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

2022 Final Crab SAFE

Compiled by

The Plan Team for the King and Tanner Crab Fisheries of
the Bering Sea and Aleutian Islands

With Contributions by

JB. Bechtol, B. Daly, M. Dorn, G. Eckert,E. Fedewa, B. Garber-Yonts, T. Hamazaki, M. Litzow, K. Milani, K. Palof, A.E. Punt, S. Rheinsmith, , M.S.M. Siddeek, W. Stockhausen, , C. Szuwalski, and M. Westphal

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North Pacific Fishery Management Council 1007
West Third, Suite 400
Anchorage, AK 99501-2252

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 triennially while Pribilof blue king crab is assessed biennially. 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	2023
Aleutian Is. golden king crab (AIGKC)	May	June	Annual	2023
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	2023
Bristol Bay red king crab (BBRKC)	September	October	Annual	2023
EBS Tanner crab	September	October	Annual	2023
Pribilof Is. red king crab (PIRKC)	September	October	Triennial	2025
Pribilof Is. blue king crab (PIBKC)	September	October	Biennial	2023
Saint Matthew blue king crab (SMBKC)	September	October	Biennial	2024

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, AIGKC) and October (BBRKC, EBS Snow crab, EBS Tanner crab, SMBKC, PIRKC, PIBKC). 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 12-15, 2022 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 2021 Crab SAFE report contains recommendations for all 10 stocks including those whose OFL and ABC were previously determined in February and June 2022. This SAFE report will be presented to the NPFMC in October 2022 for their annual review of the status of BSAI Crab stocks.

This review was attended by the entire membership of the CPT: Mike Litzow (Co-Chair), Katie Palof (Co-Chair), Diana Stram/Sarah Rheinsmith (Coordinator), Martin Dorn William Bechtol, Ben Daly, , Erin Fedewa, Brian Garber-Yonts, Krista Milani, , Shareef Siddeek, William Stockhausen, Cody Szuwalski, and Miranda Westphal..

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 completed fishing year and compared to the MSST from the most recent accepted assessment.

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 estimated total catch mortality for the most recent completed 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 will be set for and compared to the retained catch.

Overfished status is determined using the MMB estimate at the time of mating in the previous fishing year and the Minimum Stock Size Threshold (MSST). These quantities are estimated from the current stock assessment. 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

Fisheries specifications, OFL and ABC, are set using the fishing mortality rate associated with the OFL (F_{OFL}) as estimated from the current assessment, compared with MMB projected forward to the time of mating in the next fishing season. This approach was established in 2007 and was modeled after the groundfish assessment process. 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 compiles 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.

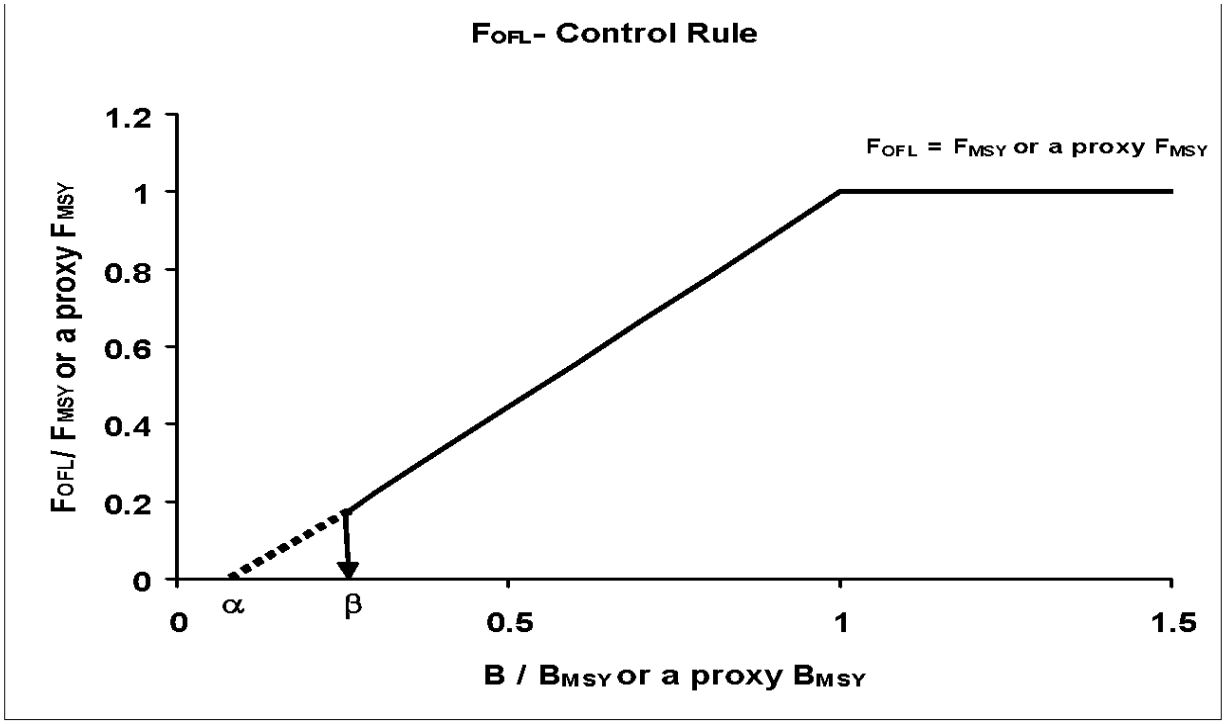

Figure 1. Overfishing control rule for Tiers 1 through 4. Directed fishing mortality is 0 below β.

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 4 and Table 5 contain the team's recommendations for 2022/2023 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 2021/22. Aleutian Islands golden king crab, EBS Tanner crab, and Pribilof Island red king crab are estimated to be above B_{MSY} for 2021/22 while Bristol Bay red king crab, and Norton Sound red king crab are estimated below B_{MSY}. EBS snow crab is estimated to be below MSST. 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 2022 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 dataed

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 2021/22 was 3,600 t (with discard mortality rates applied), while the retained catch in the directed fishery was 2,500 t. Because the total catch mortality for this stock was below the 2020/21 OFL of 7,500 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 as 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 2022 assessment include retained and total catch and length frequencies from the 2021/22 directed fishery, discard catch and length frequencies from the 2021/22 groundfish fisheries, and biomass and length frequencies from the 2022 NMFS bottom trawl survey. Results from the 2022 NMFS bottom trawl survey indicated similar abundance to the 2021 survey, but represent a severe decline in snow crab abundance relative to previous surveys.

This assessment was based on a new GMACS model that was approved for use by the SSC in June 2022. The assessment author compared last year's model (Model 21.2) with GMACS models 22.1a and 22.1ab. The two GMACs "models" were actually not different models, but rather different solutions of the same model identified by jittering the model parameters. Model 22.1a was the maximum likelihood estimate, while Model 22.1ab represented a local minimum (about 5.3 likelihood units higher than the MLE). The assessment author recommended Model 22.1ab because model fits were reasonable and the estimated fishing mortality in 2020/21 was considered plausible.

The CPT didnot find a scientific basis for choosing a model solution that differed from maximum likelihood estimate and therefore recommends model 22.1a to determine stock status and set the OFL and ABC for 2022/23. The CPT acknowledges that the high fishing mortality estimate in 2020/21 is a concern for this model, but the major uncertainties associated with timing and the dynamics of snow crab collapse would argue against overinterpretation of mortality estimates during a period of exceptional stock decline. Public comment also noted that the concentration of harvest along the US/Russia boundary in 2020/21 may indicate harvesting of crab that are not a part of the assessed EBS population in that year.

