Determining the Impacts of Dredge Bag Modifications on Flatfish Bycatch in the LAGC Scallop Fishery

A Final Report Prepared for the 2015

Sea Scallop Research Set-Aside

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Project Summary

For the 2015 RSA, the Coonamessett Farm Foundation tested a row of eight 12-inch square mesh windows behind the upper dredge frame for their ability to reduce finfish bycatch. A total of 128 successful tows were completed during the 24 days at sea. After the first set of days the experimental dredge was modified to fish similar to the control. This design remained constant for the duration of the experiment. Supplemental video footage taken of the experimental dredge under operational conditions resulted in no observations of finfish escapement via the experimental windows.

Analysis of the catch data using Generalized Estimating Equations indicated that there were no significant statistical differences in catch of scallops and finfish between the experimental and control dredges. Overall, the impact on bycatch during the course of this study was not statistically significant, although modifications made to the experimental dredge tended to reduce flatfish bycatch, particularly for windowpane flounder. An over 40% reduction of windowpane flounder bycatch was observed in the catch per unit effort summary statistics, and the model indicated that this was a promising but marginally insignificant reduction that should be investigated further. Collection of additional data using the experimental gear when windowpane catches are the highest would be beneficial. Constraints to the experimental design imposed by the logistical limitations of vessel characteristics typical of the Limited Access General Category (LAGC) fishery, contributed to reduced sample sizes, spatiotemporal clustering of observations and the inability to utilized a paired tow design. These issues may warrant the examination of alternative experimental designs to reduce the observed variability between catches. The Coonamessett Farm Foundation, Inc. will use this knowledge in future work to test modifications that can be more easily alternated in order to utilize a more robust alternate paired-tow experimental designs.

Introduction

As the environmental impacts of fishing become more easily definable through the use of ecosystem-based models, the research and development of sustainable fishing gear becomes increasingly necessary for the long-term sustainability of fisheries (Jennings and Revill, 2007). Large populations of Atlantic sea scallops (*Placopecten magellanicus*) on Georges Bank and in the Mid-Atlantic region support one of the world's most lucrative fisheries (Hart and Jacobson, 2013). The high level of economic productivity, lasting for almost a decade, is due in part to the successful collaboration of the fishing community, managers and scientists through the sea scallop Research Set Aside (RSA) program (O'Keefe and Stokesbury, 2009; Adams et al., 2014). Bycatch mitigation and avoidance utilizing current technology and innovative thinking have been a common research theme and one of the main goals of the scallop RSA program.

Gear-based bycatch solutions are often the most effective means to achieving a long-term solution for the reduction of bycatch within a fishery (Jennings and Revill, 2007). Time/area closures can be a successful means of reducing fleet-wide bycatch, but seasonal changes in bycatch rates make it difficult to optimize closures. Area closures can also displace fishing effort leading to localized overfishing of productive fishing grounds (Hiddink et al., 2006). Fishing area closures in the late 2000's that were the result of the scallop fleet exceeding the sub-Annual Catch Limit (ACL) of yellowtail flounder (*Limanda ferruginea*) prevented the economic maximization of the resource (O'Keefe and DeCelles, 2013). The development and use of environmentally responsible fishing gear, which has a greater species and size selectivity than current traditional fishing gear, can be an effective alternative to area closures and fishing effort reduction. Gear regulations can also be used in conjunction with area closures through the creation of Gear Restricted Areas (GRA). Framework 25 to the Sea Scallop Fishery Management Plan (SSFMP) utilizes a GRA as a windowpane flounder Accountability Measure (AM). The benefit of an efficient, gear based solution is that fishermen would be allowed to continue fishing while simultaneously reducing their impact on the marine ecosystem.

From 2012 to present, the Coonamessett Farm Foundation, Inc. has been investigating the efficacy of dredge bag modifications for the reduction of flatfish bycatch. In 2012 and 2013, the focus of our research was to investigate the impacts of a reduced twine top hanging ratio and a short apron (NA12NMF4540041). From those projects we were able to show that simple modifications to the bag design could have a large impact on flatfish bycatch in the scallop dredge fishery. The Northeast Fisheries Management Council (NEFMC) was able to utilize the results from this research to create and implement management measures included in Framework 26 to the SSFMP, which regulated the apron length to a maximum of 7 rows of rings. Scallop dredge bag design modifications serve to facilitate the escapement of flatfish that have already become captured in the dredge bag. The working hypothesis for why the short apron and low twine top hanging ratio reduced bycatch is that the modification increases the mechanical sorting ability of the dredge bag. Less dense material like small scallops and fish are more easily expelled through a longer, more open twine top.

From 2012 through 2014, escape windows were tested along the dredges' side pieces and along the twine top in both the Limited Access (LA) and LAGC fisheries. Due to the reduction of scallop catch and limited success in reducing flatfish bycatch, attempts to put windows in these areas have been suspended. Moving forward, other bag modifications will focus on manipulating the dredge frame and bag in other ways.

LAGC vessels in the Northeast Atlantic are regulated to a total dredge width of 10.5 feet, and for this reason, these vessels often fish a single dredge between 8 and 10.5 feet in width. These vessels are often smaller, have lower horsepower and tow at relatively slower speeds compared to LA vessels that have the capability of towing at higher speeds with greater efficiency. Due to these vessel characteristics, gear modifications may impact the LAGC fishery in unintended ways. Given the potential for unbalanced impacts between the fleets, it is necessary to test gear modifications aboard LAGC vessels independently. Vessel characteristics typical of the LAGC fleet present some challenges from an experimental design standpoint, primarily due to the inability of the vessels to tow two dredges simultaneously. In contrast, LA vessels can simultaneously tow two dredges in a paired fashion allowing for the testing of a dredge modification against a standardized design. The scale of the variation in the animal densities with this configuration is typically less due to the reduction in spatiotemporal separation of observations relative to comparative gear studies conducted on different vessels or experimental treatments separated in time and space.

With a paired experimental design, there exists a body of literature focused on analytical approaches specific to this design (Cadigan et al., 2006; Cadigan and Dowden, 2009; Holst and Revill, 2009; Miller, 2013). These approaches take advantage of the paired nature of the data to draw inference on the relative efficiency of the two gears tested in the experiment. In the case of the current study on LAGC vessels, we did not have the luxury of being able to conduct paired tows, or even make at-sea modifications to the gear to approximate paired tows via an alternate tow design, both of which would have reduced, but not eliminated the variability introduced by separating non-paired tows in both time and space.

