Fishery Data Series No. 14-49

Summary of the 2013/2014 Mandatory Crab Observer Program Database for the Bering Sea/Aleutian Islands Commercial Crab Fisheries

by

William B. Gaeuman

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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)

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. 14-49

SUMMARY OF THE 2013/2014 MANDATORY CRAB OBSERVER PROGRAM DATABASE FOR THE BERING SEA/ALEUTIAN ISLANDS COMMERCIAL CRAB FISHERIES

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ABSTRACT

Since 1988 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. This report summarizes data collected in the 2013/14 BSAI commercial crab fisheries and the 2013 Pribilof Islands golden king crab commercial fishery by ADF&G crab observers deployed on floating-processor vessels, catcher-processor vessels and catcher vessels and by ADF&G dockside samplers. Primary data summaries include estimates of catch and catch per unit effort (CPUE) and information about species, sex, size and shell condition of both discarded and retained crab. Further information about catch rates by soak time and depth, female reproductive condition, sampled pot lift locations, species composition of sampled pot lifts, and legal tally results is provided in a series of appendices.

Key words: Alaska Department of Fish and Game, Bering Sea, Aleutian Islands, crab observer, golden king crab, red king crab, snow crab, Tanner crab.

INTRODUCTION

Regulations (5 AAC 39.645) adopted by the Alaska Board of Fisheries (BOF) grant the Alaska Department of Fish and Game (ADF&G) 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 require deployment of observers on all vessels that process snow crab *Chionoecetes opilio*, Tanner crab *C. bairdi*, grooved Tanner crab *C. tanneri*, triangle Tanner crab *C. angulatus*, red king crab *Paralithodes camtschaticus*, blue king crab *P. platypus* or golden king crab *Lithodes aequispinus*. Those regulations additionally charge ADF&G with deploying observers as needed on catcher vessels participating in commercial BSAI king and Tanner crab fisheries, excluding those of Norton Sound and St. Lawrence Island Sections. Schwenzfeier et al. (2012) provide details on regulations pertaining to the *State of Alaska Shellfish Onboard Observer Program* and a history of that program from its inception in 1988.

ADF&G observers deployed on fishing vessels in the BSAI crab fisheries record the gear type, location, depth and soak time of a daily random sample of pot lifts, the species composition of their contents, and the sex and legal status of commercially important captured crabs. For a subset of sampled pot lifts, a range of biological measurements and assessments of commercially important crabs and other species of interest is also obtained. In addition, ADF&G onboard observers and dockside samplers document overall vessel catch and effort, take size-frequency samples, conduct legal tallies and estimate the average weight of delivered catch. ADF&G Westward Region staff maintain the information collected by observers and dockside samplers in a database that is used in research and management of Alaska's BSAI crab stocks.

This report summarizes data collected by onboard observers and dockside samplers during the 2013/14 Bristol Bay red king crab fishery, 2013/14 Bering Sea snow crab fishery, 2013/14 Bering Sea Tanner crab fisheries east and west of 166° W long, 2013 Pribilof Islands golden king crab fishery and 2013/14 Aleutian Islands golden king crab fisheries east and west of 174° W long (Table 1). For each of these seven fisheries, this report gives estimates of catch per unit effort (CPUE) and catch, as well as size and shell-condition distributions for both discarded and retained crabs. Further information about catch rates by soak time and depth, female reproductive condition, location and species composition of sampled pot lifts and total legal tally sample results is provided in a series of appendices.

METHODS

Methods described in this report relate to ADF&G observer and dockside sampler data-collection activities and do not encompass all observer and dockside sampler duties. In accordance with the provisions of 5 AAC 39.645, observers were deployed on all participating floating-processor and catcher-processor vessels, on randomly selected catcher vessels participating in the Bristol Bay red king crab, Bering Sea snow crab and Bering Sea Tanner crab fisheries and on the single catcher vessel that harvested Pribilof Island golden king crab during 2013. In the Aleutian Islands golden king crab (AIGKC) fisheries, all catcher vessels were required to carry an observer during harvest of at least 50% of their total harvested weight in each 3-month trimester of the 9-month season. Dockside samplers were responsible for sampling retained catch delivered by vessels with no onboard observer.

DEFINITION OF 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 crab of selected species.
Legal tally	Examination of up to 600 crab randomly selected from the retained catch to assure regulatory compliance regarding the retention of crab by species, size, and sex.
Size frequency sample	Biological measurements of up to 100 randomly selected retained crab for the purpose of determining carapace size and shell condition distribution.
Carapace length (CL)	The biological size measurement of all species of king crabs *Lithodes* and *Paralithodes* and hair crab *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* crabs taken as the greatest straight-line distance perpendicular to a line midway between the eyes to the medial-posterior margin, not including the spines (cf. *Legal measurement,* below).
Legal measurement (LM)	The measurement used to determine if male crabs are at or greater than the minimum legal size for retention: 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 (cf. *Carapace width,* above.
Ovigerous	Bearing a clutch of extruded eggs (pertains only to mature female crabs).

Uneyed eggs	Eggs that are unfertilized or in early developmental stages with no visible eyespots.
Eyed eggs	Eggs in later developmental stages with visible eyespots or prezoeae.
Barren/matted setae	An egg clutch is not present but previous egg brooding is evidenced by dirty pleopodal setae or the presence of attached dead eggs or empty egg cases.
Barren/clean setae	An egg clutch is not present and there is no evidence of previous egg brooding; pleopodal setae are clean, shiny, light in color, and very fine or, rarely, there are no visible setae on the pleopods. Females assigned this code are usually immature.
Shell condition	A description of the appearance of the crab exoskeleton that is determined by examining characteristics that change or show wear with time since the last molt (Donaldson and Byersdorfer 2005; Jadamec et al. 1999). Observers scored the shell condition of sampled crabs as either "soft," "new pliable," "new," "old," or "very old" based on shell hardness and color, the nature and extent of abrasions and wear of the shell surfaces, spines, and dactyls, and the number and type of epibionts on the shell surfaces.
Catch per unit effort (CPUE)	The mean catch for a standard unit of fishing effort. In this report CPUE represents the mean catch in number of crab per pot lift.

CRAB OBSERVER SAMPLING DUTIES

During the 2013/14 BSAI commercial crab fisheries, observers were deployed on floating-processor vessels, catcher-processor vessels and catcher vessels. Observers deployed on floating-processors had access only to previously sorted retained catch from delivering catcher vessels, whereas observers placed on catcher-processor and catcher vessels were able to examine the contents of pot lifts prior to sorting by the crew. The number of pot lifts observers were required to sample on each day of fishing activity varied by fishery and vessel type. In general, pot lift sampling goals, as well as observer ability to attain them, depend on a number of variables unique to each fishery and season, including weather, catch rates, assigned research data collection projects and the order of sampling priorities established by ADF&G. Fishery-specific observer deployments and pot lift sampling goals are outlined in Table 1. In all cases observers were expected to communicate with the vessel skipper and to examine the *Daily Fishing Log* (DFL) or other records in documenting daily and total catch and effort (number of pot lifts). Comprehensive ADF&G crab observer sampling methods are detailed in the *2014 ADF&G Crab Observer Training and Deployment Manual*[1].

[1] Crab Observer Training and Deployment Manual. September 2014. ADF&G Shellfish Observer Program, Dutch Harbor, unpublished.

Floating-Processor Vessels

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

Catcher-Processor Vessels

Sampling duties for observers deployed on catcher-processor vessels included pot lift sampling, size-frequency sampling, legal-tally sampling and determination of average weight of retained crab for each day the vessel retained catch. Occasionally, catcher vessels delivered to a catcher-processor vessel. In those situations, the observer sampled the catcher-vessel catch as if deployed on a floating processor. On rare occasions a catcher-processor vessel will deliver to a shore side processor, in which case the observer assumes the responsibilities of an observer deployed on a catcher vessel.

Catcher Vessels

The main duty for observers deployed on catcher vessels was pot lift sampling on each day the vessel fished. When the vessel delivered to a processing facility, whether at sea or on shore, the observer obtained a size-frequency sample, conducted a legal tally and determined average weight of retained crab. If deliveries were made at sea to a floating-processor vessel, all sampling was completed by the observer deployed on the catcher vessel.

DOCKSIDE SAMPLER SAMPLING DUTIES

Dockside samplers were responsible for sampling retained catch delivered to shore-side processors by vessels with no onboard observer. Sampling duties during each delivery included obtaining a size-frequency sample, conducting a legal tally and determining average weight of retained crabs. Dockside samplers were also required to document trip catch and effort (number of pot lifts) through a confidential interview with the vessel captain and examination of the DFL or other records. A full account of dockside sampler duties is available in the *ADF&G Shellfish Dockside Sampling Manual*[2].

ESTIMATION OF CPUE AND TOTAL FISHERY CATCH

With exception of the Aleutian Islands golden king crab fisheries, estimates of CPUE presented here were generated from observer-collected data using a ratio estimator introduced by Gaeuman (2009). In earlier reports different estimates of CPUE were calculated depending on the information available and on varying assumptions about the sampling design. The "sample CPUE" reported before 1997 (e.g., Tracy 1995) was calculated as the simple average catch over all sampled pot lifts. Boyle et al. (1997) introduced stratification by day within vessel, and Burt and Barnard (2003) introduced additional stratification by vessel type (catcher-processor or catcher-only) into the report series.

Inference using the current ratio estimator depends on the fact that within a fishery observers are assigned to all participating catcher-processor vessels and by simple random sampling to a subset of all participating catcher vessels. In addition, it is assumed that sampled pot lifts are selected by simple random sampling from all pot lifts on each vessel fishing day, independently across days.

[2] Shellfish Dockside Sampling Manual. September 2014. ADF&G Dockside Sampling Program, Dutch Harbor, unpublished.

Under those assumptions it is a straightforward process to estimate both total catch and total number of pot lifts for all vessels based on observed vessel days: vessel types are treated as strata, with vessels as primary sampling units within them and vessel days as strata within vessels, and with pot lifts as secondary sampling units within those. The ratio of these estimates of total catch and total number of pot lifts then is used to estimate fishery mean CPUE, defined as fishery total catch divided by fishery total effort, i.e., total number of pot lifts. A variance estimator can be developed using standard variance estimators for the component estimators of total catch and total number of pot lifts. Appendix A1 describes both the ratio estimator of CPUE and the derivation of its variance estimator.

For estimation of CPUE in the Aleutian Islands golden king crab fisheries, partial observer coverage on individual participating catcher vessels makes the ratio estimator used for other BSAI crab fisheries unsuitable. Instead, for these 2 fisheries overall fishery CPUE is estimated assuming independent simple random sampling of pots on individual vessels, with stratification by vessel and reported vessel proportions of total fishery effort (number of pot lifts) applied as known weights. It should be noted, however, that the lack of any randomization in the specific assignment of observer coverage in these fisheries fundamentally precludes properly valid design-based inference of CPUE or other fishery characteristics.

By contrast with these design-based estimates of CPUE, actual total fishery (ATF) CPUE as reported in annual management reports for commercial crab fisheries in the BSAI management areas (e.g., Fitch et al. 2012) is based on effort and catch information extracted from a combination of fish tickets, DFLs and confidential interviews with vessel captains, and represents an independent estimate of fishery CPUE. ATF CPUE estimates, however, are available only for retained legal crab. Estimated total catches reported in this document, as opposed to ATF values, were calculated by multiplying CPUE estimates from observer-collected data by corresponding ATF estimates of fishery pot lift totals.

Cod Pots

In some crab fisheries, regulations (5 AAC 34.825 (k) and 5 AAC 35.525 (d)) allow deployment of a specified number of groundfish-configured pots targeting Pacific cod *Gadus macrocephalus* for use as bait. Though some crab are typically captured in these pots, they generally have a much lower CPUE than pots targeting crab and so misrepresent fishing efficiency in the directed crab pot fishery. For this reason, ADF&G crab observers are currently instructed not to sample them, and they are omitted in the estimates of CPUE reported in this document. ATF estimates of effort and CPUE, on the other hand, depend on methods that do not distinguish catch between crab and groundfish-configured pots.

RESULTS

BRISTOL BAY RED KING CRAB

The 2013/14 Bristol Bay red king crab season commenced 15 October 2013 and closed 15 January 2014. Most fishing occurred early in the season. Total allowable catch (TAC) in this fishery was set at 8.600 million pounds, with legal harvest restricted to male crab at least 6.5 in LM. Two catcher-processors and 61 catcher vessels participated. Onboard observers sampled 657 (1.4%) of the ATF reported total of 45,927 pot lifts (Table 1). Appendix B1 (confidential) shows locations of sampled pot lifts.

Onboard observers collected CL measurements of 30,223 male red king crab from sampled pot lifts (Figure 1). Average CL was 140.6 mm, and 85.8% of the crab were classified as new shell. CL measurements of 6,045 female red king crab from sampled pot lifts averaged 115.7 mm, with 99.6% classified as new shell. CL measurements were also recorded for 10,197 male red king crab by onboard observers and dockside samplers in size-frequency sampling of retained catch. Average CL was 154.9 mm, and 79.5% of the sampled crab were new shell.

Estimated fishery CPUE of legal-retained red king crab was 25.7 crab per pot lift (Table 2), 95% confidence interval (21.06, 30.31) based on a *t*-distribution as detailed in Appendix A. The 2013/14 estimate was down from the 2012/13 value but still in line with the generally higher catch rates that have prevailed in this fishery since *Crab Rationalization* in 2005 (Figure 2). Estimated bycatch of discarded sublegal males was 23.1 crab per pot lift and estimated female bycatch was 9.1 crab per pot lift. A moderate amount of discard bycatch of legal-size males was also observed. Observers additionally reported some Tanner bycatch in this fishery, mostly discarded males, as well as a small amount of incidental retained catch, as allowed by regulation (5 AAC 35.506 (i) (2)).

Total catches of all animals identified in sampled pot lifts during the 2013/14 Bristol Bay red king crab 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 red king crab from sampled pot lifts (Appendix C4).

