

Stock Assessment and Fishery Evaluation Report  
for the  
**KING AND TANNER CRAB FISHERIES**  
of the  
Bering Sea and Aleutian Islands Regions

**2015 Final Crab SAFE**

Compiled by

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of the Bering Sea and Aleutian Islands

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for the King and Tanner Crab Fisheries  
Fisheries of the Bering Sea and Aleutian Islands Regions**

Table of Contents

Summary .....	1
Introduction	
Stock Status definitions	
Status Determination Criteria	
Crab Plan Team Recommendations	
Stock Status Summaries	
 Stock Assessment Section	
1. EBS snow crab .....	39
2. Bristol Bay red king crab .....	179
3. EBS Tanner crab .....	293
4. Pribilof Islands red king crab .....	441
5. Pribilof District blue king crab.....	511
6. Saint Matthew blue king crab .....	563
7. Norton Sound red king crab .....	647
8. Aleutian Islands golden king crab assessment .....	833
9. Pribilof Islands golden king crab .....	875
10. Western Aleutian Island red king crab.....	903
 Appendix: Crab Economic SAFE summary .....	941

## 2015 Stock Assessment and Fishery Evaluation Report for the King and Tanner Crab Fisheries in the Bering Sea and Aleutian Islands

### Introduction

The annual stock assessment and fishery evaluation (SAFE) report is a requirement of the North Pacific Fishery Management Council's *Fishery Management Plan for Bering Sea/Aleutian Islands King and Tanner Crabs* (FMP), and a federal requirement [50 CFR Section 602.12(e)]. The SAFE report summarizes the current biological and economic status of fisheries, total allowable catch (TAC) or Guideline Harvest Level (GHL), and analytical information used for management decisions. Additional information on Bering Sea/Aleutian Islands (BSAI) king and Tanner crab is available on the National Marine Fisheries Service (NMFS) web page at <http://www.fakr.noaa.gov> and the Alaska Department of Fish and Game (ADF&G) Westward Region Shellfish web page at: <http://www.cf.adfg.state.ak.us/region4/shellfish/shelhom4.php>.

This FMP applies to 10 crab stocks in the BSAI: 4 red king crab, *Paralithodes camtschaticus*, stocks (Bristol Bay, Pribilof Islands, Norton Sound and Adak), 2 blue king crab, *Paralithodes platypus*, stocks (Pribilof Islands and St Matthew Island), 2 golden (or brown) king crab, *Lithodes aequispinus*, stocks (Aleutian Islands and Pribilof Islands), southern Tanner crab *Chionoecetes bairdi* hereafter referred to as Tanner crab, and snow crab *Chionoecetes opilio*. All other crab stocks in the BSAI are exclusively managed by the State of Alaska (SOA).

The Crab Plan Team (CPT) annually assembles the SAFE report with contributions from ADF&G and the NMFS. This SAFE report is presented to the North Pacific Fishery Management Council (NPFMC) and is available to the public on the NPFMC web page at: [http://fakr.noaa.gov/npfmc/membership/plan\\_teams/CRAB\\_team.htm](http://fakr.noaa.gov/npfmc/membership/plan_teams/CRAB_team.htm). Under a process approved in 2008 for revised overfishing level (OFL) determinations, and annual catch limit (ACL) requirements in 2011, the CPT reviews one assessment in January (Norton Sound red king crab), three assessments in May to provide recommendations on OFL, acceptable biological catch (ABC) and stock status specifications for review by the NPFMC Science and Statistical Committee (SSC) in February and June. In September, the CPT reviews the remaining assessments and provides final OFL and ABC recommendations and stock status determinations. Additional information on the OFL and ABC determination process is contained in this report.

The CPT met from September 14-17, 2015 in Seattle, WA to review the final stock assessments as well as additional related issues, in order to provide the recommendations and status determinations contained in this SAFE report. This final 2015 Crab SAFE report contains all recommendations for all 10 stocks including those whose OFL and ABC were previously determined in February and June 2015. This SAFE report will be presented to the NPFMC in October for their annual review of the status of BSAI Crab stocks. Members of the team who participated in this review include the following: Bob Foy (Chair), Karla Bush (Vice-Chair), Laura Stichert, Heather Fitch, Brian Garber-Yonts, Ginny Eckert, Jason Gasper, Doug Pengilly André Punt, Buck Stockhausen, Martin Dorn, Shareef Siddeek, Jack Turnock and Diana Stram.

### Stock Status Definitions

The FMP (incorporating all changes made following adoption of Amendment 24) contains the following stock status definitions:

Acceptable biological catch (ABC) is a level of annual catch of a stock that accounts for the scientific uncertainty in the estimate of OFL and any other specified scientific uncertainty and is set to prevent, with a greater than 50 percent probability, the OFL from being exceeded. The ABC is set below the OFL.

ABC Control Rule is the specified approach in the five-tier system for setting the maximum permissible ABC for each stock as a function of the scientific uncertainty in the estimate of OFL and any other specified scientific uncertainty.

Annual catch limit (ACL) is the level of annual catch of a stock that serves as the basis for invoking accountability measures. For EBS crab stocks, the ACL will be set at the ABC.

Total allowable catch (TAC) is the annual catch target for the directed fishery for a stock, set to prevent exceeding the ACL for that stock and in accordance with section 8.2.2 of the FMP.

Guideline harvest level (GHL) means the preseason estimated level of allowable fish harvest which will not jeopardize the sustained yield of the fish stocks. A GHL may be expressed as a range of allowable harvests for a species or species group of crab for each registration area, district, subdistrict, or section.

Maximum sustainable yield (MSY) is the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions. MSY is estimated from the best information available.

F<sub>MSY</sub> control rule means a harvest strategy which, if implemented, would be expected to result in a long-term average catch approximating MSY.

B<sub>MSY</sub> stock size is the biomass that results from fishing at constant F<sub>MSY</sub> and is the minimum standard for a rebuilding target when a rebuilding plan is required.

Maximum fishing mortality threshold (MFMT) is defined by the F<sub>OFL</sub> control rule, and is expressed as the fishing mortality rate.

Minimum stock size threshold (MSST) is one half the B<sub>MSY</sub> stock size.

Overfished is determined by comparing annual biomass estimates to the established MSST. For stocks where MSST (or proxies) are defined, if the biomass drops below the MSST (or proxy thereof) then the stock is considered to be overfished. For crab stocks, biomass for determining overfished status is estimated on February 15 of the current year and compared to the MSST established by the NPFMC in October of the previous year.

Overfishing is defined as any amount of catch in excess of the overfishing level (OFL). The OFL is calculated by applying abundance estimates to the F<sub>OFL</sub> control rule which is annually estimated according to the tier system (see Chapter 6.0 in the FMP).

## **Status Determination Criteria**

The FMP defines the following status determination criteria and the process by which these are defined following adoption of amendment 24 and 38.

Status determination criteria for crab stocks are annually calculated using a five-tier system that accommodates varying levels of uncertainty of information. The five-tier system incorporates new scientific information and provides a mechanism to continually improve the status determination criteria

as new information becomes available. Under the five-tier system, overfishing and overfished criteria and ABC levels are annually formulated. The ACL for each stock equals the ABC for that stock. Each crab stock is annually assessed to determine its status and whether (1) overfishing is occurring or the rate or level of fishing mortality for the stock is approaching overfishing, (2) the stock is overfished or the stock is approaching an overfished condition, and (3) the catch has exceeded the ACL.

For crab stocks, the OFL equals the maximum sustainable yield (MSY) and is derived through the annual assessment process, under the framework of the tier system. Overfishing is determined by comparing the OFL with the catch estimates for that crab fishing year. For the previous crab fishing year, NMFS will determine whether overfishing occurred by comparing the previous year's OFL with the catch from the previous crab fishing year. For the previous crab fishing year, NMFS will also determine whether the ACL was exceeded by comparing the ACL with the catch estimates for that crab fishing year. Catch includes all fishery removals, including retained catch and discard losses, for those stocks where non-target fishery removal data are available. Discard losses are determined by multiplying the appropriate handling mortality rate by observer estimates of bycatch discards. For stocks where only retained catch information is available, the OFL and ACL will be set for and compared to the retained catch.

The NMFS will determine whether a stock is in an overfished condition by comparing annual biomass estimates to the established MSST. For stocks where MSST (or proxies) are defined, if the biomass drops below the MSST (or proxy thereof) then the stock is considered to be overfished. MSSTs or proxies are set for stocks in Tiers 1-4. For Tier 5 stocks, it is not possible to set an MSST because there are no reliable estimates of biomass.

If overfishing occurred or the stock is overfished, section 304(e)(3)(A) of the Magnuson-Stevens Act, as amended, requires the NPFMC to immediately end overfishing and rebuild affected stocks.

The Magnuson-Stevens Act requires that FMPs include accountability measures to prevent ACLs from being exceeded and to correct overages of the ACL if they do occur. Accountability measures to prevent TACs and GHs from being exceeded have been used under this FMP for the management of the BSAI crab fisheries and will continue to be used to prevent ACLs from being exceeded. These include: individual fishing quotas and the measures to ensure that individual fishing quotas are not exceeded, measures to minimize crab bycatch in directed crab fisheries, and monitoring and catch accounting measures. Accountability measures in the harvest specification process include downward adjustments to the ACL and TAC in the fishing year after an ACL has been exceeded.

Annually, the NPFMC, SSC, and CPT will review (1) the stock assessment documents, (2) the OFLs and ABCs, and TACs or GHs, (3) NMFS's determination of whether overfishing occurred in the previous crab fishing year, (4) NMFS's determination of whether any stocks are overfished and (5) NMFS's determination of whether catch exceeded the ACL in the previous crab fishing year.

Optimum yield is defined in Chapter 4 of the FMP. Information pertaining to economic, social and ecological factors relevant to the determination of optimum yield is provided in several sections of the FMP, including sections 7.2 (Management Objectives), Chapter 11, Appendix D (Biological and Environmental Characteristics of the Resource), and Appendix H (Community Profiles).

For each crab fishery, the optimum yield range is 0 to < OFL catch. For crab stocks, the OFL is the annualized MSY and is derived through the annual assessment process, under the framework of the tier system. Recognizing the relatively volatile reproductive potential of crab stocks, the cooperative management structure of the FMP, and the past practice of restricting or even prohibiting directed harvests of some stocks out of ecological considerations, this optimum yield range is intended to facilitate the achievement of the biological objectives and economic and social objectives of the FMP (see sections

7.2.1 and 7.2.2) under a variety of future biological and ecological conditions. It enables the SOA to determine the appropriate TAC levels below the OFL to prevent overfishing or address other biological concerns that may affect the reproductive potential of a stock but that are not reflected in the OFL itself. Under FMP section 8.2.2, the SOA establishes TACs at levels that maximize harvests, and associated economic and social benefits, when biological and ecological conditions warrant doing so.

### Five-Tier System

The OFL and ABC for each stock are annually estimated for the upcoming crab fishing year using the five-tier system, detailed in Table 6-1 and 6-2. First, a stock is assigned to one of the five tiers based on the availability of information for that stock and model parameter choices are made. Tier assignments and model parameter choices are recommended through the CPT process to the SSC. The SSC recommends tier assignments, stock assessment and model structure, and parameter choices, including whether information is "reliable," for the assessment authors to use for calculating the proposed OFLs and ABCs based on the five-tier system.

For Tiers 1 through 4, once a stock is assigned to a tier, the determination of stock status level is based on recent survey data and assessment models, as available. The stock status level determines the equation used in calculating the  $F_{OFL}$ . Three levels of stock status are specified and denoted by "a," "b," and "c" (see Table 6-1). The  $F_{MSY}$  control rule reduces the  $F_{OFL}$  as biomass declines by stock status level. At stock status level "a," current stock biomass exceeds the  $B_{MSY}$ . For stocks in status level "b," current biomass is less than  $B_{MSY}$  but greater than a level specified as the "critical biomass threshold" ( $\beta$ ).

