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Estimates of Red King Crab Bycatch during the 2005/2006 Bristol Bay Red King Crab Fishery with Comparisons to the 1999-2004 Seasons

by

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and

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May 2006

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Measures (fisheries)

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

Mathematics, statistics

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

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ABSTRACT

The 2005/2006 Bristol Bay red king crab *Paralithodes camtschaticus* fishery was the first fishery to be completed under the federal Crab Rationalization Program for Bering Sea/Aleutian Islands (BS/AI) king and Tanner crab fisheries. The Crab Rationalization Program replaced a competitive fishery regime with a system for allocating the harvest as quota shares (QS). Expected benefits of rationalization included a reduction in the bycatch of females and sublegal males that had occurred under the competitive fishery regime, although there were also concerns that rationalization could result in highgrading of legal males. We estimated the catch per pot lift of retained legal males, females, sublegal males, and non-retained legal males using data collected by observers during the 2005/2006 Bristol Bay red king crab fishery and compared those estimates with estimates for the 1999-2004 seasons. The results for the 2005/2006 season did not show a reduction in bycatch of females and sublegal males relative to the pre-rationalized fisheries, but did show an increase in the discard rate of captured legal males.

Key words: Alaska Department of Fish and Game, Bering Sea, Aleutian Islands, crab rationalization, Bristol Bay, red king crab *Paralithodes camtschaticus*, bycatch reduction, highgrading.

INTRODUCTION

The Fishery Management Plan (FMP) for the commercial king and Tanner crab fisheries of the Bering Sea and Aleutian Islands (BSAI) establishes a State-Federal cooperative management regime in which management is deferred to the State of Alaska with federal oversight (NPFMC 1998). In March 2005 new federal regulations were issued to establish the BSAI Crab Rationalization Program according to the provisions adopted by the North Pacific Fishery Management Council (NPFMC) in Amendments 18 and 19 to the FMP (NPFMC/NMFS 2006). Federal actions in 1998 had previously allocated 7.5% of the harvests from Bering Sea king and Tanner crab fisheries to a Community Development Quota (CDQ). The Crab Rationalization Program, however, established a quota system for allocating the entire harvest in each of the Bristol Bay red king crab *Paralithodes camtschaticus*, St. Matthew blue king crab *P. platypus*, Pribilof red and blue king crab, Bering Sea snow crab *Chionoecetes opilio*, Bering Sea Tanner crab *C. bairdi*, Eastern Aleutian Islands golden king crab *Lithodes aequispinus*, Western Aleutian Islands golden king crab, and Western Aleutian Islands red king crab fisheries. The 2005/2006 commercial fishery season was the first to be prosecuted under the new Crab Rationalization Program.

Prior to the 2005/2006 BSAI crab season, the commercial fleet participating in the "general" (i.e., non-CDQ) fisheries fished competitively towards that portion of the harvest not allocated to the CDQ program. The Alaska Department of Fish and Game (ADF&G) managed the competitive general fisheries by establishing a guideline harvest level (GHL) prior to the season, monitoring the harvest during the season, estimating the date and time that the harvest would attain the GHL, and closing the general fishery at that estimated date and time. After closure of the general fishery, the CDQ fishery for the season would open and participating vessels were allowed to fish until the CDQ allocation was harvested or until the regulatory season closing date. With implementation of the Crab Rationalization Program, ADF&G now establishes a total allowable catch (TAC) for each fishery according to State regulations and the National Marine Fisheries Service (NMFS) distributes the TAC as quota shares (QS), with 10% of the TAC allocated to the CDQ and the remaining 90% of the TAC allocated to qualifying vessels as individual fishing quotas (IFQs). ADF&G no longer manages the rationalized fisheries inseason; harvesters may harvest their QS at any time within the fishery seasons established in State regulations. Federal regulations also established other provisions for implementing the Crab Rationalization Program, including those for allocating processor shares to processors, those for

governing the consolidation of quota shares by vessels through leasing or purchasing of IFQs, and those for governing the formation of vessel cooperatives.

Crab pots are the legal gear for the BSAI commercial crab fisheries and only males meeting or exceeding the minimum size limits established in State regulations can be harvested. Females, sublegal males, and non-targeted species are also captured by the crab pots and, although State regulations require harvesters to immediately return any captured females and undersized males to the sea, there remain concerns about the mortality due to handling suffered by the discarded crabs (NPFMC 2005). Under the pre-rationalized, competitive fishery regime that the general fishery was prosecuted, high levels of vessel participation relative to the GHL often resulted in fast-paced, "derby-style" fisheries. In an attempt to control fishery effort to the level that the fisheries could be managed inseason, per-vessel pot limits were instituted in State regulations for the Bering Sea king and Tanner crab fisheries. Pot limits varied among fisheries, among vessel size classes (within fisheries, pot limits for vessels ≤ 125 ft in length were 80% of those for larger vessels) and, in some fisheries, the pot limits varied positively with the preseason GHL; 250 pots per vessel was the maximum limit for any fishery and vessel size class.

Among the problems that the Crab Rationalization Program was intended to address was the need to "… develop a management program which slows the race for fish, [and] reduces bycatch and its associated mortalities…" (NPFMC's *BSAI Crab Rationalization Problem Statement*; quoted in NMFS 2004). Replacing the competitive fishery regime with a QS-based regime under the Crab Rationalization Program was expected to obviate the need to "race for fish." Eliminating or slowing the race for fish, in turn, was expected to result in longer soak times for the crab pots, thereby increasing the effectiveness of pot escape mechanisms (escape rings or minimum mesh sizes as required by State regulations) in allowing females or undersized males to escape prior to being handled on deck and discarded (NMFS 2004). To further facilitate use of increased soak times under the Crab Rationalization Program, the Alaska Board of Fisheries in March 2005 increased pot limits to 450 pots per vessel in the Bristol Bay red king, Bering Sea Tanner, and Bering Sea snow crab fisheries and to 250 pots per vessel in the St. Matthew blue king and Pribilof red and blue king crab fisheries, regardless of vessel size or TAC. Additionally, a slower-paced fishery was expected to allow harvesters more opportunity to move their gear to areas with fewer non-retainable or undesirable crabs. On the other hand, prior to implementation of the Crab Rationalization Program, there were concerns that a QS-based regime could allow for, or even promote, "highgrading" by harvesters; i.e., discarding legally retainable, but lower-valued, crabs in order to maximize the contribution of higher-valued crabs towards the harvested QS. The concern was specifically cited during development of the Crab Rationalization Program that harvesters may sort through captured legal males for retention of the largest, cleanest-shelled crabs and discard, with the associated handling mortality, the remaining legal crabs (NMFS 2004).

