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Overview of Proposed Harvest Strategy and Minimum Size Limits for Bering Sea District Tanner Crab

by

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and

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

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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OVERVIEW OF PROPOSED HARVEST STRATEGY AND MINIMUM SIZE LIMITS FOR BERING SEA DISTRICT TANNER CRAB

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ABSTRACT

Tanner crab *(Chionoecetes bairdi)* are broadly distributed in the eastern Bering Sea, with commercial concentrations occurring in Bristol Bay and around the Pribilof Islands. The current harvest strategy for Bering Sea District Tanner crab sets separate harvest quotas east of 166° W long (the "Bristol Bay area") and west of 166° W long (the "Pribilof Islands area"), but uses the same minimum size limit for both areas. Male and female Tanner crab terminally molt to maturity (they do not molt and grow after the molt to maturity), but the current harvest strategy and minimum size limit were developed under the assumption that male Tanner crab continue to grow after they molt to maturity. The terminal molt to maturity of male Tanner crab has important implications for fisheries management measures, warranting a reexamination of the current minimum size limit and harvest strategy for Bering Sea District Tanner crab. This report provides an overview of spatial and temporal trends in size at maturity of male and female Tanner crab in the Bering Sea and reviews their fishery management implications in the context of the terminal molt to maturity. A new harvest strategy for the Bering Sea District Tanner crab fishery and minimum size limits for the Bristol Bay and Pribilof Islands areas are proposed that address terminal molt and temporal and spatial changes in size at maturity. The aim is to increase mean fishery yield, reduce on-deck sorting time and discarded bycatch of male Tanner crab, and avoid excessively targeting on fast-growing, large crab. The proposed strategy has four components: (1) minimum size limit, (2) a mature female biomass threshold, (3) a harvest control rule that varies with an index of mature male biomass, and (4) a buffer on the harvest level to avoid overfishing.

Key words: Tanner crab, Bering Sea, maturity, harvest strategy, size limits

INTRODUCTION

Tanner crab *(Chionoecetes bairdi)* are broadly distributed in the eastern Bering Sea, with commercial concentrations in the Bering Sea District generally occurring in Bristol Bay and around the Pribilof Islands. Initially targeted by Japanese and Russian fleets in 1965, the stock historically supported an important fishery. The fishery expanded quickly in the late 1960s with a catch of about 55 million lb in 1968 (Otto 1990). Foreign fishing for Tanner crab was reduced beginning in the mid-1970s and has been eliminated under the Magnuson Fisheries Conservation and Management Act since 1978. Directed fisheries for eastern Bering Sea Tanner crab by the U.S. fleet began in 1974 and catch peaked in 1978 at about 69 million lb (Otto 1990). The stock collapsed in the mid-1980s and no fishing was allowed in 1986 and 1987. The fishery was reopened in 1988, but was closed again during 1997–2004 due to stock conditions sufficiently depressed that the eastern Bering Sea Tanner crab stock was declared "overfished" under the federal criteria in 1999 (Bowers et al. 2010). The fishery was reopened again for small annual catch quotas during 2005–2009 and the stock was declared "rebuilt" under federal criteria in 2007 (Bowers 2009, Bowers et al. 2010). However, in 2010 the fishery was closed (Bowers 2010) and the stock was declared "overfished" under the federal criteria due to low abundance.

The Tanner crab fishery in the eastern Bering Sea is currently managed through three management measures. First, under state regulations, the fishery is managed under size, sex, and season restrictions. That is, only males of a minimum legal size (currently, 5.5 in, or 140 mm, in carapace width (CW), including spines; 5 AAC 35.520) may be harvested and no fishing is allowed during the spring molting and mating season. The size, sex, and season restrictions are based on economic considerations of market value and meat yield, protection of females for reproduction, and the intent to allow at least one mating season for mature males prior to harvest (Somerton 1981, Donaldson and Donaldson 1992). Second, the annual catch quota is computed according to the harvest strategy in state regulation (5 AAC 35.508), which is based on a variable harvest rate strategy that includes a stock threshold, variable mature male harvest rates, and a maximum cap on the legal male harvest rate (Zheng and Kruse 1999). Under the state harvest strategy, catch quotas are set separately for the western portion of the stock (the "Pribilof Islands area," currently defined as the area west of 166° W long) and the eastern portion of the stock (the "Bristol Bay area," currently defined as the area east of 166° W long). Third, under National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act, the mature biomass at maximum sustainable yield (B_{MSY}), a minimum stock size threshold, and the maximum fishing mortality at B_{MSY}, were established in the federal fishery management plan for Bering Sea/Aleutian Islands king and Tanner crab (FMP, NPFMC 2009) to prevent overfishing and to rebuild the stock when the stock size is below the minimum stock size threshold that defines "overfished" status.

Maturity of Tanner crab is assessed externally with morphometric data (Somerton 1980, Jadamec et al. 1999). Morphometrically mature males are distinguished from morphometrically immature males by an increase in chela ("claw") height relative to CW that occurs at the molt to maturity (Figure 1). Mature females are distinguished from immature females by a prominent increase in abdomen width at the molt to maturity. Although it has long been recognized that the molt to maturity of female Tanner crab is the terminal molt (i.e., that the crab will never molt and grow again after the molt to maturity), there had been some controversy as to whether the molt to maturity of male Tanner crab is the terminal molt (Donaldson and Johnson 1988, Paul and Paul 1995, Zheng and Kruse 1999, Zheng et al. 1998). It is now widely recognized that male Tanner crab also undergo a terminal molt to maturity (Tamone et al. 2007).

The current state harvest strategy for Bering Sea District Tanner crab was developed under the assumption that male Tanner crab can molt again after their molt to maturity (Zheng and Kruse 1999). However, a terminal molt to maturity for male Tanner crab has important implications on the minimum size limit and yield optimization in the Bering Sea Tanner crab fisheries (Conan and Comeau 1986, Zheng and Kruse 1999). Male crab that terminally molt to maturity before reaching legal size will never become available for harvest. Conversely, if a male crab terminally molts to legal size, or after having attained legal size, it may be subject to harvest before having an opportunity to mate or to attain its full reproductive potential, thus reducing reproductive potential and, perhaps, future recruitment to the stock. In terms of yield per recruit, a minimum size limit is not an efficient management measure to optimize harvest of a cohort of crab that stops growing over a wide range of sizes, as is the case with Tanner crab in the Bering Sea District (Somerton 1981, Otto and Pengilly 2002). Consequently, a conflict exists between management objectives for maximizing physical or economic yield per recruit and adequately protecting a stock's reproductive potential. Additionally, over the long term, use of a minimum size limit on an exploited stock exhibiting terminal molt can result in harvesting the fastest growing segment of the stock, which has the potential for adverse genetic consequences (Kruse 1993, Sainte-Marie et al. 1995, Law 2000).

Male and female Tanner crab in the Bristol Bay area are characterized by a larger size at maturity than in the Pribilof Islands area (Somerton 1981). Although statistically significant differences in gene frequencies have been shown to exist between samples of Tanner crab collected from east of 163° W long inside of Bristol Bay and west of 167° W long in the vicinity of the Pribilof Islands, it remains uncertain whether the geographic variation in size at maturity is due to a genetic subdivision of the stock; there are alternative hypotheses for the geographic variation in size at maturity that do not invoke a genetic separation of the stock (Otto and Pengilly 2002). Moreover, it remains uncertain as to whether the differences in gene frequencies are the result of a strong partitioning of the eastern Bering Sea Tanner crab population into subpopulations. For example, the FMP only recognizes a single eastern Bering Sea Tanner crab stock and Rugolo and Turnock (2010, page 277) argue that, “No evidence supports partitioning the unit stock into discrete, non-interbreeding, non-mixing sub-populations which can be assessed and managed separately.”

Regardless of the cause, the geographic trend in size of maturity that exists for Tanner crab in the eastern Bering Sea heightens the management implications of the male terminal molt to maturity and it has been suggested that the two subareas in the Bering Sea District be managed not only with separate catch quotas, but with different size limits (Somerton 1981). Additionally, a reexamination of the minimum size limit and harvest strategy for Bering Sea District Tanner crab is warranted by a recent recognition that there has been a general decrease over the last several decades in the size of maturity and in the proportion of male crab that attain the current legal size. This report gives an overview of a proposed new harvest strategy that addresses terminal molt, smaller size at maturity, and spatial changes in size at maturity. A more complete description of analyses, including statistical tests, is provided in Zheng (2008).

TEMPORAL CHANGES IN SIZE AT MATURITY

Summer trawl survey data for Tanner crab in the eastern Bering Sea from 1975 to 2010 were obtained from the National Marine Fisheries Service.

Annual mean sizes at maturity were estimated for female Tanner crab from 1975 to 2010. Annual sizes at 50% maturity were estimated for male Tanner crab for only 1990–2006 because male chela height data are available only since 1990, and chela height measurements between mature and immature males after 2006 are highly overlapping, making maturity status difficult to estimate. Measurements of CW from the trawl survey data presented here do not include the lateral spines and will be 1–3 mm less than the measurement made to determine legal status, which includes the spines, depending on the crab size.

Mean size of mature female Tanner crab has decreased with statistical significance in both the Bristol Bay and Pribilof Islands areas since 1975 (Figure 2). The decrease in mean size of mature females started in the late 1980s for the Bristol Bay area and started in the mid 1970s for the Pribilof Islands area. Size at 50% maturity for male Tanner crab in the Bristol Bay area in recent years decreased more than 20 mm CW from those in the early 1990s (Figure 3); the decrease over time was statistically significant. Size at 50% maturity for male Tanner crab in the Pribilof Islands area did not have a downward trend during 1990–2006. Size at 50% maturity for males in both areas before 1990 could have been larger than those during 1990–2006 based on survey size frequency data of male crab, but the chela height data were not available to estimate male maturity during the early period.

Ratios of legal male (>137 mm CW, not including spines) abundance to males >112 mm CW (the size at 50% maturity for male Bering Sea Tanner crab assumed in the current harvest strategy) also indicate changes in size at maturity for male Tanner crab since 1975. Although fishing mortality was much higher during the mid and late 1970s than during the recent 10 years, there was a much higher proportion of legal males in the mature-sized population during the earlier period than in the recent 10 years (Figure 4). The sharpest contrast was seen in the Pribilof Islands area: this ratio was close to 60% during the mid and late 1970s and was about 10% during the last 10 years (Figure 4). The apparent cyclic variation of this ratio was primarily caused by recruitment variation and exploitation. Strong recruitment increased legal male abundance and the ratio. The ratio decreased during subsequent periods of poor recruitment because sublegal males suffered much less fishing mortality than legal males.

