Fishery Data Series No. 10-01

Summary of the 2008/2009 Mandatory Shellfish Observer Program Database for the Rationalized Crab Fisheries

by

William B. Gaeuman

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Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye to fork	MEF
mideye to tail fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

Since 1988, the Alaska Department of Fish and Game (ADF&G) has required varying levels of observer coverage aboard vessels participating in Bering Sea and Aleutian Islands (BSAI) crab fisheries. In the 2008/2009 rationalized fisheries, commercially harvested crab species included golden king crab *Lithodes aequispinus* from the Aleutian Islands, red king crab *Paralithodes camtschaticus,* snow crab *Chionoecetes opilio,* and Tanner crab *C. bairdi* from the Bering Sea. This report summarizes data collected in the 2008/2009 rationalized BSAI crab fisheries by crab observers deployed on catcher-processor vessels, floating-processor vessels, and catcher-only vessels and provides historical data for comparison. Data summaries include catch rates of targeted species by soak time and depth, female reproductive condition, total bycatch from sampled pot lifts, estimates and standard errors of catch per unit effort (CPUE), retained male catch size frequency distributions, legal tally sample results, and sample pot lift locations by fishery. Comparison of estimates of legal retained CPUE based on observer data with estimates derived from fish-ticket data shows mixed results.

Key words: Alaska Department of Fish and Game, Bering Sea, Aleutian Islands, shellfish observers, database summary, golden king crab *Lithodes aequispinus*, red king crab *Paralithodes camtschaticus,* snow crab *Chionoecetes opilio,* and Tanner crab *C. bairdi*.

INTRODUCTION

Regulations adopted by the Alaska Board of Fisheries (BOF) in 1999 have provided the Alaska Department of Fish and Game (ADF&G) with the full authority and responsibility for deploying onboard observers on any vessel participating in the commercial Bering Sea and Aleutian Islands (BSAI) crab fisheries or in any fishery conducted under a commissioner's permit as necessary for fishery management and data-gathering needs. Those regulations required deployment of observers on all vessels that process Tanner crab *Chionoecetes* spp., red king crab *Paralithodes camtschaticus*, blue king crab *P. platypus*, or golden king crab *Lithodes aequispinus*. Additionally, those regulations charged ADF&G with deploying observers as needed on catcher-only vessels participating in commercial BSAI king and Tanner crab fisheries (excluding those of Norton Sound and St. Lawrence Island Sections). Details on the regulations pertaining to the State of Alaska Shellfish Onboard Observer Program and a history of that program from its inception in 1988 can be found in Bowers et al. (2008).

Along with gear type, location, depth, and soak time of each sampled pot lift, observers collect data describing its contents, including species composition and the sex and legal status of all commercially important captured crabs, as well as, for a subset of sampled pot lifts, a range of biological measurements and assessments of all commercially important crabs and selected other species of interest. They also document overall vessel catch, bycatch, and effort, monitor vessel activities for regulatory compliance, take size-frequency samples, conduct legal tallies, and estimate average weight of retained and delivered catch. ADF&G Westward Region staff maintain observer collected information in a database that is used in management and research applications to develop stock-assessment models, to estimate the magnitude and composition of bycatch, to chronicle female reproductive cycles, and as an aid in preseason and inseason projections of fishery performance. The database provides a source of information crucial to the comprehensive management of Alaska's shellfish resources in the Bering Sea and Aleutian Islands.

This report summarizes data collected by onboard observers and dockside samplers during the 2008/2009 Bering Sea snow crab fishery, the 2008/2009 Bering Sea Tanner crab fisheries east and west of 166° W longitude, the 2008/2009 Bristol Bay red king crab fishery, and the 2008/2009 Aleutian Islands golden king crab fisheries east and west of 174° W longitude. For

each fishery, this report includes estimates of catch and bycatch of crabs from sampled pot lifts, information on the size and shell condition of retained crabs and crabs captured as bycatch, and summaries of the catch composition for all species encountered in sampled pot lifts.

METHODS

Methods described in this report correspond only to the data presented and are not inclusive of all observer sampling duties. Comprehensive shellfish observer sampling methods are detailed in the most recent edition of the ADF&G Crab Observer Training and Deployment Manual (2009). As in previous seasons, observers were deployed on all catcher-processor and floating-processor vessels that participated in each of the reported fisheries. Observers were also deployed on randomly selected catcher-only vessels that participated in the Bering Sea snow crab fishery, Bering Sea Tanner crab fisheries, and the Bristol Bay red king crab fishery. In the Aleutian Islands golden king crab fisheries, on the other hand, all catcher-only vessels were required to carry an observer for at least 50% of their assigned quota caught and landed in each three-month trimester of the nine month season. The number of pot lifts observers were assigned to sample on each day of fishing activity on board catcher-processor and catcher-only vessels varied by both fishery and vessel type. In general, sample pot-lift goals, as well as observer ability to attain them, depend on a number of variables unique to each fishery and year, including weather, catch rates, research data collection projects, and the order of sampling priorities established by ADF&G (2009). Fishery specific catcher-processor and catcher-only vessel observer deployments and pot-lift sampling goals are given in Table 1.

TERMS

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

Pot-lift sample – A randomly selected pot lift from which captured crabs of all species are identified and enumerated. For a subset of these pot lifts measurements and assessments of ancillary characteristics are also recorded for crabs of selected species.

Legal tally – Examination of up to 600 crabs randomly selected from the retained catch to assure regulatory compliance regarding the retention of crabs by species, size, and sex.

Carapace length (CL) – The biological size measurement of all species of king crabs and hair crabs *Erimacrus isenbeckii* taken as the straight-line distance from the posterior margin of the right eye orbit to the medial-posterior carapace margin.

Carapace width (CW) – The biological size measurement of all species of *Chionoecetes* taken as the greatest straight-line distance perpendicular to a line midway between the eyes to the medial-posterior margin, not including the spines.

Legal measurement – The greatest straight-line distance across the carapace of male crabs, including the spines, perpendicular to a line midway between the eyes to the medial-posterior margin.

Size frequency sample – Biological measurements of up to 100 randomly selected retained crabs for the purpose of determining carapace size and shell condition distribution.

Catch per unit effort (CPUE) – The mean catch (number) of crabs for a standardized unit of fishing effort. In this report CPUE represents the mean catch per pot lift.

Uneyed eggs – Early developmental stages of an egg with no distinguishing markings.

Eyed eggs – Later developmental stages of an egg distinguished by dark eye spots.

Ovigerous – Bearing eggs, either eyed or uneyed (pertaining to female crabs).

Mated/barren – Not carrying eggs but displaying evidence of previous mating activity (pertaining to female crabs).

Non-mated/barren – Not carrying eggs and not displaying evidence of previous mating activity (pertaining to female crabs).

Recruit – New-shell male crab of legal size in its first year of availability to the commercial fishery.

Post-recruit – All old-shell male crabs of legal size and all new-shell male crabs one or more molts larger than recruit size.

Shell condition is recorded to provide an estimate of the time since a crab's last molt (ADF&G 2009; Jadamec et al. 1999; Donaldson and Byersdorfer 2005). Observers scored the shell condition of sampled crabs as either "soft", "new pliable", "new", "old", or "very old" on the basis of shell hardness, the presence and amount of abrasions, discoloration, and wear on the ventral surfaces, the presence and amount of epibionts on the dorsal surface, the color of the dorsal surface, and the degree of wear on spines and dactyls.

SAMPLING DUTIES

During the 2008/2009 BSAI crab fisheries, observers were deployed on floating-processor vessels, catcher-processor vessels, and catcher-only vessels. Observers deployed on floating-processors had access only to retained catch resulting from previous sorting by crew, whereas observers placed on catcher-processor and catcher-only vessels were able to examine the contents of pot lifts prior to sorting.

Floating-Processors

Observers deployed on floating-processors primarily monitor deliveries from catcher-only vessels. Sampling duties during each delivery included obtaining a size frequency sample, conducting a legal tally, and determining average weight of retained crab.

Catcher-Processors

Sampling duties for observers deployed on catcher-processors included pot-lift sampling, size frequency sampling, legal tally sampling, and determination of average weight of retained crab for each day the vessel retains catch. Occasionally, catcher-only vessels delivered to a catcher-

processor. In those situations, the observer sampled the catcher-only vessel catch as if deployed on a floating-processor.

Catcher-Only Vessels

Sampling duties for observers deployed on catcher-only vessels included pot-lift sampling, which was usually the main sampling activity for each day the vessel retained catch. When the vessel delivered to a processing facility (at-sea or on-shore), the observer obtained a size frequency sample, conducted a legal tally, and determined average weight of retained crab. If deliveries were made at-sea, all sampling was completed by the observer deployed on the catcher-only vessel.

ESTIMATION OF CPUE AND TOTAL FISHERY CATCH

Estimates of CPUE presented here were generated from observer data using a ratio estimator introduced in Gaeuman (2009). For the purpose of estimation it is assumed that within a fishery observers are assigned to all participating catcher-processors and by simple random sampling to a subset of all participating catcher-only vessels. It is also assumed that sampled pot lifts are selected by simple random sampling from all pot lifts on each vessel fishing day, independently across days. Under these assumptions it is straightforward to estimate both total catch and the total number of pot lifts for all vessels based on observed vessel-days, treating vessel types as strata, vessels as primary sampling units within them, vessel-days as strata within vessels, and pot lifts as secondary sampling units within those. The ratio of these estimates of total catch and total number of pot lifts then estimates fishery mean CPUE defined as fishery total catch divided by fishery total effort (total number of pot lifts). An estimated variance for the CPUE estimator can be obtained using standard variance estimators for the estimators of total catch and total number of pot lifts. Appendix A1 describes both the ratio estimator and the derivation of its variance estimator.

Prior to Gaeuman (2009), different estimates of CPUE were calculated depending on the information available and on varying assumptions about the sampling design. The "sample CPUE" reported before 1996 (Tracy 1994, 1995a, b) was calculated as the simple average catch over all sampled pot lifts. The later "stratified CPUE" estimate assumed stratification by vessel-day and employed an estimator most recently described by Barnard and Burt (2008). They additionally considered stratification by vessel type with their "weighted mean" estimator of CPUE, which was introduced into the report series in 2003.

By contrast with these design-based estimates of CPUE, actual-total-fishery (ATF) CPUE is based on fish ticket information on effort and catch reported in annual management reports for commercial crab fisheries in the BSAI management areas and represents an independent estimate of CPUE from that derived from observer data (Bowers et al. 2008). The ATF CPUE estimate, however, is available only for retained legal crabs. Estimated total catches reported in this document, as opposed to the ATF values for retained legal crabs based exclusively on fish ticket data, were calculated by multiplying CPUE estimates from observer data by the estimated ATF total number of pot lifts in each fishery. For fisheries with 100% observer coverage, the total pot lift information was taken from confidential interviews. Otherwise, data on total pot lifts were extracted from fish ticket summaries.

RESULTS

BERING SEA SNOW CRAB

The 2008/2009 Bering Sea snow crab season opened 15 October 2008, and fishing began in November and continued into May 2009. Most of the effort took place during the first three months of 2009. A total of 1,657 pot lifts selected for sampling accounted for 10.1% of the 163,536 pot lifts reported by vessel operators (ADF&G Dutch Harbor staff, personal communication). Locations of pot lifts sampled by observers during the 2008/2009 Bering Sea snow crab fishery are displayed in Appendix B1.

Measurements of CW for size frequency samples were taken from 49,512 retained male snow crabs throughout the season by onboard observers and ADF&G staff stationed at shore-side processing locations (Table 2). The mean CW of retained male snow crabs was 109.9 mm.

Onboard observers also collected CW measurements of 19,221 male snow crabs from selected pot-lift samples. Mean CW was 105.9 mm. About 9.7% of male snow crabs sampled were categorized as old or very-old shell. Figure 1 tracks male snow crab CW distribution by shell condition over the last 8 seasons based on intervals of 5 mm. Measurements of CW were also taken from 461 female snow crabs during pot-lift sampling. Mean CW for this group was 79.8 mm. 95.7% were categorized as old or very-old shell condition.

Estimated CPUE for legal retained snow crabs was 280.6 crabs per pot lift (Table 3), essentially indistinguishable from the ATF CPUE of 281.0. A 95% confidence interval for this estimate is (259.8, 301.2) from a t-distribution on 28 degrees of freedom. The corresponding estimate of total harvest was 45,888,000 legal retained males (Table 3). Legal retained males accounted for an estimated 71% of all captured snow crabs, while legal sized male crabs less than 4 inches (~ 102 mm) CW that were discarded as bycatch made up approximately 28%. Although the minimum legal size for snow crabs is 3.1 inches (~ 79 mm) CW, processing plants generally do not accept crabs less then 4 inches CW. Sublegal male and female snow crabs together comprised about 1% of the total catch and 2% of the bycatch. The 2008/2009 estimate of CPUE for legal retained snow crab reflects an almost 20% decrease over the previous season estimate, which was the highest estimated value since 1995 (Figure 2).

Total catches of all animals identified in sampled pot lifts during the 2008/2009 season are provided in Appendix C1. Additional appendices contain CPUE by soak time (Appendix C2) and depth (Appendix C3) and the reproductive condition of female snow crabs in pot-lift samples (Appendix C4).

Legal tallies conducted on catcher-processor vessels and catcher-only vessels delivering snow crab to processors totaled 90,942 crabs, which accounted for 0.2% of the ATF estimate of total catch (Appendix D1). Of these, 0.23% were illegal due to size, sex, or species restrictions.

BERING SEA TANNER CRAB

The 2008/2009 directed Bering Sea Tanner crab fishery was managed as separate fisheries west and east of 166°W longitude. In addition to allowing vessels participating in the Bering Sea directed Tanner crab fisheries to harvest legal male Tanner crabs, regulations permitted properly licensed vessels participating in the Bering Sea snow crab and Bristol Bay red king crab fisheries to retain legal Tanner crabs as incidental catch up to 5% of total landing weight. 2008/2009 Bering Sea Tanner crab ATF estimates of effort and catch of retained legal Tanner crabs were

calculated by ADF&G Dutch Harbor staff using only fish ticket data associated with directed Tanner crab deliveries (i.e., no coincident significant deliveries of other targeted species). ATF CPUE for retained legal Tanner crabs in each Tanner crab fishery was then obtained as estimated total catch divided by the estimated total number of pot lifts (ADF&G Dutch Harbor Staff, personal communication).

West of 166° W Longitude

The season opened 15 October 2008. Fishing began in November and continued into March 2009. The 77 pot lifts selected for pot-lift sampling accounted for 3.3% of the 2,336 pot lifts reported by vessel operators in the directed fishery (ADF&G Dutch Harbor staff, personal communication). Locations of pot lifts sampled by observers during the 2008/2009 Bering Sea Tanner crab fishery west of 166° W longitude are displayed in Appendix B2.

Size frequency sample measurements of CW were taken from 521 retained male Tanner crabs throughout the directed-catch season by onboard observers and ADF&G staff stationed at shore-side processing locations (Table 4). Mean CW of retained male Tanner crabs was 146.7 mm.

Onboard observers also recorded CW measurements of 3,813 male Tanner crabs from selected pot-lift samples during the directed Bering Sea Tanner crab fishery (Figure 3). Mean CW was 132.0 mm, 14.5% of which were categorized as old shell or very-old shell condition. Onboard observers also measured 118 female Tanner crabs (Figure 4). Mean CW for these crabs was 89.6 mm, and most, 93.2%, were categorized as old shell or very-old shell condition.

Estimated CPUE of legal retained Tanner crabs in the directed fishery west of 166° W was 26.8 crabs per pot lift (Table 5), with 95% confidence interval (15.2, 38.5) from a *t*-distribution on 3 degrees of freedom. By comparison, estimated ATF CPUE was 20.6. Corresponding estimated harvest of legal retained Tanner crabs in the directed fishery west of 166º was 63,000 crabs (Table 5). Legal retained males comprised only approximately one quarter of the total number of captured Tanner crabs, whereas 67% were sublegal males discarded as bycatch. In addition to those Tanner crabs harvested in the directed fishery, it was estimated that another 33,000 were harvested as incidental catch in the 2008/2009 Bering Sea snow crab fishery (Table 3). Though numerically higher, estimated 2008/2009 CPUE for retained legal Tanner crabs west of 166º W longitude was statistically indistinguishable from the previous season's estimate of 23.4 (Figure 5).

Total catches of all animals identified in sampled pot lifts during the 2008/2009 directed Tanner crab fishery west of 166º W longitude are provided in Appendix C5. Summaries of CPUE by soak time and depth for captured Tanner crabs can be found in Appendices C6 and C7, respectively, and reproductive condition of female Tanner crabs from sampled pot lifts is documented in Appendix C8.

Legal tallies conducted on catcher-only vessels delivering to processors totaled 1,624 crabs by the end of the 2008/2009 season and comprised around 3.3% of the cumulative reported harvest in the directed fishery (Appendix D1). Approximately 1.72% of sampled crabs were illegal based on size, sex or species restrictions.

East of 166° W Longitude

The season opened at noon on 15 October 2008 and closed on 31 March 2009. Fishing took place through most of the season. Onboard observers sampled 607 pot lifts accounting for 3.1%

of ATF estimated 19,401 pot lifts reported by vessel operators in the directed fishery (ADF&G Dutch Harbor staff, personal communication). Locations of pot lifts sampled by observers during the 2008/2009 eastern Bering Sea Tanner crab fishery are displayed in Appendix B3.

Size frequency sample measurements of CW were taken from 2,969 retained male Tanner crabs throughout the directed-catch season by onboard observers and ADF&G staff stationed at shore-side processing locations (Table 6). Mean CW of retained male Tanner crabs was 150.0 mm, and 91.5% were categorized as new-shell condition.

Onboard observers also obtained CW measurements of 25,352 male Tanner crabs and 528 female Tanner crabs from selected pot lift samples during the season (Figures 6 and 7). Mean CW for measured male Tanner crabs was 140.2 mm, and 10.5% were categorized as old or very-old shell condition, whereas female mean CW was 94.5 mm with approximately 23.9% categorized as old or very-old shell.

Estimated CPUE for legal retained Tanner crabs in the directed Tanner crab fishery east of 166° W was 46.7 crabs per pot lift (Table 7), with 95% confidence interval (42.3, 51.1) from a *t*-distribution on 6 degrees of freedom. The ATF CPUE, by contrast, was 39.1. Based on a total of 19,401 reported pot lifts in the directed fishery, the estimated CPUE yields an estimated total harvest of 906,000 legal retained Tanner crabs (Table 7). Legal retained Tanner crabs accounted for about a third, 32.4%, of all Tanner crabs caught in the directed fishery. As in the western Tanner crab directed fishery, a much greater proportion of the target species catch, 63.5%, consisted of sublegal males discarded as bycatch. In addition, another estimated 14,000 Tanner crabs were harvested as incidental catch in the concurrent 2008/2009 Bristol Bay directed red king crab fishery (Table 8). Estimated 2008/2009 CPUE for legal retained Tanner crabs was 81% higher than the previous season estimate of 25.8 (Figure 8).

Total catches of all animals identified in sampled pot lifts during the 2007/2008 eastern Bering Sea Tanner crab fishery are provided in Appendix C9. Summaries of CPUE by soak time and depth can be found in Appendices C10 and C11, respectively. Reproductive condition of female Tanner crabs from sampled pot lifts is given in Appendix C12.

Legal tallies conducted on catcher-only vessels delivering to processors during the 2008/2009 season totaled 11,164 crab and comprised 1.5% of the cumulative reported harvest of Tanner crabs in the eastern directed fishery (Appendix D1). Approximately 0.75% of these were illegal due to size, sex or species restrictions.

BRISTOL BAY RED KING CRAB

The 2008/2009 Bristol Bay red king crab season commenced on 15 October 2008, and fishing continued into December. A total of 1,849 pot lifts selected for sampling accounted for 1.3% of the 139,939 pot lifts reported by vessel operators (ADF&G Dutch Harbor staff, personal communication). Locations of pot lifts sampled by observers during the 2008/2009 Bristol Bay red king crab fishery are displayed in Appendix B4.

Size frequency sample measurements of CL were taken from 24,997 retained male red king crabs by onboard observers and ADF&G staff stationed at shore-side processing locations (Table 9). The mean CL of retained male red king crabs was 153.2 mm.

Throughout the season onboard observers also collected pot-lift sample CL measurements of 89,765 male red king crabs of known shell condition (Figure 9). Mean CL for this group was

136.4 mm, and the percentage of old and very-old shell condition male red king crabs was 9.7%. Measurements of CL were also taken from 8,488 female red king crabs of known shell condition (Figure 10). Mean CL was 112.1 mm. Approximately 0.7% were categorized old or very-old shell.

Estimated CPUE for legal retained red king crabs was of 23.3 crabs per pot lift (Table 8), with 95% confidence interval (22.5, 24.0) from a *t*-distribution on 20 degrees of freedom, whereas the ATF CPUE was 21.9. Based on the total 139,939 reported pot lifts, the corresponding estimate of fishery harvest was 3,261,000 legal retained red king crabs (Table 8). It is estimated that this number represents just 39.6% of all captured red king crabs, with the other portion being discarded due to size, condition or sex. Approximately 83% of discarded red king crabs were sublegal males. Estimated CPUE for legal male red king crab in 2008/2009 was 23.7 crabs per pot lift, approximately 7% lower than the previous season estimate of 29.6 and the second yearly decline in a row (Figure 11).

