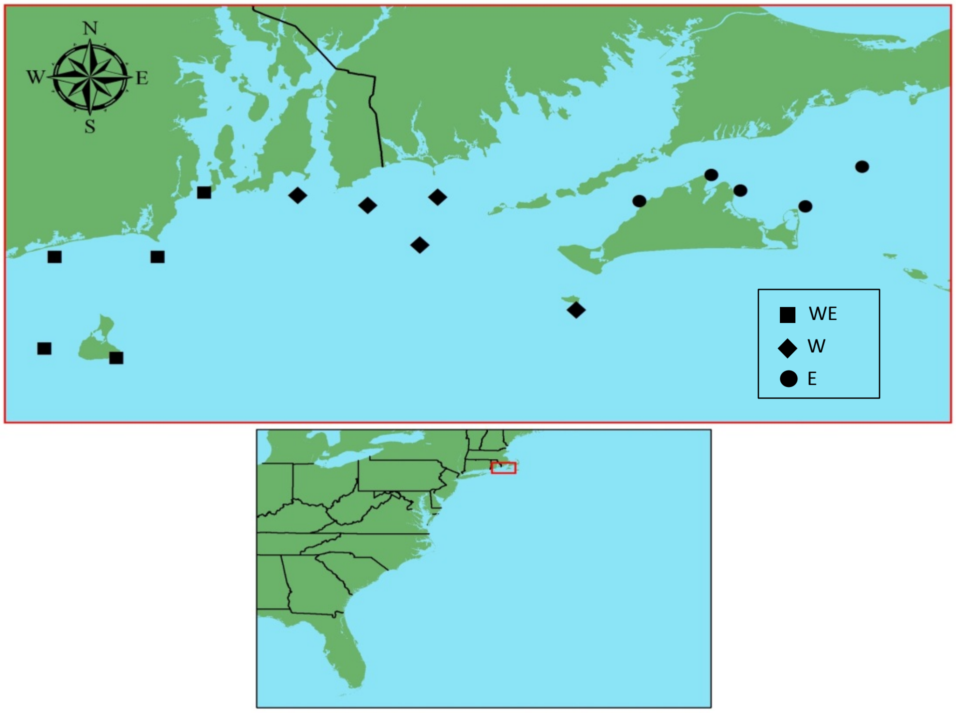

Figure 1. Map of sampling sites.

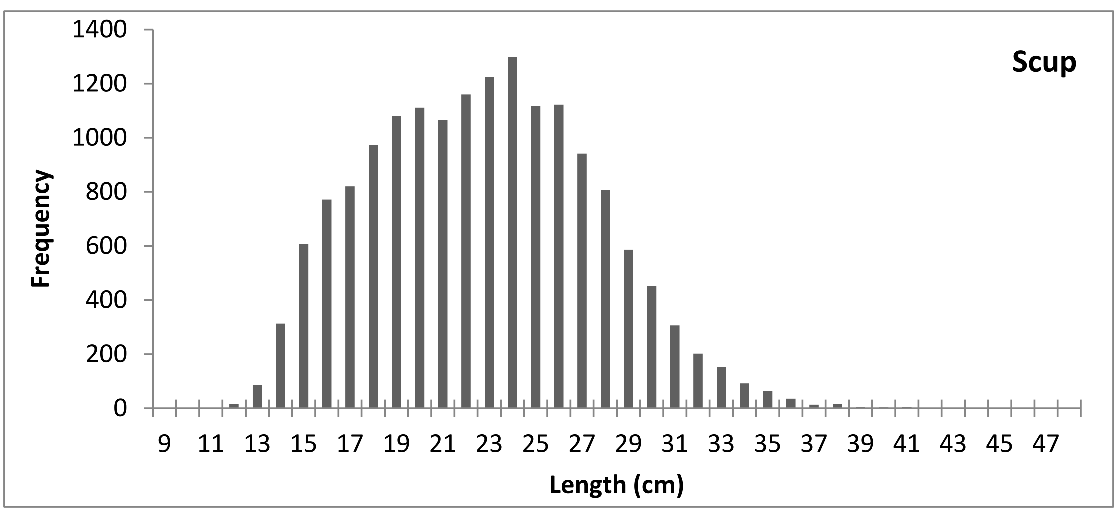

Figure 2. Length frequency of scup from ventless pot data from 2012.

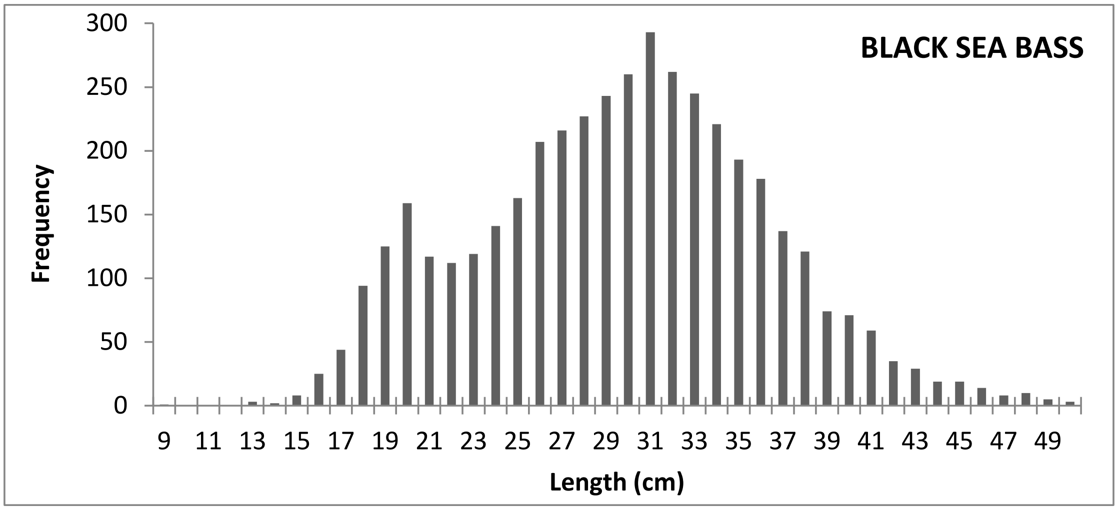

Figure 3. Length frequency of black sea bass from ventless pot data from 2012.

