C4 EBS ESR in Brief
DECEMBER 2022

2022 Eastern Bering Sea Ecosystem Status Report:

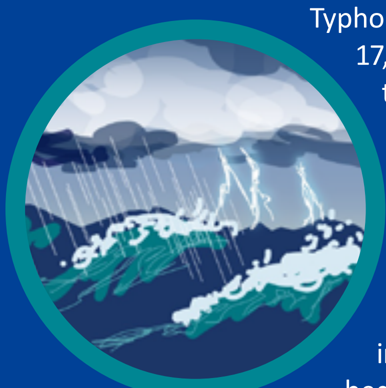
IN BRIEF

Oceanographic conditions

Ocean observations show that the extended warm phase in the eastern Bering Sea (EBS), which started in approximately 2014, has ended. Multiple measurements, like ocean temperatures and sea ice extent, showed a relaxation to average conditions over the last year (since fall 2021). Several broad-scale climate indices that track trends across the North Pacific aligned, resulting in cooler conditions. A positive state of the North Pacific Index and Arctic Oscillation, as well as a continued La Niña, meant a return to more average sea surface temperature conditions for the EBS shelf. In fact, sea surface temperatures of the shelf were average to cool for most of the year. However, summer 2022 warming brought above-average temperatures over the shelf.

During this past year, marine heatwaves were infrequent and brief compared to recent years. Record cold temperatures in November 2021 kicked off rapid sea ice growth and the largest early season (October December) ice extent since 2012. Sea ice extent remained above-average for most of the winter 2021/2022. However, ice thickness was actually less than in 2021 over most of the shelf. Thin ice is more easily broken up during storms, so the sea ice retreated quite rapidly in spring 2022. This was fueled by warming sea surface temperatures. The area of the 2022 cold pool (<2°C bottom water) expanded and was near the time series average. This represented a major change from the three prior survey years (2018, 2019, and 2021).

Ocean acidification (OA) research showed an expansion of corrosive bottom waters. Lab experiments have highlighted that pH levels below 7.0 can negatively impact pteropods and red king crab. In 2022, relatively lower pH was predicted for most of the outer and middle shelves and near Bering Strait. However, at this time, there is no evidence that OA can be linked to recent declines in surveyed snow crab and red king crab populations.



Typhoon Merbok hit Western Alaska communities on September 17, 2022. The storm's timing (i.e., early in the fall for a storm of this strength) and intensity were fueled by warm ocean waters from the north central Pacific to the northern Bering Sea. Immediate impacts of the storm included damage to infrastructure (e.g., seawalls) and disruption of the fall subsistence harvest season. Longer term impacts due to storm surges and coastal and river flooding are not yet known, but may include disturbance of Harmful Algal Bloom cyst beds nearshore or salmon eggs in the rivers.

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The Recent Warm Phase

The impact of the prolonged warm phase can be seen in a variety of ecosystem indicators. With close to average conditions forecast into 2023, and a potential bookend to the warm phase, the ecosystem response and impacts to managed groundfish and crab stocks are assessed here.

Physical environment responses:

Immediate responses: Ocean temperatures from the NOAA bottom trawl survey were above average beginning in 2014 and largely remained above average through 2022. The cold pool (<2°C bottom water) is a direct reflection of sea-ice extent over the shelf the preceding winter. The cold pool extent shrank in 2014 and the three years of 2018, 2019, and 2021 (no survey in 2020) had the smallest cold pool extents in the time series.

Cumulative responses: Throughout the warm stanza (~2014 through 2021), residual warmth in the ocean led to delayed sea-ice formation in the fall. Delayed freeze-up led to shortened ice seasons that had impacts on ice thickness, ice algae, and its cooling effect on the ocean. The thinner sea ice broke up and retreated earlier, further shortening the ice season and perpetuating the warmth into the following year.

Community-led monitoring at St. Paul Island showed an increasing trend in **salinity** that corresponds to the recent warm phase and may be the result of the loss of sea ice. Ice forms in the northern Bering Sea and, as it freezes, salts are extruded leading to localized increased salinity. The sea ice moves south over the winter and ice melt occurs at the southern ice edge, resulting in decreased salinity. In 2022, the salinity measured at St. Paul decreased, potentially due to **sea-ice** reaching the Island during winter 2021/2022.

