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 https://www.fisheries.noaa.gov/region/alaska and the Alaska Department of Fish and Game (ADF&G) Shellfish web page at: http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisheryShellfish.main.

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: https://www.npfmc.org/fishery-management-plan-team/bsai-crab-plan-team/. Due to a process to accommodate specific fishery and data availability needs to determine overfishing level (OFL) determinations, and annual catch limit (ACL) requirements, the CPT reviews assessments in a staggered time frame. Additionally, based upon consideration of stock prioritization including assessment methods and data availability, some stocks are assessed on an annual basis while others are assessed less frequently. The CPT reviews one assessment in January (Norton Sound red king crab), two assessments in May on a three-year cycle (WAI red king crab and Pribilof Islands golden king crab) and the remaining assessments (Bristol Bay red king crab, EBS snow crab, EBS Tanner crab, Saint Matthew blue king crab, Pribilof Island red king crab and Pribilof Island blue king crab, Aleutian Islands golden king crab,) in September (Table 1). Pribilof red king crab is assessed biennially while Pribilof blue king crab is assessed on a three-year cycle. Stocks can be assessed more frequently on a case-by-case basis should data indicate that it is necessary.

Table 1. Ten BSAI crab stocks: Schedule for review by the CPT and SSC and Assessment frequency

Stock	*CPT review and recommendations to SSC*	*SSC review and recommendations to Council*	*Assessment frequency*	*Year of next Assessment*
Norton Sound red king crab (NSRKC)	January	February	Annual	2020
Aleutian Is. golden king crab (AIGKC)	May	June	Annual	2020
Pribilof Is. blue king crab (PIBKC)	May	June	Biennial	2021
Pribilof Is. golden king crab (PIGKC)	May	June	Triennial	2020
Western Aleutian Is. red king crab (WAIRKC)	May	June	Triennial	2020
EBS snow crab	September	October	Annual	2020
Bristol Bay red king crab (BBRKC)	September	October	Annual	2020
EBS Tanner crab	September	October	Annual	2020
Pribilof Is. red king crab (PIRKC)	September	October	Biennial	2021
Saint Matthew blue king crab (SMBKC)	September	October	Annual	2020

Based upon the assessment frequency described in Table 1, the CPT provides recommendations on OFL, acceptable biological catch (ABC) and stock status specifications for review by the NPFMC Science and Statistical Committee (SSC) in February (NSRKC) and June (WAIRKC, PIGKC, PIBKC, AIGKC) and October (BBRKC, EBS Snow crab, EBS Tanner crab, SMBKC, PIRKC). The rationale for this staggered review process is the following: The stocks with summer fisheries as well as those established on catch data only have specifications set in June. The stocks which employ data from the EBS NMFS trawl survey thus cannot be assessed until survey data are available in early September. Summer catch data for NSRKC however are not available in time for fall specifications, nor is assessing this stock with the June timing feasible as the CDQ fishery can open as early as May thus this stock is assessed in the winter. Additional information on the OFL and ABC determination process is contained in this report.

The CPT met from September 16-20, 2019 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 2019 Crab SAFE report contains recommendations for all 10 stocks including those whose OFL and ABC were previously determined in February and June 2019. This SAFE report will be presented to the NPFMC in October 2019 for their annual review of the status of BSAI Crab stocks.

The entire CPT participated in this review. Membership on the CPT includes the following:
Martin Dorn (Co-Chair), Katie Palof (Co-Chair), James Armstrong (Coordinator), William Bechtol, Ben Daly, Ginny Eckert, Brian Garber-Yonts, Krista Milani, André Punt, Shareef Siddeek, William Stockhausen, Cody Szuwalski, Miranda Westphal, and Jie Zheng.

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_{MSY} control rule means a harvest strategy which, if implemented, would be expected to result in a long-term average catch approximating MSY.

B_{MSY} stock size is the biomass that results from fishing at constant F_{MSY} 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_{OFL} control rule and is expressed as the fishing mortality rate.

Minimum stock size threshold (MSST) is one half the B_{MSY} 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_{OFL} control rule which is annually estimated according 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 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 for most stocks 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 GHLs 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 GHLs, (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 estimated for the upcoming crab fishing year using the five-tier system, detailed in Table 2 and Table 3. 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 2). 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” (β).

In stock status level “c,” the ratio of current biomass to B_{MSY} (or a proxy for B_{MSY}) is below β. 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 α is set at a default value of 0.1, and β 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, γ, 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.

First, 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 γ.

In Tier 4, a default value of natural mortality rate (M) or an M proxy, and a scalar, γ, 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, γ, is multiplied by M to estimate the F_{OFL} for stocks at status levels **"**a**"** and **"**b,**"** and γ is allowed to be less than or greater than unity. Use of the scalar γ is intended to allow adjustments in the overfishing definitions to account for differences in biomass measures. A default value of γ 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.

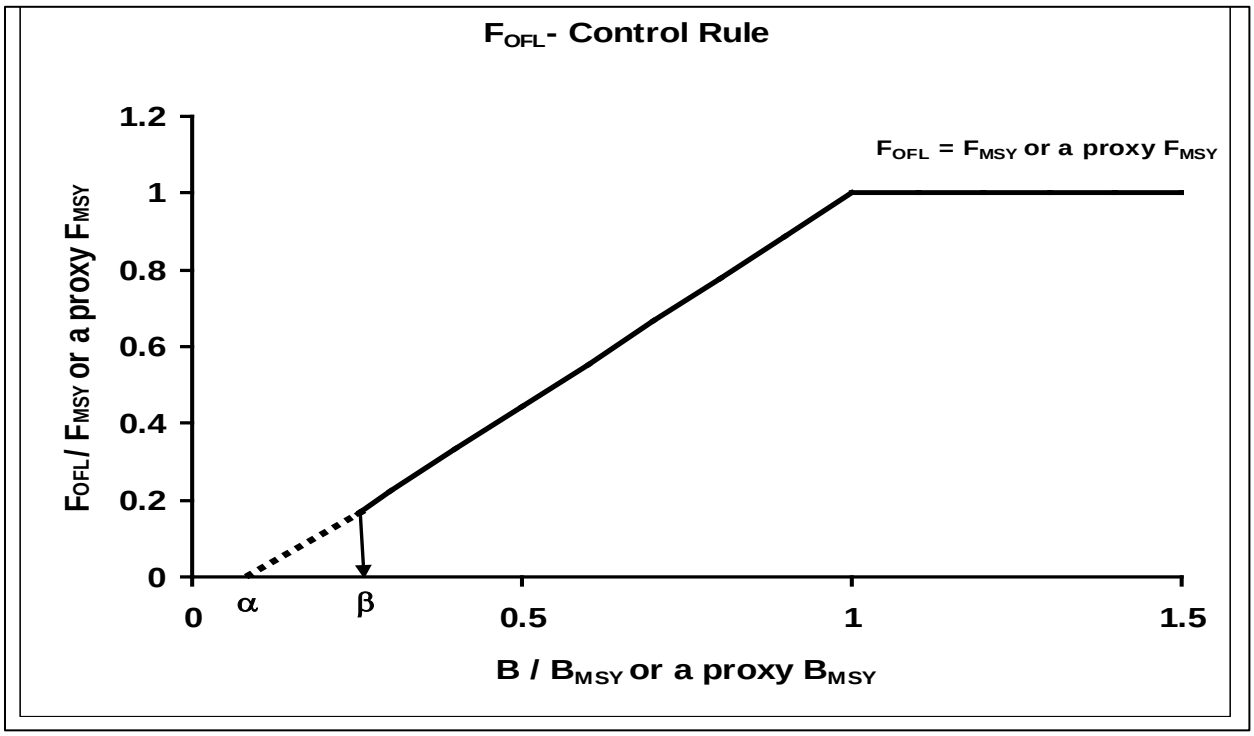

Figure 1. Overfishing control rule for Tiers 1 through 4. Directed fishing mortality is 0 below β.