A comprehensive analysis which included data collected from 2005 to 2012 was conducted by Greg DeCelles, Adam Barkley, and Dr. Steve Cadrin from the University of Massachusetts, School for Marine Science & Technology. The objective of their analysis was to evaluate the efficacy of the ventless trap survey serving as a stock abundance indicator for the Northeast US scup stock. The methods used consisted of five criteria: (1) internal consistency across years for tracking annual cohorts; (2) consistency between URI ventless trap survey and other available surveys; (3) the ability to track the cohort effect, age effect and year effect within RI trap survey index; (4) evaluating parameters that are derived from the survey-based analysis (SURBA); and (5) evaluating performance of survey data as a tuning index in the scup stock assessment model. This final report is based almost entirely on the work done by DeCelles, Barkley, and Cadrin and their report is included below.

Mid-Atlantic Research Set-Aside (RSA) Report

2012 Fishery Independent Scup Survey of Hard Bottom Areas in Southern New England Waters

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Background

Scup

The scup stock in the Northeast US had been considered to be a data-poor stock, because there was limited reliable biological information and little fishery dependent and independent information for the fishery management (Vasconcellos and Cochrane 2005). An age structured assessment program (ASAP) was successfully applied in the latest NEFSC scup stock assessment (Miller et al. 2009); but more data are required in order to estimate the abundance of older scup more accurately (Terceiro 2010).

A fixed-station ventless trap survey has been conducted by the University of Rhode Island to monitor the relative abundance of scup in areas between Sakonnet Point, RI and Buzzards Bay since 2005 (Borden et al. 2008). A research recommendation of the last stock assessment was to incorporate the Rhode Island trap survey in future scup stock assessments (Terceiro 2010). However, the efficacy of the survey data serving as a stock abundance indictor for the Northeast US scup stock has not been evaluated.

Selection of survey indices for stock assessments is a critical analytical decision that benefits from performance criterion. In this study, we developed a set of systematic methods to analyze the Rhode Island ventless trap survey data. The methods developed in this study could also be applied to other fisheries species, e.g. winter flounder in northeast US. This report updates previous analyses designed to test the effectiveness of the trap survey as a measure of relative abundance and age composition.

Black Sea Bass

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). A fix-station ventless trap survey was conducted to monitor the relative abundance of scup and sea bass in areas between Sakonnet Point, RI and Buzzard Bay (Borden et al. 2008). This report updates previous analyses of the trap survey to evaluate its effectiveness as a measure of relative abundance and size composition.

Methods

Scup

Survey indices were provided by RIDEM including the mean catch of scup by age, from 2005 to 2012 (Table 1). The 2010 indices were updated with revised age composition data. The 2011 age-based indices were derived from pooled age-length keys that included age composition data from the 2011 NMFS trawl survey (fall and spring) and the 2010 RI commercial fish trap survey. Rhode Island did not sample or age fish in 2011, so the 2010 Rhode Island samples were used as a proxy for the purpose of representing larger fish caught in the ventless trap survey.

Performance of the RI trap survey data was evaluated using two criteria 1) internal consistency across years for tracking annual cohorts; and 2) the ability to track the cohort effect, age effect, and year effect within RI trap survey index. Analysis in previous years also included: 3) consistency between URI ventless trap survey and other available surveys; 4) evaluating parameters that are derived from the survey-based analysis (SURBA); and 5) evaluating performance of survey data as a tuning index in the scup stock assessment model. However, updated information from other surveys and the fishery were not available to for criteria 3-5 this year. The analyses for the 2012 data are consistent with the work performed last year, updated with an additional year of data.

1. Cohort tracking – Survey indices of abundance typically have high noise-to-signal ratios, because many fish stocks like scup have patchy spatiotemporal distributions, and sample sizes (i.e., number of stations) are low compared to the total number of possible samples. The value of survey indices can be evaluated based on how well they reflect trends in abundance:

1) $I_{y,a} = N_{y,a} q_a e^{\varepsilon_y}$

… where $I_{y,a}$ is an observed survey index for age a in year y, $N_{y,a}$ is the underlying population abundance of age a in year y, q_a is the survey catchability for age a (the proportion of fish in the sampled area caught by the survey) and ε_y is an annual deviation in year y that represents random error, measurement error, or noise. Measurement errors in survey indices of fish stocks are often assumed to be multiplicative, justifying a lognormal error structure. For example, the stock assessment model applied to scup (Legault and Restrepo 1998) assumes lognormal measurement error. Therefore, the evaluation of scup trap survey indices were based on log transformed estimates:

2) $$I_{y,a} = Ln(\bar{x}_{y,a})$$

… where $\bar{x}_{y,a}$is the mean number of scup per trap per day.

The utility of a survey for stock assessment can be evaluated by determining its signal-to-noise ratio using several methods. One measure of signal strength is how well the survey tracks the abundance of cohorts over time value (i.e., $N_{y,a}$) using parametric correlation analysis:

3) $$\rho_{I_a,I_{a+1}} = corr(I_{y,a}, I_{y+1,a+1})$$

Given the relatively short series and potentially noisy indices, nonparametric methods (e.g., Spearman rank correlation) and exploratory analyses (e.g., graphical evaluation of pairplots) were also be applied to evaluate performance of cohort tracking.

