Fishery Data Series No. 09-76

Summary of the 2007/2008 Mandatory Shellfish Observer Program Database for the Rationalized Crab Fisheries

by

William B. Gaeuman

December 2009

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

Symbols and Abbreviations

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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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TABLE OF CONTENTS

LIST OF TABLES ii
LIST OF FIGURES ii
LIST OF APPENDICES iii
ABSTRACT 1
INTRODUCTION 1
METHODS 2
Terms 2
Sampling Duties 3
Floating-Processors 3
Catcher-Processors 3
Catcher-Only Vessels 3
Estimation of CPUE and Total Fishery Catch 4
RESULTS 5
Bering Sea Snow Crab 5
Bering Sea Tanner Crab 5
West of 166° W Longitude 6
East of 166° W Longitude 7
Bristol Bay Red King Crab 8
Aleutian Islands Golden King Crab 8
West of 174° W Longitude 8
East of 174° W Longitude 9
Accuracy and Precision of CPUE Estimates 10
ACKNOWLEDGMENTS 11
REFERENCES CITED 11
TABLES AND FIGURES 13
APPENDIX A: ESTIMATION OF CPUE FROM OBSERVER DATA 45
APPENDIX B: LOCATIONS OF SAMPLED POT LIFTS 53
APPENDIX C: ADDITIONAL CATCH AND BIOLOGICAL SUMMARIES 61
APPENDIX D: RESULTS OF LEGAL TALLY SAMPLES 83

LIST OF TABLES

Table **Page**

1. Carapace width (CW) frequency distributions by shell condition from biological measurements of retained snow crabs sampled during the 2007/2008 Bering Sea snow crab fishery. 14
2. Estimated catch per pot (CPUE) of selected crab species from 1,731 pot lifts sampled by observers deployed during the 2007/2008 Bering Sea snow crab fishery. 15
3. Carapace width (CW) frequency distributions by shell condition from biological measurements of retained Tanner crabs sampled during the 2007/2008 directed Bering Sea Tanner crab fishery west of 166° W longitude. 16
4. Estimated catch per pot (CPUE) of selected crab species from 103 pot lifts sampled by observers deployed during the 2007/2008 directed Bering Sea Tanner crab fishery west of 166° W longitude. 17
5. Carapace width (CW) frequency distributions by shell condition from biological measurements of retained Tanner crabs sampled during the 2007/2008 directed Bering Sea Tanner crab fishery east of 166° W longitude. 18
6. Estimated catch per pot (CPUE) of selected crab species from 773 pot lifts sampled by observers deployed during the 2007/2008 directed Bering Sea Tanner crab fishery east of 166° W longitude. 19
7. Estimated catch per pot (CPUE) of selected crab species from 1,918 pot lifts sampled by observers deployed during the 2007/2008 Bristol Bay red king crab fishery. 20
8. Carapace length (CL) distribution by shell condition from biological measurements of retained red king crabs sampled during the 2007/2008 Bristol Bay red king crab fishery. 21
9. Carapace length (CL) distribution by shell condition from biological measurements of retained golden king crabs sampled during the 2007/2008 Aleutian Islands golden king crab fishery west of 174° W longitude. 22
10. Estimated catch per pot (CPUE) of selected crab species from 1,084 pot lifts sampled by observers deployed during the 2007/2008 Aleutian Islands golden king crab fishery west of 174° W longitude. 23
11. Carapace length (CL) distribution by shell condition from biological measurements of retained golden king crabs sampled during the 2007/2008 Aleutian Islands golden king crab fishery east of 174° W longitude. 24
12. Estimated catch per pot (CPUE) of selected crab species from 1,004 pot lifts sampled by observers deployed during the 2007/2008 Aleutian Islands golden king crab fishery east of 174° W longitude. 25
13. 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. 26

LIST OF FIGURES

Figure **Page**

1. Carapace width distribution with shell condition for male snow crabs from pot lifts sampled during the 2001-2007/2008 Bering Sea snow crab fisheries. 27
2. Estimated CPUE for male snow crab from pot lifts sampled during the 1995-2007/2008 Bering Sea snow crab fisheries. 28
3. Carapace width distribution with shell condition for male Tanner crabs from pot lifts sampled during the 2005/2006 - 2007/2008 directed Bering Sea Tanner crab fisheries west of 166° W longitude. 29
4. Carapace width distribution with shell condition for female Tanner crabs from pot lifts sampled during the 2005/2006 - 2007/2008 directed Bering Sea Tanner crab fisheries west of 166° W longitude. 30
5. Estimated CPUE for male Tanner crab from pot lifts sampled during the 2005/2006-2007/2008 directed Bering Sea Tanner crab fisheries west of 166º W longitude. 31
6. Carapace width distribution with shell condition for male Tanner crabs from pot lift sampled during the 2006/2007 and 2007/2008 directed Bering Sea Tanner crab fisheries east of 166° W longitude. 32
7. Carapace width distribution with shell condition for female Tanner crabs from pot lifts sampled during the 2006/2007 and 2007/2008 directed Bering Sea Tanner crab fisheries east of 166° W longitude. 33
8. Estimated CPUE for male Tanner crab from pot lifts sampled during the 2006/2007-2007/2008 directed Bering Sea Tanner crab fisheries east of 166º W longitude 34

LIST OF FIGURES (Continued)

9. Carapace length distribution with shell condition for male red king crabs from pot lifts sampled during the 2000-2007/2008 Bristol Bay red king crab fisheries. 35
10. Carapace length distribution with shell condition for female red king crabs from pot lifts sampled during the 2000-2007/2008 Bristol Bay red kind crab fisheries. 36
11. Estimated CPUE for red king crabs from pot lifts sampled during the 1996-2007/2008 Bristol Bay red king crab fisheries. 37
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. ..38
13. Carapace length distribution with shell condition for female golden king crabs from pot lifts sampled during the 2000/2001-2007/2008 Aleutian Islands golden king crab fisheries west of 174° W longitude. ..39
14. Estimated CPUE for male golden king crabs from pot lifts sampled during the 1994/1995-2007/2008 golden king crab fisheries west of 174ºW longitude. 40
15. Carapace length distribution with shell condition for male golden king crabs from pot lifts sampled during the 2000-2007/2008 Aleutian Islands golden king crab fisheries east of 174° W longitude....41
16. Carapace length distribution with shell condition for female golden king crabs from pot lifts sampled during the 2000-2007/2008 Aleutian Islands golden king crab fisheries east of 174° W longitude....42
17. Estimated CPUE for male golden king crabs from pot lifts sampled during the 1995-2007/2008 Aleutian Islands golden king crab fisheries east of 174º W longitude. 43

LIST OF APPENDICES

Appendix **Page**

A1. Estimation of CPUE from observer data and estimator precision. 46

B1. Locations of pot lifts sampled by observers during the 2007/2008 Bering Sea snow crab fishery. 54
B2. Locations of pot lifts sampled by observers during the 2007/2008 directed Bering Sea Tanner crab fishery west of 166° W longitude. 55
B3. Locations of pot lifts sampled by observers during the 2007/2008 directed Bering Sea Tanner crab fishery east of 166º W longitude. 56
B4. Locations of pot lifts sampled by observers during the 2007/2008 Bristol Bay red king crab fishery. 57
B5. Locations of pot lifts sampled by observers during the 2007/2008 Aleutian Islands golden king crab fishery west of 174° W longitude. 58
B6. Locations of pot lifts sampled by observers during the 2007/2008 Aleutian Islands golden king crab fishery east of 174º W longitude. 59

C1. Total contents of 1,731 sampled pot lifts taken during the 2007/2008 Bering Sea snow crab fishery. 62
C2. Mean snow crab CPUE by soak time for 1,731 pot lifts sampled during the 2007/2008 Bering Sea snow crab fishery. 63
C3. Mean snow crab CPUE by depth for 1,731 pot lifts sampled during the 2007/2008 Bering Sea snow crab fishery. 64
C4. Reproductive condition of female snow crabs from pot lifts sampled during the 1995-2007/2008 directed Bering Sea snow crab fisheries. 65
C5. Total pot lift contents for 103 pot lifts sampled during the 2007/2008 directed Bering Sea Tanner crab fishery west of 166° W longitude. 66
C6. Mean Tanner crab CPUE by soak time for 103 pot lifts sampled during the 2007/2008 directed Bering Sea Tanner crab fishery west of 166° W longitude. 67
C7. Mean Tanner crab CPUE by depth for 103 pot lifts sampled during the 2007/2008 directed Bering Sea Tanner crab fishery west of 166° W longitude. 68
C8. Reproductive condition of female Tanner crabs from pot lifts sampled during the 2005/2006 – 2007/2008 directed Bering Sea Tanner crab fisheries west of 166° W longitude. 68
C9. Total contents of 773 pot lifts sampled during the 2007/2008 directed Bering Sea Tanner crab fishery east of 166° W longitude. 69

LIST OF APPENDICES (Continued)

C10. Mean CPUE by soak time for 773 pot lifts sampled during the 2007/2008 directed Bering Sea Tanner crab fishery east of 166° W longitude. 70
C11. Mean CPUE by depth for 773 pot lifts sampled during the 2007/2008 directed Bering Sea Tanner crab fishery east of 166° W longitude. 71
C12. Reproductive condition of female Tanner crabs from pot lifts sampled during the 2006/2007 and 2007/2008 directed Bering Sea Tanner crab fisheries east of 166° W longitude. 71
C13. Total contents of 1,918 pot lifts sampled during the 2007/2008 Bristol Bay red king crab fishery. 72
C14. Mean CPUE by soak time for 1,918 pot lifts sampled during the 2007/2008 Bristol Bay red king crab fishery. 73
C15. Mean CPUE by depth for 1,918 pot lifts sampled during the 2007/2008 Bristol Bay red king crab fishery. 74
C16. Reproductive condition of female red king crabs from pot lifts sampled during the 1996-2007/2008 Bristol Bay red king crab fisheries. 74
C17. Total contents of 2,088 pot lifts sampled during the combined 2007/2008 Aleutian Islands golden king crab fishery. 75
C18. Mean CPUE by soak time for 1,084 pot lifts sampled during the 2007/2008 Aleutian Islands golden king crab fishery west of 174° W longitude. 76
C19. Mean CPUE by depth for 1,084 pot lifts sampled during the 2007/2008 Aleutian Islands golden king crab fishery west of 174° W longitude. 77
C20. Reproductive condition of female golden king crabs from pot lifts sampled during the 1996/1997-2007/2008 Aleutian Islands golden king crab fisheries west of 174° W longitude. 78
C21. Mean CPUE by soak time for 1,004 pot lifts sampled during the 2007/2008 Aleutian Islands golden king crab fishery east of 174° W longitude. 79
C22. Mean CPUE by depth for 1,004 pot lifts sampled during the 2007/2008 Aleutian Islands golden king crab fishery east of 174° W longitude. 80
C23. Reproductive condition of female golden king crabs from pot lifts sampled during the 1996/1997-2007/2008 Aleutian Islands golden king crab fisheries east of 174° W longitude. 81

D1. Results of legal tally samples taken during the 2007/2008 Bering Sea and Aleutian Islands directed crab fisheries. 84

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 2007/2008 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 2007/2008 rationalized BSAI crab fisheries by shellfish 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, retained male catch size frequency distributions, legal tally sample results, and sample pot lift locations by fishery.

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 crab observer 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 both onboard observers and dockside samplers during the 2007/2008 Bering Sea snow crab fishery, the 2007/2008 Bering Sea Tanner crab fisheries east and west of 166° W longitude, the 2007/2008 Bristol Bay red king crab fishery and the 2007/2008 Aleutian Islands golden king crab fisheries east and west of 174° W longitude. For each fishery, it includes estimates of catch per unit effort (CPUE) and information on the size

and shell condition of retained crabs and crabs captured as bycatch and summaries of 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 sample methods are outlined in the most recent edition of the ADF&G Crab Observer Training and Deployment Manual (ADF&G 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, including 35% of those that participated in the Bering Sea snow crab fishery, 12% and 74% of those in the western and eastern Bering Sea Tanner crab fisheries, respectively, and 25% of those in the Bristol Bay red king crab fishery. In the Aleutian Islands golden king crab fisheries, 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.

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 2007/2008 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 weights.

Catcher-Processors

Sampling duties for observers deployed on catcher-processors included size frequency sampling, legal tally sampling from the retained catch, pot-lift sampling, and determination of average crab weight 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 floater-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 crab weight. If deliveries were made at sea, all sampling was completed by the observer deployed on the catcher-only vessel.

Attaining daily sampling goals for observers on board catcher-processor and catcher-only vessels (e.g., quantity of pot-lift samples conducted) was dependent upon a number of variables unique to each fishery and year. These variables include weather, catch rates, research data collection projects, and the order of sampling priorities established by ADF&G (ADF&G 2009).

Fishery specific methods, results, and discussions are combined in the results section of this report. Inconsistencies between previously published shellfish observer database reports and results presented here are due to correction of errors and more complete interpretation of historical data.

ESTIMATION OF CPUE AND TOTAL FISHERY CATCH

Estimates of CPUE presented here were generated from observer data using a ratio estimator. 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. With 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 the 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 was 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.

In past observer reports, different estimates of CPUE were calculated depending on the information available and on varying assumptions about the sampling design. The "sample CPUE," reported prior to 1996 (Tracy 1994, 1995a, b), was calculated as the simple average catch of 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 the 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, information on total pot lifts was taken from confidential interviews. Otherwise, data on total pot lifts were extracted from fish ticket summaries.

RESULTS

BERING SEA SNOW CRAB

During the 2007/2008 Bering Sea snow crab season, observers were deployed on 4 catcher-processor vessels and 26 of 74 catcher-only vessels participating in the Bering Sea snow crab fishery. The pot-lift sampling goal for observers on catcher-processors was 4 pot lifts during each day of fishing activity. The pot-lift sampling goal for observers on catcher-only vessels was 6 pot lifts during each day of fishing activity. The season opened 15 October 2007, and fishing began in November and continued into May 2008. Most of the effort took place from January through April 2008. A total of 1,731 pot lifts selected for sampling accounted for 1.20% of the 143,912 pot lifts reported by vessel operators (Bowers et al 2008). Locations of pot lifts sampled by observers during the 2007/2008 Bering Sea snow crab fishery are displayed in Appendix B1.

Measurements of CW for size frequency samples were taken from 49,860 retained male snow crabs throughout the season by onboard observers and ADF&G staff stationed at shore-side processing locations (Table 1). The mean CW of retained male snow crabs was 109.0 mm.

Onboard observers also measured CW of 222,709 male snow crabs from selected pot-lift samples. Mean CW was 104.8 mm. The percentage of male snow crabs sampled that were categorized as old shell or very-old shell condition was 6.4%. 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 365 female snow crabs during pot-lift sampling. Mean CW for this group was 70.5 mm with 58.9% categorized as old or very-old shell condition.

Estimated CPUE for legal retained snow crabs was 346.1 crabs per pot lift (Table 2). A 95% confidence interval for this estimate is (320.9, 371.3) from a t-distribution on 25 degrees of freedom, which includes the ATF CPUE of 349.7. The corresponding estimate of total harvest was 49,808,000 legal retained males. Legal retained males accounted for an estimated 68% of all snow crabs caught, while legal sized male crabs less than 4 inches (~102 mm) CW that were discarded as bycatch made up approximately 30%. Although the minimum legal size for snow crabs was 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 only about 1% of the total catch and 3% of the bycatch. The 2007/2008 estimate of CPUE for legal retained snow crab represents a 2.8% increase over the previous season estimate and was the highest estimated value since 1995 (Figure 2).

Total catches of all animals identified in sampled pot lifts during the 2007/2008 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 98,533 crabs, which accounted for 0.2% of the ATF estimate of total catch (Appendix D1). Of those, 0.22%, an estimated 110,000 crabs, were illegal, either due to size, sex or species restrictions.

BERING SEA TANNER CRAB

The 2007/2008 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 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 harvest legal Tanner crabs as incidental catch. 2007/2008 Bering Sea Tanner crab ATF estimates of effort, catch and CPUE presented in this report were calculated using only fish ticket data associated with directed Tanner crab deliveries (i.e., no coincident significant deliveries of other targeted species) and may differ substantially from values reported in Bowers et al (2008).

West of 166° W Longitude

During the 2007/2008 fishery west of 166° W longitude, observers were deployed on 2 catcher-processor vessels and on 4 of 33 catcher-only vessels registered to take directed catch in the Bering Sea Tanner crab fishery. The pot-lift sampling goal for observers on catcher-processors was 4 pot lifts during each day of fishing activity. The pot-lift sampling goal for observers on catcher-only vessels was 6 pot lifts during each day of fishing activity. The season opened 15 October 2007. Fishing began in November and continued into March 2008. The 104 pot lifts selected for pot-lift sampling accounted for 1.2% of the 8,558 pot lifts reported by vessel operators in the directed fishery (Bowers et al 2008). Locations of pot lifts sampled by observers during the 2007/2008 Bering Sea Tanner crab fishery west of 166° W longitude are displayed in Appendix B2.

Size frequency sample measurements of CW were taken from 1,658 retained male Tanner crabs throughout the directed-catch season by onboard observers and ADF&G staff stationed at shore-side processing locations (Table 3). Mean CW of retained male Tanner crabs was 145.9 mm.

Onboard observers also recorded CW of 10,441 male Tanner crabs from selected pot-lift samples during the directed Bering Sea Tanner crab fishery (Figure 3). Mean CW was 127.6 mm, and 11.3% of the measured crabs were categorized as old or very-old shell condition. Pot-lift sample measurements of CW were additionally taken throughout the season by onboard observers from 903 female Tanner crabs (Figure 4). Mean CW for female Tanner crabs from sampled pot lifts was 89.9 mm, and 88.9% of these were categorized as old or very-old shell condition.

For the directed Tanner crab fishery west of 166º W longitude, legal retained CPUE was estimated to be 23.4 crabs per pot lift (Table 13), with 95% confidence interval (17.7, 29.1) from a t-distribution on 3 degrees of freedom. By comparison, estimated ATF CPUE was 25.6. Corresponding estimated harvest of legal retained Tanner crabs in the directed fishery west of 166º was 200,000 crabs (Table 4). Legal retained males comprised only around 14% of the total number of Tanner crabs caught, whereas more than fives times as many, approximately 79%, were sublegal males discarded as bycatch. In addition to those Tanner crabs harvested in the directed fishery, another estimated 173,000 were harvested as incidental catch in the 2007/2008 Bering Sea snow crab fishery (Table 2). The 2007/2008 estimate of CPUE for retained legal Tanner crabs west of 166º W longitude was markedly lower than in the preceding two seasons at just over half of the estimated value during the 2005/2006 season (Figure 5).

Total catches of all animals identified in sampled pot lifts during the 2007/2008 Tanner crab directed 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 listed in Appendix C8.

Legal tallies conducted on catcher-only vessels delivering to processors totaled 3,850 crabs by the end of the 2007/2008 season and comprised 1.7% of the cumulative reported harvest

(Appendix D1). Approximately 0.9% of sampled crabs were illegal based on size, sex or species restrictions.

East of 166° W Longitude

During the 2007/2008 fishery season, observers were deployed on 1 catcher-processor vessel and 14 of 19 catcher-only vessels registered to take directed catch in the Bering Sea Tanner crab fishery east of 166° W longitude. The pot-lift sampling goal for observers on catcher-processors was 4 pot lifts during each day of fishing activity and 6 pot lifts during each day of fishing activity for observers on catcher-only vessels. The season opened at noon on 15 October 2007 and fishing began in October and continued until the season closed on 31 March 2008. The 773 pot lifts selected for pot-lift sampling accounted for 3.0% of ATF estimated 26,131 pot lifts reported by vessel operators in the directed fishery (Bowers et al 2008). Locations of pot lifts sampled by observers during the 2007/2008 Bering Sea Tanner crab fishery east of 166° W longitude are displayed in Appendix B3.

