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

2023 Final Crab SAFE

Compiled by

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

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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/fisheries/bsai-crab/. 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), three assessments in May (Aleutian Islands golden king crab, Western Aleutian Islands (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 Island blue king crab, Pribilof Islands red king crab and Pribilof Islands blue king crab) in September (Table 1). Pribilof Islands red king crab, WAI red king crab and Pribilof Islands golden king crab are assessed triennially, while Pribilof Islands blue king crab and Saint Matthew Island blue king crab are 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	2024
Aleutian Is. golden king crab (AIGKC)	May	June	Annual	2024
Pribilof Is. golden king crab (PIGKC)	May	June	Triennial	2026
Western Aleutian Is. red king crab (WAIRKC)	May	June	Triennial	2026
EBS snow crab	September	October	Annual	2024
Bristol Bay red king crab (BBRKC)	September	October	Annual	2024
EBS Tanner crab	September	October	Annual	2024
Pribilof Is. red king crab (PIRKC)	September	October	Triennial	2025
Pribilof Is. blue king crab (PIBKC)	September	October	Biennial	2025
Saint Matthew I. 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 12-14, 2023 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 2023 Crab SAFE report contains recommendations for all 10 stocks including those whose OFL and ABC were previously determined in February and June 2023. This SAFE report will be presented to the NPFMC in October 2023 for their annual review of the status of BSAI Crab stocks.

These reviews were attended by the entire membership of the CPT: Mike Litzow (Co-Chair), Katie Palof (Co-Chair), Sarah Rheinsmith (Coordinator), William Bechtol, Ben Daly, Ginny Eckert, Erin Fedewa, Brian Garber-Yonts, Tyler Jackson, Krista Milani, Andre Punt, 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.

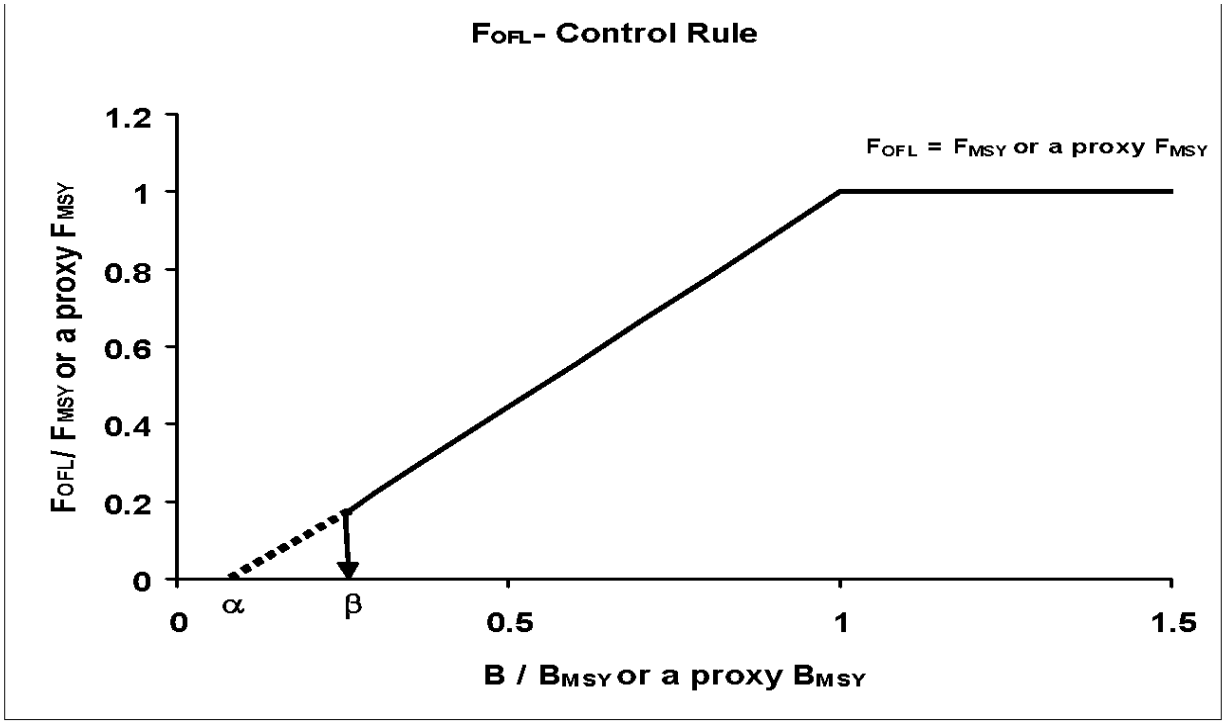

Figure 1: Overfishing control rule for Tiers 1 through 4. Directed fishing mortality is 0 below β.

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 $0 \le \beta < 1$.
  - α — a parameter with restriction that $0 \le \alpha \le \beta$.
- 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 $B \le \beta \cdot B_{MSY}$, $F = 0$ for the directed fishery and $F_{OFL} \le F_{MSY}$ 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 $\beta \cdot B_{MSY} < B \le B_{MSY}$.
  - 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 $\beta \cdot B_{MSY} < B \le B_{MSY}$.
- 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 contains status determination for the 2022/23 season. Status of stocks in relation to status determination criteria for stocks in Tiers 3 and 4 are shown in Figure 2. Table 5contain the team's recommendations for 2023/2024 on tier assignments, model parameterizations, time periods for reference biomass estimation or appropriate catch averages, OFLs and ABCs. The team recommends three stocks be placed in Tier 3 (Bristol Bay red king crab, EBS Tanner crab, and Aleutian Islands golden king crab), five stocks in Tier 4 (EBS snow crab, St. Matthew Island 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). Table 5 lists those stocks for which the team recommends an ABC less than the maximum permissible ABC for 2023/24.

