7 Norton Sound red king crab

Fishery information relative to OFL setting

The Norton Sound red king crab (NSRKC) stock supports three fisheries: summer commercial, winter commercial, and subsistence. The summer commercial fishery, which accounts for most of the catch, reached a peak in the late 1970s at a little over 1.313 thousand t retained catch. Retained catches since 1982 have been below 0.227 thousand t, averaging 0.136 thousand t, including several low years in the 1990s. As the crab population rebounded, retained catches increased to 0.231 thousand t in 2016, but decreased 69% to 0.073 thousand t in 2019. In 2020, the winter and summer commercial crab fisheries did not operate; only winter subsistence catch occurred. The winter commercial and subsistence fisheries were conducted in 2021, with retained catches of 320 and 1,763 crabs, respectively. Although the season was not closed, no harvest occurred in the summer commercial fishery in 2021.

Data and assessment methodology

Four types of surveys for NSRKC have occurred periodically during the last three decades: summer trawl, summer pot, winter pot, and preseason summer pot. These provide data on annual abundance and size/shell condition compositions. In addition, time series of standardized CPUE from the summer commercial fishery provide additional indices of abundance. Tag return data provide information on growth. Retained catch data are available from fish tickets for the winter and summer commercial fisheries, as well as from subsistence catch reports. Retained catch size composition data are generally available for the summer commercial fishery, but only limited data are available for the winter commercial fishery. Limited data on discards are available from summer commercial fishery observer data and subsistence catch reports.

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

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

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

assumptions regarding natural mortality relative to model 21.0 (respectively: fixed M=0.18 yr^{-1} for all length classes, a single estimated M applied to all length classes, and separately estimated M's applied to length bins less than and greater than 123.5 mm CL).

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

Stock biomass and recruitment trends

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

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

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

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

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

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

Status and catch specifications (million lb.)

Year	MSST	Biomass (MMB)	GHL	Retained Catch Mortality[1]	Total Catch Mortality[2]	OFL[3]	ABC[3]
2018	2.41	4.08	0.30	0.31	0.34	0.43	0.35
2019	2.24	3.12	0.15	0.08	0.08	0.24	0.19
2020	2.28	3.67	0.17	Conf.	Conf.	0.29	0.20
2021	2.26	5.00	0.31	0.007	0.007	0.59	0.35
2022	2.08	5.33				0.67	0.40

Status and catch specifications (1000 t)

Year	MSST	Biomass (MMB)	GHL	Retained Catch Mortality[1]	Total Catch Mortality[2]	OFL[3]	ABC[3]
2018	1.09	1.85	0.13	0.14	0.15	0.20	0.16
2019	1.03	1.41	0.07	0.04	0.04	0.11	0.09
2020	1.04	1.66	0.08	Conf.	Conf.	0.13	0.09
2021	1.03	2.27	0.14	0.003	0.003	0.20	0.16
2022	0.93	2.17				0.30	0.18

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

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