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.