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 2023 CPT Report).

General Recommendations for all Assessments

1. The CPT recommends that all assessment authors document assumptions and simulate data under those assumptions to test the ability of the model to estimate key parameters in an unbiased manner. These simulations would be used to demonstrate precision and bias in estimated model parameters.
2. The CPT recommends that weighting factors be expressed as sigmas or CVs or effective sample sizes. The team requests all authors to follow the Guidelines for SAFE preparation and to follow the Terms of Reference as listed therein as applicable by individual assessment for both content and diagnostics.
3. Authors should focus on displaying information on revised models as compared to last year's model rather than focusing on aspects of the assessment that have not changed from the previous year.
4. The current approach for fitting length-composition data accounts for sampling error but ignores the fact that selectivity among size classes is not constant within years; a small change in the selectivity on small animals could lead to a very large change in the catch of such animals. Authors are encouraged to develop approaches for accounting for this source of process error. This issue is generic to assessments of crab and groundfish stocks.
5. Authors are reminded that assessments should include the time series of stock estimates at the time of survey for at least the author's recommended model in that year.
6. Consider stepwise changes to data as individual model runs instead of changing multiple parameters at once so that changes in model performance may be attributed to specific data.

By convention the CPT used the following conversions to include tables in both pounds (lb) and metric tons (t) in the status summary sections:

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

Stock Status Summaries

1 Eastern Bering Sea Snow crab

Fishery information relative to OFL setting

The 2022/23 directed fishery was closed. Bycatch in the non-directed crab and groundfish fisheries resulted in a total catch mortality of 0.05 kt (with handling mortality rates applied). Because the total catch mortality for this stock was below the 2022/23 OFL of 10.3 kt, overfishing did not occur.

Data and assessment methodology

The stock assessment uses a size- and sex-structured model in which crabs are categorized as immature or mature, and growth ends with terminal molt. The model is fit to biomass and size frequency data from the NMFS trawl survey, total catch data from the directed fishery, bycatch data from the non-directed crab and groundfish fisheries. The model also utilizes biomass estimates and size frequency data from the 2009 and 2010 BSFRF surveys. Updated data in the 2023 assessment include 2023 eastern Bering Sea survey biomass and length composition data and non-directed discard length frequency and discard biomass from 2022. Results from the 2023 NMFS bottom trawl survey indicated an increase in male abundance relative to the 2022 survey, though the majority of these crab will not enter the fishery for several years. The estimated abundance in 2023 of commercially-viable male crab (> 101 mm carapace width) was the lowest in the time series.

GMACS was approved for use in this assessment by the SSC in June 2022. The assessment author compared last year's accepted model (model 22.1) with five alternatives. Model 23.1 was last year's model fit to updated data. Models 23.2, 23.3, 23.3a, and 23.3b specified the probability of having undergone terminal molt based on NMFS survey data. Model 23.3 specified survey selectivity based on BSFRF data, while model 23.3a used the BSFRF data as priors when estimating selectivity. Model 23.3b loosened the prior on natural mortality in model 23.3a.

The assessment author noted that the 23.3 model series all reduced bimodality issues in reference point calculation and recommended model 23.3a, because it incorporates the best available science on the biology of the stock and it propagates uncertainty in survey selectivity. Model 23.3b was not preferred because loosening the prior on M resulted in a high estimate of M that is inconsistent with life history. The CPT agreed with the author's recommendation that model 23.3a best represented the stock dynamics.

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 in the 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 event moved through the size classes, but that recruitment has since disappeared, and the observed MMB reached an all-time low (24.21 kt) in the 2023 survey. The model estimated a sharp uptick in MMB at the time of the survey from 2022 to 2023, despite the decrease in observed biomass.

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 2019, but it was not present in subsequent 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

Snow crab was declared overfished in 2021 on the basis that the 2021 assessment indicated MMB was below the MSST. EBS snow crab was a Tier 3 stock in previous assessments, with the OFL determined by the F_{OFL} control rule using $F_{35\%}$ as the proxy for F_{MSY}. The Tier 3 proxy for B_{MSY} ($B_{35\%}$) is the MMB at mating based on average recruitment from 1982 to present. The recommended model (23.3a) updates the annual probability of having undergone terminal molt and includes a large proportion of morphometrically mature males that are presumably too small to effectively contribute to reproduction and will not attain a commercially viable size (> 101 mm CW). Thus, $F_{35\%}$ would require near 100% exploitation of commercially viable males. The CPT noted the concern that $B_{35\%}$ assumes reproductive equivalency among mature males of all sizes, which is unlikely the case.

For 2023, the CPT recommends that Tier 4 harvest control rules be used for setting reference points for the 2023/24 fishing season. This is intended to be a temporary measure until more appropriate reference point specifications are determined for the stock. In the Tier 4 approach the F_{MSY} proxy is equivalent to natural mortality (M). In effect, using M as a proxy for F_{MSY} reduces fishing mortality on large mature males which are the most reproductively viable. The B_{MSY} proxy is the average MMB from 1982 – 2022.

The current assessment model estimates that MMB for February 15, 2023 (92.39 kt) was 34% of B_{MSY} (273.83 kt). The Tier 4 approach results in an OFL of 0.31 kt. The projected MMB at the time of mating assuming the OFL was taken for 2023/24 is above the criteria for a directed fishery closure. The CPT recommends that the ABC buffer be decreased to 20%. This decrease was based on reduced concern over model convergence and bimodality, and use of Tier 4 harvest control rules.

