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Effects of Release Method on Recovery Rates of Tagged Red King Crabs *Paralithodes camtschaticus* in the 1993 Bristol Bay Commercial Fishery

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INTRODUCTION

The Bristol Bay red king crab *Paralithodes camtschaticus* stock has been the subject of intense tagging efforts dating back to the mid-1950's (Simpson and Shippen 1968). Most of the earlier tagging work was directed towards studying growth-per-molt, seasonal migration patterns, and other life history parameters. Tagging studies have also been used in estimation of natural and fishing mortality in Bristol Bay red king crabs (Cleaver 1963). In more recent years, the Alaska Department of Fish and Game (ADF&G) has been conducting large-scale tagging programs designed to evaluate the harvest of legal male red king crabs (Watson et al. 1991).

Capture and handling of non-retained crabs in Alaska crab fisheries are known to have lethal and sublethal effects (Kruse 1993). In his review, Kruse notes that adverse effects from at-sea handling probably results in overall reductions in fishery yields and increased mortality in declining stocks. Capture and handling effects can also affect the interpretation of recovery rates for captured and released tagged crabs. Our study assesses the relative effects of two at-sea handling-and-release methods on the recovery rate of tagged legal male red king crabs released in the month prior to, and recovered during, the 1993 Bristol Bay red king crab commercial fishery.

METHODS

Sampling Design

The study area was located between 56° and 57° N. latitude and 161°50' and 164° W. longitude in Bristol Bay, Alaska (Figure 1). Sampling took place aboard the 31-m (101-ft) chartered crabber FV *Cascade* in a 21 day period from September 30 to October 20, 1993. A total of 168 pots grouped into 84 stations consisting of two pots spaced 1/8 nm apart were sampled. Each station consisted of a "control sample pot" and a "treatment sample pot". Stations were located within concentrations of legal male crabs encountered during the course of cost-recovery fishing conducted under ADF&G's Bering Sea Test Fish Program. Further details on ADF&G's 1993 Bering Sea test fishery are provided in Byersdorfer et al. (1994).

Tagging

A maximum of 30 crabs were tagged at each sample pot. Only healthy, non-injured legal-sized male red king crabs were tagged during the study. Legal-sized male red king crabs are defined as those crabs with a carapace width $\geq$ 6.5 inches carapace width (CW). Floy[1] polyvinyl "spaghetti" tags were placed through the isthmus muscle as described by Gray (1965). All sampled crabs were handled identically during tagging. Data recorded from each released tagged crab included Floy tag number, carapace length (CL), and shell age. Crabs were classified as

[1] Use of a company's name does not constitute endorsement by ADF&G.

either new-shell crabs that molted during the last molting season or old-shell crabs that failed to molt during the last molting season.

Tagged Crab Release

A total of 4,171 legal crabs were tagged and released. Of those, 2,061 (1,656 new-shell and 405 old-shell) were control crabs and 2,110 (1,690 new-shell and 420 old-shell) were treatment crabs (Appendix A).

Tagged crab release procedures were as follows:

Control releases: Crabs from control pots were released by placing, not dropping, each tagged crab in the onboard water trough, with the abdomen of the crab facing down. Each release was made while the vessel was on station and not moving. Tagged crabs were then flushed overboard, dropping approximately 38 cm (15 in) to the sea surface.

Treatment releases: Crabs from treatment pots were released by dropping each crab overboard from a set location on deck with the dorsal carapace of the crab facing down. Each release was made while the vessel moved in a straight line at a speed of 7.5 knots. Each crab was dropped from the level of the vessel rail to the sea surface, a distance of approximately 168 cm (66 in).

Capture location and date and release location and date was noted as well as the elapsed time from when crabs from a pot were brought on board to the release of the last tagged crab. Control crabs were released on station at the capture location. Release locations for treatment crabs were noted when the last crab from each treatment pot was released. Sampling protocols and data forms for the study are detailed in Watson and Pengilly (1994).

Tagged Crab Recovery

The 1993 Bristol Bay red king crab fishery began on November 1, 1993 and ended on November 10, 1993. An intensive tag recovery program involving dock-side samplers and mandatory at-sea shellfish observers was mounted for the return of tagged, legal red king crabs during the 1993 Bristol Bay red king crab fishery. Dutch Harbor was the primary site of dock-side tag recoveries, with additional tag samplers in Akutan, King Cove, Kodiak, and St. Paul. Approximately nine dock-side samplers and 35 shellfish observers were given instructions prior to the start of the commercial fishery for the receipt of tagged crabs. All tagged crabs were to be measured and assessed for shell age, with complete capture location data to be obtained from vessel captains as described by Watson and Pengilly (1992a).

Several days prior to the fishery and during vessel tank inspections, tag samplers contacted vessel crews and processing facilities to explain the tag recovery effort and attendant tag reward program. Vessel crews were given a news release detailing the program along with a form to record captured tagged crabs and tag reward information. Vessel crews were instructed to retain all tagged legal crabs and to document the date and location of capture. Vessel crews were asked to contact ADF&G upon delivery so that tag samplers could measure tagged crabs and record

available capture information. Similarly, processing crews were asked to contact ADF&G tag samplers when tagged crabs were observed in the processing facility.

