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A Handling Study of Dungeness Crab at Varying Air Exposure Intervals and Shell-Hardness Levels

by
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Division of Commercial Fisheries
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State of Alaska Steve Cowper, Governor

The Fishery Research Bulletin Series was established in 1987, replacing the Informational Leaflet Series. This new series represents a change in name rather than substance. The series continues to be comprised of divisional publications in which completed studies or data sets have been compiled, analyzed, and interpreted consistent with current scientific standards and methodologies. While most reports in the series are highly technical and intended for use primarily by fishery professionals and technically oriented fishing industry representatives, some nontechnical or generalized reports of special importance and application may be included. Most data presented are final. Publications in this series have received several editorial reviews and usually two *blind* peer reviews refereed by the division's editor and have been determined to be consistent with the division's publication policies and standards.

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ABSTRACT

Excessive handling of soft-shell Dungeness crab (*Cancer magister*), is believed to result in mortality. Estimates of handling mortality could be used to minimize the impact of commercial fishing on soft-shell crab. Dungeness crab were tagged, measured for shell hardness, and exposed to air for a specified period. Differences in recovery rates of crab with different shell hardnesses and air exposure times were not statistically significant. Nonsignificant results were attributed to small sample sizes in shell-hardness categories most sensitive to treatment. Therefore, affects of air exposure and handling on soft-shell crab could not be determined in this study. Recommendations are made for future study designs.

KEY WORDS: Dungeness crab, handling mortality, soft-shell crab, exposure, tagging of crab, Kodiak

INTRODUCTION

The Dungeness crab, *Cancer magister*, fishery in Alaska is managed solely on restriction of the size, sex, and fishing season. Only male crab 6.5 in in carapace width may be taken throughout Alaska. Fishing seasons vary from one management area to another, and the basis for seasons in many areas is not supported by convincing biological data. The Alaska Department of Fish and Game (ADF&G) may currently limit commercial fishing seasons if an excessive proportion of soft-shell crab occurs in deliveries or on the fishing grounds (ADF&G, 1988). The rationale is that unacceptable mortalities result from capture and handling of soft-shell crab. Estimates of handling mortality for Dungeness crab with varying shell conditions would greatly enhance justification for management decisions pertaining to season changes and area closures based on proportions of soft-shell crab. This study investigated handling mortalities of Kodiak Dungeness crab based on air exposure time and shell hardness. Release and recovery rates of tagged crab exposed to air were used to estimate handling mortality for crab of varying shell hardness.

METHODS

The handling mortality study was conducted in Alitak Bay on Kodiak Island between June 6 and June 15, 1987 (Figure 1). This area was selected because the state research vessel, *Coho*, was available during the time when Dungeness crab in Alitak Bay were expected to have recently molted. The area was also closed to commercial fishing during the study period enabling crab to be tagged prior to the beginning of the commercial fishing season. Two specific areas of Alitak Bay were fished, Tanner Head and Snug Cove (Figure 1). A total of 278 crab pots were fished, 152 pots in the Tanner Head area and 126 pots in Snug Cove. In the Tanner Head area, 183 crab were tagged and released, while 447 crab were tagged and released in Snug Cove.

Crab were captured using commercial Dungeness crab pots approximately 40 in in diameter and 12 in high. Each pot had two 4-in circular escape ports to allow female crab and undersize male crab to escape. Crab pots were baited with chopped squid placed in 2 pint stainless steel bait containers. Strings of crab pots with about 600 ft between pots were set and buoyed to the surface with 1/2-in polypropylene line attached to two cylindrical floats. Number of crab pots per string and number of strings set each day varied in an effort to approximate commercial fishing conditions. Pots were allowed to soak for 2 days before being pulled.

Crab were gently sorted and removed from pots, then carefully measured and tagged in an effort to minimize handling and marking affects. Female crab caught in the pots were enumerated and immediately released. All male crab were measured (carapace width), tested for shell hardness with a model 307LCRB4 durometer (Hicks and Johnson 1988), tagged, and held in a basket for differing predetermined times before being released. Durometer measurements of crab shell hardness were always taken from the same shell area on each crab: the ventral carapace approximately midway between the notch of the tenth anterolateral spine and the shoulder (coxa) of the crab. Crab were

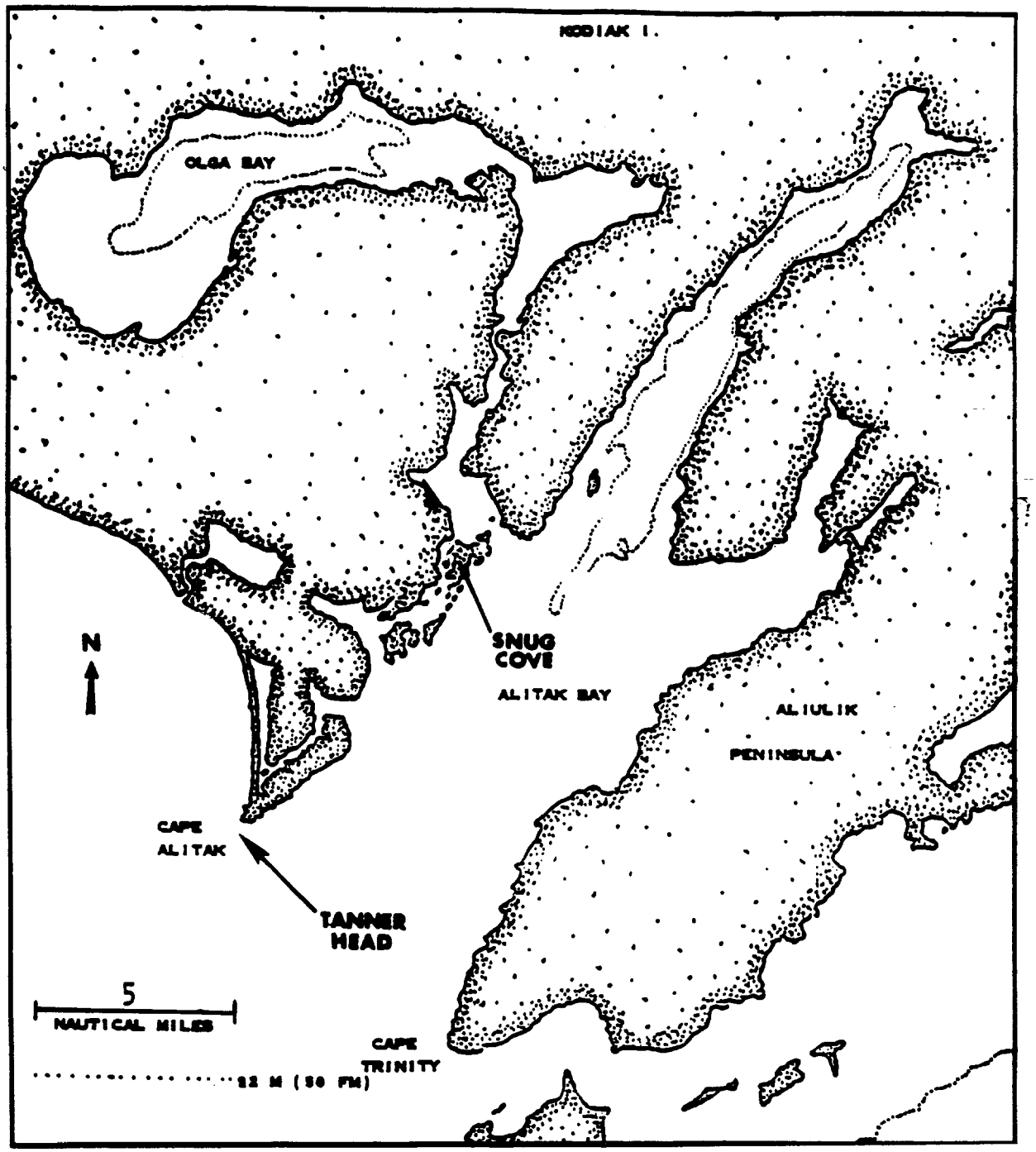

Figure 1. Alitak Bay Study Area.

