

Pribilof Islands Golden King Crab

– 2014 Tier 5 Assessment

2014 Crab SAFE Report Chapter (September 2014)

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Executive Summary

1. **Stock:** Pribilof Islands (Pribilof District) golden king crab *Lithodes aequispinus*

2. **Catches:**

Commercial fishing for golden king crab in the Pribilof District has been concentrated in the Pribilof Canyon. The domestic fishery developed in the 1982/83 season, although some limited fishing occurred at least as early as 1981/82. Peak harvest occurred in the 1983/84 season with a retained catch of 0.856-million lb (388 t) by 50 vessels. The fishing season for this stock has been defined as a calendar year (as opposed to 1-July-to-30-June “crab fishery year”) following the close of the 1983/84 season and, since then, participation in the fishery has been sporadic and annually retained catch has been variable, from 0 lb in the nine years that no vessels participated (1984, 1986, 1990–1992, 2006–2009) up to a maximum of 0.342-million lb (155 t) in 1995, when seven vessels made landings. The fishery is not rationalized. There is no state harvest strategy in regulation. A guideline harvest level (GHL) was first established for the fishery in 1999 at 0.200-million lb (91 t) and has been managed with a GHL of 0.150-million lb (68 t) since 2000. No vessels participated in the directed fishery and no landings were made during 2006–2009. One vessel landed catch in 2010, two vessels landed catch in 2011, and one vessel landed catch in each of 2012 and 2013; catch and other fishery data from the directed fishery for those three years cannot be reported here under the confidentiality requirements of State of Alaska (SOA) statute Sec. 16.05.815. Non-retained bycatch occurs in the directed golden king crab fishery and can occur in the eastern Bering Sea snow crab fishery, the Bering Sea grooved Tanner crab fishery, and Bering Sea groundfish fisheries. Estimated annual weight of non-retained bycatch in directed and non-directed crab fisheries during calendar years 2001–2013 ranges from 0 lb to 0.049-million lb (22 t). Estimates of annual total fishery mortality during calendar years 2001–2013 due to crab fisheries range from 0 to 0.160-million lb (73 t), with an average of 0.072-million lb (33 t). Estimates of annually discarded bycatch during Bering Sea groundfish fisheries are reported for crab fishery years. Those estimates range from <0.001-million (<1 t) to 0.027-million lb (12 t) annually during the 1991/92–2012/13 crab fishery years. Estimates of annual fishery mortality during 1991/92–2012/13 due to groundfish fisheries range from <0.001-million lb (<1 t) to 0.019-million lb (9 t), with an average of 0.005-million lb (2 t).

3. **Stock biomass:**

Stock biomass (all sizes, both sexes) of golden king crab have been estimated for the Pribilof Canyon area using the area-swept technique applied to data obtained from the erstwhile biennial eastern Bering Sea upper continental slope trawl survey performed by NMFS-AFSC in 2002 (Hoff and Britt 2003), 2004 (Hoff and Britt 2005), 2008 (Hoff and Britt 2009), 2010

(Hoff and Britt 2011), and 2012 (Hoff 2013). Hoff (2013) estimated total stock biomass for the entire slope survey area in 2012 to be 4.475-million lb (2.030 t) and for the Pribilof Canyon area to be 1.716-million lb (778 t).

Complete data on size-sex composition of survey catch are available only from the 2008–2012 biennial surveys (C. Armistead, NMFS-AFSC, Kodiak). Biomass estimates by sex and size class from the 2008, 2010, and 2012 surveys were presented in a May 2013 (Gaeuman 2013b) report to the Crab Plan Team and biomass estimates of mature males from the 2008–2012 biennial surveys were presented in a September 2013 (Gaeuman 2013a) report to the Crab Plan Team. Using the size-sex composition data from the 2012 NMFS-AFSC eastern Bering Sea upper continental slope survey, Gaeuman (2013b) estimated total biomass for 2012 to be 4.244-million lb (1,925 t) for the entire survey area and 1.567-million lb (711 t) in the Pribilof Canyon area and Gaeuman (2013a) estimated mature male biomass for 2012 to be 1.790-million lb (812 t) for the entire survey area and 0.565-million lb (256 t) in the Pribilof Canyon area.

Sadly, the survey scheduled for 2014 was cancelled¹.

4. Recruitment:

Biomass of golden king crab (all sizes and both sexes) as estimated from data collected during the 2002–2012 biennial NMFS-AFSC eastern Bering Sea upper continental slope surveys increased in the entire slope survey area from 2.227-million lb (1,010 t) in 2002 (Hoff and Britt 2003) to 5.071-million lb (2,300 t) in 2010 (Hoff and Britt 2011); estimated biomass in the Pribilof Canyon area increased from 1.504-million lb (682 t) in 2002 to 3.560-million lb (1,615 t) in 2010. The estimate of total biomass for the entire survey area in 2012 is 88% of the 2010 estimate, however, and the estimate of total biomass for the Pribilof Canyon area in 2012 is 48% of the 2010 estimate (see **3. Stock biomass,** above).

Using the size-sex composition data from the surveys, Gaeuman (2013a) estimated mature male biomass in the entire survey area to have increased slightly from 1.692-million lb (767 t) in 2010 to 1.790-million lb (812 t) in 2012. However, estimated mature male biomass in the Pribilof canyon area was estimated to have decreased markedly from 0.970-million lb (440 t) in 2010 to 0.565-million lb (256 t) in 2012.

5. Management performance:

No overfished determination (i.e., MSST) has been made for this stock, although approaches to using data from the biennial NMFS-AFSC eastern Bering Sea upper continental slope surveys has been presented to and considered by the Crab Plan Team Gaeuman (2013a, 2013b). Overfishing did not occur during 2013; the estimated total catch did not exceed the OFL of 0.20-million lb (91 t). Total catch did not exceed the total-catch ABC of 0.18-million lb (82 t) that was established for the 2013 season. Retained catch and total-catch mortality in 2013 are confidential under the requirements of Sec. 16.05.815 (SOA statute). The 2014 season is currently ongoing. The 2015 OFL and ABC in the table below are the author's recommendations.

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https://www.fbo.gov/index?s=opportunity&mode=form&id=b3bb5ad289a0d04224c234acb57fe5aa&tab=core&_cview=1

Year ^a	MSST	Biomass (MMB)	GHL ^b	Retained Catch ^c	Total Catch ^{c,d}	OFL ^c	ABC ^c
2011	N/A	N/A	0.150	Conf. ^e	Conf. ^e	0.18	N/A
2012	N/A	N/A	0.150	Conf. ^e	Conf. ^e	0.20	0.18
2013	N/A	N/A	0.150	Conf. ^e	Conf. ^e	0.20	0.18
2014	N/A	N/A	0.150			0.20	0.18
2015	N/A	N/A				0.20	0.15

- Season is based on a calendar year.
- Guideline harvest level expressed in millions of lb.
- Millions of lb.
- Total retained catch plus estimated bycatch mortality during crab fisheries only. Bycatch mortality due to groundfish fisheries is not included here because available data are summarized by “crab fishery year” rather than calendar year; estimates of annual bycatch mortality during 1991/92–2012/13 groundfish fisheries are ≤ 0.019 -million lb, with an average of 0.005-million lb.
- Catch statistics are confidential under Sec. 16.05.815 (SOA statute): ≤ 2 vessels participated in each season.

Year ^a	MSST	Biomass (MMB)	GHL ^b	Retained Catch ^c	Total Catch ^{c,d}	OFL ^c	ABC ^c
2011	N/A	N/A	68	Conf. ^e	Conf. ^e	82	N/A
2012	N/A	N/A	68	Conf. ^e	Conf. ^e	91	82
2013	N/A	N/A	68	Conf. ^e	Conf. ^e	91	82
2014	N/A	N/A	68			91	82
2015	N/A	N/A				91	68

- Season is based on a calendar year.
- Guideline harvest level expressed in t.
- Metric tons.
- Total retained catch plus estimated bycatch mortality of discarded bycatch during crab fisheries only. Bycatch mortality due to groundfish fisheries is not included here because available data are summarized by “crab fishery year” rather than calendar year; estimates of annual bycatch mortality during 1991/92–2012/13 groundfish fisheries are ≤ 9 t, with an average of 2 t.
- Catch statistics are confidential under Sec. 16.05.815 (SOA statute): ≤ 2 vessels participated in each season.