Stock biomass and recruitment trends

Observed mature male biomass (MMB) at the time of the survey increased from an average of 161.68 kt in the early to mid-1980s to historical highs 1990s (observed MMB during 1990, 1991, and 1997 were 443.79, 466.61, and 326.75 kt, respectively). The stock was declared overfished in 1999 in response to the total mature biomass dropping below the 1999 minimum stock size threshold. MMB in that year decreased to 95.85 kt. Observed MMB slowly increased after 1999, and the stock was declared rebuilt in 2011 when estimated MMB at mating was above $B_{35\%}$. However, after 2011, the stock declined and the observed MMB at the time of survey dropped to a low in 2016 of 63.21 kt. Recently, MMB was increasing as a large recruitment moved through the size classes, but that recruitment has since

disappeared and the observed mature male biomass at the time of the 2022 survey was 37.5 kt, a new all-time low.

Estimated recruitment shifted from a period of high recruitment to a period of low recruitment in the mid-1990s (late 1980s when lagged to fertilization). A large year class recruited to the survey gear in 2015 and was tracked until 2018 and 2019, but it was not present in the 2021 and 2022 surveys, and appears to have since disappeared from the eastern Bering Sea shelf before reaching commercial size.

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 (183.1 kt) based on average recruitment over 1982 to 2021. Snow crab was declared overfished in 2021 on the basis of the 2021 assessment that indicated that the MMB was below the MSST. A rebuilding plan is under development for the stock. The current assessment estimates that MMB for February 15, 2022 (41.2 kt) was 23% of B_{MSY} (183.1 kt), consequently the stock remains in an overfished status. The projected MMB at the time of mating when fishing at the OFL for 2022/23 (0.30 B_{MSY}) is above the criteria for a directed fishery closure based upon the Tier 3 control rule in the FMP (0.25 B_{MSY}).

The CPT recommends that the ABC be less than maximum permissible ABC. The buffer between the ABC and OFL used by the CPT and the SSC in 2021 was 25%. The CPT recommends continuation of a 25% buffer, and notes reduced concern about the lack of model vetting (an issue last year), but identifies a new concern about the presence of multiple minima in the likelihood surface and irregular model convergence. It now appears more likely that snow crab experienced a high mortality event in the last few years, but the timing of that event and the relative attribution to ecological/environmental processes (i.e., natural mortality) or fishing mortality remain highly uncertain.

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
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	76.7	26.7	20.4	20.4	26.2	95.4	71.6
2021/22	91.6	41.2	2.5	2.5	3.6	7.5	5.6
2022/23		55.0				10.3	7.7

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
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	169.1	59.0	45.0	45.0	57.8	210.3	157.7
2021/22	201.9	90.8	5.5	5.5	7.9	16.5	12.4
2022/23		121.3				22.7	17.0

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 four 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. In 2020/21, retained catch was 1.26 kt and total catch mortality was 1.57 kt. In 2021/22 the directed fishery was closed (TAC was set to 0) because mature female abundance failed to meet the State's criterion for opening the fishery and retained catch was 0.02 kt (in a cost recovery fishery) while total catch mortality was 0.10 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. While data from the 2021 NMFS trawl survey included resampling for female red king crab in Bristol Bay based on the characterization of female clutch condition early in the survey, data from the 2022 survey did not. In the model recommended by the CPT, annual stock abundance was estimated for male and female crab ≥ 65-mm CL from 1975 to 2022 and mature male (males ≥120 mm CL) biomass was projected to 15 February 2023. The assessment was updated with 2021/22 fishery data on bycatch in the red king crab and Tanner crab fisheries, bycatch in the groundfish trawl and fixed gear fisheries, and data from the 2022 NMFS trawl survey.

Three model scenarios requested by the CPT were evaluated using GMACS (version 2.01.E) for the 2022 assessment. Model 21.1b, on which the other models were based, was the same as the 2021 assessment model (21.1a), except that it included updated data (2016/17-2020/21) for bycatch in the groundfish fisheries based on a new expansion algorithm developed by the AKRO. Model 22.0 was identical to 21.1b except that it started in 1985 rather than in 1975, removing earlier time series and size composition data from the model fit. Model 22.0a was identical to 22.0 except that it estimated M for males, rather than fixing it to 0.18 yr^{-1}.

The estimated natural mortality rate on females was higher in 22.0a than in Models 21.1b and 22.0, as was the rate for males estimated in 22.0a compared with the fixed rate assumed the other two models. The elevated natural mortality rates in 22.0a were accompanied by slight rightward shifts in the estimated NMFS and BSFRF survey selectivity patterns toward larger sizes, resulting in slightly lower survey catchability at any size in 22.0a compared with 21.1b and 22.0. Estimated MMB-at-mating was slightly higher in 22.0a compared with the other two models across most of the 1985-2021 time period, but with the difference decreasing with time such that terminal year MMB (Feb. 15, 2022) was nearly identical for

all three models. The projected MMB for 2022/23 was slightly lower for 22.0a than for the other two models. All three models fit the fishery catch and bycatch biomass, NMFS survey biomass, and BSFRF survey biomass time series data similarly well. They also fit the associated size composition data well. Model 22.0a, as with models in previous assessments that estimated higher M for males, exhibited slightly better fits to the plus group in size compositions relative the other models. All three models exhibited fairly substantial retrospective patterns in MMB, with estimates of year-specific MMB increasing (displaying positive bias) as peels were removed. Mohn's rho for these patterns was smallest for Model 22.0a (0.33) and largest for 22.0 (0.45), with that for 21.1b closer to 22.0a (0.37).

In selecting a model on which to base management decisions, the CPT noted the SSC's request from its June 2022 meeting for the CPT to develop guidelines and criteria for adopting changes to the time frame used in an assessment model. The CPT has not had the opportunity yet to respond to this request. Given this and the overall similarity among the three models' fits and results, the CPT agreed with the assessment author that there was not a strong enough reason to recommend either of the 22.0 models (both of which adopted a new time frame for the assessment) for status determination and OFL setting. Thus, the CPT recommends that the author's preferred model, 21.1b, be used to determine stock status and calculate the OFL for 2022/23.

Stock biomass and recruitment trends

Based on the CPT-recommended Model 21.1b, 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 (28 kt) and 2002-2003 (~33 kt), followed by a gradual decline. The estimated MMB at time of mating in 20221/22 was 16.64 kt. The projection for the 2022/23 time of mating, which assumes the fishing mortality in 2022/23 matches that corresponding to the OFL, is 16.95 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 (59, 51, and 40 million crab, respectively).The estimate for 2022, 9.0 million, was the largest since 2018 but is highly uncertain because it is based on only the 2022 NMFS EBS survey data.

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

The Bristol Bay red king crab stock is in Tier 3. 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 Model 21.1b, the estimated $B_{35\%}$ is 24.0 kt. MMB projected for 2022/23 is 17.0 kt, 71% of $B_{35\%}$. Consequently, the BBRKC stock is in Tier 3b for 2022/23. The corresponding OFL is 3.04 kt

For 2022, the CPT recommends continuing to use a 20% buffer because it found that the level of perceived additional uncertainty in the assessment associated with the concerns expressed in 2021 remained, although the basis for those concerns has changed slightly. These include:

- Continued lack of recent recruitment
- Poor and variable environmental conditions
- NMFS female survey biomass in 2022 remains at historically low levels
- The lack of fit to the 2018-2022 NMFS female survey biomass
- The retrospective patterns exhibited by the recommended model

MMB for 2021/22 was estimated to be 16.6 kt and above MSST (12.01 kt); hence the stock was not overfished in 2021/22. The total catch mortality in 2021/22 (0.10 kt) was less than the 2021/22 OFL (2.23 kt); hence overfishing did not occur in 2020/21. Based on MCMC projections, the probability of MMB in 2022/23 dropping below the MSST when fishing at F_{OFL} was less than 0.5, so the stock is not 'approaching an overfished condition'.