Total catches of all animals identified in sampled pot lifts during the 2008/2009 Bristol Bay red king crab season are provided in Appendix C13. Additional appendices contain CPUE by soak time (Appendix C14) and depth (Appendix C15) and the reproductive condition of female red king crabs from pot-lift samples (Appendix C16).

Legal tallies conducted on catcher-processors and catcher-only vessels delivering to processors totaled 31,431 crabs by the end of the 2008/2009 season and comprised 1.0% of the cumulative reported harvest (Appendix D1). Approximately 0.18% of sampled crabs were illegal due to size, sex, or species.

ALEUTIAN ISLANDS GOLDEN KING CRAB

In March 1996, the BOF established the Aleutian Islands king crab registration area by combining two existing areas, Dutch Harbor and Adak, and directed ADF&G to manage golden king crab stocks of the Aleutian Islands east and west of 174° W longitude as two distinct stocks (Bowers et al. 2008).

West of 174° W Longitude

The western 2008/2009 Aleutian Islands golden king crab fishery opened 15 August 2008 and fishing continued into April 2009. A total of 979 pot lifts selected for sampling accounted for 3.7% of the 26,200 pot lifts reported by vessel operators (ADF&G Dutch Harbor staff, personal communication). Fishery sampled pot lift locations are displayed in Appendix B5.

Size frequency sample measurements of CL were taken from 10,182 retained male golden king crabs throughout the season by onboard observers and ADF&G staff stationed at shore-side processing locations (Table 10). Mean CL of retained male golden king crabs was 151.2 mm.

In addition, pot-lift sample measurements of CL were taken from 25,224 male golden king crabs throughout the season by onboard observers (Figure 12). Mean CL for male golden king crabs from sampled pot lifts was 143.0 mm, and 94.7% were categorized new shell condition, as opposed to old or very-old shell. Pot-lift sample measurements of CL also were taken from 7,883 female golden king crabs throughout the season by onboard observers (Figure 13). Mean CL for these female golden king crabs from sampled pot lifts was 133.5 mm, and 87.2% were categorized as new shell.

Estimated CPUE for legal retained golden king crabs was 25.3 crabs per pot lift, with 95% confidence interval (24.0, 26.6), as compared to the ATF CPUE of 22.4 (Table 11). Associated

estimated harvest based on 26,200 pot lifts was 663,000 legal golden king crabs (Table 10). The 2008/2009 estimated CPUE of 25.4 legal male golden king crabs per pot lift was 13% higher than the previous season's estimate of 22.4 and the highest estimated value since and including the 1994/1995 fishery (Figure 14). An estimated 49.8% of all golden king crabs captured during the 2008/2009 western fishery were discarded as bycatch, of which slightly more than half, approximately 52.3%, were females.

Total catches of all animals identified in sampled pot lifts during the combined 2008/2009 Aleutian Islands golden king crab fishery (both west and east of 174° W longitude) are provided in Appendix C17. Additional appendices contain CPUE by soak time (Appendix C18) and depth (Appendix C19) and reproductive condition of female golden king crabs (Appendix C20) from sampled pot lifts in the western fishery.

Legal tallies conducted on catcher-processors and catcher-only vessels delivering to processors from both east and west of 174° W longitude totaled 33,418 crabs by the end of the 2008/2009 season and comprised approximately 2.6% of the cumulative reported harvest of 1,254,607 golden king crabs (Appendix D1). Among all sampled crabs, approximately 0.37% were illegal due to size, sex, or species restrictions.

East of 174° W Longitude

The eastern Aleutian Islands golden king crab season opened 15 August 2008 and fishing continued into December. A total of 613 pot lifts selected for sampling accounted for 2.5% of the 24,466 pot lifts reported by vessel operators (ADF&G Dutch Harbor staff, personal communication). Locations of pot lifts sampled by observers during the 2008/2009 Aleutian Islands golden king crab fishery east of 174° W longitude are displayed in Appendix B6.

Size frequency sample measurements of CL were taken from 2,989 retained male golden king crabs throughout the season by onboard observers and ADF&G staff stationed at shore-side processing locations (Table 12). The mean CL of retained male golden king crabs was 151.6 mm.

CL measurements were additionally taken from 15,787 male golden king crabs in selected sample pots throughout the season by onboard observers (Figure 15). Mean CL for male golden king crabs was 147.1 mm, and observers categorized 1.9% as old or very-old shell condition. Measurements of CL were taken from 2,315 female golden king crabs throughout the season by onboard observers (Figure 16). Female mean CL was 131.9 mm. Just 0.4% of the females were judged to be old or very-old shell.

Estimated legal retained golden king crab CPUE for this fishery was 29.1 crabs per pot lift, as compared to the ATF value of 27.3 (Table 13). A 95% confidence interval for this estimate is (27.8, 30.4). Assuming a total of 24,466 pot lifts for this fishery, the associated estimate of harvest was 711,000 legal retained golden king crabs (Table 13). As holds also for the western golden king crab fishery, the historical sequence of estimates of legal male CPUE since 1995 exhibits an increasing trend, with the 2008/2009 estimate of 30.4 legal male golden king crabs per pot lift second only to the previous season's estimate of 30.8 (Figure 17). An estimated 34.8% of all golden king crabs captured during the 2008/2009 eastern fishery were discarded as bycatch. Approximately 62.6% of the discarded crabs were sublegal or non-retained legal males (Table 12).

As previously noted, total catches of all animals identified in sampled pot lifts during the combined 2008/2009 Aleutian Islands golden king crab fishery are provided in Appendix C17.

Additional appendices contain CPUE by soak time (Appendix C21) and depth (Appendix C22) and the reproductive condition of female golden king crabs (Appendix C23) from sampled pot lifts in the eastern fishery.

ACCURACY AND PRECISION OF CPUE ESTIMATES

In assessing CPUE estimates for directed catch and bycatch, their precision should be considered. In general, the precision of an estimator is a function of its repeatability or, more formally, its variance. A convenient measure of precision is the coefficient of variation (CV), which is the ratio of the standard deviation to the mean. An estimate of this quantity is provided by the ratio of the standard error (square root of the estimated variance) to the estimate itself. For the observer-based CPUE estimates of legal retained crab for the six fisheries described in this document, these values indicate good levels of precision for five of the six, ranging from 1.3% (most precise) for the Bering Sea snow crab fishery to 3.8% (least precise) for the Bering Sea Tanner crab fishery east of 166º W longitude. The exception was a CV of 13.7% for the Bering Sea Tanner crab fishery west of 166° W longitude, which may well reflect the small sample sizes at some levels of the design, with observers deployed on just 4 of 42 registered catcher-only vessels sampling a total of 77 pot lifts in this fishery.

A related measure of estimator precision is the confidence interval associated with a suitably chosen level of confidence, frequently 90 or 95%. Along with standard errors for all CPUE estimates in each directed fishery (Tables 3, 5, 7, 9, 11, 13), this document additionally reports 95% confidence intervals associated with each estimated CPUE for legal retained crabs of the target species. These confidence intervals are based on a *t*-distribution, as described in more detail in Appendix A1.

Because an estimator may be precise yet still be inaccurate in the sense of assuming a value very far from the target parameter, it is of interest to assess an estimator's accuracy, as well as its precision. Some indication of the accuracy of an estimated CPUE for legal retained crab within a particular fishery may be extracted by directly comparing it to the corresponding ATF value. As these two values represent essentially independent estimates of fishery CPUE, substantial agreement between the two presumably reflects the fact that neither is wildly inaccurate. On the other hand, a very great disparity between the two guarantees at least one estimate is well wide of the target. For the six fisheries here described, such a comparison shows mixed results, ranging from a relative difference of 0.1% for the Bering Sea snow crab fishery to relative differences as large as 19.4% and even 30.1%, respectively, for the 2008/2009 eastern and western Bering Sea Tanner crab fisheries (Table 13). This last comparison, however, must be interpreted in light of the fact that imprecision of the observer-based estimate makes it statistically indistinguishable from the ATF value.

In assessing estimates based on observer pot-lift samples, the reader should additionally take note of whether the data were gathered by observers deployed on all participating fishing vessels or on catcher-processor vessels and only a sample of registered catcher-only vessels, as well as of the extent of coverage with respect to the number of days fished by vessels selected for observation. Estimator performance depends generally both on the proportion of total pot lifts sampled and on the extent to which catch rates of sampled pot lifts on observed days aboard observed vessels are representative of those of the remaining component of fishery effort. It can at least be hoped that the conscientious application of probability sampling mechanisms in observer deployment and data collection protocols will greatly reduce the likelihood of non-ignorable and unquantifiable sampling bias.

ACKNOWLEDGMENTS

Shellfish observers deployed during the 2008/2009 Bering Sea fisheries collected the data summarized in this report. I would like to express my gratitude for their diligence in collecting biological and fisheries management information while living and working at sea, often for extended periods and sometimes under extremely challenging conditions.

Thanks to the ADF&G Dutch Harbor staff for answering questions and fulfilling data requests and to David Barnard for both specific and general assistance and support. I also thank Lisa Marcato for final preparation of the report, as well as for her great patience, and Greg Rosenkranz, Kally Spalinger, and Rob Baer of the ADF&G Westward Region staff for reviewing this summary.

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TABLES AND FIGURES

Table 1.–Observer deployment and daily pot-lift sampling goals by fishery and vessel type.

	Catcher-Only Vessels			Catcher-Processor Vessels	
Fishery	Registered	With Onboard Observers	Daily Pot-lift Sampling Goal	Participating	Daily Pot-lift Sampling Goal
Bering Sea snow crab	73	29	4	4	3
Bering Sea Tanner crab (west of 166° W)	42	4	6	0	–
Bering Sea Tanner crab (east of 166° W)	80	20	6	1	4
Bristol Bay red king crab	75	21	7	3	4
Aleutian Islands golden king crab (west of 174° W)	2	2	10	2	4
Aleutian Islands golden king crab (east of 174° W)	3	3	10	0	–

Table 2.–Carapace width (CW) frequency distribution by shell condition from biological measurements of retained snow crabs sampled during the 2008/2009 Bering Sea snow crab fishery.

Carapace Width[a] (mm)	Percent			
	New Shell	Old Shell	Very Old Shell	All
76 - 80	< 0.1	< 0.1	< 0.1	< 0.1
81 - 85	< 0.1	< 0.1	0	< 0.1
86 - 90	0.1	< 0.1	0	0.1
91 - 95	0.7	< 0.1	< 0.1	0.8
96 - 100	5.4	0.5	< 0.1	5.9
101 - 105	19.8	1.9	< 0.1	21.8
106 - 110	25.3	3	0.2	28.5
111 - 115	19.2	2.3	0.2	21.7
116 - 120	11.3	1.1	< 0.1	12.5
121 - 125	5.7	0.6	< 0.1	6.3
126 - 130	1.7	0.2	< 0.1	2.0
131 - 135	0.2	< 0.1	< 0.1	0.3
136 - 140	< 0.1	< 0.1	0	< 0.1
141 - 145	< 0.1	0	0	< 0.1
Total Number of Crabs	44,329	4,873	310	49,512
Total Percent	89.5	9.8	0.6	100

[a] Average CW = 109.9 mm.

Table 3.–Estimated catch per pot (CPUE) of selected crab species from 1,657 pot lifts sampled by observers deployed during the 2008/2009 Bering Sea snow crab fishery.

Species/Sex Class	CPUE	SE	Estimated Catch[a]
Snow crab			
retained legal males	280.6[b]	10.000	45,888,000[c]
legal males not retained	111.5	6.699	18,234,000
sublegal males	1.5	0.239	245,000
females	1.0	0.409	164,000
Tanner crab			
retained legal males	0.2	0.132	33,000
legal males not retained	0.6	0.125	98,000
sublegal males	15.0	2.398	2,453,000
females	1.1	0.227	180,000
Tanner / Snow hybrid			
retained legal males	0.5	0.348	82,000
legal males not retained	0.4	0.183	65,000
sublegal males	1.3	0.577	213,000
females	0[d]	–	–

[a] Estimated catch is the product of estimated CPUE and the total number of reported pot lifts (163,536).

[b] Actual total fishery CPUE of retained legal crabs was 281.0.

[c] Actual total fishery catch of retained legal crabs was 45,945,093.

[d] Only 3 female Tanner/snow hybrids were observed.

Table 4.–Carapace width (CW) frequency distribution by shell condition from biological measurements of retained Tanner crabs sampled during the 2008/2009 directed Bering Sea Tanner crab fishery west of 166° W longitude.

Carapace Width[a] (mm)	Percent			
	New Shell	Old Shell	Very Old Shell	All
< 136	0.2	0	0	0.2
136 - 140	12.7	4.4	0.2	17.3
141 - 145	27.1	6.1	0.2	33.4
146 - 150	18.6	3.3	0.6	22.5
151 - 155	14.0	1.9	0	15.9
156 - 160	6.7	0.6	0	7.3
161 - 165	1.7	0.2	0	1.9
166 - 170	1.0	0	0	1.0
171 - 175	0.4	0.2	0	0.6
Total Number of Crabs	429	87	5	521
Total Percent	82.3	16.7	1.0	100

[a] Average CW = 146.7 mm.

Table 5.–Estimated catch per pot (CPUE) of selected crab species from 77 pot lifts sampled by observers deployed during the 2008/2009 directed Bering Sea Tanner crab fishery west of 166° W longitude.

Species / Sex Class	CPUE	SE	Estimated Catch[a]
Tanner crab			
retained legal males	26.8[b]	3.682	63,000[c]
legal males not retained	0.3	0.125	700
sublegal males	73.2	25.383	171,000
females	8.8	7.838	21,000
Snow crab			
retained legal males	0[d]	–	–
legal males not retained	6.7	2.011	16,000
sublegal males	< 0.1	0.019	< 200
females	0[d]	–	–

[a] Estimated catch is the product of estimated CPUE and the total number of reported pot lifts (2,336).

[b] Actual total fishery CPUE of retained legal crabs was 20.6.

[c] Actual total fishery catch of retained legal crabs was 48,171.

[d] No crabs of this species/category were observed.

Table 6.–Carapace width (CW) frequency distribution by shell condition from biological measurements of retained Tanner crabs sampled during the 2008/2009 directed Bering Sea Tanner crab fishery east of 166° W longitude.

Carapace Width[a] (mm)	Percent			
	New Shell	Old Shell	Very Old Shell	All
131 - 135	0.2	0	0	0.2
136 - 140	9.6	0.7	0	10.3
141 - 145	21.0	2.3	0	23.3
146 - 150	21.0	2.1	< 0.1	23.1
151 - 155	17.7	1.5	< 0.1	19.2
156 - 160	11.9	1.1	0	13
161 - 165	6.2	0.5	0	6.7
166 - 170	2.9	0.2	0	3.1
171 - 175	0.8	< 0.1	0	0.9
176 - 180	0.1	0	0	0.1
Total Number of Crabs	2,717	249	3	2,969
Total Percent	91.5	8.4	0.1	100

[a] Average CW = 150.0 mm.

Table 7.–Estimated catch per pot (CPUE) of selected crab species from 607 pot lifts sampled by observers deployed during the 2008/2009 directed Bering Sea Tanner crab fishery east of 166° W longitude.

Species / Sex Class	CPUE	SE	Estimated Catch[a]
Tanner crab			
retained legal males	46.7[b]	1.793	906,000[c]
legal males not retained	0.7	0.084	14,000
sublegal males	91.7	3.930	1,779,000
females	5.2	0.276	101,000
Snow crab			
retained legal males	0[d]	–	–
legal males not retained	2.3	1.416	45,000
sublegal males	0.1	0.021	2,000
females	0[d]	–	–
Red king crab			
retained legal males	0[d]	–	–
legal males not retained	< 0.1	0.017	< 2000
sublegal males	0.3	0.132	6,000
females	0.2	0.085	4,000

[a] Estimated catch is the product of estimated CPUE and the total number of reported pot lifts (19,401).

[b] Actual total fishery CPUE of retained legal crabs was 39.1.

[c] Actual total fishery catch of retained legal crabs was 758,002.

[d] No crabs of this species/category were observed.

Table 8.–Estimated catch per pot (CPUE) of selected crab species from 1,849 pot lifts sampled by observers deployed during the 2008/2009 Bristol Bay red king crab fishery.

Species / Sex Class	CPUE	SE	Estimated Catch[a]
Red king crab			
retained legal males	23.3[b]	0.371	3,261,000[c]
legal males not retained	0.4	0.032	56,000
sublegal males	29.3	0.335	4,100,000
females	5.8	0.541	812,000
Tanner crab			
retained legal males	0.1	0.064	14,000
legal males not retained	1.3	0.260	182,000
sublegal males	< 0.1	0.076	< 14,000
females	< 0.1	0.011	< 14,000

[a] Estimated catch is the product of the CPUE estimate the total reported number of pot lifts (139,939).

[b] Actual total fishery CPUE of retained legal crabs was 21.9.

[c] Actual total fishery catch of retained legal crabs for was 3,066,288

Table 9.– Carapace length (CL) distribution by shell condition from biological measurements of retained red king crabs sampled during the 2008/2009 Bristol Bay red king crab fishery.

Carapace Length[a] (mm)	Percent			
	New Shell	Old Shell	Very Old Shell	All
< 116	< 0.1	0	0	< 0.1
116 - 120	< 0.1	0	0	< 0.1
121 – 125	< 0.1	0	0	< 0.1
126 - 130	< 0.1	< 0.1	0	< 0.1
131 - 135	1.4	0.1	< 0.1	1.5
136 - 140	8.1	0.9	< 0.1	9.0
141 - 145	13.4	1.8	< 0.1	15.3
146 - 150	14.3	2.5	0.1	17.0
151 - 155	14.3	3.1	0.2	17.6
156 - 160	12.0	3.1	0.3	15.3
161 - 165	8.7	2.5	0.3	11.5
166 - 170	5.7	1.5	0.2	7.5
171 - 175	2.6	0.9	0.2	3.6
176 - 180	0.9	0.3	< 0.1	1.3
181 - 185	0.3	< 0.1	< 0.1	0.4
186 - 190	< 0.1	< 0.1	0	< 0.1
191 - 195	< 0.1	< 0.1	0	< 0.1
196 - 200	< 0.1	0	0	< 0.1
Total Number of Crabs	20,449	4,203	345	24,997
Total Percent	81.8	16.8	1.4	100

[a] Average CL = 153.2 mm.

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Table 10.–Carapace length (CL) distribution by shell condition from biological measurements of retained golden king crabs sampled during the 2008/2009 Aleutian Islands golden king crab fishery west of 174° W longitude.

	Percent			
Carapace Length[a] (mm)	New Shell	Old Shell	Very Old Shell	All
121 - 125	< 0.1	0	0	< 0.1
126 - 130	0.3	0	0	0.3
131 - 135	2.8	< 0.1	< 0.1	2.8
136 - 140	11.8	0.1	0	11.9
141 - 145	18.7	0.3	< 0.1	19.1
146 - 150	18.4	0.3	< 0.1	18.8
151 - 155	16.1	0.7	< 0.1	16.8
156 - 160	10.3	0.5	< 0.1	10.8
161 - 165	8.5	0.4	< 0.1	9.0
166 - 170	5.2	0.2	< 0.1	5.5
171 - 175	2.9	< 0.1	< 0.1	3.0
176 - 180	1.5	< 0.1	0	1.5
181 - 185	0.4	< 0.1	0	0.4
186 - 190	< 0.1	0	0	< 0.1
Total Number of Crabs	9,875	276	31	10,182
Total Percent	97	2.7	0.3	100

[a] Average CL = 151.2 mm.

Table 11.–Estimated catch per pot (CPUE) of golden king crabs from 979 pot lifts sampled by observers deployed during the 2008/2009 Aleutian Islands golden king crab fishery west of 174° W longitude.

Species / Sex Class	CPUE	SE	Estimated Catch[a]
retained legal males	25.3[b]	0.682	663,000[c]
legal males not retained	0.1	0.014	3,000
sublegal males	11.4	0.474	299,000
females	12.6	0.808	330,000

[a] Estimated catch is the product of the CPUE estimate and the total number of reported pot lifts (26,200).

[b] Actual total fishery CPUE of retained legal crabs was 22.4.

[c] Actual total fishery catch of retained legal crabs 587,661.

Table 12.–Carapace length (CL) distribution by shell condition from biological measurements of retained golden king crabs sampled during the 2008/2009 Aleutian Islands golden king crab fishery east of 174° W longitude.

Carapace Length[a] (mm)	Percent			
	New Shell	Old Shell	Very Old Shell	All
< 130	< 0.1	0	0	< 0.1
131 - 135	1.9	< 0.1	0	2.0
136 - 140	11.0	0.4	0	11.4
141 - 145	20.4	0.7	< 0.1	21.2
146 - 150	16.5	1.0	0	17.5
151 - 155	14.8	0.9	0	15.7
156 - 160	11.7	0.6	0	12.2
161 - 165	7.7	0.4	0	8.2
166 - 170	5.9	0.3	0	6.2
171 - 175	2.9	< 0.1	0	2.9
176 - 180	1.3	< 0.1	0	1.4
181 - 185	0.9	0.1	0	1.0
186 - 190	0.2	0	0	0.2
Total Number of Crabs	2,850	137	2	2,989
Total Percent	95.3	4.6	0.1	100

[a] Average CL = 151.6 mm.

Table 13.–Estimated catch per pot (CPUE) of golden king crabs from 613 pot lifts sampled by observers deployed during the 2008/2009 Aleutian Islands golden king crab fishery east of 174° W longitude.

Species / Sex Class	CPUE	SE	Estimated Catch[a]
retained legal males	29.1[b]	0.686	711,000[c]
legal males not retained	1.3	0.070	32,000
sublegal males	8.4	0.493	205,000
females	5.8	0.494	142,000

[a] Estimated catch is the product of the CPUE estimate and the total number of reported pot lifts (24,446).

