2013 Stock Assessment and Fishery Evaluation Report for the Pribilof Islands Blue King Crab Fisheries of the Bering Sea and Aleutian Islands Regions

R.J. Foy
Alaska Fisheries Science Center
National Marine Fisheries Service, NOAA

Executive Summary

1. Stock: Pribilof Islands blue king crab, *Paralithodes platypus*
2. Catches: Retained catches have not occurred since 1998/1999. Bycatch and discards have been steady or decreased in recent years although a change in calculation methodology led to an increase in 2011/2012 to 0.36 t (0.0008 million lbs) and another change in calculation methodology led to an additional increase in 2012/2013.
3. Stock biomass: Stock biomass in recent years decreased between the 1995 and 2008 surveys, and continues to fluctuate with a decrease in all size classes in 2013 noting the lack of significance in any short term trends due to high uncertainty.
4. Recruitment: Recruitment indices are not well understood for Pribilof blue king crab. Pre-recruit have remained consistently low in the past 10 years although may not be well assessed with the survey.
5. Management performance:

Year	MSST	Biomass (MMB_{mating})	TAC	Retained Catch	Total Catch	OFL	ABC
2010/11	2,105 (4.64)	286 [A] (0.63)	0	0	0.18 (0.0004)	1.81 (0.004)	
2011/12	2,247 (4.95)	365 [B*] (0.80)	0	0	0.36 (0.0008)	1.16 (0.003)	1.04 (0.002)
2012/13	1,994 (4.39)	579 [C**] (1.28)	0	0	0.61 (0.0013)	1.16 (0.003)	1.04 (0.002)
2013/14		278 [D**] (0.61)				1.16 (0.003)	1.04 (0.002)

All units are tons (million pounds) of crabs and the OFL is a total catch OFL for each year. The stock was below MSST in 2012/2013 and is hence overfished. Overfishing did not occur during the 2012/2013 fishing year.

Notes:
A – Based on survey data available to the Crab Plan Team in September 2010 and updated with 2010/2011 catches
B – Based on survey data available to the Crab Plan Team in September 2011 and updated with 2011/2012 catches
C – Based on survey data available to the Crab Plan Team in September 2012 and updated with 2012/2013 catches
D – Based on survey data available to the Crab Plan Team in September 2013
* – 2011/12 estimates based on 3 year running average
** – estimates based on weighted 3 year running average using inverse variance

6. Basis for 2013/2014 OFL projection:

Year	Tier	B_{MSY}	Current MMB_{mating}	B/B_{MSY} (MMB_{mating})	γ	Years to define B_{MSY}	Natural Mortality	P*
		t (10^6 lbs)	t (10^6 lbs)				yr^{-1}	
20013/14	4c	3,988 (8.79)	278 (0.61)	0.07	1.0	1980/81-1984-85 & 1990/91-1978/79	0.18	10% buffer

7. The OFL was set based on the existing control if the slope of the rule were to continue to 0 applied to the total catch. Previously a Tier 5 calculation of average catch mortalities between 1999/2000 and 2005/2006 was done to adequately reflect the conservation needs with this stock and to acknowledge the existing non-directed catch mortality.
8. The ABC_{max} was calculated using a 10% buffer similar to that of the Tier 5 ABC control rule. The ABC_{max} was thus estimated to be 1.04 t.
9. Rebuilding analyses results summary: Proposed Crab FMP and regulatory amendments were submitted for review by the Secretary in early 2013 since NMFS determined that the stock was not rebuilding in a timely manner and would not meet the rebuilding horizon of 2014.

Summary of Major Changes:

1. Management: There were no major changes to the 2012/2013 management of the fishery.
2. Input data: The crab fishery retained and discard catch time series were updated with 2012/2013 data. A new methodology for estimating discard catch was used for 2009/10-2012/13 replacing the previous estimates.
3. Assessment methodology: The survey biomass time series was calculated with the new area definition including an additional 20 nm strip towards the east of the Pribilof Islands District. MMB was estimated with an average centered on the current year and weighted by the inverse variance.
4. Assessment results: The projected MMB decreased substantially in this assessment and remained below the MSST. Therefore, the OFL remained low with no directed fishery. Total catch mortality in 2012/2013 was 0.61 t.

Responses to SSC and CPT Comments

<u>SSC comments October 2012:</u>

Specific remarks pertinent to this assessment

The SSC supports the CPT and author's recommendation for management of Pribilof Islands blue king crab under Tier 4c. Following the advice of the CPT, the SSC recommends a Tier 5 calculation of average catch mortalities between 1999/2000 and 2005/2006, resulting in a total catch OFL of 0.00116 kt. Similarly, the SSC supports using a 10 percent buffer for the ABC calculation, resulting in an ABCmax of 0.00104 kt. The Pribilof blue king crab stock is overfished, however overfishing did not occur during the 2011/2012 season.

The MSY stock size (BMSY) is based on mature male biomass at mating (MMBmating) which serves as an approximation for egg production. For 2011/2012, BMSYprox = 3.94 kt of MMBmating derived as the mean MMB from 1980 to 1984 and 1990 to 1997. The stock demonstrated highly variable levels of MMB during both of these periods likely leading to uncertain approximations of BMSY.
Retained catches for Pribilof Island blue king crab have not occurred since 1998/1999. Bycatch and discards have been steady or decreased in recent years, although a change in calculation

methodology led to an increase in 2011/12. Stock biomass decreased between the 1995 and 2008 surveys and continues to fluctuate with no significant change estimated for recent years due to the high uncertainty in estimates. Based on September 2011 CPT and SSC comments, biomass estimates are now based on a 3-year weighted average, centered on the current year and weighted by the inverse of the variance.
A revised rebuilding plan was approved by the Council in June 2012 and will soon go through final review by the Secretary of Commerce. The revised rebuilding plan closes the Pribilof Habitat Conservation Zone to Pacific cod pot fishing.

Responses to SSC Comments: None.

SSC comments June 2013:

Specific remarks pertinent to this assessment

none

CPT comments September 2012:

Specific remarks pertinent to this assessment

The stock assessment author and the CPT recommend an OFL calculation using average catch from the status quo time series. The author presented an alternative method using biomass estimates for calculating the OFL. Neither the CPT nor the author recommended using this approach given the high uncertainty surrounding this stock and the already low OFL. Uncertainty in biomass estimates could lead to an ABC of 0 and could have large management repercussions. Biologically this stock is not responsive to management measures given an already low OFL. The current method has been used since 2008 based on average catch. Before considering alternative approaches, the CPT would like to see historical groundfish bycatch data from the catch in areas database in order to more accurately assess historical catch.

Responses to CPT Comments: Now that a new bycatch estimation procedure exists for 2009-2012 based on State of Alaska stat areas the results of the catch and areas database are no longer being used.

CPT comments May 2013:

Specific remarks pertinent to this assessment

none

Introduction

1. **Blue king crabs,** *Paralithodes platypus*

2. **Distribution -** Blue king crab are anomurans in the family Lithodidae which also includes the red king crab (*Paralithodes camtschaticus*) and golden or brown king crab (*Lithodes aequispinus*) in Alaska. Blue king crabs occur off Hokkaido in Japan, with disjunct populations occurring in the Sea of Okhotsk and along the Siberian coast to the Bering Straits. In North America, they are known from the Diomede Islands, Point Hope, outer Kotzebue Sound, King Island, and the outer parts of Norton Sound. In the remainder of the Bering Sea, they are found in the waters off St. Matthew Island and the Pribilof Islands. In more southerly areas as far as southeastern Alaska in the Gulf of Alaska, blue king crabs are found in widely-separated populations that are frequently associated with fjord-like bays (Figure 1). This disjunct, insular distribution of blue king crab relative to the similar but more broadly distributed red king crab is likely the result of post-glacial period increases in water temperature that have limited the distribution of this cold-water adapted species (Somerton 1985). Factors that may be directly responsible for limiting the distribution include the physiological requirements for reproduction, competition with the more warm-water

adapted red king crab, exclusion by warm-water predators, or habitat requirements for settlement of larvae (Somerton 1985; Armstrong et al 1985, 1987).

During the years when the fishery was active (1973-1989, 1995-1999), the Pribilof Islands blue king crab were managed under the Bering Sea king crab Registration Area Q Pribilof District, which has as its southern boundary a line from 54° 36' N lat., 168° W long., to 54° 36' N lat., 171° W long., to 55° 30' N lat., 171° W. long., to 55° 30' N lat., 173° 30' E long., as its northern boundary the latitude of Cape Newenham (58° 39' N lat.), as its eastern boundary a line from 54° 36' N lat., 168° W long., to 58° 39' N lat., 168° W long., to Cape Newenham (58° 39' N lat.), and as its western boundary the United States-Russia Maritime Boundary Line of 1991 (ADF&G 2008) (Figure 2). In the Pribilof District, blue king crab occupy the waters adjacent to and northeast of the Pribilof Islands (Armstrong et al. 1987).

3. **Stock structure** - Stock structure of blue king crabs in the North Pacific is largely unknown. To assess the potential relationship between blue king crab in the Pribilof Islands and St. Matthew, the author consulted the AFSC report entitled "Guidelines for determination of spatial management units for exploited populations in Alaskan groundfish fishery management plans" by Spencer (personal communication). Per this document, aspects of blue king crab harvest and abundance trends, phenotypic characteristics, behavior, movement, and genetics will be considered. Is was also, noted that ~200 samples were collected in 2009-2011 to support a genetic study on blue king crab population structure by a graduate student at the University of Alaska.

   To address the potential for species interactions between blue king crab and red king crab as a potential reason for PIBKC shifts in abundance and distribution, we compared the spatial extent of both speices in the Pribilof Islands from 1975 to 2009 (Figure 1). In the early 1980's when red king crab first became abundant, blue king crab males and females dominated the 1 to 7 stations where the species co-occurred in the Pribilof Islands District (Figure 1A). Spatially, the stations with co-occurance were all dominated by blue king crab and broadly distributed around the Pribilof Islands (Figure A). In the 1990's the red king crab population biomass increased substantially as the blue king crab population biomass decreased. During this time period, the number of stations with co-occurance remained around a max of 8 but they were equally dominated by both blue king crab ands red king crab sugggesting a direct overlap in distribution at the scale of a survey station (Figure 1A). Spatially during this time period, the red king crab dominated stations were dispersed around the Pribilof Islands (Figure B). Between 2001 and 2009 the blue king crab population has decreased dramatically while the red king crab have fluctuated (Figure 1B). Interstingly, the number of stations dominated by blue king crab is similar to those dominated by red king crab for both males and females suggesting continued competition for similar habitat (Figure 1A). Spatially the only stations dominated by blue king crab exist to the north and east of St. Paul Island (Figure C). It is noted that although the blue king crab protection measures also afford protection for the red king crab in this region, the red king crab stocks continue to fluctuate even considering the uncertainty in the survey.

4. **Life History** - Blue king crab are similar in size and appearance, except for color, to the more widespread red king crab, but are typically biennial spawners with lesser fecundity and somewhat larger sized (*ca.* 1.2 mm) eggs (Somerton and Macintosh 1983; 1985; Jensen et al. 1985; Jensen and Armstrong 1989; Selin and Fedotov 1996). Red king crab are annual spawners with relatively higher fecundity and smaller sized (*ca.* 1.0 mm) eggs. Blue king crab fecundity increases with size, from approximately 100,000 embryos for a 100-110 mm CL female to approximately 200,000 for a female >140-mm CL (Somerton and MacIntosh 1985). Blue king crab have a biennial ovarian cycle with embryos developing over a 12 or 13-month period depending on

whether or not the female is primiparous or multiparous, respectively (Stevens 2006a). Armstrong et al. (1985, 1987), however, estimated the embryonic period for Pribilof blue king crab at 11-12 months, regardless of previous reproductive history and Somerton and MacIntosh (1985) placed development at 14-15 months. It may not be possible for large female blue king crabs to support the energy requirements for annual ovary development, growth, and egg extrusion due to limitations imposed by their habitat, such as poor quality or low abundance of food or reduced feeding activity due to cold water (Armstrong et al. 1987, Jensen and Armstrong 1989). Both the large size reached by Pribilof Islands blue king crab and the generally high productivity of the Pribilof area, however, argue against such environmental constraints. Development of the fertilized embryos occurs in the egg cases attached to the pleopods beneath the abdomen of the female crab and hatching occurs February through April (Stevens 2006b). After larvae are released, large female Pribilof blue king crab will molt, mate, and extrude their clutches the following year in late March through mid April (Armstrong et al. 1987).

Female crabs require an average of 29 days to release larvae, and release an average of 110,033 larvae (Stevens 2006b). Larvae are pelagic and pass through four zoeal larval stages which last about 10 days each, with length of time being dependent on temperature; the colder the temperature the slower the development and vice versa (Stevens et al 2008). Stage I zoeae must find food within 60 hours as starvation reduces their ability to capture prey (Paul and Paul 1980) and successfully molt. Zoeae consume phytoplankton, the diatom *Thalassiosira* spp. in particular, and zooplankton. The fifth larval stage is the non-feeding (Stevens et al. 2008) and transitional glaucothoe stage in which the larvae take on the shape of a small crab but retain the ability to swim by using their extended abdomen as a tail. This is the stage at which the larvae searches for appropriate settling substrate, and once finding it, molts to the first juvenile stage and henceforth remains benthic. The larval stage is estimated to last for 2.5 to 4 months and larvae metamorphose and settle during July through early September (Armstrong et al. 1987, Stevens et al. 2008).

Blue king crab molt frequently as juveniles, growing a few mm in size with each molt. Unlike red king crab juveniles, blue king crab juveniles are not known to form pods. Female king crabs typically reach sexual maturity at approximately five years of age while males may reach maturity one year later, at six years of age (NPFMC 2003). Female size at 50% maturity for Pribilof blue king crab is estimated at 96-mm carapace length (CL) and size at maturity for males, as estimated from size of chela relative to CL, is estimated at 108-mm CL (Somerton and MacIntosh 1983). Skip molting occurs with increasing probability for those males larger than 100 mm CL (NOAA 2005).

Longevity is unknown for the species, due to the absence of hard parts retained through molts with which to age crabs. Estimates of 20 to 30 years in age have been suggested (Blau 1997). Natural mortality for male Pribilof blue king crabs has been estimated at 0.34-0.94 with a mean of 0.79 (Otto and Cummiskey 1990) and a range of 0.16 to 0.35 for Pribilof and St. Matthew Island stocks combined (Zheng et al. 1997). An annual natural mortality of 0.2 for all king crab species was adopted in the federal crab fishery management plan for the BSAI areas (Siddeek et. al 2002).

