DELAWARE RIVER MAIN CHANNEL DEEPENING PROJECT DELAWARE BAY WINTER CRAB SURVEY – 2000/2001 -

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ABSTRACT

The U.S. Army Corps of Engineers conducts maintenance dredging in areas of the Delaware river main channel with depth less than 12.2 m (40 ft), and plans to deepen sections of the channel with depths between 12.2 m (40 ft) and 14.3 m (47 ft). Dredging is scheduled for the winter in a small section of the Miah Maull Range as part of the Kelly Island reconstruction project. Resource agencies have raised concerns that dredging during winter may have a significant negative impact on the blue crab stock residing in the lower bay. Blue crabs are vulnerable to dredging during winter because they largely are inactive and bury themselves in the bottom sediment from November through March. Mature female crabs favor deeper waters in the lower bay. Dredging could harm the blue crab stock and the fishery if a significant portion of the population over-winter in the portion of the navigation channel scheduled to be dredged. The blue crab supports a valuable winter dredge fishery in Delaware and New Jersey. The total reported landings during the 2000/2001 winter were 26,534 bushels.

During February 2001, Versar conducted a study to quantify the number and fraction of over-wintering blue crabs that would be impacted by channel dredging. The study was limited to the Delaware Bay south of the 39° N 20' parallel, and excluded tributaries and shallow waters. Based on stratified random sampling, 105 sampling sites were selected for sampling of crabs to estimate abundance, with focus on the navigation channel. An additional 30 stations were sampled as part of an experiment to test for difference in abundance between the channel and the channel bank. Sampling was conducted from a Delaware fishing vessel equipped with a commercial dredge widely used in the winter blue crab fishery. For this study, the dredge was lined with a 12.7 mm nylon mesh to retain young-of-year crabs with carapace width greater than 15 mm. Versar estimated that 22% of the crabs present in the path of the dredge are caught, on average. After statistically adjusting for the dredge catching efficiency, the density of blue crabs in the navigation channel was estimated at 62.0 live crabs per 1000 m^2 (251 crabs per acre), as compared to 51.4 live crabs per 1000m^2 (208 crabs per acre) for the overall study area. The Miah Maull Range had 2.3 live crabs per 1000 m^2 (9.3 crabs per acre). Only a small fraction (1.6 % or less) of the blue crab population in the lower Delaware Bay resides in the navigation channel during winter. The winter mortality appeared to be substantial, with dead crabs constituting about 20% of the total. The winter-population was estimated at 71.46 million live crabs for the entire study area, and 1.1 million for the section of the navigation channel included in this study. The absolute abundance of fully recruited crabs (120 mm and greater CW) in the study area was 60.2 million crabs, and 1.05 million for the navigation channel (1.7% of the total). The estimate for the fully recruited stock was significantly higher than the 1979-1999 average (at the 5% significance level) based on modified DeLury model assessments, but did not significantly differ from the most recent DeLury estimate.

The blue crab sampling in the channel covered bottom habitats that have previously been subject to maintenance dredging, as well as areas that have not previously been dredged. Although not statistically significant, the estimated mean absolute density in previously dredged areas (2.7 crabs per 1000 m^2) was substantially lower than the mean density in areas that never have been dredged (65.9 crabs per 1000 m^2). For the small section of the channel scheduled to be dredged during winter (3.7 km (2.3 miles), 9.93 km^2 (278.7 ac.)) the estimated abundance of

live crabs across size and sex groups was 70,038 crabs based on the mean density in the entire channel (2,594 based on the estimated density for the Miah Maull Range). The number of crabs in the impacted area constitutes about 6% of the live crabs that were hibernating in the channel, and 0.1% of the crabs hibernating in the lower Delaware Bay (based on the overall mean density in the channel). In conclusion, this study suggests that the planned navigation channel deepening during winter will have negligible impact on the hibernating blue crab stock because only a small area with relatively low density of crabs will be affected.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table No. **Page**

LIST OF FIGURES

Figure No. **Page**

1.0 INTRODUCTION

The blue crab (*Callinectes sapidus*) is found from Nova Scotia through the East and Gulf coasts of the United States, and into the West Indies. Commercial and recreational fisheries for this species exist in many states, including New Jersey, Delaware, and the Carolinas. The largest fishery for the blue crab, both today and historically, is on Chesapeake Bay in the states of Maryland and Virginia. The blue crab supports the most valuable fishery in Delaware, with an average commercial catch of 50,000 bushels of hard shells and peelers per year; the pot fishery accounts for the majority of the total landings. A dredge fishery for blue crabs occurs from December 15 to March 30 in the lower Delaware Bay, targeting fully recruited crabs (carapace width ≥ 120 mm) that over-winter in deeper waters (depth > 10 m) with relatively high salinity. Mature females are dominant in these waters, and make up the vast proportion of blue crabs residing in the lower Delaware Bay. At the onset of winter, mature female blue crabs migrate to the mouth of the estuary and burrow into deep-water sediments where they remain until spring, whereas young-of-year (< 60 mm) females and male crabs of all size classes tend to burrow near their foraging habitat in shallow water. The distribution of blue crab in Chesapeake Bay during winter exhibits a similar pattern, with mature females being dominant in deep waters close to the mouth of the Bay (Van Engel 1958, Schaffner and Diaz 1988, Sharov et al. 2001). Blue crabs in the Chesapeake Bay are largely inactive and bury themselves in the bottom sediment from November through March (Van Engel, 1958); thus, they are less likely to escape the dredge by swimming. Orth and van Montfrans (1987) reported negligible catches in bottom trawls during winter, further supporting the premise that crabs are buried in the substrate. The successful blue crab fishery in the Delaware Bay during winter, and the proximity of the study area to the Chesapeake Bay suggest that a similar pattern holds for the blue crab population in Delaware Bay.

Resource agencies reviewing potential impacts of the proposed Delaware River Main Channel Deepening Project have suggested that the project may impact over-wintering female blue crab populations if dredging is conducted in the winter season in lower Delaware Bay. There is currently no spatially referenced information on abundance and population characteristics for lower Delaware Bay that can be used to assess what portion of the over-wintering crab population resides in the navigation channel relative to other habitats. If a disproportionate number of crabs over-winter in the navigation channel, the dredging operation could have deleterious effects on the winter crab dredge fishery and blue crab recruitment in the following year. In contrast, if only a small percentage of the total blue crab population utilize the section of the bay scheduled to be dredged, then the wintertime dredging will have minimal impact on the stock, and restrictions being considered by the resource agency may not be necessary to protect the resource.

The purpose of this study is to: 1) determine the density distribution of over-wintering blue crabs with respect to the navigation channel, 2) assess the potential impacts of winter dredging on blue crab abundance by sex, and 3) provide an estimate of total blue crab standing stock in lower Delaware Bay for the winter 2000/2001 fishing season.

2.0 STUDY AREA

The study was conducted in the lower Delaware Bay (including the lower portion of Section E of the Federal Navigation Channel) in an area extending from river mile 0 to the N 39° 20′ parallel, excluding tributaries and shallow waters (< 1.5 m (5 ft)). The survey area was divided into six primary geographic strata: (1) Deep Waters, Lower Bay (Deep); (2) Lower New Jersey (NJL); (3) Lower Delaware (DEL); (4) Upper New Jersey (NJU), (5) Upper Delaware (DEU), and (6) the Navigation Channel (Channel) (Figure 1). The strata were designed to encompass major areas of habitat for the over-wintering blue crab stock, and to account for differences in spatial distribution of crabs by size and sex. The navigation channel was further stratified into four longitudinal segments based on range (Table 1). The sampling in the Channel covered bottom habitat in three distinct dredging categories:

1. Previously dredged -- depths less than 12.2 m (40 ft) subjected to maintenance dredging within the last 15 years;

2. Slated to be dredged for the 13.7 m (45 ft) project -- depths between 12.2 m (40 ft) and 14.3 m (47 ft), with no previous dredging;

3. Never dredged, and not scheduled to be dredged for the 13.7 m (45 ft) project -- depths greater than 14.3 m (47 ft).

Table 1. Geographic strata, sampling allocation, and strata areas

Stratum	Area Type	Number of Stations	Area (m^2)
Liston	Channel	9	4792670
Crossledge	Channel	4	1969990
Miah Maull	Channel	7	4428000
Brandywine	Channel	10	7340260
DE_Lower	Stratum	15	367944000
DE_Upper	Stratum	15	136305000
DelBay_Deep	Stratum	15	261570000
NJ_Lower	Stratum	15	480234000
NJ_Upper	Stratum	15	123993000

The fraction of area in each dredging category for each range was estimated from bathymetry data extracted from the NOS Hydrographic Survey Database, using GIS (Table 2). The area scheduled to be dredged during winter for the Kelly Island project is limited to a 3.7 km (2.3 miles) section of the Miah Maull Range, with area 1.13 km^2 (278.7 acres).

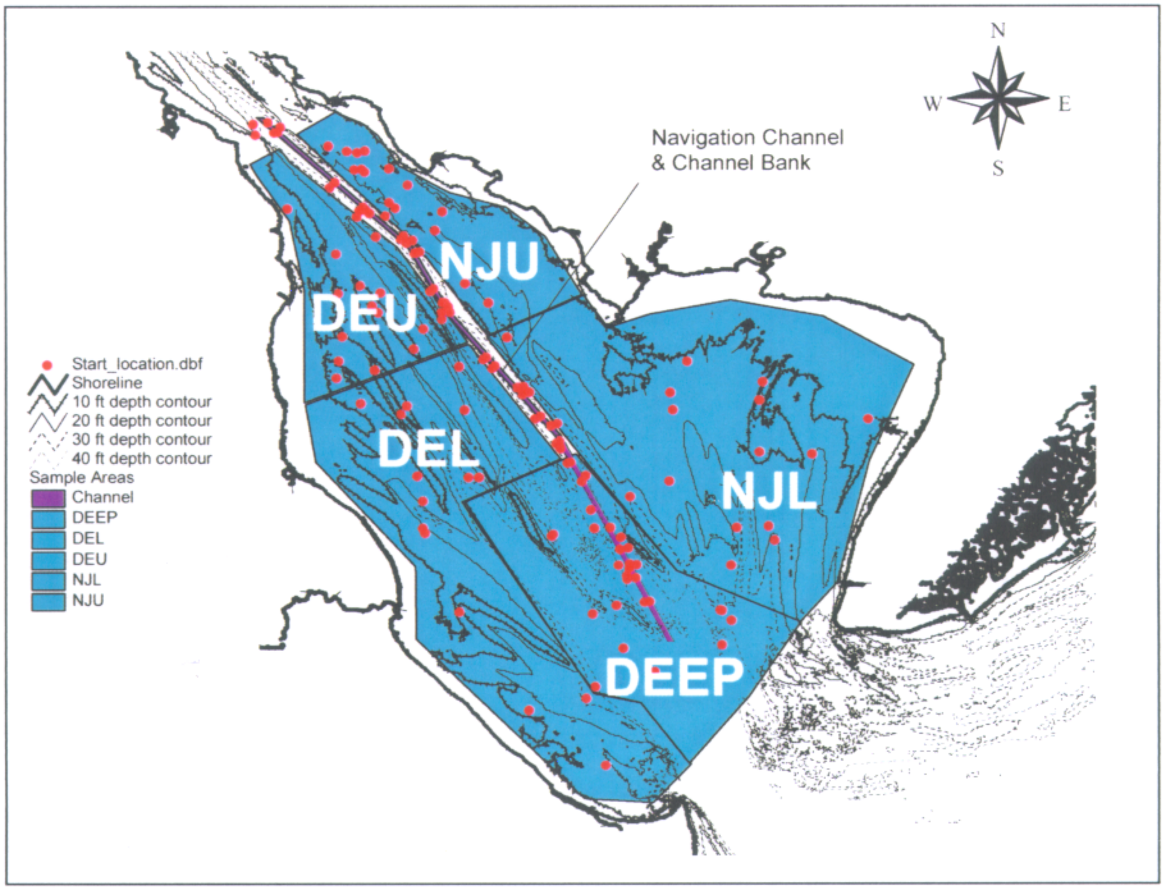

Figure 1. The Delaware Bay winter blue crab survey area, and the six primary geographic strata: (1) Deep Waters in the Lower Bay (Deep); (2) Lower New Jersey (NJL); (3) Lower Delaware (DEL); (4) Upper New Jersey (NJU), (5) Upper Delaware (DEU), and (6) the Navigational Channel & Channel Bank (Channel).

Table 2. Approximate fraction of area in each dredging category by sub-stratum (range)

Stratum	%>47 ft	%[40-47 ft]	%<40 ft
Liston	13.9	80.1	5.9
Crossledge	56.5	43.1	0.3
Miah Maull	77.0	22.9	0
Brandywine	25.5	72.6	1.8

3.0 METHODS

3.1 STRATIFIED RANDOM SURVEY

A stratified random dredge survey was conducted during January 2001 to estimate density, abundance, and size/sex composition of the blue crab (*Callinectes sapidus*). The survey was designed to obtain separate estimates of density and abundance by sex for the Navigation Channel, the channel bank, and the remaining area of lower Delaware Bay with depths greater than 1.5 m (5 ft). The station allocation by stratum is summarized in Table 3. A total of 105 stations were sampled in the standard stratified random survey, with 30 stations allocated to the Channel, and 15 stations to each of the other strata (Figure 1). In addition, 30 stations were sampled as part of an experiment to test for differences in density between the Channel and the bank along the Channel. The sampling was conducted from a commercial fishing vessel equipped with a dredge (4.3 m wide) widely used in the Delaware winter blue crab fishery. For this study, the dredge was lined with a 12.7-mm nylon mesh to retain young-of-year crabs; it is assumed to have 'knife edged' selectivity for crabs with a carapace width (CW) of at least 15 mm (Sulkin and Miller, 1975).

Table 3. Station selection procedure by stratum.

Stratum	Sample Size	Selection Procedure for Dredge Stations
Channel – approximately 1000 ft, from river mile 0 to the 39° N 20' parallel.	30	Stratified random, with approximately even sampling density in each of four ranges.
Depth transitional area along each side of channel	30	Adjacent to stations in channel, at random side of channel
Lower Delaware Deep waters	15	Simple Random
State of Delaware, Shallow lower	15	Simple Random
State of Delaware, Shallow upper	15	Simple Random
State of New Jersey, Shallow lower	15	Simple Random
State of New Jersey, Shallow upper	15	Simple Random
	Total: 135	

The dredge was generally hauled for 2 min along the bottom at a speed of 3 knots. The towing distance (in meters) for all hauls was measured by GPS, and depth was recorded from acoustic readings. The area swept for each haul was estimated as the towing distance multiplied by the width of the dredge. For two stations (DBC-205W and DBC-208) we used the mean towing distance for 2 min hauls (168 m) because of a GPS error, or transcription error while recording longitude/latitude in the field. For all catches, the number of blue crabs was recorded, and information on carapace width (CW) to the nearest mm, sex, maturity stage, and overall condition was collected for each specimen. Live crabs and dead crabs were tallied separately by sex to provide information on winter mortality. The data collection forms used are provided in Appendix B. The catch-per-unit-effort (CPUE) for each haul was standardized to number of crabs per 1000 m^2 area swept. A bottom sediment sample was collected at each survey and experimental station using a petite ponar grab. Two sub-samples of approximately 120 ml each were collected from the surface sediment for grain size analysis. Sand and silt-clay particles were separated in the laboratory by wet sieving through a 63 μm stainless sieve, and weighed. Presence of blue mussels, sulfur sponge, and other bycatch information was recorded for all hauls. Detailed station information including catch and bycatch is in the Appendices.

