ALASKA DEPARTMENT OF FISH AND GAME
SUMMARY OF THE 1999 AND 2000 MANDATORY SHELLFISH OBSERVER PROGRAM DATABASES FOR THE COMMUNITY DEVELOPMENT QUOTA CRAB FISHERIES

By

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ABSTRACT

Data collected by observers onboard vessels participating in the 1999-2000 Bering Sea Community Development Quota (CDQ) crab fisheries are summarized. Estimates of catch per unit effort (CPUE) for legally retained targeted species as well as bycatch of females, sublegal males, and selected non-target species are provided. Catch rates of targeted species are displayed by depth and soak time. Sample pot locations are provided for each fishery.

Estimated CPUE's of retained snow crabs for the CDQ fishery were greater than those estimated for the open-access fishery for both 1999 and 2000. Bycatch rates of female and sublegal, male snow crabs were also greater for the CDQ fishery in both years. The percentage of new-shell male snow crabs was similar in CDQ and open-access fisheries for both years. Females were nearly absent in the bycatch samples during the 1999 CDQ and 2000 open-access fisheries, and differed in shell age and reproductive condition for the 2000 and 1999 open-access and CDQ fisheries.

The estimated CPUE for legal red king crabs in the 1999 Bristol Bay CDQ fishery was over twice the estimated CPUE for the 1999 open-access season. Estimated catch rates for the 2000 CDQ season were 56% greater than the 2000 open-access fishery. The bycatch of sublegal males was similar for both fisheries in both years. The catch rates of female red king crabs were much higher in the 2000 CDQ fishery than the open-access fishery for the same year. Shell age statistics for male and female red king crabs were similar for CDQ and open-access fisheries in both 1999 and 2000.

INTRODUCTION

Beginning in 1999 the summaries of shellfish observer data for the Community Development Quota (CDQ) fisheries were not included with the data summaries reported for the open-access fisheries. This report summarizes that data for the 1999 and 2000 Bering Sea and Aleutian Islands CDQ crab fisheries. A comprehensive report of the CDQ fishery program is in Gish (2001). A synopsis of the Bering Sea and Aleutian Islands crab observer program follows.

In the spring of 1988, the Alaska Board of Fisheries (BOF) mandated at-sea observer coverage for all vessels processing red king crabs *Paralithodes camtschaticus,* blue king crabs *Paralithodes platypus*, golden king crabs *Lithodes aequispinus* and Tanner crabs *Chionoecetes bairdi* in state-managed fisheries. In 1990 the BOF amended observer coverage regulations to include at-sea processors in the Bering Sea snow crab *C. opilio* fishery, and in 1995 observer requirements were adopted for vessels fishing king crabs in Aleutian Island waters. In addition to establishing fixed levels of observer coverage in these fisheries, the BOF has granted the Alaska Department of Fish and Game (ADF&G) authority to place observers on commercial fishing vessels participating in other shellfish fisheries. This is primarily in circumstances when such action constitutes the only practical means for gathering data or enforcing regulations. Observer coverage implemented in recent years under this provision has included all vessels fishing for hair crabs *Erimacrus isenbeckii*, scarlet king crabs *Lithodes couesi, Paralomis multispina* (a deep-water king crab species), grooved Tanner crabs *C. tanneri*, and triangle Tanner crabs *C. angulatus*. Observer coverage has also been required on most vessels participating in crab fisheries occurring under the recently implemented CDQ Program. This report does not include data collected during the 1999 and 2000 open-access crab fisheries. However, that information is available in Moore et al. (2000) and Barnard et al. (2001).

During most deployments, an observer's primary duties are to collect biological data and record vessel catch, bycatch and effort, however, in some situations their activities are prioritized to monitor and document fishing vessel activities for regulatory compliance. Observer data are used for a number of applications including the development of models for estimating relative stock abundance, defining male and female crab size/age distributions, chronicling species reproductive cycles, quantifying levels of incidental bycatch, and producing preseason projections of fishery performance. Ultimately, the shellfish observer database provides a source of information crucial to the comprehensive management of Alaska's shellfish resources. ADF&G Westward Region staff maintains the database of biological and regulatory compliance information generated by observer deployments. Archived information ranges from gear types fished, pot locations and soak times, to the species composition, size distribution, and reproductive condition of the sampled catches.

Data compiled in this report were collected primarily within the 1999-2000 calendar years for CDQ fisheries only. Due to the substantial volume of available information, the scope of the data presented has been narrowed to include the size and shell ages of targeted crabs, the documented incidence of illegally retained crabs, and general catch and effort information resulting from sampled pots. Statistical estimates of catch per pot lift and total catch for selected species have been included. Additionally, a summary of all species encountered in pots sampled from each fishery has been included.

Any inconsistencies between previously published shellfish observer database reports and findings presented in this document are the result of updated databases and summaries, and interpretation of historical data.

METHODS

Comprehensive shellfish observer sampling methods are outlined in the most recent edition of the ADF&G Shellfish Observer Field Manual (ADF&G 1998). Methods described in this report correspond only to the data presented and are not inclusive of all observer-sampling duties.

Terms

For the purposes of this report, terms related to the discussion of sampled crabs are defined as follows:

Carapace Length (CL)	The straight line distance from the posterior margin of the right eye orbit to the medial-posterior carapace margin; CL is the biological size measurement of hair crabs and all species of king crabs.
Carapace Width (CW)	The straight line distance at greatest width forming a right angle to a line midway between the eyes to the medial-posterior margin, not including the spines; CW is the biological size measurement of all species of Tanner crab.
Legal Measurement	The straight line distance across the carapace of male crabs forming a right angle to a line midway between the eyes to the medial-posterior margin, including the spines.
Catch per unit effort (CPUE)	The value (or estimated value) representing the mean catch of crabs for a standardized unit of fishing effort; in this report CPUE represents the mean catch per pot lift.
Mature	Male and female crabs that have attained a biological size where at least 50% or more of a random sample of individuals are physiologically capable of mating.
Immature	Male and female crabs that have not attained a biological size where at least 50% or more of a random sample of individuals are physiologically capable of mating.
Soft-shell	Exoskeletons that are newly molted (zero to two weeks old) and not yet hardened.

New pliable-shell	Exoskeletons which are thin, and flexible, and not fully calcified (two to eight weeks old).
New-shell	Exoskeleton eight weeks to 12 months old (8 weeks to eighteen months for golden king crabs).
Old-shell	Exoskeleton more than 12 months and up to 24 months old (up to 36 months for golden king crabs).
Very old-shell	Exoskeleton more than 24 months old (more than 36 months old for golden king crabs).
Uneyed eggs	Early developmental stages of an egg with no distinguishing marking.
Eyed eggs	Later developmental stages of an egg distinguished by dark eye spots.
Ovigerous	Female crabs bearing eggs, either eyed or uneyed.
Mated/barren	Female crabs not carrying eggs but displaying evidence of previous mating activity.
Non-mated/barren	Female crabs not carrying eggs and not displaying evidence of previous mating activity.
Recruit	A new-shell male crab of legal size in its first year of availability to the commercial fishery.
Post-recruit	A male crab of legal size and not classified as a recruit.

Sampling Duties

During the 1999-2000 Bering Sea/Aleutian Islands shellfish CDQ fisheries, observers were deployed on catcher-only vessels and were able to examine the contents of fished pots prior to sorting. Data collection objectives for observers onboard catcher-only vessels are varied but 'bycatch sampling' is usually the prioritized activity. Bycatch sampling involves randomly selecting pots for catch composition. Methods for collecting bycatch samples include identifying and enumerating all species in the pot and recording legal and retention status, biological size, shell age, sex, and general health and vitality of all commercially important crabs. Female crabs in sampled pots are also evaluated for reproductive condition. Average weight determinations, legal tally, and biological measurements of the retained crabs are only conducted when the vessel delivers to a processing facility.

Daily sampling goals for observers on board catcher-only vessels (e.g., quantity of fished pots examined and number of crabs measured) are dependent upon a number of variables anticipated during the fishing season. These variables include special data collection projects and the order of

sampling priorities established by ADF&G. Fishery-specific sample goals are discussed in subsequent sections where appropriate.

Ad hoc research data collection projects were assigned to observers deployed on catcher-processors and catcher-only vessels during several of the 1999-2000 fishing seasons. These projects included the following.

- Recording morphometric measurements for size-at-maturity of snow crabs.
- Pot escape mechanism studies.
- Collecting individual weights from non-retained hair crabs and red king crabs.
- Tag recoveries from king crabs in Bristol Bay and the Aleutian Islands.
- Sampling crabs in all observed fisheries for handling injuries.
- On-deck air exposure resulting from catch sorting.

The results from these investigations have not been included in this report, however, that information is available from ADF&G Westward Region.

Estimation of CPUE and Total Fishery Catch

Estimates for CPUE and their standard errors were generated using weighted mean and variance formulas for stratified sampling (Cochran 1977). These formulas are listed in Appendix A.1. With this technique, each vessel-day is considered a separate stratum. The weights (w_{ij}) reflect the relative importance of a vessel's daily effort (pots pulled) compared to all the days on which fishing occurred for that vessel. The result is the greater the number of pots fished on a given day, the greater the weight for the samples collected on that day. Variances were calculated for each vessel-day and then summed over all days and all vessels for the entire fishery.

Multiple estimates of CPUE are calculated to provide a range of information and a basis for comparison (see Tables 2, 9, 14 and 21). The 'weighted CPUE' with standard error estimates uses the Cochran stratified technique as described above and in Appendix A.1. The 'sample CPUE' is generated from observer data and is based solely on the sampled bycatch pots. It is calculated as total catch from sampled pots divided by total pots sampled. This estimate has been reported in past observer reports (Tracy 1994, 1995a and 1995b). The 'actual total fishery (ATF) CPUE' is based on fish ticket information as reported in the Regional Information Reports for commercial crab fisheries in the Bering Sea and Aleutian Island Management Areas. The 'actual observed fleet (AOF or CI) CPUE' is generated from information collected during confidential interviews with the vessel's captain, which are performed by onboard observers or dockside samplers. The ATF and AOF CPUE's are generated for retained legal crabs only. Both provide information on total catch of retained crab, total pots pulled, and fishing locations. Information from confidential interviews is often recorded on a daily basis and is generally considered more accurate than information obtained from fish tickets, which summarize an entire trip between deliveries.

An estimated total catch is derived by multiplying an estimated CPUE by the total number of pots pulled in the fishery. For those fisheries with 100% observer coverage the total pots pulled information is taken from confidential interviews. Otherwise, the total pots pulled data is generated from fish ticket summaries.

When viewing CPUE and total catch estimates for both the directed catch and bycatch, the reader should note the precision and accuracy of the estimates. Precision is indicated by the standard errors. Accuracy is gauged by the comparability of the estimates for legal retained crabs obtained from observer data with those obtained from confidential interviews and fish tickets. The reader should also take note of whether the CPUE and total catch estimates provided here were based on data gathered by observers deployed on all participating fishing vessels or by observers deployed on only a portion of the fleet. Application of CPUE estimates obtained from sampled vessels to the entire fishing fleet assumes that catch rates for that distinct portion of the fleet are comparable to the remaining component of the fleet.

RESULTS

Bering Sea Snow Crab

1999

During the 1999 snow crab CDQ season, observers were deployed on 20 of the 23 participating vessels. The bycatch-sampling goal for observers on catcher-only vessels was 4 pots for each day of fishing activity. Catches in 3 of the 4 pots were only identified as to species, sex, legal and retention status, and enumerated but not measured or assessed for ad hoc research projects. The first gear was pulled on 30 March and the fishing continued until 29 May. A total of 785 fished pots were sampled, accounting for 1.7% of the 46,490 pot lifts reported for the fishery (Gish 2001). The location of pots sampled by observers during the 1999 Bering Sea CDQ snow crab fishery are in Appendix B.1.

More than 4,400 measurements of retained snow crabs were taken during the CDQ season by observers and ADF&G dockside samplers during catch deliveries to processors. Frequencies tallied at 5 mm intervals are given in Table 1. The mean CW of crabs sampled from the CDQ catch, 109.6 mm, was almost 1 mm less than the mean CW of crabs measured during the open-access fishery (mean CW = 110.3 mm).

Measurements of male snow crab CW taken from over 55,000 crabs sampled in bycatch pots also produced results comparable to those from the open-access fishery. The prominent size group was centered at 105-110 mm, the same as the open-access fishery (Figure 1). Just 11 female snow crabs were measured from bycatch samples (Figure 1). They produced a mean CW of 74 mm compared to 61 mm in the open-access fishery (n = 100, Moore et al., 2000).

The weighted estimates of CPUE for targeted and non-targeted crabs harvested in the 1999 Bering Sea CDQ snow crab fishery are in Table 2. The weighted estimate of 139.1 legal retained snow crabs represents a 10% crab per pot increase over the 1999 open-access fishery. The same increase was observed for all legal retained crabs (snow and Tanner/snow hybrids). The CPUE estimate for legal

non-retained male snow crabs was almost 74% greater in the CDQ fishery compared to the open-access fishery. Estimated catch rates of sublegal male crabs, female crabs and non-target crab species were quite similar in both fisheries. The precision of the weighted estimate of mean CPUE for all legal retained crabs (161.6, S.E. = 5.01) is quite good; the standard error is only 3.1% of the estimated mean. A 95% confidence interval for the population mean CPUE (151.6, 171.6) includes both the AOF and ATF CPUE estimates (see Table 2), indicating the weighted estimates are also accurate. The total catch of all animals identified in sampled pots during the 1999 CDQ snow crab fishery are in Table 3.

Mean soak time for the 1999 snow crab CDQ fishery was 65 hours compared to 48 hours for the open-access fishery. Estimated mean catch rates of legal retained male snow crabs appeared to generally increase with soak time up to around 200 hours and remained constant after that (Table 4 and Figure 2). The mean catch by hours soaked is plotted along with a LOWESS line in Figure 2. A LOWESS (LOcally WEighted Scatter plot Smother) line is produced by a statistical procedure that calculates smooth line relationships for the points on a bivariate plot (Minitab 1999). It can be thought of as a moving average. For retained male snow crab, this is a similar result to the open-access fishery for that year. Mean catch rates of legal non-retained male crabs increased steadily with longer soak times. This is unlike the open-access fishery where the mean CPUE appeared to be relatively constant with increasing soak times and of a lesser magnitude. Mean catch rates of sublegal male crabs were also relatively constant with soak time and larger than mean CPUE's of sublegal crabs during the open-access fishery. Mean catch rates of female snow crabs were negligible for both fisheries. Approximately 92% of the pots sampled in both fisheries were soaked less than 96 hours or 4 days.

The 58 fathom (fm) mean depth of fished pots selected for bycatch sampling appeared to generally correspond to the highest overall mean catch rates of retained male snow crabs (Table 5 and Figure 3). This is shallower than the mean depth of 68 fm from the open-access fishery where the highest mean catch rates of legal retained male crabs occurred near 80 fm and 130 fm. Mean CPUE's for legal non-retained male crabs and for sublegal male crabs were mostly greater at all depths fished in the CDQ fishery compared to the open-access fishery. Mean catch rates of female snow crabs were negligible at all depths for both fisheries. There were no sampled pots set deeper than 80 fm in the 1999 snow crab CDQ fishery.

Snow crab shell age statistics for male crabs from bycatch samples were generally comparable to those from the open-access season. New-shell male crabs comprised 88% of the total sample compared to 90% in the open-access fishery (Table 6). Old-shell crabs comprised most of the remainder in both fisheries. Relatively few female snow crabs were available in 1999 CDQ bycatch samples; the majority examined were classified as old-shell crabs followed by new-shell crabs. This is in contrast to the open-access fishery where 82% of sampled female snow crabs (n = 100) were classified as very-old-shell crabs, and new-shell female crabs accounted for only 2% of the total sample.

Snow crab female reproductive condition differed slightly between the 1999 CDQ and open-access fisheries. Nearly 69% of the 99 female crabs in the open-access bycatch samples were mature and carried clutches of eyed eggs whereas only 45% of the females in the CDQ fishery were in a similar

condition (Table 7). Approximately 73% of females in both fisheries carried eggs. The small sample size of female snow crabs in the CDQ fishery makes any inference uncertain.

Legal tallies conducted shore side during vessel deliveries to processors totaled nearly 28,000 crabs for the season and comprised less than one percent of the cumulative CDQ harvest (Table 8). Just 0.12% of sampled crabs were retained illegally, either due to size, sex or species. Most of these were sublegal male Tanner crabs; the rest were sublegal male snow crabs.

2000

For the 2000 Bering Sea CDQ snow crab fishery, observers were deployed on 12 of the 13 participating vessels. The bycatch-sampling goal for observers was 4 pots during each day of fishing activity. Catches in 3 of 4 pots were identified as to species, sex, legal and retention status, and enumerated but not measured or otherwise assessed for ancillary characteristics. In addition, observers obtained individual vessel daily catch and effort statistics. Fishing began on 16 April and continued until 12 May. A total of 611 pots selected for bycatch sampling accounted for almost 5% of the 12,568 pot lifts reported by vessel operators during the 2000 CDQ season (Gish 2001). Locations of pots sampled by observers during the 2000 Bering Sea CDQ snow crab fishery are in Appendix B.2.

Measurements of more than 2,800 retained male snow crabs were obtained during the 2000 CDQ fishery by observers and dockside samplers. The size frequencies for these measurements tallied at 5 mm intervals are in Table 1. The mean CW of crabs sampled from the CDQ catch was more than 2 mm greater than the mean CW of 111.3 mm obtained from crabs sampled during the 2000 open-access fishery.