[b] Actual total fishery CPUE of retained legal crabs was 27.3.

[c] Actual catch of retained legal crabs for the fishery was 666,946.

Table 14.–Observer coverage, pot lift sampling effort by observers, and relative difference of the weighted CPUE estimates for retained legal crabs from the Actual Total Fishery (ATF) CPUE.

	Number of vessels		Number of pot lifts			CPUE	
Fishery	Total	Observed	Total	Observed	ATF	Estimated	Percent difference[a]
Bering Sea snow crab	77	29	163,536	1,657	281.0	280.6[b]	-0.1
Bering Sea Tanner crab west of 166º W	42	4	2,336	77	20.6	26.8[b]	30.1
Bering Sea Tanner crab east of 166º W	21	8	19,401	607	39.1	46.7	19.4
Bristol Bay red king crab	78	21	139,939	1,849	21.9	23.3	6.4
Aleutian Islands golden king crab west of 174º W	3	3	26,200	979	22.4	25.3	12.9
Aleutian Islands golden king crab east of 174º W	3	3	24,466	613	27.3	29.1	6.6

[a] Percent difference is calculated as $[\frac{estimated\ CPUE - ATF\ CPUE}{ATF\ CPUE}] \times 100$.

[b] 95% confidence interval contains ATF CPUE.

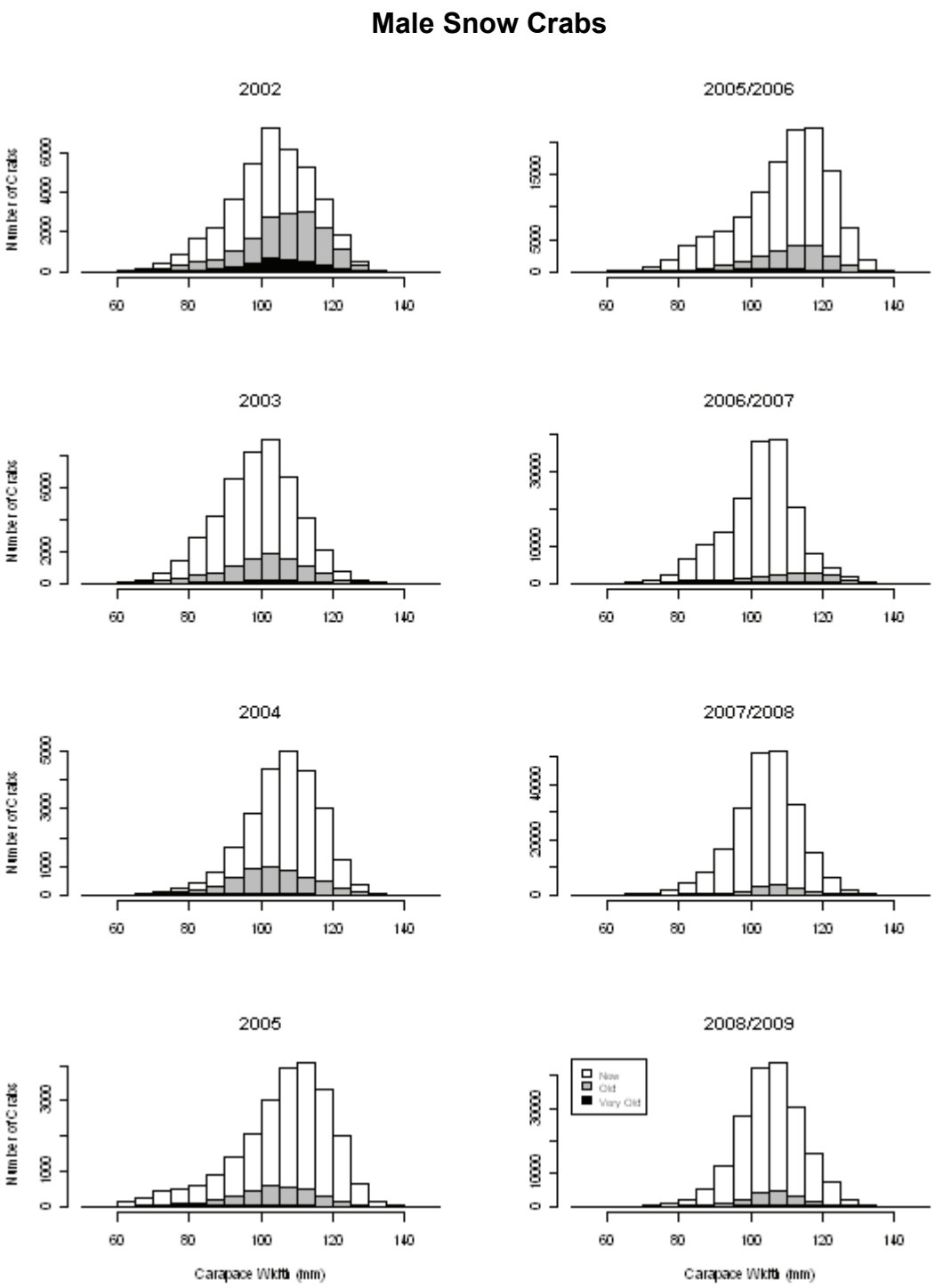


Figure 1.–Carapace width distribution with shell condition for male snow crabs from pot lifts samples during the 2002-2008/2009 Bering Sea snow crab fisheries.

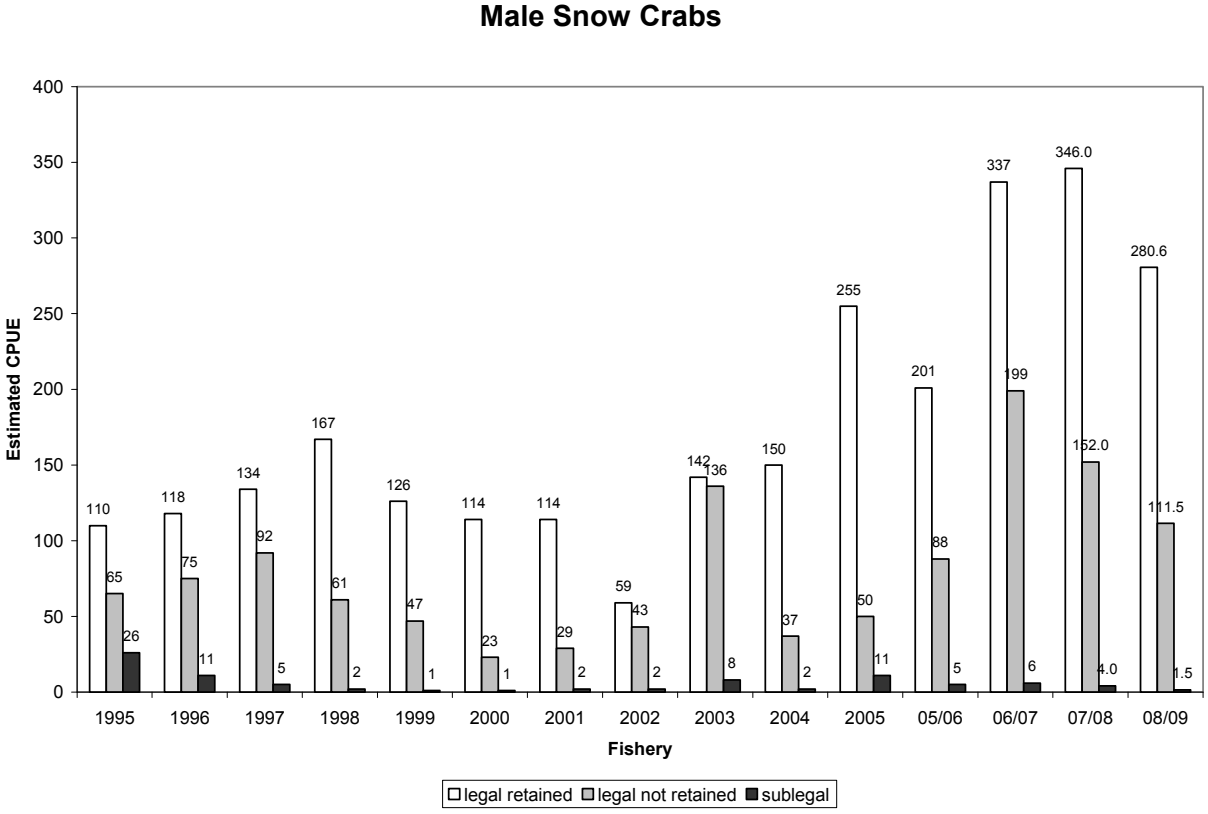


Figure 2.–Estimated CPUE for male snow crab from pot lifts sampled during the 1995-2008/2009 Bering Sea snow crab fisheries.

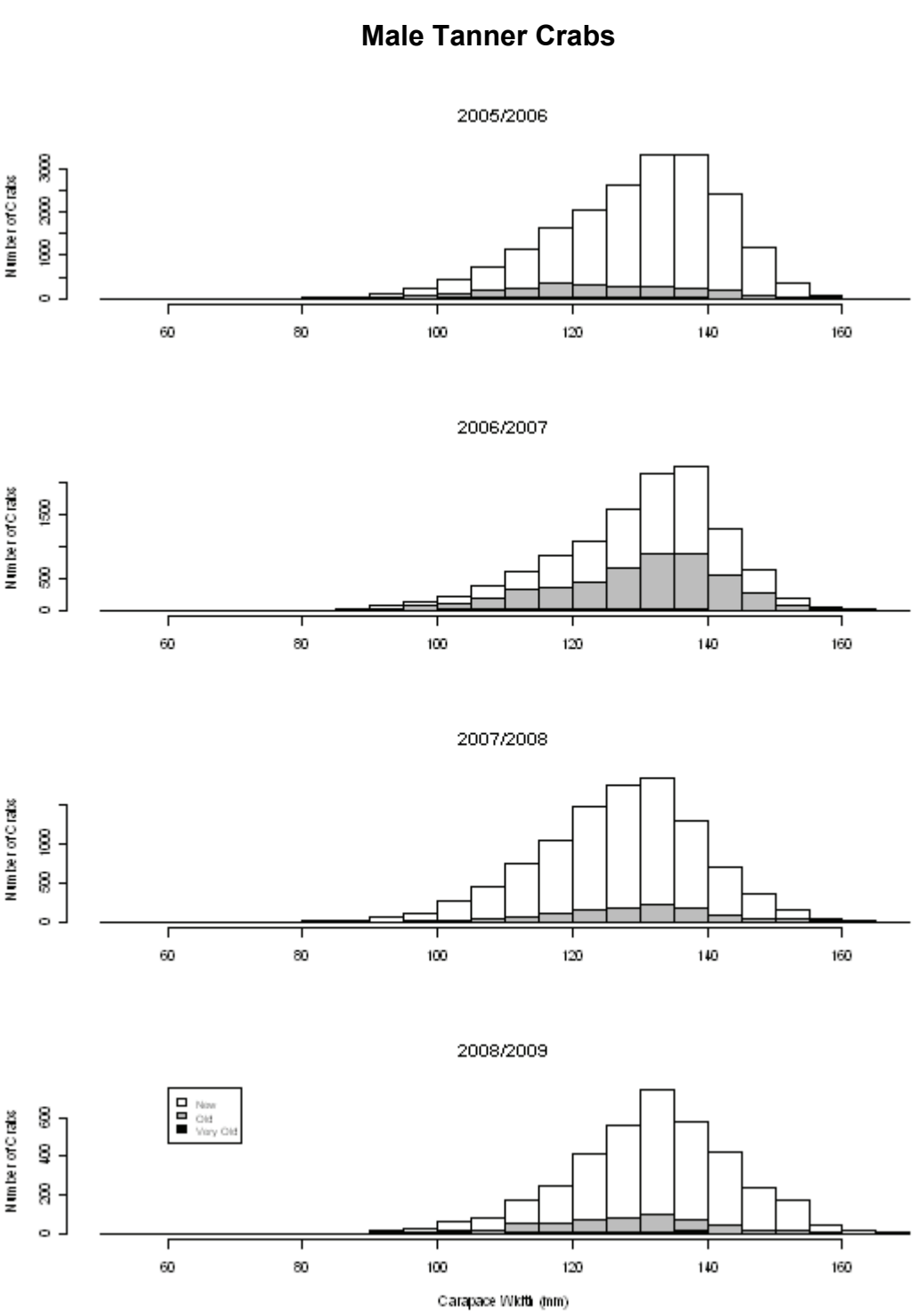


Figure 3.–Carapace width distribution with shell condition for male Tanner crabs from pot lift sampled during the 2005/2006 - 2008/2009 directed Bering Sea Tanner crab fisheries west of 166° W longitude.

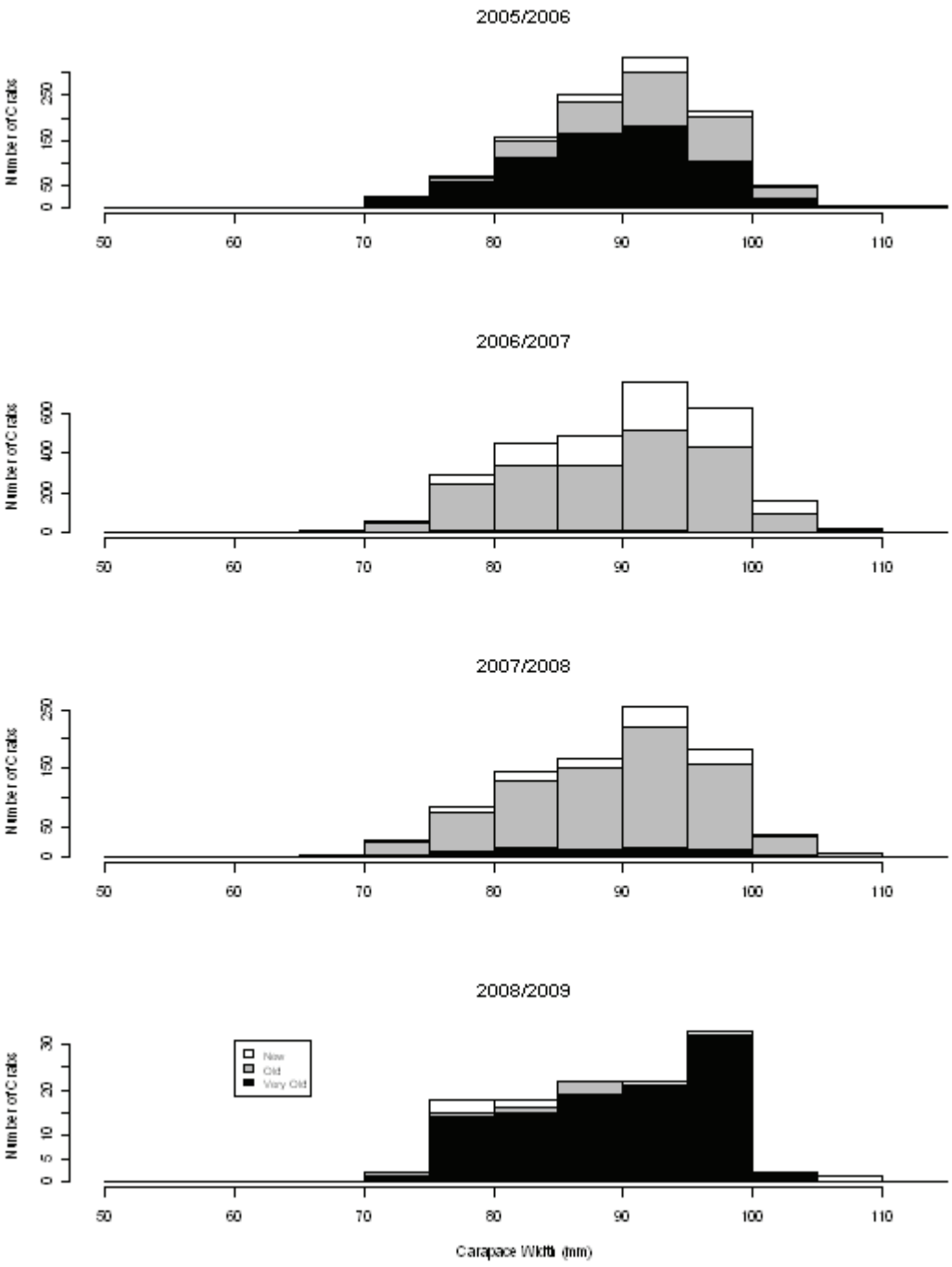


Figure 4.–Carapace width distribution with shell condition for female Tanner crabs from pot lifts sampled during the 2005/2006 - 2008/2009 directed Bering Sea Tanner crab fisheries west of 166° W longitude.

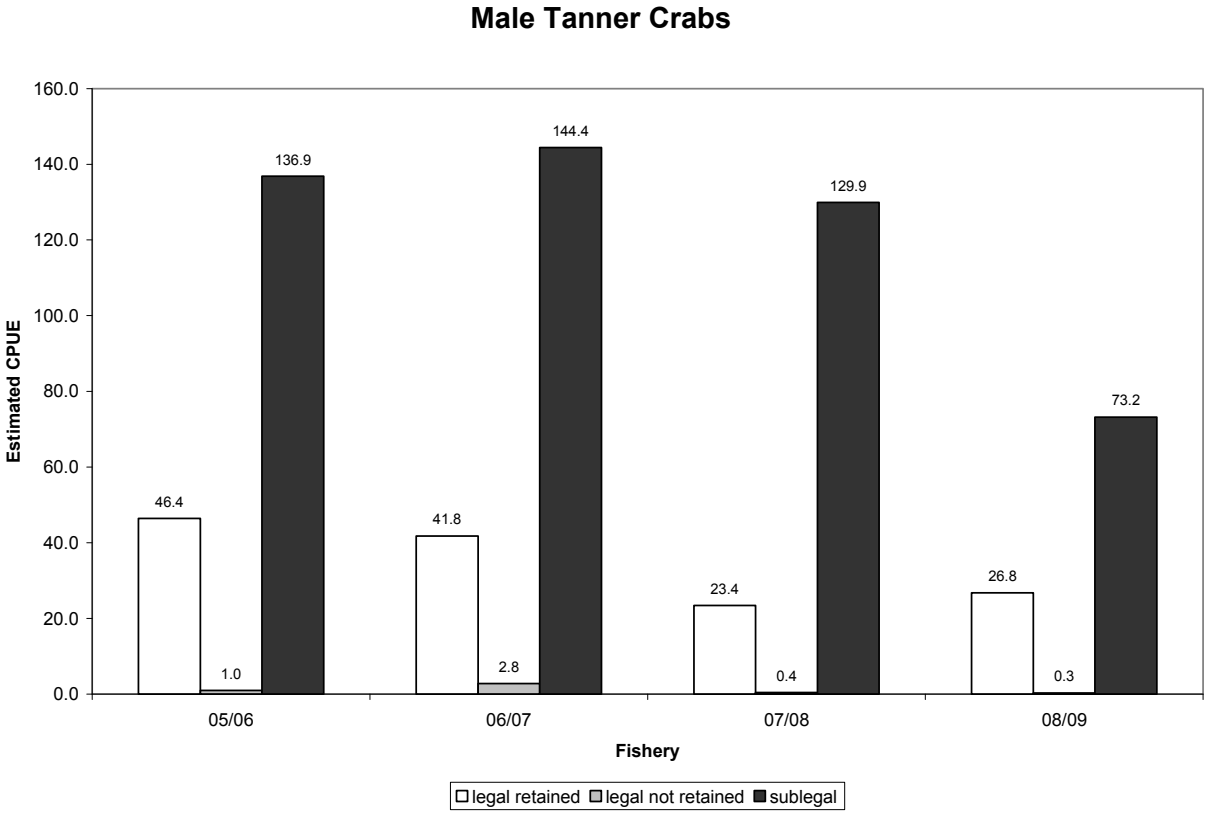


Figure 5.–Estimated CPUE for male Tanner crab from pot lifts sampled during the 2005/2006-2008/2009 directed Bering Sea Tanner crab fisheries west of 166º W longitude.