Legal tallies conducted during the 2013/14 season by onboard observers and dockside samplers totaled 16,484 crabs, accounting for 1.33% of the fishery reported harvest (Appendix D1). Approximately 0.16% of sampled crabs were illegal, mostly sublegal male red king crab.

BERING SEA SNOW CRAB

The 2013/14 Bering Sea snow crab fishery opened 15 October 2013 with a TAC of 53.983 million pounds. Legal harvest was restricted to male crab at least 3.1 in LM (note that although the minimum legal size for snow crab in this fishery is 3.1 in LM, processing plants generally do not accept crab smaller than 4 in LM). Regulatory fishery closure is May 31 in the Western Subdistrict (west of 173° W long) and May 15 in the Eastern Subdistrict (east of 173° W long). Two catcher-processor vessels and 68 catcher vessels participated. Onboard observers sampled 2,664 (1.2%) of the ATF reported 225,245 pot lifts (Table 1). Sampled pot lift locations are shown in Appendix B2 (confidential).

Onboard observers collected CW measurements of 240,047 male snow crab during pot lift sampling (Figure 3). Average CW was 103.0 mm and 89.5% of the crab were categorized as new shell. Average female snow crab CW was 70.9 mm, based on 2,935 measured females, with 50.8% of them judged new shell. CW measurements were additionally recorded on 39,012 male snow crab in size-frequency sampling of retained catch; average CW was 109.6 mm and 93.4% of the crab were new shell.

Estimated fishery CPUE of legal-retained snow crab was 186.0 crab per pot lift in 2013/14 (Table 3), 95% confidence interval (169.63, 202.36). This value continues a general decline in retained catch rate from a high of 346 in 2007/08 (Figure 4). By contrast, average catch per pot for discarded legal-size males, mostly animals smaller than 4 in (~102 mm) CW, increased substantially in 2013/14. Observers also documented some bycatch of other *Chionoecetes* crabs,

mostly discarded Tanner males, but also small numbers of Tanner males and Tanner-hybrid males that were legally retained under the provisions of 5 AAC 35.521 and 5 AAC 35.506 (i) (1).

Total catches of all animals identified in sampled pot lifts during the 2013/14 season are provided in Appendix C5. Additional appendices contain sampled pot lift CPUE by soak time (Appendix C6) and depth (Appendix C7) and the reproductive condition of female snow crab in sampled pot lifts (Appendix C8).

Legal tallies conducted on catcher-processor vessels and on catcher vessels delivering snow crab to processors totaled 80,738 crabs, which accounted for 0.19% of the reported total catch (Appendix D1). Of those, 0.05% were illegal, most of them non-target Tanner *C. bairdi*. By contrast, most of the illegal crabs encountered in other 2013/14 BSAI crab fisheries were undersized males of the target species.

BERING SEA TANNER CRAB

Bering Sea Tanner crab is currently managed independently east and west of 166° W long, with separate TACs in the two areas (Baechler 2012). In March 2011 the BOF established legal size limits of 4.8 in LM in the east and 4.4 in LM in the west. Prior to that time the legal size limit had been 5.5 in LM in both areas, and current ADF&G harvest strategy, as specified in 5 AAC 35.508, is structured around the assumption that the industry preferred size is 5.5 in LM in the east and 5.0 in LM in the west. Both fisheries open on October 15 and close by regulation on March 31.

East of 166° W Longitude

The Eastern Bering Sea Tanner crab fishery opened October 15, 2013 for the first time since the 2009/10 season with a TAC of 1.645 million pounds. Four of the 17 participating catcher vessels were required to carry an observer, as was the single participating catcher-processor vessel (Table 1). Of the ATF reported 16,613 pot lifts in the directed Tanner crab fishery east of 166° W long, observers sampled 267 (1.6%). Locations of sampled pot lifts are mapped in Appendix B3 (confidential).

Observers measured the CW of 7,627 male and 314 female Tanner crab in pot lift sampling (Figure 5). Respective average values were 138.7 mm and 99.9 mm. Observers recorded 84.6% of the males and 46.8% of the females as new shell. Size-frequency sampling of 2,523 fishery-retained male Tanner crab yielded an average CW of 145.1 mm. New shell crab comprised 89.2% of those sampled.

Estimated 2013/14 fishery CPUE of legal-retained crab was 43.9 crab per pot lift (Table 4), with approximate 95% confidence interval (24.82, 63.06). Observers also recorded moderate Tanner crab discard bycatch of both males and females. Some bycatch of subsequently discarded red king crab and snow crab also occurred.

Total catches of all animals identified in sampled pot lifts during the 2013/14 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 Tanner crab in sampled pot lifts (Appendix C12).

Legal tallies conducted on retained crab delivered to processors totaled 3,896 crabs, or 0.55% of the reported harvest (Appendix D1). A single illegal crab (sublegal male) was encountered.

West of 166° W Longitude

The western Bering Sea Tanner crab fishery opened after a 4-year closure on October 15, 2013. The TAC was set at 1.463 million pounds. A single catcher-processor vessel and 14 catcher vessels participated in the fishery (Table 1). Observers sampled 309 (1.3%) of the 23,062 ATF reported pot lifts in the directed Tanner crab fishery west of 166° W long. Their locations are shown in Appendix B4 (confidential).

Observers measured the CW of 9,661 male and 400 female Tanner crab during pot lift sampling (Figure 6). Respective average values were 130.9 mm and 92.8 mm, with 83.9% of the males and 37.5% of the females recorded as new shell. Average CW of 2,237 males measured dockside in size-frequency sampling of retained catch was 138.5 mm. New shell crab accounted for 83.5% of those sampled.

Estimated 2013/14 fishery CPUE of legal-retained crab was 37.8 crab per pot lift (Table 5), with approximate 95% confidence interval (23.07, 52.46). Estimated bycatch of discarded sublegal and legal males was, respectively, 3.6 and 18.1 crab per pot lift, with an estimated average female bycatch of 2.3 crab per pot lift. Some bycatch of subsequently discarded snow crab occurred, primarily legal-size males, along with a small number of retained legal snow crab harvested incidentally in accordance with 5 ACC 35.506 (j).

Total catches of all animals identified in sampled pot lifts during the 2013/14 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 Tanner crab in sampled pot lifts (Appendix C16).

Legal tally sampling of retained catch totaled 3,263 crabs, or 0.44% of the reported harvest (Appendix D1). No illegal crab were encountered.

PRIBILOF ISLANDS GOLDEN KING CRAB

This non-rationalized fishery is currently managed using a guideline harvest level (GHL) of 0.150 million pounds under authority of an ADF&G commissioner's permit valid for a calendar year, with legal harvest limited to male crab with a minimum LM of 5.5 in. Observer coverage is mandatory during all fishing activity. Because a single catcher vessel made landings in 2013, all information relating to the specifics of fishing activity and observer sampling effort is confidential (Table 6 and Figure 7).

ALEUTIAN ISLANDS GOLDEN KING CRAB

The BOF redesignated the Aleutian Islands king crab registration area in March 1996 by combining two existing areas, Dutch Harbor and Adak, and directed ADF&G to manage golden king crab of the Aleutian Islands east and west of 174° W long separately as two distinct stocks (Baechler 2012). In 2013/14 both fisheries were open from 15 August 2013 to 15 May 2015. Legal harvest was restricted to male crab measuring at least 6.5 in LM.

East of 174° W Longitude

Three catcher vessels participated in the 2013/14 Aleutian Islands golden king crab fishery east of 174° W long, where the TAC was set at 3.310 million pounds. Onboard observers sampled 499 pot lifts accounting for 2.4% of the ATF reported 20,687 pot lifts in the fishery (Table 1). Appendix B6 (confidential) shows sampled pot lift locations.

Average CL of 23,012 male golden king crab measured in pot lift sampling was 145.6 mm, and 97.4% were new shell; average CL of 5,000 measured females was 128.4 mm, and 89.9% were new shell (Figure 8). In size-frequency sampling of 2,455 retained crab, average CL was 152.7 mm, and 98.1% were recorded as new shell.

Estimated 2013/14 fishery legal-retained CPUE was 34.9 crab per pot lift (Table 7), 95% confidence interval (33.01, 36.69). Although this value is down slightly from last year's, it is high by comparison with the legal catch rate of earlier years (Figure 9). Estimated bycatch rates of discarded male and female golden king crab were in line with historical fisheries. No notable bycatch of any other commercially important crab species was observed in this fishery.

Total catches of all animals identified in sampled pot lifts during the 2013/14 eastern AIGKC crab fishery are provided in Appendix C21. Additional appendices contain CPUE by soak time (Appendix C22) and depth (Appendix C23) and characterize the reproductive condition of female golden king crab (Appendix C24) from sampled pot lifts.

Legal tallies conducted throughout the season on catcher vessels delivering golden king crab from the eastern Aleutian Islands fishery totaled 8,400 crabs, representing approximately 1.2% of the fishery reported harvest (Appendix D1). Of these, 0.42% were illegal, with all but one of them sublegal male golden king crab.

West of 174° W Longitude

Three catcher vessels participated in the 2013/14 AIGKC crab fishery west of 174° W long, where the TAC was set at 2.980 million pounds. Observers sampled 1,233 (3.0%) of the 40,959 ATF reported number of pot lifts (Table 1). Locations of sampled pot lifts are shown in Appendix B7 (confidential).

Onboard observers recorded CL measurements of 29,892 male and 8,147 female golden king crab captured in sampled pot lifts (Figure 10). Male and female CL averages were respectively 144.6 mm and 136.6 mm. New-shell crab made up 98.2% of the males and 99.2% of the females. Average CL of 2,408 male crab measured in size-frequency sampling of retained catch was 151.9 mm, and 99.3% were new shell.

Estimated 2013/14 legal-retained CPUE in this fishery was 15.5 crab per pot lift (Table 8), 95% confidence interval (14.64, 16.31). This value is significantly lower than the estimated 2012/13 legal-retained catch rate of 21.4 and the lowest estimated value in the nine years since crab rationalization (Figure 11). Estimates of discarded male and female golden king crab CPUE, on the other hand, are consistent with those from 2012/13 and other years since rationalization. No noteworthy bycatch of other commercially important crab species was observed in this fishery.

Appendix C25 lists total catches of all animals observed in sampled pot lifts during the 2013/14 western AIGKC fishery. Appendices C26 and C27 give sampled pot lift CPUE by soak time and depth. Appendix C28 characterizes reproductive condition of captured female golden king crab.

Legal tallies conducted on catcher vessels prosecuting the 2013/14 AIGKC fishery west of 174° W long. totaled 9,300 crabs. Sampled crabs made up 1.35% of the ATF reported harvest (Appendix D1). Approximately 0.52% of sampled animals were illegal. All but one of the illegal animals were sublegal golden king crab males.

COMPARISON OF OBSERVER AND ATF ESTIMATES OF CPUE

Table 9 summarizes all 2013/14 BSAI crab fishery observer-based estimates of legal retained CPUE and harvest number along with their ATF reported analogs. Relative agreement between the two sets of estimates is generally reasonable, except, notably, in the Bering Sea Tanner crab fishery west of 166° W long. Even that discrepancy, however, is readily accounted for in terms of the statistical uncertainty of the estimates as quantified by their estimated standard errors and associated confidence intervals (Table 5).

ACKNOWLEDGMENTS

Shellfish observers deployed during the 2013/14 BSAI crab fisheries collected the data summarized in this report. Their diligence in collecting biological and fisheries management information while living and working at sea, often for extended periods and sometimes under extremely challenging conditions, is essential to management of these fisheries.

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TABLES AND FIGURES

Table 1.–BSAI observer fisheries, observer deployment, and observer pot lift sampling effort during 2013/14.

			Catcher-processor vessels		Catcher vessels				
Fishery	Regulatory season	TAC[a]	Number[b]	Daily pot lift sampling goal	Number	With onboard observers	Daily pot lift sampling goal	ATF pot lift total[c]	Sampled pot lifts
Bristol Bay red king crab	15Oct–15Jan	8.600	2	4	61	16	7	45,927	657
Bering Sea snow crab	15Oct–31May	53.983	2	3	68	19	4	225,245	2,664
Bering Sea Tannercrab fishery(east of 166° W)	15Oct–31Mar	1.645	1	4	17	4	6	16,613	267
Bering Sea Tanner crab fishery(west of 166° W)	15Oct–31Mar	1.463	1	4	14	4	6	23,062	309
Pribilof Islandsgolden king crab	01Jan–31Dec	0.150[d]	0	NA[e]	1	1	10	-[f]	-[f]
Aleutian Islands golden king crab (east of 174° W)	15Aug–15May	3.310	0	4	3	3	7	20,687	499
Aleutian Islands golden king crab(west of 174° W)	15Aug–15May	2.980	0	4	3	3	7	40,959	1,223

[a] Total Allowable Catch in millions of pounds.

[b] All catcher-processor vessels are required to carry observers.

[c] Actual Total Fishery reported number of pot lifts.

[d] Guideline Harvest Level (GHL) in millions of pounds.

[e] No catcher-processor vessels participate in this fishery.

[f] Confidential.

Table 2.–Estimated CPUE and total catch (thousands of crab) of selected crab species from 657 pot lifts sampled by observers deployed during the 2013/14 Bristol Bay red king crab fishery.

Species	CPUE	SE	95% CI	Crab[a]
Red King Crab				
legal retained	25.7	2.16	(21.06, 30.31)	1,180
female	9.1	2.66	(3.40, 14.80)	418
sublegal	23.1	4.40	(13.65, 32.52)	1,060
legal not retained	1.5	0.93	(0, 3.55)	71
Tanner Crab				
legal retained	0.4	0.16	(0.03, 0.72)	17
female	0.1	0.02	(0.05, 0.14)	4
sublegal	0.3	0.04	(0.21, 0.38)	14
legal not retained	2.6	0.49	(1.51, 3.61)	118
Snow Crab				
female	0[b]	–	–	< 5
sublegal	0[b]	–	–	< 5
legal not retained	< 0.1	–	–	< 5

[a] Product of estimated CPUE and ATF reported 45,927 total number of pot lifts.