5. **Management history -** The king crab fishery in the Pribilof District began in 1973 with a reported catch of 590 t by eight vessels (Figure 5). Landings increased during the 1970s and peaked at a harvest of 5,000 t in the 1980/81 season with an associated increase in effort to 110 vessels (ADF&G 2008). Following 1995, declines in the stock resulted in a closure from 1999 to present. The Pribilof blue king crab stock was declared overfished in September of 2002 and the Alaska Department of Fish and Game developed a rebuilding harvest strategy as part of the North

Pacific Fishery Management Council's (NPFMC) comprehensive rebuilding plan for the stock. The fishery occurred September through January, but usually lasted less than 6 weeks (Otto and Cummiskey 1990, ADF&G 2008). The fishery was male only, and legal size was >16.5 cm carapace width (NOAA 1995). Guideline harvest level (GHL) was 10 percent of the abundance of mature male or 20 percent of the number of legal males (ADF&G 2006).

Amendment 21a to the BSAI groundfish FMP established the Pribilof Islands Habitat Conservation Area (Figure 6) which prohibits the use of trawl gear in a specified area around the Pribilof Islands year round (NPFMC 1994). The amendment went into effect January 20, 1995 and protects the majority of crab habitat in the Pribilof Islands area from impacts from trawl gear.

Blue king crab in the Pribilof District can occur as bycatch in the following crab fisheries: the eastern Bering Sea snow crab (*Chionoecetes opilio*), the eastern Bering Sea Tanner crab (*Chionoecetes bairdi*), the Bering Sea hair crab (*Erimacrus isenbeckii*), and the Pribilof red and blue king crab. In addition, blue king crab are caught in flatfish, sablefish, halibut, pollock, and Pacific cod fisheries.

Data

1. The standard survey time series data including an additional 20 nm strip on the eastern portion of the Pribilof District was updated through 2013 and the updated groundfish discards time series data through 2012 were used in this assessment. The crab fishery retained and discard catch time series was updated with 2012/2013 data.

2. a. Total catch:
   <u>Crab pot fisheries</u>
   Retained pot fishery catches (live and deadloss landings data) are provided for 1973/1974 to 2012/2013 (Table 1), including the 1973/1974 to 1987/1988 and 1995/1996 to 1998/1999 seasons when blue king crab were targeted in the Pribilof Islands District. In the 1995/1996 to 1998/1999 seasons blue king crab and red king crab were fished under the same GHL. There was no total allowable catch (TAC) and therefore zero retained catch in the 2012/2013 fishing season

   b. Bycatch and discards:
   <u>Crab pot fisheries</u>
   Non-retained (directed and non-directed) pot fishery catches are provided for sub-legal males (≤138 mm CL), legal males (>138 mm CL), and females based on data collected by onboard observers. Catch weight was calculated by first determining the mean weight (g) for crabs in each of three categories: legal non-retained, sublegal, and female. The average weight for each category was calculated from length frequency tables where the CL (mm) was converted to g using equation 1. Length to weight parameters were available for two time periods: 1973 to 2009 (males: A=0.000329, B=3.175; females: A=0.114389, B=1.9192) and 2010 to 2011 (males and females: A=0.000508, B=3.106). The average weight for each category was multiplied by the number of crabs at that CL, summed, and then divided by the total number of crabs (equation 2).

   $$\text{Weight (g)} = A * \text{CL(mm)}^{B} \quad (1)$$

   $$\text{Mean Weight (g)} = \sum(\text{weight at size} * \text{number at size}) / \sum(\text{crabs}) \quad (2)$$

   Finally, weights were the product of average weight, CPUE, and total pot lifts in the fishery. To assess crab mortalities in these pot fisheries a 50% handling mortality rate is applied to these estimates.

Historical non-retained catch data are available from 1996/1997 to present from the snow crab general, snow crab CDQ, and Tanner crab fisheries (Table 2, Bowers et al. 2011) although data may be incomplete for some of these fisheries. Prior to 1998, limited observer data exists for catcher-processor vessels only so non-retained catch before this date is not included here.

In 2012/2013, there were no Pribilof Islands blue king crab incidentally caught in crab fisheries (Table 2).

Groundfish pot, trawl, and hook and line fisheries

The 2012/2013 NOAA Fisheries Regional Office (J. Gasper, NMFS, personal communication) assessments of non-retained catch from all groundfish fisheries are included in this SAFE report. Groundfish catches of crab are reported for all crab combined by federal reporting areas and by State of Alaska reporting areas since 2009/2010. Catches from observed fisheries were applied to non-observed fisheries to estimate a total catch. Catch counts were converted to biomass by applying the average weight measured from observed tows from July 2011 to June 2012. Prior to this year for Pribilof Islands blue king crab, only Area 513 was included. It is noted that in these earlier years groundfish non-retained crab catches for Pribilof Islands blue king crab may exist in Area 521 (and other areas) but the large number of St. Mathew Section Northern District blue crab in Area 521 would overestimate the blue king crab caught in groundfish fisheries. In 2012/2013 these data were available in State of Alaska reporting areas that overlap specifically with stock boundaries so that the management unit for each stock can be more appropriately represented. To estimate sex ratios for 2012/2013 catches, it was assumed that the male to female ratio was one. To assess crab mortalities in these groundfish fisheries a 50% handling mortality rate was applied to pot and hook and line estimates and an 80% handling mortality rate was applied to trawl estimates.

Historical non-retained groundfish catch data are available from 1991/1992 to present (J. Mondragon, NMFS, personal communication) although sex ratios have not been discriminated by each year's survey proportions (Table 2). Prior to 1991data are only available in INPFC reports. Between 1991 and December 2001 bycatch was estimated using the "blend method". The blend process combined data from industry production reports and observer reports to make the best, comprehensive accounting of groundfish catch. For shoreside processors, Weekly Production Reports (WPR) submitted by industry were the best source of data for retained groundfish landings. All fish delivered to shoreside processors were weighed on scales, and these weights were used to account for retained catch. Observer data from catcher vessels provided the best data on at-sea discards of groundfish by vessels delivering to shoreside processors. Discard rates from these observer data were applied to the shoreside groundfish landings to estimate total at-sea discards from both observed and unobserved catcher vessels. For observed catcher/processors and motherships, the WPR and the Observer Reports recorded estimates of total catch (retained catch plus discards). If both reports were available, one of them was selected during the "blend" process for incorporation into the catch database. If the vessel was unobserved, only the WPR was available. From January 2003 to December 2007, a new database structure named the Catch Accounting System (CAS) led to large method change. Bycatch estimates were derived from a combination of observer and landing (catcher vessels/production data). Production data included CPs and catcher vessels delivering to motherships. To obtain fishery level estimates, CAS used a ratio estimator derived from observer data (counts of crab/kg groundfish) that is applied to production/landing information. (See http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-205.pdf). Estimates of crab are in numbers because the PSC is managed on numbers. There were two issues with this dataset that required estimation work outside of CAS:

1) The estimated number of crab had to be converted to weights. An average weight was

calculated using groundfish observer data. This weight was specific to crab year, crab species, and fixed or trawl gear. This average was applied to the estimated number of crab for crab year by federal reporting area.

2) In some situations, crab estimates were identified and grouped in the observed data to the genus level. These crabs were apportioned to the species level using the identified crab.

From January 2008 to 2012 the observer program changed the method in which they speciate crab to better reflect their hierarchal sampling method and to account for broken crab that in the past were only identified to genus. In addition, haul-level weights collected by the observers were used to estimate the weight of crab through CAS instead of applying an annual (global) weight factor. Spatial resolution was at federal reporting area.

Starting in 2013, a new data set based on the CAS system was made available for January 2009 to current. In 2009 reporting state statistical areas was required on groundfish production reports. The level of spatial resolution in CAS was formally federal reporting area since this the highest spatial resolution at which observer data is aggregated to create bycatch rates. The federal reporting area does not follow crab stock boundaries, particular for species with small stock areas such as Pribilof Islands or St. Matthew Island stocks so the new data was provided at the State reporting areas. This method uses ratio estimator (wt crab/wt groundfish) applied to groundfish reported on production/landing reports. Where possible, this dataset aggregates observer data to the stock area level to create bycatch estimates at the stock area. There are instances where no observer data is available and aggregation could go outside of a stock area, but this practice is greatly reduced compared with the pre-2009 data, which at-best was at the Federal reporting area level.

The new time series in the newly defined Pribilof stock are resulted in significantly different estimates of red king crab bycatch biomass in 2009/2010-2012/2013 (Tables 2- 3). In 2012/2013, using the new estimation method, 0.82 t of male and female blue king crab were caught in fixed gear (0.16 t) and trawl (0.67 t) gear groundfish fisheries. The targeted species in these fisheries were Pacific cod (*Gadus macrocephalus*) (19%), yellowfin sole (*Limanda aspera*) (78%), and flathead sole (*Hippoglossoides elassodon*) (3%) fisheries (Table 3). The catch was in non-pelagic trawls (81%) and longline (19%) fisheries. There was no bycatch attributed to pot fisheries. (Table 4). The discrepancy between the old and new methods highlights the problems attributing non –observed vessels from outside the stock boundaries. The analyses in this document use only the new method for 2009/2010 through 2012/2013 catch data.

c. Catch-at-length: NA

d. Survey biomass:
The 2013 NMFS EBS bottom trawl survey results (Daly et al. in press) are included in this SAFE report for the new Pribilof Islands blue king crab stock area definition (Tables 5 and 6, Figure 7). This new area was defined as a result of the new rebuilding plan and the concern that crab outside of the Pribilof District were not being accounted for in the assessment. The addition of the 20 nm strip resulted in a small effect on the time series. Annual differences between the previous time series and the new time series ranged from 0 to 9% (Figure 8). Abundance estimates of male and female crab are assessed for 5 mm length bins with shell condition for total abundances for each EBS stock (Figure 9 and 10). Weight (equation 1) and maturity (equation 3) schedules are applied to these abundances and summed to calculate mature male, female, and legal male biomass.

Proportion mature male = $1/(1 + (3.726 * 10^{15}) * e^{((CL(mm)+2.5) * -0.332)}$

$$\text{Proportion mature female} = 1/(1 + (8.495 * 10^{13}) * e^{((CL(mm)+2.5) * -0.332)} \quad (3)$$

Historical survey data are available from 1975 to the present (Tables 5 and 6). It should be noted that the survey data analyses were standardized in 1980.

Blue king crab were caught at 6 of the 77 stations in the Pribilof District; 6 stations in the high-density sampling area and zero stations in the standard-density sampling area in 2013 (Figure 11). Legal-sized males were caught at two stations north of St. George Island with a density of 62 to 219 crab nmi^{-2} (Appendix, Figures 11 and 12). The 2013 biomass estimate (± 95% CI) of legal-sized males was 190 ± 280 t and abundance was 0.07 ± 0.11 million crab, representing 38% of the total male abundance and well below the average of 1,222 ± 687 t for the previous 20 years.

Blue king crab mature males were caught at 2 of the 77 stations in the Pribilof District; 2 stations in the high-density sampling area and zero stations in the standard-density sampling area and 100% of the six mature males and three immature males caught were measured (Figure 12). One station accounted for 85% of the mature males in the survey (Figure 13). The mature male biomass estimate of 250 ± 391 t represents 94% of the total male biomass with 15 ± 28 t of immature male blue king crab estimated in the Pribilof District. All male blue king crab were captured in the Pribilof District north of St. George Island.

Six mature female blue king crab were caught in the Pribilof District high-density sampling area which extrapolated to a biomass estimate of 131 ±210 t and an abundance estimate of 0.11 ± 0.18 million crab, and represents 79% of the total female biomass. Immature female blue king crab were caught at three stations northeast of St. Paul Island in the Pribilof District high-density sampling area with a biomass estimate of 35 ± 45 t. Estimates of female biomass are imprecise due to the preference of these crab for rocky habitat which is difficult to sample with bottom trawls. Three of the six mature female blue king crab sampled in the Pribilof District were brooding eyed embryos, two had empty egg cases, and one was barren (Figure 14). The mature females with embryos had 75% full clutches. Female cohorts were apparent early in the time series been captured by the survey since the mid-2000s (Figure 15).

The centers of distribution for both males and female blue king crab are located within a 40 nm by 40 nm region east of St. Paul Island (Figure 16). The center of the blue king crab distribution moved to within 20 nm of the northeast side of St. Paul Island as the population abundance decreased in the 1980's before moving easterly the 1990's. Since then, the centers of distribution have been located at the northeastern edge of the distribution. In 2013, mature male and female centers of distribution were located approximately 20 nm south of St. Paul Island.

Analytic Approach

1. **History of modeling approaches**

   A catch survey analysis has been used for assessing the stock in the past although is currently not in development.

Calculation of MMB

To reduce the effect of high uncertainty in the survey based area swept estimates an average biomass across 3 years centered on the current year was used to calculate the MMB in the most recent year (Table 7, Figure 17). In addition, this average was weighted by the inverse variance of the survey biomass estimate to account for changes in variability among years. ***Therefore in this analysis the MMB was estimated by a three year moving average MMB weighted by the inverse variance.*** Figure 18 shows the three year running average of MMB_{mating} with confidence intervals and CVs used for the analyses in this SAFE. The survey time series with three year moving weighted averages for each major size class for males and females is presented in Tables 7 and 8.

Calculation of the OFL

1. Based on available data, the ***author recommended classification for this stock is Tier 4*** for stock status level determination defined by Amendment 24 to the Fishery Management Plan for the Bering Sea/Aleutian Islands King and Tanner Crabs (NPFMC 2008).

2. In Tier 4, MSY is the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions. In Tier 4, the fishing mortality that, if applied over the long-term, would result in MSY is approximated by F_{MSY}^{proxy}. The MSY stock size (B_{MSY}) is based on mature male biomass at mating (MMB_{mating}) which serves as an approximation for egg production. MMB_{mating} is used as a basis for B_{MSY} because of the complicated female crab life history, unknown sex ratios, and male only fishery. The B_{MSY}^{proxy} represents the equilibrium stock biomass that provides maximum sustainable yield (MSY) to a fishery exploited at F_{MSY}^{proxy}. B_{MSY} can be estimated as the average biomass over a specified period that satisfies these conditions (i.e., equilibrium biomass yielding MSY by an applied F_{MSY}). This is also considered a percentage of pristine biomass (B_0) of the unfished or lightly exploited stock. The current stock biomass reference point for status of stock determination is MMB_{mating}.

