Aleutian Islands Golden King Crab – 2013 Tier 5 Assessment

May 2013 Crab SAFE Report Chapter (18 April 2013 Draft)

 Douglas Pengilly, ADF&G, Kodiak

## 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). Management towards a formally established guideline harvest level (GHL) was introduced for the first time in the 1996/97 season. A GHL of 5.900-million lb (2,676 t) was established for the 1996/97 season, which was 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 season. Average annual retained catch for the period 1996/97–2007/08 was 5.623-million lb (2,550 t). Average annual retained catch in 2008/09–2011/12 was 5.881-million lb (2,668 t). The 2012/13 season remains open until 15 May 2013. Catch per pot lift of retained legal males decreased from the 1980s into the mid-1990’s, 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 to conduct test fisheries. 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 2007/08 and 2008/09, that bycatch was less than 10% of the weight of bycatch during the directed fishery for those seasons. Estimated bycatch in groundfish fisheries during 2009/10–2011/12 was ≤ 0.066-million lb (30 t). Annual non-retained catch of golden king crab during crab fisheries has decreased relative to the retained catch and in absolute numbers and weight since the 1990’s. Annual estimated weight of discarded bycatch during crab fisheries decreased from 13.824-million lb (6,270 t) in 1990/91 (representing 199% of the retained catch during that season), to 9.100-million lb (4,128 t) in 1996/97 (representing 156% of the retained catch for that season), and to 4.321-million lb (1,960 t) in the 2004/05 season (representing 78% of the retained catch for that season). During the seven seasons (2005/06–2011/12) prosecuted as rationalized fisheries, estimated weight of discarded bycatch has ranged from 2.524-million lb (1,145 t) for the 2005/06 season (representing 46% of the retained catch for that season) to 3.035-million lb (1,376 t) for the 2007/08 season (representing 55% 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 1995/96–2011/12, the period for which such estimates can be made; estimated total fishery mortality for 2011/12 was 6.506-million lb (2,951 t).

1. **Stock biomass:**

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

1. **Recruitment:**

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

1. **Management performance:**

See tables below. No overfished determination (i.e., MSST) is possible for this Tier 5 stock. Overfishing did not occur during 2011/12 (i.e., the OFL was not exceeded) and the ABC was not exceeded in 2011/12; the 2012/13 season remains open until 15 May 2013. The OFL and ABC values for 2013/14 are the recommended (status quo) values. The 2013/14 TAC has not yet been established; the value given in the table is the default TAC according to current SOA regulations (5 AAC 34.612).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **MSST** | **Biomass (MMB)** | **TACa** | **Retained Catcha** | **Total Catcha,b** | **OFLa, c** | **ABCa, c** |
| 2009/10 | N/A | N/A | 5.99 | 5.91 | 6.51 | 9.18, R | N/A |
| 2010/11 | N/A | N/A | 5.99 | 5.97 | 6.56 | 11.06, T | N/A |
| 2011/12 | N/A | N/A | 5.99 | 5.96 | 6.51 | 11.40, T | 10.26, T |
| 2012/13 | N/A | N/A | 6.29 |  |  | 12.54, T | 11.28, T |
| 2013/14 | N/A | N/A | 6.29 |  |  | 12.54, T | 11.28, T |

1. Millions of pounds.
2. Total retained catch plus estimated bycatch mortality of discarded bycatch during crab fisheries and groundfish fisheries.
3. Noted as “R” for retained-catch only and as “T” for total-catch.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **MSST** | **Biomass (MMB)** | **TACa** | **Retained Catcha** | **Total Catcha,b** | **OFLa, c** | **ABCa, c** |
| 2009/10 | N/A | N/A | 2.72 | 2.68 | 2.59 | 4.16, R | N/A |
| 2010/11 | N/A | N/A | 2.72 | 2.71 | 2.98 | 5.02, T | N/A |
| 2011/12 | N/A | N/A | 2.72 | 2.71 | 2.95 | 5.17, T | 4.66, T |
| 2012/13 | N/A | N/A | 2.85 |  |  | 5.69, T | 5.12, T |
| 2013/14 | N/A | N/A | 2.85 |  |  | 5.69, T | 5.12, T |

1. Metric tons.
2. Total retained catch plus estimated bycatch mortality of discarded bycatch during crab fisheries and groundfish fisheries.
3. Noted as “R” for retained-catch only and as “T” for total-catch.

**Basis for the OFL and ABC:** See table, below; 2013/14 values are the recommended (status quo) values.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Year** | **Tier** | **Years to define****Average catch (OFL)** | **Natural****Mortalitya** | **Buffer** |
| 2009/10 | 5 | 1985/86–1995/96b | 0.18 | N/A |
| 2010/11 | 5 | 1985/86–1995/96c | 0.18 | N/A |
| 2011/12 | 5 | 1985/86–1995/96c | 0.18 | 10% |
| 2012/13 | 5 | 1985/86–1995/96c | 0.18 | 10% |
| 2013/14 | 5 | 1985/86–1995/96c | 0.18 | 10% |

1. Assumed value for FMP king crab in NPFMC (2007b); does not enter into OFL estimation for Tier 5 stock.
2. OFL was for retained catch only and was determined by the average of the retained catch for these years.
3. OFL was for total catch and 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.
4. **PDF of the OFL:** Sampling distribution of the recommended (status quo) Tier 5 OFL was estimated by bootstrapping. The standard deviation of the estimated sampling distribution of the recommended OFL is 1.18-million pounds (CV = 0.09). See section G.1.
5. **Basis for the ABC recommendation:** A 10% buffer on the OFL; i.e.,

ABC = (1-0.1)·OFL.