[b] Observers encountered no female or sublegal male snow crab in pot lift sampling.

Table 3.–Estimated CPUE and total catch (thousands of crab) of selected crab species from 2,664 pot lifts sampled by observers deployed during the 2013/14 Bering Sea snow crab fishery.

Species	CPUE	SE	95% CI	Crab[a]
Snow Crab				
legal retained	186.0	7.76	(169.63, 202.36)	41,746
female	4.2	1.28	(1.53, 6.93)	953
sublegal	4.5	1.50	(1.37, 7.72)	1,024
legal not retained	150.3	16.60	(116.59, 184.09)	33,863
Tanner Crab				
legal retained	0.1	0.06	(0, 0.23)	22
female	0.4	0.07	(0.24, 0.52)	85
sublegal	3.6	0.76	(2.00, 5.19)	809
legal not retained	10.9	2.63	(5.34, 16.44)	2,452
Hybrid Tanner crab (legally *bairdi*[b])				
legal retained	0.1	0.11	(0, 0.35)	26
female	< 0.1	–	–	< 23
sublegal	< 0.1	–	–	< 23
legal not retained	0.1	0.05	(0, 0.21)	23
Hybrid Tanner crab (legally *opilio*[c])				
legal retained	0.2	0.18	(0, 0.60)	52
female	< 0.1	–	–	< 23
sublegal	< 0.1[d]	–	–	< 23
legal not retained	0.4	0.21	(0, 0.84)	87

[a] Product of estimated CPUE and ATF reported 225,245 total number of pot lifts in the Bering Sea snow crab fishery.

[b] Hybrid Tanner crab considered to be *C. bairdi* by the criteria of 5 AAC 35.521.

[c] Hybrid Tanner crab considered to be *C. opilio* by the criteria of 5 AAC 35.521.

[d] Observers recorded no *opilio*-type hybrid Tanner sublegal males in pot lift sampling.

Table 4.–Estimated CPUE and total catch (thousands of crab) of selected crab species from 267 pot lifts sampled by observers deployed during the 2013/14 Bering Sea Tanner crab fishery east of 166° W long.

Species	CPUE	SE	95% CI	Crab[a]
Tanner Crab				
legal retained	43.9	4.44	(24.82, 63.06)	730
female	3.1	0.72	(0, 6.23)	52
sublegal	6.4	2.47	(0, 16.98)	106
legal not retained	9.3	1.62	(2.33, 16.31)	155
Red King Crab				
legal retained	0[b]	–	–	< 2
female	5.6	4.2	(0, 23.68)	93
sublegal	0.8	0.56	(0, 3.18)	13
legal not retained	0.7	0.53	(0, 2.95)	11
Snow Crab				
female	0[c]	–	–	< 2
sublegal	< 0.1	–	–	< 2
legal not retained	0.5	0.15	(0, 1.11)	8

[a] Product of estimated CPUE and ATF reported 16,613 total number of pot lifts.

[b] Observers recorded no retention of legal male red king crab in the Bering Sea Tanner crab fishery east of 166° W long.

[c] Observers recorded no female snow crab in the Bering Sea Tanner crab fishery east of 166 ° W long.

Table 5.–Estimated CPUE and total catch (thousands of crab) of selected crab species from 309 pot lifts sampled by observers deployed during the 2013/14 Bering Sea Tanner crab fishery west of 166° W long.

Species	CPUE	SE	95% CI	Crab[a]
Tanner Crab				
legal retained	37.8	4.62	(23.07, 52.46)	871
female	2.3	0.64	(0.27, 4.34)	53
sublegal	3.6	0.66	(1.50, 5.67)	83
legal not retained	18.1	1.60	(13.00, 23.17)	417
Snow Crab				
legal retained	< 0.1	–	–	< 2
female	0.6	0.31	(0, 1.63)	15
sublegal	0.2	0.09	(0, 0.47)	4
legal not retained	21.0	5.82	(2.54, 39.56)	49

[a] Product of estimated CPUE and ATF reported 23,062 total number of pot lifts.

Table 6.–Estimated CPUE and total catch (thousands of crab) of selected crab species from 167 pot lifts sampled by observers deployed during the 2013 Pribilof Islands golden king crab fishery.

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Table 7.–Estimated CPUE and total catch (thousands of crab) of golden king crab from 499 pot lifts sampled by observers deployed during the 2013/14 Aleutian Islands golden king crab fishery east of 174° W long.

Species	CPUE	SE	95% CI	Crab[a]
Golden King Crab				
legal retained	34.9	0.94	(33.01, 36.69)	721
female	10.5	0.73	(9.07, 11.94)	217
sublegal	11.0	0.64	(9.75, 12.25)	228
legal not retained	1.4	0.08	(1.23, 1.56)	29

[a] Product of estimated CPUE and ATF reported 20,687 total number of pot lifts.

Table 8.–Estimated CPUE and total catch (thousands of crab) of golden king crab from 1,223 pot lifts sampled by observers deployed during the 2013/14 Aleutian Islands golden king crab fishery west of 174° W long.

Species	CPUE	SE	95% CI	Crab[a]
Golden King Crab				
legal retained	15.5	0.42	(14.64, 16.31)	634
female	6.5	0.53	(5.47, 7.54)	266
sublegal	7.8	0.40	(7.00, 8.55)	319
legal not retained	1.1	0.05	(0.99, 1.20)	45

[a] Product of estimated CPUE and ATF reported 40,959 total number of pot lifts.

Table 9.–Comparison of actual total fishery (ATF) and observer data estimates of retained catch CPUE and number (thousands of crab, including deadloss) for 2013/14 BSAI crab fisheries.

	ATF estimates		Observer data estimates		
Fishery	CPUE	Crab	CPUE	Crab	CPUE % difference[a]
Bristol Bay red king crab	27.1	1,243	25.7	1,180	-5.2
Bering Sea snow crab	186.1	41,927	186.0	41,746	-0.1
Bering Sea Tanner crab east of 166° W long	42.7	710	43.9	730	2.8
Bering Sea Tanner crab west of 166° W long	31.9	736	37.8	871	18.5
Pribilof Islands golden king crab	6.0	6	5.7	5	-5.0
Eastern Aleutian Islands golden king crab	33.8	699	34.9	721	3.3
Western Aleutian Islands golden king crab	16.8	687	15.5	634	-7.7

[a] $(CPUE_{Obs} - CPUE_{ATF}) / CPUE_{ATF} \times 100$.

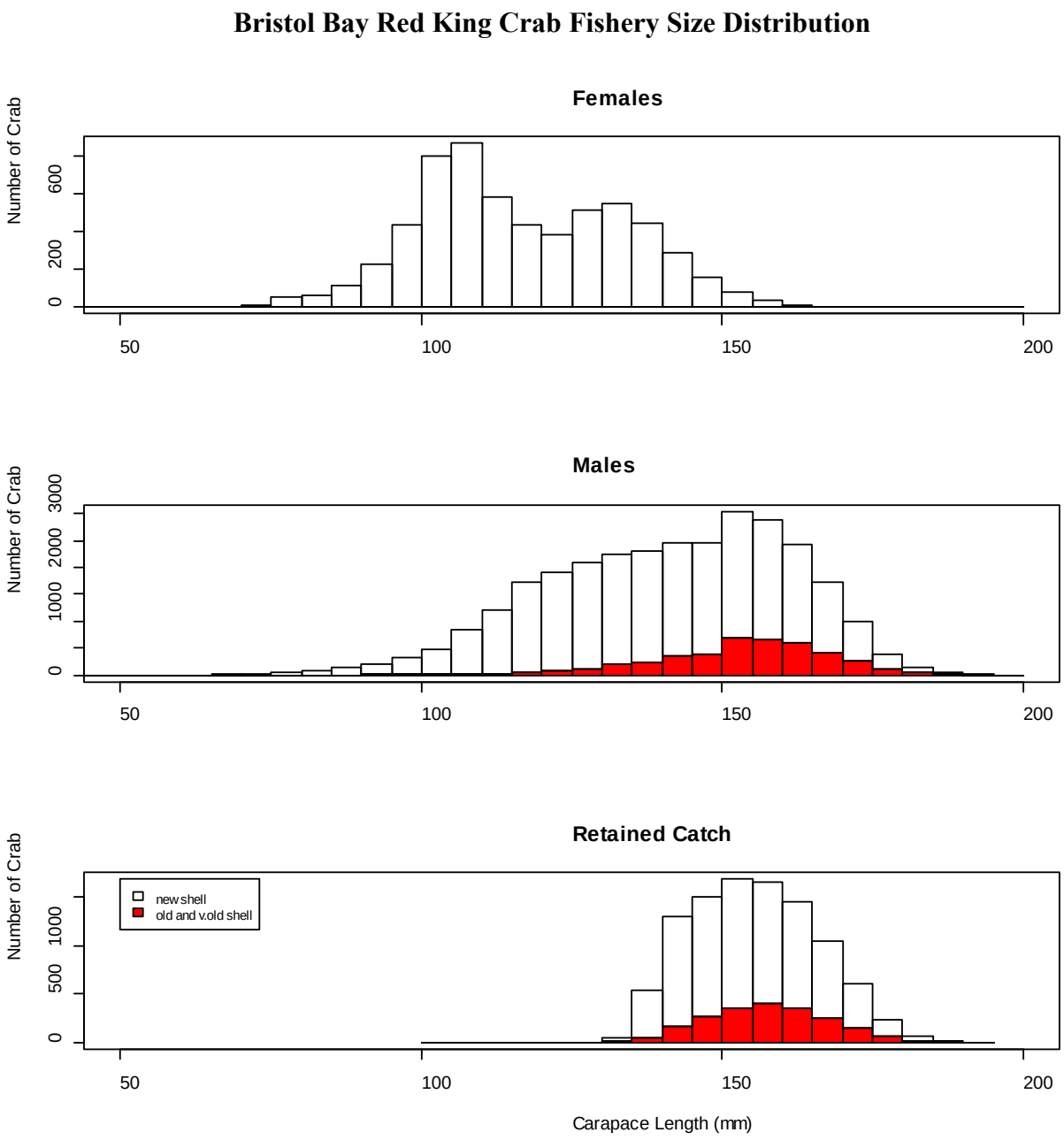

Figure 1.–Carapace length distribution with shell condition for female (top panel) and male (middle panel) red king crab from sampled pot lifts and for males from size-frequency sampling of retained catch (bottom panel) during the 2013/14 Bristol Bay red king crab fishery.

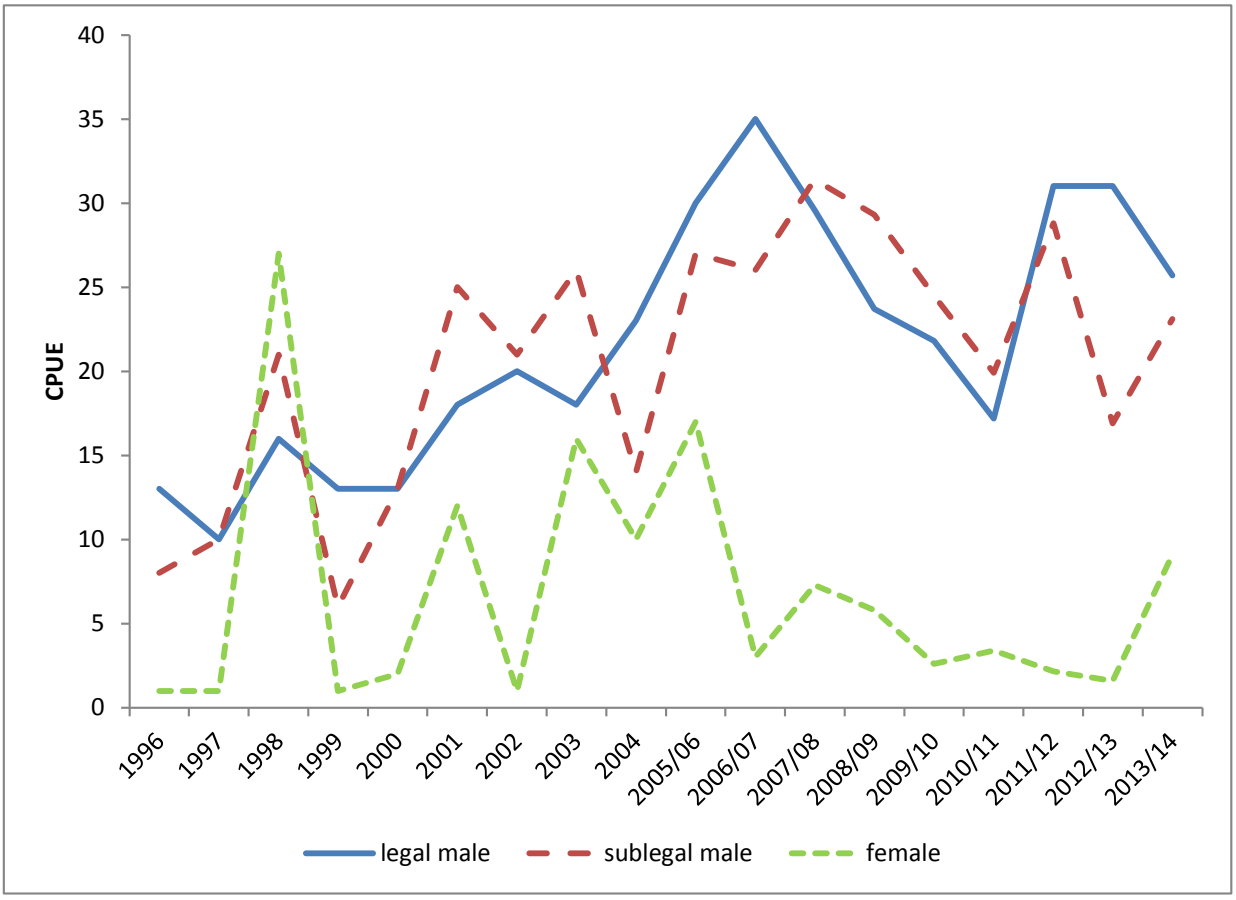

Figure 2.–Estimated red king crab CPUE from pot lifts sampled during the 1996–2013/14 Bristol Bay red king crab fisheries.