Table 2. 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 3 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	
		b. $\beta < \frac{B}{B_{msy}} \leq 1$	$F_{OFL} = \mu_A \frac{B/B_{msy} - \alpha}{1-\alpha}$	ABC≤(1-b_y) * OFL
		c. $\frac{B}{B_{msy}} \leq \beta$	*Directed fishery F = 0* $F_{OFL} \leq F_{MSY}$†	
B, B_{MSY}, F_{MSY}	**2**	a. $\frac{B}{B_{msy}} > 1$	$F_{OFL} = F_{msy}$	
		b. $\beta < \frac{B}{B_{msy}} \leq 1$	$F_{OFL} = F_{msy} \frac{B/B_{msy} - \alpha}{1-\alpha}$	ABC≤(1-b_y) * OFL
		c. $\frac{B}{B_{msy}} \leq \beta$	*Directed fishery F = 0* $F_{OFL} \leq F_{MSY}$†	
B, $F_{35\%}^*$, $B_{35\%}^*$	**3**	a. $\frac{B}{B_{35\%*}} > 1$	$F_{OFL} = F_{35\%}*$	
		b. $\beta < \frac{B}{B_{35\%}*} \leq 1$	$F_{OFL} = F^*_{35\%} \frac{\frac{B}{B^*_{35\%}} - \alpha}{1-\alpha}$	ABC≤(1-b_y) * OFL
		c. $\frac{B}{B_{35\%}*} \leq \beta$	*Directed fishery F = 0* $F_{OFL} \leq F_{MSY}$†	
B, M, $B_{msy^{prox}}$	**4**	a. $\frac{B}{B_{msy^{prox}}} > 1$	$F_{OFL} = \gamma M$	
		b. $\beta < \frac{B}{B_{msy^{prox}}} \leq 1$	$F_{OFL} = \gamma M \frac{B/B_{msy^{prox}} - \alpha}{1-\alpha}$	ABC≤(1-b_y) * OFL
		c. $\frac{B}{B_{msy^{prox}}} \leq \beta$	*Directed fishery F = 0* $F_{OFL} \leq F_{MSY}$†	
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≤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 3. A guide for understanding the five-tier system.

- F_{OFL} — the instantaneous fishing mortality (F) from the directed fishery that is used in the calculation of the overfishing limit (OFL). F_{OFL} is determined as a function of:
  - F_{MSY} — the instantaneous F that will produce MSY at the MSY-producing biomass
    - A proxy of F_{MSY} may be used; e.g., $F_{x\%}$, the instantaneous F that results in x% of the equilibrium spawning per recruit relative to the unfished value
  - B — a measure of the productive capacity of the stock, such as spawning biomass or fertilized egg production.
    - A proxy of B may be used; e.g., mature male biomass
  - B_{MSY} — the value of B at the MSY-producing level
    - A proxy of B_{MSY} may be used; e.g., mature male biomass at the MSY-producing level
  - β — a parameter with restriction that $0 \leq \beta < 1$.
  - α — a parameter with restriction that $0 \leq \alpha \leq \beta$.
- The maximum value of F_{OFL} is F_{MSY}. $F_{OFL} = F_{MSY}$ when $B > B_{MSY}$.
- F_{OFL} decreases linearly from F_{MSY} to $F_{MSY} \cdot (\beta-\alpha)/(1-\alpha)$ as B decreases from B_{MSY} to $\beta \cdot B_{MSY}$
- When $B \leq \beta \cdot B_{MSY}$, F = 0 for the directed fishery and $F_{OFL} \leq F_{MSY}$ for the non-directed fisheries, which will be determined in the development of the rebuilding plan.
- The parameter, β, determines the threshold level of B at or below which directed fishing is prohibited.
- The parameter, α, determines the value of F_{OFL} when B decreases to $\beta \cdot B_{MSY}$ and the rate at which F_{OFL} decreases with decreasing values of B when $\beta \cdot B_{MSY} < B \leq B_{MSY}$.
  - Larger values of α result in a smaller value of F_{OFL} when B decreases to $\beta \cdot B_{MSY}$.
  - Larger values of α result in F_{OFL} decreasing at a higher rate with decreasing values of B when $\beta \cdot B_{MSY} < B \leq B_{MSY}$.
- The parameter, b_y, is the value for the annual buffer calculated from a P* of 0.49 and a probability distribution for the OFL that accounts for scientific uncertainty in the estimate of OFL.
- P* is the probability that the estimate of ABC, which is calculated from the estimate of OFL, exceeds the "true" OFL (noted as OFL') (P(ABC>OFL').

Crab Plan Team Recommendations

Table 3 lists the team's recommendations for 2019/2020 on Tier assignments, model parameterizations, time periods for reference biomass estimation or appropriate catch averages, OFLs and ABCs. The team recommends four stocks be placed in Tier 3 (EBS snow crab, Bristol Bay red king crab, EBS Tanner crab and Aleutian Island golden king 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 two stocks in Tier 5 (Pribilof Islands golden king crab, and Western Aleutian Islands red king crab). Stock status in relation to status determination criteria are evaluated in this report (Table 4). Status of stocks in relation to status determination criteria for stocks in Tiers 3 and 4 are shown in Figure 2. Table 5 lists those stocks for which the team recommends an ABC less than the maximum permissible ABC for 2019/20. Aleutian Islands golden king crab, EBS snow crab, and Pribilof Island red king crab are estimated to be above B_{MSY} for 2019/20 while EBS Tanner crab, Bristol Bay red king crab, and Norton Sound red king crab are estimated below B_{MSY}. Saint Matthew blue king crab was declared to be overfished in October 2018. Pribilof Islands blue king crab stock remains overfished and is 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 next scheduled assessment. 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 2019 CPT Report).

General Recommendations for all Assessments

1. The CPT 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. 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 pounds (lb) and metric tons (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 2018/19 was 15,400 t (with discard mortality rates applied), while the retained catch in the directed fishery was 12,510 t. Because the total catch mortality for this stock was below the 2018/19 OFL of 29,700 t, **overfishing did not occur**. 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.

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. The model is fitted to biomass 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 2009 and 2010 BSFRF surveys. Updated data in the model include biomass and length frequency data from the 2019 NMFS Eastern Bering Sea trawl survey, retained and discard catch and length frequencies from the 2018/19 directed fishery, and discard catch and length frequencies from the 2018/19 groundfish fisheries.

The model estimation structure is essentially identical to the 2018 assessment. A jittering approach within a maximum likelihood framework was used to evaluate model stability, and model scenarios were evaluated based on their fits to the data, the credibility of the estimated population processes, stability of the model, the magnitude of retrospective patterns, and the strength of the influence of the assumptions of the model on the outcomes of the assessment.

The assessment author examined eight model scenarios for this assessment. Scenario 18.1 was last year's accepted model fit to last year's data. Scenario 19.1 was last year's accepted model, but updated with 2018/19 data. Scenarios 19.2 and 19.3 imposed prior values on M, based on studies by Hamel and Then et al. (0.27 and 0.315 yr^{-1}, respectively), which differed from the prior value used in 18.1 and 19.1 (0.23 yr^{-1}). Otherwise 19.2 and 19.3 were identical to 19.1. Scenarios 19.4 and 19.5 imposed linear models for growth on females and males, respectively, whereas 19.1 fit sex-specific growth curves that allowed a "kink" (i.e., a change in slope) in the otherwise linear relationship between pre- and post-molt size. Scenario 19.6 estimated sex-specific size distributions for recruits, whereas 19.1 fixed a single size distribution on both sexes. Finally, Scenario 19.7 incorporated both Hamel's prior on M (as in Scenario 19.2) and estimated linear (not kinked) growth for males (as in Scenario 19.5). A scenario based on imposing linear fits to growth data for both sexes failed to converge and was not considered further. The scenarios with increased prior values for M (19.2, 19.3, and 19.7) were suggested by a recent paper (and public comment to the CPT) by Murphy et al. that estimated time-varying mortality rates to be much higher than those used in last year's assessment(18.1 and, by extension, 19.1). Patterns in the time series for abundance of old shell males too small to be caught in the fishery also supported higher M values.

The CPT recommends the author's preferred model scenario, 19.7, to determine stock status and set the OFL and ABC for 2019/20. This scenario exhibited the best retrospective pattern for males among the seven considered, estimated fully-selected NMFS survey catchability (q) near that implied from BSFRF survey data, described male growth as linear, and estimated reasonably higher rates for M than those for the base model (19.1). Scenarios 19.1, 19.4, 19.5, and 19.6 estimated lower values for M due to using

0.23 yr^{-1} as the median prior value for M. Scenario 19.2 exhibited the worst retrospective patterns, while the model instability associated with the kinked growth curves used in 19.3 ruled out that scenario.

