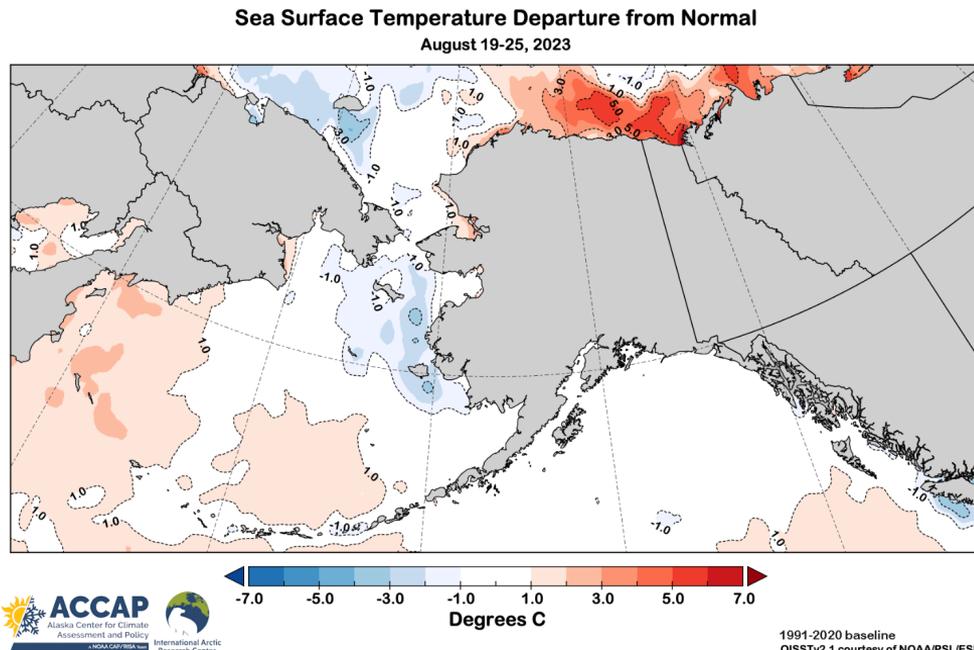


ECOSYSTEM STATUS REPORT

NPFMC Crab Plan Team
September 12, 2023

Elizabeth Siddon



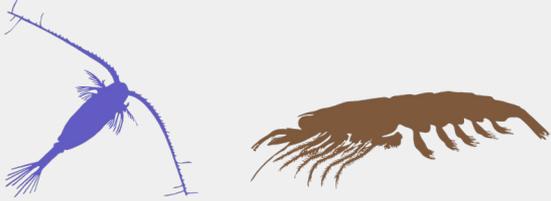


Crab-relevant ecosystem information

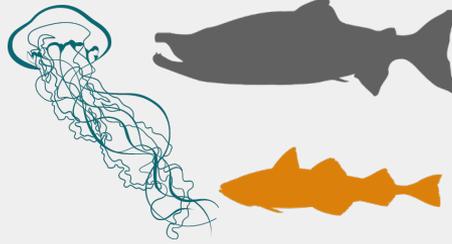
- Pelagic and benthic stages
- Environmental processes, prey, competitors, predators
- 2023 (where available) in context

Pelagic larval indicators

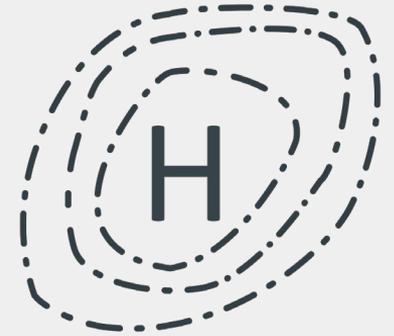
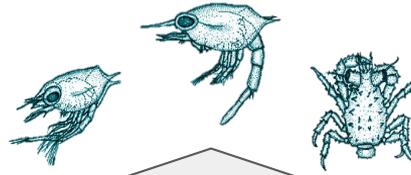
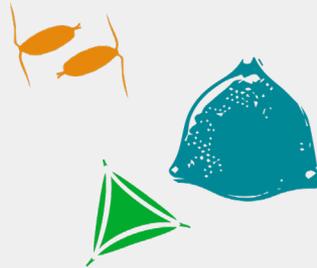
COMPETITORS



PREDATORS



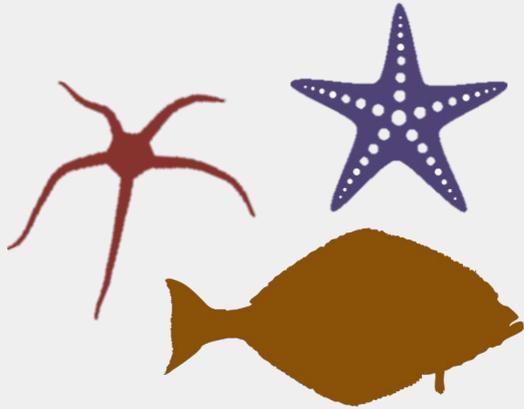
PREY



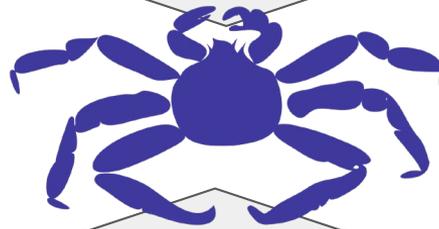
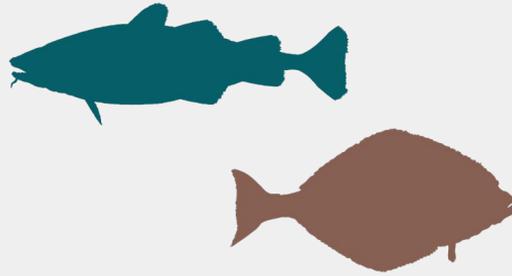
ENVIRONMENTAL PROCESSES

Benthic juvenile/adult indicators

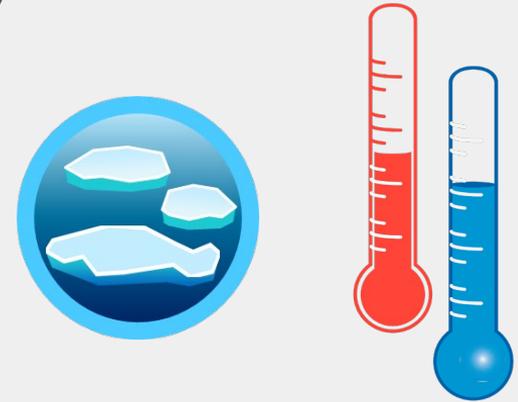
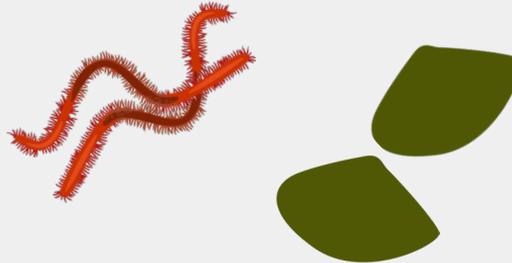
COMPETITORS



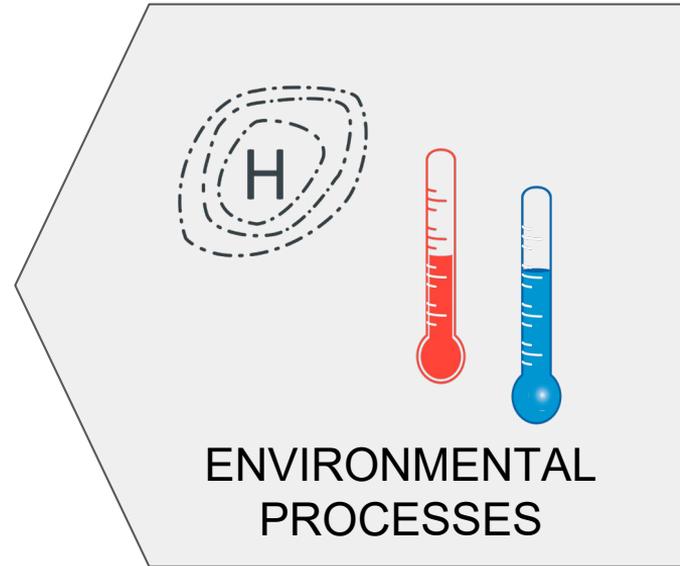
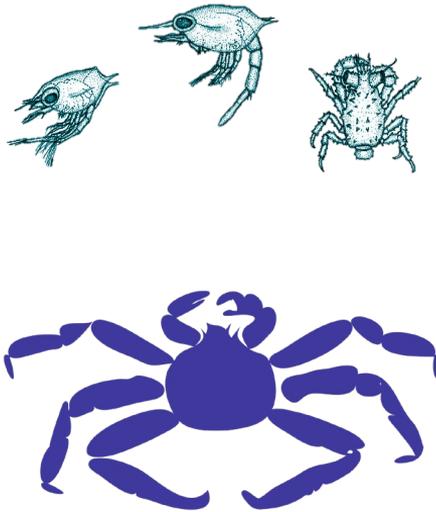
PREDATORS



PREY



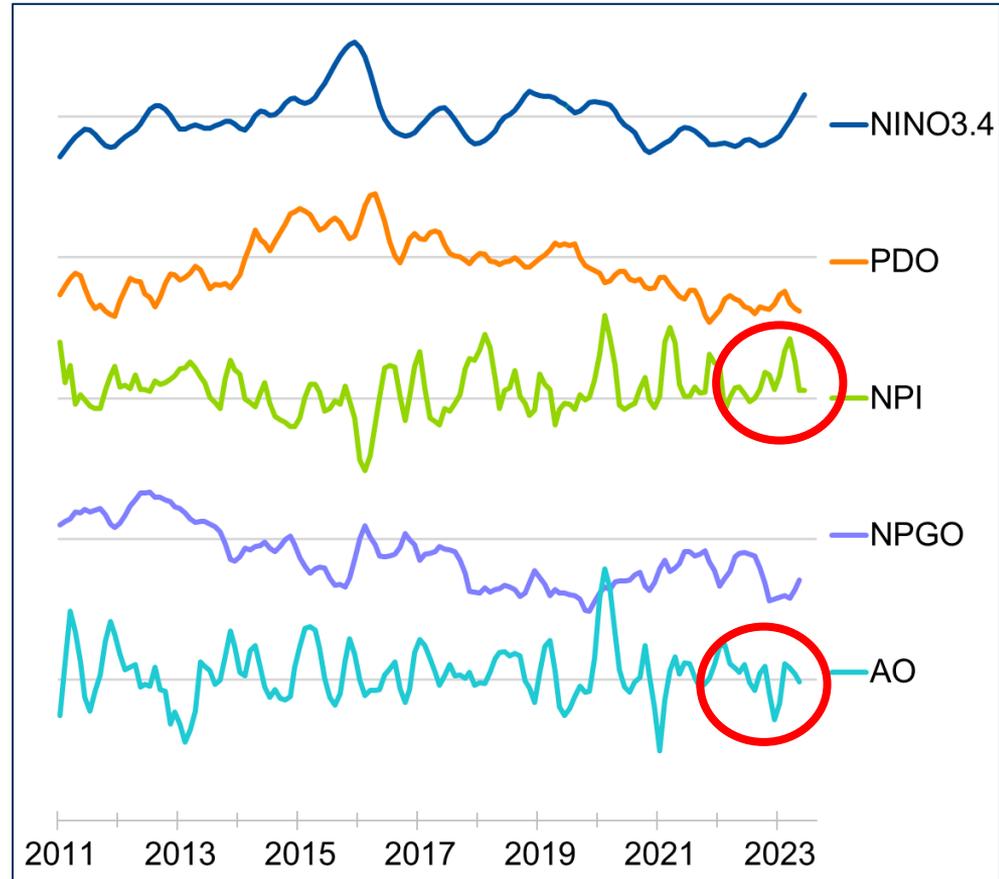
ENVIRONMENTAL
PROCESSES



North Pacific Climate Indices

Bond

- **NPI** reflects the ALPS where positive values mean:
 - Weak ALPS, High SLP, Calmer conditions
- **NPI** positive for most of 2022
 - Linked with extended La Niña and decline in PDO
- **AO** measures the polar vortex; transitioned from positive to negative in 2022
- Negative **AO** usually leads to Arctic air, but late 2022 had warm weather north of AK

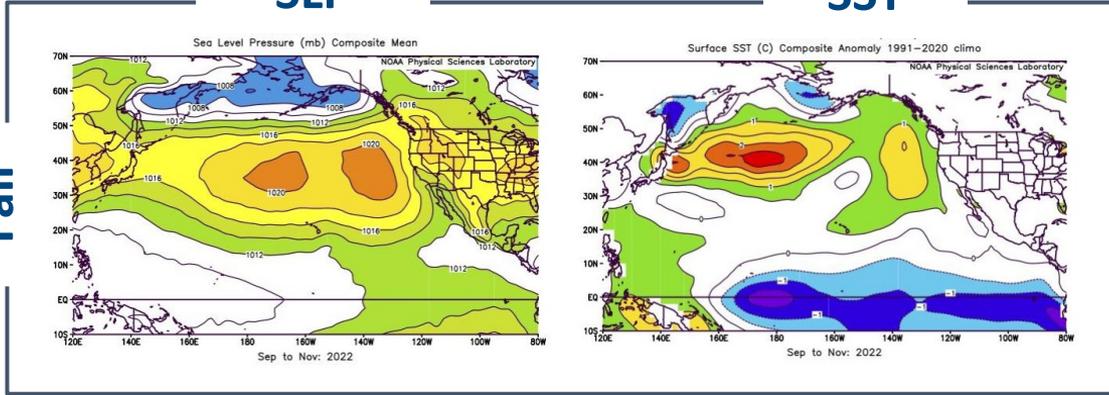


Fall & Winter 2022/2023 SLP & SST

Bond

High SLP across North Pacific; lower SLP from Siberia to Chukchi Sea.
Winds from the west across the Bering Sea.