More than 43,000 measurements were made of male snow crabs sampled in bycatch pots. The mean CW of 108.8 mm is approximately 1 mm greater than the mean CW from the open-access fishery (Figure 4). The most prominent size group is in the 110-115 mm CW interval compared to the 105-110 mm CW interval for the open-access fishery. Ninety-four female snow crabs were measured in bycatch samples resulting in a mean CW of 69 mm, 7 mm smaller than the mean CW obtained from 6 female crabs during the open-access fishery (Figure 4).

The weighted estimates of CPUE for targeted and non-targeted crab species landed in the 2000 Bering Sea snow crab CDQ fishery are listed in Table 9. The weighted estimate of 131.9 legal retained male snow crab per pot pulled represents a 14% increase over the 114.3 crabs per pot estimate for the 2000 open-access fishery. The estimate for all retained crabs, snow and Tanner/snow hybrids combined, was 15% larger than the estimate for the open-access fishery. The estimated CPUE for legal male snow crabs that were not retained, 51.7 crabs per pot, was more than twice the open-access fishery estimate. The estimated catch rate for sublegal, male, snow crabs was more than three times the estimate for the open-access fishery. With the exception of a larger estimate of the number of non-retained legal male Tanner/snow hybrid crabs, the estimates for female and non-targeted crab species were similar to the open-access fishery. The weighted estimate of CPUE for all retained legal crabs (137.7, S.E. = 5.01) was precise. The estimate of standard error was just 3.6% of the estimated CPUE. A 95% confidence interval for the population mean CPUE (127.2, 147.7) contains both the AOF and ATF CPUE estimates (see Table 9) indicating the weighted estimate is

also accurate. A listing of the animals found in sampled bycatch pots and their total numbers is in Table 10.

The mean soak time for sampled pots for the 2000 Bering Sea snow crab CDQ fishery was 46.3 hours compared to the 29.9 hour mean soak time for the open-access fishery. Estimates of mean CPUE by soak time generally increased with increased hours for legal retained male snow crab in the 2000 CDQ fishery (Table 11 and Figure 5). This differs from the open-access fishery where mean catch rates peaked around 24-30 hours. Mean catch rates of legal non-retained male snow crabs increased for the first 48 hours and remained fairly constant after that. The estimated mean CPUE's for sublegal male crabs were low and relatively constant, while those for females were negligible. These results are greater overall than estimates obtained during the open-access fishery but retain the same general pattern.

The mean depth of sampled pots for the 2000 CDQ fishery was 67 fm, the same as the mean depth in the open-access fishery. The estimated mean CPUE for legal retained male snow crabs gradually increased with depth in the CDQ fishery (Table 12 and Figure 6), unlike the open-access fishery where estimated mean CPUE appears to decrease below 60 fm. Estimated mean catch rates for legal non-retained male crabs are similar in magnitude to the mean estimates for the open-access fishery. They are less variable, appear to decrease with depth to about 70 fm and are relatively constant after that. Estimated mean CPUE's for sublegal male crabs are low, similar to those from the open-access fishery. Estimates for female snow crabs were very low for both fisheries.

Shell age statistics for male and female snow crabs sampled from the 2000 CDQ fishery are in Table 6. The results for male crabs are similar to those from the open-access fishery where new-shell male crabs dominated the samples with 92% followed by old-shell males at 6.9%. Estimates for female snow crabs differ considerably with all females in the open-access fishery being old-shell crab and 96.8% in the CDQ fishery being new-shell crab. It should be noted that the sample size for the open-access fishery was only 6 female crabs.

The reproductive condition of female snow crabs sampled during the 2000 CDQ fishery are given in Table 7. Nearly 99% of the females observed were carrying eggs and of those 80% were carrying uneyed eggs. The small sample size of female snow crabs from the open-access fishery makes it difficult to make meaningful comparisons.

Legal tallies conducted shoreside during vessel deliveries to processors totaled over 15,000 crabs for the season and comprised less than one percent of the cumulative CDQ harvest (Table 8). Just 0.13% of sampled crabs were retained illegally, either due to size, sex or species. As in the 1999 CDQ fishery, illegal crabs were sublegal male Tanner crabs and sublegal male snow crabs.

Bristol Bay Red King Crab

1999

Observers were deployed on all ten fishing vessels participating in the 1999 Bristol Bay red king crab CDQ fishery. The bycatch-sampling goal for observers on catcher-only vessels was four pots for

each day of fishing activity. Whenever possible catches in all pots were identified as to species, sex, legal and retention status, enumerated, measured, and otherwise assessed for ancillary characteristics. Fishing occurred from 25 October to 7 November. The total of 263 pots selected by observers for bycatch sampling accounted for 8.8% of 2,976 pot lifts reported by vessel operators during the CDQ fishery (Gish 2001). The location of pots sampled by observers during the 1999 Bristol Bay CDQ red king crab fishery are in Appendix B.3.

Just over 1,000 retained red king crabs were measured for CL during the CDQ season. Prominent size groups were between 141-155 mm (Table 13). Mean CL of CDQ sample crabs (152.5 mm) differed from the mean CL for the open-access fishery (148 mm) by more than 4 mm.

Distribution of CL for over 4,100 red king crab males sampled from bycatch pots was similar to sample pot results from the open-access fishery (Figure 7). Sampled male crabs had a mean CL of just less than 149 mm compared to a sample mean CL of 140 mm for the open-access fishery. Measurements from 4 female red king crabs sampled from CDQ bycatch pots ranged between 100-150 mm CL (Figure 7). The mean CL for females (124 mm) in the CDQ fishery was the same as the mean calculated from open-access fishery samples.

As all fishing vessels were required to carry observers, both the sampled fleet and the actual observed fleet retained crab CPUE estimates apply to the entire fishery. The weighted estimated mean CPUE for selected targeted and non-targeted crabs in the 1999 Bristol Bay CDQ red king crab fishery are in Table 14. Mean CPUE of legal crabs for the CDQ fishery was estimated to be more than twice the catch rate of legal crabs in the open-access red king crab fishery (31.9 crabs per pot vs. 13.4 crabs per pot). Sublegal male crabs were captured at about the same rate as sublegal male crabs in the open-access fishery. The estimated female CPUE (0.1) was similar to the open-access fishery CPUE estimate (0.2). The precision of the weighted CPUE estimate for retained crabs was fair; the standard error was 11.8 % of the estimated mean CPUE. A 95% confidence interval for the population mean CPUE for retained crab (24.4, 39.4) contained both the AOF and ATF CPUE estimates (see Table 14), indicating the weighted estimate was accurate. The difference between the weighted CPUE estimate and the AOF and ATF CPUE estimates (2.9 crabs/pot) is likely due to random error introduced by the selection of sampled pots. A listing of all animals found in sampled pots and their abundance is listed in Table 15. Bycatch rates of other commercially important crab species were relatively low, with Tanner crabs being the most prevalent bycatch species at an average of 0.5 crabs per pot.

Sampled pot soak periods recorded during the CDQ season ranged between 8 and 146 hours and averaged 35.9 hours (Table 16) in contrast to the 25 hour mean soak time for the open-access fishery. Mean CPUE's of legal retained male and sublegal male king crabs were quite variable but generally increased with soak time up to about 60 hours (Figure 8). For soak times greater than 60 hours, CPUE's of legal males appear to remain fairly constant while those for sublegal males increase slightly. Female red king crab mean CPUE's remained low regardless of sampled pot soak periods. These mean catch rates were similar to the open-access fishery.

Fishing depths of sampled pots were narrowly dispersed, with 75% recorded at depths between 45 and 55 fm and a mean depth of 46.6 fm (Table 17 and Figure 9). This is about 10 fm deeper overall than depths recorded during the open-access fishery. Within this range, catch rates of red king crabs

were dominated by legal male king crabs followed by sublegal male crabs and lastly female king crabs. Although mean CPUE's of legal-sized males were highly dispersed, they generally had maximum values at around 40-50 fm as did catch rates of sublegal male and female king crabs.

Similar to results from the open-access season, most male red king crabs in CDQ sample pots were classified as new shell (Table 18). Very old-shell crabs were the least prevalent, comprising less than two percent of the 4,119 male crabs sampled. All female red king crabs sampled in both the open-access (n = 36) and CDQ (n = 4) fisheries were new-shell.

Reproductive condition of the 4 red king crab females sampled during the CDQ fishery was evenly split between female crabs with eyed eggs and barren unmated female crabs (Table 19). This is in contrast to the open-access season (n = 36) where 86% of the female crabs carried uneyed eggs, 11% were barren and unmated and the remaining crabs were barren, mated females. Again, small sample sizes make any inference questionable.

Legal tallies conducted during landings of CDQ catch totaled over 6,100 sampled crabs accounting for 7.2% of the 1999 overall harvest (Table 20). Illegally harvested crabs comprised just 0.21% of the sample and all were undersized red king crab males.

2000

At-sea observers were deployed on all 11 vessels during the 2000 Bristol Bay red king crab CDQ season. The bycatch sample goal for observers was 10 pots during each day of fishing activity. Whenever possible the contents of all pots sampled were identified as to species, sex, legal and retained status, counted, measured and otherwise assessed for ancillary characteristics. Fishing occurred from 25 October to 7 November. A total of 428 pots selected for bycatch sampling accounted for 9.2% of 4,663 pot lifts reported by vessel operators during the 10 day season (Gish 2001). Locations of pots sampled by observers during the 2000 Bristol Bay CDQ red king crab fishery are in Appendix B.4.

Measurements of 50 red king crabs delivered to processing locations produced a mean CL of 150.4 mm (Table 13), which is 0.2 mm less than the mean for the open-access fishery. Similar to past seasons, retained crab CL was grouped tightly around the 5 mm intervals falling on either side of the mean. Crabs in this size range accounted for 64% of all retained crabs sampled in the 2000 CDQ fishery.

Mean CL of male red king crabs from pots sampled in 2000 was 136.8 mm, 2.4 mm larger than the mean CL for the 2000 open-access fishery (Figure 10). Notable in the length frequency histogram is increase in the number of immature new-shell male crabs and mature old-shell male crabs, similar to the open-access fishery. Nearly 7,000 female red king crabs were observed in sampled pots in 2000 representing a dramatic increase from the 4 females sampled in the 1999 CDQ fishery. The mean CL of 112.9 mm was nearly 20 mm larger than the mean CL estimated from the open-access fishery (Figure 10). A secondary mode for females was prominent in the 90 mm CL range.

The weighted estimates of mean CPUE for selected targeted and non-targeted crabs in the 2000 Bristol Bay red king crab CDQ fishery are presented in Table 21. The weighted estimate of 20.0

legal retained males per pot lift represents a 56% increase from the estimated CPUE for the open-access fishery. The catch rates of sublegal red king crab males increased by almost 29% over the open-access fishery estimate. The female red king crab CPUE estimate (16.5) was 7 times larger than the estimate for the open-access fishery. The precision of the weighted estimate of mean CPUE for legal retained crabs is good, with a standard error of 7.7% of the estimated mean. The weighted estimate of mean CPUE for retained crabs is identical to both the AOF and ATF CPUE estimates (Table 21), indicating the weighted estimate is also very accurate. Catches of all animals encountered in sampled pots are in Table 22.

Soak periods for sampled pots from the CDQ fishery ranged from 14 to 48 hours and averaged 26.3 hours, just over 4 hours longer than in the open-access fishery (Table 23 and Figure 11). Catch rates of legal-sized and sublegal male red king crabs generally increased with the hours soaked up to about 36 hours and then decreased after that time. A similar pattern was seen in the open-access fishery with maximum catches occurring at shorter soak times of around 24 hours. Mean CPUE of female red king crabs peaked around 24 hours soak time in both fisheries (Figure 11).

The fished depth of sampled pots ranged from 20 to 49 fm, with a mean of 38 fm, the same as the open-access fishery. Estimated mean CPUE's for legal male crabs were variable, increasing slightly with depth to about 30–35 fm and were relatively constant at greater depths (Table 24 and Figure 12). A similar trend was observed for sublegal male crabs. Catch rates of both legal and sublegal male king crabs in the open-access fishery tended to peak around 35 fm. For female red king crabs, the estimated mean CPUE in sampled pots for the open-access fishery was generally higher for depths less than 25 fm than at greater depths. In the CDQ fishery the mean CPUE for females started low but increased markedly at depths greater than 40 fm to over 100 crabs per pot.

Shell age compositions for the 2000 CDQ season were similar to results from the open-access season. Shell age composition of red king crab males sampled in the 2000 open-access fishery included 78.5% new-shell crab compared to 71.8% in the CDQ fishery (Table 18). The proportions of old and very-old shell male crabs in the CDQ sample were also similar to the open-access fishery. The increases in old-shell male crabs for the 2000 CDQ and open-access fisheries seen in Table 18 were also noted in the discussion of Figure 10. Nearly all female crabs sampled during each of the two 2000 red king crab seasons were new-shell.

Adequate numbers of female red king crab were present in the bycatch samples from the 2000 Bristol Bay CDQ fishery to assess their reproductive condition. Unlike the open-access fishery where most of the females were barren and unmated (73%), a large proportion of the female crabs examined in the CDQ fishery carried uneyed eggs (61.8%, Table 19). Eighty-nine percent of the female crabs observed during the CDQ fishery were carrying clutches of eggs compared to 26% in the open-access fishery.

There were no legal tallies taken during the 2000 Bristol Bay red king crab CDQ fishery.

Accuracy and Precision of Catch Per Unit Effort (CPUE) Estimates

When using CPUE estimates based on observer data it is important to have some assessment of their reliability in estimating the catch rates for observed vessels and, especially, for all vessels participating in a fishery. Although the observer data are the only source of information on bycatch rates in the fisheries presented in this report, confidential interviews with the operators of observed and unobserved vessels and fish tickets provide data for independent estimates of the CPUE of retained legal crabs. We can gain some understanding of the reliability of the CPUE estimates computed from observer sample data by comparing the retained legal CPUE estimates with those computed from confidential trip summaries (AOF) and fish ticket data (ATF). Observers on catcher-processors complete weekly trip summaries, and similarly, confidential interviews are conducted by both observers deployed on catcher-only vessels and by dockside samplers.

The confidential trip summary data provide estimates of retained legal CPUE from both observed and unobserved vessels participating in a fishery. In this discussion we will refer to the retained legal CPUE estimated from confidential trip summaries data as the "Confidential Interview CPUE" (AOF CPUE). Fish ticket data from all landings of all vessels participating in a fishery provide an independent estimate of the total fishery CPUE of retained legal crabs for a fishery in which observers were not required on all vessels. We will refer to the CPUE of retained legal crabs estimated from the fish ticket data for all fishery landings as the "Actual Total Fishery CPUE" (ATF CPUE).

CPUE estimates computed from observer bycatch samples for retained legal crabs are within 10% of the AOF CPUE for the 1999 Bering Sea snow crab CDQ fishery and the 1999 Bristol Bay red king crab CDQ fishery (Table 25). Differences are less than 2.5% for the 2000 CDQ fisheries. The close agreement between the observer-based and AOF CPUE estimates in the 4 Bering Sea crab fisheries indicates that observer bycatch sample data provide reliable estimates of CPUE for the observed portion of the fleet.

Since 1995, when weighted CPUE estimates were first calculated from shellfish observer bycatch data, agreement between the weighted estimates for the Bering Sea snow crab fishery and the estimates from fish ticket and confidential interview data have been the most problematic. In terms of total crabs, pounds and average catch per pot lift, the harvest of snow crabs is by far the largest of all shellfish fisheries prosecuted in the Bering Sea and Aleutian Islands. This fishery is also characterized by the highest total number of pots pulled. The 785 sampled pots in 1999 and the 611 sampled pots in 2000 account for just 1.7% and 4.9% of the total pots pulled in each year, respectively.

CPUE estimates computed from observer data for retained legal crabs in the 1999 and 2000 Bering Sea snow crab CDQ fisheries (161.6 and 137.7 crabs/pot, Tables 2 and 9) differed from both the AOF and ATF CPUE's by at most 5.4% (Table 25). This indicates a better reliability for observer bycatch sample data in providing catch rate estimates than in the open-access fisheries for those years. However, the difference in the level of coverage between the open-access and CDQ fisheries may explain most of the discrepancy between estimates.

The 'weighted' observer-based CPUE estimator used in this report is different from the 'sample' observer-based CPUE estimate used in past Mandatory Shellfish Observer Database Summaries (e.g., Tracy 1994, 1995a and 1995b). Although the weighted estimation method can provide more accurate

and precise estimates, the weighted and sample CPUE estimates are generally very close to each other. Therefore, the weighted estimates presented here are comparable to those CPUE estimates included in previous observer data summaries. The value of using the weighted CPUE estimates is that the estimation method allows for computation of the standard errors of the CPUE estimates.

The standard errors provided in this report give a measure of the precision or repeatability of the CPUE estimates. Generally, the weighted CPUE estimates appear to be precise, as reflected in the relatively small standard errors. We did not compute confidence intervals for the CPUE estimates as the sample size within each stratum (vessel-day) was not large enough to assume an asymptotic normal distribution. However, bootstrap simulation of observer data collected in the 1995 Bering Sea and Aleutian Islands crab fisheries suggests that the weighted CPUE estimates plus or minus two standard errors was adequate to characterize the true CPUE of the targeted species (Byrne and Pengilly 1998).

LITERATURE CITED

Alaska Department of Fish and Game. 1998. ADF&G Observer Manual for Alaskan Crab Processors and Catcher Only Vessels. Third Edition. Alaska Department of Fish and Game, Division of Commercial Fisheries, Dutch Harbor.

Barnard, D. R., R. Burt and H. Moore. 2001. Alaska Department of Fish and Game Summary of the 2000 Mandatory Shellfish Observer Program Database. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 4K01-39, Kodiak.

Byrne, L. C. and D. Pengilly. 1998. Estimates of CPUE for the 1995 crab fisheries of the Bering Sea and Aleutian Islands based on observer data. *In* Proceedings of the 15th Lowell Wakefield Fisheries Symposium. Fishery Stock Assessment Models for the 21st Century. University of Alaska Sea Grant College Program.