   The mature stock biomass ratio β where B/B_{MSY}^{prox} = 0.25 represents the critical biomass threshold below which directed fishing mortality is set to zero (Figure 19). The parameter α determines the slope of the non-constant portion of the control rule line and was set to 0.1. Values for α and β where based on sensitivity analysis effects on B/B_{MSY}^{prox} (NPFMC 2008). The F_{OFL} derivation where B is greater than β includes the product of a scalar (**γ**) and M (equations 5 and 6) where the default **γ** value is 1 and M for Bering Sea blue king crab is 0.18. The value of **γ** may alternatively be calculated as F_{MSY}/M depending on the availability of data for the stock.

   Overfishing is defined as any amount of fishing in excess of a maximum allowable rate, the F_{OFL} control rule resulting in a total catch greater than the OFL. For Tier 4 stocks, a minimum stock size threshold (MSST) is specified as 0.5 B_{MSY}^{prox}; if current MMB at the time of mating drops below MSST, the stock is considered to be overfished.

3. Calculation of B_{MSY}^{prox}:
   The time period for establishing $B_{MSYproxy}$ was assumed to be representative of the stock being fished at an average rate near F_{MSY} fluctuating around B_{MSY}. The criteria to select the time period was based on 2011 CPT recommendations for estimating B_{MSY}. Previously, B_{MSY}^{prox} for Pribilof Islands blue king crab was calculated as the average MMB_{mating} from 1980 to 1984 and 1990 to 1997 to avoid time periods of low abundance possibly caused by high fishing pressure. In the previous assessment, an alternative time period from 1975 to 1979 was also considered because it represents the only period where a fishery was occurring where exploitation and MMB oscillated relatively consistently over time. During the remainder of the time series, the stock was either dropping under high exploitation or recovering during a no fishing period. This alternative time period was chosen by the CPT but the SSC recommended staying with the original time series. Considerations for choosing the time series included:

   A. Production potential
      1) Between 2006 and 2013 the stock does appears to be below a threshold for responding to increased production based on the lack of response of the adult stock biomass to slight fluctuations in recruitment (male crab 120-134 mm) (Figure 20).
      2) An estimate of surplus production (ASP = MMB_{t+1} – MMB_t + total $catch_t$)

suggested that only meaningful surplus existed in the late 1970s and early 1980s while minor surplus production in the early 1990s may have led to the increases in biomass observed in the late 1990s.

3) Although a climate regime shift where temperature and current structure changes are likely to impact blue king crab larval dispersal and subsequent juvenile crab distribution, no apparent trends in production before and after 1978 were observed. There are few empirical data to identify trends that may allude to a production shift. However, further analysis is warranted given the paucity of surplus production and recruitment subsequent to 1981 and the spikes in recruits (male crab 120-134 mm) /spawner (MMB) observed in the early 1990s and 2009 (Figure 21).

B. Exploitation rates fluctuated during the open fishery periods from 1975 to 1987 and 1995 to 1998 (Figure 20) while total catch increased until 1980 before the fishery was closed in 1987 and increased again in 1995 before again closing in 1999 (Figure 22). The current F_{MSY}^{proxy} assume $F=M$ is 0.18 so time periods with greater exploitation rates should not be considered to represent a period with an average rate of fishery removals.

C. Subsequent to increases in exploitation rates in the late 1980s and 1990s, the ln (recruits/MMB) dropped suggesting that exploitation rates at the levels of MMB present were not sustainable.

4. OFL specification:

a. In the Tier 4 OFL-setting approach, the "total catch OFL" and the "retained catch OFL" are calculated by applying the F_{OFL} to all crab at the time of the fishery (total catch OFL) or to the mean retained catch determined for a specified period of time (retained catch OFL). The F_{OFL} is derived using a Maximum Fishing Mortality Threshold (MFMT) or F_{OFL} Control Rule (Figure 19) where Stock Status Level (level a, b or c; equations 4-6) is based on the relationship of current mature stock biomass (B) to B_{MSY}^{proxy}.

Stock Status Level:	F_{OFL}:	
a. $B/B_{MSY}^{prox} > 1.0$	$F_{OFL} = \gamma \cdot M$	(4)
b. $\beta < B/B_{MSY}^{prox} \leq 1.0$	$F_{OFL} = \gamma \cdot M\ [(B/B_{MSY}^{prox} - \alpha)/(1 - \alpha)]$	(5)
c. $B/B_{MSY}^{prox} \leq \beta$	$F_{directed} = 0;\ F_{OFL} \leq F_{MSY}$	(6)

b. The MMB_{mating} projection is based on application of M from the 2013 NMFS trawl survey (July 15) to mating (February 15) and the removal of estimated retained, bycatch, and discarded catch mortality (equation 7). Catch mortalities are estimated from the proportion of catch mortalities in 2010/2011 to the 2011 survey biomass.

$$MMB_{survey} \cdot e^{-PM(sm)} - \text{(projected legal male catch OFL)-(projected non-retained catch)} \quad (7)$$

where, MMB_{survey} is the mature male biomass at the time of the survey, $e^{-PM(sm)}$ is the survival rate from the survey to mating. PM(sm) is the partial M from the time of the survey to mating (8 months).

c. To project a total catch OFL for the upcoming crab fishing season, the F_{OFL} is estimated by an iterative solution that maximizes the projected F_{OFL} and projected catch based on the relationship of B to B_{MSY}^{prox}. B is approximated by MMB at mating (equation 7).

For a total catch OFL, the annual fishing mortality rate (F_{OFL}) is applied to the total crab biomass

at the fishery (equation 8).

Projected Total Catch OFL = $[1–e^{-Fofl}] \cdot$ Total Crab $Biomass_{fishery}$ (8)

where $[1–e^{-Fofl}]$ is the annual fishing mortality rate.

Exploitation rates on legal male biomass (μ_{LMB}) and mature male biomass (μ_{MMB}) at the time of the fishery are calculated as:

μ_{LMB} = [Total LMB retained and non-retained catch] / $LMB_{fishery}$ (9)

μ_{MMB} = [Total MMB retained and non-retained catch] / $MMB_{fishery}$ (10)

5. Specification of the retained catch portion of the total catch OFL:
   a. For a retained catch OFL, the annual fishing mortality rate (F_{OFL}) is applied to the legal crab biomass at the fishery (equation 11).

   Projected Retained Catch OFL = $[1–e^{-Fofl}] \cdot$ Legal Crab $Biomass_{Fishery}$ (11)

   where $[1–e^{-Fofl}]$ is the annual fishing mortality rate.

6. Recommendations:
   For 2012/2013, B_{MSY}^{prox} = 3,988t of MMB_{mating} derived as the mean MMB from 1980 to 1984 and 1990 to 1997. The stock demonstrated highly variable levels of MMB during both of these periods likely leading to uncertain approximations of B_{MSY}. Crabs were highly concentrated during the EBS bottom trawl surveys and male biomass estimates were characterized by poor precision due to a limited number of tows with crab catches.

   MMB_{mating} for 2013/2014 was estimated at 278 t for B_{MSY}^{prox}. The B/B_{MSY}^{prox} ratio corresponding to the biomass reference is 0.07. B/B_{MSY}^{prox} is < β, therefore the ***stock status level is c, $F_{directed}$ = 0, and $F_{OFL} \leq F_{MSY}$*** (as determined in the Pribilof Islands District blue king crab rebuilding plan). Total catch OFL calculations were explored in 2008 to adequately reflect the conservation needs with this stock and to acknowledge the existing non-directed catch mortality (NPFMC 2008). The preferred method was a total catch OFL equivalent to the average catch mortalities between 1999/2000 and 2005/2006. This period was after a targeted fishery and did not include the most recent changes to the groundfish fishery that led to increased blue king crab bycatch. ***The author recommended OFL for 2013/2014 based on an average catch mortality is 1.16 t***. In 2012, an alternative to establish a biomass based OFL based on the existing control rule was applied to MMB and B_{MSY}^{prox} to derive an $F_{OFL} \leq F_{MSY}$ which was then applied to the total blue king crab biomass. This method was not preferred by either the CPT or SSC.

Calculation of the ABC

1. To calculate an Annual Catch Limit (ACL) to account for scientific uncertainty in the OFL, an acceptable biological catch (ABC) control rule was developed such that ACL=ABC. For Tier 3 and 4 stocks, the ABC is set below the OFL by a proportion based a predetermined probability that the ABC would exceed the OFL (P*). Currently, P* is set at 0.49 and represents a proportion of the OFL distribution that accounts for within assessment uncertainty (σ_w) in the OFL to establish the maximum permissible ABC (ABC_{max}). Any additional uncertainty to account for uncertainty outside of the assessment methods (σ_b) will be considered as a recommended ABC below ABC_{max}. Additional uncertainty will be included in the application of the ABC by adding

the uncertainty components as $\sigma_{\text{total}} = \sqrt{\sigma_b^2 + \sigma_w^2}$. For a Tier 5 stock a constant buffer of 10% is applied to the OFL.

Specification of the probability distribution of the OFL used in the ABC:
The OFL was set based on a Tier 5 calculation of average catch mortalities between 1999/2000 and 2005/2006 to adequately reflect the conservation needs with this stock and to acknowledge the existing non-directed catch mortality.

2. List of variables related to scientific uncertainty considered in the OFL probability distribution:
Compared to other BSAI crab stocks, the uncertainty associated with the estimates of stock size and OFL for Pribilof Islands blue king crab is very high due to insufficient data and the small distribution of the stock relative to the survey sampling density. The coefficient of variation for the estimate of mature male biomass from the surveys for the most recent year is 0.75 and has ranged between 0.17 and 0.80 since the 1980 peak in biomass.

3. List of additional uncertainties considered for alternative σ_b applications to the ABC.
Several sources of uncertainty are not included in the measures of uncertainty reported as part of the stock assessment:
- Survey catchability and natural mortality uncertainties are not estimated but are rather pre-specified.
- F_{msy} is assumed to be equal to γM when applying the OFL control rule while γ is assumed to be equal to 1 and M is assumed to be known.
- The coefficients of variation for the survey estimates of abundance for this stock are very high.
- B_{msy} is assumed to be equivalent to average mature male biomass. However, stock biomass has fluctuated greatly and targeted fisheries only occurred from 1973-1987 and 1995-1998 so considerable uncertainty exists with this estimate of B_{msy}.

Given the relative amount of information available for Pribilof Island's blue king crab, the author recommended ABC would include an additional σ_b of 0.4.

4. Recommendations:
   For 2013/2014, $F_{directed}$ = 0 and the total catch OFL based on catch biomass would maintain the conservation needs with this stock and acknowledge the existing non-directed catch mortality. In that case the ***ABC_{max} based on a 10% buffer of the average catch between 1999/2000 and 2005/2006 would be 1.04 t.***

Year	MSST	Biomass (MMB_{mating})	TAC	Retained Catch	Total Catch	OFL	ABC
2010/11	2,105 (4.64)	286 [A] (0.63)	0	0	0.18 (0.0004)	1.81 (0.004)	
2011/12	2,247 (4.95)	365 [B*] (0.80)	0	0	0.36 (0.0008)	1.16 (0.003)	1.04 (0.002)
2012/13	1,994 (4.39)	579 [C**] (1.28)	0	0	0.61 (0.0013)	1.16 (0.003)	1.04 (0.002)
2013/14		278 [D**] (0.61)				1.16 (0.003)	1.04 (0.002)

All units are tons (million pounds) of crabs and the OFL is a total catch OFL for each year. The stock was below MSST in 2012/2013 and is hence overfished. Overfishing did not occur during the 2012/2013 fishing year.

Notes:
A – Based on survey data available to the Crab Plan Team in September 2010 and updated with 2010/2011 catches
B – Based on survey data available to the Crab Plan Team in September 2011 and updated with 2011/2012 catches
C – Based on survey data available to the Crab Plan Team in September 2012 and updated with 2012/2013 catches
D – Based on survey data available to the Crab Plan Team in September 2013
* – 2011/12 estimates based on 3 year running average
** – estimates based on weighted 3 year running average using inverse variance

Rebuilding Analyses

Rebuilding analyses results summary: Proposed Crab FMP and regulatory amendments were submitted for review by the Secretary in early 2013 since NMFS determined that the stock was not rebuilding in a timely manner and would not meet the rebuilding horizon of 2014.

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Table 1. Total retained catches from directed fisheries for Pribilof Islands District blue king crab (Bowers et al. 2011; D. Pengilly, ADF&G, personal communications).

Year	Catch (count)	Catch (t)	Avg CPUE (legal crab count/pot)
1973/1974	174,420	579	26
1974/1975	908,072	3224	20
1975/1976	314,931	1104	19
1976/1977	855,505	2999	12
1977/1978	807,092	2929	8
1978/1979	797,364	2901	8
1979/1980	815,557	2719	10
1980/1981	1,497,101	4976	9
1981/1982	1,202,499	4119	7
1982/1983	587,908	1998	5
1983/1984	276,364	995	3
1984/1985	40,427	139	3
1985/1986	76,945	240	3
1986/1987	36,988	117	2
1987/1988	95,130	318	2
1988/1989	0	0	0
1989/1990	0	0	0
1990/1991	0	0	0
1991/1992	0	0	0
1992/1993	0	0	0
1993/1994	0	0	0
1994/1995	0	0	0
1995/1996	190,951	628	5
1996/1997	127,712	425	4
1997/1998	68,603	232	3
1998/1999	68,419	234	3
1999/2000 to 2012/2013	0	0	0

Table 2. Non-retained total catch mortalities from directed and non-directed fisheries for Pribilof Islands District blue king crab. Handling mortalities (pot and hook/line= 0.5, trawl = 0.8) were applied to the catches. Groundfish fishery data is not available prior to 1991/1992 and ADF&G catch data is not available prior to 1996/1997 (Bowers et al. 2011; D. Pengilly, ADF&G; J. Mondragon, NMFS). ***2012 calculation of bycatch using AKRO catch in areas database in areas 513, 514, 517, 521, 523, and 524 that overlap with the newly defined Pribilof Islands blue king crab district. ** NEW 2013 calculation of bycatch using AKRO Catch Accounting System with data reported from State of Alaska reporting areas that encompass the newly defined Pribilof Islands blue king crab district.**

	Crab pot fisheries			Groundfish fisheries	
Year	Legal male non-retained (t)	Sublegal male (t)	Female (t)	All fixed (t)	All Trawl (t)
1991/1992				0.03	4.96
1992/1993				0.44	48.63
1993/1994				0.00	27.39
1994/1995				0.02	5.48
1995/1996				0.05	1.03
1996/1997	0.00	0.40	0.00	0.02	0.05
1997/1998	0.00	0.00	0.00	0.73	0.10
1998/1999	1.15	0.23	1.86	9.90	0.06
1999/2000	1.75	2.15	0.99	0.40	0.02
2000/2001	0.00	0.00	0.00	0.06	0.02
2001/2002	0.00	0.00	0.00	0.42	0.02
2002/2003	0.00	0.00	0.00	0.04	0.24
2003/2004	0.00	0.00	0.00	0.17	0.18
2004/2005	0.00	0.00	0.00	0.41	0.00
2005/2006	0.00	0.00	0.05	0.18	1.07
2006/2007	0.00	0.00	0.05	0.07	0.06
2007/2008	0.00	0.00	0.05	2.00	0.11
2008/2009	0.00	0.00	0.00	0.07	0.38
2009/2010	0.00	0.00	0.00	0.17	0.43
****2009/2010**				**1.04**	**0.17**
2010/2011	0.00	0.09	0.00	0.07	0.02
****2010/2011**				**0.05**	**0.05**
2011/2012	0.00	0.00	0.00	0.02	0.10
****2011/2012**				**0.06**	**0.01**
***2011/2012**				**0.35**	**0.01**
****2012/2013**	0.00	0.00	0.00	**0.08**	**0.535**

Table 3. Proportion by weight of the Pribilof Islands blue king crab bycatch among target species. Between 2003/2004 and 2011/2012 crab fishing seasons the data are from area 513 only. ****Years in bold use the new 2013 calculation of bycatch using AKRO Catch Accounting System with data reported from State of Alaska reporting areas that encompass the newly defined Pribilof Islands blue king crab district.** Fisheries target species that caught blue king crab but made up less than 1% of the blue king crab bycatch across all years were not shown in the table and included pollock-bottom trawl, pollock-midwater trawl, halibut, and arrowtooth flounder.

