Observing ocean acidification across agencies, knowledge systems, and large marine ecosystems in Alaska

Natalie Monacci
University of Alaska Fairbanks
College of Fisheries and Ocean Sciences
Ocean Acidification Research Center
nmonacci@alaska.edu
uaf.edu/cfos/oarc

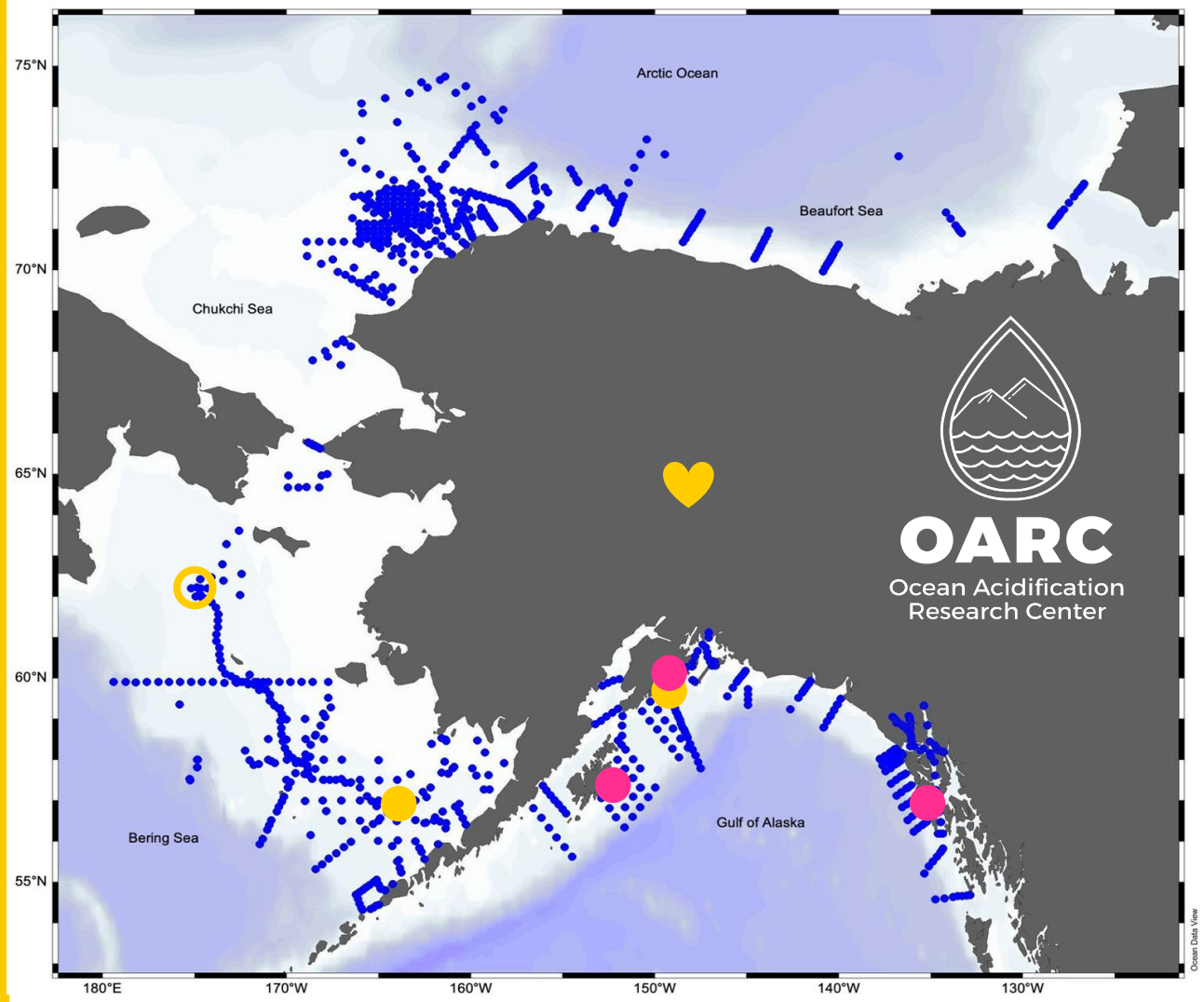
OARC
Ocean Acidification Research Center

UAF
UNIVERSITY OF ALASKA FAIRBANKS
College of Fisheries and Ocean Sciences



Observing Ocean Acidification

across agencies, knowledge systems, and large marine ecosystems











- Ship, 18+ years
- Mooring, 15+ years
- Shoreside, 14+ years

2008	2009	2010	2011	2012	2013	2014	2015	2018	2019	2020	2021	2022	2023	2024	2025	2026

Observing Ocean Acidification across agencies,

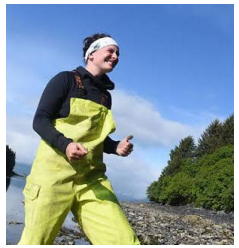
knowledge systems, and large marine ecosystems

