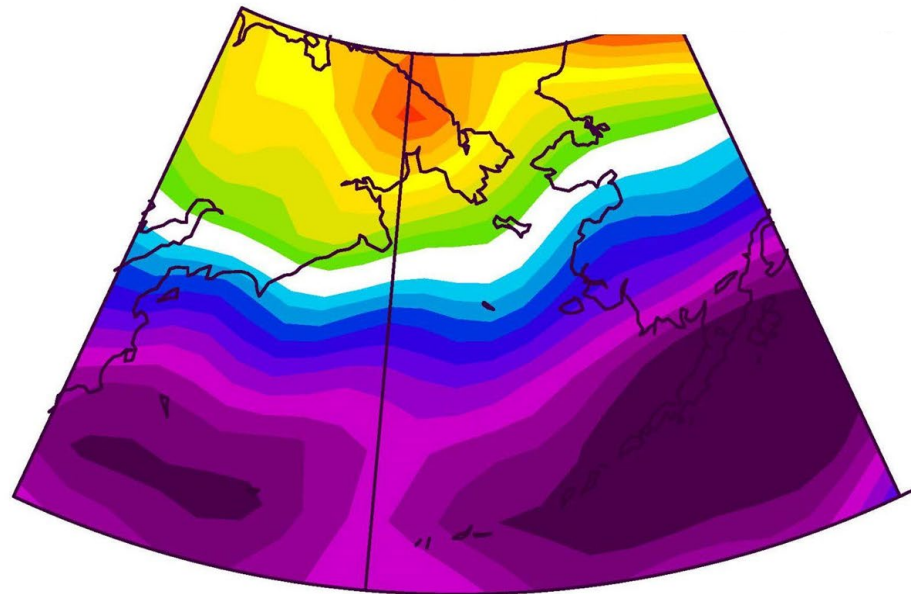


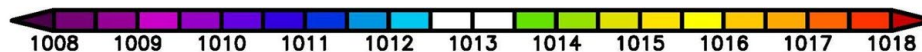
ECOSYSTEM STATUS REPORT

Scientific & Statistical
Committee
October 3, 2022

Elizabeth Siddon
Bridget Ferriss
Ivonne Ortiz
Stephani Zador



Mar to May: 2022





- 2022 Previews: Gulf of Alaska, Aleutian Islands, and Eastern Bering Sea
- 2022 EBS crab-relevant ecosystem indicators

2022 GOA Preview

Bridget Ferriss



- No emerging ecosystem concerns related to GOA groundfish to highlight for the SSC to consider between now and December **given data so far**



- Continued multi-year transition
 - marine heatwave recovery and shift to negative PDO
 - average SST with summer warming
 - signs of above average productivity at lower trophic levels
 - mixed trends in upper trophic levels

~ average/good conditions for most groundfish

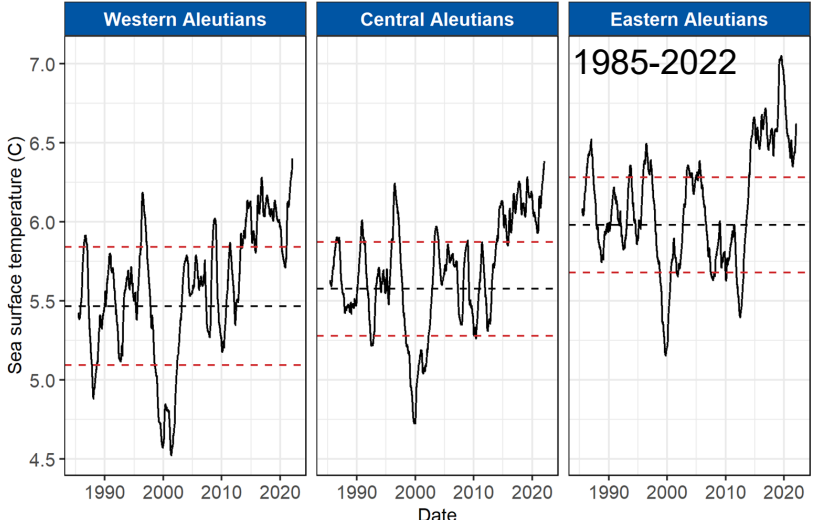
- Invasive green crab in SEAK

~ potential impacts on nearshore shellfish and eelgrass habitat



2022 AI Preview

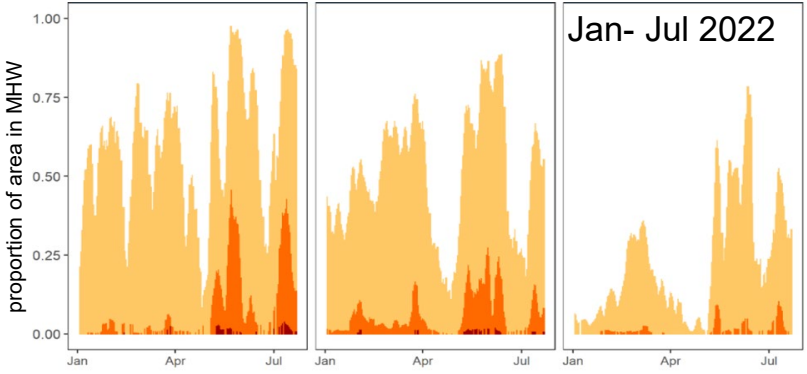
Ivonne Ortiz



Sustained sea surface temperature above 1985-2014 mean starting 2013

- Jan-Sep MHW in WAI, CAI; summer in EAI

Sustained BTS bottom temperature above 1994-2022 mean starting 2014



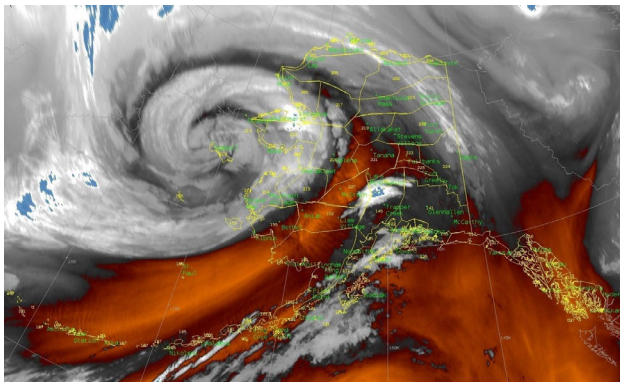
Expected:

- Stronger MHW impacts in WAI and CAI
- Cumulative effects: increased feeding and bioenergetic costs, faster growth rates, changes in prey timing and availability

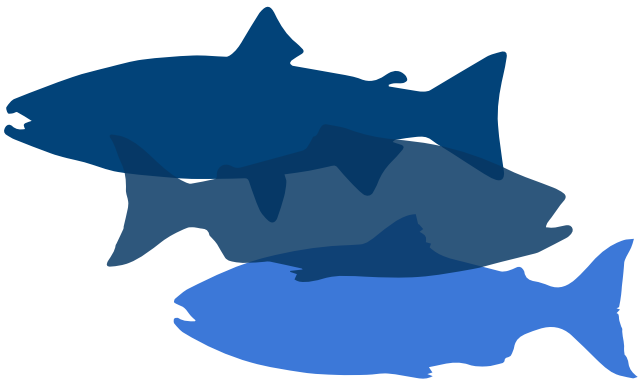
given data so far

2022 EBS Preview

Elizabeth Siddon

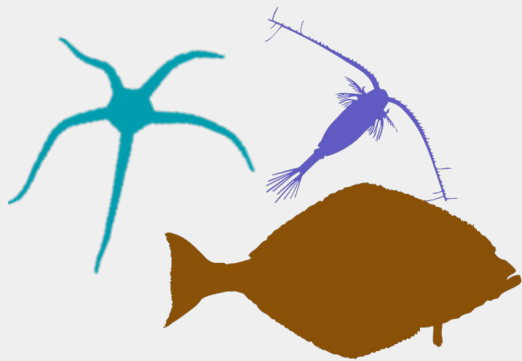


- Typhoon Merbok
 - *Known impacts* to hunting and fishing camps; subsistence harvest season.
 - *Potential impacts* to the ecosystem (e.g., disturbance of HAB cysts).