The Crab Rationalization Program has, in fact, slowed the pace of the BSAI crab fisheries. For example, the 2005/2006 Bristol Bay red king crab season was prosecuted towards the 18.329-million pound TAC over the 3-month period following the October 15, 2005 season opening date; the first delivery was made on October 20, 2005 and the last delivery was made on the day after the regulatory closure date of January 15, 2006 (F. Bowers, ADF&G, Dutch Harbor, personal communication). In contrast, the season lengths for the Bristol Bay red king crab general fisheries during 1996-2004 had all been less than one week, requiring only 3 to 5 days to harvest 7.5-million to 14.5-million pounds annually (Bowers et al. 2005).

In this report we provide information for beginning to assess the expectations and concerns relative to bycatch reduction and highgrading associated with the slower-paced rationalized fisheries. Using data collected by crab observers deployed on fishing vessels by ADF&G, we present estimates on the capture rates of female, sublegal male, and non-retained legal male crabs of the targeted species in the first fishery to have been completed under the Crab Rationalization Program, the 2005/2006 Bristol Bay red king crab fishery. We also compare those estimates with estimates for the 1999-2004 general and CDQ Bristol Bay red king crab fishery seasons and compare estimates of the size and shell-condition distributions for retained and non-retained legal males during the 2005/2006 Bristol Bay red king crab season.

METHODS

The data that we report on here was collected by observers deployed by ADF&G on vessels fishing for red king crabs during the 2005/2006 Bristol Bay season. We compared those data with summaries of data collected by observers during the general and CDQ fisheries of the pre-rationalized 1999-2004 Bristol Bay seasons, which were previously reported in annual summaries of ADF&G's Mandatory Shellfish Observer Database (Barnard 2001, Barnard and Burt 2004, Barnard et al. 2001, Burt and Barnard 2005, Burt and Barnard 2006, Moore et al. 2000, Neufeld and Barnard 2003). We limited our comparison with the pre-rationalized fisheries to the 1999-2004 seasons because the 1999 season was the first season for which catch rates of non-retained legal males were estimated from observer data. The general and CDQ fisheries were analyzed separately for the 1999-2004 because of the distinct natures of the general and CDQ fisheries in those seasons. The general fisheries during 1999-2004 opened on October 15 and remained open for 3-5 days, with GHLs ranging from 6.6-million pounds to 14.5-million pounds and 230 to 257 vessels participating annually (Bowers et al. 2005; Table 1). The CDQ fisheries during the 1999-2004 seasons opened after the closure of the general fishery with only 10 to 13 vessels participating and were prosecuted at a reduced pace relative to the general fishery until the CDQ allocation (ranging from 0.6-million to 1.2-million pounds) was harvested. We analyzed the 2005/2006 season as a single fishery, however, with no distinction made between the IFQ and CDQ fisheries because the IFQ and CDQ fisheries were prosecuted concurrently and some individual vessels simultaneously participated in both the IFQ and CDQ fishery.

Observer coverage levels varied over the seasons considered here and between the general and CDQ fisheries within the same season (Table 1). Catcher-processor vessels were required to have 100% observer coverage during all fisheries and seasons covered by this report. In the 1999 general fishery observers were deployed only on catcher-processor vessels. During the 2000-2004 general fisheries, however, observers were also randomly deployed on approximately 10% of the catcher-only vessels 75-125 ft in length and on approximately 10% of the catcher-only vessels >125 ft in length. Prior to the 2005/2006 season, the CDQ fisheries were prosecuted after the general fishery for the season had closed and observer coverage levels on catcher-only vessels were higher than in the general fishery. During the 1999 and 2000 CDQ fisheries, observers were deployed on 100% of the participating vessels. During the 2001-2004 CDQ fisheries observers were deployed on one catcher-only vessel per CDQ group, as well as on any participating catcher-processing vessels, resulting in 60% of the participating vessels carrying observers in each of those fisheries. Because the 2005/2006 Bristol Bay red king crab IFQ and CDQ fisheries were conducted concurrently and individual vessels could fish for multiple QSs

(both IFQ and CDQ), no distinction was made between the IFQ and CDQ fisheries during the selection of vessels to carry observers. Twenty percent of the catcher-only vessels that pre-registered for the 2005/2006 season in each of the 75-125 ft and >125 ft size classes were randomly selected to carry observers. In actuality, fewer vessels fished than had pre-registered for the 2005/2006 season and observers were deployed on 27% of the 89 vessels that fished in the season, including the 4 catcher-processor vessels that received 100% observer coverage.

Three sources of data collected by observers were used in this analysis: data collected from randomly-selected pot lifts during the fishery; data collected from crabs sorted and retained by the vessel crew for delivery or processing; and data collected from confidential interviews with the captain of the vessel. The methods for obtaining these data are briefly described below; the ADF&G Shellfish Observer Manual (ADF&G 2003) provides detailed descriptions of crab observer sampling duties.

Observers were directed to randomly select 3 pot lifts each day during the 1999 season and 10 pot lifts per day during each of the 2000 to 2005/2006 seasons and to record information on the location, depth, soak time, and contents of each randomly-selected pot lift. Specifically, with regard to the data collected on red king crabs captured in randomly-selected pot lifts, observers recorded: the sex, carapace length (CL) in mm, and shell condition of each red king crab; the legal status relative to the minimum legal size of 6.5-in carapace width of each male; the fate of each legal male as either retained (i.e., for delivery or processing) or non-retained (i.e., discarded); and data on the reproductive condition (clutch fullness, egg development, and egg color) of each female. Although sex, CL, and legal status can be either objectively scored or directly measured, scoring of shell condition is a more subjective determination. Shell condition is recorded to provide an estimate of the time since a crab's last molt (ADF&G 2003, Donaldson and Byersdorfer 2005). Observers scored the shell condition of sampled red king crabs as either "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 (ADF&G 2003). Observers consulted with the vessel crew and observed the sorting practices of the vessel crew to ascertain the characteristics of legal king crabs that were retained or non-retained. Observers gained further information on the characteristics needed to score legal males as either retained or non-retained by observing if the legal males that they had scored as retained or non-retained were treated as such by the vessel crew after the sampling of a pot lift was completed.

In addition to and independent of obtaining data on red king crabs in randomly-selected pot lifts, observers also sampled from the crabs that were sorted and retained by the vessel crew for delivery or processing. Observers deployed on catcher-only vessels were assigned to record the CL and shell condition from at least 100 randomly-selected retained red king crabs at the time of each delivery. Observers deployed on catcher-processor vessels were assigned to record the CL and shell condition from at least 100 randomly-selected retained red king crabs, prior to being processed, on a daily basis.

Observers also collected information on the fishing activities of their assigned vessel through daily interviews with the captain of the vessel. From the information collected during the daily interviews, the data used in this report were the number of pot lifts performed by the vessel for each day.