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
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	12.12	13.96	1.20	1.26	1.57	2.14	1.61
2021/22	12.01	16.64	0	0.02	0.10	2.23	1.78
2022/23		16.95				3.04	2.43

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
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	26.7	30.8	2.77	2.65	3.47	4.72	3.54
2021/22	26.5	36.7	0	2.65	3.47	4.91	3.92
2022/23		37.4				6.70	5.35

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 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 male biomass did not meet ADF&G criteria for opening a fishery, and there was no directed fishery harvest. The fishery was open for 2021/22, with a TAC of 499 t, for the area west of 166°W longitude, leading to a retained catch of 494 t.

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 a modified version of 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 catch and size-composition data 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. Input data sets were updated with the most recent information.

The model recommended by the CPT to set the OFL and the ABC (Model 22.03) is a slightly revised version of model 21.22a used to set the OFL and ABC last year. Model 21.22a fit the total catch data separately by sex; model 22.03 fits the sum of the total catch data across sex. The CPT considered this an improvement over last year's model because model 22.03 more effectively captures the aggregate effect of the fisheries on stock dynamics.

Stock biomass and recruitment trends

The MMB at the time of mating is estimated to have been highest in the early 1970s (close to 400 kt), with secondary peaks in 1989 (108 kt), 2008 (122 kt), and 2014 (117 kt). The estimated MMB at time of mating in 2021/22 was 62.05 kt and the projection for 2022/23 under the assumption that the OFL was taken 47.58 kt. Estimates of recruitment since 1999 have been generally low relative to the peaks estimated for the period prior to 1990. Estimates of strong recruitment in recent years do not appear to have propagated into larger size classes in subsequent years and this was a concerning source of uncertainty in the most recent assessment.

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 – 2021, based on the approach used to select the time period for the 2021 assessment, which excluded the most recent estimate of recruitment given its uncertainty.

Based on the estimated biomass on 15 February 2022, the stock is at 118% of B_{MSY}, and therefore is in Tier 3a. The F_{MSY} proxy ($F_{35\%}$) is 1.17 yr^{-1}, and the 2022/23 F_{OFL} is 1.17 yr^{-1} under the Tier 3a OFL control rule, which results in a total OFL of 32.81 kt. The maximum permissible ABC is 26.25 kt. The CPT recommended a 20% buffer to account for model uncertainty and stock productivity uncertainty be applied to the OFL to set ABC = 26.25.61 kt. The 20% buffer is the same that the SSC recommended for determination of the 2021/22 ABC.

Total catch mortality in 2021/22 (0.78 kt) was below the OFL, therefore overfishing did not occur.

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
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	17.97	56.34	1.07	0.66	0.96	21.13	16.90
2021/22	17.37	62.05	0.50	0.49	0.78	27.17	21.74
2022/23		47.58				32.81	26.25

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
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	39.61	124.19	2.35	1.44	2.11	46.58	37.26
2021/22	38.29	136.79	1.10	1.09	1.73	59.89	47.91
2022/23		104.88				72.34	54.25

4 Pribilof Islands red king crab

The Pribilof Islands red king crab (PIRKC) assessment is on a triennial cycle. A full assessment was conducted this year (2022).

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. From 1995 through 1998, combined guideline harvest levels (GHLs) were used for the Pribilof Islands red and blue king crab fishery. 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, and recent bycatch has been well below the OFL, ranging from 1.0 to 17.0 t from 2012/13 to 2020/21.

Data and assessment methodology

In 2019 a GMACS model was accepted for this stock. The 2022 assessment is based on trends in male mature biomass (MMB) from NMFS bottom trawl survey and commercial catch and trawl bycatch data through 2022. The GMACS integrated model was presented with three variations: 1) model 22.1: 2019 accepted model with updated data and .tpl file to fix small bugs in the model parameterization, 2) model 22.1a: 22.1 adding in the bycatch size composition data into the assessment, which allows for estimation of bycatch selectivity, and 3) 22.1b: 22.1a with the slope of the growth increments model fixed to zero and the intercept estimated in order to more closely match the observed biology from tagging data used in the BBRKC assessment.

Stock biomass and recruitment trends

The GMACS model fit to mature male biomass identified three peaks in the timeseries. In recent years, observed mature male biomass (>120 mm CL) peaked in 2015, then declined until 2019 when it began to increase. 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 cohort has been established recently, but its size is unclear. Numbers at length vary dramatically among years; however, three cohorts can be seen moving through the length frequencies over time. The estimated MMB peaked during 1999 to 2003 and systematically declined until 2018, had a short increase until 2020 when it began to decline again.

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

The CPT continues to recommend Tier 4 stock status determination and selected the GMACS model 22.1b. This model was selected because it incorporates all available information for the stock, including adding in the size composition data from bycatch fisheries and uses a more consistent approach to molt increment estimation relative to other red king crab stocks. In 2019 the CPT 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 2022/23 the B_{MSY} = 1,709 t derived as the 0.35*mean MMB from 2000/01 to 2021/22 from the GMACS model 22.1b. Male mature biomass at the time of mating for 2021/22 was estimated at 3,879 t. The B/B_{MSY} = 2.27 and F_{OFL}= 0.21. B/B_{MSY} is > 1, therefore the stock status level is Tier 4*a*. For the 2022/23 fishery, the OFL is 685 t. The CPT recommended a 25% buffer for an ABC from the OFL as in previous years.

The stock is above MSST in 2021/22 and was not overfished. Overfishing did not occur for PIRKC during 2021/22 because the total catch mortality did not exceed the OFL.

Status and catch specifications (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
2018/19	866	5,368	0	0	7.22	404	303
2019/20	866	6,431	0	0	3.84	864	648
2020/21	866	6,431	0		5.09	864	648
2021/22	854	3,879	0		1.47	864	648
2022/23	854	3,879	0			685	514
2023/24		3,879	0			685	514
2024/25		3,879	0			685	514

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
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	1.91	14.18	0		0.11	1.9	1.43
2021/22	1.88	8.55	0		0.00	1.9	1.43
2022/23	1.88	8.55	0			1.51	1.13
2023/24		8.55	0			1.51	1.13
2024/25		8.55	0			1.51	1.13

5 Pribilof Islands blue king crab

The Pribilof Islands blue king crab assessment is biennial with the last assessment conducted in 2021. The next assessment will occur in 2023. Information listed below summarizes the 2021 assessment, but includes updates with final retained catch and bycatch mortality estimates in the directed fishery, other crab fisheries, and the groundfish fisheries to determine the final status of whether or not overfishing occurred during the 2021/22 crab fishery year.

Fishery information relative to OFL setting.

The Pribilof Islands blue king crab fishery began in 1973, with peak landings of 4,990 t (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 454 t (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 589 – 1,134 t (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 to take action to prevent overfishing.

Data and assessment methodology

The calculation of the 2021/22 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. The NMFS EBS Shelf Survey is typically conducted on an annual basis in June-August, so biomass estimates from the survey in the year of the assessment are no longer available for the assessment. A value projected by the random effects model used to smooth survey MMB is used as a substitute to calculate MMB-at-mating for the assessment year. The most recent survey data available is from the 2022 NMFS EBS Shelf Survey; however, the last assessment was conducted in 2021 and thus does not include 2022 survey data. For the 2021 assessment, MMB at the time of survey (July 2021) was estimated from the observed time series using the random effects prediction. The values of year-to-date bycatch in the crab and groundfish fisheries on July 23, 2022 were taken as estimates of the 2021/22 year-end values to evaluate overfishing status.

Stock biomass and recruitment trends

The 2022/23 MMB at mating is projected to be 180 t, which is approximately 4% of the proxy for B_{MSY}. The Pribilof Islands 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 4,098 t for 2022/23.