3.2 EXPERIMENTAL STUDY IN THE NAVIGATION CHANNEL

A randomized block experiment was conducted to test for significant differences in the density of blue crabs between the channel and the bank along the channel. The experiment involved dredging on the bank of the channel; dredge hauls were conducted parallel with each of the 30 stations selected systematically along the length of the channel. The hauls were allocated at random to one of the channel banks. This experimental design ensured that parallel dredging was conducted in each of the sub-strata in the Channel. Parallel hauls were conducted in each of the three distinct dredging categories in the navigation channel: (1) previously dredged, (2) slated to be dredged, and (3) never dredged. Each pair of tows (inside Channel and on the bank) was considered a block in the experimental design. The experiment was analyzed using the model

$$y_{ijkl} = \mu + \alpha_i + \beta_j + \tau_k + \varepsilon_{ijkl} \quad (1.1)$$

where y is the log of (CPUE+1) for each tow, μ is the overall mean, α is the stratum effect, β is the block effect, τ is the effect of the dredging location with respect to the Channel (i.e., inside the Channel or on the bank) and ε is the error term. The errors are assumed to be independently and identically distributed in a normal distribution (Box et al. 1978). In this study, we are primarily interested in measuring τ. The other factors were introduced to remove or lessen the effects of spatial differences in catch per area swept and thereby increase the sensitivity of the analysis for detecting difference in density between the channel and the bank.

3.3 REMOVAL EXPERIMENTS

CPUE must be adjusted for the catchability coefficient of the sampling gear to estimate absolute density and abundance from the survey data (Gunderson 1993). The catchability coefficient (i.e., the fraction of crabs present in the path of the dredge that is captured) is estimated from removal experiments (Seber 1973; Ricker, 1975; Hilborn and Walters 1992). In each experiment, a closed population was sampled repeatedly over a relatively short time. For each catch, all crabs were sorted by sex, counted and measured (CW) to the nearest mm. Sediment samples were collected from each experimental site. The possible effect of body size on the catchability coefficient was evaluated by comparing mean carapace width and size frequency distributions between removals. If large crabs have a higher probability of capture than small crabs, for example, the mean carapace width of crabs in the first removals would, on average, be larger than in the final removals.

Ten removal experiments were conducted at a random subset of survey stations with positive catches. In each experiment, an area of 100 m by 4.3 m was swept 10 times by the dredge. The unit of effort is one sweep (removal) by the dredge of the experimental area. It is assumed that no emigration, immigration, or natural mortality occurs during the experiment and that no animals caught are returned to the population (Otis et al. 1978; Schnute 1983; Hirst 1994). Migration is likely to be minimal during the short period of an experiment (< 1 hour) because blue crabs are largely inactive during winter.

3.3.1 Estimating Catchability

An estimate of the catchability coefficient is based on the slope of a linear regression of CPUE on cumulative catch (Leslie and Davis 1939):

$$y_i = q[P_0 - K_{i-1}] = qP_0 - qK_{i-1} \quad (2.1)$$

where y_i is the catch from the ith removal, and K_{i-1} is cumulative catch taken before each removal. P_0 is the initial population in the area before the depletion experiment. The catchability coefficient q is simply the slope of the linear regression estimated from (2.1).

To estimate a mean catchability coefficient that is applicable to the entire survey area, estimates of catchability from each removal experiment are weighted by the abundance in the experimental area using the method described in Vølstad et al. (2000). An estimator for the overall catchability coefficient to use for calibrating CPUE in the dredge survey is

$$\bar{q} = \sum \frac{c_i q_i}{C} \quad (2.2)$$

where c_i is the total number of crabs caught in the ith experiment; q_i is the corresponding estimated gear efficiency; and C is total number of crabs caught in the n experiments. Since only 10 experiments were conducted, the standard error of (2.2) is estimated using the jackknife method (Efron and Gong 1983; Vølstad et al. 2000). The catchability coefficient was also estimated for sites with presence of mussels, and for sites with low (< 20%) or higher (≥ 20 %) silt/clay content using the same analytical approach.

3.4 ESTIMATING DENSITY AND ABUNDANCE

Let x_{ij} denote the catch per area swept (numbers per m^2) at station i in stratum j, and let $\overline{q}_{ij}$ denote the dredge catchability coefficient estimated from equation (2.2). The absolute number of crabs per m^2 at station i in stratum j is estimated as

$$y_{ij} = \frac{x_{ij}}{q_{ij}} \qquad (3.1)$$

and the mean density of crabs across stations in stratum j is estimated by

$$\overline{y}_j = \frac{1}{n_j}\sum_{i=1}^{n_j} y_{ij} \quad (3.2)$$

with variance

$$\mathrm{var}(\overline{y}_j) = \frac{\sum_{i=1}^{n_j}(y_{ij}-\overline{y}_j)^2}{n_j(n_j-1)} \qquad (3.3)$$

where n_j is the number of stations in stratum j. The stratified mean density for the entire survey area (A) is estimated by

$$\overline{y}_{st} = \sum_{j=1}^{L} W_j \overline{y}_j \quad (3.4)$$

with variance

$$\mathrm{var}(\overline{y}_{st}) = \sum_{j=1}^{L} W_j^2 \,\mathrm{var}(\overline{y}_j) \qquad (3.5)$$

where L is the number of strata, and W_j is the proportion of the total survey area in stratum j (e.g., Cochran 1977, Thompson 1992). The absolute abundance (total number of crabs) in a stratum j is estimated by extrapolating the stratum mean density to the stratum area (A_j),

$$\tau_j = A_j \times \overline{y}_j \qquad (4.1)$$

and the variance is estimated by

$$\mathrm{var}(\tau_j) = A_j^2 \,\mathrm{var}(\overline{y}_j) \quad (4.2)$$

The absolute abundance in the entire survey area (A) is estimated by

$$\tau = A \times \overline{y}_{st} \qquad (4.3)$$

and the variance of the total abundance estimate is estimated by

$$\text{var}(\tau) = A^2 \, \text{var}(\overline{y}_{st}) \quad (4.4)$$

Density of crabs in the channel by the three dredging categories with standard errors (SE) was estimated by post-stratification, using equations 3.2 and 3.3. The standard error (a measure of precision) for a mean or total is defined as the square root of its variance. The relative standard error (RSE) for a mean (or total) is the SE divided by the mean (or total). Post-stratification was also used to estimate density and abundance for the 1.13 km^2 area in the Miah Maull Range that is scheduled to be dredged during winter for the Kelly Island project.

We separated the CPUE data into three stages based on their carapace width: < 60 mm CW, 60-119 mm, and 120 mm and greater (Helser 2000, Sharov et al. 2001). The small stage represents the young-of-year (age 0) crabs hatched during the preceding summer. We assume that crabs with CW greater or equal to 60 mm are one year and older (age 1+). The large stage corresponds to fully recruited crabs. By October, the medium stage has typically merged with the distribution of older crabs resulting in a bi-modal CW distribution that represents age 0 and age 1+ crabs (Helser 2000). The frequency distribution of the blue crab carapace width in Chesapeake Bay estimated from the yearly winter dredge survey has shown this characteristic bimodal shape for all years from 1990 to 1999 (Sharov et al. 2001).

Comparisons of statistical differences between two population quantities were conducted using the standard method recommended by Schenker and Gentleman (2001), and not by examining the overlap between the two associated confidence intervals. Assume that $\hat{Q}_1$ and $\hat{Q}_2$ are two independent estimates of abundance (or density) of blue crabs, and that the associated standard errors (*SE*) are estimated by $\hat{SE}_1$ and $\hat{SE}_2$. The estimated quantities $\hat{Q}_1$ and $\hat{Q}_2$ could, for example, represent estimated density of blue crab for two geographic areas (e.g. inside the navigation channel versus the general population in the study area), or estimates of the total abundance in the study area from two independent studies. We estimated the 95% confidence interval for $\hat{Q}_1 - \hat{Q}_2$ by

$$(\hat{Q}_1 - \hat{Q}_2) \pm 1.96 \left[\hat{SE}_1^2 + \hat{SE}_2^2 \right]^{1/2} \qquad (4.5)$$

and tested (at 5% nominal level) the null hypothesis that $\hat{Q}_1 - \hat{Q}_2 = 0$ by examining whether the 95% confidence interval (eq. 4.5) contains 0. The null hypothesis that the two abundance estimates are equal was rejected if and only if the interval has not contained 0 (Scenker and Gentleman 2001).

4.0 RESULTS

4.1 CATCH EFFICIENCY OF THE DREDGE

The estimated catchability coefficient (eq. 2.1) for the commercial crab dredge with nylon liner (from individual depletion experiments) varied from 0.06 to 0.37, with a weighted mean (eq. 2.2.) of 0.22 (SE 0.03) (Table 4). The mean catchability at sites with presence of blue mussels was identical to the overall mean (0.22). The mean catchability coefficient for sites with less than 20% silt/clay content was 0.28 (SE = 0.04), as compared to 0.18 (SE = 0.04) for sites with slit/clay content greater or equal to 20%. The difference in catchability coefficient between sediment types was not significant, and therefore the experiments were pooled to estimate an overall catchability coefficient for the dredge survey with increased precision. We used a 5% significance level for all statistical tests. The lower mean catch efficiency in sediment with high silt/clay content was primarily driven by one low estimate ($\hat{q}_9$ = 0.06). No significant differences in the mean carapace width of crabs were detected between depletions for the combined experiments (Figure 2) (ANOVA, DF = 10; p >0.7). This result supports our assumption that probability of capture is independent of carapace width.

Table 4. Number of crabs per coverage (sweep of the bottom area) in each of the ten removal experiments; C is the total number of crabs caught in each experiment, $\hat{q}_i$ is the estimated gear efficiency based on model 2.1, and R^2 is the coefficient of determination for the regressions. The jackknife estimate of weighted average $\hat{q}$ for all experiments is 0.22 (SE = 0.03). The number of bushels of mussels in the first coverage is indicated.

	Removal experiment number (i)									
Coverage	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	13	16	18	24	46	46	91	17	34	42
2	15	16	19	10	35	30	57	8	20	53
3	8	10	21	5	69	26	67	10	28	44
4	1	6	7	13	58	35	103	10	7	21
5	6	3	8	9	25	20	44	4	9	14
6	0	6	2	5	14	21	18	6	17	12
7	3	0	1	2	8	7	24	4	3	9
8	3	3	0	3	5	5	15	5	3	5
9	2	4	2	1	12	2	3	1	19	1
10	3	0	0	1	30	2	3	6	27	6
C	54	64	78	73	302	194	425	71	167	207
$\hat{q}_i$	0.34	0.31	0.37	0.19	0.20	0.21	0.22	0.13	0.06	0.33
R^2	0.75	0.89	0.90	0.62	0.54	0.78	0.65	0.57	0.05	0.97
%Silt/clay	2.2	1.9	2.8	4.4	24.5	6.5	33.3	24.8	21.5	16.7
Mussels # bushels	0	0	5	2	5	5	5	0	0	0

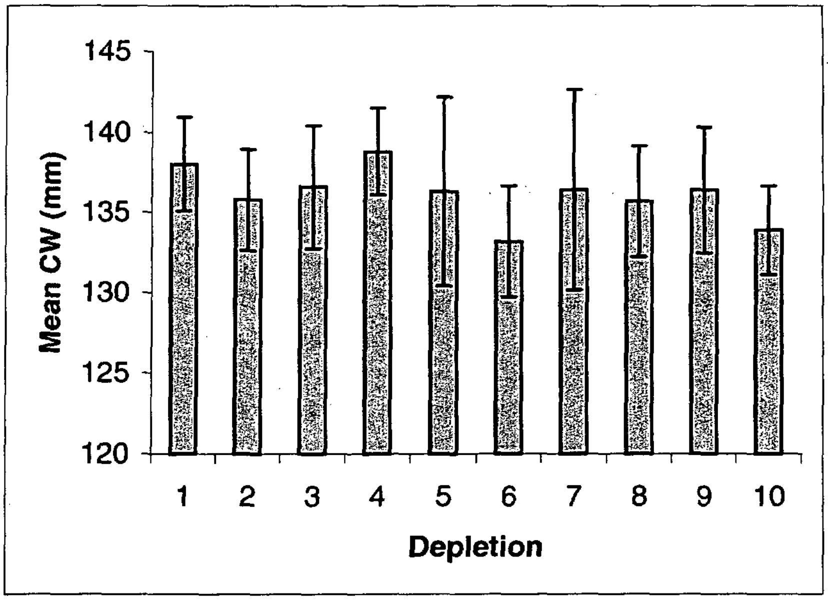

Figure 2. Mean carapace width (CW) in mm versus depletion number. The error bars show one standard error (estimated by jackknifing) on each side of the mean.

4.2 ESTIMATES OF DENSITY, ABUNDANCE, AND SIZE COMPOSITION

Although the navigation channel had higher overall estimated density of males and females for both live and dead crabs, it was not significantly different from the density in the overall survey area at the 5% significance level (Tables 5 and 6). The relative density (mean CPUE) of live crabs across size and sex for the entire survey area was estimated at 11.32 crabs per 1000 m^2 (SE = 2.33) as compared to an overall mean relative density of 13.66 crabs per 1000 m^2 in the navigation channel (SE = 8.19) (Table 5). The density estimate for the channel was highly influenced by one large catch (131 crabs at station 208) in the Brandywine range. This was reflected in the large relative standard error (RSE). The Miah Maull Range had a mean density of 1.70 crabs per 1000 m^2 (SE = 1.7); only one out of the seven hauls within this range had a catch (2 crabs). ANOVA (model 1.1) for the randomized block experiment did not reveal a significant difference in density between the channel and the channel bank (DF = 1; F = 2.53, $p > 0.11$) at the 5% significance level. The sampling stations in the channel, and on the channel bank are referenced in Figure 3. Detailed catch and habitat information for all stations are in the Appendix B.