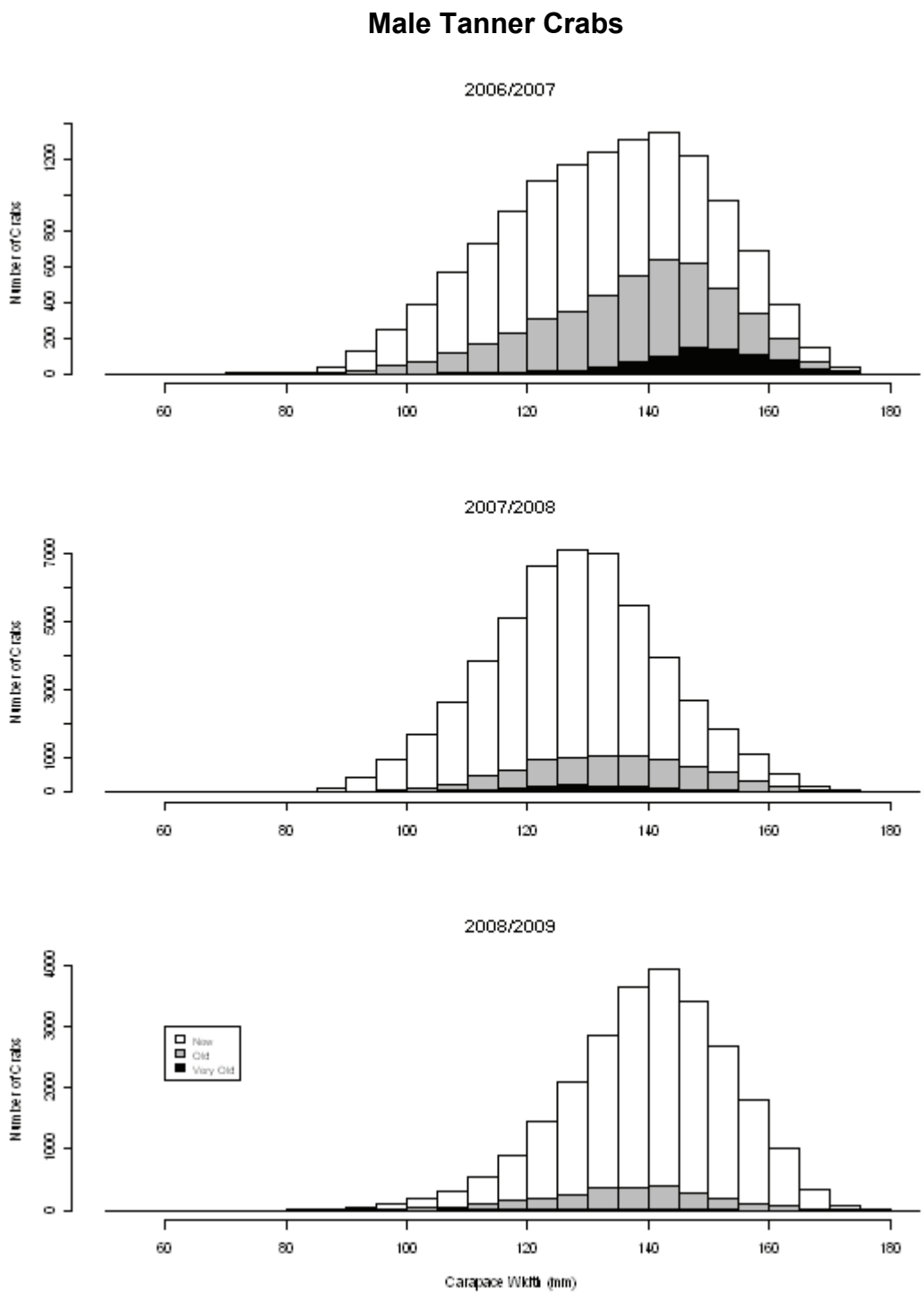


Figure 6.–Carapace width distribution with shell condition for male Tanner crabs from pot lifts sampled during the 2006/2007 - 2008/2009 directed Bering Sea Tanner crab fisheries east of 166° W longitude.

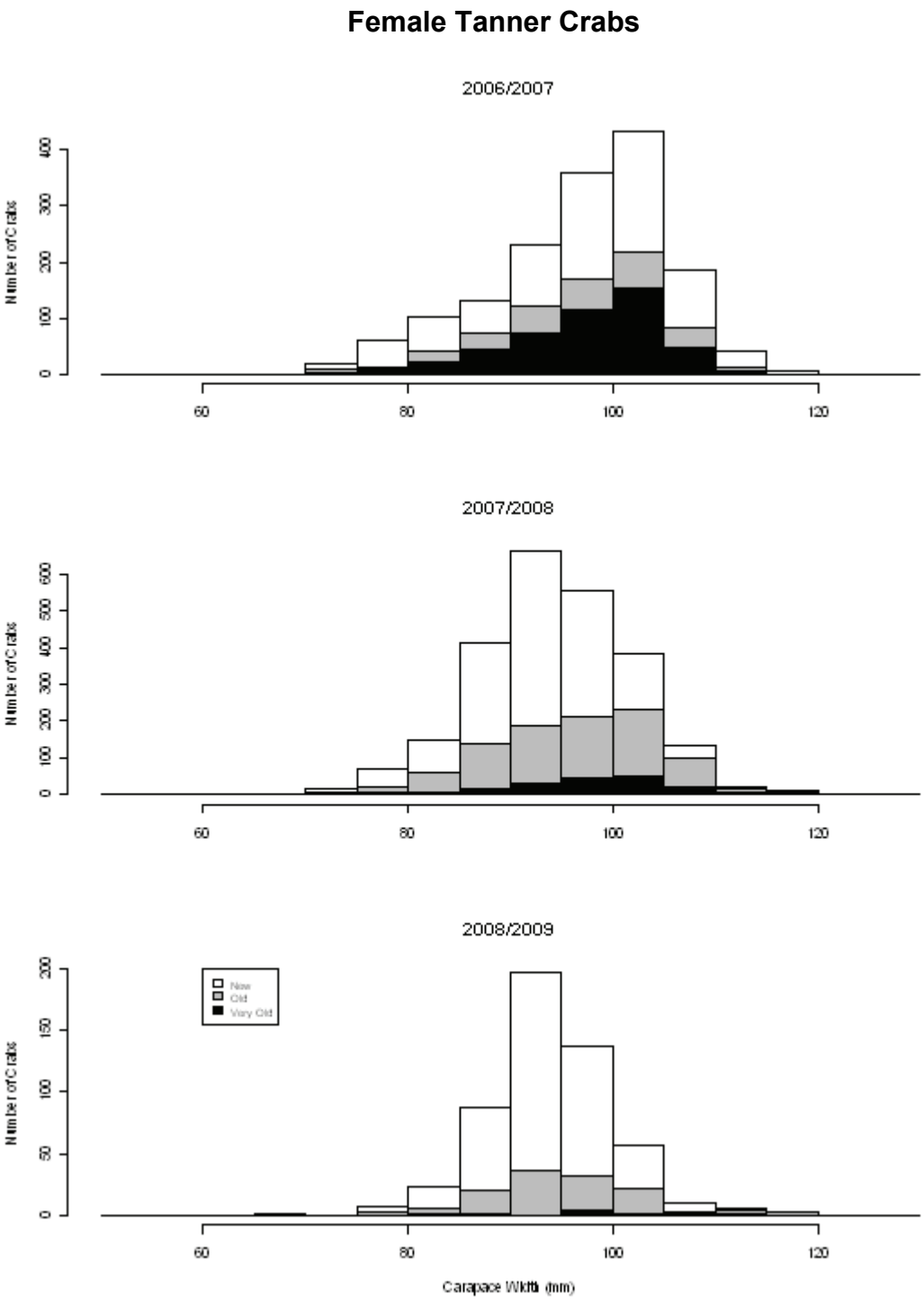


Figure 7.–Carapace width distribution with shell condition for female Tanner crabs from pot lifts sampled during the 2006/2007 - 2008/2009 directed Bering Sea Tanner crab fisheries east of 166° W longitude.

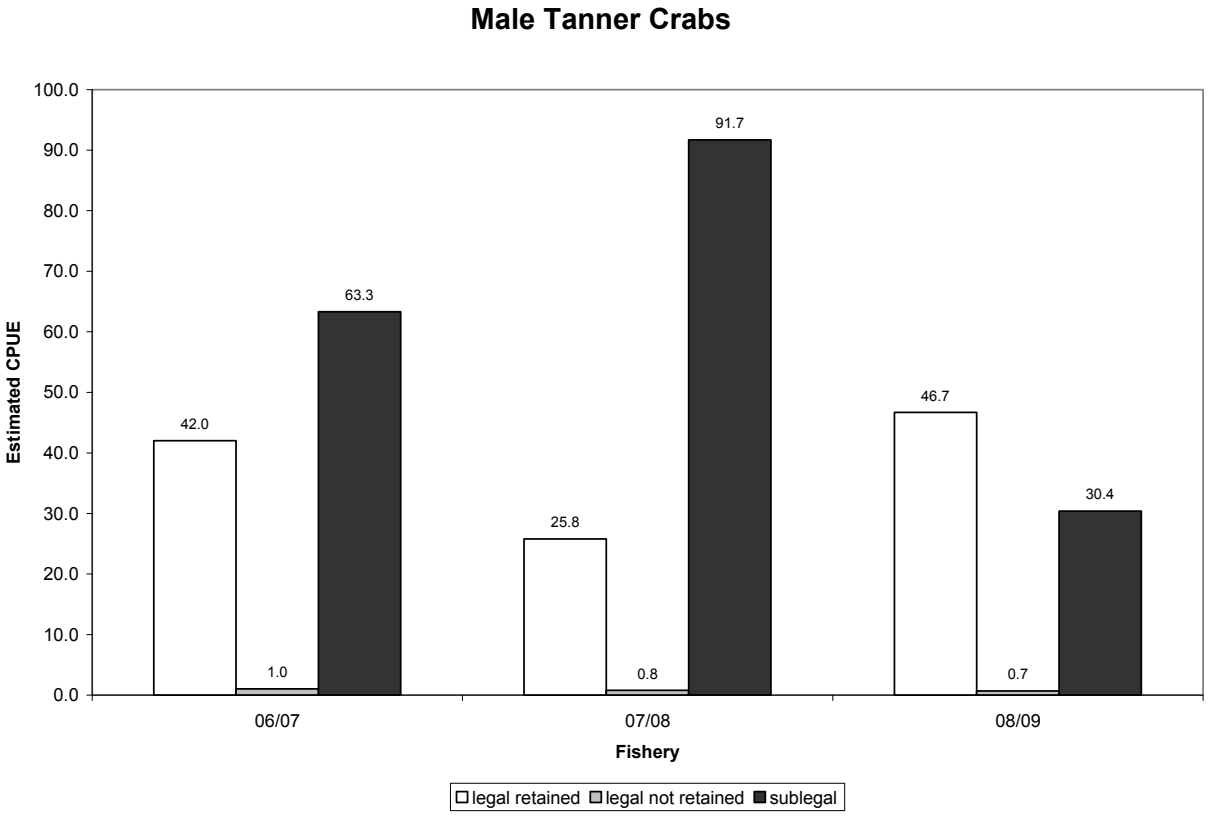


Figure 8.–Estimated CPUE for male Tanner crab from pot lifts sampled during the 2006/2007-2008/2009 directed Bering Sea Tanner crab fisheries east of 166º W longitude.

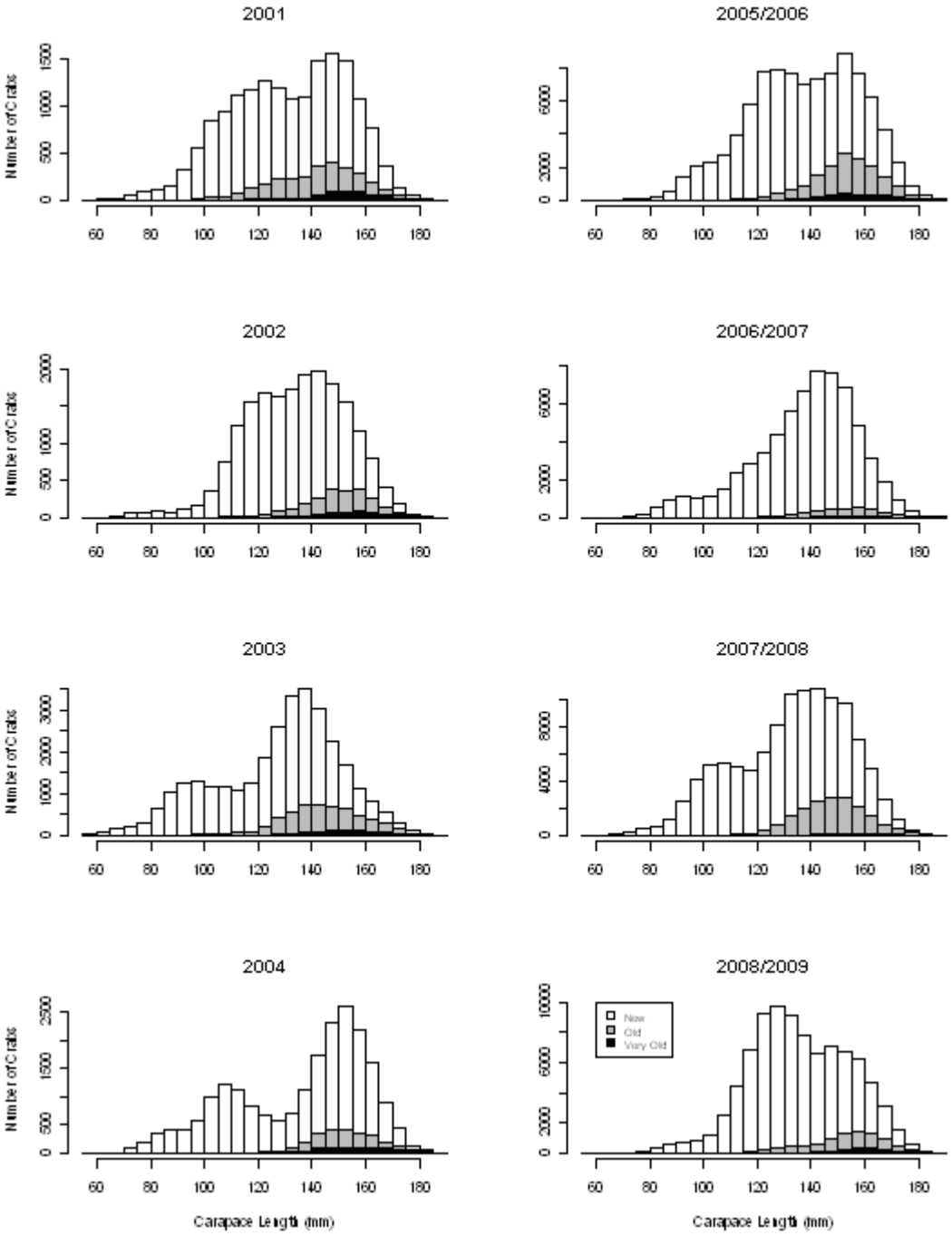


Figure 9.–Carapace length distribution with shell condition for male red king crabs from pot lifts sampled during the 2001-2008/2009 Bristol Bay red king crab fisheries.

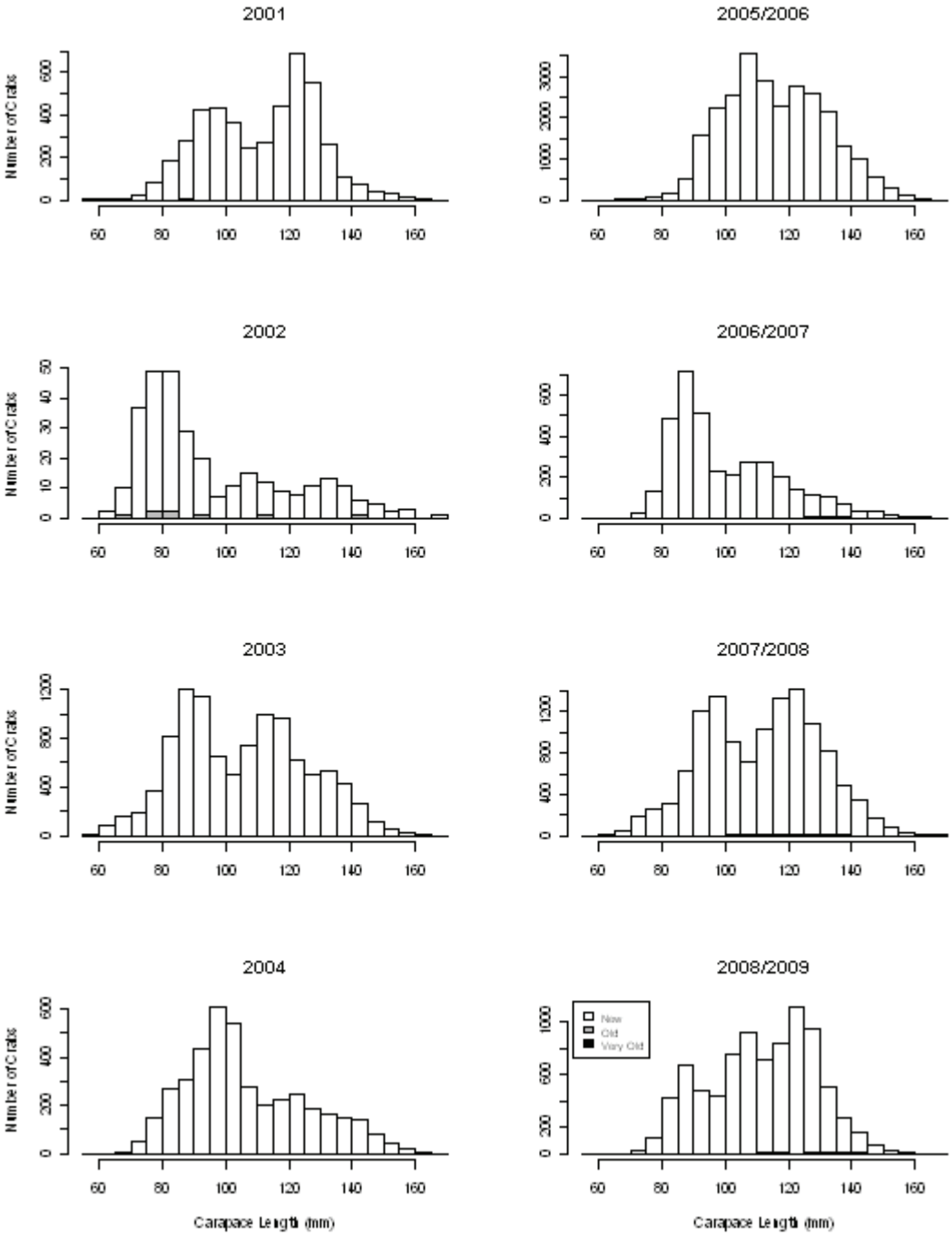


Figure 10.–Carapace length distribution with shell condition for female red king crabs from pot lifts sampled during the 2001-2008/2009 Bristol Bay red king crab fisheries.

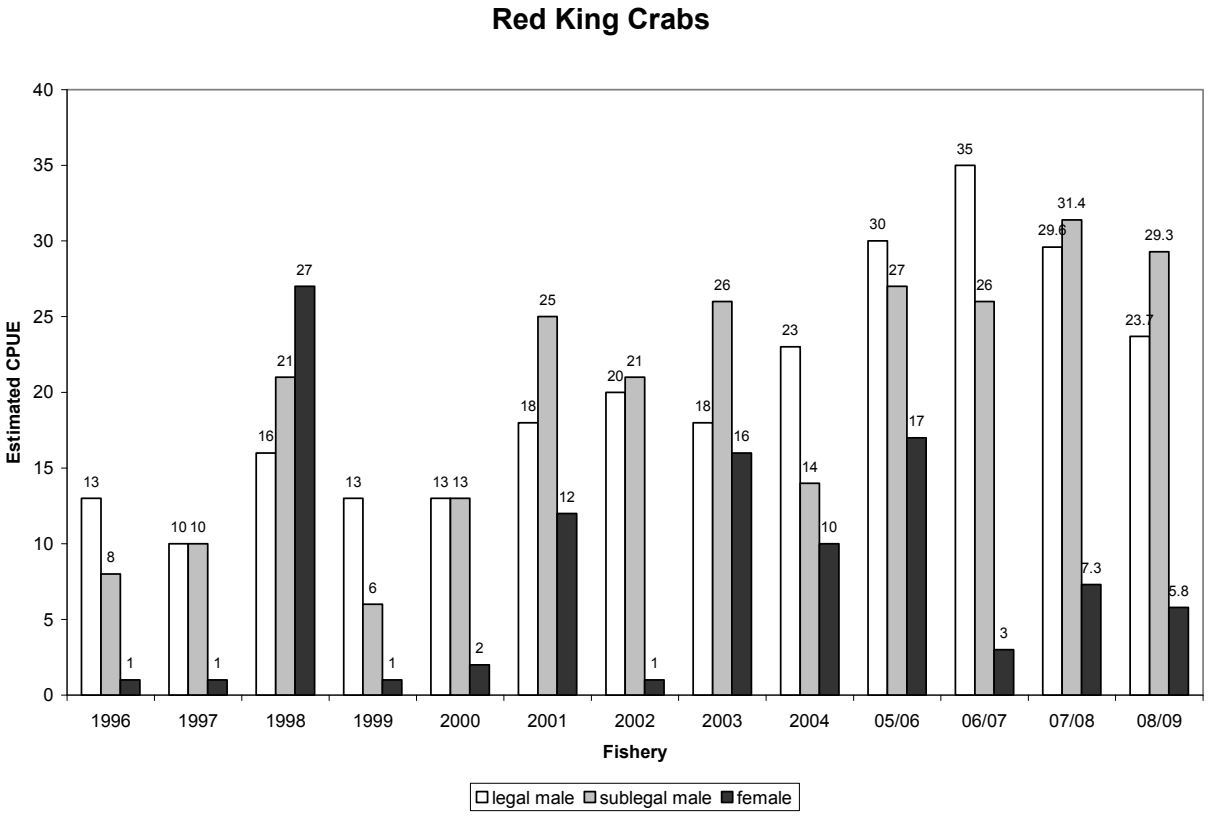


Figure 11.–Estimated CPUE for red king crab from pot lifts sampled during the 1996-2008/2009 Bristol Bay red king crab fisheries.