6. Basis for the OFL and ABC: The values for 2015 are the author’s recommendation.

Year ^a	Tier	Years to define Average catch (OFL)	Natural Mortality ^d	Buffer
2011	5	1993–1998 ^b	0.18 yr ⁻¹	N/A
2012	5	1993–1998 ^c	0.18 yr ⁻¹	10%
2013	5	1993–1998 ^c	0.18 yr ⁻¹	10%
2014	5	1993–1998 ^c	0.18 yr ⁻¹	10%
2015	5	1993–1998 ^c	0.18 yr ⁻¹	25%

- Season is based on a calendar year.
- OFL was for total catch and was determined by the average of the annual retained catch for these years times a factor of 1.05 to account for the estimated bycatch mortality occurring in the directed fishery plus an estimate of the average annual bycatch mortality due to non-directed crab fisheries and groundfish fisheries for the period.
- OFL was for total catch and was determined by the average of the annual retained catch for these years times a factor of 1.052 to account for the estimated bycatch mortality occurring in the directed fishery plus an estimate of the average annual bycatch mortality due to non-directed crab fisheries and groundfish fisheries for the period.
- Assumed value for FMP king crab in NPFMC (2007); does not enter into OFL estimation for Tier 5 stock.

7. PDF of the OFL: Sampling distribution of the recommended Tier 5 OFL was estimated by bootstrapping. The standard deviation of the estimated sampling distribution of the recommended OFL (Alternative 1) is 0.510-million lb (CV = 0.25). See section G.1.

8. **Basis for the ABC recommendation:** A 25% buffer on the OFL, the default; i.e., $ABC = (1-0.25) \cdot OFL$. This is a data-poor stock.
9. **A summary of the results of any rebuilding analyses:** Not applicable; stock is not under a rebuilding plan.

A. Summary of Major Changes

1. **Changes to the management of the fishery:** None. Fishery continued into 2014 to be managed under authority of an ADF&G commissioner's permit and with a guideline harvest level (GHL) of 0.150-million lb (68 t). As of this writing, one vessel has fished in the 2014 season (J. Shaishnikoff, ADF&G, Dutch Harbor, 27 August 2014, *pers. comm.*).
2. **Changes to the input data:**
 - Retained catch and bycatch data have been updated with the results for the 2013 directed fishery, during which only one vessel participated in the fishery, rendering the catch data confidential under the requirements of Sec. 16.05.815 (SOA statute).
 - Bycatch estimates from other non-directed crab fisheries have been updated with data from 2013.
 - Bycatch estimates from groundfish fisheries have been updated with estimates for 2012/13 and new estimates for 2009/10–2011/12.
3. **Changes to the assessment methodology:** None. This assessment follows the methodology recommended by the CPT since May 2012 and the SSC since June 2012.
4. **Changes to the assessment results, including projected biomass, TAC/GHL, total catch (including discard mortality in all fisheries and retained catch), and OFL:**
 - The OFLs for 2009 and 2010 were both established as retained-catch OFLs of 0.17-million lb. The 2009 OFL was estimated by the average annual retained catch for the period 1993–1999, whereas the 2010 OFL was estimated by the average annual retained catch for the period 1993–1998; in 2009 the CPT and SSC recommended removing 1999 from the period for computing retained catch because 1999 was the first year that a GHL was established for the fishery.
 - The OFL for 2011 was established as a total-catch OFL of 0.18-million lb and was estimated as the average retained catch (including deadloss) for the period 1993–1998 times 1.05 plus 0.006-million lb; i.e.,

$$OFL_{\text{tot},2011} = 1.05 \cdot OFL_{\text{ret},1993-1998} + 0.006\text{-million lb.}$$

$OFL_{\text{ret},1993-1998}$ is the average annual retained catch in the directed fishery during 1993–1998. The factor of 1.05 was used to account for the crab bycatch mortality in the directed crab fishery and 0.006-million lb was used to account for the “background level” of bycatch mortality occurring in the groundfish and non-directed crab fisheries, estimated by the average annual bycatch mortality using data available; 2001–2005 for crab fisheries and 1991/92–2008/09 for groundfish fisheries.

- The OFLs for 2012–2014 were each a total-catch OFL of 0.20-million lb and were estimated using 1993–1998 to compute average annual retained catch, an estimate of lb of bycatch mortality per pound of retained catch during the directed fishery, an estimate of the average annual bycatch mortality due to non-directed crab fisheries

during 1994–1998 and an estimate of average annual bycatch mortality due to groundfish fisheries during 1992/93–1998/99; i.e.,

$$\text{OFL}_{2012-2014} = (1 + R_{2001-2010}) * \text{RET}_{1993-1998} + \text{BM}_{\text{NC},1994-1998} + \text{BM}_{\text{GF},1992/93-1998/99},$$

where,

- $R_{2001-2010}$ is the average of the estimated annual ratio of lb of bycatch mortality to lb of retained in the directed fishery during 2001–2010
 - $\text{RET}_{1993-1998}$ is the average annual retained catch in the directed crab fishery during 1993–1998
 - $\text{BM}_{\text{NC},1994-1998}$ is the estimated average annual bycatch mortality in non-directed crab fisheries during 1994–1998
 - $\text{BM}_{\text{GF},1992/93-1998/99}$ is the estimated average annual bycatch mortality in groundfish fisheries during 1992/93–1998/99.
- The recommended Tier 5 OFL for 2015 is a total-catch OFL of 0.20-million lb, estimated by the calculations given for the 2012–2014 OFLs.

B. Responses to SSC and CPT Comments

- **Responses to the most recent two sets of SSC and CPT comments on assessments in general (and relevant to this assessment):**
 - CPT, May 2014: *None.*
 - SSC, June 2014: *“The SSC recommends conducting a workshop to address procedures for assigning buffers for data-poor stocks.” ... “The outcome of such a workshop should clearly articulate the procedures and minimum requirements for establishing 10%, 20%, ..., X% buffers such that they can be consistently applied across a range of species and different stocks.”*
 - Response: The 25% buffer on the OFL that the author recommends using for setting the ABC is consistent with the buffer on OFL that the SSC recommended in June 2014 for the other unsurveyed golden king crab stock managed under the BSAI Crab FMP (i.e., Aleutian Islands golden king crab).
 - CPT, September 2013: *None.*
 - SSC, October 2013: *None.*
- **Responses to the most recent two sets of SSC and CPT comments specific to the assessment:**
 - CPT, May 2014: *None.*
 - SSC, June 2014: *None.*
 - CPT, September 2013: *“The CPT recommends that the author (of an alternative Tier 5 approach for setting OFL) include an update of this alternative approach in the spring 2014 assessment as an option to the average catch OFL procedure for consideration by the team prior to setting the 2014 OFL.”*
 - Response: Biennial EBS slope survey scheduled for 2014 was cancelled and the alternative approach anticipating the use of data from that survey was not updated.
 - SSC, October 2013: *“The OFL for 2014 was calculated as 90.7 t (0.20 million lb), and the ABC is based on a 10% buffer at 81.6 t (0.18 million lb). The SSC supports the CPT recommendation of a 10% buffer to set the ABC below the maximum permissible.”*

- Response: The author recommends the same Tier 5 OFL for 2015 as the SSC recommended for 2014, but departs from the SSC's recommendations for 2014 by recommending a 25% buffer to set the ABC in 2015.

C. Introduction

1. **Scientific name**: *Lithodes aequispinus* J. E. Benedict, 1895

2. **Description of general distribution**:

General distribution of golden king crab is summarized by NMFS (2004):

Golden king crab, also called brown king crab, range from Japan to British Columbia. In the BSAI, golden king crab are found at depths from 200 m to 1,000 m, generally in high-relief habitat such as inter-island passes (pages 3–34).

Golden, or brown, king crab occur from the Japan Sea to the northern Bering Sea (ca. 61° N latitude), around the Aleutian Islands, on various sea mounts, and as far south as northern British Columbia (Alice Arm) (Jewett et al. 1985). They are typically found on the continental slope at depths of 300–1,000 m on extremely rough bottom. They are frequently found on coral bottom (pages 3–43).