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
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	41.3	2.5	2.5	3.6	7.5	5.6
2022/23	136.9	92.4	Closed	0	0.05	10.3	7.7
2023/24		69.2				0.31	0.25

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
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	91.1	5.5	5.5	7.9	16.5	12.4
2022/23	301.8	203.7	Closed	0	0.11	22.7	17.0
2023/24		152.6				0.68	0.55

2 Bristol Bay Red King Crab

Fishery information relative to OFL setting

The 2022/23 directed fishery was closed. Bycatch in the non-directed crab and groundfish fisheries resulted in a total catch mortality of 0.07 kt (with handling mortality rates applied). Because the total catch mortality for this stock was below the 2022/23 OFL of 3.04 kt, overfishing did not occur.

Data and assessment methodology

The stock assessment uses 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, bycatch in the groundfish fisheries, and dockside retained catch sampling. Annual stock abundance was estimated for male and female crab ≥ 65-mm CL from 1975 to 2023 and mature male (males ≥120 mm CL) biomass was projected to 15 February 2024. The assessment was updated with 2022/23 fishery data on bycatch in the non-directed crab and groundfish fisheries, as well as data from the 2023 NMFS trawl survey.

Three model scenarios requested by the CPT were evaluated using GMACS (version 2.01.M.01, 2023-03-13) for the 2023 assessment. Model 21.1b, on which the other models were based, was the same as the 2022 assessment model. Model 22.0 was identical to 21.1b except that it started in 1985 rather than 1975. Model 23.0a was identical to 21.1b except that it estimated M for males, rather than fixing it to 0.18 yr^{-1}.

In selecting a model on which to base management decisions, the CPT noted its previous recommendation to authors that in most cases more data is better and that the default approach should be to use all the available data. The author agreed that the rationale for ignoring data before the 1985 start time in Model 22.0 was not strong enough, when coupled with its poor retrospective patterns, to justify using it for management decisions. The author did not have strong reasons for selecting between Model 21.1b or 23.0a, but suggested that the estimated value for male M from Model 23.0a (0.23 yr^{-1}) was more biologically realistic, based on current life history-based estimators for M, than the fixed value used in 21.1b (0.18 yr^{-1}). Several members of the CPT and other experts in attendance supported this contention. CPT discussion focused on the efficacy of estimating M and noted that recent work on length-based assessments (Cronin-Fine and Punt, 2022) found that it was better to estimate M than to pre-specify it, since pre-specifying M to the wrong value could lead to inaccurate and imprecise estimates for growth parameters and spawning stock biomass. Model 23.0a also exhibited lower retrospective bias. As a result, the CPT recommends that model 22.03a be adopted for status determination and OFL setting.

Stock biomass and recruitment trends

Based on model 23.0a, the MMB at the time of mating is estimated to have been highest in the late 1970s (~128 kt), with secondary peaks in 1989 (30 kt) and 2002-2003 (~35 kt), followed by a gradual decline. The estimated MMB at time of mating in 2022/23 was 18.34 kt. The projection for the 2023/24 time of mating, which assumes the fishing mortality in 2023/24 matches that corresponding to the OFL, is 14.98 kt. Estimates of recruitment since 1985 have been generally low relative to those estimated for the period prior to 1985 and with intermittent peaks in 1995, 2002, and 2005 (83, 74, and 54 million crab, respectively). The estimate for 2023, 7.5 million crab, was the second largest since 2018 but is highly uncertain because it is based on only the 2023 NMFS EBS survey data.

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

Based on the information available, BBRKC is categorized as a Tier 3 stock. The CPT recommends computing average recruitment as has been done in recent assessments (i.e., based on model recruitment

using the time period from 1984 (corresponding to fertilization in 1977) to the penultimate year of the assessment. The estimated $B_{35\%}$ is 19.36 kt. MMB projected for 2023/24 is 14.98 kt, 77% of $B_{35\%}$. Consequently, the BBRKC stock is in Tier 3b for 2023/24. The corresponding OFL is 4.42 kt.

The CPT recommends continuing to use a 20% buffer because the level of uncertainty expressed in 2021 and 2022 remains, although the basis for those concerns has changed slightly. These include:

- Continued lack of recent recruitment
- Poor and variable environmental conditions (e.g., cold pool distributional shifts)
- NMFS female survey biomass in 2023 increased above historically low levels for the first time in five years, but this was predicated on a single exceedingly large tow (thus the accompanying uncertainty was large)
- The lack of fit to 2018-2023 NMFS female survey biomass
- The retrospective patterns exhibited by the recommended model, even though this was improved over last year's assessment model (21.1b)

MMB for 2022/23 was estimated to be 18.34 kt and above MSST (9.68 kt), hence the stock was not overfished in 2022/23. The total catch mortality in 2022/23 (0.07 kt) was less than the 2022/23 OFL (3.04 kt); hence overfishing did not occur in 2022/23. Based on MCMC projections, the probability of MMB in 2023/24 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
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	9.68	18.34	0	0.02	0.07	3.04	2.43
2023/24		14.98				4.42	3.54

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
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	21.3	40.4	0	0.05	0.16	6.70	5.35
2023/24		32.4				9.75	7.8

Note: 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

A single OFL is set for Tanner crab in the EBS. The State of Alaska sets separate TACs for directed fisheries east and west of 166° W longitude. The retained catch in the area west of 166°W longitude was 384 t, and 528 t for the area east of 166°W longitude. Bycatch in the non-directed crab and groundfish fisheries resulted in a total catch mortality of 1.19 kt (with handling mortality rates applied). Because the total catch mortality for this stock was below the 2022/23 OFL of 32.81 kt, overfishing did not occur.

