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A Pilot Mark-Recapture Study Using External Tags and Implantable Passive Integrated Transponder (PIT) Tags on Red King Crab in Bristol Bay, Alaska

by

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ABSTRACT

A pilot mark-recapture study testing the feasibility of internal, Passive Integrated Transponder (PIT) tags in Bristol Bay male red king crabs is described. PIT tags were retained in red king crabs at a high level (95.2%) and were durable and recoverable over the length (90 days) of the project. Recovery per unit effort of crabs tagged internally was comparable to recovery per unit effort of externally-tagged crabs. Recovery of externally-marked crabs was significantly influenced by the presence of tag sampling personnel, a factor which did not affect PIT tag recovery. Recovery location data from 93 externally-marked crabs indicated a general southwestward movement of crabs, which may only reflect the geographic distribution of commercial fishing relative to the tag release locations. Precise estimates of PIT tag loss rates were not obtainable from this study, which precluded an evaluation of the exploitation rate of Bristol Bay legal male red king crabs using PIT tag returns.

INTRODUCTION

An intensive mark-recapture project utilizing non-visible, injected tags (Passive Integrated Transponder or PIT tags) in conjunction with external tags (Floy tags) was initiated by the Alaska Department of Fish and Game (ADF&G) in 1990 on legal and pre-recruit male red king crabs, *Paralithodes camtschaticus*, in Bristol Bay, Alaska (Figure 1). The primary objectives of the study were to determine the feasibility of using PIT tags in a large-scale, commercial crab fishery application and to improve the accuracy of the estimated exploitation rate of legal male red king crab in Bristol Bay during the summer of 1990 through tag recovery analysis. Secondary objectives included collection of biological data such as lengths, shell condition, and fecundity. Data gathered from subsequent tagging surveys will be used to refine annual population estimates from trawl survey data and to provide information on natural mortality, growth, migration, and the effects of fishing mortality on the Bristol Bay red king crab population.

The Bristol Bay red king crab fishery has historically been one of Alaska's most valuable shellfish fisheries, with a record landed catch in 1980 of 129.9 million pounds (58.9 million tons) worth an estimated 117 million dollars ex-vessel (ADF&G 1990). The abundance of Bristol Bay red king crab has been assessed annually since 1969 from trawl surveys conducted in the eastern Bering Sea by the National Marine Fisheries Service (Stevens and MacIntosh 1990)(Table 1). Over the course of the fishery and its assessment, many unanswered questions concerning stock status and the dynamics of the Bristol Bay red king crab population have arisen. For example, trawl surveys in recent years have shown major differences in legal population numbers while the catch-per-unit-effort (CPUE) from the fishery has been relatively constant. Low precision and unknown biases in the trawl survey may be contributing factors in this apparent discrepancy. Ultimately, disruption of industry planning (based on pre-season stock assessments) results when adjustments to the guideline harvest level are precipitated by inseason fisheries performance.

To-date, attempts to address these questions through supplemental tagging efforts by NMFS has yielded little additional information due to insufficient and inconsistent tag returns (R.S. Otto, National Marine Fisheries Service, Kodiak, personal communication). Further, tagging studies conducted on Kodiak Island red king crab populations during the early 1980's were compromised by a high degree of non-cooperation from fishermen in returning externally-marked crabs, which also resulted in deficiencies in collected tag data (ADF&G 1982). High loss rates of externally-marked (i.e., Floy-tagged) juvenile red king crab in the Kodiak area suggests at-sea tag losses may be a significant factor in the rate of visible tags recovered from the fishery (B. Dew, National Marine Fisheries Service, Kodiak, personal communications). The need for a tagging program capable of

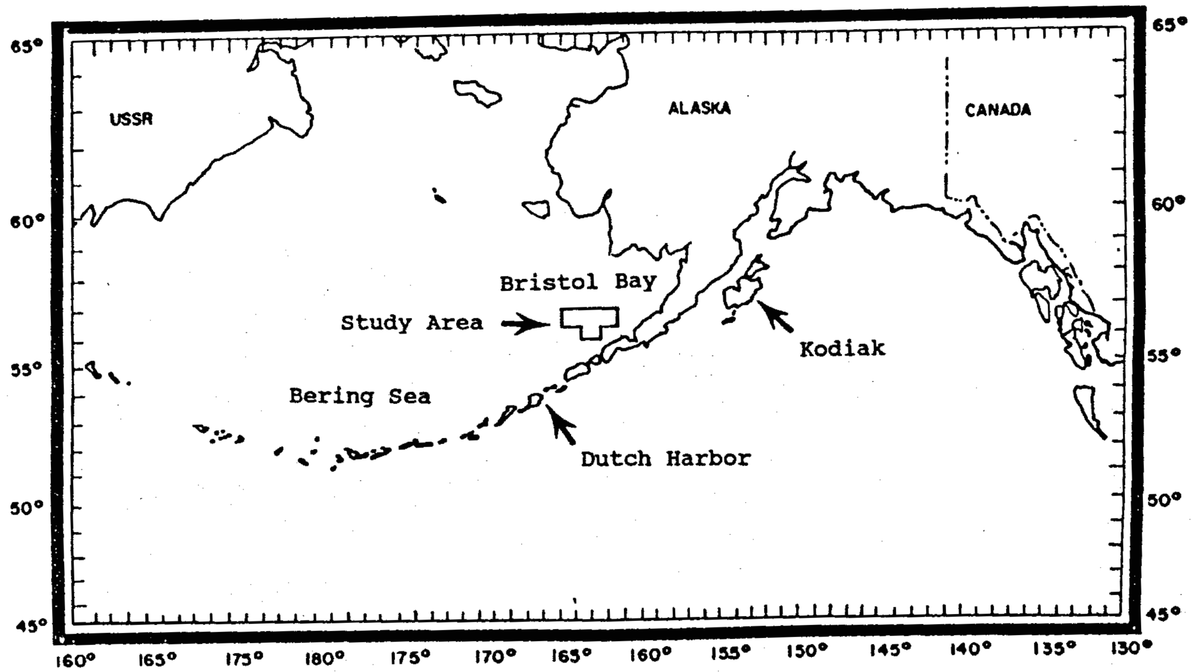

Figure 1. Location of the 1990 Bristol Bay red king crab tagging study.

Table 1. Annual abundance estimates (millions of crabs) for red king crab (*P. camtschatica*) in Bristol Bay and the Pribilof District from NMFS surveys (after Stevens and MacIntosh 1990).

	Males				Females			
Size[a] (mm) Width (in)	<110 <5.2	110-134 5.2-6.5	≥135 ≥6.5	Total	<90 <3.5	≥90 ≥3.5	Total	Grand Total
1969	41.0	20.3	9.8	71.1	18.3	28.5	46.8	117.9
1970	9.5	8.4	5.3	12.2	4.9	13.0	17.9	41.1
1972[b]	14.1	8.0	5.4	27.5	7.0	12.1	19.1	46.6
1973[c]	50.0	25.9	10.8	86.7	24.8	76.8	101.6	188.3
1974[c]	59.0	31.2	20.9	111.1	37.7	72.0	109.7	220.8
1975	84.9	31.7	21.0	137.6	70.8	58.9	129.7	267.3
1976	70.2	49.3	32.7	152.2	35.9	71.8	107.7	259.9
1977	80.2	63.9	37.6	181.7	33.5	150.1	183.6	365.3
1978	62.9	47.9	46.6	157.4	38.2	128.4	166.6	324.0
1979	48.1	37.2	43.9	129.2	45.1	110.9	156.0	285.2
1980	56.8	23.9	36.1	116.8	44.8	67.6	112.5	229.3
1981	56.6	18.4	11.3	86.3	36.3	67.3	103.6	189.9
1982	107.2	17.4	4.7	129.3	77.2	54.8	132.0	261.3
1983	43.3	10.4	1.5	55.2	24.3	9.7	34.0	89.2
1984	81.8	12.6	3.1	97.6	57.6	17.6	75.1	172.7
1985	13.7	10.1	2.5	26.3	6.9	6.8	13.7	39.9
1986	11.8	12.3	5.9	30.1	4.5	5.4	9.8	39.9
1987	20.1	12.6	7.9	40.6	16.8	18.3	35.1	75.7
1988	8.5	6.4	6.4	21.3	2.7	15.7	18.4	39.7
1989	8.6	9.4	11.9	29.9	4.4	16.9	21.2	51.1
1990	8.2	10.2	9.2	27.6	7.2	17.5	24.7	52.2
Limits[d]								
Lower	4.1	4.9	6.5	18.5	0.0	6.0	8.6	27.1
Upper	12.3	15.4	11.9	36.7	14.9	29.1	40.7	77.4
±%	50	52	29	33	108	66	65	48

[a]Carapace length (mm).
[b]Limited survey in 1971, not used for population estimate.
[c]1973 and 1974 estimates considered unreliable.
[d]Mean ± 2 standard errors for most recent year.

providing tag returns unbiased by factors associated with visible tags is clearly evident.

Implantable tags have been field-tested in several commercially-important crustaceans. The use of injected ferromagnetic or coded-wire tags in the snow crab, *Chionoecetes opilio* by Bailey and Dufour (1987) and the spot prawn, *Pandalus platyceros* by Prentice and Rensel (1977) has been tested with some success. Preliminary testing of PIT tags on small numbers of several other crustaceans, the dungeness crab, *Cancer magister* (Prentice 1986) and red king crab (W.E. Donaldson, Alaska Department of Fish and Game, Kodiak, personal communication) indicated that these tags were retained through molting and could be detected without sacrificing the tagged animal. This report describes testing and implementation of a tagging study using PIT tag technology with red king crabs on a large scale, in situ study.

TAGGING SURVEY

Methods and Procedures

Study Area

Because of logistical considerations, the study area was restricted to a 4,000 nm^2 (7,400 km^2) portion of Bering Sea red king crab habitat, located within four major commercial catch reporting in the Bristol Bay management area (Area T) (Figures 1 and 2). This area typically produced over one-half of the harvest of Bristol Bay red king crabs from 1985-1989 (ADF&G 1990). Additionally, roughly 70% of the legal male red king crab population was estimated to inhabit this area in 1990 (Stevens and MacIntosh, 1990).

Sampling Design

To maximize area and crab concentration covered, 75 sampling stations were identified for sampling in a systematic pattern (Figure 2). Each station consisted of 14, 7 ft x 7 ft (2.1 m x 2.1 m) commercial king crab pots set in a 1.625 nm (3 km) east-to-west line, approximately .125 nm (.2 km) apart. Stations were arrayed in groups of five with a north-south orientation. The distance between stations within an array was 3.0 nm (4.8 km) for a total length of 12 nm (19.4 km) for each array. A target soak time for each pot was set at 48 hours, with the exception of the pots in stations 1-5 where conditions would dictate a 24 hour soak time. Pots were baited with two quarts (1.9 L) frozen, chopped herring. When available, Pacific cod and sculpin were used as additional hanging bait.