The Pribilof District is part of king crab Registration Area Q (Figure 1). Fitch et al. (2012, page 85) define those boundaries:

The Bering Sea king crab Registration Area Q 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 Point Hope (68° 21' 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. Area Q is divided into the Pribilof District, which includes waters south of Cape Newenham, and the Northern District, which incorporates all waters north of Cape Newenham.

Results of the 2002–2012 biennial NMFS-AFSC eastern Bering Sea continental slope trawl surveys show that the biomass, number, and density (in number per area and in weight per area) of golden king crab on the eastern Bering Sea continental slope are higher in the southern areas than in the northern areas (Gaeuman 2013a; Haaga et al. 2009; Hoff 2013; Hoff and Britt 2003, 2005, 2009, 2011). Of the six survey subareas (see Figure 1 in Hoff 2013), biomass and abundance of golden king crab were estimated through 2010 to be highest in the Pribilof Canyon area (survey subarea 2). Most of the commercial fishery catch for golden king crab is reported to occur in the Pribilof Canyon area (Fitch et al. 2012; Neufeld and Barnard 2003; Barnard and Burt 2004, 2006; Burt and Barnard 2005, 2006). However, biomass was estimated to have decreased between 2010 and 2012 in the Pribilof Canyon area and to have increased between 2010 and 2012 in the survey subarea 1 (the southernmost of the survey subareas), so that biomass in 2012 was estimated to be highest in survey subarea 1.

Results of the 2002–2012 biennial NMFS-AFSC eastern Bering Sea continental slope trawl surveys showed that a majority of golden king crab on the eastern Bering Sea continental slope occurred in the 200–400 m and 400–600 m depth ranges (Haaga et al. 2009; Hoff 2013;

Hoff and Britt 2003, 2005, 2009, 2011). Commercial fishing for golden king crab in the Bering Sea typically occurs at depths of 100–300 fathoms (183–549 m; Barnard and Burt 2004, 2006; Burt and Barnard 2005, 2006; Gaeuman 2011, 2013c; Neufeld and Barnard 2003); average depth of pots fished in the Pribilof District golden king crab fishery during the 2002 fishing season (the most recently prosecuted fishery for which fishery observer data are not confidential) was 214 fathoms (391 m).

3. **Evidence of stock structure:**

Although highest densities of golden king crab are found in the deep canyons of the eastern Bering Sea continental slope, golden king crab occur sporadically on the surveyed slope at locations between those canyons in the eastern Bering Sea (Hoff 2013; Hoff and Britt 2003, 2005, 2009, 2011; Gaeuman 2013b). Stock structure within the Pribilof District and the stock relationship of the golden king crab within the Pribilof District with the golden king crab outside of the Pribilof District have not been evaluated.

4. **Description of life history characteristics relevant to stock assessments (e.g., special features of reproductive biology):**

The following review of molt timing and reproductive cycle of golden king crab is adapted from Watson et al. (2002):

Unlike red king crab, golden king crab may have an asynchronous molting cycle (McBride et al. 1982, Otto and Cummiskey 1985, Sloan 1985, Blau and Pengilly 1994). In a sample of male golden king crab 95–155-mm CL and female golden king crab 104–157-mm CL collected from Prince William Sound and held in seawater tanks, Paul and Paul (2000) observed molting in every month of the year, although the highest frequency of molting occurred during May–October. Watson et al. (2002) estimated that only 50% of 139-mm CL male golden king crab in the eastern Aleutian Islands molt annually and that the intermolt period for males ≥ 150 -mm CL averages >1 year.

Female lithodids molt before copulation and egg extrusion (Nyblade 1987). From their observations on embryo development in golden king crab, Otto and Cummiskey's (1985) suggested that time between successive ovipositions was roughly twice that of embryo development and that spawning and molting of mature females occurs approximately every two years. Sloan (1985) also suggested a reproductive cycle >1 year with a protracted barren phase for female golden king crab. Data from tagging studies on female golden king crab in the Aleutian Islands are generally consistent with a molt period for mature females of 2 years or less and that females carry embryos for less than two years with a prolonged period in which they remain in barren condition (Watson et al 2002). From laboratory studies of golden king crab collected from Prince William Sound, Paul and Paul (2001b) estimated a 20-month reproductive cycle with a 12-month clutch brooding period.

Numerous observations on clutch and embryo condition of mature female golden king crab captured during surveys have been consistent with asynchronous, aseasonal reproduction (Otto and Cummiskey 1985, Hiramoto 1985, Sloan 1985, Somerton and Otto 1986, Blau and Pengilly 1994, Blau et al. 1998, Watson et al. 2002). Based on data from Japan (Hiramoto and Sato 1970), McBride et al. (1982) suggested that spawning of golden king crab in

the Bering Sea and Aleutian Islands occurs predominately during the summer and fall.

The success of asynchronous and aseasonal spawning of golden king crab may be facilitated by fully lecithotrophic larval development (i.e., the larvae can develop successfully to juvenile crab without eating; Shirley and Zhou 1997).

Current knowledge of reproductive biology and maturity of male and female golden king crab is also reviewed by Webb (2014).

Note that asynchronous, aseasonal molting and the prolonged intermolt period (>1 year) of mature female and the larger male golden king crab likely makes scoring shell conditions very difficult and especially difficult to relate to “time post-molt,” posing problems for inclusion of shell condition data into assessment models.

5. Brief summary of management history:

A complete summary of the management history through 2010 is provided in Fitch et al. (2012, pages 89–91).

The first domestic harvest of golden king crab in the Pribilof District was in 1982 when two vessels fished. Peak harvest and participation occurred in the 1983/84 season with a retained catch of 0.856-million lb landed by 50 vessels. Since 1984 the fishery has been managed with a calendar-year season under authority of a commissioner’s permit and landings and participation has been low and sporadic. Retained catch during 1984–2009 has ranged from 0 lb to 0.342-million lb and the number of vessels participating annually has ranged from 0 to 8; no vessels registered for the fishery and there was no retained catch in 2006–2009. One vessel fished in the 2010 season and two vessels fished in the 2011 season; catch statistics for those two seasons are confidential under Sec. 16.05.815 of SOA statutes. The fishery is not rationalized and has been managed inseason to a guideline harvest level (GHL) since 1999. The GHL for 1999 was 0.200-million lb, whereas the GHL for 2000-2012 has been 0.150-million lb.

A summary of relevant fishery regulations and management actions pertaining to the Pribilof District golden king crab fishery is provided below.

Only males of a minimum legal size may be retained. By State of Alaska regulation (**5 AAC 34.920 (a)**), the minimum legal size limit for Pribilof District golden king crab is 5.5-inches (140 mm) carapace width (CW), including spines. A carapace length (CL) \geq 124 mm is used to identify legal-size males when CW measurements are not available (Table 3-5 in NPFMC 2007). Golden king crab may be commercially fished only with king crab pots (as defined in 5 AAC 34.050). Pots used to fish for golden king crab in the Pribilof Islands must have at least four escape rings of no less than five and one-half inches inside diameter installed on the vertical plane or at least one-third of one vertical surface of the pot composed of not less than nine-inch stretched mesh webbing to permit escapement of undersized golden king crab (5 AAC 34.925 (c)) and the sidewall “...must contain an opening equal to or exceeding 18 inches in length... The opening must be laced, sewn, or secured together by a single length of untreated, 100 percent cotton twine, no larger than 30 thread.” (5 AAC 39.145(1)). There is a pot limit of 40 pots for vessels \leq 125-foot LOA and of 50 pots for vessels >125-foot LOA (5 AAC 34.925 (e)(1)(B)). Golden king crab can be harvested from 1 January through 31 December only under conditions of a permit issued by the commissioner of ADF&G (**5 AAC**

34.910 (b)(3). Since 2001 those conditions have included the carrying of a fisheries observer.

D. Data

1. Summary of new information:

1. Retained catch and estimated bycatch during the 2013 directed fishery (both of which are confidential), estimated bycatch in non-directed crab fisheries during 2013, and new estimates of bycatch in groundfish fisheries during the 2009/10–2012/13 crab fishery years have been added.