tagged according to methods described in Snow and Wagner (1965). Two small holes were punched through the shell at the suture line of the posterior shell. A numbered spaghetti tag was threaded through the shell with a curved needle of number two stainless steel wire. After the spaghetti tag was inserted an overhand knot was tied approximately 1 in from the shell securing the tag and allowing room for shell growth. Once the crab from one pot were tagged they were all placed together in a basket to await the assigned exposure time of 5, 15, 30, or 60 min. These exposure times were selected to simulate the range of air exposure times that can occur while crab are handled and sorted on a commercial fishing vessel. When the exposure time for a basket was achieved the crabs were immediately released.

Tags were recovered from the commercial fishery through the cooperation of commercial fisherman and by ADF&G personnel in dockside samples of commercial crab catches. The number of commercial catches sampled was weighted according to the number of vessels delivering catch in each fishing district.

Analysis of Handling Effects

Dungeness crab handling mortality data were analyzed with the chi-square test (Sokal and Rohlf 1969) and the non-parametric Kruskal-Wallis test (Conover 1980). Primary hypotheses were designed to test whether tag recovery rates were: (1) identical for crab of similar shell hardness but exposed to air for different periods of time; and (2) identical for crab exposed to air for the same length of time but with different shell hardness.

Shell-hardness measurements were divided into 6 categories for analysis. Each category included a range of 10 durometer units. Lower durometer readings were taken from soft-shell crabs. Since, few crab were caught with durometer readings ranging between 20 - 29, 30 - 39, and 40 - 49 units, the first shell-hardness category spanned durometer readings from 20 - 49 units. This increased the sample size of soft-shell crab. Broader categories of shell hardness were also defined for additional tests of hypothesis number one.

Chi-square Tests

Expected number of tag recoveries for each exposure time and shell-hardness category were calculated as a function of the number of tagged crab released. Specifically, for any one combination of exposure time (i), and shell hardness (j), the expected tag recovery $E(r_{ij})$, was calculated as number of crab tagged for that combination (n_{ij}), divided by total number of tagged crab (N), and multiplied by total number of tagged crab recovered (R) or:

$$E(r_{ij}) = (n_{ij}/N)(R)$$

Dissimilar numbers of tagged crab were released for each combination of exposure and shell hardness. Therefore, each set of expected recoveries for a specific exposure time or shell hardness followed a different distribution requiring that each be treated as an independent sample. Chi-square tests

were run for each independent sample or: (1) each exposure time to determine if tag recoveries for an exposure time were equivalent for all shell hardnesses; (2) each category of shell hardness to determine if tag recoveries for a shell hardness were equivalent for all exposure times; (3) various combinations of shell-hardness categories to determine if tag recoveries were equivalent for broader groupings of shell-hardness measurements; and (4) pooled shell hardness to determine if tag recoveries were equivalent for all exposure times independent of shell hardness. Exposure times were not pooled because they represent treatments.

Kruskal-Wallis Tests

The distribution-free Kruskal-Wallis test was used to analyze all independent samples in the data set as a whole. The test statistic was calculated twice where exposure times and shell-hardness category were sequentially reversed in each analysis to test two different hypothesis: (1) recovery rates of crab exposed to air for different exposure times were equivalent for crab in each shell-hardness category greater than 49 durometers; and (2) recovery rates of crab with shell hardness greater than 49 durometers were equivalent for each exposure time. The Kruskal-Wallis test is based on the rank of observed data and does not include expected values. Observed tag recoveries did not exist for crab with shell-hardness values less than 49 durometers. Therefore, the first category of shell hardness was excluded in calculation of the test statistic.

Estimation of Sample Size

Abundance of crab with different shell-hardnesses was variable and few soft-shell crab were captured, tagged, and released. This inequality of sample sizes for each combination of shell hardness and exposure excluded use of ANOVA techniques and lack of a control group prevented the use of maximum liklihood estimators to estimate mortality. We determined it would be helpful to evaluate sample size and design for future studies.

Sample size estimation was approached in terms of controlling the risks of making Type I and Type II errors and specification of the minimum difference in recovery rate (in number of crab) which is important to detect with high probability between each exposure level and shell-hardness category combination. Sample sizes were estimated for a fixed effects model of ANOVA with equal sample sizes, using the following formula for the error variance:

$$\sigma^2_{\epsilon} = \frac{SSE}{(a-1)(b-1)}$$

where SSE is the sum of squares for error between observed and expected numbers of crab recovered from each combination of exposure time period and shell hardness category. The degrees of freedom term is based on a single observation in each cell since only one recovery rate is available for each

combination of exposure level (a), and shell-hardness category (b). Table A-10 in Neter, Wasserman and Kutner (1985) was used to determine sample size based on probabilities of making Type I and Type II errors, desired detectable difference and the standard deviation. Sample sizes are a function of a variance of recovery rates. Therefore, tabled values of sample size were multiplied by a factor of nine which is the soft-shell crab recovery rate. The more conservative soft-shell crab recovery rate of one in nine crabs was used instead of the hard-shell crab recovery rate of one in five crabs. This insured adequate sample size for all treatment and shell-hardness combinations.

RESULTS

A total of 630 male Dungeness crab were tagged from the 278 pots set and retrieved during the 10-d study. Data on tag releases and recoveries are presented in Appendix A. In some cases, observers were able to take a second durometer reading of shell hardness from recovered crab: 16 of 25 showed a decrease in shell-hardness. All decreases were less than 15 durometer units. Softening of a crabs carapace occurs just prior to molting and may explain these observed decreases in shell hardness. Six crab showed minimal increases in shell hardness, and two crab displayed substantial increases in shell hardness. An increase in shell hardness is due to the natural hardening of a crab carapace over time. One crab had the same shell hardness when it was released and recovered.

