2012 Stock Assessment and Fishery Evaluation Report for the Pribilof Islands Blue King Crab Fisheries of the Bering Sea and Aleutian Islands Regions

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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).
3. Stock biomass: Stock biomass in recent years decreased between the 1995 and 2008 surveys, and continues to fluctuate with an increase in all size classes in 2012 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
2009/10	2,105 (4.64)	401[A] (0.88)	0	0	0.5 (0.001)	1.81 (0.004)	
2010/11	2,105 (4.64)	286[B] (0.63)	0	0	0.18 (0.0004)	1.81 (0.004)	
2011/12	2,247 (4.95)	365[C*] (0.80)	0	0	0.36 (0.0008)	1.16 (0.003)	1.04 (0.002)
2012/13		496[D**] (1.09)				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 2011/2012 and is hence overfished. Overfishing did not occur during the 2011/20122 fishing year.

Notes:
A – Based on survey data available to the Crab Plan Team in September 2009 and updated with 2009/2010 catches
B – Based on survey data available to the Crab Plan Team in September 2010 and updated with 2010/2011 catches
C – Based on survey data available to the Crab Plan Team in September 2011 and updated with 2011/2012 catches
D – Based on survey data available to the Crab Plan Team in September 2012
* – 2011/12 estimates based on 3 year running average
** – 2012/13 estimates based on weighted 3 year running average

6. Basis for 2012/2013 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}	
20012/13	4c	3,944 (8.70)	496 (1.09)	0.13	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: The Pribilof Island blue king crab stock was declared overfished on September 23, 2002. The minimum required rebuilding time with 50% probability is 9 years (2011) and the maximum rebuilding time is 10 years (2012). As a result of not making adequate progress towards rebuilding a new rebuilding plan was initiated in 2009/2010. The new rebuilding plan is in final review with Secretary of Commerce and is expected to be complete in the fall 2012.

Summary of Major Changes:

1. Management: There were no major changes to the 2011/2012 management of the fishery.
2. Input data: The crab fishery retained and discard catch time series were updated with 2011/2012 data.
3. Assessment methodology: The survey biomass time series was calculated with a new area definition including an additional 20 nm strip towards the east. Bycatch in the groundfish fisheries was calculation using a catch in areas database to narrow catch data from the newly defined Pribilof District instead of just federal stat area 513. MMB was estimated with an average centered on the current year and weighted by the inverse CV.
4. Assessment results: The projected MMB increased in this assessment and remained below the MSST. Therefore, the OFL remained low with no directed fishery. Total catch mortality in 2011/2012 was 0.357 t.

Responses to SSC and CPT Comments

SSC comments October 2011:

General remarks pertinent to this assessment

none

Specific remarks pertinent to this assessment

The SSC agrees with the CPT recommendation for management of Pribilof Islands blue king crab under Tier 4, where γ=1, M=0.18. Estimates of mature male biomass (MMB) were calculated in the assessment as a three-year moving average using the target year's value averaged with the prior 2 years. The SSC agrees with the assessment author and the plan team that a more appropriate calculation would center the average on the target year and encourage consideration of other methods, including weighted averages, in subsequent assessments.

The CPT also recommended that the time periods for determining average MMB as a proxy for B_{MSY} be changed by adding in the earlier 1975/76 through 1979/80 time period to the time period used in the 14 September 2010 assessment (1980/81 through 1984/85 and 1990/91 through 1997/98; BMSY = 8,840 t). The CPT based their inclusion of these earlier data on a lack of evidence of a change in reproductive potential of the stock over these time periods. While the SSC understands the rationale for including the earlier time series into the BMSY proxy calculation, the addition of these data into the calculation more than doubles the estimate of BMSY (and MSST) over past assessments, with very little biological justification for adding these highly influential and uncertain data. The SSC recommends that the time periods from the September 2010 assessment be used to determine the average MMB as a proxy for BMSY (4,490 t).

The SSC agrees that this stock is in Tier 4c and accepts the CPT recommendations for OFL (116 t) and ABC (104 t) for 2011/12 based on the Tier 5-based method of averaging non-directed catch mortalities during 1999/00-2005/6 to determine the OFL and using a 10% buffer on OFL to determine the ABC. The SSC appreciates the recalculation of non-directed catches and mortalities in the SAFE chapter and continues to look forward to the implementation of a catch-survey analysis for this stock.

Responses to SSC Comments: Methodology for an average biomass centered on the current year and additional weighting methods were considered. CSA model development is on hold.

SSC comments June 2012:

General remarks pertinent to this assessment

none

Specific remarks pertinent to this assessment

As the NMFS trawl survey consistently finds blue king crabs in stations 20 nm east of the Pribilof District, the SSC recommends, as an interim measure, moving the effective stock boundary 20 nm to the east for management purposes.

Responses to SSC Comments: Survey data and bycatch data are provided for the new area defines as the Pribilof District plus 20 nm strip to the east.

CPT comments September 2011:

Specific remarks pertinent to this assessment

The CPT recommends examining different methods of estimating the average MMB using a weighted average of the last three years or a smoother that accounts for variances of the individual years. The team notes that the author calculated the average MMB using a running mean rather than a mean which is centered on the year for which an estimate is needed. This should be rectified for the May 2012 assessment but the results and conclusions of the current assessment are robust to changing how the average is computed.

The team concurred with the author's recommendation to set the ABC below the maximum permissible Tier 4 maxABC by using a 10% buffer from the OFL consistent with the Tier 5 calculation for this OFL for this stock based on its stock status.

Responses to CPT Comments: A 3 year average centered on the current year and weighted by the inverse CV was used to calculate the MMB while unaveraged survey data was used to calculate B_{MSY}^{proxy}.

CPT comments May 2012:

Specific remarks pertinent to this assessment

The CPT noted three potential options for areas used in OFL setting: 1) status quo; 2) move the boundary east 20 -40 nm based on survey blue king crab catches; and 3) include all of Bristol Bay. Although the CPT could not determine how far east to move the boundary, many team members felt confident using the eastern extent of survey catches of blue king crab rather than including all areas of groundfish bycatch.

It was discussed that in a tier 5 approach, as is currently employed for stocks at status C of tier 4, years with sustainable catches should be used to set the OFL. There is no recent catch level that could be deemed sustainable for Pribilof blue king crab, but rather

to set using years in which average mortality would not impede rebuilding. A biomass-based OFL would be preferable.

Responses to CPT Comments: Survey data and bycatch data are provided for the new area defines as the Pribilof District plus 20 nm strip to the east. A Tier 5 approach was considered for defining OFL.

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 et al. (In Prep). 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 bycatch in flatfish 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 2012 and the standard groundfish discards time series data through 2011 were used in this assessment. Groundfish discards for 2012 were estimated using the AKRO catch at areas database to apportion total observed blue king crab to groundfish fisheries actually fishing in the newly defined Pribilof District. As stated above, the new district definition includes the old are plus a 20 nm strip on the eastern portion. The crab fishery retained and discard catch time series was updated with 2011/2012 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 2011/2012 (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 2011/2012 fishing season

b. Bycatch and discards:

Crab pot fisheries

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).

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

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

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 2011/2012, there were no Pribilof blue king crab incidentally caught in crab fisheries (Table 2).

Groundfish pot, trawl, and hook and line fisheries

The 2011/2012 NMFS Alaska Region assessments of non-retained catch from all groundfish fisheries are included in this SAFE report (J. Mondragon, NMFS, personal communication). Groundfish catches of crab are typically reported for all males and females combined by federal reporting areas. For the Pribilof Islands stock 2010-2011 bycatch data only, data from observers and data on vessel movements acquired by satellite through the Vessel Monitoring System (VMS) were integrated by NMFS/Alaska Region. This VMS-Observer Enabled Catch-In-Areas database was used to assess the spatial resolution of the observed and unobserved groundfish fisheries in the newly defined Pribilof District. The VOE-CIA database integrates catch data from the Catch Accounting System (which has the spatial resolution of a NMFS Reporting Area) into a database that resolves the GIS data into polygons with areas of approximately seven kilometers. 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 2010 to June 2011. For Pribilof Islands blue king crab in this document, data prior to 2011/2012 only includes catch data from Area 513. 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 2011/2012 catch data are drawn from all federal stat areas that intersect the new Pribilof Islands District. To

estimate sex ratios for 2011/2012 groundfish catches, sex ratios by size and sex from the 2011EBS bottom trawl survey were applied. 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).