1. **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.

1. **Changes to the input data:**
* Fishery data has been updated with the results for 2011/12: retained catch for the directed fishery and bycatch estimates for the directed fishery, non-directed crab fisheries, and groundfish fisheries.
1. **Changes to the assessment methodology:** None. This assessment follows the methodology recommended by the CPT in May 2012 and the SSC in June 2012.

1. **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 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 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 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 recommended OFL and ABC for 2013/14 are a total-catch OFL of 12.54-million lb (5.69 kt) and an ABC set at the maximum (i.e., with a 10% buffer below the OFL) of 11.28 million lb (5.12 kt); those are the status quo values from 2012/13.

### 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 2012: *None*.
* SSC, June 2012: *None*.
* CPT, September 2012 (via Sept 2012 SAFE):
	+ - * *“The team recommends that all assessment authors document assumptions and simulate data under those assumptions to test the ability of the model to estimate key parameters in an unbiased manner. These simulations would be used to demonstrate precision and bias in estimated model parameters.”*
				+ Response: Not applicable for Tier 5 assessment.
		- *“The CPT recommends the listing of sigmas instead of absolute weights as being more informative for factors such as L50 and β. Also, the team recommends specifying weights for the penalties on L50 and from the standard errors from the analysis on which the estimates for these parameters were based.”*
			* Response: Not applicable for Tier 5 assessment.
			* *“The team requests all authors to consult the Guidelines for SAFE preparation and to follow the Terms of Reference as listed therein as applicable by individual assessment for both content and diagnostics.”*
			* Response: Guidelines for SAFE preparation as supplied in 26 July 2012 email from the CPT chair were consulted and followed.
			* *“The team requests that to the extent possible assessments include a listing of the tables and figures in the assessment (i.e., Table of Tables, Table of Figures).”*
			* Response: A table of tables and a table of figures are included.
* SSC, October 2012: *None*.

1. **Responses to the most recent two sets of SSC and CPT comments specific to the assessment:**
* CPT, May 2012 (May 2012 CPT minutes): *None.*
* SSC, June 2012 (June 2012 SSC minutes): *“… The SSC agrees with the CPT recommendation that this stock continue to be managed using Tier 5 allowing a total catch OFL of 5.69 kt and ABC of 5.12 kt for 2012/2013. The ABC is based on the ABC control rule which specifies a 10% buffer between the OFL and ABC.”*
	+ Response: The author’s recommended OFL and ABC for 2013/14 follow the SSC’s recommendations for 2012/13.
* CPT, September 2012 (via Sept 2012 SAFE): *None*.
* SSC, October 2011: *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, golden king crab are found at depths from 200 m to 1,000 m, generally in high-relief habitat such as inter-island passes (page 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 (page 3-43).

The Aleutian Islands king crab stock boundary is defined by the boundaries of the Aleutian Islands king crab Registration Area O (Figure 1). Baechler (2012, 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 2012). At its March 1996 meeting, the Alaska Board of Fisheries (BOF) replaced the Adak and Dutch Harbor areas with the newly created Aleutian Islands Registration Area O and directed 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, as is shown by the longitudinal pattern in fishery production prior to the 1996/97 season (Figure 3). The longitudinal pattern in fishery production during recent fisheries since that change in management is shown in Figure 4. In this chapter we use “Aleutian Islands Area” to mean 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 2010/11 season the pots sampled by at-sea observers were fished at an average depth of 175 fathoms (320 m; N=436) in the area east of 174° W longitude and 175 fathoms (320 m; N=867) for the area west of 174° W longitude (Gaeuman 2011).

1. **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 is largely limited to the geographic location of commercial fishery catch and effort. Effort and catch by statistical area since 1982 and locations of over 70,000 fished pots that were sampled by observers since 1996 seasons indicate that habitat for legal-sized males may be continuous throughout the waters adjacent to the Aleutian Islands. However, regions in which available habitat is attenuated or in which golden king crab are present at only low densities are suggested by regions of low fishery catch. In particular, Figures 3 and 4 show that catch has been low in the fishery in the area between 174° W longitude and 176° W longitude (i.e., the Atka I. area) in comparison to adjacent areas. Catch of golden king crab during the 2002, 2004, 2006, 2010, and 2012 NMFS Aleutian Islands bottom trawl survey (von Szalay et al. 2011) also show an area of low CPUE for golden king crab in the area between 174° W longitude and 176° W longitude (i.e., the Atka I. area) in comparison to adjacent areas. Additionally, there is a gap of catch and effort in statistical areas between Petrel Bank/Petrel Spur and Bowers Bank, both of which areas 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 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 of 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 (L. J. Watson, Fishery Biologist, ADF&G, Kodiak, retired; personnel communication).

1. **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 (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 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).

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.

1. **Brief summary of management history:**

A complete summary of the management history through the 2010/11 season is provided in Baechler (2012, pages 12–18). 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 the 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 pound 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 that specified if conservation concerns arise. Over the period 1996/97–2011/12 the total of the annual retained catch has been 2% below the total of the annual GHL/TACs. By season, over the period 1996/97–2011/12 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 2011/12 season was <1% below the 5.985-million lb (2,715 t) TAC.