SPATIAL CHANGES IN SIZE AT MATURITY AND ABUNDANCE

After adjusting for autocorrelation, mean sizes of mature females were statistically significantly correlated only with mean longitude and bottom depth in the Bristol Bay area, and only with mean summer bottom temperature in the Pribilof Islands area (Zheng 2008). Stock abundance did not seem to affect size at maturity for Tanner crab in either area. Bottom depth was strongly correlated with longitude and latitude in the Bristol Bay area, where depth increases from northeast and to southwest. In the Bristol Bay area, mean sizes of mature females decreased from east to west and from shallow waters to deep waters (Figures 5 and 6). Changes in size at maturity appear to have occurred only in the area of 163°–168° W long, i.e., in the area immediately to the east and west of the 166° W long line that divides the Bristol Bay and Pribilof Islands areas (Figure 7).

Spatial distributions of Tanner crab varied over time. The distribution centers of mature females tended to be more eastward within the Bristol Bay area and more westward in the Pribilof Islands area during the early years of the 1975–2010 time period (Figure 8). More recently, the distribution centers have tended to be closer to each other and to the 166° W long line separating the two areas. Mature females were highly concentrated in the Bristol Bay area during 1975–1988, but were at very low densities in the Bristol Bay area, especially east of 163° W long, during recent years (Figure 9). Correlated with the decrease in mean size of female maturity in the Bristol Bay and Pribilof Islands areas since the late 1980s, mature females in the area east of 163° W long, where the largest mature females tend to occur (Figure 7), have become increasing rare relative to the abundance of mature females in the area of 163°–168° W long since the late 1980s (Figure 10).

FISHERIES MANAGEMENT IMPLICATIONS

Temporal and spatial changes in size at maturity and terminal molt to maturity have important implications for the assessment and management of the eastern Bering Sea Tanner crab fishery.

A decrease in size at maturity resulted in fewer male Tanner crab in the eastern Bering Sea able to grow above the current legal size limit. The current minimum size limit of 140 mm CW (138 mm CW, not including the lateral spines) was established in 1976 for two purposes: (1) preserving a broodstock by allowing males to remain at liberty for at least one year after reaching maturity and (2) reducing wastage by restricting the harvest to only those large male crab considered acceptable to processors (Somerton 1981, Donaldson and Donaldson 1992). The minimum size limit was developed with an assumption that male Tanner crab could continue to molt after reaching maturity (Somerton 1981). Based on 12 recent years of survey length frequency data and laboratory studies (e.g., Tamone et al. 2007), this assumption does not apply to eastern Bering Sea Tanner crab. Although the current minimum size limit and decreases in size at maturity may provide added reproductive safeguards at low stock sizes, other management options, such as lowering the minimum size limit, are needed to reduce the loss of harvest opportunity for smaller-sized, mature crab, reduce on-deck sorting time and discarded bycatch of male Tanner crab, and avoid potential adverse genetic consequences of size selection.

With male crab maturing at smaller sizes in the Pribilof Islands area and terminal molt to maturity, lowering the minimum size limit would increase fishery yield[1] (Zheng 2008). Because of different sizes at maturity and the possible stock subdivision between the Tanner crab of the Bristol Bay and Pribilof Islands areas suggested by genetics data (Merkouris et al. 1998), different minimum size limits are needed for the two areas. Even though there is not a clear-cut longitude to divide the Eastern Subdistrict of the Bering Sea District into Bristol Bay and Pribilof Islands areas on the basis of Tanner crab size at maturity (Otto and Pengilly 2002), the current dividing line, 166° W long, should serve well for the purpose of fisheries management. Sizes at maturity for Tanner crab east of 166° W long were larger than those west of 166° W long, and there was not a clear pattern of sizes at maturity for Tanner crab west of 166° W long related to longitude. If minimum size limits are reduced, then harvest rates will also need to be reduced to preserve the spawning stock. An economic analysis on size limit reduction has been conducted to evaluate the economic values of small-size crab (Bechtol et al. *Unpublished*).

PROPOSED NEW HARVEST STRATEGY

The Alaska Department of Fish and Game, under proposal 307, is proposing a new Tanner crab harvest strategy for the Bering Sea District that addresses male terminal molt and temporal and spatial changes in male and female size at maturity. The proposed harvest strategy aims to increase mean fishery yield, reduce on-deck sorting time and discarded bycatch of male Tanner crab, and avoid excessively targeting the harvest on fast-growing, large crab. The proposed strategy has four components: (1) minimum size limit, (2) a mature female biomass threshold, (3) a harvest control rule that varies with an index of mature male biomass, and (4) a buffer on the harvest level to avoid overfishing.

Under the current size limit regulation, the Bristol Bay and Pribilof Islands areas are managed with the same male minimum size limit for legal retention. We propose separate male minimum size limits for legal retention in the Bristol Bay area and the Pribilof Islands area. The proposed minimum size for each area is roughly equal to the mean size at 50% maturity for males in each area, with the result that the proposed minimum size for legal retention in the Pribilof Islands area is smaller than that for the Bristol Bay area.

As in the current harvest strategy, under the proposed harvest strategy the Bering Sea District Tanner crab fishery can only open if the biomass of mature female Tanner crab estimated for the Eastern Subdistrict exceeds a threshold value. However, the current harvest strategy uses the same size at maturity for female Tanner crab in the Bristol Bay area as in the Pribilof Islands area to compute the mature female biomass. The proposed harvest strategy uses a smaller mean size at maturity for female Tanner crab in the Pribilof Islands area relative to the Bristol Bay area in the computation of mature female biomass to reflect the different sizes at maturity for females in the two areas. The mature female biomass threshold in the proposed harvest strategy is set at 40% of the long-term average of the annual mature female biomass during 1975–2010, which approximates the 21 million lb mature female biomass threshold in the current harvest strategy (Figure 11).

As in the current harvest strategy, the harvest levels under the proposed harvest strategy would be calculated separately for the Bristol Bay and Pribilof Islands areas and the fishery in each area

[1] Bechtol, W.R., G. H. Kruse, J. Greenberg, and H. Geier. 2010. Analysis of the minimum size limit for eastern Bering Sea Tanner crab fisheries. An unpublished report. Hereafter referred to as Bechtol et al. *Unpublished*.

would be regulated independent of the other area. Under the harvest control rule in the proposed harvest strategy, the harvest level in each area varies with the current year's "mature male biomass index" in that area relative to the long-term average of the mature male biomass index for that area during 1975–2010. Concordant with the different sizes at 50% maturity for males in the two areas, different size groups are used to define mature males for the two areas in the computation of the mature male biomass index. Dependent on the magnitude of the mature male biomass index relative to the long-term average, annual harvests in each area under the proposed harvest strategy can range from 0 lb to 90% of a limit on retained catch of "exploited legal males" in each area that is determined annually in the federal stock assessment process. Exploited legal males are defined separately for each area in the proposed harvest strategy by the size of legal males predicted to be targeted by the commercial fishery in each area; the minimum size defining exploited legal males in an area is greater than the minimum legal size for retention in that area.

The harvest control rule caps the harvest at 90% of a limit on the retained catch of exploited legal males that corresponds with the overfishing limit determined in the annual federal stock assessment process. That provides a buffer to avoid overfishing similar to the federal rule to avoid overfishing of Tier 5 stocks in the BSAI FMP crab fisheries. The North Pacific Fishery Management Council recently adopted a 90% buffer to determine the allowable biological catch from the overfishing limit (i.e., the allowable biological catch is set at 90% of the overfishing limit) for Tier 5 BSAI crab stocks.

Male Tanner crab terminally molt to maturity over a wide range of sizes, making it difficult to use a minimum size limit within areas to set catch quotas that achieves both high economic yield and stock conservation. Because the catch of male Tanner crabs prior to sorting by size for retention during the commercial fishery has consisted primarily of mature crab, regardless of CW (Figure 12), ADF&G does not anticipate that a lower size limit will lead to significant increases in catches of immature crab. Therefore, ADF&G proposes setting a lower minimum size limit for legal retention in each area to increase yield, reduce on-deck sorting and discarded bycatch of male Tanner crab, and reduce the potential risk of genetic effects due to size selection of catch. To avoid overharvesting the stock, the catch quota would be set by a limit on the catch of exploited legal males and at a rate that varies with the mature male biomass index. The proposed minimum size for exploited legal males in each area is higher than the proposed minimum size limit for legal retention in the area, an approach similar to the current snow crab harvest strategy (5 AAC 35.517). The minimum size to define exploited legal males for the Bristol Bay area in the proposed harvest strategy is the same as the current minimum size limit for the Bering Sea District, whereas the minimum size to define exploited legal males is smaller for the Pribilof Islands area, reflecting the different sizes at maturity in the two areas.

The proposed new harvest strategy and minimum size limit regulations follow:

5 AAC 35.508. BERING SEA DISTRICT *C. BAIRDI* TANNER CRAB HARVEST STRATEGY

(a) In the Bering Sea District, the commercial *C. bairdi* Tanner crab fishery may open only if an analysis of preseason survey data indicates that the population at the time of the survey is at or above 40% of the long-term average (1975–2010) of mature female crab biomass in the Eastern Subdistrict, where

(1) in the area east of 166° W long, a "mature female crab" is defined as a female *C. bairdi* Tanner crab that is more than 84 millimeters in carapace width; and

(2) in the area west of 166° W long, a "mature female crab" is defined as a female *C. bairdi* Tanner crab that is more than 79 millimeters in carapace width.

(b) If preseason survey data indicates that the population at the time of the survey is at or above the long-term average of mature female crab biomass in the Eastern Subdistrict for the second consecutive year, the department shall establish separate total allowable catch levels for each of the portions of the Bering Sea District east of 166° W long and west of 166° W long according to (b)(1) and (b)(2) of this section. If the commercial fishery in the Bering Sea District did not open in the previous season because it did not meet the threshold requirements specified in (a) of this section, the total allowable catch levels for each of the portions of the Bering Sea District east of 166° W long and west of 166° W long, as computed according to (b)(1) and (b)(2) of this section, shall be reduced by one-half.