Size frequency sample measurements of CW were taken from 4,169 retained male Tanner crabs throughout the directed-catch season by onboard observers and ADF&G staff stationed at shore-side processing locations (Table 5). The mean CW of retained male Tanner crabs was 148.0 mm.

Onboard observers also obtained CW measurements of 51,531 male Tanner crabs from selected pot-lift samples during the season (Figure 6). Mean CW for these crabs was 128.5 mm, and 16.1% were categorized as old or very-old shell condition. Pot-lift sample measurements of CW were likewise taken throughout the season by onboard observers from 2,415 female Tanner crabs from the Bering Sea Tanner crab fishery (Figure 7). The mean CW for female Tanner crabs from sampled pot lifts was 94.9 mm. Observers judged approximately 40.7% to be old or very-old shell.

Estimated CPUE for legal retained Tanner crabs in the directed Tanner crab fishery east of 166° W longitude was 25.8 crabs per pot lift (Table 6) with 95% confidence interval (23.5, 28.1) based on a t-distribution on 13 degrees of freedom, which includes the ATF CPUE of 25.6. Based on a total of 26,131 reported pot lifts in the directed fishery, the estimated CPUE yields an estimated total harvest of 674,000 legal retained Tanner crabs (Table 6). Legal retained Tanner crabs accounted for approximately 20.9% of the total Tanner crab catch in the directed fishery. As in the western Tanner crab directed fishery, a much greater proportion of the target species catch, 74.2%, consisted of sublegal males discarded as bycatch. In addition, another estimated 11,000 Tanner crabs were harvested as incidental catch in the concurrent 2007/2008 Bristol Bay directed red king crab fishery. See Table 8. Whereas the 2007/2008 estimated CPUE for sublegal crabs was higher than in the previous year, estimated CPUE for legal retained Tanner crabs showed a nearly 40% reduction (Figure 7).

Total catches of all animals identified in sampled pot lifts during the 2007/2008 Tanner crab directed fishery east of 166° W longitude 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 the sampled pot lifts is documented in Appendix C12.

Legal tallies conducted on catcher-only vessels delivering to processors totaled 12,827 crabs by the end of the 2007/2008 season and comprised 1.9% of the cumulative reported harvest (Appendix D1). It is estimated that from all sampled crabs in this fishery, approximately 0.9% were illegal due to size, sex or species restrictions.

BRISTOL BAY RED KING CRAB

Observers were deployed on 3 catcher-processor vessels and 17 of 71 registered catcher-only vessels during the 2007/2008 Bristol Bay red king crab fishery. The observer sampling goal was 5 pot lifts during each day of fishing activity on catcher-processors and 10 pot lifts on catcher-only vessels. The season began on 15 October 2007 and fishing continued into January 2008. A total of 1,918 pot lifts selected for sampling accounted for 1.7% of the 113,214 pot lifts reported by vessel operators (Bowers et al 2008). Locations of pot lifts sampled by observers during the 2007/2008 Bristol Bay red king crab fishery are displayed in Appendix B4.

Size frequency sample measurements of CL were taken from 22,388 retained male red king crabs throughout the season by onboard observers and ADF&G staff stationed at shore-side processing locations (Table 8). The mean CL of retained male red king crabs was 151.2 mm.

Throughout the season onboard observers also obtained CL measurements of 111,261 male red king crabs and 12, 417 female red king crabs from sampled pot lifts (Figures 9 and 10). Mean CL for male red king crabs from sampled pot lifts was 133.5 mm, and the percentage of old and very-old shell condition male red king crabs in was 16.1%. Mean CL for female red king crabs from sampled pot lifts was 111.9 mm. Approximately.0.9% were categorized as old or very-old shell.

Estimated CPUE for legal retained red king crabs was of 29.2 crabs per pot lift (Table 8), with 95% confidence interval (26.9, 31.5) from a t-distribution on 16 degrees of freedom, which includes the ATF CPUE of 27.7. Based on the total of 113,214 reported pot lifts, the corresponding estimate of fishery harvest was 3,306,000 legal retained red king crabs (Table 8). It is estimated that this number represents 42.2% of all captured red king crabs, with the other portion being discarded due to size, condition or sex. Approximately 80% of those discarded were sublegal males. Estimated 2007/2008 CPUE for legal male red king crabs was 29.6 crabs per pot lift and was approximately 15% lower than the previous season estimate of 34.7, which, however, was the highest estimated value since 1995 (Figure 11).

Total catches of all animals identified in sampled pot lifts during the 2007/2008 season are provided in Appendix C13. Additional appendices contain CPUE by soak time (Appendix C14) and depth (Appendix C15) and 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 28,879 crabs by the end of the 2007/2008 season and comprised 0.9% of the cumulative reported harvest (Appendix D1). Approximately 0.3% were illegal due to size, sex or species restrictions.

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

During the 2007/2008 Aleutian Islands golden king crab fishery west of 174° W longitude, observers were deployed on 1 catcher-processor vessel and 2 catcher-only vessels. The sampling

goal for observers on catcher-processors was 9 pot lifts for each day fished and 14 pot lifts for each day fished for those on catcher-only vessels. The fishery opened 15 August 2007 and continued until May 2008. A total of 1,084 pot lifts were selected for sampling, accounting for 3.6% of the 29,950 pot lifts reported by vessel operators (Bowers et al 2008). Locations of pot lifts sampled by observers during the 2007/2008 Aleutian Islands golden king crab fishery west of 174° W longitude are displayed in Appendix B5.

Size frequency sample measurements of CL were taken from 9,669 retained male golden king crabs throughout the season by onboard observers and ADF&G staff stationed at shore-side processing locations (Table 9). Mean CL of retained male golden king crabs was 151.3 mm.

In addition, pot-lift sample measurements of CL were taken from 55,816 male golden king crabs throughout the season by onboard observers (Figure 12). Mean CL for male golden king crabs from sampled pot lifts was 132.1 mm, and 96.1% were categorized as new shell condition, as opposed to old or very-old shell condition. Pot-lift sample measurements of CL were also taken from 39,329 female golden king crabs throughout the season by onboard observers (Figure 13). Female mean CL for golden king crabs from sampled pot lifts was 126.5 mm, and 98.8% were categorized as new shell condition.

The 2007/2008 estimated CPUE for legal retained golden king crabs was 22.3 crabs per pot lift (Table 10), with 95% confidence interval (21.1, 23.5) based on a standard normal distribution. The ATF CPUE was 20.1. Associated estimated harvest based on 29,950 pot lifts was 668,000 legal golden king crabs (Table 10). The 2007/2008 estimated CPUE of 22.4 for legal male golden king crab, though not statistically distinguishable from the previous year's estimate, was the highest estimated value since the 1994/1995 fishery (Figure 14). An estimated 51.5% of all golden king crabs captured during the 2007/2008 fishery were discarded as bycatch, of which more than half, approximately 56.1%, were females.

Total catches of all animals identified in sampled pot lifts during the combined 2007/2008 Aleutian Islands golden king crab seasons 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 from sampled pot lifts for the golden king crab fishery west of 174° W (Appendix C20).

Legal tallies conducted on catcher-processors and catcher-only vessels delivering to processors from both east and west of 174° W longitude totaled 41,333 crabs by the end of the 2007/2008 season and comprised approximately 3.3% of the cumulative reported harvest (Appendix D1). Among all sampled crabs, 0.38% were illegal due to size, sex or species restrictions.

East of 174° W Longitude

During the 2007/2008 Aleutian Islands golden king crab fishery east of 174° W longitude, observers were deployed on 1 catcher-processor vessel and 3 catcher-only vessels. The sampling goal was 9 pot lifts per fishing day for observers on catcher-processors and for 14 pot lifts per fishing day for observers on catcher-only vessels. The season opened 15 August 2007 and fishing continued into January 2008. The 1,004 pot lifts selected for sampling accounted for 4.4% of the 22,653 pot lifts reported by vessel operators (Bowers et al 2008). Locations of pot lifts sampled by observers during the 2007/2008 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 2,950 retained male golden king crabs throughout the season by onboard observers and ADF&G staff stationed at shore-side processing locations (Table 11). The mean CL of retained male golden king crabs was 151.9 mm.

Measurements of CL were also taken from 84,667 male golden king crabs in sampled pot lifts throughout the season by onboard observers (Figure 15). Male mean CL for was 129.4 mm, and observers categorized 3.8% as old or very old shell condition. Onboard observers additionally obtained CL measurements of 54,403 female golden king crabs (Figure 16). Female mean CL for golden king crabs from sampled pot lifts was 117.3 mm, and 3.4% were judged to be old or very old shell.

Estimated legal retained golden king crab CPUE for this fishery was 29.9 crabs per pot lift, as compared to the ATF value of 28.0 (Table 12). A 95% confidence interval for this estimate is (27.9, 30.4) from a standard normal distribution. Assuming the reported total of 22,653 pot lifts for this fishery, the associated estimate of harvest is 677,000 legal retained golden king crabs. The historical sequence of estimates of legal male CPUE exhibits an increasing trend since the 1994 fishery, with the 2007/2008 estimate of 29.9 legal male golden king crabs per pot lift the highest observed (Figure 17). An estimated 33% of all golden king crabs captured during the 2007/2008 fishery were discarded as bycatch. Approximately 62.3% of the discarded crabs were males (Table 12).

Total catches of all animals identified in sampled pot lifts during the combined 2007/2008 Aleutian Islands golden king crab season are provided in Appendix C17. Additional appendices contain CPUE by soak time (Appendix C21) and depth (Appendix C22) and reproductive condition of female golden king crabs from sampled pot lifts for the eastern fishery (Appendix C23).

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, 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 all indicate reasonable levels of precision, ranging from 0.02 (most precise) for the Aleutian Islands golden king crab fishery east of 174º W longitude to 0.08 (least precise) for the Bearing Sea Tanner crab fishery west of 166º W longitude. Another measure of 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 2, 4, 6, 8, 10, 12), this document additionally reports 95% confidence intervals associated with each estimated CPUE for retained legal crabs of the target species. These confidence intervals are based on a *t*-distribution, as described in more detail in Appendix A1. It is of note that with the exception of the western Aleutian Islands golden king crab fishery, all reported confidence intervals include the corresponding ATF estimate of CPUE derived from fish ticket data (Table 13).

Because an estimator may be precise and still be inaccurate in the sense of assuming a value very far from the target parameter, in addition to its precision it is of interest also to assess an estimator's accuracy. Some indication of the accuracy of an estimated CPUE for legal retained

crab within a particular fishery may be gained by directly comparing it to the corresponding ATF estimate. 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. Overall, the two estimates of CPUE for legal retained crabs are reasonably close for all six directed fisheries described in this document, the largest discrepancy being a relative difference of 10.9 % in the western Aleutian Islands golden king crab fishery (Table 13).

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, on catcher-processor vessels and only a sample of registered catcher-only vessels, or on catcher-processor vessels only, 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 pots 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.

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TABLES AND FIGURES

Table 1.–Carapace width (CW) frequency distributions by shell condition from biological measurements of retained snow crabs sampled during the 2007/2008 Bering Sea snow crab fishery.

Carapace Width[a] (mm)	Percent			
	New Shell	Old Shell	Very Old Shell	All
< 76	< 0.1	< 0.1	0	< 0.1
76-80	< 0.1	< 0.1	0	< 0.1
81-85	< 0.1	< 0.1	0	< 0.1
86-90	0.1	< 0.1	0	0.2
91-95	0.6	0.1	< 0.1	0.7
96-100	4.9	0.7	< 0.1	5.6
101-105	22.5	2.9	< 0.1	25.4
106-110	27	4.3	0.1	31.5
111-115	17.6	3.1	< 0.1	20.8
116-120	8.5	1.5	< 0.1	10.0
121-125	3.7	0.7	< 0.1	4.4
126-130	0.9	0.2	< 0.1	1.2
131-135	0.2	0.1	< 0.1	0.2
136-140	< 0.1	< 0.1	0	< 0.1
141-145	0	< 0.1	0	< 0.1
146-150	0	< 0.1	0	< 0.1
Total Crab	42,847	6,778	235	49,860
Total Percent	85.9	13.6	0.5	100

[a] Average CW = 109.0 mm.

Table 2.–Estimated catch per pot (CPUE) of selected crab species from 1,731 pot lifts sampled by observers deployed during the 2007/2008 Bering Sea snow crab fishery.

Species/Sex Class	CPUE	SE	Estimated Catch[a]
Snow crab			
retained legal males	346.1[b]	12.243	49,808,000[c]
legal males not retained	152.3	6.699	21,918,000
sublegal males	4.4	0.527	633,000
females	0.9	0.700	130,000
Tanner crab			
retained legal males	1.2	0.484	173,000
legal males not retained	1.7	0.636	245,000
sublegal males	25.3	4.368	3,641,000
females	2.1	0.402	302,000
Tanner / Snow hybrid			
retained legal males	0.3	0.269	43,000
legal males not retained	0.2	0.149	29,000
sublegal males	0.2	0.042	29,000
females	< 0.1	0.009	< 14,000

[a] Estimated catch is the product of estimated CPUE and the total number of reported pot lifts (143,912).

[b] Actual total fishery CPUE of retained legal crabs was 349.7.

[c] Actual total fishery catch of retained legal crabs was 50,327,594.

Table 3.–Carapace width (CW) frequency distributions by shell condition from biological measurements of retained Tanner crabs sampled during the 2007/2008 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	< 0.1	< 0.1	0	< 0.1
136-140	10.9	9.8	< 0.1	20.7
141-145	20.0	15.5	0.1	35.6
146-150	14.2	8.9	0.1	23.2
151-155	7.6	5.1	< 0.1	12.8
156-160	2.5	2.4	0	4.9
161-165	0.5	1.4	0	1.9
166-170	0.2	0.2	0	0.4
171-175	0.3	0.1	0	0.4
Total Crab	932	720	6	1,658
Total Percent	56.2	43.4	0.4	100

[a] Average CW = 145.9 mm.

Table 4.–Estimated catch per pot (CPUE) of selected crab species from 103 pot lifts sampled by observers deployed during the 2007/2008 directed Bering Sea Tanner crab fishery west of 166° W longitude.

Species / Sex Class	CPUE	SE	Estimated Catch[a]
Tanner crab			
retained legal males	23.4[b]	1.777	200,000[c]
legal males not retained	0.4	0.195	3,000
sublegal males	129.9	23.775	1,112,000
females	10.1	4.322	86,000
Snow crab			
retained legal males	11.3	9.672	97,000
legal males not retained	12.6	2.357	108,000
sublegal males	0.3	0.163	3,000
females	< 0.1	0.024	< 1,000

[a] Estimated catch is the product of estimated CPUE and the total number of reported pot lifts (8,558).

[b] Actual total fishery CPUE of retained legal crabs was 25.6.

[c] Actual total fishery catch of retained legal crabs was 219,061.

Table 5.–Carapace width (CW) frequency distributions by shell condition from biological measurements of retained Tanner crabs sampled during the 2007/2008 directed Bering Sea Tanner crab fishery east of 166° W longitude.

Carapace Width[a] (mm)	Percent			
	New Shell	Old Shell	Very Old Shell	All
< 136	0.1	0	0	0.1
136-140	11.4	4.7	0.3	16.4
141-145	19.0	9.2	0.5	28.7
146-150	13.7	7.6	0.7	22
151-155	9.6	5.3	0.4	15.3
156-160	6.7	3.0	0.3	10.0
161-165	3.4	1.8	0.1	5.3
166-170	1.2	0.6	0	1.8
171-175	0.3	< 0.1	< 0.1	0.4
176-180	< 0.1	< 0.1	0	0.1
Total Crab	2,730	1,346	93	4,169
Total Percent	65.5	32.3	2.2	100

[a] Average CW = 148.0 mm.

Table 6.–Estimated catch per pot (CPUE) of selected crab species from 773 pot lifts sampled by observers deployed during the 2007/2008 directed Bering Sea Tanner crab fishery east of 166° W longitude.

Species / Sex Class	CPUE	SE	Estimated Catch[a]
Tanner crab			
retained legal males	25.8[b]	1.081	674,000[c]
legal males not retained	0.8	0.297	3,000
sublegal males	91.7	7.024	2,396,000
females	5.2	0.513	136,000
Snow crab			
retained legal males	0[d]	–	–
legal males not retained	23.3	1.852	609,000
sublegal males	0.7	0.066	18,000
females	< 0.1	0.007	< 3,000
Red king crab			
retained legal males	0[d]	–	–
legal males not retained	< 0.1	0.062	< 3,000
sublegal males	< 0.1	0.019	< 3,000
females	< 0.1	0.054	< 3,000

[a] Estimated catch is the product of estimated CPUE and the total number of reported pot lifts (26,131).

[b] Actual total fishery CPUE of retained legal crabs was 25.6.

[c] Actual total fishery catch of retained legal crabs was 669,208.

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

Table 7.– Estimated catch per pot (CPUE) of selected crab species from 1,918 pot lifts sampled by observers deployed during the 2007/2008 Bristol Bay red king crab fishery.

Species / Sex Class	CPUE	SE	Estimated Catch[a]
Red king crab			
retained legal males	29.2[b]	1.105	3,306,000[c]
legal males not retained	0.4	0.084	45,000
sublegal males	31.4	5.341	3,555,000
females	7.3	1.133	826,000
Tanner crab			
retained legal males	0.1	0.078	11,000
legal males not retained	0.2	0.051	223,000
sublegal males	0.4	0.092	45,000
females	< 0.1	0.015	< 11,000

[a] Estimated catch is the product of the CPUE estimate and the total reported number of pot lifts (113,214).

[b] Actual total fishery CPUE of retained legal crabs was 27.7

[c] Actual total fishery catch of retained legal crabs for was 3,139,337.

Table 8.–Carapace length (CL) distribution by shell condition from biological measurements of retained red king crabs sampled during the 2007/2008 Bristol Bay red king crab fishery.

Carapace Length[a] (mm)	Percent			
	New Shell	Old Shell	Very Old Shell	All
< 131	< 0.1	0	0	< 0.1
131-135	1.3	0.3	< 0.1	1.6
136-140	8.7	2.4	< 0.1	11.2
141-145	13.8	4.6	0.3	18.7
146-150	13.4	5.8	0.3	19.5
151-155	11.8	5.6	0.4	17.8
156-160	9.2	4.3	0.3	13.8
161-165	5.6	3.0	0.3	8.9
166-170	2.8	2.1	0.2	5.1
171-175	1.0	1.1	0.1	2.3
176-180	0.3	0.4	< 0.1	0.8
181-185	< 0.1	< 0.1	< 0.1	0.2
186-190	< 0.1	< 0.1	< 0.1	< 0.1
191-195	0	< 0.1	0	< 0.1
196-200	0	< 0.1	0	< 0.1
Total Crabs	15,250	6,695	443	22,388
Total Percent	68.1	29.9	2.0	100

[a] Average CL = 151.2 mm.

Table 9.–Carapace length (CL) distribution by shell condition from biological measurements of retained golden king crabs sampled during the 2007/2008 Aleutian Islands golden king crab fishery west of 174° W longitude.

Carapace Length[a] (mm)	Percent			
	New Shell	Old Shell	Very Old Shell	All
< 126	0	0	0	0
126-130	< 0.1	0	0	< 0.1
131-135	2.3	< 0.1	0	2.3
136-140	11.8	0.1	< 0.1	12.0
141-145	19.7	0.3	< 0.1	20.0
146-150	18.3	0.4	< 0.1	18.8
151-155	14.7	0.4	< 0.1	15.1
156-160	11.4	0.4	0	11.9
161-165	8.6	0.4	< 0.1	9.0
166-170	5.7	0.2	0	5.9
171-175	2.8	0.2	0	3.0
176-180	1.3	< 0.1	0	1.3
181-185	0.5	< 0.1	0	0.5
18 - 90	0.1	0	0	0.1
191-195	< 0.1	< 0.1	0	< 0.1
196-200	< 0.1	0	0	< 0.1
Total Crabs	9,411	248	10	9,669
Total Percent	97.3	2.6	0.1	100

[a] Average CL = 151.3 mm.

