# Pribilof Islands Golden King Crab

# 2008 Crab SAFE Report Chapter

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## Executive Summary

Stock: Golden king crab/Pribilof Islands

Catches: The domestic fishery developed in 1982. Since then, participation in the fishery has been sporadic and retained catch have been variable, from 0 pounds in seven years that no vessels participated (1984, 1986, 1990–1992, 2006–2007) up to a maximum of 342-thound pounds in 1995 when seven vessels made landings. The fishery is not rationalized and has been managed towards a GHL of 150-thousand pounds since 2000. Non-retained bycatch can occur in the directed fishery as well as the estern Bering Sea snow crab fishery and the Bering Sea grooved Tanner crab fishery. Estimated weight of non-retained bycatch has ranged from 19-thousand to 49-thousand pounds annually during 2000–2005.

Data and assessment: There is no survey and no assessment model in use for this stock. Available data are from fish tickets (including retained catch numbers, retained catch weight, and pot lifts by statistical area and landing date), size-frequency data from samples of landed crabs, and at-sea observer data from pot lifts sampled during the fishery (including date, location, soak time, catch composition, size, sex, and reproductive condition of crabs, etc). However, much of the fishery data is confidential due to low numbers of participating vessels or processors.

Unresolved problems and major uncertainties: Stock size is unknown and has not been estimated.

Reference points: This stock is recommended for Tier 5 stock. BMSY and MSST are not estimated and OFL is defined as "the average retained catch from a time period determined to be representative of the production potential of the stock" (NPFMC 2007).

Stock biomass: Estimates of stock biomass are not available.

Recruitment: Between 2002 and 2005, the average size of legal male golden king crab taken during the commercial fishery has decreased while CPUE has increased suggesting that strong recruitment to the legal male portion of the stock has recently occurred.

Exploitation status: Estimates of fishing mortality are not available. No landings were reported for the directed fishery in 2006 and 2007.

Management performance: The fishery has been managed with a GHL of 150,000 pounds since 2000. During 2000–2002 the retained catch was within 15% of the GHL.

Forecasts: No forecasts of catch and biomass are available.

Decision table: Not available.

Recommendations: Keep this stock in Tier 5.

### *Summary of Major Changes*

Changes (if any) in the input data — N/A (= "not applicable" or "not available" or both)

Changes (if any) in the assessment methodology — N/A

Changes (if any) in the assessment results, including projected biomass, GHL, total catch (including discard mortality and retained catch), and FOFL (the full selection fishing mortality rate (F) that results in overfishing) — N/A

### *Responses to SSC Comments*

Responses to SSC comments specific to this assessment (for each comment that is addressed in the main text, list comment and give name of section where it is discussed; if the SSC did not make any comments specific to this assessment, say so) — N/A

Responses to SSC comments on assessments in general (for each comment that is addressed in the main text, list comment and give name of section where it is discussed; if the SSC did not make any comments on assessments in general, say so) — N/A

## Introduction

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

Description of general distribution

General distribution of golden king crabs 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).

Commercial fishing for golden king crabs in the Bering Sea typically occurs at depths of 100–300 fathoms (183–549 m; Neufeld and Barnard 2003; Barnard and Burt 2004, 2006; Burt and Barnard 2005, 2006); average depth of pots fished in the Pribilof golden king crab fishery during the 2001 (the most recently prosecuted fishery for which fishery data are not confidential was 214 fathoms (391 m; Table 1).

Description of management unit(s) (be sure to include any spatial and/or seasonal management measures):

From Bowers et al. (2008, page 79–80; see also Figure 1):

> The Bering Sea king crab Registration Area Q has as its southern boundary a line from 54° 36' N lat., 168° W long., to 54° 36' N lat., 171° W long., to 55° 30' N lat., 171° W. long., to 55° 30' N lat., 173° 30' E long., as its northern boundary the latitude of Point Hope (68° 21' N lat.), as its eastern boundary a line from 54° 36' N lat., 168° W long., to 58° 39' N lat., 168° W long., to Cape Newenham (58° 39' N lat.), and as its western boundary the United States-Russia Maritime Boundary Line of 1991. Area Q is divided into the Pribilof District, which includes waters south of Cape Newenham, and the Northern District, which incorporates all waters north of Cape Newenham.

By State of Alaska regulation (5 AAC 34.910 (b) (3)), male golden king crab may be taken from january 1 through December 31 only under conditions of a permit issued by the commissioner.

Evidence of stock structure, if any

We are aware of no data for evaluating stock structure within this stock.

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

The following review on molt timing and reproductive cycle is adapted with some additions from Watson et al. (2002):

> Unlike red king crabs, golden king crabs 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 crabs 95–155-mm CL and female golden king crabs 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 crabs 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 crabs, 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 crabs. Data from tagging studies on female golden king crabs in the Aleutian Islands are generally consistent with a molt period for mature females of ≤2 years 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 crabs collected from Prince William Sound, Paul and Paul (2001c) 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 crabs 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 crabs may be facilitated by fully lecithotrophic larval development (i.e., the larvae can develop successfully to juvenile crabs 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 crabs 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.

### *Fishery*

- Description of the directed fishery

Only males of a minimum legal size may be retained by the Pribilof Islands golden king crab fishery. By State of Alaska regulation (5 AAC 34.920 (a)), the minimum legal size limit is 5.5-inches (140 mm)

carapace width (CW), including spines. A carapace length (CL) ≥124 mm is used to identify legal-size males when CW measurements are not available (Table 3-5 in NPFMC2007 ).