Data Analysis

Presence of an effect on recovery rate due to shell age differences of crabs within release type was tested prior to analysis of the effect due to release method. To test for a discrepancy in recovery rate between new-shell and old-shell legal crabs released with the same method (control or treatment), recovery data of tagged legal crabs were grouped by the pot in which they were captured in and released from. Only those crabs released from survey pots in which both new-shell and old-shell legal crabs were captured were included in this analysis. For control releases, this reduced the number of tagged crabs considered to 1,573 new-shell and 405 old-shell crabs that were released from 77 pots. For treatment releases, the number of tagged crabs considered was reduced to 1,627 new-shell and 420 old-shell crabs that were released from 79 pots. The statistical significance of the differences in recovery probabilities between new-shell and old-shell crabs was tested separately for the control and treatment releases following the procedures of Cox and Snell (1989, pp. 56-59) for tests involving several 2 x 2 contingency tables. For control releases, there were 77 separate 2 x 2 contingency tables; for treatment releases there were 79 separate 2 x 2 contingency tables.

We used the difference between the logistic transforms (Cox and Snell 1989, p. 44) of the recovery probabilities as a measure of the discrepancy between recovery probabilities of new-shell and old-shell crabs. The conditional maximum likelihood estimate of the logistic difference (Cox and Snell 1989, p. 50) was computed by treating the data as coming from 77 + 79 = 156 separate 2 x 2 contingency tables using the saddle-point approximation method of Barndorff-Nielsen and Cox (1979). An approximate 95% confidence interval for the logistic difference was obtained using the asymptotic chi-squared distribution for a generalized likelihood ratio (e.g., Mood et al. 1974).

Presence of an effect on recovery rate due to release method was tested separately for new-shell and old-shell tagged crabs. The statistical significance of the difference in recovery probabilities between control and treatment releases for tagged crabs of the same shell age was tested by grouping recovery data by tagging station and using Cox and Snell's procedure (1989, pp. 56-59) for tests involving several 2 x 2 contingency tables. Since new-shell crabs were tagged and released from both pots in each of the 84 tagging stations, the test for presence of release effect in new-shell crabs used the recovery data from all 1,656 control new-shell crabs and all 1,690 treatment new-shell crabs grouped into 84 separate 2 x 2 contingency tables. Old-shell crabs were not released from both control and treatment pots in all the 84 tagging stations, however. Consequently, the test for presence of release effect in old-shell crabs used data from 389 control crabs and 400 treatment crabs grouped into 74 separate 2 x 2 contingency tables.

RESULTS

Of the 4,171 tagged crabs that were released, 1,136 (27.2%) were recovered during the 1993 commercial fishery (Appendix A). Of the 2,061 crabs released using the control method, 558 (27.1%) were recovered, while 578 (27.4%) of the 2,110 crabs released using the treatment method were recovered.

Differential Recovery Rates by Shell Age

Differences existed between the recovery rates of new-shell and old-shell crabs released using the same method. Control crabs in new-shell condition showed a higher recovery rate (473 recoveries out of 1,656, or 28.6%) than from those tagged in old-shell condition (85 recoveries out of 405, or 21%). As was true in the data from all control crabs, new-shell crabs released from the 77 control pots from which both new-shell and old-shell crabs were tagged and released were recovered at a higher rate than old-shell crabs (452 out of 1,573, or 28.7%, for new-shell crabs as compared to 85 out of 405, or 21%, for old-shell crabs). In 52 of those 77 control releases, new-shells had a higher recovery rate than old shells, while old shells had higher recovery rates than new-shells in 19 of the control releases. Under the null hypothesis that there is no difference within those 77 control releases between the tag-recovery probabilities of new-shell and old-shell crabs, the expected number of recoveries from new-shell crabs in the 537 total recoveries is 424.16 with a variance of 53.969. An approximate test of the statistical significance of the difference between recovery probabilities can be made by treating the test statistic,

$$z=\frac{452-424.16-\frac{1}{2}}{\sqrt{53.969}}=3.721,$$

as an observation from a standard normal distribution. In this case, the observed value of 3.721 corresponds to a P-value of 0.0002 in a two-sided normal test.

Similarly, new-shell crabs also showed a higher recovery rate (482 recoveries out of 1,690, or 28.5%) than old-shell crabs (96 recoveries out of 420, or 22.9%) in the treatment releases. New-shell crabs were also recovered at a higher rate than old-shell crabs from the 79 treatment releases that included both new-shell and old-shell crabs (469 out of 1,627, or 28.8%, for new-shell crabs as compared to 96 out of 420, or 22.9%, for old-shell crabs). In 58 of those 79 treatment releases, new-shells had a higher recovery rate than old-shells, while old-shells had higher recovery rates than new-shells in 19 of the treatment releases. Under the null hypothesis that there is no difference within those 79 treatment releases between the tag-recovery probabilities of new-shell and old-shell crabs, the expected number of recoveries from new-shell crabs in the 565 total recoveries is 446.19 with a variance of 56.778. The test statistic for an approximate test of the statistical significance of the difference between recovery probabilities is 2.961, corresponding to a P-value of 0.0031 in a two-sided normal test.