The data on red king crabs in randomly-selected pot lifts and on daily vessel effort from confidential interviews were used to estimate the catch per pot lift (CPUE) of female, sublegal male, retained legal male, and non-retained legal male red king crabs. CPUE was estimated using a weighted mean formula for stratified sampling (Burt and Barnard 2006). Briefly, each day an observed vessel fished (vessel-day) was considered a separate stratum and data within a vessel-day stratum was weighted by the vessel's effort (number of pot lifts) for that day relative to the vessel's total effort for the season. Hence data from pot lifts sampled on vessel-days with more effort were given greater weight in the estimates. Beginning in 2003, data were further stratified by vessel category to account for the differences between vessel size classes in pot limits and for the difference in observer coverage levels between catcher-only vessels and catcher-processor vessels. The 3 strata for vessel category were catcher-only vessels ≤125 ft, catcher-only vessels >125 ft, and catcher-processor vessels. For the 2005/2006 season vessels were stratified into only two vessel classes, catcher-only vessels and catcher-processor vessels. Catcher-only vessels were not stratified by size class in 2005/2006 because pot limits were no longer applied differentially by vessel size class. The total number of red king crabs by sex-size class caught by the entire fleet during a fishery was estimated by multiplying the estimated CPUEs by the total number of pot lifts for the entire fleet during the fishery. The value used for total fishery pot lifts in the 2005/2006 season (117,079) was a preliminary value provided by F. Bowers (ADF&G, Dutch Harbor, personal communication).

There is no other data source on bycatch during these fisheries that can be used to directly assess the accuracy of the CPUE estimates for females, sublegal males, and non-retained legal males that were obtained using data collected by observers from pot lift samples. However, the data recorded on fish tickets and on confidential interviews with vessel captains by observers and dockside samplers provide an independent data source for assessing the accuracy of the CPUE estimates for retained legal crabs. Data from fish tickets and confidential interviews are compiled annually to compute and report (e.g., Bowers et al. 2005) the actual fishery CPUE (i.e., the number of all live and dead crabs that were delivered or retained for processing during the season divided by the total number of pot lifts performed during the season by all participating vessels). The annually reported summaries of ADF&G's Mandatory Shellfish Observer Database provide comparisons for each observed fishery of the estimated CPUE of retained crabs with the actual fishery CPUE. Those comparisons show that the CPUE estimates of retained crabs are generally accurate; in particular, the CPUE estimates of retained crabs for each of the 1999-2004 Bristol Bay red king crab general fisheries have been within ± 9% of the actual fishery CPUE (Barnard and Burt 2004, Barnard et al. 2001, Burt and Barnard 2005, Burt and Barnard 2006, Moore et al. 2000, Neufeld and Barnard 2003).

Data collected from randomly-selected pot lifts were also used to compare the estimated size and shell-condition frequency distributions of captured male red king crabs across seasons and to estimate the size and shell-condition frequency distributions of captured legal, retained legal, and non-retained legal red king crabs during the 2005/2006 season. Additionally, for the 2005/2006 season only, the shell-condition data collected from legal males in randomly-selected pot lifts were compared on a vessel-by-vessel basis with the shell-condition data collected from samples of the crabs that were sorted and retained by the vessel crew for delivery or processing. The statistical significance of vessel-by-vessel differences between the shell-condition distributions of legal males in randomly-selected pot lifts and the shell-condition distribution of legal males sorted for delivery or processing was tested using methods for analyzing multiple independent contingency tables (Cox and Snell 1989).

RESULTS

The mean soak time of the pot lifts that were randomly selected for sampling by observers during the 2005/2006 season was 65 hours (Table 2). Of the seasons and fisheries considered here, that value was exceeded only by the mean soak time for pot lifts sampled during the 2004 CDQ fishery (67 hours) and is more than twice that for any of the general fisheries in the 1999-2004 seasons. The CPUE of retained legal males estimated from randomly-sampled pot lifts during the 2005/2006 season was 23.8 per pot lift (Table 2); by comparison, the actual fishery CPUE for the 2005/2006 season has been preliminarily determined to be 23.3 crabs per pot lift (F. Bowers, ADF&G, Dutch Harbor, personal communication). That value was higher than those for the 1999-2003 general fisheries, comparable to that for the 2004 general fishery, but lower than those for the 2003 and 2004 CDQ fisheries.

The estimated CPUE of discarded red king crabs (i.e., females, sublegal males, and non-retained legal males) for the 2005/2006 season was 49.8 crabs per pot lift, a value exceeded only by that for the 2004 CDQ from among those estimates that we report here (Table 2). Expressed as a percentage, discarded red king crabs were estimated to have comprised 68% of the total (i.e., retained and discarded) red king crabs captured during the 2005/2006 season, the second highest percentage estimated for any of the fisheries or seasons considered here (Figure 1). An estimated 5.831-million red king crabs were captured and discarded during the 2005/2006 season. That estimate is comparable to the highest estimate for total number of discarded red king crabs in any one season among the 1999-2004 seasons (general and CDQ fisheries combined), 5.807-million crabs in 2003 (Figure 2).

As in the 1999-2004 seasons, sublegal males were estimated to constitute the largest component (53%) of the discarded red king crab catch during the 2005/2006 season (Table 2, Figure 2). The size distribution of males in sampled pot lifts during the 2005/2006 season tracks well with those for the previous 5 seasons (Figure 3). In particular, a mode at approximately 98-mm CL in the size distribution for the 2003 season tracks to a mode at approximately 128-mm CL in the size distribution for the 2005/2006 season. Seventy-four percent of the non-retained males (60% of the sublegal males and all the non-retained legal males) in sampled pot lifts during the 2005/2006 season were ≥ 120-mm CL, the size used to identify mature male red king crabs for management of the Bristol Bay fishery (5 AAC 34.816 (b) (3); Figure 4). Females accounted for an estimated 35% of the red king crab bycatch during the 2005/2006 season and 87% of the females in sampled pot lifts during that season were classified as mature on the basis of the presence of eggs or empty egg cases.

Particularly notable in the CPUE estimates for the 2005/2006 season as compared to the 1999-2004 fisheries was the estimated CPUE of non-retained legal red king crabs (5.8 crabs per pot; Table 2) and their estimated contribution to the total legal males captured (20%), total non-retained red king crabs captured (12%), and total red king crabs captured (8%). The percentage of the total captured red king crabs that were non-retained legal males during the 2005/2006 season was markedly higher than the percentages estimated for any of the general fisheries during 1999-2004 and nearly twice the highest percentage estimated for the CDQ fisheries during 1999-2004 (Figure 1). An estimated 677-thousand legal male red king crabs were captured and discarded during the 2005/2006 season, whereas the highest estimate for total discarded legal males among any of the 1999-2004 seasons (general and CDQ fisheries combined) was 80-thousand crabs in the 2002 season (Figure 2).