Stock biomass and recruitment trends

Observed mature male biomass in the NMFS EBS bottom trawl survey, based on applying a maturity ogive, decreased from a peak of 167,100 t in 2011 to 97,500 t in 2013, increased to 163,500 t in 2014, fell to 63,200 t in 2016, then increased once again to 84,000 t in 2017 and 198,400 t in 2018. The 2018 survey mature male biomass was the largest since 1998. In 2019, survey mature male biomass decreased to 169,100 t. Observed survey mature female biomass rose quickly from a low of 52,200 t in 2009 to 175,800 t in 2011, its highest value since 1991, decreased steadily to 55,400 t in 2016, then increased to 106,800 t in 2017 and to a peak of 165,900t in 2018. Observed survey mature female biomass decreased in 2019 to 110,400 t.

The model estimates for mature male biomass-at-mating (MMB) declined from a 10-year high of 159,900 t in 2009/10 to a low in 2015/16 of 42,600 t. MMB increased in subsequent years and was estimated to be 111,400 t in 2018/19. Model-estimated mature female biomass-at-mating (MFB) began to decline somewhat earlier, from a peak in 2006/07 (66,800 t) to a low in 2009/10 (48,500 t), followed by increases in 2010/11 and 2011/12 to 92,800t, after which it declined to 60,300 t in 2015/16. Since 2015/16, it has increased steadily to 140,400 t in 2018/19.

Estimated recruitment to the population has been episodic, with peaks in recruitment generally preceding peak in mature biomass by a few years. The most recent peaks were in 2008/09 (2,664,000 crab), preceding peaks in MMB and MFB in 2009/08 and 2011/12, respectively, and in 2015/16 (2,828,000 crab), preceding the increases in MMB and MFB that began in 2015/16.

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_{OFL} control rule using $F_{35\%}$ as the proxy for F_{MSY}. The proxy for B_{MSY} ($B_{35\%}$) is the mature male biomass at mating (126.1 kt) based on average recruitment over 1982 to 2018. Consequently, the minimum stock size threshold (MSST) is 63.0 kt. Projected MMB for 2019/20 (167.3) is above the MSST, so **the stock is not overfished**. The CPT recommends that the ABC be less than maximum permissible ABC. The CPT recommends continuing the buffer of 20% used for the 2017 and 2018 assessments for setting the 2019/20 ABC. This level of buffer is justified given the continuing concerns about model misspecification (growth) and parameter confounding, the ongoing evidence for retrospective patterns, and the uncertainty surrounding rates of natural mortality.

Historical status and catch specifications for snow crab (kt). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2015/16	75.8	91.6	18.4	18.4	21.4	83.1	62.3
2016/17	75.8	96.1	9.7	9.7	11.0	23.7	21.3
2017/18	71.4	99.6	8.6	8.6	10.5	28.4	22.7
2018/19	63.0	123.1	12.5	12.5	15.4	29.7	23.8
2019/20		167.3				54.9	43.9

Historical status and catch specifications for snow crab (million lb). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2015/16	167.1	201.9	40.6	40.6	47.2	183.2	137.4
2016/17	167.1	211.9	21.4	21.4	24.3	52.3	47.0
2017/18	157.4	219.6	19.0	19.0	23.2	62.6	50.0
2018/19	138.9	271.4	27.6	27.6	34.0	65.5	52.5
2019/20		368.8				121.0	96.8

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. 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 58.9 kt 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 (≥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 (≥90 mm CL) females and 6.6 kt 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 8.6 kt since data collection began in 1990. Total catch (retained and bycatch mortality) increased from 7.6 kt in 2004/05 to 10.6 kt in 2007/08 but has decreased since then; retained catch in 2018/19 was 2.03 kt and total catch mortality was 2.65 kt.

Data and assessment methodology

The stock assessment is based on 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 observer sampling, and dockside retained catch sampling. In the model recommended by the CPT, annual stock abundance was estimated for male and female crabs ≥ 65-mm CL from 1975 to the time of the 2019 survey and mature male (males ≥120 mm CL) biomass was projected to 15 February 2019. 2018/19 fishery catch data on retained catch in the directed fishery were obtained from ADF&G fish tickets and reports (retained catch numbers, retained catch weight, and pot lifts by statistical area and landing date), on bycatch in the red king crab and Tanner crab fisheries from the ADF&G observer database, and on bycatch in the groundfish trawl fisheries from the NMFS groundfish observer database. The 1975-2018 NMFS trawl survey dataset was updated with data from the 2019 survey, including sex-specific area-swept estimates of abundance, biomass, and size composition. The 2019 survey biomass estimate for mature males was similar to that in 2018.

Changes to the basic model methods included: (1) treating the Tanner crab fishery bycatch size compositions similarly to those from the groundfish fisheries by having the size compositions sum to 1 for both sexes combined (2) transitioning the mode to the General Model for Assessing Crab Stocks (GMACS) modeling framework by performing a bridging analysis between the current model and a similar model structure in GMACS

Three model scenarios were evaluated for the 2019 assessment. Model 18.0d was the accepted model from the 2018 assessment with 2019 data and separating the groundfish fisheries bycatch data into trawl and fixed gear during 1996-2018. Model 18.0e changed the length compositions of the Tanner crab fishery bycatch in each year to sum to 1 for both sexes combined, thus treating this data the same as the groundfish fisheries bycatch in the model. Model 19.0 is the GMACS model which is as close to model 18.0e as possible between the old framework and GMACS. The differences between models 18.0d and 18.0e were minimal and 18.0e was consistent in the treatment of all bycatch data therefore the model comparisons focused on model 18.0e and 19.0.

The CPT selected model scenario 19.0 as its recommended model for status determination and OFL setting. Results from all scenarios were quite similar, and all of the models overpredicted the very low 2018 and 2019 NMFS survey biomasses. The CPT noted that a similar lack of fit has been found previously when survey biomass dropped suddenly, reflecting uncertainty in whether the underlying cause was a change in availability or mortality (i.e., the "hide 'em/kill 'em" uncertainty). Some of the main differences between models 18.0e and 19.0 were the treatment of penalties and priors in GMACS. Sensitivity analyses showed that, while they could not be mimicked in the model 18.0e framework, they had little effect on model output. Treatment of selectivity is also different between the two models, with model 18.0e having three parameters while model 19.0 has four parameters for male and female logistic curves for a given period. This affects the estimation of selectivity of smaller size groups in model 19.0 and therefore the shape of the selectivity curves. There are also differences between the models in the treatment of the relationship between the NMFS trawl survey and the BSFRF survey. The GMACS model fits the NMFS biomass better than the BSFRF biomass whereas model 18.0e does the opposite. Overall, considerable work has been done to bridge the current model with the GMACS modeling framework and the CPT acknowledges this and recommends adopting model 19.0. This model transitions this stock to the GMACS modeling platform. OFL and ABC's were adopted from the GMACS model, with a 20% buffer for ABC, consistent with last year's ABC buffer and adoptions in other crab stocks.

Stock biomass and recruitment trends

Based on the CPT-recommended scenario, 19.0, the MMB at the time of mating is estimated to have been highest early in the late 1970s (approximately 111 kt), with secondary peaks in 1989 (28 kt) and 2002/03 and 2010/11 (~31 kt). The estimated MMB at time of mating in 2018/19 was 16.92 kt. The projection for the 2019/20 time of mating, which assumes the fishing mortality in 2019/20 matches that corresponding to the OFL, is 15.96 kt. Estimates `of recruitment since 1985 have been generally low relative to those estimated for the period prior to 1985 and intermittent peaks in 1995, 2002, and 2005 (49, 42, and 39 million crab, respectively). The relatively low recruitment estimate of 4.7 million crab for 2019 was lower than that estimated last year.

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 1976/77 climate regime shift in the EBS, the CPT recommends computing average recruitment as has been done in recent assessments (i.e., based on model recruitment using the time period 1984 and corresponding to fertilization in 1977) to the penultimate year of the assessment. Following discussions at the January and May 2018 CPT meetings, the CPT concurred with the author's recommendation to drop the terminal year recruitment from the time period for average recruitment because it is highly uncertain. The estimated $B_{35\%}$ is 21.2 kt. MMB projected for 2019/20 is 15.96 kt, 75% of $B_{35\%}$. Consequently, the BBRKC stock is in Tier 3b in 2019/20.

The CPT recommends that the OFL for 2019/20 be set according to model scenario 19.0, for which the calculated OFL is 3.40 kt. Given the inability of the model to adequately fit the last two years (2018 and 2019) survey biomasses, the team recommends that the ABC for 2019/20 be set below the maximum permissible ABC. The team recommends that a 20% buffer from the OFL be used to set the ABC at 2.72 kt. This buffer is consistent with 2018 CPT recommendations, which were based on the rather unusual environmental conditions in the EBS the last two years (e.g., elevated bottom temperatures, lack of a cold pool) and the model's poor fit to the 2018 and 2019 survey data increase the uncertainty associated with this stock and warrant additional precaution.