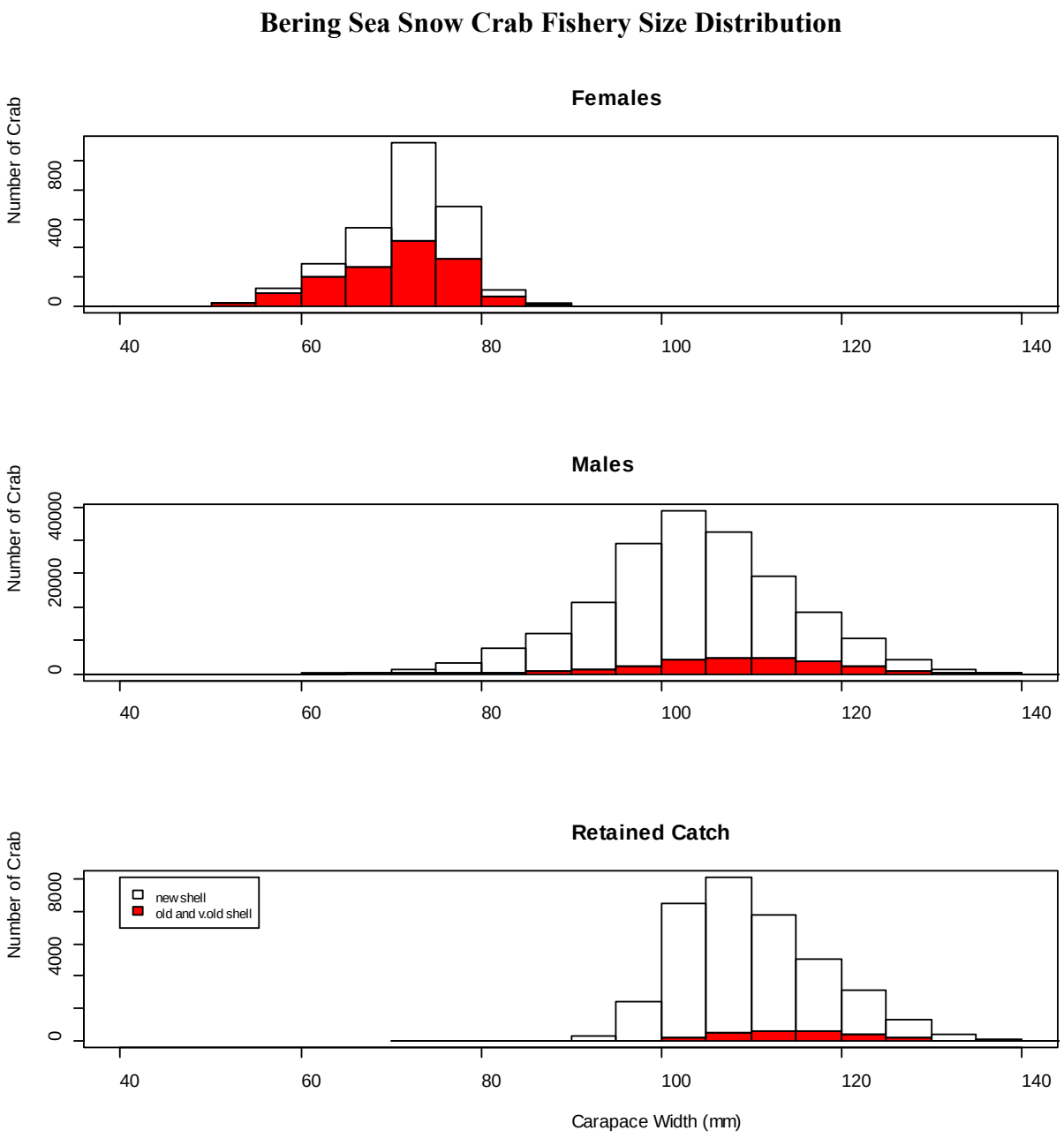

Figure 3.–Carapace width distribution with shell condition for female (top panel) and male (middle panel) snow crab from sampled pot lifts and for males from size-frequency sampling (bottom panel) of retained catch during the 2013/14 directed Bering Sea snow crab fishery.

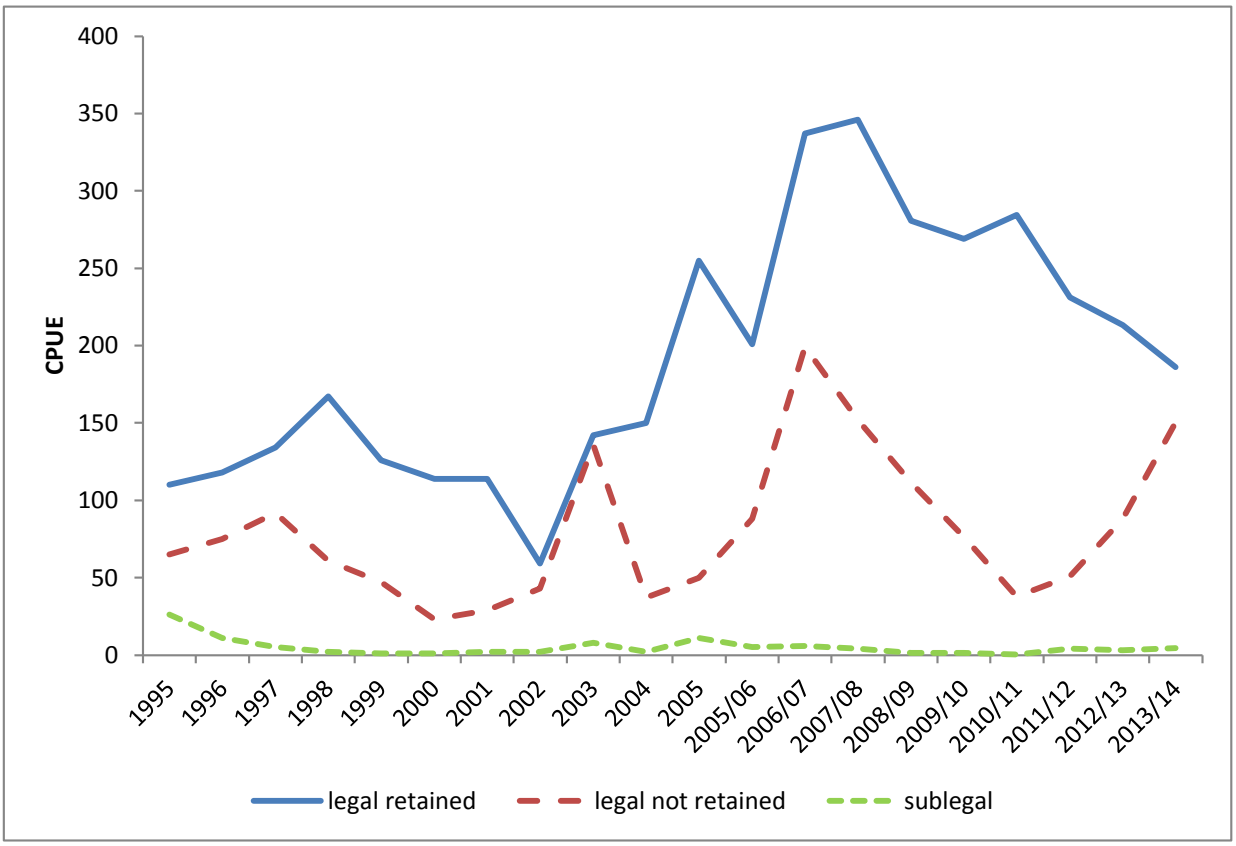

Figure 4.–Estimated snow crab CPUE from pot lifts sampled during the 1995–2013/14 Bering Sea snow crab fisheries.

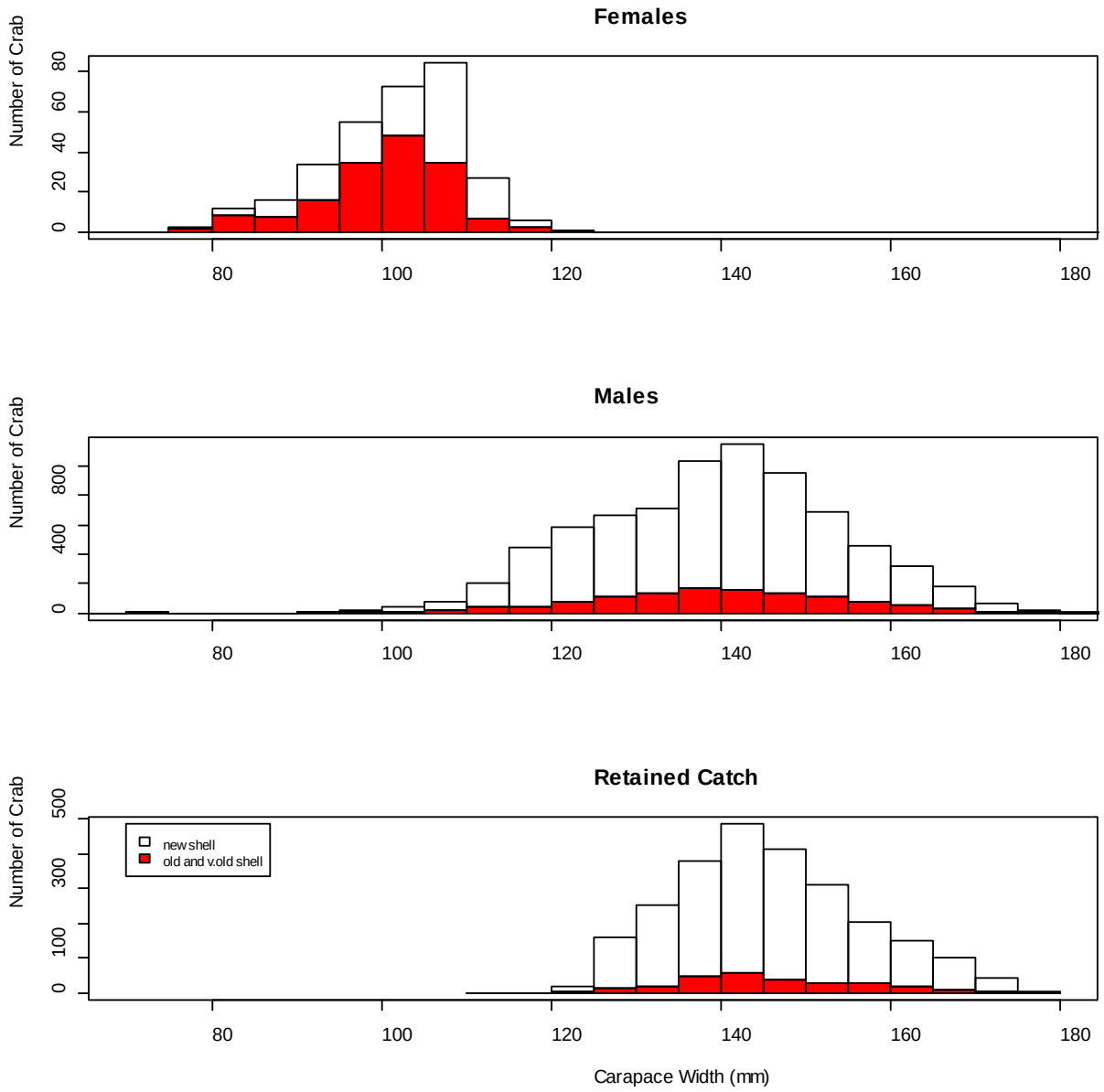

Figure 5.–Carapace width distribution with shell condition for female (top panel) and male (middle panel) Tanner crab from sampled pot lifts and for males from size-frequency sampling of retained catch (bottom panel) during the 2013/14 eastern Bering Sea Tanner crab fishery.

