Fishery Data Series No. 06-36

Alaska Department of Fish and Game Summary of the 2005 Mandatory Shellfish Observer Program Database for the Non-rationalized Bering Sea Crab Fisheries

by

David R. Barnard

and

Ryan Burt

July 2006

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

FISHERY DATA SERIES NO. 06-36

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by
David R. Barnard
and
Ryan Burt

Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

July 2006

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David R. Barnard,
Alaska Department of Fish and Game, Division of Commercial Fish,
211 Mission Road, Kodiak, AK 99615 USA
and
Ryan Burt
Alaska Department of Fish and Game, Division or Commercial Fish
P.O. Box 920587, Dutch Harbor, AK 99692 USA

This document should be cited as:
Barnard, D. R. and R. Burt. 2006. Alaska Department of Fish and Game summary of the 2005 mandatory shellfish observer program database for the non-rationalized Bering Sea crab fisheries. Alaska Department of Fish and Game, Fishery Data Series No. 06-36, Anchorage.

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ABSTRACT

Since 1988, the Alaska Department of Fish and Game has required varying levels of observer coverage aboard vessels participating in Bering Sea and Aleutian Islands (BSAI) crab fisheries. This report summarizes data collected in the 2005 pre-rationalized BSAI crab fisheries by shellfish observers deployed on catcher-processor vessels, floater-processor vessels and catcher-only vessels. The 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. In the 2005 pre-rationalized fisheries, commercially harvested crab species from the Bering Sea area include golden king crab *Lithodes aequispinus*, scarlet king crab *L. couesi*, snow crab *Chionoecetes opilio* and grooved Tanner crab *C. tanneri*.

Key words: Alaska Department of Fish and Game, Bering Sea, shellfish observers, database, summary, golden king crab *Lithodes aequispinus*, scarlet king crab *L. couesi*, snow crab *Chionoecetes opilio*, and grooved Tanner crab *C. tanneri*.

INTRODUCTION

Regulations adopted by the Alaska Board of Fisheries 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). Bowers et al. (*In prep*) provides 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.

Observers collect biological data from the catch in sampled pot lifts and from samples of retained or delivered catch, document vessel catch, bycatch, and effort, and monitor vessel activities for regulatory compliance. Those data are used in management and research applications to develop stock-assessment models, to estimate the amount and composition of bycatch, to chronicle female reproductive cycles, and as an aid in preseason and inseason projections of fishery performance. ADF&G Westward Region staff maintains a database of data collected by observers that includes gear types fished, pot-lift locations and soak times, and species composition, size distribution, and reproductive condition in sampled catches. That database provides a source of information crucial to the comprehensive management of Alaska's shellfish resources in the Bering Sea and Aleutian Islands.

This report summarizes data collected by onboard observers during the general and Community Development Quota (CDQ) commercial crab fisheries that ended in calendar year 2005 before the implementation of the BSAI Crab Rationalization Program in August of 2005. Those fisheries were: the 2005 Bering Sea snow crab *C. opilio* general and CDQ fisheries; the 2005 Bering Sea golden king crab fishery; and the 2005 Bering Sea grooved Tanner *C. tanneri* fishery. Observers were deployed on all catcher-processor and floating processor vessels that participated in each of those fisheries. Observers were

also deployed on all catcher-only vessels that participated in the Bering Sea golden king crab fishery, the Bering Sea grooved Tanner crab fishery, and the Bering Sea snow crab CDQ fishery. During the Bering Sea snow crab general fishery, observers were randomly assigned to approximately 10% of the participating catcher-only vessels.

Due to the substantial volume of available information, the scope of the data presented here has been narrowed. For each fishery, this report includes estimates of catch and bycatch of crabs from sampled pot lifts, information on the sizes and shell conditions of retained crabs and crabs captured as bycatch, and summaries of the catch composition for all species encountered in sampled pot lifts.

METHODS

Comprehensive shellfish observer sample methods are outlined in the most recent edition of the ADF&G Shellfish Observer Field Manual (ADF&G 2003). Methods described in this report correspond only to the data presented and are not inclusive of all observer sampling duties.

TERMS

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

Pot-lift sample – A randomly selected pot lift from which crabs of all species captured are identified and enumerated, and, from a subset of the selected pot lifts, measurements and assessments of ancillary characteristics are recorded from 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 hair crabs *Erimacrus isenbeckii* and all species of king crabs 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 Dungeness crabs *Cancer magister* and 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 at a right angle to a line midway between the eyes to the medial-posterior margin including the spines.

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.

Shell condition is recorded to provide an estimate of the time since a crab's last molt (ADF&G 2003; 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 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.

Soft-shell – Exoskeleton is not yet hardened, 0 to 2 weeks after molting.

New pliable-shell – Exoskeleton is thin, flexible and not fully calcified, 2 to 8 weeks after molting.

New-shell – Exoskeleton estimated to be 8 weeks to 12 months old (8 weeks to 18 months for golden king crabs).

Old-shell – Exoskeleton estimated to be more than 12 months and up to 24 months old (up to 36 months for golden king crabs).

Very old-shell – Exoskeleton estimated to be more than 24 months old (more than 36 months old for golden king crabs).

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

SAMPLING DUTIES

During the 2005 BSAI crab fisheries, observers were deployed on floater-processor vessels, catcher-processor vessels, and catcher-only vessels. Observers deployed on floater-processors had access only to previously-sorted, retained catches, whereas observers placed on catcher-processor and catcher-only vessels were able to examine the contents of pot lifts prior to sorting.

Floater-Processors

Observers deployed on floater-processors primarily monitor deliveries from catcher-only vessels. Sampling duties during each delivery included obtaining a size frequency sample and conducting a legal tally.

Catcher-Processors

Sampling duties for observers deployed on catcher-processors included size frequency sampling, legal tally sampling from the retained catch and 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.

Ad hoc research data-collection projects were assigned to observers deployed on catcher-processors and catcher-only vessels during 2005. These included sampling crabs from the Bering Sea golden king crab fishery for handling injuries and on-deck air exposure resulting from catch sorting. The results of these investigations have not been included in this report, but are available from ADF&G, Region IV.

For ease of reading, 2005 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 and their standard errors were generated using weighted mean and variance formulas for stratified sampling (Cochran 1977; Appendices A1 and A2). With this technique, each vessel-day was considered a separate stratum where the weighting reflected the relative importance of each vessel's daily effort (number of pot lifts)

compared to the vessel's total effort. The greater the number of pot lifts on a given day, the greater the weight given to the samples collected on that day. Variances were calculated for each vessel-day then summed over all vessels and all days for the entire fishery. In fisheries with partial coverage of catcher-only vessels, vessels were stratified by vessel type (catcher-only versus catcher-processor) to account for differences in observer coverage levels, and size (> 125 ft versus ≤ 125 ft in length) to account for different pot limits based on vessel size class (see Appendix A2).

Different estimates of CPUE were calculated depending on the information available. The "stratified CPUE" with standard error estimate used the Cochran stratified technique as described above and in Appendices A1 and A2. The "sample CPUE" was generated from observer data and is based solely on the pot lifts sampled and was calculated as total catch from the sampled pot lifts divided by the total number of sampled pot lifts. This estimate was reported in observer reports prior to 1996 (e.g., Tracy 1994, 1995a,b). The stratified estimates outlined in Appendix A1 were introduced in this report series in 1996, and the additional vessel-type stratum described in Appendix A2 was introduced in 2003. The "actual total fishery (ATF) CPUE" was based on fish ticket information reported in the annual management reports for commercial crab fisheries in the BSAI management areas. The ATF CPUE was generated for retained legal crabs only.

Estimated total catch was calculated by multiplying a CPUE estimate by the total number of pot lifts in the fishery. For fisheries with 100% observer coverage, the total pot lifts information is taken from confidential interviews. Otherwise, total pot lifts data are generated from fish ticket summaries.

When viewing CPUE estimates for the directed catch and bycatch, the precision and accuracy of the estimates should be noted. Precision is indicated by the standard error estimates. Accuracy may be gauged by the similarity of the estimates for legal retained crabs obtained from observer data to those obtained from confidential interviews and fish tickets. The reader should take note of whether the CPUE and total catch estimates provided here were based on data gathered by observers deployed on all participating fishing vessels, on a representative sample of all fishing vessels, or on catcher-processor vessels only. The application of CPUE estimates obtained from catcher-processor vessels to the entire fishing fleet assumes that catch rates for that distinct portion of the fleet are comparable to the remaining catcher-only vessel component of the fleet.

RESULTS

BERING SEA SNOW CRAB

General Fishery

During the 2005 fishing season, observers were deployed on 6 catcher-processor vessels, 3 floating processor vessels, and 13 of 162 catcher-only vessels participating in the 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. Fishing began on 15 January and continued until 20 January. A total of 427 pot lifts selected for sampling accounted for 0.6% of the 69,863 pot lifts reported by vessel operators (Bowers et al. *In prep*). The locations of pot lifts sampled by observers during the 2005 Bering Sea snow crab fishery are displayed in Appendix B1.

Measurements of CW for size frequency samples were taken from 18,681 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 113.1 mm.

Measurements of CW from pot-lift samples were taken from 23,559 male snow crabs throughout the season by onboard observers. The mean CW for male snow crabs from sampled pot lifts was 106.6 mm. The size frequency distribution revealed a prominent mode between 111 and 115 mm (Figure 1). The percentage of male snow crabs sampled that were categorized as old shell and very-old shell was 14.0%. Measurements of CW were taken from 9 female snow crabs during pot-lift sampling and the mean CW was 64.6 mm.

The stratified CPUE estimate of 255.5 legal retained snow crabs per pot lift (Table 2) was a 70.8% increase over the 2004 fishery estimate (Figure 2). The stratified CPUE estimate of 259.3 (SE=22.5) for all legal retained crabs (including Tanner x snow crab hybrids) was a 67.6% increase over 2004. The precision of the stratified CPUE estimate was good for all legal retained crabs; the standard error was 8.7% of the estimated mean. The 95% confidence interval for the CPUE of legal retained crabs estimated from sampled pot lifts was 214.4 to 304.2 crabs per pot lift. This interval included the ATF CPUE of 239, indicating that the sampled pot lifts were representative of the total fishery. Approximately 20% of the total catch of snow crabs was discarded as bycatch, most of which were legal-sized crabs < 4 inches (102 mm) CW. Although the minimum legal size for snow crabs was 3.1 inches (79 mm) CW, processing plants generally do not accept crabs < 4 inches CW.

Total catches of all animals identified in sampled pot lifts during the 2005 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-processors and catcher-only vessels delivering to processors totaled 48,255 crabs, which accounted for 0.29% of the cumulative reported harvest (Appendix D1). Of all sampled crabs, 0.37% were deemed illegal, either due to size, sex, or species.

Community Development Quota Fishery

Observers were deployed on the 1 catcher-processor vessel and all 8 catcher-only vessels during the 2005 fishing season. 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. Fishing began on 28 January and continued until 22 February. A total of 210 pot lifts selected for pot-lift sampling accounted for 6.3% of the 3,345 pot lifts reported by vessel operators (Bowers et al. *In prep*). The locations of pot lifts sampled by observers during the 2005 Bering Sea CDQ snow crab fishery are displayed in Appendix B2.

Size frequency measurements of CW were taken from 3,703 retained male snow crabs throughout the season by onboard observers and ADF&G staff stationed at shore-side processing locations (Table 3). The mean CW of retained male snow crabs was 114.8 mm.

Pot-lift sample measurements of CW were taken from 20,490 male snow crabs throughout the season by onboard observers. The mean CW for all male snow crabs from sampled pot lifts was 111.9 mm. The size frequency distribution of those measurements revealed a mode between 111 and 115 mm (Figure 3), similar to results from the general fishery. The percentage of sampled male snow crabs identified as old shell and very old shell was 8.9%. No female snow crabs were observed in pot-lift samples by onboard observers.

The stratified CPUE estimate of 380.3 legal retained snow crabs per pot lift (Table 4) was a 300% increase from the 2004 CDQ fishery estimate and a 49% increase over the 2005 general fishery. The stratified CPUE estimate of 385.9 (SE = 15.8) for all legal retained crabs (including Tanner x snow crab hybrids) was also a 300% increase from the 2004 CDQ fishery estimate. The precision of the stratified CPUE estimate was good for all legal retained crabs; the standard error was 4.1% of the estimated mean. The 95% confidence interval for the CPUE for legal retained crabs estimated from the sampled pot lifts was 354.3 to 417.4 crabs per pot lift. This interval included the ATF CPUE of 389, indicating the sampled pot lifts provided data representative of the total fishery. Approximately 13% of the total catch of snow crabs was discarded as bycatch, most of which were legal-sized crabs < 4 inches (102 mm) CW.

Total catches of all animals identified in sampled pot lifts during the 2005 CDQ fishery are provided in Appendix C5. Additional appendices contain CPUE by soak time (Appendix C6) and depth (Appendix C7) and the reproductive condition of female snow crabs from the bycatch (Appendix C8).

Legal tallies conducted on catcher-processors and catcher-only vessels delivering to processors totaled 21,455 crabs and comprised 1.6% of the cumulative reported harvest (Appendix D1). From all sampled crabs, 0.16% were deemed illegal, either due to size, sex or species.

