Noteworthy

Changes in large scale sea surface temperature patterns

Recent studies have identified several large scale changes in sea surface temperature patterns and their implications for climate indices. The first is a thermal regime shift in North Pacific annual mean sea surface temperature that occurred in 2013/2014, when temperatures increased abruptly, similar to what occurred in 1977. The thermal regime shift in 2013-2014 aligns with regional satellite SST temperatures for the Aleutian Islands and is reflected in the increased number of days under marine heatwave conditions. It also coincides with increased temperatures recorded as part of the Alaska Fisheries Science Center's annual longline survey. Mean bottom temperatures observed during the AFSC Aleutian Islands bottom trawl survey also increased beginning in 2014. These changes can make indices like the Pacific Decadal Oscillation (PDO), which have provided good insights into spatial patterns in the past, less reliable for capturing current spatial patterns. As a result, indicators like the PDO may not be as useful in the future as their relationships with physical and ecological processes may vary as the climate continues to change.

Key temperature ranges for commercial species in the Aleutian Islands.

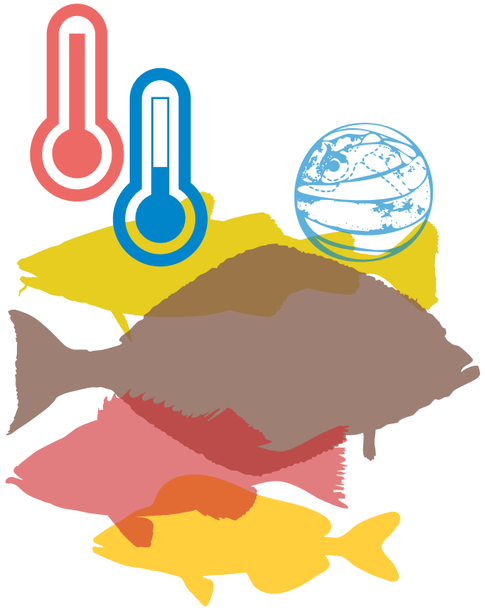
Vulnerability to persistent warm conditions in the Aleutian Islands is likely to differ among groundfish species. Pacific cod eggs may be the most vulnerable. Pacific cod have a narrow optimal temperature range for egg hatching success above 20% (3–6°C), when spawning occurs in January to May. Pollock eggs have above 20% hatching success within a wider temperature range (-1–12°C), and their spawning season extends from March to June. Atka mackerel nests in the Aleutians have been observed at a wide temperature range (3.9–10.7 °C), and they spawn from late July to mid-October. For Atka mackerel, temperatures below 3 °C or above 15 °C can be lethal to eggs or unfavorable for embryonic development depending on the exposure time. Long-lived marine species such as Pacific ocean perch may be relatively more resilient to environmental variability because they are capable of adapting to and surviving varying environmental conditions during their first year of life. Thus, they are able to maintain a wide genetic variability suitable for many different environmental conditions. Marine heat waves are defined by temperatures at the sea surface, and bottom temperature data, closer to where groundfish spawn, are not readily available year round, so it is difficult to determine how groundfish spawning is impacted during marine heatwaves. The maximum summer bottom temperature recorded to date is 6.6°C, but winter temperature can be similar or several degrees cooler depending on depth and longitude.

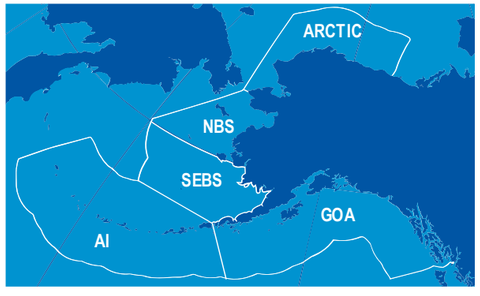
Changes in Pacific cod diet

The Alaska Fisheries Science Center Trophic Interactions Lab routinely analyzes stomach samples collected during the biennial bottom trawl survey for the Aleutian Islands. A preliminary analysis of Pacific cod diets (for fish between 30–85 cm, from 1991–2022) shows invertebrates such as shrimp are now more prevalent in their diets than fish, which were more prevalent in the past. The trend may be partially influenced by the decline in the Atka mackerel stock. However the trend could also reflect changes in the availability of all prey, as there is an overall decline in prey consumed as a proportion of predator weight. The change in the ratio of fish to invertebrates in cod diets over time is seen across the Aleutians west of Samalga Pass but is not evident to the east. It is unclear whether other groundfish predators or marine mammals have experienced similar changes in their diets over the same time period. However, several of these species, like halibut, have been decreasing in abundance in past years, which could indicate less favorable foraging conditions for them.

Management Uses

This section will be completed following the December 2023 North Pacific Fishery Management Council meeting.





Reference: Ortiz, I. and Zador, S., 2023. Ecosystem Status Report 2023: Aleutian Islands, Stock Assessment and Fishery Evaluation Report. North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, AK 99501.

