

Aleutian Islands Golden King Crab – 2015 Tier 5 Assessment

2015 Crab SAFE Report Chapter (May 2015 Draft)

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Executive Summary

1. **Stock:** Aleutian Islands golden king crab *Lithodes aequispinus*

2. **Catches:**

The fishery has been prosecuted as a directed fishery since the 1981/82 season and has been open every season since then. Retained catch peaked during the 1985/86–1989/90 seasons (average annual retained catch = 11.876-million lb, 5,387 t), but the retained catch dropped sharply from the 1989/90 to 1990/91 season and average annual retained catch for the period 1990/91–1995/96 was 6.931-million lb (3,144 t). A guideline harvest level (GHL) was introduced into management for the first time in the 1996/97 season. A GHL of 5.900-million lb (2,676 t) was established in the 1996/97 and subsequently reduced to 5.700-million lb (2,585 t) beginning with the 1998/99 season. The GHL (or, since the 2005/06 season, the total allowable catch, or TAC) remained at 5.700-million lb (2,585 t) through the 2007/08 season, but was increased to 5.985-million lb (2,715 t) for 2008/09–2011/12 seasons and increased to 6.290-million lb (2,853 t) for the 2012/13 and 2013/14 seasons. Average annual retained catch for the period 1996/97–2007/08 was 5.623-million lb (2,550 t). Average annual retained catch in 2008/09–2012/13 was 5.959-million lb (2,703 t). The TAC for the 2012/13 season was 6.290-million lb (2,853 t) and the landed harvest was 6,268-million lb (2,843 t). Catch per pot lift of retained legal males decreased from the 1980s into the mid-1990s, but increased steadily following the 1994/95 season and increased markedly at the initiation of the Crab Rationalization program in the 2005/06 season. Non-retained bycatch occurs mainly during the directed fishery. Although minor levels of bycatch can occur during other crab fisheries, there have been no such fisheries prosecuted since 2004/05, except as surveys for red king crab conducted by industry under a commissioner’s permit. Bycatch also occurs during fixed-gear and trawl groundfish fisheries. Although bycatch during groundfish fisheries exceeded 0.100-million lb (45 t) for the first time during the 2007/08 and 2008/09 seasons, that bycatch was less than 10% of the weight of bycatch during the directed fishery for those seasons. Estimated bycatch of golden king crab in groundfish fisheries during 2009/10–2012/13 was \leq 0.066-million lb (30 t). Annual non-retained catch (i.e., discarded bycatch) of golden king crab during crab fisheries has decreased relative to the retained catch and in absolute numbers and weight since the 1990s. Annual estimated weight of discarded bycatch during crab fisheries decreased from 13.824-million lb (6,270 t) in 1990/91 (equivalent to 199% of the retained catch during that season), to 9.100-million lb (4,128 t) in 1996/97 (equivalent to 156% of the retained catch for that season), and to 4.321-million lb (1,960 t) in the 2004/05 season (equivalent to 78% of the retained catch for that season). During the nine seasons (2005/06–2013/14) since fishery rationalization, estimated weight of discarded bycatch during crab fisheries has ranged from 2.524-million lb (1,145 t) for the

2005/06 season (equivalent to 46% of the retained catch for that season) to 3.165-million lb (1,436 t) for the 2013/14 season (representing 50% of the retained catch for that season). Estimates of the annual weight of bycatch mortality have correspondingly decreased since 1996/97, both in absolute value and relative to the retained catch weight. Estimated total fishery mortality (retained catch plus estimated bycatch mortality during crab and groundfish fisheries) has ranged from 5.816-million lb (2,638 t) to 9.375-million lb (4,252 t) during 1995/96–2013/14; estimated total fishery mortality for 2013/14 was 7.037-million lb (3,192 t). In addition to the catch of 6.273-million lb (2,845 t) that was retained toward the 2013/14 TAC, an additional 0.107-million lb (0.05 t) was retained towards a cost-recovery fishery goal of \$300,000 that ADF&G was authorized to receive from the harvest and sale of Aleutian Islands golden king crab during 2013/14.

The 2014/15 season ends by regulation on 15 May 2015 and complete fishery data are not yet available. Currently available data from the 2014/15 season in the area west of 174° W longitude are confidential due to the participation of less than three fishing vessels (M. Westphal, ADF&G, Dutch Harbor, *pers. comm.* 6 April 2015)

3. **Stock biomass:**

Estimates of stock biomass are not available for this Tier 5 assessment.

4. **Recruitment:**

Estimates of recruitment trends and current levels relative to virgin or historic levels are not available for this Tier 5 assessment.

5. **Management performance:**

Overfishing did not occur during 2013/14 because the estimated total catch did not exceed the Tier 5 overfishing limit (OFL) of 12.54-million lb (5.69 kt). The total catch did not exceed the ABC established for 2013/14 (11.28-million lb, or 5.12 kt). The TAC for 2013/14 does not include landings towards a cost-recovery fishing goal of \$300,000 to cover costs of observer deployments in the fishery; the catch totals for 2013/14 do include the catch towards the 2013/14 cost-recovery fishery. Fishery catch data from the ongoing 2014/15 are not available at this time. The 2014/15 TAC has not yet been established. The OFL and ABC values for 2015/16 are the author’s recommended values.

Year	MSST	Biomass (MMB)	TAC ^a	Retained Catch ^a	Total Catch ^{a,b}	OFL ^a	ABC ^a
2011/12	N/A	N/A	5.99	5.96	6.51	11.40	10.26
2012/13	N/A	N/A	6.29	6.27	6.87	12.54	11.28
2013/14	N/A	N/A	6.29	6.38	7.04	12.54	11.28
2014/15	N/A	N/A	6.29			12.53	9.40
2015/16	N/A	N/A				12.53	9.40

a. Millions of lb.

b. Total retained catch plus estimated bycatch mortality of discarded bycatch during crab fisheries and groundfish fisheries.

Year	MSST	Biomass (MMB)	TAC ^a	Retained Catch ^a	Total Catch ^{a,b}	OFL ^a	ABC ^a
2011/12	N/A	N/A	2.72	2.71	2.95	5.17	4.66
2012/13	N/A	N/A	2.85	2.84	3.12	5.69	5.12
2013/14	N/A	N/A	2.85	2.89	3.19	5.69	5.12
2014/15	N/A	N/A	2.85			5.69	4.26
2015/16	N/A	N/A				5.69	4.26

a. kt.

b. Total retained catch plus estimated bycatch mortality of discarded bycatch during crab fisheries and groundfish fisheries.

Basis for the OFL and ABC: See table below; 2015/16 values are the author's recommended values.

Year	Tier	Years to define Average catch (OFL)	Natural Mortality ^a	Buffer
2011/12	5	1985/86–1995/96 ^b	0.18	10%
2012/13	5	1985/86–1995/96 ^b	0.18	10%
2013/14	5	1985/86–1995/96 ^b	0.18	10%
2014/15	5	1985/86–1995/96 ^b	0.18	25%
2015/16	5	1985/86–1995/96 ^b	0.18	25%

a. Assumed value for FMP king crab in NPFMC (2007b); does not enter into OFL estimation for Tier 5 stock.

b. OFL was for total catch as was computed as the average of the retained catch for these years times an estimated average annual value of (bycatch mortality in crab fisheries)/(retained catch) plus an estimated average annual bycatch mortality in groundfish fisheries.

6. **PDF of the OFL:** Sampling distribution of the recommended (status quo) Tier 5 OFL was estimated by bootstrapping (see section G.1). The standard deviation of the estimated sampling distribution of the recommended OFL is 1.18-million lb (CV = 0.09). Note that generated sampling distribution and computed standard deviation are meaningful as measures in the uncertainty of the OFL only if assumptions on the choice of years used to compute the Tier 5 OFL are true (see Sections E.2 and E.4.f).
7. **Basis for the ABC recommendation:** A 25% buffer on the OFL; i.e., $ABC = (1.0-0.25) \cdot OFL$.
8. **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:

- In March 2014 the BOF changed the 9-month season opening date from 15 August to 1 August; that change will become effective in the 2015/16 season.
- In 2014 the SOA legislature increased the allocation that ADF&G may receive annually from the harvest and sale of Aleutian Islands golden king crab from

\$300,000 to \$500,000. Retained catch from that cost-recovery fishing is not counted towards attainment of the annually-established TAC.

2. Changes to the input data:

- Fishery data has been updated with the data for the 2013/14 season: retained catch for the directed fishery and bycatch estimates for the directed fishery, non-directed crab fisheries, and groundfish fisheries. Complete data from the ongoing 2014/15 season are not available.

3. Changes to the assessment methodology: None: the computation of OFL in this assessment follows the methodology recommended by the CPT in May 2012 and the SSC in 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 OFL established for each of 2008/09 and 2009/10 was 9.18-million lb (4.16 kt) of retained catch and was estimated by the average annual retained catch (not including deadloss) for the period 1985/86–1995/96.
- The OFL for 2010/11 was established as a total-catch OFL of 11.06-million lb (5.02 kt) and, following the recommendation of the SSC in June 2010, was computed as the average of the annual retained catch during 1985/86–1995/96 plus the average of the annual retained catch during 1985/86–1995/96 times the estimated average annual value of (bycatch mortality in crab fisheries)/(retained catch) during 1996/97–2008/09 plus the estimated average annual bycatch mortality in groundfish fisheries during 1996/97–2008/09.
- The OFL for 2011/12 was established as a total-catch OFL of 11.40-million lb (5.17 kt), with the ABC set at the maximum (i.e., with a 10% buffer below the OFL) of 10.26 million lb (4.66 kt). Methods and results followed the June 2010 CPT, May 2011 CPT and June 2011 SSC recommendations by using 1985/86–1995/96 data for retained catch, incorporating as much data on bycatch as is available, and “freezing” the final year of bycatch data included in the assessment at 2008/09. The recommended total catch OFL was computed as the average of the annual retained catch during 1985/86–1995/96 plus the average of the annual retained catch during 1985/86–1995/96 times the estimated average annual value of (bycatch mortality in crab fisheries)/(retained catch) during 1990/91–2008/09 (excluding 1993/94–1994/95 due to lack of sufficient data) plus the estimated average annual bycatch mortality in groundfish fisheries during 1993/94–2008/09.
- The OFL and ABC for 2012/13 and 2013/14 was a total-catch OFL of 12.54-million lb (5.69 kt), with the ABC set at the maximum (i.e., with a 10% buffer below the OFL) of 11.28 million lb (5.12 kt). The methods to compute the OFL were the same as for the 2011/12 OFL, except that a different time period was used to estimate the average annual value of (bycatch mortality in crab fisheries)/(retained catch) in the directed fishery (1990/91–1995/96 as opposed to 1990/91–2008/09).
- The OFL and ABC for 2014/15 were a total-catch OFL of 12.53-million lb (5.69 kt) and an ABC of 9.40-million lb (4.26 kt) that was set using a 25% buffer (i.e., set at 75% of the OFL). The 2014/15 OFL was the status quo value whereas the 2014/15 ABC was a departure from the maximum-value ABC (i.e., set with a 10% buffer below the OFL) that was established for 2013/14.

- The OFL and ABC recommended for 2015/16 are the status quo from 2014/15: a total-catch OFL of 12.53-million lb (5.69 kt) and an ABC of 9.40-million lb (4.26 kt) that was set using a 25% buffer.

B. Responses to SSC and CPT Comments

1. 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 pertaining to a Tier 5 assessment.*
- SSC, June 2014: *Recommended that the Scallop and Crab Plan Teams conduct a workshop to address procedures for data-poor stocks with participants from all Plan Teams that are dealing with Tier 5 assessments and with the desired outcome of clearly articulating “the procedures and minimum requirements for establishing 10%, 20%,..., X% buffers such that they can be applied consistently across a range of species and different stocks.”*
 - Response: Activities in response dependent upon scheduling of workshop; results would be incorporated into May 2016 assessment.
- CPT, September 2014 (via September 2014 SAFE Introduction chapter): *None pertaining to a Tier 5 assessment.*
- SSC, October 2014: *Recommended that an uncertainty workshop be held in the fall of 2015 to address ABCs.*
 - Response: Results would be incorporated into the May 2016 assessment.