Crab fishing season	yellowfin sole %	Pacific cod %	flathead sole %	rocksole %	sablefish %		TOTAL (# crabs)
2003/2004	47	22	31				252
2004/2005		100					259
2005/2006		97	3				757
2006/2007	54	20		26			96
2007/2008	3	96	1				2,950
2008/2009	77	23					295
2009/2010	51	39	10				487
****2009/2010**	**4**	**92**	**2**		**2**		**3,147**
2010/2011		86	14				256
****2010/2011**		**59**	**38**		**<1**	**3**	**128**
2011/2012		26		74			117
****2011/2012**		**99**			**<1**	**<1**	**67**
****2012/2013**	**78**	**19**	**3**		**<1**		**406**

Table 4. Proportion by weight of the Pribilof Islands blue king crab bycatch from area 513 among gear types between 2003/2004 and 2011/2012 crab fishing seasons. ***2012 calculation of bycatch using AKRO catch in areas database in areas 513, 514, 517, 521, 523, and 524 that overlap with the Pribilof Island District. **Years in bold use the new 2013 calculation of bycatch using AKRO Catch Accounting System with data reported from State of Alaska reporting areas that encompass the newly defined Pribilof Islands blue king crab district.**

Crab fishing season	hook and line %	non-pelagic trawl %	pot %	pelagic trawl %	TOTAL (# crabs)
2003/04	21	79	0		252
2004/05	99	1	0		259
2005/06	18	3	79		757
2006/07	20	20	0		96
2007/08	1	3	95		2,950
2008/09	23	77	0		295
2009/10	21	61	18		487
****2009/10**	**4**	**9**	**87**	**<1**	**3,147**
2010/11	4	14	83		256
****2010/11**	**29**	**38**	**33**	**<1**	**128**
2011/12	22	78	0		117
***2011/12**	**95**	**2**	**0**	**3**	**494**
**2011/12	**94**	**6**	**0**	**<1**	**67**
**2012/13	**19**	**81**	**0**	**0**	**406**

Table 5. Pribilof Islands District blue king crab abundance, mature biomass, legal male biomass, and totals estimated based on the NMFS annual EBS bottom trawl survey with no running average. These data are estimated using the new stock boundaries established in 2012 which included a 20 nm column to the east of the previous stock boundary definition.

Year	Mature Male Abundance	Mature male biomass @ survey t	Mature male biomass @ mating t	Legal Male biomass @ survey t	Total male biomass @ survey t	Total female biomass @ survey t
1975/1976	14955818	33862	29432	24037	41292	12172
1976/1977	3568103	9573	5752	8585	13333	5770
1977/1978	13043983	38756	32093	36706	42137	13572
1978/1979	6140638	15798	11450	12291	18315	6492
1979/1980	5232918	12974	9081	10843	14275	4097
1980/1981	5432065	14253	8075	12163	16050	63713
1981/1982	3921734	10744	5735	9686	13014	9911
1982/1983	2344203	6691	4113	6241	7740	9376
1983/1984	1851301	4919	3478	4069	5795	10248
1984/1985	674376	1761	1452	1446	1860	2580
1985/1986	428076	959	635	687	995	523
1986/1987	480198	1368	1120	1340	1372	2431
1987/1988	903180	2659	2089	2529	2833	913
1988/1989	237868	766	690	766	921	717
1989/1990	239948	752	677	752	1914	1746
1990/1991	1738237	3259	2934	1549	5376	3811
1991/1992	2014086	4266	3839	3025	5521	2776
1992/1993	1935278	3995	3573	2761	5635	2649
1993/1994	1875500	4144	3718	2913	5136	2092
1994/1995	1263447	3028	2724	2491	3578	4858
1995/1996	3139328	7753	6379	6365	8616	4843
1996/1997	1712015	4221	3394	3522	4899	5585
1997/1998	1201296	2940	2425	2515	3288	3028
1998/1999	967097	2545	2061	2283	3175	2182
1999/2000	617258	1573	1414	1297	1719	2868
2000/2001	725050	1902	1712	1588	2005	1462
2001/2002	522239	1454	1309	1329	1533	1817
2002/2003	225476	618	557	588	618	1401
2003/2004	228897	638	575	610	656	1307
2004/2005	47905	97	87	44	130	123
2005/2006	91932	313	281	313	610	847
2006/2007	50638	137	124	115	210	558
2007/2008	100295	254	228	170	417	257
2008/2009	18256	42	37	42	235	672
2009/2010	248626	452	407	170	684	625
2010/2011	138787	322	290	202	420	440
2011/2012	165525	461	415	399	461	37
2012/2013	272233	644	579	459	809	237
2013/2014	104361	250		190	265	166

Table 6. CVs for Pribilof Islands District blue king crab abundance, mature biomass, legal male biomass, and totals estimated based on the NMFS annual EBS bottom trawl survey with no running average. These data are estimated using the new stock boundaries established in 2012 which included a 20 nm column to the east of the previous stock boundary definition.

Year	Mature Male Abundance	Mature males @ survey CV	Legal Males @ survey CV	Total males @ survey CV	Total females @ survey CV
1975/1976	0.50	0.50	0.50	0.48	0.64
1976/1977	0.42	0.41	0.42	0.47	0.89
1977/1978	0.74	0.77	0.78	0.73	0.87
1978/1979	0.50	0.56	0.64	0.51	0.72
1979/1980	0.27	0.26	0.25	0.27	0.44
1980/1981	0.32	0.30	0.28	0.31	0.89
1981/1982	0.17	0.17	0.17	0.17	0.45
1982/1983	0.18	0.19	0.19	0.17	0.67
1983/1984	0.19	0.18	0.17	0.19	0.78
1984/1985	0.23	0.23	0.25	0.23	0.38
1985/1986	0.28	0.27	0.28	0.26	0.45
1986/1987	0.31	0.30	0.31	0.30	0.90
1987/1988	0.41	0.41	0.41	0.40	0.53
1988/1989	0.51	0.53	0.53	0.46	0.47
1989/1990	0.62	0.64	0.64	0.55	0.50
1990/1991	0.44	0.42	0.38	0.43	0.37
1991/1992	0.36	0.39	0.45	0.37	0.38
1992/1993	0.42	0.42	0.45	0.43	0.46
1993/1994	0.31	0.31	0.30	0.30	0.40
1994/1995	0.34	0.35	0.35	0.34	0.44
1995/1996	0.54	0.54	0.54	0.56	0.42
1996/1997	0.28	0.27	0.27	0.28	0.49
1997/1998	0.29	0.28	0.27	0.29	0.41
1998/1999	0.25	0.25	0.25	0.25	0.39
1999/2000	0.33	0.34	0.35	0.33	0.47
2000/2001	0.30	0.30	0.31	0.30	0.46
2001/2002	0.71	0.73	0.76	0.73	0.72
2002/2003	0.47	0.51	0.52	0.51	0.78
2003/2004	0.39	0.40	0.41	0.39	0.73
2004/2005	0.56	0.58	1.00	0.46	0.50
2005/2006	0.71	0.71	0.71	0.59	0.61
2006/2007	0.57	0.60	0.70	0.46	0.67
2007/2008	0.85	0.80	0.73	0.66	0.71
2008/2009	1.00	1.00	1.00	0.80	0.70
2009/2010	0.73	0.71	0.60	0.70	0.82
2010/2011	0.48	0.46	0.48	0.52	0.60
2011/2012	0.79	0.84	0.89	0.84	0.67
2012/2013	0.80	0.74	0.64	0.79	0.64
2013/2014	0.86	0.80	0.75	0.75	0.65

Table 7. Three year weighted (inverse variance) running average of Pribilof Islands District blue king crab abundance, mature biomass, and legal male biomass based on the NMFS annual EBS bottom trawl survey.

Year	Mature Male Abundance	Mature males @ survey t	Mature males @ mating t	Legal Males @ survey t	Mature females @ survey t
1975/1976	3999214	10821	6349	9865	3194
1976/1977	4200609	11280	6580	10247	3508
1977/1978	4234074	11020	6650	9579	3502
1978/1979	5517339	13598	9534	11191	3206
1979/1980	5404179	13645	8781	11402	3103
1980/1981	4311444	11615	6445	10304	3466
1981/1982	2898311	8353	4940	7783	8586
1982/1983	2300630	6214	4129	5253	8625
1983/1984	1017736	2686	2205	2291	2805
1984/1985	614303	1401	950	1030	636
1985/1986	508803	1223	852	925	647
1986/1987	475461	1133	772	853	590
1987/1988	369370	1165	1010	1153	558
1988/1989	278353	901	818	902	589
1989/1990	261166	879	792	931	633
1990/1991	362449	1250	1126	1206	1057
1991/1992	1897982	3766	3385	1941	1908
1992/1993	1930678	4139	3713	2897	1733
1993/1994	1550754	3575	3210	2714	1767
1994/1995	1547448	3632	3265	2816	2267
1995/1996	1521470	3713	3185	3085	4694
1996/1997	1428799	3480	2851	2952	3565
1997/1998	1136930	2943	2396	2590	2283
1998/1999	838049	2166	1865	1848	2239
1999/2000	752767	1948	1713	1639	1737
2000/2001	648723	1696	1526	1422	1740
2001/2002	336836	954	859	905	1490
2002/2003	237187	658	592	628	1447
2003/2004	72140	138	124	71	127
2004/2005	67024	134	120	70	142
2005/2006	52721	119	107	68	147
2006/2007	60960	171	154	147	309
2007/2008	29890	67	60	67	316
2008/2009	23986	57	51	70	308
2009/2010	28621	69	61	80	419
2010/2011	154495	357	322	195	26
2011/2012	153347	364	327	238	40
2012/2013	139469	337	482	259	40
2013/2014	128996	309		241	110

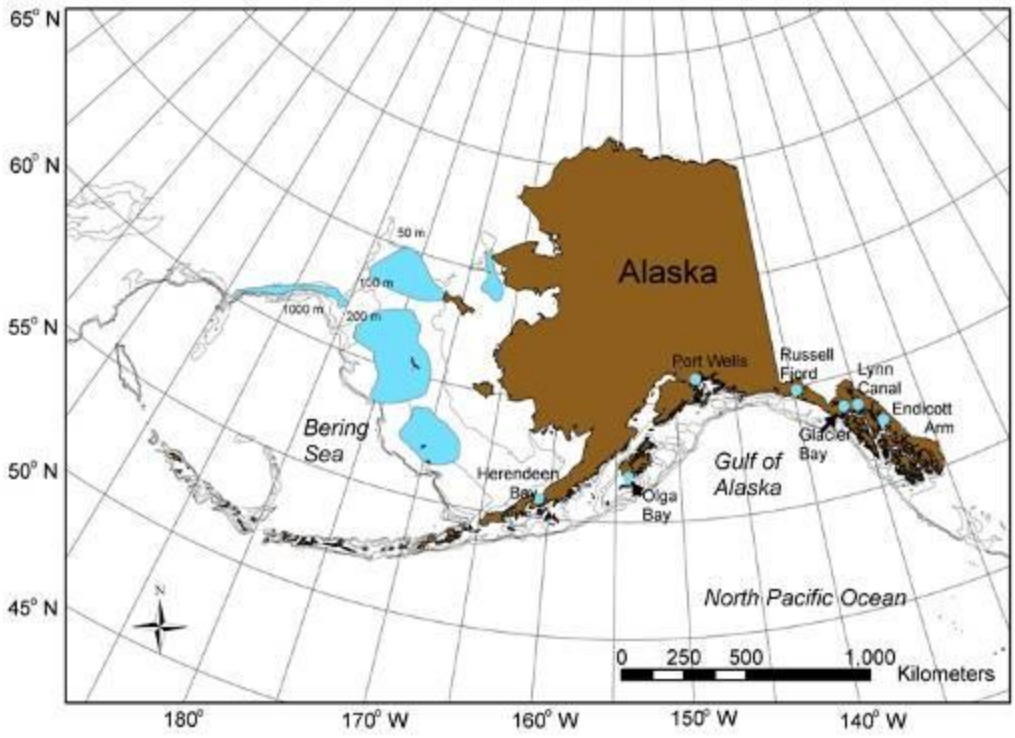

Figure 1. Distribution of blue king crab (*Paralithodes platypus*) in Alaskan waters.