BERING SEA GOLDEN KING CRAB

Observers have been deployed during the Bering Sea golden king crab fishery since 2001. During the 2005 fishery, observers were deployed on all 5 participating catcher-only vessels. The pot-lift sampling goal for observers on catcher-only vessels was 10 pot lifts during each day of fishing activity. The fishery opened by commissioner's permit on 1 January and fishing took place from 31 January to 14 April. A total of 602 pot lifts selected for pot-lift sampling accounted for 25.1% of the 2,397 pot lifts reported by vessel operators (Bowers et al. *In prep*). The locations of pot lifts sampled by observers during the 2005 Bering Sea golden king crab fishery are displayed in Appendix B3.

Size frequency sample measurements of CL were taken from 219 retained male golden king crabs throughout the season by onboard observers and ADF&G staff stationed at shore-side processing locations (Table 5). The mean CL of retained male golden king crabs was 141.4 mm.

Pot-lift sample measurements of CL were taken from 3,892 male golden king crabs throughout the season by onboard observers. The mean CL for all male golden king crabs from sampled pot lifts was 136.7 mm. The size distribution of male golden king crabs showed a mode at 136-140 mm CL (Figure 4). Pot-lift sample measurements of CL were

taken from 1,196 female golden king crabs throughout the season by onboard observers (Figure 5). The mean CL for all female golden king crabs from sampled pot lifts was 121.4 mm.

The stratified CPUE estimate of 5.9 legal retained golden king crabs per pot lift (Table 6) was a 61% decrease from the 2004 fishery estimate (Figure 6). The precision of the stratified CPUE estimate for all legal retained crabs was fair; the standard error was 12.9% of the estimated mean. The 95% confidence interval for the CPUE for legal retained crabs estimated from the sampled pot lifts was 4.3 to 7.4 crabs per pot lift. This interval includes the ATF CPUE of 6, indicating that the sampled pot lifts provided data for accurately estimating CPUE for the total fishery. An estimated 40% of all golden king crabs captured during the 2005 fishery were female or sublegal male crabs and were discarded as bycatch.

Total catches of all animals identified in sampled pot lifts during the 2005 season are provided in Appendix C9. Additional appendices contain CPUE by soak time (Appendix C10) and depth (Appendix C11) and the reproductive condition of female golden king crabs from the bycatch (Appendix C12).

Legal tallies conducted on catcher-only vessels delivering to processors totaled 299 crabs by the end of the 2005 season and comprised 2.1% of the cumulative reported harvest (Appendix D1). From all sampled crabs, 0.33% were deemed illegal, either due to size, sex or species.

BERING SEA GROOVED TANNER CRAB

During the 2005 Bering Sea grooved Tanner crab fishery, an observer was deployed on the only participating catcher-only vessel. The pot-lift sampling goal for the observer was 10 pot lifts during each day of fishing activity. The fishery opened by commissioner's permit on 1 January and fishing took place from 29 June to 3 July. In addition to grooved Tanner crabs, legal triangle Tanner crabs *C. angulatus* and legal scarlet king crabs were also retained during this fishery.

A total of 35 pot lifts selected for pot-lift sampling accounted for 3.8% of the 912 pot lifts reported by vessel operators (Bowers et al. *In prep*). The locations of pot lifts sampled by observers during the 2005 Bering Sea grooved Tanner crab fishery are displayed in Appendix B4.

Pot-lift sample measurements of CW were taken from 161 male grooved Tanner crabs throughout the season by the onboard observer (Figure 7). The mean CW for all male grooved Tanner crabs from sampled pot lifts was 148.9 mm. Pot-lift sample measurements of CW were taken from 12 female grooved Tanner crabs throughout the season by onboard observers (Figure 8). The mean CW for all female grooved Tanner crabs from sampled pot lifts was 105.5 mm.

The stratified CPUE estimate was 4.7 legal retained grooved Tanner crabs per pot lift (Table 7, Figure 9). The precision of the stratified CPUE estimate for all legal retained crabs was very poor; the standard error was 118% of the estimated mean. The 95% confidence interval for the CPUE for legal retained crabs estimated from the sampled pot lifts was 0 to 15.9 crabs per pot lift. Even though the precision of the estimate was poor,

the estimate was close to the ATF CPUE of 4, indicating the sampled pot lifts provided data for accurately estimating CPUE for the total fishery.

Total catches of all animals identified in sampled pot lifts during the 2005 season are provided in Appendix C13. Additional appendices contain CPUE by soak time (Appendix C14) and depth (Appendix C15) and the reproductive condition of female grooved Tanner crabs from the bycatch (Appendix C16). No size frequency samples or legal tallies were conducted at the end of the 2005 season.

Accuracy and Precision of CPUE Estimates

In using CPUE estimates based on observer data it was important to have some assessment of their reliability for observed vessels and, especially, for all vessels participating in a fishery. Although the observer data were the only source of information on bycatch CPUEs for the fisheries presented in this report, fish tickets also provided data for independent estimates of the CPUE of retained legal crabs. We can gain some understanding of the reliability of the estimated CPUE computed from observer sample data by comparing it to the ATF CPUE computed from fish ticket data.

Fish ticket data from all landings of all vessels participating in a fishery provided an independent estimate of the total fishery CPUE of retained legal crabs. This was particularly useful for fisheries in which observers were required on catcher-processor vessels and only a fraction of the catcher-only vessels.

With the exception of two fisheries, CPUE estimates for retained legal crabs computed from observer pot-lift samples were within 5% of the ATF CPUE for the reported fisheries (Table 8). The exceptions were the Bering Sea snow crab general fishery and the Bering Sea grooved Tanner crab fishery. Additionally, all ATF CPUEs were contained within the 95% confidence intervals for CPUEs derived from observer data. The close agreement between the observer-based and ATF CPUE estimates for retained legal crab in those BSAI crab fisheries indicated that observer pot-lift sample data provide reliable estimates of CPUE for the entire fleet.

CPUE estimates computed from observer data for retained legal crabs in the 2005 Bering Sea snow crab general fishery (Table 2) differed from the ATF CPUE by 8.6% or 20.5 crabs per pot lift, the equivalence of one standard error. The other fishery with less reliable estimates was the Bering Sea grooved Tanner crab fishery (Table 7). The 11.9% difference between observer and ATF CPUE estimates, or 0.5 crabs per pot lift, was based on a relatively small sample size of 35 pot lifts.

Comparing stratified CPUE estimates for retained legal crabs with the ATF CPUE in the 2 other fisheries indicated the coverage provided adequate data for estimation of total fishery CPUE. The Bering Sea snow crab CDQ and the Bering Sea golden king crab fisheries discussed in this report realized the best agreement between estimates. These results are consistent with 100% observer coverage in past fisheries.

The “stratified” observer-based CPUE estimator used in this report was different from the “sample” observer-based CPUE estimate used in Mandatory Shellfish Observer Database Summaries prior to 1996 (e.g., Tracy 1994, 1995a, b). Although the stratified estimation method can provide more accurate and precise estimates, the stratified and sample CPUE estimates are generally very close to each other. Therefore, the stratified estimates

presented here are comparable to those CPUE estimates included in previous observer data summaries. The value of using the stratified CPUE estimates was that the estimation method allows for computation of the standard errors of the CPUE estimates.

The standard errors provided in this report give a measure of the precision or repeatability of the CPUE estimates. A general measure of statistical precision was the ratio of the standard error of an estimate to the estimate itself; they are expressed here as a percent (ratio × 100). Ratios that are less than 10% are considered to be acceptable for the estimates made using data collected by observers; 5% or less are desirable. Generally, the stratified CPUE estimates appeared to be precise for both 2005 Bering Sea snow crab fisheries, as all ratios of standard errors to CPUE estimates were less than 10%. They ranged from a low of 4.1% for the Bering Sea snow crab CDQ fishery to 8.7% for the general fishery. The precision of the 2005 Bering Sea golden king crab CPUE estimates was less acceptable with a ratio of 12.9%. The precision of the Bering Sea grooved Tanner crab estimates was quite poor at 118%. We also computed 95% confidence intervals for the CPUE estimates even though the sample size within each stratum (vessel-day) was not large enough to assume an asymptotic normal distribution. However, bootstrap simulation of observer data collected in the 1995 BSAI crab fisheries suggested that the stratified CPUE estimates plus or minus two standard errors was adequate to characterize the true CPUE of the targeted species (Byrne and Pengilly 1998).

ACKNOWLEDGMENTS

Shellfish observers deployed during the 2005 Bering Sea fisheries collected the data summarized in this report. We would like to express our gratitude for their diligence in collecting biological and fisheries management information while living and working at sea, often for extended periods.

The Alaska Department of Fish and Game data entry staff of Tammy Chisum and Savanna Kochuten is acknowledged for their timely data entry. Rachel Alinsunurin is acknowledged for her efforts in editing data. We thank Lucinda Neel for final preparation of the report, and Shari Coleman, Kally Spalinger and Dan Urban of the Westward Region staff for their assistance in reviewing this summary.

This project was funded in part by the National Oceanic and Atmospheric Administration (NOAA) Awards NA17FN1273, NA03NMF4370188, NA04NMF4410089, NA04NMF44370175, and NA04NMF4370176. The views expressed here are those of the authors and do not necessarily reflect the view of NOAA or any of its subagencies.

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TABLES AND FIGURES

Table 1.-Carapace size frequency distributions by shell condition from biological measurements of retained snow crabs sampled during the 2005 Bering Sea snow crab general fishery.

Width (mm)[a]	New Percent	Old Percent	Very old Percent	All Percent
< 76	< 0.1	< 0.1	0	0.1
76-80	< 0.1	< 0.1	0	0.1
81-85	0.1	< 0.1	< 0.1	0.1
86-90	0.3	< 0.1	< 0.1	0.4
91-95	1.0	0.1	< 0.1	1.2
96-100	3.9	0.6	0.1	4.7
101-105	10.0	2.0	0.1	12.1
106-110	16.3	3.0	0.1	19.3
111-115	19.8	2.6	0.1	22.4
116-120	18.8	1.8	0.1	20.7
121-125	12.0	0.8	< 0.1	12.9
126-130	4.7	0.3	< 0.1	5.0
131-135	1.0	< 0.1	< 0.1	1.0
> 135	0.1	< 0.1	0	0.1
Total Crab	16,463	2,115	103	18,681
Total Percent	88.1	11.3	0.6	100.0

[a] Average carapace width (CW) = 113.1 mm

Table 2.-Estimated catch per pot (CPUE) of selected crab species from pot lifts sampled by observers deployed during the 2005 Bering Sea snow crab general fishery. The estimates are from 427 pot lifts.

	Sampled Fleet Estimates		
Species / Sex class	CPUE	SE	Estimated Total Catch [a]
Snow Crab			
Legal males - retained	255.5[b]	21.20	17,848,000[c]
Legal males - not retained	50.4	11.04	3,520,000
Sublegal males	11.4	3.85	796,000
Females	0.2	0.01	11,000
Tanner/Snow Hybrid			
Legal males - retained	3.8[b]	3.36	266,000[c]
Legal males - not retained	0.6	0.50	40,000
Sublegal males	1.1	1.00	75,000
Females	< 0.1	< 0.01	1,000

[a] Estimated catch is the product of the catch per unit effort (CPUE) estimate and 69,863, the total number of pots pulled for the 2005 Bering Sea snow crab general fishery (ADF&G 2005).
[b] Actual total fishery CPUE of retained legal crabs was 239 for all vessels (ADF&G 2005).
[c] Actual catch of retained legal crabs for the fishery was 16,684,751 (ADF&G 2005).

Table 3.-Carapace size frequency distributions by shell condition from biological measurements of retained snow crabs sampled during the 2005 Bering Sea snow crab community development quota (CDQ) fishery.

Width (mm)[a]	New Percent	Old Percent	Very old Percent	All Percent
< 76	<0.1	0	0	<0.1
76-80	0	0	0	0
81-85	0	0	0	0
86-90	0.1	0.1	0	0.1
91-95	0.2	0.1	0	0.3
96-100	1.1	0.2	0	1.3
101-105	7.6	0.8	0	8.5
106-110	16.8	1.2	<0.1	18.0
111-115	26.2	1.3	<0.1	27.5
116-120	23.0	1.0	0.1	24.1
121-125	13.3	0.4	0	13.8
126-130	4.8	0.1	0	4.9
131-135	1.3	0	0	1.3
> 135	0.2	0	0	0.2
Total Crab	3,509	190	4	3,703
Total Percent	94.8	5.1	0.1	100.0

[a] Average carapace width (CW)=114.8 mm.

Table 4.-Estimated catch per pot (CPUE) of selected crab species from pot lifts sampled by observers deployed during the 2005 Bering Sea snow crab Community Development Quota (CDQ) fishery. The estimates are from 210 pot lifts.

	Sampled Fleet Estimates		
Species / Sex class	CPUE	SE	Estimated Total Catch [a]
Snow Crab			
Legal males - retained	380.3[b]	15.71	1,272,000[c]
Legal males - not retained	51.7	3.31	173,000
Sublegal males	4.2	0.68	14,000
Females	<0.1	0.01	30
Tanner X Snow Hybrid			
Legal males - retained	5.6	1.06	19,000
Legal males - not retained	0.6	0.17	2,000
Sublegal males	0.5	0.12	1,700
Females	0	0	0

[a] Estimated catch is the product of the catch per unit effort (CPUE) estimate and 3,345, the total number of pot lifts for the 2005 Bering Sea snow crab community development quota (CDQ) fishery (ADF&G 2005).