Golden king crabs may be commercially fished only with king crab pots (as defined in 5 AAC 34.050). Pots used to fish for golden king crabs in the Pribilof Islands must have at least four escape rings of no less tan five and one-half inches inside diameter installed on the vertical plane or at least one-third of one vertical surface of the pot composed of not less than nine-inch stretched mesh webbing to permit escapement of undersized golden king crabs (5 AAC 34.925 (c)).

The following is historical review of the Aleutian Islands golden king crab fishery is from Bowers et al. (2008, pages 84–85):

> Golden king crabs *Lithodes aequispina* are found in commercial concentrations in only a few deep canyons in the Bering Sea District and have never sustained large harvests when compared to other Bering Sea king crab fisheries. As with many other crab fisheries in the Bering Sea, the fishery for golden king crabs was pioneered by foreign fishing fleets. A domestic fishery developed during the 1982/83 season after BOF directed ADF&G to regulate fishing for golden king crabs in the Pribilof District by emergency order. By the 1984 season, BOF directed ADF&G to manage the Area Q golden king crab fishery under authority of a commissioner's permit that allowed the fishery to develop and expand into new areas.
>
> The first domestic harvest of golden king crabs in the Bering Sea occurred in June of 1982 when two vessels fished in the Pribilof District. Effort increased to 10 vessels during the following season with a harvest of nearly 70,000 pounds. The size limit for golden king crabs in the Pribilof District was reduced from six and one-half inches to five and one-half inches in 1983. Subsequently, effort in the Pribilof District peaked during the 1983/84 season when 50 vessels harvested 856,000 pounds of golden king crabs. From 1984 to 1992, no more than two vessels participated each year in the fishery. Since the 1983/84 season, harvest has not exceeded 350,000 pounds annually. The Pribilof District golden king crab fishery reached a maximum exvessel value of just over $1.1 million in 1995, and the highest price fishers received per pound was $3.99 in 1994. During the last nine years in the Pribilof District fishery an average of five vessels have annually harvested an average of 166,000 pounds. CPUE has averaged seven legal crabs per pot lift with an average weight of 4.0 pounds. Most harvest in the Pribilof District has occurred in the area immediately to the south of the Pribilof Islands.
>
> At the March 1993 meeting, BOF developed pot limits for all king crab fisheries in the Bering Sea. Current pot limits in the Pribilof District are set at 40 pots for vessels 125 feet or less in length and 50 pots for vessels greater than 125 feet in length.
>
> In 2000, the Pribilof District golden king crab fishery opened with a GHL of 150,000 pounds, which was 50,000 pounds less than the 1999 harvest level. This adjustment better complies with guidelines outlined in the FMP for the king and Tanner crab fisheries of the Bering Sea and Aleutian Islands and is based on the average harvest from 1983 to 1997. Seven vessels harvested 127,000 pounds in 2000. The GHL was not reached; thus the fishery remained open until the end of the year. In 2001, six vessels harvested 146,000 pounds and the fishery was closed by emergency order.
>
> The golden king crab fishery in the Bering Sea is managed using inseason catch reports provided by processors and observers. Fishing is restricted to depths of 100 fathoms or greater. Starting in 2001, 100% observer coverage was required for each vessel

registered for the fishery to provide fishery and biological data that has not previously been available. In addition, vessel logbooks issued with the commissioner's permit provide location of fishing operations, effort, and estimates of bycatch that supplement data collected by observers. Primary bycatch species include non-retained golden king crabs, Pacific halibut *Hippoglossus stenolepis*, Pacific cod *Gadus macrocephalus* and snow crabs.

The 2002 fishery opened January 1 with a GHL of 150,000 pounds, and closed by emergency order on May 14. The total harvest was 150,434 pounds. CPUE averaged six legal crabs per pot lift, a decrease from the CPUE of eight legal crabs per pot during the 2001 fishery. Landed crabs averaged 4.3 pounds per crab, the same as the 2001 season. The 2002 Pribilof District golden king crab fishery had a total fishery value of $438,000, which was $9,000 more than the 2001 fishery value.

The 2003 Pribilof District golden king crab fishery opened on January 1 with a GHL of 150,000 pounds. Three vessels registered for the fishery and began fishing in late March. A fourth vessel registered in April but did not fish. Because only two processors participated in the fishery, most harvest information is confidential. The majority of the harvest in 2003 occurred south of Saint George Island near Pibilof Canyon.

Five vessels registered for the 2004 Pribilof District golden king crab fishery. Fishing effort began in late February and the fishery was closed by emergency order on March 12. Most of the 2004 harvest information is confidential because only two processors purchased the harvest. Catch rates during the 2004 fishery were among the highest on record and the fishery was the shortest ever at approximately three weeks in duration. Most of the 2004 harvest occurred immediately to the south of Saint George Island in the vicinity of the Pribilof Canyon.

Four vessels participated in the 2005 Pribilof District golden king crab fishery, however harvest information is confidential because only two processors purchased the harvest. The entire GHL was not taken in 2005, therefore the fishery was open until December 31, 2005.

No vessels registered to fish for Pribilof Islands golden king in 2006 and 2007.

The Pribilof Islands golden king crab fishery is not included in the Crab Rationalization program.