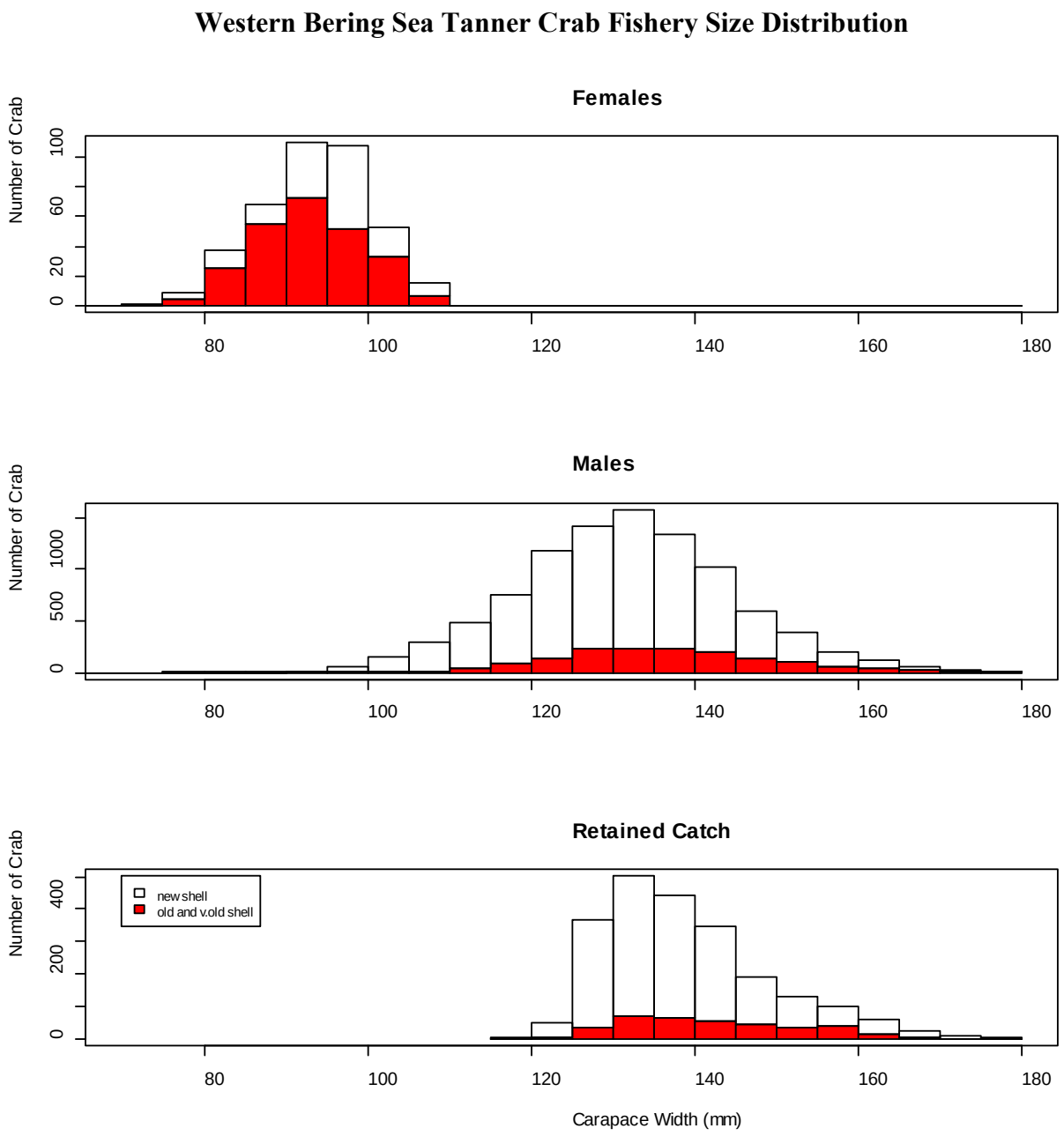

Figure 6.–Carapace width distribution with shell condition for female (top panel) and male (middle panel) Tanner crab from sampled pot lifts and for males from size-frequency sampling of retained catch (bottom panel) during the 2013/14 Bering Sea Tanner crab fishery (west of 166° W long).

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Figure 7.–Carapace width distribution with shell condition for female (top panel) and male (middle panel) golden king crab from sampled pot lifts and for males from size-frequency sampling of retained catch (bottom panel) during the 2013/14 Pribilof Islands golden king crab fishery.

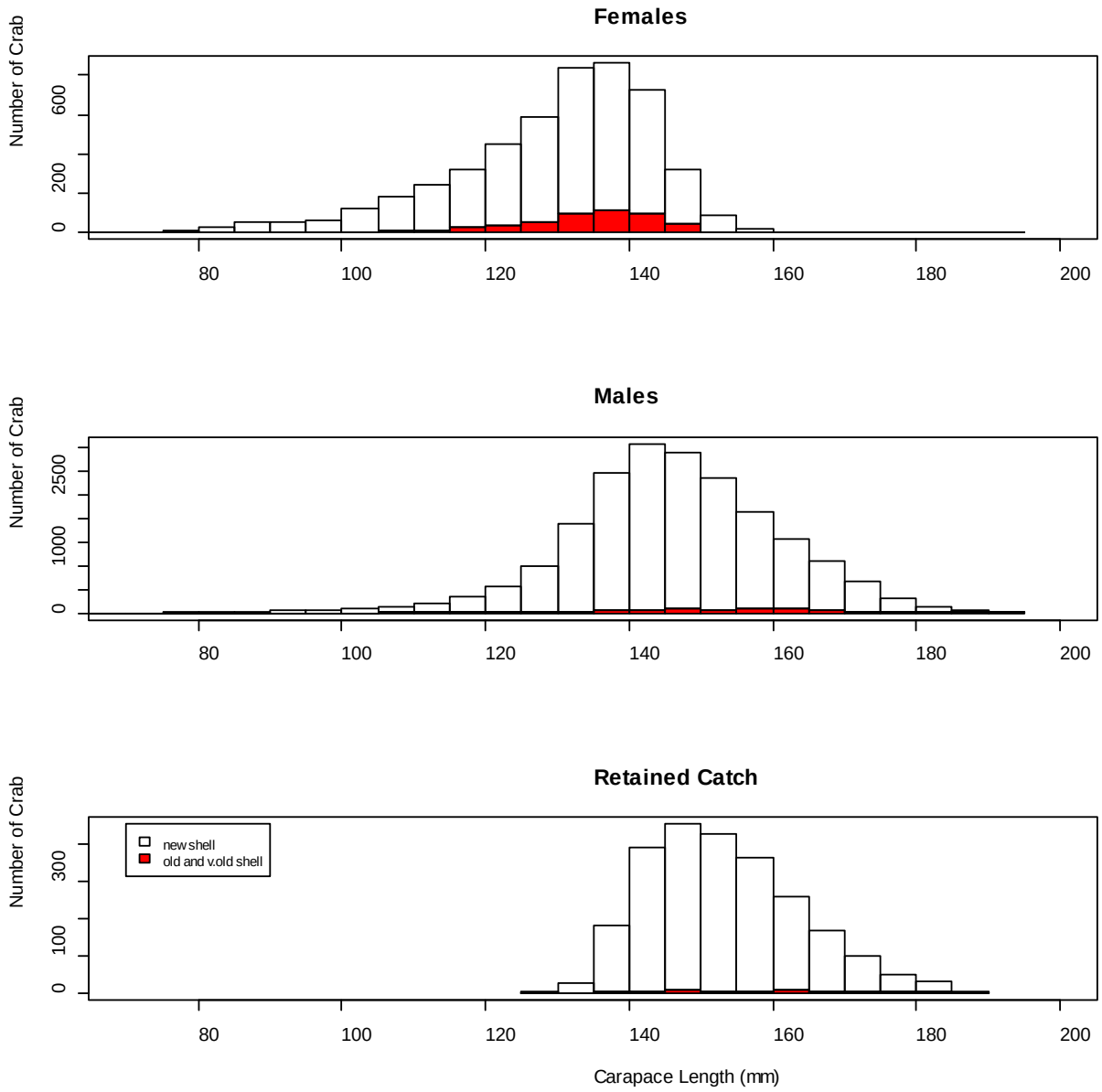

Figure 8.–Carapace length distribution with shell condition for female (top panel) and male (middle panel) golden king crab from sampled pot lifts and for males from size-frequency sampling of retained catch (bottom panel) during the 2013/14 Aleutian Islands golden king crab fishery east of 174°W long.

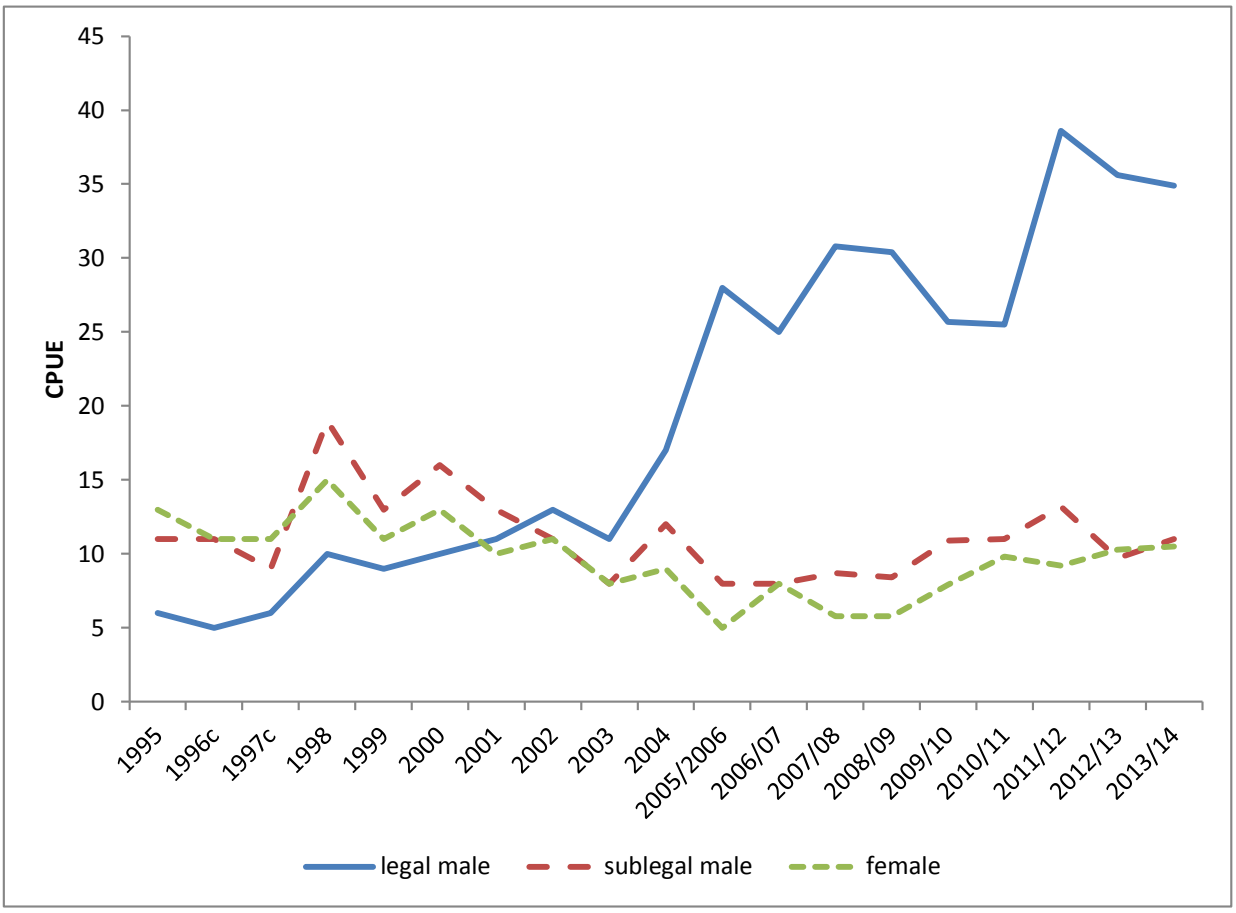

Figure 9.–Estimated golden king crab CPUE from pot lifts sampled during the 1998–2013/14 Aleutian Islands golden king crab fisheries east of 174° W long.

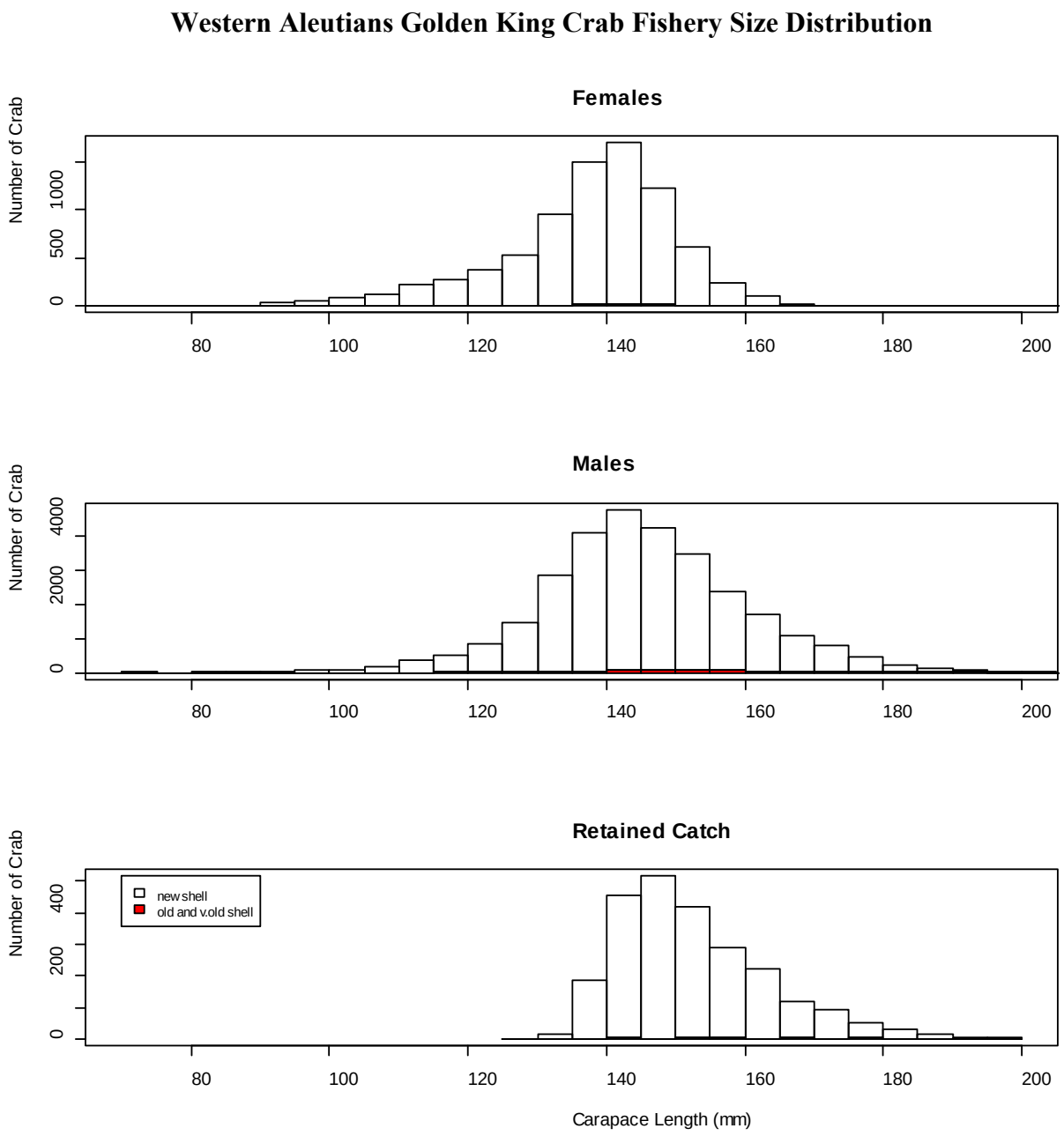

Figure 10.–Carapace length distribution with shell condition for female (top panel) and male (middle panel) golden king crab from sampled pot lifts and for males from size-frequency sampling of retained catch (bottom panel) during the 2013/14 Aleutian Islands golden king crab fishery west of 174°W long.

