# Ecosystem Status Report: Eastern Bering Sea 2024


Elizabeth Siddon

*With contributions from:*

Grant Adams, Donald M. Anderson, Alex Andrews, Kelia Axler, Kerim Aydin, Diana Baetscher, Sunny Bak-Hospital, Steve Barbeaux, Cheryl Barnes, Lewis Barnett, Sonia Batten, Jessica Beck, Shaun Bell, Emily Bowers, Caroline Brown, Thaddaeus Buser, Matt Callahan, Patrick Charapata, Dan Cooper, Bryan Cormack, Jessica Cross, Deana Crouser, Curry J. Cunningham, Lukas DeFilippo, Andrew Dimond, Lauren Divine, Sherri Dressel, Lisa B. Eisner, Jack Erickson, Evangeline Fachon, Thomas Farrugia, Erin Fedewa, H. William Fennie, Emily Fergusson, Sarah Gaichas, Jeanette C. Gann, Sabrina Garcia, Alicia Godersky, Benjamin Gray, Shannon Hennessey, Tyler Hennon, Kirstin K. Holsman, Kathrine Howard, Rebecca Howard, Jim Ianelli, Kelly Kearney, Esther Kennedy, Mandy Keogh, David Kimmel, Jesse Lamb, Geoffrey M. Lang, Ben Laurel, Kimberly Ledger, Elizabeth Lee, Kathi Lefebvre, Emily Lemagie, Aaron Lestenkof, Mike Levine, Jackie Lindsey, Mike Litzow, W. Christopher Long, Jacek Maselko, Annie Masterman, Cathy Mattson, Sara Miller, Todd Miller, Natalie Monacci, James Murphy, Laurel Nave-Powers, Jens Nielsen, Clare Ostle, Jim Overland, Johanna Page, Robert Pickart, Darren Pilcher, Cody Pinger, Drew Porter, Steven Porter, Bianca Prohaska, Patrick Ressler, Jonathan Reum, Jon Richar, Nancy Roberson, Lauren Rogers, Sean Rohan, Matthew Rustand, Emily Ryznar, Gay Sheffield, Kalei Shotwell, Elizabeth Siddon, Margaret Siple, Brooke Snyder, Adam Spear, Phyllis Stabeno, Raphaela Stimmelmayr, Anna Sulc, Rob Suryan, Jasmine Terry-Shindelman, Rick Thoman, James T. Thorson, Cathy Tide, Stacy Vega, Muyin Wang, Sophia Wassermann, George A. Whitehouse, Ellen Yasumiishi, Stephani Zador, and Adam Zaleski


NOAA FISHERIES

# Outline

- Response to SSC Comments
- Ecosystem Considerations for Risk Tables
- New and Noteworthy Topics
- Ecosystem Assessment
  - Southeastern Bering Sea
  - Northern Bering Sea

# Response to SSC Comments (Dec 2023)

*“...more focus on multi-year patterns…independent of warm or cold stanzas….”*

The Ecosystem Assessment addresses the response (both SEBS and NBS) to the shift from interannual variability (prior to 2000), to the recent prolonged warm period, to the return to average thermal conditions since ~2021.

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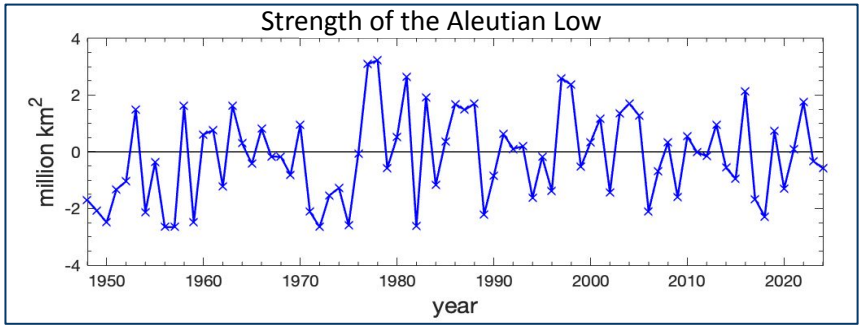
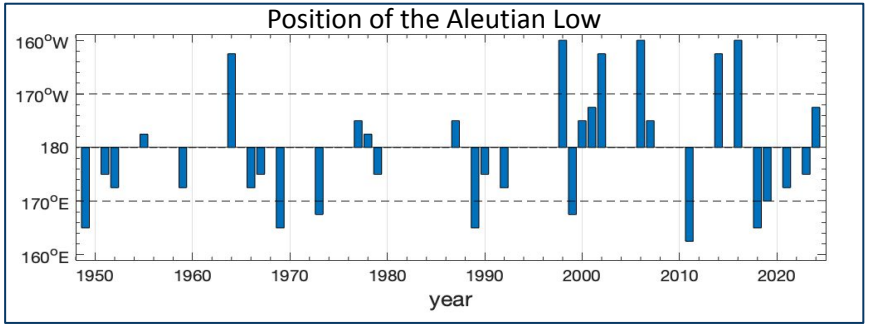
The ESRs include a new contribution from Jim Overland and Muyin Wang that describes the strength and position of the Aleutian Low Pressure System (p. 47 in the 2024 EBS ESR).



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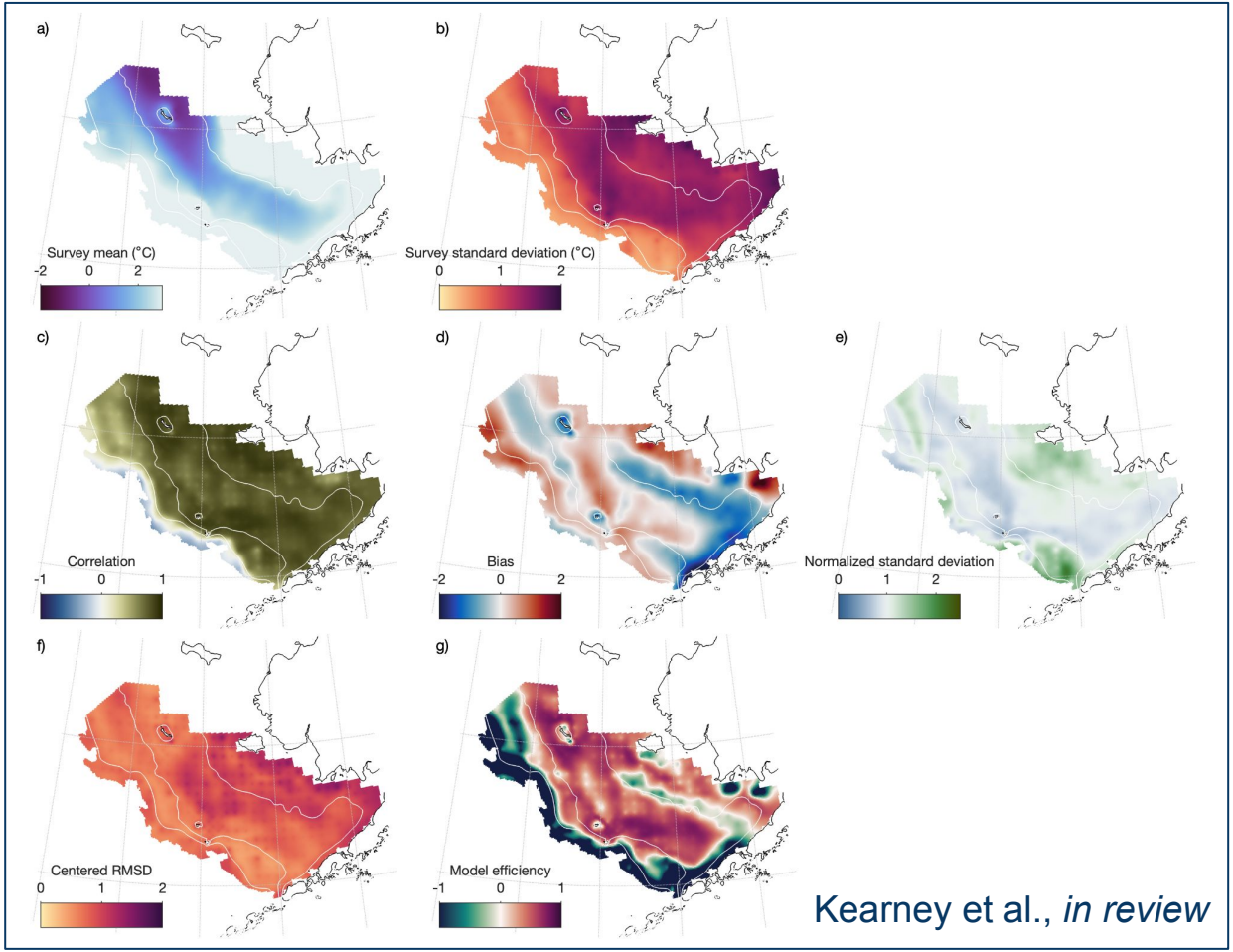
*"...Dynamic Structural Equation Modeling as a promising new tool…also recommends using species-specific case studies…."*
Please see "Forage Fish Dynamics in the Eastern Bering Sea" (p. 115 in the 2024 EBS ESR).

# Response to SSC Comments (October 2024)

*"...when physical data from a model output (e.g., ROMS) are first used that comparisons with available in situ data be provided (spatially if relevant) to assess potential biases..."*

- Validation of bottom water temperatures from the ROMS model was presented as a Noteworthy in the 2021 EBS ESR (see peer-reviewed references therein).

- Updated spatial skill assessment of the Bering10K model survey-replicated temperature raster relative to the observational raster has been completed and the paper is in press at *Frontiers in Marine Science*.




Kearney et al., *in review*

# Ecosystem Considerations for Risk Tables

***Level 1***

*No apparent ecosystem concerns related to biological status (e.g., environment, prey, competition, predation), or minor concerns with uncertain impacts on the stock.*

EBS Pollock
Yellowfin sole
Northern rock sole
Greenland turbot
Kamchatka flounder
Alaska plaice
Flathead sole
Other flatfish
+ESP Sablefish

***Level 2***

*Indicator(s) with adverse signals related to biological status (e.g., environment, prey, competition, predation).*

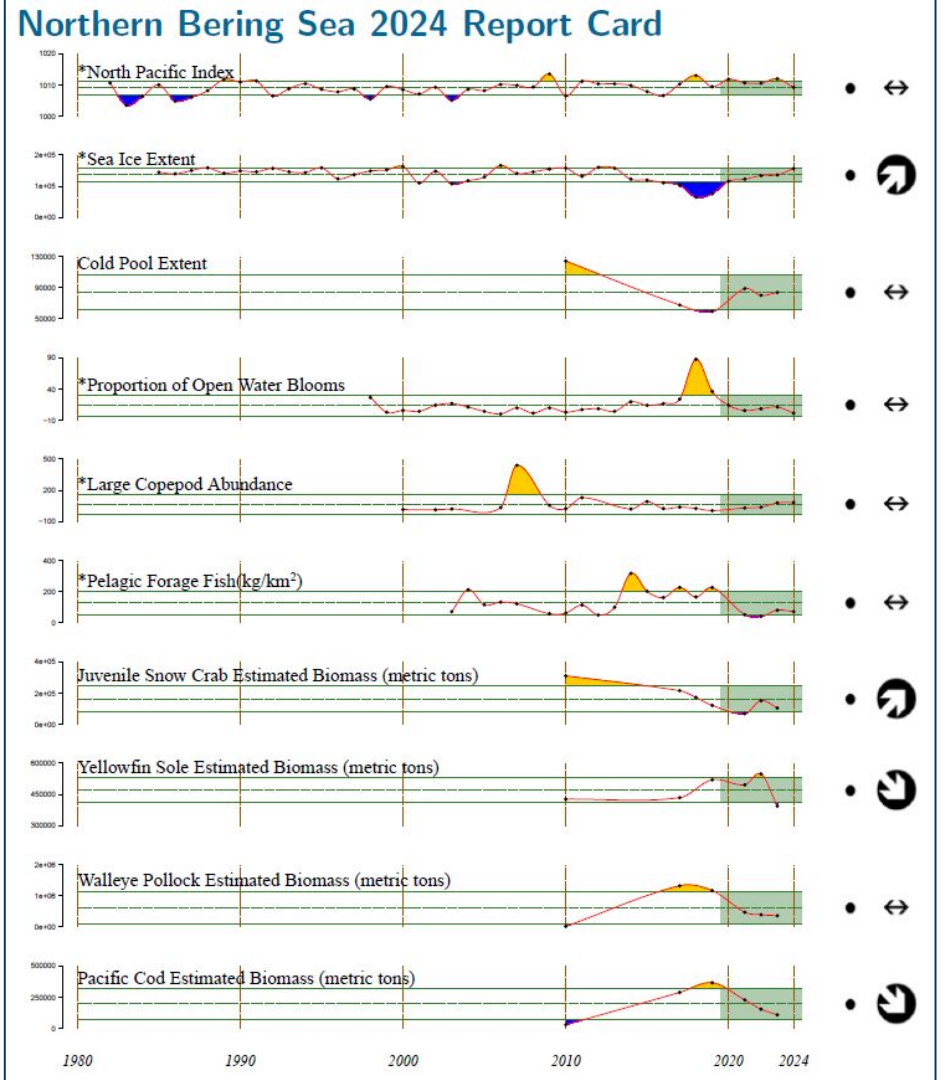
EBS Pacific cod +ESP

**Environment:** Oceanographic conditions were largely average based on multiple metrics

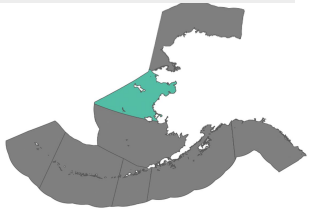
**Prey:** Prey conditions over the SEBS shelf potentially more limiting than over the NBS. Pcod condition continued to decrease over the SEBS from 2022 to 2024. The majority of the Pcod biomass has been over the SEBS in recent years.