- <u>Information on bycatch and discards</u>

Information on bycatch and discards during the Pribilof Islands golden king crab fishery is obtained by observers deployed on fishing vessels by the State of Alaska shellfish observer program (Schwenzfeier et al. 2008). 2001 was the first year observers were deployed in Bering Sea golden king crab fisheries (Neufeld and Barnard 2003) and 100% observer coverage is required in this fishery (Scwhenzfeier et al. 2008).

A summary of the information obtained by observers on bycatch and discards during the Aleutian Islands golden king crab fishery is provided in annual reports (e.g., Barnard and Burt 2006); however, much of the data on this fishery in those reports are confidential due to low participation of vessels or processors. Most of the bycatch of Pribilof Islands golden king crabs occurs during the directed fishery, when prosecuted. A estimates of the weight of bycatch (discarded non-retained) golden king crabs during the Pribilof Islands golden king crab fishery and other Aleutian Islands crab fisheries are reported under the section "DATA: Total catch, partitioned by strata used in the assessment model, if any," below.

- <u>Summary of historical catch distributions</u>

Table 2a provides the time series of GHLs, retained catch weight, and estimated discard weight from 2001 through 2005; Table 2b provides estimates of golden king crab bycatch during groundfish fisheries in reporting area 513, 517, and 521 during 2003–2007. A total catch weight (retained catch plus handling mortality of discards) was not estimated because of the variety of fisheries in which bycatch can occur, the lack of accepted handling mortality rates for golden king crabs in those fisheries, and the confidential nature of retained catch in most years.

### *Data (Items in this section should be presented in tabular form.)*

Data which should be presented as time series:

- Total catch, partitioned by strata used in the assessment model, if any

Harvest history for the Pribilof Islands golden king crab fishery (number of vessels, number of landings, number of crabs and pounds of crabs landed, pot lifts, fishery catch per unit effort, and average weight of landed crabs, average carapace length of landed crabs) by fishery season from the 1981/82 season through 2006 is provided in Table 3.

Observer data on size distribution and estimated catch numbers of non-retained catch collected since observer coverage began in the Pribilof Islands golden king crab fishery (2001) from the Pribilof Islands golden king crab fishery, the eastern Bering sea snow crab fishery, and the Bering sea grooved Tanner crab fishery were used to estimate the annual weight of non-retained catch during commercial fisheries of golden king crabs from 2001–2005 (provided by D. Barnard, ADF&G, 20 July 2007).

- Catch at age or catch at length, as appropriate

The size (carapace length, CL, mm) distribution of retained legal male golden king crabs from the Pribilof Islands golden king crab fishery sampled prior to processing at-sea and dockside by observers and ADF&G catch samplers during 2002 is provided in Table 4. 2002 is the only year for which these data are not confidential and which currently be separated from catch samples from the St. Matthew golden king crab fishery.

- Survey biomass estimates and variances, and/or confidence intervals — N/A

- Survey numbers at age or numbers at length, as appropriate

There is no survey for Pribilof Islands golden king crabs.

- Other time series data (e.g., predator abundance, fishing effort)

The time series of fishing effort (pot lifts) are provided in Table 3.

- Sample sizes (e.g., numbers of age or length samples by year, gear, and area)

Sample size for the length sample from the 2002 fishery is provided in Table 4.

Data which may be aggregated over time:

- Length at age

There is no length-at-age relationship established for golden king crab.

- Growth per molt

We are not aware of data on growth per molt of Pribilof Islands golden king crabs. Growth per molt of juvenile golden king crabs, 2–35-mm CL, collected from Prince William Sound have been observed in a laboratory setting and equations describing the increase in CL and intermit period were estimated from those observations (Paul and Paul 2001a); those results are not provided here.

- Weight at length or weight at age

Parameters for estimating weight (g) from carapace length (CL, mm) of Pribolof Islands golden king crabs are provided in Table 5.

## Analytic Approach

### *Model Structure — N/A*

Description of overall modeling approach (e.g., age/size structured versus biomass dynamic, maximum likelihood versus Bayesian) — N/A

Reference for software used (e.g., Synthesis, AD Model Builder) — N/A

Description of, or reference for, population dynamic representations used in the model (e.g., Baranov catch equation, Brody length-at-age equation) — N/A

List and description of all likelihood components in the model — N/A

Discussion of changes in any of the above since the previous assessment — N/A

### *Parameters Estimated Independently*

List of parameters that are estimated independently of others (e.g., the natural mortality rate, parameters governing the maturity schedule)

- Natural mortality rate:

There are no estimates of natural mortality pertaining specifically to Pribilof Islands golden king crabs. Using data on tag recoveries of golden king crabs in the Aleutian Islands commercial fisheries, Siddeek et al (2002) provide estimates of M = 0.375, M = 0.484, and M = 0.573. NPFMC (2007) assumed a natural mortality rate of M =0.18 for king crabs species.

- Parameters governing maturity schedule:

Males: Carapace length (CL) at maturity for male golden king crabs in the Bering Sea has been estimated by Otto and Cummiskey (1985) using Somerton's (1980) method of estimating the intersection point of lines estimated to fit two phases of growth in height of the right chela relative to CL:

  - Central Bering Sea (north of 54°14' N and south of 58° 31' N latitude): 107.0-mm CL (SD = 4.6 mm)

Paul and Paul (2001b) studied mating success of male golden king crabs collected from Prince William Sound. The two smallest males studied (95-mm CL and 99-mm CL) could not induce females to ovulate. The smallest male examined that fertilized a female (a 101-mm CL male) fertilized a clutch in which only 71% of the eggs initiated division. In almost all of the clutches fertilized by hardshell males ≥107-mm CL, ≥90% of the eggs initiated division.

