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/about/alaska-regional-office 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	2021
Aleutian Is. golden king crab (AIGKC)	May	June	Annual	2021
Pribilof Is. blue king crab (PIBKC)	May	June	Biennial	2021
Pribilof Is. golden king crab (PIGKC)	May	June	Triennial	2023
Western Aleutian Is. red king crab (WAIRKC)	May	June	Triennial	2023
EBS snow crab	September	October	Annual	2021
Bristol Bay red king crab (BBRKC)	September	October	Annual	2021
EBS Tanner crab	September	October	Annual	2021
Pribilof Is. red king crab (PIRKC)	September	October	Biennial	2021
Saint Matthew blue king crab (SMBKC)	September	October	Annual	2021

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 that 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 14-17, 2020 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 2020 Crab SAFE report contains recommendations for all 10 stocks including those whose OFL and ABC were previously determined in February and June 2020. This SAFE report will be presented to the NPFMC in October 2020 for their annual review of the status of BSAI Crab stocks.

This review was attended by the entire membership of the CPT: Martin Dorn (Co-Chair), Katie Palof (Co-Chair), James Armstrong (Coordinator), William Bechtol, Ben Daly, Ginny Eckert, Erin Fedewa, 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.

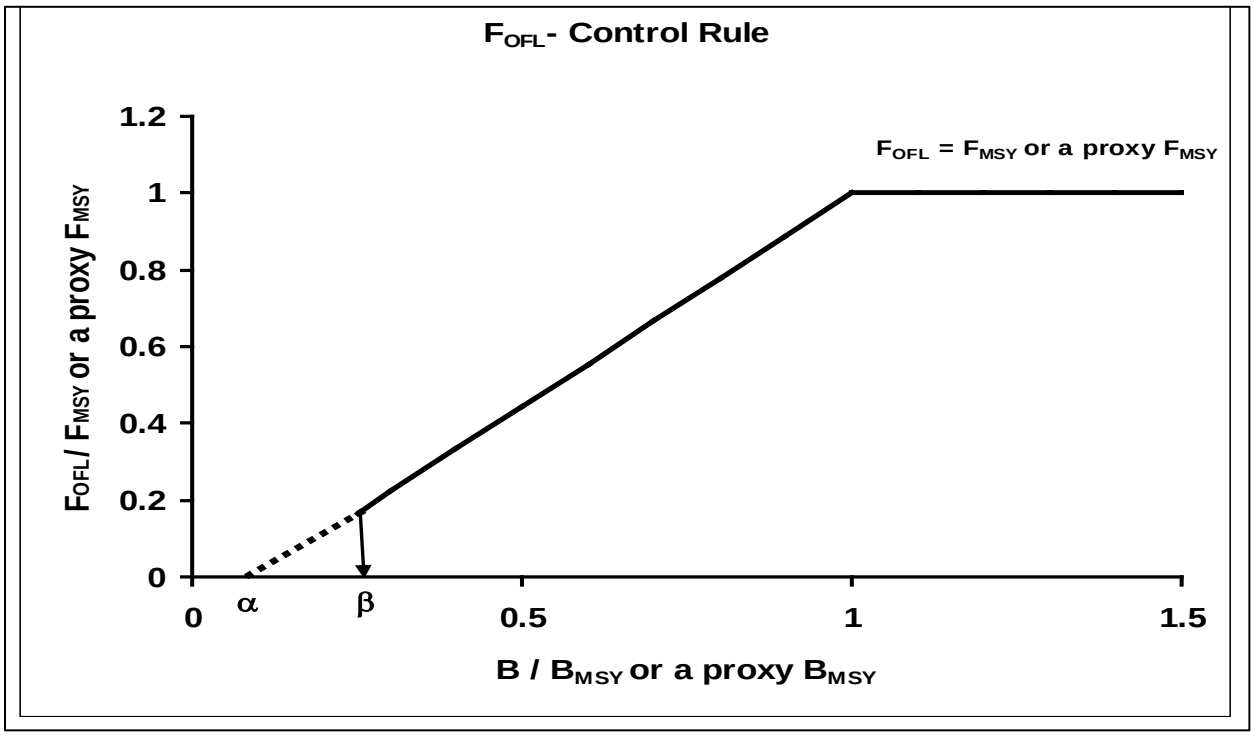

Figure 1. Overfishing control rule for Tiers 1 through 4. Directed fishing mortality is 0 below β.

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 and provides the maximum permissible ABC.
- 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 2019/20 was 20,800 t (with discard mortality rates applied), while the retained catch in the directed fishery was 15,400 t. Because the total catch mortality for this stock was below the 2019/20 OFL of 54,900 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, and account is taken of a terminal molt. 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 2020 assessment include retained and total catch and length frequencies from the 2019/20 directed fishery, and discard catch and length frequencies from the 2019/20 groundfish fisheries. There were no new survey data because there was no 2020 NMFS trawl survey.