Cochran, W.G. 1977. Sampling Techniques. John Wiley and Sons. New York. 428 pp.

Gish, Robert K. 2001. Bering Sea/Aleutian Islands Community Development Quota Crab Fisheries, 2000. *In* Annual Management Report for the Shellfish Fisheries of the Westward Region, 2000. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 4K01-45, Kodiak.

Minitab. 1999. User's Guide 1: Data, Graphics, and Macros. Minitab Inc.

Moore, H., L. C. Byrne, and M. C Schwenzfeier. 2000. Alaska Department of Fish and Game Summary of the 1999 Mandatory Shellfish Observer Program Database. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 4K00-50, Kodiak.

Tracy, D. A. 1994. Alaska Department of Fish and Game Summary of the 1992 Mandatory Shellfish Observer Program Database. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 4K94-10, Kodiak.

Tracy, D. A. 1995a. Alaska Department of Fish and Game Summary of the 1993 Mandatory Shellfish Observer Program Database. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 4K95-14, Kodiak.

Tracy, D. A. 1995b. Alaska Department of Fish and Game Summary of the 1994 Mandatory Shellfish Observer Program Database. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 4K95-32, Kodiak.

Table 1. Carapace size frequency distributions from biological measurements of retained snow crabs sampled during the 1999-2000 Bering Sea snow crab CDQ fisheries.

	1999		2000	
Width (mm)	Number	Percent	Number	Percent
86-90	6	0.1	2	0.1
91-95	40	0.9	11	0.4
96-100	279	6.2	52	1.8
101-105	964	21.5	283	10.0
106-110	1,285	28.6	596	21.0
111-115	1,005	22.4	782	27.5
116-120	616	13.7	646	22.7
121-125	220	4.9	337	11.8
126-130	65	1.4	115	4.0
131-135	5	0.1	16	0.6
Totals	4,485	99.8	2,840	99.9
Mean CW (mm)	109.6		113.6	

Table 2. Estimated catch per pot (CPUE) of selected crab species from pot lifts sampled by observers deployed during the 1999 Bering Sea snow crab CDQ fishery. Standard errors of the estimates are included in parentheses.

Species / Class	Total Pot Sample Catch	Sampled Fleet Estimated CPUE	Estimated Total Catch[a]
Snow crab			
Legal males retained	102,037	139.1[b] (4.76)	6,467,000[c]
Legal males not retained	58,871	81.3 (3.51)	3,780,000
Sublegal males	2,005	2.8 (0.31)	130,000
Females	54	0.1 (0.07)	5,000
Tanner / Snow Hybrid			
Legal males retained	17,196	22.5 (1.03)	1,046,000
Legal males not retained	12,015	15.7 (1.20)	730,000
Sublegal males	529	0.7 (0.13)	33,000
Females	142	0.2 (0.15)	9,000
Tanner crab			
Legal males not retained	95	0.1 (0.05)	5,000
Sublegal males	1,977	2.6 (0.39)	121,000
Females	91	0.1 (0.06)	5,000

[a] Estimated CPUE multiplied by 46,490 total pot lifts during the fishery (Gish 2001).

[b] Actual CPUE for retained legal crabs (legal retained male snow crabs and Tanner/snow hybrids combined) for the fishery as reported on confidential interview forms was 153.3 for observed vessels. Actual total fishery CPUE of retained legal crabs was 165 for all vessels (Gish 2001).

[c] Actual catch of retained legal crabs for the fishery was 7,747,876 (Gish 2001).

Table 3. Total pot contents from 785 bycatch samples taken during the 1999 Bering Sea snow crab CDQ fishery.

Species	Total catch	CPUE[a]
Snow crab	162,967	
Legal males retained	102,037	130.0
Legal males not retained	58,871	75.0
Sublegal males	2,005	2.6
Females	54	0.1
Tanner / Snow Hybrid	29,882	
Legal males retained	17,196	21.9
Legal males not retained	12,015	15.3
Sublegal males	529	0.7
Females	142	0.2
Tanner crab	2,163	
Legal males not retained	95	0.1
Sublegal males	1,977	2.5
Females	91	0.1
Blue king crab	4	
Legal males not retained	2	<0.1
Sublegal males	0	0
Females	2	<0.1
Snail (unidentified)	5,951	
Neptunea pribilofensis	1,941	
Sea star (unidentified)	538	
Hermit crab (unidentified)	360	
Sculpin (unidentified)	325	
Pacific cod	231	
Hairy triton	224	
Yellow Irish lord	194	
Yellowfin sole	72	
Buccinum spp.	53	
Neptunea spp.	34	
Walleye pollock	23	
Lyre crab	10	
Rock sole	4	
Halibut	3	
Octopus	2	
Neptunea heros	2	
Prowfish	1	
Snailfish (unidentified)	1	

[a] Estimated CPUEs are calculated by dividing the total catch by the number of bycatch sample pots.

Table 4. Estimated CPUE of snow crabs by soak hours from 785 bycatch samples taken during the 1999 Bering Sea snow crab CDQ fishery.

	Pots sampled		Catch per sampled pot				
Soak hours	Number	Percent	Legal retained	Legal not retained	Sublegal	Female	Total
13-18	1	0.1	79.0	125.0	1.0	0	205.0
19-24	10	1.3	61.3	27.7	1.2	0	90.2
25-30	12	1.5	54.5	28.9	3.0	0.2	86.6
31-36	39	5.0	77.1	50.6	1.3	0.1	129.1
37-42	52	6.6	117.2	74.0	1.7	0.1	192.9
43-48	202	25.8	127.5	71.2	1.6	0.1	200.4
49-54	113	14.4	124.7	76.2	2.5	<0.1	203.5
55-60	54	6.9	141.7	80.1	2.4	<0.1	224.2
61-66	43	5.5	140.3	91.7	3.6	0.5	236.0
67-72	85	10.9	128.2	77.9	3.1	<0.1	209.2
73-78	37	4.7	149.9	71.1	2.3	0	223.4
79-84	20	2.6	146.4	86.3	5.3	0.1	238.1
85-90	14	1.8	159.9	84.9	6.1	0	250.9
91-96	38	4.9	145.9	54.3	1.3	<0.1	201.5
97-102	12	1.5	117.4	52.9	1.3	0	171.6
103-108	4	0.5	88.3	59.8	1.3	0	149.3
109-114	7	0.9	158.9	82.1	2.4	0.1	243.6
115-120	8	1.0	199.1	86.1	4.9	0	290.1
121-126	6	0.8	133.3	99.0	5.2	0	237.5
133-138	1	0.1	46.0	35.0	0	0	81.0
139-144	2	0.3	264.0	36.0	1.0	0	301.0
151-156	5	0.6	118.8	120.2	6.0	0	245.0
163-168	1	0.1	499.0	105.0	2.0	0	606.0
175-180	2	0.3	277.5	167.5	6.5	0.5	452.0
187-192	3	0.4	101.0	134.7	18.7	0	254.3
193-198	1	0.1	205.0	166.0	8.0	0	379.0
199-204	1	0.1	212.0	64.0	3.0	0	279.0
> 204	10	1.3	250.4	213.4	11.9	0	475.7
Mean soak: 64.8 hours	Overall CPUE		130.0	75.0	2.6	0.1	207.6

Table 5. Estimated CPUE of snow crabs by depth from 785 bycatch samples taken during the 1999 Bering Sea snow crab CDQ fishery.

Depth (fathoms)	Pots sampled		Catch per sampled pot				
	Number	Percent	Legal retained	Legal not retained	Sublegal	Female	Total
36-40	1	0.1	71.0	191.0	8.0	0	270.0
41-45	14	1.8	103.9	76.9	2.6	0	183.4
46-50	70	8.9	131.1	65.3	1.3	<0.1	197.7
51-55	179	22.9	132.8	70.6	1.6	<0.1	205.0
56-60	288	36.8	151.9	79.8	2.2	0.2	234.0
61-65	155	19.8	104.4	76.8	3.3	<0.1	184.5
66-70	44	5.6	101.6	81.5	3.3	0	186.4
71-75	28	3.6	102.2	63.3	10.4	0	175.8
76-80	4	0.5	0	0	0.0	0	0.0
Mean depth: 58.1 fm	Overall CPUE		130.0	75.0	2.6	0.1	207.6

Table 6. Shell ages of male and female snow crabs in bycatch samples taken during the 1999-2000 Bering Sea snow crab CDQ fisheries.

Year	1999		2000	
Gender	Male	Female	Male	Female
Sample size	55,750	11	43,193	94
% New shell	88.1	36.4	85.6	96.8
% Old shell	10.7	45.4	12.0	3.2
% Very old shell	1.2	18.2	2.4	0

Table 7. Reproductive condition of female snow crabs in bycatch samples taken during the 1999-2000 Bering Sea snow crab CDQ fisheries.

Year	1999	2000
Sample size	11	93
% Eyed eggs	45.5	19.4
% Uneyed eggs	27.2	79.6
% Barren, mated	27.2	0
% Barren, non-mated	0	1.1

Table 8. Results of legal tally samples taken during the 1999-2000 Bering Sea snow crab CDQ fisheries.

Year	Sample size	Male snow crab Percent	Female snow crab Percent	Other crabs Percent	Total Percent Illegal	Estimated Number of Illegal Crabs
1999	27,900	0.03	0	0.09	0.12	9,164
2000	15,050	0.04	0	0.09	0.13	2,292

Table 9. Estimated catch per pot (CPUE) of selected crab species from pot lifts sampled by observers during the 2000 Bering Sea snow crab CDQ fishery. Standard errors of the estimates are included in parentheses.

Species / Class	Total Pot Sample Catch	Sampled Fleet Estimated CPUE	Estimated Total Catch[a]
Snow crab			
Legal males retained	83,469	131.9[b] (4.89)	1,658,000[c]
Legal males not retained	33,692	51.7 (2.65)	650,000
Sublegal males	2,764	4.6 (0.37)	58,000
Females	298	0.4 (0.71)	5,000
Tanner / Snow Hybrid			
Legal males retained	5,059	5.8 (0.49)	73,000
Legal males not retained	2,262	18.8 (0.31)	236,000
Sublegal males	117	0.2 (0.05)	2,500
Females	15	<0.1 (0.02)	500
Tanner crab			
Legal males not retained	59	0.1 (0.03)	1,000
Sublegal males	2,144	3.7 (0.66)	46,000
Females	253	0.6 (0.53)	8,000

[a] Estimated CPUE multiplied by 12,568 total pot lifts during the fishery (Gish 2001).

[b] Actual CPUE for retained legal crabs (legal retained male snow crabs and Tanner/snow hybrids combined) for the fishery as reported on confidential interview forms was 134.5 for observed vessels. Actual total fishery CPUE of retained legal crabs was 144 for all vessels (Gish 2001).

[c] Actual catch of retained legal crabs for the fishery was 1,815,885 (Gish 2001).

Table 10. Total pot contents from 611 bycatch samples taken during the 2000 Bering Sea snow crab CDQ fishery.

Species	Total catch	CPUE[a]
Snow crab	120,223	
Legal males retained	83,469	136.6
Legal males not retained	33,692	55.1
Sublegal males	2,764	4.5
Females	298	0.5
Tanner / Snow Hybrid	7,453	
Legal males retained	5,059	8.3
Legal males not retained	2,262	3.7
Sublegal males	117	0.2
Females	15	<0.1
Tanner crab	2,456	
Legal males not retained	59	0.1
Sublegal males	2,144	3.5
Females	253	0.4
Snail (unidentified)	3,680	
Pacific cod	202	
Lyre crab	93	
Sculpin (unidentified)	47	
Hermit crab (unidentified)	28	
Sea star (unidentified)	25	
Shortspine thornyhead	10	
Sea anemone	9	
Octopus	8	
Halibut	7	
Walleye pollock	7	
Skate (unidentified)	2	
Greenland turbot	1	
Yellow Irish lord	1	

[a] Estimated CPUEs are calculated by dividing the total catch by the number of bycatch sample pots.

Table 11. Estimated CPUE of snow crabs by soak hours from 611 bycatch samples taken during the 2000 Bering Sea snow crab CDQ fishery.

	Pots sampled		Catch per sampled pot				
Soak hours	Number	Percent	Legal retained	Legal not retained	Sublegal	Female	Total
7-12	4	0.7	9.3	6.5	1.8	0.2	17.8
13-18	13	2.1	98.3	52.9	3.7	0	154.9
19-24	36	5.9	111.9	32.0	2.7	0.1	146.7
25-30	76	12.4	119.4	38.0	4.2	0.1	161.7
31-36	76	12.4	103.8	54.3	4.6	2.4	165.1
37-42	111	18.2	119.7	47.3	4.3	0.1	171.4
43-48	119	19.5	147.7	61.8	4.7	0.7	214.8
49-54	52	8.5	144.6	62.9	4.8	<0.1	212.4
55-60	23	3.8	172.5	50.6	7.1	<0.1	230.2
61-66	9	1.5	140.6	104.8	8.3	0.6	254.2
67-072	32	5.2	152.5	54.6	3.9	<0.1	211.0
73-78	11	1.8	196.2	63.2	3.5	0.2	263.1
79-84	7	1.1	187.6	61.0	4.1	0	252.7
85-90	6	1.0	225.0	49.5	17.0	0	291.5
91-96	10	1.6	195.5	91.2	2.3	0	289.0
97-102	1	0.2	2.0	2.0	0.0	0	4.0
103-108	10	1.6	257.6	111.1	4.4	0	373.1
115-120	13	2.1	220.4	101.6	3.5	0.1	325.5
127-132	2	0.3	223.5	163.5	5.5	0	392.5
Mean soak: 46.3 hours	Overall CPUE		136.6	55.1	4.5	0.5	196.8

Table 12. Estimated CPUE of snow crabs by depth from 611 bycatch samples taken during the 2000 Bering Sea snow crab CDQ fishery.

Depth (fathoms)	Pots sampled		Catch per sampled pot				
	Number	Percent	Legal retained	Legal not retained	Sublegal	Female	Total
51-55	3	0.5	114.3	56.0	9.3	0.7	180.3
56-60	37	6.1	134.5	84.0	4.0	0.2	222.6
61-65	258	42.2	135.6	71.7	4.8	1.1	213.1
66-70	92	15.1	142.8	49.6	6.2	<0.1	198.7
71-75	179	29.3	124.6	32.4	4.0	0.1	161.0
76-80	37	6.1	194.5	36.4	2.0	0.1	233.0
81-85	3	0.5	106.7	45.7	0	0	152.3
86-90	1	0.2	0	3.0	0	0	3.0
106-110	1	0.2	218.0	70.0	7.0	0	295.0
Mean depth: 67.4 fm	Overall CPUE		136.6	55.1	4.5	0.5	196.8

Table 13. Carapace size frequency distributions from biological measurements of retained red king crabs sampled during the 1999-2000 Bristol Bay red king crab CDQ fisheries.

	1999		2000	
Length (mm)	Number	Percent	Number	Percent
131-135	5	0.5	0	0
136-140	85	8.3	5	10.0
141-145	190	18.6	4	8.0
146-150	203	19.9	21	42.0
151-155	184	18.1	11	22.0
156-160	130	12.8	4	8.0
161-165	100	9.8	3	6.0
166-170	73	7.2	2	4.0
171-175	31	3.0	0	0
176-180	10	1.0	0	0
Totals	1011	99.2	50	100.0
Mean Length (mm)	152.5		150.4	

Table 14. Estimated catch per pot (CPUE) of red king crab from pot lifts sampled by observers deployed during the 1999 Bristol Bay red king crab CDQ fishery. Standard errors of the estimates are included in parentheses.

Species / Class	Total Pot Sample Catch	Sampled Fleet Estimated CPUE	Estimated Total Catch[a]
Red king crab			
Legal males retained	7,968	31.9[b] (3.76)	95,000[c]
Legal males not retained	346	0.9 (0.51)	3,000
Sublegal males	1,907	7.3 (1.34)	22,000
Females	21	0.1 (0.11)	300

[a] Estimated CPUE multiplied by 2,976 total pot lifts during the fishery (Gish 2001).

[b] Actual CPUE for retained legal red king crabs for the fishery as reported on confidential interview forms was 29 for observed vessels. Actual total fishery CPUE of retained legal crabs was 29 for all vessels (Gish 2001).

[c] Actual catch of retained legal crabs for the fishery was 85,996 (Gish 2001).

Table 15. Total pot contents from 263 bycatch samples taken during the 1999 Bristol Bay red king crab CDQ fishery.

Species	Total catch	CPUE[a]
Red king crab	10,242	
Legal males retained	7,968	30.3
Legal males not retained	346	1.4
Sublegal males	1,907	7.3
Females	21	0.1
Tanner crab	143	
Legal males not retained	75	
Sublegal males	64	
Females	4	
Snow crab	77	
Legal males not retained	66	
Sublegal males	11	
Females	0	
Tanner / Snow Hybrid	13	
Legal males not retained	10	
Sublegal males	3	
Females	0	
Pacific cod	274	
Snail (unidentified)	107	
Yellowfin sole	30	
Sea star (unidentified)	15	
Halibut	6	
Sculpin (unidentified)	5	
Great sculpin	5	
Hermit crab (unidentified)	4	
Lyre crab	3	
Octopus	3	
Skate (undentified)	2	

[a] Estimated CPUEs are calculated by dividing the total catch by the number of bycatch sample pots.

Table 16. Estimated CPUE of red king crabs by soak hours from 263 bycatch samples taken during the 1999 Bristol Bay red king crab CDQ fishery.