Crab were considered to be hard-shell crab (handleable) if they scored 70 durometers or higher. Crab < 70 durometers were considered soft (fragile). A summary of the number of hard and soft-shell male crab released and recovered by exposure time is shown in Table 1. Far more hard-shell crab were released than soft-shell crab. Soft-shell crab were not as soft as originally anticipated for the time and area studied. Releases by shell hardness were 81.9% hard-shell crab and 18.1% soft-shell crab. Recoveries by shell hardness were 88.8% of the hard-shell crab released and 11.2% of the soft-shell crab released. One in five hard-shell crab released were recovered, while only one in nine of the soft-shell crab were recovered. Recoveries of hard-shell crab were high even at the maximum exosure time, confirming that hard-shell crab are extremely rugged crustaceans. Number of crabs released, observed number of crabs recovered and expected number of crabs recovered are summarized in Table 2 by time and the finite shell-hardness categories used in calculation of chi-square and Kruskal-Wallis test statistics.

Chi-square Test Results

Chi-square values testing for differences in recovery rates of crab due to shell hardness are presented in Table 3. Chi-square values testing for differences in recovery rates of crab due to exposure time are shown in Table 4. Recovery rates were found to be comparable for: (1) each shell-hardness category with the same exposure time; (2) varying combinations of shell-hardness categories with the same exposure time; (3) for pooled shell-

Table 1. The number and percent composition of male Dungeness crab released and recovered by exposure time and shell-hardness category.

	Number of releases		
Exposure Time	Soft Shell	Hard Shell	Total
5 min	32 (20.4%)	125 (79.6%)	157
15 min	23 (13.9%)	142 (86.1%)	165
30 min	24 (15.3%)	133 (84.7%)	157
60 min	35 (23.2%)	116 (76.8%)	151
Total	114 (18.1%)	516 (81.9%)	630

	Number of recoveries		
Exposure Time	Soft Shell	Hard Shell	Total
5 min	3 (10.3%)	26 (89.6%)	29
15 min	3 (10.0%)	27 (90.0%)	30
30 min	3 (12.5%)	21 (87.5%)	24
60 min	4 (12.1%)	29 (87.8%)	33
Total	13 (11.2%)	103 (88.8%)	116

Table 2. Number of crab released, observed number of crab recovered, and expected number of crab recovered by exposure time and shell-hardness category.

Exposure Time	Durometer Units 20-49	50-59	60-69	70-79	80-89	90-99	Total
5 min							
Released	9	7	16	9	52	64	157
Recovered	0	0	3	0	10	16	29
Expected	1.657	1.289	2.946	1.657	9.575	11.784	28.908
15 min							
Released	5	4	14	16	61	65	165
Recovered	0	2	1	2	13	12	30
Expected	0.921	0.737	2.578	2.946	11.232	11.968	30.381
30 min							
Released	6	5	13	13	72	48	157
Recovered	0	0	3	0	13	8	24
Expected	1.105	0.921	2.394	2.394	13.257	8.838	28.908
60 min							
Released	11	10	14	11	56	49	151
Recovered	0	2	2	1	16	12	33
Expected	2.025	1.841	2.578	2.025	10.311	9.022	27.802
Total							
Released	31	26	57	49	241	226	630
Recovered	0	4	9	3	52	48	116
Expected	5.708	4.788	10.496	9.022	44.375	41.612	116.0

Table 3. Sample size, degrees of freedom, chi-square value and associated probability for the test of equal recovery rates of male Dungeness crab by exposure time.

Exposure Time	N	df	X^2	Probability[1]
5 min	29	5	6.131	$.3 > P(X^2) > .2$
15 min	30	5	4.633	$.5 > P(X^2) > .4$
30 min	24	5	4.658	$.5 > P(X^2) > .4$
60 min	33	5	6.810	$.3 > P(X^2) > .2$
5-60 min	116	5	1.810	$.7 > P(X^2) > .6$

[1]Probability of rejecting a true H_0, where H_0: recovery rates are equal for each shell-hardness category at the corresponding exposure time.

Table 4. Sample size, degrees of freedom, chi-square value and associated probability for the test of equal recovery rates of male Dungeness crab by shell-hardness category.

Durometers	N	df	X^2	Probability[1]
20 - 49	0	3	5.708	$.2 > P(X^2) > .1$
50 - 59	4	3	4.379	$.3 > P(X^2) > .2$
60 - 69	9	3	1.250	$.8 > P(X^2) > .7$
70 - 79	3	3	4.874	$.2 > P(X^2) > .1$
80 - 89	52	3	3.441	$.4 > P(X^2) > .3$
90 - 99	48	3	2.571	$.5 > P(X^2) > .4$
20 - 59	4	3	5.943	$.2 > P(X^2) > .1$
60 - 79	12	3	2.937	$.5 > P(X^2) > .4$
80 - 99	100	3	1.202	$.8 > P(X^2) > .7$
20 - 69	13	1	3.162	$.1 > P(X^2) > .05$
70 - 99	103	1	3.645	$.1 > P(X^2) > .05$

[1]Probability of rejecting a true H_0, where
H_0: Recovery rates are equal for each exposure time at the corresponding shell-hardness category.

hardness categories with the same exposure time; and (4) for each exposure time with the same shell hardness.

Kruskal-Wallis Test Results

The Kruskal-Wallis test of the hypothesis that recovery rates of crab exposed to cold air for increasing amounts of time are equivalent for shell hardness greater than 49 durometers resulted in a value equal to 3.026. This value is comparable to the chi-square distribution at 7 df. (the original eight categories of shell hardness, minus one[1]). The probability of rejecting the true null hypothesis based on this test statistic lies between .90 and .80. Test of the hypothesis that recovery rates of crab with shell hardness greater than 49 durometers are equivalent for each exposure time resulted in a test statistic value equal to 2.748 at 3 df. The probability of rejecting the true null hypothesis is between .50 and .30 for this test statistic. Recovery rates of crab with shell hardness values greater than 49 durometers were similar for each air exposure time. Recovery rates of crab exposed for increasing amounts of time were considered similar for shell hardnesses greater than 49 durometers.

Sample Size Results

Sample sizes for several detectable differences in number of crab recovered by number of treatments and probabilities of Type I and Type II errors are presented in Table 5. Optional values are presented for each of these parameters to enable comparison of the costs and benefits of several sample designs. Sample size values represent the equal number of crab to be sampled for each cell or combination of exposure time period (treatment) and shell-hardness category. The minimum difference in crab recoveries between cells, to be detected as statistically significant was set at three, four, and five crab. These levels of detectable difference were based on a mean of 4.8 crab equal to the mean of differences in crab recoveries between cells in this study. The number of treatments shown in Table 5 range from four to six and include a control group: e.g., exposure times for four treatments could be 0(control group), 10, 20 and 40 min. A series of Type I and Type II error probabilities were also presented to allow a choice in the accuracy of analyses.

Soft-shell and hard-shell crab sample sizes used in this study were inadequate. For α=.05, 1-β=.95, four treatments and three shell hardness levels corresponding to the three soft-shell categories (12 cells), the sample size for soft-shell crab in this study was only 11% of the number needed if the minimum difference to be detected between cells was set at

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[1]Calculation of the test statistic is the same if you include crab recoveries from all eight categories of shell hardness or only the non-zero crab recoveries.

Table 5. Sample sizes for several detectable differences in number of crab recovered by number of treatments and hypothesis testing probabilities.