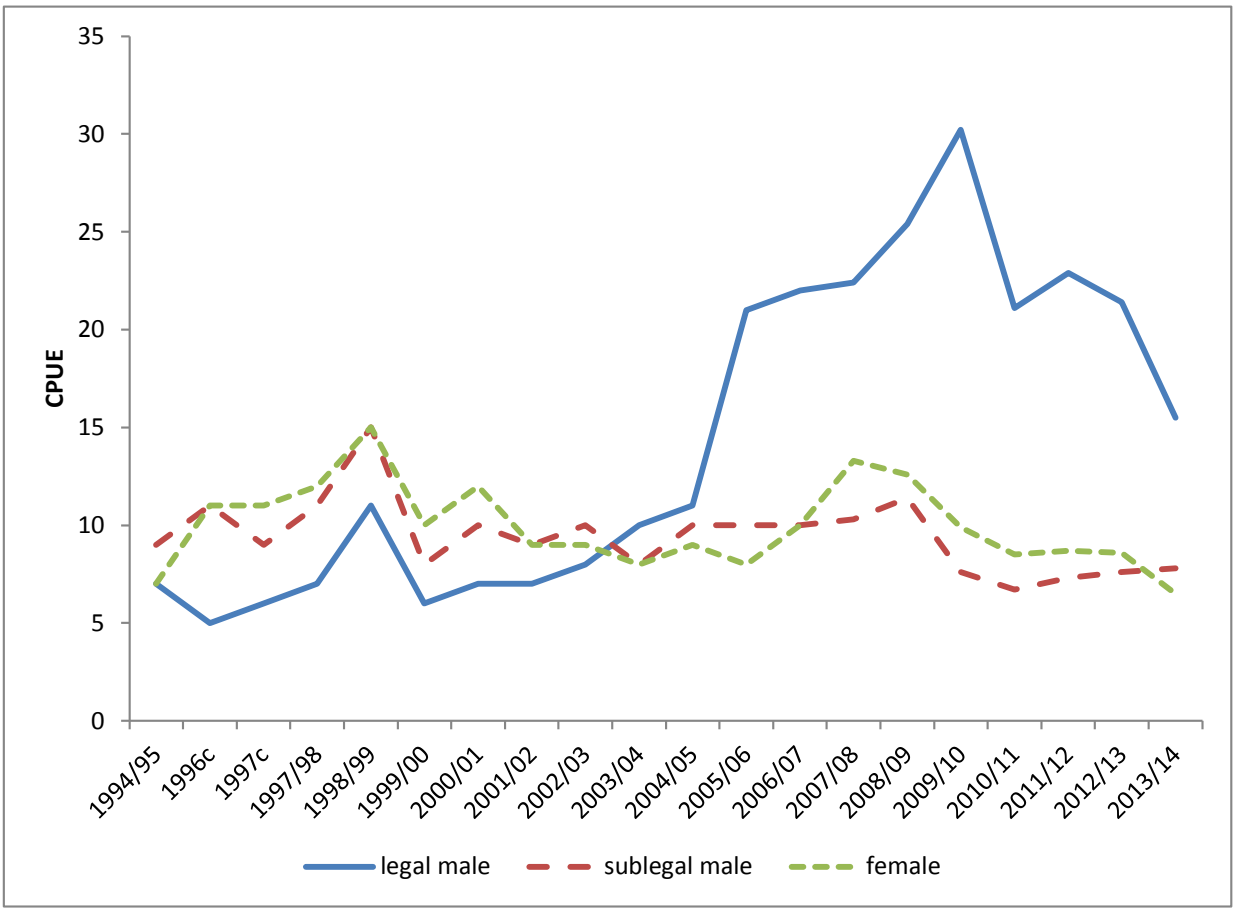

Figure 11.–Estimated golden king crab CPUE from pot lifts sampled during the 1998/99–2013/14 golden king crab fisheries west of 174° W long.

APPENDIX A. ESTIMATION OF CPUE FROM OBSERVER DATA

It is here assumed that under the current sampling design, observed vessels are randomly selected independently within each vessel type, as are pot lifts within each day fished by each observed vessel. We first consider vessels of a single type, e.g. catcher vessels. Let

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

m = number of vessels within given type sampled for observation

D_j = number of days fished by vessel j

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

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

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

c_{jkl} = number of crab 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 crab per pot on day k

τ_j = vessel j total catch over all pots and days fished

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

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

with variance estimator

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

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

-continued-

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

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

since, conditioning on S, we have

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

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

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

with $\bar{\hat{\tau}} = \frac{1}{m}\sum_{j}^{m}\hat{\tau}_j$, the average of the observed vessel estimated total catches (Cochran 1977, Theorem 11.2). Note that if all vessels of the given type are sampled, as is typically true of the

-continued-

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 (e.g. from confidential interviews with vessel captians), an unbiased estimate of the vessel type total number of pot lifts is the simple expansion estimator

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

with unbiased variance estimator

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

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

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

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

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

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

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

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

and

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

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

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

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

-continued-

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

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

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

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

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

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

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

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

-continued-

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

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

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

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

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

is a natural candidate for estimating fishery CPUE, and an estimate of its variance is easily obtained from (8). However, though ratio estimators such as (11) are in general not design unbiased, in some applications they can perform well in the sense of having smaller mean square error (MSE) than their unbiased counterparts (Lohr 1999, p. 151). For the application at hand we expect vessel catch and vessel pot lift totals to be highly positively correlated and hence that (11) should provide reasonable estimates of the target parameter. Moreover, (11) is robust to undercoverage resulting from failure to sample pots on all days fished by a vessel selected for observation, so long as sampled pots and observed daily pot lift totals are mostly representative of those on unobserved days. The unbiased estimator (17) decidedly lacks this sort of robustness. 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-collected 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 2013/14 Bristol Bay red king crab fishery.

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Appendix B2.–Locations of pot lifts sampled by observers during the 2013/14 Bering Sea snow crab fishery.

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Appendix B3.–Locations of pot lifts sampled by observers during the 2013/14 Bering Sea Tanner crab fishery east of 166° W long.

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Appendix B4.–Locations of pot lifts sampled by observers during the 2013/14 Bering Sea Tanner crab fishery west of 166° W long.

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Appendix B5.–Locations of pot lifts sampled by observers during the 2013 Pribilof Islands golden king crab fishery.

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Appendix B6.–Locations of pot lifts sampled by observers during the 2013/14 Aleutian Islands golden king crab fishery east of 174° W long.

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Appendix B7.–Locations of pot lifts sampled by observers during the 2013/14 Aleutian Islands golden king crab fishery west of 174° W long.

CONFIDENTIAL

APPENDIX C. ADDITIONAL CATCH AND BIOLOGICAL SUMMARIES

Appendix C1.–Total contents of 657 pot lifts sampled during the 2013/14 Bristol Bay red king crab fishery.

Commercial crab species	Number	Other species	Number
Red King Crab		bigmouth sculpin	2
legal	17,538	Dover sole	1
sublegal	12,723	giant octopus	1
female	6,070	graceful decorator crab	2
Tanner Crab		great sculpin	29
legal	1,925	hermit crab unident.	6
sublegal	194	jellyfish unident.	334
female	62	mussel unident.	12
Snow Crab		Pacific cod	161
legal	9	Pacific halibut	27
sublegal	0	Pacific lyre crab	1
female	0	Pribilof whelk	1
Hair Crab		pygmy cancer crab	1
legal	86	rockfish unident.	1
sublegal	32	sculpin unident.	19
female	39	sea anemone unident.	13
		sea cucumber unident.	8
		snailfish unident.	1
		snail unident.	43
		sponge unident.	26
		starfish unident.	9
		tunicate unident.	13
		worm unident.	2
		yellowfin sole	251
		yellow Irish lord	3

Appendix C2.–Red king crab catch per pot by soak time for 657 pot lifts sampled during the 2013/14 Bristol Bay red crab fishery.

		Average number of crab per pot				
Soak[a] (hours)	Percent of sampled pots	LRT	LNR	SUB	FEM	Total
0-12	0.5	9.7	1.3	10.3	15.7	37.0
12-24	10.4	12.1	0.2	13.3	15.1	40.8
24-36	24.7	18.9	0.5	25.6	10.2	55.4
36-48	25.7	26.7	2.8	20.1	7.9	57.5
48-60	11.0	31.1	0.4	20.7	8.3	60.5
60-72	5.0	23.6	0.8	13.7	7.2	45.2
72-84	3.5	24.0	3.0	10.3	16.8	54.2
84-96	3.0	30.6	8.3	18.7	0.6	58.2
96-108	3.3	37.8	2.7	22.6	4.4	67.5
108-120	3.8	28.7	0.9	10.7	9.3	49.6
120-132	2.4	30.3	0.4	20.3	0.6	51.6
132-144	0.5	34.0	2.3	27.7	0.3	64.3
144-156	0.9	43.7	0.5	17.0	0.7	61.8
156-168	0.8	45.0	0.6	14.8	31.8	92.2
168-180	0.9	30.5	10.0	14.5	22.3	77.3
180-192	0.3	34.5	1.5	13.5	38.0	87.5
192-204	0.8	22.8	9.4	15.4	0.6	48.2
204-216						
216-228	0.5	62.0	0.0	10.0	0.3	72.3
228-240	0.2	48.0	1.0	9.0	0.0	58.0
240-252	0.5	41.7	4.0	10.7	0.0	56.3
252-264	0.3	30.5	3.5	3.5	0.0	37.5
264-276	0.8	46.2	2.0	7.8	6.6	62.6
276-288	0.3	60.5	0.5	4.0	0.0	65.0
288-300	0.2	51.0	0.0	15.0	12.0	78.0

Note: Observers categorize all sampled crabs as either legal-size retained male (LRT), legal-size non-retained male (LNR), sublegal male (SUB), or female (FEM).

[a] Average soak time was 58 hours.

Appendix C3.–Red king crab catch per pot by depth for 657 pot lifts sampled during the 2013/14 Bristol Bay red king crab fishery.

		Average number of crab per pot				
Depth[a] (fathoms)	Percent of sample pots	LRT	LNR	SUB	FEM	Total
30-35	0.2	11.0	0.0	9.0	0.0	20.0
35-40	13.1	28.8	3.2	16.2	2.2	50.4
40-45	42.6	26.8	2.5	19.2	6.5	55.0
45-50	33.9	22.5	0.4	21.6	12.6	57.2
50-55	10.2	20.9	0.7	16.7	18.7	57.0

Note: Observers categorize all sampled crabs as either legal-size retained male (LRT), legal-size non-retained male (LNR), sublegal male (SUB), or female (FEM).

[a] Average depth was 44 fathoms.

Appendix C4.–Reproductive condition (by percent) of female red king crab from pot lifts sampled during the 1996–2013/14 Bristol Bay red king crab fisheries.

		Ovigerous		Barren	
Year	Number of crab	Eyed eggs	Uneyed eggs	Matted setae	Clean setae
1996	11	0	0	0	100
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
2005/06	26,753	41.3	45.0	0.2	13.4
2006/07	3,586	16.5	32.5	1.4	49.5
2007/08	12,451	41.0	41.0	1.7	22.9
2008/09	8,486	50.5	27.8	1.1	20.6
2009/10	6,049	17.2	71.4	1.0	10.2
2010/11	6,840	15.4	76	0.3	8.3
2011/12	1,752	32.8	24.8	0.7	41.4
2012/13	562	61.4	6.8	0.5	31.3
2013/14	6,070	34.4	51.5	0.2	7.1

Appendix C5.–Total contents of 2,664 pot lifts sampled during the 2013/14 Bering Sea snow crab fishery.

Commercial crab species	Number	Other species	Number	Other species	Number
Snow crab		angled buccinum	1	sea anemone unident.	189
legal	860,855	arrowtooth flounder	2	sea urchin unident.	3
sublegal	10,898	Atka mackerel	1	sea whip unident.	3
female	11,389	basket star	148	sinuous whelk	6
sex unknown		bigmouth sculpin	1	skate unident.	6
Tanner Crab		Buccinum snail unident.	9	snail unident.	13,274
legal	32,582	circumboreal toad crab	1	spinyhead sculpin	1
sublegal	10,481	cockle unident.	1	sponge unident.	6
female	1,076	crab unident.	1	starfish unident.	17
sex unknown		flatfish unident.	1	walleye pollock	30
Tanner Crab unident.		flathead sole	1	worm unident.	2
male	1,169	giant octopus	43	yellowfin sole	6
female	2	great sculpin	3	yellow Irish lord	109
Hybrid Tanner Crab		Oregon triton	248		
(legally *opilio*[a])		hermit crab unident.	123		
legal	1,263	jellyfish unident.	25		
sublegal	0	ladder whelk	91		
female	37	lyre whelk	1		
Hybrid Tanner Crab		mussel unident.	2		
(legally *bairdi*[b])		Neptune snail unident.	27		
legal	407	northern rockfish	1		
sublegal	57	octopus unident.	18		
female	9	Pacific cod	682		
Red king Crab		Pacific halibut	77		
legal	94	Pacific lyre crab	12		
sublegal	0	Pribilof whelk	1038		
female	0	prowfish	3		
Golden King Crab		rex sole	1		
legal	0	rockfish unident.	3		
sublegal	0	scale worm unident.	1		
female	1	sculpin unident.	2		

[a] Hybrid Tanner crab that are considered to be *C. opilio* by the criteria of 5 AAC 35.521.

[b] Hybrid Tanner crab that are considered to be *C. bairdi* by the criteria of 5 AAC 35.521.

Appendix C6.–Snow crab catch per pot by soak time for 2,664 pot lifts sampled during the 2013/14 Bering Sea snow crab fishery.