In 2011/2012, using the old method only focused on area 513, 0.1 t of male and female blue king crab were caught in fixed gear (0.04 t) and trawl (0.13 t) gear groundfish fisheries. The targeted species in these fisheries were rock sole (*Lepidopsetta bilineata*) (74%) and Pacific cod (*Gadus macrocephalus*) (26%) (Table 3). Notably absent in 2010/2011 were catches in the yellowfin sole (*Limanda aspera*) and flathead sole (*Hippoglossoides elassodon*) fisheries. The catch was in non-pelagic trawls (78%) and longline (22%) fisheries. There was no bycatch attributed to pot fisheries. (Table 4). Using the new VOE-CIA method bycatch , 0.39 t of male and female blue king crab were caught in fixed gear (0.35 t) and trawl (0.04 t) gear groundfish fisheries. Bycatch of blue king crab was attributed to fishing vessels in areas 513, 514, 517, 521, 523, and 524. The fisheries involved in the catch were hook and line (95%), non-pelagic trawls (2%), and pelagic trawls (3%). The discrepancy between the old and new methods highlights the problems using just area 513 to attribute blue king crab bycatch. The analyses in this document use only the new method for 2011/2012 catch data.

c. Catch-at-length: NA

d. Survey biomass:
The 2012 NMFS EBS bottom trawl survey results (Foy and Armistead in press) are included in this SAFE report for the new Pribilof Islands blue king crab stock area definition (Table 5, Figure 7) and the new stock area definition which adds 20 nm to the eastern edge of the previous boundary. 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). Weight (equation 1) and maturity (equation 3) schedules are applied to these abundances and summed to calculate mature male, female, and legal male biomass.

$$\text{Proportion mature male} = 1/(1 + (3.726 * 10^{15}) * e^{((CL(mm)+2.5) * -0.332)}$$
$$\text{Proportion mature female} = 1/(1 + (8.495 * 10^{13}) * e^{((CL(mm)+2.5) * -0.332)} \quad (3)$$

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

In 2012, 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 (Foy and Armistead in press, Figure 10). Legal-sized males were caught at one station northeast of St. Paul Island with a density of 73 to 442 crab nmi^{-2} (Figure 11). The 2012 biomass estimate (± 95% CI) of legal-sized males was 459 ± 579 t and abundance was 0.16 ± 0.22 million crab, representing 57% of the total male abundance and well below the average of 1,545 ± 1,264 t for the previous 20 years (Figure 7).

Blue king crab mature males were caught at 4 of the 77 stations in the Pribilof District; 3 stations in the high-density sampling area and zero stations in the standard-density sampling area and 100% of the nine mature males caught were measured. One station accounted for 79% of the mature males in the survey. The mature male biomass estimate of 644 ± 928 t represents 80% of the total male abundance with 165 ± 323 t of immature male blue king crab estimated in the Pribilof District.

In 2012, crabs caught in the 85 to 125 mm range were not observed in the past few surveys (Figure 9). The 145 mm to 155 mm CL size class surveyed in 2010 was not observed as larger crabs in 2012. Eight legal-sized male blue king crab were captured on the 2012 survey in the Pribilof District; six new hardshell males and two oldshell male were caught east of St. Paul Island.

Five mature female blue king crab were caught at different stations in the Pribilof District high-density sampling area which extrapolated to a biomass estimate of 106 ± 91 t and an abundance estimate of 0.1 ± 0.1 million crab, and represents 46% of the total female biomass. Immature female blue king crab were caught at one station northeast of St. Paul Island in the Pribilof District high-density sampling area with a biomass estimate of 122 ± 240 t. Four of the five mature female blue king crab sampled in the Pribilof District were brooding uneyed embryos, while ten immature females were in new hardshell condition and one crab had empty egg cases with an old shell. The majority of mature females with embryos had 100% full clutches.

Analytic Approach

1. **History of modeling approaches**
   A catch survey analysis has been used for assessing the stock in the past and is in development.

Calculation of MMB

Taking an average biomass across 3 years centered on the current year to calculate the MMB in the most recent year was considered to reduce the effect of high uncertainty in the survey based area swept estimates (Figure 12). In addition, this average was weighted by the inverse CV of the survey biomass estimate to account for changes in variability among years. A loess weighting function was also considered but did not fit the data trends adequately (Figure 12). An unweighted average was also considered but overfit the data in years with a large amount of variance. ***Therefore in this analysis the MMB was estimated by a three year moving average MMB weighted by the inverse CV.*** Figure 13 shows the weighted three year running average of MMB_{mating} with confidence intervals and CVs used for the analyses in this SAFE. The survey time series with weighted three year moving averages for each major size class for males and females is presented in Table 6.

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 14). 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 2012 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 15).
      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 16).
   B. Exploitation rates fluctuated during the open fishery periods from 1975 to 1987 and 1995

to 1998 (Figure 15) while total catch increased until 1980 before the fishery was closed in 1987 and increased again in 1995 before again closing in 1999 (Figure 17). 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 14) 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 2012 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).

$$\text{Projected Total Catch OFL} = [1-e^{-F\text{ofl}}] \cdot \text{Total Crab Biomass}_{fishery} \quad (8)$$

where $[1-e^{-F\text{ofl}}]$ 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:

$$\mu_{LMB} = \text{[Total LMB retained and non-retained catch]} / LMB_{fishery} \quad (9)$$

$$\mu_{MMB} = \text{[Total MMB retained and non-retained catch]} / MMB_{fishery} \quad (10)$$

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).

   $$\text{Projected Retained Catch OFL} = [1-e^{-F\text{ofl}}] \cdot \text{Legal Crab Biomass}_{\text{Fishery}} \quad (11)$$

   where $[1-e^{-F\text{ofl}}]$ is the annual fishing mortality rate.

6. Recommendations:
   For 2011/2012, ***B_{MSY}^{prox} = 3,944 t 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 2012/2013 was estimated at 496 t for B_{MSY}^{prox}. The B/B_{MSY}^{prox} ratio corresponding to the biomass reference is 0.13. 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 2011/2012 based on an average catch mortality is 1.16 t***. An alternative to establish a biomass based OFL 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. The alternative OFL for 2012/2013 is 2.71 t. ***The F_{OFL} corresponding to the biomass reference and the control rule was 0.005***.

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.

   <u>Specification of the probability distribution of the OFL used in the ABC:</u>
   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.

   An alternative approach was considered with the OFL calculated based on the control rule for total crab biomass. A distribution for the OFL which quantifies uncertainty was constructed using

bootstrapping methods approximating the lognormal distribution. This involves generating values for M and annual MMB_{mating} (e.g. by assuming that MMB is log-normally distributed and M is normally distributed) and for each simulation calculating the OFL using the standard methods in sections 3 and 4 of the OFL Calculation section above. The OFL distribution for Pribilof Island red king crab is skewed to the right due to the patchy spatial distribution and small abundance which affects the variability of density estimates among trawl survey stations. This lognormal distribution suggests that use of the mean value (as opposed to the median) of the distribution would be appropriate as it changes with greater variability.