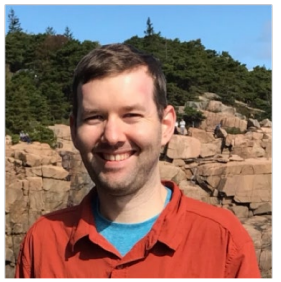


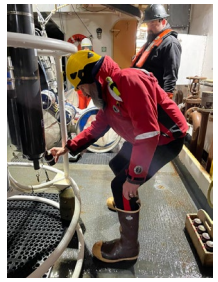










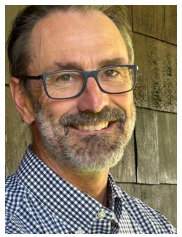





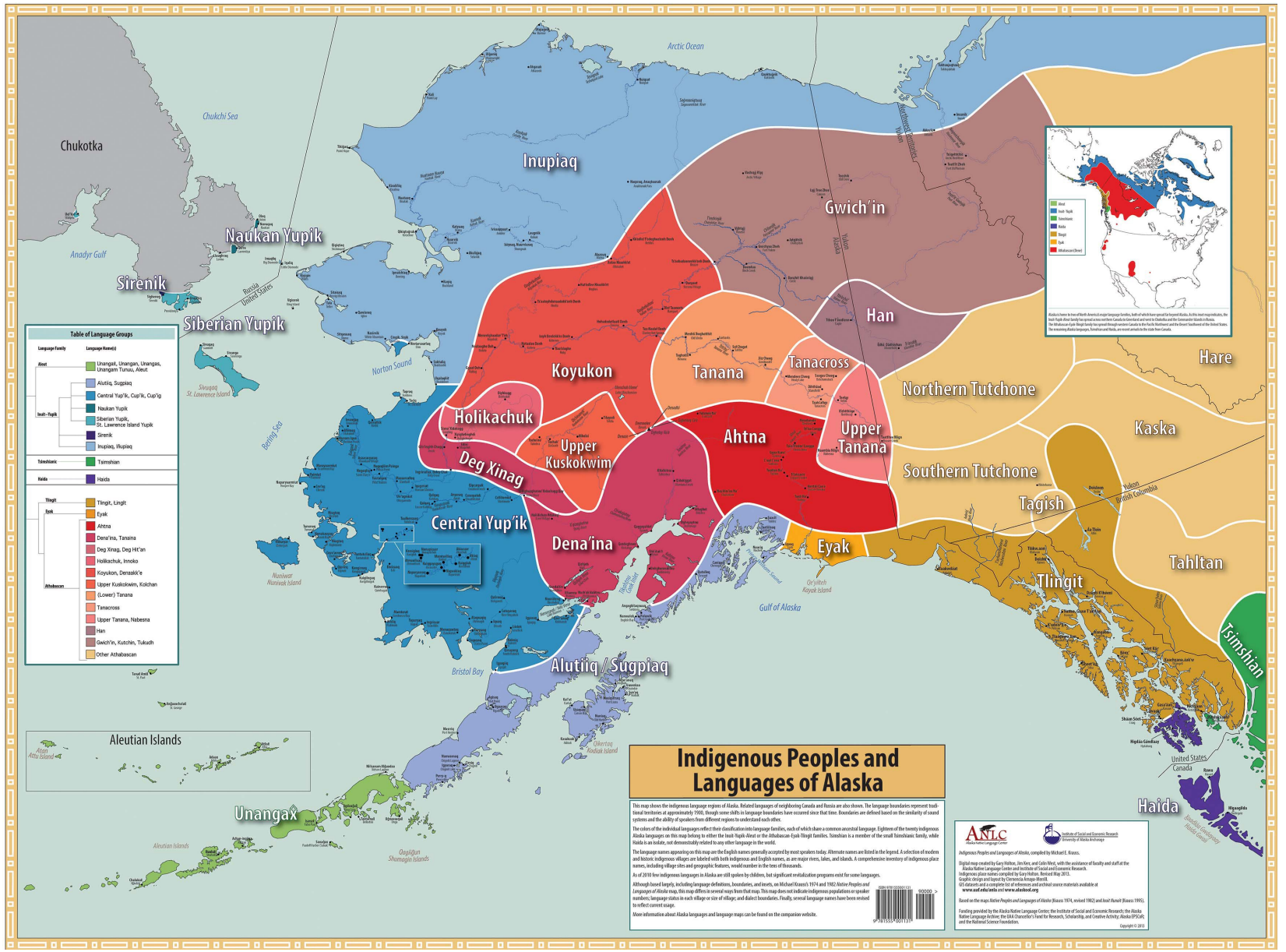






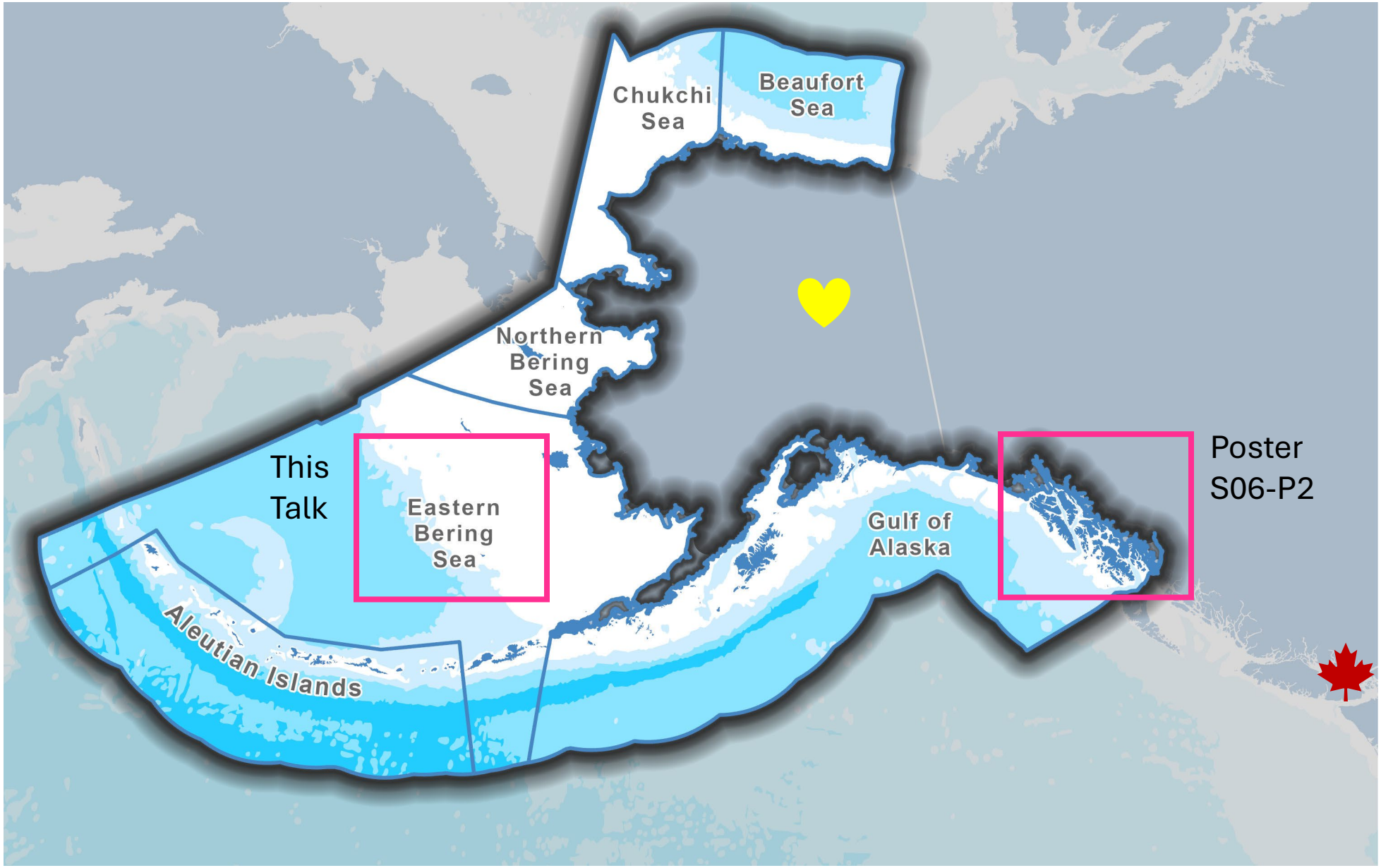




Observing Ocean Acidification across agencies, knowledge systems, and large marine ecosystems

