APPENDIX B5: Selectivity of commercial sea scallop dredges with 4" rings

A size-selectivity curve was constructed to characterize the performance of the commercial New Bedford style sea scallop (*Placopecten magellanicus*) ("commercial") dredge, configured to meet the requirements of Amendment #10 to the Sea Scallop Fishery Management Plan. In order to construct an absolute size-selectivity curve, the commercial (experimental) gear must be compared to a non-selective (control) gear. The National Marine Fisheries Service (NMFS) survey dredge ("survey") served as the control gear in this study. The survey dredge is assumed to be non-selective because there is a liner sewn into the dredge bag which prohibits scallops from escaping. With the catch-at-length data from the two dredges, the Share Each LEngth's Catch Total (SELECT) model developed by Millar (1992) was used to generate the curve.

Data Collection and Analysis

The catch-at-length data needed to generate the selectivity curve was gathered during three cruises aboard commercial sea scallop vessels between 2005 and 2006. One cruise was completed in Georges Bank (in the Groundfish Closed Area II (CA2 2005)) and two in the mid-Atlantic (both in the Elephant Trunk Closed Area (ETCA 2005 and 2006)). Within each area, pre-determined stations, selected within a systematic random grid, were sampled. At each station, a standard NMFS survey dredge was towed simultaneously with a New Bedford style commercial sea scallop dredge. Simultaneously towing the two dredges from the same vessel allowed for similar type of substrate and population of scallops to be sampled. The survey dredge was 8-feet (2.4 m) in width, was configured with 2-inch (51 mm) rings, a 3.5-inch (89 mm) diamond mesh twine top, and a 1.5-inch (3.8 cm) diamond mesh liner and the commercial dredges were 15-feet (4.6 m) in width, had 4-inch (102mm) rings, a 10-inch (25.4 cm) mesh twine top and no liner. Rock chains and chafing gear were used on both dredges as dictated by the area surveyed and current regulations.

Each tow, from all cruises, was evaluated and deemed invalid if any of the following conditions were observed: hangs, flips, crossing or tangling of the gear, the tow was not deemed "good" in the comments section of the deck or bridge log, the inclinometer indicated that the gear was not fishing correctly, no scallops were caught or there were fewer than 20 scallops caught in either dredge. A catch of less than 20 suggests that there were actually no scallops present at the station; rather, scallops from a preceding tow may have been lodged in the dredge or left on deck.

The number of scallops caught per each 5 mm length class (evaluated as the mid-point of the length class, i.e., length "7.5 mm" represents the length class 5-10 mm) from each gear, was multiplied by an expansion factor equal to the number of baskets of scallops caught divided by the number of baskets measured. The tows were then combined by cruise, closed area, year and all tows together. For each tow and combination of tows, a plot was made of the ratio of the number of scallops in each length class in the commercial dredge to the total in both dredges (Commercial/Total) in order to determine if the commercial gear was behaving selectively. This assessment validated proceeding with the analysis.

The catch-at-length data for each tow combination were then analyzed with the Share Each LEngth's Catch Total (SELECT) model developed by Millar (1992). The SELECT model generates the parameters needed to create the selectivity curve as well as a parameter that denotes relative fishing intensity between the two gears (experimental and control). This is the

split parameter, p_j, which accounts for how catch among gears (j=1,…, n) will vary due to affects such as differential fishing effort, fish avoidance behavior and localized fish concentrations.

Due to variation in wind speed, water depth, sea state, scallop density and other factors that cannot be controlled, there is variation in selectivity from one tow to the next. This must be considered when tows are combined. A test for overdispersion (variation exceeding that which is predicted by the model) was completed using the replication estimate of between-haul variation (REP) combined hauls approach discussed in Millar et al. 2004. In order to avoid over-inflating the degrees of freedom for this analysis, only length classes where, when all tows are combined, one dredge has caught at least 20 scallops were used. In order to determine if this affected the estimated parameters, the model was run under this criterion as well as under the criteria that, for each length class, at least one dredge had more than: 1) zero scallops, 2) 60 scallops and 3) 1,000 scallops. In general, with fewer length classes used in the analysis, the 50% retention length, selection range, split parameter and log likelihood values all increased; however, these changes were not substantial.

In order to create a selectivity curve that is representative of the offshore commercial fleet, sampling was conducted aboard commercial scallop vessels, under conditions that mimicked commercial practices and the experiments were performed during different months and in different areas, which contained a variety of substrates. The only aspect of this study that is not representative of commercial practices is tow duration; however, an assessment of how the number of baskets of scallops and trash caught in the commercial dredge affects the parameters of the selectivity curve was made. This served as a proxy for how tow duration might affect the selection process. It must be noted, though, that tow duration does not predict the size of the catch. For this assessment, tows from all three cruises were grouped into five categories based on the number of baskets of scallops caught in the commercial dredge: 1) fewer than three, 2) three to six, 3) six to twelve, 4) twelve to twenty-four, and 5) more than twenty-four. These increments were chosen because there were a similar number of tows that fit into each group. A selectivity curve was generated for each category, using the same length classes that were used to evaluate all tows combined. A Spearman's rank correlation coefficient analysis was then completed on the resulting 50% Retention Length (l_{50}), Selection Range (SR) and split parameter (p_c) values. This procedure was repeated with increasing baskets of trash. Categories for this analysis were based on the number of baskets of trash in the commercial dredge: 1) less than 0.25, 2) 0.25 to one, 3) one, 4) one to two, and 5) more than two.