2. Data presented as time series:

a. Total catch and b. Information on bycatch and discards:

- The 1981/82–1983/84, 1984–2013 time series of retained catch (number and lb of crab harvested, including deadloss), effort (vessels, landings, and pot lifts), average weight of landed crab, average carapace length of landed crab, and CPUE (number of landed crab captured per pot lift) are presented in Table 1.
- The 1993–2013 time series of weight of retained catch, estimated bycatch and estimated weight of fishery mortality of Pribilof golden king crab during commercial crab fisheries are given in Table 2. Bycatch of Pribilof golden king crab occurs mainly in the directed golden king crab fishery, when prosecuted, and to a lesser extent in the Bering Sea snow crab fishery and the Bering Sea grooved Tanner crab fishery. Because the Bering Sea snow crab fishery is prosecuted mainly or entirely between January and May and the Bering Sea grooved Tanner crab fishery is prosecuted with a calendaryear season, bycatch for the crab fisheries can be estimated on a calendaryear basis to align with the season for Pribilof District golden king crab. Observer data on size distributions and estimated catch numbers of non-retained catch were used to estimate the weight of non-retained catch of golden king crab by applying a weight-at-length estimator (see below). Observers were first deployed to collect bycatch data during the Pribilof District golden king crab fishery in 2001 and during the Bering Sea grooved Tanner crab fishery in 1994. Retained catch or observer data are confidential for at least one of the crab fisheries in 1999–2001, 2003–2005, and 2010–2013. Following Siddeek et al. (2011), the bycatch mortality rate of golden king crab captured and discarded during Aleutian Islands golden king crab fishery was assumed to be 0.2. Following Foy (2013), bycatch mortality rate of king crab during the snow crab fishery was assumed to be 0.5. The bycatch mortality rate during the grooved Tanner crab fishery was also assumed to be 0.5.
- The groundfish fishery bycatch data were grouped into crab fishery years, rather than into calendar years. The 1991/92–2012/13 time series of estimated annual weight of bycatch and total fishery mortality of golden king crab during federal groundfish fisheries by gear type (combining pot and hook-and-line gear as a single “fixed gear” category and combining non-pelagic and pelagic trawl gear as a single “trawl” category) is provided in Table 3. Following Foy (2013), the bycatch mortality of king crab captured by fixed gear during groundfish fisheries was assumed to be 0.5 and of king crab captured by trawls during groundfish fisheries was assumed to be 0.8. Data from 1991/92–2008/09 are from federal reporting areas 513, 517, and 521, whereas the data from 2009/10–2012/13 (received 30 July 2014) are from the State statistical areas falling within the Pribilof district (see various attachments to 30 July 2014 email from R. Foy, NMFS-AFSC-Kodiak).

- c. **Catch-at-length:** Not used in a Tier 5 assessment; none are presented.

- d. **Survey biomass estimates:** Survey biomass estimates are not used in a Tier 5 assessment. However, see Gaeuman (2013a) for biomass estimates of mature male golden king crab using data from NMFS-AFSC eastern Bering Sea upper continental slope trawl survey.
- e. **Survey catch at length:** Survey catch at length data are not used in a Tier 5 assessment. However, see Gaeuman (2013b) and Hoff (2013) for size data composition by sex of golden king crab during Bering Sea upper continental slope trawl surveys.
- f. **Other data time series:** None.

3. Data which may be aggregated over time:

a. Growth-per-molt; frequency of molting, etc. (by sex and perhaps maturity state):

The author is not aware of data on growth per molt collected from golden king crab in the Pribilof District. Growth per molt of juvenile golden king crab, 2–35 mm CL, collected from Prince William Sound have been observed in a laboratory setting and equations describing the increase in CL and intermolt period were estimated from those observations (Paul and Paul 2001a); those results are not provided here. Growth per molt has also been estimated from golden king crab with CL ≥ 90 mm that were tagged in the Aleutian Islands and recovered during subsequent commercial fisheries (Watson et al. 2002); those results are not presented here because growth-per-molt information does not enter into a Tier 5 assessment.

See section C.4 for discussion of evidence that mature female and the larger male golden king crab exhibit asynchronous, aseasonal molting and a prolonged intermolt period (>1 year).

b. Weight-at length or weight-at-age (by sex):

Parameters (A and B) used for estimating weight (g) from carapace length (CL, mm) of male and female golden king crab according to the equation, $\text{Weight} = A \cdot \text{CL}^B$ (from Table 3-5, NPFMC 2007) are: A = 0.0002988 and B = 3.135 for males and A = 0.001424 and B = 2.781 for females; note that although the estimated parameters, A and B, are those estimated for ovigerous females, those parameters were used to estimate the weight of all females without regard to reproductive status. Estimated weights in grams were converted to lb by dividing by 453.6.

c. Natural mortality rate:

The default natural mortality rate assumed for king crab species by NPFMC (2007) is $M=0.18$. Note, however, natural mortality was not used for OFL estimation because this stock belongs to Tier 5.

4. Information on any data sources that were available, but were excluded from the assessment:

- Standardized bottom trawl surveys to assess the groundfish and invertebrate resources of the eastern Bering Sea (EBS) upper continental slope were performed in 2002, 2004, 2008, 2010, and 2012 (Hoff and Britt 2003, 2005, 2009, 2011; Haaga et al. 2009, Gaeuman 2013a, b). Data and analysed results from the 2008–2012 EBS upper continental slope surveys were presented in Gaeuman (2013a, b), but are not presented in this Tier 5 assessment.
- Data on the size and sex composition of retained catch and bycatch of Pribilof District golden king crab during the directed fishery and other crab fisheries are available but are not presented in this Tier 5 assessment.

E. Analytic Approach

1. History of modeling approaches for this stock:

Although Gaeuman (2013a, b) presented assessment-modelling approaches for this stock to the Crab Plan Team using data from the biennial NMFS EBS continental slope survey, this stock continues to be managed as a Tier 5 stock as recommended by NPFMC (2007) and by the CPT and SSC in 2008–2013.

2. Model Description: *Subsections a–i are not applicable to a Tier 5 sock.*

Only an OFL and ABC is estimated For Tier 5 stocks, where “the OFL represent[s] the average retained catch from a time period determined to be representative of the production potential of the stock” (NPFMC 2007). Although NPFMC (2007) defined the OFL in terms of the retained catch, total-catch OFLs may be considered for Tier 5 stocks for which non-target fishery removal data are available (Federal Register/Vol. 73, No. 116, 33926). The CPT (in May 2010) and the SSC (in June 2010) endorsed the use of a total-catch OFL to establish the OFL for this stock. This assessment recommends – and only considers – use of a total-catch OFL for 2015.

Additionally, NPFMC (2007) states that for estimating the OFL of Tier 5 stocks, “The time period selected for computing the average catch, hence the OFL, should be based on the best scientific information available and provide the required risk aversion for stock conservation and utilization goals.” Given that a total-catch OFL is to be used, alternative configurations for the Tier 5 model are limited to: 1) alternative time periods for computing the average total-catch mortality; and 2) alternative approaches for estimating the non-retained component of the total catch mortality during that period.

With regard to choosing from alternative time periods for computing average annual catch to compute the OFL, NPFMC (2007) suggested using the average retained catch over the years 1993 to 1999 as the estimated OFL for Pribilof Islands golden king crab. Years post-1984 were chosen based on an assumed 8-year lag between hatching and growth to legal size after the 1976/77 “regime shift”. With regard to excluding data from years 1985 to 1992 and years after 1999, NPFMC (2007) states, “The excluded years are from 1985 to 1992 and from 2000 to 2005 for Pribilof Islands golden king crab when the fishing effort was less than 10% of the average or the GHL was set below the previous average catch.” In 2008 the CPT and SSC endorsed the approach of estimating OFL as the average retained catch during 1993–1999 for setting a retained-catch OFL for 2009. However, in May 2009 the CPT setting a retained-catch OFL for 2010, but using the average retained catch during 1993–1998; 1999 was excluded because it was the first year that a preseason GHL was established for the fishery. In May 2010, the CPT established a total-catch OFL computed as a function of the average retained catch during 1993–1998, a ratio-based estimate of the bycatch mortality during the directed fishery of that period, and an estimate of the “background” bycatch mortality due to other fisheries. Other time periods, extending into years post-1999, had been considered for computing the average retained catch in the establishment of the 2009, 2010, 2011 OFLs, but those time periods were rejected by the CPT and the SSC. Hence the period for calculating the retained-catch portion of the Tier 5 total-catch OFL for this stock has been firmly established by the CPT and SSC at 1993–1998 (the CPT said “this freezes the time frame...”). For the 2012 and the 2013 OFLs, the CPT and SSC recommended the period 2001–2010 for calculating the ratio-based estimate of the bycatch mortality during the 1993–1998 directed fishery, the period 1994–1998 for calculating the estimated bycatch mortality due to non-

directed crab fisheries during 1993–1998, and the period 1992/93–1998/99 for calculating the estimated bycatch mortality due to groundfish fisheries during 1993–1998.

