Ecosystem Status Report 2026

GULF OF ALASKA



Edited by:

Bridget Ferriss

Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, NOAA Fisheries

With contributions from:

Anna Abelman, Shaun Bell, Erendira Aceves Bueno, Mayumi Arimitsu, Kerim Aydin, Kelia Axler, Brenda Ballachey, Sonia Batten, Brian Brettschneider, Jessica Beck, Piper D. Bishop, Dana F. Bloch, James Bodkin, Brian Brettschneider, Mariela Brooks, Matt W. Callahan, Reuben Cash, Maggie Chan, Wei Cheng, Heather Coletti, Daniel Cushing, Seth Danielson, Sherri Dressel, Brie Drummond, Erica Ebert, George Esslinger, Stacie Evans, Emily Fergusson, Thomas Farrugia, Bridget Ferriss, Teresa Fish, Tara Flood, Christine Gabriele, Sarah Gaichas, Jeanette C. Gann, Scott Hatch, Madison Haumschild, Claudine Hauri, Gwenn Hennon, Tyler Hennon, David Hill, Russell Hopcroft, Katrin Iken, John J. Jansen, Darin Jones, Robert Kaler, Kelly Kearney, David Kimmel, Kim Kloecker, Brenda Konar, Gulce Kurtay, Emily Lemagie, Mike Levine, Josh M. London, Carley Lowe, Jenna Malek, Brett M. McClintock, Denise McKelvey, Kay McMonigal, Sara Miller, John Moran, Janet Neilson, Clare Ostle, Remi Pages, Melanie Paquin, Alia Payne, Andrew Piston, Meredith Pochardt, Isaac Reister, Heather Renner, Patrick Ressler, Lauren Rogers, Nora Rojek, Joshua R. Russell, Akash Sastri, Quinn Smith, Hank Statscewich, William Stockhausen, Wesley Strasburger, Janice Straley, Florence Sullivan, Robert Suryan, Rick Thoman, Troy Thynesl, Cathy Tide, Sarah Traiger, Scott C. Vulstek, Muyin Wang, Shannon Whelan, George A. Whitehouse, Carrie Worton, Stephani Zador

This information is distributed solely for the purpose of pre-dissemination peer review under applicable information quality guidelines. It has not been formally disseminated by the National Marine Fisheries Service and should not be construed to represent any agency determination or policy.

Reviewed by:
The Plan Teams for the Groundfish Fisheries of the Gulf of Alaska, November 20, 2026
North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, Alaska 99501-2252

Citing the complete report:
Ferriss, B.E. 2026. Ecosystem Status Report 2026: Gulf of Alaska, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, Alaska 99501.

Citing the Ecosystem Assessment:
Ferriss, B.E. 2026. Ecosystem Assessment. In: Ferriss, B.E. 2026. Ecosystem Status Report 2026: Gulf of Alaska, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, Alaska 99501.

Citing an individual section:
Contributor name(s), 2026. Contribution title. In: Ferriss, B.E. 2026. Ecosystem Status Report 2026: Gulf of Alaska, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, Alaska 99501.

Citing information within a Synthesis section:
Contributor name(s), 2026. Sub-section heading. In: Synthesis section. In: Ferriss, B.E. 2026. Ecosystem Status Report 2026: Gulf of Alaska, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West 3rd Ave., Suite 400, Anchorage, Alaska 99501.

Do not use or distribute any information of graphics from this Report without direct permission from individual contributors and/or the Ecosystem Status Report lead editor.

QR code for NOAA Alaska Fisheries Science Center's Ecosystem Status Reports webpage[1]. Time series from the report cards are also available[2].

[1] https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands

[2] https://alaskaesr.psmfc.org

Purpose of the Ecosystem Status Reports

This document is intended to provide the North Pacific Fishery Management Council (NPFMC), including its Scientific and Statistical Committee (SSC) and Advisory Panel (AP), with information on ecosystem status and trends. It follows the same annual schedule and review process as groundfish stock assessments, and is made available to the Council at the annual December meeting when Alaska's federal groundfish harvest recommendations are finalized.

Ecosystem Status Reports (ESRs) include indicators developed and contributed by scientists and fishery managers at NOAA, other U.S. federal and state agencies, academic institutions, tribes, nonprofits, and other sources. The ecosystem information in this report will be presented to the Groundfish and Crab plan teams in their annual September and November meetings, presentations to the Council in their annual October and December meetings, and submission of the final report to the Council in December (Figure 1).

The SSC is the primary audience for this report, as final acceptable biological catch (ABCs) is determined by the SSC, based on biological and environmental scientific information through the stock assessment and Tier process[3],[4]. Total allowable catch (TAC) may be set lower than the ABCs due to biological and socioeconomic information. Thus, the ESRs are also presented to the AP and Council to provide ecosystem context to inform TAC as well as other Council decisions. Additional background can be found in the Appendix (p. 232). Outside the annual harvest specification cycle, the Alaska Region and NPFMC use ESRs to support National Environmental Policy Act assessments for regulatory and plan amendments, discussion papers, protected species analyses, responses to constituency inquiries, and policy write-ups.

ESRs and Ecosystem and Socioeconomic Profiles (ESPs) are complementary documents that allow for incorporating ecosystem information into stock-specific Risk Tables (Dorn and Zador, 2020) and thereby directly considering ecosystem dynamics in management decisions (i.e., EBFM). Both documents inform the SSC's ABC and overfishing limit (OFL) recommendations, as well as for the Council's final TAC determination for groundfish and crab. ESRs provide ecosystem status and trends annually for three Large Marine Ecosystems: the Eastern Bering Sea, Aleutian Islands, and the Gulf of Alaska. ESRs include assessments that reflect ecosystem components ranging from physical oceanography up through the food web. ESPs are both a process and a product and serve as a proving ground to identify key ecosystem and socioeconomic indicators within the stock assessment model and are presented as appendices in high priority stock assessments (see current list of available ESPs in Figure 1).

[3] https://www.npfmc.org/wp-content/PDFdocuments/fmp/GOA/GOAfmp.pdf
[4] https://www.npfmc.org/wp-content/PDFdocuments/fmp/BSAI/BSAIfmp.pdf

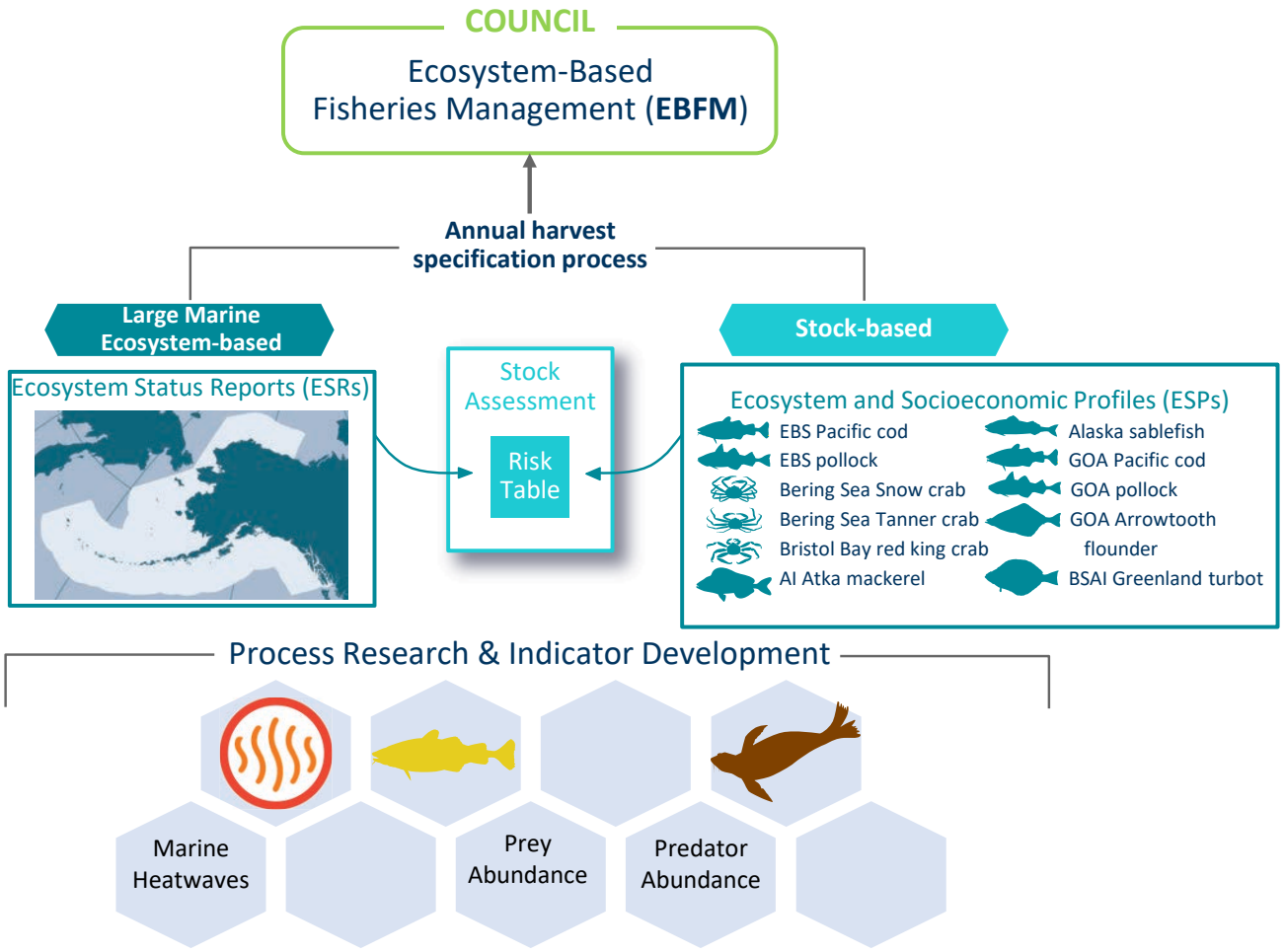


Figure 1: Ecosystem information mapping to support Ecosystem-Based Fisheries Management through Alaska's annual harvest specification process. The 'honeycomb' on the bottom shows examples of ecosystem indicators that are provided to Ecosystem Status Reports (ESRs) at the Large Marine Ecosystem (LME) scale and/or to Ecosystem and Socioeconomic Profiles (ESPs) at the stock-based level.

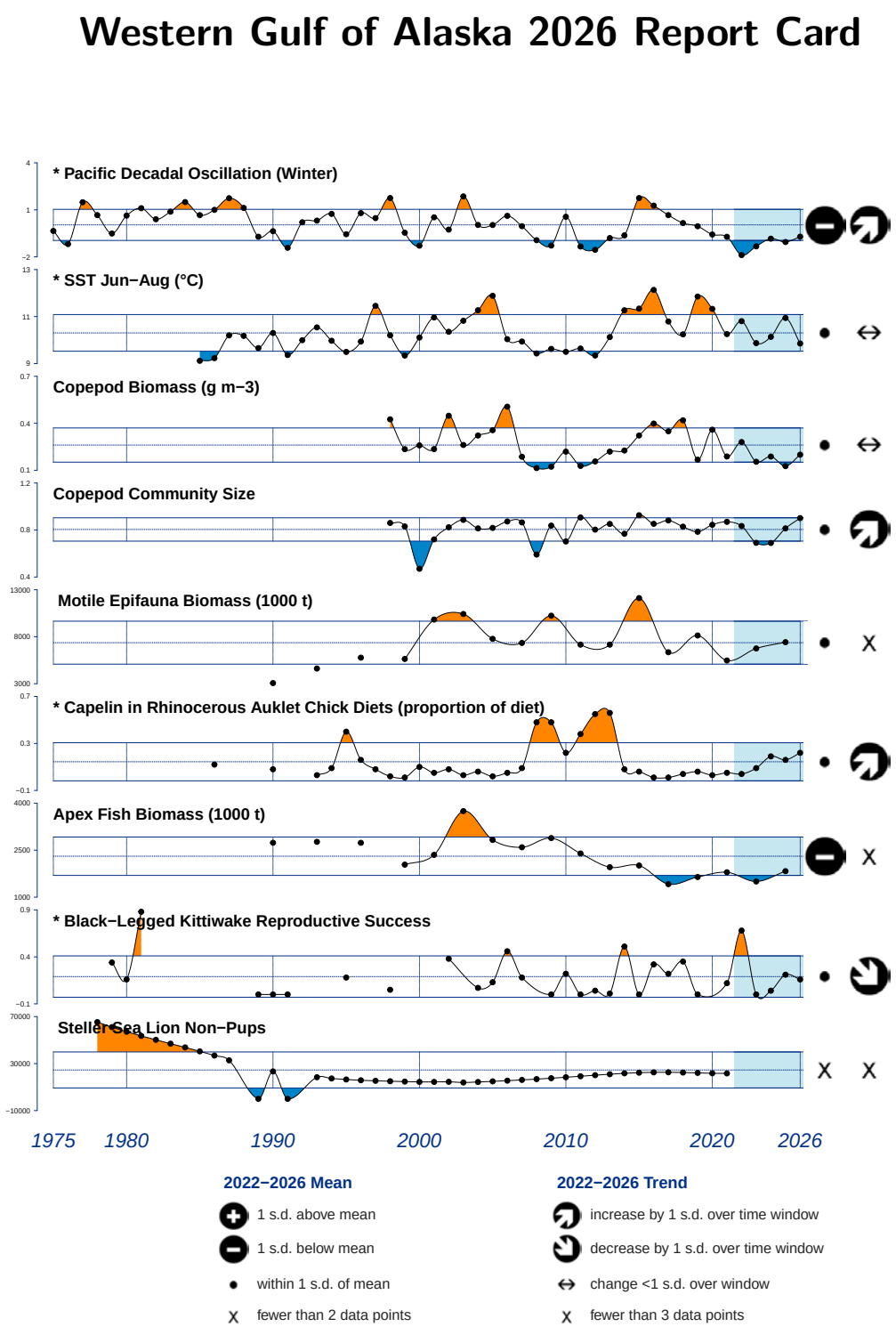


Figure 2: Western Gulf of Alaska report card indicators. For additional information on these indicators, refer to "Report Card indicator Description and Methods" in the Appendix 3 of this Report (p.239) and relevant contributions in this Report. * Indicates time series updated with 2026 data.

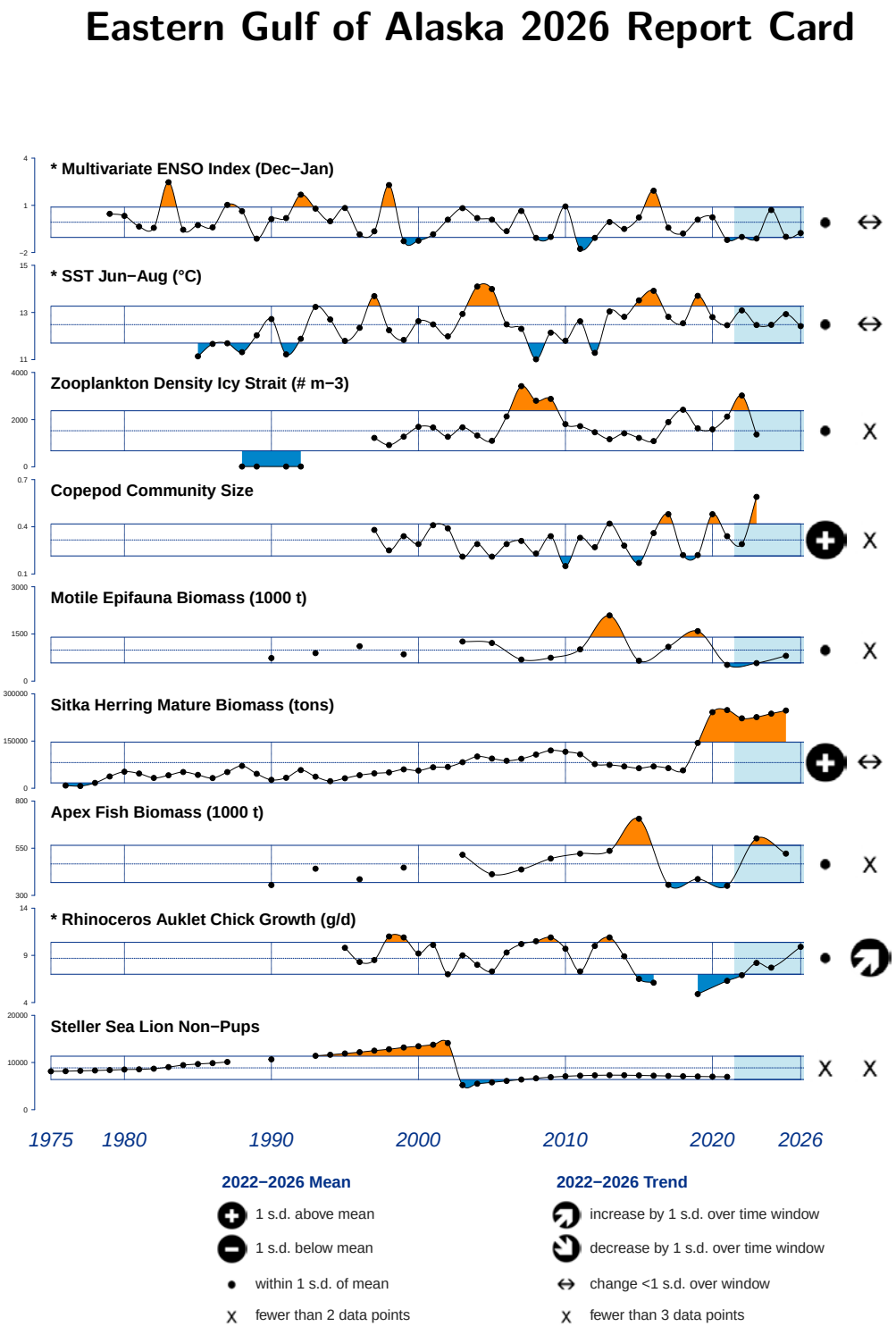


Figure 3: Eastern Gulf of Alaska report card indicators. For additional information on these indicators, refer to "Report Card indicator Description and Methods" in the Appendix 3 of this Report (p.239) and relevant contributions in this Report. * Indicates time series updated with 2026 data.

Western Gulf of Alaska 2026 Report Card

For more information on individual Report Card indicators, please see "Report Card indicator Description and Methods" in the Appendix of this Report (p.239).

- **Winter average PDO index** (Dec./Jan., 1975 – 2026) continued its negative trend in 2026.
- **Sea-surface temperatures in the summer (°C)** (Jun.-Aug.) in the western GOA were cooler than average (baseline 1985 – 2024), and cooler than 2025.
- **Copepod biomass (g m^{-3})** was below average (1998 – 2025) in 2026, but increased from 2025. Total (large and small) calanoid copepods are surveyed south of Seward in May of each year. Euphausiid biomass was above average during the same time period.
- **Copepod community size** (ratio of large calanoid copepods to total calanoid copepods) was one standard deviation above average (1998 – 2025) in 2026, indicating increased large copepods in the community, relative to small copepods. Total (large and small) calanoid copepods are surveyed south of Seward in May of each year.
- **Motile epifauna biomass (1,000 t)** increased from 2023 to 2025 and is near the long-term mean (1984 – 2023). The biomass of this guild is dominated by hermit crabs, brittle stars, other echinoderms, and octopus. In 2025, hermit crab biomass increased 20%, while brittle stars and other echinoderms decreased by 6% and 1%, respectively. These data have not been updated since 2025 due to biennial NOAA bottom trawl surveys.
- **Capelin abundance (proportion of diet by weight)**, as sampled by rhinoceros auklets at Middleton Island (Apr.-Aug., 1986 – 2026), increases in seabird chick diets above the long-term mean, reflecting a continued presence of capelin in the GOA.
- **Fish apex predator biomass (1,000 t)** increased from 2023 to 2025 but remains below the long-term mean (1984 – 2023). The biomass trends for apex predators, as sampled by NOAA's bottom trawl survey, are primarily driven by arrowtooth flounder, Pacific cod, Pacific halibut, and sablefish. All four species are below their long-term means. However, arrowtooth flounder, Pacific halibut, and Pacific cod all increased from 2023 to 2025. These data have not been updated since 2025 due to biennial NOAA bottom trawl surveys.
- **Black-legged kittiwakes reproductive success** in June-July, 2026 at the Semidi Islands remain around the long-term average (1980 – 2025).
- **Western Gulf of Alaska Steller sea lion non-pup** model predicted counts continued a slightly decreasing trend from previous years, remaining within one standard deviation of the long-term mean. These data have not been updated since 2021 due to lack of GOA surveys.

Eastern Gulf of Alaska 2026 Report Card

- **Multivariate ENSO Index** was negative, La Niña conditions in winter 2026. The ENSO index transitioned to positive El Niño values in the summer of 2026 (not shown in this Report Card) and has developed into the strongest El Niño on record.
- **Sea-surface temperatures (°C)** in the summer of 2026 (Jun.-Aug.), were approximately average (1985 – 2025) in the eastern GOA.
- **Total zooplankton density (# m^{-3})** in southeastern Alaska inside waters (May-Aug.) decreased from one standard deviation above long-term mean (baseline 1988 – 2023), to average, including a decrease in calanoid copepods. Euphausiid densities remained above average. This suggests below-average foraging conditions for planktivorous fish, seabirds, and mammals. These data have not been updated since 2023 as NOAA's Southeast Coastal Monitoring Survey has stopped collecting zooplankton data in recent years.
- **Copepod community size** (ratio of large calanoid copepods to total calanoid copepods) increased to one standard deviation above average in 2023 (May-Aug., 1997 – 2023). The copepod community is sampled in Icy Strait (southeast Alaska Inside waters). This suggests above-average quality zooplankton prey in SEAK inside waters (but at lower biomass). These data have not been updated since 2023 as NOAA's Southeast Coastal Monitoring Survey has stopped collecting zooplankton data in recent years.
- **Motile epifauna biomass (1,000 t)** increased from 2023 to 2025 and is below the long term mean. Eelpouts, hermit crabs, brittle stars, and other echinoderms are dominant components of this guild. Brittle stars, hermit crabs, and other echinoderms have increased from 2023 to 2025. These data have not been updated since 2025 due to biennial NOAA bottom trawl surveys.
- **Estimated total mature herring biomass (age 3+) of Sitka herring** in spring 2025 remains one standard deviation above average (1980 – 2024) continuing a 7 year trend of the largest values in the time series (since 1980) due to strong 2016, 2020, and 2022 year classes. 2026 data are not yet available.
- **Fish apex predator biomass (1,000 t)** has decreased 13% from 2023 to 2025 and is above the long-term mean. Apex predator biomass in the eastern GOA is primarily driven by arrowtooth flounder and Pacific halibut. From 2023 to 2025, arrowtooth flounder biomass increased by 13% while Pacific halibut decreased by 51%. These data have not been updated since 2023 due to biennial NOAA bottom trawl surveys.
- **Growth rates of piscivorous rhinoceros auklet chicks in June and July (g d^{-1})** increased from 2025 to 2026 approaching 1 standard deviation above the mean. The high growth rate suggests sufficient forage fish prey to support chick growth (including capelin).
- **Eastern Gulf of Alaska Steller sea lion non-pups** model predicted counts continue a decreasing trend, but remain above one standard deviation of the long-term mean (1980 – 2021) through 2021. However, counts suggest that non-pup have been lower than predicted in 2019 and 2017. These data have not been updated since 2021 due to lack of GOA surveys.

Ecosystem Assessment: The Status of the Gulf of Alaska 2026

Bridget Ferriss, Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, NOAA Fisheries
Contact: bridget.ferriss@noaa.gov
Last updated: November 2026

This Assessment reflects the recognition that the western and eastern GOA ecosystems (divided at 147 ºW) have substantial differences (Waite and Mueter, 2013; Mueter et al., 2016). The GOA is characterized by topographical complexity, including islands, deep sea mounts, a continental shelf interrupted by large gullies, and varied and massive coastline features such as Cook Inlet, Prince William Sound, Copper River, and Cross Sound, which bring both freshwater and nutrients into the GOA. The topographical complexity leads to ecological complexity, such that species richness and diversity differ from the western to eastern GOA. Thus, local effects of ecosystem drivers may swamp basin-wide signals. With this in mind, we highlight differences in the ecosystem state for the western and eastern GOA ecoregions in the Report Cards and Assessment.

Summary

The Gulf of Alaska's (GOA) shelf marine ecosystem experienced a productive year in 2026, after a warmer and less productive 2025. Groundfish data from 2026 are limited due to the NOAA Gulf of Alaska bottom trawl and EcoFOCI surveys occurring only in odd years. Highlights of the year include indicators of above-average phytoplankton and zooplankton production, suggesting a good prey base for juvenile and plankton-eating adult groundfish, forage fish, and seabirds. Capelin and herring populations remain present in predator diets across the GOA, further supporting a productive prey base for groundfish, seabirds, and marine mammals in 2026. Marine mammal populations continue to be responding to the reduced prey availability of the 2014 – 2016 and 2019 marine heatwave years, including declining harbor seal populations, changing Glacier Bay humpback whale population dynamics, and the first year of Prince William Sound humpback whales returning to 2014 whale encounter rates. Of particular note, estimated black-footed albatross bycatch in the GOA declined from 327 birds in 2024 to zero birds in 2025 (the last full year of data). This dramatic reduction may be attributed to a combination of wind patterns, shifts in sablefish longline fishing effort, and/or shifts in albatross distribution (Beck et al., p.200). The current El Niño is expected to warm GOA shelf surface temperatures in 2027 to a similar magnitude as observed in the previous very strong El Niño of 2015/2016. However, the average temperatures and relatively

productive initial conditions in 2026 and the predicted ENSO transition to neutral conditions in 2027 have set the stage for a one-year ecological response to the El Niño, versus the multi-year cumulative ecological response to the 2014 – 2016 marine heatwave years. The GOA ecosystem is still expected to experience reduced food web productivity, that could stress early responders to environmental change, such as forage fish and seabirds populations. Warm ocean temperatures will impact age-0 groundfish survival, and potentially adult groundfish condition and distribution, but not likely to lead to extensive adult groundfish mortality. These statements are based on observations from previous strong El Niños and marine heatwave events. A large amount of uncertainty remains in how the GOA will respond to this strongest El Niño on record.

Gulf of Alaska Shelf 2026

The GOA shelf ocean temperatures rapidly cooled from warm conditions in 2025 to within known ranges of optimal temperatures for groundfish across their life history stages during 2026. Winter winds from the north brought cooling temperatures into the GOA, cooling shelf waters to approximately average on the western and eastern shelf from January to August (Lemagie et al., p.28, Ocean Temperature Synthesis, p.41). A west-to-east gradient of heat was present in the GOA, with cooler than survey average temperatures at the surface (March, 2.2 °C) and depth (March: 3.3 °C, summer: 5.8 °C) in the western GOA winter and summer surveys (McKelvey and Levine, p.41, Worton et al., p.41), cooler than average temperatures in the northern GOA at the surface (May, 7 °C) but warmer at depth (May: 5.7 °C), Danielson, p.79), and warmer at the surface in southeast Alaska (satellite-derived, Lemagie and Callahan, p.41). The late winter and early spring surface temperatures were within the range of known optimal temperatures for egg and larval success of early spring spawners (e.g., walleye pollock, Pacific cod, northern rock sole), while the warmer temperatures in southeast AK may have favored survival and growth of late spring/early summer spawners including rockfish.

Indicators of circulation on the shelf, influencing nutrient delivery, water temperatures, and along-shelf and cross-shelf larval transport, varied across the atmospheric and ocean circulation metrics. The Aleutian Low was very weak in the winter of 2026 (similar to 2006, and 1982) (Lemagie et al., p.28), indicating weak wind-driven surface circulation. Spring wind direction near Shelikof Strait (Rogers, p.69) and the Papa Trajectory Index (Stockhausen, p.64) support the narrative of weak winter and spring wind-driven circulation. Conversely, the Northern Gulf of Alaska Oscillation index was at the strongest negative value since 1993, indicating strong winter/spring subarctic gyre circulation which feeds the Alaska Current on the GOA shelf (Pages and Hauri, p.67). While the Aleutian Low pressure system is related to the strength of the subarctic gyre, there can be a delayed response of atmospheric variability to ocean circulation changes (Wills et al., 2019). The reconciliation of these indicators is challenging but the cooler waters, and productive foodweb (described below) weight the interpretation of these indicators towards reflections of good ocean circulation on the shelf.

Indicators of spring zooplankton biomass suggested good prey resources for zooplankton-eating adult groundfish (e.g., walleye pollock, Pacific Ocean perch, dusky and northern rockfish), and larval/juvenile groundfish. The phytoplankton community was dominated by larger-celled diatoms, supportive of efficient energy transfer through the food web (Hennon, p.78). Diatom production on the shelf is supported by upwelling in the central GOA gyre, bringing nitrate-rich waters to the surface and onto the shelf through increased advection (Conte et al., 2024), indicative of higher gyre circulation discussed above. Strong diatom production supports larger, more energy rich zooplankton species (euphausiids and large copepods), which manifested as Seward Line euphausiid biomass more than one standard

deviation above the survey average (1998 – 2025), and led to above average copepod community size (biomass of large copepods relative to all copepods (Seward Line surveys Hopcroft, p.93). Planktivorous seabird reproductive success, an indicator of zooplankton availability and nutritional quality, was above average across the GOA, in some cases one standard deviation above average (Seabird Synthesis, p.145). Juvenile (outmigrating) salmon in Southeast Alaska (Icy Strait) largely saw relatively higher CPUE than 2025, again reflecting productive nearshore conditions and zooplankton prey availability. The 2026 CPUE of juvenile pink salmon in Icy Strait rose to above the survey average for the first time since 2016 (baseline 1997 – 2025; Strasburger et al., p.123).

The GOA forage fish prey base on the shelf in 2026 reflected adequate prey availability for fish-eating groundfish (e.g., P. cod, sablefish, arrowtooth flounder, and yelloweye rockfish), piscivorous seabirds, and marine mammals. Herring populations remain elevated in Sitka and Craig herring populations in Southeast Alaska and continue to be present in seabird diets across the GOA, supported by strong 2020 and 2022 year classes (Smith et al., p.111, Arimitsu et al, p.104). Capelin, another high energy forage fish, had an above-average age 1+ index in the west and central GOA seabird diets, and an average index value in the eastern GOA, reflecting good availability as a prey resource (Arimitsu et al, p.104). Surprisingly, the sand lance population index remains below-average in seabird diets, with no obvious recovery in this dataset since the 2014 – 2016 marine heatwave years. Eulachon populations show mixed trends (Arimitsu et al., p.104, Pochardt et al., p.115). The reproductive success of piscivorous, diving seabirds which share prey resources with many groundfish, was generally above average across the GOA (Seabird Synthesis, p.145).

Multi-year trends/ Community Dynamics

The Gulf of Alaska marine ecosystem undergoes interannual variability (the primary focus of this Report) in the context of multi-year oceanographic and ecological trends. The GOA shelf's long-term sea surface temperature continues to increase from 1900 through 2026, across the winter and summer months (Thoman, p.41), although 2026 was cooler than 2025. Temperatures at depth in the central GOA (200m – 250m) have increased since at least 1970 including above survey average temperatures in 2026 (GAK1 mooring, Danielson, p.79). Over the same 56 year time period, and continuing in 2026, stratification has increased (reducing vertical mixing in the water column), and salinity has decreased at the surface (fresher water) while increasing at depth (more saline waters) (GAK1, Danielson, p.79).

Marine mammal populations continue to respond to the 2014 – 2016 and 2019 marine heatwave years. GOA harbor seal populations have been generally declining over the 2016 – 2023 period (latest year of survey data), except the Glacier Bay/Icy Strait population (London et al., p.167). The Glacier Bay/Icy Strait humpback whales are missing reproductive females from the 2014 – 2019 period that would have been expected to produce their first calf in 2026 – 2032 (Gabriele et al., p.159). Conversely, the Prince William Sound humpback whale survey observed the highest number of whales per nautical mile since 2014 and a sustained increase in calf production within Prince William Sound, implying improved prey availability (herring and euphausiids) and a recovering/returning population (Moran, p.192). Finally, gray whale strandings in Alaska increased during the 2024 to 2026 period, with a total of 67 strandings reported across the 3 years (54 reported in the GOA) shortly after the Unusual Mortality Event (UME) for gray whales starting in 2019 was ended in 2023 (Malek et al., p.163). The initial UME was attributed to diminished subarctic and Arctic feeding areas but the cause of these strandings is less clear.

Another way to look at multi-year trends since 2014 is an ecosystem state analyses (dynamic factor

and threshold analyses) that identified a new GOA ecosystem state during the 2014 – 2019 period that persists through 2026, despite ongoing interannual variability (Ferriss, p.173). The exception was a change in ecosystem state in the western GOA lower trophic level submodel. This group is largely driven by reduced abundance of larval groundfish in 2025, with the exception of rockfish spp. and southern rock sole (NOAA EcoFOCI spring survey). Additional indicators driving this trend include larger and earlier spring phytoplankton blooms, and persistent below-average copepod biomass through 2026 (Seward Line survey).

The top six groundfish species (by biomass) surveyed in NOAA's biennial GOA bottom trawl survey (walleye pollock, Pacific ocean perch (POP), P. cod, arrowtooth flounder, sablefish, and P. halibut), account for an estimated 60% of total ecosystem consumption (Gaichas et al., 2015) and have a large predatory impact on the GOA ecosystem. In 2021, and 2023 the two planktivorous species (walleye pollock and POP) had the highest estimated consumption of these six species. In 2025, the planktivores still dominate estimated consumption despite a decrease in POP, an increase in fish-eating arrowtooth flounder, and an increase in walleye pollock, due to changes in surveyed biomass (Aydin, p.142). The dominance of planktivorous groundfish differs from the early 2000's when a high biomass of arrowtooth flounder drove the dominance of fish-eating groundfish in the GOA.

Looking Ahead to 2027

A very strong, or 'super', El Niño (greater than 2 °C SST anomaly at the equator) has been developing since the summer of 2026 and is the strongest El Niño on record (Lemagie et al., p.28). Previous El Niño events of similar strength occurred in 2015/2016, 1997/1998, and 1982/1983, all of which had observed ecological impacts in the Gulf of Alaska. While the duration and intensity of ocean warming is uncertain, all ocean temperature forecasts in this Report support warming of sea surface temperatures beginning in the eastern GOA during late fall 2026 and moving to the western GOA by spring 2027. Modeled surface temperature warm anomalies from January through March range from 0.25 °C (National Multi-Model Ensemble; NMME; baseline 1991 – 2020) to 1 °C (MOM6; baseline 1994 – 2023) in the western GOA and 0.5 °C (NMME) to 2 °C (MOM6) in the eastern GOA (Lemagie, p.35, Ocean Temperature Synthesis, p.41). Empirical-based forecasts of 2027 integrated water column temperature warm anomalies at GAK1 (northern GOA) range from 0.1 °C (Sitka air prediction; Hennon, p.37) to 1.5 °C (GAK1 April 2027 forecast; Danielson, p.79).

In the GOA, this event is likely to be more ecologically comparable to the one-year 1997/1998 very strong El Niño event, versus the more recent multi-year, cumulative marine heatwave event from 2014 – 2016 that included the "Blob" marine heatwave followed by the 2015/2016 El Niño (ENSO is predicted to transition to neutral conditions in 1997). The 1997/1998 reduced phytoplankton biomass and reduced regional food web productivity (Whitney and Welch, 2002). Boeing and Duffy-Anderson (2008) connected increased larval abundance of arrowtooth flounder, Pacific halibut, northern lampfish, and northern flashlight fish (deepwater, offshore spawners) to years with stronger alongshore winds and positive El Niño indices, alluding to optimal larval transport to nearshore habitat. Additional slope-spawning groundfish such as rex sole, rockfish spp., and sablefish may also benefit from this enhanced cross-shelf larval transport (Bailey and Susan J. Picquelle, 2002). Indicators of reduced forage fish availability in the GOA, key prey for numerous groundfish, seabirds, and marine mammals, were also reported from the 1997/1998 event. Seabird indicators included die-offs (shearwaters and common murres), reduced reproductive success, and delayed phenology (Anderson and Piatt, 1999). Reduced prey availability can also arise from trophic mismatch, such as the earlier spawning event observed in Sitka Sound herring

(Kruse, 1998).

The predicted warming in the GOA from fall 2026 to spring 2027 could lead to a less productive food web, including a shift in the phytoplankton community toward smaller, flagellate-dominated plankton, a shift in the zooplankton community toward smaller copepods and fewer nutrient-rich euphausiids, and potential declines in nutrient-rich capelin as a key forage fish. Juvenile and adult groundfish may have increased consumption rates (because warmer temperatures result in increased metabolic rates) and a reduced prey base, resulting in reduced body condition. The distribution of some adult groundfish (e.g., P. cod, arrowtooth flounder, walleye pollock) may shift deeper if the warm surface waters persist and sink below the surface (Yang et al., 2019) leading to changes in species' distributions and overlap with other species, with other fisheries, and with surveys. There is potential for the surface temperatures to exceed the optimal temperatures for larval survival and feeding of the early spring shelf spawners (Pacific cod, walleye pollock, northern rock sole), negatively impacting the 2027 year classes of these species. Conversely, warm surface waters in spring and summer can be favorable for rockfish and sablefish larval survival. As it takes time for warm surface waters to mix to depth, the extent of warming that might occur in the deeper habitat of adult groundfish is dependent on the intensity and persistence of the surface warming, but would be a delayed effect of the winter El Niño warming event. In summary, GOA groundfish stocks will be entering a year of greater environmental uncertainty, potentially lower prey availability, and increased temperatures (2027) from a year of above-average productivity (2026). These conclusions are based on observations from previous events, but this strongest El Niño on record falls outside the range of historical data. Novel and strengthened ecosystem responses are expected.

Contents

Gulf of Alaska Report Cards **5**

Ecosystem Assessment: The Status of the Gulf of Alaska 2026 **9**

Noteworthy **23**

†Proposals for Ocean Iron Fertilization Trials in the Gulf of Alaska 23

Ecosystem Indicators **26**

Physical Environment 26

Summary 26

Climate 28

State of the North Pacific Ocean 28

Forecasts of Ocean Temperature 35

Seasonal Projections from the National Multi-Model Ensemble 35

Predicted Ocean Temperatures in Northern Gulf of Alaska 37

Ocean Temperature: Synthesis 41

Ocean Transport 60

Eddies 60

Ocean Surface Currents – Papa Trajectory Index 64

Northern Gulf of Alaska Oscillation and Gulf of Alaska Downwelling index 67

Surface Wind in the Coastal Western Gulf of Alaska during April - May 69

Habitat 73

Structural Epifauna 73

Primary Production . . . 73
Satellite-derived Chlorophyll-a Trends . . . 73
Seward Line May Phytoplankton Size Index . . . 78
Northern Gulf of Alaska Physical Hydrography: Trends and El Niño Outlook . . . 79
Spring Bloom Timing over the Central Gulf of Alaska Shelf . . . 83
Zooplankton . . . 86
Continuous Plankton Recorder Data from the Northeast Pacific . . . 86
Current and Historical Trends for Zooplankton in the Western Gulf of Alaska . . . 89
Spring and Fall Large Copepod and Euphausiid Biomass: Seward Line . . . 93
†Spring biomass of large subarctic copepods in the central Gulf of Alaska, outer Line P. . . 97
Sea Jellies . . . 100
Ichthyoplankton . . . 100
Larval Fish Abundance . . . 100
Abundance of YOY Pollock and Capelin in Western Gulf of Alaska . . . 104
Morphometric Condition of Walleye Pollock Larvae . . . 104
Seabird Diets in the Gulf of Alaska . . . 104
Fisheries-independent Survey-based Indices of Forage Fishes in the Gulf of Alaska . . . 111
Southeastern Alaska Herring . . . 111
Southeastern Alaska Eulachon . . . 115
Salmon . . . 120
Trends in Alaska Commercial Salmon Catch . . . 120
Juvenile Salmon Abundance in Icy Strait, Southeast Alaska . . . 123
Juvenile Salmon Size, Condition, and Diet Trends in Icy Strait, Southeast Alaska . . . 128
Trends in Survival of Coho, Sockeye, and Pink Salmon from Auke Creek, Southeast Alaska 132
Groundfish . . . 136
Groundfish Condition . . . 136
ADF&G Gulf of Alaska Trawl Survey . . . 136
Distribution of Rockfish Species along Environmental Gradients . . . 141

Trends in Survey Estimated Biomass of Groundfish . . . 141
Environmental Conditions Experienced by Groundfish . . . 141
Summer Food Habits of Groundfish in the Gulf of Alaska . . . 142
Benthic Communities and Non-target Species . . . 145
Miscellaneous Species — NOAA Bottom Trawl Survey . . . 145
Seabirds . . . 145
Seabird Synthesis . . . 145
Marine Mammals . . . 159
Trends in Humpback Whale Calving in Glacier Bay and Icy Strait . . . 159
Marine Mammal Strandings . . . 163
Steller Sea Lions . . . 167
†Harbor Seal Abundance, Trends, and Ecosystem Indicators in the Gulf of Alaska . . . 167
Ecosystem or Community Indicators . . . 171
Foraging Guild Biomass . . . 171
Stability of Groundfish Biomass . . . 171
Mean Length of the Fish Community . . . 172
Mean Lifespan of the Fish Community . . . 172
Ecosystem or Community Indicators . . . 172
†Gulf of Alaska Ecosystem State . . . 173
Disease & Toxins Indicators . . . 178
Harmful Algal Blooms . . . 178
"Mushy" Halibut Syndrome Occurrence . . . 182
Intertidal Ecosystem Indicators in the Northern Gulf of Alaska . . . 183
Prince William Sound Herring . . . 191
Fall Surveys of Humpback Whales in Prince William Sound . . . 192
Fishing Indicators . . . 194
Maintaining Diversity: Discards and Non-Target Catch . . . 194
Time Trends in Groundfish Discards . . . 194

Time Trends in Non-target Species Catch 197
Seabird Bycatch Estimates for Groundfish and Halibut Fisheries 200
Sustainability 206
Fish Stock Sustainability Index 206

References **210**

Appendices **232**

A1. History of the ESRs 232
A2. Responses to North Pacific Fishery Management Council's Comments 236
A3. Report Card Indicator Descriptions & Methods 239

† indicates new contribution

List of Tables

1 Southeast Alaska eulachon return observations. 118

2 Humpback whale calf production and survival in Glacier Bay & Icy Strait, Alaska. 160

3 Reported stranded marine mammals from 2022–2026. 166

4 Status summary for Gulf of Alaska harbor seal stocks. 169

5 Summary of humpback whale counts in Prince William Sound. 193

6 Seabird bycatch in the eastern Gulf of Alaska groundfish fisheries, 2016–2025. 202

7 Seabird bycatch in western Gulf of Alaska groundfish fisheries, 2016–2025. 202

8 GOA FSSI stocks under NPFMC jurisdiction 208

List of Figures

1 Ecosystem information mapping to support EBFM in Alaska. 4

2 Western Gulf of Alaska report card indicators. 5

3 Eastern Gulf of Alaska report card indicators. 6

4 Map of currents and bathymetry in North Pacific and U.S. Arctic. 29

5 Time series of Climate Indices NINO3.4, PDO, NPGO, indices. 30

6 Time series of Climate Indices NPI, AL, and AO indices. 31

7 Monthly mean maps of sea surface temperature and surface winds. 33

8 Map of Aleutian low mean wind and SST patterns in 2026, El Niño, La Niña 34

9 Predicted SST anomalies from the NMME model for the 2026–2027 season. 36

10 Sitka, AK air temperature anomalies. 38

11 Predicted 2027 water column temperatures at GAK1, Seward Line. 39

12 Relationship of climate indices and Sitka air temperature. 40

13 Long-term sea surface temperatures, 1900–2026. 43

14 Hierarchical cluster analysis of MOM6 model-derived surface and bottom temperature anomalies. 44

15 Satellite-derived sea surface temperature anomalies 1985–2026. 46

16 Observed temperatures at surface and at depth, from fall surveys. 47

17 Observed temperatures at surface and at depth, from winter surveys 48

18 Observed temperatures at surface and at depth, from spring surveys 49

19 Observed temperatures at surface and at depth, from summer surveys. 50

20 Observed temperatures at surface and at depth, from fall surveys. 51

21 Marine heatwaves in the western GOA and eastern GOA 2023–2026. 52

22 Number of marine heatwave days, 1985–2026. 53
23 Spatial extent of marine heatwaves in 2024. 54
24 MOM6 model-derived bottom temperature for GOA shelf for 2026. 55
25 MOM6 foreacst of SST in the Northeast Pacific 56
26 Eddy kinetic energy map of regions. 61
27 Eddy kinetic energy time series. 62
28 Simulated surface drifter trajectories for winters 1968–2026. 65
29 Simulated surface drifter trajectories for winters 1902–2026. 66
30 Time-series of the Northern Gulf of Alaska Oscillation 1993–2026. 68
31 Time-series of the Northern Gulf of Alaska Oscillation and the Gulf of Alaska Downwelling Index fall 2024–2025. 68
32 Time-series of the Gulf of Alaska Downwelling Index 1993–2026. 69
33 Coastal wind trajectories in the western GOA (2004–2026). 71
34 Coastal wind direction in the western GOA (1980 – 2026). 72
35 Average chlorophyll-a concentration in western and eastern GOA. 75
36 Heat map of peak bloom timing of chlorophyll-a in western and eastern GOA. 76
37 Time Series of peak bloom timing of chlorophyll-a in western and eastern GOA, 1998–2023. 77
38 Spring Seward Line phytoplankton size index, 2001–2026. 79
39 Annual mean anomalies of temperature and salinity from GAK1, Seward Line. 80
40 Monthly temperature and salinity anomalies at GAK1 and Multivariate ENSO Index. . . 82
41 Annual mean anomalies of temperature and salinity along the Seward Line. 84
42 Location of continuous plankton recorder data collection 2025. 87
43 Three indices of lower trophic levels in the continuous plankton recorder 2025. 88
44 Distribution of copepods in western GOA, spring 2025. 90
45 Time series of abundance of copepods in western GOA, spring 2025. 91
46 Biomass of zooplankton along the Seward Line. 94
47 Biomass of zooplankton along the Seward Line. 95
48 Biomass of zooplankton along the Seward Line. 96
49 Map of the Line P transect and stations for zooplankton samples. 97

50 Biomass of calanoid copepods at select Line P stations. 99
51 Distribution of late spring larval walleye pollock in central GOA. 101
52 Interannual variation in late spring larval fish abundance in the GOA, 1981–2023. 102
53 Seabird diets from colonies across the GOA. 108
54 Rhinoceros aukley diet similatiries across GOA colonies. 109
55 Indices of Pacific capelin, P. sandlance, P. herring from seabird diets 110
56 Map of Pacific herring spawning locations in southeast Alaska. 112
57 Estimated biomass of mature herring in southeast Alaska. 114
58 Map of eulachon monitoring sites. 116
59 Eulachon population estimate on the Chilkoot River. 117
60 Chilkoot River eulachon spring eDNA rate. 119
61 Alaska and GOA commercial salmon harvest 1985–2026. 122
62 Time series of juvnile salmon CPUE in Icy Strait, southeast Alaska, 1997–2026. 124
63 Time series of commercial salmon harvest in Southeast Alaska, 1997–2026. 127
64 Average fork length of juvenile salmon in Icy Strait, southeast Alaska, 1997–2026. 129
65 Average energy density of juvenile salmon in Icy Strait, southeast Alaska, 1997–2026. . . 130
66 Average July diet of juvenile salmon in Icy Strait, southeast Alaska, 1997 – 2026. 131
67 Auke Creek (SE Alaska) salmon marine survival and productivity indices. 133
68 ADF&G Kodiak inshore and offshore trawl survey. 137
69 Total catch per km towed of selected species off of Kodiak Island, 1988 – 2026. 139
70 Anomalies of species catch during the Kodiak ADF&G trawl survey, 1988–2026. 140
71 Total consumption by major groundfish predators in GOA. 143
72 Major prey of walleye pollock and Pacific ocean perch in the GOA 143
73 Main prey of arrowtooth flounder, sablefish, and Pacific halibut in the GOA. 144
74 Summary of 2026 seabird status. 147
75 Reproductive timing of GOA seabirds in western GOA. 151
76 Reproductive timing of GOA seabirds in eastern GOA. 152
77 Reproductive success of seabirds in western GOA. 153

78 Reproductive success of seabirds in eastern GOA. . . . 154
79 Carcasses of fish-eating seabirds encountered on beaches in Gulf of Alaska. . . . 155
80 Carcasses of black-legged kittiwakes encountered on beaches in Gulf of Alaska. . . . 156
81 Densities of seabirds along the spring Seward Line surveys, 2007–2026. . . . 157
82 Crude birth rate and number of calves in Glacier Bay-Icy Strait, 1985–2026. . . . 160
83 Humpback whale health assessment photograph of calves in 2026. . . . 161
84 Map of reported stranded cetaceans in Alaska. . . . 164
85 Map of reported stranded pinnipeds in Alaska. . . . 165
86 Map of Alaska showing the approximate extent of harbor seals and the 12 delineated stocks. . . . 168
87 Abundance and survey effort for 9 stocks of harbor seals within the Gulf of Alaska. . . . 170
88 Ecosystem state of the western and eastern GOA (1985–2026). . . . 174
89 DFA trends and loadings from the western GOA (1985–2026). . . . 175
90 DFA trends and loadings from the eastern GOA (1985–2026). . . . 176
91 Tracks of the three IFCBs deployed in Alaska in 2026. . . . 180
92 Tracks of the IFCBs deployed in GOA in 2026. . . . 181
93 Intertidal temperature anomalies in the western GOA, 2011–2026. . . . 187
94 Percent cover anomalies for rockweed in western GOA, 2006–2026. . . . 188
95 Density anomalies for large mussels in the northern GOA. . . . 189
96 Density of sea stars in northern GOA, 2005–2024. . . . 190
97 Total biomass and percent of FMP groundfish catch discarded. . . . 195
98 Total biomass of FMP groundfish discarded by sector and week. . . . 196
99 Total catch of non-target species in groundfish fisheries, 2011–2025. . . . 199
100 Seabird bycatch in the GOA, Bering Sea, and Aleutian Islands, 2016–2025. . . . 201
101 Albatross bycatch in Alaska groundfish fisheries, 2016–2025. . . . 203
102 Trend in Gulf of Alaska FSSI, 2006–2026. . . . 207
103 The trend in Alaska FSSI, 2006–2026. . . . 209
104 The integrated ecosystem assessment (IEA) process. . . . 235

Noteworthy

We include information here that is relevant to ecosystem considerations of fisheries managers, but does not fit our typical indicator format. Information included here is often new, a one-time event, or a deeper discussion on a topic of interest.

Proposals for Ocean Iron Fertilization Trials in the Gulf of Alaska

Contributed by Tara Flood, Alia Payne, Erendira Aceves Bueno, School of Marine and Environmental Affairs, University of Washington, Seattle, WA
Contact: tflood@uw.edu

While international climate agreements are working to substantially reduce greenhouse gas (GHG) emissions, researchers have recently given more serious consideration to carbon dioxide removal (CDR) strategies. These CDR methods aim to remove legacy GHGs and mitigate the emissions from "hard-to-abate" sectors (Intergovernmental Panel on Climate Change (IPCC), 2023). One explored method of marine carbon dioxide removal (mCDR), ocean iron fertilization (OIF), seeks to utilize primary production and the ocean's natural biological carbon pump to increase atmospheric CO_2 uptake (Martin, 1990). Through photosynthesis, phytoplankton living at the ocean's surface convert inorganic carbon (including dissolved CO_2) into organic carbon that sinks or mixes through the water column as carbon-rich marine snow. In optimal scenarios, this carbon is exported to a depth of at least 500 m (Siegel et al., 2021) where it can be stored on decadal to centennial timescales (Ricour et al., 2023; Turner, 2015).

The ocean is currently able to take up about 25% of annual anthropogenic CO_2 emissions (Mayot et al., 2024), but in high nutrient, low chlorophyll (HNLC) regions like the subarctic North Pacific Ocean, photosynthetic carbon uptake is limited by the supply of the micronutrient iron (Fe) (Browning and Moore, 2023; Heinze et al., 2015; Nishioka and Obata, 2017). Inputs of Fe into surface waters via artificial OIF deployments could stimulate additional primary production and would ideally enhance carbon sequestration (Aumont and Bopp, 2006). In recent decades, there have been 13 OIF field experiments, including the 2002 Subarctic Ecosystem Response to Iron Enrichment Study in the Gulf of Alaska (SERIES), which have resulted in successful phytoplankton blooms (de Baar et al., 2005). Atmospheric carbon export has been observed to varying depths in several of these trials, however exact quantities are uncertain due to inconsistent tracking methods (Tagliabue et al., 2023; Buesseler et al.,

2026).

Although evidence of significant bloom events exist, the extent to which this alters marine ecosystems remains unclear. Potential ecological risks like 'nutrient robbing', hypoxia, harmful algal blooms, and alterations to marine food webs have been noted since the emergence of OIF (Cullen and Boyd, 2008; Trick et al., 2010). In the Gulf of Alaska, there is particular interest in understanding how OIF could impact fisheries and other species in upper trophic levels.

Previous hypotheses suggested that an increase in phytoplankton growth, driven by iron supplementation, could increase prey availability for planktivorous salmon and allow for the stronger returns (Olgun et al., 2013; Parsons and Whitney, 2012). However, updated mCDR literature indicates that there are many confounding processes that impact salmon survival and it would be inaccurate to assume long-term benefits to salmon from such short trials (McKinnell, 2013; National Academies of Sciences, Engineering, and Medicine (NASEM), 2022). Moreover, longer and more expansive OIF experiments could lead to a reduction in macronutrients from nearby areas causing downstream declines in biological productivity, a phenomenon commonly referred to as 'nutrient robbing' (The Royal Society, 2009). It remains unclear how significant nutrient robbing could be in the North Pacific, but the strong connection between global ocean basins suggest that OIF deployments in some regions could create non-localized productivity declines which could negatively impact fisheries in the future (Gnanadesikan et al., 2003; National Academies of Sciences, Engineering, and Medicine (NASEM), 2022; Yu et al., 2026).

In addition to nutrient robbing, increased primary production also poses the risk of hypoxia. A reduction in oxygen levels has the potential to affect the distribution, migration, ontogeny, and reproductive success of a variety of marine species, and can be lethal for fish and shellfish (Oschlies et al., 2025; Roman et al., 2024). Harmful algal blooms, in particular those composed by the diatom *Pseudonitzschia*, are also a concern for large-scale OIF efforts. These diatoms can be consumed by filter feeders and consequently expose the predator species, and coastal communities that harvest them to neurotoxins (Silver et al., 2010). After an iron fertilization study done in the Subarctic Eastern Pacific, toxic algal blooms dominated by *Pseudonitzschia* spread across the photic zone (Trick et al., 2010). This draws concern for how OIF could impact higher trophic levels in areas where OIF experiments are expected to be executed.

These potential ecosystem-level impacts provide important context for evaluating proposed OIF experiments in the Gulf of Alaska. They also raise questions about how OIF could influence regional productivity, trophic wide interactions, and fisheries beyond the immediate study area. Seeking to advance this type of OIF research, an international scientific consortium formed the not-for-profit program ExOIS (*Exploring Ocean Iron Solutions*) in 2022. Hosted by the Woods Hole Oceanographic Institution (WHOI), ExOIS has published plans for large-scale OIF experiments in the Gulf of Alaska. According to updates announced in the summer 2026, the group is working with the EPA on a preliminary application to initiate an experiment approximately 700 km off shore of Alaska with target concentrations of about 1.0 - 2.0 nM Fe (ExOIS, 2026). The proposed site lies within the Alaska gyre, an HNLC zone with low eddy kinetic energy that could preserve the shape and limit the spread of the 30 x 30 km Fe patch. Monitoring efforts, via satellites, ships, and autonomous vehicles will be used to observe ecological and chemical changes in the surrounding study site for up to three months following the deployment (ExOIS, 2026). Due to the unprecedented scale and duration of the project, it is challenging to accurately forecast the outcomes of OIF efforts, such as the ExOIS experiment. However, baseline oceanographic data provided by Ocean Station Papa (located 250 km from the ExOIS site) and previous OIF experiments, such as SERIES, offer insight into the plausible consequences of OIF in the northeast Pacific Ocean (Wong et al., 2006).

At a time when the need for climate solutions is increasingly urgent, OIF presents a unique opportunity. However, continued research is essential to better understand possible impacts on coastal communities and to identify ways to anticipate, prevent, or mitigate these unintended consequences. Ongoing research of the positive or negative impacts of OIF on Pacific salmon and other marine species can help direct monitoring efforts as future OIF experiments are developed and management practices are considered.

Ecosystem Indicators

Physical Environment

Summary

Climate: The winter 2026 Aleutian Low pressure system was the weakest in at least 20 years, contributing to the arrival of winds blowing from the north brining cooling pressures across Alaska marine ecosystems. The GOA shelf rapidly cooled from warmer than average ocean temperatures in 2025 (through December) due to winter/spring winds from the north and west. The ocean temperatures remained warmer than average in the northwest Pacific and central north Pacific, continuing a multi-year trend. As of November 8, 2026 from the NOAA Climate Program Center[5] the 2026 El Niño continues to strengthen with a greater than 90% chance of a very strong event (perhaps the strongest since 1950) during the Northern Hemisphere fall and winter 2026 – 2027. Impacts of El Niño in the GOA can depend on the intensity and duration of the event but may include warmer surface temperatures arriving in the southeast AK late fall/early winter.

Ocean Temperature: Long-term surface temperatures (1900 – 2026) show a persistent warming across the GOA shelf, driven largely by increasing temperatures in the summer months (May - Oct.) (Thoman in this Report, p.41). The GOA shelf ocean temperatures rapidly cooled from a warm 2025 year, to within known ranges of optimal temperatures for groundfish across their life history stages in 2026. Winter winds from the north brought cooling temperatures into the GOA, cooling shelf waters to approximately average on the western and eastern shelf from January to August (Lemagie et al., p.28), Lemagie and Callahan, p.41). A west-to-east gradient of heat was present in the GOA, with cooler than survey average temperatures at the surface (March, 2.2 °C) and depth (March: 3.3 °C, summer: 5.8 °C) in the western GOA winter and summer surveys (McKelvey et al., p.41,Worton et al., p.136), cooler than average temperatures in the northern GOA at the surface (May, 7 °C) but warmer at depth (May: 5.7 °C), (Danielson, p.79), and warmer at the surface in southeast Alaska (satellite-derived, Lemagie and Callahan, p.41).

Satellite-derived shelf average surface temperatures rapidly cooled to approximately average across the western and central GOA shelf in the winter and spring, with the exception of southeast Alaska surface and Seward Line at depth retaining some of its heat (Lemagie and Callahan, p.41, Danielson, p.79). The GOA shelf did not experienve marine heatwave conditions to-date in 2026 (Lemagie and Callahan, p.41). Temperatures at depth in Shelikof Strait also cooled by at least early spring, indicating minimal

[5] https://cpc.ncep.noaa.gov/products/analysis_monitoring/enso/roni/strengths/

retention of heat at depth in this region after above-average temperatures the previous year (McKelvey et al., p.41). The central GOA gyre experienced increased upwelling, bringing cooler waters to the surface in this offshore region (Pages and Hauri in this Report, p.67). These average temperatures are predicted to transition to warmer sea surface temperatures moving from the eastern to western GOA shelf in winter 2027, in alignment with the strengthening El Niño conditions (National Multi-model Ensemble Model, Lemagie and Bell, p.35). The GOA Sitka air temperature prediction (Hennon, p.37) predicts average water column temperatures at GAK1 (near Seward) in 2027, either not yet responding to the warm El Niño conditions moving north, representing lower predictive skill this year, or a more moderate forecast for the upcoming winter.

Ocean Transport: The Aleutian Low was very weak in the winter of 2026 (similar to 2006, 1982), indicating weak wind-driven surface circulation. Spring wind direction near Shlikof Str. (Rogers et al., p.64 and the Papa Trajectory Index (Stockhausen, p.64) support the narrative of weak winter and spring wind-driven circulation. Conversely, the North Gulf of Alaska Oscillation index was the strongest negative value since 1993, indicating strong winter/spring subarctic gyre circulation which feeds the Alaska Current on the GOA shelf (Pages, p.67). While the Aleutian Low pressure system is related to the strength of the subarctic gyre, there can be a delayed response of atmospheric variability to ocean circulation changes (Wills et al., 2019). The 2026 GOA winter/spring experienced increased upwelling at the center of the GOA gyre, bringing cooler, more nutrient rich waters to the surface and onto the shelf (Pages and Hauri in this Report, p.67). The GAK1 mooring (near Seward) measured lower salinity in the surface waters, reflecting increased transport of freshwater from southeast AK (Danielson in this Report, p.79).

Climate

State of the North Pacific Ocean

Contributed by Emily Lemagie, Shaun Bell, and Muyin Wang, NOAA's Pacific Marine Environmental Laboratory
Contact: emily.lemagie@noaa.gov
Last updated: September 2026

Description of Indicator: Sea surface temperatures (SST) data and sea ice data from the NOAA High-resolution Blended Analysis of Daily SST and Ice (OI SST V2[6]), along with 10-m wind data from the ERA5 Reanalysis2[7] from September 2025 – August 2026 are described across eight regions of the North Pacific Ocean (Figure 4). Note the transition this year to the ERA5 Reanalysis from the National Centers for Environmental Prediction (NCEP) due to data availability; the conclusions in this report are not impacted by the change.

The Aleutian low is the dominant feature of the atmospheric pressure system in the Northern North Pacific during winter (December to March), which develops and strengthens seasonally between the Beaufort high and North Pacific high pressure regions. Variability in strength and the position of the low is important to the Alaska marine ecosystem through its impact on circulation, surface heat fluxes, mixed layer depth, and the extent of sea ice cover over the Bering Sea, all of which influence the rich biological resources of the sea (Rodionov and Overland, 2005; Wooster and Hollowed, 1995). In general, the intensity and position of the Aleutian Low can significantly influence storm tracks, ocean circulation, and weather patterns across the North Pacific, impacting North America. Motivated by work from Rodionov and Overland (2005), we defined the Aleutian Low Index (ALI) as the areas where sea level pressure (SLP) is less than or equals to 1000hPa in the North Pacific region (40 – 60 °N, and 160 °E – 160 °W). Aleutian Low is a statistical low, which exists in winter only. We computed the monthly Aleutian Low Index, and then averaged for the winter mean (January and February). A 30-yr climatology (1991 – 2020) mean is removed from the index.

The North Pacific underwent a rapid transition from La Niña to El Niño conditions this last year (Figure 5). Notably, strong winds from the north drove rapid cooling and sea ice expansion across the Bering Sea in March and April. This late season burst resulted in the most sea ice coverage at the southern Bering Sea shelf M2 ecosystem mooring than observed since 2017. Through summer, cool surface temperature anomalies extended across the Bering Sea and Gulf of Alaska. However, warm anomalies that have been present since 2020 persisted in the western and central North Pacific from south of the Aleutian Islands and into the Bering Sea deep basin. By late summer, as the El Niño in the tropical Pacific gained strength, the Gulf of Alaska has rapidly transitioned back to above-average surface temperatures, with anomalies projected to increase through the coming winter.

Status and trends:
While SST have been cool over the Bering Sea and into the Gulf of Alaska this spring, due to the strong wind anomaly and southward sea ice advection in March - April, marine heatwave conditions

[6] https://psl.noaa.gov/data
[7] https://cds.climate.copernicus.eu/datasets/reanalysis-era5-land

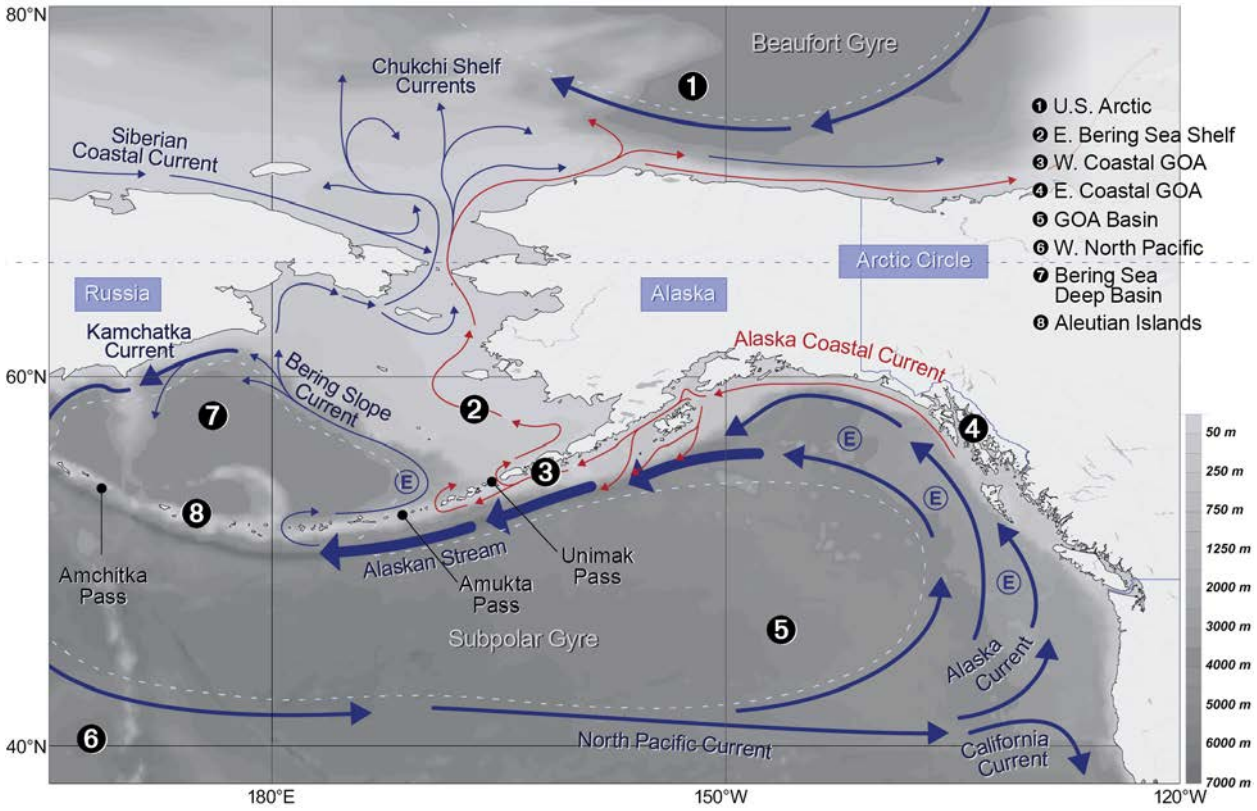


Figure 4: Geographic regions of interest, ocean bathymetry, and mean currents across the North Pacific and U.S. Arctic. Figure courtesy of Sarah Battle, PMEL.

have continued in the central and western North Pacific and Aleutian Islands (Figure 7). Strong positive SST anomalies have dominated the mid-latitudes of the global oceans this summer. As these anomalies increase in the eastern equatorial Pacific, El Niño conditions have strengthened. The latest update as of August 13, 2026 from the NOAA Climate Program Center is for a 90% chance of a very strong El Niño this coming autumn through winter. Though weaker in magnitude, positive SST anomalies have also dominated in the North Pacific and Bering Sea basins (Figure 7). In contrast, along the Gulf of Alaska and Bering sea shelves–especially above $\sim$ 50 °N – surface ocean temperatures have been below average since spring. In winter, as El Niño reaches peak strength, warm anomalies are expected to emerge beginning in the Gulf of Alaska, where ocean forecasts from the NOAA Physical Sciences Laboratory projects 50% chance of reaching marine heatwave threshold by winter.

Western Coastal Gulf of Alaska: Coastal temperatures in the western Gulf of Alaska were warmer than average from the summer of 2025 through the end of the year (Figure 7). Driven by a weak winter Aleutian Low, southerly warm air advection remained minimal (Figure 8). Strong spring winds from the west then brought cool air into the region, deepening the mixed layer and delaying stratification. As a result, western coastal Gulf of Alaska temperatures have tracked near or below average since spring 2026. Warm anomalies are expected to reemerge associated with the strong winter El Niño and propagation of warm coastal anomalies that are already impacting the U.S. west coast.

Eastern Coastal Gulf of Alaska: Similar to the western coastal Gulf of Alaska, surface temperatures

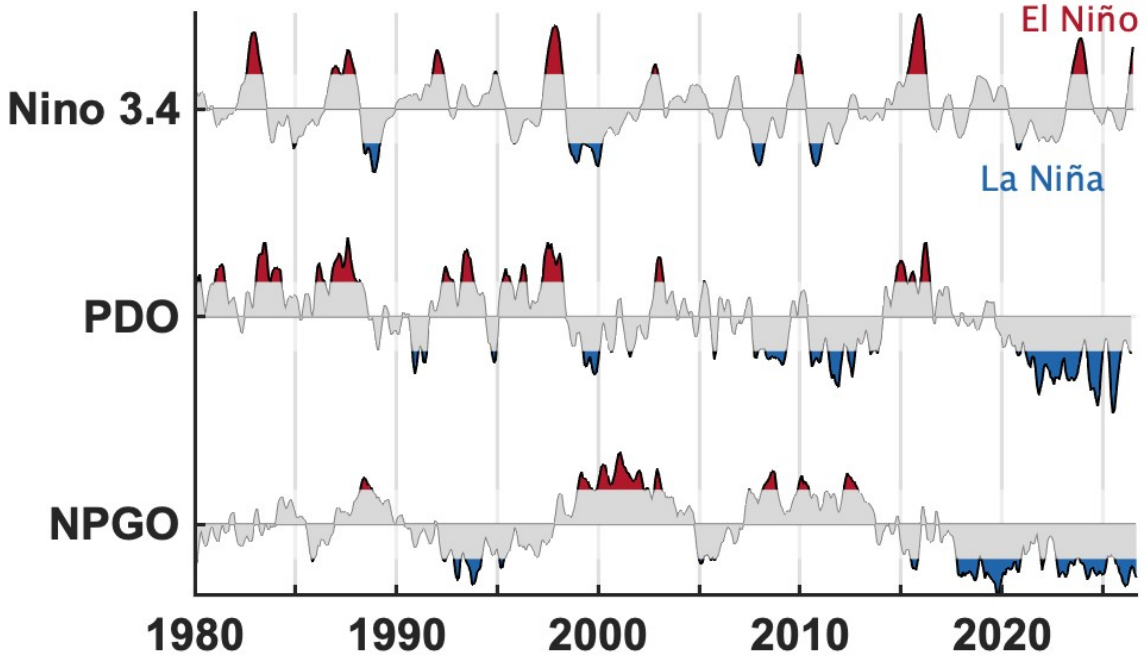


Figure 5: Time series of three commonly used indices for relating patterns across the Alaska marine ecosystem, including the NINO3.4 index for the state of the El Niño/Southern Oscillation, the Pacific Decadal Oscillation (PDO) index, and the North Pacific Gyre Oscillation (NPGO) index, from 1980 to present. Each monthly index is normalized using a 30-year climatology from 1991–2020 and smoothed using a 3-month running mean. Red and blue shading indicates positive and negative values outside of one standard deviation, respectively. Lighter shaded areas are within one standard deviation of the 30-year climatology. Additional information on these indices can be found on the NOAA Physical Sciences Laboratory website[8].

along the eastern region were above average for the latter half of 2025 (Figure 7). In contrast to the western coastal region, the atmospheric patterns this winter and spring with winds from the south were favorable to coastal downwelling, and alongshore transport of heat from lower latitudes. As a result, surface temperature anomalies have remained near or above historical average values. Warm anomalies have been most persistent around southeast Alaska, which is likely to see the earliest increases in warming this winter associated with the coastal propagation of the warm El Niño signal.

Gulf of Alaska Basin: The Gulf of Alaska surface temperature anomalies are more variable on seasonal timescales and less strongly associated with subsurface heat storage than in the central and western North Pacific, where heat anomalies extending to 100m, have persisted since 2020. Since autumn 2025, SST in the Gulf of Alaska has been within $\sim$ 1°C of the historical mean. Between spring and summer 2026, conditions displayed a latitudinal gradient near 50 °N, with cooler-than-average waters to the north and slight warm anomalies to the south.

Eastern Bering Sea Shelf: In autumn 2025, the eastern Bering shelf surface temperatures were 1 – 2 °C above average (Figure 7). In November, southward winds through the Bering Strait began to cool the northern Bering sea shelf and advect sea ice southward. As the sea ice advanced over the shelf from November through February, its extent varied between below average and near-average, associated

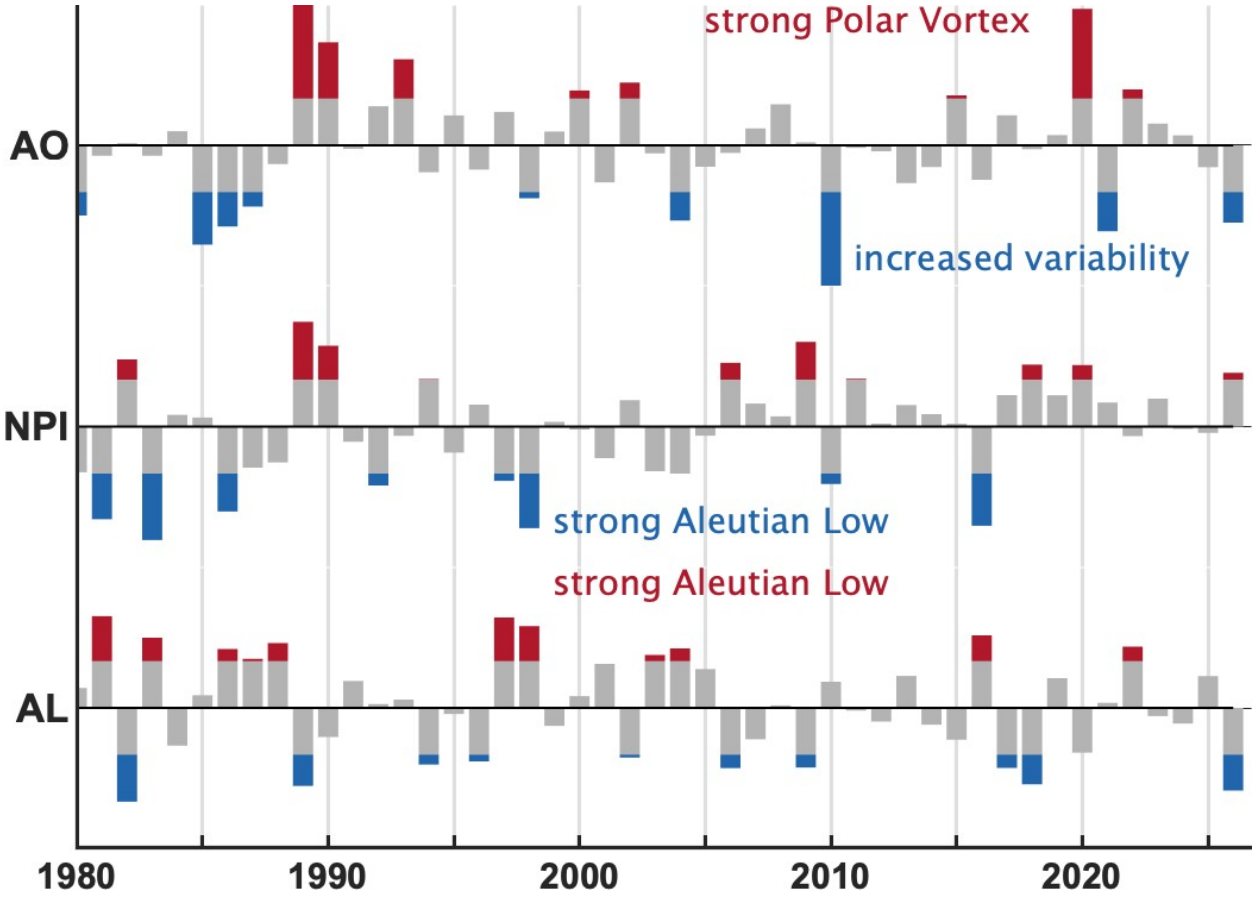


Figure 6: Time series of three indices for relating atmospheric patterns across the Alaska marine ecosystem, including the Arctic Oscillation (AO), North Pacific Index (NPI), and Aleutian Low index (AL) from 1980 to present. The AO and NPI indices are averaged over the winter period from November to March, while the Aleutian Low index is calculated as averaged over the months of January and February. The NPI and AL are normalized using a 30-year climatology from 1991 – 2020. Red and blue shading indicates positive and negative values, respectively, outside of a threshold value (AO $= \leq 1$) or of one standard deviation from the mean (NPI and AL). Additional information on these indices can be found on the NOAA Physical Sciences Laboratory website.[9].

with the prevailing winds. In March and April, a six week period of anomalous southward winds drove a rapid expansion of sea ice southward–reaching the long-term M2 mooring–followed by a rapid retreat in mid-April. The sea ice cooled the waters of the southeastern Bering Sea shelf and temperatures > 2 °C below average have persisted through the summer.

Aleutian Islands: Since 2020, strong SST anomalies and subsurface warming has persisted over the central North Pacific Ocean, captured by ocean indices such as the Pacific Decadal Oscillation and marine heatwave statistics (Figure 8 and Lemagie and Callahan, p.41). Corresponding weaker, but mostly persistent warm anomalies, have also spanned much of the Aleutian Islands region–particularly in the western regions–and Bering Sea basin. Notably the anomalous winds this spring and summer, causing divergence from typical atmospheric and oceanic pathways of heat transport, have contributed to the cool temperature anomaly that has spread eastward along the archipelago. The marine heatwave

subsided as sea surface temperatures dropped below the threshold. The region experienced a summer reprieve with near-average surface temperatures. As subsurface warmth mixes to the surface alongside the peak of El Niño, marine heatwave conditions are expected to reemerge this winter.

Wintertime Aleutian Low Index: This past winter, the Aleutian Low was extremely weak (Figures 8 and 6). This reduced the poleward advection of warm air masses over the eastern North Pacific and the southward advection of Arctic air masses over the Bering Sea. Winter air temperature anomalies were cool over much of Alaska, except along the northern coast, while warm air temperature anomalies spanned the Russian continent and most of the North Pacific west of the dateline. This contrast marks a departure from the previous three winters, when above-average temperatures were anchored over Alaska and neighboring regions experienced far greater variability. In spring, the steep pressure gradient between the high pressure to the north and low pressure systems moving across the Aleutian Islands and Gulf of Alaska drove strong southward winds, bringing cold air and sea ice across the Bering Sea and rapid cooling into the North Pacific.

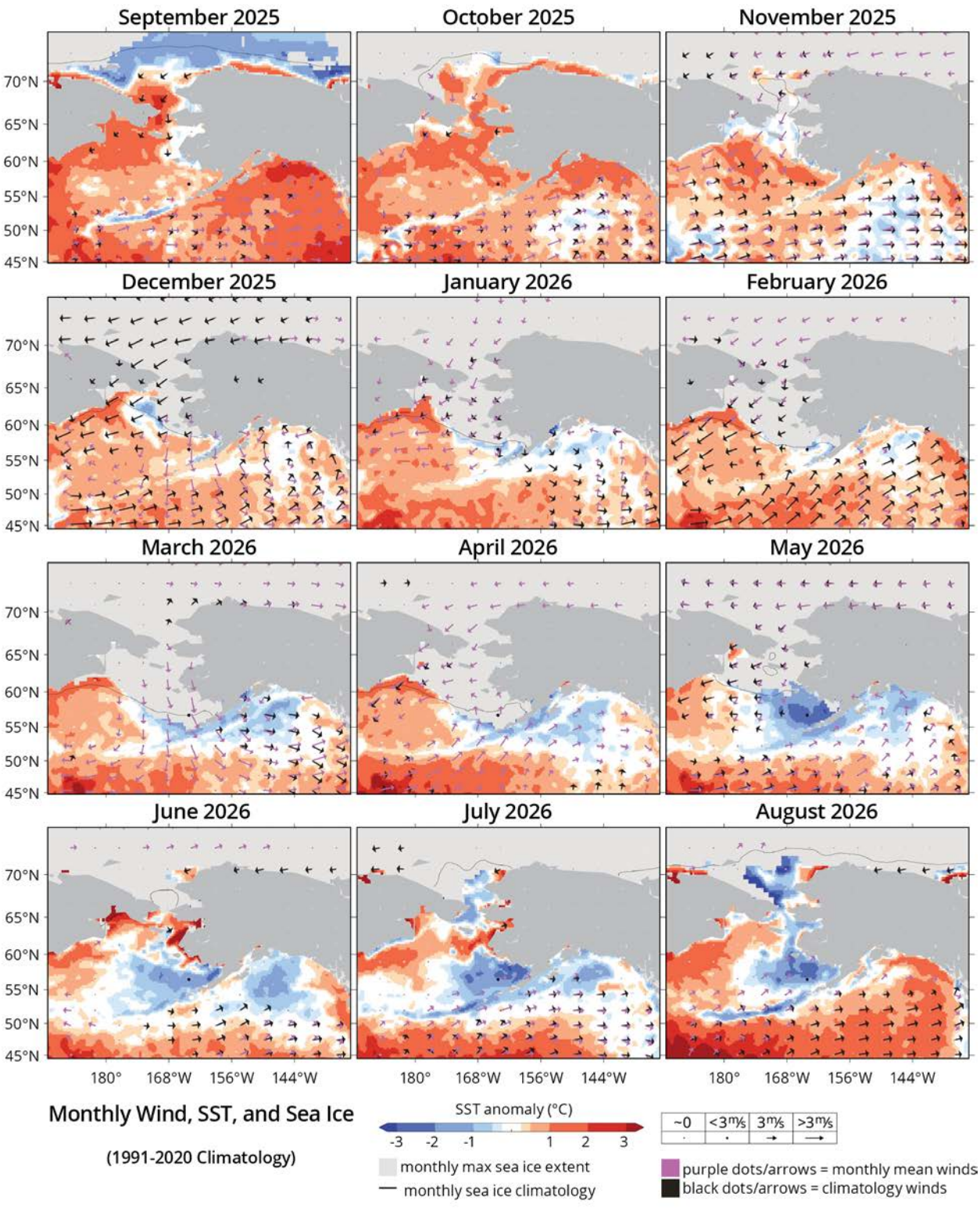


Figure 7: Monthly mean maps of sea surface temperature (SST) anomalies and surface winds. Monthly climatological winds (black) are compared to monthly mean winds (purple). The climatological period is from 1991 – 2020. SST data are from the NOAA High-resolution Blended Analysis of Daily SST and Ice (OISST), and 10-m wind data are from the NCEP/NCAR Reanalysis II; both are available from NOAA's Physical Sciences Laboratory[10] and 10-m wind data are from the ERA5 Reanalysis available from the Copernicus Climate Change Service[11]. Figure courtesy of Sarah Battle, PMEL.

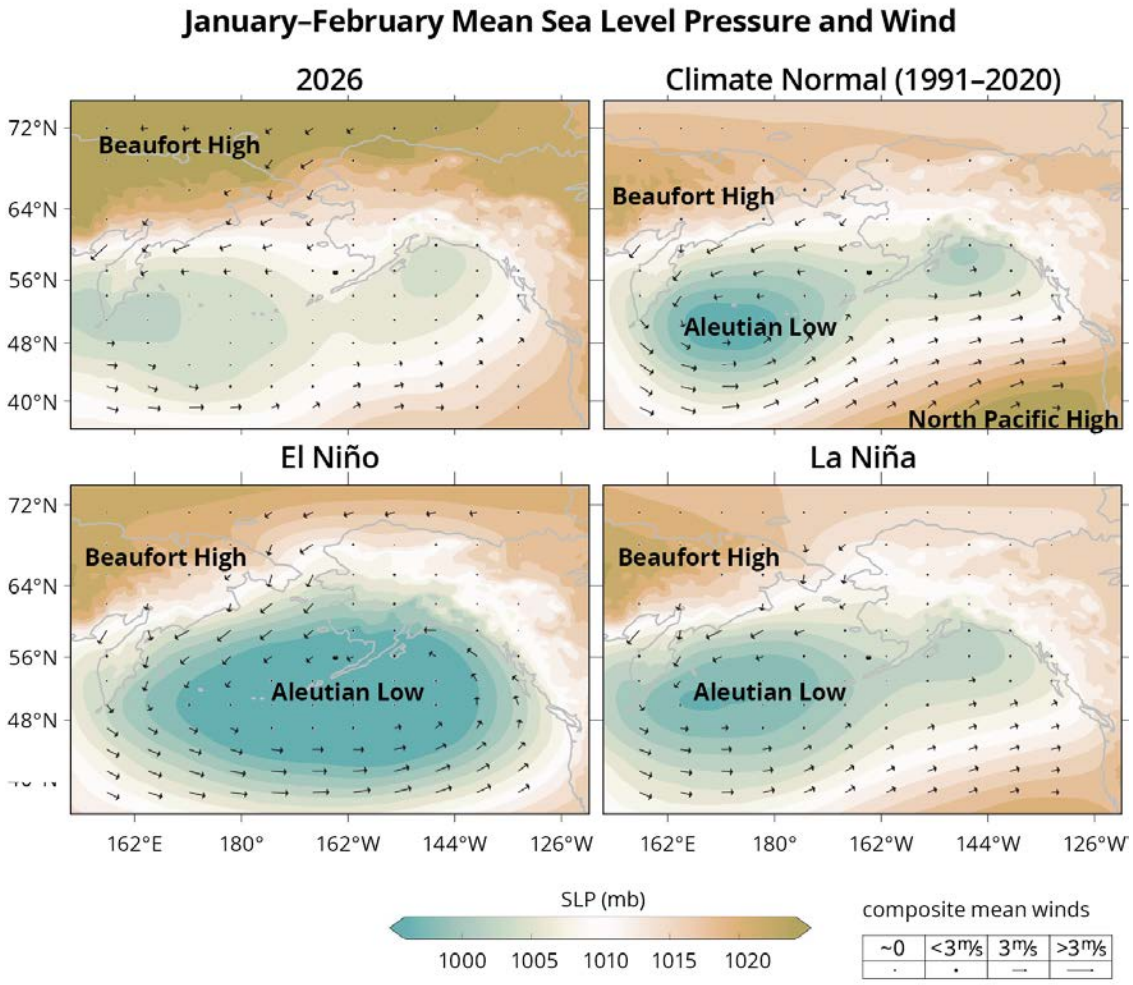


Figure 8: Top row: Mean January–February SLP and surface wind patterns in 2024, from the climatological mean (1991 – 2020). For reference, January–February SLP composite mean patterns for negative (strong Aleutian low) and positive NPI (weak Aleutian low) conditions are also shown.

Forecasts of Ocean Temperature

Seasonal Projections from the National Multi-Model Ensemble (NMME)

Contributed by Emily Lemagie, NOAA's Pacific Marine Environmental Laboratory
Contact: emily.lemagie@noaa.gov
Last updated: October 2026

Description of indicator: Seasonal predictions of SST anomalies from the National Multi-Model Ensemble (NMME) are shown in Figure 9. An ensemble approach incorporating different models is particularly appropriate for seasonal and interannual predictions. The NMME represents the average of eight climate models. The uncertainties and errors in the predictions from any single climate model can be substantial. More detail on the NMME, and predictions of other variables, are available at the NCEP website[12]. A description of the probability forecasts can be found on the NOAA NMME website[13]. This probability forecast combines predictions from 79 model ensembles and divides the outcomes into three equal groups: Above normal, Below normal, and Near normal. Map contours highlight a specific category whenever a clear consensus emerges: Above (A) or Below (B) is shown if at least 38% of models favor that outcome while fewer than 33% favor the opposite. If Near Normal is also high (over 33%), the Above or Below forecast still takes priority. Near Normal (N) is shown only when more than 38% of models predict average conditions and both Above and Below remain under 33%. White areas indicate uncertainty where no single category dominates—either because model votes are split evenly across all three outcomes, or because models are conflicting heavily between Above and Below.

Status and trends: Surface temperatures are projected to be below–but within 0.5 °C–of the historical mean temperature over the eastern Bering Sea shelf Figure 9. However, the winter and spring forecasts are highly dependent on seasonal sea ice coverage. Warm surface ocean temperatures $\leq$ 1 °C above typical are likely to persist over the central and western North Pacific and the western Bering Sea. Gulf of Alaska temperature anomalies are projected to increase over time, with greater warmth along the coast, particularly in the eastern coastal Gulf of Alaska, through spring 2026. This pattern is consistent with a lagged response to the ongoing El Niño in the tropical Pacific. In the eastern north Pacific basin, south of the Gulf of Alaska, near-normal or slightly below-average surface temperatures are forecast. There is high model agreement across the ensemble member forecasts, particularly in the western and central North Pacific and in the Gulf of Alaska.

[12] http://www.cpc.ncep.noaa.gov/products/NMME
[13] https://www.cpc.ncep.noaa.gov/products/NMME/NMME_PROB_descr.html

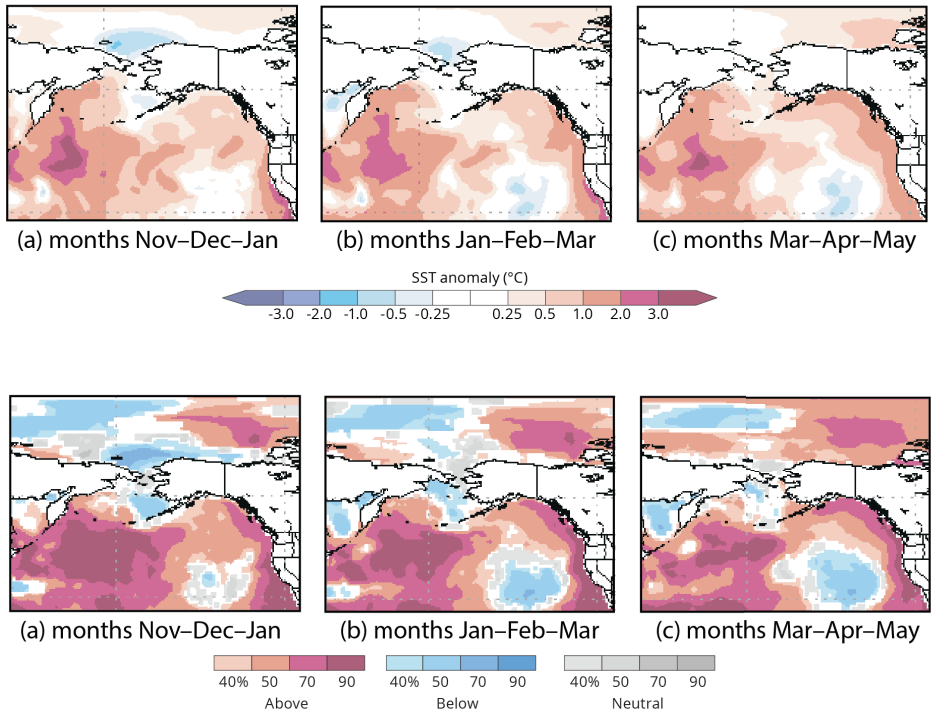


Figure 9: Predicted SST anomalies (top) and corresponding forecast probabilities from the NMME model for Nov–Dec–Jan (1-month lead) for the 2026 – 2027 season, Jan–Feb–Mar (3-month lead), and Mar–Apr–May (5-month lead) 2027.

Predicted Ocean Temperatures in Northern Gulf of Alaska

Contributed by Tyler Hennon and Seth Danielson, College of Fisheries and Ocean Science, University of Alaska Fairbanks
Contact: tdhennon@alaska.edu
Last updated: September 2026

Description of indicator: Air temperatures in Sitka, AK are dominated by the marine climate. Danielson et al. (2022) found Sitka air temperatures had a weak but significant predictive power for integrated coastal water column temperatures in the following year at the nearshore station (GAK1) of the Seward Line Transect, in the northern GOA ($r^2 = 0.37$, $p < 0.05$). This predictive power may be explained by Sitka's 'upstream' location of GAK1 along the Alaska Coastal Current. Records of Sitka air temperatures exist since 1850 and GAK1 has recorded ocean temperatures since 1970. The anomalies for both GAK1 oceanic temperature and Sitka air temperature are seasonally adjusted, and relative to the long-term average (1970-present for GAK1).

Status and Trends: The 2027 integrated water column temperatures for the nearshore GAK1 station of the Seward Line transect are predicted to be about average based on 2026 Sitka air temperatures. The average Sitka air temperature through September 1st, 2026 was ~ 0.1 °C warmer than the long-term average (Figure 10). If the anomalies observed through 2026 persist (i.e., Sitka air temperatures in Sep. to Dec. remain ~ 0.1 °C above seasonal averages), we could expect whole water column GAK1 temperatures in 2027 to be $\sim 0.1 \pm 0.5$ °C above average (Figure 11). The GAK1 full water column depth-averaged temperature is 6.24 °C for the period of record. Based on the anomalies observed thus far through 2026, GAK1 integrated ocean temperatures ($\pm$ 1SD) are predicted to range from 5.7 to 6.8 °C (centered on 6.3 °C) in 2027.

Factors influencing observed trends: Both Sitka air temperature and GAK1 water temperature are impacted, in part, by large scale climate systems. Detrended (decadal trend removed) Sitka air temperature anomalies are positively correlated with the Multivariate ENSO Index (MEI) and Pacific Decadal Oscillation (PDO) ($p < 0.001$ for both) (Figure 12). While there is a tighter correlation between detrended Sitka air temperature anomalies and PDO, there is a marked departure within from 2022 to 2025, where an extended negative state of PDO has also coincided with relatively warm air temperatures. Into 2026 we see a return to the typical correlation clustering between Sitka air temperature and PDO.

Implications: It is important to note that Sitka air temperature just a single predictor of GAK1 water column anomalies, with modest skill ($r^2 = 0.37$). The building El Niño event is expected to trigger warming throughout the northern Gulf of Alaska, and it is possible this is a year where the prediction of average water temperature at GAK1 in 2027 does not prove accurate.

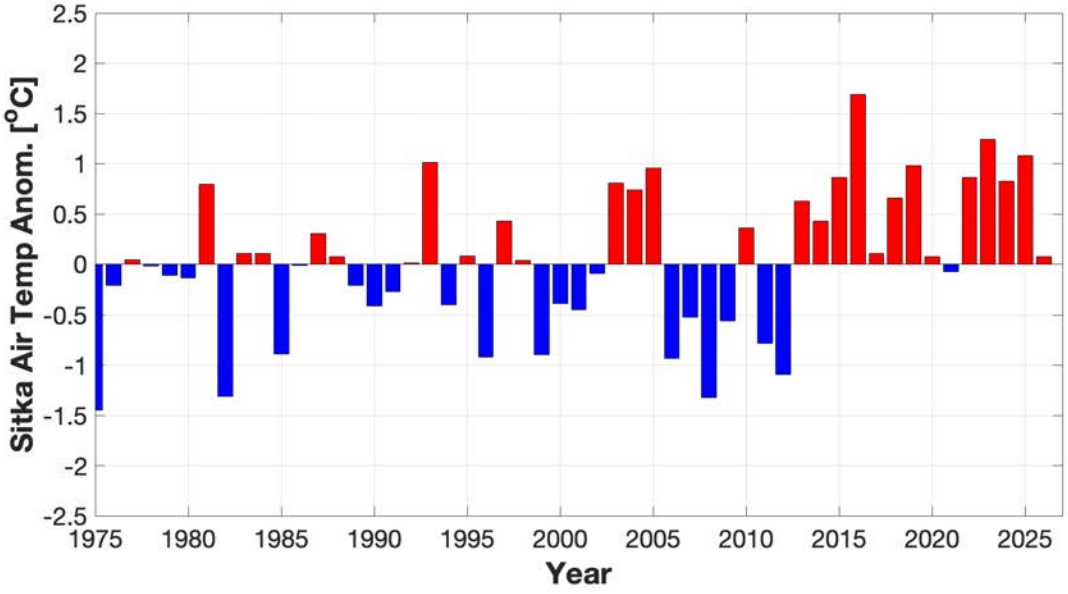


Figure 10: Annual averages of monthly temperature anomalies (seasonal climatology removed) Sitka, Alaska air temperature (entire record is 1828 – 2026; figure shows 1975 to present). Records are shown relative to a 50-year baseline computed over 1970 – 2020, updated from Danielson et al. (2022).

