4K92-33

ANNUAL BIOLOGICAL SUMMARY OF THE WESTWARD REGION SHELLFISH OBSERVER DATABASE, 1991

By

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Regional Information Report[1] No. 4K92-33

Alaska Department of Fish and Game
Division of Commercial Fisheries
211 Mission Road
Kodiak, Alaska 99615

December 1992

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[1]The Regional Information Report Series was established in 1987 to provide an information access system for all unpublished division reports. These reports frequently serve diverse ad hoc informational purposes or archive basic uninterpreted data. To accommodate timely reporting of recently collected information, reports in this series undergo only limited internal review and may be subsequently finalized and published in the formal literature. Consequently, these reports should not be cited without prior approval of the author or the Division of Commercial Fisheries.

ACKNOWLEDGMENTS

I would like to express my gratitude to the many crab observers for persevering through adverse conditions in the Bering Sea to collect raw data analyzed in this report.

I thank the following ADF&G personnel who assisted in making this report possible: Observer program coordinator Rance Morrison, assistant coordinator Donn Tracy, and staff biologist Ben Kirkpatrick who administer the collection and editing of the raw data; Jim Blackburn for managing programming and data entry of the observer database; Dutch Harbor management staff biologists Dave Skordelis and Kathy Hobart for editing and data entry; Leslie Watson and Doug Pengilly for their technical support and advice; Lisa Gustafson and Nang Heim who provided the data entry.

I would also like to credit the Pacific Fisheries Information Network (PacFIN) for recognizing the importance of continued funding of Bering Sea research.

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INTRODUCTION

This document is the second in a series of reports summarizing raw biological data collected by mandatory crab observers. The first report (Beers 1991) summarized data collected from the inception of the program(September, 1988) to September 1990; this report covers observed fisheries that occurred after September 1990 and were completed prior to January 1, 1992. Some of these data are presented with data from the first report to facilitate multi-year comparisons.

The primary objective of biological data collection by observers is to establish a database to monitor long term stability of commercial fisheries in Alaska where shellfish are processed at sea. The presence of observers on vessels provides a unique opportunity to randomly sample pots during the fishery for legal size compliance and biological documentation. The majority of these fisheries occur in the Bering Sea, as shown in Figures 1 and 2. Species covered by the mandate are red king crab *Paralithodes camtschaticus*, blue king crab *Paralithodes platypus*, brown king crab *Lithodes aequispina*, snow crab *Chionoecetes opilio*, and Tanner crab *Chionoecetes bairdi*. Additionally, for several species of pink scallops (genus *Chlamys*) observers may be required by permit.

Data collection falls into three categories: random pot sampling records on catcher- processors, length frequency samples of retained crabs and legal tallies on both catcher-processors and catcher-only vessels delivering to floating processors. The bulk of this report will summarize random pot sampling records collected on catcher-processors. In 1991 observers spent 325.3 man-

months onboard vessels, and participated in 191 catcher-processor fishing trips and 74 floating processor trips (ADF&G 1991).

While the bulk of data reported here is representative of the entire crab fleet, some bias may exist due to the increased capabilities of larger catcher-processor vessels over smaller catcher-only vessels. Catcher-processor vessels tend to carry more pots and have the capability of covering larger areas than catcher-only vessels; they tend to have longer soak times and hence slightly higher catch rates. In fast paced short fisheries (e.g. St. Matthew blue king crab fishery) methods and areas fished may be very similar to catcher-only vessels and less bias exists in the data. Methods and capabilities between the two groups tend to diverge in the longer more remote crab fisheries (e.g. Adak golden king crab fishery). Additionally, while catcher-processors harvest the majority of the commercial golden king crab catch, the catcher-only fleet dominates the havest of Tanner and snow crab.

Catcher-processor fishing effort is documented by fishery in the Westward Region annual management report (ADF&G 1991). Additional information on fishing effort and timing from that report may be useful to readers interpreting data reported here.

METHODS

Complete sampling methodologies are described in the ADF&G Observer Manual for Alaskan Crab Processors (unpublished report).

Floating Processors

All vessels delivering crabs to floating processors are sampled. One hundred randomly selected crabs of each species from the retained catch are measured for carapace length (king crab) or width (Tanner and snow crabs). These crabs are also categorized according to shell age (new/soft, new, old, and very old) and checked for sex and minimum size requirements. If more than 3% non-legal crabs are encountered in the biological sample, observers were instructed to sample another 600 crabs for minimum size.

Length frequencies of retained crabs are published in the annual management report; data from floating processors reported here will focus on legal tally records. The legal width measurement is the greatest straight line distance across the carapace including spines, at a right angle to an imaginary line midway between the eye to the midpoint of the posterior portion of the carapace.

Catcher-processors

One hundred random carapace length (king crabs) or width measurements (Tanner and snow crabs) are recorded throughout each day on retained crabs. Those samples are also examined for shell age and legal size. At least six hundred crabs are randomly sampled for minimum legal size requirements each day.

When legal compliance has been met, observers conduct random pot sampling. The majority of data collected in this report is from this type of sampling. A minimum of one randomly selected pot per vessel each fishing day is the goal; sampling rates are increased during short fisheries. If conditions exist where random pot sampling procedures interfere with normal fishing operations or safety procedures, observers may choose the final pot in a string or whenever conditions exist (e.g. lunch breaks, breakdowns) to sample pots safely.

Pot sampling records include enumeration of all animals in the pot, carapace length or width measurements, and a check for legal size on commercial species of crab landed. Catch per unit effort (CPUE) may vary slightly from those reported in the annual management report; those calculations were derived from skipper interviews and not actual counts as reported here.

Females are examined for size, shell age, clutch size (percent fullness), egg development (eyed or uneyed) and clutch condition (barren or dead eggs present). Males are sampled for size and shell age. Commercially important fish species are measured, whereas other bycatch species are tallied. Location, depth, soak time, and gear type are also recorded.

For the purposes of this report, the term "landed" will be used to identify all animals brought up in pots before sorting on the deck occurs. Non-legal refers to undersize male crabs and female crabs of the target species, or any crab, including legal-size crabs if the season is closed for that species. The term "retained" refers to all animals (including non-legal) not immediately returned

to the sea. Barren females are those crabs without egg clutches; the term does not denote maturity.

RESULTS AND DISCUSSION

St. Matthew Blue King Crab Fishery

During the 1991 season, observers were the only source of information to monitor non-legal crab retention and to collect biological data inseason. In past years, collection of biological data has been foregone to concentrate on inseason catch reporting and legal size sampling. Since a four day fishery was announced prior to the opening, inseason radio reports by observers were omitted and pot sampling was given a higher priority than in previous fisheries. Observers were given a goal to randomly sample four pots per day.

Pots randomly sampled from seven vessels averaged one day soak periods at a mean of 38 fms. An average catch per pot (C/P) of 19.5 legal male crabs was landed, the highest CPUE recorded in the fishery since 1974 (Figure 3). Catch rates for the first three days of the fishery were above 20 legal crabs per pot, then declined to 13 legal males per pot the final day. Females and sublegal male blue king crabs dominated the bycatch at 20.4 and 17 crabs per pot. Few other crab or fish species were encountered as bycatch (Table 1).

Length and shell age distributions for male and female crabs are shown in Figure 4. Male and female carapace length (CL) averaged 118 mm and 87 mm, respectively. No previous pot sampling data are available for comparison to evaluate the lack of prerecruit males (105 mm-119 mm CL) in the 124-pot sample.

Shell age classification is deceptive for blue king crabs. In 1990, 22% of the crabs sampled were softshell (shell age 0-2 months) males, indicating that a molt occurred just prior to the season. While shell age of these crabs was estimated to be 11-14 months when the 1991 fishery took place, such ages render crabs hard to categorize as either premolt (new-shell) (3-12 months old) or skip molt (old-shell) (13-24 months old) crabs. Only 1% of male and female crabs were described as soft-shell in 1991; new-shell males and females accounted for 89% and 74% respectively, whereas old-shell crabs (shell age>12months) accounted for 9.5% (males) and 24%(females). Mature females (>79 mm CL) had the highest skip molt rate (33%) of any shell age grouping.

Of the 2,040 females examined in 1991, none carried eggs. All 27 females examined in the 1990 fishery were barren. Likewise, data available from the annual National Marine Fisheries Service survey (NMFS 1991) show a lack of gravid female blue king crabs near St. Matthew Island. The 1989 survey documented that only 4 of 85 female blue king crabs carried new, uneyed embryo clutches. In 1990, only 2 mature female crabs were landed in survey catches, both with clutches. During the 1991 survey, 16 mature female crabs were caught, only one of which was gravid. These data do not corroborate with traditional theory on blue king crab populations where crabs

in the Pribilof Island area have been described as biennial spawners, with a portion of the population spawning each year (Jenson et al. 1985).

While no conclusions can be drawn from the limited data available, the lack of gravid female crabs captured in the pot samples during the fishery and summer trawl surveys in recent years, plus a shortage of prerecruit male crabs warrants further investigations. The increased biological sampling by observers initiated in 1991 is necessary to acquire baseline information for biologists to adequately evaluate the St. Matthew crab stocks, currently described as depressed (ADF&G, 1991).

Bristol Bay Red King Crab Fishery

The 1991 red king crab season occurred during November 1-8. The average pot soak time for the fishery was 2 days at an average depth of 39 fms. Average C/P of legal male red king crabs was 11.4, the average C/P was 6.3 for sublegal males (Figure 5). Female king crab bycatch was 80% less than the previous year at 2.1 crabs per pot. Total Tanner crab bycatch was less than 10 crabs per pot. A complete listing of animals landed in 272 randomly sampled pots from 24 catcher-processors are given in Table 2.

Male and female shell length and shell age distributions for 1990 and 1991 are shown in Figure 6. In 1991 male red king crabs averaged 139 mm CL, 15% of which were old-shell or skip

molt crabs. Over 99% of female crabs sampled in the 1991 fishery were characterized as new shell. Females averaged only 99 mm CL, compared to a 117 mm CL average in the 1990 fishery.

Female red king crab egg clutch records show lower percentages of gravid animals than the previous year (Table 3). Only 193 (51%) of 376 crabs were described as having 100% clutches in 1991; this compares to 84% the previous year. This difference may be explained by the apparent increase of immature animals less than 90 mm CL, the median size of maturity (NMFS 1991), and decrease of large females greater than 90 mm CL (Figure 6).

The non-legal crab retention rate among catcher-only vessels delivering crabs to floating processors was 0.5% of 79,657 crabs sampled from 150 deliveries. Twenty four catcher-processors had a combined 0.6% nonlegal retention rate on 105,921 crabs sampled for legal size. The major proportion of nonlegal crabs were undersize male red king crabs; Tanner crabs were second in abundance, and female red kings had the lowest rate of retention. Evidence was collected on six vessels with high nonlegal retention rates.

Bering Sea Tanner Crab Fishery

Data summaries from two 1990-91 Bering Sea Tanner crab fisheries were combined. These included the original 1990 winter fishery (January 15 - April 24) and the second 1990-91 fishery beginning at the new starting date, seven days after the Bristol Bay red king crab fishery closure

(November 22, 1990). The new closure date (March 31st) appears to have solved the problem of high bycatch rates of molting female red king crabs that have precipitated emergency closures in the past.

Average C/P of legal size male Tanner crabs was 22.4 animals (Figure 7). Sublegal male crabs and legal size snow crabs had the highest C/P at 24.9 crabs. Approximately 40% of the total snow crabs harvested were retained for processing during the Tanner crab target fishery; the rest were either landed and discarded due to the closed snow crab fishery, or they were not retained after the January 15 snow crab opening because the vessel chose to process only Tanner crabs. Pot soak times ranged from 1 to 76 days, with a mean of 4 days; average fishing depth was 47 fms. A wide variety of crab and fish bycatch was landed in the fishery (Table 4).

The average carapace width (CW) of male Tanner crabs in the winter fishery (January-April) was 138 mm; fall (November-March) Tanner crabs averaged 136 mm (Figure 8). Size distributions for the past two seasons show adequate prerecruit (110-134 mm CW) and recruit (140-164 mm CW) crabs into the fishery.

Female Tanner crab averaged 99 mm CW, with 63% being old- or very old-shell crabs (Figure 9). Typically high fecundity rates occurred in 1990-91 (Table 5). Sixty-six percent of all female crabs examined were characterized as having full (100%) egg clutches; only 3% were barren. The major period of egg transition to eyed from uneyed occurred from November to January; percentages of uneyed eggs continued to decrease through the spring. The lack of uneyed eggs

well into the spring suggests that hatching and fresh extrusion of eggs occurred after the fishery closed.

Retention of non-legal Tanner crabs continues to be a major problem in Bering Sea Tanner and snow crab fisheries. Undersize crabs harvested inseason and illegal bycatch harvest during the snow crab fishery took an estimated 7.5% of the legal Tanner crab quota in 1991. A combination of identification problems between snow, Tanner and hybrid Tanner crabs, a general lack of crab sorting due to the fast pace of the fisheries, and inadequate enforcement resulted in an estimated harvest of 1.2 million non-legal male Tanner crabs during the November 1990 through June 1991 Tanner and snow crab fisheries.

Rates of Tanner crab non-legal retention vary between fisheries and processor types (Table 6). Data were collected from 2,357 deliveries from catcher-only vessels which delivered to floating processors and daily sampling on 27 catcher-processors over the eight month crab fisheries. The majority of illegal retention of crabs takes place on catcher-only vessels delivering crabs to floating processors, often in remote areas of the Bering Sea when the fishery targets on snow crabs. In fact, the portion of the fleet harvesting the highest number of sublegal crabs were catcher-only vessels delivering crabs to either shore-based plants or floating processors. Catcher-only vessels also had the highest rates of sublegal retention; 5.1% non-legal male crabs were retained on catcher-only vessels delivering to floating processors when both fisheries were open and vessels target on Tanner crabs.

The lower retention rates on catcher-processors is likely due to the presence of mandatory observers, though incentives for observers and vessels to react to enforcement problems are diminished due to a lack of prosecution of such cases and poor ability of the state to control vessel/contractor/observer relationships. Observers are often put in the precarious situation of reporting violations on vessels that pay third party contractors who in turn pay observers for their services. Vessels need only request a new observer to replace unrelenting observers following state guidelines concerning violations. Observers on catcher-processors have documented "pot dumping", the landing of crabs with no sorting occurring before processing. Nonprocessed undersize and female crabs may then be subject to grinding before being dumped at sea.

Bering Sea Snow Crab Fishery

Sufficient evidence indicating catcher-processors were processing Tanner crabs illegally during the 1990 snow crab fishery prompted the state to pass regulations to require mandatory observers for the 1991 fishery. This fishery has a variable bycatch that includes all three species of king crabs, Tanner crabs, hybrid crabs, and several species of fish (Table 7). Soak times ranged from 1 to 48 days, the average being 3 days. Depths fished ranged from 38 to 97 fms and averaged 69 fms.

Legal size (3.1 inch CW) snow crabs are by far the predominant animal landed with an overall CPUE of 239 crabs per pot (Figure 10). Although 17.6 legal size hybrid Tanner crabs per pot were available to be harvested and processed as snow crab, not all of these crabs were processed.