(1) In the area east of 166° W long of the Bering Sea District and under the restrictions of (c) and (d) of this section

(A) if B_E is less than 25% of $B_{E,1975–2010}$, the fishery will not open;

(B) if B_E is between 25% and 100% of $B_{E,1975–2010}$, the total allowable catch will be computed as $(0.9)x(B_E/B_{E,1975–2010})xC_{E,MSY}$; and

(C) if B_E is greater than 100% of $B_{E,1975–2010}$, the total allowable catch will be computed as $(0.9)xC_{E,MSY}$;

(D) where

(i) B_E denotes the mature male biomass index, estimated for the time of the preseason survey;

(ii) $B_{E,1975–2010}$ denotes the mean value of the mature male biomass index annually estimated for the time of the preseason survey for the period 1975–2010;

(iii) $C_{E,MSY}$ denotes the catch biomass of exploited legal males resulting from fishing on the estimated mature male biomass at the estimated mean time of mating at the F_{MSY} rate or at a proxy for the F_{MSY} rate;

(iv) the "mature male biomass index" is defined as the biomass of all male *C. bairdi* Tanner crab that are more than 112 millimeters in carapace width;

(v) "exploited legal males" are defined as the product of the number of males that are 140 millimeters (five and one-half inches) or greater in carapace width, including the lateral spines, and the corresponding selectivity.

(2) In the area west of 166° W long of the Bering Sea District and under the restrictions of (c) and (d) of this section

(A) if B_W is less than 25% of $B_{W,1975–2010}$, the fishery will not open;

(B) if B_W is between 25% and 100% of $B_{W,1975–2010}$, the total allowable catch will be computed as $(0.9)x(B_W/B_{W,1975–2010})xC_{W,MSY}$; and

(C) if B_W is greater than 100% of $B_{W,1975–2010}$, the total allowable catch will be computed as $(0.9)xC_{W,MSY}$;

(D) where

(i) B_W denotes the mature male biomass index, estimated for the time of the preseason survey;

(ii) $B_{W,1975–2010}$ denotes the mean value of the mature male biomass index annually estimated for the time of the preseason survey for the period 1975–2010;

(iii) $C_{W,MSY}$ denotes the catch biomass of exploited legal males resulting from fishing on the estimated mature male biomass at the estimated mean time of mating at the F_{MSY} rate or at a proxy for the F_{MSY} rate;

(iv) the "mature male biomass index” is defined as the biomass of all male *C. bairdi* Tanner crab that are more than 102 millimeters in carapace width;

(v) "exploited legal males” in the area east of 166° W long are defined as the product of the number of males that are 127 millimeters (five inches) or greater in carapace width, including the lateral spines, and the corresponding selectivity.

(c) Notwithstanding (b) of this section, the total allowable catch for each portion of the Bering Sea District east of 166° W long and west of 166° W long may not exceed 50 percent of the estimated biomass of exploited legal males that would survive in the absence of fishing mortality until the estimated mean time of mating.

(d) Notwithstanding (b) and (c) of this section, in implementing this harvest strategy, the board directs the department to consider the reliability of estimates of *C. bairdi* Tanner crab, the manageability of the fishery, and other factors the department determines necessary to be consistent with sustained yield principles and to use the best scientific information available and consider all sources of uncertainty as necessary to avoid overfishing, as frameworked in Amendment 24 to the federal Fishery Management Plan for Bering Sea and Aleutian Islands King and Tanner Crabs (FMP), of the eastern Bering Sea Tanner crab stock as defined in the FMP.

5 AAC 35.520. SIZE LIMITS FOR REGISTRATION AREA J

(b) In the Bering Sea District, Tanner crab size limits are as follows:

(1) male C. bairdi Tanner crab, or hybrid Tanner crab conforming to the identification criteria described at 5 AAC 35.521(a), must be [5 1/2] 4.4 inches or greater in width of shell, except in waters of the district west of 166° W long male C. bairdi Tanner crab, or hybrid Tanner crab conforming to the identification criteria described at 5 AAC 35.521(a), must be 4.0 inches or greater in width of shell;

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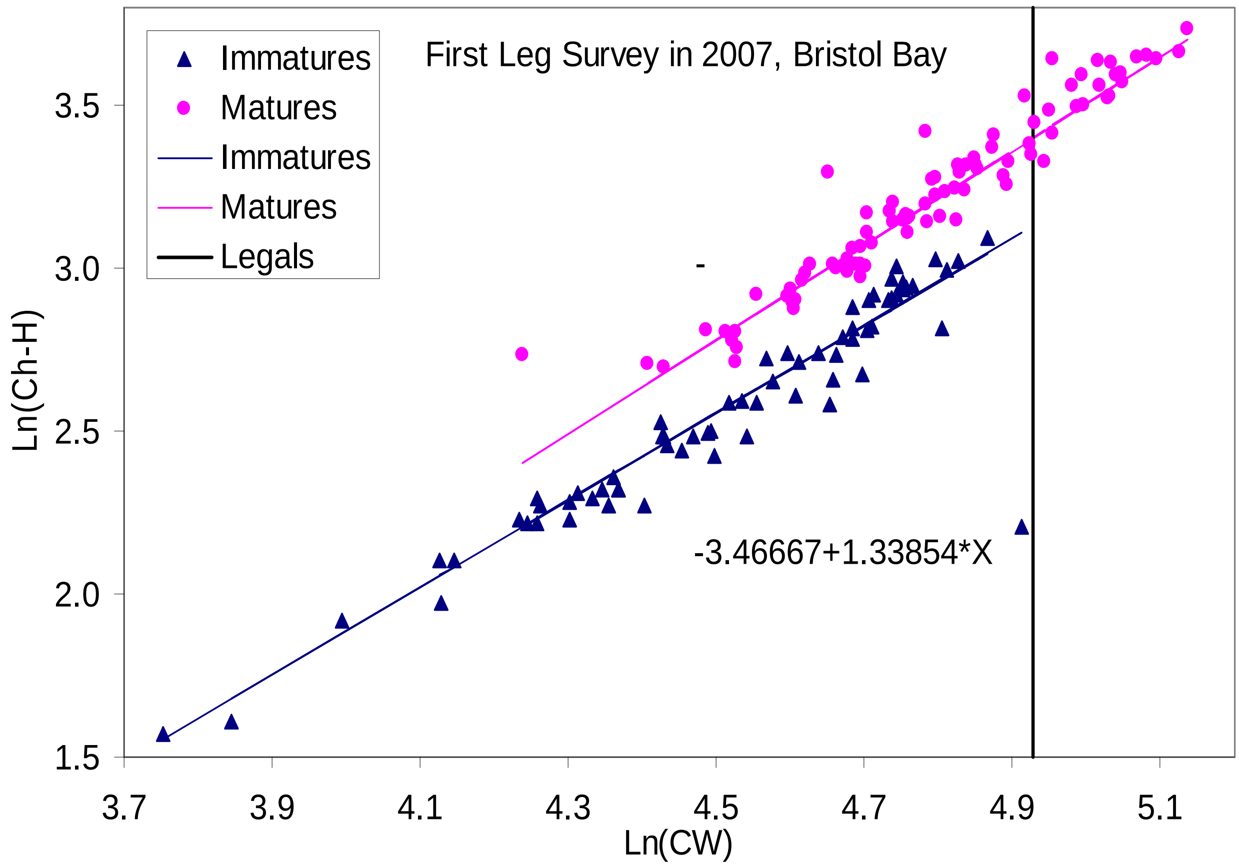
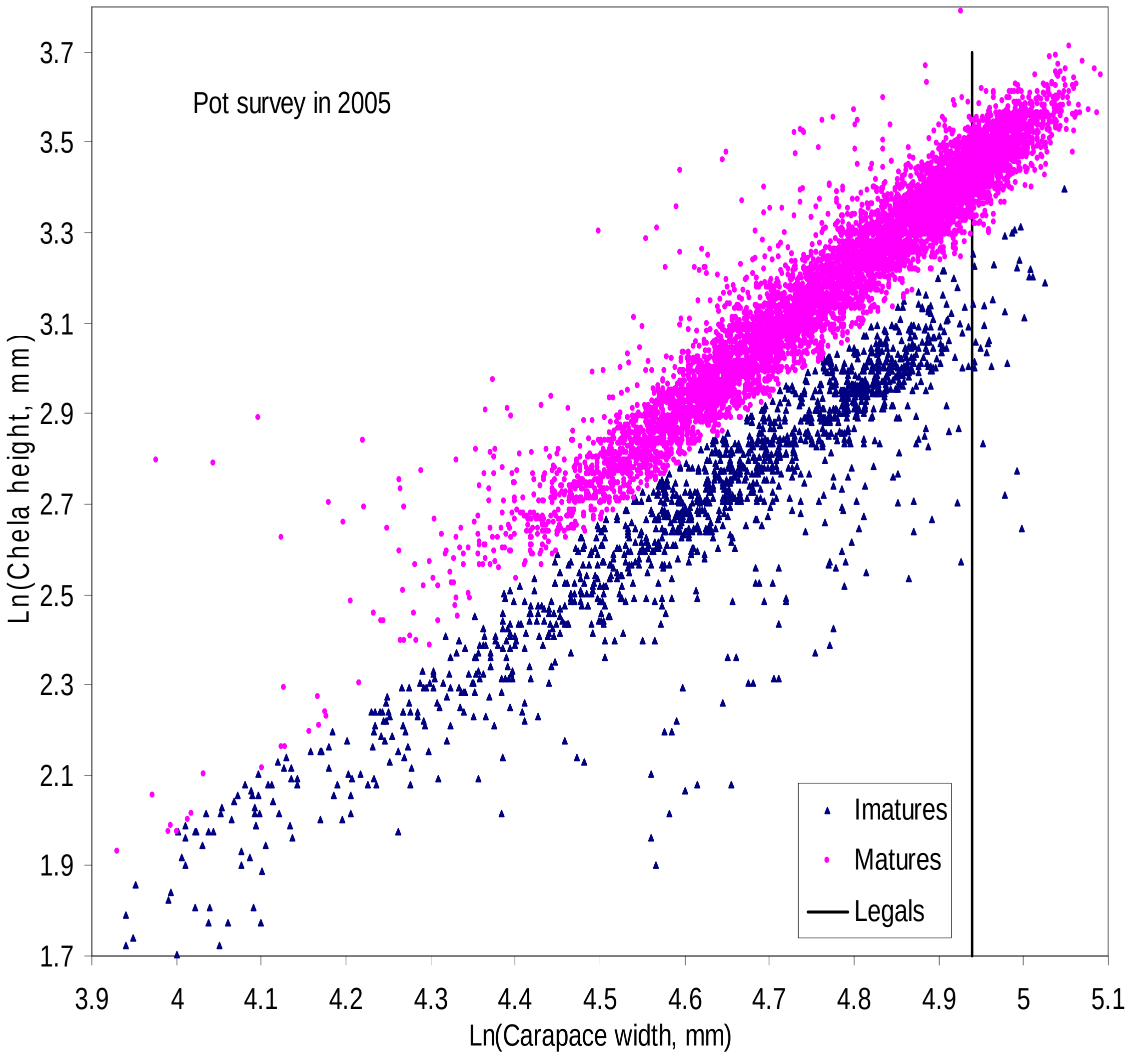
FIGURES



Note: The current minimum size limit, 138 mm CW (not including spines), corresponds with 4.93 on the log-transformed scale (vertical line); the log-transform of 125 mm and 100 mm are 4.83 and 4.61, respectively.