After adjusting for gear-efficiency (eqs. 3.1 – 3.5; $\bar{q} = 0.22$), the absolute density of live crabs in the entire lower Delaware Bay was estimated at 51.45 crabs per 1000 m^2 (SE = 10.59), as compared to 62.09 crabs per 1000 m^2 (SE = 37.23) for the navigation channel (Table 6). A comparison of the mean densities for the channel and the overall study area (using equation 4.5) shows no significant difference between the two estimates. The absolute density of live crabs in areas that have previously been dredged

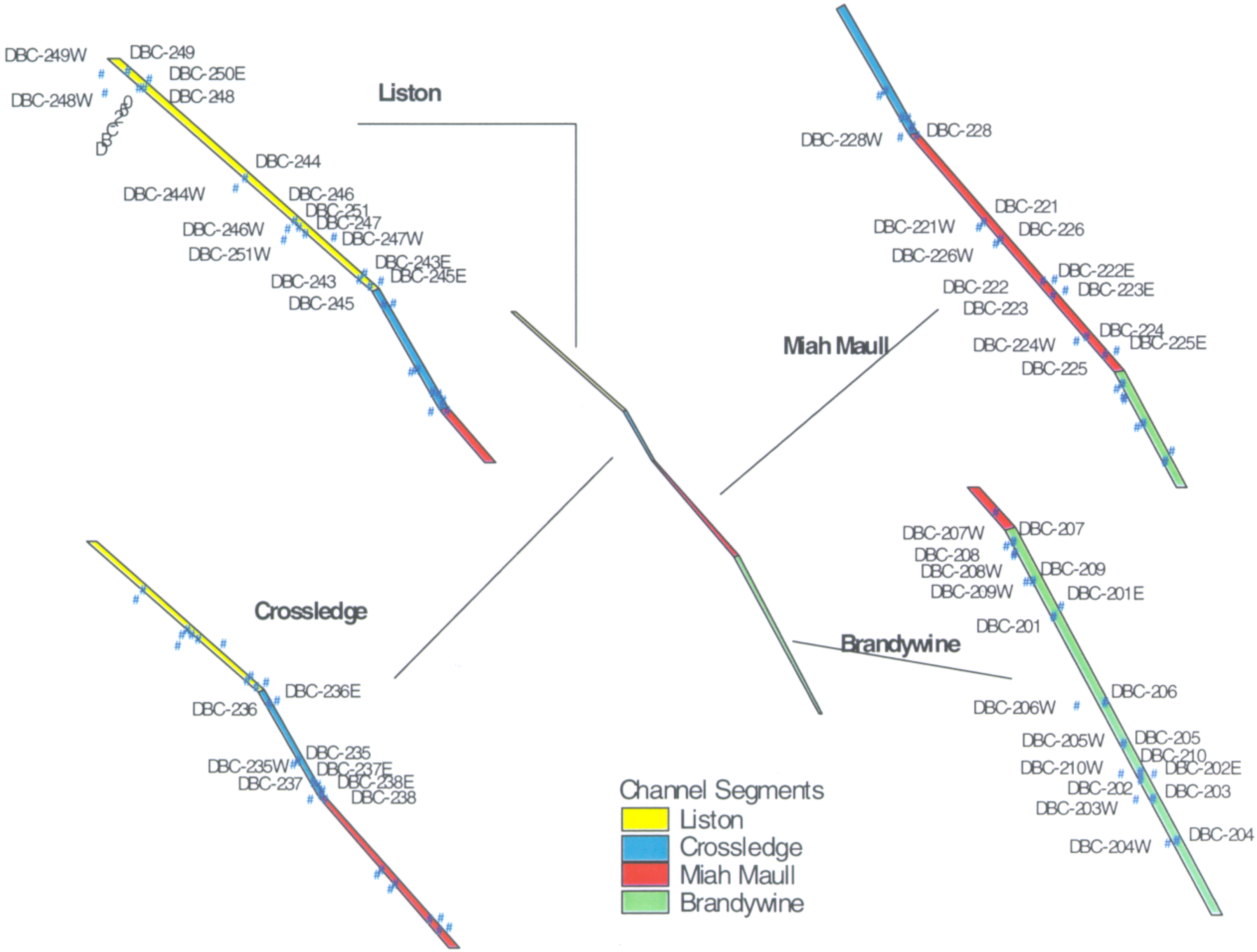

Figure 3. Sampling stations in the navigation channel and at the channel bank

(dredging category 1) was estimated at 2.70 crabs per 1000 m^2 (SE = 2.70), as compared to 65.91 crabs per 1000 m^2 (SE = 40.62) for areas with no previous dredging (dredging categories 2 and 3). The area to be dredged for the 13.7 m (45 ft) deepening project had an estimated density of 134.62 crabs per 1000 m^2 (SE = 85.94) (Table 7). The large standard error reflects the influence of two large catches. The difference in density between the three dredging categories was not significantly different. One out of six stations in the previously dredged area had mussels, and one station had sponges (Appendices A and B).

Table 5. Estimated relative density (mean number of crabs caught per 1000 m^2 swept) for all size classes combined. The relative standard error (RSE= $SE/\bar{x}$) is a measure of precision.

	All strata			Navigation Channel		
Category	$\bar{x}$	**SE**	**RSE**	$\bar{x}$	**SE**	**RSE**
All live crabs	11.32	2.33	0.21	13.66	8.19	0.60
All dead crabs	2.11	0.87	0.41	1.76	0.98	0.56
Live females	9.09	2.15	0.24	13.10	8.08	0.62
Dead females	1.88	0.81	0.43	1.65	0.95	0.57
Live males	2.24	0.48	0.22	0.56	0.26	0.47
Dead males	0.23	0.09	0.40	0.10	0.07	0.72

Table 6. Estimated absolute density (mean number of crabs per 1000 m^2 swept) for all size classes combined. The estimated mean catchability coefficient for the sampling dredge is assumed to be constant (0.22) for all hauls. The relative standard error (RSE= $SE/\bar{x}$) is a measure of precision.

	All strata			Navigation Channel		
Category	$\bar{x}$	**SE**	**RSE**	$\bar{x}$	**SE**	**RSE**
All live crabs	51.45	10.59	0.21	62.09	37.23	0.60
All dead crabs	9.59	3.95	0.41	8.00	4.54	0.56
Live females	41.32	9.77	0.24	59.55	36.73	0.62
Dead females	8.55	3.68	0.43	7.50	4.32	0.57
Live males	10.18	2.18	0.22	2.55	1.18	0.47
Dead males	1.05	0.41	0.40	0.45	0.32	0.72

Table 7. Estimated absolute density (mean number of crabs per 1000 m^2 swept) in the navigation channel by dredging category for all size classes combined. The estimated mean catchability coefficient for the sampling dredge is assumed to be constant (0.22) for all hauls. Category 1: Previously dredged ; Category 2: Slated to be dredged for the 13.7 m (45 ft) project ; and Category 3: Never dredged, and not scheduled to be dredged.

	Dredging Category					
	1		2		3	
Category	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
All live crabs	2.70	2.70	134.62	85.94	7.77	3.93
All dead crabs	0	0	17.67	10.34	0.74	0.74
Live females	2.70	2.70	132.79	84.86	3.10	1.78
Dead females	0	0	17.25	9.99	0	0
Live males	0	0	1.83	1.33	4.67	2.88
Dead males	0	0	0.42	0.42	0.74	0.74
# Stations	6		11		13	

The absolute abundance in the study area was estimated by extrapolating the estimated absolute density across all strata to the total survey area of 1388.58 km^2 (eqs. 4.1-4.4). The estimated overall absolute density in the channel was used to estimate absolute abundance in the channel (18.48 km^2), and for the section of the Miah Maull Range scheduled to be dredged during winter (1.13 km^2). The absolute abundance of live crabs across size and sex classes was estimated at 71.46 million crabs (SE = 14.73 million) for the lower Delaware Bay, and 1.15 million crabs (SE = 0.69 million) for the entire channel (1.6% of the total) (Tables 6, 8, and 9). The estimated absolute abundance in the area scheduled to be dredged is 70,038 crabs (SE = 42,023), which constitutes 0.1% of the standing stock in the entire survey area. Based on the mean density within the Miah Maull Range, the absolute abundance in the area scheduled to be dredged was 2,594 crabs (SE = 2,594). Only one out of seven hauls in the Miah Maull Range had blue crab (2 crabs), indicating that this range provides less favorable habitat for blue crabs. The bottom substrate in this range was dominated by sand, with large rocks at one site. Two sites had blue mussels, and one site had sponge (Appendix Table B).

The area of the channel with depth less than 14.3 m (47 ft) is approximately 10.19 km^2, with an estimated total abundance of 0.63 million crabs (SE = 0.38 million), constituting about 0.9% of the total abundance in the lower Delaware Bay. The abundance of live females was 57.18 million (SE = 13.72 million) for the entire survey area, as compared to 1.10 million (SE = 0.68 million) for the channel (1.9 % of the total). An estimated 80% of the population across strata was females, as compared to 96% for the channel. The density and sex composition in the channel was not significantly different from the general population in lower Delaware Bay.

Table 8. Estimated absolute density (mean number of crabs per 1000 m^2 swept) and abundance (total number of specimens) of live crabs in the channel by range. The relative standard error (RSE) is a measure of precision, defined as $\sqrt{var(\bar{y})}/\bar{y}$ for density and $\sqrt{var(\tau)}/\tau$ for abundance.						
Range	Area (m^2)	Number of Stations	Density		Abundance	
			$\bar{y}$	RSE	τ	RSE
Liston	4792670	9	10.5	0.53	50083	0.53
Crossledge	1969990	4	1.7	1.00	3310	1.00
Miah Maull	4428000	7	2.3	1.00	10272	0.53
Brandywine	7340260	10	148.1	0.63	1,087,019	0.63
All	18530920	30	62.1	0.60	1,150,685	0.60

Table 9. Estimated absolute abundance ($\hat{\tau}$) and standard errors (millions) for all size classes combined. The estimated mean catchability coefficient for the sampling dredge is assumed to be constant (0.22) for all hauls. The relative standard error is $SE/\hat{\tau}$.						
Category	All strata			Navigation Channel		
	$\hat{\tau}$	SE	RSE	$\hat{\tau}$	SE	RSE
All live crabs	71.44	15.00	0.21	1.15	0.69	0.60
All dead crabs	13.32	5.46	0.41	0.15	0.08	0.56
Live females	57.38	13.77	0.24	1.10	0.68	0.62
Dead females	11.87	5.11	0.43	0.14	0.08	0.57
Live males	14.14	3.11	0.22	0.05	0.02	0.47
Dead males	1.46	0.58	0.40	0.008	0.006	0.72

The size composition of crabs by stratum suggests that young-of-year crabs (CW < 60 mm) primarily inhabit the upper Delaware bay during winter (Figures 4-11). We also estimated the percentage of crabs in each of the three size categories (< 60 mm, 60-119 mm, and 120 mm and greater) (Figure 11). The absolute abundance of fully recruited crabs (120 mm and greater CW) in the study area was 60.2 million crabs (SE 13.8 million), as compared to 1.05 million (SE = 0.64 million) for the navigation channel. In Delaware, the total reported landings from December 2000 to March 2001 was 22,951 bushels (22,019 bushels of females, and 933 bushels of males) (Jeff Tinsman, DENREC, pers. comm.). In New Jersey, a total landing of 3,583 bushels (318 bushels of males, and 3,265 bushels of females) was reported for the same period (Paul Scarlett, NJ Division of Fish and Wildlife, pers. comm.). Assuming 100 males and 150 females per bushel respectively, we estimated that the total landing (26,534 bushels) for the winter 2000/2001 fishing season corresponds to about 4 million crabs. The combined landing for December 2000 and January 2001 (i.e., before the winter dredge survey) was 20,312 bushels (922 bushels of females and 19,390 bushels of males), corresponding to about 3 million crabs. Assuming no errors in reported landings, the 95% interval estimate for the number of fully recruited crabs in the study area at the beginning of December is 39.4 million to 88.0 million crabs.

The lower Delaware Bay encompassing deeper waters (Deep), and the lower part of the bay in New Jersey (LNJ) had zero age 0 crabs in the survey catches (Figure 11). An estimated 17% and 16% of the blue crab population in the upper bay strata (NJU and DEU) respectively consisted of age 0 crabs (Figure 11). The fraction of dead crabs (males and females) for all size classes combined was 16% in the entire survey area, and 11% in the Channel (Table 6).

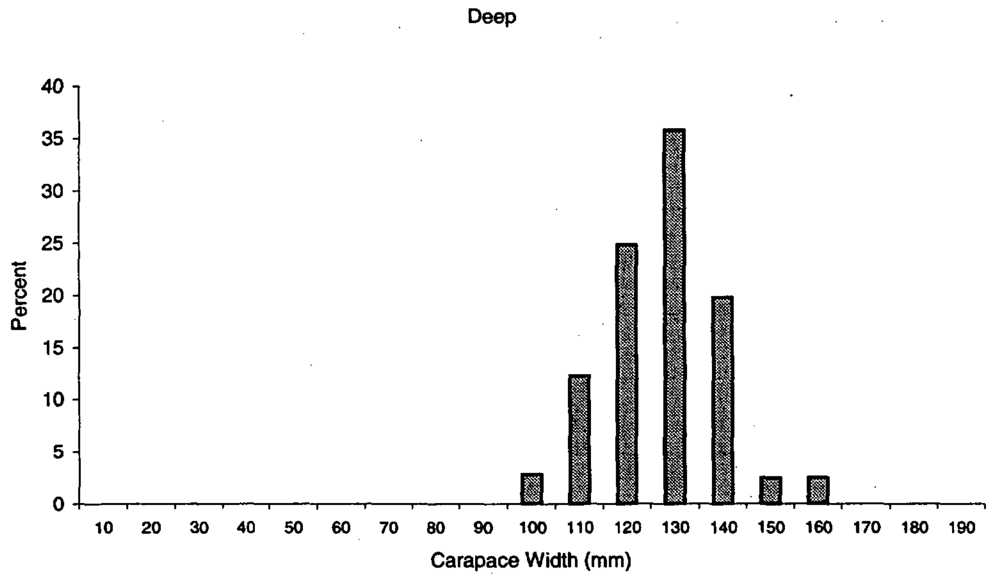

Figure 4. Size distribution of live crabs (Carapace width) in the deep water stratum in lower Delaware Bay.

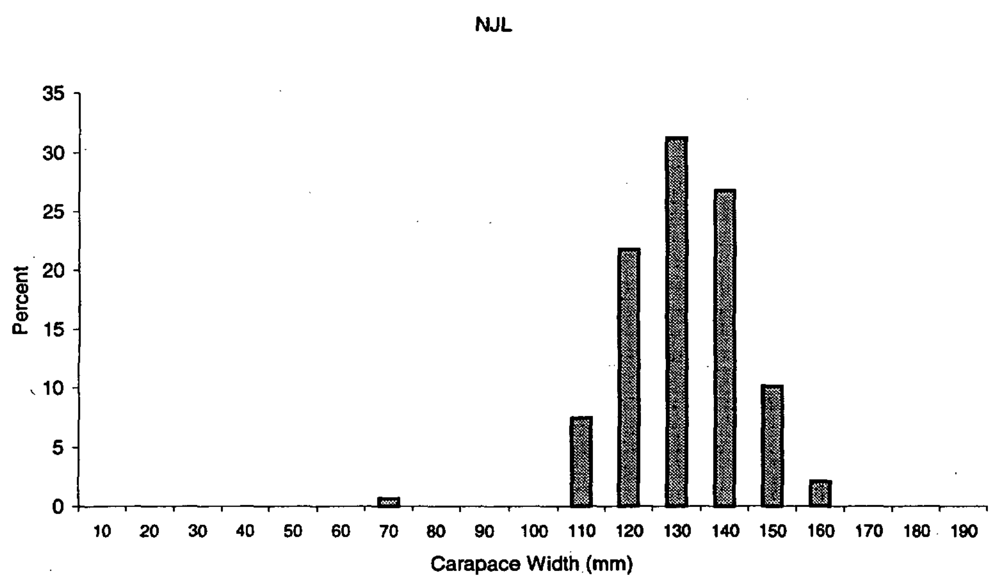

Figure 5. Size distribution of live crabs (Carapace width) in the lower New Jersey straum

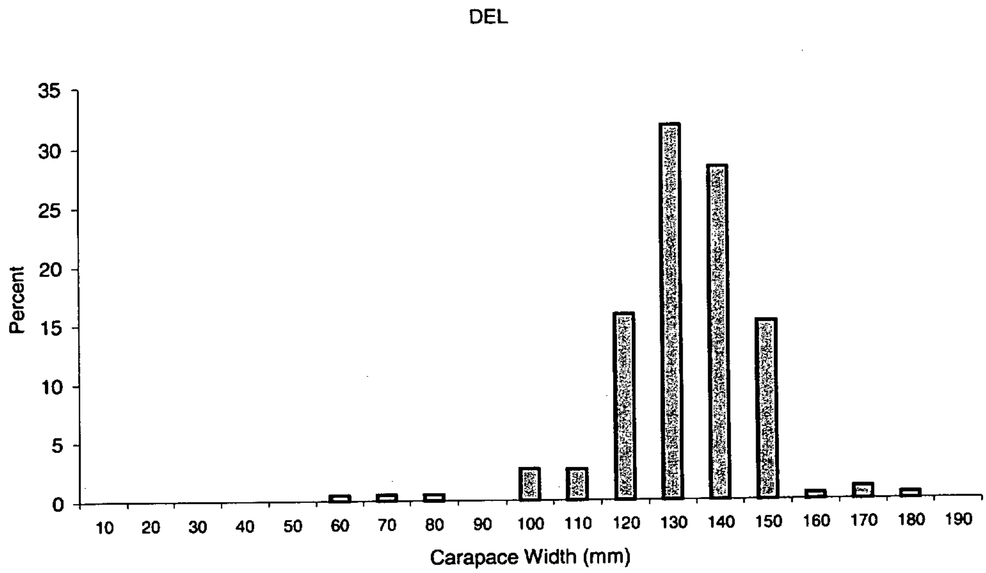

Figure 6. Size distribution of live crabs (Carapace width) in the lower Delaware stratum