Data and assessment methodology

The stock assessment uses a size- and sex-structured model in which crabs are categorized as immature or mature, and growth ends with terminal molt. The model is fit to biomass and size frequency data from the NMFS trawl survey, total catch data from the directed fishery, bycatch data from the non-directed crab and groundfish fisheries. Updated data in the 2023 assessment include 2023 eastern Bering Sea survey biomass and length composition data, retained and total catch data in the directed fishery, and bycatch data in the groundfish fisheries.

The CPT-recommended model 22.03b is a slightly revised version of model 22.03 that was updated to fix a parameter that was hitting a bound.

Stock biomass and recruitment trends

The MMB at the time of mating was 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 on February 15, 2023 was 74.17 kt and the projection for February 15, 2024 was 48.77 kt under the assumption that the OFL was taken. 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 – 2022, based on the approach used to select the time period for the 2022 assessment, which excluded the most recent estimate of recruitment given its uncertainty.

Based on the estimated biomass on February 15, 2023, the stock is at 137% of B_{MSY}, and therefore is in Tier 3a. The F_{MSY} proxy ($F_{35\%}$) is 1.16 yr^{-1}, and the 2023/24 F_{OFL} is 1.16 yr^{-1} under the Tier 3a OFL control rule, which results in a total OFL of 36.20 kt. The CPT recommended a 25% buffer to account for model uncertainty and stock productivity uncertainty be applied to the OFL to set ABC = 27.15 kt. The 25% buffer is an increase from previous years due to increased concerns regarding the appropriateness of $B_{35\%}$ and $F_{35\%}$ as proxies due to uncertainty related to MMB as the currency of management, similar to those expressed for snow crab.

Total catch mortality in 2022/23 (1.19 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
2019/20	18.31	56.16	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	18.19	74.17	0.91	0.91	1.19	32.81	26.25
2023/24		48.77				36.20	27.15

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
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	40.11	163.52	2.02	2.01	2.62	72.34	54.25
2023/24		107.52				79.82	59.86

4 Pribilof Islands red king crab

The Pribilof Islands red king crab (PIRKC) assessment is on a triennial cycle. A full assessment was conducted in 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, the next assessment will occur in 2025.

Fishery information relative to OFL setting.

The 2022/23 directed fishery was closed. Bycatch in the non-directed crab and groundfish fisheries resulted in a total catch mortality of 0.25 t (with handling mortality rates applied). Because the total catch mortality for this stock was below the 2022/23 OFL of 1.16 t, overfishing did not occur. The stock was declared overfished in 2002 and a rebuilding plan was 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. The stock remains under a rebuilding plan, with no time specified to rebuild.

Data and assessment methodology

The 2021 assessment was conducted in May, prior to the 2021 NMFS EBS shelf survey and the completion of the crab year (July 1-June 30). The timing of the assessment was subsequently changed to September beginning in 2023, to be able to incorporate the current year's EBS shelf survey and bycatch data for the complete crab year.

The current methodology is the same as in the 2021 assessment. This approach uses a state space/random effects random walk model to smooth survey MMB prior to estimating MMB at mating (February 15), accounting for natural and fishing mortality in the period between the survey and the time of mating.

The 2023 assessment evaluated three scenarios addressing the observation of zero mature males in the 2023 NMFS EBS shelf survey: 1) to treat 2023 as missing data (i.e., 'NA'), 2) to set 2023 to a small constant, or 3) assume a Tweedie error distribution as opposed to lognormal. Following Groundfish Plan Team recommendations, the CPT recommends treating 2023 as missing data, since model predictions were sensitive to the small constant used and MCMC results could not be produced for the Tweedie model.

Stock biomass and recruitment trends

The 2023/24 MMB at mating is projected to be 181 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

The CPT recommends that stock status be evaluated using Tier 4 methods. B_{MSY} was estimated using the time periods 1980/81 -1984/85 and 1990/91-1997/98. This range was chosen as representative of the productive potential of the stock. B_{MSY} is estimated at 4,196 t for 2023/24. Because the projected 2023/24 estimate of MMB is less than 25% B_{MSY}, the stock is in stock status c and the directed fishery F is 0.

The OFL specified as part of the rebuilding plan is based on average groundfish bycatch between 1999/2000 and 2005/06. The recommended OFL for 2023/24 and 2024/25 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 buffer levels for other stocks for which the OFL is based upon average catch.

Total catch mortality was below the OFL for 2022/23; 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
2020/21	2,049	181	Closed	0	0.00	1.16	0.87
2021/22	2,098	235	Closed	0	0.102	1.16	0.87
2022/23	2,098	180	Closed	0	0.25	1.16	0.87
2023/24		181				1.16	0.87
2024/25		181				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
2020/21	4.517	0.399	Closed	0	0.0000	0.0026	0.0019
2021/22	4.625	0.518	Closed	0	0.0002	0.0026	0.0019
2022/23	4.625	0.397	Closed	0	0.0006	0.0026	0.0019
2023/24		0.398				0.0026	0.0019
2024/25		0.398				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.

Historical status and catch specifications for St. Matthew Island 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)	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

Historical status and catch specifications for St. Matthew Island 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	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. During the 2022 fishery, 2,708 crab (3.48 t) were harvested in the winter and 125,042 crab (0.144 thousand t) were harvested in the summer commercial fishery. In the winter subsistence fishery, 7,565 crab (6.94 t) were caught and retained, and 2,476 crab (1.12 t) were not retained.

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 2022: retained catch and size-composition data from the commercial and subsistence fisheries for 2022; discards for the winter subsistence fishery; 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 2022 NOAA Northern Bering Sea summer trawl survey.

The assessment is based on a length-based model of male crab abundance that combines these multiple sources of data. 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 penalized maximum likelihood approach is used to estimate quantities relevant in management.