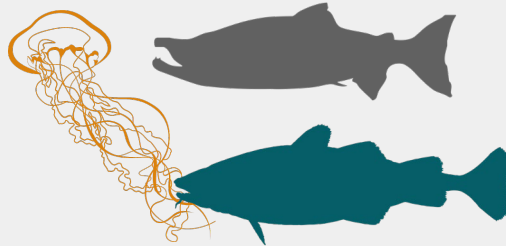


- Western Alaska salmon run failures
 - Continue to examine potential ecosystem drivers.
 - Integrative approach with community perspectives.

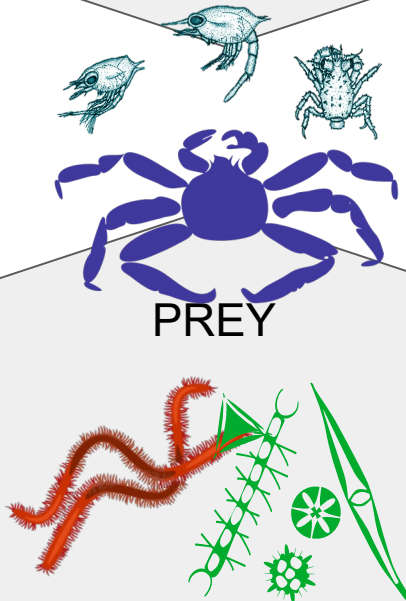
COMPETITORS



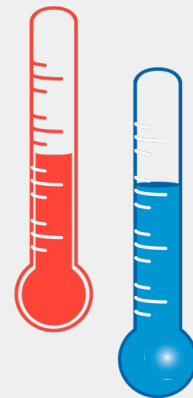
PREDATORS



PREY



ENVIRONMENTAL PROCESSES



The combination of 3 climate indices (positive NPI and AO, La Niña) meant a return to more average SST conditions for the EBS shelf.

- **NPI** has been positive for 5 of last 6 winters (i.e., weak ALPS and calmer conditions).
- Positive **AO** since spring 2021; usually means cold temps, but 2021-2022 had near-normal temps.
- Continuation of La Niña conditions into 2023.

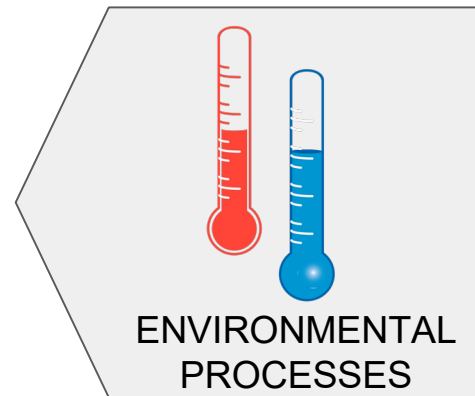
Bond (slides 20-21)

- Since fall 2021, SSTs largely similar to the long-term mean in fall, winter, and spring. SSTs were slightly above average in summer.
- This past year, MHWs have been infrequent and brief compared to recent years.

Lemagie & Callahan (slides 22-23)

- Winter 2022 had winds that were more northerly than the long-term average (first winter since 2017).

Thoman (slide 24)

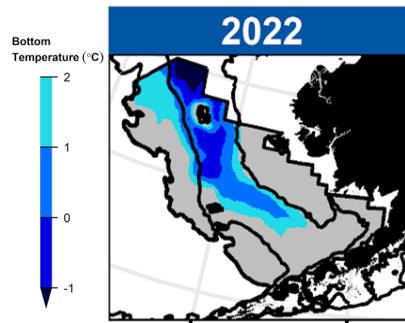
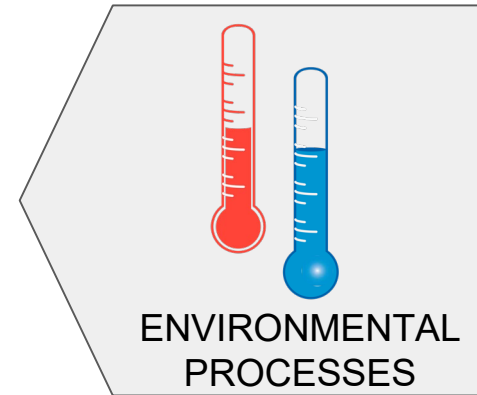


*Sea ice extent was above the median for much of the winter,
but ice thickness was less than 2021 across the NBS.
The cold pool was similar to other average-to-cool years.*

- Rapid sea ice growth in November followed by dramatic ice loss in April.
- Early season ice extent was the highest since 2012.
- Ice thickness was lower than 2021 in all NBS areas.
- 2022 cold pool was near the historical average and resembles other average-to-cool years, most similar to 2017.

Thoman (slides 25-30)

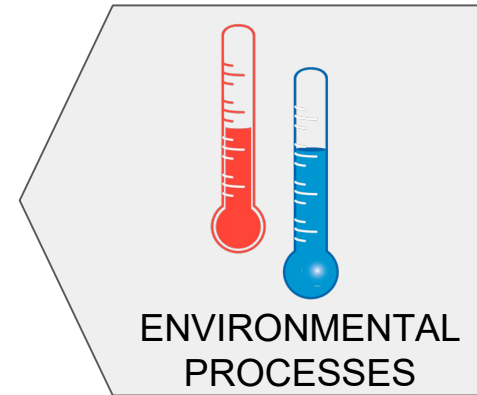
Kearney, Rohan & Barnett (slides 31-33)



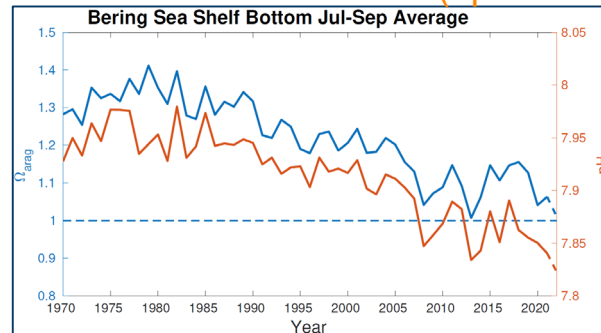


Expansion of bottom water conditions (pH and aragonite) experimentally shown to negatively impact pteropods and red king crab.

- Bottom pH and aragonite saturation have decreased at a rate comparable to the global oceans due to OA.
- 2022: relatively lower pH for most of outer/middle shelves and near Bering Strait.
- Long-term decrease means expansion of bottom water conditions experimentally shown to negatively impact growth and survival of pteropods and red king crab.



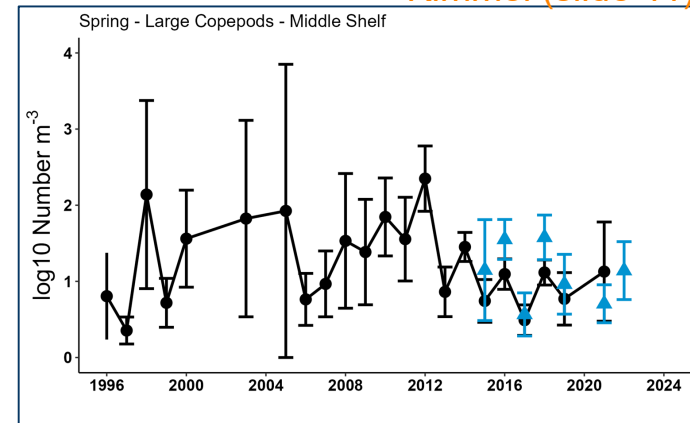
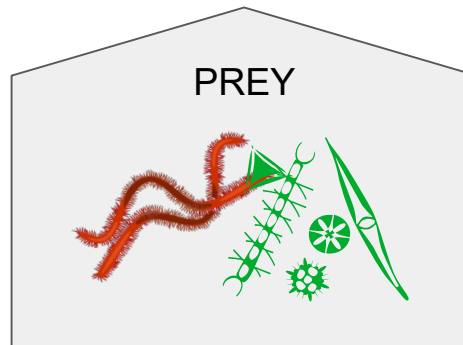
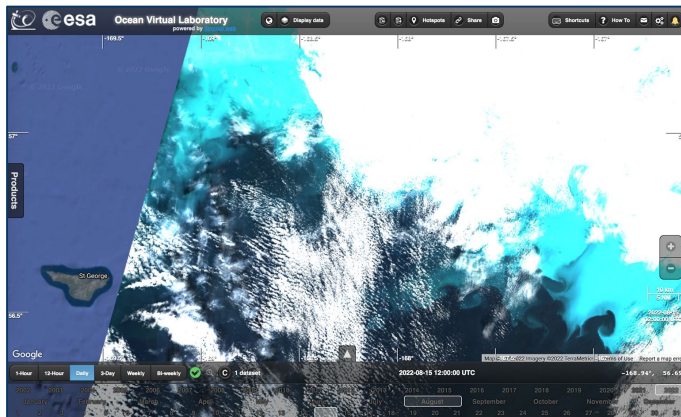
Pilcher & Cross (updated since CPT)





Mixed trends for prey productivity (*given data so far*).