2. Responses to the most recent two sets of SSC and CPT comments specific to the assessment:

- CPT, May 2014 (May 2014 CPT minutes):
 - *“The CPT agreed that there is more uncertainty in Aleutian Islands golden king crab assessment than is consistent with a 10% buffer. However, the CPT could not agree on an appropriate approach to determine a buffer for between the OFL and ABC.”*
 - Response: The author’s recommends a 25% buffer between OFL and ABC for 2015/16, as was recommended for 2014/15 by the SSC in June 2014.
- SSC, June 2014 (June 2014 SSC minutes):
 - *“The SSC recommends that a 25% buffer suggested by the author be adopted for setting the ABC for this stock.”*
 - Response: The author’s recommended ABC for 2015/16 is based on the 25% buffer recommended by the SSC.
- CPT, September 2014 (via Sept 2014 SAFE): *None.*
- SSC, October 2014: *None.*

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 [Bering Sea and Aleutian Islands], golden king crab are found at depths from 200 m to 1,000 m, generally in high-relief habitat such as inter-island passes (Chapter 3, pages 34–35).

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 (Chapter 3, page 44).

The Aleutian Islands king crab stock boundary is defined by the boundaries of the Aleutian Islands king crab Registration Area O (Figure 1). Baechler and Cook (2014, page 7) define those boundaries:

The Aleutian Islands king crab Registration Area O has as its eastern boundary the longitude of Scotch Cap Light (164° 44' W long.), its northern boundary a line from Cape Sarichef (54° 36' N latitude) to 171° W long., north to 55° 30' N lat., and as its western boundary the Maritime Boundary Agreement Line as that line is described in the text of and depicted in the annex to the Maritime Boundary Agreement between the United States and the Union of Soviet Socialist Republics signed in Washington, June 1, 1990. Area O encompasses both the waters of the Territorial Sea (0–3 nautical miles) and waters of the Exclusive Economic Zone (3–200 nautical miles).

During the 1984/85–1995/96 seasons, the Aleutian Islands king crab populations had been managed using the Adak and Dutch Harbor Registration Areas, which were divided at 171° W longitude (Figure 2), but from the 1996/97 season to present the fishery has been managed using a division at 174° W longitude (Figure 1; Baechler and Cook 2014). In March 1996 the Alaska Board of Fisheries (BOF) replaced the Adak and Dutch Harbor areas with the newly created Aleutian Islands Registration Area O and directed Alaska Department of Fish and Game (ADF&G) to manage the golden king crab fishery in the areas east and west of 174° W longitude as two distinct stocks. That re-designation of management areas was intended to more accurately reflect golden king crab stock distribution, coherent with the longitudinal pattern in fishery production prior to the 1996/97 season (Figure 3). The longitudinal pattern in fishery production since 1996/97 is similar to that observed prior to the change in management (Figure 4). In this chapter, “Aleutian Islands Area” means the area described by the current definition of Aleutian Islands king crab Registration Area O.

Commercial fishing for golden king crab in the Aleutian Islands Area typically occurs at depths of 100–275 fathoms (183–503 m). During the 2012/13 season the pots sampled by at-sea observers were fished at an average depth of 176 fathoms (322 m; N=499) in the area east of 174° W longitude and 158 fathoms (289 m; N=1,223) for the area west of 174° W longitude (Gaeuman 2014).

3. **Evidence of stock structure:**

Given the expansiveness of the Aleutian Islands Area and the existence of deep (>1,000 m) canyons between some islands, at least some weak structuring of the stock within the area would be expected. Data for making inferences on stock structure of golden king crab within the Aleutian Islands are largely limited to the geographic distribution of commercial fishery

catch and effort. Effort and catch data by statistical area are available since 1982 and locations of over 70,000 fished pots sampled by observers since the 1996/97 season indicate that habitat for legal-sized males may be continuous throughout the waters adjacent to the Aleutian Islands. However, regions of low fishery catch suggest that availability of suitable habitat, in which golden king crab are present at only low densities, may vary longitudinally. Catch has been low in the fishery in the area between 174° W longitude and 176° W longitude (the Adak Island area, Figures 3 and 4) in comparison to adjacent areas, a pattern that is consistent with low CPUE for golden king crab between 174° W longitude and 176° W longitude (Figure 5) during the 2002, 2004, 2006, 2010, and 2012 NMFS Aleutian Islands bottom trawl surveys (von Szalay et al. 2011). In addition to longitudinal variation in density, there is also a gap in fishery catch and effort between the Petrel Bank-Petrel Spur area and the Bowers Bank area; both of those areas, which are separated by Bowers Canyon, have reported effort and catch. Recoveries during commercial fisheries of golden king crab tagged during ADF&G surveys (Blau and Pengilly 1994; Blau et al. 1998; Watson and Gish 2002; Watson 2004, 2007) provided no evidence of substantial movements by crab in the size classes that were tagged (males and females ≥ 90 -mm carapace length [CL]). Maximum straight-line distance between release and recovery location of 90 golden king crab released prior to the 1991/92 season and recovered through the 1992/93 season was 33.1 nm (61.2 km; Blau and Pengilly 1994). Of the 4,053 recoveries reported through 14 March 2008 for the golden king crab tagged and released between 170.5° W longitude and 171.5° W longitude during the 1997, 2000, 2003, and 2006 triennial ADF&G Aleutian Island golden king pot surveys, none were recovered west of 174° W longitude and only four were recovered west of 172° W longitude (V. Vanek, ADF&G, Kodiak, personnel communication).

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 (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 (2001) 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 Cumiskey 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 precise scoring of shell conditions very difficult. This pattern would obscure potential relationships between shell condition and time-elapsd since molting and pose problems for inclusion of shell condition data into assessment models.

5. Brief summary of management history:

A complete summary of the management history through the 2011/12 season is provided in Baechler and Cook (2014, pages 13–19). The first commercial landing of golden king crab in the Aleutian Islands was in 1975/76, but directed fishing did not occur until 1981/82. Peak harvest occurred during 1986/87 when 14.739-million lb (6,686 t) were harvested. Between 1981/82 and 1995/96 the fishery was managed as two separate fisheries in two separate registration areas, the Adak and Dutch Harbor areas, with the two areas divided at 172° W longitude through 1983/84 and at 171° W longitude after 1983/84. Prior to the 1996/97 season no formal preseason harvest target or limit was established for the fishery and average annual retained catch during 1981/82 – 1995/96 was 8.456-million lb (3,836 t).

The Aleutian Islands golden king crab fishery was restructured beginning with the 1996/97 season to replace the Adak and Dutch Harbor areas with the newly created Aleutian Islands Registration Area O and golden king crab in the areas east and west of 174° W longitude were managed separately as two stocks. The 1996/97–1997/98 seasons were managed under a 5.900-million lb (2,676 t) guideline harvest level (GHL), with 3.200-million lb (1,452 t) apportioned to the area east of 174° W longitude and 2.700-million lb (1,225 t) apportioned to the area west of 174° W longitude. The 1998/99–2004/05 seasons were managed under a 5.700-million lb (2,585 t) GHL, with 3.000-million lb (1,361 t) apportioned to the area east of 174° W longitude and 2.700-million lb (1,225 t) apportioned to the area west of 174° W longitude. The 2005/06–2007/08 seasons were managed under a 5.700-million lb (2,585 t) total allowable catch (TAC), with 3.000-million lb (1,361 t) apportioned to the area east of 174° W longitude and 2.700-million lb (1,225 t) apportioned to the area west of 174° W longitude. By state regulation (5 AAC 34.612), the TAC for retained catch for the Aleutian Islands golden king crab fishery for each of the 2008/09–2011/12 seasons was 5.985-million lb (2,715 t), apportioned as 3.150-million lb (1,429 t) for the area east of 174° W longitude and 2.835-million lb (1,286 t) for the area west of 174° W longitude. In March 2012 the BOF

changed **5 AAC 34.612** so that the TAC beginning with the 2012/13 season would be 6.290-million lb (2,853 t), apportioned as 3.310-million lb (1,501 t) for the area east of 174° W longitude and 2.980-million lb (1,352 t) for the area west of 174° W longitude. Additionally, the BOF added a provision to **5 AAC 34.612** that allows ADF&G to lower the TAC below the specified level if conservation concerns arise. Over the period 1996/97–2013/14 the total of the annual retained catch during commercial fishing (including ADF&G cost-recovery fishing that occurred during the 2013/14 season) has averaged 2% below the total of the annual GHL/TACs. During 1996/97–2013/14 the retained catch has been as much as 13% below (the 1998/99 season) and as much as 6% above (the 2000/01 season) the GHL/TAC. The retained catch for the 2013/14 season was 1% above the 6.290-million lb (2,853 t) TAC due to the cost-recovery fishery. The TAC for the ongoing 2014/15 season was established at 6.290-million lb (2,853 t); in addition to the retained catch that is counted towards the 2014/15 TAC, legal crab sufficient to provide \$300,000 in receipts to ADF&G were also retained during a cost-recovery fishery.

A summary of other relevant SOA fishery regulations and management actions pertaining to the Aleutian Islands golden king crab fishery is provided below.

The 2005/06 season was the first Aleutian Islands golden king crab fishery prosecuted under the Crab Rationalization Program. Accompanying the implementation of the Crab Rationalization program was implementation of a community development quota (CDQ) fishery for golden king crab in the eastern Aleutians (i.e., east of 174° W longitude) and the Adak Community Allocation (ACA) fishery for golden king crab in the western Aleutians (i.e., west of 174° W longitude; Hartill 2012). The CDQ fishery in the eastern Aleutians is allocated 10% of the golden king crab TAC for the area east of 174° W longitude and the ACA fishery in the western Aleutians is allocated 10% of the golden king crab TAC for the area west of 174° W longitude. The CDQ fishery and the ACA fishery are prosecuted concurrently with the IFQ fishery and are managed by ADF&G.

Only males of a minimum size may be retained by the commercial golden king crab fishery in the Aleutian Islands Area. By SOA regulation (**5 AAC 34.620 (b)**), the minimum legal size limit is 6.0-inches (152 mm) carapace width (CW), including spines. A carapace length (CL) \geq 136 mm is used to identify legal-size males when CW measurements are not available (Table 3-5 in NPFMC 2007b). Note that size limit for golden king crab has been 6-inches (165 mm) CW for the entire Aleutian Islands Area only since the 1985/86 season. Prior to the 1985/86 season the legal size limit was 6.5-inches for at least one of the now-defunct Adak or Dutch Harbor Registration Areas.

Golden king crab may be commercially fished only with king crab pots (defined in **5 AAC 34.050**). Pots used to fish for golden king crab in the Aleutian Islands Area must be operated from a shellfish longline and, since 1996, must have at least four escape rings of five and one-half inches minimum 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 34.625 (b)**). Prior to the regulation requiring an escape mechanism on pots, some participants in the Aleutian Islands golden king crab fishery voluntarily sewed escape rings (typically 139-mm or 5.5 inches) into their gear or, more rarely, included panels with escape mesh (Beers 1992). With regard to the gear used by fishers since the establishment of **5 AAC 34.625 (b)** in 1996, Linda Kozak, a representative of the industry, reported in a 19 September 2008 email to the Crab Plan Team that, "... the golden king crab fleet has modified their gear to allow for

small crab sorting,” and provided a written statement from Lance Nylander, of Dungeness Gear Works in Seattle, who “believes he makes all the gear for the golden king crab harvesting fleet,” saying that, “Since 1999, DGW has installed 9[-inch] escape web on the door of over 95% of Golden Crab pot orders we manufactured.” A study to estimate the contact-selection curve for male golden king crab that was conducted aboard one vessel commercial fishing for golden king crab during the 2012/13 season showed that gear and fishing practices used by that vessel was highly effective in reducing bycatch of sublegal-sized males and females (Vanek et al. 2013). In March 2011 (effective for the 2011/12 season), the BOF amended **5 AAC 34.625 (b)** to relax the “biotwine” specification for pots used in the Aleutian Islands golden king crab fishery relative to the requirement in **5 AAC 39.145** (Escape Mechanism for Shellfish and Bottomfish Pots) that “(1) a sidewall ...of all shellfish and bottomfish pots 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.” Regulation **5 AAC 34.625 (b)(1)** allows the opening described in **5 AAC 39.145 (1)** to be “laced, sewn, or secured together by a single length of untreated, 100 percent cotton twine, no larger than 60 [rather than 30] thread.”