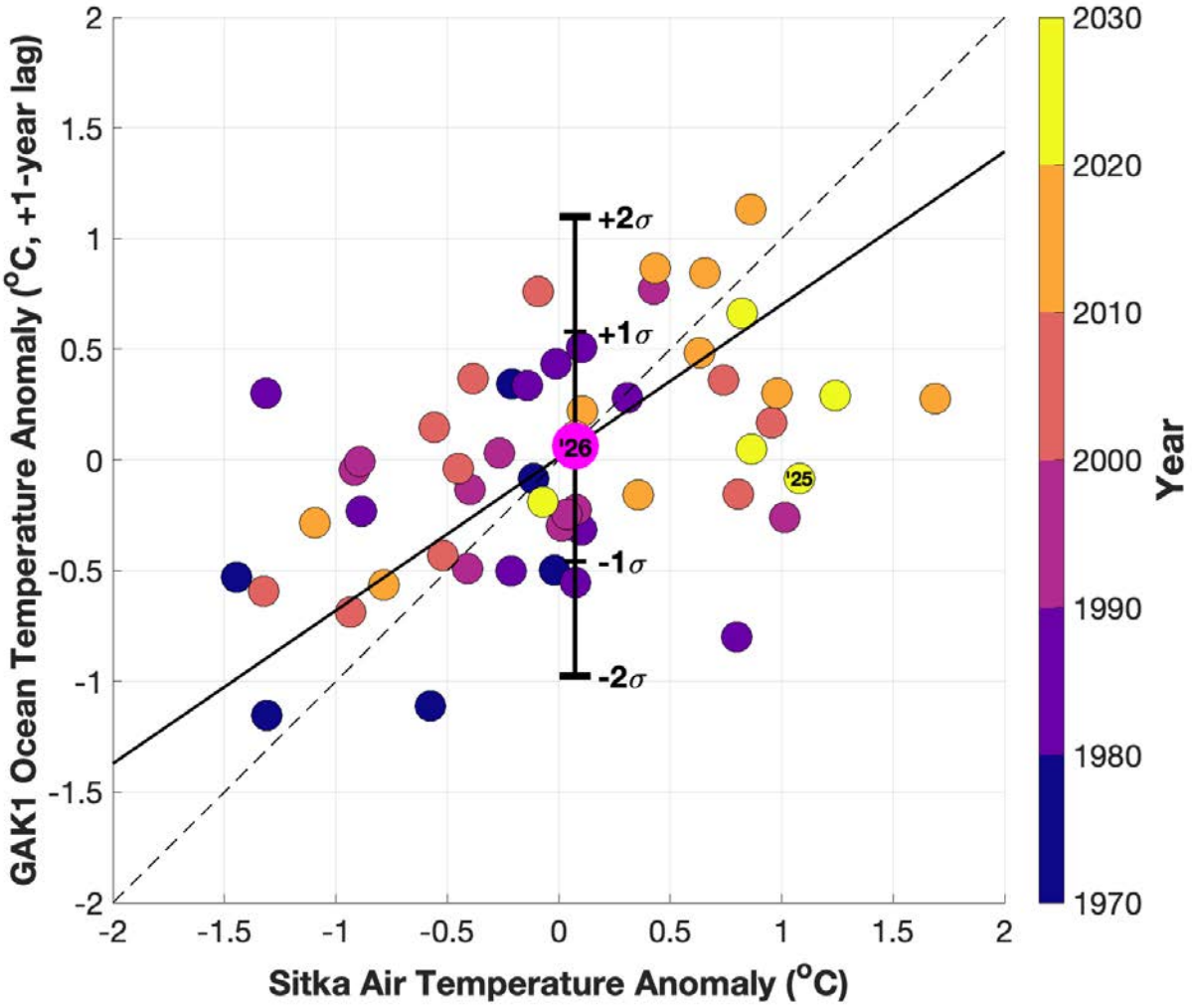


Figure 11: Relationship between the detrended annual Sitka air temperature anomaly (x-axis) and the following-year whole water column ocean average temperature anomaly measured at station GAK1 (y-axis), with a +1 year lag compared to Sitka. Dashed black line shows a 1:1 slope and the solid black line is the least squares best fit line between the two records. Both anomalies are referenced to the average temperature from the early 1970s to present. The blue to yellow dots show each yearly comparison between Sitka air anomaly and the next year's GAK1 anomaly. The pink dot shows the 2026 air temperature anomaly (through September 1st, 2026). The error bars show one and two standard deviations of variability from the trend line (solid black line, the dashed line is 1:1), for bounds ($\Sigma = 1$ standard deviation) on the expected water temperature at GAK1 in 2027.

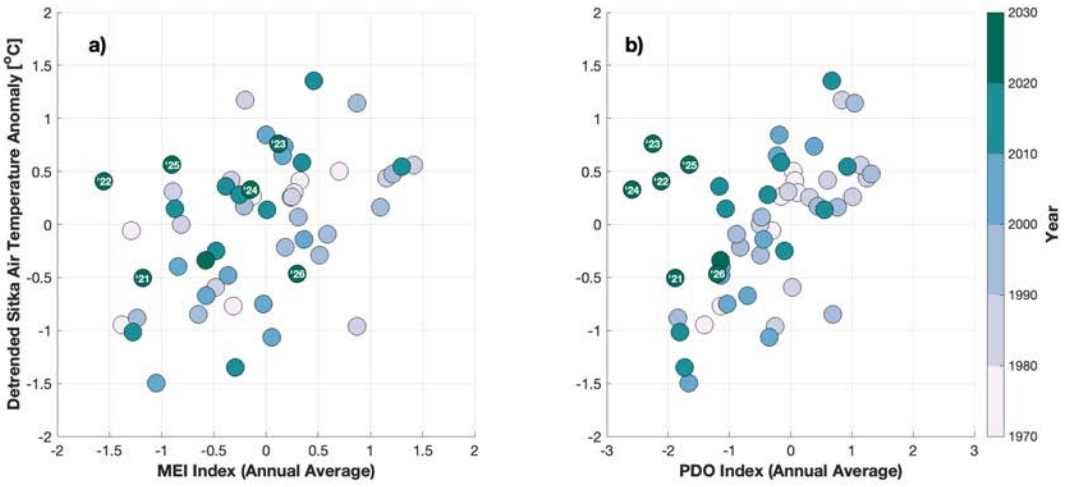


Figure 12: a) The relationship between the annually-averaged Multivariate El Niño/Southern Oscillation Index (MEI) and the detrended (decadal trend removed) annual anomalies of Sitka air temperature. Color shows the decade of comparison, with recent years labelled. b) Same as (a), but using Pacific Decadal Oscillation (PDO) for the climate index.

Ocean Temperature: *Synthesis

Satellite Data: Emily Lemagie, NOAA's Pacific Marine Environmental Laboratory; Contact: emily.lemagie@noaa.gov and
Matt Callahan, Alaska Fisheries Information Network; Contact: matt.callahan@noaa.gov
Seward Line Survey: Seth L. Danielson and Russell R Hopcroft, University of Alaska, Fairbanks; Contact: sldanielson@alaska.edu, rrhopcroft@alaska.edu
NOAA Southeast Coastal Monitoring Survey: Emily Fergusson and Wesley Strasburger, Auke Bay Laboratories, Alaska Fisheries Science Center, NOAA Fisheries; Contact: emily.fergusson@noaa.gov
NOAA Bottom Trawl Survey: Sean Rohan, Groundfish Assessment Program, Alaska Fisheries Science Center, NOAA Fisheries; Contact: sean.rohan@noaa.gov
NOAA Longline Survey: Kevin Siwicke, Marine Ecology and Stock Assessment Program, Alaska Fisheries Science Center, NOAA Fisheries; Contact: kevin.sewicki@noaa.gov
Long-term SST: Rick Thoman, International Arctic Research Center,University of Alaska Fairbanks; Contact:rthoman@alaska.edu and
Brian Brettschneider, NOAA National Weather Service Alaska Region Headquarters
NOAA EcoFOCI Spring Larval Survey: Kelia Axler and Lauren Rogers, EcoFOCI, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, NOAA Fisheries; Contact: kelia.axler@noaa.gov
ADF&G Large Mesh Trawl Survey: Carrie Worton, Alaska Department of Fish and Game, Kodiak; Contact: carrie.worton@alaska.gov
NOAA Acoustic-Trawl Survey: Denise McKelvey and Mike Levine, Midwater Assessment and Conservation Engineering Program (MACE), Alaska Fisheries Science Center (AFSC), NOAA Fisheries; Contact: denise.mckelvey@noaa.gov
MOM6 near-reattime hindcast: Kelly Kearney, Resource Ecology and Fisheries Management, Alaska Fisheries Science Center (AFSC), NOAA Fisheries; Contact: kelly.kearney@noaa.gov

Last updated: October 2026

Description of indicator: Ocean temperature can vary sub-regionally, due to differences in circulation, freshwater runoff, wind-driven mixing, and other oceanographic drivers (Bograd et al., 2005). Local temperatures can influence survival or condition of critical life history periods of certain species, such as salmon in the inside waters of southeast Alaska. Year-to-year changes in temperatures can influence physiological processes of fish (e.g., metabolic rates and growth rates), fish distribution (Yang et al., 2019), trophic interactions, availability of spawning habitat (Laurel and Rogers, 2020), and energetic value of prey (Von Biela et al., 2019). Extended periods of elevated SST for greater than 5 consecutive days are defined as marine heat waves (MHWs), which can drastically influence ecosystem dynamics (Bond et al., 2015; Hobday et al., 2016). Sea surface temperature (SST) is a foundational characteristic of the marine environment and temperature dynamics impact many biological processes. Extended periods of increased SST can drastically influence ecosystem dynamics (Bond et al., 2015; Hobday et al., 2016).

In recent years, warm water events have become so frequent in the world's oceans that a new method for describing them has been formalized. We consider marine heatwaves (MHWs) to occur when SST exceeds a particular threshold for five or more days. That threshold is the 90 th percentile of temperatures for a particular day of the year based on a 30-year baseline (Hobday et al., 2016). The intensity of a

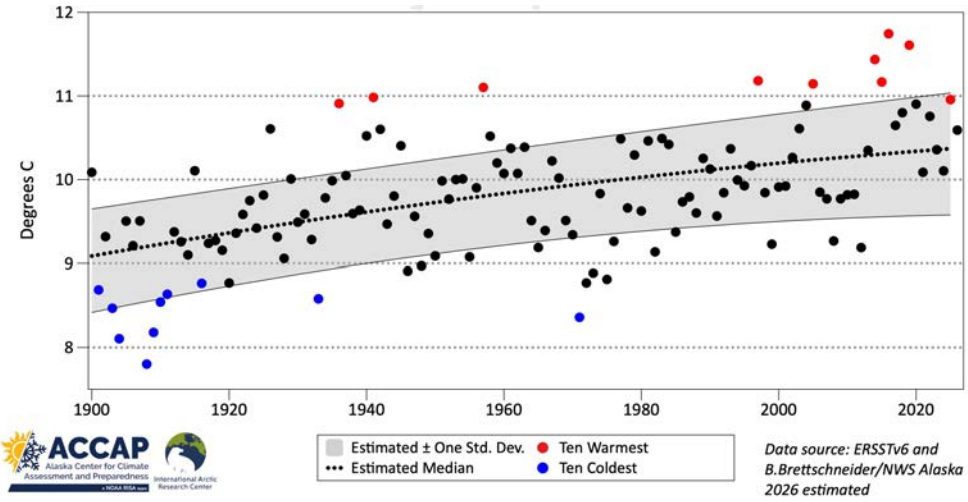
MHW can be further characterized by examining the difference between the 90 th percentile threshold for a given day and the baseline temperature for that day. If the threshold is exceeded, the event is considered *moderate*, *strong* (2 times the difference between then threshold and normal), *severe* (3 times the difference between the threshold and normal), or *extreme* ($\leq$ 4 times the difference) (Hobday et al., 2018).This section presents a collection of empirically collected temperature measurements from 2021 spring and summer surveys.

In this section we describe trends in ocean temperature at surface and at depth throughout the GOA. We first show GOA sea surface temperatures (averaged across the shelf) in context of long-term trends (1900-present) using NOAA's Extended Reconstructed SST V5 data[14]. We then present satellite-derived sea surface temperatures, averaged across the western GOA and eastern GOA shelf. This is followed by a description of trends observed across multiple GOA sub-regional surveys conducted in the winter, spring, and summer, and fall. We then show observations related to marine heatwave conditions and MOM6 forecasts of temperatures at the surface and at depth in 2027. Detailed methods are listed at the end of the contribution.

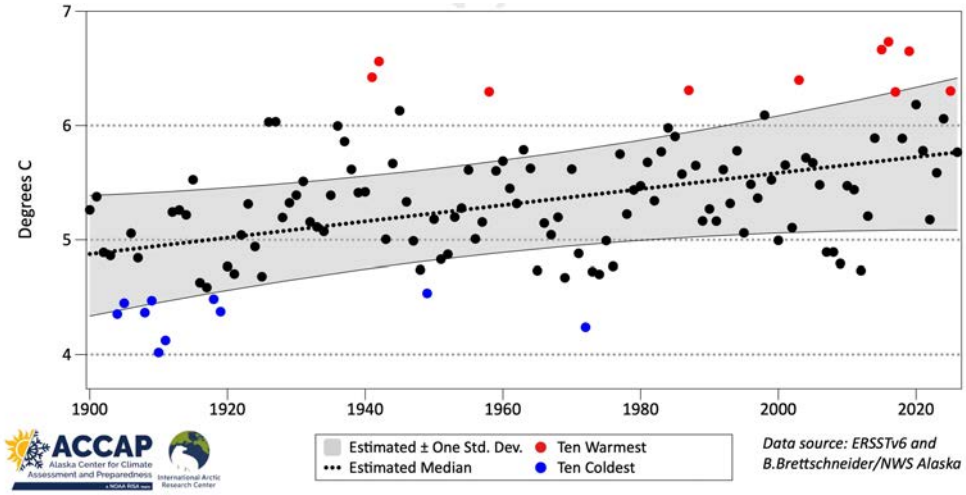
Status and trends:

Long-term sea surface temperatures (1900 – 2026): Summer (May - Oct.) and winter (Nov. - April) sea surface temperatures (Figure 13) over the GOA shelf (10 m - 200 m) were cooler than the warm year of 2025, and were slightly above (summer) or at (winter) the long-term median. It should be noted the summer (May - Oct.) 2026 mean SST was estimated by using the observed May - Aug. temperatures and then assuming Sept. and Oct. sea surface temperatures will be at the 1991 – 2020 mean. If Sept. and Oct. sea surface temperatures differ significantly from that 30-year mean, this result would change. The overall trend in summer temperatures show a warming during the first decades of the 20 th century followed by an extended period of little long-term trend, with substantial warming resuming in the late 1990s. In contrast, Winter (Nov.- April) temperatures show much less warming over the past 123 years. The 2026 MOM6 modelled surface temperatures in the summer most closedly resembled the thermal conditions in the summers of 2003 and 2006 (Figure 14). The 2026 MOM6 modelled surface temperatures in the spring most closedly resembled the thermal conditions in the spring of 1995 (Figure 14; see 'Methods' for model details).

[14] `https://psl.noaa.gov/data/gridded/data.noaa.ersst.v5.html`



(a) Summer (May - Oct.)



(b) Winter (Nov. - April)

Figure 13: Sea surface temperatures for the Gulf of Alaska from 1900 – 2026 for (a) summer (May-Oct.) and (b) winter (Nov.-April). Presented here are the quantiles representing $\pm$ 1 standard deviation of a Gaussian distribution and for completeness the median calculated using constrained B-Spline regression.

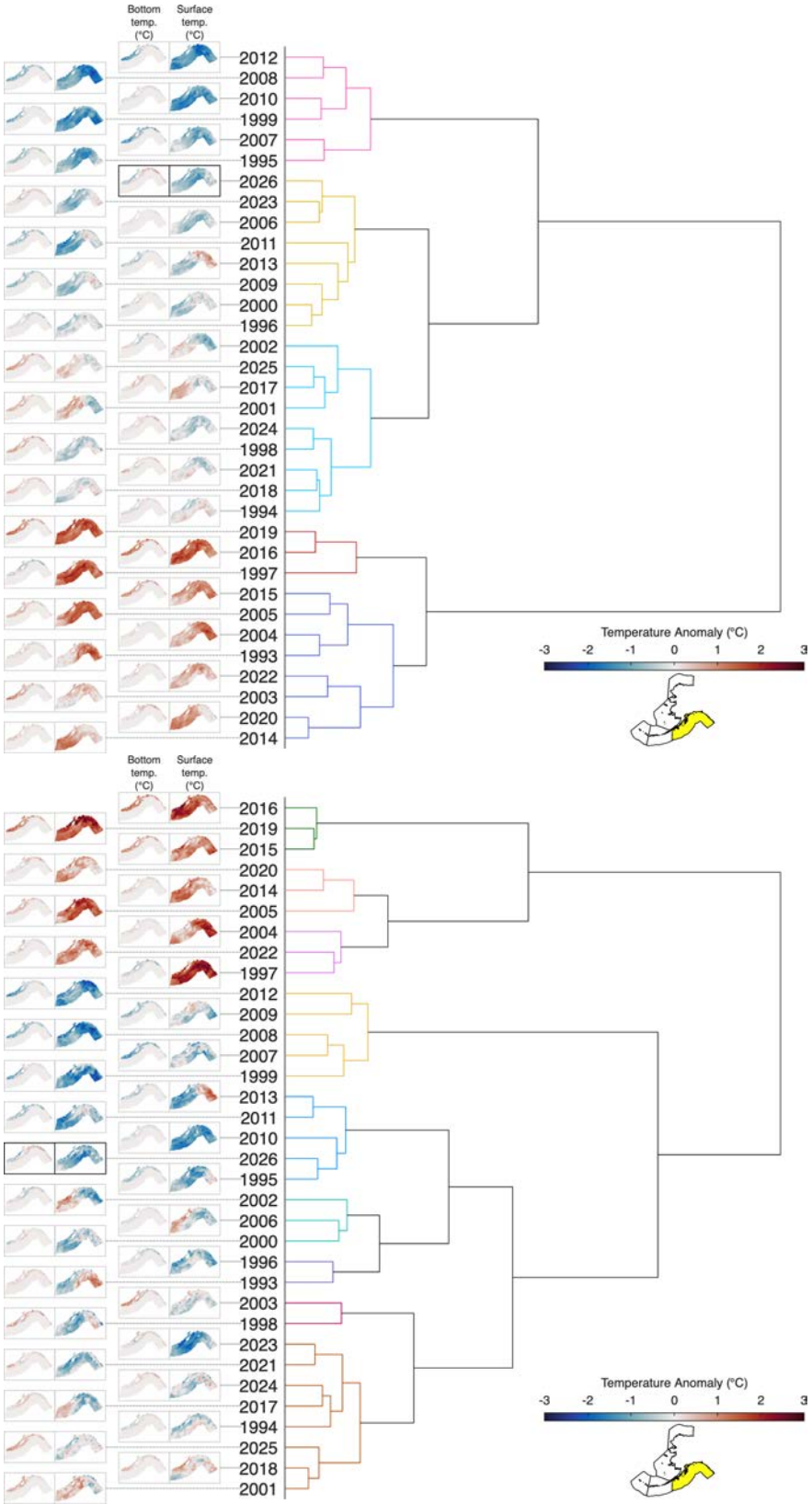


Figure 14: Hierarchical cluster analysis of surface and bottom temperature anomalies (relative to the 1993 – 2022 climatology). (Top) temporally-averaged across the period of 06/01 – 08/13 of each year, within the Gulf of Alaska ecosystem status report area, and (Bottom) temporally-averaged over the first week of each month between Feb and July of each year, within the Gulf of Alaska ecosystem status report area (maps depict anomaly in the July 1-7 week).

Seasonal temperatures at surface and depth in 2026 on the GOA shelf

Fall 2025: Fall of last year (2025) was warm at surface and at depth extending a warm year in the GOA shelf waters through December 15). The fall Seward Line survey recorded September temperatures at the surface of 13.27 °C (above the survey average of 11.55 °C, 1997 – 2024) and at depth of 5.75 °C (above the survey average 5.65 °C; Figure 16).

Winter 2026: For most of the winter through early summer in both regions, surface temperatures were predominantly cooler than 2025. In the western and eastern GOA, satellite-derived surface water temperatures cooled rapidly from warm anomalies at the start of the year to near-average temperatures through the winter (baseline: 1991 – 2020; Figure 15). At a smaller regional scale in Shelikof Strait, 2026 observed temperatures were cooler than survey-specific average including at the surface (2.18 °C; baseline 1989 – 2025) and around 100m (3.35 °C (Figure 17). The MOM6 modelled shelf bottom temperature fluctuated around the mean (baseline 1993 – 2022) until it cooled in March (Figure 24).

Spring 2026: Between February and April 2026, satellite-derived surface water temperatures cooled around two (eastern GOA) to three (western GOA) times the rate of the seasonal climatology (baseline: 1991 – 2020; Figure 15). In contrast, surface temperatures had warmed slightly over this period in 2025 across both regions. The Seward Line survey (averaged across shelf stations 1 – 9) observed a decrease in May surface temperatures from 2025 (6.86 °C) to 2026 (5.98 °C), cooler than the mean value of the survey time series (1998 – 2025). The Seward Line also observed cooling at around 176 – 226m depth to 5.75 ° (Figure 18), which still remains warmer than the survey average (5.56 °C). The warmth remaining at depth in this region is further described by Daneilson in this Report (p.79).

Summer 2026: During the period of seasonably weak winds in June 2026, satellite-derived surface water warming was accelerated, driving temperatures toward the long-term climatology through July across the GOA (baseline: 1991 – 2020; Figure 15). Following a dip of $\sim$ 1 °C in early August, temperatures remained near (western GOA) or slightly above (eastern GOA) average. In the western GOA, the only surveyed temperature time series updated in 2026 was the ADF&G large mesh trawl survey that recorded a bottom temperature of 5.81 °C, slightly cooler than the survey average (1990 – 2025; Figure 20). In the eastern GOA, the June/July average surface temperatures in Southeast Alaska inside waters (Icy Strait) (9.42 °C) were cooler than the survey average (baseline 1997 – 2025; Figure 20).

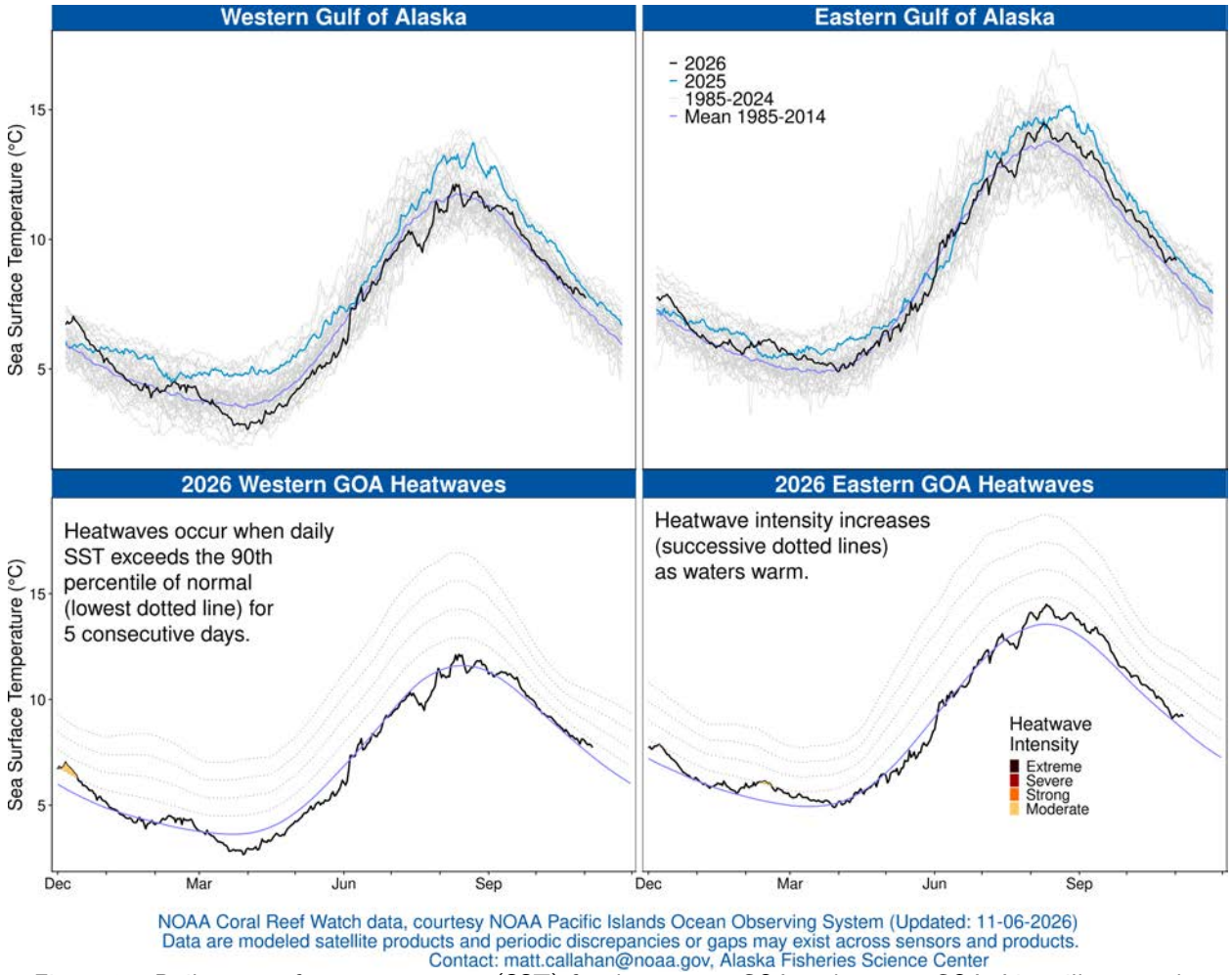


Figure 15: Daily sea surface temperatures (SST) for the western GOA and eastern GOA. Lines illustrate the daily SST for 2026 through October 31 (black), the daily SST for 2025 (blue), the 30-year (1991 – 2020) mean SST for each day (purple), and daily SST for each year of the time series (1985 – 2022; gray). Details are in the "Methods" section at the end of this contribution.

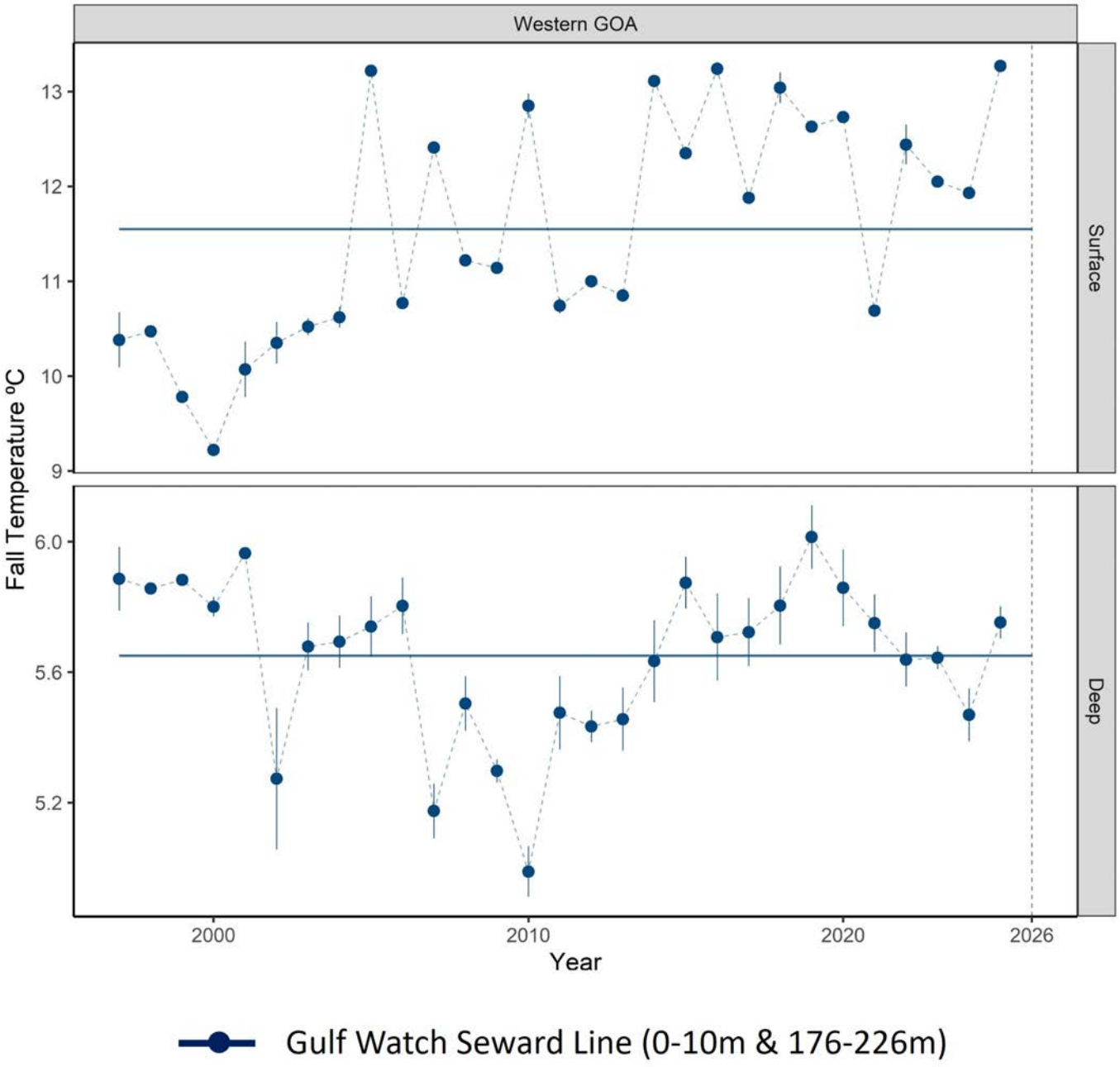


Figure 16: Observed temperatures at surface and depth from the Gulfwatch Alaska summer(July) Seward Line survey. Survey details are in the "Methods" section at the end of this contribution.

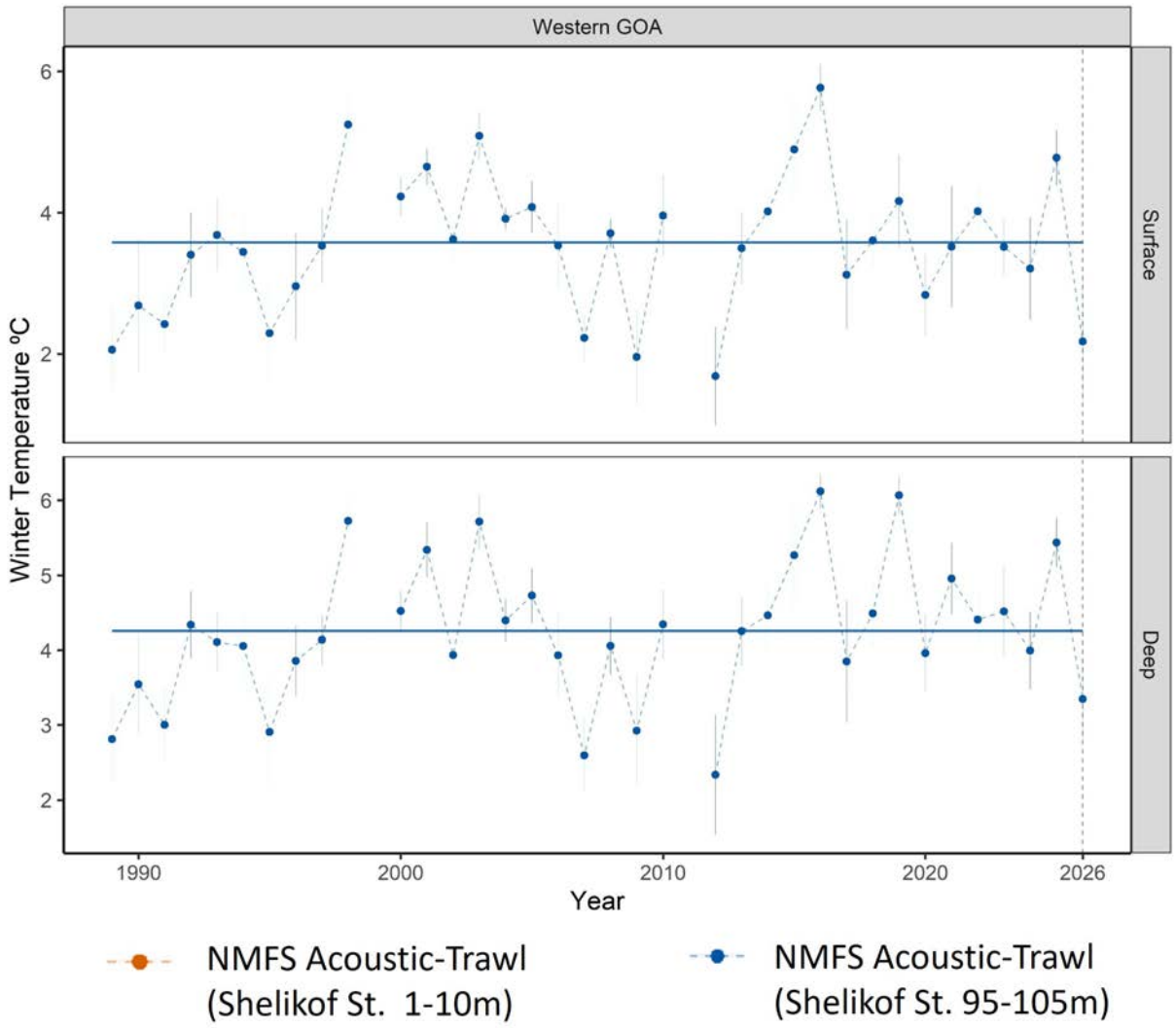


Figure 17: Average 'surface' (1 – 10 m) and 'deep' (95 – 105 m; blue) temperature (°C) at trawl locations during acoustic-trawl surveys of Shelikof Strait from 1980 (surface) and 2001 (depth) to 2026. Error bars indicate 1 standard deviation. Details are in the "Methods" section at the end of this contribution.

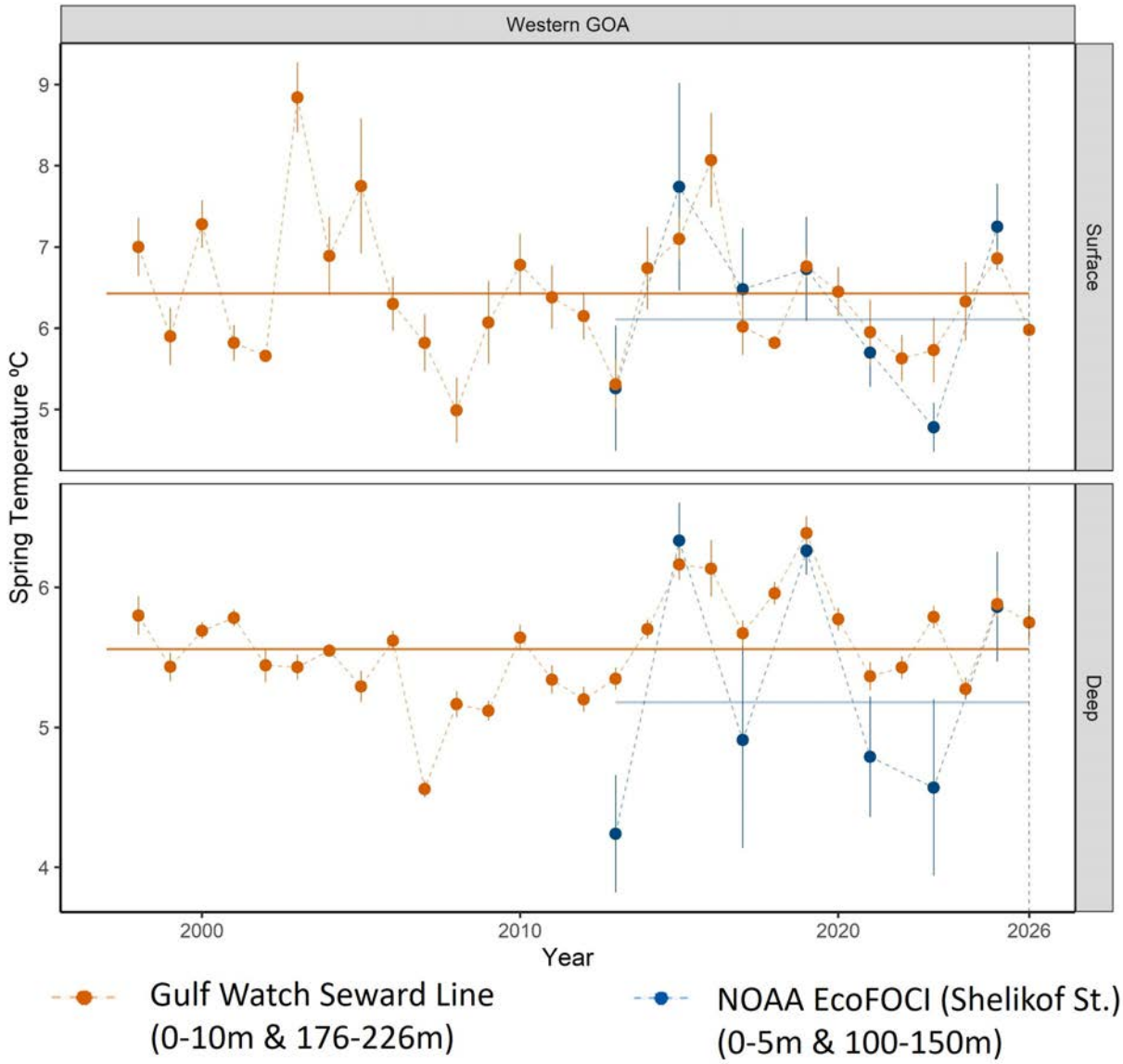


Figure 18: Observed temperatures at surface and depth from the AFSC EcoFOCI spring (May-June, alternating years) larval survey and the Gulfwatch Alaska spring (May) Seward Line survey. Multiple surveys are shown to reflect commonalities or differences in trends, primarily due to temporal and spatial coverage. Survey details are in the "Methods" section at the end of this contribution.

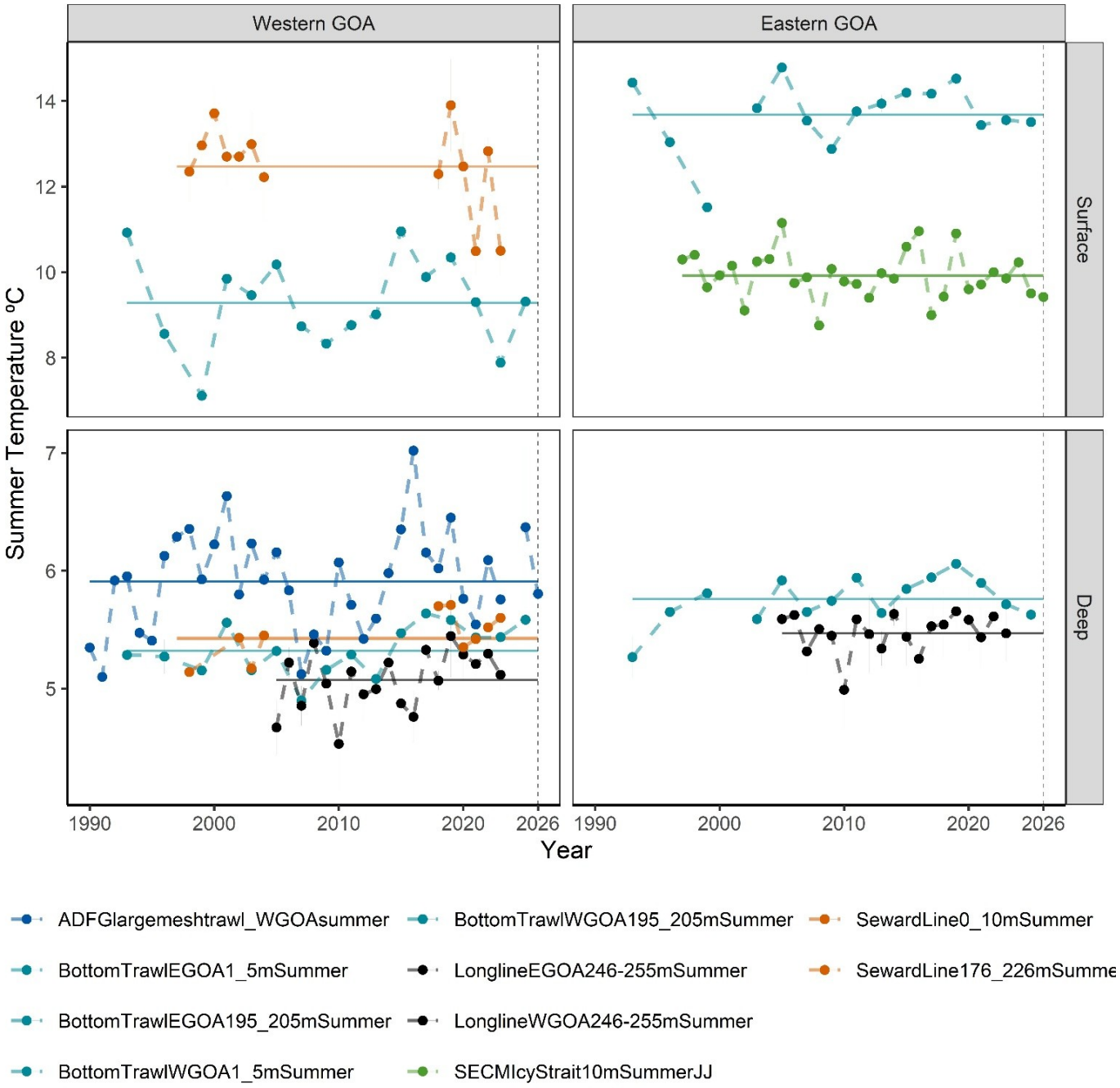


Figure 19: Observed temperatures at surface and depth from the AFSC Bottom Trawl Survey (alternating years, May - Sep.), AFSC Longline Survey (western GOA: June, eastern GOA: August), AFSC Southeast Alaska Coastal Monitoring (SECM Survey; May - Aug.), ADF&G Large Mesh Trawl Survey (Jun./Jul.), and the Gulfwatch Alaska summer(July) Seward Line survey. Multiple surveys are shown to reflect commonalities or differences in trends, primarily due to temporal and spatial coverage. Survey details are in the "Methods" section at the end of this contribution.

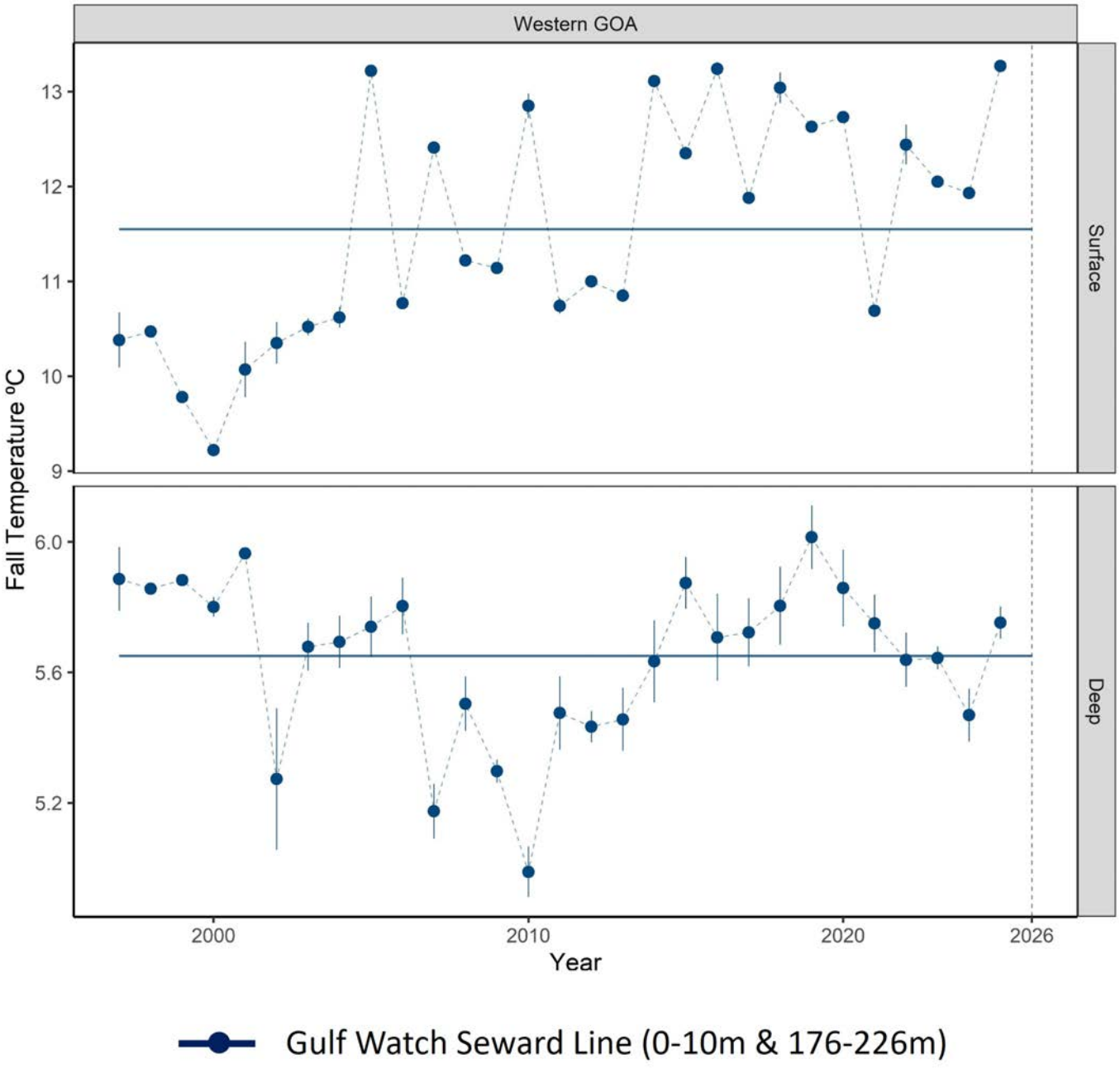


Figure 20: Observed temperatures at surface and depth from the Gulfwatch Alaska summer (July) Seward Line survey. Survey details are in the "Methods" section at the end of this contribution.

Marine Heat Waves: Except for a small period in February, there were no marine heatwaves in the coastal GOA through early autumn in 2026 (baseline: 1991 – 2020; Figure 21). Aside from 2025, when marine heatwaves occurred every season, there have been relatively few marine heatwave days in the western GOA for the last five years relative to the warm period from 2013 – 2020 (Figure 22). In the eastern GOA, fewer marine heatwaves were observed in 2026 than over the last 5 years. An important

ecological consideration with marine heatwaves is the extent of a particular area that experiences the warm conditions, and whether there may be thermal refugia for species within that domain. In spring and late summer, there were multiple periods when $>$ 25% of the satellite pixels (5 km grid) in the eastern GOA experienced a marine heatwave, while in the western GOA only a small fraction of the region was simultaneously in marine heatwave status at a given time (Figure 23).

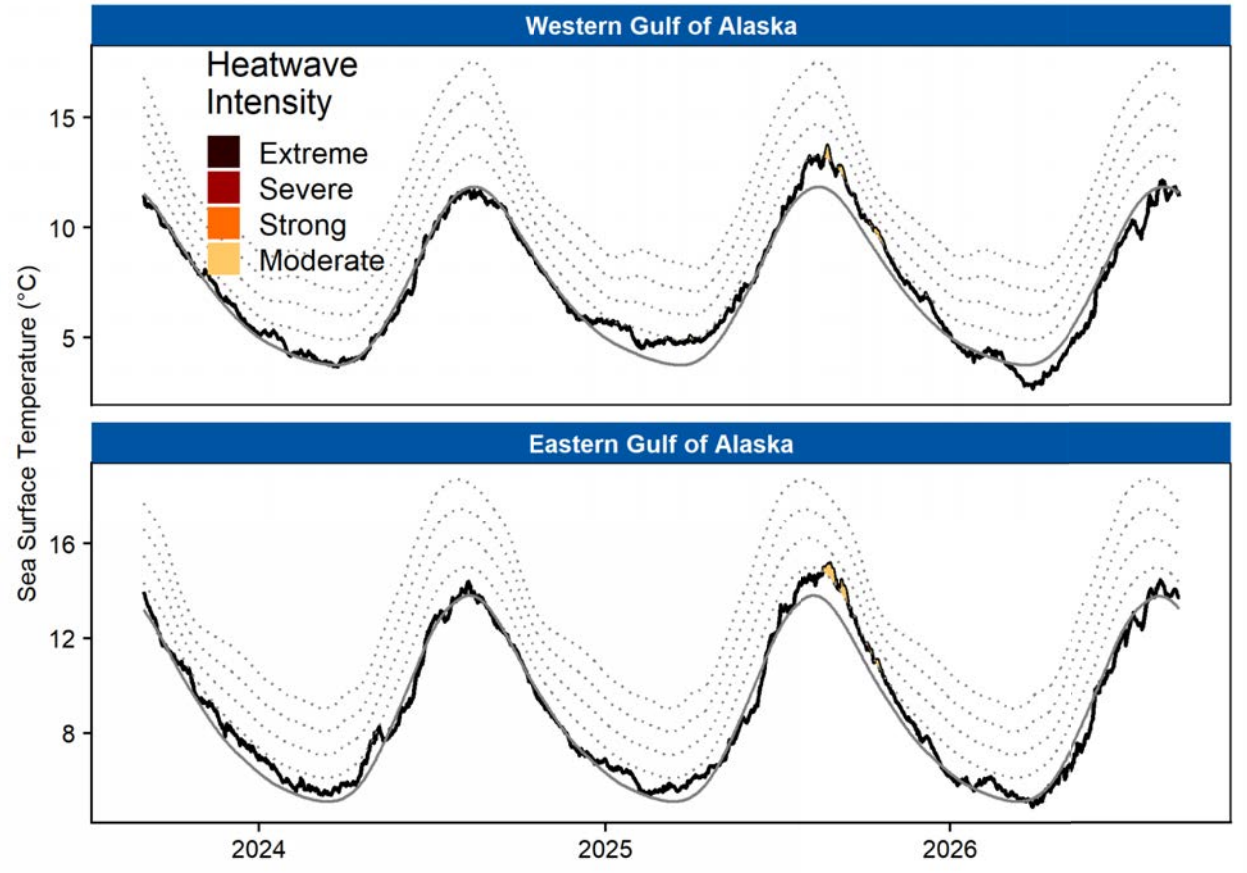


Figure 21: Marine heatwave (MHW) status from Sep. 2023 through Oct. 2026. Filled (yellow) areas depict MHW events. Black lines represent the 30-year baseline (smoothed line; 1991 – 2020.) and observed daily sea surface temperatures (jagged line). Faint gray dotted lines illustrate the MHW severity thresholds in increasing order: if the threshold is exceeded, the event is considered moderate, strong (2 times the difference between then threshold and normal), severe (3 times the difference between the threshold and normal), or extreme ($\leq$ 4 times the difference) (Hobday et al., 2018).

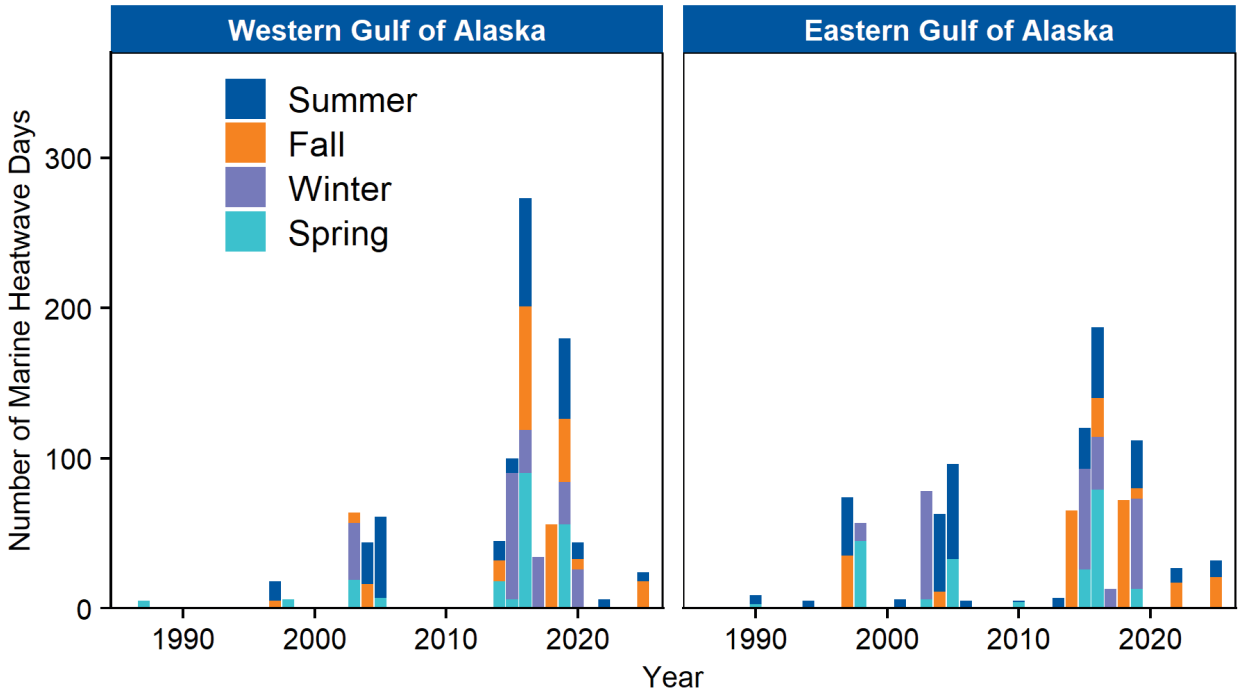


Figure 22: Number of days during which marine heatwave conditions persisted in a given year, through Aug 31, 2026. Seasons are summer (Jun. - Aug.), fall (Sept. - Nov.), winter (Dec. - Feb.), spring (Mar. - Jun.). Years are shifted to include complete seasons so December of a calendar year is grouped with the following year to aggregate winter data (e.g., Dec. 2025 occurs with winter of 2026).

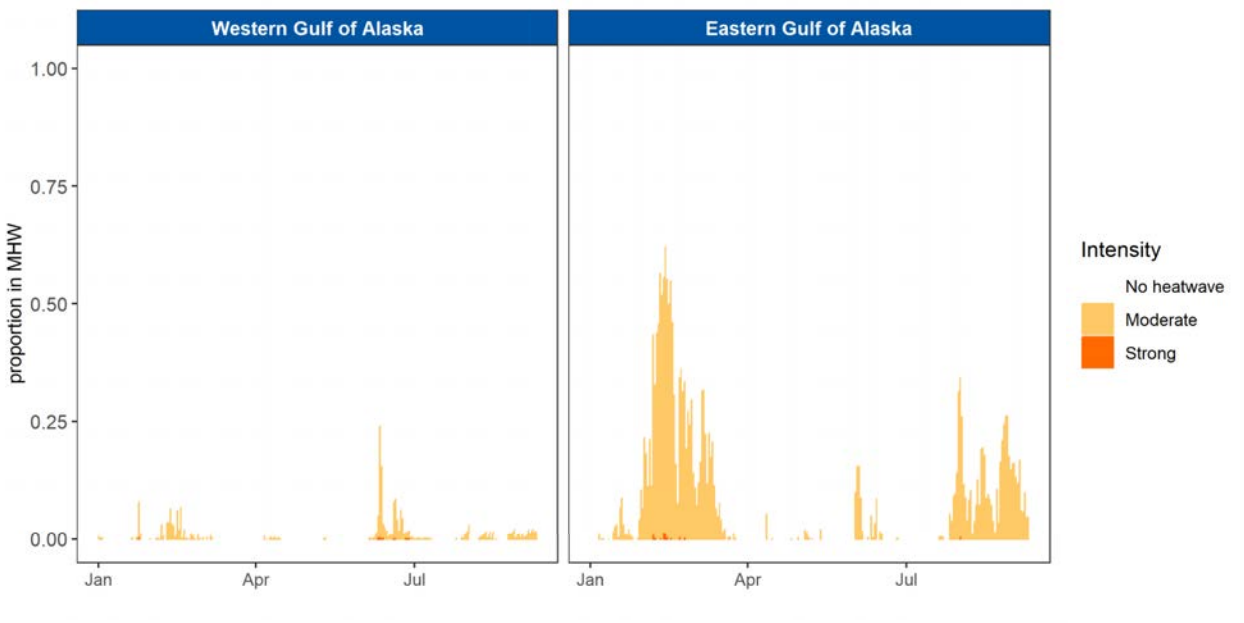


Figure 23: Proportion of region in heatwave status, through Oct. 21, 2026. Heatwave status calculations were performed on each 5 x 5 km grid cell within the Gulf of Alaska. This figure shows a five day rolling average of the proportion of cells within each region that are in heatwave status.

Modelled bottom temperature in 2026 and ocean temperature forecasts: The Modular Ocean Model version 6 Northeast Pacific (MOM6-COBALT-NEP10k) model (Drenkard et al., 2025) (MOM6-NEP) produced an October 2026 initiated forecast of surface and bottom temperatures (Figures 24, 25). While still undergoing regional validation analyses, the GOA region is considered to have high skill ($>$ 0.6 comparison of anomaly corelation coefficients) for a lead time of 1 to 5 months (Jacox et al., In Review). The model-derived bottom temperature from Jan-Aug 2026 the spring-initiaed persistence forecast fluctuated around the time series mean (1993 – 2026) with the exception of a cooler than average period from March through mid-June (Figure 24) The forecasted bottom temperatures for the GOA shelf and slope regiona (down to 1000m) rise to temperatures warmer than observed in the range seen in the 1993-2026 hindcast. The forecasted surface temperature anomalies from January through March range of $\sim$ 1 °C above average (MOM6; baseline 1994 – 2023) in the western GOA to 2 °C above average in the eastern GOA (Figure 25). While the absolute temperatures should be considered in the contect of the model uncertainty around these forecasts, they align with other forecasts showing warmer ocean temperatures from winter through spring in the GOA shelf in 2027.

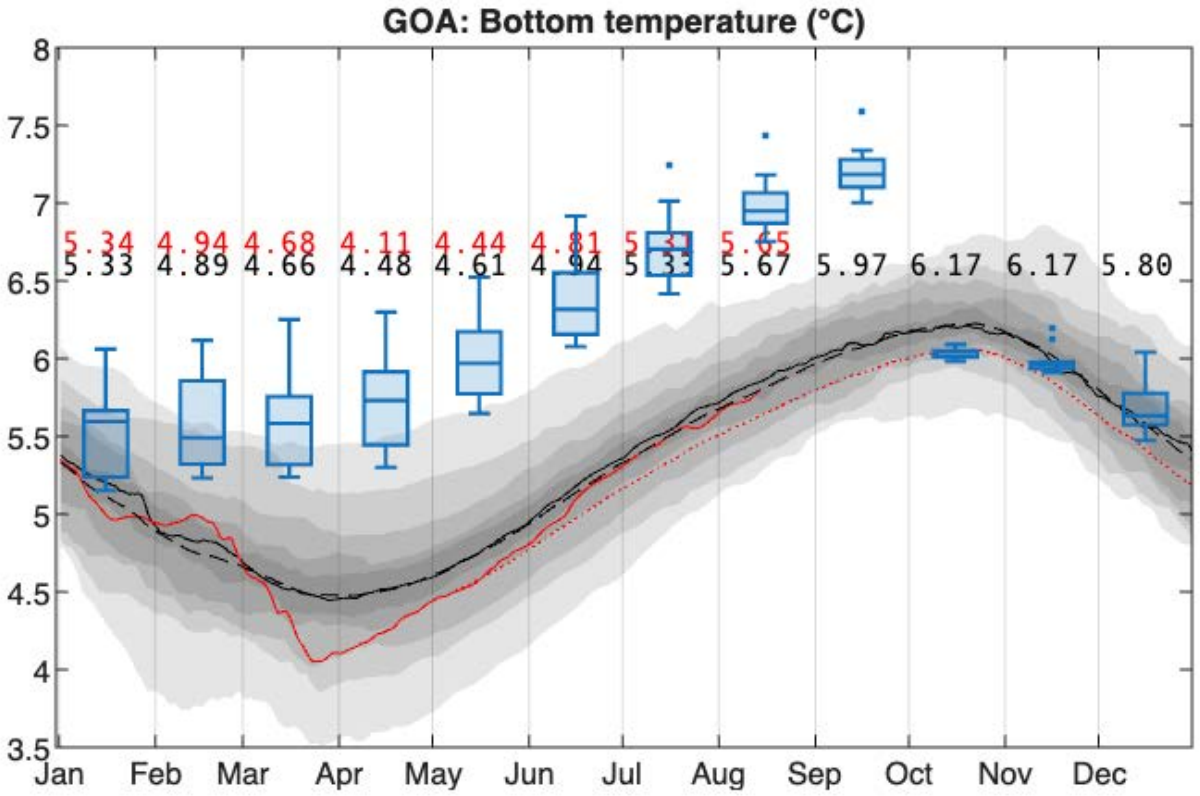


Figure 24: Time series calculated across the Gulf of Alaska survey area. Red line = 2026, red dotted line = spring-initiated persistence forecast, black solid line = median across 1993–2026, black dashed line = climatological (1993 – 2022) mean, shaded gray = 1993 – 2026 percentiles (lightest = 0 – 10% and 90 – 100%, darkest = 40 – 60%). Numbers indicate the values on the first of the month in the climatological mean (bottom, black) and in 2026 (red, top). Blue boxplots depict the October-initiated dynamic seasonal forecast, running from Oct 2026 through Sep 2027, with boxes indicating the spread across the 10-member ensemble.Details are in the "Methods" section at the end of this contribution.

Factors influencing observed trends: The GOA shelf surface waters have been warming since 1900. Summer temperatures are primarily driving this warming trend. The seasonal difference in warming trends could be due to changes in stratification, precipitation and freshwater runoff, cloud cover, circulation or other oceanographic and atmospheric drivers. As conditions transitioned from La Niña to El Niño in 2026, strong equatorward wind anomalies helped maintain more moderate ocean temperatures over the western GOA, while downwelling and poleward ocean advection helped maintain warm anomalies in the eastern GOA. Defining or contextualizing heatwaves depends upon the selection of baseline years (currently 1991 – 2020). As long-term climate change leads to warmer temperatures, the baseline will change as well, requiring consideration of how baseline selection affects our interpretation of deviations from normal and thus, events like MHWs. The more warm years that are included in the baseline, the warmer that baseline will appear.

Implications: The thermal responses of species in the GOA marine ecosystem must be considered in terms of longer-term shifts in temperature in addition to seasonal and interannual variability and cumulative impacts. As of this report, surface temperatures were cooler than average across the GOA with some warmth retained at depth along the Seward Line and warm surface anomalies in southeast

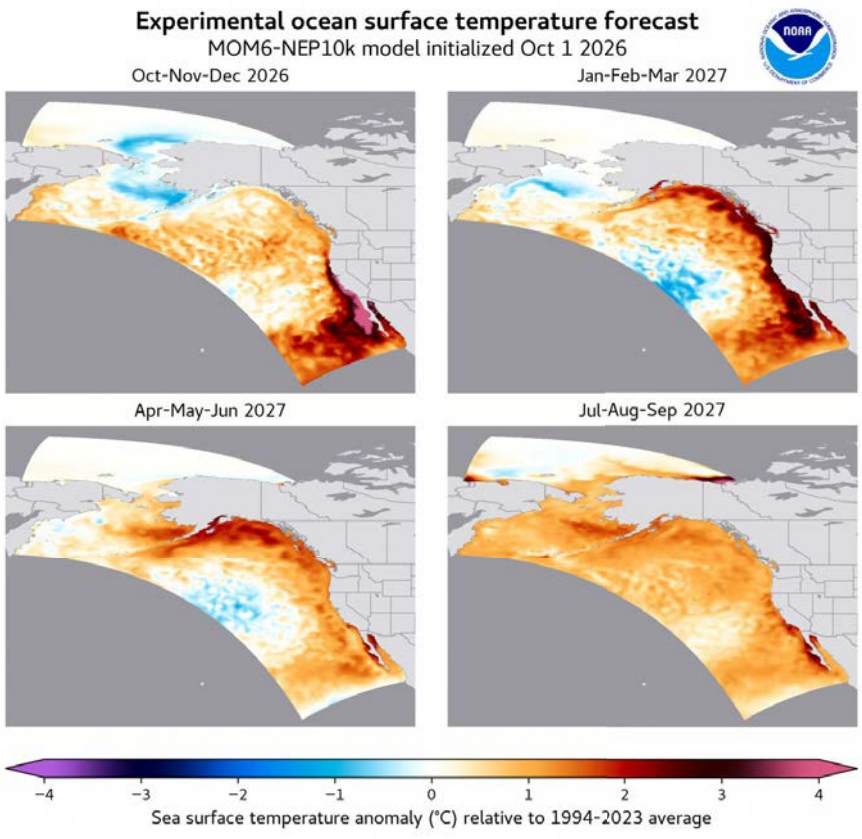


Figure 25: Modular Ocean Model version 6 (MOM6) seasonal forecast of sea surface temperature anomalies (relative to a 1993 – 2023 baseline) averaged across 10 simulations. This forecast was initialized in October 2026. Figure from Geophysical Fluid Dynamics Laboratory, Experimental Regional Ocean Forecasts[15].

Alaska. Icy Strait (Southeast Alaska) is a principal migration corridor for juvenile and returning salmon and temperature can influence the species composition of the zooplankton community, thereby affecting prey quality and availability (i.e., warmer temperatures can be associated with smaller zooplankton species with lower lipid densities). Temperatures are expected to warm in 2027 associated with the ongoing El Niño. Extremely warm conditions in the Gulf of Alaska could potentially lear to poor larval survival of Pacific cod, walleye pollock, and northern rock sole and potentially improved recruitment of rockfish and sablefish. Warm GOA marine ecosystems are associated with reduced zooplankton and forage fish availability for groundfish, seabirds, and marine mammals.

Methods:

Long-term Sea Surface Temperature: Sea surface temperatures in the Gulf of Alaska can be calculated using NOAA's Extended Reconstructed SST V6 data[16]. ERSST is a global monthly sea surface temperature dataset produced at 2 ° x 2 ° resolution starting in 1854. Statistical processes are used to infill data sparse/missing areas and standardize the many ways that ocean surface temperatures have been collected and reported over the decades. However, known problems remain, especially pre-1900 and in the WW2 era and in general in Arctic and Southern Oceans. Constrained B-Spline regression used here is a form of nonparametric quantile regression using quadratic splines. This approach allows for conditional estimates of any quantile of interest. Initial analyses examined eastern and western GOA separately (divided 147 °W) but the regions were combined due to reduced subregional sample sizes and similar trends across the western and eastern shelf. This report switched from NOAA ERSSTv5 data to ERSSTv6 data in 2026. The most significant changes from ERSSTv5 are in the pre-1950 values.

AFSC EcoFOCI Spring Larval Survey: EcoFOCI conducts biennial surveys in spring (May-June) and summer (August-September) in the Western Gulf of Alaska, targeting early life stages of fishes and their prey. At each sampling station, a bongo net array is towed obliquely from surface to 100 m (spring) or 200 m (late summer), or to 10 m off bottom in shallower waters. Attached to the wire above the bongo frame is a Seabird FastCAT profiler which measures temperature, salinity, and depth. Up casts were processed and used to generate maps and time-series of temperatures at the surface and at 100–150 m depth using the custom R package FastrCAT[17]. While surveys have been ongoing for multiple decades, time-series are provided here for the most recent 6 surveys with similar survey extent. In 2023, the spring survey dates were May 16–21, 2023 and the summer survey dates were September 4–12, 2023. Due to crew staffing shortages and reduced ship time, the Shelikof Strait was not able to be sampled in 2023 and no summer survey was conducted in 2021.

AFSC Bottom Trawl Survey: Since 1993, water column temperatures have been routinely recorded during Alaska Fisheries Science Center (AFSC) Resource Assessment and Conservation Engineering Groundfish Assessment Program (RACE-GAP) GOA bottom trawl surveys using bathythermograph data loggers attached to the headrope of the bottom trawl net. In 2003, a SeaBird (SBE-39) microbathythermograph (Sea-Bird Electronics, Inc., Bellevue, WA) replaced the Brancker XL200 data logger (Richard Brancker Research, Ltd., Kanata, Ontario, Canada) which had been in use from 1993 to 2001 (Buckley et al., 2009). The analyses presented here combine these two types of bathythermic data; the downcast data from each RACE-GAP trawl haul were isolated and used to inform our models.

Spatial and temporal coverage of the GOA RACE-GAP summer bottom trawl surveys has varied from year to year. Starting dates have ranged from the middle of May to the first week in June, and survey end dates ranged from the third week in July to the first week in September. The number of vessels employed, the areal extent, and the maximum depth of the GOA survey have all varied among survey years (e.g., water temperatures were not collected from the eastern GOA in 1993 and 2001, stations in the deepest GOA stratum [700–1000 m] have been sampled in just 5 of the last 13 surveys). Since the GOA survey sweeps from west to east over the late spring and summer, the expectation is a trend toward warmer water temperatures collected late in the summer in southeast Alaska compared with those collected in the western GOA in late spring; this anticipated trend is expected to be particularly pronounced in the upper layers of the water column. 2023 temperatures were not standardized to account for the effect of collection date as in past years.

[16] https://psl.noaa.gov/data/gridded/data.noaa.ersst.v6.html
[17] https://github.com/Copepoda/FastrCAT

Gulfwatch Alaska Seward Line Survey: Since 1998, hydrographic transects have been completed in May (typically during the first 10 days of the month) along a sampling line that extends from the mouth of Resurrection Bay near Seward to the outer continental slope of the northern GOA. Data analyzed here are water column profile data that have been averaged over the top 100m of the water column to provide an index of upper water column heat content on the northern GOA shelf.

AFSC Southeast Coastal Monitoring Survey (Icy Strait): Temperature has been collected annually in Icy Strait during monthly (May to August) fisheries oceanography surveys conducted by the Southeast Coastal Monitoring (SECM) project of Auke Bay Laboratories, AFSC. The Icy Strait Temperature Index (ISTI, °C) is the average temperature of the upper 20 m integrated water column.

Satellite Data: Satellite Data: Satellite SST data and 5 km grid mhw status from the NOAA Coral Reef Watch Program were accessed via the Alaska Fisheries Information Network (AKFIN) for January 1985 - October 2026. Daily SST data were averaged within the western (147 °W– 164 °W) and eastern (133 °W – 147 °W) Gulf of Alaska for depths from 10m – 200m (i.e., on the shelf). Detailed methods are online[18] and Watson and Callahan (2021) describes the automation of sst aggregation in depth. We use the most recent full decade 30-year time series (1991 – 2020) as the baseline period for mean and standard deviation comparisons although the guidance on such choice varies across studies (Hobday et al., 2018; Schlegel et al., 2019).

AFSC Summer Longline Survey: The Alaska Fisheries Science Center (AFSC) has been conducting a longline survey since 1987 to sample groundfish from the upper continental slope annually in the GOA, during odd years in the Bering Sea (BS), and during even years in the Aleutian Islands (AI). More details related to this survey can be found in (Siwicke, 2022). The survey samples the GOA from west to east for the western portion of the region during the second half of June before transiting to Ketchikan and sampling from east to west and ending southwest of Kodiak Island in late August. Beginning in 2005, a temperature (depth) recorder (TDR) has been used for the purpose of measuring in-situ bottom temperature at each station. There are 71 stations sampled by the AFSC longline survey located within the GOA ESR region (41 in the western GOA and 30 in the eastern GOA), but sometimes units fail, so not all stations are successfully sampled every year.

The TDR used is an SBE 39 (Seabird Electronics) which is attached directly to the middle of the longline, with a second TDR being attached deeper starting in 2019. The TDR records water temperature and depth every 10 seconds, and the downcast is processed to 1-m increments via the double parabolic method used by the World Ocean Atlas 2018 (Reiniger and Ross, 1968; Locarnini et al., 2019). The mean of the temperature while the TDR is on the bottom is a point estimate of the bottom temperature while the longline is fishing (which is usually two to six hours), and the range of temperatures recorded can be useful in interpreting how much variation occurs at a station.

The mean temperature from 1-m increment depths over the 246–255 m depth range was selected as an index for subsurface temperature because this layer was shallow enough to be consistently sampled across space and time and also deep enough to be below thermoclines and mixed layer dynamics. The depth of the profile does not always reach $\sim$ 250 m depth, but sample sizes have improved since 2019 because the second TDR deployment could be used if the first was unsuccessful or too shallow. Temperatures were weighted relative to the area of the depth-stratified regions the survey stations were in, which are described in Echave et al. (2013).

ADF&G Large Mesh Trawl Survey: The Alaska Department of Fish and Game conducts an annual trawl

[18] `https://github.com/MattCallahan-NOAA/ESR/tree/main/SST`

survey for crab and groundfish in GOA targeting areas of crab habitat around Kodiak Island, the Alaska Peninsula, and the Eastern Aleutian Islands (Spalinger and Knutson 2022). Parts of these areas have been surveyed annually since 1984, but the most consistent time series begins in 1988. While the survey covers a large portion of the central and western GOA, results from Kiliuda and Ugak Bays (inshore) and the immediately contiguous Barnabas Gully (offshore) are generally representative of the survey results across the region. Temperature anomalies were calculated using average bottom temperatures recorded for each haul from 1990 to present.

NOAA Acoustic-Trawl Survey: The MACE program conducts annual acoustic-trawl surveys of pre-spawning walleye pollock (*Gadus chalcogrammus*) in Shelikof Strait in the northern Gulf of Alaska in March (for detailed methods see McKelvey and Levine, InPrep). Temperature profiles are measured at survey trawl locations (from near surface to the deepest depth reached by the trawl) using a temperature-depth probe (SBE 39, Sea-Bird Scientific) attached to the trawl headrope. Trawls are not conducted at fixed locations, but are conducted opportunistically throughout the survey area where acoustic backscatter is present and are used to scale the backscatter to the nearest haul's species composition and length distribution for survey estimates of pollock biomass and abundance. Near-surface temperature is also measured along transects at a depth of approximately 1.4 m with a sensor in the flow thru scientific computing system (SBE 38, Sea-Bird Scientific). These higher resolution measurements are available for some but not all past surveys. In surveys where they are available, the averages of these higher-resolution measurements are highly correlated with averages of similar measurements at the more widely-spaced trawl locations. Therefore, we feel confident in reporting the trawl location near-surface temperatures as representative of survey-wide near-surface temperatures.

MOM6 Model: We used the most recent MOM6-NEP near-real-time hindcast extension, which runs through Aug 14, 2026, to analyze the seasonal evolution of surface and bottom temperature throughout the three management regions: Bering Sea, Aleutian Islands, and Gulf of Alaska. Modular Ocean Model version 6 Northeast Pacific (MOM6-COBALT-NEP10k) model (Drenkard et al., 2025) is part of the Changing Ecosystem and Fisheries Initiative (CEFI), which aims to provide operational regional model support for fisheries management across US coastal waters. The MOM6-NEP domain covers the northeast Pacific region, extending from the Chukchi Sea in the north to the Baja Peninsula in the south, and is designed to support marine resource management across the Bering Sea and Aleutian Islands, Gulf of Alaska, and California Current ecosystems. By spanning all three Alaska ecosystems, as well as coastal ecosystems along the west coast of the US and Canada, the model is able to cohesively simulate the relevant environmental processes throughout the region and model transboundary processes across ecosystems, management regions, and national boundaries. The MOM6-NEP10k model grid has a 10-km horizontal resolutions and a novel internal vertical coordinate scheme that allows one to use a more flexible set of coordinates while resolving realistic bathymetry across shelf, slope, and basin regions. The MOM6-NEP implementation uses 75 z* vertical levels (i.e., near-constant geopotential surfaces that deform slightly in response to dynamic sea surface height), with layer thickness ranging from 2 m at the surface to 250 m at depth. The MOM6-NEP10k model cover runs from 1993 to the present. This temporal coverage reflects the extent of the reanalysis datasets that are used to drive the simulations;therefore, the regional MOM6 hindcast simulations are currently limited to the extent of the parent ocean-forcing dataset (1993–present). Additional details on the model and methods for ESR contributions are available[19].

New seasonal forecasts are run four times per year, in January, April, July, and October for an ensemble of 10 simulations, using a different ensemble member from SPEAR for each, and the results are

[19] https://beringnpz.github.io/ak_regional_mom6/esr2026_data.html

averaged to show mean temperature anomalies (Jacox et al., In Review). Note that these experimental predictions are not official NOAA forecasts. Additional details for the forecasts can be found at the Geophysical Fluid Dynamics Laboratory, Experimental Regional Ocean Forecasts website[20] `https://www.gfdl.noaa.gov/experimental-regional-ocean-forecasts/`; accessed 11/5/2026). Jacox et al. (In Review) describes the skill of the MOM6 sea surface and bottom temperature forecasts in the GOA continental shelf and upper slope ($<$ 1000 m isobath) using temperature anomaly correlation coefficients (ACC). The ACC for GOA sea surface temperature is $>$ 0.6 up to a lead time of 5 months at which point it varies around 0.6 from month 5 to month 9. The GOA ACC for bottom temperature were significant and quite high ($>$ 0.6) across all lead times (1 month to 12 months) and initializations (initialized in October, July, April, and January). More information about the model and an assessment of forecast skill for a set of reforecasts from 1993 – 2024 are available from Jacox et al. (In Review).

Eddies

Contributed by Wei Cheng, Cooperative Institute for Climate, Ocean, and Ecosystem Studies, University of Washington, Seattle, WA
Contact: Wei.C.Cheng@noaa.gov
Last updated: September 2026

Description of indicator: Eddies in the northern GOA have been shown to influence distributions of nutrients (Ladd et al., 2009, 2005, 2007) including dissolved iron (Crusius et al., 2017; Ladd et al., 2009), phytoplankton (Brickley and Thomas, 2004), and ichthyoplankton (Atwood et al., 2010). In addition, the settlement success of arrowtooth flounder (Goldstein et al., 2020), the feeding environment for juvenile pink salmon (Siwicke et al., 2019), and the foraging patterns of fur seals (Ream et al., 2005) can be influenced by the presence of eddies. Eddies propagating along the slope in the northern and western GOA are generally formed in the eastern Gulf in winter or spring (Okkonen et al., 2001) and are sometimes associated with gap winds from Cross Sound (Ladd and Cheng, 2016). Using altimetry data from 1993 to 2001, Okkonen et al. (2003) found that strong, persistent eddies occurred more often after 1997 than in the period from 1993 to 1997. Ladd (2007) extended that analysis to 2006 and found that, in the region near Kodiak Island (Figure 26; region c), eddy energy in the years 2002 – 2004 was the highest in the altimetry record. The Ssalto/Duacs altimeter products were produced and distributed by the Copernicus Marine and Environment Monitoring Service (CMEMS)[21].

Since 1992, a suite of satellite altimeters has been monitoring sea surface height. Eddy kinetic energy (EKE) can be calculated from gridded altimetry data (Ducet et al., 2000), giving a measure of the mesoscale energy in the system. A map of eddy kinetic energy in the GOA averaged over the altimetry record (updated from Ladd, 2007) shows four regions with local maxima (labeled a, b, c and d in Figure 26). The first two regions are associated with the formation of the Haida (a) and Sitka (b) eddies. Eddies that move along the shelf-break often feed into the third and fourth high EKE regions (c and d). By averaging EKE over the regions, we obtain an index of energy associated with eddies in these regions (Figure 27).

The most recent data were downloaded September 3rd, 2026, providing a daily time series from 1/1/1993 to the present on a 0.125 ° longitude x 0.125 ° latitude grid. Original data set is global, but we subset it

[21] `http://www.marine.copernicus.eu`

to 150 °E – 125 °W and 39 °N – 71 °N during downloading. Data from January 1st, 1993 to January 6, 2026 is the reprocessed product, thereafter it is the "NRT" (near real time) product. Maps of long-term mean EKE (Figure 26) and monthly climatology of regional EKE (Figure 27, red line) are computed using data from 1993 to 2025 (period with full year coverage).

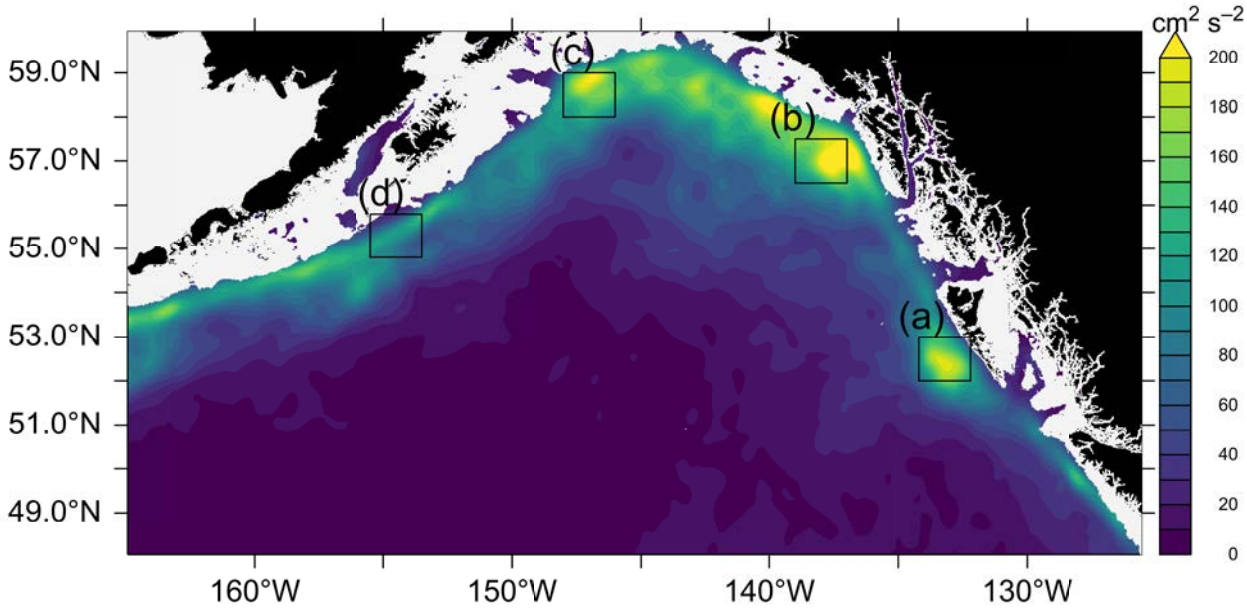


Figure 26: Long-term mean (January 1993 – December 2025) of eddy kinetic energy (EKE; cm ^{2} s $^{-2}$) based on satellite altimetry. EKE hot spots in the eastern GOA are associated with Haida (region a) and Sitka (region b) eddies. Region c and d are named northern GOA and western GOA (NGOA and WGOA), respectively. EKE averaged over each of the regions (a to d) is shown on Figure 27.

Current Status and trends: So far this year (January 1st to early September, 2026), eddy kinetic energy (EKE) in the Gulf of Alaska across all regions (a-d) is generally below or near the climatological seasonal cycle (Figure 27). In region a) and c), this is in sharp contrast to the state of EKE in 2025 when both regions had strong positive EKE anomalies relative to long-term climatology. Region b) have similar EKE in 2025 and 2026. EKE in Region d) increased at the start of 2026 relative to its 2025 level but it is not significantly different from climatology. These results suggest a relatively weak Alaska gyre circulation this year and relatively weak Aleutian Low pressure system. In the equatorial Pacific Ocean, a very strong (with equatorial Pacific SST anomalies $>$ 2 °C) El Niño is developing. We would expect higher than normal eastern GOA EKE following an El Niño event, especially if the El Niño is very strong. This would be something to watch out for in 2026/2027 winter and spring of 2027. Formation of shelf-break eddies in the GOA is also related to local forcing such as freshwater input and gap winds. These forcing acts on the background seasonal sea level gradient. Other modes of climate variability (such as ENSO and PDO) also influence sea level gradients, although ENSO, PDO, and gyre oscillation are not totally independent of each other.

EKE has well defined mean seasonal cycles in the eastern and central GOA (Figure 26, regions a-c) with

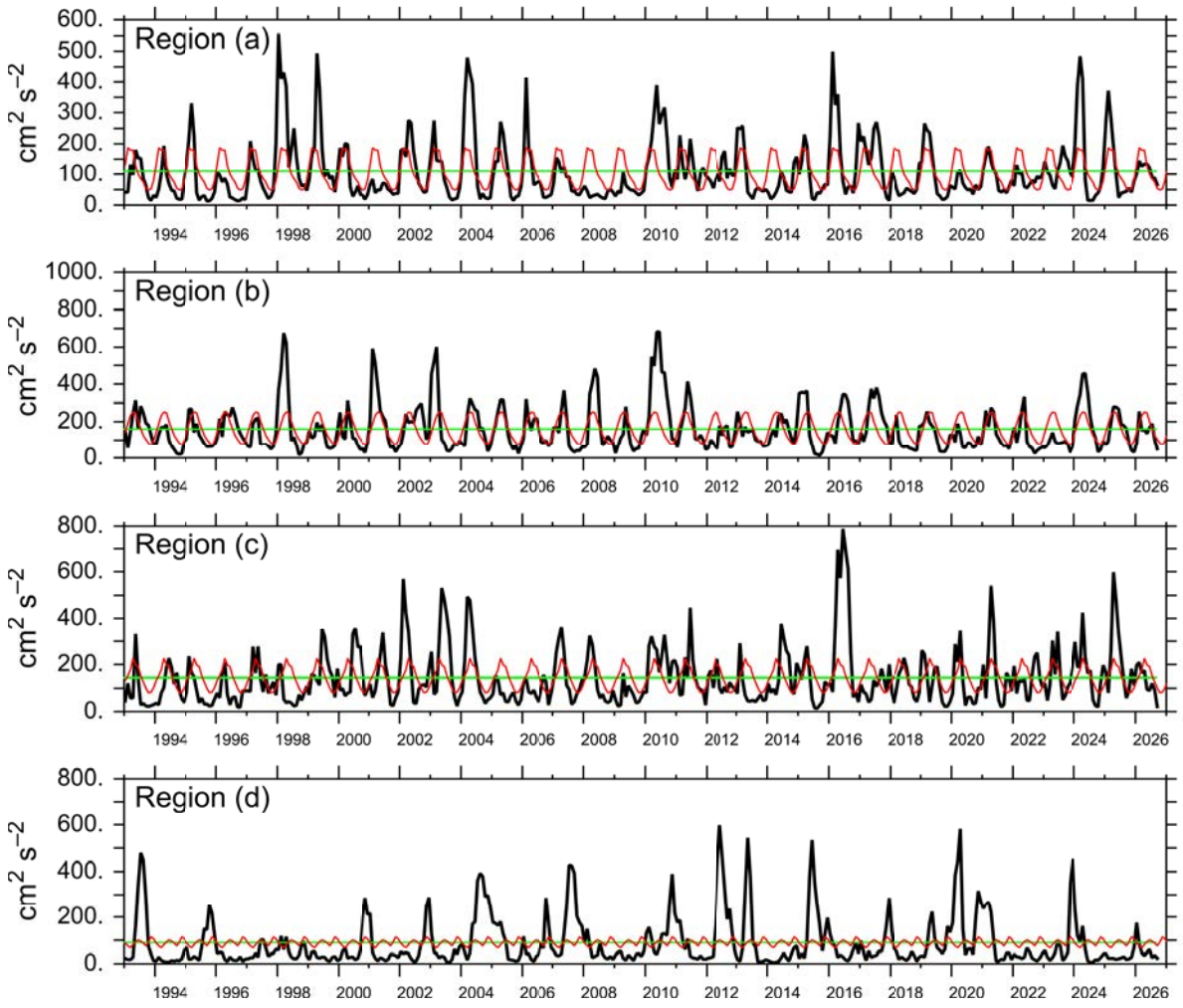


Figure 27: Eddy kinetic energy (cm ^{2} s $^{-2}$) averaged over regions shown in Figure 26. Results shown include monthly averages through August 2026 (black line), monthly climatology from year 1993 – 2025 (red line), and long-term average over the entire time period (green straight line).

similar phasing (high in winter/spring and low in summer/fall), suggesting their formation mechanisms are inter-related. In contrast, EKE in the western GOA (Figure 26, region d) does not have a well-defined mean seasonal cycle, by it tends to be higher in late spring and late fall than in the other seasons, suggesting different eddy formation mechanisms in the western GOA.

Factors influencing observed trends: In the eastern Gulf of Alaska, interannual changes in surface winds (related to the Pacific Decadal Oscillation, El Niño, and the strength of the Aleutian Low) modulate the development of eddies (Combes and Di Lorenzo, 2007; Di Lorenzo et al., 2013). Regional scale gap-wind events may also play a role in eddy formation in the eastern Gulf of Alaska (Ladd and Cheng, 2016). In the western Gulf of Alaska, variability is related both to the propagation of eddies from their formation regions in the east and to intrinsic variability. Previous studies suggest that eastern GOA eddy activities (regions a and b) are related to large-scale forcing such that downwelling favorable wind anomalies along the Alaskan coast can generate positive SSH anomalies which promote formation

of anticyclonic eddies. Downwelling favorable winds tend to happen during positive phases of PDO, but the correspondence between eddy activities and ENSO events is not always strong. ENSO associated forcing effects can be both local (via local wind anomalies) and remote (via coastal trapped waves arriving from lower latitudes and generate SSH anomalies along the Alaska coast). In comparison, interannual variability of eddies in the western GOA (region c and region d) tends to happen intrinsically and is not necessarily associated with large-scale forcing, although eddies from the eastern GoA could also arrive here.

Implications: At the lower trophic level, eddies in the GOA affect nutrient cycling and ocean primary productivity by transporting iron-rich coastal water to offshore high-nutrient low-chlorophyll regions (Ito et al. 2026). Eddies sampled in 2002 – 2004 were found to contain different ichthyoplankton assemblages than surrounding slope and basin waters indicating that eddies along the slope may influence the distribution and survival of fish (Atwood et al., 2010). Carbon isotope values suggest that cross-shelf exchange due to eddies may be important to the marine survival rate of pink salmon (Kline, 2010). And eddies may result in enhanced settlement and recruitment for arrowtooth flounder (Goldstein et al., 2020).

Ocean Surface Currents – Papa Trajectory Index

Contributed by William T. Stockhausen, Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, NOAA Fisheries
Contact: william.stockhausen@noaa.gov
Last updated: July 2026

Description of indicator: The Papa Trajectory Index (PTI) provides an annual index of near-surface water movement variability, based on the trajectory of a simulated surface drifter released at Ocean Station Papa (50 °N, 145 °W; Figure 28). The simulation for each year is conducted using the "Ocean Surface CURrent Simulator" (OSCURS[22]). Using daily gridded atmospheric pressure fields, OSCURS calculates the speed and direction of water movement at the ocean's surface at the location of a simulated surface drifter. It uses this information to update the position of the simulated drifter on a daily basis over a specified time period. For the index presented here, OSCURS was run for 90 days to simulate a surface drifter released at Ocean Station Papa on December 1 for each year from 1901 to 2025 (trajectory endpoints years 1902 – 2026).

Status and trends: The trajectory for 2025/26 was fairly typical among the time series, as were the trajectories for 2022/23 and 2023/24 (Figure 28). In this respect, these represented a return to more "average" winter atmospheric conditions (baseline 1968 – 2025). In general, the trajectories fan out northeastward toward the North American continent; the 2016/17 and 2021/22 trajectories were among the relatively few that initially moved strongly to the southeast and ended south of Ocean Station PAPA. The ending latitude for the 2024/25 trajectory, and thus its PTI value, was the highest since 1991/92. Similar high values also occurred in the intervening time period in 2011/12 and 2015/16.

The PTI time series (Figure 29) indicates high interannual variation in the north/south component of drifter trajectories, with an average between-year change of greater than 4 ° and a maximum change of greater than 13 ° (between 1968/1969 – 1969/1970). The change in the PTI between 2015/2016 and 2016/2017 was the largest since 1968/69 – 1969/70, while the changes between 2010/2011 and 2011/2012, and between 2020/2021 and 2021/2022, represent reversals with slightly less, but diminishing, magnitude. Such swings, however, were not uncommon over the entire time series. The PTI has been below the mean for seven of the ten previous years. While the 2024/25 value (59.35 °N) was the largest since 1991/92 (as noted above), the 2025/26 value (53.56 °N) is much closer to, and slightly below, the longterm average (54.53 °N).