Females: Otto and Cummiskey (1985) estimated CL at maturity for female golden king crabs in three areas within the Aleutian Islands Area as the estimated CL at which 50% of females are mature (SM50; as evidenced by presence of clutches of eggs or empty):

  - Central Bering Sea (north of 54°14' N and south of 58° 31' N latitude): 99.9-mm CL (SD = 0.2 mm)

### *Parameters Estimated Conditionally — N/A*

List of parameters that are estimated conditionally on those described above (e.g., full-selection fishing mortality rates, parameters governing the survey and fishery selectivity schedules, recruitments) — N/A

Description of how these parameters are estimated (e.g., error structures assumed, list of likelihood components, constraints on parameters) — N/A

Critical assumptions and consequences of assumption failures — N/A

### Model Evaluation — N/A

Description of alternative models, if any (e.g., alternative M values or likelihood weights) — N/A

Evidence of search for balance between realistic (but possible over-parameterized) and simpler (but not realistic) models — N/A

Use hierarchical approach where possible (e.g. asymptotic vs domed selectivities, constant vs time varying selectivities) — N/A

Do parameter estimates make sense, are they credible? — N/A

Description of criteria used to evaluate the model or to choose between alternative models, including the role (if any) of uncertainty — N/A

Residual analysis (e.g. residual plots, time series plots of observed and predicted values or other approach) — N/A

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 — N/A

List of final parameter estimates, with confidence intervals or other statistical measures of uncertainty if possible (if the set of parameters includes quantities listed in the "Results" section below, the values of these quantities should be presented in the "Results" section rather than here) — N/A

Schedules, if any, defined by final parameter estimates — N/A

## TIER 5 OFL BACKGROUND ANALYSIS

No assessment model for the Pribilof Islands golden king crab stock exists and none is in development; hence this stock should be considered a Tier 5 stock. 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 the average retained catch from a time period determined to be representative of the production potential of the stock" (NPFMC 2007). Additionally, NPFMC (2007) states that for estimating the OFL of Tier 5 stocks, "The time period selected for computing the average catch, hence the OFL, should be based on the best scientific information available and provide the required risk aversion for stock conservation and utilization goals." This section provides background for considering the appropriate time period for estimating OFL.

Time periods for averaging the retained catch. NPFMC (2007) suggested using the average retained catch over the years 1993 to 1999 as the estimated OFL for Aleutian Islands golden king crab. Years post- 984 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 1985 to 1992 and years after 1999,

NPFMC (2007) states, "The excluded years are from 1985 to 1992 and from 2000 to 2005 for Pribilof Islands golden king crab when the fishing effort was less than 10% of the average or the GHL was set below the previous average catch." With regard to the period 1985–1992, it should be noted that for four of those years (1985, 1987–1989) the retained catch is confidential and for the other four years (1986, 1990–1992) there were no landings from the fishery (Table 3). With regard to using years after 1999, it should be noted that for three of the years (2003–2005) the retained catch is confidential, for two of the years (2006 and 2007) there were no landings from the fishery, and for the remaining three years (2000–2002) the retained catch is from fisheries which were managed for the first time to a GHL of 150,000 pounds.

Bowers et al. (2008, pages 85–86) offered the following observations on current stock status:

> The golden king crab population in the Pribilof District is not surveyed and no estimate of abundance has been made. There are no plans to survey this population, nor has a formal harvest strategy been developed. Population size is believed to be limited by the amount of available habitat in the Pribilof District. The fishery is currently managed using a GHL set from the long-term average harvest. Data collected by onboard observers in conjunction with data from the landed catch are used to annually evaluate the status of the stock. Since 2002, the average size of legal male golden king crab taken during the commercial fishery has decreased while CPUE has increased suggesting that strong recruitment to the legal male portion of the stock has recently occurred.

## Results

Definition of biomass measures used (e.g., biomass at length 50 and above):

- weight of retained catch during the commercial fishery for estimation of OFL

Definition of recruitment measures used (e.g., numbers at length 40-70) – N/A

Definition of fishing mortality measures used (e.g., full-recruitment F multiplied by selectivity for lengths 80 and above):

- weight of retained catch during the commercial fishery

Table of estimated abundance and biomass time series, including spawning biomass as one measure, with confidence bounds or other statistical measure of uncertainty if possible. Include estimates from previous SAFE for retrospective comparisons:

- Tables 2 and 3 provide the annual weight of retained catch in a variety of formats and contexts.

Table of estimated recruitment time series, including average, with confidence bounds or other statistical measure of uncertainty if possible. Include estimates from previous SAFE for retrospective comparisons
— N/A

Table of estimated catch/biomass time series, with confidence bounds or other statistical measure of uncertainty if possible:

- Tables 2 and 3 provide the annual weight of retained catch in a variety of formats and contexts.

Graphs of fishery and survey selectivities, molting probabilities, and other schedules depending on parameter estimates
— N/A

Graph of estimated male, female, total and effective mature biomass time series, with confidence bounds if possible — N/A

Include a graph of the estimated fishing morality versus estimated spawning stock biomass, including applicable OFL and maximum $F_{target}$ definitions for the stock. The rationale is that graphs of this type are useful to evaluate management performance:

- The actual retained catch and GHL for the Pribilof Islands golden king crab fishery for 2000–2002 is compared graphically in Figure 2; in other years there was either no GHL established or the retained catch data is confidential. Over the period 2000–2002 the average retained catch has been as much as 15% below the GHL (2000) and as much as 0.3% above the GHL (2002).