Regulation (**5 AAC 34.610 (b)**) sets the commercial fishing season for golden king crab in the Aleutian Islands Area as 15 August through 15 May. The BOF in March 2014 voted to change regulation (**5 AAC 34.610 (b)**) to set the commercial fishing season for golden king crab in the Aleutian Islands Area as 1 August through 30 April; that change will become effective in the 2015/16 season.

Current regulations stipulate that onboard observers are required during the harvest of 50% of the total golden king crab weight harvested by each catcher vessel and 100% of the fishing activity of each catcher-processor during each of the three trimesters as outlined in **5 AAC 39.645 (d)(4)(A)**.

6. Brief description of the annual ADF&G harvest strategy:

The annual TAC is set by state regulation, **5 AAC 34.612 (Harvest Levels for Golden King Crab in Registration Area O)**, as approved by the BOF in March 2012:

(a) Until the Aleutian Islands golden king crab stock assessment model and a state regulatory harvest strategy are established, the harvest levels for the Registration Area O golden king crab fishery are as follows:

- (1) east of 174° W long.: 3.31 million pounds; and
- (2) west of 174° W long.: 2.98 million pounds;

(b) The department may reduce the harvest levels based on the best scientific information available and considering the reliability of estimates and performance measures, sources of uncertainty as necessary to avoid overfishing, and any other factors necessary to be consistent with sustained yield principles.

In addition to the retained catch that is limited by the TAC established by ADF&G under **5 AAC 34.612**, ADF&G also has authority to annually receive receipts of \$500,000 through cost-recovery fishing on Aleutian Islands golden king crab. The retained catch from that cost-recovery fishing is not counted against attainment of the annually-established TAC.

7. **Summary of the history of B_{MSY}** : Not applicable for this Tier 5 stock.

D. Data

1. Summary of new information:

- Fishery data on retained catch and non-retained bycatch during 2013/14 crab fisheries have been added.
- Data on bycatch during groundfish fisheries in reporting areas 541, 542, and 543 have been updated with data grouped by “fixed” (hook-and-line and pot) and “trawl” (non-pelagic trawl) for 2013/14 have been added.
- Estimates of total fishery mortality (retained catch plus estimated bycatch mortality during crab and groundfish fisheries) during 2013/14 have been added.

2. Data presented as time series:

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

- Fish ticket data on retained catch numbers, retained catch weight, pot lifts, CPUE, and average weight of retained catch for the 1981/82–2013/14 seasons are presented (Table 1).
- Statistics from all available data on bycatch of Aleutian Islands golden king crab obtained from pot lifts sampled by at-sea observers during the directed and non-directed crab fisheries are presented for 1990/91–1992/93 and 1995/96–2013/14 (Table 2). Some observer data exists for the 1988/89–1989/90 seasons, but those data are not considered reliable. Although bycatch can occur in the red king crab, scarlet king crab, grooved Tanner crab, and triangle Tanner crab fisheries of the Aleutian Islands, such bycatch accounts for $\leq 2\%$ of the estimated total weight in the crab fisheries annually when those fisheries are prosecuted. Only one vessel was observed during the directed fishery throughout the 1993/94 season and only two vessels were observed throughout the 1994/95 season (an additional catcher vessel carried an observer for one trip during the 1993/94 season and an additional three catcher vessels carried an observer for one trip during the 1994/95 season, but observed effort was small relative to the total season effort for those vessels and the author does not consider the data from those vessels reliable). Hence data on bycatch during the 1993/94 and 1994/95 directed fishery seasons are confidential and not presented here. Observer data on size distributions and estimated catch numbers of non-retained catch were used to estimate the weight of non-retained catch of red king crab by applying a weight-at-length estimator (see below); data on the size distribution of non-retained legal males was not recorded prior to 1998/99 and weights of retained legal males are used to estimate the weights of non-retained legal males during those years. Data on bycatch of golden king crab obtained by at-sea observers during groundfish fisheries in reporting areas 541, 542, and 543 (Figure 6) for crab fishery years 1993/94–2013/14 are presented (estimates for 1991/92–1992/93 are also presented, but they appear to be suspect; Table 3).
- Estimates of bycatch mortality during 1990/91–1992/93 and 1995/96–2013/14 directed and non-directed crab fisheries and 1993/94–2013/14 groundfish fisheries are presented in Table 4. Estimates of total fishery mortality (retained catch plus estimated bycatch mortality during crab and groundfish fisheries) during 1995/96–2013/14 are presented (Table 4). Following Siddeek et al. (2014), the bycatch mortality rate of king crab captured and discarded during Aleutian Islands king crab fisheries was assumed to be 0.2; that value was also applied as the bycatch mortality during other crab fisheries. Following Foy (2012a, 2012b), 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.

- c. **Catch-at-length:** Not used in a Tier 5 assessment; none are presented.
- d. **Survey biomass estimates:** Not used in a Tier 5 assessment; none are presented.
- e. **Survey catch at length:** Not used in a Tier 5 assessment; none are presented (see section D.4).
- f. **Other data time series:** See section D.4 on other time-series data that are available, but not presented here.

3. Data which may be aggregated over time:

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

Growth per molt and probability of molt estimates are not used in a Tier 5 assessment. However, growth per molt and probability of molt have been estimated for Aleutian Islands golden king crab by Watson et al. (2002) based on information received from recoveries during the 1997/98–2000/01 commercial fisheries in the area east of 174° W longitude of male and female golden king crab tagged and released during July–August 1997 in the area east of 174° W longitude (see Tables 24–28 in Pengilly 2009).

Watson et al. (2002) used logistic regression to estimate the probability as a function of carapace length (CL, mm) at release that a male tagged and released in new-shell condition would molt within 12–15 months after release:

$$P(\text{molt}) = \exp(17.930 - 0.129 \cdot \text{CL}) / [1 + \exp(17.930 - 0.129 \cdot \text{CL})].$$

Based on the above logistic regression, Watson et al. (2002) estimated that the size at which 50% of new-shell males would be expected to molt within 12–15 months is 139-mm CL (S.E. = 0.81-mm CL).

Watson et al. (2002) used logistic regression to estimate the probability as a function of carapace length (CL, mm) at release that a male tagged and released as a sublegal ≥ 90 -mm CL in new-shell condition would molt to legal size within 12–15 months after release:

$$P(\text{molt to legal size}) = 1 - \exp(15.541 - 0.127 \cdot \text{CL}) / [1 + \exp(15.541 - 0.127 \cdot \text{CL})].$$

Based on the above logistic regression, Watson et al. (2002) estimated that the size at which 50% of sublegal ≥ 90 -mm CL, new-shell males would be expected to molt to legal size within 12–15 months is 123-mm CL (S.E. = 1.54-mm CL).

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 2007b) are: $A = 0.0002988$ and $B = 3.135$ for males and $A = 0.001424$ and $B = 2.781$ for females. Although the parameters A and B were derived from 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 (2007b) is $M=0.18$. However, that natural mortality assumption was not used in this Tier 5 stock assessment.

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

Data from triennial ADF&G pot surveys for Aleutian Islands golden king crab in a limited area east of 174° W longitude (between $170^\circ 21'$ and $171^\circ 33'$ W longitude) that were performed during 1997 (Blau et al. 1998), 2000 (Watson and Gish 2002), 2003 (Watson 2004), and 2006 (Watson 2007) are available, but were not used in this Tier 5 assessment.

E. Analytic Approach

1. History of modeling approaches for this stock: This is a Tier 5 stock.

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

It was recommended by NPFMC (2007b) that the Aleutian Islands golden king crab stock be managed as a Tier 5 stock until an assessment model is accepted for use in management. In 2014 the SSC recommended that this stock continue to be managed under Tier 5 for 2014/15 (June 2012 SSC minutes). An Aleutian Islands golden king crab assessment model (Siddeek et al. 2014) will be reviewed for use in Tier 4 or Tier 3 management of this stock by the Crab Plan Team in May 2015.

For Tier 5 stocks only an OFL is estimated, because it is not possible to estimate MSST without an estimate of biomass, and “the OFL represent[s] the average retained catch from a time period determined to be representative of the production potential of the stock” (NPFMC 2007b). Additionally, NPFMC (2007b) 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.” Although NPFMC (2007b) defined the OFL in terms of the retained catch, total-catch OFLs may be considered for Tier 5 stocks for which nontarget 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 2010/11 and subsequent OFLs for this stock. This assessment recommends – and only considers – use of a total-catch Tier 5 OFL for 2014/15.

For estimating the OFL of Tier 5 stocks, NPFMC (2007b) states, “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.” Prior to 2008, two time periods were considered for computing the average retained catch for Aleutian Islands golden king crab: 1985–2005 (NPFMC 2007a) and 1985–1999 (NPFMC 2007b). The average retained catch over the years 1985 to 1999 was recommended by NPFMC (2007b) for the estimated OFL for Aleutian Islands golden king crab. Years post-1984 were chosen based on an assumed 8-year lag between hatching during the 1976/77 “regime shift” and growth to legal size. With regard to excluding data

from years after 1999, NPFMC (2007b) states, “Years from 2000 to 2005 were excluded for Aleutian Islands golden king crab when the TAC was set below the previous average catch.” Note, however, that there was no TAC or GHl established for the entire Aleutian Islands Area prior to the 1996/97 season (see above) and the GHl for the Aleutian Islands Area was reduced from 5.9-million lb (2,676 t) for the 1996/97 and 1997/98 seasons to 5.7-million lb (2,585 t) for the 1998/1999 season; the GHl or TAC has remained at 5.7-million lb (2,585 t) for all subsequent seasons until it was increased to 5.985-million lb (2,715 t) for the 2008/09 season. Pengilly (2008) discussed nine periods, spanning periods as long as 26 seasons (1981/82–2006/07) to as short as six seasons (1990/91–1995/96), for computing average annual retained catch and estimating the OFL for the 2008/09 season. Only periods beginning no earlier than 1985/86 were recommended for consideration, however, due to the size limit change that occurred prior to the 1985/86 season (Table 1, footnotes d–f). The Crab Plan Team in May 2008 recommended using the period 1990/91–1995/96 for computing the 2008/09 OFL. The CPT recommended the period 1990/91–1995/96 due to concerns raised by a decline in retained catch and CPUE that occurred from 1985/86 into the mid-1990s, the seasons of unconstrained catch under the current size limit. The SSC recommended using the period 1985/86–1995/96 for computing the 2008/09 OFL, however, because the period 1985/86–1995/96 is the longest possible period of unconstrained catch under the current size limit (“Earlier years were not recommended for inclusion because of a difference in the size limit regulations prior to 1985/86.” Minutes of the NPFMC SSC meeting, 2–4 June 2008). Pengilly (2009) discussed only three time periods to consider for setting the 2009/10 OFL: 1985/86–1995/96 (the period recommended by the SSC for the 2008/09 OFL); 1990/91–1995/96; (the period recommended by the CPT for the 2008/09 OFL); and 1987/88–1995/96. The period 1987/88–1995/96 was offered for consideration on the basis of having the longest period of unconstrained catch under the current size limit, while excluding the two seasons with the highest retained catch in the history of the fishery (the 1985/86–1986/87 seasons). Trends of declining catch, declining CPUE, and declining average weight of landed crab that occurred from 1985/86 into the mid-1990s could be interpreted as resulting from a fishery that relied increasingly on annual recruitment to legal size while harvesting a declining stock of legal-size males. Hence the catches during the full period of unconstrained catch under the current size limit, 1985/86–1995/96, could be viewed as unsustainable. Removal of the two highest-catch seasons, 1985/86–1986/87, at the beginning of that time period was offered as a compromise between the desire for the longest period possible for averaging catch and the desire for a period reflecting long-term production potential of the stock. Of those, the Crab Plan Team at the May 2009 again recommended using the period 1990/91–1995/96 for computing the 2009/10 OFL, whereas the SSC again recommended 1985/86–1995/96, noting that “the management system was relatively constant from 1985 onward” and that a “longer time period likely provides a more robust estimate than a shorter time period.” (Minutes of the NPFMC SSC meeting, 1–3 June 2009).