2. Partitioning cohort and year effects – The relative contribution of signal and noise in the trap survey index was more formally evaluated using a Generalized Linear Model (GLM) of year effects, age effects and cohort effects (Sinclair and Choinard 1991):

4) $$I_{y,a} = \beta_0 + \beta_y y + \beta_a a + \beta_c c + \varepsilon$$

… where β_0 is the average survey index (related to mean recruitment and survey catchability over the time series), β_y is the year effect (an annual deviation from the mean survey catchability), β_a is the age effect (related to average survival rate), and β_c is the cohort effect (related to annual deviation from mean recruitment). The approach assumes that the age effect (survival or mortality rate) is constant over time. Significance of β_c is a measure of how well the survey monitors relative abundance, and its relative magnitude to β_y is an approximate measure of signal to noise. Significance of β_a is a measure of how well the survey monitors survival or mortality. Although the full model (with cohort, age and year effects) is over-parameterized (i.e., each parameter is not uniquely identifiable), model selection techniques (e.g., Akaike's Information Criterion, AIC) were used to evaluate the relative significance of each effect.

Black Sea Bass

Black sea bass captured during the unvented pot survey were measured to the nearest cm, and the total number of black sea bass caught in each unvented pot was recorded. The catches of black sea bass were aggregated by area, station, and sampling month for further analysis.

1. Analysis of Catch Rates- The catch rates of black sea bass were compared between the three areas that were sampled during the unvented pot survey (E, W, and WE). A one-way Analysis of Variance (ANOVA) was used to test for significant differences in the mean catch rates of black sea bass between sampling areas. A two-way ANOVA was used to test for significant differences in the catch rates of black sea bass between sampling areas, and between the five months that were sampled during the survey.

2. Comparison of length-frequency distributions to other survey data- Kolmogorov-Smirnov tests were used to test for significant differences in the length frequency distributions of black sea bass sampled at the three sampling areas covered during the ventless pot survey (W, E, and WE).

The length frequency distributions of black sea bass caught in the three sampling areas were combined to form a single aggregated length frequency distribution. A Kolmogorov-Smirnov test was used to investigate whether the aggregated length frequency distribution of black sea bass sampled during the ventless pot survey differed significantly from the length frequency distributions observed in the other available indices (2012 Massachusetts Division of Marine Fisheries Spring Trawl Survey, the 2012 Northeast Fisheries Science Center Spring trawl survey and 2012 recreational fisheries samples from Massachusetts). The length frequency distributions of black sea bass observed during each survey were also plotted for comparison.

Results

Scup

1. Internal consistency across annual cohorts– For survey data collected between 2005 and 2011, positive correlations in survey indices were noted for scup between the ages of 1 and 5 (Table 2a). The correlations between ages 1 and 2, between ages 3 and 4, and between ages 4 and 5 were strong (>0.8), while the correlation between ages 2 and 3 was moderate (0.436). However, the correlations between the youngest (ages 0 to 1) and oldest (ages 6-8+) were negative. In general, the magnitude and direction of the correlation coefficients were similar between the parametric method, the nonparametric method, and visual inspection of pair plots (Table 2b and Figure 1). When the 2012 data are included in the analysis, there is little change in the correlation coefficients. Again, a positive relationship is noted for adjacent age classes between age 1 and age 5, and the strength of these relationships is moderate to strong (0.40 to 0.93). Similar results were obtained using both the parametric and non-parametric (Spearman Rank) correlation methods (Tables 2c and 2d). The relationships between the youngest (ages 0 to 1) and oldest age classes (ages 6 to 8+) are either very weak or negative. These weak relationships suggest that the catchability of the ventless trap survey may be low for both the youngest and oldest age classes in the population.

2. Partitioning age, cohort and year effects– Because of the over parameterized model, some coefficients could not be estimated to track the year effect, age effect and cohort effect simultaneously. Therefore, we tried different selections of variables and compared their AIC values (Table 3). The three models with the lowest AIC values all included age as an explanatory variable, indicating there was a relatively significant age effect. By forward model selection, adding a year effect as the second variable produced the lowest AIC. Therefore, there are considerable year effects in the survey that suggest interannual variability in survey catchability.

Consistent results can be found in the coefficient result tables (Tables 4a-4f) that age effect was the most significant of the three effects that were examined. When age was tested as the only explanatory variable, ages 1 through 4 were found to have a significant effect. In the most parsimonious model (age and year effect), ages 1 through 4 were found to be significant, as were the years 2009 and 2010. Cohort effects were generally not found to be significant, except for the 2008 cohort, which was found to have marginal significance (0.05 to 0.10) in all three models that included a cohort effect. Generally, the results suggest that the age of sea bass in the population has the most influence on the survey indices of abundance in the Rhode Island ventless trap survey.

Black Sea Bass

1. Analysis of Variance within the fixed gear survey- The catch rates of black sea bass at each of the three sampling areas is shown in Table 5. Overall, the highest monthly catch rates were observed in the W sampling site, while the lowest catch rates were noted in the E sampling area. Overall, the catch rates were remarkably consistent between the months that were sampled, with the smallest mean black sea bass catches observed in July (mean = 28) and the greatest catches observed in September (mean = 40).

The results of the one-way ANOVA indicated that catch rates differed significantly between the three sampling areas ($p < 0.001$). The two-way ANOVA found significant differences in mean catch rates between sampling areas ($p < 0.01$), but mean catch rates did not differ significantly between months ($p = 0.45$), and the interaction between sampling area and month was not found to be significant ($p = 0.887$).