[b] Actual total fishery CPUE of retained legal crabs was 389 for all vessels (ADF&G 2005).

[c] Actual catch of retained legal crabs for the fishery was 1,300,994 (ADF&G 2005).

Table 5.-Carapace length (CL, mm) frequency distributions by shell condition from biological measurements of retained golden king crabs sampled during the 2005 Bering Sea golden king crab fishery.

Length (mm)[a]	New Percent	Old Percent	Very old Percent	All Percent
116-120	0.5	0	0	0.5
121-125	6.4	0	0	6.4
126-130	11.0	0	0	11.0
131-135	15.5	0	0	15.5
136-140	18.3	0.5	0	18.7
141-145	12.8	0	0	12.8
146-150	14.6	0.5	0	15.1
151-155	6.8	0	0	6.8
156-160	6.4	0	0	6.4
161-165	3.2	0	0	3.2
166-170	1.8	0	0	1.8
171-175	1.4	0	0	1.4
176-180	0.5	0	0	0.5
Total Crab	217	2	0	219
Total Percent	99.1	0.9	0	100.0

[a] Average carapace length (CL)=141.4 mm.

Table 6.-Estimated catch per pot (CPUE) of selected crab species from pot lifts sampled by observers deployed during the 2005 Bering Sea golden king crab fishery. The estimates are from 602 pot lifts.

	Sampled Fleet Estimates		
Species / Sex class	CPUE	SE	Estimated Total Catch [a]
Golden King Crab			
Legal males - retained	5.9[b]	0.76	14,000[c]
Legal males - not retained	<0.1	0.01	20
Sublegal males	1.2	0.24	3,000
Females	2.7	0.81	6,000

[a] Estimated catch is the product of the catch per unit effort (CPUE) estimate and 2,397, the total number of pot lifts for the 2005 Bering Sea golden king crab fishery (ADF&G 2005).

[b] Actual total fishery CPUE of retained legal crabs was 6 for all vessels (ADF&G 2005).

[c] Actual catch of retained legal crabs for the fishery was 14,503 (ADF&G 2005).

Table 7.-Estimated catch per pot (CPUE) of selected crab species from pot lifts sampled by observers deployed during the 2005 Bering Sea grooved Tanner crab fishery. The estimates are from 35 pot lifts.

Species / Sex class	Sampled Fleet Estimates		Estimated Total Catch [a]
	CPUE	SE	
Grooved Tanner Crab			
Legal males - retained	4.7[b]	5.58	4,300[c]
Legal males - not retained	0	0	0
Sublegal males	<0.1	0.10	30
Females	0.3	0.61	300
Scarlet King Crab			
Legal males - retained	0.1	0.23	100
Legal males - not retained	0	0	0
Sublegal males	0.4	0.38	400
Females	0.1	0.13	50

[a] Estimated catch is the product of the catch per unit effort (CPUE) estimate and 912, the total number of pot lifts for the 2005 Bering Sea grooved Tanner crab fishery (ADF&G 2005).

[b] Actual total fishery CPUE of retained legal grooved Tanner crabs was 4 for all vessels (ADF&G 2005).

[c] Actual catch of retained legal grooved Tanner crabs for the fishery was 3,799 (ADF&G 2005).

Table 8.-Observer coverage, pot lift sampling effort by observers, and relative difference of the weighted catch per unit effort (CPUE) estimates for retained legal crabs from the Actual Total Fishery (ATF) CPUE. Data is from crab fisheries with mandatory observers.

Fishery	Vessels		Pot Lifts		Percent difference of the weighted CPUE estimate from ATF CPUE[a]
	Observed	Total Fishery	Observed	Total Fishery	
2005 Bering Sea snow crab general (with legal hybrids)	19	170	427	69,863	+8.6[b]
2005 Bering Sea snow crab CDQ (with legal hybrids)	9	9	210	3,345	-0.8[b]
2005 Bering Sea golden king crab	4	4	602	2,397	-3.3[b]
2005 Bering Sea grooved Tanner crab	1	1	35	912	+11.9[b]

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

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

[b] ATF CPUE is contained within the 95% confidence interval for the stratified, weighted CPUE estimate.

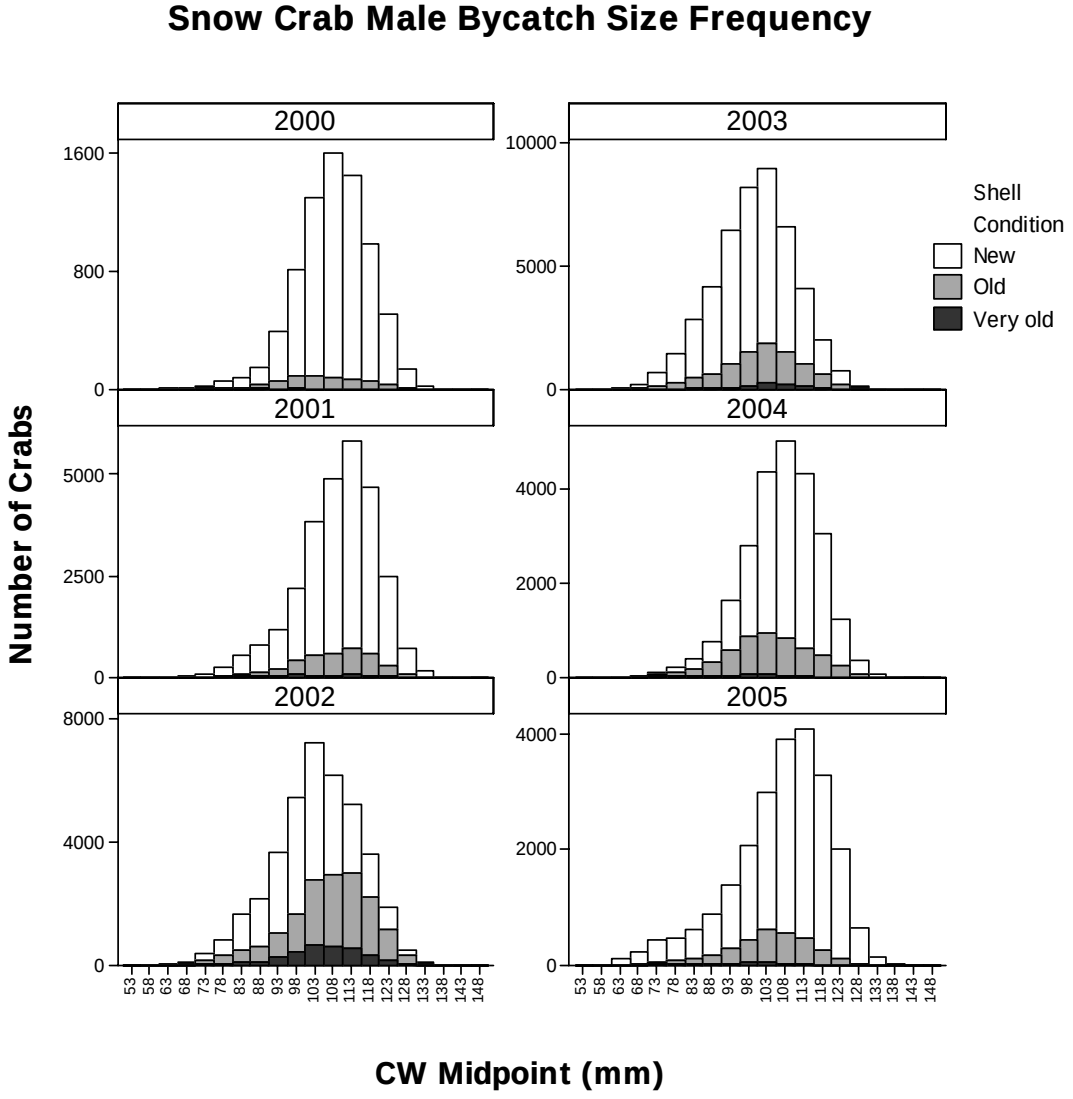


Figure 1.-Carapace size frequency distributions with corresponding shell conditions for male snow crabs from pot lifts sampled during the 2000-2005 Bering Sea snow crab general fisheries.

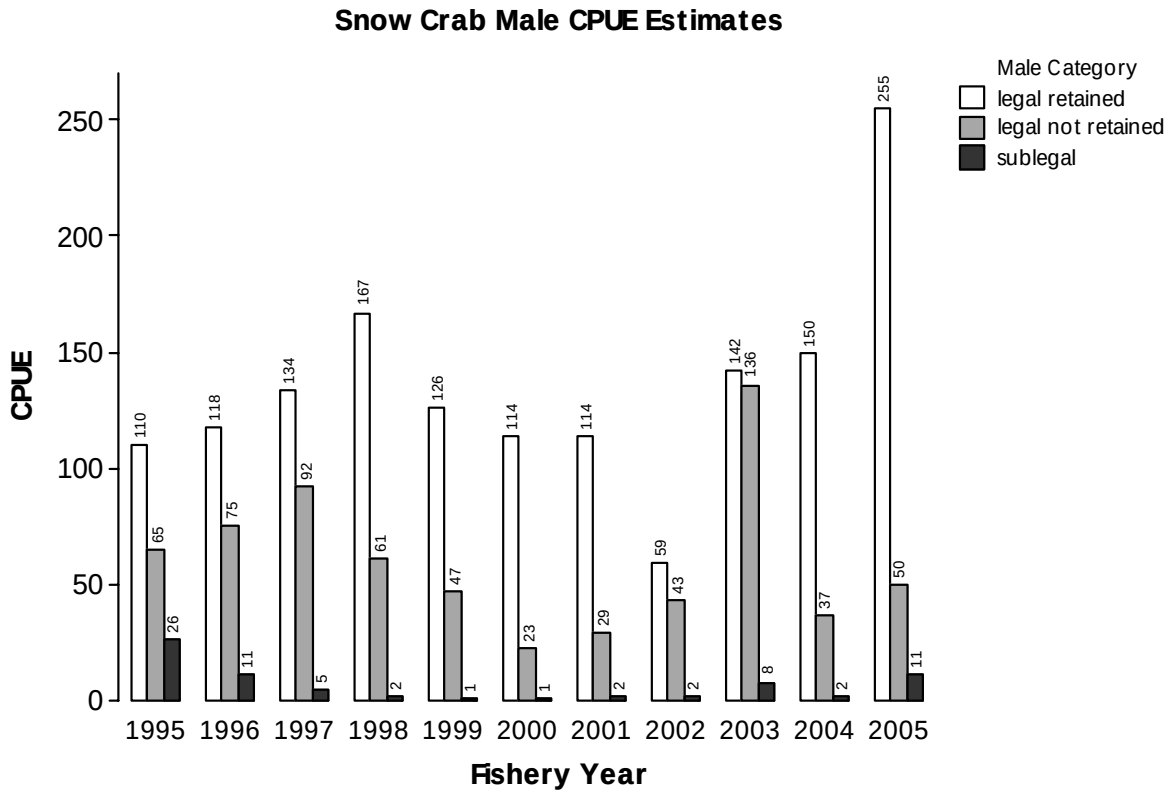


Figure 2.-Estimated catch per unit effort (CPUE) of male snow crabs from pot lifts sampled during the 1995-2005 Bering Sea snow crab general fisheries.

