UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

MEMORANDUM FOR: Jeff Ruch, Director, Pacific PEER. Public Employees for Environmental Responsibility

FROM: NOAA/ National Marine Fisheries Service

SUBJECT: Public Employees for Environmental Responsibility Request for Correction under the Information Quality Act: Bristol Bay Red King Crab

DATE: November 3, 2022

This memorandum serves the NOAA response to the Information Quality Act Request for Correction regarding Bristol Bay King Crab, from Jeff Ruch, Director of Pacific PEER.

NOAA Response

This request for correction of disseminated information under the Information Quality Act is related to the federal survey and assessment of the Bristol Bay red king crab stock in the Federal Bering Sea/Aleutian Islands King and Tanner Crabs Fishery Management Plan. Like all NOAA Fisheries stock assessments, the Bristol Bay red king crab stock assessment has been subject to a public, transparent, and rigorous, peer-review process. Over time, the assessment process has continued to be enhanced and improved with input from a variety of sources. The Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801, et seq.) (Magnuson-Stevens Act) requires that a fishery management plan (FMP) be prepared by the North Pacific Fisheries Management Council (NPFMC) for the Bristol Bay red king crab stock.

That FMP delegates Bristol Bay red king crab management to the State of Alaska with Federal oversight as part of a State/Federal cooperative management regime. As such, the State of Alaska is authorized to set guideline harvest levels that limit the total annual harvest. Under this cooperative management regime, stock assessment responsibilities are split between federal scientists and State of Alaska scientists. The Bristol Bay red king crab stock assessment is developed by the State of Alaska and reviewed for federal management regulation by the NPFMC. A history of the development of previous FMPs and historical changes in the federal crab fishery management can be found in the current FMP. Prior to the first federal FMP, the State of Alaska managed king crab fisheries inside and outside State waters since statehood in 1959.

Additional information on Bering Sea/Aleutian Islands (BSAI) king and Tanner crab fisheries management is available on the National Marine Fisheries Service (NMFS) web page: https://www.fisheries.noaa.gov/alaska/sustainable-fisheries/bering-sea-and-aleutian-islands-bsai-crab-fisheries; the

State of Alaska - Alaska Department of Fish and Game (ADF&G) Shellfish web page: http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisheryShellfish.main; and the NPFMC website: https://www.npfmc.org/fishery-management-plan-team/bsai-crab-plan-team/.

To support the above federal and state management processes associated with Bristol Bay red king crab, NOAA Fisheries has conducted the eastern Bering Sea (EBS) bottom trawl survey since the early 1970s with relatively consistent methods, timing, and spatial coverage. Prior to this, surveys that provided some data on Bristol Bay red king crab were conducted with inconsistent timing, spatial extent, and methodology (Hayes 1983). Starting in 1975, surveys were conducted annually and were expanded beyond Bristol Bay to include the majority of the Bering Sea continental shelf with the original purpose of assessing potential resource impacts of offshore oil development (Pereyra et al. 1978). The purpose of the survey has since been to collect data on the distribution and abundance of crab, groundfish, and other benthic resources to estimate population abundances and to inform management. Throughout decades of improved and better-defined management processes, the Bristol Bay red king crab abundance and catches have been highly variable with causes attributed to fishing effects on the Bering Sea ecosystems, environmental variability, predation/competition, and fisheries management (bycatch, exploitation rate, etc.) (Loher et al. 1995).

The request for correction of information concerns survey design, data collection, stock assessment, and fisheries management decisions. This response is focused on federal data collected and analyzed and does not address the Bristol Bay red king crab stock assessment model conducted by the State of Alaska or the discussions/decisions of the North Pacific Fisheries Management Council Crab Plan Team or Science and Statistical Committee.