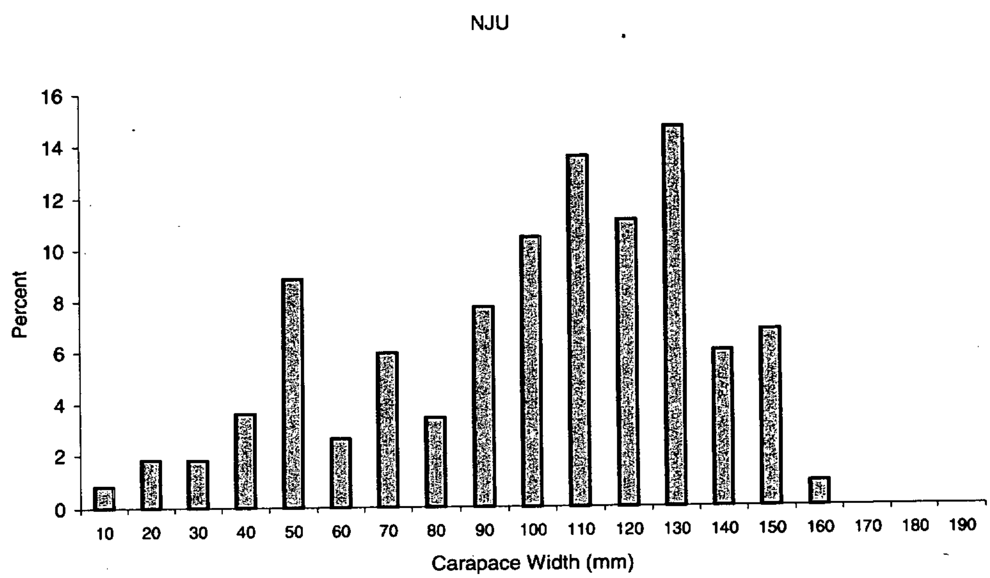

Figure 7. Size distribution of live crabs (Carapace width) in the upper New Jersey stratum

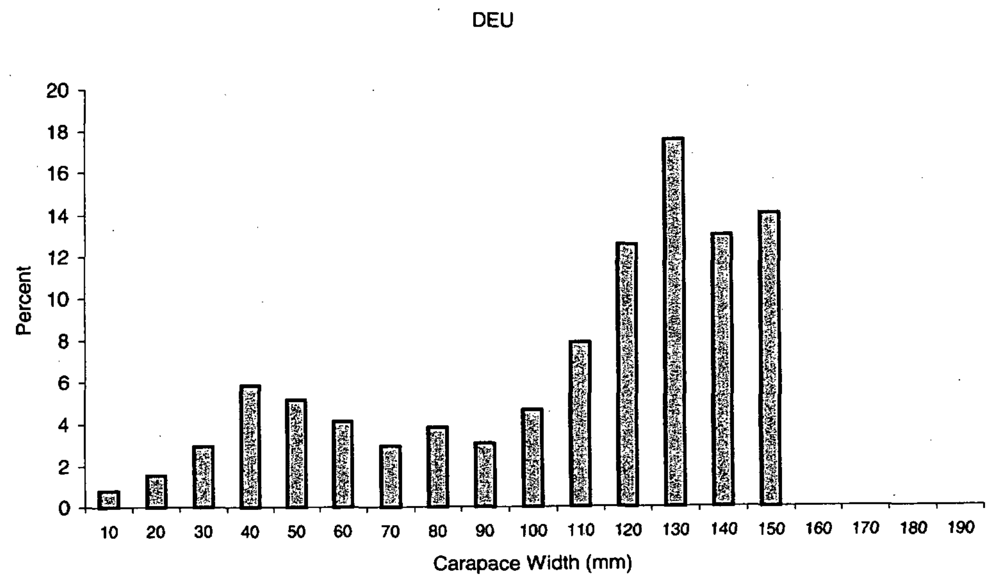

Figure 8. Size distribution of live crabs (Carapace width) in the upper Delaware straum

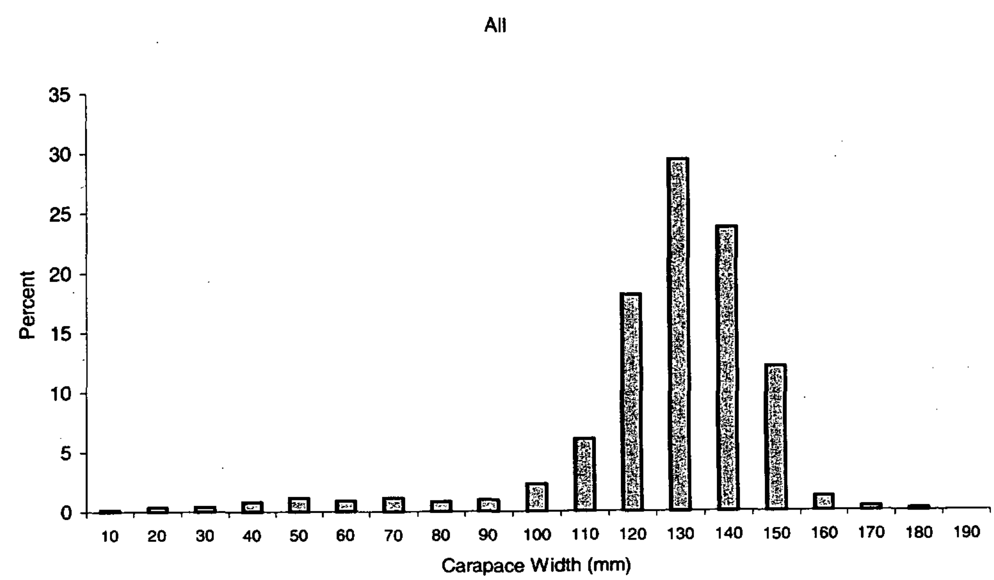

Figure 9. Size distribution of live crabs (Carapace width) in all strata combined.

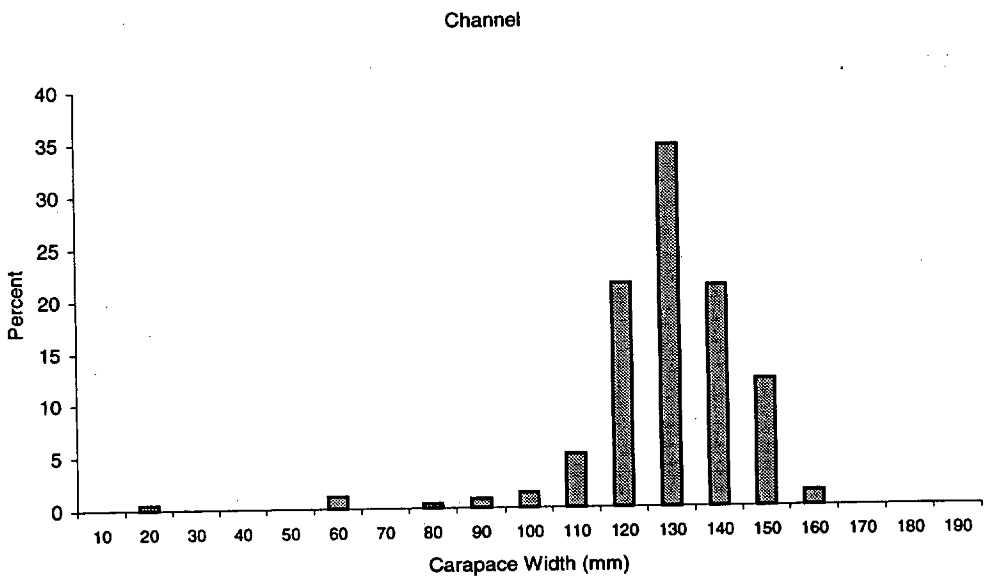

Figure 10. Size distribution of live crabs (carapace width) in the navigation channel

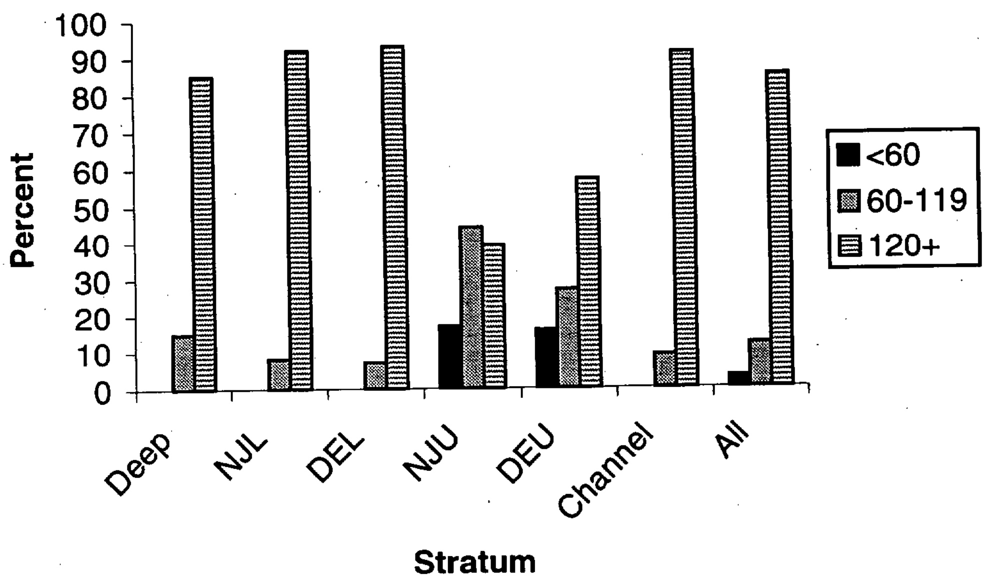

Figure 11. Percentage of the stock in each of three major carapace width size categories: < 60 mm, 60-119 mm, and 120 mm and greater by stratum.

5.0 DISCUSSION AND CONCLUSION

The estimated absolute abundance of fully recruited (120 mm and greater) crabs in the Delaware Bay based on the winter dredge survey (60.2 million crabs, RSE = 0.23) was within the range of abundance estimates for 1979-1999 (6 to 65 million) based on the modified DeLury method (Helser 2000). The abundance estimate from the dredge survey was significantly higher than the 1979 – 1999 DeLury average of 25 million (RSE = 0.37) reported in Helser (2000), but did not significantly differ from the 1999 DeLury estimate (42.2 million, RSE = 0.30). A direct comparison of abundance estimates based on the two methods can only be made when the DeLury stock assessment is updated. Our study provides a snapshot of the winter population in the lower Delaware Bay, and does not cover the entire distribution area of the blue crab. The dominance of age 1+ females in the dredge samples can be attributed to the spatial coverage of the survey. Mature female crabs favor deeper waters in the lower bay. A significant number of age 0 crabs and adult males (age 1+) are likely to over-winter in the upper Delaware Bay and its tributaries, and were not sampled effectively in this study. This portion of the stock is unlikely to be affected by the deepening project, and therefore was not a target for this study.

The estimated absolute density in the Delaware Bay and the navigation channel was relatively high compared to the densities observed for the Chesapeake Bay in the 1990s (Sharov et al. 2001). The mean absolute density in the entire Chesapeake Bay declined from a high of 35-38 crabs per 1000 m^2 in 1990-1991 to 8.3 crabs per 1000 m^2 in 1999 (Sharov et al. 2001). In the lower Chesapeake Bay, the mean absolute density of crabs during winter ranged from 11.8 to 44.8 crabs per 1000 m^2 between 1994 and 1999 (A. Sharov, pers. comm.). The lower Chesapeake Bay has high salinity (25-35 ppt) and relatively deep waters, and like Delaware Bay is almost exclusively inhabited by mature females during winter (Sharov et al. 2001); females made up 88% to 96% of the age 1+ population in lower Chesapeake Bay from 1994 to 1999. The estimated density of crabs in Delaware Bay for 2001 did not significantly differ from the high densities observed in Chesapeake Bay for this component of the stock.

The estimated catchability coefficient for the vessel and commercial dredge used in this study is reasonable when compared to estimated efficiencies for the vessels and gear used in the Chesapeake Bay winter dredge survey (Vølstad et al. 2000, Sharov et al. 2001). The average catchability coefficient for the four vessels participating in the Chesapeake Bay survey between 1990 and 1999 ranged from 0.13 to 0.29. The sampling gear used in the Delaware Bay survey consists of two 2.15 m wide dredges that are hinged together. The wider dredge may be more stable than the 1.87 m modified Virginia oyster dredge used in the Chesapeake Bay, and thus could have increased catch efficiency.

The estimated absolute abundance, obtained after statistically adjusting for the catching efficiency of the dredge, suggests that only a small fraction (0.1 %) of the blue crab population in the lower Delaware Bay resides in the limited area of the channel scheduled to be dredged during winter. The navigation channel had a similar average density of blue crab as for the overall lower Delaware Bay. Only 1.13 km^2 in the Miah Maull Range is subject to dredging during winter. Thus, the planned navigation channel deepening project during winter is likely to have marginal impact on the blue crab stock.

Although not statistically significant, the lower density estimate (2.70 crabs per 1000 m^2, SE = 2.70) for the section of the navigation channel that has been subject to maintenance dredging as compared to the density (65.91 crabs per 1000 m^2, SE = 40.62) in areas that have not been dredged indicates that dredging may result in less suitable habitat for hibernating blue crabs. This could be further investigated in future surveys by stratifying the sampling in the channel by dredging categories and increasing the sample size.