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 to be 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 legal size may be retained by the commercial golden king crab fishery in the Aleutian Islands Area. By State of Alaska 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) ≥135 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 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 (as defined in **5 AAC 34.050**). Pots used to fish for golden king crab in the Aleutian Islands Area may be operated only 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") 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" escape web on the door of over 95% of Golden Crab pot orders we manufactured.” 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.” **5 AAC 34.625 (b)(1)** allowsthe 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.”

By State of Alaska regulation (**5 AAC 34.610 (b)**), the commercial fishing season for golden king crab in the Aleutian Islands Area is August 15 through May 15.

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)**.

1. **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.

1. **Summary of the history of BMSY:** Not applicable for this Tier 5 stock.

### D. Data

1. **Summary of new information:**
* Fishery data on retained catch and non-retained bycatch during 2011/12 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 2011/12 have been added.
* Estimates of total fishery mortality (retained catch plus estimated bycatch mortality during crab and groundfish fisheries) during 2011/12 have been added.
1. **Data presented as time series:**
2. ***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 1981/82–2011/12 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 1995/96–2011/12 (Table 2). Some observer data exists for the 1988/89–1989/90 seasons, but that data is 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 ≤2% of the estimated total weight in the crab fisheries annually. 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 1993/94–2011/12 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 1995/96–2011/12 directed and non-directed crab fisheries and 1993/94–2011/12 groundfish fisheries are presented in Table 4. Estimates of total fishery mortality (retained catch plus estimated bycatch mortality during crab and groundfish fisheries) during 1995/96–2011/12 are presented (Table 4). Following Siddeek et al. (2012), 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.
1. ***Catch-at-length:*** Not used in a Tier 5 assessment; none are presented.
2. ***Survey biomass estimates:*** Not used in a Tier 5 assessment; none are presented.
3. ***Survey catch at length:*** Not used in a Tier 5 assessment; none are presented (see section D.4).
4. ***Other data time series:*** See section D.4 on other time-series data that are available, but not presented here.
5. **Data which may be aggregated over time:**
	1. ***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 has 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(molt) = exp(17.930 – 0.129\*CL)/[1 + exp(17.930 – 0.129\*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(molt to legal size) = 1 – exp(15.541 – 0.127\*CL)/[1 + exp(15.541 – 0.127\*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).

* 1. ***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 red king crab according to the equation, Weight = A\*CLB (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; 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 pounds by dividing by 453.6.

1. ***Natural mortality rate:***

The default natural mortality rate assumed for king crab species by NPFMC (2007b) is M=0.18. Note, however, that this natural mortality assumption was not used in this Tier 5 stock assessment.

1. **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° 21’ and 171° 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. There is an assessment model in development for this stock (Siddeek et al. 2012).

### 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. Such a model is in development (Siddeek et al. 2012), but has not been accepted. In 2012 the SSC recommended that this stock be managed under Tier 5 for 2012/13 (June 2012 SSC minutes).

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 2013/14.

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.” Prior to 2008, two time periods considered for computing the average retained catch for Aleutian Islands golden king crab: 1985–2005 (NPFMC 2007a) and 1985–1999 (NPFMC 2007b). NPFMC (2007b) suggested using the average retained catch over the years 1985 to 1999 as 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 pounds for the 1996/97 and 1997/98 seasons to 5.7-million pounds for the 1998/1999 season; the GHL or TAC has remained at 5.7-million pounds for all subsequent seasons until it was increased to 5.985-million pounds 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 6 seasons (1990/91–1995/96), for computing average annual retained catch to estimated 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 at the 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-1990’s, the first five 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-1990’s could be interpreted as resulting from fishery that relied increasingly on annual recruitment to legal size as it fished on 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):

OFL2010/11 = (1+R96/97-08/09)•RET85/86-95/96 + BMGF,96/97-08/09 =11.0 million lbs.,

where

* R96/97-08/09 is the average of the estimated annual ratios of pounds of bycatch mortality due to crab fisheries to pounds of retained catch in the directed fishery during the period 1996/97-2008/09,
* RET85/86-95/96 is the average annual retained catch in the directed crab fishery during the period 1985/86-1995/96, and
* BMGF, 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 was 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:

OFL2011/12 = (1+R90/91-08/09)•RET85/86-95/96 + BMGF,93/94-08/09 ,

where,

* R90/91-08/09 is the average of the estimated annual ratios of pounds of bycatch mortality due to crab fisheries to pounds of retained catch in the directed fishery during the period 1990/91-2008/09 (excluding 1993/94–1994/95, due to data confidentialities and insufficiencies)
* RET85/86-95/96 is the same as defined for OFL2010/11, above (i.e., the average annual retained catch in the directed crab fishery during the period 1985/86-1995/96), and
* BMGF,93/94-08/09 is the same as defined for OFL2010/11, 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 pounds of bycatch mortality due to crab fisheries to pounds 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 pounds of bycatch mortality due to crab fisheries to pounds 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:

OFL2012/13 = (1+R90/91-95/96)•RET85/86-95/96 + BMGF,93/94-08/09,

where,

* R90/91-95/96 is the average of the estimated annual ratios of pounds of bycatch mortality due to crab fisheries to pounds 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),
* RET85/86-95/96 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
* BMGF,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).