		Average number of crab per pot				
Soak[a] (hours)	Percent of sample pots	LRT	LNR	SUB	FEM	Total
12-24	5.3	115.1	127.5	4.8	2.4	249.8
24-36	23.4	168.8	162.1	6.9	4.0	341.8
36-48	33.9	187.8	147.1	4.2	4.8	343.9
48-60	12.6	176.8	128.1	2.2	5.7	312.8
60-72	5.1	183.7	127.5	2.3	3.5	317.0
72-84	3.7	206.9	150.5	3.7	3.6	364.7
84-96	2.4	176.4	129.2	2.3	5.2	313.1
96-108	2.6	209.2	153.3	4.1	4.4	371.0
108-120	1.7	210.1	141.2	0.8	7.4	359.5
120-132	1.7	167.8	119.5	2.4	6.0	295.6
132-144	0.6	216.3	139.2	0.9	0.5	356.8
144-156	0.9	167.7	130.9	1.2	5.0	304.8
156-168	0.9	229.6	125.2	1.2	0.8	356.9
168-180	0.7	187.3	102.8	0.8	0.4	291.3
180-192	0.5	228.6	137.4	1.5	0.9	368.5
192-204	0.8	216.0	119.6	0.6	0.6	336.9
204-216	0.3	228.3	80.1	0.4	0.0	308.9
216-228	0.9	202.2	71.7	0.4	0.0	274.3
228-240	0.2	208.2	93.7	0.8	6.8	309.5
240-252	0.2	187.2	126.8	0.3	0.0	314.3
252-264	0.3	126.0	91.8	3.1	0.2	221.1
264-276	0.2	185.5	132.5	0.8	0.5	319.2
276-288	0.1	210.5	198.0	1.5	0.0	410.0
288-300	0.2	93.2	73.0	0.0	0.0	166.2
300+	0.6	216.7	103.7	0.9	0.6	321.8

Note: Observers categorize all sampled crabs as either legal-size retained male (LRT), legal-size non-retained male (LNR), sublegal male (SUB), or female (FEM).

[a] Average soak time was 59 hours.

Appendix C7.–Snow crab catch per pot by depth for 2,664 pot lifts sampled during the 2013/14 Bering Sea snow crab fishery.

		Average number of crab per pot				
Depth[a] (fathoms)	Percent of sampled pots	LRT	LNR	SUB	FEM	Total
50-55	0.1	16.5	4.5	0.0	0.5	21.5
55-60	7.1	181.9	128.2	2.1	5.6	317.8
60-65	29.3	168.5	130.0	5.5	3.3	307.3
65-70	29.0	185.5	150.4	5.2	1.7	342.8
70-75	13.4	183.2	148.3	2.2	3.0	336.6
75-80	15.3	177.2	145.8	2.1	13.2	338.2
80-85	3.3	175.2	133.4	1.0	0.4	309.9
85-90	0.6	156.6	124.6	4.4	0.1	285.7
90-95	0.5	194.4	190.7	8.1	0.2	393.4
95-100	0.4	261.9	235.7	12.3	0.0	509.9
100+	1.2	334.3	236.8	5.3	0.0	576.5

Note: Observers categorize all sampled crabs as either legal-size retained male (LRT), legal-size non-retained male (LNR), sublegal male (SUB), or female (FEM).

[a] Average depth was 68 fathoms.

Appendix C8.–Reproductive condition (by percent) of female snow crab from pot lifts sampled during the 1995–2013/14 Bering Sea snow crab fisheries.

		Ovigerous		Barren	
Year	Number of crab	Eyed eggs	Uneyed eggs	Matted setae	Clean setae
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	21.9	71.0	1.6	3.8
2008/09	461	28.4	71.4	0	0.2
2009/10	246	3.3	64.2	8.9	22.8
2010/11	459	3.7	56.0	11.1	29.2
2011/12	5,607	88.7	4.6	3.5	2.5
2012/13	1,096	24.6	55.1	10.0	6.7
2013/14	2,939	5.5	3.6	0.0	90.9

Appendix C9.–Total contents of 267 pot lifts sampled during the 2013/14 Bering Sea Tanner crab fishery east of 166° W long.

Commercial crab species	Number	Other species	Number
Tanner Crab		Bering flounder	1
legal	13,108	brittle star unident.	4
sublegal	1,463	flathead sole	2
female	686	giant octopus	1
Red King Crab		graceful decorator crab	6
legal	142	great sculpin	6
sublegal	181	Oregon triton	11
female	1,100	hermit crab unident.	14
Snow Crab		jellyfish unident.	106
legal	164	Pacific cod	109
sublegal	9	Pacific halibut	3
female	0	Pacific lyre crab	10
Hybrid Tanner Crab		Pribilof whelk	4
(legally *bairdi*[a])		sand dollar unident.	3
legal	7	scale worm unident.	1
sublegal	3	sea anemone unident.	1
female	0	sea cucumber unident.	1
Hybrid Tanner Crab		snail unident.	498
(legally *opilio*[b])		sponge unident.	5
legal	1	starfish unident.	658
sublegal	0	yellowfin sole	84
female	0	yellow Irish lord	7
Hair Crab			
legal	9		
sublegal	0		
female	0		

[a] Hybrid Tanner crab that are considered to be *C. bairdi* by the criteria of 5 AAC 35.521.

[b] Hybrid Tanner crab that are considered to be *C. opilio* by the criteria of 5 AAC 35.521.

Appendix C10.–Tanner crab catch per pot by soak time for 267 pot lifts sampled during the 2013/14 Bering Sea Tanner crab fishery east of 166° W long.

		Average number of crab per pot				
Soak[a] (hours)	Percent of sampled pots	LRT	LNR	SUB	FEM	Total
0-12	1.1	64.7	16.3	11.7	8.0	100.7
12-24	19.5	26.4	5.9	4.3	2.6	39.2
24-36	48.3	42.7	9.7	6.7	3.3	62.3
36-48	18.4	44.1	6.1	3.6	1.4	55.1
48-60	3.7	53.9	8.2	9.2	1.9	73.2
60-72	0.4	85.0	5.0	8.0	0.0	98.0
72-84	0.7	40.0	5.0	5.0	0.0	50.0
84-96	0.4	68.0	2.0	2.0	0.0	72.0
96-108	1.9	38.8	0.4	1.8	0.4	41.4
108-120	1.9	60.2	15.2	4.4	1.8	81.6
120-132	0.4	67.0	15.0	12.0	0.0	94.0
132-156						
156-168	0.4	38.0	9.0	2.0	2.0	51.0
168-180						
180-192	0.7	14.5	6.0	1.0	0.0	21.5
192-216						
216-228	0.7	22.0	4.0	0.5	0.5	27.0
228-252						
252-264	0.7	73.5	10.5	3.5	3.5	91.0
264-276	0.4	86.0	3.0	1.0	0.0	90.0
276-288						
288-300	0.4	38.0	3.0	1.0	0.0	42.0

Note: Observers categorize all sampled crabs as either legal-size retained male (LRT), legal-size non-retained male (LNR), sublegal male (SUB), or female (FEM).

[a] Average soak time was 40 hours.

Appendix C11.–Tanner crab catch per pot by depth for 267 pot lifts sampled during the 2013/14 Bering Sea Tanner crab fishery east of 166° W long.

		Average number of crab per pot				
Depth[a] (fathoms)	Percent of sampled pots	LRT	LNR	SUB	FEM	Total
20-25	1.9	0.0	0.0	0.4	0.0	0.4
25-30	0.7	0.0	0.0	0.5	0.0	0.5
30-35	1.1	0.0	0.0	0.0	0.0	0.0
35-40	0.7	0.0	0.0	0.0	0.0	0.0
40-45	17.6	51.6	12.0	4.0	1.6	69.3
45-50	67.8	43.6	8.5	6.7	3.2	62.1
50-55	9.7	23.9	1.8	2.2	1.1	29.0
55-60	0.4	10.0	0.0	1.0	0.0	11.0

Note: Observers categorize all sampled crabs as either legal-size retained male (LRT), legal-size non-retained male (LNR), sublegal male (SUB), or female (FEM).

[a] Average depth was 46 fathoms.

Appendix C12.–Reproductive condition (by percent) of female Tanner crab from pot lifts sampled during the 2006/07-2009/10 and 2013/14 Bering Sea Tanner crab fisheries east of 166° W long.

		Ovigerous		Barren	
Year	Number of crab	Eyed eggs	Uneyed eggs	Matted setae	Clean setae
2006/07	1,573	95.6	2.9	0.8	0.6
2007/08	2,416	27.9	68.5	1.9	1.2
2008/09	536	20.1	78.4	0.0	1.5
2009/10	147	8.2	87.8	0.7	2.7
2013/14	315	71.1	27.0	1.0	1.0

Appendix C13.–Total contents of 309 pot lifts sampled during the 2013/14 Tanner crab fishery west of 166° W long.

Commercial crab species	Number	Other species	Number
Tanner Crab		hermit crab unident.	5
legal	16,883	jellyfish unident.	2
sublegal	5,033	Pacific cod	120
female	691	Pacific halibut	11
Snow Crab		Pacific lyre crab	51
legal	6,464	Pribilof whelk	66
sublegal	63	rock sole unident.	8
female	197	sea anemone unident.	47
Hybrid Tanner Crab		snail unident.	6,391
(legally *bairdi*[a])		starfish unident.	23
legal	1	walleye pollock	1
sublegal	0	worm unident.	1
female	0	yellowfin sole	16
Hybrid Tanner Crab		yellow Irish lord	10
(legally *opilio*[b])			
legal	6		
sublegal	0		
female	0		

[a] Hybrid Tanner crab that are considered to be *C. bairdi* by the criteria of 5 AAC 35.521.

[b] Hybrid Tanner crab that are considered to be *C. opilio* by the criteria of 5 AAC 35.521.

Appendix C14.–Tanner crab catch per pot by soak time for 309 pot lifts sampled during the 2013/14 Bering Sea Tanner crab fishery west of 166° W long.

		Average number of crab per pot				
Soak[a] (hours)	Percent of sampled pots	LRT	LNR	SUB	FEM	Total
12-24	12.3	35.1	16.8	2.4	1.3	55.5
24-36	18.8	38.6	18.7	3.9	1.7	62.9
36-48	42.4	33.7	18.0	33.6	2.5	87.8
48-60	21.7	34.5	17.9	4.1	2.3	58.7
60-72	1.6	57.8	26.0	2.4	3.2	89.4
72-84	0.3	32.0	5.0	5.0	0.0	42.0
84-108						
108-120	1.6	97.2	19.8	2.8	2.0	121.8
120-132	0.6	51.5	23.5	2.0	19.5	96.5
132-144	0.3	54.0	19.0	3.0	0.0	76.0
144-156	0.3	47.0	6.0	1.0	0.0	54.0

Note: Observers categorize all sampled crabs as either legal-size retained male (LRT), legal-size non-retained male (LNR), sublegal male (SUB), or female (FEM).

[a] Average soak time was 42 hours.

Appendix C15.–Tanner crab catch per pot by depth for 309 pot lifts sampled during the 2013/14 Bering Sea Tanner crab fishery west of 166° W long.

		Average number of crab per pot				
Depth[a] (fathoms)	Percent of sampled pots	LRT	LNR	SUB	FEM	Total
50-55	10.0	55.1	15.3	0.8	0.8	72.0
55-60	13.3	29.8	19.4	3.2	0.2	52.7
60-65	61.5	38.7	18.2	24.6	2.8	84.4
65-70	3.2	28.6	14.4	3.3	5.9	52.2
70-75	1.3	6.2	13.8	4.5	0.0	24.5
75-80	10.0	21.8	19.9	4.8	2.0	48.5
80-85	0.6	12.0	12.5	2.0	1.0	27.5

Note: Observers categorize all sampled crabs as either legal-size retained male (LRT), legal-size non-retained male (LNR), sublegal male (SUB), or female (FEM).

[a] Average depth was 62 fathoms.

Appendix C16.–Reproductive condition (by percent) of female Tanner crab from pot lifts sampled during the 2005/06-2008/09 and 2013/14 Bering Sea Tanner crab fisheries west of 166° W long.

		Ovigerous		Barren	
Year	Number of crab	Eyed eggs	Uneyed eggs	Matted setae	Clean setae
2005/06	1,101	21.9	75.8	0.6	1.6
2006/07	2,859	25.9	73.5	0.5	0.0
2007/08	903	21.9	75.6	1.2	0.9
2008/09	118	86.4	2.5	3.4	7.6
2013/14	400	1.8	71.0	7.5	18.3

Appendix C17.–Total pot lift contents for 167 pot lifts sampled during the 2013 Pribilof Islands golden king crab fishery.

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Appendix C18.–Golden king crab catch per pot by soak time for 167 pot lifts sampled during the 2013 Pribilof Islands golden king crab fishery.

CONFIDENTIAL

Appendix C19.–Golden king crab catch per pot by depth for 167 pot lifts sampled during the 2013 Pribilof Islands golden king crab fishery.

CONFIDENTIAL

Appendix C20.–Reproductive condition (by percent) of female golden king crab from pot lifts sampled during the 2010-2013 Pribilof Islands golden king crab fisheries.

CONFIDENTIAL

Appendix C21.–Total pot lift contents for 499 pot lifts sampled during the 2013/14 Aleutian Islands golden king crab fishery east of 174° W long.