Non-retention of the legal males captured by the pot lifts sampled by observers during the 2005/2006 season was correlated with shell condition. By comparison with all (retained and non-retained) legal males in the pot lifts sampled during the 2005/2006 season, crabs classified as new-shell were over-represented in the legal males scored as retained and crabs classified as old- and very-old-shell were highly over-represented in the legal males scored as non-retained (Table 3, Figure 5). There was also some association between non-retention of legal males and their size, with a tendency for higher proportions of the larger legal males in sampled pot lifts to be scored as non-retained than the smaller legal males (Figures 4 and 5). Among the legal males measured by observers in sampled pot lifts during the 2005/2006 season, 16% of the 12,453 that were 131-145 mm CL in size, 23% of the 34,617 that were 146-170 mm CL in size, and 31% of the 3,496 that were 171-195 CL mm in size were scored as non-retained. As a result, there was a slight difference in the mean size between the legal males in sampled pot lifts scored as retained (153.4-mm CL, n = 39,578) and non-retained (156.1-mm CL, n = 11,036); the 95% confidence interval for the difference in mean CL was 2.4 - 2.9 mm.

The tendency during the 2005/2006 season for legal males in new-shell condition to be over-represented in the retained catch as compared to all captured legal males (retained and non-retained) was also revealed by a vessel-by-vessel comparison of the shell-condition data collected from legal males in randomly-selected pot lifts with the shell-condition data collected from the legal males that were sorted and retained for delivery or processing by the vessel crew (Figure 6). For all but 2 of the 24 observed vessels, the percentage of legal males classified as new-shell by observers in the sample of the legal males that were sorted by the vessel crew for delivery or processing exceeded the percentage classified as new-shell in the sample of the legal males (regardless of scoring as retained or non-retained) contained in the randomly-selected pot lifts from the same vessel. For 18 of the 24 vessels the difference in new-shell percentages was 8% or greater and the average of the differences for the 24 vessels was 15%; the differences in new-shell percentages over the 24 vessels is statistically significant ($P << 0.001$, $z = 39.9$).

DISCUSSION

Data on soak time of randomly-selected pot lifts from observed vessels during the 1999 through 2005/2006 Bristol Bay red king crab fishery seasons were consistent with the increased soak times anticipated for a QS-based fishery regime under the Crab Rationalization Program. Mean soak time for sampled pot lifts sampled during the 2005/2006 season was more than double that for any of the 1999-2004 general fisheries and was, at 65 hours, comparable to that for the 2004 CDQ fishery. An experimental study conducted with commercial king crab pots in Bristol Bay has shown that increased soak times, in conjunction with the pot-escape mechanisms required in State regulations, result in a decrease in the ratio of non-legal to legal red king crabs captured (Pengilly and Tracy 1998). The actual catch or CPUE of non-retained crabs relative to retained legal crabs during a commercial red king crab fishery, however, also depends on other factors, such as the size-sex distribution of the red king crab population, where fishing is conducted relative to the spatial distribution of non-legal and legal crabs, and the sorting of legal crabs for retention or non-retention. Despite the longer soak times used in the 2005/2006 Bristol Bay red king crab season, estimates of CPUE and catch of non-retained red king crabs and of the percentage of the red king crabs that were captured but not retained were generally high relative to the general and CDQ fisheries of the preceding six seasons.

The estimated number of non-retained red king crabs for the 2005/2006 season (5.831-million) was higher than for any of the combined general and CDQ fisheries in the 1999-2004 seasons. That may be partly attributable to the TAC for the 2005/2006 season (18.329-million pounds) being higher than harvests during the 1999-2004 seasons (i.e., the highest combined general and CDQ harvest during 1999-2004 was 15.697-million pounds for the 2003 season; Bowers et al. 2005). However, the estimated catch of non-retained red king crabs as a percentage of the total red king crabs captured in the 2005/2006 season (68%) was amongst the highest of the estimates made for any of the fisheries (general or CDQ) since the 1999 season. Preseason data from the NMFS eastern Bering Sea trawl survey indicated that the abundance of sublegal males and mature females in the Bristol Bay red king crab population was relatively high in 2005 (J. Zheng, ADF&G, Juneau, personal communication) and that may account for the high bycatch of sublegal males and females during the 2005/2006 season. Most of the non-retained crabs sampled during the 2005/2006 season (74% of the males and 87% of the females) were mature or of the size used to identify maturity for management purposes.

The observer data from the 2005/2006 season was unique relative to the other seasons considered in the degree to which legal males contributed to the non-retained catch. For the first time since the annual estimation of the CPUE of non-retained legal males in the Bristol Bay red king crab fishery was initiated in 1999, legal males were estimated to account for a substantial portion of the total discarded red king crabs in the 2005/2006 season. The number of legal males estimated to have been captured and discarded during the 2005/2006 season (677-thousand crabs) represents 12% of the estimated total catch of non-retained red king crabs and 20% of the estimated total catch of legal males for the season. Prior to the 2005/2006 season, it had been noted that a "…small level of highgrading has been observed in the CDQ crab fisheries…, but this is not widespread" (NMFS 2004). The 2003 and 2004 Bristol Bay red king crab CDQ fisheries did, in fact, have higher estimates of CPUE for non-retained legal males than for those of the 1999-2004 general fisheries. By all measures, however, the catch rates of non-retained legal males during the 2005/2006 season were markedly higher than for the CDQ fisheries in previous seasons. Additionally, although the discard rates of legal males during the recent CDQ seasons were high relative to the general fisheries, the CDQ fisheries accounted for only 7.5% of the total harvest and a smaller percentage of the total effort for a season. Hence the catch of non-retained legal males in each of the complete (i.e., general and CDQ fisheries combined) 1999-2004 seasons was negligible in comparison to the 2005/2006 season.

Concerns that highgrading for the retention of only the largest, cleanest-shelled legal males would occur in rationalized fisheries (NMFS 2004) were only partially borne out by the data collected by observers during the 2005/2006 Bristol Bay red king crab season. Shell condition, specifically a strong preference for new-shell crabs over old-shell or very-old-shell crabs, was a more important correlate of retention or non-retention than size. In fact, the legal males in pot lift samples that were scored as non-retained tended to be slightly larger than the legal males in pot lift samples that were scored as retained. That size difference probably reflects a positive association between size and the proportion of males in old and very-old-shell conditions, coupled with the tendency to retain new-shell legal males and discard old and very-old shell legal males, rather than any selection for retention based on size.