## Model Selection and Evaluation:

* 1. ***Description of alternative model configurations***

During the 2008–2012 reviews of a Tier 5 OFL stock (see section 2, above), the SSC has recommended that “time period be frozen to stabilize the control rule” and that computation of the Tier 5 OFL 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 was not available and presented in 2012, 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 that was established in 2012):

OFL2013/14 = (1+R90/91-95/96)•RET85/86-95/96 + BMGF,93/94-08/09,

where,

* R90/91-95/96 is the average of the estimated annual ratios of pounds of bycatch mortality due to crab fisheries to pounds 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),
* RET85/86-95/96 is the average annual retained catch in the directed crab fishery during the period 1985/86-1995/96, and
* BMGF,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, RET(85/86-95/96, R90/91-95/96, and BMGF,93/94-08/09 are provided in Table 6; the column means in Table 6 are the calculated values of RET(85/86-95/96, R90/91-95/96, and BMGF,93/94-08/09. Using those calculated values of RET(85/86-95/96, R90/91-95/96, and BMGF,93/94-08/09, OFL2013/14 is computed as,

OFL2013/14 = (1+0.363)•(9,178,438) + 23,359=12,537,757 lb (12.54-million lb; 5.69 kt)

* 1. ***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.
	2. ***Evidence of search for balance between realistic (but possibly over-parameterized) and simpler (but not realistic) models:*** See the section A.4.
	3. ***Convergence status and convergence criteria for the base-case model (or proposed base-case model):*** Not applicable.
	4. ***Table (or plot) of the sample sizes assumed for the compositional data:*** Not applicable.
	5. ***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 1985/86–2011/12 in retained catch and in the available estimates of bycatch mortality due 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 1985/86–2011/12. Retained catch data come from fish tickets and annual retained catch is assumed to be known. Estimates of bycatch from crab fisheries data are generally considered credible (e.g., Byrne and Pengilly 1998, Gaeuman 2011). Estimates of bycatch mortality are estimates of bycatch times an assumed bycatch mortality rate. The assumed bycatch mortality rates have not been estimated from data or estimated from limited .

* 1. ***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.
	2. ***Residual analysis (e.g. residual plots, time series plots of observed and predicted values or other approach):*** Not applicable.
	3. ***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 mintues) 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: they are from 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 pounds of bycatch mortality due to crab fisheries to pounds of retained crab in the directed fishery since 1996/97 (Figures 8 and 9).

## Results (best model(s)):

1. ***List of effective sample sizes, the weighting factors applied when fitting the indices, and the weighting factors applied to any penalties:*** Not applicable.
2. ***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 5–7.
3. ***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.
4. ***Evaluation of the fit to the data:*** Not applicable for Tier 5 stock.
5. ***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.
6. ***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) pretty much covered all the bases on alternative choices for time periods that could be used to compute the retained-catch portion of the OFL. Interested readers are directed to that document, although we can note here that the average retained-catch of the OFL for the nine alternative time periods presented ranged from 5.63 million pounds (for 1996/97–2006/07) up to 9.18 million pounds (for 1985/86–1995/96, the time period 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 6.93-million pounds). In both 2008 and 2009, the SSC overrode the CPT’s recommendation and recommended that the years 1985/86–1995/96 to compute the retained-catch OFL at 9.18-million pounds. 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 pounds of bycatch mortality to pounds of retained crabs 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 Table 2; see also Figure 8 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 <0.01-million pounds to 0.130-million pounds. Because the estimates of bycatch biomass due to groundfish fisheries is small relative to the biomass of retained catch (≥4.82-million pounds annually during 1985/86–2010/11), the effect of choice of years here is negligibly small.
* The assumed bycatch mortality rates used in estimation of total fishery mortality. Bycatch mortality is unknown and no data that could be used to estimate the bycatch mortality of this stock is known to the author. 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 increases (decreases) linearly with increases (decreases) in the bycatch mortality rate assumed for the crab fisheries: double the assumed bycatch mortality rate from 0.2 to 0.4, and the OFL estimate increases by a factor of 1.4/1.2 = 1.17; half the assumed bycatch mortality rate from 0.2 to 0.1, and the OFL estimate decreases by a factor of 1.1/1.2 = 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 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.
1. **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.
2. **Specification of the OFL:**
	1. ***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.”

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

***Specification of FOFL, 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 2013/14 are the recommended (status quo) values. The 2013/14 TAC has not yet been established; the value given in the table is the default TAC according to current SOA regulations (5 AAC 34.612).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **MSST** | **Biomass (MMB)** | **TACa** | **Retained Catcha** | **Total Catcha,b** | **OFLa, c** | **ABCa, c** |
| 2009/10 | N/A | N/A | 5.99 | 5.91 | 6.51 | 9.18, R | N/A |
| 2010/11 | N/A | N/A | 5.99 | 5.97 | 6.56 | 11.06, T | N/A |
| 2011/12 | N/A | N/A | 5.99 | 5.96 | 6.51 | 11.40, T | 10.26, T |
| 2012/13 | N/A | N/A | 6.29 |  |  | 12.54, T | 11.28, T |
| 2013/14 | N/A | N/A | 6.29 |  |  | 12.54, T | 11.28, T |