Table 10.–Estimated catch per pot (CPUE) of selected crab species from 1,084 pot lifts sampled by observers deployed during the 2007/2008 Aleutian Islands golden king crab fishery west of 174° W longitude.

Species / Sex Class	CPUE	SE	Estimated Catch[a]
Golden king crab			
retained legal males	22.3[b]	0.634	668,000[c]
legal males not retained	0.2	0.019	6,000
sublegal males	10.3	0.482	308,000
females	13.3	0.924	398,000

[a] Estimated catch is the product of the CPUE estimate and the total number of reported pot lifts (29,950).

[b] Actual total fishery CPUE of retained legal crabs was 20.1.

[c] Actual total fishery catch of retained legal crabs 600,604.

Table 11.–Carapace length (CL) distribution by shell condition from biological measurements of retained golden king crabs sampled during the 2007/2008 Aleutian Islands golden king crab fishery east of 174° W longitude.

Carapace Length[a] (mm)	Percent			
	New Shell	Old Shell	Very Old Shell	All
< 126	< 0.1	< 0.1	0	< 0.1
126-130	0	0	0	0
131-135	1.7	0.6	0	2.3
136-140	9.2	1.7	0	10.9
141-145	15.8	2.2	0	18.0
146-150	16.4	1.5	< 0.1	17.9
151-155	15.8	1.5	0.1	17.4
156-160	11.1	1.6	0	12.7
161-165	8.3	0.9	0	9.2
166-170	5.8	0.4	0	6.2
171-175	2.7	0.3	0	3.0
176-180	1.4	0.2	0	1.5
181-185	0.6	0.1	0	0.7
186-190	< 0.1	< 0.1	0	0.1
191-195	< 0.1	0	0	< 0.1
Total Crabs	2,621	325	4	2,950
Total Percent	88.8	11.0	0.1	100

[a] Average CL = 151.9 mm.

Table 12.–Estimated catch per pot (CPUE) of selected crab species from 1,004 pot lifts sampled by observers deployed during the 2007/2008 Aleutian Islands golden king crab fishery east of 174° W longitude.

Species / Sex Class	CPUE	SE	Estimated Catch[a]
Golden king crab			
retained legal males	29.9[b]	0.624	677,000[c]
legal males not retained	0.9	0.065	20,000
sublegal males	8.7	0.512	19,7000
females	5.8	0.374	131,000

[a] Estimated catch is the product of the CPUE estimate and the total number of reported pot lifts (22,653).

[b] Actual total fishery CPUE of retained legal crabs was 28.0.

[c] Actual catch of retained legal crabs for the fishery was 653,252 .

Table 13.–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	78	30	143,912	1,731	349.7	346.1[b]	-1.0
Bering Sea Tanner crab west of 166º W	35	6	10,065	103	25.6	23.4[b]	-8.6
Bering Sea Tanner crab east of 166º W	20	15	26,441	773	25.6	25.8[b]	0.8
Bristol Bay red king crab	74	21	113,214	1,918	27.7	29.2[b]	5.4
Aleutian Islands golden king crab west of 174º W	3	3	29,950	1,084	20.1	22.3	10.9
Aleutian Islands golden king crab east of 174º W	4	4	22,653	1,004	28.0	29.9[b]	6.8

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

[b] 95% confidence interval contains ATF CPUE.

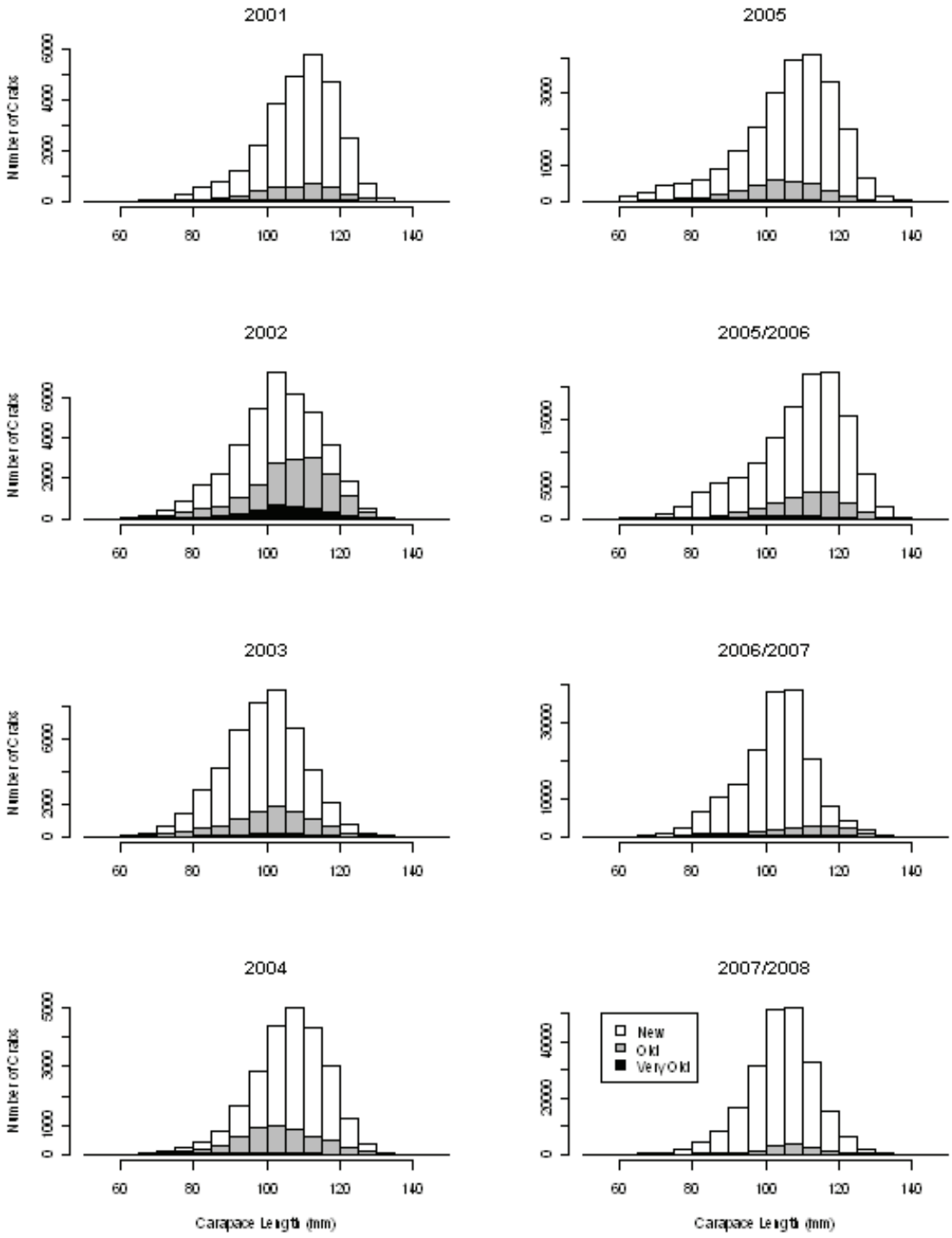


Figure 1.–Carapace width distribution with shell condition for male snow crabs from pot lifts sampled during the 2001-2007/2008 Bering Sea snow crab fisheries.

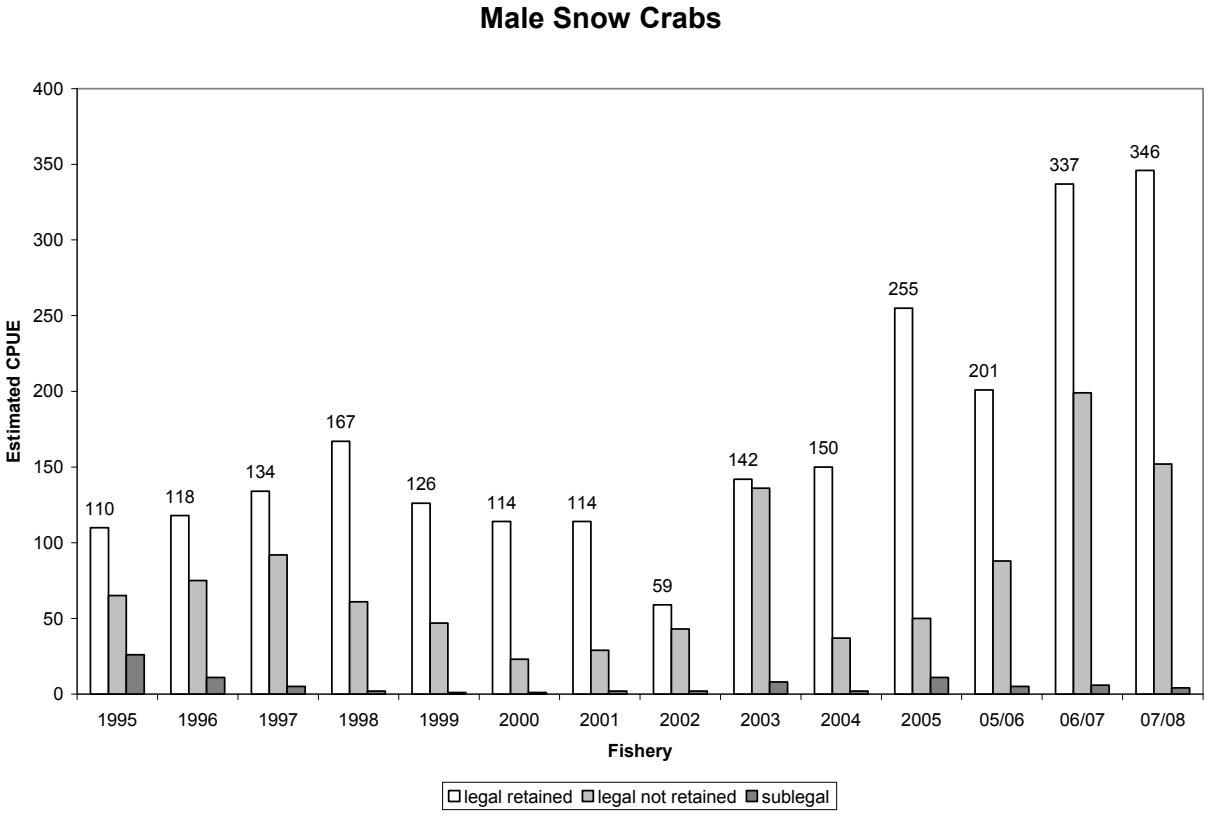


Figure 2.–Estimated CPUE for male snow crab from pot lifts sampled during the 1995-2007/2008 Bering Sea snow crab fisheries.

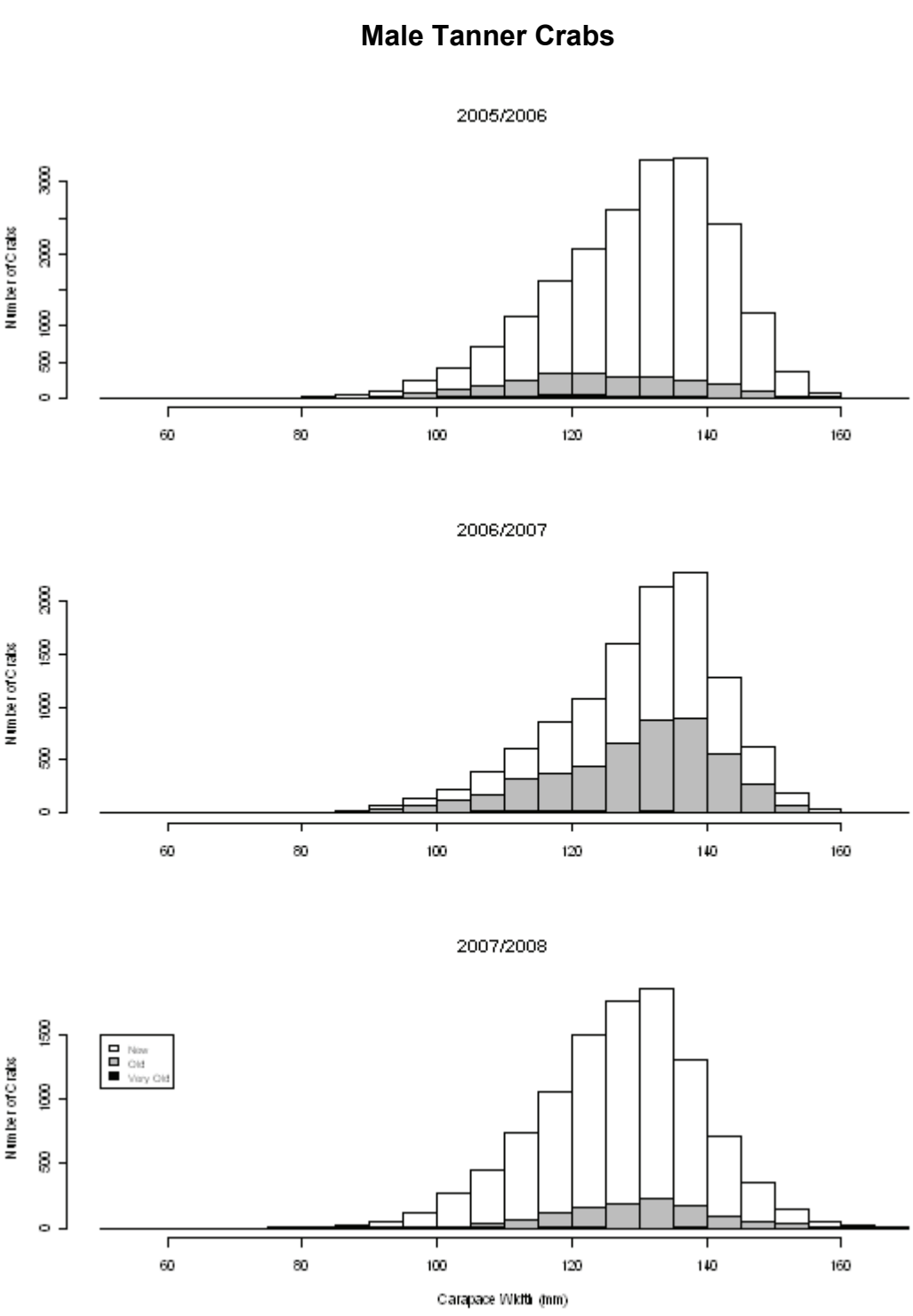


Figure 3.–Carapace width distribution with shell condition for male Tanner crabs from pot lifts sampled during the 2005/2006 - 2007/2008 directed Bering Sea Tanner crab fisheries west of 166° W longitude.

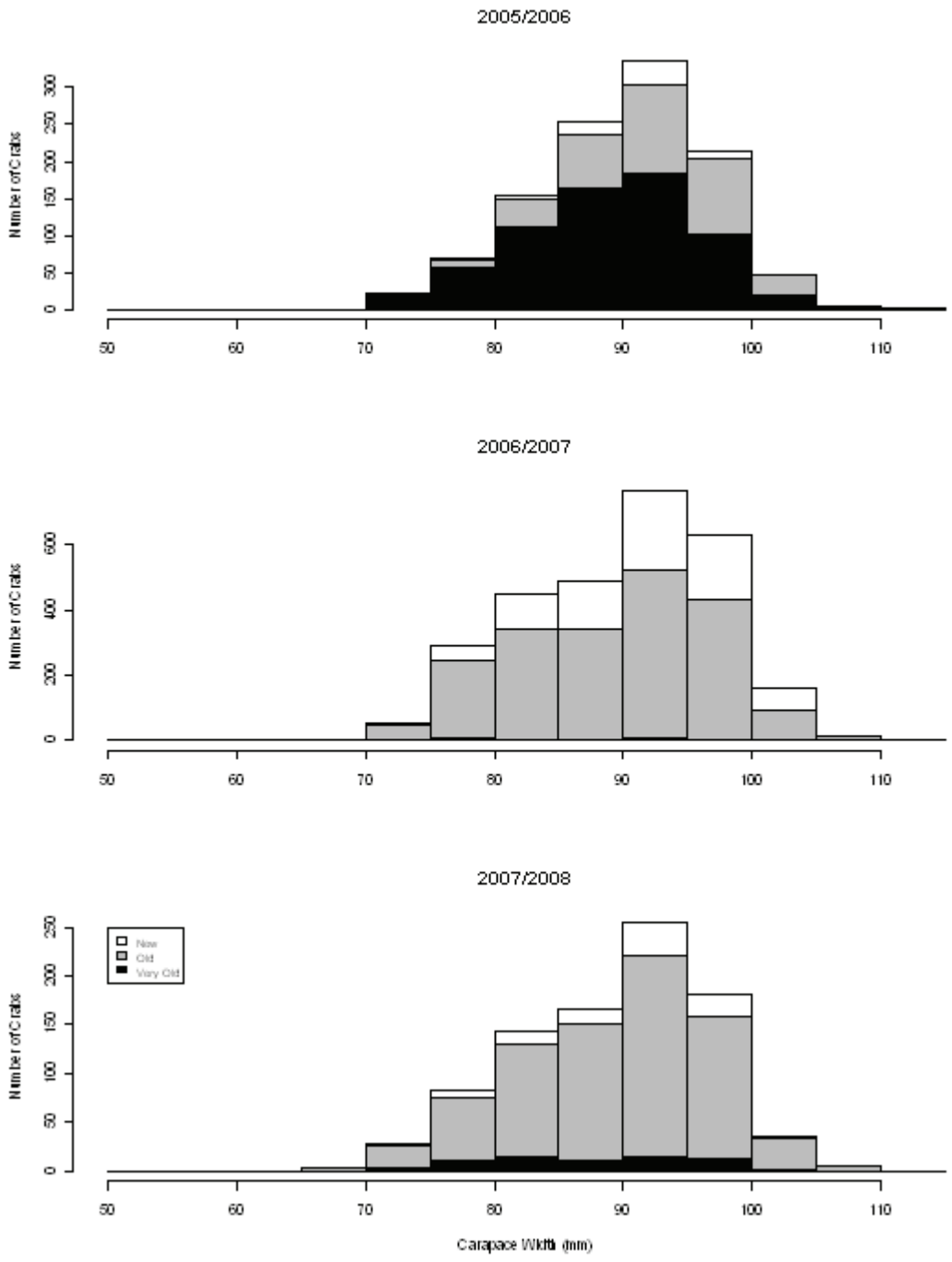


Figure 4.–Carapace width distribution with shell condition for female Tanner crabs from pot lifts sampled during the 2005/2006 - 2007/2008 directed Bering Sea Tanner crab fisheries west of 166° W longitude.