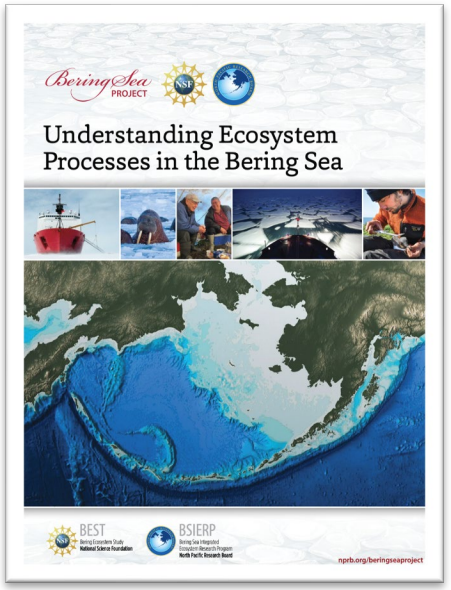


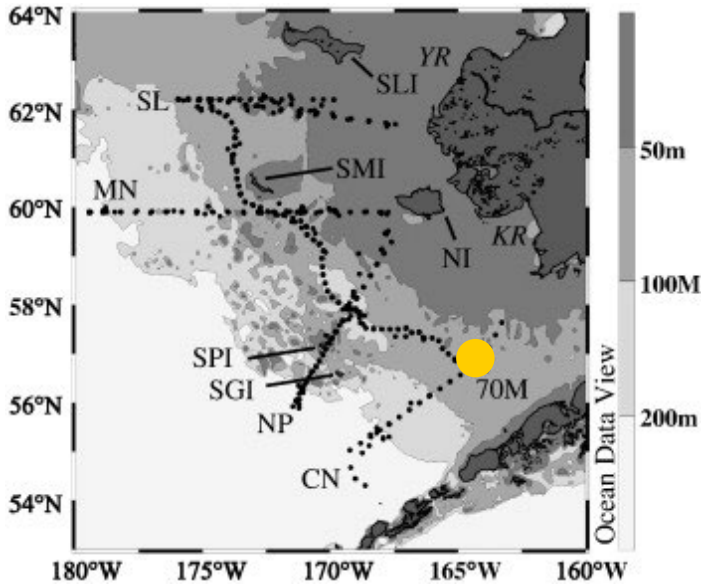
Alaska Native Language Center

Observing Ocean Acidification across agencies, knowledge systems, and large marine ecosystems



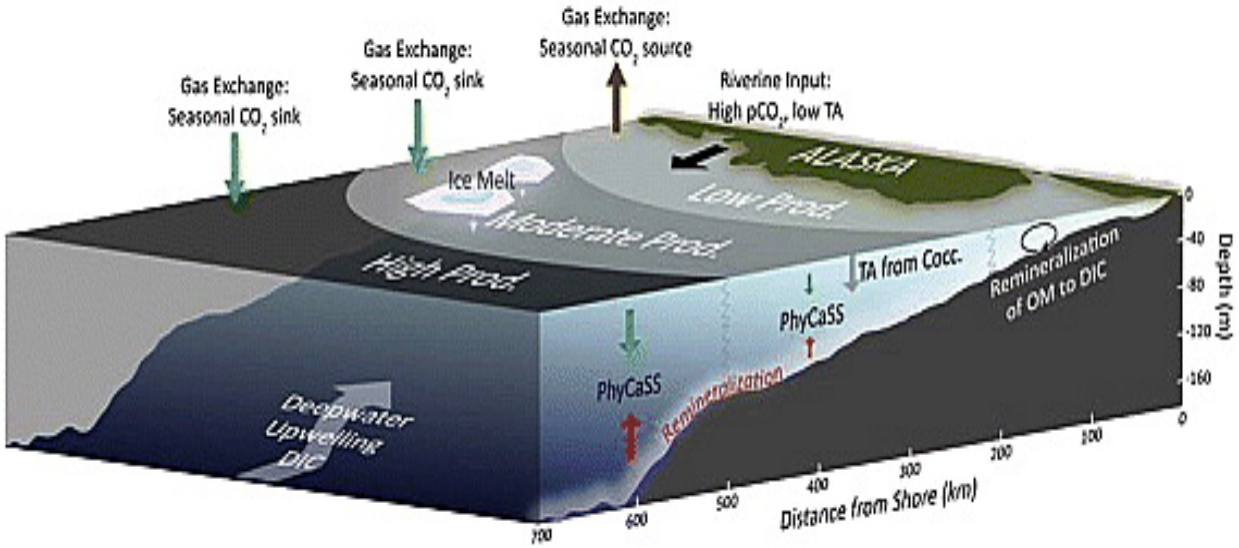
Bering Sea: Case Study







PhyCaSS!