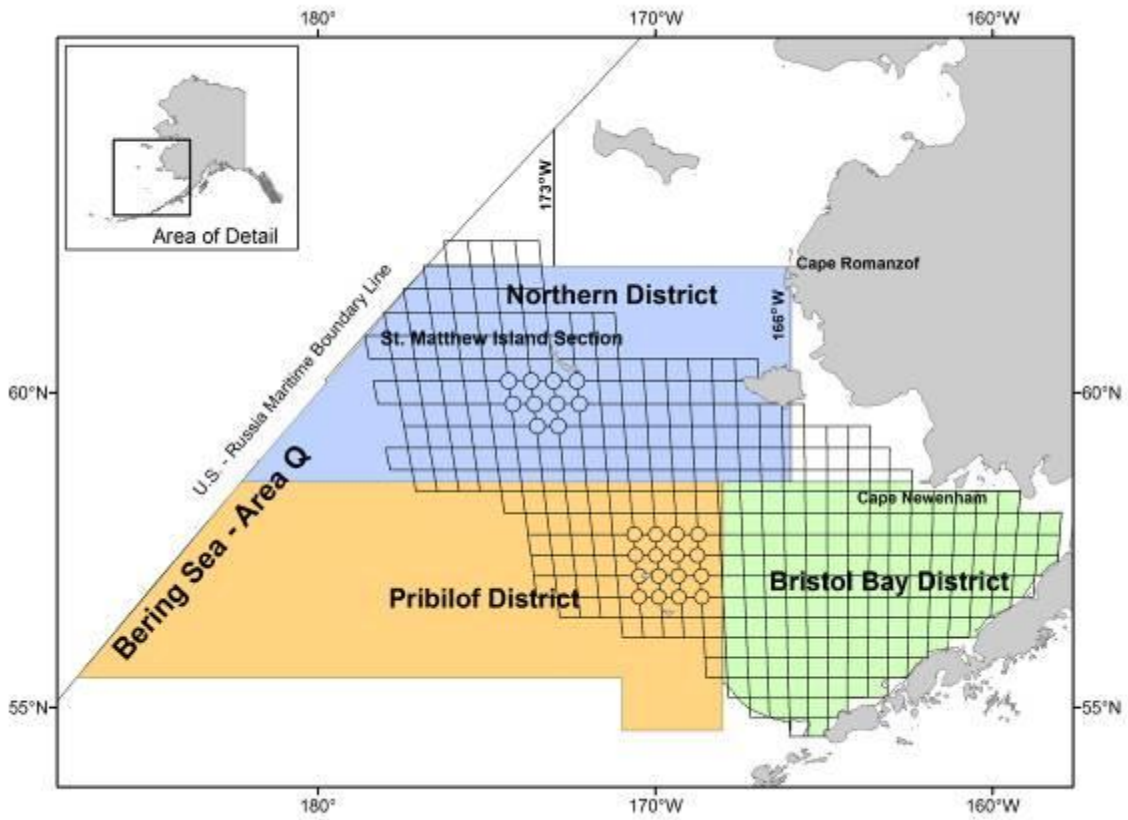

Figure 2. King crab Registration Area Q (Bering Sea) showing the Pribilof District. This figure does not show the additional 20 nm strip considered this year for biomass and catch data in the Pribilof District.

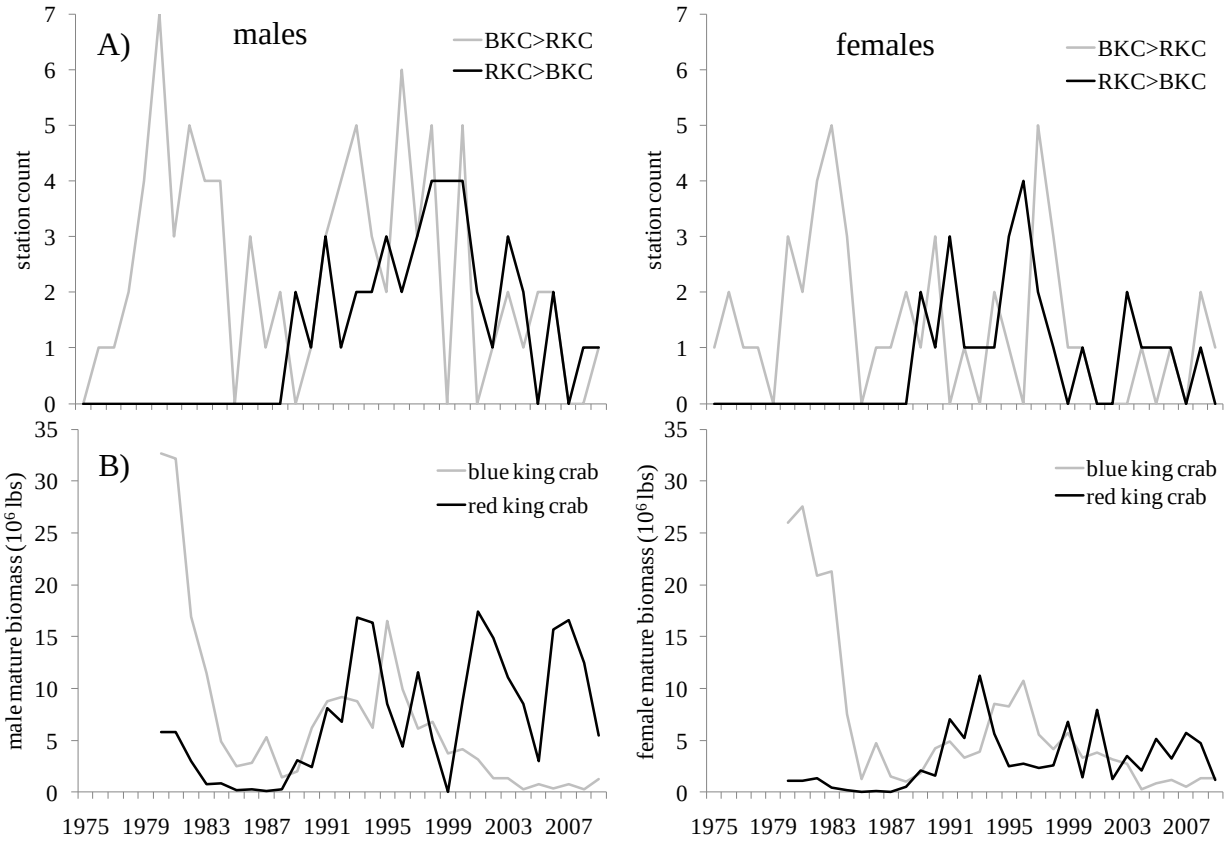

Figure 1. Time series of overlap between blue king crab and red king crab for males and females in the eastern Bering Sea showing A) the number of stations with blue king crab (BKC) or red king crab (RKC) as the dominant species and B) the mature biomass of both species.

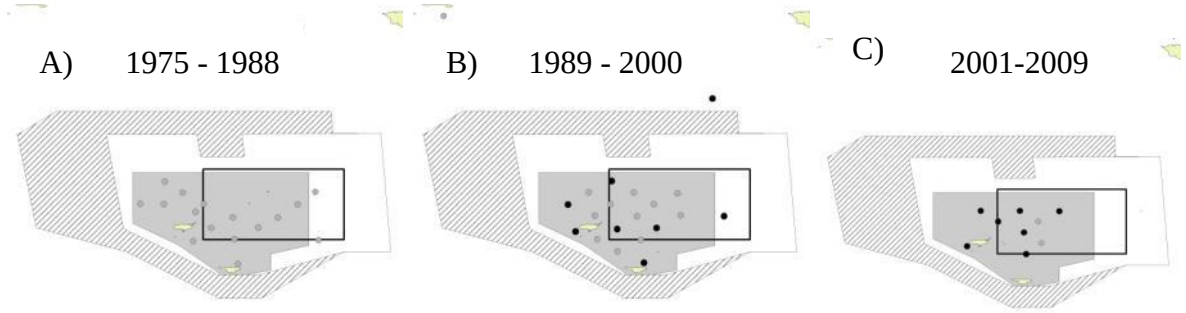

Figure 4. Spatial distribution of stations where there is overlap between blue king crab and red king crab males showing the dominant species (blue king crab=gray circles; red king crab=black circles) corresponding to time periods of major changes in biomass of both species.

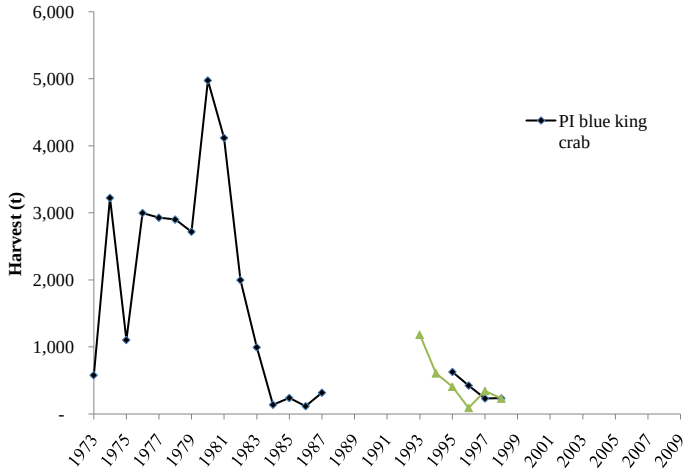

Figure 5. Historical harvests (t) and GHLs for Pribilof Island blue and red king crab (Bowers et al. 2011).

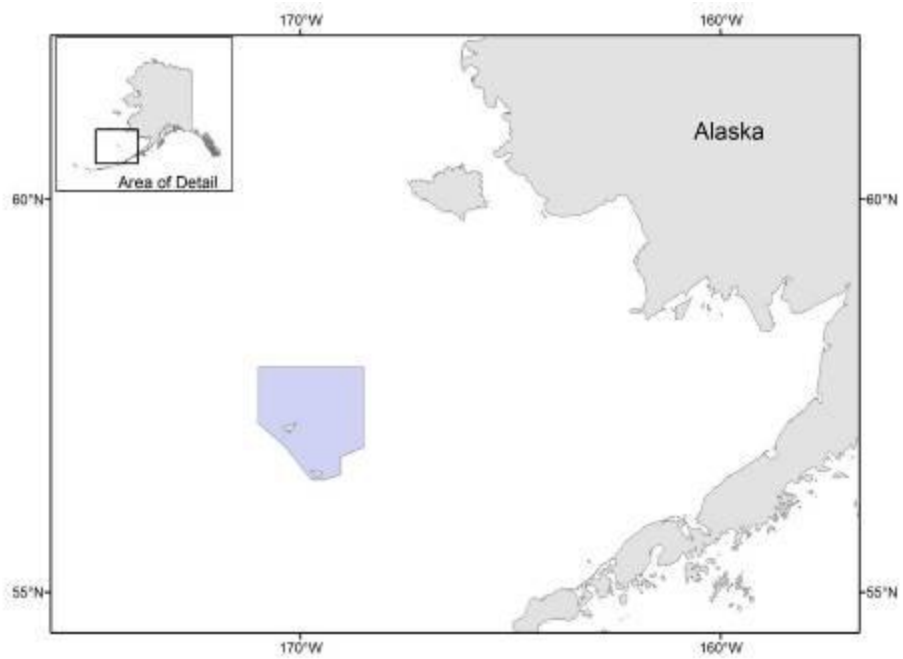

Figure 6. The shaded area shows the Pribilof Islands Habitat Conservation area. Trawl fishing is prohibited year-round in this zone.

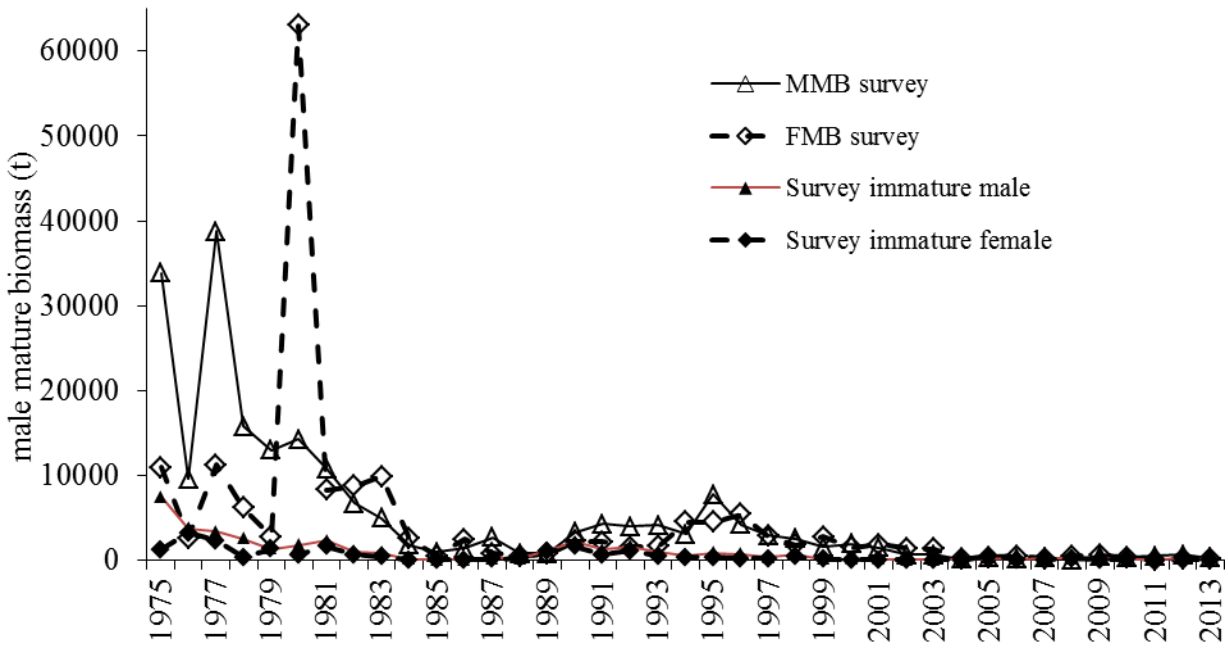

Figure 7. Time series of Pribilof Islands blue king crab estimated from the NMFS annual EBS bottom trawl survey.