The assessment author presented results from one model (21.0) with updated data for consideration by the CPT for status determination and OFL/ABC calculation. 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 M of 0.62 yr^{-1}.

The two important decision points considered by the CPT were: 1) whether to calculate the OFL based on an F_{OFL} that is size-dependent and proportional to natural mortality at size; and 2) how to calculate discards to determine the total catch for comparison against the OFL. After evaluating the model in terms of fits to the updated data, estimability of parameters, and reasonableness of assumptions, the CPT recommended model 21.0 to determine status and calculate OFL and ABC.

Stock biomass and recruitment trends

Estimated mature male biomass was 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 in 2021 increased to the highest level since the late 1980s after the lowest estimated levels in 2019. Estimated MMB in 2022 was slightly lower than 2021 estimates. Estimated recruitment has generally been variable, and the most recent recruitment estimate is one of the largest since the late 1970s. The 2022 NMFS survey estimate of male abundance declined slightly from the 2021 estimate. Standardized CPUE from the 2022 summer commercial fishery increased sharply from the lows observed in 2019.

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

The B_{MSY} proxy for model 21.0 was calculated as the average of mature male biomass on February 1 during 1980-2023 and equaled 1.98 thousand t. The estimated 2023 mature male biomass on February 1 was 2.40 thousand t, which was above the B_{MSY} proxy for this stock, placing Norton Sound red king crab in status category 4a. The Tier 4 F_{MSY} proxy for NSRKC is M =0.18 yr^{-1}, and the associated F_{OFL} was 0.18 yr^{-1} using the default gamma (=1.0) because the 2023 mature male biomass is greater than the B_{MSY} proxy. The CPT recommended using a length-invariant M to set the fully selected F_{OFL} for calculation of the OFL given uncertainties around mechanisms behind the estimated changes in natural mortality by size, which is how the OFL has been calculated in previous years. The CPT also recommended a retained catch OFL for 2023, which is different than the total catch OFL used for 2022. Given these recommendations, the 2023 Tier 4a retained catch OFL is 0.292 thousand t (0.643 million lb).

The CPT recommended that the ABC for 2023 be set below the maximum permissible ABC. The team recommended that the SSC-endorsed 2022 buffer of 40% from the OFL be reduced to 30% given a reduction in the number of concerns with the status of the stock and assessment model since 2022. Previous concerns that are still an issue include:

- uncertainty regarding biological characteristics
    - M and 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 the ADFG and NOAA NBS survey estimates remain unresolved
- 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

Concerns in 2022 that are no longer concerns include:

- Low standardized fishery CPUE
- High proportions of barren females
- Poor recruitment and uncertainty in the most recent large pseudocohort

Uncertainty caused by attempting to set a total catch OFL when there is no observed discards, which was a key reason for the higher buffer of 40% in 2021

The resulting ABC is 0.204 thousand t (0.450 million lb).

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	0.63	0.35
2022	2.08	5.33	0.34	0.34	0.36	0.67	0.40
2023	2.65	5.29				0.643	0.450

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	0.29	0.16
2022	0.95	2.42	0.15	0.15	0.16	0.30	0.18
2023	1.20	2.40				0.292	0.204

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 in 2021-2022, but return to retained catch values in 2023.

Discard catch mortality was estimated within the model to be 0.01 thousand t and was added to observed retained catch to produce a total catch mortality. Total catch mortality in 2022 (0.16 thousand t) was less than the OFL (0.30 thousand t); therefore, overfishing did not occur.

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 remained at 2.586 kt (5.7 million lb) until 2005/06 when the fishery was rationalized, at which time the TAC was set to the same value. The TAC remained at 2.586 kt (5.7 million lb) until 2008/09, at which point it was increased to 2.715 kt (5.99 million lb) and remained so until the 2011/12 season. Between 2012/13 and 2021/22, the TAC fluctuated between 2.515 kt (5.6 million lb; 2016/17 season) and 3.257 kt (7.18 million lb; 2019/20 season). Since 2019/20, the TACs have been based on the harvest strategy adopted by the Alaska Board of Fisheries in March 2019.

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. Prior to 2022/23, retained catch in the post-rationalized fishery ranged from 2.379 kt (5.3 million lb) in 2006/07 to 3.319 kt (7.32 million lb) in 2019/20. Total catch mortality ranged from 2.506 to 3.729 kt (5.5 to 8.2 million lb) for the same period. At the time of the 2023/24 assessment, the fisheries had not been completed, so retained catch and total catch mortality are estimates. The estimated retained catch in 2022/23 was 2.369 t (5.2 million lb), the lowest in the post-rationalized period, while the estimated total catch mortality was 2.612 kt (5.8 million lb), the third lowest in this time period.

Data and assessment methodology

The assessment for AI golden king crab establishes a single OFL and ABC for the whole stock. However, separate models are evaluated for the EAG and the WAG owing to, *inter alia,* different abundance trends in each area. A Tier 3 modeling framework for AI golden king crab based on fisheries-only data was developed over several years starting in 2011 with model assumptions and data inputs refined by reviews by the SSC and CPT. This modeling framework was recommended for the assessment by the CPT in September 2016 and approved by the SSC in October 2016. More recently, transition from this bespoke model to the GMACS modeling framework has been underway for several years. The CPT endorsed, and the SSC subsequently approved, the GMACS model for this stock in January 2023. This assessment includes the bespoke model accepted for the 2022 assessment modified for comparison with GMACS and updated with 2022/23 data, and an equivalent GMACS model.

