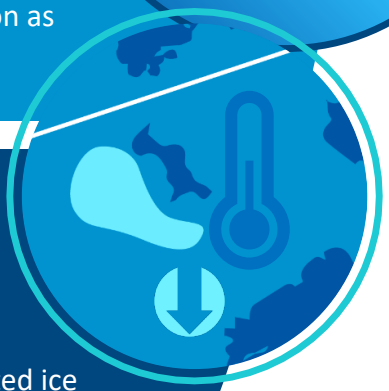
2021 Eastern Bering Sea Ecosystem Status Report:

IN BRIEF

Current Conditions

Along with much of the North Pacific, the eastern Bering Sea has remained in an extended **warm phase** since approximately 2014. Satellite observations of sea surface temperatures (SSTs) in both the northern and southern Bering Sea have remained higher than the average from 1985-2014. However, after the extremely warm years of 2018 and 2019, conditions in 2020 and 2021 subsided to 1°C above average. The extended warm phase also impacts sea ice formation and extent. **Water temperature** and **winds** play key roles in the annual development and retreat of sea ice.

Sea-ice formation in fall of 2020 was delayed due to warmth in the ocean. This has become the `new normal.' Early season sea ice extent (between October 15-December 15, 2020) was approximately half the long-term average. **Delayed freeze-up** leads to shortened ice seasons that have impacts on ice thickness, ice algae, and thermal modulation as well as impacts on transportation and subsistence activities.



Wind patterns in February 2021 highlight the **differences in ecosystem dynamics** between the northern and southern Bering Sea. Over the northern shelf, cold northerly winds prevailed and contributed to the stability and thickness of sea ice in the north. Over the southern shelf, warm southerly winds prevailed that inhibited ice formation in the south. These opposing prevailing winds resulted in differences between the northern (thicker ice) and southern (thinner/no ice) shelves.

The current warm phase is also present at depth. Bottom waters in the northern Bering Sea were very warm in coastal waters with a small area of cold water (i.e., the 'cold pool') to the southwest of St. Lawrence Island. The size of the **cold pool** in 2021 was the 4th lowest on record. The southern shelf had moderately warm bottom waters.

NOAA FISHERIES

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Ecosystem Impacts

Northern Bering Sea

Two winters (2017/2018 and 2018/2019) of little sea ice in the NBS, and two summers (2018 and 2019) of reduced cold pool extent, resulted in ecosystem changes across the Bering Sea. NOAA bottom trawl surveys saw northward shifts in fish species. The northward movement of stocks into the NBS changed the **food web** through predation pressure. Concerns about the food web dynamics and carrying capacity of the NBS have existed since 2018.

The groundfish community had shifted to the north and into shallower water since 2014, but between 2019 and 2021 the distribution shifted back to the southeast. Catch per unit effort (CPUE) of fish and invertebrates sampled during the 2021 NOAA bottom trawl survey decreased. In the NBS, CPUE decreased substantially between 2019 and 2021. In the southern portion of the survey, CPUE decreased between 2019 and 2021 to the lowest level since 2009.

Coincident Collapses in the NBS:

In 2021, multiple ecosystem 'red flags' occurred in the NBS: (1) **crab** population declines, (2) **salmon** run failures in the Arctic-Yukon-Kuskokwim region, and (3) **seabird die-offs** combined with low colony attendance and poor reproductive success. Although the collapses are coincident in 2021, they reflect cumulative dynamics over the last few years. The mechanisms are not fully understood, but a common thread in these collapses is the marine environment in the NBS, which underwent an abrupt and dramatic change starting in late 2017.

1) In 2018 more than 50% of Pacific cod biomass was found in the NBS. Pacific cod predation on **snow crab** is one potential contributing factor that may be behind the decline in snow crab observed in 2021.

2) Salmon run failures in 2021 in the Arctic-Yukon-Kuskokwim Region included **Chinook, chum, and coho** salmon. The low returns in 2021 reflect a multiple age-class failure as warm ocean conditions over several years affected juvenile salmon life stages across multiple years.