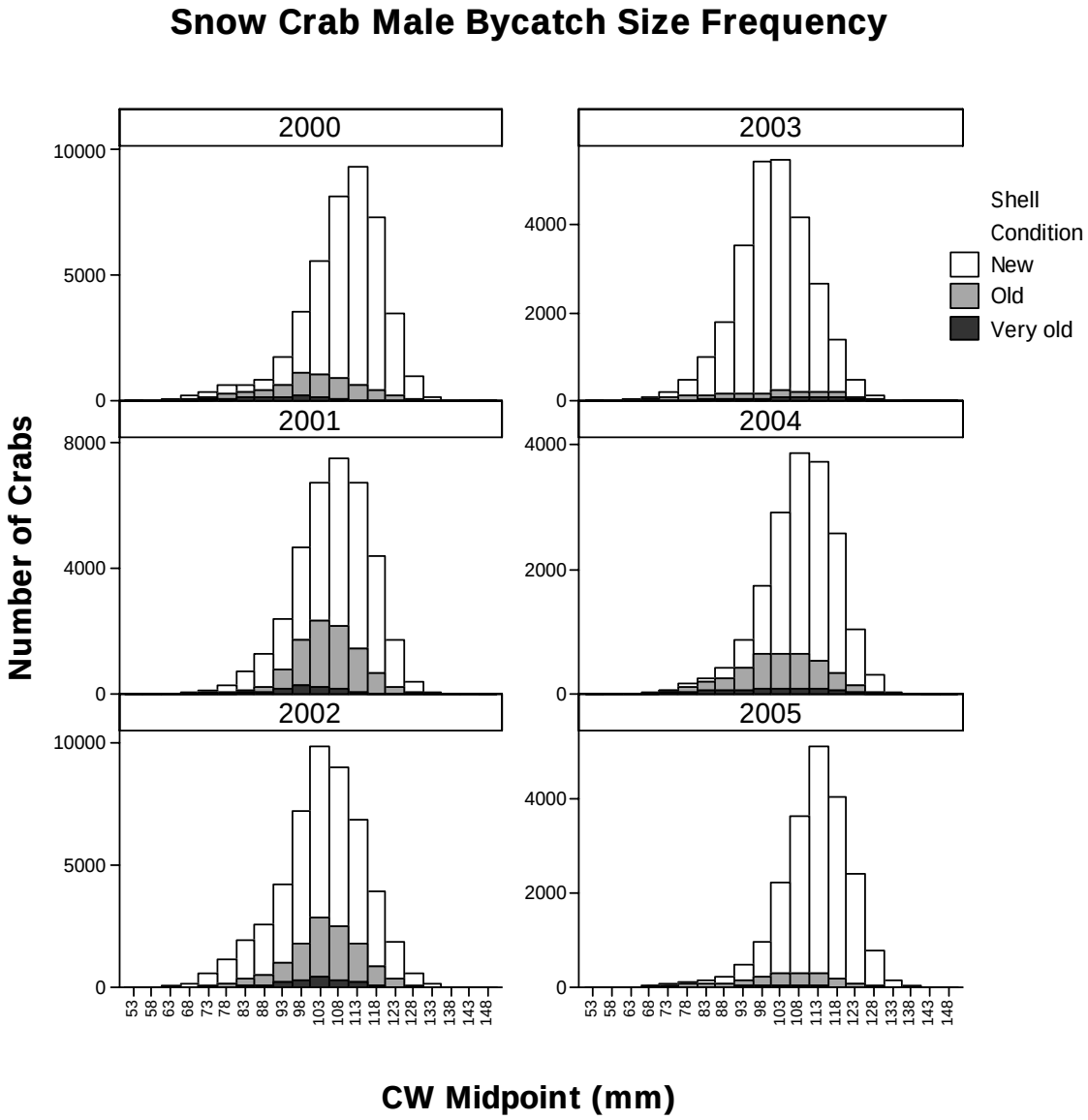


Figure 3.-Carapace size frequency distributions with corresponding shell conditions for male snow crabs from pot lifts sampled during the 2000-2005 Bering Sea snow crab community development quotas (CDQ) fisheries.

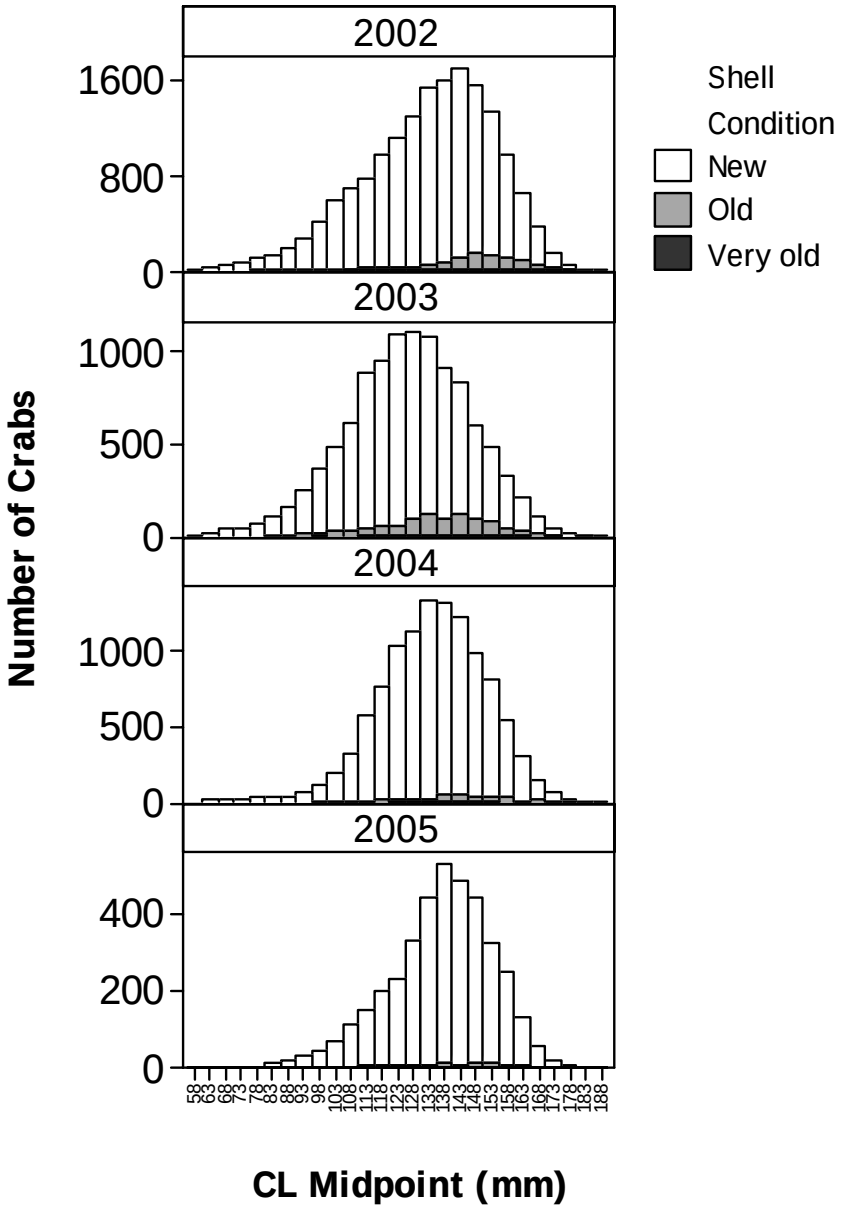


Figure 4.-Carapace length (CL, mm) frequency distributions with corresponding shell conditions for male golden king crabs from pot lifts sampled during the 2002-2005 Bering Sea golden king crab fisheries.

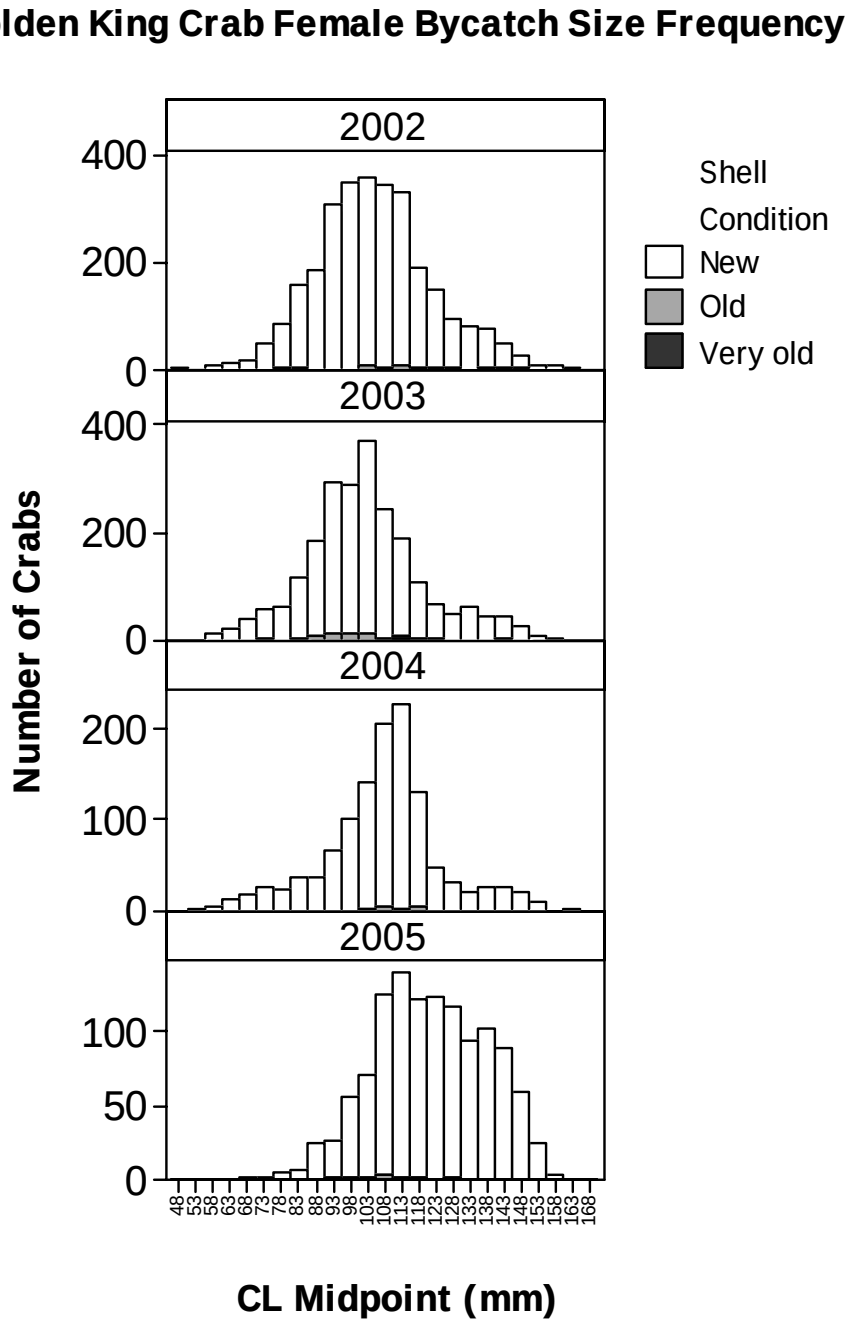


Figure 5.-Carapace length (CL, mm) frequency distributions with corresponding shell conditions for female golden king crabs from pot lifts sampled during the 2002-2005 Bering Sea golden king crab fisheries.

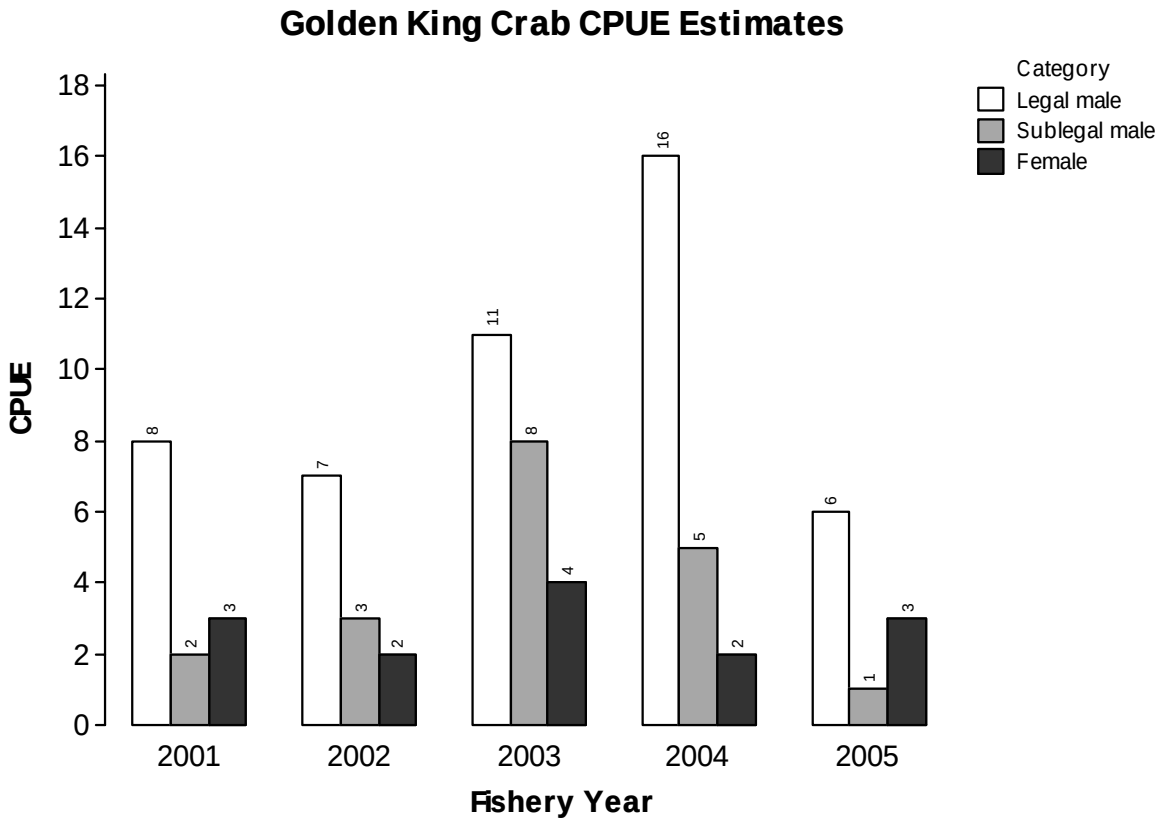


Figure 6.-Estimated catch per unit effort (CPUE) of golden king crabs from pot lifts sampled during the 2001-2005 Bering Sea golden king crab fisheries.