In general, the processing industry prefers snow crabs 4 inches (102 mm CW) or greater. This often creates major discards of legal size, but unmarketable crabs at shoreside plants and remote floating processors. For male snow crabs the average CW was 104 mm, with 5.9% of them skip molt crabs. Female CW averaged 60 mm, of which 66% were skip molt crabs (Figure 11).

Of 2,055 female egg clutches examined over the 5 month season, 33% were described as full (100%) clutches and 29% were barren. Extreme changes in egg condition and female CPUE in May and June indicate an egg release and extrusion of fresh uneyed eggs in this time frame (Table 8). Catch rates increased from less than 3 female crabs per pot in January through April, to 17.5 and 24.5 female crabs per pot in May and June, respectively. An increase in uneyed eggs (from 41% in April to 85% in May), combined with an increase in barren females (from 3% in May to 45% in June) confirms that hatching occurred in that time frame.

This change in the female composition of the catch may be due to changes initiated by the egg release; females may be present in the crab population during the entire season, but enter pot gear infrequently due to lower feeding activity during the latter stages of egg development. Other explanations include possible female crab migration into areas of high fishing activity or movement of the fishing fleet into female spawning grounds.

The increased number of hybrid Tanner crabs into the 1991 snow crab fishery caused identification problems for observers, biologists and fishermen alike, and the crabs ended up accounting for 7% of the 265.1 million crabs harvested. The observer program began setting

criteria for distinguishing hybrid crabs from true Tanner and snow crabs when identification problems surfaced in 1989. At that time no genetic data was available to confirm species identification characteristics, but a consensus between biologists on morphometric characteristics used to identify crabs was developed for observers to be taught during their certification training. The magnitude of the problem increased as hybrid populations grew and retention of nonlegal Tanner crabs became a major issue in the Tanner/snow crab fisheries. In 1991, a genetic study was conducted by ADF&G to confirm that commonly used external characteristics could accurately be used to resolve identification of Tanner, snow and hybrid Tanner crabs. A second genetic study on hybrid Tanner crabs, with electrophoretic samples being collected by a shellfish observer, was conducted by ADF&G in 1992 (S. Merkouris ADF&G pers. comm).

Carapace width for male hybrid crabs landed during the snow crab fishery averaged 105 mm, while those landed during the Tanner crab fishery averaged 116 mm (Figure 12). Shell ages were similar to the target species of those fisheries with 93 and 88 percent documented as new shell crabs in the respective snow and Tanner crab fisheries. Few legal size (>5.5 inch CW) hybrid crabs were available to harvest during the Tanner crab fishery; however, the majority of these crabs were larger than both the snow crab legal size (3.1 inch CW) and the industry standard of a 4 inch (102 mm) width for the snow crab fishery.

Dutch Harbor Golden King Crab Fishery

Data summarized here includes both 1990 and 1991 Dutch Harbor golden king crab fisheries; data from the 1990 fishery were not summarized in the previous report. Typically, vessels fish the Dutch Harbor registration area during September and October, then effort declines as vessels move to the Adak golden and red king crab fishery opening on November 1st.

The 1990 fishery was characterized by high bycatch rates of non-legal crabs. Pot sampling records from 4 vessels (139 pots sampled) indicate over 63 female and sublegal male golden king crabs were landed for every 7 legal males (Figure 13). Commercial fish bycatch was also high compared to other fisheries (Table 9). Average depth fished was 226 fms, and a mean soak time was 3 days per pot.

The 1991 fishery had an increase in crab bycatch rates. Female golden king crabs remained the predominant animal landed with an average catch per pot of 22.5; sublegal male crabs were second at 13.9 and legal male crabs at 5.3 per pot. The rate of non-legal crab bycatch has increased despite the use of escape rings by vessels targeting on golden king crabs. The stainless steel rings are usually placed in the tunnels of pots, allowing crabs under the legal size limit (6 inch CW) to escape. A comparison of catch rates with and without rings is summarized later in this report. Average soak time was 4 days and average depth fished was 229 fms.

During the 1991 fishery, samples of pot catches revealed that male golden king crabs had a mean length of 126 mm, 97% of which were new-shell crabs (Figure 14). Length frequency distributions for male golden king crabs continue to show high recruitment of juvenile and prerecruit males into the fishery in 1990 and 1991, and presumably account for increased bycatch rates of these animals.

Female golden king crabs sampled in the 1991 fishery averaged 116 mm, 94% of which were new-shell crabs (Figure 15). Of 3,701 examined for clutch condition, 52% were barren, while 33% had full (100%) egg clutches (Table 10). Of 1,611 clutches examined for egg development, 916 (57%) were uneyed, while 695 (43%) had visible eyes.

Overall, females sampled in 1991 were less fecund than female crabs sampled in the 1990 fishery (Table 10). Barren female crabs were again the most abundant (58%); this high rate indicates a likely period of egg release, molt and extrusion of fresh eggs during the fishery. Full clutches were recorded in only 19% of females examined. The majority of 1,636 crabs examined had uneyed eggs. Average length was 113 mm CL, with a 3% skip molt rate.

Adak Golden King Crab Fishery

The majority of observer manned vessels in Adak target on golden king crabs. However, situations may occur when other species may be retained from the same pot. These other species

include red king crab, deepwater king crab *Lithodes couesi*, four species of *Chionoecetes*, Korean hair crabs *Erimacrus isenbeckii* and several species of fish.

A wide assortment of species are landed from vessels targeting on golden king crabs in Adak (Table 11). The average depth fished from the 508-pot sample was 241 fms; average soak time was 6 days per pot. As in the Dutch Harbor golden king crab fishery, high bycatch rates of sublegal male (14.1 per pot) and female (16.5) golden king crabs dominated landings (Figure 16). Legal males were landed at a rate of 6.3 per pot. Weekly harvest reports by observers during the season provided data indicating a possible over harvest of mature males in some sections of the Area R fishing district; area closures were made based on this information.

During the 1990-91 fishery, male golden king crab averaged 128 mm CL; 5% were old-shell crabs. The past three years show continued high recruitment of juvenile and prerecruit males into the fishery (Figure 17). Female golden king crab averaged 121 mm CL; 4% were old or very old-shell crabs (Figure 18).

Fecundity data summaries are similar to previous years. Fifty percent of the 5,231 females randomly sampled for clutch size were barren, and 32% were described as full clutch animals (Table 12). The increase in barren females during the latter part of the fishery indicated that the majority of spawning occurs during the summer and fall months. This is consistent with other reports on golden king crab reproductive cycles (NMFS 1982).

Adak Red King Crab Fishery

The 1991 Adak red king crab fishery had less effort than previous years due to changes in the Bristol Bay red king and Eastern Bering Sea Tanner crab fishery opening dates. Legal male red king crabs were landed at a rate of 7.9 per pot, whereas sublegal male and female crabs were landed at 11 and 4.9, per pot, respectively (Figure 19). Average depth fished was 69 fms; soak time mean was 5 days. A complete listing of animals landed in the 145 pot sample is given in Table 13.

Male red king crabs averaged 129 mm CL, and 287 (10%) of the 2,228 crabs examined were old-shell. Though the population is considered to be depressed (ADF&G 1991), there is apparent recruitment of juvenile and prerecruit male crabs into the fisheries (Figure 20).

Female red king crabs averaged 113 mm CL; only 20 (2.7%) of 736 crabs examined were described as old-shell crabs. Twenty-four percent were barren, while 368 (66%) of 561 gravid female crabs examined held uneyed eggs (Table 14). Only 11 (1.5%) crabs were under 89 mm CL, the 50% size at maturity (Blau 1990).

Pink Scallop Fishery

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Fish Bycatch

Four important commercial species of fish are landed in gear targeting on crabs - Pacific cod, halibut, sablefish, and yellowfin sole. Pacific cod are normally the only species retained (for bait) by observer-manned crab vessels. They often mix "cod pots" in with conventional crab pots when bycatch in crab gear is low. These pots are modified with triggers to prevent fish escapement.

Vessels fishing commercial crab pots may retain a fish bycatch of up to 20% non-prohibited species without additional permits and pot gear modification. Halibut and sablefish are the only prohibited species recorded in observer data. Sablefish are prohibited from being retained in crab gear east of 170° W. longitude in the Gulf of Alaska and halibut are never permitted to be retained. Other species of fish may be harvested for bait or sale when the season and area are open for that particular species.

Crab fishermen are required by regulation to report fish bycatch harvested for bait on standard fish tickets. Since this law is widely ignored by industry, an attempt will be made here to expand fish bycatch rates from catcher-processors to the entire fleet to estimate the total Pacific cod harvest for the Bristol Bay red king crab fishery. This fishery was chosen because both catcher-processors and catcher-only vessels tend to use similar methods in roughly the same fishing area. Substantial bias may exist in other fisheries (e.g. Adak golden king crab fishery) where methods,

areas fished, and weight coefficients used in these calculations have greater variation between vessel types. No data is available from catcher-only vessels to adjust estimates.

During the 1991 Bristol Bay red king crab season 62 Pacific cod were landed in the 272-pot sample, for a catch rate of .228 Pacific cod per pot (Table 15). Cod pots were included as part of the random sample. Weight frequencies on 61 fish were derived by using a conversion equation on observer length measurements. Coefficients used in this equation were developed from random Pacific cod weights taken by federal domestic groundfish observers and only apply to unsexed Pacific cod in the Bristol Bay area (J. Blackburn ADF&G pers. comm).

$$W = (a)L^{b}$$

W = weight (grams)
L = length (mm)
a = .0000043973
b = 3.163560

The total weight for the 61 cod is 330.8 kilograms, for an average of 5.4 kilograms (11.9 lbs) each. A total of 227,555 pots were pulled in the fishery (ADF&G 1991); using the above CPUE (.228 cod/pot) and average weight it is estimated that 280.2 metric tons were landed during the fishery. Yellowfin sole and halibut catch rates were .239 and .037 per pot. Total estimated landing for yellowfin sole is 54,386 fish; halibut bycatch is estimated at only 8,420 animals.

The groundfish bycatch during the 1990-91 Adak golden king crab fishery was lower than 1989-90 fishery. Pacific cod were landed at a rate of 0.33 fish per pot. Halibut and sablefish were landed at the rate of .04 and .07 per pot. The total number of pots pulled in the fishery was

160,960. The estimate of total number of halibut and sablefish landed is 6,438 and 11,267, respectively.

The 1990-91 Bering Sea Tanner crab fishery had rates of Pacific cod and yellowfin sole bycatch at .72 and .45 fish per pot. Gear conflicts with the groundfish fleet were regularly reported by observers in the both the Tanner and snow crab fisheries.

Data from both years suggest that fish bycatch in the major Bering Sea crab fisheries has negligible impact on the commercial groundfish industry. Investigations into crab bycatch on groundfish vessels need to be conducted to properly assess groundfish impacts on crab stocks.

Gear Modifications (Escape Rings)

High bycatch rates in the golden king crab fisheries have led some vessels to voluntarily sew escape rings into their gear. The benefit of rings is that fewer nonlegal crabs need to be sorted and hence gear can be pulled at faster rates. Catch efficiency varies depending on whether escape rings are used (Table 16). The ring diameter may vary slightly from vessel to vessel, but the majority of rings were found to be 139 mm, or just under the legal size measurement (6 inches CW) for golden king crab. They are usually placed in the tunnels on the square pots or on the sides of round pots. Preliminary data on other types of gear modification, such as net panels with larger mesh indicate that they are not as effective as the rings, possibly due to shape.

During the Dutch Harbor fishery, nonlegal golden king crab catch per pot dropped from 26.1 crabs per pot without rings to 10.1 with rings, a 61% reduction. In Adak, the nonlegal golden king bycatch dropped from 39 animals per pot, to 20.1. This 18.9 crabs per pot drop represents a 49% reduction in crab bycatch using escape ring equipped gear.

While little data is available on bycatch mortality in any crab fisheries, lowering landing rates of nonlegal animals substantially can only benefit the fisheries. Not only are these animals subject to deck handling mortalities, but wide fluctuations in depth may return animals to radically different habitat than they were trapped in. Female crabs, often with egg clutches in various stages of development are exposed to freezing deck temperatures much of the year.

Escape rings are a low cost gear modification that effectively reduce bycatch. Such modifications should be encouraged, possibly through regulation. A requirement to have several rings strategically placed on longline pot gear would be easy to monitor and enforce. Resistance from the fleet would be minimal, as many are switching to rings voluntarily.

CONCLUSIONS

Biological data collection by mandatory observers continues to provide useful descriptive information on Bering Sea fisheries. While the main objective of the database is to establish long term monitoring of crab populations, valuable information on recruitment, fecundity and bycatch problems has been made available to managers in the short time the program has been in place.

Documentation of potential biological problems such as a lack of fecundity in female blue king crabs at St. Matthew Island, or retention of nonlegal crabs during the Tanner crab fisheries are factors that can be used to develop alternative management strategies in the short term to maintain productive fisheries. The effectiveness of escape rings in golden king crab bycatch reduction was discovered through data summaries on vessels observers reported their use on. One observer was recently trained in electrophoretic tissue sampling to assist department geneticists in solving hybrid Tanner crab identification problems in the Pribilof Islands.

The larger scope of evaluating biological parameters of these fisheries need longer periods of data collection to develop better inseason life history models of the individual fisheries. Not enough information is available for accurate interpretation of what documented changes in recruitment, fecundity, or bycatch rates have on these fisheries. Several more years of consistent data collection are needed to evaluate components driving these fisheries.

Problems within the program that need to be overcome include inconsistent training practices that exclude department biologists. Administration of the program often must focus on problems with observers, contractors and vessels instead of quality biological data collection, reporting and analysis. Legal compliance on vessels remains a priority for observers who follow instructions, yet few cases are ever prosecuted. Despite these problems, the shellfish observer program has become the cornerstone of management and research efforts in the Bering Sea.

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Table 1. Summary of pot sampling during the St Matthew blue king crab fishery in 1991 (7 vessels, 124 pots sampled).

Species	Number of Animals
Blue king crab	
legal size males	2,416
sub-legal males	2,106
females	2,525
Snow crab	22
Lyre crab	157
Snailfish	1
Yellowfin sole	34
Pacific cod	62
Sculpins	12

Table 2. Summary of pot sampling during the Bristol Bay red king crab fishery in 1991 (24 vessels, 272 pots sampled).

Species	Number of Animals
Red king crab	
legal size males	3,098
sub-legal males	1,710
females	582
Tanner crab	
legal size males	1,565
sub-legal males	613
females	271
Snow crab	16
Hybrid Tanner crab	11
Rockfish	2
Halibut	10
Yellowfin sole	62
Pacific cod	62
Sculpins	11

Table 3. Fecundity of red king crabs in Bristol Bay in 1991 (24 vessels, 272 pots sampled).*

Percent Fullness	Number of Occurrences	Egg Condition	Number of Occurrences
0%	134	No dead eggs	128
1% - 20%	2	Dead eggs < 20%	3
21% - 40%	0	Dead eggs > 20%	0
41% - 60%	7	Barren	123
61% - 80%	39		
81% - 99%	1		
100%	193		

* Totals for each category do not equal each other due to incomplete records.

Table 4. Summary of pot sampling during the Bering Sea Tanner crab fishery in 1991 (22 vessels, 933 pots sampled).