Fall

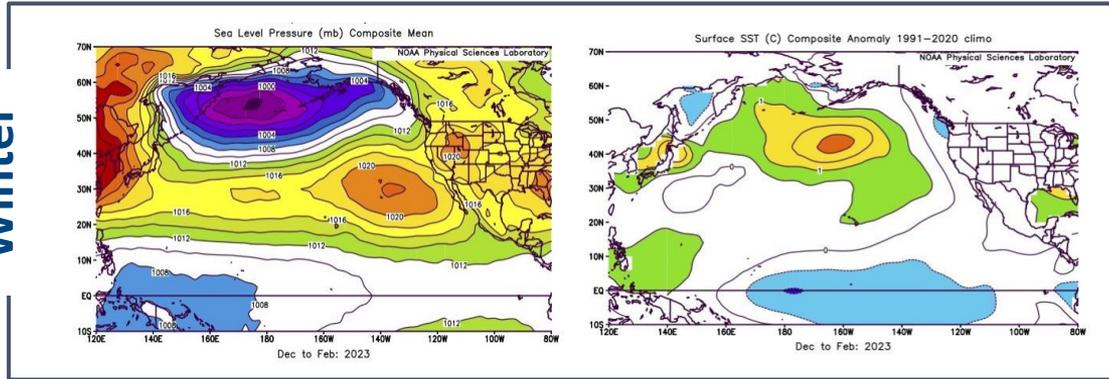


Cool tropical Pacific associated with La Niña.

Cool SST conditions on EBS shelf.

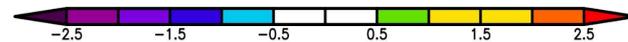
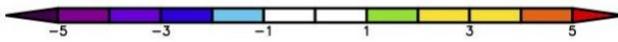
ALPS shifted west.
Winds from the west from Sea of Okhotsk to eastern Aleutian Islands.

Winter



La Niña weakened.

Average SSTs on EBS shelf.



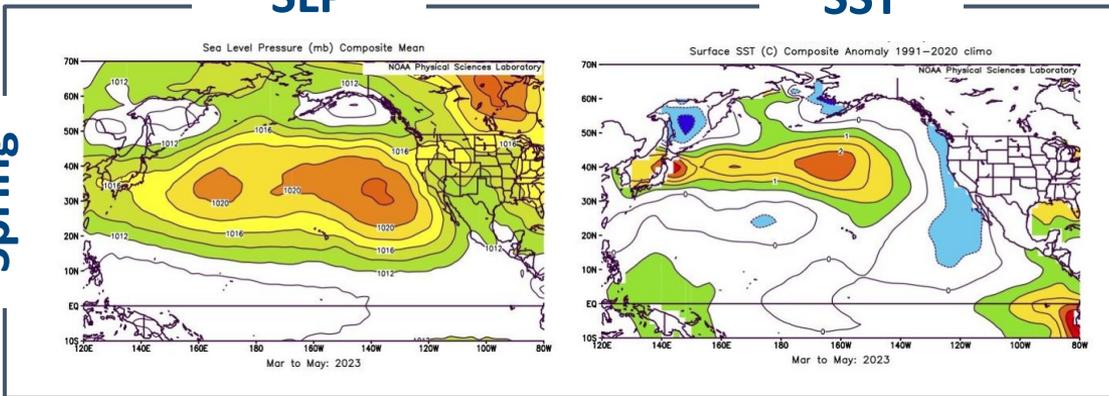
Spring & Summer 2023 SLP & SST

Bond

SLP

SST

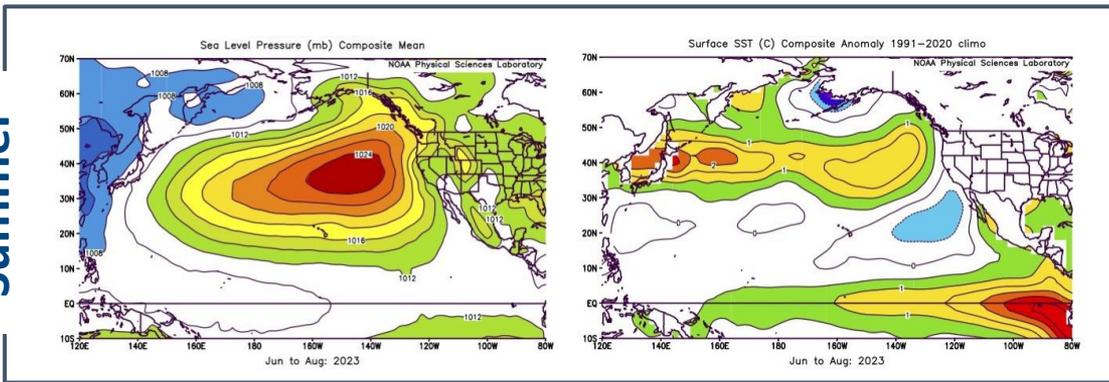
Spring



Average SSTs in tropical Pacific.

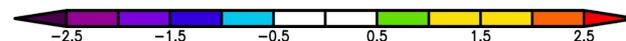
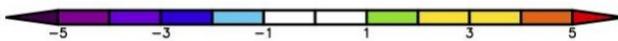
Return of cool SST conditions on EBS shelf.

Summer



Strong warming in tropical Pacific defined El Niño in June 2023.

Continuation of cool conditions on EBS shelf.

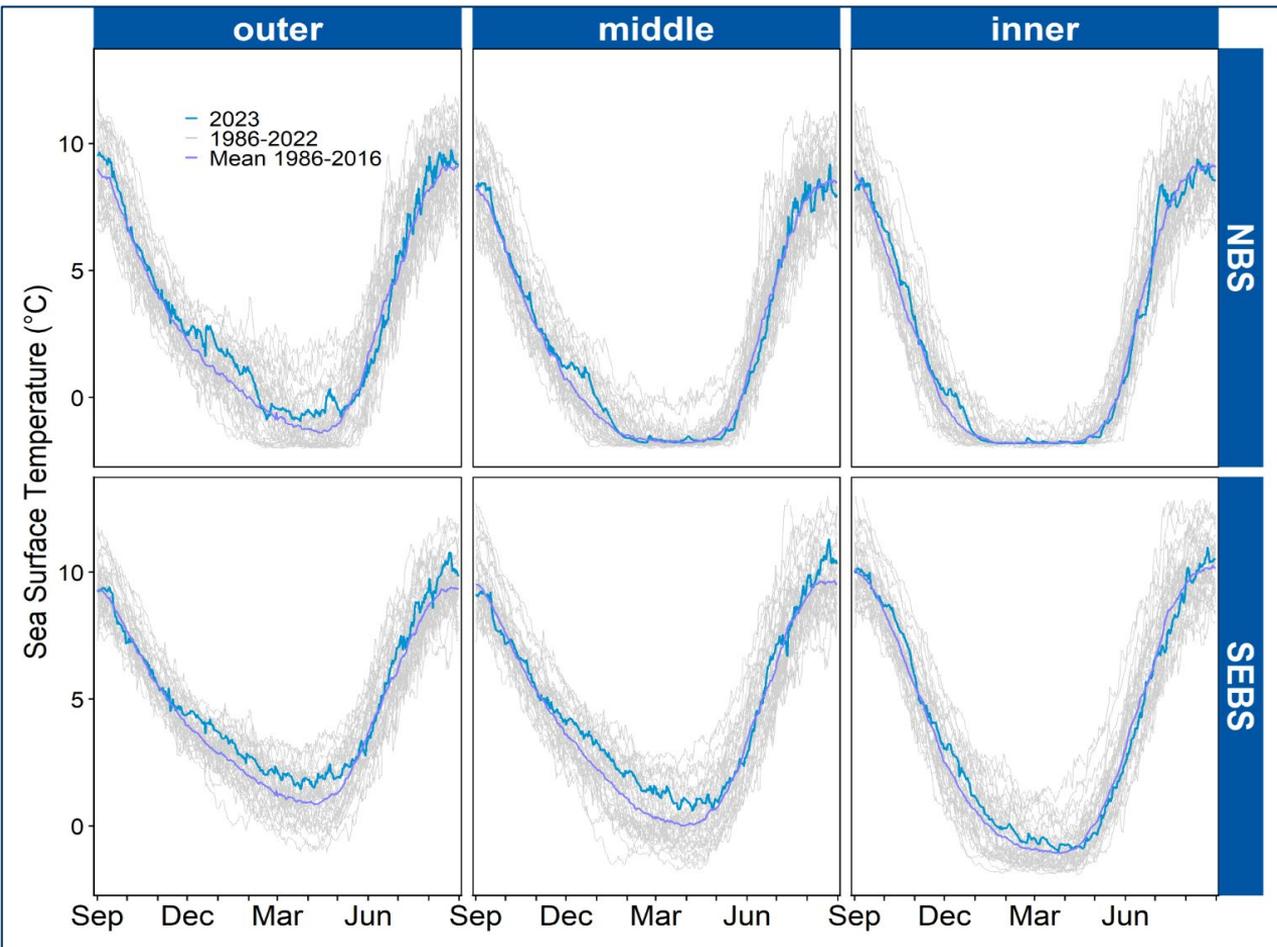


High SLP in North Pacific. **Winds from the west** across most of the Bering Sea.

Dipole in western North Pacific: lower SLP from Sea of Okhotsk to Alaska and higher south of 40°N. **Southwesterly winds** between dipole.

Sea Surface Temperature

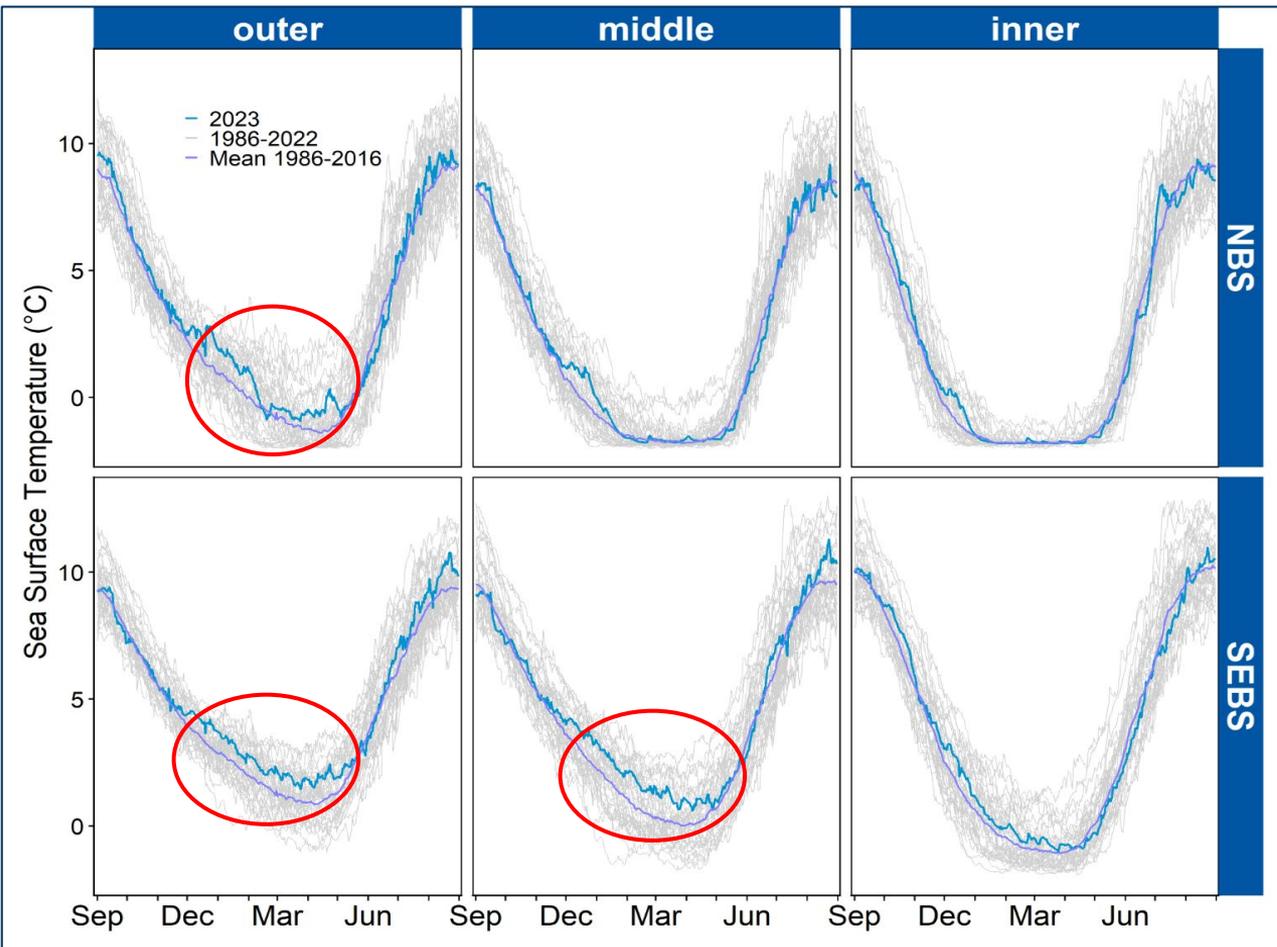
Lemagie & Callahan



- SSTs were similar to the long-term mean in fall 2022 and spring/summer 2023
- SSTs were slightly above the long-term mean in winter 2022/2023, especially in the outer domain and southern middle domain