Over the past century, the filtered (5-year running average) PTI has undergone five complete oscillations with distinct crossings of the mean, although the durations of the oscillations are not identical: 26 years (1904 – 1930), 17 years (1930 – 1947), 17 years (1947 – 1964), 41 years (1964 – 2005), and 10 years (2005 – 2015). The filtered index indicates that a shift occurred in the mid 2000s to predominantly southerly anomalous flow following a ∼25 year period of predominantly northerly anomalous flow. This was indicative of a return to conditions (at least in terms of surface drift) similar to those prior to the 1977 environmental regime shift, although this cycle ended rather quickly, as the filtered PTI crossed the mean in the opposite direction in 2011. A similar shift back to an anomalous southerly flow appears to have occurred in 2016. Since 2005, the PTI appears to be fluctuating on a much shorter time scale (∼10 years per mean crossing) than previously. Given recent results, the filtered PTI was expected to

[22] http://oceanview.pfeg.noaa.gov/oscurs

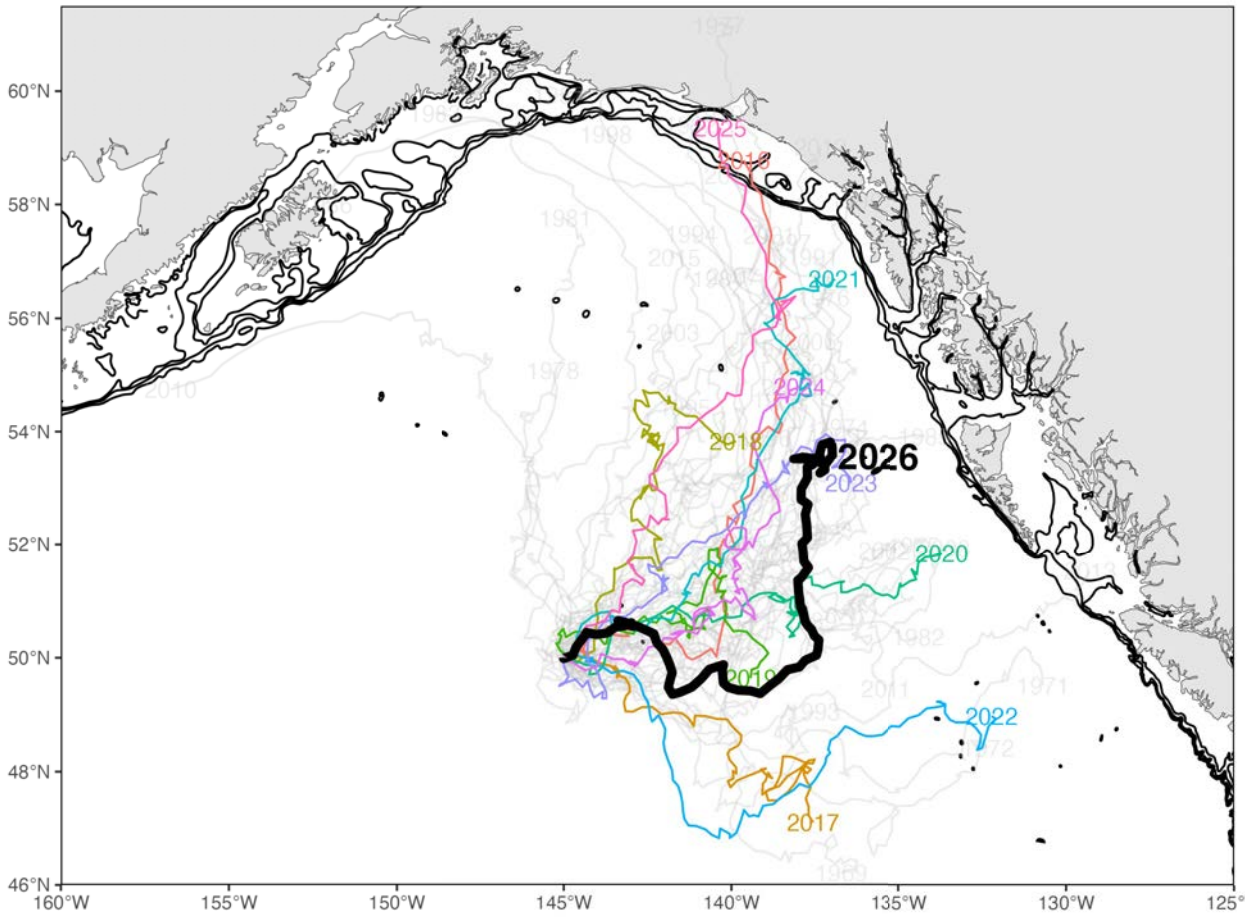


Figure 28: Simulated surface drifter trajectories for winters 1968 – 2026 (endpoint year). End points of 90-day trajectories for simulated surface drifters released on Dec. 1 of the previous year at Ocean Station Papa are labeled with the year of the endpoint. The trajectory in black is 2025/2026, those in color end in 2015/2016 – 2024/2025, and those in gray end prior to 2015/2016.

shift back, at least in the short term, to a positive phase in 2026. However, this did not occur and it is highly uncertain whether it will next year.

Factors influencing observed trends: Individual trajectories reflect interannual variability in regional (northeast Pacific) wind patterns which drive short-term changes in ocean surface currents, as well as longer term changes in atmospheric forcing that influence oceanic current patterns on decadal time scales.

Implications: The year-to-year variability in near-surface water movements in the North Pacific Ocean has been shown to have important effects on the survival of walleye pollock (*Gadus chalcogrammus*) by affecting its spatial overlap with predators (Wespestad et al., 2000), as well as to influence recruitment success of winter spawning flatfish in the eastern Bering Sea (EBS; Wilderbuer et al., 2002). Filtered PTI values greater than the long-term mean are indicative of increased transport and/or a northerly shift in the Alaska Current, which transports warm water northward along the west coast of Canada and southeast Alaska from the south and consequently plays a major role in the GOA's heat budget. Interdecadal changes in the PTI reflect changes in ocean climate that appear to have widespread impacts on biologi-

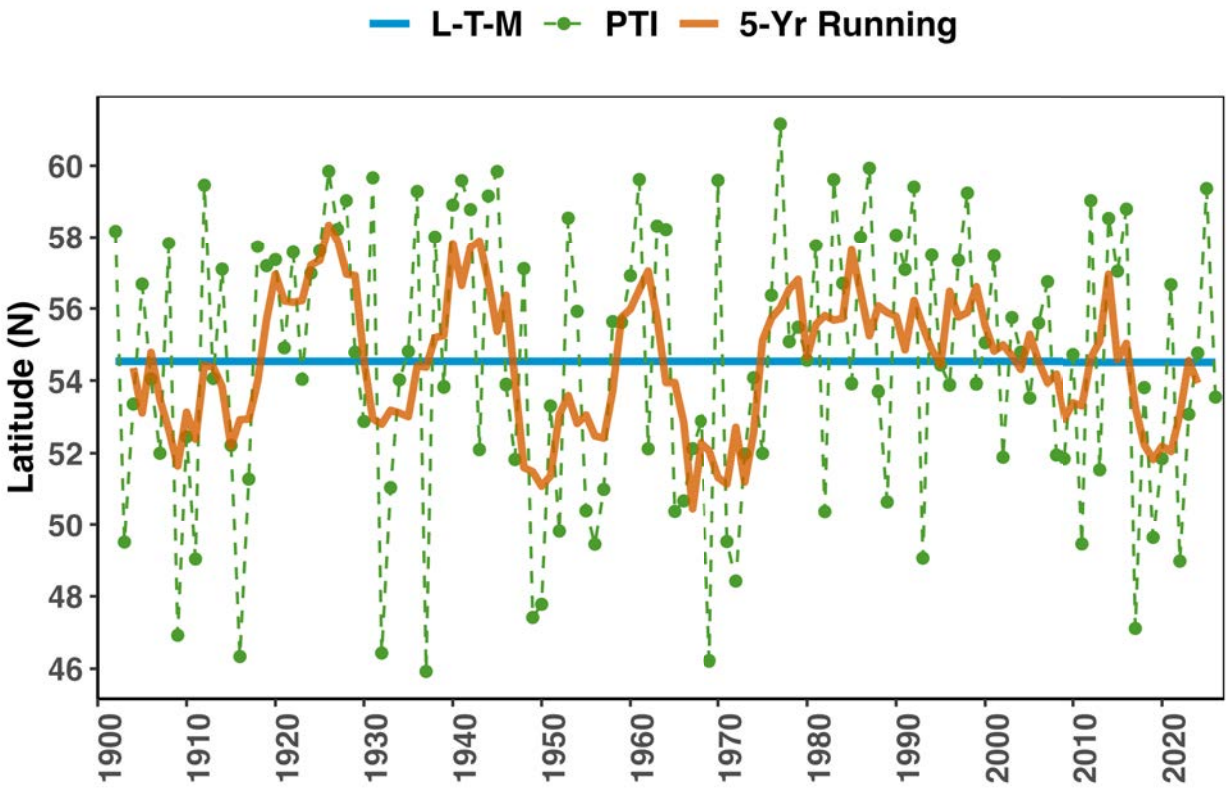


Figure 29: Annual, long-term mean (blue line), and 5-year running mean (orange line and squares) of the Papa Trajectory Index time series end-point latitudes (dotted green line and points) for 1902 – 2026 winters.

cal variability at multiple trophic levels (King, 2005). There is strong evidence that the productivity and possibly the carrying capacity of the Alaska Gyre, and of the continental shelf, were enhanced during the "warm" regime that began in 1977. Zooplankton production was positively affected after the 1977 regime shift (Brodeur and Ware, 1992), as were recruitment and survival of salmon and demersal fish species. Recruitment of rockfish (Pacific ocean perch) and flatfish (arrowtooth flounder, halibut, and flathead sole) also increased. However, shrimp and forage fish such as capelin were negatively affected by the 1977 shift (Anderson, 2003). The reduced availability of forage fish may have contributed to the decline in marine mammal and seabird populations observed after the 1977 shift (Piatt and Anderson, 1996).

Northern Gulf of Alaska Oscillation and Gulf of Alaska Downwelling index

Contributed by: Remi Pages and Claudine Hauri
International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, AK, USA
Contact author email: chauri@alaska.edu
Last updated: October 2026

Description of indicator: TThe Gulf of Alaska is characterized by persistent offshore upwelling and coastal downwelling. This results in negative sea surface height (SSH) in the gyre center and elevated SSH over the continental shelf area.

The Northern Gulf of Alaska Oscillation (NGAO) index describes the strength of the cyclonic circulation in the Gulf of Alaska, and therefore, the intensity of the offshore upwelling in the Alaskan gyre (Hauri et al., 2021). The NGAO corresponds to the primary mode of variability, identified through Empirical Orthogonal Function (EOF) decomposition performed on SSH anomalies (with trends and monthly climatology removed). A positive NGAO phase is characterized by a weak cyclonic circulation leading to weak offshore upwelling and therefore brings less cold, acidic and de-oxygenated waters to the sub-surface. A negative NGAO phase is characterized by a strong cyclonic circulation leading to strong offshore upwelling that brings cold, acidic and de-oxygenated waters to the sub-surface.

The Gulf of Alaska Downwelling Index (GOADI) quantifies the intensity of positive coastal SSH anomalies in the Gulf of Alaska, indicating the strength of coastal downwelling (Hauri et al., 2024). This index is derived from the second mode of variability identified by Empirical Orthogonal Function (EOF) decomposition, applied to SSH anomalies after removing trends and monthly climatology. The GOADI serves as a measure of the intensity of coastal downwelling and, consequently, acts as a proxy for the intrusion of deep water onto the continental shelf's seafloor. A positive GOADI phase is characterized by high SSH anomalies and strong downwelling, making deep water intrusions less likely. During a negative GOADI phase SSH anomalies are low in the shelf area, leading to weaker downwelling that permits intrusion of cold, salty, deoxygenated, and acidic deep water onto the shelf.

Status and trends: Northern Gulf of Alaska Oscillation (NGAO) — The NGAO remained predominantly negative through 2025 and mid 2026, reaching its lowest value in the 1993–present satellite record in July 2026 (– 2.47; Figure 32). This strongly negative phase is consistent with an intensified Alaskan gyre and enhanced offshore upwelling in the central Gulf of Alaska. During the same period, the central Gulf experienced pronounced cold conditions, with approximately 16% of the region below its local 5th-percentile SST-anomaly threshold on a 30-day mean (Figure 31C).

Since July, however, the NGAO has reversed rapidly (Figure 31A, B and D). The index increased to – 1.64 in August and – 1.00 in September, corresponding to a two-month increase of 1.47 NGAO units. This change is at approximately the 99.8th percentile of all two-month NGAO changes since 1993 (Figure 31D), indicating that the recent rebound is exceptionally rapid relative to the historical record. Over the same period, the central Gulf cold-extreme area declined from about 16% to less than 1%, while a small warm-extreme area has begun to emerge, reaching approximately 4% by late September.

Gulf of Alaska Downwelling Index (GOADI): — The GOADI was negative during the first part of 2024, indicating weaker coastal downwelling and conditions more favorable for the intrusion of deeper water onto the continental shelf (Figure 3). The index shifted toward positive conditions during the second

half of 2024 and remained predominantly positive through 2025 and present day (September 2026). These positive values indicate stronger coastal downwelling and consistent with stronger onshore Ekman transport, conditions that tend to limit the transport of deep, cold, acidic, and low-oxygen water onto the shelf (Hauri et al., 2024).Combined with the strong El Niño, this may set the stage for a subsurface heatwave.

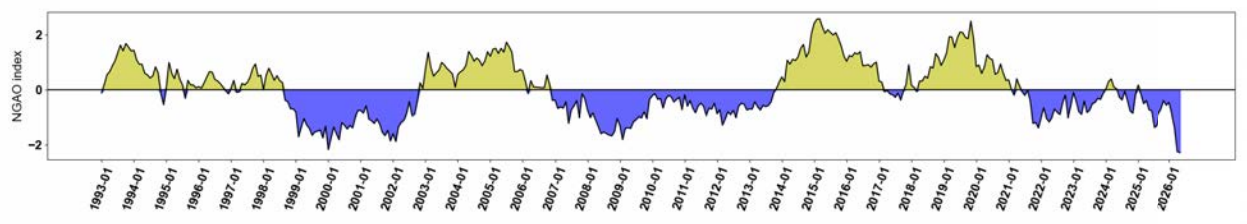


Figure 30: Time-series of the Northern Gulf of Alaska Oscillation. See Hauri et al. (2024) for methods.

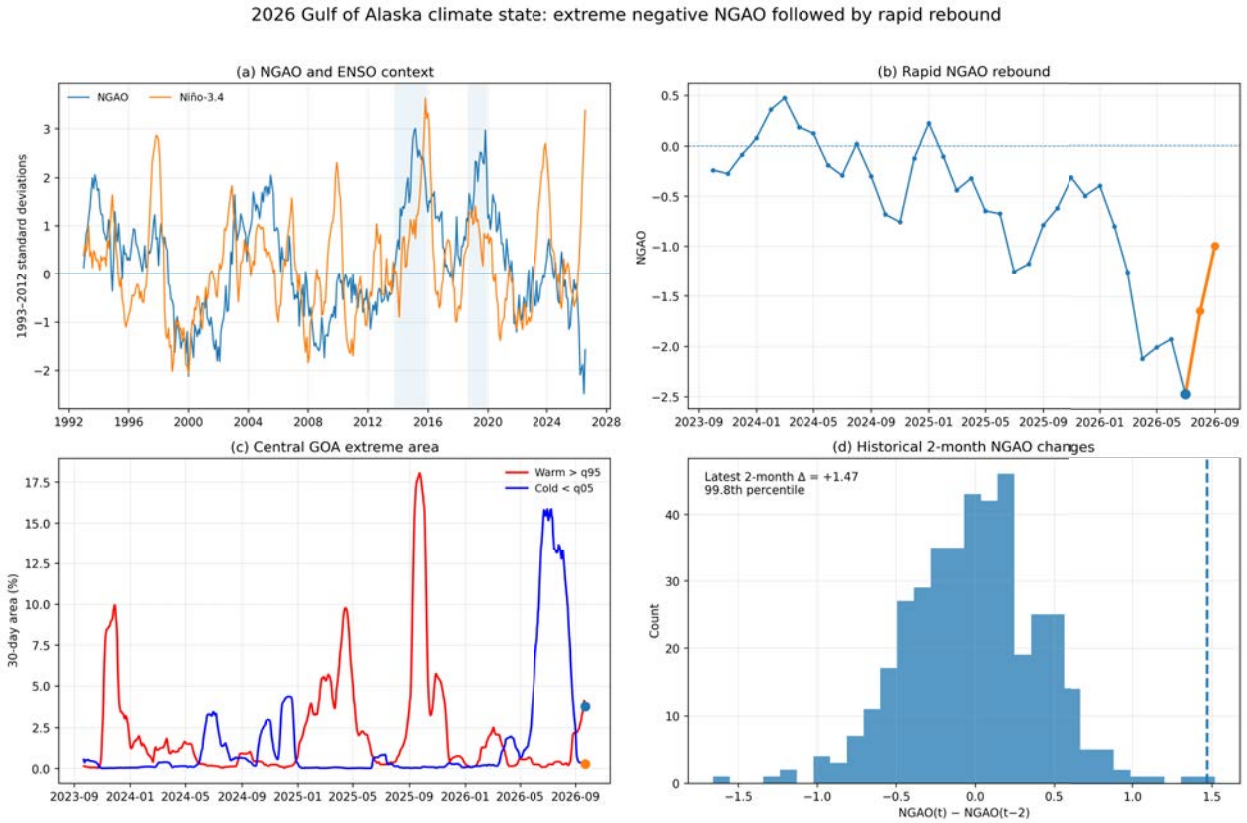


Figure 31: Recent evolution of the Northern Gulf of Alaska Oscillation (NGAO), ENSO, and temperature extremes in the central Gulf of Alaska. (a) Monthly NGAO and Niño-3.4 indices standardized relative to the 1993 – 2012 period. Shaded intervals indicate the 2013 – 2015 and 2018 – 2019 Gulf of Alaska marine heatwave periods. (b) Monthly NGAO since September 2023. (c) Thirty-day running mean percentage of the central Gulf of Alaska experiencing warm ($>$ 95th percentile; red)[5.1] or cold ($<$ 5th percentile; blue) SST-anomaly extremes. (d) Historical distribution of all two-month NGAO changes since 1993. The July–September 2026 increase of +1.47 NGAO units lies at the 99.8th percentile of the historical distribution (dashed line).

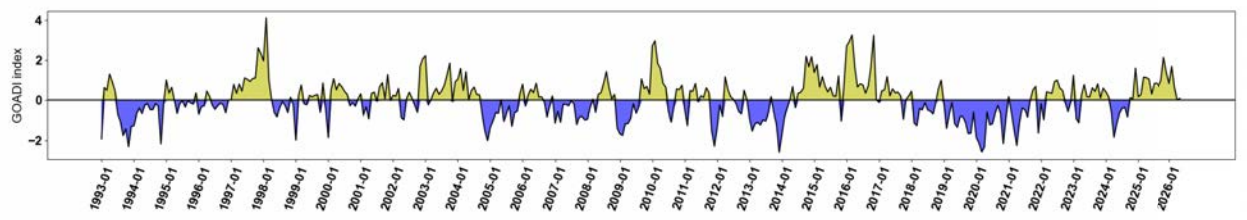


Figure 32: Time-series of the Gulf of Alaska Downwelling Index.

Factors influencing observed trends: Ocean circulation in the Gulf of Alaska Gyre, can influence the oceanographic characteristics (dissolved oxygen, pH, temperature, salinity) that can cumulatively impact groundfish habitat, affecting distribution and potentially survival (Hauri et al., 2024). A positive GOADI indicates stronger coastal downwelling, limiting intrusion of deeper waters onto the shelf bottom that are low in dissolved oxygen, more acidic, cooler temperature, and more saline. Negative NGAO indicates stronger upwelling in the central GOA gyre due to stronger gyre circulation, bringing deeper waters that are low in dissolved oxygen, more acidic, cooler temperature, and more saline up to the surface in the central gyre (offshore) and potentially onto the shelf.

Implications: This fast transition of the NGAO index is occurring against a very strong El Niño, which is a first in the available satellite-era record. Despite this rapid increase, the NGAO remains negative, and it is not yet clear whether the rebound will continue toward neutral or positive conditions. Continued monitoring over the coming months will be important to determine whether the NGAO remains weak or shifts into a positive state, which together with an El Niño would favor a strong marine heat wave.

Decreased DO at depth may limit the availability of deeper waters as refuge from warmer temperatures. Some deeper-dwelling slope adult groundfish, including thornyhead (*Sebastolobus* spp.; 100 – 1,200m), rougheye (*S. aleutianus*), blackspotted (*S. melanostictus*; 300 – 500m), and shortraker rockfish (*S. borealis*; 300 – 400m), already live in reduced oxygen environments. A decrease in DO in those habitats may drive shifts in distribution to shallower waters (Thompson et al., 2023).

Surface Wind in the Coastal Western Gulf of Alaska during April - May

Contributed by Lauren Rogers[1] and Emily Lemagie[2]
Based on a contribution developed by Matt Wilson
[1]EcoFOCI, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, NOAA Fisheries
[2]EcoFOCI, Pacific Marine Environmental Laboratory, NOAA
Contact: lauren.rogers@noaa.gov
Last updated: July 2026

Description of indicator: Surface wind is fundamental to the oceanography, biology and ecology of the Gulf of Alaska ecosystem. As a driver of coastal circulation, surface wind affects upwelling/downwelling,

turbulent mixing (e.g., mixed layer depth), and transport of planktonic organisms. Its relevance to regional groundfish production in the Gulf is illustrated by studies of wind-driven turbulent mixing on walleye pollock larvae (e.g., Porter et al., 2005) and of wind-driven transport on juveniles and recruitment (Wilson and Laman, 2021).

Two complementary datasets were used to indicate springtime (April – May) surface wind in the coastal Gulf. This period coincides with the seasonal occurrence of many groundfish larvae. The first dataset consists of high-resolution empirical measurements recorded by the National Data Buoy Center (NDBC) at site AMAA2. We chose AMAA2 as its location might be considered a gateway of sorts where winds determine whether coastal flow either funnels into and down Shelikof Strait along the Alaska Peninsula or is diverted southward around Kodiak Island (Ladd and Cheng, 2016). Springtime measurements at AMAA2 are currently available for 19 years: 2004 to 2026, except 2007, 2008, 2018, and 2025 with measurements recorded at 30 min intervals[23]. The second dataset consists of lower-resolution, reanalysis-based data from the ERA5 model provided by the Copernicus Climate Data Store at [24] (Copernicus Climate Change Service, 2023). Mean monthly winds at 10m were averaged by season (Apr-May) and year from 1980 – 2026. We specified the geographic area to be 55 – 60oN and 150 – 160oW (200 – 210oE). Previous versions of this indicator used NCEP/NCAR Reanalysis data (Kalnay et al., 1996), but that product was discontinued in 2026.

For both datasets, NDBC-AMAA2 and ERA5, wind was expressed as the components u (+u is wind blowing to the east, "westerly" wind) and v (+v is northward wind, "southerly" wind). Correlation of annual means (n = 19) between the two datasets was r = 0.62 for the u component, and r = 0.77 for the v component. The NDBC-AMAA2 data are used to construct progressive wind diagrams; conceptually, these can be thought of as a progression through time of the hypothetical displacement from AMAA2 station during any given year (Wilson and Laman, 2021).

Status and trends: The progressive wind diagram, or hypothetical displacement, at NDBC-site AMAA2 indicated a brief period of winds blowing offshore in early April, followed by a period of northward winds, and then an extended and consistent period of winds blowing to the west through May (Figure 33). Spring winds at AMAA2 were most similar to those observed in 2015 in mean direction and magnitude. These patterns are in contrast to the typical pattern of springtime winds blowing towards the southwest ("northeasterlies"), and represent the second-most northerly end point in the timeseries. The lower-resolution ERA5 winds indicated strong mean April - May wind towards the north (Figure 34). ERA5 winds in 2026 were most similar in direction and magnitude to 1998, and similar to the period 2015 – 2019 when means indicated a relatively strong northward component in this region.

The lower-resolution ERA5 winds indicated strong mean April - May wind towards the north (Figure 34). ERA5 winds in 2026 were most similar in direction and magnitude to 1998, and similar to the period 2015 – 2019 when means indicated a relatively strong northward component in this region.

Factors influencing observed trends: In the Gulf, winds are dominated by cyclonic storm systems that exhibit pronounced seasonality (Stabeno et al., 2004). During spring, cyclonic winds begin to moderate and anticyclonic winds can drive intermittent upwelling. The Aleutian Low influences wintertime conditions and the El Niño-Southern Oscillation can affect conditions at multi-year intervals. Local terrain effects can intensify flow and lead to "gap" winds that affect oceanographic processes. Gap wind events in the AMAA2 region lead to diversion of the ACC to the outside of Kodiak and reduced transport down Shelikof Strait (Ladd and Cheng, 2016).

[23] `https://www.ndbc.noaa.gov/`

[24] `https://cds.climate.copernicus.eu/`

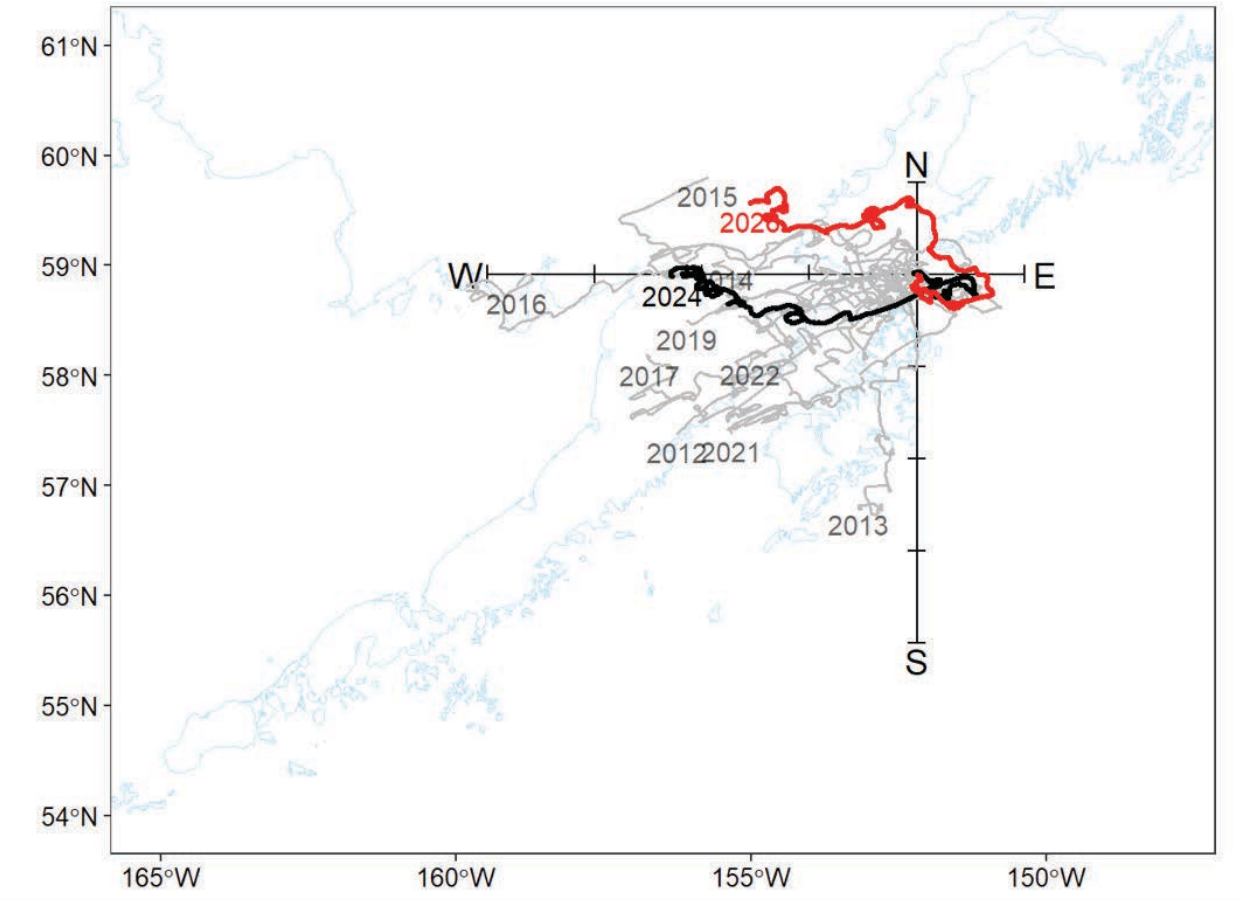


Figure 33: Progressive wind diagrams (PWD) from NDBC-AMAA2 for spring (April – May) 2004 – 2026 (except 2007, 2008, 2018, and 2025). Select trajectory endpoints are labeled by year, with the 2026 trajectory in red and the 2024 trajectory in black. The diagram is superimposed on the Alaska coastline with the origin centered on the location of the AMAA2 site. Note, the scale of distance differs between the trajectories and the coastline; PWD 1 tick mark $\sim$ 2700 nm.

Implications: Wind speed and direction influences coastal circulation in the Gulf at multiple scales. At small scales, wind-driven turbulence has implications for vertical stratification of the water column, and the patchiness and vertical distribution of plankton, including fish larvae. At larger scales, wind drives upwelling and downwelling with consequent effects on vertical circulation and transport. At large scales, wind-driven transport influences the replenishment of adult fish and shellfish stocks by transporting larvae to favorable or unfavorable habitat. When the AMAA2 wind trajectories for this period (April - May) are toward the southwest (down Shelikof Strait), estimates of age-1 pollock abundance tend to increase, possibly because downwelling-favorable northeasterly winds enhance retention of larvae (Stabeno et al., 1996, 2004) and juveniles in areas that favor survival (Wilson and Laman, 2021). Historically, the number of gap wind events during spring (January - May) was positively correlated with Pacific cod recruitment and negatively correlated with arrowtooth flounder recruitment (Ladd and Cheng, 2016), and these relationships should be re-evaluated with more recent observations. The observed southerly winds in April – May 2026 suggest poor retention for pollock larvae and juveniles.

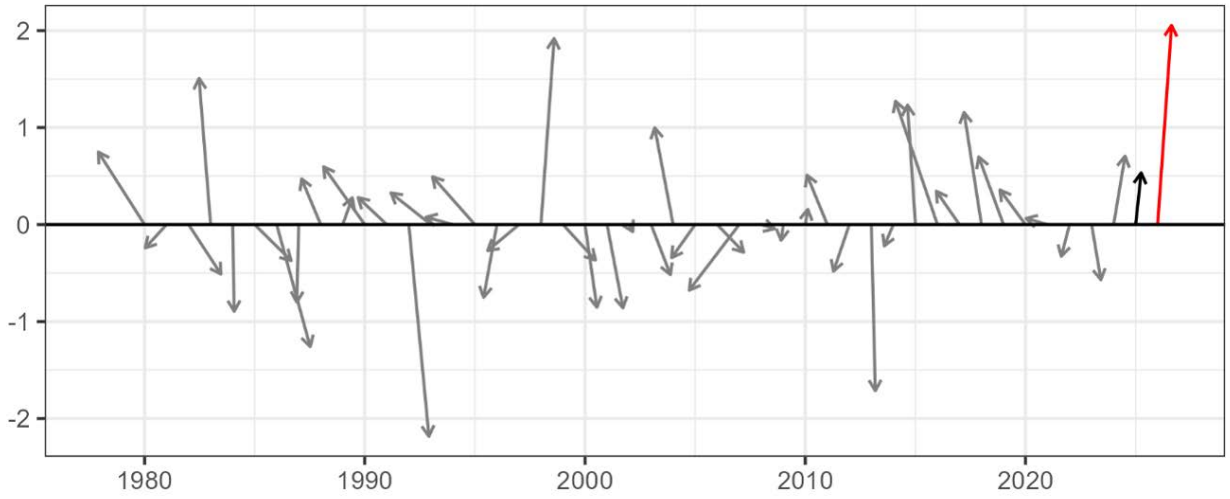


Figure 34: Mean wind from ERA5 for spring (April – May) 1980 – 2024 (gray), 2025 (black), and 2026 (red). Each "stick" represents the magnitude (y-axis) and direction (e.g., northward is up, eastward is to the right) toward which the wind is blowing during each year.

Habitat

Structural Epifauna

Contributed by Alexandra Dowlin and Ned Laman, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, NOAA Fisheries
Contact: Ned.Laman@noaa.gov
Last updated: October 2025

NOAA Fisheries' Gulf of Alaska Bottom Trawl Survey is conducted every other year. Please refer to the archives[25] for past reports.

Primary Production

Satellite-derived Chlorophyll-a Trends

Contributed by Jeanette C. Gann[1], Matt W. Callahan[2], Jens M. Nielsen[3,4]
[1]Auke Bay Laboratories, Alaska Fisheries Science Center, NOAA Fisheries
[2]Pacific States Marine Fisheries Commission, Alaska Fish Information Network
[3]Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, NOAA Fisheries
[4]Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES), University of Washington, Seattle, WA
Contact: jeanette.gann@noaa.gov

Last updated: September 2026

Description of indicator: Phytoplankton provide basal resources for secondary consumers like zooplankton and larval fish. During spring, a large bloom occurs once the upper surface of the water column stratifies, and light intensity becomes strong enough to support phytoplankton growth. This bloom takes advantage of abundant nutrient stores remaining in surface waters after winter storms when phytoplankton activity is low. The spring bloom is critical for nourishing zooplankton, which in turn provide food for fish populations. The timing and magnitude of a phytoplankton bloom varies annually and may play an important role in the success of cohorts each year. We used 8-day composite satellite chlorophyll *a* (chla) data from the Ocean Colour ECV project[26]. We average concentrations from April–June, across the eastern and western GOA (divided at 147 ^{0}W), to capture the conditions during the spring bloom. The coastal areas of focus (on the continental shelf; depths 10 – 200m) coincide with

[25] https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands
[26] https://climate.esa.int/en/projects/ocean-colour/

major fish and zooplankton feeding and spawning areas. We summarized the mean chlorophyll value through spring (Figure 35), in addition to the magnitude of the annual spring event (Figure 36). A persistent consideration with satellite-based chlorophyll data is the effect of cloud cover, which precludes quality data collection. On average, 15 – 20% of data was missing during the spring periods examined for each year, which adds uncertainty to our assessments. Coverage for 2026 had an average of 94% in the western GOA and 78% in the eastern GOA.

Status and trends: The spring bloom progresses from inshore to offshore for the eastern GOA, while the western GOA is more complex. Both regions exhibit high inter-annual variability for the whole time series (time series: 1998 – 2026).

Bloom Timing and Peak Magnitude: In 2026, the peak bloom in the western GOA was well above the mean and reached a record high (2026 – 4.06 mg m-3 vs mean peak of 2.72 mg m-3) (Figure 35), while bloom timing was early (April 27, compared to an average date of May 22). For the eastern GOA, the peak bloom was above the mean (2026 – 3.53 mg m-3 vs mean peak – 2.89 mg m-3). The eastern GOA bloom was also early this year (2026 April 19, compared to an average date of May 14).

Seasonal Chlorophyll concentrations: The seasonal mean (April –June) in western GOA peaked early and was well above average then dipped below the long term and previous year means in June (Figures 36 and 37). The eastern GOA chlorophyll also peaked early and was above average and dipped below both long-term and 2025 means in late May. Mean 2026 chla was within one standard deviation of the mean in the western GOA, and almost exactly one standard deviation above its mean in the eastern GOA.

Factors influencing observed trends: Given the complexity of phytoplankton, a number of factors may be contributing to variations in chlorophyll-a concentrations. Mesoscale eddies play a large role in the GOA chlorophyll patterns offshore of the continental shelf, with evidence of influence via eddy-moderated shelf-slope exchange creating phytoplankton 'hot spots' over the shelf (Okkonen et al., 2003). Additionally, spring runoff and ambient nutrient concentrations can affect timing of blooms over the shelf (Waite and Mueter, 2013). It is unclear why both the western GOA and eastern GOA blooms were so early and high this year.

Implications: Timing and magnitude of peak chlorophyll concentrations are important for gauging general food availability for zooplankton and are thus also relevant for many of the planktivores that rely on zooplankton. In the eastern GOA, chlorophyll inter-annual variations are correlated with zooplankton biomass, which in turn are correlated with annual catch yields of resident fishes (Ware and Thomson, 2005). Factors affecting phytoplankton blooms can be complicated, and more extensive work is required to resolve any direct connections between groundfish recruitment and chlorophyll concentrations. Implications of the high early blooms in the eastern GOA are unclear although high chlorophyll during April and May could benefit young and growing fish during this time. It should be noted that smaller geographic areas in addition to depth-averaged in-situ data as opposed to remotely sensed data can show vastly different trends (e.g., Seward line). Overall, western GOA chlorophyll concentrations reached a record high for 2026, and eastern GOA was slightly above the mean, while both eastern GOA and western GOA were early in timing.

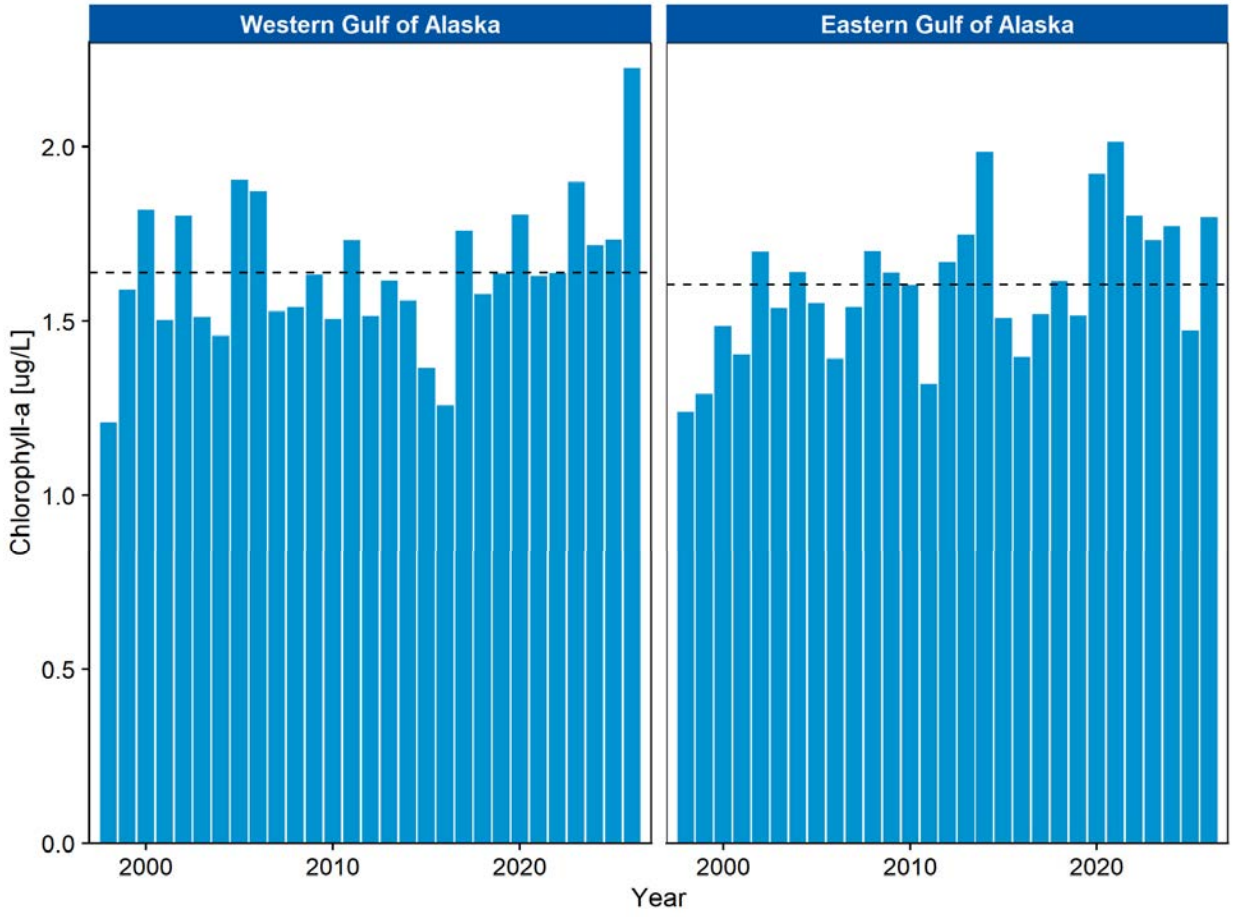


Figure 35: Average spring (April-June) chlorophyll-*a* concentrations based Ocean Colour ECV satellite 8 day composites for the western and eastern GOA. The horizontal dashed line is the long-term mean (2003 – 2025). A persistent consideration with satellite-based chlorophyll data is the effect of cloud cover, which precludes quality data collection. Satellite coverage was lower during April and May in the eastern GOA, which adds uncertainty to our assessments.

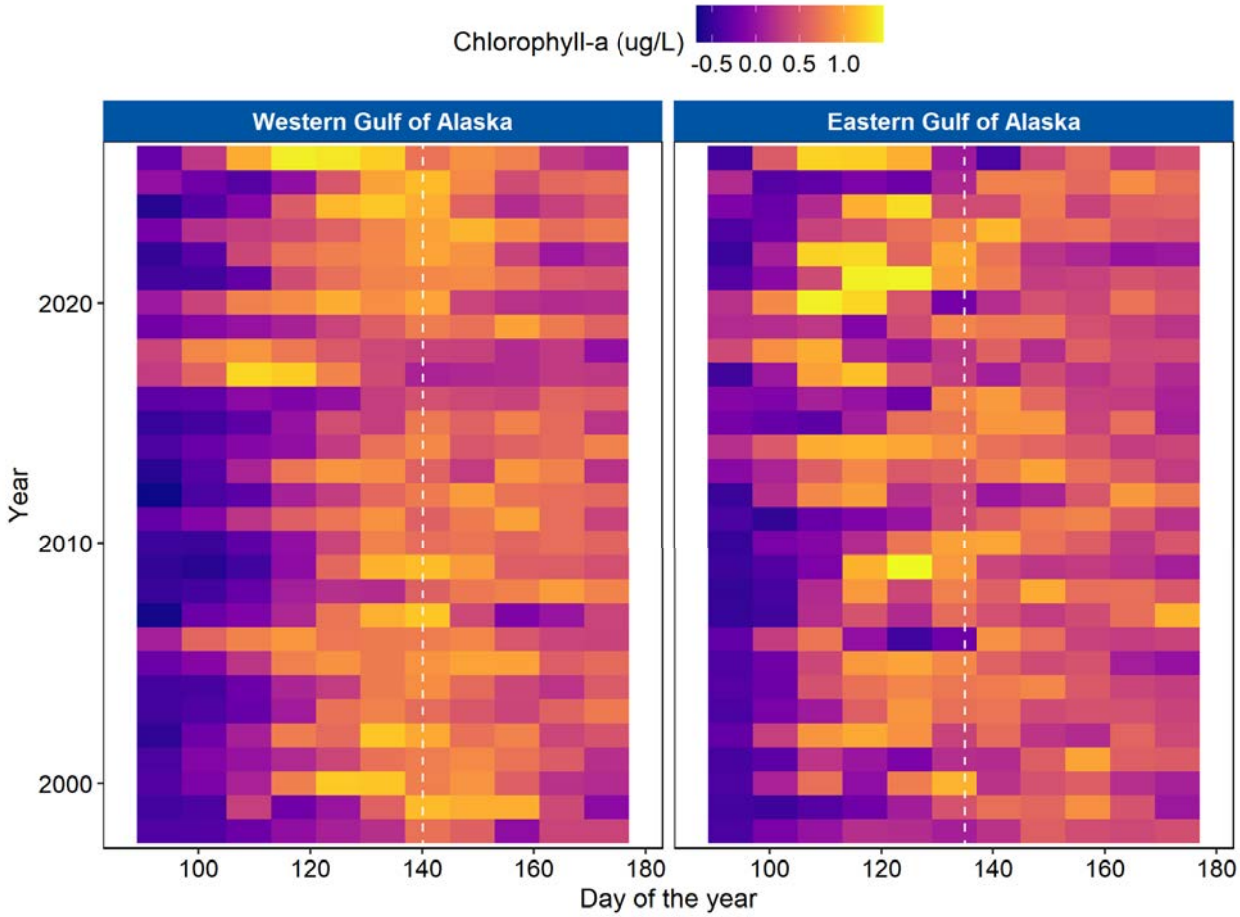


Figure 36: Average 8-day composite chlorophyll-*a* concentrations (log-transformed) for the western and eastern GOA. The brightest (yellow) color within each year will represent the peak bloom (less bright yellow reflects a lower peak). All years are on the same color scale. Vertical dashed lines illustrate the mean day of the year of spring bloom timing for the western (day 117; $\sim$ April 27) and the eastern (day 109; $\sim$ April 19) Gulf of Alaska. For reference, days of year 100 and 180 fall around April 9 and June 30, depending on leap years.

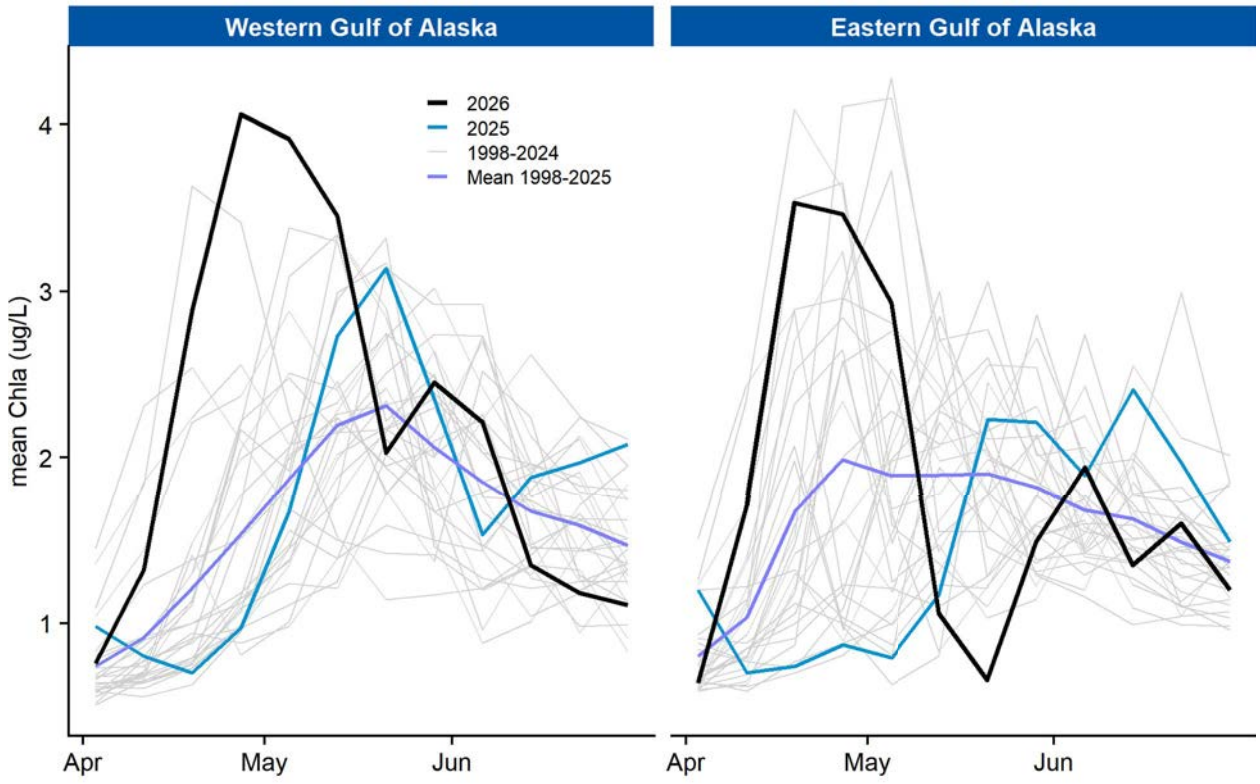


Figure 37: Average 8 day composite chlorophyll-*a* concentrations for the western and eastern GOA from April through June. The 1 year mean chla is represented by the black line in 2026, the blue line in 2025, and the gray lines for all previous years. The purple line is the long-term mean (1998 – 2024). The average peak bloom occurs on day 117 (∼ April 27) in the western GOA and day 109 (∼ April 19) in the eastern GOA.

Seward Line May Phytoplankton Size Index

Contributed by Gwenn Hennon, University of Alaska Fairbanks, College of Fisheries and Ocean Sciences, 2150 Koyukuk Drive, Fairbanks, AK 99775
Contact: gmhennon@alaska.edu
Last updated: September 2026

Description of indicator: Since 1998, hydrographic transects have been completed in May (typically during the first 10 days of the month) along a sampling line that extends from the mouth of Resurrection Bay near Seward to the outer continental slope of the northern Gulf of Alaska. Episodically beginning in 2001 and annually beginning in 2011, chlorophyll-a (chl-a) in two size fractions (< 20 μm and > 20 μm) as well as total chl-a have been measured at 6–7 depths (0 to 50 or 75 m) at stations spanning the continental shelf and offshore waters. Data provided here are an index of size composition of the phytoplankton shelf community, originally developed by Suzanne Strom of Western Washington University. The index is computed from depth-integrated shelf station chl-a values, for each early May cruise, and is equal to the fraction total chl-a found in the large (> 20 μm) size class (i.e., chl-$a_{>20}$ / chl-a_{total}). In most cases, 9 stations are averaged to generate the index. High values of the size index correspond to diatom-dominated communities, while low values of the size index correspond to phytoplankton communities dominated by small flagellates and cyanobacteria. Comparison with remote sensing-based estimates of spring bloom timing and magnitude shows that the size index is a predictor of two important aspects of the spring bloom. 1) When the index is (≤ 0.25, meaning that small cells strongly dominate, the spring bloom begins and peaks relatively late in the year. 2) When the index is ≥ 0.5, meaning that large cells comprise half or more of the total chl-a, the value of the index is strongly correlated ($r^2 = 0.65$) with the cumulative magnitude of the spring bloom (April – June) as measured by remote sensing.

Status and trends: This year (2026) we observed a return to high index values associated with spring diatom blooms (baseline: 2001 – 2025, Figure 38). This contrasted strongly to the previous few years (2021 – 2024) which had some of the high to moderately high index values consistent with the spring diatom blooms. Corroborating this interpretation of the chlorophyll index, we observed in Imaging FlowCytobot data collected on the same cruise a bloom dominated by chain-forming diatoms in the genus *Chaetoceros*.

No long-term secular trend is evident in the phytoplankton size index, although there is a suggestion that variance has increased in recent years. The marine heatwave years of 2014 – 2016 show the lowest values in the time series, with the (lesser) heatwave year of 2019 also showing a low value. Last year (2025) had a low value that was comparable to a marine heatwave year which suggested that warmer than average temperature in the proceeding winter was associated with a smaller cell-dominated spring bloom.

Factors influencing observed trends: The mix of winter sea-surface temperature, resource availability (light, micro- and macronutrients) and top-down controls leading to shifts in the spring size index is under active investigation.

Implications: High values of the size index correspond to diatom-dominated communities, which are known to provide high amounts of lipid-rich prey for zooplankton (i.e., copepods and euphausiids). Low values of the size index correspond to phytoplankton communities dominated by small flagellates and cyanobacteria, which are less available to large zooplankton and may lead to less efficient transfer

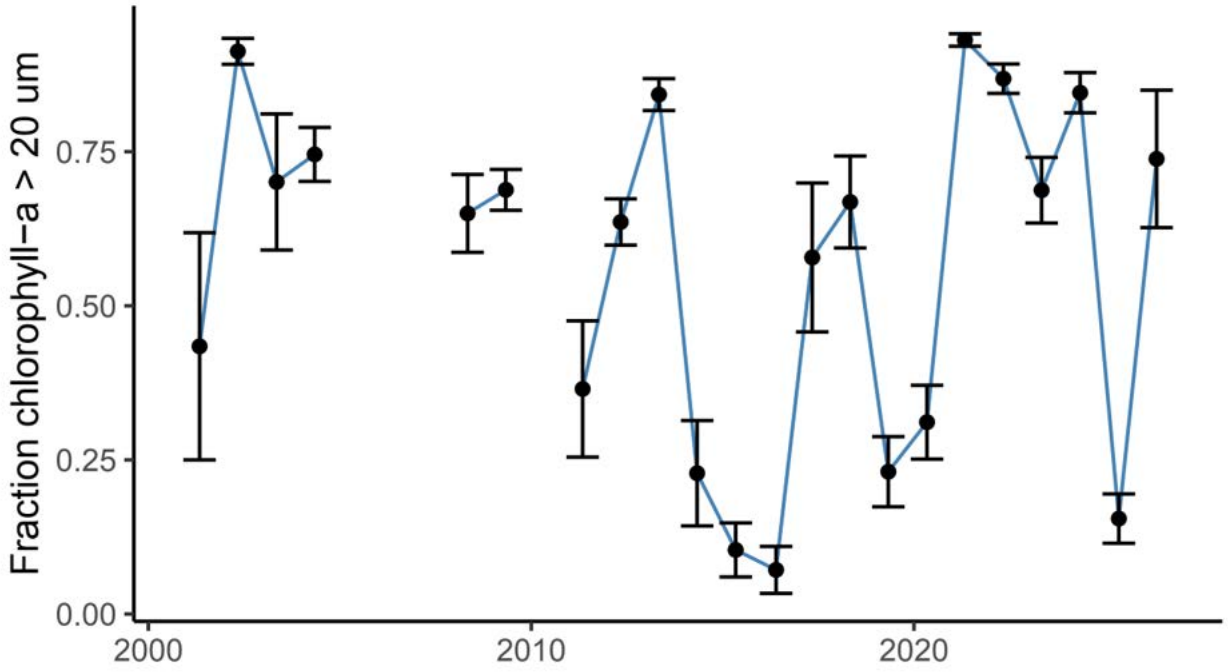


Figure 38: May 2001 – 2026 time series of phytoplankton size index (fraction of total chl-a present in cells > 20 μm) for the Seward Line shelf stations (mean $\pm$ SE).

of primary production to higher trophic levels. A late spring bloom could lead to timing mismatches between the emergence/development of important zooplankton grazers and the availability of diatom prey, which would have negative effects on transfer of production to higher trophic levels. Conversely, a larger spring bloom introduces more primary production into the ecosystem in a form that can be efficiently transferred to higher trophic levels in the water column and the benthos.

Northern Gulf of Alaska Physical Hydrography: Trends and El Niño Outlook

Contributed by Seth Danielson[1], Tyler Hennon[1], David Hill[2], Kay McMonigal[1], and Russ Hopcroft[1]
[1]College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Fairbanks, AK
[2]Civil and Construction Engineering, Oregon State University, Corvallis, OR
Contact: sldanielson@alaska.edu

Last updated: September 2026

Description of indicator: Nominally monthly water column hydrographic profiles of temperature and salinity have been collected since December 1970 at oceanographic station GAK1 (59.845 °N, 149.467

°W), near the mouth of Resurrection Bay, Alaska. Oceanographic moorings have collected data at GAK1 since December 1999. Cross-shelf hydrographic transects of the Seward Line have been occupied annually in May since 1998. A combined GAK1 CTD profile and mooring record (Danielson et al., 2026) form a maximally complete time series of hydrographic conditions at standard oceanographic sampling levels (0, 10, 20, 30, 50, 75, 100, 150, 200 and 250 m depths). The GAK1 record documents coastal Gulf of Alaska oceanic conditions, including the effects of climate warming, melting glacier ice, marine heatwaves, and El Niño Southern Oscillation (ENSO) events. Considering both moderate and strong ENSO events, the GAK1 record since 1970 spans 5 Eastern Pacific El Niño, 13 Central Pacific Niño, and 21 La Niña events. Recent analysis of the GAK1 record (Danielson et al., 2026) reveals the typical evolution of these three types of ENSO events. The El Niño of 2026 shows elevated warming across both the Central Pacific (CP) and Eastern Pacific (EP). In this report we focus on the EP response pattern, because it drives a larger response in the coastal Gulf of Alaska (Danielson et al., 2026).

Status and trends: Analysis of the period of record (Figure 39, Danielson et al., 2026) reveals that the entire Gulf of Alaska coastal water column (0 – 250 m) is warming, though somewhat faster over 0 – 50 m depth (+0.21 ± 0.05 °C decade-1) than over 200 – 250 m depth (+0.16 ± 0.03 °C decade^{-1}). Surface waters are freshening (-0.05 ± 0.02 decade^{-1}) and near-bottom waters are getting progressively saltier (+0.04 ± 0.01 decade^{-1}). We find that the warming is not uniform through all seasons: greatest rates of near bottom warming (approx. 0.3 °C decade^{-1}) occur in late winter and early spring. Seward Line data (Figure 39) show the northern Gulf of Alaska shelf to be on the cool side of neutral in Spring 2026. For salinity, a near-bottom positive salinity anomaly is over the mid-shelf and at mid-depth offshore, while negative salinity anomalies were found at shallower depths.

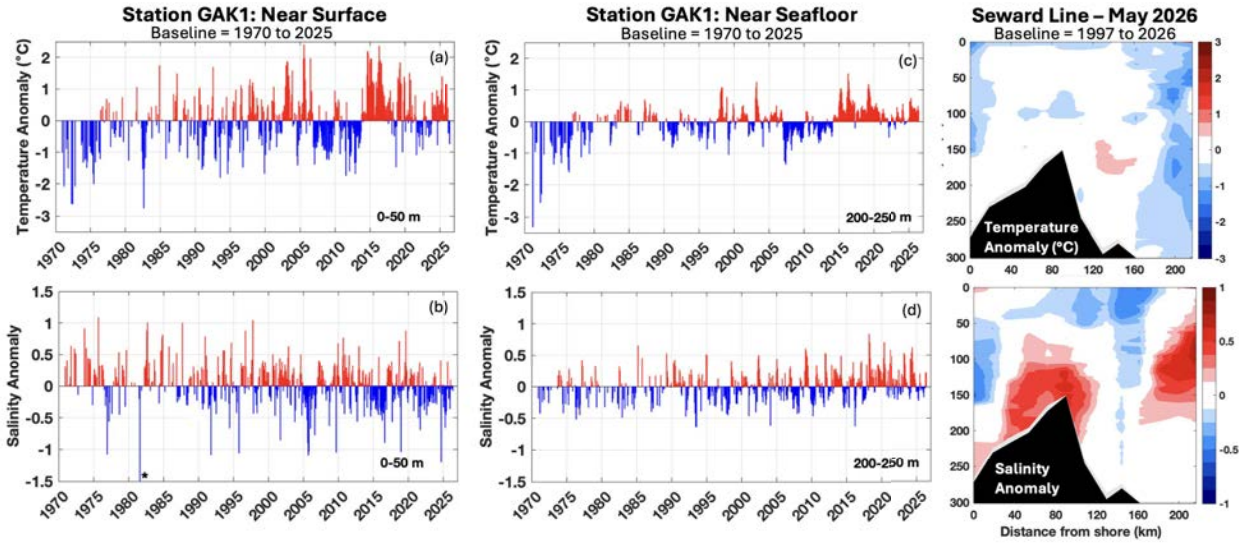


Figure 39: Station GAK1 1970 – 2026 (left four panels) and Seward Line May 2026 transect (right two panels) showing temperature (top) and salinity (bottom) anomalies. Note different baselines.

Factors influencing observed trends: Northern Gulf of Alaska period of record trends in GAK1 temperature and salinity data are both linked to the effects of a warming climate. Correlation analysis with known drivers of hydrographic variability indicates that the salinity trends are associated with long-term trends of increasing surface freshwater inputs from ablating glaciers and the diminishment of downwelling wind stress (Danielson et al., 2026). ENSO climate signals manifest in the Gulf of Alaska

through hemispheric-scale teleconnections that alter surface winds and ocean-atmosphere heat fluxes. A "super" El Niño event developed in the equatorial Pacific in the first half of 2026 and contributed to a global sea surface temperature record in August 2026 (Copernicus Climate Change Service, 2026). A GAK1 composite of EP-type ENSO events (Figure 40, Danielson et al., 2026) indicates expected warming of nearly +1.5 °C from April of Year 1 (2026) to April of Year 2 (2027), and a temperature anomaly of about +1.1 °C by May of Year 2.

Implications: Because ENSO events are well predictable up to six months in advance, Gulf of Alaska coastal temperature and salinity anomalies can be skillfully forecast up to 24 months in advance from January of the ENSO onset year (Danielson et al., 2026). From a Year 1 (spring 2026) GAK1 near-bottom temperature anomaly of about +0.5 °C relative to the GAK1 period of record, El Niño-induced warming could rival conditions observed at GAK1 during the 2016 marine heatwave (Danielson et al., 2022). On the other hand, the spring 2026 surface temperature anomaly was negative, so surface waters would need to warm even more than in the typical EP event to approach the +2 °C anomalies that were observed in 2015 and 2016.

We expect that the 2026 El Niño will cause above-normal temperatures and below normal surface salinities to persist in the coastal Gulf of Alaska through most of 2027. Enhanced anomalous upper ocean stratification could help trigger an early spring bloom, but too much stratification could lead to early nutrient depletion that in turn would favor development of smaller phytoplankton size classes and induce a less efficient transfer of energy to upper trophic levels.

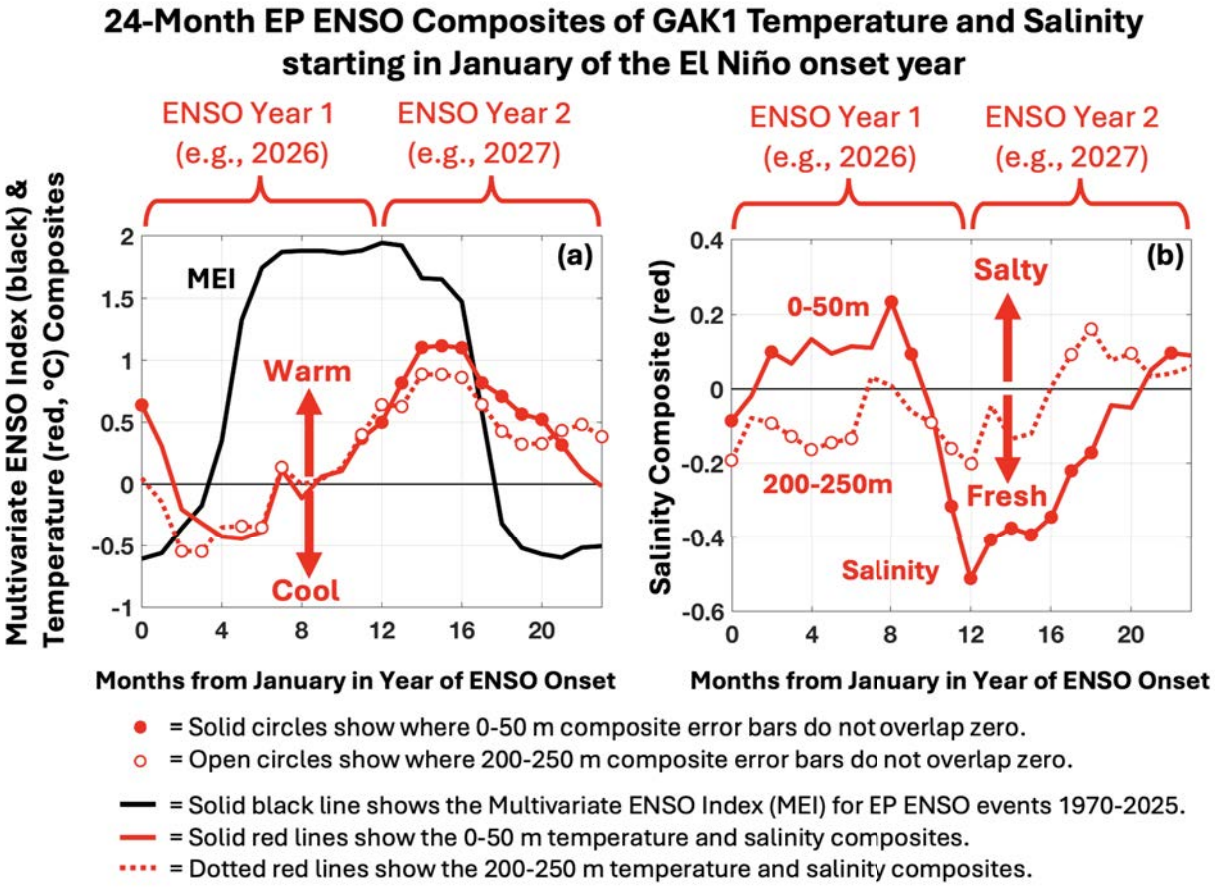


Figure 40: Monthly composite averages of GAK1 monthly anomalies and the Multivariate ENSO Index (MEI), across the two years spanning ENSO onset, growth and decay. The left panel shows composites during Eastern Pacific (EP) type ENSO events for the MEI (black) and temperature (red) and the right panel shows the corresponding composites for salinity (red). Solid and dotted red lines denote near-surface (0 – 50 m) and near-bottom (200 – 250 m) depth layers, respectively. Filled and open circles indicate GAK1 EP ENSO composite averages that significantly differ ($p < 0.05$) from the GAK1 surface and bottom layer monthly climatology, respectively. Modified from Figure 8 of Danielson et al. (2026).

Spring Bloom Timing over the Central Gulf of Alaska Shelf

Contributed by Hank Statscewich, Isaac Reister, and Seth Danielson; College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Fairbanks, AK
Contact: hank.stats@alaska.edu
Last updated: September 2026

Description of indicator: Autonomous glider observations (AOOS Glider Observatory, 2023, 2024, 2025, 2026) collected on the central northern Gulf of Alaska (NGA) continental shelf near 59 °N, 148.6 °W (Figure 41a) describe the timing and magnitude of the spring phytoplankton bloom (Figure 41b) and the physical conditions associated with its development (Figure 41c-e). The indicator includes daily average 0 – 50 m chlorophyll-a fluorescence with 0 – 10 m photosynthetically active radiation (PAR), mixed layer depth (MLD), and stratification index integrated over 0 – 100 m depth. A depth-time section of chlorophyll-a fluorescence (Figure 41a) shows that the bloom's 2026 vertical structure extended to $\sim$ 60 m, deeper than the MLD and deeper than the typical optical depth viewed by satellites. MODIS imagery from NASA Worldview provides regional context for the near-surface chlorophyll-a standing crop in the midst of the bloom (NASA Ocean Biology Processing Group, 2025*a*,*b*). Glider observations were binned to a 1 m x 6-hour grid and then averaged to daily and 3-day values. MLD was defined as the first depth where in situ density exceeded the density measured at 3m depth by 0.07 kg m^{-3}. Chlorophyll-a fluorescence is an optical proxy for chlorophyll-a concentration and may be affected by sensor calibration, phytoplankton community composition, and daytime nonphotochemical quenching.

Status and trends: The records show interannual differences in bloom onset timing and magnitude. The magnitude of the bloom varies year-to-year: 2023 experienced only a weak bloom before the record ended in early May; 2024 showed a strong bloom that did not start to ramp up until late April; 2025 showed a moderate bloom through much of April. It is possible that the 2023 and 2025 blooms further accelerated after the end of the glider missions in these two years. The 2026 record contained two distinct bloom pulses. A short pulse centered near April 19, 2026 was followed by a sharp decline and a second, broader bloom in early May that exceeded 300 mg m^{-2} (= 6 mg m^{-3} over 0 – 50 m depth). The decline was associated with isopycnal shoaling and a mesoscale feature associated with low chlorophyll-a in the April 29, 2026, satellite image (Figure 41a).

Factors influencing observed trends: In all years, the bloom onset can be related to irradiance and upper ocean stratification conditions; nutrients are not limiting at this time of year. Exact timing depends on the timing of synoptic weather patterns along with seasonally increasing light levels, stratification, and shoaling of the mixed layer depth. In 2026, chlorophyll-a briefly declined after the April pulse, even as stratification strengthened, while the larger May bloom developed as the mixed layer deepened. The sequence is not explained by a simple application of the critical-depth hypothesis based only on mixed-layer shoaling and increasing light (Franks, 2015). Other processes, including advection, nutrient supply, grazing, sinking, and changes in phytoplankton growth and loss rates, may also have contributed. On April 29, 2026, the glider was sampling the low chlorophyll-a interval between the two bloom pulses. Satellite imagery from the same day provides regional context and shows that most of the continental shelf from Kayak Island to Kodiak Island was enveloped in the bloom. Satellite ocean color primarily represents the near-surface optical layer, whereas the glider section shows that elevated chlorophyll-a fluorescence can extend tens of meters below the surface and even below the mixed layer depth. Satellite

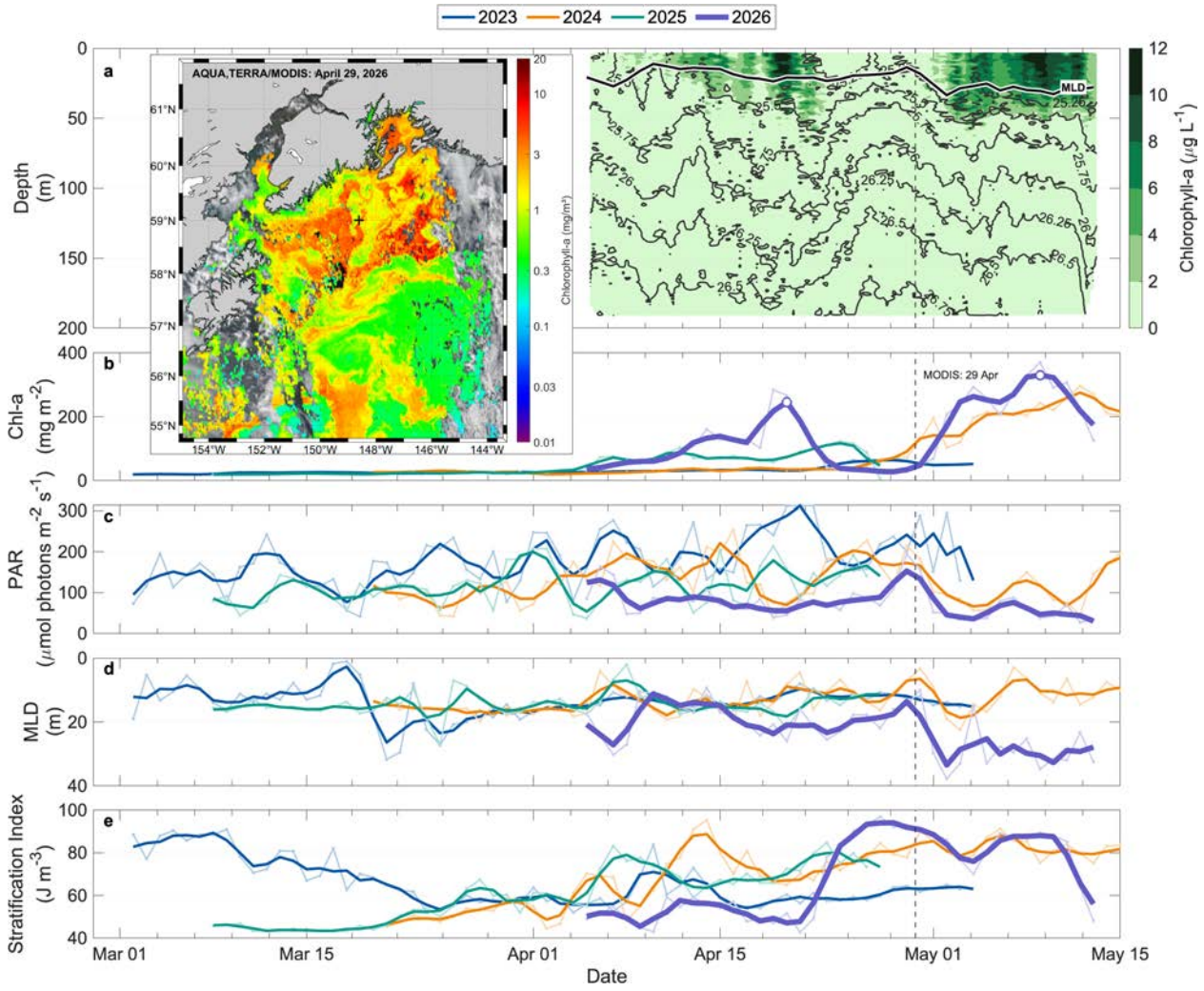


Figure 41: Spring bloom timing, amplitude and associated environmental conditions over 2023 – 2026, observed by an autonomous glider within 10 km of the Gulf of Alaska Ecosystem Observatory mooring (GEO; black "+" at 59.0 °N, 148.6 °W). Panel (a) shows the 2026 vertical distribution of chlorophyll-a fluorescence with density contours (kg m^{-3} -1000) and the three-day mean mixed layer depth (MLD). The inset shows MODIS satellite near-surface chlorophyll-a concentrations (NASA Worldview, April 29, 2026). Other panels include (b) 0 – 50 m chlorophyll-a fluorescence inventory (mg m^{-2}), (c) average daily 0 – 10 m photosynthetic available radiation (PAR), (d) MLD, and (e) stratification index integrated over 0 – 100 m. Light lines show daily means; bold lines show three-day means. White circles identify the peaks of two distinct 2026 bloom pulses. The dashed vertical line indicates the Worldview image date.

imagery cannot resolve the vertical structure of the bloom and in 2026 probably underestimated the standing crop because of the depth to which the fluorescence signal extended. The satellite image confirms that spatial patchiness and mesoscale advective features influenced observed conditions at the monitoring site. Wind forcing, ocean currents, nutrients, oxygen and additional satellite observations are needed to further evaluate these mechanisms.

Implications: Spring bloom timing, amplitude and persistence affect the transfer of primary production biomass to microzooplankton and mesozooplankton consumers. Interannual differences in bloom devel-

opment could alter trophic coupling to both pelagic and benthic food webs. NGA glider deployments provide high resolution, surface-to-seafloor observations of environmental and bio-optical conditions. The value of this indicator will increase as the annually collected time series lengthens and is evaluated alongside zooplankton, fish, and other environmental data.

Zooplankton

Continuous Plankton Recorder Data from the North-east Pacific, 2002–2025

Contributed by Clare Ostle[1] and Sonia Batten[2]
[1] CPR Survey, The Marine Biological Association, The Laboratory, Citadel Hill, Plymouth, Devon, PL1 2PB, UK
[2] PICES, West Saanich Road, Sidney, BC, V8L4B2, Canada
Contact: claost@mba.ac.uk
Last updated: July 2026

Description of indicator: Continuous Plankton Recorders (CPRs) have been deployed in the North Pacific routinely since 2000. Two transects are sampled seasonally, both originating in the Strait of Juan de Fuca, one sampled monthly (∼Apr – Sept) which terminates in Cook Inlet, the second sampled 3 times per year (in spring, summer and autumn) which follows a great circle route across the Pacific terminating in Asia. Several indicators are now routinely derived from the CPR data and updated annually. In this Report we update three indices for three regions (Figure 42); the abundance per sample of large diatoms (the CPR only retains large, hard-shelled phytoplankton so while a large proportion of the community is not sampled, the data are internally consistent and may reveal trends), meso-zooplankton biomass (estimated from taxon-specific weights and abundance data) and mean copepod community size (see Richardson et al., 2006 for details but essentially the length of an adult female of each species is used to represent that species and an average length of all copepods sampled calculated) as an indicator of community composition. Anomaly time series of each index have been calculated as follows: A monthly mean value for each region is first calculated. Each sampled month's mean is then compared to the long-term geometric mean of that month and an anomaly calculated ($\log_{10}$). The mean anomaly of all sampled months in each year is calculated to give an annual anomaly.

The indices are calculated separately for the oceanic eastern GOA, oceanic western GOA (divided at 147 ºW), and the Alaskan shelf southeast of Cook Inlet (Figure 42). The oceanic eastern GOA region has better sampling resolution than the Alaskan shelf and oceanic western GOA region as both transects intersect here. This region has been sampled up to 8 times per year with some months sampled twice. The Alaskan shelf region is sampled 5 – 6 times per year by the north-south transect and the western GOA region is sampled 36 times per year, mostly by the east-west transect.

Status and trends: The large diatom abundance anomaly reached the highest value in its time series in 2025 for both the Alaskan Shelf (0.66, exceeding the previous high of 0.60 in 2005) and the eastern oceanic Gulf of Alaska (0.50, exceeding the previous high of 0.35 in 2003) (Figure 43). In contrast, the diatom anomaly in the western oceanic Gulf of Alaska reversed to negative in 2025, following four consecutive positive years (2021 – 2024). The copepod community size anomaly was slightly negative across all three regions in 2025, continuing the near-neutral to negative values seen in recent years. Meso-zooplankton biomass anomalies in the eastern oceanic Gulf of Alaska were positive in 2025, for a third consecutive year, and the western oceanic Gulf of Alaska biomass anomaly also turned positive in 2025 after two years of negative values. In the Alaskan Shelf, the biomass anomaly turned negative in 2025 following two consecutive positive years (2023 – 2024).

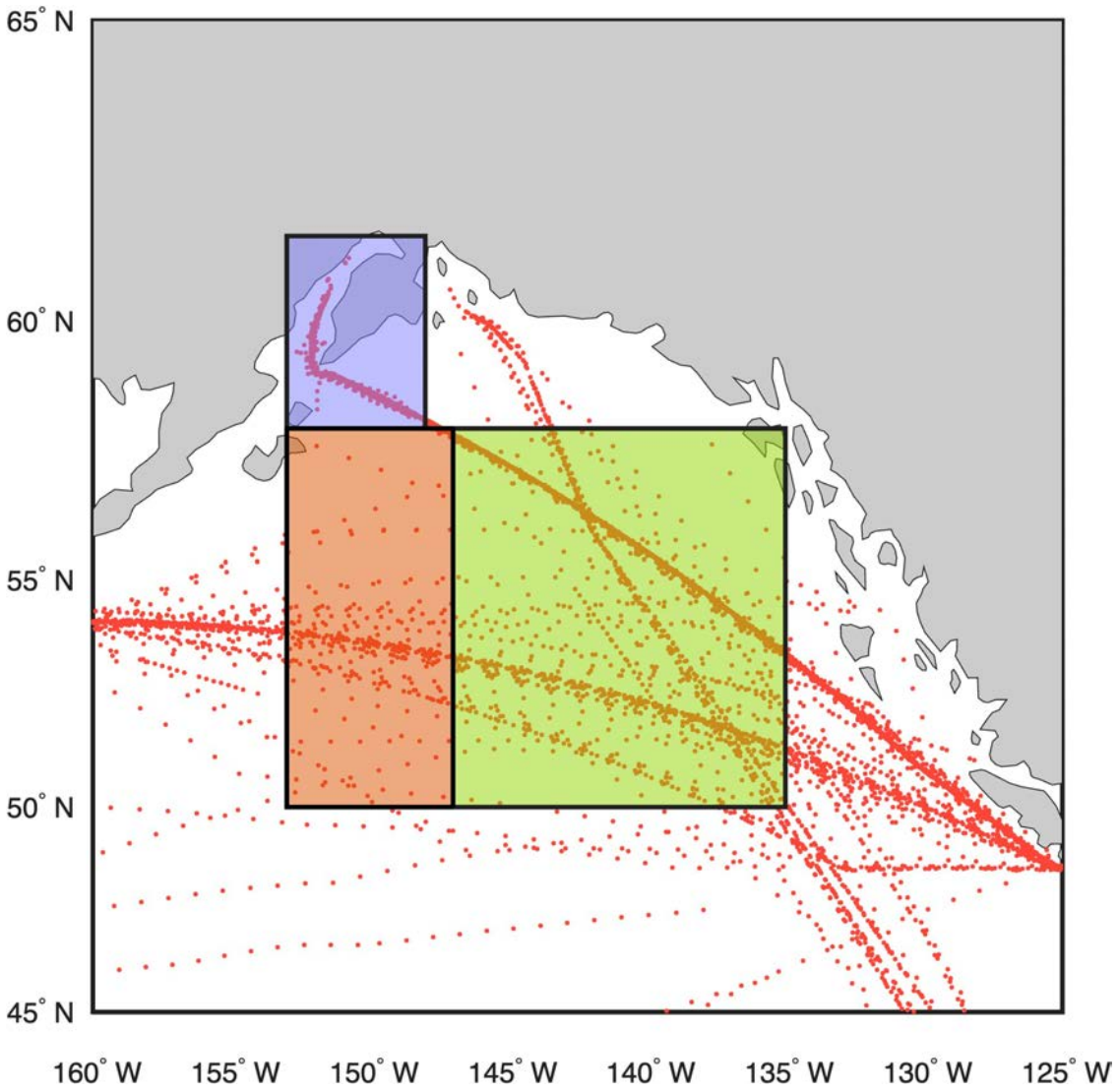


Figure 42: Location of the data used in this report, highlighted as Alaskan shelf (blue rectangle), eastern oceanic Gulf of Alaska (green rectangle), and western oceanic Gulf of Alaska (red rectangle). Red dots indicate actual sample positions (for the shelf region the multiple transects overlay each other almost entirely).

Factors influencing observed trends: The large diatom abundance anomalies in the Alaskan Shelf and eastern oceanic Gulf of Alaska reached the highest values in each region's time series in 2025 driven by high numbers of *Cheatoceros* spp. As in 2024, it is unclear what has driven this continued increase in diatom abundance, though warming and potentially a sustained reduction in grazing pressure remains a plausible explanation. *Cheatoceros* spp. is a diatom that have setae (silica spines), that can cause problems for juvenile fish species feeding on them when they are in very high numbers as they can irritate and clog gills (Albright et al., 1992). The reversal to a negative diatom anomaly in the western Gulf of Alaska in 2025, breaking four consecutive positive years, is a divergence from the shelf and eastern regions that is not yet understood. The copepod community size index remained negative across all three regions in 2025, consistent with the tendency for smaller-bodied copepod communities to persist under the warm conditions of recent years (Batten et al., 2022).

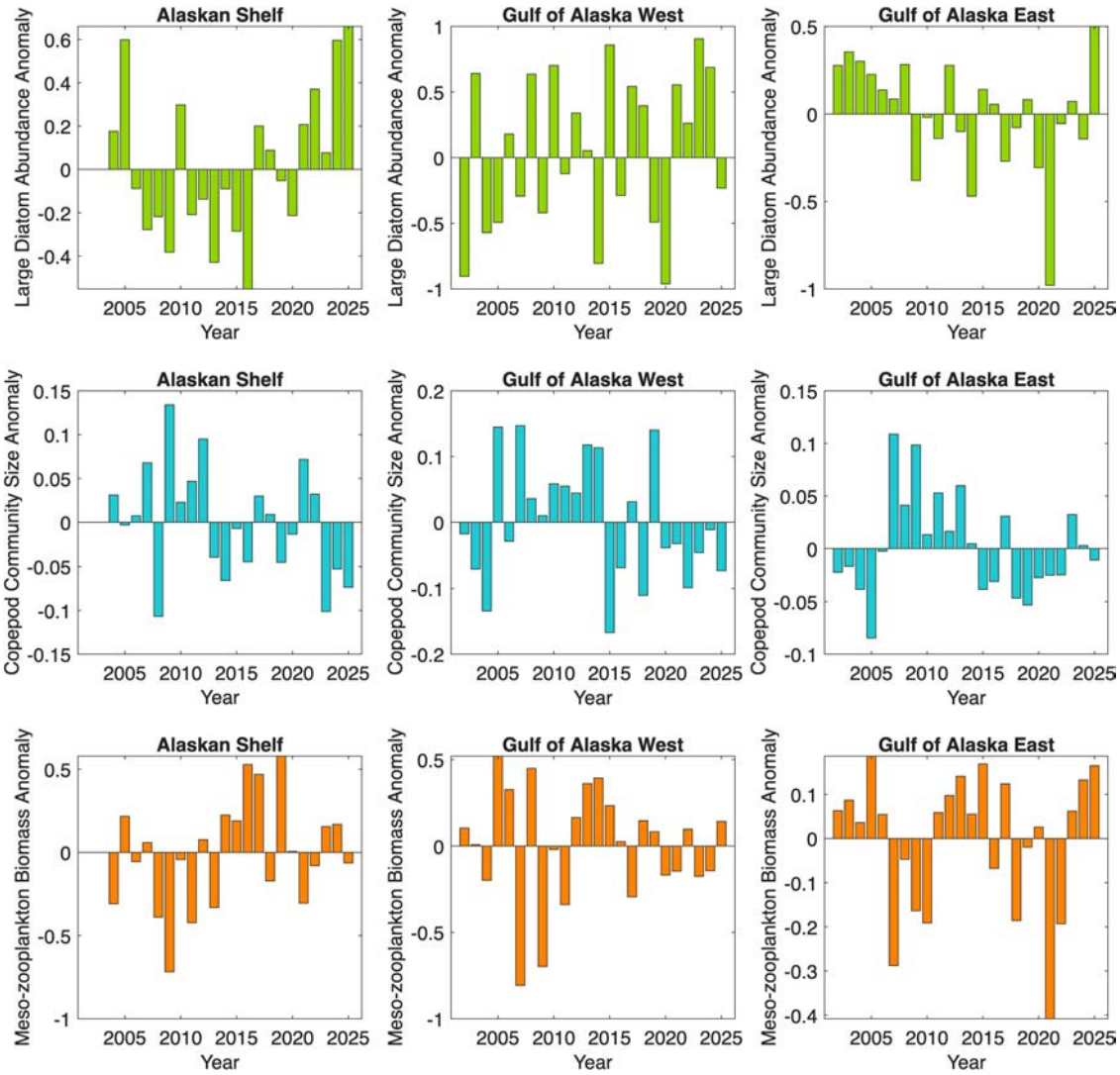


Figure 43: Annual anomalies of three indices of lower trophic levels (see text for description and derivation) for all three regions shown in Figure 42. Note that sampling of the shelf region did not begin until 2004.

Implications: Each of these variables is important to the way that ocean climate variability is passed though the phytoplankton to zooplankton and up to higher trophic levels. Changes in community composition (e.g., abundance and composition of large diatoms, prey size as indexed by mean copepod community size) may reflect changes in the nutritional quality of the organism to their predators. Changes in abundance or biomass, together with size, influences availability of prey to predators.

Current and Historical Trends for Zooplankton in the Western Gulf of Alaska

Contributed by David Kimmel, Jesse Lamb, and Adam Spear
Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, NOAA Fisheries
Contact: david.kimmel@noaa.gov
Last updated: September 2026

Description of indicator: AFSC implemented a Rapid Zooplankton Assessment (RZA) to provide leading indicator information on zooplankton abundance trends in Alaska's Large Marine Ecosystems in 2015 (Kimmel et al., 2024). The RZA is a rough count conducted at sea from paired 20/60 cm oblique bongo tows and provides a preliminary estimates of zooplankton abundance (Kimmel et al., 2024). The RZA uses standard zooplankton processing methods to enumerate zooplankton into three categories: small copepods $<$ 2 mm (example species: *Acartia* spp., *Oithona* spp., and *Pseudocalanus* spp.), large copepods $>$ 2 mm (example species: *Calanus* spp. and *Neocalanus* spp.), and euphausiids $<$ 15 mm (example species: *Thysanoessa* spp.). Small copepods were counted from the 153 μm mesh, 20 cm diameter net and large copepods and euphausiids were counted from the 505 μm mesh, 60 cm diameter net. Detailed taxonomic information on these groups is provided after laboratory processing has been completed (approximately one year post survey) and abundance indices are updated with laboratory processed counts in the following year. All current survey year zooplankton abundance estimates are derived from the RZA.

Methodological changes: This year we have made changes to the zooplankton contribution. First, we are no longer reporting euphausiid abundances as we are developing an acoustic index for EcoFOCI surveys. This will provide a more accurate abundance index for euphausiids moving forward as bongo net estimates are considered less reliable for abundance estimation due to net avoidance (Hunt et al., 2016). We made a minor change in the mapping of the current year's RZA data to allow for better visual comparisons across surveys. We now report abundance estimates in $\log_{10}$ number m^{-2} for all three taxonomic groups. This has the effect of keeping the scales more conistent from both within and between surveys. Second, we have standardized the annual abundance indices for each coarse taxonomic group using spatiotemporal modeling (Shelton et al., 2014; Thorson and Kristensen, 2016). This approach better accounts for spatial variability arising from different sampling regimes across years as the spatial coverage and timing of the survey may differ between years (Anderson et al., 2022). Standardized indices provide an area-weighted population index predicted from a model covering a specified grid area and are therefore independent of sampling locations that vary annually. We used the *sdmTMB* package in R (Anderson et al., 2022) to develop the strandardized, annual abundance indices based on prior work demonstrating the effectiveness of spatiotemporal modeling for exploring the seasonal dynamics of *Calanus marshallae/glacialis* in the Bering Sea (Thorson et al., 2020). All models accounted for spatial random fields and independent spatiotemporal fields using stochastic partial differential equation (SPDE) approximation to Gaussian random fields with Gaussian Markov random fields (Lindgren et al., 2011). Annual abundance indices were modeled using year as a factor and may or may not include a smoother, day-of-year effect to account for shifts in sample collection times year to year. Day-of-year was standardizd to day 135 ($\sim$ 15 May) for the spring index and day 248 ($\sim$ 5 September) for the summer/fall index. The spatial area used to estimate the spring and summer/fall indices for the Gulf of Alaska remains unchanged from prior years' spatial area and is the same used

to estimate larval abundance indices (see Rogers et al., p.100). Zooplankton data were modeled using the Tweedie distribution (to account for zero-inflated data) or the lognormal distribution and included spatial random effects and spatiotemporal random effects (Anderson et al., 2022). The entire, area-weighted summer abundance over 20 km^2 grid cells is then estimated for each zooplankton group and reported as an annual time-series.

We completed no surveys in the Gulf of Alaska in 2026. Here, we report results from 2025. We conducted a spring larval survey from 17 May to 4 June 2025. Here, we show maps from the 2025 survey and an updated spring long-term time-series for the western Gulf of Alaska that include processed data updated to 2025. The summer age-0 survey was not conducted in 2025; therefore, no data are able to be presented for this survey in the form of abundance maps, and the time-series has not changed since 2023, therefore we do not report results for the late summer.

Status and trends: Both small and large copepod abundances during the spring larval survey showed minimal spatial variability (Figure 44). Small copepods were very abundant, above 1 standard deviation of the long-term mean, in 2025 (Figure 45). This continues a trend that began in 2012, where small copepod abundances have been elevated during the spring. In contrast, large copepods were low with increased abundances in the region just southwest of Kodiak Island and modeled abundances were below average relative to the long-term mean (Figure 45)

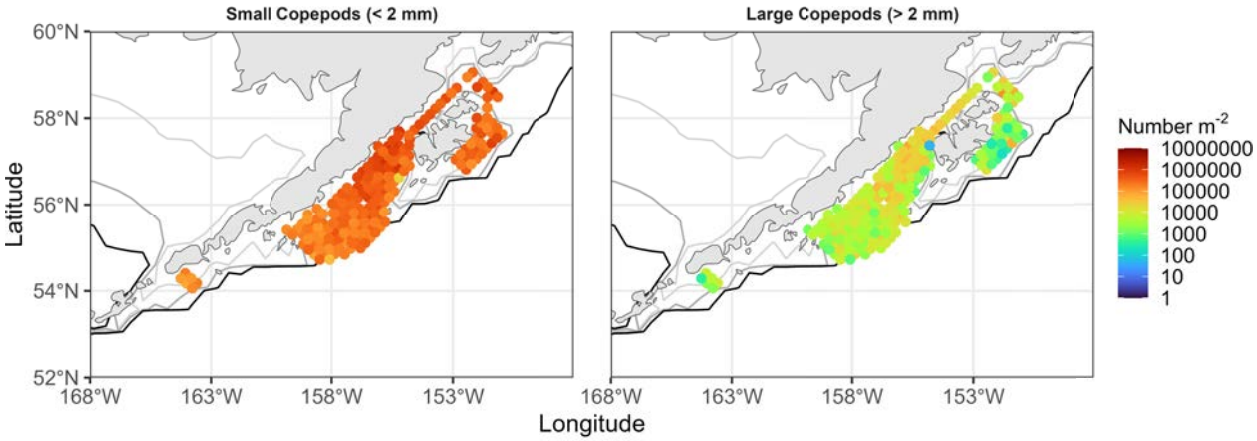


Figure 44: Maps show the abundance of small (left) and large copepods (right) estimated by the rapid zooplankton assessment during the spring larval survey in 2025. X indicates a sample with abundance of zero individuals m^{-2}. Bathymetry is shown by light gray (50 m), medium gray (100 m), and black (200 m) lines.

Factors influencing observed trends: Warm spring temperatures resulted in high abundances of small copepods, which have been observed since 2012 and coinciding with the marine heat wave conditions that occurred in 2014 – 2016 and 2019. Temperatures during spring of 2025 were at or near heatwave values. Small copepod abundances increase during warm conditions because small copepods have multiple generations per year, faster turnover times, and metabolic rates that scale less dramatically with temperature than large copepods (Kiörboe and Sabatini, 1995). Large copepods were a mixture of *Neocalanus* spp. and *Calanus marshallae* and overall abundances were low relative to the long-term time-series (Figure 45). Warm temperatures tend to reduce *Neocalanus* spp. numbers as they may enter diapause earlier in the spring under warm conditions, reducing overall abundances. The abundances of *C. marshallae* typically increase in warmer springs (Kimmel and Duffy-Anderson, 2020), however this

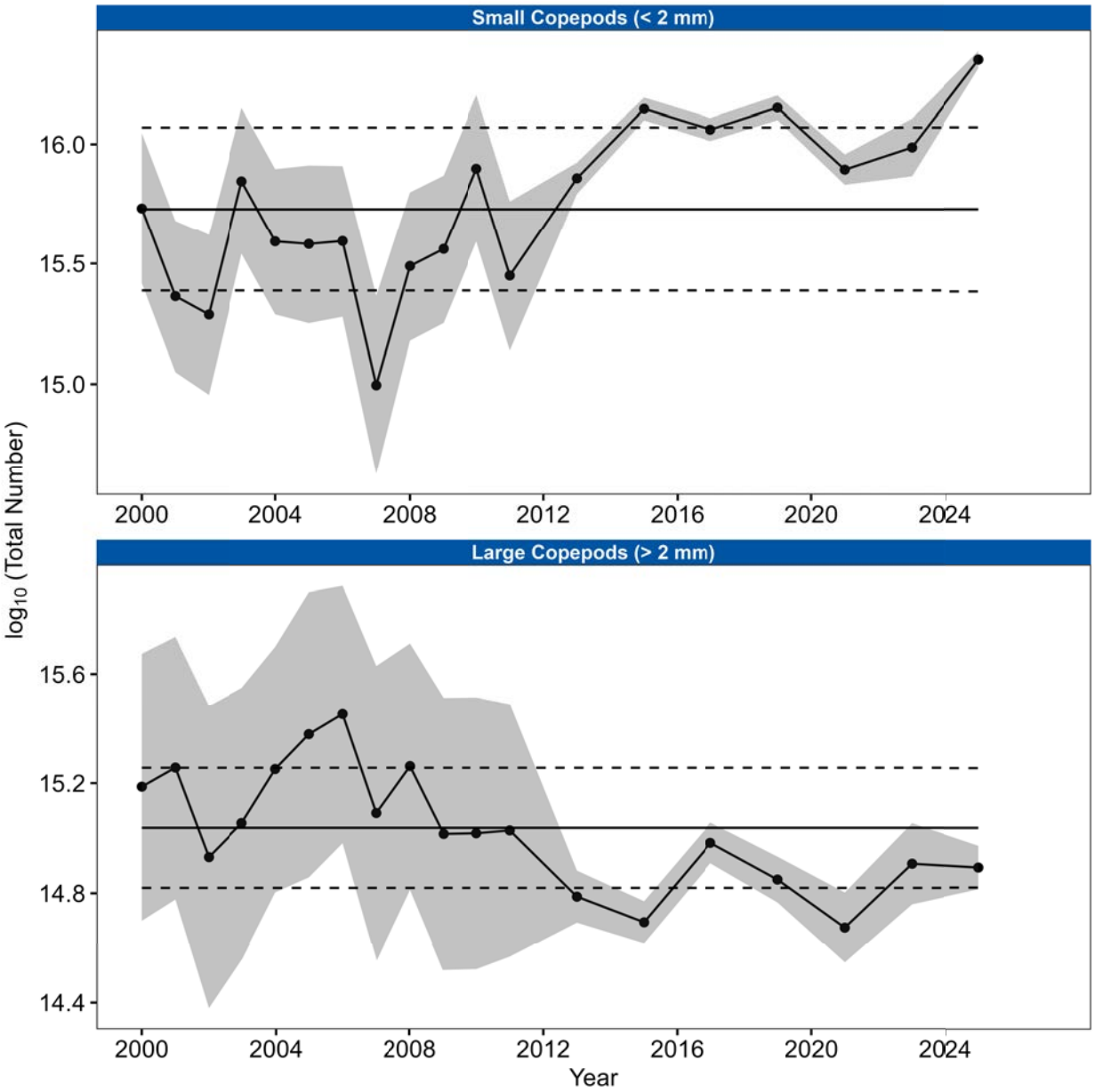


Figure 45: Standardized annual abundance indices for the spring updated to 2025. Annual, area weighted abundance estimate (black circles), abundance estimate based on RZA data (blue triangle), upper and lower confidence intervals of the estimates (shaded area), mean abundance for the total data record (solid black line), and ± 1 standard deviation of the mean abundance for the total data record (dashed lines).

was not observed in 2025. This may be related to the timing of the survey combined with warmer temperatures impacting *C. marshallae* phenology and/or mortality.