The 2019 and earlier assessments were based on a bespoke model coded in ADMB. The assessment author provided the CPT and SSC with a preliminary version of a model implemented using GMACS in May 2020, and the CPT endorsed its use for the 2020 assessment. The assessment author developed GMACS further after the May 2020 CPT meeting to enable reference points to be calculated.

The assessment author examined four model scenarios for this assessment. Scenario 19.1 was the final model from 2019 with updated bycatch data, Scenario 20.1 was the same as Scenario 19.1 except that the 2019/20 directed fishery and groundfish data were included, Scenario 20.2 was the same as Scenario 20.1 but implemented in GMACS; and Scenario 20.3 was the same as Scenario 20.1, but with extra weight placed on the BSFRF data to force the estimated catchability coefficient to equal the catchability implied by the BSFSF data. The assessment author preferred Scenario 20.2 because it fit the data better than the 2019 model for most data sources, including the survey estimates of male biomass. In addition to fitting the data better, the GMACS model also led to more realistic estimates of fishing mortality during the 1980s and early 1990s, more realistic estimates of growth for females and estimates of immature M that are higher than mature M. The assessment author preferred Scenario 20.2 to model 20.3 because Scenario 20.2 led to more realistic estimates of biomass and fishing mortality.

The CPT recommends the author's preferred model scenario, 20.2, to determine stock status and set the OFL and ABC for 2020/21 because of the improved fits to the data, and the more realistic estimates of growth, natural mortality and fishing mortality. The CPT recommends that GMACS be used to conduct the 2021 assessment, and form the basis for additional model development work.

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, 198,400 t in 2018, and 169,100 t in 2019. 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 209,600 t in 2009/10 to a low in 2015/16 of 66,900 t. MMB increased in subsequent years and was estimated to be 560,200 t in 2020/21. Model-estimated mature female biomass-at-mating (MFB) began to decline somewhat later, from a peak in 2011/12 (546,700 t) to a low in 2016/17 (201,200 t), followed by increases to 432,900 t in 2019/20. MFB declined to 352,800t in 2020/21.

Estimated recruitment to the population has been episodic, with peaks in recruitment generally preceding peaks in mature biomass by a few years. The most recent peaks were in 2008/09 (1,370,000 crab), preceding peaks in MMB and MFB in 2009/08 and 2011/12, respectively, and in 2015/16 (15,720,000 crab), preceding the increases in MMB and MFB that began in 2015/16. The estimate of 2015/16 recruitment is substantially higher in this year's assessment than the 2019 assessment.

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 (113.7 kt) based on average recruitment over 1982 to 2018. Consequently, the minimum stock size threshold (MSST) is 56.8 kt. Projected MMB for 2020/21 (276.7kt) is above the MSST, so **the stock is not overfished**. The CPT recommends that the ABC be less than maximum permissible ABC. The buffer between the ABC and OFL was 20% for 2017, 2018 and 2019 assessments, reflecting uncertainty about model misspecification (growth) and parameter confounding, the ongoing evidence for retrospective patterns, and the uncertainty surrounding rates of natural mortality. There is less concern about growth in the 2020 assessment, but the CPT was concerned about the reasons for the substantial increase in 2015/16 recruitment, which may be a consequence of GMACS imposing only weak penalties on the recruitment deviations. Thus ignoring the effect of the lack of a 2020 survey, the CPT recommends a buffer of 25% based only on uncertainties related to the model fit.

The 2020 NMFS bottom trawl surveys were cancelled due to concerns related to the COVID-19pandemic, and this stock assessment is missing survey data for the terminal year. The 2020 assessment of EBS snow crab is the most sensitive of the 2020 model-based assessments to the lack of terminal year survey data, with a median relative over-estimate of the OFL of close to 25%. The CPT therefore recommends an additional 25% buffer resulting in a total buffer of 50% between the OFL and ABC for the 2020/21 fishing year.

Status and catch specifications (1000 t) for snow crab. 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
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	56.8	167.3	15.4	15.4	20.8	54.9	43.9
2020/21		276.7				184.9	92.5

Status and catch specifications (million lb) for snow crab. 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
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	125.2	368.8	34.0	34.0	45.9	121.0	96.8
2020/21		610.0				407.6	203.8

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 thresholds 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 has 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 2019/20 was 1.78 kt and total catch mortality was 2.22 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 July 1, 2020 and mature male (males ≥120 mm CL) biomass was projected to 15 February 2021. 2019/20 fishery 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 2020 NMFS EBS shelf bottom trawl survey was cancelled due to safety concerns associated with the COVID-19 pandemic; consequently, the model was fit using 1975-2019 NMFS trawl survey dataset, which included sex-specific area-swept estimates of abundance, biomass, and size composition.