Sea Surface Temperature

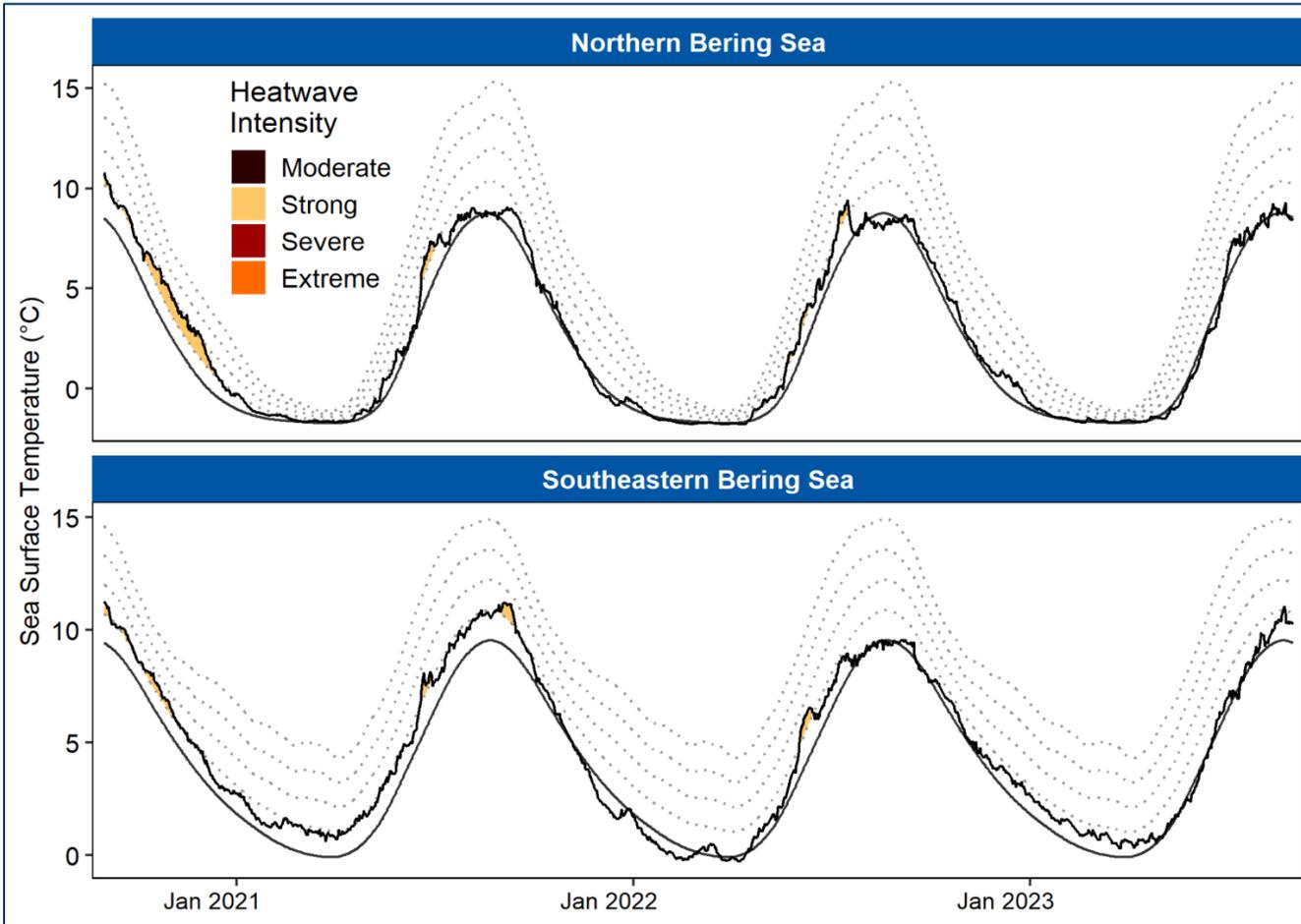
Lemagie & Callahan



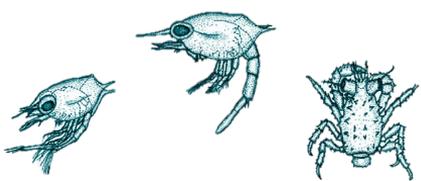
- SSTs were similar to the long-term mean in fall 2022 and spring/summer 2023
- SSTs were slightly above the long-term mean in winter 2022/2023, especially in the outer domain and southern middle domain

Marine Heatwave Index

Lemagie & Callahan

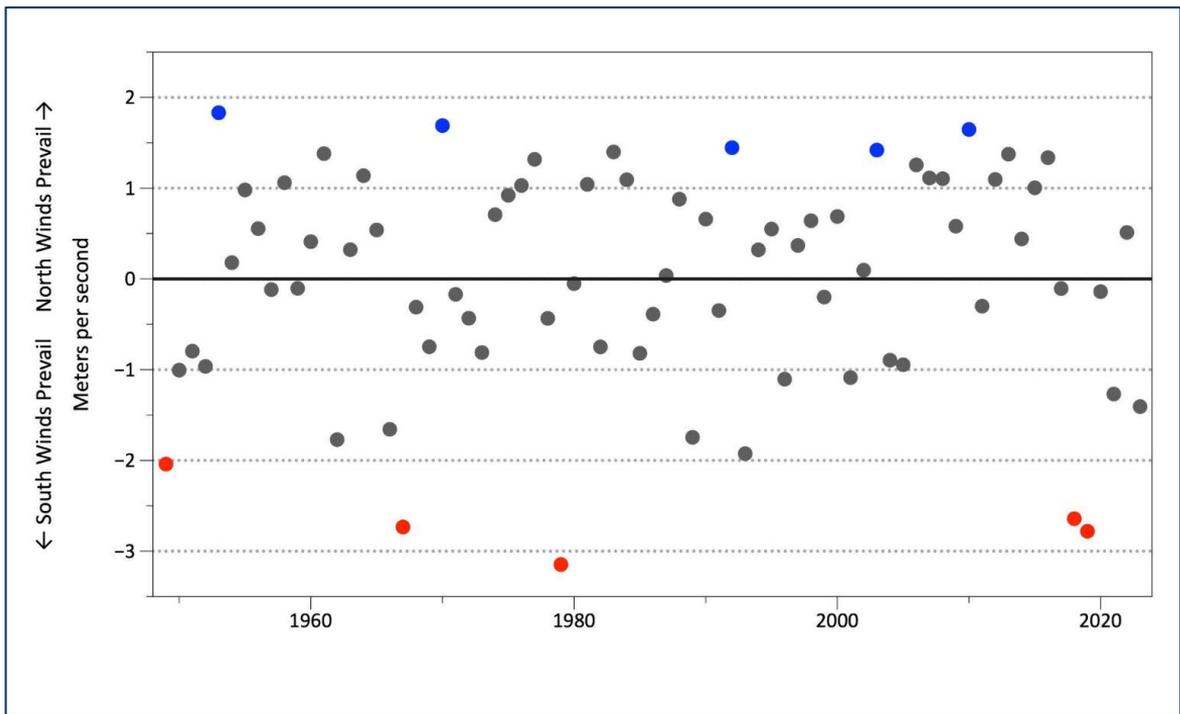


- MHWs have been brief and infrequent since 2021



Winter Winds (Nov. - Mar.)

Thoman



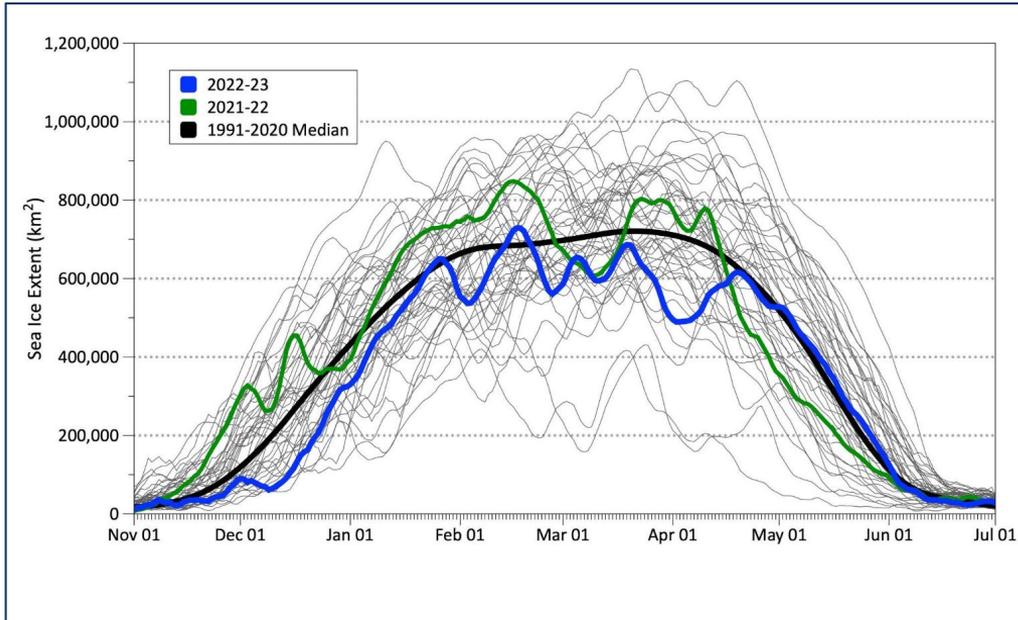
- Winds were more southerly (from the south) in winter 2022/2023
- Southerly winds bring warmer air over the EBS
- 6 of the past 7 winters had southerly winds

● Winters ending in 2018 and 2019 were among 5 years with the strongest south winds, which contributed to low sea ice extent in those years.



2023 Sea Ice

Thoman



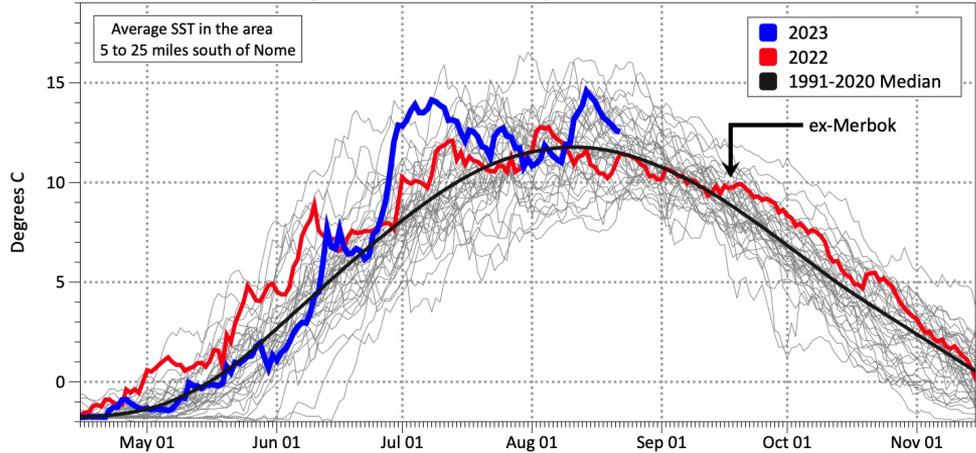
- Ice phenology shifted ~1 month later than 2021/2022
- Delayed sea ice growth in Nov & Dec:
 - Stormy weather
 - Slow freeze-up in the Chukchi
 - Impact of Merbok (next slide)
- Ice melt-out in spring was slowed by cold April temperatures
- Maximum ice extent occurred February 17; sea ice did not reach St. Paul Island (9th year in past decade)



2023 Sea Ice

Thoman

Offshore Nome, Alaska
Daily Sea Surface Temperature, 1985-2023



Data source: NOAA Coral Reef Watch
Area 64.1 to 64.4N, 165.25 to 165.75W
Updated through August 22, 2023

- Ice phenology shifted ~1 month later than 2021/2022
- Delayed sea ice growth in Nov & Dec:
 - Stormy weather
 - Slow freeze-up in the Chukchi
 - Impact of Merbok (next slide)
- Ice melt-out in spring was slowed by cold April temperatures
- Maximum ice extent occurred February 17; sea ice did not reach St. Paul Island (9th year in past decade)

Wind Anomalies

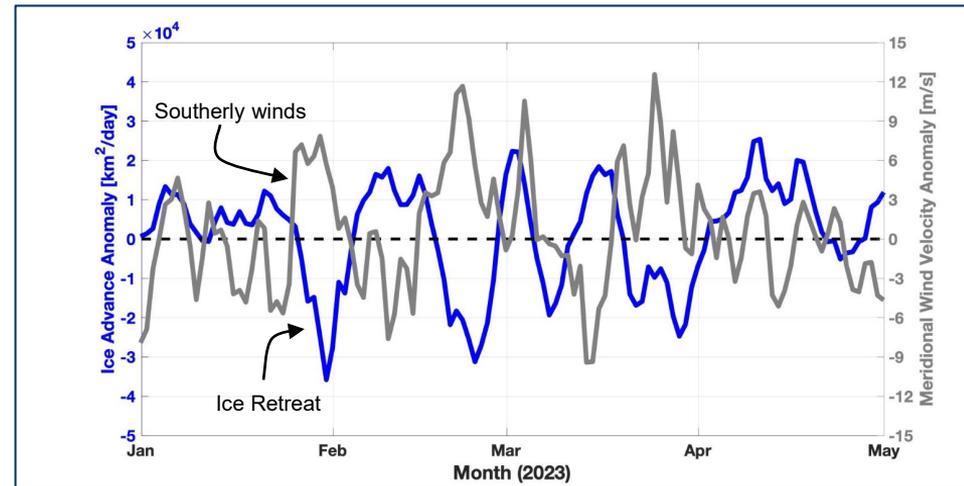
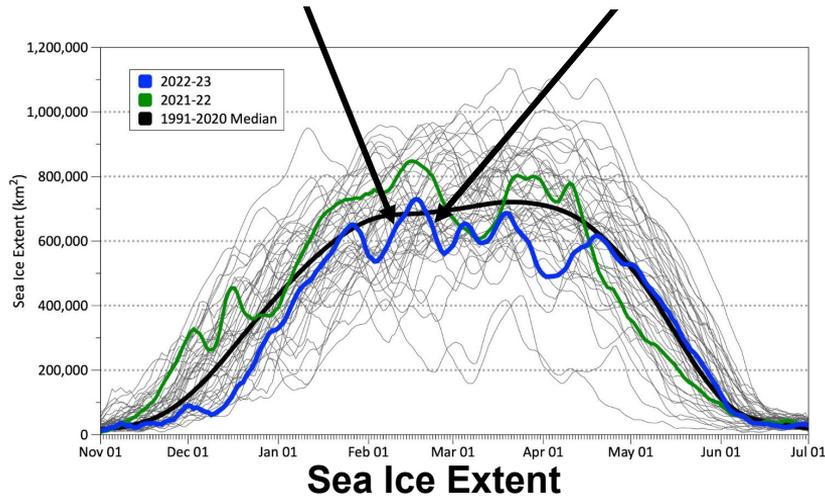
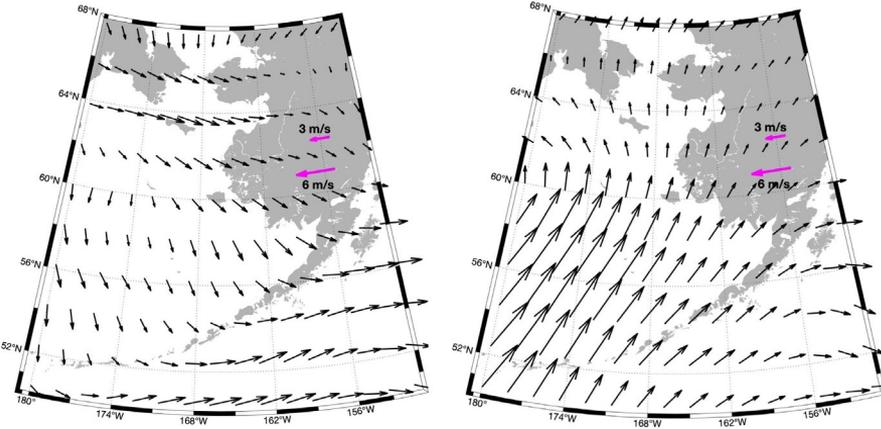
Winds & Sea Ice