The estimates of CPUE based on data collected from randomly-selected pot lifts are, in fact, estimates. Moreover, the estimated CPUEs of retained legal males and non-retained legal males are based on the scoring of sampled legal males as such by observers. Hence it is worth

considering the accuracy of the CPUE estimates, particularly for the estimated CPUE of non-retained legal males for the 2005/2006 season. Two lines of evidence provide support for the validity of the CPUE estimate for non-retained legal males during 2005/2006. The first is the accuracy of the CPUE estimate for retained males. The CPUE estimate for retained legal males for the 2005/2006 season (23.8 crabs per pot lift) was within 2% of the actual fishery CPUE that has preliminarily determined from the reported deliveries, processing, and effort for the entire season (23.3 crabs per pot lift; F. Bowers, ADF&G, Dutch Harbor, personal communication). The second is the higher percentage of new-shell crabs in legal males that were retained for delivery or processing than in the legal males that were in randomly-selected pot lifts prior to sorting for retention by the vessel crew. Hence the data collected by observers on retained males, independently of the data that they collected on legal males from pot-lift samples, were consistent with a tendency for the harvesters to preferentially retain legal males in new-shell condition and to discard legal males in old- or very-old-shell condition.

In summary, the data collected by observers during the 2005/2006 Bristol Bay red king crab season provided no indication that the first fishery completed under the Crab Rationalization Program achieved the goal of reducing the bycatch and discarding of females and sublegal males. Instead, those data substantiated the concerns that a fully-rationalized, QS-based fishery regime could lead to increased discarding of captured legal males, concerns that had earlier gained some validity from results for previous CDQ fisheries. It is possible, but entirely conjectural, that the bycatch of sublegal males and females would have been higher during the 2005/2006 season if it had not been managed under a QS-based regime that allowed for longer soak times. However, relatively high abundance of sublegal males and mature females does not account for the estimated 12% of the discarded catch that were legal males. Moreover, the discarding of an estimated 20% of the captured legal males during the 2005/2006 season also likely had the effect of increasing the bycatch of females and sublegal males by increasing the number of pot lifts necessary to harvest the TAC.

Finally, note that we do not generalize these findings from the 2005/2006 Bristol Bay red king crab season to the four other fisheries that opened under the Crab Rationalization Program in the 2005/2006 season (i.e., the Bering Sea snow crab, Bering Sea Tanner crab, Eastern Aleutian Islands golden king crab, and Western Aleutian Islands golden king crab fisheries). Those fisheries were still being prosecuted and observer data from those fisheries were not fully available at the time of this report.

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TABLES AND FIGURES

Table 1.-Number of participating fishing vessels, number of observed fishing vessels, total number of pot lifts, and number of pot lifts sampled by observers during the 1999-2005/2006 Bristol Bay red king crab fisheries.

Season-Fishery	Number of Vessels	Number of Observed Vessels	Number of Total Pot Lifts	Number of Pot Lifts Sampled
1999-General	257	9	146,997	178
1999-CDQ	10	10	2,976	263
2000-General	246	21	98,694	673
2000-CDQ	11	11	4,663	428
2001-General	230	30	63,242	494
2001-CDQ	10	6	3,158	166
2002-General	242	28	68,328	487
2002-CDQ	10	6	3,909	251
2003-General	252	31	129,019	731
2003-CDQ	13	8	5,814	279
2004-General	251	29	90,972	536
2004-CDQ	12	8	5,359	226
2005/2006[a]	89	24	117,079	1,855

[a] IFQ and CDQ fisheries combined.

Table 2.-Estimated catch per pot lift (CPUE) with standard errors (in parentheses) of red king crabs by category (retained legal male, non-retained legal male, sublegal male, and female) from randomly-selected pot lifts sampled by observers during the 1999-2005/2006 Bristol Bay red king crab fisheries.

Season-Fishery	Retained Legal Males	Non-retained Legal Males	Sublegal Males	Females	Total Discarded [a]	Mean Soak Time (hr)
1999-General	13.4 (1.1)	<0.1 (<0.1)	6.1 (0.8)	0.2 (0.1)	6.3	25
1999-CDQ	[b]	[b]	[b]	[b]	[b]	36
2000-General	12.8 (1.3)	<0.1 (<0.1)	13.3 (1.7)	2.3 (0.8)	15.1	22
2000-CDQ	[b]	[b]	[b]	[b]	[b]	26
2001-General	18.4 (2.0)	<0.1 (<0.1)	24.7 (4.4)	12.2 (2.1)	36.9	24
2001-CDQ	[b]	[b]	[b]	[b]	[b]	34
2002-General	19.0 (1.4)	1.1 (<0.1)	21.3 (3.0)	0.7 (0.6)	23.1	18
2002-CDQ	[b]	[b]	[b]	[b]	[b]	45
2003-General	17.8 (1.5)	0.2 (0.1)	26.5 (3.4)	16.5 (3.1)	43.2	31
2003-CDQ	30.1 (3.3)	3.2 (0.8)	26.9 (4.7)	11.2 (2.5)	41.3	42
2004-General	23.1 (1.5)	0.1 (<0.1)	14.2 (2.5)	9.6 (6.2)	23.8	28
2004-CDQ	33.8 (2.1)	3.5 (0.5)	42.5 (3.9)	10.3 (1.3)	56.2	67
2005/2006 [c]	23.8 (1.6)	5.8 (0.9)	26.6 (3.7)	17.4 (2.0)	49.8	65

[a] Sum of CPUEs for non-retained legal male, sublegal male and female crabs.
[b] Confidential.
[c] IFQ and CDQ fisheries combined.

Table 3.-Relative frequency (percent) distributions of shell condition for all legal male, retained legal male, and non-retained legal male red king crabs sampled and scored as retained or non-retained by observers from randomly-selected pot lifts during the 2005/2006 Bristol Bay red king crab season.

Shell Condition	All Legal Males (n=50,614)	Retained Legal Males (n=39,578)	Non-retained Legal Males (n=11,036)
New	71.5%	82.9%	30.3%
Old	24.2%	15.1%	56.7%
Very old	4.3%	1.9%	13.0%