MMB for 2018/19 was estimated to be 16.92 kt and above MSST (10.62 kt); hence the stock was not overfished in 2018/19. The total catch in 2018/19 (2.65 kt) was less than the 2018/19 OFL (5.34 kt); hence overfishing did not occur in 2018/19. The stock at 2019/20 time of mating is projected to be above

the MSST and 75% of $B_{35\%}$ (see above); hence the stock is not approaching an overfished condition in 2019/20.

Historical status and catch specifications for Bristol Bay red king crab (kt). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2015/16	12.89	27.68	4.52	4.61	5.34	6.73	6.06
2016/17	12.53	25.81	3.84	3.92	4.28	6.64	5.97
2017/18	12.74	24.86	2.99	3.09	3.48	5.60	5.04
2018/19	10.62	16.92	1.95	2.03	2.65	5.34	4.27
2019/20		15.96				3.40	2.72

Historical status and catch specifications for Bristol Bay red king crab (million lb). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2015/16	28.4	61.0	9.97	10.17	11.69	14.84	13.36
2016/17	27.6	56.9	8.47	8.65	9.63	14.63	13.17
2017/18	28.1	54.8	6.60	6.82	7.93	12.35	11.11
2018/19	23.4	37.3	4.31	4.31	5.85	11.76	9.41
2019/20		35.2				7.5	6.00

3 Eastern Bering Sea Tanner crab

Fishery information relative to OFL setting

Eastern Bering Sea (EBS) Tanner crab are caught in directed Tanner crab fisheries, as bycatch in the groundfish and scallop fisheries, as bycatch in 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. 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 fishery was closed from 2010/11 through 2012/13 crab fishery years.

NMFS determined the stock was rebuilt in 2012 based on a new assessment model with a revised estimate of B_{MSY}. The directed fishery was open for the 2013/14 to 2015/16 seasons with a total allowable catch (TAC) of 1,410 t in 2013/14, 6,850 t in 2014/15, and 8,920 t in 2015/16. The total retained catch in 2015/16 (8,910 t) was the largest taken in the fishery since 1992/93. In 2016/17, ADF&G determined that mature female biomass did not meet the criteria for opening a fishery according to the regulatory harvest strategy, and the TAC was set at zero. Consequently, there was no directed harvest in 2016/17. In 2017/18, ADF&G determined that a directed fishery could occur in the area west of 166°W longitude. The TAC was set at 1,110 t for 2018/19, of which 100% was taken.

Data and assessment methodology

The SSC accepted a size-structured assessment model for use in harvest specifications in 2012 and classified the EBS Tanner stock as a Tier 3 stock. This year's assessment used the modeling framework, TCSAM02, which was endorsed by the SSC in June 2017. The model is structured by crab size, sex, shell condition, and maturity. The model uses available data on quantity 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. Input data sets were updated with the most recent information, including the NMFS EBS trawl survey in 2019; bycatch, and size composition data from the 2018/19 crab fisheries; and data on Tanner crab bycatch in the groundfish fisheries in 2018/19.

The model recommended by the CPT to set the OFL and the ABC incorporated the most recent survey data and fishery data that was updated with both the most recent data and revised historical total catches. These estimates were nearly the same as the original estimates after 1995 but showed much larger changes in 1992-1995 (catches prior to 1992 were not revised). The revised fishery estimates had a relatively large impact on the scale of the population relative to previous assessments--including the data increased the estimated size of the population. However, given the re-analysis, this appears to be the best available information and the CPT recommended adopting them after further discussion at the May 2019 CPT. It was not clear to the CPT what was driving the extreme sensitivity of the model to the revised catch estimates and this could be a topic of further research in the future.

Stock biomass and recruitment trends

The MMB at the time of mating is estimated to have been highest in the early 1970s (approximately 300 kt), with secondary peaks in 1989 (75 kt), 2008/09 (76 kt), and in 2014/15 (83 kt). The estimated MMB at time of mating in 2018/19 was 82.61 kt and the projection for the 2019/20 time of mating is 39.55 kt. Estimates of recruitment since 1999 have been generally low relative to the peaks estimated for the period

prior to 1990. There was a relatively strong recruitment estimated for 2017, 2018, and 2019, but these estimates are very uncertain and will need to be confirmed by subsequent assessments.

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

The CPT 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 average recruitment corresponding to B_{MSY} under prevailing environmental conditions. This recommended time period is 1982 – 2019; 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 2019, the stock is at Tier 3b. The F_{MSY} proxy ($F_{35\%}$) is 1.18 yr^{-1}, and the 2019/20 F_{OFL} is 1.08 yr^{-1} under the Tier 3b OFL Control Rule, which results in a total male and female OFL of 28.86 kt. The CPT recommends a 20% buffer to account for model uncertainty and stock productivity uncertainty be applied to the OFL to set ABC = 23.09 kt. The 20% buffer is the same that the SSC recommended for determination of the 2018/19 ABC.

Historical status and catch specifications for Eastern Bering Sea Tanner crab (kt). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
2015/16	12.82	73.93	8.92	8.91	11.38	27.19	21.75
2016/17	14.58	77.96	0.00	0.00	1.14	25.61	20.49
2017/18	15.15	64.09	1.13	1.13	2.37	25.42	20.33
2018/19	20.54	82.61	1.11	1.11	1.90	20.87	16.70
2019/20		39.55				28.86	23.09

Historical status and catch specifications for Eastern Bering Sea Tanner crab (million lb). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
2015/16	28.27	162.99	19.67	19.64	25.09	59.94	47.95
2016/17	32.15	171.87	0.00	0.00	2.52	56.46	45.17
2017/18	33.40	95.49	2.50	2.50	5.22	56.03	44.83
2018/19	45.27	182.09	2.44	2.44	4.18	46.01	36.82
2019/20		87.18				63.62	50.89

4 Pribilof Islands red king crab

The Pribilof Islands red king crab assessment is biennial with the last assessment conducted in 2017. Information listed below summarizes the 2019 assessment.

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 GHLs 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 GHLs. 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 bycatch has been well below the OFL, ranging from 1.0 to 17.0 t in 2012/13–2018/19.

Data and assessment methodology

The 2019 assessment is based on trends in male mature biomass (MMB) from NMFS bottom trawl survey and commercial catch and trawl bycatch data through 2018/19. Three assessment methods using a Tier 4 harvest control rule 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 a random effects model, and the third was a GMACS integrated method. The GMACS integrated model was presented with five variations: 1) model 19.1: M from BBRKC, 2) model 19.2: 19.1+ more of the population selected in the trawl bycatch, 3) model 19.3: 19.1+ molting probability shifted to the left, 4) model 19.4: 19.1+ increased M (by Hamel method), and 5) model 19.5: 19.1+ increased M (by the Then and Hoenig method).

Stock biomass and recruitment trends

GMACS model fit to mature male biomass identified two peaks of biomasses. In recent years, observed mature male biomass (>120 mm CL) peaked in 2015 and has steadily declined since then. The mature male biomass varied widely over the history of the survey time series and uncertainty around area-swept estimates of biomass were largely due to relatively low sample sizes. Recruitment estimated by the GMACS integrated model appeared to be episodic. Survey length composition data suggest a new year-class has been established recently, but its size is unclear. Numbers at length vary dramatically from year to year; however, two cohorts can be seen moving through the length frequencies over time. GMACS model estimated MMB peaked during 1999 to 2003 and systematically declined since then. However, the 2019 MMB (4,024 t) increased over that in 2018 (2,293 t).

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

The CPT recommended the Tier 4 stock status determination and selected the GMACS model 19.4. This model was selected because it incorporates all available information for the stock and uses a more defensible prior for M. The CPT also recommended use of a modified method of B_{MSY} estimation, which is equal to 0.35*average MMB for 2000 to present, during which no directed fishery occurred. For 2019/20 the B_{MSY} = 1,733 t derived as the 0.35*mean MMB from 2000/01 to 2018/19 from the GMACS model 19.4. Male mature biomass at the time of mating for 2018/19 was estimated at 5,368 t. The B/B_{MSY} = 3.1 and F_{OFL}= 0.21. $B/B_{MSY\ Proxy}$ is > 1, therefore the stock status level is Tier 4*a*. For the 2019/20 fishery, the OFL is 864 t. The CPT recommended a 25% buffer for an ABC from the OFL as in previous years.