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 0.74 and has ranged between 0.17 and 0.80 in 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 2012/2013, $F_{directed} = 0$ 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.*** Considering the alternative using the OFL based on the control rule for total crab biomass, the multiplier equivalent to a P* of 0.49 was 0.37. The alternative ABC_{max} was thus estimated to be 1.00 t. Incorporating additional uncertainty by applying a σ_b of 0.4 resulted in a multiplier of 0.28 and an ABC of 0.75 t.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained Catch	Total Catch	OFL	ABC
2009/10	2,105	401 [A]	0	0	0.45	1.81	
2010/11	2,105	286 [B]	0	0	0.18	1.81	
2011/12	2,247	365 [C]	0	0	0.36	1.16	1.04
2012/13		496 [D]				1.16	1.04

All units are tons of crabs and the OFL is a total catch OFL for each year. The stock was below MSST in 2011/12 and is hence overfished. Overfishing did not occur during the 2011/12 fishing year.

Notes:

A – Based on survey data available to the Crab Plan Team in September 2009 and updated with 2009/2010 catches

B – Based on survey data available to the Crab Plan Team in September 2010 and updated with 2010/2011 catches

C – Based on survey data available to the Crab Plan Team in September 2011 and updated with 2011/2012 catches

D – Based on survey data available to the Crab Plan Team in September 2012

Rebuilding Analyses

Under the current rebuilding plan, this stock has to recover to the B_{MSY} proxy in 2011/2012 and 2012/2013 to be defined as rebuilt. As the 2009/10 mature male biomass was smaller than B_{MSY} and has not shown signs of recovery in an adequate timeframe, the stock was deemed likely fail to recover as planned. A new rebuilding plan was developed and is in final review with the Secretary of Commerce.

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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 2011/2012	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). ***New 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.**

	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
2010/2011	0.00	0.09	0.00	0.07	0.02
2011/2012	0.00	0.00	0.00	0.02	0.10
***2011/2012**				**0.35**	**0.01**

Table 3. Proportion of the Pribilof Islands blue king crab bycatch from area 513 among target species between 2003/2004 and 2011/2012 crab fishing seasons.

Crab fishing season	Yellowfin sole %	Pacific cod %	Flathead sole %	Rocksole %	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
2010/2011		86	14		256
2011/2012		26		74	117

Table 4. Proportion of the Pribilof Islands blue king crab bycatch from area 513 among gear types between 2003/2004 and 2011/2012 crab fishing seasons. ***New 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.**

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
2010/11	4	14	83		256
2011/12	22	78	0		117
2011/12*	**95**	**2**	**0**	**3**	**494**

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.

Year	Mature Male Abundance	Mature males @ survey t	Mature males @ mating t	Legal Males @ survey t	Total males @ survey t	Total females @ survey t
1975/1976	15019937	34051	29138	24267	41393	12166
1976/1977	3549948	9543	5575	8595	13304	5773
1977/1978	13043983	38756	31552	36706	42137	13572
1978/1979	6140638	15798	11217	12291	18315	6492
1979/1980	5275966	13261	9142	11198	14582	4138
1980/1981	5630220	14782	8318	12418	16376	63676
1981/1982	3897456	10675	5501	9617	12893	9923
1982/1983	2286666	6584	3915	6185	7633	9376
1983/1984	1822397	4867	3359	4069	5744	10248
1984/1985	609592	1615	1298	1342	1713	2580
1985/1986	428076	959	620	687	995	523
1986/1987	480198	1368	1101	1340	1372	2394
1987/1988	903180	2659	2051	2529	2833	913
1988/1989	237868	766	679	766	920	697
1989/1990	239948	752	667	752	1914	1746
1990/1991	1676791	3121	2768	1411	5196	3806
1991/1992	1980317	4203	3725	3025	5458	2779
1992/1993	1922884	3982	3508	2790	5636	2649
1993/1994	1844170	4072	3599	2841	5064	2092
1994/1995	1263447	3028	2683	2491	3578	4858
1995/1996	3111858	7696	6220	6307	8558	4843
1996/1997	1712015	4221	3334	3522	4864	5585
1997/1998	1201296	2940	2384	2515	3288	3028
1998/1999	938796	2453	1944	2191	3083	2182
1999/2000	588718	1476	1308	1201	1623	2868
2000/2001	725050	1902	1687	1588	2005	1462
2001/2002	522239	1454	1289	1329	1533	1817
2002/2003	225476	618	548	588	618	1401
2003/2004	228897	638	566	610	656	1307
2004/2005	47905	97	86	44	130	121
2005/2006	91932	313	277	313	610	847
2006/2007	50638	137	122	115	205	553
2007/2008	100295	254	224	170	417	257
2008/2009	18256	42	37	42	235	672
2009/2010	248626	452	401	170	684	625
2010/2011	138787	322	286	202	420	433
2011/2012	165525	461	409	399	461	37
2012/2013	272233	644		459	809	229

Table 6. Three year weighted 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	15019937	20677	29196	15786	7085
1976/1977	3549948	24789	5615	20503	8313
1977/1978	13043983	18489	31552	16579	6515
1978/1979	6140638	18691	11217	16236	5915
1979/1980	5275966	14319	9136	11854	18595
1980/1981	5630220	12485	8318	10855	17491
1981/1982	3897456	10142	5597	9116	21170
1982/1983	2286666	7547	4009	6731	8840
1983/1984	1822397	4652	3405	4135	5991
1984/1985	609592	2842	1428	2379	3333
1985/1986	428076	1381	620	1164	1756
1986/1987	480198	1537	1101	1401	1028
1987/1988	903180	1630	2051	1576	1030
1988/1989	237868	1543	679	1487	652
1989/1990	239948	1772	667	1101	1218
1990/1991	1676791	3057	2890	1866	1742
1991/1992	1980317	3850	3782	2405	1985
1992/1993	1922884	4136	3508	2909	1784
1993/1994	1844170	3719	3662	2737	2586
1994/1995	1263447	4576	2683	3556	3568
1995/1996	3111858	4586	6271	3794	4781
1996/1997	1712015	4428	3334	3685	4184
1997/1998	1201296	3220	2384	2769	3267
1998/1999	938796	2408	2025	2094	2461
1999/2000	588718	2056	1393	1775	1987
2000/2001	725050	1696	1687	1430	2031
2001/2002	522239	1434	1289	1242	1537
2002/2003	225476	822	548	770	1506
2003/2004	228897	482	566	496	823
2004/2005	47905	392	86	407	517
2005/2006	91932	175	277	169	316
2006/2007	50638	228	122	199	376
2007/2008	100295	150	224	116	422
2008/2009	18256	272	37	138	438
2009/2010	248626	301	401	157	468
2010/2011	138787	395	286	237	341
2011/2012	165525	450	409	333	170
2012/2013	272233	559		434	81

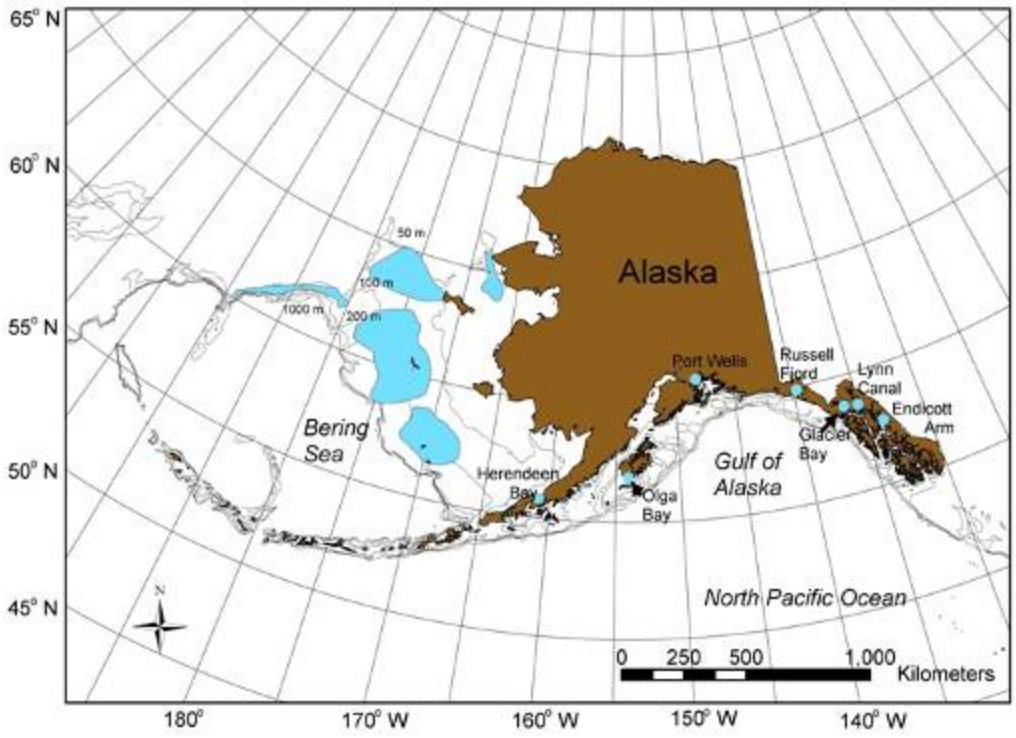

Figure 1. Distribution of blue king crab (*Paralithodes platypus*) in Alaskan waters.