Three alternatives were considered for setting a total-catch OFL for 2010/11 (see the Executive Summary of the May Draft of the 2010 Crab SAFE), none of which could be chosen with consensus by the CPT in May 2010 and all of which were rejected by the SSC in June 2010. In June 2010 the SSC recommended an approach to computing a total-catch OFL for this stock for 2010/11 as follows (Minutes of the NPFMC SSC meeting, 7–9 June 2010):

$$\text{OFL}_{2010/11} = (1 + R_{96/97-08/09}) \cdot \text{RET}_{85/86-95/96} + \text{BM}_{\text{GF},96/97-08/09} = 11.0 \text{ million lbs.},$$

where

- $R_{96/97-08/09}$ is the average of the estimated annual ratios of lb of bycatch mortality due to crab fisheries to lb of retained catch in the directed fishery during the period 1996/97-2008/09,
- $RET_{85/86-95/96}$ is the average annual retained catch in the directed crab fishery during the period 1985/86-1995/96, and
- $BM_{GF, 96/97-08/09}$ is the average of the annual estimates of bycatch mortality due to groundfish fisheries over the period 1996/97-2008/09.

Additionally, the SSC in June 2010 recommended that “...this time period be frozen to stabilize the control rule.”

Data on bycatch during crab fisheries prior to 1996/97 were presented to the CPT in May 2011 and the CPT recommended the following OFL for the 2011/12 season, which was also recommended by the SSC in June 2011:

$$OFL_{2011/12} = (1+R_{90/91-08/09}) \cdot RET_{85/86-95/96} + BM_{GF,93/94-08/09},$$

where,

- $R_{90/91-08/09}$ is the average of the estimated annual ratios of lb of bycatch mortality due to crab fisheries to lb of retained catch in the directed fishery during the period 1990/91-2008/09 (excluding 1993/94–1994/95, due to data confidentiality and insufficiencies)
- $RET_{85/86-95/96}$ is the same as defined for $OFL_{2010/11}$, above (i.e., the average annual retained catch in the directed crab fishery during the period 1985/86-1995/96), and
- $BM_{GF,93/94-08/09}$ is the same as defined for $OFL_{2010/11}$, above (i.e., the average of the annual estimates of bycatch mortality due to groundfish fisheries over the period 1993/94-2008/09).

Trends in the estimated annual ratios of lb of bycatch mortality due to crab fisheries to lb of retained catch in the directed fishery during the period 1990/91-2008/09 were presented to the CPT in May 2012 and SSC in June 2012. The SSC found that the estimated annual ratios of lb of bycatch mortality due to crab fisheries to lb of retained catch in the directed fishery prior to the 1996/97 season were a better reflection of bycatch mortality during the 1985/86–1995/96 seasons than the estimates from the 1996/97–2008/09 seasons. Accordingly, the SSC (June 2012 SSC minutes) recommended that the OFL for the 2012/13 season be computed as:

$$OFL_{2012/13} = (1+R_{90/91-95/96}) \cdot RET_{85/86-95/96} + BM_{GF,93/94-08/09},$$

where,

- $R_{90/91-95/96}$ is the average of the estimated annual ratios of lb of bycatch mortality due to crab fisheries to lb of retained catch in the directed fishery during the period 1990/91–1995/96 (excluding 1993/94–1994/95, due to data confidentiality and insufficiencies),
- $RET_{85/86-95/96}$ is the same as defined for Alternative 1, above (i.e., the average annual retained catch in the directed crab fishery during the period 1985/86-1995/96), and
- $BM_{GF,93/94-08/09}$ is the same as defined for Alternative 1, above (i.e., the average of the annual estimates of bycatch mortality due to groundfish fisheries over the period 1993/94-2008/09).

The OFLs for 2013/14–2014/15 were determined following the same procedure as for 2012/13.

3. Model Selection and Evaluation:

a. Description of alternative model configurations

The SSC has recommended that the “time period be frozen to stabilize the control rule” in determination of a Tier 5 OFL (see section 2, above). With regard to the Tier 5 OFL for the Aleutian Islands golden king crab stock, the SSC has recommended that computation of the OFL computation should use: 1) the period 1985/86–1995/96 to compute the average retained catch (June 2008, and 2009 SSC minutes); 2) the “time period [to compute the Tier 5 OFL] be frozen to stabilize the control rule” at 1985/86–2008/09 (June 2010 SSC minutes); and 3) that bycatch data from crab fisheries from the period prior to 1996/97 be used to compute the Tier 5 OFL. Given those recommendations from the SSC and the lack of any additional fishery data from the period 1985/86–2008/09 that were not already available and presented during 2012–2014, only one alternative is presented, the author’s recommended alternative, which is the status quo (i.e., the same as the Tier 5 OFL for 2012/13–2014/15 that was established in 2012):

$$\text{OFL}_{2015/16} = (1 + R_{90/91-95/96}) \cdot \text{RET}_{85/86-95/96} + \text{BM}_{\text{GF},93/94-08/09},$$

where,

- $R_{90/91-95/96}$ is the average of the estimated annual ratios of lb of bycatch mortality due to crab fisheries to lb of retained catch in the directed fishery during the period 1990/91–1995/96 (excluding 1993/94–1994/95, due to data confidentialities and insufficiencies),
- $\text{RET}_{85/86-95/96}$ is the average annual retained catch in the directed crab fishery during the period 1985/86–1995/96, and
- $\text{BM}_{\text{GF},93/94-08/09}$ is the average of the annual estimates of bycatch mortality due to groundfish fisheries over the period 1993/94–2008/09.

Statistics on the data and estimates used to calculate, $\text{RET}_{85/86-95/96}$, $R_{90/91-95/96}$, and $\text{BM}_{\text{GF},93/94-08/09}$ are provided in Table 5; the column averages in Table 5 are the calculated values of $\text{RET}_{85/86-95/96}$, $R_{90/91-95/96}$, and $\text{BM}_{\text{GF},93/94-08/09}$. Using those calculated values of $\text{RET}_{85/86-95/96}$, $R_{90/91-95/96}$, and $\text{BM}_{\text{GF},93/94-08/09}$, $\text{OFL}_{2015/16}$ is computed as,

$$\text{OFL}_{2015/16} = (1 + 0.363) \cdot (9,178,438) + 23,359 = 12,533,570 \text{ lb (12.53-million lb; 5.69 kt).}$$

Note that although the OFL for 2015/16 is computed using the same procedure and values as were used to compute the OFL for 2012/13–2014/15, the resulting computed value expressed in lb for $\text{OFL}_{2015/16}$ (12,533,569 lb) is inexplicably different from the value reported for $\text{OFL}_{2012/13}$ and $\text{OFL}_{2013/14}$ (12,537,757 lb) in the 2012 and 2013 SAFEs.

- 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 section A.4.
- c. **Evidence of search for balance between realistic (but possibly over-parameterized) and simpler (but not realistic) models:** See the section A.4.

- 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 1985/86–2008/09 time period and the time periods for fishery mortality subcomponents within 1985/86–2008/09 used for determining the OFL were established by the SSC during 2008–2012. The values for retained catch and estimated bycatch mortality used in the OFL computation are in Table 5. Temporal trends during 1985/86–2013/14 in retained catch and in the available estimates of bycatch mortality due to crab fisheries and groundfish fisheries are shown in Figure 7. Trends in the ratio of the estimated bycatch mortality due to crab fisheries to the retained catch are shown in Figures 8 and 9 for the years that data and estimates are available during 1985/86–2013/14. Retained catch data come from fish tickets and annual retained catch is assumed to be known. Estimates of catch from crab fishery observer data are generally considered credible (e.g., Byrne and Pengilly 1998; Gaeuman 2014). Estimates of bycatch mortality were derived as estimates of bycatch times an assumed bycatch mortality rate. The assumed bycatch mortality rates (i.e., 0.2 for crab fisheries, 0.5 for fixed-gear groundfish fisheries, and 0.8 for trawl groundfish fisheries) 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:** The model for computing the single recommended OFL follows the SSC recommendations to freeze the time period to stabilize the control role by using only 1985/86–1995/96 to estimate the average annual retained catch component of the OFL (June 2008 and June 2009 SSC minutes), to not include bycatch data after 2008/09 (June 2010 SSC minutes), and to use only the bycatch mortality estimates from the crab fisheries that are available from 1990/91–1995/96 (June 2012 SSC minutes). The author and the SSC (June 2012 SSC minutes) agree that the bycatch data from crab fisheries during 1990/91–1995/96 are the most representative data available of the conditions that existed during 1985/86–1995/96: those years fall within the period 1985/86–1995/96; regulations stipulating escape mechanisms in pots became effective after 1995/96 (see section **C.5-Brief summary of management history**); and there is a clear decreasing trend in the estimated ratio of lb of bycatch mortality due to crab fisheries to lb of retained crab in the directed fishery since 1996/97 (Figures 8 and 9).
- 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 5–6.

- 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 stocks.
- 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 stocks.
- 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 a Tier 5 assessment, the major uncertainties are:
- Whether the chosen 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.
 - The Tier 5 OFL for this stock is highly sensitive to the choice of years used to compute the average annual catch. The table on page 19 of Pengilly (2008) addressed the justifications for alternative choices of time periods that could be used to compute the retained-catch portion of the OFL. Interested readers are directed to that document; briefly, however, the average retained-catch of the OFL for the nine alternative time periods presented ranged from 5.633 million lb (2,555 t; for 1996/97–2006/07) to 9.178 million lb (4,163 t; for 1985/86–1995/96, the time period selected and “frozen” by the SSC). The CPT in 2008 and 2009 recommended that the years 1990/91–1995/96 be used to compute the retained-catch OFL (resulting in a retained-catch OFL of 6.931-million lb; 3,144 t). In both 2008 and 2009, the SSC overrode the CPT’s recommendation and selected the years 1985/86–1995/96 to compute the retained-catch OFL at 9.178-million lb (4,163 t). The SSC recommended that the time period for computing the retained-catch portion of the OFL “be frozen” at 1985/86–1995/96 “to stabilize the control rule.”
 - The Tier 5 OFL is also sensitive to the choice of years used to estimate the average annual ratio of lb of bycatch mortality to lb of retained crab in the crab fisheries. The SSC recommended that the time period for computing the bycatch-mortality portion of the OFL be frozen to end at 2008/09. The estimates of annual bycatch biomass (not discounted for bycatch mortality) to retained catch are generally highest during 1990/91–1995/96 and show a decreasing trend during 1996/97–2008/09: that ratio during 1990/91–1995/96 ranges from 1.5:1 to 2.1:1, during 1996/97–2004/05 ranges from 0.8:1 to 1.7:1, and during 2005/06–2008/09 ranges from 0.5:1 to 0.6:1 (see Figures 8 and 9 for the trend in ratios after a default bycatch mortality rate is applied to the bycatch biomass estimates). Hence including the later years to compute the average annual ratio decreases the OFL estimate, whereas restricting the period to 1990/91–1995/96 increases the OFL estimate.
 - The Tier 5 OFL has only a slight sensitivity to the choice of years used to compute the bycatch due to groundfish fisheries. This assessment only

considers the period 1993/94–2008/09 for bycatch in the groundfish fisheries. Estimates of annual bycatch mortality due to groundfish fisheries during 1993/94–2008/09 range from <0.001-million lb (<1 t) to 0.130-million lb (59 t). Because the estimate of bycatch biomass due to groundfish fisheries is small relative to the biomass of retained catch (≥ 4.819 -million lb [2,186 t] annually since 1985/86), the effect of choice of years here is negligibly small.