1. Millions of pounds.
2. Total retained catch plus estimated bycatch mortality of discarded bycatch during crab fisheries and groundfish fisheries.
3. Noted as “R” for retained-catch only and as “T” for total-catch.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **MSST** | **Biomass (MMB)** | **TACa** | **Retained Catcha** | **Total Catcha,b** | **OFLa, c** | **ABCa, c** |
| 2009/10 | N/A | N/A | 2.72 | 2.68 | 2.59 | 4.16, R | N/A |
| 2010/11 | N/A | N/A | 2.72 | 2.71 | 2.98 | 5.02, T | N/A |
| 2011/12 | N/A | N/A | 2.72 | 2.71 | 2.95 | 5.17, T | 4.66, T |
| 2012/13 | N/A | N/A | 2.85 |  |  | 5.69, T | 5.12, T |
| 2013/14 | N/A | N/A | 2.85 |  |  | 5.69, T | 5.12, T |

1. Metric tons.
2. Total retained catch plus estimated bycatch mortality of discarded bycatch during crab fisheries and groundfish fisheries.
3. Noted as “R” for retained-catch only and as “T” for total-catch.
4. **Specification of the retained-catch portion of the total-catch OFL:**

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

Retained-catch portion = average retained catch during 1985/86–1995/96

= 9,178,438 pounds (9.18-million lb; 4.16 kt).

1. **Recommended FOFL, OFL total catch and the retained portion for the coming year:**

See sections ***F.3*** and ***F.4***, above; no FOFL 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 R90/91-95/96, RET85/86-95/96, BMGF,93/94-08/09  and OFLAlt-2,2010/11). Table 6 provides statistics on the generated distributions.

**2. List of variables related to scientific uncertainty.**

* The time period to compute the average catch relative to assumption that it 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 addititional uncertainties for alternative sigma-b.** Not applicable to this Tier 5 assessment.

1. **Author recommended ABC.**

(1-0.1)·12,537,757 lb = 11,283,981 lb (11.28-million lb; 5.12 kt)

### H. Rebuilding Analyses

## Entire section is not applicable; this stock has not been declared overfished.

## *I.* Data Gaps and Research Priorities

## Currently, there are no biomass estimates for this stock. The process of development and annual use of an assessment model (e.g., Siddeek et al 2012) to estimate spawning biomass or a proxy will identify data gaps and research priorities. Triennial pot survey for portion of stock were not performed in 2009 and 2012 and will likely not be performed in the future. Bycatch mortality rate in directed fishery is unknown.

## *J. Literature Cited*

Baechler, B. 2012. Annual management report for the commercial and subsistence shellfish fisheries of the Aleutian Islands, 2010/11. Pages 75–176 *in* Fitch, H., M. Schwenzfeier, B. Baechler, T. Hartill, M. Salmon, M. Deiman, E. Evans, E. Henry, L. Wald, J. Shaishnikoff, K. Herring, and K. Herring. 2012. Annual management report for the commercial and subsistence shellfish fisheries of the Aleutian Islands, Bering Sea and the Westward Region’s Shellfish Observer Program, 2010/11. Alaska Department of Fish and Game, Fishery Management Report No. 12-22, Anchorage.

## Beers, D. E. 1992. Annual biological summary of the Westward Region shellfish observer database, 1991. Alaska Department of Fish and game, Division of Commercial Fisheries, Regional Information Report 4K92-33, Kodiak.

## Blau, S. F., and D. Pengilly. 1994. Findings from the 1991 Aleutian Islands golden king crab survey in the Dutch Harbor and Adak management areas including analysis of recovered tagged crabs. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report 4K94-35, Kodiak.

## Blau, S. F., L. J. Watson, and I. Vining. 1998. The 1997 Aleutian Islands golden king crab survey. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report 4K98-30, Kodiak.

Byrne, L. C., and D. Pengilly. 1998. Evaluation of CPUE estimates for the 1995 crab fisheries of the Bering Sea and Aleutian Islands based on observer data. Pages 61–74 *in*: Fishery stock assessment models, edited by F. Funk, T.J. Quinn II, J. Heifetz, J.N. Iannelli, J.E. Powers, J.F. Schweigert, P.J. Sullivan, and C.-I Zhang, Alaska Sea Grant College Program Report No. AK-SG-98-01, University of Alaska Fairbanks, 1998.

Foy, R. J., 2012a. 2012 Stock Assessment and Fishery Evaluation Report for the Pribilof Islands Blue King Crab Fisheries of the Bering Sea and Aleutian Islands Regions. *In*: Stock Assessment and fishery Evaluation report for the King and Tanner Crab Fisheries of the Bering Sea and Aleutian Islands Regions: 2012 Final Crab SAFE. NPFMC, Anchorage, September 2012.

Foy, R. J., 2012b. 2012 Stock Assessment and Fishery Evaluation Report for the Pribilof Islands Red King Crab Fisheries of the Bering Sea and Aleutian Islands Regions. *In*: Stock Assessment and fishery Evaluation report for the King and Tanner Crab Fisheries of the Bering Sea and Aleutian Islands Regions: 2012 Final Crab SAFE. NPFMC, Anchorage, September 2012.

Gaeuman, W. B. 2011. Summary of the 2010/2011 Mandatory Crab Observer Program Database for the Bering Sea/Aleutian Islands commercial crab fisheries. Alaska Department of Fish and Game, Fishery Data Series No. 11-73, Anchorage.

Hartill, T. 2012. Annual management report for the community development quota and Adak Community Allocation crab fisheries in the Bering Sea and Aleutian Islands, 2010/11. Pages 177–194 *in* Fitch, H., M. Schwenzfeier, B. Baechler, T. Hartill, M. Salmon, M. Deiman, E. Evans, E. Henry, L. Wald, J. Shaishnikoff, K. Herring, and K. Herring. 2012. Annual management report for the commercial and subsistence shellfish fisheries of the Aleutian Islands, Bering Sea and the Westward Region’s Shellfish Observer Program, 2010/11. Alaska Department of Fish and Game, Fishery Management Report No. 12-22, Anchorage.