In stock status level "c," the ratio of current biomass to  $B_{MSY}$  (or a proxy for  $B_{MSY}$ ) is below  $\beta$ . At stock status level "c," directed fishing is prohibited and an  $F_{OFL}$  at or below  $F_{MSY}$  would be determined for all other sources of fishing mortality in the development of the rebuilding plan. The Council will develop a rebuilding plan once a stock level falls below the MSST.

For Tiers 1 through 3, the coefficient  $\alpha$  is set at a default value of 0.1, and  $\beta$  set at a default value of 0.25, with the understanding that the SSC may recommend different values for a specific stock or stock complex as merited by the best available scientific information.

In Tier 4, a default value of natural mortality rate ( $M$ ) or an  $M$  proxy, and a scalar,  $\gamma$ , are used in the calculation of the  $F_{OFL}$ .

In Tier 5, the OFL is specified in terms of an average catch value over an historical time period, unless the SSC recommends an alternative value based on the best available scientific information.

Second, the assessment author prepares the stock assessment and calculates the proposed OFLs by applying the  $F_{OFL}$  and using the most recent abundance estimates. The assessment authors calculate the proposed ABCs by applying the ABC control rule to the proposed OFL.

Stock assessment documents shall:

- use risk-neutral assumptions;
- specify how the probability distribution of the OFL used in the ABC control rule is calculated for each stock; and
- specify the factors influencing scientific uncertainty that are accounted for in calculation of the probability distribution of the OFL.

Second, the CPT annually reviews stock assessment documents, the most recent abundance estimates, the proposed OFLs and ABCs, and complies the SAFE. The CPT then makes recommendations to the SSC on the OFLs, ABCs, and any other issues related to the crab stocks.

Third, the SSC annually reviews the SAFE report, including the stock assessment documents, recommendations from the CPT, and the methods to address scientific uncertainty.

In reviewing the SAFE, the CPT and the SSC shall evaluate and make recommendations, as necessary, on:

- the assumptions made for stock assessment models and estimation of OFLs;
- the specifications of the probability distribution of the OFL;
- the methods to appropriately quantify uncertainty in the ABC control rule; and
- the factors influencing scientific uncertainty that the SOA has accounted for and will account for on an annual basis in TAC setting.

The SSC will then set the final OFLs and ABCs for the upcoming crab fishing year. The SSC may set an ABC lower than the result of the ABC control rule, but it must provide an explanation for setting the ABC less than the maximum ABC.

As an accountability measure, the total catch estimate used in the stock assessment will include any amount of harvest that may have exceeded the ACL in the previous fishing season. For stocks managed under Tiers 1 through 4, this would result in a lower maximum ABC in the subsequent year, all else being equal, because maximum ABC varies directly with biomass. For Tier 5 stocks, the information used to establish the ABC is insufficient to reliably estimate abundance or discern the existence or extent of biological consequences caused by an overage in the preceding year. Consequently, the subsequent year's maximum ABC will not automatically decrease. However, when the ACL for a Tier 5 stock has been exceeded, the SSC may decrease the ABC for the subsequent fishing season as an accountability measure.

### Tiers 1 through 3

For Tiers 1 through 3, reliable estimates of  $B$ ,  $B_{MSY}$ , and  $F_{MSY}$ , or their respective proxy values, are available. Tiers 1 and 2 are for stocks with a reliable estimate of the spawner/recruit relationship, thereby enabling the estimation of the limit reference points  $B_{MSY}$  and  $F_{MSY}$ .

- Tier 1 is for stocks with assessment models in which the probability density function (pdf) of  $F_{MSY}$  is estimated.
- Tier 2 is for stocks with assessment models in which a reliable point estimate, but not the pdf, of  $F_{MSY}$  is made.
- Tier 3 is for stocks where reliable estimates of the spawner/recruit relationship are not available, but proxies for  $F_{MSY}$  and  $B_{MSY}$  can be estimated.

For Tier 3 stocks, maturity and other essential life-history information are available to estimate proxy limit reference points. For Tier 3, a designation of the form “ $F_X$ ” refers to the fishing mortality rate associated with an equilibrium level of fertilized egg production (or its proxy such as mature male biomass at mating) per recruit equal to  $X\%$  of the equilibrium level in the absence of any fishing.

The OFL and ABC calculation accounts for all losses to the stock not attributable to natural mortality. The OFL and ACL are total catch limits comprised of three catch components: (1) non-directed fishery discard losses; (2) directed fishery discard losses; and (3) directed fishery retained catch. To determine the discard losses, the handling mortality rate is multiplied by bycatch discards in each fishery.

Overfishing would occur if, in any year, the sum of all three catch components exceeds the OFL.

#### Tier 4

Tier 4 is for stocks where essential life-history, recruitment information, and understanding are insufficient to achieve Tier 3. Therefore, it is not possible to estimate the spawner-recruit relationship. However, there is sufficient information for simulation modeling that captures the essential population dynamics of the stock as well as the performance of the fisheries. The simulation modeling approach employed in the derivation of the annual OFLs captures the historical performance of the fisheries as seen in observer data from the early 1990s to present and thus borrows information from other stocks as necessary to estimate biological parameters such as  $\gamma$ .

In Tier 4, a default value of natural mortality rate ( $M$ ) or an  $M$  proxy, and a scalar,  $\gamma$ , are used in the calculation of the  $F_{OFL}$ . Explicit to Tier 4 are reliable estimates of current survey biomass and the instantaneous  $M$ . The proxy  $B_{MSY}$  is the average biomass over a specified time period, with the understanding that the Council's Scientific and Statistical Committee may recommend a different value for a specific stock or stock complex as merited by the best available scientific information. A scalar,  $\gamma$ , is multiplied by  $M$  to estimate the  $F_{OFL}$  for stocks at status levels "a" and "b," and  $\gamma$  is allowed to be less than or greater than unity. Use of the scalar  $\gamma$  is intended to allow adjustments in the overfishing definitions to account for differences in biomass measures. A default value of  $\gamma$  is set at 1.0, with the understanding that the Council's Scientific and Statistical Committee may recommend a different value for a specific stock or stock complex as merited by the best available scientific information.

If the information necessary to determine total catch OFLs and ACLs is available for a Tier 4 stock, then the OFL and ACL will be total catch limits comprised of three catch components: (1) non-directed fishery discard losses; (2) directed fishery discard losses; and (3) directed fishery retained catch. If the information necessary to determine total catch OFLs and ACLs is not available for a Tier 4 stock, then the OFL and ACL are determined for retained catch. In the future, as information improves, data would be available for some stocks to allow the formulation and use of selectivity curves for the discard fisheries (directed and non-directed losses) as well as the directed fishery (retained catch) in the models. The resulting OFL and ACL from this approach, therefore, would be the total catch OFL and ACL.

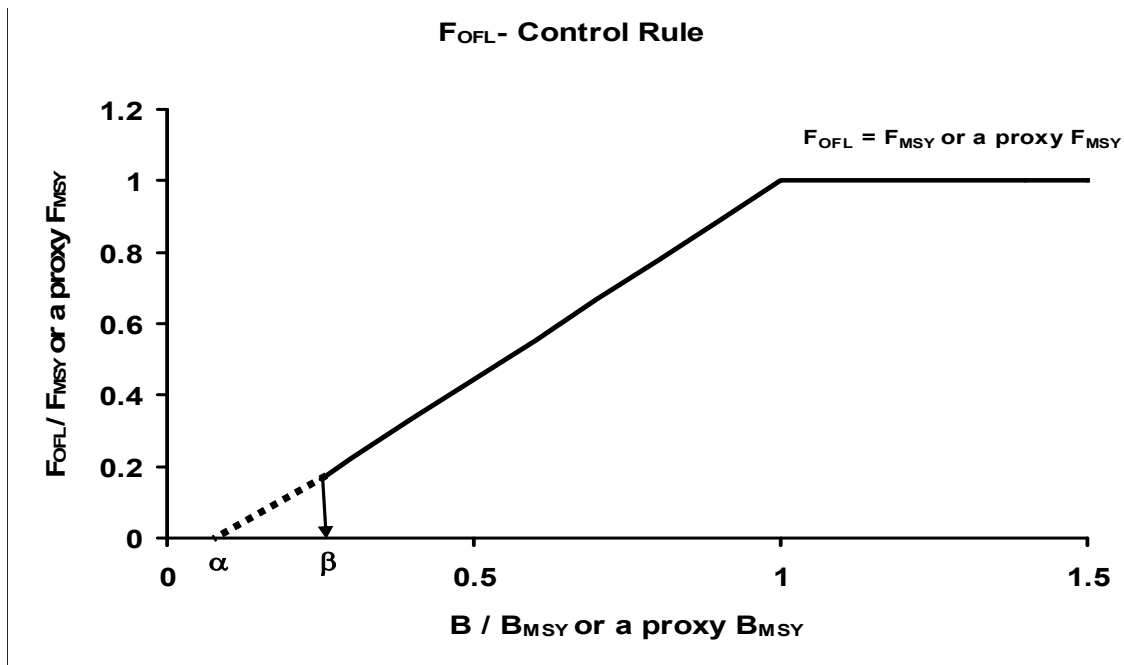
#### Tier 5

Tier 5 stocks have no reliable estimates of biomass and only historical catch data are available. For Tier 5 stocks, the OFL is set equal to the average catch from a time period determined to be representative of the production potential of the stock, unless the Scientific and Statistical Committee recommends an alternative value based on the best available scientific information. The ABC control rule sets the maximum ABC at less than or equal to 90 percent of the OFL and the ACL equals the ABC.

For Tier 5 stocks where only retained catch information is available, the OFL and ACL will be set for the retained catch portion only, with the corresponding limits applying to the retained catch only. For Tier 5 stocks where information on bycatch mortality is available, the OFL and ACL calculations could include discard losses, at which point the OFL and ACL would be applied to the retained catch plus the discard losses from directed and non-directed fisheries.



Figure 1. Overfishing control rule for Tiers 1 through 4. Directed fishing mortality is 0 below  $\beta$ .



**Table 1 Five-Tier System for setting overfishing limits (OFLs) and Acceptable Biological Catches (ABCs) for crab stocks. The tiers are listed in descending order of information availability. Table 2 contains a guide for understanding the five-tier system.**

Information available	Tier	Stock status level	$F_{OFL}$	ABC control rule
$B, B_{MSY}, F_{MSY}$ , and pdf of $F_{MSY}$	1	a. $\frac{B}{B_{msy}} > 1$	$F_{OFL} = \mu_A$ =arithmetic mean of the pdf	$ABC \leq (1-b_y) * OFL$
		b. $\beta < \frac{B}{B_{msy}} \leq 1$	$F_{OFL} = \mu_A \frac{B/B_{msy} - \alpha}{1 - \alpha}$	
		c. $\frac{B}{B_{msy}} \leq \beta$	Directed fishery $F = 0$ $F_{OFL} \leq F_{MSY}^\dagger$	
$B, B_{MSY}, F_{MSY}$	2	a. $\frac{B}{B_{msy}} > 1$	$F_{OFL} = F_{msy}$	$ABC \leq (1-b_y) * OFL$
		b. $\beta < \frac{B}{B_{msy}} \leq 1$	$F_{OFL} = F_{msy} \frac{B/B_{msy} - \alpha}{1 - \alpha}$	
		c. $\frac{B}{B_{msy}} \leq \beta$	Directed fishery $F = 0$ $F_{OFL} \leq F_{MSY}^\dagger$	
$B, F_{35\%}, B_{35\%}$	3	a. $\frac{B}{B_{35\%}^*} > 1$	$F_{OFL} = F_{35\%}^*$	$ABC \leq (1-b_y) * OFL$
		b. $\beta < \frac{B}{B_{35\%}^*} \leq 1$	$F_{OFL} = F_{35\%}^* \frac{B/B_{35\%}^* - \alpha}{1 - \alpha}$	
		c. $\frac{B}{B_{35\%}^*} \leq \beta$	Directed fishery $F = 0$ $F_{OFL} \leq F_{MSY}^\dagger$	
$B, M, B_{msy}^{prox}$	4	a. $\frac{B}{B_{msy}^{prox}} > 1$	$F_{OFL} = \gamma M$	$ABC \leq (1-b_y) * OFL$
		b. $\beta < \frac{B}{B_{msy}^{prox}} \leq 1$	$F_{OFL} = \gamma M \frac{B/B_{msy}^{prox} - \alpha}{1 - \alpha}$	
		c. $\frac{B}{B_{msy}^{prox}} \leq \beta$	Directed fishery $F = 0$ $F_{OFL} \leq F_{MSY}^\dagger$	
Stocks with no reliable estimates of biomass or M.	5		OFL = average catch from a time period to be determined, unless the SSC recommends an alternative value based on the best available scientific information.	$ABC \leq 0.90 * OFL$

\*35% is the default value unless the SSC recommends a different value based on the best available scientific information.