Two alternative approaches for determination of the 2013 OFL were presented to the CPT and SSC in May–June 2013. Alternative 1 was the status quo approach (i.e., the approach used to establish the 2012 total-catch OFL). Alternative 2 was the same as Alternative 1 except that it used updated bycatch data from crab fisheries in 2011. Alternative 2 was presented specifically to allow the CPT and the SSC to clarify whether the 2013 and subsequent OFLs should be computed using data collected after 2010, or if the time periods for data used to calculate the 2013 and subsequent OFLs should be “frozen” at the years used to calculate the 2012 OFL. The CPT and the SSC both recommended Alternative 1, clarifying that Tier 5 OFLs for future years should be computed using only data collected through 2010. Following that recommendation from CPT and the SSC, only one alternative for computing the 2014 Tier 5 OFL was presented (i.e., the Alternative 1 that was presented in 2013). The 2015 Tier 5 OFL recommended here is the same as for the 2014 Tier 5 OFL.

3. **Model Selection and Evaluation:**

a. **Description of alternative model configurations**

Alternative 1 (status quo and author’s recommendation). The recommended OFL is set as a total-catch OFL using 1993–1998 to compute average annual retained catch, an estimate of lb of bycatch mortality per pound of retained catch during the directed fishery, an estimate of the average annual bycatch mortality due to the non-directed crab fisheries during 1994–1998 and an estimate of average annual bycatch mortality due to the groundfish fisheries during 1992/93–1998/99; i.e.,

$$\text{OFL}_{1, 2015} = (1 + R_{2001-2010}) * \text{RET}_{1993-1998} + \text{BM}_{\text{NC}, 1994-1998} + \text{BM}_{\text{GF}, 92/93-98/99},$$

where,

- $R_{2001-2010}$ is the average of the estimated annual ratio of lb of bycatch mortality to lb of retained catch in the directed fishery during 2001–2010
- $\text{RET}_{1993-1998}$ is the average annual retained catch in the directed crab fishery during 1993–1998
- $\text{BM}_{\text{NC}, 1994-1998}$ is the estimated average annual bycatch mortality in non-directed crab fisheries during 1994–1998
- $\text{BM}_{\text{GF}, 92/93-98/99}$ is the estimated average annual bycatch mortality in groundfish fisheries during 1992/93–1998/99.

The average of the estimated annual ratio of lb of bycatch mortality to lb of retained in the directed fishery during 2001–2010 is used as a factor to estimate bycatch mortality in the directed fishery during 1993–1998 because, whereas there are no data on bycatch for the directed fishery during 1993–1998, there are such data from the directed fishery during 2001–2010 (excluding 2006–2009, when there was no fishery effort).

The estimated average annual bycatch mortality in non-directed fisheries during 1994–1998 is used to estimate the average annual bycatch mortality in non-directed fisheries during 1993–1998 because there are no bycatch data available for the non-directed fisheries during 1993.

The estimated average annual bycatch mortality in groundfish fisheries during 1992/93–1998/99 is used to estimate the average annual bycatch mortality in groundfish fisheries during 1993–1998 because 1992/93–1998/99 is the shortest time period of crab fishery years that encompasses calendar years 1993–1998.

Statistics on the data and estimates used to calculate $RET_{1993-1998}$, $R_{2001-2010}$, $BM_{NC,1994-1998}$, and $BM_{GF,93/94-98/99}$ are provided in Table 4; the column means in Table 4 are the calculated values of $RET_{1993-1998}$, $R_{2001-2010}$, $BM_{NC,1994-1998}$, and $BM_{GF,93/94-98/99}$. Using the calculated values of $RET_{1993-1998}$, $R_{2001-2010}$, $BM_{NC,1994-1998}$, and $BM_{GF,93/94-98/99}$, $OFL_{1,2015}$ is,

$$OFL_{1,2015} = (1+0.052)*173,722 + 13,418 + 8,353 = 204,611 \text{ lbs (0.20-million lbs).}$$

- b. **Show a progression of results from the previous assessment to the preferred base model by adding each new data source and each model modification in turn to enable the impacts of these changes to be assessed:** See the table, below.

Model	Retained- vs. Total-catch	Time Period	Resulting OFL (millions of lb)
Alt. 1 – recommended/status quo	Total-catch	1993–1998	0.20

Alternative 1 is recommended and is the status quo; it is recommended as being the best approach with the limited data available and follows the advice of the CPT and SSC to “freeze” the period for calculation of the OFL at the time period that was established for the 2012 OFL.

- c. **Evidence of search for balance between realistic (but possibly over-parameterized) and simpler (but not realistic) models:** See Section E, above.
- d. **Convergence status and convergence criteria for the base-case model (or proposed base-case model):** Not applicable.
- e. **Table (or plot) of the sample sizes assumed for the compositional data:** Not applicable.
- f. **Do parameter estimates for all models make sense, are they credible?:**
The time period used for determining the OFL was established by the SSC in June 2012. Estimates of total retained catch (lb) during a season are from fish tickets landings and are assumed here to be correct. Estimates of bycatch from crab fisheries data are generally considered credible (e.g., Byrne and Pengilly 1998, Gaeuman 2011, 2013c), but may have greater uncertainty in a small, low effort fishery such as the Pribilof golden king crab fishery. Estimates of bycatch mortality are estimates of bycatch times an assumed bycatch mortality rate. Bycatch mortality rates have not been estimated from data.
- g. **Description of criteria used to evaluate the model or to choose among alternative models, including the role (if any) of uncertainty:** See section E.3.c, above.

- h. Residual analysis (e.g. residual plots, time series plots of observed and predicted values or other approach): Not applicable.
- i. Evaluation of the model, if only one model is presented; or evaluation of alternative models and selection of final model, if more than one model is presented: See section E.3.c, above.
4. Results (best model(s)):
- a. List of effective sample sizes, the weighting factors applied when fitting the indices, and the weighting factors applied to any penalties: Not applicable.
- b. Tables of estimates (all quantities should be accompanied by confidence intervals or other statistical measures of uncertainty, unless infeasible; include estimates from previous SAFEs for retrospective comparisons): See Tables 2–5.
- c. Graphs of estimates (all quantities should be accompanied by confidence intervals or other statistical measures of uncertainty, unless infeasible): Information requested for this subsection is not applicable to a Tier 5 stock.
- d. Evaluation of the fit to the data: Not applicable for Tier 5 stock.
- e. Retrospective and historic analyses (retrospective analyses involve taking the “best” model and truncating the time-series of data on which the assessment is based; a historic analysis involves plotting the results from previous assessments): Not applicable for Tier 5 stock.
- f. Uncertainty and sensitivity analyses (this section should highlight unresolved problems and major uncertainties, along with any special issues that complicate scientific assessment, including questions about the best model, etc.): For this assessment, the major uncertainties are:
- Whether the time period is “representative of the production potential of the stock” and if it serves to “provide the required risk aversion for stock conservation and utilization goals.” Or whether any such time period exists.
 - Only a period of 6 years is used to compute the OFL, 1993–1998. The SSC has noted its uneasiness with that situation (“6 years of data are very few years upon which to base these catch specifications.” June 2011 SSC minutes).
 - No data on bycatch due to the directed fishery are available from the period used to compute the OFL. Estimation of the OFL rests on the assumption that data on the ratio of bycatch to retained catch during the post-2000 seasons can be used to accurately estimate that ratio for the 1993–1998 seasons.
 - The bycatch mortality rates used in estimation of total catch. Bycatch mortality is unknown and no data that could be used to estimate the bycatch mortality of this stock are known to the author. Hence, only the values that are assumed for other BSAI king crab stock assessments are considered in this assessment. The estimated OFL increases (or decreases) relative to the bycatch mortality rates assumed: doubling the assumed bycatch mortality rates increases the OFL estimate by a factor of 1.15; halving the assumed bycatch mortality rates decreases the OFL estimate by a factor of 0.92.