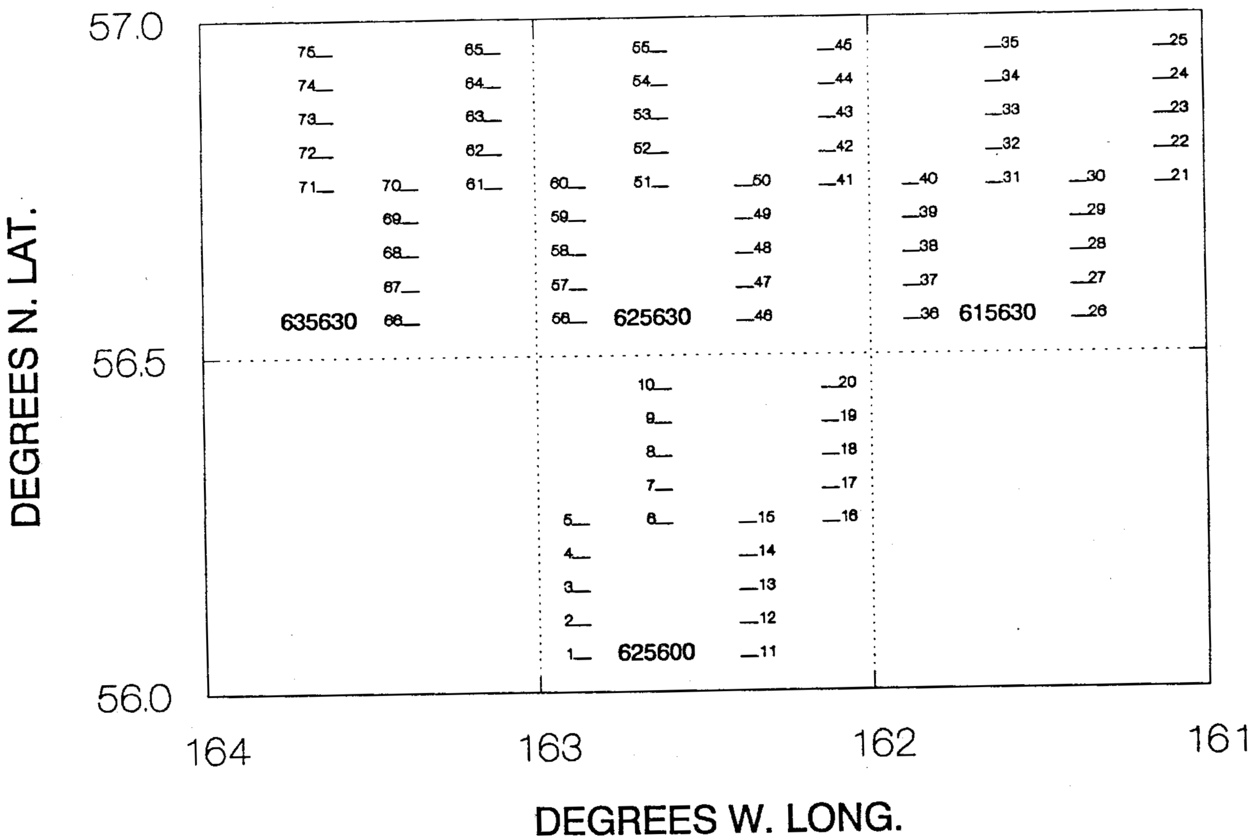

Figure 2. Layout of the 75 tagging stations in the 1990 Bristol Bay red king crab tagging study. Note that stations 21-25 were not sampled.

Catch Sampling

The contents of each sampled pot were unloaded onto a sorting table where the catch of king and Tanner crabs was sorted by species and sex and then transferred to a tagging/measuring table. Each sampled crab (including all tagged crabs) was measured to the nearest mm (carapace length or CL for red king crab; carapace width or CW for Tanner crab) and checked for shell condition. An additional, commercial measure of carapace width outside the lateral spines was made for males of both species to classify them as either legal or sub-legal size crab. Crab referred to as legal or sub-legal were defined by the commercial measurement. In instances where large numbers of Tanner crabs, sub-legal male red king crabs and female red king crabs were encountered, the catch was sub-sampled to allow additional deck time for tagging. Ovigerity information was recorded for all females examined. After each crab was measured and tagged, its PIT tag number was verified and stored in the reader by passing the scanning wand over the tagged area. Only healthy, non-injured crabs were tagged. Care was taken to tag crab in a gentle manner and to return them on station to the sea as quickly as possible.

Tagging Strategy

Approximately half of the sub-legal male red king crabs between 6 and 6.5 inches (152-165 mm) CW and half of the legal male crabs greater than 6.5 inches (165 mm) CW were to be retained for project cost recovery. The remaining half of those crabs were either to be PIT-tagged or dual-tagged with PIT tags and polyvinyl isthmus tags (or Floy tags) and released. Recovery of the PIT-tagged crabs was to be tested in processing plants using the portable detection-reader devices described below. The purpose of dual-tagging crabs was to monitor retention of the PIT tag by flagging the crab using a Floy tag.

Legal and sub-legal size crabs were to be tagged at a 1:1 ratio. A total of 2,500 legal male red king crabs were to be PIT-tagged; half of these crabs (1,250) were also to be Floy-tagged. Likewise, a total of 2,500 sub-legal male red king crabs were to be PIT-tagged and half of these crabs (1,250) would also receive a Floy tag. The purpose of tagging sub-legal crabs was to provide tag retention and recovery information from subsequent commercial fisheries. During tagging, every other PIT-tagged crab would receive a Floy tag. Tags were to be distributed in direct proportion to the density of crabs caught in each pot, i.e., all crabs that met the tagging criteria were tagged.

Tagging of legal size male Tanner crabs 5.5 inches (140 mm) CW using carapace dart tags was conducted on an opportunistic basis. Tag recovery results will be documented in a future report.

Tagging Equipment and Procedures

The tagging system, developed by Destron-Identification Devices, Inc.[1] consisted of TX1400L 125 kHz Passive Integrated Transponder tags 10 mm in length and 2.1 mm in diameter. The electronic components of the tag are encapsulated in a glass tube and are uniquely coded. The tag, when excited with an external power source provided by an HS5102L 125 kHz portable detector-reader, transmits its unique code which is then captured, displayed and stored by the reader. Tags were implanted into red king crab using a model I-300 automatic PIT tag injector developed by NMFS. For a complete technical description of the equipment and tag, refer to Prentice et al. (1990b).

The proximal segment of the fifth, right leg was chosen as the site for tag implantation. As this leg is not processed because of its small size the possibility of product contamination is avoided. The fifth leg normally remains attached to the abdomen of the crab and not broken during processing. The tagging needle was inserted through the articulation membrane and the tag released longitudinally into the leg muscle. Tag orientation within the leg is shown in Figure 3.

Results and Discussion

The tagging survey was conducted aboard the 128 ft (39 m) chartered crabber FV Kristen Gail from August 8-26, 1990. In addition to capturing crab for tagging, crab were also retained for sale to offset the cost of the project through the state's test fishery program. Approximately 9,700 male red king crabs 6 inches (152 mm) CW were sold. An additional 4,000 red king crabs and 1,500 *C. bairdi* Tanner crabs were landed as dead loss. Rough weather conditions and a lengthy holding time were the major factors contributing to the dead loss. Average weight per crab was calculated at 5.7 lb, as calculated from fish ticket receipts.

A total of 70 stations were fished; stations 21-25 were deleted due to sparse concentrations of crab and time constraints. Eleven of the 70 stations were fished with 7 pots only, which eliminated pots being set for obtaining crabs for sale in these stations. Pots used for obtaining crabs for tagging were set using identical spacing at all stations. A total of 906 pots were set and pulled during the tagging survey; 579 pots were sampled. Average soak time for each pot was 44.2 hours and ranged from 16.6 to 69.0 hours. The 150 crab pots used were not identical due to mesh size in one side panel of each pot. Fourteen pots examined had small mesh (3 inches, stretched mesh) and 95 pots had large mesh (5 inches, stretched mesh). The mesh size of the side panel in the remaining 41 pots was not recorded.

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[1]Reference to trade names does not imply endorsement by ADF&G.

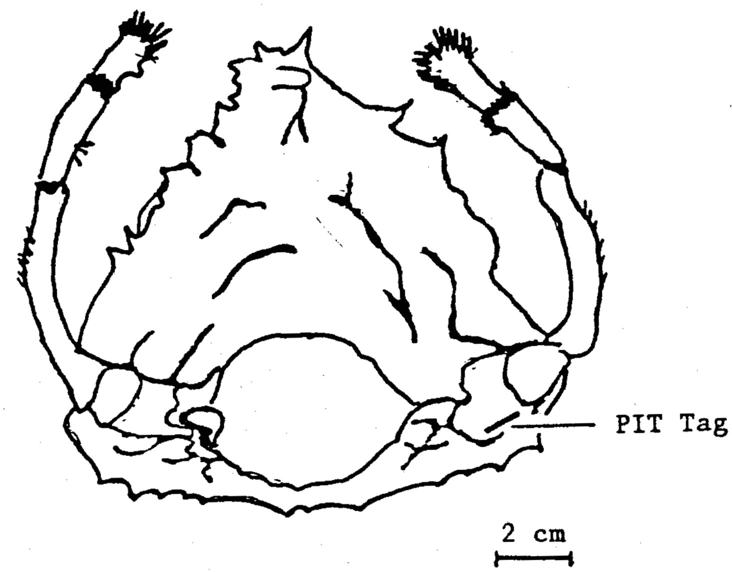

Figure 3. Ventral aspect of a red king crab abdomen showing the placement of the PIT tag in the proximal segment of the right, fifth leg.

Tagging Summary

A total of 6,750 male red king crabs were tagged, which exceeded the tagging goal by 1,750 crabs. Sampling goals were modified when it became apparent midway through the charter that a larger number of legal crabs could be marked, resulting in a legal to sub-legal tagging ratio of 2.3:1. Of the 4,722 legal-sized tagged crabs, 2,304 (or 48.8%) were PIT-tagged; the remaining 2,418 crabs (51.2%) were dual-tagged (PIT-Floy). Of the 2,028 sub-legal crabs tagged, 1,073 (or 52.9%) were PIT-tagged; the remaining 955 crabs (47.1%) were dual-tagged (Table 2). Distribution of PIT-tagged crabs and dual-tagged crabs is shown in Figure 4.

Catch and Length Data

A total of 24,194 red king crab were caught in the 579 sampled pots. Slightly under half (46.5%) were males; the remaining 53.5% were females. Average catch per pot of legal male red king crabs within stations ranged from 0.6 to 40.7 crabs per pot with an overall average of 9.2 crabs per pot for the survey (Figure 5). Red king crab catch by station is summarized in Appendix A.

Among all males, 71.7% were new shell crab and 28.3% were old shell crab. However, of the 5,329 legal-sized males caught, 41.1% were old shell crab, which is comparable to the 44.4% old shell crab as determined by the NMFS trawl survey (Stevens and MacIntosh 1990). Peak size modes for male red king crabs were noted at 85 mm and 135 mm. Peak size modes for females were noted at 85 mm and 115 mm. Comparisons of length data between the tagging survey and the NMFS trawl survey are only somewhat useful due to possible differences in the areas covered by these surveys. Blackburn et. al. (1990) found that the survey area affected size selection of crabs more so than gear type. Length frequency distributions for male and female red king crab are shown in Figures 6 and 7.