Crab Species	Number of Animals	Other Species	Number of Animals
Tanner crab			
legal size males	20,938	Halibut	24
sub-legal males	23,233	Yellowfin sole	415
females	4,068	Pacific cod	675
Snow crab		Sculpins	115
legal size males	23,182	Rock sole	10
sub-legal males	1,178	Alaska plaice	1
females	806	Pollock	43
Hybrid Tanner crab		Arrowtooth flounder	1
legal size males	68	Flathead	2
sub-legal males	1,033	Prowfish	1
females	22	Rockfish	1
Red king crab	7,732	Octopus	16
Blue king crab	1		
Korean hair crab	13		
Lyre crab	168		
Hermit crab	12		

Table 5. Fecundity of Tanner crabs in the Bering Sea in 1990-91 (22 vessels, 933 pots sampled).*

Percent Fullness	Number of Occurrences
0%	132
1% - 20%	154
21% - 40%	73
41% - 60%	258
61% - 80%	527
81% - 99%	359
100%	2,920

Egg Condition	Number of Occurrences
No dead eggs	4,166
Dead eggs < 20%	42
Dead eggs > 20%	10
Barren	132

	JAN90	FEB90	MAR90	APR90	NOV90	DEC90	JAN91	Total
Uneyed	68	82	1	1	779	875	79	1,885
Eyed	484	110	81	136	127	835	387	2,160

* Totals for each category do not equal each other due to incomplete records.

Table 6. Non-legal male Tanner crab retention during the Bering Sea Tanner and snow crab fisheries in 1990-91.

FISHERY	PROCESSOR	SAMPLER	No. CRABS SAMPLED	No. NONLEGAL TANNER CRABS	% NONLEGAL TANNER CRABS	TOTAL NUMBER OF CRABS HARVESTED	TOTAL NONLEGAL TANNER CRAB
Snow Crab	Floater	Observer	558,615	1,491	0.27%	110,527,685	298,424
	Catcher processor	Observer	482,371	707	0.15%	30,403,513	45,605
	Shoreplant	F & G*	18,534	22	0.12%	35,867,405	43,040
Both: Target is Snow Crabs	Floater	Observer	33,017	49	0.15%	79,185,006	118,777
	Catcher processor	Observer	350,021	825	0.24%	24,686,509	59,247
	Shoreplant	F & G*	31,709	143	0.45%	31,752,884	142,888
Both: Target is Tanner Crabs	Floater	Observer	25,282	1,290	5.10%	3,126,006	159,426
	Catcher processor	Observer	58,028	573	0.99%	557,305	5,517
	Shoreplant	F & G*	1,152	42	3.65%	1,904,563	69,516
Tanner Crab	Floater	Observer	13,560	220	1.62%	6,816,748	110,431
	Catcher processor	Observer	439,366	5,512	1.25%	2,425,694	30,321
	Shoreplant	F & G*	28,016	1,211	4.32%	3,592,238	155,184

* Alaska Department of Fish and Game sampler.

Table 7. Summary of pot sampling during the Bering Sea snow crab fishery in crab fishery in 1991 (20 vessels, 628 pots sampled).

Crab Species	Number of Animals	Other Species	Number of Animals
Snow crab			
legal size males	150,060	Halibut	5
sub-legal males	2,617	Yellowfin sole	3
females	8,862	Pacific cod	554
Tanner crab		Sculpins	123
legal size males	1,630	Snailfish	24
sub-legal males	2,987	Sablefish	2
females	95	Pollock	24
Hybrid Tanner crab		Arrowtooth flounder	1
legal size males	11,035	Skates	5
sub-legal males	340	Octopus	12
females	250		
Blue king crab	59		
Red king crab	74		
Golden king crab	1		
Lyre crab	27		
Hermit crab	6		

Table 8. Fecundity of snow crabs in the Bering Sea in 1991 (20 vessels, 628 pots sampled).*

Percent Fullness	Number of Occurrences
0%	601
1% - 20%	376
21% - 40%	60
41% - 60%	117
61% - 80%	196
81% - 99%	25
100%	680

Egg Condition	Number of Occurrences
No dead eggs	1,359
Dead eggs < 20%	29
Dead eggs > 20%	49
Barren	618

	JAN	FEB	MAR	APR	MAY	JUN	Total
No. Pots	19	66	94	94	178	177	628
No. Female Crabs landed	484	110	81	136	127	835	2,160
Female CPUE	0	0.3	3.0	2.5	17.5	24.5	
Uneyed	90	31	18	53	623	694	1,509
Eyed	1	7	27	39	85	25	184
Barren	4	15	17	15	28	562	641

* Totals for each category do not equal each other due to incomplete records.

Table 9. Summary of pot sampling during the Dutch Harbor golden king crab fisheries in 1990 and 1991.

1990 (4 vessels, 139 pots)				1991 (4 vessels, 299 pots)			
CRABS		OTHER SPECIES		CRABS		OTHER SPECIES	
Golden king crab		Greenland turbot	19	Golden king crab		Greenland turbot	153
Legal size males	911	Halibut	53	Legal size males	1,586	Halibut	79
Sub-legal males	3,645	Pacific cod	114	Sub-legal males	4,141	Pacific cod	154
Females	5,198	Sablefish	19	Females	6,727	Sablefish	36
		Greenling	1			Pollock	2
Lithodes couesi crabs	2	Rockfish	3	Lithodes couesi crabs	59	Rockfish	3
C. tanneri crabs	3	Sea poacher	1	C. tanneri crabs	96	Arrowtooth	3
		Sculpins	3	C. angulatus crabs	1	Sculpins	11
		Octopus	1			Snailfish	1
		Skates	1				

Table 10. Fecundity of Dutch Harbor golden king crabs in 1990 and 1991.

1991 Fishery

Percent Fullness	Number of Occurrences
0%	1,915
1% - 20%	47
21% - 40%	27
41% - 60%	88
61% - 80%	232
81% - 99%	181
100%	1,211

Egg Condition	Number of Occurrences
No deab eggs	1,557
Dead eggs < 20%	33
Dead eggs > 20%	24
Barren	1,898

Egg Stage	
Eyed	695
Uneyed	916

1990 Fishery

Percent Fullness	Number of Occurrences
0%	2,224
1% - 20%	32
21% - 40%	40
41% - 60%	169
61% - 80%	350
81% - 99%	285
100%	729

Egg Condition	Number of Occurrences
No dead eggs	1,497
Dead eggs < 20%	92
Dead eggs > 20%	20
Barren	2,220

Egg Stage	
Eyed	762
Uneyed	874

*Totals for each category do not equal each other due to incomplete records.

Table 11. Summary of pot sampling during the Adak golden king crab fishery in 1990-91 (6 vessels, 508 pots sampled.

CRAB SPECIES		OTHER SPECIES	
Golden king crab		Arrowtooth flounder	1
Legal size males	3,224	Atka mackerel	9
Sub-legal males	7,150	Greenland turbot	10
Females	8,370	Halibut	20
Red king crab		Octopus	12
Legal size males	81	Pacific cod	168
Sub-legal males	71	Rockfish	25
Females	0	Sculpins	24
Lithodes couesi crab		Sablefish	35
Legal size males	150	Skates	3
Sub-legal males	247	Yellowfin sole	1
Females	580		
Tanner crab	9		
Snow crab	2		
C. angulatus crab	14		
Korean hair crab	33		
Lyre crab	6		

Table 12. Fecundity of Adak golden king crabs in 1990-91. (6 vessels, 508 pots sampled).*

Percent Fullness	Number of Occurrences	Egg Condition	Number of Occurrences
0%	2,636	No dead eggs	2,202
1% - 20%	45	Dead eggs < 20%	74
21% - 40%	63	Dead eggs > 20%	12
41% - 60%	162	Barren	2,385
61% - 80%	517		
81% - 99%	122		
100%	1,686		

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
Eyed	295	66	74	37	15	94	77	81	289	191	1,219
Uneyed	163	133	51	43	31	266	182	80	191	169	1,309
Barren	29	35	36	29	120	347	220	212	968	387	2,383
% Barren	6%	15%	22%	27%	72%	49%	46%	59%	67%	52%	49%

* Totals for each category do not equal each other due to incomplete records.

Table 13. Summary of pot sampling during the Adak red king crab fishery in 1990-91 (5 vessels, 145 pots sampled).

CRAB SPECIES		OTHER SPECIES	
Red king crab		Scallops	84
legal size males	1,145	Rockfish	11
sub-legal males	1,600	Halibut	3
females	708	Snailfish	2
Golden king crab	58	Pacific cod	119
Tanner crab		Sculpins	85
legal size males	13		
sub-legal males	156		
females	2		
Snow crab	6		
Korean hair crab	18		
Lyre crab	147		

Table 14. Fecundity of Adak red king crab in 1990-91 (5 vessels, 145 pots sampled).*

Percent Fullness	Number of Occurrences
0%	175
1% - 20%	12
21% - 40%	7
41% - 60%	60
61% - 80%	232
81% - 99%	76
100%	175

Egg Condition	Number of Occurrences
No dead eggs	368
Dead eggs < 20%	193
Dead eggs > 20%	0
Barren	175

Egg Stage	
Uneyed	368
Eyed	193

* Totals for each category do not equal each other due to incomplete records.

Table 15. Fish bycatch on catcher-processors for two consecutive years in Bristol Bay red king, Adak golden king, and Bering Sea Tanner crab fisheries.

	1990 Bristol Bay Red King Fishery (140 pot sample)			1989-90 Adak Golden King Fishery (1,874 pots sampled)			1989 Bering Sea Bairdi Fishery (340 pot sample)		
	Landed	Retained	CPUE	Landed	Retained	CPUE	Landed	Retained	CPUE
Pacific cod	43	43	0.31	610	610	0.33	253	253	0.74
Halibut	3	0	0.02	149	0	0.08	11	0	0.03
Sablefish	0	0		228	*	0.12	0	0	
Yellowfin sole	46	0	0.33	0	0		272	0	0.8
	1991 Bristol Bay Red King Fishery (272 pot sample)			1990-91 Adak Golden King Fishery (508 pots sampled)			1990-91 Bering Sea Bairdi Fishery (933 pot sample)		
	Landed	Retained	CPUE	Landed	Retained	CPUE	Landed	Retained	CPUE
Pacific cod	62	62	0.23	287	287	0.33	675	675	0.72
Halibut	10	0	0.04	23	0	0.04	24	0	0.03
Sablefish	0	0		36	*	0.07	0	0	
Yellowfin sole	62	0	0.23	0	0		415	0	0.45

* Unknown

Table 16. Catch efficiency of legal, sublegal, and female golden king crabs by pots with and without escape rings.

		Number of Pots Sampled	1991 Dutch Harbor Golden King Fishery (3 vessels) Number	CPUE	Number of Pots Sampled	1991-92 Adak Golden King Fishery (3 vessels) Number	CPUE	Number of Pots Sampled	Total Number	CPUE
Legal Males	W/Rings	484	991	2.05	105	1,066	10.2	589	2,057	3.5
	No Rings	229	595	2.60	58	815	14.1	287	1,410	4.9
Sublegal Males	W/Rings	484	1,362	2.81	105	1,369	13.0	589	2,731	4.6
	No Rings	229	2,779	12.14	58	1,169	20.2	287	3,948	13.8
Females	W/Rings	484	3,538	7.31	105	1,798	17.1	589	5,336	9.1
	No Rings	229	3,189	13.93	58	1,092	18.8	287	4,281	14.9

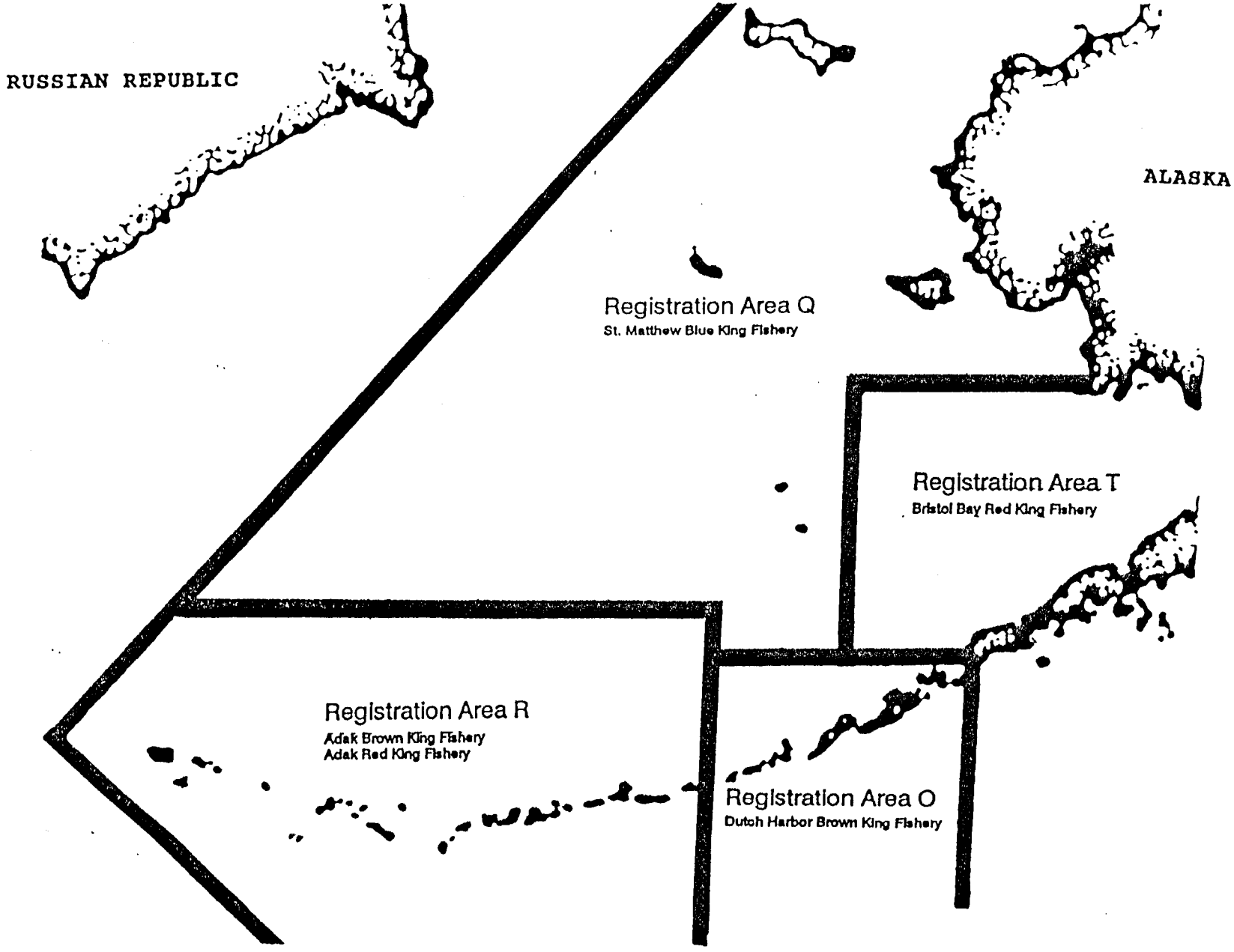


Figure 1. Target fisheries for observer manned vessels (king crab).