**Competitors:** Competitors of Pcod increased substantially from 2023 to 2024, including arrowtooth flounder (+26%) and pollock (+74%), especially over the SEBS.

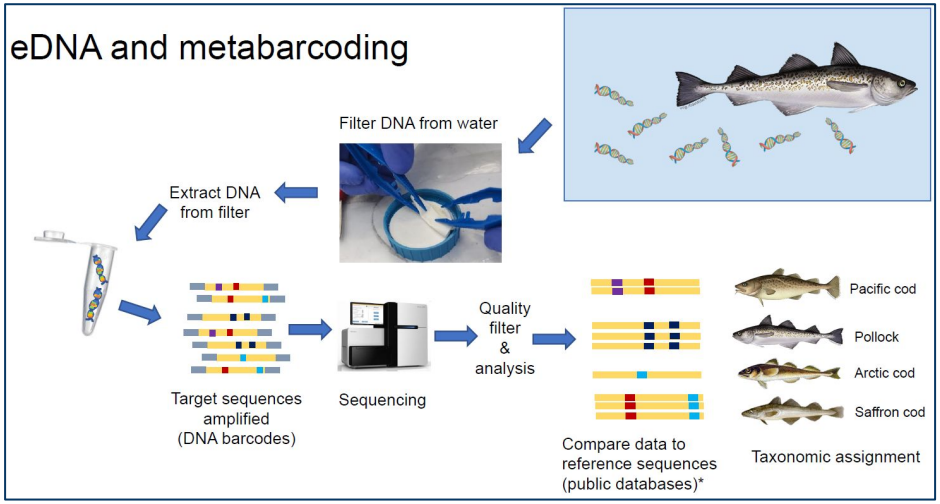
**Predators:** The 2023 CEATTLE model indicated above average predation pressure on Pcod; that trend reversed in 2024.

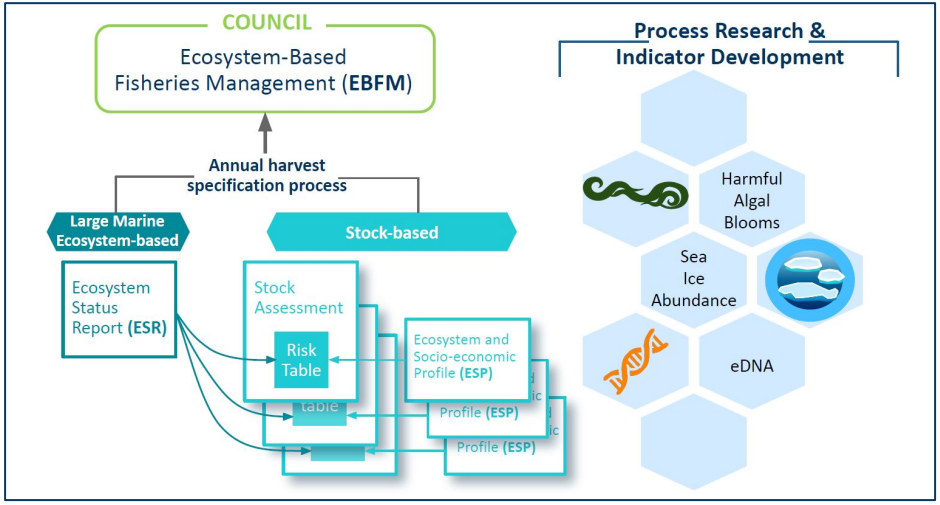



# New in 2024



- Sea ice extent now available by sub-region
  - PolarWatch Shinyapp: https://polarwatch.github.io/alaska-seaice/
- Juvenile snow crab biomass
  - immature females + small males
- Foraging guilds (e.g., motile epifauna) not available for NBS
  - No ecopath-estimated catchability coefficient



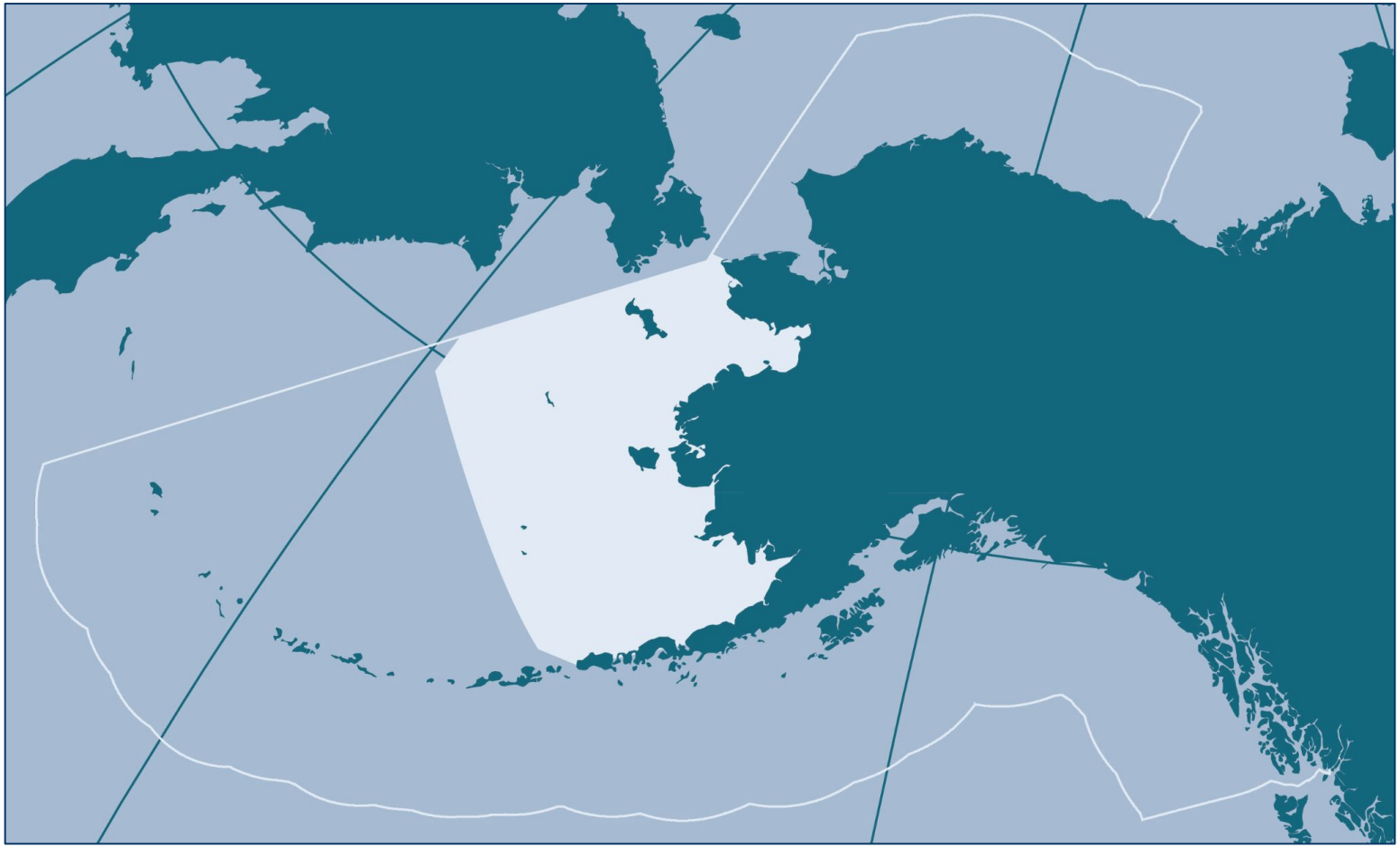




# Noteworthy

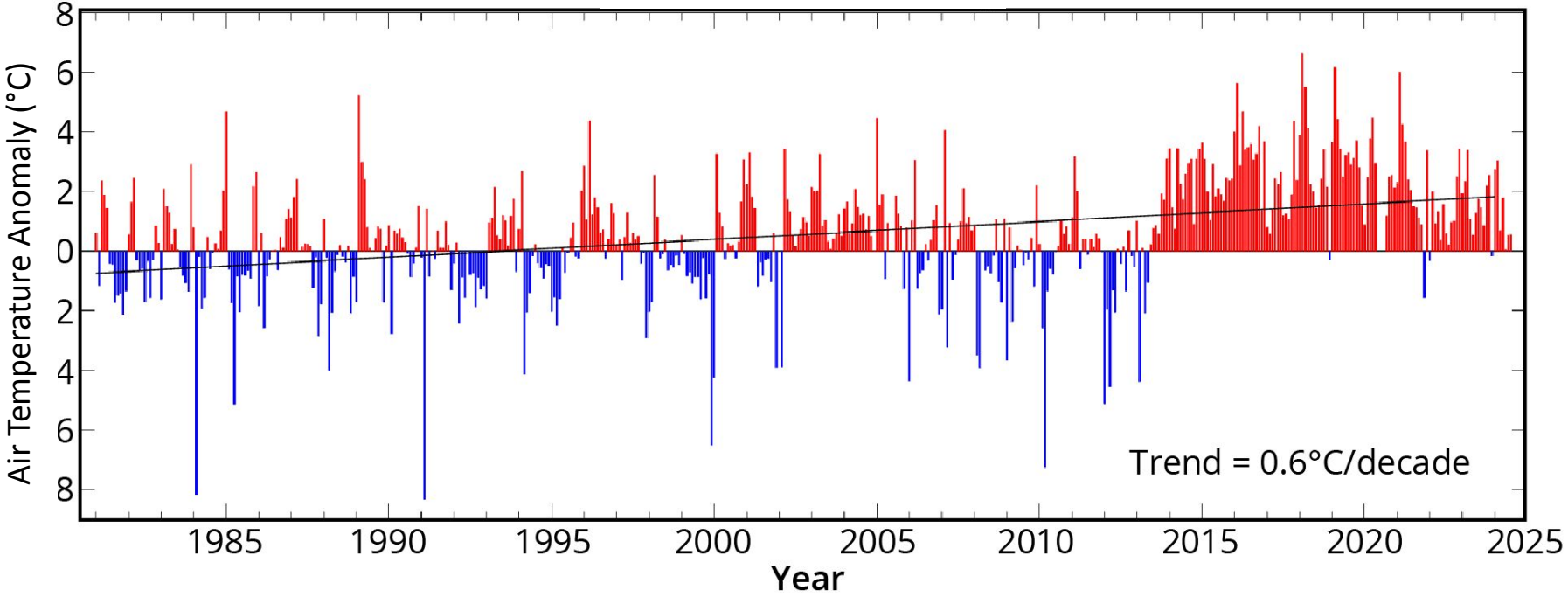
- Single-species quantitative PCR (qPCR)
  - eDNA concentration
- Multi-species metabarcoding
  - Relative abundance
- Advantages
  - Easy/efficient to collect
  - Fill spatial/temporal survey gaps
  - Detects species that avoid nets
- Drawbacks
  - Size/age class
  - Effective area sampled
  - Comparing to survey data sources
- Current collaborations
  - Arctic gadid distributions
  - Paired sampling on trawl surveys
  - Northern fur seal & Steller sea lion diets
  - Ice seal surveys