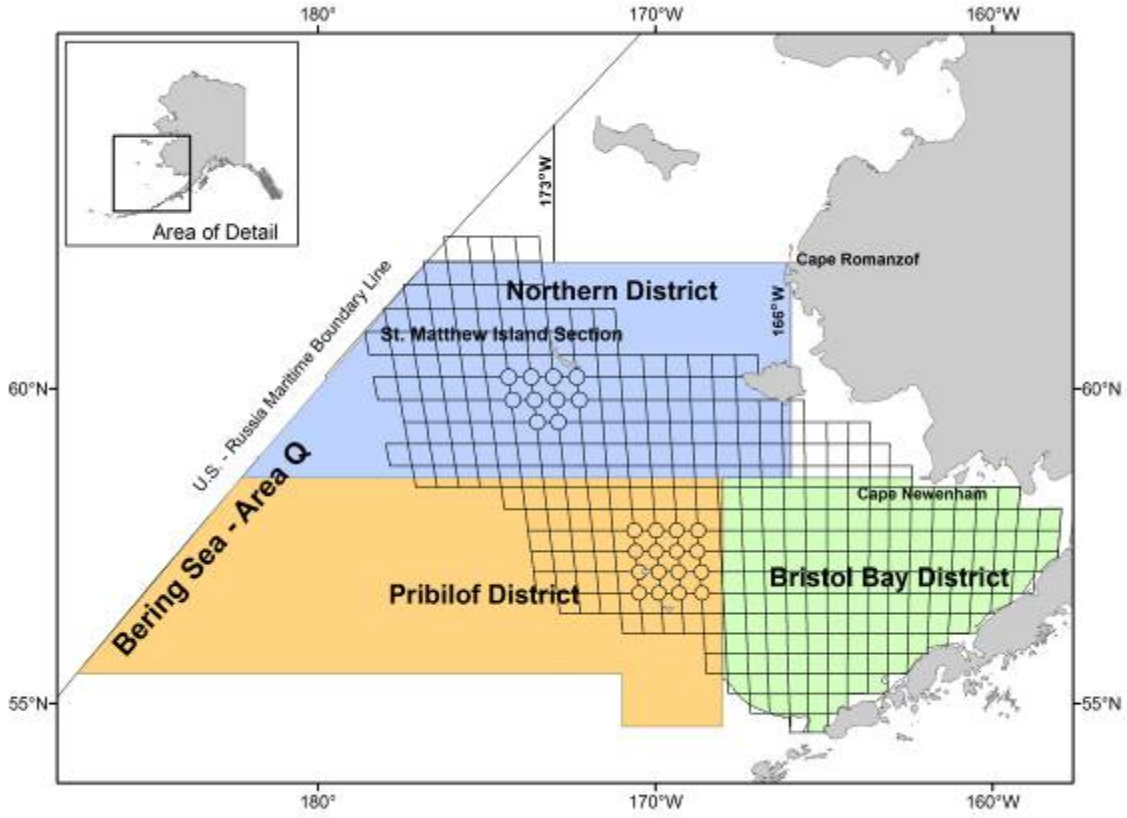

Figure 2. King crab Registration Area Q (Bering Sea) showing the Pribilof District. This figure does not show the additional 20 nm strip considered this year for biomass and catch data in the Pribilof District.

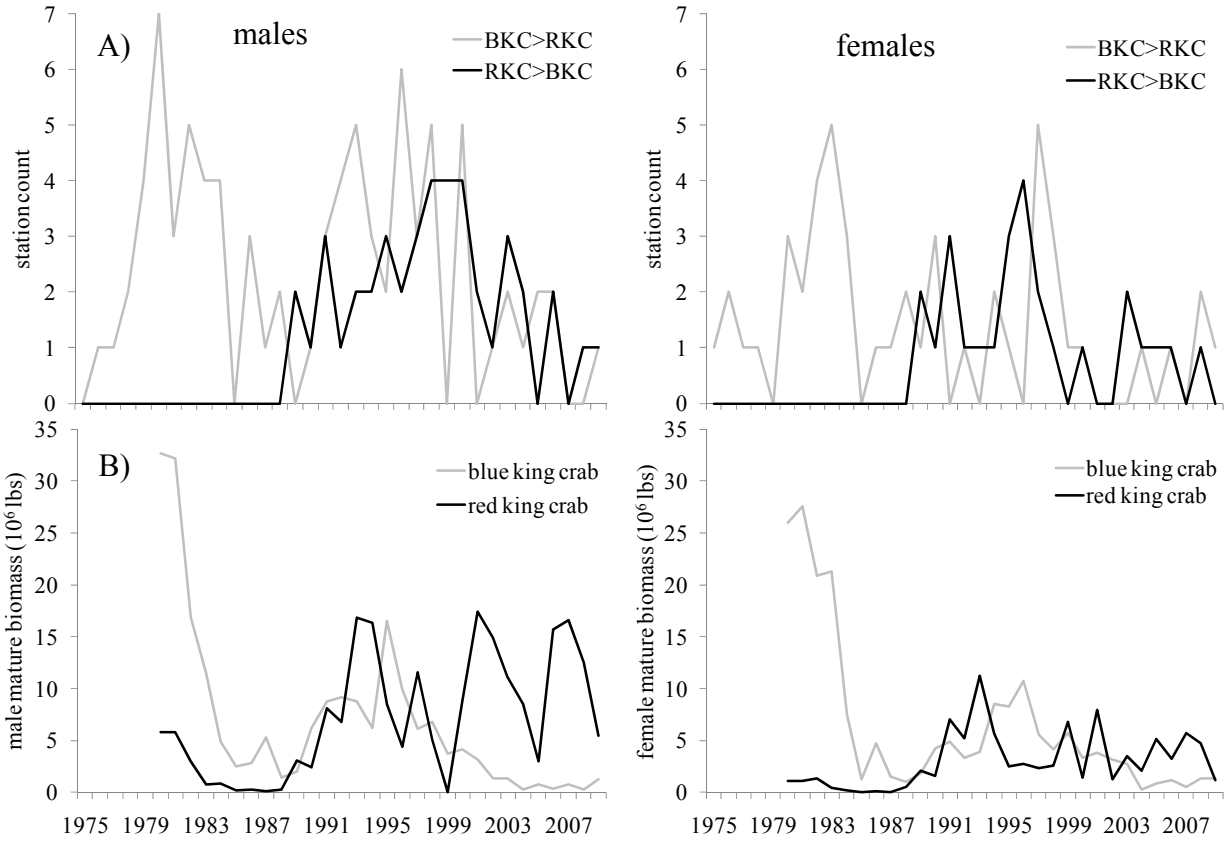

Figure 1. Time series of overlap between blue king crab and red king crab for males and females in the eastern Bering Sea showing A) the number of stations with blue king crab (BKC) or red king crab (RKC) as the dominant species and B) the mature biomass of both species.