Graph of estimated full selection F over time. — N/A

Graphs of model fits to survey numbers or proportions by age or length. — N/A

Graphs of model fits to catch numbers or proportions by age or length. — N/A

Uncertainty and sensitivity analyses. — N/A

1. The best approach for describing uncertainty and range of probable biomass estimates in stock assessments may depend on the situation. Approaches used previously are:
   a) Sensitivity analyses (tables or figures) that show ending biomass levels or likelihood component values obtained while systematically varying emphasis factors for each type of data in the model. — N/A
   b) Likelihood profiles for parameters or biomass levels may also be used. — N/A
   c) CVs for biomass estimated by bootstrap, implicit autodifferentiation, or the delta method; — N/A
   d) Subjective appraisal of magnitude and sources of uncertainty; — N/A
   e) Comparison of alternate models; — N/A
   f) Comparison of alternate assumptions about recent recruitment. — N/A

2. If a range of model runs (e.g.; based on CV's or alternate assumptions about model structure or recruitment) is used to depict uncertainty, then it is important that some qualitative or quantitative information about relative probability be included. If no statements about relative probability can be made, then it is important to state that all scenarios (or all scenarios between the bounds depicted by the runs) are equally likely. — N/A

3. if possible, ranges depicting uncertainty should include at least three runs: (a) one judged most probable; (b) at least one that depicts the range of uncertainty in the direction of lower current biomass levels; and (c) one that depicts the range of uncertainty in the direction of higher current biomass levels. The entire range of uncertainty should be carried through stock projections and decision table analyses. — N/A

4. retrospective analysis (retrospective bias in base model or models for each area). — N/A

5. historic analysis (plot of actual estimates from current and previous assessments for each area). — N/A

6. Simulation results (if available). — N/A

### Projections and Harvest Alternatives

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:

- OFL = "The average retained catch from a time period determined to be representative of the production potential of the stock"

Specification of FOFL , OFL, the upper bound on Ftarget, and other applicable measures (if any) relevant to determining whether the stock is overfished or if overfishing is occurring:

- Estimated OFLs estimated as average retained catch over the period of years suggested by NPFMC (2007) is provided below.

| Time period | Number of seasons | OFL ( = average retained catch) |
|---|---|---|
| 1993–1999 | 7 | 174,206 |

List of standard harvest scenarios and description of projection methodology

- Standard harvest scenario is that retained catch will be within 15% of the GHL.

Table of 12-year projected catches corresponding to the alternative harvest scenarios, using stochastic methods if possible (mean values or other statistics may be shown in the case of stochastic recruitment scenarios) — N/A

Table of 12-year 5-year (or 10-year, if the stock is overfished) projected spawning biomass corresponding to the alternative harvest scenarios, using stochastic methods if possible (mean values or other statistics may be shown in the case of stochastic recruitment scenarios) — N/A

Table of 12-year projected fishing mortality rates corresponding to the alternative harvest scenarios, using stochastic methods if possible (mean values or other statistics may be shown in the case of stochastic recruitment scenarios) — N/A

Discussion of information, if any, that might warrant setting the GHL or total catch below the upper bound:

- ?

Recommendation of $F_{OFL}$ , OFL total catch, OFL retained catch for coming year: TBA

Include a subsection titled "Area Allocation of Harvests" and provide results and details of any apportionment schemes that are used. — N/A

### *Data gaps and research priorities*

The process of development and annual use of an assessment model to estimate spawning biomass will identify data gaps and research priorities.

### Summary

Table showing M, Tier (previous year or recommended), projected total biomass (give age or length range), female spawning biomass, male spawning biomass and total spawning biomass for current year and for next year. Male spawning biomass values at the time of mating for B0 and Bmsy and Fmsy (if available from stock-recruit relationship) or proxy values, FOFL , the maximum allowable value for Ftarget , the recommended value of OFL, the maximum allowable total catch.

| Parameter | Value |
|---|---|
| M | Default =0.18 |
| Tier | 5 |
| Projected total biomass | N/A |
| Female spawning biomass, current year (2007/08) | N/A |
| Male spawning biomass, current year (2007/08) | N/A |
| Total spawning biomass, current year (2007/08) | N/A |
| Female spawning biomass, next year (2008/09) | N/A |
| Male spawning biomass, next year (2008/09) | N/A |
| Total spawning biomass, next year (2008/09) | N/A |
| Male spawning biomass values at the time of mating for B0 and Bmsy and Fmsy, or proxy values | N/A |
| Maximum allowable value for Ftarget | N/A |
| Recommended value of OFL | 174,206 pounds (retained catch) |
| Maximum allowable total catch | N/A |

## Literature Cited

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Note: Perhaps in the future, dependent on the availability of time and information, a section on "ecosystem considerations" pertaining to Pribilof Islands golden king crabs will be included in this chapter.