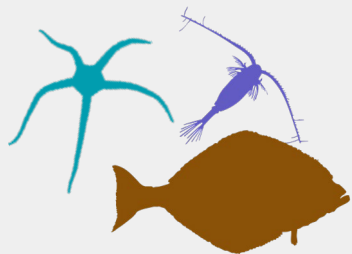
- Chl-a biomass trends are close to the long term average over much of the shelf (with few exceptions) and the bloom timing appears average. Nielsen (slide 39)
- A noticeable coccolithophore bloom. Gann & Lange (slide 40)
- Spring copepods were more abundant in 2022 than 2021, particularly small copepods. *Calanus* were low in lipid. Kimmel (slide 41)



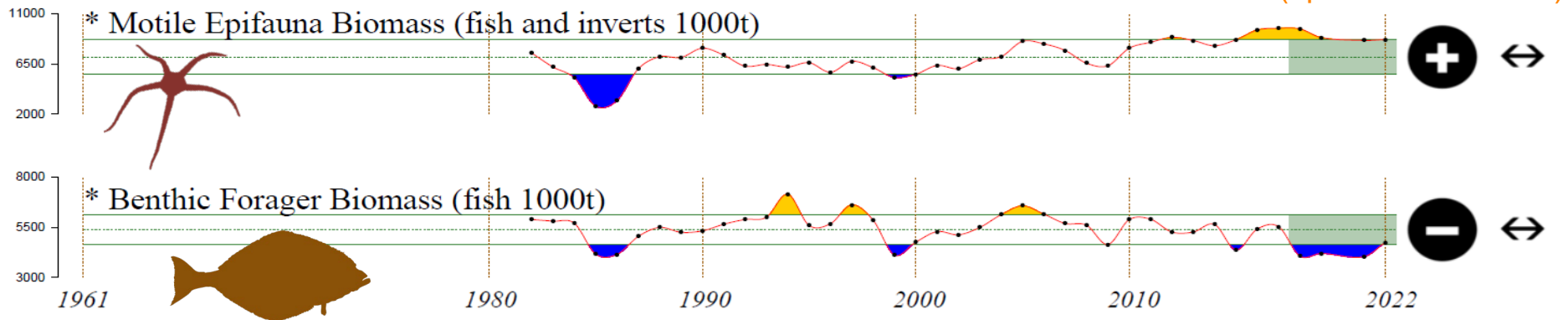


Competitors for pelagic crab increased in 2022.
Competitors for benthic crab remained high or increased in 2022.

COMPETITORS



- Motile epifauna biomass peaked in 2017 and remained above the long-term mean in 2022, driven by brittle/sea stars and other echinoderms.
- Benthic forager biomass was at the lowest level in the time series in 2021, but increased 18% in 2022, with increases in the four dominant species.



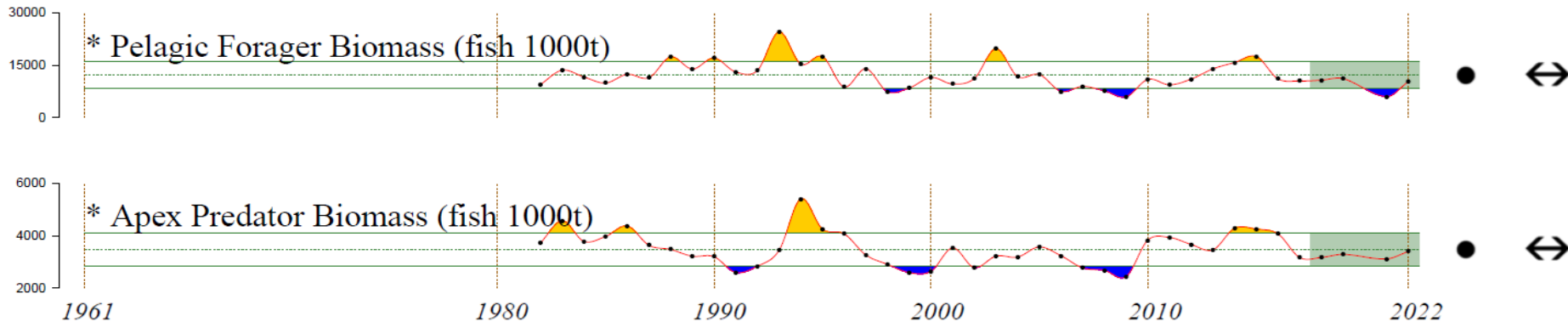
Predators of both pelagic and benthic crab increased in 2022.



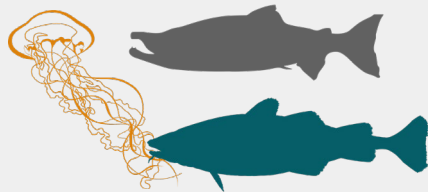
PREDATORS

- Pelagic foragers increased from 2021 to 2022 (+70%), driven by pollock and herring.
- Apex predators increased from 2021 to 2022, driven by PCod and ATF.

Whitehouse (updated since CPT)



Predators of both pelagic and benthic crab increased in 2022.