3) Fish-eating seabirds (i.e., **black-legged kittiwakes**, **common murres**) had poor reproductive success or complete reproductive failure, on both St. Lawrence Island and Hall Island. Plankton-eating seabirds had mixed reproductive success - **least auklets** did well on both Hall Island and St. Lawrence Island, but **crested auklets** (on St. Lawrence Island) had poor reproductive success.

Southeastern Bering Sea

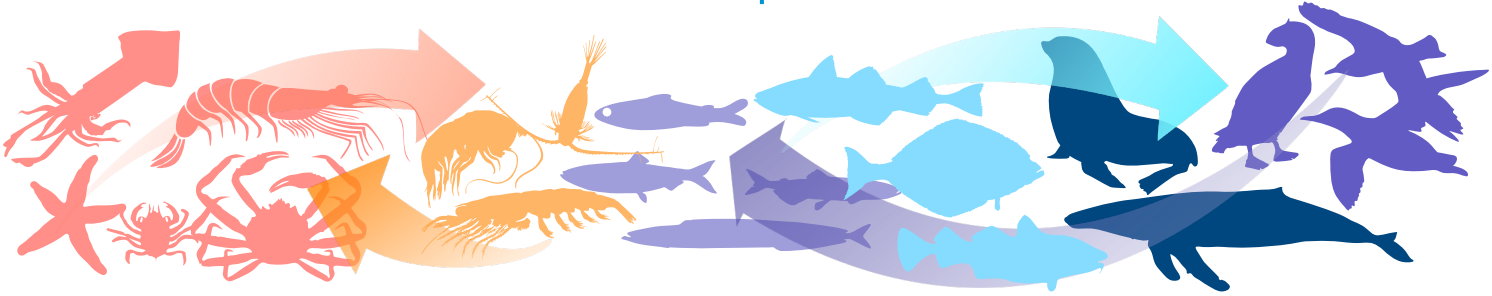
The loss of sea ice leads to increased water temperature (i.e., lack of cold pool), decreases in ice-associated algae, and **increases in salinity** that change water density and stratification. Community-led monitoring on St. Paul Island shows an increasing trend in salinity and water density since 2014. Water density and stratification impact the distribution of organisms in the water column. Visual predators, such as seabirds, may have had reduced foraging success due to an algal **coccolithophore bloom** over the southern shelf, although the timing of breeding and abundance of fish-eating seabirds (i.e., **murres** and **puffins**) appeared average at St. Paul Island.

Chlorophyll-a biomass was low along the shelf-break, continuing that trend since 2014, and winds did not consistently demonstrate upwelling or downwelling conditions. Small copepod abundance was slightly reduced in spring but unlikely to impact food availability for larval fish. Observations of *Calanus* spp. suggest they were developing more slowly. This would increase this important prey for juvenile fish and help increase overwinter survival of the fish.

Fish and invertebrate guilds can tell us about different parts of the ecosystem and food web. For example, motile epifauna (including seastars and crabs) tell us about benthic productivity. In 2021, motile epifauna remained above average because **brittle stars**, sea stars, and other echinoderms off-set below-average biomass for all **crabs**. Benthic foragers (e.g., **flatfishes**) were at their lowest level. The aggregate **forage fish** guild describes available prey for seabirds and larger fish (i.e., adult pollock). This guild has declined since 2014 and may have contributed to other substantial ecosystem changes in the southeastern Bering Sea. In 2021, pelagic foragers (e.g., **adult pollock**) dropped to their second lowest value. Apex predators, largely driven by adult Pacific cod, were below average in 2021.

Under warm ocean conditions, groundfish experience increased thermal exposure and metabolic demands. Fish condition trended downward from 2019 to 2021 for multiple groundfish species, including benthic, pelagic, and apex predators, indicating poor feeding conditions across guilds. However, the condition of **juvenile pollock** (100-250 mm) has trended upward since 2017, indicating good food availability. Additionally, juvenile pollock experienced less predation due to declining biomass of predators.

The 2021 **Bristol Bay sockeye** salmon inshore run is the largest on record since 1963. These stocks experienced positive ocean conditions in the EBS in the summers of 2018 and 2019, and winters of 2018-2019 and 2019-2020.