	Pots sampled		Catch per sampled pot				
Soak hours	Number	Percent	Legal retained	Legal not retained	Sublegal	Female	Total
7-12	3	1.1	20.3	0.7	2.0	0.3	23.3
13-18	8	3.0	1.9	0.1	1.0	0	3.0
19-24	41	15.6	27.1	0.8	4.5	0	32.4
25-30	45	17.1	23.5	0.0	7.5	<0.1	31.0
31-36	55	20.9	42.4	0.1	8.8	<0.1	51.4
37-42	72	27.4	27.5	0.3	7.0	<0.1	34.7
43-48	19	7.2	34.3	1.1	5.7	0.8	41.8
49-54	5	1.9	43.2	1.0	15.4	0	59.6
55-60	5	1.9	61.2	10.8	12.6	0	84.6
61-66	4	1.5	0.0	50.5	8.3	0	58.8
145-150	6	2.3	39.3	0.0	17.5	0	56.8
Mean soak: 35.9 hours	Overall CPUE		30.3	1.4	7.3	0.1	38.9

Table 17. Estimated CPUE of red king crabs by depth from 263 bycatch samples taken during the 1999 Bristol Bay red king crab CDQ fishery.

Depth (fathoms)	Pots sampled		Catch per sampled pot				
	Number	Percent	Legal retained	Legal not retained	Sublegal	Female	Total
26-30	1	0.4	0	0	0	0	0
36-40	54	20.5	30.6	0	12.1	0	42.7
41-45	10	3.8	5.5	0.1	1.8	0	7.4
46-50	180	68.4	30.4	1.9	5.9	0.1	38.3
51-55	18	6.8	43.6	0.1	9.9	0.1	53.6
Mean depth: 46.6 fm	Overall CPUE		30.3	1.4	7.3	0.1	38.9

Table 18. Shell ages of male and female red king crabs in bycatch samples taken during the 1999-2000 Bristol Bay red king crab CDQ fisheries.

Year	1999		2000	
Gender	Male	Female	Male	Female
Sample size	4,119	4	14,657	6,894
% New pliable shell	0	0	0.1	<0.1
% New shell	90.6	100.0	71.8	99.9
% Old shell	7.5	0	24.7	0
% Very old shell	1.9	0	3.4	0

Table 19. Reproductive condition of female red king crabs in bycatch samples taken during the 1999-2000 Bristol Bay red king crab CDQ fisheries.

Year	1999	2000
Sample size	4	6,984
% Eyed eggs	50.0	27.3
% Uneyed eggs	0	61.8
% Barren, mated	0	0.2
% Barren, non-mated	50.0	10.7

Table 20. Results of legal tally samples taken during the 1999 Bristol Bay red king crab CDQ fishery.

Year	Sample size	Male red king crab Percent	Female red king crab Percent	Other crabs Percent	Total Percent Illegal	Estimated Number of Illegal Crabs
1999	6,173	0.21	0	0	0.21	181

Table 21. Estimated catch per pot (CPUE) of red king crab from pot lifts sampled by observers deployed during the 2000 Bristol Bay red king crab CDQ fishery. Standard errors of the estimates are included in parentheses.

Species / Class	Total Pot Sample Catch	Sampled Fleet Estimated CPUE	Estimated Total Catch[a]
Red king crab			
Legal males retained	8,104	20.0[b] (1.54)	93,000[c]
Legal males not retained	67	0.2 (0.08)	1,000
Sublegal males	6,486	17.1 (2.53)	80,000
Females	6,984	16.5 (2.44)	77,000

[a] Estimated CPUE multiplied by 4,663 total pot lifts during the fishery (Gish 2001).

[b] Actual CPUE for retained legal red king crabs for the fishery as reported on confidential interview forms was 20 for observed vessels. Actual total fishery CPUE of retained legal crabs was 20 for all vessels (Gish 2001).

[c] Actual catch of retained legal crabs for the fishery was 91,390 (Gish 2001).

Table 22. Total pot contents from 428 bycatch samples taken during the 2000 Bristol Bay red king crab CDQ fishery.

Species	Total catch	CPUE
Red king crab	21,641	
Legal males retained	8,104	18.9
Legal males not retained	67	0.2
Sublegal males	6,486	15.2
Females	6,984	16.3
Snow crab	397	
Legal males not retained	389	
Sublegal males	8	
Females	0	
Tanner / Snow Hybrid	58	
Legal males not retained	58	
Sublegal males	0	
Females	0	
Tanner crab	248	
Legal males not retained	87	
Sublegal males	153	
Females	8	
Hair crab	5	
Legal males not retained	4	
Sublegal males	1	
Females	0	
Pacific cod	434	
Yellowfin sole	328	
Sculpin (unidentified)	57	
Great sculpin	44	
Sea star (unidentified)	17	
Snail (unidentified)	14	
Halibut	10	
Hermit crab (unidentified)	4	
Lyre crab	2	
Decorator crab	1	
Walleye pollock	1	
Rockfish	1	
Bigmouth sculpin	1	
Yellow Irish lord	1	

[a] Estimated CPUEs are calculated by dividing the total catch by the number of bycatch sample pots.

Table 23. Estimated CPUE of red king crabs by soak hours from 428 bycatch samples taken during the 2000 Bristol Bay red king crab CDQ fishery.

	Pots sampled		Catch per sampled pot				
Soak hours	Number	Percent	Legal retained	Legal not retained	Sublegal	Female	Total
13-18	20	4.7	10.4	0.1	5.2	9.4	25.1
19-24	212	49.5	18.4	0.1	16.3	19.5	54.3
25-30	100	23.4	16.9	0.2	13.7	17.1	47.8
31-36	65	15.2	25.1	0.2	15.5	11.8	52.6
37-42	19	4.4	24.8	0.3	24.8	5.3	55.2
43-48	12	2.8	17.9	0.3	7.1	7.3	32.7
Mean soak: 26.3 hours	Overall CPUE		18.9	0.2	15.2	16.3	50.6

Table 24. Estimated CPUE of red king crabs by depth from 428 bycatch samples taken during the 2000 Bristol Bay red king crab CDQ fishery.

	Pots sampled		Catch per sampled pot				
Depth (fathoms)	Number	Percent	Legal retained	Legal not retained	Sublegal	Female	Total
16-20	1	0.2	15.0	0	9.0	0	24.0
26-30	47	11.0	19.9	0.4	16.1	7.7	44.1
31-35	105	24.5	20.0	<0.1	18.3	3.2	41.5
36-40	89	20.8	21.1	0.2	15.1	8.1	44.5
41-45	157	36.7	17.1	0.1	13.4	26.9	57.5
46-50	29	6.8	17.0	0.3	12.3	46.5	76.0
Mean depth: 38.3 fm	Overall CPUE		18.9	0.2	15.2	16.3	50.6

Table 25. Observer coverage, pot sampling effort by observers, and relative difference of the weighted CPUE estimates for retained legal crabs from the Actual Observed Fleet (AOF) CPUE and from the Actual Total Fishery (ATF) CPUE.

Fishery (Table referenced)	Vessels		Pot Lifts		Percent difference of the weighted CPUE estimate from:	
	Observed	Total Fishery	Observed	Total Fishery	AOF CPUE[a]	ATF CPUE[b]
1999 Bering Sea snow crab (Table 2)						
C. opilio only	20	23	785	46,490	-9.3%	-15.7
with legal hybrids	20	23	785	46,490	5.4%	-2.1
2000 Bering Sea snow crab (Table 9)						
C. opilio only	12	13	611	12,568	-1.9%	-8.4%
with legal hybrids	12	13	611	12,568	2.4%	-4.4%
1999 Bristol Bay red king crab (Table 14)	10	10	263	2,976	10.0%	10.0%
2000 Bristol Bay red king crab (Table 21)	11	11	428	4,663	0%	0%

[a] AOF CPUE is based on confidential interviews with vessel operators. Percent difference is calculated as:

$$\left[\frac{(weightedCPUE)-(AOFCPUE)}{(AOFCPUE)}\right]\times 100\%.$$

[b] ATF CPUE is based on fish ticket data on all landings in the fishery. Percent difference is calculated as:

$$\left[\frac{(weightedCPUE)-(ATFCPUE)}{(ATFCPUE)}\right]\times 100\%.$$

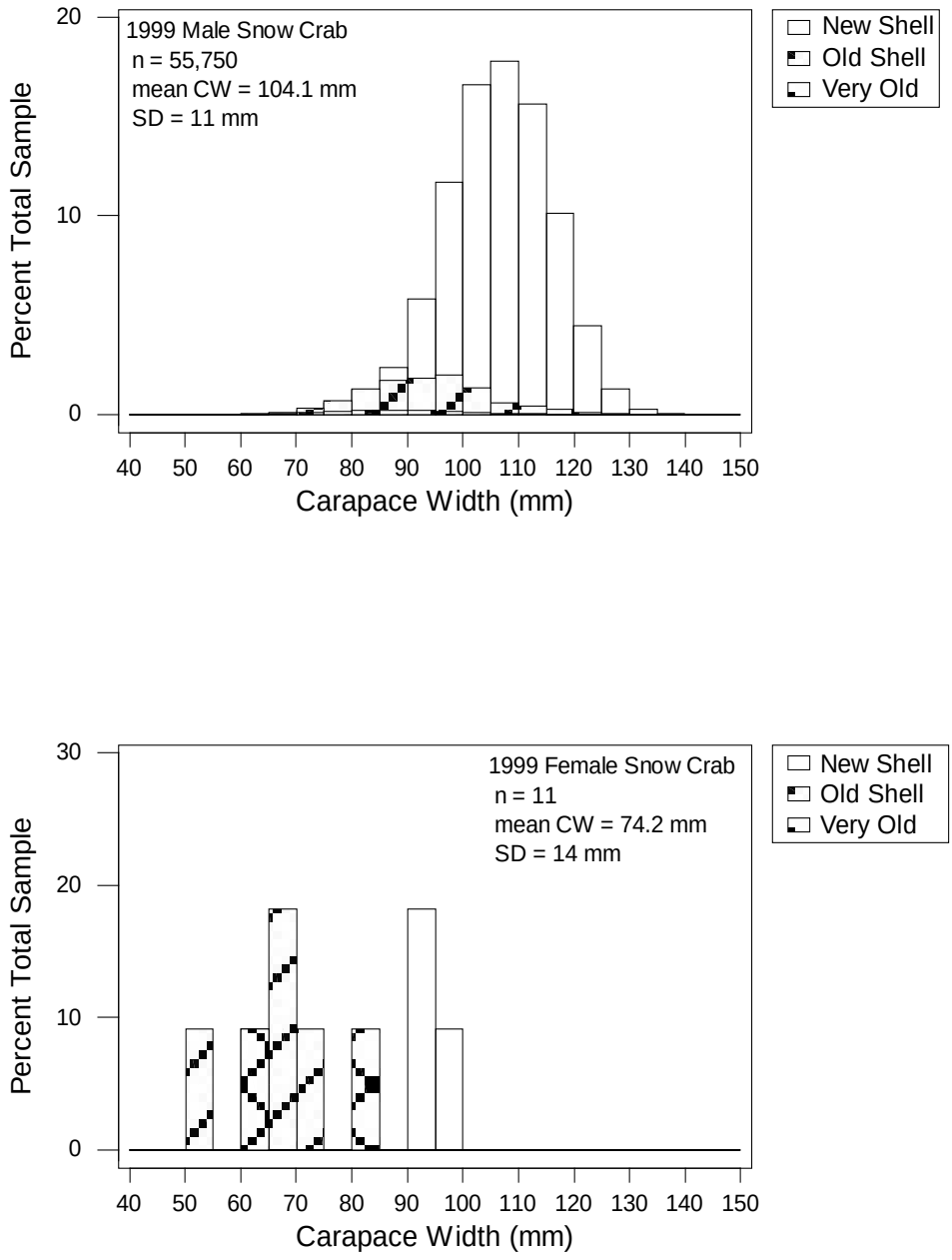
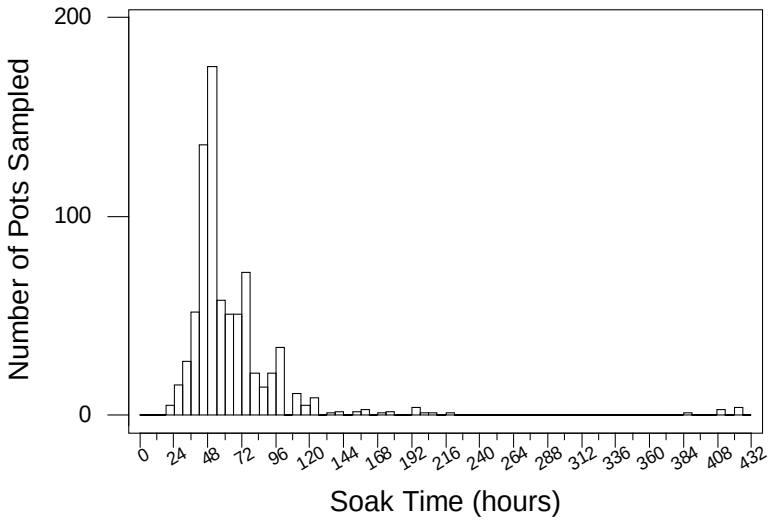


Figure 1. Carapace size frequency distributions with corresponding shell ages for male and female snow crabs from bycatch samples taken during the 1999 Bering Sea snow crab CDQ fishery.



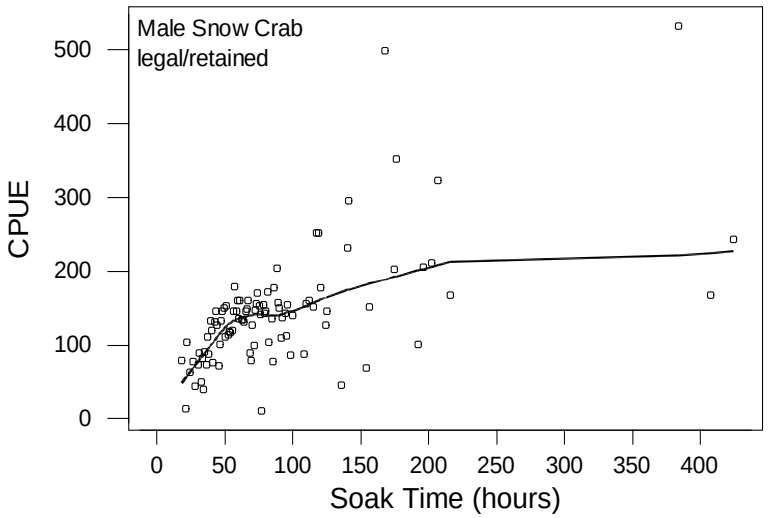
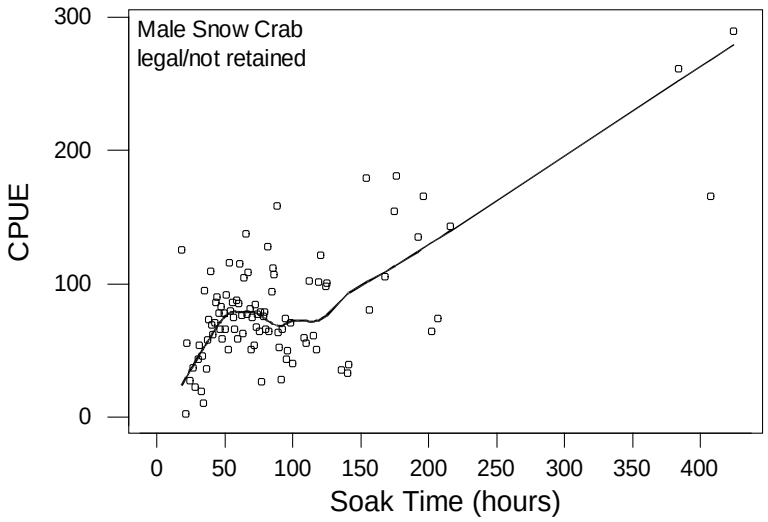


Figure 2. The distribution of soak times for 785 sampled pots and the estimated mean CPUE of legal/retained, legal/non-retained, and sublegal male snow crabs by soak hours with LOWESS lines from bycatch samples taken during the 1999 Bering Sea snow crab CDQ fishery. (page 1 of 2)



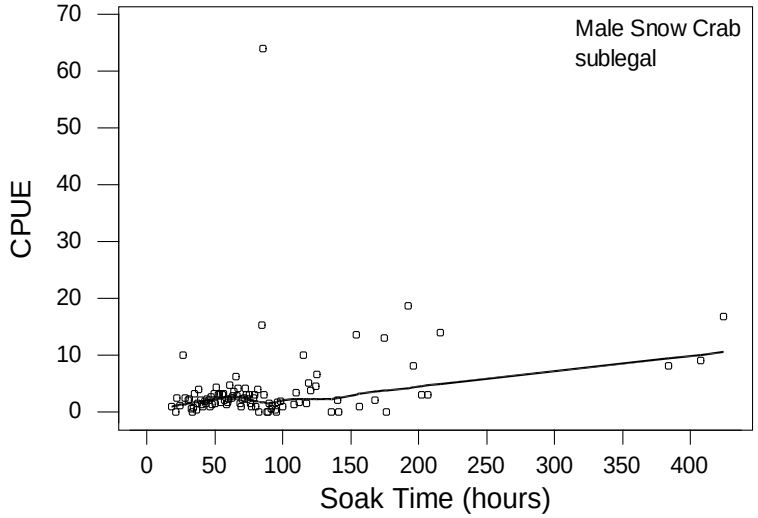
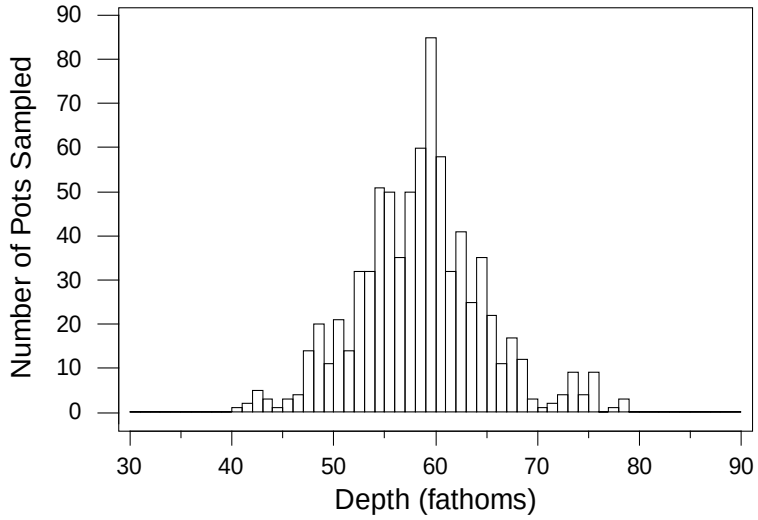