Low seawater pH and Ω

PhyCaSS = Phytoplankton-Carbonate Saturation State

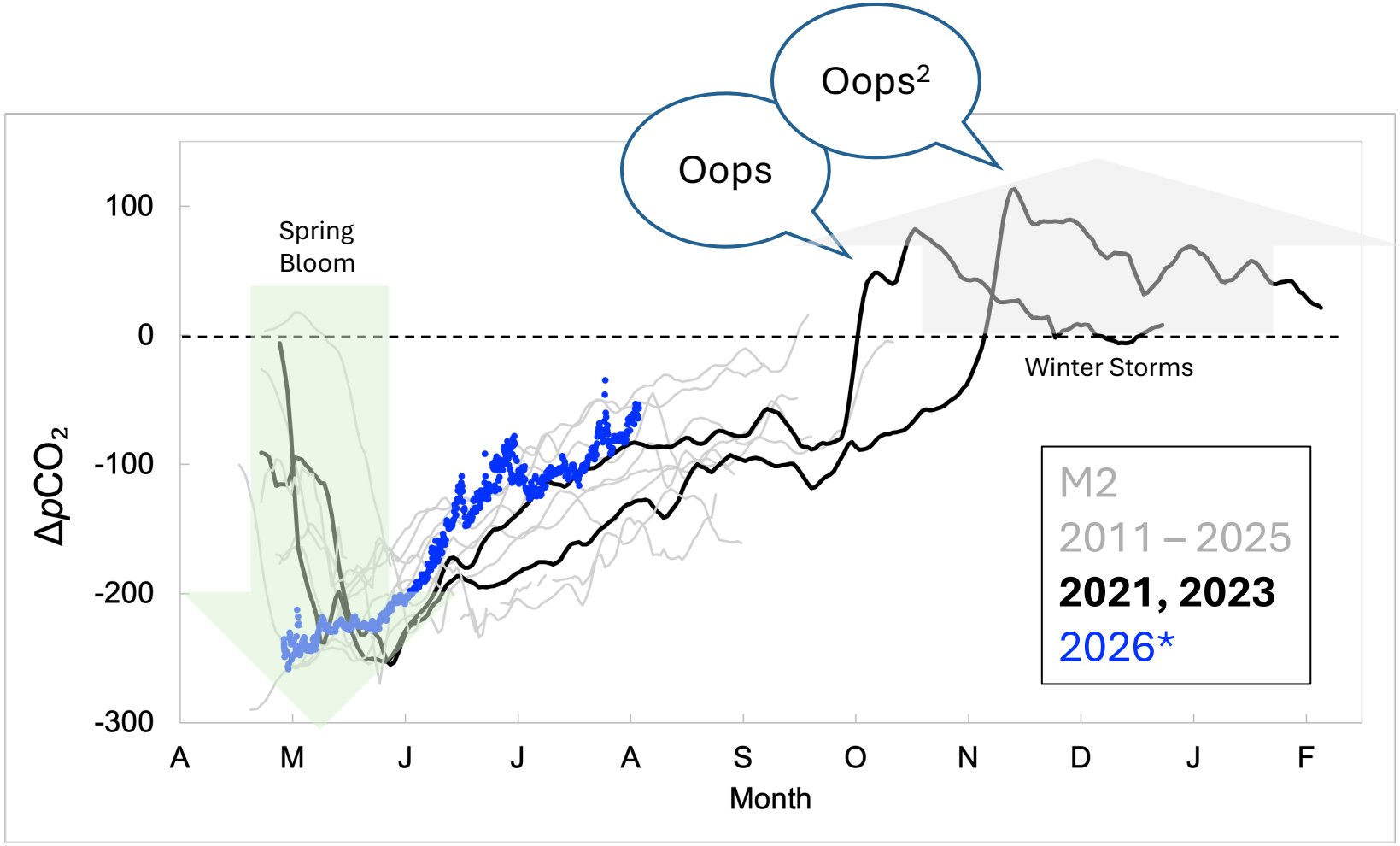
Non-conservative biogeochemical factors

Cross et al. 2011, 2012, 2013

Bering Sea: M2 CO_2



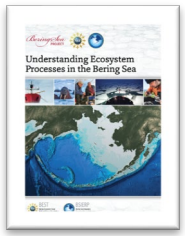
Strong seasonal signal



MAPCO2™
Moored Autonomous pCO_2 System

ΔpCO_2 = Seawater pCO_2 – Air pCO_2

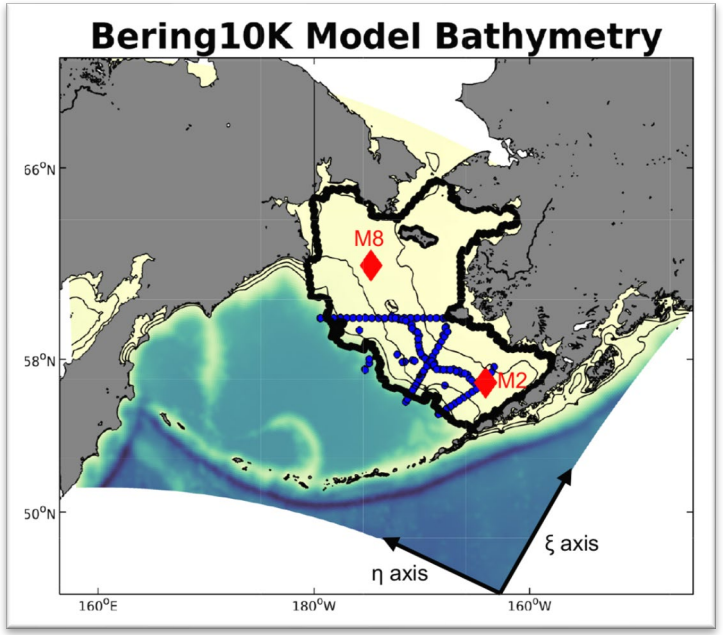
*2026 data are preliminary



Monacci et al. 2011-2026

2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026

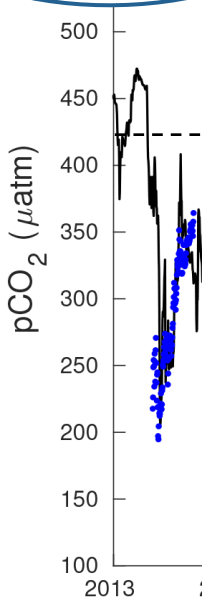
Bering Sea: ROMS Bering10k → Validation → Forecasts