- The bycatch mortality rates used in estimation of total fishery mortality are assumed values. Bycatch mortality is unknown and no data that could be used to estimate the bycatch mortality of this stock is known to the author. After discussion on information presented on the apparent “hardiness” of golden king relative to red king crab at the May 2013 meeting, the CPT conclude that the handling mortality rate used in golden king crab assessments remain at the status quo, 0.2, until data for estimating handling mortality are presented (May 2013 CPT minutes). Hence only the values that are assumed for other BSAI king crab stock assessments are considered in this assessment. Due to the difference in scale between the estimated bycatch in crab fisheries and the groundfish fisheries (see bullet above), the estimated OFL is most sensitive to the assumed bycatch mortality in crab fisheries and less sensitive to the assumed bycatch in groundfish fisheries. Given a fixed period of years to compute the average of annual bycatch biomass estimates for the crab fisheries, the estimated OFL is inversely related to the bycatch mortality rate assumed for the crab fisheries. If the assumed bycatch mortality rate is doubled from 0.2 to 0.4, the OFL estimate increases by a factor of 1.17 (1.4/1.2); if halved from 0.2 to 0.1, the assumed bycatch mortality rate, and the OFL estimate decreases by a factor of 0.92 (1.1/1.2).
- There has been no program to survey this stock in its entirety and a program to survey a portion of this stock on a triennial basis ended after 2006 due to the costs of survey implementation. The CPT in September 2013 strongly recommended that, “A survey is needed to provide a better index of abundance and information on recruitment for stock assessment” and encouraged ADF&G, NMFS, and industry to discuss how to make such a survey happen. Such discussions occurred at meetings amongst ADF&G, NMFS, and the Aleutian King Crab Research Foundation (AKCRF) in January and March 2014 and follow-up meetings between ADF&G and AKCRF to develop plans for a survey designed to be implemented with cooperating commercial fishing vessels (see May 2014 CPT minutes for more details on the survey design that was developed). An 11-day “pilot survey” to test implementation of the survey design that developed from those meetings was performed during September 2014 in the Aleutian Islands east of 174° W longitude through a cooperative effort between ADF&G and the AKCRF from aboard the commercial crab-fishing vessel *F/V Patricia Lee* (M. Westphal, ADF&G, Dutch Harbor, *pers. comm.*).

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 computed as the estimated average annual total catch over a specified period.
- Recommended time period for computing retained-catch portion of the OFL: 1985/86–1995/96.
- Recommended time period for computing bycatch mortality due to crab fisheries: 1990/91–1995/96.
- Recommended time period for computing bycatch due to groundfish fisheries: 1993/94–2008/09.

- Recommended bycatch mortality rates: 0.2 for crab fisheries; 0.5 for fixed-gear groundfish fisheries; 0.8 for trawl groundfish fisheries.

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 stocks.

3. Specification of the 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 (2007b) 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 stocks.

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 tables below. The OFL and ABC values for 2015/16 in the table below are the recommended values. The 2015/16 TAC has not yet been established. The TAC for 2013/14 and 2014/15 in the table below does not include landings towards a cost-recovery fishing goal to cover costs of observer deployments in the fishery.

Year	MSST	Biomass (MMB)	TAC ^a	Retained Catch ^a	Total Catch ^{a,b}	OFL ^a	ABC ^a
2011/12	N/A	N/A	5.99	5.96	6.51	11.40	10.26
2012/13	N/A	N/A	6.29	6.27	6.87	12.54	11.28
2013/14	N/A	N/A	6.29	6.38	7.04	12.54	11.28
2014/15	N/A	N/A	6.29			12.53	9.40
2015/16	N/A	N/A				12.53	9.40

a. Millions of lb.

b. Total retained catch plus estimated bycatch mortality of discarded bycatch during crab fisheries and groundfish fisheries.

Year	MSST	Biomass (MMB)	TAC ^a	Retained Catch ^a	Total Catch ^{a,b}	OFL ^a	ABC ^a
2011/12	N/A	N/A	2.72	2.71	2.95	5.17	4.66
2012/13	N/A	N/A	2.85	2.84	3.12	5.69	5.12
2013/14	N/A	N/A	2.85	2.89	3.19	5.69	5.12
2014/15	N/A	N/A	2.85			5.69	4.26
2015/16	N/A	N/A				5.69	4.26

a. kt.

- b. Total retained catch plus estimated bycatch mortality of discarded bycatch during crab fisheries and groundfish fisheries.

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

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

$$\begin{aligned} \text{Retained-catch portion} &= \text{average retained catch during 1985/86–1995/96} \\ &= 9,178,438 \text{ lb (9.18-million lb; 4,163 t)}. \end{aligned}$$

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. Bootstrap estimate of the sampling distribution (assuming no error in estimation of bycatch) of the recommended OFL is shown in Figure 10 (1,000 samples drawn with replacement independently from each of the three columns of values in Table 5 to calculate $R_{90/91-95/96}$, $RET_{85/86-95/96}$, $BM_{GF,93/94-08/09}$ and $OFL_{\text{Alt-2,2010/11}}$). Table 6 provides statistics on the generated distributions. Note that generated sampling distribution and computed standard deviation are meaningful as measures in the uncertainty of the OFL only if assumptions on the choice of years used to compute the Tier 5 OFL are true (see Sections E.2 and E.4.f).

2. List of variables related to scientific uncertainty.

- The time period to compute the average catch relative to an assumption that this represents “a time period determined to be representative of the production potential of the stock.”
- 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 total-catch 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 1985/86–1995/96.
- See *E.4.f* for details.

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

5. Author recommended ABC.

$$(1.0-0.25) \cdot 12,533,570 \text{ lb} = 9,400,177 \text{ lb (9.40-million lb; 4,264 t)}.$$

The recommended ABC for 2015/16 was computed according to the status quo buffer of 0.25 recommended by the Crab Plan Team and SSC for 2014/15. The 2014 SAFE, May 2014 CPT minutes, and June 2014 SSC minutes provide the reasoning for use of a buffer of 0.25, rather than a buffer of 0.1 as was used to compute the ABCs for 2011/12 – 2013/14.

H. Rebuilding Analyses

Not applicable; this stock has not been declared overfished.

I. Data Gaps and Research Priorities

Currently, there are no biomass estimates for this stock and no program for providing fishery-independent data on the stock. The CPT in September 2013 identified development of a survey to provide better data than fishery CPUE and other fishery-dependent data to index stock abundance and recruitment. To address that priority need, ADF&G, NMFS, and industry began discussions in January 2014 to develop such a survey and a “pilot survey” using a cooperating commercial fishing vessel was performed during September 2014 in the Aleutian Islands east of 174° W longitude.

Bycatch mortality rate in directed fishery is unknown.

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Table 1. Harvest history for the Aleutian Islands golden king crab fishery (GHL/TAC, lb and number of retained crabs, pot lifts, fishery catch per unit effort, and average weight of landed crab) by fishery season from the 1981/82 season through the 2013/14 season, including the Community Development Quota (CDQ) and Adak Community Allocation (ACA) fisheries for the 2005/06–2013/14, and cost-recovery fishery for 2013/14 (from 2014 Crab SAFE, updated for 2013/14).

Season	GHL/TAC		Harvest Number ^a	Pot lifts	CPUE ^b	Average Weight ^c
	Millions of Lb	Harvest Lb ^a				
1981/82	-	1,319,666	242,407	28,263	8.4	5.4 ^d
1982/83	-	9,236,942	1,746,206	179,888	9.4	5.3 ^d
1983/84	-	10,495,045	1,964,772	267,519	7.2	5.3 ^d
1984/85	-	4,819,347	995,453	90,066	10.7	4.8 ^e
1985/86	-	12,734,212	2,811,195	236,281	11.9	4.5 ^f
1986/87	-	14,738,744	3,340,627	433,020	7.7	4.4 ^f
1987/88	-	9,257,005	2,174,576	306,730	7.1	4.2 ^f
1988/89	-	10,627,042	2,488,433	321,927	7.6	4.3 ^f
1989/90	-	12,022,052	2,902,913	357,803	8.0	4.1 ^f
1990/91	-	6,950,362	1,703,251	214,814	7.7	4.1 ^f
1991/92	-	7,702,141	1,847,398	234,857	7.7	4.2 ^f
1992/93	-	6,291,197	1,528,328	203,221	7.4	4.1 ^f
1993/94	-	5,551,143	1,397,530	234,654	5.8	4.0 ^f
1994/95	-	8,128,511	1,924,271	386,593	4.8	4.2 ^f
1995/96	-	6,960,406	1,582,333	293,021	5.2	4.4 ^f
1996/97	5.900	5,815,772	1,334,877	212,727	6.0	4.4 ^f
1997/98	5.900	5,945,683	1,350,160	193,214	6.8	4.4 ^f
1998/99	5.700	4,941,893	1,150,029	119,353	9.4	4.3 ^f
1999/00	5.700	5,838,788	1,385,890	186,169	7.2	4.2 ^f
2000/01	5.700	6,018,761	1,410,315	172,790	8.0	4.3 ^f
2001/02	5.700	5,918,706	1,416,768	168,151	8.3	4.2 ^f
2002/03	5.700	5,462,455	1,308,709	131,021	9.8	4.2 ^f
2003/04	5.700	5,665,828	1,319,707	125,119	10.3	4.3 ^f
2004/05	5.700	5,575,051	1,323,001	91,694	14.2	4.2 ^f
2005/06	5.700	5,520,318	1,263,339	54,685	22.9	4.4 ^f
2006/07	5.700	5,262,342	1,178,321	53,065	22.0	4.5 ^f
2007/08	5.700	5,508,100	1,233,848	52,609	23.5	4.5 ^f
2008/09	5.985	5,680,084	1,254,607	50,666	24.8	4.5 ^f
2009/10	5.985	5,912,287	1,308,218	52,787	24.8	4.5 ^f
2010/11	5.985	5,968,849	1,297,229	55,795	23.2	4.6 ^f
2011/12	5.985	5,964,416	1,284,946	44,241	29.0	4.6 ^f
2012/13	6.290	6,267,759	1,360,582	53,543	25.4	4.6 ^f
2013/14 ^g	6.290	6,379,553	1,407,103	63,223	22.3	4.5 ^f

a. Includes deadloss.

b. Catch (number of crab) per pot lift.

c. Average weight (lb) of landed crab, including deadloss.

d. Managed with 6.5" CW minimum size limit.

e. Managed with 6.5" CW minimum size limit west of 171° W longitude and 6.0" minimum size limit east of 171° W longitude.

f. Managed with 6.0" minimum size limit.

g. Catch and effort data includes cost-recovery fishery.

Table 2. Retained catch (thousands of lb) of Aleutian Islands golden king crab, with the estimated non-retained catch (thousands of lb; not discounted for an assumed bycatch mortality rate) and components of non-retained catch (non-retained legal males, non-retained sublegal males, non-retained females) during commercial crab fisheries by season, 1990/91–2013/14 (from 2014 Crab SAFE, updated for 2013/14); observer data on non-retained catch during the 1993/94 and 1994/95 seasons are confidential and considered to have poor reliability.