Methods

Limited Access General Category Field Sampling Methods

The proposed modification included two rows of square mesh panels in place of the skirt of the dregde. This design was based upon previous work done on a 13-foot dredge in the mid-Atlantic region. Once we removed the skirt on the 9-foot dredge it became apparent that two rows would have been cut too far back into the twine top and result in increased loss of catch. This resulted in a design of one row of ~12 inch square meshes made of chain. Chain was chosen in place of rope to increase the strength of the meshes when under load and reduce wear.

The *F/V Mister G.* utilized the vessel's 9-foot Provincetown dredge (MRG), with a standard bag configuration, as the control. An experimental 9-foot Provincetown dredge (CFF) was constructed to be identical to the vessel's dredge in order to compare the bag modification. The experimental dredge had the two rows of rings (skirt of dredge) behind the upper dredge frame removed. This open space was fitted with a row of 8 chain-square meshes that were ~12in by 12in (Figure 1). The square meshes were constructed of 5/16" hardened transport chain, the vertical chains were 8 links with two shackles and the horizontal chain was 80 links in length. The vertical chains were shackled every 10th link along the horizontal chain and every 12 inches along the top of the dredge frame to create the square windows. The twine top was fitted to a chain that ran parallel to the dredge frame and shackles were used in place of rings to maintain the hanging ratio.

The vessel was asked to fish the control bag and experimental bag configurations, alternating the dredge bag every other day. The control and experimental bag configurations were tested for a total of twelve paired days or 24 days at sea. Towing speed and scope (~4.2 knots and 3:1 +/- 10 fathoms) were held constant and based on the vessel's typical operating parameters. For each tow, a standard tow time of approximately 50 minutes was chosen based on catch rates. Latitude and longitude, vessel speed, and tow distance were recorded for each tow using a handheld GPS. All relevant atmospheric data was recorded on the bridge logs. The Beaufort scale was used as a proxy for sea state and wind intensity because it's a standard measurement that can be objectively recorded at sea. Catch and bycatch were sampled from each tow on all trips. The amount of scallops in the catch was evaluated by the number of baskets and weight. Bycatch species were weighed (for total weight), counted, and individually measured to the nearest centimeter. The research trips all occurred on "open bottom" in Southern New England, southeast of Block Island, RI.

Figure 1. *Location and configuration of the row of 12 inch windows behind the dredge frame.*

Data collected for each LAGC tow included:

- Scallop catch rates (bushel(s)/total weight/tow)
- Scallop shell height frequency (one bushel sub-sample/weight/tow)
- Finfish catch rates (# of individuals/tow)
- Finfish and invertebrate length frequency (by species and species groups (i.e. controlled groundfish species, other groundfish species, and pelagic species))
- Skate catch rates (# of individuals/tow)
- Skate weight (total weight/tow)

GoPro® Hero 4's were used to monitor the modification during the beginning of the study. The cameras were mounted above and below the dredge frame looking down the length of the experiemental meshes. The information gathered from these videos was used improve the +- modification for the duration of the study.

Analytical methods

As mentioned above, the experimental design of this study imposed a number of analytical challenges. Given the non-paired nature of the observations, we were unable to utilize the analytical approaches considered to be the current standard approaches (Cadigan et. al, 2006; Cadigan and Dowden; 2009, Holst and Revill, 2009; Miller, 2013). Given these constraints, our overarching objective was to construct a model that would predict the catch of either the target or bycatch species as a function of a suite of predictor variables collected during the trials. The candidate explanatory variables included gear configuration, water depth, and sea conditions. While the design precluded the utilization of the paired-tow analytical approaches referenced above, the statistical framework used in these studies is informative with respect the analyses of the data from this experiment. Generalized linear models (GLMs) provide a statistical basis to relate response and predictor variables to nonlinear data. These approaches are especially useful in situations where responses are dichotomous or otherwise not normally distributed (Smith and Smith, 2006).

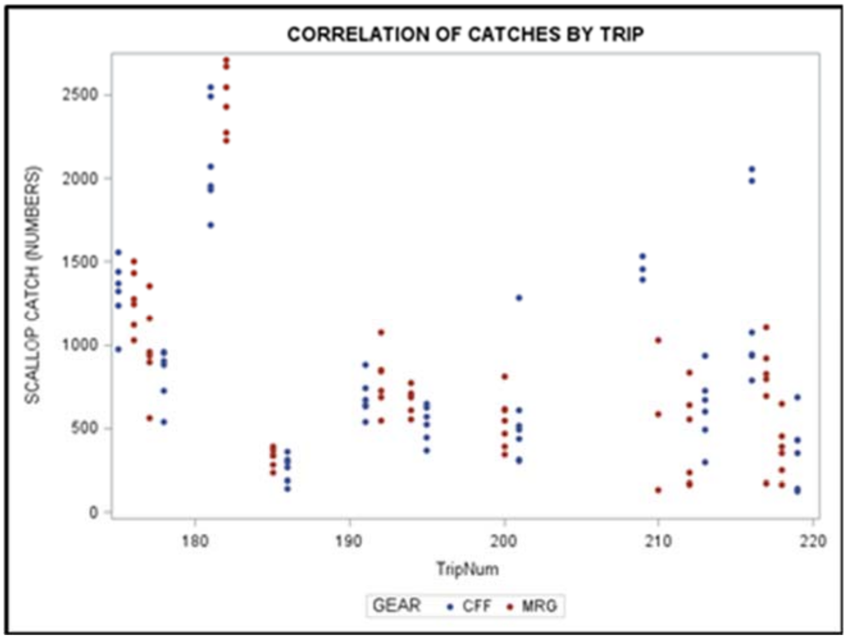

Figure 2. *Scallop catch by trip and gear tested. Catches within each trip show correlation as a function of the spatiotemporal nature of the sampling.*

Linear models can be extended to the nonlinear case by modelling population means via a linear predictor scaled with an appropriate canonical link function. In addition to accounting for the nonlinear nature of the data, outcome data are often correlated. For example, in longitudinal studies that follow subjects over time, results can be correlated as a function of the repeated measurements of the same individuals (e.g. in growth studies, measurements during subsequent time periods are correlated to those taken at previous times since growth is incremental). In addition, correlation can result from a clustering of data on the subject level for other reasons. These correlated outcomes must be accounted for to allow for correct statistical inference. In the case of this analysis, correlation existed as a result of the experimental design of the study where a single gear was tested on the first day of the series and the next day the other gear was tested in the same area. This resulted in the correlation of the outcomes (i.e. catches). This clustering of catches can be seen in Figure 2 that shows the distribution of catches by trip. Consecutive days with different gears tested can clearly be seen to have similar levels of catch.