Biological responses:

Chlorophyll-a, an indicator of primary production, has been decreasing along the shelf-break since 2014. This may be a limitation at the base of the food web. Zooplankton are food for young stages of groundfish and crab. During the warm stanza, spring surveys showed a distinct increase in small copepods alongside a decrease in large copepods. Late-summer surveys showed no long-term trend in the abundance of small copepods, but a shift to markedly lower abundances of large copepods. Spring foraging conditions appeared favorable for young groundfish and crab. However, late-summer declines in large, lipid-rich copepods may have limited overwinter survival.

Forage fish represent a critical trophic link in the ecosystem and are prey for larger fish, seabirds, and marine mammals. Forage fish (e.g., age-0 pollock, juvenile salmonids) were seen in higher abundances during the warm stanza compared to the previous cooler stanza (~2009-2013). This trend suggests that the summer foraging conditions were more robust during the recent warm stanza. This was especially true for surface-feeding organisms like fish-eating seabirds.

Bristol Bay **adult sockeye salmon** returns showed a large increase during the recent warm stanza. Inshore run sizes in 2015-2022 all exceeded 50 million salmon (the 2022 estimate is the largest on record since 1963). In contrast, declines in juvenile Chinook salmon have been observed since 2013 and adult salmon runs (e.g., **Chinook, chum, and coho**) throughout the Arctic-Yukon-Kuskokwim region have had unprecedented failures in recent years (see Chinook salmon Hot Topic on the back page). These contrasting trends highlight different responses to changing ocean conditions. The dynamic life histories within salmon species are impacted by a mix of freshwater and marine habitat conditions.

The **2018 year class of pollock** in the EBS is well above-average. Recruitment of young fish was bolstered by increased overwinter survival to age-1 in 2019. Cool summer sea surface temperatures in 2018 were followed by warmer spring conditions for age-1 fish in 2019; that temperature difference is correlated with larger year classes. Age-0 pollock in 2018 had a large proportion of euphausiids in their diets, supporting the idea that availability of euphausiids may compensate for lower large copepod abundances. Survival of the 2018 year class was also bolstered by reduced predation and mortality in 2019-2021. The biomass of predators (i.e., adult pollock, Pacific cod, Arrowtooth flounder) was lower, which reduced predation mortality. In addition, the smaller cold pools of 2018-2021 meant a likely spatial separation of juvenile and adult pollock as adult pollock expanded into the northern Bering Sea, further reducing predation mortality.

Summary:

The recent warm stanza was unprecedented in terms of its magnitude and duration. The near-absence of sea ice in the winters of 2017/2018 and 2018/2019 also meant the near-absence of a cold pool over the shelf. Northward shifts in the distribution of groundfish and crab stocks have been documented. Stocks experiencing increased survival in recent years include the 2014-2019 year classes of sablefish (with juvenile sablefish increasing in the EBS), the 2017 year class of **Togiak herring**, the 2018 year class of pollock, and the last 8 years of Bristol Bay sockeye salmon returns (year classes precede returns by 3-5 years). Stocks experiencing declines include several crab stocks (notably **snow crab** and Bristol Bay **red king crab**) and multiple Western Alaska Chinook, chum, and coho salmon runs.

Current Conditions:

Primary productivity varied over the shelf in 2022. However, estimates of the spring bloom peak timing were similar to the long-term average. The **coccolithophore** bloom was among the highest ever observed. The milky aquamarine color of the water during a coccolithophore bloom can reduce foraging success for species including different seabirds. However, **seabird species** at the Pribilof Islands had an exceptional year in terms of reproductive success (except thick-billed murres), suggesting that their foraging conditions were not limited by the bloom.

The spring zooplankton community had a lower abundance of **large copepods** and a higher abundance of **small copepods**, which is similar to trends in warm years. By late summer over the southern shelf, both large and small copepods were in low abundance. This decrease in available food may have been mitigated by an increased abundance of **euphausiids**. Euphausiids were also seen in higher abundances over the northeastern shelf, suggesting widespread abundance.