Table 1. Mean CPUE by depth for 1,497 bycatch samples taken during the 2002 Pribilof Islands golden king crab fishery. (from Barnard and Burt 2004).

| | Percent of Sampled | Catch per sampled pot | | | |
|---|---|---|---|---|---|
| Depth | Pots | Legal | Sublegal | Female | Total |
| 101-110 | 0.2 | 0 | 0 | 0 | 0 |
| 111-120 | 0.5 | 0.6 | 0.3 | 0 | 0.9 |
| 121-130 | 1.4 | 3.4 | 0.1 | 0 | 3.6 |
| 131-140 | 4.9 | 5.7 | 0.5 | 0.1 | 6.3 |
| 141-150 | 10.8 | 5.8 | 1.3 | 0.6 | 7.7 |
| 151-160 | 10.8 | 6.6 | 2.6 | 1.0 | 10.2 |
| 161-170 | 7.3 | 8.7 | 2.7 | 1.1 | 12.6 |
| 171-180 | 4.9 | 8.1 | 4.7 | 3.4 | 16.3 |
| 181-190 | 9.6 | 10.4 | 10.3 | 5.6 | 26.3 |
| 191-200 | 4.2 | 8.6 | 8.3 | 4.0 | 20.8 |
| 201-210 | 3.1 | 11.2 | 3.6 | 4.2 | 19.0 |
| 211-220 | 1.9 | 10.2 | 1.8 | 2.1 | 14.1 |
| 221-230 | 2.1 | 8.0 | 1.3 | 0.9 | 10.2 |
| 231-240 | 1.0 | 6.3 | 1.3 | 1.1 | 8.7 |
| 241-250 | 2.5 | 4.4 | 1.4 | 0.6 | 6.4 |
| 251-260 | 2.2 | 6.8 | 2.1 | 1.3 | 10.2 |
| 261-270 | 5.1 | 6.1 | 2.9 | 2.5 | 11.4 |
| 271-280 | 5.3 | 5.9 | 3.9 | 3.4 | 13.2 |
| 281-290 | 5.5 | 7.2 | 2.1 | 1.5 | 10.7 |
| 291-300 | 2.7 | 6.9 | 1.2 | 1.1 | 9.2 |
| 301-310 | 2.7 | 11.4 | 3.3 | 2.1 | 16.8 |
| 311-320 | 3.6 | 11.3 | 2.2 | 0.6 | 14.2 |
| 321-330 | 3.4 | 10.2 | 1.9 | 0.4 | 12.5 |
| 331-340 | 3.6 | 8.9 | 1.6 | 0.4 | 10.9 |
| 341-350 | 0.1 | 0 | 2.0 | 0 | 2.0 |
| 351-360 | 0.3 | 0.3 | 0.3 | 0 | 0.5 |
| 361-370 | 0.1 | 0 | 0 | 0 | 0 |
| 371-380 | 0.1 | 0 | 0 | 0 | 0 |

Table 2a. Annual guideline harvest level (GHL) for retained catch (pounds), actual retained catch (pounds), and estimated non-retained discards (pounds) for the Pribilof Islands golden king crab fishery, 2001–2005. There were no landings of Pribilof Islands golden king crab during 2006–2007. Non-retained catch includes bycatch during the Pribilof Islands golden king crab fishery, the eastern Bering Sea snow crab fishery, and the Bering Sea grooved Tanner crab fishery (bycatch weight estimates were provided by D. Barnard, ADF&G, 20 July 2007).

| Year | GHL | Retained catch | Non-retained discards |
|---|---|---|---|
| 2001 | 150,000 | 145,876 | 42,054 |
| 2002 | 150,000 | 150,434 | 42,223 |
| 2003 | 150,000 | Confidential | 49,118 |
| 2004 | 150,000 | Confidential | 30,266 |
| 2005 | 150,000 | Confidential | 18,659 |

Table 2b. Estimated annual weight (pounds) of discarded bycatch of Aleutian Islands golden king crabs (all sizes, males and females) during groundfish fisheries (all gear types and fisheries pooled) in reporting areas 513, 517, and 521, 2003 –2007 (summary of the data provided by J. Mondragon, NMFS-Alaska Region Office, 31 March 2008).

| Year | 513 | 517 | 521 | Total |
|---|---|---|---|---|
| 2003 | 12 | 988 | 145 | 1,144 |
| 2004 | 1 | 605 | 93 | 699 |
| 2005 | 4 | 365 | 601 | 970 |
| 2006 | 1 | 2,762 | 204 | 2,968 |
| 2007 | 25 | 1,887 | 251 | 2,162 |
| Average | 9 | 1,321 | 259 | 1,589 |

Table 3. Harvest history for the Pribilof Islands golden king crab fishery from the 1981/82 season through the 2006.