Generalized Estimating Equations (GEEs) introduced by Liang and Zeger (1986) provide a framework for analyzing data with correlated responses (i.e. within-subject correlation). An extension of the GLM approach, GEEs allow for the specification of a suite of working correlation matrix structures (independence, unstructured, exchangeable, autoregressive) to account for the within-subject correlation. This family of models, fit with quasi-likelihood approximations, does not provide a model selection criteria such as Akaike Information Criterion (Akaike, 1973) that would be possible with true likelihood approximation techniques. Model selection for GEEs can be performed with the quasi-AIC (QIC).

GEEs provide a flexible analytical framework to examine data with correlated outcomes. This family of models accommodates a family of distributions along with the associated link functions. Appropriate statistical distributions to describe count data collected in this study are the Poisson distribution that describes the probability of an event occurring during a discrete time or space. With respect to fisheries data in general and our data specifically, variance typically exceed the mean and results in overdispersion. The relaxation of the requirement of equal mean and variance imposed by the Poisson distribution is typically characterized by the negative binomial distribution. Given the nature of the data to be analyzed here (potentially overdispersed count data), a family of regression analyses based on the Poisson and negative binomial distributions were explored to create a predictive model to describe the catch data.

GEEs (Poisson and negative binomial) were used to examine the catch data and describe the important factors influencing observed differences in catch. As mentioned above, the explanatory variables included categorical variables of gear and Beaufort scale, as well as the continuous variable of water depth. Descriptive statistics for each of these variables are shown in Tables 1-2. Due to the differences in areal coverage for each tow, the catch data was adjusted within the modelling framework to allow for equal scaling of the catch data. This was accomplished by the inclusion of an offset term in the regression that accounted for the differences in the tow length of the individual tows, and as a result, tow distance was not included as an explanatory variable in the model. The determination of whether the data was best described by either the Poisson or negative binomial distributions was assessed by examining the significance of an estimated dispersion parameter in the negative binomial model run. A parameter estimate significantly different from 0 was deemed to be indicative of an overdispersed situation, best described by the negative binomial distribution. For each species of interest (unclassified skates, summer flounder, fourspot flounder, yellowtail flounder, winter flounder, windowpane flounder, monkfish and sea scallops), the distributional characteristics were evaluated and the factors included in the model that best fit the data was determined via QIC. For each species, an estimate of mean catch for the most parsimonious model was calculated to provide a realistic mean catch value.

Results

Through the period of July 2015 to May 2016, a total of 144 tows were completed aboard the *F/V Mister G*. The first set of back-to-back days, which included a total of 10 tows, were excluded from analysis as the CFF gear was subsequently modified to improve catch efficiency of scallops. Over the course of the rest of the trials, six tows were declared invalid due to weather and operational issues and were excluded from analysis. Therefore, of the 144 completed tows, only 128 valid tows were used for analysis - 64 with the MRG and 64 with CFF dredge configurations. The locations of all valid tows included in the analysis area shown in Figure 3.

Examination of GoPro® Hero 4 video footage indicated that minor adjustments had to be made to the chain frame of the openings. After the first set of days, the chains were adjusted on the experimental dredge so that the bag opened and fished similar to the control dredge. No flatfish or monkfish were observed escaping through the chain meshes in any of the video footage.

Box plots of the observed scaled catches by species and gear variants are shown in Figure 4. Scaled length frequency distributions for each species that reflect the differential areal coverage per tow are shown in Figure 5. Catch per unit effort (CPUE), as numbers per nautical mile towed, by species and the observed percent change in catch are shown in Table 3. Total catch and average catch per tow for the two gears is shown in Table 4. The model formulation, as well as the statistical distribution that best fit the data obtained for each species of interest, is shown in Table 5. Parameter estimates from the best model fit for each species are shown in Tables 6-10 and estimated mean catch calculated from a model that included only the effect of gear type is shown in Table 11. The estimated mean catches are presented as a function of the scaling by the offset variable and represent the catch for a given species per nautical mile towed. Observed CPUE is also included in Table 11 for ease of comparison between observed and modeled catch.

Discussion

An examination of the CPUE for each bag type and percent reductions in catch suggest an increase in scallop and monkfish catch and a reduction in flatfish and skate catch as a function of the gear modification (Table 3). Yet the GEE results suggest that for most species, the windows had little effect on catch rate and the observed changes in catch were not statistically significant. This was the case for most of the species with adequate catch for analysis, including four flatfish species as well as monkfish, skates, and scallops. Gear was included in the best model specification for yellowtail flounder and skates (Table 5), but it was not a retained predictor in all three cases (Tables 8 and 9). For the other species (scallops, monkfish, winter flounder, summer flounder and fourspot flounder), gear was not retained as a predictor in the best model (Table 5).These conflicting outcomes can be explained because the GEE model adjusted catch numbers based on trip effects as well as areal coverage, thereby accounting for more of the variability in the data collected throughout the project.

Of all of the species examined, windowpane flounder showed the most promising potential for reduction with windows. Scaled CPUE data indicates a 42% reduction in flounder catch while using the CFF gear with windows in the bag. The best GEE model included gear as a factor (Table 5) and supported this potential reduction as a function of the windows despite the variability in the data, with a marginally insignificant ($p = 0.08$) reduction in catch (Table 8).

With the exception of sea scallops, skates and monkfish, the catch rates observed in this experiment were quite low. Most species were captured at an average rate of less than one animal per nautical mile towed (Table 3). The observations of the flatfish species of interest in particular were quite low, contributing additional uncertainty to the results by reducing the ability to detect differences in the observed process. Due to these low catch numbers, coupled with other sources of variability in the data, the overall reductions that were observed on a percentage basis must be interpreted with care. While the experimental design of this project introduced variability as a function of differences in time and space between the gear configurations, the family of regression models (GEEs) used here provided an efficient means to examine the catch data that consisted of, in most cases, over dispersed count data with correlated outcomes.

Examination of the CPUE data is suggestive of reductions in the CFF dredge configuration containing windows. Relatively low numbers of observations, low bycatch rates and variability introduced by the experimental design made detecting statistically significant reductions a challenge. These factors coupled with differences in the gear variants that might be modest, resulted in low statistical power leading to our failure to reject the null hypothesis of no difference in catch rates as a function of gear configuration across the species examined. Given these caveats, coupled with the suggestion of reductions from the CPUE analysis, further consideration of this modification may be warranted, especially with the currently species of interest - windowpane flounder. Further research using the experimental gear during times of the year and in locations where windowpane catches are the highest may be informative and allow for a greater understanding of the impact of the dredge bag windows on windowpane catch.

If considered for further investigations, future gear research in the LAGC fleet would benefit from modifications that can be switched onboard the vessel allowing for alternate paired towing. The Coonamessett Farm Foundation will use this methodology in its 2016 funded RSA project with the LAGC fishery. We believe this will provide us with the best available data for comparison when limited to using one dredge. Future researchers should take this into consideration when working with the LAGC fleet.