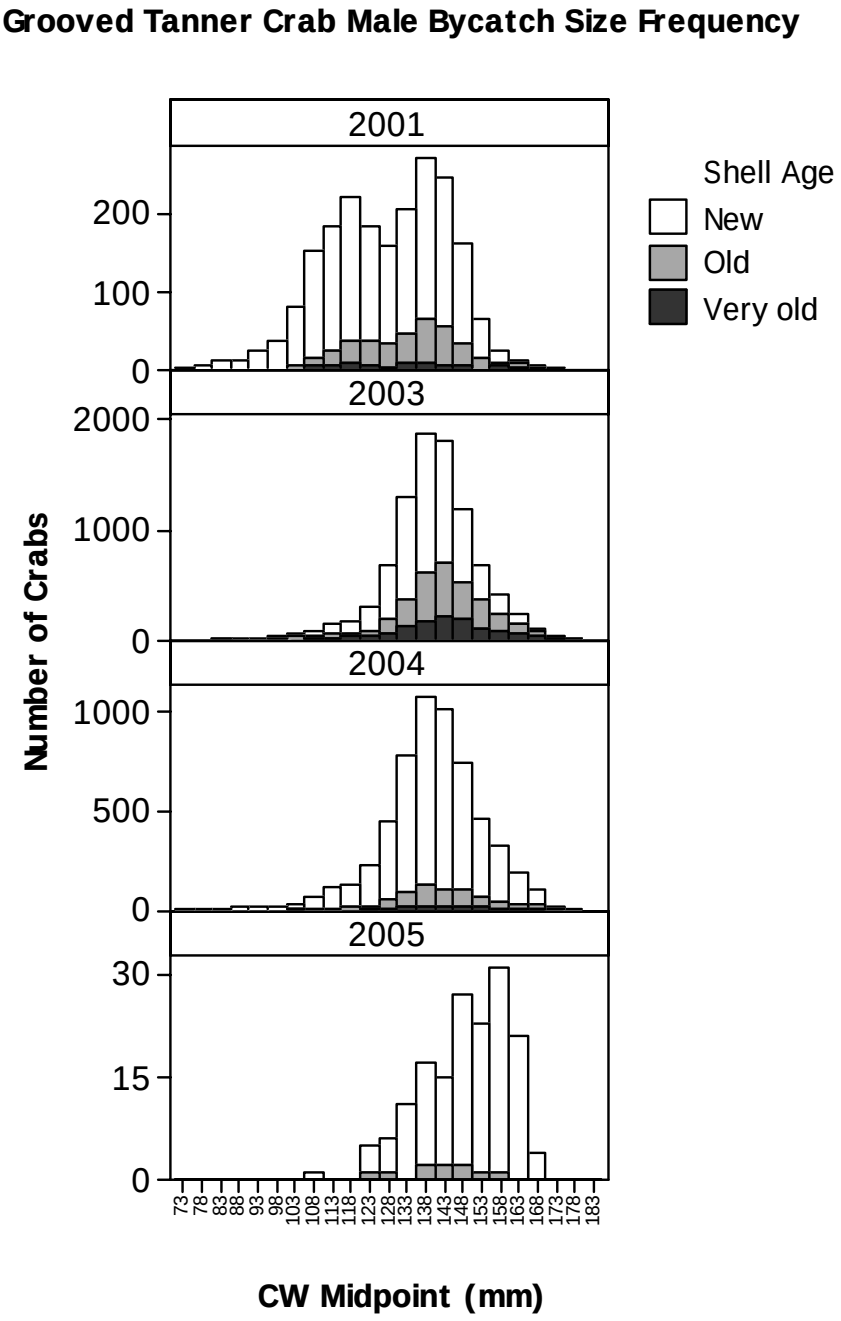


Figure 7.-Carapace width (CW, mm) frequency distributions with corresponding shell conditions for male grooved Tanner crabs from pot lifts sampled during the 2001, and 2003-2005 Bering Sea grooved Tanner crab fisheries.

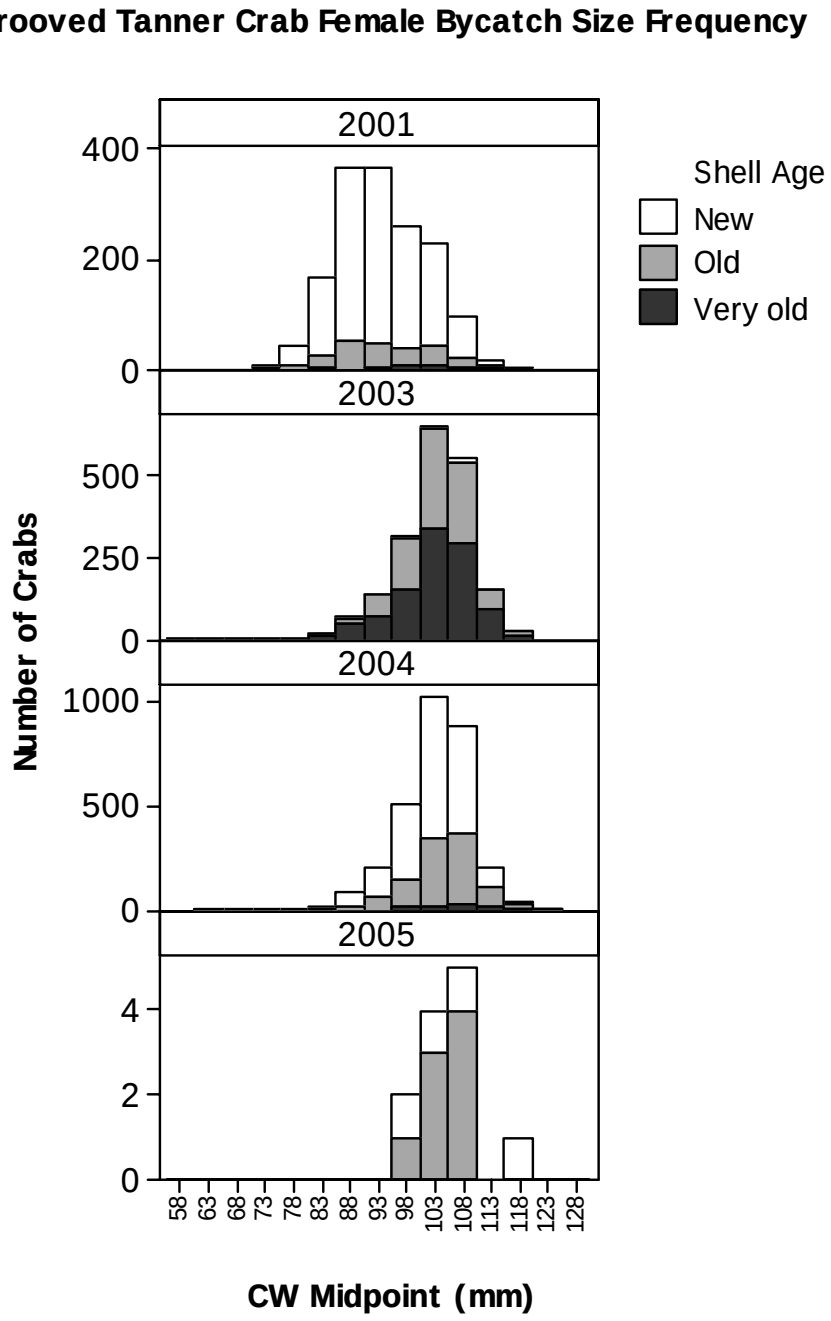


Figure 8.-Carapace width (CW, mm) frequency distributions with corresponding shell conditions for female grooved Tanner crabs from pot lifts sampled during the 2001, and 2003-2005 Bering Sea grooved Tanner crab fisheries.

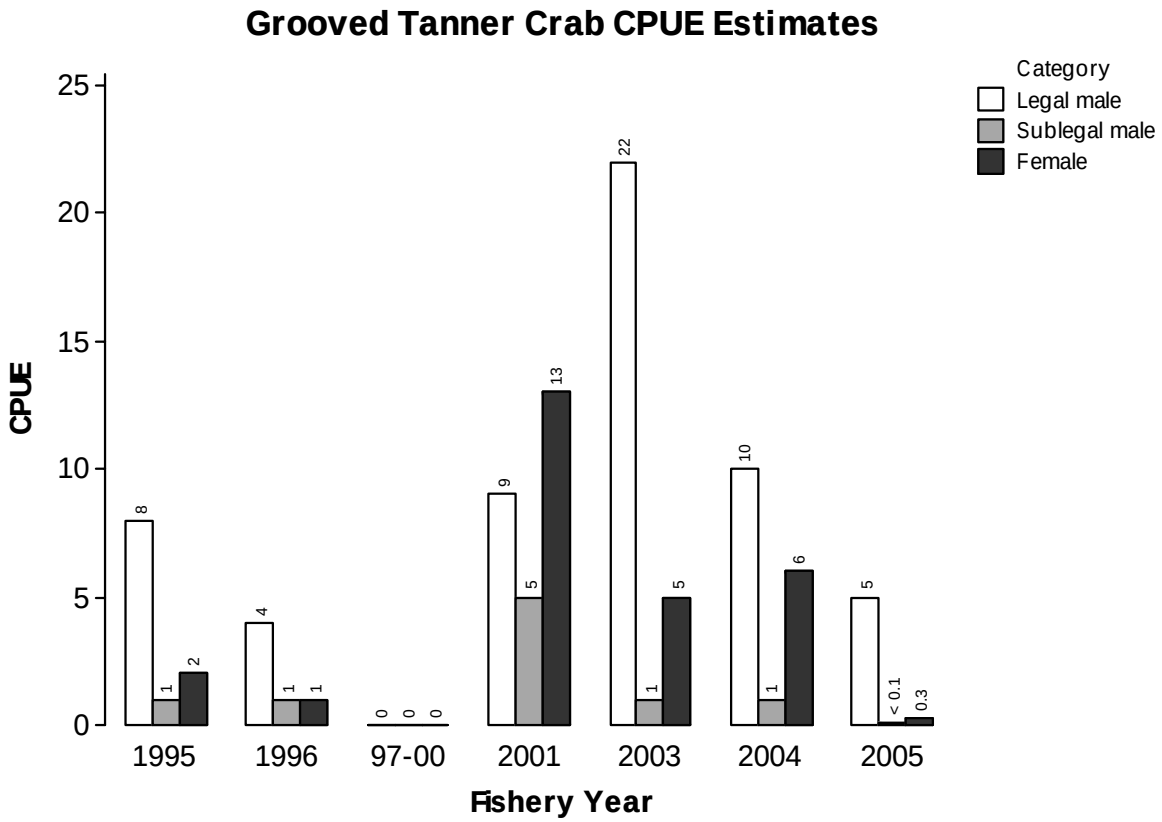


Figure 9.-Estimated catch per unit effort (CPUE) of grooved Tanner crabs from pot lifts sampled during the 1995-1996, 2001 and 2003-2005 Bering Sea golden king crab fisheries.

APPENDIX A: FORMULAS USED TO CALCULATE WEIGHTED MEAN AND VARIANCE ESTIMATES

Appendix A1.-Formulas used to calculate weighted mean and variance estimates for catch per unit effort (CPUE) in fisheries with 100% observer coverage.

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

The mean CPUE for vessel *j* on day *k* is $$\bar{c}_{jk.} = \frac{1}{n_{jk}}\left(\sum_{l} c_{jkl}\right)$$

and the variance for this estimator is $$\hat{\text{var}}\left(\bar{c}_{jk.}\right) = \frac{1}{n_{jk}}\left[\frac{\sum_{l}\left(c_{jkl} - \bar{c}_{jk.}\right)^2}{n_{jk} - 1}\right]$$

where c_{jkl} is the number of crab in a sampled pot lift where

j is the vessel

k is the day

l is the pot sampled

It follows that

the estimated total catch by vessel *j* on day *k* is $\left(\bar{c}_{jk.} \times N_{jk}\right)$,

the estimated total catch by vessel *j* over the fishery is $\sum_{k}\left(\bar{c}_{jk.} \times N_{jk}\right)$,

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

$$\frac{1}{N_{j.}}\left[\sum_{k}\left(\bar{c}_{jk.} \times N_{jk}\right)\right]$$

$$= \sum_{k}\left(\bar{c}_{jk.} \times w_{jk}\right)$$

$$= \bar{c}_{j..}$$

and $$\hat{\text{var}}\left(\bar{c}_{j..}\right) = \sum_{k}\left[\hat{\text{var}}\left(\bar{c}_{jk.}\right) \times w_{jk}^2\right]$$

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

-continued-

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

$$\begin{aligned}
\bar{c}_{...} &= \frac{1}{N_{..}}\left[\sum_j \left(\bar{x}_{j..} \times N_{j.}\right)\right] \\
&= \frac{1}{N_{..}}\left[\sum_j \left(\sum_k \left(\bar{c}_{jk.} \times w_{jk}\right)\right) \times N_{j.}\right] \\
&= \frac{1}{N_{..}}\left[\sum_j \left(\sum_k \left(\bar{c}_{jk.} \times \frac{N_{jk}}{N_{j.}}\right)\right) \times N_{j.}\right] \\
&= \frac{1}{N_{..}} \sum_j \sum_k \left(\bar{c}_{jk.} \times N_{jk}\right).
\end{aligned}$$

The variance of this estimator is

$$\begin{aligned}
\hat{\mathrm{var}}\left(\bar{c}_{...}\right) &= \sum_j \left[\hat{\mathrm{var}}\left(\bar{c}_{j..}\right) \times w_{j.}^2\right] \\
&= \sum_j w_{j.}^2 \left\{\sum_k \left[\hat{\mathrm{var}}\left(\bar{c}_{jk.}\right) \times w_{jk}^2\right]\right\} \\
&= \sum_j \left(\frac{N_{j.}}{N_{..}}\right)^2 \left\{\sum_k \left[\hat{\mathrm{var}}\left(\bar{c}_{jk.}\right) \times \left(\frac{N_{jk}}{N_{j.}}\right)^2\right]\right\} \\
&= \sum_j \left\{\sum_k \left[\hat{\mathrm{var}}\left(\bar{c}_{jk.}\right) \times \left(\frac{N_{jk}}{N_{..}}\right)^2\right]\right\} \\
&= \frac{1}{N_{..}^2} \sum_j \sum_k \left[\hat{\mathrm{var}}\left(\bar{c}_{jk.}\right) \times N_{jk}^2\right]
\end{aligned}$$

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

Appendix A2.-Formulas used to calculate weighted mean and variance estimates for catch per unit effort (CPUE) in fisheries with partial observer coverage.