Figure 2. (page 2 of 2)



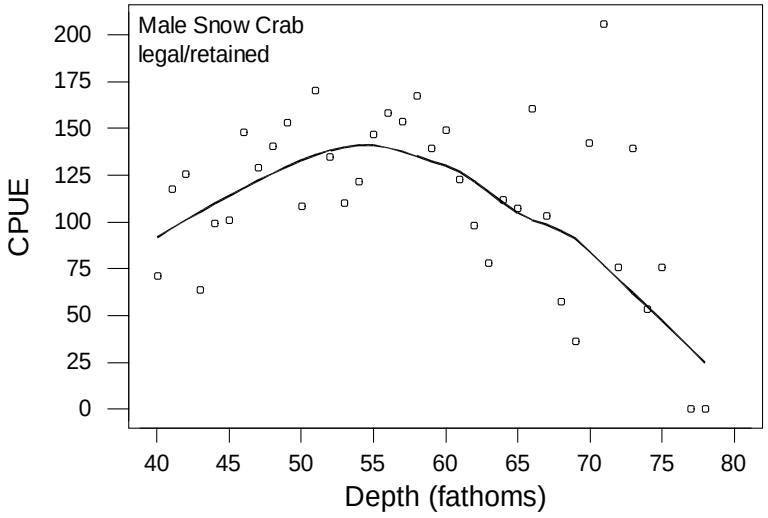
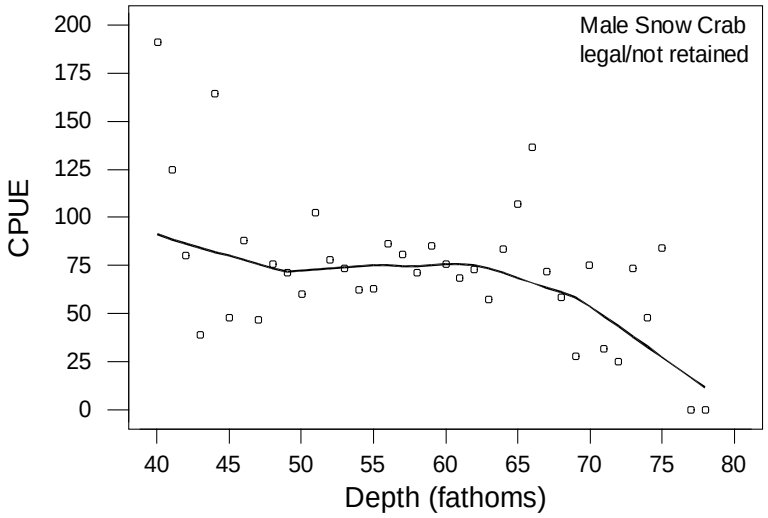
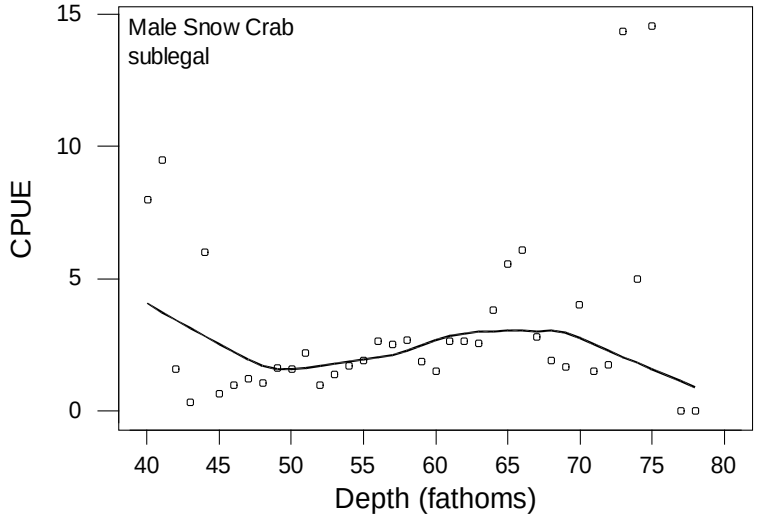


Figure 3. The distribution of depths fished for 785 sampled pots and the estimated mean CPUE of legal/retained, legal/non-retained, and sublegal male snow crabs by depth with LOWESS lines from bycatch samples taken during the 1999 Bering Sea snow crab CDQ fishery. (page 1 of 2)





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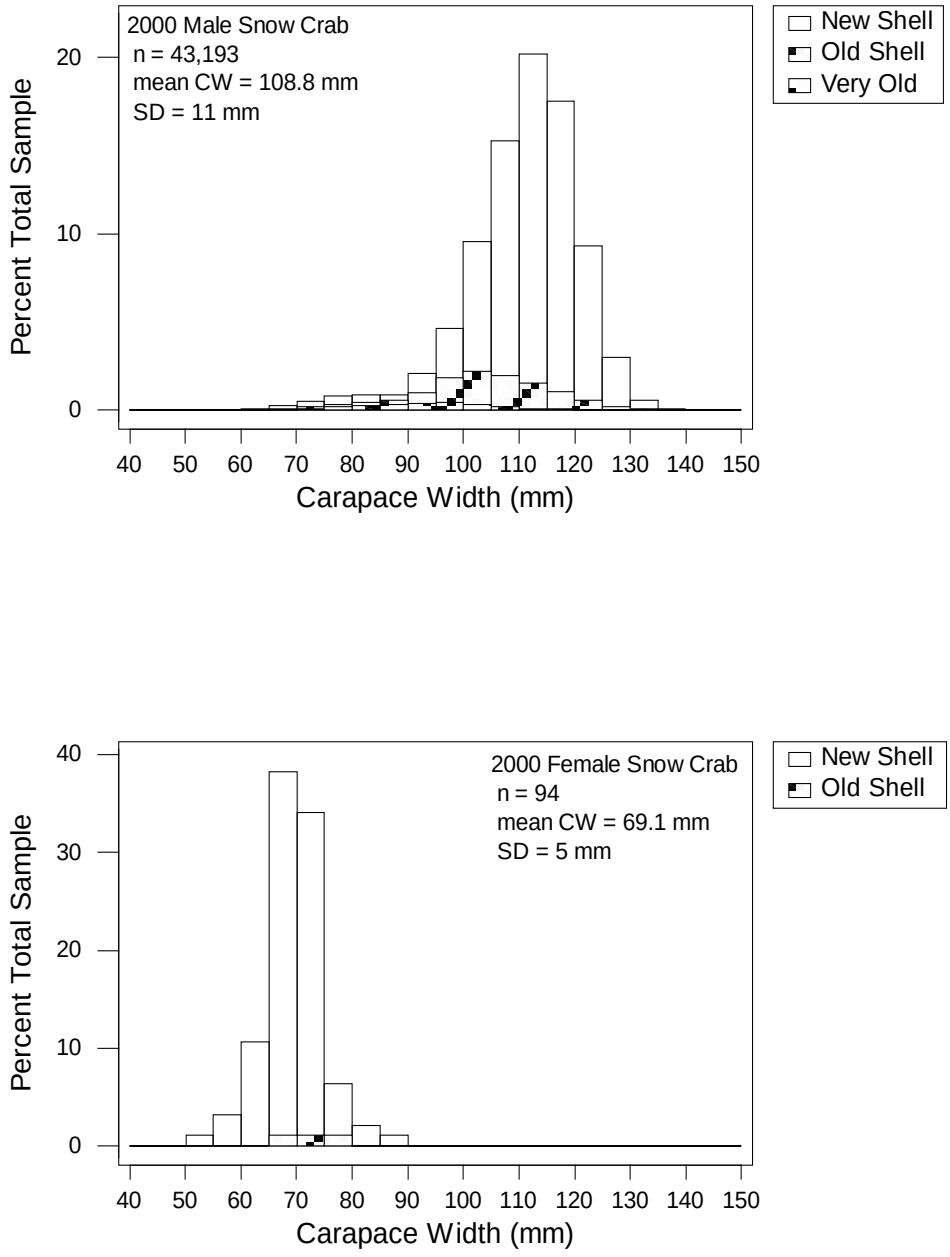
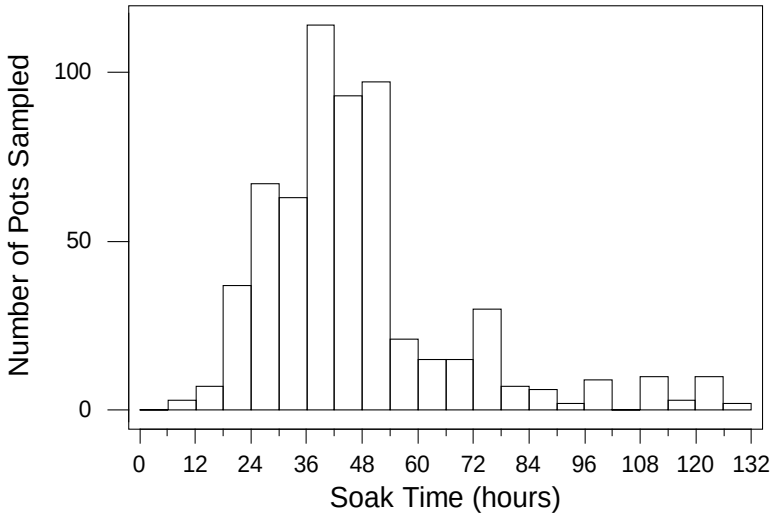


Figure 4. Carapace size frequency distributions with corresponding shell ages for male and female snow crabs from bycatch samples taken during the 2000 Bering Sea snow crab CDQ fishery.



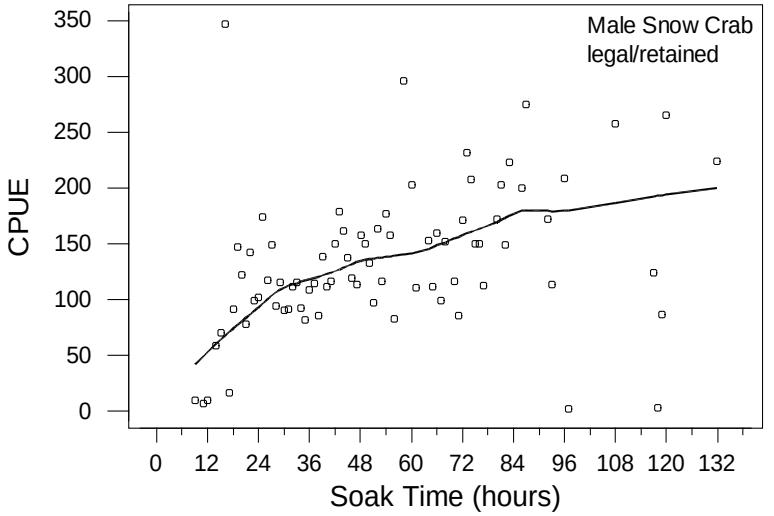
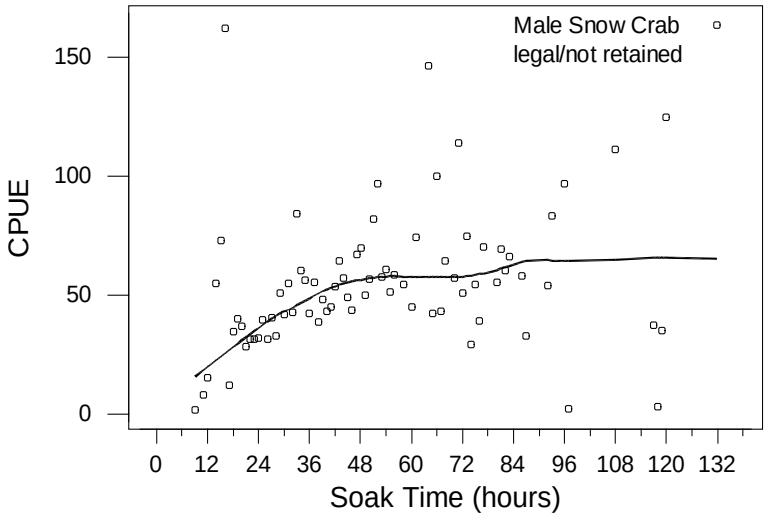


Figure 5. The distribution of soak times for 611 sampled pots and the estimated mean CPUE of legal/retained, legal/non-retained, and sublegal male snow crabs by soak hours with LOWESS lines from bycatch samples taken during the 2000 Bering Sea snow crab CDQ fishery. (page 1 of 2)



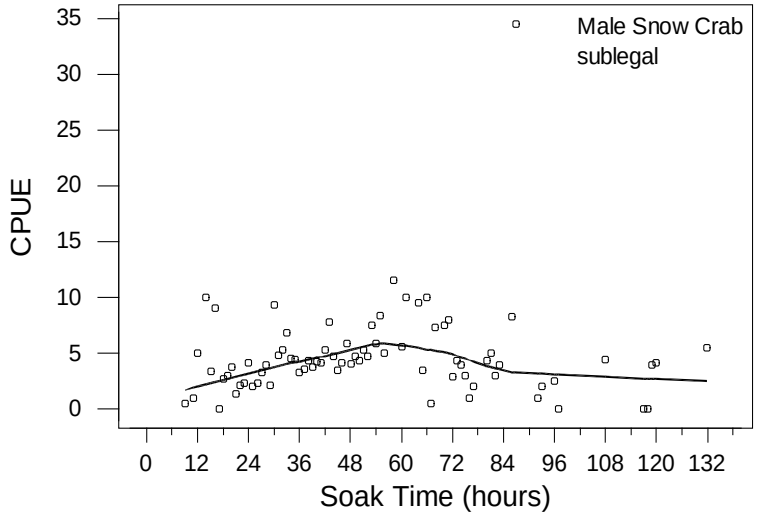
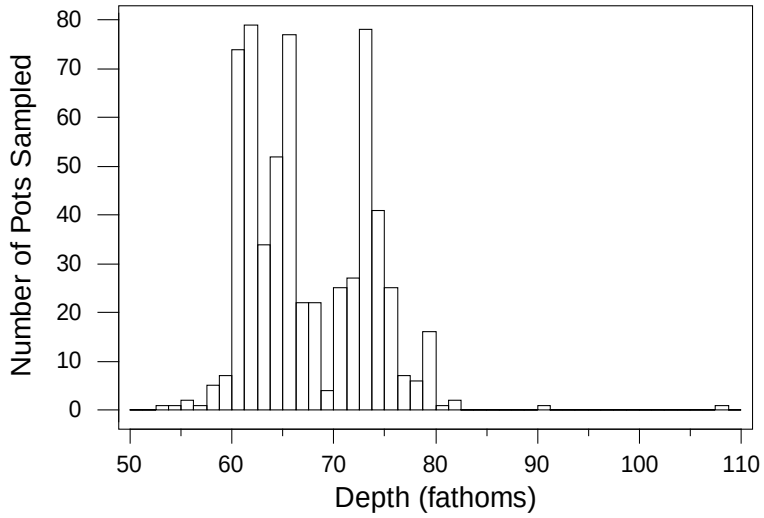


Figure 5. (page 2 of 2)



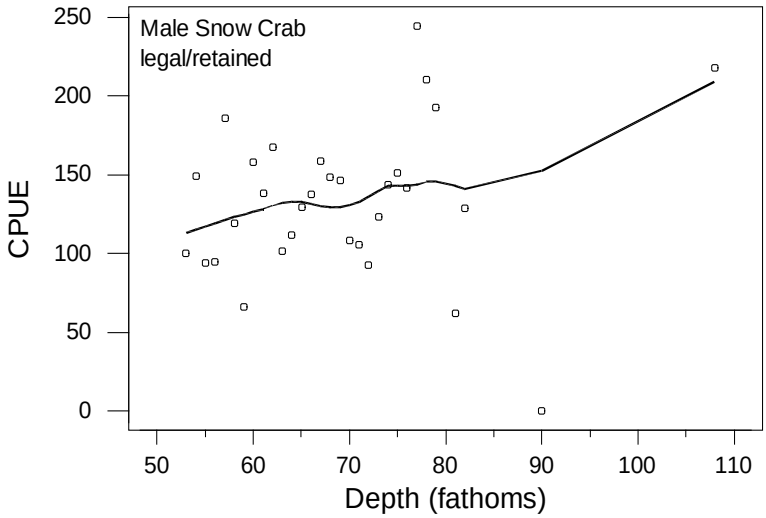
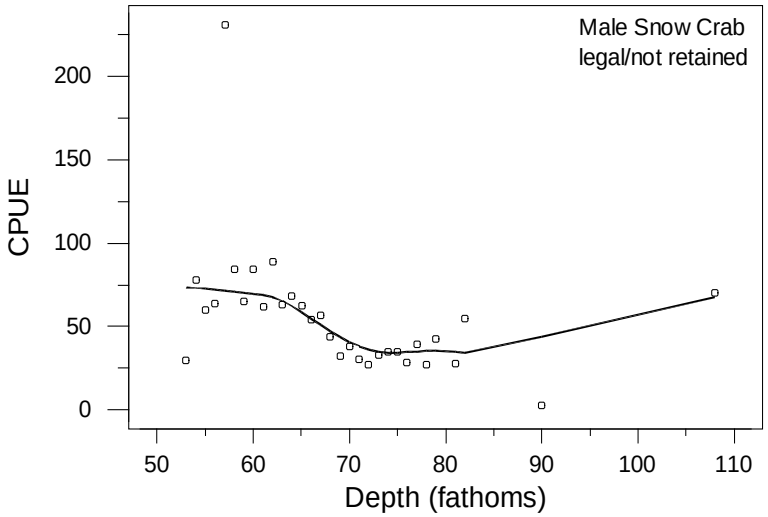
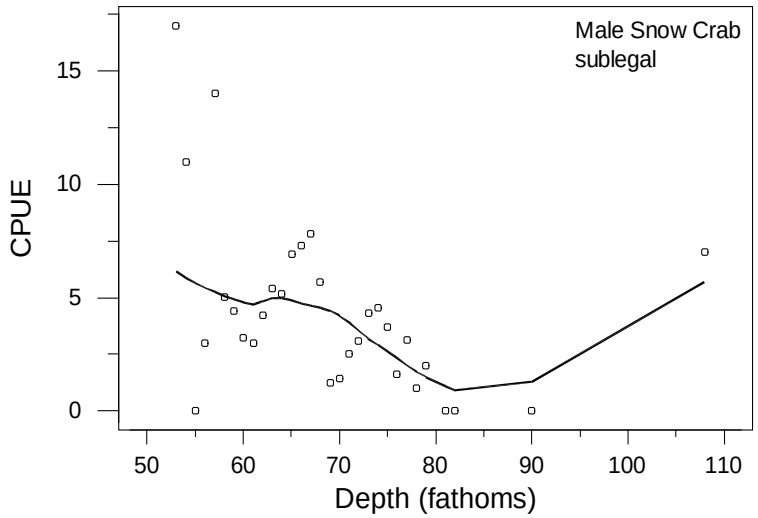