† An  $F_{OFL} \leq F_{MSY}$  will be determined in the development of the rebuilding plan for an overfished stock.

**Table 2 A guide for understanding the five-tier system.**

<ul style="list-style-type: none"> <li>• <math>F_{OFL}</math> — the instantaneous fishing mortality (F) from the directed fishery that is used in the calculation of the overfishing limit (OFL). <math>F_{OFL}</math> is determined as a function of: <ul style="list-style-type: none"> <li>○ <math>F_{MSY}</math> — the instantaneous F that will produce MSY at the MSY-producing biomass <ul style="list-style-type: none"> <li>▪ A proxy of <math>F_{MSY}</math> may be used; e.g., <math>F_{x\%}</math>, the instantaneous F that results in x% of the equilibrium spawning per recruit relative to the unfished value</li> </ul> </li> <li>○ B — a measure of the productive capacity of the stock, such as spawning biomass or fertilized egg production. <ul style="list-style-type: none"> <li>▪ A proxy of B may be used; e.g., mature male biomass</li> </ul> </li> <li>○ <math>B_{MSY}</math> — the value of B at the MSY-producing level <ul style="list-style-type: none"> <li>▪ A proxy of <math>B_{MSY}</math> may be used; e.g., mature male biomass at the MSY-producing level</li> </ul> </li> <li>○ <math>\beta</math> — a parameter with restriction that <math>0 \leq \beta &lt; 1</math>.</li> <li>○ <math>\alpha</math> — a parameter with restriction that <math>0 \leq \alpha \leq \beta</math>.</li> </ul> </li> <li>• The maximum value of <math>F_{OFL}</math> is <math>F_{MSY}</math>. <math>F_{OFL} = F_{MSY}</math> when <math>B &gt; B_{MSY}</math>.</li> <li>• <math>F_{OFL}</math> decreases linearly from <math>F_{MSY}</math> to <math>F_{MSY} \cdot (\beta - \alpha) / (1 - \alpha)</math> as B decreases from <math>B_{MSY}</math> to <math>\beta \cdot B_{MSY}</math></li> <li>• When <math>B \leq \beta \cdot B_{MSY}</math>, <math>F = 0</math> for the directed fishery and <math>F_{OFL} \leq F_{MSY}</math> for the non-directed fisheries, which will be determined in the development of the rebuilding plan.</li> <li>• The parameter, <math>\beta</math>, determines the threshold level of B at or below which directed fishing is prohibited.</li> <li>• The parameter, <math>\alpha</math>, determines the value of <math>F_{OFL}</math> when B decreases to <math>\beta \cdot B_{MSY}</math> and the rate at which <math>F_{OFL}</math> decreases with decreasing values of B when <math>\beta \cdot B_{MSY} &lt; B \leq B_{MSY}</math>. <ul style="list-style-type: none"> <li>○ Larger values of <math>\alpha</math> result in a smaller value of <math>F_{OFL}</math> when B decreases to <math>\beta \cdot B_{MSY}</math>.</li> <li>○ Larger values of <math>\alpha</math> result in <math>F_{OFL}</math> decreasing at a higher rate with decreasing values of B when <math>\beta \cdot B_{MSY} &lt; B \leq B_{MSY}</math>.</li> </ul> </li> <li>• The parameter, <math>b_y</math>, is the value for the annual buffer calculated from a <math>P^*</math> of 0.49 and a probability distribution for the OFL that accounts for scientific uncertainty in the estimate of OFL.</li> <li>• <math>P^*</math> is the probability that the estimate of ABC, which is calculated from the estimate of OFL, exceeds the “true” OFL (noted as OFL’) (<math>P(ABC &gt; OFL')</math>).</li> </ul>
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## Crab Plan Team Recommendations

Table 3 lists the team’s recommendations for 2015/2016 on Tier assignments, model parameterizations, time periods for reference biomass estimation or appropriate catch averages, OFLs and ABCs. The team recommends three stocks be placed in Tier 3 (EBS snow crab, Bristol Bay red king crab and EBS Tanner crab), four stocks in Tier 4 (St. Matthew blue king crab, Pribilof Islands blue king crab, Pribilof Islands red king crab, and Norton Sound red king crab) and three stocks in Tier 5 (AI golden king crab, Pribilof Islands golden king crab, and Adak red king crab). Table 4 lists those stocks for which the team recommends an ABC less than the maximum permissible ABC for 2015/16. Stock status in relation to status determination criteria are evaluated in this report (Table 5). Status of stocks in relation to status determination criteria for stocks in Tiers 3 and 4 are shown in Figure 1. EBS Tanner crab and Pribilof Islands red king crab are estimated to be above  $B_{MSY}$  for 2015/16 while snow crab, Bristol Bay red king crab, Saint Matthew blue king crab and Norton Sound red king crab are estimated below  $B_{MSY}$ . Pribilof Islands blue king crab stock remains overfished and estimated to be well below its MSST.

The CPT has general recommendations for all assessments and specific comments related to individual assessments. All recommendations are for consideration for the 2016 assessments. The general comments are listed below while the comments related to individual assessments are contained within the summary of CPT deliberations and recommendations contained in the stock specific summary section. Additional details regarding recommendations are contained in the Crab Plan Team Report (September 2015 CPT Report).

### **General recommendations for all assessments**

1. 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.
2. The CPT recommends that weighting factors be expressed as sigmas or CVs or effective sample sizes. The team requests all authors to follow 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.
3. Authors should focus on displaying information on revised models as compared to last year's model rather than focusing on aspects of the assessment that have not changed from the previous year.
4. The current approach for fitting length-composition data accounts for sampling error but ignores the fact that selectivity among size classes is not constant within years; a small change in the selectivity on small animals could lead to a very large change in the catch of such animals (as may have happened for NSRKC). Authors are encouraged to develop approaches for accounting for this source of process error. This issue is generic to assessments of crab and groundfish stocks.
5. Authors are reminded that assessments should include the time series of stock estimates at the time of survey for at least the author's recommended model in that year.
6. Consider stepwise changes to data as individual model runs instead of changing multiple parameters at once so that changes in model performance may be attributed to specific data

By convention the CPT used the following conversions to include tables in both lb and t in the status summary sections:

- million lb to 1000 t [ $/2.204624$ ]
- 1000 t to million lb [ $/0.453592$ ]

## Stock Status Summaries

### 1 Eastern Bering Sea Snow crab

#### *Fishery information relative to OFL setting*

Total catch mortality in 2014/15 was 34,300 t (with discard mortality rates applied), while the retained catch in the directed fishery was 30,820 t. This was below the 2014/15 OFL of 69,000 t. Snow crab bycatch occurs in the directed fishery and to a lesser extent in the groundfish trawl fisheries. Estimates of trawl bycatch in recent years are less than 1% of the total snow crab catch. Estimates of stock status were above  $B_{35\%}$  since 2010/11, but have generally declined recently. For 2015/16, projected MMB (147,200 t) fishing at the  $F_{OFL}$  is 93.3% of the  $B_{35\%}$  value (157,800 t) used as the  $B_{MSY}$  proxy in this assessment.

#### *Data and assessment methodology*

The stock assessment is based on a size- and sex-structured model in which crabs are categorized into immature or mature and new- or old shell. The model is fitted to abundance and size frequency data from the NMFS trawl survey, total catch data from the directed fishery, bycatch data from the trawl fishery, size frequency data for male retained catch in the directed fishery, and male and female bycatch in the directed and trawl fisheries. The model is also fitted to biomass estimates and size frequency data from the 2019 and 2010 BSFRF surveys. Updated data in the model include biomass and length frequency data from the 2015 NMFS Eastern Bering Sea trawl survey, retained and discard catch and length frequencies from the 2014/15 directed fishery, and discard catch and length frequencies from the 2014/15 groundfish fisheries.

The assessment author examined six model scenarios in this assessment. Model 0 was the September 2014 scenario, with the standard deviation parameter of the growth function fixed at an arbitrarily small value of 0.5. Model 1 changed: (1) the survey logistic curves from estimating size at 95%-selected to an offset from the size at 50% parameter; (2) survey  $q$  for the first time period to a probit scale; and (3) 2010 industry survey availability to a probit scale. Model 2 additionally removed a constraint on maturation probability, increased the weight on the smoothness for female maturity, and increased the weight on the trawl bycatch data. In Model 3 the length at 50% selected for female discards was changed from 4.2 to 4.4 (log scale), and the likelihood weight for growth data increased from 2.0 to 3.0. Model 4 removed a penalty on directed fishing mortality estimates for male crab after 1991. Model 5 removed a penalty on female fishing mortality estimates after 1991; potlift data are used to estimate pre-1992 fishing mortality for female discards.

The author selected Model 5 as the preferred model, because it removes the 1992–present fishing mortality penalties, which have been shown to result in bias. Model estimates of biomass,  $F_{35\%}$ , and  $B_{35\%}$  were similar between Models 0 and 1, and moderately similar among Models 2–5, but there was insufficient information to fully understand the substantial change in estimates from Model 1 to 2. There were three potentially significant changes to the model between model 1 to Model 2 and it was unclear to the CPT which of these changes was affecting model results. Pending full understanding of the changes, the CPT recommends Model 0 as the preferred model, with current Model 5 as a potential target for future modeling.

#### *Stock biomass and recruitment trends*

Observed survey mature male biomass decreased from 167,400 t in 2011 to 96,100 t in 2013, increased to 156,900 t in 2014, then fell to 79,000 t in 2015. Similarly, the observed survey mature female biomass decreased from 280,000 t in 2011 to 195,100 t in 2013, increased to 212,500 t in 2014, then fell to 128,100 t in 2015. The 2015 model estimates of mature male biomass showed similar trends as survey biomass during 2011–2014, but failed to match the substantial survey decline observed in 2015. Model estimates of mature female biomass have generally increased since 2010 in contrast to a general decline in

survey biomass since 2011. Under the 2015 model, mature male biomass and mature female biomass are both under-predicted at the time of the survey for 2014 and substantially over-predicted in 2015. The model estimates are partly driven by a peak in estimated recruitment from the 2005 fertilization year. This recruitment has not been observed subsequent to the 2010 survey. Fits by the 2015 model to the size frequency data since about 2011 were poor; fitted size frequencies were lower than observed for females and higher than observed for males.

*Tier determination/Plan Team discussion and resulting OFL/ABC determination Status and catch specifications*

The CPT recommends that the EBS snow crab is a Tier 3 stock so the OFL will be determined by the  $F_{35\%}$  control rule. The proxy for  $B_{MSY}$  ( $B_{35\%}$ ) is the mature male biomass at mating (157.8 thousand t) based on average recruitment over 1978 to present. Consequently, the minimum stock size threshold (MSST) is 73.2 thousand t. The CPT recommends that the ABC be less than maximum permissible ABC. The extent of contradiction between the model and the data is more extreme than in previous years. The CPT recommends a 25% buffer for setting the 2015/16 ABC due to the model uncertainties and contradictions between model trends and survey and fishery observations.