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Table 1. Descriptive statistics for the LAGC data set. The overall number of tows included for each level of the variable gear and the corresponding attributes of the continuous variables tow distance and depth. Tow distance was used in the regression analysis as an offset term to scale the catches to a common scale.

	MRG (no windows)	**CFF (windows)**
Tows included in analysis	64	64
Tow Distance (nm)		
Mean tow distance	5.01	4.96
Standard deviation	0.60	0.84
Minimum tow distance	2.16	1.38
Maximum tow distance	6.00	7.55
Depth (meters)		
Mean depth	46.41	45.59
Standard deviation	6.41	6.24
Minimum depth	32.8	32.8
Maximum depth	63.77	55.5

Table 2. Descriptive statistics for the variable describing wind and sea conditions encountered for each tow by each gear tested (Beaufort scale).

	Beaufort Scale	**Frequency**	**Percent**	**Cumulative Frequency**	**Cumulative Percent**
MRG (no windows)	0	3	4.35	3	4.35
	1	18	26.09	21	30.43
	2	22	31.88	43	62.32
	3	19	27.54	62	89.86
	4	6	8.70	68	98.55
	5	1	1.45	69	100
CFF (windows)	0	3	5.17	3	5.17
	1	16	27.59	19	32.76
	2	24	41.38	43	74.14
	3	5	8.62	48	82.76
	4	4	6.9	52	89.66
	5	6	10.34	58	100

Table 3. Catch per unit effort (numbers per nautical mile towed) by species and percent difference of the CFF relative to the MRG.

Species	MRG (no windows)	CFF (windows)	Percent Difference
Unclassified Skates	17.50	17.26	-1.38
Summer Flounder	0.75	0.59	-20.17
Fourspot Flounder	0.48	0.36	-23.56
Yellowtail flounder	0.14	0.13	-10.78
Winter Flounder	0.10	0.08	-13.80
Windowpane Flounder	0.72	0.42	-41.91
Monkfish	2.37	2.63	11.01
Sea Scallop	169.65	184.22	8.59

Table 4. Total catch and average total catch per tow.

	Total catch		Average catch per tow	
Species	MRG (no windows)	CFF (windows)	MRG (no windows)	CFF (windows)
Unclassified Skates	5,600	5,345	87.50	83.52
Summer Flounder	231	181	3.61	2.83
Fourspot Flounder	154	117	2.41	1.83
Yellowtail flounder	45	40	0.72	0.63
Winter Flounder	30	26	0.47	0.41
Windowpane Flounder	228	130	3.56	2.03
Monkfish	750	823	11.72	12.86
Sea Scallop	53,929	56,423	842.65	881.60

Table 5. Model building for each species. The distribution and explanatory variables that best fit the catch data for each species.

Species	**Distribution**	**Model**
Unclassified Skates	Negative Binomial	Catch~Gear + Depth
Summer Flounder	Negative Binomial	Catch~
Fourspot Flounder	Negative Binomial	Catch~Beaufort Number
Yellowtail Flounder	Negative Binomial	Catch~Gear
Winter Flounder	Negative Binomial	Catch~
Windowpane Flounder	Negative Binomial	Catch~Gear
Monkfish	Negative Binomial	Catch~
Sea Scallop	Negative Binomial	Catch~ Depth

Table 6. Parameter estimates for the species where the intercept only model resulted in the best fit to the data.

Species	**Parameter**	**Estimate**	**Std Err**	**Lower 95% CI**	**Upper 95% CI**	**Z**	**Prob > Z**
Summer Flounder	Intercept	-0.4355	0.2795	-0.9833	0.1124	-1.56	0.1192
	Scale	0.9520					
Winter Flounder	**Intercept**	**-2.4505**	**0.2166**	**-2.8749**	**-2.0260**	**-11.32**	**<0.0001**
	Scale	-0.9768					
Monkfish	**Intercept**	**0.9148**	**0.1986**	**0.5255**	**1.3042**	**4.61**	**<0.0001**
	Scale	0.8095					

Table 7. Parameter estimates for the species where the model that included depth resulted in the best fit to the data.

Species	**Parameter**	**Estimate**	**Std Err**	**Lower 95% CI**	**Upper 95% CI**	**Z**	**Prob > Z**
Sea Scallop	**Intercept**	**6.4123**	**0.8471**	**4.7520**	**8.0726**	**7.57**	**<0.0001**
	Depth	-0.0265	0.0180	-0.0617	0.0087	-1.48	0.1396
	Scale	1.0545					

Table 8. Parameter estimates for the species where the model that included gear resulted in the best fit to the data.

Species	**Parameter**	**Estimate**	**Std Err**	**Lower 95% CI**	**Upper 95% CI**	**Z**	**Prob > Z**
Yellowtail Flounder	**Intercept**	**-1.9297**	**0.1969**	**-2.3156**	**-1.5438**	**-9.80**	**<0.0001**
	Gear - CFF	-0.1387	0.2884	-0.7040	0.4266	-0.48	0.6307
	Gear - MRG	0.0000	0.0000	0.0000	0.0000		
	Scale	1.1659					
Windowpane Flounder	Intercept	-0.3461	0.2185	-0.7744	0.0822	-1.58	0.1132
	Gear - CFF	-0.5565	0.3225	-1.1885	0.0756	-1.73	0.0844
	Gear - MRG	0.0000	0.0000	0.0000	0.0000		
	Scale	0.9312					

Table 9. Parameter estimates for the species where the model that included gear and depth resulted in the best fit to the data.

Species	**Parameter**	**Estimate**	**Std Err**	**Lower 95% CI**	**Upper 95% CI**	**Z**	**Prob > Z**
Unclassified Skates	**Intercept**	**4.2979**	**0.5392**	**3.2411**	**5.3547**	**7.97**	**<0.0001**
	Gear - CFF	-0.0384	0.1562	-0.3446	0.2678	-0.25	0.8058
	Gear - MRG	0.0000	0.0000	0.0000	0.0000		
	Depth	**-0.0313**	**0.0113**	**-0.0534**	**-0.0092**	**-2.77**	**0.0056**
	Scale	0.9969					

Table 10. Parameter estimates for the species where the model that included Beaufort number resulted in the best fit to the data. BeaufortN = Beaufort number.