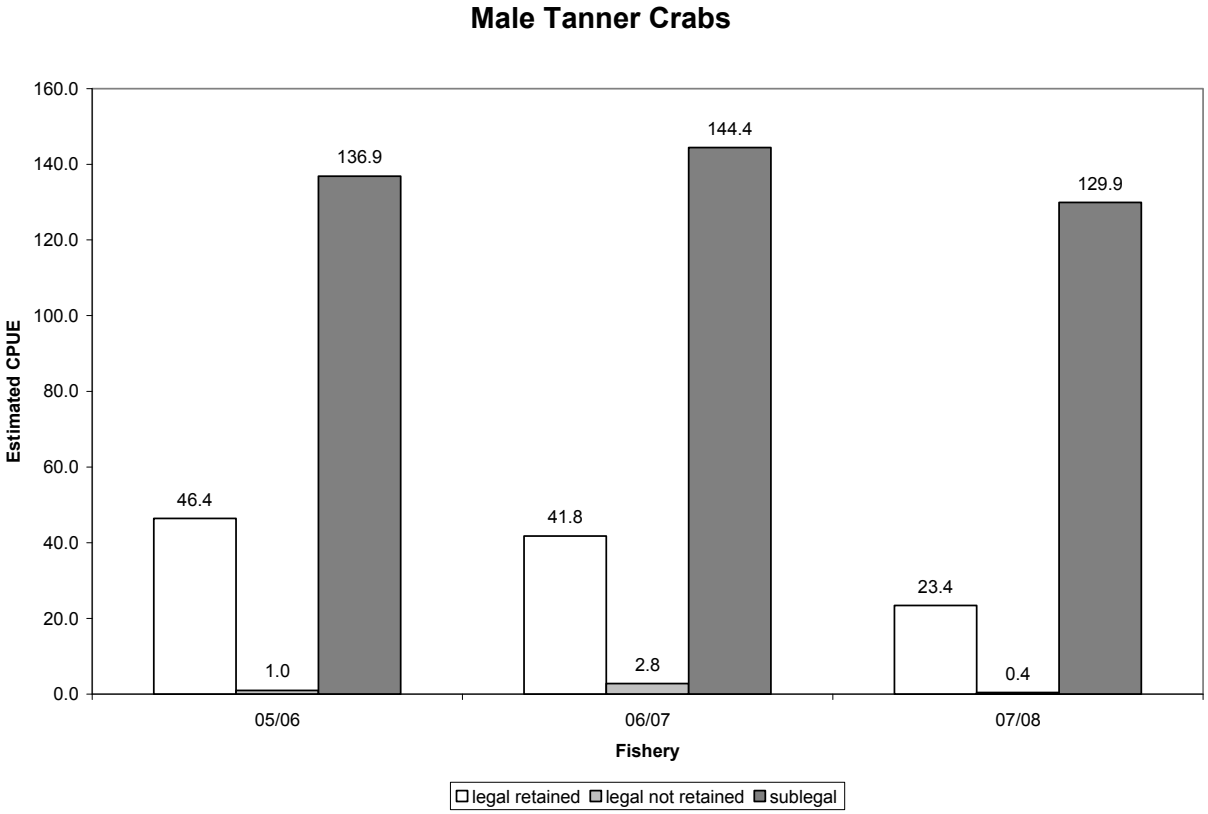


Figure 5.–Estimated CPUE for male Tanner crab from pot lifts sampled during the 2005/2006-2007/2008 directed Bering Sea Tanner crab fisheries west of 166º W longitude.

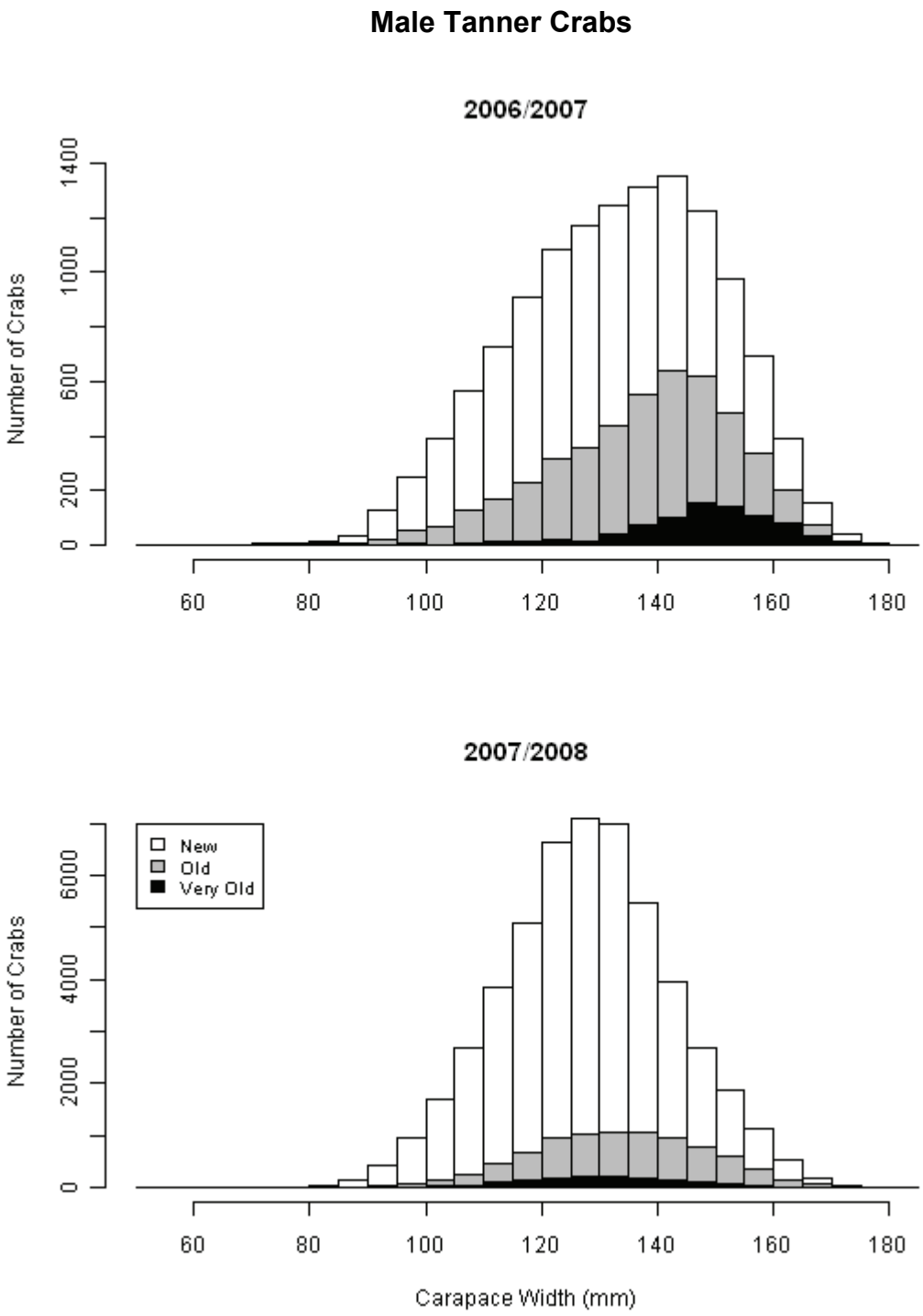


Figure 6.–Carapace width distribution with shell condition for male Tanner crabs from pot lift sampled during the 2006/2007 and 2007/2008 directed Bering Sea Tanner crab fisheries east of 166° W longitude.

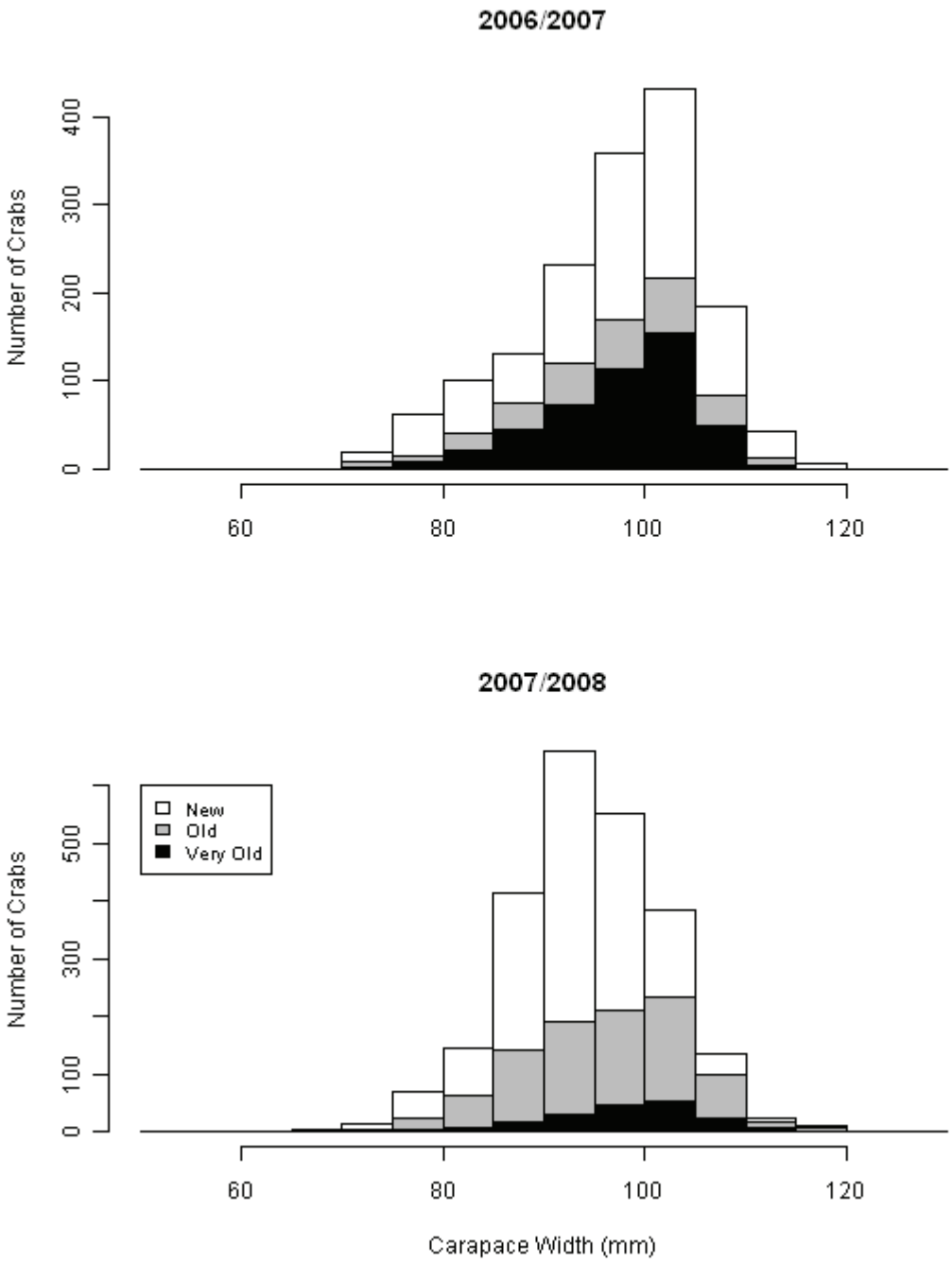


Figure 7.–Carapace width distribution with shell condition for female Tanner crabs from pot lifts sampled during the 2006/2007 and 2007/2008 directed Bering Sea Tanner crab fisheries east of 166° W longitude.

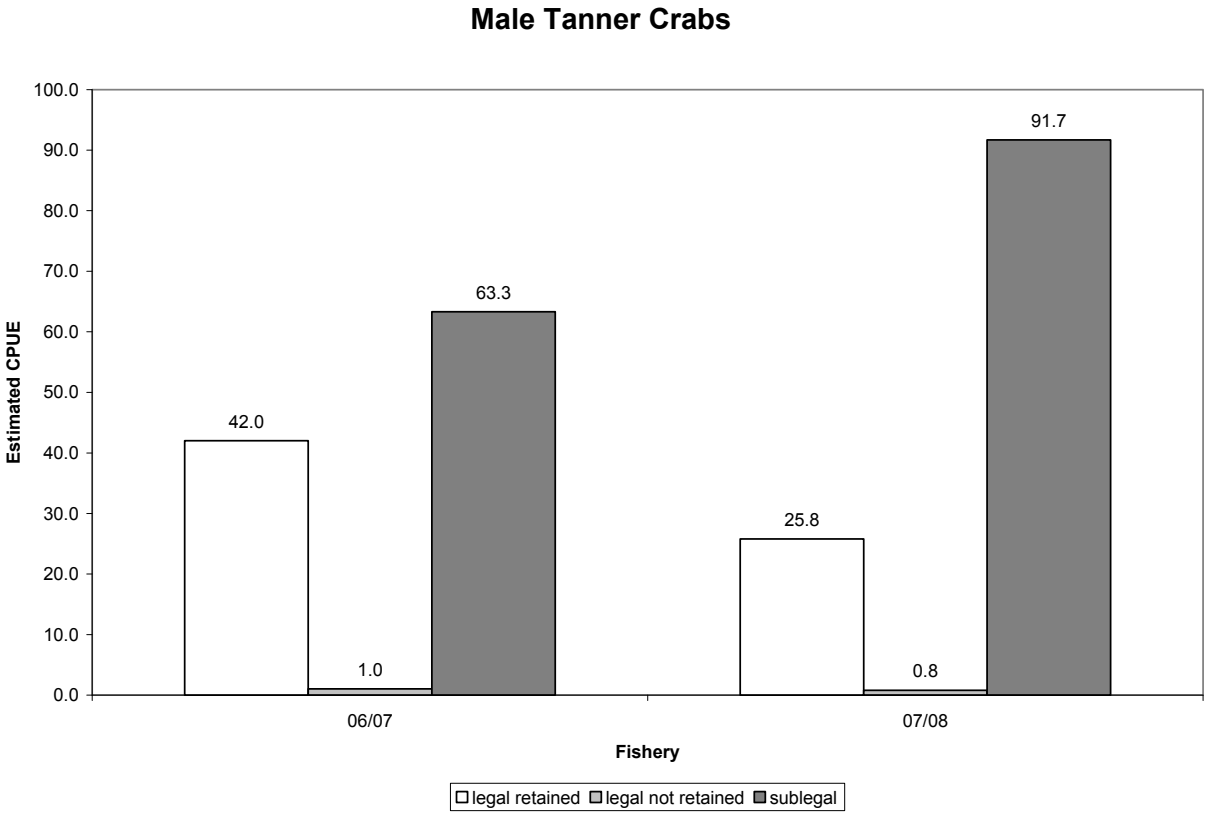


Figure 8.–Estimated CPUE for male Tanner crab from pot lifts sampled during the 2006/2007-2007/2008 directed Bering Sea Tanner crab fisheries east of 166º W longitude.

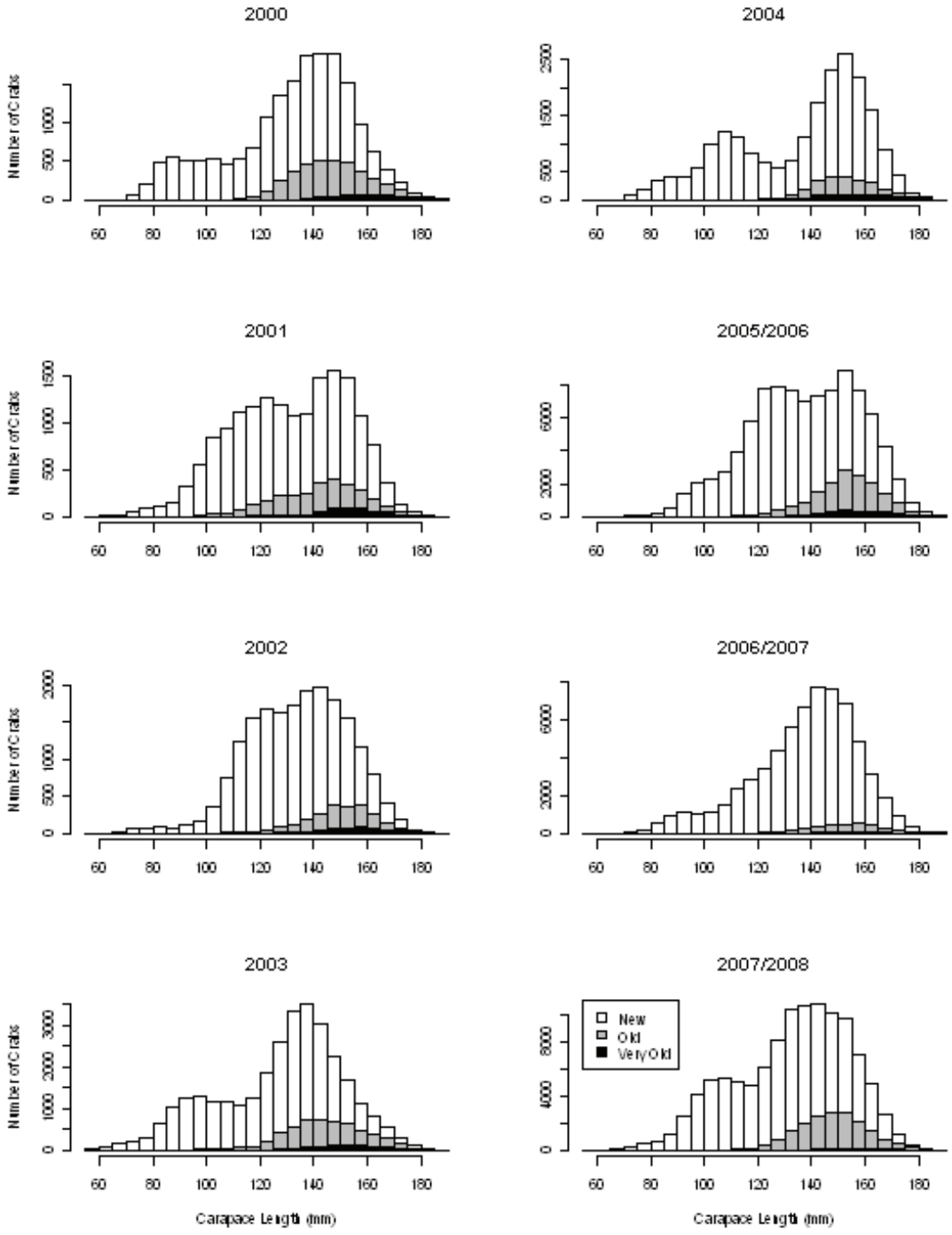


Figure 9.–Carapace length distribution with shell condition for male red king crabs from pot lifts sampled during the 2000-2007/2008 Bristol Bay red king crab fisheries.