Because the projected 2022/23 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 2022/23 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 is 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.

The most recent full assessment was conducted in May 2021 and the stock was below MSST in 2020/21 and continues to be overfished. Total catch in 2021/22 was below the OFL therefore overfishing did not occur.

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
2018/19	2,053	230	Closed	0	0.40	1.16	0.87
2019/20	2,049	180	Closed	0	0.42	1.16	0.87
2020/21	2,049	181	Closed	0	0.00	1.16	0.87
2021/22		180	Closed	0	0.102	1.16	0.87
2022/23		180				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
2018/19	4.526	0.507	Closed	0	0.0009	0.0026	0.0019
2019/20	4.517	0.397	Closed	0	0.0009	0.0026	0.0019
2020/21	4.517	0.399	Closed	0	0.0000	0.0026	0.0019
2021/22		0.397	Closed	0	0.0002	0.0026	0.0019
2022/23		0.397				0.0026	0.0019

6 St. Matthew Island 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 after a 10-year closure, closed in 2013/14 due to declining trawl-survey biomass, and opened from 2014/15 to 2015/16 with a TAC of 300 t (0.655 million lb). But fishery performance was relatively poor with retained catches of 140 t (0.309 million lb) in 2014/15 and 48 t (0.105 million lb) in 2015/16, and has remained 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 was implemented in October 2020.

Data and assessment methodology

This assessment uses a GMACS model, 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; (2) NMFS annual trawl survey; (3) ADF&G triennial pot survey; (4) bycatch in the groundfish trawl and groundfish fixed-gear fisheries; and (5) ADF&G crab-observer size composition.

Stock biomass and recruitment trends

The 1978-2022 NMFS trawl survey mean biomass is 5,448 t with the 2022 value (2,366 t) below the long-term median and near the median since 2000. This 2022 biomass of ≥90 mm carapace length (CL) male crab (5.22 million pounds; 2,368 t; CV = 50%) is 43% of the long-term mean, and a 23% increase from the 2021 biomass. The most recent 3-year average of NMFS surveys is 46% below the mean value, indicating a decline in biomass compared to historical survey estimates, notably in 2010 and 2011 that were over four times the current average. However, the 2022 value increased from 2021, like the increase observed in the 2019 survey data. The last ADF&G pot survey in 2018 gave the lowest biomass index in the time series (12% of the mean from the 11 surveys conducted since 1995). This 2022 pot survey is underway and will not be completed until after the 2022 assessment cycle. New data will be included in the 2024 assessment. Assessment model estimates suggest this stock (in survey biomass units) is presently near 39% of the long-term model-predicted survey mean. The trend suggests relative stability in the last few years, although the 2019 NMFS survey is not well fit.

Recruitment was assessed as the number of male crab in the 90–104 mm CL size class. The 2022 trawl-survey area-swept estimate of 0.617 million male recruits is near the average since 1978, and increased from the last 5 years of survey data. Recent six-year (2016-2022) average recruitment is 37% of the long-term mean. In the pot survey, the abundance of this size group in 2017 was also the second lowest in the time series (22% of the mean) whereas in 2018 the value was the lowest observed (10% of the mean value).

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

The stock assessment is based on the previously accepted model configuration, Model 16.0, updated with 2021/22 groundfish bycatch and 2022 NMFS trawl survey data.

The CPT concurs with the author's recommendation to use Model 16.0 for the 2022/23 crab year. The stock is in Tier 4. The CPT recommends that the full assessment period (1978/79–2021/22) be used to define the proxy B_{MSY} in terms of average estimated MMB_{mating}. The projected MMB estimated for 2022/23 is 1,310 t and the F_{MSY} proxy is the natural mortality rate (0.18^{-1} year) and F_{OFL} is 0.061, results in a mature male biomass OFL of 0.07 kt. The MMB/B_{MSY} ratio is 0.4. The author recommended and the CPT concurred with a 25% buffer on the OFL for the ABC. The ABC based on this buffer is 0.05 kt.

Given that this is a biennial assessment, the CPT further recommends that the OFL and ABC for 2023/2024 remain at an OFL of 0.07 kt and ABC of 0.05 kt. This stock will next be assessed in 2024.

The stock was found to be below MSST in 2021/22 as well as 2022/23 (as projected) and remains in overfished condition. Total catch was less than the OFL in 2020/21 and hence overfishing did not occur.

Table 1:Status and catch specifications (1000 t) for the base model.

Year	MSST	Biomass (MMB)	GHL	Retained Catch Mortality[1]	Total Catch Mortality[2]	OFL[3]	ABC[3]
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	1.65	1.14	0.00	0.00	0.001	0.05	0.04
2021/22	1.63	1.18	0.00	0.00	0.001	0.05	0.04
2022/23		1.31	0.00	0.00	0.001	0.066	0.050
2023/24		1.31				0.066	0.050

Table 2: Status and catch specifications (million pounds) for the base model.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2018/19	3.84	2.54	0.00	0.00	0.002	0.08	0.07
2019/20	3.68	2.34	0.00	0.00	0.002	0.096	0.08
2020/21	3.64	2.52	0.00	0.00	0.002	0.112	0.08
2021/22	3.59	2.59	0.00	0.00	0.002	0.112	0.08
2022/23		2.9				0.146	0.11
2023/24		2.9				0.146	0.11

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 thousand t retained catch. Retained catches since 1982 have been below 0.227 thousand t, averaging 0.136 thousand t, including several low years in the 1990s. As the crab population rebounded, retained catches increased to 0.231 thousand t in 2016, but decreased 69% to 0.073 thousand t in 2019. In 2020, the winter and summer commercial crab fisheries did not operate; only winter subsistence catch occurred. The winter commercial and subsistence fisheries were conducted in 2021, with retained catches of 320 and 1,763 crabs, respectively. Although the season was not closed, no harvest occurred in the summer commercial fishery in 2021.

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. These provide data on annual abundance and size/shell condition compositions. In addition, time series of standardized CPUE from the summer commercial fishery provide additional indices of abundance. Tag return data provide information on growth. Retained catch data are available from fish tickets for the winter and summer commercial fisheries, as well as from subsistence catch reports. Retained catch size composition data are generally available for the summer commercial fishery, but only limited data are available for the winter commercial fishery. Limited data on discards are available from summer commercial fishery observer data and subsistence catch reports.

The assessment has been updated to include the following new data for 2021: retained catch information from the winter commercial and subsistence fisheries for 2021 (no catches occurred during the summer commercial fishery); discards were calculated using the author-preferred "proportional" method; standardized CPUE time series were recalculated after separating the data into three time periods based on changes in vessel and retention characteristics; and survey abundance and shell condition/size composition data from the 2021 ADFG and NOAA Northern Bering Sea summer trawl surveys.

The assessment is based on a length-based model of male crab abundance that combines these multiple sources of data. The model does not estimate fishing mortality rates; observed harvests and estimated discards are subtracted from the model-estimated abundance. Logistic functions are used to describe fishery and survey selectivities, except for a dome-shaped function used for the winter pot fishery. The ADFG trawl survey is assigned a catchability of 1, but catchabilities are estimated for other surveys and the standardized CPUE indices. Molting and growth are combined into a size transition matrix. The model allows for length-dependent natural mortality. A maximum likelihood approach is used to estimate quantities relevant in management.