Species	**Parameter**	**Estimate**	**Std Err**	**Lower 95% CI**	**Upper 95% CI**	**Z**	**Prob > Z**
Fourspot Flounder	**Intercept**	**2.1306**	**0.8923**	**-3.8794**	**-0.3818**	**-2.39**	**0.0169**
	BeaufortN 0	**2.0512**	**0.9516**	**0.1861**	**3.9163**	**2.16**	**0.0311**
	BeaufortN 1	1.6065	0.9185	-0.1938	3.4068	1.75	0.0803
	BeaufortN 2	1.0061	0.9147	-0.7866	2.7989	1.10	0.2713
	BeaufortN 3	1.2848	0.9192	-0.5167	3.0864	1.40	0.1622
	BeaufortN 4	0.7034	0.9405	-1.1399	2.5466	0.75	0.4545
	BeaufortN 5	0.0000	0.0000	0.0000	0.0000		
	Scale	1.0688					

Table 11. Predicted catch rates as a function of gear configuration - model mean estimates and upper and lower confidence intervals (CIs). While gear may not have been included in the best model specification for each individual species, since it was the factor of primary interest it is informative to be able to compare the catch rates between the levels of that factor. Observed and modeled catch rates are depicted as the mean catch (numbers) per nautical mile towed.

Species	Level	Observed CPUE	Model Mean Estimate	Lower 95% CI	Upper 95% CI
Unclassified Skates	CFF	17.26	16.98	13.38	21.55
	MRG	17.50	17.22	12.81	23.16
Summer Flounder	CFF	0.59	0.59	0.28	1.26
	MRG	0.75	0.70	0.32	1.49
Fourspot Flounder	CFF	0.36	0.37	0.25	0.55
	MRG	0.48	0.46	0.28	0.75
Yellowtail Flounder	CFF	0.13	0.12	0.08	0.18
	MRG	0.14	0.14	0.09	0.22
Winter Flounder	CFF	0.08	0.08	0.03	0.17
	MRG	0.10	0.09	0.05	0.14
Windowpane Flounder	CFF	0.42	0.40	0.26	0.62
	MRG	0.72	0.70	0.45	1.11
Monkfish	CFF	2.63	2.66	1.54	4.6
	MRG	2.37	2.32	1.31	4.09
Sea Scallops	CFF	184.22	189.24	133.77	267.71
	MRG	169.65	167.12	111.90	249.61

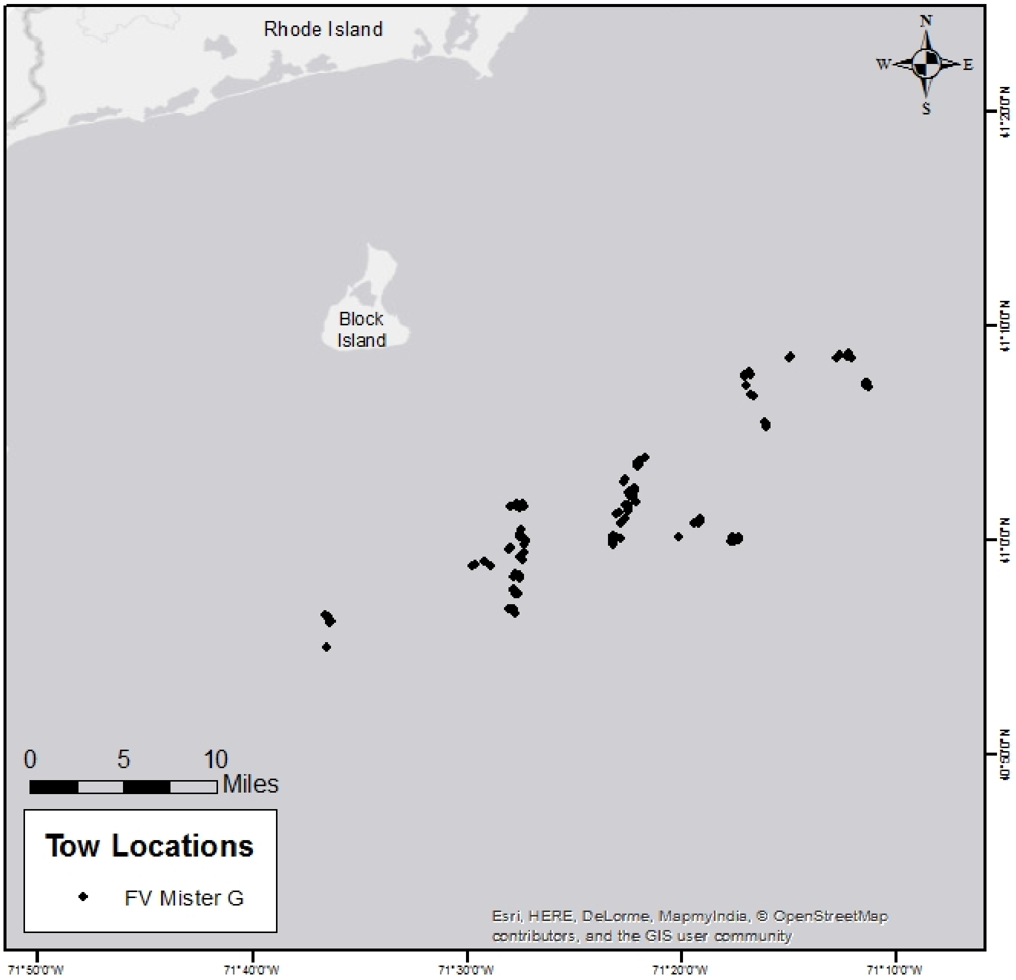


Figure 3. *Map showing the locations of the 128 completed tows aboard the F/V Mister G*