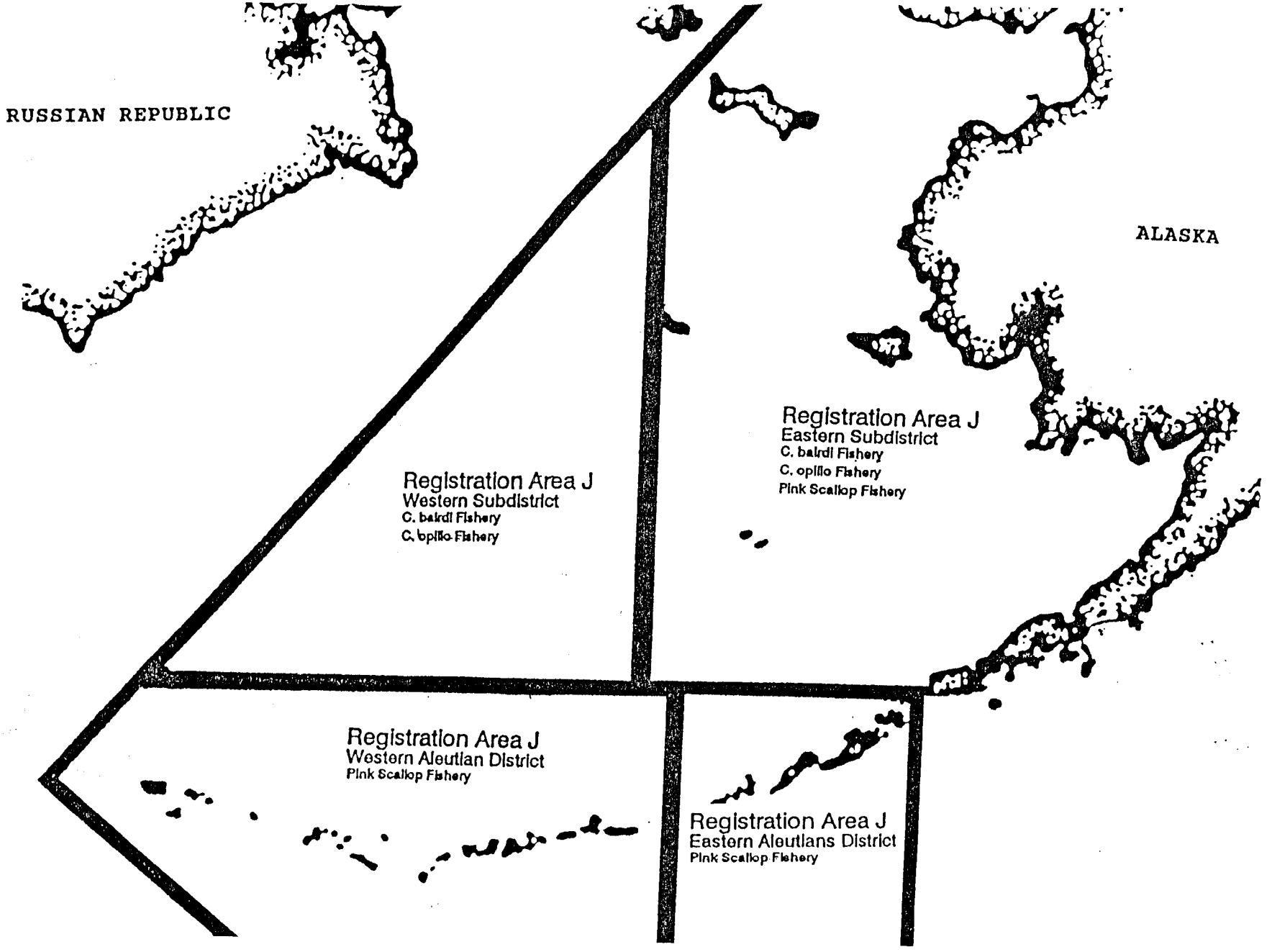
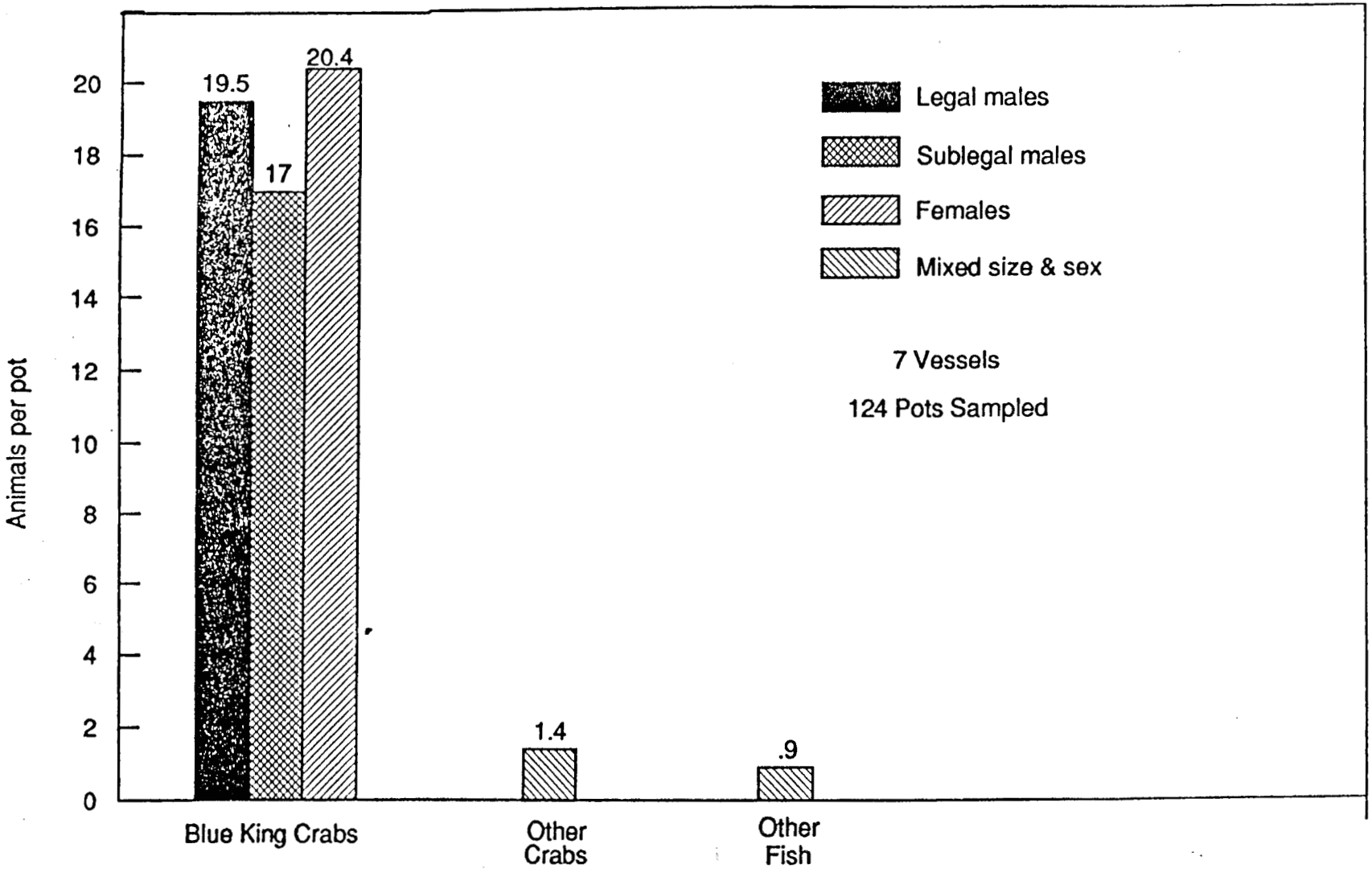


Figure 2. Target fisheries for observer manned vessels (Tanner and snow crab and scallops).

Figure 3. Catch per unit effort (CPUE) for the St. Matthew blue king crab fishery in 1991.



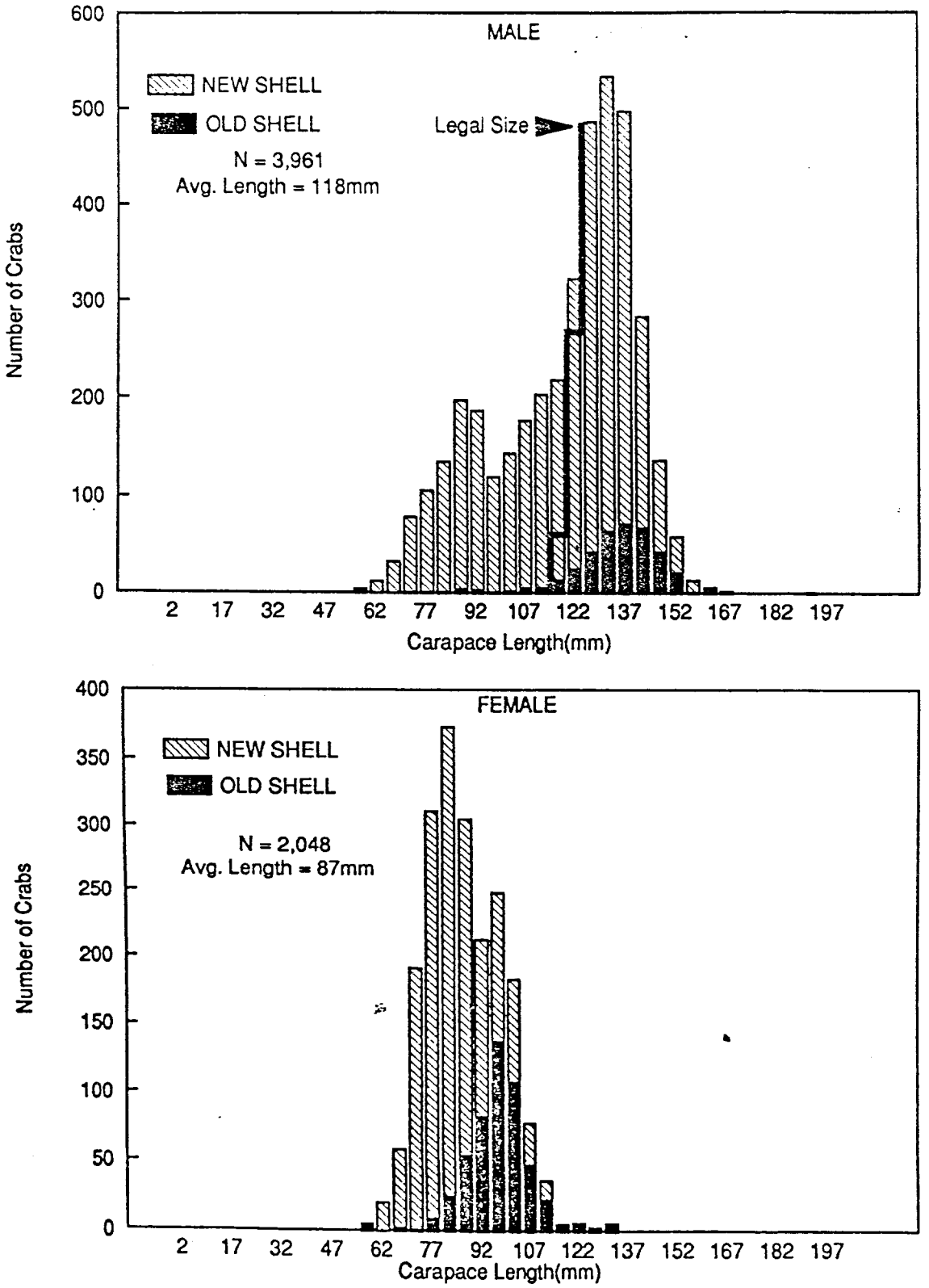
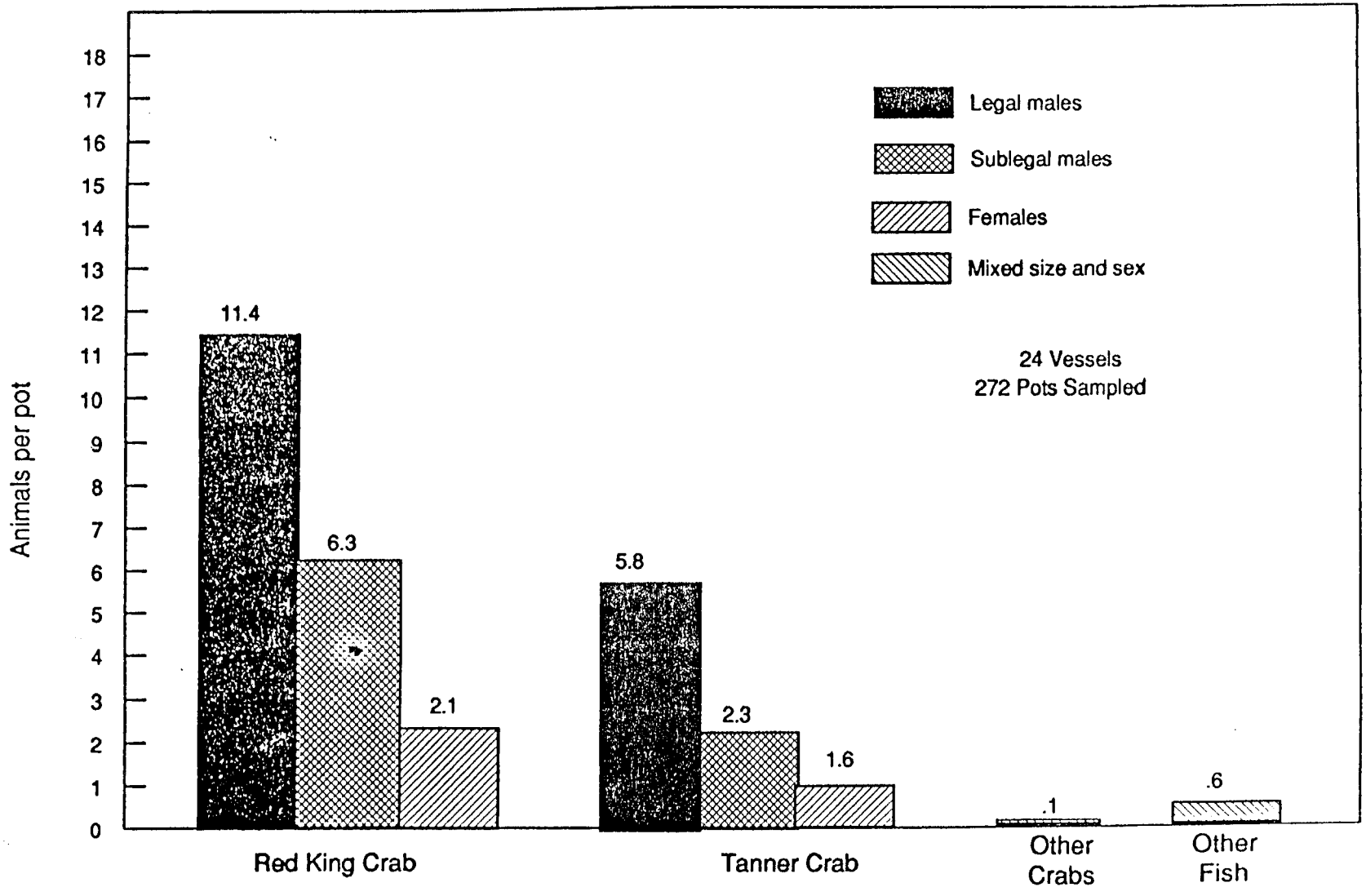


Figure 4. St. Matthew blue king crab length frequency distribution by sex in 1991.