Hennon, Thoman

- Short term variability in sea ice extent is correlated to anomalous wind events
- Ice generally **advances** with **northerly** (from the north) winds and **retreats** with **southerly** winds

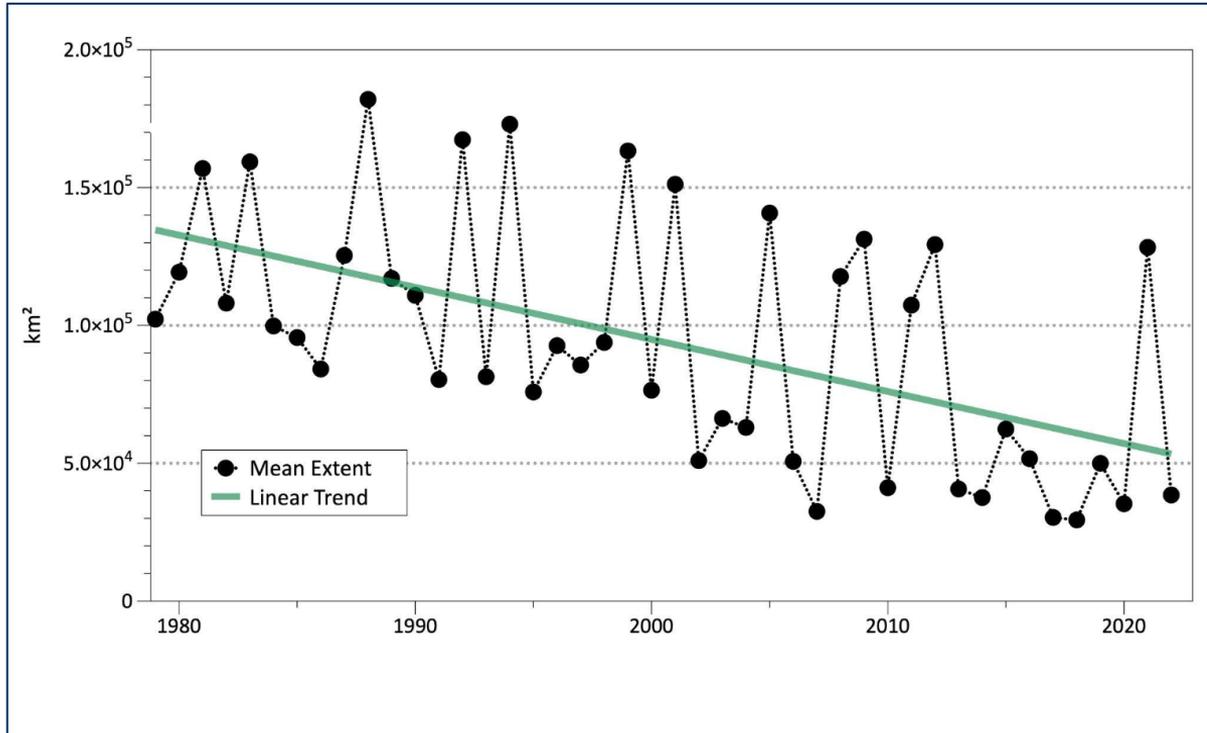
Feb-01 to Feb-14 (2023)

Feb-15 to Feb-28 (2023)



Early Season Ice Extent (Oct.-Dec.)

Thoman



- 2022 was similar to most years since 2013 (except 2021)
- 2022 was lower than any year prior to 2007
- Early season ice extent has decreased 55% over 45-year time series

Bering Sea Ice Thickness

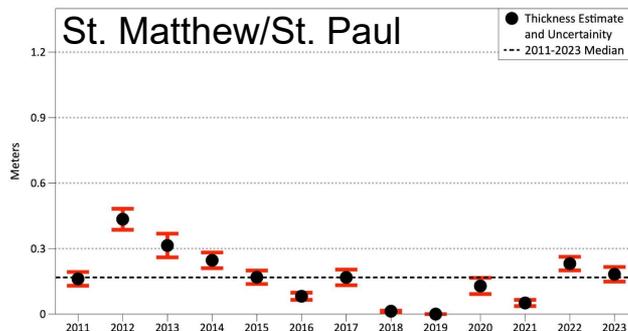
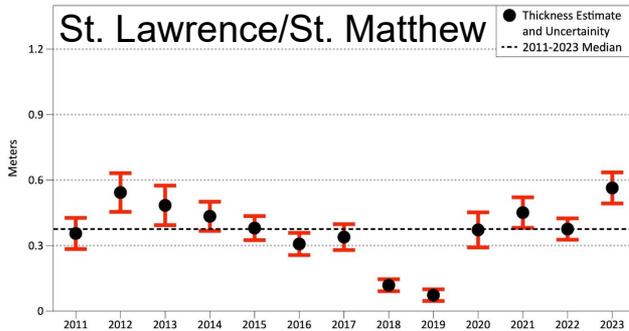
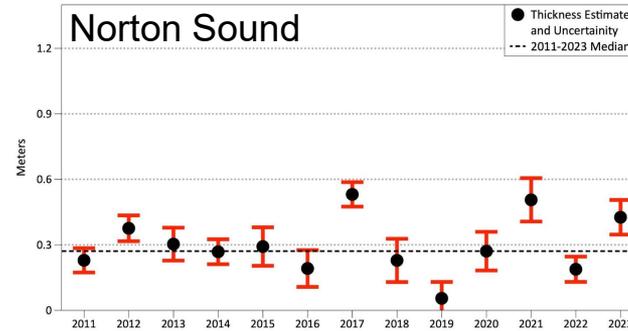
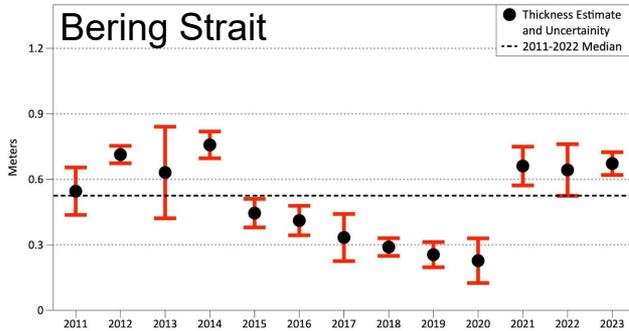
Thoman



- 3rd week of March
- Ice thickness is related to duration or residency of ice over the shelf
- Abundance of ice-associated algae correlated to ice duration?

Bering Sea Ice Thickness

Thoman



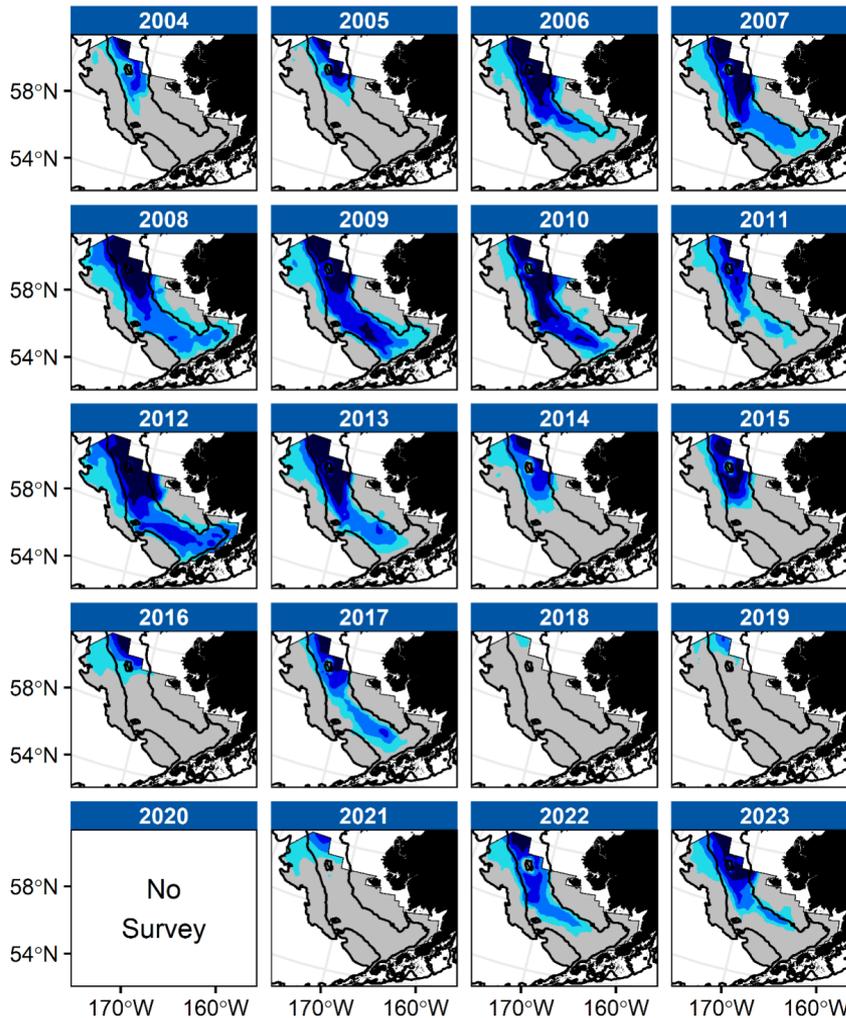
- Ice thickness was higher in Norton Sound and St. Lawrence to St. Matthew than 2022
- St. Lawrence to St. Matthew ice thickness was the highest since 2013
- Other regions close to the 13-year median



Cold Pool

Rohan & Barnett

Bottom
Temperature (°C)



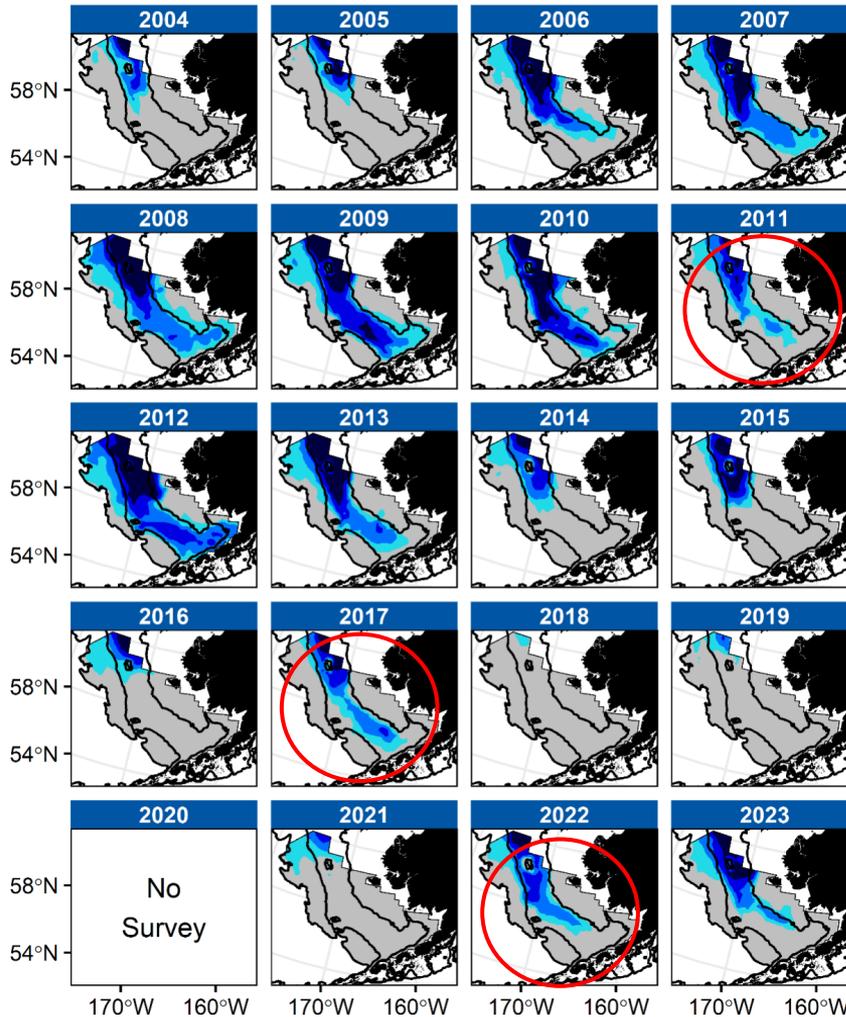
- Average cold pool extent
 - *Slightly* larger than 2022
- Footprint of the cold pool was similar to 2011, 2017, and 2022
- Cold tongue along the inner front was shifted inshore



Cold Pool

Rohan & Barnett

Bottom
Temperature (°C)