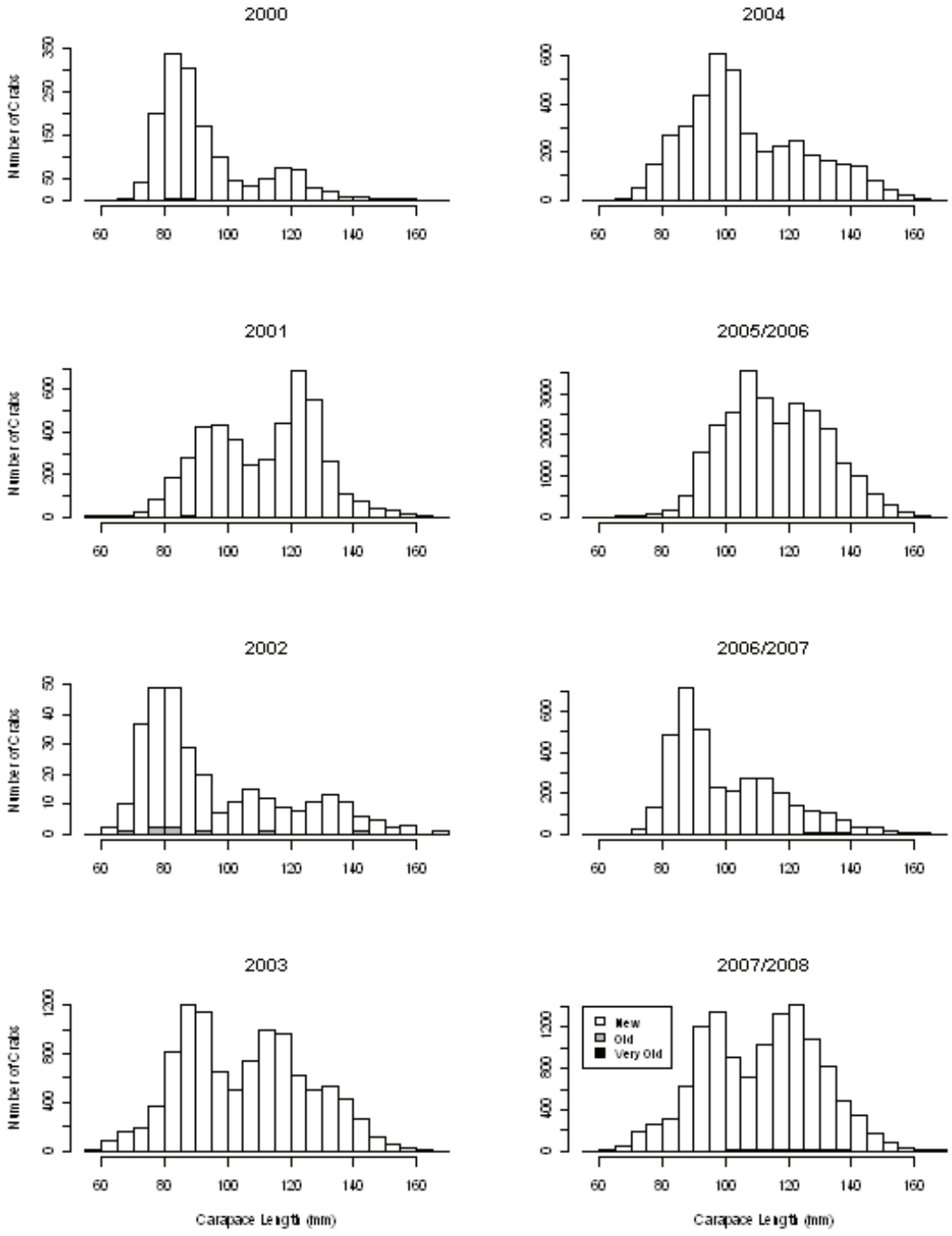


Figure 10.–Carapace length distribution with shell condition for female red king crabs from pot lifts sampled during the 2000-2007/2008 Bristol Bay red kind crab fisheries.

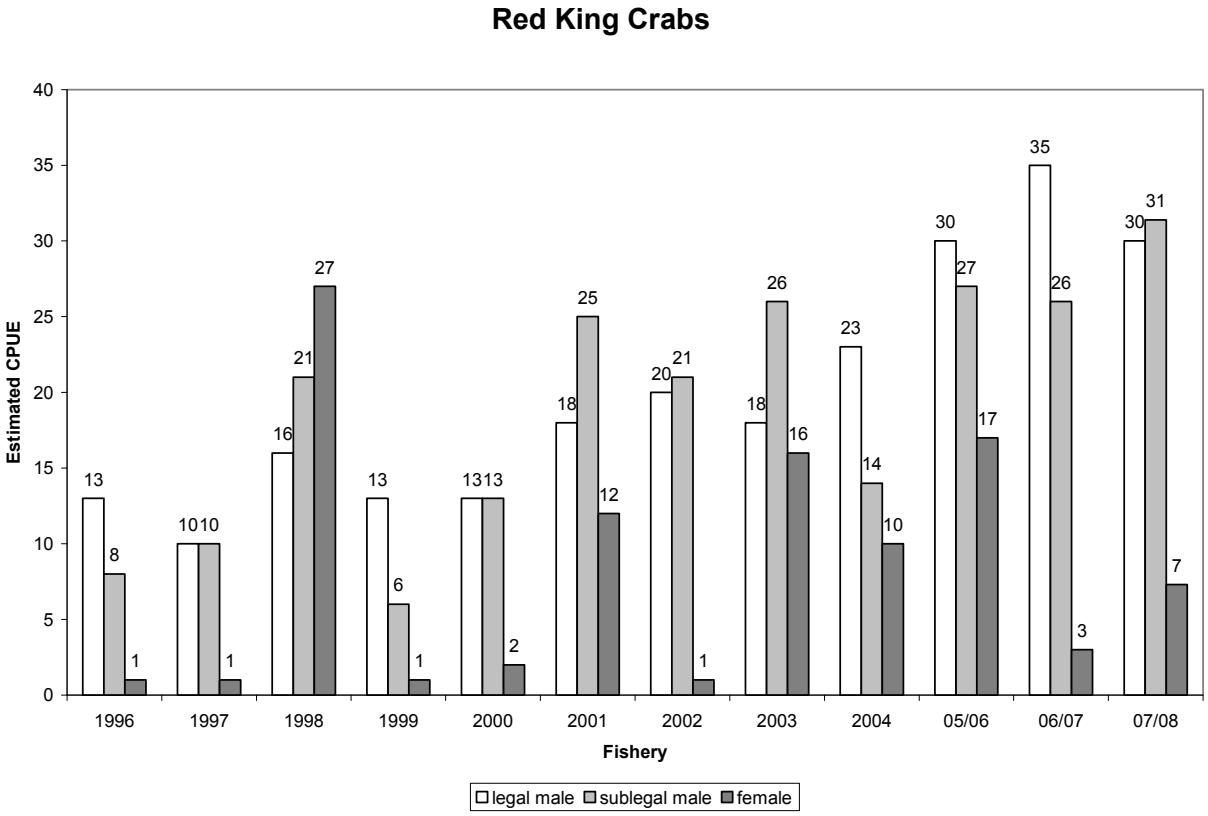


Figure 11.–Estimated CPUE for red king crabs from pot lifts sampled during the 1996-2007/2008 Bristol Bay red king crab fisheries.

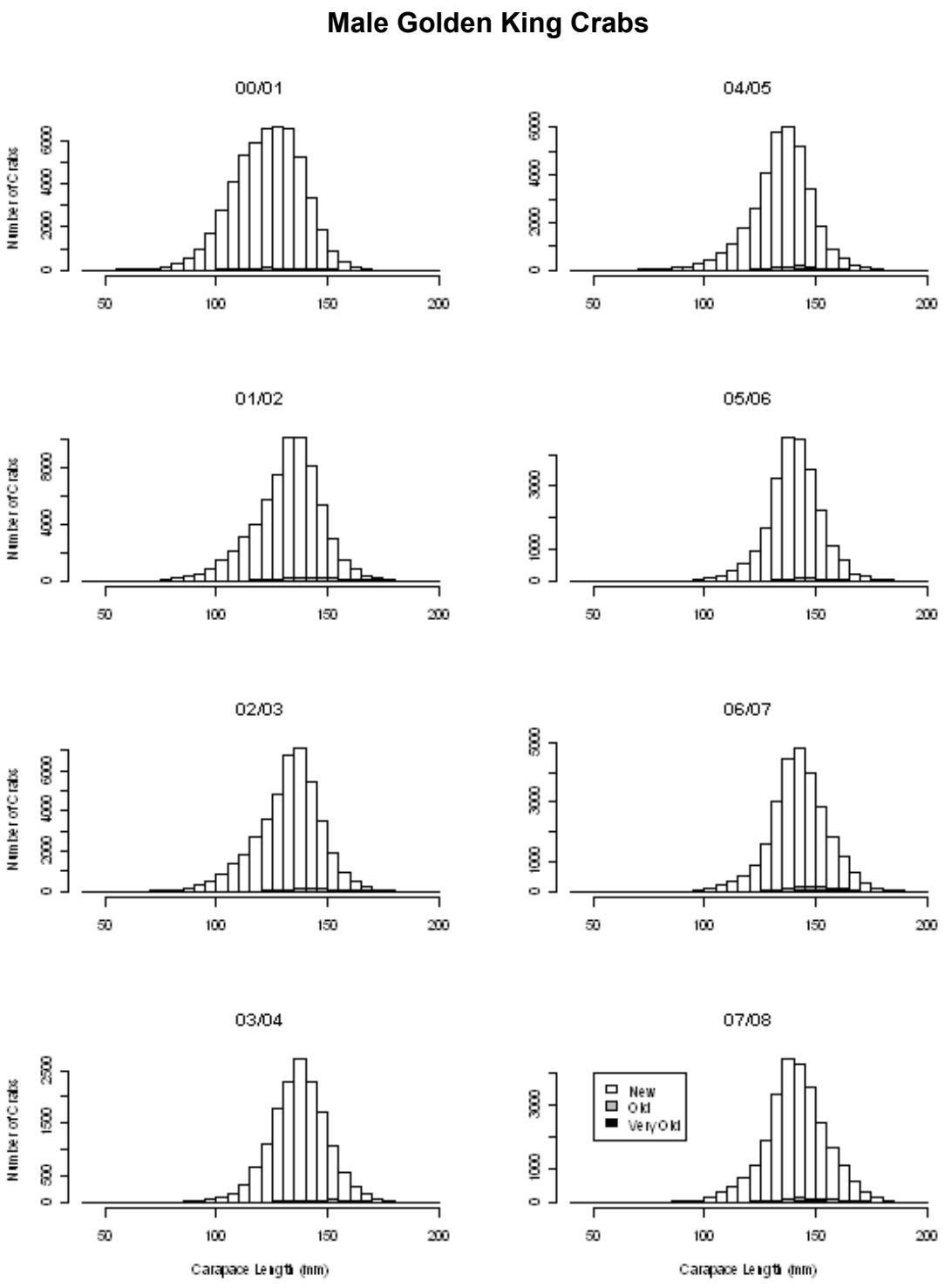


Figure 12.–Carapace length distribution with shell condition for male golden king crabs from pot lifts sampled during the 2000/2001-2007/2008 Aleutian Islands golden king crab fisheries west of 174° W longitude.

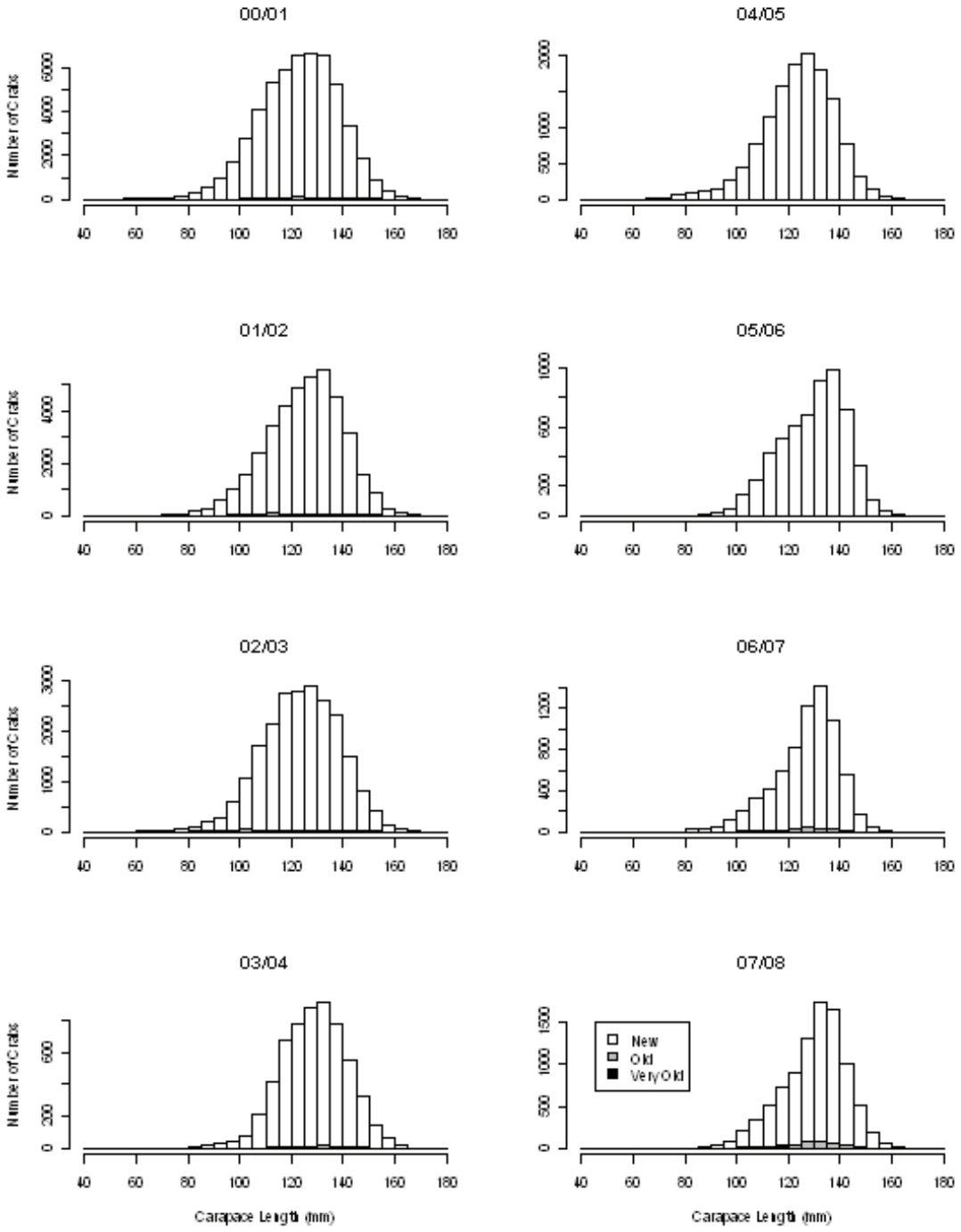


Figure 13.–Carapace length distribution with shell condition for female golden king crabs from pot lifts sampled during the 2000/2001-2007/2008 Aleutian Islands golden king crab fisheries west of 174° W longitude.

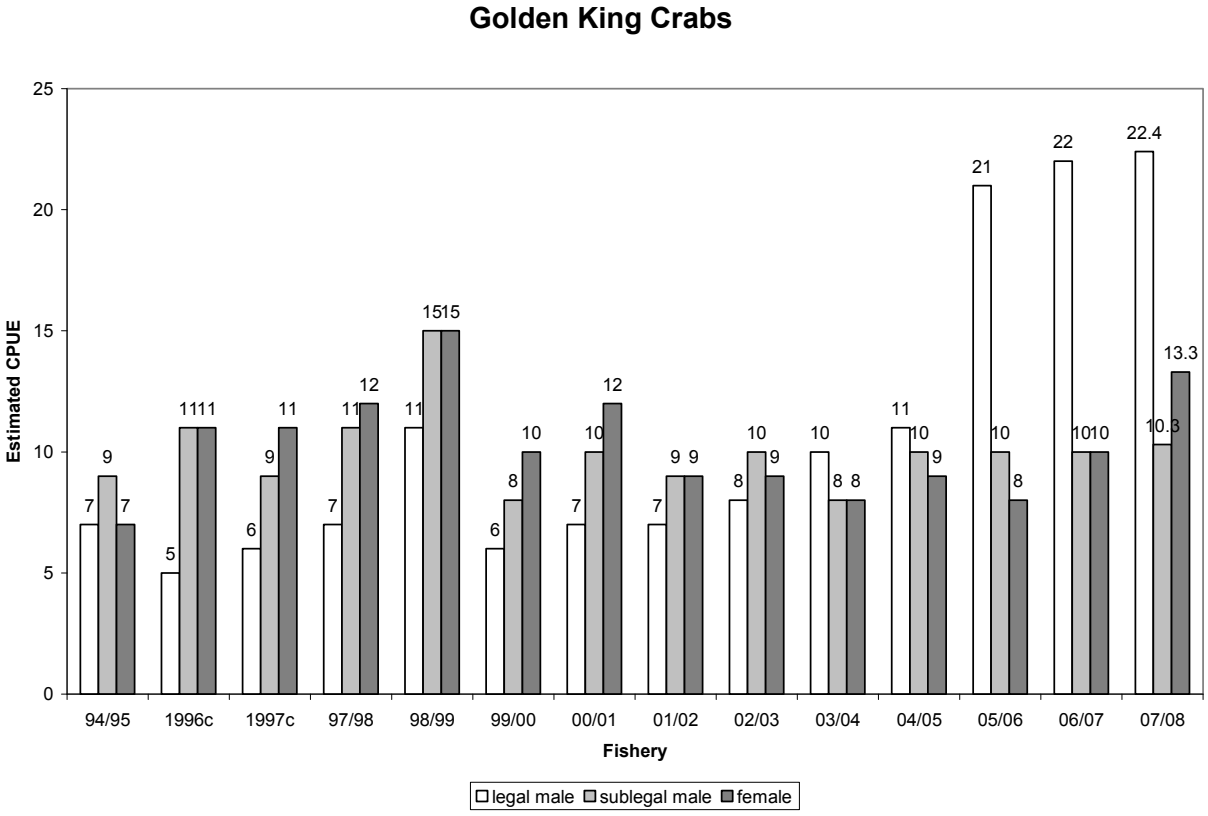


Figure 14.–Estimated CPUE for male golden king crabs from pot lifts sampled during the 1994/1995-2007/2008 golden king crab fisheries west of 174ºW longitude.

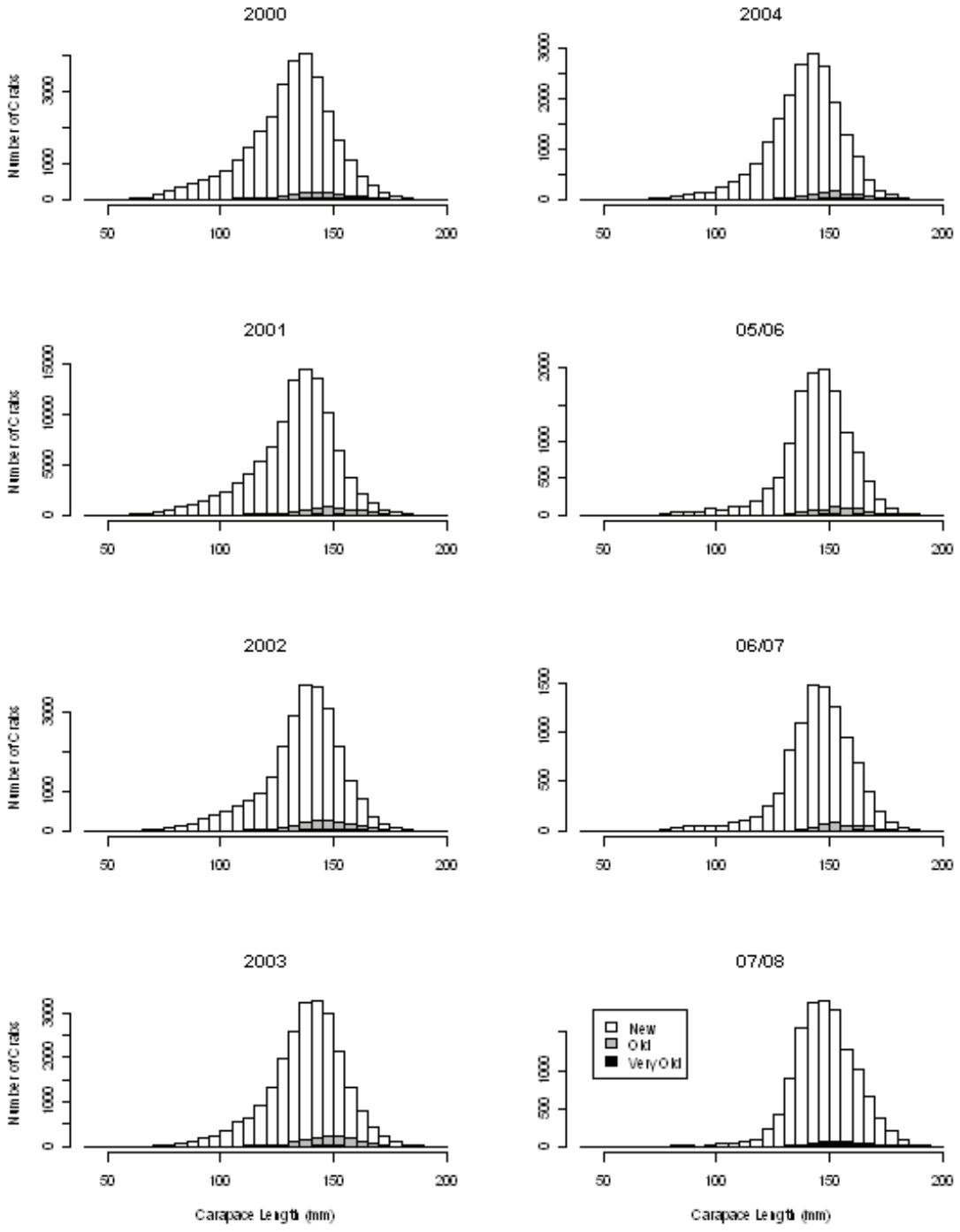


Figure 15.–Carapace length distribution with shell condition for male golden king crabs from pot lifts sampled during the 2000-2007/2008 Aleutian Islands golden king crab fisheries east of 174° W longitude.