Three principal model scenarios were evaluated using GMACS for the 2020 assessment. Model 19.0a was identical to the 2019 assessment model (19.0), except that an error specifying the reference period for the mean sex ratio required to calculate $B_{35\%}$ was corrected. Scenario 19.3 was the same as 19.0a except for the way natural mortality (M) was treated: a constant M estimated for males during 1980-1984, M fixed to $0.18yr^{-1}$ for males during other years, and an estimated constant multiplier applied to male M to obtain female M. Finally, scenario 19.3b was the same as model 19.3 except that the CV of the prior for trawl survey catchability was doubled to reduce its effect . Because estimates for the terminal year recruitment in all of these models were extremely uncertain due to the absence of data from the cancelled 2020 NMFS EBS bottom trawl survey, two scenarios otherwise identical to 19.0a and 19.3 (19.0b and 19.3a, respectively) were defined such that recruitment in the terminal year was fixed to the mean recruitment during the previous seven years (thus reducing the uncertainty in the estimate of terminal year recruitment). This allowed multi-year projections with reasonable values for future recruitment to be run for scenarios 19.0a and 19.3 (projections were not run for 19.3b).

As expected, results (other than projections) for scenarios 19.0a and 19.0b were nearly identical, as were those from scenarios 19.3 and 19.3a. Also as expected, scenario 19.3b estimated an unreasonably high catchability for the trawl survey (>1.0), resulting in overall lower biomass estimates. Biomass estimates from 19.0a were greater for recent years, compared with those from 19.3 and 19.3b. The differences were largely explained by differences in estimated natural mortality rates between the 19.0 and 19.3 scenarios. All models fit the fishery catch and bycatch biomass data extremely well. Model scenario 19.3 fit the data somewhat better than 19.0a with one fewer parameter and was the CPT's preliminary choice for the recommended model scenario during its May 2020 meeting. Scenario 19.3b was primarily a sensitivity run, while the CPT found the 7-year averaging period for the estimate of terminal recruitment in scenarios 19.0b and 19.3a rather arbitrary. Thus, the CPT selected the author's preferred model scenario, 19.3, as its recommended model for status determination and OFL setting.

Stock biomass and recruitment trends

Based on the CPT-recommended scenario, 19.3, the MMB at the time of mating is estimated to have been highest early in the late 1970s (approximately 120 kt), with secondary peaks in 1989 (27 kt) and 2002/03 (~33 kt), followed by a gradual decline. The estimated MMB at time of mating in 2019/20 was 14.24 kt. The projection for the 2020/21 time of mating, which assumes the fishing mortality in 2020/21 matches that corresponding to the OFL, is 14.93 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 (61, 52, and 42 million crab, respectively). The relatively low estimate of recruitment for 2019 (3.8 million crab) was the second lowest since 1994. The estimate for 2020, 18.9 million, was the largest since 2010 but was highly uncertain due to the lack of 2020 survey data to inform the model.

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

Bristol Bay red king crab is in Tier 3. Based on previous discussion at the January and May 2018 CPT meetings regarding an apparent reduction in stock productivity associated with the 1976/77 climate regime shift in the EBS, the CPT concurred with the author's recommendation to drop the terminal year recruitment from the time period for average recruitment when calculating $B_{35\%}$ because it is highly uncertain. 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. Based on scenario 19.3, the estimated $B_{35\%}$ is 25.4 kt. MMB projected for 2020/21 is 14.93 kt, 59% of $B_{35\%}$. Consequently, the BBRKC stock is in Tier 3b for 2020/21. The corresponding OFL is 2.14 kt.

Last year, the CPT recommended setting the ABC below the maximum permissible, using a 20% buffer on the OFL to account for additional uncertainty in the assessment associated with the model's lack of fit to the 2018 and 2019 NMFS EBS bottom trawl survey data and recent environmental conditions (e.g., elevated bottom temperatures, lack of a cold pool). This year, the CPT considers the absence of the 2020 NMFS EBS bottom trawl survey from the data used to fit the model to be a potentially substantial additional source of uncertainty to be considered when determining the ABC. The CPT adopted a two-stage approach to characterizing additional uncertainty in the context of determining the ABC. The first stage was to discuss whether or not, ignoring the issue of the cancelled 2020 NMFS bottom trawl survey, the level of uncertainty associated with the assessment differed substantially (either better or worse) from last year's model and thus warranted changing the buffer used last year. The second stage would consider whether the canceled survey introduced enough additional uncertainty to warrant expanding the buffer.

After substantial discussion, the CPT concluded that the level of uncertainty associated with the assessment, ignoring the issue of the cancelled 2020 NMFS survey, had not changed substantially from last year. Although scenario 19.3 fit female survey biomass in 2018 and 2019 much better than 19.0a did, it still overpredicted male survey biomass in these years. In addition, continued concern over poor

environmental conditions (as reflected in the BBRKC ESP) and lack of recent recruitment was expressed by several CPT members. However, members agreed that the uncertainty associated with these issues was already included in the 20% buffer previously adopted and did not warrant further increase.