Contact: ivonne.ortiz@noaa.gov

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

Gina M. Raimondo
U.S. Secretary of Commerce

Richard W. Spinrad
Under Secretary of Commerce for Oceans and Atmosphere

Janet Coit
Assistant Administrator for Fisheries

National Marine Fisheries Service
Alaska Fisheries Science Center
7600 Sand Point Way N.E., Seattle, WA 98115-6349
www.fisheries.noaa.gov

2023 Aleutian Islands Ecosystem Status Report:

IN BRIEF

Current Conditions

- Relatively stormy during the winter of 2022-23 and summer of 2023.
- Warmest winter sea surface temperatures since 1900
- Cooler (but still above average) spring-summer conditions.
- The upper mixed layer extended deeper than during 2022, which potentially impacted the vertical distribution and availability of prey throughout the water column.
- Wind patterns and low eddy kinetic energy suggest that there was lower transport of heat and nutrients through the passes.
- Seabird reproductive success in the eastern Aleutian Islands was at or above average, indicating wide availability of zooplankton and fish prey. Seabird reproductive success was mixed in the western Aleutian Islands.
- Eastern Kamchatka pink salmon abundance was the third highest on record.
- Paralytic shellfish toxins in blue mussels sampled in June were 47 times above the legal limit.

Multi-year Patterns observed across the Aleutian Islands continued in 2023:

Persistent warm conditions since 2013-14. Water column temperatures have been above-average for the last decade, consistent with warmer mean annual sea surface temperatures across the North Pacific as a whole. These warm conditions suggest that there has been lower productivity across the ecosystem. Spring phytoplankton abundance was below the 1998-2022 average in 2023, which appears to fit a declining trend in abundance over time. In many cases, warmer temperatures lead to increased fish metabolism, faster growth rates for zooplankton and larvae, and shorter incubation periods for fish eggs

Increased abundance of Eastern Kamchatka pink salmon in odd-numbered years. Their abundance during even-numbered years has also increased, although numbers remain much lower compared to the odd-numbered years. Several other ecosystem indicators show a biennial pattern. For example, satellite chl-a is lower in even years, and tufted puffin chick hatching dates are earlier in odd years, although tufted puffin reproductive success does not vary by year the same way.

Rockfish continue to be the most abundant pelagic foragers. Stock assessment estimates show that rockfish, which include Pacific Ocean perch and northern rockfish, are the dominant groundfish pelagic foragers. This is a change from the early 1990s, when Atka mackerel and pollock were dominant. Longer-lived species such as rockfish help to increase the stability of the food web because their numbers don't vary with environmental conditions as much as shorter-lived species. However, this also means there is a lower availability of Atka mackerel and pollock which are common prey for predators in the region. Rockfish in the Aleutians are not a common prey in the region. Analysis of Pacific cod diets in this region reflects these trends. See Noteworthy for Pacific cod diets.

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Regional Highlights

The western Aleutians were under a moderate heat wave throughout winter before cooling in spring and summer. Heatwave conditions have largely persisted since August. Eddy kinetic energy was below average, suggesting that there was **lower transport of heat and nutrients through the passes**. There **was lower phytoplankton biomass across the chain.**

The reproductive success of least, whiskered and crested auklets, planktivorous seabirds at Buldir Island was average, but was below average for parakeet auklets. This suggests that **overall zooplankton availability** was sufficient to support seabird reproductive success in 2023 and potentially other plankton-eating commercial groundfish species. However, conditions were not as good as in 2022 when reproductive success was average to above the long-term average for all seabirds.

Reproductive success of fish-eating seabirds was mixed for both divers and surface-foragers. Tufted and horned puffins had above-average and average reproductive success respectively in 2023, signaling **potentially favorable conditions for fish foragers.** They fed chicks mostly **squid** (63% by weight) and Pacific saury (18%), while horned puffins fed chicks mostly Atka mackerel (43%) and **squid** (30%). In contrast, the reproductive success of fork-tailed storm-petrels, kittiwakes, and thick-billed murres was below average.

The central Aleutians were also under a moderate marine heat wave throughout winter. These conditions resumed in fall. Eddy kinetic energy during 2023 was generally below the 1993-2022 average. This indicates a **potentially below-average flux of nutrients and heat across the passes** from the Pacific Ocean to the Bering Sea. Phytoplankton biomass, as represented by chl-a concentration, was also generally below the long-term average.

School enrollment continued a decreasing trend in the 2022-2023 school year. This trend was driven by decreased enrollment in Adak, where school enrollment decreased from 13 to 5 students. Alaska schools need at least 10 students minimum for schools to qualify for state funding. Amid rising operating costs and flat funding in general, small schools like those at Adak and Atka are at increasing risk of closure. Thus, decreasing enrollment impacts family stability in those communities.

In the eastern Aleutians as in past years, sea surface temperatures during 2023 were not as high during winter as in the western and central Aleutians**. Winds suppressing northward flow** and eddy kinetic energy was below average, suggesting that there was **lower transport of heat and nutrients through Unimak Pass**. Fish-eating seabirds, such as murres, puffins and gulls, had above-average reproductive success. **Capelin comprised 86% (by weight) of the forage fish in tufted puffin check meals.** Storm-petrels, which feed on a mix of invertebrates and zooplankton, had average to above-average reproductive success. **The continued overall seabird reproductive success** suggests that there was **enough fish and invertebrate prey** to support seabird chick-rearing, which may indicate that there were favorable foraging conditions for some species of groundfish.

Paralytic shellfish toxins in blue mussels sampled in June at Sand Point, Unalaska, False Point and Akutan **were 47 times above the regulatory limit**. **School enrollment fell for the third year in a row** to the lowest point in the time series. Enrollment at Unalaska Elementary school peaked in 2019-2020 at 238 students but currently has 176 students. As is the case in the central Aleutians, decreasing enrollment impacts family stability in those communities.

Aleutian Island LME