Implications: Zooplankton are an important prey base for larval and juvenile fishes in spring and summer. Small copepod numbers remained high, indicating that there is sufficient nauplii and smaller copepods available as prey for larval fish during spring. Note the small copepod proportion does not include nauplii (the primary prey for early larval fishes) and a decline in nauplii did occur during the

recent marine heatwave (Rogers et al., 2020). The lack of large copepods is less relevant in spring when larval fishes predominate; however, it may indicate that the system timing for larger copepods is changing or may indicate shifts in overall productivity (Kimmel and Duffy-Anderson, 2020). Thus, phenological changes that have been detected for walleye pollock in the western GOA (Rogers et al., 2018) may also be occurring for copepods. It will be interesting to see if the low abundances of *C. marshallae* persist or rebound, as was observed in 2017 after the 2014 – 2016 marine heatwave when abundances increased. A lack of large copepods and euphausiids in the Gulf of Alaska leads to age-0 walleye pollock diet shifts where less energetically dense prey items are consumed (Lamb and Kimmel, 2021). However, there was no age-0 survey in 2025, so we have no data on large copepod numbers in the summer/fall. Recent summer abundance numbers for large copepods have been near the long-term mean, even during recent marine heatwave years. In conclusion, we suggest the zooplankton community in the western GOA in 2025 showed similar abundances to recent marine heatwave years in the spring.

Spring and Fall Large Copepod and Euphausiid Biomass: Seward Line

Contributed by Russell R Hopcroft, University of Alaska, Fairbanks
Contact: rrhopcroft@alaska.edu
Last updated: September 2026

Description of indicator: Transects have been completed south of Seward Alaska typically during the first 10 days of May and during mid-September for over 25 years to determine species composition, abundance and biomass of the zooplankton community. Data is averaged over the top 100 m of the water column to provide estimates of wet-weight biomass of zooplankton summarized here for all small copepods, larvaceans and pteropods retained by a 0.15mm mesh net and a 0.5mm mesh net for large copepods and euphausiids (a.k.a. krill). These categories represent key prey for a variety of fish, marine mammals, and seabirds.

Status and trends: Preliminary analysis suggests large calanoid biomass was near normal in 2026 after a 3-year run of low values, but biomass at offshore stations was elevated by high number of the oceanic copepod *Eucalanus bungii* (baseline 1998 – 2025, Figures 46, 47, 48). Once again, the historically dominant *Neocalanus flemingeri* has been overtaken by *N. plumchrus* on the shelf while *N. cristatus* dominated calanid biomass off the shelf. Small copepod biomass during May 2026 was below average. Large subpolar larvaceans were particularly abundant during spring 2026. May euphausiid biomass of 2026 appears to have slightly above-average biomass (baseline 1998 – 2025, Figures 46,47). September biomass for euphausiids has been roughly average for the past 5 years, although no biomass estimate is available for September 2023 (due to equipment failures), and 2026 data will not be available until December (baseline 1998 – 2025, Figures 46, 48).

Factors influencing observed trends: Temperatures during May 2026 were about 0.3 °C below the 29-year thermal mean along the Seward Line during spring, similar to other non-heatwave years since 2020. Septembers of 2026 was 0.8 °C below normal, based on GAK1-9 only as the four offshore stations were not sampled in 2026. Given offshore surface temperatures were warmer than shelf temperatures in September, it is likely the average temperature anomaly would be closer to zero if all stations were sampled. Large copepod biomass during May is impacted by spring temperatures, because they grow faster and therefore individuals are older/larger when waters are warmer, however a strong spring bloom can also favor faster growth, and a weak bloom slow growth. By September most large calanoids have descended into offshore waters and their biomass is greatly reduced, making krill relatively more important. Smaller-bodied copepod biomass shows less change between seasons. May euphausiid biomass appears to be negatively impacted by warm springs, with peaks in May often driven by high abundances of their larval stages when conditions are favorable. Continued euphausiid growth and recruitment often lead to higher biomass by September.

Implications: While high biomass of larger zooplankton does not guarantee success of species dependent upon them (due to a variety of other factors), low biomass does make predator success challenging. Changes in the mixture (and energetic content) of species contributing to overall biomass may be of consequence to specific predators. While biomass of large copepods appeared close to average in 2026, it was somewhat inflated by the biomass of the nutritionally dilute Eucalanus. Many fish species larval stages are dependent initially on small-bodied copepods that have now been scarce during 2025 and 2026. Euphausiids biomass in May 2026 was not particularly favorable to fisheries compared to the 3

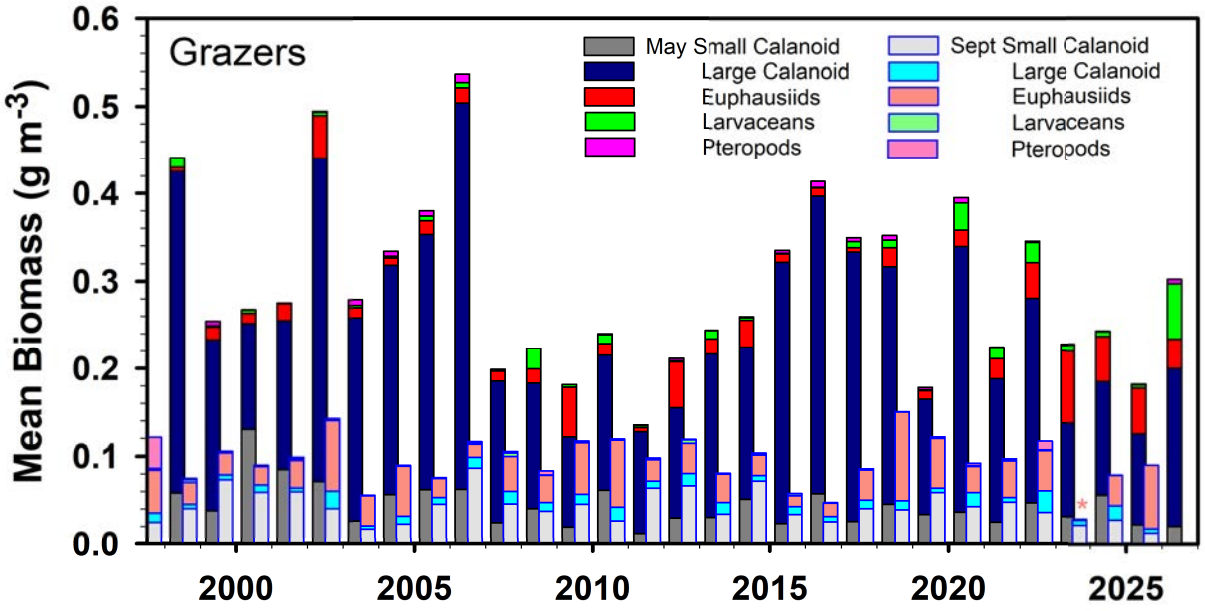


Figure 46: Biomass of herbivorous zooplankton along the Seward Line sampled using a 0.15mm during days and a 0.5-mm mesh at night. Transect means are calculated on power-transformed data. Data for 2023 – 2026 is only available from a subset of stations and may change as more stations are completed.

preceding years. Based on the cool temperatureswe expect the biomass of small copepods during fall to be below normal.

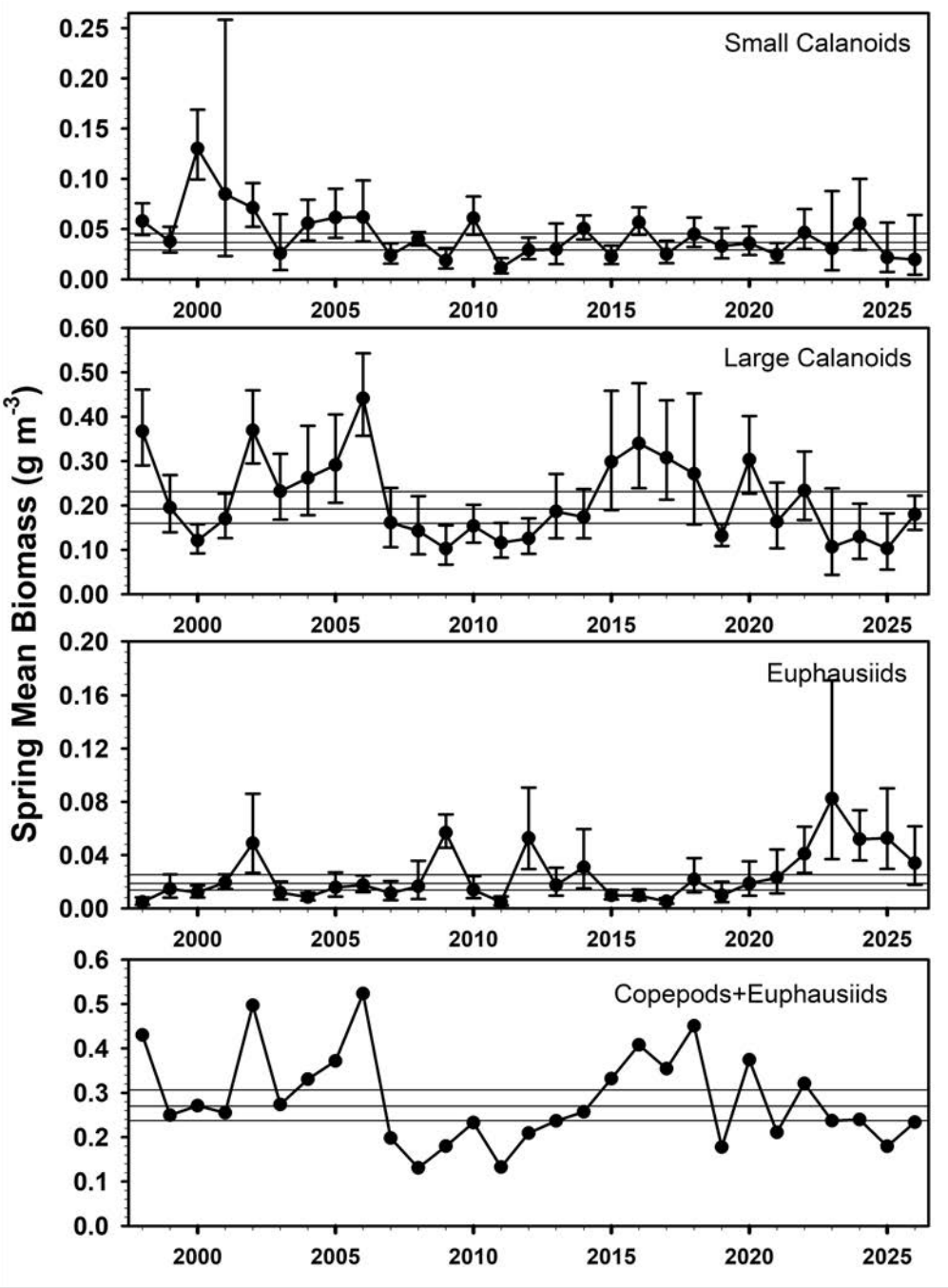


Figure 47: Biomass of zooplankton along the Seward Line sampled during the spring (May), using a 0.15mm during days and a 0.5-mm mesh at night. Transect means are calculated on power-transformed data. Data for 2023 – 2026 is only available from a subset of stations and may change as more stations are completed.

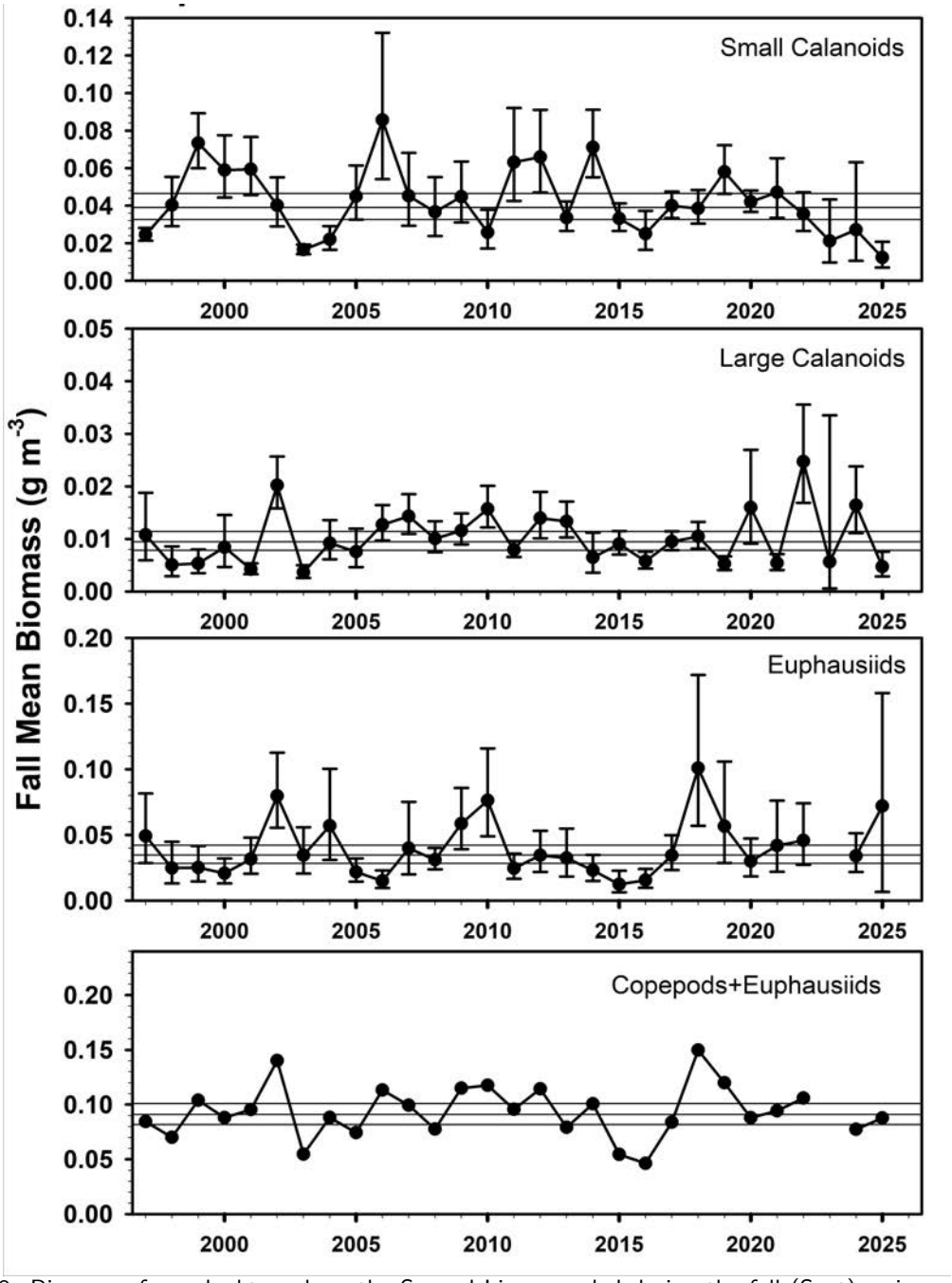


Figure 48: Biomass of zooplankton along the Seward Line sampled during the fall (Sept), using a 0.15mm during days and a 0.5-mm mesh at night. Transect means are calculated on power-transformed data. Data for 2023 – 2026 is only available from a subset of stations and may change as more stations are completed.

Spring biomass of large subarctic copepods in the central Gulf of Alaska, outer Line P.

Contributed by Akash Sastri, Fisheries and Oceans Canada, Sidney, BC, Canada
Contact: akash.sastri@dfo-mpo.gc.ca
Last updated: September 2026

Description of indicator: The modern Line P oceanographic program is maintained by the Ocean Sciences Division, Fisheries and Oceans Canada, at the Institute of Ocean Sciences. Zooplankton have been sampled winter, spring, and summer at seven stations (Figure 49) along the ∼1500 km coastal-offshore transect since 1997 (Mackas et al., 1998; Mackas and Tsuda, 1999). Stations at the offshore end of the line, P20 - P26, are located in High Nutrient Low Chlorophyll waters of the central Gulf of Alaska. The biomass of the zooplankton assemblage in this region is dominated by four large, lipid rich, calanoid copepod species: *Neocalanus plumchrus*, *N. cristatus*, *N. flemingeri*, and *Eucalanus bungii*. Samples are collected with vertical hauls of 236 μm mesh Bongo nets from 250 m to the surface and sample contents identified to species and developmental stage. Individual size is large and nutritional value of this group is high. Interannual variation of biomass is similar between species and together, combined biomass is a sensitive climate indicator.

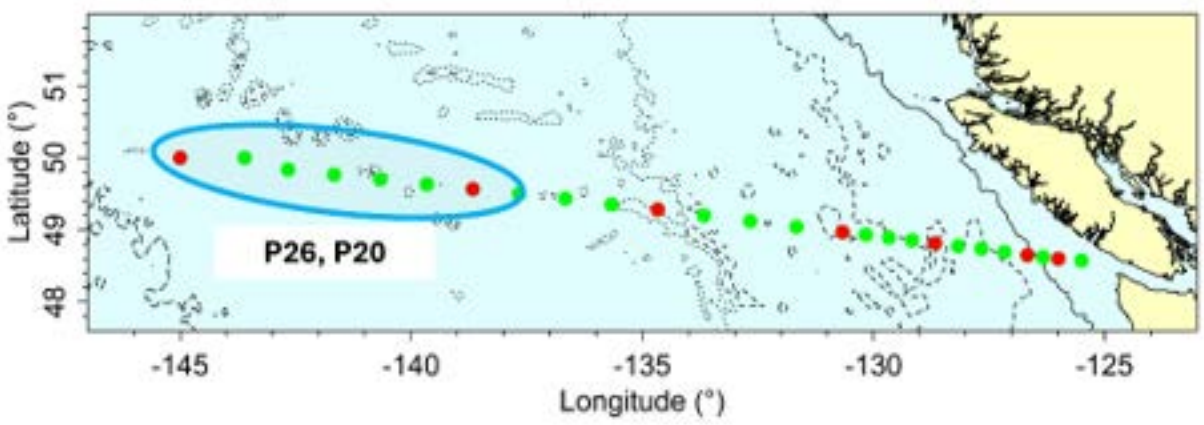


Figure 49: Map of the Line P transect in the northeast subarctic Pacific Ocean showing the locations of sampling stations (red indicates routine zooplankton sampling). Stations P20 and P26 are highlighted with filled red symbols and enclosed by the blue ellipse, indicating the study area analyzed in this report.

Factors influencing observed trends: Subarctic zooplankton taxa typically follow seasonal cycles in their respective densities, however, responses to climate change vary by species. Additionally, changes in density are influenced by seasonal timing cues, phenology, physiology, and environmental factors including temperature, salinity and phytoplankton bloom intensity (Mackas et al., 2012). These responses also depend on the timing, magnitude, and duration of temperature anomalies in warm or cold years.

Status and trends: In 2026, stations P20 and P26 were sampled in January, May, and September. Results presented here are for May only, since sample enumeration for September is not yet complete. Maximum annual biomass (mg dry weight m^{-2}) for each species is typically observed during the April, May, June period (Figure 50). *Neocalanus flemingeri* development is fastest and it is the first to descend to overwintering depths in early summer followed by *N. plumchrus*, *E. bungii*, and *N. cristatus* by September. In late May 2026, *Neocalanus cristatus* and *N. plumchrus* were the biomass dominant members of the group, consistent with historical expectations. Total spring biomass for the indicator group in 2026 was positive and near the time series mean. Cool periods generally favour above-average biomass in spring whereas below-average biomass is typically associated with warm climate periods. Pronounced low-biomass years accompany notable annual events such as strong El Niño and atmospheric blocking events (e.g., 1997/1998, 2005, 2013/2014).

Factors influencing observed trends: Spring biomass of large subarctic copepods reflects the cumulative effects of overwinter survival, timing of reproduction, and food availability during the spring growth period. Biomass in 2026 was slightly above the long-term average, indicating generally favourable conditions for population development. Differences among years reflect variation in picophytoplankton productivity, microbial web processes and regional oceanographic conditions which influence growth and survival of life stages feeding in surface waters.

Implications: The positive spring biomass anomaly observed in 2026 suggests that production of large, lipid-rich copepods in offshore Gulf of Alaska waters remained within the range of historical variability. Biomass near or above average indicates that the availability of this important zooplankton prey resource for epipelagic fish and seabirds was not reduced during spring 2026.

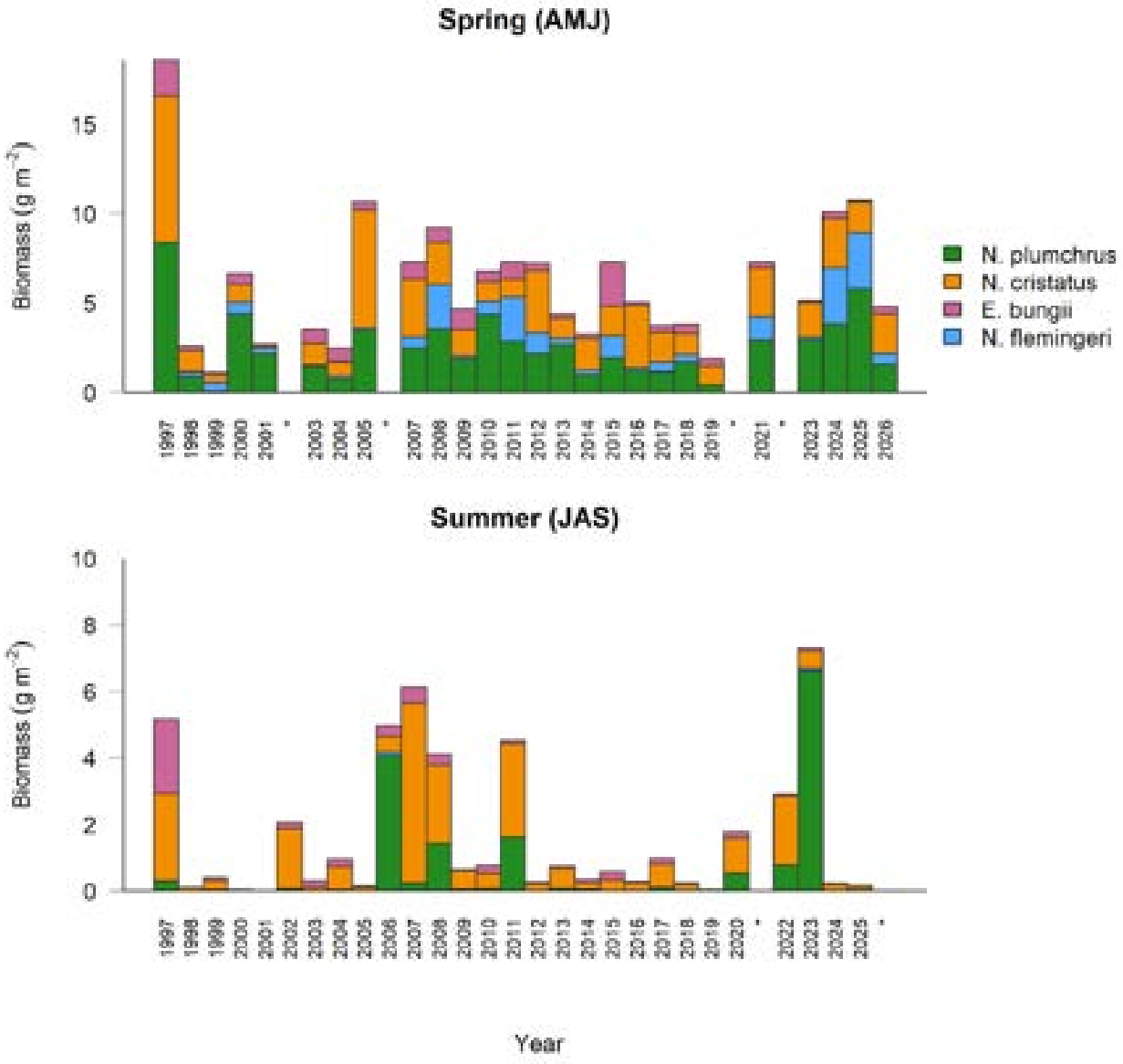


Figure 50: Seasonal biomass of large subarctic calanoid copepods at stations P20 and P26 along Line P during spring (AMJ; April to June) and summer (JAS; July to September) from 1997 to 2025. Stacked bars show the biomass (g dry weight m^{-2}) of the four constituent copepod species: *Neocalanus plumchrus* (green), *N. cristatus* (orange), *Eucalanus bungii* (pink), and *N. flemingeri* (blue). Total bar height represents the combined biomass of all species in each year and season. Year/Season identified by "$*$" indicate observational gaps.

Sea Jellies

Contributed by Alexandra Dowlin and Ned Laman, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, NOAA Fisheries
Contact: Ned.Laman@noaa.gov
Last updated: October 2025

NOAA Fisheries' Gulf of Alaska Bottom Trawl Survey is conducted every other year. Please refer to the archives[27] for past reports.

Ichthyoplankton

Larval Fish Abundance

Contributed by Lauren Rogers, Kelia Axler, and Melanie Paquin
EcoFOCI Program, Resource Assessment and Conservation Engineering, Alaska Fisheries Science Center, NOAA Fisheries
Contact: lauren.rogers@noaa.gov
Last updated: September 2026

Description of indicator: The Alaska Fisheries Science Center's (AFSC) Ecosystems and Fisheries Oceanography Coordinated Investigations Program (EcoFOCI) conducts spring larval fish surveys in the Gulf of Alaska (GOA), with annual sampling from 1981 – 2011 and biennial sampling thereafter (Matarese et al., 2003, Ichthyoplankton Information System[28]). A subset of data from a consistently sampled time window (mid-May through early June) and area (Figure 51) has been developed into time-series of relative larval abundances for 12 taxa. In 2023, time-series calculations were updated to use a model-based approach (sdmTMB; Anderson et al., 2022) instead of the previous area-weighted mean, in part to better account for variable survey coverage in recent years due to ship-time constraints. Correlations between time-series estimated using the two approaches were high ($r = 0.91 - 0.99$). Rapid Larval Assessments are conducted for 7 species by sorting samples at sea, allowing provisional time-series updates in the year of collection; however, quantitative data require a year for full laboratory processing and verification. This update to the larval abundance time-series includes laboratory-verified larval data for 12 taxa through 2025. These time-series provide insights into ecosystem changes over decades.

Status and trends: In 2025, larval abundances were below average for all taxa except rockfishes and Southern Rock Sole (Figure 52). Walleye Pollock, Pacific Cod, Arrowtooth Flounder, Flathead Sole, and Pacific Sand Lance were all at or near record low abundances. For pollock and cod in particular, abundances have been exceptionally low for 5 of the last 6 years when sampling occurred, with the exception of 2017 for pollock, when abundance was above average. cod abundances have

[27] https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands
[28] https://apps-afsc.fisheries.noaa.gov/ichthyo/index.php

stayed below the mean since 2015. Both arrowtooth flounder and northern rock sole had shown an upward trend in abundances since 2019 but dropped well below average in 2025. Southern Rock Sole abundance was approximately average, consistent with the previous three years of observations. Ronquils (bathymasterids) increased from the low abundances observed in 2021 and 2023 but remained below average. Rockfish (*Sebastes* spp.) abundance was high, increasing from the approximately average abundances observed the past four years.

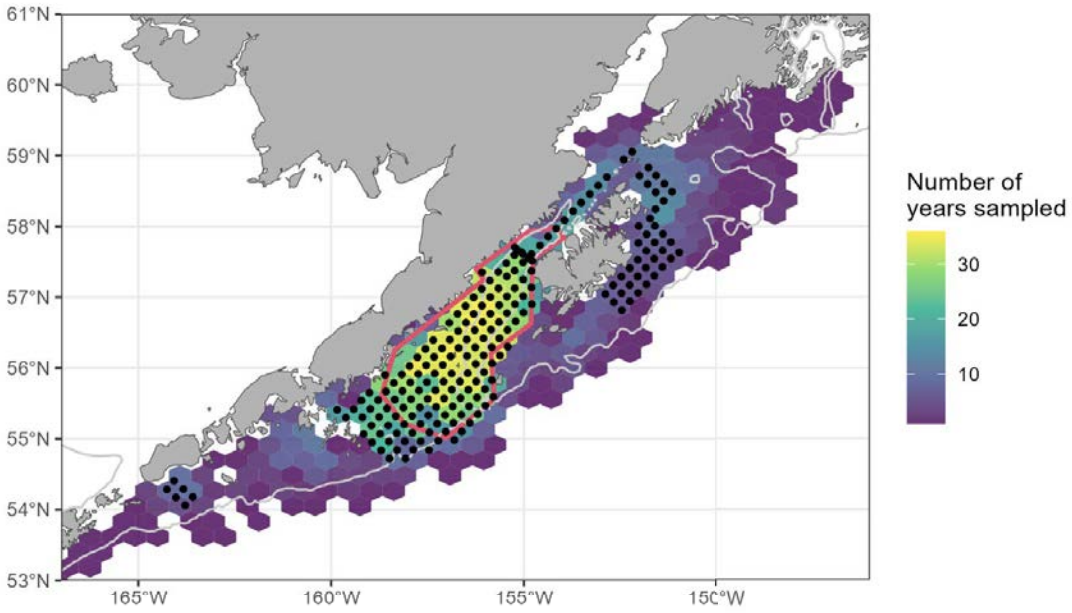


Figure 51: Distribution of historical May-June ichthyoplankton sampling in the Gulf of Alaska by NOAA's Alaska Fisheries Science Center using a 60-cm frame bongo net. Sampling effort is illustrated by the number of years of sampling in each grid cell during late spring. A time-series has been developed for the years 1981 – 2025 from collections in the core area outlined in red where sampling has been most consistent during mid-May through early June. Black dots show sampling locations in 2025.

Factors influencing observed trends: Sea surface temperatures in the Gulf of Alaska were above average during the winter and spring of 2025, which has been associated with lower abundances of late winter and early-spring spawners in recent years. These species include Pacific cod, pollock, and northern rock sole (Doyle et al., 2009; Laurel and Rogers, 2020). The two taxa with moderate to high larval abundances in 2025 were southern rock sole and rockfishes, which spawn in late spring to summer. These results are consistent with findings that species with a common spawning strategy tend to covary in their larval abundances (Doyle et al., 2009). Temperature could affect larval abundance through effects on egg or larval survival (Laurel and Rogers, 2020) as well as through effects on phenology (Rogers and Dougherty, 2019; Rogers et al., 2026). If species spawn and hatch earlier in warmer years, the presence of larvae during the late-spring EcoFOCI survey may vary, and the impacts of this shift will depend on spawning strategy. For deep-spawning species such as arrowtooth flounder, halibut, and rockfishes, on-shelf transport of early life stages may be affected by ocean conditions (Goldstein et al., 2020) which is likely important for springtime larval abundance.

Implications: Ichthyoplankton surveys can provide early-warning indicators for ecosystem conditions and

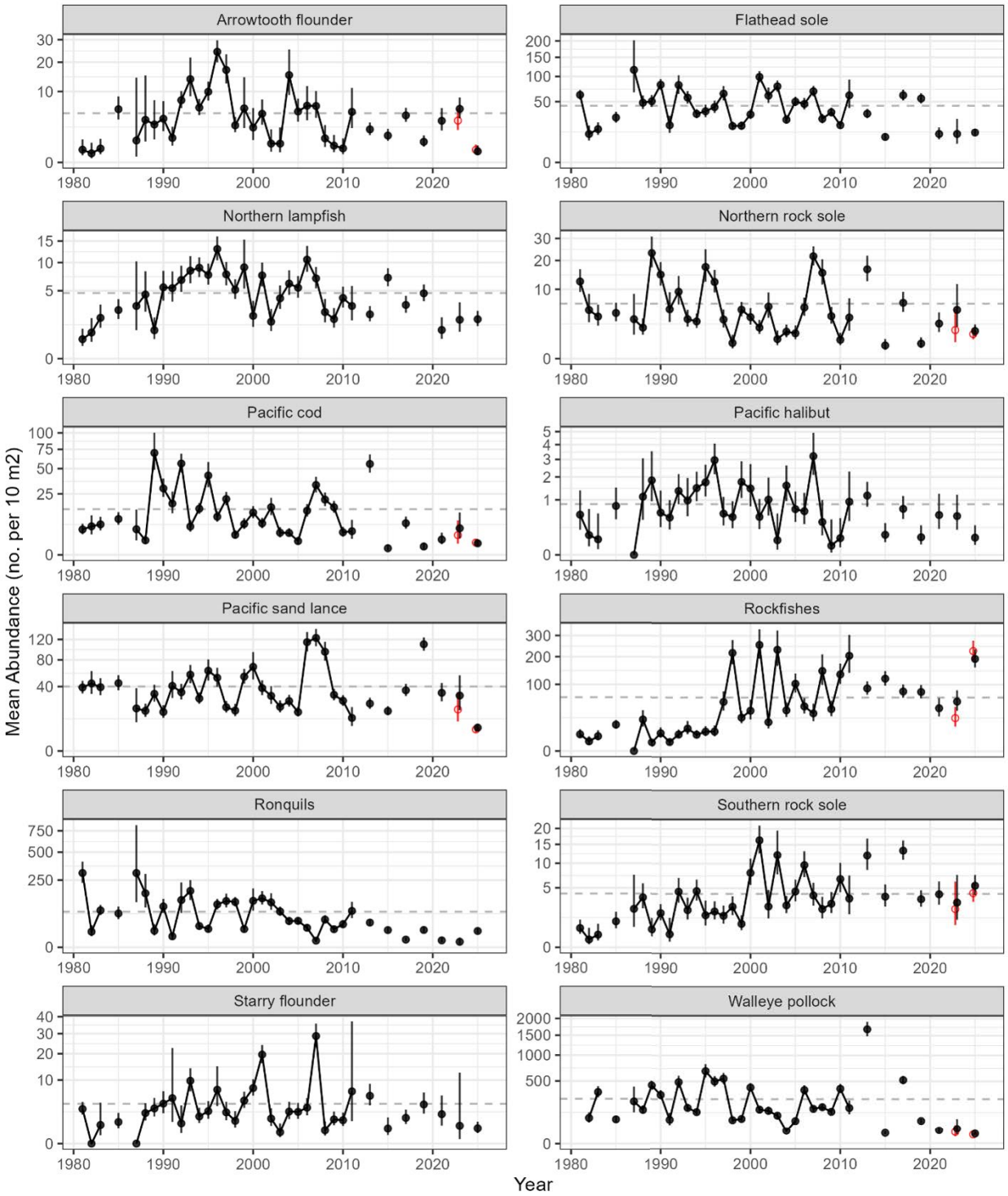


Figure 52: Interannual variation in late spring larval fish abundances in the Gulf of Alaska. The larval abundance index is expressed as the mean density (no. 10 m^{-2}), and the long-term mean is indicated by the dashed line. Error bars show $\pm$ 1 SE. Symbols in red show estimates based on the at-sea Rapid Larval Assessment (7 of 12 taxa only), whereas black shows laboratory-verified data (12 taxa).

recruitment patterns in marine fishes. In both 2015 and 2019, low abundances of walleye pollock and Pacific cod larvae were the first indicators of failed year-classes for those species. In 2025, abundances of walleye pollock and Pacific cod larvae were again low, suggesting another poor year class. The low abundances of gadid larvae, combined with low to average abundances of all other indicator species (except rockfishes), suggests poor to average forage for piscivorous predators. This may affect the Gulf of Alaska food web, including seabirds and juvenile salmon which feed on larval pollock and lipid-rich forage fish like Pacific sand lance during spring and summer.

Abundance of YOY pollock and capelin in Western Gulf of Alaska

Contributed by Lauren Rogers and Steven Porter
EcoFOCI Program, Resource Assessment and Conservation Engineering Division,Alaska Fisheries Science Center, NOAA Fisheries
Contact: lauren.rogers@noaa.gov
Last updated: October 2025

NOAA Fisheries' Gulf of Alaska EcoFOCI Survey is conducted every other year. Please refer to the archives[29] for past reports.

Morphometric Condition of Walleye Pollock Larvae

Contributed by Steven Porter, Kelia Axler, Will Fennie, David Kimmel, and Lauren Rogers
EcoFOCI Program, Resource Assessment and Conservation Engineering Division,Alaska Fisheries Science Center, NOAA Fisheries
Contact: steve.porter@noaa.gov

Last updated: August 2025

Seabird Diets in the Gulf of Alaska

Contributed by Mayumi Arimitsu[1], Shannon Whelan[2], Scott Hatch[2], Nora Rojek[3], Brie Drummond[3], Mariela Brooks[4], Heather Renner[3], Daniel Cushing[5]

[1]Ocean Bight LLC, Gulf Watch Alaska
[2]Institute for Seabird Research and Conservation, Gulf Watch Alaska
[3]U.S. Fish and Wildlife Service Alaska Marine National Wildlife Refuge
[4]NOAA Alaska Fisheries Science Center Auke Bay Lab, Juneau, AK
[5]University of Alaska Fairbanks
Contact: marimitsu@usgs.gov
Last updated: October 2026

Description of indicator: Seabird diet data span more than 45 years (1978 – 2026) and >3000 km in the Gulf of Alaska (GOA) and Aleutian Islands (Figure 53). Puffins (tufted puffins *Fratercula cirrhata*, horned

[29]https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands

puffins *F. corniculate*, rhinoceros auklets *Cerorhinca monocerata*, hereafter "puffins") and black-legged kittiwakes *Rissa tridactyla* (hereafter, kittiwakes) feed primarily on small pelagic schooling fish, juvenile groundfish, and mesopelagic species (Hatch, 2013; Sydeman et al., 2017; Piatt et al., 2018). Puffin diets are monitored annually at five colonies by the U.S. Fish and Wildlife Service Alaska Maritime National Wildlife Refuge monitoring program (https://www.fws.gov/project/seabird-science-alaska-sized-scale) and the Institute for Seabird Research and Conservation (ISRC, www.isrcmiddleton.org). Western GOA colonies include Aiktak near Unimak Pass, Chowiet and Suklik in the Semidi Islands along the Alaska Peninsula, and Middleton Island at the shelf break offshore of Prince William Sound (Figure 53). The eastern GOA colony is St. Lazaria in southeast Alaska near Sitka. At Middleton, surface-feeding kittiwake diets are also sampled by ISRC as part of the Gulf Watch Alaska forage fish monitoring program[30]. Additional information about seabird diet collection efforts and datasets from long-term monitoring sites in Alaska are available at Hatch et al. (2023) and Turner et al. (2024).

Data presented here include updated time series plots of relative frequency (frequency of occurrence as a proportion of the total frequency across species) for puffin and kittiwake prey communities across colonies through 2026 (Figure 53). Additionally, we present two analyses that evaluate changes in seabird prey communities across colonies spanning the eastern GOA to western GOA regions. First, we used non-metric multi-dimensional analysis (NMDS) to better understand differences between rhinoceros auklet prey communities at Middleton Island compared to USFWS refuge colonies in the Semidi Islands (western GOA, Chowiet and Suklik) and southeast Alaska (eastern GOA, St. Lazaria). We used Bray-Curtis distances on frequency of occurrence of dominant (mean FO $>$ 0.03) species followed by PERMANOVA and PERMDISP to quantify community differences among colonies and years (Anderson and Euinton, 2026).

For Pacific capelin (*Mallotus catervarius*), Pacific sand lance (*Ammodytes personatus*), and Pacific herring (*Clupea pallasi*) (hereafter, capelin, sand lance, herring), we used multivariate state space models implemented in tinyVAST (Thorson et al., 2025) to estimate annual indices of two size-based life stages (larval or age-0, and age-1+) from seabird diet data collected during 1993 – 2026. Data came from four colony locations in the Gulf of Alaska (Figure 53). Each fish species was modeled separately, with both life stages in one model. Fish were assigned to life stages based on size, and biomass by life stage was summed within each sample using observed or estimated masses. Puffin bill loads (rhinoceros auklet, tufted puffin, horned puffin) were modeled using separate components for occurrence and biomass when present, kittiwake regurgitation samples during spring and summer also informed encounter rates at Middleton. The models accounted for differences among predators, colonies, and annual variation in biomass per encounter. Larval/age-0 stage abundance in one year informed the age-1+ stage the following year for sand lance and herring, but this relationship was not supported for capelin. Colony indices represented expected biomass per bill load of a reference predator and were centered on their 1993 – 2026 means. Regional indices combined colonies with equal weight on the log-scale, with 95% intervals derived from 2000 joint draws from each fitted model[31].

Status and trends: Sampling effort during 2026 included puffin diet samples (bill loads: Middleton = 390 rhinoceros auklet and 34 tufted puffin; St. Lazaria = 52 rhinoceros auklet; Chowiet/Suklik = 45 rhinoceros auklet, 43 tufted puffin, and 23 horned puffin; Aiktak = 138 tufted puffin and 19 horned puffin) and kittiwake samples (regurgitations: Middleton = 1765). FWS colony data (St. Lazaria, Chowiet/Suklik, and Aiktak) are provisional for 2026. At Middleton in 2026, myctophids including garnet lampfish (*Stenobrachius nannochir*) reached their highest recorded frequency in kittiwake diets

[30] `https://gulfwatchalaska.org`

[31] `https://oceanbight.com/models/forage_fish_v5.2_tinyvast.html` (accessed 10/26/2026)

(83% of spring and 51% of summer samples, greenlings were especially prevalent (78%) in rhinoceros auklet diets, and age-0 sablefish occurred in 20% of auklet bill loads. Capelin and age-0 walleye pollock dominated at Aiktak, while sand lance remained the principal prey at Chowiet/Suklik. At St. Lazaria, diets were divided among herring, Atka mackerel, and capelin.

Multivariate community analysis (NMDS, Figure 54) of prey communities revealed differences in rhinoceros auklet diets among Gulf of Alaska colonies (2D stress = 0.175). Chowiet/Suklik years grouped on the sand lance side of the plot (Figure 54), while Middleton years grouped toward greenling, sablefish, and salmon, and St. Lazaria years toward herring and Atka mackerel. For 1993 – 2026, colony explained 48% of the variation in diet composition (PERMANOVA, $p < 0.001$) and year explained 30% ($p < 0.001$). All three pairs of colonies differed ($p < 0.001$). Chowiet/Suklik and Middleton differed most ($t = 9.8$; average dissimilarity 46%), and Middleton and St. Lazaria differed least ($t = 4.7$, 37%). Sand lance made up most of the similarity among Chowiet/Suklik years (68%). Middleton diets combined sand lance, greenling, capelin, and salmon, and St. Lazaria diets combined sand lance, herring, and capelin. Herring was absent from Chowiet.Suklik bill loads. The colonies also differed in how much diets varied among years (PERMDISP, $p < 0.001$). Variation was lowest at Middleton and highest at St. Lazaria, so part of the colony effect reflects differences in spread as well as in composition. Capelin did not separate the colonies, instead it varied among years at every colony and was most correlated with a third axis in a 3D ordination (stress 0.117, $r = 0.83$). The 2026 diets fell within the range of earlier years at each colony.

State space models estimate annual biomass indices of forage fish by size and species after accounting for sampling variability and differences among predators and colonies (Figure 55). Indices were most precise at Middleton, where sampling is most intensive, and least certain for larval capelin, which are sampled reliably only at Middleton.

Capelin: Age-1+ capelin regional index in 2026 was about twice the 1993 – 2026 average and similar to the highs of 2009 – 2011 (Figure 55). The index has been above average since 2023, after falling to the lowest levels of the series during the 2014 – 2019 heatwaves and remaining below average through 2021. In 2026, age-1+ capelin colony indices were above average at Aiktak, Chowiet/Suklik, and Middleton, and near average at St. Lazaria. The larval capelin index at Middleton was high in 2025 and below average in 2026.

Sand Lance: Age-1+ sand lance regional index was highest in 1998 – 2003, declined through the 2000s, reached a low in 2015 (Figure 55). The decline was strongest at Middleton and St. Lazaria. At Chowiet/Suklik, where age-1+ sand lance occur in 80% of rhinoceros auklet bill loads, the index remained near average. Age-0 sand lance regional indices fell below average in 2021, while age-1+ sand lance remained near average through 2022, suggesting the decline began with poor recruitment rather than with fewer older fish. Nearly all of the 2024 – 2026 age-1+ largely followed the preceding weak age-0 year classes through the lagged age-0 effect.

Herring: Age-1+ herring regional indices increased over the time series, and more so at Middleton than at St. Lazaria (Figure 55). Age-1+ herring were below average in most years before 2007, variable from 2007 – 2014, and above average in every year since 2015. From 2015 to 2021 the regional age-1+ index was higher in odd years than even years. Since 2022 the age-1+ herring regional index has remained above average but relatively flat because the age-1+ odd year pattern continued at Middleton, while St. Lazaria was high in 2024 and 2026 (Figure 55). The 2026 age-1+ herring index was above average at both colonies. Age-0 herring indices were more variable, and were lowest in 2001 – 2002 and highest in 2016, with above-average index values in most years since 2014. Age-0 herring are sampled by seabirds

more often later in the summer, after they transform from larvae into juveniles and become available to foraging seabirds, so the age-0 index is standardized to Aug 3. At Middleton, summer kittiwake diets since 2015 sampled age-0 herring in an alternating pattern of cohort strength, with stronger age-0 in even years and age-1+ in odd years.

Factors influencing observed trends: From 1993 to 2013 Pacific capelin and Pacific sand lance in GOA seabird diets fluctuated out of phase, with sand lance associated with warmer temperatures and capelin associated with cooler temperatures (Sydeman et al., 2017). Both species declined in diets during the marine heatwave (Arimitsu et al., 2021), and their trajectories have diverged again in recent years, with sand lance at an all time low in 2025 – 2026 (Figure 55). Herring populations in Prince William Sound and Sitka were affected by a strong year class in 2016, evident in the seabird diet trends at age-0 and also at age-1 in 2017. During the heatwave years the seabirds switched from forage fishes to alternate prey, such as age-0 sablefish and greenling. Since then, recurring alternation between shelf-associated forage fishes and offshore mesopelagic prey reflect corresponding shifts in seabird foraging habitat in alternating years at Middleton Island.

Implications: Long-term seabird diet monitoring provides fishery-independent indicators of forage fish availability across the Gulf of Alaska, including Pacific capelin and Pacific sand lance that are poorly sampled by most surveys. Recent multi-year lows in both age classes of sand lance, a recovery of capelin following their collapse in the Gulf of Alaska and increasing herring availability especially on the shelf near Prince William Sound indicate substantial changes in forage fish communities since the heatwave years. Annual updates to these indices can complement fisheries surveys and be used to track prey availability relative to predator needs, identify persistent stage-specific declines or localized food shortages.

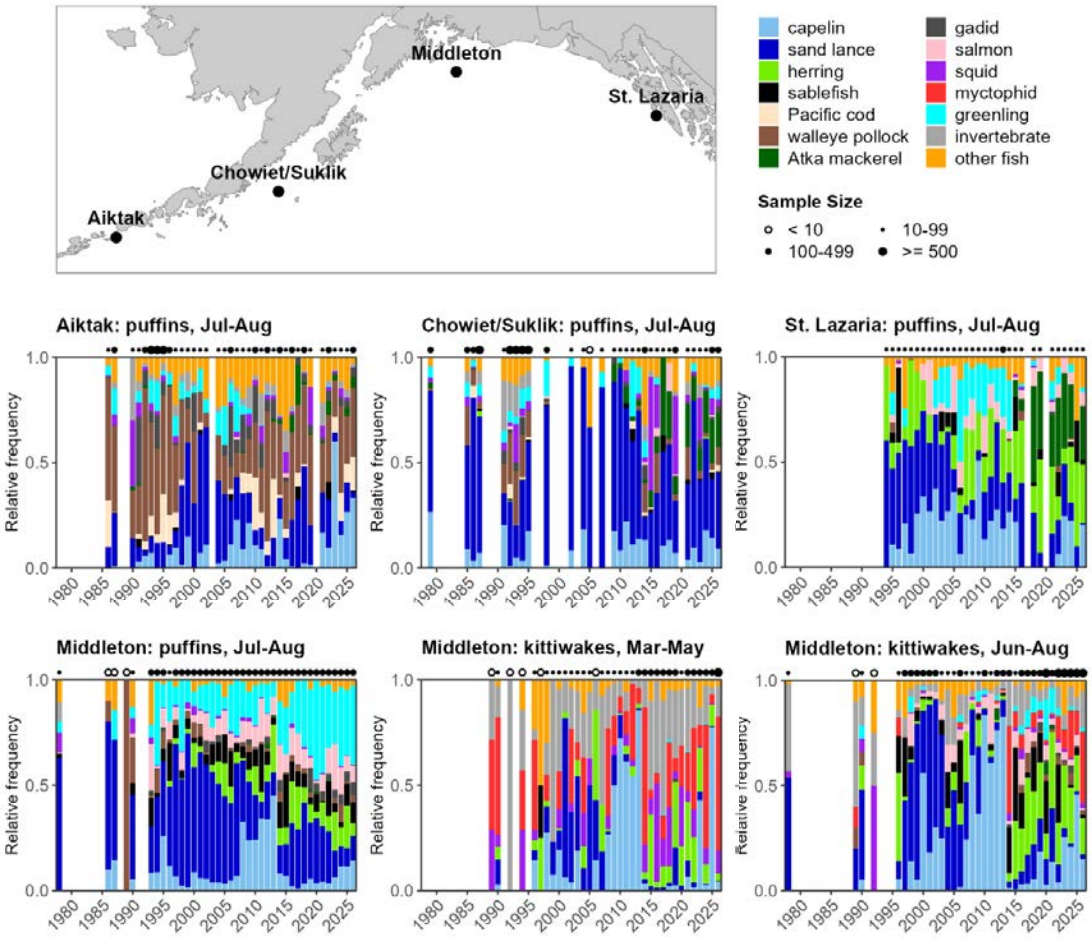


Figure 53: Seabird diet composition data 1978 – 2026. Top left: colony locations. Lower panels: relative frequency of prey groups (color) by colony, predator group (puffins - rhinoceros auklet, tufted puffin, horned puffin; or kittiwake – black-legged kittiwake), and year. Relative frequency is the frequency of occurrence as a proportion of the total frequency across species. Circles above each panel indicate the number of samples per year.

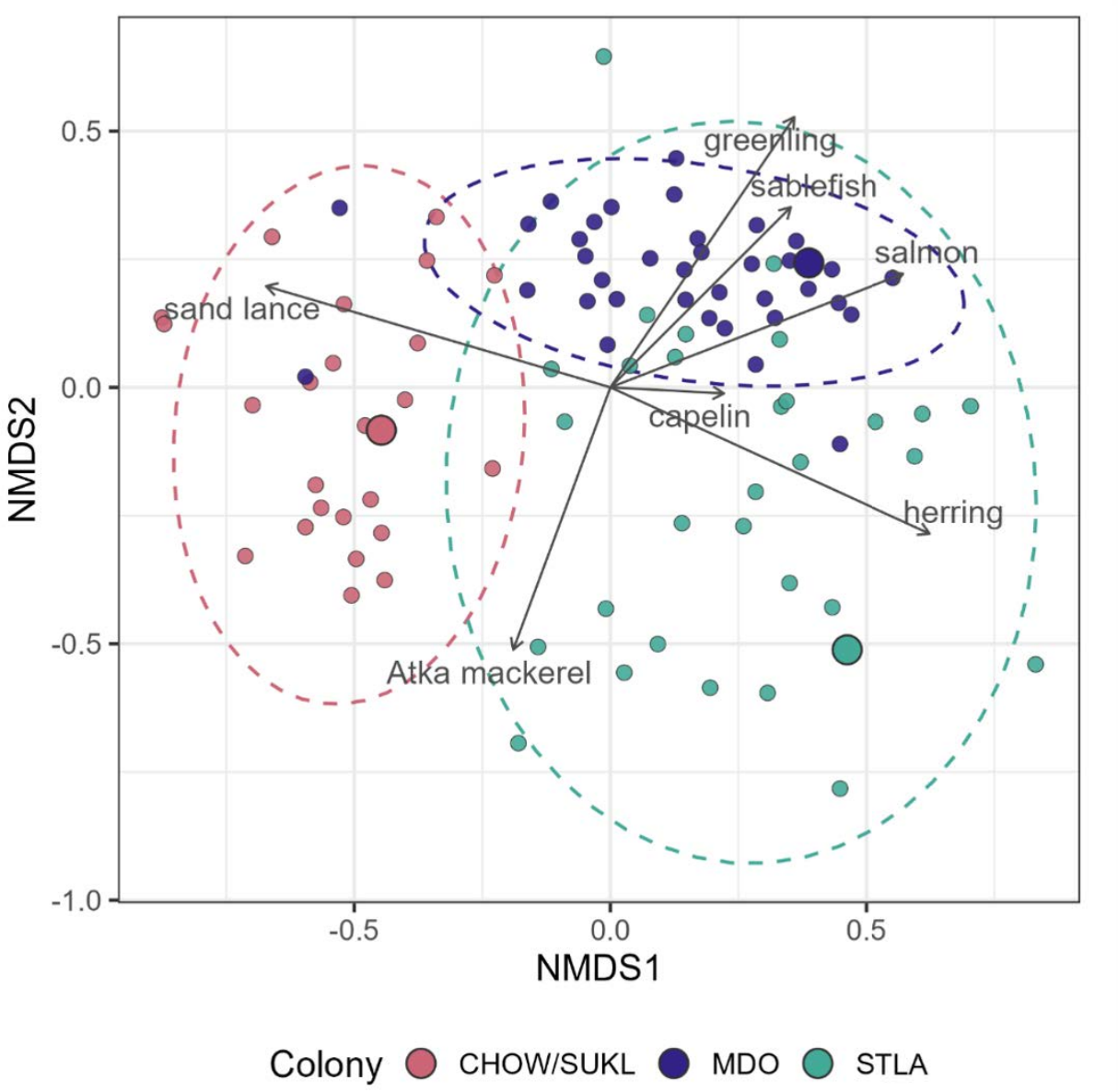


Figure 54: Non-metric multidimensional scaling (NMDS) of rhinoceros auklet diets at Chowiet and Suklik (CHOW/SULK), Middleton Island (MDO), and St. Lazaria (STLA), 1978 – 2026. Each point is one colony-year (n = 93). Larger circles for each colony indicate 2026 values, and dashed ellipses are 95% data ellipses for each colony. Arrows show Pearson correlations of each prey species' square root frequency of occurrence (FO) with the two axes, with longer arrows indicating stronger correlations.

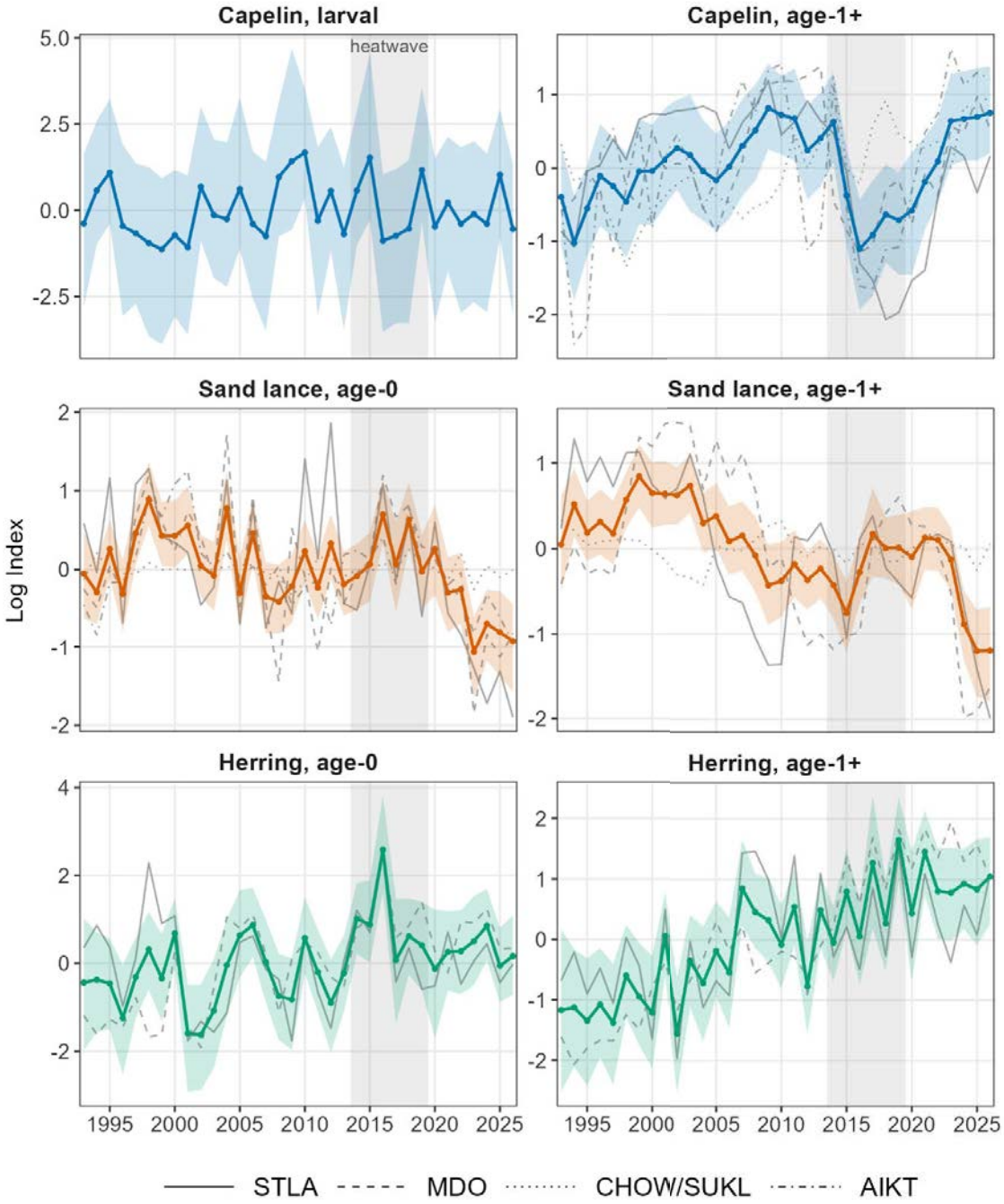


Figure 55: Regional indices of Pacific capelin, Pacific sand lance, and Pacific herring biomass in seabird diets, 1993 – 2026, for larval or age-0 (left) and age-1+ (right) fish. Each index is the log of expected grams per bill load of a reference predator. It is centered on its 1993 – 2026 mean, so 0 is the long-term average and a difference of 1 is about 2.7-fold change. Colored lines are indices (median), by colony: St. Lazaria (STLA), Middleton (MDO), Chowiet and Suklik (CHOW/SUKL), and Aiktak (AIKT). Larval capelin indices are from Middleton only. The grey polygon marks the 2014 – 2019 marine heatwave.

Fisheries-independent Survey-based Indices of Forage Fishes in the Gulf of Alaska

Contributed by Ned Laman and Alexandra Dowlin, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, NOAA Fisheries
Contact: ned.laman@noaa.gov

Last updated: October 2025

NOAA Fisheries' Gulf of Alaska Bottom Trawl Survey is conducted every other year. Please refer to the archives[32] for past reports.

Southeastern Alaska Herring

Contributed by Quinn Smith, Sherri Dressel, Sara Miller, and Troy Thynesl, Alaska Department of Fish and Game, Commercial Fisheries Division, Juneau, AK
Contact: sherri.dressel@alaska.gov
Last updated: September 2026

Description of indicator: Pacific herring (*Clupea pallasii*) stocks that reside in Southeast Alaska waters are defined on a spawning area basis. In recent decades there have been nine spawning areas where spawning events have typically been annual and meaningful in size in terms of potential for commercial exploitation. These spawning areas include Sitka Sound, Craig, Seymour Canal, Hoonah Sound, Hobart Bay-Port Houghton, Tenakee Inlet, Ernest Sound, West Behm Canal, and Kah Shakes-Cat Island (Figure 56). Indices of abundance for these stocks are represented by annual estimates of mature (pre-spawning) herring biomass prior to spring fisheries. Biomass is estimated either by surveys (two-stage surveys that include aerial surveys for milt along shoreline and spawn deposition SCUBA dive surveys for estimating egg abundance) converted to spawning herring biomass or statistical catch-at-age models that incorporate survey estimates (Figure 57). Sitka Sound and Craig are considered "outside stocks" because they are directly exposed to Gulf of Alaska waters, whereas the other stocks are considered "inside stocks" due to their reduced exposure to open-ocean influence (with the exception of Kah Shakes-Cat Island, which is not distinctly outside or inside). Monitoring of spawning stock size has been conducted at some of these areas for over 50 years by the Alaska Department of Fish and Game, primarily by combining estimates of egg abundance from surveys with herring age and size information (Hebert, 2025). However, starting in 2016, spawn deposition SCUBA surveys became limited due to budget cuts and low mileage of milt observed during aerial surveys. In most of the seven inside spawning stocks, it was evident the low mileage of spawn observed from aerial surveys would not result in the stock making regulatory thresholds that would support a commercial fishery. Beginning in 2024, aerial surveys were reduced to four of the seven inside stocks with monitoring of the remaining three stocks conducted as budgets allowed. Spawn deposition surveys for inside stocks continued to be conducted on an as-needed basis and have only occurred for the Tenakee and Kah Shakes stocks (Figure 57). The

[32] https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands

reduction in aerial surveys was due primarily to budget cuts but also due to low spawning biomass for some areas and decline in demand for commercial sac roe harvest. As a result, while the indices for Sitka Sound and Craig extend through 2025, the combined index for the seven other stocks ends in 2015 because all seven stocks were not surveyed annually (Figure 57). Although the nine areas account for a large proportion of the spawning biomass in Southeast Alaska in any given year, they do not represent the entirety of herring spawning activity in Southeast Alaska, as numerous smaller spawn events are observed in other areas throughout Southeast Alaska.

Little or no stock assessment activity occurs for these smaller spawning events other than the occasional aerial observation while en route to survey other areas, documentation on satellite imagery, or reports by other entities. The herring that spawn in all areas of Southeast Alaska are believed to be affected by broad-scale physical and chemical characteristics of Gulf of Alaska waters. The spawning areas directly exposed to the open coast (Sitka Sound, Craig, and possibly Kah Shakes-Cat Island) are likely to experience these influences more strongly or earlier than inside spawning areas. Herring that spawn in the inside waters may be affected more by localized changes.

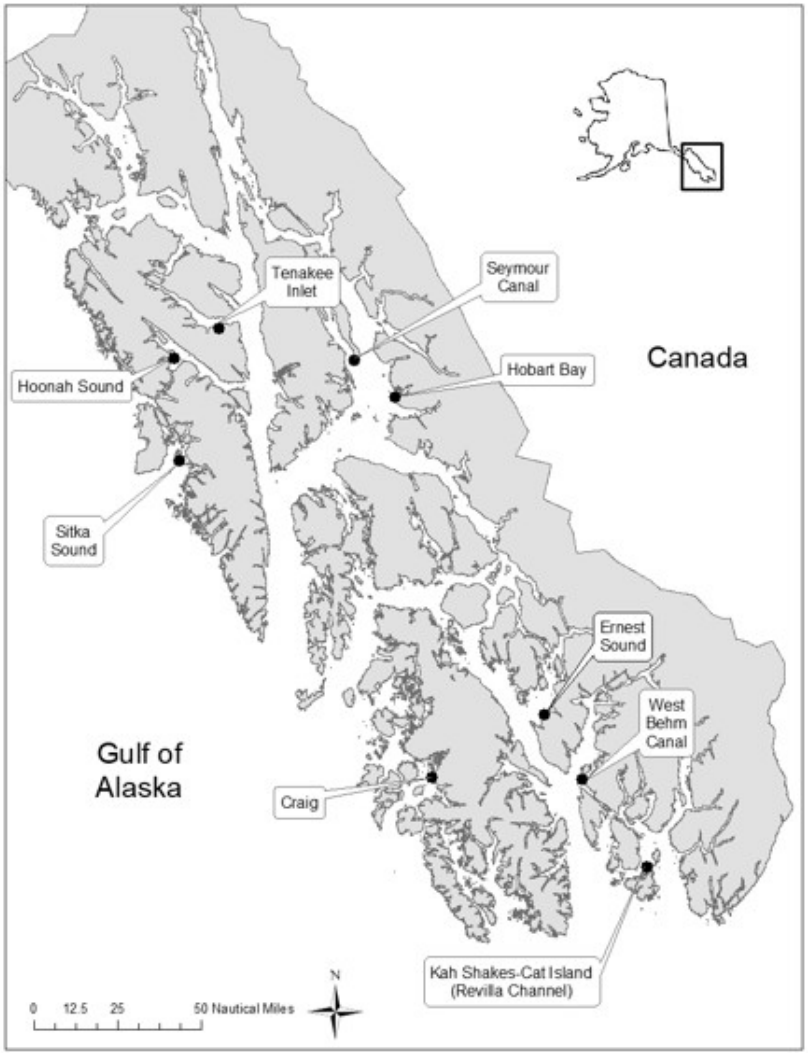


Figure 56: Location of nine Pacific herring spawning locations, historically surveyed in Southeast Alaska.

Status and trends: Mature biomass for Sitka Sound remains at a high level through 2025 and Craig remains at a relatively high level despite a decrease since 2021 (Figure 57). The large drop in biomass in the Craig area over the past few years is due to the aging and cumulative mortality of the exceptional 2016 year class. That decline may be slowing, however, due to relatively strong age-3 recruitments in 2023 (2020 year class) and 2025 (2022 year class). The Sitka biomass is still strongly supported by the 2019 age-3 fish (2016 year class), as well as a moderately strong 2023 age-3 recruitment (2020 year class). The 2019 age-3 recruitment event is by far the largest recruit class in the Sitka Sound and Craig model time-series (since 1976 for Sitka Sound and since 1988 for Craig).

The estimated Sitka population trend since 2021 changed in this contribution compared to the 2025 ESR, reflecting uncertainty in the estimated biomass over the past several years. The estimated Sitka population trend in last year's contribution showed the highest biomass in 2021 and a steep decline in abundance through 2024. This decrease was due to an estimated 64% survival for 2022 through 2024. With the addition of 2025 data, the best fitting statistical catch at age model used to forecast biomass in 2026 included a higher estimated survival for these years (77%), resulting in a peak in biomass in 2021 followed by a relatively stable biomass from 2022 through 2025 (Figure 57). Data collected in upcoming years will help clarify the trajectory in Sitka Sound herring biomass.

Although industrial-scale herring reduction fisheries and foreign fisheries operated in Southeast Alaska beginning in the early 1900s, with catch peaking in 1935, the most reliable estimates of biomass exist from those data collected by the State of Alaska within the last 50 years, which are discussed here. Prior to Alaska statehood (1959), herring fisheries were first managed and studied by the U.S. Department of Commerce, Bureau of Fisheries, in the 1930s, then by the U.S. Department of the Interior, Fish and Wildlife Service, in the 1940s and 1950s. Over the past 50 years, the Sitka Sound and Craig herring stocks have increased in biomass, whereas other Southeast stocks have been variable and are currently at relatively low levels (Figure 57). Following low biomass in the 1970s and a period of intermediate biomass during the 1980s through the mid-1990s, Sitka Sound herring increased to a relatively high level between 2008 and 2011. Craig and other Southeast stocks were variable until 2011. Southeast stocks then declined substantially until at least 2015, when stock assessments for the inside stocks were curtailed. Sitka Sound and Craig, the two largest and most consistently abundant stocks, declined moderately during this time. Both stocks increased dramatically in 2019 to historic levels following the largest recruitment of age-3 herring documented for these areas. The large 2016 year class has been documented in age composition samples and population abundance indices of mature herring across the Gulf of Alaska; in Prince William Sound (Pegau et al. 2022), Southeast Alaska and Kodiak Island (Hebert, 2022). It has also been documented in aerial surveys of age-1 herring in Prince William Sound (Pegau et al., 2022) and high mean frequency of occurrence of age-0 and age-1 herring in the diets of both diving and surface feeding birds at Middleton Island in 2016 and 2017 (Arimitsu et al., 2021). Biomass levels for most stocks in Southeast Alaska other than Sitka Sound and Craig are not well known because of survey reductions, but aerial surveys and limited spawn deposition surveys suggest that these stocks remain at relatively low levels compared to spawn mileage observations since 1980. However, there are indications that some stocks may be increasing over the past several years.

Factors influencing observed trends: Herring abundance is known to fluctuate dramatically over years, and is susceptible to environmental influences (e.g., Toresen, 2001). The underlying causes for the overall increase in herring biomass in Sitka Sound and Craig and indications of continued low abundance for other stocks are not known but may be due to multiple factors. Recent shifts in water temperatures, including the unprecedented 2014–2016 marine heatwave (Gentemann et al., 2017; Walsh et al., 2018) and the subsequent 2019 marine heatwave (Amaya et al., 2020), may have affected herring

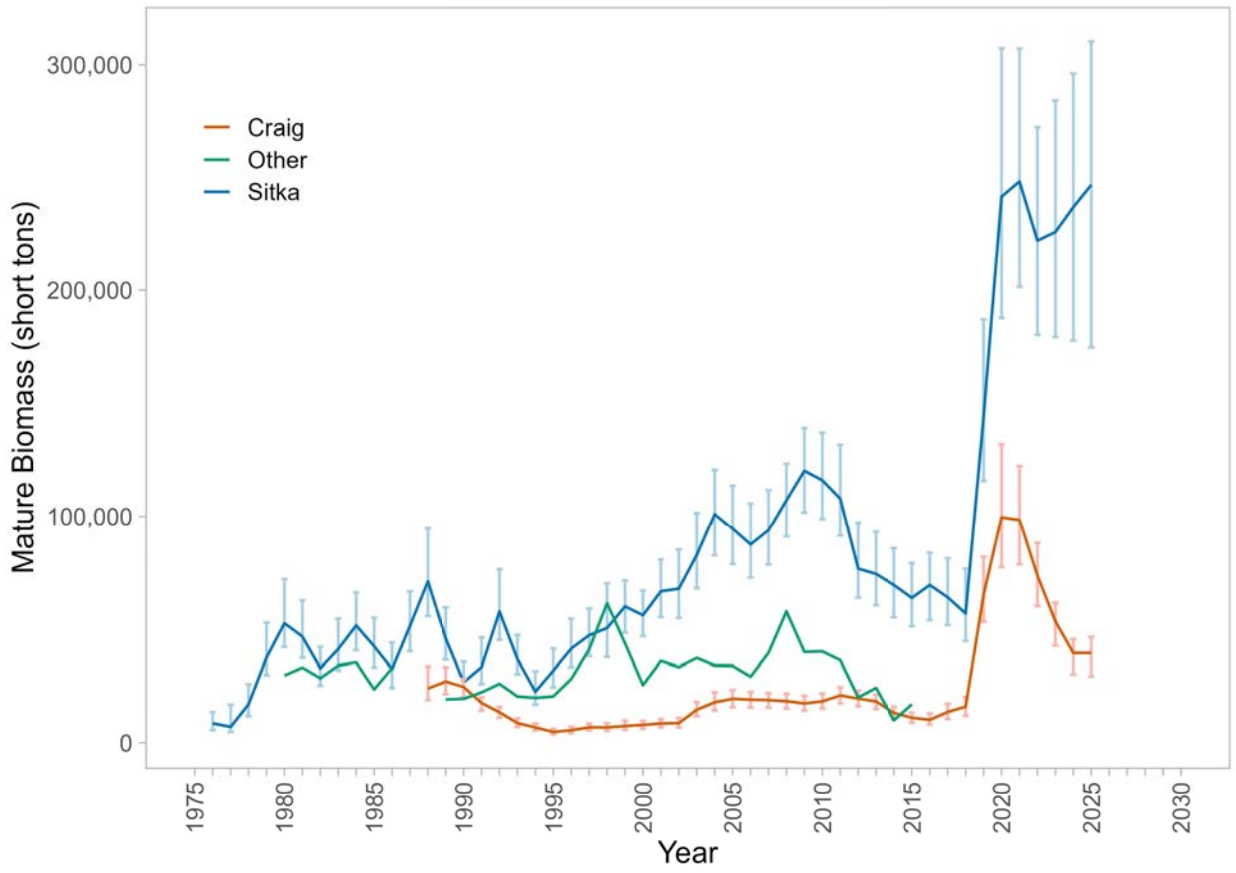


Figure 57: Estimated mature herring biomass (i.e., pre-fishery biomass) for herring spawning areas historically surveyed in Southeast Alaska. Biomass estimates for Sitka Sound and Craig are from integrated statistical catch-at-age models (the Sitka model starts in 1976, and Craig model starts in 1988) with 95% bootstrapped confidence intervals. For all other stocks, biomass estimates are spawn deposition or hydroacoustic survey estimates, which began in different years, but for simplicity are shown starting in 1980. For years 1987 – 1988 and 2016 – 2025, biomass estimates for the combined seven stocks were excluded from the plot because estimates were not made for all stocks in those years.

food sources, life history, spawn timing, and metabolism. Additional contributing factors may include fluctuating population levels of predatory marine mammals, such as humpback whales and Stellar sea lions (Muto et al., 2017; Fritz et al., 2016), and varying levels of predatory fish. While commercial fishing has occurred during some years for some inside water stocks, the similarity in declines among inside water stocks, which for some occurred in the absence of fishing, emphasizes that environmental factors may have contributed to the declines. The high mature biomass in Sitka Sound observed in 2025 was due to the continued presence of the unprecedented high 2016 year class, but also due to another high age-3 recruitment observed in 2023 (i.e., 2020 year class). Both of these year classes hatched during, or immediately following, notable marine heat waves documented in the Northeast Pacific Ocean (Gentemann et al., 2017; Walsh et al., 2018; Amaya et al., 2020). As ocean temperature has been positively correlated with recruitment in Atlantic herring (*Clupea harengus*) (Toresen, 2001) and Pacific herring (Zebdi and Collie, 1995), the marine heat waves may have led to success of these year classes by providing favorable early-life marine conditions. While the age-3 recruitment for the Craig

stock in 2023 was strong relative to other years in the recruitment time series, it was much lower than that observed in 2019. Consequently, the biomass of the Craig stock declined between 2022 and 2024, although it remained at a relatively high level. Age-3 recruitment estimated for 2025 was moderate in Sitka and strong (second only to 2019) in Craig; however, this was based on a single year observing the cohort (i.e., 2022 year class), and a full understanding of that cohort's strength will not be known until another year or two of data has been collected.

Implications: The high herring biomass along the outer coast has persisted for seven years through 2025 and is expected to remain at a relatively high level in 2026 as the strong 2016, 2020, and potentially 2022 year classes continue to contribute; however, the 2016 year class will be age-10 in 2026 and will continue to decline. Marine species that may benefit are numerous and include those that rely on adult or juvenile herring, such as demersal fishes, humpback whales, salmon and eagles, and those that consume herring eggs, such as gray whales, scoters, and gulls. The high biomass may also benefit traditional subsistence harvests, which have great cultural importance and are shared widely (Sill and Barnett, 2023), and commercial fisheries, seafood processors and communities in and around the areas of Sitka Sound and Craig/Klawock and beyond. In contrast, the persistent low biomass for inside water stocks may hinder or cause behavior shifts in herring predators and subsistence activities in these areas and will continue to restrict commercial fishery opportunities until stocks rebound to higher levels. However, because adult Pacific herring are known to migrate seasonally up to hundreds of kilometers from their natal grounds (Flostrand et al., 2009; Roundsfell and Dahlgren, 1935) it is plausible that the very high herring abundance originating from outside waters may contribute to the forage base for marine species of inside waters of Southeast Alaska during feeding and overwintering months, thereby buffering the impact of continued low spawning biomass in inside waters to some degree.

Southeast Alaska Eulachon

Contributed by Meredith Pochardt[1], Reuben Cash[2], and Stacie Evans[3]
[1]Chilkoot Indian Association, Haines, AK 99827
[2]Skagway Traditional Council, Skagway, AK 99840
[3]Takshanuk Watershed Council, Haines, AK 99827
Contact: mpochardt@gmail.com

Last updated: September 2026

Description of indicator: In Southeast Alaska, eulachon (*Thaleichthys pacificus*) are a culturally and biologically important anadromous fish. Eulachon populations have declined throughout their range since the 1990's and today all populations south of the Nass River in British Columbia have been severely depleted or become extinct (Hay and Mccarter, 2000). There are at least thirty-five rivers in Alaska where eulachon are known to spawn (Moffitt et al., 2002); however, it is thought that most runs are either unknown or anecdotal (Betts, 1994). To better understand the eulachon spawning population in northern Southeast Alaska the Chilkoot Indian Association initiated a mark-recapture study on the Chilkoot River in 2010. In 2014 this was complemented with the addition of environmental DNA (eDNA) sampling at the Chilkoot River. Furthermore, in 2017 eDNA sampling was expanded to include the Berners, Lace and Antler Rivers in Berners Bay and the Skagway and Taiya Rivers near Skagway, AK in partnership with the Skagway Traditional Council. In 2022 the use of eDNA to monitor

eulachon spawning populations was expanded to include the Unuk River in southern Southeast Alaska in partnership with the Ketchikan Indian Community and US Forest Service. And in 2023 the Southeast Alaska Eulachon Monitoring Network was further expanded with eDNA monitoring on the Situk and Ahrnklin Rivers near Yakutat in partnership with the Yakutat Tlingit Tribe and US Forest Service (Figure 58).

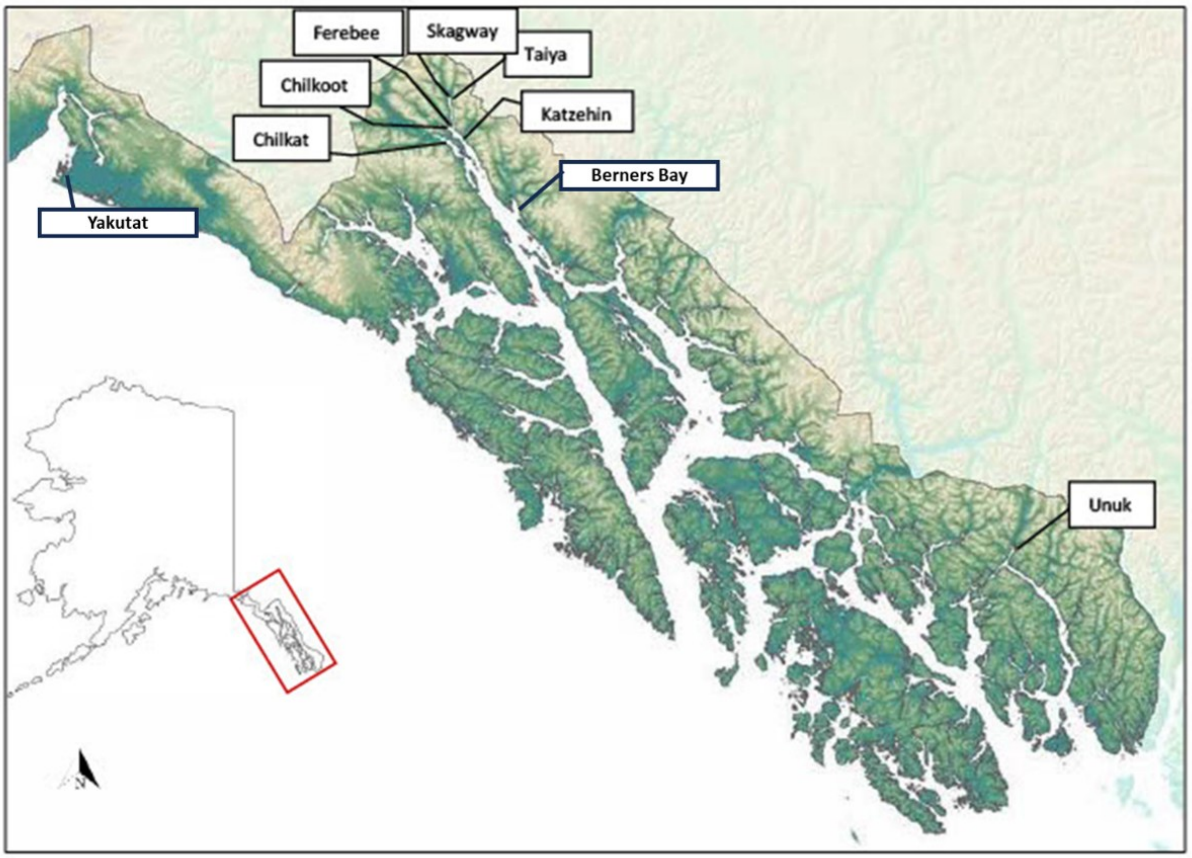


Figure 58: Location of Eulachon eDNA population monitoring sites in 2024.

Status and trends: In 2026, eulachon populations in southeast Alaska saw a range of returns from some below average to some around average (Table 1). In recent decades, declines in eulachon populations have increased concern about the health of eulachon across their range. In 2007 the Cowlitz Indian Tribe petitioned the National Marine Fisheries Service (NMFS) to list eulachon under the Endangered Species Act. In May 2010, the southern Distinct Population Segment (SDP), including California, Oregon, and Washington, was listed as "threatened" under the Endangered Species Act (NOAA, 2010). In May 2011 the Canadian Committee on the Status of Endangered Wildlife listed three British Columbia populations for protection including the Central Pacific Coast, Fraser River, and Nass/Skeena River populations (COSEWIC, 2011). In Southeast Alaska there has been limited monitoring of eulachon spawning populations. The Forest Service has conducted aerial surveys along the Unuk River since 2001, and a mark-recapture population estimate on rivers within Berners Bay from 2004 – 2008. However, these studies only represent a small portion of the eulachon spawning habitat in Southeast Alaska. On the rivers north of Berners Bay there was no population data being collected until the Chilkoot Indian

Association initiated a mark-recapture study in 2010, out of concern for declining eulachon populations elsewhere and a lack of available data.

The mark-recapture population estimate for the Chilkoot river near Haines, Alaska has seen a wide range in eulachon spawning abundance; estimates have ranged from a couple hundred thousand to over 20 million (Figure 59). 2024 was the last year the Chilkoot Indian Association conducted the mark-recapture portion of its eulachon monitoring program. All future monitoring is being conducted solely using environmental DNA (eDNA).

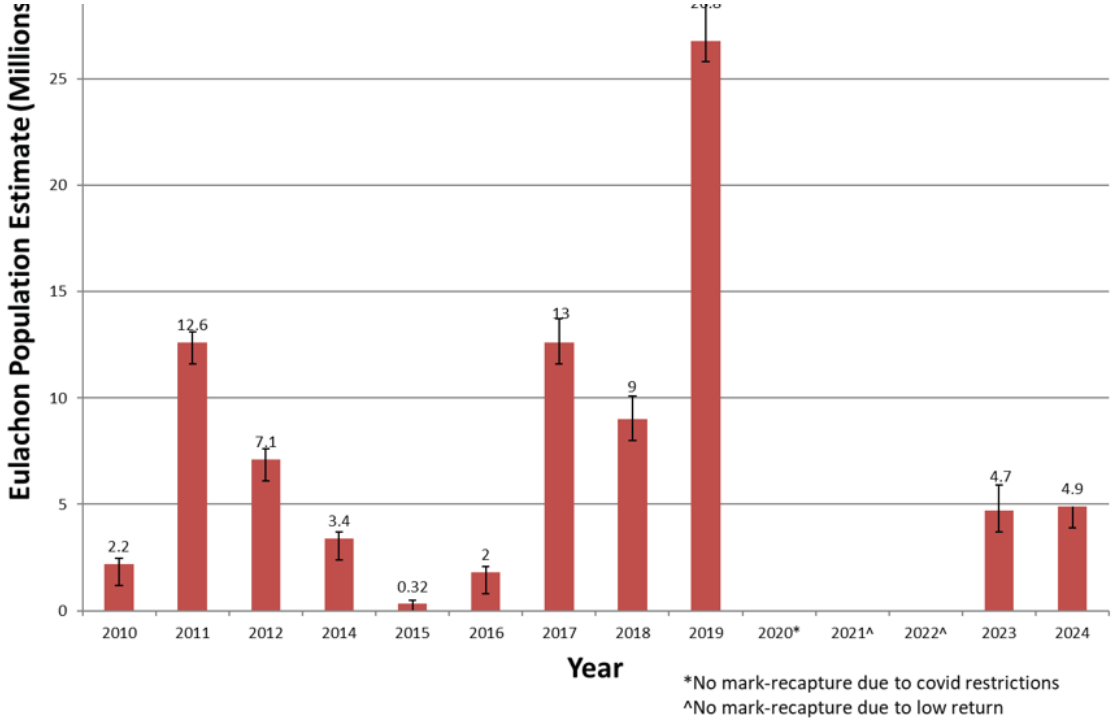


Figure 59: Eulachon population estimate on the Chilkoot River using mark-recapture method. Error bars represent 1 standard deviation.*No mark-recapture survey conducted in 2020 due to covid-19 restrictions. ^No survey conducted in 2021 and 2022 due to lack of return.

The eulachon eDNA surveys were conducted at the Chilkoot River from 2014 – 2025 (Figure 60).The ease of collecting eDNA samples (i.e., only one technician necessary to collect samples) and the sensitivity of the methods allowed for eDNA surveys to be conducted in years when the mark-recapture method was not at the Chilkoot River (2020 – 2022). The eDNA concentration at the Chilkoot River followed similar trends to the mark-recapture data in the years that the methods coincided. The log eDNA rate for 2025 indicates that the return was average compared to the previously monitored years (Figure 60). eDNA results for 2026 are still pending.

The regional population structure of eulachon initiated the need to begin a regional population monitoring effort in 2017 through the use of eDNA. The 2026 eDNA data is still pending for Chilkoot, Chilkat, Ferebee, Katzehin, Taiya, Skagway, and Berners Bay sites, but the regional trends observed are depicted in Table 1.

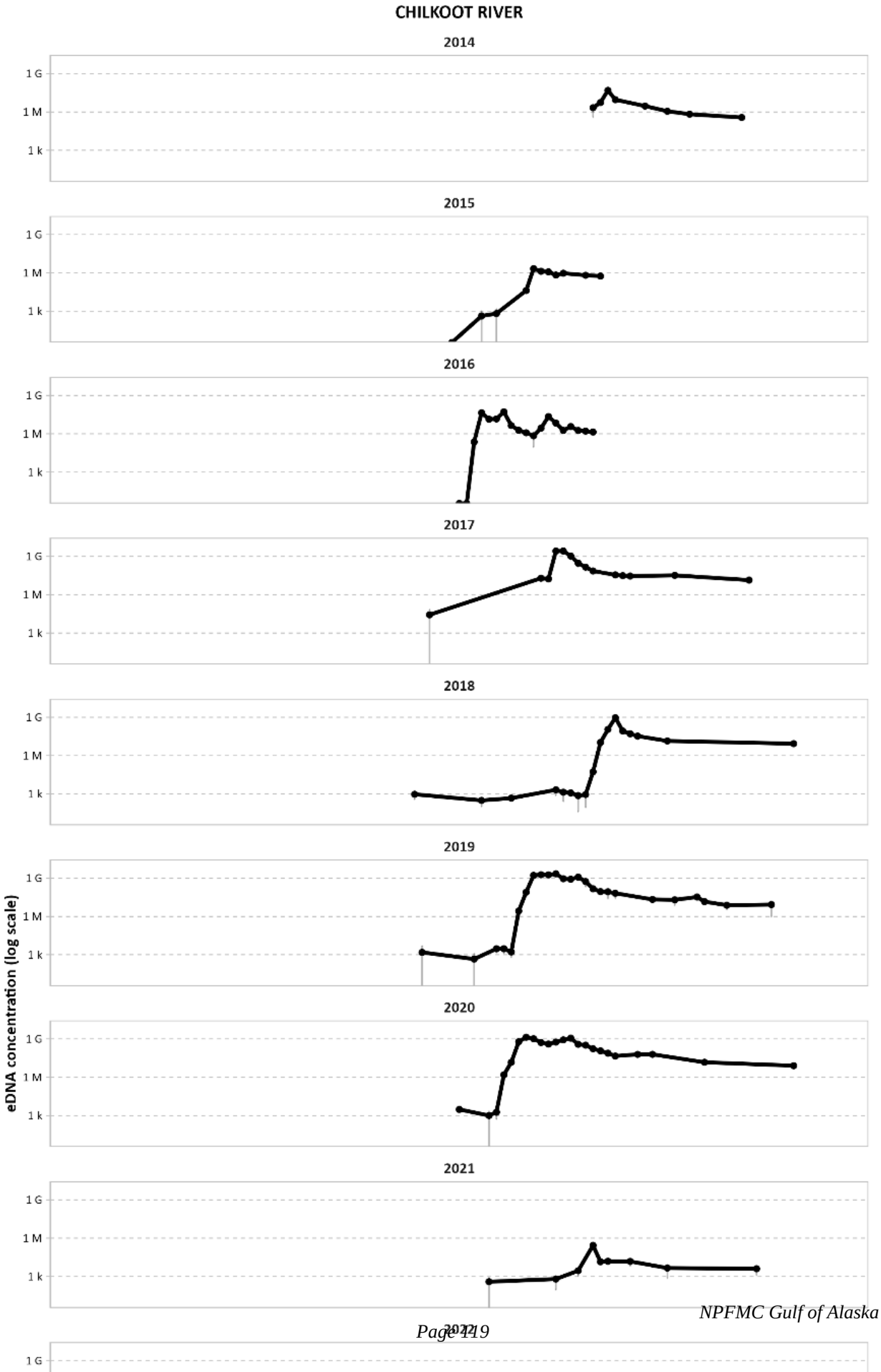
Factors influencing observed trends: Eulachon populations are sensitive to environmental influences and the annual spawning population at a river can vary substantially (Olds et al., 2016). Additionally,

Table 1: 2026 Southeast Alaska eulachon return observations

River	Adjacent community	2026 Eulachon Return Observations
Chilkoot	Haines	Average to below average
Chilkat	Haines	Average
Ferebee	Haines	Unknown/observations difficult
Katzehin	Haines	Unknown/observations difficult
Taiya	Skagway	Average
Skagway	Skagway	Average
Berners Bay	Juneau	Below average
Unuk	Ketchikan	Below average
Situk	Yakutat	Below average
Ahrnklin	Yakutat	Below average

there is little known about the life history of eulachon (Spangler, 2002), which makes assessing trends between parent-year and offspring difficult. It is thought that eulachon in Alaska are approximately two to five years of age at spawning (Spangler, 2002). Most eulachon are thought to be semelparous (Clarke et al., 2007), however it has been observed that eulachon do move back into the marine environment after spawning.

Implications: Anecdotal information and traditional knowledge indicates that eulachon spawning populations have historically varied in abundance (Olds et al., 2016). The limited timeseries of data available on eulachon spawning populations across the Southeast Alaska region limits any inference concerning the health of the overall eulachon population. Continued, and expanded, monitoring will be necessary to reliably assess the overall eulachon spawning population. A decline in the eulachon population in Southeast Alaska would have adverse impacts both culturally and ecologically. Eulachon have been termed the "salvation fish" by Northwest Coast Native peoples and eulachon oil was the most important trade item on a network of 'grease trails' between coastal and interior peoples (Moody and Pitcher, 2010). Today, eulachon are still valued as a subsistence resource. Additionally, eulachon are an important prey item for seabirds and marine mammals. Eulachon spawn prior to the breeding season for many predators, thus providing a high-energy resource at an energetically demanding time (Sigler et al., 2004).


CHILKOOT RIVER
2014
2015
2016
2017
2018
2019
2020
2021
2022
1 G
1 M
1 k
eDNA concentration (log scale)

Salmon

Trends in Alaska Commercial Salmon Catch

Contributed by George A. Whitehouse, Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES), University of Washington, Seattle, WA
Contact: gaw@uw.edu

Last updated: October 2026

Description of indicator: This contribution provides historic and current commercial catch information for salmon of the Gulf of Alaska. This contribution summarizes data and information available in current Alaska Department of Fish and Game (ADF&G) agency reports (e.g., Gleason and Munro, 2026) and on their website [33].

Pacific salmon in Alaska are managed in four regions based on freshwater drainage basins[34], Southeast/Yakutat, Central (encompassing Prince William Sound, Cook Inlet, and Bristol Bay), Arctic-Yukon-Kuskokwim, and Westward (Kodiak, Chignik, and Alaska peninsula). ADF&G prepares harvest projections for all areas rather than conducting run size forecasts for each salmon run. There are five Pacific salmon species with directed commercial fisheries in Alaska; they are sockeye salmon (*Oncorhynchus nerka*), pink salmon (*O. gorbuscha*), chum salmon (*O. keta*), Chinook salmon (*O. tshawytscha*), and coho salmon (*O. kisutch*).

Status and trends: *Statewide*—Combined catches from directed fisheries on the five salmon species have fluctuated over recent decades but in total have been strong statewide (Figure 61a). The salmon commercial harvests from 2025 totaled 197 million fish, which was 17 million less than the preseason forecast of 214 million fish. In particular, the 2025 total commercial harvest of 120 million pink salmon was below the harvest projection of 138 million. While the 2026 harvest data are not yet final, preliminary data from ADF&G for 2026 indicates a statewide total commercial salmon harvest of about 83 million fish (as of 25 September), which is below the preseason projection of 125 million fish. Individually, the preliminary 2026 statewide pink salmon harvest of 37 million fish is below the projected harvest of 56 million.

Gulf of Alaska—The total commercial salmon harvests in the Gulf of Alaska are dominated by pink salmon which follow a cycle of strong odd years and weak even years (Figure 61b). In the Prince William Sound Area of the Central region, the 2025 pink salmon harvest continued to follow the pattern of strong odd years with a harvest of 45 million fish which was below the 5-year, odd-year average of 67 million fish. Preliminary harvest numbers for 2026, indicate maintenance of the weak even-year pattern with a commercial harvest of about 3.5 million pink salmon in the Prince William Sound Area.