2. Comparison of length-frequency distributions to commercial catch data- Black sea bass captured in the 2012 unvented pot survey ranged from 9 to 50cm (Figure 2). The overall length frequency distribution shows that the majority of black sea bass caught during the survey were between 17 and 40cm, and the distribution is somewhat bimodal, which may provide insight into the relative contribution of each year class to the survey catches. Kolmogorov-Smirnov tests were used to test for differences in the length frequency distribution of black sea bass sampled at the three sampling areas (W, E, and WE) during the 2012 ventless pot survey. The results indicated that the length frequency distributions of black sea bass differed significantly between the three sampling areas (Table 6). At the E sampling sites, a large proportion of the black sea bass observed were relatively small ($\leq$23cm), while these smaller fish were less abundant at the W sampling site (Figure 3). The length frequency distribution of black sea bass at the WE sampling area was roughly bimodal, while the size distribution at the W sampling area was unimodal. The results suggest that black sea bass may have been segregated by size and age over the area that was sampled during the unvented pot survey in 2012.

Kolmogorov-Smirnov tests were used to test for differences in the length frequency distribution of black sea bass sampled during the unvented pot survey and those observed in other indices (2012 MADMF spring and fall trawl surveys, 2012 NEFSC spring trawl survey and 2012 MA recreational fisheries samples). The results of the K-S test indicate that the length frequency of black sea bass observed during the unvented pot survey differed significantly from the length frequency of sea bass observed in the other available indices (Table 7).

Because the sample sizes differ substantially between the different indices, the proportional length frequency distributions were examined (Figure 4). In 2012 the unvented pot survey sampled smaller black sea bass than the recreational fishery. The greatest proportion of sea bass sampled in the unvented pot survey was noted around 31cm, which is smaller than the mode of recreational catches (38cm). The MADMF fall trawl survey primarily sampled very small black sea bass. The length distribution of black sea bass in the NEFSC spring survey was bimodal, and the survey appears to primarily sample one and two year old black sea bass. The MADMF spring survey sampled black sea bass across a range of sizes, although the survey rarely captured the smallest (<20cm) black sea bass in the population.

Discussion

Scup

In summary, strong correlations were estimated within year classes of scup among adjacent years for ages 1 to 5 in the RI ventless trap survey. On the other hand, correlations at the youngest (ages 0-1) and oldest (ages 6-8+) age classes were weak or negative. These results suggest that the catchability of the RI ventless trap survey is adequate for scup of intermediate age, but catchability may be too low to track changes in the abundance of the youngest and oldest age classes adequately. With this result in mind, it may be prudent to continue the RI ventless trap survey in future years, as the survey can serve as an informative fishery independent index for scup between the ages of 1 and 5. Scup at these intermediate sizes are not sampled adequately in other surveys, which confounds efforts to develop an adequate assessment method for this resource.

Overall, the best Generalized Linear Model fit was found when age and year effects were included in the model. However, some year effects are also significant. The results suggest that the ventless trap survey can adequately track survival for scup between the ages of 1 and 4, but is not as reliable for estimating the survival of older age classes. The most parsimonious model also suggests that the 2009 and 2010 year classes were significantly larger than average. These analyses demonstrate that performance evaluation of survey indices should be a routine task for regular stock assessments. We expect that the methods and results derived from this project can be used to consider the survey data for inclusion in the scup stock assessment.

Black Sea Bass

Results of the ANOVA indicated that there was significant variability in the catch rates of black sea bass between the areas sampled in the fixed gear survey (W, E, and WE). This result suggests that black sea bass are not homogenously distributed within a survey area, and instead may exhibit a patchy distribution that is related to food availability or habitat preference. The length frequency distribution of black sea bass was found to vary significantly between sampling areas. Smaller black sea bass were observed in the E sampling sites, while black sea bass at the W and WE sampling sites tended to be larger on average. There were also significant differences in the length frequency distributions of black sea bass observed in the unvented pot survey and those sampled on the NEFSC spring trawl survey, the MADMF spring and fall trawl surveys and in the 2012 Massachusetts recreational catch (Table 7; Figure 4). The unvented pot survey sampled intermediate sized black sea bass effectively, but did not typically capture the smallest and largest sea bass. The preponderance of small sea bass (<10cm) captured during the MADMF fall trawl survey (Figure 4) suggests that this may be an appropriate fisheries independent index to monitor recruitment in the black sea bass stock. The NEFSC spring survey appears to be a suitable index for assessing the relative abundance of age one and two black sea bass. The relatively large 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.

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Tables

Table 1. Survey indices of scup (fish/pot/soak time) for the RI unvented pot survey between 2005 and 2012.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+	Total
2005	0.014	0.306	0.904	0.980	0.352	0.391	0.071	0.026	0.003	3.047
2006	0.031	0.472	1.337	0.803	0.263	0.214	0.189	0.125	0.046	3.480
2007	0.041	0.661	1.397	2.204	0.385	0.199	0.628	0.170	0.051	5.736
2008	0.005	0.794	1.664	2.875	0.824	0.352	0.202	0.039	0.068	6.823
2009	0.028	1.557	2.313	3.840	1.150	0.578	0.436	0.068	0.051	10.021
2010	0.112	0.699	4.311	3.897	1.985	0.481	0.408	0.134	0.002	12.033
2011	0.018	0.413	1.551	2.080	1.421	0.710	0.164	0.092	0.010	6.458
2012	0.098	1.930	2.189	0.801	1.528	0.609	0.247	0.075	0.032	7.509