Δ[1]	Δ/σ[2]		α[3]=.01 1-β[4]=.90	α=.01 1-β=.95	α=.05 1-β=.90	α=.05 1-β=.95	α=.10 1-β=.90	α=.10 1-β=.95
5	3.397	T[5]=6	63	72	45	54	36	45
		T=5	63	63	45	54	36	45
		T=4	54	63	45	45	36	45
4	2.717	T=6	81	90	63	72	54	63
		T=5	81	90	54	63	45	54
		T=4	72	81	54	63	45	54
3	2.038	T=6	117	135	90	99	72	90
		T=5	108	126	81	99	72	81
		T=4	108	117	81	90	63	81

[1]Δ is the difference in number of crab recovered that is desirable to detect between treatments.

[2]σ is the standard deviation between observed and expected number of crab recovered at each combination of exposure time period and shell hardness category with N=24 (one subject per cell).

[3]α is the probability of rejecting a true null hypothesis. The null hypothesis for the above scenario is mean recoveries of crab from each combination of exposure time period and shell hardness category are equal.

[4]β is the probability of failing to reject a false null hypothesis or failure to establish a treatment effect when it exists.

[5]T is a treatment and for the purposes of determining sample size can be viewed as the number of exposure time periods.

three crabs. To detect a difference of five crabs, more than 4.5 times the number of soft-shell crab should have been sampled. Based on the above constraints where the three shell hardness levels now correspond to the three hard-shell categories, the sample size of hard-shell crab in this study was 48% and 96% of that needed to detect a difference of three and five crab, respectively.

DISCUSSION

The lack of statistically significant differences in recovery rates of Dungeness crab with different shell hardness and air exposure times could mean (1) there were no differences in mortality, or (2) that differences were not detectable because of small sample sizes. Each of these hypotheses needs to be scrutinized before undertaking future studies of Dungeness crab handling mortality.

Our field observations (not shown) reveal that soft-shell crab are more vulnerable to adverse conditions than hard-shell crab. For example, limb loss is prevalent among soft-shell crab during handling when the primary objective is efficient removal and sorting of crab from a pot. Evidence also exists in the literature supporting the hypothesis that soft-shell crab are more vulnerable to handling mortalities than hard-shell crab. Early studies in Oregon by Waldron (1958) showed a significantly greater percentage of Dungeness crabs released in a hard-shell condition were recovered than those released with a medium hard shell. Information presented by Tegelberg (1972) suggested that soft-shell Dungeness crab are subject to significant mortality from discard handling when crab fishing is permitted during periods of soft-shell crab abundance. Results from a study by Barry (1984) indicated handling mortality rates are directly related to the condition of Dungeness crabs. Both field observations and cases from the literature indicate differences in handling mortality exist between soft and hard-shell crab. Unfortunately this study was not able to provide additional evidence.

Differences in mortalities between each combination of exposure and shell condition may not have been detected because of corresponding gross inequalities in sample size. The recovery rate of soft-shell crab was almost half that of hard-shell crab, yet the difference in recovery rates did not test significant. Sample sizes of soft-shell crab for all exposure times were much smaller than those of hard-shell crab. The soft-shell crab sample size used in this study was only one-fifth of the number needed to accurately analyze recovery rates of soft and hard-shell crab.

Future studies to estimate handling mortality are needed to strengthen justification of management decisions that affect fishing seasons and area closures based on soft-shell crab abundance. Recommendations for future handling mortality studies are presented in detail in Appendix B. The most important considerations for a handling mortality study include: (1) an untreated control group of crab; (2) estimates of commercial fishing effort in each tag release site; (3) number of study sites; (4) timing of release and recovery effort; and (5) effects of tagging on crab.

CONCLUSIONS

1. The sample size for soft-shell crab was insufficient to detect differences in handling mortality between soft- and hard-shell Dungeness crab.

2. Future studies are needed to enhance justification of management decisions.

3. Design and timing of future handling mortality studies are critical to statistical assessment of any difference between soft-shell and hard-shell crab handling mortality.

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APPENDICES

Appendix A. Release and return information by tag number.

TAG	DATE	WIDTH	DUROMETERS	DECK TIME	RECOVERY	COMMENTS
A00545	060887	161	96	15	0	Tanner Head, overcast, rain
A00546	060887	111	33	5	0	
A00547	060887	160	93	5	0	
A00548	060887	175	49	5	0	
A00549	060987	175	68	30	0	Tanner Head, overcast, rain
A00550	060987	160	91	30	0	
A00551	060987	163	92	30	0	
A00552	060987	160	72	30	0	
A00553	060987	156	61	5	0	
A00554	060987	162	91	15	0	
A00555	060987	160	88	30	0	
A00556	060987	156	88	30	0	
A00557	060987	155	82	30	0	
A00558	060987	160	84	30	0	
A00559	060987	151	89	30	0	
A00560	060987	150	89	30	0	
A00561	060987	148	85	30	0	
A00562	060987	155	93	30	0	
A00563	060987	162	94	5	1	Tag only
A00564	060987	161	89	30	0	
A00565	060987	176	94	30	0	
A00566	061187	162	91	5	0	Tanner Head, overcast, rain
A00567	061187	168	92	15	1	Tag only
A00568	061187	161	91	30	0	
A00569	061187	171	98	60	0	
A00570	061187	166	94	60	0	
A00571	061187	168	94	60	0	
A00572	061187	161	82	60	1	160 mm newshell
A00573	061187	164	86	5	0	
A00574	061187	169	92	5	0	
A00575	061187	175	90	30	1	
A00576	061187	158	94	15	0	
A00577	061187	162	86	30	0	
A00578	061187	166	91	30	1	Tag not recovered, info from log book
A00579	061187	180	90	5	1	180 mm, 79 durometers
A00580	061187	170	64	5	0	
A00581	061187	163	56	30	0	
A00582	061187	165	86	30	0	
A00583	061187	179	89	30	1	Tag only

-continued-

TAG	DATE	WIDTH	DUROMETERS	DECK TIME	RECOVERY	COMMENTS
A00584	061187	162	90	5	0	
A00585	061187	174	45	60	0	
A00586	061187	162	95	60	0	
A00587	061187	172	91	60	0	
A00588	061187	161	95	60	0	
A00589	061187	177	94	60	1	179mm
A00590	061187	165	88	60	0	
A00591	061187	154	44	15	0	
A00592	061187	177	89	15	0	
A00593	061187	168	90	15	0	
A00594	061187	182	91	15	0	
A00595	061187	167	93	5	1	162mm 89 duro, cracked carapace
A00596	061187	162	90	5	0	
A00597	061187	156	84	30	0	
A00598	061187	169	89	30	1	
A00599	061187	160	92	30	0	
A00600	061187	169	96	60	0	
A00601	061187	165	92	60	0	
A00602	061187	170	91	60	1	Tag only
A00603	061187	184	84	15	1	184mm, 76 duro, IM[a] missing
A00604	061187	147	90	15	0	
A00605	061187	160	93	15	0	
A00606	061187	160	95	15	0	
A00607	061187	175	58	5	0	
A00608	061187	170	90	5	1	
A00609	061187	174	90	5	0	
A00610	061187	162	78	30	0	
A00611	061187	173	69	30	0	
A00612	061187	162	94	5	1	Tag not recovered, info from log book
A00613	061187	165	52	60	0	
A00614	061187	161	92	60	0	
A00615	061187	176	94	30	0	
A00616	061187	169	66	30	0	
A00617	061187	174	96	30	0	
A00618	061187	160	94	60	0	
A00619	061187	179	96	60	1	Tag only
A00620	061187	174	71	15	0	
A00621	061187	155	97	15	0	
A00622	061187	168	96	15	0	