F. Calculation of the OFL

1. Specification of the Tier level and stock status level for computing the OFL:

- Recommended as Tier 5, total-catch OFL estimated by estimated average total catch over a specified period.
- Recommended time period for computing retained-catch OFL: 1993–1998.
 - This is the same time period that was used to establish OFL for the 2010–2014 seasons. The time period 1993–1998 provides the longest continuous time period through 2014 during which vessels participated in the fishery, retained-catch data can be retrieved that are not confidential, and the retained catch was not constrained by a GHL. Data on bycatch mortality contemporaneous with 1993-1998 to the extent possible are used to calculate the total-catch OFL in the recommended Alternative 1.

2. List of parameter and stock size estimates (or best available proxies thereof) required by limit and target control rules specified in the fishery management plan: Not applicable for Tier 5 stock.

3. Specification of the total-catch OFL:

a. Provide the equations (from Amendment 24) on which the OFL is to be based:

From **Federal Register** / Vol. 73, No. 116, page 33926, “For stocks in Tier 5, the overfishing level is specified in terms of an average catch value over an historical time period, unless the Scientific and Statistical Committee recommends an alternative value based on the best available scientific information.” Additionally, “For stocks where nontarget fishery removal data are available, catch includes all fishery removals, including retained catch and discard losses. Discard losses will be determined by multiplying the appropriate handling mortality rate by observer estimates of bycatch discards. For stocks where only retained catch information is available, the overfishing level is set for and compared to the retained catch” (FR/Vol. 73, No. 116, 33926). That compares with the specification of NPFMC (2007) that the OFL “represent[s] the average retained catch from a time period determined to be representative of the production potential of the stock.”

b. Basis for projecting MMB to the time of mating: Not applicable for Tier 5 stock.

- c. **Specification of F_{OFL} , OFL, and other applicable measures (if any) relevant to determining whether the stock is overfished or if overfishing is occurring:** See table below. Although the retained and total catch for 2013 cannot be presented here due to the confidentiality of data, the author can report that total catch in 2013 did not exceed the 2013 OFL. Values for the 2015 OFL and ABC are the author's recommendations.

Year ^a	MSST	Biomass (MMB)	GHL ^b	Retained Catch ^c	Total Catch ^{c,d}	OFL ^c	ABC ^c
2011	N/A	N/A	0.150	Conf. ^e	Conf. ^e	0.18	N/A
2012	N/A	N/A	0.150	Conf. ^e	Conf. ^e	0.20	0.18
2013	N/A	N/A	0.150	Conf. ^e	Conf. ^e	0.20	0.18
2014	N/A	N/A	0.150			0.20	0.18
2015	N/A	N/A				0.20	0.15

- a. Season is based on a calendar year.
 b. Guideline harvest level expressed in millions of lb.
 c. Millions of lb.
 d. Total retained catch plus estimated bycatch mortality during crab fisheries only. Bycatch mortality due to groundfish fisheries is not included here because available data are summarized by "crab fishery year" rather than calendar year; estimates of annual bycatch mortality during 1991/92–2010/11 groundfish fisheries are ≤ 0.019 -million lb, with an average of 0.006-million lb.
 e. Catch statistics are confidential under Sec. 16.05.815 (SOA statute): ≤ 2 vessels participated in each season.

Year ^a	MSST	Biomass (MMB)	GHL ^b	Retained Catch ^c	Total Catch ^{c,d}	OFL ^c	ABC ^c
2011	N/A	N/A	68	Conf. ^e	Conf. ^e	82	N/A
2012	N/A	N/A	68	Conf. ^e	Conf. ^e	91	82
2013	N/A	N/A	68	Conf. ^e	Conf. ^e	91	82
2014	N/A	N/A	68			91	82
2015	N/A	N/A				91	68

- a. Season is based on a calendar year.
 b. Guideline harvest level expressed in t.
 c. Metric tons.
 d. Total retained catch plus estimated bycatch mortality of discarded bycatch during crab fisheries only. Bycatch mortality due to groundfish fisheries is not included here because available data are summarized by "crab fishery year" rather than calendar year; estimates of annual bycatch mortality during 1991/92–2010/11 groundfish fisheries are ≤ 9 t, with an average of 3 t.
 e. Catch statistics are confidential under Sec. 16.05.815 (SOA statute): ≤ 2 vessels participated in each season.

4. Specification of the retained-catch portion of the total-catch OFL:

a. Equation for recommended retained-portion of total-catch OFL.

$$\begin{aligned} \text{Retained-catch portion} &= \text{average retained catch during 1993–1998} \\ &= 173,722 \text{ lb (0.17-million lb; 79 t)}. \end{aligned}$$

5. **Recommended F_{OFL} , OFL total catch and the retained portion for the coming year:**

See sections *F.3* and *F.4*, above; no F_{OFL} is recommended for a Tier 5 stock.

G. Calculation of ABC

1. **PDF of OFL.** A bootstrap estimates of the sampling distribution (assuming no error in estimation of bycatch) of the status quo Alternative 1 OFL is shown in Figure 2 (1,000 samples drawn with replacement independently from each of the four columns of values in Table 4 to calculate $R_{2001-2010}$, $RET_{1993-1998}$, $BM_{NC,1994-1998}$, $BM_{GF,92/93-98/99}$ and $OFL_{1,2014}$). Table 5 provides statistics on the generated distributions.

2. List of variables related to scientific uncertainty.

- Bycatch mortality rate in each fishery that bycatch occurs. Note that for Tier 5 stocks, an increase in an assumed bycatch rate will increase the OFL (and hence the ABC), but has no effect on the retained-catch portion of the OFL or the retained-catch portion of the ABC.
- Estimated bycatch and bycatch mortality for each fishery that bycatch occurred in during 1993–1998.
- The time period to compute the average catch under the assumption of representing “a time period determined to be representative of the production potential of the stock.”
- Stock size in 2015 is unknown.

3. List of additional uncertainties for alternative sigma-b. Not applicable to this Tier 5 assessment.

4. Author recommended ABC. 25% buffer on OFL; i.e., $ABC = (1-0.25) \cdot (204,612 \text{ lb}) = 0.15\text{-million lb (68 t)}$.

H. Rebuilding Analyses

Not applicable; this stock has not been declared overfished.

I. Data Gaps and Research Priorities

Data from the 2008–2012 biennial NMFS-AFSC eastern Bering Sea upper continental shelf trawl surveys have been examined for their utility in determining overfishing levels and stock status by Gaeuman (2103a, b). Cancellation of the survey that was scheduled for 2014 raises uncertainties on the prospects for obtaining fishery-independent survey data on this stock in the future.

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List of Tables.

Table 1: page 23. Harvest history for the Pribilof District golden king crab fishery from the 1981/82 season through 2013 (from 2013 SAFE, updated with 2013 data provided by J. Shaisnikoff, ADF&G, Kodiak via 27 September 2014 email).

Table 2: page 24. Weight (in lb) of retained catch and estimated non-retained bycatch of Pribilof golden king crab during crab fisheries, 1993–2013, with total fishery mortality estimated by assuming a bycatch mortality rate of 0.2 for the directed fishery and a bycatch mortality rate of 0.5 for non-directed fisheries (from 2013 Crab SAFE, with update for 2013 catch and bycatch data).

Table 3: page 25. Estimated annual weight (lb) of discarded bycatch of Pribilof golden king crab (all sizes, males and females) during federal groundfish fisheries by gear type (fixed or trawl), 1991/92–2012/13, with total bycatch mortality (lb) estimated by assuming bycatch mortality rate = 0.5 for fixed-gear fisheries and bycatch mortality rate = 0.8 for trawl fisheries (updated from 2013 SAFE with 2009/10–2012/13 data provided by R. Foy AFSC, Kodiak Laboratory via 30 July 2014 email).