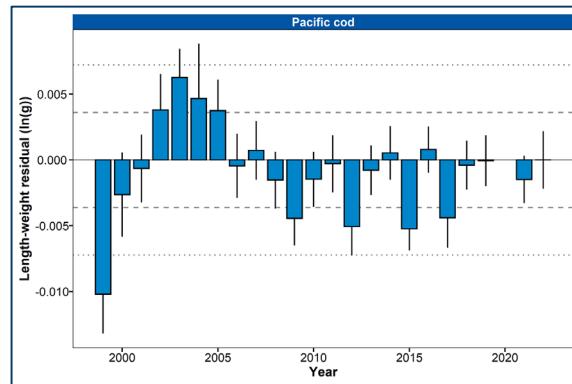


PREDATORS

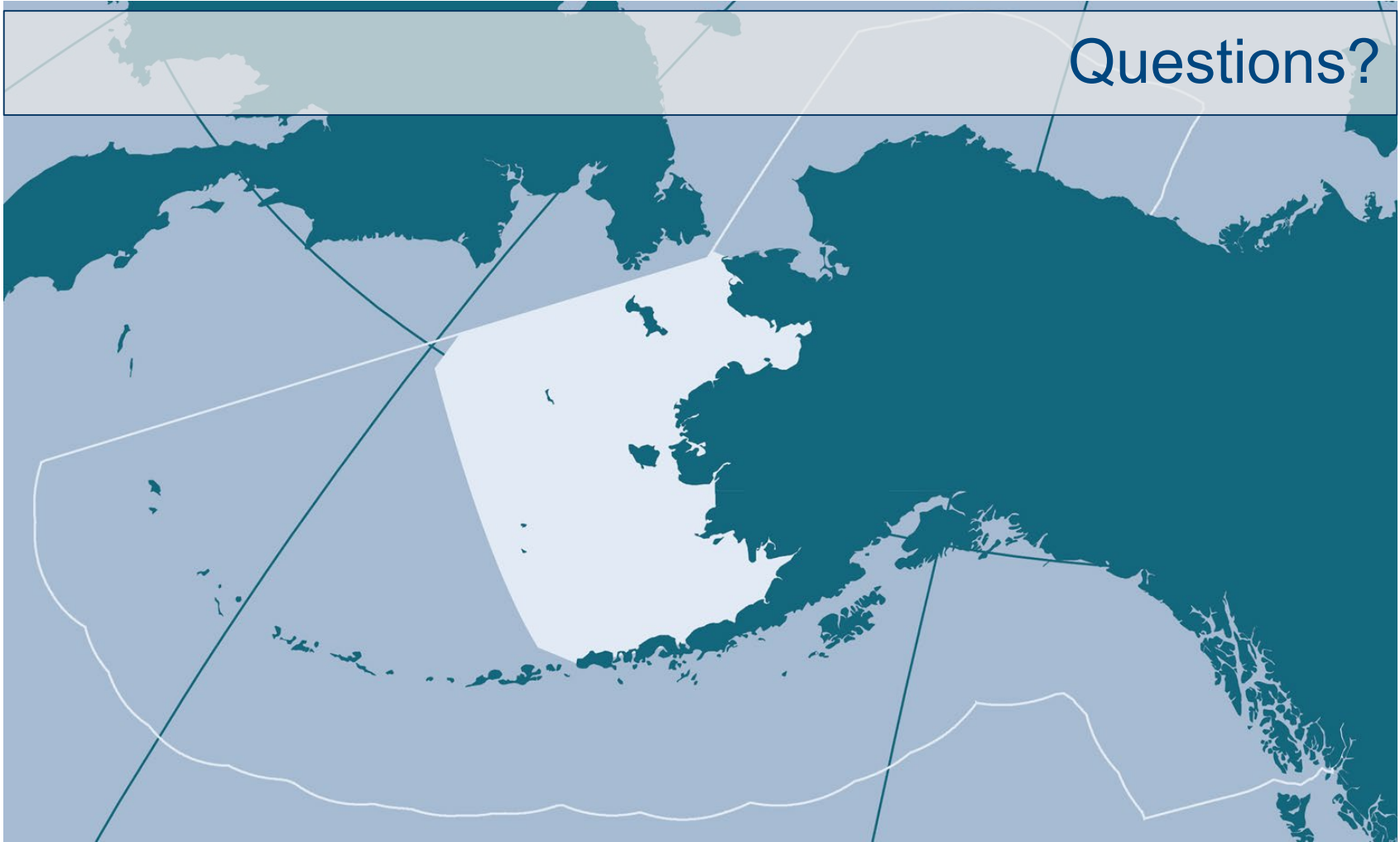
- 2022 fish condition of PCod was average for the EBS survey area, an improvement from below-average condition in 2021.
- 2022 was largest Bristol Bay sockeye run on record (>78 mil). Small size-at-age and higher than expected proportion of 1.3 fish.

Rohan & Prohaska (updated since CPT)

Cunningham (slide 48)



Questions?



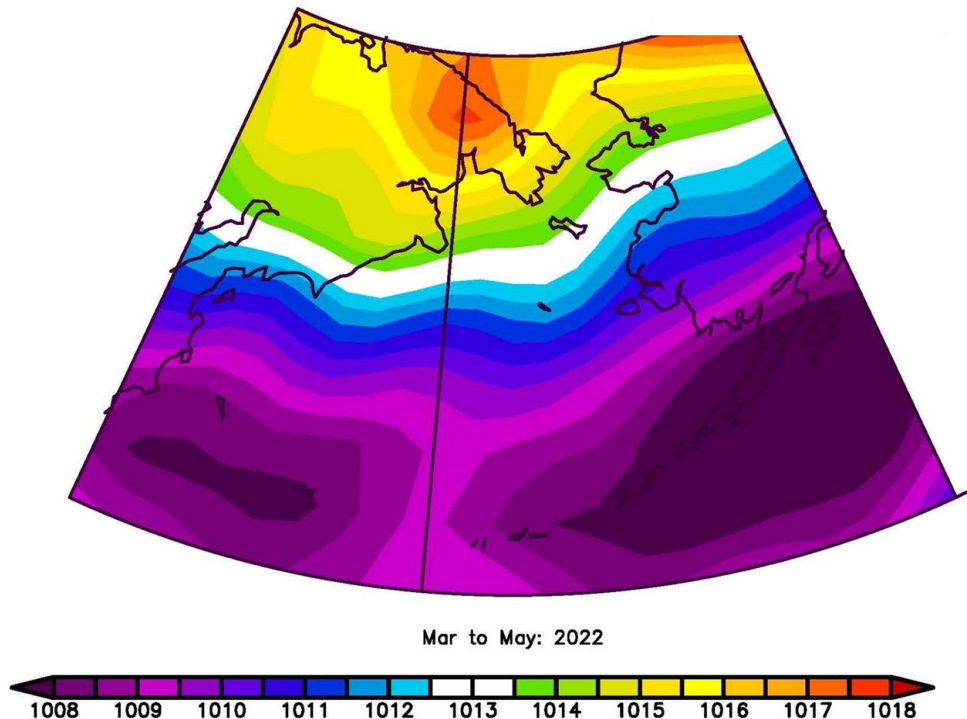
ECOSYSTEM STATUS REPORT

NPFMC Crab Plan Team
September 12, 2022

Elizabeth Siddon



NCEP/NCAR Reanalysis
Sea Level Pressure (mb) Composite Mean





Crab-relevant ecosystem information

- Pelagic and benthic stages
- Environmental processes, prey, competitors, predators
- 2022 (where available) in context

pelagic larval indicators

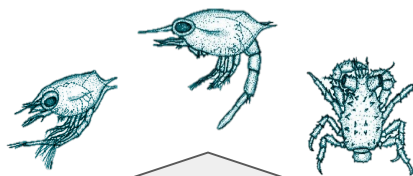
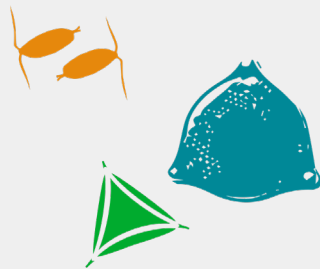
COMPETITORS



PREDATORS



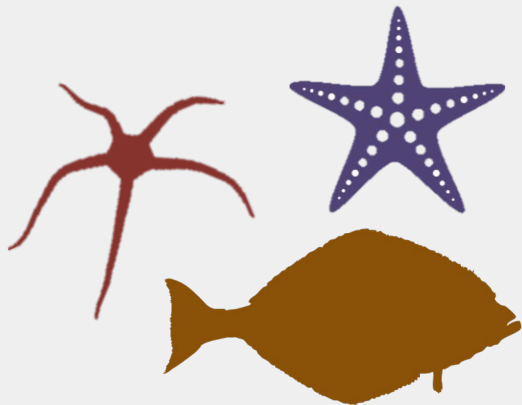
PREY



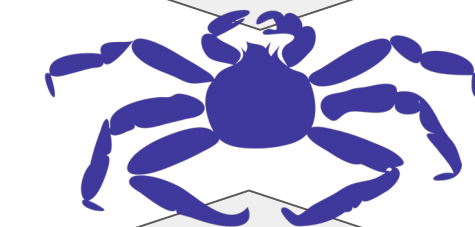
ENVIRONMENTAL PROCESSES

benthic juvenile/adult indicators

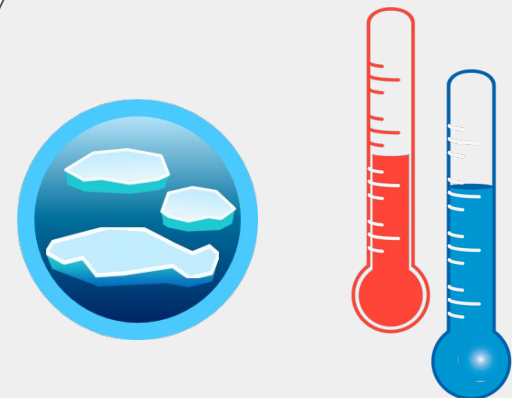
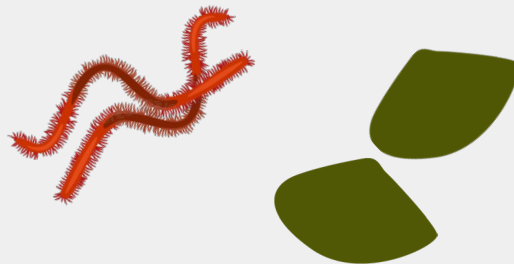
COMPETITORS