Figure 1a.–Log-transformed chela height (Ch-H) and carapace width (CW; mm, not including spines) from male Tanner crab captured during the 2007 NMFS bottom trawl survey in the Bristol Bay area (data collected by Joel Webb, ADF&G) showing the distinction between morphometrically mature ("large-clawed"; upper line) and immature ("small-clawed; lower line) males.



Note: The current minimum size limit, 138 mm CW (not including spines), corresponds with 4.93 on the log-transformed scale (vertical line); the log-transform of 125 mm and 100 mm are 4.83 and 4.61, respectively.

Figure 1b.–Log-transformed chela height and carapace width (not including spines) from male Tanner crab collected during the 2005 ADF&G king crab pot survey of the Pribilof Islands area showing the distinction between morphometrically mature ("large-clawed") and immature ("small-clawed") males.

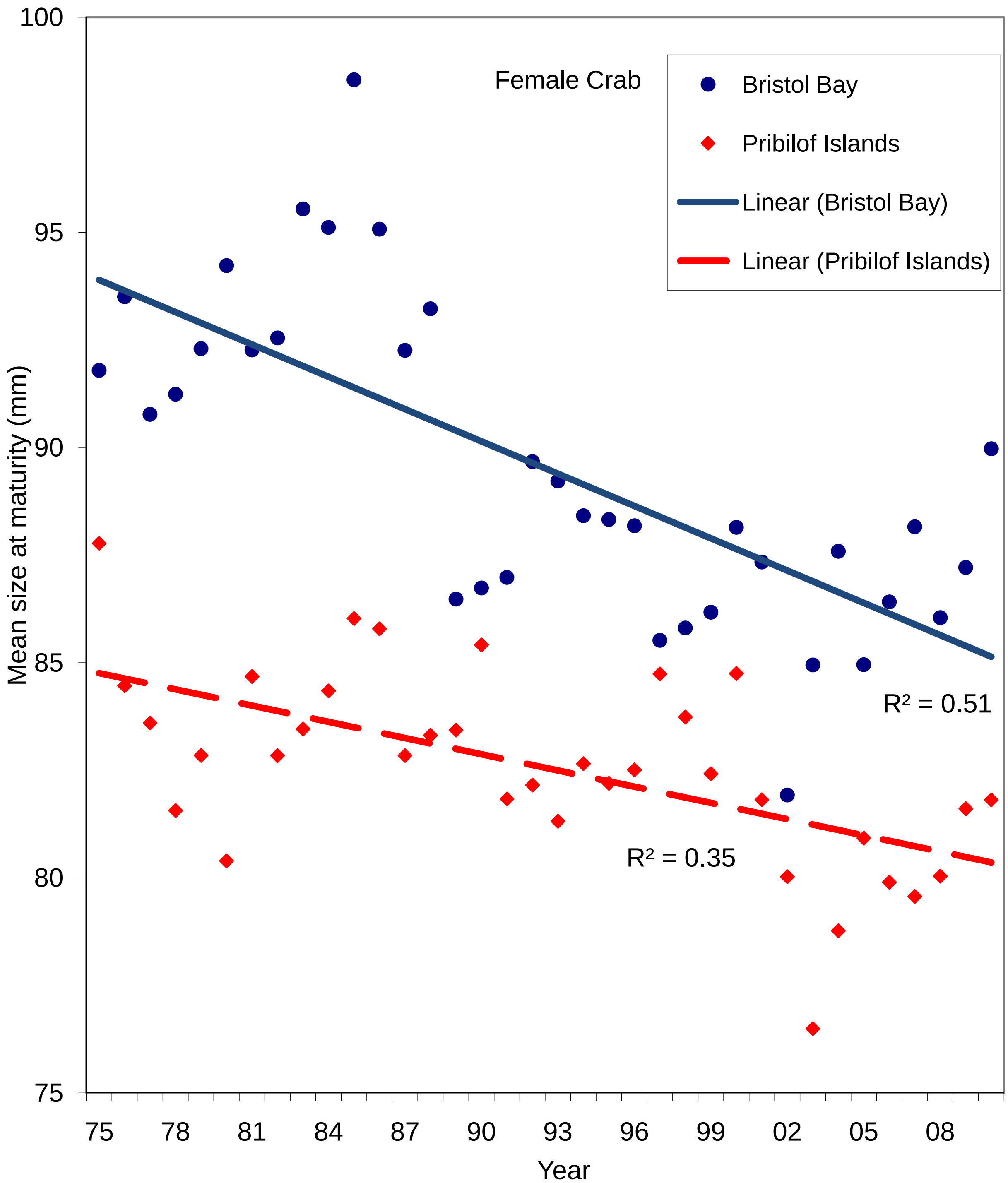


Figure 2.–Female Tanner crab mean sizes at maturity from 1975 to 2010 in the Bristol Bay and Pribilof Islands areas.

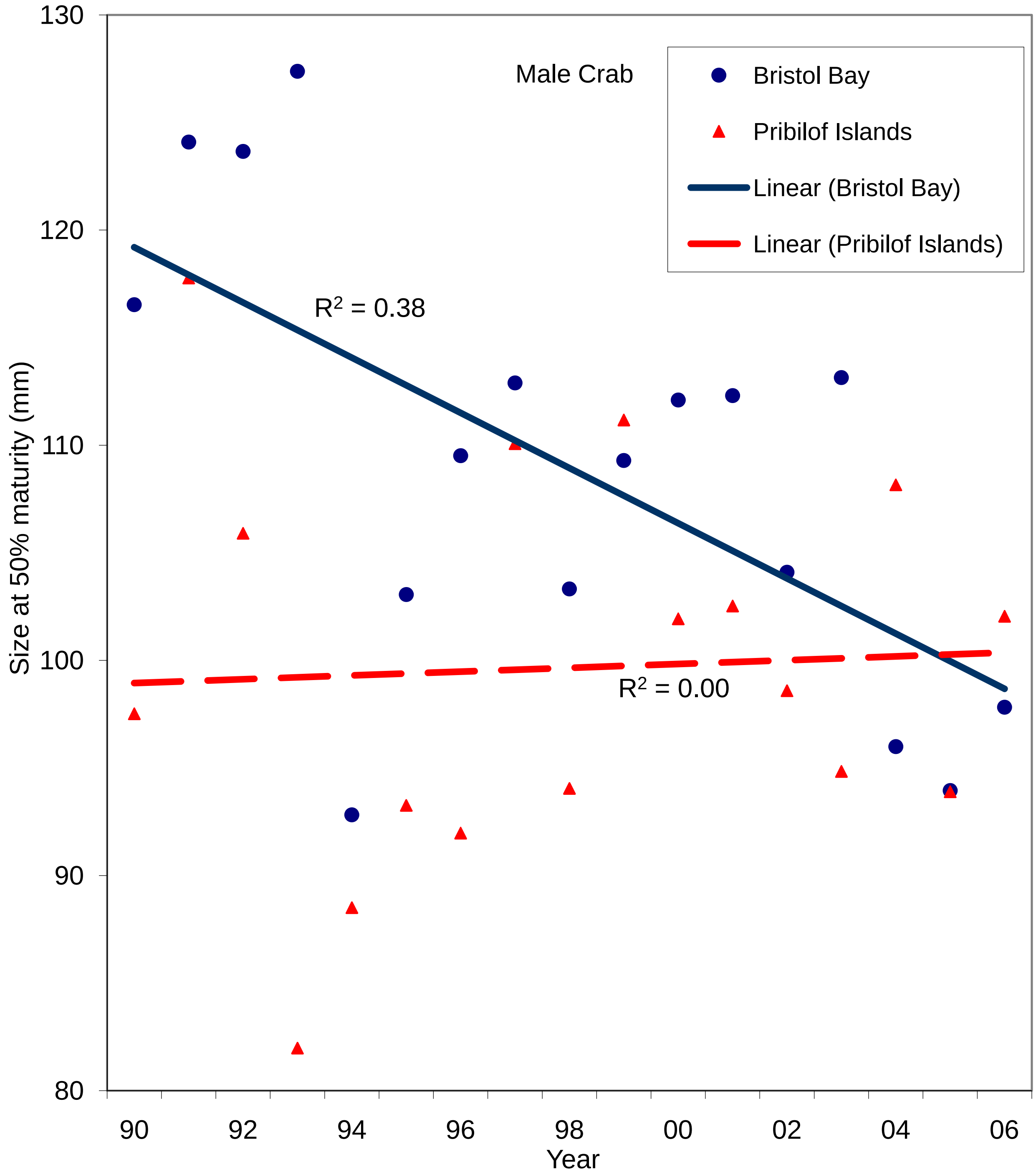


Figure 3.–Male Tanner crab sizes at 50% maturity from 1990 to 2006 in the Bristol Bay and Pribilof Islands areas.