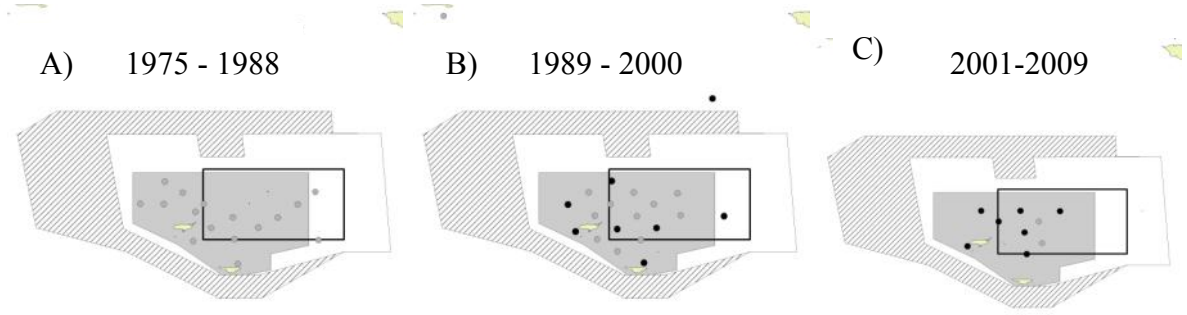

Figure 4. Spatial distribution of stations where there is overlap between blue king crab and red king crab males showing the dominant species (blue king crab=gray circles; red king crab=black circles) corresponding to time periods of major changes in biomass of both species.

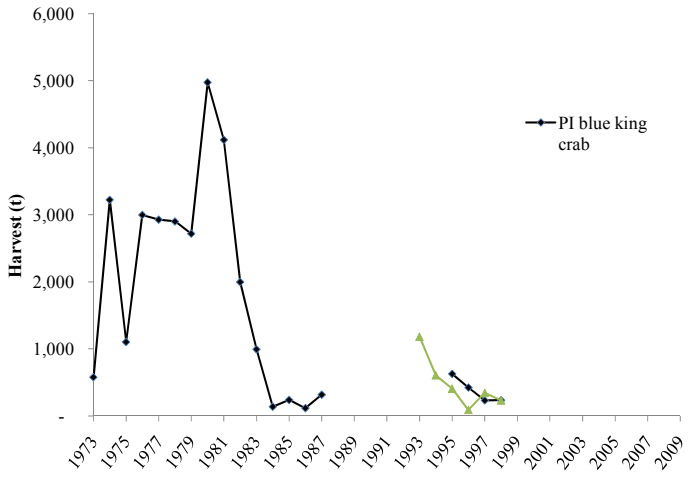

Figure 5. Historical harvests (t) and GHLs for Pribilof Island blue and red king crab (Bowers et al. 2011).

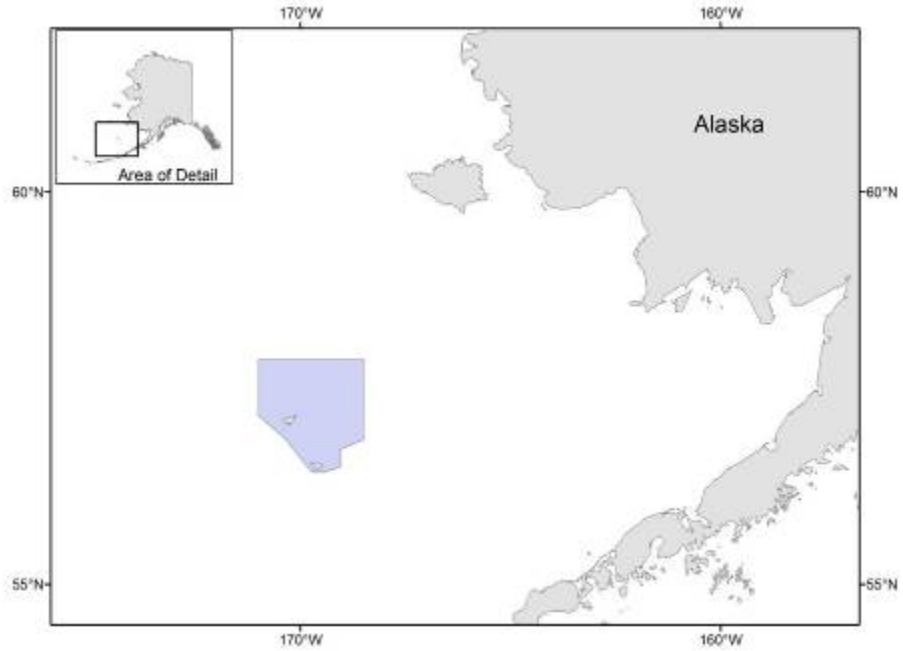

Figure 6. The shaded area shows the Pribilof Islands Habitat Conservation area. Trawl fishing is prohibited year-round in this zone.

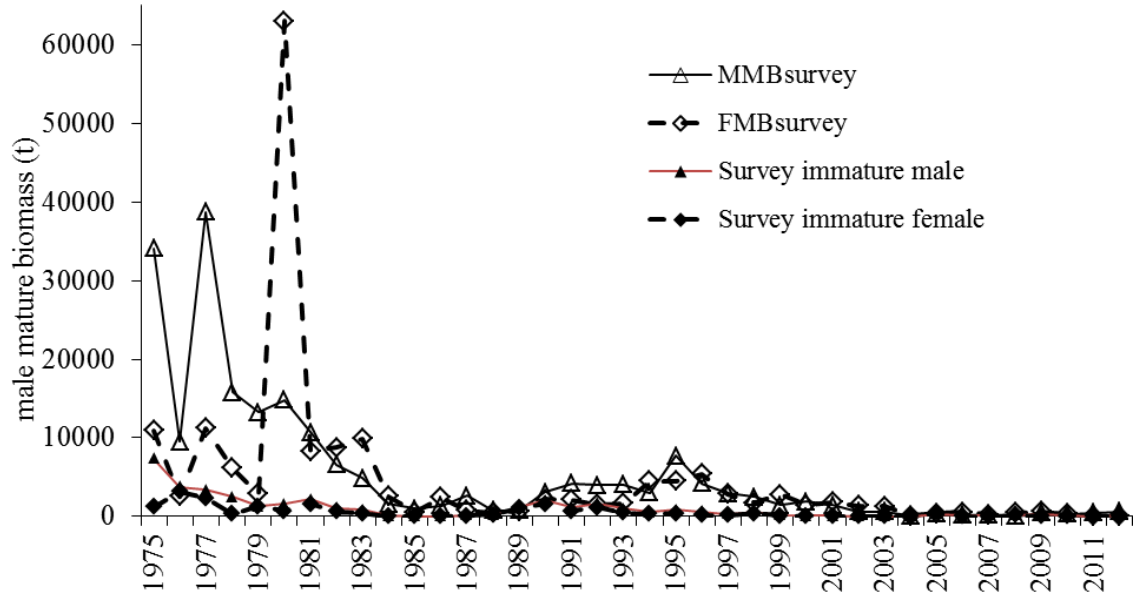

Figure 7. Time series of Pribilof Island blue king crab estimated from the NMFS annual EBS bottom trawl survey.