Let c_{ijkl} = number of crabs in sampled pot lift *l* for day *k* on vessel *j* of type *i*

n_{ijk} = number of sampled pot lifts for day *k* on vessel *j* of type *i*

N_{ijk} = total number of pot lifts pulled for day *k* on vessel *j* of type *i*

m_i = number of vessels observed in stratum *i*

M_i = number of vessels in stratum *I*

where *i* = vessel type (CP, CV > 125 ft, CV ≤ 125 ft), a stratum

j = vessel observed, element of a simple random sample

k = day fished, a stratum

l = pot lift sampled, element of a simple random sample

For each observed vessel, consider each day fished as a separate stratum where the sampled pot lifts (n_{ijk}) are a simple random sample of all pot lifts pulled (N_{ijk}) for vessel *j* of type *i* on day *k*. Then the estimated mean number of crabs per pot lift (and its variance) for day *k* on vessel *j* of type *i* is

$$\bar{c}_{ijk.} = \frac{1}{n_{ijk}} \sum_{l} c_{ijkl} \qquad \text{and} \qquad \hat{v}(\bar{c}_{ijk.}) = \frac{1}{n_{ijk}} \left[\frac{\sum_{l} (c_{ijkl} - \bar{c}_{ijk.})^2}{(n_{ijk} - 1)} \right]. \qquad \textbf{(A)}$$

This formulation ignores the finite population correction factor (fpc), the penalty being an overestimation of the population variance as the ratio, $n_{ijk}/N_{ij.}$, is usually less than 10% for the fisheries in question.

It follows from (A) that the estimated weighted mean number of crabs per pot lift (and variance) for vessel *j* of type *i* over the fishery is

$$\bar{c}_{ij..} = \sum_{k} (\bar{c}_{ijk.} \times w_{ijk}) \qquad \text{and} \qquad \hat{v}(\bar{c}_{ij..}) = \sum_{k} \left[\hat{v}(\bar{c}_{ijk.}) \times w_{ijk}^2 \right] \qquad \text{where } w_{ijk} = \frac{N_{ijk}}{N_{ij.}}. \qquad \textbf{(B)}$$

This is a straightforward, weighted, stratified, mean estimate for vessel *j* of type *i*.

-continued-

Vessel *j* is a randomly chosen element from the vessel type stratum *i*. After Cochran (1977) it follows from (B) that the vessel stratum estimates are

$$\bar{c}_{i\ldots} = \frac{1}{m_i}\sum_j \bar{c}_{ij..} \quad \text{and} \quad \hat{v}(\bar{c}_{i\ldots}) = \left[\frac{M_i - m_i}{M_i} \times \frac{1}{m_i}\left(\frac{\sum_j (\bar{c}_{ij..} - \bar{c}_{i\ldots})^2}{(m_i - 1)}\right)\right] + \left[\frac{1}{M_i m_i}\sum_j \hat{v}(\bar{c}_{ij..})\right]. \qquad \textbf{(C)}$$

The first term of the variance estimator accounts for the error among vessels in stratum *i* and includes the fpc. The fpc may be ignored if m_i/M_i is negligible. The second term is the mean within vessel variance for the sampled vessels in stratum *i*. No weighting was used at this stage as it was assumed that all vessels within a stratum were treated as equal in terms of catch.

The final stage combined the results of the separate strata into an overall estimate of mean catch. Taking the results in (C), we arrive at

$$\bar{c}_{\ldots\ldots} = \sum_i \left(\bar{c}_{i\ldots} \times \frac{M_i}{M_.}\right) \quad \text{and} \quad \hat{v}(\bar{c}_{\ldots\ldots}) = \sum_i \left(\hat{v}(\bar{c}_{i\ldots}) \times \frac{M_i^2}{M_.^2}\right). \qquad \textbf{(D)}$$

Calculating forms

The estimated mean catch for the fishery, we can substitute results for the means from (C), (B) and (A) into (D) to arrive at the following

$$\begin{aligned}
\bar{c}_{\ldots\ldots} &= \sum_i \left(\frac{1}{m_i}\sum_j \bar{c}_{ij..} \times \frac{M_i}{M_.}\right) = \sum_i \frac{M_i}{m_i M_.}\sum_j \bar{c}_{ij..} \\
&= \sum_i \frac{M_i}{m_i M_.}\sum_j \left(\sum_k (\bar{c}_{ijk.} \times w_{ijk})\right) \\
&= \sum_i \frac{M_i}{m_i M_.}\sum_j \left[\frac{1}{N_{ij.}}\sum_k \left(\bar{c}_{ijk.} \times N_{ijk}\right)\right] \qquad \textbf{(E)}
\end{aligned}$$

-continued-

Similarly, the estimated variance of the mean estimate is

$$\hat{v}(\bar{c}_{....}) = \sum_i \left[\frac{M_i^2}{M_.^2} \left(\left[\frac{M_i - m_i}{M_i} \times \frac{1}{m_i} \left(\frac{\sum_j (\bar{c}_{ij..} - \bar{c}_{i...})^2}{(m_i - 1)} \right) \right] + \left[\frac{1}{M_i m_i} \sum_j \hat{v}(\bar{c}_{ij..}) \right] \right) \right]$$

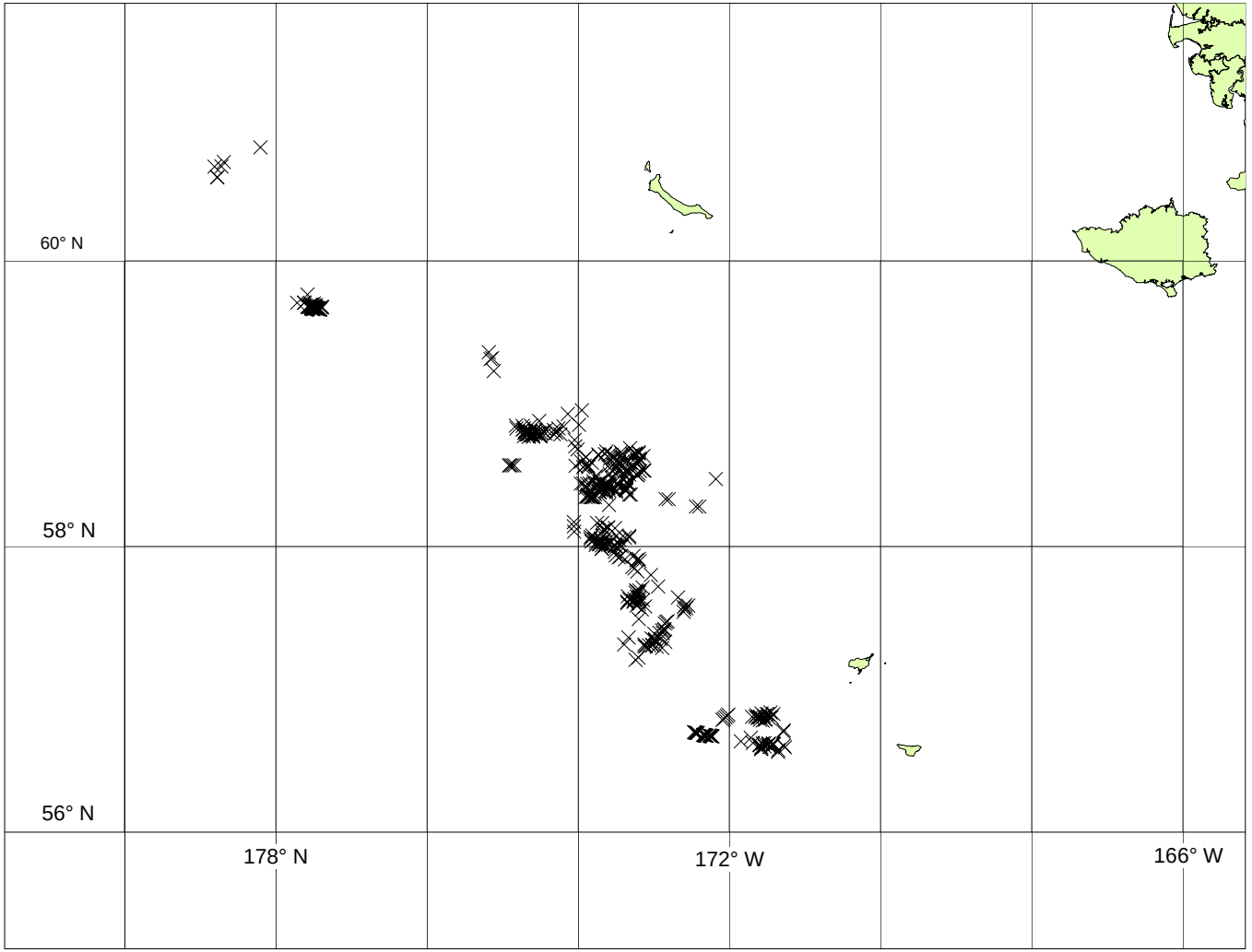
$$= \sum_i \frac{M_i^2}{M_.^2} \left[\left(\frac{M_i - m_i}{M_i} \times \frac{1}{m_i} \left(\frac{\sum_j (\bar{c}_{ij..} - \bar{c}_{i...})^2}{(m_i - 1)} \right) \right) + \frac{1}{M_i m_i} \sum_j \left(\sum_k \left[\hat{v}(\bar{c}_{ijk.}) \times \left(\frac{N_{ijk}}{N_{ij.}} \right)^2 \right] \right) \right]$$

$$= \sum_i \frac{M_i^2}{M_.^2} \left[\left(\frac{M_i - m_i}{M_i} \times \frac{1}{m_i} \left(\frac{\sum_j (\bar{c}_{ij..} - \bar{c}_{i...})^2}{(m_i - 1)} \right) \right) + \frac{1}{M_i m_i} \sum_j \left(\sum_k \left[\hat{v}(\bar{c}_{ijk.}) \right] \times \left(\frac{N_{ijk}}{N_{ij.}} \right)^2 \right) \right]$$