The additional uncertainty associated with the cancelled 2020 NMFS survey was addressed by the assessment author using: 1) results from a pair of retrospective analyses in which the terminal year survey was either included or excluded from the model fits, 2) comparison of CV's for management-related quantities from the 2019 assessment run with and without the 2019 NMFS survey included in the model fit, and 3) comparison of management-related quantities from scenarios (19.3l and 19.3h) using simulated 2020 survey biomass data based on the predicted 2020 survey biomass from scenario 19.3 and the 25^{th} and 75^{th} quantiles for relative errors in the fits to the survey biomass time series. For 1), management-related quantities (e.g., B_{MSY}, OFL) from the survey-included/excluded model runs were compared for each retrospective peel. Results from these comparisons indicate the likely additional uncertainty introduced by the cancelled survey is approximately 5%. The CPT was concerned that the stock in 2021 was estimated to be at 59% of B_{MSY}, which is close to the overfished threshold. The CPT concluded that the cancelled survey in 2020 reduced the ability to reliably determine stock status, which warrants the additional buffer. The CPT recommends an additional buffer of 5% based on the retrospective analysis that indicated the OFL tended to be over-estimated by about 5% when there was no survey in the terminal year. This recommendation would result in a total buffer of 25%.

MMB for 2019/20 was estimated to be 14.24 kt and above MSST (10.62 kt); hence the stock was not overfished in 2019/20. The total catch mortality in 2019/20 (2.22 kt) was less than the 2019/20 OFL (3.40 kt); hence overfishing did not occur in 2019/20. However, several CPT members expressed concern that the stock will be overfished in a few years and that king crab stocks do not seem to rebuild easily, once an overfished condition is reached. It was suggested that it may be time to review the use of $F_{35\%}$ as a proxy for F_{MSY} for this and other Alaskan crab stocks.

Status and catch specifications (1000 t) for Bristol Bay red king crab. 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
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	12.72	14.24	1.72	1.78	2.22	3.40	2.72
2020/21		14.93				2.14	1.61

Status and catch specifications (million lb) for Bristol Bay red king crab. 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
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	28.0	31.4	3.80	3.91	4.89	7.50	6.00
2020/21		32.9				4.72	3.54

Note: The relatively low MSST in 2018/19 (and B_{MSY} in 2019/20) in the tables above was the result of a problem in the previous GMACS application, which used the sex ratio of recruitment in the terminal year to calculate $B_{35\%}$. A low estimate for the male recruitment ratio in the terminal year in the 2019 assessment resulted in a lower mean male recruitment for $B_{35\%}$ in 2019/20. The current version of GMACS uses the average sex ratio at recruitment during the reference period to estimate $B_{35\%}$, which results in a much more stable sex ratio (about 50%) for the reference point calculation.

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. In 2019/20, mature female biomass again did not meet ADF&G criteria for opening a fishery, and there was no directed harvest.

In March 2020, the harvest control rule for Tanner crab was changed by the Alaska Board of Fisheries based on results from an extensive management strategy evaluation (MSE) conducted with input from industry stakeholders, NMFS and academic scientists, and ADF&G managers. The current HCR defines the period for calculating average mature biomass as 1982-2018, and determines exploitation rates on mature males using sliding scale functions of the ratios of MMB and mature female biomass to their long-term averages.

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; and 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. There was limited new information for Tanner crab this year due to a closed directed fishery and a cancelation of 2020 NMFS EBS trawl survey. Input data sets were updated with the most recent information on bycatch and size composition data from other 2019/20 crab fisheries, as well as data on Tanner crab bycatch in the groundfish fisheries in 2019/20.

The model recommended by the CPT to set the OFL and the ABC is a revised model (Model 20.07) that incorporates the BSFRF trawl survey data from its cooperative "side-by-side" (SBS) catch comparison studies with the NMFS EBS shelf bottom trawl survey to better fix the scale of the NMFS survey data. Empirical availability curves for the BSFRF were estimated outside the assessment model using a generalized additive model with cubic splines. These were used in the model to relate the BSFRF estimates of absolute abundance (at spatial scales smaller than the stock distribution) and the stock abundance estimated by the assessment model. The CPT regarded this model as an improvement over last

year's model because it made robust use of data from BSFRF catch comparison studies, which had not been used previously for Tanner crab.

Stock biomass and recruitment trends

The MMB at the time of mating is estimated to have been highest in the early 1970s (approximately 400 kt), with secondary peaks in 1991 (99 kt), 2008 (108 kt), and in 2014 (111 kt). The estimated MMB at time of mating in 2019/20 was 56.15 kt and the projection for 2020/21 is 35.33 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 2016, 2017, and 2018, but these estimates remain 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 had been used in previous OFL determinations, but this year a decision was made to exclude the recruitment estimate for the terminal year in this calculation. This estimate is extremely uncertain this year due to the lack of survey information.