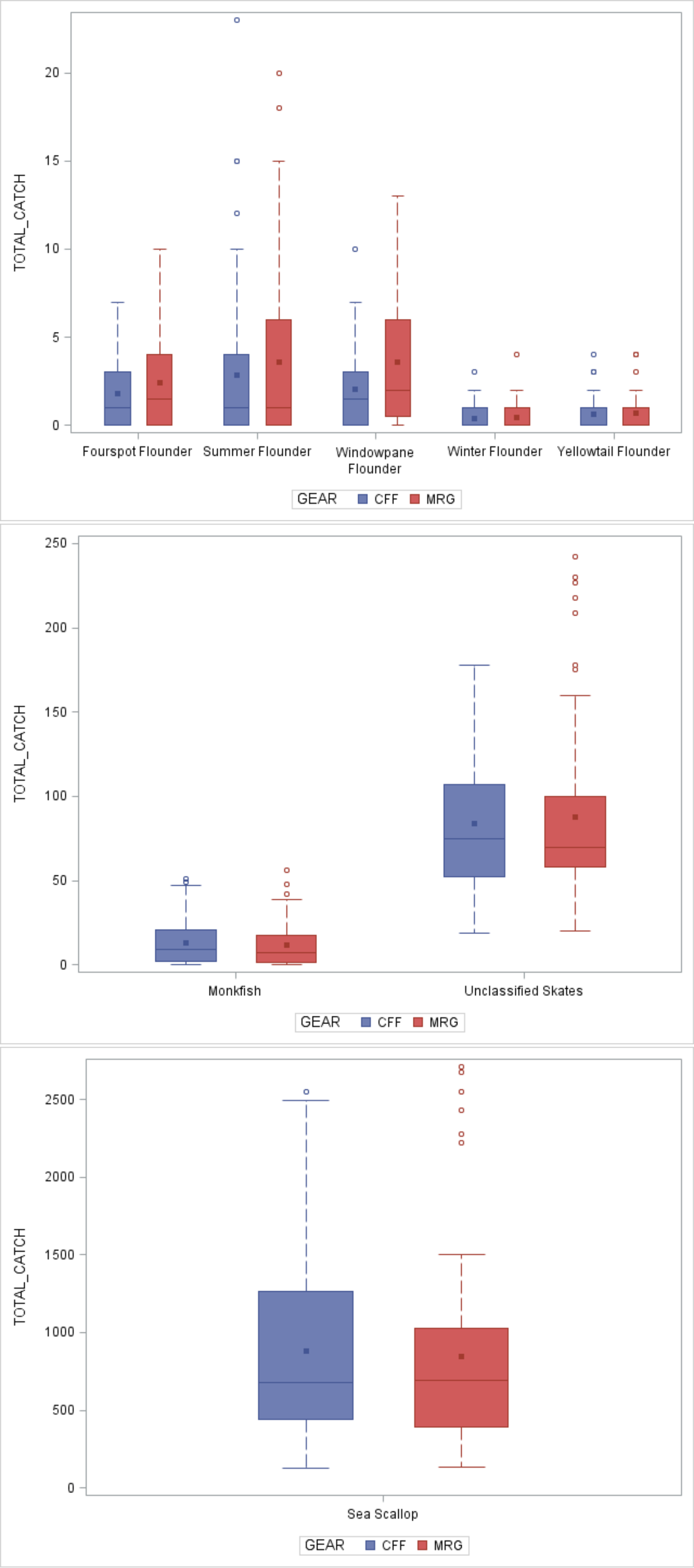
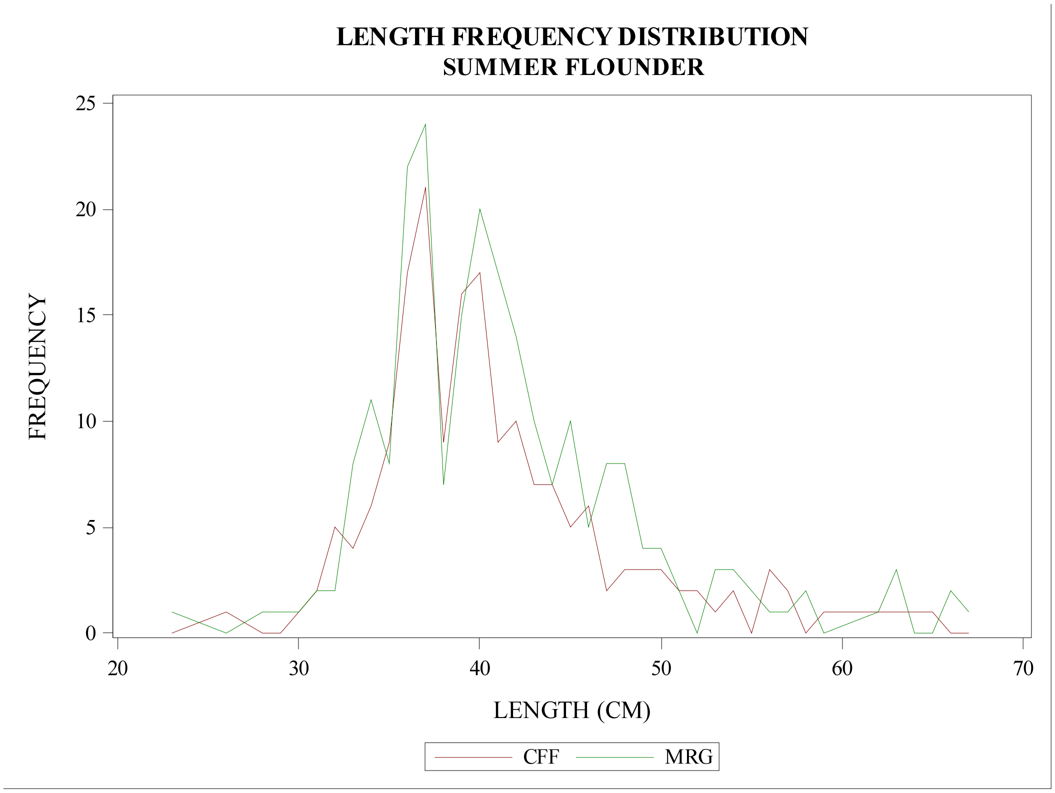