Figure 6. The distribution of depths fished for 611 sampled pots and the estimated mean CPUE of legal/retained, legal/non-retained, and sublegal male snow crabs by depth with LOWESS lines from bycatch samples taken during the 2000 Bering Sea snow crab CDQ fishery. (page 1 of 2)





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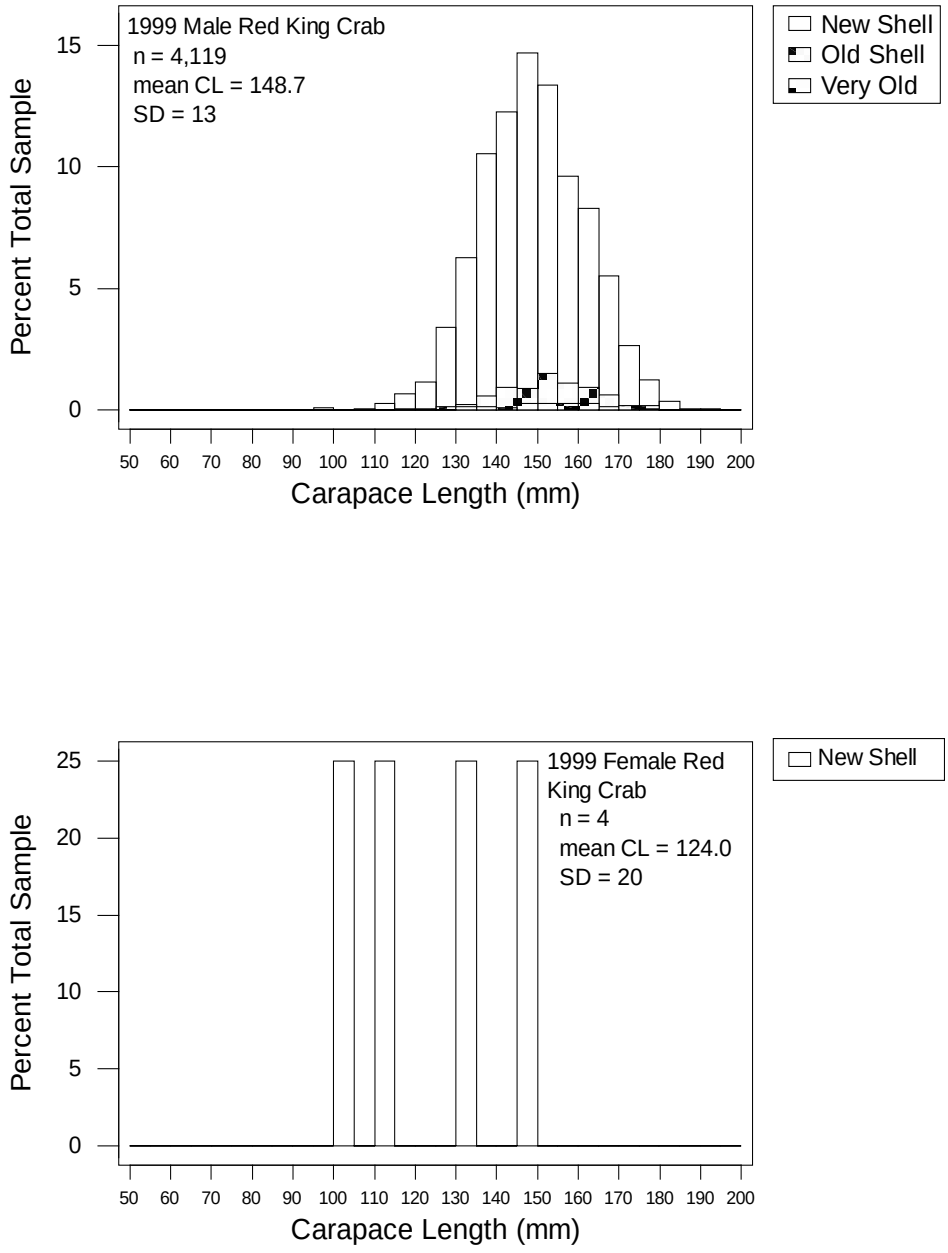


Figure 7. Carapace size frequency distributions with corresponding shell ages for male and female red king crabs from bycatch samples taken during the 1999 Bristol Bay red king crab CDQ fishery.

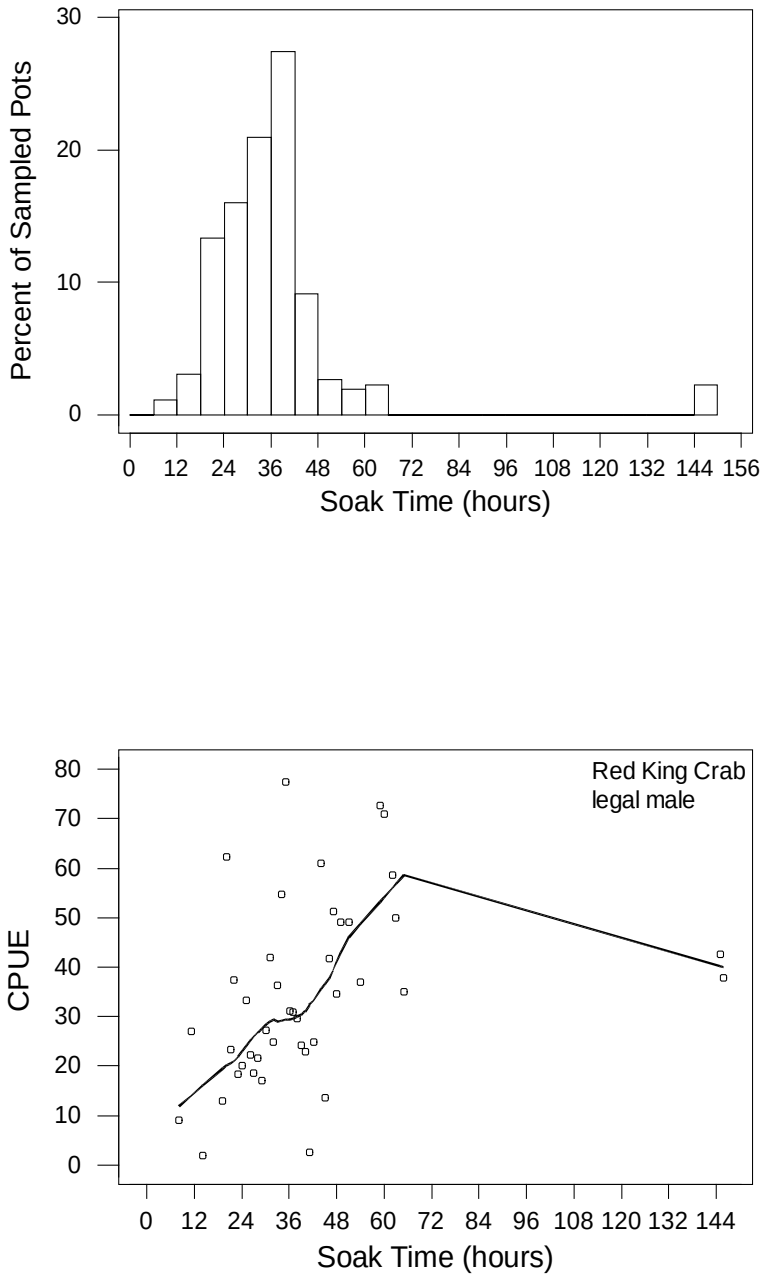
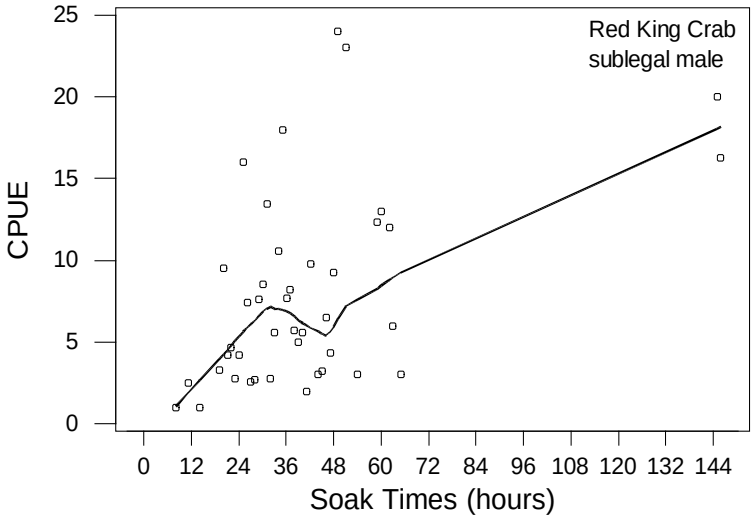
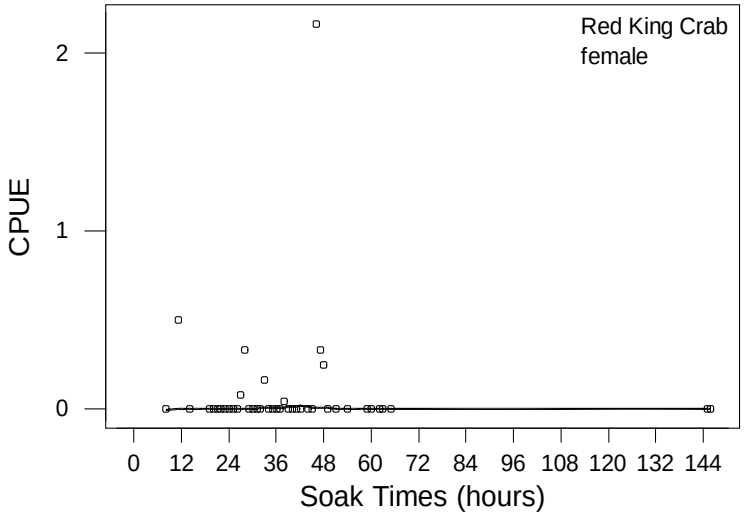


Figure 8. The distribution of soak times for 263 sampled pots and the estimated mean CPUE of legal male, sublegal male, and female red king crabs by soak hours with LOWESS lines from bycatch samples taken during the 1999 Bristol Bay red king crab CDQ fishery. (page 1 of 2)





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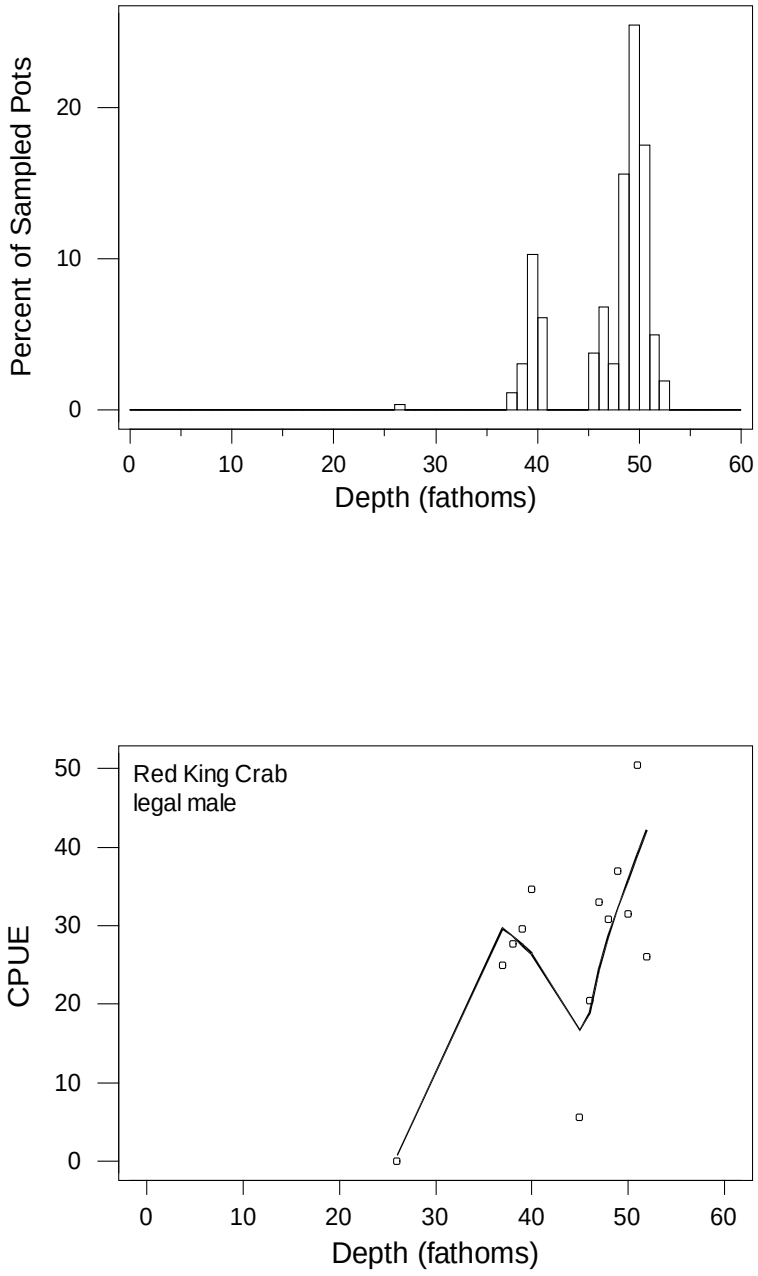
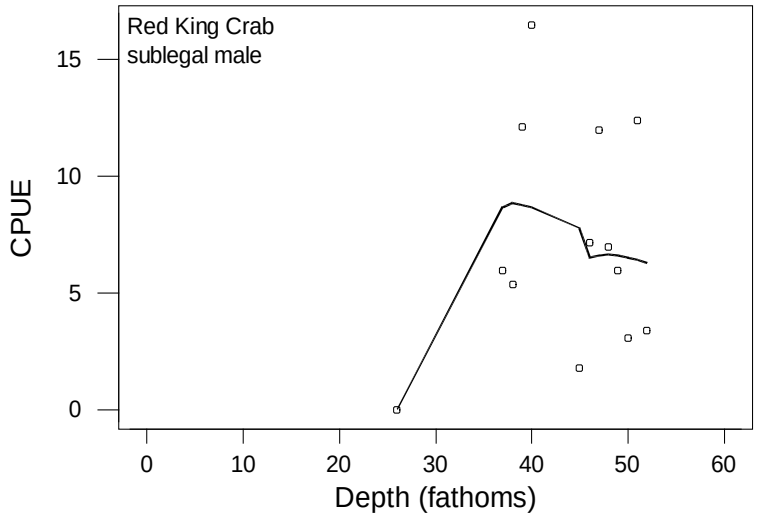


Figure 9. The distribution of depths fished for 263 sampled pots and the mean estimated CPUE of legal male, sublegal male, and female red king crabs by depth with LOWESS lines from bycatch samples taken during the 1999 Bristol Bay red king crab CDQ fishery. (page 1 of 2)



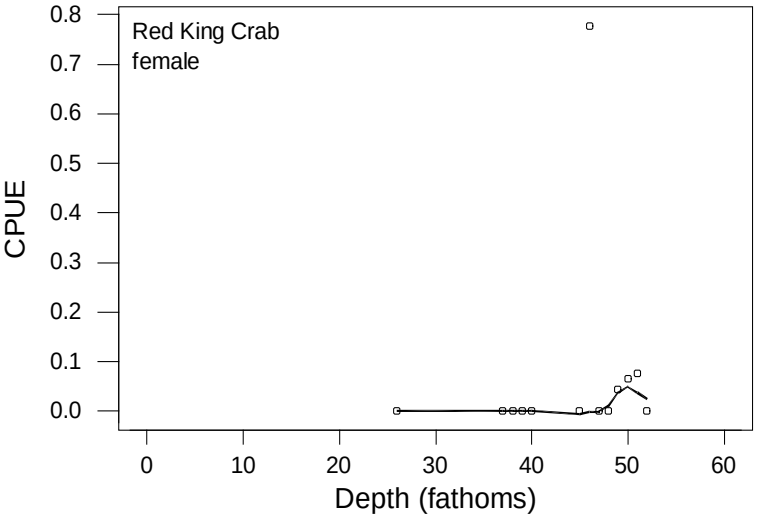


Figure 9. (page 2 of 2)