Based on the estimated biomass at 15 February 2020, the stock is at 96% of B_{MSY}, and therefore is in Tier 3b. The F_{MSY} proxy ($F_{35\%}$) is 0.98 yr^{-1}, and the 2020/21 F_{OFL} is 0.94 yr^{-1} under the Tier 3b OFL Control Rule, which results in a total OFL of 21.13 kt. The CPT recommends a 20% buffer to account for model uncertainty and stock productivity uncertainty be applied to the OFL to set ABC = 16.90 kt. The 20% buffer is the same that the SSC recommended for determination of the 2019/20 ABC. The CPT concluded that no additional buffer was needed to account for the cancelled NMFS EBS bottom trawl survey in 2020.

Status and catch specifications (1000 t) for Tanner crab. 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
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	18.31	56.15	0.00	0.00	0.54	28.86	23.09
2020/21		35.31				21.13	16.90

Status and catch specifications (million lb) for Tanner crab. 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
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	40.36	123.77	0.00	0.00	1.20	63.62	50.89
2020/21		77.84				46.58	37.26

4 Pribilof Islands red king crab

The Pribilof Islands red king crab (PIRKC) assessment is on a biennial cycle. This year (2020) is an 'off' year in the cycle, so an update to determine whether or not overfishing occurred in 2019/20 is presented here. The next full assessment will occur in 2021.

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.

Status and catch specifications (1000 t) for Pribilof Islands red king crab. 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	2,756	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	866	6,431	0	0	3.84	864	648
2020/21		6,431				864	648

Status and catch specifications (million lb) for Pribilof Islands red king crab. 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	1.91	14.18	0	0	0.01	1.9	1.43
2020/21		14.18				1.9	1.43

The most recent full assessment was conducted in September 2019 and the stock was above MSST in 2018/19 and was not overfished. Overfishing did not occur for PIRKC during 2019/20 because the total catch mortality did not exceed the OFL.

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	2,053	175	Closed	0	0.42	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	4.526	0.386	Closed	0	0.0009	0.0026	0.002
2020/21		0.386				0.0026	0.002

The most recent full assessment was conducted in May 2019 and the stock was above MSST in 2018/19 and was not overfished. Overfishing did not occur for PIBKC during 2019/20 because the total catch mortality did not exceed the OFL.

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. 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 16.0 - the 2019 recommended model; (2) Model 16.0 – the base model, i.e., last year's model updated with new data; (3) Model 16.0a, which fixes the estimate of the terminal year of recruitment as the average of the past seven years; and (4) Model 20.1, which excludes the ADF&G pot survey.

The CPT concurs with the author's recommendation to use the base model 16.0 for the 2020/21 crab year. This stock is in Tier 4. The CPT recommends that the full assessment period (1978/79–2019/20) be used to define the proxy for B_{MSY} in terms of average estimated MMB_{mating}. The projected MMB estimated for 2020/21 under the recommended model is 1,120 t and the F_{MSY} proxy is the natural mortality rate (0.18^{-1} year) and F_{OFL} is 0.047, resulting in a mature male biomass OFL of 0.05 kt. The MMB/B_{MSY} ratio is 0.34.

The author recommended and the CPT concurred with a 25% buffer on the OFL for the ABC which was a return to the correct buffer from a mistakenly applied 20% last year. The ABC based on this buffer is 0.04 kt.

Status and catch specifications (1000 t) for St Matthew blue king crab. 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
2016/17	1.97	2.23	0.00	0.00	0.001	0.14	0.11
2017/18	1.85	2.05	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	1.67	1.06	0.00	0.00	0.001	0.04	0.03
2020/21		1.12				0.05	0.04

Status and catch specifications (million lb) for Saint Matthew blue king crab. 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
2016/17	4.30	4.91	0.00	0.000	0.002	0.31	0.25
2017/18	4.10	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	3.68	2.34	0.00	0.000	0.002	0.096	0.08
2020/21		2.48				0.112	0.08

The stock was found to be below MSST in 2017/18 and was declared overfished, and the Council's recommended rebuilding plan will be effective by October 22, 2020. Total catch was less than the OFL in 2019/20 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 fisheries: summer commercial, winter commercial, and subsistence. The summer commercial fishery, which accounts for most of the catch, reached a peak in the late 1970s at a little over 1.313 kt retained catch. Retained catches since 1982 have been below 0.227 kt, averaging 0.136 kt., including several low years in the 1990s. As the crab population rebounded, retained catches increased to 0.231 kt in 2016, but decreased 69% to 0.073 kt. in 2019.