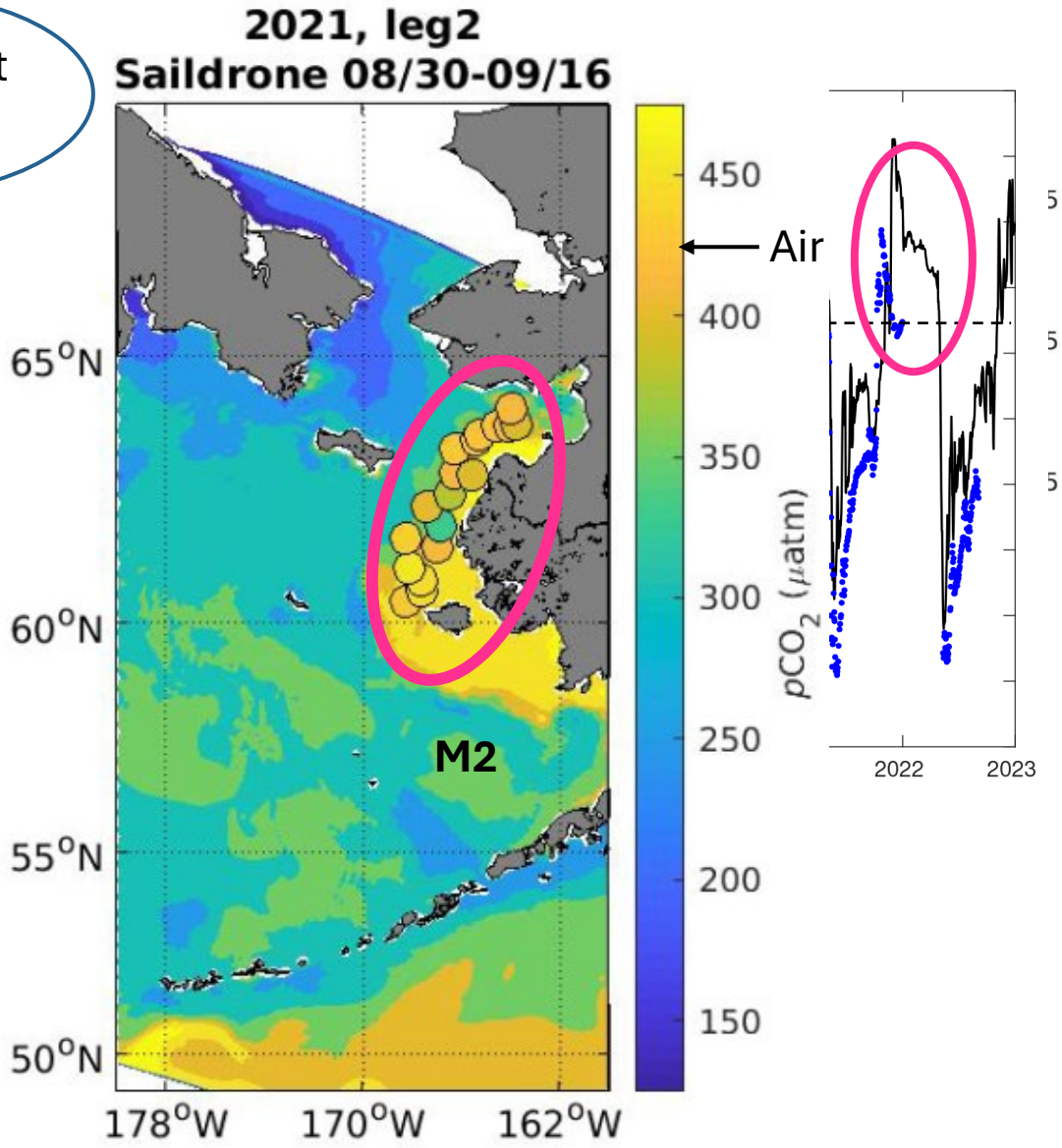






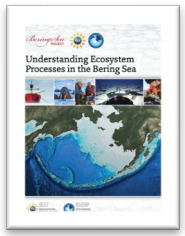


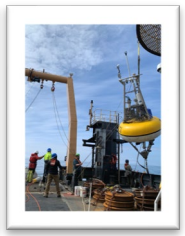




Modeled effect of coastal processes

Forecasts support fisheries management





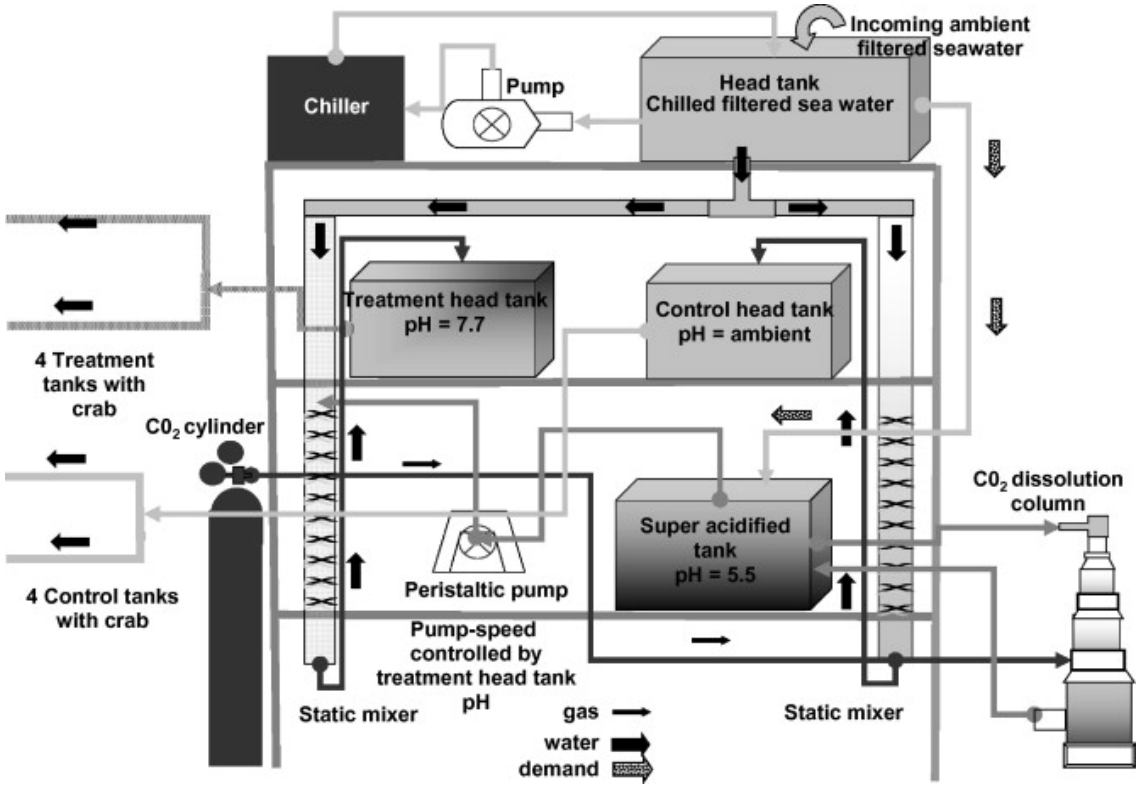
Pilcher et al. 2019, 2022, 2025, 2026

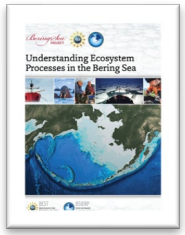
2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026

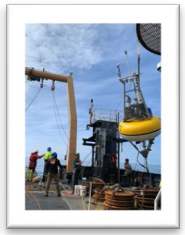
Bering Sea: Red King Crab

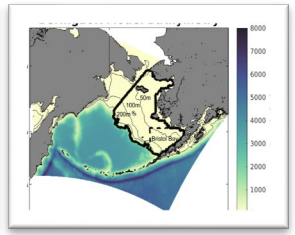
Paralithodes camtschaticus









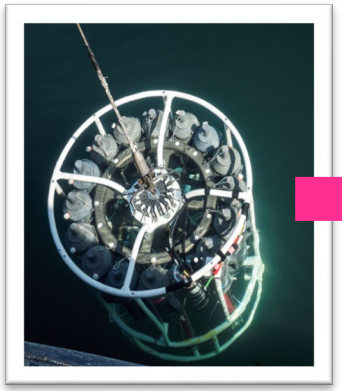


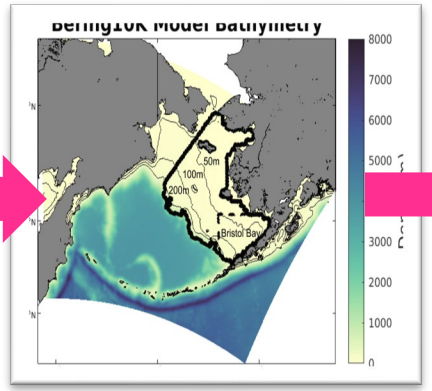
Physiological response research to co-stressors such as temperature and pH

many Long et al., Weems et al., Gardner et al.