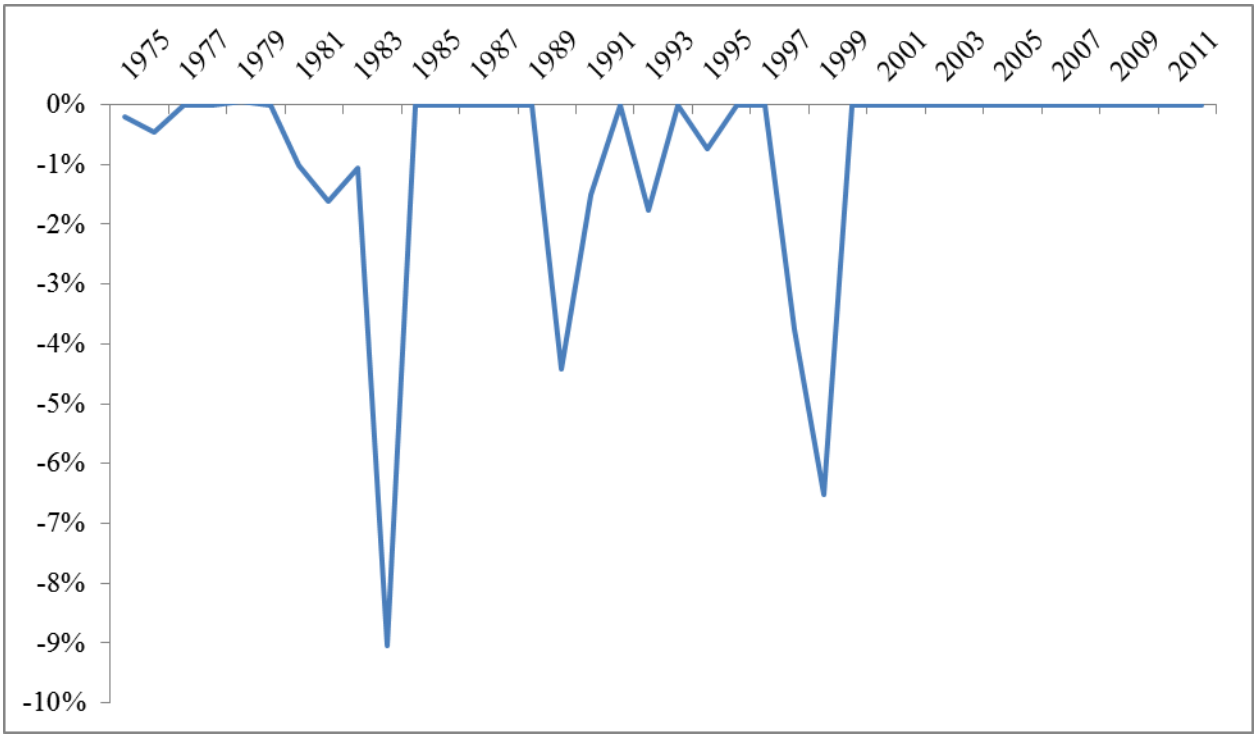

Figure 8. Percent change in MMB between the previous survey biomass estimate and the new estimate which includes an additional region 20 nm on the eastern edge of the Pribilof District.

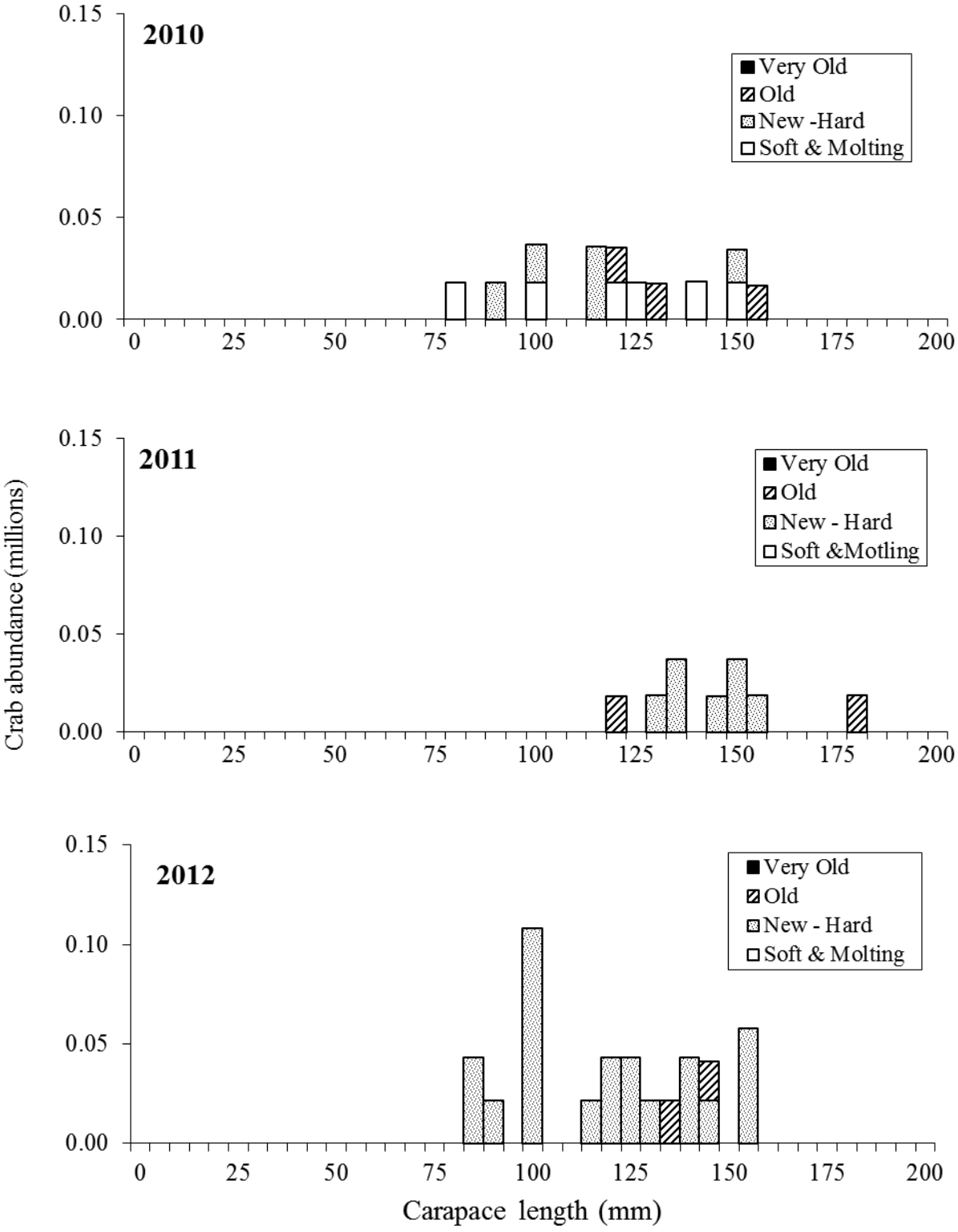

Figure 9. Distribution of Pribilof Island blue king crab in 5 mm length bins by shell condition for the last 3 surveys.

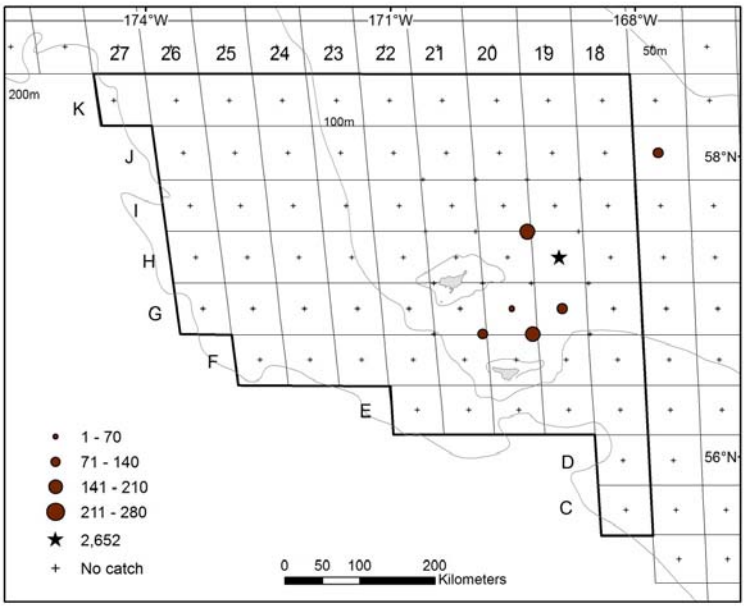

Figure 10. Total density (number/nm^2) of blue king crab in the Pribilof District in the 2012 EBS bottom trawl survey.