The assessment author presented seven alternative models (19.0e, 21.0, 21.1, 21.2, 21.3, 21.4, and 21.5) for consideration by the CPT for status determination and OFL/ABC calculation. Results from the accepted 2021 assessment model (19.0b) updated with 2021 data were not presented; results from model 19.0e were presented instead. Model 19.0e differed from 19.0b in how discards were estimated. Model 19.0b used the LNR2 method endorsed by the CPT and SSC for the 2021 assessment, while model 19.0e used the "proportional" method recommended by the author in fall of 2021. Model 21.0 was based on model 19.0e, but divided the summer fishery CPUE standardization into three time periods with associated q's (catchability coefficients) and estimated retention probabilities in the winter and summer commercial fisheries in two time periods reflecting differences in high grading of retained crab (<, ≥2008). Models 21.2 and 21.3 were CPT-requested bridging models from model 19.0e to model 21.0 to ascertain the drivers

for changes in model results from models 19.0e to 21.0. Models 21.1, 21.4, and 21.5 incorporated different assumptions regarding natural mortality relative to model 21.0 (respectively: fixed M=0.18 yr^{-1} for all length classes, a single estimated M applied to all length classes, and separately estimated M's applied to length bins less than and greater than 123.5 mm CL).

After evaluating the models in terms of fits to the data, estimability of parameters, and reasonableness of assumptions, the CPT recommended model 21.0 to determine status and calculate OFL and ABC. This model assumes a constant M *of* 0.18 yr^{-1} for all length classes except the >123mm CL length-class, which had an estimated value of 0.62 yr^{-1}.

Stock biomass and recruitment trends

Estimated mature male biomass was at a low in 1982 following a sharp decline from the peak biomass in 1977. MMB increased from a historic low in 1996 to a peak in 2010, after which it fluctuated about the $B_{MSY\ proxy}$. Estimated MMB is currently increasing from low levels in 2019 that were comparable to the lowest estimates of MMB in 1996. Estimated recruitment has generally been variable, and the most recent recruitment estimate is one of the largest since the late 1970s. However, this recruitment will not be corroborated until it enters the fishery in several years. The 2020 ADFG survey estimate of male abundance declined sharply from the 2019 estimate (to 40% of the 2019 estimate) but increased in 2021 by 40% relative to the 2020 estimate. The 2019 and 2021 estimates of male abundance from the NOAA NBS survey were similar to one another (no survey was conducted in 2020).

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

The CPT recommended model 21.0 to determine stock status and set the OFL for 2022. The B_{MSY} proxy for model 21.0, calculated as the average of mature male biomass on February 1 during 1980-2022 was 1.90 thousand t. The estimated 2022 mature male biomass on February 1 was 2.17 thousand t, which was above the B_{MSY} proxy for this stock, placing Norton Sound red king crab in status category 4a. The F_{MSY} proxy for stocks in Tier 4 is M =0.18 yr^{-1}, and the associated F_{OFL} was 0.18 yr^{-1} using the default gamma (=1.0) because the 2022 mature male biomass is greater than the B_{MSY} proxy. The CPT-recommended OFL is a total catch OFL, encompassing both retained catch and discard mortality (prior to 2021, the OFL referred only to retained catch). The resulting Tier 4a total catch mortality OFL is 0.30 thousand t (0.67 million lb).

The CPT recommended that the ABC for 2022 be set below the maximum permissible ABC. The team recommended that the SSC-endorsed 2021 buffer of 40% from the OFL be maintained given the list of concerns with the status of the stock and assessment model similar to those in 2021, including:

- uncertainty regarding biological characteristics
    - M, size-at-maturity are borrowed from other stocks
    - impact of seasonal movement on survey estimates
    - uncertainty in stock vs. survey areas
- shortage of discard data on which to base estimates of total catch mortality
- estimates of total catch mortality rely on *ad hoc* methods to estimate discards
- absence of standardized CPUE for 2020, 2021
- discrepancies between ADFG and NMFS NBS survey estimates remain unresolved
- new information on barren females in surveys was not presented
- some parameters are at bounds, indicating potential problems with convergence
- the model consistently overestimates the proportion of large crab
- issues with very high M in largest size class remain unresolved
- retrospective patterns remain similar to the previous assessment

The resulting ABC is 0.18 thousand t (0.40 million lb).

Total catch mortality in 2021 (0.003 thousand t) was less than the OFL (0.20 thousand t), therefore overfishing did not occur.

Status and catch specifications (1000 t)

Year	MSST	Biomass (MMB)	GHL	Retained Catch Mortality[1]	Total Catch Mortality[2]	OFL[3]	ABC[3]
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	0.08	Conf.	Conf.	0.13	0.09
2021	1.03	2.27	0.14	0.003	0.003	0.20	0.16
2022	0.95	2.42				0.30	0.18

Notes:
[1]2018:2020: Refers to commercial fisheries only; 2021: refers to all (commercial + subsistence) retained catch
[2]2018:2020: Does not include discard mortality (total retained catch only; 2021: includes estimated discard mortality)
[3]OFL/ABC are total catch values starting 2021. (These were retained catch OFL/ABCs in previous years)

Status and catch specifications (million lb.)

Year	MSST	Biomass (MMB)	GHL	Retained Catch Mortality[1]	Total Catch Mortality[2]	OFL[3]	ABC[3]
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	0.17	Conf.	Conf.	0.29	0.20
2021	2.26	5.00	0.31	0.007	0.007	0.59	0.35
2022	2.08	5.33				0.67	0.40

8. Aleutian Islands Golden King Crab

Fishery information relative to OFL setting

The directed fishery has been prosecuted annually since the 1981/82 season. Retained catch peaked in 1986/87 at 6.685 kt (14.8 million lb) and averaged 5.398 kt (11.9 million lb) over the 1985/86-1989/90 seasons. Average harvests dropped sharply from 1989/90 to 1990/91 to a level of 3.110 kt (6.9 million lb) for the period 1990/91–1995/96. Management based on a formally established GHL began with the 1996/97 season; individual GHLs are applied to areas east and west of 174°W longitude (referred to here as the EAG and WAG, respectively). The 2.677 kt (5.9 million lb) combined GHL established for the 1996/97 season, which was based on the previous five-year average catch, was subsequently reduced to 2.586 kt (5.7 million lb) beginning in 1998/99. The GHL (or TAC, since 2005/06) remained at 2.586 kt (5.7 million lb) for 2007/08 but was increased to 2.715 kt (5.99 million lb) for the 2008/09-2011/12 seasons, and to 2.853 kt (6.3 million lb) starting with the 2012/13 season. The TAC was reduced to 2.515 kt (5.6 million lb) for the 2016/17 season and increased to 2.883 kt (6.4 million lb) for the 2018/19 season and 3.257 kt (7.18 million lb) for the 2019/20 season. It was reduced to 2.999 kt (6.6 million lb) for the 2020/21 season and 2.689 kt (5.9 million lb) for the 2021/22 season. Since 2019/20, the TACs have been based on the harvest strategy adopted by the Alaska Board of Fisheries in March 2019. This fishery is rationalized under the Crab Rationalization Program.

Total mortality of Aleutian Islands (AI) golden king crab includes retained catch in the directed fishery, mortality of discarded catch, and bycatch in fixed-gear and trawl groundfish fisheries, though bycatch in other fisheries is low compared to mortality in the directed fishery. Retained catch in the post-rationalized fishery (2005/06-2021/22) has ranged from 2.379 kt (5.3 million lb) in 2006/07 to 3.319 kt (7.32 million lb) in 2019/20. Total mortality ranged from 2.506 to 3.729 kt (5.5 to 8.2 million lb) for the same period. The retained catch during the 2021/22 fishery was estimated to be 2.476 kt (5.5 million lb), split between the EAG: 1.706 kt (3.8 million lb) and the WAG: 0.770 kt (1.7 million lb), but the WAG fishery was still active when the assessment was conducted.