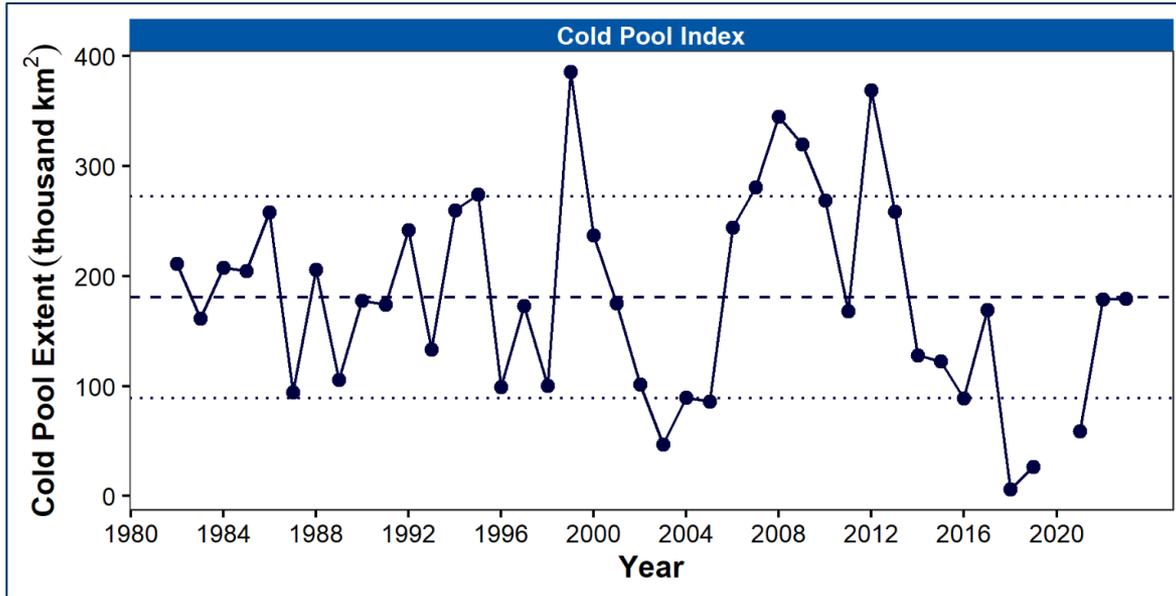


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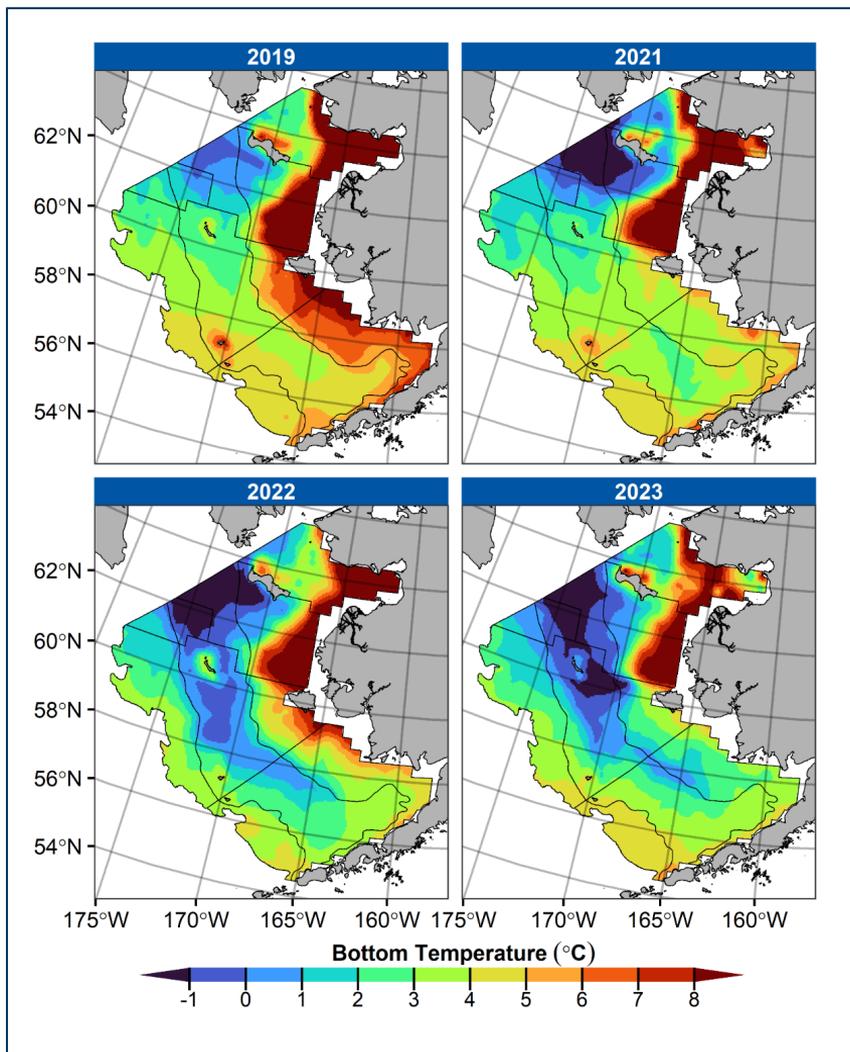


Cold Pool

Rohan & Barnett



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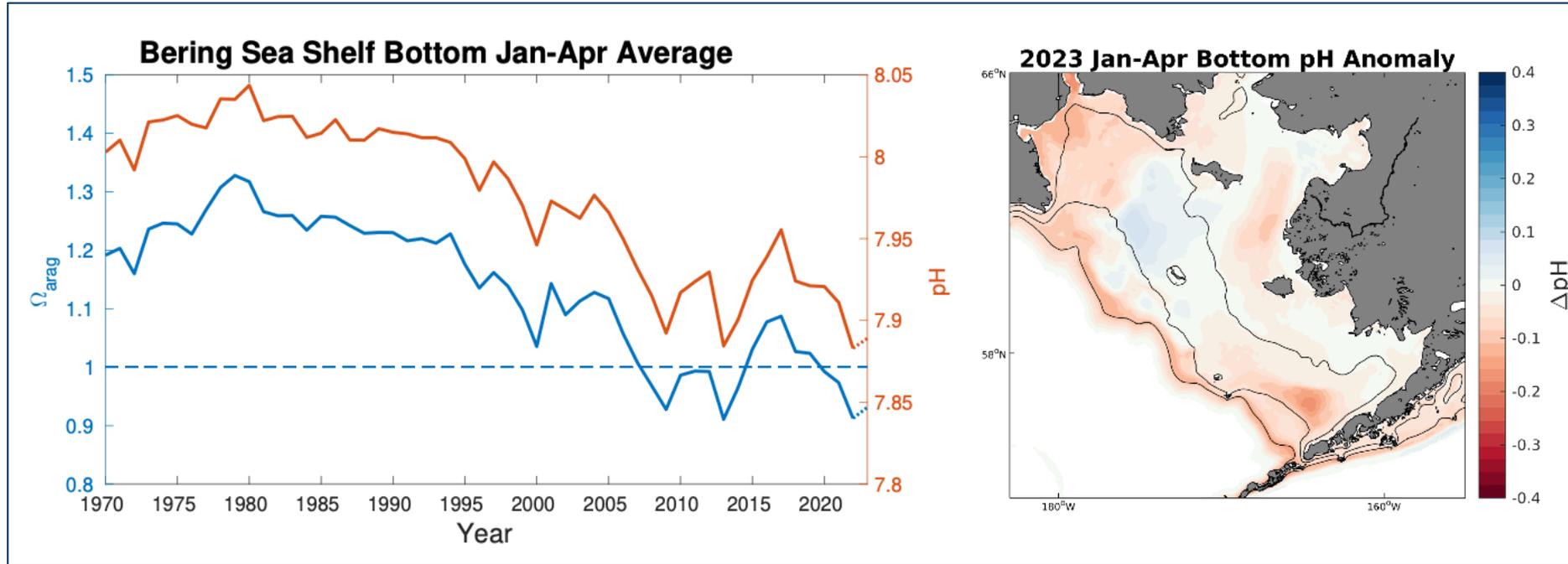
Cold Pool

Rohan & Barnett

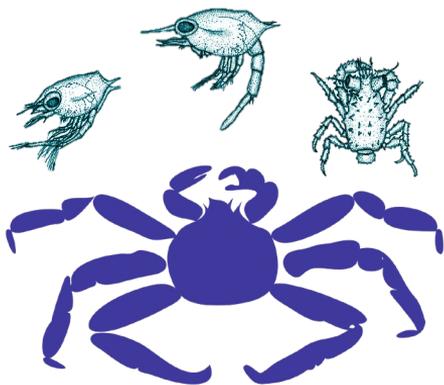
- Bottom and surface temperatures were slightly colder than time series average
- Very cold bottom temperatures south of St. Matthew Island for the first time since 2015
- Coldest bottom temperatures in the southern inner domain since 2013

EBS Ocean Acidification

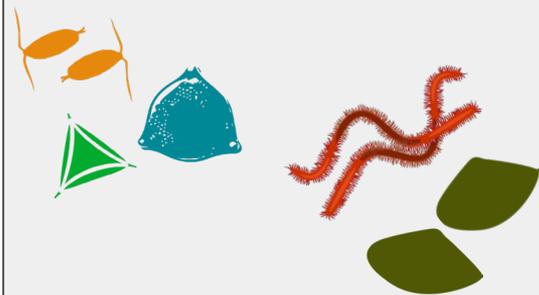
Pilcher & Monacci

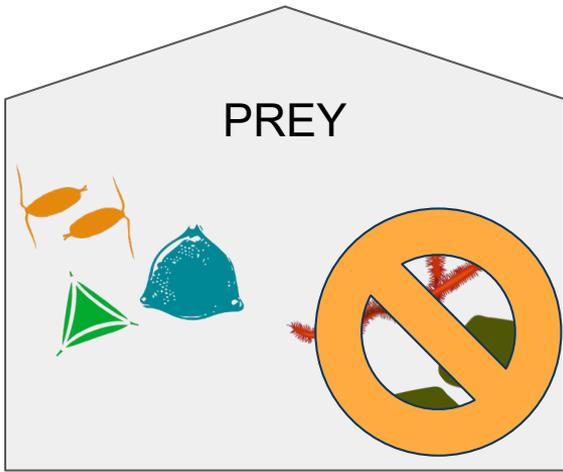
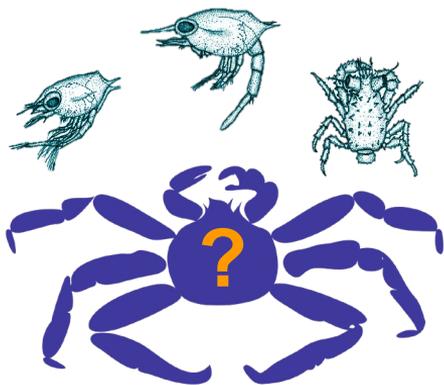


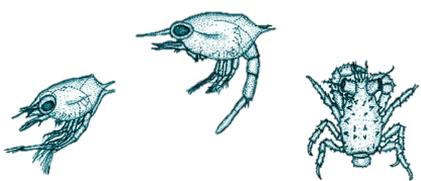
- Through Jan-Apr of 2023, Ω_{arag} and pH continuing near lowest values
- Multi-year outer shelf low pH anomaly diminished somewhat, though still present in southeastern shelf



PREY

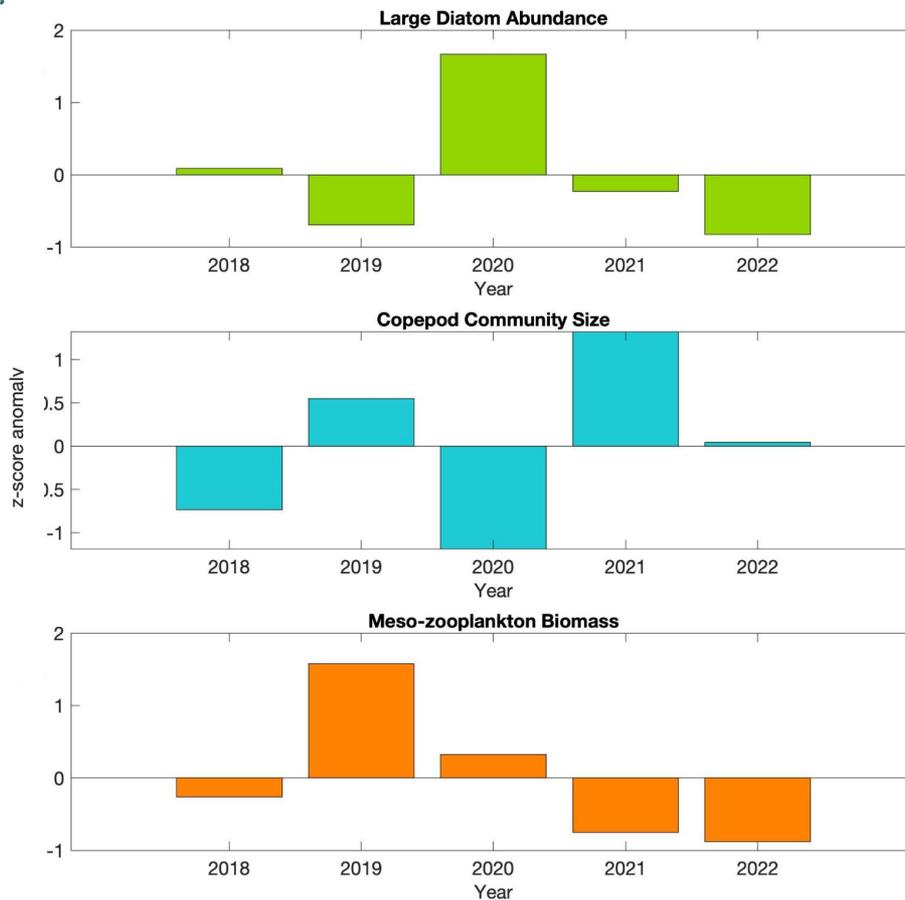
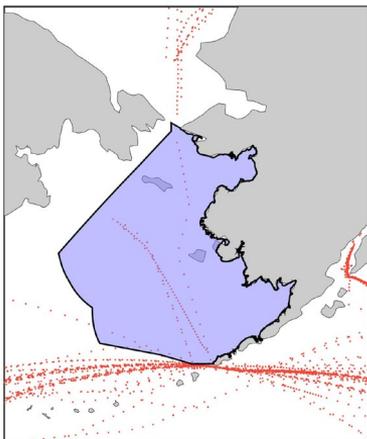




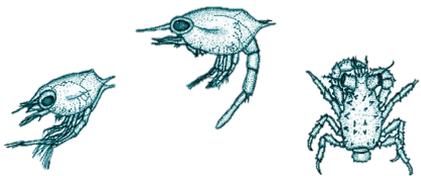


2022 Continuous Plankton Recorder

Ostle & Batten

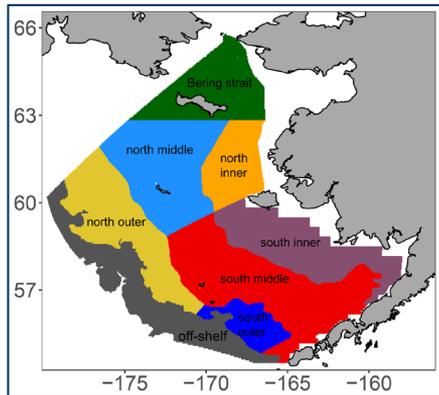


- The mean diatom abundance was negative in 2022
- Copepod community size was positive in 2021, where it had been negative in 2020
- Meso-zooplankton biomass was negative in 2022