| | Number of | | | | | Average | | | |
|---|---|---|---|---|---|---|---|---|---|
| Season | Vessels | Landings | Crabs[a] | Pots lifted | Harvest[a,b] | Weight[b] | CPUE[c] | Length[d] | Deadloss[b] |
| 1981/82 | 2 | | | | CONFIDENTIAL | | | | |
| 1982/83 | 10 | 19 | 15,330 | 5,252 | 69,970 | 4.6 | 3 | 151 | 570 |
| 1983/84 | 50 | 115 | 253,162 | 26,035 | 856,475 | 3.4 | 10 | 127 | 20,041 |
| 1984 | 0 | | | | NO LANDINGS | | | | |
| 1985 | 1 | | | | CONFIDENTIAL | | | | |
| 1986 | 0 | | | | NO LANDINGS | | | | |
| 1987 | 1 | | | | CONFIDENTIAL | | | | |
| 1988 | 2 | | | | CONFIDENTIAL | | | | |
| 1989 | 2 | | | | CONFIDENTIAL | | | | |
| 1990 | 0 | | | | NO LANDINGS | | | | |
| 1991 | 0 | | | | NO LANDINGS | | | | |
| 1992 | 0 | | | | NO LANDINGS | | | | |
| 1993 | 5 | 15 | 17,643 | 15,395 | 67,458 | 3.8 | 1 | NA | 0 |
| 1994 | 3 | 5 | 21,477 | 1,845 | 88,985 | 4.1 | 12 | NA | 730 |
| 1995 | 7 | 22 | 82,489 | 9,551 | 341,908 | 4.1 | 9 | NA | 716 |
| 1996 | 6 | 32 | 91,947 | 9,952 | 329,009 | 3.6 | 9 | NA | 3,570 |
| 1997 | 7 | 23 | 43,305 | 4,673 | 179,249 | 4.1 | 9 | NA | 5,554 |
| 1998 | 3 | 9 | 9,205 | 1,530 | 35,722 | 3.9 | 6 | NA | 474 |
| 1999 | 3 | 9 | 44,098 | 2,995 | 177,108 | 4.0 | 15 | NA | 319 |
| 2000 | 7 | 19 | 29,145 | 5,450 | 127,217 | 4.4 | 5 | NA | 4,599 |
| 2001 | 6 | 14 | 33,723 | 4,262 | 145,876 | 4.3 | 8 | 143 | 8,227 |
| 2002 | 8 | 20 | 34,860 | 5,279 | 150,434 | 4.3 | 6 | 144 | 8,984 |
| 2003 | 3 | | | | CONFIDENTIAL | | | | |
| 2004 | 5 | | | | CONFIDENTIAL | | | | |
| 2005 | 4 | | | | CONFIDENTIAL | | | | |
| 2006 | 0 | | | | NO LANDINGS | | | | |

[a]Deadloss included.
[b]In pounds.
[c]Number of legal crabs per pot lift.
[d]Carapace length in millimeters.
NA = Not available.
Confidential = Less than three vessels or processors participated in the fishery.

Table 4. Carapace length (CL, mm) frequency distribution from biological measurements of retained golden king crabs sampled by season during the 2002 Pribilof Islands golden king crab fishery (data from ADF&G shellfish observer database, Kodiak, April 2008).

| CL (mm) | Count |
|---|---|
| 116 | 1 |
| 117 | 0 |
| 118 | 1 |
| 119 | 1 |
| 120 | 1 |
| 121 | 2 |
| 122 | 5 |
| 123 | 4 |
| 124 | 11 |
| 125 | 11 |
| 126 | 18 |
| 127 | 13 |
| 128 | 24 |
| 129 | 12 |
| 130 | 22 |
| 131 | 15 |
| 132 | 22 |
| 133 | 18 |
| 134 | 29 |
| 135 | 32 |
| 136 | 18 |
| 137 | 25 |
| 138 | 29 |
| 139 | 20 |
| 140 | 33 |
| 141 | 21 |
| 142 | 33 |
| 143 | 26 |
| 144 | 29 |
| 145 | 23 |
| 146 | 18 |
| 147 | 20 |
| 148 | 20 |
| 149 | 18 |
| 150 | 30 |

(continued)

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| CL (mm) | Count |
|---|---|
| 151 | 10 |
| 152 | 21 |
| 153 | 19 |
| 154 | 18 |
| 155 | 15 |
| 156 | 14 |
| 157 | 14 |
| 158 | 18 |
| 159 | 14 |
| 160 | 11 |
| 161 | 12 |
| 162 | 5 |
| 163 | 12 |
| 164 | 8 |
| 165 | 12 |
| 166 | 10 |
| 167 | 10 |
| 168 | 12 |
| 169 | 3 |
| 170 | 9 |
| 171 | 1 |
| 172 | 5 |
| 173 | 4 |
| 174 | 3 |
| 175 | 1 |
| 176 | 0 |
| 177 | 2 |
| 178 | 1 |
| 179 | 0 |
| 180 | 2 |
| 181 | 0 |
| 182 | 0 |
| 183 | 0 |
| 184 | 0 |
| 185 | 0 |
| 186 | 0 |
| 187 | 1 |
| Total | 872 |

Table 5. Estimated parameters (A and B) for estimating weight (g) from carapace length (CL, mm) of male and ovigerous female Aleutian Islands golden king crabs according to the equation, Weight = $A*CL^B$ (from Table 3-5, NPFMC 2007).

| Parameter | Males | Ovigerous females |
|---|---|---|
| A | 0.0002988 | 0.001424 |
| B | 3.135 | 2.781 |