Season	Retained Catch	Non-retained Catch	Components of non-retained catch:		
			Legal males	Sublegal males	Females
1990/91	6,950	13,824	12	6,407	7,405
1991/92	7,702	11,257	214	5,533	5,510
1992/93	6,291	13,082	62	5,875	7,145
1993/94	5,551	—	—	—	—
1994/95	8,129	—	—	—	—
1995/96	6,960	12,050	64	6,054	5,932
1996/97	5,816	9,100	25	4,222	4,854
1997/98	5,946	8,733	40	4,199	4,494
1998/99	4,942	7,388	41	4,303	3,044
1999/00	5,839	7,552	64	3,930	3,557
2000/01	6,019	8,902	35	4,782	4,084
2001/02	5,919	6,888	27	3,787	3,075
2002/03	5,462	5,671	42	3,113	2,516
2003/04	5,666	4,973	39	2,664	2,271
2004/05	5,575	4,321	76	2,512	1,733
2005/06	5,520	2,524	140	1,479	905
2006/07	5,262	2,573	120	1,263	1,190
2007/08	5,508	3,035	128	1,505	1,402
2008/09	5,680	2,764	175	1,365	1,223
2009/10	5,912	2,787	164	1,364	1,260
2010/11	5,969	2,726	223	1,249	1,255
2011/12	5,964	2,540	269	1,181	1,089
2012/13	6,268	2,900	342	1,235	1,323
2013/14	6,380	3,165	369	1,489	1,307

Table 3. Estimated annual weight (lb) of discarded bycatch of golden king crab (all sizes, males and females) and bycatch mortality (lb) during federal groundfish fisheries in federal reporting areas 541, 542, and 543 (see Figure 6) by gear type (fixed or trawl), 1991/92–2013/14 (assumes bycatch mortality rate of 0.5 for fixed-gear fisheries and 0.8 for trawl fisheries (from 2014 Crab SAFE, updated for 2013/14).

Year	Bycatch		Bycatch Mortality		
	Fixed Gear	Trawl Gear	Fixed Gear	Trawl Gear	Total
1991/92	0	0	0	0	0
1992/93	5	3	3	2	5
1993/94	3,960	8,164	1,980	6,531	8,511
1994/95	1,346	2,674	673	2,139	2,812
1995/96	367	5,165	184	4,132	4,316
1996/97	26	13,862	13	11,090	11,103
1997/98	539	1,071	270	857	1,126
1998/99	3,901	1,381	1,951	1,105	3,055
1999/00	10,572	1,422	5,286	1,138	6,424
2000/01	7,166	669	3,583	535	4,118
2001/02	1,387	417	694	334	1,027
2002/03	75,952	871	37,976	697	38,673
2003/04	86,186	1,498	43,093	1,198	44,291
2004/05	2,450	2,452	1,225	1,962	3,187
2005/06	1,246	4,151	623	3,321	3,944
2006/07	72,306	3,077	36,153	2,462	38,615
2007/08	254,225	3,641	127,113	2,913	130,025
2008/09	108,683	22,712	54,342	18,170	72,511
2009/10	44,226	18,061	22,113	14,449	36,562
2010/11	31,456	34,801	15,728	27,841	43,569
2011/12	36,236	20,038	18,118	16,030	34,148
2012/13	1,191	24,593	596	19,674	20,270
2013/14	3,480	27,382	1,740	21,906	23,645

Table 4. Estimated annual weight (thousands of lb) of total fishery mortality to Aleutian Islands golden king crab, 1990/91–2013/14, partitioned by source of mortality: retained catch, bycatch mortality during crab fisheries, and bycatch mortality during groundfish fisheries (from 2014 Crab SAFE, updated for 2013/14).

Season	Retained Catch	Bycatch Mortality by Fishery Type		Total Fishery Mortality
		Crab	Groundfish	
1990/91	6,950	2,765	—	—
1991/92	7,702	2,251	—	—
1992/93	6,291	2,616	—	—
1993/94	5,551	—	9	—
1994/95	8,129	—	3	—
1995/96	6,960	2,410	4	9,375
1996/97	5,816	1,815	11	7,642
1997/98	5,946	1,739	1	7,685
1998/99	4,942	1,478	3	6,423
1999/00	5,839	1,510	6	7,356
2000/01	6,019	1,780	4	7,803
2001/02	5,919	1,378	1	7,297
2002/03	5,462	1,134	39	6,635
2003/04	5,666	995	44	6,705
2004/05	5,575	864	3	6,442
2005/06	5,520	505	4	6,029
2006/07	5,262	515	39	5,816
2007/08	5,508	607	130	6,245
2008/09	5,680	553	73	6,305
2009/10	5,912	557	37	6,506
2010/11	5,969	545	44	6,558
2011/12	5,964	508	34	6,506
2012/13	6,268	580	20	6,868
2013/14	6,380	633	24	7,037

Table 5. Data for calculation of $RET_{85/86-95/96}$ and estimates used in calculation of $R_{90/91-95/96}$ and $BM_{GF,93/94-08/09}$ for calculation of the recommended (status quo) Aleutian Islands golden king crab Tier 5 2015/16 OFL (lb); values under $RET_{85/86-95/96}$ are from Table 1, values under $R_{90/91-95/96}$ were computed from the retained catch data and the crab bycatch mortality estimates in Table 4; values under $BM_{GF,93/94-08/09}$ are from Table 4.

Season	$RET_{85/86-95/96}^a$	$R_{90/91-95/96}^b$	$BM_{GF,93/94-08/09}^c$
1985/86	12,734,212		
1986/87	14,738,744		
1987/88	9,257,005		
1988/89	10,627,042		
1989/90	12,022,052		
1990/91	6,950,362	0.398	
1991/92	7,702,141	0.292	
1992/93	6,291,197	0.416	
1993/94	5,551,143	—	8,511
1994/95	8,128,511	—	2,812
1995/96	6,960,406	0.346	4,315
1996/97			11,102
1997/98			1,126
1998/99			3,055
1999/00			6,424
2000/01			4,119
2001/02			1,027
2002/03			38,673
2003/04			44,291
2004/05			3,187
2005/06			3,944
2006/07			38,614
2007/08			130,026
2008/09			72,511
N	11	4	16
Average	9,178,438	0.363	23,359
S.E.M.	896,511	0.028	8,827
CV	0.10	0.08	0.38

- $RET_{85/86-95/96}$ is the average annual retained catch (lb) in the directed crab fishery during the period 1985/86–1995/96; data from Table 1.
- $R_{90/91-95/96}$ is the average of the estimated annual ratios of lb of bycatch mortality due to crab fisheries to lb of retained catch in the directed fishery during the period 1990/91–1995/96 (excluding 1993/94–1994/95, due to data confidentiality and insufficiencies); data from Table 4.
- $BM_{GF,93/94-08/09}$ is the average of the annual estimates of bycatch mortality (lb) due to groundfish fisheries over the period 1993/94–2008/09; data from Table 4.

Table 6. Statistics for 1,000 bootstrap OFLs (lb) calculated according to the author recommended (status quo) approach for 2015/16 OFL calculation, with the computed OFL for comparison (from 2013 Crab SAFE).

	Recommend – status quo approach
Computed OFL (lb)	12,537,757
Mean of 1,000 bootstrapped OFLs (lb)	12,510,742
Std. dev. of 1,000 bootstrapped OFLs	1,184,511
CV = (std. dev.)/(Mean)	0.09

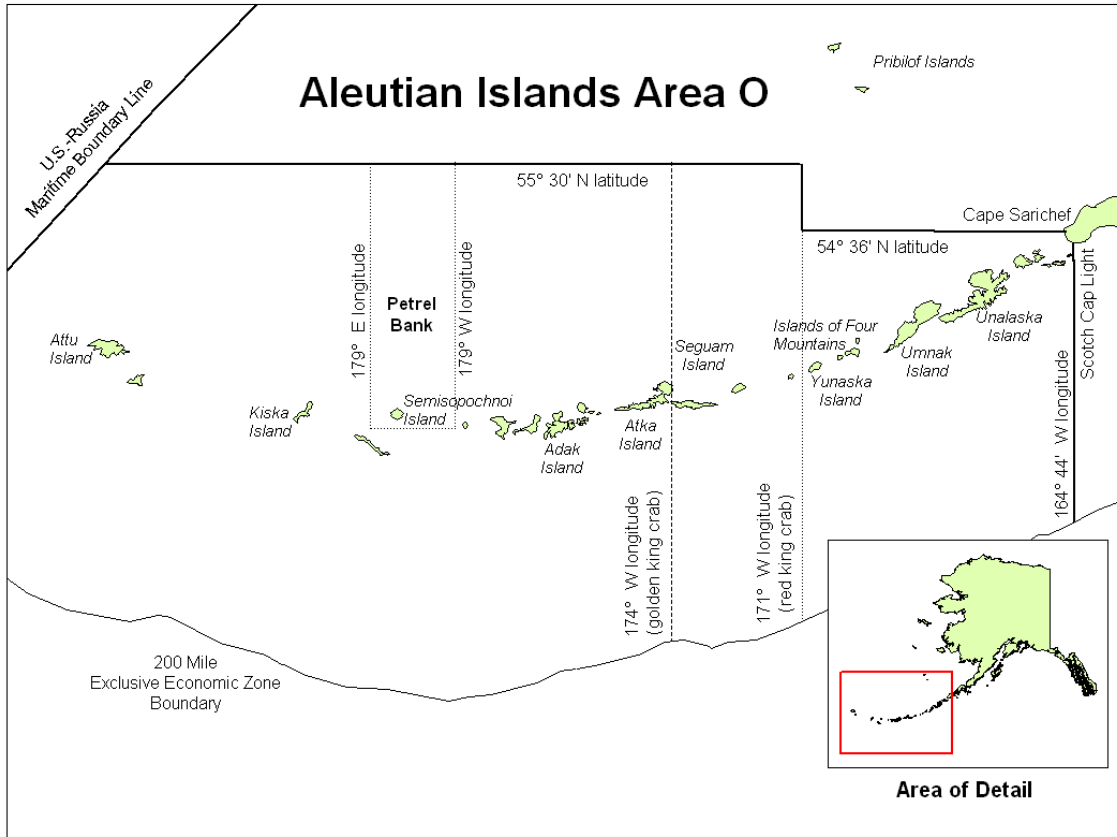


Figure 1. Aleutian Islands, Area O, red and golden king crab management area (from Baechler and Cook 2014).

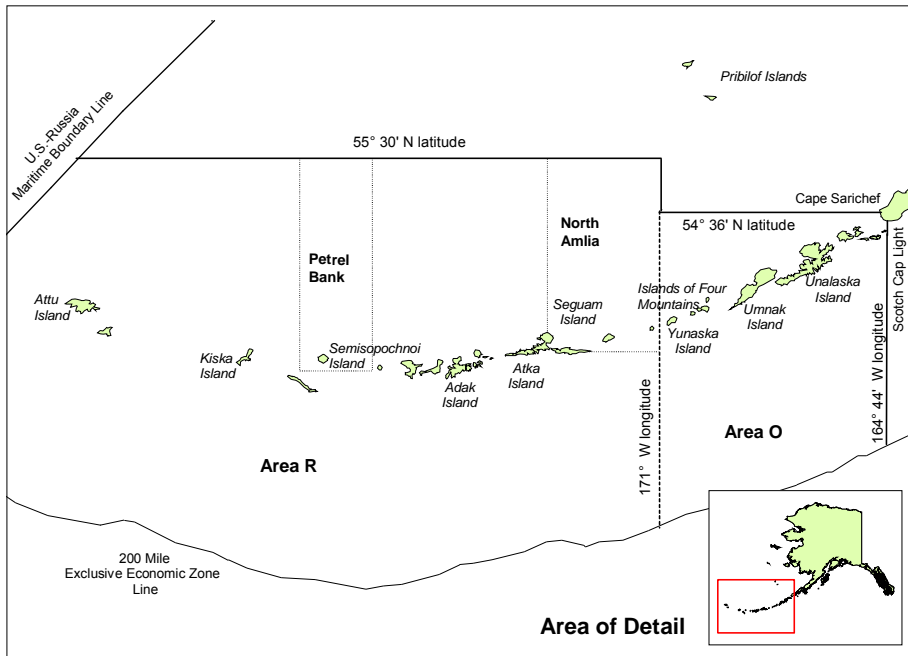


Figure 2. Adak (Area R) and Dutch Harbor (Area O) king crab Registration Areas and Districts, 1984/85–1995/96 seasons (from Baechler 2012).