*Historical status and catch specifications for snow crab (thousand t).*

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2011/12	77.3	165.2 <sup>A</sup>	40.3	40.5	44.7	73.5	66.2
2012/13	77.1	170.1 <sup>A</sup>	30.1	30.1	32.4	67.8	61.0
2013/14	71.5	126.5 <sup>A</sup>	24.5	24.5	28.1	78.1	70.3
2014/15	78.9	168.0 <sup>A</sup>	30.8	30.8	34.3	69.0	62.1
2015/16		147.2 <sup>B</sup>				83.1	62.3

A - Estimated biomass at the time of mating for the year concerned. Note this represents a revised estimate from the projection the previous year.

B - Projected biomass from the current stock assessment. This value will be updated next year.

*Historical status and catch specifications for snow crab (millions of lb).*

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2011/12	170.4	364.2 <sup>A</sup>	88.8	89.3	98.5	162.0	145.9
2012/13	170.0	375.0 <sup>A</sup>	66.4	66.4	71.4	149.5	134.5
2013/14	157.6	279.0 <sup>A</sup>	54.0	54.0	62.0	172.2	155.0
2014/15	173.9	370.4 <sup>A</sup>	67.9	67.9	75.4	152.1	137.0
2015/16		324.8 <sup>B</sup>				183.2	137.4

A - Estimated biomass at the time of mating for the year concerned. Note this represents a revised estimate from the projection the previous year.

B - Projected biomass from the current stock assessment. This value will be updated next year.

## 2 Bristol Bay Red King Crab

*Fishery information relative to OFL setting.*

The commercial harvest of Bristol Bay red king crab (BBRKC) dates to the 1930s, and the fishery was initially prosecuted mostly by foreign fleets, but shifted to a largely domestic fishery in the early 1970s. Retained catch peaked in 1980 at 129.9 million lb (58.9 thousand t), but harvests dropped sharply in the early 1980s, and population abundance has remained at relatively low levels over the last two decades compared to those seen in the 1970s. The fishery is managed for a total allowable catch (TAC) coupled with restrictions for sex (males only), a minimum size for legal retention (6.5-in carapace width; 135-mm carapace length is used a proxy for 6.5-in carapace width in the assessment), and season (no fishing during mating/molting periods). In addition to the retained catch that occurs during the commercial fishery, which is limited by the TAC, there is also retained catch that occurs in the ADF&G cost-recovery fishery.

The current SOA harvest strategy allows a maximum harvest rate of 15% of mature-sized ( $\geq 120$  mm CL) males, but also incorporates a maximum harvest rate of 50% of legal males and a threshold of 8.4 million mature-sized ( $\geq 90$  mm CL) females and 14.5 million lb (6.6 thousand t) of effective spawning biomass (ESB), to prosecute a fishery. Annual non-retained catch of female and sublegal male RKC during the fishery averaged less than 3.9 million lb (8.6 thousand t) since data collection began in 1990. Total catch (retained and bycatch mortality) increased from 16.9 million lb (7.6 thousand t) in 2005/06 to 23.4 million lb (10.6 thousand t) in 2007/08, but has decreased since then; retained catch in 2014/15 was 10.01 million lb (4.54 thousand t) and total catch was 11.99 million lb (5.44 thousand t).

*Data and assessment methodology*

The stock assessment model is a sex- and size-structured population dynamics model incorporating data from the NMFS eastern Bering Sea trawl survey, the Bering Sea Fisheries Research Foundation (BSFRF) trawl survey, landings of commercial catch, at-sea observers, and dockside samplers. In the model recommended by the CPT, annual stock abundance was estimated for male and female crabs  $\geq 65$ -mm carapace length from 1975 to the time of the 2015 survey and mature male (males  $\geq 120$  mm CL) biomass was projected to 15 February 2016. Catch data (retained catch numbers, retained catch weight, and pot lifts by statistical area and landing date) from the directed fishery, which targets males  $\geq 135$  mm (6.5 in carapace length), were obtained from ADF&G fish tickets and reports, red king crab and Tanner crab fisheries bycatch data from the ADF&G observer database, and groundfish trawl bycatch data from the NMFS trawl observer database. NMFS trawl survey data were updated with the newly re-estimated time series provided by NMFS in 2015; catch and bycatch data were updated with data from the 2014/15 crab fishery year.

Three alternative models were evaluated: the accepted model for the 2014 assessment, which served as the base model (model scenario 1); and two variants of the base model (model scenarios 1a and 1b) that explored alternative ways to model the dependence of trawl survey catchability on bottom temperature. Both approaches to modeling a temperature-catchability relationship suggested that there was a weakly positive relationship between temperature and trawl survey catchability, but the relationship was not statistically significant, and had almost no impact on model results. Therefore the author recommended model scenario 1 for use in the 2015 stock assessment. The CPT also selected model scenario 1 as its recommended model as the basis for status determination and OFL setting.

*Stock biomass and recruitment trends*

Model (scenario 1) estimates of total survey biomass increased from 247.1 thousand t in 1975 to 349.5 thousand t in 1978, fell to 34.5 thousand t in 1985, generally increased to 93.9 thousand t in 2007, and subsequently declined to 70.8 thousand t in 2015. Estimated recruitment was high during the 1970s and early 1980s and has been generally low since 1985. The near-term outlook for this stock is a continued gradual declining trend. Recruitment has been poor (less than the mean from 1984-2015) since 2006. The 2011 survey produced a high catch of juvenile males and females <65 mm CL in one survey tow but that catch did not track into the 2012–2015 surveys. The survey area-swept estimates for abundance and biomass in 2015 were more consistent with previous surveys, in comparison to 2014, when the estimates were anomalously high.

*Tier determination/Plan Team discussion and resulting OFL and ABC determination*

Bristol Bay red king crab is in Tier 3. Based on the author's discussion regarding an apparent reduction in stock productivity associated with the well-known 1976/77 climate regime shift in the EBS, the CPT continues to recommend computing average recruitment based on model recruitment using the time period 1984 (corresponding to fertilization in 1977) to the last year of the assessment. The estimated  $B_{35\%}$  is 26.1 thousand t). MMB projected for 2015/16 is 24.7 thousand t, 95% of  $B_{35\%}$ . Consequently, the BBRKC stock is in Tier 3b in 2015/16.

The team recommends that the OFL for 2015/16 be set according to model scenario 1, for which the calculated OFL is 6.73 thousand t (14.84 million lb). The team recommends that the ABC for 2015/16 be set below the maximum permissible ABC. The team recommends that a 10% buffer from the OFL be used to set the ABC at 6.06 thousand t (13.36 million lb).

MMB for 2014/15 was estimated to be 27.3 thousand t and above MSST (13.03 thousand t); hence the stock was not overfished in 2014/15. The total catch in 2014/15 (5.44 thousand t) was less than the 2014/15 OFL (6.82 thousand t); hence overfishing did not occur in 2014/15. The stock at 2015/16 time of mating is projected to be above the MSST and 95% of  $B_{35\%}$  (see above); hence the stock is not projected to be in overfished condition in 2015/16.



*Status and catch specifications (thousand t) for Bristol Bay red king crab*

<b>Year</b>	<b>MSST</b>	<b>Biomass (MMB)</b>	<b>TAC</b>	<b>Retained Catch</b>	<b>Total Catch</b>	<b>OFL</b>	<b>ABC</b>
2011/12	13.77	30.88 <sup>A</sup>	3.55	3.61	4.09	8.80	7.92
2012/13	13.19	29.05 <sup>A</sup>	3.56	3.62	3.90	7.96	7.17
2013/14	12.85	27.12 <sup>A</sup>	3.90	3.99	4.56	7.07	6.36
2014/15	13.03	27.25 <sup>A</sup>	4.49	4.54	5.44	6.82	6.14
2015/16		24.69 <sup>B</sup>				6.73	6.06

A - Estimated biomass at the time of mating for the year concerned. Note this represents a revised estimate from the projection the previous year.

B - Projected biomass from the current stock assessment. This value will be updated next year.

*Status and catch specifications (millions of lb) for Bristol Bay red king crab*

<b>Year</b>	<b>MSST</b>	<b>Biomass (MMB)</b>	<b>TAC</b>	<b>Retained Catch</b>	<b>Total Catch</b>	<b>OFL</b>	<b>ABC</b>
2011/12	30.4	68.1 <sup>A</sup>	7.83	7.95	9.01	19.39	17.46
2012/13	29.1	64.0 <sup>A</sup>	7.85	7.98	8.59	17.55	15.80
2013/14	28.3	59.9 <sup>A</sup>	8.60	8.80	10.05	15.58	14.02
2014/15	28.7	60.1 <sup>A</sup>	9.99	10.01	11.99	15.04	13.53
2015/16		54.4 <sup>B</sup>				14.84	13.36

A - Estimated biomass at the time of mating for the year concerned. Note this represents a revised estimate from the projection the previous year.

B - Projected biomass from the current stock assessment. This value will be updated next year.

### 3 Eastern Bering Sea Tanner crab

*Fishery information relative to OFL setting.*

Eastern Bering Sea (EBS) Tanner crabs are caught in a directed Tanner crab fishery, and as bycatch in the groundfish fisheries, scallop fisheries, the directed Tanner crab fishery (mainly as non-retained females and sublegal males), and other crab fisheries (notably, eastern Bering Sea snow crab and, to a lesser extent, Bristol Bay red king crab). A single OFL is set for Tanner crab in the EBS. Under the Crab Rationalization Program, ADF&G sets separate TACs for directed fisheries east and west of 166° W longitude. Both fisheries were closed from 1997 to 2004 due to low abundance. In 2005/06, abundance increased to a level to support a fishery in the area west of 166° W longitude. ADF&G opened both fisheries for the 2006/07 to 2008/09 crab fishing years, and to the area east of 166° W longitude only in 2009/10.

The mature male biomass was estimated to be below the Minimum Stock Size Threshold ( $0.5B_{MSY}$ ) in February 2010 (the assumed time of mating) based on trends in mature male biomass from the survey, and NMFS declared the stock overfished in September 2010. The directed fisheries were closed from 2010/11 through 2012/13 crab fishery years. NMFS determined the stock was not overfished in 2012 based on a new assessment model with a revised estimate of  $B_{MSY}$ . The fishery was opened for the 2013/14 season with total allowable catch (TAC) of 746.2 t (1,645,000 lb) for the area west of 166° W longitude and 663.6 t (1,463,000 lb) for the area east of 166° W longitude (combined = 1.41 thousand t ; 3.11 million lb,) and for the 2014/15 season with TAC of 2,328.7 t (6,625,000 lb) for the area west of 166° W longitude and 3,829.3 t (8,480,000 lb) for the area east of 166° W longitude (6.85 thousand t ; 15.10 million lb.). Total retained catch in the 2014/15 season was 6.16 thousand t (13.58 million lb): 2.33 thousand t (6.63 million lb) from the area west of 166° W longitude and 3.83 thousand t (8.48 million lb) from the area east of 166° W longitude.

#### *Data and assessment methodology*

The SSC accepted the stock assessment model for use in harvest specifications in 2012 and classified the EBS Tanner stock as a Tier 3 stock. The current model structure, based on crab size, sex, shell condition, and maturity, is the same as in the 2014 assessment. The model uses available data on the magnitude and size-composition from: the NMFS trawl survey; landings and discards by the directed fishery; bycatch in the Bristol Bay red king crab, EBS snow crab, and groundfish fisheries. The model includes prior distributions on parameters related to natural mortality and catchability, and penalties on changes in recruitment and in the proportion maturing. New input data were added to the time series for the 2015 assessment and updates or corrections to previously used data were made: the current “standard” dataset for crab from the NMFS EBS trawl survey, 1975–2015, with use of current standard NMFS estimator for weight-from-width; a correction to the 2013/14 fishery data used in the 2014 assessment; the retained catch, bycatch, and size composition data from the 2014/15 crab fisheries; and data on Tanner crab bycatch in the groundfish fisheries in 2014/15.

#### *Stock biomass and recruitment trends*

The MMB at the time of mating is estimated to have been highest early in the early 1970s (approximately 300 thousand t), with secondary peaks in 1989 (60 thousand t) and 2008 – 2009 (57 – 58 thousand t). The estimated MMB at time of mating in 2015 is 72 thousand t and the projection for the 2016 time of mating is 54 thousand t. Estimates of recruitment since 1999 have been generally low relative to the peaks estimated for the period prior to 1990 and estimates of recruitment in the last four years are below the 1982 – 2015 average.