Historical status and catch specifications for Pribilof Islands red king crab (t). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained Catch	Total Catch	OFL	ABC
2015/16	2,756	9,062	0	0	4.32	2,119	1,467
2016/17	2,751	4,788	0	0	0.94	1,492	1,096
2017/18	2,751	3,439	0	0	1.41	404	303
2018/19	866	5,368	0	0	7.22	404	303
2019/20						864	648

Historical status and catch specifications for Pribilof Islands red king crab (million lb). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2015/16	6.08	19.98	0	0	0.01	4.67	3.23
2016/17	6.06	10.56	0	0	0	3.29	2.42
2017/18	6.06	7.58	0	0	0	0.89	0.67
2018/19	1.91	11.83	0	0	0.02	0.89	0.67
2019/20						1.90	1.43

The stock was above MSST in 2018/19 and was not overfished. Overfishing did not occur during the 2018/19 fishing year.

5 Pribilof Islands blue king crab

The Pribilof Islands blue king crab assessment is biennial with the last assessment conducted in 2017. Information listed below summarizes the 2019 assessment.

Fishery information relative to OFL setting.

The Pribilof Islands 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 for the 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 2004. The rebuilding plan closed directed fishing for Pribilof blue king crab until the stock is 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 2014. 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. To prevent overfishing, ADF&G also implements closure areas for the commercial crab fisheries to reduce the blue king crab bycatch. NMFS has implemented procedures to account for blue king crab bycatch in the groundfish fisheries and take action to prevent overfishing.

Data and assessment methodology

The calculation of the 2018/19 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 uses the 2016/17 methodology to project MMB and calculate B_{MSY}. Prior to 2016/17, MMB 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 current methodology to calculate MMB and B_{MSY} uses a random effects model to smooth the survey time series.

In 2017, the assessment was moved from September to May, which has required that several data inputs to the model (assessment year MMB at the time of the survey and retained catch and bycatch values from the crab fishery year prior to the assessment year) be estimated in some fashion. For the 2019 assessment, MMB at the time of survey (July 2019) was estimated from the observed time series using the random effects as a 1-step ahead prediction. The values of year-to-date bycatch in the crab and groundfish fisheries on April 1, 2019 were taken as estimates of the 2018/19 year-end values for rebuilding status determination. These values were updated in September 2019 to evaluate overfishing status, which did not occur.

Stock biomass and recruitment trends

The 2019/20 MMB at mating is projected to be 175 t, which is approximately 4% 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 4,106 t for 2019/20.

Because the projected 2019/20 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. For this stock, the F_{OFL} is based on average groundfish bycatch between 1999/2000 and 2005/06, a time period determined as part of the rebuilding plan. The recommended OFL for 2019/20 is 1.16 t.

The CPT continues to recommend 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.

Historical status and catch specifications for Pribilof Islands blue king crab (t). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2015/16	2,058	361	Closed	0	1.18	1.16	0.87
2016/17	2,053	232	Closed	0	0.38	1.16	0.87
2017/18	2,053	230	Closed	0	0.33	1.16	0.87
2018/19	2,053	230	Closed	0	0.41	1.16	0.87
2019/20		175				1.16	0.87
2020/21		175				1.16	0.87

Historical status and catch specifications for Pribilof Islands blue king crab (million lb). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2015/16	4.537	0.796	Closed	0	0.0026	0.0026	0.002
2016/17	4.526	0.511	Closed	0	0.0008	0.0026	0.002
2017/18	4.526	0.507	Closed	0	0.0007	0.0026	0.002
2018/19	4.526	0.507	Closed	0	0.0009	0.0026	0.002
2019/20		0.386				0.0026	0.002
2020/21		0.386				0.0026	0.002

The total catch for 2017/18 (0.33 t) and 2018/19 (0.41 t) was less than the associated OFLs (1.16 t for both years) so overfishing did not occur during 2017/18 or 2018/19. The 2019/20 projected MMB estimate of 175 t is below the proxy for MSST (MMB/B_{MSY} = 0.04) so the stock is projected to continue 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 4,288 t (9.453 million lb) were landed by 164 vessels. Harvest was fairly stable from 1986/87 to 1990/91, averaging 568 t (1.252 million lb) annually. Harvest increased to a mean catch of 1,496 t (3.298 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 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 identified 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, closed in 2013/14, opened from 2014/15 – 2015/16, and has been closed since 2016/17. Bycatch of non-retained blue king crab has occurred in the St. Matthew blue king crab fishery, the eastern Bering Sea snow crab fishery, and trawl and fixed-gear groundfish fisheries. The stock declined below the minimum stock size threshold in 2018 and was declared overfished. A rebuilding plan is under development.

Data and assessment methodology

This assessment is conducted in GMACS, which was first accepted for use by the SSC in June 2016. This assessment uses the same model configuration as last year but differs from the original GMACS model in that natural and fishing mortality are continuous within 5 discrete seasons. The model incorporates the following data: (1) commercial catch data; (2) annual trawl survey data; (3) triennial pot survey data; (4) bycatch data in the groundfish trawl and groundfish fixed-gear fisheries; and (5) ADF&G crab-observer composition data.

Stock biomass and recruitment trends

Following a period of low values after the stock was declared overfished in 1999, trawl-survey indices of stock abundance and biomass generally increased to well above average during 2007–2012. In 2013 survey biomass declined (~40% of the mean value) but was followed by average biomass estimates in 2014 and 2015, but with survey CVs of 77% and 45%, respectively). The 2016 survey biomass fell to 3,485 t, followed by continued declines to the 2018 survey estimate of 1,731 t. The 2019 survey estimate of 3,170 t represents an increase of 83% from 2018 but remains low in a historical context.

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 2019 trawl-survey area-swept estimate of 0.403 million males in this size class is the twelfth lowest in the 42-year time series since 1978 and follows two of the lowest observed recruitments in 2017 and 2018.

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

The stock assessment examines four model configurations: (1) Model 18.0 - the 2018 recommended model; (2) Model 19.0 – the reference model updated with new data; (3) Model 19.1, which gives greater weight to fitting the NMFS trawl and the ADF&G pot surveys, and Model 19.2, which estimates an additional CV for the ADF&G pot survey. A variant of model 19.0 (Model 19.0a) differs only in the range of years used to calculate reference points.

The CPT concurs with the author's recommendation to use the reference model 19.0 for the 2019/20 crab year. This stock is in Tier 4. The CPT recommends that the full assessment period (1978/79–2018/19) be

used to define the proxy for B_{MSY} in terms of average estimated MMB_{mating}. The projected MMB estimated for 2019/20 under the recommended model is 1,151 t and the F_{MSY} proxy is the natural mortality rate (0.18^{-1} year) and F_{OFL} is 0.042, resulting in a mature male biomass OFL of 0.04 kt. The MMB/B_{MSY} ratio is 0.310. 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 0.03 kt.

Historical status and catch specifications for Saint Matthew blue king crab (kt). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained Catch	Total Male Catch	OFL	ABC
2015/16	1.84	2.11	0.19	0.05	0.05	0.28	0.22
2016/17	1.97	2.23	0.00	0.00	0.001	0.14	0.11
2017/18	1.85	1.29	0.00	0.00	0.003	0.12	0.10
2018/19	1.74	1.15	0.00	0.00	0.001	0.04	0.03
2019/20		1.08				0.04	0.03

Historical status and catch specifications for Saint Matthew blue king crab (million lb). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained Catch	Total Male Catch	OFL	ABC
2015/16	4.0	4.65	0.41	0.105	0.117	0.62	0.49
2016/17	4.30	4.91	0.00	0.000	0.002	0.31	0.25
2017/18	4.1	2.85	0.00	0.000	0.007	0.27	0.22
2018/19	3.84	2.54	0.00	0.000	0.002	0.08	0.07
2019/20		2.38				0.10	0.08

The stock was below MSST in 2017/18 and was declared overfished. A rebuilding plan for the stock is under development. Total catch was less than the OFL in 2018/19 and hence overfishing did not occur.

7 Norton Sound red king crab

Fishery information relative to OFL setting

The Norton Sound red king crab (NSRKC) stock supports three main fisheries: summer commercial, winter commercial, and winter subsistence. The summer commercial fishery, which accounts for most of the catch, reached a peak in the late 1970s at a little over 2.9 million lb. retained catch. Retained catches since 1982 have been below 0.5 million lb., averaging 0.3 million lb., including several low years in the 1990s. As the crab population rebounded, retained catches have increased to around 0.5 million lb. in recent years, but were around 0.3 million lb. in 2018.