Since there was no indication of an interaction between release method and shell age influencing recovery rates (see below), an estimate of the logistic difference (the logistic transform of the old-shell crab recovery probability minus that of the new-shell crab recovery probability) was estimated using recovery data for all releases from the 156 pots from which both new-shell and old-shell crabs were released (i.e., regardless of release method). The resulting estimate of the logistic difference is -0.485 with an approximate 95% confidence interval of -0.685 to -0.289. On an untransformed scale, this estimate corresponds to estimating the recovery:non-recovery odds of an old-shell crab to be 62% (50% to 75%) of that of a new-shell crab released from the same pot.

Effects of Release Method on Recovery Rate

Given the differences in recovery rates for new-shell and old-shell crabs, the effects of release method were analyzed separately for new-shell and old-shell crabs. In crabs of either shell age there was little evidence for a difference between the recovery rates of control and treatment released crabs. Of the 1,656 new-shell crabs released using the control method from 84 stations, 473 (28.6%) were recovered. This compares closely to the 28.5% recovery rate (482 recoveries out of 1,690 releases) for the new-shell crabs released using the treatment method from the same 84 stations. Under the null hypothesis that there is no difference within the 84 release stations between the tag-recovery probabilities of new-shell crabs released using the control and treatment methods, the expected number of recoveries from the control releases in the 955 total recoveries is 474.41 with a variance of 162.375. An approximate test of the statistical significance of the difference between recovery probabilities can be made by treating the test statistic,

$$z=\frac{473-474.41+\frac{1}{2}}{\sqrt{162.375}}=-0.071,$$

as an observation from a standard normal distribution. The observed value of -0.071 corresponds to a P-value of 0.9431 in a two-sided normal test.

Similarly, the recovery rate of old-shell crabs released using the control method compared closely with that of the old-shell crabs released using the treatment method; 85 out of all 405 (21.0%) control old-shell crabs were recovered while 96 out of all 420 (22.9%) treatment old-shell crabs were recovered. In the 74 stations where old-shells were released using both the control and treatment method, 82 of the 389 (21.1%) old-shell crabs released using the control method were recovered while 93 out of the 400 (23.3%) treatment old-shell crabs were recovered. Under the assumption that there is no difference within the 74 release stations between the tag-recovery probabilities of old-shell crabs released using the control and treatment methods, the expected number of recoveries from the control releases is 82.69 with a variance of 28.170. The test statistic for an approximate test of the statistical significance of the difference between recovery probabilities is -0.036, corresponding to a P-value of 0.9711 in a two-sided normal test. Non-significance of effects due to release type within both shell age classes indicates that there is no effect due to interaction of shell age and release type.

Elapsed Time and Distance Traveled to Last Release From Pot

Table 2 provides summary statistics of elapsed on-deck time and distance from pot lift location for the last tagged crab released from a pot. Since there was some variation in the number of crabs released between stations and between control and treatment pots within stations, statistics of elapsed time and distance after adjustment by the number of tagged crabs released are also noted in Table 2. Note that those adjusted values do not reflect average values per crab, however. For controlling any differences due to number of crabs released, a better comparison of the on-deck time and capture-release location displacement between control and treatment crabs is provided by Table 3, which summarizes only the data from 34 stations where 30 tagged crabs were released from both control and treatment pots.

Time on deck of tagged crabs prior to release was comparable for control and treatment crabs. Treatment crabs, which were released while the vessel was running, tended to be displaced further from the initial capture location when released than were control crabs (for control crabs some displacement prior to release occurred due to drift of the vessel from the initial capture location). For the 34 stations in which there were 30 control and treatment releases each, the displacement of last released treatment crab from a pot averaged 0.24 nm, while for control crabs that value averaged 0.17 nm (Table 3). Within each of those 34 stations, the displacement of the last treatment crab released averaged 1.9 times that of the last released control crab.

DISCUSSION

Our study has focussed on comparing the effects of two methods for releasing pot-captured crabs from a vessel at sea: placing the crab with ventral side down while standing at the pot lift location (the "control" method) and dropping the crab with dorsal side down over the vessel rail while the vessel is running at 7.5 knots (the "treatment" method). As well as being subjected to greater impact when dropped over the rail, treatment crabs were generally displaced farther from the initial capture location when released than were control crabs; time on deck prior to release was, however, comparable between control and treatment crabs. Our results indicate no difference in the effects between the two release methods on recovery rates in the short-term, 37 day period from the first tagged crab release on October 4, 1993 to the last documented tagged crab recovery on November 10, 1993. Those results cannot be used to address the potential for differences in recovery rates when longer periods exist between time of release and recovery. We also note that the treatment received by crabs under both release methods used in this study may be mild compared to the treatment received by bycatch crabs that are discarded during a commercial fishery and that no crabs that sustained apparent injuries during initial capture were tagged and released in our study.