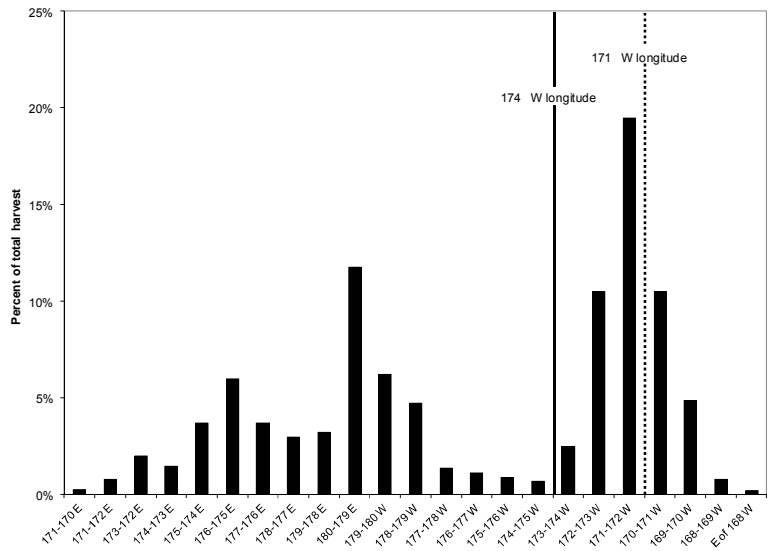


Figure 3. Percent of total 1981/82–1995/96 golden king crab harvest from one-degree longitude intervals in the Aleutian Islands, with dotted line denoting the border at 171° W longitude used during the 1984/85–1995/96 seasons to divide fishery management between the Dutch Harbor Area (east of 171° W longitude) and the Adak Area (west of 171° W longitude) and solid line denoting the border at 174° W longitude used since the 1996/97 season to manage crab east and west of 174° W longitude (adapted from Figure 4-2 in Morrison et al. 1998).

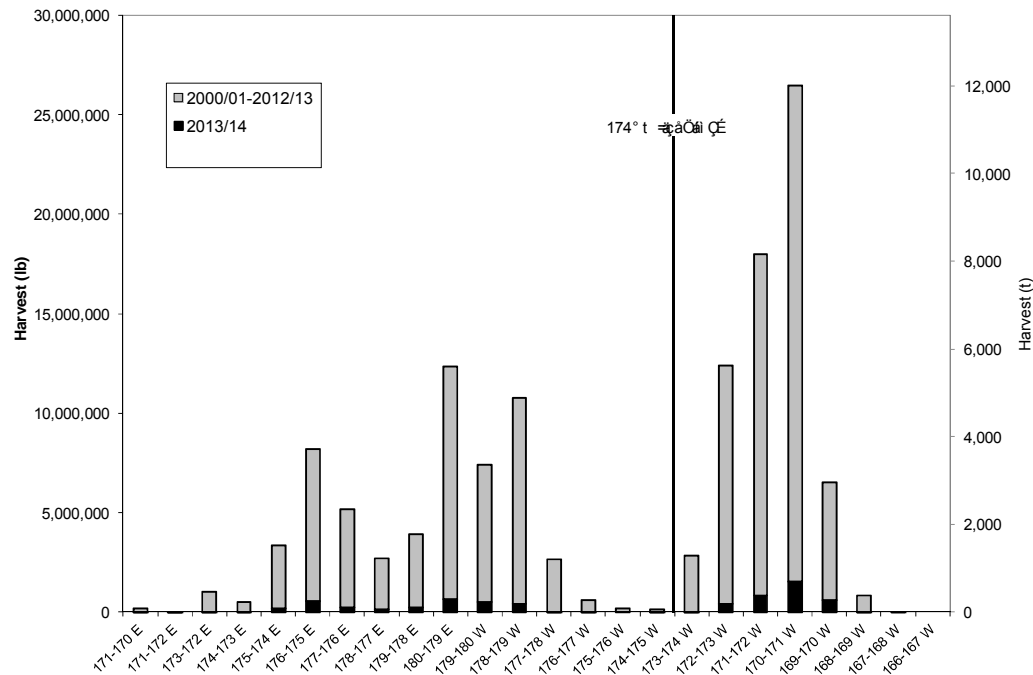


Figure 4. Harvest (lb on left axis and t on right axis) of golden king crab from one-degree longitude intervals in the Aleutian Islands during the 2000/01 through 2013/14 commercial fishery seasons; solid line denotes the border at 174° W longitude that has been used since the 1996/97 season to manage Aleutian Island golden king crab as separate stocks east and west of 174° W longitude (from 2014 Crab SAFE, updated for 2013/14).

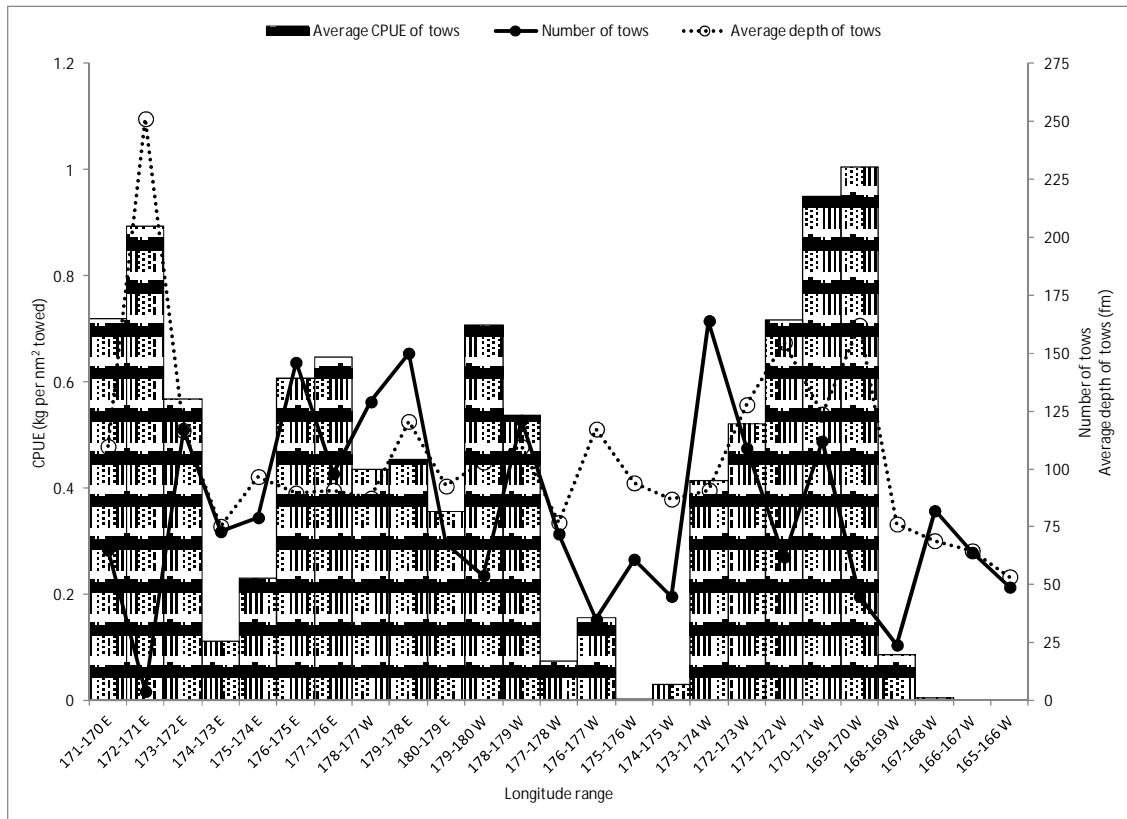


Figure 5. Average golden king crab CPUE (kg/nm²) for tows, number of tows, and average depth of tows from one-degree longitude intervals during the 2002, 2004, 2006, 2010, and 2012 NMFS Aleutian Islands bottom trawl surveys; preliminary summary of data obtained on 1 April 2013 from http://www.afsc.noaa.gov/RACE/groundfish/survey_data/default.htm.

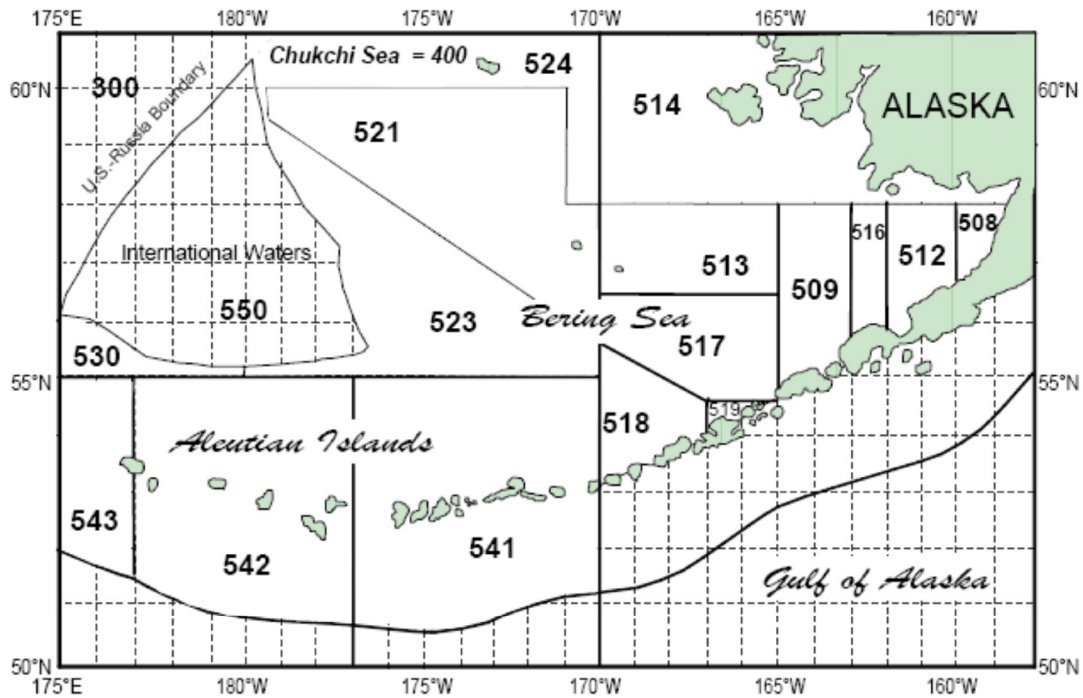


Figure 6. Map of federal groundfish fishery reporting areas for the Bering Sea and Aleutian Islands showing reporting areas 541, 542, and 543 that are used to summarize groundfish fisheries bycatch data for Aleutian Islands golden king crab (from <http://www.alaskafisheries.noaa.gov/rr/figures/fig1.pdf>).