Data and assessment methodology

Four types of surveys for NSRKC 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. The assessment is based on a male-only length-based model of male crab abundance 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: total catch, catch length composition, discard length composition data from the 2018 summer commercial fishery, and 2018 winter commercial and subsistence catch. New trend data in the assessment included 2018 ADFG survey in Norton Sound. In addition, the standardized commercial catch CPUE indices were updated to include data for 1977-2018. The current model assumes a constant M=0.18 yr^{-1} for all length classes except the the > 123mm CL length-class, which had an estimated value of 0.583 yr^{-1}. Logistic functions are used to describe fishery and survey selectivities, except for a dome-shaped function examined for the winter pot fishery.

The assessment author envaulted eight model alternatives, a base model (model 18.0) that assumes fixed retention selectivity and uses retention and discards length-composition data to estimate total catch selectivity, and several other models that incorporate different stanzas (1987-1994 and 2012-2018) of size composition data from the summer and winter commercial fisheries and estimate separate retention selectivities for the summer and winter fisheries.

The CPT recommended model 18.2b which estimates commercial fishery retention selectivity using summer commercial 2012-2018 total catch length composition data, 1987-1994 summer commercial fishery discard length composition data, and 2015-2018 winter commercial fishery retention length composition data. Estimating retention selectivity did not change fit to population dynamics, but improved fits of commercial retention and tag recovery data that inform the size transition matrix and molt probabilities. Estimating separate retention selectivities for the summer and winter fisheries did not improve the model fit.

Stock biomass and recruitment trends

Mature male biomass was estimated to be at an historic low in 1982 following a sharp decline from the peak biomass in 1977. The MMB then exhibited an increase from a low in 1997 to a peak in 2010, before showing minor declines and increases close to the $B_{MSY\,\text{proxy}}$. The stock is currently estimated to be on a downward trend. 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 decrease in the last several years.

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

The team continues to recommend Tier 4 for Norton Sound red king crab. The $B_{MSY\,\text{proxy}}$, calculated as the average of mature male biomass on February 1 during 1980-2019 was 4.57 million lb. The estimated

2019 mature male biomass on February 1 using Model 18.2b is 3.12 million lb., which is below the $B_{MSY\ proxy}$ for this stock, placing Norton Sound red king crab in status category 4b. The $F_{MSY\ proxy}$ is M =0.18 yr^{-1} and the F_{OFL}=0.118yr^{-1}, because the 2019 mature male biomass is less than $B_{MSY\ proxy}$, with the CPT choosing the default of gamma =1.0.

The CPT recommends that the OFL for 2019 be set according to model 18.2b, for which the calculated OFL is 0.24 million lb. (0.11 thousand t). The team recommends that the ABC for 2019 be set below the maximum permissible ABC. The team recommends that the SSC-endorsed buffer of 20% from the OFL be used to set the ABC at 0.19 million lb. (0.09 thousand t). The OFL is a retained catch OFL although a total catch OFL is computed as part of the assessment. The recommendation of an ABC less than the maximum permissible is recommended due to concern about model specification and unresolved competing hypotheses about whether the lack of large male crab in the fisheries and surveys is from increased natural mortality or movement out of the area.

Status and catch specifications (1000t). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	GHL	Retained Commercial Catch	Total Retained Catch	Retained Catch OFL	Retain catch ABC
2015	1.09	2.33	0.18	0.18	0.24	0.33	0.26
2016	1.03	2.66	0.24	0.23	0.24	0.32	0.26
2017	1.05	2.33	0.23	0.22	0.24	0.30	0.24
2018	1.09	1.85	0.13	0.14	0.15	0.20	0.16
2019	1.03	1.41	TBD	TBD	TBD	0.11	0.09

1: Summer commercial fishery
2: Summer commercial fishery, winter commercial fishery and subsistence fishery

Status and catch specifications (million lb.) Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	GHL	Retained Catch[1]	Total Catch[2]	Retained Catch OFL	Retain catch ABC
2015	2.41	5.13	0.39	0.40	0.52	0.72	0.58
2016	2.26	5.87	0.52	0.51	0.52	0.71	0.57
2017	2.31	5.14	0.50	0.49	0.50	0.67	0.54
2018	2.41	4.08	0.30	0.31	0.34	0.43	0.35
2019	2.24	3.12	TBD	TBD	TBD	0.24	0.19

Total retained catch during 2018 did not exceed the OFL for this stock, thus overfishing is not occurring. Stock biomass is above MSST; thus, the stock is not overfished.

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. The TAC was reduced to 5.545 million lb for the 2016/17 season and increased to 6.356 million lb for the 2018/19 season. This fishery is rationalized under the Crab Rationalization Program.

Total mortality of AI golden king crab includes retained catch in the directed fishery, mortality of discarded catch, and bycatch in fixed-gear and trawl groundfish fisheries, though bycatch in other fisheries is low compared to mortality in the directed fishery. Retained catch in the post-rationalized fishery (2005/06-2018/19) has ranged from 5.245 million lb in 2006/07 to 6.536 million lb in 2018/19. Total mortality ranged from 5.427 to 7.396 million lb for the same period.

Data and assessment methodology

The assessment for AI golden king crab establishes a single OFL and ABC for the whole stock; however, separate models are evaluated for EAG and WAG owing to different abundance trends in each area. A modeling framework based on only fisheries data for AI golden king crab was under development for several years with model assumptions and data inputs refined by reviews by the SSC and CPT. The CIE also reviewed the model and stock assessment in June 2018. The current modeling framework was recommended by the CPT in September 2016 and approved by the SSC in October 2016.

The model-based stock assessment involves fitting male-only population dynamics models to data on catches and discards in the directed fishery, discards in the groundfish fishery, standardized indices of abundance based on observer data, fish ticket data, length-frequency data for the directed fishery (landing and total catch), and mark-recapture data. These data are complete through the 2018/19 season.

The assessment authors examined five model scenarios for EAG and five model scenarios for WAG in this assessment cycle. Model 18_0 was the base model last year (Model 17_0) with new data in the 2017/18 fishing season. Model 18_1 is the same as Model 18_0 except the number of gear codes was reduced for fishery CPUE standardization. Model 19_0 is the same as Model 18_0 with new data from the 2018/19 fishing season. Model 19_1 is the same as Model 18.1 with new data from the 2018/19 fishing season. Model 19_2a is the same as Model 19_1 plus a year and area interaction factor during years 2005/06 - 2018/19 for EAG, and Model 19_2 is the same as Model 19_1 plus a year and area interaction factor during years 1995/96 - 2018/19 for WAG. The authors recommended Model 19_1 or Models 19_2/19_2a for a base model for overfishing determination.

The CPT considered Models 19_0, 19_1, and 19_2/19_2a (all include the 2018/19 fishery data). Model 19_1 is preferred over Model 19_0 due to simplification of gear codes and the fact that model performances were very similar. Models 19_2 and 19_2a include a year and area interaction factor which may be important for fishery CPUE standardization. However, the CPT has concerns about the current area footprint calculation and with not using the year and area interaction factor during 1995/96-2004/05 for EAG due to high estimated log(CPUE) variances. It appears that further improvement is needed for

Models 19_2 and 19_2a before adoption as the base model. The CPT recommends base model 19_1 for OFL and ABC determination for 2019/2020.

This is the only crab assessment that relies solely on fishery CPUE as an index of abundance, with the CPUE index standardization process subject to past CPT and SSC review. The CPT recommended that the model be used to provide management reference points based on the Tier 3 control rule in January 2017 and this tier recommendation was endorsed by the SSC in February 2017.

An industry-ADF&G collaborative survey has been conducted for this stock during 2015-2018. A preliminary model using the first two years' index from this survey was evaluated in the assessment in 2018; however, additional index development is needed before the model with the survey data is suitable to provide management advice.

Stock biomass and recruitment trends

Estimated mature male biomass (MMB) for the EAG decreased from high levels until the 1990s after which the trend has been increasing. In contrast, the MMB for WAG increased from a low in the 1990s until 2007/08 and then declined again. There has been a slight increase in MMB in WAG since 2014. Recruitment for the EAG was variable and high during 2014-2016 while recruitment for WAG is lower in recent years than during the 1980s. Stock trends reflected the fishery standardized CPUE trends in both areas.