Hiramoto, K. 1985. Overview of the golden king crab, *Lithodes aequispina*, fishery and its fishery biology in the Pacific waters of Central Japan. In: Proc. Intl. King Crab Symp., Univ. of Alaska Sea Grant Rpt. 85-12, Fairbanks, pp. 297-317.

Hiramoto, K., and S. Sato. 1970. Biological and fisheries survey on an anomuran crab, *Lithodes aequispina* Benedict, off Boso Peninsula and Sagami Bay, central Japan. Jpn. J. Ecol. 20:165-170. In Japanese with English summary.

Jewett, S. C., Sloan, N. A., and Somerton, D. A. 1985. “Size at sexual maturity and fecundity of the fjord-dwelling golden king crab *Lithodes aequispina* Benedict from northern British Columbia.” *J. Crust. Biol.*, 5, pp. 377-385.

McBride, J., D. Fraser, and J. Reeves. 1982. Information on the distribution and biology of the golden (brown) king crab in the Bering Sea and Aleutian Islands area. NOAA, NWAFC Proc. Rpt. 92-02.

Morrison, R., R. K. Gish, M. Ruccio. 1998. Annual management report for the shellfish fisheries of the Aleutian Islands. Pages 82–139 *in*: ADF&G. 1998. Annual management report for the shellfish fisheries of the Westward Region. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4K98-39, Kodiak.

National Marine Fisheries Service (NMFS). 2004. Bering Sea Aleutian Islands Crab Fisheries Final Environmental Impact Statement. DOC, NOAA, National Marine Fisheries Service, AK Region, P.O. Box 21668, Juneau, AK 99802-1668, August 2004.

North Pacific Fishery Management Council (NPFMC). 2007a. Initial Review Draft: Environmental Assessment for proposed Amendment 24 to the Fishery Management Plan for Bering Sea and Aleutian Islands King and Tanner Crabs to Revise Overfishing Definitions. 17 January 2007. North Pacific Fishery Management Council, Anchorage.

North Pacific Fishery Management Council (NPFMC). 2007b. Public Review Draft: Environmental Assessment for proposed Amendment 24 to the Fishery Management Plan for Bering Sea and Aleutian Islands King and Tanner Crabs to Revise Overfishing Definitions. 14 November 2007. North Pacific Fishery Management Council, Anchorage.

Nyblade, C.F. 1987. Phylum or subphylum Crustacea, class Malacostraca, order Decopoda, Anomura. In: M.F. Strathman (ed), Reproduction and development of marine invertebrates on the northern Pacific Coast. Univ. Wash. Press, Seattle, pp.441-450.

Otto, R. S., and P. A. Cummiskey. 1985. Observations on the reproductive biology of golden king crab (*Lithodes aequispina*) in the Bering Sea and Aleutian Islands. Pages 123–136 *in* Proceedings of the International King Crab Symposium. University of Alaska Sea Grant Report No. 85-12, Fairbanks.

Paul, A. J., and J. M. Paul. 2000. Changes in chela heights and carapace lengths in male and female golden king crabs *Lithodes aequispinus* after molting in the laboratory. Alaska Fishery Research Bulletin 6(2): 70–77.

Paul, A. J., and J. M. Paul. 2001. The reproductive cycle of golden king crab *Lithodes aequispinus* (Anomura: Lithodidae). J. Shellfish Res. 20:369–371.

Pengilly, D. 2008. Aleutian Islands golden king crab (assessment). *In*: Stock Assessment and Fishery Evaluation Report for the King and Tanner Crab Fisheries of the Bering Sea and Aleutian Islands Regions (2008 Crab SAFE), September 2008. North Pacific Fishery Management Council, Anchorage, AK.

Pengilly, D. 2009. Aleutian Islands golden king crab (assessment). *In*: Stock Assessment and Fishery Evaluation Report for the King and Tanner Crab Fisheries of the Bering Sea and Aleutian Islands Regions (2009 Crab SAFE), September 2009. North Pacific Fishery Management Council, Anchorage, AK.

Shirley, T. C., and S. Zhou. 1997. Lecithotrophic development of the golden king crab *Lithodes aequispinus* (Anomura: Lithodidae). Journal of Crustacean Biology 17:207–216.

Siddeek, M.S.M., D. Pengilly, and J. Zheng. 2012. Aleutian Islands golden king crab (*Lithodes aequispinus*) model based stock assessment (For the January 2012 Model Workshop). <http://www.fakr.noaa.gov/npfmc/PDFdocuments/membership/PlanTeam/Crab/GKCModelBasedAssessWorkShopJan2012.pdf>

Sloan, N.A. 1985. Life history characteristics of fjord-dwelling golden king crabs *Lithodes aequispina*. Mar. Ecol. Prog. Ser. 22:219-228.

Somerton, D.A., and R.S. Otto. 1986. Distribution and reproductive biology of the golden king crab, *Lithodes aequispina*, in the eastern Bering Sea. Fish. Bull. 84:571-584.

Von Szalay, P.G., C.N. Roper, N.W. Raring, and M.H. Martin. 2011. Data report: 2010 Aleutian Islands bottom trawl survey. U.S. Dep. Commerce., NOAA Technical Memorandum NMFS-AFSC-215.