In general, the request(s) for correction of information stem from the concern that "During the 1970s and 1980s, extra, ad hoc, non-design-based sampling defeated the purpose of the NMFS systematic sampling design to provide random, unbiased samples." As such, the following specific issues were raised in the request:

1. Non-random and biased sampling. Response:

   The eastern Bering Sea (EBS) bottom trawl survey is based on a stratified systematic design consisting of a grid with a fixed sampling station at the center of each 37.04 × 37.04 km grid square. Throughout the time series, however, the sampling design has been modified to improve estimates, decrease uncertainty, and address crab distributions. In each year of the survey, the best information available at the time was used for management. For instance, higher density stations (a.k.a. "corner stations") have been sampled around St. Matthew and the Pribilof Islands to improve precision in king crab abundance estimates.

   The survey has covered the Bristol Bay region since approximately 1969 and the distribution of Bristol Bay red king crab since 1972; prior to which, stations did not consistently cover the region. However, even after 1969, there was variability in the station distribution and station sampling methods in Bristol Bay. This variability was due to the sampling and analysis tools as well as the accepted methodology available at the

time to sample a contagiously distributed species such as crab. In each year, the best scientific information available at the time was used.

Examples of interannual variability included tow duration, number of tows per stations, survey timing, and area swept calculation (i.e. number of crab per area towed). From 1969 to 1976, most abundance estimates were based on 60-minute tows until studies to improve survey efficiency showed that 30-minute tows resulted in similar catch per area swept (Otto et al. 1978). In an effort to increase precision due to the contagious distribution of crab, extra tows that were conducted at a particular station from separate study projects were used to calculate area swept estimates. Additionally, extra tows were conducted during a roughly 17-year period when specific sample catches reached a threshold (a.k.a. hotspot tows conducted since 1990). In 1999, 2000, 2006-2012, 2017, and 2021 up to 30 Bristol Bay stations were resampled (a.k.a. "Bristol Bay retow") one month after the original tow due to delayed molting and mating cycles for red king crab likely caused by cold bottom temperatures. The resampling was necessary to assess accurately the crab abundance migrating during cold years and the final size distribution of the adult stock. Lastly, from at least 1975 to 1981, there was little information available to calculate the net width estimates used for the area-swept calculations. After 1981, net mensuration data were collected and improved each year thus improving the area-swept calculation. However, to maintain consistency with historical calculations of crab abundances the net mensuration data were not used until 2009 (see below).

In short, over time, the surveys have evolved to reflect improvements in gear design, statistical understanding, and incorporation of variance in models. Through each of these survey augmentations, no effort was made, before 2015, to revisit historical estimates, as there would not be an effect on current management. The methods used in any particular year were based on the current understanding of statistical approaches to sample contagiously distributed animals, resources available for surveys, and the understanding of the crab biology. The best scientific information available in each year was used.

2. Point #3 Survey time series revision in 2015. Response:

Prior to 1994, Bristol Bay red king crab abundance was estimated using an area swept method. This method used a stratified design based on management units. For Bristol Bay red king crab, these units included and still include standard density and high-density stratum. Population abundance estimates were calculated in each stratum and then summed among strata. Variance of the total abundance estimate for each size class was calculated by summing the variance of each stratum.

In 1994, as analytical tools improved and became accessible to fisheries stock assessment analysts, a length-based assessment model was developed to incorporate multiple years and sources of data (Zheng et al. 1995). Developed to reduce annual measurement errors and incorporate survey variance associated with abundance estimates derived from the survey area-swept method, the model combines multiple sources of survey, catch, and bycatch data using a maximum likelihood approach to estimate abundance, recruitment,

selectivity, catch, bycatch, and natural mortality; a substantial improvement on area swept abundance only.