In the Southeast region, the 2025 commercial salmon harvests totaled 38.2 million fish, which was below the recent 10-year average harvest of 39.8 million fish. The 2025 harvest of 21.1 million pink salmon was below than the preseason forecast of 29 million fish. The harvest of 14.7 million chum

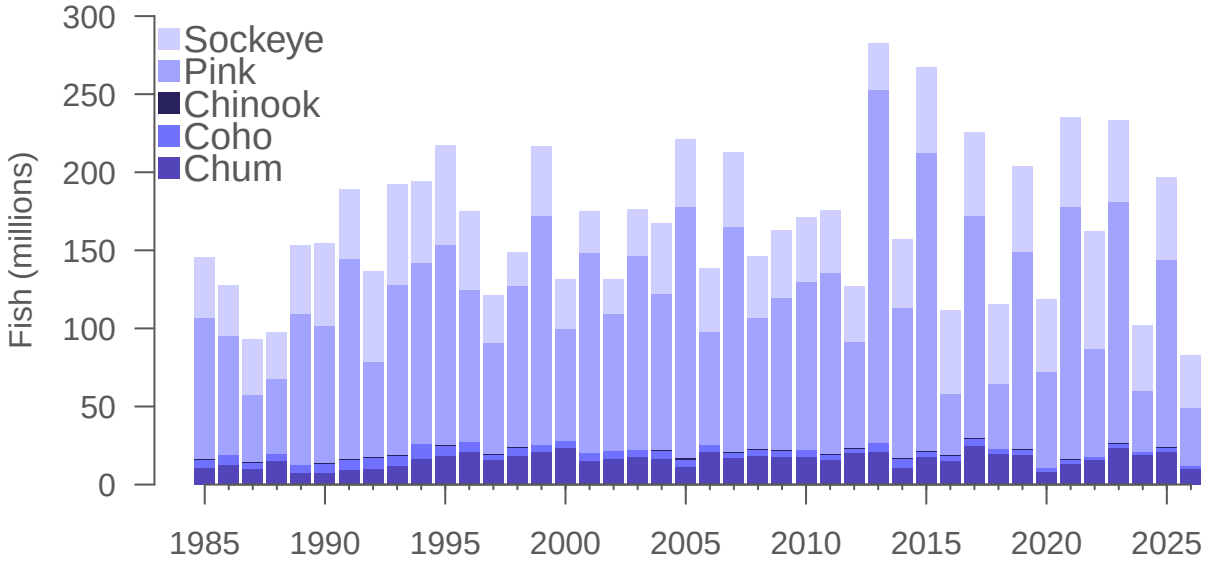
[33] https://www.adfg.alaska.gov/
[34] https://www.adfg.alaska.gov/index.cfm?adfg=commercialbyfisherysalmon.salmonareas

salmon in 2025 exceeded the recent 10-year average of 10.7 million fish. Preliminary data for 2026 from ADF&G indicates a catch of 20 million pink salmon in the Southeast Region which is above the preseason projection of 19 million fish.

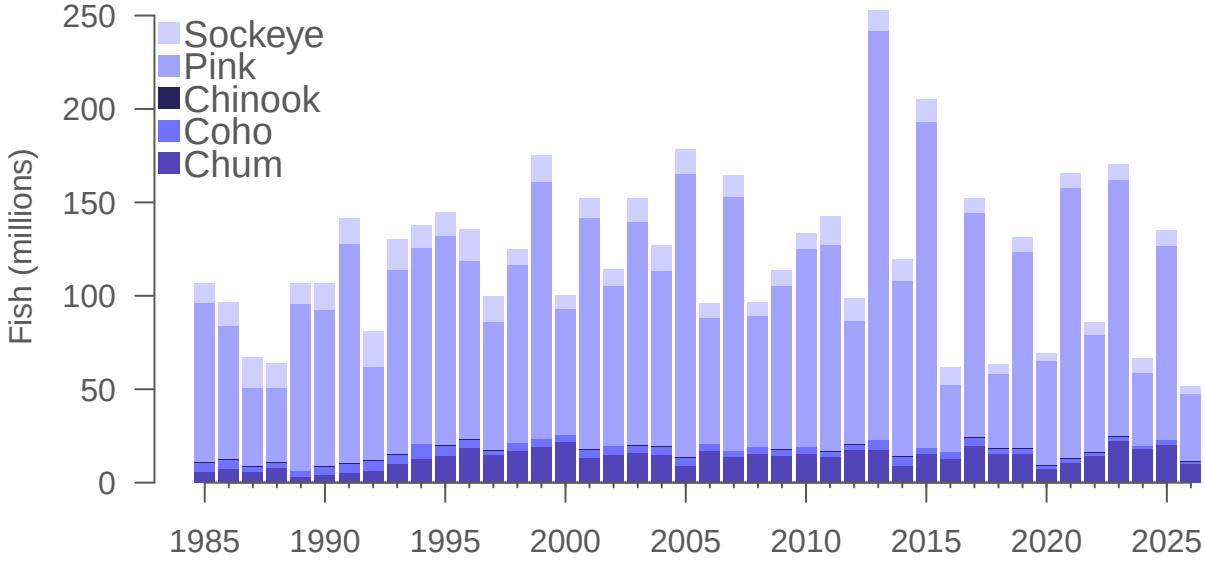
In the Kodiak management area, the 2025 total commercial salmon harvest of 37 million fish was above the recent 10-year average harvest of 23 million fish. The 2025 pink salmon commercial harvest of 34.6 million was below the recent 10-year average of 19.7 million fish. The 2025 sockeye salmon harvest of 1.5 million fish was below the recent 10-year average of 2.3 million fish. Preliminary data from ADF&G on the 2026 commercial harvest in the Kodiak management area indicates pink salmon harvest of about 12.5 million fish which is just above the preseason harvest projection of 12.3 million pink salmon.

Factors influencing observed trends: Historically, pink salmon catches increased in the late 1970s to the mid-1990s and have generally remained high in all regions in the last decade (Figure 61a). While both natural and hatchery populations return to Prince William Sound, a large majority of the returning fish are hatchery fish, upwards of up to one half billion are released from four hatcheries (Kline et al., 2008). Pink salmon have an abbreviated life cycle, consisting of three phases 1) brood year, 2) early marine year, and 3) return year (Kline et al., 2008). Interannual variation in Alaska statewide total salmon abundance is partly due to the even-year, odd-year cycle in pink salmon, which typically have larger runs in odd years. Pink salmon run strength is established during early marine residence and may be influenced by diet and food availability (Cooney and Willette, 1997). Survival rates of Alaska pink salmon are positively related to sea surface temperatures and may reflect increased availability of zooplankton prey during periods with warmer surface temperatures (Mueter and Norcross, 2002). Chinook runs have been declining statewide since 2007. Size-dependent mortality during the first year in the marine environment is thought to be a leading contributor to low Chinook run sizes (Beamish and Mahnken, 2001; Graham et al., 2019).

Implications: Salmon have important influences on Alaska marine ecosystems through interactions with marine food webs as predators on lower trophic levels and as prey for other species such as Steller sea lions. In years of great abundance, salmon may exploit prey resources more efficiently than their competitors, affecting the body condition, growth, and survival of competitors (Ruggerone et al., 2003; Toge et al., 2011; Kaga et al., 2013; Rand and Ruggerone, 2024). In odd years when pink salmon are most abundant they can initiate pelagic trophic cascades (Batten et al., 2018) which may negatively impact the population dynamics of several other species, including other salmonids, forage fishes, seabirds, and whales (Ruggerone et al., 2023). A biennial pattern in seabird reproductive success has been attributed to a negative relationship with years of high pink salmon abundance (Springer and van Vliet, 2014). Directed salmon fisheries are economically important for the state of Alaska. The trend in total statewide salmon catch in recent decades has been for strong harvests despite annual fluctuations and lower catches for some species in specific management areas.



(a) Alaska



(b) Gulf of Alaska

Figure 61: Contemporary commercial salmon catches from Alaska statewide (a) and Gulf of Alaska (b), 1985-Sept 2026. Values from 2026 are preliminary. (Source: ADF&G, `http://www.adfg.alaska.gov`. ADF&G is not responsible for errors or deficiencies in the reproduction, subsequent analysis, or interpretation of data.)

Juvenile Salmon Abundance in Icy Strait, Southeast Alaska

Contributed by Wesley Strasburger[1], Emily Fergusson[1], Andrew Piston[2], Teresa Fish[2]
[1]Auke Bay Laboratories Division, Alaska Fisheries Science Center, NOAA Fisheries
[2]Alaska Department of Fish and Game
Contact: Wes.Strasburger@noaa.gov
Last updated: September 2026

Description of indicator: Juvenile salmon catch-per-unit-effort (CPUE) and oceanographic conditions are collected during the Southeast Coastal Monitoring (SECM) surveys (Fergusson et al., 2021; Murphy et al., 2021). SECM data are used in a variety of research applications; however, the information on juvenile salmon (*Oncorhynchus* spp.) CPUE is a key data product from the survey due to its use in harvest and run forecast models (Murphy et al., 2019). SECM surveys and salmon forecast models (Brenner et al., 2021) are part of a cooperative research effort by NOAA's Alaska Fisheries Science Center (AFSC) and the Alaska Department of Fish and Game (ADFG). This research supports salmon management in the U.S./Canada Pacific Salmon Treaty Northern Boundary area and Southeast Alaska (SEAK) domestic fisheries.

Juvenile salmon CPUE indices are constructed from surface (0 – 23 m) rope-trawl catches in Icy Strait, the northern migratory corridor between the inside waters of SEAK and the Gulf of Alaska. CPUE indices are the peak monthly average log-transformed catch per 20-min trawl set in Icy Strait during the months of June and July. Data have been standardized to the long-term mean to visualize anomalies. These indices are adjusted for fishing-power differences between the survey vessels that have conducted SECM surveys over time (Wertheimer et al., 2010). CPUE data for Chinook (*O. tshawytscha*), chum (*O. keta*), coho (*O. kisutch*), pink (*O. gorbuscha*), and sockeye (*O. nerka*) salmon are included in Figure 63.

Because salmon return at different ages, the implications of the improved 2026 juvenile indices will emerge over different time scales. Pink salmon return predominantly the following year, making the 2026 juvenile index particularly relevant to expectations for the 2027 Southeast Alaska pink salmon return and harvest. Juvenile pink salmon abundance from SECM has been incorporated into harvest forecast models for Southeast Alaska, reflecting the value of these early marine indices for anticipating subsequent production (Murphy et al., 2019; Brenner et al., 2021). Coho salmon are also expected to respond relatively quickly, whereas chum, sockeye, and Chinook salmon have more variable and generally older age-at-return schedules, so the 2026 juvenile signal is expected to contribute to returns over a broader period extending several years into the future.

Status and trends: Peak juvenile salmon CPUEs improved substantially in 2026 for several species, interrupting the broadly negative pattern observed during much of the previous decade (Figure 63). Pink salmon showed the strongest increase and was above the long-term mean in 2026. Chum salmon also increased to above average, while coho salmon improved to approximately the long-term mean. Chinook and sockeye salmon remained below average, but both increased relative to 2025.

These observations indicate that substantially more juveniles of several species successfully reached the Icy Strait migration corridor in 2026 than during most recent years. Commercial harvests provide context for the cohorts returning to Southeast Alaska in 2026 rather than for the juveniles observed by SECM

during the same year. Preliminary 2026 harvest remained below the long-term mean for all five species (Figure 63). Harvest was especially low for coho, sockeye, and Chinook salmon, while chum harvest was relatively close to average and pink salmon remained moderately below average.

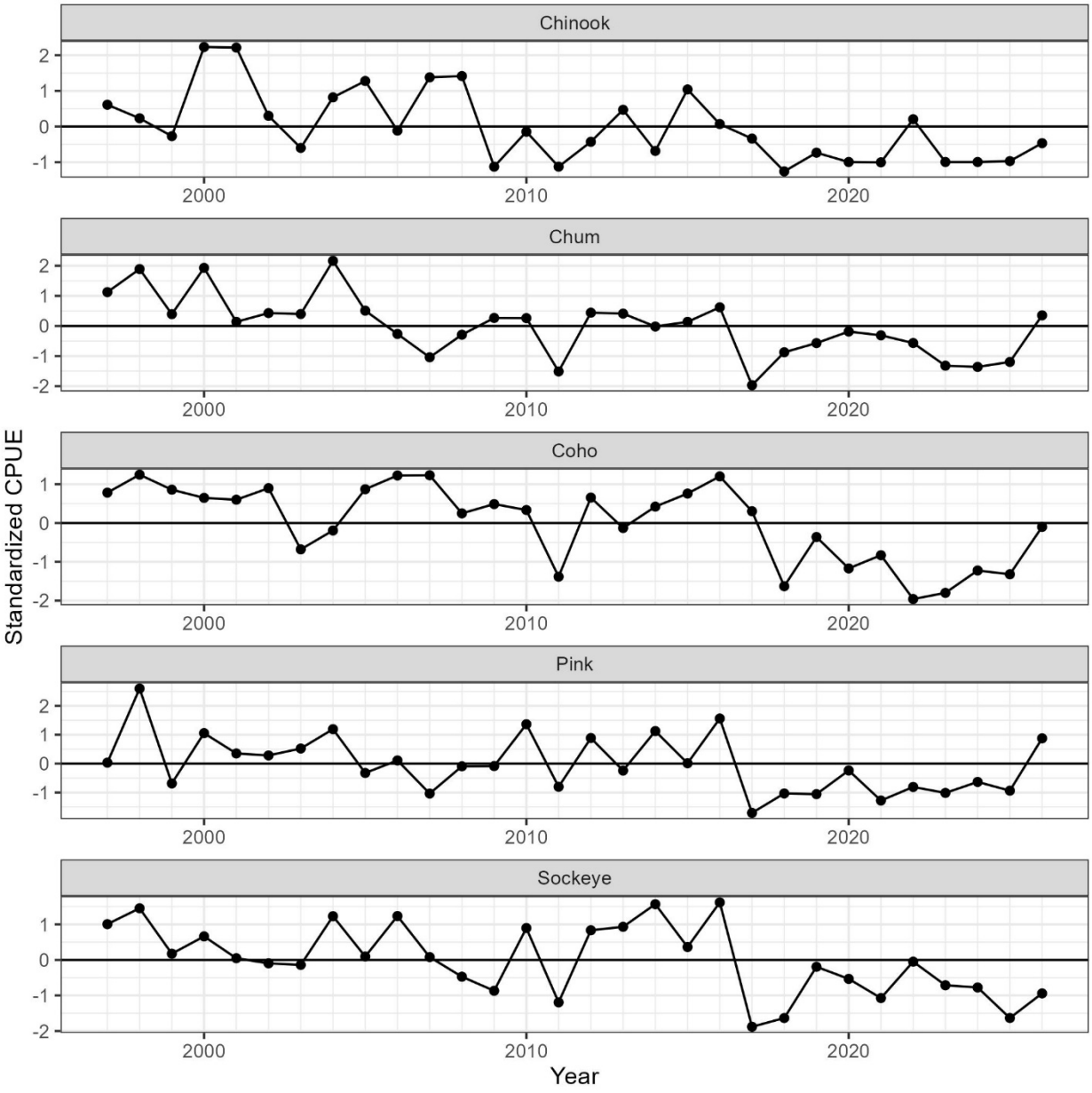


Figure 62: Standardized catch-per-unit-effort (CPUE) of juvenile salmon during Southeast Coastal Monitoring surveys in Icy Strait, 1997 – 2026.

Factors influencing observed trends: Multiple factors contribute to variation in juvenile salmon catch rates over time, and their relative importance differs among species. Early life-history ecology and mortality remain primary influences on juvenile abundance, while spawner abundance, freshwater production, hatchery releases, migration timing, and juvenile distribution can also affect year-to-year

variation (Murphy et al., 2021; Fergusson et al., 2021).

The marked improvement in 2026 suggests that conditions experienced by several salmon species prior to or during early marine migration were more favorable than in recent years. However, abundance in Icy Strait represents only one stage of marine life history. Juveniles subsequently migrate into coastal and offshore waters, where growth, prey availability, energetic condition, predation, and overwinter survival can substantially modify the number of fish that ultimately return as adults.

Pink salmon: Juvenile CPUE increased markedly in 2026 and was above the long-term mean. This represents a substantial improvement from the negative anomalies observed during most recent years and provides a favorable signal for the 2027 return. Pink salmon have a fixed two-year life cycle, making the relationship between juvenile abundance and the following year's adult return relatively direct, compared with the other species. SECM juvenile abundance has been used in Southeast Alaska pink salmon forecasting because early marine abundance can provide information about subsequent harvest potential (Murphy et al., 2019; Brenner et al., 2021). Even-year escapement goals were frequently not met from 2012 through 2024 in the northern inside region of Southeast Alaska, so variation in brood abundance may also contribute to subsequent juvenile abundance (Piston and Heinl, 2020, and unpublished ADF&G data).

Chum salmon: Juvenile chum abundance increased substantially and was above average in 2026. Hatchery fish typically account for more than 80% of the Southeast Alaska chum harvest, so natural brood escapement exerts less influence on regional juvenile abundance than for predominantly wild stocks. Instead, variation in hatchery production and early marine survival likely contributed strongly to the observed pattern. The positive 2026 juvenile index improves expectations for cohorts returning over the next several years, although subsequent marine survival will determine how much of that signal is ultimately expressed in adult returns.

Sockeye salmon: Juvenile sockeye abundance improved from 2025 but remained well below average in 2026. Sockeye salmon spend at least one year in freshwater before migrating to sea, so freshwater production as well as early marine survival can influence juvenile abundance and subsequent adult returns. The 2026 value therefore indicates some improvement relative to the previous year but remains a relatively weak signal compared with the long-term mean.

Coho salmon: Juvenile coho CPUE improved sharply to approximately the long-term mean after several years of below-average abundance. Because many Southeast Alaska coho return after one winter at sea, improved juvenile abundance in 2026 provides a more favorable expectation for 2027 returns than the very low juvenile indices observed during recent years. Their extended residence in inside waters and subsequent offshore distribution can weaken the direct relationship between Icy Strait abundance and eventual harvest, but juvenile abundance still provides an early indication of cohort strength.

Chinook salmon: Juvenile Chinook abundance improved in 2026 but remained below average. Chinook salmon have more complex age structure and marine migration patterns than pink or coho salmon, so the 2026 juvenile cohort will contribute to adult returns over multiple future years. Previous SECM research has demonstrated the utility of first-year marine indicators for evaluating Chinook salmon production, although the relationship to adult returns is distributed across several subsequent years (Orsi et al., 2016).

Implications: The 2026 SECM observations provide the first broad indication in several years of improved juvenile salmon production across multiple species in northern Southeast Alaska. The strongest signals are for pink and chum salmon, with coho also returning to approximately average abundance. These

increases improve expectations for future adult returns relative to those generated from the much weaker juvenile cohorts observed during recent years.

The timing of potential improvements differs among species. The 2026 pink salmon index is most directly relevant to the 2027 return, and coho salmon may also show much of the response in 2027. Chum, sockeye, and Chinook salmon mature over a broader range of ages, so the 2026 juvenile cohort is expected to contribute to returns over several subsequent years.

At the same time, high juvenile abundance does not guarantee strong adult returns. The SECM index measures fish that have successfully reached Icy Strait during early marine migration, but substantial mortality can occur after fish leave inside waters. Ocean temperature, prey abundance and quality, growth, energetic condition, predation, and overwinter survival can all influence whether a strong juvenile cohort ultimately produces a strong adult return. SECM sampling of juvenile salmon and oceanographic conditions is designed in part to evaluate these processes and improve understanding of the mechanisms influencing salmon production (Fergusson et al., 2021; Murphy et al., 2021).

The improved 2026 juvenile indices therefore represent a favorable starting point for future returns rather than evidence that strong adult returns are assured. If subsequent marine conditions support adequate growth and survival, the stronger juvenile cohorts observed in 2026 should increase the potential for improved returns beginning in 2027 and extending into later years for older-maturing species. Continued SECM monitoring will help determine whether the 2026 increase represents a persistent improvement in juvenile production and whether that signal is subsequently reflected in adult returns and fisheries.

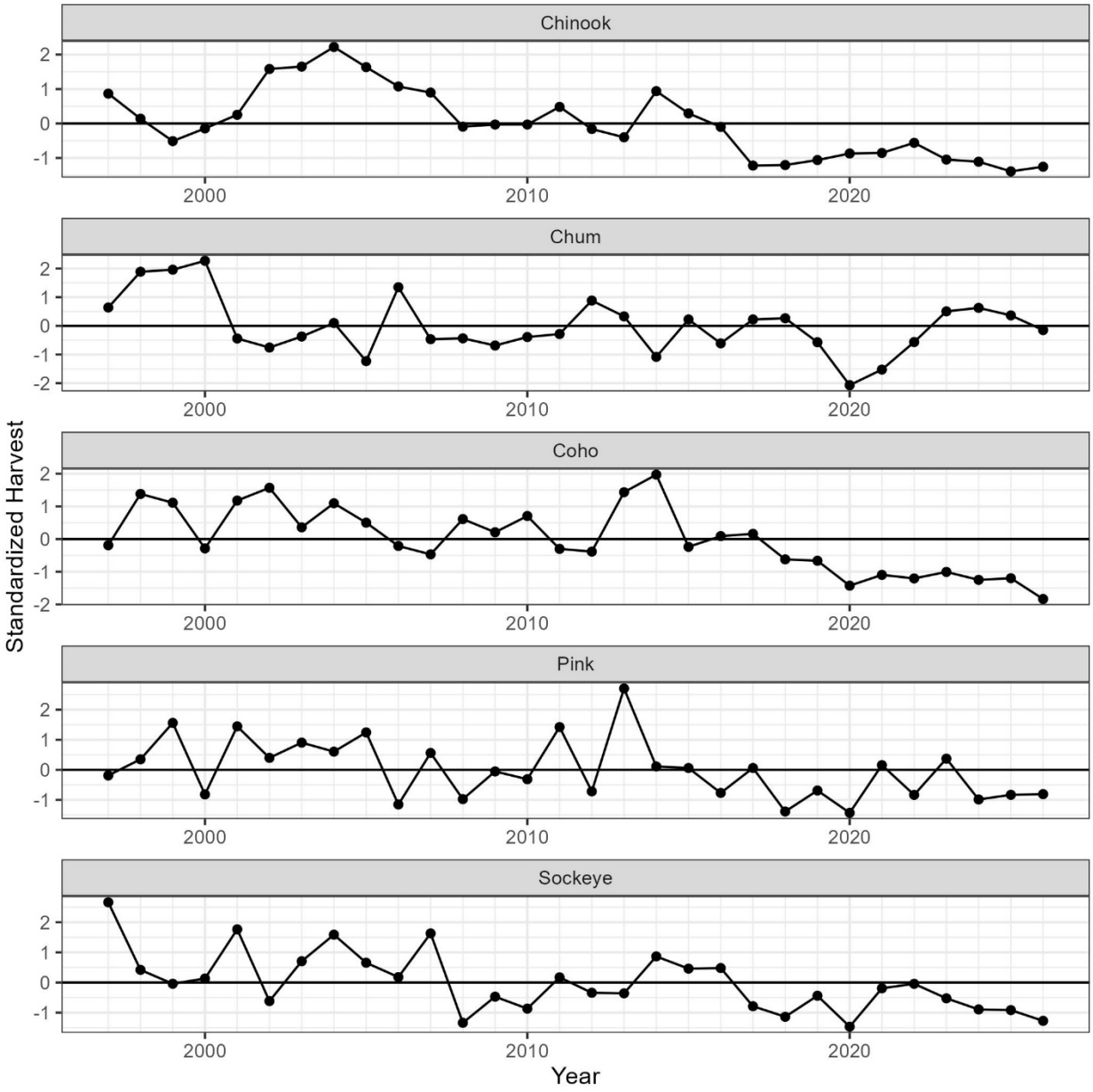


Figure 63: Standardized commercial harvest (metric tons) of salmon in Southeast Alaska, 1997 – 2026. Harvest data through 2025 are from ADFG[35]; 2026 harvests are preliminary from ADFG[36].

Juvenile Salmon Size and Condition Trends in Icy Strait, Southeast Alaska

Contributed by Emily Fergusson and Wesley Strasburger, Auke Bay Laboratories, Alaska Fisheries Science Center, NOAA Fisheries
Contact: emily.fergusson@noaa.gov
Last updated: September 2026

Description of indicator: The Southeast Coastal Monitoring project (SECM, Auke Bay Laboratories, AFSC) has investigated climate-ecosystem linkages in southeast Alaska nearshore marine habitats in relation to juvenile salmon (*Oncorhynchus* spp.) and associated biophysical factors since 1997 (Fergusson et al., 2020; Murphy et al., 2020). Juvenile pink (*O. gorbuscha*), chum (*O. keta*), sockeye (*O. nerka*), and coho (*O. kisutch*) salmon size, condition, and diet data have been collected annually in Icy Strait during monthly (June and July) fisheries oceanographic surveys.

During early marine entry and residency, juvenile salmon must grow quickly to avoid predation while also acquiring enough lipid reserves to survive winter when food is severely limited (Beamish and Mahnken, 2001; Moss et al., 2005). Size trends over time reflect differences in growth, migration routes, and timing of hatch, outmigration, and hatchery releases of the fish in response to climate and ocean conditions during early marine residency. Energy density trends over time can reflect the condition of juvenile salmon and other taxa in response to climate and ocean conditions during their early marine residency. Diet composition reflects both prey availability and feeding selectivity and provides ecological context for observed trends in growth and condition.

This report presents July 2026 size (fork length) and energy density data in relation to the past 29-year trend from Icy Strait.

Status and trends: In 2026, juvenile salmon fork-length anomalies were below the 1997 – 2026 average for all four species (Figure 64). This continues the trend of below-average lengths since 2023.

Energy density anomalies (ED, kJ/g dry weight) varied among the four juvenile salmon species (Figure 65). Pink and sockeye salmon ED dropped to just below average, following above-average levels in 2024 and 2025. Meanwhile, chum salmon ED remained above average, and coho salmon ED held steady at average levels, consistent with five-year trends.

Juvenile salmon diets varied among the four juvenile salmon species (Figure 66) and only three empty coho salmon stomachs were observed. Pink and chum salmon diets were similar to diets in 2025 with gelatinous prey (larvaceans) contributing to the diets. Sockeye salmon diets switched to primarily amphipods (*Themisto* sp.) from a three-year trend of gelatinous prey. Coho salmon diets have been dominated by decapod larvae for the past decade.

Factors influencing observed trends: heatwave and localized thermal refugia inside southeast Alaska. The 2026 sampling occurred during NEP26A, a pronounced marine heatwave that began in early May and spans much of the Northeast Pacific, including the Gulf of Alaska (NOAA Marine Heatwave Tracker "Blobtracker"[37]). The Gulf of Alaska is also experiencing El Niño warming conditions which are forecast

[37] https://www.integratedecosystemassessment.noaa.gov/regions/california-current/california-current-marine-heatwave-tracker-blobtracker?utm_source=chatgpt.com

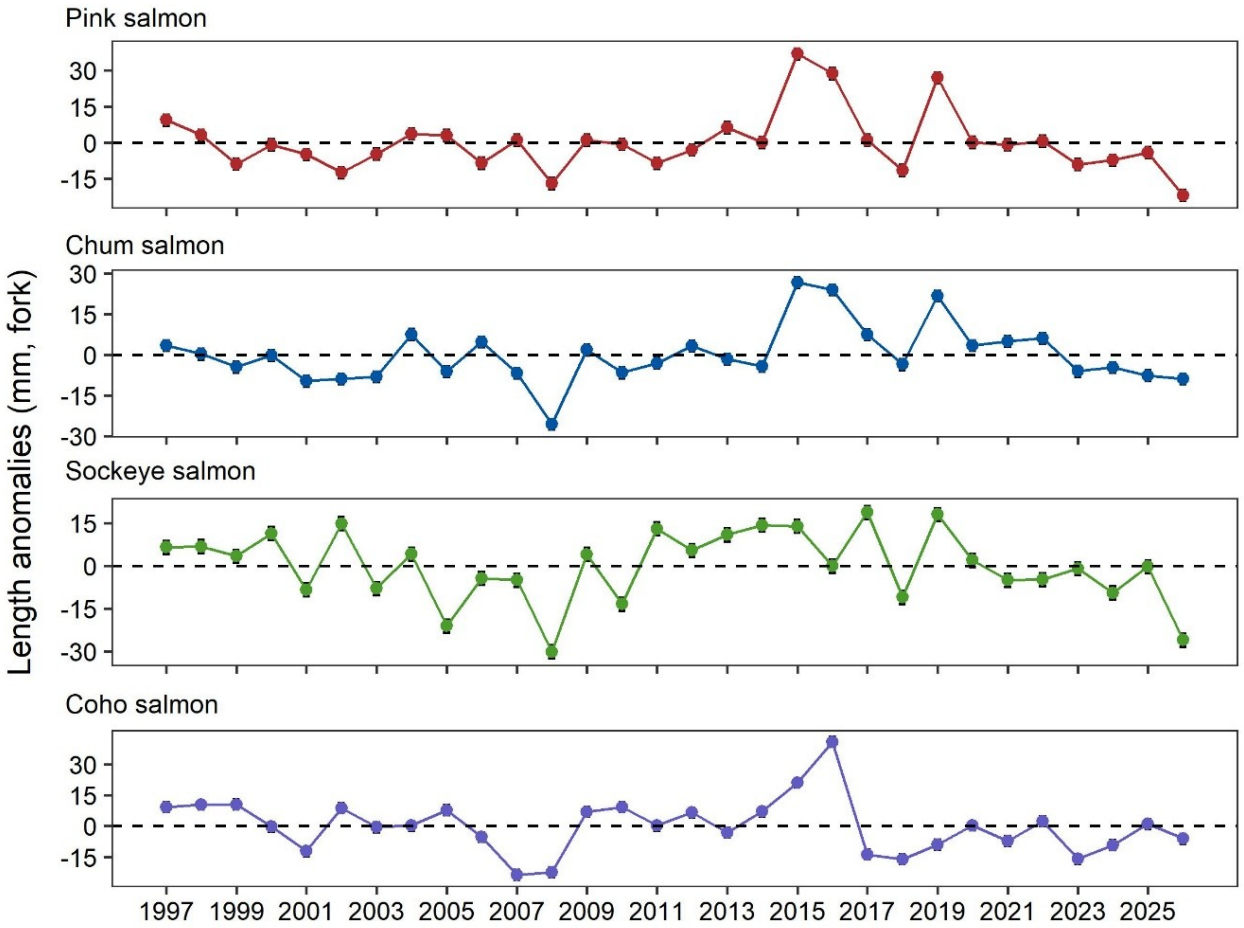


Figure 64: Average fork length anomalies (mm; ±1 standard error) of juvenile salmon captured in Icy Strait, AK by the Southeast Coastal Monitoring project, 1997 – 2026. Time series average is indicated by the dashed line.

to extend through the fall and winter of 2026. Such widespread upper-ocean warming typically alters phytoplankton bloom timing, zooplankton prey availability, and species composition.

However, inside waters of Southeast Alaska, including Icy Strait, appear to provide partial thermal refuge during these basin-scale warm events. The average 20-m upper water column in Icy Strait continued a trend of colder than average water temperatures (unpublished data). Brooks et al. (2025) found that juvenile salmon body condition in Southeast Alaska was relatively resilient during recent marine heatwaves and suggested that the region's complex oceanography—including strong freshwater influence, tidal mixing, and generally cooler nearshore conditions relative to the eastern Gulf of Alaska. These conditions likely mitigate severe energy density losses, facilitate lipid accumulation, and sustain an abundant prey base; however, cold conditions can also result in slower growth rates.

Implications: The length anomalies observed in 2026 for juvenile salmon continue to reflect the colder water temperatures experienced in their early marine residency in Icy Strait. Smaller fish generally have decreased foraging success and an increased predation risk resulting in lower survival.

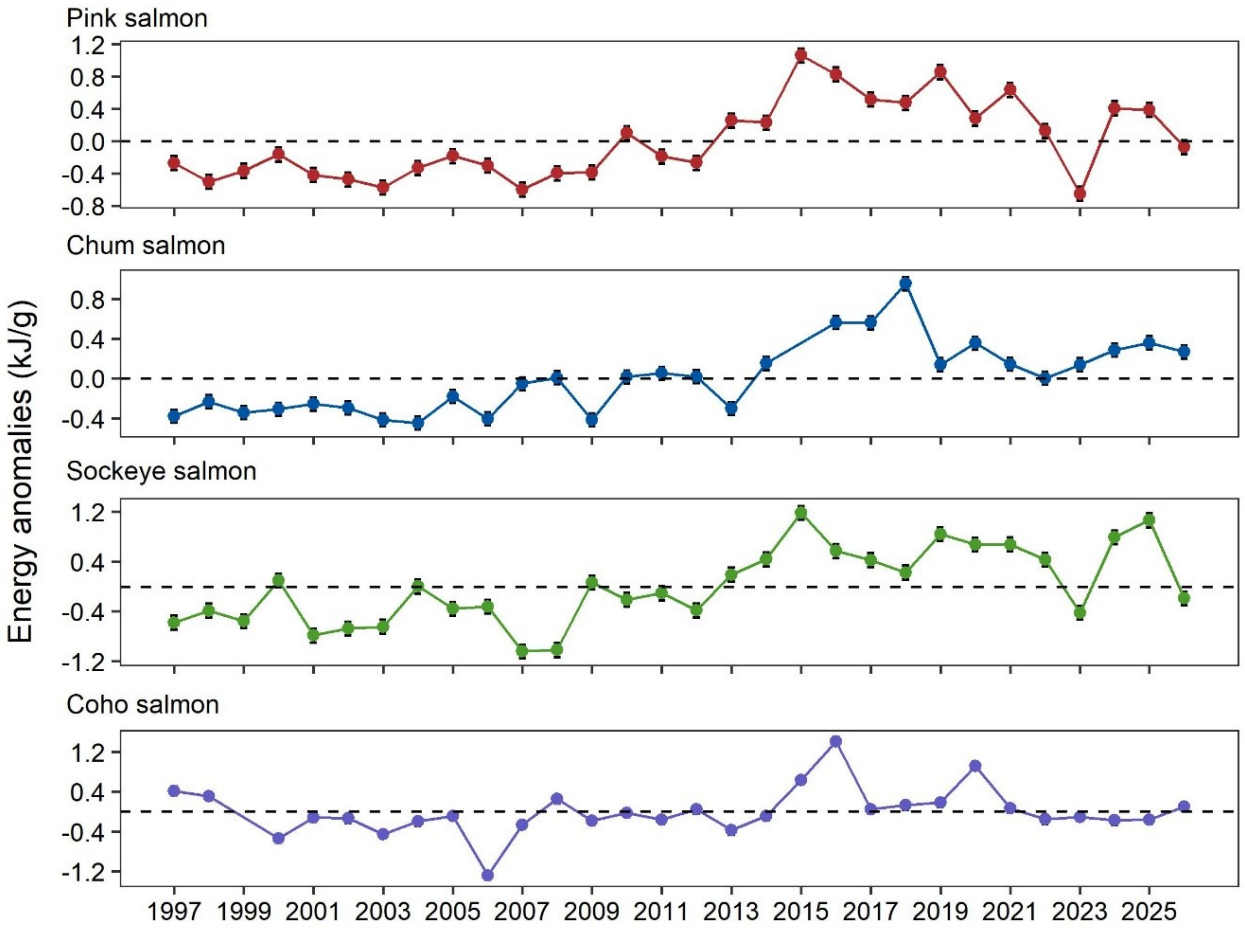


Figure 65: Average energy density anomalies (kJ/g, dry weight; ±1 standard error) of juvenile salmon captured in Icy Strait, AK by the Southeast Coastal Monitoring project, 1997 – 2026. The dashed line indicated the time series average.

Based on the 2026 length frequency and energy results relative to the long-term averages by species, juvenile salmon are entering the GOA in 2026 with below-average size and energy levels similar to or lower than what has been seen in recent years. However, diets reflect positive feeding conditions, which may contribute to higher survival and escapement especially as they pertain to their overwinter survival when food is most limited. Therefore, further growth and survival will be dependent on favorable over-winter conditions in the GOA, which do not seem likely with the current NEP26A and El Niño events.

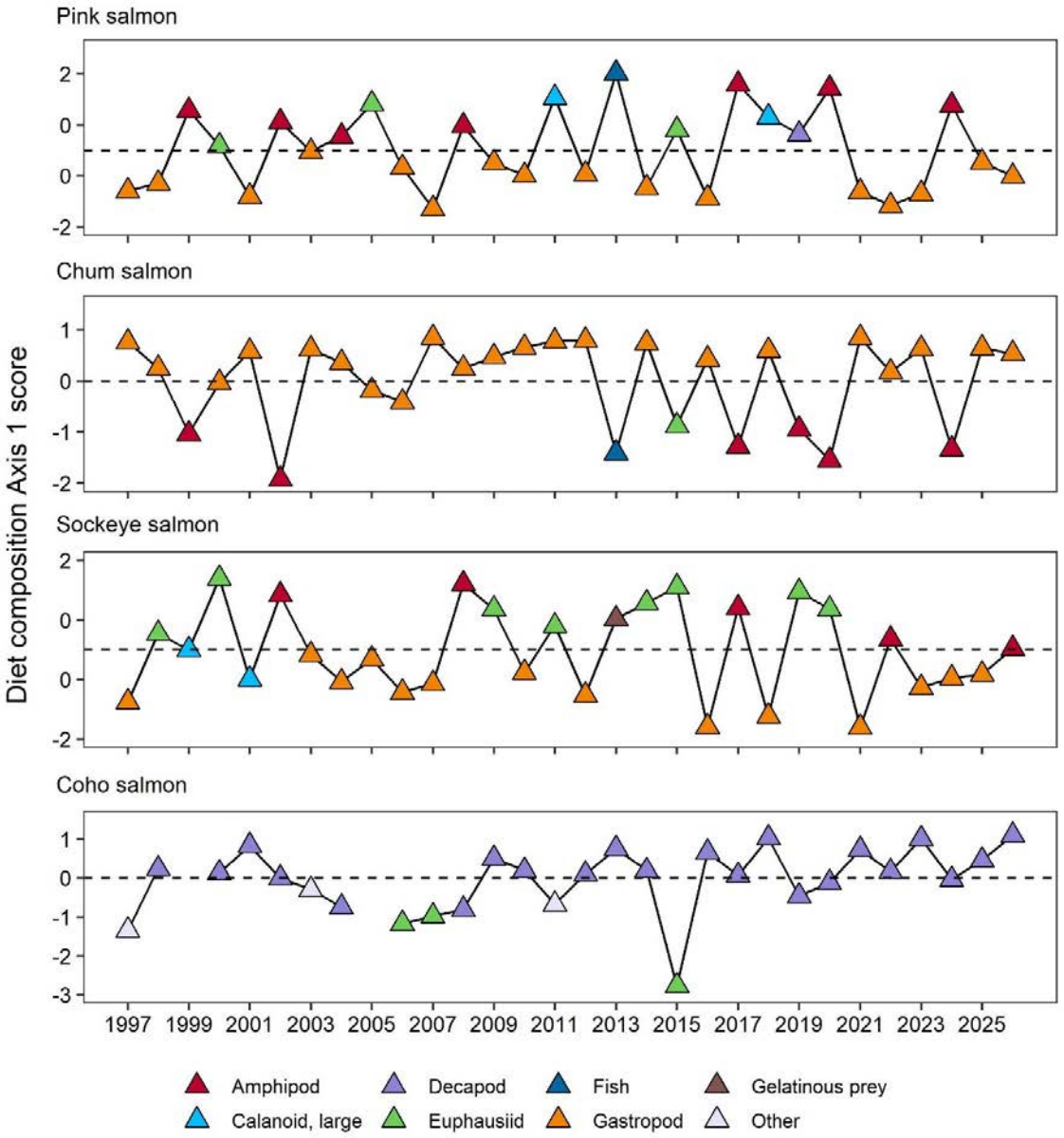


Figure 66: Interannual variation in July diet composition of juvenile salmon captured in Icy Strait, Alaska, by the Southeast Coastal Monitoring project, 1997 – 2026. For each salmon species, points represent the annual mean Axis 1 score from the bootstrap analysis of diet composition, with greater separation along Axis 1 indicating greater differences in overall diet composition among years. Symbols identify the prey taxon or prey group contributing most strongly to the diet in each year, as determined by SIMPER (Similarity Percentages) analysis with year as the grouping factor. The dashed horizontal line at zero is an analytical reference for the Axis 1 scores and does not represent an ecological threshold or absence of prey.

Survival of Coho, Sockeye, and Pink Salmon from Auke Creek, Southeast Alaska

Contributed by Scott C. Vulstek and Joshua R. Russell
Auke Bay Laboratories Division, Alaska Fisheries Science Center, NOAA Fisheries
Contact: scott.vulstek@noaa.gov

Last updated: September 2026

Description of indicator: The time series of marine survival estimates for wild coho, sockeye, and pink salmon from the Auke Creek Weir in Southeast Alaska is the most precise and longest-running continuous series available in the North Pacific. Auke Bay Laboratory began continuously monitoring wild salmon survival in 1980. The Auke Creek weir structure facilitates near-complete capture of all migrating sockeye smolt and returning adults and is the only weir capable of such precision on a wild system in the North Pacific. All coho salmon smolts leaving the Auke Lake watershed have been counted, subsampled for age and length, and injected with coded wire tags (CWT). These migrating fish included those with both 1 and 2 freshwater annuli and 0 or 1 ocean annuli. Coho marine survival is estimated as the number of adults (harvest plus escapement) per smolt. The index is presented by smolt (outmigration) year. It is the only continuous marine survival and scale data set in the North Pacific that recovers all returning age classes of wild, CWT coho salmon as ocean age 0 and 1. The precision of the survival estimate was high due to 100% marking and high sampling fractions that minimized the variance in the survival estimate and made the series an excellent choice for model input relating to nearshore and gulf-wide productivity. While no stock-specific harvest information is available for Auke Creek sockeye and pink salmon for a direct estimation of marine survival, the precision of this long-term dataset is still unmatched, and the series is an excellent choice for model input relating to nearshore and gulf-wide productivity.

Status and trends: The historical trends show marine survival of wild coho salmon from Auke Creek varies from 5.2% to 45.0%, with an average survival of 20.3% from smolt years 1980 – 2025 (Figure 67a). Marine survival for 2025 was the seventh lowest on record at 9.4% and overall survival averaged 11.7% over the last 5 years and 10.8% over the last 10 years. The survival index for ocean age-0 coho varies from 0.2% to 11.2% from smolt years 1980 – 2025 (Figure 67b).

Productivity of wild sockeye salmon smolts from Auke Creek varies from 1619 to 33616, with an average productivity of 15147 from ocean entry years 1980 – 2026. In 2026 there were 9086 outmigrant smolts, the thirteenth lowest on record (Figure 67c). Escapement of wild sockeye salmon into Auke Creek has varied from 325 to 6123, with an average escapement of 2428 from return years 1980 – 2026. The 2026 season saw the third lowest escapement of sockeye salmon to Auke Creek with 607 returning adults (Figure 67d).

Marine survival of wild pink salmon from Auke Creek varies from 1.1% to 53.3%, with an average survival of 11.6% from ocean entry years 1980 – 2025 (Figure 67e). Marine survival for the 2025 ocean entry year was 9.8% and overall survival averaged 11.3% over the last 5 years and 12.6% over the last 10 years. 2026 saw the fourteenth lowest return of pink salmon to Auke Creek with 2677 returning adults (Figure 67f).

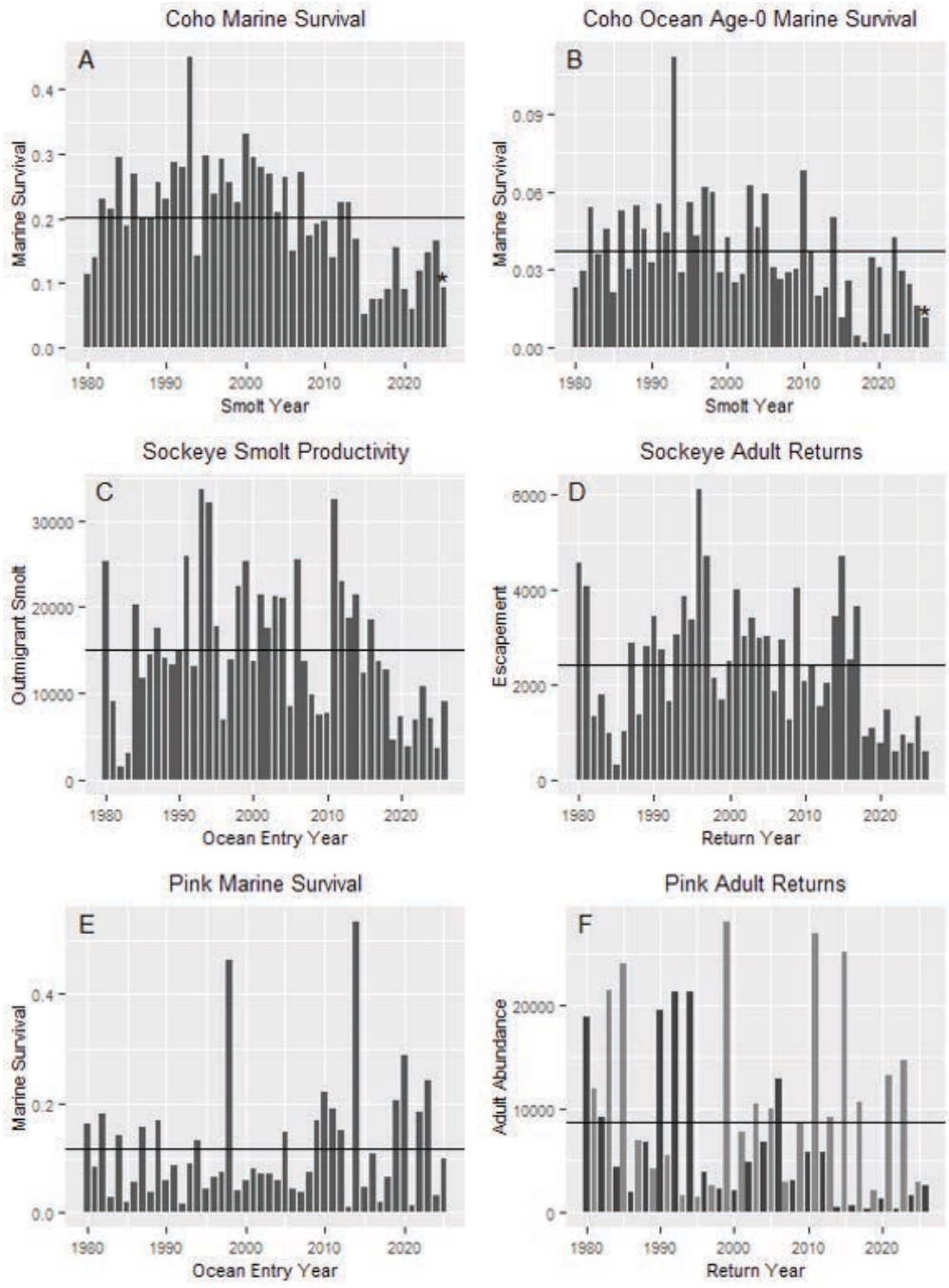


Figure 67: Auke Creek (SE Alaska) salmon marine survival and productivity indices. Coho salmon are represented by total marine survival (ocean age-0 and age-1 harvest plus escapement) (A), and percentage of ocean age-0 coho per smolt (escapement only) by smolt year (B). Sockeye salmon are represented by smolt productivity by ocean entry year (C) and adult returns (D). Pink salmon are represented by marine survival index, represented by ocean entry year (E) and adult returns by year (F). Return year 2026 data are denoted with an asterisk as these may change by the end of the year. For coho, sockeye and pink indices, the solid, horizontal line indicates the 1980 – 2026 average.

Factors influencing observed trends: Factors influencing observed trends in coho survival include: smolt age, smolt size, migration timing, fishery effort and location, and marine environmental conditions (Briscoe et al., 2005; Robins, 2006; Malick et al., 2009; Kovach et al., 2013*a*). Coho salmon marine survival is influenced by a number of life history parameters such as juvenile growth rate and size, smolt age, and smolt ocean entry timing (Weitkamp et al., 2011). Recent studies have shown that climate change has shifted the median date of migration later for juveniles and earlier for adults (Kovach et al., 2013*a*). The marine survival of Auke Creek coho reflects nearshore rearing productivity and, as such, is utilized to infer regional trends in coho salmon productivity as one of four indicator stocks utilized by the Alaska Department of Fish and Game to manage coho salmon over all of southeast Alaska (Shaul et al., 2011). The marine survival of Auke Creek coho salmon and growth inferred by scales samples is influenced and reflective of broad scale oceanographic indices in the GOA (Briscoe et al., 2005; Robins, 2006; Malick et al., 2009; Orsi et al., 2013).

Sockeye salmon marine survival has been influenced by trends that include: smolt age, smolt size, migration timing, predation, and marine environmental conditions. Age and size at saltwater entry, along with regional sea surface temperature have been shown to influence juvenile mortality at ocean entry (Yasumiishi et al., 2016). Within the Auke Creek watershed, a system undergoing rapid climatic change, climate-induced phenological shifts have been shown to influence a trend of later migration of sockeye adults and age-1.0 smolts, while age-2.0 smolts are trending earlier (Shanley et al., 2015; Kovach et al., 2013*a*). Additionally, positive effects of temperature have been observed on sockeye biomass and length of age-2.0 smolts in the Auke Creek system (Kovach et al., 2014). In Southeast Alaska, sablefish have been observed to prey upon juvenile sockeye in early summer before more abundant food resources become available (Sturdevant et al., 2009).

Factors that have influenced these observed trends in pink salmon survival include: migration timing, fishery effort and timing, predation, growth rates, maintained genetic variation, and stream conditions. Within the Auke Creek system, climate-induced phenological shifts have been shown to influence the trend of earlier migration of both the early and late run of pink adults, as well as juvenile fry migration (Kovach et al., 2013*b*; Shanley et al., 2015). The effect of fishing pressure on pink salmon has some obvious effects on marine survival, as well as, unapparent impacts including decreases in body weight, variations in length, increases in earlier-maturing fish, and increases in heterozygosity at PGM (Hard et al., 2008). As pink salmon are one of the most numerous and available food sources of larger migrating juvenile salmon and other marine species, their early marine survival can be heavily impacted by predation (Parker, 1971; Landingham et al., 1998; Mortensen et al., 2000; Orsi et al., 2013). One resistance to this predation is that pink salmon fry are able to quickly outgrow their main predators of juvenile coho and sockeye salmon and become unavailable as a food resource due to their size (Parker, 1971). During juvenile development, the local conditions of stream discharge and temperature are strong determinants of egg and fry survival. In addition, many of these influencing factors have been shown to have a genetic component that can strongly influence survival (Geiger et al., 1997; McGregor et al., 1998; Kovach et al., 2013*a*).

Implications: The marine survival index of coho, sockeye and pink salmon at Auke Creek is related to ocean productivity indices and to important rearing habitats shared by groundfish species. The productivity and escapement indices of Auke Creek salmon provide an opportunity for the examination of annual variation in habitat quality of rearing areas and general ocean conditions and productivity. Ocean age-0 coho leave freshwater in May through June and return in August through October, the same time sablefish are moving from offshore to nearshore habitats. In contrast, ocean age-1 coho salmon occupy those nearshore habitats for only a short time before entering the Gulf of Alaska and

making a long migratory loop. They return to the nearshore habitats on their way to spawning grounds after the first winter that age-0 sablefish spend in nearshore habitats. The relative growth and survival of ocean age-0 and age-1 coho salmon from Auke Creek may provide important proxies for productivity, overwintering survival of sablefish, and recruitment of sablefish to age-1. Within Southeast Alaska, sockeye salmon productivity and escapement are of great interest to the Pacific Salmon Commission with relation to the Transboundary and Northern Boundary areas and indices such as Auke Creek help in assessment. As a result of these implications, the productivity and escapement of Auke Creek sockeye salmon provide valuable proxies for Gulf of Alaska and Southeast Alaska productivity and may provide insight to the overwintering survival and recruitment of sablefish and other groundfish species. Due to the one ocean year life history of pink salmon, we are able to use their marine survival as a proxy for the general state of the Gulf of Alaska. Pink fry have been shown to be an important food resource for juvenile sablefish, making up a large percentage of their diet (Sturdevant et al., 2009, 2012). The growth and marine survival of Auke Creek pink salmon provide valuable proxies for Gulf of Alaska and Southeast Alaska productivity, as well as the overwintering survival and recruitment of sablefish.

Groundfish

Groundfish Condition

Contributed by Bianca Prohaska and Sean Rohan
Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, NOAA Fisheries
Contact: cecilia.oleary@noaa.gov
Last updated: September 2025

NOAA Fisheries' Gulf of Alaska Bottom Trawl Survey is conducted every other year. Please refer to the archives[38] for past reports.

ADF&G Gulf of Alaska Trawl Survey

Contributed by Carrie Worton, Alaska Department of Fish and Game, Kodiak, AK
Contact: carrie.worton@alaska.gov
Last updated: September 2026

Description of indicator: The Alaska Department of Fish and Game conducts an annual trawl survey for crab and groundfish in Gulf of Alaska targeting areas of crab habitat around Kodiak Island, the Alaska Peninsula, and the Eastern Aleutian Islands (Spalinger and Silva, 2024). Parts of these areas have been surveyed annually since 1984, with the most consistent time series beginning in 1988. The trawl survey uses a 400-mesh eastern otter trawl constructed with stretch mesh ranging from 10.2 cm in the body, decreasing to 3.2 cm in the codend. Constructed to sample crab, it can also reliably sample a variety of fish species and sizes, ranging from 15 cm to adult sizes, but occasionally capturing fish as small as 7 cm for some species. While the survey covers a large portion of the central and western GOA, results from Kiliuda and Ugak Bays (inshore) and the immediately contiguous Barnabas Gully (offshore) are generally representative of the survey results across the region (Figure 68).

In 2026, 50 stations were sampled from July 24 through July 2. The survey catches (mt/km) from Kiliuda and Ugak Bays and Barnabas Gully were summarized by year for selected species groups. Using a method described by (Link et al., 2002), standardized anomalies, a measure of departure from the mean catch (kg) per distance towed (km), were also calculated for selected species: arrowtooth flounder (*Atheresthes stomias*), flathead sole (*Hippoglosoides elassodon*), Tanner crab (*Chionoecetes bairdi*), Pacific cod (*Gadus macrocephalus*), skates, walleye pollock (*G. chalcogrammus*) and Pacific halibut (*Hippoglossus stenolepis*). Temperature anomalies were calculated using average bottom temperatures recorded for each haul from 1990 to 2026.

Status and trends: The catches of arrowtooth flounder, flathead sole, Pacific cod, Pacific halibut, skates, Tanner crab, and walleye pollock are all at or below the average anomaly values for both the

[38] https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands

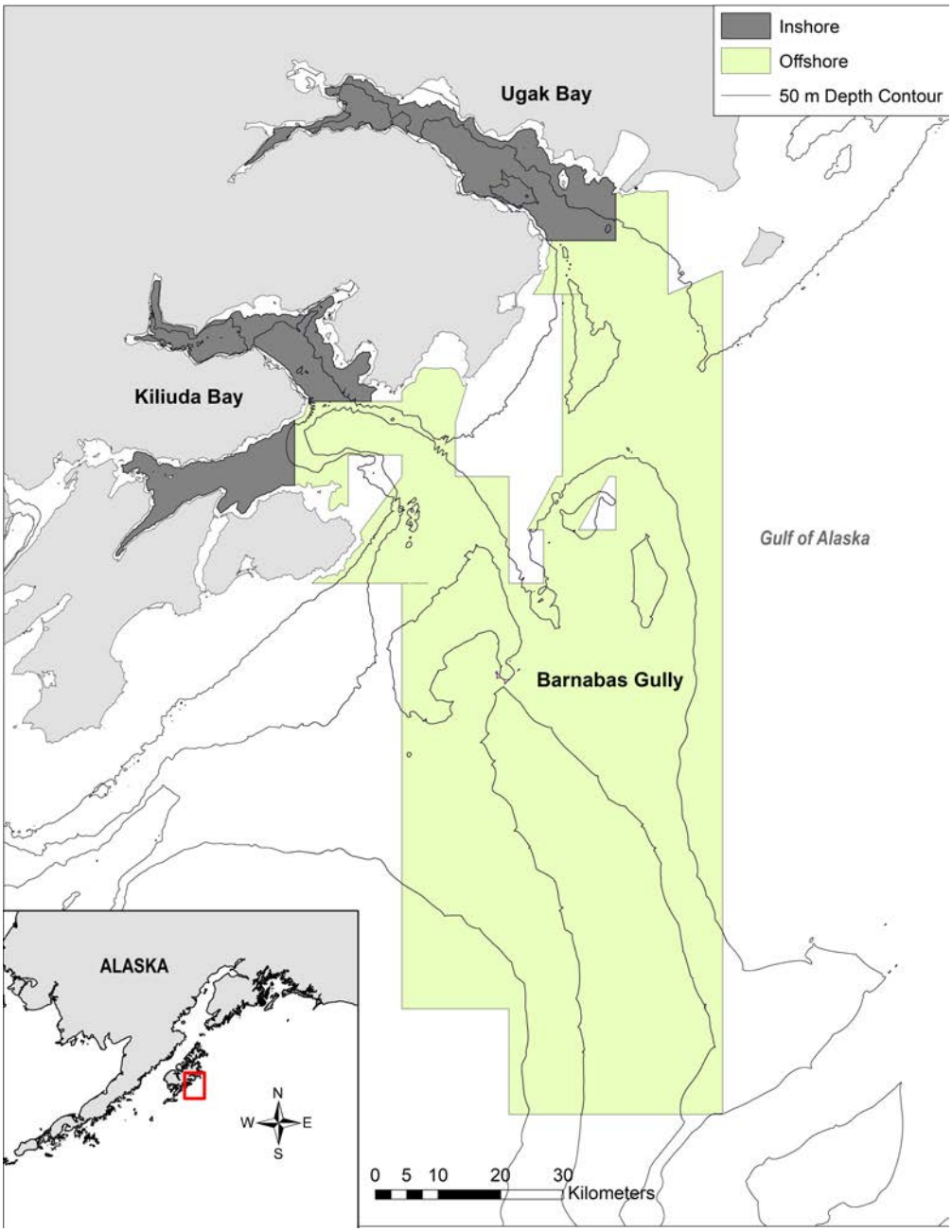


Figure 68: Kiliuda Bay, Ugak Bay, and Barnabus Gully survey areas used to characterize inshore (dark gray, 14 stations) and offshore (light gray, 36 stations) trawl survey results, Kodiak, Alaska.

inshore and offshore stations in 2026 (Figure 69). While Pacific cod made up 88% and walleye pollock 10% of the gadid catch in 1976-1977, catch compositions have reversed with Pacific cod making up 18.7% of catch, up from 17.6% in 2025, and walleye pollock at 81.3% in 2026, a slight decrease from 82.4% in 2025.

Prior to the start of our standard trawl survey in 1988, Ugak Bay was the subject of an intensive seasonal trawl survey in 1976 – 1977 (Blackburn, 1977). Today, the Ugak Bay species composition is markedly

different than in 1976. Red king crabs (*Paralithodes camtschaticus*) were the main component of the catch in 1976 – 1977 but now are nearly non-existent. Flathead sole, skate, and gadid catch rates have all increased roughly 10-fold.

A sharp decrease in overall biomass is apparent from 2007 to 2017 from the years of record high catches occurring from 2002 to 2005 (Figure 69). The 2026 survey data showed an increase in overall biomass in the offshore stations and a decrease in the inshore stations. Arrowtooth flounder have consistently been the predominant species in the ADF&G trawl survey catches at the offshore stations, with much lower catches in the inshore stations. In the last two years, flathead sole was the predominant species inshore. Gadids catches decreased in both inshore and offshore stations, while Tanner crab catches decreased significantly in the offshore stations and increased slightly in the inshore stations. Starfish show a continuing increase in biomass with *Pycnopodia helianthoides* (sunflower sea star) the predominant starfish species in both inshore and offshore stations. Increases in both biomass and numbers of *P. helianthoides* indicate this species may be recovering from the significant die off that started in 2014.

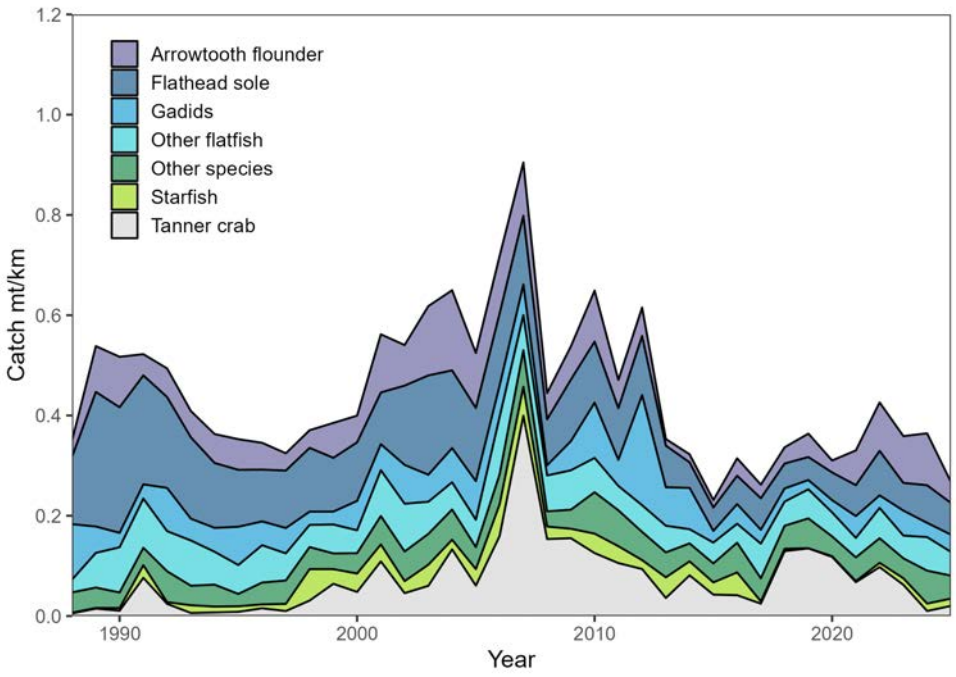
Summer temperature anomaly values for both inshore and offshore stations were below average in 2026 following a winter of colder-than-average temperatures [39] (see western GOA summer temperatures in this Report, p.51). While the higher-than-average temperature in past years frequently occurs during moderate and strong El Niño years. [40].

Factors influencing observed trends: It appears that significant changes in volume and composition of the catches on the east side of Kodiak are occurring, but it is unknown to what extent predation, environmental changes, and fishing effort are contributing. The lower overall catch from 1993 to 1999 (Figure 69) may reflect the greater frequency of El Niño events on overall production, while the period of less frequent El Niño events, 2000 to 2003, corresponds to years of increasing production and correspondingly higher catches. Lower than average temperatures were recorded from 2006 to 2009 along with decreasing overall abundances in 2008 and 2009. This may indicate a possible lag in response to changing environmental conditions or some other factors may be affecting abundance that are not yet apparent. Declines in Pacific cod abundance during the 2014 – 2016 period of the anomalously warm water event in the GOA were well documented (Barbeaux et al., 2020*a*; Suryan et al., 2021). Subsequent decreases in Tanner crab catches in 2026, from periods of high abundance, are likely influenced by natural mortality and increase in predation during years with the increasing abundance of Pacific cod, flathead sole, and halibut catches in recent years.

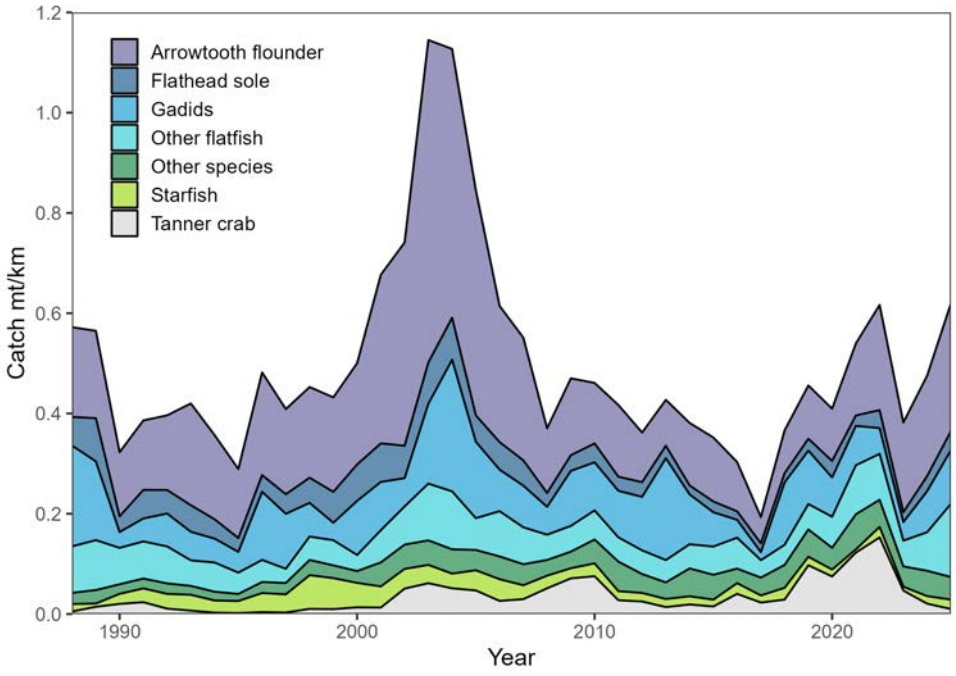
Implications: Although trends in abundance in the trawl survey appear to be influenced by major oceanographic events such as El Niño, local environmental changes, predation, movements, and fishery effects may influence species specific abundances. Monitoring these trends is an important process used in establishing harvest levels for state water fisheries. These survey data are used to establish guideline harvest levels of state managed fisheries and supply abundance estimates of the nearshore component of other groundfish species such as Pacific cod and pollock. Decreases in species abundance will most likely be reflected in decreased guideline harvest levels.

[39] https://www.weather.gov/arx/winter2526outlook)

[40] http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml



(a) Kiliuda and Ugak Bay



(b) Barnabas Gully

Figure 69: Total catch per km towed (mt/km) of selected species from Kiliuda and Ugak Bays (a) and Barnabas Gully (b) survey areas off the east side of Kodiak Island, 1988 – 2026.

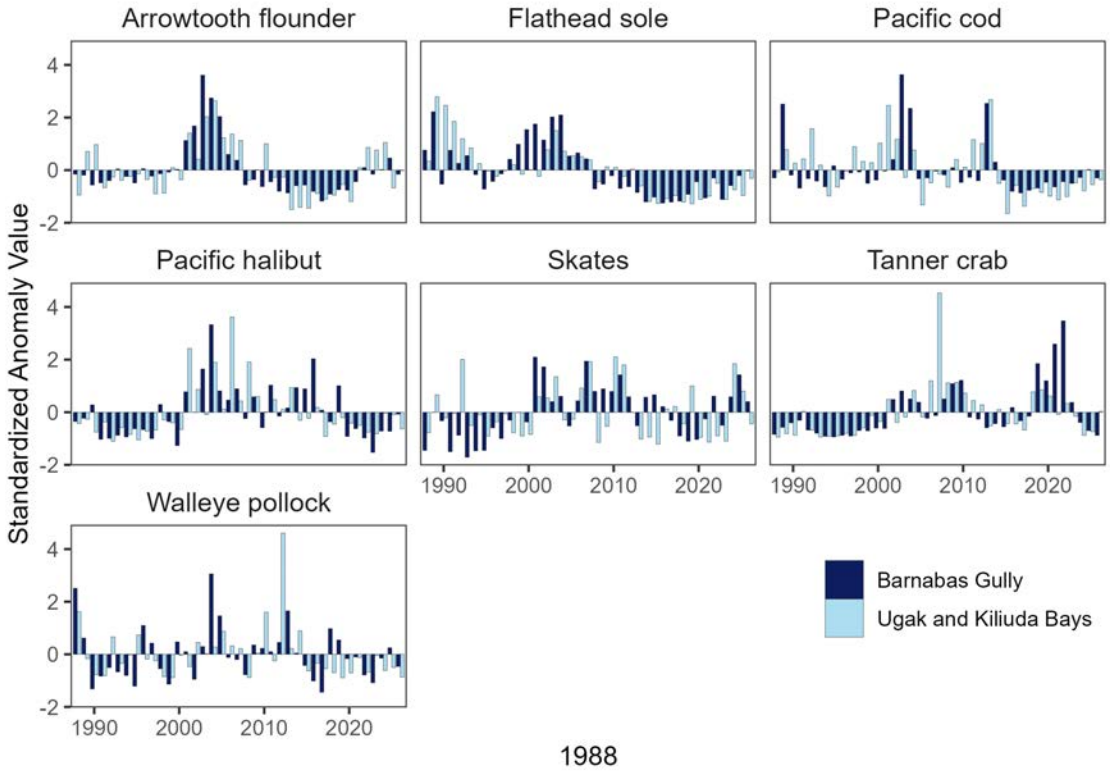


Figure 70: A comparison of standardized anomaly values, based on catch (kg) per distance towed (km) for selected species caught from 1988 – 2026 in Barnabas Gully and Kiliuda and Ugak Bays during the ADF&G trawl survey, Kodiak.

Distribution of Rockfish Species along Environmental Gradients

Contributed by Alexandra Dowlin and Ned Laman, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, NOAA Fisheries
Contact: Alexandra.Dowlin@noaa.gov

Last updated: October 2025

NOAA Fisheries' Gulf of Alaska Bottom Trawl Survey is conducted every other year. Please refer to the archives[41] for past reports.

Trends in Groundfish Biomass

Contributed by Sean Rohan[2], Matt Callahan[1], Lewis Barnett[2], Bridget Ferriss[3]
[1]Alaska Fisheries Information Network, Pacific States Marine Fisheries Commission
[2]Groundfish Assessment Program, Alaska Fisheries Science Center, NOAA Fisheries
[3]Resource Ecology and Fisheries Management, Alaska Fisheries Science Center, NOAA Fisheries
Contact: lewis.barnett@noaa.gov
Last updated: October 2025

Environmental Conditions Experienced by Groundfish

Contributed by Bridget Ferriss[1], Parkes Kendrick[2], James T. Thorson[1],
[1]Alaska Fisheries Science Center, NOAA Fisheries
[2]University of Washington
Contact: bridget.ferriss@noaa.gov
Last updated: October 2025

This contribution was not updated this year. Please refer to the archives[42] for past reports.

[41] https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands

[42] https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands

Summer Food Habits of Major Groundfish in the Gulf of Alaska

Contributed by: Kerim Aydin, Resource Ecology and Fishery Management Division, Alaska Fisheries Science Center, NOAA Fisheries
Contact: kerim.aydin@noaa.gov
Last updated: October 2026

Description of indicator: Stomachs of walleye pollock (*Gadus chalcogrammus*), Pacific cod (*Gadus macrocephalus*), arrowtooth flounder (*Atheresthes stomias*), Pacific ocean perch (POP, *Sebastes alutus*), sablefish (*Anoplopoma fimbria*), and Pacific halibut (*Hippoglossus stenolepis*) have been collected on the Alaska Fisheries Science Center's Gulf of Alaska (GOA) bottom-trawl shelf survey between 1990 – 2025; samples were preserved in formalin and prey contents identified to the lowest resolvable taxonomic category and weighed. To estimate diet proportions for the population, samples are stratified by length and survey stratum and weighted by the survey biomass for each length class and stratum and estimated ration for each size class. Ration for each predator was estimated using Von Bertalanffy growth functions fit to GOA age-length data for each predator. Ration at length was assumed to be fixed and did not vary by year, temperature or stomach content weights for this analysis; further, these ration estimates do not account for differences between predator and prey caloric densities. While these assumptions may obscure some consumption variability, these simplified common assumptions allow for summation of consumption across species. Collection, analysis, and stratification methods are described in Livingston et al. (2017) while ration estimation is described in Holsman and Aydin (2015). Ecosystem-level analysis (Gaichas et al., 2015) suggests that these six species account for approximately 60% of the total ecosystem consumption by upper trophic levels across the GOA, with the remaining consumption being by other groundfish (30%), marine mammals (8%) and birds (2%).

Status and trends: Total consumption by the six tracked species is shown in Figure 71. In 2021 and 2023, the two planktivorous species (walleye pollock and POP) consumed the greatest amount of food; however, in 2025 the consumption by POP dropped sharply, due to its biomass decline in the survey. Consumption by arrowtooth flounder is lower in recent years than in the early 2000s, but that consumption level is still significantly higher than for any other apex predator. Consumption by cod and halibut has been relatively stable in the most recent surveys; while sablefish consumption increased with its population increase in 2019 – 2021, that has dropped in 2023 – 2025.

The diets (proportion by weight) of the two planktivorous species is shown in Figure 72. Both species have diets dominated by euphausiids; the exception was 2017 when copepods were more prevelant. In 2025, consumption of copepods declined to its lowest level in the time series for both species. For POP, euphausiids were also low in 2025 diets, with diets instead consisting of a range of other plankton and fish.

The four groundfish top predators consumed a range of fish species (Figure 73). In 2025, pollock was a low proportion of all of these diets, particularly when compared to diets in the 1990s. The other forage fish species (within the "other fish" category) varied over time; in recent years, herring have been the single largest component of this category, followed by capelin. In 2023 – 2025, consumption of tanner crab was higher for Pacific cod and Pacific halibut than in previous years - there is very little tanner crab predation by arrowtooth flounder or sablefish in the diet database.

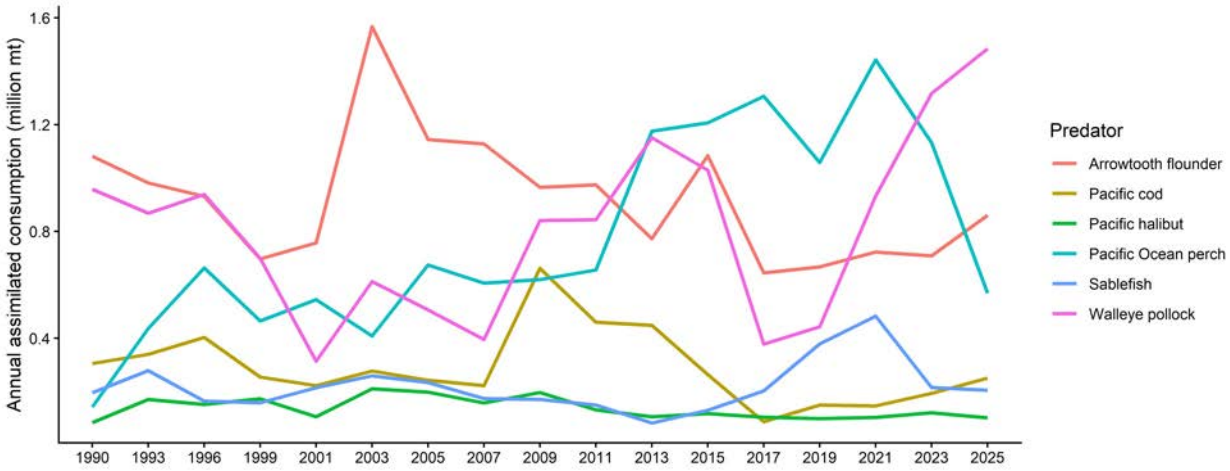


Figure 71: Total annual assimilated consumption by six major groundfish predators in the Gulf of Alaska, as calculated from bottom-trawl survey biomass-at-length and ration as estimated from fits of non year-specific GOA age-length data to Von Bertalanffy growth curves.

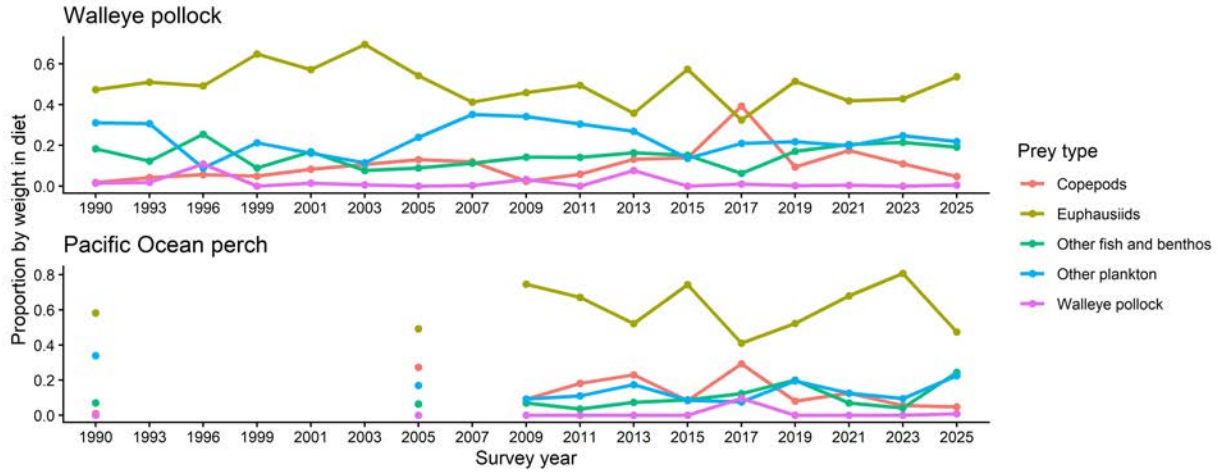


Figure 72: Percent by weight in diet of major prey types of walleye pollock and Pacific Ocean perch in the Gulf of Alaska, weighted by survey stratum and predator survey biomass in each stratum.

Factors influencing observed trends: When viewing population-level consumption across the entire GOA, shifts in diet proportion may come from changes in prey populations within a single strata; however, the shifts may also be due to changes in predator distribution between strata or differences in the size composition of the predator population as age classes with differing feeding ontogeny move through the ecosystem.

Implications: Changes in diet composition of fish may be an indicator of fish health condition, growth, or later recruitment, and may also signal potential changes in productivity that would come with longer-term climate change. In 2025, walleye pollock diets were relatively consistent with long-term averages; however, POP showed a decline in their preferred prey (euphausiids) along with an increase in diet diversity with both more fish and other plankton; this may indicate diet stress for POP. The relatively high amount of herring in diets between 2021 – 2025 may arise from their increase in the ecosystem

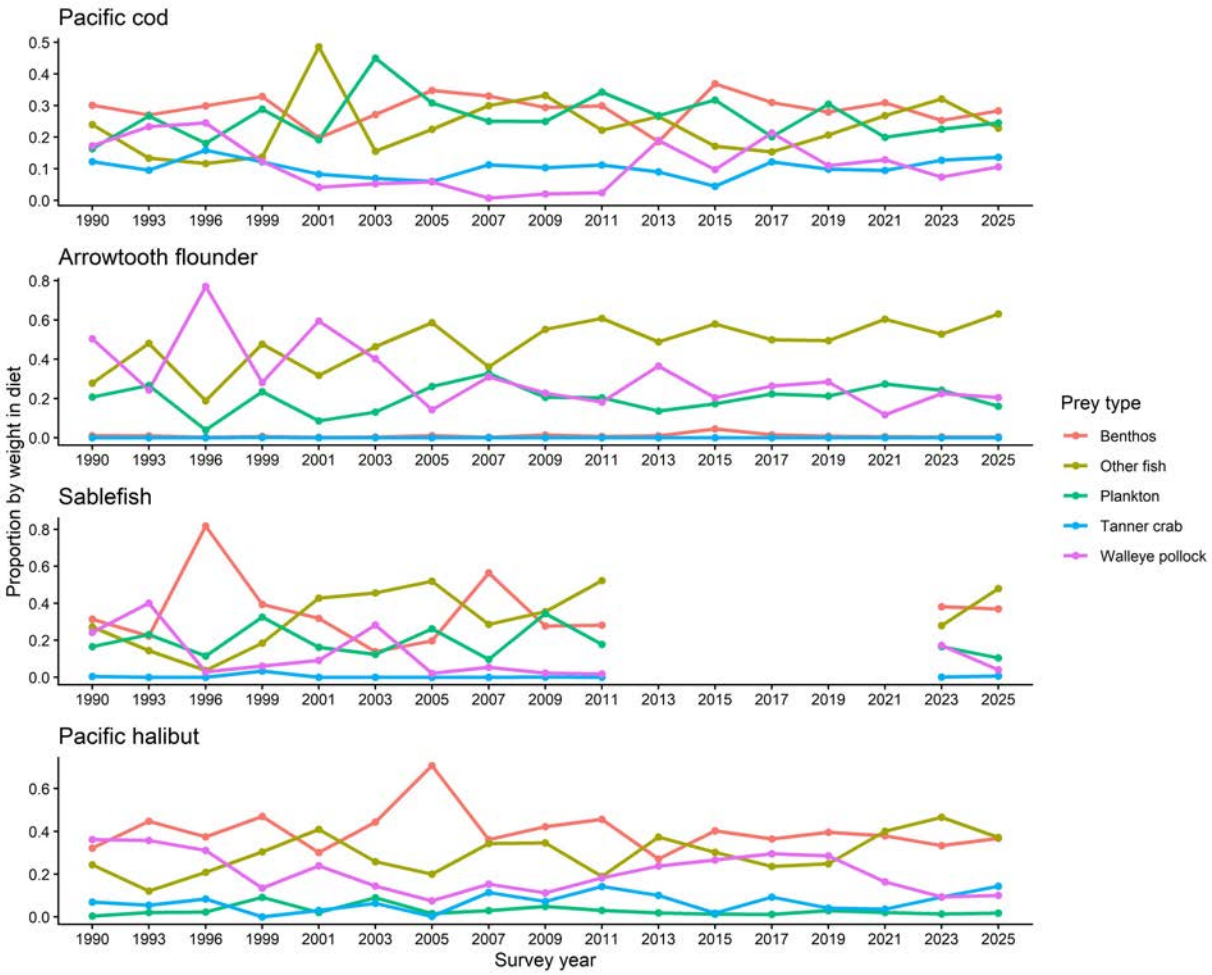


Figure 73: Percent by weight in diet of major prey types of Pacific cod, arrowtooth flounder, sablefish, and Pacific halibut in the Gulf of Alaska, weighted by survey stratum and predator survey biomass in each stratum.

overall. Recent (2023 – 2025) tanner crab consumption by Pacific cod and Pacific halibut may be an early indicator of the recruitment strength of incoming crab populations.

Benthic Communities and Non-target Fish Species

Miscellaneous Species — NOAA Bottom Trawl Survey

Contributed by Sarah Friedman and Alexandra Dowlin, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, NOAA Fisheries
Contact: sarah.friedman@noaa.gov
Last updated: October 2025

NOAA Fisheries' Gulf of Alaska Bottom Trawl Survey is conducted every other year. Please refer to the archives[43] for past reports.

Seabirds

Seabird Synthesis

Contributed by Daniel Cushing[1], Brie Drummond[2], Scott Hatch[3], Robert Kaler[4], Florence Sullivan[5], and Shannon Whelan[3]
[1]University of Alaska Fairbanks, Fairbanks, AK: dacushing@alaska.edu
[2]U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge: Contact: Brie_Drummond@fws.gov
[3]Institute for Seabird Research and Conservation; Contact: shatch.isrc@gmail.com
[5]U.S. Fish and Wildlife Service, Anchorage, Alaska; Contact: robert_kaler@fws.gov
[6]University of Washington, Coastal Observation and Seabird Survey Team; Contact: coasst@uw.edu
Last updated: October 2026

Summary Statement: Gulf of Alaska (GOA) seabird reproductive trends indicate above-average availability of forage fish and zooplankton, and spatially varying environmental conditions during the spring of 2026. Reproductive success was generally average to high across seabird groups and colonies (Chowiet Isl., Middleton Isl., and St. Lazaria Isl.), reflecting available fish and zooplankton prey resources (Figure 74). Spatially varying hatch timing may reflect different spring ocean temperatures between the western (cooler) and eastern (warmer) GOA (Figure 74). Notable exceptions include the low reproductive success of black-legged kittiwakes on Middleton Isl., potentially reflecting reduced capelin availability in their diets, and late hatch timing of pelagic cormorants on Middleton Isl. The distribution of seabirds observed on the Seward Line spring survey (central GOA cross shelf transect) expanded from 2025 to a broader use of the middle and outer slope, an indicator of more available prey. There was no large-scale

[43] https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands

mortality event recorded in 2026, a positive sign of adequate prey resources and lower environmental stress.

Reproductive success was above average for most fish-eating seabirds across Chowiet Isl., Middleton Isl., and St. Lazaria Isl (western to eastern GOA). Exceptions included pelagic cormorants (near average) and black-legged kittiwakes (average/below average) on Chowiet Is. and Middleton Isl. The availability of specific forage fish species may have varied across the western GOA, and with depth. and more myctophids and other offshore prey in the diets of black-legged kittiwakes on Middleton Isl. (see Arimitsu et al. in this Report, p.104). Elevated Sitka and Craig herring populations in southeast AK may have benefitted fish-eating seabirds on St. Lazaria Isl. (Smith et al. in this Report, p.111). On Middleton Isl. (central GOA), diving, fish-eating rhinoceros auklets had a good breeding year, relative to surface-oriented fish-eating black-legged kittiwakes. Kittiwakes increased use of offshore/slope areas south of the island with a diet dominated by myctophids. Rhinoceros auklets had higher occurrence of capelin in their diet, perhaps only available at deeper depths.

The positive success of plankton-eating seabirds across the GOA (including the highest breeding success of parakeet auklets on record at Chowiet Isl.) would indicate good availability of nutritious zooplankton in the spring. This is partially supported by the reporting of relative high euphausiid biomass along the central GOA Seward Line, yet low copepod biomass, relative to the time series (starting 1998) (Hopcroft in this Report, 93). A relatively higher biomass of larvaceans was observed along the Seward Line, potentially benefitting forage fish populations (and indirectly fish-eating seabirds) in that region. Low pink salmon returns to the GOA in 2026 may have released competition pressure on zooplankton biomass, to the benefit of planktivorous seabirds (Whitehouse in this report, p.120, Vulstek in this report, p.132).

Hatch timing was variable across the three colonies and groups of seabirds. The plankton-eating seabirds' mean hatch date was generally later than average in the western GOA (Chowiet Isl.) and earlier than average in the eastern GOA (St. Lazaria Isl.). The spatial differences in hatch timing may reflect the cooling of sea surface temperatures in the western GOA in the winter/spring of 2026, and the persistence of warmth in southeast Alaska (see Ocean Temperature Synthesis, p.41). The early spring hatch timing in the eastern GOA could reflect earlier phenology in the lower trophic levels (earlier onset of stratification, earlier spring bloom, zooplankton phenology) that can occur in warm winter/spring ocean conditions in the GOA.

Implications for groundfish include sufficient to good zooplankton prey for juvenile groundfish and adult Pacific ocean perch, walleye pollock, dusky rockfish. In addition, adequate but diverse forage fish prey are available to pre-recruit sablefish, Pacific cod, arrowtooth flounder, and other fish-eating groundfish.

Description of indicator: Seabirds are sensitive indicators of changes in the productivity of marine ecosystems, and their populations can signal processes affecting the availability of prey for commercial fish stocks (Warzybok et al., 2018). From field data and observations collected by government, university and non-profit partners, we provide a summary of the best available data on seabird productivity in the Gulf of Alaska in 2026. We forefront environmental impacts on seabirds (e.g., heatwaves) and interpret changes in seabird mortality, attendance, and reproduction as a reflection of ecosystem productivity and prey availability (Koehn et al., 2021).

Seabirds represent different aspects of prey resources, depending on species-specific life histories and foraging characteristics. The three seabird colonies summarized in this section span the Gulf of Alaska shelf from west (Chowiet Isl.), central (Middleton Isl.), to east (St. Lazaria Isl.). Seabird diet data,

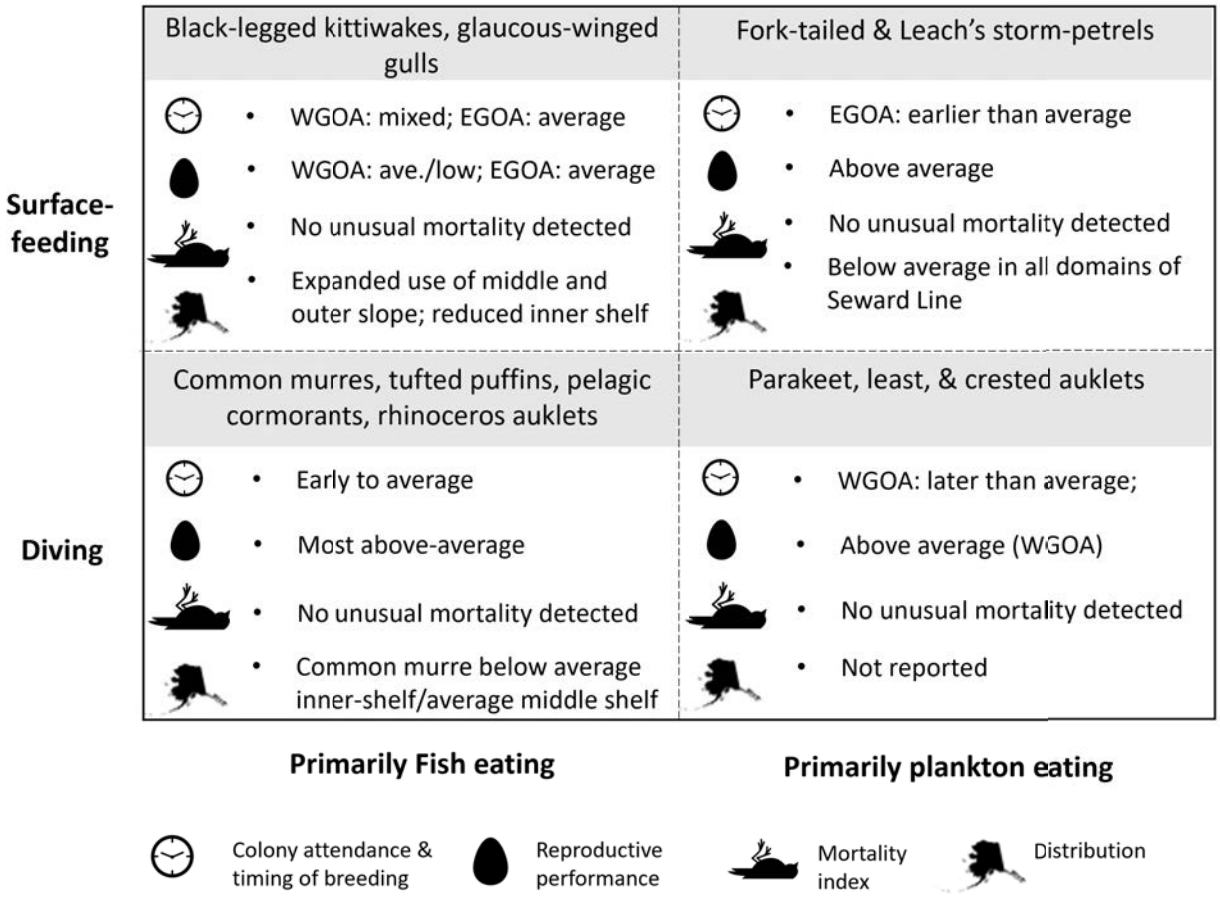


Figure 74: Summary of 2026 indicators for timing of breeding, reproductive performance, mass mortality events, and distribution of seabird feeding guilds (surface-feeding and diving, fish and plankton-eating) in the Gulf of Alaska.

relevant to reproductive success and timing and distribution, are presented in the Seabird-Derived Forage Fish Indicators chapter of this Report (Arimitsu et al., p.104).

In this synthesis, we divide seabirds by preferred prey: fish or plankton, and foraging location: deep or surface because each group responds to a different part of the ocean ecosystem. To describe the status of seabird groups we use three types of information that represent different spatial and temporal scales of seabird responses:

1. **Breeding timing** can represent conditions prior to breeding and/or phenological variation in the environment. Birds arriving to breed at a later date can reflect poor winter and/or spring foraging conditions, or later peaks in ocean productivity. This metric is defined as the mean hatch date and uses data provided from USFWS and Middleton Isl.

2. **Reproductive success** which can represent food availability around the colony during the breeding season (summer), with a lower number of fledged chicks generally reflecting lower local abundance of high-quality prey. Early laying/hatching (good forage conditions) followed by low chick production (poor forage conditions) might reflect a decrease in food availability from spring to summer. Rhinoceros auklets can represent a broader spatial range of foraging conditions, given their ability

to dive and broad foraging range. Kittiwakes have more variable reproductive performance in response to short-term environmental fluctuations, while murres have more consistent breeding patterns, indicative of broader foraging conditions and more extreme events. This metric is defined as the following:

- The ratio of fledged chicks to eggs for murres, auklets, puffins, and storm-petrels (USFWS)
- The ratio of nests producing fledglings to nests for black-legged kittiwakes (USFWS)
- Chicks fledged per laying pair for pelagic cormorants on Middleton Isl.
- Late-stage chicks per egg for rhinoceros auklets on Middleton Isl.

3. **Mortality** which gives insight into environmental and ecosystem impacts beyond breeding colonies and the breeding season. Unusual mortality events in the Gulf of Alaska have been linked to declines in prey abundance and quality during recent marine heatwaves (Piatt et al., 2020).
4. **Distribution** which provides area-specific and season-specific index of use as a function of physical environmental drivers that affect the characteristics of the habitat and influence the distribution and availability of prey.

Status and trends:

Primarily fish-eating, surface feeding seabirds: Fish-eating, surface feeding seabirds in the Gulf of Alaska include black-legged kittiwakes *Rissa tridactyla* and glaucous-winged gulls *Larus glaucescens*. These species feed on small schooling fish that are available at the surface (e.g., sand lance, sablefish, capelin and herring), making them potential indicators of processes affecting juvenile groundfish that migrate to the surface to feed.

Breeding timing: *Breeding timing ranged from very early to very late in the western GOA and was average in the eastern GOA in 2026*. In the western GOA (Chowiet Isl. and Middleton Isl.), hatch dates for black-legged kittiwakes ranged from slightly earlier than average (Chowiet Isl., baseline 1990 – 2025) to almost one standard deviation earlier than average (Middleton Isl., baseline 1996 – 2025) (Figure 75). Mean hatching date for Middleton Isl. black-legged kittiwakes was June 28 in 2026, same as 2025, and earlier than 2024. Hatch dates for glaucous-winged gulls on Chowiet Isl. were greater than one standard deviation later than the time series average (baseline, 1990 – 2025), tying 2011 for the latest date in the time series. Hatch timing for glaucous-winged gulls on St. Lazaria Isl. (eastern GOA) remained approximately average (baseline 1996 – 2024, no data collected in 2025) (Figure 76).

Reproductive success: *Reproductive success ranged from very low (Middleton Isl.) to average (Chowiet Isl.) in 2026*. Black-legged kittiwakes (Chowiet Isl.) continued a second year of approximately average reproductive success in 2026 (baseline 1990 – 2025) (Figure 77). Naturally foraging kittiwakes on Middleton Isl. had low breeding productivity (0.39 chicks fledged per pair; Figure 77), which was the lowest success since 2018. The decrease was possibly due to the reduced proportion of energy-rich capelin *Mallotus villosus* in their diets and high reliance on oceanic prey during the chick-rearing period. Reproductive success for glaucous-winged gulld on St. Lazaria Isl. (eastern GOA) was approximately average in 2026 (Figure 78).

Distribution: *Average middle-shelf use; increased use of the outer shelf/oceanic domain; variable but long foraging distances*. Along the Seward line transect, in the northern Gulf of Alaska, black-legged kittiwake densities in spring 2026 were below average on the inner shelf, average on the middle shelf, above average on the outer shelf, well above average in the oceanic domain. The above-average densities

on the outer shelf and outer domain were at time series high in 2024, below average in 2025, and back to above average in 2026 (Figure 81c). In contrast, they were most abundant on the inner shelf in 2023 and 2025. This parallels recent biennial variability in diets of kittiwakes nesting at Middleton Island. Historical GPS-tracking shows that kittiwakes tagged on Middleton Isl. tended to forage close to the island when capelin were abundant prior to the heatwave, then expanded their foraging range during and after the heatwave (Osborne et al., 2020). In 2026, GPS tracking showed variable but generally long foraging distances. In spring, kittiwakes used almost exclusively oceanic and slope foraging habitat; use of the neritic shelf increased over the summer, however with continued high use of oceanic/slope habitat.