Figure 4. *Box plots of observed catches by species*



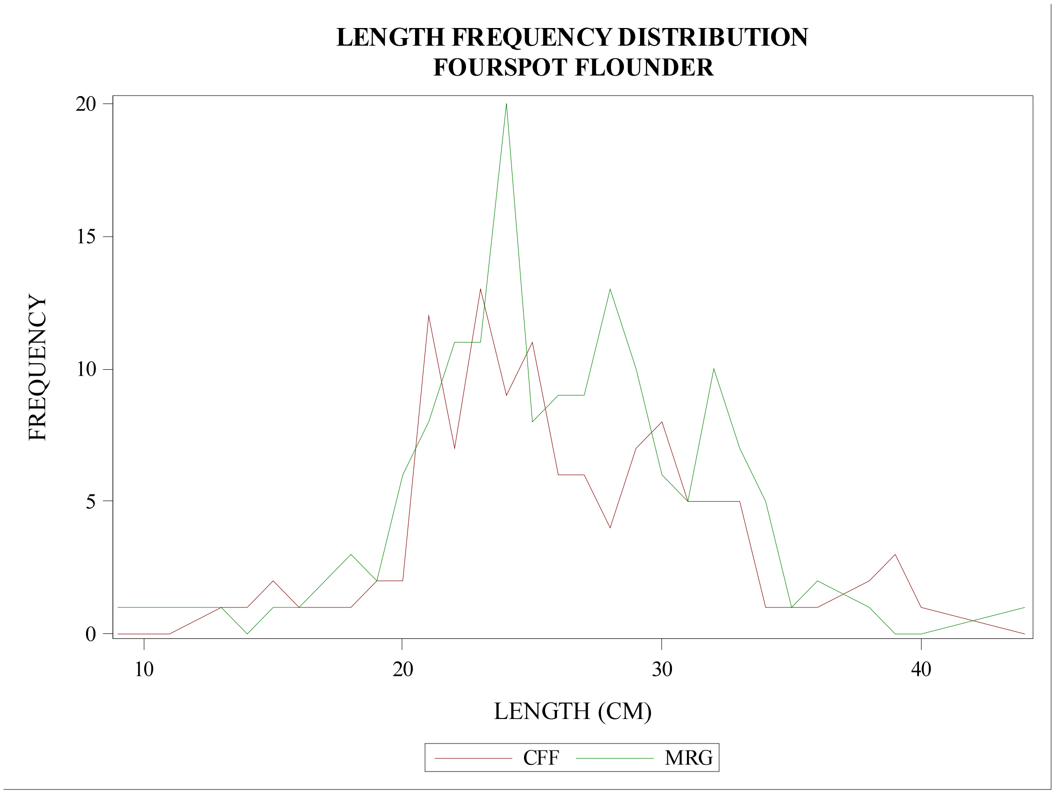


Figure 5. *Length frequency distributions for sea scallops and finfish encountered during the study.*

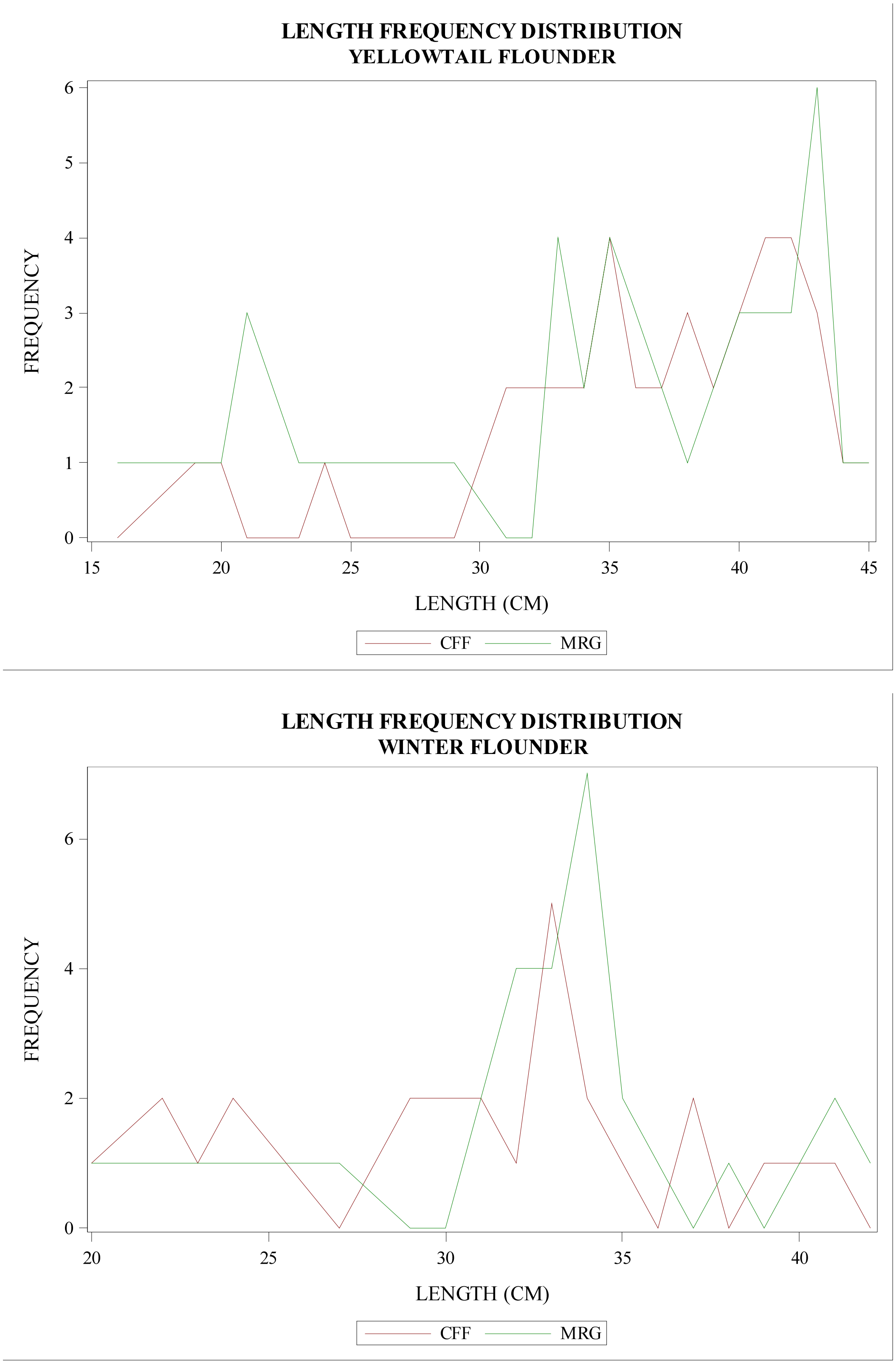
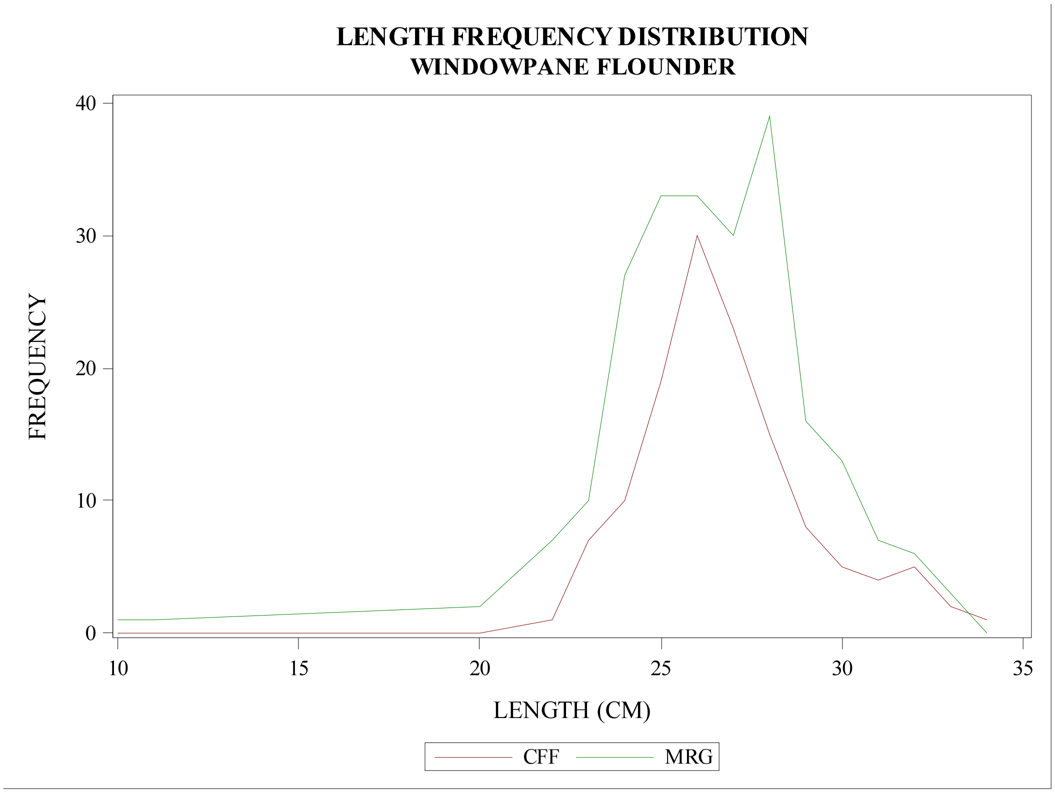


