Significant Changes in the Bering Sea Since 2004
(Bullets & References final 03.24.23)

- Beginning in 2014, the eastern Bering Sea entered a warm phase of unprecedented duration and intensity beginning 2014, almost certainly caused by anthropogenic global warming (Walsh et al. 2018). This warming appears to be a secular trend that will likely continue during the next several decades (Drinkwater et al. 2021). These warming waters have led to a host of changes in the productivity of the Bering Sea, and to the community structure and functioning of the marine food web (Mueter et al. 2021, Logerwell et al. 2022). Most of the responses documented in the following bullet points are presented more formally in Belkin and Short (2023).
- Warming surface waters have caused declines in the maximum extent of sea ice in the Bering Sea, resulting in earlier spring ice retreats (Stroeve et al. 2014) and later onset of ice in fall (Barber et al. 2017), extending ice-free conditions by nearly three months near the southern limits of sea ice (Stammerjohn et al. 2012).
- The effects of changes in sea ice extent and persistence on biological productivity and community structure are not clearly understood (Mueter et al. 2021). Longer ice-free conditions will likely increase primary productivity in the water column while decreasing productivity associated with sea ice. However, increased productivity in the water column may be attenuated by increased cloud cover. Nutrient limitation may result in smaller planktonic organisms available for consumption by fish and other consumers, leading to longer food chains and altered species and size composition of zooplankton communities that would decrease the availability of food for fish and other higher-order consumer species including seabirds and marine mammals (Batchelder et al. 2012, Barneche et al. 2021, du Pontavice et al. 2020, Hébert et al. 2016, 2017, Venello et al. 2021, 2022).
- Warming bottom waters have led to northwestward expansions or shifts of the distribution of benthic and pelagic fish and shellfish, including commercially important species such as Alaska pollock, king crab and tanner crab (Landeira et al. 2018, Thorson et al. 2019, Logerwell et al. 2022). These distribution shifts may increase travel costs for commercial fishing vessels, or limit the availability of target species if they move into Russian waters. In some cases, habitat compression resulting from

such shifts will likely reduce prey availability for Pacific walrus, which is harvested as a food resource by Alaska Natives, and of commercially fished flatfish such as yellowfin sole and Alaska plaice (Logerwell et al. 2022).

- While predicting the net result of warming-associated changes in the ecological structure and functioning of the Bering Sea food web remains problematic (Mueter et al. 2021), recent population trends of several ecologically or commercially important species suggest widespread declines.
- Mean pollock recruitment since 2000 has been below the long-term average, with especially poor recruitment years associated with warm spring sea surface temperatures and early sea-ice retreat in the southeastern Bering Sea (Ianelli et al. 2021; Fig. 1-58 therein).
- Populations of mature king, tanner and snow crabs remain depressed following recent declines that began around 2015 (Richar 2021).
- Chinook salmon runs in the Arctic-Yukon-Kuskokwim region have remained depressed since about 2008, while chum and coho runs have been depressed since 2019 (Liller 2021).
- As of 2022, the Kuskokwim River is experiencing a catastrophic multi-species salmon decline with low numbers of Chinook, chum and coho (KRITFC 2023). Due to the multi-species nature of the salmon collapse the 2022 season was the most restricted subsistence fishing season ever seen on the Kuskokwim. Brood-year productivity of Chinook salmon has declined to replacement levels leaving no or limited subsistence harvest opportunities. Due to declines of Chinook, Kuskokwim River salmon dependent communities have not met their Chinook salmon "amounts necessary for subsistence" for the past 10 years (KRITFC 2023).
- The Yukon river is experiencing very low runs of Chinook salmon and the near-total collapse of both summer chum and fall chum salmon runs resulting in a failure to meet all chum salmon escapement goals as well as US-CAN treaty obligations for both fall chum and Chinook salmon (JTC 2022, USFWS 2023). As a result of this concurrent Chinook and chum crash, for the first time in living memory there were <u>zero harvest opportunities in the entire Yukon River for any salmon species in both 2021 and 2022</u> (JTC 2022, USFWS 2023). This unprecedented chum salmon crash is deeply troubling

because chum salmon serve as a critical food security supplement in the region in times of low Chinook runs.

- Pacific halibut abundance in the southeastern Bering Sea has been on a downward trajectory since 2015, and below every year since 1993 (International Pacific Halibut Commission 2022).
- Reproductive success of most seabird species in the southeastern Bering Sea plummeted after 2013, with mixed signs of recovery in 2019 (Romano et al. 2019).
- The breeding population of northern fur seals in the Bering Sea continues its long-term decline (Muto et al. 2022), and early sea-ice retreats in 2018 and 2019 resulted in poor body condition and unusual mortality events of ice-dependent seals (Boveng 2019). Declines of the St. Paul population are associated with high commercial catches of pollock in the eastern Bering Sea (Short et al. 2021). Lactating female fur seals that must travel greater distances to find high concentrations of prey (primarily pollock) are less able to nourish their pups (McHuron et al. 2022), thereby decreasing pup survival probability.
- Harmful algal blooms such as those causing paralytic shellfish poisoning appear to be spreading more frequently and widely throughout the eastern Bering Sea as sea surface temperatures rise (Natsuike et al. 2017).
- The Bering Sea is especially vulnerable to adverse effects of ocean acidification, resulting from the combination of cool temperatures, low alkalinity associated with low salinity, and high carbon dioxide concentrations from remineralized organic matter (Falkenberg et al. 2018). These conditions are already corrosive to shells of pteropods and other organisms with the aragonite form of calcium carbonate in parts of the Bering Sea (Drinkwater et al. 2021). Pteropods are an important food source for chum salmon (Tadokoro et al. 1996). Ecosystem stress from ocean acidification will exacerbate stress from warming ocean temperatures and declining sea ice in the Bering Sea.

Summary Observation by J Ayers:

The recent broadly concurrent adverse trends noted above reflect alarming changes in the structure and functioning of the Bering Sea marine ecosystem that are more than likely to continue for the foreseeable future. This reflects an urgent situation requiring a change in management approach to one that recognizes the interrelationship of the fisheries economic driven actions, society and the environment. Peoples living within and depending on the health of the ecosystem must become a priority; it's a matter of Justice. This urgent situation has been discussed and documented by NOAA and other international renowned forums; and cries out for action by the North Pacific Fisheries Management Council and National Marine Fisheries Service. It's beyond time to construct a new PEIS; and implement interim precautionary management measures.

Fisheries management should focus on actions bolstering the resilience of the western Alaska ecosystem and stocks, by preserving the genetic diversity that is the foundation of the capacity of these stocks to adapt to environmental change. Chinook salmon, for example, have adapted to much larger changes over the course of their more than six million years as a species (Waples et al. 2008), and protection of their genetic diversity increases the likelihood this species will adapt to the future changes they face. But this adaptation is not possible, if there continues to be management enabling unsustainable anthropogenic collateral mortality caused by commercial fisheries.

There is every indication precautionary management actions could be taken to strengthen resilience of the ecosystem as well as species like King Crab, N. Fur Seals, Chinook and Chum Salmon and other impacted species. These management actions would in turn provide opportunities for restoration of Western Alaska Native families' subsistence way of life as well as opportunities for other Alaska families relying on the sea for their wellbeing.

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