In 2009, NOAA Fisheries and the Crab Plan Team concluded that some of the methods used to assess contagiously distributed crab stocks statistically were no longer relevant now that a mature stock assessment model was available. For instance, the variance of area swept among stations should be addressed within the stock assessment model instead of invoking a post-hoc sampling method as was done historically. Between 2009 and 2015, NOAA Fisheries working through the NPFMC, reassessed the data used in the entire time series to inform the ever increasingly complex length-based assessment model. Due to the capabilities of the assessment model to incorporate uncertainty in data input, estimate variables, and use area swept data directly without external calculations, revisiting the original estimates was warranted to once again improve the abundance estimate precision for stock assessment advice. Prior to 2015, survey reports identified the potential for bias associated with the methods employed at the time (e.g. Daly et al. 2015).

To re-constitute the time series in a digital format, NOAA analysts combined historical digital files as well as written reports with maps and abundance estimates used for assessment in each year (see International North Pacific Fisheries Commission - INPFC reports). Because of changes in data storage technology and corporate changes in structure and location prior to the formation of the current National Marine Fisheries Service under NOAA in 1970, not all data were readily available outside paper reports. Therefore, it is not clear what survey data were used in the final estimates in the INPFC reports, which often contain insufficient detail. The original time series was reproduced as close as possible given non-digital data from the 1960s and 1970s. With guidance and approval of the NPFMC Crab Plan Team and Science and Statistical Committee, the following criteria were developed to remove any *ad hoc* sampling or outdated methodology and recalculate the time series from the data that could be re-constituted (see NPFMC Crab Plan Team minutes January 2014, May 2014; NPFMC Science And Statistical Committee minutes May 2015):

- Database errors and incorporation of unmeasured crab (crushed in tow so average length used to add to abundance estimate) resulted in 1-25% change in an individual station. Previously, unmeasured crab were not included in the abundance estimate with no way to allocate to size bins. The new estimates weighed the importance of providing additional information on abundance by applying length frequency distributions from the part of the catch that could be measured.
- Extra research tows (not affiliated with original survey) were deleted.
- When multiple tows were purposefully sampled, the first tow (whether higher or lower than the average) was used.
- Only 30-minute tows were used.
- Size-weight regressions were used to calculate biomass instead of average catch weight.
- Maturity was determined using morphological criteria instead of size thresholds.

- Area swept from 1982 to 1987 was estimated using the inverse relationship between net scope and net width. From 1988 to current, the net width was estimated using a net mensuration system. Prior to 1982, a fixed width was used in the absence of additional data. This resulted in individual station specific area swept estimate changes between 1 and 10%.

The new times series was then compared to the old time series noting increases and decreases versus what was used at the time. Even with the changes, the variance of the 1970s data remained extremely high relative to variance since 1980 suggesting that the early survey data are still highly uncertain, even though considered to be the best available. The peer-reviewed data were then incorporated into stock assessments within the year (see NPFMC minutes October 2015).

The present survey still employs higher density station spacing around the Pribilof Islands and St. Matthew Island to increase sample sizes of crab for better understanding of the distribution and biology of the stocks. Survey indices, bias corrected variance, and modeled estimates of species selectivity are continually updated as appropriate statistical and modeling tools become available.

Summary response for requested "remedies" in part V of the complainant's letter:

Remedies 1 and 2: NMFS has already publically documented the shift from statistical sampling to dynamic modeling and updated survey index (Zheng et al. 1995, Daly et al. 2015) through the NPFMC process. As noted above, this is a routine part of incorporating best practices and improved capability in our population estimate process, this revision was an improvement in methodology. Questions and discussion about the accuracy of these historical methods and their impact on management decisions made 40 to 45 years ago are suitable for discussion in the scientific peer review literature. However, revising those previous estimates, based on new methods, does not serve a current management purpose as that historical information does not affect current management. (See NMFS IQA guidelines 04-108 III.A.2.c).

Remedies 3,4, and 5: These proposed remedies call for action by the North Pacific Fishery Management Council and not NMFS. Specifically requests for revisions to previous SAFE reports. Those reports are products of the Council and as such those requests should be directed to that body. If the Council decides to revise them, NMFS can assist in that process.

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