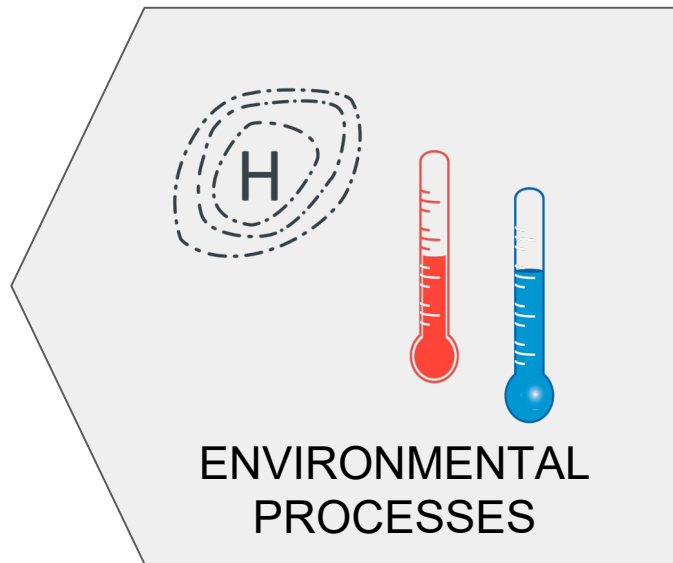
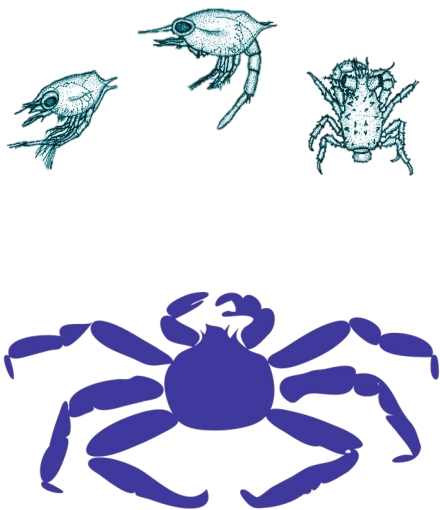
PREDATORS



PREY

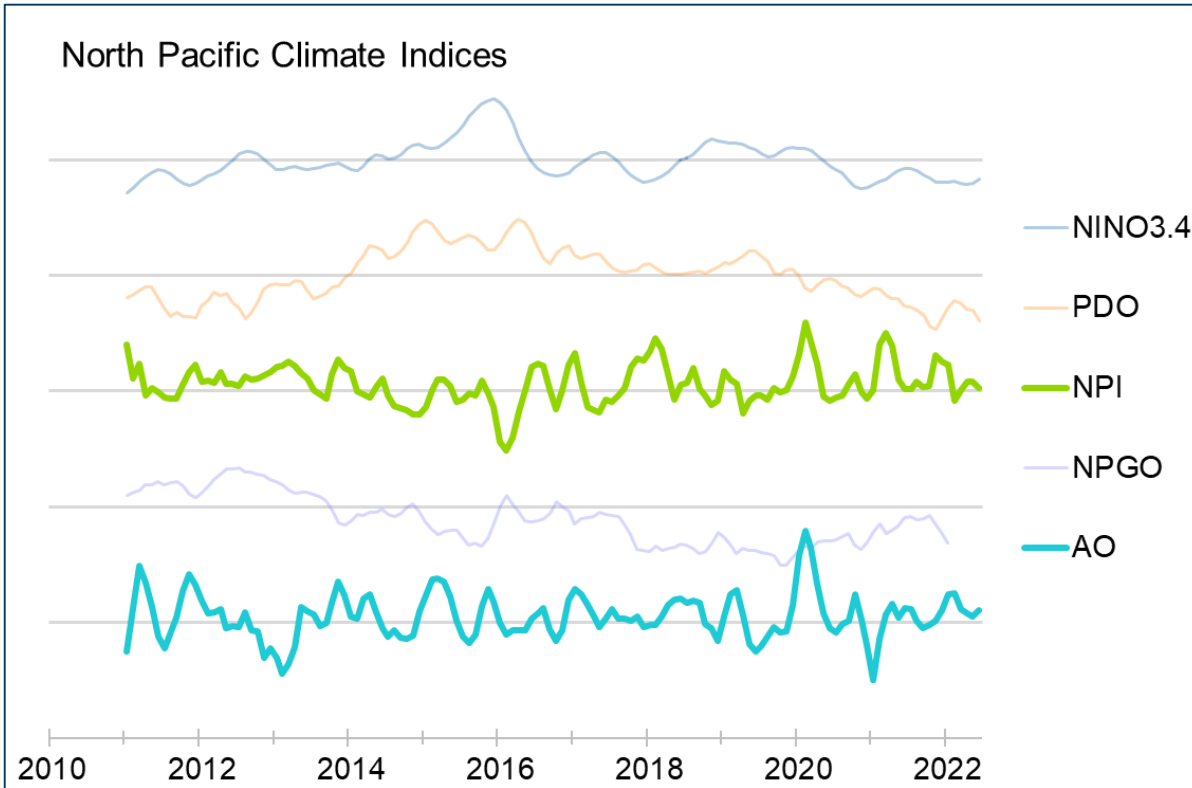


ENVIRONMENTAL PROCESSES



Climate Indices

Bond

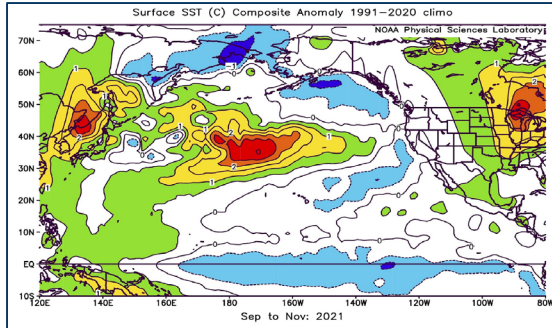


- **NPI** reflects the ALPS; Positive values mean weak ALPS and calmer conditions.
- **NPI** has been positive for 5 of last 6 winters.
- The **AO** measures the polar vortex; mostly positive since the spring of 2021.
- Positive **AO** in winter usually means cold temps, but 2021-2022 had near-normal temperatures.

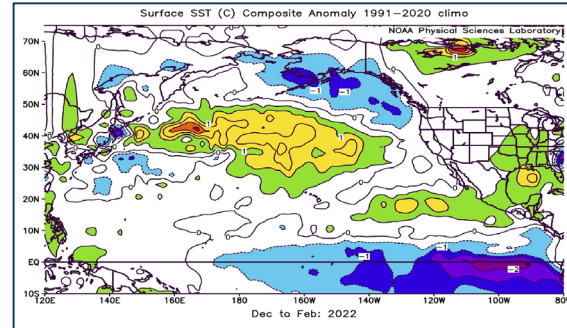
Sea Surface Temperature Anomalies

Bond

Cool conditions over the middle domain; average for the inner/outer domains.



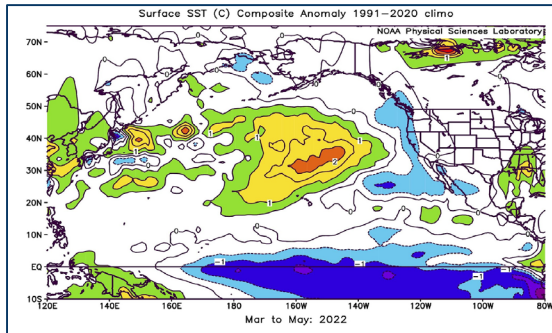
Fall 2021



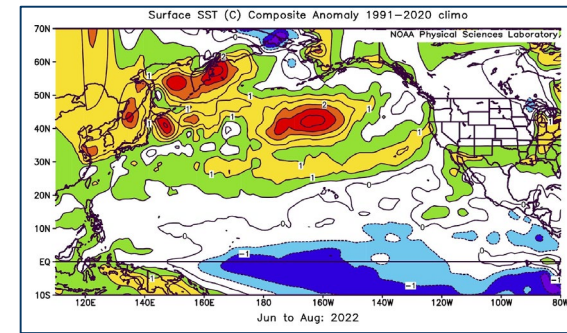
Winter 2021/2022

Quite cold SSTs in SEBS (inner shelf $>2^{\circ}\text{C}$ below normal).

Less cool conditions over the EBS shelf.