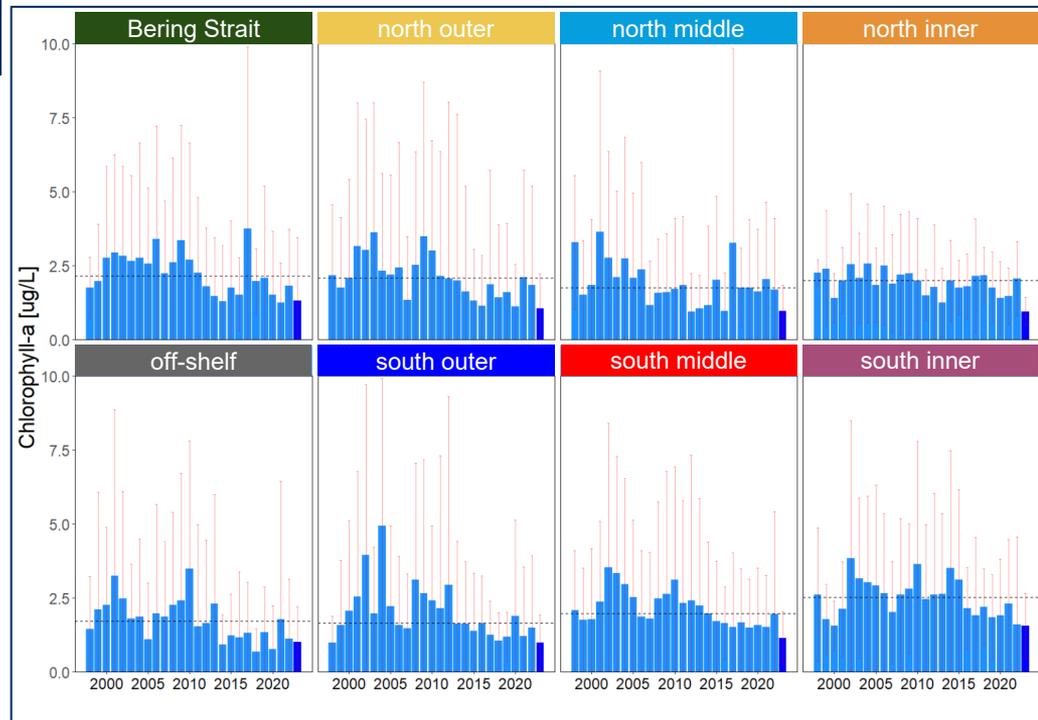


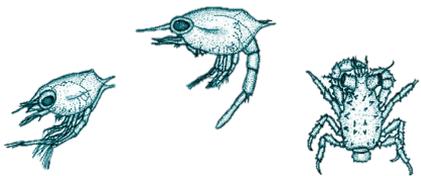
2023 Spring Bloom

Nielsen, Callahan



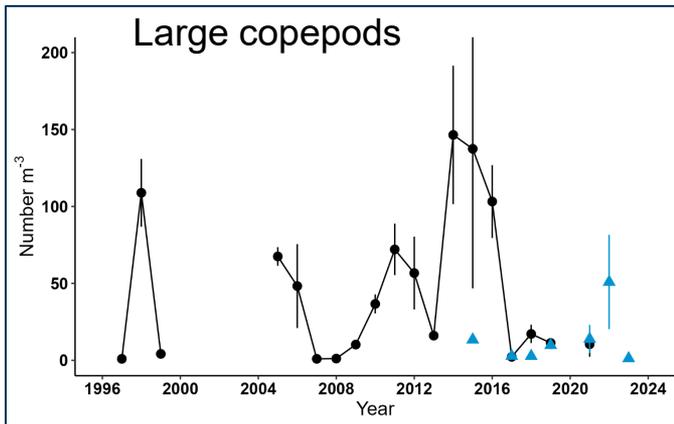
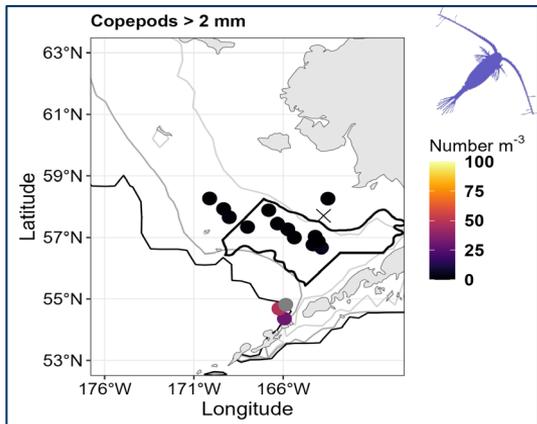
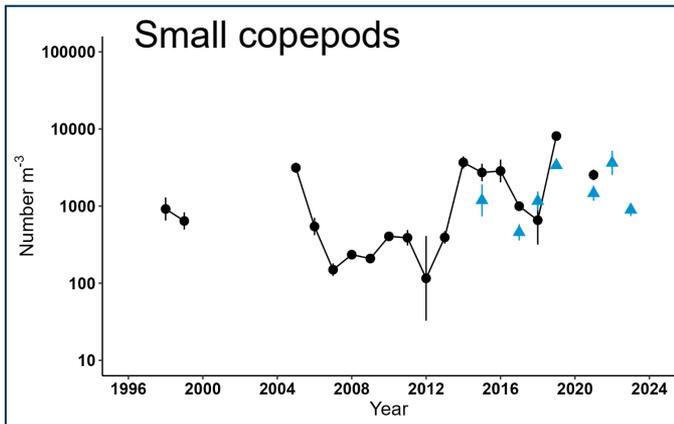
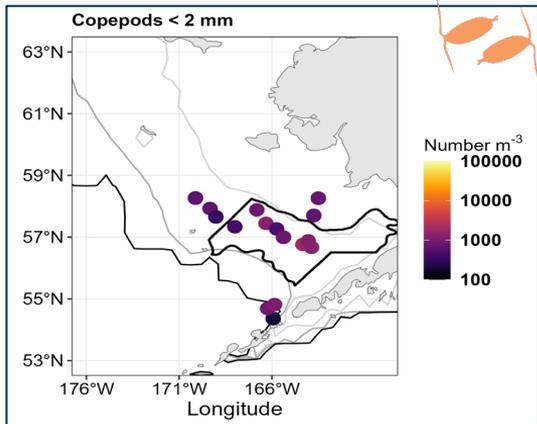
- Preliminary interpretation:
- Now using Globcolour because MODIS is not consistently updated
- Chl-a biomass for 2023 is among the lowest in every region
- Still investigating the reason; bloom timing analysis underway



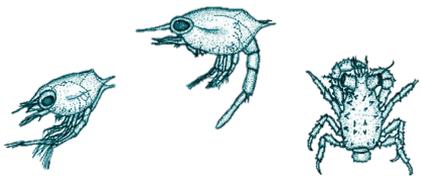


Spring 2023 Rapid Zooplankton Assessment

Kimmel



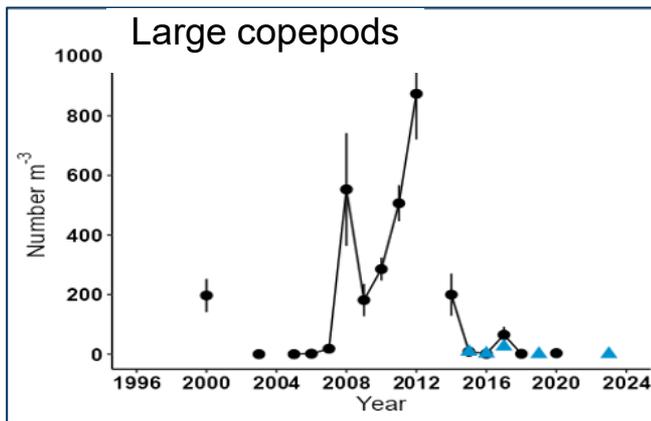
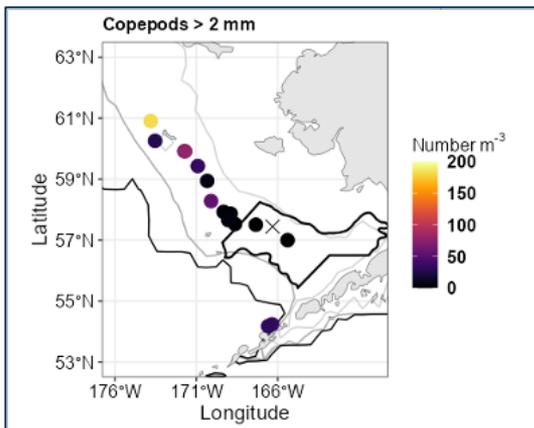
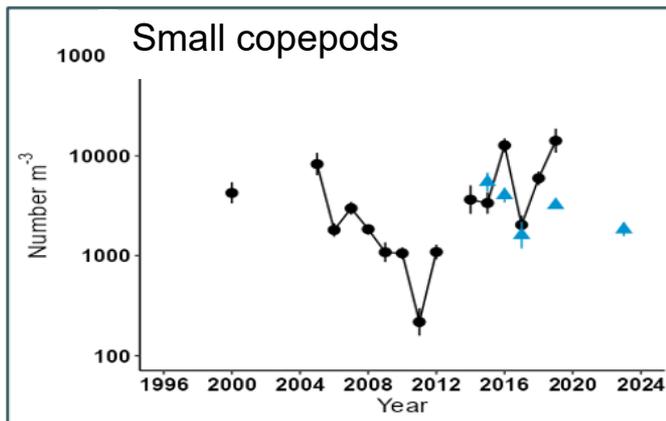
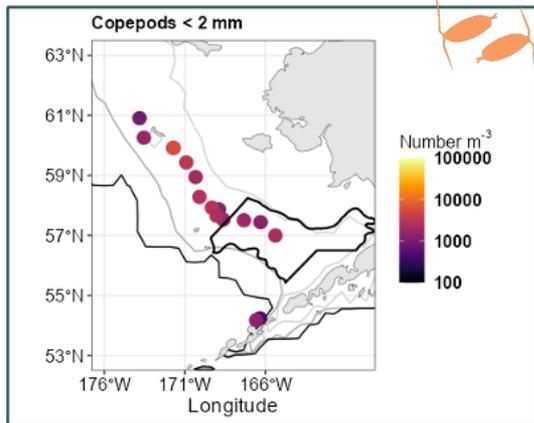
- Spring RZA abundances very low
- Small copepods low, similar to cold years. Cold temps limit population growth by reducing development time & turnover rates
- Large copepods low, similar to cold years after warm periods
- Euphausiid numbers very low, typical of early spring



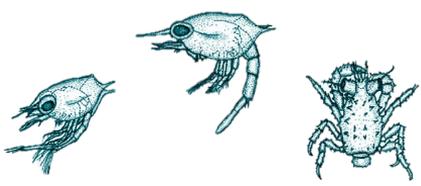
Fall 2023

Rapid Zooplankton Assessment

Kimmel



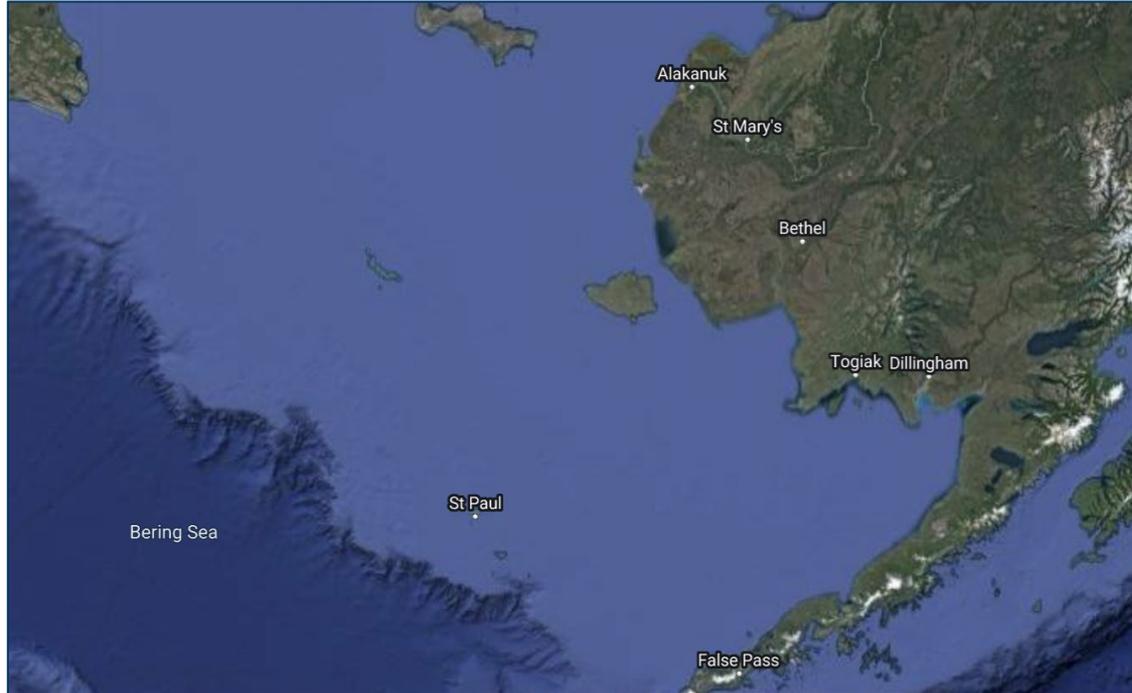
- Small copepods moderate; no N/S spatial gradient; similar abundance to colder years and lower than recent warm years
- Large copepods (and euphausiids) were low in the south and increased to the north
- Lipid-rich copepods in NBS, but not SEBS (cold pool did not extend south)