Of 8,581 *C. bairdi* Tanner crabs caught, most (96.2%) were males. Average catch per pot of legal male Tanner crabs within stations ranged from 0.4 to 56.6 crabs per pot with an overall average of 12.2 crabs per pot for the survey. *C. bairdi* Tanner crab catch by station is summarized in Appendix B.

Among all males, 85.9% were new shell crab and 14.1% were old shell crab. Of the 7,062 legal-sized males caught, most (92.2%) were new shell crab. A peak size mode for males was noted at 165-170 mm. Width frequency distributions for male and female Tanner crab are shown in Figures 8 and 9.

PIT TAG SEEDING EXPERIMENTS

Seeding experiments were conducted to test the detectability of PIT tags from butchered crabs under active processing conditions. The

Table 2. Number of tags released and recovered during the 1990 Bristol Bay mark-recapture study for legal (≥6.5 inches CW) and sub-legal (<6.5 inches CW) male red king crabs.

	Legal Crab		Sub-legal Crab	
Tag Class	No. Tagged	No. Recovered	No. Tagged	No. Recovered
PIT Tag	2,304	33	1,073	1
PIT Tag and Floy Tag	2,418	249	955	24

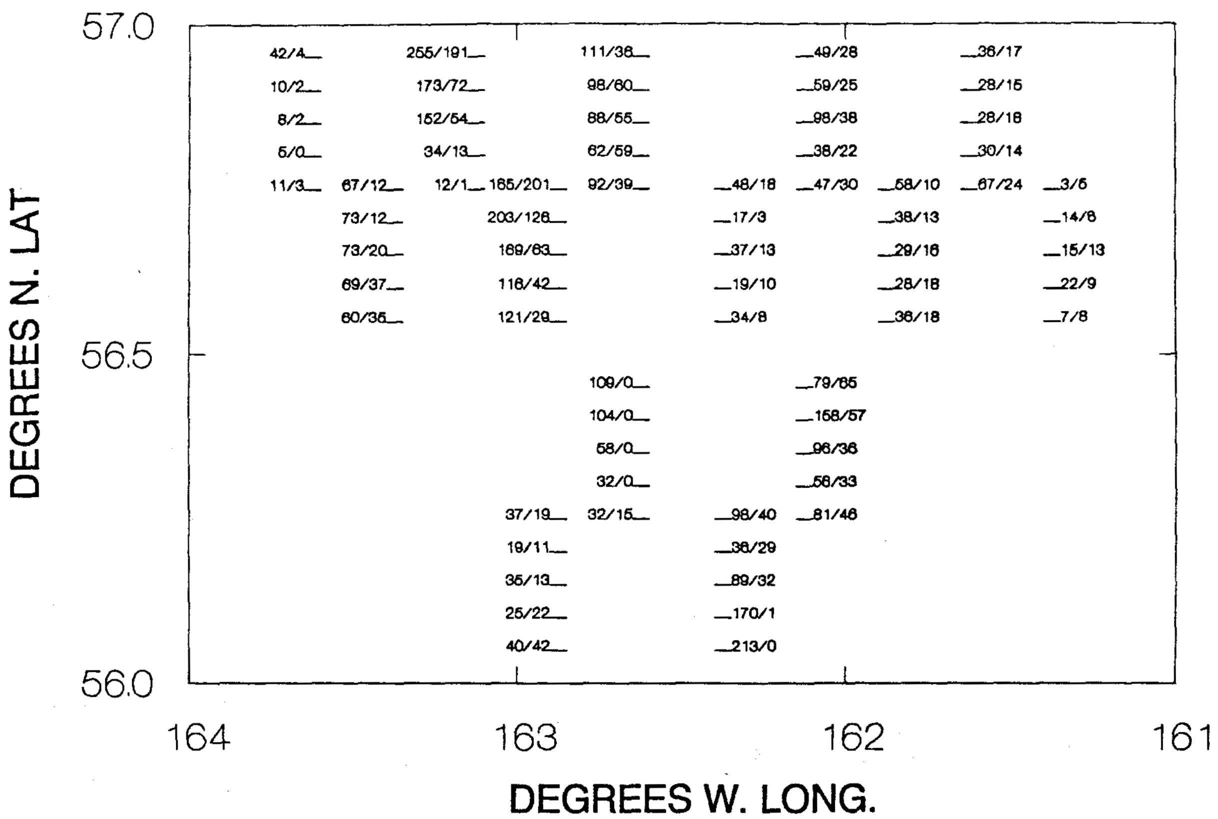

Figure 4. Distribution of PIT tagging effort (number of legal males/number of sub-legal males), by station and statistical area for the 1990 Bristol Bay red king crab tagging study.

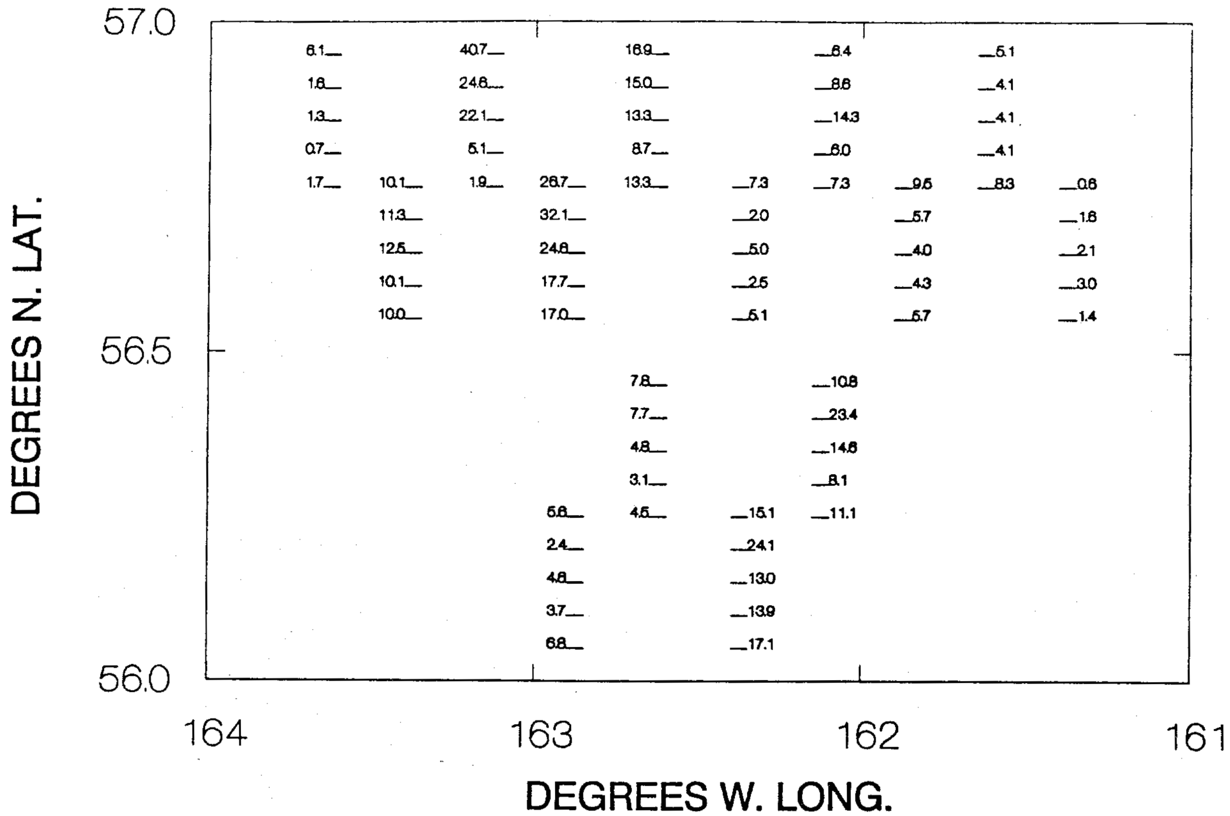

Figure 5. Average catch per pot of legal male red king crabs at 70 stations sampled during the 1990 Bristol Bay red king crab tagging study.

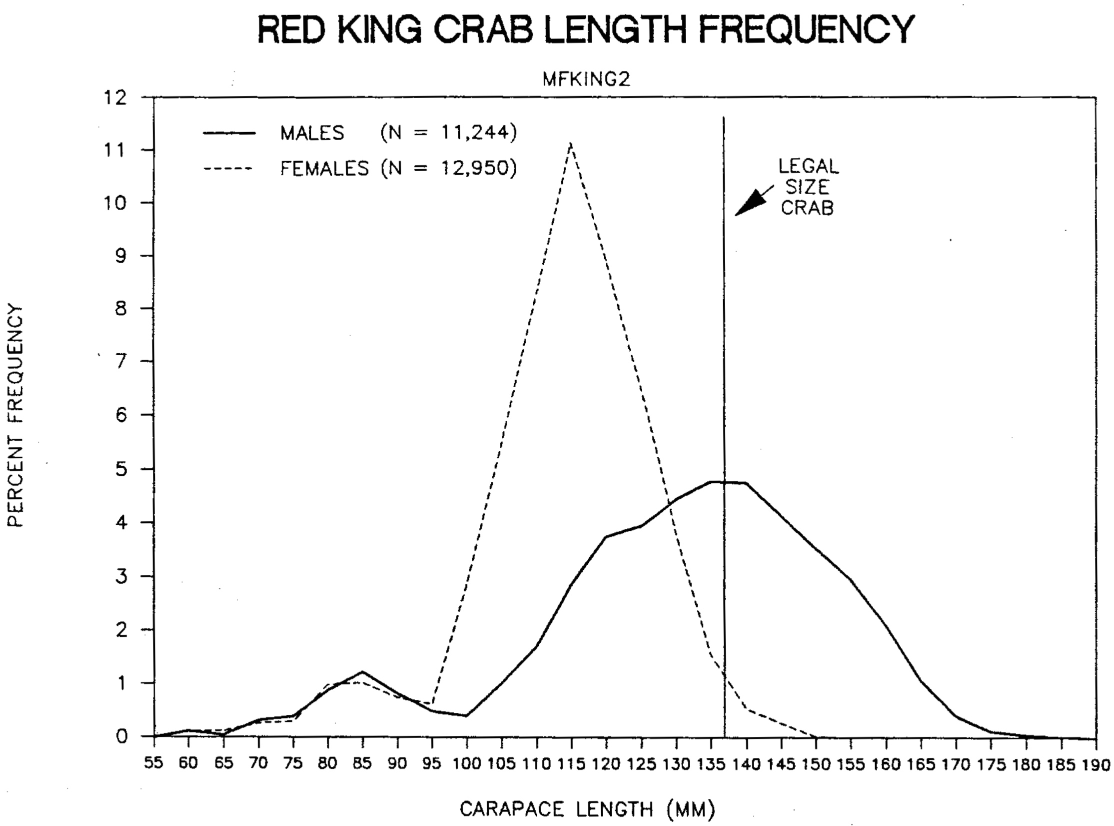

Figure 6. Length frequency of male and female red king crabs from the 1990 Bristol Bay tagging study, by 5 mm length classes.