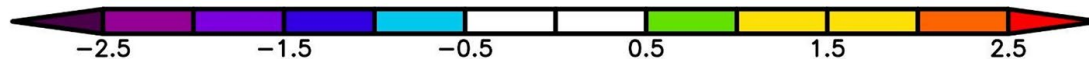


Spring 2022



Summer 2022

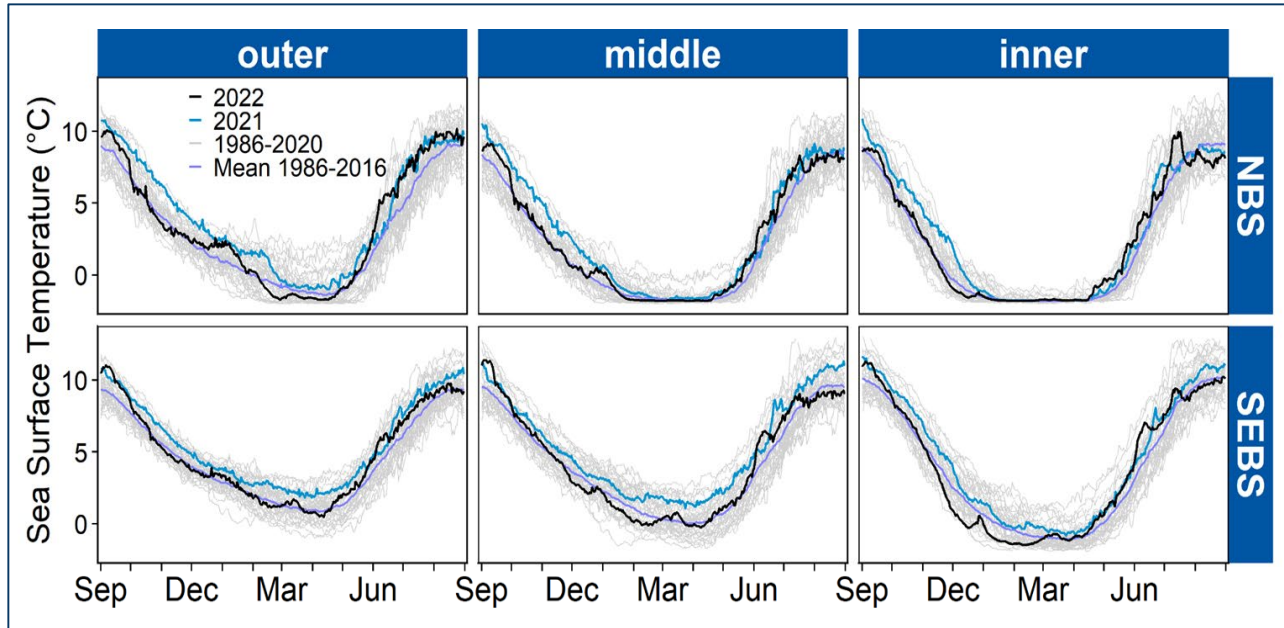
Modest warming driven by warm air temperatures in coastal Alaska.



From NOAA's Optimum Interpolation SST analysis

Sea Surface Temperature

Lemagie & Callahan

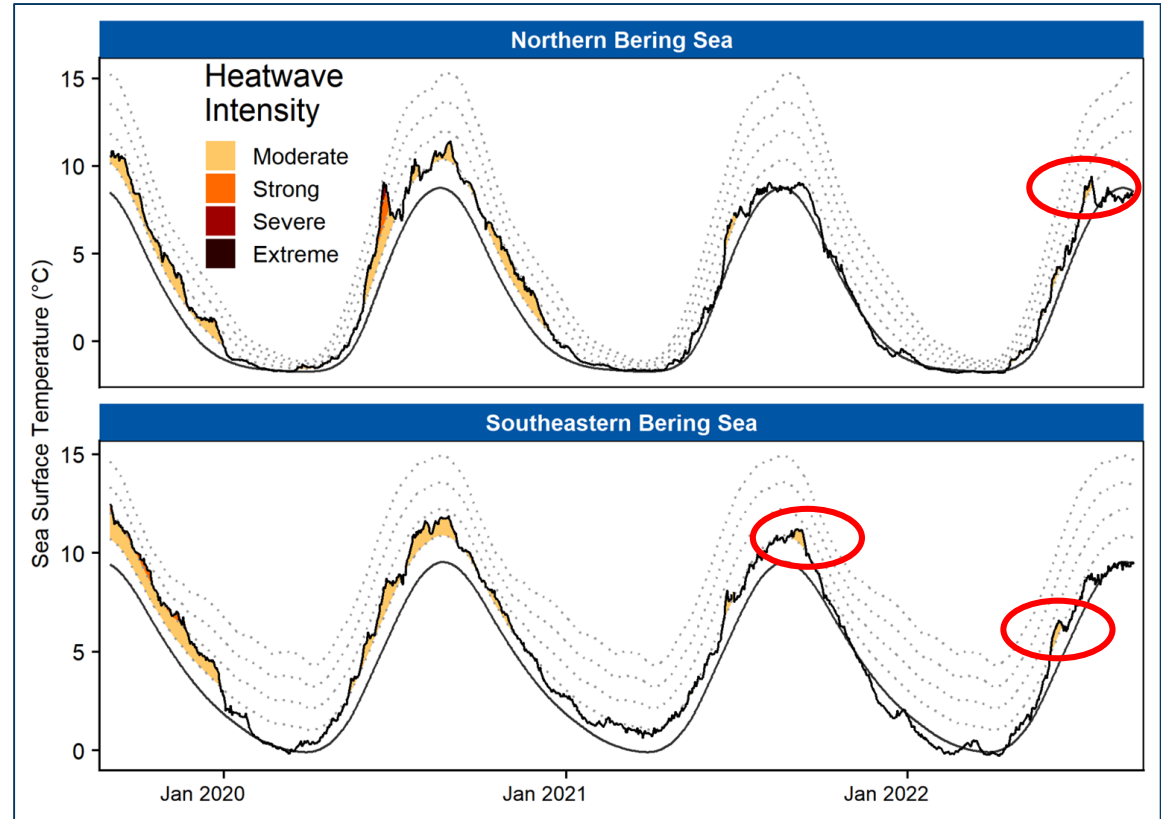


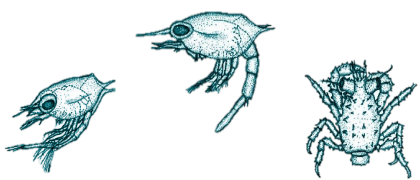
- SSTs largely similar to (and in some cases below) the long-term mean in fall, winter, and spring.
- SSTs were slightly above average in summer.

Marine Heatwave Index

Lemagie & Callahan

- MHWs in 2022 have been infrequent and brief compared to recent years.
- No MHWs occurred between early fall 2021 and mid-spring 2022.

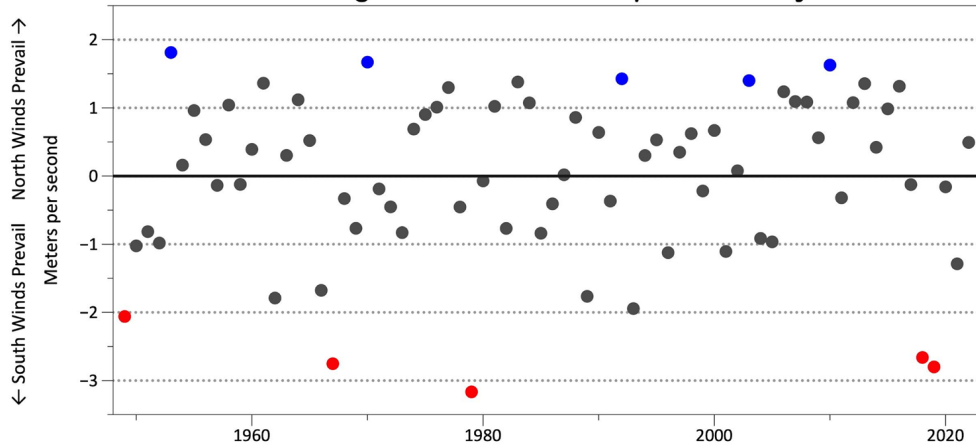




Winter Winds

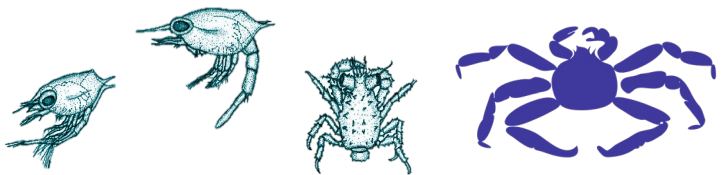
Thoman

November through March, 1948-49 through 2021-22
Eastern Bering Sea
Average North-South Wind Speed Anomaly