Mortality: *No large-scale mortality event was recorded in the western GOA in 2026.* No large-scale mortality event was recorded based on beach surveys in the Western Gulf of Alaska in 2026 (Figure 80). On Middleton Island, black-legged kittiwakes were observed exhibiting symptoms consistent with avian botulism. This disease was first documented on the island in 2021 and has been observed every year since then, however fewer birds have been affected since the larger 2021 – 2022 die-offs.

Primarily fish-eating, diving seabirds: Fish-eating, diving seabirds in the Gulf of Alaska include common murres *Uria aalge*, rhinoceros auklets *Cerorhinca monocerata*, tufted puffins *Fratercula cirrhata* and pelagic cormorants *Urile pelagicus*. The status of this group is impacted by changes in the availability of small, schooling fish up to $\sim$ 90 m (300 feet) below the surface, making them potential indicators of feeding conditions that may affect fish-eating groundfish species.

Breeding timing: *Hatch timing was average in Chowiet Isl. and Middleton Isl, except later for pelagic cormorants; hatch timing was average/early in St. Lazaria Isl.* Mean hatch dates of common murres (July 20), thick-billed murres (July 21), horned puffins (July 28), and tufted puffins (July 22) were approximately average relative to their species-specific baselines on Chowiet Isl (Figure 75). The mean hatch date of common murres returned closer to the average timing, relative to increased from the previous 5 years of early hatch dates near or below 1SD below average (baseline 1990 – 2025). On Middleton Isl., the mean hatching date of rhinoceros auklets (June 21) was near-average, while the mean hatching date of pelagic cormorants (July 4) was one standard deviation later than average in 2026 (Figure 75). In the eastern GOA (St. Lazaria Isl.) common murres increased their hatch date to approximately average (baseline 1996 – 2024; no data in 2025) and rhinoceros auklets hatch times were earlier than average (Figure 76).

Reproductive success: *Reproductive success was above-average for all species and regions except pelagic cormorants on Middleton Isl.(approximately average) in 2026.* In the western GOA, the reproductive success of common murres, thick-billed murres, horned puffins, and tufted puffins on Chowiet Isl, and rhinoceros auklets on Middleton Isl., were above average in 2026 (Figure 77). Horned puffins continue to exhibit alternating higher and lower reproductive success (2026 was a higher year). Breeding success of rhinoceros auklets was above average on Middleton Island in 2026, which was the first above-average breeding success since 2021. Breeding success of pelagic cormorants was near-average (Figure 77). In the eastern GOA, common murres had above-average reproductive success and thick-billed murres were one standard deviation above average on St. Lazaria Isl. (baseline 1994 — 2024; no data collected in 2025; Figure 78).

Mortality index: *No large-scale mortality event was recorded in 2026.* No large-scale mortality event was recorded based on beach surveys in the Western Gulf of Alaska in 2026 (Figure 79).

Distribution: *Common murres densities were below average (inner shelf) to average (middle shelf)*

along Seward Line). Densities of common murres along the Seward Line in spring 2026 continued to be below average on the inner shelf and increased to average on the middle shelf (Figure 81b). Murres were absent from the middle shelf in 2025 after reaching a 9 year high in 2024.

Primarily plankton-eating seabirds: Plankton-eating seabirds in the Gulf of Alaska include surface-feeding species such as Leach's and fork-tailed storm-petrels (*Hydrobates leucorhous*, *Hydrobates furcatus*), and diving species such as least auklets (*Aethia pusilla*), crested auklets (*Aethia cristatella*), and parakeet auklets (*Aethia psittacula*). The status of these groups is impacted by changes in zooplankton production, making them potential indicators of feeding conditions that may affect planktivorous groundfish species, including the larvae and juveniles of fish-eating species.

Breeding timing: *Breeding timing ranged from very late (western GOA) to average/very early (eastern GOA).* In the western GOA, Parakeet auklets breeding timing increased to one standard deviation later than average on Chowiet Isl. (baseline: 2002 – 2025; Figure 75). In the eastern GOA (St. Lazaria Isl.), fork-tailed storm-petrel timing was one standard deviation earlier than average (June 15), a fourth year of earlier than average breeding timing (2022 – 2026, but no data collected in 2025) while Leach's storm-petrels had approximately average timing (July 27, baseline 1996 – 2024; no data collected in 2025) (Figure 76).

Reproductive success: *Reproductive success was above average for plankton-eating seabirds in 2026.* In the western GOA (Chowiet Isl.), the reproductive success of parakeet auklets continued three years at approximately one standard deviation greater than average (baseline: 1998 – 2025) (Figure 77). In eastern GOA, earlier breeding St. Lazaria fork-tailed and later breeding Leach's storm-petrels were approximately one standard deviation above average (baseline starting in 1994 and 1995 respectively) (Figure 78).

Mortality index: *No large-scale mortality event was recorded in 2026.* No auklet carcasses were observed during beached bird surveys in 2026. Parakeet auklets *Aethia psittacula*, were last observed in beached bird surveys in 2023, in abundances not suggestive of unusual/elevated mortality. Crested auklets last appeared dead on beaches, 2015 – 2016, following the marine heatwave; no least auklets have been found in the Gulf of Alaska since monitoring was established (2006).

Distribution: *Continued below-average densities throughout Seward Line.* Densities of fork-tailed storm-petrels along the Seward Line in spring 2026 were below average in all domains, similar to 2025 (Figure 81d). In addition to storm-petrels, densities of other species of tubenoses were also low in 2026. Densities of total tubenoses were well below average in all domains, and northern fulmars were nearly absent.

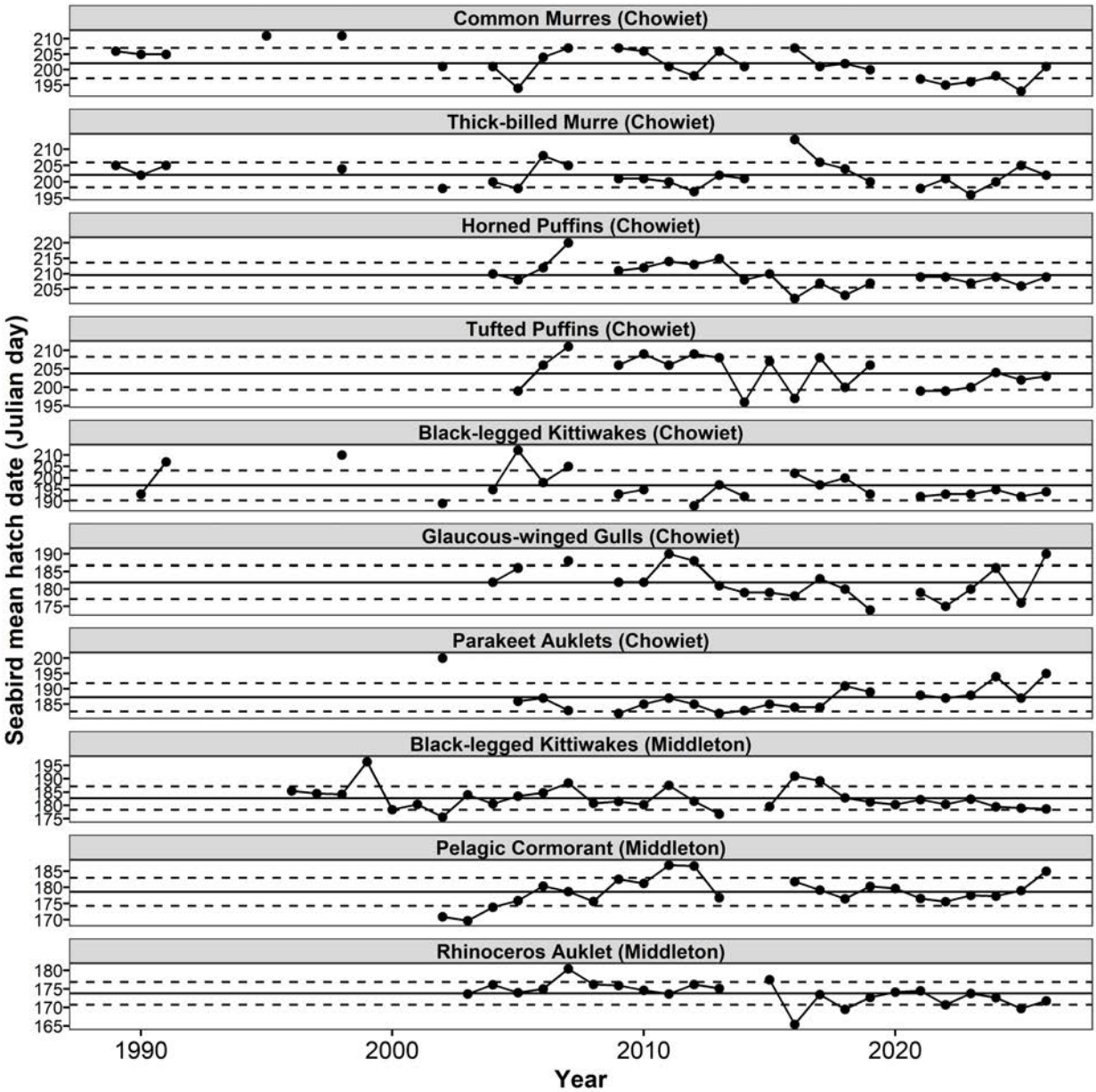


Figure 75: Reproductive timing of western Gulf of Alaska piscivorous (common murres, thick-billed murres, horned puffins, tufted puffins, black-legged kittiwakes) and planktivorous (parakeet auklets) seabird species on Chowiet Isl. and Middleton Isl. The solid line is the long-term average, and the dashed lines are $\pm$ 1 SD. Data provided by the U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge and the Institute for Seabird Research and Conservation.

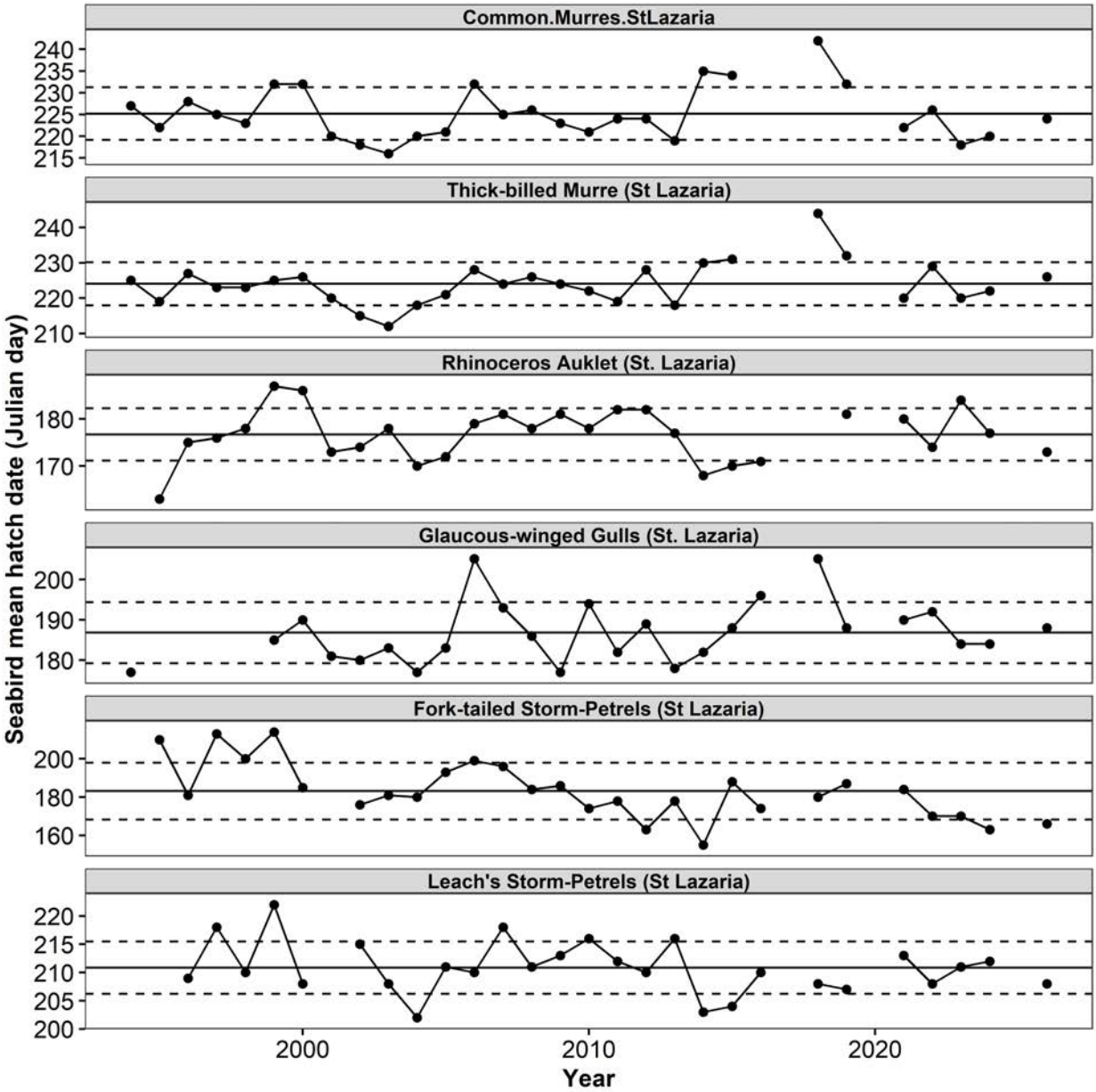


Figure 76: Reproductive timing of eastern Gulf of Alaska piscivorous (common murres, thick-billed murres, rhinoceros auklets, glaucous-winged gulls) and planktivorous (fork-tailed storm-petrels, Leach's storm-petrels) seabird species on St. Lazaria Isl. The solid line is the long-term average, and the dashed lines are $\pm$ 1 SD. Data provided by the U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge.

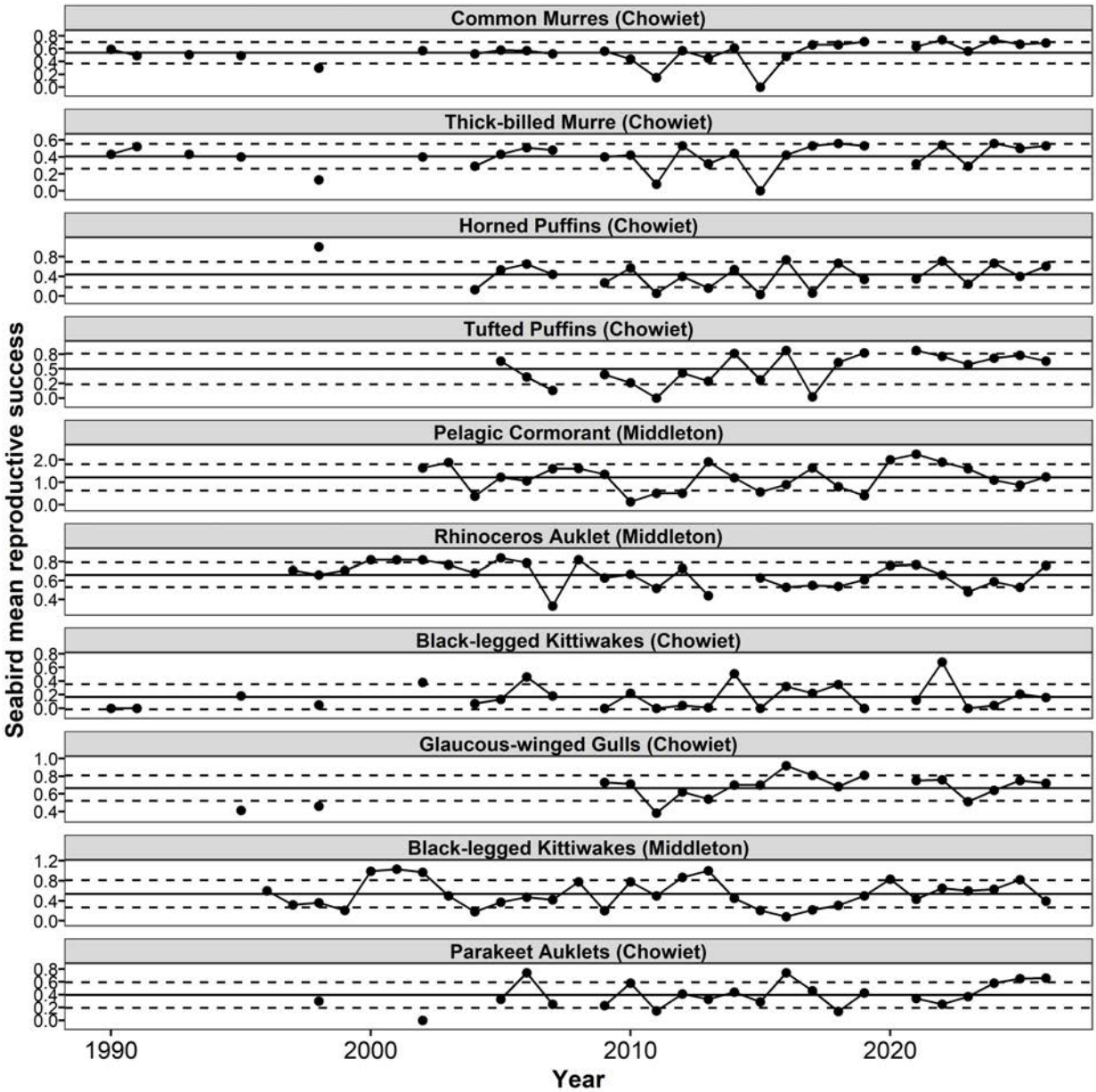


Figure 77: Reproductive success of western Gulf of Alaska piscivorous (common murres, thick-billed murres, horned puffins, tufted puffins, pelagic cormorants, rhinoceros auklets, black-legged kittiwakes) and planktivorous (parakeet auklets) seabird species on Chowiet Isl. and Middleton Isl. The solid line is the long-term average, and the dashed lines are $\pm$ 1 SD. Data provided by the U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge and the Institute for Seabird Research and Conservation.

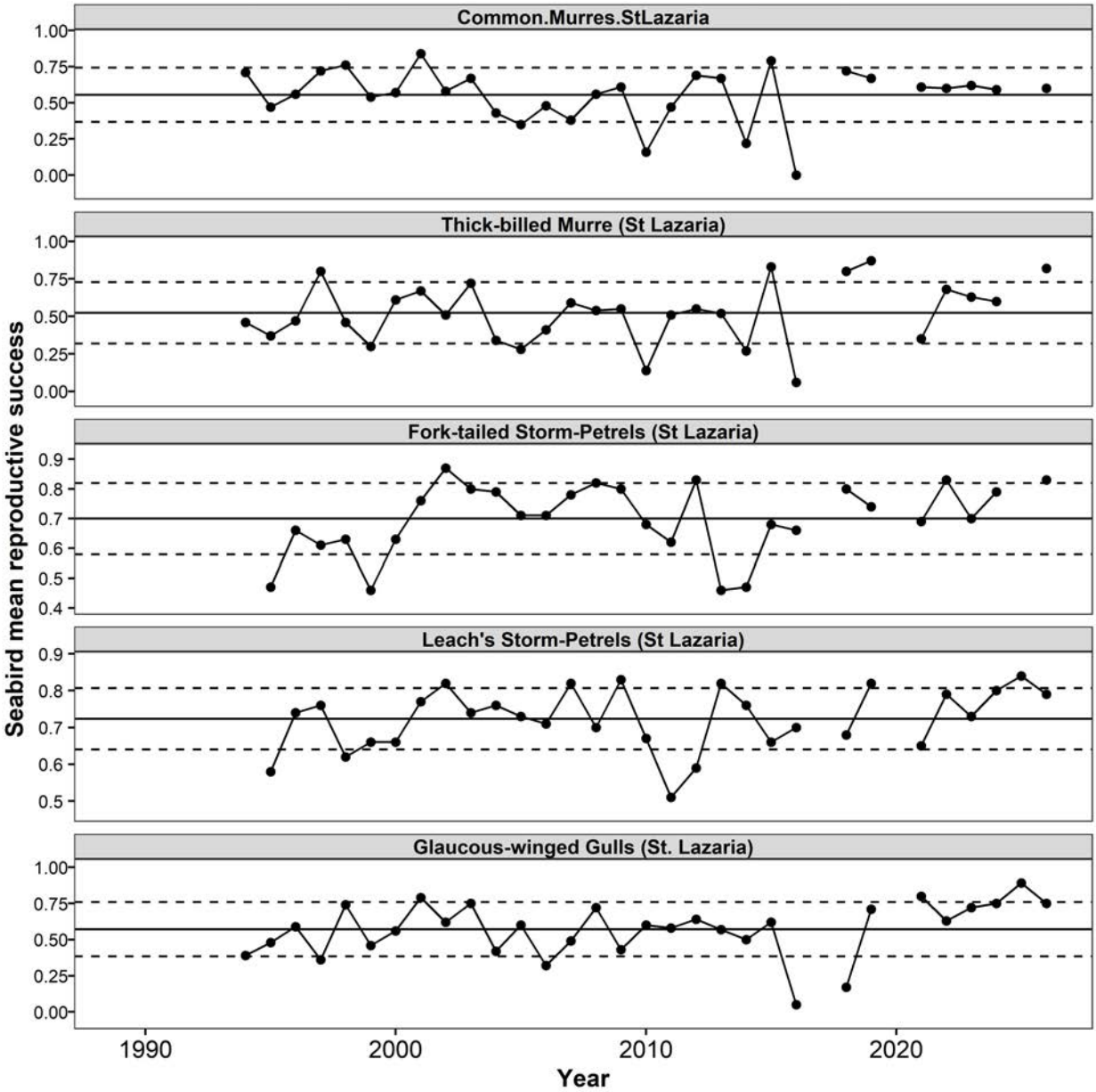


Figure 78: Reproductive success of eastern Gulf of Alaska, piscivorous (common murres, thick-billed murres) and planktivorous (fork-tailed storm-petrels, Leach's storm-petrels) seabird species on St. Lazaria Isl. The solid line is the long-term average, and the dashed lines are $\pm$ 1 SD. Data provided by the U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge.

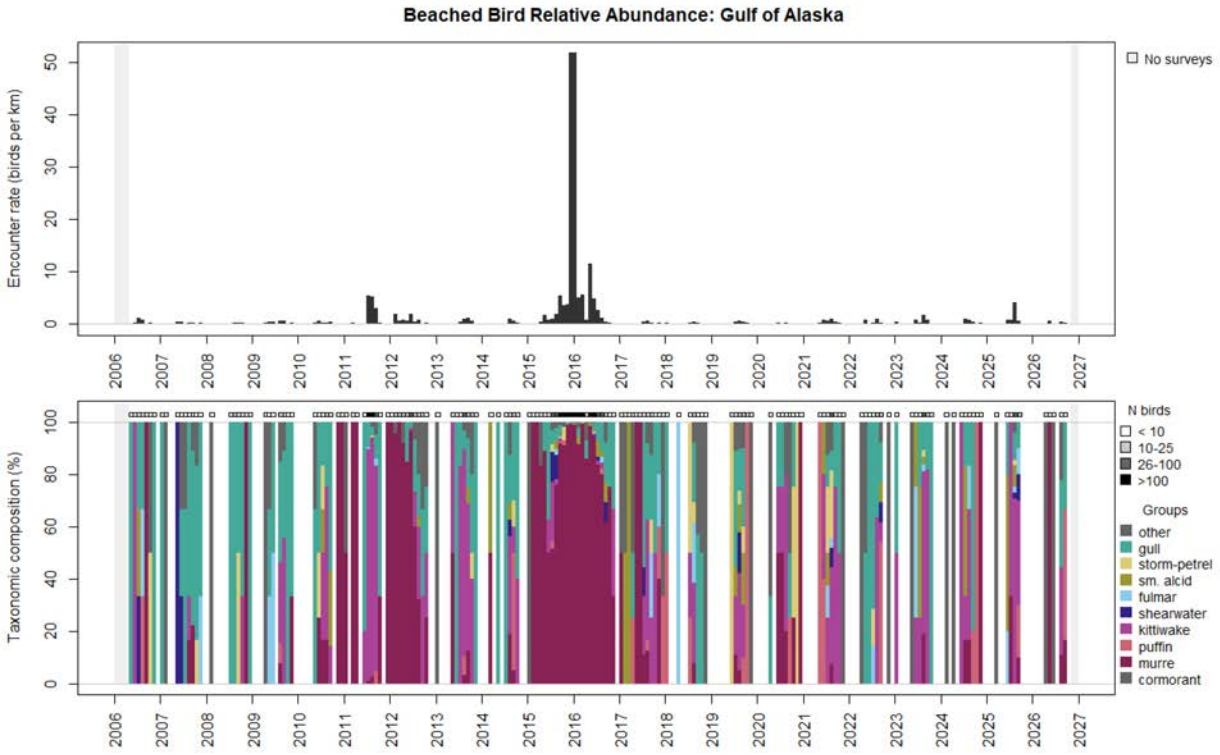


Figure 79: The relative abundance of beached birds encountered per km of beach surveyed by citizen scientists in the Gulf of Alaska. Data indicate regional trends but are biased toward more accessible beaches in areas of higher human population density. Light gray shading indicates time periods when surveys were not performed. Figure provided by the Coastal Observation and Seabird Survey Team.

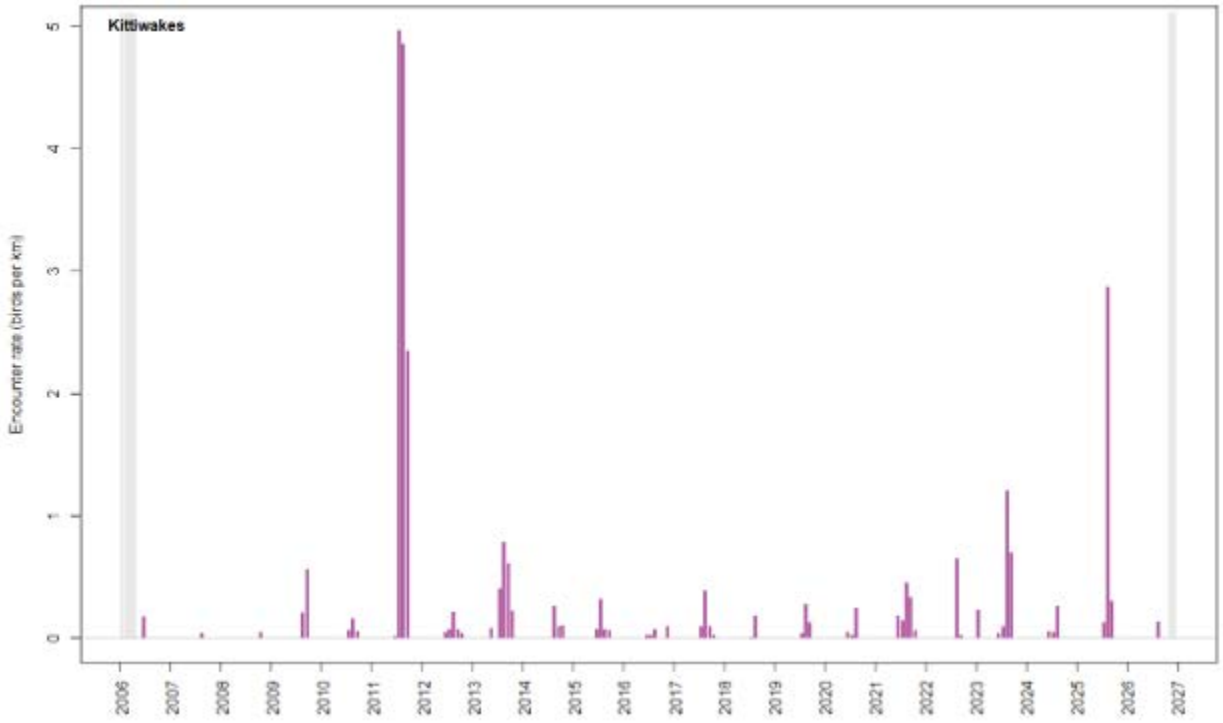


Figure 80: The number of black-legged kittiwakes (primarily fish-eating, surface feeding) encountered per km of beach surveyed by citizen scientists in the Gulf of Alaska. Data indicate regional trends but are biased toward more accessible beaches in areas of higher human population density. A single day hyper-local wreck event in Homer Alaska is reflected in the August 2025 encounter rate. Light gray shading indicates time periods when surveys were not performed. Figure provided by the Coastal Observation and Seabird Survey Team (COASST), October 2026.

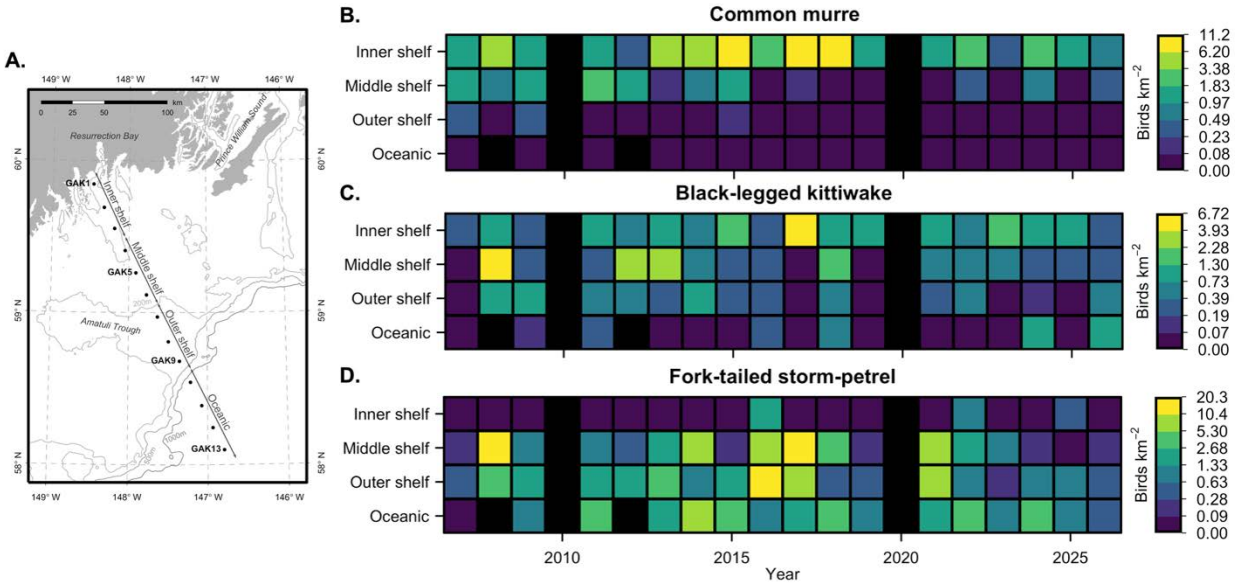


Figure 81: The spring Seward Line in the Northern Gulf of Alaska, and four domains used for analysis (A). Mean densities (birds km^{-2}) of common murres, black-legged kittiwakes, and fork-tailed storm-petrels within domains during spring Seward Line cruises, 2007 – 2026 (B-D). Black indicates no seabird surveys were conducted. Figure provided by University of Alaska, Fairbanks, and US Fish and Wildlife Service, Migratory Birds – Alaska.

Methods:

- The Coastal Observation and Seabird Survey Team (COASST) Monitoring by the Coastal Observation and Seabird Survey Team (COASST) and regional partners provides a standardized measure of relative beached bird abundance. Carcass identifications are verified using collected measurements and photographs. Basic data (carcass count, identity and condition information) are used to create a baseline (long-term normal) against which unusual events can be compared. Surveys began in the Gulf of Alaska in 2006, and since that time, 5536 surveys have taken place across 114 beaches, and 167 surveys took place across 40 beaches in 2026. Most surveys were conducted on the Kenai Peninsula, but sites on Kodiak Island, Shelikof Strait and Chowiet Island were also surveyed. Detailed methods for beach bird surveys can be found in Jones et al. (2019).
- The Institute for Seabird Research and Conservation (ISRC) The Institute for Seabird Research and Conservation (ISRC) provided data on breeding timing and/or reproductive performance of pelagic cormorants, rhinoceros auklets and black-legged kittiwakes on Middleton Island. These data have been collected since the mid-1990s, including an experiment involving feeding a group of kittiwakes to highlight the effect of food availability on the reproductive performance of wild-foraging birds.
- USFWS Migratory Birds We used vessel-based seabird surveys conducted as a component of multidisciplinary sampling of the Seward Line, during spring (typically the first 10 days of May), 2007 – 2026, to examine cross-shelf distribution of three selected seabird species representative of their foraging guild: common murre (diving, primarily feed on forage fish during the summer breeding season but also feed on small nektonic invertebrates such as euphausiids and squid, especially during the non-breeding period), black-legged kittiwake (surface-feeding, primarily feed forage fish and other small nektonic invertebrates, with a higher proportion of fish during the breeding season) and fork-tailed storm-petrel (surface feeding, primarily feed on zooplankton and ichthyoplankton, also small fish). Seabird surveys were conducted while the vessel was underway using USFWS survey protocol and subsequently divided into $\sim$ 3 km transects for analysis. For each year, transects within 10 km of each of the 13 stations along the Seward Line were used to calculate densities (birds km^{-2}) for each species within each station-centered cell; these station-centered values were then averaged within each of 4 domains (Inner shelf, Middle shelf, Outer shelf, Oceanic). We considered observations within the lowest decile of the data to be "well below average", the lowest tercile to be "below average", the middle tercile to be "near average", the upper tercile to be "above average" and the upper decile to be "well above average".
- The Alaska Maritime National Wildlife Refuge has monitored seabirds at colonies around Alaska in most years since the early to mid-1970's. Time series of annual breeding success and phenology (and other parameters) are available from over a dozen species at eight Refuge sites in the GOA, Aleutian Islands, and Bering and Chukchi Seas. Monitored colonies in the GOA include Chowiet (Semidi Islands), East Amatuli (Barren Islands), and St. Lazaria (southeast Alaska) islands.

Marine Mammals

Trends in Humpback Whale Calving in Glacier Bay and Icy Strait

Contributed by Christine M. Gabriele, Janet L. Neilson, Piper D. Bishop, and Dana F. Bloch, Glacier Bay National Park and Preserve, Gustavus, AK 99826
Contact: chris_gabriele@nps.gov
Last updated: September 2026

Description of indicator: Humpback whale (*Megaptera novaeangliae*) reproductive success in Glacier Bay and Icy Strait can be considered an indicator of changes in prey quantity and/or quality available for groundfish in the eastern Gulf of Alaska because groundfish and humpback whales target the same lipid-rich prey i.e., forage fish and euphausiids.

Annually since 1985, Glacier Bay National Park biologists have used consistent methods and levels of effort from June 1 – August 31 to photographically identify individual humpback whales and document reproduction in Glacier Bay and Icy Strait (Gabriele et al., 2017). We match photographs of the flukes and dorsal fin of each whale to curated catalogs of identified individuals. We document the reproductive status and survival of Glacier Bay and Icy Strait whales when they are elsewhere in the North Pacific using the collaborative Southeast Alaska Database maintained by Glacier Bay National Park and the University of Alaska Southeast Sitka as well as the Happywhale.com automated humpback whale fluke identification system (Cheeseman et al., 2023). Individual sightings from research collaborators are reported with their permission. From these data, we document 1) crude birth rate (CBR) (defined as the number of calves divided by the total whale count in June-August); 2) within-season calf survival and 3) opportunistic observations of the body condition of cows and calves. We explore factors such as female age at first calving, and female calving intervals that provide context for the CBR.

Status and trends:

Crude birth rate: The total whale count for 2026 (n = 143) was the lowest annual count since 2018 (n = 101) and we observed two calves, resulting in a crude birth rate (CBR) of 1.4% (Table 2, Figure 82). This year's CBR is far below the long-term average CBR (9.2%, 1985 – 2013) observed before the Northeast Pacific marine heatwave (PMH, Di Lorenzo and Mantua, 2016; Walsh et al., 2018). Surprisingly, this year's CBR was even lower than the mean calving rate during and immediately after the PMH (2.5%, 2014 – 2019) when reproductive rates sharply declined (Table 2, Figure 82).

Within-season calf survival: The 2026 calves were only observed once or twice each, but both pairs were still together on our final observations of the season, thus we documented no mid-season calf mortalities (Table 2). Mother #1834 was with her calf at least through July 23, 2026 (Happywhale sighting by Alaska Yacht Charters).

Body condition of cows and calves: It was difficult to assess the body condition of the 2026 calves with available data. Both mothers were noted to be in poor body condition, based on protruding scapulas and/or low amounts of nuchal fat, caudal to their blowholes. The two sightings of mother #1834 occurred early in the feeding season (mid-May and early June, shown in Figure 83) when it is not

unusual for mothers to be thin (van Aswegen et al., 2025). However, mother #2533 still appeared thin much later into the feeding season (August 7).

Table 2: Humpback whale calf production and survival in Glacier Bay & Icy Strait, Alaska. Crude birth rate is calculated by dividing the number of calves by the total number of whales in June-August. The number of calves lost is calculated by dividing the number of mothers who were without their calf on their final sighting(s) of the season by the total number of mother/calf pairs sighted that season. Time periods are oriented around the northeast Pacific marine heatwave (PMH) period of 2014 – 2019.

Time Period	Mean Number of Calves (June-Aug)	Total Number of Calves (June-Aug)	Mean Crude Birth Rate (%)	Mean Number of Calves lost (%)
Pre-PMH 1985-2013	9.1	265	9.2	8(3%)
During and immediately after PMH 2014–2019	4.0	24	2.5	7(29%)
Post-PMH 2020–2025	11.7	70	6.2	2(3%)
Current year 2026	2	2	1.4	0

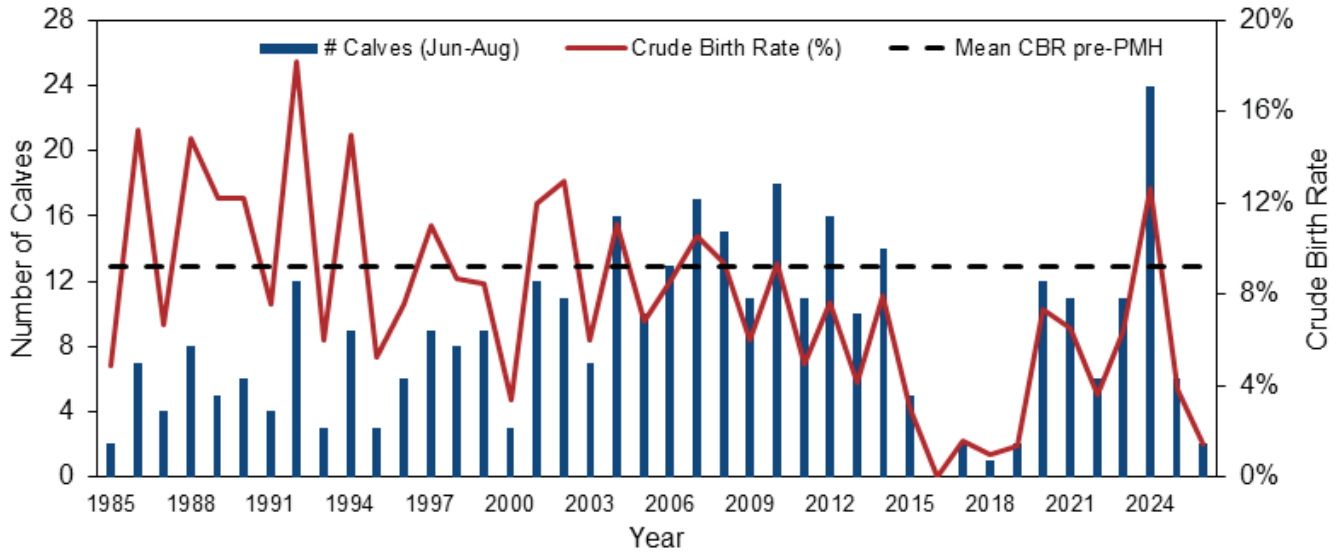


Figure 82: Annual number of calves (blue bars) and crude birth rate (CBR, red line) in Glacier Bay-Icy Strait, 1985 – 2026. CBR is calculated by dividing the number of calves by the total number of whales identified in June-August each year. The CBR for 2026 is 1.4% based on a final whale count of 143 individually identified whales during the monitoring period. The dotted line indicates the long-term mean CBR of 9.2% observed 1985 – 2013, prior to the Northeast Pacific marine heatwave.

Factors influencing observed trends: Most of the humpback whales in Southeast Alaska winter in Hawaii (Baker et al., 1986) and the very low CBR documented in our study area reflects, at least in part, a relatively low calving rate documented in the Hawaii wintering area in 2026. Standardized shore-based counts by the Hawai'i Marine Mammal Consortium (HMMC) yielded a 3% CBR (HMMC, unpublished data), which is lower than their 2001 – 2015 mean annual CBR of 6.5%, but higher than the 2.1% CBR in 2016 – 2019 during and after the PMH (Frankel et al., 2021). The low Hawaii CBR in 2026 (3%) suggests poor resource conditions in 2025 across many feeding areas along the Pacific rim, including Southeast Alaska. Frankel et al. (2021) found that the CBR of whales in Hawaii (2001 – 2019) declined when climate indices showed warmer water on high latitude feeding grounds in the North Pacific during



Figure 83: Photograph of mother #1834 with her calf in the study area on May 13, 2026, showing the thin blubber layer of the mother, indicating poor body condition. (National Park Service photo by Piper D. Bishop, NMFS permit #27027).

the prior feeding season or seasons. Oceanographic indices for 2025 were mixed, but there is some evidence that the Gulf of Alaska experienced warmer than average temperatures in spring and summer 2025 (Lemagie et al., 2026).

The poor body condition of at least one mother late in the feeding season (#2533) suggests that feeding conditions may have made it difficult for females to regain their energy reserves after gestation and lactation (van Aswegen et al., 2025). Overall, most whales in the study area looked to be in reasonablly good body condition.

Calving intervals may be getting longer: There were at least 39 known sexually mature females (age 7 or greater, Gabriele et al., 2017) in the study area in 2026, but only two were accompanied by a calf. Taking a closer look at these non-mothers, 21 (54%) calved in the past two years, so *if* they have a calf in 2027, they will still be within the typical two- to three-year calving interval range for this population (Gabriele et al., 2017). There is evidence that calving intervals may be increasing, as four of eight females with continuous annual sighting histories last produced a calf three years ago, and the other four last produced a calf 5 – 6 years ago. Of the remaining eight females, four have previously been seen with a calf and four have not. The sighting histories of these remaining eight females are sporadic, therefore it is possible they had calves we did not detect, outside the study area.

If a high proportion of females that had a calf during the "baby boom" in 2024 (Figure 82) exhibit a three-year calving interval, we may see another strong peak in CBR in 2027. Note that this degree of reproductive synchrony leaves these females more vulnerable to ecological instabilities such as future marine heatwaves and the strong El Niño forecast for 2026 – 2027.

Age at first successful calving appears to be increasing: Female #2533 (minimum age 15) had previous calves in 2023 and 2021, typical of the calving interval documented for this population (Baker et al., 1987; Gabriele et al., 2017). We have no calving interval data for female #1834 (minimum age 26) because, as noted below, she has not been sighted with a calf before and does not visit the study area every year. Age at first successful calving appears to be increasing: Female #1834 (minimum age 26) had a calf in 2026 but has not been sighted with a calf before. Her age at first calving is unknown because she was not sighted in our study area or elsewhere[44] in 2005, 2008, or 2016 and she may have had a calf in one or more of those years. There were two known-aged females sighted in the study area this year who have never been sighted with a calf: female #2150 (age 18) has a continuous annual sighting history and female #2486 (age 14) who was missing only in 2016 at age four. These females may have had one or more calves that died as neonates, or they may not have reproduced yet. Regardless, they are older than the typical age at which females successfully return to the feeding area with their first calf (12 years, Gabriele et al., 2017). Food limitation has been associated with delayed onset of reproduction in taxa including baleen whales and ungulates (Gaillard et al., 2000; Kraus et al., 2009; Meyer-Gutbrod et al., 2015; Holbrook et al., 2019) and could be impacting post-PMH humpback whale populations.

Implications: The humpback whale CBR, body condition of cows and calves, and the reproductive parameters described above may reflect below-average groundfish prey availability in 2024 and 2025. However, other factors are likely at play in both populations since fish and whales have quite different life history characteristics. For example, groundfish may not require the high densities of prey that are required to sustain humpback whale reproduction. In addition, we cannot rule out disease or increased predation as potential factors in our observations of a decreased calving rate.

It is clear that the profound ecological effects of the PMH (e.g., Von Biela et al., 2019; Piatt et al., 2020; Arimitsu et al., 2021; Frankel et al., 2021; Suryan et al., 2021) induced a six-year period of low humpback whale calf survival, low productivity, and negligible recruitment that began in 2014 (Gabriele et al., 2022). This resulted in a missing cohort of females that would have been expected to produce their first calf in 2026 – 2032. In addition, mortality among non-calves in the study area significantly increased during and after the PMH, with many adult females now presumed dead (Neilson et al., 2024, In Prep.). The effects of the PMH will likely result in below-average CBRs for at least the next several years, even if feeding conditions are favorable. Moreover, if lingering effects of the PMH or other trophic disruptions continue to alter the age at first calving and calving intervals, as suggested by our past few years' observations, long-term population growth will be affected.

[44] Happywhale.com

Marine Mammal Strandings

Contributed by Jenna Malek and Carley Lowe, Alaska Regional Office, NOAA Fisheries
Contact: jenna.malek@noaa.gov
Last updated: September 2026

Description of indicator: Since 1985, members of the NMFS Alaska Marine Mammal Stranding Network (AMMSN) have collected and compiled reports on marine mammal strandings throughout Alaska. These reports are indices of events witnessed by members of the stranding network, the scientific community, and the general public, with varying degrees of knowledge regarding marine mammal biology and ecology. A marine mammal is considered "stranded" if it meets one of the following criteria: 1) dead, whether found on the beach, ice, or floating in the water; 2) alive on a beach (or ice) but unable to return to the water; 3) alive on a beach (or ice) and in need of apparent medical attention; or 4) alive in the water and unable to return to its natural habitat without assistance. The causes of marine mammal strandings are often unknown but some causes include disease, exposure to contaminants or harmful algal blooms, vessel strikes, and entanglement in or ingestion of human-made gear or debris.

When a stranded marine mammal is reported, information is collected including species, location, age class or size. In some cases, the initial photos and observations reported to AMMSN may be the only opportunity to collect information on the event. When possible, trained and authorized AMMSN members respond and collect life history data and samples as part of a partial or full necropsy. Photos and carcasses are evaluated for potential human interactions such as vessel strike. These responses are conducted under the Marine Mammal Protection Act authorization either under a 112 (c) agreement issued by NMFS to AMMSN members through a Stranding Agreement or under 109 (h) authority exercised by local, state, federal or tribal entities. All responses involving ESA-listed species and some enhanced responses (e.g., remote sedation) are authorized under the NOAA Permit No. 24359.

Status and trends: The number of confirmed strandings in Alaska has increased over time. Stranding data was not included in the 2025 Ecosystem Status Report; the current report includes complete 2024 and 2025 stranding data (January 1 - December 31; Table 3), in addition to data from January 1, 2026 through September 30, 2026. Thus far in 2026, 215 confirmed stranded marine mammals were reported within Alaska; 133 occurred in the Gulf of Alaska (Table 3). These numbers do not include entangled pinnipeds with no response or live, entangled baleen whales. The majority of reports were from populated areas where AMMSN members are located (Figures 84 and 85). Further, increased outreach and dedicated surveys (e.g., Kodiak Island) associated with high priority species or events (e.g., 2019 gray whale Unusual Mortality Event) also contributed to reported strandings in some areas and years. Reported strandings in the Gulf of Alaska since 2022 varied between years without an overall pattern or consistent increase in reports (Table 3). The data from January 1, 2026 through September 30, 2026 are preliminary and the details may change as we review reports and receive additional information.

Factors influencing observed trends: It is important to recognize that stranding reports represent effort which has varied substantially over time and location. Overall, this effort has increased over time and area, particularly in areas with higher human population densities.The number of stranded marine mammals is likely grossly underestimated as observations are opportunistic and without consistent effort in some parts of the Gulf of Alaska region. Unusual Mortality Events (UME), including the 2019 gray whale UME, can have a large influence on variability between years in this area (Table 3). Under the Marine Mammal Protection Act, an UME is defined as "a stranding that is unexpected;

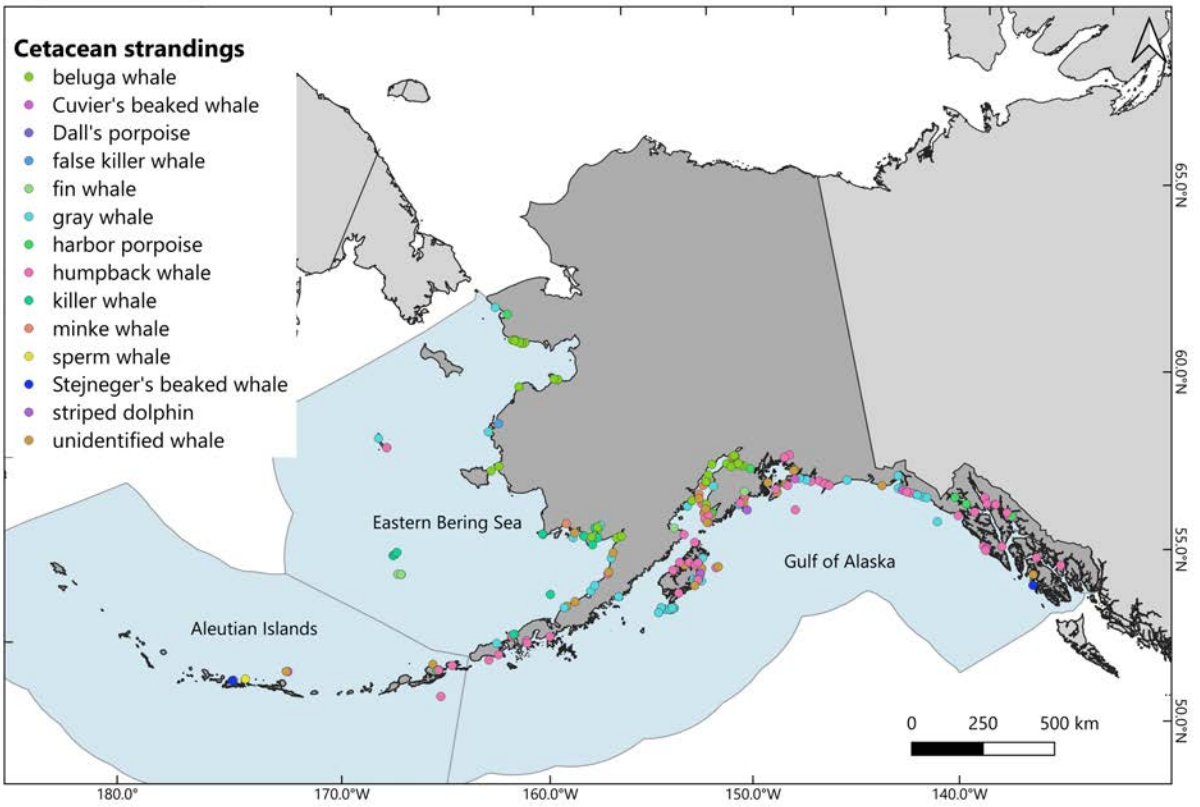


Figure 84: Reported cetacean strandings from Sept 1, 2024 through Sept 30, 2026 in Alaska. For clarity, unidentified baleen whales were grouped together for the map. Please see Table 3 for exact genus or species identification

involves a significant die-off of any marine mammal population; and demands immediate response." Other factors that may influence the number and species of marine mammals being reported include changing populations of some species and increased public awareness through outreach such as with the endangered Cook Inlet beluga, a NOAA Fisheries Species in the Spotlight. Further, the number of stranded marine mammals in an area can vary due to potential conflict with fishery resources either directly through prey competition or indirectly through interactions with fishing gear.

Implications: Across Alaska, reported marine mammal strandings have varied by year and location. It is important to track and have a sense of the regular number of strandings in an area to provide a context to mass strandings or Unusual Mortality Events. For example, in 2019, the increase in gray whale strandings across the migration route between Mexico and Alaska led to the declaration of an UME which continued until November 9, 2023. There were 148 stranded gray whales in Alaska during this UME. The UME Investigative Team concluded that the preliminary cause of this UME was localized ecosystem changes in the whale's subarctic and Arctic feeding areas that led to changes in food, malnutrition, decreased birth rates, and increased mortality. After several years of decreased stranding numbers, there has been an increase in gray whale strandings from 2024 to present, with a total of 67 animals (54 reported in the Gulf of Alaska; Table 3). The factors documented as causes of death during the gray whale UME may also be responsible for the recent increase in strandings, but further assessment is needed. As in the case of the gray whale UME, increases in marine mammal strandings,

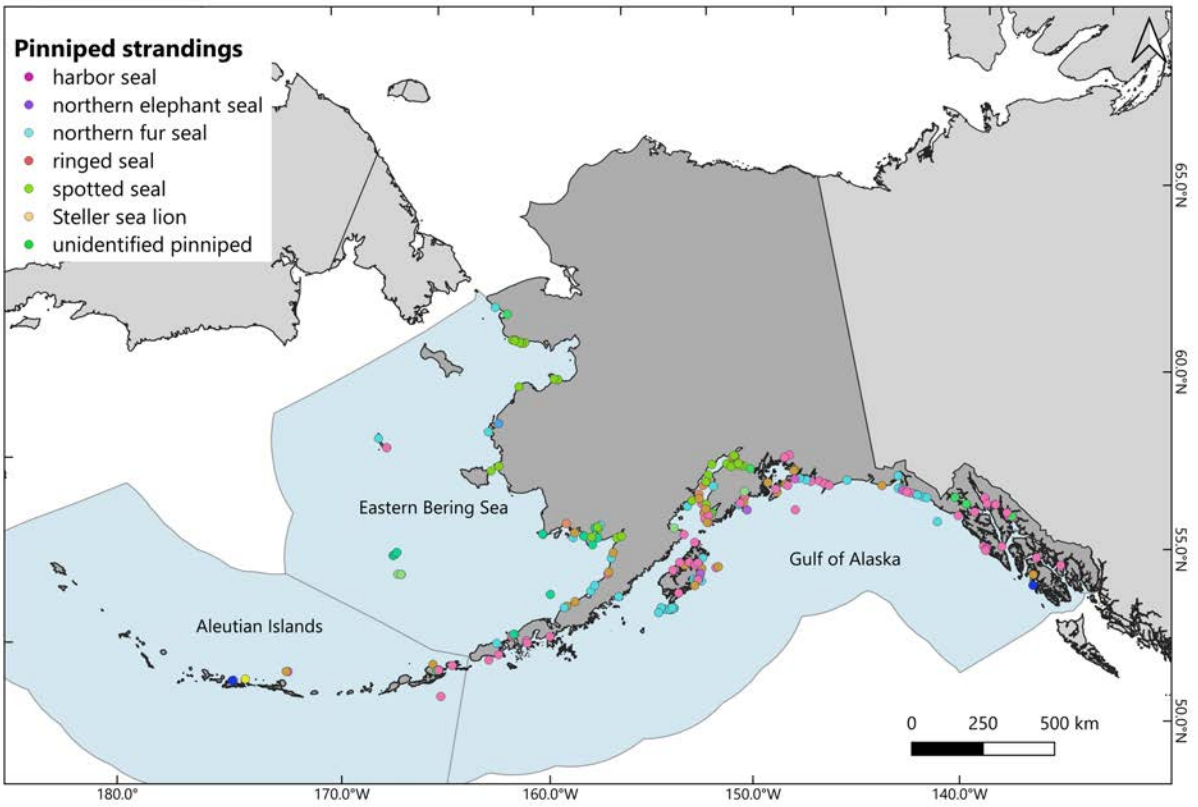


Figure 85: Reported pinniped strandings from Sept 1, 2024 through Sept 30, 2026 in Alaska.

when paired with other datasets, may signal changes in the environment or other stressors (e.g., human interactions such as entanglements, vessel strikes).

Table 3: Reported NMFS marine mammal strandings from 2022 – 2026 in the Gulf of Alaska Region by species. The numbers represent combined dead and live strandings. 2026 stranding data includes confirmed strandings reported between January 1, 202 and September 30, 2026.

Species	2022	2023	2024	2025	2026
Baird's beaked whale			1		
Bowhead whale			1		
Cook Inlet beluga whale	5	20	8	4	9
Cuvier's beaked whale	1	1	2		3
Dall's porpoise	1	2	2		
Fin whale		1	1	1	2
Gray whale	11	5	5	32	17
Harbor porpoise	6	5	3	3	4
Humpback whale	11	26	18	29	26
Killer whale	1	2			
Minke whale	1			3	
Sperm whale		1			
Stejneger's beaked whale				1	
Striped dolphin					2
Unidentified balaenopterid whale		1		2	
Unidentified beaked whale	1		1		
Unidentified baleen whale	1	2	1	1	3
Unidentified cetacean	3	2	2	5	10
Unidentified dolphin		1			
Unidentified mysticete				1	1
Unidentified porpoise		1			
Unidentified rorqual whale		1	2		1
Total Cetaceans	42	71	47	82	78
California sea lion		1			
Harbor seal	26	29	25	46	32
Northern elephant seal	3			3	
Northern fur seal		1			
Steller sea lion	37	75	30	28	22
Unidentified pinniped	1		1		1
Unidentified sea lion			1		
Unidentified seal		2			
Total Pinnipeds	67	108	57	77	55
Total Animals	109	179	104	159	133

Steller Sea Lions

Contributed by Katie Sweeney and Tom Gelatt, Alaska Ecosystem Program, Marine Mammal Lab, Alaska Fisheries Science Center, NOAA Fisheries
Contact: katie.sweeney@noaa.gov
Last updated: September 2022

Please refer to the archives[45] for past reports.

Harbor Seal Abundance, Trends, and Ecosystem Indicators in the Gulf of Alaska

Contributed by Josh M. London, Brett M. McClintock, John J. Jansen; Alaska Fisheries Science Center, Marine Mammal Laboratory, NOAA Fisheries, Seattle, Washington
Contact: josh.london@noaa.gov
Last updated: September 2026

Description of indicator: Pacific harbor seals (*Phoca vitulina richardii*) are an important protected species in Alaska and a valuable cultural resource for Alaska Native communities. Harbor seals are also key upper-trophic predators and nearshore ecosystem sentinels throughout coastal waters of the Gulf of Alaska (GOA). Occupying intertidal shorelines, estuaries, and floating ice in tidewater glacial fjords, harbor seals integrate oceanographic and trophic processes across a range of on-shelf marine habitats. They serve as general indicators for three important components: coastal and pelagic forage fish populations, glacial fjord habitat changes, and coastal health and ocean warming.

In 2010, the National Marine Fisheries Service formally recognized 12 demographically independent Alaska harbor seal management stocks (Figure 86). Nine of these stocks reside within the GOA ecosystem: Cook Inlet/Shelikof Strait, South Kodiak, North Kodiak, Prince William Sound, Glacier Bay/Icy Strait, Sitka/Chatham Strait, Lynn Canal/Stephens Passage, Clarence Strait, and Dixon/Cape Decision.

Harbor seals are likely influenced by shifts in the abundance and composition of the fish community within coastal marine ecosystems of Alaska. There are limited dietary studies for harbor seals in the GOA region, and those that do exist are decades old. Nevertheless, these studies, along with results from other regions of the Pacific, can provide insights into the prominent prey consumed by harbor seals in the GOA. A range of dietary studies (typically from scat analysis) show that harbor seals are opportunistic predators that often rely on high-lipid forage fish (herring, capelin, eulochon) alongside gadids (walleye pollock) and, seasonally or locally, salmonids (outmigrating smolts and returning adults). Pitcher (1980), reported diet composition from the stomachs of 269 harbor seals from 1973 through 1978. Top-ranked prey from the GOA region were walleye pollock, octopus, capelin, eulachon, and Pacific herring. Walleye pollock was the most prominent prey in eastern regions of the GOA with eulachon more prevalent in freswater habitats such as Copper River Delta. Octopus and shrimp were the dominant prey item in the lower Cook Inlet, Kodiak, and Alaska peninsula regions. Herreman et al.

[45] https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands

(2009) reported similar findings from scats collected in Prince William Sound (PWS) from 2004 – 2005 with pollock and herring as two of the most prevalent prey items.

Harbor seals are not only indicators of the fisheries ecosystem. Tidewater glacial fjords support 10–15% of Alaska's harbor seals, offering floating ice that seals use for pupping, nursing, and molting, and as refuge from predators. The PWS, Glacier Bay/Icy Strait, and Lynn Canal/Stephens Passage stocks of harbor seals each have important tidewater glacial habitat. Rapid ice loss is causing thinning, retreating, and altered calving of these tidewater glaciers, leading to loss of critical seal habitat. These impacts to seal habitat are compounded by ever-increasing marine tourism and near-daily visits in the summer of ships to some fjords, particularlyduring pupping. Lastly, the non-migratory behavior and coastal site fidelity of harbor seals makes them valuable for monitoring the coastal marine ecosystem for anthroprogenic impacts, persistent pollutants and heavy metals, and harmful algal blooms (HABs) exacerbated by warming events.



Figure 86: Geographic range and stock boundaries of harbor seal stocks in Alaska. This map represents the approximate extent of harbor seals in Alaskan waters with shaded colors representing the 12 different managed stocks. Stock delineations are based on genetic information, movement ecology, and traditional knowledge of local communities. Transparent shades are stocks outside of the Gulf of Alaska ecosystem. Adapted from Boveng et al. (2026).

Status and trends: Stock abundance and trend estimates are derived from a multi-decadal monitoring effort based on aerial photographic surveys (1996 – 2023) conducted by the Alaska Fisheries Science Center's Marine Mammal Laboratory and analyzed using a two-stage Bayesian hierarchical model (Boveng et al., 2026; Ver Hoef et al., 2025). The framework integrates survey counts with haul-out timelines from satellite bio-loggers to correct for availability (seals in the water during surveys) and survey covariates (tide, solar hour, date). The modeling approach, importantly, enables annual estimates of abundance and trend with uncertainty, even in years with limited or no survey effort.

In 2023, statewide harbor seal abundance in Alaska was estimated at 201,122 seals (95% CI: 194,459 – 208, 174; CV = 0.018). The statewide population trajectory showed general growth from 1996 – 2009, reaching a peak of approximately 225,000 seals in 2015. This growth likely reflects continued recovery after implementation of protections within the Marine Mammal Protection Act of 1973. Statewide growth, however, does not fully reflect regional variability and, notably, the Glacier Bay/Icy Strait stock showed overall decline during the 1996 – 2009 period (Figure 87). Regional declines and variability in population dynamics expanded to include a number of stocks in the later period from 2010 – 2023. None of the Gulf of Alaska stocks experienced net population growth during the second half of the monitoring period (2010 – 2023), contrasting with widespread growth documented across 7 of 9 GOA stocks during 1996 – 2009.

In 2023, Prince William Sound ($\hat{N}$=31,551), Cook Inlet/Shelikof Strait ($\hat{N}$=28,056), and Clarence Strait ($\hat{N}$=25,449) stocks had the highest abundance of harbor seals. North Kodiak ($\hat{N}$=6,412) and Glacier Bay/Icy Strait ($\hat{N}$=8,185) were the smallest stocks. For harbor seals in Alaska, an 8-year trailing trend is used to evaluate population status in a given year (Table 4). During the most recent calculated 8-year trailing trend (2016 – 2023), only Glacier Bay/Icy Strait is increasing. Along with the relative trend estimate, a probability of decline is calculated based on the proportion of the posterior distribution of the trend estimate that is less than zero. The Prince William Sound (trailing 8-year trend estimate of -2.66% /year and a 99.94% posterior probability of decline), South Kodiak (trailing 8-year trend estimate of -2.88% /year and a 99.14% posterior probability of decline), and Dixon/Cape Decision (trailing trend of -1.07% /year and a 94.08% posterior probability of decline) stocks all show concerning negative trends with very high probabilities of decline.

Aerial surveys for Gulf of Alaska stocks were not conducted in 2024 and 2025. In 2026, Cook Inlet/Shelikof Strait along with North and South Kodiak were surveyed and new abundance and trend estimates for those stocks are expected in 2027.

Table 4: Abundance and trend estimates in 2023, by stock, for harbor seals in the Gulf of Alaska along with respective estimates of precision (95% Confidence Interval (CI) and Coefficient of Variation (CV)). The trend estimate represents the annualized percent change in abundance from 2016 to 2023. The probability of decline represents the proportion of the posterior distribution of the trend estimate that is less than 0. Those with lower probability of decline are highlighted with shades of green and those with higher probability of decline are highlighted in shades of purple.

Stock	Estimate	95% CI	CV	Trend (%/Year) (2016–2023)	Prob. Decline (2016–2023)
Cook Inlet/Shelikof Strait	28,056	25,705–30,635	0.05	-0.79%	89%
South Kodiak	13,433	11,442–15,718	0.08	-2.88%	99%
North Kodiak	6,412	5,272–7,695	0.10	-0.87%	72%
Prince William Sound	31,551	28,717–34,681	0.05	-2.66%	100%
Glacier Bay/Icy Strait	8,185	7,031–9,528	0.08	1.26%	15%
Sitka/Chatham Strait	12,868	11,531–14,360	0.06	-0.35%	67%
Lynn Canal/Stephens Passage	12,115	10,824–13,570	0.06	-0.28%	63%
Dixon/Cape Decision	18,463	16,639–20,384	0.05	-1.07%	94%
Clarence Strait	25,449	23,522–27,495	0.04	-0.60%	85%

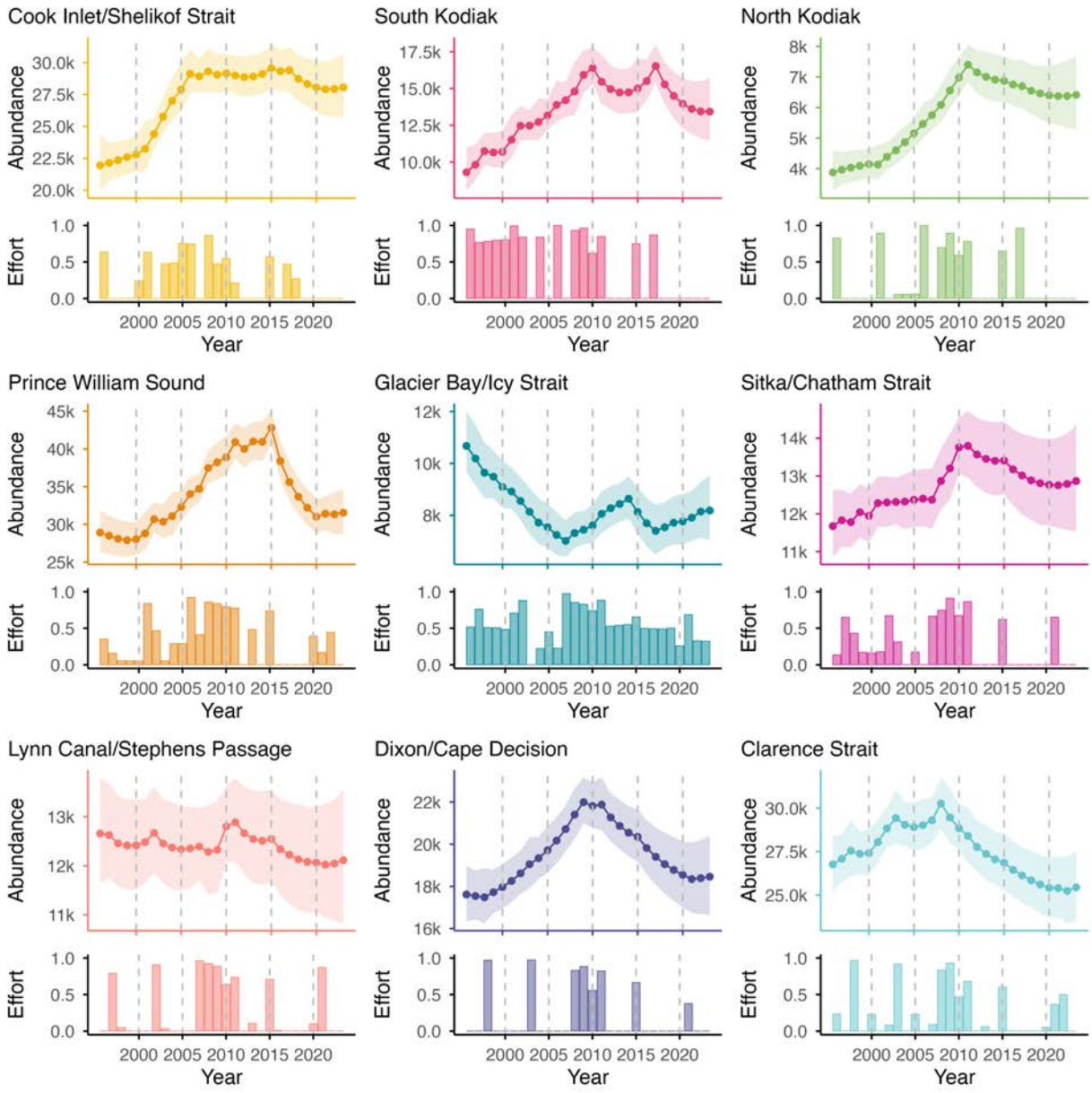


Figure 87: Abundance and survey effort for 9 stocks of harbor seals within the Gulf of Alaska (adapted from (Boveng et al., 2026). Estimated abundances by year displayed as solid circles. Ninety-five percent credible intervals are displayed as shaded regions in the upper panel of each subfigure. In the lower panel of each subfigure, bars depict an index of survey effort, calculated as the sum of the estimated abundance for those SSUs that were surveyed at least once in that year, divided by that year's estimated abundance for the entire stock.

Factors influencing observed trends: During the severe 2014 – 2016 and 2019 – 2021 Pacific marine heatwaves, warm ocean anomalies disrupted forage fish abundance, energy density, and recruitment (Suryan et al., 2021). A strong majority of harbor seal stocks within the GOA show a coincident declining 8-year trend over the 2016 – 2023 period. While a direct, quantitative assessment of the linkage between harbor seal population trajectories and these warming events has not been conducted, several studies (McHuron et al., 2024; Moran et al., 2026; Piatt et al., 2020) report observed responses in other PWS and GOA upper trophic predators (e.g., common murres, humpback whales, Steller sea lions). Additionally, a study of changes in harbor seal body condition within the Aleutian Islands (Boveng et al., 2020) showed an annual decline in body condition of 45g body mass per centimeter of body length from 2014 – 2016. This decline in body condition was likely an acute response to short-term environmental variation and may reflect a lag response to the 2014 – 2016 warm period. While unmonitoried, it is reasonable to expect harbor seals in the GOA region experienced similar changes in body condition during the Pacific marine heatwaves.

Implications: Harbor seal predation likely represents an important source of natural mortality for forage fish species (herring, eulochon, and capelin), key groundfish (walleye pollock, Pacific cod), and salmon within the GOA region. The lack of recent and consistent food habits data for seals in the region, though, severely limits our understanding of the trophic impact. With improved data on food habits and continued population monitoring, trophic linkages between harbor seals and commercial fisheries could be quantified and, potentially, included in future multi-species fisheries management models.

Harbor seals also serve as a primary prey for transient killer whales and killer whale predation provides some level of top-down population control. While bycatch from commercial fisheries remains below PBR for each of the stocks in GOA, several fisheries managed by the State of Alaska are unmonitored. The Prince William Sound salmon drift gillnet fishery is notable because the fishery is known to interact with harbor seals but the bycatch estimates used are over 30 years old (Wynne et al., 1991, 1992).

Ecosystem or Community Indicators

Foraging Guild Biomass

Contributed by George A. Whitehouse[1] and Kerim Y. Aydin[2]
[1]Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES), University of Washington, Seattle WA
[2]Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, NOAA Fisheries
Contact: gaw@uw.edu
Last updated: October 2025

NOAA Fisheries' Gulf of Alaska Bottom Trawl Survey is conducted every other year. Please refer to the archives[46] for past reports.

[46]https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands

Stability of Groundfish Biomass

Contributed by George A. Whitehouse, Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES), University of Washington, Seattle WA
Contact: gaw@uw.edu
Last updated: October 2025

NOAA Fisheries' Gulf of Alaska Bottom Trawl Survey is conducted every other year. Please refer to the archives[47] for past reports.

Mean Length of the Fish Community

Contributed by George A. Whitehouse[1] and Geoffrey M. Lang[2]
[1]Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES), University of Washington, Seattle WA
[2]Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, NOAA Fisheries
Contact: gaw@uw.edu
Last updated: October 2025

NOAA Fisheries' Gulf of Alaska Bottom Trawl Survey is conducted every other year. Please refer to the archives[48] for past reports.

Mean Lifespan of the Fish Community

Contributed by George A. Whitehouse[1] and Geoffrey M. Lang[2]
[1]Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES), University of Washington, Seattle WA
[2]Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, NOAA Fisheries
Contact: gaw@uw.edu
Last updated: October 2025

NOAA Fisheries' Gulf of Alaska Bottom Trawl Survey is conducted every other year. Please refer to the archives[49] for past reports.

[47] https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands
[48] https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands
[49] https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands

Ecosystem or Community Indicators

Gulf of Alaska Ecosystem State

Contributed by: Bridget Ferriss[1] and Mary Hunsicker[2]
[1]Resource Ecology and Fishery Management Division, Alaska Fisheries Science Center, NOAA Fisheries
[2]Estuarine and Ocean Ecology Program, Northwest Fisheries Science Center, NOAA Fisheries
Contact: bridget.ferriss@noaa.gov
Last updated: October 2026

Description of indicator: Syntheses of ecosystem indicators can identify higher level ecosystem trends and clarify the communication of changes in ecosystem state. Dynamic factor analyses (DFA) is used to identify suites of commonly varying indicators and latent trends in ecosystem variability (Zuur et al., 2003). Hidden Markov Models (HMM) identify potential ecosystem states within DFA trends, helping identify the relative magnitude of change in ecosystem trends and allowing comparability to past states (Ward et al., 2019; Hunsicker et al., 2022). GOA environmental time series considered responsive to environmental change were updated from Ferriss et al. (2025) through 2026.

Indicators were divided into western (approximately 147 °W to Unimak Pass) and eastern GOA (147 °W to the Alaska-Canada border) reflecting documented oceanographic and ecological differences between the two sub-regions (Waite and Mueter, 2013). To summarize broad patterns of non-stationary change, indicators were analyzed in six models including climate (e.g., ocean temperature), lower trophic (e.g., biomass of zooplankton and larval fish), mid-trophic (e.g., forage fish abundance), seabird (e.g., reproductive success), and all-biology (subset of species from each biological model) in each region. Details of these datasets and analyses are in Ferriss et al. (2025), and most are included in this Report.

Status and trends: Updated ecosystem state analyses (dynamic factor and threshold analyses) from 2022 (Ferriss et al., 2025) to 2026 suggest no change in ecosystem state across western and eastern GOA ecosystems except for the western GOA lower trophic level submodel (Figure 88). This group is largely driven by reduced abundance of larval groundfish in 2025, with the exception of increased rockfish spp. and southern rock sole (NOAA EcoFOCI spring survey, Rogers et al., p.100). The trend was also influenced by larger and earlier spring phytoplankton blooms, and persistent below-average copepod biomass through 2026 (Seward Line survey, Hopcroft, p.93) (Figure 89). All other submodels (climate, lower trophic level, mid-trophic level, seabirds) have remained in the same ecosystem stanza from 2013 – 2019 (varying by sub-model) to 2026 (eastern GOA) or 2014 – 2016 to 2026 (western GOA) suggesting the 2014 – 2019 period of multiple marine heatwave years created a new GOA ecosystem stanza that continues to persist, despite ongoing interannual variability (Figure 88).

Factors influencing observed trends: The western GOA mid-trophic level model reflects observed declines in capelin after the 2014 – 2016 marine heatwave (Figure 89). This sub-model does not include the full suite of forage fish (including sand lance, herring) that are known to respond differently to environmental variability, and thus should be interpreted with caution. The eastern GOA mid-trophic level and seabird model trends follow observed trajectories of individual populations but present opportunities to further explore non-intuitive results (e.g., the inverse relationships of herring and juvenile salmon) driving the two mid-trophic level trends (Figure 89). The western GOA lower trophic level was the only submodel to change ecosystem state in the 2022 – 2026 update. This sub-model primarily

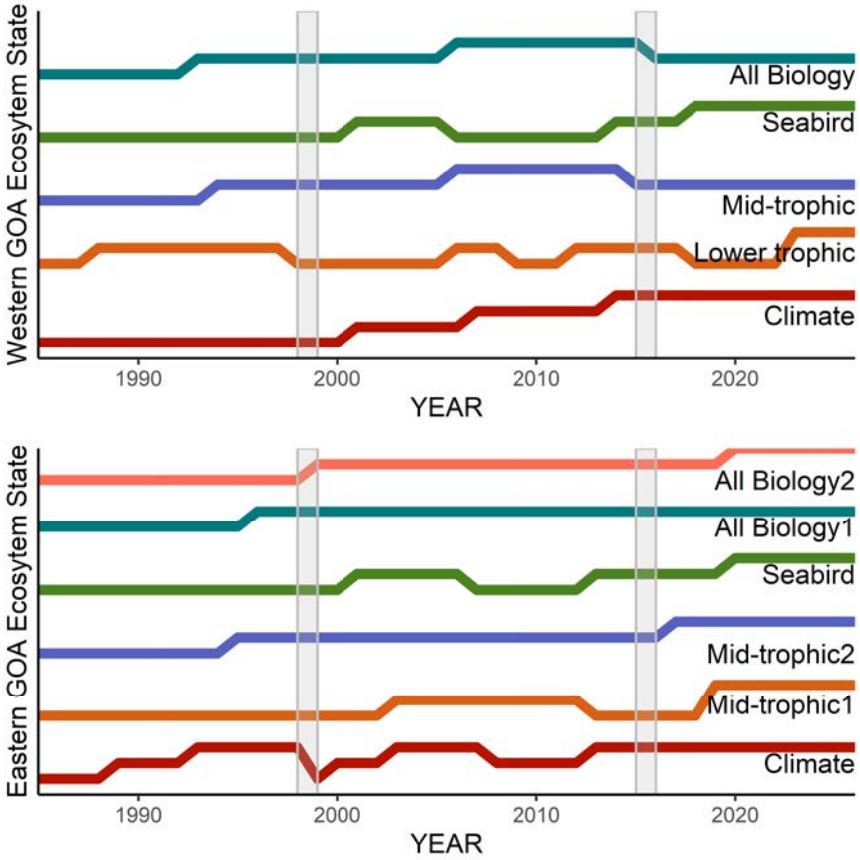


Figure 88: Ecosystem States across climate, lower trophic level, mid-trophic level, and seabird and all biology models from 1985 – 2026 in the western (top) and eastern (bottom) Gulf of Alaska. A step change represents a new state within each model. Previously strong El Niños are shown as gray bars. Figure updated from (Ferriss et al., 2025).

includes larval groundfish surveyd but NOAA's spring EcoFOCI survey which occurs only in odd years. Therefore, the time series update only includes 2023 and 2025 data points. The survey results in 2025 did show consistent low CPUE of most larval groundfish, and high CPUE of larval rockfish and southern rock sole (NOAA EcoFOCI spring survey, Rogers et al., p.100). The eastern GOA mid-traophic level model Trend 1 increases and remains elevated from 2019 to 2026. This trend is largely dirven by Sitka and Craig herring biomass which had very strong 2020 and 2022 year classes contributing to elevated populations (Smith et al., p.111). As reported in Ferriss et al. (2025), the El Niño of 1998/1999 (Peterson and Schwing, 2003; Batten and Welch, 2004) coincided with an ecosystem state change that was identified in the western GOA lower trophic level and seabirds, but not the mid-trophic level and all-biology model. The 2014 ecosystem state shift (Bond et al., 2015; Di Lorenzo and Mantua, 2016) was identified in all our western and eastern GOA models, with a delayed eastern GOA mid-trophic level change, agreeing with the broad ecosystem dynamics documented from that time period (Piatt et al., 2020; Gabriele et al., 2022; Arimitsu et al., 2021; Barbeaux et al., 2020*b*).

Implications: The definition of ecosystem shifts in the GOA can vary depending on the length of time series and focal species to include in the models (Litzow et al., 2020; Suryan et al., 2021; Ferriss, 2026). These model results support a shift in ecosystem state across different parts of the GOA marine ecosystem (climate, lower trophic level, mid-trophic level, seabirds) during the 2014 – 2019 period of

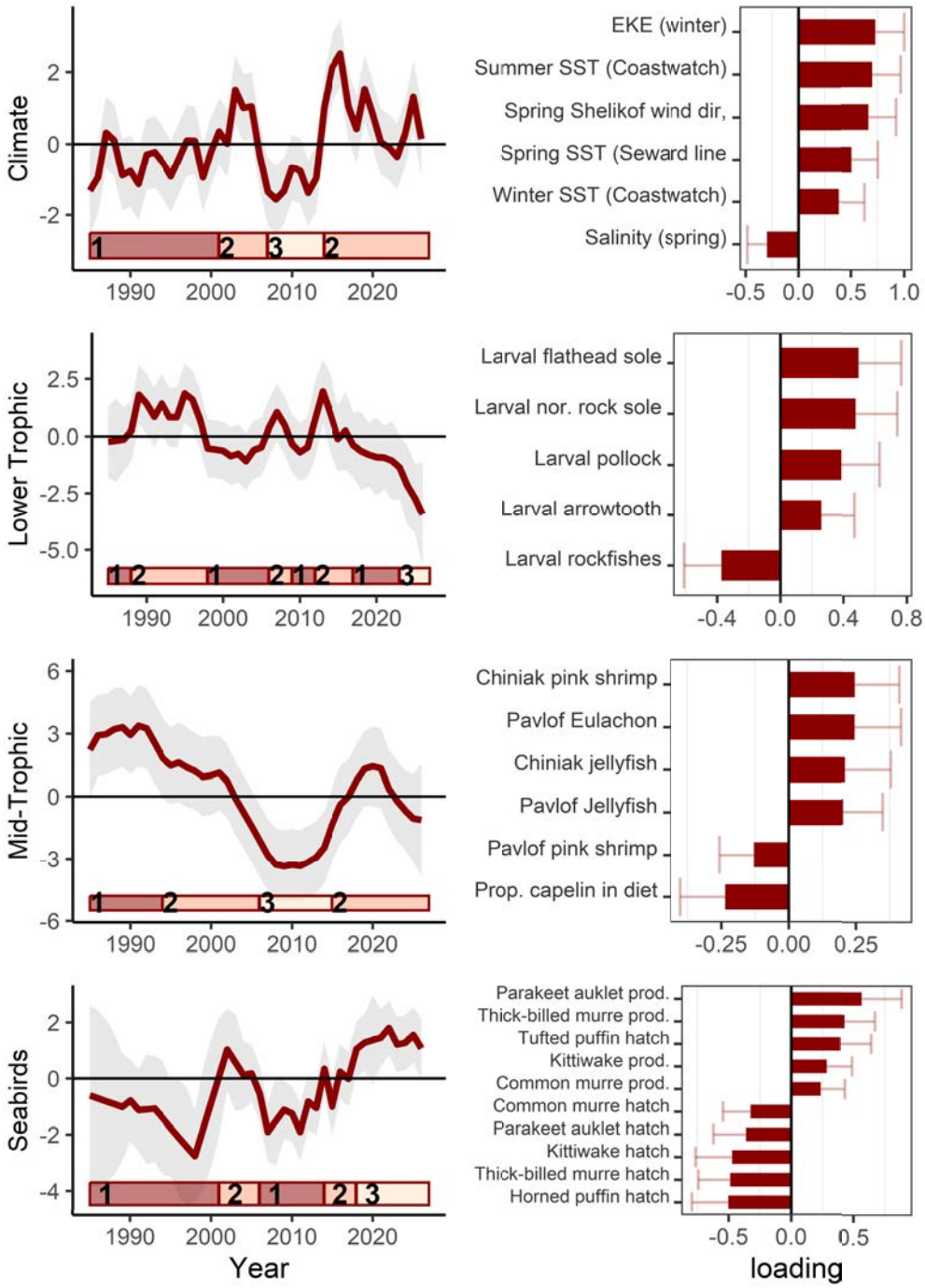


Figure 89: Western Gulf of Alaska model results for climate, lower trophic level, mid-trophic level (1985 – 2026), and seabirds (1990 – 2026). Model trend lines (left) are plotted with 95% confidence intervals shown in gray shading. Ecosystem states (identified by hidden Markov models) are represented by the horizontal bars at the bottom of each trend plot (left). (Right) The loadings for only the significant variables in the best-fit models (i.e., confidence intervals to not cross zero) are shown with 95% confidence intervals. Figure updated from (Ferriss et al., 2025).

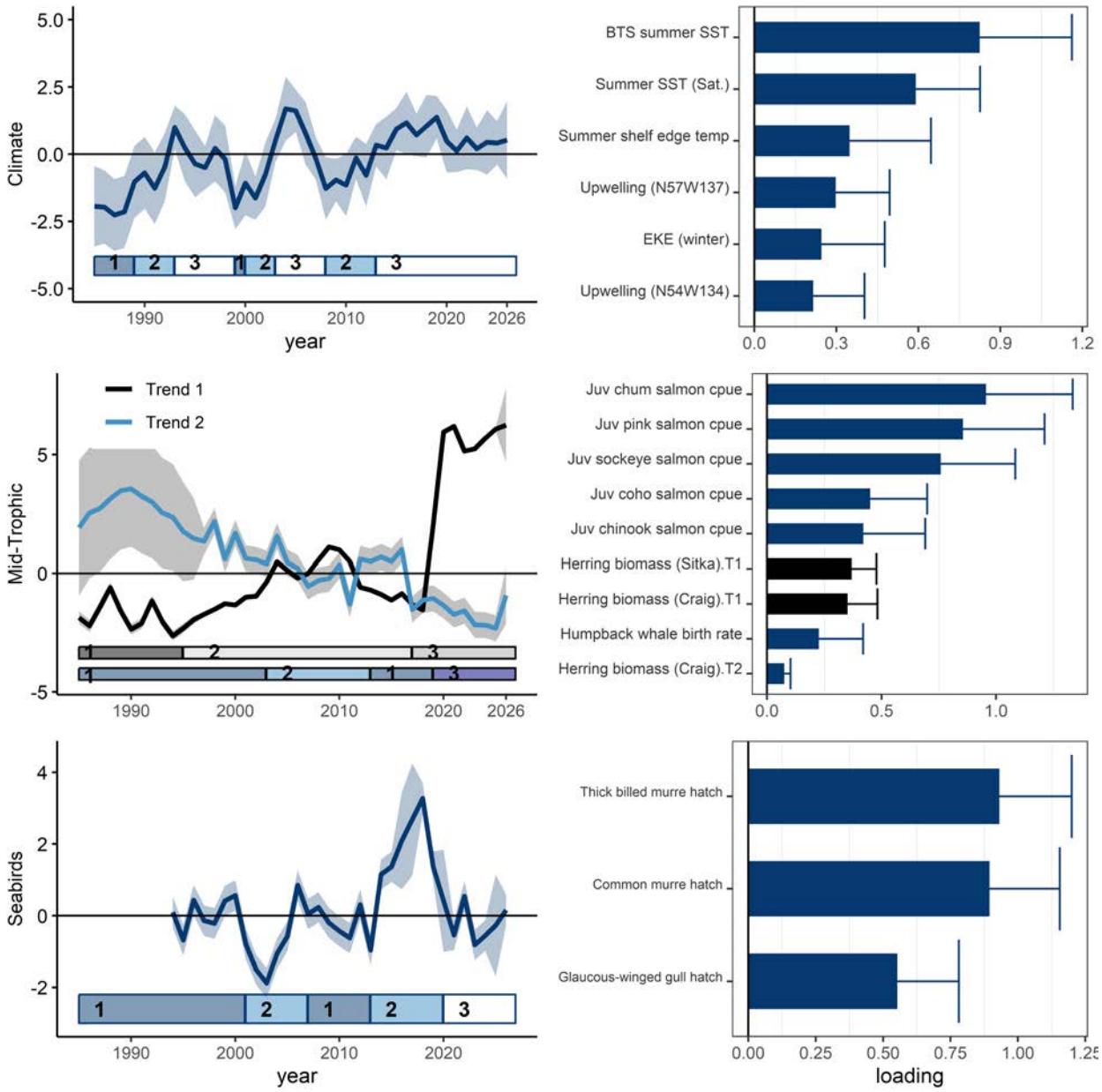


Figure 90: Eastern Gulf of Alaska model results for climate (1985 – 2026), lower trophic level, mid-trophic level (1985 – 2026), and seabirds (1995 – 2026). Model trend lines (left) are plotted with 95% confidence intervals shown in gray shading. The best-fit mid-trophic DFA model had two common trends (blue and black). Ecosystem states (identified by hidden Markov models) are represented by the horizontal bars at the bottom of each trend plot (left). (Right) The loadings for only the significant variables in the best-fit models (i.e., confidence intervals to not cross zero) are shown with 95% confidence intervals. In the 2 trend mid-trophic model, the black Trend 1 line corresponds with the black/gray ecosystem state bars at the bottom of the left-hand figure, and with the black loading bars on the right. The blue Trend 2 line corresponds with the blue ecosystem state bars and blue loadings. Figure updated from (Ferriss et al., 2025).

multiple marine heatwave years including the 2015/2016 very strong El Niño. Updating these analyses suggests the same ecosystem states largely persists in the GOA since that period. These analyses can support early warnings of shifts in ecosystem events and what we might expect from groups of species

that respond to environmental change in similar ways. While 2025 (Ferriss, 2026) was another warm year in the Gulf of Alaska, it did not register in these analyses as a shift in ecosystem state (with the exception of western GOA lower trophic level). Future updates of the analyses will inform ecosystem state dynamics, such as if the mid-trophic level and/or seabird models change in a lagged response to the lower trophic level shift, and if the 2026/2027 El Niño create large changes in the GOA marine ecosystem.

Disease & Toxins Indicators

Harmful Algal Blooms

Contributed by Thomas Farrugia[1], Gulce Kurtay[2], Madison Haumschild[1]
[1]Alaska Ocean Observing System, Anchorage, AK
[2]GEOMAR, Helmholtz Centre for Ocean Research Kiel, Kiel, Germany
Last updated: October 2026

Description of indicator: Alaska's most well-known and toxic harmful algal blooms (HABs) are caused by phytoplankton in the genera of *Alexandrium* and *Pseudo-nitzschia*. *Alexandrium* produces paralytic shellfish toxins (PST) which can cause paralytic shellfish poisoning (PSP) and has been responsible for five deaths and over 100 cases of PSP in Alaska since 1993 (State of Alaska, 2022). Analyses of paralytic shellfish toxins are commonly reported as μg of toxin/100 g of tissue, where the FDA regulatory limit is 80μg/100g. Toxin levels between 80μg - 1000 μg/100 g are considered to potentially cause non-fatal symptoms, whereas levels above 1000 μg/100g ($\sim$ 12x regulatory limit) are considered potentially fatal. Testing for PSTs is done for all commercial species by regulation, whereas for marine subsistence food items, testing is done as funding allows.

Another harmful algal species, *Pseudo-nitzschia* produces domoic acid which can cause amnesic shellfish poisoning and inflict permanent brain damage. Domoic Acid has been detected in 13 marine mammal species in Alaska and has the potential to impact the health of marine mammals and birds. No human health impacts of domoic acid have been reported in Alaska, although both acute and chronic amnesic shellfish poisoning has been reported in several states, including Washington and Oregon.

Another organism, *Dinophysis* spp., produces okadaic acid which can lead to diarrhetic shellfish poisoning. This primarily impacts the gastrointestinal system and is not usually life-threatening but can lead to nausea, vomiting, abdominal cramping, and diarrhea. Although there have not been recorded cases of diarrhetic shellfish poisoning in Alaska, *Dinophysis* has been detected throughout Alaska, and okadaic acid is at times detected in shellfish.

As a way of detecting these harmful species in Alaska and using them as an ecosystem status indicator, we have started to develop a monitoring program using Imaging FlowCytoBots (IFCBs). IFCBs are connected to the flow-through seawater system of research vessels and sample 5mL approximately every 20 minutes. These samples are run through a flow cell and images are taken of individual particles up to 150 μm in size. To learn more about IFCBs in Alaska, refer to Gann et al. (2026). In 2026, the Alaska Ocean Observing System (AOOS) deployed three IFCBs on research vessels that transited through Alaskan waters between Seattle, Prince William Sound and the Chukchi Sea (Figure 91). When a bloom of a potentially toxic species is detected by the IFCBs, a HAB advisory is drafted and sent to nearby communities to alert them of the situation.

The State of Alaska tests all commercial shellfish harvest, however there is no state-run shellfish testing program for recreational and subsistence shellfish harvest. Regional programs, run by Tribal, agency, and university entities, have expanded over the past five years to provide test results to inform harvesters and researchers and reduce human health risk. All of these entities are partners in the Alaska Harmful Algal Bloom Network (AHAB) which was formed in 2017 to provide a statewide approach to HAB

awareness, research, monitoring, and response in Alaska. More information can be found on the AHAB Network website[50] or through the sampling partners listed above. For a summary of HAB events and testing results once they are available, visit the HAB Alerts page[51].

Status and trends:
Alaska Region: The three IFCBs sampled for over 270 days in Alaska waters (Figure 91) and results from the IFCB monitoring in 2026 showed a generally similar picture of phytoplankton from 2025 and 2024. However, detection of HAB species seemed to have been slightly lower, especially in the Gulf of Alaska.

The only bloom of a harmful algal species detected by IFCBs this summer happened in the Bering Sea, where an Alexandrium bloom seemed to have started at low levels at the end of June east of the Pribilof Islands, and by the end of August there was a widespread and fairly dense bloom covering much of the southeast Bering Sea. This is now the third year in a row that this Alexandrium bloom is detected in this general area, suggesting that this may be a perennial feature of the southeast Bering Sea. Unlike 2024 and 2025, no mortalities of northern fur seals were linked to paralytic shellfish toxins in 2026.

Although low levels of *Pseudo-nitzschia* and *Dinophysis* were also detected throughout the season, and showed occasional slight upticks, nothing that would be categorized as a bloom was detected. 2026 seemed to have been an overall cooler year in terms of sea surface temperatures, and this likely accounted for the slight decrease in bloom events. Over the last few years, the dinoflagellate *Dinophysis* has become more common and abundant in water samples, and 2026 continued that trend. We are also seeing a geographic expansion of areas that are sampling for phytoplankton species.

Gulf of Alaska: Four vessel deployments and an onshore location provided IFCB data in 2026 (Figure 92). A wide diversity of phytoplankton were detected across the Gulf of Alaska, with locations closer to shore showing higher diversity and abundance compared to offshore areas sampled. No HABs were detected in the Gulf of Alaska during this time.