Figure 5. Catch per unit effort (CPUE) for the Bristol Bay red king crab fishery in 1991.



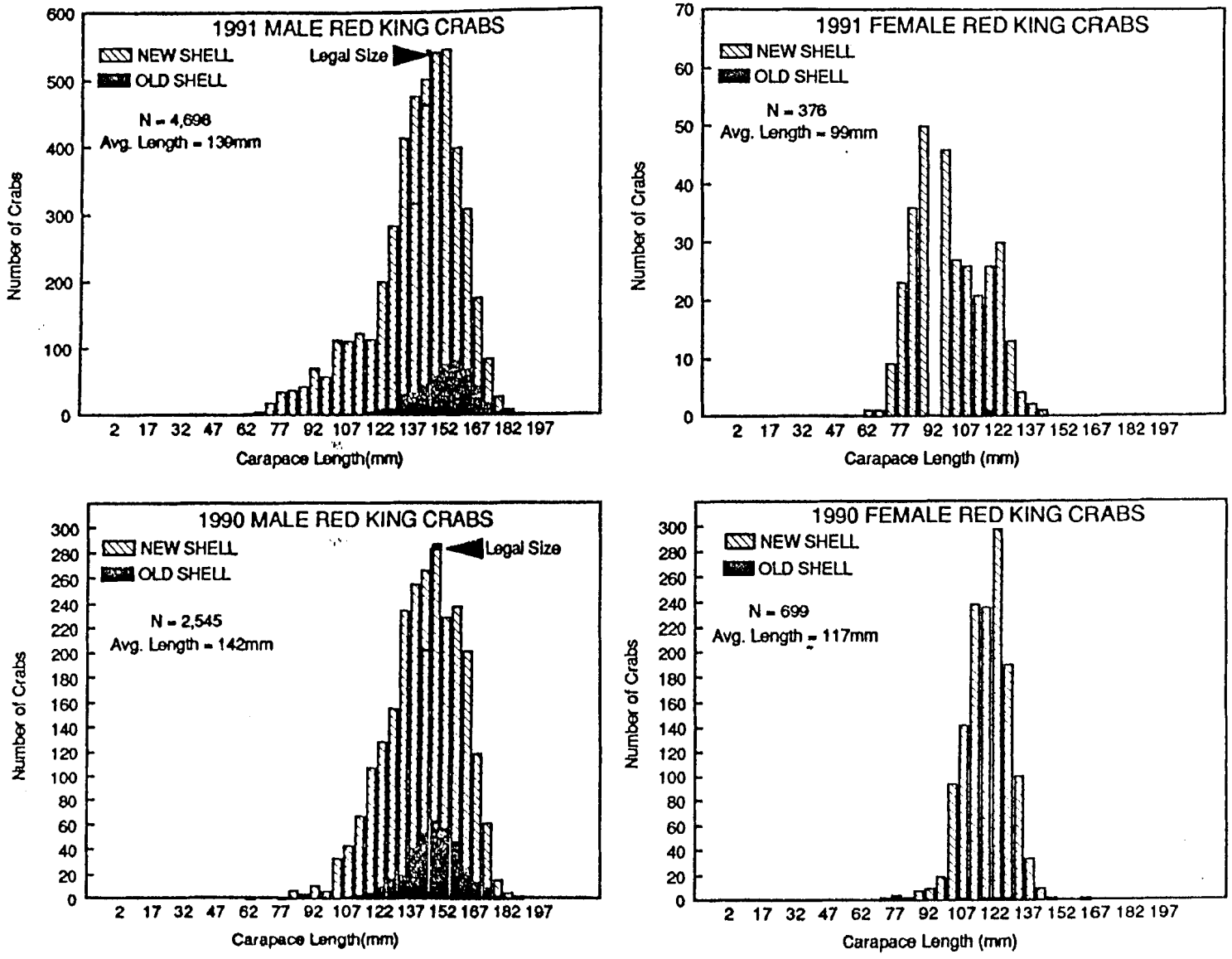
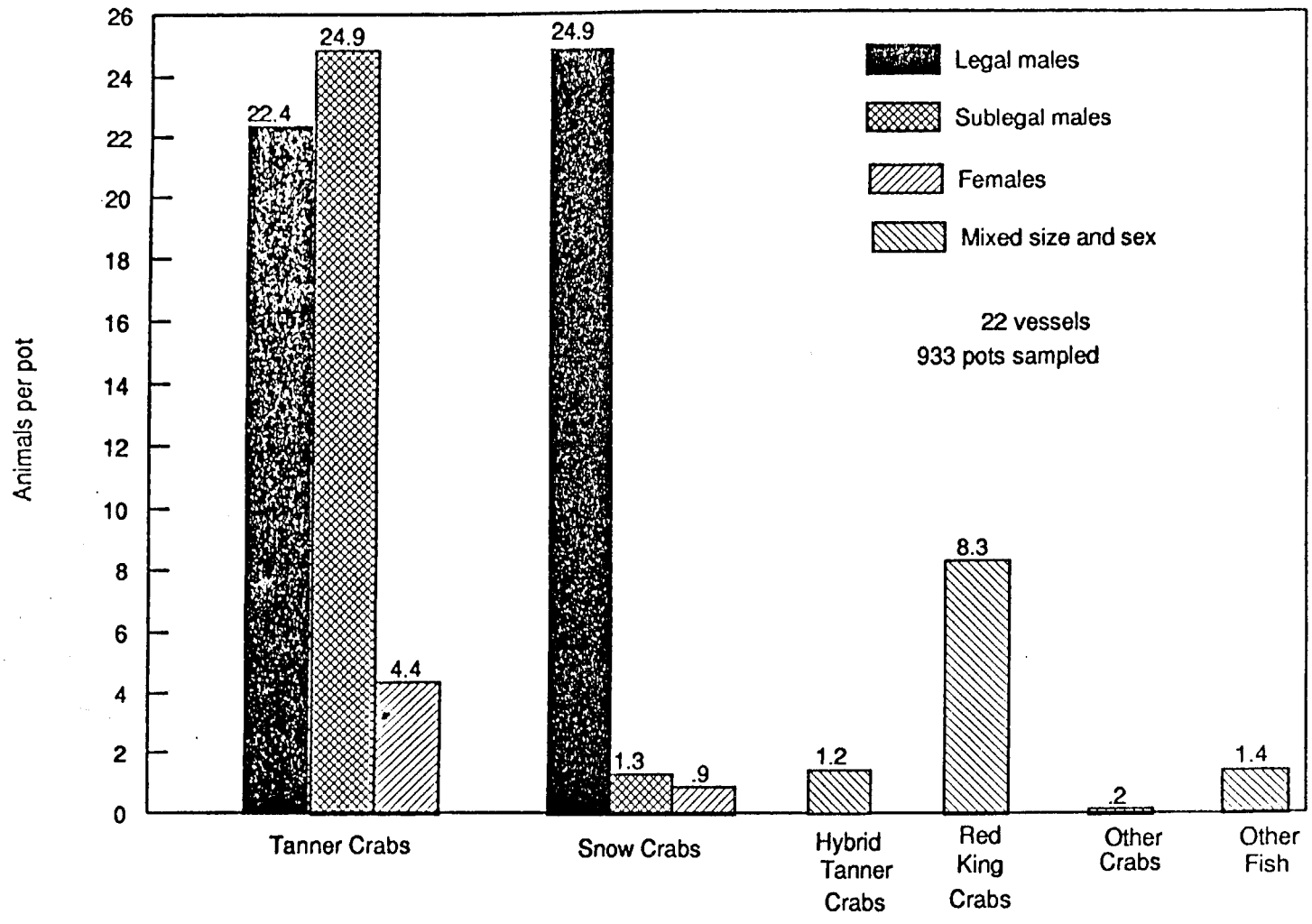


Figure 6. Bristol Bay red king crab length frequency distributions by sex in 1990 and 1991.

Figure 7. Catch per unit effort (CPUE) for the Bering Sea Tanner crab fishery in 1990-91.



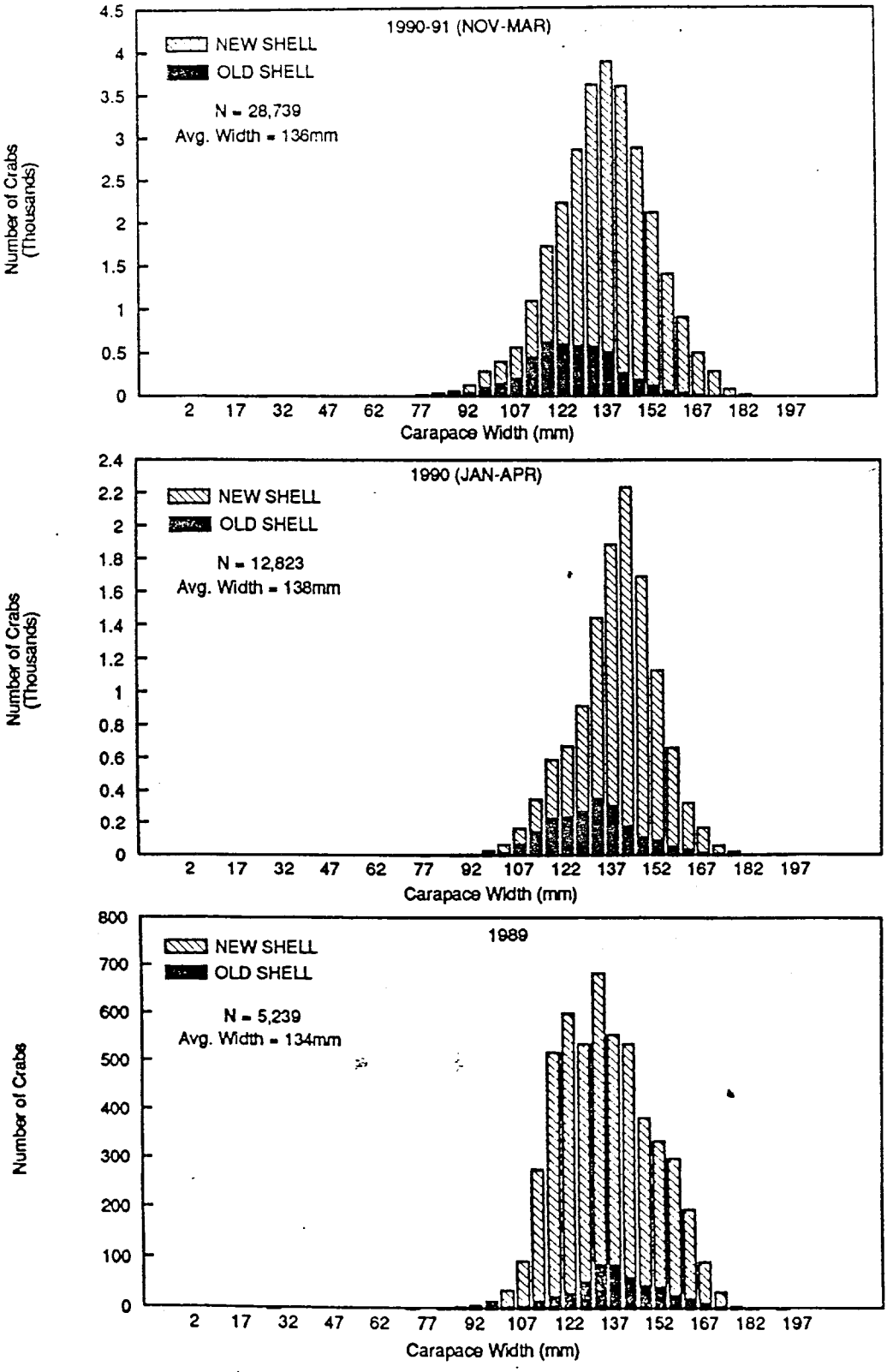


Figure 8. Bering Sea male Tanner crab width frequency distributions from 1989 to 1991.

Figure 9. Bering Sea female Tanner crab width frequency distribution in 1990-91.