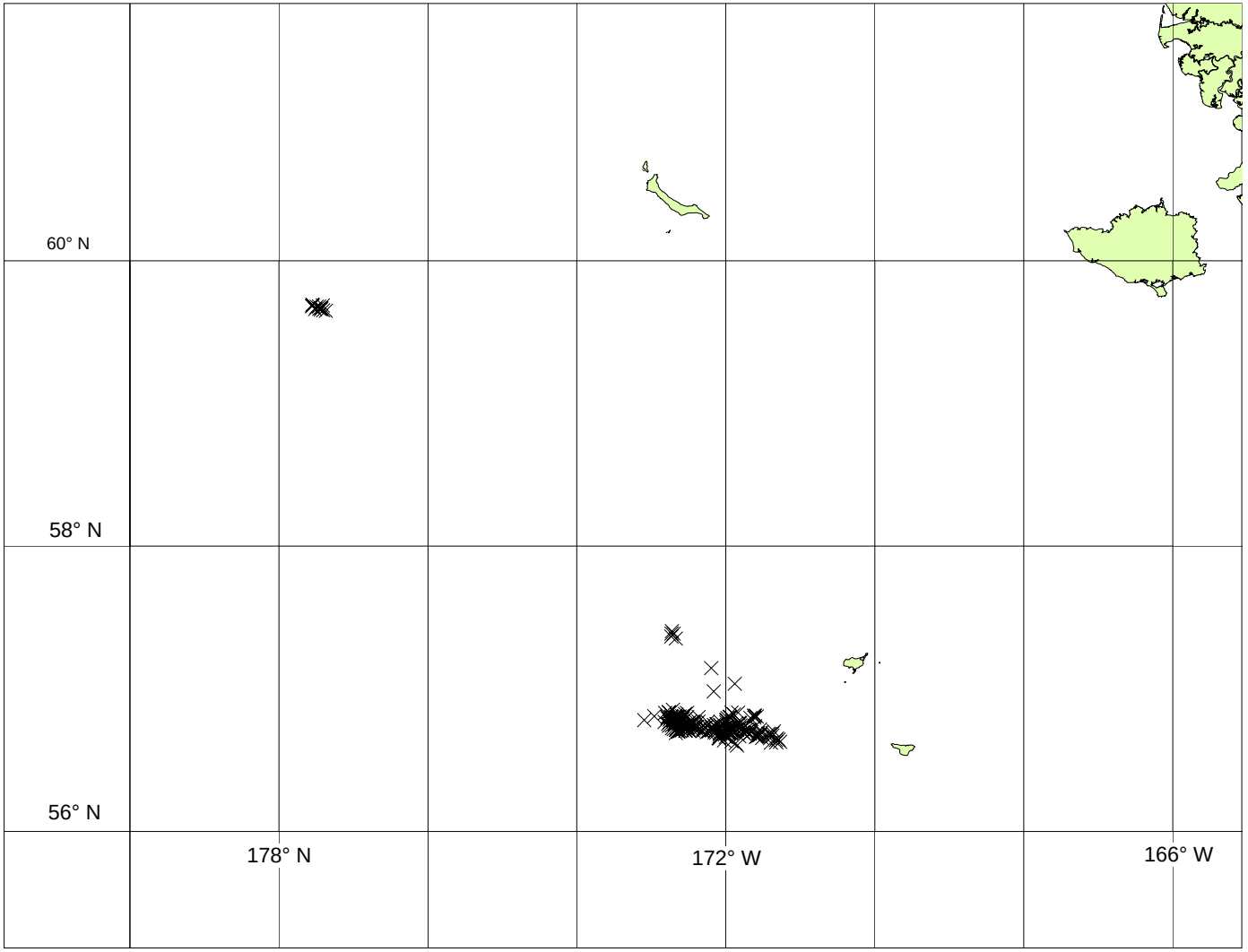
Let $\hat{v}(\bar{a}_i) = \left(\frac{M_i - m_i}{M_i} \times \frac{1}{m_i} \left(\frac{\sum_j (\bar{c}_{ij..} - \bar{c}_{i...})^2}{(m_i - 1)} \right) \right)$ and $\hat{v}(\bar{b}_i) = \left(\frac{1}{M_i m_i} \sum_j \left(\frac{1}{N_{ij.}^2} \sum_k \left[\hat{v}(\bar{c}_{ijk.}) \right] \times N_{ijk}^2 \right) \right)$

Then $\hat{v}(\bar{c}_{....}) = \sum_i \frac{M_i^2}{M_.^2} \left[\left(\hat{v}(\bar{a}_i) \right) + \left(\hat{v}(\bar{b}_i) \right) \right]$. **(F)**

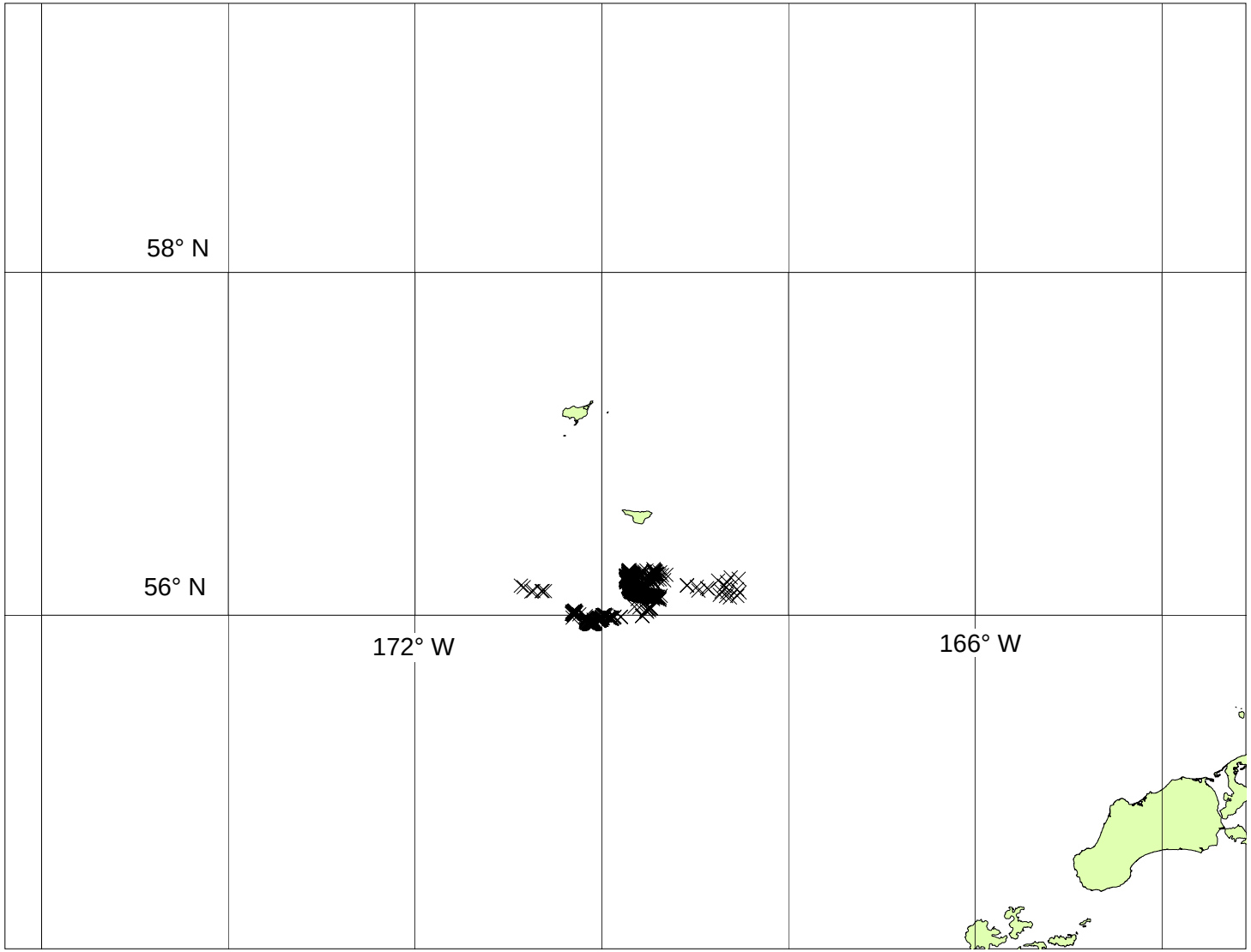
APPENDIX B: LOCATIONS OF POT LIFTS



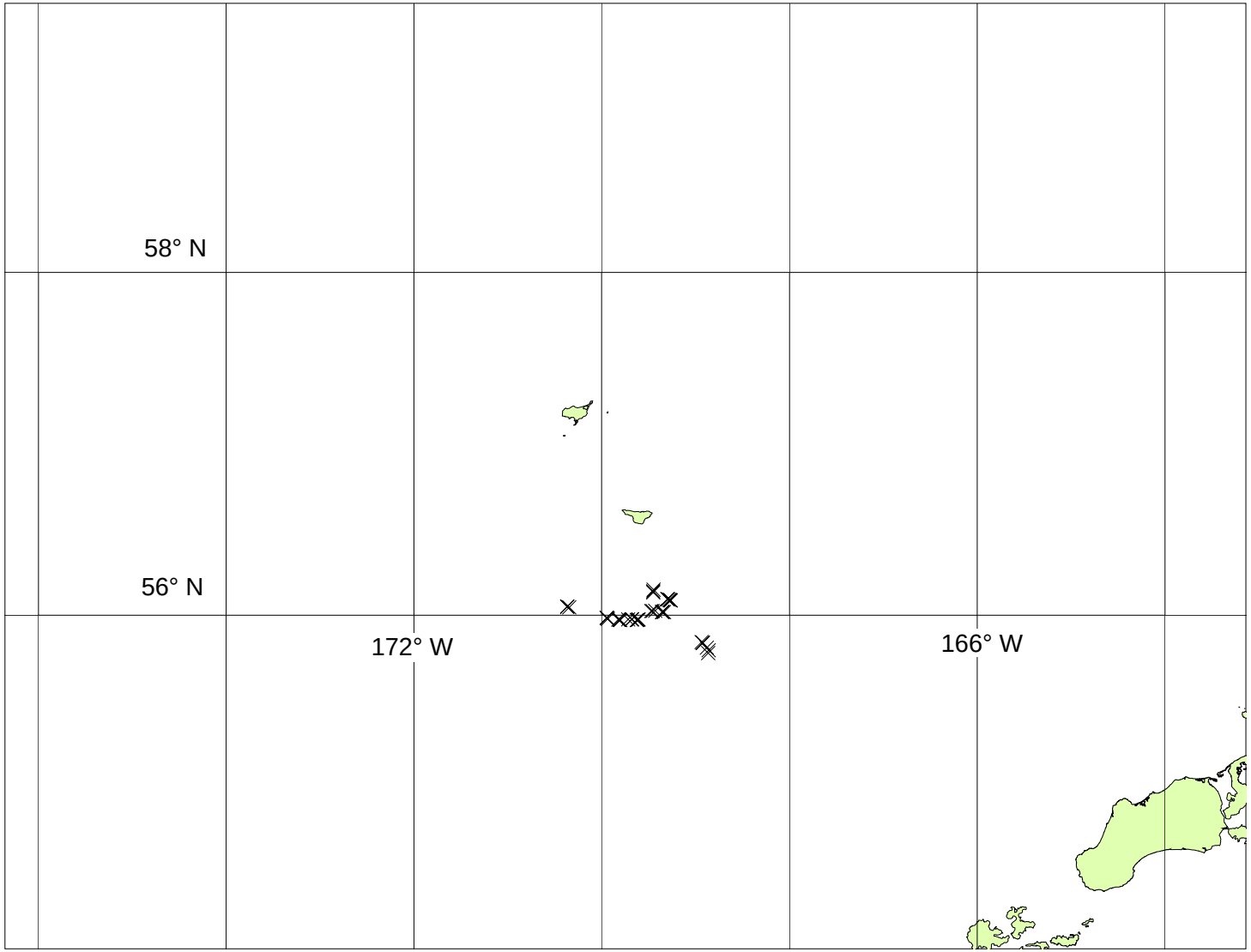
Appendix B1.-Locations of pot lifts sampled by observers during the 2005 Bering Sea snow crab general fishery.



Appendix B2.-Locations of pot lifts sampled by observers during the 2005 Bering Sea snow crab community development quota (CDQ) fishery.



Appendix B3.-Locations of pot lifts sampled by observers during the 2005 Bering Sea golden king crab fishery.



Appendix B4.-Locations of pot lifts sampled by observers during the 2005 Bering Sea Grooved Tanner crab fishery.

APPENDIX C: ADDITIONAL CATCH AND BIOLOGICAL INFORMATION

Appendix C1.-Total pot contents for 427 pot lifts sampled during the 2005 Bering Sea snow crab general fishery.

Species	Total Catch	Species	Total Catch
Snow Crab			
Legal males	127,303	Arrowtooth flounder	3
Sublegal males	5,131	Walleye pollock	3
Females	123	Oregon triton	2
		Sea jelly (unidentified)	2
Tanner/Snow Crab Hybrid		Sculpin (unidentified)	2
Legal males	1,969	Sea anemone (unidentified)	2
Sublegal males	396	Sea star (unidentified)	2
Females	5	Atka Mackeral	1
		Pacific halibut	1
Tanner crab		Skate (unidentified)	1
Legal males	61	Yellow Irish lord	1
Sublegal males	2,326		
Females	1,457		
Snail (unidentified)	288		
Pacific cod	147		
Hermit crab (unidentified)	49		
Neptunea spp.	16		
Octopus	15		

Appendix C2.- CPUE by soak times for 426 pot lifts sampled during the 2005 Bering Sea snow crab general fishery.

Soak Hours[a]	Percent of Sampled Pots	CATCH PER SAMPLED POT LIFT				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
1-6	0.2	68.0	29.0	68.0	0	102.0
7-12	9.6	172.6	26.0	172.6	0	203.8
13-18	30.3	229.5	42.6	229.5	0.3	281.6
19-24	44.4	266.4	65.7	266.4	0.5	347.2
25-30	9.2	223.1	84.4	223.1	0	325.4
31-36	1.2	187.6	34.8	187.6	0	225.4
37-42	0.7	307.7	96.0	307.7	0	432.3
43-48	1.9	336.5	29.8	336.5	0	372.9
49-54	1.9	363.4	23.0	363.4	0	391.6
55-60	0.2	378.0	17.0	378.0	0	406.0
61-66	0.2	87.0	74.0	87.0	0	181.0
67-72	0.2	161.0	29.0	161.0	0	197.0

[a] Mean soak time = 20.9 hours

Appendix C3.-Catch per unit effort **(**CPUE) by depth for 426 pot lifts sampled during the 2005 Bering Sea snow crab general fishery.