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TAG	DATE	WIDTH	DUROMETERS	DECK TIME	RECOVERY	COMMENTS
A00623	061187	170	71	15	0	
A00624	061187	162	94	15	0	
A00625	061187	183	87	15	0	
A00626	061187	170	93	15	1	Tag only
A00627	061187	173	87	15	1	173 mm, 87 durometers
A00628	061187	167	55	15	0	
A00629	061187	160	67	5	0	
A00630	061187	159	58	5	0	
A00631	061187	175	86	30	0	
A00632	061187	167	88	30	0	
A00633	061187	165	44	30	0	
A00634	061187	192	94	5	0	
A00635	061187	168	68	5	0	
A00636	061187	164	89	5	0	
A00637	061187	162	94	15	0	
A00638	061187	161	83	15	0	
A00639	061187	168	89	15	0	
A00640	061187	163	98	15	0	
A00641	061187	157	38	5	0	
A00642	061187	178	94	15	0	
A00643	061287	165	34	15	0	Snug Cove, partly cloudy, cool
A00644	061287	168	86	15	0	
A00645	061287	163	83	5	0	
A00646	061287	162	89	5	0	
A00647	061287	177	56	5	0	
A00648	061287	175	84	5	0	
A00649	061287	156	86	5	0	
A00650	061287	163	87	30	0	
A00651	061287	164	88	30	0	
A00652	061287	167	88	30	0	
A00653	061287	162	94	30	0	
A00654	061287	168	40	30	0	
A00655	061287	158	91	30	0	
A00656	061287	165	84	30	0	
A00657	061287	159	93	30	0	
A00658	061287	152	94	30	0	
A00659	061287	153	80	30	0	
A00660	061287	172	94	30	0	
A00661	061287	159	88	30	0	

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TAG	DATE	WIDTH	DUROMETERS	DECK TIME	RECOVERY	COMMENTS
A00662	061287	168	83	30	0	
A00663	061287	161	76	30	0	
A00664	061287	159	66	30	0	
A00665	061287	163	94	30	0	
A00666	061287	159	92	30	0	
A00667	061287	159	94	30	0	
A00668	061287	156	80	30	0	
A00669	061287	171	64	30	0	
A00670	061287	156	84	30	0	
A00671	061287	187	95	5	1	187 mm, 84 durometers
A00672	061287	162	95	5	0	
A00673	061287	164	80	5	0	
A00674	061287	166	94	5	0	
A00675	060987	160	74	30	0	
A00676	060987	169	86	30	0	
A00677	060987	161	90	30	0	
A00678	060987	162	88	15	1	Tag only
A00679	060987	157	88	15	0	
A00680	060887	160	76	15	0	
A00681	060887	160	93	15	0	
A00682	061287	163	94	5	0	
A00683	061287	169	90	60	0	
A00684	061287	165	92	60	0	
A00685	061287	162	90	60	0	
A00686	061287	160	95	60	0	
A00687	061287	157	94	30	0	
A00688	061287	168	81	30	0	
A00689	061287	153	71	30	0	
A00690	061287	157	92	30	0	
A00691	061287	167	70	15	0	
A00692	061287	162	61	15	0	
A00693	061287	168	45	15	0	
A00694	061287	162	85	15	1	162 mm
A00695	061287	173	94	15	0	
A00696	061287	164	90	15	0	
A00697	061287	161	85	15	0	
A00698	061287	169	91	15	0	
A00699	061287	170	52	15	1	169 mm, 73 durometers
A00700	061287	164	92	15	0	

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TAG	DATE	WIDTH	DUROMETERS	DECK TIME	RECOVERY	COMMENTS
A00701	061287	157	91	30	1	
A00702	061287	170	48	30	0	
A00703	061287	157	72	30	0	
A00704	061287	174	90	30	1	173 mm, 92 durometers
A00705	061287	163	91	30	0	
A00706	061287	170	90	30	1	170 mm
A00707	061287	158	89	30	0	
A00708	061287	168	69	30	1	
A00709	061287	155	87	30	0	
A00710	061287	170	90	60	0	
A00711	061287	161	91	60	0	
A00712	061287	160	92	60	0	
A00713	061287	167	88	60	1	166 mm
A00714	061287	165	96	60	1	165 mm
A00715	061287	173	65	60	0	
A00716	061287	169	34	60	0	
A00717	061287	163	84	60	0	
A00718	061287	166	63	60	0	
A00719	061287	172	90	5	1	172 mm
A00720	061287	160	92	5	0	
A00721	061287	169	63	5	0	
A00722	061287	175	62	5	0	
A00723	061287	166	86	5	0	
A00724	061287	163	90	5	0	
A00725	061287	166	94	5	0	
A00726	061287	172	82	15	0	
A00727	061287	170	92	15	1	170 mm
A00728	061287	165	89	15	0	
A00729	061287	163	92	15	0	
A00730	061287	168	70	15	0	
A00731	061287	164	68	15	0	
A00732	061287	173	82	15	0	
A00733	061287	162	88	15	0	
A00734	061287	177	90	15	0	
A00735	061287	166	92	15	0	
A00736	061287	160	94	15	0	
A00737	061287	161	90	15	0	
A00738	061287	163	86	30	0	
A00739	061287	161	86	5	0	

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TAG	DATE	WIDTH	DUROMETERS	DECK TIME	RECOVERY	COMMENTS
A00740	061287	170	65	5	1 169 mm	
A00741	061287	165	90	5	0	
A00742	061287	165	94	5	0	
A00743	061287	164	94	5	0	
A00744	061287	165	27	60	0	
A00745	061287	161	89	60	1	
A00746	061287	160	80	60	0	
A00747	061287	183	87	60	1 182 mm	
A00748	061287	161	92	60	1 161 mm,	93 durometers
A00749	061287	164	77	60	0	
A00750	061287	168	49	60	0	
A00751	061287	166	28	60	0	
A00752	061287	173	92	60	1 173 mm	
A00753	061287	164	73	60	0	
A00754	061287	176	86	60	0	
A00755	061287	165	90	60	1 165 mm	
A00756	061287	163	92	5	0	
A00757	061287	167	96	5	0	
A00758	061287	182	89	5	0	
A00759	061287	162	94	5	1 162 mm	
A00760	061287	165	92	5	0	
A00761	061287	165	91	15	0	
A00762	061287	166	93	15	0	
A00763	061287	171	96	15	0	
A00764	061287	173	94	15	0	
A00765	061287	165	93	15	0	
A00766	061287	163	98	15	0	
A00767	061287	184	92	5	0	
A00768	061287	160	92	5	0	
A00769	061287	156	76	5	0	
A00770	061287	171	92	5	0	
A00771	061287	173	82	5	1	
A00772	061287	154	91	60	0	
A00773	061287	162	66	60	0	
A00774	061287	169	91	60	0	
A00775	061287	171	72	60	0	
A00776	061287	164	73	60	0	
A00777	061287	170	69	5	0	
A00778	061287	170	85	5	0	