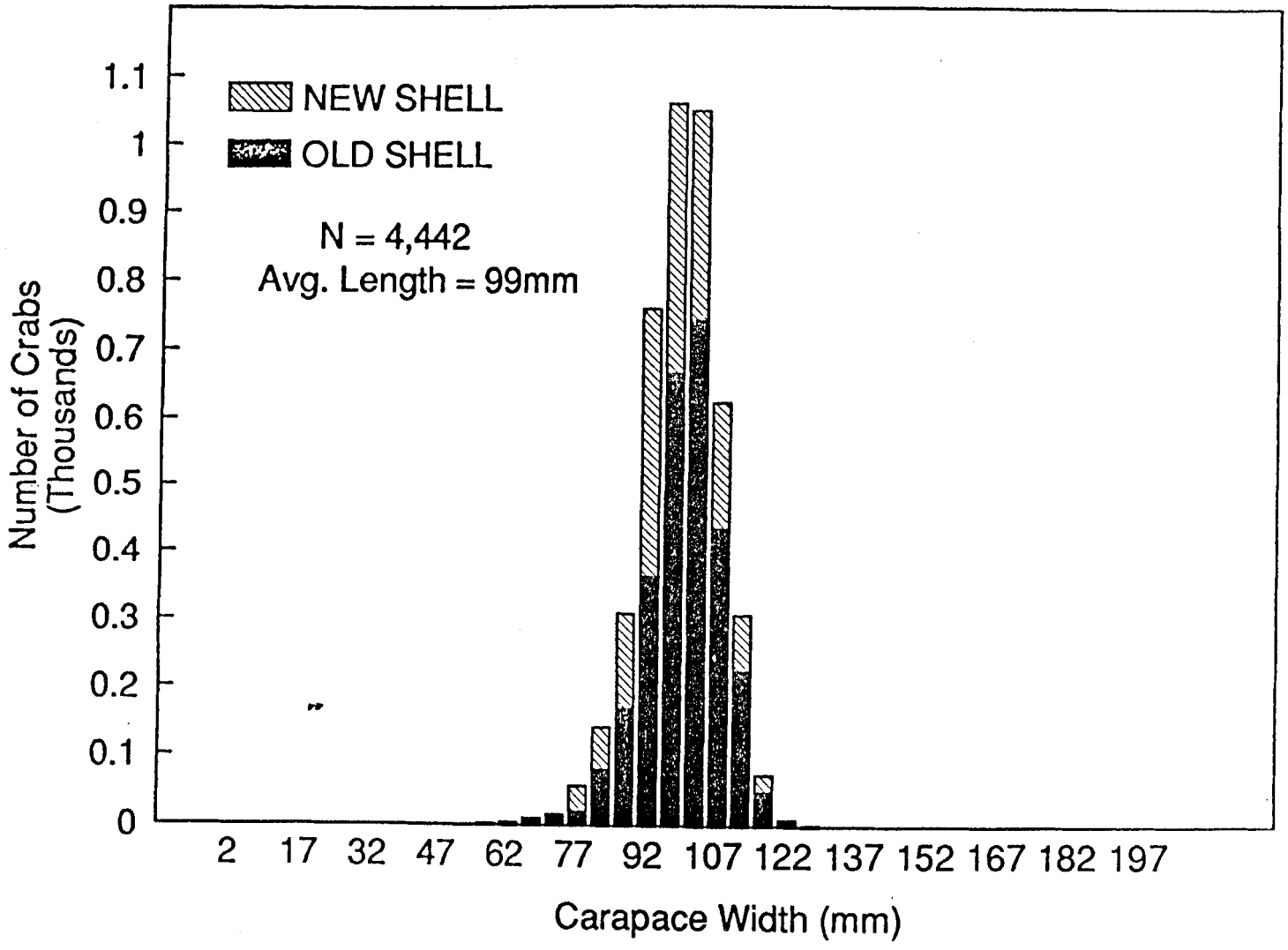
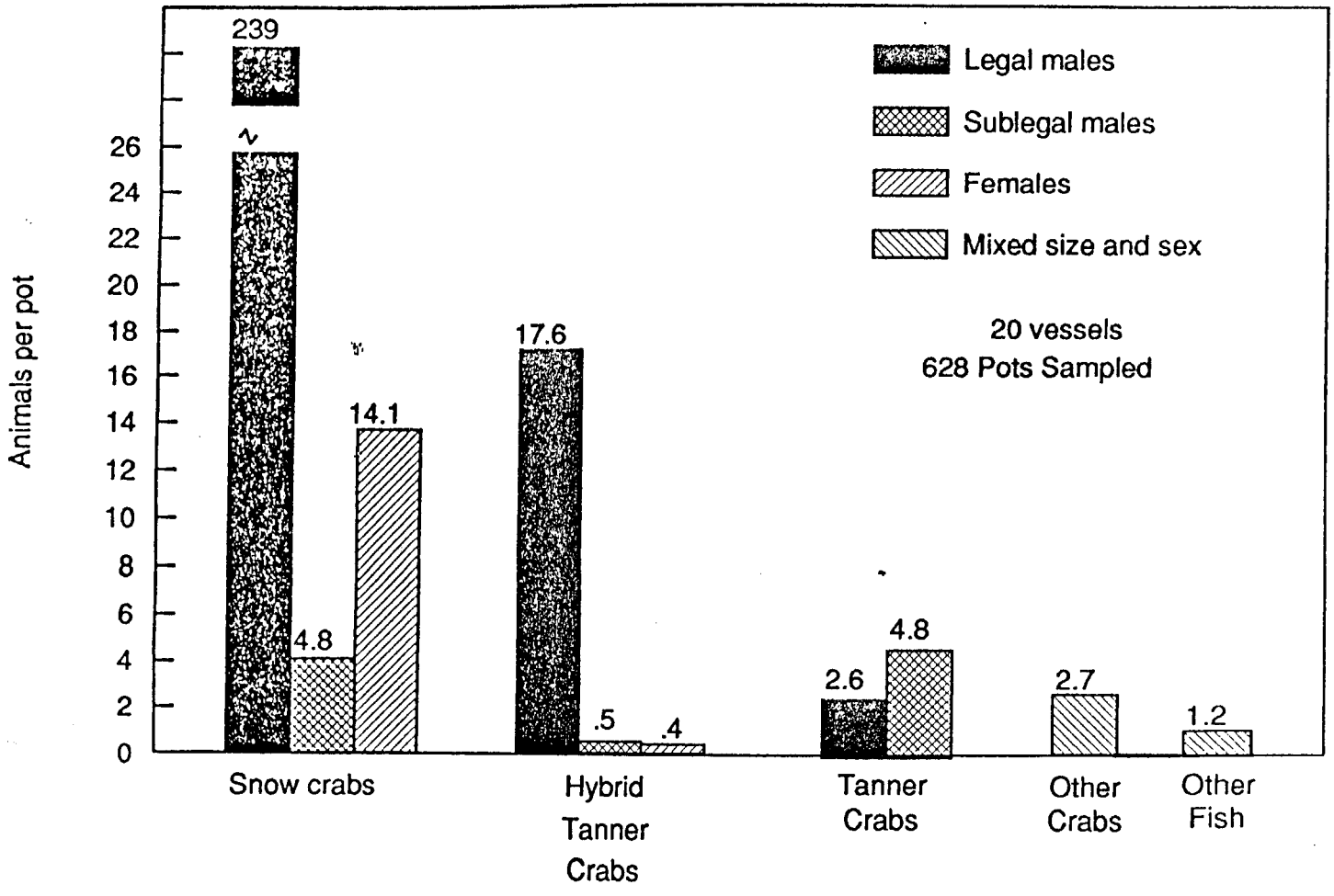


Figure 10. Catch per unit effort (CPUE) for the Bering Sea snow crab fishery in 1991.



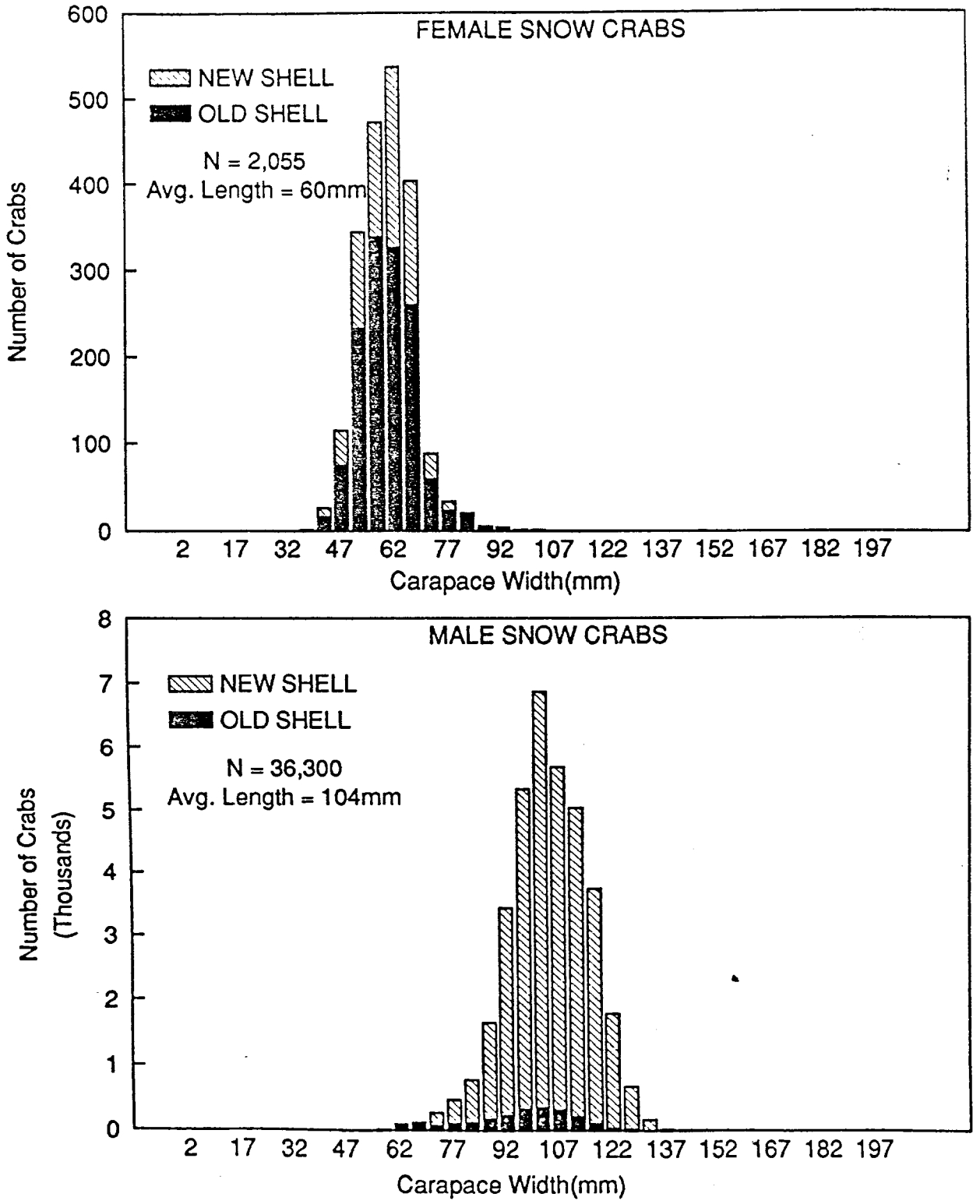
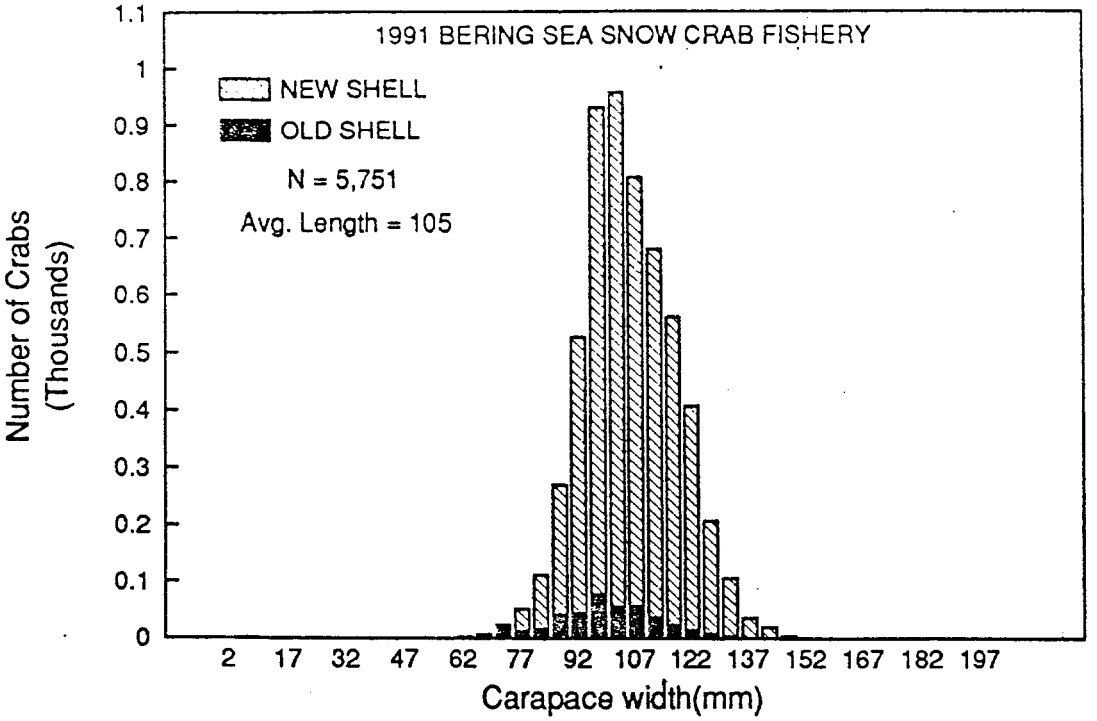


Figure 11. Bering Sea snow crab width frequency distributions by sex in 1991.



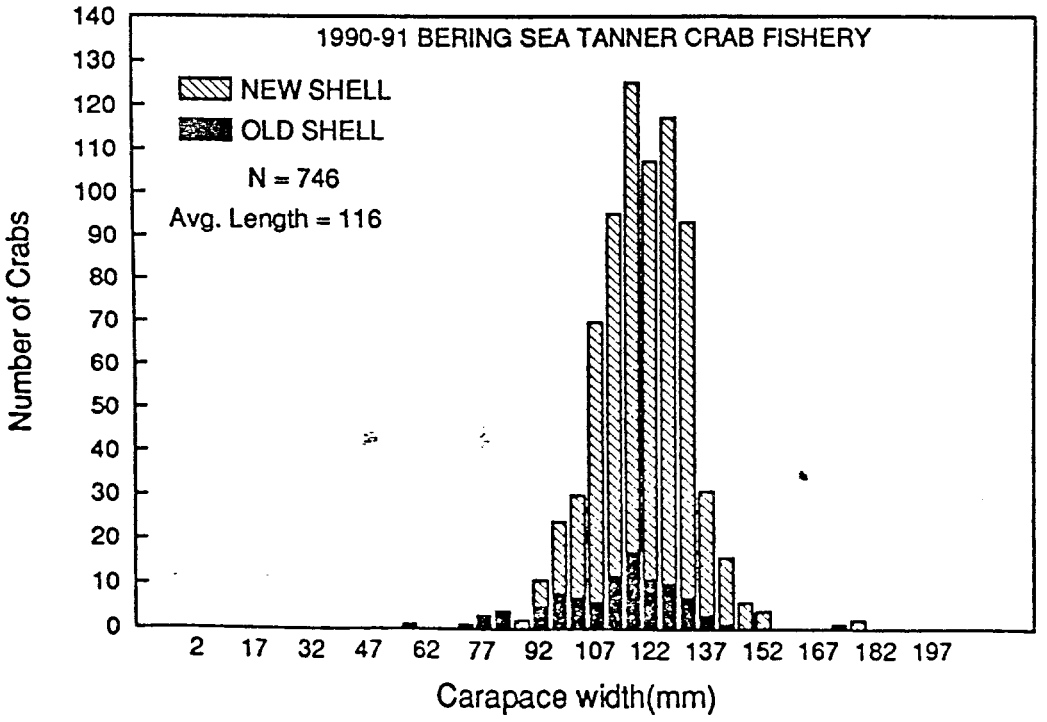
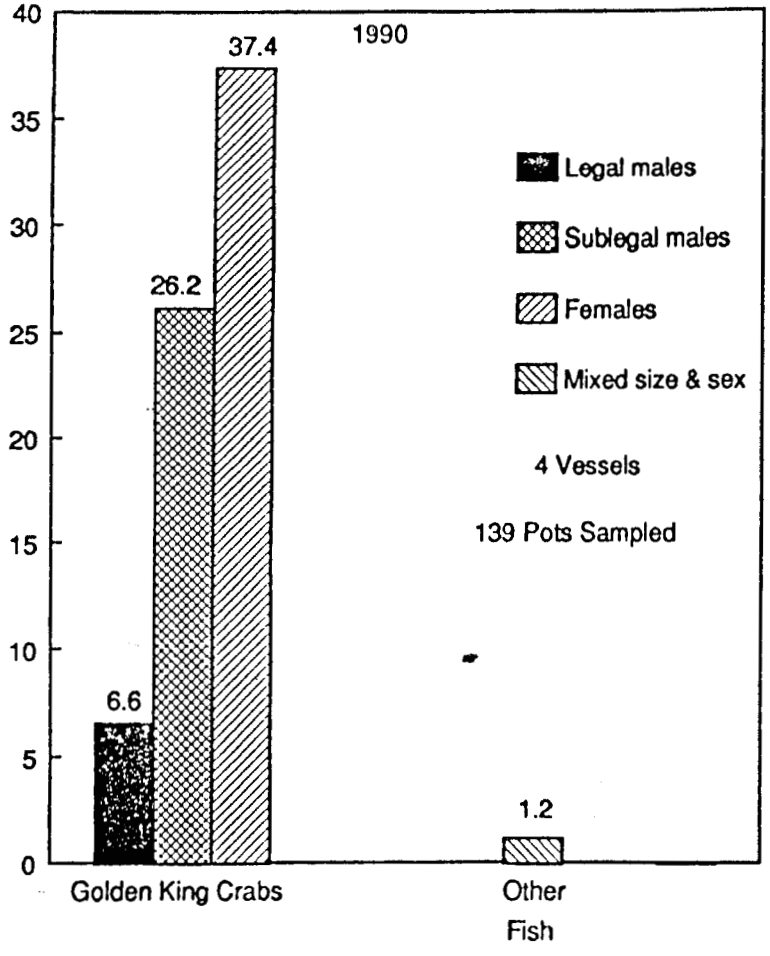
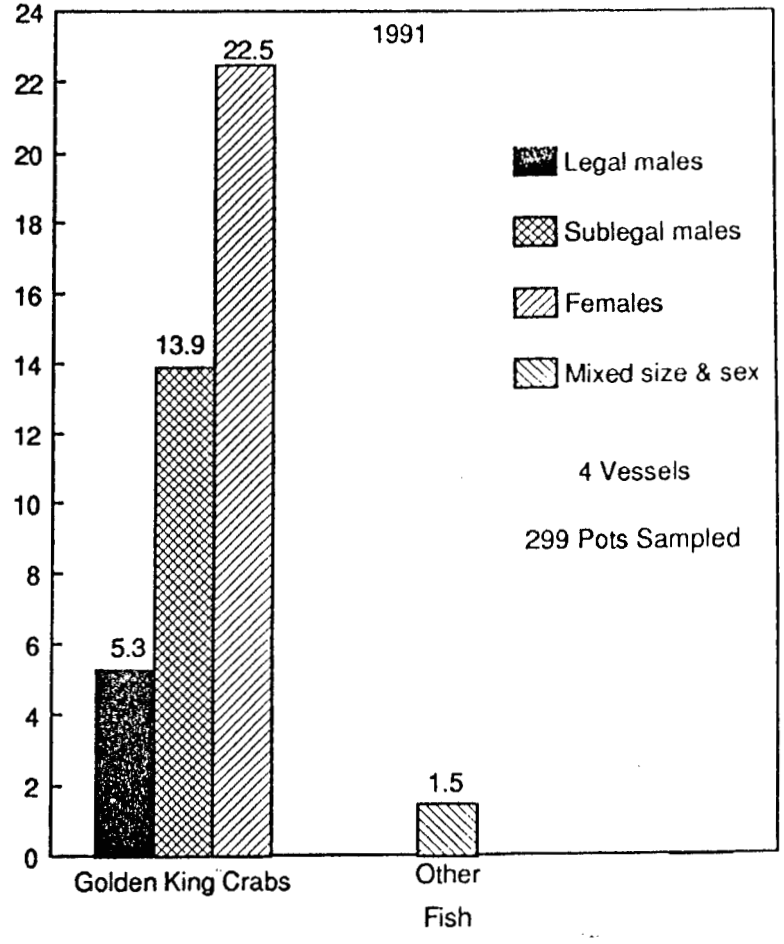