The model-based stock assessment involves fitting a male-only population dynamics model to data on catches and discards in the directed fishery, discards in the groundfish fishery, standardized indices of abundance based on observer and fish ticket data, length-frequency data for the directed fishery (landings and total catch), and mark-recapture data. The fisheries in both areas were still operating when the assessment was conducted (March 17, 2023), so the assessment was based on the CPT/SSC-recommended assumption that the 2022/23 TACs for the EAG and WAG would be taken before the fishery seasons closed. Year-end total catches in both areas were then projected using the predicted final effort in each area to scale the nominal final-year total catch CPUE, where the predicted final effort was estimated as the ratio of TAC to the final-year retained catch CPUE. Additionally, a cooperative survey was conducted by the Aleutian King Crab Research Foundation (an industry group) and ADF&G during the 2022/23 fishing year. This survey has been conducted annually (except 2020) in the EAG since 2016, and once in the WAG in 2018.

The assessment authors examined three model scenarios applied in common to both the EAG and WAG this assessment cycle. Model 22.9c was the 2022 assessment model, modified for comparison with the equivalent GMACS model and updated with 2022/23 data. Model 22.1e2 was the equivalent GMACS version. The two versions produced almost identical results. This model configuration included three catchability periods, knife-edge male maturity size at 116 mm CL, M set to 0.22 yr^{-1}, a fixed period (1987–2017) for reference points calculation, and the addition of new data for 2022/23. Model 22.1f was identical to 22.1e2 but was fit to CPUE data that included a Year x Block effect in the CPUE standardization procedures.

Two additional models for the EAG, Models 22.1g and 22.1h, were also examined: these were based on Models 22.1e and 22.1f, respectively, but with the 2015-2022 cooperative survey data substituted for the total catch CPUE. The CPT noted that the cooperative survey data should have been added to these models as an additional fleet, not simply replacing the existing total catch CPUE indices, because the latter approach assumes the same selectivity and catchability apply in the fishery and survey.

For the EAG, the three "common" models provided very similar results. All three fit the retained catch, total catch, and groundfish bycatch data well, except that Model 22.9c did not fit the retained catch data at the start of the time series. Otherwise, the three models fit the catch data almost identically. All three models also fit the standardized CPUE indices similarly, but the overall fits were poor. The fits to the retained catch and total catch size compositions were good, except in the smallest size bin for total catch prior to 2005/06, where the models substantially underestimated the relative abundance. This, however, was likely due to this bin acting as an accumulator for all crab smaller than the model size range, although the reasons why so many small crab were caught during this time period remained unknown. The CPT noted that, in any case, a standard procedure would be to exclude crab smaller than the modeled size range from the size composition data but also cautioned that it might be necessary to drop the early data as suspect. It also noted that fitting these data may in part explain the large change in fishery selectivity between the pre-and post-rationalization periods.

For the WAG, all three models fit the respective catch data and standardized CPUE indices equally well and produced similar estimates for the recruitment and MMB time series. The models followed the trends in standardized CPUE much better than the EAG models. However, the issue with the high relative abundances of small crab in the total catch size compositions was also evident in the data for the WAG.

The authors' preferred models were 22.1f for the WAG and 22.1e2 for the EAG, noting that a case could be made for including the Year *x* Block interaction term in the CPUE standardization for the WAG but not the EAG. The CPT noted several potential issues with the Year *x* Block standardization for the WAG, including a large spike in CPUE in 2009 in block 5 and apparent quantization in the associated partial residual plots for several other blocks. The consensus recommendation by the CPT was to use 22.1e2 for the two areas.

Stock biomass and recruitment trends

Estimated mature male biomass (MMB) for the EAG decreased from the 1980s to the 1990s, then increased during the 2000s, decreased marginally during 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, Model 22.1e2, is identical to the model used in the previous assessment, except that it is implemented using GMACS. New data for the assessment included fishery data for the 2022/23 fishing season; in addition, the standardized CPUE indices were updated.

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 2023/24. A single OFL and ABC is defined for AIGKC. However, separate models are available by area. During its 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. However, area-specific stock status is 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 summed 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 2023 concern?	Reason
Only crab assessment that relies entirely on fishery CPUE as an index of abundance	2020	Yes	No change.
Uncertainty in natural mortality	2020	Less	A revised estimate for natural mortality based on a peer-reviewed study (Siddeek et al., 2022) was used.
The limited spatial coverage of the fishery with respect to the total stock distribution	2020	Yes	No change.
The small number of vessels on which CPUE is based	2020	Yes	No change.
Retrospective pattern for the EAG	2020	Yes	No change. Retrospective patterns were not presented, but assumed to be similar to those seen last year.
CPUE standardization is still subject to some methodological concerns	2020	Less	No change. Principal methodological concerns have been met, but some issues remain.
Catches from the WAG that were not included in the assessment	2021	Less	Method to extrapolate retained and total catches to year end has been documented; CPT accepted the method used.
Model convergence concerns reflecting potential parameter confounding (jitter analysis resulted in multiple solutions for MMB and $B_{35\%}$ at same likelihood values)	2021	Unknown	Jitter analysis was not conducted for the CPT-recommended models.

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. In 2022/23, the CPT recommended, and the SSC concurred with, reducing the buffer for the ABC back to 25%, its value before 2021/22, principally because no problems of this sort occurred for the 2022 recommended models and the CPT found reasons to reduce or eliminate several other concerns. For 2023/24, the CPT found that several previously expressed concerns continued to exist, the principal one being the retrospective patterns for the recommended EAG model. Thus, the CPT recommends continuing to use a 25% buffer, its value last year, on the OFL for the ABC.

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
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	3.056	4.817	3.372
2022/23	5.832	13.600	2.291	2.369[a]	2.612[a]	3.761	2.821
2023/24		12.069				4.182	3.137

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
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	6.737	10.620	7.434
2022/23	12.857	29.984	5.050	5.223[a]	5.659	8.291	6.219
2023/24		26.607				9.220	6.916

[a] The fisheries were still being prosecuted when the 2023 assessment was conducted.