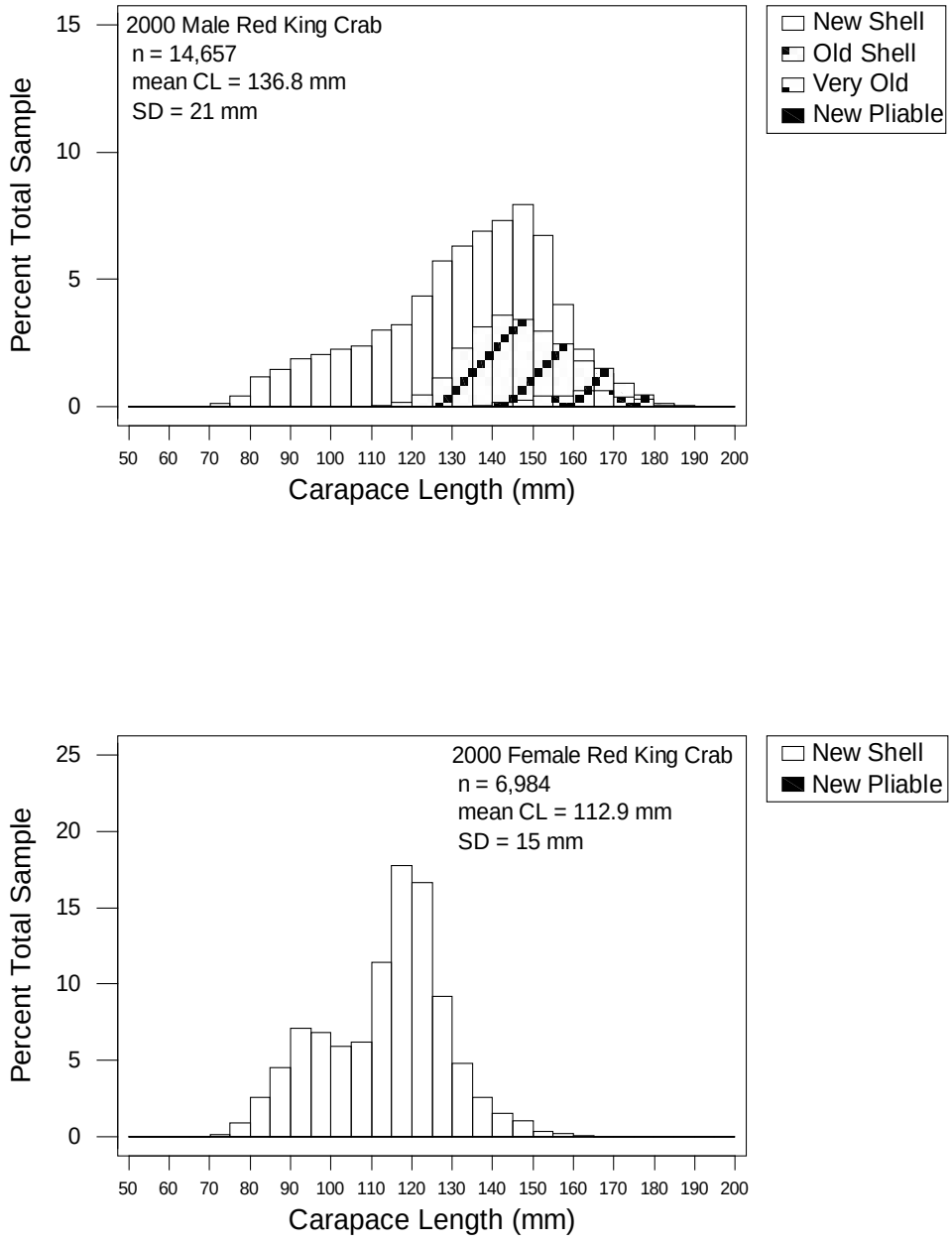


Figure 10. Carapace size frequency distributions with corresponding shell ages for male and female red king crabs from bycatch samples taken during the 2000 Bristol Bay red king crab CDQ fishery.

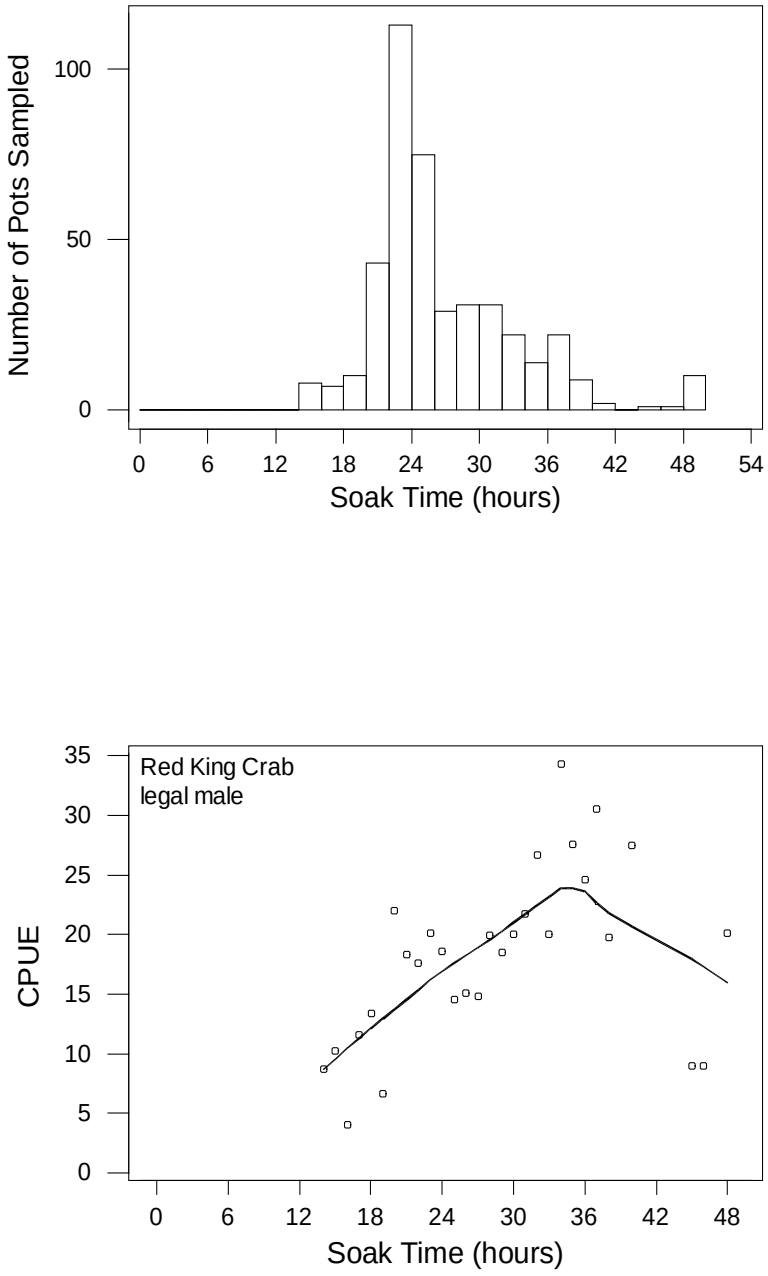
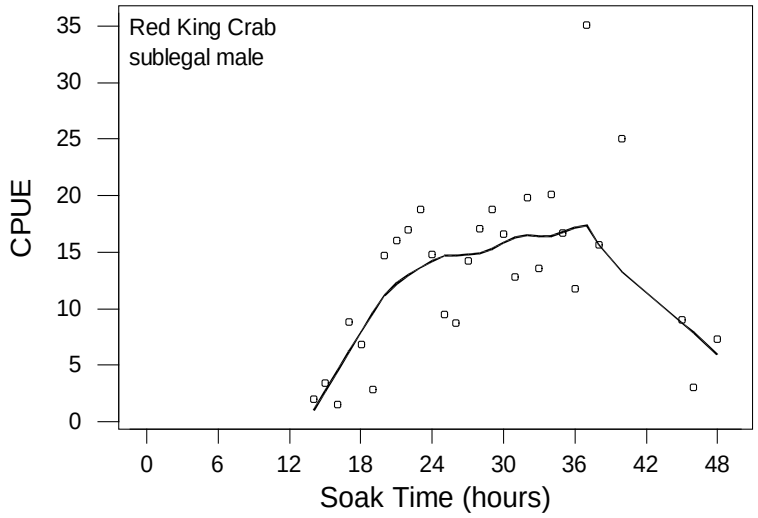


Figure 11. The distribution of soak times for 428 sampled pots and the estimated mean CPUE of legal male, sublegal male, and female red king crabs by soak hours with LOWESS lines from bycatch samples taken during the 2000 Bristol Bay red king crab CDQ fishery. (page 1 of 2)



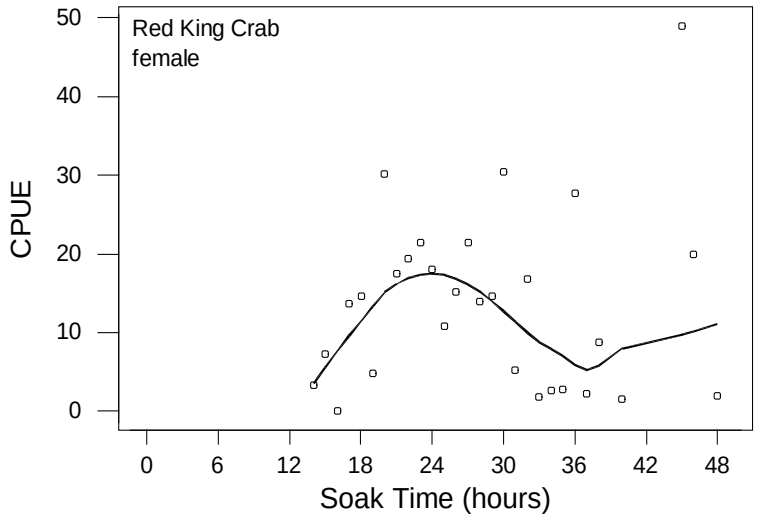
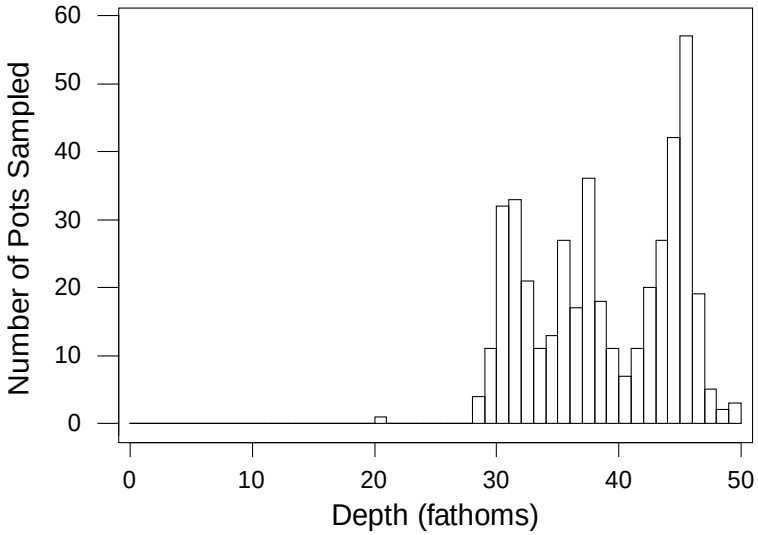


Figure 11. (page 2 of 2)



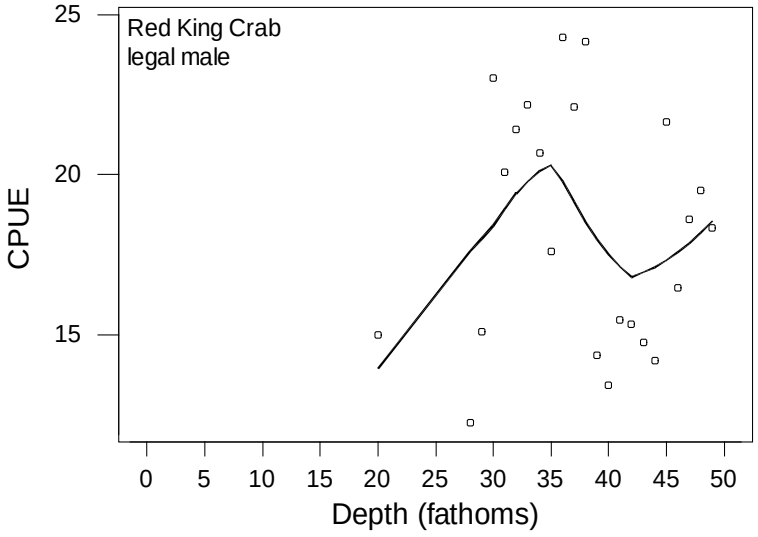
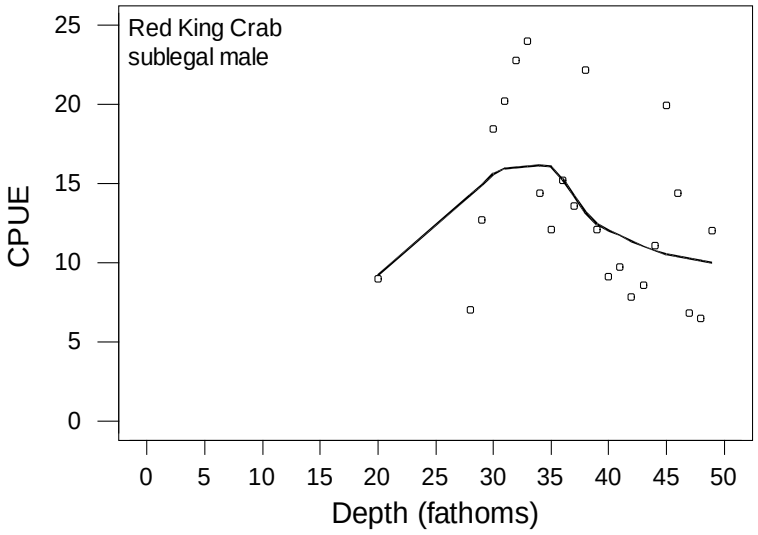


Figure 12. The distribution of depths fished for 428 sampled pots and the mean estimated CPUE of legal male, sublegal male, and female red king crabs by depth with LOWESS lines from bycatch samples taken during the 2000 Bristol Bay red king crab CDQ fishery. (page 1 of 2)



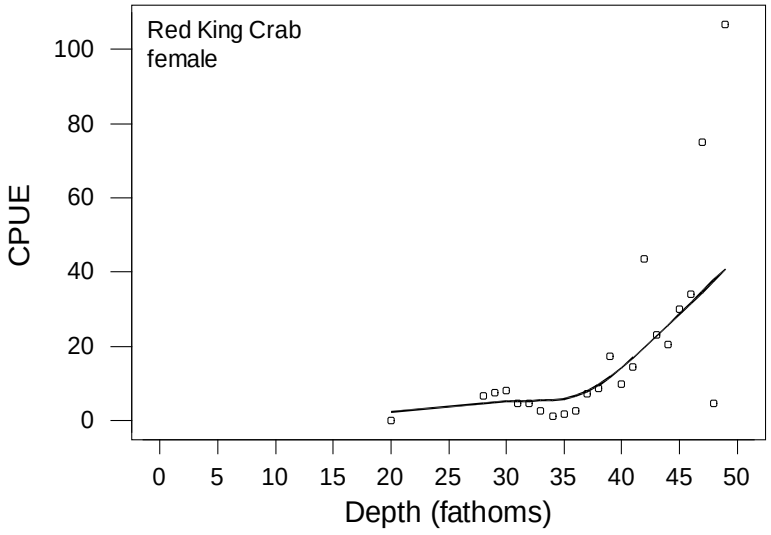


Figure 12. (page 2 of 2)

APPENDIX

Appendix A.1. Formulas used to calculate weighted mean and variance estimates for CPUE.

For a given fishery, observers are instructed to randomly sample n potlifts per day. In practice this number will vary by day, vessel and observer. Observers actually sample n_{ij} pots per day from a total of N_{ij} pots pulled by vessel i on day j. Formulas follow Cochran (1977).

The mean CPUE for vessel i on day j is $$\bar{x}_{ij.} = \frac{1}{n_{ij}}\left(\sum_k x_{ijk}\right)$$

and the variance for this estimator is $$\hat{\text{var}}\left(\bar{x}_{ij.}\right) = \frac{1}{n_{ij}}\left[\frac{\sum_k \left(x_{ijk} - \bar{x}_{ij.}\right)^2}{n_{ij} - 1}\right]$$

where x_{ijk} is the number of crab in a pot sampled where

i is the vessel
j is the day
k is the pot sampled
n is the number of pots sampled.

It follows that

the estimated total catch by vessel i on day j is $\left(\bar{x}_{ij.} \times N_{ij}\right)$,

the estimated total catch by vessel i over the fishery is $\sum_j \left(\bar{x}_{ij.} \times N_{ij}\right)$,

the estimated weighted mean catch per pot lift by vessel i over the fishery is

$$\frac{1}{N_{i.}}\left[\sum_j \left(\bar{x}_{ij.} \times N_{ij}\right)\right]$$
$$= \sum_j \left(\bar{x}_{ij.} \times w_{ij}\right)$$
$$= \bar{x}_{i..}$$

and $$\hat{\text{var}}\left(\bar{x}_{i..}\right) = \sum_j \left[\hat{\text{var}}\left(\bar{x}_{ij.}\right) \times w_{ij.}^2\right]$$

where $w_{ij} = N_{ij} / N_i$. The weights reflect the importance of a day's sampling based on the number of pots lifted on day j by vessel i relative to the total number of pots lifted by vessel i over the course of the fishery.