Figure 12. Bering Sea male hybrid Tanner crab width frequency distributions in 1990-91.

Figure 13. Catch per unit effort (CPUE) for the Dutch Harbor golden king crab fisheries in 1990 and 1991.





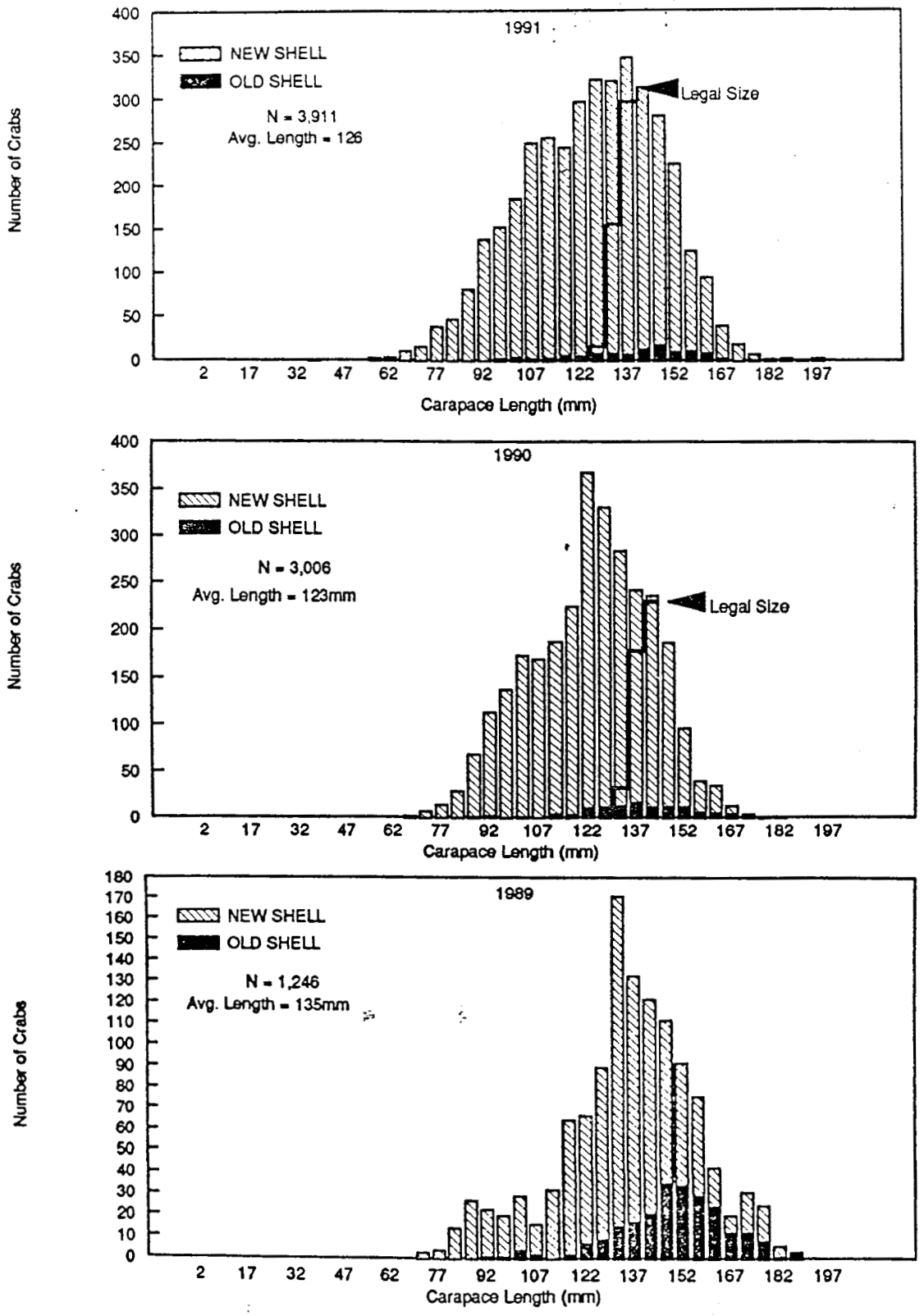


Figure 14. Dutch Harbor male golden king crab length frequency distributions from 1989 to 1991.

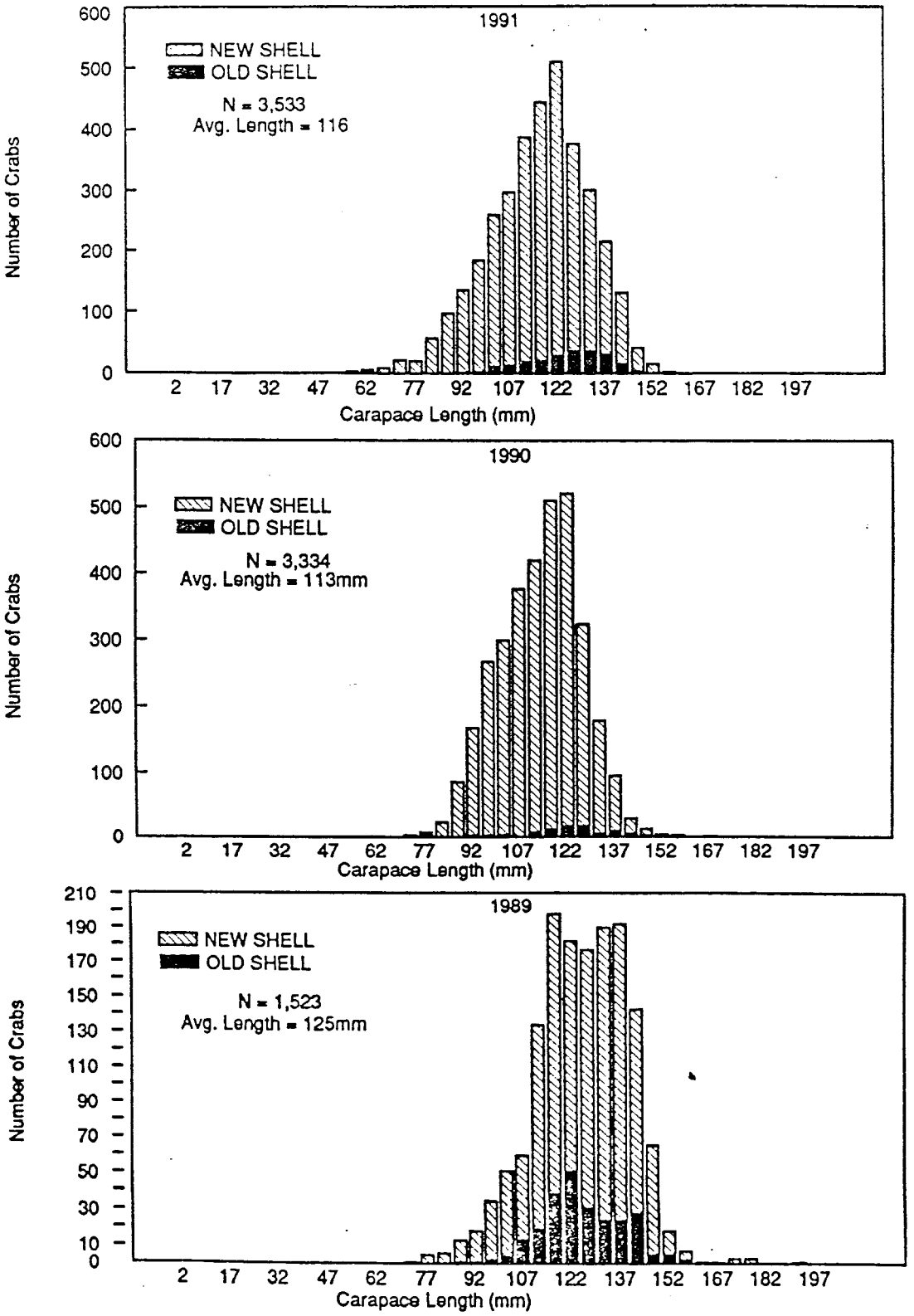


Figure 15. Dutch Harbor female golden king crab length frequency distributions from 1989 to 1991.

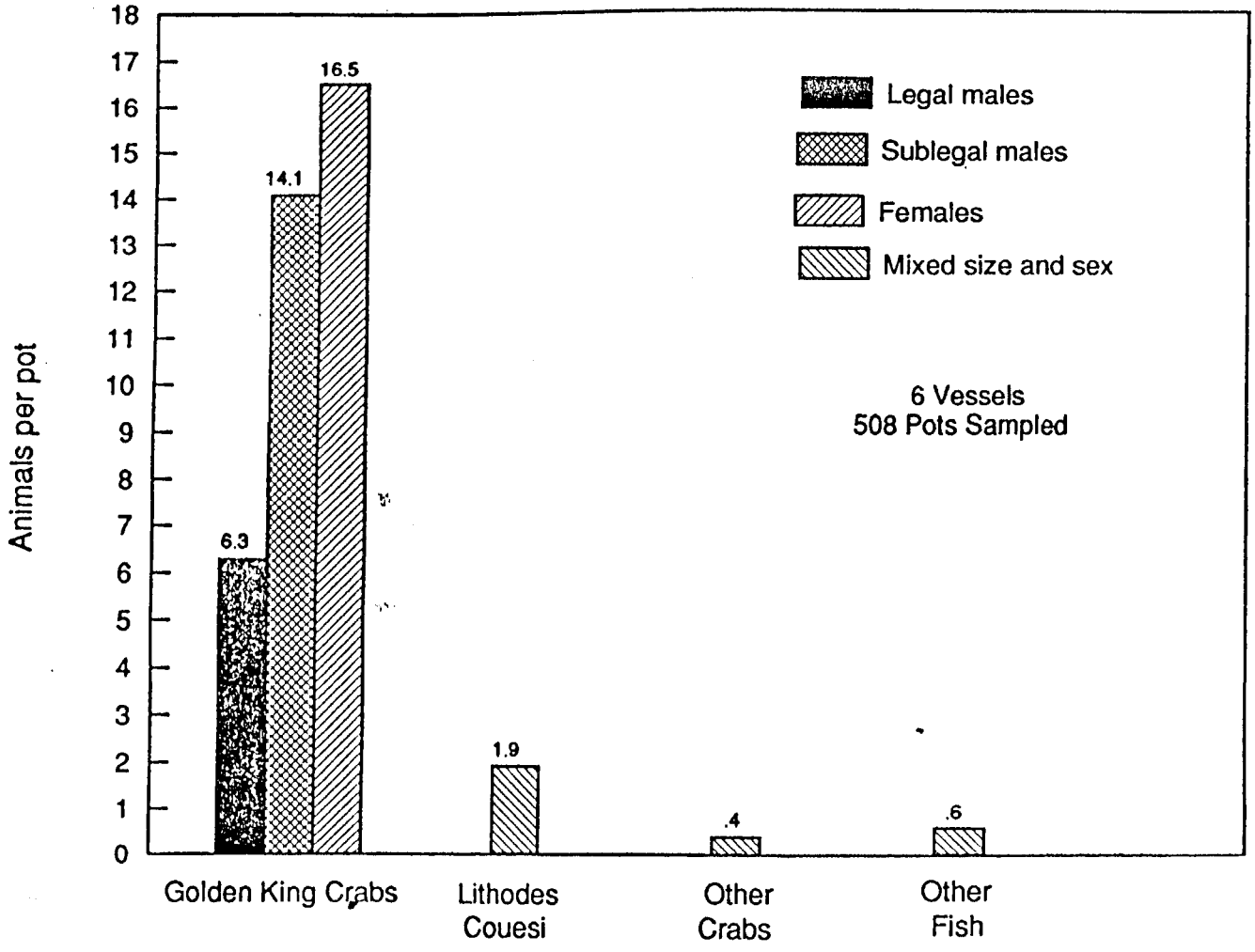


Figure 16. Catch per unit effort (CPUE) for the Adak golden king crab fishery in 1990-91.