Commercial crab species	Number	Other species	Number	Other species	Number
Golden King Crab		Anthomastus sp.	3	Pacific cod	2
legal	17,923	arrowtooth flounder	2	Pacific halibut	16
sublegal	5,094	basket star	106	Pacific lyre crab	1
female	5,038	brittle star unident.	24	Pacific ocean perch	1
Scarlet King Crab		bryozoan unident.	30	Plexauridae unident.	2
legal	28	Calcigorgia sp.	3	Primnoidae Group I	64
sublegal	3	capelin	1	Primnoidae unident.	1
female	5	chiton unident.	2	red-tree coral	5
		Crypthelia sp.	5	sea anemone unident.	1
		Cup coral unident.	4	sea urchin unident.	9
		Cyclohelia sp.	9	shrimp unident.	1
		Distichopora sp.	3	skate unident.	2
		Errinopora sp.	6	snail unident.	23
		Fanellia sp.	3	soft coral unident.	3
		Flabellum sp.	3	sponge unident.	84
		flatfish unident.	3	starfish unident.	23
		hydroid unident.	18	stony coral unident.	1
		jellyfish unident.	2	Stylaster sp.	54
		Kamchatka coral	12		

Appendix C22.–Golden king crab catch per pot by soak time for 499 pot lifts sampled during the 2013/14 Aleutian Islands golden king crab fishery east of 174° W long.

		Average number of crab per pot				
Soak (days)	Percent of sampled pots	LRT	LNR	SUB	FEM	Total
0-3	0.2	41.0	0.0	22.0	9.0	72.0
3-6	3.8	28.6	0.7	2.1	0.3	31.7
6-9	6.0	28.8	0.6	2.6	3.6	35.7
9-12	20.8	29.6	1.2	7.7	9.6	48.1
12-15	39.1	35.7	1.3	12.3	13.6	63.0
15-18	15.4	36.1	1.5	9.2	8.1	54.9
18-21	5.8	48.2	2.1	18.0	9.1	77.4
21-24	5.8	37.4	2.5	12.0	8.9	60.9
24-27	2.0	29.5	0.6	10.7	7.6	48.4
27-30	1.0	36.8	1.8	14.4	7.2	60.2

Note: Observers categorize all sampled crabs as either legal-size retained male (LRT), legal-size non-retained male (LNR), sublegal male (SUB), or female (FEM).

[a] Average soak time was 14 days.

Appendix C23.–Golden king crab catch per pot by depth for 499 pot lifts sampled during the 2013/14 Aleutian Islands golden king crab fishery east of 174° W long.

		Average number of crab per pot				
Depth[a] (fathoms)	Percent of sample pots	LRT	LNR	SUB	FEM	Total
80-90	3.6	28.5	0.7	18.3	7.9	55.4
90-100	2.2	37.5	0.3	8.5	4.3	50.6
100-110	8.6	35.1	1.2	6.7	10.1	53.1
110-120	7.6	24.4	0.8	5.6	3.9	34.8
120-130	5.8	28.8	1.0	3.3	8.6	41.6
130-140	8.2	31.8	1.0	6.8	4.5	44.1
140-150	7.8	34.5	1.4	3.3	9.5	48.7
150-160	8.8	33.0	1.3	6.0	9.6	49.8
160-170	5.4	41.6	2.1	11.0	9.4	64.1
170-180	4.8	32.7	1.2	8.8	17.5	60.2
180-190	2.2	37.7	2.2	9.7	12.6	62.3
190-200	2.2	33.8	0.5	7.6	9.2	51.2
200-210	3.4	26.1	2.3	10.0	11.2	49.6
210-220	3.4	36.9	2.1	12.6	8.5	60.1
220-230	2.0	45.4	1.3	13.3	27.4	87.4
230-240	4.2	31.8	1.4	13.8	10.1	57.0
240-250	2.6	37.6	1.2	12.5	14.9	66.2
250-260	1.4	60.1	2.0	17.7	18.0	97.9
260-270	1.8	42.0	1.2	16.4	18.0	77.7
270-280	4.2	41.0	2.0	17.2	10.9	71.1
280-290	3.4	35.3	2.5	21.5	7.5	66.8
290-300	1.4	44.3	1.3	16.4	9.4	71.4
300+	4.6	50.7	1.5	23.4	20.1	95.8

Note: Observers categorize all sampled crabs as either legal-size retained male (LRT), legal-size non-retained male (LNR), sublegal male (SUB), or female (FEM).

[a] Average depth was 176 fathoms.

Appendix C24.–Reproductive condition (by percent) of female golden king crab from pot lifts sampled during the 1996/97–2013/14 Aleutian Islands golden king crab fisheries east of 174° W long.

		Ovigerous		Barren	
Year	Number of crab	Eyed eggs	Uneyed eggs	Matted setae	Clean setae
1996/97	59,210	20.8	22.5	18.6	38.1
1997/98	5,383	25.2	19.3	22.1	33.4
1998/99	44,352	18.1	21.0	23.9	37.0
1999/00	36,695	22.1	21.0	23.1	33.8
2000/01	13,615	26.9	18.7	20.1	34.3
2001/02	14,912	20.4	12.5	15.4	51.1
2002/03	9,651	29.6	19.2	18.9	32.3
2003/04	7,990	20.9	33.2	13.6	31.5
2004/05	5,430	24.9	24.7	24.9	25.5
2005/06	1,489	25.8	25.2	18.3	30.7
2006/07	2,328	29.6	35.7	9.1	25.6
2007/08	1,397	18.3	52.5	10.1	19.1
2008/09	2,308	31.3	35.3	17.9	15.5
2009/10	2,604	45.0	26.8	9.4	18.3
2010/11	3,769	40.8	32.3	8.1	18.8
2011/12	3,173	37.4	21.6	26.3	12.7
2012/13	4,510	24.9	29.6	20.7	24.2
2013/14	5,038	32.7	28.1	18.5	20.4

Appendix C25.– Total pot lift contents for 1,223 pot lifts sampled during the 2013/14 Aleutian Islands golden king crab fishery west of 174° W long.

Commercial crab species	Number	Other species	Number	Other species	Number
Golden King Crab		Alaskagorgia aleutiana	2	Pacific halibut	8
legal	20,393	amphipod unident.	2	Pacific lyre crab	1
sublegal	9,528	Anthomastus sp.	20	Plexauridae unident.	55
female	8,165	Arthrogorgia sp.	35	Primnoidae Group I	226
Red King Crab		Atka mackerel	1	Primnoidae unident.	1
legal	11	bamboo coral	1	red-tree coral	11
sublegal	2	Bamboo coral unident.	1	rockfish unident.	6
female	1	basket star	159	sand dollar unident.	1
Scarlet King Crab		bigmouth sculpin	1	scaled crab	1
legal	9	bivalve unident.	1	scale worm unident.	9
sublegal	0	brittle star unident.	1,047	scallop unident.	7
female	0	bryozoan unident.	241	sculpin unident.	6
		Calcigorgia sp.	40	sea anemone unident.	12
		chiton unident.	21	sea cucumber unident.	2
		Clavularia sp.	19	sea lily unident.	14
		Coral unident.	2	sea whip unident.	1
		Crypthelia sp.	14	sea pen unident.	11
		Cup coral unident.	21	sea raspberry	2
		Cyclohelia sp.	20	sea spider unident.	15
		Distichopora sp.	43	sea urchin unident.	54
		Errinopora sp.	15	sea whip unident.	2
		Fanellia sp.	67	shortspine thornyhead	1
		flatfish unident.	4	shrimp unident.	4
		giant octopus	8	skate unident.	9
		Greenland turbot	4	snail unident.	44
		Oregon triton	13	soft coral unident.	14
		hermit crab unident.	2	sponge unident.	428
		hydroid unident.	365	starfish unident.	96
		invertebrate unident.	13	stony coral unident.	13
		jellyfish unident.	1	Stylaster sp.	190
		Kamchatka coral	10	tube worm unident.	27
		mussel unident.	4	tunicate unident.	11
		octopus unident.	4	worm unident.	140
		Pacific cod	1		

Appendix C26.– Golden king crab catch per pot by soak time for 1,223 pot lifts sampled during the 2013/14 Aleutian Islands golden king crab fishery west of 174° W long.

		Average number of crab per pot				
Soak[a] (days)	Percent of sampled pots	LRT	LNR	SUB	FEM	Total
0-3	0.1	10.0	1.0	9.0	6.0	26.0
3-6						
6-9	1.4	13.9	1.1	14.6	7.3	36.9
9-12	2.0	25.3	0.8	17.6	6.0	49.7
12-15	5.4	14.5	1.4	11.4	10.9	38.2
15-18	10.5	16.6	1.4	8.4	7.5	33.9
18-21	20.4	14.2	0.8	8.1	7.3	30.4
21-24	23.3	15.5	1.1	7.3	5.6	29.5
24-27	12.1	15.2	1.6	6.2	10.4	33.4
27-30	8.2	13.8	1.0	7.6	3.9	26.2
30-33	4.2	19.5	0.8	8.4	2.0	30.7
33-36	3.3	23.9	1.3	12.8	7.4	45.4
36-39	1.5	16.7	1.1	6.4	7.7	31.9
39-42	1.0	13.0	2.8	2.5	6.4	24.8
42-45	2.1	18.2	0.7	2.0	3.0	23.8
45-48	2.8	7.0	0.6	0.9	2.7	11.1
48-51	0.9	10.0	1.4	2.1	1.8	15.3
51-54	0.6	23.3	0.3	3.3	8.1	35.0
54-57						
57-60	0.1	13.0	0.0	3.0	0.0	16.0
60-63	0.2	21.7	5.3	3.3	3.3	33.7

Note: Observers categorize all sampled crabs as either legal-size retained male (LRT), legal-size non-retained male (LNR), sublegal male (SUB), or female (FEM).

[a] Average soak time was 24 days.

Appendix C27.–Golden king crab catch per pot by depth for 1,223 pot lifts sampled during the 2013/14 Aleutian Islands golden king crab fishery west of 174° W long.

		Average number of crab per pot				
Depth[a] (fathoms)	Percent of sampled pots	LRT	LNR	SUB	FEM	Total
60-70	0.7	10.5	1.2	1.9	0.9	14.5
70-80	2.3	14.4	1.2	4.8	4.4	24.8
80-90	4.2	18.8	1.0	9.6	9.9	39.5
90-100	2.6	14.0	1.5	7.7	3.2	26.4
100-110	4.1	16.8	0.9	8.3	4.5	30.6
110-120	4.8	12.9	0.9	5.2	5.0	24.0
120-130	7.2	18.6	1.3	7.5	2.1	29.5
130-140	8.6	15.2	1.1	9.3	4.6	30.3
140-150	8.7	15.8	1.1	7.3	6.3	30.6
150-160	9.2	13.1	1.2	8.2	6.7	29.2
160-170	11.0	17.6	1.2	8.6	5.4	32.7
170-180	8.8	14.9	0.9	6.9	6.0	28.7
180-190	7.8	18.9	1.2	8.5	6.6	35.2
190-200	5.2	13.9	1.2	7.8	12.7	35.6
200-210	3.5	13.4	1.1	7.6	12.5	34.7
210-220	3.0	11.7	1.1	7.8	13.8	34.5
220-230	1.8	9.1	1.1	7.1	6.2	23.5
230-240	1.2	12.8	0.7	5.8	9.7	29.0
240-250	1.9	17.3	0.8	5.4	12.1	35.7
250-260	0.7	19.2	2.0	3.3	11.1	35.7
260-270	0.8	16.0	2.6	4.1	18.4	41.1
270-280	0.2	4.3	0.0	0.3	0.3	5.0
280-290	0.4	18.8	0.4	10.8	7.0	37.0
290-300	0.4	19.2	0.2	17.6	6.8	43.8
300+	0.8	13.7	1.0	17.0	5.1	36.8

Note: Observers categorize all sampled crabs as either legal-size retained male (LRT), legal-size non-retained male (LNR), sublegal male (SUB), or female (FEM).

[a] Average depth was 158 fathoms.

Appendix C28.–Reproductive condition (by percent) of female golden king crab from pot lifts sampled during the 1996/97–2013/14 Aleutian Islands golden king crab fisheries west of 174° W long.

		Ovigerous		Barren	
Year	Number of crab	Eyed eggs	Uneyed eggs	Matted setae	Clean setae
1996/97	67,314	23.6	25.5	21.2	29.6
1997/98	39,343	24.0	26.8	19.8	29.4
1998/99	22,208	23.4	25.9	16.3	34.4
1999/00	45,645	21.3	29.6	19.1	29.9
2000/01	53,716	26.2	28.7	17.1	27.9
2001/02	38,829	26.6	27.8	22.4	23.2
2002/03	22,479	32.8	20.9	11.9	33.9
2003/04	5,946	32.8	26.8	19.2	21.2
2004/05	12,970	26.1	31.7	21.6	20.6
2005/06	5,798	35.2	33.5	21.7	9.6
2006/07	7,136	31.6	36.0	19.3	13.0
2007/08	9,281	43.2	23.9	19.1	13.8
2008/09	7,922	27.5	34.5	15.3	22.7
2009/10	7,155	31.3	30.3	29.1	5.9
2010/11	7,382	31.3	33.4	20.0	15.3
2011/12	7,370	31.6	29.1	19.6	18.5
2012/13	9,505	28.3	28.6	30.0	11.2
2013/14	8,165	35.4	29.5	25.2	8.9

APPENDIX D. RESULTS OF LEGAL TALLY SAMPLES

Appendix D1.–Results of ADF&G legal tally samples from the 2013/14 Bering Sea and Aleutian Islands directed crab fisheries.

Fishery	Sample size	Percent of landed catch[a]	Number of illegal crabs: Male	Female	Non-target species	Total	Percent illegal
Bristol Bay red king crab	16,484	1.33	23	0	3	36	0.16
Bering Sea snow crab	80,738	0.19	7	5	26	38	0.05
Bering Sea Tanner crab (east of 166° W)	3,896	0.55	1	0	0	1	0.03
Bering Sea Tanner crab (west of 166° W)	3,263	0.44	0	0	0	0	0
Pribilof Islands golden king crab	-[d]	-[d]	-[d]	-[d]	-[d]	-[d]	-[d]
E. Aleutian Islands golden king crab[b]	8,400	1.20	34	1	0	35	0.42
W. Aleutian Islands golden king crab[c]	9,300	1.35	47	1	0	48	0.52

[a] Based on actual total fishery (ATF) reported catch number.

[b] East of 174° W long.

[c] West of 174° W long.

[d] Confidential.