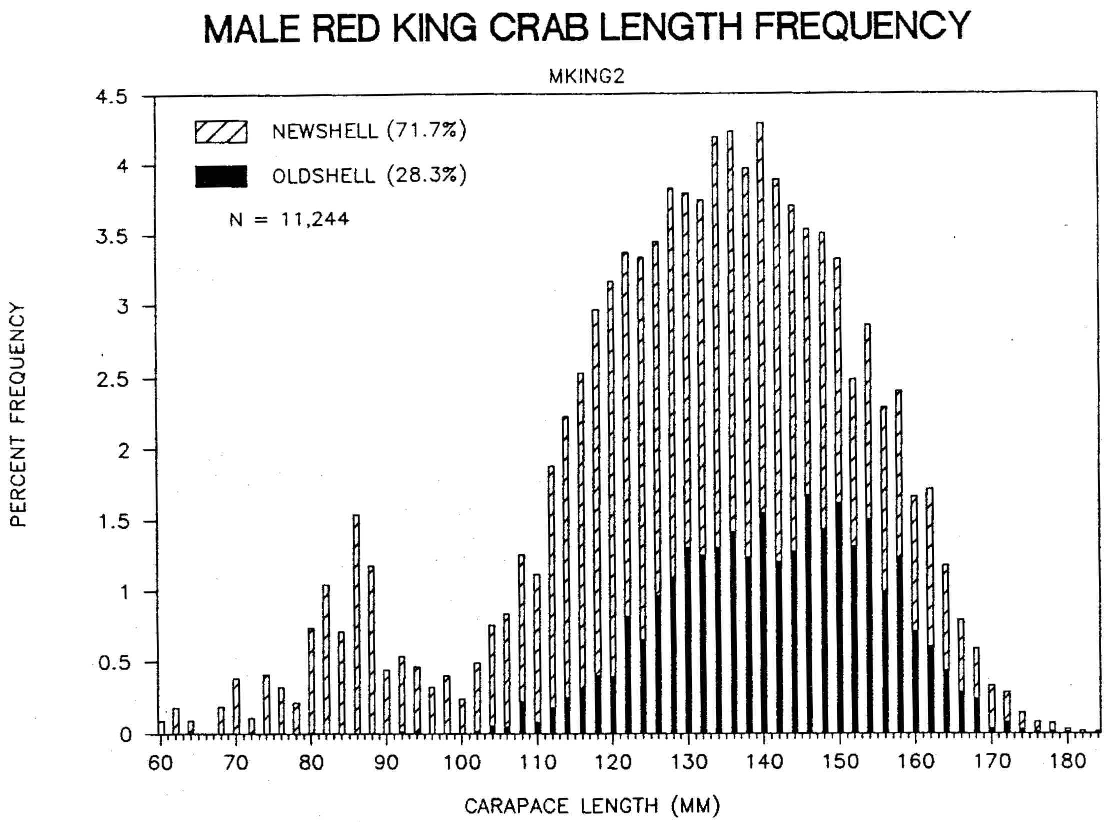

Figure 7. Shell condition of male red king crabs from the 1990 Bristol Bay tagging study, by 2 mm length classes.

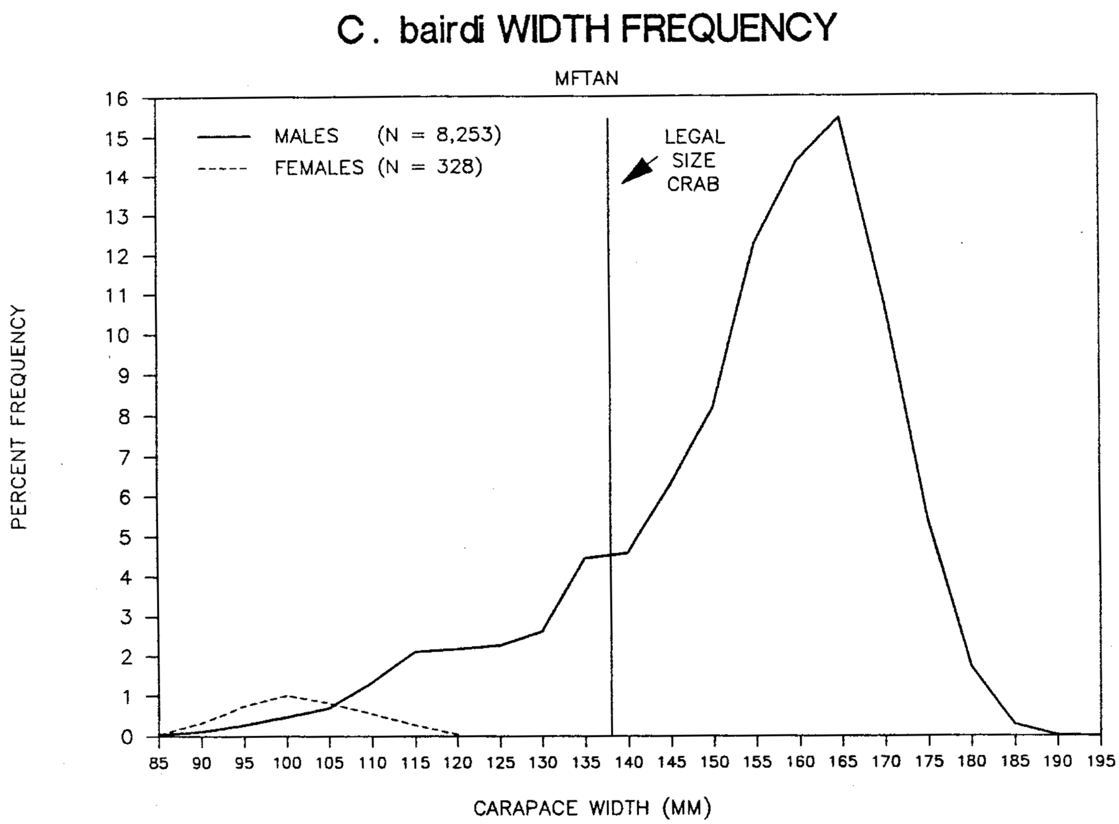

Figure 8. Width frequency of male and female *C. bairdi* Tanner crabs from the 1990 Bristol Bay tagging study, by 5 mm width classes.

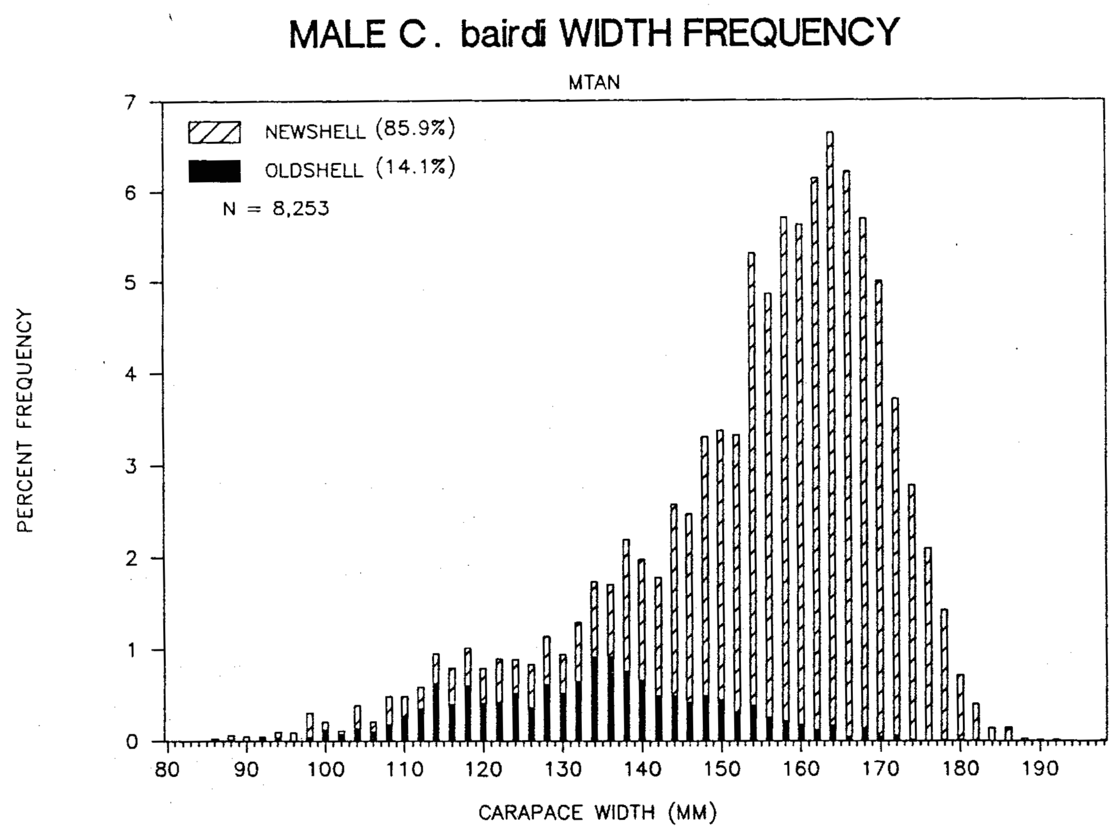

Figure 9. Shell condition of male *C. bairdi* Tanner crabs from the 1990 Bristol Bay tagging study, by 2 mm width classes.

first seeding experiment was performed in August 1990 in conjunction with the delivery for sale of crab retained from the tagging survey. Five days prior to delivery, 75 PIT-tagged crabs and 24 dual-tagged (Floy and PIT tags) crabs were added to approximately 7,000 red king crabs in a single tank of the FV Kristen Gail. Roughly 1,500 more crabs were added after the seeding.

Of the 8,500 crabs aboard at the time of delivery, approximately 4,000 crabs died prior to processing. Tail sections of the remaining 4,500 processed crabs were scanned for PIT tags by two ADF&G tag samplers. The processing crew was instructed to look for Floy tags and to bring live crabs with floy tags to the two ADF&G tag samplers. Fifty-nine PIT tags from the 75 PIT-tagged crabs were detected for a detection rate of 79%. Given the high rate (over 45%) of dead loss in this landing, which may have included seeded crabs, the 79% detection rate should be considered a minimum estimate of the true rate of PIT tag detection during this seed recovery trial. Beyond that, it is difficult to make generalized inferences about PIT tag detection rates based on the detection rate observed in this trial. Though the dead loss among seeded crabs is unknown, it is notable that of the 24 dual-tagged crabs, 23 (96%) were accounted for amongst the processed crabs either as whole crabs with Floy tags attached, as unattached Floy tags, or as PIT tags in the tail sections of processed crabs. 18 of the dual-tagged crabs were recovered alive from the processing crew and 17 of the 18 (94%) still had PIT tags detectable in their tail sections.