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APPENDIX A

SAMPLING STATION INFORMATION

Appendix Table A-1. Dredging information for the winter crab survey of Delaware Bay during 2001											
Station	Start Latitude	Start Longitude	End Latitude	End Longitude	Date	Time	Depth (ft)	Time	Direction	Tide	Weather
Deep-01	38° 57.030'	75° 8.411'	38° 57.087'	75° 8.484'	01/23/2001	10:25	40.0	2:00	Upstream	Ebb	Partly cloudy
Deep-02	38° 53.907'	75° 6.623'	38° 53.833'	75° 6.540'	01/23/2001	9:20	67.0	2:00	Downstream	High	Clear
Deep-03	38° 55.167'	75° 3.475'	38° 55.239'	75° 3.545'	01/23/2001	11:00	49.0	2:00	Upstream	Ebb	Clear
Deep-04	38° 59.716'	75° 7.874'	38° 59.790'	75° 7.913'	01/23/2001	15:20	50.0	2:00	Upstream	Low	Clear
Deep-05	39° 0.359'	75° 11.353'	39° 0.459'	75° 11.375'	01/24/2001	8:00	50.0	2:00	Upstream	Flood	Partly cloudy
Deep-06	39° 1.519'	75° 9.601'	39° 1.719'	75° 9.732'	01/24/2001	9:20	43.0	2:00	Upstream	Flood	Partly cloudy
Deep-07	38° 56.799'	75° 3.556'	38° 56.880'	75° 3.608'	01/23/2001	11:50	36.0	2:00	Upstream	Ebb	Clear
Deep-08	38° 53.204'	75° 9.404'	38° 53.300'	75° 9.461'	01/23/2001	8:55	41.0	2:00	Upstream	High	Clear
Deep-09	38° 56.609'	75° 9.518'	38° 56.690'	75° 9.570'	01/23/2001	10:00	59.0	2:00	Upstream	Ebb	Clear
Deep-10	39° 0.276'	75° 11.435'	39° 0.377'	75° 11.460'	01/24/2001	7:50	47.0	2:00	Upstream	Flood	Partly cloudy
Deep-11	38° 54.995'	75° 8.090'	38° 55.084'	75° 8.159'	01/23/2001	9:40	56.0	2:00	Upstream	Ebb	Clear
Deep-12	39° 0.218'	75° 8.203'	39° 0.316'	75° 8.267'	01/24/2001	8:40	51.0	2:00	Upstream	Flood	Overcast
Deep-13	38° 56.310'	75° 3.023'	38° 56.393'	75° 3.074'	01/23/2001	11:15	39.0	2:00	Upstream	Ebb	Clear
Deep-14	38° 58.412'	75° 7.932'	38° 58.497'	75° 7.981'	01/23/2001	14:25	47.0	2:00	Upstream	Ebb	Clear
Deep-15	38° 56.769'	75° 3.469'	38° 56.857'	75° 3.522'	01/23/2001	11:30	35.0	2:00	Downstream	Ebb	Clear
NJL-26	39° 0.076'	75° 1.011'	39° 0.165'	75° 1.011'	01/23/2001	12:35	23.0	2:00	Upstream	Ebb	Clear
NJL-27	39° 0.743'	75° 1.303'	39° 0.832'	75° 1.275'	01/23/2001	12:50	11.0	2:00	Upstream	Ebb	Clear
NJL-28	39° 2.134'	75° 7.764'	39° 2.217'	75° 7.828'	02/07/2001	8:00	33.0	2:00	Upstream	Flood	Clear
NJL-29	39° 4.129'	74° 59.269'	39° 4.224'	74° 59.245'	02/07/2001	9:10	24.0	2:00	Upstream	High	Clear
NJL-30	39° 6.684'	75° 1.733'	39° 6.777'	75° 1.774'	02/07/2001	10:15	15.0	2:00	Upstream	Ebb	Clear
NJL-31	39° 7.035'	75° 5.897'	39° 7.114'	75° 5.949'	02/07/2001	11:15	18.0	2:00	Upstream	Ebb	Clear
NJL-32	39° 0.695'	75° 2.787'	39° 0.782'	75° 2.785'	01/23/2001	13:05	25.0	2:00	Upstream	Ebb	Clear
NJL-33	39° 5.786'	74° 56.643'	39° 5.879'	74° 56.678'	02/07/2001	9:40	14.0	2:00	Upstream	High	Clear
NJL-34	39° 4.241'	75° 1.719'	39° 4.332'	75° 1.782'	02/07/2001	8:50	15.0	2:00	Upstream	Flood	Clear
NJL-35	39° 2.871'	75° 5.942'	39° 2.971'	75° 5.973'	02/07/2001	8:20	25.0	2:00	Upstream	Flood	Clear
NJL-36	38° 58.907'	75° 3.055'	38° 58.999'	75° 3.066'	01/23/2001	12:15	24.0	2:00	Upstream	Ebb	Clear
NJL-37	39° 8.518'	75° 5.116'	39° 8.606'	75° 5.175'	02/07/2001	11:00	15.0	2:00	Upstream	Ebb	Clear
NJL-38	39° 7.547'	75° 1.588'	39° 7.639'	75° 1.632'	02/07/2001	10:30	15.0	2:00	Upstream	Ebb	Clear
NJL-39	39° 9.636'	75° 13.525'	39° 9.700'	75° 13.582'	02/07/2001	12:20	28.0	2:00	Upstream	Ebb	Clear
NJL-40	39° 6.239'	75° 5.773'	39° 6.329'	75° 5.812'	02/07/2001	11:30	19.0	2:00	Upstream	Ebb	Clear

Appendix Table A-1. (Continued)

Station	Start Latitude	Start Longitude	End Latitude	End Longitude	Date	Time	Depth (ft)	Time	Direction	Tide	Weather
DEL-51	39° 8.271'	75° 15.774'	39° 8.173'	75° 15.719'	01/24/2001	14:00	36.0	2:00	Upstream	Ebb	Clear
DEL-52	38° 52.660'	75° 9.822'	38° 52.755'	75° 9.881'	01/23/2001	8:35	36.0	2:00	Upstream	High	Clear
DEL-53	39° 3.049'	75° 14.834'	39° 3.135'	75° 14.903'	01/24/2001	14:40	25.0	2:00	Upstream	Ebb	Partly Cloudy
DEL-54	39° 6.034'	75° 18.499'	39° 6.122'	75° 18.563'	01/22/2001	9:40	39.0	2:00	Upstream	Ebb	Clear
DEL-55	39° 6.239'	75° 15.502'	39° 6.332'	75° 15.530'	01/24/2001	14:15	18.0	2:00	Upstream	Ebb	Clear
DEL-56	39° 6.420'	75° 18.207'	39° 6.329'	75° 18.146'	01/22/2001	10:00	12.7	2:00	Downstream	Ebb	Clear
DEL-57	39° 0.426'	75° 17.369'	39° 0.507'	75° 17.463'	01/22/2001	8:05	20.0	2:00	Upstream	High	Clear
DEL-58	38° 49.528'	75° 8.911'	38° 49.442'	75° 8.822'	01/23/2001	8:10	24.0	2:00	Downstream	High	Clear
DEL-59	39° 3.043'	75° 15.333'	39° 3.126'	75° 15.355'	01/24/2001	14:55	31.0	2:00	Upstream	Ebb	Clear
DEL-60	39° 6.542'	75° 20.371'	39° 6.626'	75° 20.425'	01/22/2001	10:15	14.0	2:00	Upstream	Ebb	Clear
DEL-61	38° 56.713'	75° 15.769'	38° 56.621'	75° 15.672'	01/22/2001	7:24	13.0	2:00	Downstream	High	Clear
DEL-62	39° 3.114'	75° 17.732'	39° 3.025'	75° 17.663'	01/22/2001	9:11	20.0	2:00	Downstream	High	Clear
DEL-63	39° 1.946'	75° 17.463'	39° 1.868'	75° 17.379'	01/22/2001	8:51	20.0	2:00	Downstream	High	Clear
DEL-64	38° 52.094'	75° 12.503'	38° 52.036'	75° 12.391'	01/23/2001	7:40	18.0	2:00	Downstream	High	Clear
DEL-65	39° 0.651'	75° 17.471'	39° 0.571'	75° 17.388'	01/22/2001	8:26	21.0	2:00	Downstream	High	Clear
NJU-76	39° 18.385'	75° 21.003'	39° 18.465'	75° 21.063'	02/08/2001	13:20	22.0	2:00	Upstream	Ebb	Partly Cloudy
NJU-77	39° 15.996'	75° 19.043'	39° 16.075'	75° 19.128'	02/08/2001	11:30	25.0	2:00	Upstream	High	Overcast
NJU-78	39° 17.524'	75° 20.666'	39° 17.545'	75° 20.679'	02/08/2001	12:40	18.0	0:30	Upstream	Ebb	Partly Cloudy
NJU-79	39° 14.686'	75° 16.902'	39° 14.751'	75° 17.008'	02/08/2001	10:35	28.0	2:00	Upstream	Flood	Partly Cloudy
NJU-80	39° 18.634'	75° 21.871'	39° 18.726'	75° 21.862'	02/08/2001	13:40	22.0	2:00	Upstream	Ebb	Partly Cloudy
NJU-81	39° 16.809'	75° 18.177'	39° 16.891'	75° 18.211'	'02/08/2001	11:45	21.0	2:00	Upstream	High	Partly Cloudy
NJU-82	39° 17.577'	75° 19.064'	39° 17.656'	75° 19.147'	02/08/2001	12:00	24.0	2:00	Upstream	High	Partly Cloudy
NJU-83	39° 15.571'	75° 16.557'	39° 15.655'	75° 16.624'	02/08/2001	10:50	21.0	2:00	Upstream	High	Partly Cloudy
NJU-84	39° 17.420'	75° 20.179'	39° 17.492'	75° 20.249'	02/08/2001	12:10	18.0	2:00	Upstream	Ebb	Partly Cloudy
NJU-85	39° 12.172'	75° 15.481'	39° 12.242'	75° 15.558'	02/07/2001	13:55	17.0	2:00	Upstream	Ebb	Clear
NJU-86	39° 18.414'	75° 20.155'	39° 18.476'	75° 20.209'	02/08/2001	13:00	17.0	2:00	Upstream	Ebb	Partly Cloudy
NJU-87	39° 15.731'	75° 18.757'	39° 15.807'	75° 18.845'	02/08/2001	11:10	24.0	2:00	Upstream	High	Partly Cloudy
NJU-88	39° 17.546'	75° 20.327'	39° 17.619'	75° 20.405'	02/08/2001	12:30	19.0	2:00	Upstream	Ebb	Partly Cloudy
NJU-89	39° 11.279'	75° 14.402'	39° 11.352'	75° 14.446'	02/07/2001	13:40	23.0	2:00	Upstream	Ebb	Clear
NJU-90	39° 18.333'	75° 20.534'	39° 18.415'	75° 20.585'	02/08/2001	13:10	16.0	2:00	Upstream	Ebb	Partly Cloudy

Appendix Table A-1. (Continued)

Station	Start Latitude	Start Longitude	End Latitude	End Longitude	Date	Time	Depth (ft)	Time	Direction	Tide	Weather
DEU-101	39° 11.127'	75° 19.843'	39° 11.205'	75° 19.897'	01/22/2001	12:15	11.5	2:00	Upstream	Ebb	Clear
DEU-102	39° 10.504'	75° 16.580'	39° 10.419'	75° 16.530'	02/08/2001	8:20	29.0	2:00	Downstream	Flood	Clear
DEU-103	39° 10.042'	75° 17.441'	39° 9.946'	75° 17.372'	01/22/2001	12:50	24.0	2:00	Downstream	Ebb	Clear
DEU-104	39° 9.085'	75° 17.883'	39° 8.983'	75° 17.810'	01/22/2001	13:00	7.0	2:00	Downstream	Ebb	Clear
DEU-105	39° 10.797'	75° 19.567'	39° 10.876'	75° 19.637'	01/22/2001	12:10	12.0	2:00	Upstream	Ebb	Clear
DEU-106	39° 11.725'	75° 19.448'	39° 11.795'	75° 19.504'	01/22/2001	12:30	12.0	2:00	Upstream	Ebb	Clear
DEU-107	39° 14.384'	75° 19.661'	39° 14.459'	75° 19.734'	02/08/2001	14:30	27.0	2:00	Upstream	Ebb	Partly Cloudy
DEU-108	39° 13.576'	75° 21.512'	39° 13.496'	75° 21.445'	02/09/2001	12:30	16.0	2:00	Downstream	Ebb	Partly Cloudy
DEU-109	39° 8.112'	75° 19.721'	39° 8.201'	75° 19.768'	01/22/2001	11:12	15.0	2:00	Upstream	Ebb	Clear
DEU-110	39° 9.674'	75° 21.225'	39° 9.752'	75° 21.277'	01/22/2001	11:40	11.0	2:00	Upstream	Ebb	Clear
DEU-111	39° 15.693'	75° 23.785'	39° 15.613'	75° 23.720'	02/09/2001	12:00	13.0	2:00	Downstream	High	Partly Cloudy
DEU-112	39° 8.522'	75° 21.393'	39° 8.619'	75° 21.437'	01/22/2001	10:50	12.0	2:00	Upstream	Ebb	Clear
DEU-113	39° 12.081'	75° 20.404'	39° 11.996'	75° 20.351'	02/09/2001	13:10	14.0	2:00	Downstream	Ebb	Overcast
DEU-114	39° 7.727'	75° 21.492'	39° 7.626'	75° 21.423'	01/22/2001	10:35	13.5	2:00	Downstream	Ebb	Clear
DEU-115	39° 11.689'	75° 21.410'	39° 11.600'	75° 21.363'	02/09/2001	13:00	14.0	2:00	Downstream	Ebb	Overcast

Appendix Table A-1. (Continued)

Station	Dredging Category	Start Latitude	Start Longitude	End Latitude	End Longitude	Date	Time	Depth (ft)	Time	Direction	Tide	Weather
Brandywine Range												
DBC-201	2	39° 2.851'	75° 10.018'	39° 2.941'	75° 10.093'	01/23/2001	9:40	50.0	2:00	Upstream	Flood	Partly Cloudy
DBC-201E		39° 3.132'	75° 9.841'	39° 3.218'	75° 9.911'	01/24/2001	9:55	45.0	2:00	Upstream	Flood	Partly Cloudy
DBC-202	3	38° 58.763'	75° 7.805'	38° 58.846'	75° 7.846'	01/23/2001	14:35	50.0	2:00	Upstream	Ebb	Clear
DBC-202E		38° 58.939'	75° 7.470'	38° 59.021'	75° 7.501'	01/23/2001	14:45	49.0	2:00	Upstream	Low	Clear
DBC-203	3	38° 58.309'	75° 7.498'	38° 58.404'	75° 7.540'	01/23/2001	14:15	49.0	2:00	Upstream	Ebb	Clear
DBC-203W		38° 58.245'	75° 7.908'	38° 58.334'	75° 7.965'	01/23/2001	14:05	45.0	2:00	Upstream	Ebb	Clear
DBC-204	1	38° 57.208'	75° 6.861'	38° 57.292'	75° 6.903'	01/23/2001	13:40	46.0	2:00	Upstream	Ebb	Clear
DBC-204W		38° 57.184'	75° 7.110'	38° 57.263'	75° 7.159'	01/23/2001	13:50	49.0	2:00	Upstream	Ebb	Clear
DBC-205	2	38° 59.667'	75° 8.249'	38° 59.759'	75° 8.320'	01/24/2001	8:30	53.0	2:00	Upstream	Flood	Overcast
DBC-205W		38° 59.649'	75° 8.238'	38° 59.735'	75° 8.955'	01/24/2001	8:15	46.0	2:00	Upstream	Flood	Overcast
DBC-206	2	39° 0.693'	75° 8.702'	39° 0.780'	75° 8.749'	01/24/2001	8:55	54.0	2:00	Upstream	Flood	Partly Cloudy
DBC-206W		39° 0.651'	75° 9.445'	39° 0.742'	75° 9.505'	01/24/2001	9:10	48.0	2:00	Upstream	Flood	Partly Cloudy
DBC-207	2	39° 4.758'	75° 11.084'	39° 4.836'	75° 11.141'	01/24/2001	11:30	49.0	2:00	Upstream	Ebb	Clear
DBC-207W		39° 4.632'	75° 11.210'	39° 4.711'	75° 11.255'	01/24/2001	11:40	41.0	2:00	Upstream	Ebb	Partly Cloudy
DBC-208	2	39° 4.468'	75° 11.036'	39° 4.495'	*	01/24/2001	10:50	46.0	2:00	Upstream	High	Partly Cloudy
DBC-208W		39° 4.393'	75° 11.022'	39° 4.485'	75° 11.073'	01/24/2001	11:15	42.0	2:00	Upstream	Ebb	Partly Cloudy
DBC-209	2	39° 3.756'	75° 10.551'	39° 3.853'	75° 10.653'	01/24/2001	10:05	50.0	2:00	Upstream	High	Partly Cloudy
DBC-209W		39° 3.723'	75° 10.699'	39° 3.813'	75° 10.752'	01/24/2001	10:35	42.0	2:00	Upstream	High	Partly Cloudy
DBC-210	3	38° 58.973'	75° 7.795'	38° 59.016'	75° 7.815'	01/23/2001	14:55	51.0	2:00	Upstream	Low	Clear
DBC-210W		38° 58.910'	75° 8.303'	38° 58.990'	75° 8.346'	01/23/2001	15:05	43.0	2:00	Upstream	Low	Clear

Appendix Table A-1. (Continued)