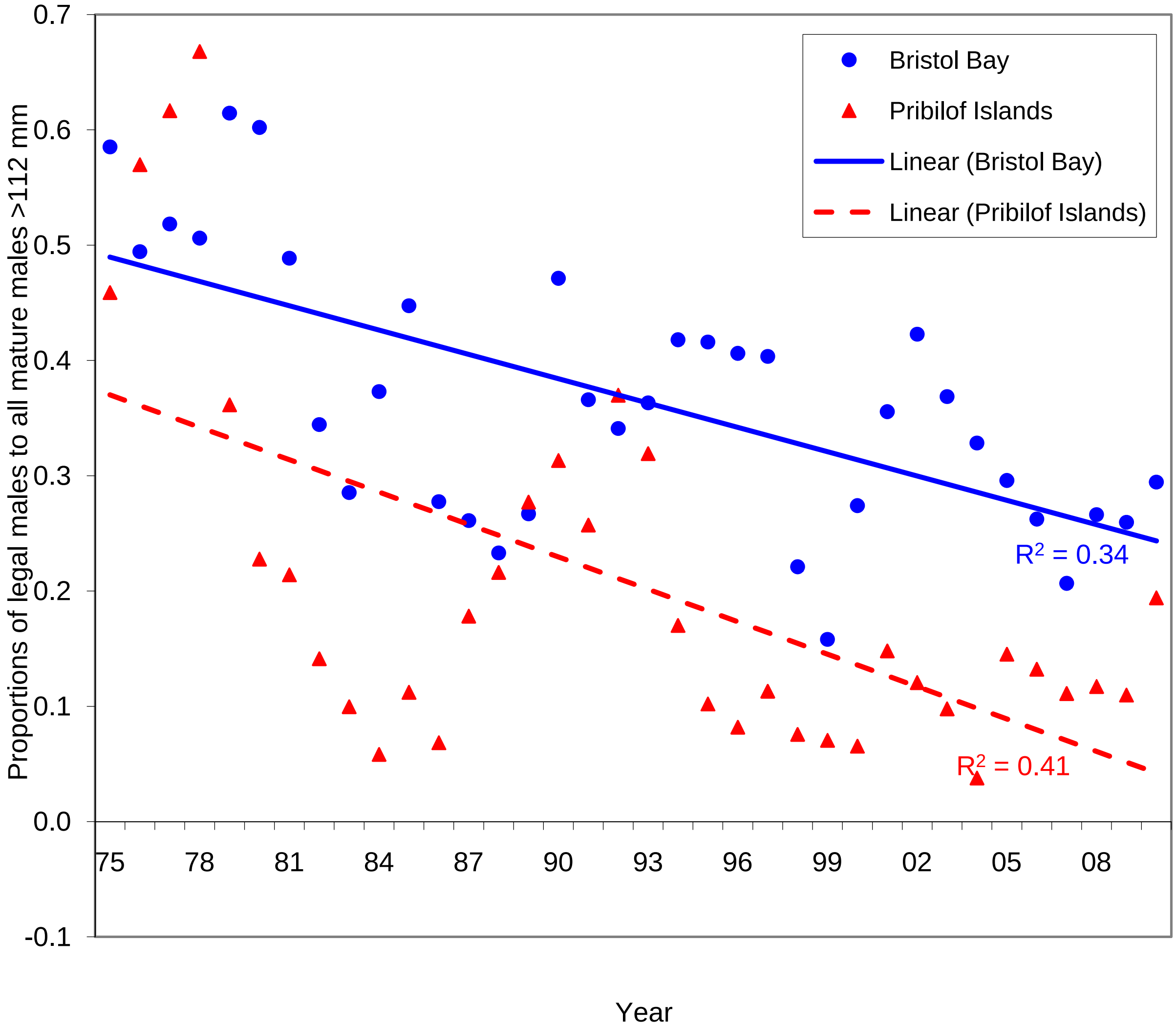


Figure 4.–Ratios of legal male abundance (>137 mm carapace width, not including spines) to mature-sized male abundance (>112 mm carapace width for Tanner crab in the Bristol Bay and the Pribilof Islands areas, 1975–2010.

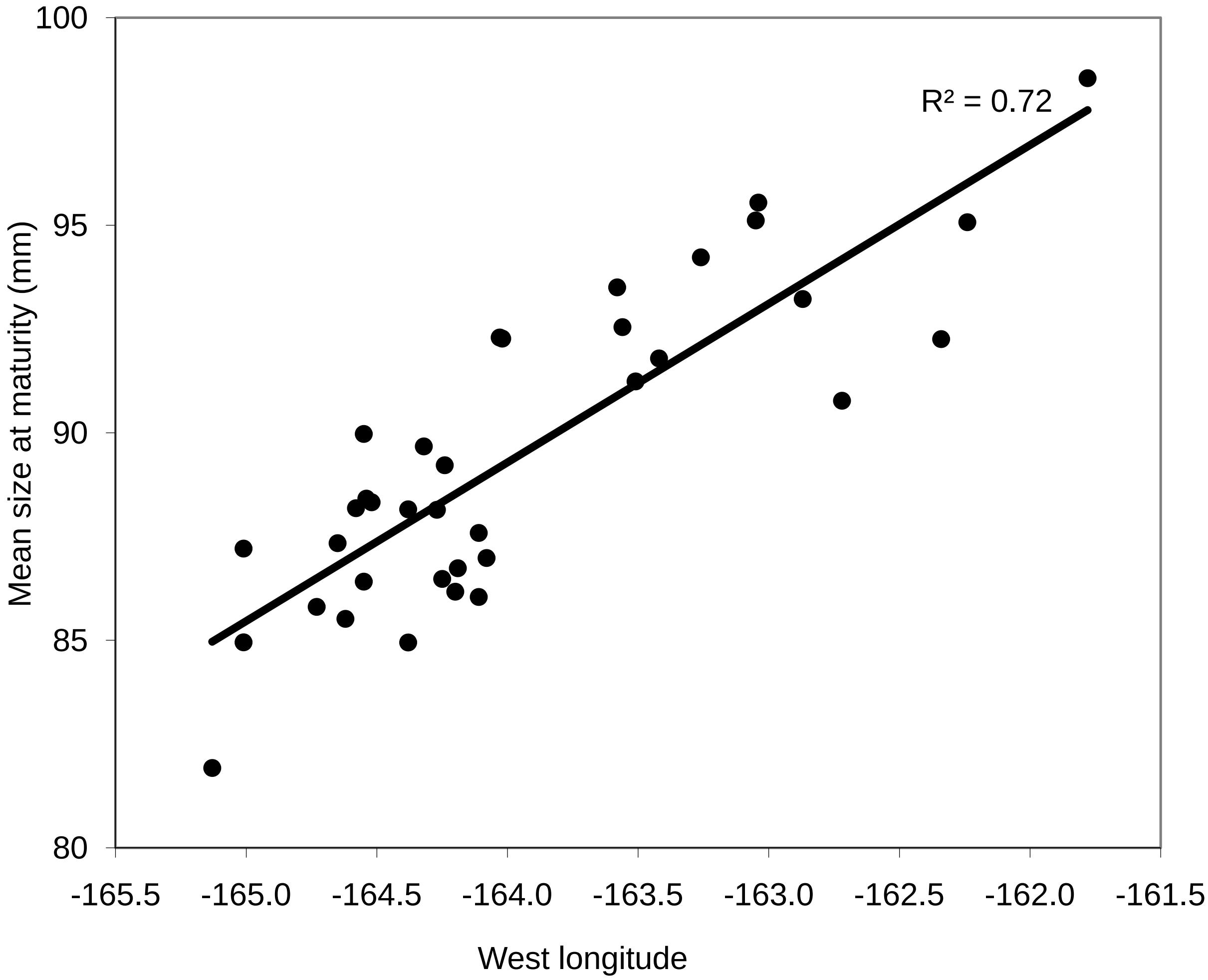


Figure 5.–Relationship between mean size (carapace width, mm) of mature females and longitude for Tanner crab in the Bristol Bay area, 1975–2010.

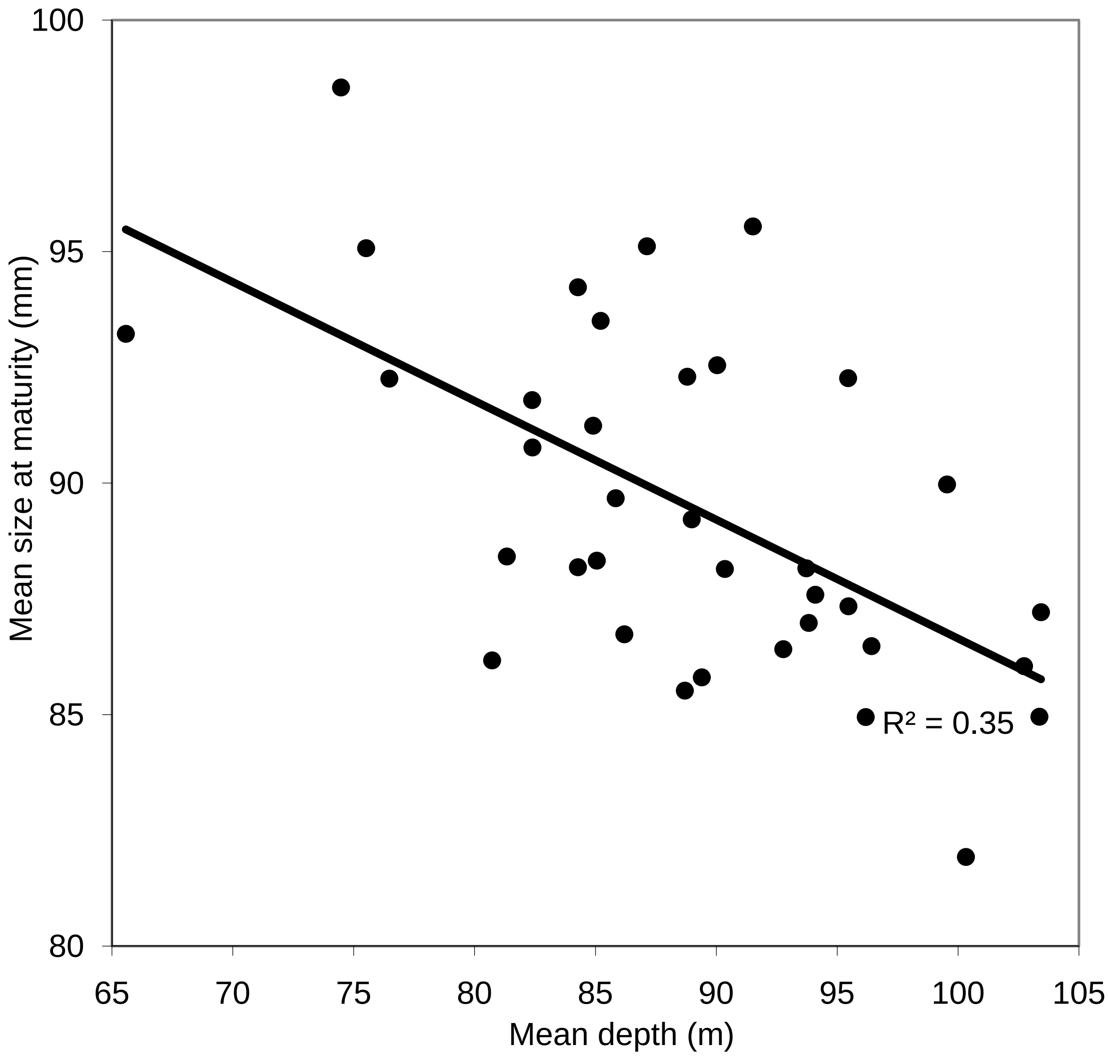
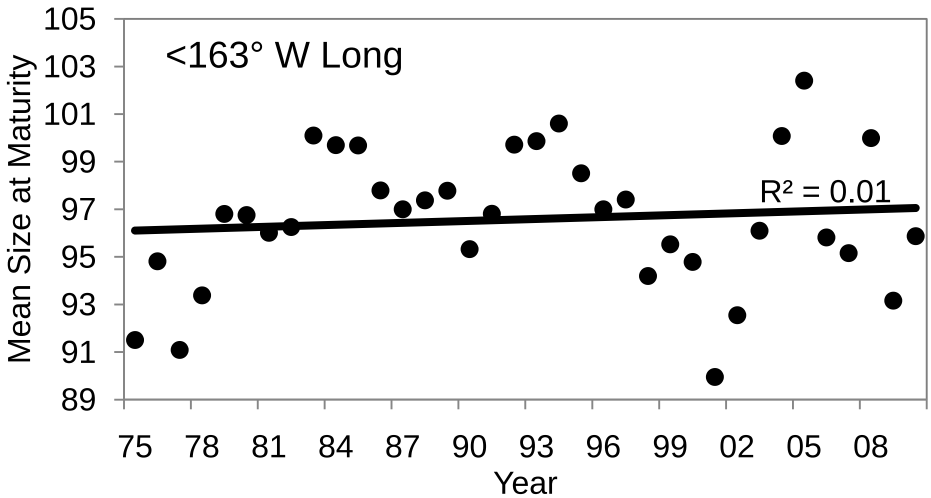
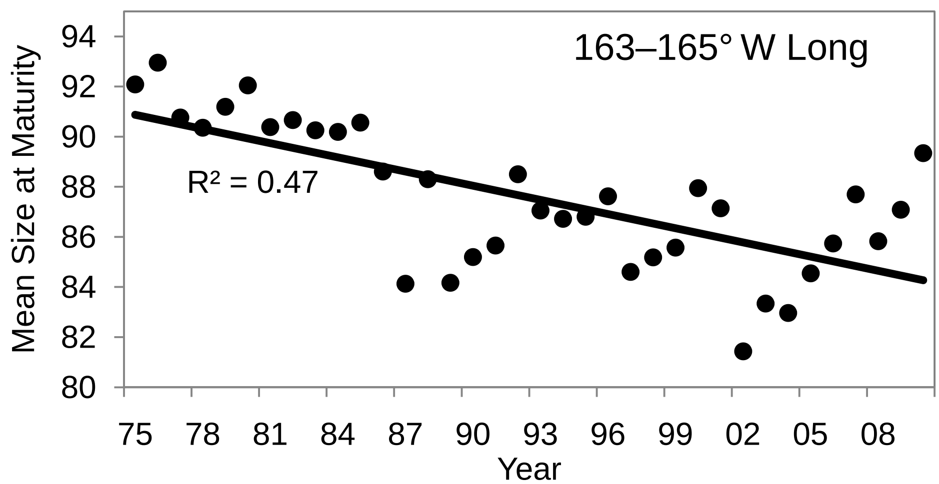