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, *inter alia,* different abundance trends in each area. A modeling framework based on only fisheries data for AI golden king crab was under development for several years with model assumptions and data inputs refined by reviews by the SSC and CPT. The CIE also reviewed the model and stock assessment in June 2018. The current modeling framework was recommended by the CPT in September 2016 and approved by the SSC in October 2016.

The model-based stock assessment involves fitting male-only population dynamics models to data on catches and discards in the directed fishery, discards in the groundfish fishery, standardized indices of abundance based on observer data, fish ticket data, length-frequency data for the directed fishery (landings and total catch), and mark-recapture data. The data for the EAG are complete through the 2021/22 season. The fishery in the WAG was still operating when the assessment was conducted, with 73% of the WAG TAC taken (88% when the assessment was reviewed by the CPT), and the assessment was based on the assumption that 2021/22 TAC for the WAG will be taken. A cooperative survey, performed by the Aleutian Islands King Crab Foundation (an industry group) and ADF&G annually (except 2020) since 2018, was conducted during the 2021/22 fishing year.

The assessment authors provided an updated analysis of male size-at-maturity based on chela height data that addressed questions and concerns raised by the CPT and SSC when the original analysis was presented last year. The new analyses followed methods recently applied to southeast Alaska golden king crab stocks in a peer-reviewed study. Specifically, results from broken stick model fits were presented using older data collected in the 1980s and 1990s, newer data collected since 2018, and the combined dataset. The estimates of size-at-maturity differed depending on which dataset was used (~108 mm CL using the older data, 118 mm CL using the newer data, and 123 mm CL using the combined dataset), as well as by area using the newer data (110 mm CL for the EAG and 120 mm CL for the WAG). The CPT selected the size-at-maturity estimate based on the newer data alone as the best estimate for the following reasons: the sample sizes are much higher in the newer data, the sampling protocols for the newer data are documented and well-understood, and information on how the earlier data were collected is lacking. The CPT suggested that it may be worthwhile to use area-specific values for size-at-maturity in the future, but that this decision should be addressed within a broader consideration of stock structure. The updated size-at-maturity used in the assessment model is 116 mm CL, to better align it with the size bins used in the model.

The assessment authors examined ten model scenarios applied to each area in this assessment cycle. Model 21.1a was last year's assessment model. Model 21.1e included three catchability parameters and associated additional CVs, which corrected an error in Model 21.1a in which the same catchability coefficient was applied to both the fish ticket and observer CPUE time series. Otherwise, 21.1e was identical to 21.1a (the latter used two time blocks for catchability and associated CV's). Model 21.1f was similar to 21.1e, but substituted observer CPUE data standardized using year-area interactions for the previous standardization that did not include the interaction terms. Because the fishery in the WAG was still open at the time the assessment was conducted, the final catch taken in the WAG for 2021/22 was uncertain, as was the total effort; the authors made the assumption (strongly supported by fishery performance in recent years) that the entire TAC would be taken by the time the fishery was closed, while the CPUE would be similar to that when the assessment was conducted, in order to estimate final effort. The CPT supported the authors' approach, but recommends that they conduct a retrospective analysis to better evaluate how well the projected CPUE at the time of the assessment captures that at the end of the season.

For the WAG, all three models fit the respective standardized CPUE indices and catch data equally well and produced similar estimates for recruitment and MMB time series. Retrospective patterns for Models 21.1a and 21.1e were small (the authors did not conduct retrospective analyses for Model 21.1f), while estimated selectivity and retention curves, recruitment estimates, and estimated trends in MMB were very similar across the models. For the EAG, all three models exhibited very poor fits to the respective standardized CPUE indices in the post-rationalization period. It was suggested that this reflected an inability of the models to simultaneously fit the index data and the size composition data, and was the reason for poor retrospective patterns exhibited by Models 21.1a and 21.1e (the authors did not conduct a retrospective analysis for 21.1f). A diagnostic model with time-varying catchability was able to reduce the retrospective patterns.

Two additional models for each area, 21.1e2 and 21.1f2, were identical to the respective 21.1e and 21.1f models, but used the new estimate of size-at-maturity to calculate reference points. Other than the values for the reference points, the results from 21.1e2 and 21.1f2 were identical to those from 21.1e and 21.1f. Finally, GMACS versions of each of the five models (21.1a, 21.1e, 21.1f, 21.1e2, and 21.1f2) for each area were also examined. Fits to the data were very similar between the corresponding models, while trends in MMB differed in the model "spin-up" period prior to the index data due to known differences in R_0 between the two types of models, as was expected.

The authors' preferred models for both the EAG and WAG were the respective GMACS versions of Model 21.1e2, given the similarity of results compared with the non-GMACS versions and the advantages of moving to GMACS. The CPT also preferred the GMACS versions but found a discrepancy in the estimates

of B_{MSY} between GMACS and the current models that need to be explored further. Consequently, the GMACS versions of Model 21.1e2 were not adopted by the CPT as bases for reference point calculations for this assessment cycle. Model 21.1f was also not adopted by the CPT because the authors did not provide retrospective analyses for it. Therefore, the CPT endorsed Model 21.1e2 for both the EAG and the WAG as the basis for status determination and the OFL.

Stock biomass and recruitment trends

Estimated mature male biomass (MMB) for EAG decreased from the 1980s to the 1990s, then increased during the 2000s, decreased marginally in the early 2010s, and has systematically increased since 2014. Estimated MMB for the WAG decreased substantially during the late 1980s and 1990s, increased somewhat during the 2000s, decreased for several years after 2008 and has since fluctuated about a relatively low value. Stock trends have generally reflected the fishery standardized CPUE trends in both regions.

Summary of major changes

The assessment model recommended by the CPT is similar to the model used in the previous assessment, but uses three time periods for catchability and additional variances for the CPUE data rather than the two used in the previous assessment. New data for the assessment included fishery data for the 2021/22 fishing season; in addition, the standardized CPUE indices were updated. The size-at-maturity used to determine reference points has been changed from 111 mm CL to 116 mm CL based on results from the chela height analysis.

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 2021/22. A single OFL and ABC is defined for AIGKC. However, separate models are available by area. During our May 2017 meeting the CPT recommended that stock status be determined by adding the area-specific estimates of current MMB and B_{MSY} to ensure that there would only be one stock status for the AIGKC stock. The AIGKC 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 CPT recommends that the B_{MSY} proxy for the Tier 3 harvest control rule be based on the average recruitment from 1987-2017, years for which recruitment estimates are relatively precise.

This is the only crab assessment that relies solely on fishery CPUE as an index of abundance. The CPUE index standardization process, subject to past CPT and SSC review, is a key reason for the 25% buffer between the OFL and the ABC used in past years. Concerns raised in recent assessments are summarized in the following table:

Concern	year expressed	CPT 2022 concern?	Reason
Only crab assessment that relies entirely on fishery CPUE as an index of abundance	2020	Yes	No change
Uncertainties in size at maturity, including the untested regression approach involving chela height against carapace length	2020	Less	Uncertainties in size-at-maturity remain, but regression approach has been tested and revised in line with other studies. Results warrant an increase in size-at-maturity used for MMB calculations.
Uncertainty in natural mortality estimation	2020	Yes	No change
The limited spatial coverage of the fishery with respect to the	2020	Yes	No change

Concern	year expressed	CPT 2022 concern?	Reason
total stock distribution			
The small number of vessels on which CPUE is based	2020	Yes	No change
Retrospective pattern for the EAG	2020	Yes	Retrospective patterns continue to be an issue
CPUE standardization is still subject to some methodological concerns	2020	Less	Principle methodological concerns have been met
Fewer large animals in the total catch length-frequency for the EAG between 2016 and 2020	2021	Yes	No change
Catches from the WAG that were not included in the assessment	2021	Less	WAG fishery not concluded at time of assessment, TAC was used as a placeholder
CPUE index for the WAG declined more when account was taken of year*area interactions	2021	Yes	No change
The size at maturation may be larger than currently assumed	2021	No	Larger size at maturity now used
Model convergence concerns in WAG reflecting potential parameter confounding (jitter analysis resulted in multiple solutions for MMB and $B_{35\%}$ at same likelihood values)	2021	No	Jitter analysis resulted in no apparent convergence issues in WAG

The SSC adopted a 30% buffer for the ABC in 2021/22 based primarily on concerns raised by a jitter analysis that suggested the model may be converging to local minima, exhibiting multiple values for reference points associated with a single value for the likelihood. No problems of this sort occurred for this year's recommended models, while the CPT found reasons to reduce or eliminate several other concerns. However, several previously expressed concerns continue to exist, the principal one being the retrospective patterns that continue to be exhibited by the recommended EAG model. Thus, the CPT recommends reducing the 2022/23 buffer for the ABC back to 25%, its value before last year.