*Tier determination/Plan Team discussion and resulting OFL and ABC determination*

The team recommends the OFL for this stock be based on the Tier 3 control rule. Application of the Tier 3 control rule requires a set of years for defining  $R_{MSY}$ , the mean recruitment corresponding to  $B_{MSY}$  under prevailing environmental conditions. The recommended time period for defining  $R_{MSY}$  is 1982 – 2015; the 1982-and-onwards time period has been used in previous OFL determination and follows the most-recent recommendation of the SSC.

Based on the estimated biomass at 15 February 2016, the stock is at Tier 3 level a. The  $F_{MSY}$  proxy ( $F_{35\%}$ ) is  $0.58 \text{ yr}^{-1}$ , and the 2015/16  $F_{OFL}$  is  $0.58 \text{ yr}^{-1}$  under the Tier 3 OFL Control Rule, which results in a total male and female OFL of 27.19 thousand t (59.94 million lb). The CPT recommends a 20% buffer to account for model uncertainty and stock productivity uncertainty be applied to the OFL, to set  $ABC = 21.75$  thousand t (47.95 million lb). The 2015/16 OFL is estimated from the same model that was used to estimate the 2014/15 OFL and the 20% buffer is the same that the SSC recommended for determination of the 2014/15 ABC.

*Status and catch specifications (1000 t) for eastern Bering Sea Tanner crab.*

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
2011/12	11.40	58.59 <sup>A</sup>	0	0	1.24	2.75	2.48
2012/13	16.77	59.35 <sup>A</sup>	0	0	0.71	19.02	8.17
2013/14	16.98	72.70 <sup>A</sup>	1.41	1.26	2.78	25.35	17.82
2014/15	13.40	71.57 <sup>A</sup>	6.85	6.16	9.16	31.48	25.18
2015/16		53.70 <sup>B</sup>				27.19	21.75

A - Estimated biomass at the time of mating for the year concerned. Note this represents a revised estimate from the projection the previous year.

B - Projected biomass from the current stock assessment. This value will be updated next year.

*Status and catch specifications (million lb) for eastern Bering Sea Tanner crab.*

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
2011/12	25.13	129.17 <sup>A</sup>	0.00	0.00	2.73	6.06	5.47
2012/13	36.97	130.84 <sup>A</sup>	0.00	0.00	1.57	41.93	18.01
2013/14	37.43	160.28 <sup>A</sup>	3.12	2.78	6.13	55.89	39.29
2014/15	29.53	157.78 <sup>A</sup>	15.10	13.58	20.19	69.40	55.51
2015/16		118.38 <sup>B</sup>				59.94	47.95

A - Estimated biomass at the time of mating for the year concerned. Note this represents a revised estimate from the projection the previous year.

B - Projected biomass from the current stock assessment. This value will be updated next year.

## 4 Pribilof Islands red king crab

### *Fishery information relative to OFL setting*

The Pribilof Islands red king crab fishery began in 1973 as bycatch during the blue king crab fishery. In 1993 and 1994 the red king crab fishery was open to directed fishing and blue king crab was closed. From 1995 through 1998, combined Pribilof Islands red and blue king crab GHs were used. Declines in crab abundance of both red and blue king crab stocks from 1996 to 1998 resulted in poor fishery performance with annual harvests below the GHs. The Pribilof red king crab fishery has been closed since 1999 due to uncertainty in estimated red king crab abundance and concerns for bycatch mortality of blue king crab, which is overfished and severely depressed. Fishery closures near the Pribilof Islands have resulted in low bycatch, recent catches have been well below the OFL, ranging from 0.002 to 0.029 t (1.06 to 13.1 million pounds; 2011/12–2014/15).

### *Data and assessment methodology*

The 2015 assessment is based on trends in male mature biomass (MMB) at the time of mating inferred from NMFS bottom trawl survey from 1975-2015 and commercial catch and observer data from 1973/74 to 2014/15. Two assessment methods were presented for evaluation: one calculated an annual index of MMB derived as the 3-yr running average using inverse variance weighting; the second was an integrated length-based assessment model which was first presented in the spring of 2014. While the integrated assessment model appeared to fit survey length frequency composition data, it was rejected by the CPT because it did not fit the survey data. Natural mortality was used as a proxy for  $F_{MSY}$  and a proxy for  $B_{MSY}$  was calculated by averaging MMB from the 1991/92 through the current season.

### *Stock biomass and recruitment trends*

Male and female abundance varies widely over the history of the survey time series and uncertainty around area-swept estimates of abundance are large due to relatively low sample sizes. Male crab were observed at 9 of 35 stations in the Pribilof District during the 2015 NMFS survey and female crab were found in 5 stations; most crab were caught in one station. The centers of distribution for both males and females have moved within a 40 nm by 40 nm region around St. Paul Island.

Recruitment for this stock is episodic, and has been low in recent years. Numbers at length vary dramatically from year to year; however, two (possibly three) cohorts can be seen moving through the length frequencies over time.  $MMB_{mating}$  increased over 2011 to 2015. Estimates for the 3-year moving average for  $MMB_{mating}$  have recently returned to levels exceeding those estimated during the early 1990s, peaking in 2015 at 13,685 t (30.2 million pounds).

### *Tier determination/Plan Team discussion and resulting OFL and ABC determination*

The assessment included the status quo approach (a 3-year inverse-variance running average) as well as multiple scenarios using an integrated length-based assessment model. The CPT recommended using the 3-year inverse-variance running average assessment, and to remain in Tier 4 for stock status level determination. For 2015/16 the  $B_{MSY} = 5,649$  t derived as the mean  $MMB_{mating}$  from 1991/92 to 2014/15. Male mature biomass at the time of mating for 2015/16 was estimated at 13,685 t. The  $B/B_{MSY} = 2.42$  and  $F_{OFL} = 0.18$ .  $B/B_{MSY Proxy}$  is  $> 1$ , therefore the stock status level is *a*. For the 2015/16 fishery, the OFL is 2,119 t (4.7 million lb).

The CPT recommended a 25% buffer for an ABC from the OFL.

*Status and catch specifications (t) of Pribilof Islands red king crab*

Year	MSST	Biomass (MMB <sub>mating</sub> )	TAC	Retained Catch	Total Catch	OFL	ABC
2011/12	2,571	2,775 <sup>A*</sup>	0	0	5.4	393	307
2012/13	2,609	4,025 <sup>A**</sup>	0	0	13.1	569	455
2013/14	2,582	4,679 <sup>A**</sup>	0	0	2.25	903	718
2014/15	2,871	8,894 <sup>A**</sup>	0	0	1.06	1,359	1,019
2015/16	2,825	13,685 <sup>B**</sup>				2,119	1,467

A - Estimated biomass at the time of mating for the year concerned. Note this represents a revised estimate from the projection the previous year.

B - Projected biomass from the current stock assessment. This value will be updated next year.

\*Estimate based on 3 year running average

\*\*Estimates based on weighted 3 year running average using inverse variance

*Status and catch specifications (million lb) of Pribilof Islands red king crab*

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2011/12	5.67	6.12 <sup>A*</sup>	0	0	0.011	0.87	0.68
2012/13	5.75	8.87 <sup>A**</sup>	0	0	0.029	1.25	1.00
2013/14	5.66	10.32 <sup>A**</sup>	0	0	0.005	1.99	1.58
2014/15	6.33	19.61 <sup>A**</sup>	0	0	0.002	3.00	2.25
2015/16	6.23	30.17				4.67	3.23

A - Estimated biomass at the time of mating for the year concerned. Note this represents a revised estimate from the projection the previous year.

B - Projected biomass from the current stock assessment. This value will be updated next year.

\*Estimate based on 3 year running average

\*\*Estimates based on weighted 3 year running average using inverse variance

The stock is above MSST in 2015/16 and is hence not overfished. Overfishing did not occur during the 2014/15 fishing year.

## 5 Pribilof Islands blue king crab

*Fishery information relative to OFL setting.*

The Pribilof blue king crab fishery began in 1973, with peak landings of 11.0 million lb during the 1980/81 season. A steep decline in landings occurred after the 1980/81 season. Directed fishery harvest from 1984/85 until 1987/88 was annually less than 1.0 million lb with low CPUE. The fishery was closed from 1988/89 through 1994/95 fishing seasons. The fishery reopened from 1995/96 to 1998/99 seasons. Fishery harvests during this period ranged from 1.3 to 2.5 million lb. The fishery closed again for the 1999/00 season due to declining stock abundance and has remained closed to the present.

The stock was declared overfished in 2002 and a rebuilding plan implemented in 2003. The rebuilding plan closed directed fishing for Pribilof blue king crab until the stock was rebuilt. In 2009, NMFS determined the stock would not meet its 10-year rebuilding horizon. Subsequently, Amendment 43 to the King and Tanner Crab FMP and Amendment 103 to the BSAI Groundfish FMP were approved by the Secretary of Commerce in January 2015. This action, a revised rebuilding plan, closed the Pribilof Island Habitat Conservation Zone to Pacific cod pot fishing, which accounts for the highest recent rates of bycatch of this stock. This area was already closed to groundfish trawl fishing.

*Data and assessment methodology*

The calculation of the 2015/16 survey biomass uses the stock area definition established in 2012/13 that includes an additional 20 nm strip east of the Pribilof District. This assessment changes the method used to project MMB and calculate  $B_{MSY}$ . Prior to this assessment, MMB for the current year was estimated from the NMFS EBS bottom trawl survey using a three-year running average weighted by the inverse of the variance of the area-swept estimate. The CPT recommended a new method to calculate MMB and  $B_{MSY}$  that uses a random effects model to smooth the survey time series. This model smooths the MMB estimates without low abundance estimates having undue influence. Differences in abundance estimates from the two methods were largest during periods of high inter-annual variability. Differences between the methods were small in recent years. Results from this method are shown in the 2014/15 MMB and 2015/2016 projected MMB.

In 2014/2015, nearly all the female and male bycatch mortality in the groundfish fishery (0.07 t) occurred in the hook-and-line fishery for Pacific cod. No bycatch was recorded in the pot or trawl fisheries.

*Stock biomass and recruitment trends*

The 2015/16 MMB at mating is projected to be 344 t, which is 8% of the proxy for  $B_{MSY}$ . The Pribilof blue king crab stock biomass continues to be low with no indication of recruitment.

*Tier determination/Plan Team discussion and resulting OFL and ABC determination*

This stock is recommended for placement into Tier 4.  $B_{MSY}$  was estimated using the time periods 1980/81-1984/85 and 1990/91-1997/98. This range was chosen because it eliminates periods of extremely low abundance that may not be representative of the production potential of the stock.  $B_{MSY}$  is estimated at 4,109 t (9.06 million pounds).

Because the projected 2015/16 estimate of MMB is less than 25%  $B_{MSY}$ , the stock is in stock status c and the directed fishery F is 0. However, an  $F_{OFL}$  must be determined for the non-directed catch. Ideally this should be based on the rebuilding strategy. For this stock the  $F_{OFL}$  is based on average groundfish bycatch between 1999/00 and 2005/06. The recommended OFL for 2015/16 is 1.16 t (0.003 million lb).

The CPT recommended setting the ABC less than the maximum permissible by employing a 25% buffer on the OFL. This recommendation was based upon continuing concerns with stock status and consistency with relative buffer levels for other stocks for which the OFL is based upon average catch.

*Status and catch specifications (t) of Pribilof Islands blue king crab in recent years.*

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2011/12	2,247	365 <sup>A</sup>	Closed	0	0.36	1.16	1.04
2012/13	1,994	579 <sup>A</sup>	Closed	0	0.61	1.16	1.04
2013/14	2,001	225 <sup>A</sup>	Closed	0	0.03	1.16	1.04
2014/15	2,055	344 <sup>A</sup>	Closed	0	0.07	1.16	0.87
2015/16		455 <sup>B</sup>				1.16	0.87

A - Estimated biomass at the time of mating for the year concerned. Note this represents a revised estimate from the projection the previous year.