Table 4: page 26. Data for calculation of $RET_{1993-1998}$ and estimates used in calculation of $R_{2001-2010}$, $BM_{NC,1994-1998}$, and $BM_{GF,92/93-98/99}$ for calculation of the Alternative 1 Pribilof Islands golden king crab Tier 5 2015 total-catch OFL; values under $RET_{1993-1998}$ are from Table 1, values under $R_{2001-2010}$ were computed from the retained catch data and the directed fishery bycatch estimates in Table 2 (assumed bycatch mortality rate = 0.2), values under $BM_{NC,1994-1998}$ were computed from the non-directed crab fishery bycatch estimates in Table 2 (assumed bycatch mortality rate = 0.5) and values under $BM_{GF,92/93-98/99}$ are from Table 3; from 2012 SAFE.

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Table 1. Harvest history for the Pribilof District golden king crab fishery from the 1981/82 season through 2013 (from 2013 SAFE, updated with 2013 data provided by J. Shaisnikoff, ADF&G, Kodiak via 27 September 2014 email).

Season	Number of				GHL ^b	Harvest ^{a,c}	Average			Deadloss ^c
	Vessels	Landings	Crabs ^a	Pots lifted			Weight ^c	CPUE ^d	Length ^e	
1981/82	2	CF	CF	CF	-	CF	CF	CF	CF	CF
1982/83	10	19	15,330	5,252	-	69,970	4.6	3	151	570
1983/84	50	115	253,162	26,035	-	856,475	3.4	10	127	20,041
1984	0	0	0	0	-	0	0	0	0	0
1985	1	CF	CF	CF	-	CF	CF	CF	CF	CF
1986	0	0	0	0	-	0	0	0	0	0
1987	1	CF	CF	CF	-	CF	CF	CF	CF	CF
1988	2	CF	CF	CF	-	CF	CF	CF	CF	CF
1989	2	CF	CF	CF	-	CF	CF	CF	CF	CF
1990	0	0	0	0	-	0	0	0	0	0
1991	0	0	0	0	-	0	0	0	0	0
1992	0	0	0	0	-	0	0	0	0	0
1993	5	15	17,643	15,395	-	67,458	3.8	1	NA	0
1994	3	5	21,477	1,845	-	88,985	4.1	12	NA	730
1995	7	22	82,489	9,551	-	341,908	4.1	9	NA	716
1996	6	32	91,947	9,952	-	329,009	3.6	9	NA	3,570
1997	7	23	43,305	4,673	-	179,249	4.1	9	NA	5,554
1998	3	9	9,205	1,530	-	35,722	3.9	6	NA	474
1999	3	9	44,098	2,995	200,000	177,108	4.0	15	NA	319
2000	7	19	29,145	5,450	150,000	127,217	4.4	5	NA	4,599
2001	6	14	33,723	4,262	150,000	145,876	4.3	8	143	8,227
2002	8	20	34,860	5,279	150,000	150,434	4.3	6	144	8,984
2003	3	CF	CF	CF	150,000	CF	CF	CF	CF	CF
2004	5	CF	CF	CF	150,000	CF	CF	CF	CF	CF
2005	4	CF	CF	CF	150,000	CF	CF	CF	CF	CF
2006-2009	0	0	0	0	150,000	0	0	0	0	0
2010	1	CF	CF	CF	150,000	CF	CF	CF	CF	CF
2011	2	CF	CF	CF	150,000	CF	CF	CF	CF	CF
2012	1	CF	CF	CF	150,000	CF	CF	CF	CF	CF
2013	1	CF	CF	CF	150,000	CF	CF	CF	CF	CF

Note: CF = confidential, less than three vessels or processors participated in fishery

^a Deadloss included.

^b Guideline harvest level (lb).

^c lb.

^d Number of legal crab per pot lift.

^e Carapace length in millimeters.

Table 2. Weight (in lb) of retained catch and estimated non-retained bycatch of Pribilof golden king crab during crab fisheries, 1993–2013, with total fishery mortality estimated by assuming a bycatch mortality rate of 0.2 for the directed fishery and a bycatch mortality rate of 0.5 for non-directed fisheries (from 2013 Crab SAFE, with update for 2013 catch and bycatch data).

Year	Retained Catch (lb)	Bycatch in crab fisheries (lb; no mortality rate applied)			Total Mortality (lb)
		Pribilof Islands golden king crab	Bering Sea snow crab	Bering Sea grooved Tanner crab	
1993	67,458	no data	0	no data	—
1994	88,985	no data	8,387	2,531	—
1995	341,908	no data	1,391	34,492	—
1996	329,009	no data	526	5,151	—
1997	179,249	no data	8,937	no fishing	—
1998	35,722	no data	72,760	no fishing	—
1999	177,108	no data	0	confidential	—
2000	127,217	no data	0	confidential	—
2001	145,876	39,278	0	confidential	confidential
2002	150,434	41,894	2,335	no fishing	159,980
2003	confidential	confidential	329	confidential	159,184
2004	confidential	confidential	0	confidential	147,552
2005	confidential	confidential	0	confidential	65,817
2006	no fishing	no fishing	0	0	0
2007	no fishing	no fishing	0	0	0
2008	no fishing	no fishing	0	no fishing	0
2009	no fishing	no fishing	2,122 ^a	no fishing	1,061 ^a
2010	confidential	confidential	0	no fishing	confidential
2011	confidential	confidential	591 ^b	no fishing	confidential
2012	confidential	confidential	598 ^c	no fishing	confidential
2013	confidential	confidential	1,284 ^d	no fishing	confidential

- a. Only 5 golden king crab (1 sublegal male and 4 legal males) were counted in 1,657 pot lifts sampled out of the 163,536 pot lifts performed during the 2008/09 Bering Sea snow crab fishery (including waters north of the Pribilof District; Gaeuman 2010), but none of those were measured to provide an estimate of weight. Bycatch weight was estimated by $(4.3) \times (5) \times (163,536) / (1,657)$; the assumed average weight per crab (4.3 lb) is the average weight of landed golden king crab during the 2002 Pribilof District golden king crab fishery.
- b. Only 2 golden king crab (1 sublegal male and 1 legal male) were counted in 2,142 pot lifts sampled out of the 147,244 pot lifts performed during the 2010/11 Bering Sea snow crab fishery (including waters north of the Pribilof District; Gaeuman 2011), but none of those were measured to provide an estimate of weight. Bycatch weight was estimated by $4.3 \times (2 \times 147,244) / 2,142$; the assumed average weight per crab (4.3 lb) is the average weight of landed golden king crab during the 2002 Pribilof District golden king crab fishery.
- c. A single 156 mm CL legal male golden king crab occurred in the 2,235 pot lifts sampled out of the 270,602 pot lifts performed during the 2011/12 Bering Sea snow crab fishery (including waters north of the Pribilof District; Gaeuman 2013c). Total bycatch weight was estimated by $(4.9) \times (270,602) / (2,235)$, where 4.9 is the average weight (lb) of a 156 mm CL male golden king crab estimated by the weight-at-length estimator (Section D.3.b).
- d. Only 2 sublegal and 1 legal male golden king crab of unknown sizes were counted in the 2,348 pot lifts sampled within the Pribilof District and within calendar year 2013 during the 2012/13 Bering Sea snow crab fishery; no golden king crab occurred in pot lifts sampled during the 2013/14 snow crab season prior to 1 Jan 2014. During the 2012/13 snow crab season, 216,580 pot lifts were recorded within the Pribilof District. The author assumed a very generous average weight of 4.64 lb for the 3 captured golden king crab males. You do the math.

Table 3. Estimated annual weight (lb) of discarded bycatch of Pribilof golden king crab (all sizes, males and females) during federal groundfish fisheries by gear type (fixed or trawl), 1991/92–2012/13, with total bycatch mortality (lb) estimated by assuming bycatch mortality rate = 0.5 for fixed-gear fisheries and bycatch mortality rate = 0.8 for trawl fisheries (updated from 2013 SAFE with 2009/10–2012/13 data provided by R. Foy AFSC, Kodiak Laboratory via 30 July 2014 email).