During the processing of the commercial catch in November 1990 another series of seeding experiments were conducted at the four processors in Dutch Harbor where ADF&G tag recovery crews worked. 852 live crabs were tagged with PIT tags and seeded into the landings of 12 vessels that totaled 180,000 live crabs. At least one seeding trial was performed at each of the four processors and each of the 15 ADF&G tag samplers was a subject at least once in a seed recovery trial. The landings of vessels that were seeded ranged in size from 5,000 to 21,000 live crabs.

Beyond insuring coverage of all participating Dutch Harbor processors and all ADF&G tag samplers, the actual seeding of tagged crabs into landings was performed opportunistically. Landings were seeded with anywhere from 49 to 148 PIT-tagged crabs independent of the size of the landing. PIT-tagged crabs were seeded variously into vessel holds, brailers, and hoppers. Because of the opportunistic nature of the seeding, it was not possible to randomly distribute the seeded crabs throughout a landing. Instead, seeded crab were distributed unevenly amongst landed crabs in clusters of varying size. Occasionally, for example, all seeded crabs were concentrated into one or a few brailers and hoppers. The seeding procedure was not consistent across trials and the clustering of seeded crabs varied among the seeding trials. Hence, the results of the seeding trials cannot be considered comparable across trials.

Sampling of processed crabs for detection of seeded PIT tags was conducted concurrent with the in-season tag recovery program. The number of tails that were scanned for PIT tags from the 12 seeded landings varied from 40% to 80% of the number of landed crabs. As well as variation in sampling rates among vessel landings, it should be noted that the sampling rate on an individual vessel landing was never constant over time due to varying rates at which crab tails were made available for sampling. The rate at which tail sections were made available for sampling was largely out of the control of the PIT tag recovery crew. As a result of the variable sampling rate, the crabs in different vessel holds, different brailers, and different hoppers for a single landing were sampled at different rates.

The percentage of seeded PIT tags detected in the landings ranged from 12% to 51%. The detection rate of PIT tags, however, did not show the expected positive relationship with sampling effort; i.e., vessels that had a higher proportion of their landing sampled did not tend to have a higher proportion of seeded PIT tags detected. Because of the problems associated with the seedings described above, there is no way to account for variation in the PIT detection rates among trials or to determine reliable estimates of the detectability of PIT tags in the processing line from the seeding trial data. The variation among vessels in the observed detection rates of seeded PIT tags among vessel landings may largely reflect variation in the seeding procedure.

TAG RECOVERY EFFORT

Methods and Procedures

Sampling Goals

Sampling was to commence when processing began following the opening of the Bristol Bay red king crab fishery on November 1, 1990. A sample size of approximately 50% of the projected 17.1 million pound guideline harvest was desired. Using the 1989 commercial fishery average weight of 6 lb per crab (ADF&G 1990), a total of 1.4 million crabs were to be sampled. Ten processing plants (7 shore-based and 3 at-sea) were pre-selected for tag recovery sampling to achieve this goal.

News releases were issued and meetings held soliciting the aid of affected processors and fishermen in the tag recovery effort. Industry was notified that tagging information from the study would not be used to adjust the current season. Prior to the November fishery, individual processors were contacted to ascertain suitable sampling sites within the plant. Upon capture of tagged, legal-sized crab, fishermen were instructed to leave the Floy tag on the crab, record the capture date and location, and notify ADF&G upon delivery of the tagged crab for subsequent sampling.

Catch Sampling

Each tag sampler was equipped with a portable detector-reader and positioned on processing lines where they had access to abdominal (or 'tail') sections containing the fifth, right leg. Each sampler scanned crab tails for 12 hours per shift, noting the number of tails scanned per vessel and any equipment problems. Portable, rechargeable 12-volt batteries were used during tag recovery to ensure a continuous power supply. The scanning wand of the portable reader was passed either directly on or within 2 inches (5 cm) of the tag-bearing leg segment. If a PIT tag was present the unit would automatically store the tag number. Samplers were instructed to document all Floy tag returns through skipper interviews and to scan all Floy-tagged crabs for the presence of PIT tags prior to butchering. Additional Floy tag returns were obtained through at-sea observers and dock-side samplers. At the end of each shift, data from each portable reader was down-loaded to a computer for retrieval of any PIT tag numbers detected during sampling. All PIT-tagged legs recovered were frozen for future dissection and examination.

Butchered tail sections of crabs were grossly examined on an ad hoc basis for a microsporidian infestation commonly referred to as "cottage cheese disease". A total of 54 tail sections were noted as having the infestation; samples were collected for later analysis.

Results and Discussion

Tag Returns

Tag recovery was accomplished from November 8-18, 1990 during the Bristol Bay red king crab fishery. Fifteen tag recovery personnel were stationed at 7 shore-based processors in the Dutch Harbor, Akutan and King Cove areas; three tag recovery personnel were placed aboard 3 at-sea floating processors in the Port Moller area. A total of 385.7 thousand crabs (12.4%) were sampled for PIT tags from 3.1 million crabs harvested during the November fishery (ADF&G 1991). A total of 34 PIT tags were detected; 33 from legal-sized crabs and one from a sub-legal crab. A total of 273 dual-tagged crabs were accounted for (249 from legal crabs and 24 from sub-legal crabs)(Table 2). For the remainder of this report, results and discussion will focus on tag returns from legal crabs only.

PIT Tag Retention. Two-thirds of the 249 dual-tagged crabs were available for scanning for the presence of PIT tags. One hundred thirty-eight of 145 PIT tags (95.2%) were retained in the crab during the 90-day period from the August tagging survey to the November tag recovery effort (Figure 10). Though this rate is slightly less than PIT tag retention rates documented in salmonids

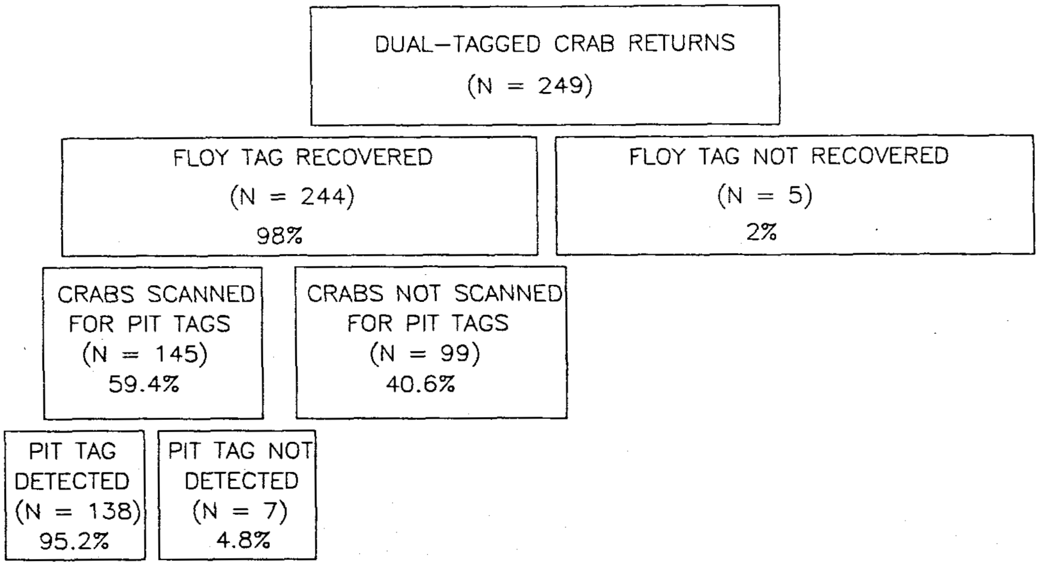

Figure 10. Recovery of Floy tags and detection of PIT tags from the 249 dual-tagged crab returns.

(range 98.5-100%) (Prentice et al. 1990a), it is similar to the retention rate (96.4%) of coded-wire tags in snow crab observed by Bailey and Dufour (1987). Since this field experiment was conducted outside of the molting season, a full evaluation of retention through a molt is premature. However, all females that were tagged and molted during initial testing retained their tags (W.E. Donaldson, Alaska Department of Fish and Game, Kodiak, personal communication).

Sources of Tag Loss. Two of the seven PIT tags that were not detected were known to have been lost through butchering either from severing of the tagged leg segment or removal of the flesh from the tagged leg. The causes of tag loss of the other five PIT tags that were not detected is unknown.

Five dual-tagged crabs were identified only through PIT tag scanning, with the corresponding Floy tags never recovered. Visible tags can be lost at sea through natural mortality or death due to tagging itself. Subsequent to capture, tags may be lost in vessel holds, within processing plants or at other points within the capture-processing chain. Additionally, tags may be recovered and not reported by fishermen and processing workers. Data collected from this study does not indicate the degree to which fishermen and processing workers do not participate in visible tag return programs.

Comparison of PIT Tag and Floy Tag Recoveries. Thirty-three PIT tags were recovered from the 95 vessels whose landings were scanned for PIT tags[2]. This compares to the recovery of 116 Floy tags from those same vessels. Since, pot-by-pot, the number of legal crabs tagged with Floy tags was roughly equal to the number tagged with PIT tags only, we would expect (assuming no differential mortality, movement, or tag loss rates between dual-tagged crabs and crabs tagged only with PIT tags) that the number of Floy-tagged crabs and the number of crabs tagged only with PIT tags would be roughly equal in the commercial landings. Differences in numbers of recoveries per unit effort between the two tag types would indicate either differences in detectability between tag types, or a departure from the expected 1:1 ratio in the commercial landings of Floy-tagged crabs to crabs tagged only with PIT tags.

Recovery per unit effort for PIT tags was measured as the number of PIT tags recovered per 100 thousand tail sections scanned. Recovery per unit effort for Floy tags was measured as the number of Floy tags recovered per 100 thousand processed crab. We used the number of processed crabs as the unit of effort for Floy tag recoveries because use of visible tags assumes that a tag on a

[2]Throughout this section, when referring to PIT tags, we mean PIT tags from crabs that were tagged with PIT tags only. We are not considering PIT tags from dual-tagged crabs in this section.

handled crab will be detected and because each processed crab is handled individually at least once by a butcher. To maintain comparability of results, we used only the landings from vessels that were scanned for PIT tags in our comparison. From those 95 vessels, 1.3 million live crab were processed and 386 thousand tails were scanned. With 116 Floy tags and 33 PIT tags recovered from the 95 vessels, the resulting rates were 8.9 Floy tags recovered per 100 thousand processed crabs to 8.5 PIT tags recovered per 100 thousand scanned tails.