Total fishery mortality in 2021/22 is 2.725 kt (6.007 million lb), which is less than the OFL of 4.817 kt (10.620 million lb) so overfishing did not occur at the time of assessment, but will need to be updated once the fishing year is complete.

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
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	6.026	16.207	2.999	3.000	3.444	4.798	3.599
2021/22	5.859	12.592	2.690	2.699[a]	3.056[a]	4.817	3.372
2022/23		11.941				3.761	2.821

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
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	13.284	35.730	6.610	6.614	7.593	10.579	7.934
2021/22	12.917	27.760	5.930	5.951[a]	6.737[a]	10.620	7.434
2022/23		26.326				8.291	6.219

[a] The retained and total catch were estimated using the completed fisheries data for 2021/22

Additional Plan Team recommendations

The CPT made the following recommendations to the assessment authors:

- Transition to GMACS for the AIGKC assessment should continue to be a priority.
- Continue work to obtain an index using the cooperative pot survey data for use in the EAG assessment model.
- Identify and eliminate the conflict between the model and the data giving rise to the retrospective patterns for EAG models.
    - Revisit the analysis considering a model with time-varying catchability, but impose a penalty on the devs to allow the index data to inform the model
- Plot observed vs. predicted values for fitted data to help diagnose misfits.
- Add confidence intervals to plots of fits to catch data (i.e., retained catch, total catch) reflecting assumed data uncertainty.
- Perform retrospective analyses for all models that have the potential to serve as the basis for calculating reference points.
- Calculate reference points using both combined-area and area-specific size-at-maturity values.
- Perform a retrospective analysis on the ability to predict year-end CPUE prior to the end of the season.
- Re-evaluate the time frame over which to calculate mean recruitment every year.

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 2001–2021 due to crab fisheries range from 0 to 73 t. Estimates of annual fishery mortality during 1991/92–2021 due to groundfish fisheries range from negligible to 9 t. Total fishery mortality in groundfish fisheries during the 2021 crab fishing year was 2 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 during the 2020 assessment; 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.

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 2023. 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 2021-2023 OFL calculation is the same as recommended by the SSC for 2013−2020:

$OFL_{2023} = (1+R_{2001–2010})*RET_{1993\text{-}1998} + BM_{NC,1994\text{-}1998} + BM_{GF,1992/93–1998/99}$

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.

Total catch in 2021 was below the OFL thus overfishing did not occur.

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			59	0	0.24	91	68
2017			59	Conf.	Conf.	93	70
2018			59	Conf.	Conf.	93	70
2019			59	Conf.	Conf.	93	70
2020			59	49	52	93	70
2021			59	16	21	93	70
2022			59			93	70
2023						93	70

Status and catch specifications (million 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			0.13	0	<0.001	0.20	0.15
2017			0.13	Conf.	Conf.	0.20	0.15
2018			0.13	Conf.	Conf.	0.20	0.15
2019			0.13	Conf.	Conf.	0.20	0.15
2020			0.13	0.11	0.12	0.20	0.15
2021			0.13	0.03	0.05	0.20	0.15
2022			0.13			0.20	0.15
2023						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 2022/23 specifications. 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 2021/22 averaged 28 t. The average retained catch during that period was 21 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 2020/21 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 2022/23 season. The CPT concurs with the assessment author's recommendation of an OFL based on the 1995/96–2007/08 average total catch following the recommendation of the SSC in June 2010 to set the time period for computing the OFL at 1995/96–2007/08. The CPT recommends an OFL for 2022/23 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 2022/23 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).

The total catch in 2021/22 was less than the OFL therefore overfishing did not occur.

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			Closed	0	<1	56	34
2017/18			Closed	0	<1	56	34
2018/19			Closed	0	<1	56	14
2019/20			Closed	0	<1	56	14
2020/21			Closed	0	<1	56	14
2021/22			Closed	0	<1	56	14
2022/23						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			Closed	0	0.00045	0.12387	0.07432
2017/18			Closed	0	0.00075	0.12387	0.03097
2018/19			Closed	0	0.00031	0.12387	0.03097
2019/20			Closed	0	0.00164	0.12387	0.03097
2020/21			Closed	0	0.00073	0.12387	0.03097
2021/22			Closed	0	0.00035	0.12387	0.03097
2022/23			Closed			0.12387	0.03097