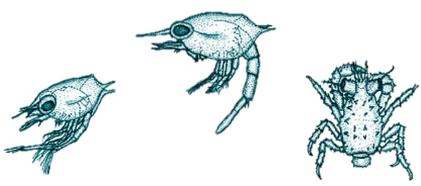


2023 Coccolithophores

Eisner & Lange

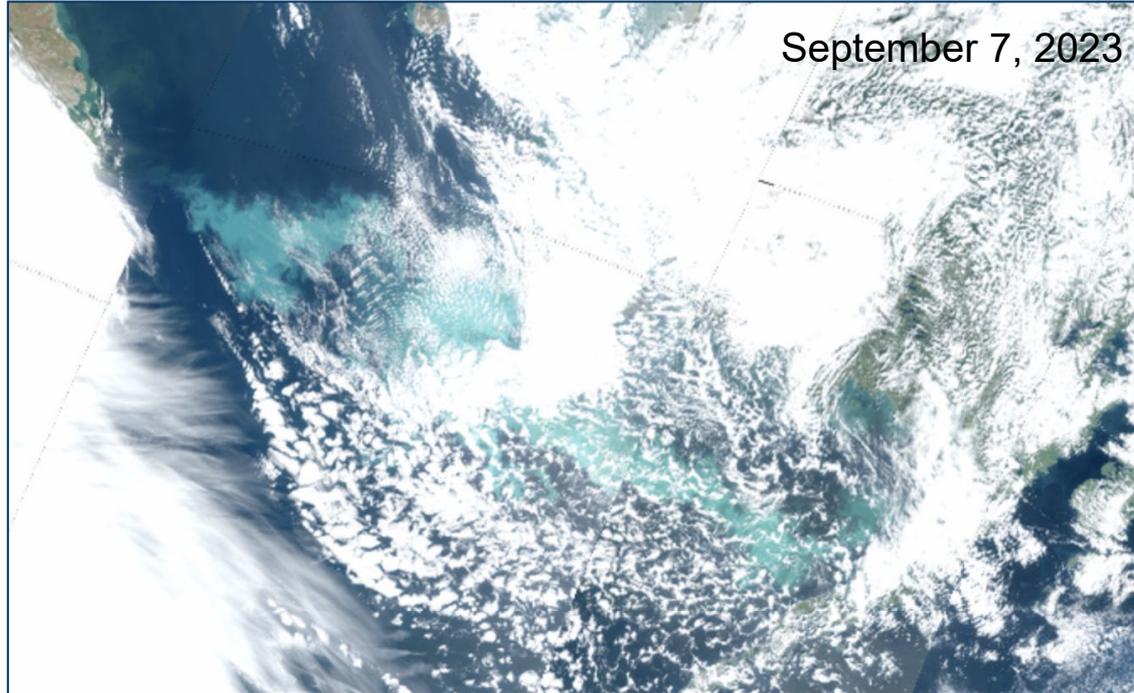
- Coccolithophore bloom index increasing since 2018 in inner and middle domains
- 2023: a noticeable coccolithophore bloom (full index available in October)
- *Implications:* coccolithophores result in longer trophic chains, may be a less desirable food source, and can reduce foraging success for visual predators





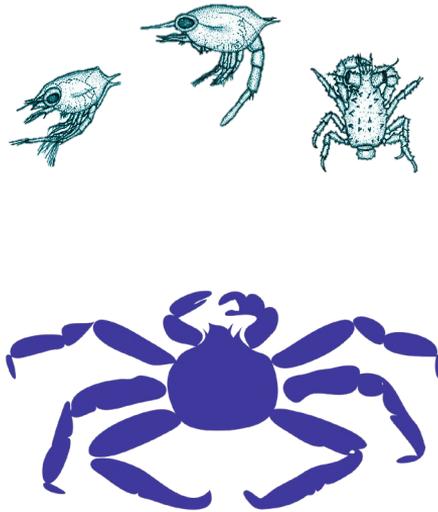
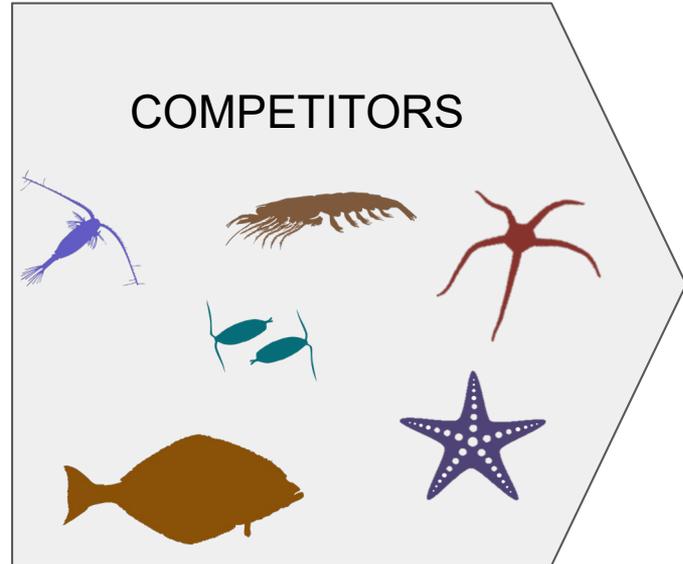
2023 Coccolithophores

Eisner & Lange



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COMPETITORS





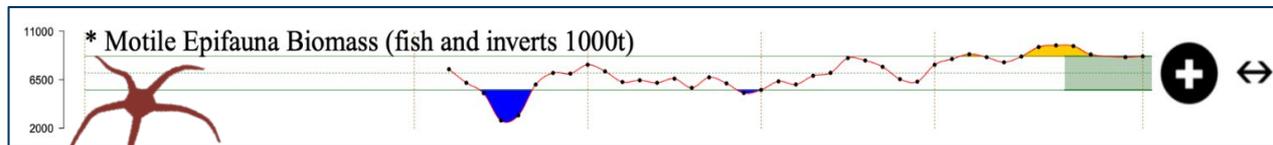
2022 Motile Epifauna and Benthic Foragers

Whitehouse

Motile epifauna and benthic foragers are competitors with benthic crab for prey and space.

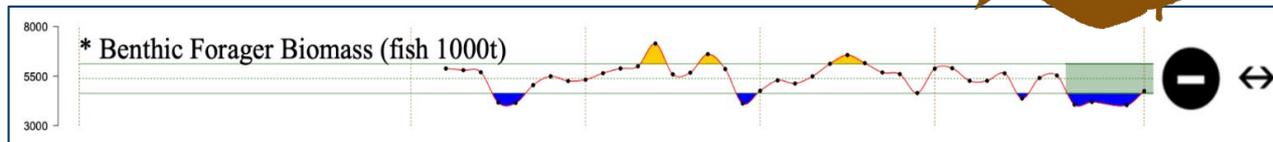
Indicates benthic productivity

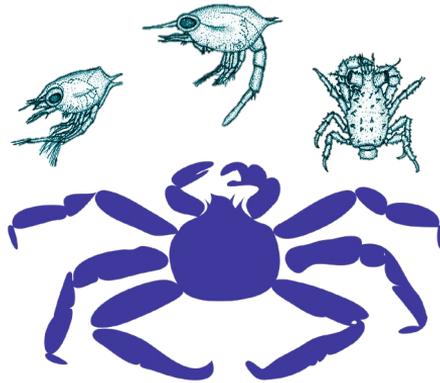
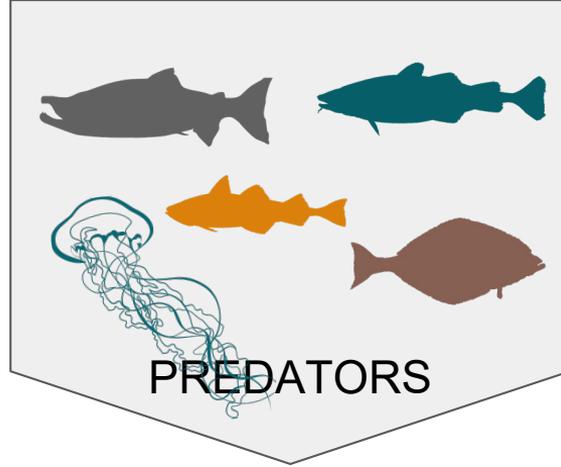
- Motile epifauna biomass peaked in 2017 and remained above the long-term mean in 2022



Indirect indicator of infauna

- Benthic foragers biomass increased 18% in 2022 from time series low in 2021; remained below time series mean

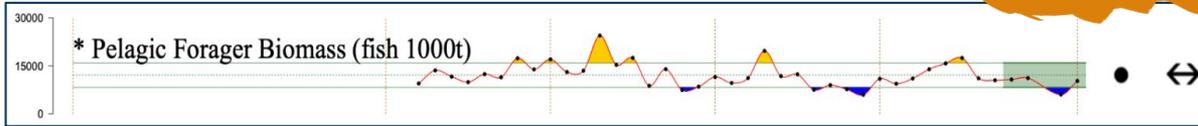




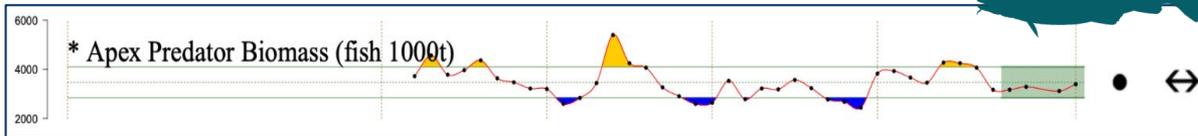
2022 Pelagic Foragers and Apex Predators

Whitehouse

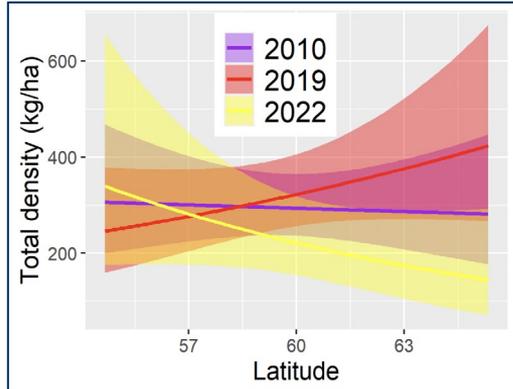
Pelagic foragers are predators of larvae while apex predators consume small benthic crab stages.



- Pelagic foragers (pollock and herring) increased sharply from 2021 to 2022.



- Apex predators (P. cod and ATF) increased from 2021 to 2022 to long term mean.



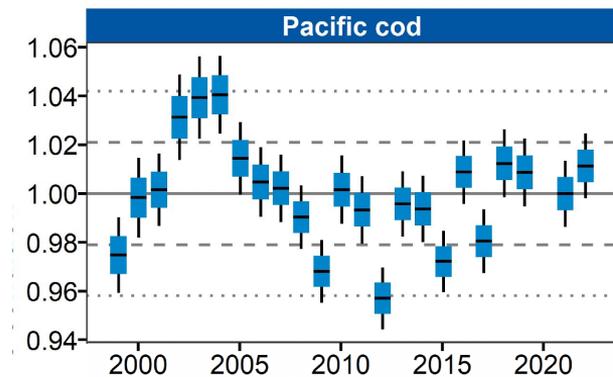
- The groundfish community shifted north between 2010 and 2019, then south in 2021 as conditions cooled, and into slightly deeper waters in 2022



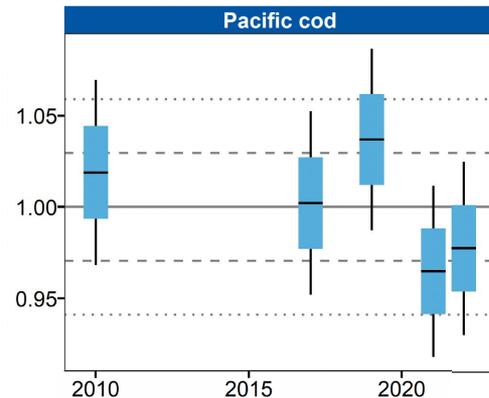
2022 Adult Pacific Cod Condition

Rohan & Prohaska

EBS



NBS



- EBS: PCod condition positive and slightly higher than 2021
- NBS: PCod condition continued to be negative, though slightly higher than 2021

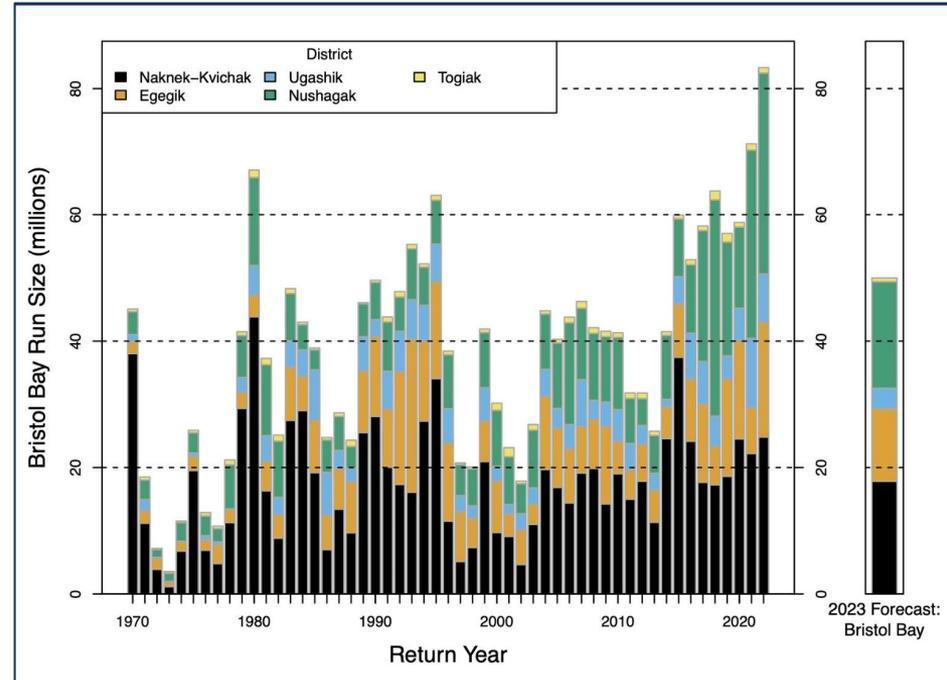


2023 Bristol Bay Sockeye Salmon

Cunningham

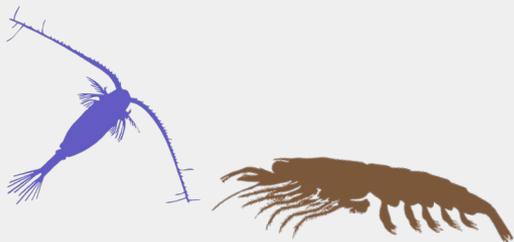


- 2023 (estimate: 54 million) was lower than the 2022 record run of 83 million sockeye
- Smaller size-at-age (density-dependent growth)
- Large average size of sockeye compared to recent years (>80% 3-ocean: 1.3+2.3)
- Juvenile sockeye feed on zooplankton and age-0 pollock in warm years; adults feed on zooplankton and krill