B - Projected biomass from the current stock assessment. This value will be updated next year.

*Status and catch specifications (million lb) of Pribilof Islands blue king crab in recent years.*

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2011/12	4.95	0.80 <sup>A</sup>	Closed	0	0.0008	0.003	0.002
2012/13	4.39	1.28 <sup>A</sup>	Closed	0	0.0013	0.003	0.002
2013/14	4.41	0.50 <sup>A</sup>	Closed	0	0.0001	0.003	0.002
2014/15	4.53	0.76 <sup>A</sup>	Closed	0	0.0002	0.003	0.002
2015/16		1.00 <sup>B</sup>				0.003	0.002

A - Estimated biomass at the time of mating for the year concerned. Note this represents a revised estimate from the projection the previous year.

B - Projected biomass from the current stock assessment. This value will be updated next year.

The total catch for 2014/15 (0.07 t, 0.0002 million lb) was less than the 2014/15 OFL (1.16 t, 0.003 million lb) so overfishing did not occur during 2014/15. The 2015/16 projected MMB estimate of 455 t (0.70 million lb) is below the proxy for MSST ( $MMB/B_{MSY} = 0.05$ ) so the stock continues to be in an overfished condition.

## 6 St. Matthew blue king crab

### *Fishery information relative to OFL setting*

The fishery was prosecuted as a directed fishery from 1977 to 1998. Harvests peaked in 1983/84 when 9.454 million lb were landed by 164 vessels. Harvest was fairly stable from 1986/87 to 1990/91, averaging 1.252 million lb annually. Harvest increased to a mean catch of 3.297 million lb during the 1991/92 to 1998/99 seasons until the fishery was declared overfished and closed in 1999 when the stock size estimate was below the MSST. In November of 2000, Amendment 15 to the FMP was approved to implement a rebuilding plan for the St. Matthew Island blue king crab stock. The rebuilding plan included a harvest strategy established in regulation by the Alaska Board of Fisheries, an area closure to control bycatch, and gear modifications. In 2008/09 and 2009/10, the MMB was estimated to be above  $B_{MSY}$  for two years and the stock declared rebuilt in 2009.

The fishery re-opened in 2009/10 with a TAC of 1.167 million lb and 0.461 million lb of retained catch were harvested. The 2010/11 TAC was 1.600 million lb and the fishery reported a retained catch of 1.264 million lb. The 2011/12 harvest of 1.881 million lb represented 80% of the 2.539 million lb TAC. In 2012/13, by contrast, harvesters landed 99% (1.616 million lb) of a reduced TAC of 1.630 million lb, though fishery efficiency, at about 10 crab per pot, was little changed from what it had been in each of the previous three years. The directed fishery was closed in 2013/14 due to declining trawl survey estimates of abundance and concerns about the health of the stock. The directed fishery resumed again in 2014/15 with a TAC of 0.655 million pounds, but the fishery performance was relatively poor with the retained catch of 0.309 million pounds. Bycatch of non-retained blue king crab has been observed in the St. Matthew blue king crab fishery, the eastern Bering Sea snow crab fishery, and trawl and fixed-gear groundfish fisheries. Based on limited observer data, bycatch of sublegal male and female crabs in the directed blue king crab fishery off St. Matthew Island was relatively high when the fishery was prosecuted in the 1990s, and total bycatch (in terms of number of crabs captured) was often twice as high or higher than total catch of legal crabs.

### *Data and assessment methodology*

A three-stage catch-survey analysis (CSA) is used to assess the male crab  $\geq 90$  mm CL. The three size categories are: 90–104 mm CL; 105–119 mm CL; and  $\geq 120$  mm CL. Males  $\geq 105$  are used as a proxy to identify mature males, and males  $\geq 120$  mm CL are used as a proxy to identify legal males. The CSA incorporates the following data: (1) commercial catch data from 1978/79 -1998/99, 2009/10- 2012/13, 2014/15; (2) annual trawl survey data from 1978 to 2015; (3) triennial pot survey data from 1995 to 2015; (4) bycatch data in the groundfish trawl and groundfish fixed-gear fisheries from 1991 to 2014; and (5) ADF&G crab-observer composition data for the years 1990/91–1998/99, 2009/10–2012/13, 2014/15.

Trawl survey data are from the NMFS summer trawl survey for stations within the St. Matthew Section. The pot survey data originate from the ADF&G triennial pot surveys that occurred during July and August in 1995, 1998, 2001, 2004, 2007, 2010, 2013, and 2015. The pot survey samples areas of high-relief habitat important to blue king crab (particularly females) that the NMFS trawl survey cannot sample. Data used are from only the 96 stations fished in common during each of the six pot survey years. The CPUE (catch per pot lift) indices from those 96 stations for the male categories listed above were used in the assessment.

Groundfish discard information for trawl and fixed gear is estimated from NMFS observer data. Bycatch composition data were not available so total biomass caught as bycatch was estimated by summing blue king crab biomass from federal reporting areas 524 and 521 according to gear type.



*Stock biomass and recruitment trends*

Following a period of low numbers after the stock was declared overfished in 1999, trawl-survey indices of SMBKC stock abundance and biomass generally increased in subsequent years, with survey estimated mature male biomass reaching 20.98 million pounds in 2011, the second highest in the 37-year time series used in this assessment. Survey mature male biomass then declined to 12.46 million pounds in 2012 and to 4.459 million pounds in 2013 before going back up to 12.06 million pounds in 2014 and 11.32 million pounds in 2015.

Because little information about the abundance of small crab is available for this stock, recruitment has been assessed in terms of the number of male crab within the 90-104 mm CL size class in each year. The 2013 trawl-survey area-swept estimate of 0.335 million male SMBKC in this size class marked a three-year decline and was the lowest since 2005. That decline reversed in 2014 with an estimate of 0.723 million. The survey recruitment is 0.992 million in 2015, but the majority of crab came from one tow resulting in a high estimate of uncertainty.

*Tier determination/Plan Team discussion and resulting OFL and ABC determination*

The stock assessment examines 20 model configurations: 1) the base model (Model T) used previously; 2) scenario 0: effective sample sizes are determined differently from scenario T; 3) scenario 00: scenario 0 plus reduction of penalty weights for groundfish fisheries bycatch fishing mortality; 4) scenario 1: scenario 00 plus changes in the effective sample sizes for pot fishery observer length composition data and use of pot fishery discarded biomass (please refer to the assessment report for definition of other scenarios). In scenario 9, authors consider two time blocks, pre-2000 and post-2000, for two separate selectivity and molt probability estimation. Authors recommend scenario 10-4 to be used for stock status determination in 2015. This scenario considers a reduction factor of 0.3751 for R24 abundance estimation. The CPT expressed concerns about this approach and instead recommended to stratify station R24 and to use a pot survey based variance scaled by density for that stratum, which then could be added to survey variance. The CPT observed that scenarios above scenario 1 were not sufficiently justified and concern was expressed regarding the estimation of additional variance term for the pot survey only. The CPT recommends the use of scenario 1 for stock status determination.

This stock is in Tier 4. The CPT-recommended model uses the full assessment period (1978/79-2014/15) to define the proxy for  $B_{MSY}$  in terms of average estimated  $MMB_{mating}$ . The MMB estimated for 2015/16 under the recommended model is 5.40 million lb (2,450 t) and the  $F_{MSY}$  proxy is the natural mortality rate ( $0.18^{-1}$  year), resulting in a mature male biomass OFL of 0.620 million lb (280 t). The author recommended and the CPT concurred with a 20% buffer on the OFL for the ABC which was consistent with the approach used last year. The ABC based on this buffer is 0.490 million lb (220 t).

*Status and catch specifications of St. Matthew blue king crab (1,000 t):*

Year	MSST	Biomass (MMB <sub>mating</sub> )	TAC	Retained Catch	Total Male Catch	OFL	ABC
2011/12	1.50	5.03 <sup>A</sup>	1.15	0.85	0.95	1.70	1.54
2012/13	1.80	2.85 <sup>A</sup>	0.74	0.73	0.82	1.02	0.92
2013/14	1.50	3.01 <sup>A</sup>	0	0	0.0003	0.56	0.45
2014/15	1.86	2.48 <sup>A</sup>	0.30	0.14	0.15	0.43	0.34
2015/16		2.45 <sup>B</sup>				0.28	0.22

A - Estimated biomass at the time of mating for the year concerned. Note this represents a revised estimate from the projection the previous year.

B - Projected biomass from the current stock assessment. This value will be updated next year.

*Status and catch specifications of St. Matthew blue king crab (million lb):*

Year	MSST	Biomass (MMB <sub>mating</sub> )	TAC	Retained Catch	Total Male Catch	OFL	ABC
2011/12	3.4	11.09 <sup>A</sup>	2.539	1.881	2.10	3.74	3.40
2012/13	4.0	6.29 <sup>A</sup>	1.630	1.616	1.81	2.24	2.02
2013/14	3.4	6.64 <sup>A</sup>	0	0	0.0006	1.24	0.99
2014/15	4.1	5.47 <sup>A</sup>	0.655	0.309	0.329	0.94	0.75
2015/16		5.40 <sup>B</sup>				0.62	0.49

A - Estimated biomass at the time of mating for the year concerned. Note this represents a revised estimate from the projection the previous year.

B - Projected biomass from the current stock assessment. This value will be updated next year.

The stock was above MSST in 2014/15 and is hence not overfished. The total catch was less than OFL in 2014/15 and hence overfishing did not occur.

*Additional Plan Team recommendations*

The CPT requested further investigation on appropriate way to handle R24 high abundance in total abundance estimation.

## 7 Norton Sound Red King Crab

### *Fishery information relative to OFL setting*

This stock supports three main fisheries: summer commercial, winter commercial, and winter subsistence. The summer commercial fishery, which accounts for the majority of the catch, reached a peak in the late 1970s at a little over 2.9 million pounds retained catch. Retained catches since 1982 have been below 0.5 million pounds, averaging 0.3 million pounds, including several low years in the 1990s. As the crab population rebounded, retained catches have increased to around 0.4 million pounds in recent years.

### *Data and assessment methodology*

Four types of surveys have occurred periodically during the last three decades: summer trawl, summer pot, winter pot, and preseason summer pot, but none of these surveys have been conducted every year. To improve abundance estimates, a male-only length-based model of male crab abundance was previously developed that combines multiple sources of data. A maximum likelihood approach was used to estimate abundance, recruitment, and selectivity and catchability of the commercial pot gear. The model has been updated to include the following data: 1980–2012 winter pot survey; 2013/2014 winter commercial and subsistence catches; revised commercial catch CPUE for 1977–2014; and the 1976–2014 triennial trawl survey data. The current model assumes a constant  $M=0.18\text{yr}^{-1}$ , except for a fixed value of  $0.648\text{yr}^{-1}$  for the largest length class. Logistic functions are used to describe fishery and survey selectivities, except for a dome-shaped function examined for the winter pot fishery. The model timeline was also revised to have the assessment year start February 1.

The author summarized six model run alternatives, with the base model (Model 0) and alternatives originating from the 2014 modeling workshop. The CPT selected Model 6 as the recommended configuration based on several attributes: one selectivity for the NMFS and ADF&G trawl surveys and one selectivity for all commercial fisheries; inclusion of winter survey data as a means of informing the winter fishery harvest (this had negligible impact on model results); and estimation of a growth matrix inside the model (separated for newshell and oldshell crab).

### *Stock biomass and recruitment trends*

Mature male biomass was estimated to be at an historic low in 1982 following a crash from the peak biomass in 1977. The MMB then exhibited an increase from a recent low in 1997 to a peak in 2010, before declining in recent years. Estimated recruitment was weak during the late 1970s and high during the early 1980s, with a slight downward trend from 1983 to 1993. Estimated recruitment has generally been variable, with a slight increase in recent years.