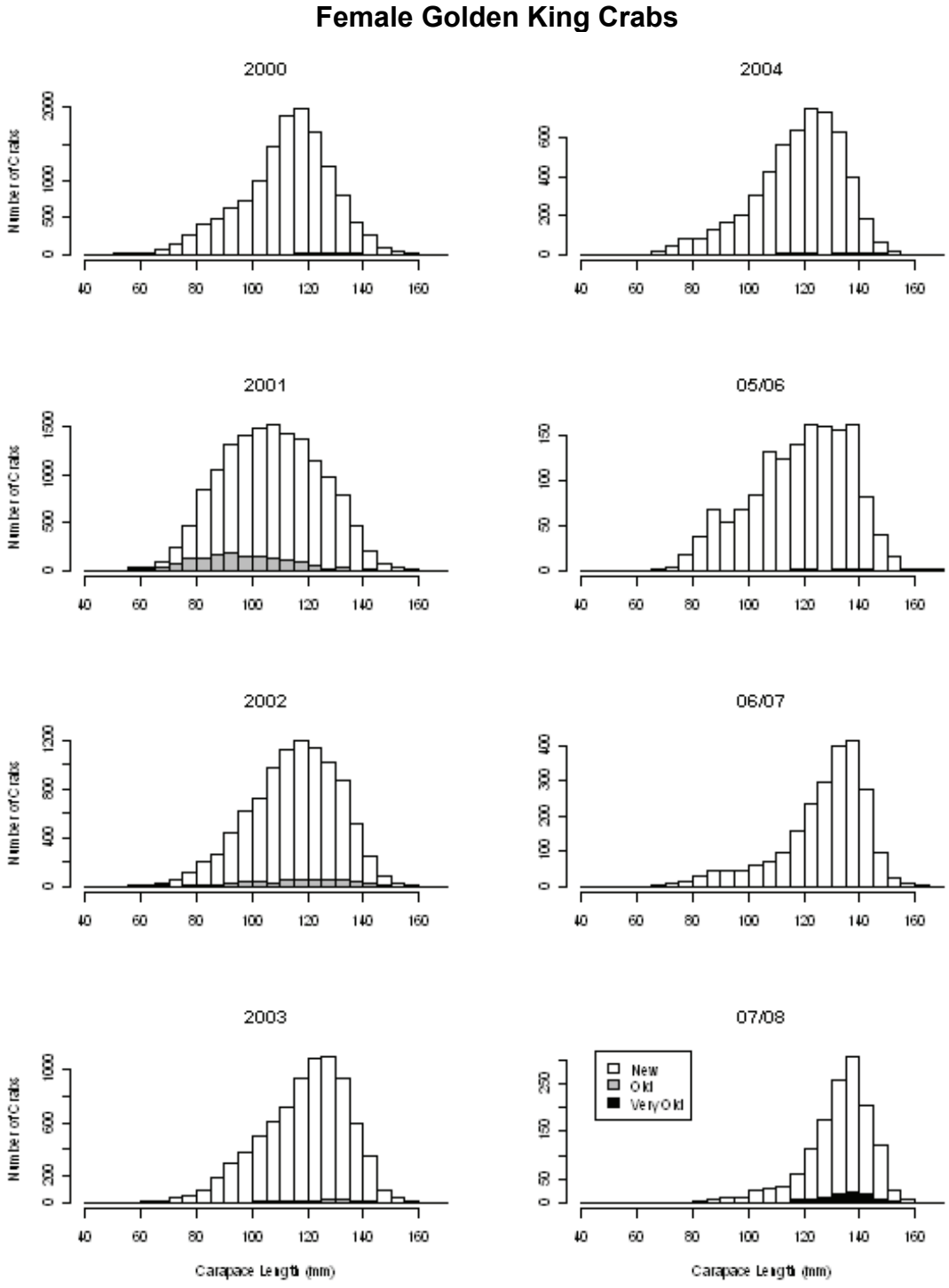


Figure 16.–Carapace length distribution with shell condition for female golden king crabs from pot lifts sampled during the 2000-2007/2008 Aleutian Islands golden king crab fisheries east of 174° W longitude.

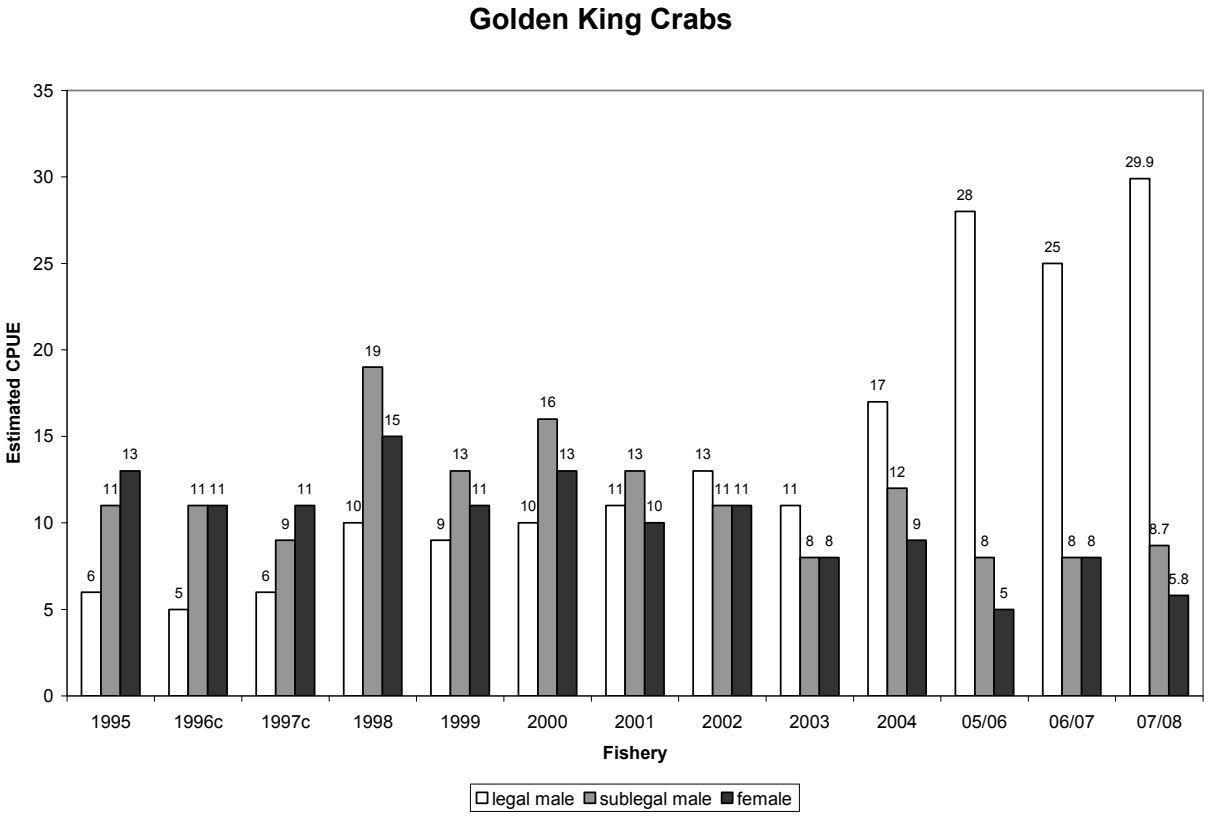


Figure 17.–Estimated CPUE for male golden king crabs from pot lifts sampled during the 1995-2007/2008 Aleutian Islands golden king crab fisheries east of 174º W longitude.

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 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

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

-continued-

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

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

-continued-

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, 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 λ is the simple expansion estimator

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

with unbiased variance estimator

$$\hat{Var}[\hat{\lambda}] = M^2(1-\frac{m}{M})\frac{1}{m}\frac{\sum_j^m(N_j-\bar{N})}{m-1} \tag{6}$$

where $\bar{N}$ 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, respectively, 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

-continued-

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

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

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

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 $\mu = \frac{\tau_F}{\lambda_F}$ 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

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

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

$$Var[\sum_j^m(\frac{1}{\lambda_F}\hat{\tau}_j - \frac{\tau_F}{\lambda_F^2}N_j)] = Var[E[\sum_j^m(\frac{1}{\lambda_F}\hat{\tau}_j - \frac{\tau_F}{\lambda_F^2}N_j) \mid S]\} + E[Var[\sum_j^m(\frac{1}{\lambda_F}\hat{\tau}_j - \frac{\tau_F}{\lambda_F^2}N_j) \mid S]]$$

$$= Var[\sum_j^m(\frac{1}{\lambda_F}E[\hat{\tau}_j \mid S] - \frac{\tau_F}{\lambda_F^2}N_j)] + E[\sum_j^m \frac{1}{\lambda_F^2}Var[\hat{\tau}_j \mid S]]$$

-continued-

$$= Var[\sum_{j}^{m}(\frac{1}{\lambda_F}\hat{\tau}_j - \frac{\tau_F}{\lambda_F^2}N_j)] + E[\sum_{j}^{m}\frac{1}{\lambda_F^2}Var[\hat{\tau}_j]$$

$$= m(1-\frac{m}{M})\frac{\sum_{j}^{M}(q_j-\bar{q})^2}{M-1} + \frac{m}{M\lambda_F^2}\sum_{j}^{M}Var[\hat{\tau}_j] \tag{13}$$

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

$$Var[\hat{\mu}] \cong \frac{M_C^2}{m_C}(1-\frac{m_C}{M_C})S_{qC}^2 + \frac{M_C}{m_c\lambda_F^2}\sum_{j}^{M_C}Var[\hat{\tau}_j^C]$$
$$+ \frac{M_{CP}^2}{m_{CP}}(1-\frac{m_{CP}}{M_{CP}})S_{qCP}^2 + \frac{M_{CP}}{m_{CP}\lambda_F^2}\sum_{j}^{M_{CP}}Var[\hat{\tau}_j^{CP}] \tag{14}$$

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

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

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

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

where $t_{df,\alpha}$ denotes the $100(1-\alpha)^{th}$ percentile of the *t*-distribution on *df* degrees of freedom. In general, we take $df = m_C - 1$, unless all catcher vessels participating in the directed fishery are observed, in which case we use the standard normal distribution to determine the appropriate

-continued-

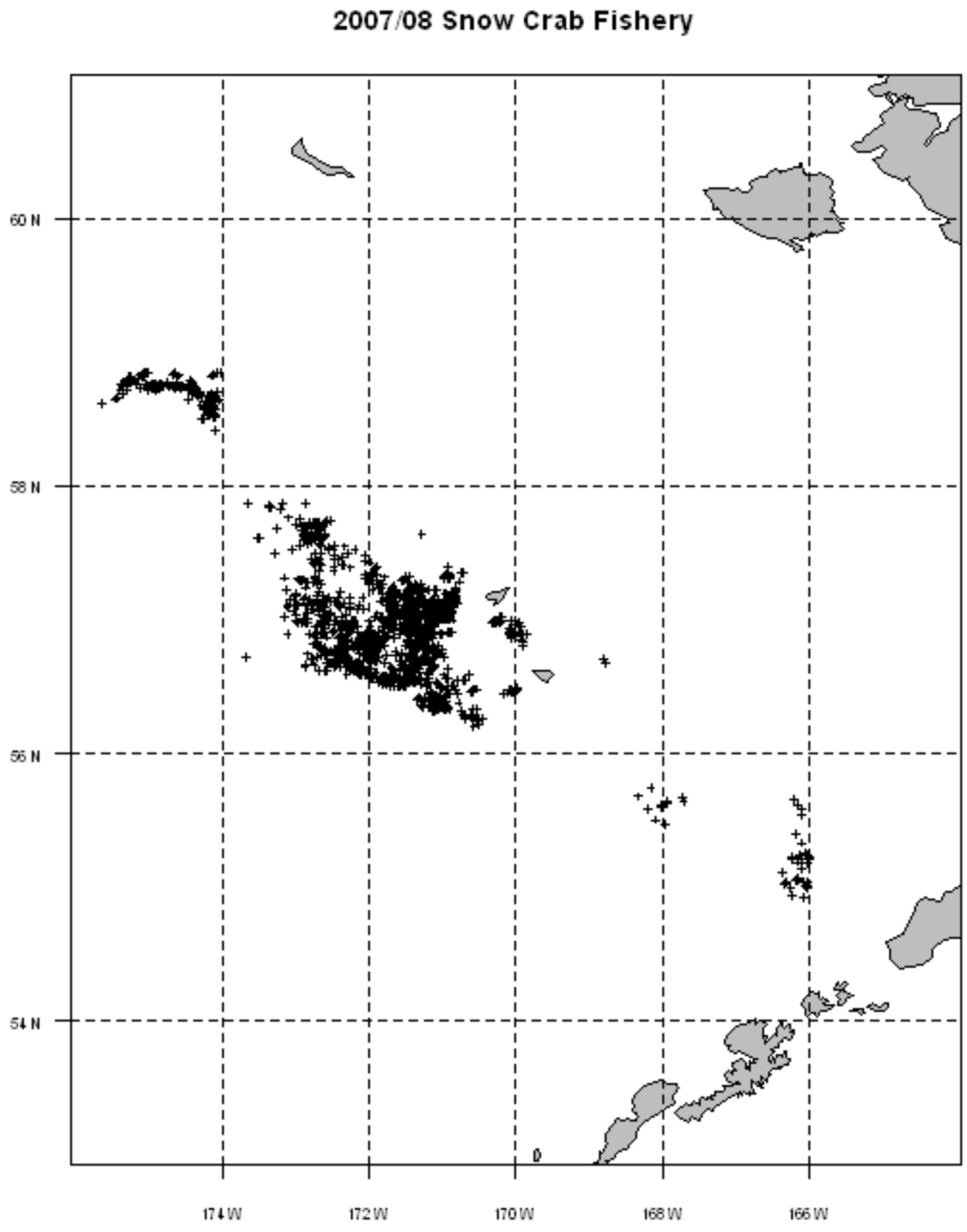
multiplier. (Recall that m_C is the number of observed catcher-only vessels in the directed fishery.) Small sample sizes at some levels of the design, underlying skewed pot count distributions, theoretical bias of the ratio estimator and the use of an approximate variance admittedly give reason for concern 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

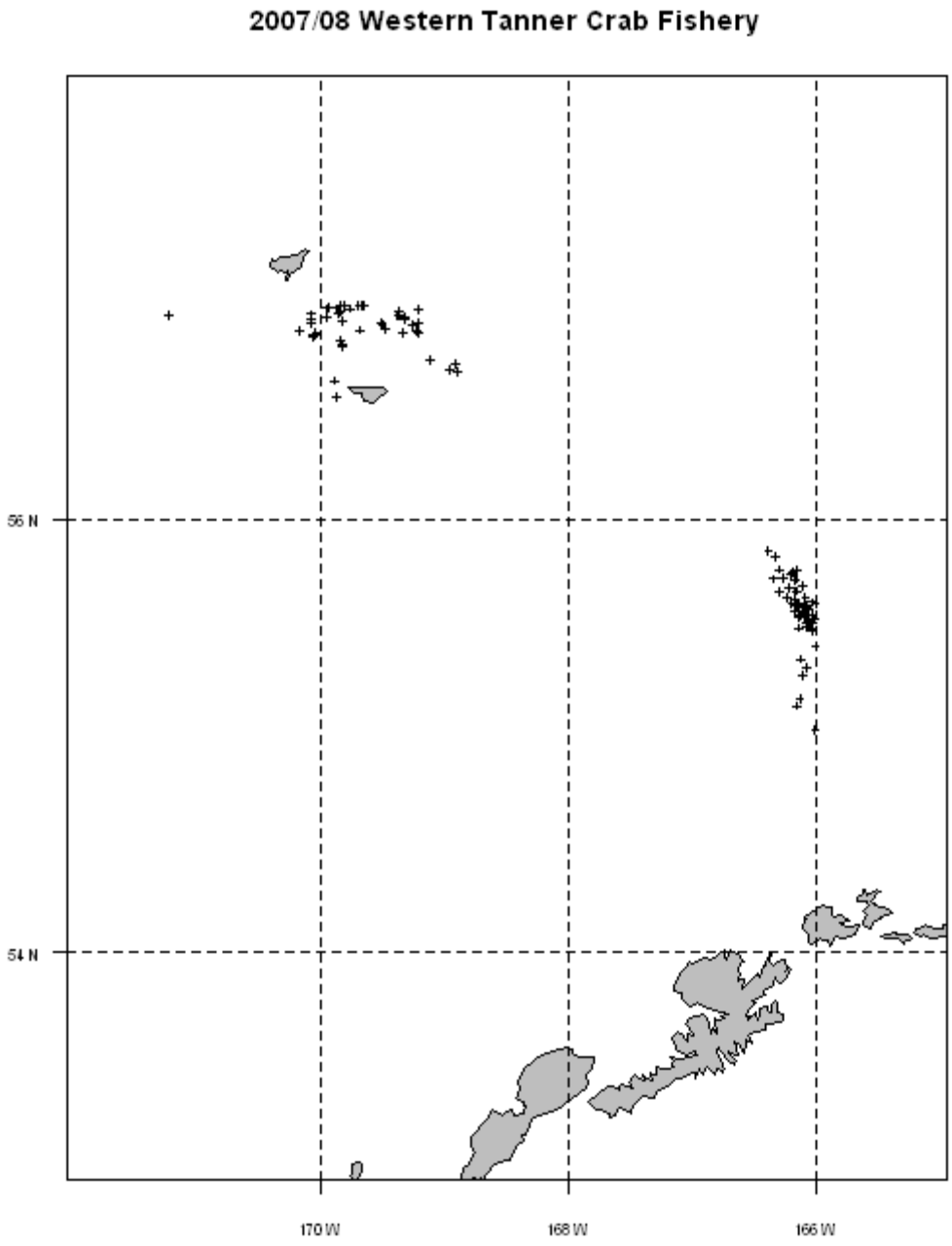
$$\hat{\mu}_u = \frac{\hat{\tau}_F}{\lambda_F} \tag{17}$$

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.