Bering Sea: Bottom water

Acidifying 3x the global rate









Canadian Journal of Fisheries and Aquatic Sciences

OPEN ACCESS | Communication

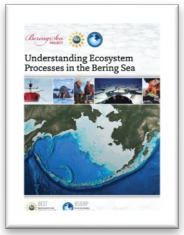
Ocean acidification may contribute to recruitment failure of Bering Sea red king crab

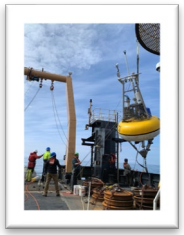
Michael A. Litzow[a], W. Christopher Long[a], Katie J. Palof[b], and Darren J. Pilcher[c]

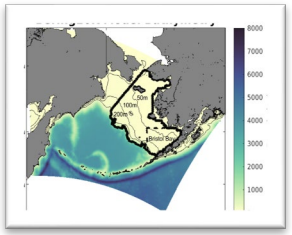
[a]Alaska Fisheries Science Center, National Marine Fisheries Service, Kodiak, AK 99615, USA; [b]Commercial Fisheries Division, Alaska Department of Fish and Game, Juneau, AK 99802, USA; [c]Cooperative Institute for Climate, Ocean, and Ecosystem Studies, University of Washington, Seattle, WA 98105, USA

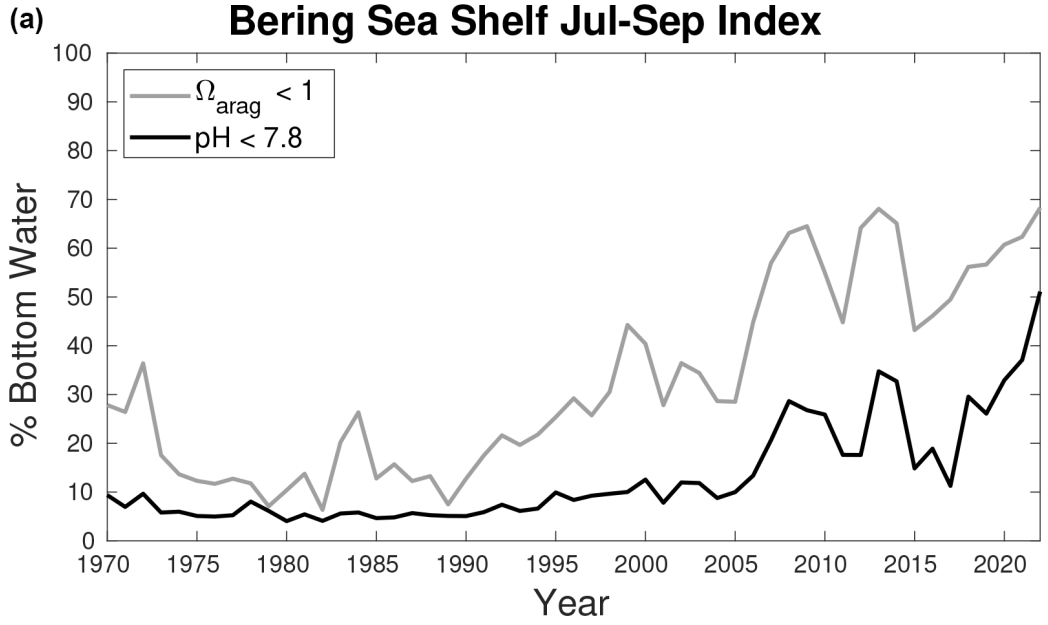
Corresponding author: **Michael A. Litzow** (email: mike.litzow@noaa.gov)