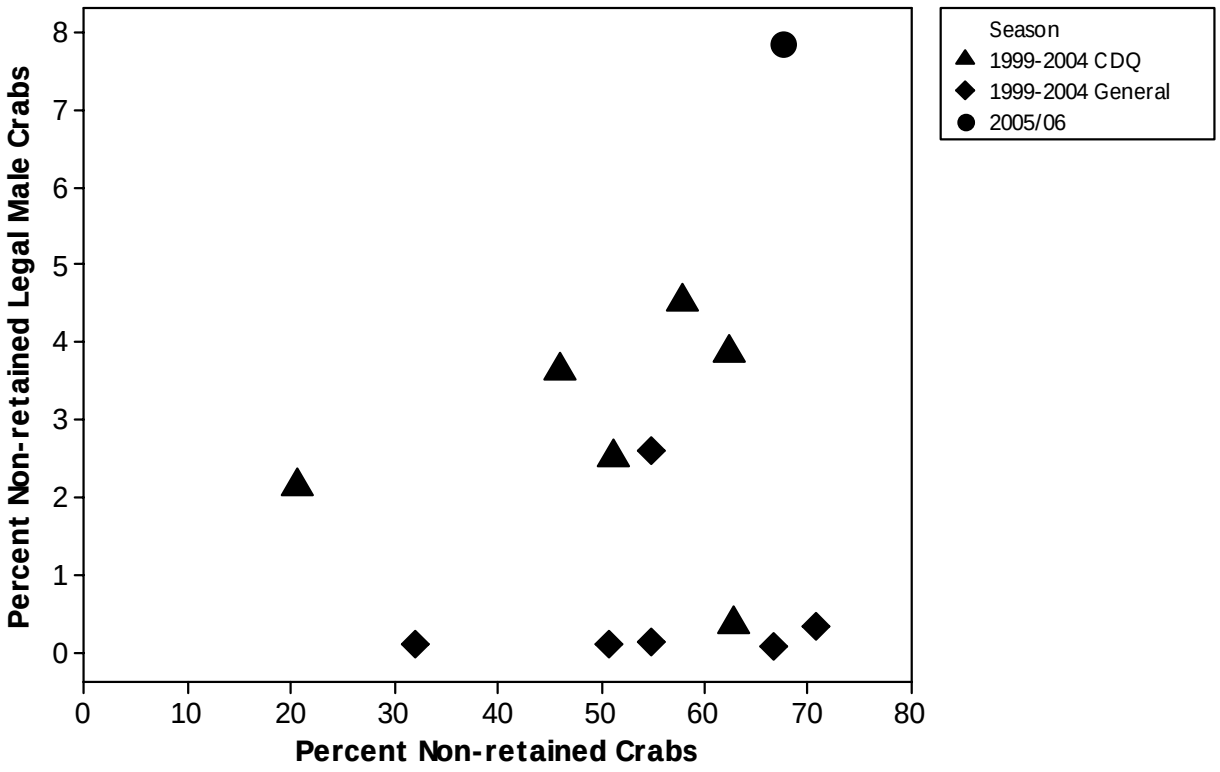

Figure 1.-Estimated percent of red king crabs captured during a Bristol Bay red king crab fishery season that were non-retained (females, sublegal males, and non-retained legal males; horizontal axis) versus the estimated percent of red king crabs captured during the same fishery season that were non-retained legal males (vertical axis) for the 2005/2006 Bristol Bay red king crab season, the 1999-2004 Bristol Bay red king crab CDQ fishery seasons, and the Bristol Bay red king crab general fishery seasons 1999-2004.

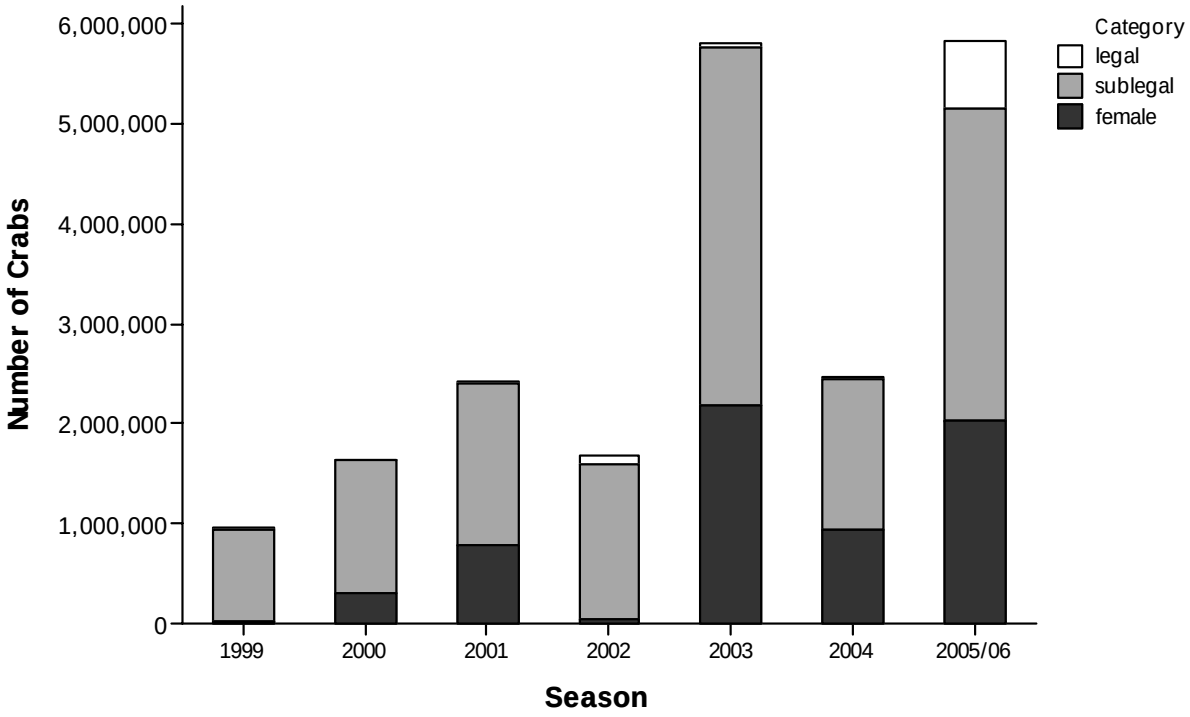

Figure 2.-Estimated numbers of discarded red king crabs by sex and by legal status of males during each of the 1999-2004 Bristol Bay red king crab seasons (general and CDQ fisheries combined) and the 2005/2006 Bristol Bay red king crab season.