What do the indicators tell us this year?

Hot Topic Updates

Ice Seal Unusual Mortality Event

On September 12, 2019, NOAA Fisheries declared an Unusual Mortality Event (UME) for three species of ice seals in Alaska. The UME investigation continued through 2021. The increased mortality of seals during 2018-2019 coincided with the dramatic reduction in sea ice habitat for pupping and nursing in the northern Bering Sea. Stranding reports from 2018-2019 indicated several seals were emaciated. Reports from 2020-2021, however, did not identify emaciation as a factor. The ice seal UME may reflect an ecological shock from those two extreme years superimposed on a longer-term trend.

Gray Whale Unusual Mortality Event

In May of 2019, elevated numbers gray whale mortalities resulted in the declaration of a UME. Gray whale life history includes an annual round-trip migration from the southern Baja California Peninsula, where they overwinter to mate and calve, to Alaskan waters where foraging occurs. The cause of the UME has not yet been determined and the investigation is continuing. Preliminary findings have shown evidence of emaciation; however, these findings are not consistent across all whales examined. Gray whales strandings dropped ~50% in 2021. Closure of the UME has been discussed and will be reassessed in early summer 2022.

Incidental Catch of Herring

The incidental catch of **herring** in the 2020 directed pollock fishery was unusual because it occurred during a period of relatively high nominal CPUE values for pollock fishing. It also was highest in the winter A season rather than the B season. The pollock fleet may have encountered high numbers of Togiak age-4 fish, as the 2016 year class is estimated to be the largest in recent history. This provides a partial explanation of the abrupt increase of incidental catch in 2020. Industry professionals and assessment scientists collaborated, sharing expertise to develop hypotheses to help move fishery management forward.

Future Projections

Temperatures are predicted to cool in early 2022 due to high sea level pressure centered over the western Bering Sea, consistent with a moderate La Nina winter.

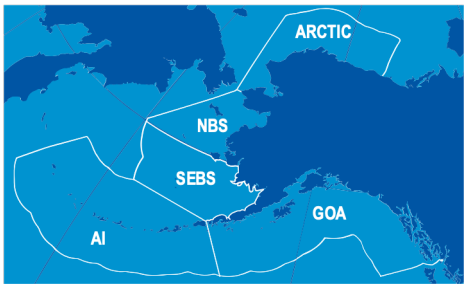
Projections from the National Multi-Model Ensemble (NMME) show near-normal temperatures for the Bering Sea through spring of 2022. There is variability in the sea ice forecast, though most models suggest ice could extend south of 60°N and as far south as Bristol Bay.

Management Uses

Ecosystem and stock assessment scientists worked together to account for the influence of environmental conditions in the Bering Sea on commercially-important fish stocks. They considered ecosystem information in seven full assessments for the Bering Sea and Aleutian Islands stocks plus the Alaska-wide sablefish stock in 2021. Four of these assessments classified ecosystem dynamics at risk level 2 (out of 4), noting substantially increased concerns: EBS pollock, EBS and AI Pacific cod, and yellowfin sole.

The acceptable biological catch (ABC) for EBS pollock was reduced 11% from the Tier 1 to Tier 2 maximum permissible noting assessment, ecosystem, and fishery performance concerns. For yellowfin sole (YFS), the Scientific and Statistical Committee (SSC) recommended the maximum permissible ABC rather than the proposed reduction by the stock assessment author and BSAI Groundfish Plan Team. During deliberation, the SSC agreed that some concerns existed for YFS but they did not appear elevated from the previous assessment and did not warrant a reduction at this time.

For the remaining six stocks, including EBS and AI Pacific cod, precautionary measures already incorporated into setting catch levels were considered sufficient to address uncertainty about current ecosystem dynamics.



Reference: Siddon, E. 2021. Ecosystem Status Report for the Eastern Bering Sea, Stock Assessment and Fishery Evaluation Report. North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, AK 99501.

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More information on these and other topics can be found on the Ecosystem Status Report website.

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