The 27% recovery rate from the 1993 commercial fishery of the crabs released for this study is roughly 3-4 times higher than the recovery rates during the 1990 and 1991 commercial fisheries of the Floy-tagged crabs released by ADF&G prior to those fisheries; 244 (10.1%) of the tags from the 2,418 legal crabs released in 1990 were recovered during the 1990 commercial season, while 372 (6.9%) of the tags from the 5,415 legal crabs released in 1991 were recovered during the 1991 commercial fishery (Watson et al. 1991, Pengilly and Watson *in press*). Crabs tagged

in the 1990 and 1991 tagging studies were generally released by dropping them in the vessel's overflow water trough while the vessel was travelling to the next tagging pot (a variation of the treatment release method used in the current study). Our results from the present study, however, indicate that the same-year recovery rates of the 1990 and 1991 would not have been appreciably improved had the crabs been placed in the water trough while the vessel was stopped at the capture location (i.e., the control release method of the present study). Controlled laboratory studies of female and sublegal male red king crab have likewise indicated no increased mortality due to the impacts sustained by dropping crabs into water from the height of a vessel rail as compared to release through a water trough (Zhou and Shirley 1994).

Our comparison of recovery rates during the 1993 commercial season between the new-shell and old-shell legal crabs that were tagged and released in this study is consistent with a trend seen in the 1990 and 1991 tag release studies (Pengilly and Watson 1992b): old-shell crabs tend to have a lower recovery probability than new-shell crabs released from the same pot. Over the 1990, 1991, and 1993 tagging studies same-year recovery rates of tagged old-shell legal crabs were from 50% to 70% of that of tagged new-shell legal crabs. That no effects due to release method on the recovery rates of either new-shell or old-shell crabs were demonstrable in the present study indicates that the differential recovery rates of new-shell and old-shell crabs are not due to greater susceptibility of handling effects in old-shell crabs relative to new-shell crabs. That the differential recovery rate has existed in studies for which the time between release and recovery has ranged from one month or less (the 1993 study) to as long as three months (the 1990 study) indicates that the differential is not attributable to higher rates of either handling or natural mortality in old-shell crabs. Hence, the differences in recovery rates may be due to differences in seasonal movements or other behavior and condition differences that make an old-shell crab less likely than a new-shell crab to be captured during the relatively short (one to two weeks) Bristol Bay commercial fishery.

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Table 1. Summary of October 1993 releases of Floy-tagged legal Bristol Bay red king crabs and subsequent recoveries during the November 1993 Bristol Bay red king crab commercial fishery.

No. of Tagged Legal Crabs	1993 Fishery Recoveries
Control (n=2,061)	558 (27.1%)
Treatment (n=2,110)	578 (27.4%)
Total (n=4,171)	1,136 (27.2%)

Table 2. Summary statistics (mean, minimum, maximum, and standard deviation) on elapsed time from retrieval of pot to last release of tagged crab from pot and distance from pot retrieval location to last release location of tagged crab from pot by release method. Data is from all 84 stations.

Release Type	Distance (nm)	Elapsed Time (min)	Adjusted Distance (nm)[a]	Adjusted Elapsed Time (sec)[b]
Control				
(mean)	0.15	16.3	0.006	41
(minimum)	0.01	2.5	0.001	33
(maximum)	0.63	23.0	0.021	63
(std. dev.)	0.128	4.89	0.0051	5.1
Treatment				
(mean)	0.23	16.8	0.011	41
(minimum)	0.04	4.2	0.002	33
(maximum)	0.90	25.0	0.052	56
(std. dev.)	0.155	4.99	0.0091	4.7

[a] Distance divided by number of tagged crabs released.

[b] Elapsed time divided by number of tagged crabs released.

Table 3. Summary statistics (mean, minimum, maximum, and standard deviation) on elapsed time from retrieval of pot to last release of tagged crab from pot and distance from pot retrieval location to last release location of tagged crab from pot by release method. Data is from 34 stations in which 30 tagged crabs were released from both the control and treatment pots.

Release Type	Distance (nm)	Elapsed Time (min)
Control		
(mean)	0.17	19.1
(minimum)	0.04	16.6
(maximum)	0.63	23.0
(std. dev.)	0.155	1.62
Treatment		
(mean)	0.24	19.5
(minimum)	0.07	16.3
(maximum)	0.52	23.1
(std. dev.)	0.130	1.82