Station	Dredging Category	Start Latitude	Start Longitude	End Latitude	End Longitude	Date	Time	Depth (ft)	Time	Direction	Tide	Weather
Miah Maull Range												
DBC-221	2	39° 8.712'	75° 14.509'	39° 8.789'	75° 14.580'	02/07/2001	13:15	47.0	2:00	Upstream	Ebb	Clear
DBC-221W		39° 8.615'	75° 14.640'	39° 8.692'	75° 14.706'	02/07/2001	13:05	29.0	2:00	Upstream	Ebb	Clear
DBC-222	2	39° 7.276'	75° 13.052'	39° 7.336'	75° 13.109'	01/24/2001	13:20	48.0	2:00	Upstream	Ebb	Clear
DBC-222E		39° 7.315'	75° 12.756'	39° 7.366'	75° 12.792'	01/24/2001	13:30	40.0	2:00	Upstream	Ebb	Clear
DBC-223	1	39° 6.956'	75° 12.802'	39° 7.013'	75° 12.843'	01/24/2001	13:05	49.0	2:00	Upstream	Ebb	Clear
DBC-223E		39° 7.050'	75° 12.477'	39° 7.125'	75° 12.530'	01/24/2001	12:55	40.0	2:00	Upstream	Ebb	Clear
DBC-224	2	39° 5.931'	75° 11.954'	39° 6.002'	75° 12.010'	01/24/2001	12:25	49.0	2:00	Upstream	Ebb	Clear
DBC-224W		39° 5.814'	75° 12.200'	39° 5.891'	75° 12.260'	01/24/2001	12:35	41.0	2:00	Upstream	Ebb	Clear
DBC-225	1	39° 5.477'	75° 11.487'	39° 5.541'	75° 11.527'	01/24/2001	11:55	48.0	2:00	Upstream	Ebb	Clear
DBC-225E		39° 5.581'	75° 11.184'	39° 5.654'	75° 11.236'	01/24/2001	12:05	40.0	2:00	Upstream	Ebb	Clear
DBC-226	2	39° 8.312'	75° 14.097'	39° 8.361'	75° 14.147'	02/07/2001	12:40	47.0	2:00	Upstream	Ebb	Clear
DBC-226W		39° 8.194'	75° 14.221'	39° 8.268'	75° 14.291'	02/07/2001	12:50	31.0	2:00	Upstream	Ebb	Clear
DBC-228	1	39° 10.834'	75° 16.184'	39° 10.752'	75° 16.128'	02/08/2001	8:40	50.0	2:00	Downstream	Flood	Clear
DBC-228W		39° 10.799'	75° 16.607'	39° 10.722'	75° 16.557'	02/08/2001	8:30	37.0	2:00	Downstream	Flood	Clear
Cross Ledges Range												
DBC-235	3	39° 11.933'	75° 16.970'	39° 12.011'	75° 17.018'	02/07/2001	14:10	52.0	2:00	Upstream	Ebb	Clear
DBC-235W		39° 11.822'	75° 17.117'	39° 11.904'	75° 17.168'	02/07/2001	14:20	40.0	2:00	Upstream	Ebb	Clear
DBC-236	3	39° 13.609'	75° 17.852'	39° 13.530'	75° 17.813'	02/08/2001	9:25	60.0	2:00	Downstream	Flood	Clear
DBC-236E		39° 13.675'	75° 17.619'	39° 13.591'	75° 17.562'	02/08/2001	9:30	40.0	2:00	Downstream	Flood	Clear
DBC-237	2	39° 11.293'	75° 16.551'	39° 11.368'	75° 16.581'	02/08/2001	14:40	48.0	2:00	Upstream	Ebb	Clear
DBC-237E		39° 11.274'	75° 16.410'	39° 11.317'	75° 16.433'	02/07/2001	14:50	36.0	2:00	Upstream	Ebb	Clear
DBC-238	1	39° 10.934'	75° 16.326'	39° 10.905'	75° 16.311'	02/08/2001	9:00	52.0	1:00	Downstream	Flood	Clear
DBC-238E		39° 11.090'	75° 16.277'	39° 11.069'	75° 16.264'	02/08/2001	9:05	40.0	1:00	Downstream	Flood	Clear

Appendix Table A-1. (Continued)

Station	Dredging Category	Start Latitude	Start Longitude	End Latitude	End Longitude	Date	Time	Depth (ft)	Time	Direction	Tide	Weather
Liston Range												
DBC-243	3	39° 14.275'	75° 18.501'	39° 14.249'	75° 18.486'	02/08/2001	10:00	59.0	1:30	Downstream	Flood	Clear
DBC-243E		39° 14.419'	75° 18.370'	39° 14.353'	75° 18.290'	02/08/2001	10:05	38.0	2:00	Downstream	Flood	Clear
DBC-244	1	39° 16.928'	75° 21.584'	39° 16.992'	75° 21.663'	02/08/2001	14:00	47.0	2:00	Upstream	Ebb	Partly Cloudy
DBC-244W		39° 16.666'	75° 21.816'	39° 16.723'	75° 21.901'	02/08/2001	14:10	34.0	2:00	Upstream	Ebb	Partly Cloudy
DBC-245	3	39° 14.088'	75° 18.232'	39° 14.021'	75° 18.172'	02/08/2001	9:45	60.0	2:00	Downstream	Flood	Clear
DBC-245E		39° 14.217'	75° 17.947'	39° 14.135'	75° 17.864'	02/08/2001	10:20	27.0	2:00	Downstream	Flood	Partly Cloudy
DBC-246	3	39° 15.780'	75° 20.267'	39° 15.755'	75° 20.234'	02/09/2001	9:10	57.0	2:00	Downstream	Flood	Clear
DBC-246W		39° 15.613'	75° 20.433'	39° 15.685'	75° 20.512'	02/09/2001	9:55	47.0	2:00	Upstream	Flood	Clear
DBC-247	3	39° 15.476'	75° 19.973'	39° 15.430'	75° 19.924'	02/09/2001	8:55	58.0	2:00	Downstream	Flood	Clear
DBC-247W		39° 15.355'	75° 19.209'	39° 15.297'	75° 19.143'	02/09/2001	8:45	42.0	2:00	Downstream	Flood	Clear
DBC-248	3	39° 19.265'	75° 24.249'	39° 19.208'	75° 24.186'	02/09/2001	10:45	67.0	2:00	Downstream	Flood	Partly Cloudy
DBC-248W		39° 19.155'	75° 25.285'	39° 19.090'	75° 25.191'	02/09/2001	11:30	33.0	2:00	Downstream	Flood	Partly Cloudy
DBC-249	3	39° 19.732'	75° 24.706'	39° 19.688'	75° 24.663'	02/09/2001	11:10	68.0	2:00	Downstream	Flood	Partly Cloudy
DBC-249W		39° 19.658'	75° 25.385'	39° 19.586'	75° 25.313'	02/09/2001	11:20	45.0	2:00	Downstream	Flood	Partly Cloudy
DBC-250	3	39° 19.259'	75° 24.395'	39° 19.203'	75° 24.327'	02/09/2001	10:20	62.0	2:00	Downstream	Flood	Partly Cloudy
DBC-250E		39° 19.515'	75° 24.120'	39° 19.447'	75° 24.046'	02/09/2001	10:30	47.0	2:00	Downstream	Flood	Partly Cloudy
DBC-251	3	39° 15.643'	75° 20.143'	39° 15.713'	75° 20.200'	02/09/2001	9:20	58.0	2:00	Upstream	Flood	Clear
DBC-251W		39° 15.329'	75° 20.549'	39° 15.395'	75° 20.615'	02/09/2001	9:40	39.0	2:00	Upstream	Flood	Clear

* Not reported because of transcription error.
Dredging Categories:
1 = Previously dredged subjected to maintenance dredging within the last 15 years.
2 = Slated to be dredged for the 13.7 m (45 ft) project, with no previous dredging.
3 = Never dredged, and not scheduled to be dredged for the 13.7 m (45 ft) project.

Appendix Table B-2. Bottom habitat characteristics, catch per unit effort for blue crab, and bycatch for dredge tows of the winter crab survey of Delaware Bay during 2001

Station	Sediment Type	%silt/clay	%sand	area swept (m^2)	Blue crab cpue	Blue crab cpue/q	Sponge	Slipper Shell	Moon Snail	Dog Welk	Channeled Whelk	Knobbed Whelk	Blood ark	Blue Mussel	Oyster	Hard-shelled Clam	Surf Clam	Horseshoe Crab	Mantis Shrimp	Hermit Crab	Spider Crab	Rock Crab	Jonah crab	Lady Crab	Mud Crab	Brittle-star	Sea Urchin	Sea Cucumber	Clearnose Skate	Menhaden	Herring sp.	Oyster Toadfish	White Perch	Hog-choker	Window-pane	Winter Flounder
Deep-01	Sand	1.07	98.93	634.74	1.58	7.16	< 1 bu		1			1		< 1 bu				2		1	7	3				3	1							1	1	
Deep-02	Sand	1.72	98.28	774.72	0.00	0						1						19	1	3	1			1		4								1	4	
Deep-03	Sand	1.45	98.55	712.05	9.83	44.69						5						7				4										1		3	4	
Deep-04	Sand	1.41	98.59	630.71	0.00	0.00						1						4		1						1			5					3		
Deep-05	Sandy Mud	13.53	86.47	800.46	1.25	5.68						3						4		7		2												1	1	
Deep-06	Sand	2.32	97.68	1770.11	2.82	12.84						3								1	2													6	2	
Deep-07	Muddy sand	1.98	98.02	714.12	1.40	6.37					1	5						3		3						1			1						2	
Deep-08	Mud	31.56	68.44	834.31	13.18	59.93												17		6						77								2		
Deep-09	Sand	2.17	97.83	714.29	1.40	6.36						5		5 bu				18			2								1					8	1	
Deep-10	Sandy Mud	13.78	86.22	811.26	3.70	16.81						11		< 1 bu				3	1	39	1	5				2								1		
Deep-11	Sand	1.46	98.54	820.24	7.31	33.25	< 1 bu					2						6		3	3					2			3					1		
Deep-12	Sand	1.07	98.93	867.15	0.00	0.00	< 1 bu					4						2		1		3				1			2						3	
Deep-13	Mud	51.54	48.46	725.58	8.27	37.59			11			1						5		11		11				1									1	
Deep-14	Sand	1.93	98.07	735.02	0.00	0.00												3		3	2	1		1		1			1					3		
Deep-15	Sand	1.18	98.82	766.71	0.00	0.00						2		< 1 bu				1		14		1							1					1	2	
NJL-26	Sandy Mud	7.60	92.40	701.96	1.42	6.48						1						5				1													1	
NJL-27	Sand	1.44	98.56	723.13	0.00	0.00																														
NJL-28	Muddy sand	3.44	96.56	763.18	3.93	17.87						3				1		5				3							1					1	4	
NJL-29	Muddy sand	32.12	67.88	763.58	23.57	107.15					1	2				3		6			3											1		1	2	
NJL-30	Sand	1.48	98.52	775.49	15.47	70.34						1				1		2		1																
NJL-31	Sand	4.37	95.63	699.99	71.43	324.68						1								1	3															
NJL-32	Muddy sand	21.84	78.16	686.45	0.00	0.00						4				1		3		3	1	11							1							
NJL-33	Mud, shell hash	85.26	14.74	764.29	0.00	0.00					4	2	3			102		5																		
NJL-34	Sand	1.23	98.77	815.16	0.00	0.00						1										1														
NJL-35	Sand	1.59	98.41	811.62	0.00	0.00						2						1		4	1								1							
NJL-36	Sand	3.28	96.72	729.22	0.00	0.00												1											1						1	
NJL-37	Sand	2.63	97.37	782.14	28.13	127.85						1				1		2																		
NJL-38	Mud	23.53	76.47	774.38	19.37	88.05					2	2				1						2														
NJL-39	Sand	5.90	94.10	613.71	8.15	37.03										2		5																1	1	
NJL-40	Sand	3.93	96.07	749.08	24.03	109.23	< 1 bu											1			1														1	
DEL-51	Muddy sand	14.26	85.74	843.10	0.00	0.00					1	1		12 bu		4		1		1		3										1		1		
DEL-52	Mud	25.37	74.63	832.25	52.87	240.31						2						21		9	1	4				12								1	1	
DEL-53	mud	5.55	94.45	799.24	65.06	295.74	< 1 bu	2				5		12 bu				15		12	1					1								1		
DEL-54	mud	13.04	86.96	796.77	38.91	176.85					1	3				1		9			1							1						1	1	
DEL-55	Muddy sand	23.90	76.10	753.38	5.31	24.13						10	1			2		12				1												1	1	
DEL-56	sandy mud	5.65	94.35	809.41	1.24	5.62						1						7																		
DEL-57	mud	19.42	80.58	860.54	17.43	79.23												2		1									1			1		2		
DEL-58	sandy mud	7.89	92.11	871.90	0.00	0.00						1		< 1 bu		1		5		2						1			4						1	
DEL-59	Sand	2.51	97.49	668.38	1.50	6.80				1		8						3																1		
DEL-60	Mud	28.32	71.68	740.54	2.70	12.28						2	1			1		1		2														1		
DEL-61	sand	3.14	96.86	938.93	0.00	0.00														1																
DEL-62	mud	8.17	91.83	819.42	21.97	99.85						2				1		5		3														1		
DEL-63	Muddy sand	6.57	93.43	802.26	11.22	50.99						3						5		1	1							1	1					1		
DEL-64	Muddy sand	18.95	81.05	825.83	0.00	0.00					3	10				1		15		2		1												1		
DEL-65	mud	27.11	72.89	810.47	8.64	39.26						4				8		2	1				1													
NJU-76	Oyster shell/ mud	20.80	79.20	729.56	26.04	118.38									22			1																3		
NJU-77	Oyster shell/ mud	16.95	83.05	811.33	8.63	39.22									19			1														1				
NJU-78	Oyster shell	No sample	No sample	183.75	0.00	0.00									> 1000																					
NJU-79	Sand	9.51	90.49	826.04	30.26	137.57									5			5																	1	
NJU-80	Oyster shell/ mud	16.55	83.45	727.71	30.23	137.42									> 1000							2										2				
NJU-81	sand	1.45	98.55	679.59	0.00	0.00	< 1 bu								27			1																		
NJU-82	mud/ shell/ worm tubes	21.02	78.98	803.52	1.24	5.66									16			2														2				
NJU-83	Oyster shell/ sand	5.42	94.58	778.93	10.27	46.68									13																					
NJU-84	Oyster shell	No sample	No sample	710.69	0.00	0.00									> 1000																					
NJU-85	sandy mud	6.53	93.47	725.31	34.47	156.67									1	1		1		1																
NJU-86	sand/ lg stones	1.77	98.23	589.69	1.70	7.71									6			2																		
NJU-87	mud/ oyster shell	29.03	70.97	805.18	4.97	22.58							1			1		1				2										1				
NJU-88	oyster shell	No sample	No sample	747.41	0.00	0.00									> 1000																					
NJU-89	sand	3.15	96.85	635.89	4.72	21.44					1									1																
NJU-90	oyster shell/ lg stones	16.77	83.23	718.05	0.00	0.00									3			1																		
DEU-101	Sandy mud	23.57	76.43	698.34	10.02	45.56					1	1				4		2																		2
DEU-102	sandy mud	21.59	78.41	737.09	1.36	6.17						2				7																1			1	
DEU-103	mud	24.39	75.61	867.00	9.23	41.94						11						1																4	1	
DEU-104	muddy/sand	12.03	87.97	920.36	0.00	0.00																														
DEU-105	mud	16.52	83.48	756.07	1.32	6.01										1		1																1		
DEU-106	Sandy mud	11.28	88.72	649.61	4.62	20.99												1															1	1		
DEU-107	sand	4.07	95.93	741.03	2.70	12.27												1																2		
DEU-108	mud	86.08	13.92	752.44	1.33	6.04									>1000			1							3							2				
DEU-109	fine sand	10.89	89.11	758.69	89.63	407.40						3						13																		
DEU-110	mud	35.28	64.72	692.74	5.77	26.25												5																		
DEU-111	muddy/sand	17.98	82.02	745.62	13.41	60.96									1			1							3							2	1			