Figure 6.–Relationship between mean size (carapace width, mm) of mature females and mean depth for Tanner crab in the Bristol Bay area, 1975–2010.





Note: Changes in size at maturity over time are not significantly different for areas east of 163° W long, and west of 168° W long, and significantly different for areas between 163–168° W long.

Figure 7.–Mean sizes (carapace width, mm) at maturity for female Tanner crab during 1975–2010 shown for swaths of three degrees of longitude in each graph.

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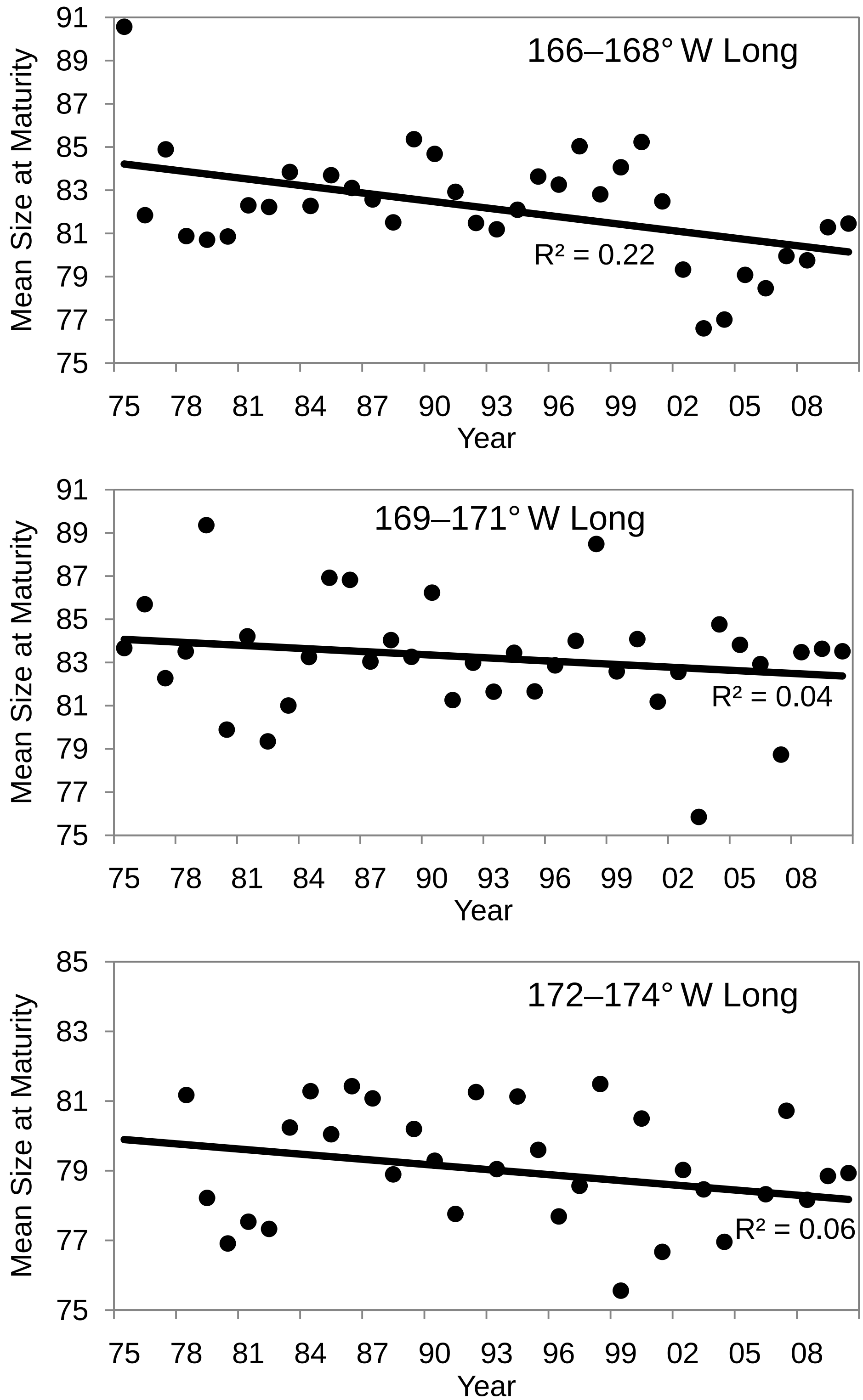


Figure 7.–Page 2 of 2.