When originally deciding to implement a tagging program using PIT tags, we assumed that this newer technology would be at least as efficient in providing recoveries per unit of effort as the historically-used Floy tags. We tested the statistical significance of the observed difference in recovery per unit effort as follows. Letting P_{PIT} denote the probability that a scanned tail results in a PIT tag detection and P_{Floy} denote the probability that a processed crab has a Floy tag recovered from it, we tested the null hypothesis,

$$H_0 : P_{PIT} = P_{Floy} ,$$

versus the alternative hypothesis,

$$H_A : P_{PIT} < P_{Floy} .$$

Rather than pooling all the data from the 95 vessels' landings into a single 2 X 2 contingency table, the test was performed as if comparing a binary response to two treatments with the data arranged in 95 separate 2 X 2 contingency tables (Cox and Snell, 1989, pp. 4-5 and 56-58). This is treating the data as if from a matched pair experimental design in which the recoveries of PIT tags is compared to that of Floy tags on a vessel-by-vessel basis. Under the assumption that the null hypothesis, H_0, is true, the expected number of PIT tag recoveries is 34.154 with a variance of 4.878. The standardized deviate, corrected for continuity, is (34.154-33.5)/4.878=0.13. Using the asymptotic normal approximation, the P-value for the test is 0.45, leading to retention of the null hypothesis. In summary, although the observed recovery per unit effort for Floy tags from the 95 vessels' landings was slightly greater than that for PIT tags, the difference is so slight as to be easily attributable to chance[3].

[3]Note that since 2,418 legal crabs were tagged with Floy tags while 2,304 were tagged only with PIT tags, the null hypothesis should set P_{PIT} to be at least 95% (=2,304/2,418) of P_{Floy}. Thus, the null and alternative hypotheses, H_0 and H_A, as formulated for the test slightly favor the recovery per effort of Floy tags over that of PIT tags. Failure to reject H_A in the test as formulated implies failure to reject the alternative to the stricter null hypothesis stated here.

Effects of Monitoring Tag Recoveries. The level of ADF&G presence varied within the commercial fleet and among processing sites. Mandatory observers were present on all catcher-processor vessels, while there were no observers on catcher vessels. Processing plants that were PIT tag recovery sites had at least one ADF&G tag recovery representative present 24 hours a day, while at other processing plants the ADF&G activity was intermittent. We wished to determine if increased presence of ADF&G representatives increased the number of Floy tags recovered per unit effort. This was performed by comparing the number of Floy tags recovered per 100 thousand processed crabs among three classes of vessel landings: those from catcher-processor vessels, those from catcher vessels that were sampled for PIT tags, and those from catcher vessels that were not sampled for PIT tags.

The number of Floy tags recovered per 100 thousand crabs processed is compared across the three classes of landings in Table 3. A chi-square test indicates that real differences exist among the three classes of landings (chi-square=17.98, for 2 d.f. P=0.0001). The greatest difference in Floy tags recovered per 100 thousand processed crabs existed between the landings of catcher vessels that were scanned for PIT tags and of catcher vessels that were not scanned for PIT tags. By comparing these two classes of landings, we can estimate the relative increase in probability of a Floy tag recovery that results from the presence of ADF&G tag recovery representatives at processing plants. An approximate 95% confidence interval for the ratio of the probabilities (Cox and Snell, 1989, pp 49-51) indicates that Floy tags recoveries from commercial landings are 1.4 to 2.6 times likelier in the active presence of ADF&G tag recovery representatives at the processing site than in their absence.

Movement of Crabs. Reliable recovery location data was provided by fishing vessel captains for 93 of the recovered Floy tagged legal crabs. An additional 11 recovery locations were not considered reliable due to obvious errors in data recording or imprecision in recorded location. When coupled with the tag release location, the recovery location can be used to determine the net movements of these crabs from the mid-August time of tagging to the early November commercial fishery season. However, general inferences about the movements of legal red king crabs in Bristol Bay based on these data should only be made with great caution. The tag release locations were not a random sample of Bristol Bay legal red king crab locations in August and the 93 recovery locations cannot be considered a random sample from the early November locations of extant Floy tagged crabs. The results reported here should be considered entirely descriptive and reflecting the movements from systematically determined release locations to recovery locations systematically determined by the geographic distribution of the commercial fishing fleet.

The 93 crabs showed a general movement towards the southwest. The mean vector of net movement from release location was 8.0 nm to the

Table 3. Comparison of Floy tags recovered per 100,000 red king crabs processed among three classes of landings during the November 1990 Bristol Bay commercial fishery.

Landing Category	Number of processed crabs (millions)	Number of Floy tags recovered	Floy Tags per 100,000 processed crabs
Catcher-processor vessels	0.42	34	8.0
Catcher vessels sampled for PIT tags	1.30	116	8.9
Catcher vessels not sampled for PIT tags	1.38	65	4.7
All vessels	3.10	215	6.9

south and 13.3 nm to the west (Table 4). Net distance of travel tended to be greater along the longitudinal axis than along the latitudinal axis. The net distance traveled had a maximum of 62.9 nm and a mean of 23.0 nm. Direction and distance of net travel varied substantially, however, and the net distance traveled south was only slightly correlated (r=0.19) with net distance traveled west (Figure 11). Crabs released at more northern latitudes tended to have a greater net distance traveled south, while those released at more eastern longitudes tended to have a greater net distance traveled west (Figure 12).

The general southwest movement of the 93 crabs does not seem to reflect an overall southwestward migration of Bristol Bay legal red king crabs as much as it reflects the geographic distribution of commercial fishing relative to the tag release locations.

Sampling Efficiency

The total number of tail sections scanned (12.4%) fell far short of the expected (50%). Prior to the November sampling, we anticipated a constant supply of tail sections which resulted in an over-estimation of the total number of tails that could be scanned during the fishery. Although PIT tag sampling was hindered by a number of factors, the most important was the lack of access to tail sections. We could not sample at several plants in Dutch Harbor because of space limitations or because crab were being processed whole. Additionally, within the plants tail sections were observed in waste chutes and on processing floors that were not scanned. The intense nature of this fishery (approximately 3.1 million crabs landed in a 10 day period) shortened the sampling window of opportunity considerably. In most cases, we could have sampled more tails had they been available. The labor-intensive nature of the sampling also hampered scanning efforts even though several plants assigned personnel to help us sample. At times, having one or two samplers installed within processing lines had a major effect on processing at several plants.

Another factor related to sampling efficiency was the variability in sampling intensity at each of the 10 sampled plants. For example, while almost 20% (291 thousand) of the total crabs available for sampling at the 10 selected plants were landed to a single plant, only about 8% (22 thousand) of the tail sections were scanned. Conversely, at a plant where less than 2% (25 thousand) of the total crabs were available for sampling, about 28% (7 thousand) of the tail sections were scanned. Overall, we were able to scan 25% (386 thousand) of the 1,527 thousand crabs available for scanning at the 10 sampling sites. Variability of sampling intensity at the 10 sites is summarized in Figure 13.

Table 4. Net movements of tagged red king crabs released in mid-August 1990 and recovered in the commercial fishery during November 1990 summarized by direction and axis, in nautical miles.

	Direction		Axis		
	North	West	Latitude	Longitude	Total
Minimum	-41	-19	0	0	3
Maximum	27	61	41	61	63
Mean	-8.0	13.3	12.4	16.4	23.0
Median	-9	11	12	12	22
Standard Deviation	12.6	16.9	8.3	13.9	12.4

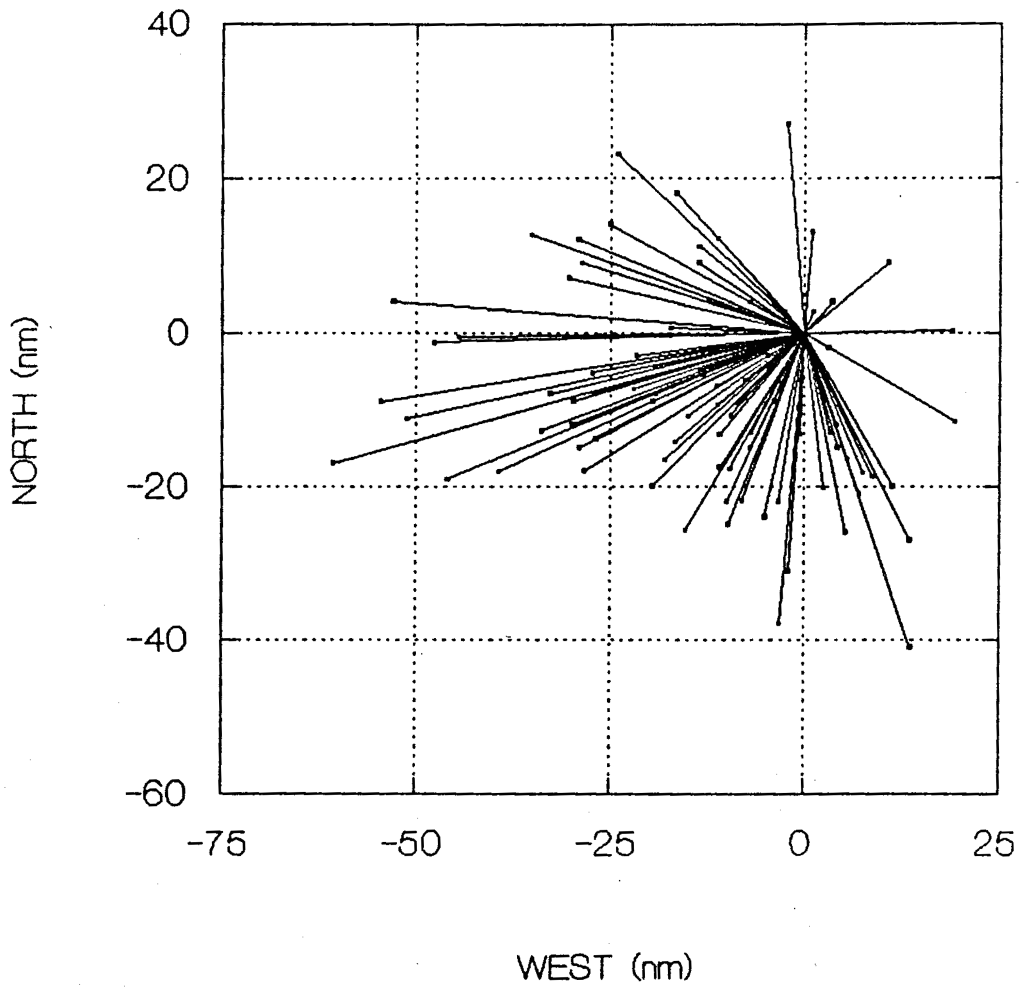

Figure 11. Distance and direction of travel of 93 Floy-tagged legal male red king crabs recovered during the 1990 Bristol Bay fishery.