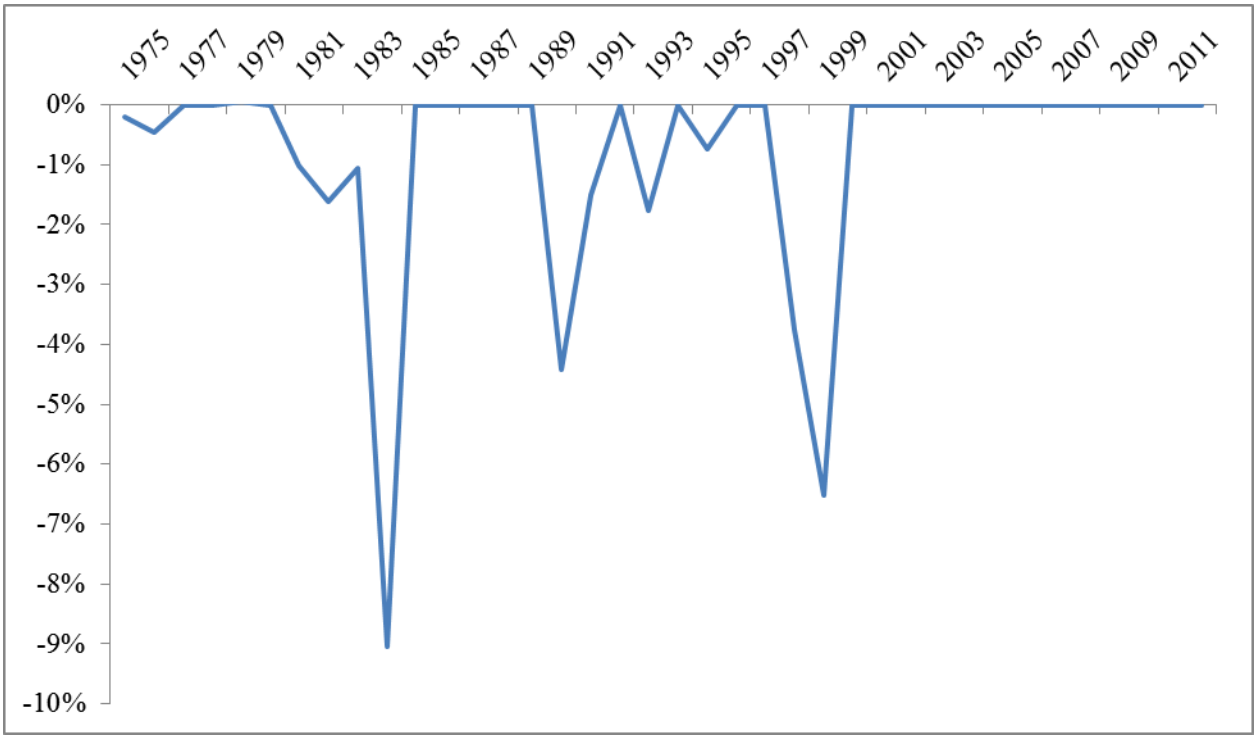

Figure 8. Percent change in MMB between the previous survey biomass estimate and the new estimate which includes an additional region 20 nm on the eastern edge of the Pribilof District.

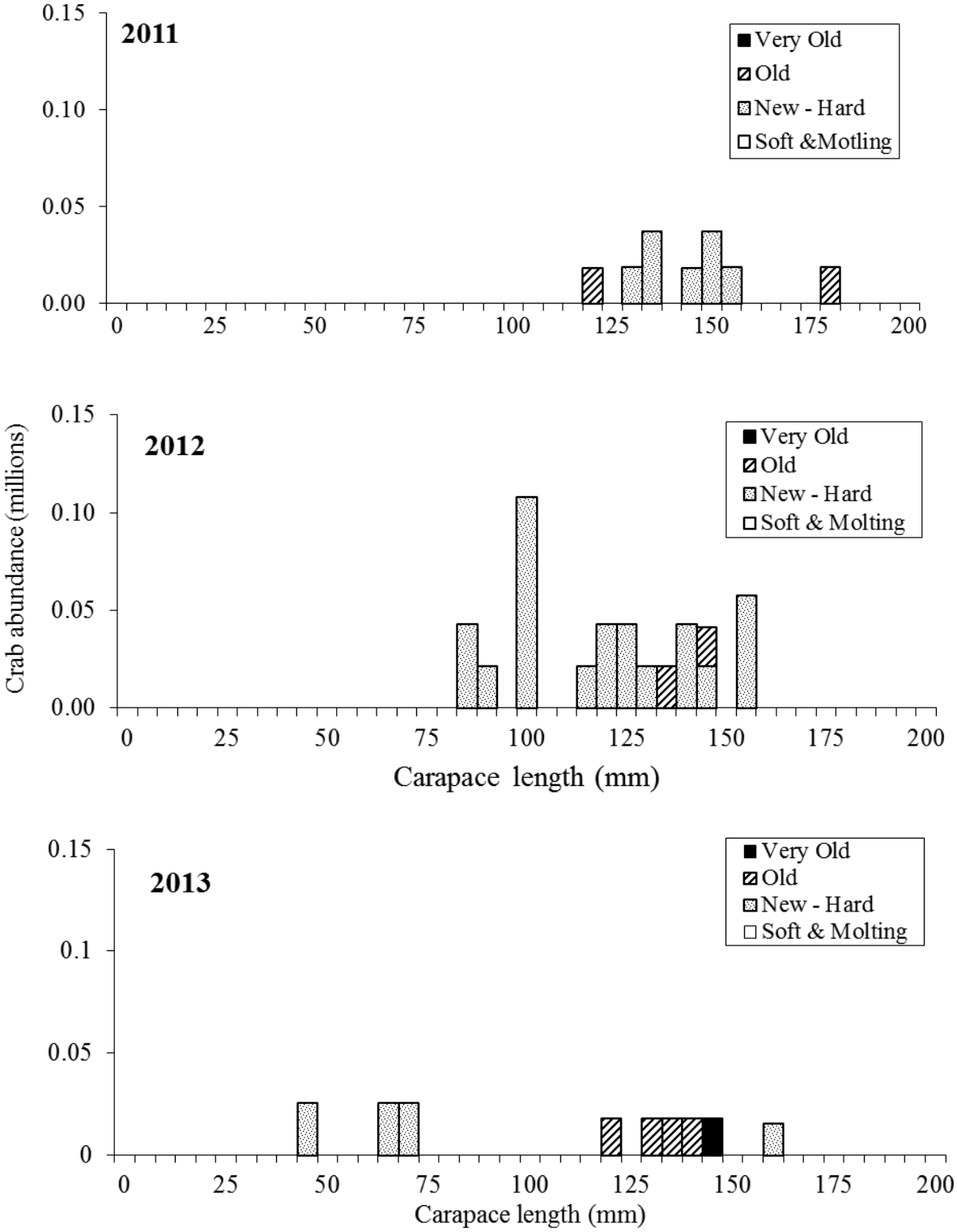

Figure 9. Distribution of Pribilof Island blue king crab in 5 mm length bins by shell condition for the last 3 surveys.

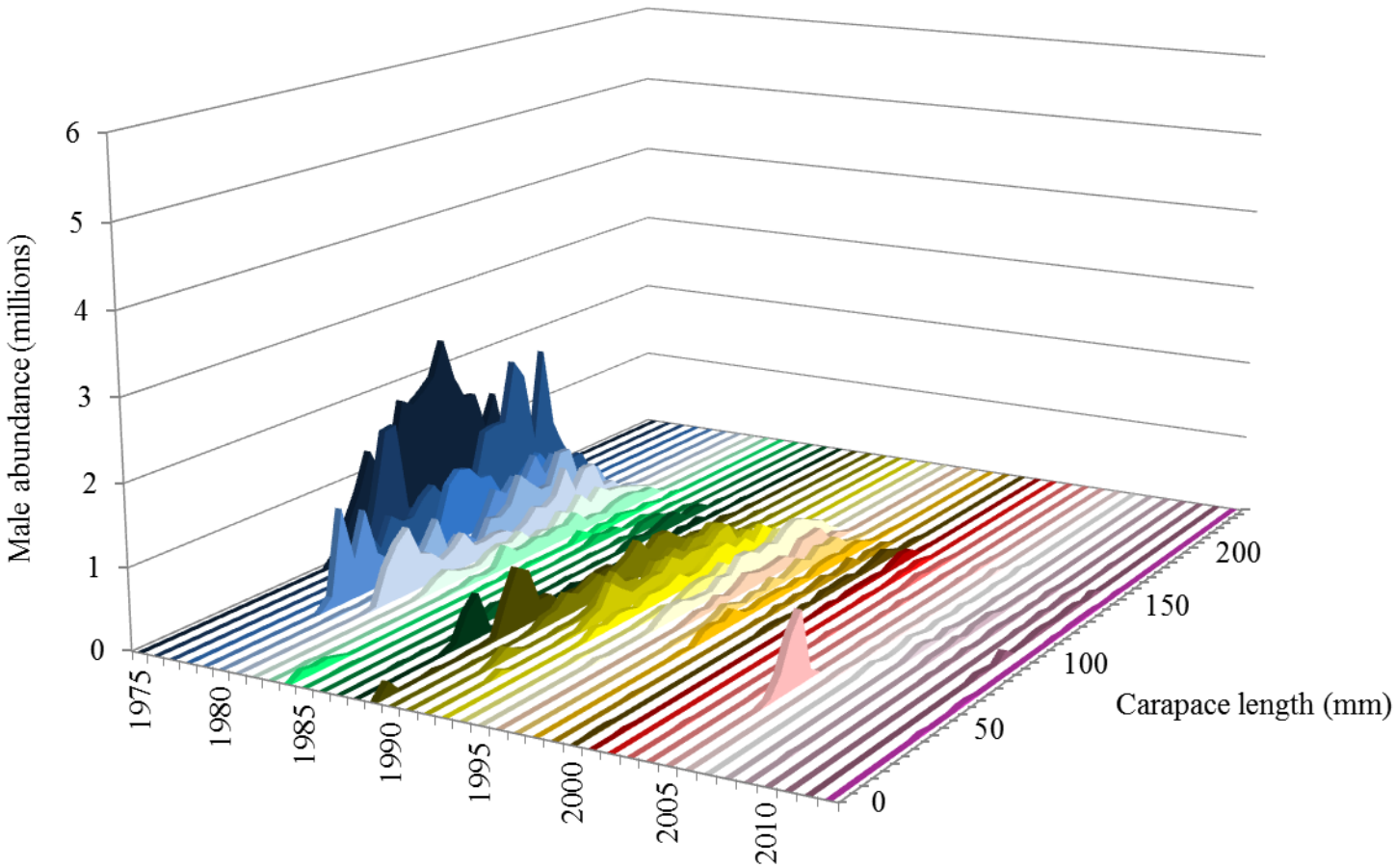

Figure 10. Size frequency by 5 mm length classes of Pribilof Islands male blue king crab (*Paralithodes camtschaticus*) from 1975 to 2013.

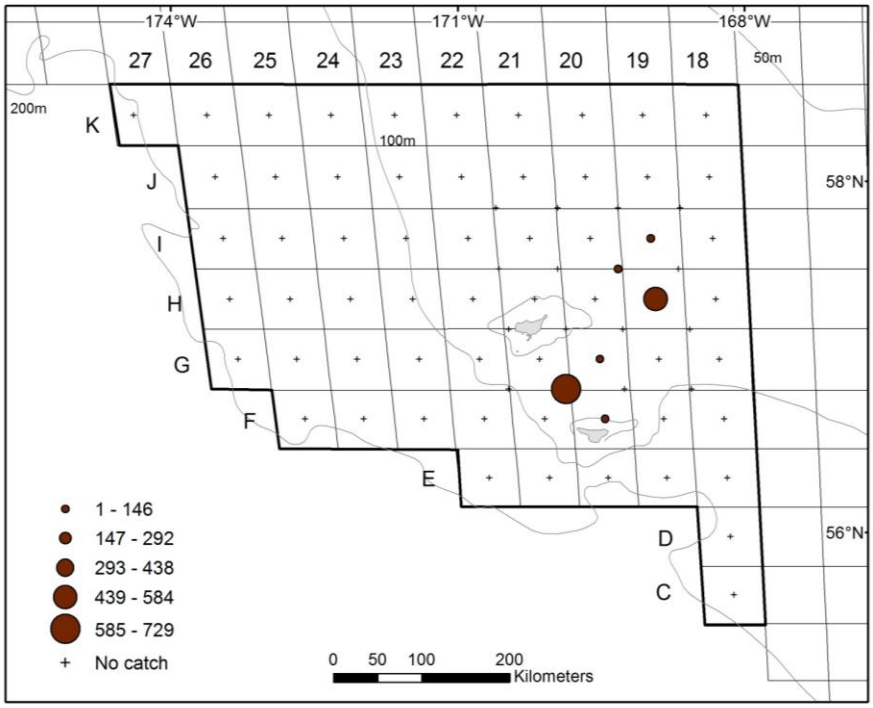

Figure 11. Total density (number/nm^2) of blue king crab in the Pribilof District in the 2013 EBS bottom trawl survey.

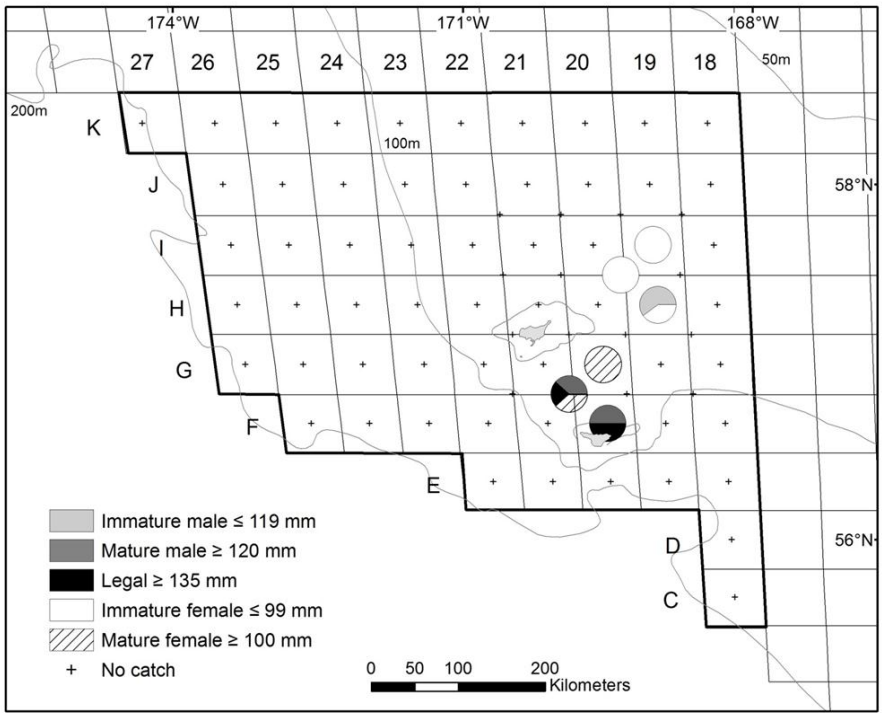

Figure 12. 2013 EBS bottom trawl survey size class distribution of blue king crab in the Pribilof District.