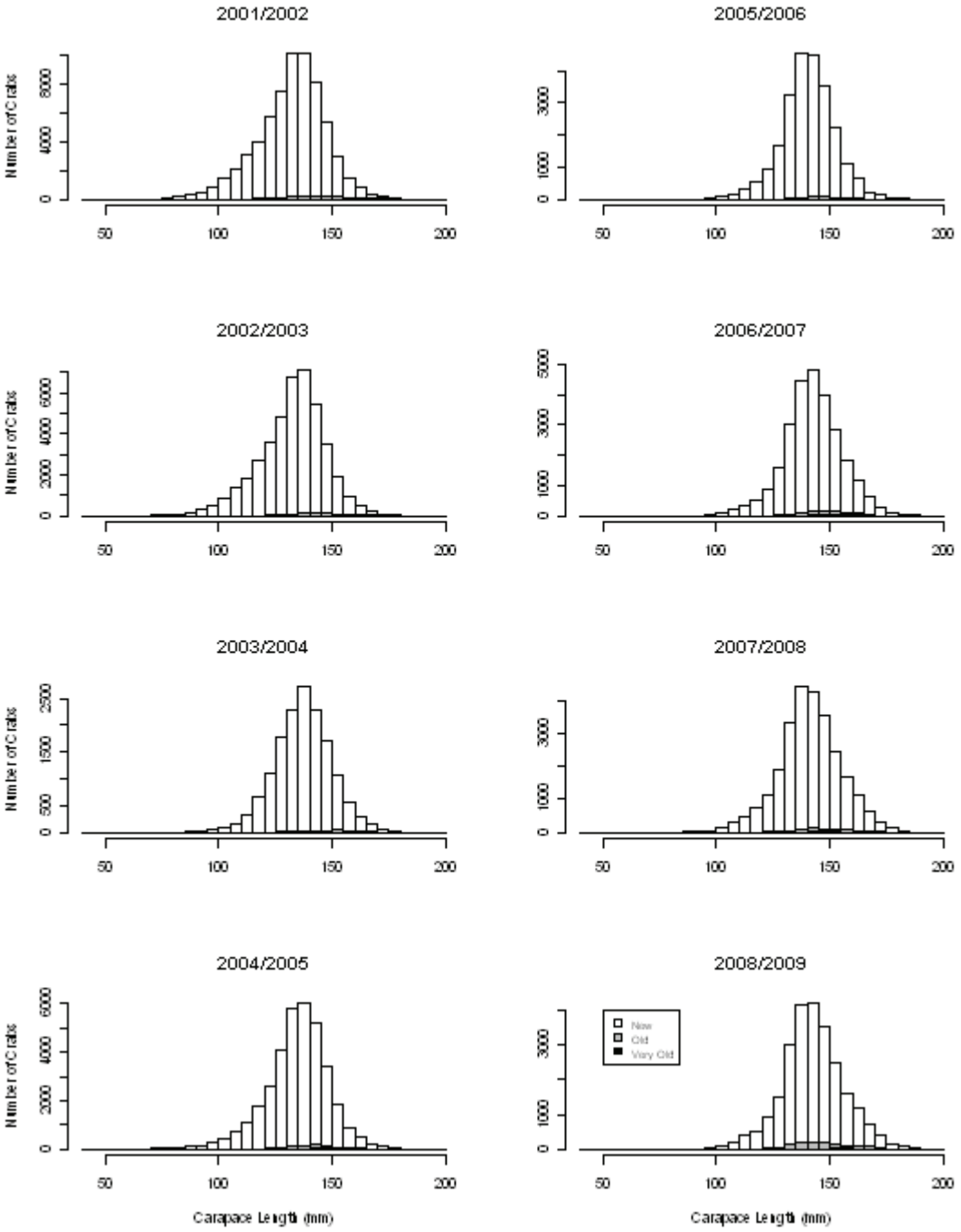


Figure 12.–Carapace length distribution with shell condition for male golden king crabs from pot lifts sampled during the 2000/2001-2007/2008 Aleutian Islands golden king crab fisheries west of 174° W longitude.

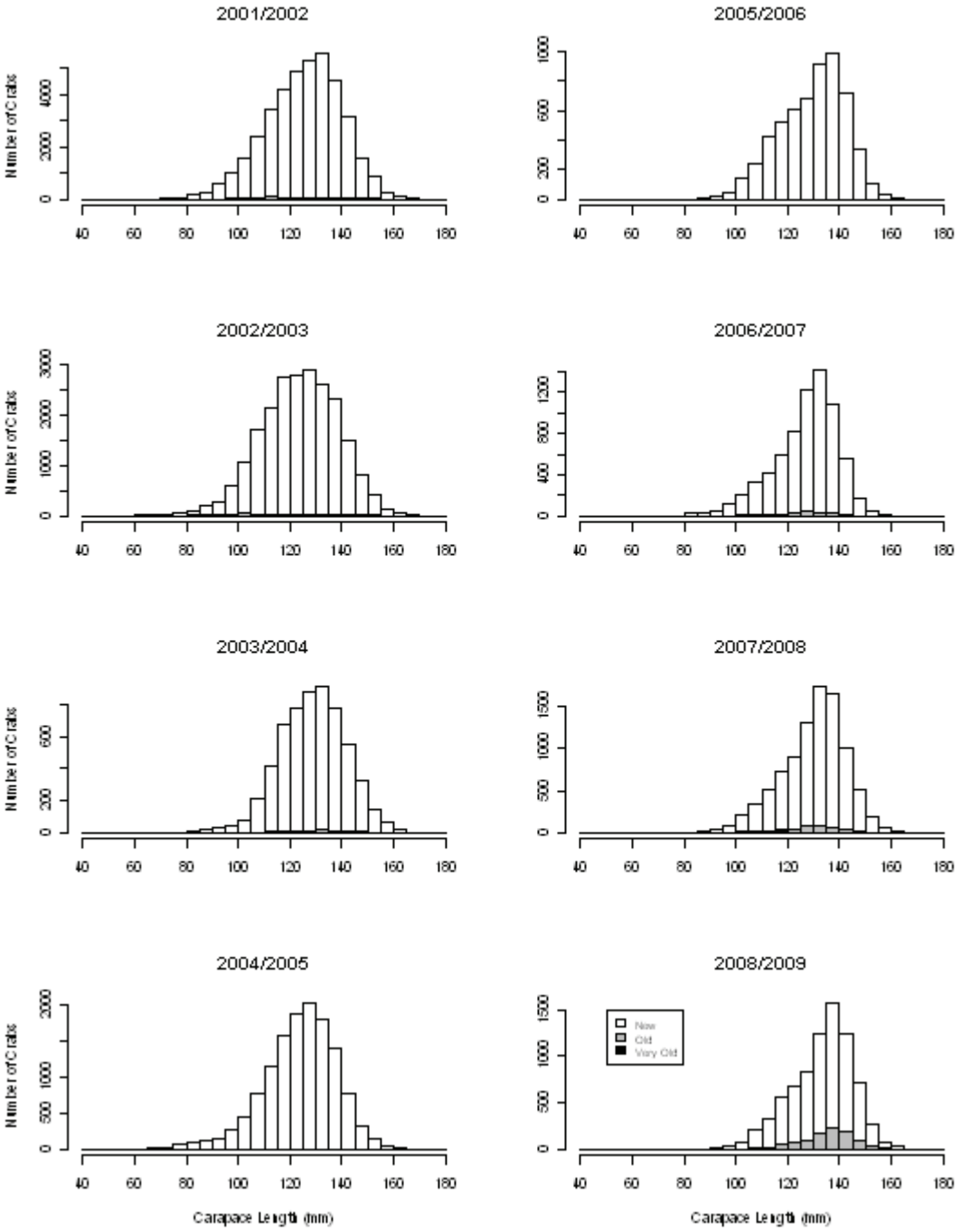


Figure 13.–Carapace length distribution with shell condition for female golden king crabs from pot lifts sampled during the 2001/2002-2008/2009 Aleutian Islands golden king crab fisheries west of 174° W longitude.

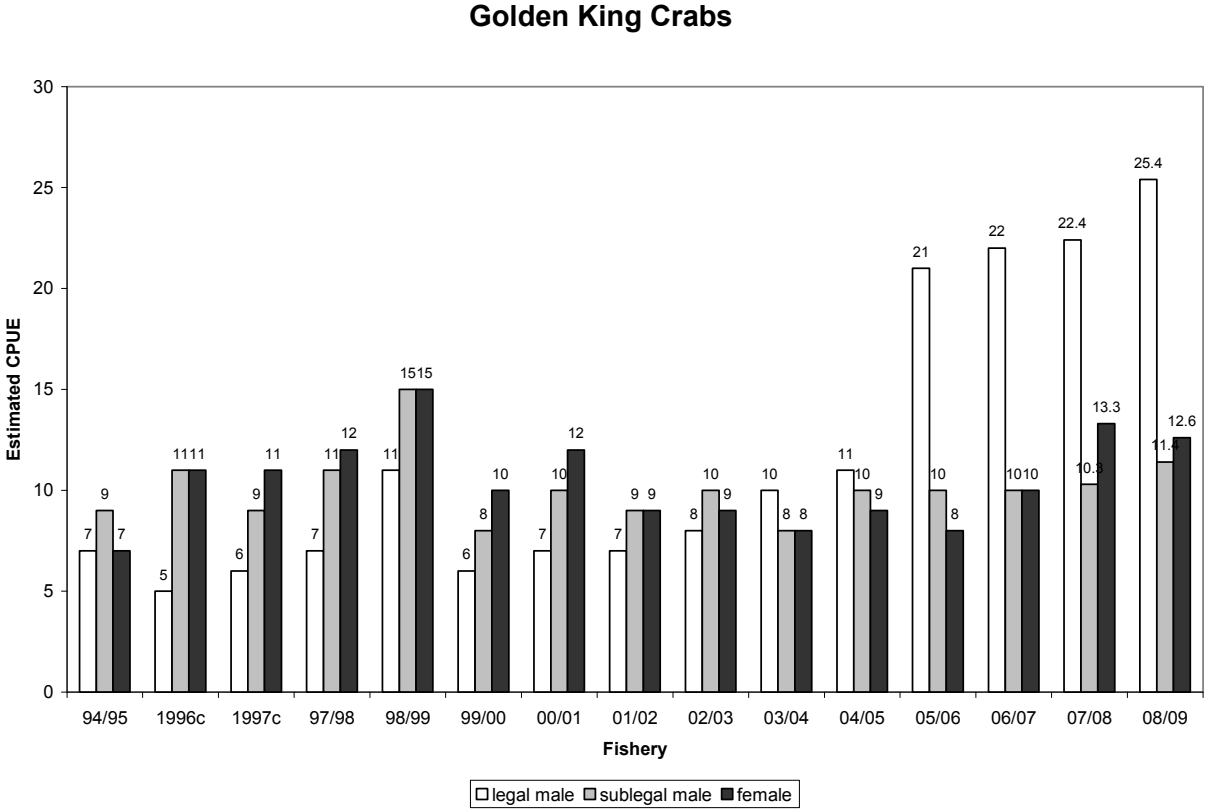


Figure 14.–Estimated CPUE for male golden king crabs from pot lifts sampled during the 1994/1995-2008/2009 golden king crab fisheries west of 174ºW longitude. Note: 1996 and 1997 values are for the combined eastern and western fisheries.

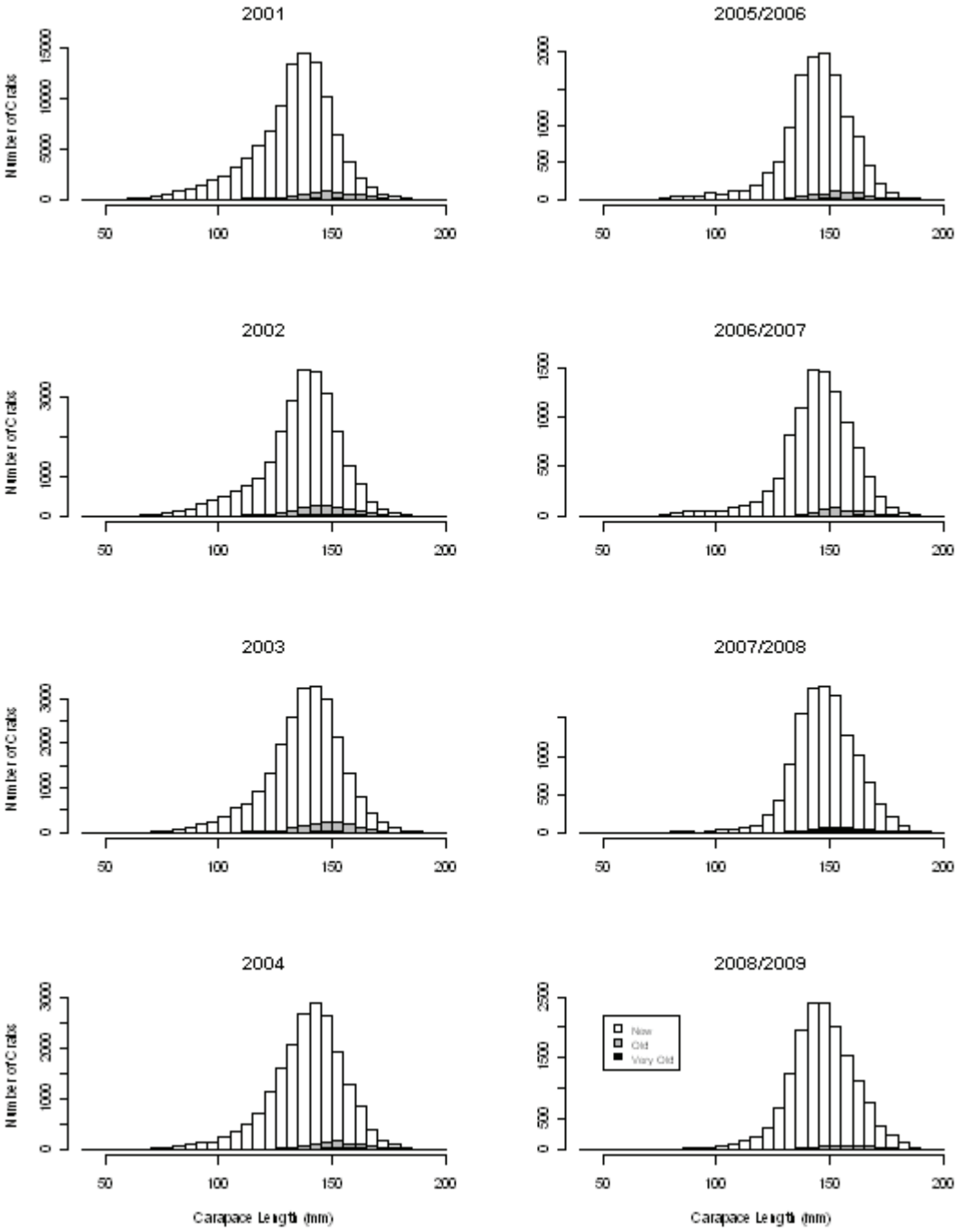


Figure 15.–Carapace length distribution with shell condition for male golden king crabs from pot lifts sampled during the 2001-2008/2009 Aleutian Islands golden king crab fisheries east of 174° W longitude.

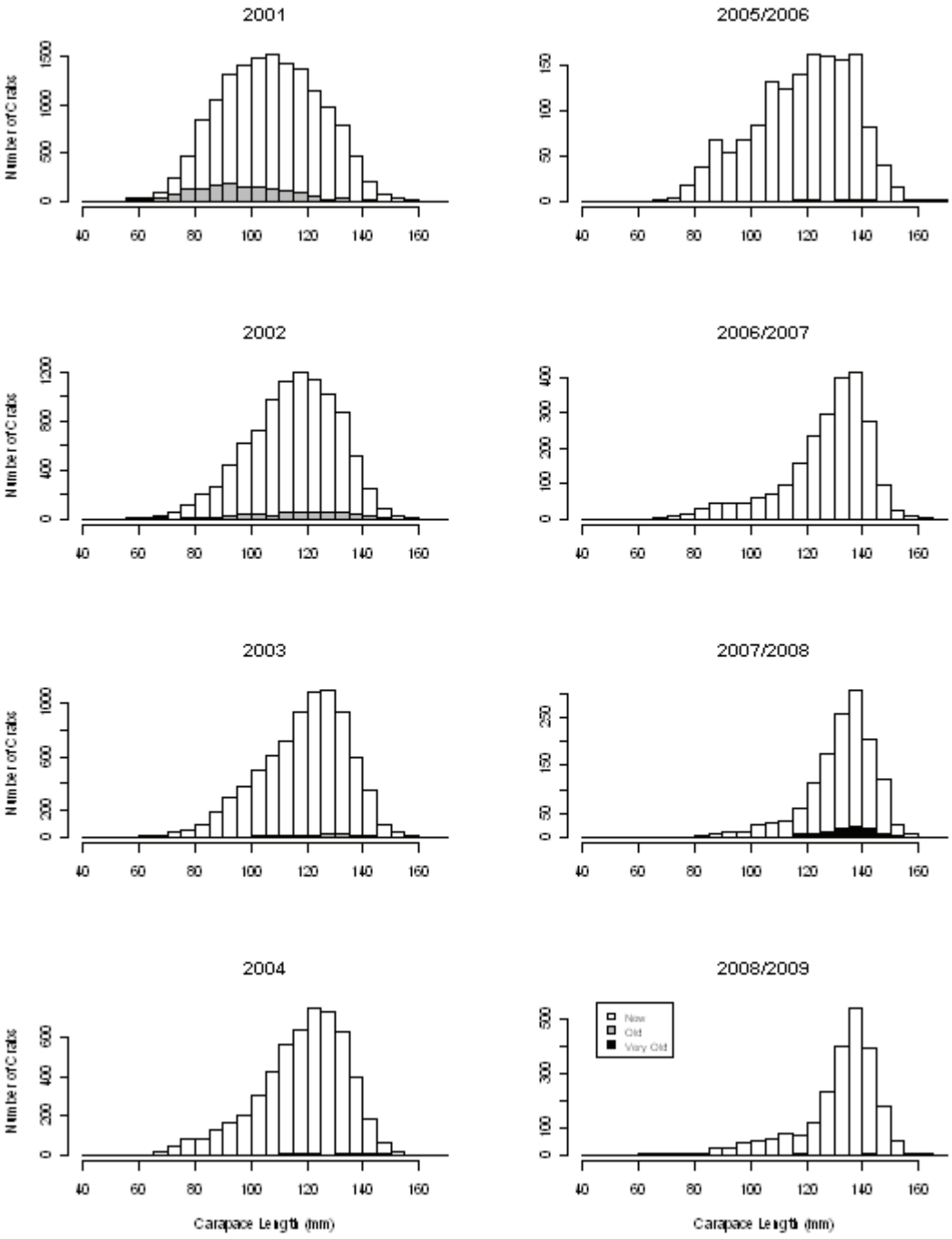


Figure 16.–Carapace length distribution with shell condition for female golden king crabs from pot lifts sampled during the 2001-2008/2009 Aleutian Islands golden king crab fisheries east of 174° W longitude.

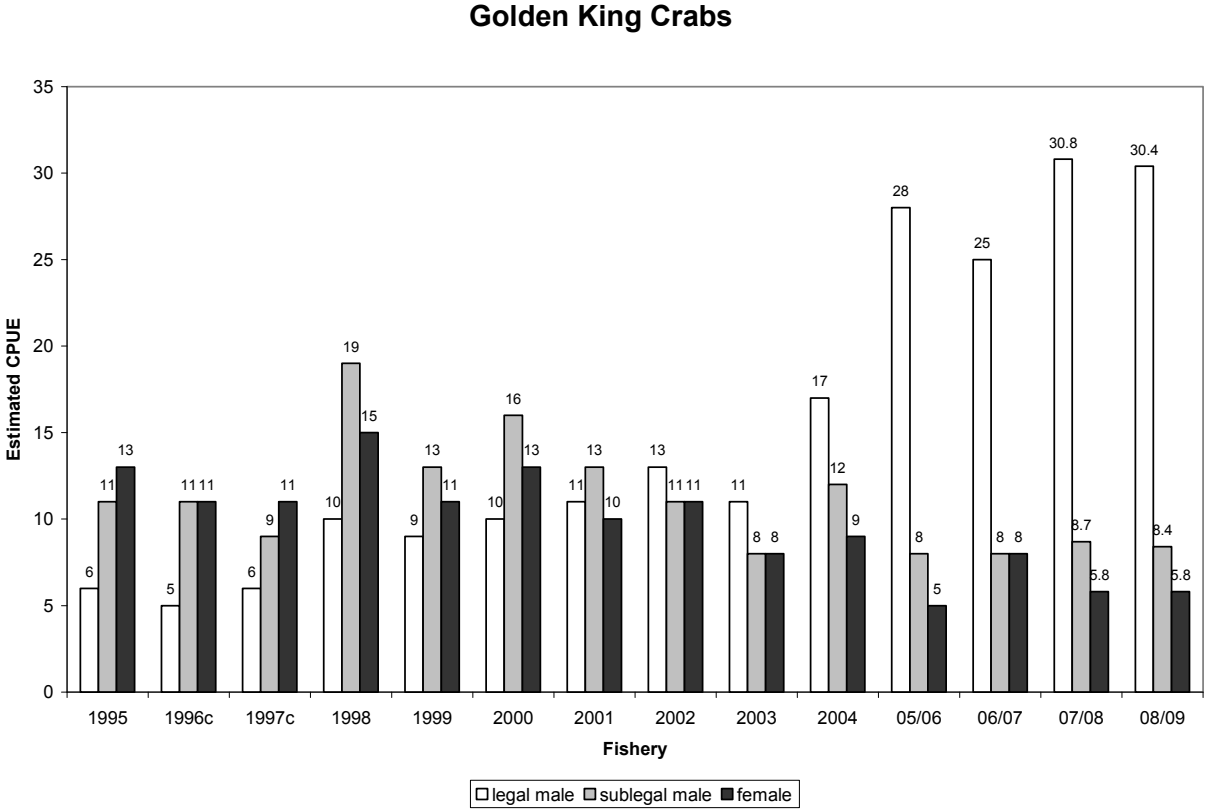


Figure 17.–Estimated CPUE for male golden king crabs from pot lifts sampled during the 1995-2008/2009 Aleutian Islands golden king crab fisheries east of 174º W longitude. Note: 1996 and 1997 values are for the combined eastern and western fisheries.