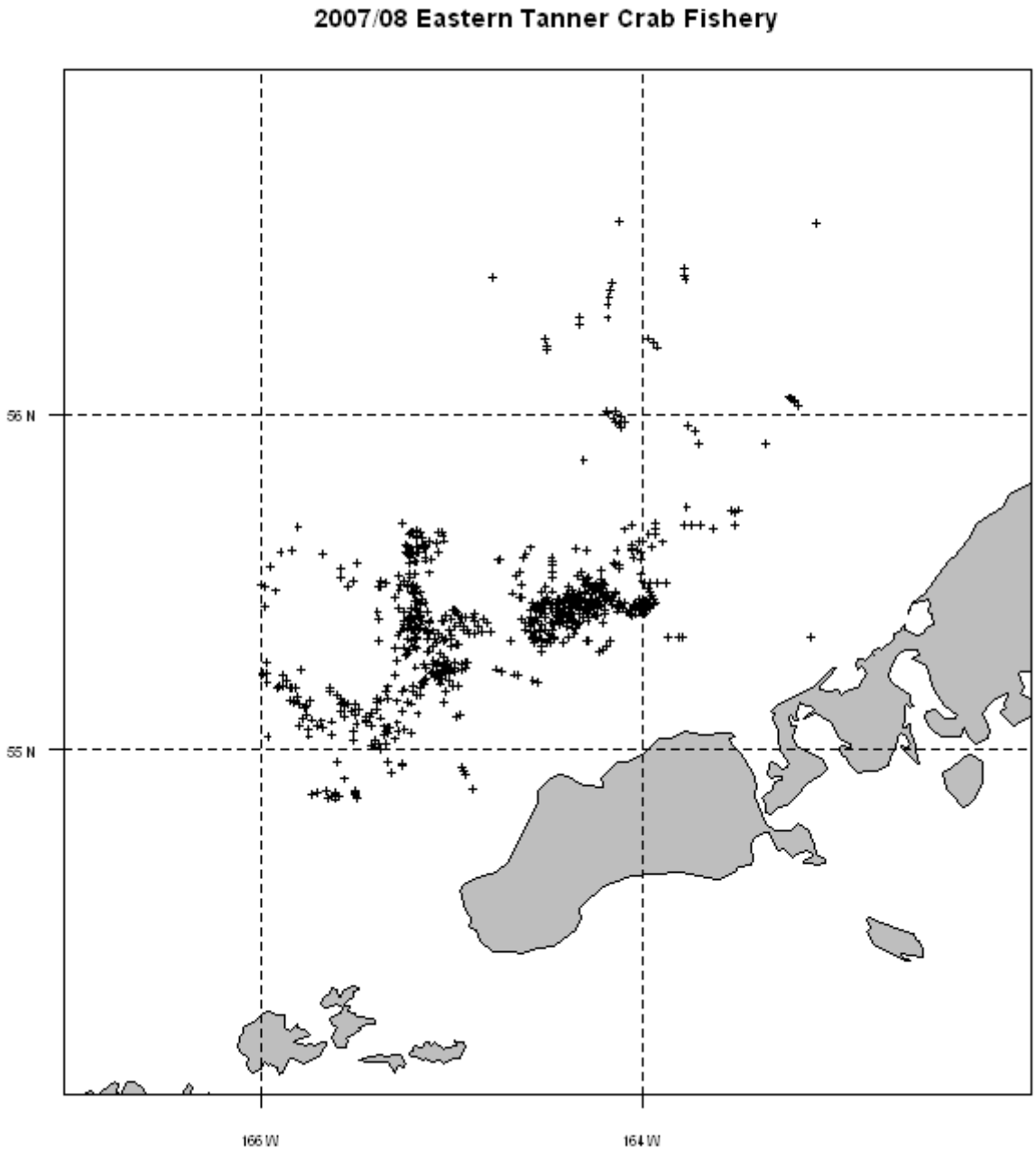
APPENDIX B: LOCATIONS OF SAMPLED POT LIFTS



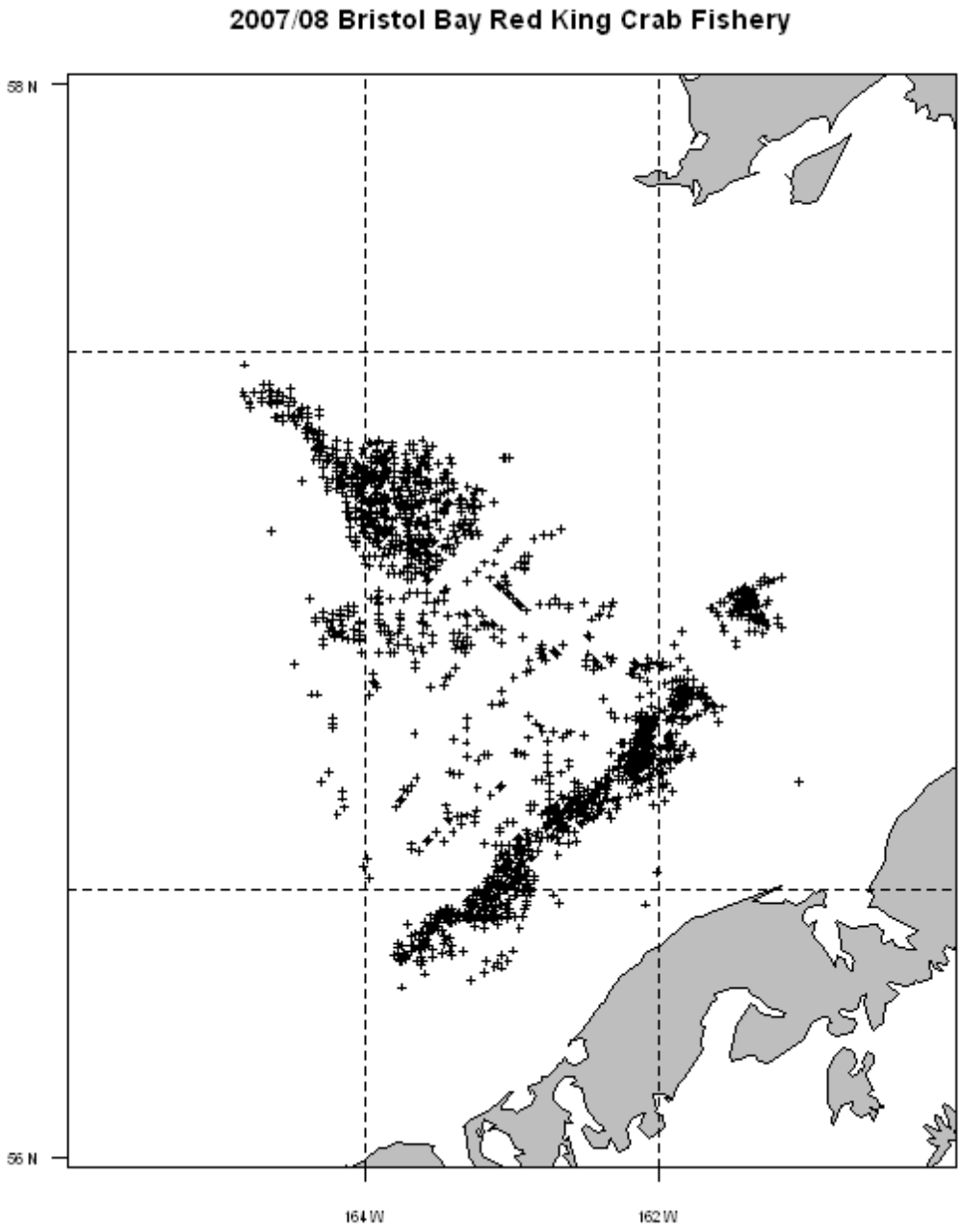
Appendix B1.–Locations of pot lifts sampled by observers during the 2007/2008 Bering Sea snow crab fishery.



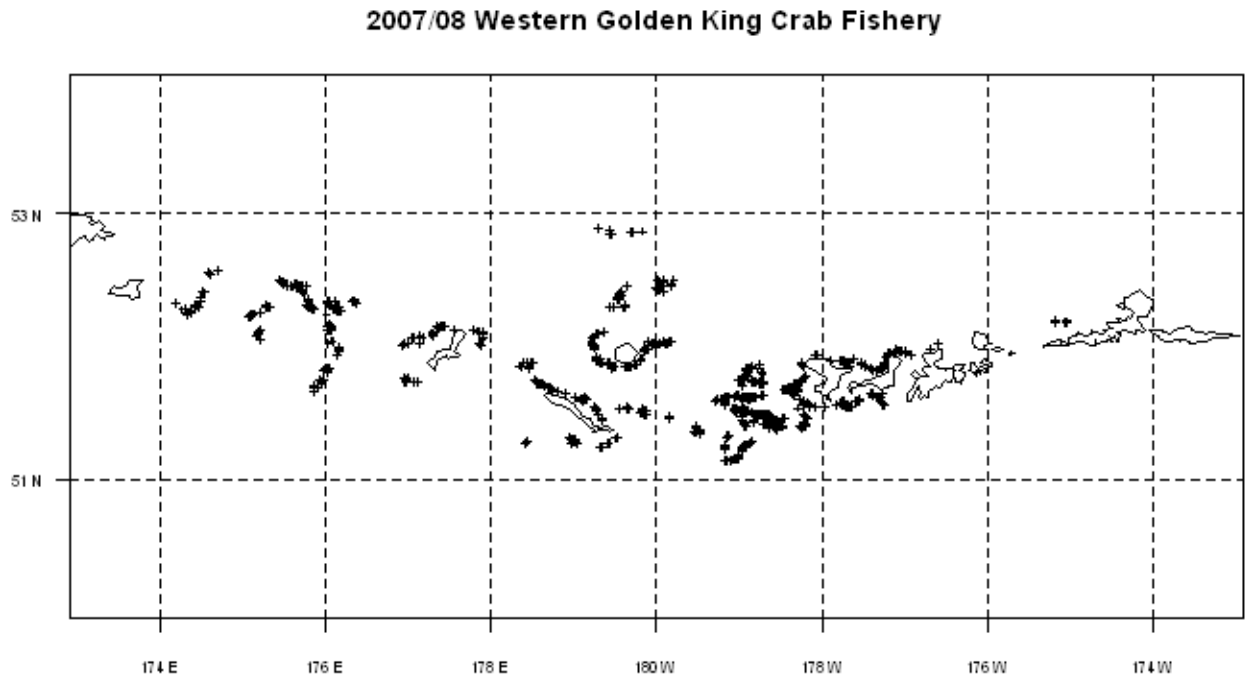
Appendix B2.–Locations of pot lifts sampled by observers during the 2007/2008 directed Bering Sea Tanner crab fishery west of 166° W longitude.



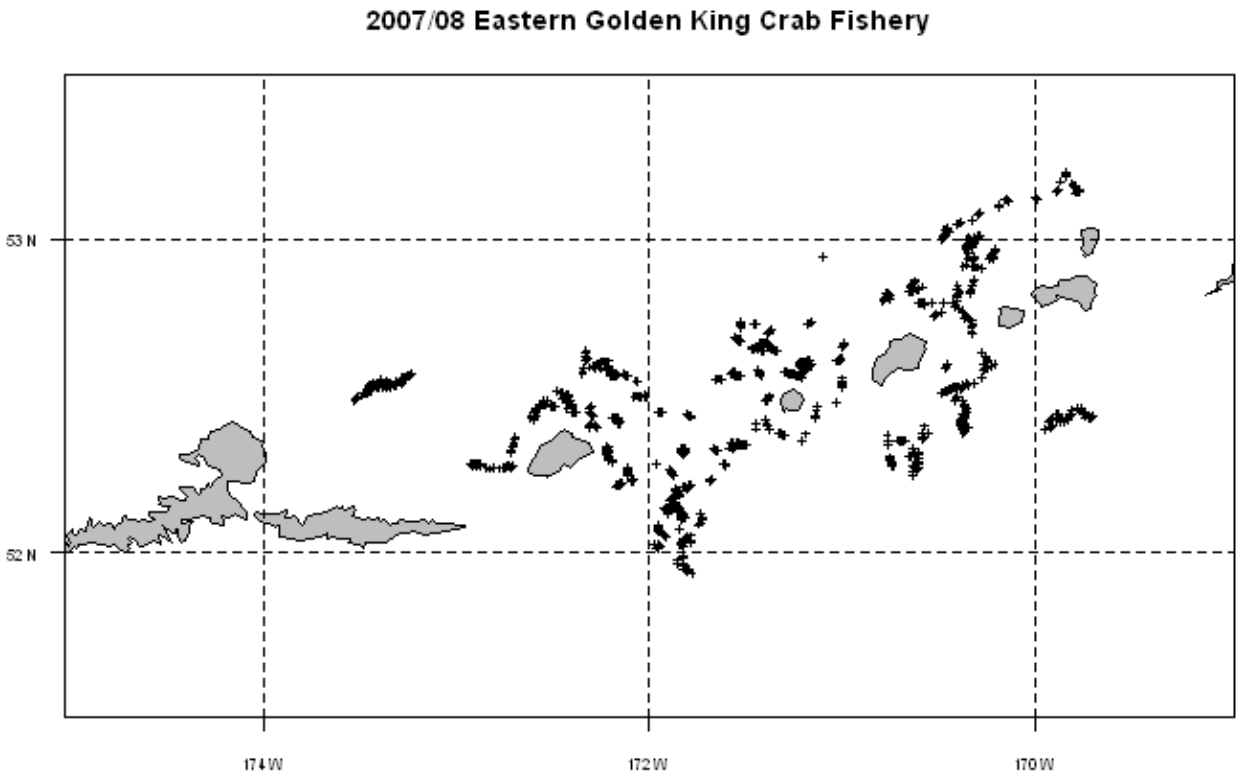
Appendix B3.–Locations of pot lifts sampled by observers during the 2007/2008 directed Bering Sea Tanner crab fishery east of 166º W longitude.



Appendix B4.–Locations of pot lifts sampled by observers during the 2007/2008 Bristol Bay red king crab fishery.



Appendix B5.–Locations of pot lifts sampled by observers during the 2007/2008 Aleutian Islands golden king crab fishery west of 174° W longitude.



Appendix B6.–Locations of pot lifts sampled by observers during the 2007/2008 Aleutian Islands golden king crab fishery east of 174º W longitude.

APPENDIX C: ADDITIONAL CATCH AND BIOLOGICAL SUMMARIES

Appendix C1.–Total contents of 1,731 sampled pot lifts taken during the 2007/2008 Bering Sea snow crab fishery.

Species	Total Catch	Species	Total Catch
Snow crab		Pacific cod	461
legal males	846,717	Yellow Irish lord	291
sublegal males	6,608	Sculpin [u]	194
females	1,890	Pribilof neptune (or Pribilof whelk)	179
		Starfish [u]	159
Tanner crab		Hermit crab [u]	60
legal males	4,830	Yellowfin sole	59
sublegal males	39,923	Sea anemone [u]	57
females	3,239	Hairy triton (or Oregon triton)	52
		Giant octopus	31
Hybid *C. bairdi*		Basket star	24
legal males	618	Neptune snail [u]	22
sublegal males	344	Pacific lyre crab	11
females	18	Jellyfish [u]	8
		Pacific halibut	8
Hybrid *C. opilio*		Flathead sole	7
legal males	39	Skate [u]	5
sublegal males	2	Sea whip [u]	4
females	0	Brittle star [u]	3
		Bivalve [u]	2
Red king crab		Flatfish [u]	2
legal males	1	Sponge [u]	2
sublegal males	1	Walleye pollock	2
females	2	Arrowtooth flounder	1
		Graceful decorator crab	1
Hair crab		Great sculpin	1
legal males	1	Rock sole [u]	1
sublegal males	0	Sea cucumber [u]	1
females	0	Sea urchin [u]	1
		Searcher	1
Snail [u]	8,223	Snailfish [u]	1

[u] Unidentified

Appendix C2.–Mean snow crab CPUE by soak time for 1,731 pot lifts sampled during the 2007/2008 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	0.2	1.0	3.0	0	0	4.0
13-24	4.5	240.2	117.1	6.9	1.0	365.2
25-36	19.3	313.0	155.2	4.7	2.8	475.6
37-48	21.9	350.0	146.6	4.2	0.7	501.6
49-60	10.9	336.5	163.3	4.2	1.4	505.4
61-72	8.6	376.6	166.5	2.5	0.7	546.2
73-84	5.0	317.9	175.4	2.8	0.1	496.3
85-96	3.5	369.1	167.0	4.0	0.3	540.3
97-108	3.0	323.5	129.6	1.5	0.5	455.0
109-120	3.8	370.1	151.8	1.5	< 0.1	523.5
121-132	1.9	253.8	118.9	2.2	0.4	375.3
133-144	3.4	408.8	164.2	3.8	1.5	578.3
145-156	1.9	377.1	159.4	4.7	1.7	542.9
157-168	3.2	313.3	144.5	4.2	0.5	462.5
169-180	2.0	287.4	103.2	0.9	0	391.4
181-192	2.6	379.4	173.8	4.8	0.3	558.4
193-204	1.7	516.8	174.4	1.6	0	692.8
205-216	0.5	393.4	110.3	1.9	0	505.5
217-228	0.2	412.0	147.8	0.3	0	560.0
229-240	0.1	466.0	140.5	3.0	0	609.5
241-252	0.6	115.4	43.1	0.2	0.2	158.9
253-264	0.1	233.0	160.5	1.0	0	394.5
265-276	0.3	320.4	105.8	2.6	0.4	429.2
277-288	0.6	292.9	131.8	1.9	0	426.6
289-300	0.1	578.0	187.0	0	0	765.0
301-312	0.1	205.5	88.5	0	0	294.0
313-324	0.1	320.0	102.5	1.5	0	424.0
325-336	0.1	248.0	198.0	0	0	446.0
349-360	0.1	267.0	135.0	0	0	402.0
361-372	0.1	280.0	117.0	0	0	397.0

[a] Mean soak time = 76.8 hours.

Appendix C3.–Mean snow crab CPUE by depth for 1,731 pot lifts sampled during the 2007/2008 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
21-25	0.1	125.0	43.0	1.0	3.0	172.0
26-35	0.2	0	2.8	0	0	2.8
36-40	2.0	52.2	15.9	0.2	3.2	71.4
41-45	0.8	345.4	86.5	2.6	0	434.5
46-50	3.1	471.6	127.4	1.5	< 0.1	600.6
51-55	5.3	455.9	118.0	1.4	< 0.1	575.4
56-60	17.6	338.6	175.5	4.0	1.5	519.6
61-65	24.1	378.6	169.7	5.9	2.9	557.1
66-70	18.3	348.6	145.7	3.8	0.3	498.3
71-75	13.2	232.6	141.3	3.5	< 0.1	377.4
76-80	9.9	305.1	158.4	2.4	< 0.1	466.0
81-85	3.4	356.5	147.4	1.8	0	505.7
86-90	1.6	369.0	127.4	2.5	0	498.9
91-95	0.2	277.0	126.5	0	0	403.5
96-100	0.1	0	0	0	0	0
111-115	0.1	0	0	0	0	0

[a] Mean depth = 65.3 fathoms

Appendix C4.–Reproductive condition of female snow crabs from pot lifts sampled during the 1995-2007/2008 directed 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
2005/06	129	6.2	89.2	2.3	2.3
2006/07	57	84.2	14.0	0	1.8
2007/08	365	71.0	21.9	1.6	3.8

Appendix C5.–Total pot lift contents for 103 pot lifts sampled during the 2007/2008 directed Bering Sea Tanner crab fishery west of 166° W longitude.

Species	Total Catch
Tanner Crab	
legal males	2,289
sublegal males	12,731
females	1,016
Snow crab	
legal males	2,182
sublegal males	31
females	3
Blue king crab	
legal males	0
sublegal males	0
females	1
Red king crab	
legal males	1
sublegal males	0
females	0
Snail [u]	157
Yellow Irish lord	55
Starfish [u]	39
Pacific cod	35
Yellowfin sole	18
Pacific lyre crab	12
Sculpin [u]	8
Crab [u]	6
Sea anemone [u]	6
Sea cucumber [u]	4
Giant octopus	3
Great sculpin	1
Jellyfish [u]	1
Rock sole [u]	1

[u] Unidentified

Appendix C6.–Mean Tanner crab CPUE by soak time for 103 pot lifts sampled during the 2007/2008 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
13-24	1.9	18.0	0	117.5	13.5	149.0
25-36	23.3	19.0	< 0.1	95.8	5.0	119.8
37-48	35.0	19.4	0.4	141.5	8.1	169.3
49-60	18.4	23.3	0.5	140.8	20.7	185.3
61-72	3.9	38.8	1.3	99.8	1.0	140.8
73-84	6.8	17.4	0.4	70.9	6.4	95.1
85-96	1.9	47.0	2.5	179.5	35.0	264.0
97-120	3.9	42.8	0.8	219.8	3.0	266.2
121-144	1.0	28.0	0	160.0	44.0	232.0
145-168	1.9	17.5	0	54.0	5.0	76.5
169-180	1.9	6.0	0	13.0	0	19.0

[a] Mean soak time = 54.5 hours.