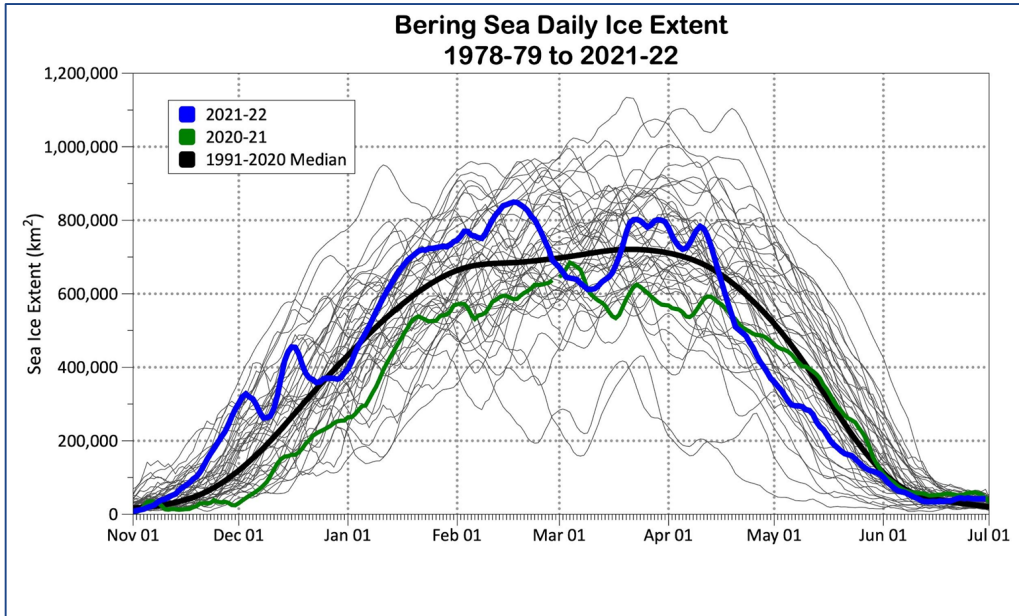
- Winter 2020 had winds near the long-term average.
- Winter 2021 had winds that prevailed from the south.
- Winter 2022 had winds that were more northerly than the long-term average (first winter since 2017).

● 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.



2022 Sea Ice

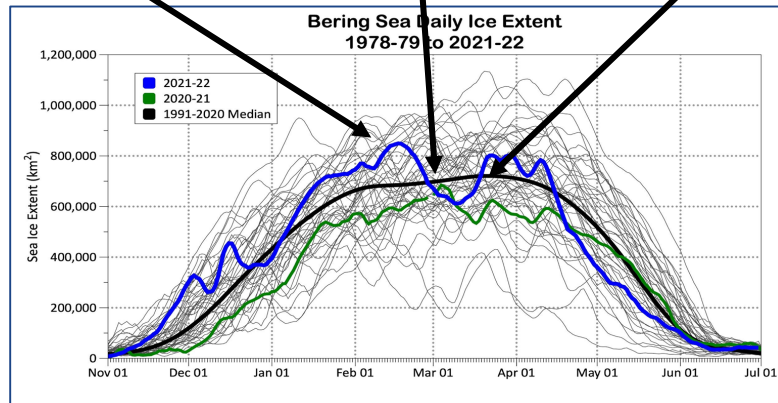
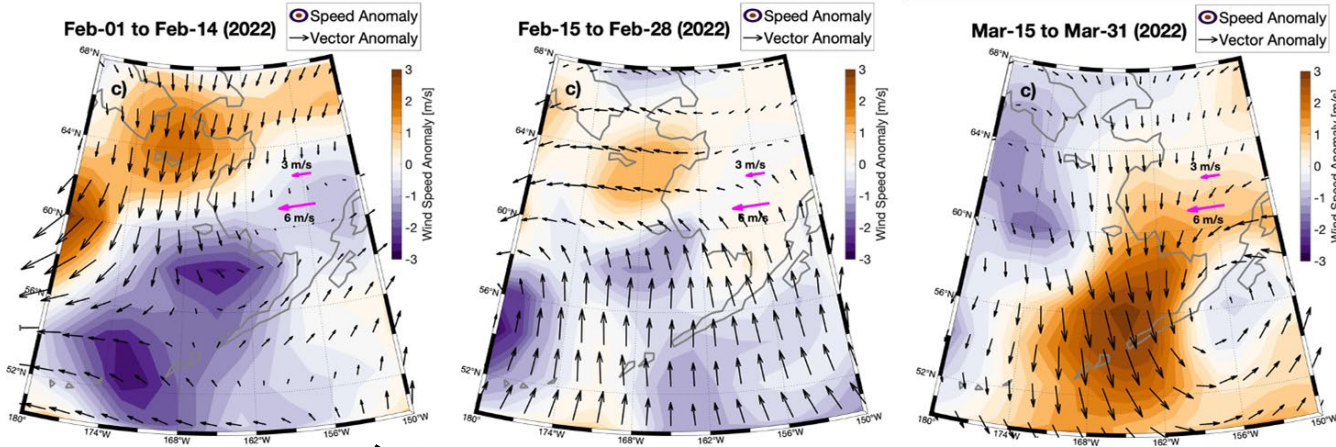
Thoman



- Rapid sea ice growth in November:
 - Cold temps over western Alaska
 - Less open water in the Chukchi; ice able to form/move south of the Bering Strait
- Dramatic ice loss in April:
 - Thin ice (plots coming next)
 - Storminess
- Maximum ice extent occurred February 17, almost a month earlier than the median.

Winds & Sea Ice

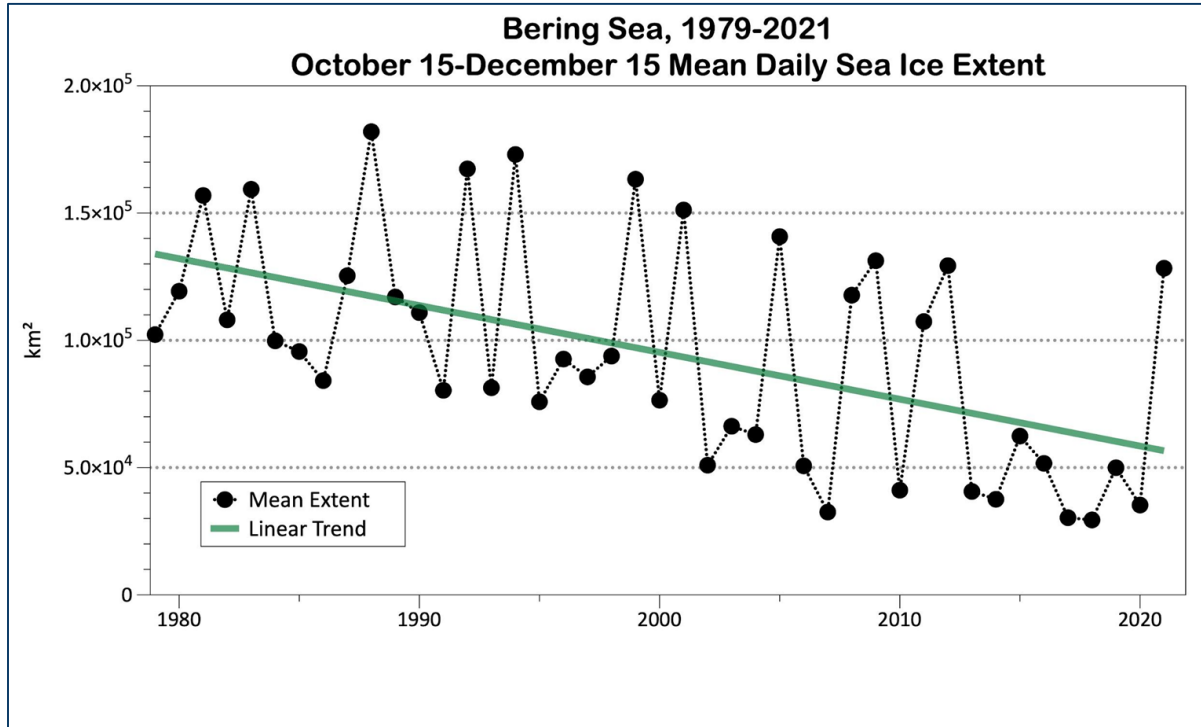
Hennon, Thoman



Wind anomalies correlate with sudden shifts in sea ice extent.