* Based on average area swept for 2 minute hauls.
bu = bushel

Appendix Table B-2. (Continued)

Station	Sediment Type	%silt/clay	%sand	area swept (m²)	Blue crab cpue	Blue crab cpue/q	Sponge	Slipper Shell	Moon Snail	Dog Welk	Channeled Whelk	Knobbed Whelk	Blood ark	Blue Mussel	Oyster	Hard-shelled Clam	Surf Clam	Horseshoe Crab	Mantis Shrimp	Hermit Crab	Spider Crab	Rock Crab	Jonah crab	Lady Crab	Mud Crab	Brittle-star	Sea Urchin	Sea Cucumber	Clearnose Skate	Menhaden	Herring sp.	Oyster Toadfish	White Perch	Hog-choker	Window-pane	Winter Flounder
DEU-112	mud	32.68	67.32	811.31	3.70	16.81					1					3		10													1		1			
DEU-113	sandy mud	21.62	78.38	744.99	6.71	30.51					1					8		5																1		
DEU-114	mud	41.04	58.96	901.62	13.31	60.50					3	8				7		6															1	1		
DEU-115	mud	22.04	77.96	758.89	9.22	41.93										3		9																2		
DBC-201	sand	1.99	98.01	845.73	1.18	5.37			1									1																2		
DBC-201E	sand	2.01	97.99	802.36	24.93	113.30						3						2		2	4	3						1						3	2	
DBC-202	sand	2.37	97.63	701.78	0.00	0.00						2						1			2	1				1			1					5	1	
DBC-202E	sandy mud	12.27	87.73	673.98	0.00	0.00					1							5				1				1			2					3		
DBC-203	sand	1.55	98.45	792.34	0.00	0.00						1						1								1			1					1		
DBC-203W	sand	2.03	97.97	784.20	0.00	0.00												1		1		1				5										
DBC-204	sand	1.45	98.55	711.01	0.00	0.00						2										1				5			1					2	1	
DBC-204W	sand	2.74	97.26	691.71	0.00	0.00						2								5	2					7			1					1		
DBC-205	sand	1.23	98.77	846.32	0.00	0.00																														
DBC-205W	sand	5.46	94.54	716.89*	0.22	1.02						2						1		1						3			2							
DBC-206	sand	0.99	99.01	744.45	0.00	0.00												1																	1	
DBC-206W	sand	2.07	97.93	806.77	2.48	11.27			1			4						1		2	1	1				4								1	1	
DBC-207	muddy/sand	2.34	97.66	707.45	18.38	83.53						2		20 bu				3		2	2														1	
DBC-207W	mud	39.97	60.03	681.59	1.47	6.67			1			7		10 bu		4		2		1	1	10														
DBC-208	muddy sand	19.13	80.87	716.89*	22.76	103.47						12		20 bu				1		3	14	13						2								
DBC-208W	mud	52.38	47.62	790.00	3.80	17.26						14				4				6	2	26										1				
DBC-209	muddy sand	24.55	75.45	988.02	123.48	561.27			2			38		20 bu				1	1	3	14	5														
DBC-209W	mud	49.57	50.43	780.66	5.12	23.29			1			10		20 bu						5	1	23														
DBC-210	sand	1.88	98.12	360.82	0.00	0.00			1												2	2												2		
DBC-210W	sand	1.36	98.64	684.33	1.46	6.64						5						4		2	3					3			2					2	2	
DBC-221	sand	5.67	94.33	746.59	0.00	0.00												2																4		
DBC-221W	sandy mud	20.33	79.67	729.69	4.11	18.69						2	2			1		2																		
DBC-222	large rocks	1.42	98.58	588.01	0.00	0.00	12 bu					7				1			1		2	5										1				
DBC-222E	sand	1.98	98.02	458.72	0.00	0.00												3			1	2												3		
DBC-223	course sand	1.33	98.67	514.90	0.00	0.00							2								3	2												1		
DBC-223E	sponge	1.64	98.36	674.71	1.48	6.74	20 bu					1									1	1												3		
DBC-224	sand	1.59	98.41	656.71	0.00	0.00						4				15																			1	
DBC-224W	mud	59.34	40.66	709.75	0.00	0.00						1	1	5 bu				1	1			5														
DBC-225	sand	1.90	98.10	561.36	3.56	16.19							1	20 bu			2					5										1				
DBC-225E	sand	1.53	98.47	657.83	3.04	13.82												1		3	2													6	1	
DBC-226	sand	1.38	98.62	493.03	0.00	0.00												2			1															
DBC-226W	sand	6.64	93.36	723.79	1.38	6.28						1	1			1		1	1																	
DBC-228	sand	1.88	98.12	732.03	0.00	0.00												9			3										1			3	1	
DBC-228W	muddy sand	16.76	83.24	679.87	1.47	6.69					1	3																					1	2		
DBC-235	muddy clay	96.18	3.82	681.73	0.00	0.00										6		5				1												8		
DBC-235W	Sandy mud	10.98	89.02	718.26	91.89	417.68					1	2	4			18																	2			
DBC-236	sand	1.93	98.07	667.40	1.50	6.81										4		1																5		
DBC-236E	sandy mud	17.09	82.91	748.65	6.68	30.36						2				3		1																2	1	
DBC-237	sand/rocks	1.21	98.79	619.46	0.00	0.00										6		3															1	1		
DBC-237E	large rocks	29.00	71.00	367.32	0.00	0.00						3				1		1														6		1		
DBC-238	sand/rocks	1.07	98.93	246.34	0.00	0.00	< 1 bu																													
DBC-238E	rocks	No sample	No sample	183.65	0.00	0.00						1				1				2												2				
DBC-243	sand/rocks	1.56	98.44	224.95	0.00	0.00												1																		
DBC-243E	sand/shell	6.30	93.70	714.33	2.80	12.73						2				1														1			2	1		
DBC-244	sand	7.28	92.72	698.50	0.00	0.00																												4		
DBC-244W	mud	58.92	41.08	686.85	0.00	0.00					1							3																7		
DBC-245	sand/rocks	2.42	97.58	643.40	10.88	49.45							1								1													6		
DBC-245E	muddy sand	11.54	88.46	822.28	15.81	71.86										3		1																		
DBC-246	sand/rocks	0.78	99.22	282.11	0.00	0.00																												2		
DBC-246W	sand	1.67	98.33	745.39	0.00	0.00												5																3		
DBC-247	sand/lg. Rock	0.86	99.14	470.01	4.26	19.34										2		1															1	6		
DBC-247W	muddy sand	3.24	96.76	609.96	16.39	74.52																												1		
DBC-248	mud	89.91	10.09	591.64	0.00	0.00									2																			3		
DBC-248W	mud/oyster shell	76.15	23.85	769.45	0.00	0.00									10																		7			
DBC-249	mud	92.46	7.54	435.46	2.30	10.44												1														2		1		
DBC-249W	sandy mud	31.46	68.54	718.11	6.96	31.65												2																1		
DBC-250	mud/large rock	84.61	15.39	605.94	3.30	15.00												2																9		
DBC-250E	mud/oyster shell	55.13	44.87	701.03	5.71	25.94									18							2										5				
DBC-251	sand	0.61	99.39	652.56	0.00	0.00												1																2		
DBC-251W	mud/oyster shell	28.79	71.21	658.52	18.22	82.83									3	2		1				3										6	2	8		

*Based on average towing distance for 2 min hauls.

Appendix Table B-3. Dredging information from the gear efficiency experiments for the winter crab survey of Delaware Bay during 2001

Station	Pass	Start Latitude		Start Longitude		End Latitude		End Longitude		Date	Time	Depth (ft)	Time	Direction	Tide	Weather
GE-1	1	39	2.335	75	10.338	39	2.252	75	10.250	02/13/2001	12:48	36	2:00	Downstream	Flood	Partly Cloudy
GE-1	2	39	2.338	75	10.343	39	2.249	75	10.231	02/13/2001	12:53	35	2:07	Downstream	Flood	Partly Cloudy
GE-1	3	39	2.340	75	10.345	39	2.249	75	10.235	02/13/2001	13:00	35	2:07	Downstream	Flood	Partly Cloudy
GE-1	4	39	2.340	75	10.346	39	2.249	75	10.241	02/13/2001	13:06	35	2:15	Downstream	Flood	Partly Cloudy
GE-1	5	39	2.340	75	10.348	39	2.247	75	10.236	02/13/2001	13:12	35	2:13	Downstream	Flood	Partly Cloudy
GE-1	6	39	2.339	75	10.344	39	2.249	75	10.238	02/13/2001	13:19	35	2:07	Downstream	Flood	Partly Cloudy
GE-1	7	39	2.341	75	10.350	39	2.249	75	10.238	02/13/2001	13:25	35	2:18	Downstream	Flood	Partly Cloudy
GE-1	8	39	2.340	75	10.350	39	2.249	75	10.234	02/13/2001	13:31	35	2:16	Downstream	Flood	Partly Cloudy
GE-1	9	39	2.341	75	10.350	39	2.248	75	10.235	02/13/2001	13:36	35	2:22	Downstream	Flood	Partly Cloudy
GE-1	10	39	2.337	75	10.346	39	2.248	75	10.236	02/13/2001	13:45	35	2:16	Downstream	High	Partly Cloudy
GE-2	1	39	2.363	75	10.470	39	2.271	75	10.376	02/13/2001	13:55	37	2:00	Downstream	High	Partly Cloudy
GE-2	2	39	2.365	75	10.471	39	2.265	75	10.366	02/13/2001	14:00	37	2:18	Downstream	High	Partly Cloudy
GE-2	3	39	2.360	75	10.469	39	2.271	75	10.375	02/13/2001	14:08	37	2:05	Downstream	High	Partly Cloudy
GE-2	4	39	2.367	75	10.467	39	2.271	75	10.379	02/13/2001	14:14	37	2:11	Downstream	High	Partly Cloudy
GE-2	5	39	2.356	75	10.461	39	2.269	75	10.371	02/13/2001	14:20	37	2:07	Downstream	High	Partly Cloudy
GE-2	6	39	2.361	75	10.469	39	2.271	75	10.378	02/13/2001	14:28	37	2:10	Downstream	High	Partly Cloudy
GE-2	7	39	2.362	75	10.468	39	2.270	75	10.377	02/13/2001	14:35	37	2:08	Downstream	Ebb	Partly Cloudy
GE-2	8	39	2.352	75	10.457	39	2.274	75	10.382	02/13/2001	14:40	37	1:56	Downstream	Ebb	Partly Cloudy
GE-2	9	39	2.368	75	10.478	39	2.273	75	10.379	02/13/2001	14:46	37	2:26	Downstream	Ebb	Partly Cloudy
GE-2	10	39	2.361	75	10.466	39	2.272	75	10.377	02/13/2001	14:55	37	2:12	Downstream	Ebb	Partly Cloudy
GE-3	1	39	2.930	75	13.691	39	2.806	75	13.714	02/14/2001	7:40	30	2:00	Downstream	Ebb	Overcast
GE-3	2	39	2.938	75	13.690	39	2.802	75	13.712	02/14/2001	7:50	30	2:01	Downstream	Ebb	Overcast
GE-3	3	39	2.935	75	13.694	39	2.803	75	13.716	02/14/2001	7:55	30	2:00	Downstream	Ebb	Overcast
GE-3	4	39	2.936	75	13.690	39	2.804	75	13.715	02/14/2001	8:00	30	2:11	Downstream	Ebb	Overcast
GE-3	5	39	2.936	75	13.687	39	2.804	75	13.715	02/14/2001	8:10	30	2:22	Downstream	Ebb	Overcast
GE-3	6	39	2.938	75	13.690	39	2.805	75	13.713	02/14/2001	8:15	30	2:07	Downstream	Ebb	Overcast
GE-3	7	39	2.940	75	13.690	39	2.803	75	13.713	02/14/2001	8:22	30	2:10	Downstream	Ebb	Overcast
GE-3	8	39	2.940	75	13.689	39	2.802	75	13.713	02/14/2001	8:28	30	2:13	Downstream	Ebb	Overcast
GE-3	9	39	2.940	75	13.693	39	2.803	75	13.714	02/14/2001	8:34	30	2:13	Downstream	Ebb	Overcast
GE-3	10	39	2.942	75	13.691	39	2.799	75	13.716	02/14/2001	8:42	30	2:25	Downstream	Ebb	Overcast
GE-4	1	39	2.937	75	13.325	39	2.836	75	13.241	02/14/2001	9:06	28	2:00	Downstream	Low	Overcast
GE-4	2	39	2.934	75	13.335	39	2.830	75	13.245	02/14/2001	9:11	28	2:05	Downstream	Low	Overcast
GE-4	3	39	2.938	75	13.327	39	2.831	75	13.248	02/14/2001	9:18	28	2:08	Downstream	Low	Overcast
GE-4	4	39	2.936	75	13.330	39	2.835	75	13.248	02/14/2001	9:24	27	2:00	Downstream	Low	Overcast
GE-4	5	39	2.937	75	13.331	39	2.832	75	13.246	02/14/2001	9:32	28	2:07	Downstream	Low	Overcast
GE-4	6	39	2.937	75	13.330	39	2.835	75	13.250	02/14/2001	9:36	28	1:59	Downstream	Low	Overcast
GE-4	7	39	2.938	75	13.330	39	2.832	75	13.248	02/14/2001	9:42	28	2:02	Downstream	Low	Overcast
GE-4	8	39	2.936	75	13.334	39	2.833	75	13.250	02/14/2001	9:50	28	3:00	Downstream	Low	Overcast
GE-4	9	39	2.933	75	13.333	39	2.831	75	13.247	02/14/2001	9:56	28	2:04	Downstream	Low	Overcast
GE-4	10	39	2.936	75	13.333	39	2.833	75	13.251	02/14/2001	10:00	28	1:56	Downstream	Low	Overcast
GE-5	1	39	3.081	75	14.915	39	3.189	75	15.015	02/14/2001	10:20	26	2:00	Upstream	Flood	Overcast
GE-5	2	39	3.084	75	14.911	39	3.188	75	15.013	02/14/2001	10:26	26	2:02	Upstream	Flood	Overcast
GE-5	3	39	3.081	75	14.912	39	3.186	75	15.017	02/14/2001	10:34	26	2:09	Upstream	Flood	Overcast

Appendix Table B-3.(Continued)