Summary of major changes

The assessment model recommended by the CPT is similar to the model used in the previous assessment. There were minor changes in the CPUE standardization that had minor effects on assessment results.

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

The CPT recommends that this stock be managed as a Tier 3 stock in 2019/20. A single OFL and ABC is defined for AIGKC; however, separate models are available by area. The CPT recommends that stock status be determined by adding the estimates of current MMB and B_{MSY} by area. This stock status is then used to determine the ratio of F_{OFL} to $F_{35\%}$ by area, which is then used to calculate the OFLs by area which are then added together to calculate an OFL for the entire stock. The SSC has concurred with this approach. The stock is currently estimated to be above B_{MSY} in both areas therefore no adjustment is needed to the F_{OFL} to determine the combined OFL for both areas.

The CPT recommends that the B_{MSY} proxy for the Tier 3 harvest control rule be based on the average recruitment from 1987-2012, years for which recruitment estimates are relatively precise.

Status and catch specifications (1000 t) for Aleutian Islands golden king crab (scenario 19_1). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2015/16	N/A	N/A	2.853	2.729	3.076	5.69	4.26
2016/17	N/A	N/A	2.515	2.593	2.947	5.69	4.26
2017/18	6.044	14.205	2.515	2.585	2.942	6.048	4.536
2018/19	5.880	17.848	2.883	2.965	3.355	5.514	4.136
2019/20		15.944				5.249	3.937

Status and catch specifications (million lb) for Aleutian Islands golden king crab (scenario 19_1). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2015/16	N/A	N/A	6.290	6.016	6.782	12.53	9.40
2016/17	N/A	N/A	5.545	5.716	6.497	12.53	9.40
2017/18	13.325	31.315	5.545	5.699	6.487	13.333	10.000
2018/19	12.964	39.348	6.356	6.536	7.396	12.157	9.118
2019/20		35.150				11.572	8.679

Total fishery mortality in 2018/19 was 7.396 million lb, less than the OFL of 12.157 million lb, thus overfishing for the 2018/19 season did not occur.

Additional Plan Team recommendations

The CPT recommended additional assessment work in a number of areas. Additional development is needed for fishery CPUE standardization, including further development in year-area interactions. The chela measurement data should be reanalyzed using recently collected fishery and survey data to better estimate the maturity of AIGKC. The bias of retrospective biomass estimates for EAG needs to be checked and investigated for any model misspecifications. Uncertainty of recruitment estimates in the terminal years should be assessed to determine how many years of recruitment estimates in the terminal years are excluded for $B_{35\%}$ estimation. Use of GMACS for the AIGKC assessment should be explored. Finally, additional work is needed to obtain an index using the cooperative pot survey data for use in the EAG assessment model.

9 Pribilof District Golden King Crab

In accordance with the approved schedule, no assessment was conducted for Pribilof District golden king crab this year, however, a full stock assessment will be conducted in 2020. Until then, the values generated from the previous stock assessment (below) will be rolled over for 2018/19 specifications. Additional information listed below summarizes the 2017 assessment.

Fishery information relative to OFL setting

The Pribilof Islands golden king crab fishery began in the 1981/82 season, but is currently managed by calendar year. The directed fishery mainly occurs in Pribilof Canyon of the continental slope. Peak directed harvest was 388 t by 50 vessels during the 1983/84 season; fishery participation has since been sporadic and retained catches vary from 0 to 155 t. A guideline harvest level (GHL) was first established in 1999 at 91 t and the fishery has been managed with a GHL of 68 t since 2000. No directed fishery occurred during 2006–2009, 2015, and 2016, but one vessel landed catch in 2010, two vessels landed catch in 2011, one vessel landed catch each year from 2012 to 2014, two vessels landed catch in 2017, and one vessel landed catch in 2018. Discarded (non-retained) catch has occurred in the directed golden king crab fishery, the eastern Bering Sea snow crab fishery, the Bering Sea grooved Tanner crab fishery, and in Bering Sea groundfish fisheries. Estimates of annual total fishery mortality during 2001–2018 due to crab fisheries range from 73 t. Estimates of annual fishery mortality during 1991/92–2018 due to groundfish fisheries range from negligible to 8.84 t. Total fishery mortality in groundfish fisheries during the 2018 crab fishing year was 1.54 t.

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. A random effects model using slope survey data was explored; however, the model fit was poor for mature and legal size male, likely due to small number of data points and the high variance.

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 2018, 2019, and 2020. 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 2018–2020 OFL calculation is the same as recommended by the SSC for 2012−2017:

$$OFL_{2018–2020} = (1+R_{2001–2010})*RET_{1993\text{-}1998} + BM_{NC,1994\text{-}1998} + BM_{GF,1992/93–1998/99}$$

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.
- $RET_{1993\text{-}1998}$ is the average annual retained catch in the directed crab fishery during 1993–1998.
- $BM_{NC,1994\text{-}1998}$ 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

Calendar Year	MSST	Biomass (MMB)	GHL	Retained Catch	Total Catch	OFL	ABC
2015	N/A	N/A	59	0	1.92	91	68
2016	N/A	N/A	59	0	0.24	91	68
2017	N/A	N/A	59	Conf.	Conf.	93	70
2018	N/A	N/A	59	Conf.	Conf.	93	70
2019	N/A	N/A	59	Conf.	Conf.	93	70
2020	N/A	N/A				93	70

N/A = not available
Conf. = confidential

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

Calendar Year	MSST	Biomass (MMB)	GHL	Retained Catch	Total Catch	OFL	ABC
2015	N/A	N/A	0.13	0	0.004	0.20	0.15
2016	N/A	N/A	0.13	0	<0.001	0.20	0.15
2017	N/A	N/A	0.13	Conf.	Conf.	0.20	0.15
2018	N/A	N/A	0.13	Conf.	Conf.	0.20	0.15
2019	N/A	N/A	0.13	Conf.	Conf.	0.20	0.15
2020	N/A	N/A				0.20	0.15

N/A = not available
Conf. = confidential

10 Western Aleutian Islands red king crab

In accordance with the approved schedule, no assessment was conducted for Western Aleutian Islands king crab this year, however, a full stock assessment will be conducted in 2020. Until then, the values generated from the previous stock assessment (below) will be rolled over for 2018/19 specifications. Additional information listed below summarizes the 2017 assessment.

Fishery information relative to OFL and ABC setting

The domestic fishery has been prosecuted every season from 1960/61 to 1995/96. 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°15' W longitude. Peak harvest occurred during the 1964/65 season with a retained catch of 9,611 t. As the annual retained catch decreased into the mid-1970s and the early-1980s, the area west of 179°15' W longitude began to account for a larger portion of the retained catch. After 1995/96, the fishery was opened only occasionally. There was an exploratory fishery in 1998/99, three commissioner's permit fisheries in limited areas during 2000/01–2002/03 to allow for ADF&G-Industry surveys, and two commercial fisheries with a GHL of 227 t in 2002/03 and 2003/04 in the Petrel Bank area. The fishery has been closed since 2003/04.

Retained catch from 1985/86 to 1994/95 averaged 426 t, but the retained catch during the 1995/96 season dropped to 18 t. 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 were opened only in the Petrel Bank area with 231 t in 2002/03 and 218 t in 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 in the crab fisheries during the 1995/96 to 2018/19 seasons averaged 1 t in crab fisheries and 1 t in groundfish fisheries. Estimated annual total fishing mortality from 1995/96 to 2018/19 averaged 31 t. The average retained catch during that period was 24 t. 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 2018/19 and from groundfish fisheries from 1993/94 to 2018/19 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, recruitment trends, and current levels relative to virgin or historic levels are not available for this stock. 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. A cooperative red king crab survey was performed by the Aleutian Islands King Crab Foundation and ADF&G in the Petrel Bank area in November 2016 averaged less than one crab per pot lift suggesting that the stock is in poor condition.

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

The CPT recommends that this stock be managed under Tier 5 for the 2017/18, 2018/19, and 2019/20 seasons. 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 2017/18 to 2019/20 of 56 t.

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 14 t for 2017/18, 2018/19, and 2019/20 which is equivalent to a 75% buffer on OFL. The recommended ABC is less than that which was recommended by the SSC for 2012/13 – 2016/17 because 1) the industry has not expressed interest in a small test fishery, and 2) because the stock is severely depressed as indicated by the 2016 Petrel survey (CPT minutes for May 2017).