Baetscher & Ledger, p. 29

# Ecosystem Assessment



# *The Bering Sea has cooled to **average** thermal conditions*




Overland & Wang, p. 55

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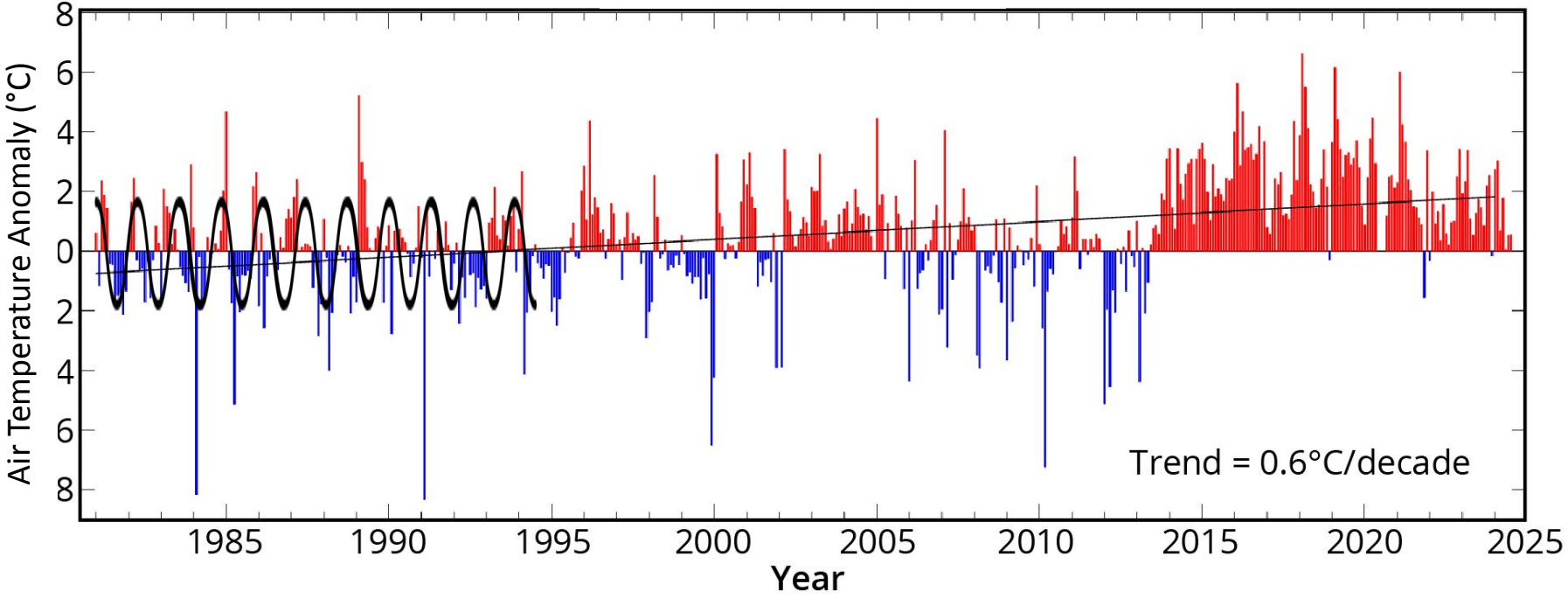


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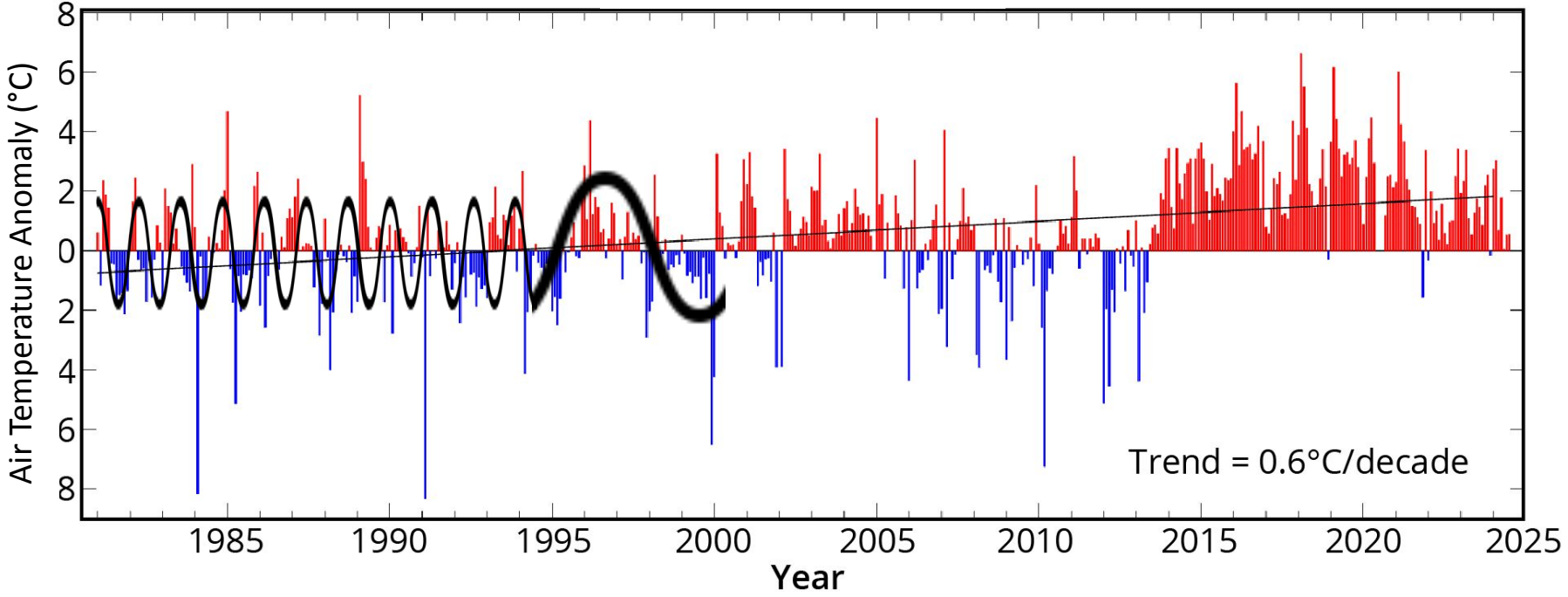


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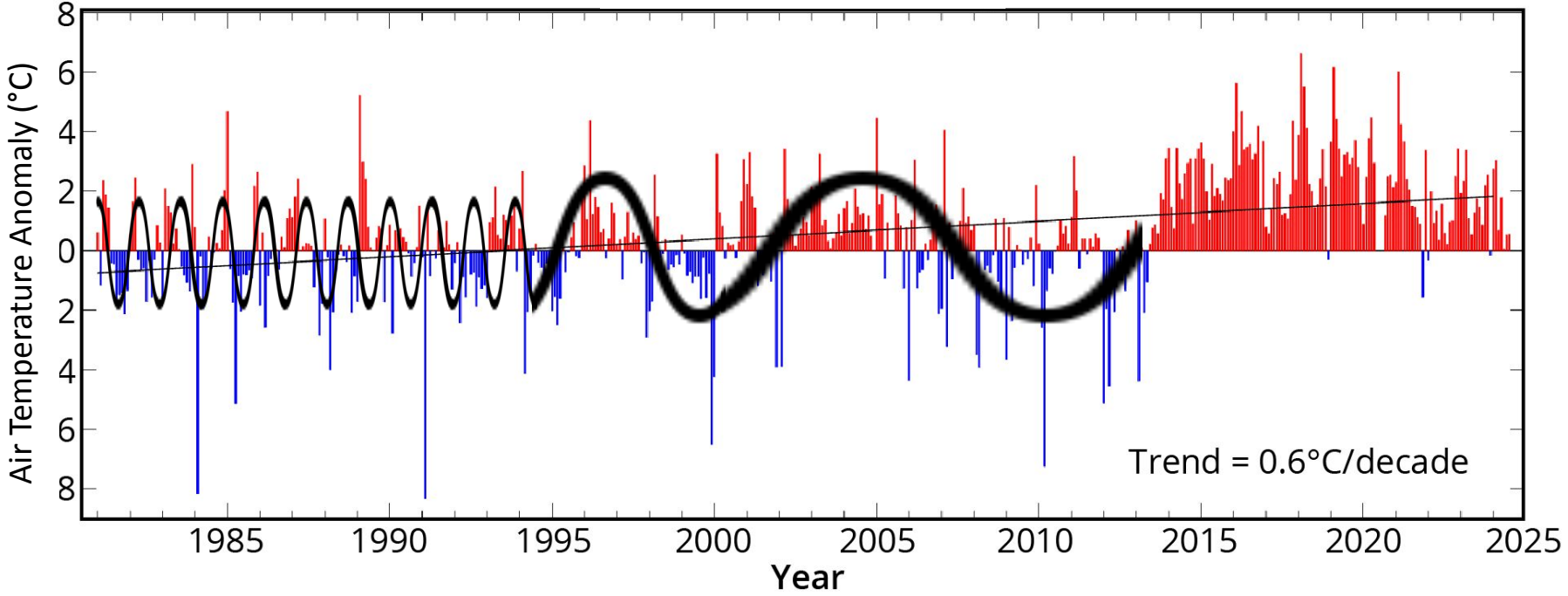


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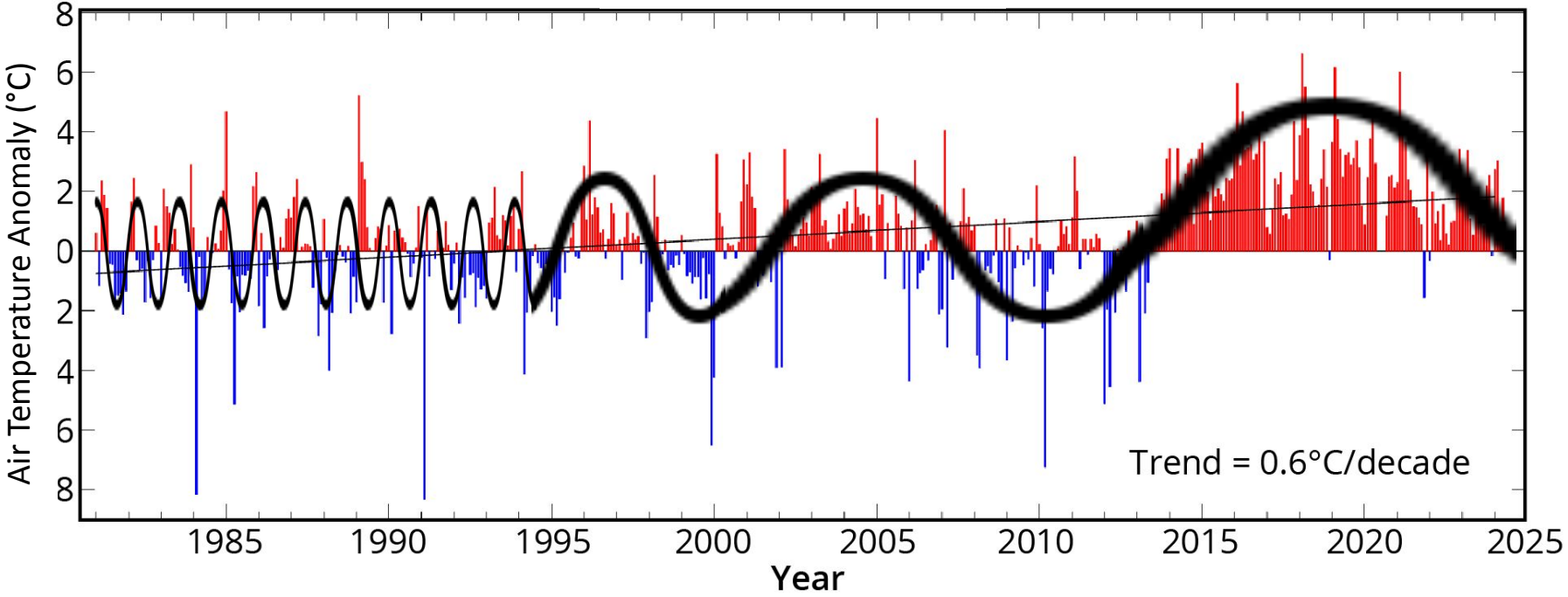


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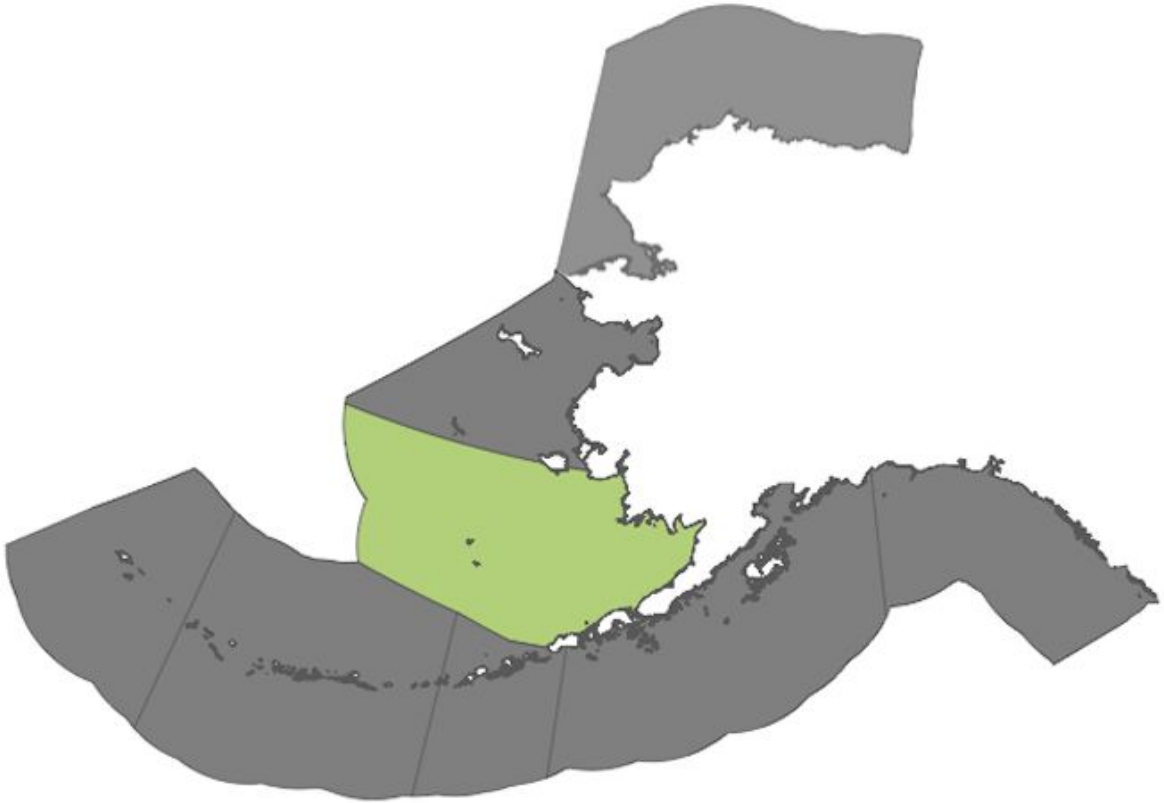
# Southeastern Bering Sea