### *Tier determination/Plan Team discussion and resulting OFL and ABC determination*

The team recommended Tier 4, stock status a, for Norton Sound red king crab. The CPT recommended the authors recommendation of Model 6 for use in estimating retained catch. Model-based total catch estimates were provided; however, these estimates were model-generated from limited observer data and the team did not recommend their use in generating a total catch OFL. Thus the OFL and ABC are based on retained catch only.

The estimated abundance and biomass in 2015 using Model 6 are:

Mature male biomass: 5.13 million lb with a standard deviation of 0.87 million lb.

The  $B_{MSY\text{ proxy}}$ , calculated as the average of mature male biomass during 1980–2015, was  $B_{MSY\text{ proxy}} = 4.81$

million lb. The  $F_{MSY\ proxy}$  is  $M = 0.18\ yr^{-1}$  and the  $F_{OFL} = 0.18\ yr^{-1}$ , because the 2015 mature male biomass is larger than  $B_{MSY\ proxy}$  with the CPT choosing the default of  $\gamma = 1.0$ .

The maximum permissible ABC would be 0.721 million lb, based on retained catch. The CPT recommended an ABC less than the maximum permissible due to concerns with model specification, lack of bycatch data as well as issues noted with the M employed for the largest length group. The CPT recommended an ABC = 80% of the OFL (20% buffer) of 0.577 million lb.

*Status and catch specifications (1000 t) of Norton Sound red king crab*

Year	MSST	Biomass (MMB)	GHL	Retained Catch	Total Catch	OFL	ABC
2010/11	0.71	2.47 <sup>A</sup>	0.18	0.19	0.22	0.33	
2011/12	0.57	2.13 <sup>A</sup>	0.16	0.18	0.20	0.30	0.27
2012/13	0.80	2.08 <sup>A</sup>	0.21	0.21	0.21	0.24	0.22
2013/14	0.93	2.27 <sup>A</sup>	0.23	0.16	0.16	0.26	0.24
2014/15	1.09	2.33 <sup>B</sup>	TBD	TBD	TBD	0.33	0.26

*Status and catch specifications (million lb) of Norton Sound red king crab*

Year	MSST	Biomass (MMB)	GHL	Retained Catch	Total Catch	OFL	ABC
2010/11	1.56	5.44 <sup>A</sup>	0.40	0.42	0.46	0.73	
2011/12	1.25	4.70 <sup>A</sup>	0.36	0.40	0.43	0.66	0.59
2012/13	1.76	4.59 <sup>A</sup>	0.47	0.47	0.47	0.53	0.48
2013/14	2.06	5.00 <sup>A</sup>	0.50	0.35	0.35	0.58	0.52
2014/15	2.41	5.13 <sup>B</sup>	TBD	TBD	TBD	0.72	0.58

A – Estimated biomass in May for the year concerned.

B – Estimated biomass on February 1.

Total catch in 2014/15 did not exceed the OFL for this stock, thus overfishing is not occurring. Stock biomass is above MSST; thus, the stock is not overfished.

*Additional Plan Team recommendations*

The CPT has the following recommendations for the next assessment:

- more comprehensive description of the survey data;
- trawl survey CPUE standardization method needs to be explained.

## 8 Aleutian Islands Golden King Crab

### *Fishery information relative to OFL setting*

The directed fishery has been prosecuted annually since the 1981/82 season. Retained catch peaked in 1986/87 at 14.7 million lb and averaged 11.9 million lb over the 1985/86-1989/90 seasons. Average harvests dropped sharply from 1989/90 to 1990/91 to a level of 6.9 million lb for the period 1990/91–1995/96. Management based on a formally established GHL began with the 1996/97 season. The 5.9 million lb GHL established for the 1996/97 season, which was based on the previous five-year average catch, was subsequently reduced to 5.7 million lb beginning in 1998/99. The GHL (or TAC, since 2005/06) remained at 5.700 million lb for 2007/08, but was increased to 5.985 million lb for the 2008/09-2011/12 seasons, and to 6.290 million lb starting with the 2012/13 season. Average annual retained catch for the period 1996/97–2007/08 was 5.62 million lb and 5.96 million lb for the period 2008/09-2012/13. The retained catch for 2013/14 was 6.38 million lb. This fishery is rationalized under the Crab Rationalization Program. The 2014/15 season ends by regulation on 15 May 2015.

Non-retained bycatch occurs mainly in the directed fishery, and to a minor extent in other crab fisheries. Bycatch also occurs in fixed-gear and trawl groundfish fisheries although that bycatch is low relative to bycatch in the directed fishery. Total annual non-retained catch of golden king crab during crab fisheries decreased relative to the retained catch after the 1990s. Bycatch in the post-rationalized fishery (2005/06-2013/14) has ranged from 2.5 million lb in 2005/06 (46% of the retained catch) to 3.2 million lb for 2013/14 (50% of the retained catch). Estimated total mortality (retained catch plus bycatch in crab and groundfish fisheries) ranged from 5.8 to 9.4 million lb since 1995/96. Estimated total mortality in 2013/14 was 7.0 million lb.

### *Data and assessment methodology*

Available data used in the Tier 5 assessment are from ADF&G fish tickets, size-frequencies from samples of landed crabs, at-sea observations from pot lifts sampled during the fishery, and bycatch estimates from the groundfish fisheries. These data are available through the 2013/14 season; complete data from the 2014/15 fishery season, which ends on 15 May 2015, are not currently available. Most of the available data were obtained from the directed fishery which targets legal-size ( $\geq 6$ -inch CW) males. A new survey and assessment model are currently being developed for this stock.

### *Stock biomass and recruitment trends*

Although a stock assessment model is in development, it has not yet been accepted for use in management. There are consequently no estimates of stock biomass. Estimates of recruitment trends and current levels relative to virgin or historic levels are also not available.

### *Summary of major changes*

Fishery data that have been updated with the results for 2013/14 include: retained catch for the directed fishery and bycatch estimates for the directed fishery, non-directed crab fisheries, and groundfish fisheries.

### *Tier determination/Plan Team discussion and resulting OFL and ABC determination*

The CPT recommends that this stock be managed as a Tier 5 stock in 2015/16. The  $B_{MSY}$  and MSST are not estimated for this stock. Observer data on bycatch from the directed fishery and groundfish fisheries provide the estimate of total bycatch mortality. Bycatch data from the directed fishery for the 1990/91 – 1995/96 seasons (excluding 1993/94 and 1994/95 seasons due to insufficient data) and from the groundfish fisheries from the 1993/94 – 2008/09 seasons were used. There are no directed fishery observer data prior to the 1988/89 season and observer data are lacking or confidential for four seasons in at least one management area in the Aleutian Islands during 1988/89–1994/95.

This assessment author recommended using the same approach for determining the 2015/16 total catch

OFL as has been used to determine the total catch OFL since 2012/13. This approach uses data for 1985/86–1995/96 to estimate the mean retained catch in the crab fisheries, and bycatch data for 1990/91–95/96 to estimate the mean bycatch rate (0.363):

$$\text{OFL}_{2015/16} = (1 + R_{90/91-95/96}) \cdot \text{RET}_{85/86-95/96} + \text{BM}_{\text{GF},93/94-08/09} = 12,533,570 \text{ lb}$$

where,

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

The assessment author recommended a 25% buffer between the OFL and ABC, which is the same buffer used to set the 2014/15 ABC. There remains uncertainty regarding the time-period that represents productivity. The CPT agrees with the assessment author's recommendation and notes that this is consistent with considering uncertainty in other crab stocks. The CPT recommended ABC is 9,400,178 lb.

*Status and catch specifications (1000 t) of Aleutian Islands golden king crab*

Year	MSST	Biomass (MMB)	TAC	Retained Catch <sup>a</sup>	Total Catch <sup>a</sup>	OFL	ABC
2011/12	N/A	N/A	2.72	2.71	2.95	5.17	4.66
2012/13	N/A	N/A	2.85	2.84	3.12	5.69	5.12
2013/14	N/A	N/A	2.85	2.89	3.19	5.69	5.12
2014/15	N/A	N/A	2.85	2.77	3.08	5.69	4.26
2014/15	N/A	N/A	2.85			5.69	4.26

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

*Status and catch specifications (million lb) of Aleutian Islands golden king crab*

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch <sup>a</sup>	OFL	ABC
2011/12	N/A	N/A	5.99	5.96	6.51	11.40	10.26
2012/13	N/A	N/A	6.29	6.27	6.87	12.54	11.28
2013/14	N/A	N/A	6.29	6.38	7.04	12.54	11.28
2014/15	N/A	N/A	6.29	6.11	6.79	12.53	9.40
2015/16	N/A	N/A	6.29			12.53	9.40

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

Overfishing did not occur during 2014/15 because the estimated total catch did not exceed the Tier 5 overfishing limit (OFL) of 12.53-million lb (5.69 kt). The total catch did not exceed the ABC established for 2014/15 (9.40-million lb, or 4.26 kt). The OFL and ABC values for 2015/16 are the values

recommended by the SSC in June 2015. The 2015/16 TAC was established by ADF&G on 15 July 2015. The TACs for 2013/14 – 2014/15 do not include landings towards a cost-recovery fishing goal of \$300,000 to cover costs of observer deployments in the fishery or landings towards a cost-recovery fishing goal of \$200,000 in 2014/15 to support Aleutians king crab research; however, the catch totals for 2013/14 and 2014/15 include the catch towards the cost-recovery fishery.

*Additional Plan Team recommendations*

The CPT reviewed progress on the assessment model for Aleutian Islands golden king crab. Detailed comments and recommendations for the model are contained in the CPT report.

## 9 Pribilof District Golden King Crab

### *Fishery information relative to OFL setting*

The Pribilof District golden king crab fishery began in the 1981/82 season. The directed fishery mainly occurs in Pribilof Canyon of the continental slope. Peak directed harvest was 0.856-million lb (388 t) by 50 vessels during the 1983/84 season; fishery participation has since been sporadic and retained catches vary from 0 to 0.342-million lb (155 t). The fishing season is based on a calendar year. A guideline harvest level (GHL) was first established in 1999 at 0.200-million lb (91 t) and the fishery has been managed with a GHL of 0.150-million lb (68 t) since 2000; a GHL for 2015 has not yet been set. No directed fishery occurred during 2006–2009. One vessel landed catch in 2010, two vessels landed catch in 2011, and one vessel landed catch each year from 2012 to 2014. The 2015 season is ongoing and no vessels have participated so far. Data from the directed fishery since 2003 cannot be reported under state confidentiality regulations; however, the GHL has not been reached. Non-retained bycatch occurs in the directed fishery and can occur in the eastern Bering Sea snow crab fishery, Bering Sea grooved Tanner crab fishery, and Bering Sea groundfish fisheries. Estimated fishing mortality from 2001 to 2014 due to directed and non-directed crab fisheries ranged from 0 to 0.160 million lb (73 t). Bycatch mortality in the groundfish fisheries ranged from <0.001 million lb (< 1 t) to 0.019 million lb (12 t) from 1991/92 to 2013/14.

### *Data and assessment methodology*

There is no assessment model for this stock. Fish ticket and observer data are available, size-frequency data from samples of landed crabs, and pot lifts sampled during the fishery, and from the groundfish fisheries. Much of the directed fishery data are confidential due to low participation levels.

### *Stock biomass and recruitment trends*

There is no stock biomass data used in this Tier 5 assessment.