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. The assessment is based on a length-based model of male crab abundance that combines multiple sources of data. A maximum likelihood approach was used to estimate quantities relevant in management. The model has been updated to include the following data: total catch, catch length composition, discard length composition data from the 2019 summer and winter commercial fisheries (retained size composition data were not collected for the winter fishery due to low harvest). The standardized commercial catch CPUE indices were updated based on data for 1977-2019 and 14 new tag recoveries were included in the assessment. The current model assumes a constant M=0.18 yr-1 for all length classes except the >123mm CL length-class, which had an estimated value of 0.58 yr-1. Logistic functions are used to describe fishery and survey selectivities, except for a dome-shaped function used for the winter pot fishery.

The assessment author presented six model alternatives, including a base model (model 19.0) that was adopted in 2018 and several other models that examine the influence of tagging data on estimated molting probability, the validity of assumptions about trawl survey q, and the assumptions of size-dependent natural mortality.

The CPT recommended the base model 19.0.

Stock biomass and recruitment trends

Estimated mature male biomass was at an historic low in 1982 following a sharp decline from the peak biomass in 1977. MMB increased from a low in 1997 to a peak in 2010, after which it fluctuated about the $B_{MSY\ proxy}$. Estimated MMB is currently near the low in 1982. Estimated recruitment has generally been variable and the most recent recruitment estimate is one of the largest since the late 1970s, but will not be corroborated until it enters the fishery in 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} proxy, calculated as the average of mature male biomass on February 1 during 1980-2019 was 2.068 kt The estimated 2020 mature male biomass on February 1 using Model 19.0 is 1,660 t which is below the B_{MSY} proxy for this stock, placing Norton Sound red king crab in status category 4b. The FMSY proxy is M =0.18 yr-1 and the F_{OFL}=0.141yr-1, because the 2020 mature male biomass is less than B_{MSY} proxy using the default gamma =1.0.

The CPT recommends model 19.0 to set the OFL for 2020, resulting in an OFL of 0.287 million lb. (0.13 thousand t). The team recommends that the ABC for 2020 be set below the maximum permissible ABC. The team recommends that the SSC-endorsed buffer of 20% from the OFL be increased to 25% given very low fishery CPUE and unusually large numbers of old-shell males in the fishery. The resulting ABC is 0.100 kt. The OFL is a retained catch OFL. The author calculated a total catch OFL as part of the

assessment, but it is not used because no way to estimate discards from the fishery monitoring program has been adopted.

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	Retained catch ABC
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	0.07	0.04	0.04	0.11	0.09
2020	1.04	1.66				0.13	0.10

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 Commercial Catch	Total Retained Catch	Retained Catch OFL	Retained catch ABC
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	0.15	0.08	0.08	0.24	0.19
2020	2.28	3.67				0.29	0.22

Total retained catch during 2019 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. Management based on a formally established GHL began with the 1996/97 season. The Alaska Board of Fisheries adopted an abundance-based harvest strategy for the stock in March 2019. This fishery has been managed under the Crab Rationalization Program since 2005. 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. Total mortality in the post-rationalized fishery has ranged from 2,506 t in 2006/07 to 3,735t in 2019/20.

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 the EAG and the WAG owing to different abundance trends in each area. 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 (landings and total catch), and mark-recapture data. 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 assessment authors examined six model scenarios for the EAG and three model scenarios for the WAG in this assessment cycle. Model 19.1 was last year's base model. Model 20.1b was the same as Model 19.1 except that the standardization of the Fish Ticket CPUE was based on a negative binomial error model. Model 20.1b is an improvement over last year's base model because it better accounts for the noise in the base model. The CPT recommends Model 20.1b with mean recruitment based on the estimates for years 1987-2012 for OFL and ABC determination for 2020/21.

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 the WAG increased from a low in the 1990s until 2007/08 and then declined again, and has since recovered to the MMB levels of those in the mid-2000s. Recruitment for the EAG was variable and high during 2014-2016 while recruitment for the WAG was 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 for the Fish Ticket data 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 2020/21. 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. As in 2019, 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. 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
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	5.909	16.323	3.257	3.319	3.735	5.249	3.937
2020/21		14.774				4.798	3.599

Status and catch specifications (million lb) for Aleutian Islands golden king crab. 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
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	13.027	35.985	7.180	7.317	8.234	11.572	8.679
2020/21		32.571				10.579	7.934

The total fishery mortality in 2019/20 was 3,735 t, less than the OFL of 5,249 t, thus overfishing has not occurred. The mature male biomass was 16,323 t, above MSST of 5,909 t, hence the stock was not overfished.

Additional Plan Team recommendations

The CPT recommended additional development of fishery CPUE standardization, including further development of how to account for year-area interactions when constructing indices of abundance and their uncertainty. Work should continue to obtain an index using the cooperative pot survey data for use in the EAG assessment model. Finally, GMACS for the AIGKC assessment should be explored.