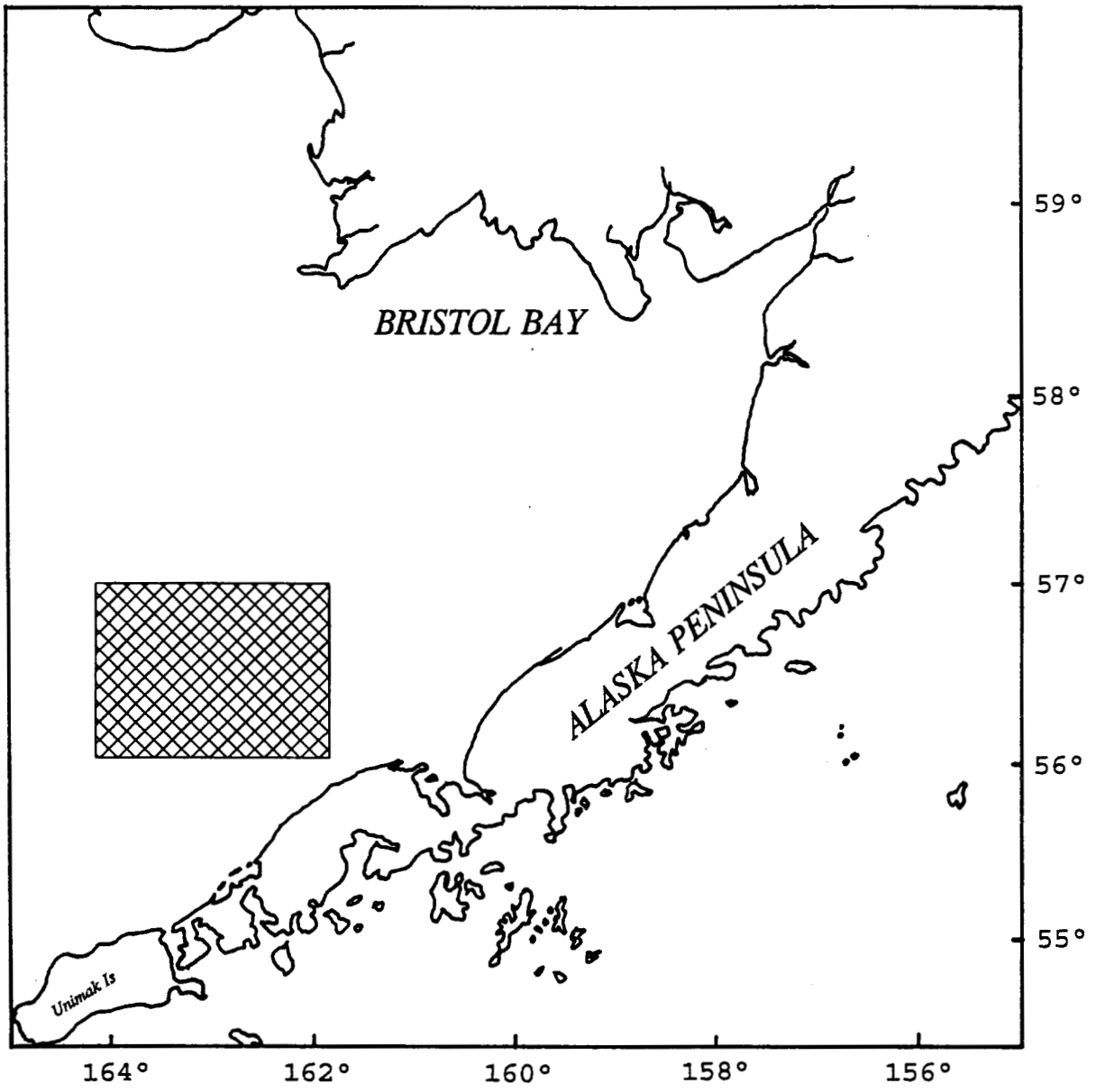

Figure 1. Location of the 1993 Bristol Bay red king crab tagging study.

APPENDIX

Appendix A. Release and recovery data from the 1993 Bristol Bay red king crab handling release tagging study.

Station Number	Release Date	Release Location				Release Type(1)	No. of Crabs Released			No. of Crabs Recovered		
		N. Latitude		W. Longitude			New-shell	Old-shell	Total	New-shell	Old-shell	Total
		DEG	MIN	DEG	MIN							
1	04-Oct	56	19.76	163	18.83	1	10	0	10	0	0	0
1	04-Oct	56	19.81	163	18.69	2	3	3	6	1	0	1
2	04-Oct	56	20.06	163	4.51	1	10	3	13	1	0	1
2	04-Oct	56	20.00	163	4.23	2	12	1	13	3	0	3
3	04-Oct	56	20.16	162	57.86	1	24	1	25	3	0	3
3	04-Oct	56	20.16	162	57.60	2	28	2	30	7	0	7
4	05-Oct	56	40.05	163	15.47	1	7	3	10	0	0	0
4	05-Oct	56	40.09	163	15.27	2	11	4	15	1	0	1
5	05-Oct	56	40.13	163	10.01	1	1	2	3	0	1	1
5	05-Oct	56	40.12	163	9.82	2	10	3	13	3	0	3
6	05-Oct	56	40.08	163	4.57	1	13	3	16	1	0	1
6	05-Oct	56	40.08	163	4.38	2	8	4	12	2	0	2
7	05-Oct	56	40.09	162	59.20	1	9	6	15	4	1	5
7	05-Oct	56	40.08	162	59.03	2	9	4	13	0	0	0
8	05-Oct	56	40.04	162	53.88	1	13	5	18	6	0	6
8	05-Oct	56	40.03	162	53.63	2	18	7	25	0	0	0
9	05-Oct	56	40.01	162	48.36	1	14	3	17	5	2	7
9	05-Oct	56	40.01	162	48.16	2	23	7	30	4	0	4
10	05-Oct	56	39.98	162	42.93	1	6	2	8	3	1	4
10	06-Oct	56	39.99	162	42.70	2	15	3	18	3	2	5
11	06-Oct	56	25.18	162	38.23	1	25	5	30	3	1	4
11	06-Oct	56	25.18	162	38.40	2	22	8	30	3	0	3
12	06-Oct	56	25.12	162	43.63	1	21	9	30	9	3	12
12	06-Oct	56	25.10	162	43.83	2	15	0	15	4	0	4
13	06-Oct	56	25.08	162	49.07	1	26	4	30	10	0	10
13	06-Oct	56	25.07	162	49.24	2	23	7	30	6	0	6