APPENDIX A:
ESTIMATION OF CPUE FROM OBSERVER DATA

Under the current sampling design, observed vessels are selected by simple random sampling independently within each vessel type, as are sampled pot lifts within each day fished by each observed vessel. We first consider vessels of a single type, e.g. catcher-only. Let

M = number of vessels of given type (catcher-only or catcher-processor) in fishery

m = number of vessels within given type sampled for observation

D_j = number of days fished by vessel j

N_{jk} = number of pots lifted by vessel j on day k

N_j = total number of pots lifted by vessel j over all D_j days fished

N = total number of pots lifted by all vessels of the given type during fishery

c_{jkl} = number of crabs observed on vessel j on day k in sampled pot l

n_{jk} = number of pots sampled on vessel j on day k

$\bar{c}_{jk} = \frac{1}{n_{jk}} \sum_{l}^{n_{jk}} c_{jkl}$

= vessel j sample average number of crabs per pot on day k

Further, let τ_j = vessel j total catch over all pots and days fished. We want to estimate overall vessel type CPUE $\mu = \frac{\sum_{j}^{M} \tau_j}{\sum_{j}^{M} N_j}$ (vessel type total catch divided by total number of pot lifts) from the observer data $\{c_{jkl}\}$. Under independent simple random sampling of pots on each day on each vessel and stratifying by day, the usual stratified estimator of τ_j is

$$\hat{\tau}_j = \sum_{k}^{D_j} N_{jk} \bar{c}_{jk} \tag{1}$$

with variance estimator

$$\hat{V}[\hat{\tau}_j] = \sum_{k}^{D_j} N_{jk}^2 \hat{V}ar[\bar{c}_{jk}]$$

$$= \sum_{k}^{D_j} N_{jk}^2 \left(1 - \frac{n_{jk}}{N_{jk}}\right) \frac{1}{n_{jk}} \frac{\sum_{l}^{n_{jk}} (c_{jkl} - \bar{c}_{jk})^2}{n_{jk} - 1} \tag{2}$$

-continued-

by virtue of standard results. See, for example, Cochran (1977). Assuming a simple random sample S of m out of M vessels of the given type, an unbiased estimator of vessel type total catch τ is then simply

$$\hat{\tau} = \frac{M}{m}\sum_{j}^{m}\hat{\tau}_j\,, \tag{3}$$

since conditioning on S we have

$$\begin{aligned}
E[\hat{\tau}] &= E[\frac{M}{m}\sum_{j}^{m}\hat{\tau}_j] \\
&= E[E[\frac{M}{m}\sum_{j}^{m}\hat{\tau}_j \mid S]] \\
&= E[\frac{M}{m}\sum_{j}^{m}E[\hat{\tau}_j \mid S]] \\
&= E[\frac{M}{m}\sum_{j}^{m}\tau_j] \\
&= ME[\frac{1}{m}\sum_{j}^{m}\tau_j] \\
&= M\frac{1}{M}\sum_{j}^{M}\tau_j \\
&= \sum_{j}^{M}\tau_j \\
&= \tau\,.
\end{aligned}$$

Its variance, which may also be obtained by conditioning on the initial sample of vessels, is given by $Var[\hat{\tau}] = M^2(1-\frac{m}{M})\frac{1}{m}\frac{\sum_{j}^{M}(\tau_j-\bar{\tau})^2}{M-1} + \frac{M}{m}\sum_{j}^{M}Var[\hat{\tau}_j]$, where $\bar{\tau}$ denotes the mean of the τ_j. An unbiased estimate of this variance is

$$\hat{Var}[\hat{\tau}] = M^2(1-\frac{m}{M})\frac{1}{m}\frac{\sum_{j}^{m}(\hat{\tau}_j-\bar{\hat{\tau}})^2}{m-1} + \frac{M}{m}\sum_{j}^{m}Var[\hat{\tau}_j] \tag{4}$$

with $\bar{\hat{\tau}} = \frac{1}{m}\sum_{j}^{m}\hat{\tau}_j$, the average of the observed vessel estimated total catches (Cochran, 1977,

-continued-

Theorem 11.2). Note that if all vessels of the given type are sampled, as is typically true of the catcher/processor fleet, this reduces to $\hat{Var}[\hat{\tau}] = \sum_{j}^{m=M} Var[\hat{\tau}_j]$. On the other hand, since fishery pot lift totals N_j for each observed vessel are in principle known, an unbiased estimate of the vessel type total number of pot lifts is the simple expansion estimator

$$\hat{\lambda} = \frac{M}{m}\sum_{j}^{m} N_j \tag{5}$$

with unbiased variance estimator

$$\hat{Var}[\hat{\lambda}] = M^2(1-\frac{m}{M})\frac{1}{m}\frac{\sum_{j}^{m}(N_j - \overline{N})}{m-1}, \tag{6}$$

where $\overline{N}$ is the N_j sample mean, again in accordance with basic results.

For the combined fishery, given estimates $\hat{\tau}_C$ and $\hat{\tau}_{CP}$ of catcher vessel and catcher-processor vessel total catch, an estimate of overall fishery total catch τ_F is simply their sum

$$\hat{\tau}_F = \hat{\tau}_C + \hat{\tau}_{CP}, \tag{7}$$

and under the assumption that sampling of vessels within each type occurs independently, an estimate of its variance is

$$\hat{Var}[\hat{\tau}_F] = \hat{Var}[\hat{\tau}_C] + \hat{Var}[\hat{\tau}_{CP}]. \tag{8}$$

Both of these estimators inherit unbiasedness from their components. In the same way, an estimate of the overall fishery total number of pot lifts and an estimate of its variance are given by

$$\hat{\lambda}_F = \hat{\lambda}_C + \hat{\lambda}_{CP} \tag{9}$$

and

$$\hat{Var}[\hat{\lambda}_F] = \hat{Var}[\hat{\lambda}_C] + \hat{Var}[\hat{\lambda}_{CP}], \tag{10}$$

likewise unbiased under unbiasedness of the individual vessel type estimators. Overall fishery CPUE can then be estimated using the ratio estimator

$$\hat{\mu} = \frac{\hat{\tau}_F}{\hat{\lambda}_F}. \tag{11}$$

To obtain an approximate variance for (11) we first expand it in a first order Taylor series around

-continued-

$\mu = \frac{\tau_F}{\lambda_F}$ as $\hat{\mu} \cong \mu + \frac{1}{\lambda_F}(\hat{\tau}_F - \tau_F) - \frac{\tau_F}{\lambda_F^2}(\hat{\lambda}_F - \lambda_F)$. Since vessels are selected independently within the two vessel types, taking variances and rearranging things results in

$$\hat{Var}[\hat{\mu}] \cong \frac{M_C^2}{m_C^2} Var[\sum_j^{m_C}(\frac{1}{\lambda_F}\hat{\tau}_j^C - \frac{\tau_F}{\lambda_F^2}N_j^C)] + \frac{M_{CP}^2}{m_{CP}^2} Var[\sum_j^{m_{CP}}(\frac{1}{\lambda_F}\hat{\tau}_j^{CP} - \frac{\tau_F}{\lambda_F^2}N_j^{CP})]. \quad (12)$$

The variances on the right side of (12) can be evaluated by conditioning on the initial simple random sample *S* of vessels within each type. Ignoring for the moment the particular vessel type, this procedure leads to

$$\begin{aligned} Var[\sum_j^m(\frac{1}{\lambda_F}\hat{\tau}_j - \frac{\tau_F}{\lambda_F^2}N_j)] &= Var[E[\sum_j^m(\frac{1}{\lambda_F}\hat{\tau}_j - \frac{\tau_F}{\lambda_F^2}N_j) \mid S]\} + E[Var[\sum_j^m(\frac{1}{\lambda_F}\hat{\tau}_j - \frac{\tau_F}{\lambda_F^2}N_j) \mid S]] \\ &= Var[\sum_j^m(\frac{1}{\lambda_F}E[\hat{\tau}_j \mid S] - \frac{\tau_F}{\lambda_F^2}N_j)] + E[\sum_j^m \frac{1}{\lambda_F^2}Var[\hat{\tau}_j \mid S]] \\ &= Var[\sum_j^m(\frac{1}{\lambda_F}\hat{\tau}_j - \frac{\tau_F}{\lambda_F^2}N_j)] + E[\sum_j^m \frac{1}{\lambda_F^2}Var[\hat{\tau}_j] \\ &= m(1-\frac{m}{M})\frac{\sum_j^M (q_j - \bar{q})^2}{M-1} + \frac{m}{M\lambda_F^2}\sum_j^M Var[\hat{\tau}_j], \end{aligned} \quad (13)$$

where $q_j = \frac{1}{\lambda_F}\tau_j - \frac{\tau_F}{\lambda_F^2}N_j$ and $\bar{q} = \frac{1}{M}\sum_j^M q_j$. Appropriate double substitution of (13) into the right side of (12) then gives

$$\begin{aligned} Var[\hat{\mu}] \cong{}& \frac{M_C^2}{m_C}(1-\frac{m_C}{M_C})S_{qC}^2 + \frac{M_C}{m_c\lambda_F^2}\sum_j^{M_C} Var[\hat{\tau}_j^C] \\ &+ \frac{M_{CP}^2}{m_{CP}}(1-\frac{m_{CP}}{M_{CP}})S_{qCP}^2 + \frac{M_{CP}}{m_{CP}\lambda_F^2}\sum_j^{M_{CP}} Var[\hat{\tau}_j^{CP}], \end{aligned} \quad (14)$$

where S_{qC}^2 and S_{qCP}^2 denote the population variances of the quantities q_j^C and q_j^{CP}. Upon replacing these with their sample analogues s_{qC}^2 and s_{qCP}^2 and substituting the estimators determined by (2) for $Var[\hat{\tau}_j^C]$ and $Var[\hat{\tau}_j^{CP}]$ and those in (3) and (5) for τ_F and λ_F, we obtain the variance estimator

$$\hat{Var}[\hat{\mu}] = \frac{M_C^2}{m_C}(1-\frac{m_C}{M_C})s_{qC}^2 + \frac{M_C}{m_c\hat{\lambda}_F^2}\sum_j^{m_C}\hat{Var}[\hat{\tau}_j^C] + \frac{M_{CP}^2}{m_{CP}}(1-\frac{m_{CP}}{M_{CP}})s_{qCP}^2 + \frac{M_{CP}}{m_{CP}\hat{\lambda}_F^2}\sum_j^{m_{CP}} Var[\hat{\tau}_j^{CP}]. \quad (15)$$

-continued-

It should be noted that the overall totals τ_F and λ_F are used in defining the quantities q_j^C and q_j^{CP} and so (3) and (5) are to be used in estimating the latter. With (11) and (15) in hand an approximate $100(1-2\alpha)$ percent confidence interval for overall fishery CPUE μ is

$$\hat{\mu} \pm t_{df,\alpha} \sqrt{\hat{V}ar[\hat{\mu}]}\,, \tag{16}$$

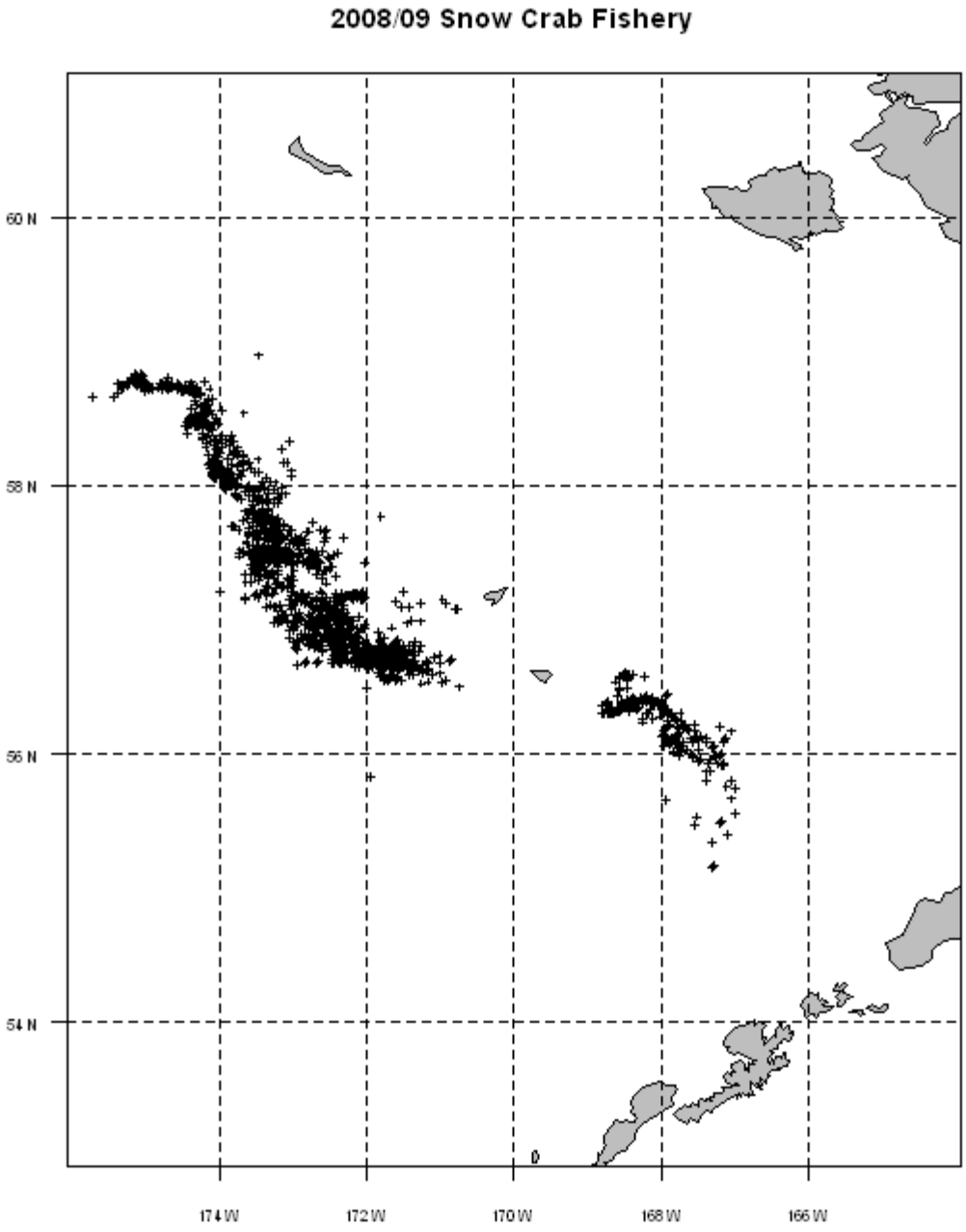
where $t_{df,\alpha}$ denotes the $100(1-\alpha)^{\text{th}}$ percentile of the *t*-distribution on *df* degrees of freedom. In general, we take $df = m_C - 1$, unless all catcher-only vessels are observed, in which case we use the standard normal distribution to determine an appropriate multiplier, i.e. we put $df = \infty$. (Recall that m_C is the number of observed catcher-only vessels in the directed fishery.) Small sample sizes at some levels of the design, underlying skewed pot count distributions, theoretical bias of the ratio estimator and the use of an approximate variance admittedly give reason for concern about the applicability of standard asymptotic confidence intervals, and future investigation is warranted. Nevertheless, we believe this approach is reasonable and likely conservative rather than otherwise.

As a final note we remark that if the total number of pot lifts λ_F is in fact known, the unbiased estimator

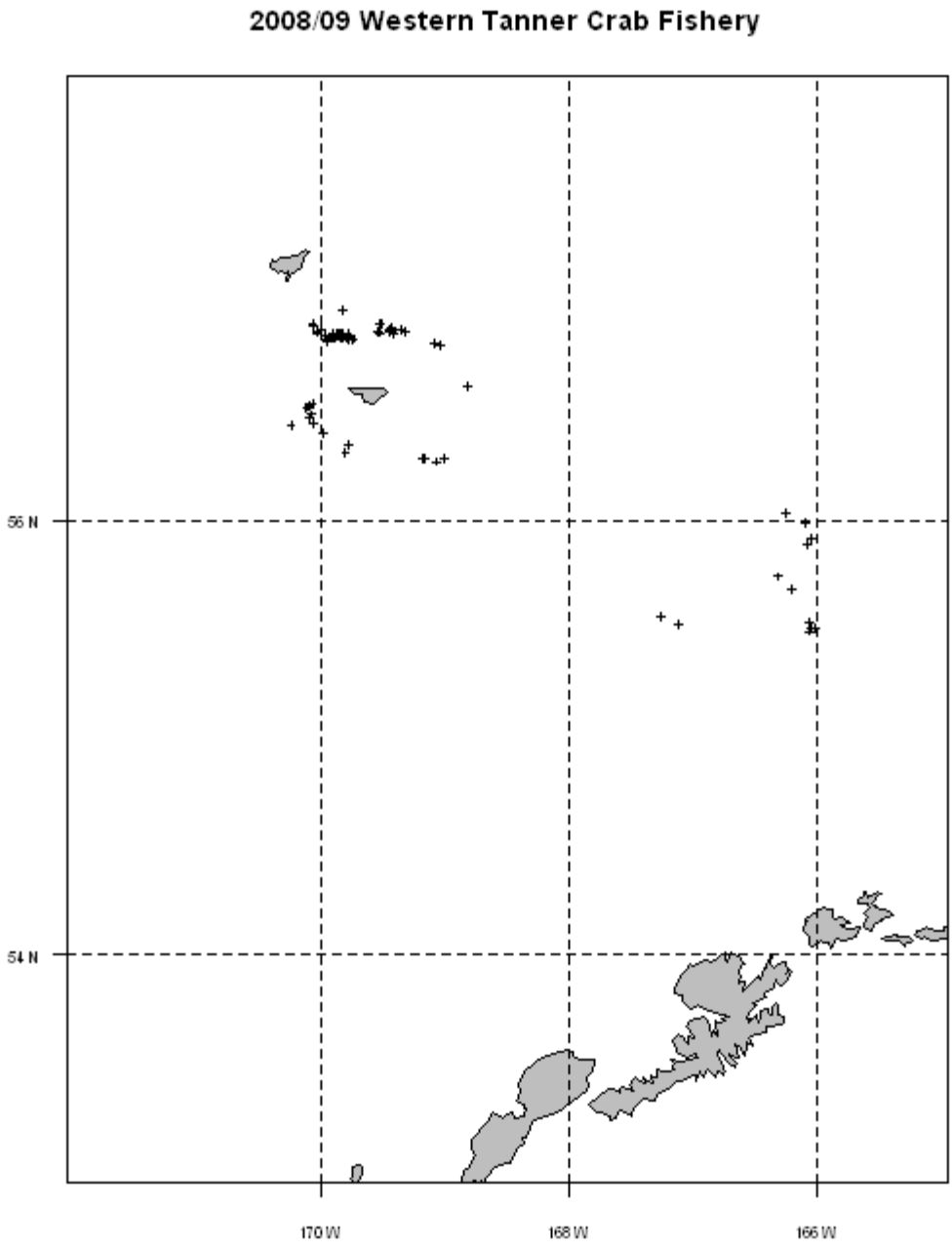
$$\hat{\mu}_u = \frac{\hat{\tau}_F}{\lambda_F} \tag{17}$$

is a natural candidate for estimating fishery CPUE, and an estimate of its variance is easily obtained from (8). However, though ratio estimators such as (11) are in general not design unbiased, in some applications they can perform well in the sense of having smaller mean square error (MSE) than their unbiased counterparts (Lohr 1999, p. 151). For the application at hand we expect vessel catch and vessel pot lift totals to be highly positively correlated and hence that (11) should provide reasonable estimates of the target parameter. Moreover, (11) is robust to undercoverage resulting from failure to sample pots on all days fished by a vessel selected for observation, so long as sampled pots and observed daily pot-lift totals are mostly representative of those on unobserved days. The unbiased estimator (17) decidedly lacks this sort of robustness, and we note that significant undercoverage of the type described can occur, especially in the Aleutian Islands golden king crab fishery. It should also be observed that although fishery pot lift totals λ_F, as well as λ_C and λ_{CP}, are routinely extracted from fish ticket data, some uncertainty is associated with these values. More importantly, neither that uncertainty nor its relationship to the observer data is readily quantified, rendering problematic the inferential usefulness of those values in this context.