9 Pribilof District Golden King Crab

In accordance with the approved schedule, the Pribilof Islands golden king crab (PIGKC) assessment is conducted triennially with the previous assessment in 2020. Therefore, a full stock assessment was conducted in 2023 with results to be applied for the 2024–2026 specifications. The PIGKC stock is managed by calendar year, rather than a crab year, basis. Additional information listed below summarizes the 2023 assessment.

Fishery information relative to OFL setting

The PIGKC fishery began in the 1981/82 season. 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, which was 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 1991/92–2022 due to groundfish fisheries range from negligible to 9 t.

Data and assessment methodology

There is no assessment model for this stock. Fish ticket and observer data are available, as are size-frequency data from samples of landed crabs, and pot lifts sampled during crab fisheries, 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 2023 assessment; however, there is no indication that the slope survey will be conducted with any regularity in future years. The CPT recommends that the Tier 4 model not be adopted until updated survey data become available.

Stock biomass and recruitment trends

There are 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 2024-2026. The CPT concurs with the author's recommended status quo OFL of 94.7 t and an ABC of 71.1 t. The OFL and ABC differ from the previous SAFE due to updates to the estimates of historical bycatch in the groundfish fisheries. 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.

Total catches in 2020-2022 were 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
2019			59	Conf.	Conf.	93	70
2020			59	49	52	93	70
2021			59	16	21	93	70
2022			59	Conf.	Conf.	93	70
2023			59			93	70
2024						95	71
2025						95	71
2026						95	71

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
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	Conf.	Conf.	0.20	0.15
2023			0.13			0.20	0.15
2024						0.21	0.16
2025						0.21	0.16
2026						0.21	0.16

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 2020. Therefore, a full stock assessment was conducted in 2023 with results to be applied for the 2023/24, 2024/25, and 2025/26 specifications. Additional information listed below summarizes the 2023 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.

Bycatch 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 2022/23 averaged 27 t. The average retained catch during that period was 20 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 2022/23 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 2022/23 and from groundfish fisheries from 1993/94 to 2022/23 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 historical 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 aging 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 King Crab Research Foundation and ADF&G in the Adak area in 2015 and the Petrel Bank area in 2016, which 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 2023/24, 2024/25, and 2025/26 seasons. The CPT concurs with the assessment author's recommendation of an OFL based on the 1995/96–2007/08 average total catch following the recommendation of the SSC in June 2010 to set the time period for computing the OFL at 1995/96–2007/08. The CPT recommends an OFL for 2023/24, 2024/25, and 2025/26 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 2023/24, 2024/25, and 2025/26 which is equivalent to a 75% buffer on OFL. The recommended ABC of 14 t is the same as that recommended by the CPT in 2017 and 2020. The ABC was lowered in 2017 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 most recent industry-cooperative surveys. This logic still applies for this assessment cycle. The total catch in 202/21, 2021/22, and 2022/23 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
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			Closed	0	<1	56	14
2023/24						56	14
2024/25						56	14
2025/26						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
2018/19			Closed	0	0.00146	0.12387	0.07432
2019/20			Closed	0	0.00166	0.12387	0.03097
2020/21			Closed	0	0.00075	0.12387	0.03097
2021/22			Closed	0	0.00016	0.12387	0.03097
2022/23			Closed	0	0.00009	0.12387	0.03097
2023/24						0.12387	0.03097
2024/25						0.12387	0.03097
2025/26						0.12387	0.03097