Litzow et al., 2025



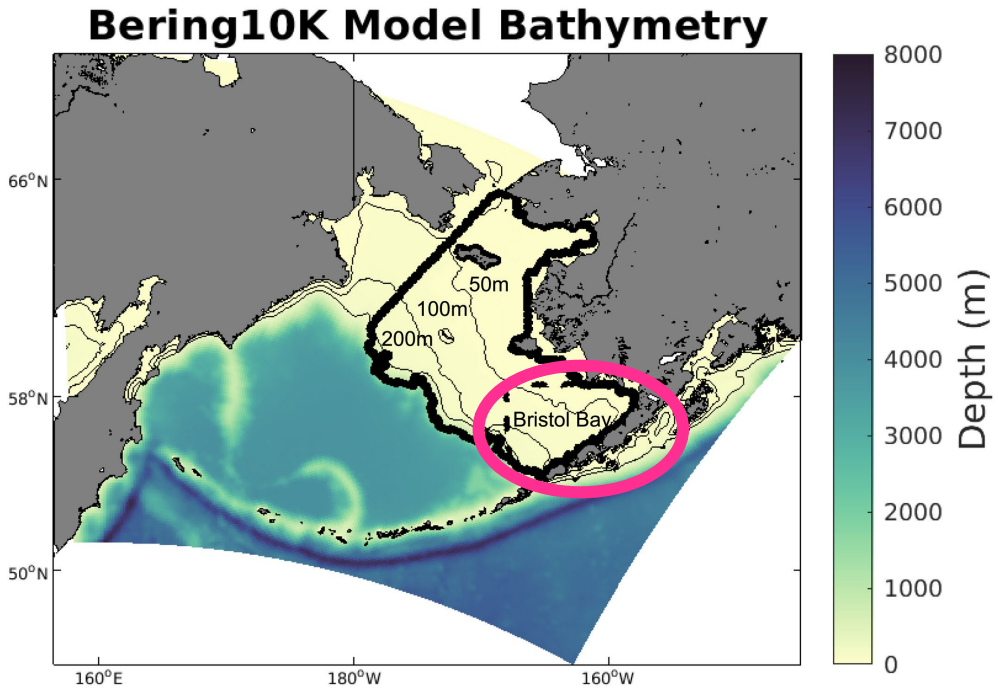






Pilcher et al., 2025

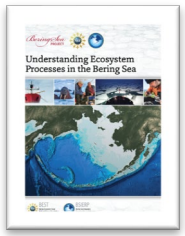
Bering Sea: Bristol Bay

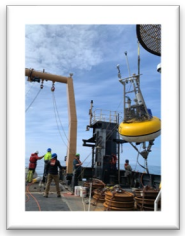


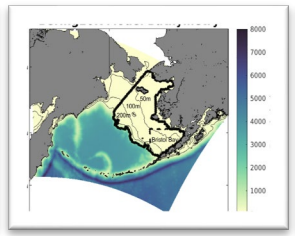




Model forecast skill is strong in Bristol Bay → New validation projects











ALASKA BERING SEA CRABBERS









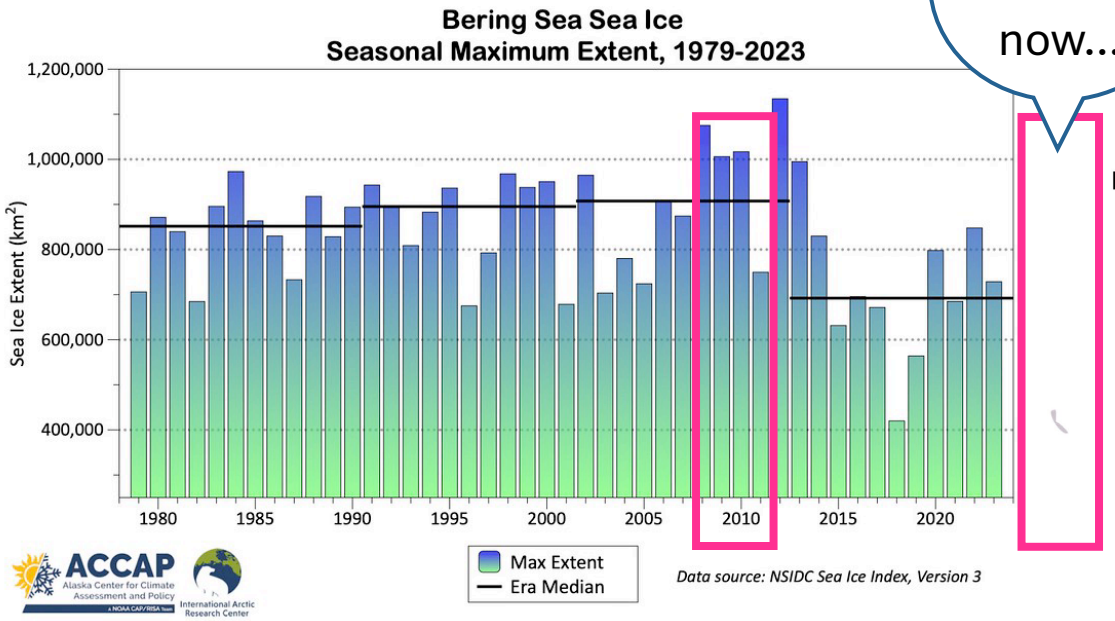


BSFRF
Bering Sea Fisheries Research Foundation



2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026

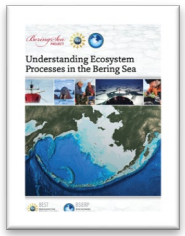
Bering Sea: 2027+

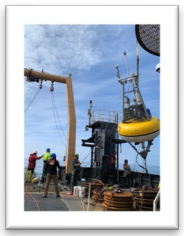


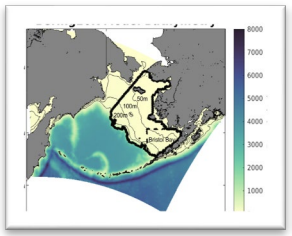
Taking bets now...



2027 = 4+ surveys with observations











CHUGACH REGIONAL RESOURCES COMMISSION
ALUTIIQ PRIDE

2027

2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026

PICES 2026: Actionable Science for a Changing Ocean



NORTH PACIFIC MARINE SCIENCE ORGANIZATION PICES PRESS Vol. 34, No. 1 | Winter 2026

The Bering Sea: Current Status And Recent Trends

Emily Lemagie and Elizabeth Siddon

Eastern Bering Sea Shelf Overview

The mean atmospheric conditions over the winter of 2024-2025 were similar to the previous five years. In the spring of 2025, a strong North Pacific high pressure and a mean low pressure centred around Kodiak Island resulted in unseasonably strong winds over the Gulf of Alaska and the Bering Sea. Through the summer, the persistence of the mean high pressure over the North Pacific was also associated with anomalous winds towards the northeast over the southern Bering Sea. In October 2025, Typhoon Halong brought hurricane-force winds to the Bering Sea.

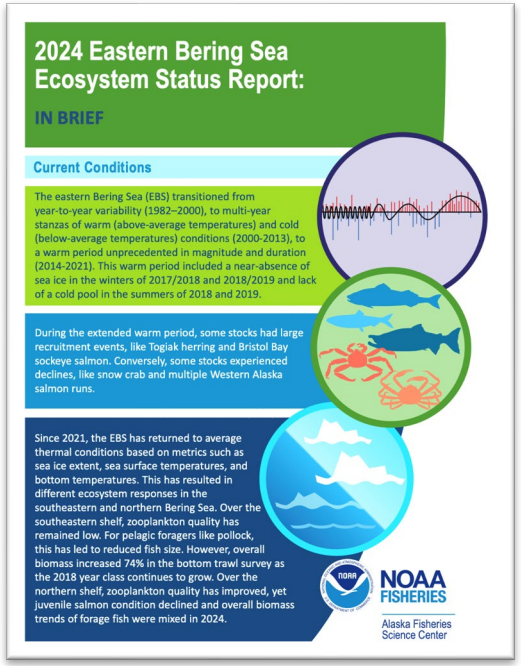
Strong summer winds in 2024 had maintained a deep mixed layer and, correspondingly, cooler than average surface temperatures over the Bering Sea shelf, which lasted through October 2024. The onset of seasonal winds mixed the heat content that was retained in the water column. Seasonal sea ice advance was a competition between the acceleration driven by winds from the north and melting over the anomalously warm waters. There were also reversals in the ice advance due to strong winds from the south and east, notably in mid-December 2024 and mid-February 2025. South and east wind anomalies over the shelf can drive the sea ice directly and enhance northward oceanic heat advection onto the shelf via Ekman transport. This balance between ocean and atmospheric forces also characterised the spring over the eastern Bering Sea shelf, as the warm SST anomalies persisted south of the ice edge and winds from the north maintained the ice extent at around 60°N. The sea ice presence over the northern Bering Sea shelf contributed to the return of cool bottom temperatures in winter, which have become less common in recent years. However, temperatures on the southeastern Bering Sea shelf south of 60°N were mostly warm this year, aside from a brief return to cool or near-normal SST over the shelf in May and June associated with wind anomalies from the west along the Aleutian Islands. Through summer 2025, depth-averaged temperatures were warm across the southeastern Bering Sea shelf, as measured at mooring M2 (Figure 1). In contrast to the summer of 2024, when the surface temperatures were cooler, positive ocean temperature anomalies were observed throughout the water column at M2 (not shown).

Warm surface temperatures, particularly over the southeastern Bering Sea shelf, exceeded the marine heatwave (MHW) threshold several times in 2025 (Figure 2). The surface temperature and integrated heat content anomalies were greater than have been observed over the last three years. The NOAA Climate Prediction Center's forecast is for warm SST anomalies to persist into 2026.

Winds At The Shelf Break

During 2025, there were several notable departures from the 1980-2025 wind climatology (Figure 3). Though along-shelf winds (driving on-shelf or off-shelf transport) are usually weak throughout much of the year, February 2025 had strong along-shelf winds (to the northwest) that may have driven significant onshore Ekman transport (Figure 4). The along-shelf winds in June, July, and August 2025 were also weakly favourable to on-shelf Ekman transport, whereas during this span typically neither onshore nor offshore winds are favoured. The cross-shelf component over 2025, however, generally followed the climatological trend, with no strong departures from average.

Figure 1. Depth-averaged temperature anomoly measured at NOAA's long-term ecosystem observatory M2 from 1995-2024. Time-averages are from 1995-2010.