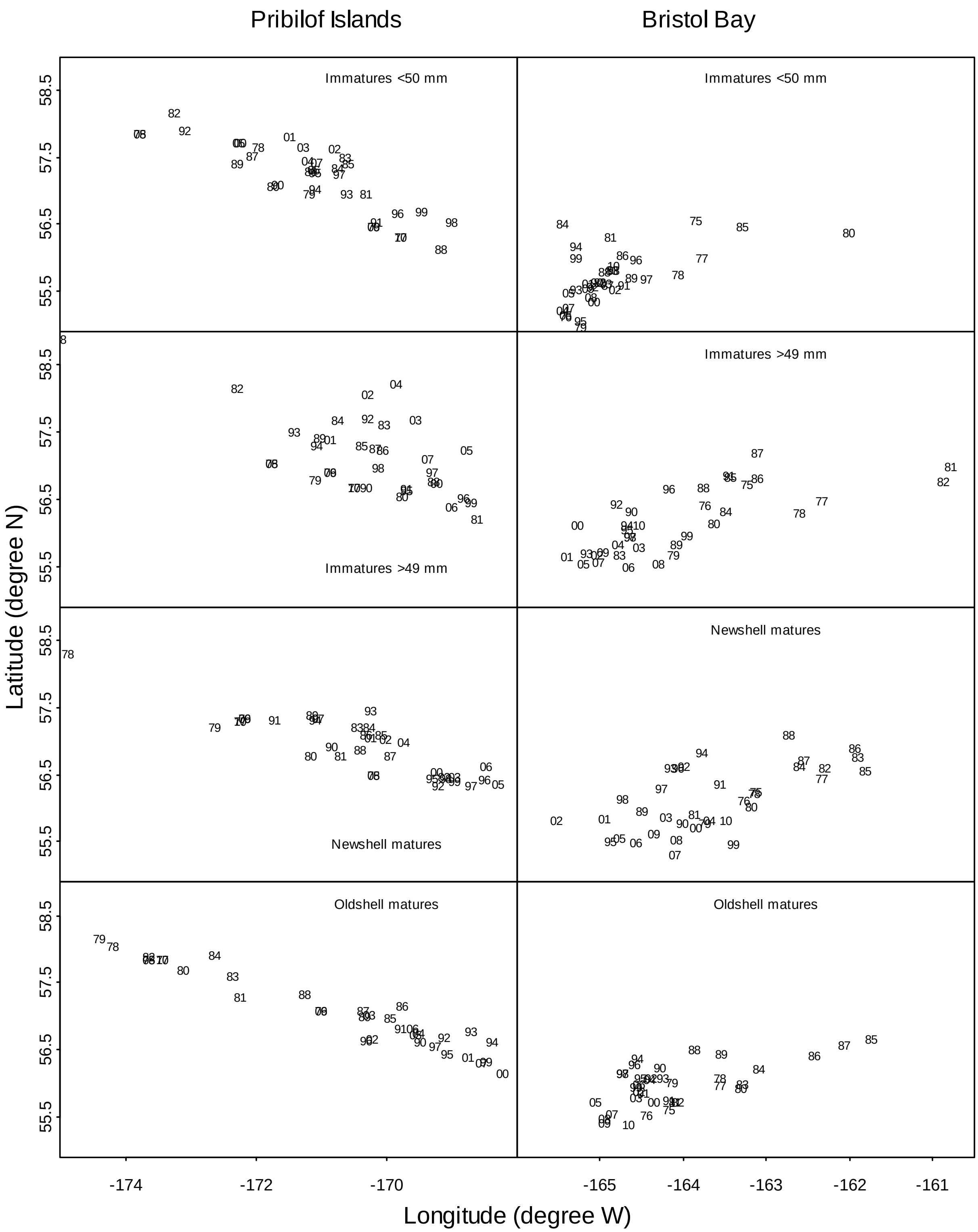
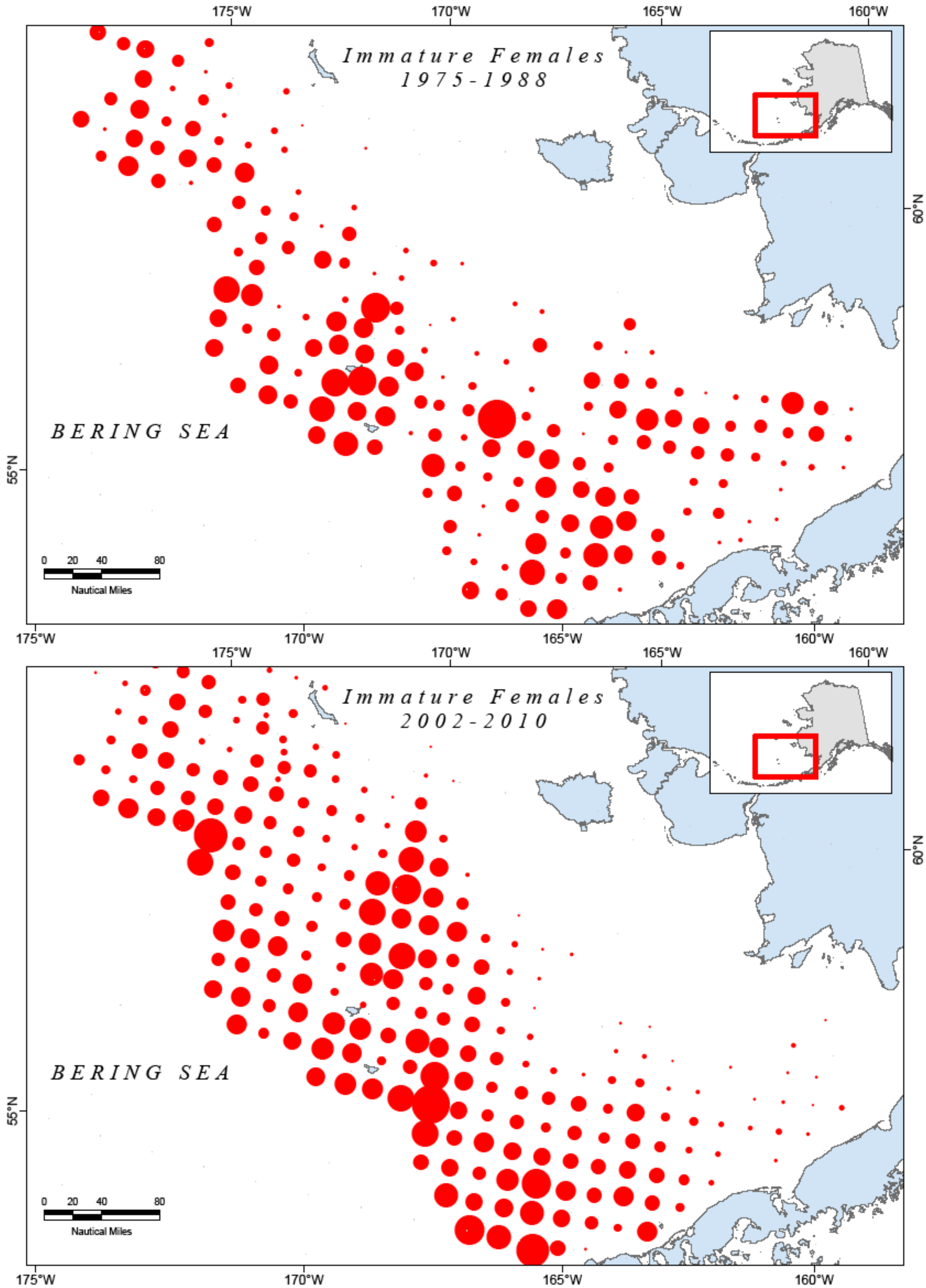
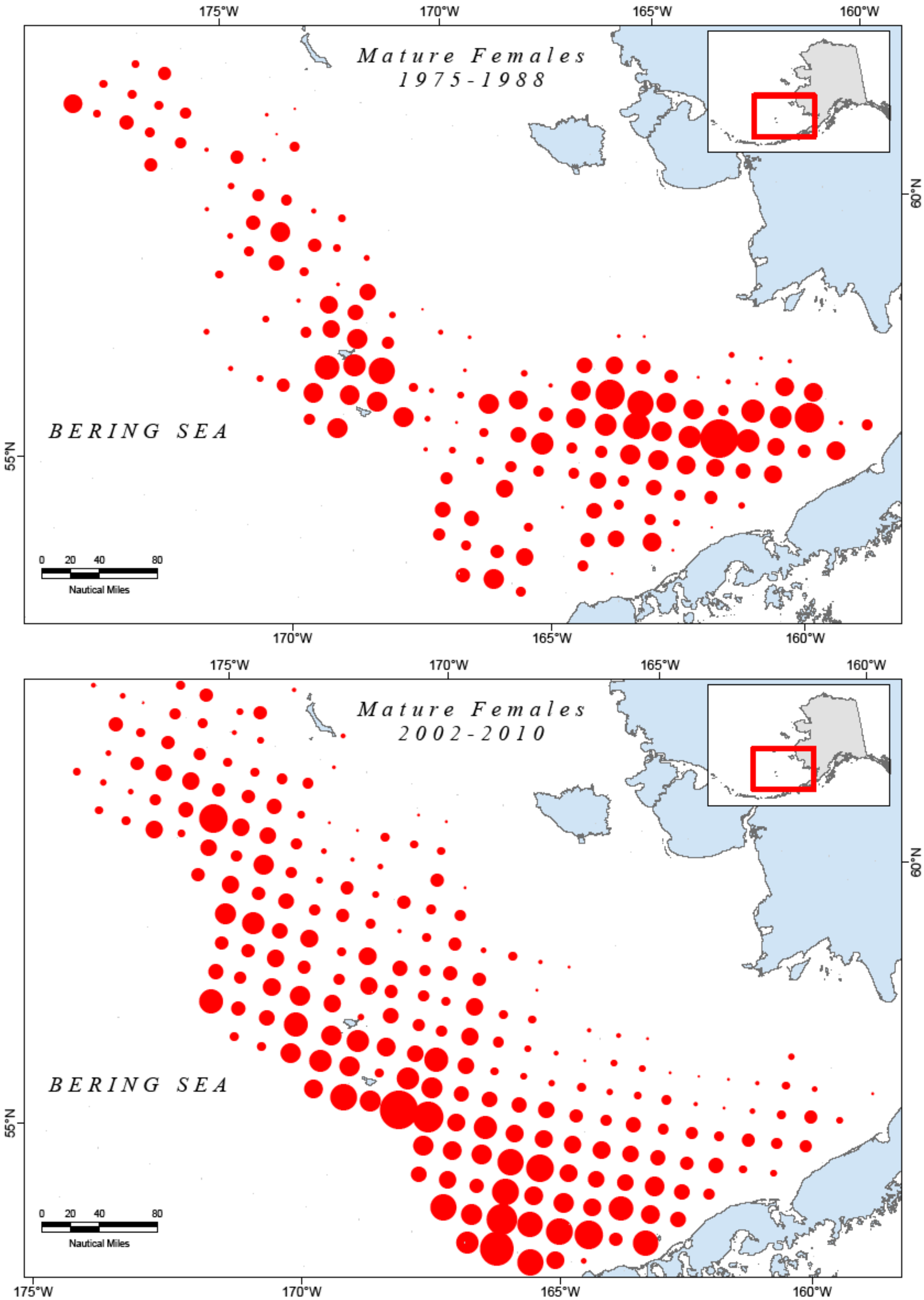


Figure 8.–Centers of distribution of eastern Bering Sea female Tanner crab derived from NMFS summer trawl survey data from 1975 to 2010.



Note: The size of dots represents relative crab abundance.

Figure 9a.–Distributions of immature female Tanner crab during 1975–1988 and 2002–2010, based on NMFS summer trawl survey data.



Note: The size of dots represents relative crab abundance.

Figure 9b.–Distributions of mature female Tanner crab during 1975–1988 and 2002–2010, based on NMFS summer trawl survey data.