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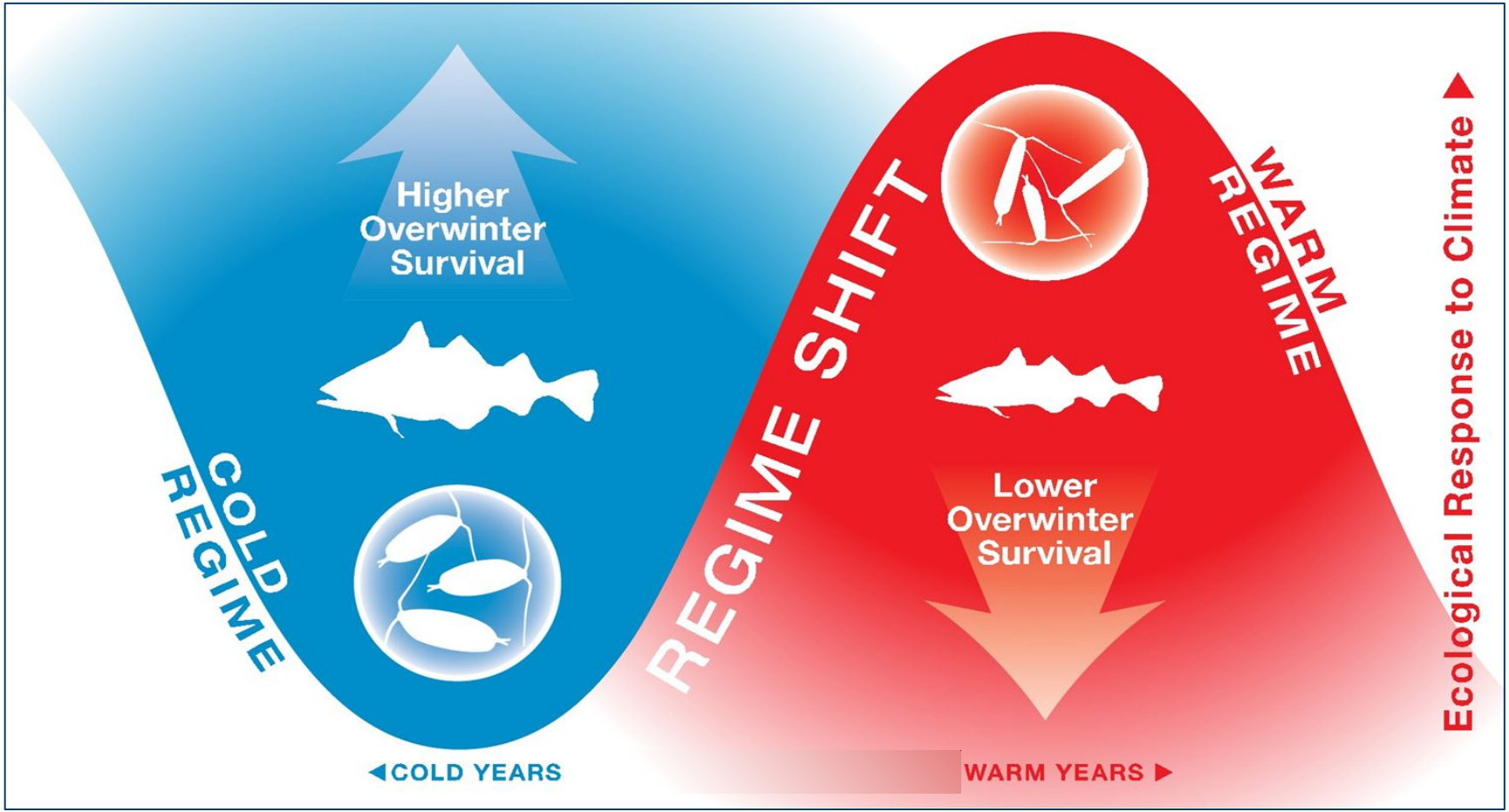
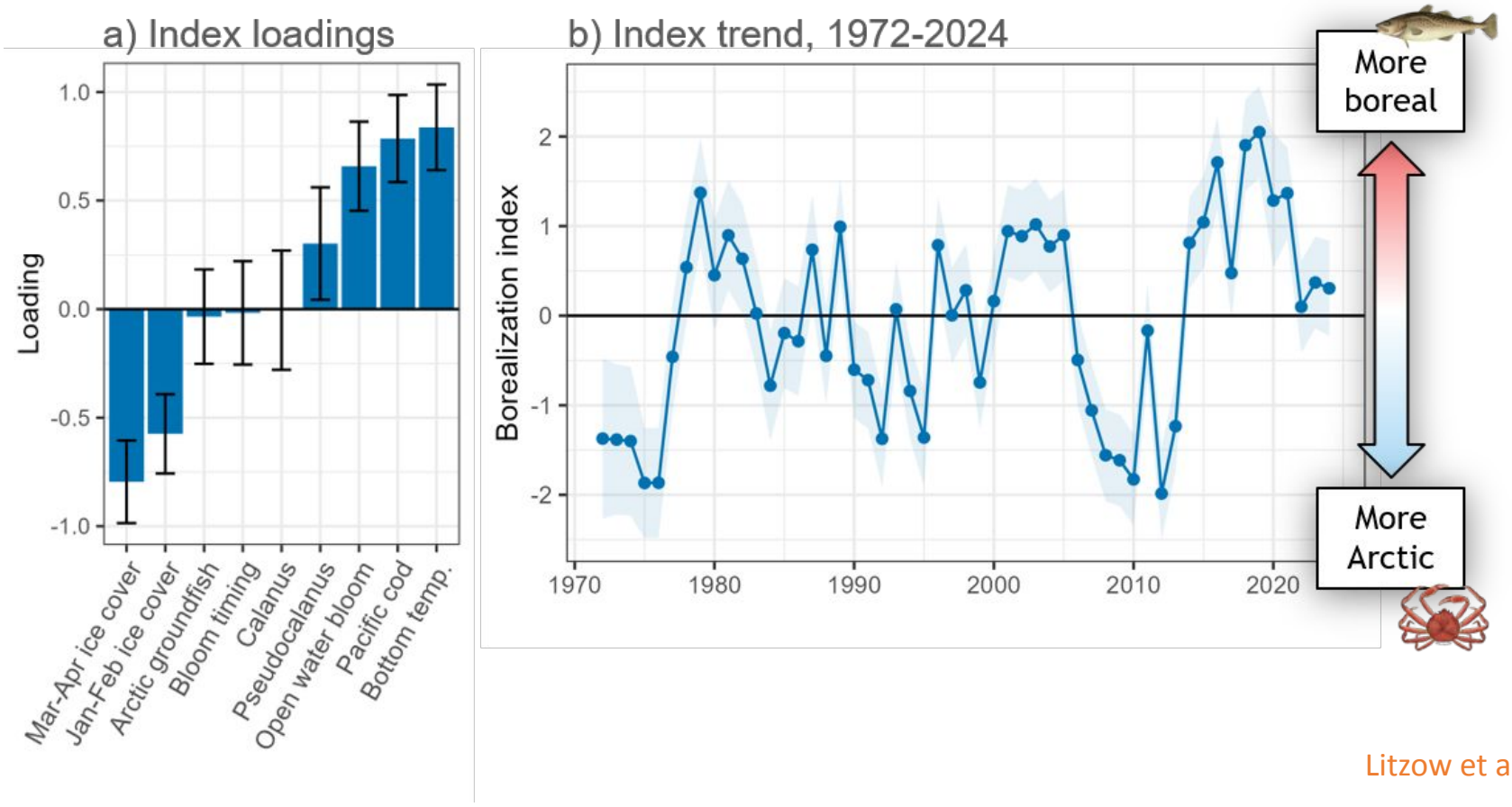
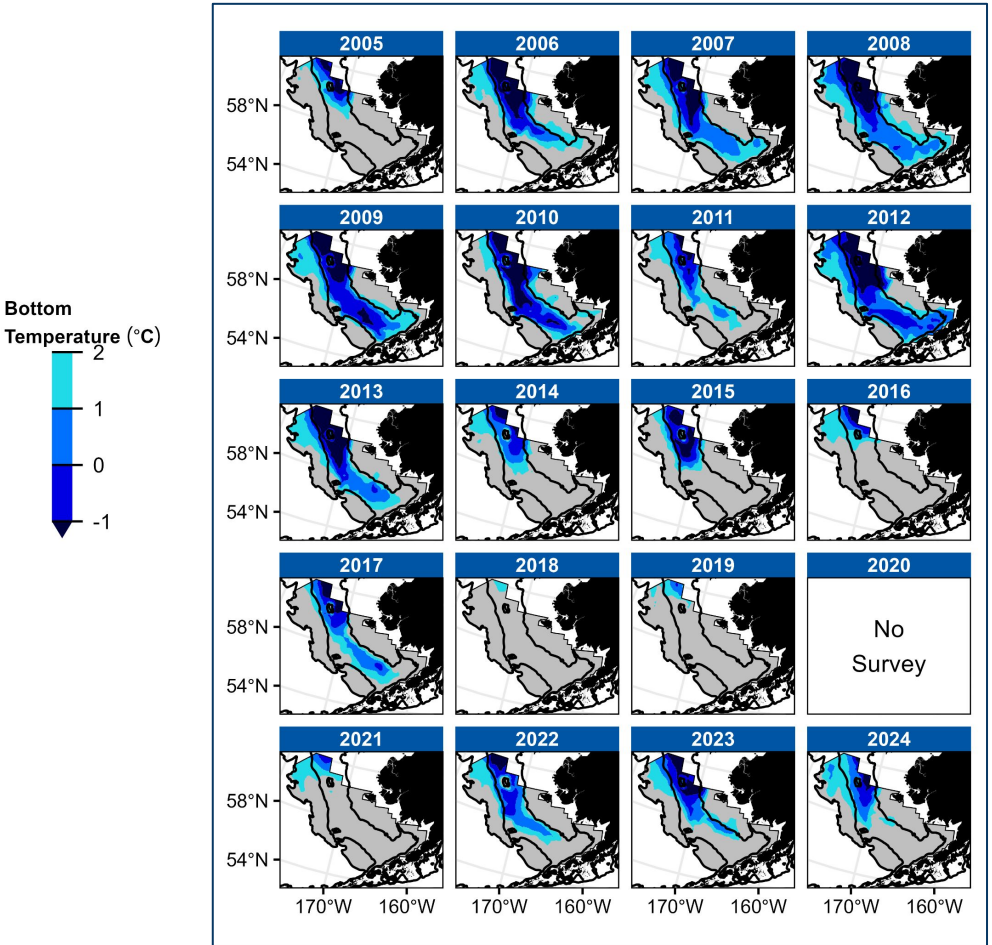


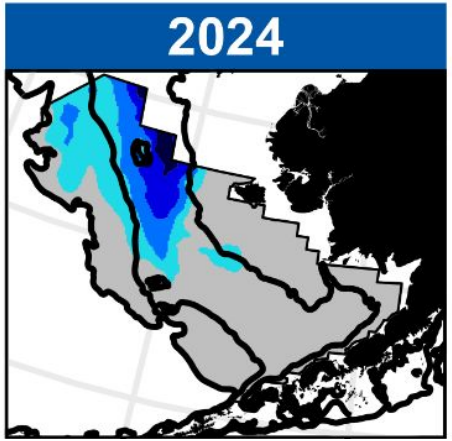
# *The borealization index for the SEBS has reverted to the mean during 2022–2024*