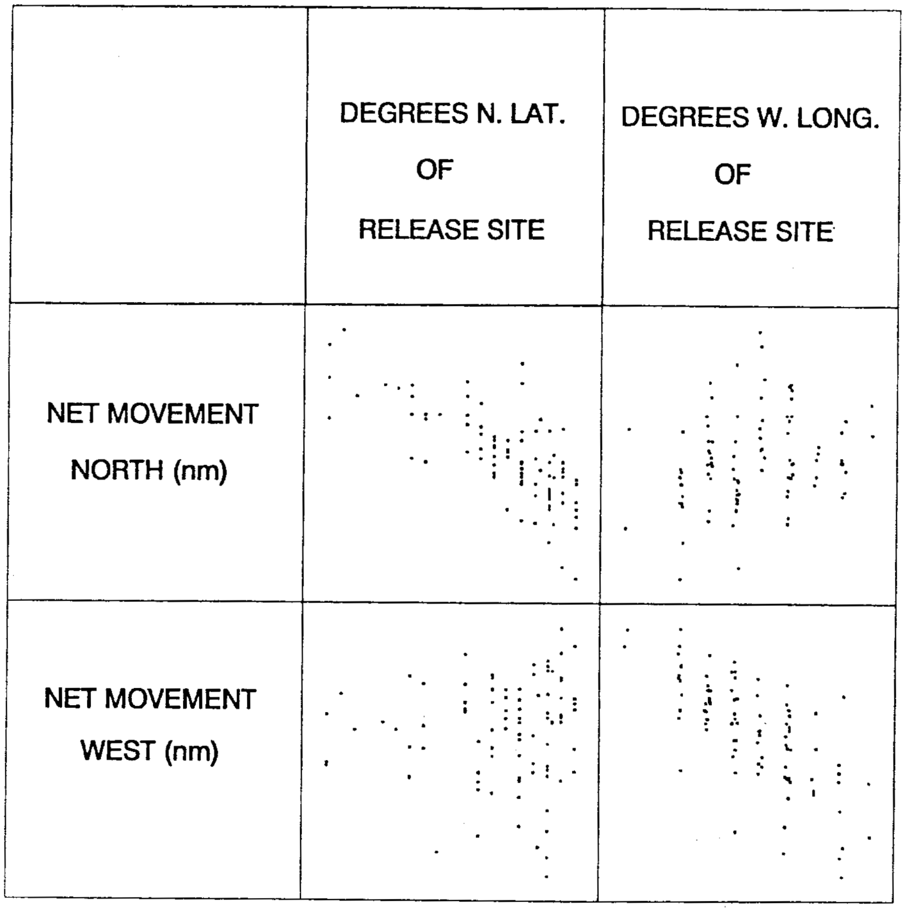

Figure 12. Net movements of 93 Floy-tagged legal male red king crabs recovered during the 1990 Bristol Bay fishery.

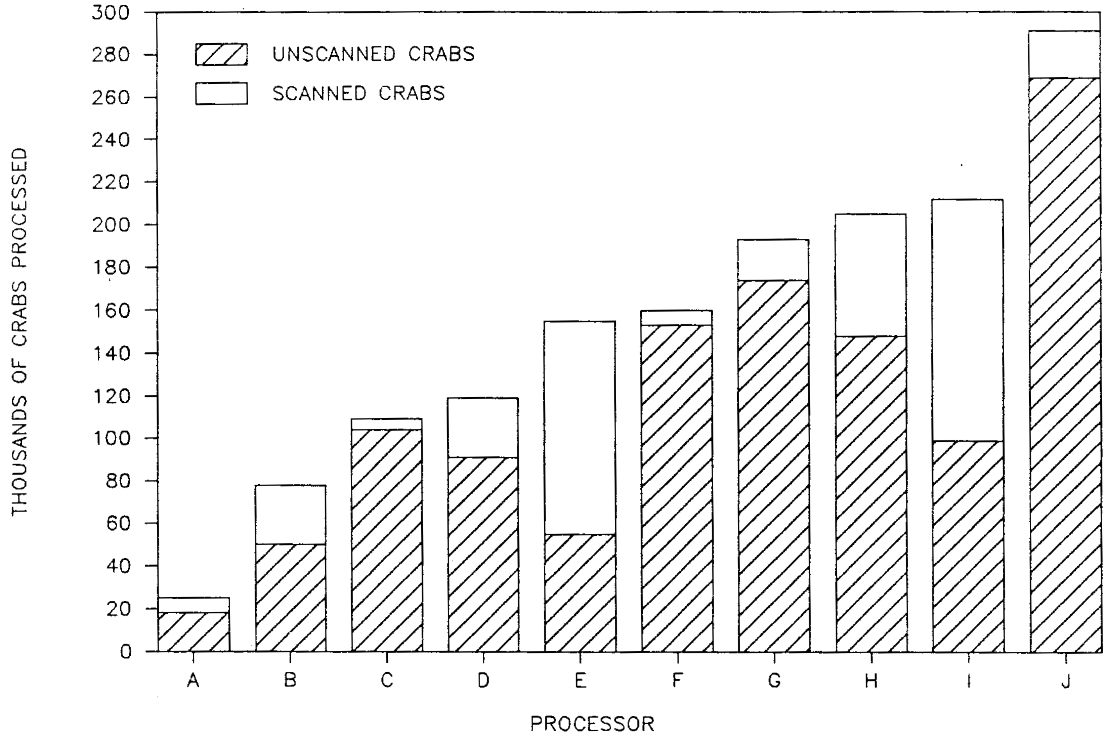

Figure 13. Variability of sampling intensity at each of the 10 processing sites sampled during the 1990 Bristol Bay red king crab tagging study.

Equipment Performance

The 10 mm PIT tags recovered from whole and butchered crab showed no apparent sign of damage. The portable detector-readers were fairly reliable in the wet environment encountered during both tag and recovery operations. Portable readers and scanning wands were enclosed in plastic freezer bags secured with duct tape in an effort to make them water-resistent. However, ambient moisture was a problem in some of the wands; the degree to which this hampered PIT tag detection is unknown. Tag samplers tested their equipment frequently; when they could not detect their test PIT numbers, their wands were repaired or replaced. As the wand-to-tag distance could be no greater than 2 inches in order for the reader to detect a tag, tag samplers had to insure that their scanning technique met this criteria. The automatic PIT tag injector was reliable as long as care was taken to occasionally clean the breach of the injector which would tend to foul with coagulated blood. When this occurred, tags would jam and break.

CONCLUSIONS AND RECOMMENDATIONS

1. PIT tags are retained in red king crabs at a high level and are durable and recoverable over a 90-day period. The high rate of retention is attributable to the location of the tag in the proximal segment of the fifth leg, a site which affords maximum protection against loss of the tagged leg. Additionally, since the electronic components of the tag have an estimated life expectancy of over 10 years (Prentice et al. 1990a), and the tag apparently did not promote infection in the surrounding tissue, the use of PIT tags in this application was found to be quite feasible.

2. The recovery rate of PIT tags was comparable to the recovery rate of Floy tags, indicating that a non-visible tag can provide results commensurate with traditional visible tags. The recovery of visible tags is influenced by the presence or absence of tag samplers, a factor which does not affect PIT tag recovery. Once the technical aspects of PIT tag detection are resolved, the reliability of PIT tag returns will likely far exceed that of Floy tag returns.

3. Sampling of crab tail sections must be automated in future studies to provide a larger overall sample size, thereby eliminating the very labor-intensive effort mounted in the study. Development of trough (or flatbed) scanners to be installed in the waste chutes of processing lines is in progress. Concomitant with the automated detectors, a larger (18 mm) tag will be used in future studies to increase the effective scanning distance from 2 inches or less to 5 inches or more.

4. Data from this study provides useful insights into estimating overall PIT tag loss rates from the time of tagging through the processing of the crabs. However, precise estimates of PIT tag loss rates at different stages of this process are not obtainable from this study. Since we could not estimate tag loss rates, an independent evaluation of the current year exploitation rate of Bristol Bay legal male red king crabs was not possible. Random seeding experiments designed to identify sources of tag loss and the extent of tag loss at each source should be initiated prior to in-season sampling in all future studies.

This study was the initial step towards refining our understanding of red king crab population abundances and other aspects of crab population dynamics. Results from the study may aid interpretation of historic tag recovery data obtained from visible tags. The recommendations outlined above will be implemented in the upcoming August 1991 study. Additionally, survey efforts will be expanded into other portions of the Bering Sea and Aleutian Islands fishery management areas.

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APPENDICES

Appendix A. Summary data from the 1990 Bristol Bay tagging survey where red king crabs were taken.

Sta-tion	Date	Lat	Long	Loran C	Depth (FMS)	No. Pots Sampled	Females	Males <110 CM	Males 110-134 CM	Males >134 CM	Males Total	Males Average Catch/Pot Of Legals (>134 CM)
1	8/9	56 3	162 52	472273 339992	44	14	264	28	178	95	301	24.0
2	8/9	56 6	162 51	472218 339846	44	14	77	6	92	52	150	3.7
3	8/10	56 9	162 52	472264 339739	45	14	90	31	145	65	241	4.6
4	8/10	56 12	162 52	472275 339613	44	14	76	3	41	34	78	2.4
5	8/10	56 15	162 52	472263 339477	45	14	4	3	60	78	141	5.6
6	8/10	56 15	162 37	471272 339678	42	14	335	8	77	63	148	4.5
7	8/10	56 18	162 37	471284 338952	43	13	86	8	30	40	78	3.1
8	8/10	56 21	162 37	471287 338818	43	14	123	6	42	67	115	4.8
9	8/11	56 24	162 37	471290 338682	42	14	179	6	52	108	166	7.7
10	8/11	56 27	162 37	471256 338530	41	15	240	36	123	117	276	7.8
11	8/11	56 3	162 22	470291 339203	41	14	1216	14	208	239	461	17.1
12	8/12	56 6	162 22	470293 339075	40	14	2921	30	208	194	432	13.9
13	8/12	56 9	162 23	470318 338960	41	7	551	12	58	91	161	13.0
14	8/12	56 12	162 22	470301 338825	38	7	491	22	166	169	357	24.1
15	8/12	56 15	162 22	470301 338693	41	7	143	11	59	106	176	15.1
16	8/13	56 15	162 8	469323 338310	42	8	613	10	75	89	174	11.1
17	8/13	56 18	162 7	469283 338162	44	7	415	5	53	57	115	8.1
18	8/13	56 21	162 7	469273 338021	40	7	248	7	54	102	163	14.6
19	8/13	56 24	162 6	469266 337886	47	7	154	5	78	164	247	23.4
20	8/13	56 27	162 7	469273 337749	38	8	530	234	113	86	433	10.8
26	8/15	56 33	161 22	466266 336324	39	7	43	2	7	10	19	1.4
27	8/15	56 36	161 22	466241 336169	36	7	205	5	16	21	42	3.0
28	8/15	56 39	161 22	466242 336028	36	7	78	5	16	15	36	2.1
29	8/15	56 42	161 22	466211 335873	42	8	59	2	8	13	23	1.6
30	8/15	56 45	161 22	466207 335722	40	7	112	71	7	4	82	0.6
31	8/17	56 45	161 37	467219 336100	38	8	369	123	65	66	254	8.3
32	8/17	56 48	161 37	467184 335938	43	7	10	9	23	29	61	4.1
33	8/16	56 51	161 37	467194 335792	41	7	20	3	25	29	57	4.1
34	8/16	56 54	161 37	467189 335636	38	7	50	4	25	29	58	4.1
35	8/16	56 57	161 38	467200 335484	37	7	22	7	22	36	65	5.1
36	8/14	56 33	161 52	466262 337078	43	7	122	6	25	40	71	5.7
37	8/14	56 36	161 52	468246 336928	37	7	765	19	38	30	87	4.3
38	8/14	56 39	161 52	468253 336787	43	7	97	8	28	28	64	4.0
39	8/14	56 42	161 52	468237 336631	43	7	109	123	16	40	179	5.7
40	8/14	56 45	161 52	468196 336469	43	6	31	4	15	57	76	9.5
41	8/18	56 45	162 7	469236 336871	37	7	46	8	35	51	94	7.3
42	8/18	56 48	162 7	469193 336702	39	7	70	29	32	42	103	6.0
43	8/18	56 51	162 7	469204 336555	39	7	31	40	75	100	215	14.3
44	8/18	56 54	162 7	469202 336397	37	7	62	193	99	60	352	8.6
45	8/18	56 57	162 8	469220 336248	33	8	410	22	55	51	128	6.4
46	8/19	56 33	162 22	470237 337843	40	7	31	5	19	36	60	5.1
47	8/19	56 36	162 22	470236 337708	40	8	16	2	18	20	40	2.5
48	8/19	56 39	162 22	470233 337553	37	7	14	7	28	35	70	5.0
49	8/19	56 42	162 22	470258 337419	38	8	7	15	14	16	45	2.0