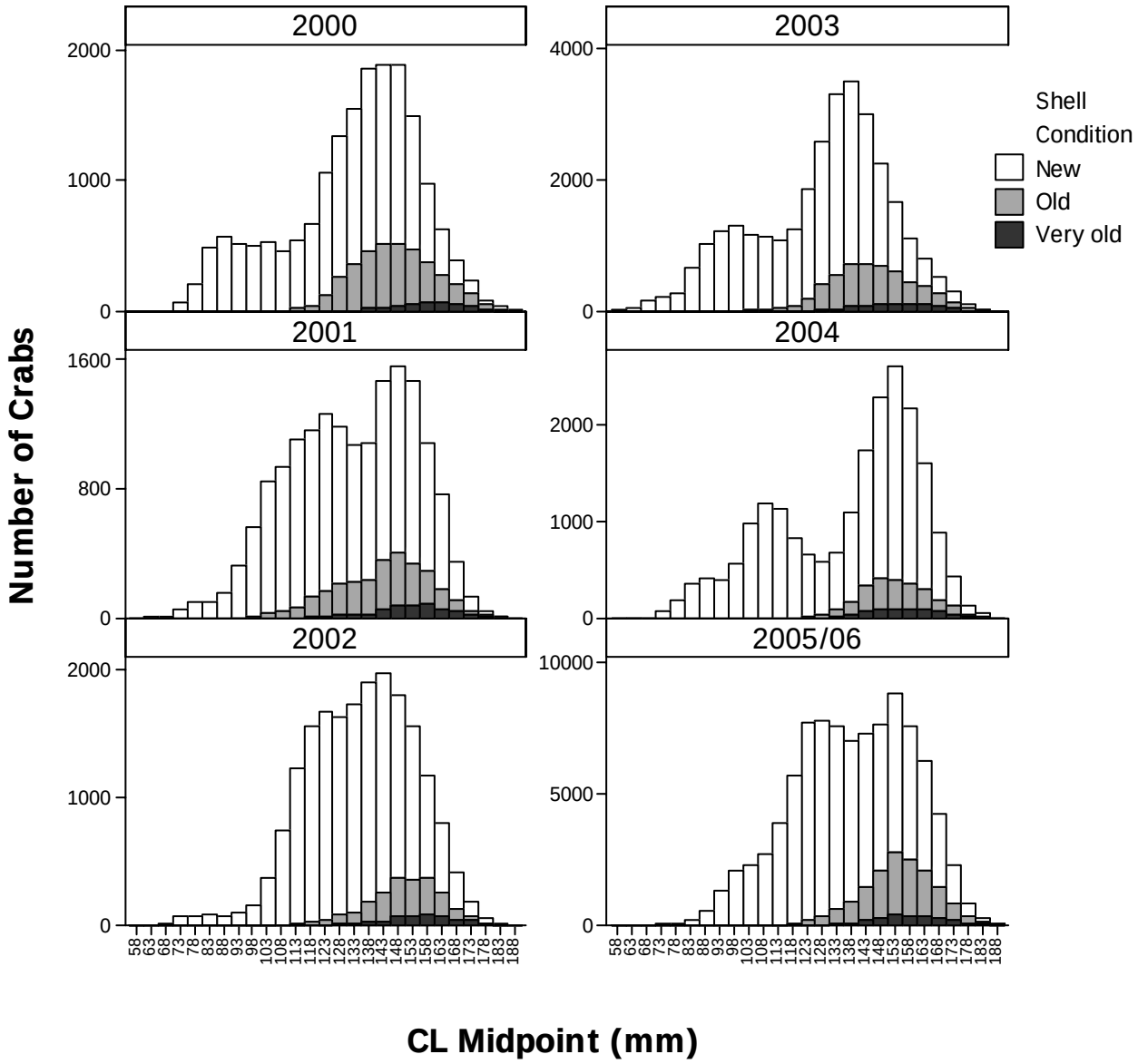

Figure 3.-Carapace length (CL) frequency distributions by shell condition for male red king crabs sampled from randomly-selected pot lifts during the 2000-2004 Bristol Bay red king crab general fisheries and the 2005/2006 Bristol Bay red king crab season.

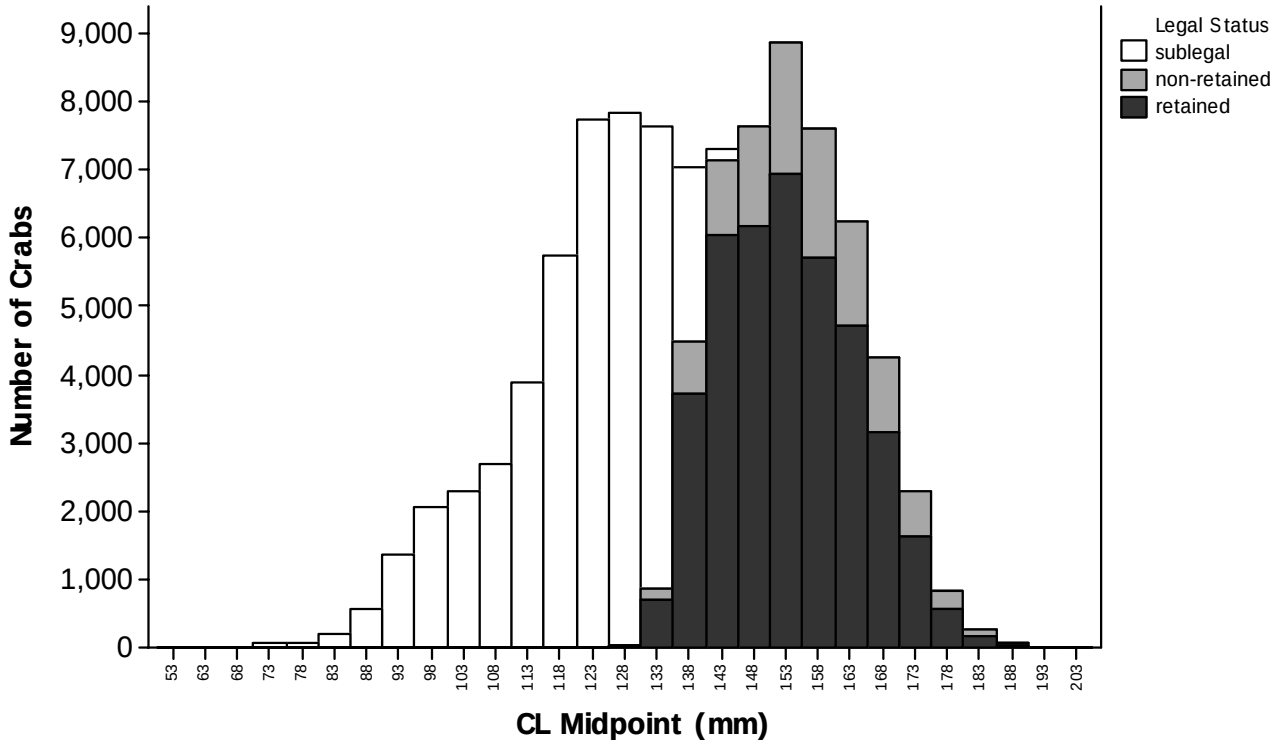

Figure 4.-Carapace length (CL) frequency distribution of sublegal male, non-retained legal male, and retained legal male red king crabs sampled by observers from randomly-selected pot lifts during the 2005/2006 Bristol Bay red king crab season.