9 Pribilof District Golden King Crab

In accordance with the approved schedule, the Pribilof Islands golden king crab assessment is conducted triennially with the previous assessment in 2017. Therefore, a full stock assessment was conducted in 2020 with results to be applied for the 2021–2023 specifications. Additional information listed below summarizes the 2020 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 was managed with a GHL of 68 t from 2000 to 2014, and reduced to 59 t in 2015. 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 2001–2019 due to crab fisheries range from 0 to 73 t. Estimates of annual fishery mortality during 1991/92–2019 due to groundfish fisheries range from negligible to 9 t. Total fishery mortality in groundfish fisheries during the 2019 crab fishing year was 4 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 for moving toward a Tier 4 assessment was explored; however, several model aspects needed better documentation to understand the model. The CPT was encouraged by these efforts and would like to see future development of this model in 2021.

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 2021. The CPT concurs with the author's recommended status quo OFL of 93 t and an ABC of 70 t. 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 2021 OFL calculation is the same as recommended by the SSC for 2013−2020:

$OFL_{2021} = (1+R_{2001–2010})*RET_{1993\text{-}1998} + BM_{NC,1994\text{-}1998} + BM_{GF,1992/93–1998/99}$

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) for Pribilof Islands golden king crab. 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	Total Catch	OFL	ABC
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	59			93	70
2021	N/A	N/A				93	70

Status and catch specifications (lb) for Pribilof Islands golden king crab. 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	Total Catch	OFL	ABC
2016	N/A	N/A	130,000	0	<0.001	0.20	0.15
2017	N/A	N/A	130,000	Conf.	Conf.	0.20	0.15
2018	N/A	N/A	130,000	Conf.	Conf.	0.20	0.15
2019	N/A	N/A	130,000	Conf.	Conf.	0.20	0.15
2020	N/A	N/A	130,000			0.20	0.15
2021	N/A	N/A				0.20	0.15

10 Western Aleutian Islands red king crab

In accordance with the approved schedule, the Western Aleutian Islands king crab assessment is conducted triennially with the previous assessment in 2017. Therefore, a full stock assessment was conducted in 2020 with results to be applied for the 2020/21specifications. Additional information listed below summarizes the 2020 assessment.

Fishery information relative to OFL and ABC setting

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.

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 annual total fishing mortality from 1995/96 to 2019/20 averaged 30 t. The average retained catch during that period was 23 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 2019/20 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 2019/20 and from groundfish fisheries from 1993/94 to 2019/20 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 2020/21season. 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 2020/21 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 2020/21 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) for Western Aleutian Islands red king crab. 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.

Fishing Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2016/17	N/A	N/A	Closed	0	<1	56	34
2017/18	N/A	N/A	Closed	0	<1	56	34
2018/19	N/A	N/A	Closed	0	<1	56	14
2019/20	N/A	N/A	Closed	0	<1	56	14
2020/21	N/A	N/A				56	14

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

Fishing Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
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	Closed	0	0.00164	0.12387	0.03097
2020/21	N/A	N/A				0.12387	0.03097