Table 2. Correlation coefficients for the RI unvented pot survey between the survey indices for scup in year *y* and age *a* and those in year *y+1* and age *a+1*, a) using 2005-2011 data under a parametric method, b) using 2005-2011 data under a nonparametric method, c) using 2005-2012 data under a parametric method, and d) using 2005-2012 data under a nonparametric method.

a)

Age/Age	0	1	2	3	4	5	6	7	8+
0		-0.736							
1			0.912						
2				0.436					
3					0.959				
4						0.925			
5							-0.193		
6								-0.512	
7+									-0.040

b)

Age/Age	0	1	2	3	4	5	6	7	8+
0		-0.438							
1			0.940						
2				0.509					
3					0.866				
4						0.939			
5							-0.371		
6								-0.445	
7+									0.336

c)

Age/Age	0	1	2	3	4	5	6	7	8+
0		-0.632							
1			0.809						
2				0.400					
3					0.910				
4						0.934			
5							-0.237		
6								-0.451	
7+									-0.030

d)

Age/Age	0	1	2	3	4	5	6	7	8+
0		-0.512							
1			0.750						
2				0.395					
3					0.672				
4						0.955			
5							-0.192		
6								-0.293	
7+									0.307

Table 3. Results of the Generalized Linear Models that were applied to scup catch data from the RI unvented pot survey.

Model Name	Model Equation	AIC
year & age-effect model	$I_{y,a} \sim \beta_0 + \beta_y y + \beta_a a + \varepsilon$	137.4
age & cohort-effect model	$I_{y,a} \sim \beta_0 + \beta_a a + \beta_c c + \varepsilon$	139.3
age-effect model	$I_{y,a} \sim \beta_0 + \beta_a a + \varepsilon$	147.9
cohort-effect model	$I_{y,a} \sim \beta_0 + \beta_c c + \varepsilon$	208.2
year-effect model	$I_{y,a} \sim \beta_0 + \beta_y y + \varepsilon$	209.7
year & cohort-effect model	$I_{y,a} \sim \beta_0 + \beta_y y + \beta_c c + \varepsilon$	217.1

Table 4. Results of the different Generalized Linear Models that were applied to the scup catch data from the RI ventless trap survey, a) age-effect model, b) cohort-effect model, c) year-effect model, d) year & cohort-effect model , e) year & age-effect model, and f) age & cohort-effect model. Significance codes: "***": 0~0.001, "**": 0.001~0.01, "*": 0.01~0.05, ".": 0.05~0.1, "": 0.1~1.

a)

	Estimate	Std. Error	t value	Pr(>|t|)	
β_0	0.043	0.222	0.195	0.845	
a1	0.810	0.314	2.579	0.012	*
a2	1.914	0.314	6.092	0.000	***
a3	2.141	0.314	6.814	0.000	***
a4	0.945	0.314	3.007	0.003	**
a5	0.398	0.314	1.268	0.209	
a6	0.250	0.314	0.795	0.429	
a7	0.047	0.314	0.152	0.879	
a8+	-0.010	0.314	-0.033	0.973	

b)

	Estimate	Std. Error	t value	Pr(>|t|)	
β_0	0.003	0.920	0.003	0.997	
c1998	0.033	1.130	0.029	0.977	
c1999	0.079	1.062	0.075	0.941	
c2000	0.201	1.028	0.196	0.845	
c2001	0.254	1.007	0.252	0.802	
c2002	0.282	0.994	0.284	0.777	
c2003	0.429	0.984	0.436	0.664	
c2004	0.719	0.976	0.737	0.464	
c2005	0.825	0.976	0.846	0.401	
c2006	1.302	0.984	1.324	0.191	
c2007	1.509	0.994	1.519	0.134	
c2008	1.893	1.007	1.878	0.066	.
c2009	0.766	1.029	0.745	0.459	
c2010	0.901	1.062	0.849	0.399	
c2011	0.971	1.127	0.862	0.393	
c2012	0.095	1.301	0.073	0.942	

c)

	Estimate	Std. Error	t value	Pr(>|t|)	
β_0	0.339	0.323	1.047	0.299	
y2006	0.048	0.458	0.105	0.917	
y2007	0.299	0.458	0.653	0.516	
y2008	0.420	0.458	0.916	0.363	
y2009	0.775	0.458	1.692	0.096	.
y2010	0.998	0.458	2.179	0.033	*
y2011	0.379	0.458	0.828	0.411	
y2012	0.496	0.458	1.083	0.283	

d)

	Estimate	Std. Error	t value	Pr(>|t|)	
β_0	0.003	0.949	0.003	0.998	
y2006	-0.102	0.464	-0.221	0.826	
y2007	-0.014	0.475	-0.031	0.975	
y2008	-0.097	0.486	-0.199	0.843	
y2009	0.197	0.498	0.397	0.693	
y2010	0.336	0.511	0.659	0.513	
y2011	-0.402	0.526	-0.766	0.448	
y2012	-0.278	0.548	-0.509	0.613	
c1998	0.084	1.186	0.071	0.944	
c1999	0.118	1.129	0.105	0.917	
c2000	0.254	1.102	0.231	0.818	
c2001	0.257	1.086	0.237	0.814	
c2002	0.229	1.075	0.213	0.832	
c2003	0.441	1.068	0.413	0.682	
c2004	0.765	1.064	0.719	0.476	
c2005	0.871	1.064	0.818	0.417	
c2006	1.354	1.088	1.244	0.219	
c2007	1.552	1.102	1.408	0.165	
c2008	1.942	1.121	1.732	0.089	.
c2009	0.803	1.147	0.701	0.487	
c2010	1.102	1.187	0.856	0.396	
c2011	1.311	1.259	1.041	0.303	
c2012	0.373	1.45	0.258	0.798	

e)