Watson, L. J. 2004. The 2003 triennial Aleutian Islands golden king crab survey and comparisons to the 1997 and 2000 surveys (revised October 17, 2005). Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4K04-42, Kodiak. [Revised 10/17/2005].

Watson, L. J. 2007. The 2006 triennial Aleutian Islands golden king crab survey. Alaska Department of Fish and Game, Fishery Management Report No. 07-07, Anchorage.

Watson, L. J., and R. K. Gish. 2002. The 2000 Aleutian Islands golden king crab survey and recoveries of tagged crabs in the 1997 – 1999 and 2000 – 2002 fishing seasons. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4K02-6, Kodiak.

## Watson, L. J., D. Pengilly, and S. F. Blau. 2002. Growth and molting probability of golden king crabs (*Lithodes aequispinus*) in the eastern Aleutian Islands, Alaska. Pages 169–187 *in* 2002. A. J. Paul, E. G. Elner, G. S. Jamieson, G. H. Kruse, R. S. Otto, B. Sainte-Marie, T. C. Shirley, and D. Woodby (eds). Crabs in coldwater regions: Biology, Management, and Economics. University of Alaska Sea Grant, AK-SG-02-01, Fairbanks. 876 pp.

**Table of tables**.

**Table 1: page 27**. Harvest history for the Aleutian Islands golden king crab fishery (GHL/TAC, pounds 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 2011/12 season (includes the Community Development Quota and Adak Community Allocation fisheries for the 2005/06–2011/12 seasons; from 2012 SAFE).

**Table 2: page 28**. Retained catch (thousands of pounds) of Aleutian Islands golden king crab, with the estimated non-retained catch (thousands of pounds; 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,1990/91–2011/12; from 2012 SAFE).

**Table 3: page 29**. Estimated annual weight (pounds) of discarded bycatch of golden king crab (all sizes, males and females) and bycatch mortality (pounds) during federal groundfish fisheries by gear type (fixed or trawl) in reporting areas 541, 542, and 543 (Aleutian Islands west of 170° W longitude), 1991/92–2011/12 (assumes bycatch mortality rate of 0.5 for fixed-gear fisheries and 0.8 for trawl fisheries; from 2012 SAFE).

**Table 4: page 30**. Estimated annual weight (thousands of pounds) of total fishery mortality to Aleutian Islands golden king crab, 1990/91–2011/12, partitioned by source of mortality: retained catch, bycatch mortality during crab fisheries, and bycatch mortality during groundfish fisheries; from Table 2, with assumed bycatch mortality rate of 0.2 for crab fisheries applied, and Table 3.

**Table 5: page 31**. Data for calculation of RET85/86-95/96a and estimates used in calculation of R90/91-95/96b and BMGF,93/94-08/09c for calculation of the recommended (status quo) Aleutian Islands golden king crab Tier 5 2013/14 OFL; values under RET85/86-95/96 are from Table 1, values under R90/91-95/96 were computed from the retained catch data and the crab bycatch mortality estimates in Table 4, and values under BMGF,93/94-08/09 are from Table 4.

**Table 6: page 32**. Statistics for 1,000 bootstrap OFLs calculated according to the recommended (status quo) approach for 2013/14 OFL calculation, with the computed OFL for comparison.

**Table of figures.**

**Figure 1**: **page 33**. Aleutian Islands, Area O, red and golden king crab management area (from Baechler 2012).

**Figure 2: page 33**. Adak (Area R) and Dutch Harbor (Area O) king crab Registration Areas and Districts, 1984/85 – 1995/96 seasons (from Baechler 2012).

**Figure 3: page 34**. Percent of total 1982–1996 golden king crab harvest by one-degree longitude intervals in the Aleutian Islands, with dotted line denoting the border at 171° W longitude that was used until the end of the 1995/96 season 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 that has been used since the 1996/97 to manage Aleutian Island golden king crab as separate stocks east and west of 174° W longitude (from Figure 4-2 *in* Morrison et al. 1998).

**Figure 4: page 34**. Harvest (pounds) of golden king crab by one-degree longitude intervals in the Aleutian Islands during the 2000/01 through 2011/12 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 2012 SAFE, updated with final 2011/12 data from J. Shaisnikoff, ADF&G, 28 March 2013 email).

**Figure 5: page 35.** Average golden king crab CPUE (kg/nm2) for tows, number of tows, and average depth of tows by one-degree longitude intervals for the tows performed during the 2002, 2004, 2006, 2010, and 2012 NMFS Aleutian Islands; preliminary summary of data obtained on 1 April 2013 from

<http://www.afsc.noaa.gov/RACE/groundfish/survey_data/default.htm>.

**Figure 6: page 36**. 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 obtain data on bycatch of Aleutian Islands golden king crab during groundfish fisheries

(from <http://www.fakr.noaa.gov/rr/figures/fig1.pdf>).

**Figure 7: page 37**. Retained catch during the Aleutian Islands golden king crab fishery and estimated bycatch mortality (when available) during all crab fisheries and estimated bycatch mortality (when available) during all groundfish fisheries of Aleutian Islands golden king crab, 1985/86–2011/12 (from Tables 1 and 4).

**Figure 8: page 38**. 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, 1990/91–2011/12 (ratios for 1993/94–1994/95 not available due to data confidentialities and insufficiencies).

**Figure 9: page 39**. 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, 1990/91–2011/12 (ratios for 1993/94–1994/95 not available due to data confidentialities and insufficiencies).