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TAG	DATE	WIDTH	DUROMETERS	DECK TIME	RECOVERY	COMMENTS
A00779	061287	168	94	5	0	
A00780	061287	163	89	5	0	
A00781	061287	160	89	5	0	
A00782	061287	163	72	5	0	
A00783	061287	161	94	15	1	161 mm, missing RM[b] and RR[c]
A00784	061287	159	94	15	0	
A00785	061287	160	94	15	0	
A00786	061287	168	91	15	0	
A00787	061287	175	90	15	0	
A00788	061287	163	90	15	0	
A00789	061287	168	95	15	0	
A00791	061287	145	79	15	0	
A00792	061287	172	92	15	0	
A00793	061287	163	91	30	0	
A00794	061287	162	94	5	0	
A00795	061287	159	76	5	0	
A00796	061287	162	94	5	0	
A00797	061287	163	82	15	1	
A00798	061287	167	66	15	0	
A00799	061287	160	88	15	1	160 mm
A00800	061287	158	95	15	1	Tag not recoverd, info from log book
A00801	061287	169	91	15	0	
A00802	061287	163	66	15	0	
A00803	061287	162	83	15	1	Tag only
A00804	061287	168	82	5	0	
A00805	061287	167	93	15	0	
A00806	061287	172	92	15	0	
A00807	061287	178	58	15	0	
A00808	061287	172	81	15	0	
A00809	061287	165	79	15	0	
A00810	061287	158	89	5	0	
A00811	061287	157	90	5	0	
A00812	061387	173	67	15	0	Tanner Head, sunny, cool
A00813	061387	171	44	5	0	
A00814	061387	161	58	30	0	
A00815	061387	161	43	30	0	
A00816	061387	173	94	5	1	
A00817	061387	167	91	60	0	
A00818	061387	170	59	60	0	

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TAG	DATE	WIDTH	DUROMETERS	DECK TIME	RECOVERY	COMMENTS
A00819	061387	177	91	5	0	
A00820	061387	168	65	5	1	
A00822	061387	158	80	15	0	
A00823	061387	172	44	60	0	
A00824	061387	180	63	5	1	180 mm
A00825	061387	162	72	30	0	
A00826	061387	161	54	30	0	
A00827	061387	164	89	30	0	
A00828	061387	162	55	30	0	
A00829	061387	157	94	30	0	
A00830	061387	162	96	30	0	
A00831	061387	155	78	30	0	
A00832	061387	150	92	30	0	
A00833	061387	166	86	5	1	
A00834	061387	177	62	5	0	
A00835	061387	163	96	30	1	Tag not recovered, info from log book
A00836	061387	162	80	30	0	
A00837	061387	165	40	30	0	
A00838	061387	161	84	15	0	
A00839	061387	162	74	15	0	
A00840	061387	155	94	15	0	
A00841	061387	171	91	5	1	
A00842	061387	162	95	5	0	
A00843	061387	186	87	5	0	
A00844	061387	163	96	5	0	
A00845	061387	162	96	5	0	
A00846	061387	185	92	5	0	
A00847	061387	160	84	60	0	
A00848	061387	155	87	60	0	
A00849	061387	163	66	60	0	
A00850	061387	167	94	15	1	171 mm
A00851	061387	187	90	15	1	187 mm, 75 durometers
A00852	061387	165	88	15	1	
A00853	061387	157	94	15	0	
A00854	061387	160	86	5	0	
A00855	061387	158	84	5	0	
A00856	061387	178	58	5	0	
A00857	061387	192	90	30	0	
A00858	061387	161	93	30	0	

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TAG	DATE	WIDTH	DUROMETERS	DECK TIME	RECOVERY	COMMENTS
A00859	061387	159	88	30	1	159 mm, 73 durometers
A00860	061387	155	96	30	0	
A00861	061387	161	86	30	1	Tag not recovered, info from log book
A00862	061387	162	90	30	0	
A00863	061387	159	74	30	0	
A00864	061387	161	89	15	0	
A00865	061387	174	93	15	0	
A00866	061387	169	95	15	1	168 mm, 82 durometers
A00867	061387	168	90	15	0	
A00868	061387	156	85	15	0	
A00869	061387	170	91	5	0	
A00870	061387	159	90	60	0	
A00871	061387	155	94	60	0	
A00872	061387	158	96	60	0	
A00873	061387	158	91	60	0	
A00874	061387	154	94	60	0	
A00875	061387	155	83	60	0	
A00876	061387	172	97	60	1	Tag not recovered, info from log book
A00877	061387	157	92	60	0	
A00878	061387	155	90	60	0	
A00879	061387	157	95	60	0	
A00880	061387	158	72	60	0	
A00881	061387	160	85	5	0	
A00882	061387	167	92	5	0	
A00883	061387	168	96	5	1	162 mm, 85 duro, IM missing
A00884	061387	158	89	5	1	
A00885	061387	174	91	5	1	Tag not recovered, info from log book
A00886	061387	164	94	15	0	
A00887	061387	168	63	5	0	
A00888	061387	181	87	5	0	
A00889	061387	164	66	15	0	
A00890	061387	177	91	5	0	
A00891	061487	158	90	30	0	Outer Moser and Snug Cove, overcast
A00892	061487	170	69	30	1	170 mm
A00893	061487	184	62	30	1	183 mm
A00894	061487	156	85	30	0	
A00895	061487	156	60	30	0	
A00896	061487	167	86	15	0	
A00897	061487	162	90	15	0	

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TAG	DATE	WIDTH	DUROMETERS	DECK TIME	RECOVERY	COMMENTS
A00898	061487	168	88	15	0	
A00899	061487	155	84	15	0	
A00900	061487	165	83	15	0	
A00901	061487	174	89	15	0	
A00902	061487	172	29	15	0	
A00903	061487	162	86	15	1	162 mm
A00904	061487	167	79	15	0	
A00905	061487	165	62	15	0	
A00906	061487	192	89	5	0	
A00907	061487	174	90	5	0	
A00908	061487	158	88	60	0	
A00909	061487	157	87	60	0	
A00910	061487	168	59	60	0	
A00911	061487	155	86	60	0	
A00912	061487	168	84	60	0	
A00913	061487	167	86	60	0	
A00914	061487	156	82	60	0	
A00915	061487	155	83	60	0	
A00916	061487	166	28	5	0	
A00917	061487	165	86	5	1	165 mm
A00918	061487	163	80	30	0	
A00919	061487	162	87	30	0	
A00920	061487	166	90	30	1	169 mm
A00921	061487	160	87	30	1	161 mm
A00922	061487	163	89	30	1	164 mm
A00923	061487	159	90	30	0	
A00924	061487	163	81	30	1	163 mm
A00925	061487	163	89	30	0	
A00926	061487	179	90	30	0	
A00927	061487	161	86	30	0	
A00928	061487	182	89	30	1	182 mm, 93 durometers
A00929	061487	162	81	30	0	
A00930	061487	160	85	5	1	160 mm
A00931	061487	157	83	5	0	
A00932	061487	166	84	5	0	
A00933	061487	160	95	5	0	
A00934	061487	156	86	5	0	
A00935	061487	159	72	5	0	
A00936	061487	165	69	5	0	