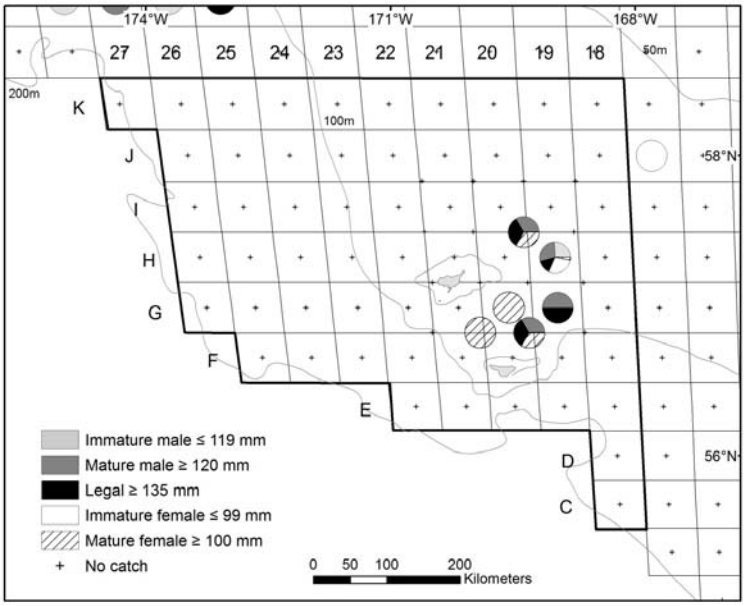

Figure 11. 2012 EBS bottom trawl survey size class distribution of blue king crab in the Pribilof District.

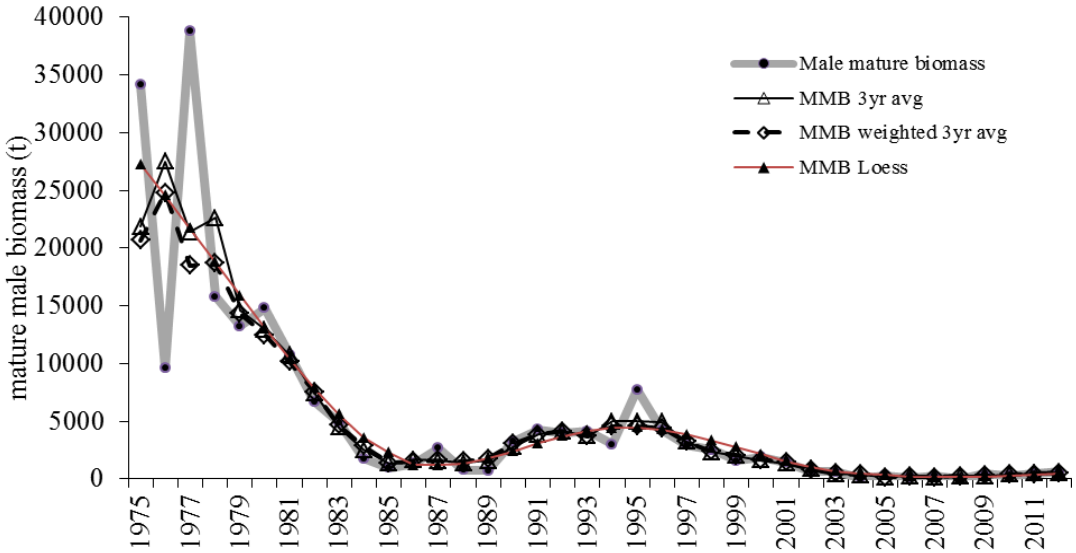

Figure 12. Time series comparison of MMB and the three year running average MMB at the time of the survey.

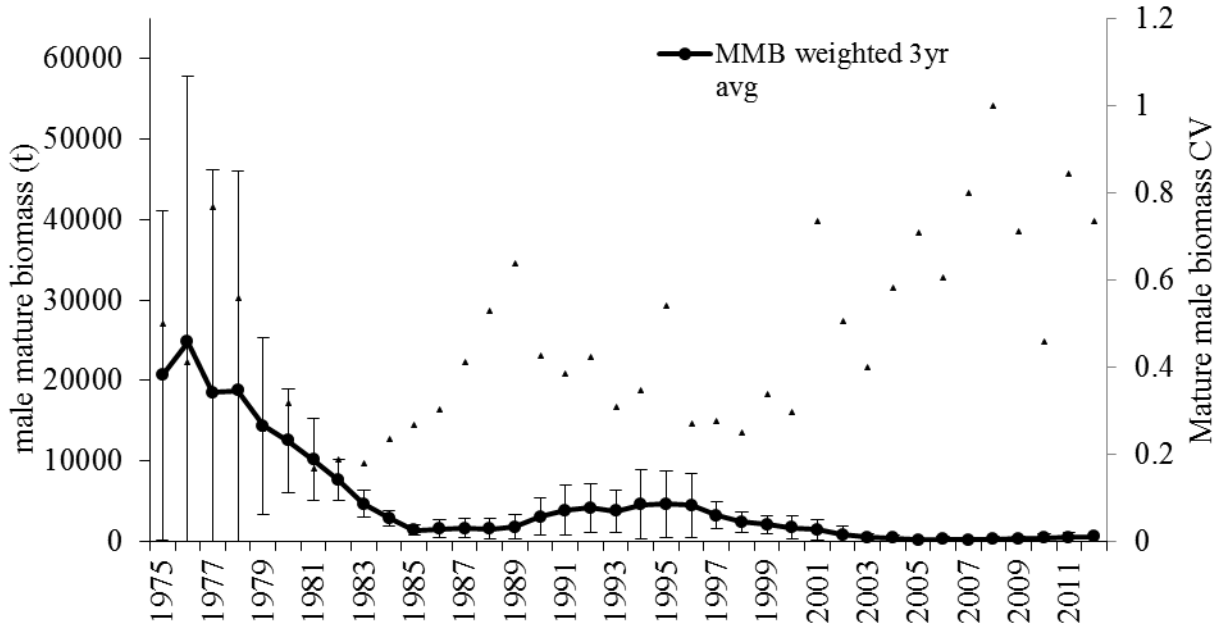

Figure 13. Time series of Pribilof Island blue king crab 3 year moving averaged mature male biomass (95% C.I.) and mature male biomass CV estimated from the NMFS annual EBS bottom trawl survey.

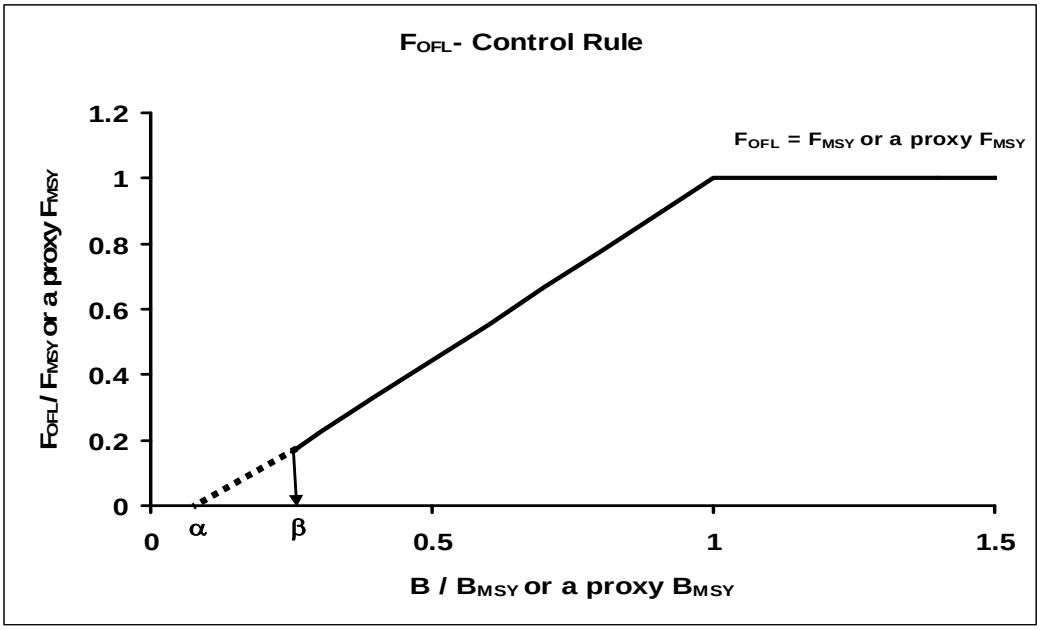

Figure 14. F_{OFL} Control Rule for Tier 4 stocks under Amendment 24 to the BSAI King and Tanner Crabs fishery management plan. Directed fishing mortality is set to 0 below β.