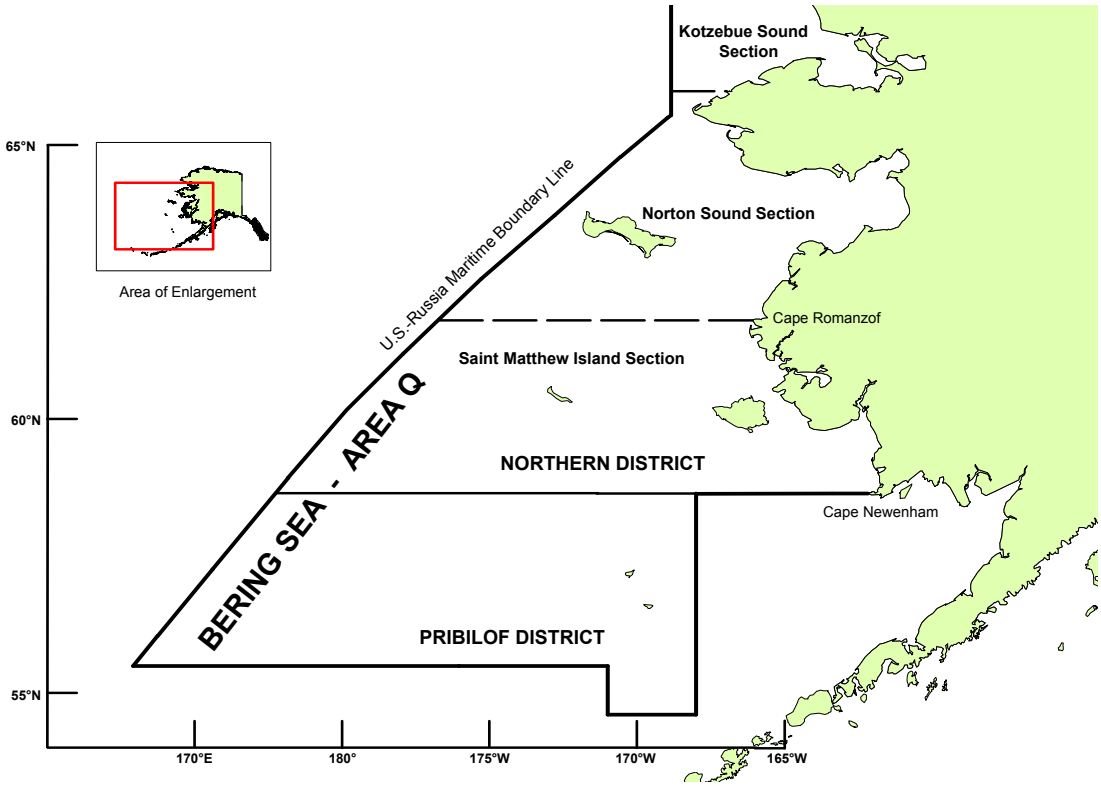


Figure 1. King crab Registration Area Q (Bering Sea) (from Bowers et al. 2008).

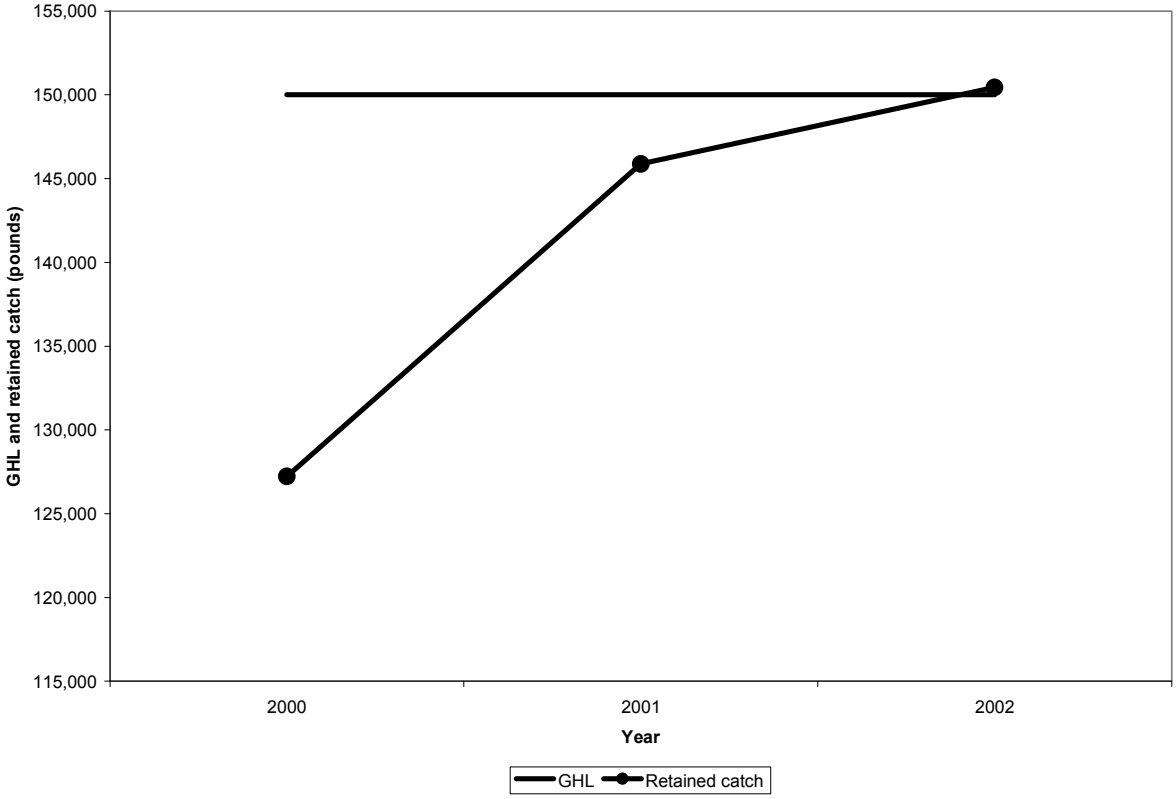


Figure 2. Pre-season GHL (pounds) compared to the retained catch (pounds) during 2000–2002 Pribilof Islands golden king crab fishery.