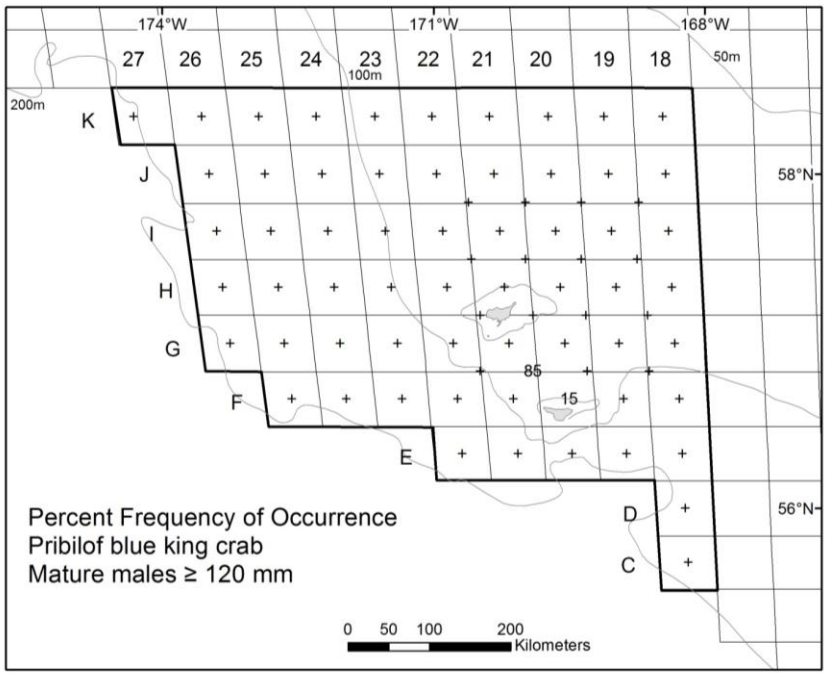

Figure 13. 2013 EBS bottom trawl survey frequency of occurrence of mature male blue king crab in the Pribilof District

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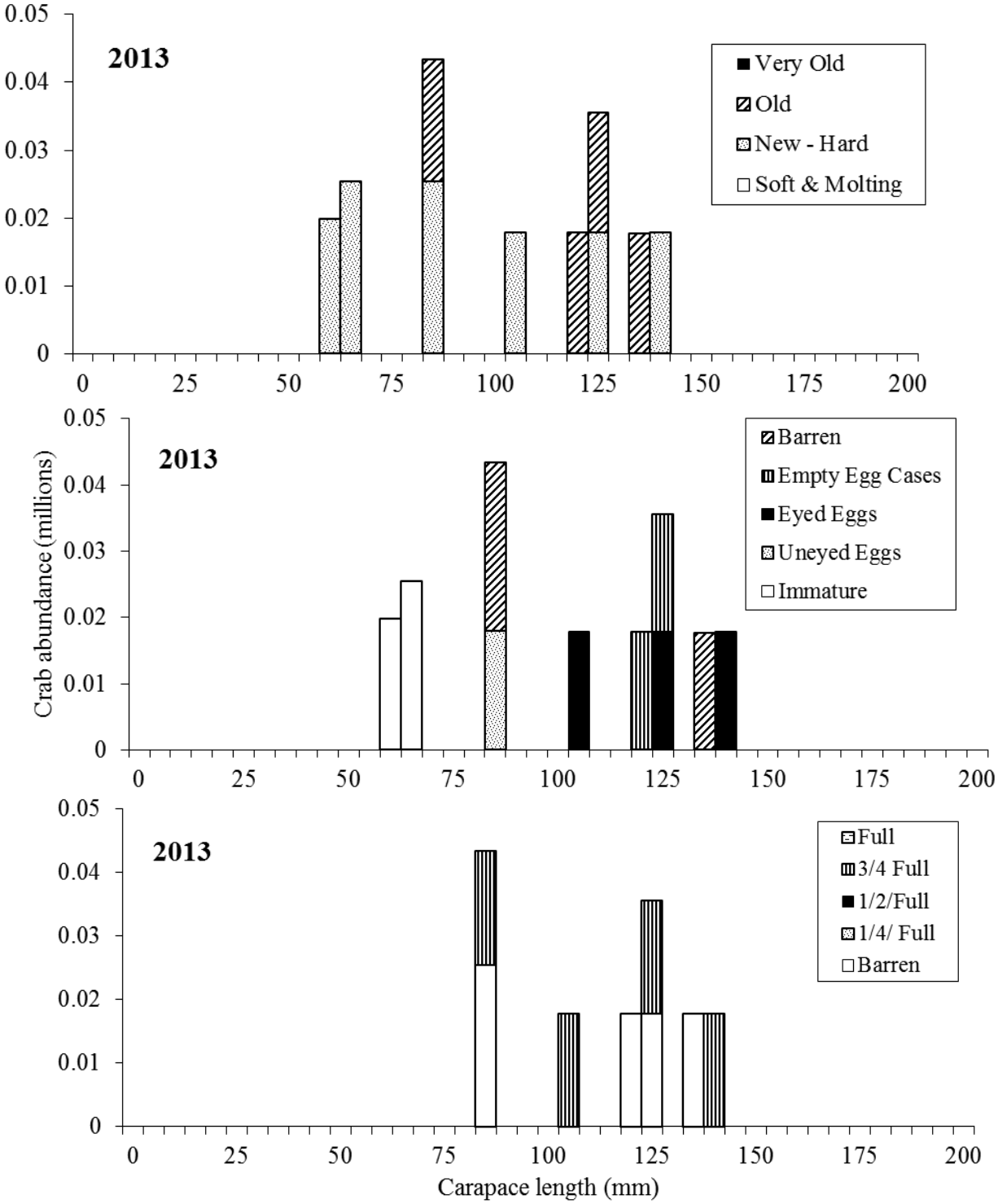


Figure 14. Size-frequency by shell condition, egg condition, and clutch fullness of Pribilof District female blue king crab (*Paralithodes platypus*) by 5 mm length classes in 2013.

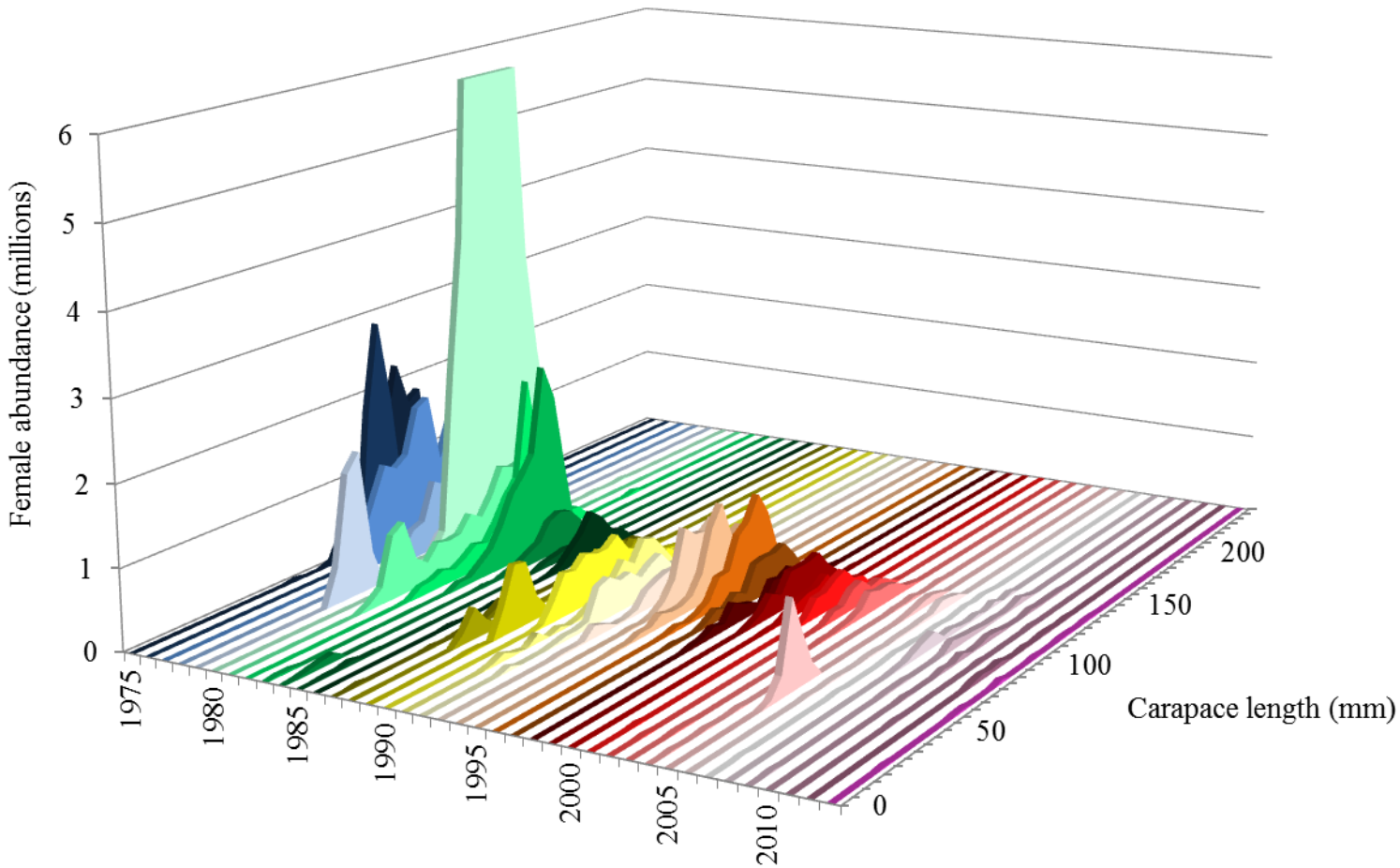
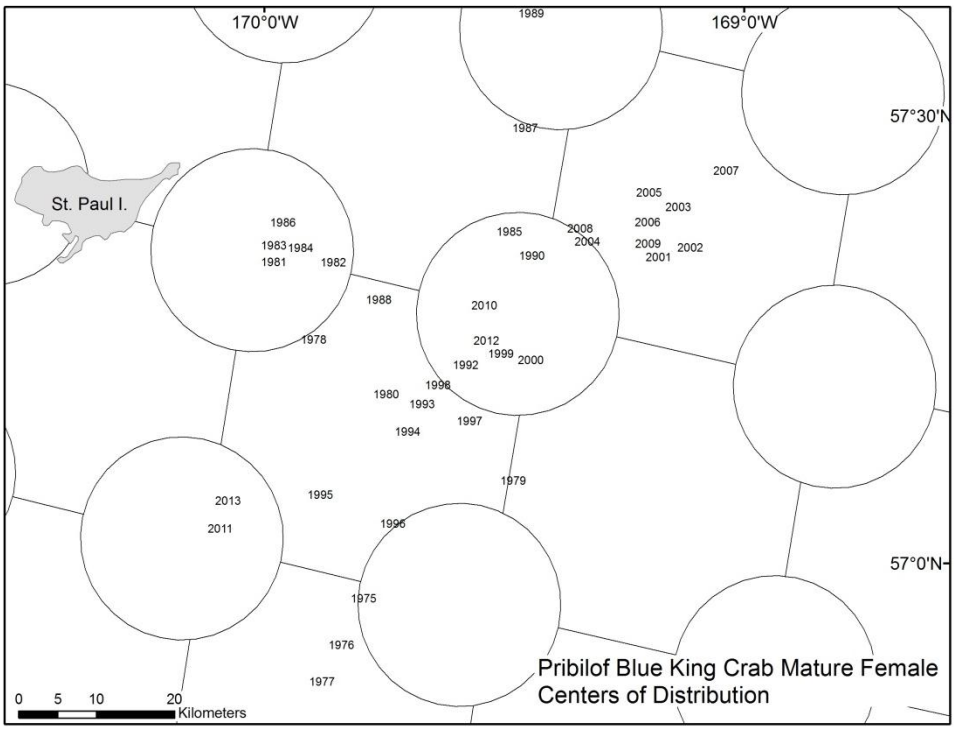


Figure 15. Size frequency by 5 mm length classes of Pribilof Islands female blue king crab (*Paralithodes camtschaticus*) from 1975 to 2013.



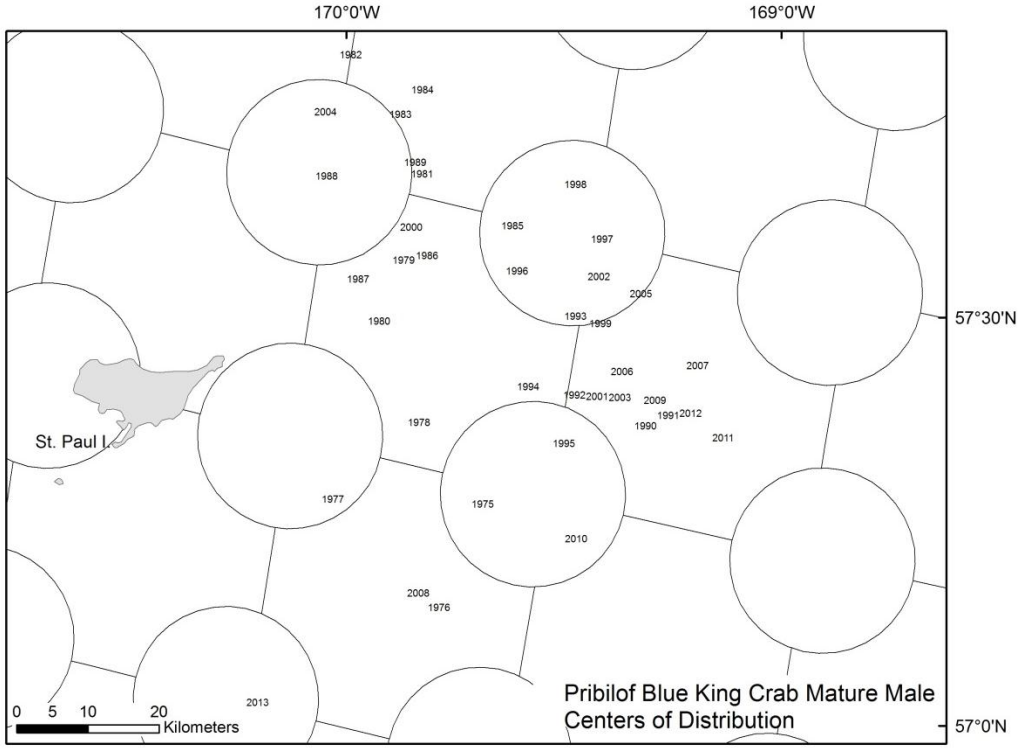


Figure 16. Centers of stock distribution of Pribilof Islands female and male blue king crab (*Paralithodes platypus*) from 1975 to 2013.