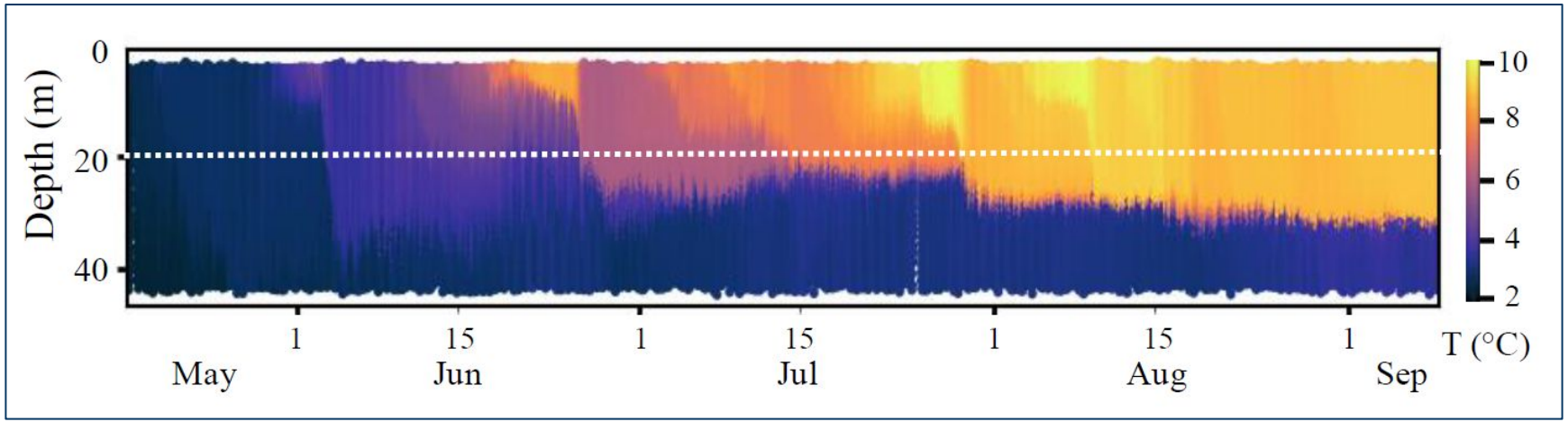

Litzow et al., p. 35

# *The cold pool (<2°C) extent was average; the coldest bottom waters (<0°C, <-1°C) were similar to a warm year*



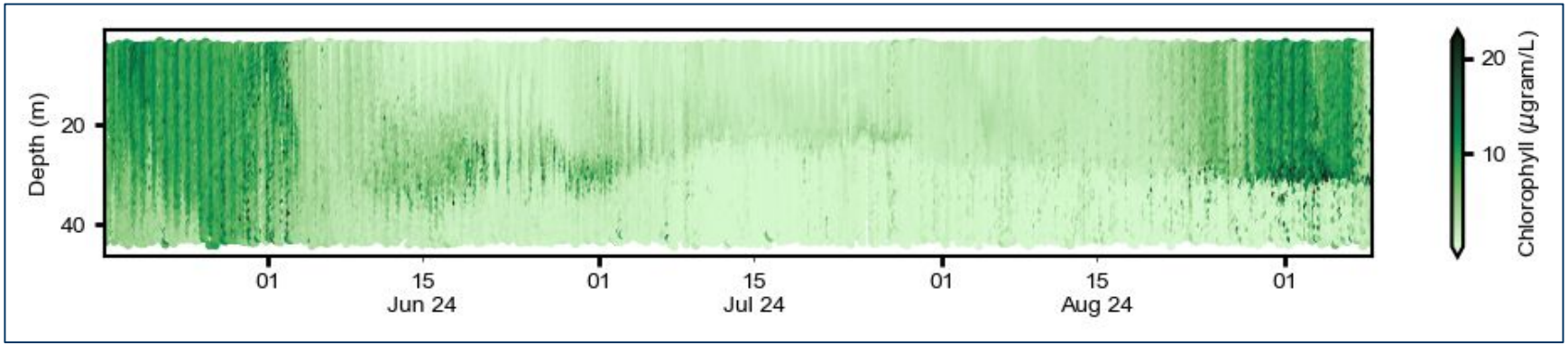

Rohan & Barnett, p. 75




- Persistent storms mixed the surface layer deeper
  - Mixed cooler water from depth
  - Same heat content as a warm year, but spread over more water
  - SSTs remained cooler

Stabeno, p. 62

# *Storms → weaker stratification & nutrients → early fall bloom*




- Persistent storms resulted in weaker stratification
  - Mixing brought nutrients to the surface
  - Early fall bloom
  - Reduced coccolithophore bloom
  - May provide a sustained prey resource for zooplankton through the fall

Stabeno et al., p. 84

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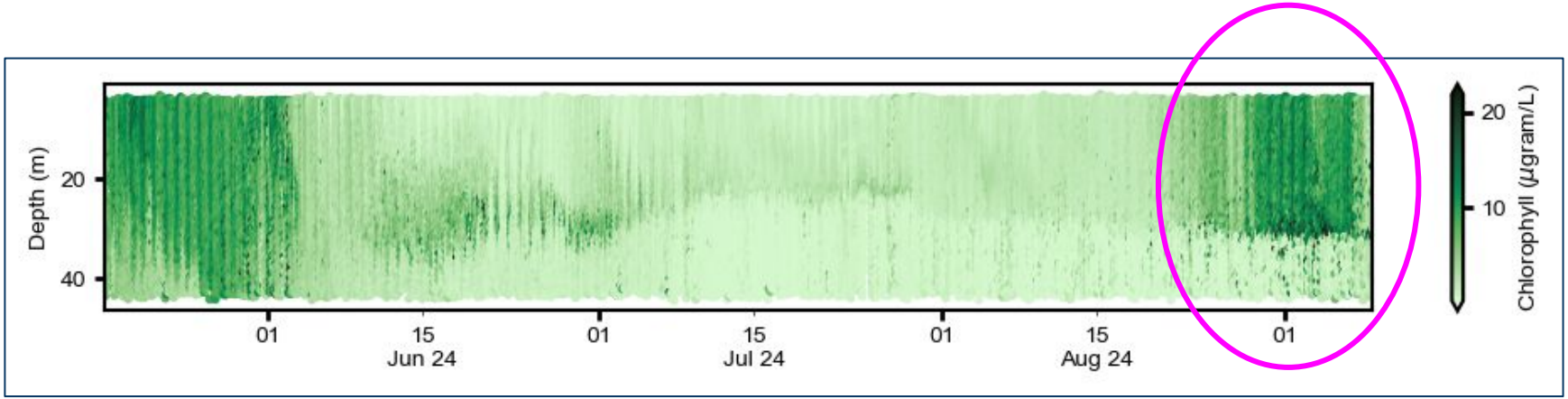


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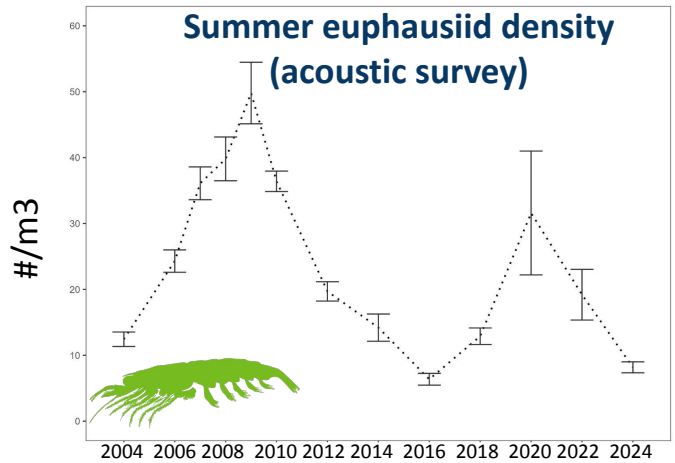
# *Pelagic prey dominated by small copepods*

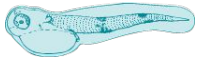
| | Spring | Summer | Fall |
|---|---|---|---|
| Small copepods | Moderate | Low | Moderate |
| Large copepods | Low | Near-zero | Near-zero |
| Small euphausiids | Near-zero | Moderate | Low |



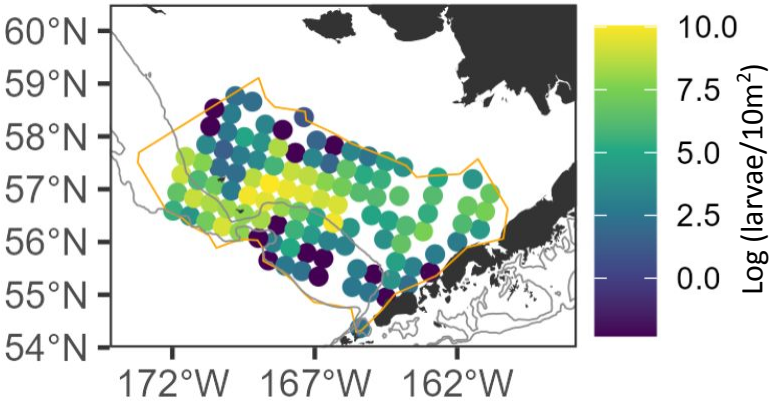

- Pelagic prey was dominated by small copepods
  - southern middle domain
- Euphausiid density (summer acoustic survey) declined to the second-lowest value
- Jellyfish biomass remained low to average
  - no significant change in competitive pressure for planktivorous predators
- Seabird reproductive success was mixed
  - higher on St. George Island than on St. Paul Island

Kimmel et al., p. 89, Levine & Ressler, p. 102, Yasumiishi et al., p. 105, Buser & Rohan, p. 107, Lindsey et al., p. 192

# *Unexpected patterns for pollock?*



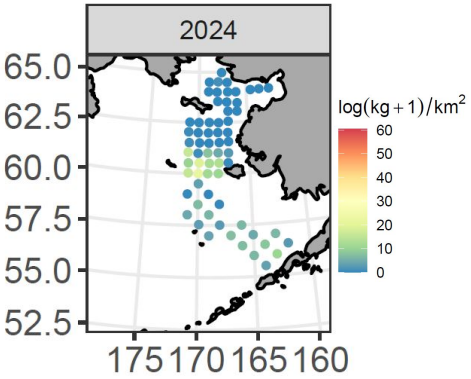
- Larval pollock (May)
  - Highest estimated abundance since 2012 (warm or cold)

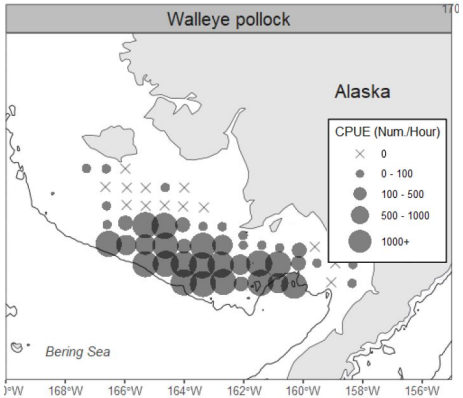



Rogers et al., p. 109, Andrews et al., p. 121, Garcia et al., p. 32, Spear & Andrews, p. 124, Aydin, p. 164

# *Unexpected patterns for pollock?*

- Age-0 pollock (late-summer)
  - Low estimated abundance (middle domain)
  - Most numerous non-salmonid (inner domain)
  - Shallower distribution (similar to warm years)

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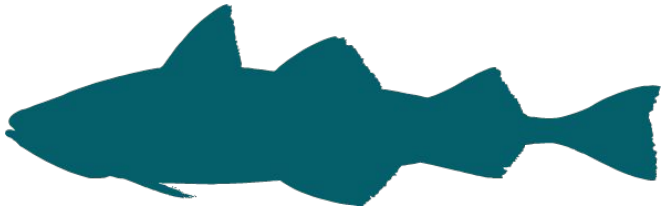
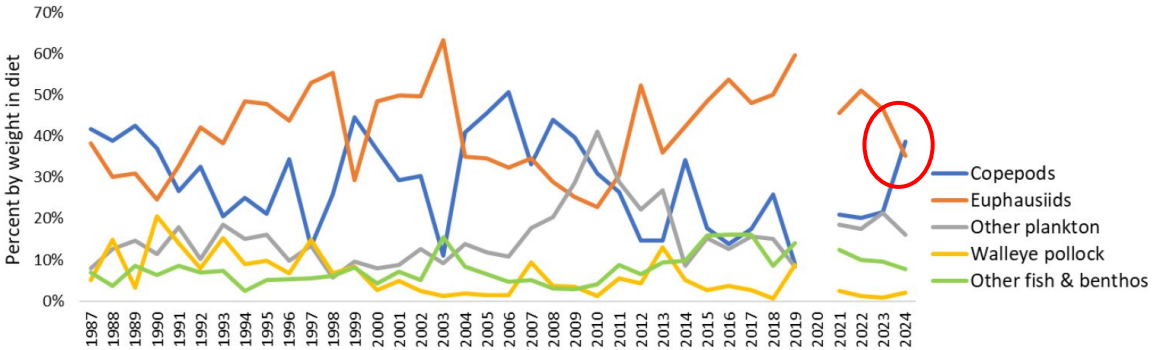


- Summer adult pollock
  - Food Habits: more copepods than euphausiids

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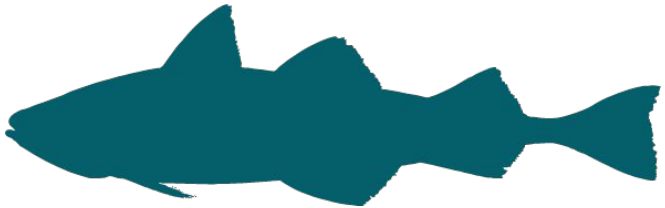