-Continued-

Appendix A. Release and recovery data from the 1993 Bristol Bay red king crab handling release tagging study.

Station Number	Release Date	Release Location N. Latitude DEG	N. Latitude MIN	W. Longitude DEG	W. Longitude MIN	Release Type(1)	No. of Crabs Released New-shell	Old-shell	Total	No. of Crabs Recovered New-shell	Old-shell	Total
14	06-Oct	56	24.99	162	54.55	1	23	2	25	5	0	5
14	06-Oct	56	24.99	162	54.70	2	29	1	30	5	0	5
15	07-Oct	56	30.13	162	24.08	1	23	7	30	10	1	11
15	07-Oct	56	30.14	162	24.30	2	17	13	30	5	2	7
16	07-Oct	56	30.17	162	29.37	1	18	12	30	6	0	6
16	07-Oct	56	30.16	162	29.61	2	21	4	25	7	0	7
17	07-Oct	56	30.17	162	34.78	1	18	12	30	1	0	1
17	07-Oct	56	30.14	162	34.99	2	9	5	14	2	1	3
18	07-Oct	56	19.59	162	36.93	1	23	6	29	8	1	9
18	07-Oct	56	19.45	162	37.11	2	26	4	30	5	2	7
19	07-Oct	56	19.10	162	37.79	1	21	9	30	3	2	5
19	07-Oct	56	19.03	162	37.92	2	26	4	30	8	0	8
20	07-Oct	56	18.70	162	38.54	1	25	5	30	5	2	7
20	07-Oct	56	18.62	162	38.70	2	28	2	30	7	0	7
21	07-Oct	56	18.30	162	39.31	1	8	1	9	0	0	0
21	07-Oct	56	18.22	162	39.47	2	25	5	30	4	0	4
22	08-Oct	56	14.50	162	46.45	1	19	6	25	4	1	5
22	08-Oct	56	14.60	162	46.40	2	24	6	30	6	1	7
23	08-Oct	56	14.95	162	45.77	1	26	4	30	2	1	3
23	08-Oct	56	15.07	162	45.58	2	23	5	28	4	2	6
24	08-Oct	56	15.40	162	44.87	1	26	4	30	7	0	7
24	08-Oct	56	15.48	162	44.72	2	26	4	30	9	1	10
25	08-Oct	56	15.78	162	44.02	1	25	5	30	6	0	6
25	08-Oct	56	15.88	162	43.90	2	29	1	30	6	0	6
26	08-Oct	56	16.19	162	43.21	1	26	4	30	10	0	10
26	08-Oct	56	16.28	162	43.04	2	26	4	30	6	0	6

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Appendix A. Release and recovery data from the 1993 Bristol Bay red king crab handling release tagging study.

Station Number	Release Date	Release Location N. Latitude DEG	N. Latitude MIN	W. Longitude DEG	W. Longitude MIN	Release Type(1)	No. of Crabs Released New-shell	Old-shell	Total	No. of Crabs Recovered New-shell	Old-shell	Total
27	08-Oct	56	16.59	162	42.38	1	18	6	24	3	0	3
27	08-Oct	56	16.65	162	42.19	2	10	2	12	3	0	3
28	08-Oct	56	16.97	162	41.60	1	17	4	21	6	0	6
28	08-Oct	56	17.00	162	41.45	2	27	3	30	2	0	2
29	08-Oct	56	17.40	162	40.75	1	12	1	13	2	0	2
29	08-Oct	56	17.46	162	40.69	2	8	0	8	1	0	1
30	08-Oct	56	17.81	162	40.02	1	25	5	30	3	0	3
30	08-Oct	56	17.88	162	39.88	2	19	6	25	7	3	10
31	08-Oct	56	19.84	162	28.69	1	21	0	21	3	0	3
31	08-Oct	56	19.69	162	28.84	2	20	10	30	5	1	6
32	08-Oct	56	19.27	162	29.54	1	26	4	30	8	2	10
32	08-Oct	56	19.16	162	29.73	2	26	4	30	6	2	8
33	09-Oct	56	14.53	162	37.62	1	12	6	18	4	0	4
33	09-Oct	56	14.60	162	37.46	2	13	0	13	3	0	3
34	09-Oct	56	14.92	162	36.91	1	23	7	30	0	0	0
34	09-Oct	56	15.03	162	36.73	2	28	1	29	5	0	5
35	09-Oct	56	16.28	162	34.58	1	25	5	30	6	0	6
35	09-Oct	56	16.40	162	34.39	2	25	5	30	5	0	5
36	09-Oct	56	16.80	162	33.72	1	23	7	30	2	0	2
36	09-Oct	56	16.90	162	33.59	2	24	6	30	3	1	4
37	09-Oct	56	17.26	162	33.00	1	25	5	30	4	1	5
37	09-Oct	56	17.35	162	32.79	2	23	7	30	4	2	6
38	09-Oct	56	17.79	162	32.15	1	13	6	19	6	2	8
38	09-Oct	56	17.84	162	31.94	2	25	5	30	1	0	1
39	09-Oct	56	18.21	162	31.37	1	21	9	30	4	1	5
39	09-Oct	56	18.28	162	31.18	2	25	5	30	7	0	7