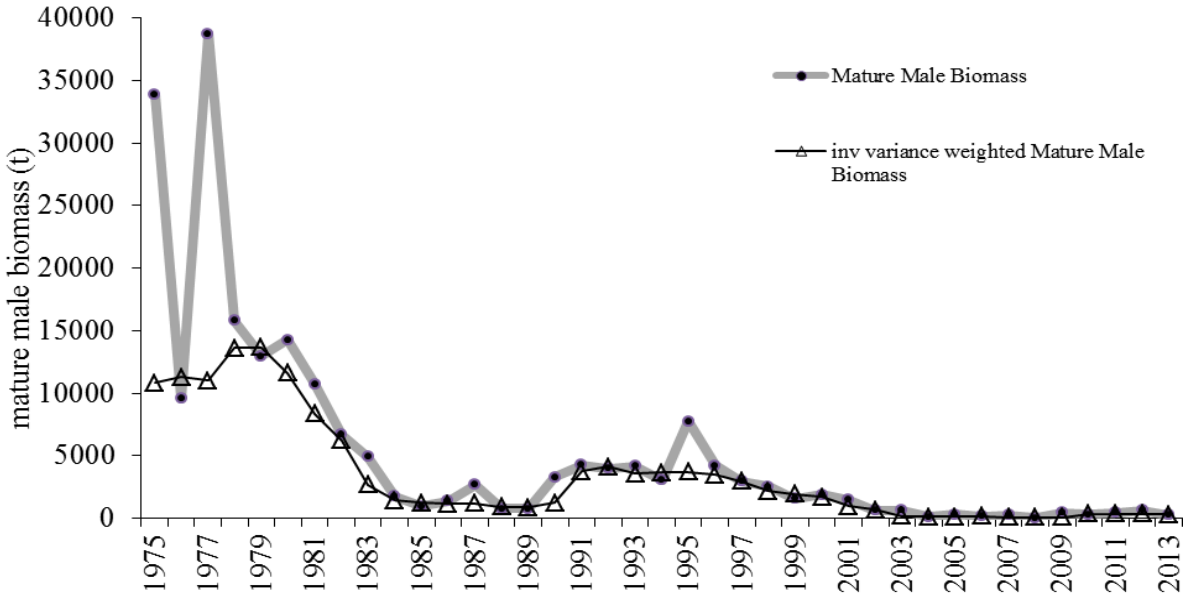


Figure 17. Time series comparison of MMB and the three year running average MMB at the time of the survey.

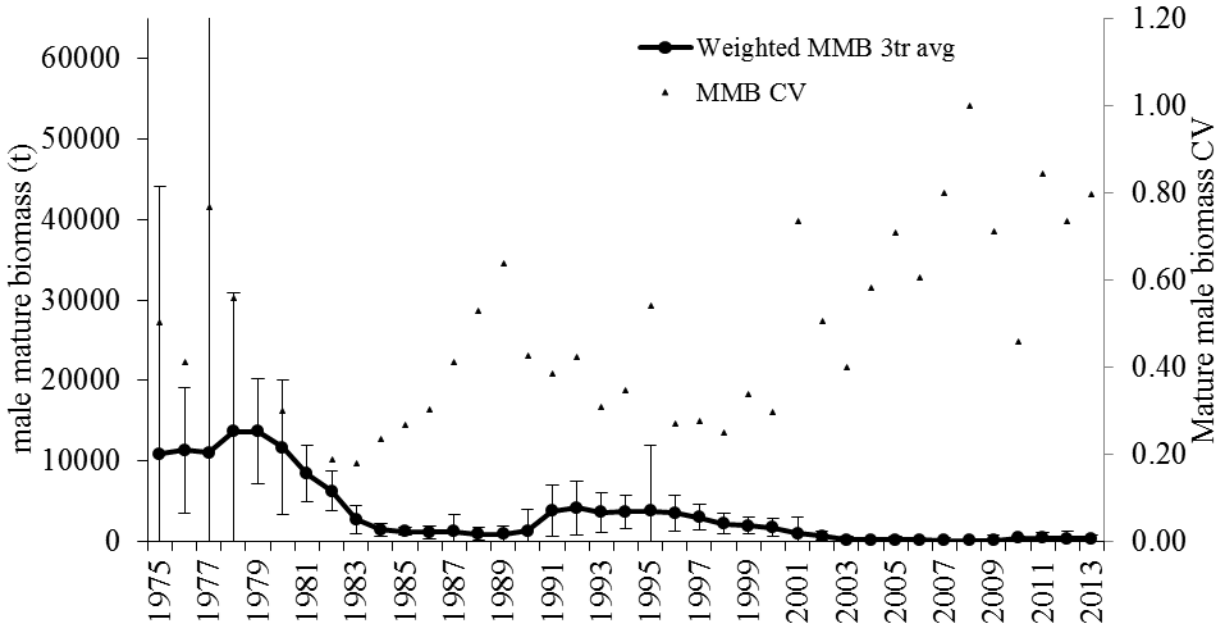


Figure 18. Time series of Pribilof Island blue king crab 3 year moving averaged mature male biomass (95% C.I.) and mature male biomass CV estimated from the NMFS annual EBS bottom trawl survey.

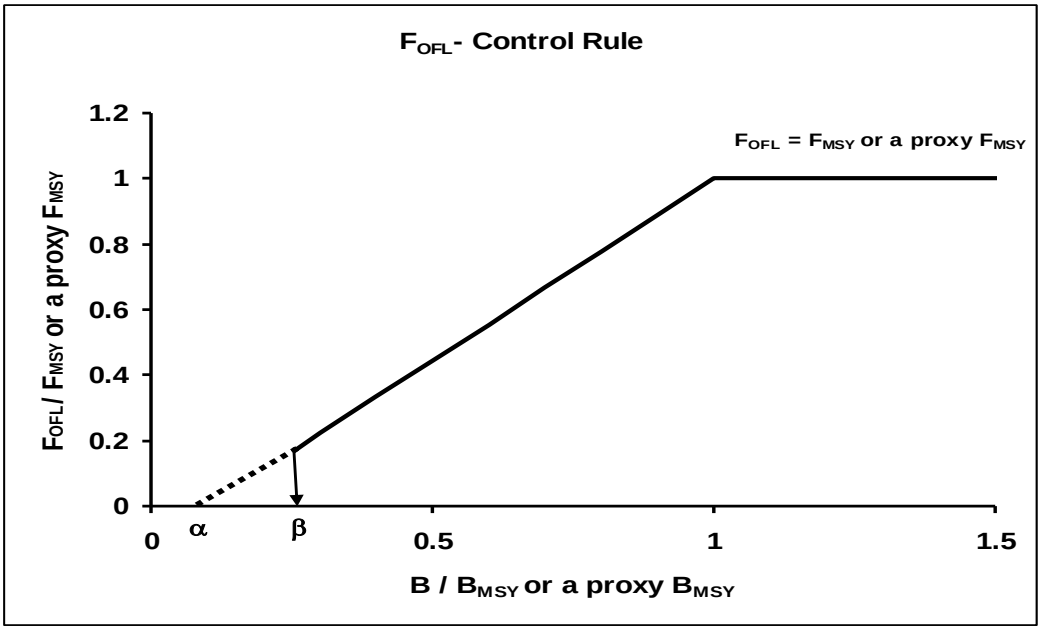


Figure 19. F_{OFL} Control Rule for Tier 4 stocks under Amendment 24 to the BSAI King and Tanner Crabs fishery management plan. Directed fishing mortality is set to 0 below β.

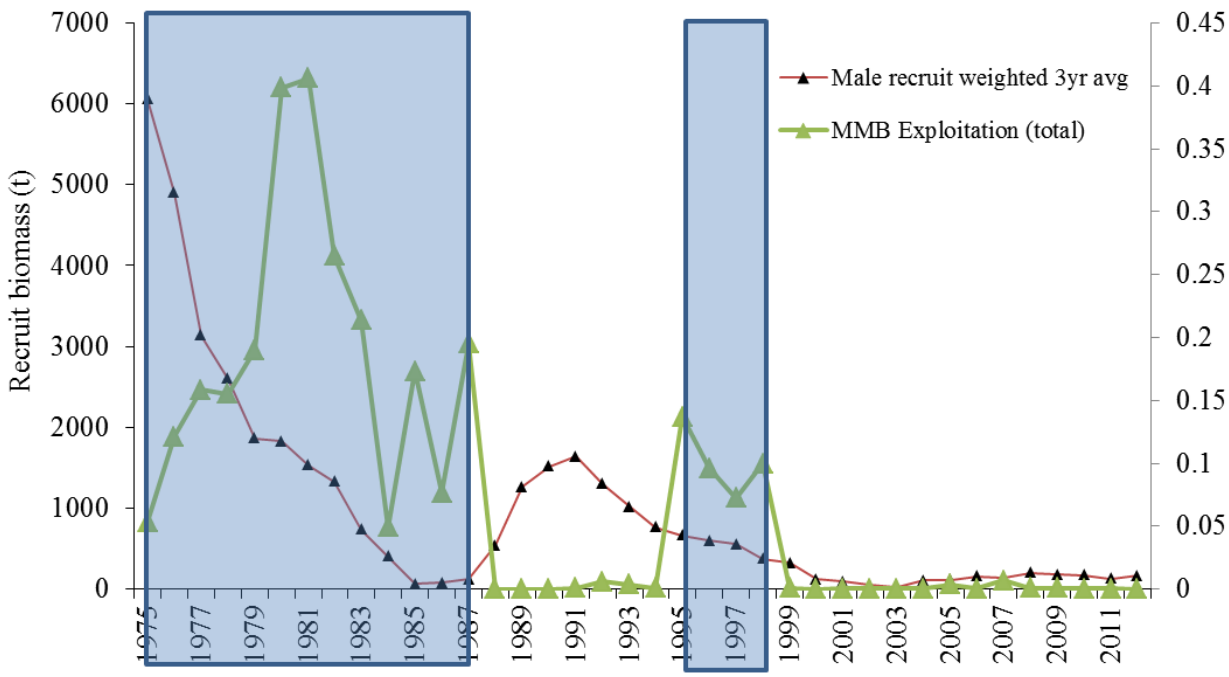


Figure 20. Time series of survey estimated recruit biomass (males 120-134 mm) and exploitation rate (based on total catch) of mature male biomass. The shaded region represents a period where commercial removals were occurring.

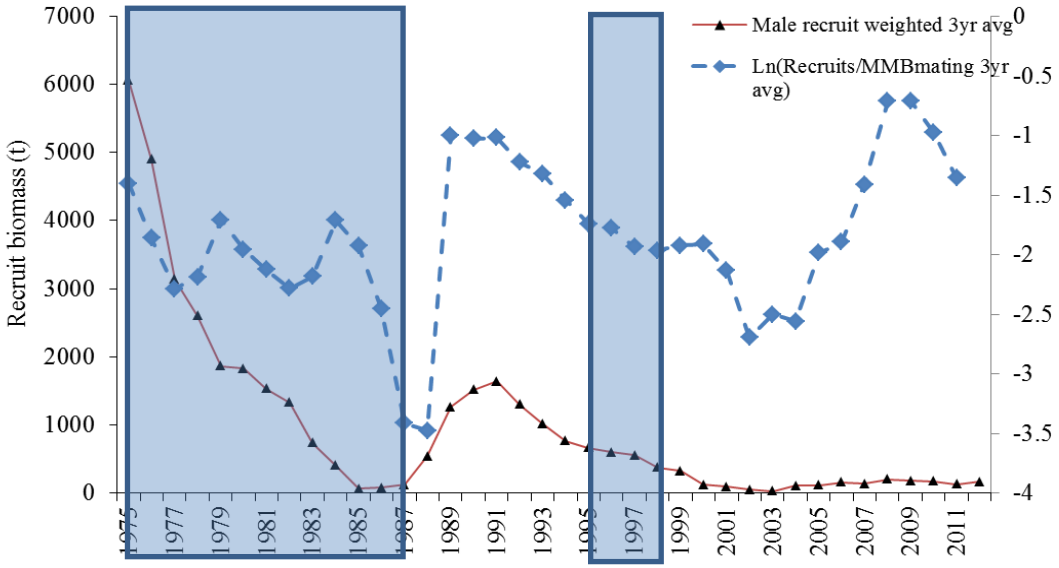


Figure 21. Time series of survey estimated recruit biomass (males 120-134 mm) and ln(Recruits/MMB). The shaded region represents a period where commercial removals were occurring.

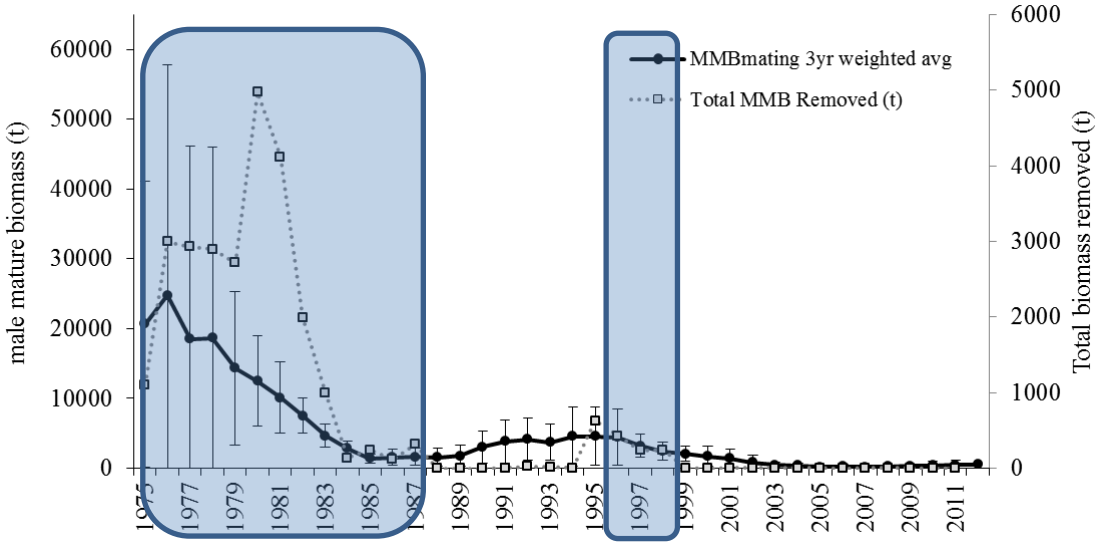


Figure 22. Time series of survey estimated Pribilof Island blue king crab 3 year moving averaged mature male biomass at mating (95% C.I.) and total catch removals.