Figures and Tables

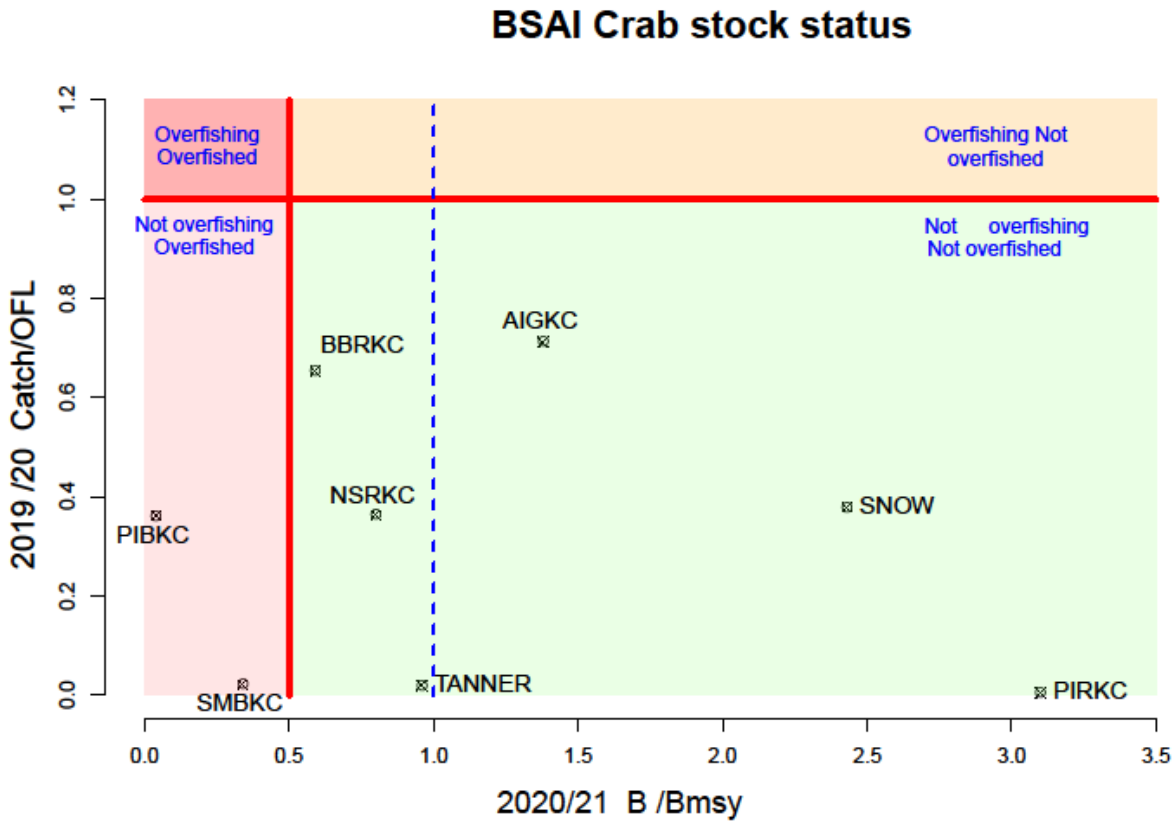

Figure 2. Status of eight Bering Sea and Aleutian Islands crab stocks in relation to status determination criteria (B_{MSY}, MSST, overfishing) for 2020. Note that information is insufficient to assess Tier 5 stocks according to these criteria (WAIRKC, PIGKC).

Table 4. Summary recommendations for each BSAI crab stock from the final 2020 SAFE. Hatched areas indicate parameters not applicable for that tier. Biomass values are in thousand metric tons (kt).

SAFE Chapt.	Stock	Tier	F_{OFL}	B_{MSY} or $B_{MSYproxy}$	B_{MSY} basis years[1]	2020/21[2] MMB	2020/21 MMB / MMB_{MSY}	γ	Natural Mortality (M)	2020/21 [3] OFL	2020/21 ABC[3]	ABC Buffer	Add'l 2020 Buffer[4]
1	E. Bering Sea snow crab	3a	1.65	113.7	1982-2019 [recruitment]	276.7	2.43		0.34 (mat.fem) 0.36 (imm.). 0.36 (mat.male)	184.90	92.5	25%	25%
2	Bristol Bay red king crab	3b	0.16	25.4	1984-2019 [recruitment]	14.93	0.59		0.18	2.14	1.61	20%	5%
3	E. Bering Sea Tanner crab	3b	0.93	36.62	1982-2018 [recruitment]	35.31	0.96		0.32 (mat.fem) 0.24 (imm.) 0.29 (mat.male)	21.13	16.90	20%	**0%**
4	Pribilof Is. red king crab	4a	0.21	1.73	2001-2018 [MMB]	6.43	3.72	1	0.18	0.86	0.65	25%	
5	Pribilof Is. blue king crab	4c	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 blue king crab	4c	0.047	3.34	1978-2019 [MMB]	1.12	0.34	1	0.18	0.05	0.04	25%	0%
7	Norton Sound red king crab	4b	0.141	2.07	1980-2019 [MMB]	1.66	0.80	1	0.18	0.13	0.10	25%	
8	Aleutian Is. golden king crab	3a	EAG (0.61) WAG (0.56)	11.82	1987/88-2012/13	14.77	1.25		0.21	4.798	3.599	25%	
9	Pribilof Is. golden king crab	5	-	-	See intro chapter	-	-	-	-	0.093	0.070	25%	
10	W. Aleutian Is. red king crab	5	-	-	1995/96-2007/08	-	-	-	-	0.056	0.014	75%	

[1] For Tiers 3, 4 where BMSY proxy 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 of this year for Norton Sound red king crab, and June of this year 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
[4] Additional ABC buffer added for some stock to address added uncertainty in OFL due to absence of 2020 trawl survey data

Table 5. Maximum permissible ABCs for 2020/21 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	2020/21 *Max* ABC	2020/21 ABC
EBS Snow Crab[1]	3	184.2	92.5
Bristol Bay RKC[2]	3	2.13	1.61
Tanner Crab[3]	3	20.87	16.90
Pribilof Islands RKC[1]	4	0.857	0.648
Pribilof Islands BKC[4]	4	0.00104	0.00087
Saint Matthew BKC[2]	4	0.05	0.04
Norton Sound RKC[2]	4	0.129	0.10
Aleutian Islands GKC[2]	3	4.773	3.599
Pribilof Islands GKC[4]	5	0.092	0.070
Western Aleutian Islands RKC[4]	5	0.056	0.014

Basis for P* calculation of Max ABC:
[1]CV on terminal year biomass
[2]CV on OFL
[3]MCMC
[4]90%OFL (Tier 5)