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Appendix A. Release and recovery data from the 1993 Bristol Bay red king crab handling release tagging study.

Station Number	Release Date	Release Location				Release Type(1)	No. of Crabs Released			No. of Crabs Recovered		
		N. Latitude		W. Longitude			New-shell	Old-shell	Total	New-shell	Old-shell	Total
		DEG	MIN	DEG	MIN							
40	09-Oct	56	18.70	162	30.51	1	16	9	25	3	0	3
40	09-Oct	56	18.82	162	30.40	2	15	5	20	6	1	7
41	10-Oct	56	35.17	162	18.80	1	20	10	30	5	2	7
41	10-Oct	56	35.10	162	19.11	2	14	16	30	4	4	8
42	10-Oct	56	35.13	162	19.72	1	7	23	30	4	6	10
42	10-Oct	56	35.14	162	19.97	2	10	20	30	3	5	8
43	10-Oct	56	35.15	162	20.65	1	11	19	30	4	9	13
43	10-Oct	56	35.13	162	20.81	2	6	24	30	3	8	11
44	10-Oct	56	35.15	162	38.92	1	8	1	9	5	1	6
44	10-Oct	56	35.16	162	38.77	2	15	4	19	6	0	6
45	10-Oct	56	35.20	162	38.04	1	4	0	4	1	0	1
45	10-Oct	56	35.18	162	37.94	2	7	0	7	1	0	1
46	10-Oct	56	35.20	162	37.15	1	5	0	5	3	0	3
46	10-Oct	56	35.20	162	36.91	2	5	3	8	1	1	2
47	10-Oct	56	35.20	162	36.22	1	13	0	13	4	0	4
47	10-Oct	56	35.19	162	36.01	2	8	2	10	3	1	4
48	10-Oct	56	35.18	162	35.34	1	12	3	15	4	1	5
48	10-Oct	56	35.17	162	35.12	2	5	3	8	2	0	2
49	10-Oct	56	35.18	162	34.40	1	12	1	13	5	0	5
49	10-Oct	56	35.17	162	34.21	2	18	12	30	7	3	10
50	10-Oct	56	35.21	162	33.47	1	28	2	30	9	0	9
50	10-Oct	56	35.21	162	33.17	2	25	5	30	13	1	14
51	10-Oct	56	35.18	162	32.45	1	16	6	22	5	1	6
51	10-Oct	56	35.16	162	32.23	2	16	8	24	4	1	5
52	10-Oct	56	35.16	162	31.53	1	25	5	30	7	0	7
52	10-Oct	56	35.14	162	31.33	2	19	11	30	6	3	9

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Appendix A. Release and recovery data from the 1993 Bristol Bay red king crab handling release tagging study.

Station Number	Release Date	Release Location				Release Type(1)	No. of Crabs Released			No. of Crabs Recovered		
		N. Latitude		W. Longitude			New-shell	Old-shell	Total	New-shell	Old-shell	Total
		DEG	MIN	DEG	MIN							
53	10-Oct	56	35.14	162	30.60	1	22	3	25	5	0	5
53	10-Oct	56	35.14	162	30.38	2	16	14	30	4	9	13
54	10-Oct	56	35.17	162	29.80	1	26	4	30	9	0	9
54	10-Oct	56	35.17	162	29.48	2	21	7	28	7	2	9
55	10-Oct	56	35.12	162	21.34	1	20	10	30	8	6	14
55	10-Oct	56	35.19	162	21.51	2	21	9	30	9	2	11
56	10-Oct	56	35.10	162	22.30	1	25	5	30	11	3	14
56	10-Oct	56	35.12	162	22.64	2	22	8	30	6	4	10
57	12-Oct	56	35.13	162	23.31	1	25	5	30	12	3	15
57	12-Oct	56	35.14	162	23.61	2	20	10	30	12	3	15
58	12-Oct	56	35.12	162	25.23	1	18	12	30	7	5	12
58	12-Oct	56	35.13	162	25.41	2	24	6	30	11	1	12
59	12-Oct	56	35.14	162	26.95	1	21	9	30	10	2	12
59	12-Oct	56	35.16	162	27.17	2	24	6	30	12	1	13
60	13-Oct	56	20.22	162	26.42	1	29	1	30	9	0	9
60	13-Oct	56	20.19	162	26.63	2	27	1	28	7	1	8
61	13-Oct	56	20.18	162	28.32	1	28	2	30	10	0	10
61	13-Oct	56	20.18	162	28.48	2	27	3	30	12	0	12
62	13-Oct	56	22.64	162	26.42	1	27	3	30	11	0	11
62	13-Oct	56	22.64	162	26.58	2	27	3	30	5	1	6
63	14-Oct	56	30.21	162	15.81	1	25	5	30	10	2	12
63	14-Oct	56	30.22	162	16.02	2	25	4	29	9	3	12
64	14-Oct	56	30.19	162	19.47	1	20	10	30	6	1	7
64	14-Oct	56	30.20	162	19.73	2	23	7	30	8	1	9
65	14-Oct	56	30.18	162	26.40	1	25	5	30	6	1	7
65	14-Oct	56	30.18	162	26.60	2	28	2	30	11	2	13