Results and Discussion

The catch-at-length data obtained during this study were evaluated with the SELECT model using the logistic as well as Richards, log-log and complementary-log-log curves in order to determine the most appropriate model for the data. The deviance residuals from the logistic fit showed no considerable trends and the curve adequately fit the data. The other three curves did not significantly improve the fit, based on AIC values, and, therefore, the results will only be presented for the logistic SELECT model. Also, the REP assessment for combining multiple tows indicated that there was extra variation for all tow combinations (by cruise, year, area and all combined) and, therefore, the standard errors for the estimated parameters were multiplied by the square root of REP.

The logistic parameters estimated for each combination of tows were inserted into the selectivity curve equation. The range of l_{50} values from the different combinations of data was

98.1-105.2 mm and of selection range values was 18.6-28.7. However, the final results are those that were estimated for all valid tows for the CA2 and ETCA cruises combined since an evaluation of the resulting parameters and confidence intervals from all combinations of data (by cruise, area and year) revealed little significant difference. Additionally, by including tows from multiple cruises on different vessels, during different times of the year and in different areas and substrates the selectivity curve becomes more representative of the commercial fleet. The resulting SR for this analysis is 23.6 mm, the l_{50} is 100.1 mm and the estimated split parameter is 0.77.

The next assessment evaluated how increasing number of baskets of trash and scallops caught in the commercial dredge might affect the estimated selectivity parameters. This served as an indication of whether the results were affected by the reduced tow duration used in this study. The Spearman's rank correlation coefficient significantly indicated that with increasing number of scallops the selection range and the split parameter values increase. While the results for the 50% retention length appear to show a similar trend, the results were not significant. In contrast, none of the evaluated parameters showed a significant relationship with increasing number of baskets of trash; however, the l_{50} values show a decreasing trend with increasing baskets of trash. It can be assumed that the selectivity curve generated in this study does represent commercial practices since there is not a significant difference in the l_{50} values with increasing baskets of scallops or trash. Additionally, during the survey cruises, the dredge bag ranged from being empty to completely full, which mirrors the range observed during commercial operations.

Lastly, the final results for this study were compared to those obtained from an additional cruise in the Nantucket Lightship Closed Area (NLCA). This cruise was conducted under the same conditions and during the same time period as the aforementioned cruises; however, the survey and commercial dredges used in the NLCA were not configured as they were in the other areas. For this reason, data from the NLCA were not combined with the other cruises. The estimated parameters for the NLCA cruise yielded a 50% retention length of 101.6 mm, a selection range of 17.63 mm and a split parameter value of 0.76. Standard errors for the estimated parameters were multiplied by the square root of REP because the data were overdispersed. Results from the NLCA are comparable to the results from the other cruises combined. An assessment of these parameters with confidence intervals reveals that there is no significant difference between the two 50% retention lengths and split parameters, but that there is between the selection ranges. Regardless, the similarity of the results for the NLCA cruise and for the other cruises combined indicates that the selection curve generated for this study is robust to changes in gear configuration. Additionally, the length frequency distribution in the NLCA is different from the other closed areas. This implies that the selection curve is also robust to differences in length frequency distribution.

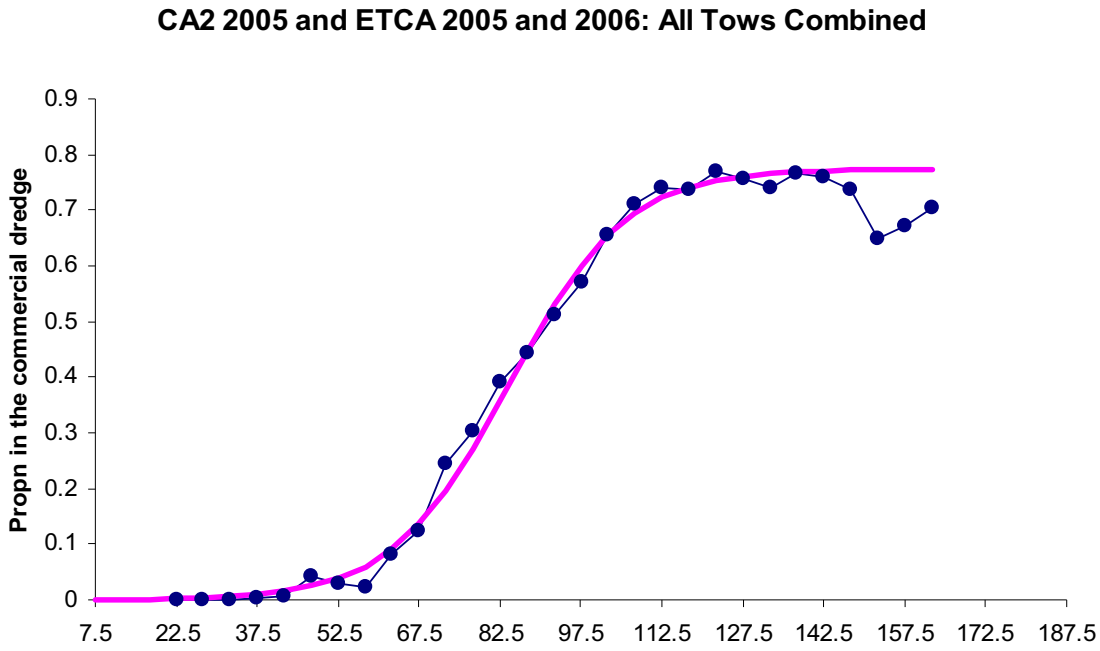
To maximize the effectiveness of the resulting curve from this study, more information is required regarding incidental mortality and the fate of scallops that interact with or escape from the commercial dredge and of the scallops that are landed on deck but are not harvested.