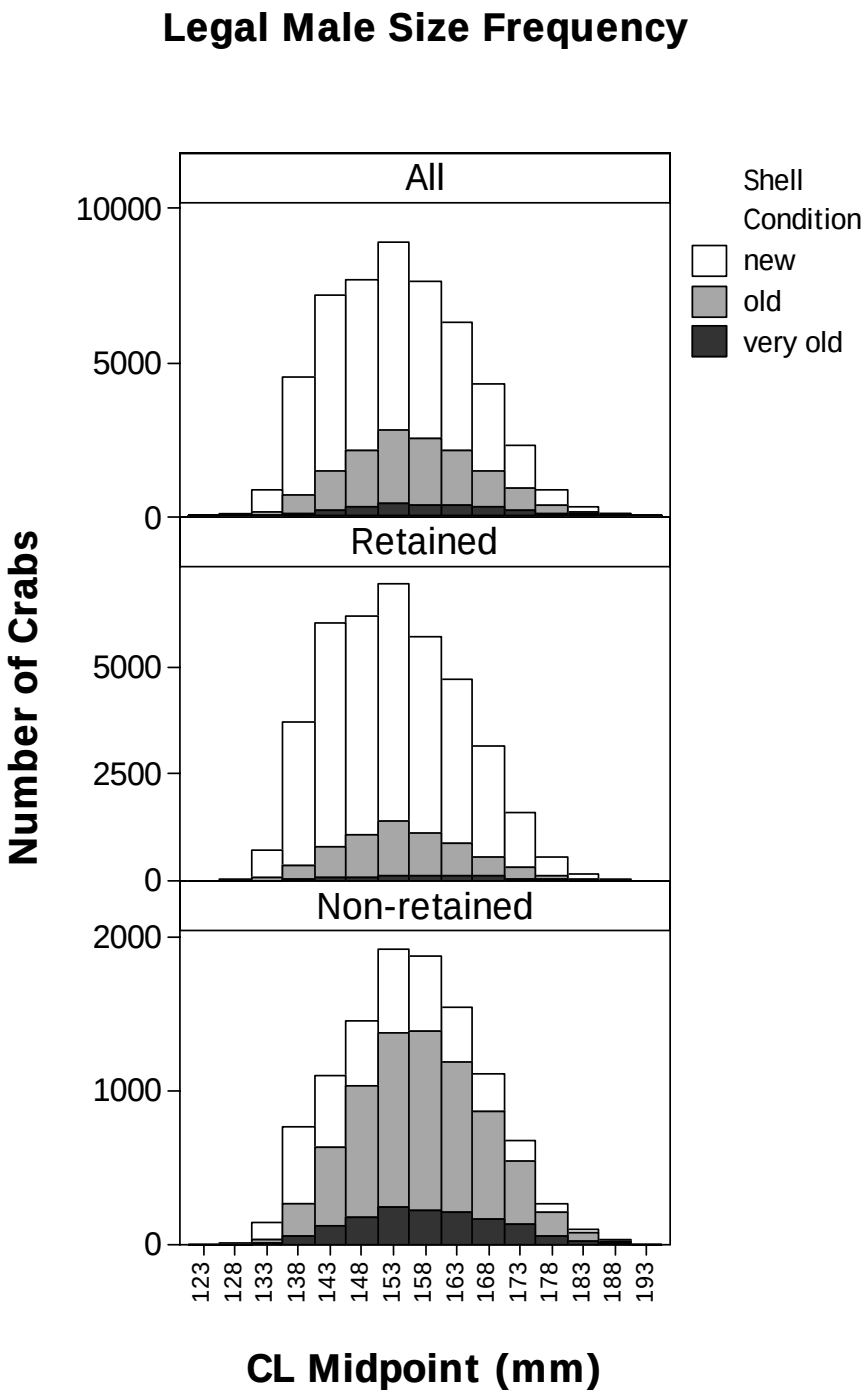

Figure 5.-Carapace length (CL) frequency distributions by shell condition for all legal male (top panel; n=50,614), retained legal male (middle panel; n=39,578), and non-retained legal male (bottom panel; n=11,036) red king crabs sampled and scored as retained or non-retained by observers from randomly-selected pot lifts during the 2005/2006 Bristol Bay fishery.

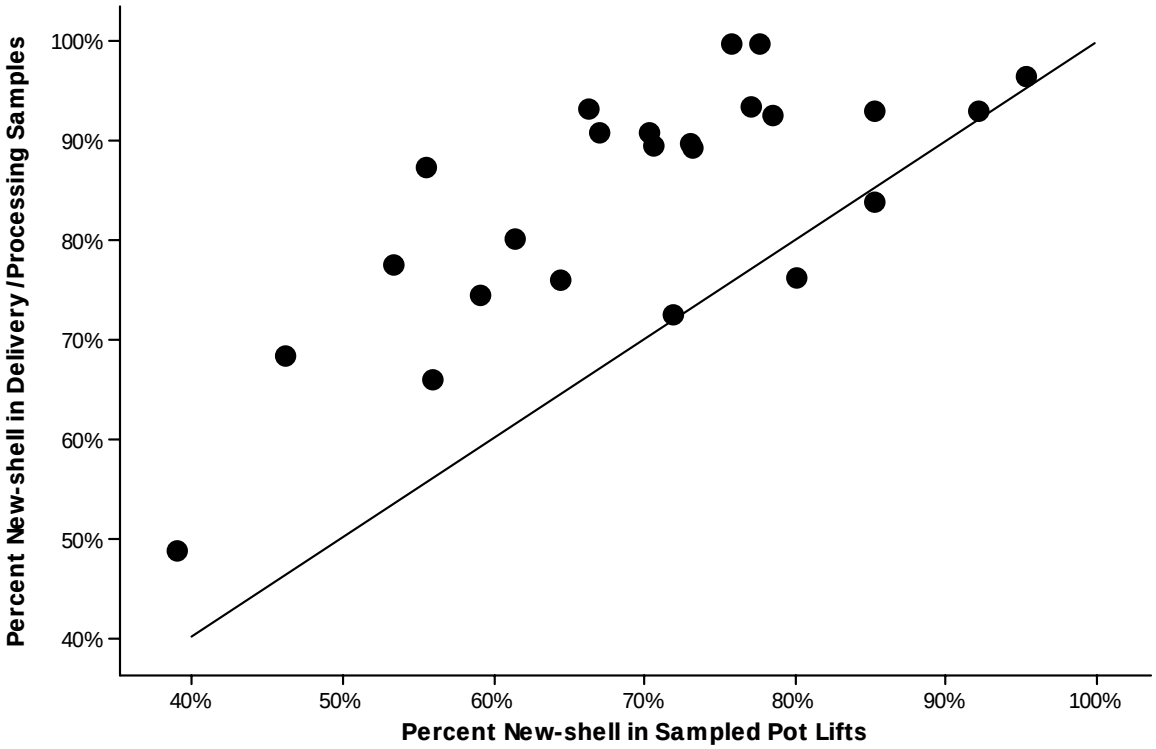

Figure 6.-Percent new-shell condition for legal male red king crabs in randomly-selected pot lifts from a vessel (horizontal axis) versus the percent new-shell condition in samples of the legal male red king crabs retained for delivery or processing by the same vessel (vertical axis) for each of the 24 fishing vessels that carried observers during the 2005/2006 Bristol Bay red king crab season; the line represents equal percent new-shell condition in the two sample types for the same vessel.