Appendix C7.–Mean Tanner crab CPUE by depth for 103 pot lifts sampled during the 2007/2008 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
31-35	7.8	30.3	0.9	99.9	2.9	133.9
36-40	21.4	18.3	0.9	75.2	26.6	121.0
41-45	13.6	19.0	0.3	85.4	2.1	106.9
46-50	1.0	22.0	0	42.0	1.0	65.0
51-55	2.9	8.3	0	30.7	3.0	42.0
56-60	1.0	3.0	0	28.0	0	31.0
61-65	29.1	25.4	0.3	179.8	5.4	210.8
66-70	20.4	23.0	< 0.1	149.4	8.0	180.5
71-75	2.9	14.3	0	129.7	12.7	156.7

[a] Mean depth = 53.8 fathoms.

Appendix C8.–Reproductive condition of female Tanner crabs from pot lifts sampled during the 2005/2006 – 2007/2008 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)
2005/06	1,101	21.9	75.8	0.6	1.6
2006/07	2,859	25.9	73.5	0.5	< 0.1
2007/08	903	21.9	75.6	1.2	0.9

Appendix C9.–Total contents of 773 pot lifts sampled during the 2007/2008 directed Bering Sea Tanner crab fishery east of 166° W longitude.

Species	Total Catch	Species	Total Catch
Tanner crab		Snail [u]	13,085
legal males	19,375	Yellowfin sole	981
sublegal males	59,012	Hairy triton (or Oregon triton)	520
females	3,555	Sea anemone [u]	334
		Starfish [u]	279
Snow crab		Pribilof neptune (or Pribilof whelk)	276
legal males	15,112	Pacific cod	262
sublegal males	445	Pacific lyre crab	230
females	10	Jellyfish [u]	97
		Hermit crab [u]	79
Hybird *C. bairdi*		Neptune snail [u]	39
legal males	30	Basket star	15
sublegal males	54	Sponge [u]	13
females	0	Giant octopus	11
		Pacific halibut	6
Hybrid *C. opilio*		Sculpin [u]	5
legal males	98	Yellow Irish lord	5
sublegal males	0	Graceful decorator crab	4
females	0	Sea urchin [u]	4
		Flatfish [u]	3
Red king crab		Walleye Pollock	3
legal males	90	Alaska plaice	2
sublegal males	39	Skate [u]	2
females	52	Bigmouth sculpin	1
		Crab [u]	1
Hair crab		Dusky rockfish	1
legal males	1	Flathead sole	1
sublegal males	0	Great sculpin	1
females	0	Scallop [u]	1

[u] Unidentified

Appendix C10.–Mean CPUE by soak time for 773 pot lifts sampled during the 2007/2008 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
1-12	0.1	1.0	0	2.0	1.0	4.0
13-24	6.6	16.3	1.9	95.4	5.6	119.1
25-36	16.1	20.0	0.5	64.8	4.0	89.3
37-48	33.0	24.8	1.2	82.0	4.3	112.3
49-60	16.7	24.3	0.1	79.4	6.8	110.7
61-72	6.6	27.9	< 0.1	69.8	6.1	103.8
71-84	3.6	28.0	0.4	56.5	3.8	88.7
85-96	2.1	32.2	0.6	44.1	1.9	78.9
97-108	1.9	28.5	1.3	75.6	4.6	109.9
109-120	2.2	14.7	8.1	35.5	1.0	59.4
121-132	1.0	16.0	0.1	56.6	4.6	77.4
133-144	1.6	32.8	0	65.7	3.6	102.0
145-156	2.6	19.0	0.2	61.8	2.9	83.8
157-168	0.6	19.4	0	16.8	3.0	39.2
169-180	0.3	16.5	0	88.5	2.0	107.0
181-192	0.1	22.0	0	166.0	0	188.0
193-204	0.6	36.8	0.8	42.6	2.4	82.6
205-216	0.5	26.8	0.3	198.5	1.8	227.2
217-228	0.4	37.3	0.7	112.3	5.7	156.0
229-252	0.3	58.5	1.0	145.0	5.0	209.5
253-264	0.5	58.8	1.0	148.5	3.3	211.5
265-276	0.1	54.0	1.0	119.0	2.0	176.0
277-300	0.1	35.0	0	103.0	1.0	139.0
301-336	0.1	33.0	0	162.0	5.0	200.0
337-348	0.1	29.0	0	123.0	2.0	154.0
361-372	1.2	30.2	0.1	123.2	1.4	155.0
373-384	0.1	45.0	0	211.0	2.0	258.0
385-396	0.3	17.0	0	70.0	0.5	87.5
397-408	0.4	57.7	4.3	62.3	10.7	135.0

[a] Mean soak time = 66.9 hours.

Appendix C11.–Mean CPUE by depth for 773 pot lifts sampled during the 2007/2008 directed Bering Sea Tanner crab fishery east of 166° W longitude.

Depth[a] (fathoms)	Percent of Sampled Pots	Mean Catch per Sampled Pot				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
24-25	0.1	0.0	0	2.0	0	2.0
31-35	0.1	22.0	0	35.0	4.0	61.0
36-40	0.9	8.7	0	40.6	1.0	50.3
41-45	1.0	2.0	0.3	11.8	0.6	14.6
46-50	13.5	11.4	0.2	21.3	1.7	34.6
51-55	36.7	28.0	0.6	35.8	4.1	68.5
56-60	23.6	25.3	0.7	114.7	7.8	148.4
61-65	15.0	23.9	2.7	127.9	4.7	159.2
66-70	6.7	34.6	< 0.1	178.4	3.2	216.3
71-75	0.3	9.5	0	111.5	5.5	126.5
76-80	1.6	11.0	7.8	54.5	4.1	77.4
81-85	0.4	7.3	0	89.7	0	97.0
161-165	0.1	73.0	0	43.0	11.0	127.0

[a] Mean depth = 56.9 fathoms.

Appendix C12.–Reproductive condition of female Tanner crabs from pot lifts sampled during the 2006/2007 and 2007/2008 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)
2006/07	1,573	95.6	2.9	0.8	0.6
2007/08	2,416	27.9	68.5	1.9	1.2

Appendix C13.–Total contents of 1,918 pot lifts sampled during the 2007/2008 Bristol Bay red king crab fishery.

Species	Total Catch	Species	Total Catch
Red king crab		Starfish [u]	2488
legal males	54,280	Yellowfin sole	808
sublegal males	57,295	Pacific cod	552
females	12,457	Snail [u]	388
		Sculpin [u]	280
Tanner crab		Jellyfish [u]	140
legal males	543	Pacific halibut	92
sublegal males	824	Hermit crab [u]	76
females	91	Great sculpin	52
		Tunicate [u]	45
Snow crab		Pacific lyre crab	34
legal males	346	Bigmouth sculpin	22
sublegal males	25	Circumboreal toad crab	18
females	1	Basket star	17
		Sea cucumber [u]	9
Hybird *C. bairdi*		Flatfish [u]	7
legal males	0	Neptune snail [u]	7
sublegal males	2	Skate [u]	5
females	0	Yellow Irish lord	5
		Arrowtooth flounder	2
Hybrid *C. opilio*		Sponge [u]	2
legal males	4	Bivalve [u]	1
sublegal males	1	Dusky rockfish	1
females	0	Flathead sole	1
		Greenland halibut (or Greenland turbot)	1
Hair crab		Kamchatka coral (or bubblegum coral)	1
legal males	7	Octopus [u]	1
sublegal males	3	Rock sole [u]	1
females	0	Walleye Pollock	1
Blue king crab			
legal males	2		
sublegal males	0		
females	0		

[u] Unidentified

Appendix C14.–Mean CPUE by soak time for 1,918 pot lifts sampled during the 2007/2008 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	0.3	2.4	0	7.4	1.2	11.0
12-24	7.9	19.1	0.4	38.5	9.3	67.3
25-36	26.6	21.8	0.6	36.2	6.9	65.4
37-48	23.9	30.2	0.4	33.7	5.6	69.9
49-60	16.3	27.6	0.5	20.8	5.7	54.6
61-72	6.0	26.6	1.1	19.8	6.7	54.2
73-84	2.9	27.6	1.1	20.8	4.3	53.8
85-96	2.5	41.0	0.9	51.4	6.0	99.3
109-108	1.8	41.0	1.4	30.7	6.7	79.9
109-120	1.8	35.6	0.4	17.6	5.1	58.8
121-132	2.3	36.0	0.2	13.9	6.3	56.4
133-144	2.2	39.4	< 0.1	18.0	8.8	66.3
145-156	1.7	37.5	0.3	20.5	8.0	66.3
157-168	1.0	35.2	0.5	21.5	6.9	64.1
169-180	1.4	42.4	< 0.1	18.7	10.7	71.8
181-192	0.7	41.4	0.3	18.9	7.4	68.0
193-204	0.4	50.0	0.6	21.6	2.3	74.4
205-216	0.2	55.7	0	14.0	3.3	73.0
217-228	0.2	40.7	0	24.3	8.3	73.3
301-312	0.1	43.0	0	19.0	1.0	63.0

[a] Mean soak time =56.9 hours.

Appendix C15.–Mean CPUE by depth for 1,918 pot lifts sampled during the 2007/2008 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
16-20	0.1	13.0	0	42.0	2.0	57.0
21-25	1.6	25.3	0.1	11.8	4.8	42.0
26-30	23.7	31.8	0.2	15.6	4.8	52.4
31-35	15.3	29.1	0.4	24.4	6.9	60.7
36-40	21.2	26.7	0.6	34.1	5.8	67.2
41-45	24.2	26.7	1.1	45.2	9.0	82.0
46-50	13.5	23.3	0.4	29.6	6.2	59.4
51-55	0.4	16.9	0	2.6	0	19.4

[a] Mean depth = 37.2 fathoms.

Appendix C16.–Reproductive condition of female red king crabs from pot lifts sampled during the 1996-2007/2008 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	33.8	1.7	22.9

Appendix C17.–Total contents of 2,088 pot lifts sampled during the combined 2007/2008 Aleutian Islands golden king crab fishery.

Species	Total Catch	Species	Total Catch
Golden King crab		*Fanellia* sp.	50
legal males	53,008	Plexauridae [u]	43
sublegal males	21,116	Primnoidae [u]	40
females	20,868	Rockfish [u]	29
		Kamchatka coral (or bubblegum coral)	27
Scarlet King crab		*Cyclohelia* sp.	22
legal males	28	Skate [u]	22
sublegal males	14	*Crypthelia* sp.	20
females	1	Hairy triton (or Oregon triton)	19
		Pacific halibut	19
Red King crab		*Calcigorgia* sp.	18
legal males	2	*Anthomastu*s sp.	17
sublegal males	6	*Arthrogorgia* sp.	16
females	3	Snailfish [u]	15
		Clavularia sp.	10
Hair crab		Pacific cod	10
legal males	1	Sculpin [u]	9
sublegal males	0	Sea lily (or feather star) [u]	9
females	0	Tunicate [u]	9
		Arrowtooth flounder	8
Paralomis multispina		Cup coral [u]	8
legal males	1	Giant octopus	7
sublegal males	0	Flatfish [u]	
females	0	Red-tree coral	6
		Sea spider [u]	6
Triangle Tanner crab		Grenadier (or rattail) [u]	5
legal males	1	Hydrocoral [u]	5
sublegal males	0	Coral [u]	4
females	0	Sea anemone [u]	4
		Bryozoan [u]	3
Sponge [u]	500	*Errinopora* sp.	3
Basket star	487	Greenland halibut (or Greenland turbot)	3
Hydroid [u]	361	Soft coral [u]	3
Brittle star [u]	258	Hermit crab [u]	2
Stylaster sp.	188	Atka mackerel	1
Sea urchin [u]	172	Rock sole [u]	1
Primnoidae Group I	137	Pacific lyre crab	1
Starfish [u]	131	Sablefish (or black cod)	1
Snail [u]	91	Sea pen [u]	1
Distichopora sp.	54	Tube worm [u]	1

[u] Unidentified

Appendix C18.–Mean CPUE by soak time for 1,084 pot lifts sampled during the 2007/2008 Aleutian Islands golden king crab fishery west 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
97-144	0.3	5.3	0.0	5.7	34.7	45.7
145-192	1.7	15.7	0.2	11.3	39.1	66.3
193-240	4.3	12.1	0.1	18.0	15.1	45.2
241-288	10.6	11.3	0.1	10.5	20.3	42.2
289-336	9.4	14.7	0.1	12.8	12.0	39.5
337-384	6.8	19.5	0.2	23.1	23.9	66.6
385-432	8.3	23.5	< 0.1	13.6	8.8	46.0
433-480	9.4	21.1	0.1	11.3	11.1	43.5
481-528	7.8	25.9	0.4	9.6	24.4	60.2
529-576	5.4	18.0	0.3	9.9	6.6	34.7
577-624	5.4	22.2	0.3	9.5	18.6	50.6
625-672	2.3	23.4	0.6	29.5	16.0	69.5
673-720	3.0	27.5	0.2	12.1	11.7	51.5
721-768	6.8	27.7	< 0.1	10.1	11.0	48.9
769-816	1.8	28.5	0.0	4.3	6.5	39.4
817-864	4.9	26.5	< 0.1	4.1	8.4	39.0
865-912	3.1	24.5	< 0.1	4.5	3.6	32.7
913-960	5.1	24.0	0.0	4.1	6.0	34.1
961-1008	1.4	19.9	0.1	1.7	22.3	44.1
1009-1056	0.4	0.5	0.0	0.5	0.5	1.5
1057-1104	0.1	46.0	1.0	4.0	1.0	52.0
1153-1200	1.0	2.4	0.0	1.2	0.2	3.7
1249-1296	0.1	0.0	0.0	0.0	0.0	0.0
1489-1536	0.2	0.0	0.0	0.0	0.0	0.0
1777-1824	0.3	1.0	0.0	1.3	2.3	4.7

[a] Mean soak time = 533.9 hours.

Appendix C19.–Mean CPUE by depth for 1,084 pot lifts sampled during the 2007/2008 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
76-100	1.9	36.2	< 0.1	7.2	16.6	60.2
101-125	5.2	25.7	0.3	16.6	11.8	54.4
126-150	16.5	21.2	0.1	14.1	12.9	48.3
151-175	21.1	21.8	0.2	10	17.2	49.2
176-200	26.2	17.8	0.1	10.9	12.9	41.8
201-225	15.8	16.1	< 0.1	11.4	15.2	42.9
226-250	7.8	21.7	0.1	10	13.8	45.7
251-275	4.2	18.8	0.2	7.1	8	34.1
276-300	0.7	26.2	0	9.9	9.2	45.4
301-325	0.4	49.2	0	2.5	14.8	66.5
326-350	0.1	41	0	8	13	62
376-400	0.1	21	0	5	65	91

[a] Mean depth = 181.4 fathoms.

Appendix C20.–Reproductive condition of female golden king crabs from pot lifts sampled during the 1996/1997-2007/2008 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

Appendix C21.–Mean CPUE by soak time for 1,004 pot lifts sampled during the 2007/2008 Aleutian Islands golden king crab fishery east of 174° W longitude.

Soak Time[a] (hours)	Percent of Samples Pots	Mean Catch per Sampled Pot				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
1-48	0.1	19.0	1.0	2.0	12.0	34.0
145-192	0.5	8.0	0.4	2.4	5.6	16.4
193-240	6.2	25.0	1.5	14.2	5.7	46.5
241-288	22.8	26.6	0.8	8.9	5.8	42.1
289-336	12.3	29.2	0.6	11.9	5.6	47.2
337-384	10.8	32.7	0.3	11.7	7.8	52.6
385-432	12.1	31.4	0.5	7.4	4.9	44.2
433-480	11.0	35.6	1.6	7.4	6.7	51.3
481-528	9.8	33.9	1.3	9.6	5.6	50.4
529-576	4.7	30.4	1.4	3.9	2.3	37.9
577-624	2.7	25.8	0.9	4.0	1.0	31.7
625-672	1.0	39.7	1.3	9.7	6.8	57.5
673-720	0.4	38.5	0	1.8	2.0	42.2
721-768	1.5	28.7	0.5	3.9	8.7	41.9
865-912	0.5	23.2	0	1.8	18.2	43.2
913-960	1.9	23.2	2.5	1.6	1.5	28.7
961-1008	1.3	18.5	0.9	0.7	1.5	21.6
1057-1104	0.2	56.0	0.5	6.5	4.0	67.0
1105-1152	0.5	5.4	0	0.2	0	5.6

[a] Mean soak time = 412.7 hours.

Appendix C22.–Mean CPUE by depth for 1,004 pot lifts sampled during the 2007/2008 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	5.3	31.0	0.8	9.3	7.2	48.4
101-125	20.7	33.0	1.0	8.0	7.3	49.4
126-150	18.7	28.8	1.2	8.1	3.0	41.1
151-175	11.4	26.4	1.0	6.4	4.7	38.5
176-200	9.5	27.1	0.9	8.7	7.1	43.6
201-225	9.6	32.6	1.0	7.8	4.3	45.7
226-250	9.0	28.4	0.7	9.5	6.6	45.2
251-275	5.9	28.8	0.8	7.9	3.5	40.9
276-300	6.2	25.5	0.5	14.7	8.4	49.1
301-325	3.4	37.5	0.2	15.2	5.2	58.1
326-350	0.5	32.8	0.4	15.6	5.0	53.8

[a] Mean depth = 177.2 fathoms.

Appendix C23.–Reproductive condition of female golden king crabs from pot lifts sampled during the 1996/1997-2007/2008 Aleutian Islands golden king crab fisheries east of 174° W longitude.

Year	Crabs Sampled	Eyed Eggs (percent)	Uneyed Eggs (percent)	Barren, Mated (percent)	Barren, Non-mated (percent)
1996	59,210	20.8	22.5	18.6	38.1
1997	5,383	25.2	19.3	22.1	33.4
1998	44,352	18.1	21.0	23.9	37.0
1999	36,695	22.1	21.0	23.1	33.8
2000	13,615	26.9	18.7	20.1	34.3
2001	14,912	20.4	12.5	15.4	51.1
2002	9,651	29.6	19.2	18.9	32.3
2003	7,990	20.9	33.2	13.6	31.5
2004	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

APPENDIX D: RESULTS OF LEGAL TALLY SAMPLES

Appendix D1.–Results of legal tally samples taken during the 2007/2008 Bering Sea and Aleutian Islands directed crab fisheries.

Fishery	Sample Size	Percent Illegal Crabs: Male Target Species	Female Target Species	Male/Female Non-target Species	Total	Estimated Number Illegal Crabs[a]
Bering Sea snow crab	98,533	0.02	< 0.01	0.20	0.22	110,000
Bering Sea Tanner crab (west of 166 W)	3,850	0.73	0.13	0	0.86	2,000
Bering Sea Tanner crab (east of 166 W)	12,827	0.84	0.01	0.03	0.88	6,000
Bristol Bay red king crab	28,879	0.31	0.01	0	0.32	10,000
Combined Aleutian Islands golden king crab	41,333	0.34	0.03	0	0.38	5,000

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