### *Tier determination/Plan Team discussion and resulting OFL and ABC determination*

The CPT recommends this stock be managed under Tier 5 in 2016. The CPT concurs with the author's recommended status quo OFL of 0.20 million lb and an ABC of 0.15 million lb. The ABC was derived by applying a 25% buffer of the OFL,  $ABC = 0.75 * OFL$ , the same buffer used for other Tier 5 stocks with similar levels of concern. The 2016 OFL calculation is the same as recommended by the SSC for 2012–2015:

$$OFL_{2016} = (1 + R_{2001-2010}) * RET_{1993-1998} + BM_{NC,1994-1998} + BM_{GF,1992/93-1998/99}$$

where,

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



*Status and catch specifications (t) of Pribilof District golden king crab*

<b>Year</b>	<b>MSST</b>	<b>Biomass (MMB)</b>	<b>GHL</b>	<b>Retained Catch</b>	<b>Total Catch</b>	<b>OFL</b>	<b>ABC</b>
2012	N/A	N/A	68	Conf.	Conf.	91	82
2013	N/A	N/A	68	Conf.	Conf.	91	82
2014	N/A	N/A	68	Conf.	Conf.	91	82
2015	N/A	N/A	TBA			91	68
2016	N/A	N/A				91	68

N/A = not available

Conf. = confidential

TBA = to be announced

*Status and catch specifications (millions lb) of Pribilof District golden king crab*

<b>Year</b>	<b>MSST</b>	<b>Biomass (MMB)</b>	<b>GHL</b>	<b>Retained Catch</b>	<b>Total Catch</b>	<b>OFL</b>	<b>ABC</b>
2012	N/A	N/A	0.15	Conf.	Conf.	0.20	0.18
2013	N/A	N/A	0.15	Conf.	Conf.	0.20	0.18
2014	N/A	N/A	0.15	Conf.	Conf.	0.20	0.18
2015	N/A	N/A	TBA			0.20	0.15
2016	N/A	N/A				0.20	0.15

N/A = not available

Conf. = confidential

TBA = to be announced

## 10 Western Aleutian Islands red king crab

### *Fishery information relative to OFL and ABC setting*

The domestic fishery was opened every season from 1960/61 to 1995/96. After 1995/96, the fishery was opened only in 1998/99, and from 2000/01 to 2003/04. The fishery has been closed since the end of the 2003/04 season. Peak harvest occurred during the 1964/65 season with a retained catch of 21.19 million lb. During the early years of the fishery through the late 1970s, most or all of the retained catch was harvested in the area between 172° W longitude and 179° W longitude. As the annual retained catch decreased into the mid-1970s and the early-1980s, a large portion of the retained catch came from the area west of 179° W longitude.

Retained catch from 1985/86 to 1994/95 averaged 0.94 million lb, but the retained catch during the 1995/96 season dropped to 0.04 million lb. Most of the catch since the 1990/91 season was harvested in the Petrel Bank area (between 179° W longitude and 179° E longitude) and the last two commercial fishery seasons (2002/03 and 2003/04) were opened only in the Petrel Bank area. Retained catches in those two seasons were 0.51 million lb (2002/03) and 0.48 million lb (2003/04).

Non-retained catch of red king crabs occurs in both the directed red king crab fishery, the Aleutian Islands golden king crab fishery, and in groundfish fisheries. Estimated bycatch mortality during the 1995/96 to 2013/14 seasons averaged 0.002 million lb in crab fisheries and 0.018 million lb in groundfish fisheries. Estimated annual total fishing mortality from 1995/96 to 2013/14 averaged 0.087 million lb. The average retained catch during that period was 0.066 million lb. This fishery is rationalized under the Crab Rationalization Program only for the area west of 179° W longitude.

### *Data and assessment methodology*

The 1960/61 to 2007/08 time series of retained catch (number and pounds of crabs), effort (vessels, landings and pot lifts), average weight and average carapace length of landed crabs, and catch-per-unit effort (number of crabs per pot lift) are available. Bycatch from crab fisheries from 1995/96 to 2013/14 and from groundfish fisheries from 1993/94 to 2013/14 are available. There is no assessment model for this stock. The standardized surveys of the Petrel Bank area conducted by ADF&G in 2006 and 2009 and the ADF&G-Industry Petrel Bank surveys conducted in 2001 were too limited in geographic scope and too infrequent for reliable estimation of abundance for the entire western Aleutian Islands area.

### *Stock biomass and recruitment trends*

Estimates of stock biomass are not available for this stock. Estimates of recruitment trends and current levels relative to virgin or historic levels are not available. The fishery has been closed since 2003/04 due to apparent poor recruitment. A 2009 survey conducted by ADF&G in the Petrel Bank area encountered an ageing population of legal male crab occurring in a more limited area and at lower densities than were found in a 2006 survey and provided no expectations for recruitment. A test fishery conducted by a commercial vessel during October-December 2009 in the area west of Petrel Bank yielded only one legal male red king crab.

Industry is working with ADF&G to conduct a “reconnaissance survey” in the Adak Island area in September 2015. No red king crab will be retained in the survey, but handling mortality is expected and will be accounted for.

*Tier determination/Plan Team discussion and resulting OFL and ABC determination*

The CPT recommends that this stock be managed under Tier 5 for the 2015/16 season. The CPT concurs with the assessment author's recommendation of an OFL based on the 1995/96–2007/08 average total catch following the recommendation of the SSC in June 2010 to set the time period for computing the OFL at 1995/96–2007/08. The CPT recommends an OFL for 2015/16 of 0.12 million lb.

The CPT continues to have concerns regarding the depleted condition of this stock. Groundfish bycatch in recent years has accounted for the majority of the total catch. The CPT recommends an ABC of 0.074 million lb for 2015/16, which is below the maximum permissible ABC of 0.11 million lb; equivalent to a 40% buffer.

*Status and catch specifications of Western Aleutian Islands red king crab*

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch <sup>a</sup>	OFL	ABC
2011/12	N/A	N/A	Closed	0	1	56	12
2012/13	N/A	N/A	Closed	0	<1	56	34
2013/14	N/A	N/A	Closed	0	<1	56	34
2014/15	N/A	N/A	Closed	0	<1	56	34
2015/16	N/A	N/A	Closed			54	32

a. Includes bycatch mortality of discarded bycatch.

*Status and catch specifications (millions lb) of Western Aleutian Islands red king crab*

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch <sup>a</sup>	OFL	ABC
2011/12	N/A	N/A	Closed	0	0.002	0.12	0.03
2012/13	N/A	N/A	Closed	0	<0.001	0.12	0.07
2013/14	N/A	N/A	Closed	0	<0.001	0.12	0.07
2014/15	N/A	N/A	Closed	0	<0.001	0.12	0.07
2015/16	N/A	N/A	Closed			0.12	0.07

a. Includes bycatch mortality of discarded bycatch.

Overfishing did not occur during 2014/15; the estimated total catch did not exceed the Tier 5 OFL of 0.12-million lb (56 t). The total catch did not exceed the ABC established for 2014/15 (0.7-million lb, or 34 t). The OFL and ABC values for 2015/16 in the tables below are the values recommended by the SSC in June 2015.

## Figures and Tables

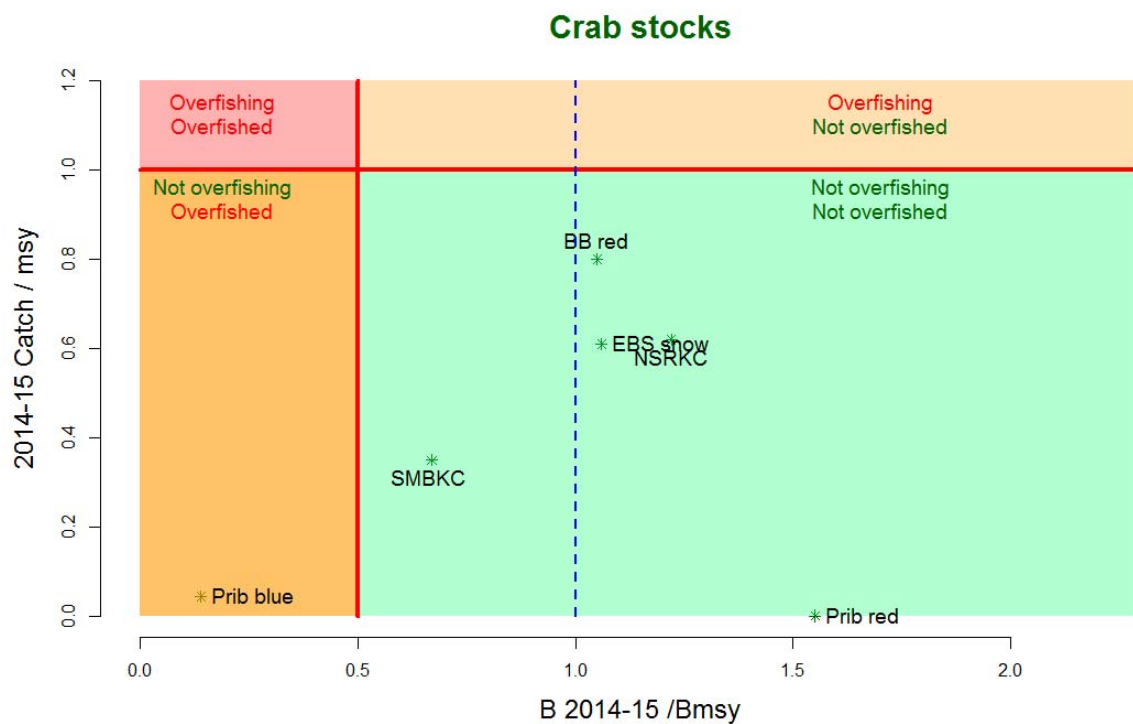


Figure 1. Status of 7 Bering Sea crab stocks in relation to status determination criteria ( $B_{MSY}$ , MSST, overfishing). Note that information is insufficient to assess Tier 5 stocks according to these criteria (WAIRKC, AIGKC, PIGKC).

Table 3 Crab Plan Team recommendations for September 2015 (stocks 1-6). Note that recommendations for stocks 7,8,9, 10 represent those final values recommended by the SSC in April and June 2015. Note diagonal fill indicates parameters are not applicable for that tier

Chapter	Stock	Tier	Status (a,b,c)	F <sub>OFL</sub>	B <sub>MSY</sub> or B <sub>MSYproxy</sub>	Years <sup>1</sup> (biomass or catch)	2015/16 <sup>2,3</sup> MMB	2015 MMB / MMB <sub>MSY</sub>	$\gamma$	Mortality (M)	2015/16 OFL	2015/16 ABC	ABC buffer (%)
1	EBS snow crab	3	b	1.32	157.8	1979-current [recruitment]	147.2	0.93		0.23(females) 0.386 (imm) 0.2613 (mat males)	83.1	62.3	25%
2	BB red king crab	3	b	0.27	26.1	1984-current [recruitment]	24.1	0.92		0.18 default Estimated <sup>4</sup>	6.73	6.06	10%
3	EBS Tanner crab	3	a	0.58	26.8	1982-current [recruitment]	71.6	2.67		0.34 (females), 0.25 (mat male), 0.247 (imm males and females)	27.18	21.75	20%
4	Pribilof Islands red king crab	4	a	0.18	5.65	1991-current	13.7	2.42	1.0	0.18	1.36	1.02	25%
5	Pribilof Islands blue king crab	4	c	0.18	4.1	1980-1984 1990-1997	0.034	0.06	1.0	0.18	1.16	0.87	25%
6	St. Matthew Island blue king crab	4	b	0.18	3.72	1978-current	2.45	0.65	1.0	0.18	0.28	0.22	20%
7	Norton Sound red king crab	4	b	0.157	1.9	1980-current [model estimate]	1.68	0.88	1.0	0.18 0.68 (>123 mm)	0.21	0.19	10%
8	Aleutian Islands golden king crab	5				See intro chapter					5.69	4.26	25%
9	Pribilof Islands golden king crab	5				See intro chapter					0.09	0.07	25%
10	Adak red king crab	5				1995/96– 2007/08					0.05	0.03	40%

1 For Tiers 3 and 4 where B<sub>MSY</sub> or B<sub>MSYproxy</sub> is estimable, the years refer to the time period over which the estimate is made. For Tier 5 stocks it is the years upon which the catch average for OFL is obtained.

2 MMB as projected for 2/15/2016 at time of mating.

3 Model mature biomass on 7/1/2013.

4 Additional mortality males: two periods-1980-1985; 1968-1979 and 1986-2013. Females three periods: 1980-1984; 1976-1979; 1985 to 1993 and 1968-1975; 1994-2013. See assessment for mortality rates associated with these time periods.