**Figure 10: page 40.** Bootstrapped estimates of the sampling distribution of the recommended 2013/2014 Tier 5 OFL (pounds of total-catch) for the Aleutian Islands golden king crab stock; histograms in left column, quantile plots in right column.

Table 1. Harvest history for the Aleutian Islands golden king crab fishery (GHL/TAC, pounds 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 2011/12 season (includes the Community Development Quota and Adak Community Allocation fisheries for the 2005/06–2011/12 seasons; from 2012 SAFE).

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

1. Includes deadloss.
2. Catch (number of crab) per pot lift.
3. Average weight (pounds) of landed crab, including deadloss.
4. Managed with 6.5" CW minimum size limit.
5. Managed with 6.5" CW minimum size limit west of 171° W longitude and 6.0" minimum size limit east of 171° W longitude.
6. Managed with 6.0" minimum size limit.

Table 2. Retained catch (thousands of pounds) of Aleutian Islands golden king crab, with the estimated non-retained catch (thousands of pounds; 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,1990/91–2011/12; from 2012 SAFE).

|  |  |  |  |
| --- | --- | --- | --- |
|  | Retained | Non-retained | Components of non-retained catch: |
| Season | Catch | 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 |

Table 3. Estimated annual weight (pounds) of discarded bycatch of golden king crab (all sizes, males and females) and bycatch mortality (pounds) during federal groundfish fisheries by gear type (fixed or trawl) in reporting areas 541, 542, and 543 (Aleutian Islands west of 170° W longitude), 1991/92–2011/12 (assumes bycatch mortality rate of 0.5 for fixed-gear fisheries and 0.8 for trawl fisheries; from 2012 SAFE).

|  |  |  |  |
| --- | --- | --- | --- |
| 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 |

Table 4. Estimated annual weight (thousands of pounds) of total fishery mortality to Aleutian Islands golden king crab, 1990/91–2011/12, partitioned by source of mortality: retained catch, bycatch mortality during crab fisheries, and bycatch mortality during groundfish fisheries; from Table 2, with assumed bycatch mortality rate of 0.2 for crab fisheries applied, and Table 3.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Bycatch Mortality by Fishery Type | Total Estimated |
| Season | Retained Catch | Crab  | Groundfish | Fishery Mortality |
| 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 |

Table 5. Data for calculation of RET85/86-95/96a and estimates used in calculation of R90/91-95/96b and BMGF,93/94-08/09c for calculation of the recommended (status quo) Aleutian Islands golden king crab Tier 5 2013/14 OFL; values under RET85/86-95/96 are from Table 1, values under R90/91-95/96 were computed from the retained catch data and the crab bycatch mortality estimates in Table 4, and values under BMGF,93/94-08/09 are from Table 4.

|  |  |  |  |
| --- | --- | --- | --- |
| Season | RET85/86-95/96 | R90/91-95/96 | BMGF,93/94-08/09 |
| 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 |
| Mean | 9,178,438 | 0.363 | 23,359 |
| S.E.M. | 896,511 | 0.028 | 8,827 |
| CV | 0.10 | 0.08 | 0.38 |

1. RET85/86-95/96 is the average annual retained catch in the directed crab fishery during the period 1985/86-1995/96
2. R90/91-95/96 is the average of the estimated annual ratios of pounds of bycatch mortality due to crab fisheries to pounds 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).
3. BMGF,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.

Table 6. Statistics for 1,000 bootstrap OFLs calculated according to the recommended (status quo) approach for 2013/14 OFL calculation, with the computed OFL for comparison.

|  |  |
| --- | --- |
|   | Recommend – status quoapproach |
| Computed OFL | 12,537,757 |
| Mean of 1,000 bootstrapped OFLs | 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 2012).

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 by one-degree longitude intervals in the Aleutian Islands, with dotted line denoting the border at 171° W longitude that was 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 that has been used since the 1996/97 to manage Aleutian Island golden king crab as separate stocks east and west of 174° W longitude (adapted from Figure 4-2 *in* Morrison et al. 1998).

Figure 4. Harvest (pounds) of golden king crab by one-degree longitude intervals in the Aleutian Islands during the 2000/01 through 2011/12 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 2012 SAFE, updated with final 2011/12 data from J. Shaisnikoff, ADF&G, 28 March 2013 email).

Figure 5. Average golden king crab CPUE (kg/nm2) for tows, number of tows, and average depth of tows by one-degree longitude intervals for the tows performed during the 2002, 2004, 2006, 2010, and 2012 NMFS Aleutian Islands; 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 obtain data on bycatch of Aleutian Islands golden king crab during groundfish fisheries

(from <http://www.fakr.noaa.gov/rr/figures/fig1.pdf>).

Figure 7. Retained catch during the Aleutian Islands golden king crab fishery and estimated bycatch mortality (when available) during all crab fisheries and estimated bycatch mortality (when available) during all groundfish fisheries of Aleutian Islands golden king crab, 1985/86–2011/12 (from Tables 1 and 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, 1990/91–2011/12 (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, 1990/91–2011/12 (ratios for 1993/94–1994/95 not available due to data confidentialities and insufficiencies).

Figure 10. Bootstrapped estimates of the sampling distribution of the recommended 2013/2014 Tier 5 OFL (pounds of total-catch) for the Aleutian Islands golden king crab stock; histograms in left column, quantile plots in right column.