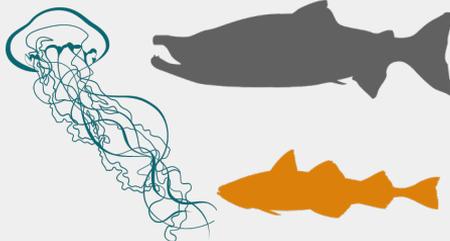
2023 Summary & Larval Implications

COMPETITORS



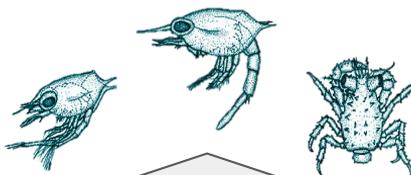
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PREDATORS



-

PREY



-



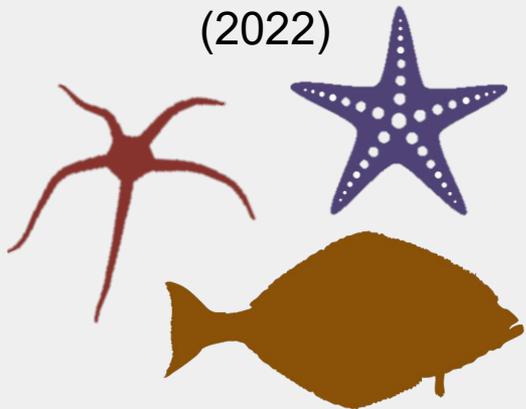
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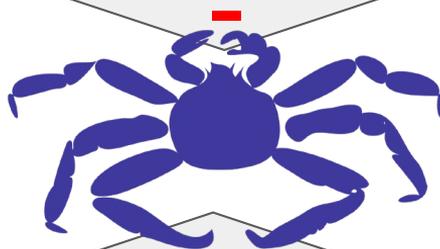
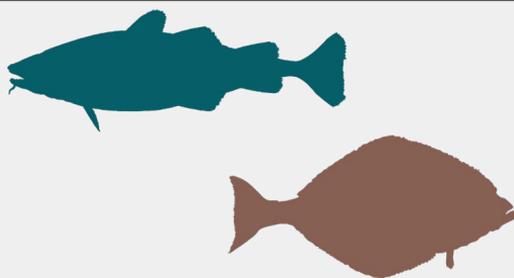
ENVIRONMENTAL
PROCESSES

2023 Summary & Adult Implications

COMPETITORS
(2022)



PREDATORS
(2022)



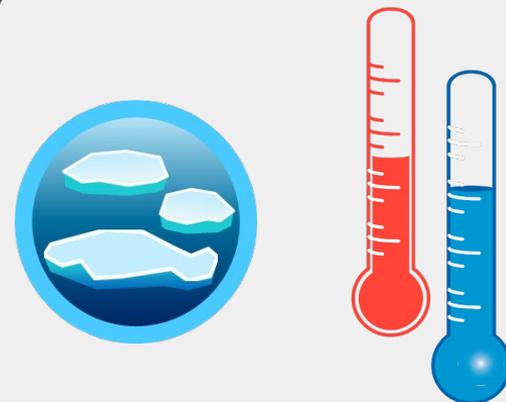
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(indirect)

PREY

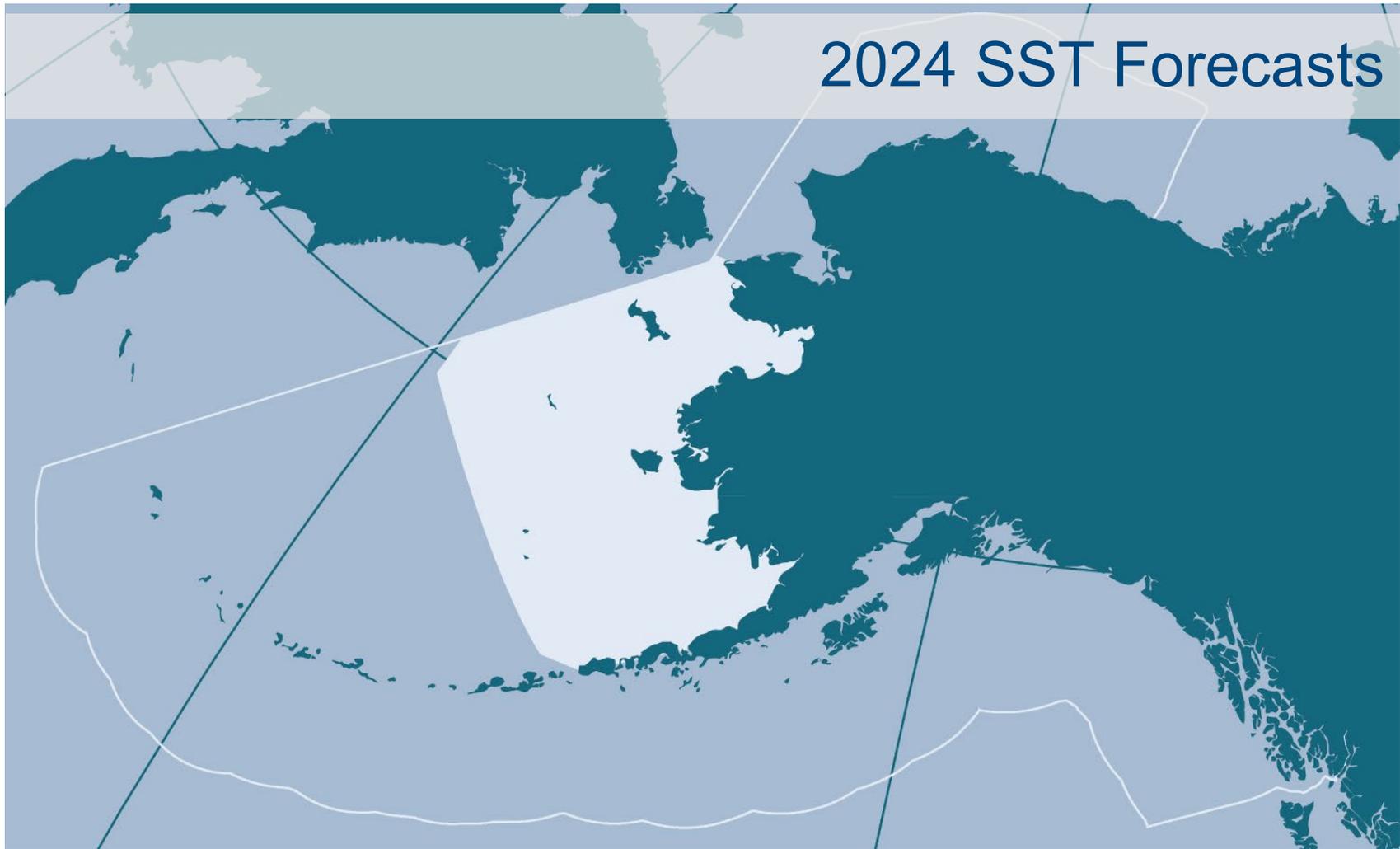


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ENVIRONMENTAL
PROCESSES

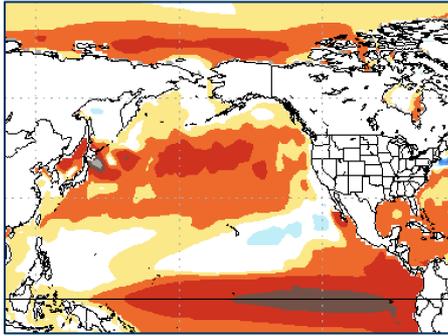
2024 SST Forecasts



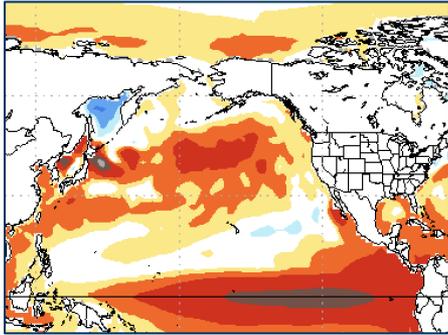
SST Projections from the National Multi-Model Ensemble

Bond

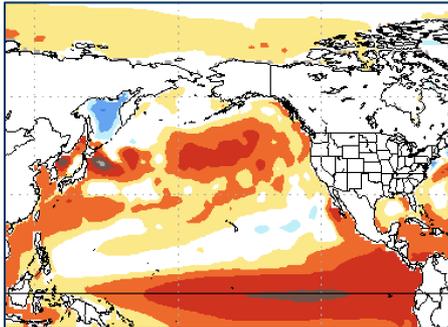
Oct - Dec
2023



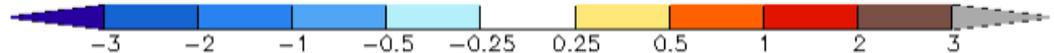
Dec 23 -
Feb 24



Feb -
April
2024



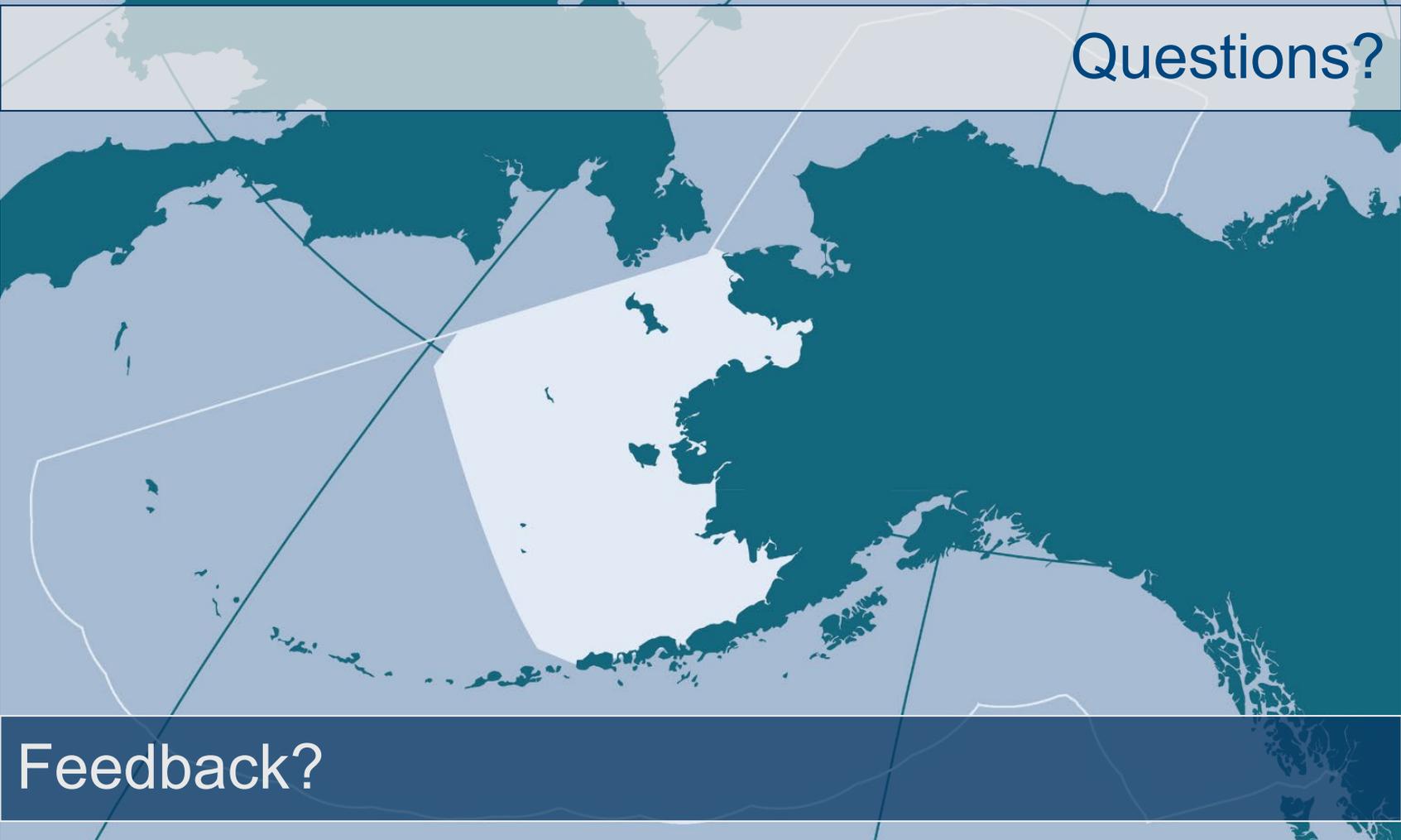
- **TOP:** El Niño in tropical Pacific. Modest warming for western Aleutian Islands, southeast Bering Sea shelf, and Gulf of Alaska.
- **MIDDLE:** Similar to earlier period (Oct-Dec 2023). Tropical Pacific has SST anomalies $>2^{\circ}\text{C}$, representing a strong El Niño.
- **BOTTOM:** Moderation of tropical Pacific SSTs; warming along PNW coast and SEAK (typical response to El Niño). Sea ice could extend south of 60°N and as far south as Bristol Bay.



Please note...

- AFSC Ecosystem Status Reports underwent a CIE (Center for Independent Experts) review in Spring 2023
- The panel provided several recommendations in response to the review's Terms of Reference
- A summary of those recommendations will be presented by Dr. Ivonne Ortiz during the Groundfish Plan Team next week
- Some recommendations (e.g., Risk Tables) may be of interest to CPT members or crab stock assessment authors, so please consider tuning in next week



A map of the Pacific Northwest region of the United States, including parts of Washington, Oregon, and Idaho. A white polygon highlights a specific area in the central part of the region, roughly between the coast and the Cascade Range. The map is overlaid with a grid of latitude and longitude lines. The text "Questions?" is in the top right, and "Feedback?" is in the bottom left.

Questions?

Feedback?