	Estimate	Std. Error	t value	Pr(>|t|)	
β_0	-0.383	0.265	-1.446	0.154	
y2006	0.048	0.265	0.181	0.856	
y2007	0.299	0.265	1.126	0.265	
y2008	0.419	0.265	1.582	0.119	
y2009	0.775	0.265	2.921	0.005	**
y2010	0.998	0.265	3.763	0.004	***
y2011	0.379	0.265	1.429	0.158	
y2012	0.496	0.265	1.869	0.067	.
a1	0.810	0.281	2.881	0.005	**
a2	1.915	0.281	6.806	0.000	***
a3	2.141	0.281	7.613	0.000	***
a4	0.945	0.281	3.360	0.001	**
a5	0.398	0.281	1.416	0.162	
a6	0.249	0.281	0.888	0.378	
a7	0.048	0.281	0.170	0.866	
a8+	-0.010	0.281	-0.037	0.970	

f)

	Estimate	Std. Error	t value	Pr(>|t|)	
β_0	-0.761	0.659	-1.154	0.254	
a1	0.892	0.287	3.109	0.003	**
a2	2.174	0.295	7.360	0.000	***
a3	2.499	0.304	8.228	0.000	***
a4	1.308	0.312	4.186	0.000	***
a5	0.904	0.322	2.809	0.007	**
a6	0.873	0.333	2.624	0.011	*
a7	0.771	0.345	2.233	0.030	*
a8+	0.764	0.362	2.109	0.040	*
c1998	0.029	0.690	0.043	0.965	
c1999	0.041	0.659	0.062	0.951	
c2000	0.138	0.643	0.214	0.831	
c2001	0.094	0.634	0.148	0.882	
c2002	-0.139	0.629	-0.222	0.825	
c2003	-0.134	0.626	-0.215	0.931	
c2004	0.211	0.624	0.338	0.737	
c2005	0.412	0.637	0.647	0.520	
c2006	0.831	0.645	1.289	0.203	
c2007	0.978	0.653	1.495	0.141	
c2008	1.283	0.666	1.928	0.059	.
c2009	0.139	0.681	0.205	0.838	
c2010	0.644	0.705	0.913	0.366	
c2011	1.289	0.748	1.722	0.091	.
c2012	0.859	0.859	0.999	0.322	

Table 5. The monthly mean catch rates of black sea bass (number of black sea bass/haul) observed at each survey area during the 2012 unvented pot survey.

Area	June	July	August	September	October	*Area Mean*
W	71.1	52.8	51.1	72.6	66.0	62.7
E	6.3	15.9	23.9	28.6	2.6	15.5
WE	16.1	15.4	15.6	18.7	28.1	18.8
Monthly Average	31.2	28.0	30.2	40.0	32.2	**32.3**

Table 6. Results of the Kolmogorov-Smirnov tests that were used to test for significant differences in the length frequency distributions of black sea bass observed in different sampling areas during the 2012 unvented pot survey.

Factors	D	p-value
W vs. E	0.28	<0.0000
W vs. WE	0.17	<0.0000
WE vs. E	0.21	<0.0000

Table 7. Results of the Kolmogorov-Smirnov tests that were used to test for significant differences in the length frequency distributions of black sea bass observed during the 2012 unvented pot survey and other fishery dependent and fishery independent indices.

Factors	D	p-value
Fixed gear vs. 2012 MADMF Spring Survey	0.24	<0.0000
Fixed gear vs. 2012 MADMF Fall Survey	0.92	<0.0000
Fixed gear vs. 2012 NEFSC Spring Survey	0.55	<0.0000
Fixed gear vs 2012 MA recreational catch	0.74	<0.0000

Figures

Figure 1. Graphical evaluation of the scup survey indices in year *y* age *a* and those in year *y+1* and age *a+1* for the unvented pot survey between 2005 and 2012.