2024 Eastern Bering Sea Ecosystem Status Report:

IN BRIEF

Current Conditions

The eastern Bering Sea (EBS) transitioned from year-to-year variability (1982–2000), to multi-year stanzas of warm (above-average temperatures) and cold (below-average temperatures) conditions (2000-2013), to a warm period unprecedented in magnitude and duration (2014-2021). This warm period included a near-absence of sea ice in the winters of 2017/2018 and 2018/2019 and lack of a cold pool in the summers of 2018 and 2019.

During the extended warm period, some stocks had large recruitment events, like Togiak herring and Bristol Bay sockeye salmon. Conversely, some stocks experienced declines, like snow crab and multiple Western Alaska salmon runs.

Since 2021, the EBS has returned to average thermal conditions based on metrics such as sea ice extent, sea surface temperatures, and bottom temperatures. This has resulted in different ecosystem responses in the southeastern and northern Bering Sea. Over the southeastern shelf, zooplankton quality has remained low. For pelagic foragers like pollock, this has led to reduced fish size. However, overall biomass increased 74% in the bottom trawl survey as the 2018 year class continues to grow. Over the northern shelf, zooplankton quality has improved, yet juvenile salmon condition declined and overall biomass trends of forage fish were mixed in 2024.

NOAA FISHERIES

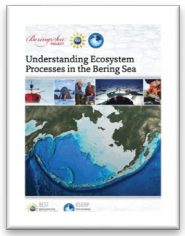
Alaska Fisheries Science Center

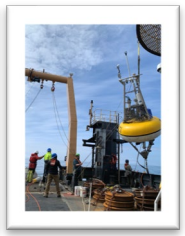


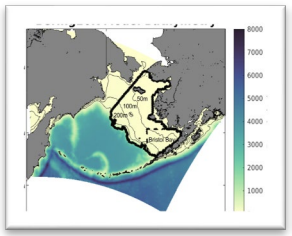
ALASKA OCEAN ACIDIFICATION NETWORK

aoan.aoos.org

2016 - 2026







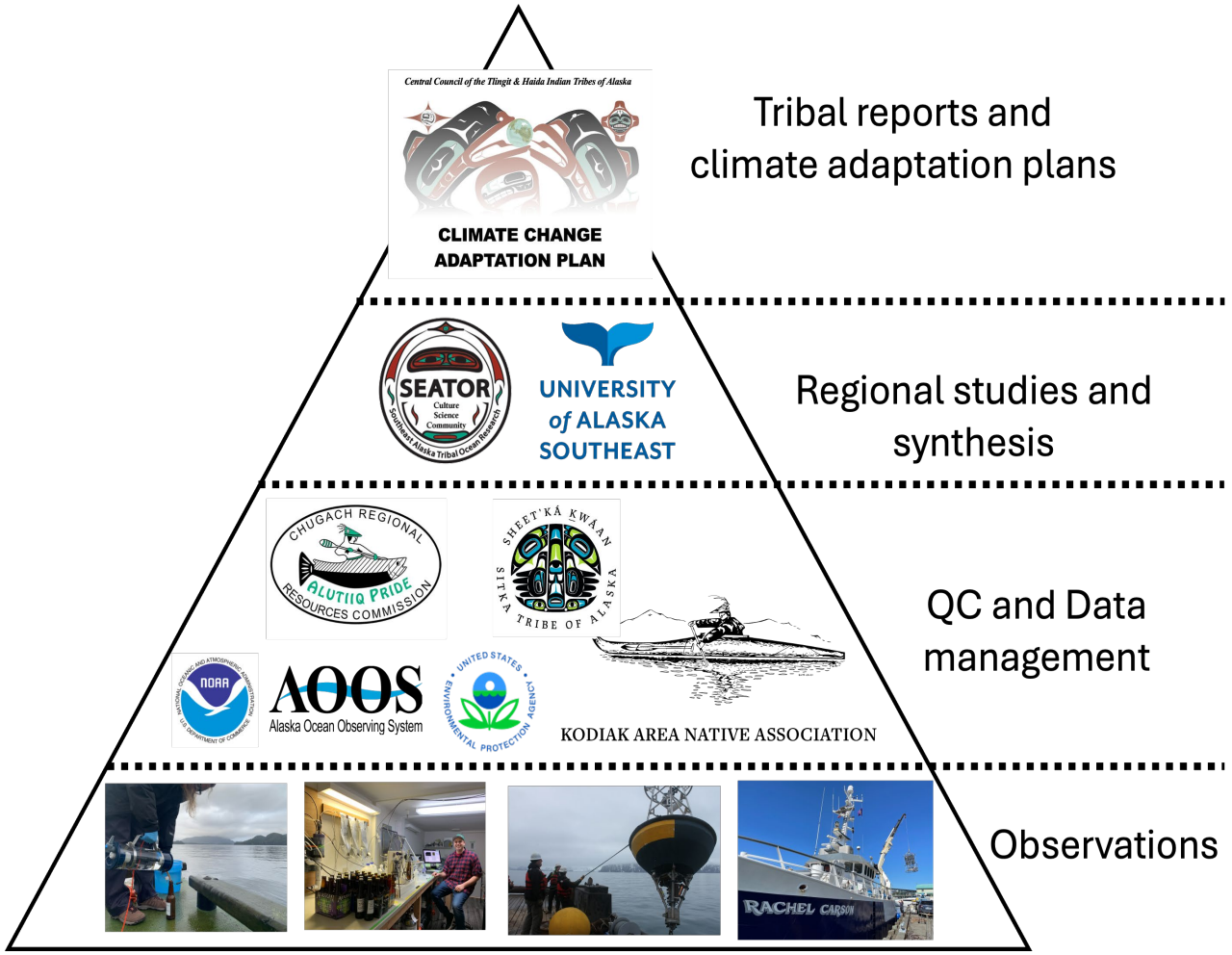


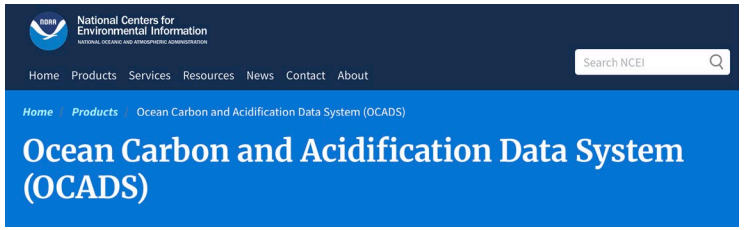


Information shared through data sets, manuscripts, reports, mapped index tools, websites, brochures, newsletters, and webinars.

2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026

S10: Long-term observations to support resilient ecosystems and communities





Public Data are:

- ✓ Integrated
- ✓ Best Practices
- ✓ FAIR
- ✓ CARE

Poster
S06-P2

Jiang et al., 2023