Station	Pass	Start Latitude		Start Longitude		End Latitude		End Longitude		Date	Time	Depth (ft)	Time	Direction	Tide	Weather
GE-5	4	39	3.085	75	14.910	39	3.190	75	15.013	02/14/2001	10:42	27	2:08	Upstream	Flood	Overcast
GE-5	5	39	3.084	75	14.911	39	3.188	75	15.013	02/14/2001	10:50	26	2:08	Upstream	Flood	Overcast
GE-5	6	39	3.085	75	14.909	39	3.187	75	15.011	02/14/2001	11:00	26	2:04	Upstream	Flood	Overcast
GE-5	7	39	3.087	75	14.913	39	3.187	75	15.013	02/14/2001	11:08	26	1:53	Upstream	Flood	Overcast
GE-5	8	39	3.084	75	14.911	39	3.188	75	15.012	02/14/2001	11:14	27	2:05	Upstream	Flood	Overcast
GE-5	9	39	3.084	75	14.911	39	3.188	75	15.012	02/14/2001	11:20	27	2:14	Upstream	Flood	Overcast
GE-5	10	39	3.081	75	14.915	39	3.189	75	15.013	02/14/2001	11:30	26	2:16	Upstream	Flood	Overcast
GE-6	1	39	2.872	75	14.662	39	2.982	75	14.754	02/14/2001	11:43	28	2:00	Upstream	Flood	Overcast
GE-6	2	39	2.876	75	14.664	39	2.987	75	14.752	02/14/2001	11:54	28	2:00	Upstream	Flood	Overcast
GE-6	3	39	2.874	75	14.666	39	2.984	75	14.751	02/14/2001	12:04	28	1:58	Upstream	Flood	Overcast
GE-6	4	39	2.875	75	14.664	39	2.986	75	14.752	02/14/2001	12:12	29	2:03	Upstream	Flood	Overcast
GE-6	5	39	2.875	75	14.669	39	2.985	75	14.756	02/14/2001	12:22	28	2:01	Upstream	Flood	Overcast
GE-6	6	39	2.872	75	14.661	39	2.984	75	14.756	02/14/2001	12:30	29	2:28	Upstream	Flood	Overcast
GE-6	7	39	2.873	75	14.665	39	2.986	75	14.753	02/14/2001	12:36	29	2:10	Upstream	Flood	Overcast
GE-6	8	39	2.877	75	14.663	39	2.984	75	14.755	02/14/2001	12:44	29	1:58	Upstream	Flood	Overcast
GE-6	9	39	2.874	75	14.662	39	2.986	75	14.756	02/14/2001	12:50	29	2:07	Upstream	Flood	Overcast
GE-6	10	39	2.873	75	14.662	39	2.985	75	14.755	02/14/2001	12:58	29	2:08	Upstream	Flood	Overcast
GE-7	1	39	3.214	75	14.971	39	3.319	75	15.065	02/14/2001	13:15	27	2:00	Upstream	Flood	Overcast
GE-7	2	39	3.216	75	14.967	39	3.330	75	15.065	02/14/2001	13:25	27	2:19	Upstream	Flood	Overcast
GE-7	3	39	3.214	75	14.958	39	3.322	75	15.074	02/14/2001	13:34	27	2:13	Upstream	Flood	Overcast
GE-7	4	39	3.208	75	14.976	39	3.324	75	15.066	02/14/2001	13:42	27	2:22	Upstream	Flood	Overcast
GE-7	5	39	3.209	75	14.968	39	3.323	75	15.069	02/14/2001	13:55	28	2:18	Upstream	Flood	Overcast
GE-7	6	39	3.213	75	14.967	39	3.323	75	15.070	02/14/2001	14:02	27	2:18	Upstream	Flood	Overcast
GE-7	7	39	3.209	75	14.969	39	3.326	75	15.070	02/14/2001	14:10	27	2:15	Upstream	Flood	Overcast
GE-7	8	39	3.210	75	14.966	39	3.325	75	15.070	02/14/2001	14:16	27	2:25	Upstream	Flood	Overcast
GE-7	9	39	3.211	75	14.964	39	3.322	75	15.065	02/14/2001	14:24	27	2:19	Upstream	Flood	Overcast
GE-7	10	39	3.211	75	14.966	39	3.322	75	15.066	02/14/2001	14:30	27	2:10	Upstream	Flood	Overcast
GE-8	1	38	52.712	75	9.730	38	52.650	75	9.601	02/13/2001	7:50	34	2:00	Downstream	Low	Overcast
GE-8	2	Location not recorded				38	52.648	75	9.603	02/13/2001	7:55	34	2:00	Downstream	Low	Overcast
GE-8	3	38	52.723	75	9.734	38	52.357	75	9.612	02/13/2001	8:00	34	2:00	Downstream	Low	Overcast
GE-8	4	38	52.718	75	9.740	38	52.654	75	9.608	02/13/2001	8:10	34	2:00	Downstream	Low	Overcast
GE-8	5	38	52.726	75	9.748	38	52.653	75	9.611	02/13/2001	8:17	34	2:25	Downstream	Flood	Overcast
GE-8	6	38	52.723	75	9.751	38	52.652	75	9.612	02/13/2001	8:25	34	2:25	Downstream	Flood	Overcast
GE-8	7	38	52.721	75	9.751	38	52.659	75	9.627	02/13/2001	8:32	34	2:10	Downstream	Flood	Overcast
GE-8	8	38	52.723	75	9.757	38	52.651	75	9.616	02/13/2001	8:38	34	2:34	Downstream	Flood	Overcast
GE-8	9	38	52.718	75	9.750	38	52.649	75	9.625	02/13/2001	8:44	34	2:25	Downstream	Flood	Overcast
GE-8	10	38	52.724	75	9.743	38	52.655	75	9.631	02/13/2001	8:51	34	2:02	Downstream	Flood	Overcast
GE-9	1	38	52.797	75	10.019	38	52.853	75	10.137	02/13/2001	9:06	32	2:00	Upstream	Flood	Overcast
GE-9	2	38	52.796	75	10.018	38	52.856	75	10.147	02/13/2001	9:12	33	1:53	Upstream	Flood	Overcast
GE-9	3	38	52.792	75	10.018	38	52.856	75	10.150	02/13/2001	9:20	32	2:00	Upstream	Flood	Partly Cloudy
GE-9	4	38	52.796	75	10.021	38	52.856	75	10.146	02/13/2001	9:25	32	1:52	Upstream	Flood	Partly Cloudy
GE-9	5	38	52.796	75	10.022	38	52.855	75	10.146	02/13/2001	9:36	32	1:50	Upstream	Flood	Partly Cloudy
GE-9	6	38	52.796	75	10.023	38	52.858	75	10.152	02/13/2001	9:43	33	1:53	Upstream	Flood	Partly Cloudy
GE-9	7	38	52.796	75	10.023	38	52.856	75	10.146	02/13/2001	9:50	34	1:50	Upstream	Flood	Partly Cloudy
GE-9	8	38	52.793	75	10.022	38	52.857	75	10.146	02/13/2001	9:55	33	1:55	Upstream	Flood	Partly Cloudy

Appendix Table B-3.(Continued)

Station	Pass	Start Latitude		Start Longitude		End Latitude		End Longitude		Date	Time	Depth (ft)	Time	Direction	Tide	Weather
GE-9	9	38	52.792	75	10.023	38	52.856	75	10.150	02/13/2001	10:01	33	1:49	Upstream	Flood	Partly Cloudy
GE-9	10	38	52.790	75	10.022	38	52.856	75	10.153	02/13/2001	10:08	33	2:08	Upstream	Flood	Partly Cloudy
GE-10	1	38	52.995	75	10.118	38	53.071	75	10.249	02/13/2001	10:23	33	2:00	Upstream	Flood	Partly Cloudy
GE-10	2	38	52.989	75	10.119	38	53.074	75	10.256	02/13/2001	10:30	33	2:06	Upstream	Flood	Partly Cloudy
GE-10	3	38	52.997	75	10.117	38	53.075	75	10.256	02/13/2001	10:38	33	2:03	Upstream	Flood	Partly Cloudy
GE-10	4	38	52.996	75	10.118	38	53.074	75	10.256	02/13/2001	10:46	33	2:00	Upstream	Flood	Partly Cloudy
GE-10	5	38	52.999	75	10.122	38	53.077	75	10.258	02/13/2001	10:54	34	1:52	Upstream	Flood	Partly Cloudy
GE-10	6	38	53.006	75	10.135	38	53.074	75	10.256	02/13/2001	11:00	34	1:51	Upstream	Flood	Partly Cloudy
GE-10	7	38	53.017	75	10.151	38	53.078	75	10.262	02/13/2001	11:06	33	1:43	Upstream	Flood	Partly Cloudy
GE-10	8	38	53.021	75	10.162	38	53.076	75	10.253	02/13/2001	11:13	34	1:40	Upstream	Flood	Partly Cloudy
GE-10	9	38	53.020	75	10.162	38	53.075	75	10.254	02/13/2001	11:20	33	1:21	Upstream	Flood	Partly Cloudy
GE-10	10	38	53.008	75	10.141	38	53.073	75	10.259	02/13/2001	11:26	34	1:44	Upstream	Flood	Partly Cloudy

Appendix Table B-4. Bycatch by haul for the gear efficiency experiments conducted for the winter crab survey on the Delaware Bay during 2001

Eff. Exper.	Pass	Moon Snail	Channeled Whelk	Knobbed Whelk	Blue Mussel (bushel)	Hard-shelled Clam	Horse-shoe Crab	Hermit Crab	Spider Crab	Rock Crab	Brittle star	sea urchin	sea cucumber	Skate	Hogchoker	Window-pane	Winter Flounder	Summer Flounder
GE-1	1			1	<1		1		1						1	3		
GE-1	2			8										1		1		
GE-1	3				<1		2							1	2			
GE-1	4			11	<1		2								2			
GE-1	5			16			2			1					3	1		
GE-1	6			5			1		1						2			1
GE-1	7			6			2	1	1						4			
GE-1	8			6			1									1		
GE-1	9			4			3	2		1								
GE-1	10			3			2								2			
GE-2	1			1			1				2					2		
GE-2	2			2			3	1		1	1			1		1		
GE-2	3			3			2	1							1	1		
GE-2	4			7			8		1		2			1	1			
GE-2	5			3			6			1					4			
GE-2	6		1	4			10				1				1			
GE-2	7			2			1								3			
GE-2	8			3			2							1	1			
GE-2	9			6			4		1						2			
GE-2	10			1			4		2						1			
GE-3	1			42	5		7	6		4				1				
GE-3	2			73	4		7	10		1					2			1
GE-3	3			37	4		10	7		2	1				2			
GE-3	4			55	2		12	5	2		1				1			
GE-3	5			63	1.5		10	1		1	1				1			
GE-3	6			62	0.5		5				1							
GE-3	7			51	0.5		2			1					1			
GE-3	8			54	0.1		3											
GE-3	9			56	1		4	1		1					2			
GE-3	10			44	0.5		2			2								
GE-4	1			20	2		6	6						3	1	1		
GE-4	2			42	1		7	8		2						1		
GE-4	3		1	60	1	1	10	8		4				1	1	1		
GE-4	4			62	1		8	7		2					1	1		
GE-4	5		1	51	1	1	2	5		3								
GE-4	6			51	2		8	6							3			
GE-4	7			66	1.5		8	2		2								
GE-4	8			55	1		9			2				1				
GE-4	9			36	1		4			1			1					
GE-4	10			50	1		12											
GE-5	1			9	3		13	18		5	2							
GE-5	2			6	5		8	12		5	10				1			1
GE-5	3			20			15	10	3	4	8				1			
GE-5	4			25	5		11	8	2		6					1		
GE-5	5	1		26	3		9	8	2	3	2				2			
GE-5	6			24		1	8	5	1		2				1			
GE-5	7			21			8	3	1	4	2						1	
GE-5	8	1		22	0.5		3	3		2	7				1			
GE-5	9			19			6	6	2									
GE-5	10		1	33			7	15	4	7	2				2			
GE-6	1			15	5		20	40		5				4	1			
GE-6	2			30			12	40	3	15				1	1			
GE-6	3			35	5		6	30	3	3	2				1			
GE-6	4			26	5		10	60	5	10				1	3	1		
GE-6	5			51	5		7	25	5	10								
GE-6	6			85	4		9	30	5	4								

Appendix Table B-4. (Continued)

Eff. Exper.	Pass	Moon Snail	Channeled Whelk	Knobbed Whelk	Blue Mussel (bushel)	Hard-shelled Clam	Horse-shoe Crab	Hermit Crab	Spider Crab	Rock Crab	Brittle star	sea urchin	sea cucumber	Skate	Hogchoker	Window-pane	Winter Flounder	Summer Flounder
GE-6	7	2	2	54	3		6	12	1	2								
GE-6	8			54	2		8	24		1					1			
GE-6	9		1	49	1		5	10					1					
GE-6	10		1	63	1		4	12					1					
GE-7	1			10	5		11	10	2					2	4			
GE-7	2			20	3		14	6	4	2	1							
GE-7	3		1	12	3		16	4							2			
GE-7	4		1	18	3		14	11	4	2				1				
GE-7	5			28	3		12	3	1				1		1			
GE-7	6			15	2		9	4	4	1					1			
GE-7	7		1	23	2		14	4	1									
GE-7	8		2	35	2		15	9		1								
GE-7	9		1	37	1		4	11		1								
GE-7	10		1	42	1		5	4							1			
GE-8	1			1			12		1	1	24							
GE-8	2			10			10	3		2	30							
GE-8	3						20		1		24							
GE-8	4						10	5	1		10			1	4			
GE-8	5		1	3		1	15	5		2								
GE-8	6						9		1		10					1		
GE-8	7						8	5	1	2	10							
GE-8	8			5			6	8		2	10					1		
GE-8	9			6		1	3	5		2	15				2			
GE-8	10			33			15	5	1						1			
GE-9	1						25	10		5								
GE-9	2			1			20	10	2									
GE-9	3						10	15										
GE-9	4			1			12	10	1		3							
GE-9	5			2			15	10				1						
GE-9	6			1			10	20	1		10							
GE-9	7		1	1			7											
GE-9	8			2			8	2		1								
GE-9	9			2			17	12	1		3			1				
GE-9	10						12	18	1		5							
GE-10	1			1			32	10	1		15					1		
GE-10	2						20	15			20			1	5			
GE-10	3						20	12		3	15			21	2			
GE-10	4		1				30	12		1								
GE-10	5						12	5		2	15							
GE-10	6			1			12	5			4							
GE-10	7			1			18	10		1					2			
GE-10	8					1	8	9										
GE-10	9			1		1	10	5			3							
GE-10	10			1			18	23			6				2			

APPENDIX B

DATA COLLECTION SHEET

DELAWARE BAY WINTER BLUE CRAB ASSESSMENT

Date:____/____/_'01_ Time:____:____ Crew:________/________/________

Station: _____-_____ (DEEP 01-25; NJL 26-50; DEL 51-75; NJU 76-100; DEU 101-125; DBC 200-260) Depth(m)________

Start: Latitude:____°____.______' Longitude:____°____.______' Tow(min)________

End: Latitude:____°____.______' Longitude:____°____.______' Direction: US / DS

Tide: F / HS / E / LS Weather:______ (1=clear, 2=partly cloudy, 3=overcast, 4=rain, 5=snow, 6=fog)

Water Quality:

Depth (m)	Temp. (C)	DO (mg/L)	% Sat	pH	Salinity (ppt)	Conductivity (mS/cm)	Turbidity (NTU)
0.5	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.

Sediment Characterization:
Mud / Sand / Muddy-sand / Sandy-mud / Oyster-shell / Other____________________

Species: Blue Crab (*Callinectes sapidus*) **Total Measured:**

1 M	2 M	3 M	4 M	5 M	6 M	7 M	8 M	9 M	10 M
11 M	12 M	13 M	14 M	15 M	16 M	17 M	18 M	19 M	20 M
21 M	22 M	23 M	24 M	25 M	26 M	27 M	28 M	29 M	30 M
31 M	32 M	33 M	34 M	35 M	36 M	37 M	38 M	39 M	40 M
41 M	42 M	43 M	44 M	45 M	46 M	47 M	48 M	49 M	50 M
51 M	52 M	53 M	54 M	55 M	56 M	57 M	58 M	59 M	60 M
61 M	62 M	63 M	64 M	65 M	66 M	67 M	68 M	69 M	70 M
71 M	72 M	73 M	74 M	75 M	76 M	77 M	78 M	79 M	80 M
81 M	82 M	83 M	84 M	85 M	86 M	87 M	88 M	89 M	90 M
91 M	92 M	93 M	94 M	95 M	96 M	97 M	98 M	99 M	100 M
101 M	102 M	103 M	104 M	105 M	106 M	107 M	108 M	109 M	110 M
111 M	112 M	113 M	114 M	115 M	116 M	117 M	118 M	119 M	120 M
121 M	122 M	123 M	124 M	125 M	126 M	127 M	128 M	129 M	130 M
131 M	132 M	133 M	134 M	135 M	136 M	137 M	138 M	139 M	140 M
141 M	142 M	143 M	144 M	145 M	146 M	147 M	148 M	149 M	150 M

Ancillary Species:	Total		Total
Horseshoe crab		Hard clam	
Spider crab		Moon snail	
Lady crab		Knobbed whelk	
Hermit crab		Channeled whelk	