Depth[a] (fathoms)	Percent of Sampled Pots	CATCH PER SAMPLED POT LIFT				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
21-25	0.2	352.0	31.0	352.0	0	383.0
--	--	--	--	--	--	--
51-55	0.2	447.0	20.0	447.0	0	467.0
56-60	1.2	247.2	127.8	247.2	0	409.2
61-65	35.2	253.3	83.0	253.3	0.8	356.6
66-70	27.9	225.2	54.1	225.2	0.1	293.8
71-75	18.8	238.1	36.6	238.1	0	277.9
76-80	4.0	303.2	33.2	303.2	0	339.1
81-85	0.2	185.0	7.0	185.0	0	192.0
86-90	0	--	--	--	--	--
91-95	0.2	98.0	1.0	98.0	0	99.0
96-100	0.2	1.0	2.0	1.0	0	3.0
101-105	0.5	321.5	1.0	321.5	0	322.5
106-110	0.2	193.0	5.0	193.0	0	198.0
111-115	1.6	240.1	1.7	240.1	0	241.9
116-120	1.4	175.2	4.5	175.2	0	179.7
121-125	2.6	234.1	4.0	234.1	0	238.1
126-130	3.8	269.7	5.3	269.7	0	275.0
131-135	1.2	292.2	4.4	292.2	0	296.6
136-140	0.5	325.0	3.0	325.0	0	328.0

[a] Mean depth = 73.8 fathoms

Appendix C4.-Reproductive condition of female snow crabs from pot lifts sampled during the 1995-2005 Bering Sea snow crab general fisheries.

Year	Crabs Sampled	Eyed Eggs	Uneyed Eggs	Barren, Matted	Barren, Non-matted
		Percent	Percent	Percent	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

Appendix C5.-Total pot lift contents for 210 pot lifts sampled during the 2005 Bering Sea snow crab community development quota (CDQ) fishery.

Species	Total Catch	Species	Total Catch
Snow Crab			
Legal males	88,929	Hermit crab (unidentified)	13
Sublegal males	790	Oregon triton	11
Females	2	Sea star (unidentified)	11
		Octopus	8
Tanner X Snow Crab Hybrid		Sea anemone (unidentified)	6
Legal males	2,003	Yellow Irish lord	3
Sublegal males	100	Pacific halibut	1
Females	0	Lyre crab	1
		Flatfish (unidentified)	1
Tanner Crab		Sea jelly (unidentified)	1
Legal males	64	Northern rockfish	1
Sublegal males	733	Sea urchin (unidentified)	1
Females	69	Walleye pollock	1

Appendix C6.-Catch per unit effort (CPUE) by soak times for 209 pot lifts sampled during the 2005 Bering Sea snow crab community development quota (CDQ) fishery.

Soak Hours[a]	Percent of Sampled Pots	CATCH PER SAMPLED POT LIFT				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
1-12	1.9	141.0	24.8	2.0	0	167.8
13-24	14.8	243.2	41.7	6.9	0	291.8
25-36	18.7	322.9	28.6	2.4	0	353.9
37-48	12.4	439.3	32.8	3.5	0	475.6
49-60	11.5	474.5	35.8	3.1	0	513.3
61-72	6.7	345.9	36.4	1.6	0	383.9
73-84	2.9	505.2	46.3	5.2	0	556.7
85-96	2.4	393.0	28.4	2.6	0	424.4
97-108	1.9	277.0	74.3	2.5	0	353.8
109-120	1.4	436.3	40.3	3.0	0	479.7
121-132	2.4	403.6	89.4	5.6	0	498.6
133-144	4.3	417.4	89.8	5.4	0	512.7
145-156	5.3	416.2	81.7	3.8	0	501.7
157-168	1.4	265.3	144.0	3.3	0	412.7
169-180	4.3	350.0	209.2	3.1	0.1	562.4
181-192	1.0	481.0	39.5	4.0	0	524.5
193-204	1.0	503.5	167.5	6.0	0	677.0
205-216	2.4	402.4	58.2	1.8	0	462.4
217-228	1.4	433.3	109.0	4.0	0	546.3
229-240	0.5	474.0	81.0	7.0	0	562.0
241-252	0	--	--	--	--	--
253-264	1.0	489.0	28.5	2.5	0	520.0
--	--	--	--	--	--	--
289-300	0.5	195.0	154.0	4.0	0	353.0

[a] Mean soak time = 76.0 hours.

Appendix C7.-Catch per unit effort (CPUE) by depth for 208 pot lifts sampled during the 2005 Bering Sea snow crab community development quota (CDQ) fishery.

Depth[a] (fathoms)	Percent of Sampled Pots	CATCH PER SAMPLED POT LIFT				
		Legal Retained	Legal Not Retained	Sublegal	Female	Total
46-50	0.5	503.0	106.0	19.0	0.0	628.0
51-55	0	--	--	--	--	--
56-60	0	--	--	--	--	--
61-65	25.0	367.6	93.4	3.6	0	464.6
66-70	38.9	402.2	55.4	5.4	0	463.1
71-75	29.3	384.7	25.3	2.2	0	412.3
76-80	0.5	1.0	1.0	0.0	0	2.0
--	--	--	--	--	--	--
106-110	0.5	14.0	0	0	0	14.0
111-115	0	--	--	--	--	--
116-120	1.4	33.3	0.7	0	0	34.0
121-125	1.4	14.0	1.0	0	0	15.0
126-130	1.9	184.5	56.0	0	0	240.5
131-135	0.5	22.0	0	0	0	22.0

[a] Mean depth = 71.6 fathoms.

Appendix C8.-Reproductive condition of female snow crabs from pot lifts sampled during the 1999-2005 Bering Sea snow crab community development quota (CDQ) fisheries.

Year	Crabs Sampled	Eyed Eggs	Uneyed Eggs	Barren, Matted	Barren, Non-matted
		Percent	Percent	Percent	Percent
1999	11	45.5	27.2	27.2	0
2000	93	19.4	79.6	0	1.1
2001	4	0	75.0	25	0
2002	534	40.8	44.0	5.1	10.1
2003	1	100.0	0	0	0
2004	12	83.3	0	0	16.7
2005	0	--	--	--	--

Appendix C9.-Total pot lift contents for 602 pot lifts sampled during the 2005 Bering Sea golden king crab fishery.

Species	Total Catch	Species	Total Catch
Golden king crab		Snail (unidentified)	162
Legal male	3,576	Pacific halibut	89
Sublegal male	763	Sea star (unidentified)	87
Female	1,532	Pacific cod	62
		Brittle star (unidentified)	56
Grooved Tanner crab		Hydroid (unidentified)	50
Legal male	14	Sculpin (unidentified)	40
Sublegal male	5	Arrowtooth flounder	33
Female	1	Basket star (unidentified)	33
		Hermit crab (unidentified)	21
Tanner crab		Sea cucumber (unidentified)	14
Legal male	0	Rockfish (unidentified)	7
Sublegal male	31	Sea anemone (unidentified)	5
Female	9	Snailfish (unidentified)	5
		Yellow Irish lord	5
Scarlet king crab		Primnoa Group I	3
Legal male	1	Sea urchin (unidentified)	3
Sublegal male	0	Skate (unidentified)	3
Female	0	Sponge (unidentified)	3
		Flathead sole	2
Hair crab		Octopus	2
Legal male	1	*Clavularia* sp.	1
Sublegal male	0	Rougheye rockfish	1
Female	0	Graceful Decorator Crab	1

Appendix C10.-Catch per unit effort (CPUE) by soak times for 602 pot lifts sampled during the 2005 Bering Sea golden king crab fishery.

Soak Hours[a]	Percent of Sampled Pots	CATCH PER SAMPLED POT LIFT			
		Legal	Sublegal	Female	Total
13-24	61.1	5.7	1.3	2.9	9.9
25-36	13.8	6.9	1.4	1.9	10.2
37-48	11.1	5.5	1.3	0.7	7.5
49-60	3.8	5.3	2.1	4.3	11.7
61-72	3.7	4.7	0.7	1.0	6.4
73-84	0.2	4.0	0	2.0	6.0
--	--	--	--	--	--
121-132	0.2	2.0	2.0	0	4.0
133-144	0	--	--	--	--
145-156	0.5	10.3	4.0	1.3	15.7
157-168	2.2	11.3	0.5	0.5	12.3
169-180	0	--	--	--	--
181-192	1.8	6.1	0.7	9.2	16.0
193-204	0.2	6.0	0.0	5.0	11.0
205-216	1.3	4.6	0.5	0.3	5.4
217-228	0	--	--	--	--
229-240	0.2	3.0	3.0	2.0	8.0

[a] Mean soak time = 38.8 hours.

Appendix C11.-Catch per unit effort (CPUE) by depth for 598 pot lifts sampled during the 2005 Bering Sea golden king crab fishery.

Depth[a] (fathoms)	Percent of Sampled Pots	CATCH PER SAMPLED POT LIFT			
		Legal	Sublegal	Female	Total
101-125	3.3	5.6	0.7	0.7	6.9
126-150	20.4	10.0	1.9	1.6	13.5
151-175	31.4	7.2	1.4	3.9	12.5
176-200	18.2	4.4	1.3	4.4	10.2
201-225	7.5	2.7	0.5	1.3	4.5
226-250	10.7	2.5	0.9	0.5	3.9
251-275	5.0	2.0	0.8	0.2	3.0
276-300	3.0	2.4	0.3	0.1	2.8
301-325	0.2	1.0	0	0	1.0
326-350	0.2	0	0	0	0

[a] Mean depth = 181.7 fathoms.

Appendix C12.-Reproductive condition of female golden king crabs from pot lifts sampled during the 2001-2005 Bering Sea golden king crab fisheries.

Year	Crabs Sampled	Eyed Eggs	Uneyed Eggs	Barren, Matted	Barren, Non-matted
		Percent	Percent	Percent	Percent
2001	3,506	17.8	25.9	20.9	28.7
2002	2,849	21.5	12.4	2.1	64.0
2003	2,224	13.3	13.3	6.0	66.5
2004	1,185	11.1	36.1	4.1	48.7
2005	1,193	35.3	32.4	13.2	19.2

Appendix C13.-Total pot lift contents for 35 pot lifts sampled during the 2005 Bering Sea grooved Tanner crab fishery.

Species	Total Catch	Species	Total Catch
Grooved Tanner Crab			
Legal male	160	Arrowtooth flounder	7
Sublegal male	1	Sea cucumber (unidentified)	6
Female	12	Sea star (unidentified)	4
		Buccinum spp.	2
Scarlet King Crab		Octopus	1
Legal male	4	Greenland turbot	1
Sublegal male	16	Grenadier (unidentified)	1
Female	2	Soft coral (unidentified)	1
Golden King Crab			
Legal male	9		
Sublegal male	5		
Female	1		

Appendix C14.-Catch per unit effort (CPUE) by soak times for 35 pot lifts sampled during the 2005 Bering Sea grooved Tanner crab fishery.

Soak Hours[a]	Percent of Sampled Pots	CATCH PER SAMPLED POT LIFT			
		Legal	Sublegal	Female	Total
25-36	34.3	2.1	0.1	0.4	2.6
37-48	0	--	--	--	--
49-60	8.6	12.0	0	0	12.0
61-72	34.3	1.8	0	0.2	1.9
73-84	8.6	26.0	0	1.7	27.7
--	--	--	--	--	--
133-144	14.3	0	0	0	0

[a] Mean soak time = 64.6 hours.

Appendix C15.-Catch per unit effort (CPUE) by depth for 35 pot lifts sampled during the 2005 Bering Sea grooved Tanner crab fishery.

Depth[a] (fathoms)	Percent of Sampled Pots	CATCH PER SAMPLED POT LIFT			
		Legal	Sublegal	Female	Total
281-300	5.7	1.0	0	0	1.0
301-320	11.4	0.3	0	0.5	0.8
321-340	28.6	1.9	0	0.3	2.2
341-360	22.9	9.0	0.1	0.6	9.8
361-380	14.3	10.2	0	0.4	10.6
381-400	5.7	0	0	0	0
401-420	8.6	5.0	0.0	0.0	5.0
--	--	--	--	--	--
481-500	2.9	0	0	0	0

[a] Mean depth = 358.3 fathoms.

Appendix C16.-Reproductive condition of female grooved Tanner crabs from pot lifts sampled during the 1995, 1996, 2001, and 2003-2005 Bering Sea grooved Tanner crab fisheries.

Year	Crabs Sampled	Eyed Eggs	Uneyed Eggs	Barren, Matted	Barren, Non-matted
		Percent	Percent	Percent	Percent
1995	8,800	3.1	89.2	1.4	6.3
1996	569	43.3	40.1	5.3	11.4
2001	1,513	80.7	6.9	2.2	10.9
2003	1,904	26.5	69.8	1.8	1.8
2004	2,937	39.6	56.9	0.2	3.3
2005	12	25.0	75.0	0	0

APPENDIX D: RESULTS OF LEGAL TALLY SAMPLES

Appendix D1.-Results of legal tally samples taken during the 2005 Bering Sea crab fisheries.

Fishery	Sample Size	Male Target Species Percent Illegal	Female Target Species Percent Illegal	Non-target Species Percent Illegal	Total Percent Illegal	Estimated Number of Illegal Crabs[a]
Bering Sea snow crab	48,255	0.15	<0.01	0.21	0.37	61,546
Bering Sea snow crab CDQ	21,455	0.04	0	0.13	0.16	2,122
Bering Sea golden king crab	299	0.33	0	0	0.33	49
Bering Sea grooved Tanner crab	0	--	--	--	--	--

[a] Estimated number of illegal crabs derived from percentage of total illegal crabs multiplied by number of crabs harvested during the fishery.