Patterns in seabird reproductive success track patterns in food availability. Zooplankton-eating seabirds, like **auklets**, did well on the Pribilof Islands and on St. Lawrence Island. Fish-eating seabirds also did well on the Pribilof Islands. However, reproductive failures were observed for fish-eating seabirds, like **kittiwakes**, on St. Lawrence Island. This pattern tracks the availability of forage fish over the shelf, with higher abundance in the south and lower abundance in the north.

Cooler ocean temperatures began in 2021 (though still above average) and continued cooling to **average** conditions in 2022. These cooler temperatures mean reduced metabolic demands on the fish. In fact, groundfish condition improved from 2021 to 2022 for all monitored species over the southern shelf, except adult pollock that remained comparable to 2021; trends were more variable over the northern shelf.

The groundfish community shifted northward during the recent warm stanza. The community remained near its northern maximum through 2019 before shifting south again in 2021 as conditions cooled. In 2022, the groundfish community shifted into slightly deeper waters. A drop in catch-per-unit-effort (CPUE) in the northern Bering Sea between 2019 and 2021 was due to large decreases in all of the dominant species. The continued drop in CPUE from 2021 and 2022 may indicate migration of stocks out of the survey area or that the carrying capacity of the system was exceeded during the exceptionally warm years of 2018 and 2019.

Hot Topics:

Chinook salmon

Western Alaska Chinook salmon runs have concurrently declined for over a decade. Salmon are integral to the Western Alaska ecosystem, bridging marine and freshwater habitats, filling both prey and predator niches, and supporting vital subsistence harvests. Cumulative ecosystem factors since 2016 impacted the spawning adults, to the marine-stage juveniles, and ultimately to the returning adults in 2022.

Climate projections

Summer ocean temperatures in the Bering Sea were projected to the end-of-century under two carbon scenarios. A “high” carbon mitigation scenario refers to greater reductions in carbon emissions; a “low” carbon mitigation scenario refers to a “business as usual” (no change to current rates of carbon emissions). “High” mitigation scenarios predict a future Bering Sea that is slightly warmer, but relatively similar to contemporary conditions. “Low” mitigation scenarios predict ocean warming that drives the modeled Bering Sea system to conditions well beyond those observed to date.

Future Projections

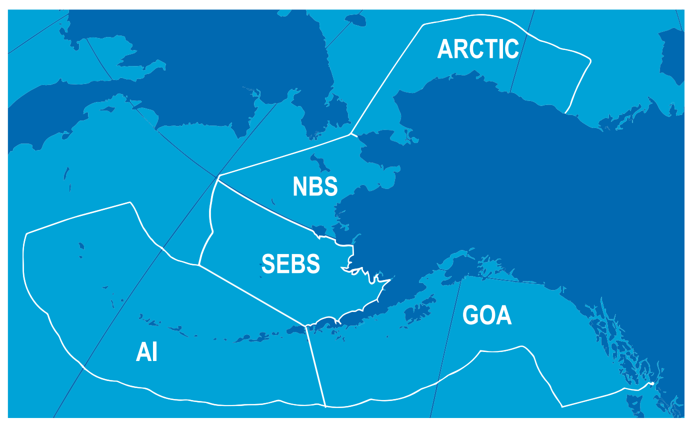
Average temperatures are predicted to continue into early 2023, consistent with a weak-moderate La Niña this winter.

Projections from the National Multi-Model Ensemble (NMME) suggest average conditions for the eastern Bering Sea shelf that would result in ice extending south of 60˚N and possibly as far south as Bristol Bay along the west coast of Alaska.

Management Uses

In 2022, ecosystem information was formally considered in 17 full stock assessments for Bering Sea/Aleutian Islands groundfish stocks as well as the Alaska-wide sablefish stock assessment.

This section will be completed following the December 2022 North Pacific Fishery Management Council meeting.



Links to full reports from Large Marine Ecosystems are available here: https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands

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