APPENDIX B5 Table 1. Estimated parameters from the logistic SELECT analyses on catch-at-length data for all length classes with at least 20 scallops in one of the dredges. Listed are lengths used in the analyses and the starting values to estimate the parameters in both R and Excel. The estimated values (left column) for logistic parameters *a* and *b*, as well as the 50% retention length (l_{50}), the selection range (SR= l_{75} - l_{25}) and the relative efficiency split parameter (p_c) are given. The number of tows (No. Tows) used for each analysis, log likelihood (L) and the replication estimate of between-haul variation (REP) are specified as well as the standard errors (right column), which have been multiplied by the square root of REP.

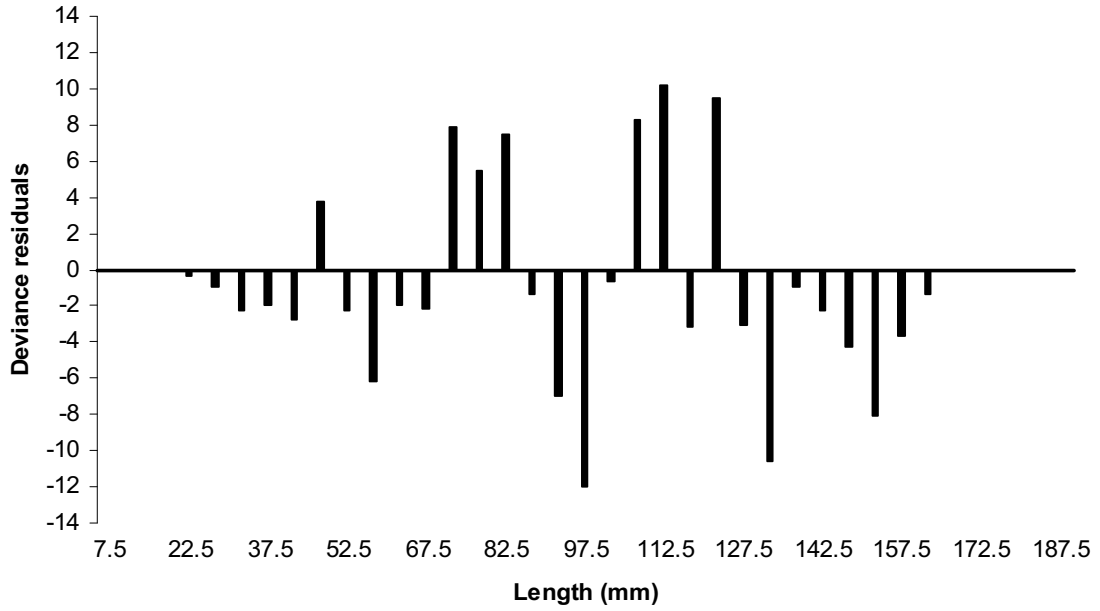
	NLCA 2005		**CA2 2005, ETCA 2005 & 2006**	
Lengths	42.5-172.5		22.5-162.5	
Start values	(-12, 0.12, 0.8)		(-12, 0.12, 0.8)	
a	-12.6700		-9.32	
b	0.12		0.09	
p_c	0.76	0.005	0.77	0.004
l_{50} **(mm)**	101.63	1.42	100.11	0.60
SR (mm)	17.63	1.85	23.61	0.59
L	-50672		-311035	
REP	8.01		7.98	
No. Tows	35		1052	

APPENDIX B5 Figure 1. (A) Logistic SELECT curve fitted to the proportion of the total catch in the commercial gear and (B) deviance residuals for CA2 2005, ETCA 2005 and ETCA 2006 cruises combined.

A



B



APPENDIX B5 Figure 2. Logistic selection curve for the New Bedford style dredge which incorporates all valid tows from the three cruises. The lengths at 25%, 50% and 75% probability of retention are shown. The selection range is the difference between the 75% and 25% retention lengths (l_{75}- l_{25}).