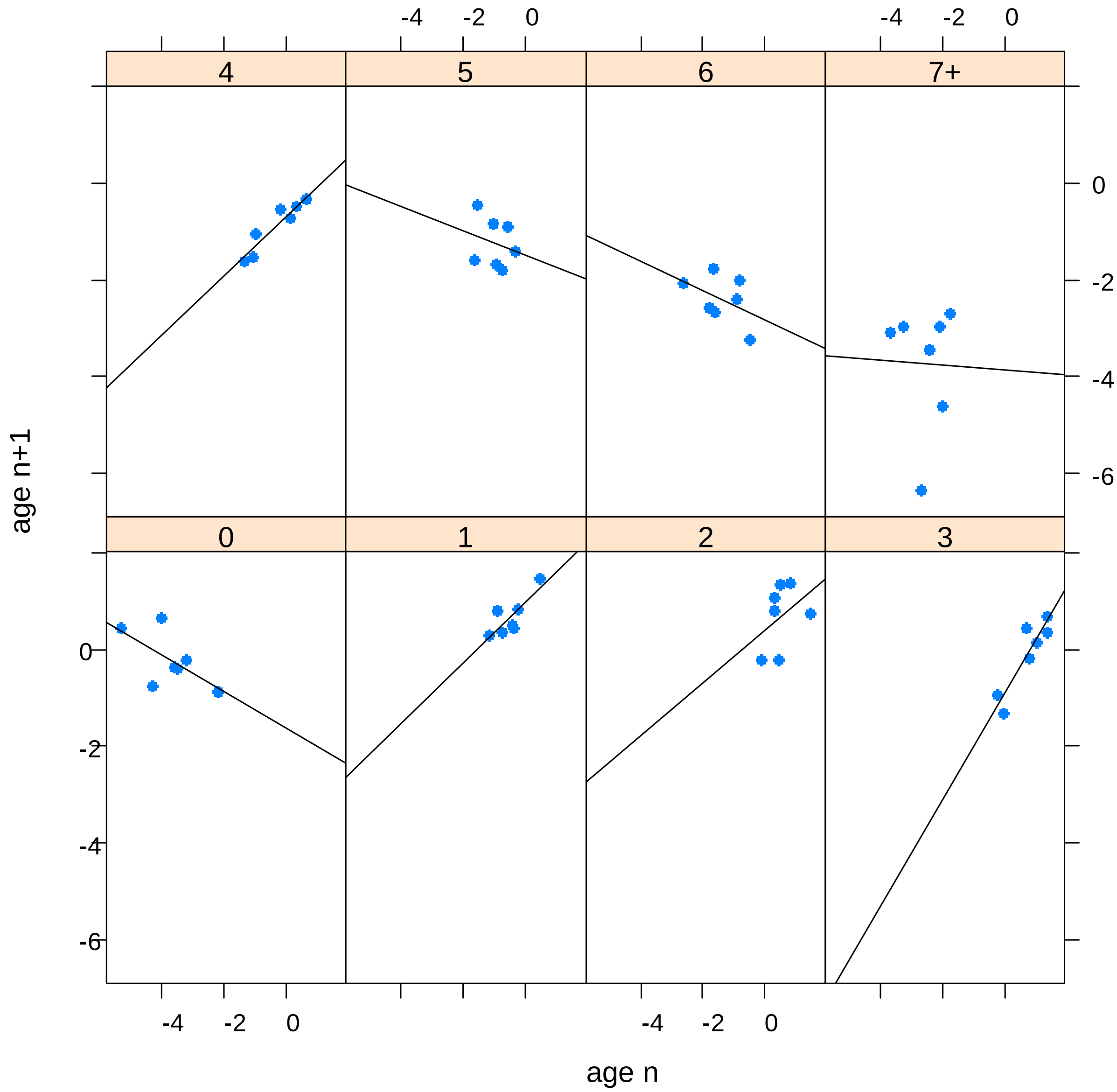


Figure 2. Length frequency distribution of black sea bass observed during the 2012 unvented pot survey.

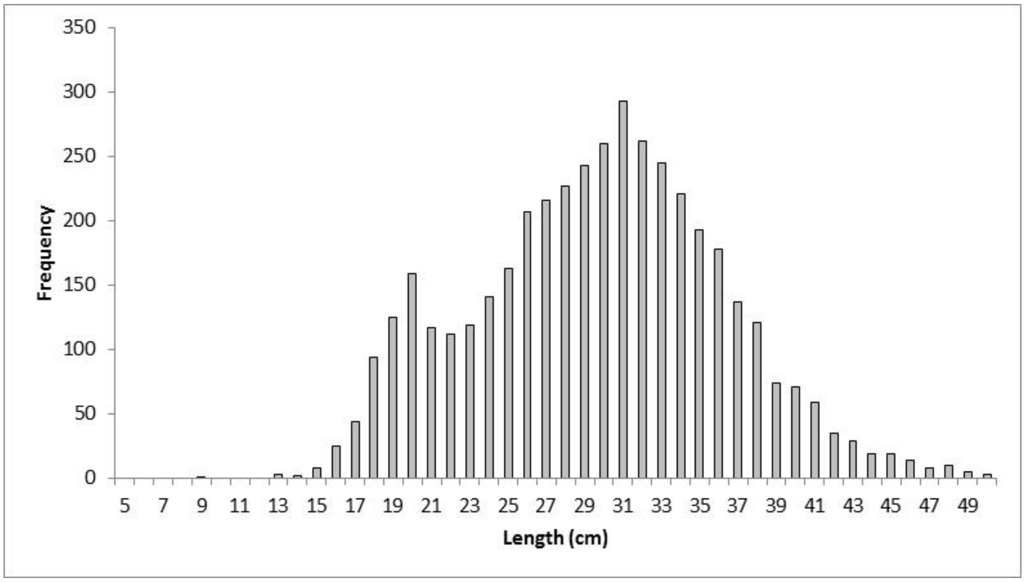


Figure 3. Proportional length-frequency distribution of black sea bass sampled at the three sampling areas during the 2012 unvented pot survey.