Figure 5. *continued.*



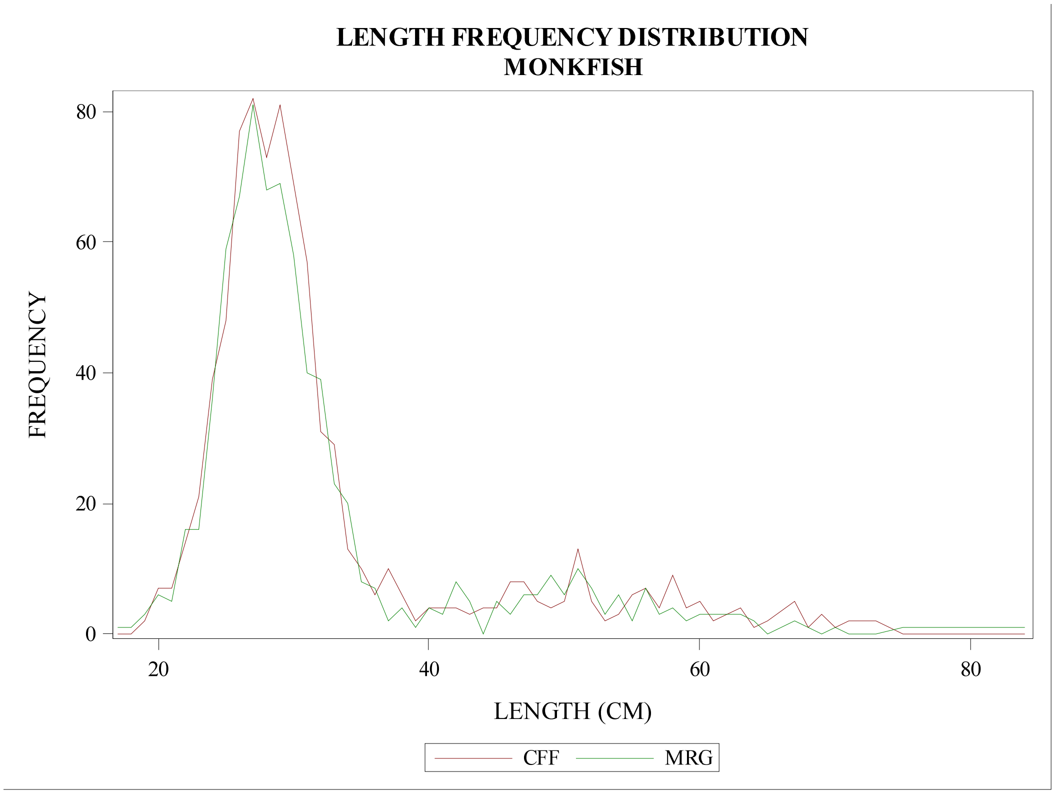


Figure 5. *continued.*

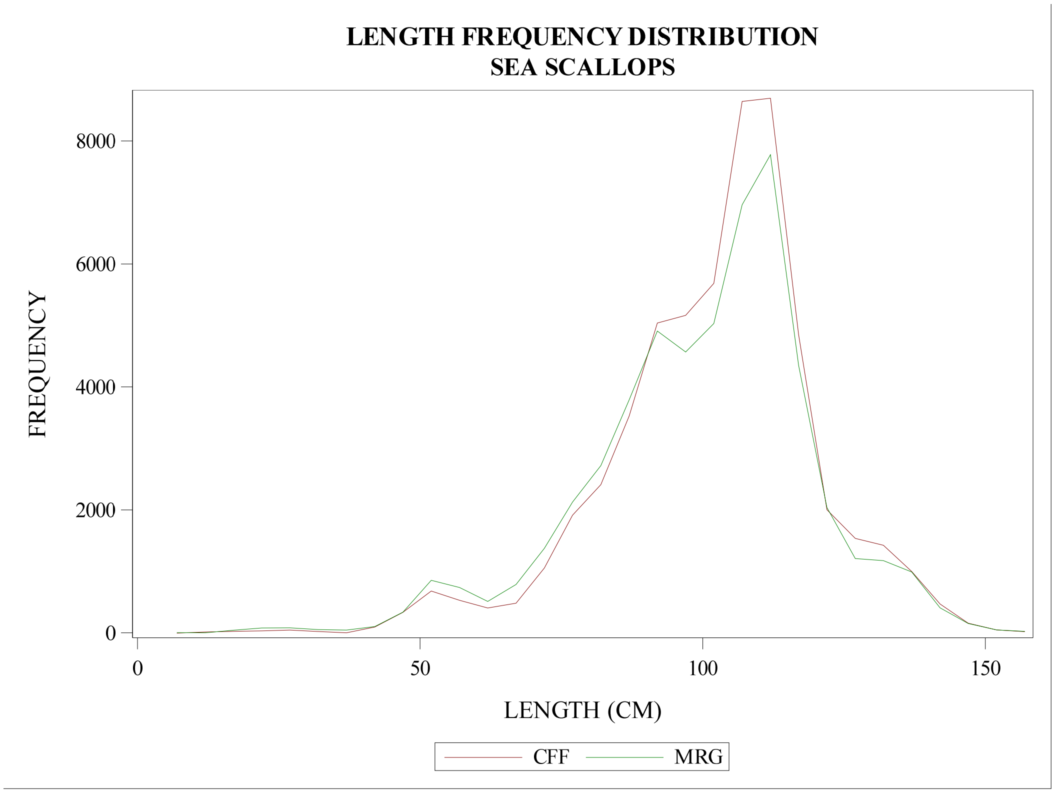


Figure 5. *continued.*