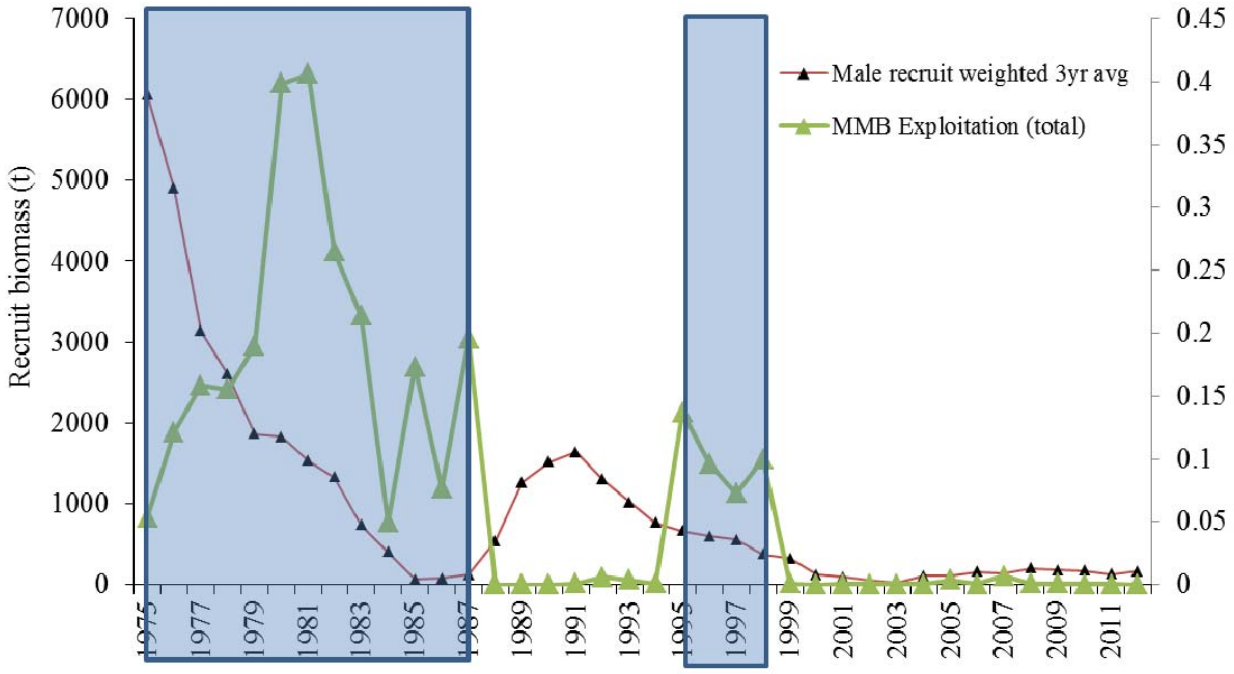

Figure 15. Time series of survey estimated recruit biomass (males 120-134 mm) and exploitation rate (based on total catch) of mature male biomass. The shaded region represents a period where commercial removals were occurring.

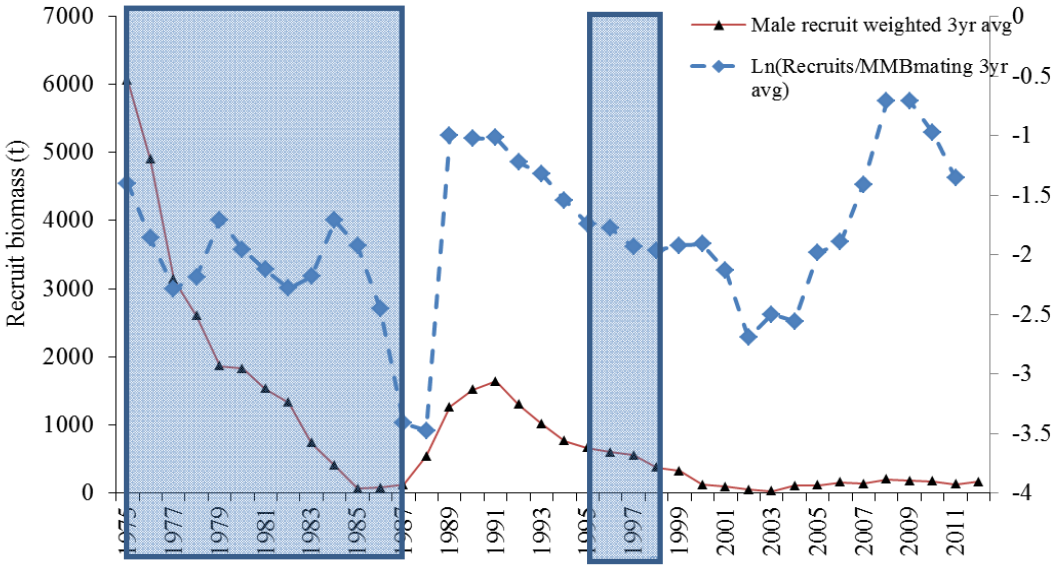

Figure 16. Time series of survey estimated recruit biomass (males 120-134 mm) and ln(Recruits/MMB). The shaded region represents a period where commercial removals were occurring.

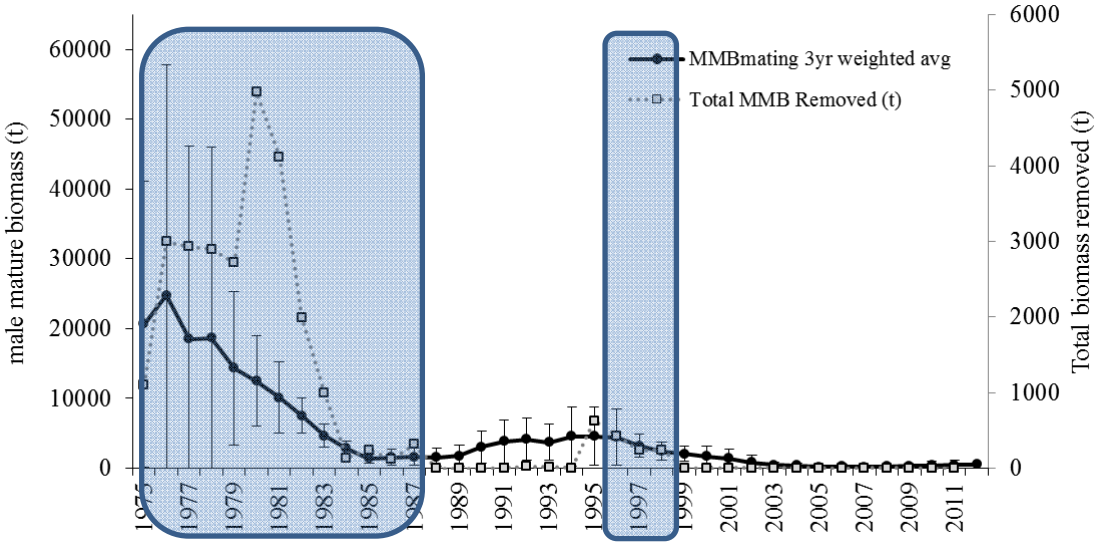

Figure 17. Time series of survey estimated Pribilof Island blue king crab 3 year moving averaged mature male biomass at mating (95% C.I.) and total catch removals.