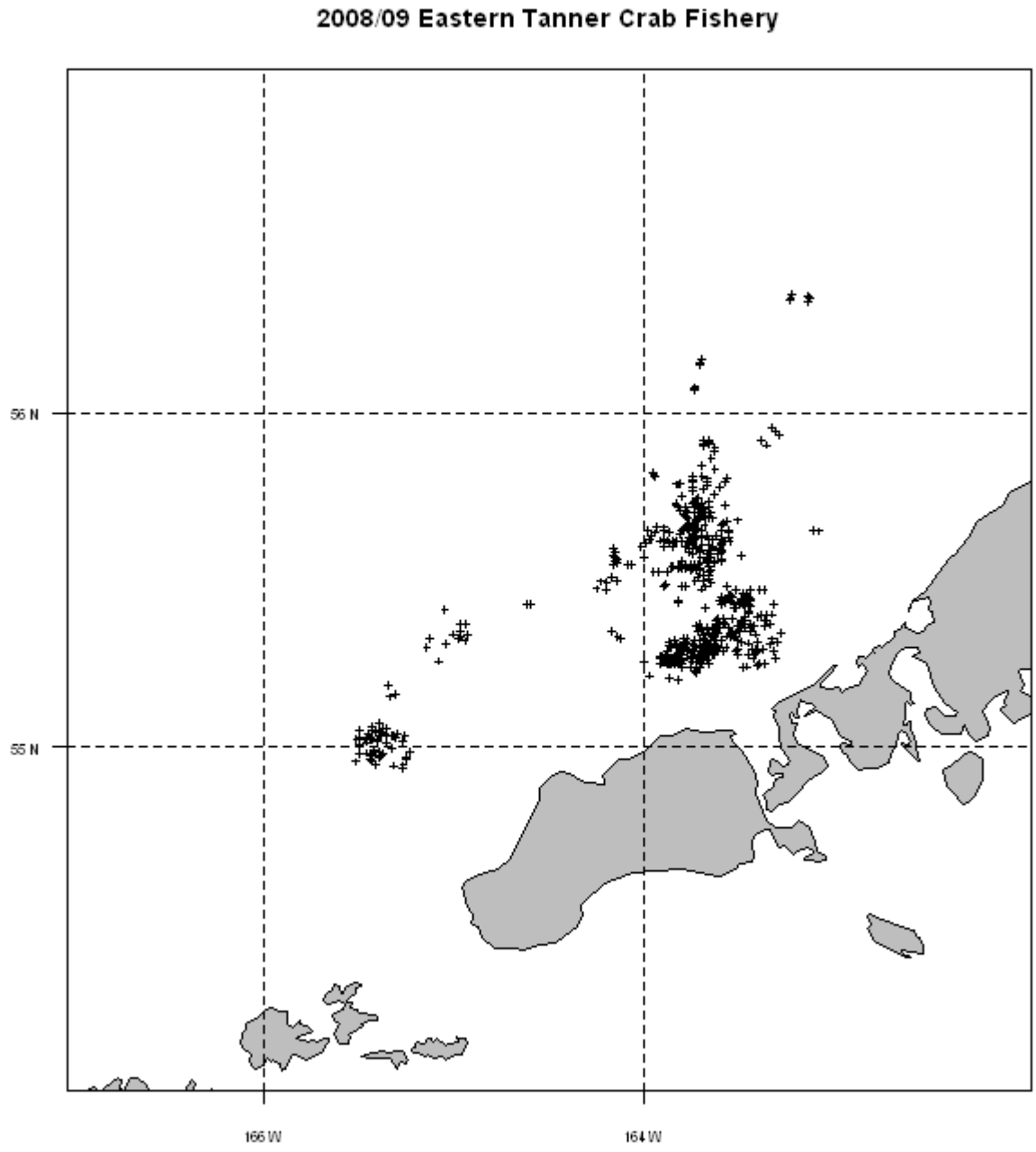
APPENDIX B:
LOCATIONS OF SAMPLED POT LIFTS



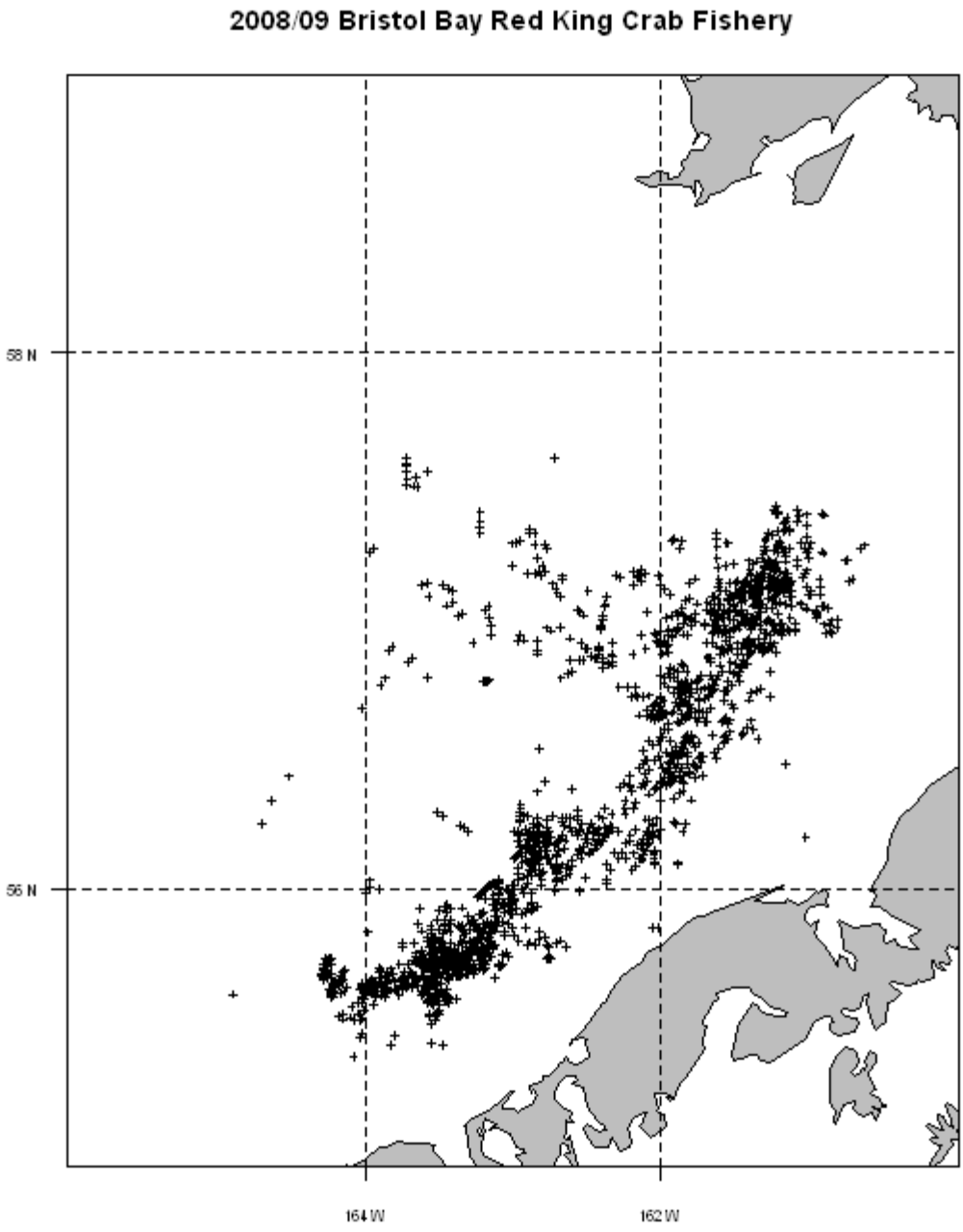
Appendix B1.–Locations of pot lifts sampled by observers during the 2008/2009 Bering Sea snow crab fishery.



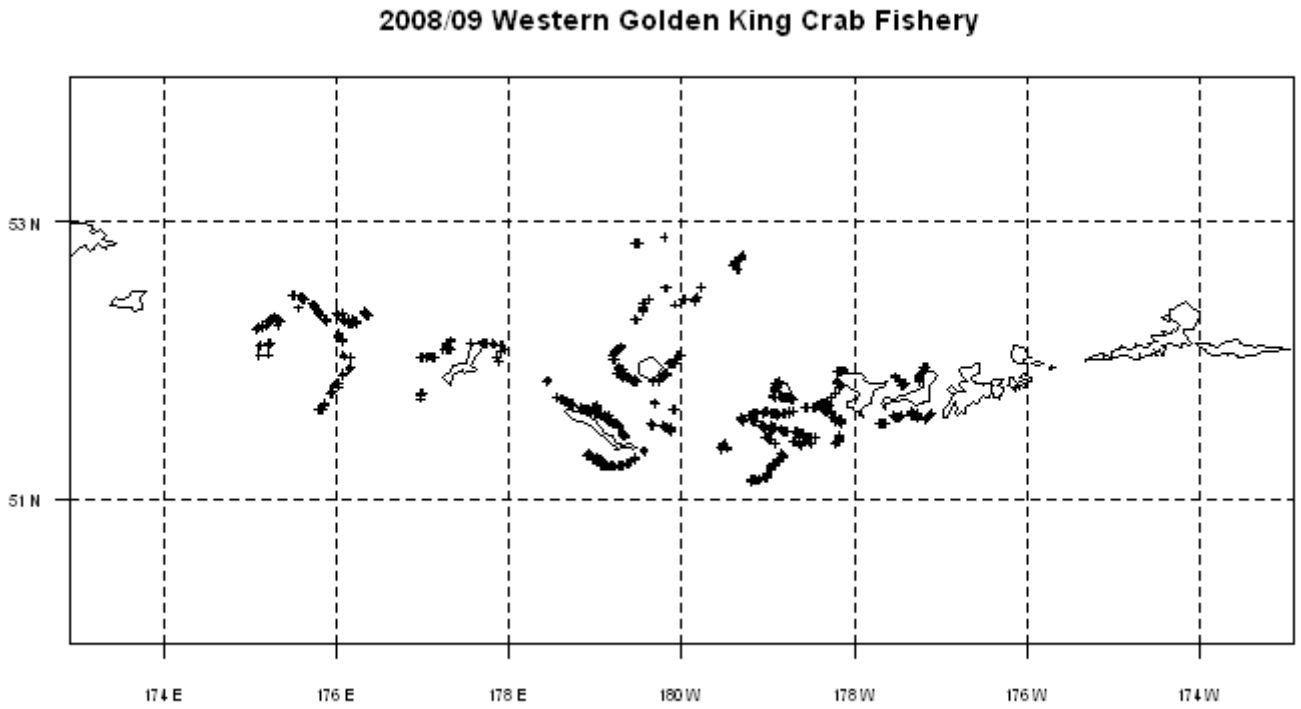
Appendix B2.–Locations of pot lifts sampled by observers during the 2008/2009 directed Bering Sea Tanner crab fishery west of 166° W longitude.



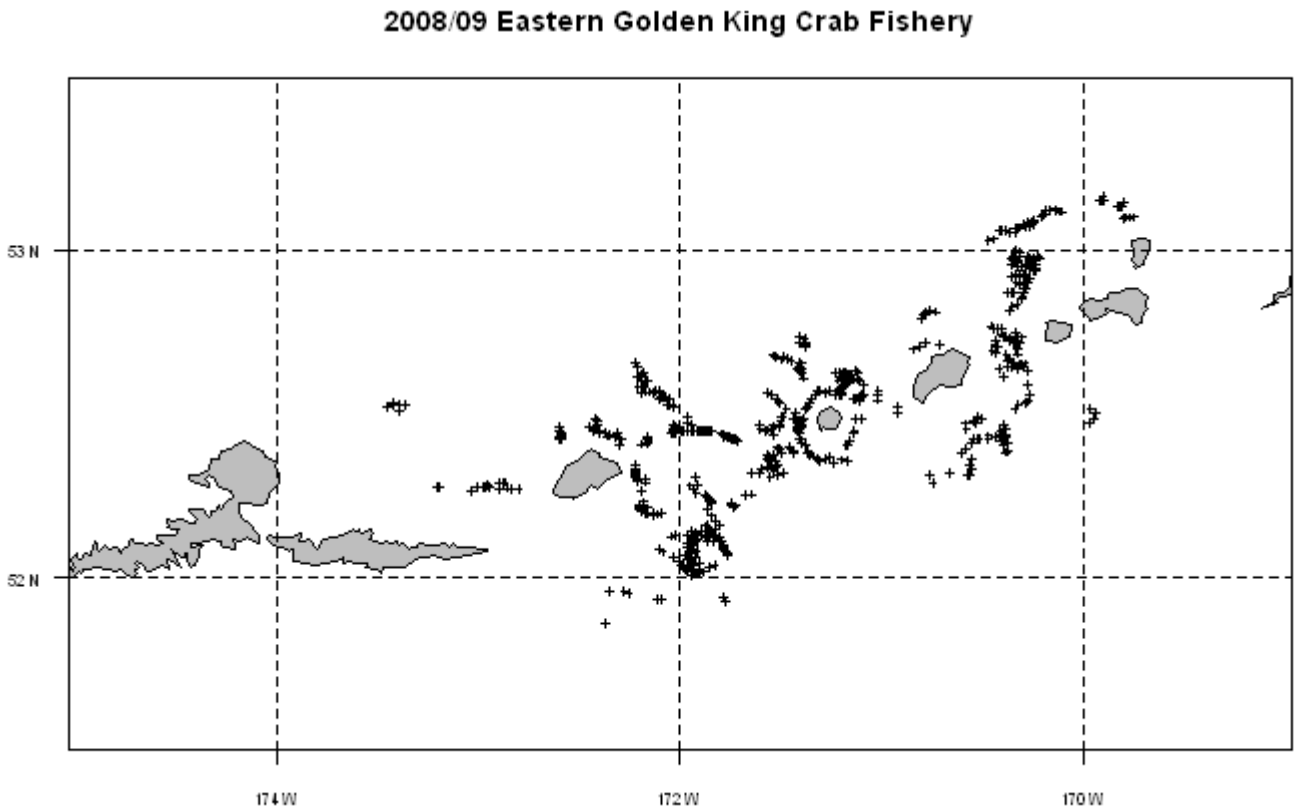
Appendix B3.–Locations of pot lifts sampled by observers during the 2008/2009 directed Bering Sea Tanner crab fishery east of 166º W longitude.



Appendix B4.–Locations of pot lifts sampled by observers during the 2008/2009 Bristol Bay red king crab fishery.



Appendix B5.–Locations of pot lifts sampled by observers during the 2008/2009 Aleutian Islands golden king crab fishery west of 174° W longitude.



Appendix B6.–Locations of pot lifts sampled by observers during the 2008/2009 Aleutian Islands golden king crab fishery east of 174º W longitude.

APPENDIX C:
ADDITIONAL CATCH AND BIOLOGICAL SUMMARIES

Appendix C1.–Total contents of 1,657 pot lifts sampled during the 2008/2009 Bering Sea snow crab fishery.

Species	Total Catch	Species	Total Catch
Snow crab		Hair crab	
legal males	625,146	legal males	1
sublegal males	2,252	sublegal males	0
females	1,523	females	0
Tanner crab		Snail [u]	6,793
legal males	1,142	Pacific cod	524
sublegal males	22,816	Hermit crab [u]	82
females	1,719	Basket star	81
		Starfish [u]	79
Hybrid *C. bairdi*		Pacific halibut	44
legal males	30	Sea anemone [u]	38
sublegal males	2,065	Yellow Irish lord	29
females	3	Hydroid [u]	20
		Pacific lyre crab	15
Hybrid *C. opilio*		Arrowtooth flounder	11
legal males	1,329	Giant octopus	11
sublegal males	3	Sculpin [u]	11
females	0	Octopus [u]	10
		Sea urchin [u]	10
Golden king crab		Jellyfish [u]	9
legal males	4	Skate [u]	9
sublegal males	1	Crab [u]	8
females	0	Hairy triton (or Oregon triton)	8
		Yellowfin sole	6
Blue king crab		Rock sole [u]	5
legal males	0	Rockfish [u]	3
sublegal males	2	Sea cucumber [u]	3
females	0	Walleye pollock	3
		Flathead sole	2
Red king crab		Coral [u]	1
legal males	1	prowfish	1
sublegal males	0	Sea pen [u]	1
females	0	Shrimp [u]	1

[u] Unidentified

Appendix C2.–Mean snow crab CPUE by soak time for 1,657 pot lifts sampled during the 2008/2009 Bering Sea snow crab fishery.

Soak Time[a] (hours)	Percent of Sampled Pots	Mean Catch per Sampled Pot				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
1-12	0.3	91.6	77.6	0.8	0	170.0
13-24	14	205.6	85.0	1.1	0.1	291.8
25-36	28.6	244.9	96.1	1.3	1.8	344.1
37-48	21.1	284.2	117.9	2.0	1.3	405.4
49-60	8.7	291.8	121.3	1.1	0.1	414.4
61-72	6.5	306.3	114.1	1.6	0.4	422.3
73-84	3.1	332.4	118.3	1.3	0.4	452.6
85-96	2.2	295.3	105.7	1.2	0.7	402.9
97-108	1.3	305.3	122.0.	0.9	0	428.2
109-120	1.5	360.3	130.4	0.6	<0.1	491.4
121-132	0.8	369.8	134.2	0.9	<0.1	505.1
133-144	1.8	319.2	111.2	1.9	1.4	433.7
145-156	1.4	317.7	123.8	0.7	0	442.2
157-168	2.2	315.0	124.1	1.1	<0.1	440.2
169-180	0.9	295.9	114.1	0.5	0	410.5
181-192	1.1	343.6	105.0	1.1	0	449.7
193-204	0.4	328.4	90.0	0	0	418.4
205-216	0.7	321.8	90.7	1.4	<0.1	414.0
217-228	0.1	573.0	158..0	2.0	0	733.0
229-240	1.1	325.1	137.0	0.9	0	463.0
241-252	0.6	291.5	73.6	0.1	0	365.2
253-264	0.4	362.7	137.1	1.1	0	501.0
277-288	0.4	327.7	71.7	1.2	0	400.5
289-300	0.1	156.5	29.5	0	0	186.0
301-312	0.1	181.5	56.5	0	0	238.0
313-324	0.3	301.8	102.8	4.0	2.4	411.0
337-348	0.1	313.0	52.0	0	0	365.0
397-408	0.1	127.0	46.0	2.0	0	175.0

[a] Mean soak time = 61.1 hours.

Appendix C3.–Mean snow crab CPUE by depth for 1,657 pot lifts sampled during the 2008/2009 Bering Sea snow crab fishery.

Depth[a] (fathoms)	Percent of Sampled Pots	Mean Catch per Sampled Pot				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
46-50	0.1	3.5	4.0	0	0	7.5
51-55	0.1	112.0	53.0	2.0	0	167.0
56-60	2.1	199.1	74.8	0.9	<0.1	274.9
61-65	18.2	269.2	122.1	2.2	3.2	396.7
66-70	37.0	280.1	117.9	1.5	0.7	400.2
71-75	24.6	262.4	95.3	1.2	0.3	359.2
76-80	10.7	278.2	83.4	0.7	0	362.3
81-85	5.0	271.9	90.1	0.3	0	362.4
86-90	1.6	292.8	106.4	0	0	399.2
91-95	0.3	488.2	102.4	0.2	0	590.8
96-100	0.1	102.0	2.0	0	0	104.0
101-105	0.1	105.0	4.0	16.0	0	125.0
116-120	0.1	0	0	0	0	0
121-125	0.1	0	0	0	0	0

[a] Mean depth = 70.1 fathoms.

Appendix C4.–Reproductive condition of female snow crabs from pot lifts sampled during the 1995-2008/2009 Bering Sea snow crab fisheries.

Year	Crabs Sampled	Eyed Eggs (percent)	Uneyed Eggs (percent)	Barren, Mated (percent)	Barren, Non-mated (percent)
1995	423	80.4	12.5	6.1	0.9
1996	136	59.6	3.7	16.2	20.6
1997	789	40.9	0.6	30.4	28.0
1998	90	21.1	8.9	37.8	32.2
1999	99	68.7	5.1	22.2	4.0
2000	6	0	16.7	16.7	66.6
2001	11	18.2	36.4	0	45.4
2002	19	26.3	57.9	10.5	5.3
2003	62	41.9	45.2	9.7	3.2
2004	10	10.0	30.0	0	60.0
2005	9	88.9	11.1	0	0
2005/2006	129	6.2	89.2	2.3	2.3
2006/2007	57	84.2	14.0	0	1.8
2007/2008	365	21.9	71.0	1.6	3.8
2008/2009	461	28.4	71.4	0	0.2

Appendix C5.–Total contents of 77 pot lifts sampled during the 2008/2009 directed Bering Sea Tanner crab fishery west of 166° W longitude.

Species	Total Catch	Species	Total Catch
Tanner crab		Sculpin [u]	172
legal males	1,719	Neptune snail [u]	37
sublegal males	3,813	Pacific cod	22
females	244	Snail [u]	22
		Yellowfin sole	13
Snow crab		Sea urchin [u]	6
legal males	566	Starfish [u]	5
sublegal males	2	Pacific lyre crab	2
females	0	Jellyfish [u]	1
		Pacific halibut	1
Hybrid *C. bairdi*		Poacher [u]	1
legal males	0	Sea anemone [u]	1
sublegal males	10	Skate [u]	1
females	0		
Hybrid *C. opilio*			
legal males	12		
sublegal males	0		
females	0		

[u] Unidentified

Appendix C6.–Mean Tanner crab CPUE by soak time for 77 pot lifts sampled during the 2008/2009 directed Bering Sea Tanner crab fishery west of 166° W longitude.

Soak Time[a] (hours)	Percent of Sampled Pots	Mean Catch per Sampled Pot				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
1-12	2.6	0	0	1.0	0	1.0
13-24	2.6	45.5	0	63.0	0	108.5
25-36	32.5	18.4	0.2	40.4	3.6	62.7
37-48	36.4	20.1	0.2	44.9	5.1	70.3
49-60	14.3	31.8	0.3	80.6	0.6	113.4
61-72	11.7	25.4	1.1	59.0	0.4	86.0

[a] Mean soak time = 42.3 hours.

Appendix C7.–Mean Tanner crab CPUE by depth for 77 pot lifts sampled during the 2008/2009 directed Bering Sea Tanner crab fishery west of 166° W longitude.