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TAG	DATE	WIDTH	DUROMETERS	DECK TIME	RECOVERY	COMMENTS
A00937	061487	168	60	60	0	
A00938	061487	178	62	60	0	
A00939	061487	169	86	60	0	
A00940	061487	173	84	60	0	
A00941	061487	161	61	60	0	
A00942	061487	173	83	60	1	172 mm
A00943	061487	165	92	60	0	
A00944	061487	157	72	60	0	
A00945	061487	167	85	15	1	168 mm
A00946	061487	166	85	15	0	
A00947	061487	165	92	15	1	165 mm
A00948	061487	169	79	15	1	169 mm
A00949	061487	167	73	15	0	
A00950	061487	160	94	15	0	
A00951	061487	168	90	30	0	
A00952	061487	173	82	30	0	
A00953	061487	161	93	30	0	
A00954	061487	174	90	30	0	
A00955	061487	154	80	5	0	
A00956	061487	159	58	5	0	
A00957	061487	158	46	5	0	
A00958	061487	155	87	5	0	
A00959	061487	167	59	5	0	
A00960	061487	151	89	15	0	
A00961	061487	168	92	15	1	167 mm, 91 durometers
A00962	061487	156	60	15	0	
A00963	061487	158	58	5	0	
A00964	061487	175	91	5	0	
A00965	061487	156	86	30	0	
A00966	061487	163	26	30	0	
A00967	061487	172	80	30	0	
A00969	061487	166	82	15	1	165 mm
A00970	061487	165	80	15	0	
A00971	061487	157	81	5	0	
A00972	061587	174	84	5	0	
A00972	061487	164	90	5	0	
A00973	061587	162	56	60	0	Snug Cove, overcast, rain, cool
A00974	061587	169	87	60	1	168 mm, 88 durometers
A00975	061587	168	91	60	1	Anonymous return, broken carapace and tag only

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TAG	DATE	WIDTH	DUROMETERS	DECK TIME	RECOVERY	COMMENTS
A00976	061587	159	88	60	0	
A00977	061587	164	88	60	1	165 mm
A00978	061587	162	51	60	0	
A00979	061587	163	82	60	0	
A00980	061587	170	57	60	1	
A00981	061587	171	90	60	0	
A00982	061587	158	84	60	1	158 mm, 83 durometers
A00983	061587	160	85	60	0	
A00984	061587	165	85	60	0	
A00985	061587	166	80	60	0	
A00986	061587	174	94	60	0	
A00987	061587	163	60	60	0	
A00988	061587	160	69	60	0	
A00989	061587	169	90	60	1	163 mm, 82 durometers
A00990	061587	161	88	60	0	
A00991	061587	161	81	60	0	
A00992	061587	157	91	60	0	
A00993	061587	157	90	60	0	
A00994	061587	168	88	60	0	
A00995	061587	164	82	60	0	
A00996	061587	161	90	60	0	
A00997	061587	167	89	60	1	166 mm
A00998	061587	164	89	60	0	
A00999	061587	166	80	60	0	
A01000	061587	155	86	60	0	
J04001	061587	170	90	60	0	
J04002	061587	153	86	60	0	
J04003	061587	156	74	60	0	
J04004	061587	163	89	60	0	
J04005	061587	166	84	60	0	
J04006	061587	168	94	60	0	
J04007	061587	171	91	60	1	170 mm
J04008	061587	164	91	60	1	162 mm
J04009	061587	166	44	60	0	
J04010	061587	183	83	60	1	182 mm
J04011	061587	169	83	60	1	168 mm, 80 durometers
J04012	061587	159	86	60	0	
J04013	061587	168	40	60	0	
J04014	061587	155	78	60	1	163 mm

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TAG	DATE	WIDTH	DUROMETERS	DECK TIME	RECOVERY	COMMENTS
J04015	061587	164	80	60	0	
J04016	061587	170	83	60	0	
J04017	061587	163	55	60	1	162 mm
J04018	061587	170	78	60	0	
J04019	061587	164	61	60	1	164 mm
J04020	061587	165	86	60	1	165 mm
J04021	061587	169	66	60	0	
J04022	061587	165	65	60	0	
J04023	061587	152	48	60	0	
J04024	061587	168	56	60	0	
J04025	061587	165	90	60	0	
J04026	061587	152	86	60	0	
J04027	061587	168	84	60	1	168 mm
J04028	061587	165	83	60	1	165 mm
J04029	061587	174	80	60	1	174 mm
J04033	061587	189	86	60	1	188 mm, 82 durometers
J04034	061587	165	82	30	0	
J04035	061587	169	94	30	0	
J04036	061587	162	50	30	0	
J04037	061587	173	85	30	0	
J04038	061587	162	41	15	0	
J04039	061587	171	92	15	0	
J04040	061587	166	90	15	0	
J04041	061587	160	70	15	0	
J04042	061587	165	84	15	0	
J04044	061587	162	86	15	0	
J04045	061587	160	90	5	0	
J04046	061587	163	88	5	0	
J04047	061587	152	95	5	0	
J04048	061587	161	90	5	0	
J04049	061587	162	90	5	0	
J04050	061587	178	75	5	0	
J04051	061587	164	79	5	0	
J04052	061587	160	70	30	0	
J04053	061587	165	89	30	1	165 mm
J04054	061587	162	90	30	1	162 mm
J04055	061587	157	91	30	0	
J04056	061587	174	86	30	1	173 mm
J04057	061587	166	77	15	1	166 mm, 78 durometers

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TAG	DATE	WIDTH	DUROMETERS	DECK TIME	RECOVERY	COMMENTS
J04058	061587	157	87	15	0	
J04059	061587	161	86	15	0	
J04060	061587	164	90	15	0	
J04062	061587	164	88	15	1	
J04063	061587	166	69	15	1	167 mm
J04064	061587	162	84	15	0	
J04065	061587	170	67	15	0	
J04066	061587	160	64	5	0	
J04067	061587	170	93	5	0	
J04068	061587	159	81	5	0	
J04069	061587	173	84	30	0	
J04070	061587	163	82	30	0	
J04071	061587	164	85	30	0	
J04072	061587	164	85	30	0	
J04073	061587	163	84	30	0	
J04074	061587	155	87	30	1	
J04075	061587	148	71	15	0	
J04076	061587	155	79	15	0	
J04077	061587	173	82	15	0	
J04078	061587	165	81	5	0	
J04079	061587	163	89	5	0	
J04080	061587	172	82	5	0	
J04081	061587	161	86	5	0	
J04082	061587	165	90	5	1	
J04083	061587	161	86	5	0	
J04084	061587	175	77	5	0	
J04085	061587	166	65	30	0	
J04086	061587	161	82	30	0	
J04087	061587	167	83	30	0	
J04088	061587	168	60	30	0	
J04089	061587	154	74	30	0	
J04090	061587	164	81	30	0	
J04091	061587	157	90	30	0	
J04092	061587	157	76	30	0	
J04093	061587	162	80	30	0	
J04094	061587	159	86	30	1	159 mm
J04095	061587	172	90	5	0	
J04096	061587	185	89	5	1	185 mm
J04097	061587	158	82	5	0	