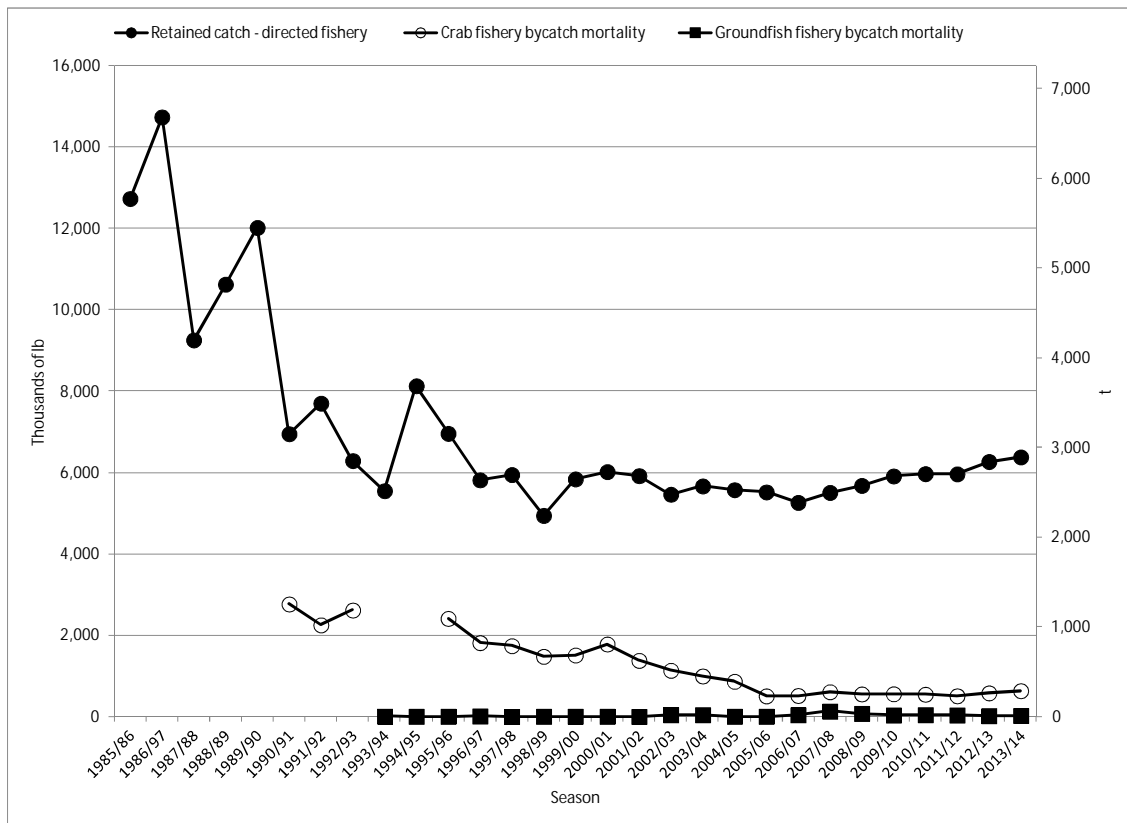


Figure 7. Retained catch during the Aleutian Islands golden king crab (AIGKC) fishery, estimated bycatch mortality of AIGKC (when available) during all crab fisheries, and estimated bycatch mortality of AIGKC (when available) for all groundfish fisheries, 1985/86–2013/14 (thousands of lb on left axis and t on right axis; from Table 4).

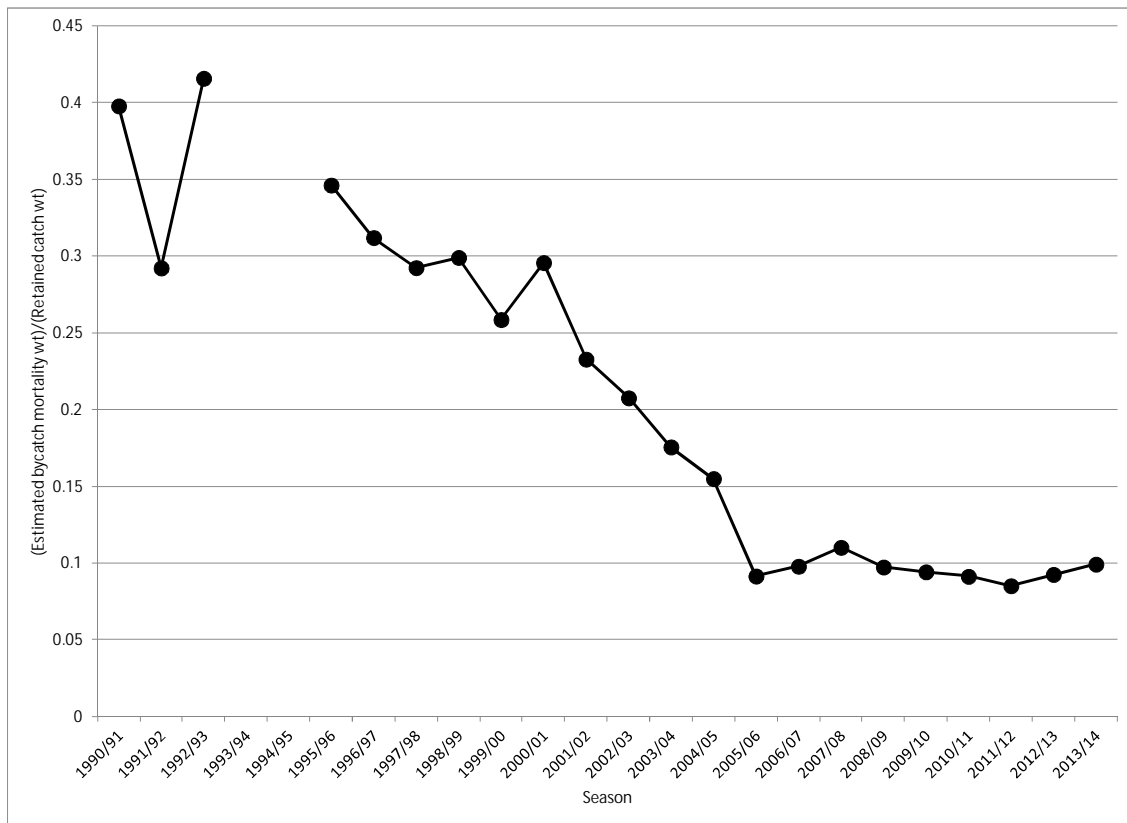


Figure 8. Ratio of estimated weight of bycatch mortality in directed and non-directed crab fisheries to weight of retained catch for Aleutian Islands golden king crab, 1990/91–2013/14 (ratios for 1993/94–1994/95 not available due to data confidentialities and insufficiencies).

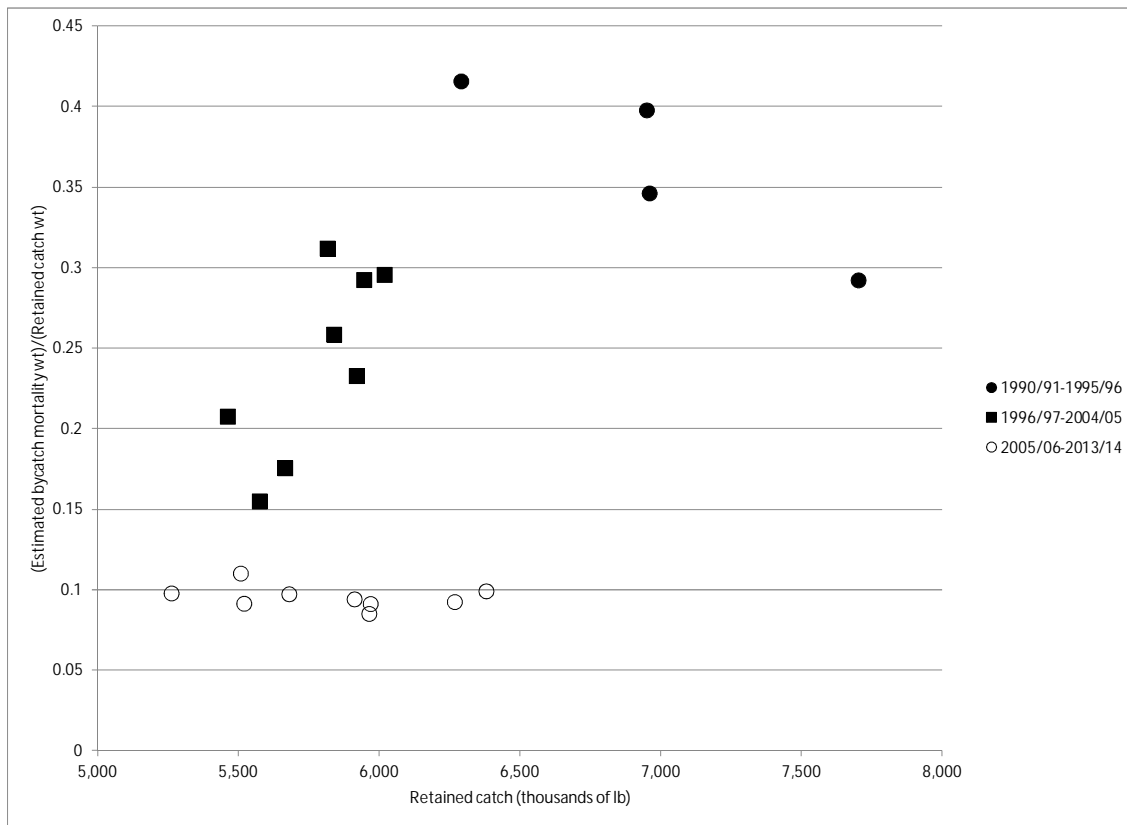


Figure 9. Ratio of estimated weight of bycatch mortality in directed and non-directed crab fisheries to weight of retained catch for Aleutian Islands golden king crab plotted against weight of retained catch, 1990/91–2013/14 (ratios for 1993/94–1994/95 not available due to data confidentiality and insufficiencies).

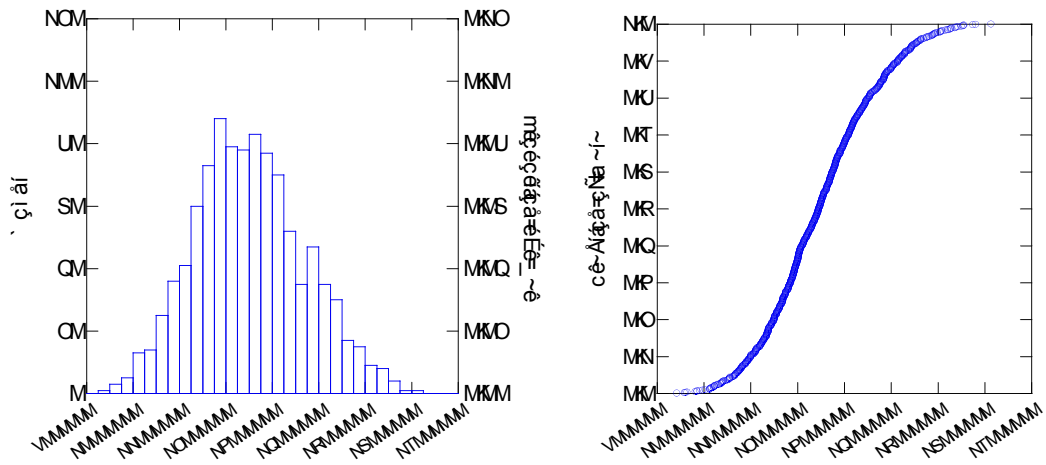


Figure 10. Bootstrapped estimates of the sampling distribution of the recommended 2015/2016 Tier 5 OFL (lb of total-catch) for the Aleutian Islands golden king crab stock; histograms in left column, cumulative distribution in right column (from 2013 Crab SAFE).

Appendix A1. Information added at request of Crab Plan Team, 4 May 2015. Harvest (number of retained crab) and CPUE (number of retained crab per pot lift) in the Aleutian Islands golden king crab fishery, 1985/86–2013/14, presented separately for the areas east and west of 174° W longitude; 2013/14 data does not include catch towards cost-recovery fishing .