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Appendix A. Release and recovery data from the 1993 Bristol Bay red king crab handling release tagging study.

Station Number	Release Date	Release Location				Release Type(1)	No. of Crabs Released			No. of Crabs Recovered		
		N. Latitude		W. Longitude			New-shell	Old-shell	Total	New-shell	Old-shell	Total
		DEG	MIN	DEG	MIN							
66	15-Oct	56	32.62	161	48.68	1	28	1	29	3	0	3
66	15-Oct	56	32.54	161	48.52	2	25	5	30	7	0	7
67	15-Oct	56	31.59	161	46.75	1	26	4	30	3	0	3
67	15-Oct	56	31.50	161	46.58	2	25	1	26	6	0	6
68	15-Oct	56	30.56	161	44.74	1	15	0	15	3	0	3
68	15-Oct	56	30.48	161	44.62	2	13	2	15	1	0	1
69	15-Oct	56	35.11	162	12.53	1	18	12	30	7	3	10
69	15-Oct	56	35.12	162	12.75	2	24	5	29	10	2	12
70	15-Oct	56	35.16	162	16.14	1	23	7	30	7	3	10
70	15-Oct	56	35.14	162	16.34	2	25	5	30	10	3	13
71	15-Oct	56	32.77	162	13.28	1	29	1	30	12	0	12
71	15-Oct	56	32.81	162	13.34	2	19	1	20	7	0	7
72	16-Oct	56	32.74	162	18.57	1	23	6	29	12	1	13
72	16-Oct	56	32.75	162	18.80	2	25	5	30	11	3	14
73	16-Oct	56	32.73	162	21.31	1	25	5	30	11	4	15
73	16-Oct	56	32.71	162	21.50	2	24	6	30	11	3	14
74	16-Oct	56	32.67	162	24.01	1	26	3	29	9	1	10
74	16-Oct	56	32.66	162	24.26	2	26	4	30	10	3	13
75	16-Oct	56	27.68	162	23.04	1	25	5	30	11	2	13
75	16-Oct	56	27.68	162	23.14	2	24	6	30	9	1	10
76	16-Oct	56	27.67	162	23.86	1	26	3	29	8	1	9
76	16-Oct	56	27.65	162	24.05	2	29	1	30	3	0	3
77	17-Oct	56	24.68	162	30.19	1	25	5	30	9	3	12
77	17-Oct	56	24.80	162	30.02	2	27	3	30	12	1	13
78	17-Oct	56	25.46	162	29.01	1	28	2	30	6	0	6
78	17-Oct	56	25.56	162	28.88	2	28	2	30	2	0	2

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Appendix A. Release and recovery data from the 1993 Bristol Bay red king crab handling release tagging study.

Station Number	Release Date	Release Location				Release Type(1)	No. of Crabs Released			No. of Crabs Recovered		
		N. Latitude		W. Longitude								
		DEG	MIN	DEG	MIN		New-shell	Old-shell	Total	New-shell	Old-shell	Total
79	17-Oct	56	27.00	162	26.70	1	23	1	24	7	0	7
79	17-Oct	56	27.07	162	26.56	2	24	6	30	8	1	9
80	17-Oct	56	28.55	162	24.42	1	28	2	30	5	0	5
80	17-Oct	56	28.64	162	24.31	2	26	4	30	9	1	10
81	17-Oct	56	30.13	162	22.27	1	26	3	29	8	0	8
81	17-Oct	56	30.22	162	22.14	2	26	4	30	11	0	11
82	17-Oct	56	30.89	162	21.19	1	29	1	30	7	0	7
82	17-Oct	56	31.09	162	20.96	2	29	1	30	14	0	14
83	18-Oct	56	37.53	162	7.48	1	9	3	12	2	1	3
83	18-Oct	56	37.45	162	7.61	2	4	1	5	2	0	2
84	18-Oct	56	32.99	162	14.65	1	15	0	15	7	0	7
84	18-Oct	56	32.90	162	14.78	2	20	0	20	4	0	4
						Totals:	3346	825	4171	955	181	1136

(1) Release Type: 1 = Control; 2 = Treatment