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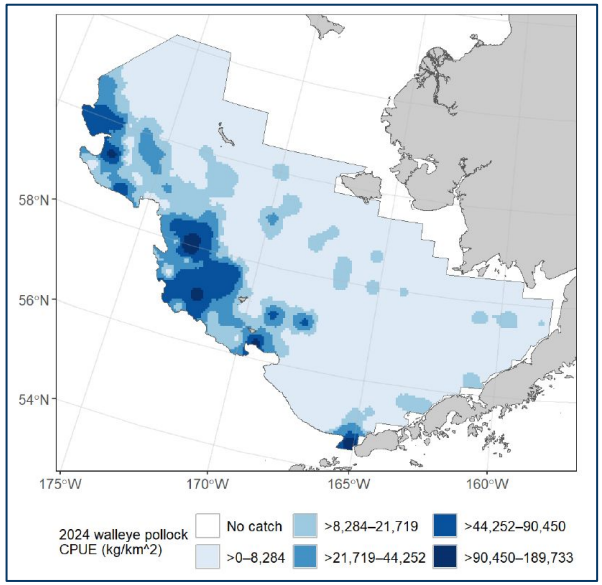


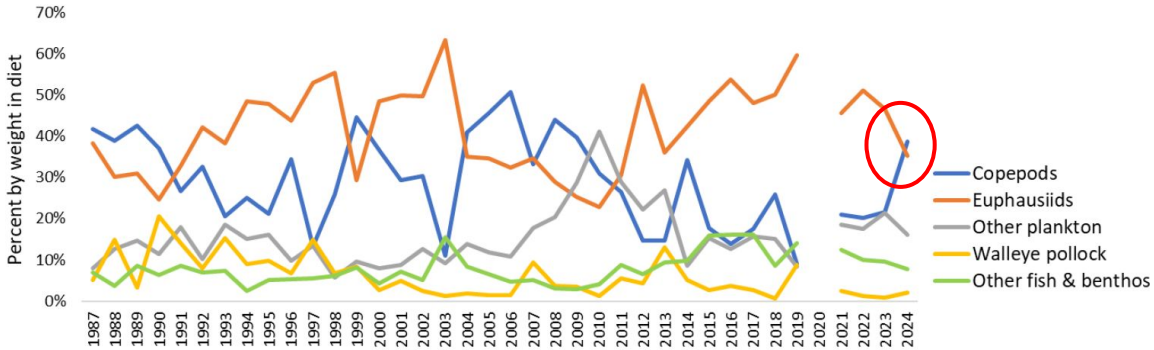


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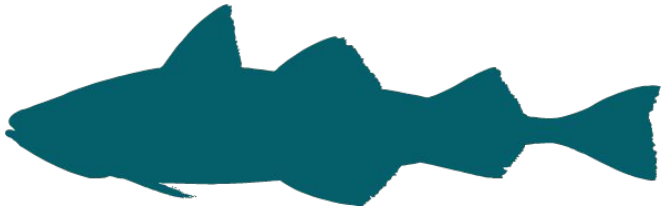

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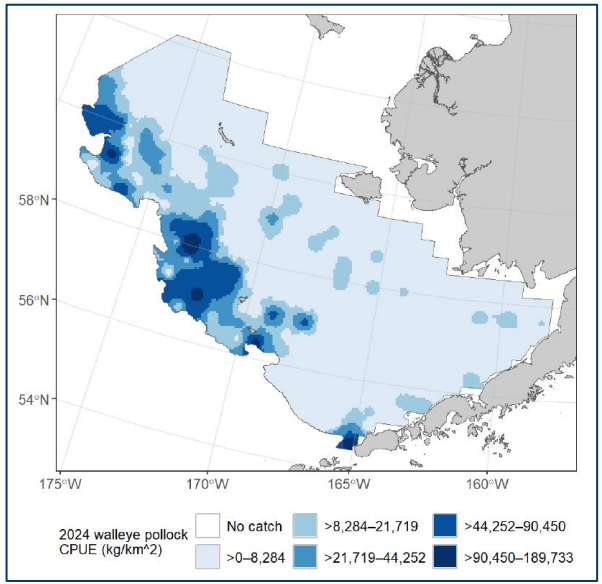
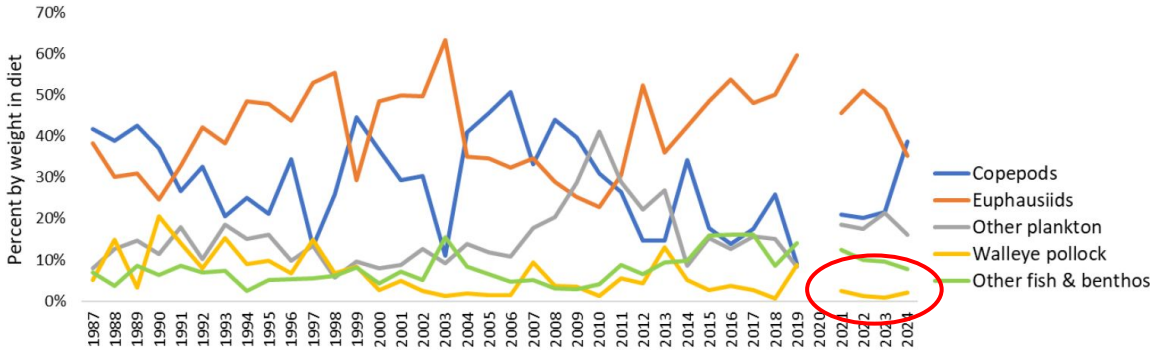
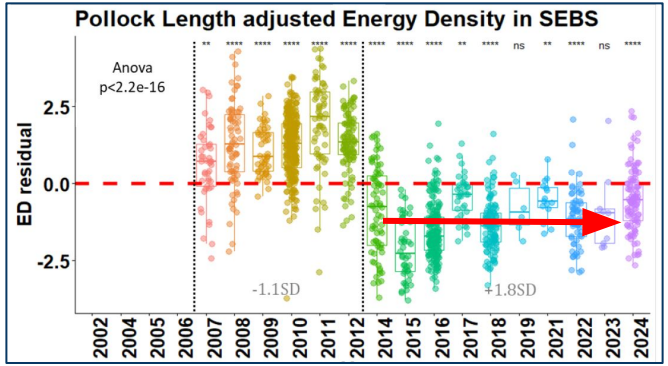
  - Rates of cannibalism low between 2021-2024

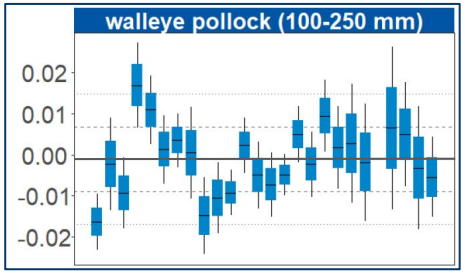


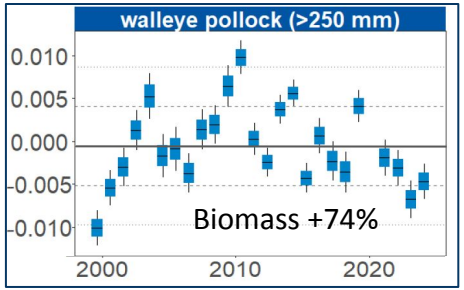



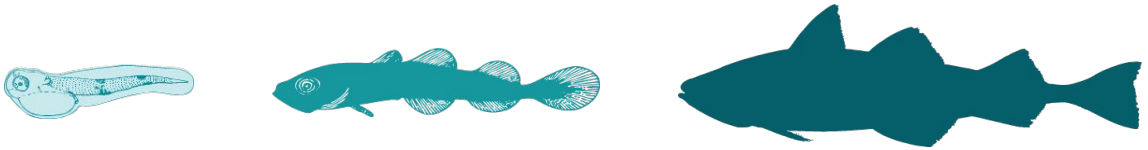

Rogers et al., p. 109, Andrews et al., p. 121, Garcia et al., p. 32, Spear & Andrews, p. 124, Aydin, p. 164

*Individual fish condition low,*
*population biomass buoyed by previous year classes*



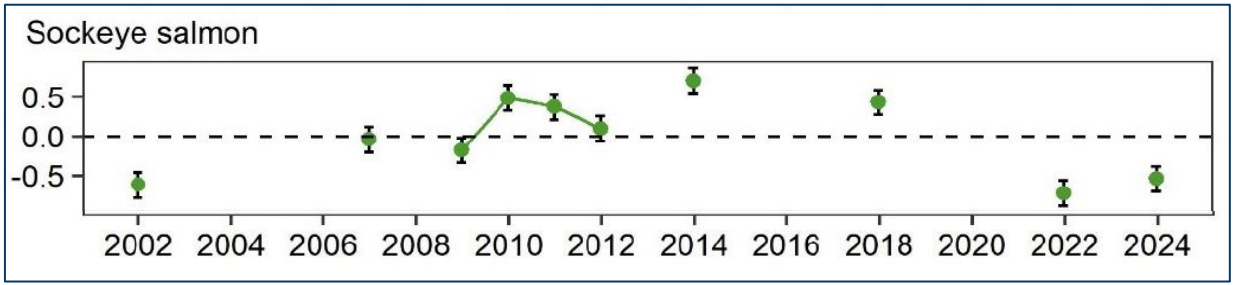



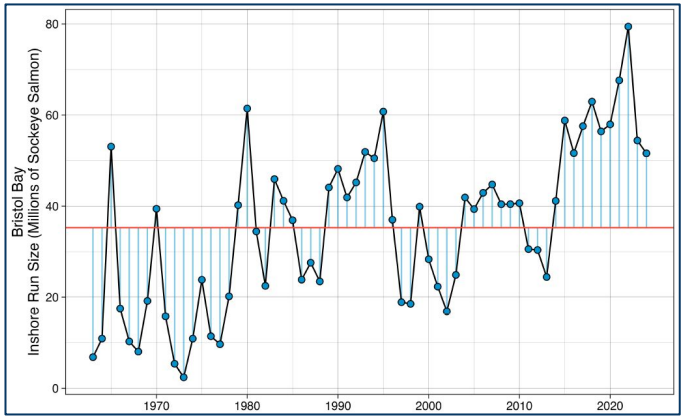



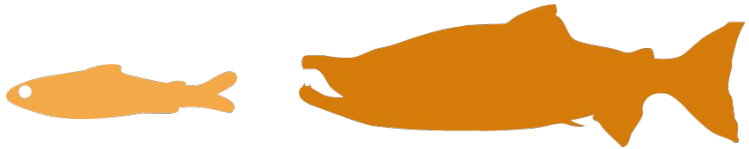
- Age-0 pollock energy density has been lower since 2014
- Age-1 & 2 pollock condition has declined since 2021
- Adult pollock condition remains below average in 2024

Page et al., p. 126, Prohaska et al., p. 156,
Fergusson et al., p. 144, Cunningham et al., p. 150

# *Individual fish condition low, population biomass buoyed by previous year classes*



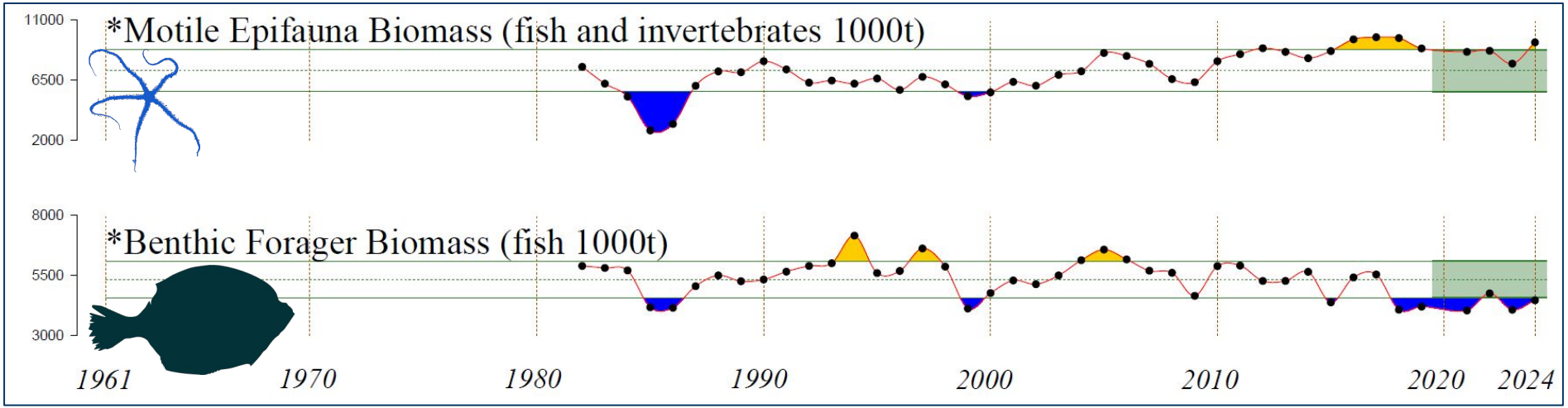



- Juvenile sockeye energy density low
- Bristol Bay sockeye abundance above average since 2015

Page et al., p. 126, Prohaska et al., p. 156, Fergusson et al., p. 144, Cunningham et al., p. 150