Season	Bycatch in groundfish fisheries (lb; no mortality rate applied)			Total
	Fixed	Trawl	Total	Mortality (lb)
1991/92	110	13,464	13,574	10,826
1992/93	7,690	19,544	27,234	19,480
1993/94	1,116	21,248	22,364	17,556
1994/95	558	7,103	7,661	5,962
1995/96	895	4,187	5,082	3,797
1996/97	53	1,918	1,971	1,561
1997/98	2,952	1,074	4,026	2,335
1998/99	14,930	395	15,324	7,781
1999/00	10,556	1,426	11,982	6,419
2000/01	3,589	4,134	7,723	5,101
2001/02	3,300	783	4,083	2,276
2002/03	1,219	472	1,691	987
2003/04	503	401	904	572
2004/05	342	860	1,202	859
2005/06	198	126	324	200
2006/07	2,915	254	3,168	1,660
2007/08	18,678	351	19,028	9,619
2008/09	8,799	3,433	12,231	7,145
2009/10	5,299	2,573	7,873	4,708
2010/11	1,431	2,070	3,501	2,372
2011/12	1,614	2,502	4,117	2,809
2012/13	1,549	1,929	3,478	2,318
Average	3,690	4,425	8,116	5,385

Table 4. Data for calculation of $RET_{1993-1998}$ and estimates used in calculation of $R_{2001-2010}$, $BM_{NC,1994-1998}$, and $BM_{GF,92/93-98/99}$ for calculation of the Alternative 1 Pribilof Islands golden king crab Tier 5 2015 total-catch OFL; values under $RET_{1993-1998}$ are from Table 1, values under $R_{2001-2010}$ were computed from the retained catch data and the directed fishery bycatch estimates in Table 2 (assumed bycatch mortality rate = 0.2), values under $BM_{NC,1994-1998}$ were computed from the non-directed crab fishery bycatch estimates in Table 2 (assumed bycatch mortality rate = 0.5) and values under $BM_{GF,92/93-98/99}$ are from Table 3; from 2012 SAFE.

Season ^a	Season ^b	$RET_{1993-1998}$	$R_{2001-2010}$	$BM_{NC,1994-1998}$	$BM_{GF,92/93-98/99}$
1993	1992/93	67,458			19,480
1994	1993/94	88,985		5,459	17,556
1995	1994/95	341,908		17,941	5,962
1996	1995/96	329,009		2,839	3,797
1997	1996/97	179,249		4,469	1,561
1998	1997/98	35,722		36,380	2,335
1999	1998/99				7,781
2000	1999/00				
2001	2000/01		0.054		
2002	2001/02		0.056		
2003	2002/03		conf.		
2004	2003/04		conf.		
2005	2004/05		conf.		
2006	2005/06				
2007	2006/07				
2008	2007/08				
2009	2008/09				
2010	2009/10		conf.		
	N	6	6	5	7
	Mean	173,722	0.052	13,418	8,353
	S.E.M	54,756	0.004	6,337	2,750
	CV	0.32	0.07	0.47	0.33

a. Season convention corresponding with values under $RET_{1993-1998}$, $R_{2001-2010}$, and $BM_{NC,1994-1998}$.

b. Season convention corresponding with values under $BM_{GF,92/93-98/99}$.

Table 5. Statistics for 1,000 bootstrap 2015 OFL for Pribilof Islands golden king crab stock calculated according to Alternatives 1 with the computed OFL for comparison.

	Alternative 1 OFL
Computed OFL	204,611
Mean of 1,000 bootstrapped OFLs	203,870
Std. dev. of 1,000 bootstrapped OFLs	51,030
CV = (std. dev.)/(Mean)	0.25

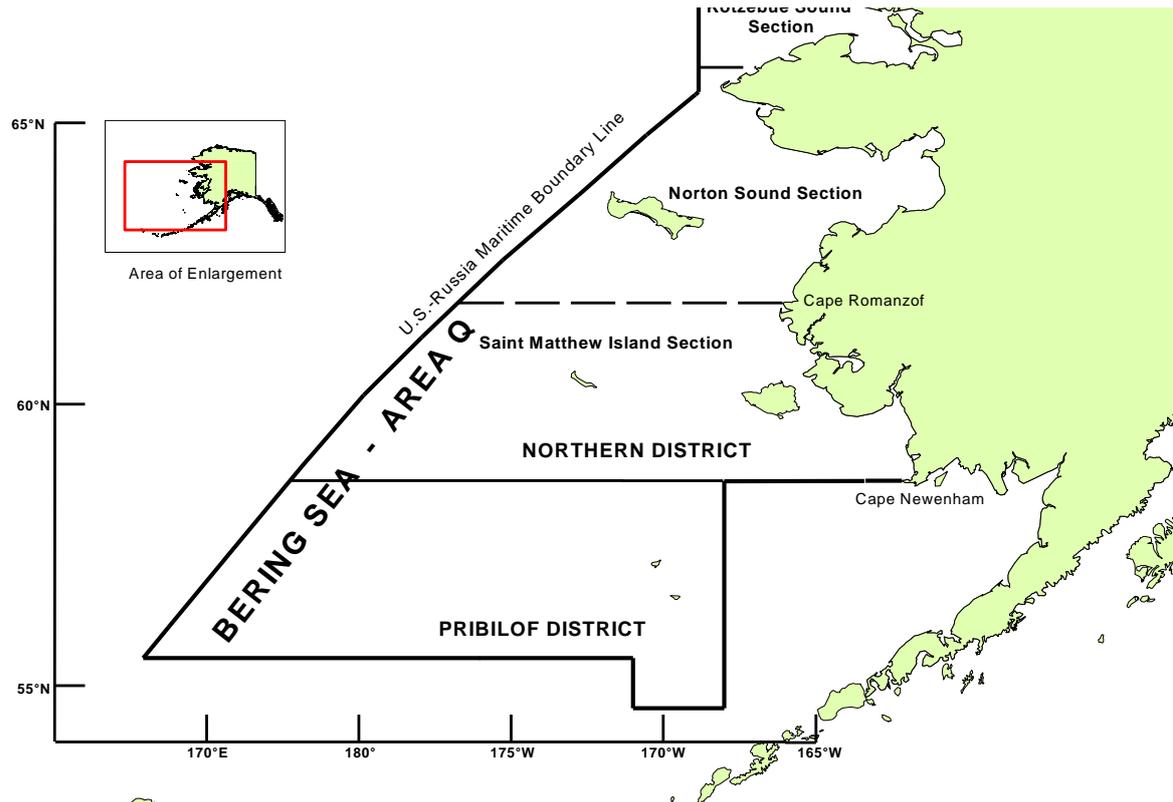


Figure 1. King crab Registration Area Q (Bering Sea), showing borders of the Pribilof District (from Figure 2-4 in Fitch et al. 2012).

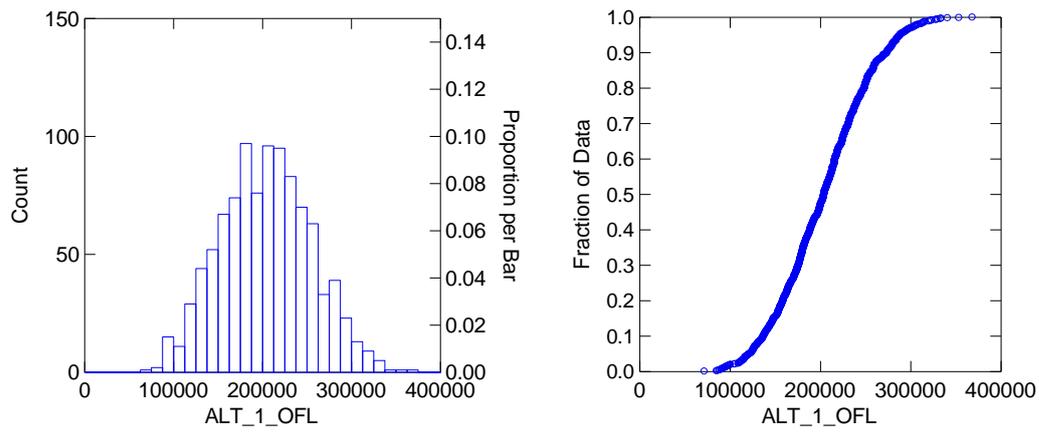


Figure 2. Bootstrapped estimates of the sampling distribution of the Alternative 1 2015 Tier 5 OFLs (lb of total catch) for the Pribilof Islands golden king crab stock; histograms in left column, quantile plots in right column.