Figures and Tables

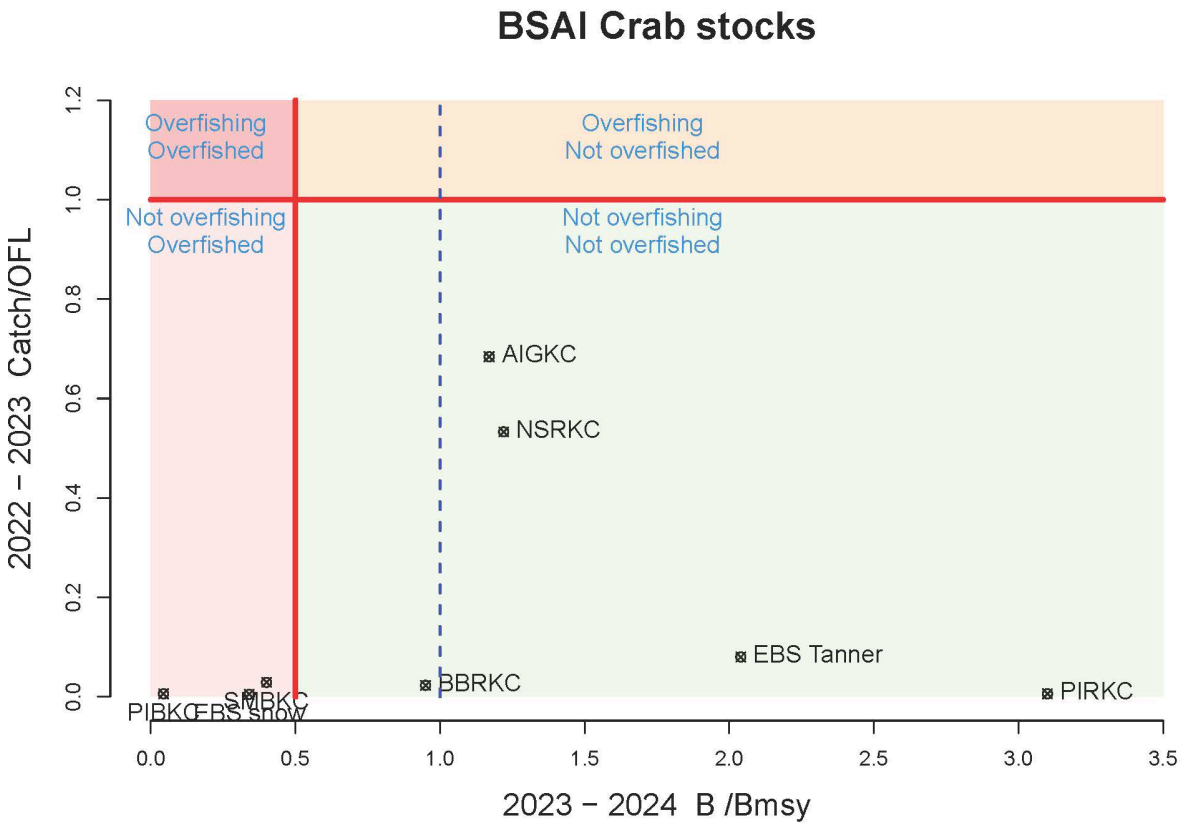

Figure 2: Status of eight Bering Sea and Aleutian Islands crab stocks in relation to status determination criteria (B_{MSY}, MSST, overfishing) for 2022/23. Note that information is insufficient to assess Tier 5 stocks according to these criteria (WAIRKC, PIGKC).

Table 4: Stock status in relation to status determination criteria for 2022/23 as estimated by the most recent assessment. Hatched areas indicate parameters not applicable for that tier. Values are in thousands of metric tons (kt).

Chapter	Stock	Tier	MSST[1]	BMSY or BMSYproxy	2022/23[2] MMB	2022/23 MMB/ MMBMSY	2022/23 OFL	2022/23 Total Catch	Rebuilding Status
1	EBS snow crab	3	136.9	273.8	92.4	0.34	10.32	0.05	**overfished**
2	BB red king crab	3	9.68	19.36	18.34	0.95	3.04	0.07	
3	EBS Tanner crab	3	18.19	36.39	74.17	2.04	32.81	2.62	
4	Pribilof Islands red king crab	4	0.85	1.71	3.88	2.27	0.685	0.004	
5	Pribilof Islands blue king crab	4	2.10	4.10	0.18	0.044	0.00116	0.00	**overfished**
6	St. Matthew Island blue king crab	4	1.63	3.26	1.31	0.40	0.07	0.002	**overfished**
7	Norton Sound red king crab [2]	4	0.95	1.98	2.42	1.22	0.30	0.16	
8	AI golden king crab	3	5.832	11.66	13.60	1.17	3.76	2.57	
9	Pribilof Islands golden king crab [3]	5					0.093	Conf.	
10	Western AI red king crab	5					0.056	<0.001	

[1] As estimated in the 2023 assessment.
[2] For Norton Sound red king crab, MMB on 2/1/2023 is estimated using the current assessment in January 2023. Stock status for NSRKC is determined in February.
[3] PIGKC specifications are set on a calendar year basis.

Table 5: CPT recommendations for Eastern Bering Sea crab stocks. Stocks for which specifications are rolled over between assessments (Pribilof Islands blue king crab, Pribilof Islands golden king crab and Western Aleutian Islands red king crab) or were set in February (Norton Sound red king crab) are also included. Biomass values are in thousand metric tons (kt). Tier designations in this table are based on the projected stock status in 2023/2024. Stocks for which the SSC recommended different harvest specifications from the CPT are bolded. 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). Chapter 7 is set in February.

Chapter	Stock	Tier	FOFL	BMSY or BMSYproxy	BMSY basis years[1]	2023/2024[2] MMB	2023/24 MMB / MMBMSY	Natural Mortality (M)	2023/24 OFL	2023/24 ABC	ABC Buffer
1	E. Bering Sea snow crab	4b	0.05	273.8	1982-2022	69.2	0.34	0.29	0.31	0.25	20%
2	Bristol Bay red king crab	3b	0.30	19.36	1984-2022	14.98	0.76	0.18	4.42	3.54	20%
3	E. Bering Sea Tanner crab	3a	1.16	36.39	1982-2022	48.77	1.34	0.23	36.20	27.15	25%
4	Pribilof Is. red king crab	4a	0.21	1.71	2000-2021	3.88	2.27	0.21	0.685	0.51	25%
5	Pribilof Is. blue king crab	4c	0	4.10	1980/81-1984/85; 1990/91-1997/98	0.18	0.04	0.18	0.00116	0.00087	25%
6	St. Matthew blue king crab	4b	0.06	3.26	1978-2021	1.31	0.40	0.18	0.07	0.05	25%
7	Norton Sound red king crab	4a	0.18	1.98	1980-2023	2.4	1.21	0.18	**0.31**	**0.22**	30%
8	Aleutian Is. golden king crab [3]	3a	0.59 (EAG) 0.50 (WAG)	11.66	1987-2017	12.07	1.04	0.22	4.18	3.14	25%
9	Pribilof Is. golden king crab [4]	5	-	-	-	-	-	-	**0.114**	**0.085**	25%
10	W. Aleutian Is. red king crab	5	-	-	-	-	-	-	0.056	0.014	75%

[1] For Tiers 3, 4 where BMSY proxy is estimable, the years refer to the time period over which the estimate is made. For Tier 5 stocks it is the years from which the catch average for OFL is estimated. MMB on 2/1/23 is estimated using the current assessment for Norton Sound red king crab.

[2] MMB is estimated on 2/1/2023 for Norton Sound red king crab and on 2/15/2023 for all other Tier 1-4 stocks, using the current assessments.

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

[4] PIGKC specifications are set on a calendar year bas