-Continued-

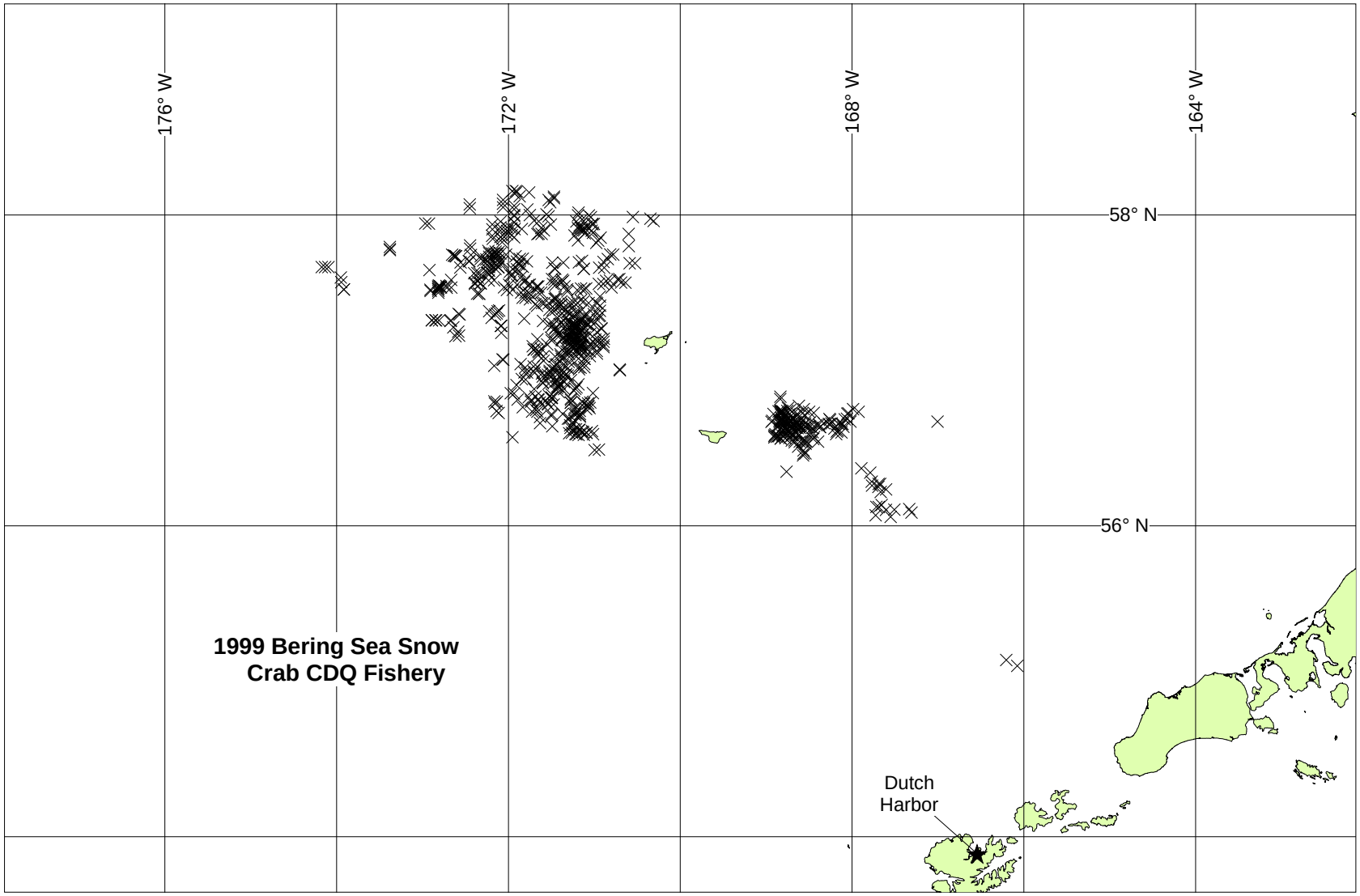
The estimated mean catch per pot lift for all vessels over the fishery is

$$\begin{aligned}\bar{x}_{...} &= \frac{1}{N_{..}}\left[\sum_i \left(\bar{x}_{i..} \times N_{i.}\right)\right] \\ &= \sum_j \left(\bar{x}_{ij.} \times w_{ij}\right) \\ &= \sum_i \left(\bar{x}_{i..} \times w_i\right) \\ &= \frac{1}{N_{..}} \sum_i \sum_j \left(\bar{x}_{ij.} \times N_{ij}\right).\end{aligned}$$

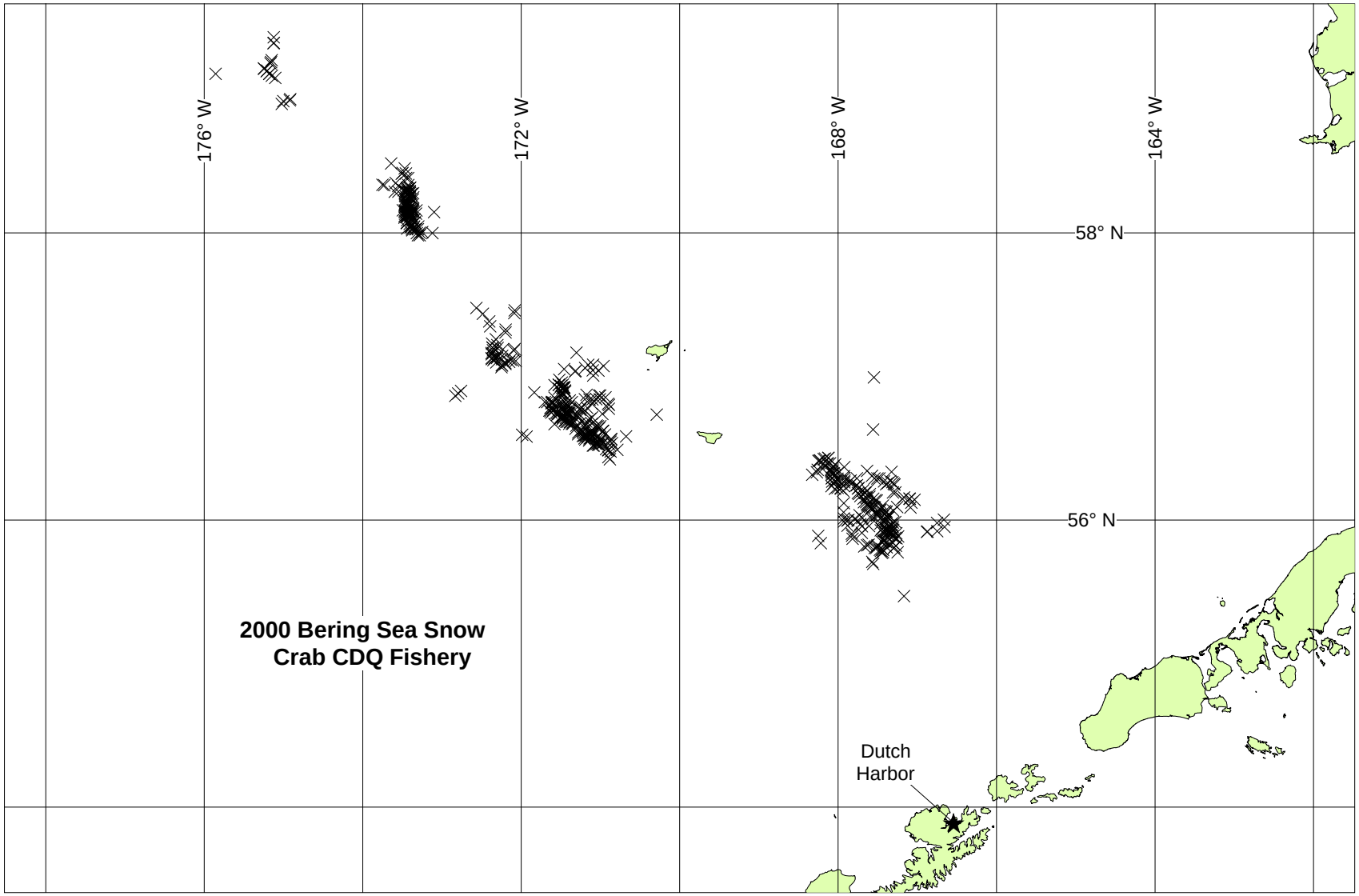
The variance of this estimator is

$$\begin{aligned}\hat{\text{var}}\left(\bar{x}_{...}\right) &= \sum_i \left[\hat{\text{var}}\left(\bar{x}_{i..}\right) \times w_{i.}^2\right] \\ &= \sum_i w_{i.}^2 \left\{\sum_j \left[\hat{\text{var}}\left(\bar{x}_{ij.}\right) \times w_{ij}^2\right]\right\} \\ &= \sum_i \left(\frac{N_{i.}}{N_{..}}\right)^2 \left\{\sum_j \left[\hat{\text{var}}\left(\bar{x}_{ij.}\right) \times \left(\frac{N_{ij}}{N_{i.}}\right)^2\right]\right\} \\ &= \sum_i \left\{\sum_j \left[\hat{\text{var}}\left(\bar{x}_{ij.}\right) \times \left(\frac{N_{ij}}{N_{..}}\right)^2\right]\right\} \\ &= \frac{1}{N_{..}^2} \sum_i \sum_j \left[\hat{\text{var}}\left(\bar{x}_{ij.}\right) \times N_{ij}^2\right]\end{aligned}$$

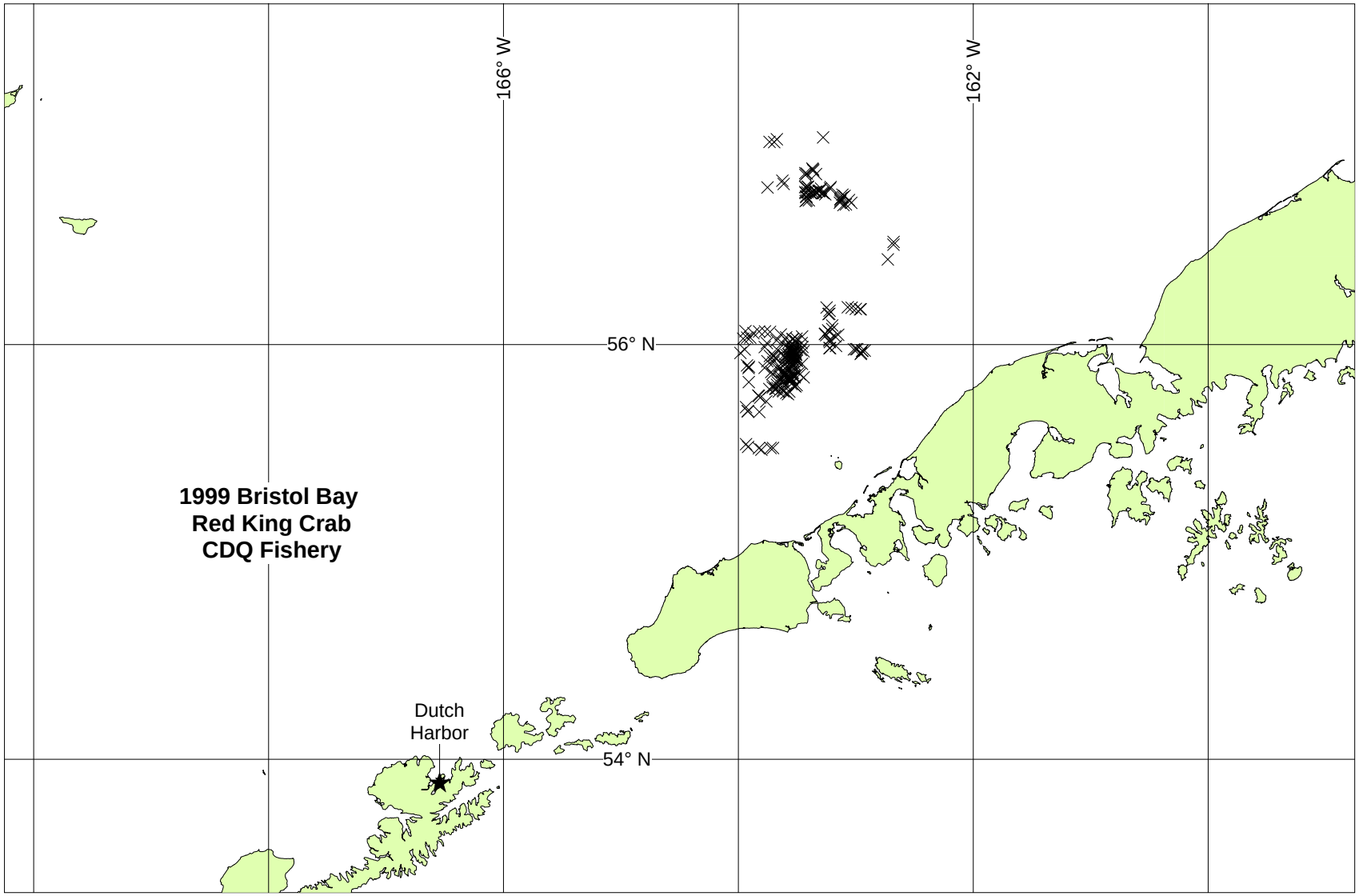
where $w_{i.} = N_{i.} / N_{..}$.



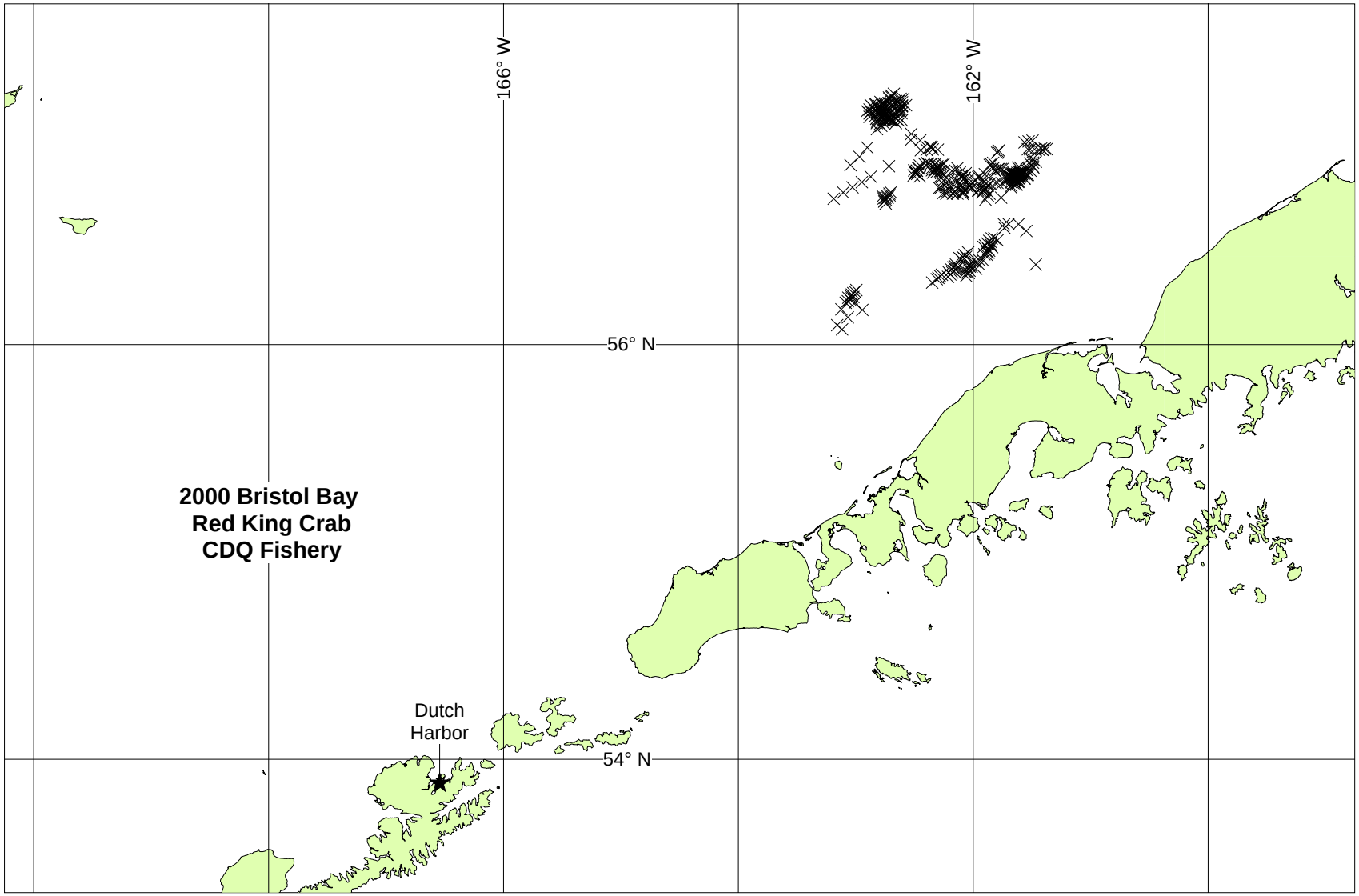
Appendix B.1. Locations of pots sampled by shellfish observers during the 1999 Bering Sea snow crab CDQ fishery.



Appendix B.2. Locations of pots sampled by shellfish observers during the 2000 Bering Sea snow crab CDQ fishery.



Appendix B.3. Locations of pots sampled by shellfish observers during the 1999 Bristol Bay red king crab CDQ fishery.



Appendix B.4. Locations of pots sampled by shellfish observers during the 2000 Bristol Bay red king crab CDQ fishery.