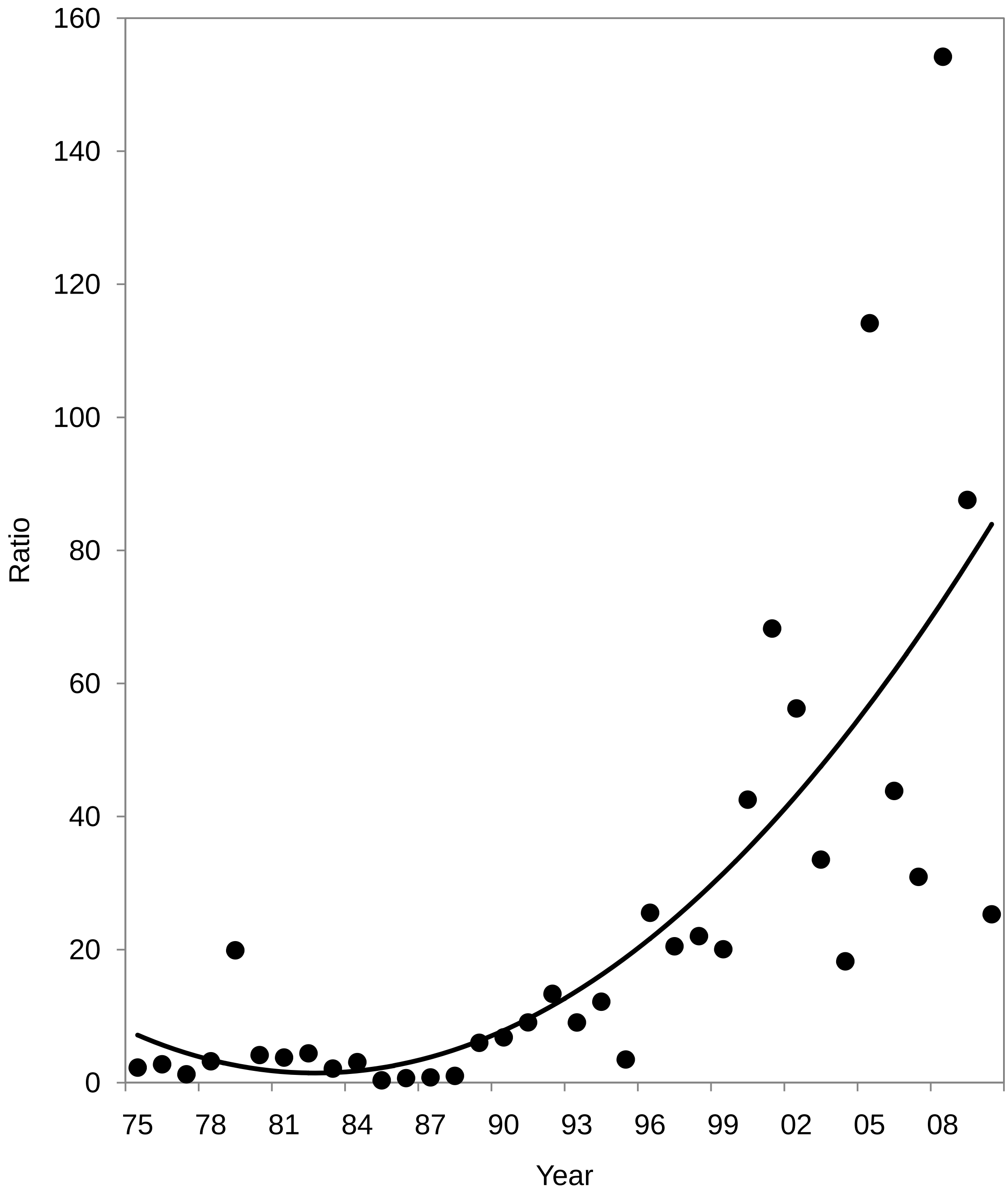
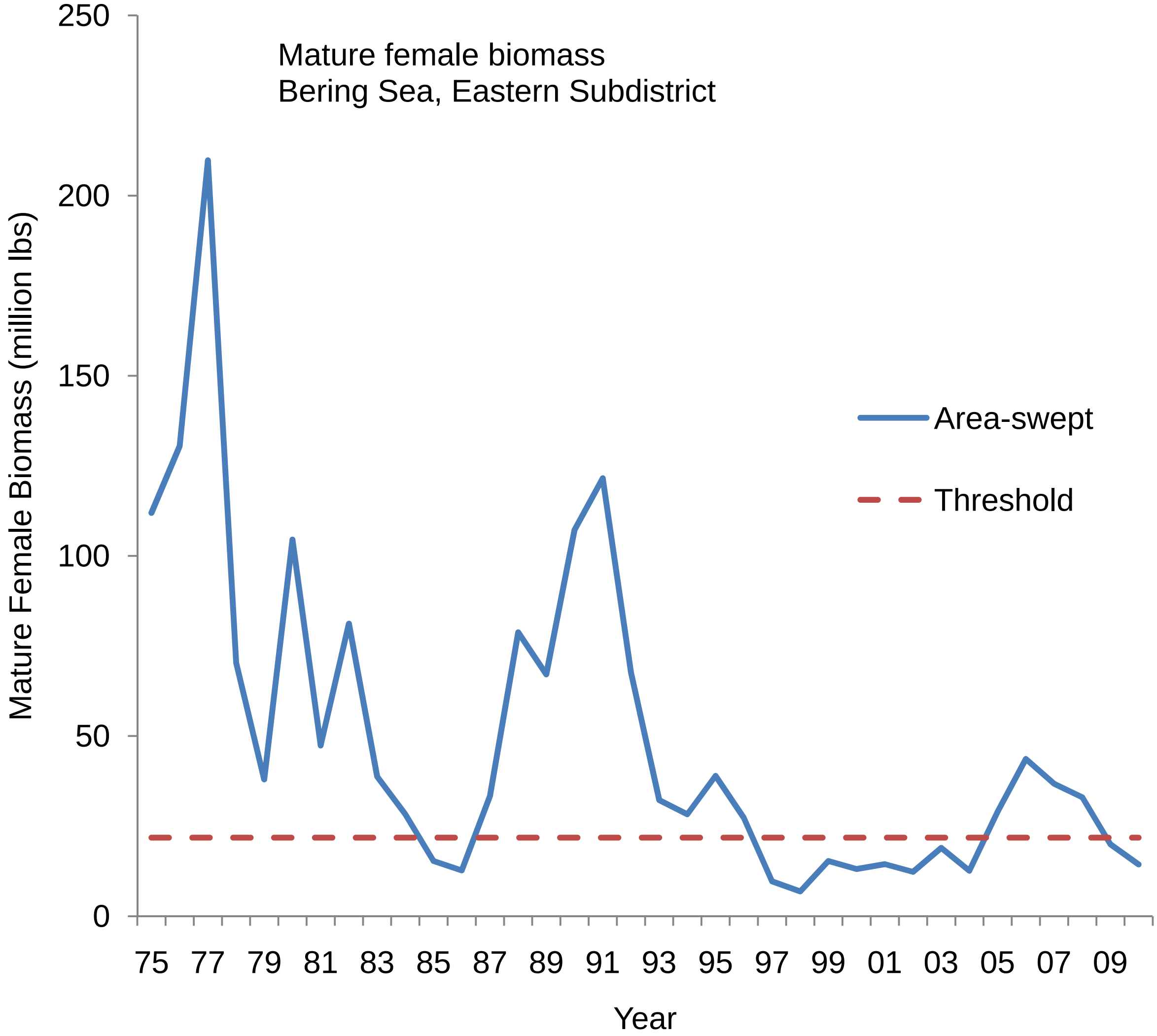
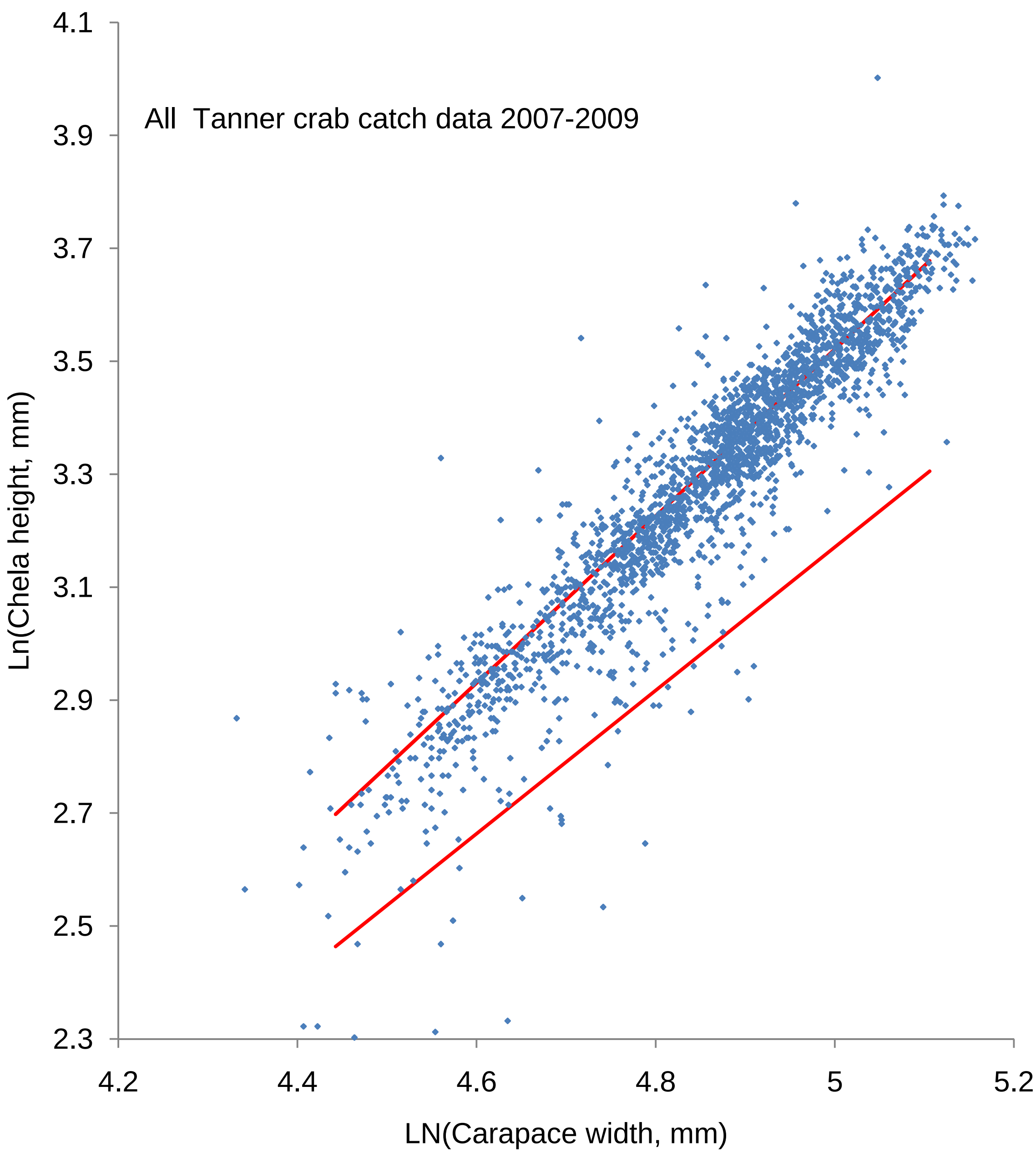


Figure 10.–Ratios of mature female abundance in 163–168° W long to those east of 163° W long.



Note: The threshold is 40% of the long-term average value.

Figure 11.–Mature female Tanner crab biomass in the Bering Sea Eastern Subdistrict from 1975 to 2010 from area-swept estimates.



Note: The current minimum size limit, 138 mm CW (not including spines), corresponds with 4.93 on the log-transformed scale; the log-transform of 125 mm and 100 mm are 4.83 and 4.61, respectively.

Figure 12.–Log-transformed chela height and carapace width (not including spines) from male Tanner crab captured during the Bering Sea Tanner crab fishery during 2007–2009 (data collected by observers from crab captured in randomly sampled pot lifts), with the predictive lines for the chela height–carapace width relationship in morphometrically mature ("large-clawed", upper line) and immature ("small-clawed", lower line) males.