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TAG	DATE	WIDTH	DUROMETERS	DECK TIME	RECOVERY	COMMENTS
J04098	061587	148	87	15	0	
J04099	061587	158	67	15	0	
J04100	061587	173	41	60	0	
J04101	061587	169	60	60	0	
J04102	061587	170	62	60	1	170 mm
J04103	061587	165	39	5	0	
J04104	061587	155	72	5	0	
J04105	061587	161	39	5	0	
J04106	061587	165	83	5	0	
J04107	061587	165	87	5	0	
J04108	061587	165	82	15	0	
J04109	061587	166	81	15	1	167 mm
J04110	061587	164	87	15	0	
J04111	061587	158	91	15	0	
J04112	061587	167	75	15	0	
J04113	061587	164	90	15	0	
J04114	061587	162	68	15	0	
J04115	061587	161	88	15	0	
J04116	061587	169	92	15	1	169 mm, 89 durometers
J04117	061587	167	87	15	0	
J04118	061587	159	83	30	0	
J04119	061587	171	85	30	0	
J04120	061587	171	86	30	1	171 mm
J04121	061587	160	66	30	0	
J04122	061587	152	92	30	0	
J04123	061587	155	84	15	0	
J04124	061587	162	87	15	0	
J04125	061587	158	85	15	0	
J04126	061587	172	88	15	0	
J04127	061587	163	84	15	0	
J04128	061587	179	84	15	1	179 mm
J04129	061587	179	91	15	1	179 mm, 83 durometers
J04130	061587	167	60	15	0	
J04131	061587	161	90	5	0	
J04132	061587	170	82	5	1	168 mm
J04133	061587	164	93	5	1	164 mm, 95 durometers
J04134	061587	161	69	5	0	
J04135	061587	160	86	5	1	160 mm
J04137	061587	161	82	5	0	

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TAG	DATE	WIDTH	DUROMETERS	DECK TIME	RECOVERY	COMMENTS
J04138	061587	166	82	30	0	
J04139	061587	160	86	30	0	
J04140	061587	166	91	5	1	166 mm, 90 durometers
J04141	061587	159	81	15	0	
J04142	061587	165	81	15	0	
J04143	061587	162	89	15	0	
J04144	061587	164	92	5	0	
J04145	061587	165	89	5	0	
J04146	061587	160	70	60	0	
J04147	061587	161	54	60	0	
J04148	061587	171	59	60	0	
J04149	061587	165	70	5	0	
J04150	061587	145	80	60	0	
J04151	061587	156	85	60	0	
J04152	061587	154	31	60	0	
J04153	061587	148	86	60	0	
J04154	061587	155	87	60	0	
J04155	061587	151	79	60	0	
J04157	061587	151	86	60	0	
J04159	061587	166	87	15	0	
J04160	061587	168	87	15	0	
J04161	061587	162	89	5	1	162 mm
J04162	061587	159	86	5	0	
J04163	061587	170	87	30	0	
J04164	061587	162	84	30	0	
J04165	061587	155	92	30	0	
J04166	061587	166	80	30	0	
J04167	061587	162	92	5	0	
J04168	061587	162	67	15	0	
J04169	061587	170	59	15	1	169 mm, 91 durometers
J04170	061587	158	90	15	0	
J04171	061587	161	84	5	1	162 mm
J04172	061587	168	44	5	0	
J04173	061587	159	86	15	0	
J04174	061587	161	84	30	0	
J04175	061587	156	69	5	0	
J04176	061587	161	81	5	0	
J04177	061587	161	83	30	0	
J04178	061587	156	65	30	0	

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TAG	DATE	WIDTH	DUROMETERS	DECK TIME	RECOVERY	COMMENTS
J04179	061587	158	82	15	0	
J04180	061587	154	75	30	0	
J04181	061587	155	86	30	0	
J04182	061587	164	90	30	0	
J04183	061587	168	91	5	0	
J04184	061587	163	90	5	0	

[a]LM missing - left middle leg missing.
[b]RM missing - right middle leg missing.
[c]RR missing - right rear leg missing.

Appendix B. Recommendations for future handling mortality studies.

Design and subsequent analysis of a tag release-recovery study is a function of the dependence of survival and capture probabilities on treatments, release-recovery sites, and release-recovery time (Burnham et al.)

The probability of a crab surviving a treatment is estimated as the ratio of two survival probabilities. Specifically, the ratio of the survival probability between release and recovery sites for treatment crab to the survival probability between release and recovery sites for control crab. A control crab is one that is tagged but does not experience any treatment. Design of future studies should, therefore, include a control group of crab for each shell hardness category.

The probability of capture is estimated from the allocation of effort to recovery sites. In this type of study, commercial fishing effort is the typical method of recovering tagged crab. It is not feasible however, to proportionally allocate the effort of the commercial fishing fleet. Estimates of commercial fishing effort in each of the tag release sites should be obtained.

The degree of dependence, each of the survival and capture probabilities has on treatments, release-recovery sites, and release-recovery time dictates the complexity of the model used to estimate these probabilities. Therefore, it is important to consider each of these affects in design of a handling effects study. Investigation of handling affects is primarily an estimation of treatment effects or crab survival. The affect of release or recovery site will be negligible if all release and recovery sites include one homogeneous population. Design of a study should include three or more release-recovery sites. This will allow a test of the assumption that the capture probability at a site is equal for treatment and control crabs. In addition, several randomly selected release sites could be used as replicates to estimate sampling variance. The timing of release and recovery can in two main ways, significantly alter the sample design and subsequent model selection for analysis. First, the time between release and recovery of crabs should be short in order to minimize the effect of any outside sources of mortality. Ideally one would tag crab at the end of the soft shell period to: (1) reduce the time crab are at large before the commercial fishery is opened to recover the crab; and (2) minimize confounding of handling mortality by increased natural mortality associated with the molting period. Similarly, it would be best if the commercial crab fleet concentrated effort at the beginning of the fishery in the area where crab were released. Second, if the proportion of crab available in each shell hardness category does not meet sample design requirements, multi-stage sampling may be necessary. This type of sampling is less desirable for two reasons: (1) crab with different shell hardnesses will be at large for variable amounts of time prior to recovery; and (2) recapture of previously tagged crab may affect survival. Both of these factors would have to be accounted for in model selection.

If the purpose of a handling experiment on crab is to provide convincing biological data to support changes in commercial fishing seasons and areas, then every effort should be made to simulate commercial handling of crab. Additional handling effects that may occur from tagging crab should be addressed in a concurrent experiment. Specifically, 15 to 25 tagged and untagged crab from each shell-hardness category should be held seperately for five days in pots with escape gaps wired shut. If a differential tagging mortality is detected between these groups, then it too should be included in the model for estimating survival and capture probabilities.

Further studies should time sample collection to coincide with molting period in order to insure adequate sample sizes in the shell hardness categories most sensitive to treatment. The unpredictable nature of crab molting will require intermittent sampling of a crab population to determine the soft shell period.