Status and catch specifications (t) of Western Aleutian Islands red king crab

Fishing Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2015/16	N/A	N/A	Closed	0	1.3	56	34
2016/17	N/A	N/A	Closed	0	<1	56	34
2017/18	N/A	N/A	Closed	0	<1	56	14
2018/19	N/A	N/A	Closed	0	<1	56	14
2019/20	N/A	N/A				56	14

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

Fishing Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2015/16	N/A	N/A	Closed	0	0.00296	0.12387	0.07432
2016/17	N/A	N/A	Closed	0	0.00045	0.12387	0.07432
2017/18	N/A	N/A	Closed	0	0.00075	0.12387	0.03097
2018/19	N/A	N/A	Closed	0	0.00031	0.12387	0.03097
2019/20	N/A	N/A				0.12387	0.03097

Figures and Tables

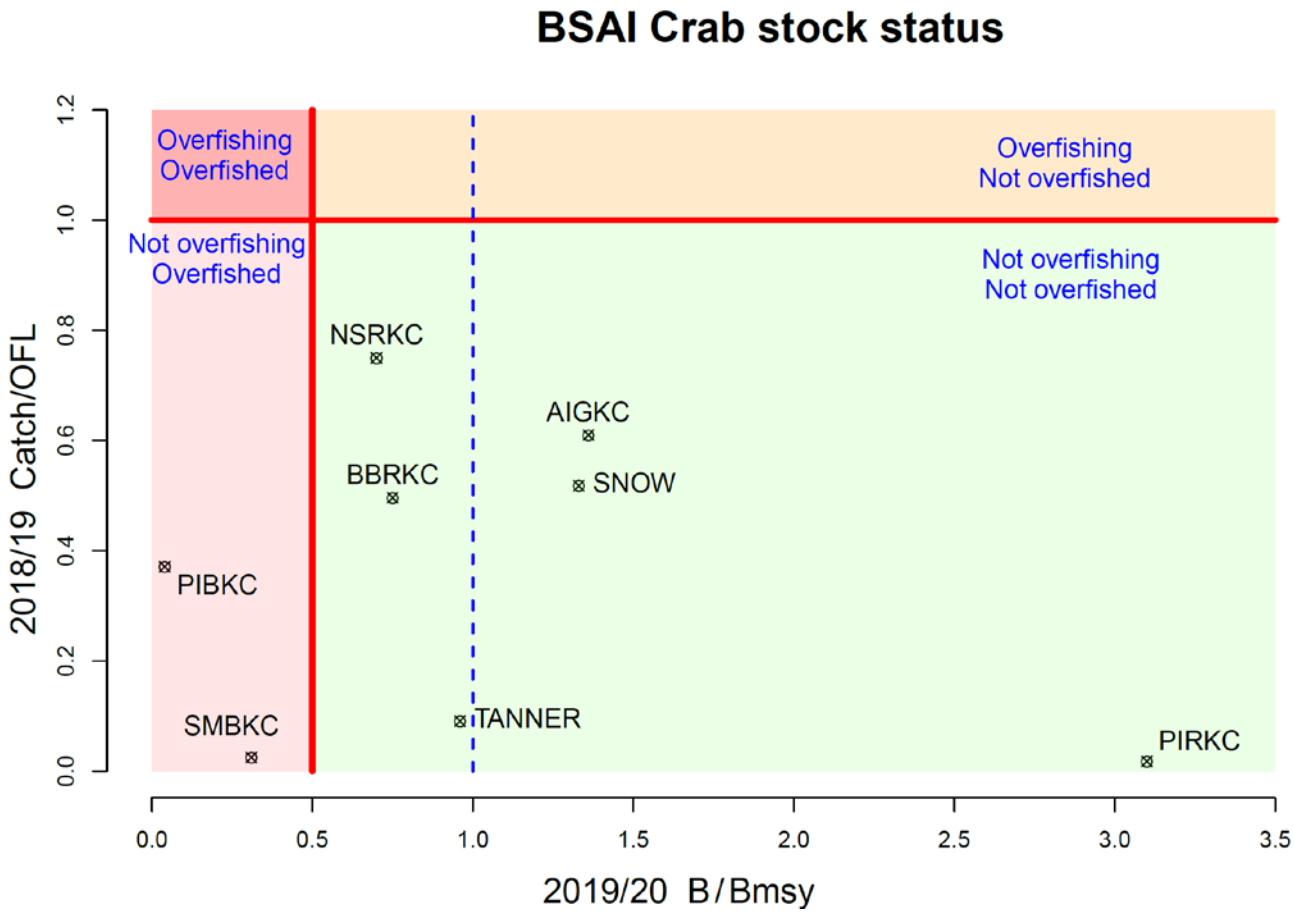

Figure 2. Status of eight Bering Sea and Aleutian Islands crab stocks in relation to status determination criteria (B_{MSY}, MSST, overfishing) for 2019. Note that information is insufficient to assess Tier 5 stocks according to these criteria (WAIRKC, PIGKC).

Table 4. Crab Plan Team recommendations from the September 2019 meeting. Note that recommendations are final values from the SSC for stock 7 (February) and 5 and 8 (June); stocks 9 and 10 were not assessed in 2019. Hatched areas indicate parameters not applicable for that tier. Values are in thousand metric tons (kt).

Chapter	Stock	Tier	Status (a,b,c)	F_{OFL}	B_{MSY} or $B_{MSYproxy}$	B_{MSY} basis years[1]	2019/20[2] MMB	2019/20 MMB / MMB_{MSY}	γ	Mortality (M)	2019/20[3] OFL	2019/20 ABC	ABC Buffer
1	EBS snow crab	3	a	1.93	126.1	1982-2018 [recruitment]	167.3	1.33		0.41 (mat. females) 0.31 (imm.) 0.30 (mat. males)	54.90	43.90	20%
2	BB red king crab	3	b	0.22	21.25	1984-2018 [recruitment]	15.96	0.75		0.18	3.40	2.72	20%
3	EBS Tanner crab	3	b	1.08	41.07	1982-current [recruitment]	39.55	0.96		0.30 (mat. females) 0.23 (imm.) 0.30 (mat. males)	28.86	23.09	20%
4	Pribilof Islands red king crab	4	a	0.21	1.73	2001-present [MMB]	5.37	3.10	1	0.21	0.86	0.65	25%
5	Pribilof Islands blue king crab	4	c	0.18	4.11	1980/81-1984/85 & 1990/91-1997/98 [MMB]	0.175	0.04	1	0.18	0.00116	0.00087	25%
6	St. Matthew Island blue king crab	4	c	0.04	3.48	1978-2018 [MMB]	1.08	0.31	1	0.18	0.044	0.035	20%
7	Norton Sound red king crab	4	b	0.12	2.06	1980-2018 [MMB]	1.41	0.68	1	0.18	0.11	0.09	20%
8	AI golden king crab	3	a	EAG (0.66) WAG (0.60)	11.76	1987/88-2012/13	15.94	1.36		0.21	5.25	3.94	25%
9	Pribilof Islands golden king crab	5				See intro chapter					0.09	0.07	25%
10	Western AI red king crab	5				1995/96-2007/08					0.06	0.01	75%

[1] For Tiers 3 and 4 where B_{MSY} or $B_{MSYproxy}$ 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 in Feb 2019 for Norton Sound red king crab, and June 2019 for AIGKC.
[3] AIGKC OFL and ABC calculated by author outside the chapter for using the Approach 2 combination of EAG and WAG and 25% buffer between OFL and ABC.

Table 5. Maximum permissible ABCs for 2019/20 and SSC recommended ABCs for three stocks where the SSC recommendation is below the maximum permissible ABC, as defined by Amendment 38 to the Crab FMP. Values are in thousand metric tons (kt).

Stock	Tier	2019/20 *Max* ABC	2019/20 ABC
EBS Snow Crab[1]	3	54.777	43.9
Bristol Bay RKC[2]	3	3.371	2.72
Tanner Crab[3]	3	28.790	23.09
Pribilof Islands RKC[1]	4	0.853	0.65
Pribilof Islands BKC[4]	4	0.00104	0.00087
Saint Matthew BKC[2]	4	0.0438	0.035
Norton Sound RKC[2]	4	0.109	0.09
Aleutian Islands GKC[2]	3	5.224	3.94
Pribilof Islands GKC[4]	5	0.081	0.07
Western Aleutian Islands RKC[4]	5	0.054	0.01

Basis for P* calculation of Max ABC:

[1]CV on terminal year biomass

[2]CV on OFL

[3]MCMC

[4]90%OFL (Tier 5)