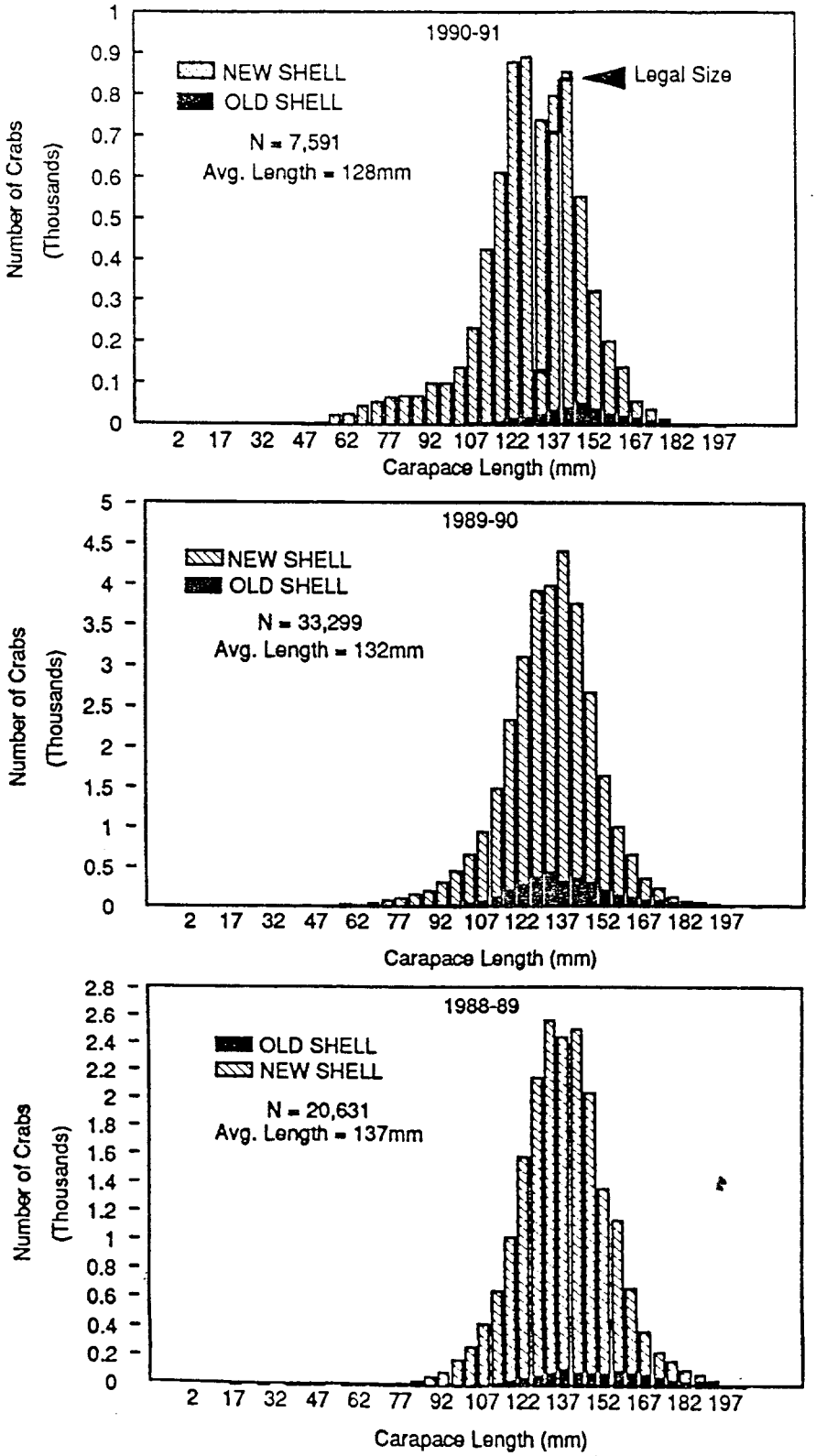


Figure 17. Adak male golden king crab length frequency distributions from 1988 to 1991.

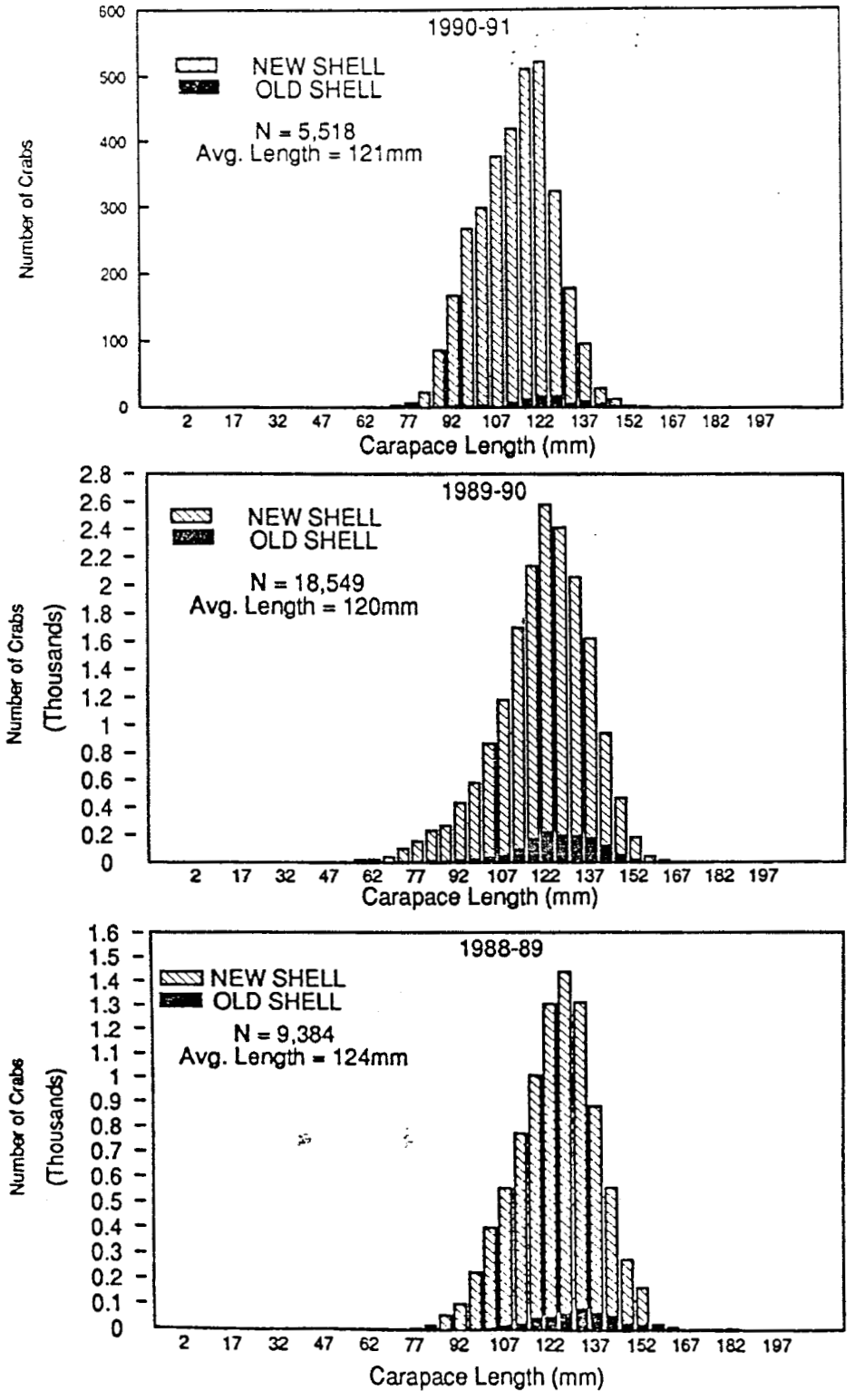


Figure 18. Adak female golden king crab length frequency distributions from 1988 to 1991.

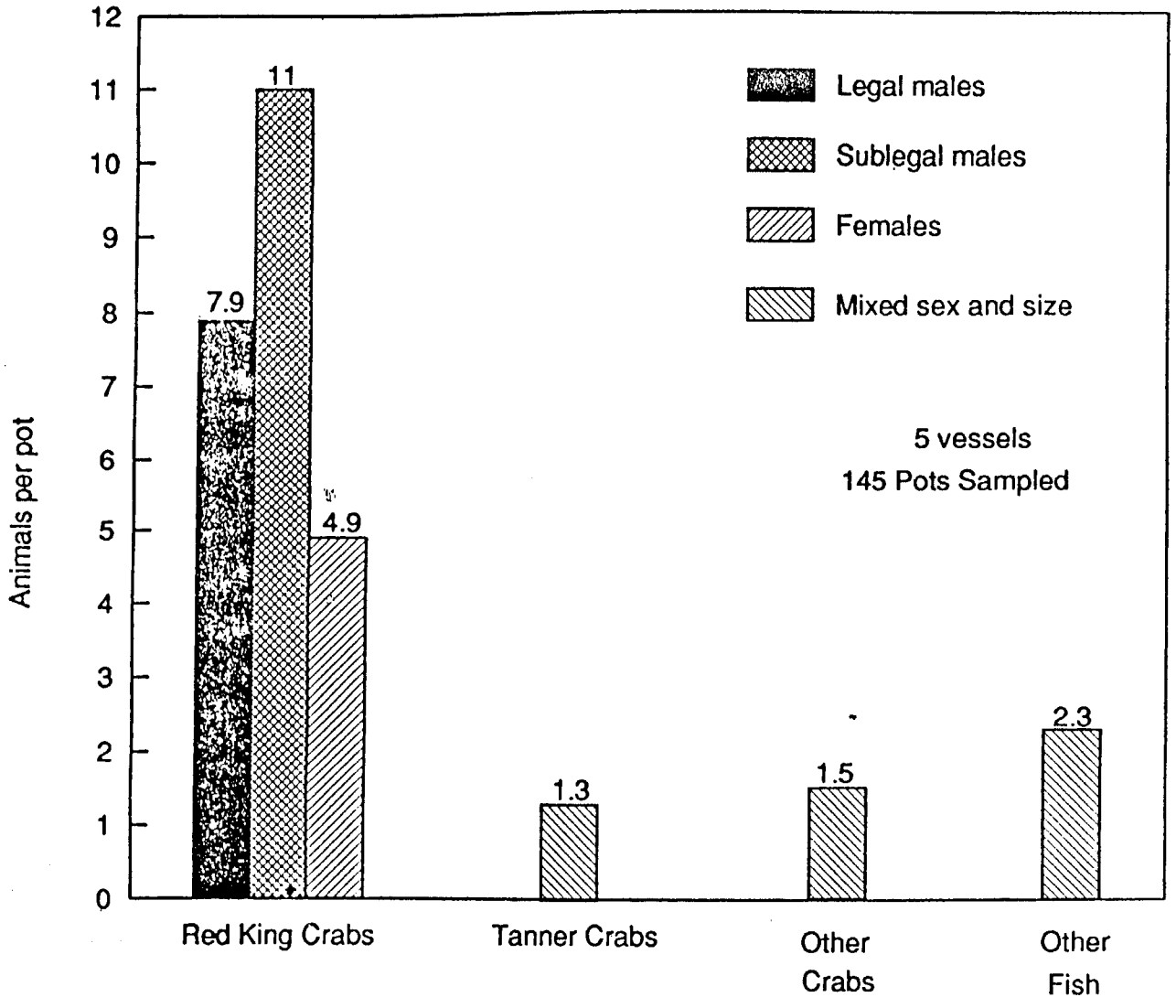


Figure 19. Catch per unit effort (CPUE) for the Adak red king crab fishery in 1990-91.

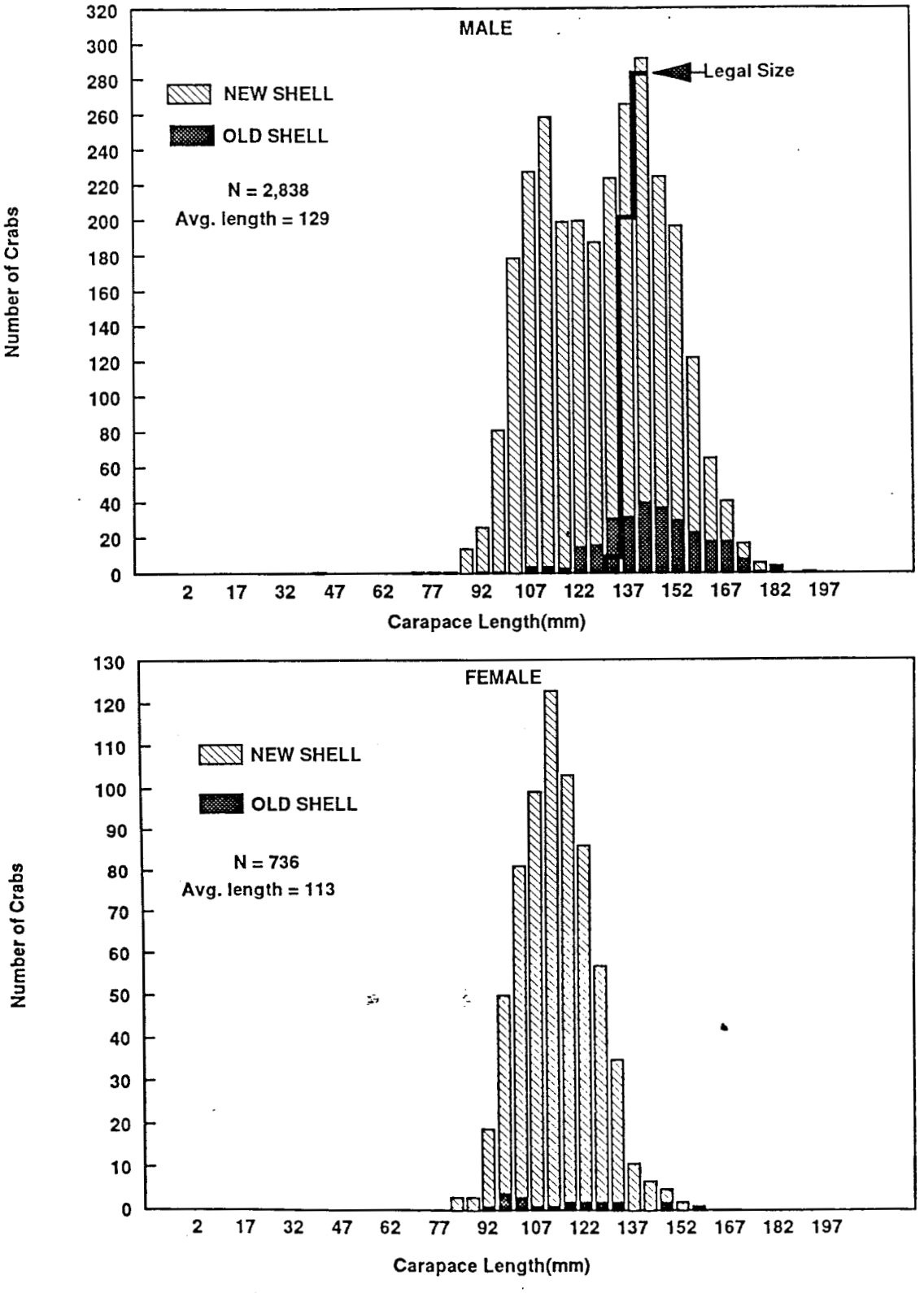


Figure 20. Adak red king crab length frequency distribution by sex in 1990-91.