Details about each deployment, as well as images taking by the IFCBs and maps of sampled locations can be accessed through the following Woods Hole Oceanographic Institution (WHOI) dashboards (dates indicate the date range for which the IFCB collected data in the Gulf of Alaska):

- R/V Sally Ride (May 1 – 20)[52]
- Kasitsna Bay Lab dock (May 28 – July 7)[53]
- R/V Woldstad (June 17 – June 21 and Aug 26 – Aug 29)[54]
- R/V Sikuliaq (August 21 – 27)[55]
- R/V Tiglax (Sept 14 – Sept 22)[56]

[50] ahab.aoos.org
[51] https://ahab.aoos.org/hab-alerts/
[52] https://habon-ifcb.whoi.edu/timeline?dataset=sallyride0526
[53] https://habon-ifcb.whoi.edu/timeline?dataset=KBL_dock
[54] https://habon-ifcb.whoi.edu/timeline?dataset=Woldstad2026
[55] https://habon-ifcb.whoi.edu/timeline?dataset=Sikuliaq2026
[56] https://habon-ifcb.whoi.edu/timeline?dataset=Tiglax0926

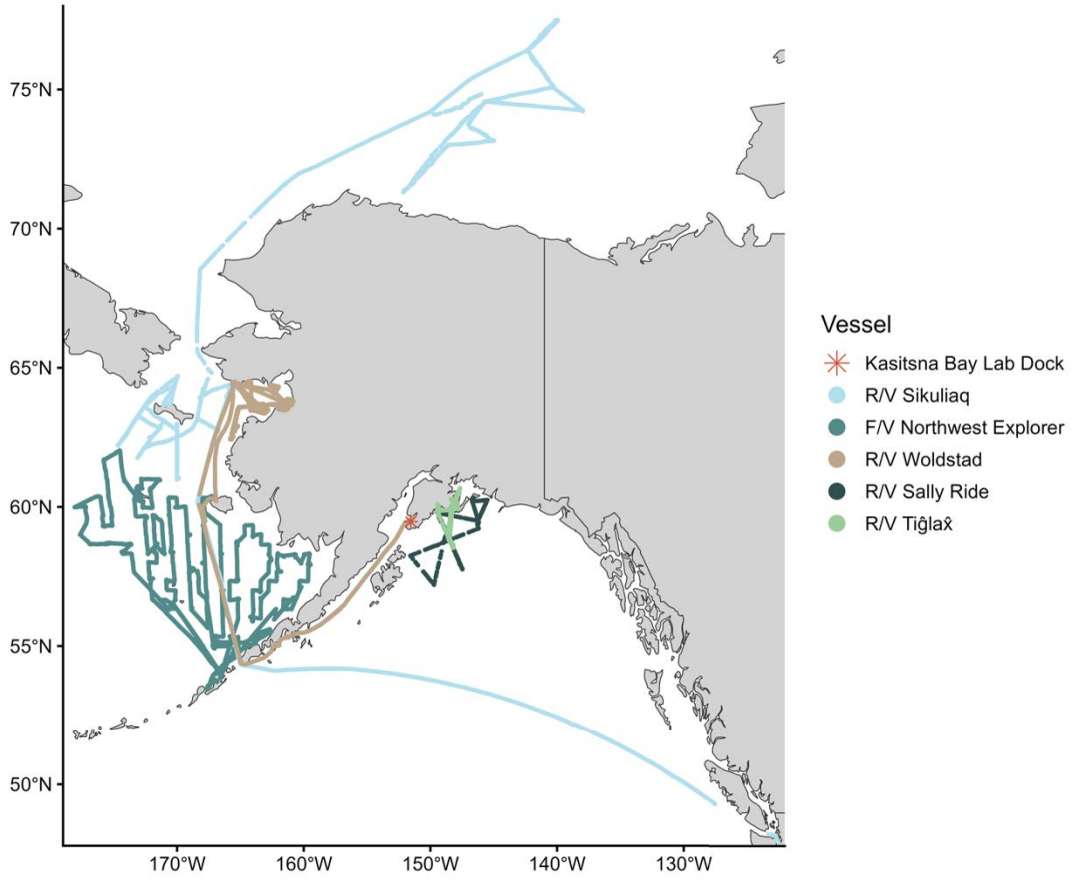


Figure 91: Tracks of the three IFCBs deployed on research vessels at on shore during May-October 2026. Colors represent different deployments (see text for details and links to the data dashboards for each deployment).

Implications: HABs pose a risk to human health when present in wildlife species that people consume, including shellfish, birds and marine mammals. Research across the state is attempting to better understand the presence and circulation of HABs in the food web. HAB toxins have been detected in stranded and harvested marine mammals from all regions of Alaska in past years (Lefebvre et al., 2016). A multi-disciplinary statewide study funded by NOAA's ECOHAB program is underway and encompasses ship-based sediments samples, water samples, zooplankton samples, krill samples, copepod samples, multiple species of fish, bivalves, and the continuation of sampling subsistence-harvested and dead stranded marine mammals.

HABs are likely to increase in intensity and geographic distribution in Alaska waters with warming water temperatures. Observations in Southeast and Southcentral Alaska suggest Alexandrium blooms occur at temperatures above 10°C and salinities above 20 (Vandersea et al., 2018; Tobin et al., 2019; Harley et al., 2020). As waters warm throughout Alaska, blooms may increase in frequency and geographic extent.

The Alaska Department of Health, Section of Epidemiology (SOE) continues to partner with the AHAB

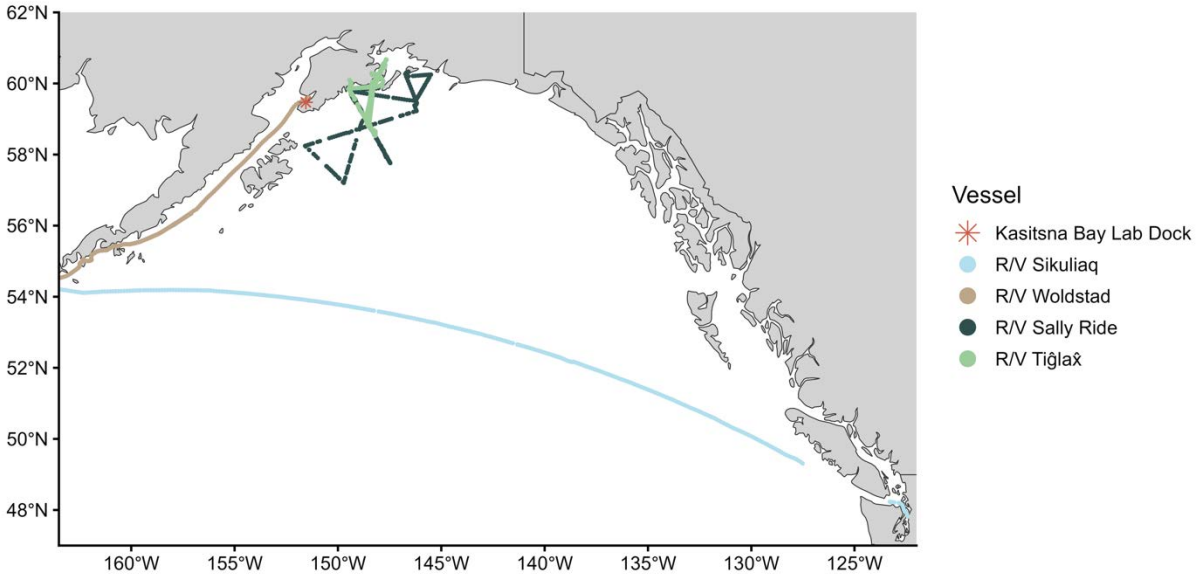


Figure 92: Tracks of IFCB deployments in the Gulf of Alaska. Colors represent different deployments (see text for details and links to the data dashboards for each deployment).

network. Nurse consultants join in on the monthly meetings and collaborate with stakeholders so they can be made aware of reportable illness such as Paralytic shellfish Poisoning (PSP). SOE published an Epidemiology Bulletin describing cases of PSP from 1993 – 2021[57]. More information about PSP and other shellfish poisoning can be found on the SOE website[58].

[57] https://epi.alaska.gov/bulletins/docs/b2022_05.pdf
[58] https://health.alaska.gov/en/education/shellfish-poisoning/

"Mushy" Halibut Syndrome Occurrence

Contributed by Stephani Zador
Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, NOAA Fisheries
Contact: stephani.zador@noaa.gov
Last updated: October 2026

Description of indicator: Mushy Halibut Syndrome was first detected in GOA halibut in 1998. When prevalent, it is most often observed in smaller halibut of 15- - 20 lbs in the Cook Inlet area, but has also been noted in Kodiak, Seward, and Yakutat. Alaska Department of Fish and Game (ADF&G) describes the typical condition consisting of fish having large areas of body muscle that are abnormally opaque and flaccid or jelly-like. The overall body condition of these fish is usually poor, and often they are released because of the potential inferior meat quality. Data are collected through searches of ADF&G fishing reports[59]) and queries to IPHC and ADF&G staff. Incidence of mushy halibut is reported opportunistically in recreational fishing reports and by port samplers, and may not represent true trends. In particular, for these types of qualitative indicators, absence of reporting does not prove absence in the environment.

Status and trends: There were no reported incidences of mushy halibut in 2026 by port samplers (pers. comm. Marian Ford, ADF&G) or in the ADF&G central Alaska fishing reports. Increased prevalence occurred in 2005, 2011, 2012, 2015, and 2016. It was apparently absent in 2013 and 2014. Since 2017 there have been very few to no reports of mushy halibut.

Factors influencing observed trends: The condition is considered a result of nutritional myopathy/deficiency, and thus may be indicative of poor prey availability for halibut when it is prevalent. According to ADF&G, the Cook Inlet and Homer/Seward areas are nursery grounds for large numbers of young halibut that feed primarily on forage fish that have recently declined in numbers. Stomach contents of smaller halibut now contain mostly small crab species. Whether this forage is deficient, either in quantity or in essential nutrients is not known. However, mushy halibut syndrome is similar to that described for other animals with nutritional deficiencies in vitamin E and selenium. This muscle atrophy would further limit the ability of halibut to capture prey, possibly leading to further malnutrition and increased severity of the primary nutritional deficiency. Also, as the reporting for this indicator is opportunistic and subject to observation error, it may not reflect true prevalence or absence in the ecosystem.

Implications: The relatively few reports of mushy halibut since the end of the 2014 – 2016 marine heatwave in the GOA may indicate that foraging conditions for young halibut have been more favorable in recent years. However, the absence of mushy halibut reports during the 2019 heatwave year suggests there there is not a simple link between environmental conditions and the prevalence of this condition.

[59] `http://www.adfg.alaska.gov/sf/fishingreports/`

Intertidal Ecosystem Indicators in the Northern Gulf of Alaska

Contributed by Heather Coletti[1], Sarah Traiger [2], Katrin Iken [2], James Bodkin [3], Brenda Ballachey [3], George Esslinger [3], Kim Kloecker [3], Brenda Konar [2], Erica Ebert[1], and Robert Suryan[4]
[1]National Park Service, Inventory and Monitoring Program, 240 W 5th Avenue, Anchorage, AK
[2]University of Alaska Fairbanks
[3]U.S. Geological Survey, Alaska Science Center
[4]NOAA Alaska Fisheries Science Center
Contact: heather_coletti@nps.gov
Last updated: September 2026

Description of indicator: Nearshore monitoring in the Gulf of Alaska (GOA) provides ongoing evaluation of the status and trends of more than 200 species associated with intertidal and shallow subtidal habitats (Suryan et al., 2023). The spatial extent of sampling includes 21 sites distributed across four regions in the northern GOA: western Prince William Sound (WPWS), Kenai Fjords National Park (KEFJ), Kachemak Bay (KBAY), and Katmai National Park and Preserve (KATM). Since 2018, we have reported on one physical indicator (intertidal water temperature; U.S. Geological Survey - Alaska Science Center, National Park Service - Southwest Alaska - Inventory and Monitoring Network, and University of Alaska Fairbanks - College of Fisheries and Ocean Sciences, 2016) and three biological indicators monitored annually beginning between 2005 and 2007, depending on region and indicator. Respectively, these indicators represent key nearshore ecosystem components of primary production (algal cover; U.S. Geological Survey - Alaska Science Center, National Park Service - Southwest Alaska Inventory and Monitoring Network, 2022), prey abundance (mussel density; U.S. Geological Survey - Alaska Science Center, National Park Service - Southwest Alaska Inventory and Monitoring Network, 2016), and predator abundance (sea star density; U.S. Geological Survey - Alaska Science Center, National Park Service - Southwest Alaska Inventory and Monitoring Network, 2022). The algal cover indicator used is percent cover of rockweed (*Fucus distichus*) in quadrats sampled at the mid intertidal level (1.5 m). Intertidal prey are represented by density estimates of large ($\geq$ 20 mm) Pacific blue mussels (*Mytilus trossulus*) sampled quantitatively within mussel beds. The nearshore predator abundance indicator is density of sea stars, estimated along an approximately 200 m^2 transect at each rocky intertidal monitoring site. Indicators are presented as annual anomalies compared to the long-term mean of the data record, which is an average across sites within each region. Disclaimer: Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Status and trends: In 2026, at the time of data collection (mid-summer), the four regions sampled (WPWS, KEFJ, KBAY, and KATM) were cooler than average. In the past, nearshore water temperature across the GOA from Prince William Sound to the Alaska Peninsula were elevated from 2014 through 2016 across all regions and into 2017 in WPWS and KEFJ (Figure 93). These results confirm that the 2014 – 2016 Pacific marine heatwave (PMH) in the GOA was expressed in intertidal zones in addition to known patterns in open ocean environments (Danielson et al., 2022). While temperatures returned to cooler conditions in 2017, another heat spike was recorded in all regions starting in 2018, which was punctuated with a brief cooling across all regions in 2020, although highly variable with more pronounced cooling in KATM and KBAY and minimal cooling in WPWS and KEFJ. Warming then continued through 2020 in all regions. In general, it has been cool or close to average temperatures more frequently across all four regions since 2021. Higher among-region temperature variability persists,

which was not observed prior to the PMH.

In 2026, KATM, KBAY and KEFJ had roughly average *Fucus* cover with KATM being slightly positive and KBAY and KEFJ slightly negative. WPWS was strongly negative, a contrast to the previous 4 years when WPWS was approximately average. In KATM and KEFJ, data summaries indicate that variability around the mean appears to be decreasing during more recent years, coinciding with cooler water temperatures (Figure 94). KBAY has not shown any specific trend over time, with roughly average *Fucus* cover without a noticeable response to temperature fluctuations.

In 2026, large mussel densities ($\geq$ 20 mm) in all regions sampled had negative anomalies compared to long-term means. However, trends in densities of large mussels were variable across the regions. For example, since 2022, KATM has experienced negative anomalies in the density of large mussels, concurrent with positive to strongly positive anomalies in sea star abundance. This trend continued through 2026 (Figures 95 and 96). KBAY exhibited similar patterns to KATM with positive large mussel anomalies throughout 2023 and strongly negative anomalies from 2024 through 2026, concurrent with positive sea star density anomalies. In contrast, WPWS has exhibited below-average large mussel densities and sea star densities since 2025. Prior to 2025, mussels and sea star metrics were both above average in 2023 – 2024 in WPWS. In KEFJ during 2026, both large mussel and sea star density anomalies were below average. KEFJ has had below-average mussel density since 2024, however, in 2024 (KEFJ wasn't sampled in 2025), KEFJ had high sea star density, matching historical pattern of low mussel abundance coincided with high sea star abundance. During the PMH and SSW perturbations, large mussel densities ($\geq$ 20 mm) anomalies showed an overall positive trend across regions, in this case switching from generally negative prior to 2014 to positive after 2014 (Figure 95); this is an opposite response compared to Fucus cover and sea stars (Figures 94 and 96). Variability in mussel abundance at these regional spatial scales supports our conclusion that, in the absence of broad-scale perturbations like the PMH or SSW, other variables and local conditions become the primary drivers of mussel abundance (Bodkin et al., 2018; Traiger et al., 2022; LaBarre et al., 2007). We also suspect that the species composition of the sea star community may also play a role in the variation of the observed densities of mussels in each region.

In 2026, sea star density, species distribution and size distributions were measured in all four regions. KATM and KBAY remain positive through 2026 however, both regions' sea star density anomalies are closer to the long-term mean, indicating a decline from 2025. Anomalies in WPWS were more negative in 2026 than in 2025, also indicating a decline in sea star density. Sea star anomalies in KEFJ were also negative and while not sampled in 2025, anomalies were strongly positive in 2024, indicating a marked departure from recent positive trends (Figure 96). Species composition data from 2026 also showed that variability in sea star species distribution among (and within) regions continues. In KATM, *Evasterias* again was the dominant sea star with 46% in 2026 (46% in 2025) while *Pisaster* accounted for 42% (45% in 2025). *Pycnopodia* were also recorded in KATM in 2026 with 10% of the total proportion observed. In WPWS, Dermasterias continues to be the dominant species with 69% (65% in 2025) followed by *Pisaster*, which increased to 26% (up from 4% in 2025) and *Pycnopodia* declined from 26% (2025) to 4% in 2026. *Evasterias* continued to decline from 6% in 2025 to 2% in 2026. In KBAY, *Evasterias* continued to dominate the observed sea star assemblage in 2026 with 88% (90% in 2025). *Orthasterias* was 9% in 2026, a slight increase from 7% in 2025. No *Pycnopodia* were observed at our monitoring sites in KBAY or KEFJ. KEFJ was dominated by *Pisaster* (71%) and *Dermasterias* (26%) with a small proportion of *Evasterias* (3%). Historically, variability in density and species composition of sea stars differed greatly among regions through 2015. Starting between 2015 and 2017, densities declined and remained strongly negative across all regions through 2019 (Figure 96), with average to

below-average densities continuing through 2021. Declines were likely due to sea star wasting (Konar et al., 2019), possibly exacerbated by the PMH (Harvell et al., 2019). More recently, we suspect that higher variability in the sea star assemblage among regions and lower variability in the abundance within regions may be an indication of the ecosystem returning to one dominated by local-scale conditions as opposed to being driven by large-scale perturbations such as sea star wasting and the PMH.

Data from 2024 also indicated that variability in sea star composition among (and within) regions has increased. For example, in 2023 *Pisaster* was the dominant species in KEFJ (72%) and KATM (76%). However, in KEFJ during 2024 sampling, *Pisaster* only accounted for 46% with *Dermasterias* and *Evasterias* at 34% and 18%, respectively. In KATM, *Evasterias* dominated the sea star assemblage with 66% (up from 19% in 2023) and *Pisaster* accounting for 32%. In WPWS, *Dermasterias* continues to be the dominant species with 54% (an increase from 34% in 2023) followed by *Evasterias* at 10% (down from 26% in 2023), *Pisaster* at 4% (down from 19% in 2023), and *Pycnopodia* increasing to 32% (up from 20% in 2023). In KBAY, densities were slightly higher than average. *Orthasterias* was proportionally dominant at 64% in 2023 but that proportion declined to 8% in 2024. *Evasterias* dominated the observed sea star assemblage in 2024 with 83% (up from 14% in 2023). Variability in the sea star assemblage (both by density and species composition) among regions and across years within regions may be an indication of the ecosystem returning to one dominated by local-scale conditions as opposed to driven by large-scale perturbations such as sea star wasting and the PMH.

Factors influencing observed trends: During the PMH, negative anomalies of Fucus in three of the four regions and negative anomalies of sea stars across all regions were coincident with warm water temperatures in nearshore areas. The decline in sea star abundance across the GOA was likely due to sea star wasting (Konar et al., 2019), first detected south of Alaska in 2013 and generally thought to be exacerbated by warm water temperature anomalies (Eisenlord et al., 2016; Harvell et al., 2019). Recent work by Prentice et al. (2025) determined the bacterium, *Vibria pectenicida*, as the causative agent of SSW. This finding may allow researchers to determine the persistence of *V. pectenicida* in the environment and examine what conditions (such as warming waters) may increase transmission. Warming waters and concurrent declines in sea stars were associated with increased mussel densities across our study regions (Traiger et al., 2022), with a general trend of algal dominated systems turning more into invertebrate dominated systems (Weitzman et al., 2021). This pattern is similar to those observed in other rocky intertidal systems of the North Pacific following the recent large-scale temperature perturbations (Meunier et al., 2024). However, as nearshore waters appeared to cool starting in 2021, large increases in *Fucus* percent cover in KBAY and WPWS have not occurred (Figure 94). KATM is the exception, with *Fucus* increasing in 2024 – 2026, after negative anomalies being observed since 2014. Intertidal temperature was anomalously warm in 2025. This warm water pattern did not persist and in general, 2026 temperatures were cooler than average. Even with average to low cover of *Fucus* continuing to provide open space for mussel settlement, high densities of large mussels have not persisted through time. While there has been some recovery of sea stars in these regions, further examination of species composition and size distribution may provide insights as to changes in community structure. We have documented that these nearshore communities can be driven by large-scale perturbations such as the PMH and SSW with similar responses across the GOA. We have also documented diverse community structure under local conditions, in the absence of large-scale perturbations. However, patterns of reduced variability within regions in the abundance of some of our target species may indicate some recovery of nearshore communities from these large-scale perturbations.

Implications: Collectively, these indicators demonstrate responses to consistent and persistent, broad-scale perturbations of nearshore ecosystems coincident with the PMH throughout much of the western

GOA, including areas both inside (WPWS, KBAY) and outside (KEFJ and KATM) of protected marine waters. Even though *Fucus* did not decline markedly in KBAY (Figure 94), a comprehensive analysis of rocky intertidal community structure was completed, indicating a change of autotroph-macroalgal dominated communities to heterotroph-filter-feeder communities, ultimately resulting in a homogenization of community structure across all four regions (Weitzman et al., 2021). Concurrently, we found that the loss of sea stars likely contributed to the increase in large mussel density due to a decline in predation pressure from sea stars (Traiger et al., 2022). However, other factors such as predation pressure from a suite of nearshore invertebrates and vertebrates, shifts in primary productivity, and changes in environmental variables (e.g., salinity) may also influence mussel density (Traiger et al., 2022) and will be evaluated over time. Synergistic phenomena, like invertebrate disease outbreaks, predation and marine heatwaves may be driving apparent shifts in rocky intertidal communities (Meunier et al., 2024). Continued monitoring will provide insights to the temporal and spatial scales of ecosystem responses, where sites may differ in how they change over time. We hypothesize that more local conditions will drive regional nearshore communities, now that broad, Gulf-wide effects of the PMH have dissipated. Intertidal and nearshore ecosystems provide valuable habitat for early life stages of various commercially important species in the GOA, including Dungeness crab (*Metacarcinus magister*), Pacific cod (*Gadus macrocephalus*), salmonids and several species of rockfish (*Sebastes spp*). Our indicators suggest that some nearshore biological responses to the PMH appeared to continue into 2021 in some regions and could have affected recruitment and survival of species whose life stages rely on nearshore habitat. For some metrics, evidence of return to more average conditions in nearshore habitats suggests that PMH effects, both positive and negative, are dissipating. A major pattern that is emerging, however, is that the variability of biological indicators across regions is larger than it was before the PMH. Marine heatwaves are expected to become more common and widespread as a consequence of climate change (Frölicher et al., 2018). From primary producers to top-level consumers, our studies offer insight as to the varying extent of species' responses to these wide-scale perturbation and the timescales over which effects are expressed. Further, we also hypothesize that in the long-term, we may see responses of nearshore-reliant, upper trophic level species (such as sea otters and sea ducks) to shifts in prey availability from changing ocean conditions across the GOA.

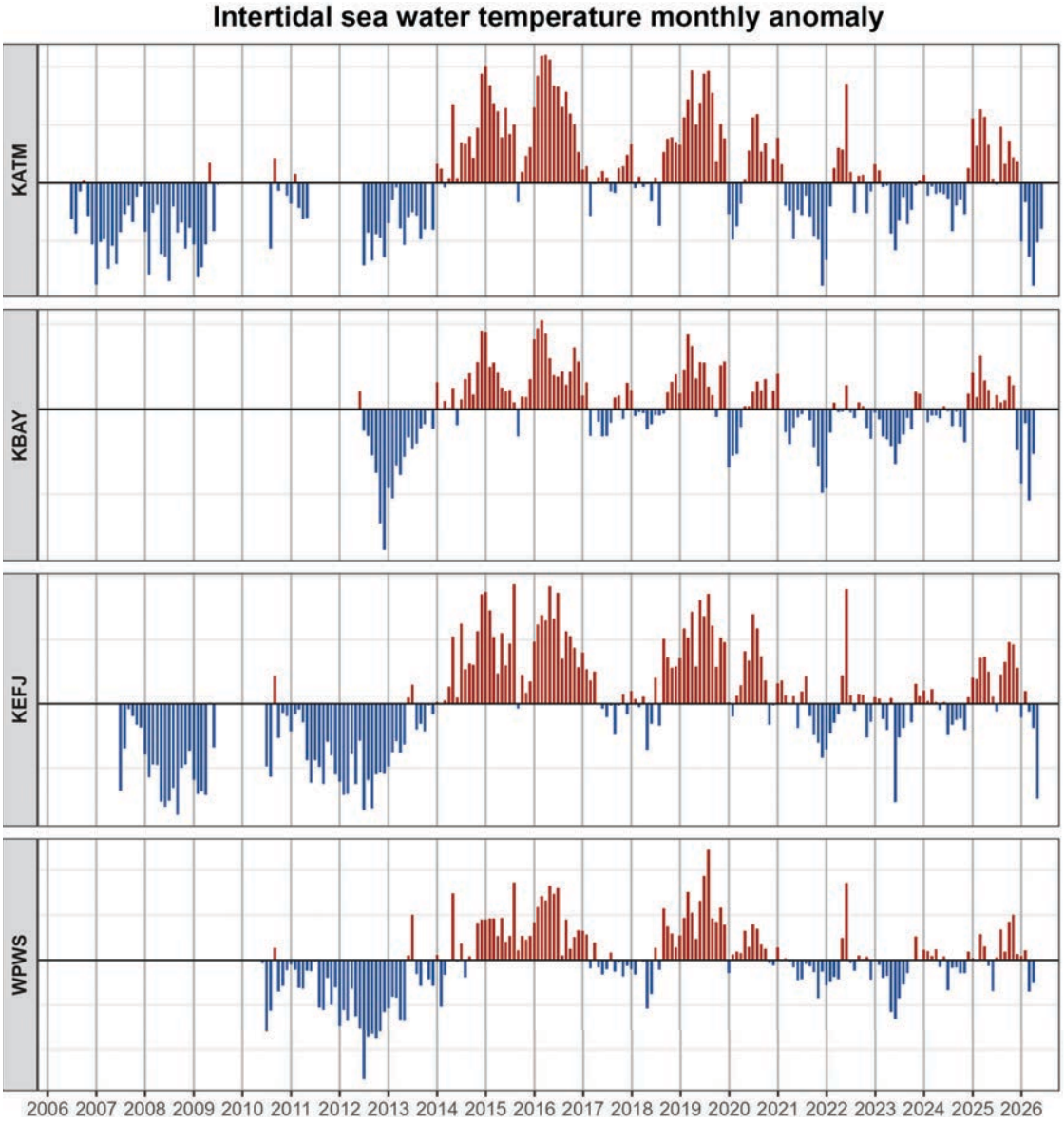


Figure 93: Seasonal intertidal water temperature anomalies at the 0.5 m tide level four regions of the western Gulf of Alaska (west of 144 °W), western Prince William Sound (WPWS; 2011 – 2026), Kenai Fjords National Park (KEFJ; 2008 – 2026), Kachemak Bay (KBAY; 2013 – 2026), and Katmai National Park adjacent to Shelikof Strait (KATM; 2006 – 2026). 2026 data included are Jan-Jun for KATM, Jan-Apr for KBAY, Jan-May for KEFJ and Jan-Apr for WPWS. Data are available in (U.S. Geological Survey - Alaska Science Center, National Park Service - Southwest Alaska - Inventory and Monitoring Network, and University of Alaska Fairbanks - College of Fisheries and Ocean Sciences, 2016).

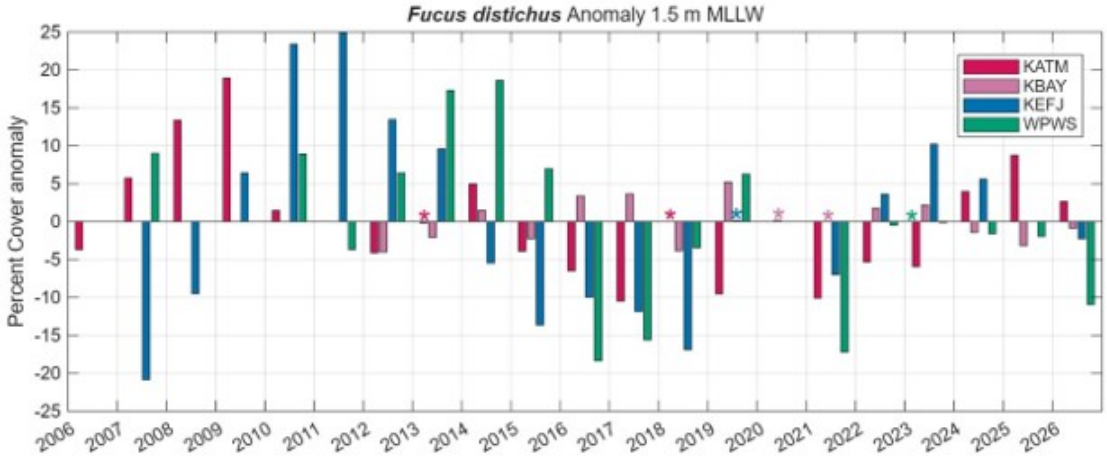


Figure 94: Percent cover anomalies for rockweed (*Fucus distichus*) in four regions of the western Gulf of Alaska, WPWS (2007, 2010 – 2019, 2021 – 2026), KEFJ (2008 – 2019, 2021 – 2024, 2026), KBAY (2012 – 2026), and KATM (2006 – 2010, 2012 – 2019, 2021 – 2026). WPWS, KEFJ and KATM were not sampled in 2020 due to COVID-19. KEFJ was not sampled in 2025. Note: years when anomalies are very close to zero and bars are not clearly visible are indicated by an asterisk. Data are available in (U.S. Geological Survey - Alaska Science Center, National Park Service - Southwest Alaska Inventory and Monitoring Network, 2022).

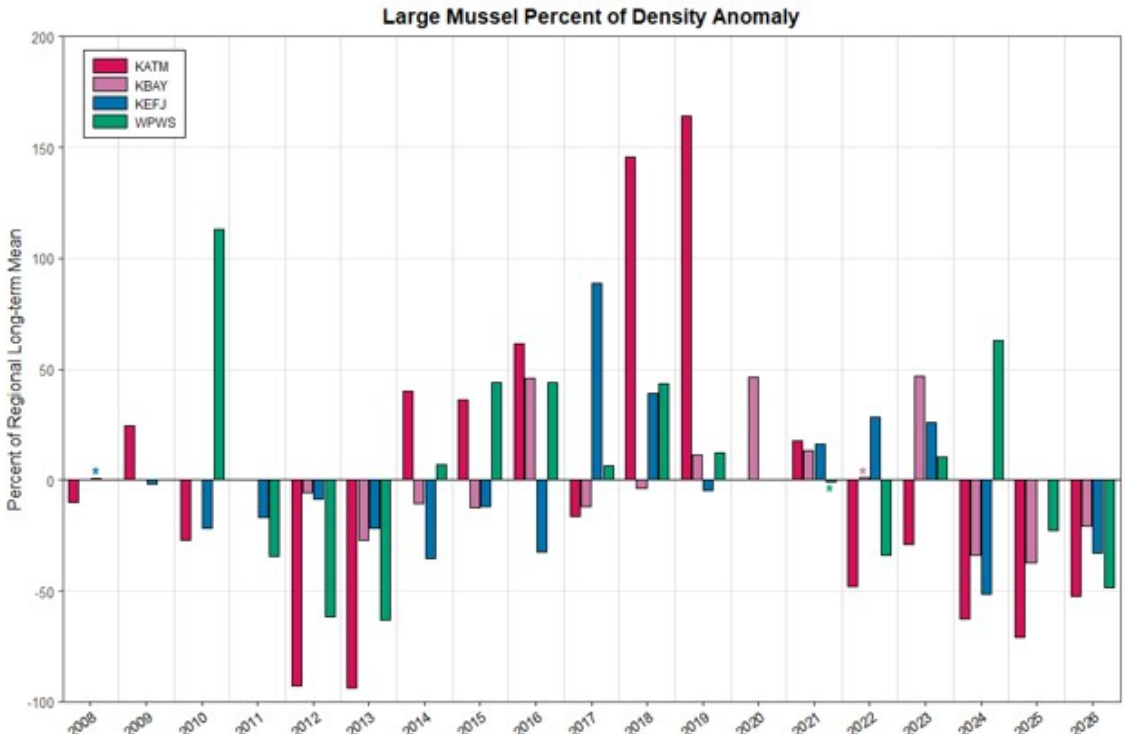


Figure 95: Percent of density anomalies for large mussels ($\geq$ 20 mm) in four study regions spanning the northern Gulf of Alaska. WPWS (2010 – 2019, 2021 – 2026), KEFJ (2008 – 2019, 2021 – 2024, 2026), KBAY (2012 – 2026), and KATM (2008 – 2010, 2012 – 2019, 2021 – 2026). Note: years when anomalies are very close to zero and bars are not clearly visible are indicated by an asterisk. KEFJ was not sampled in 2025. Data are available in (U.S. Geological Survey - Alaska Science Center, National Park Service - Southwest Alaska Inventory and Monitoring Network, 2016).

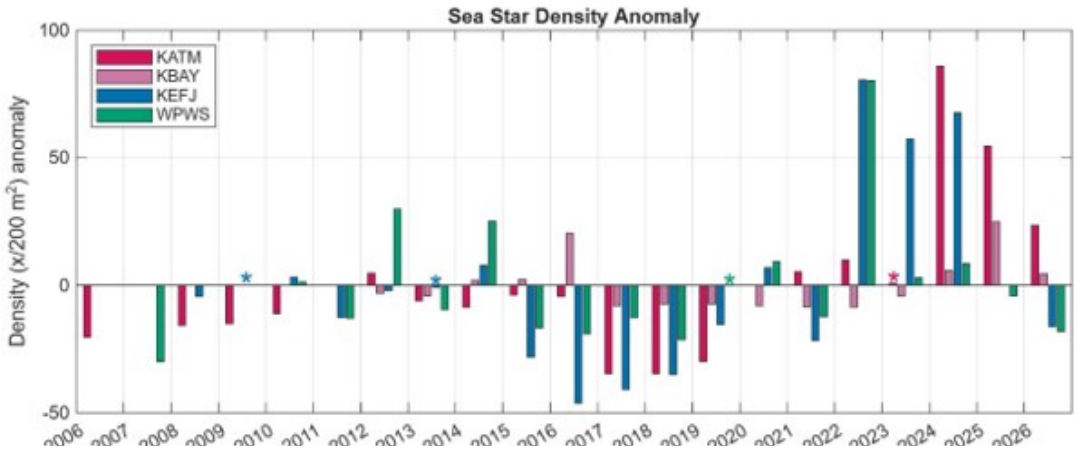


Figure 96: Density anomalies of sea stars (primarily *Dermasterias imbricata*, *Evasterias troschelii*, *Pisaster ochraceus*, and *Pycnopodia helianthoides*) in four study areas spanning the northern Gulf of Alaska. WPWS (2007, 2010 – 2026), KEFJ (2008 – 2019, 2021–2024, 2026), KBAY (2011 – 2026), and KATM (2006, 2008 – 2010, 2012 – 2019, 2021 – 2026). KEFJ was not sampled in 2025. Note: years when anomalies are very close to zero and bars are not clearly visible are indicated by an asterisk. Data are available in (U.S. Geological Survey - Alaska Science Center, National Park Service - Southwest Alaska Inventory and Monitoring Network, 2022).

Prince William Sound Herring

Contributed by Jennifer Morella[1], W. Scott Pegau[2], C. L. Roberts[3], and Joshua Zahner[3]
[1]ADF&G, Division of Commercial Fisheries, Box 669, Cordova, AK 99574
[2]Prince William Sound Science Center, Box 705, Cordova, AK 99574
[3]School of Aquatic and Fishery Sciences, University of Washington, Box 355020, Seattle, WA 98195
Contact: Jennifer.morella@alaska.gov
Last updated: August 2025

Not updated in 2026. Please refer to the archives[60] for past reports.

[60]https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands

Fall Surveys of Humpback Whales in Prince William Sound

Contributed by John Moran[1] and Janice Straley[2]
[1]NOAA Fisheries, Auke Bay Laboratory, Alaska Fisheries Science Center, Juneau, AK
[2]University of Alaska Southeast, Sitka, AK
Contact: john.moran@noaa.gov
Last updated: Ocotber 2026

Description of indicator: The humpback whale *Megaptera novaeangliae*) population in the North Pacific rebounded from near extinction caused by commercial whaling in the late 1960s to an estimated 34,000 individuals in 2012 (Barlow et al., 2024). During 2014 – 2016, the northeast Pacific marine heatwave reduced prey availability, resulting in the loss of $\sim$ 7,000 humpback whales, a 20% decline across the North Pacific basin (Cheeseman et al., 2024). Over much of the same period in Prince William Sound, the dominant forage fish, Pacific herring (*Clupea pallasii*), shifted from a multi-decadal high in 1989 to a severely diminished state by 1994. A commercial fishing moratorium has not restored the herring population to its former levels. Humpback whale abundance and calf production within Prince William Sound often track herring availability, signaling the overall capacity of the ecosystem to support large vertebrate predators.

Status and trends: Pre-heatwave observations from 2008 to 2013 documented up to 80 individual whales targeting shoals of energy-rich adult herring in predictable locations as they moved into the Sound. During and post-heatwave surveys through 2025 found far fewer whales and documented shifts in foraging behavior and target prey (Moran et al., 2026). The few whales present fed individually on small schools of juvenile herring and aggregations of euphausiids.

Preliminary observations from acoustic prey surveys in 2026, however, suggest that herring and euphausiid abundances have increased. We found $\sim$ 25 whales feeding together on euphausiids between Whale Bay and Bainbridge Passage. Groups of two to five were seen in the western and central Sound targeting euphausiids and small schools of juvenile herring, while three whales were associated with a large school of adult herring near The Needle. For the first time in 9 years, encounter rates (whales/nm traveled) trended toward pre-heatwave levels (Table 5). Reproduction in 2026 was also positive, with four mother-calf pairs observed during the survey, comparable to four pairs in 2023 and five in 2024, suggesting that humpback whales are responding to improved foraging conditions in Prince William Sound.

Factors influencing observed trends: The abundance of suitable whale prey, primarily euphausiids and herring, in Prince William Sound seems to be increasing. While the herring population returned to pre-heatwave levels several years ago, humpback whale numbers are slowly recovering within Prince William Sound and are approaching their pre-heatwave abundance. A sustained increase in humpback whale calf production within Prince William Sound implies improved prey availability in the previous four to five years. A female humpback whale requires three years of successful forage to rear a calf. She must be in good condition to successfully migrate and conceive in year one, carry the fetus to term in year two, and nurse the calf in year three.

Implications: The increase in whale numbers within Prince William Sound indicates a much delayed, but positive recovery toward pre-heatwave levels. The sustained calf production observed in 2023, 2024,

Table 5: Summary of Prince William Sound humpback whale counts, effort in nautical miles and encounter rate during fall surveys 2008 – 2026. No surveys occurred in 2009, 2010, 2015, 2016.

Month/year	Counts of all whales	Counts of calves	Nautical miles surveyed	Encounter rate whale/nm
Sep-08	71	7	412	0.17
Oct-11	62	2	441	0.14
Sep-12	81	5	444	0.18
Sep-13	113	6	355	0.32
Sep-14	181	1	427	0.42
Sep-17	12	0	543	0.02
Sep-18	17	1	541	0.03
Sep-19	35	0	573	0.06
Sep-20	14	2	331	0.04
Sep-21	23	0	525	0.04
Sep-22	19	1	504	0.04
Sep-23	34	4	497	0.07
Sep-24	38	5	540	0.07
Sep-25	29	0	490	0.06
Sep-26	61	4	487	0.12

and 2026 demonstrates that whales are foraging successfully, a positive sign for ecosystem recovery. Interestingly, we found large schools of age-0 walleye pollock (*Gadus chalcogrammus*) and age-0 Pacific cod (*Gadus macrocephalus*) throughout the survey. It is important to evaluate a change in the abundance of whales in Prince Williams Sounds relative to other regions of the Gulf of Alaska. An increase in whale numbers within Prince William sound may stem from poor conditions in the Gulf of Alaska driving whales into coastal waters, rather than a broader population recovery.

Fishing Indicators

Maintaining Diversity: Discards and Non-Target Catch

Time Trends in Groundfish Discards

Contributed by Anna Abelman, Resource Ecology and Fisheries Management Division, AFSC, NOAA Fisheries, and Alaska Fisheries Information Network, Pacific States Marine Fisheries Commission
Contact: anna.abelman@noaa.gov
Last updated: October 2026

Description of indicator: Estimates of groundfish discards for 1993 – 2002 are sourced from NMFS Alaska Region's blend data, while estimates for 2003 and later come from the Alaska Region's Catch Accounting System. These sources, which are based on observer data in combination with industry landing and production reports, provide the best available estimates of groundfish discards in the North Pacific. Discard rates, as shown in Figure 97, are calculated as the weight of groundfish discards divided by the total (i.e., retained and discarded) catch weight for the relevant areagear-target sector. Where rates are described for species or species groups, they represent the total discarded weight of the species/species group divided by the total catch weight of the species/species group for the relevant area-gear-target sector. These estimates include only catch of FMP-managed groundfish species within the FMP groundfish fisheries. Discards of groundfish in the halibut fishery and discards of forage fish and species managed under prohibited species catch limits, such as halibut, are not included.

Status and trends: Discard biomass in the non-pollock trawl sectors, in 2026, is trending lower relative to the previous 5 years through week 42, whereas trawl pollock and fixed gear discard biomass is trending higher than previous years (Figure 98). Since 1993 discard rates of groundfish species in federally-managed Alaskan groundfish fisheries have generally declined in both pollock and non-pollock trawl fisheries in the Gulf of Alaska (GOA) (Figure 97). In the non-pollock trawl sector, discard rates dropped from 40% in 1994 to 21% in 1998, trended upwards from 1998 to 2003, and generally declined to a low of 8% in 2015 and 2016 before increasing slightly to 11% in 2017. The 2023 discard biomass for non-pollock trawl was its lowest at 2,938 mT and rate of 6%, but since then slightly increase to 3,440 mT at 6%. Discard rates in the GOA pollock trawl sectors declined from over 10% in 1993 to about 1% in 1998 and have since fluctuated between 1% and 3%. Discard biomass in the fixed gear (hook-and-line and pot) sector has generally declined from 2013 onward, though discard rates for fixed gear across the GOA as a whole increased to over 17% in 2018 and 2019 after remaining at 11% or lower from 2013 to 2025.

Factors influencing observed trends: Fishery discards may occur for economic or regulatory reasons. Economic discards include discarding of lower value and unmarketable fish, while regulatory discards are those required by regulation (e.g., upon reaching an allowable catch limit for a species). Minimizing discards is recognized as an ecological, economic, and moral imperative in various multilateral initiatives and in National Standard 9 of the Magnuson-Stevens Fishery Conservation and Management Act (Alverson et al., 1994; FAO, 1995; National Marine Fisheries Service, 2011). In the North Pacific

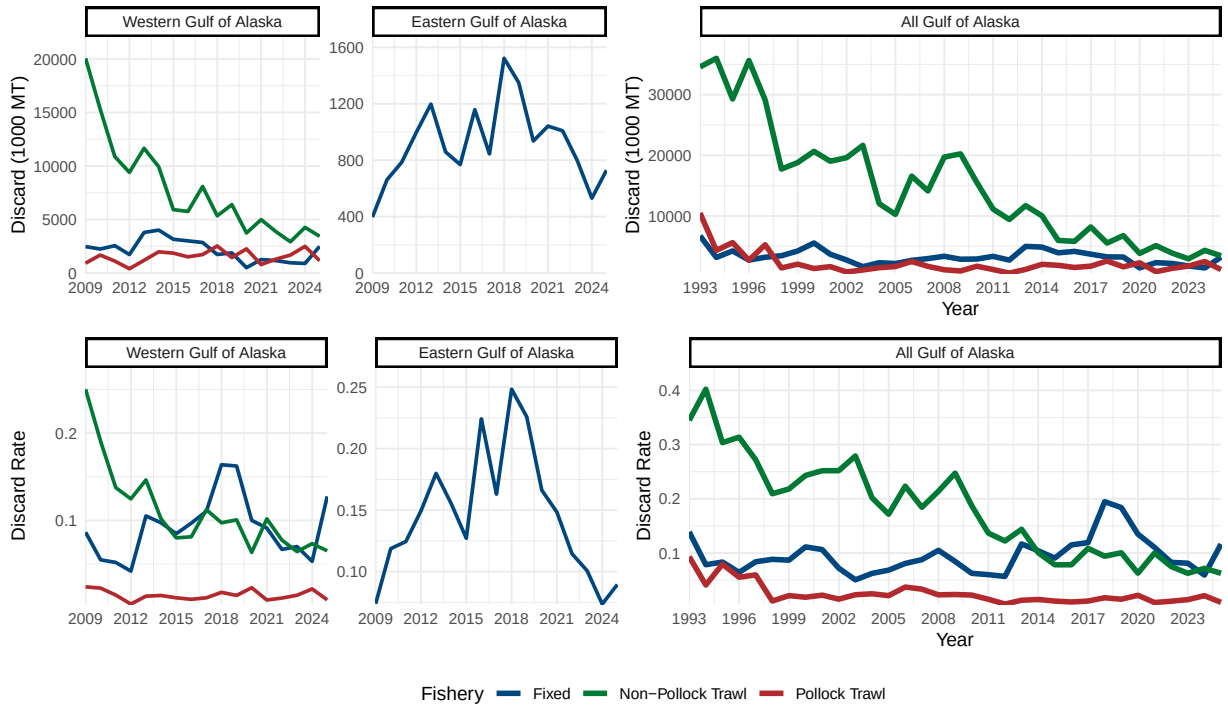


Figure 97: Total biomass and percent of total catch biomass of FMP groundfish discarded in the fixed gear, pollock trawl, and non-pollock trawl sectors for the Gulf of Alaska region, 1993 – 2025; and for and eastern and western GOA subregions, 2009 – 2025. Discard rates are calculated as total discard weight of FMP groundfish divided by total retained and discarded weight of FMP groundfish for the sector (includes only catch counted against federal TACs).

groundfish fisheries, mechanisms to reduce discards include:

- Limited access privilege programs (LAPPs), which allocate catch quotas and may reduce economic discards by slowing down the pace of fishing
- In-season closure of fisheries once target or bycatch species quotas are attained
- Minimum retention and utilization standards for certain fisheries
- Maximum retainable amounts (MRAs), which allow for limited retention of species harvested incidentally in directed fisheries.

In the Gulf of Alaska LME, management and conservation measures aimed at reducing bycatch have contributed to an overall decline in groundfish discards since the early 1990s (NPFMC, 2016).

Pollock roe stripping, wherein harvesters discard all but the the highest value pollock product, was prohibited in 1991 (56 Federal Register 492). In 1997 arrowtooth flounder was added as a basis species for retention of pollock and Pacific cod (62 Federal Register 11109), and in 1998 full retention requirements for pollock and cod were implemented for federally-permitted vessels fishing for groundish, leading to overall declines in pollock and cod discards in the GOA (62 Federal Register 65379).

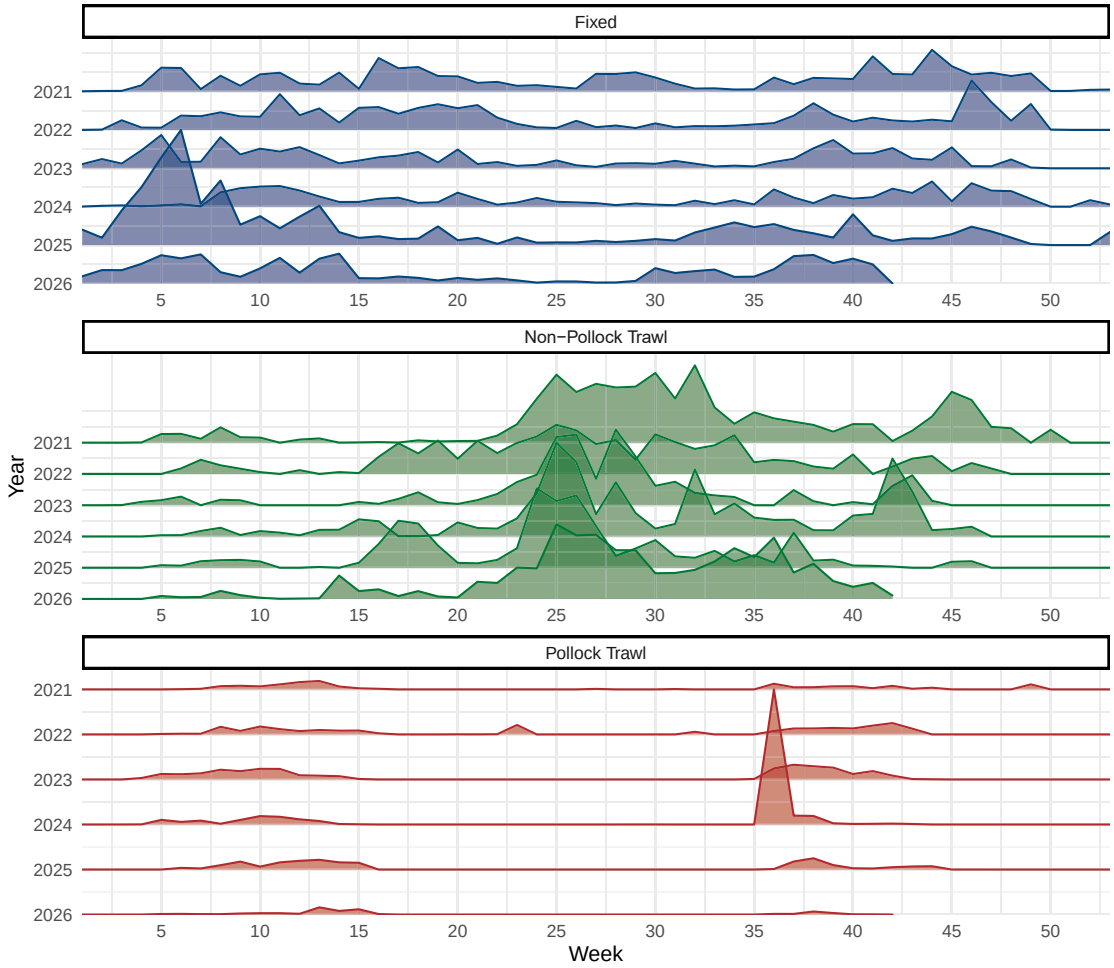


Figure 98: Total biomass of FMP groundfish discarded in the Gulf of Alaska by sector and week, 2021 - 2026 (data for 2026 is shown through week 42). Plotted heights are not comparable across fisheries.

Additional retention requirements went into effect in 2003 for shallow-water flatfish species across the entire GOA (62 Federal Register 65379) and in 2004 for demersal shelf rockfish in the Southeast Outside district of the Eastern Gulf (69 Federal Register 68095). In 2009, NMFS revised the MRA for groundfish caught in the Gulf of Alaska arrowtooth flounder fishery, including an increase from 0 to 20 percent for flatfish species (74 Federal Register 13348). Under the GOA groundfish FMP, fisheries with discard rates over 5% for shallow-water flatfish are subject to annual review by the North Pacific Council. Reductions in flatfish discards account for most of the general decline in discards and discard rates for the non-pollock trawl sector.

As of March 2020, the regulations 50 CFR 679.20(j) and 50 CFR 679.7(a)(5) were implemented to require operators of catcher vessels using hook-and-line, pot, or jig gear (fixed gear) to fully retain rockfish landings in the BSAI or GOA. These regulations also limits the amount of rockfish that can enter into the market with the overall purpose of limiting total catch of rockfish.

Measures for reducing discards are included in the Pacific halibut and Sablefish Individual Fishing Quota (IFQ) Program, implemented in 1995, and the Central Gulf of Alaska (CGOA) Rockfish Program, piloted in 2007 and fully implemented in 2012. In the IFQ program, retention of sablefish and halibut is

required as long as the harvester has catch quota available, which restricts the practice of high grading. Additionally, all Pacific cod and rockfish must be retained when IFQ halibut or sablefish are on board, subject to other regulations. Vessels participating in cooperatives with CGOA Rockfish Program catch quota are prohibited from discarding catch of allocated target species (Pacific ocean perch and northern, dusky, and thornyhead rockfish) and bycatch species (Pacific cod, sablefish, and rougheye and shortraker rockfish).

In recent years the species historically comprising the "other groundfish" assemblage (skate, sculpin, shark, squid, and octopus) have overtaken flatfish as the largest source of discards in the GOA. Most discards of these species currently occur in the longline fishery, although expanded observer coverage of smaller hook and line vessels beginning in 2013 may account for some of the recent increase in fixed gear sector discards. Retention rates for skate and octopus have fluctuated over time, in part due to changing market conditions for these species (Conners and Conrath, 2017; Ormseth, 2017). Interest in retention of skates and directed fishing for skates, despite management under bycatch-only status beginning in 2005, resulted in annual overages of longnose and big skate TACs from 2007 to 2013. Discards and discard rates of skate increased between 2013 and 2016 as NMFS took action to prevent such overages, including regulatory discard requirements for big skate in the Central GOA, imposed at progressively earlier dates during the year from 2013 to 2015, and, in 2016, a reduction in the MRA for GOA skates from 20% to 5% (Ormseth, 2017).

In April 2025, the North Pacific Fishery Management Council (NPFMC) recommended allowing economically undesirable small sablefish to be discarded (North Pacific Fishery Management Council newsletter[61]). While this is still pending NMFS rulemaking, the Advisory Panel is urging implementation in time for the 2027 season (North Pacific Fishery Management Council Advisory Panel June 2026 Report[62]). Later, in October 2025, the Council recommended updating the Maximum Retainable Amounts (MRA) for groundfish in the BSAI and GOA. This change could reduce regulatory discards without increasing overall harvest limits, though it is also currently pending rulemaking (North Pacific Fishery Management Council Oct. 2025 newsletter[63]).

Implications: Fishery discards add to the total human impact on biomass without providing a benefit to the Nation and as such are perceived as "contrary to responsible stewardship and sustainable utilization of marine resources" (Kelleher, 2005). Discards may constrain the utilization of target species and increase the uncertainty around total fishing-related mortality, making it more difficult to assess stocks, define overfishing levels, and monitor fisheries for overfishing (Alverson et al., 1994; National Marine Fisheries Service, 2011; Clucas, 1997). Although ecosystem effects of discards are not fully understood, discards of whole fish and offal have the potential to alter energy flow within ecosystems and have been observed to result in changes to habitat (e.g., oxygen depletion in the benthic environment) and community structure (e.g., increases in scavenger populations) (Queirolo et al., 1995; Alverson et al., 1994; Catchpole et al., 2006; Zador and Fitzgerald, 2008). Monitoring discards and discard rates provides a means of assessing the efficacy of measures intended to reduce discards and increase groundfish retention and utilization.

[61] https://www.npfmc.org/april-2025-newsletter/

[62] https://meetings.npfmc.org/CommentReview/DownloadFile?fileName=F+AP+Report.pdf&p=6fa31f15-8c66-49ec-9ba3-bcb1bd2ed6b1.pdf

[63] https://www.npfmc.org/october-2025-newsletter/

Time Trends in Non-Target Species Catch

Contributed by George A. Whitehouse[1] and Sarah Gaichas[2]
[1]Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES), University of Washington, Seattle WA,
[2]Hydra Scientific LLC, Falmouth MA
Contact: gaw@uw.edu
Last updated: August 2026

Description of indicator: This indicator reports the catch of non-target species in groundfish fisheries in the Gulf of Alaska (GOA). Catch since 2003 has been estimated using the Alaska Region's Catch Accounting System (Cahalan et al. 2014). This sampling and estimation process does result in uncertainty in catches, which is greater when observer coverage is lower and for species encountered rarely in the catch. Since 2013, the three categories of non-target species tracked here are:

1. Scyphozoan jellyfish
2. Structural epifauna (seapens/whips, sponges, anemones, corals, tunicates)
3. Assorted invertebrates (bivalves, brittle stars, hermit crabs, miscellaneous crabs, sea stars, marine worms, snails, sea urchins, sand dollars, sea cucumbers, and other miscellaneous invertebrates).

The catch of non-target species/groups from the GOA includes the reporting areas 610, 620, 630, 640, 649, 650, and 659[64]. Within reporting area 610, the GOA and Aleutian Islands (AI) Large Marine Ecosystems (LMEs) are divided at 164 °W. Non-target species caught east of 164 °W are within the GOA LME and the catch west of 164 °W is within the AI LME.

Status and trends: The trend in the catch of jellies from 2020 – 2025 has been generally flat, with the time series low in 2022. The catch of Scyphozoan jellies in the GOA has been variable from 2011 – 2020, with peaks in 2012, 2015, 2016, and 2019 (Figure 99). Scyphozoan jellies are primarily caught in the pollock fishery.The catch of structural epifauna gradually increased from 2011 to 2016, and has since trended downward to the time series low in 2023 and has remained low in 2024 and 2025. Sea anemones comprised the majority of the structural epifauna catch from 2011 – 2019 and in 2024 – 2025 and were co-dominant with unidentified corals and bryozoans from 2020 – 2022. Sponges were the dominant component of structural epifauna catch in 2023. Structural epifauna has primarily been caught in hook and line and non-pelagic trawl fisheries. The catch of assorted invertebrates increased from 2012 to a peak in 2015 then decreased each year to a low in 2021 and has remained low each year since. Sea stars dominate the assorted invertebrate catch, accounting for more than 76% of the total assorted invertebrate catch in each year. Sea stars are caught primarily in pot and hook and line fisheries.

Factors influencing observed trends: The catch of non-target species may change if fisheries change, if ecosystems change, or both. Because non-target species catch is unregulated and unintended, if there have been no large-scale changes in fishery management in a particular ecosystem, then large-scale signals in the non-target catch may indicate ecosystem changes. Trends in the catch of non-target

[64]https://www.fisheries.noaa.gov/alaska/sustainable-fisheries/alaska-fisheries-figures-maps-boundaries-regulatory-areas-and-zones

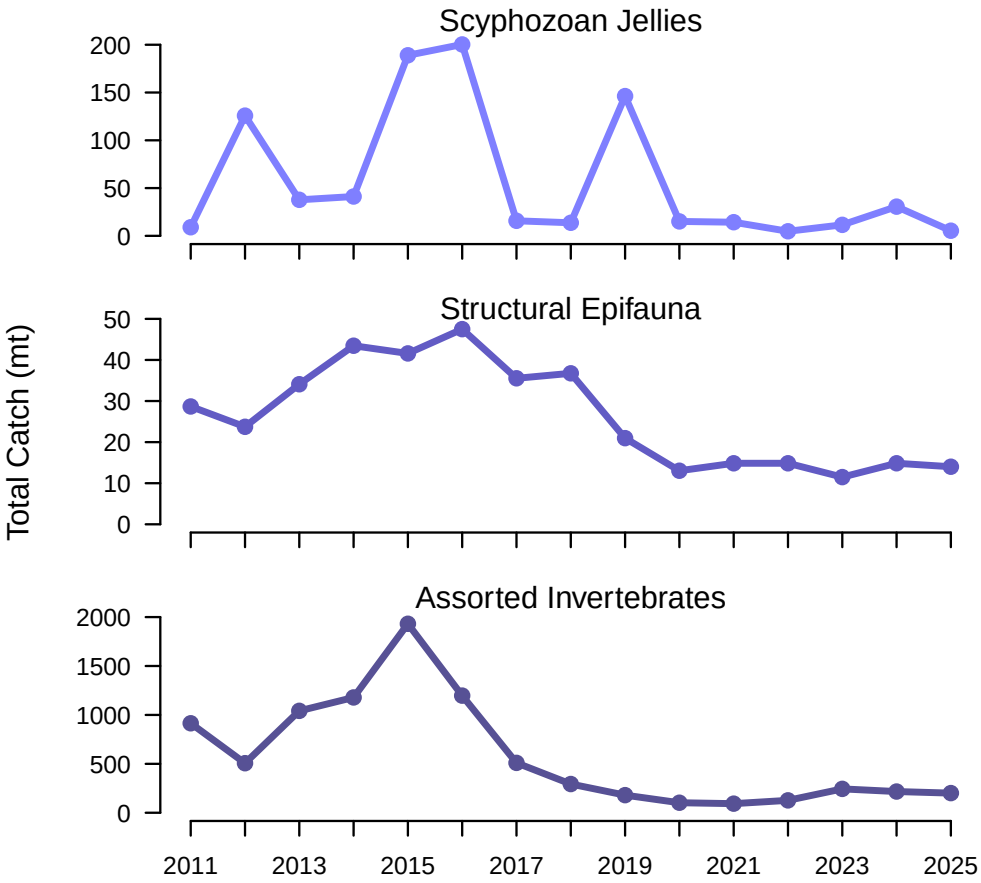


Figure 99: Total catch of non-target species (tons) in the GOA groundfish fisheries (2011 – 2025). Note the different y-axis scales between species groups.

species may be driven by changes in biomass or changes in distribution (overlap with the fishery) or both.

Jellyfish population dynamics are influenced by a suite of biophysical factors affecting the survival, reproduction, and growth of jellies including temperature, wind-mixing, ocean currents, and prey abundance (Purcell, 2005; Brodeur et al., 2008). The lack of a clear trend in the catch of scyphozoan jellies may reflect interannual variation in jellyfish biomass or changes in the overlap with fisheries.

Implications: The catch of structural epifauna species and assorted invertebrates is very low compared with the catch of target species. Abundant jellyfish may have a negative impact on fishes as they compete with planktivorous fishes for prey resources (Purcell and Sturdevant, 2001; Ruzicka et al., 2020), and may prey upon the early life history stages (eggs and larvae) of fishes (Purcell and Arai, 2001; Robinson et al., 2014). Additionally, jellyfish may be an important prey resource for predators, including commercially important groundfishes (Brodeur et al., 2021).

Seabird Bycatch Estimates for Groundfish Fisheries

Contributed by Jessica Beck[1], Maggie Chan[2], and Cathy Tide[2]
[1]Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, NOAA Fisheries
[2]Sustainable Fisheries Division, Alaska Regional Office, NOAA Fisheries
Contact: jessica.beck@noaa.gov
Last updated: September 2026

Description of indicator: This report provides estimates of the numbers of seabirds caught as bycatch in commercial groundfish and halibut fisheries operating in waters off Alaska in the Gulf of Alaska (GOA) for 2016 through 2025. Estimates of seabird bycatch from earlier years using different methods are not included here, nor are estimates prior to the start of data collection in the Pacific halibut longline fishery (see previous Ecosystem Status Reports for these estimates). Fishing gear types represented are demersal longline, pot, pelagic trawl, and non-pelagic trawl. These numbers do not apply to jig, gillnet, seine, or troll fisheries [65].

The NOAA Fisheries Alaska Regional Office Catch Accounting System (CAS) produces the estimates (Cahalan et al., 2010, 2014) and provides near real-time delivery of accurate groundfish and prohibited species catch and bycatch information for inseason management decisions. These estimates are based on three sources of information: (1) data provided by NMFS-certified fishery observers deployed to vessels and floating or shoreside processing plants, (2) video review of electronically monitored (EM) fixed gear vessels, and (3) industry reports of catch and production. CAS also estimates non-target species (such as invertebrates) and seabird bycatch in the groundfish and halibut fisheries. The data sets used by CAS are subject to change over time. Each year, an Annual Deployment Plan (ADP) describes the science driven method for deployment of observers and EM on vessels in the partial coverage component of the North Pacific Observer Program (50 CFR 679.51(a))[66]. The ADP specifies the scientific deployment design for the partial coverage fisheries and the selection rate—the portion of trips that are sampled by observers and EM. Deployment rates can differ by gear type, location, or other factors. In the full coverage category of the North Pacific Observer Program, every trip is monitored by 1 or 2 observers. In 2025, 99.8% of the demersal longline fishing trips were in the partial coverage category in the GOA and 0.2% were in full coverage (Table 4-2; Alaska Fisheries Science Center and Alaska Regional Office, 2026).

This report delineates and separately discusses estimates of seabird bycatch in the eastern GOA and the western GOA (divided at 147 °W). Estimates of seabird bycatch from the eastern GOA include reporting areas 659, 650, 640, and 649 (east of 147 °W). Estimates from the western GOA include reporting areas 649 (west of 147 °W), 630, 620, and 610 (east of 164 °W)[67].

[65]This report does not include estimates of seabird bycatch in fisheries using jig, gillnet, seine, or troll gear because NOAA Fisheries does not have independent observer data from these fisheries. These estimates also do not apply to State of Alaska-managed salmon, herring, shellfish (including crab), or dive fisheries.

[66]https://www.fisheries.noaa.gov/tags/north-pacific-observer-program?title=annual%20deployment&field_species_vocab_target_id=&sort_by=created

[67]https://www.fisheries.noaa.gov/alaska/sustainable-fisheries/alaska-fisheries-figures-maps-boundaries-regulatory-areas-and-zones

Status and trends: The number of seabirds estimated to be caught incidentally in the eastern GOA in 2025 (23 birds) declined 90% compared to the 2016 – 2024 average (245 birds, Table 6). In the western GOA, a total of 77 seabird bycatch takes were estimated, down 82% from the 2016 – 2024 average (434 birds, Table 7). A primary driver of this decline was the lack of black-footed albatross (*Phoebastria nigripes*) takes in Alaska waters in 2025. This is the first year since at least 1993 of zero estimated takes of black-footed albatross (pre-2016 data in Fitzgerald et al., 2008; Eich et al., 2018) in the GOA. Compared to the 2016 – 2024 average, 2025 also had reduced takes of Laysan albatross (*Phoebastria immutabilis*; down 95% in eastern GOA and 40% in western GOA) and Northern Fulmars (*Fulmarus glacialis*; down 100% in eastern GOA and 90% in western GOA). In 2025, takes of gull species (*Laridae* spp.) were also reduced 63% in eastern GOA and 36% in western GOA, compared to the 2016 – 2024 average.

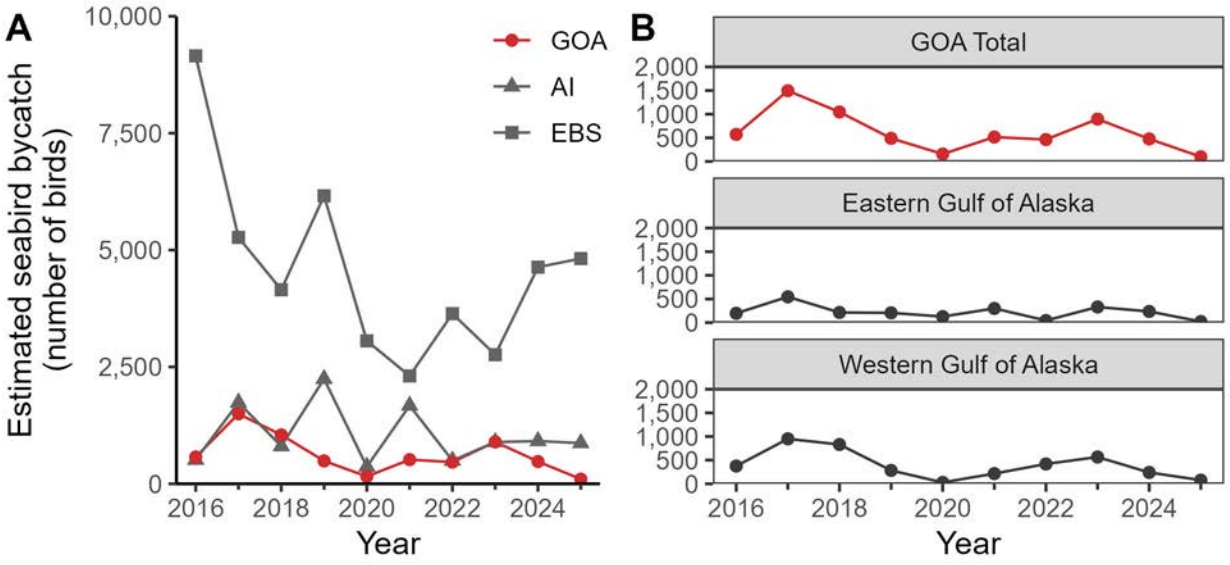


Figure 100: Total estimated seabird bycatch in Gulf of Alaska (GOA), Aleutian Islands (AI), and eastern Bering Sea (EBS) groundfish and halibut fisheries, all gear types combined, 2016 through 2025. (B) Total estimated seabird bycatch in the GOA (GOA Total), Eastern Gulf of Alaska, and Western Gulf of Alaska groundfish and halibut fisheries, all gear types combined, 2016 through 2025.

Table 6: Estimated seabird bycatch in the eastern Gulf of Alaska groundfish and halibut fisheries for all gear types, 2016 through 2025. Note that these numbers represent extrapolations from observed bycatch, not direct observations. See text for estimation methods.

Species Group	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Unidentified Albatross	0	0	42	1	0	0	0	0	4	0
Short-tailed Albatross	0	0	0	0	0	0	0	0	0	0
Laysan Albatross	4	2	4	36	13	5	0	119	0	1
Black-footed Albatross	95	228	105	100	74	254	13	93	194	0
Northern Fulmars	8	37	21	47	2	12	2	3	39	0
Shearwaters	2	24	2	2	6	0	0	38	0	0
Storm Petrels	0	0	0	0	0	0	0	0	0	0
Gulls	87	244	41	22	19	29	30	77	0	22
Kittiwake	0	0	0	0	0	0	0	0	0	0
Murre	0	0	0	0	0	0	0	0	0	0
Puffin	0	0	0	0	0	0	0	0	0	0
Auklets	0	0	0	0	0	0	0	0	0	0
Cormorants	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Unidentified Birds	2	1	0	0	14	0	0	0	0	0
Grand Total	198	546	215	207	128	300	45	331	237	23

Table 7: Estimated seabird bycatch in the western Gulf of Alaska groundfish and halibut fisheries for all gear types, 2016 through 2025. Note that these numbers represent extrapolations from observed bycatch, not direct observations. See text for estimation methods.

Species Group	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Unidentified Albatross	0	0	8	18	0	0	11	0	27	0
Short-tailed Albatross	0	0	0	0	0	0	0	0	0	0
Laysan Albatross	39	23	19	2	9	15	0	29	0	21
Black-footed Albatross	75	441	202	112	8	86	169	3	133	0
Northern Fulmars	173	230	224	85	5	81	193	28	80	10
Shearwaters	17	12	38	30	2	0	0	49	0	0
Gulls	55	231	199	35	3	23	46	52	0	46
Kittiwake	0	0	0	0	0	0	0	0	0	0
Murre	0	0	0	0	0	0	0	0	0	0
Puffin	0	0	0	0	0	0	0	0	0	0
Auklets	0	0	0	0	0	0	0	0	0	0
Other Alcids	0	0	0	0	0	0	0	0	0	0
Cormorants	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Unidentified Birds	16	13	140	0	3	10	0	404	0	0
Grand Total	375	951	831	283	29	216	419	566	240	77

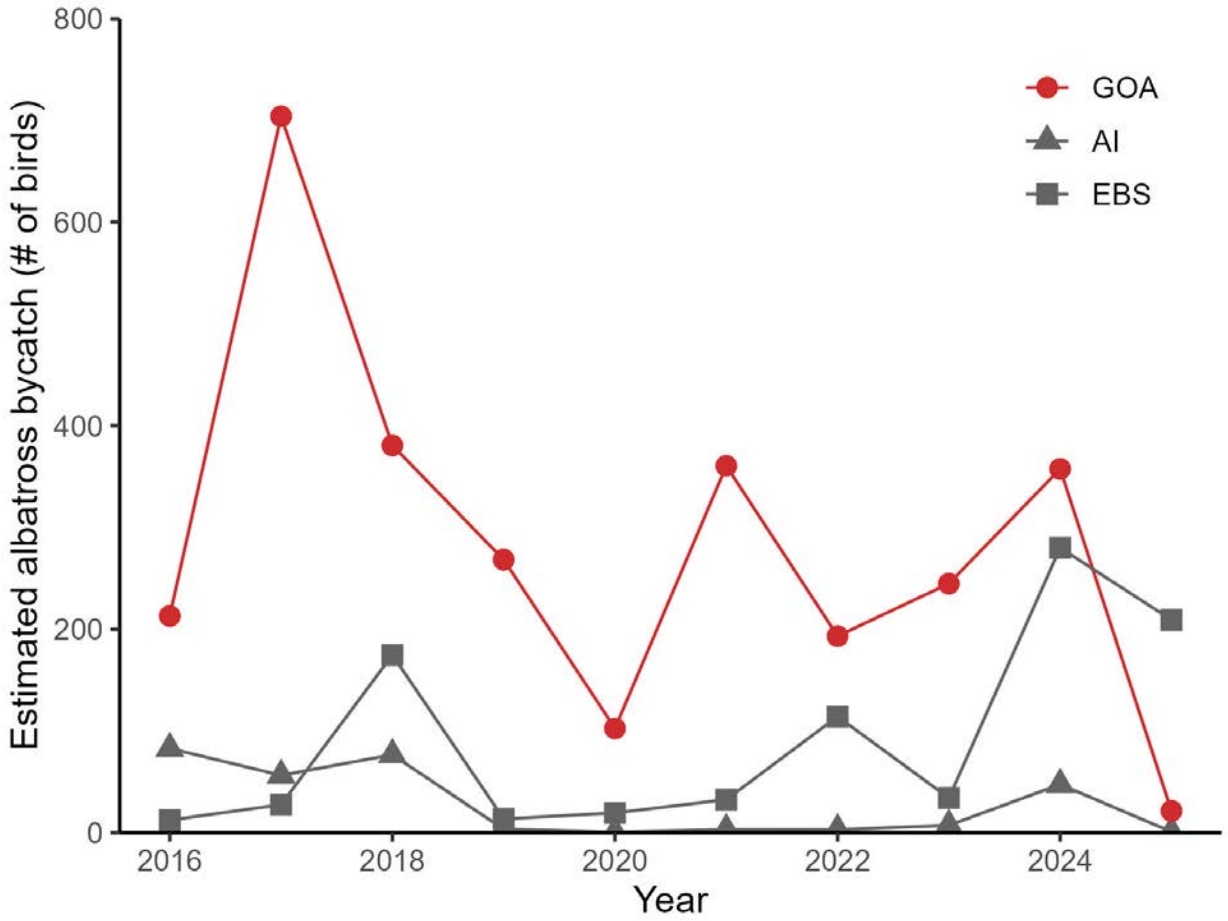


Figure 101: Total estimated albatross bycatch in Gulf of Alaska (GOA), Aleutian Islands (AI), and eastern Bering Sea (EBS) groundfish and halibut fisheries, all gear types combined, 2016 through 2025.

Factors influencing observed trends: Many factors influence annual variation in bycatch rates, including seabird distribution and ecology, population trends, prey supply, and fisheries activities.

Lack of black-footed albatross takes Black-footed albatross are one of three albatross species that utilize Alaska waters, with the highest densities of sightings in fisheries independent surveys being in the GOA in late summer and fall (Suryan and Kuletz, 2018). Important factors in habitat models for black-footed albatross include wind speed and sea floor depth (Suryan and Kuletz, 2018; Fischer, 2008), as well as sea surface temperature and chlorophyll (as a proxy for phytoplankton; Fischer, 2008; Kappes et al., 2010). Takes of black-footed albatross have been recorded in a variety of métiers in Alaska groundfish fisheries (Eich et al., 2016). In previous years, black-footed albatross bycatch in Alaska has largely been driven by takes in the GOA region (Eich et al., 2018), with the highest annual averages among hook-and-line vessels operating in the sablefish fisheries (both catcher processor and catcher vessels; Eich et al., 2016). This has been due to a multitude of ecological and fleet factors, such as high fleet spatial and temporal overlap with the species's distribution range along the continental shelf break during late summer and early fall (Eich et al., 2016).

Estimated black-footed albatross bycatch in the GOA declined from 327 birds in 2024 to zero in 2025.

Available indicators of fishing activity show mixed changes. Hook-and-line catcher-processor participation was unchanged at seven vessels, while catcher-vessel participation increased from 238 to 261 vessels, in 2024 and 2025 respectively. Looking at months when albatross bycatch rates historically peaked in the region, catcher-vessel participation declined slightly during April–May, from 180 to 176 vessels, and more substantially during September, from 53 to 32 vessels. Vessel-weeks for hook-and-line sablefish catcher vessels under 60 feet declined from 410 to 323. These indicators suggest reduced activity in some seasonal and fleet strata, but vessel participation and apportioned vessel-weeks do not directly measure hooks deployed or the spatial and temporal overlap between fishing and black-footed albatrosses. The available evidence therefore does not yet establish how much reduced fishing effort contributed to zero estimated bycatch in 2025. Other potential fleet-related explanations include changes in the location and timing of fishing, target and vessel composition, vessel-specific operating or seabird-avoidance practices, and observer coverage and sampling. Data can be found in the Abelman et al. (In Prep.).

Interannual changes in black-footed albatross distribution are also important factors that intersect with possible fleet overlap explanations. One factor to consider is local storm anomalies. Albatross are long-distance fliers and rely on low-altitude winds to access foraging grounds across their ranges. Albatross species also avoid strong storms, possibly due to lower chances of foraging success in these conditions or to avoid injury (Darby et al., 2024). In September of 2025, strong storms in both the Aleutian Islands and the GOA may have caused wind currents to push black-footed albatross towards western Aleutians and avoid the GOA. Concurrently, a strong pressure ridge extending down from Haida Gwaii may have encouraged black-footed albatross to forage along the British Columbia shelf and further south in the California Current. However, while these early fall storms may have contributed to lower bycatch during this season, they do not account for zero takes of black-footed albatross throughout the rest of 2025.

Temporal or spatial changes in wind currents at a north Pacific basin-wide scale may also have impacted black-footed albatross overlap with groundfish fisheries in Alaska, and contributed to a decline in bycatch in this region in 2025. Black-footed albatross heavily utilize winds associated with dominant currents (e.g., north Pacific and Kuroshio currents) to access foraging grounds from Japan to California and Alaska. While fishery-independent albatross distribution data at a basin-scale were not available for this publication, bycatch trends in other regions can indicate interannual albatross range changes. The West Coast Groundfish Observer Program (covering the west coast groundfish fisheries) saw lower levels of black-footed albatross than average, but not zero (K. Somers, pers. obs.), possibly indicating lower albatross use of that region. In 2025, the Pacific Islands Region Observer Program saw increased levels of black-footed albatross in shallow-set longline fleets that frequently fish north of 23 °N, possibly pointing to an increased black-footed albatross use of the eastern central Pacific (data preliminary; L. Rassel, pers. obs.). While there are likely various factors influencing black-footed albatross bycatch patterns in the GOA and more broadly in Alaska groundfish fisheries, a single factor that clearly can explain the lack of black-footed albatross bycatch in 2025 has not yet been identified. A more in-depth analysis is needed to better understand underlying variables and their interactions.

Reduced takes of Laysan albatross and northern fulmars in 2025 Local storm anomalies in the GOA may also have contributed to reduced takes of Laysan albatross and possibly northern fulmars. Similar to black-footed albatross, Laysan albatross use low-altitude wind currents to access foraging grounds and likely avoid storm systems for similar reasons. However, Laysan albatross utilize the GOA less frequently than black-footed albatross, preferring outer and middle shelf domains in the Aleutian Islands and eastern Bering Sea. Data for the eastern Bering Sea region show lower Laysan albatross bycatch compared to 2024, but still high levels relative to the 2016 – 2024 average (Beck et al., 2026). In the future, increased environmental variability and related implications for increased storm anomalies could impact seabird

bycatch trends in Alaska groundfish fisheries, with varying results by species, region, overlapping fleets, and season.

ESA species: There were no takes of ESA-listed seabirds in the GOA in 2024 or 2025 in federally-managed groundfish and halibut fisheries. Observers are trained to retain any specimens that they suspect could be ESA-listed species, even if they cannot positively identify the specimen to species in the field[68].

Implications: Estimated seabird bycatch in the GOA fisheries off Alaska in 2025 decreased compared to the 2016 – 2024 average. It is difficult to determine how seabird bycatch estimates and trends are linked to changes in ecosystem components. Many seabirds caught in groundfish and halibut fisheries in Alaska are wide-ranging and can fly hundreds of miles per day, resulting in less restricted foraging areas. Of the species caught as bycatch in the GOA, only gull species and northern fulmars breed in the region. Changes in fleet dynamics also affect seabird bycatch estimates, further complicating direct links with ecosystem components. Fisheries bycatch can also affect seabird populations directly. In Alaska, bycatch of ESA-listed species is tightly regulated, and NOAA works in conjunction with outside agencies and partners to assess and manage the risk of bycatch to unlisted seabird species, including requiring seabird bycatch mitigation tools in hook-and-line groundfish and halibut fisheries[69].

[68] https://www.fisheries.noaa.gov/resource/document/north-pacific-observer-sampling-manual
[69] https://www.fisheries.noaa.gov/alaska/bycatch/seabird-avoidance-gear-and-methods

Sustainability (for consumptive and non-consumptive uses)

Fish Stock Sustainability Index

Contributed by George A. Whitehouse, Cooperative Institute for Climate Ocean and Ecosystem Studies (CICOES), University of Washington, Seattle, WA
Contact: gaw@uw.edu
Last updated: August 2026

Description of indicator: The Fish Stock Sustainability Index (FSSI) is a performance measure for the sustainability of fish stocks selected for their importance to commercial and recreational fisheries[70]. The FSSI will increase as overfishing ends and stocks rebuild to the level that provides maximum sustainable yield. The FSSI is calculated by awarding points for each fish stock based on the following rules:

1. Stock has known status determinations:
   (a) overfishing level is defined = 0.5
   (b) overfished biomass level is defined = 0.5
2. Fishing mortality rate is below the "overfishing" level defined for the stock = 1.0
3. Biomass is above the "overfished" level defined for the stock = 1.0
4. Biomass is at or above 80% of the biomass that produces maximum sustainable yield (B_{MSY}) = 1.0 (this point is in addition to the point awarded for being above the "overfished" level)

The maximum score for each stock is 4.

In the Alaska Region, there are 35 FSSI stocks and an overall FSSI of 140 would be achieved if every stock scored the maximum value, 4. Over time, the number of stocks included in the FSSI has changed as stocks have been added and removed from Fishery Management Plans (FMPs). To keep FSSI scores for Alaska comparable across years we report the FSSI as a percentage of the maximum possible score.

In the GOA region there are 14 FSSI stocks, including sablefish. The assessment for sablefish is based on aggregated data from the GOA and BSAI regions. Additionally, in Alaska there are 33 non-FSSI stocks, three ecosystem component species complexes, and Pacific halibut, which are managed under an international agreement. Two of the non-FSSI crab stocks in the BSAI region are overfished but are not subject to overfishing. None of the other non-FSSI stocks are known to be subject to overfishing, are overfished, or known to be approaching an overfished condition. For more information on non-FSSI stocks see the Status of U.S. Fisheries webpage[71].

[70] https://www.fisheries.noaa.gov/national/population-assessments/fishery-stock-status-updates
[71] https://www.fisheries.noaa.gov/national/population-assessments/fishery-stock-status-updates

Status and trends: The GOA FSSI in 2026 remains at 86.6%, after increasing from 84.8% in 2022 to 86.6% in 2023 (Figure 102). As of June 30, 2026, none of the GOA groundfish stocks or stock complexes are subject to overfishing, are known to be overfished, or known to be approaching an overfished condition (Table 8). Points continue to be deducted for the shortraker rockfish stock, the demersal shelf rockfish complex, and the thornyhead rockfish complex for unknown status determinations and not estimating B/B_{MSY}.

The statewide Alaska FSSI decreased slightly to 90.0% in 2026. The statewide Alaska FSSI generally trended upwards from 80% in 2006 to a high of 94% in 2018, then trended downward from 2018 to 2020 (Figure 103). It has increased incrementally to 89% in 2023 and 90.3% in 2024 and 2025.

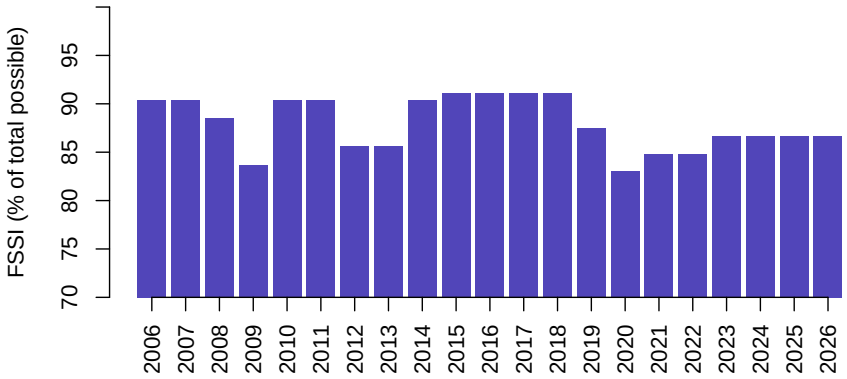


Figure 102: The trend in GOA FSSI from 2006 through 2026 as a percentage of the maximum possible FSSI. All scores are reported through the second quarter (June) of each year and are retrieved from the NOAA Fishery Stock Status Updates[72].

Table 8: GOA FSSI stocks under NPFMC jurisdiction updated June 2026 adapted from the NOAA Fishery Stock Status Updates[73]. *See FSSI and Non-FSSI Stock Status Table on the Fishery Stock Status Updates webpage for definitions of stocks and stock complexes. The multiple B/B_{MSY} values in a given row represent western/central and eastern regions for northern and southern rock sole (shallow water flatfish) and rex sole.

Stock	Overfishing	Overfished	Approaching	Progress	B/B_{MSY}	FSSI Score
GOA Arrowtooth flounder	No	No	No	N/A	2.05	4
GOA Flathead sole	No	No	No	N/A	2.83	4
GOA Shallow water flatfish complex*	No	No	No	N/A	1.44/2.40/1.86/2.19	4
GOA Rex sole	No	No	No	N/A	2.79/2.19	4
GOA Blackspotted and rougheye rockfish complex*	No	No	No	N/A	1.73	4
GOA Shortraker rockfish	No	Unknown	Unknown	N/A	Not estimated	1.5
GOA Demersal shelf rockfish complex*	No	Unknown	Unknown	N/A	Not estimated	1.5
GOA Dusky rockfish	No	No	No	N/A	1.79	4
GOA Thornyhead rockfish complex*	No	Unknown	Unknown	N/A	Not estimated	1.5
Northern rockfish-western / central GOA	No	No	No	N/A	1.37	4
GOA Pacific Ocean perch	No	No	No	N/A	1.91	4
GOA Pacific cod	No	No	No	N/A	0.9	4
Walleye pollock-western / central GOA	No	No	No	N/A	1.93	4
GOA BSAI Sablefish*	No	No	No	N/A	1.49	4

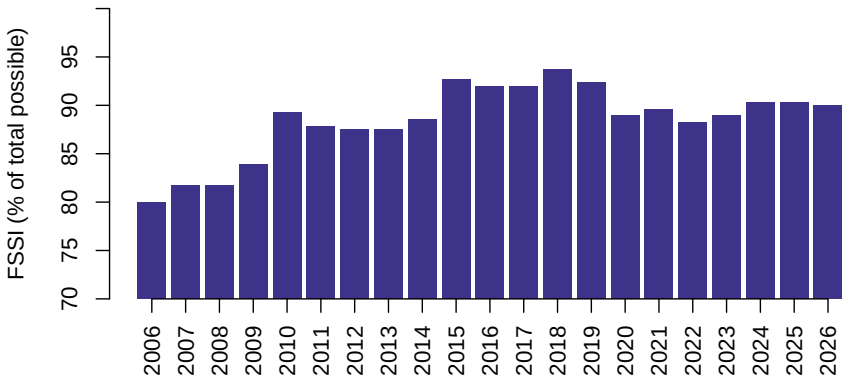


Figure 103: The trend in statewide Alaska FSSI, as a percentage of the maximum possible FSSI, from 2006 through 2026. The maximum possible FSSI is 140 for 2006 to 2014, 144 from 2015 to 2019, and 140 since 2020. All scores are reported through the second quarter (June) of each year and are retrieved from the NOAA Fishery Stock Status Updates website[74].

Factors influencing observed trends: Since 2006, the GOA FSSI has been generally steady, fluctuating between a low of 83% in 2020 to a high of 91% from 2015 – 2018 (Figure 103). There were minor drops in the FSSI in 2008 – 2009, in 2012 – 2013, and 2019 – 2020. In 2008 and 2009, a point was lost each year for B_{MSY} walleye pollock in the western/central GOA dropping below 0.8. In 2009, an additional 2.5 points were lost for the Rex sole stock having unknown status determinations and for not estimating B_{MSY}. In 2012 and 2013, 2.5 points were lost for having unknown status determinations and not estimating B_{MSY} for the deepwater flatfish complex. The drop in 2019 was due to biomass dropping below 80% B_{MSY} for Pacific cod and sablefish. An additional point was gained in 2023 for GOA Pacific cod biomass increasing above B_{MSY}. The GOA FSSI has been unchanged since 2023.

Implications: The majority of Alaska groundfish fisheries appear to be sustainably managed, including GOA groundfish fisheries. Until the overfished status determinations are defined for the Demersal Shelf Rockfish complex, the Thornyhead Rockfish complex, and shortraker rockfish, it will be unknown whether these stocks are overfished or approaching an overfished condition.

References

Abelman, A., A. Abolhassani, M. Dalton, R. Dame, R. Felthoven, B. Garber-Yonts, J. Lee, C. Seung, M. Szymkowiak, , and S. Wise. In Prep. Stock assessment and fishery evaluation report for the groundfish fisheries of the Gulf of Alaska and Bering Sea/Aleutian Islands area: Economic status of the groundfish fisheries off Alaska, 2026. Anchorage, AK: North Pacific Fishery Management Council.

Alaska Fisheries Science Center and Alaska Regional Office. 2026. North Pacific Observer Program 2025 Annual Report. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way N.E., Seattle, Washington 98115.

Albright, L. J., S. Johnson, and A. Yousif. 1992. Temporal and spatial distribution of the harmful diatoms *Chaetoceros concavicornis* and *Chaetoceros convolutus* along the British Columbia coast. Canadian Journal of Fisheries and Aquatic Sciences **49**:1924–1931.

Alverson, D., M. Freeberg, J. Pope, and S. Murawski. 1994. A global assessment of fisheries bycatch and discards.FAO Fisheries Technical Paper. No. 339. Rome, FAO. 1994. 233p.

Amaya, D., A. Miller, S. Xie, and Y. Kosaka. 2020. Physical drivers of the summer 2019 North Pacific marine heatwave. Nature Communications **11**:1903.

Anderson, M., and D. Euinton. 2026. 'PRIMER 8 with PERMANOVA+ (v3.1.0).' PRIMER-e (Quest Research Limited): Auckland, New Zealand.

Anderson, P., and J. Piatt. 1999. Community reorganization in the Gulf of Alaska following ocean climate regime shift. Marine Ecology Progress Series **189**:117–123.

Anderson, P. J. 2003. Gulf of Alaska small mesh trawl survey trends, In: J.L.Boldt (Ed.), Ecosystem Considerations for 2004. Appendix C of the BSAI/GOA Stock Assessment and Fishery Evaluation Reports. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Anderson, S. C., E. J. Ward, P. A. English, and L. A. K. Barnett. 2022. sdmTMB: an R package for fast, flexible, and user-friendly generalized linear mixed effects models with spatial and spatiotemporal random fields. bioRxiv. https://doi.org/10.1101/2022.03.24.485545.

AOOS Glider Observatory. 2023. UAF G191 glider deployment in the North Pacific Ocean [Data set]. University of Alaska Fairbanks College of Fisheries and Ocean Science `https://gliders.ioos.us/erddap/tabledap/unit_191-20230215T0000.html`.

AOOS Glider Observatory. 2024. UAF G191 glider deployment in the North Pacific Ocean [Data set]. University of Alaska Fairbanks College of Fisheries and Ocean Science `https://gliders.ioos.us/erddap/info/unit_191-20240309T1200/index.html`.

AOOS Glider Observatory. 2025. UAF G191 glider deployment in the North Pacific Ocean [Data set]. University of Alaska Fairbanks College of Fisheries and Ocean Science https://gliders.ioos.us/erddap/info/unit_191-20250226T0000/index.html.

AOOS Glider Observatory. 2026. UAF G191 glider deployment in the North Pacific Ocean [Data set]. University of Alaska Fairbanks College of Fisheries and Ocean Science https://gliders.ioos.us/erddap/info/unit_191-20260324T0000/index.html.

Arimitsu, M., J. Piatt, H. S., R. Suryan, S. Batten, M. Bishop, R. Campbell, H. Coletti, D. Cushing, K. Gorman, and R. Hopcroft. 2021. Heatwave-induced synchrony within forage fish portfolio disrupts energy flow to top pelagic predators. Global Change Biology **27**:1859–1878.

Atwood, E., J. K. Duffy-Anderson, J. K. Horne, and C. Ladd. 2010. Influence of mesoscale eddies on ichthyoplankton assemblages in the Gulf of Alaska. Fisheries Oceanography **19**:493–507.

Aumont, O., and L. Bopp. 2006. Globalizing results from ocean in situ iron fertilization studies. Global Biogeochemical Cycles **20**:GB2017.

Bailey, K. M., and S. J. Susan J. Picquelle. 2002. Larval distribution of offshore spawning flatfish in the Gulf of Alaska: potential transport pathways and enhanced onshore transport during ENSO events. Marine Ecology Progress Series **236**:205–217.

Baker, C., L. Herman, A. Perry, W. Lawton, J. Straley, A. Wolman, G. Kaufman, H. Winn, J. Hall, J. Reinke, and J. Östman. 1986. Migratory movement and population structure of humpback whales (*Megaptera novaeangliae*) in the central and eastern North Pacific. Marine Ecology Progress Series **31**:105–119.

Baker, C. S., A. A. Perry, and L. M. Herman. 1987. Reproductive histories of female humpback whales (*Megaptera novaeangliae*) in the North Pacific. Marine Ecology Progress Series **41**:103–114.

Barbeaux, S., B. Ferriss, W. Palsson, K. Shotwell, I. Spies, M. Wang, and S. Zador. 2020*a*. Assessment of Pacific Cod Stock in the Gulf of Alaska [In] Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. North Pacific Fishery Management Council, Anchorage.

Barbeaux, S., K. Holsman, and S. Zador. 2020*b*. Marine heatwave stress test of ecosystem-based fisheries management in the Gulf of Alaska Pacific cod fishery. Frontiers in Marine Science **703**:1–21.

Barlow, J., J. Calambokidis, E. Falcone, C. Baker, A. Burdin, P. Clapham, J. Ford, C. Gabriele, R. LeDuc, D. Mattila, and T. Quinn. 2024. Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. Marine Mammal Science **27**:793–818.

Batten, S. D., C. Ostle, P. Hélaouët, and A. W. Walne. 2022. Responses of Gulf of Alaska plankton communities to a marine heat wave. Deep Sea Research Part II: Topical Studies in Oceanography **195**:105002.