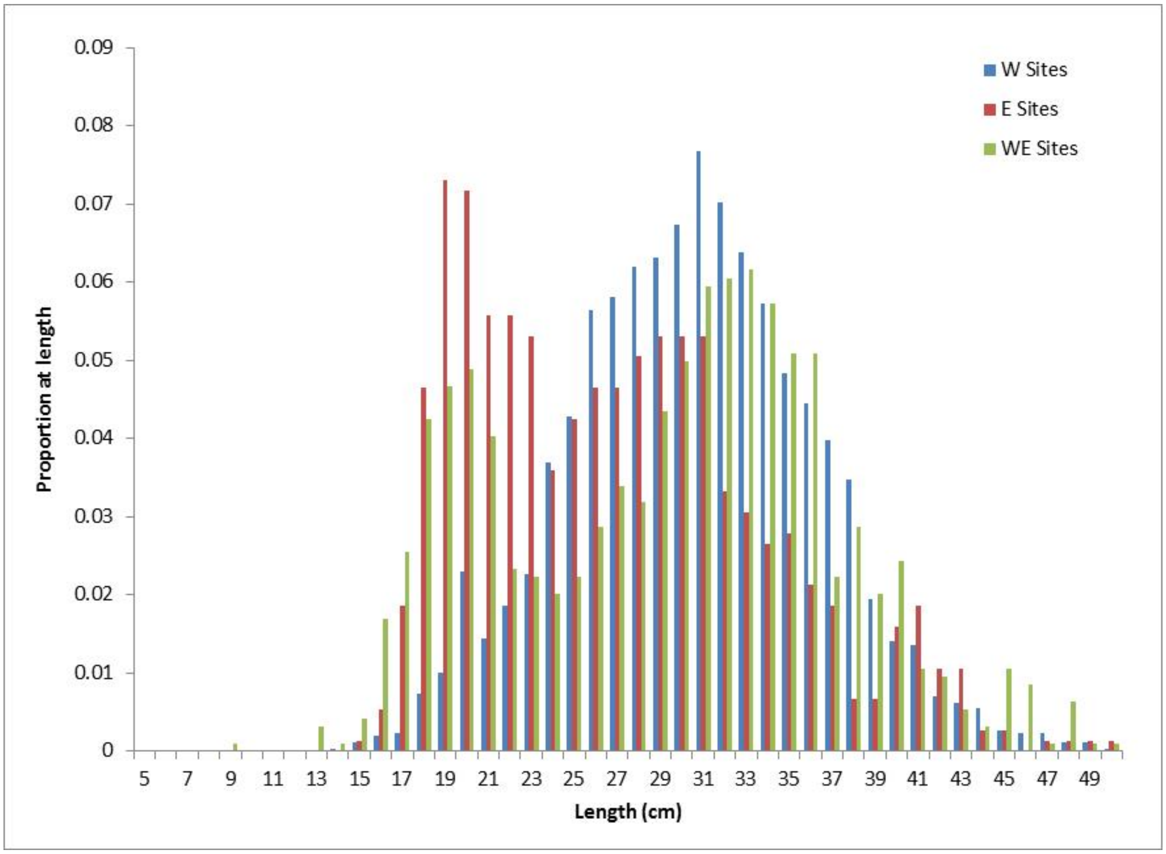
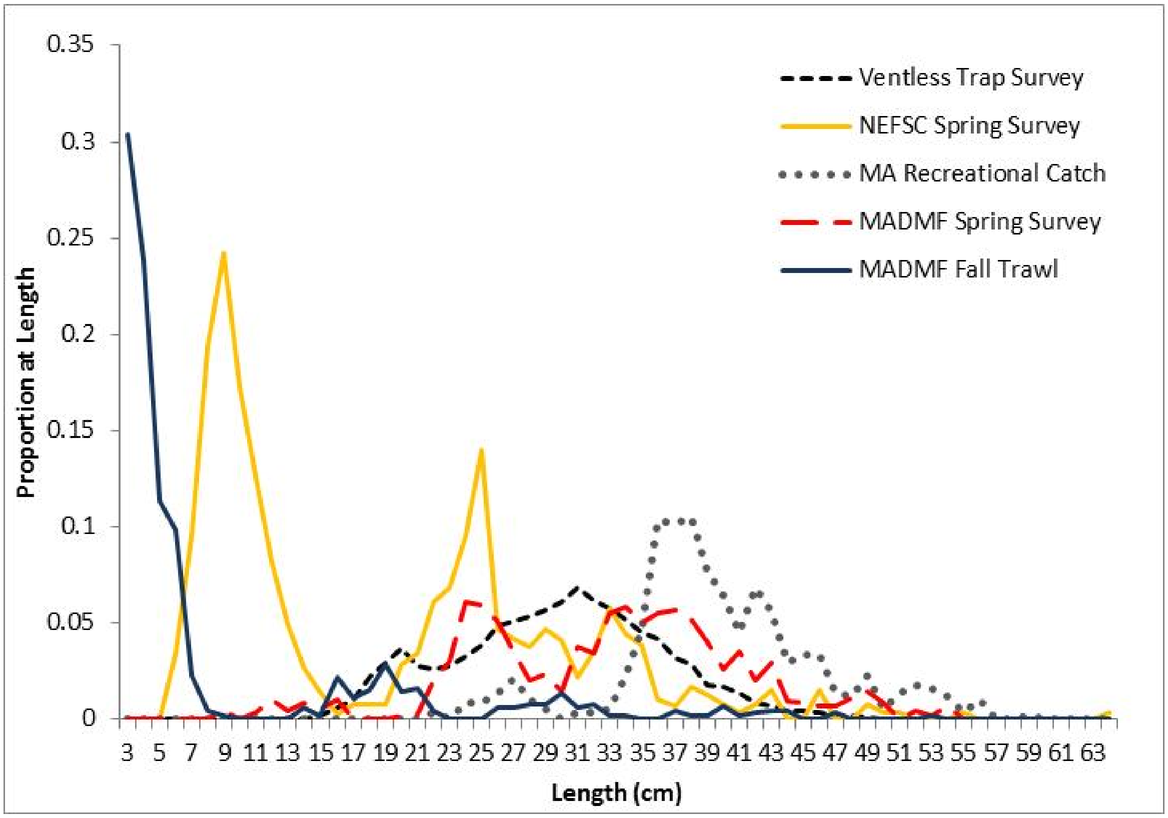


Figure 4. Proportional length-frequency plot of black bass sampled in the unvented pot survey, the NEFSC spring survey, the MA spring and fall surveys and MA recreational catch. This plot shows the proportion of black sea bass at each length category for the five indices.



Ventless Trap Survey
NEFSC Spring Survey
MA Recreational Catch
MADMF Spring Survey
MADMF Fall Trawl
Proportion at Length
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
3 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 59 61 63
Length (cm)