-Continued-

								Males				
Sta-tion	Date	Lat	Long	Loran C	Depth (FMS)	No. Pots Sampled	Females	<110 CM	110-134 CM	>134 CM	Total	Average Catch/Pot Of Legals (>134 CM)
50	8/19	56 45	162 22	470204 337247	38	7	59	116	39	51	206	7.3
51	8/20	56 45	162 37	471231 337652	37	7	57	63	93	93	249	13.3
52	8/20	56 48	162 37	471222 337496	36	7	220	27	117	61	205	8.7
53	8/20	56 51	162 37	471198 337334	35	7	301	33	135	93	261	13.3
54	8/20	56 54	162 37	471194 337177	36	7	420	1	85	105	191	15.0
55	8/20	56 57	162 37	471181 337013	35	7	345	2	41	118	161	16.9
56	8/21	56 33	162 52	472273 338658	42	7	3	3	52	119	174	17.0
57	8/22	56 36	162 52	472242 338501	41	7	2	4	55	124	183	17.7
58	8/21	56 39	162 52	472255 338360	40	7	1	7	85	172	264	24.6
59	8/21	56 42	162 52	472262 338214	39	7	0	6	162	225	393	32.1
60	8/21	56 45	162 52	472243 338057	37	7	1	16	314	187	517	26.7
61	8/22	56 45	163 7	473247 338465	38	7	1	0	1	13	14	1.9
62	8/22	56 48	163 7	473254 338316	37	7	0	0	17	36	53	5.1
63	8/23	56 51	163 7	473222 338151	36	7	0	1	75	155	231	22.1
64	8/23	56 54	163 7	473237 337998	36	7	0	8	111	172	291	24.6
65	8/23	56 57	163 7	473206 337830	35	7	0	29	275	285	589	40.7
66	8/24	56 33	162 22	474273 339475	44	7	1	5	39	70	114	10.0
67	8/24	56 36	162 22	474284 339333	42	7	0	1	19	71	91	10.1
68	8/24	56 39	162 22	474269 339181	41	6	1	0	23	75	98	12.5
69	8/24	56 42	162 22	474277 339037	40	7	1	0	11	79	90	11.3
70	8/24	56 45	162 22	474245 338875	39	7	2	2	11	71	84	10.1
71	8/24	56 45	162 38	475276 339300	40	7	0	0	2	12	14	1.7
72	8/24	56 48	162 37	475258 339138	39	7	0	0	0	5	5	0.7
73	8/25	56 51	162 37	475253 338983	38	7	0	0	2	9	11	1.3
74	8/25	56 54	163 37	475255 338826	38	7	0	0	2	11	13	1.6
75	8/25	56 57	163 37	475218 338657	37	7	0	0	5	43	48	6.1
TOTALS						579	12950	1521	4394	5329	11244	9.2

Appendix B. Summary data from the 1990 Bristol Bay tagging survey where *C. bairdi* Tanner crabs were taken.

								Males				
Station	Date	Lat	Long	Loran C	Depth (FMS)	No. Pots Sampled	Females	<110 CM	110-134 CM	>134 CM	Total	Average Catch/Pot Of Legals (>134 CM)
1	8/9	56 3	162 52	472273 339992	44	14	4	30	155	69	254	4.9
2	8/9	56 6	162 51	472218 339846	44	14	3	6	22	30	58	2.1
3	8/10	56 9	162 52	472264 339739	45	14	2	1	22	22	45	1.6
4	8/10	56 12	162 52	472275 339613	44	14	3	1	10	8	19	0.6
5	8/10	56 15	162 52	472263 339477	45	14	9	2	21	41	64	2.9
6	8/10	56 15	162 37	471272 339678	42	14	3	1	17	21	39	1.5
7	8/10	56 18	162 37	471284 338952	43	13	2	2	14	9	25	0.7
8	8/10	56 21	162 37	471287 338818	43	14	1	0	6	10	16	0.7
9	8/11	56 24	162 37	471290 338682	42	14	1	0	3	8	11	0.6
10	8/11	56 27	162 37	471256 338530	41	15	0	1	5	35	41	2.3
11	8/11	56 3	162 22	470291 339203	41	14	3	22	25	9	56	0.6
12	8/12	56 6	162 22	470293 339075	40	14	1	51	60	14	125	1.0
13	8/12	56 9	162 23	470318 338960	41	7	2	0	10	11	21	1.6
14	8/12	56 12	162 22	470301 338825	38	7	0	2	4	3	9	0.4
15	8/12	56 15	162 22	470301 338693	41	7	0	2	6	23	31	3.3
16	8/13	56 15	162 8	469323 338310	42	8	2	2	16	22	40	2.8
17	8/13	56 18	162 7	469283 338162	44	7	39	2	49	148	199	21.1
18	8/13	56 21	162 7	469273 338021	40	7	41	5	37	42	84	6.0
19	8/13	56 24	162 6	469266 337886	47	7	1	0	6	61	67	8.7
20	8/13	56 27	162 7	469273 337749	38	8	0	0	4	36	40	4.5
26	8/15	56 33	161 22	466266 336324	39	7	1	1	6	24	31	3.4
27	8/15	56 36	161 22	466241 336169	36	7	1	1	4	56	61	8.0
28	8/15	56 39	161 22	466242 336028	36	7	3	0	2	120	122	17.1
29	8/15	56 42	161 22	466211 335873	42	8	3	0	4	172	176	21.5
30	8/15	56 45	161 22	466207 335722	40	7	2	0	2	67	69	9.6
31	8/17	56 45	161 37	467219 336100	38	8	37	0	5	185	190	23.1
32	8/17	56 48	161 37	467184 335938	43	7	18	1	28	227	256	32.4
33	8/16	56 51	161 37	467194 335792	41	7	22	0	8	150	158	21.4
34	8/16	56 54	161 37	467189 335636	38	7	17	0	10	235	245	33.6
35	8/16	56 57	161 38	467200 335484	37	7	3	3	9	142	154	20.3
36	8/14	56 33	161 52	466262 337078	43	7	18	0	3	151	154	21.6
37	8/14	56 36	161 52	468246 336928	37	7	0	0	7	146	153	20.9
38	8/14	56 39	161 52	468253 336787	43	7	1	2	4	39	45	5.6
39	8/14	56 42	161 52	468237 336631	43	7	6	1	8	54	63	7.7
40	8/14	56 45	161 52	468196 336469	43	6	17	1	7	124	132	20.7
41	8/18	56 45	162 7	469236 336871	37	7	0	0	3	50	53	7.1
42	8/18	56 48	162 7	469193 336702	39	7	1	0	1	78	79	11.1
43	8/18	56 51	162 7	469204 336555	39	7	3	9	29	193	231	27.6
44	8/18	56 54	162 7	469202 336397	37	7	2	0	2	43	45	6.1
45	8/18	56 57	162 8	469220 336248	33	8	0	1	3	20	24	2.5
46	8/19	56 33	162 22	470237 337843	40	7	0	2	7	30	39	4.3
47	8/19	56 36	162 22	470236 337708	40	8	0	1	4	29	34	3.6
48	8/19	56 39	162 22	470233 337553	37	7	1	4	10	31	45	4.4
49	8/19	56 42	162 22	470258 337419	38	8	0	2	3	32	37	4.0
50	8/19	56 45	162 22	470204 337247	38	7	1	2	10	96	108	13.7

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Appendix B. (page 2 of 2)

Sta-tion	Date	Lat	Long	Loran C	Depth (FMS)	No. Pots Sampled	Females	Males <110 CM	Males 110-134 CM	Males >134 CM	Males Total	Average Catch/Pot Of Legals (>134 CM)
51	8/20	56 45	162 37	471231 337652	37	7	0	2	18	145	165	20.7
52	8/20	56 48	162 37	471222 337496	36	7	0	1	8	95	104	13.6
53	8/20	56 51	162 37	471198 337334	35	7	4	1	5	70	76	10.0
54	8/20	56 54	162 37	471194 337177	36	7	2	0	3	84	87	12.0
55	8/20	56 57	162 37	471181 337013	35	7	2	1	10	86	97	12.3
56	8/21	56 33	162 52	472273 338658	42	7	2	1	4	99	104	14.1
57	8/22	56 36	162 52	472242 338501	41	7	2	2	10	90	102	12.9
58	8/21	56 39	162 52	472255 338360	40	7	3	2	24	114	140	16.3
59	8/21	56 42	162 52	472262 338214	39	7	0	4	12	181	197	25.9
60	8/21	56 45	162 52	472243 338057	37	7	3	2	14	125	141	17.9
61	8/22	56 45	163 7	473247 338465	38	7	3	1	11	232	244	33.1
62	8/22	56 48	163 7	473254 338316	37	7	3	1	34	302	337	43.1
63	8/23	56 51	163 7	473222 338151	36	7	3	0	5	275	280	39.3
64	8/23	56 54	163 7	473237 337998	36	7	1	0	10	282	292	40.3
65	8/23	56 57	163 7	473206 337830	35	7	2	0	27	171	198	24.4
66	8/24	56 33	162 22	474273 339475	44	7	5	2	2	118	122	16.9
67	8/24	56 36	162 22	474284 339333	42	7	10	1	19	220	240	31.4
68	8/24	56 39	162 22	474269 339181	41	6	0	0	20	242	262	40.3
69	8/24	56 42	162 22	474277 339037	40	7	3	0	29	284	313	40.6
70	8/24	56 45	162 22	474245 338875	39	7	2	0	15	396	411	56.6
71	8/24	56 45	162 38	475276 339300	40	7	0	1	13	85	99	12.1
72	8/24	56 48	162 37	475258 339138	39	7	2	2	11	62	75	8.9
73	8/25	56 51	162 37	475253 338983	38	7	0	0	2	35	37	5.0
74	8/25	56 54	163 37	475255 338826	38	7	2	2	18	85	105	12.1
75	8/25	56 57	163 37	475218 338657	37	7	0	2	7	68	77	9.7
TOTALS						579	328	189	1002	7062	8253	12.2