Batten, S. D., G. T. Ruggerone, and I. Ortiz. 2018. Pink salmon induce a trophic cascade in plankton populations in the southern Bering Sea and around the Aleutian Islands. Fisheries Oceanography **27**:548–559.

Batten, S. D., and D. W. Welch. 2004. Changes in oceanic zooplankton populations in the north-east Pacific associated with the possible climatic regime shift of 1998/1999. Deep Sea Research Part II: Topical Studies in Oceanography **51**:863–873.

Beamish, R. J., and C. Mahnken. 2001. A critical size and period hypothesis to explain natural regulation of salmon abundance and the linkage to climate and climate change. Progress in Oceanography **49**:423–437.

Beck, J., M. Chan, and C. Tide. 2026. Seabird Bycatch Estimates for Groundfish and Halibut Fisheries in the Eastern Bering Sea, 2016–2025. In: Siddon, E. 2024. Ecosystem Status Report 2024: Eastern Bering Sea, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West 3rd Ave., Suite 400, Anchorage, Alaska 99501.

Betts, M. F. 1994. The subsistence hooligan fishery of the Chilkat and Chilkoot Rivers. Technical Paper Series **213**:1–69.

Blackburn, J. E. 1977. Demersal fish and shellfish assessment in selected estuary systems of Kodiak Island. Annual Report, OCSEAP Research Unit 512, ADF&G, Kodiak, Alaska.

Bodkin, J. L., H. A. Coletti, B. E. Ballachey, D. H. Monson, D. Esler, and T. A. Dean. 2018. Variation in abundance of Pacific blue mussel (*Mytilus trossulus*) in the northern Gulf of Alaska, 2006–2015. Deep Sea Research Part II: Topical Studies in Oceanography **147**:87–97.

Boeing, W. J., and J. T. Duffy-Anderson. 2008. Ichthyoplankton dynamics and biodiversity in the Gulf of Alaska: responses to environmental change. Ecological Indicators **8**:292–302.

Bograd, S. J., R. Mendelssohn, F. B. Schwing, and A. J. Miller. 2005. Spatial heterogeneity of sea surface temperature trends in the Gulf of Alaska. Atmosphere-Ocean **43**:241–247.

Bond, N. A., M. F. Cronin, H. Freeland, and N. Mantua. 2015. Causes and impacts of the 2014 warm anomaly in the NE Pacific. Geophysical Research Letters **42**:3414–3420.

Boveng, P., G. Brady, M. Cameron, C. Christman, S. Dahle, L. Hiruki-Raring, J. Jansen, S. Koslovsky, J. London, B. Mcclintock, R. Montgomery, E. Moreland, E. Richmond, M. Simpkins, S. Walcott, D. Withrow, J. Womble, K. Yano, and H. Ziel. 2026. Abundance and Trends of Harbor Seals (*Phoca Vitulina Richardii*) in Alaska, 1996-2023. Preprint, bioRxiv, September 3.

Boveng, P., H. Ziel, B. McClintock, and M. Cameron. 2020. Body condition of phocid seals during a period of rapid environmental change in the Bering Sea and Aleutian Islands, Alaska. Deep Sea Research Part II: Topical Studies in Oceanography **181-182**:104904.

Brenner, R., S. Larsen, A. Munro, and A. Carroll. 2021. Run forecasts and harvest projections for 2021 Alaska salmon fisheries and review of the 2020 season. Alasks Department of Fish and Game, Special Publications No. 21-07. Anchorage, AK.

Brickley, P. J., and A. C. Thomas. 2004. Satellite-measured seasonal and inter-annual chlorophyll variability in the Northeast Pacific and coastal Gulf of Alaska. Deep-Sea Research Part II-Topical Studies in Oceanography **51**:229–245.

Briscoe, R., M. Adkison, A. Wertheimer, and S. Taylor. 2005. Biophysical factors associated with the marine survival of Auke Creek, Alaska, coho salmon. Transactions of the American Fisheries Society **134**:817–828.

Brodeur, R., and D. M. Ware. 1992. Long-term variability in zooplankton biomass in the subarctic Pacific Ocean. Fisheries Oceanography **1**:32–37.

Brodeur, R. D., T. W. Buckley, G. M. Lang, D. L. Draper, J. Buchanan, and R. E. Hibpshman. 2021. Demersal fish predators of gelatinous zooplankton in the Northeast Pacific Ocean. Marine Ecology Progress Series **658**:89–104.

Brodeur, R. D., M. B. Decker, L. Ciannelli, J. E. Purcell, N. A. Bond, P. J. Stabeno, E. Acuna, and G. L. Hunt. 2008. Rise and fall of jellyfish in the eastern Bering Sea in relation to climate regime shifts. Progress in Oceanography **77**:103–111.

Brooks, M., E. Fergusson, M. Rogers, W. Strasburger, and R. Suryan. 2025. Juvenile salmon body condition in Southeast Alaska is buffered during marine heatwaves. Marine Ecology Progress Series **760**:135–149.

Browning, T. J., and C. M. Moore. 2023. Global analysis of ocean phytoplankton nutrient limitation reveals high prevalence of co-limitation. Nature Communications **14**:5014.

Buesseler, K. O., D. Bianchi, W. Burns, F. Chai, J. T. Cullen, M. Estapa, M. Honda, S. John, D. M. Karl, C. Klaas, D. Li, Z. Liu, J. McGillicuddy, D. J., P. J. Morris, J. Nishioka, M. M. Omand, K. Ramakrishna, K. M. Roche, D. A. Siegel, and J.-E. Yoon. 2026. The case for ocean iron fertilization field trials. Dialogues on Climate Change **0**:N/A.

Cahalan, J., J. Mondragon, and J. Gasper. 2010. Catch sampling and estimation in the federal groundfish fisheries off Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-205, 42 p.

Cahalan, J. A., J. R. Gasper, and J. Mondragon. 2014. Catch sampling and estimation in the federal groundfish fisheries off Alaska, 2015 edition. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-286, 46 p.

Catchpole, T., C. Frid, and T. Gray. 2006. Importance of discards from the English *Nephrops norvegicus* fishery in the North Sea to marine scavengers. Marine Ecology Progress Series **313**:215–226.

Cheeseman, T., J. Barlow, J. Acebes, K. Audley, L. Bejder, C. Birdsall, O. Bracamontes, A. Bradford, J. Byington, C. J., R. Cartwright, J. Cedarleaf, A. Chavez, J. Currie, R. De Castro, J. De Weerdt, N. Doe, T. Doniol-Valcroze, K. Dracott, O. Filatova, R. Finn, K. Flynn, J. Ford, A. Frisch-Jordán, C. Gabriele, B. Goodwin, C. Hayslip, J. Hildering, M. Hill, J. Jacobsen, M. Jiménez-López, M. Jones, N. Kobayashi, M. Lammers, E. Lyman, M. Malleson, E. Mamaev, P. Loustalot, A. Masterman, C. Matkin, C. McMillan, J. Moore, J. Moran, J. Neilson, H. Newell, H. Okabe, M. Olio, C. Ortega-Ortiz, A. Pack, D. Palacios, H. Pearson, E. Quintana-Rizzo, R. Barragán, N. Ransome, H. Rosales-Nanduca, F. Sharpe, T. Shaw, K. Southerland, S. Stack, I. Staniland, J. Straley, A. Szabo, T. S., O. Titova, J. Urban-Ramirez, M. van Aswegen, M. Vinicius, O. von Ziegesar, B. Witteveen, J. Wray, K. Yano, I. Yegin, D. Zwiefelhofer, and P. Clapham. 2024. Bellwethers of change: population modelling of North Pacific humpback whales from 2002 through 2021 reveals shift from recovery to climate response. Royal Society Open Science **11**:231462.

Cheeseman, T., K. Southerland, J. Acebes, and et al. 2023. A collaborative and near-comprehensive North Pacific humpback whale photo-ID dataset. Scientific Reports **13**:10237.

Clarke, A. D., A. Lewis, K. H. Telmer, and J. M. Shrimpton. 2007. Life history and age at maturity of an anadromous smelt, the eulachon *Thaleichthys pacificus* (Richardson). Journal of Fish Biology **71**:1479–1493.

Clucas, I. 1997. A study of the options for utilization of bycatch and discards from marine capture fisheries. FAO Fisheries Circular. No. 928. Food and Agriculture Organization, Rome. 59pp.

Combes, V., and E. Di Lorenzo. 2007. Intrinsic and forced interannual variability of the Gulf of Alaska mesoscale circulation. Progress in Oceanography **75**:266–286.

Conners, M. E., and C. L. Conrath. 2017. Assessment of the Octopus Stock Complex in the Gulf of Alaska. In: Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pacific Fishery Management Council, 605 W 4th Ave Suite 306, Anchorage, Alaska 99501. 36 pp.

Conte, L., J. Fiechter, S. Strom, R. R. Hopcroft, S. L. Danielson, and A. Aguilar-Islas. 2024. Modeling planktonic food web interannual variability of the northern Gulf of Alaska shelf. Journal of Geophysical Research: Oceans **129**:e2024JC021116.

Cooney, R. T., and T. Willette. 1997. Factors influencing the marine survival of pink salmon in Prince William Sound, Alaska, page 313 . U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-29.

Copernicus Climate Change Service. 2026. Daily global sea surface temperature breaks 2024 record. `https://climate.copernicus.eu/copernicus-daily-global-sea-surface-temperature-breaks-2024-record`.

COSEWIC. 2011. COSEWIC assessment and status report on the Nass / Skeena Rivers population, Central Pacific Coast population and the Fraser River population *Thaleichthys pacificus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xv + 88 pp.

Crusius, J., A. W. Schroth, J. A. Resing, J. Cullen, and R. W. Campbell. 2017. Seasonal and spatial variabilities in northern Gulf of Alaska surface water iron concentrations driven by shelf sediment resuspension, glacial meltwater, a Yakutat eddy, and dust. Global Biogeochemical Cycles **31**:942–960.

Cullen, J. J., and P. W. Boyd. 2008. Predicting and verifying the intended and unintended consequences of large-scale ocean iron fertilization. Marine Ecology Progress Series **364**:295–301.

Danielson, S., T. Hennon, K. McMonigal, and D. Hill. 2026. Local surface and ENSO forcings induce predictable temperature and salinity responses in the coastal Gulf of Alaska. Journal of Geophysical Research: Oceans **131**:e2026JC024703.

Danielson, S., T. Hennon, D. Monson, R. Suryan, R. Campbell, S. Baird, K. Holderied, and T. Weingartner. 2022. Temperature variations in the northern Gulf of Alaska across synoptic to century-long time scales. Deep Sea Research Part II: Topical Studies in Oceanography **203**:105155.

Darby, J., R. A. Phillips, H. Weimerskirch, E. D. Wakefield, J. C. Xavier, J. M. Pereira, and S. C. Patrick. 2024. Strong winds reduce foraging success in albatrosses. Current Biology **34**:5615–5621.

de Baar, H. J. W., P. W. Boyd, K. H. Coale, M. R. Landry, A. Tsuda, P. Assmy, D. C. E. Bakker, Y. Bozec, R. T. Barber, M. A. Brzezinski, K. O. Buesseler, M. Boye, P. L. Croot, F. Gervais, M. Y. Gorbunov, P. J. Harrison, W. T. Hiscock, P. Laan, C. Lancelot, and A. M. Waite. 2005. Synthesis of iron fertilization experiments: From the Iron Age in the Age of Enlightenment. Journal of Geophysical Research **110**:C09S16.

Di Lorenzo, E., and N. Mantua. 2016. Multi-year persistence of the 2014/15 North Pacific marine heatwave. Nature Climate Change **6**:1042–1047.

Di Lorenzo, E., D. Mountain, H. Batchelder, N. Bond, and E. Hofmann. 2013. Advances in marine ecosystem dynamics from US GLOBEC: The horizontal-advection bottom-up forcing paradigm. Oceanography **26**:22–33.

Domke, L., E. Siddon, A. Andrews, J. Gann, D. Kimmel, and M. Levine. 2026. Forage Fish Dynamics in the Eastern Bering Sea. In: Siddon, E. 2026. Ecosystem Status Report 2026: Eastern Bering Sea, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West 3rd Ave., Suite 400, Anchorage, Alaska 99501.

Dorn, M., and S. Zador. 2020. A risk table to address concerns external to stock assessments when developing fisheries harvest recommendations. Ecosystem Health and Sustainability **6**:1813634.

Doyle, M. J., S. J. Picquelle, K. L. Mier, M. Spillane, and N. Bond. 2009. Larval fish abundance and physical forcing in the Gulf of Alaska, 1981-2003. Progress in Oceanography **80**:163–187.

Drenkard, E. J., C. A. Stock, A. C. Ross, Y.-C. Teng, T. Cordero, W. Cheng, A. Adcroft, E. Curchitser, R. Dussin, R. Hallberg, C. Hauri, K. Hedstrom, A. Hermann, M. G. Jacox, K. A. Kearney, R. Pagès, D. J. Pilcher, M. Pozo Buil, V. Seelanki, and N. Zadeh. 2025. A regional physical–biogeochemical ocean model for marine resource applications in the Northeast Pacific (MOM6-COBALT-NEP10k v1.0). Geoscientific Model Development **18**:5245–5290.

Ducet, N., P. Y. Le Traon, and G. Reverdin. 2000. Global high-resolution mapping of ocean circulation from TOPEX/Poseidon and ERS-1 and-2. Journal of Geophysical Research-Oceans **105**:19477–19498.

Echave, K., C. Rodgveller, and S. Shotwell. 2013. Calculation of the geographic area sizes used to create population indices for the Alaska Fisheries Science Center longline survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-253, 93 p.

Eich, A., K. Mabry, S. Wright, and S. Fitzgerald. 2016. Seabird Bycatch and Mitigation Efforts in Alaska Fisheries Summary Report: 2007 through 2015. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/AKR-12, 47 p. .

Eich, A., J. Roberts, and S. Fitzgerald. 2018. ASeabird Bycatch Estimates for Alaska Groundfish Fisheries 2016 through 2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/AKR-18, 32 p.

Eisenlord, M. E., M. L. Groner, R. M. Yoshioka, J. Elliott, J. Maynard, S. Fradkin, M. Turner, K. Pyne, N. Rivlin, R. van Hooidonk, and C. D. Harvell. 2016. Ochre star mortality during the 2014 wasting disease epizootic: role of population size structure and temperature. Philosophical Transactions of the Royal Society B: Biological Sciences **371**:20150212.

ExOIS. 2026. The North Pacific Carbon Study [Brochure].

FAO. 1995. Code of Conduct for Responsible Fisheries. Rome, Food and Agriculture Organization 41 p.

Fergusson, E., A. Gray, and J. Murphy. 2020. Annual survey of juvenile salmon, ecologically-related species, and biophysical factors in the marine waters of southeastern Alaska, May–August 2018. NPAFC Doc. 43 pp. National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Alaska Fisheries Science Center, Auke Bay Laboratories, Ted Stevens Marine Research Institute (Available at http://www.npafc.org).

Fergusson, E., J. Murphy, and A. Gray. 2021. Southeast Alaska Coastal Monitoring Survey: salmon trophic ecology and bioenergetics, 2019. NPAFC Doc. 41 pp. National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Alaska Fisheries Science Center, Auke Bay Laboratories, Ted Stevens Marine Research Institute. http://www.npafc.org.

Ferriss, B. 2026. Gulf of Alaska Ecosystem State Analyses. In: Ferriss, B.E. 2026. Ecosystem Status Report 2026: Gulf of Alaska, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, Alaska 99501.

Ferriss, B., M. Hunsicker, E. Ward, M. Litzow, L. Rogers, M. Callahan, W. Cheng, S. Danielson, B. Drummond, E. Fergusson, C. Gabriele, K. Hebert, R. Hopcroft, J. Nielsen, K. Spalinger, W. Stockhausen, W. Strasburger, and S. Whelan. 2025. Identifying common trends and ecosystem states to inform Gulf of Alaska ecosystem-based fisheries management. PLOS ONE **20**:1–23.

Fischer, K. 2008. Marine habitat use of black-footed and Laysan albatrosses during the post-breeding season and their spatial and temporal overlap with commercial fisheries. Oregon State University, Corvallis.

Fitzgerald, S., M. Perez, and K. Rivera. 2008. Summary of seabird bycatch in Alaskan groundfish fisheries, 1993 through 2006. In Boldt, J. (Ed). Ecosystem considerations 2009, Appendix C of the Bering Sea/Aleutian Islands and Gulf of Alaska groundfish stock assessment and fishery evaluation report. Anchorage, AK: North Pacific Management Council. pp. 116–141.

Flostrand, L. A., J. F. Schweigert, K. S. Daniel, and J. S. Cleary. 2009. Measuring and modelling Pacific herring spawning-site fidelity and dispersal using tag-recovery dispersal curves. ICES Journal of Marine Science **66**:1754–1761.

Frankel, A., C. Gabriele, S. Yin, and S. Rickards. 2021. Humpback whale abundance in Hawai'i: Temporal trends and response to climatic drivers. Marine Mammal Science **38**:118–138.

Franks, P. J. S. 2015. Has Sverdrup's critical depth hypothesis been tested? Mixed layers vs. turbulent layers. ICES Journal of Marine Science **72**:1897–1907.

Fritz, L. W., K. Sweeney, R. G. Towell, and T. W. Gelatt. 2016. Aerial and ship-based surveys of Steller sea lions (*Eumetopias jubatus*) conducted in Alaska in June-July 2013 through 2015, and an update on the status and trend of the western distinct population segment in Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-321, 72 p.

Frölicher, T. L., E. M. Fischer, and N. Gruber. 2018. Marine heatwaves under global warming. Nature **560**:360–364.

Gabriele, C., C. Amundson, J. Neilson, J. Straley, C. Baker, and S. Danielson. 2022. Sharp decline in humpback whale (*Megaptera novaeangliae*) survival and reproductive success in southeastern Alaska during and after the 2014–2016 Northeast Pacific marine heatwave. Mammalian Biology **102**.

Gabriele, C. M., J. L. Neilson, J. M. Straley, C. S. Baker, J. A. Cedarleaf, and J. F. Saracco. 2017. Natural history, population dynamics, and habitat use of humpback whales over 30 years on an Alaska feeding ground. Ecosphere **8**:e01641.

Gaichas, S., K. Aydin, and R. C. Francis. 2015. Wasp waist or beer belly? Modeling food web structure and energetic control in Alaskan marine ecosystems, with implications for fishing and environmental forcing. Progress in Oceanography **138**:1–17.

Gaillard, J., M. Festa-Bianchet, N. Yoccoz, A. Loison, and C. Toigo. 2000. Temporal variation in fitness components and population dynamics of large herbivores. Annual Review of Ecology and Systematics **31**:367–393.

Gann, J., C. Kurtay, J. Nielsen, T. Farrugia, E. Fachon, M. Pathare, and M. Brosnahan. 2026. Imaging FlowCytobot: Phytoplankton, Lower Trophic Dynamics, and Survey Modernization. In: Siddon, E. 2026. Ecosystem Status Report 2026: Eastern Bering Sea, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West 3rd Ave., Suite 400, Anchorage, Alaska 99501.

Geiger, H., W. Smoker, L. Zhivotovsky, and A. Gharrett. 1997. Variability of family size and marine survival in pink salmon (*Oncorhynchus gorbuscha*) has implications for conservation biology and human use. Canadian Journal of Fisheries and Aquatic Sciences **54**:2684–2690.

Gentemann, C. L., M. Fewing, and M. Garcia-Reyes. 2017. Satellite sea surface temperatures along the West Coast of the United States during the 2014–2016 northeast Pacific marine heat wave. Arctic **44**:312–319.

Gleason, C., and A. Munro. 2026. Run forecasts and harvest projections for 2026 Alaska salmon fisheries and review of the 2025 season. Alaska Department of Fish and Game, Special Publication No. 26-08, Anchorage, AK.

Gnanadesikan, A., J. L. Sarmiento, and R. D. Slater. 2003. Effects of patchy ocean fertilization on atmospheric carbon dioxide and biological production. Global Biogeochemical Cycles **17**:1050.

Goldstein, E. D., J. L. Pirtle, J. T. Duffy-Anderson, W. T. Stockhausen, M. Zimmermann, M. T. Wilson, and C. W. Mordy. 2020. Eddy retention and seafloor terrain facilitate cross-shelf transport and delivery of fish larvae to suitable nursery habitats. Limnology and Oceanography .

Graham, C. J., T. M. Sutton, M. D. Adkison, M. V. McPhee, and P. J. Richards. 2019. Evaluation of growth, survival, and recruitment of Chinook Salmon in Southeast Alaska rivers. Transactions of the American Fisheries Society **148**:243–259.

Hard, J., M. Gross, M. Heino, R. Hilborn, R. Kope, R. Law, and J. Reynolds. 2008. Evolutionary consequences of fishing and their implications for salmon. Evolutionary Applications **1**:388–408.

Harley, J. R., K. Lanphier, E. Kennedy, T. Leighfield, A. Bidlack, M. O. Gribble, and C. Whitehead. 2020. The Southeast Alaska Tribal Ocean Research (SEATOR) Partnership: Addressing data gaps in harmful algal bloom monitoring and shellfish safety in Southeast Alaska. Toxins **12**:407.

Harvell, C. D., D. Montecino-Latorre, J. M. Caldwell, J. M. Burt, K. Bosley, A. Keller, S. F. Heron, A. K. Salomon, L. Lee, O. Pontier, C. Pattengill-Semmens, and J. K. Gaydos. 2019. Disease epidemic and a marine heat wave are associated with the continental-scale collapse of a pivotal predator (*Pycnopodia helianthoides*). Science Advances **5**:eaau7042.

Hatch, S. A. 2013. Kittiwake diets and chick production signal a 2008 regime shift in the Northeast Pacific. Marine Ecology Progress Series **477**:271–284.

Hatch, S. A., M. L. Arimitsu, J. F. Piatt, S. Whelan, and C. E. Marsteller. 2023. Seabird Diet Data Collected on Middleton Island, Gulf of Alaska: U.S. Geological Survey data release, https://doi.org/10.5066/P93I0P67.

Hauri, C., R. Pagès, K. Hedstrom, S. Doney, S. Dupont, B. Ferriss, and M. Stuecker. 2024. More than marine heatwaves: A new regime of heat, acidity, and low oxygen compound extreme events in the Gulf of Alaska. AGU Advances .

Hauri, C., R. Pagès, A. McDonnell, M. F. Stuecker, S. Danielson, K. Hedstrom, B. Irving, C. Schultz, and S. Doney. 2021. Modulation of ocean acidification by decadal climate variability in the Gulf of Alaska. Communications Earth and Environment **2**:191.

Hay, D., and P. B. Mccarter. 2000. Status of eulachon *Thaleichtheys pacificus* in Canada. Fisheries and Oceans Canada. Canadian Stock Assessment, 2000/145.

Hebert, K. 2022. Southeast Alaska 2020 herring stock assessment surveys. Alaska Department of Fish and Game, Fishery Data Series No. 22-21, Anchorage.

Hebert, K. 2025. 2023 Southeast Alaska Herring Stock Assessment Survey. Alaska Department of Fish and Game, Fishery Data Series No. 25-16, Anchorage.

Heinze, C., S. Meyer, N. Goris, L. Anderson, R. Steinfeldt, N. Chang, C. Le Quere, and D. C. E. Bakker. 2015. The ocean carbon sink – impacts, vulnerabilities and challenges. Earth System Dynamics **6**:327–358.

Hobday, A. J., L. V. Alexander, S. E. Perkins, D. A. Smale, S. C. Straub, E. C. Oliver, J. A. Benthuysen, M. T. Burrows, M. G. Donat, and M. Feng. 2016. A hierarchical approach to defining marine heatwaves. Progress in Oceanography **141**:227–238.

Hobday, A. J., E. C. J. Oliver, A. S. Gupta, J. A. Benthuysen, M. T. Burrows, M. G. Donat, N. Holbrook, P. Moore, M. Thomsen, T. Wernberg, and D. Smale. 2018. Categorizing and naming marine heatwaves. Oceanography **31**:162–173.

Holbrook, N. J., H. A. Scannell, A. Sen Gupta, J. A. Benthuysen, M. Feng, E. C. J. Oliver, L. Alexander, M. Burrows, M. Donat, A. Hobday, P. Moore, S. Perkins-Kirkpatrick, D. Smale, S. Straub, and T. Wernberg. 2019. A global assessment of marine heatwaves and their drivers. Nature Communications **10**:1–13.

Holsman, K. K., and K. Aydin. 2015. Comparative methods for evaluating climate change impacts on the foraging ecology of Alaskan groundfish. Marine Ecology Progress Series **521**:217–235.

Hunsicker, M. E., E. J. Ward, M. A. Litzow, S. C. Anderson, C. J. Harvey, J. C. Field, J. Gao, M. G. Jacox, S. Melin, A. R. Thompson, and P. Warzybok. 2022. Tracking and forecasting community responses to climate perturbations in the California Current Ecosystem. PLOS Climate **1**:1–29.

Hunt, G. L., P. H. Ressler, G. A. Gibson, A. De Robertis, K. Aydin, M. F. Sigler, I. Ortiz, E. J. Lessard, B. C. Williams, and A. Pinchuk. 2016. Euphausiids in the eastern Bering Sea: A synthesis of recent studies of euphausiid production, consumption and population control. Deep Sea Research Part II: Topical Studies in Oceanography **134**:204–222.

Intergovernmental Panel on Climate Change (IPCC). 2023. Summary for policymakers. In Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

Jacox, M., D. Dukhovskoy, J. Liu, M. Alexander, E. Drenkard, A. Ross, N. Freeman, D. Amaya, S. Bograd, A. Cluett, N. Lovenduski, S. Mogen, M. Pozo Buil, C. Stock, W. Cheng, A. Hermann,

L. Jia, N. Johnson, K. Kearney, C. McHugh, and D. Pilcher. In Review. Seasonal forecasts of Northeast Pacific physics and biogeochemistry using MOM6-COBALT-NEP10k. EGUsphere .

Jones, D., N. Lauffenberger, K. Williams, and A. De Robertis. 2019. Results of the acoustic-trawl survey of walleye pollock (*Gadus chalcogrammus*) in the Gulf of Alaska, June-August 2017 (DY2017–06). AFSC Processed Rep. No. 2019–08. Alaska Fisheries Science Center, NOAA, National Marine Fisheries Service, Seattle, WA.

Kaga, T., S. Sato, T. Azumaya, N. D. Davis, and M. Fukuwaka. 2013. Lipid content of chum salmon *Oncorhynchus keta* affected by pink salmon *O. gorbuscha* abundance in the central Bering Sea. Marine Ecology Progress Series **478**:211–221.

Kalnay, E., M. Kananitcu, R. Kistler, W. Collins, and D. Deaven. 1996. The NCEP/NCAR 40-year reanalysis project. Bulletin of the American Meteorological Society **77**:437–471.

Kappes, M., S. Shaffer, Y. Tremblay, D. Foley, D. Palacios, P. Robinson, S. Bograd, and D. Costa. 2010. Hawaiian albatrosses track interannual variability of marine habitats in the North Pacific. Progress in Oceanography **86**:246–260.

Kelleher, K. 2005. Discards in the world's marine fisheries: an update. FAO Fisheries Technical Paper. No. 470. Rome, FAO. 2005. 131p.

Kimmel, D., K. Axler, D. Crouser, H. Fennie, A. Godersky, J. Lamb, J. Murphy, S. Porter, and B. Snyder. 2024. Current and Historical Trends for Zooplankton in the Bering Sea. In: Siddon, E. 2024. Ecosystem Status Report 2024: Eastern Bering Sea, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West 3rd Ave., Suite 400, Anchorage, Alaska 99501.

Kimmel, D., and J. Duffy-Anderson. 2020. Zooplankton abundance trends and patterns in Shelikof Strait, western Gulf of Alaska, USA, 1990–2017. Journal of Plankton Research **42**:334–354.

King, J. 2005. Report of the Study Group on Fisheries and Ecosystem Responses to recent regime shifts. PICES Scientific Report No. 28.

Kiörboe, T., and M. Sabatini. 1995. Scaling of fecundity, growth and development in marine planktonic copepods. Marine Ecology Progress Series **120**:285–298.

Kline, J., T. C. 2010. Stable carbon and nitrogen isotope variation in the northern lampfish and Neocalanus, marine survival rates of pink salmon, and meso-scale eddies in the Gulf of Alaska. Progress in Oceanography **87**:49–60.

Kline, T. C., J. Boldt, E. Farley, L. J. Haldorson, and J. H. Helle. 2008. Pink salmon (*Oncorhynchus gorbuscha*) marine survival rates reflect early marine carbon source dependency. Progress in Oceanography **77**:194–202.

Koehn, L., M. Siple, and T. Essington. 2021. A structured seabird population model reveals how alternative forage fish control rules benefit seabirds and fisheries. Ecological Application **31**:e02401.

Konar, B., T. J. Mitchell, K. Iken, H. Coletti, T. Dean, D. Esler, M. Lindeberg, B. Pister, and B. Weitzman. 2019. Wasting disease and static environmental variables drive sea star assemblages in the Northern Gulf of Alaska. Journal of Experimental Marine Biology and Ecology **520**:151209.

Kovach, R., A. Gharrett, and D. Tallmon. 2013*a*. Temporal patterns of genetic variation in a salmon population undergoing rapid change in migration timing. Evolutionary Applications **6**:795–807.

Kovach, R. P., J. Joyce, S. Vulstek, E. Barrientos, and D. Tallmon. 2014. Earlier migration timing, decreasing phenotypic variation, and biocomplexity in multiple salmonid species. Canadian Journal of Fisheries and Aquatic Sciences **71**:799–807.

Kovach, R. P., J. E. Joyce, J. D. Echave, M. S. Lindberg, and D. A. Tallmon. 2013*b*. Earlier migration timing, decreasing phenotypic variation, and biocomplexity in multiple salmonid species. PLoS ONE **8**:e53807.

Kraus, S. D., R. M. Pace, and T. R. Frasier. 2009. High investment, low return: the strange case of reproduction in *Eubalaena glacialis*. In: Kraus, S.D. and Rolland, R.M. eds., The urban whale: North Atlantic right whales at the crossroads. Harvard University Press.

Kruse, G. H. 1998. Salmon run failures in 1997-1998: A link to anomalous ocean conditions? Alaska Fishery Research Bulletin **5**:55–63.

LaBarre, A., B. Konar, and K. Iken. 2007. Influence of environmental conditions on *Mytilus trossulus* size frequency distributions in two glacially influenced estuaries. Estuaries and Coasts **46**:1–16.

Ladd, C. 2007. Interannual variability of the Gulf of Alaska eddy field. Geophysical Research Letters **34**:L11605.

Ladd, C., and W. Cheng. 2016. Gap winds and their effects on regional oceanography Part I: Cross Sound, Alaska. Deep Sea Research II **132**:41–53.

Ladd, C., W. R. Crawford, C. Harpold, W. Johnson, N. B. Kachel, P. Stabeno, and F. Whitney. 2009. A synoptic survey of young mesoscale eddies in the Eastern Gulf of Alaska. Deep-Sea Research Part II **56**:2460–2473.

Ladd, C., N. B. Kachel, C. W. Mordy, and P. J. Stabeno. 2005. Observations from a Yakutat eddy in the northern Gulf of Alaska. Journal of Geophysical Research-Oceans **110**:C03003.

Ladd, C., C. W. Mordy, N. B. Kachel, and P. J. Stabeno. 2007. Northern Gulf of Alaska eddies and associated anomalies. Deep-Sea Research Part I-Oceanographic Research Papers **54**:487–509.

Lamb, J. F., and D. G. Kimmel. 2021. The contribution of diet to the dramatic reduction of the 2013 year class of Gulf of Alaska walleye pollock (*Gadus chalcogrammus*). Fisheries Oceanography doi 10.1111/fog.12557 .

Landingham, J. H., M. V. Sturdevant, and R. D. Brodeur. 1998. Feeding habits of juvenile Pacific salmon in marine waters of southeastern Alaska and northern British Columbia. Fishery Bulletin **96**:285–302.

Laurel, B. J., and L. A. Rogers. 2020. Loss of spawning habitat and prerecruits of Pacific cod during a Gulf of Alaska heatwave. Canadian Journal of Fisheries and Aquatic Sciences **77**:644–650.

Lefebvre, K. A., L. Quakenbush, E. Frame, K. B. Huntington, G. Sheffield, R. Stimmelmayr, A. Bryan, P. Kendrick, H. Ziel, T. Goldstein, J. A. Snyder, T. Gelatt, F. Gulland, B. Dickerson, and V. Gill. 2016. Prevalence of algal toxins in Alaskan marine mammals foraging in a changing arctic and subarctic environment. Harmful Algae **55**:13–24.

Lemagie, E., M. Callahan, S. Danielson, R. Hopcroft, E. Fergusson, W. Strasburger, R. Thoman, K. Axler, R. Rogers, D. Jones, M. Levine, and P. Ressler. 2026. Ocean Temperature: *Synthesis In: Ferriss, B.E. 2026. Abbreviated Ecosystem Status Report 2025: Gulf of Alaska, Stock Assessment and

Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska, North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, Alaska 99501.

Lindgren, F., H. Rue, and J. Lindström. 2011. An Explicit Link Between Gaussian Fields and Gaussian Markov Random Fields: The Stochastic Partial Differential Equation Approach. Journal of the Royal Statistical Society Series B: Statistical Methodology **73**:423–498.

Link, J. S., J. K. T. Brodziak, S. F. Edwards, W. J. Overholtz, D. Mountain, J. W. Jossi, T. D. Smith, and M. J. Fogarty. 2002. Marine ecosystem assessment in a fisheries management context. Canadian Journal of Fisheries and Aquatic Sciences **59**:1429–1440.

Litzow, M., M. Hunsicker, E. Ward, S. Anderson, J. Gao, S. Zador, et al. 2020. Evaluating ecosystem change as Gulf of Alaska temperature exceeds the limits of preindustrial variability. Progress in Oceanography **186**:102393.

Livingston, P., K. Aydin, T. Buckley, G. Lang, M. Yang, and B. Miller. 2017. Quantifying food web interactions in the North Pacific – a data-based approach. Environmental Biology of Fishes **100**:443–470.

Locarnini, R., A. Mishonov, O. Baranova, T. Boyer, M. Zweng, H. Garcia, J. J.R. Reagan, D. Seidov, K. Weathers, C. Paver, and I. Smolyar. 2019. World Ocean Atlas 2018, Volume 1: Temperature. A. Mishonov, Technical Editor. NOAA Atlas NESDIS 81, 52pp.

Mackas, D. L., R. Goldblatt, and A. Lewis. 1998. Interdecadal variation in development timing of Neocalanus plumchrus populations at Ocean Station P in the subarctic North Pacific. Canadian Journal of Fisheries and Aquatic Sciences **55**:1878–1893.

Mackas, D. L., W. Greve, M. Edwards, S. Chiba, K. Tadokoro, D. Eloire, M. G. Mazzocchi, S. Batten, A. J. Richardson, C. Johnson, E. Head, A. Conversi, and T. Peluso. 2012. Changing zooplankton seasonality in a changing ocean: Comparing time series of zooplankton phenology. Progress in Oceanography **97–100**:31–62.

Mackas, D. L., and A. Tsuda. 1999. Mesozooplankton in the eastern and western subarctic Pacific: community structure, seasonal life histories, and interannual variability. Progress in Oceanography **43**:335–363.

Malick, M. J., M. Adkison, and A. Wertheimer. 2009. Variable effects of biological and environmental processes on coho salmon marine survival in southeast Alaska. Transactions of the American Fisheries Society **138**:846–860.

Martin, J. H. 1990. Glacial-interglacial CO2 change: The Iron Hypothesis. Paleoceanography **5**:1–13.

Matarese, A. C., D. M. Blood, S. J. Picquelle, and J. L. Benson. 2003. Atlas of abundance and distribution patterns of ichthyoplankton from the northeast Pacific Ocean and Bering Sea ecosystems based on research conducted by the Alaska Fisheries Science Center (1972-1996).

Mayot, N., E. T. Buitenhuis, R. M. Wright, J. Hauck, D. C. E. Bakker, and C. Le Quere. 2024. Constraining the trend in the ocean CO2 sink during 2000-2022. Nature Communications **15**:8429.

McGregor, A. J., S. Lane, and M. Thomason. 1998. Migration timing , a life history trait important in the genetic structure of pink salmon. North Pacific Anadromous Fish Commission **1**:262–273.

McHuron, E. A., K. L. Sweeney, and B. S. Fadely. 2024. Effects of the 2014–2016 marine heatwave on Steller sea lions in the Gulf of Alaska and implications for top-down forcing. Mar. Ecol. Prog. Ser. **736**:129–145.

McKelvey, D., and M. Levine. InPrep. Results of the Acoustic-Trawl Survey of Walleye Pollock (Gadus chalcogrammus) in the Shumagin Islands, Marmot Bay, and the Shelikof Strait February and March 2026 (DY26-01 and DY26-02). U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-XXX:XX p.

McKinnell, S. 2013. Challenges for the Kasatoshi volcano hypothesis as the cause of a large return of sockeye salmon (Oncorhynchus nerka) to the Fraser River in 2010. Fisheries Oceanography **22**:337–344.

Meunier, Z. D., S. D. Hacker, and B. A. Menge. 2024. Regime shifts in rocky intertidal communities associated with a marine heatwave and disease outbreak. Nature Ecology & Evolution pages 1–13 .

Meyer-Gutbrod, E., C. Greene, S. P.J., and P. A.J. 2015. Climate-associated changes in prey availability drive reproductive dynamics of the North Atlantic right whale population. Marine Ecology Progress Series **535**:243–258.

Moffitt, S., B. H. Marston, and M. Miller. 2002. Summary of eulachon research in the Copper River Delta, 1998–2002. Alaska Deptartment of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A02–34 Anchorage.

Moody, M. F., and T. J. Pitcher. 2010. Eulachon (*Thaleichthys pacificus*): past and present. The Fisheries Centre, University of British Columbia, Canada, 18(2), 197.

Moran, J. R., J. M. Straley, J. M. Maselko, L. A. Wild, and R. M. Suryan. 2026. The decline of humpback whales in Prince William Sound, Alaska, following the 2014–2016 Northeast Pacific marine heatwave. Marine Mammal Science **22**:e70195.

Mortensen, D., A. Wertheimer, C. Taylor, and J. Landingham. 2000. The relation between early marine growth of pink salmon, *Oncorhynchus gorbuscha*, and marine water temperature, secondary production, and survival to adulthood. Fishery Bulletin .

Moss, J. H., D. A. Beauchamp, A. D. Cross, K. W. Myers, E. V. Farley Jr, J. M. Murphy, and J. H. Helle. 2005. Evidence for size-selective mortality after the first summer of ocean growth by pink salmon. Transactions of the American Fisheries Society **134**:1313–1322.

Mueter, F., S. Shotwell, S. Atkinson, B. Coffin, M. Doyle, S. Hinckley, K. Rand, and J. Waite. 2016. Gulf of Alaska Retrospective Data Analysis NPRB GOA Project Retrospective Component Final Report. 165p.

Mueter, F. J., and B. L. Norcross. 2002. Spatial and temporal patterns in the demersal fish community on the shelf and upper slope regions of the Gulf of Alaska. Fishery Bulletin **100**:559–581.

Murphy, J., E. Fergusson, A. Piston, S. Heinl, and A. Gray. 2020. Southeast Alaska coastal monitoring survey cruise report, 2018. NPAFC Doc. 1894. 23 pp. National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Alaska Fisheries Science Center, Auke Bay Laboratories, and Alaska Department of Fish and Game (Available at https://npafc.org).

Murphy, J., E. Fergusson, A. Piston, S. Heinl, A. Gray, and E. Farley. 2019. Southeast Alaska pink salmon growth and harvest forecast models. NPAFC Tech. Rept. 15:75-81. National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Alaska Fisheries Science Center, Auke Bay Laboratories, and Alaska Department of Fish and Game (Available at https://npafc.org).

Murphy, J. M., A. Piston, J. Moss, S. Heinl, E. Fergusson, W. Strasburger, and A. Gray. 2021. Southeast Alaska coastal monitoring survey: salmon distribution, abundance, size, and origin, 2019. NPAFC Doc. 1970. 23 pp. Alaska Fisheries Science Center, and Alaska Department of Fish and Game. (Available at https://npafc.org).

Muto, M., V. Helker, R. Angliss, B. Allen, P. Boveng, J. Breiwick, M. Cameron, P. Clapham, S. Dahle, M. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, R. G. Towell, P. R. Wade, J. N. Waite, and A. N. Zerbini. 2017. Alaska marine mammal stock assessments, 2016. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-355, 366 p.

NASA Ocean Biology Processing Group. 2025*a*. Aqua MODIS Level-2 Regional Ocean Color (OC) Data, version 2022.0 [Dataset]. NASA Ocean Biology Distributed Active Archive Center. https://doi.org/10.5067/AQUA/MODIS/L2/OC/2022.0DateAccessed:2026-09-17.

NASA Ocean Biology Processing Group. 2025*b*. Terra MODIS Level-2 Regional Ocean Color (OC) Data, version 2022.0 [Dataset]. NASA Ocean Biology Distributed Active Archive Center. https://doi.org/10.5067/TERRA/MODIS/L2/OC/2022.0DateAccessed:2026-04-29.

National Academies of Sciences, Engineering, and Medicine (NASEM). 2022. A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration.

National Marine Fisheries Service. 2011. U.S. National Bycatch Report [W. A. Karp, L. L. Desfosse, S. G. Brooke, Editors].U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-117E, 508 pp.

Neilson, J. L., T. Cheeseman, J. Maselko, M. D. Christodoulou, C. M. Gabriele, J. M. Straley, C. S. Baker, L. Bejder, D. Bloch, R. Cartwright, J. J. Currie, N. Doe, K. Dracott, R. Finn, A. Frisch-Jordán, B. Goodwin, C. Hayslip, M. E. Jiménez López, M. Jones, M. Lammers, S. W. Lewis, E. Lyman, P. Martínez Loustalot, C. J. McMillan, J. Moran, A. A. Pack, D. M. Palacios, H. C. Pearson, N. Ransome, H. Rosales Nanduca, F. Sharpe, S. H. Stack, A. Szabo, S. S. Teerlink, J. Urbán R., and M. van Aswegen. In Prep. Detecting hidden mortality in long lived migratory species: Conceptual advances from a marine heatwave.

Neilson, J. L., C. M. Gabriele, and L. E. McCaslin. 2024. Glacier Bay & Icy Strait Humpback Whale Population Monitoring: 2023 Update. National Park Service Resource Brief, Gustavus, Alaska. irma.nps.gov/DataStore/DownloadFile/700644.

Nishioka, J., and H. Obata. 2017. Dissolved iron distribution in the western and central subarctic Pacific: HNLC water formation and biogeochemical processes. Limnology and Oceanography **62**:2004–2022.

NOAA. 2010. Endangered and threatened wildlife and plants: Threatened status for southern distinct population segment of eulachon. In Federal Register (Vol. 75, Issue 52). https://doi.org/10.1021/j100299a032.

O'Brien, K., M. Litzow, F. Mueter, E. Fedewa, D. Kimmel, T. Kristiansen, J. Nielsen, and E. Ryznar. 2026. A Spatially Resolved Borealization Index for the Bering Sea. In: Siddon, E. 2026. Ecosystem

Status Report 2026: Eastern Bering Sea, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West 3rd Ave., Suite 400, Anchorage, Alaska 99501.

Okkonen, S. R., G. A. Jacobs, E. J. Metzger, H. E. Hurlburt, and J. F. Shriver. 2001. Mesoscale variability in the boundary currents of the Alaska Gyre. Continental Shelf Research **21**:1219–1236.

Okkonen, S. R., T. J. Weingartner, S. L. Danielson, D. L. Musgrave, and G. M. Schmidt. 2003. Satellite and hydrographic observations of eddy-induced shelf-slope exchange in the northwestern Gulf of Alaska. Journal of Geophysical Research-Oceans **108**:10.1029/2002JC001342.

Olds, A. L., S. B. Moran, and M. Castellini. 2016. Integrating local and traditional knowledge and historical sources to characterize run timing and abundance of eulachon in the Chilkat and Chilkoot rivers. By Allyson Olds. Thesis Submitted in Partial Fulfillment of the Requirements for the University of Alaska, Fairbanks.

Olgun, N., S. Duggen, B. Langmann, M. Hort, C. F. Waythomas, L. Hoffmann, and P. Croot. 2013. Geochemical evidence of oceanic iron fertilization by the Kasatochi volcanic eruption in 2008 and the potential impacts on Pacific sockeye salmon. Marine Ecology Progress Series **488**:81–88.

Ormseth, O. 2017. Assessment of the skate stock complex in the Gulf of Alaska. North Pacific Fishery Management Council, 605 W 4th Ave Suite 306, Anchorage, Alaska 99501. 58 pp.

Orsi, J. A., E. A. Fergusson, A. Wertheimer, and E. Farley. 2016. Chinook salmon first-year production indicators from ocean monitoring in Southeast Alaska. North Pacific Anadromous Fish Commission Bulletin 6:169–179.

Orsi, J. A., M. Sturdevant, and E. Fergusson. 2013. Connecting the "dots" among coastal ocean metrics and Pacific salmon production in Southeast Alaska, 1997–2012. North Pacific Anadromous Fish Commission Technical Report No. 9: 260-266.

Osborne, O., P. O'Hara, S. Whelan, P. Zandbergen, S. Hatch, and K. Elliott. 2020. Breeding seabirds increase foraging range in response to an extreme marine heatwave. Marine Ecology Progress Series **646**:161–173.

Oschlies, A., C. P. Slomp, A. H. Altieri, N. D. Gallo, M. Gregoire, K. Isensee, L. A. Levin, and J. Wu. 2025. Title Not Provided. Environmental Research Letters **20**:073002.

Parker, R. R. 1971. Size selective predation among juvenile salmonid fishes in a British-Columbia inlet. Journal of the Fisheries Research Board of Canada **28**:1503–1510.

Parsons, T. R., and F. A. Whitney. 2012. Did volcanic ash from Mt. Kasatoshi in 2008 contribute to a phenomenal increase in Fraser River sockeye salmon (Oncorhynchus nerka) in 2010? Fisheries Oceanography **21**:374–377.

Pegau, W. S., J. Zahner, and J. Morella. 2022. Prince William Sound herring. In: Ferriss, B. and Zador, S., 2022. Ecosystem Status Report 2022: Gulf of Alaska, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, Alaska 99501-2252.

Peterson, W. T., and F. B. Schwing. 2003. A new climate regime in northeast Pacific ecosystems. Geophysical Research Letters **30**:4.

Piatt, J., M. Arimitsu, W. Sydeman, S. Thompson, H. Renner, S. Zador, D. Douglas, S. Hatch, A. Kettle, and J. Williams. 2018. Biogeography of pelagic food webs in the North Pacific. Fisheries Oceanography **27**:366–380.

Piatt, J., J. Parrish, H. Renner, S. Schoen, T. Jones, M. Arimitsu, K. Kuletz, B. Bodenstein, M. García-Reyes, R. Duerr, and R. Corcoran. 2020. Extreme mortality and reproductive failure of common murres resulting from the northeast Pacific marine heatwave of 2014–2016. PloS ONE **15**:e0226087.

Piatt, J. F., and P. J. Anderson. 1996. Response of Common Murres to the Exxon Valdez oil spill and long-term changes in the Gulf of Alaska marine ecosystem. American Fisheries Society Symposium **18**:720–737.

Piston, A., and S. Heinl. 2020. Pink salmon stock status and escapement goals in Southeast Alaska through 2019. Alaska Department of Fish and Game, Special Publication No. 20-09, Anchorage.

Porter, S. M., L. Ciannelli, N. Hillgruber, K. M. Bailey, K.-S. Chan, M. F. Canino, and L. J. Haldorson. 2005. Environmental factors influencing larval walleye pollock *Theragra chalcogramma* feeding in Alaskan waters. Marine Ecology Progress Series **302**:207–217.

Prentice, M., G. Crandall, A. Chan, K. Davis, P. Hershberger, J. Finke, J. Hodin, A. McCracken, C. Kellogg, R. Clemente-Carvalho, C. Prentice, K. Zhong, C. Harvell, C. Suttle, and A. Gehman. 2025. Vibrio pectenicida strain FHCF-3 is a causative agent of sea star wasting disease. Nat Ecol Evol **9**:1739–1751.

Purcell, J. E. 2005. Climate effects on formation of jellyfish and ctenophore blooms: a review. Journal of the Marine Biological Association of the United Kingdom **85**:461–476.

Purcell, J. E., and M. N. Arai. 2001. Interactions of pelagic cnidarians and ctenophores with fish: a review. Hydrobiologia **451**:27–44.

Purcell, J. E., and M. V. Sturdevant. 2001. Prey selection and dietary overlap among zooplanktivorous jellyfish and juvenile fishes in Prince William Sound, Alaska. Marine Ecology Progress Series **210**:67–83.

Queirolo, L. E., L. Fritz, P. Livingston, M. Loefflad, D. Colpo, and Y. DeReynier. 1995. Bycatch, utilization, and discards in the commercial groundfish fisheries of the Gulf of Alaska, eastern Bering Sea, and Aleutian Islands. U.S. Dep. Commer., NOAA Tech.Memo. NMFS-AFSC-58, 148 p.

Rand, P., and G. Ruggerone. 2024. Biennial patterns in Alaskan sockeye salmon ocean growth are associated with pink salmon abundance in the Gulf of Alaska and the Bering Sea. ICES Journal of Marine Science **81**:701–709.

Ream, R. R., J. T. Sterling, and T. R. Loughlin. 2005. Oceanographic features related to northern fur seal migratory movements. Deep-Sea Research Part II-Topical Studies in Oceanography **52**:823–843.

Reiniger, R., and C. Ross. 1968. A method of interpolation with application to oceanographic data. Deep Sea Research **15**:185–193.

Ricour, F., L. Guidi, M. Gehlen, and et al. 2023. Century-scale carbon sequestration flux throughout the ocean by the biological pump. National Geosciences **16**:1105–1113.

Robins, J. B. 2006. Biophysical factors associated with the marine growth and survival of Auke Creek, Alaska Coho Salmon. Masters thesis, University of Alaska Fairbanks.

Robinson, K. L., J. J. Ruzicka, M. B. Decker, R. D. Brodeur, R. J. Hernandez, J. Quinones, E. M. Acha, S.-i. Uye, H. Mianzan, and W. M. Graham. 2014. Jellyfish, Forage Fish, and the World's Major Fisheries. Oceanography **27**:104–115.

Rodionov, S., and J. E. Overland. 2005. Application of a sequential regime shift detection method to the Bering Sea ecosystem. Ices Journal of Marine Science **62**:328–332.

Rogers, L. A., K. E. Axler, and J. S. Bigman. 2026. Widespread phenological shifts with temperature in Alaska's marine fishes. Global Change Biology **32**:e70708.

Rogers, L. A., A. Deary, and K. L. Mier. 2018. Larval Fish Abundance in the Gulf of Alaska, 1981-2017.

Rogers, L. A., and A. B. Dougherty. 2019. Effects of climate and demography on reproductive phenology of a harvested marine fish population. Global Change biology **25**:708–720.

Rogers, L. A., M. Wilson, J. Duffy-Anderson, D. Kimmel, and J. Lamb. 2020. Pollock and "the Blob": Impacts of a marine heatwave on walleye pollock early life stages. Fisheries Oceanography **30**:142–158.

Roman, M. R., A. H. Altieri, D. Breitburg, E. M. Ferrer, N. D. Gallo, S. Ito, K. Limburg, K. Rose, M. Yasuhara, and L. A. Levin. 2024. Biological indicators of oxygen stress in marine water-breathing animals. Biogeosciences **21**:4975–5004.

Roundsfell, G., and E. Dahlgren. 1935. Races of Herring, *Clupea pallasii* in Southeastern Alaska. Bulletin of the Bureau of Fisheries, U.S. Department of Commerce, Vol. XLVIII, Bulletin No. 17, U.S. Government Printing Office, Washington, D.C.

Ruggerone, G., A. Springer, G. van Vliet, B. Connors, J. Irvine, L. Shaul, M. Sloat, and W. Atlas. 2023. From diatoms to killer whales: impacts of pink salmon on North Pacific ecosystems. Marine Ecology Progress Series **719**:1–40.

Ruggerone, G. T., M. Zimmermann, K. W. Myers, J. L. Nielsen, and D. E. Rogers. 2003. Competition between Asian pink salmon (*Oncorhynchus gorbuscha*) and Alaskan sockeye salmon (*O-nerka*) in the North Pacific Ocean. Fisheries Oceanography **12**:209–219.

Ruzicka, J., R. Brodeur, K. Cieciel, and M. Decker. 2020. Examining the ecological role of jellyfish in the Eastern Bering Sea. ICES Journal of Marine Science **77**:791–802.

Schlegel, R., E. Oliver, A. Hobday, and A. Smit. 2019. Detecting marine heatwaves with sub-optimal data. Frontiers in Marine Science **6**:737.

Shanley, C. S., S. Pyare, M. I. Goldstein, P. B. Alaback, D. M. Albert, C. M. Beier, T. J. Brinkman, R. T. Edwards, E. Hood, and A. MacKinnon. 2015. Climate change implications in the northern coastal temperate rainforest of North America. Climatic Change **130**:155–170.

Shaul, L. K., E. Crabtree, S. McCurdy, and B. Elliott. 2011. Coho salmon stock status and escapement goals in Southeast Alaska. Alaska Department of Fish and Game, Special Publication No. 11-21 3.

Shelton, A., J. Thorson, E. Ward, and B. Feist. 2014. Spatial semiparametric models improve estimates of species abundance and distribution. Canadian Journal of Fisheries and Aquatic Sciences **71**:1655–1666.

Siddon, E., K. Shotwell, and J. Ianelli. 2026. Eastern Bering Sea Walleye Pollock Early Survival Pathways. In: Siddon, E. 2026. Ecosystem Status Report 2026: Eastern Bering Sea, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West 3rd Ave., Suite 400, Anchorage, Alaska 99501.

Siegel, D. A., T. DeVries, S. C. Doney, and T. Bell. 2021. Assessing the sequestration time scales of some ocean-based carbon dioxide reduction strategies. Environmental Research Letters **16**:104003.

Sigler, M. F., J. N. Womble, and J. J. Vollenweider. 2004. Availability to Steller sea lions (*Eumetopias jubatus*) of a seasonal prey resource: a prespawning aggregation of eulachon (*Thaleichthys pacificus*). Canadian Journal of Fisheries and Aquatic Sciences **61**:1475–1484.

Sill, L. A., and T. Barnett. 2023. The subsistence harvest of Pacific herring spawn in Sitka Sound, Alaska, 2022. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 492, Douglas.

Silver, M. W., S. Bargu, S. L. Coale, C. R. Benitez-Nelson, A. C. Garcia, K. J. Roberts, E. Sekula-Wood, K. W. Bruland, and K. H. Coale. 2010. Toxic diatoms and domoic acid in natural and iron enriched waters of the oceanic Pacific. Proceedings of the National Academy of Sciences U.S.A. **107**.

Siwicke, K. 2022. Summary of temperature and depth recorder data from the Alaska Fisheries Science Center's longline survey (2005–2021). U.S. Dep. Commer., NOAA Tech. Memo. NMFSAFSC-437, 74 p.

Siwicke, K. A., J. Moss, B. Beckman, and C. Ladd. 2019. Effects of the Sitka Eddy on juvenile pink salmon in the eastern Gulf of Alaska. Deep-Sea Res. II **165**:348–363.

Spalinger, K., and J. Silva. 2024. Large-mesh bottom trawl survey of crab and groundfish: Kodiak, Chignik, South Peninsula, and Eastern Aleutian Management Districts, 2023. Alaska Department of Fish and Game, Fishery Management Report No. 24-09, Anchorage.

Spangler, E. 2002. The Ecology of Eulachon (*Thaleichthys pacificus*) in Twentymile River, Alaska. By E. A. K. Spangler. Thesis Submitted in Partial Fulfillment of the Requirements for the University of Alaska, Fairbanks.

Springer, A. M., and G. B. van Vliet. 2014. Climate change, pink salmon, and the nexus between bottom-up and top-down forcing in the subarctic Pacific Ocean and Bering Sea. Proceedings of the National Academy of Sciences **111**:E1880–E1888.

Stabeno, P. J., N. A. Bond, A. J. Hermann, N. B. Kachel, C. W. Mordy, and J. E. Overland. 2004. Meteorology and oceanography of the Northern Gulf of Alaska. Continental Shelf Research **24**:859–897.

Stabeno, P. J., J. D. Schumacher, K. M. Bailey, R. D. Brodeur, and E. D. Cokelet. 1996. Observed patches of walleye pollock eggs and larvae in Shelikof Strait, Alaska: Their characteristics, formation and persistence. Fisheries Oceanography **5(Suppl. 1)**:81–91.

State of Alaska. 2022. Paralytic Shellfish Poisoning — Alaska, 1993–2021. Epidemiology Bulletin No. 5, April 21, 2022. Available at: `http://www.epi.alaska.gov/bulletins/docs/b2022_05.pdf`.

Sturdevant, M., J. Orsi, and E. Fergusson. 2012. Diets and trophic linkages of epipelagic fish predators in coastal Southeast Alaska during a period of warm and cold climate years, 1997–2011. Marine and Coastal Fisheries **4**:526–545.

Sturdevant, M., M. Sigler, and J. Orsi. 2009. Sablefish predation on juvenile Pacific salmon in the coastal marine waters of Southeast Alaska in 1999. Transactions of the American Fisheries Society **138**:675–691.

Suryan, R., M. Arimitsu, H. Coletti, R. Hopcroft, M. Lindeberg, S. Barbeaux, S. Batten, W. Burt, M. Bishop, J. Bodkin, R. Brenner, R. Campbell, D. Cushing, S. Danielson, M. Dorn, B. Drummond, D. Esler, T. Gelatt, D. Hanselman, S. Hatch, S. Haught., K. Holderied, K. Iken, D. Irons, A. Kettle, D. Kimmel, B. Konar, K. Kuletz, B. Laurel, J. Maniscalco, C. Matkin, C. McKinstry, D. Monson, J. Moran, D. Olsen, W. Palsson, S. Pegau, J. Piatt, L. Rogers, N. Rojek, A. Schaefer, I. Spies, J. Straley, S. Strom, K. Sweeney, M. Szymkowiak, B. Weitzman, E. Yasumiishi, and S. Zador. 2021. Ecosystem response persists after a prolonged marine heatwave. Scientific Reports **11**:6235.

Suryan, R. M., and K. J. Kuletz. 2018. Distribution, habitat use, and conservation of albatrosses in Alaska. Iden **72**:156–164.

Suryan, R. M., M. R. Lindeberg, M. L. Arimitsu, D. Esler, H. A. Coletti, R. R. Hopcroft, and W. S. Pegau. 2023. Gulf Watch Alaska: Long-term research and monitoring in the Gulf of Alaska: Open Access Government, pp.468-469, https://doi.org/10.56367/OAG-038-10678.

Sydeman, W., J. Piatt, S. Thompson, M. García-Reyes, S. Hatch, M. Arimitsu, L. Slater, J. Williams, N. Rojek, S. Zador, and H. Renner. 2017. Puffins reveal contrasting relationships between forage fish and ocean climate in the North Pacific. Fisheries Oceanography **26**:379–395.

Tagliabue, A., B. S. Twining, N. Barrier, O. Maury, M. Berger, and L. Bopp. 2023. Ocean iron fertilization may amplify climate change pressures on marine animal biomass for limited climate benefit. Global Change Biology **29**:5250–5260.

The Royal Society. 2009. Geoengineering the climate: Science, governance and uncertainty.

Thompson, P. L., J. Nephin, S. Davies, A. Park, D. Lyons, C. Rooper, A. Peña, J. Christian, K. Hunter, E. Rubidge, and A. Holdsworth. 2023. Groundfish biodiversity change in northeastern Pacific waters under projected warming and deoxygenation. Philosophical Transactions of the Royal Society B **378**:20220191.

Thorson, J., C. Adams, E. Brooks, L. Eisner, D. Kimmel, C. Legault, L. Rogers, and E. Yasumiishi. 2020. Seasonal and Interannual Variation in Spatio-Temporal Models for Index Standardization and Phenology Studies. ICES Journal of Marine Science **77**:1879–1892.

Thorson, J., S. Anderson, P. Goddard, and C. Rooper. 2025. TINYVAST: R Package With an Expressive Interface to Specify Lagged and Simultaneous Effects in Multivariate Spatio-Temporal Models. Global Ecology and Biogeography **34**:e70035.

Thorson, J. T., and K. Kristensen. 2016. Implementing a generic method for bias correction in statistical models using random effects, with spatial and population dynamics examples. Fisheries Research **175**:66–74.

Tobin, E. D., C. Wallace, C. Crumpton, G. Johnson, and G. Eckert. 2019. Environmental drivers of paralytic shellfish toxin producing *Alexandrium catenella* blooms in a fjord system of northern Southeast Alaska. Harmful Algae **88**:101659.

Toge, K., R. Yamashita, K. Kazama, M. Fukuwaka, O. Yamamura, and Y. Watanuki. 2011. The relationship between pink salmon biomass and the body condition of short-tailed shearwaters in the

Bering Sea: can fish compete with seabirds? Proceedings of the Royal Society B-Biological Sciences **278**:2584–2590.

Toresen, R. 2001. Spawning stock fluctuations and recruitment variability related to temperature for selected herring (*Clupea harengus*) stocks in the North Atlantic. In Herring: Expectations for a New Millennium, Alaska Sea Grant College Program, volume AK-SG-01-04, pg 315-334.

Traiger, S., J. Bodkin, H. Coletti, B. Ballachey, T. Dean, D. Esler, K. Iken, B. Konar, M. Lindeberg, D. Monson, B. Robinson, R. Suryan, and B. Weitzman. 2022. Evidence of increased mussel abundance related to the Pacific marine heatwave and sea star wasting. Marine Ecology **43**:e12715.

Trick, C. G., B. D. Bill, W. P. Cochlan, M. L. Wells, V. L. Trainer, and L. D. Pickell. 2010. Iron enrichment stimulates toxic diatom production in high-nitrate, low-chlorophyll areas. Proceedings of the National Academy of Sciences U.S.A. **107**:5887–5892.

Turner, J. T. 2015. Zooplankton fecal pellets, marine snow, phytodetritus and the ocean's biological pump. Progress in Oceanography **130**:205–248.

Turner, L., M. Arimitsu, J. Piatt, G. Eckert, and C. Cunningham. 2024. Alaska Forage Fish Database (AFFD): U.S. Geological Survey data release, https://doi.org/10.5066/P9WZQJ8N.

U.S. Geological Survey - Alaska Science Center, National Park Service - Southwest Alaska - Inventory and Monitoring Network, and University of Alaska Fairbanks - College of Fisheries and Ocean Sciences. 2016. Intertidal temperature data from Kachemak Bay, Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park (ver 8.0, September 2026): U.S. Geological Survey data release, `https://doi.org/10.5066/F7WH2N3T`.

U.S. Geological Survey - Alaska Science Center, National Park Service - Southwest Alaska Inventory and Monitoring Network. 2016. Intertidal mussel (*Mytilus*) data from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park (ver 7.0, August 2026): U.S. Geological Survey data release, `https://doi.org/10.5066/F7FN1498`.

U.S. Geological Survey - Alaska Science Center, National Park Service - Southwest Alaska Inventory and Monitoring Network. 2022. Rocky intertidal data from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park (ver 5.0, September 2026): U.S. Geological Survey data release, `https://doi.org/10.5066/F7WH2N3T`.

van Aswegen, M., A. Szabo, J. Currie, S. Stack, L. Evans, J. Straley, J. Neilson, C. Gabriele, K. Cates, D. Steel, and L. Bejder. 2025. Maternal investment, body condition and calf growth in humpback whales. The Journal of Physiology **603**:551–578.

Vandersea, M., S. Kibler, P. Tester, K. Holderied, D. Hondolero, K. Powell, S. Baird, A. Doroff, D. Dugan, and R. Litaker. 2018. Environmental factors influencing the distribution and abundance of *Alexandrium catenella* in Kachemak Bay and lower Cook Inlet, Alaska. Harmful Algae **77**:81–92.

Ver Hoef, J. M., B. T. McClintock, P. L. Boveng, J. M. London, and J. K. Jansen. 2025. An integrated data model to estimate abundance from counts with temporal dependence and imperfect detection. Ecology **106**:e70073.

Von Biela, V. R., M. L. Arimitsu, J. F. Piatt, B. Heflin, S. K. Schoen, J. L. Trowbridge, and C. M. Clawson. 2019. Extreme reduction in nutritional value of a key forage fish during the pacific marine heatwave of 2014-2016. Marine Ecology Progress Series **613**:171–182.

Waite, J. N., and F. Mueter. 2013. Spatial and temporal variability of chlorophyll-a concentrations in the coastal Gulf of Alaska, 1998–2011, using cloud-free reconstructions of SeaWiFS and MODIS-Aqua data. Progress in Oceanography **116**:179–192.

Walsh, J. E., R. L. Thoman, U. S. Bhatt, P. A. Bieniek, B. Brettschneider, M. Brubaker, S. Danielson, R. Lader, F. Fetterer, and K. Holderied. 2018. The high latitude marine heat wave of 2016 and its impacts on Alaska. Bulletin of the American Meteorological Society **99**:S39–S43.

Ward, E. J., S. C. Anderson, L. A. Damiano, M. E. Hunsicker, and M. A. Litzow. 2019. Modeling regimes with extremes: the bayesdfa package for identifying and forecasting common trends and anomalies in multivariate time-series data. R J. **11**:46.

Ware, D. M., and R. E. Thomson. 2005. Bottom-up ecosystem trophic dynamics determine fish production in the Northeast Pacific. Science **308**:1280–1284.

Warzybok, P., J. Santora, D. Ainley, R. Bradley, J. Field, C. P.J., C. R.D., E. M., J. Beck, G. McChesney, M. Hester, and J. Jahncke. 2018. Prey switching and consumption by seabirds in the central California Current upwelling ecosystem: Implications for forage fish management. Journal of Marine Systems **185**:25–39.

Watson, J., and M. Callahan. 2021. Automated and operational access to environmental data for Alaska's management areas. AFSC Processed Rep. 2021-06, 34 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., Auke Bay Laboratories,17109 Pt. Lena Loop Road, Juneau, AK, 99801.

Weitkamp, L. A., J. A. Orsi, K. Myers, and R. Francis. 2011. Contrasting early marine ecology of Chinook salmon and coho salmon in Southeast Alaska: insight into factors affecting marine survival. Marine and Coastal Fisheries **3**:233–249.

Weitzman, B., B. Konar, K. Iken, H. Coletti, D. Monson, R. Suryan, T. Dean, D. Hondolero, and M. Lindeberg. 2021. Changes in rocky intertidal community structure during a marine heatwave in the northern Gulf of Alaska. Frontiers in Marine Science **8**:1–18.

Wertheimer, D., A., J. A. Orsi, E. A. Fergusson, and M. V. Sturdevant. 2010. Calibration of Juvenile Salmon Catches using Paired Comparisons between Two Research Vessels Fishing Nordic 264 Surface Trawls in Southeast Alaska, July 2009.(NPAFC Doc. 1277). Auke Bay Laboratories, Alaska Fisheries Science Center, National Marine Fisheries Service (Available at https://npafc.org).

Wespestad, V. G., L. W. Fritz, W. J. Ingraham, and B. A. Megrey. 2000. On relationships between cannibalism, climate variability, physical transport, and recruitment success of Bering Sea walleye pollock (*Theragra chalcogramma*). ICES Journal of Marine Science **57**:272–278.

Whitney, F., and D. Welch. 2002. Impact of the 1997 1998 El Niño and 1999 La Niña on nutrient supply in the Gulf of Alaska. Progress in Oceanography **54**:405–421.

Wilderbuer, T. K., A. B. Hollowed, W. J. Ingraham, P. D. Spencer, M. E. Conners, N. A. Bond, and G. E. Walters. 2002. Flatfish recruitment response to decadal climatic variability and ocean conditions in the eastern Bering Sea. Progress in Oceanography **55**:235–247.

Wills, R. C. J., D. S. Battisti, C. Proistosescu, L. Thompson, D. L. Hartmann, and K. C. Armour. 2019. Ocean Circulation Signatures of North Pacific Decadal Variability. Geophysical Research Letters **46**:1690–1701.

Wilson, M. T., and N. Laman. 2021. Interannual variation in the coastal distribution of a juvenile gadid in the northeast Pacific Ocean: The relevance of wind and effect on recruitment. Fisheries Oceanography **30**:3–22.

Wong, C. S., D. A. Timothy, C. S. Law, Y. Nojiri, L. Xiea, S. K. E. Wong, and J. S. Page. 2006. Carbon distribution and fluxes during the SERIES iron fertilization experiment with special reference to the fugacity of carbon dioxide (fCO2). Deep-Sea Research II **53**:2053–2074.

Wooster, W., and A. Hollowed. 1995. Decadal-Scale Variations in the Eastern Subarctic Pacific, 1: Winter Ocean Conditions. Canadian Special Publication of Fisheries and Aquatic Sciences **121**:81–85.

Wynne, K. M., D. Hicks, and N. Munro. 1991. 1990 Salmon Gillnet Fisheries Observer Programs in Prince William Sound and South Unimak Alaska. Saltwater Inc.

Wynne, K. M., D. Hicks, and N. Munro. 1992. 1991 Marine Mammal Observer Program for the Salmon Driftnet Fishery of Prince William Sound Alaska. Saltwater Inc.

Yang, Q., E. D. Cokelet, P. J. Stabeno, L. Li, A. B. Hollowed, W. A. Palsson, N. A. Bond, and S. J. Barbeaux. 2019. How "The Blob" affected groundfish distributions in the Gulf of Alaska. Fisheries Oceanography **28**:434–453.

Yasumiishi, E., E. Farley, G. Ruggerone, B. Agler, and L. Wilson. 2016. Trends and factors influencing the length, compensatory growth, and size-selective mortality of juvenile Bristol Bay, Alaska, sockeye salmon at sea. Marine and Coastal Fisheries **8**:315–333.

Yu, J., J. K. Moore, F. W. Primeau, A. F. Michaels, A. G. Nuno, K. M. Krumhardt, M. N. Levy, K. Lindsay, H. Wang, J. T. Randerson, and A. C. Martiny. 2026. Climate benefit and ecological cost trade-offs for ocean iron fertilization. Nature **656**:106–114.

Zador, S. G., and S. Fitzgerald. 2008. Seabird Attraction to Trawler Discards. AFSC Processed Rep. 2008-06, 26 p. Alaska Fisheries Science Center, NOAA, National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle WA 98115.

Zebdi, A., and J. Collie. 1995. Effect of climate on herring (*Clupea pallasi*) population dynamics in the Northeast Pacific Ocean: Climate change and northern fish populations., 1995, pp. 277-290, Canadian special publication of fisheries and aquatic sciences /Publication speciale canadienne des sciences halieutiques et aquatiques Ottawa ON [Can. Spec. Publ. Fish. Aquat. Sci./Publ. Spec. Can. Sci. Halieut. Aquat.], no. 121.

Zuur, A., I. Tuck, and N. Bailey. 2003. Dynamic factor analysis to estimate common trends in fisheries time series. Canadian journal of fisheries and aquatic sciences **60**:542–552.

Appendices

A1. History of the ESRs

Since 1995, staff at the Alaska Fisheries Science Center have prepared a separate Ecosystem Status (formerly Considerations) Report within the annual Stock Assessment and Fishery Evaluation (SAFE) report. Each new Ecosystem Status Report provides updates and new information to supplement the original report. The original 1995 report presented a compendium of general information on the Gulf of Alaska, Bering Sea, and Aleutian Island ecosystems as well as a general discussion of ecosystem-based management. The 1996 edition provided additional information on biological features of the North Pacific, and highlighted the effects of bycatch and discards on the ecosystem. The 1997 edition provided a review of ecosystem-based management literature and ongoing ecosystem research, and provided supplemental information on seabirds and marine mammals. The 1998 edition provided information on the precautionary approach, essential fish habitat, effects of fishing gear on habitat, El Niño, local knowledge, and other ecosystem information. The 1999 edition again gave updates on new trends in ecosystem-based management, essential fish habitat, research on effects of fishing gear on seafloor habitat, marine protected areas, seabirds and marine mammals, oceanographic changes in 1997/98, and local knowledge.

In 1999, a proposal came forward to enhance the Ecosystem Status Report by including more information on indicators of ecosystem status and trends and more ecosystem-based management performance measures. The purpose of this enhancement was to accomplish several goals:

1. Track ecosystem-based management efforts and their efficacy
2. Track changes in the ecosystem that are not easily incorporated into single-species assessments
3. Bring results from ecosystem research efforts to the attention of stock assessment scientists and fishery managers
4. Provide a stronger link between ecosystem research and fishery management
5. Provide an assessment of the past, present, and future role of climate and humans in influencing ecosystem status and trends

Each year since 1999, the Ecosystem Status Reports have included some new contributions and will continue to evolve as new information becomes available. Evaluation of the meaning of observed changes should be in the context of how each indicator relates to a particular ecosystem component.

For example, particular oceanographic conditions, such as bottom temperature increases, might be favorable to some species but not for others. Evaluations should follow an analysis framework such as that provided in the draft Programmatic Groundfish Fishery Environmental Impact Statement that links indicators to particular effects on ecosystem components.

In 2002, stock assessment scientists began using indicators contained in this report to systematically assess ecosystem factors such as climate, predators, prey, and habitat that might affect a particular stock. Information regarding a particular fishery's catch, bycatch, and temporal/spatial distribution can be used to assess possible impacts of that fishery on the ecosystem. Indicators of concern can be highlighted within each assessment and can be used by the Groundfish Plan Teams and the Council to justify modification of allowable biological catch (ABC) recommendations or time/space allocations of catch.

We initiated a regional approach to the ESR in 2010 and presented a new ecosystem assessment for the eastern Bering Sea. In 2011, we followed the same approach and presented a new assessment for the Aleutian Islands based on a similar format to that of the eastern Bering Sea but with regional report cards for the western, central, and eastern Aleutian Islands. In 2012, we provided a preliminary ecosystem assessment on the Arctic. Our intent was to provide an overview of general Arctic ecosystem information that may form the basis for more comprehensive future Arctic ecosystem assessments. In 2015, we presented a new Gulf of Alaska report card and assessment, which was further divided into Western and Eastern Gulf of Alaska report cards beginning in 2016. This was also the year that the previous Alaska-wide ESR was split into four separate reports, one for the Gulf of Alaska, Aleutian Islands, eastern Bering Sea, and the Arctic[75].

The eastern Bering Sea and Aleutian Islands ecosystem assessments were based on additional refinements contributed by Ecosystem Synthesis Teams. For these assessments, the teams focused on a subset of broad, community-level indicators to determine the current state and likely future trends of ecosystem productivity in the EBS and ecosystem variability in the Aleutian Islands. The teams also selected indicators that reflect trends in non-fishery apex predators and maintaining a sustainable species mix in the harvest as well as changes to catch diversity and variability. Indicators for the Gulf of Alaska report card and assessment were also selected by a team of experts, via an online survey first, then refined in an in-person workshop.

Originally, contributors to the Ecosystem Status Reports were asked to provide a description of their contributed indicator, summarize the historical trends and current status of the indicator, and identify potential factors causing those trends. Beginning in 2009, contributors were also asked to describe why the indicator is important to groundfish fishery management and implications of indicator trends. In particular, contributors were asked to briefly address implications or impacts of the observed trends on the ecosystem or ecosystem components, what the trends mean and why are they important, and how the information can be used to inform groundfish management decisions. Answers to these types of questions will help provide a "heads-up" for developing management responses and research priorities.

In 2018, a risk table framework was developed for individual stock assessments as a means of documenting concerns external to the stock assessment model, but relevant to setting the Acceptable Biological Catch (ABC) value for the current year. These concerns could be categorized as those reflecting the assessment model, the population dynamics of the stock, and environmental and ecosystem concerns—including those based on information from Ecosystem Status Reports. In the past, concerns used to justify an ABC below the maximum estimated by the assessment model were documented in an ad-hoc

[75]The Arctic Report has not been regularly produced.

manner in the stock assessment report or in the minutes of the Groundfish Plan Teams or Scientific and Statistical Committee (SSC) reviews. With the risk table, formal consideration of concerns—including ecosystem—are documented and ranked, and the stock assessment author presents a recommendation for the maximum ABC as specified by the stock assessment model or a lower value. The recommended ABC (whether at maximum or lower) from the lead stock assessment author is subsequently reviewed and adjusted or accepted by the Groundfish Plan Team and the Scientific and Statistical Committee. Five risk tables were completed in 2018 as a test case. After review, the Council requested risk tables to be included in all full stock assessments in 2019. The SSC also requested a fourth category of concern to be added to the risk tables. The fishery performance category serves to represent any concerns related to the recommended ABC that can be inferred from commercial fisheries performance. Importantly, these concerns refer to indications of stock status, not economic performance.

In Briefs were started in 2018 for the Eastern Bering Sea, 2019 for the Gulf of Alaska, and 2020 for the Aleutian Islands. These more public-friendly succinct versions of the full ESRs have since been produced annually in tandem with the ESRs.

In 2019, risk tables were completed for all full assessments. Ecosystem scientists collaborated with stock assessment scientists to use the Ecosystem Status Reports to help inform the ecosystem concerns in the risk tables. Some ecosystem information can also be used to inform concerns related to the population dynamics of the stock. Initially, there were 4 levels of concern from no concern to extreme. In 2023 (and revised in 2024), based on a recommendation from the SSC, the levels of risk were reduced to 3: Level 1 (Normal), Level 2 (Increased concern), and Level 3 (Extreme concern). For stock assessments which include an Ecosystem and Socioeconomic Profile (ESP), the ESP is also used to inform the ecosystem risk column as well as the population dynamics and fisheries performance columns.

ESPs were initiated in 2017 (sablefish) and ESR editors began working closely with ESP teams in 2019 (starting with GOA walleye pollock). These complimentary annual status reports inform groundfish management and alignment in research that feeds these reports increases efficiency and collaboration between ecosystem and stock assessment scientists.

Full ESRs were not produced in 2025 due to the lapse in government appropriations that fall, though, an Abbreviated Gulf of Alaska ESR was published.

This report represents much of the first three steps in Alaska's IEA: defining ecosystem goals, developing indicators, and assessing the ecosystems (Figure 104). The primary stakeholders in this case are the North Pacific Fishery Management Council. Research and development of risk analyses and management strategies is ongoing and will be referenced or included as possible.

It was requested that contributors to the Ecosystem Status Reports provide actual time series data or make them available electronically. The Ecosystem Status Reports and data for many of the time series presented within are available online at: `https://alaskaesr.psmfc.org`. These reports and data are also available through the NOAA-wide IEA website at: `https://www.integratedecosystemassessment.noaa.gov/regions/alaska`.

Past reports and all groundfish stock assessments are available at `https://www.fisheries.noaa.gov/alaska/population-assessments/north-pacific-groundfish-stock-assessment-and-fishery-evaluation`

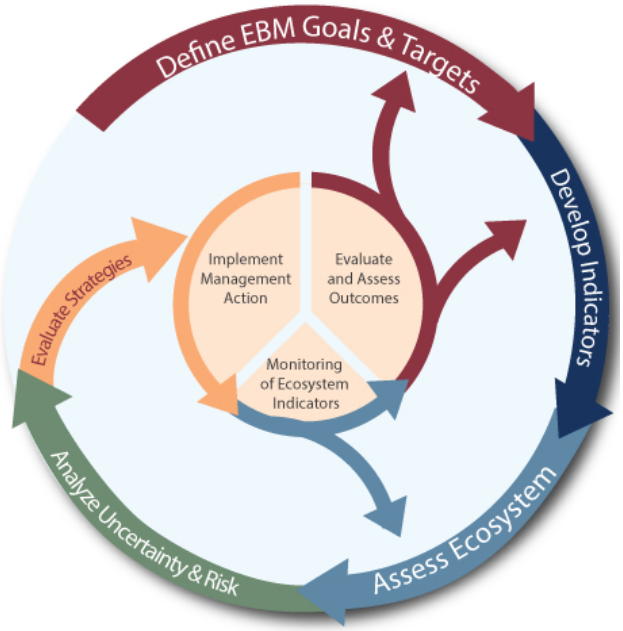


Figure 104: The integrated ecosystem assessment (IEA) process.

A2. Responses to Comments from the North Pacific Fishery Management Council's Science and Statistical Committee (December 2024, October 2025, January 2026 meetings) and the Groundfish Plan Team (September 2025, September 2026)

December 2024 SSC Final Report to the NPFMC

General Comments Applicable to all three ESRs

The SSC thanks the authors for their responses to SSC comments, in particular the development of integrated metrics to track changes in ecosystem state, modeling approaches to help discern linkages among indices affecting individual species, and references to how conditions will affect different groundfish species depending on spawn timing, larval ecology, and varying responses to temperature changes. The SSC encourages continued efforts along these lines.

The ESR team appreciates this line of encouragement. Examples in the 2026 ESRs include updated Ecosystem State metrics in Ferriss (2026), updated DSEM analyses connecting ecosystem conditions to groundfish population dynamics (Siddon et al., 2026; Domke et al., 2026).

The SSC looks forward to the continued consideration of socioeconomic metrics that could be included in ESRs.

The ESR team continues to engage with NOAA's Alaska Fisheries Science Center to advance the development of socioeconomic metrics that could be used in ESRs.

The SSC requests that for report cards, contributors not connect time series points in figures if there is a gap greater than the standard survey interval to avoid indicating a trend between missing years.

Starting in 2026, ESR Report Cards no longer connect time series points when there is a gap greater than the standard survey interval. ESR editors have also requested a similar approach from contributors and will continue to update figures in future ESR editions.

The SSC notes the value of continuing dynamic structural equation modeling (DSEM) modeling efforts, but recommends including the full model for comparison with the final most parsimonious model to clearly identify which hypothesized links were not supported by the data. The SSC appreciates the five-month lead climate forecasts.

The 2026 EBS ESR includes two applications of DSEM modeling: "Forage Fish Dynamics in the Eastern Bering Sea" and "Eastern Bering Sea Walleye Pollock Early Survival Pathways" (Siddon et al., 2026; Domke et al., 2026). Regarding climate forecasts, the ESRs will continue including NMME forecasts. This years the GOA ESR and AI ESR also include forecasts from MOM6 NEP10k

The SSC appreciates the confirmation that satellite-derived chlorophyll-a metrics are routinely validated with in-situ measurements to ensure accuracy. To this end, the ESR authors noted inconsistencies in

2024 satellite-derived chlorophyll-a values and decided to postpone updating these contributions until 2025.

The 2026 ESRs include satellite-derived chlorophyll-a metrics based on OC-CCI, a merged product that combines information from Visible-Infrared Imaging Radiometer Suite (VIIRS), MODerate resolution Imaging Spectroradiometer (MODIS), Sea-viewing Wide Field-of-view Sensor (SeaWiFS), and the Ocean and Land Color Instrument (OLCI), using 8-day composites at a 4 km x 4 km resolution. For more information, see Gann in this report, p.73

Reasons for the low pink salmon returns are currently unknown and the SSC supports further investigation into plausible explanations for juvenile salmon and other species that showed similarly low abundances in this region, such as sand lance.

The ESR lead agrees with this comment and will contiue to work with collaborators to explore these population trends.

The SSC appreciates the integration of groundfish early life history information when summarizing how current trends in metrics might affect various species.

The ESR lead will continue to include this integration when information is available and relevant.

The SSC appreciates and supports the new ecosystem state analysis provided by the author.

The Ecosystem State analysis was updated and included in the 2026 GOA Ecosystem Status Report (Ferriss, p/.

The SSC recommends evaluation of spatial variability beyond the existing east and west GOA boundaries

The ESR lead will pursue these evaluation when they are available.

September 2025 Groundfish Plan Team

Joint Plan Team
Ecosystem Status Report – Climate Overview

While the presentation was focused on climate and physical oceanography, there was much discussion on whether to expand on some of the hypothesized ecosystem impacts during the September report (such information is typically presented in November). The Teams recommended that in future September reports, the ESR team continue working to link climate trends to ecosystem and groundfish community processes (e.g., recruitment, phenology across groups of species).

The ESR team will continue to link climate trends to ecosystem and groundfish community processes in future September Plan Team meetings, while staying within the bounds of a "climate" presentation. The November Plan Team meeting includes more fully integrated ESR presentations as we have synthesized all ecological information at that point.

January 2026 NPFMC SSC

GOA ESR

There were no suggestions or recommendations from the SSC.

September 2026 Groundfish Plan Team

Joint Plan Team

Ecosystem Status Report – Climate Overview

There were no suggestions or recommendations from the Groundfish Plan Team.

October 2026 SSC

C-1 BSAI Crab

Ecosystem Status Report Preview

The SSC recommends the authors work with ESR contributors to evaluate composite metrics of physical and biological indices that provide leading indicators of overall conditions or potential change. The SSC further recommends authors articulate uncertainty in metrics to the extent possible and identify which products are validated versus which are under development, description of base models and skill, and clearly identify modeled products.

The ESR team continues to work with our contributors to develop and evaluate composite metrics and leading indicators of ecosystem conditions. Examples include the revised spatially resolved borealization index (O'Brien et al., 2026) and ecosystem state analyses (Ferriss, 2026) in the GOA. New this year for the Aleutian Islands is the contribution on summer groundfish diets which includes the total estimated daily consumption by prey type for indicator species Aydin and Ortiz (2026) and an extended contribution for apex predators and pelagic foragers Ortiz et al. (2026). We will strive to improve communication of uncertainty and skill in these and future metrics.

A3. Report Card Indicator Descriptions & Methods

We present separate Western and Eastern Gulf of Alaska Report Cards to highlight inherent differences in ecosystem structure and function between the eastern and western ecoregions. Top-ranked indicators were selected for each category: physical, plankton, benthic, forage fish, non-forage fish, seabirds, marine mammals, and humans. We include two physical and plankton indicators and one from each of the other categories where available. The indicators are defined below.

Western Gulf of Alaska

Winter Pacific Decadal Oscillation

The leading mode of monthly sea surface temperature anomalies in the North Pacific Ocean, poleward of 20 °N. The monthly mean global average SST anomalies are removed to separate this pattern of variability from any "global warming" signal that may be present in the data. The winter index is the average monthly values from December – February. Data from `https://oceanview.pfeg.noaa.gov/erddap/tabledap/cciea_OC_PDO.htmlTable?time,PDO`. (See Lemagie and Bell, p.28)

Contact: emily.lemagie@noaa.gov

Summer Sea Surface Temperature

The NOAA Coral Reef Watch Program provides a gap-free daily SST dataset (`https://coralreefwatch.noaa.gov/product/5km/`) that was accessed via the NOAA Coast WatchWest Coast Node ERDDAP server (`https://coastwatch.pfeg.noaa.gov/erddap/griddap/NOAA_DHW.html`). Daily summer temperatures (June-August) were averaged for the western GOA (147 °W – 163 °W). (See Lemagie and Callahan, p.41)

Contact: emily.lemagie@noaa.gov

Copepod biomass

Total copepod biomass (g m^{-3}) is the sum of large and small calanoid copepod biomass, sampled south of Seward Alaska typically during the first 10 days of May. Data are averaged over the top 100 m of the water column to provide estimates of wet-weight biomass of zooplankton represented by all calanoid copepods retained by a 0.150 mm mesh net. (See Hopcroft, p.93)

Contact: rrhopcroft@alaska.edu

Copepod community size

The ratio of large calanoid copepods to total large and small calanoid copepods is used to represent copepod community size. Zooplankton are sampled south of Seward Alaska typically during the first 10 days of May. Data are averaged over the top 100 m of the water column to provide estimates of wet-weight biomass of zooplankton represented by all calanoid copepods retained. Small copepods data is taken from a vertical 0.15 mm net and large copepod data is taken from a towed 0.5 mm mesh net. (See Hopcroft, p.93)

Contact: rrhopcroft@alaska.edu

Motile epifauna biomass

The NOAA bottom trawl survey has been conducted triennially since 1984, and biennially since 1999. The motile epifauna foraging guild is calculated from the survey data modified by an ecopath-estimated catchability. This guild includes: eelpouts, octopi, crab, sea stars, brittle stars, sea urchins, sand dollars, sea cucumbers, snails, and hermit crabs. This indicator is presented to reflect the trends in the benthic community in the western GOA. (See Whitehouse, p.171)

Contact: andy.whitehouse@noaa.gov

Capelin

Previously we used the common trend identified by Dynamic Factor Analysis of capelin in prey composition time series from various piscivorous seabird and groundfish species, considered to be "samplers" of the forage fish community. In 2019, data were not available in time for this indicator to be updated and we use the time series that loaded most strongly on the DFA trend: the percent biomass of capelin from rhinoceros auklets (*Cerorhinca monocerata*) chick diets at Middleton Island (ISRC). This alternative metric was used again in 2020 as the full suite of data were not available in 2020 due to COVID-19 related seabird survey cancellations. We have continued using the percent biomass of capelin from rhinoceros auklets (*Cerorhinca monocerata*) chick diets at Middleton Island since then (See Arimitsu et al., p 104).

Contact: marimitsu@usgs.gov

Apex predator biomass

The NOAA bottom trawl survey has been conducted triennially since 1984, and biennially since 1999. The apex predator foraging guild is calculated from the survey data modified by an Ecopath-estimated catchability. Fish in this guild include: Pacific cod, arrowtooth flounder, Pacific halibut, sablefish, large sculpins, rougheye/blackspotted rockfish, and skates. (See Whitehouse, p.171)

Contact: andy.whitehouse@noaa.gov

Black-legged kittiwake reproductive success

Black-legged kittiwakes are common surface-foraging, piscivorous seabirds that nest in the GOA. Reproductive success is defined as the proportion of nest sites with fledged chicks from the total nest sites that were built. Reproductive success of this species is considered to be more sensitive to foraging conditions than that of common murres, another common seabird that has less variable reproductive success due to behaviors that can buffer the effects of poor food supply. Data are collected by the Alaska Maritime National Wildlife Refuge staff, U.S. Fish and Wildlife Service. These data were not updated in 2020 due to COVID-19 related survey cancellations. (See AMNWR data in Seabird Synthesis, p 145)

Contact: brie_drummond@fws.gov

Steller sea lion non-pup estimates

The R package agTrend model was used to produce abundance estimates of Steller sea lions within the bounds of the GOA. This region includes the GOA portion of the western Distinct Population Segment (known as the west, central and east GOA).

Contact: kathryn.sweeney@noaa.gov

Eastern Gulf of Alaska

Multivariate ENSO Index (MEI)

The bi-monthly Multivariate El Niño/Southern Oscillation (ENSO) index (MEI.v2) is the time series of the leading combined Empirical Orthogonal Function (EOF) of five different variables (sea level pressure (SLP), sea surface temperature (SST), zonal and meridional components of the surface wind, and outgoing longwave radiation (OLR) over the tropical Pacific basin (30 °S-30 °N and 100 °E-70 °W). The EOFs are calculated for 12 overlapping bi-monthly "seasons" (Dec-Jan, Jan-Feb, Feb-Mar,..., Nov-Dec) in order to take into account ENSO's seasonality, and reduce effects of higher frequency intraseasonal variability. We include the Dec-Jan value in the East Gulf of Alaska Report Card, with the year corresponding to January.

Key features of composite positive MEI events (warm, El Niño) include (1) anomalously warm SSTs across the east-central equatorial Pacific, (2) anomalously high SLP over Indonesia and the western tropical Pacific and low SLP over the eastern tropical Pacific, (3) reduction or reversal of tropical Pacific easterly winds (trade winds), (4) suppressed tropical convection (positive OLR) over Indonesia and Western Pacific and enhanced convection (negative OLR) over the central Pacific. Key features of composite negative MEI events (cold, La Niña) are of mostly opposite phase. For any single El Niño or La Niña situation, the atmospheric articulations may depart from this canonical view. Data are from `http://www.esrl.noaa.gov/psd/enso/mei/table.html`. (See Lemagie and Bell, p.28)

Contact: emily.lemagie@noaa.gov

Summer Sea Surface Temperature

The NOAA Coral Reef Watch Program provides a gap-free daily SST dataset (`https://coralreefwatch.noaa.gov/product/5km/`) that was accessed via the NOAA Coast WatchWest Coast Node ERDDAP server (`https://coastwatch.pfeg.noaa.gov/erddap/griddap/NOAA_DHW.html`). Daily summer temperatures (June - August) were averaged for the eastern GOA (133 °W – 147 °W). (See Lemagie and Callahan, p.41)

Contact: emily.lemagie@noaa.gov

Mesozooplankton biomass

Zooplankton biomass is represented by zooplankton density (number per m ^{3}) as captured by 333-μm bongo net samples during summer months in Icy Strait.)

Contact: emily.fergusson@noaa.gov

Copepod Community size

The ratio of large calanoid copepods to total large and small calanoid copepods as sampled in Icy Strait is used to represent copepod community size.)

Contact: emily.fergusson@noaa.gov

Motile epifauna biomass

The NOAA bottom trawl survey has been conducted triennially since 1984, and biennially since 1999. The motile epifauna foraging guild is calculated from the survey data modified by an ecopath-estimated catchability. This guild includes: eelpouts, octopi, crab, sea stars, brittle stars, sea urchins, sand dollars, sea cucumbers, snails, and hermit crabs. This indicator is presented to reflect the trends in the benthic community in the GOA. These values are summarized for the eastern region, where survey efforts vary among years. (See Whitehouse, p.171)

Contact: andy.whitehouse@noaa.gov

Sitka mature herring biomass

The stock assessment estimates of the Sitka herring stock is used to represent forage fish trends in the eastern GOA region. Previously, total mature herring biomass was estimated from nine primary sites for which regular assessments are conducted and probably account for the majority of the spawning biomass in southeastern Alaska in any given year. The Sitka stock has the longest time series of assessed biomass. (See Smith et al., p.111)

Contact: sherri.dressel@alaska.gov

Apex predator biomass

The NOAA bottom trawl survey has been conducted triennially since 1984, and biennially since 1999. The apex predator foraging guild is calculated from the survey data modified by an Ecopath-estimated catchability. Fish in this guild include: Pacific cod, arrowtooth flounder, Pacific halibut, sablefish, large sculpins, rougheye/blackspotted rockfish, and skates. These values are summarized for the eastern region, where survey efforts vary among years. (See Whitehouse, p.171)

Contact: andy.whitehouse@noaa.gov

Rhinoceros auklet chick growth rate

Mean growth rates of rhinoceros auklet chicks at St. Lazaria Island. Reproductive success is difficult to determine for these burrow-nesting seabirds because they are sensitive to disturbance. Data are only included for chicks that were measured at least three times during the linear phase of growth; chicks that did not exhibit linear growth were excluded. Data are collected by the Alaska Maritime National Wildlife Refuge staff, U.S. Fish and Wildlife Service. The colony was not monitored in 2017. These data were not updated in 2020 due to COVID-19 related seabird survey cancellations. (See AMNWR data in Seabird Synthesis, p.145)

Contact: brie_drummond@fws.gov

Steller sea lion non-pup estimates

The R package agTrend model was used to produce abundance estimates of Steller sea lions within the bounds of the GOA. This region includes the eastern Distinct Population Segment known as southeast Alaska.

Contact: kathryn.sweeney@noaa.gov