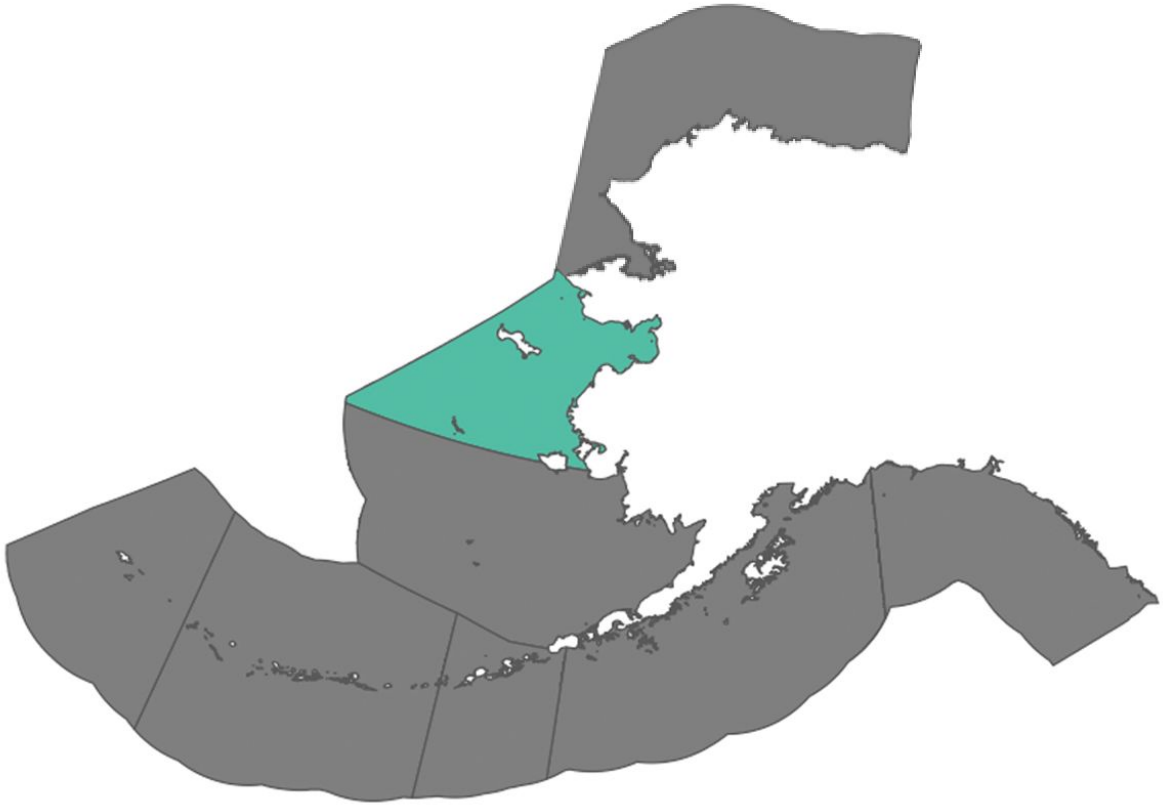
# *Benthic epifauna dominated by echinoderms*



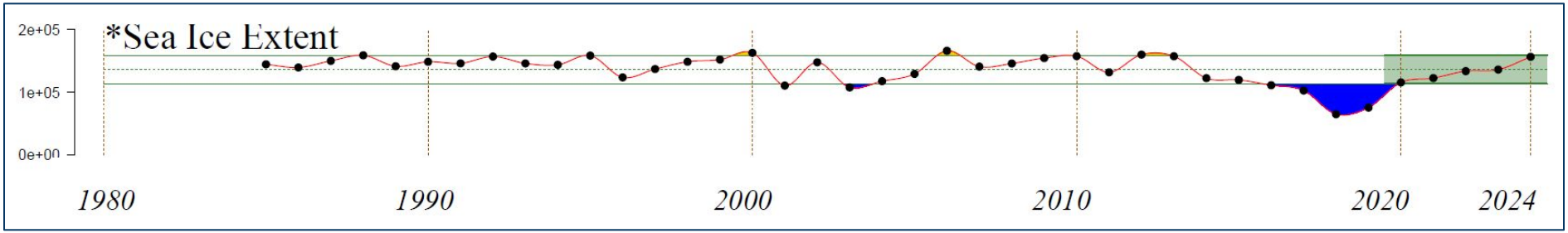

- Motile epifauna remain above the long-term mean
  - Echinoderm biomass above average
  - Crab biomass below average
- Benthic foragers (e.g., small-mouthed flatfishes) remain below the long-term mean
  - Estimates of biomass mixed in 2024 (YFS +8%, NRS +4%, plaice -3%)
  - Condition of small-mouthed flatfishes has been mixed since 2021

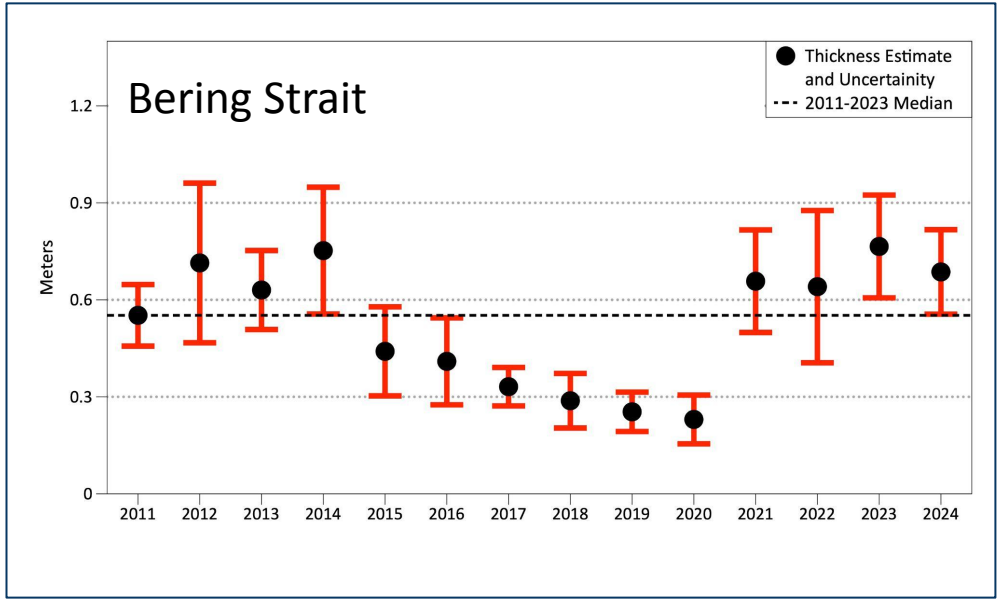
Whitehouse Fig. 2, GAP/SAP BTS, Prohaska Fig. 95

# Northern Bering Sea



# *Steady increase in sea-ice extent since 2018; step-change increase in sea-ice thickness since 2021*



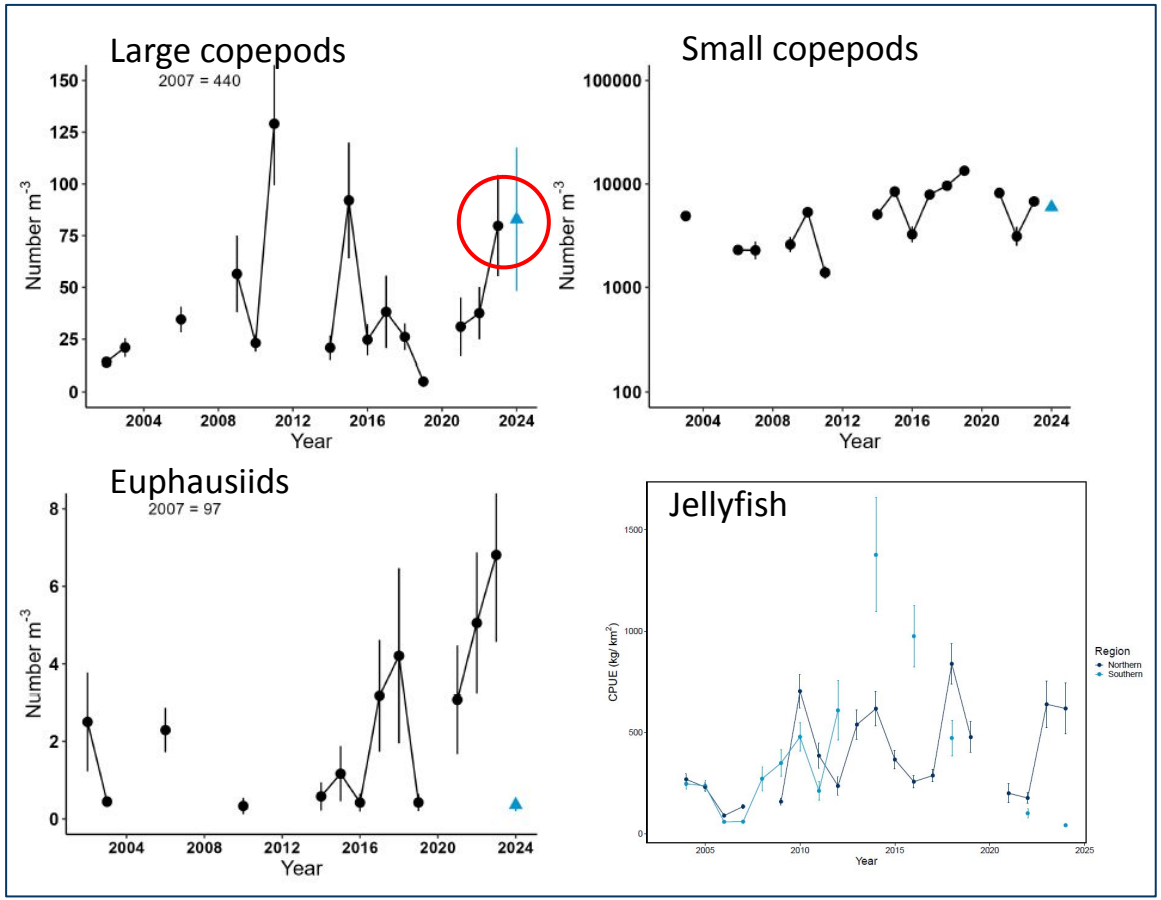




- Steady increase in ice extent since 2018
- Increase in ice thickness since 2021

Ice thickness → residency time → ice algae → productivity of NBS ecosystem

Bak-Hospital, Fig 3, Thoman, page 70

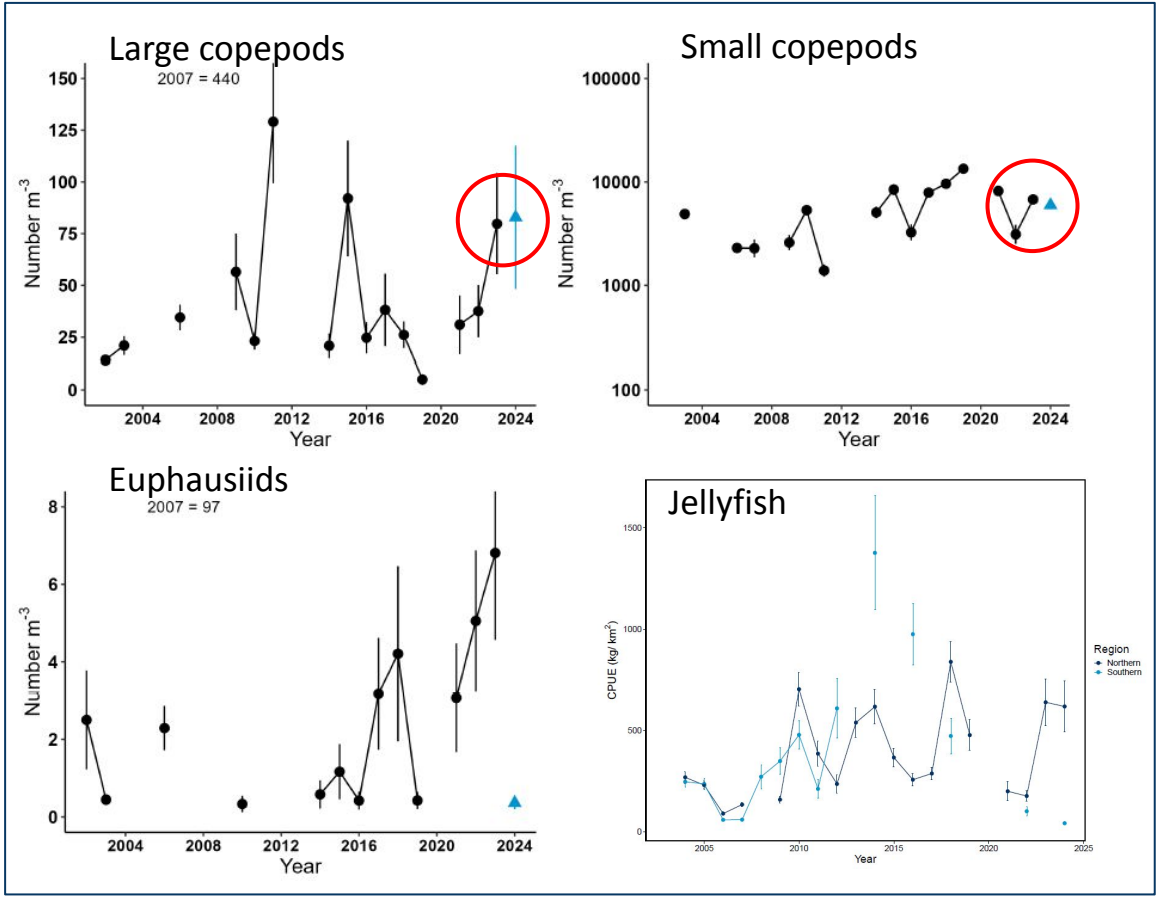
# *Signs of improved pelagic forage in 2023 and 2024*