Depth[a] (fathoms)	Percent of Sampled Pots	Mean Catch per Sampled Pot				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
36-40	42.9	30.4	0.4	46.5	6.3	83.6
41-45	11.7	34.3	0.3	64.2	0.3	99.2
46-50	2.6	15.5	0.5	58.5	9.0	83.5
51-55	2.6	1.0	0	3.5	0	4.5
56-60	14.3	9.7	<0.1	19.5	0	29.4
61-65	5.2	11.2	1.2	61.8	0.5	74.8
66-70	10.4	23.8	0.4	124.1	1.5	149.8
71-75	3.9	0.7	0	8.7	0	9.3
76-80	2.6	1.0	0	14.5	0	15.5
81-85	3.9	1.0	0	21.7	0	22.7

[a] Mean depth = 50.7 fathoms.

Appendix C8.–Reproductive condition of female Tanner crabs from pot lifts sampled during the 2005/2006 – 2008/2009 directed Bering Sea Tanner crab fisheries west of 166° W longitude.

Year	Crabs Sampled	Eyed Eggs (percent)	Uneyed Eggs (percent)	Barren, Mated (percent)	Barren, Non-mated (percent)
2005/2006	1,101	21.9	75.8	0.6	1.6
2006/2007	2,859	25.9	73.5	0.5	< 0.1
2007/2008	903	21.9	75.6	1.2	0.9
2008/2009	118	86.4	2.5	3.4	7.6

Appendix C9.–Total contents of 607 pot lifts sampled during the 2008/2009 directed Bering Sea Tanner crab fishery east of 166° W longitude.

Species	Total Catch	Species	Total Catch
Tanner crab	26,625	Snail [u]	1422
legal males	16,489	Starfish [u]	801
sublegal males	879	Yellowfin sole	354
females		Jellyfish [u]	73
		Pacific cod	67
Snow crab		Hairy triton (or Oregon triton)	28
legal males	1,270	Pacific lyre crab	22
sublegal males	67	Sand dollar [u]	22
females	0	Sea anemone [u]	21
		Butter sole	15
Hybrid *C. bairdi*		Sponge [u]	12
legal males	1	Rock sole [u]	8
sublegal males	4	Octopus [u]	6
females	0	Pacific halibut	6
		Hermit crab [u]	5
Hybrid *C. opilio*		Lyre whelk	4
legal males	1	Sculpin [u]	4
sublegal males	0	Arrowtooth flounder	3
females	0	Flathead sole	3
		Giant octopus	3
Red king crab		Skate [u]	3
legal males	26	Pribilof neptune (or Pribilof whelk)	2
sublegal males	168	Flatfish [u]	1
females	163	Nudibranch [u]	1
		Sea urchin [u]	1
Hair crab		Yellow Irish lord	1
legal males	1		
sublegal males	1		
females	1		

[u] Unidentified

Appendix C10.–Mean CPUE by soak time for 607 pot lifts sampled during the 2008/2009 directed Bering Sea Tanner crab fishery east of 166° W longitude.

Soak Time[a] (hours)	Percent of Sampled Pots	Mean Catch per Sampled Pot				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
13-24	2.8	35.2	0.1	18.1	0.7	54.1
25-36	33.4	42.0	1.0	26.9	1.8	71.6
37-48	42.8	43.7	0.6	30.5	1.6	76.4
49-60	7.4	44.8	0.3	17.1	0.7	63.0
61-72	1.5	38.9	0.8	6.4	0.6	46.7
73- 84	0.8	63.0	0.4	19.2	0	82.6
85-96	4.4	38.5	0.4	11.0	<0.1	50.0
97-108	2.0	39.8	<0.1	12.7	0	52.5
109-120	2.5	56.1	0.1	17.4	0.3	73.9
121-132	0.3	62.5	0.5	8.5	0	71.5
133-144	0.3	55.5	3.5	55.5	0	114.5
145-156	0.8	53.2	2.6	67.4	2.4	125.6
157-168	0.3	40.0	0	137.0	4.0	181.0
169-180	0.3	29.5	0	107.0	11.5	148.0
181-192	0.2	48.0	2.0	201.0	8.0	259.0

[a] Mean soak time = 46.9 hours.

Appendix C11.–Mean CPUE by depth for 607 pot lifts sampled during the 2008/2009 directed Bering Sea Tanner crab fishery east of 166° W longitude.

Depth (fathoms)	Percent of Sampled Pots	Mean Catch per Sampled Pot				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
21-25	2.1	71.9	1.5	45.6	<0.1	119.1
26-30	16.0	48.3	1.2	21.7	0.7	71.9
31-35	20.3	50.5	1.7	18.6	0.9	71.8
36-40	5.3	43.4	0	12	<0.1	55.4
41-45	12.4	52.1	0.1	15.7	0.2	68.1
46-50	22.2	32.1	0.2	9.4	0.6	42.2
51-55	10.2	44.5	0.3	14.6	1.8	61.2
56-60	2.3	31.5	<0.1	68.7	5.6	105.9
61-65	7.4	26.9	0.1	120.6	7.4	155
66-70	1.8	31.2	0	125.8	7.3	164.3

[a] Mean depth = 42.5 fathoms.

Appendix C12.–Reproductive condition of female Tanner crabs from pot lifts sampled during the 2006/2007 - 2008/2009 directed Bering Sea Tanner crab fisheries east of 166° W longitude.

Year	Crabs Sampled	Eyed Eggs (percent)	Uneyed Eggs (percent)	Barren, Mated (percent)	Barren, Non-mated (percent)
2006/2007	1,573	95.6	2.9	0.8	0.6
2007/2008	2,416	27.9	68.5	1.9	1.2
2008/2009	536	20.1	78.4	0	1.5

Appendix C13.–Total contents of 1,849 pot lifts sampled during the 200/2009 Bristol Bay red king crab fishery.

Species	Total Catch	Species	Total Catch
Red king crab		Pacific cod	283
legal males	41,428	Jellyfish [u]	183
sublegal males	48,907	Sculpin [u]	142
females	8,737	Great sculpin	129
		Snail [u]	115
Tanner crab		Pacific halibut	74
legal males	2,768	Lyre whelk	26
sublegal males	1,041	Hermit crab [u]	22
females	121	Leech [u]	20
		Bigmouth sculpin	17
Snow crab		Sponge [u]	17
legal males	182	Tunicate [u]	17
sublegal males	5	Yellow Irish lord	11
females	2	Neptune snail [u]	10
		Worm unident.	9
Hybrid *C. bairdi*		Sea cucumber [u]	8
legal males	0	Graceful decorator crab	7
sublegal males	1	Starry flounder	7
females	0	Pacific lyre crab	6
		Arrowtooth flounder	5
Hybrid *C. opilio*		Octopus [u]	5
legal males	1	Smooth lumpsucker	5
sublegal males	0	Invertebrate [u]	4
females	1	Hairy triton (or Oregon triton)	3
		Sea anemone [u]	3
Hair crab		Giant octopus	2
legal males	23	Scallop [u]	2
sublegal males	5	Weathervane scallop	2
females	15	Bivalve	1
		Brittle star [u]	1
Blue king crab		Flatspine triangle crab	1
legal males	0	Mussel [u]	1
sublegal males	0	Pribilof neptune (or Pribilof whelk)	1
females	1	Rockfish [u]	1
		Skate [u]	1
Starfish [u]	1831	Snailfish [u]	1
Yellowfin sole	1167	Spinyhead sculpin	1

[u] Unidentified

Appendix C14.–Mean CPUE by soak time for 1,849 pot lifts sampled during the 2008/2009 Bristol Bay red king crab fishery.

Soak Time[a] (hours)	Percent of Sampled Pots	Mean Catch per Sampled Pot				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
1-12	0.2	0.7	0	6.0	2.3	9.0
13-24	5.1	14.5	0.2	31.0	4.7	50.3
25-36	21.2	18.9	0.2	26.7	5.6	51.4
37-48	32.4	21.3	0.5	25.2	4.5	51.5
49-60	15.3	19.6	0.6	23.3	3.7	47.2
61-72	5.2	22.4	0.5	21.0	5.9	49.7
73-84	2.6	33.8	0.9	45.7	4.9	85.3
85-96	4.7	33.5	0.4	24.6	4.8	63.3
97-108	3.9	24.0	0.8	23.3	3.9	52.1
109-120	3.1	23.3	0.6	29.5	6.9	60.2
121-132	2.4	29.8	0.4	47.9	5.8	84.0
133-144	1.2	24.3	0.7	27.2	2.5	54.7
145-156	0.7	43.4	0.9	39.4	0.2	83.9
157-168	0.6	31.5	1.1	26.1	1.1	59.8
169-180	0.4	35.6	0.4	22.1	0.9	59.0
181-192	0.7	36.8	0.7	19.6	5.9	63.0
193-204	0.1	52.0	1.5	30.0	0	83.5
205-216	0.2	37.0	4.7	17.7	0.3	59.7

[a] Mean soak time = 56.8 hours.

Appendix C15.–Mean CPUE by depth for 1,849 pot lifts sampled during the 2008/2009 Bristol Bay red king crab fishery.

Depth[a] (fathoms)	Percent of Sampled Pots	Mean Catch per Sampled Pot				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
26–30	3.8	17.2	0.4	16.5	0.4	34.5
31–35	12.8	20.4	0.5	19.9	1.7	42.5
36–40	21.5	20.8	0.4	27.6	6.5	55.3
41–45	33.8	23.8	0.6	35.6	6.0	65.9
46–50	22.3	22.1	0.4	20	4.7	47.2
51–55	5.7	21.6	0.1	14.6	<0.1	36.4

[a] Mean depth = 41.7 fathoms.

Appendix C16.–Reproductive condition of female red king crabs from pot lifts sampled during the 1996-2008/2009 Bristol Bay red king crab fisheries.

Year	Crabs Sampled	Eyed Eggs (percent)	Uneyed Eggs (percent)	Barren, Mated (percent)	Barren, Non-mated (percent)
1996	11	0	0	0	100.0
1997	70	65.7	18.6	0	15.7
1998	4,091	45.6	51.8	<0.1	2.6
1999	36	0	86.1	2.8	11.1
2000	1,486	4.0	22.3	0.5	73.2
2001	4,574	66.0	18.7	0.3	15.0
2002	311	32.1	2.6	0.6	64.6
2003	10,391	9.1	51.5	3.4	35.9
2004	4,111	21.4	48.4	0.6	29.6
2005/2006	26,753	41.3	45.0	0.2	13.4
2006/2007	3,586	16.5	32.5	1.4	49.5
2007/2008	12,451	41.0	41.0	1.7	22.9
2008/2009	8,486	50.5	27.8	1.1	20.6

Appendix C17.–Total pot lift contents for 1,592 pot lifts sampled during the combined 2008/2009 Aleutian Islands golden king crab fishery.

Species	Total Catch	Species	Total Catch
Golden king crab		*Distichopora* sp.	11
legal males	41,996	Rockfish [u]	10
sublegal males	18,086	Primnoidae [u]	8
females	16,225	Sea spider [u]	7
		Shrimp [u]	7
Scarlet king crab		*Clavularia* sp.	6
legal males	17	Cup coral [u]	5
sublegal males	20	Skate egg case [u]	5
females	3	*Errinopora* sp.	4
		Pacific cod	4
Red king crab		Red tree coral	4
legal males	1	Sea anemone [u]	4
sublegal males	2	Sea whip [u]	4
females	3	Yellow Irish lord	3
		Arrowtooth flounder	2
Basket star	454	Atka mackerel	2
Sponge [u]	382	*Crypthelia* sp.	2
Brittle star [u]	360	Flatfish [u]	2
Hydroid [u]	261	Giant octopus	2
Stylaster sp.	170	Grenadier (rattail) [u]	2
Starfish [u]	159	Hermit crab	2
Sea urchin [u]	134	Hydrocoral [u]	2
Primnoidae Group I	124	Invertebrate [u]	2
Bryozoan [u]	60	Octopus [u]	2
Tunicate [u]	52	Pacific ocean perch	2
Fanellia sp.	48	Bamboo coral [u]	1
Snail [u]	48	Barnacle [u]	1
Anthomastus sp.	26	Bigmouth sculpin	1
Plexauridae [u]	25	*Caryophyllia* sp.	1
Worm [u]	23	Hairy triton (or Oregon triton)	1
Arthrogorgia sp.	22	Sablefish (or black cod)	1
Kamchatka coral (or bubblegum coral)	21	Sculpin [u]	1
Cyclohelia sp.	19	Sea cucumber [u]	1
Pacific halibut	16	Sea pen [u]	1
Calcigorgia sp.	14	Sea raspberry	1
Sea lily (or feather star) [u]	13	Shortspine thornyhead	1
Skate [u]	13	Stony coral [u]	1

[u] Unidentified

Appendix C18.–Mean CPUE by soak time for 979 pot lifts sampled during the 2008/2009 Aleutian Islands golden king crab fishery west of 174° W longitude.

Soak Time[a] (hours)	Percent o f Sampled Pots	Mean Catch per Sampled Pot				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
145-192	0.4	25.5	0.0	38.8	14.5	78.8
193-240	0.4	28.5	0.2	45.2	13.8	87.8
241-288	2.2	23.0	< 0.1	40.0	22.5	85.5
289-336	6.5	23.0	0.2	16.7	20.4	60.3
337-384	7.6	24.5	0.3	13.9	14.9	53.5
385-432	13.9	22.2	0.2	12.8	16.5	51.6
433-480	13.5	21.5	0.2	15.3	14.6	51.7
481-528	9.1	28.3	0.2	16.4	11.9	56.9
529-576	7.9	25.9	0.3	19.2	9.9	55.4
577-624	6.6	22.4	< 0.1	13.2	8.1	43.7
625-672	5.5	21.9	< 0.1	6.9	15.9	44.8
673-720	2.9	38.0	0.0	15.8	6.1	59.9
721-768	5.2	25.6	< 0.1	6.9	7.4	40.0
769-816	4.9	26.6	0.5	7.2	14.1	48.5
817-864	2.8	26.3	< 0.1	7.6	13.4	47.4
865-912	1.5	35.3	0.0	9.3	7.9	52.5
913-960	4.6	20.5	0.3	5.2	12.2	38.1
961-1008	1.7	20.8	< 0.1	4.8	6.1	31.7
1009-1056	0.4	28.0	0.0	4.2	2.5	34.8
1057-1104	0.7	5.3	0.0	0.7	0.4	6.4
1105-1152	0.6	38.7	0.0	8.2	13.5	60.3
1249-1296	0.3	13.0	0.0	1.7	18.0	32.7
1297-1344	0.4	0.2	0.0	0.0	0.0	0.2
2881-2928	0.3	0.0	0.0	0.0	0.0	0.0

[a] Mean soak time = 576.7 hours.

Appendix C19.–Mean CPUE by depth for 979 pot lifts sampled during the 2008/2009 Aleutian Islands golden king crab fishery west of 174° W longitude.

Depth[a] (fathoms)	Percent of Sampled Pots	Mean Catch per Sampled Pot				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
51-75	0.2	33.5	0.0	1.0	0.0	34.5
76-100	1.9	32.4	< 0.1	3.3	10.7	46.5
101-125	5.6	24.9	0.2	16.3	23.3	64.7
126-150	17.7	29.9	< 0.1	15.8	13.1	58.9
151-175	20.4	24.6	0.2	14.1	12.1	50.9
176-200	26.7	22.2	0.3	14.2	6.7	43.5
201-225	16.9	18.9	0.2	13.1	17.7	49.9
226-250	7.3	23.6	0.2	7.7	17.2	48.6
251-275	2.3	21.4	< 0.1	4.6	30.1	56.1
276-300	0.9	36.7	0.0	5.8	14.6	57.0
301-325	0.1	36.0	0.0	19.0	22.0	77.0

[a]Mean depth = 178.4 fathoms.

Appendix C20.–Reproductive condition of female golden king crabs from pot lifts sampled during the 1996/1997-2008/2009 Aleutian Islands golden king crab fisheries west of 174° W longitude.

Year	Crabs Sampled	Eyed Eggs (percent)	Uneyed Eggs (percent)	Barren, Mated (percent)	Barren, Non-mated (percent)
1996/1997	67,314	23.6	25.5	21.2	29.6
1997/1998	39,343	24.0	26.8	19.8	29.4
1998/1999	22,208	23.4	25.9	16.3	34.4
1999/2000	45,645	21.3	29.6	19.1	29.9
2000/2001	53,716	26.2	28.7	17.1	27.9
2001/2002	38,829	26.6	27.8	22.4	23.2
2002/2003	22,479	32.8	20.9	11.9	33.9
2003/2004	5,946	32.8	26.8	19.2	21.2
2004/2005	12,970	26.1	31.7	21.6	20.6
2005/2006	5,798	35.2	33.5	21.7	9.6
2006/2007	7,136	31.6	36.0	19.3	13.0
2007/2008	9,281	43.2	23.9	19.1	13.8
2008/2009	7,922	27.5	34.5	15.3	22.7

Appendix C21.– Mean CPUE by soak time for 613 pot lifts sampled during the 2008/2009 Aleutian Islands golden king crab fishery east of 174° W longitude.

Soak Time[a] (hours)	Percent of Sampled Pots	Mean Catch per Sampled Pot				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
49-96	0.3	5.0	1.0	0.5	0	6.5
97-144	4.6	19.5	0.5	3.9	0.5	24.3
145-192	2.4	25.3	0.5	5.3	< 0.1	31.1
193-240	6.2	30.1	1.4	9.6	2.2	43.3
241-288	10.4	26.5	1.2	10.8	5.6	44.0
289-336	22.5	30.4	1.4	8.5	8.0	48.2
337-384	22.5	26.0	1.2	8.2	6.7	42.1
385-432	12.7	27.0	1.3	9.1	6.7	44.1
433-480	4.1	45.2	0.6	9.2	5.8	60.7
481-528	5.4	32.9	2.1	8.1	1.2	44.4
529-576	2.9	25.3	0.8	4.2	1.1	31.3
577-624	2.0	27.2	1.5	5.2	1.4	35.2
625-672	1.5	31.2	0.8	1.8	2.9	36.7
673-720	1.1	43.7	3.1	6.4	2.4	55.7
817-864	0.3	25.5	0	4.0	22.5	52.0
865-912	1.0	26.7	0.8	3.8	1.2	32.5

[a] Mean soak time = 358.2 hours.

Appendix C22.– Mean CPUE by depth for 613 pot lifts sampled during the 2008/2009 Aleutian Islands golden king crab fishery east of 174° W longitude.

Depth[a] (fathoms)	Percent of Sampled Pots	Mean Catch per Sampled Pot				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
76-100	3.6	34.8	1.5	17.9	1.7	56.0
101-125	17.3	27.4	1.2	8.9	5.5	43.0
126-150	16.0	29.6	0.9	6.5	3.0	39.9
151-175	8.0	26.0	0.8	5.1	2.2	34.1
176-200	9.5	33.8	0.8	7.2	6.3	48.1
201-225	12.2	28.4	1.2	8.3	5.5	43.5
226-250	11.3	26.5	1.7	8.5	9.9	46.5
251-275	9.3	26.2	1.5	7.8	6.6	42.1
276-300	8.2	31.1	1.5	9.6	7.3	49.6
301-325	4.1	23.3	1.4	7.5	3.8	36.0
326-350	0.7	14.5	2.8	3.2	1.5	22.0

[a] Mean depth = 191.0 fathoms.

Appendix C23.–Reproductive condition of female golden king crabs from pot lifts sampled during the 1996/1997-2008/2009 Aleutian Islands golden king crab fisheries east of 174° W longitude.

Year	CrabsSampled	Eyed Eggs(percent)	Uneyed Eggs(percent)	Barren, Mated(percent)	Barren,Non-mated(percent)
1996/1997	59,210	20.8	22.5	18.6	38.1
1997/1998	5,383	25.2	19.3	22.1	33.4
1998/1999	44,352	18.1	21.0	23.9	37.0
1999/2000	36,695	22.1	21.0	23.1	33.8
20002001	13,615	26.9	18.7	20.1	34.3
2001/2002	14,912	20.4	12.5	15.4	51.1
2002.2003	9,651	29.6	19.2	18.9	32.3
2003/2004	7,990	20.9	33.2	13.6	31.5
20042005	5,430	24.9	24.7	24.9	25.5
2005/2006	1,489	25.8	25.2	18.3	30.7
2006/2007	2,328	29.6	35.7	9.1	25.6
2007/2008	1,397	18.3	52.5	10.1	19.1
2008/2009	2,308	31.3	35.3	17.9	15.5

APPENDIX D:
RESULTS OF LEGAL TALLY SAMPLES

Appendix D1.–Results of legal tally samples from the 2008/2009 Bering Sea and Aleutian Islands directed crab fisheries.

Fishery	Sample Size	Percent Illegal Crabs				Estimated Number of Illegal Crabs[a]
		Male Target Species	Female Target Species	Male/Female Non-target Species	Total	
Bearing Sea snow crab	90,942	0.01	< 0.01	0.21	0.23	10,000
Bearing Sea Tanner crab (west of 166º W)	1,624	1.72	0	0	1.72	800
Bearing Sea Tanner crab (east of 166º W)	11,164	0.74	< 0.01	0	0.75	6,000
Bristol Bay red king crab	31,431	0.17	0	< 0.01	0.18	5,000
Aleutian Islands golden king crab (combined)	33,418	0.34	0.02	0	0.37	5,000

[a] Estimated number of illegal crabs = ATF estimated catch multiplied by total percentage of illegal crabs.