Figures and Tables

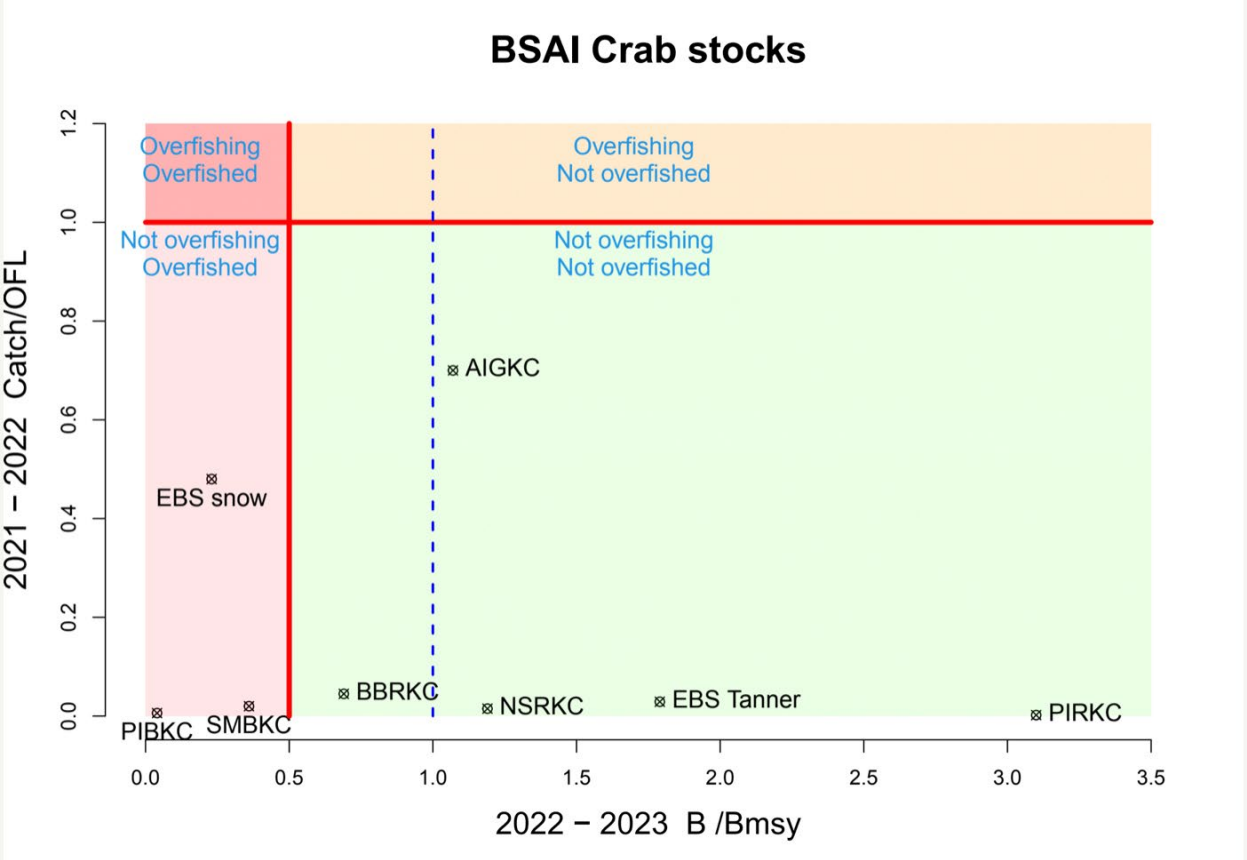

Figure 2. Status of eight Bering Sea and Aleutian Islands crab stocks in relation to status determination criteria (B_{MSY}, MSST, overfishing) for 2022. Note that information is insufficient to assess Tier 5 stocks according to these criteria (WAIRKC, PIGKC).

Table 4. Crab Plan Team recommended stock status in relation to status determination criteria for 2021/22 as estimated in 2022. Hatched areas indicate parameters not applicable for that tier. Values are in thousands of metric tons (kt).

Chapter	Stock	Tier	MSST[1]	B_{MSY} or $B_{MSYproxy}$	2021/22[2] MMB	2021/22 MMB/ MMB_{MSY}	2021/22 OFL	2021/22 Total Catch	Rebuilding Status
1	EBS snow crab	3	91.6	183.1	41.2	0.23	7.5	3.6	**overfished**
2	BB red king crab	3	12.01	24.0	16.6	0.69	2.2	0.10	
3	EBS Tanner crab	3	17.37	34.7	62.1	1.79	27.2	0.78	
4	Pribilof Islands red king crab	4	0.86	1.71	3.88	2.22	0.86	0.001	
5	Pribilof Islands blue king crab	4	2.05	4.10	0.2	0.04	0.00116	0.10[3]	**overfished**
6	St. Matthew Island blue king crab	4	1.63	3.26	1.2	0.37	0.05	0.001	**overfished**
7	Norton Sound red king crab	4	1.03	2.05	2.3	1.10	0.20	0.003	
8	AI golden king crab	3	5.86	11.7	12.6	1.07	4.81	3.06[3]	
9	Pribilof Islands golden king crab	5					0.093	0.021	
10	Western AI red king crab	5					0.056	<0.001	

[1] As estimated in the 2022 assessment. [2] For Norton Sound red king crab, MMB on 2/1/2022 is estimated using the current assessment in January 2022.

Table 5. CPT recommendations from the final 2022 SAFE. Stocks for which specifications are rolled over between assessments (Pribilof Islands golden king crab and Western Aleutian Islands red king crab) or were set in February 2022 (Norton Sound red king crab) or June (Aleutian Island Golden King Crab) are also included. Biomass values are in thousand metric tons (kt). Harvest specifications for SAFE Chapters 1 – 4 and 6 are set in October and Chapters 5 and 8 – 10 are set in June, in the year according to the assessment frequency cycle (see current SAFE Introduction for assessment cycle). Note that any modified CPT OFL and ABC recommendations from the SSC from January and June are included in this table.

SAFE Ch.	Stock	Tier	F_{OFL}	B_{MSY} or $B_{MSYproxy}$	B_{MSY} basis years[1]	2022/23[2] MMB	2022/23 MMB / MMB_{MSY}	γ	Natural Mortality (M)	2022/23 OFL	2022/23 ABC	ABC Buffer
1	E. Bering Sea snow crab	3b	0.32	183.1	1982-2021	55.0	0.30		0.28,0.29	10.3	7.7	25%
2	Bristol Bay red king crab	3b	0.20	24.0	1984-2021	17.0	0.71		0.18	3.04	2.43	20%
3	E. Bering Sea Tanner crab	3a	1.17	34.7	1982-2021	47.58	1.37		0.23	32.81	26.25	20%
4	Pribilof Is. red king crab	4a	0.21	1.71	2000-2021	3.88	2.27	1	0.21	0.685	0.514	25%
5	Pribilof Is. blue king crab	4c	0	4.10	1980/81-1984/85 & 1990/91-1997/98 [MMB]	0.18	0.04	1	0.18	0.00116	0.00087	25%
6	St. Matthew blue king crab	4b	0.06	3.26	1978-2021	1.31	0.40	1	0.18	0.066	0.050	25%
7	Norton Sound red king crab	4a	0.18	1.90	1980-2022 [MMB]	2.42	1.27	1	0.18 (0.58 >124 mm)	0.30	0.18	40%

[1] For Tiers 3, 4 where B_{MSY} 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. MMB on 2/1/22 as estimated using the current assessment for Norton Sound red king crab.

[2] MMB on 2/1/2022 as estimated for Norton Sound red king crab and on 2/15/2022 for AIGKC, using the current assessments.

Table 5 (cont). CPT recommendations from the final 2022 SAFE. Stocks for which specifications are rolled over between assessments (Pribilof Islands golden king crab and Western Aleutian Islands red king crab) or were set in February 2022 (Norton Sound red king crab) or June (Aleutian Island Golden King Crab) are also included. Biomass values are in thousand metric tons (kt). Harvest specifications for SAFE Chapters 1 – 4 and 6 are set in October and Chapters 5 and 8 – 10 are set in June, in the year according to the assessment frequency cycle (see current SAFE Introduction for assessment cycle).

8	Aleutian Is. golden king crab [3]	3a	0.52 (EAG) 0.43 (WAG)	11.7	1987-2017	11.94	1.02		0.21	3.76	2.82	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%

[3] AIGKC OFL and ABC calculated by combining two separate assessment models for the EAG and WAG, as presented in the current assessment

Table 6. Maximum permissible ABCs for 2022/23 and CPT-recommended ABCs for three stocks where the CPT recommendation is below the maximum permissible ABC, as defined by Amendment 38 to the Crab FMP. For those stocks where P* was not used to calculate maxABC, OFL was used as a proxy; therefore, maxABC=OFL. Stocks for which specifications are rolled over between assessments (Pribilof Islands GKC and Western Aleutian Islands RKC) or were set in February 2021 (Norton Sound red king crab) are included. Values are in thousand metric tons (kt). Harvest specifications for SAFE Chapters 1 – 4 and 6 are set in October, and Chapters 5 and 8 – 10 are set in June, in the year according to the assessment frequency cycle (see current SAFE Introduction for assessment cycle).

SAFE Ch.	Stock	Tier	2022/23 Max. ABC	2021/22 ABC
1	EBS Snow Crab[1,3]	3	10.3	7.7
2	Bristol Bay RKC [1,2]	3	3.04	2.43
3	Tanner Crab	3	32.76	26.25
4	Pribilof Islands RKC [1,3]	4	0.69	0.51
5	Pribilof Islands BKC [1,5]	4	0.00116	0.00087
6	Saint Matthew BKC [1,2]	4	0.07	0.05
7	Norton Sound RKC [1,2]	4	0.30	0.18
8	Aleutian Islands GKC [1,2]	3	3.76	2.82
9	Pribilof Islands GKC [1,4]	5	0.093	0.070
10	Western Aleutian Islands RKC[1,4]	5	0.056	0.014

Basis for P* calculation of Max ABC,

[1] P* was not used to calculate the Max ABC for this stock therefore Max ABC = OFL

[2] CV on OFL

[3] CV on terminal year biomass

[4] Tier 5 (90% OFL)