- Large copepod abundance increased in 2023 and remained high in 2024

Kimmel et al., p. 89,
Yasumiishi et al., p. 105

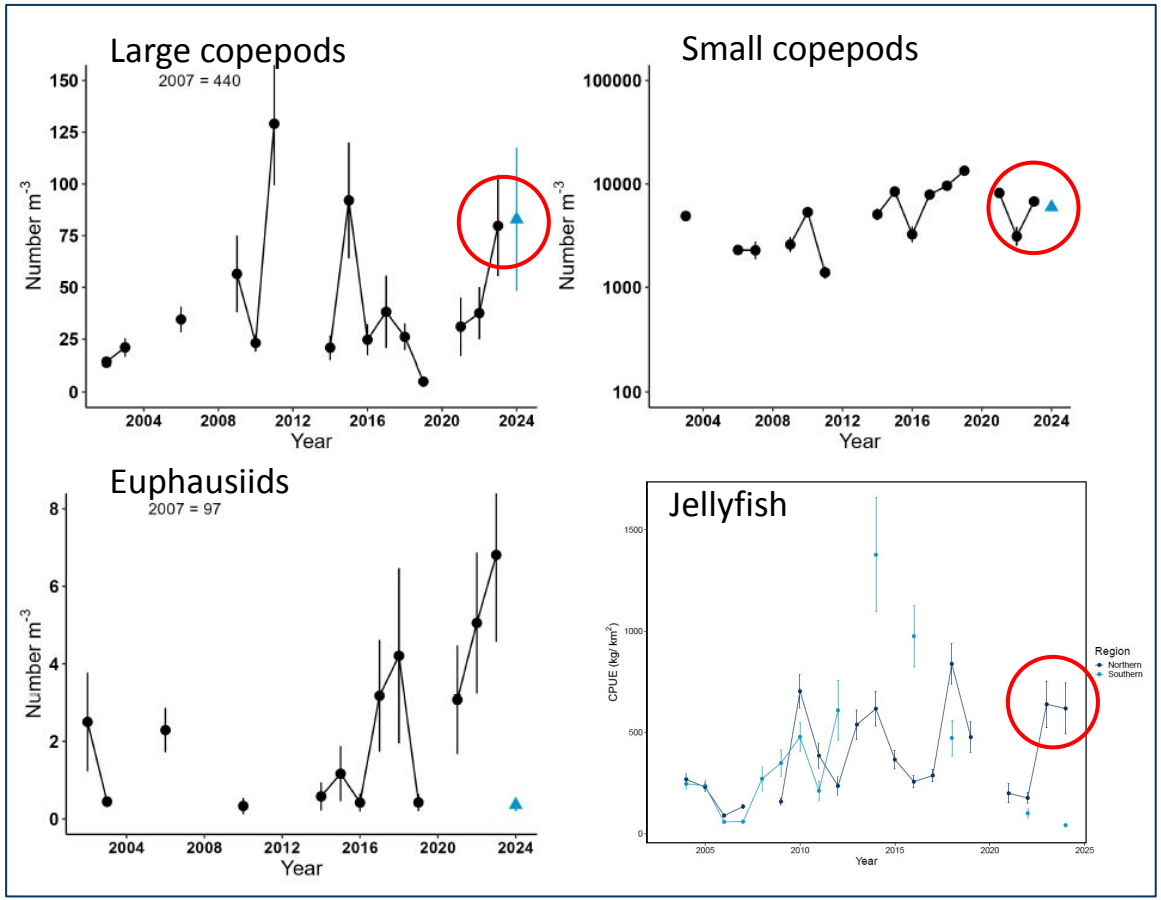
# *Signs of improved pelagic forage in 2023 and 2024*




- Large copepod abundance increased in 2023 and remained high in 2024
- Small copepod abundance remained high and shows less variability over time

Kimmel et al., p. 89,
Yasumiishi et al., p. 105

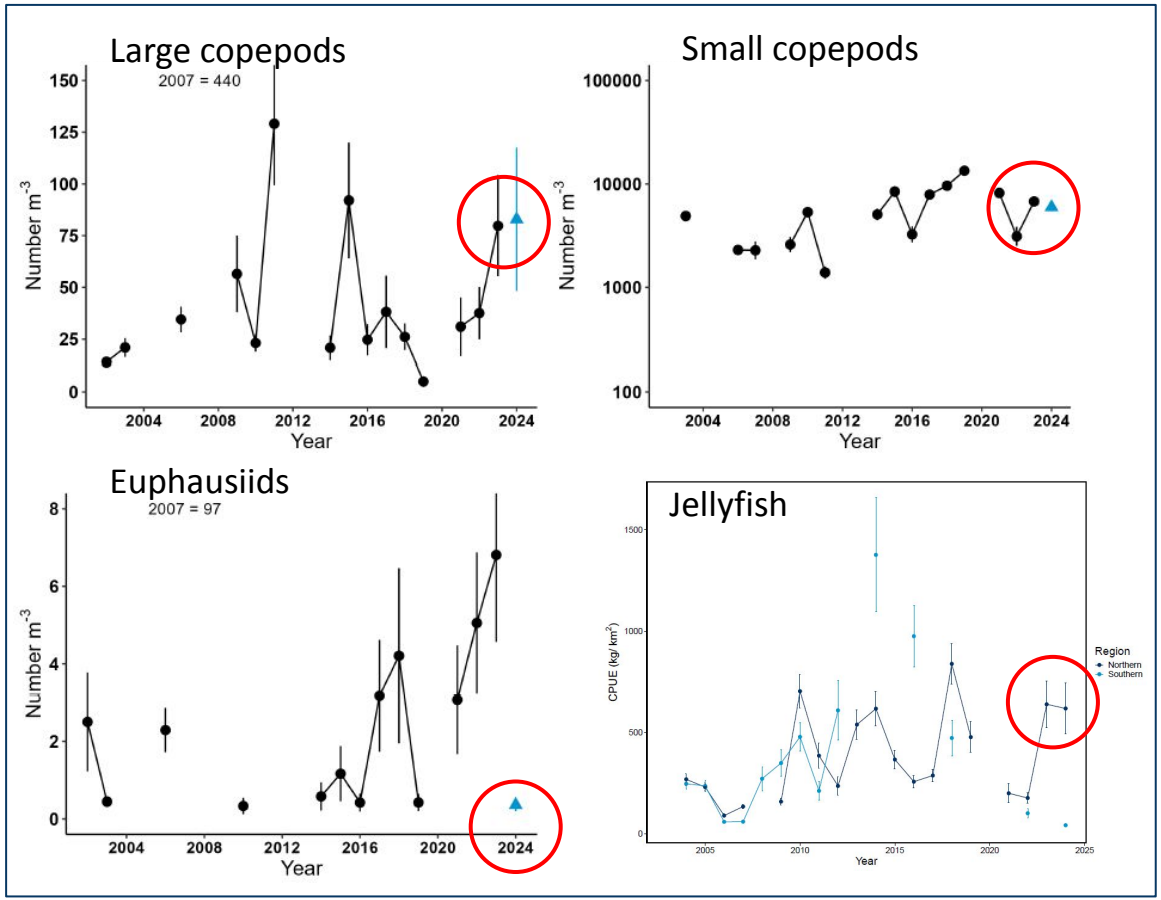
# *Signs of improved pelagic forage in 2023 and 2024*




- Large copepod abundance increased in 2023 and remained high in 2024
- Small copepod abundance remained high and shows less variability over time
- Jellyfish biomass increased in 2023 and remained high in 2024

Kimmel et al., p. 89,
Yasumiishi et al., p. 105

# *Signs of improved pelagic forage in 2023 and 2024*

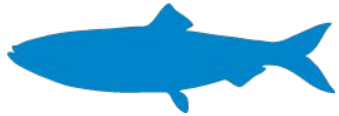



- Large copepod abundance increased in 2023 and remained high in 2024
- Small copepod abundance remained high and shows less variability over time
- Jellyfish biomass increased in 2023 and remained high in 2024
- Euphausiid abundance was near zero; ends an upward trend since 2021

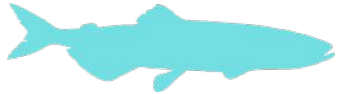
Kimmel et al., p. 89,
Yasumiishi et al., p. 105

# *Pelagic productivity has been mixed*

- Age-0 pollock
  - Low abundance, low weight, low energy density, average % lipid



- Herring abundance low

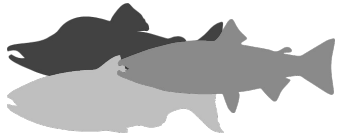


- Capelin abundance increasing; significant increase in 2024

- Juvenile Chinook salmon abundance decreasing; record low in 2024

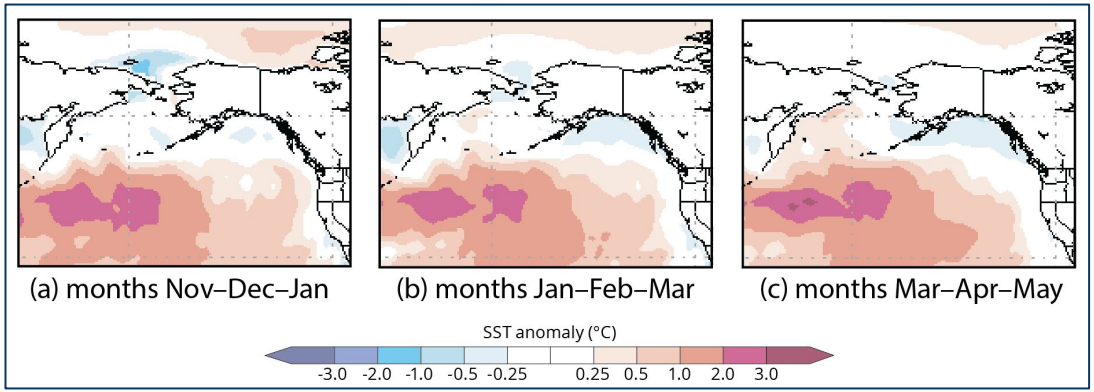
- Fall juvenile chum abundance at record high in 2024

- Juvenile pink, chum, and coho salmon condition decreased from positive to average; Chinook salmon condition increased from average to positive

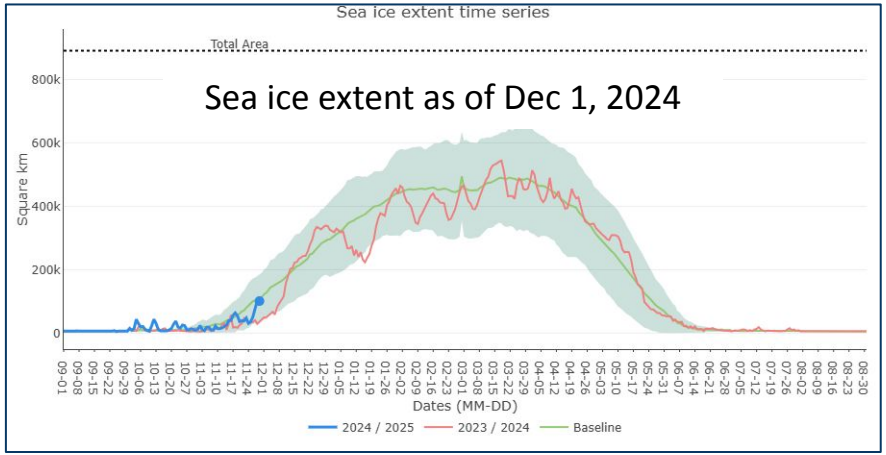


Andrews et al., p. 121, Page et al., p. 126, Andrews et al., p. 131, Murphy et al., p. 147, Fergusson et al., p. 144

# *Looking ahead to 2025*




- Expected transition to La Niña
  - continued cooler conditions (within 0.25°C of normal)




- Cooler conditions in early ice season (Oct - Dec) may contribute to earlier formation of sea ice
- But fall storms may no entrain relatively warmer water into surface layer and delay ice formation

Lemagie, Fig. 16, Bak-Hospital shinyapp

# 2024 Summary and *implications*

The Bering Sea has cooled to **average** thermal conditions

*Individual species thermal preferences may result in a new balance in the ecosystem*

**Southeastern Bering Sea: in ecological transition**

Persistent storms mixed the water column

*Cooler SSTs, but heat content similar to a warm year;*

*Increased nutrients and early fall phytoplankton bloom*

Small copepods over the middle domain; large copepods over the outer domain

*Spatial distribution of fish and match-mismatch with prey*

Benthic epifauna dominated by echinoderms

*Declines in prey quality for crabs and small-mouthed flatfishes?*

**Northern Bering Sea: some signs of recovery**

Step-change increase in sea-ice thickness since 2021

*May indicate increased platform for ice algae and increased productivity*

Signs of improved pelagic forage in 2023 and 2024

*Mixed trends in pelagic foragers since 2021*