Early Season Ice Extent

Thoman



- One of the coldest Novembers on record produced rapid sea ice growth.
- Early season ice extent was the highest since 2012.

Bering Sea Ice Thickness

Thoman



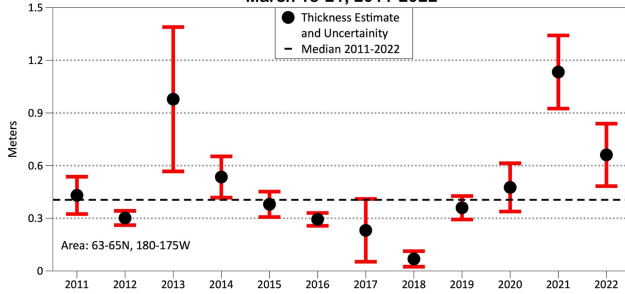
- 3rd week of March.
- Ice thickness is related to duration or residency of ice over the shelf.
- Abundance of ice-associated algae correlated to ice duration?

Bering Sea Ice Thickness

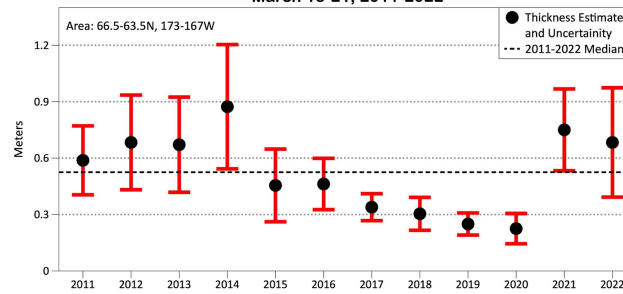
Thoman

- Ice **extent** was higher than recent years.
- Ice **thickness** was lower than 2021 in all NBS areas.
- Norton Sound ice thickness was 2nd lowest of record.

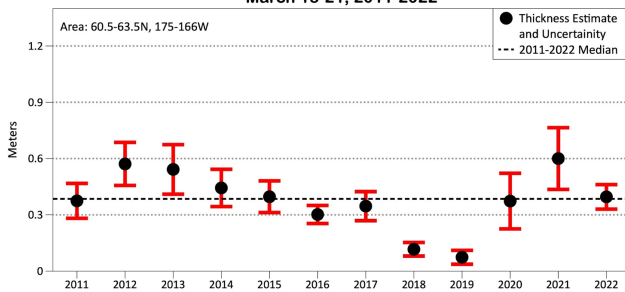
Gulf of Anadyr
Average Sea Ice Thickness
March 15-21, 2011-2022



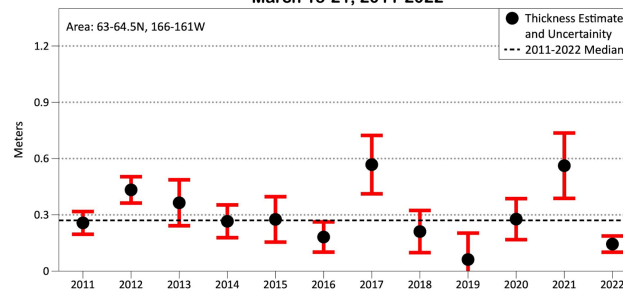
Bering Strait
Average Sea Ice Thickness
March 15-21, 2011-2022



St. Lawrence Island to St. Matthew Island
Average Sea Ice Thickness
March 15-21, 2011-2022



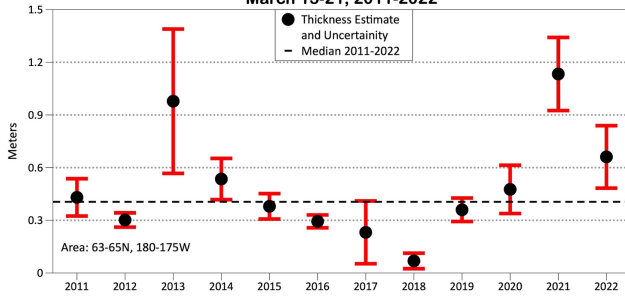
Norton Sound
Average Sea Ice Thickness
March 15-21, 2011-2022



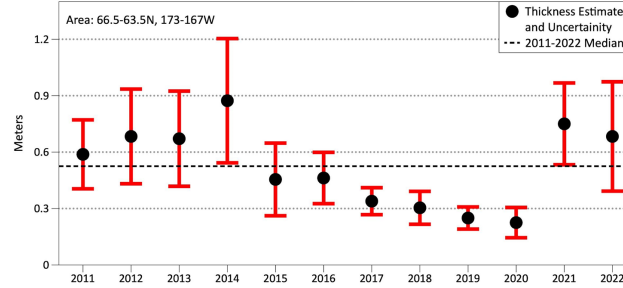
Bering Sea Ice Thickness

Thoman

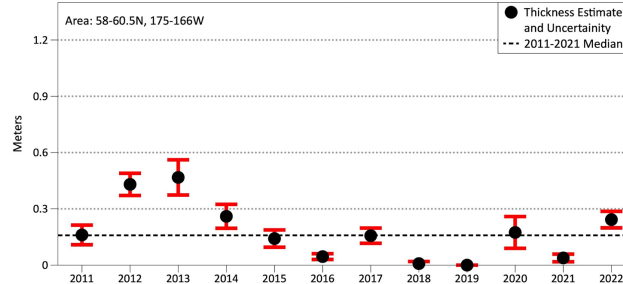
Gulf of Anadyr
Average Sea Ice Thickness
March 15-21, 2011-2022



Bering Strait
Average Sea Ice Thickness
March 15-21, 2011-2022



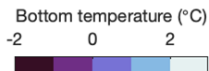
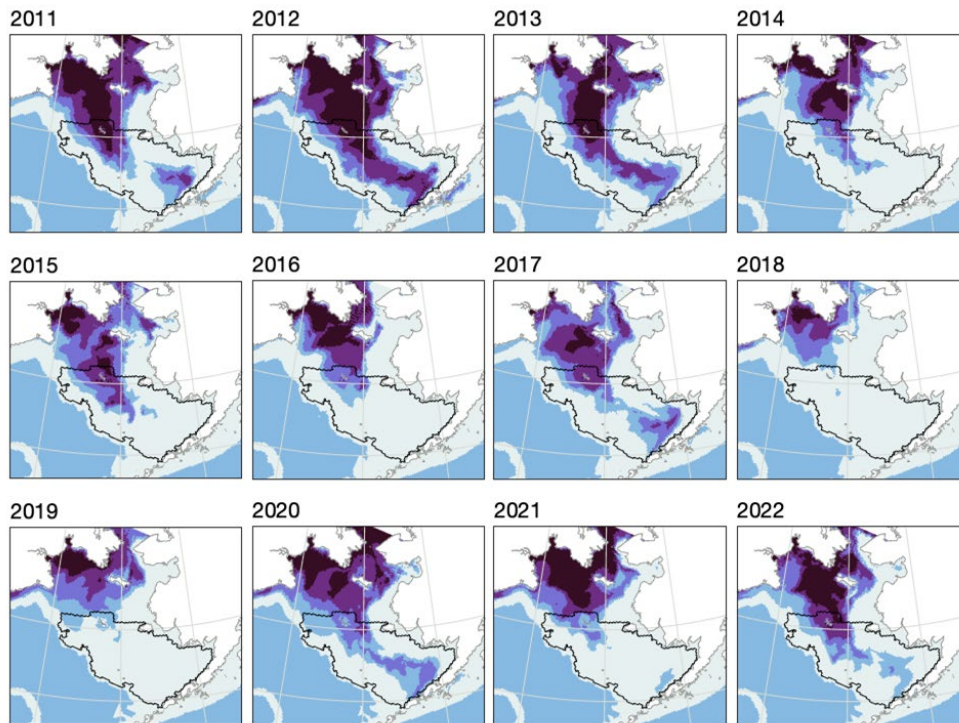
St. Matthew Island to St. Paul Island
Average Sea Ice Thickness
March 15-21, 2011-2022



- Ice **extent** was higher than recent years.
- Ice **thickness** was lower than 2021 in all NBS areas.
- Norton Sound ice thickness was 2nd lowest of record.
- Only thicker ice in 2022 was St. Matthew to St. Paul, which had near-zero in 2021.



Cold Pool Kearney

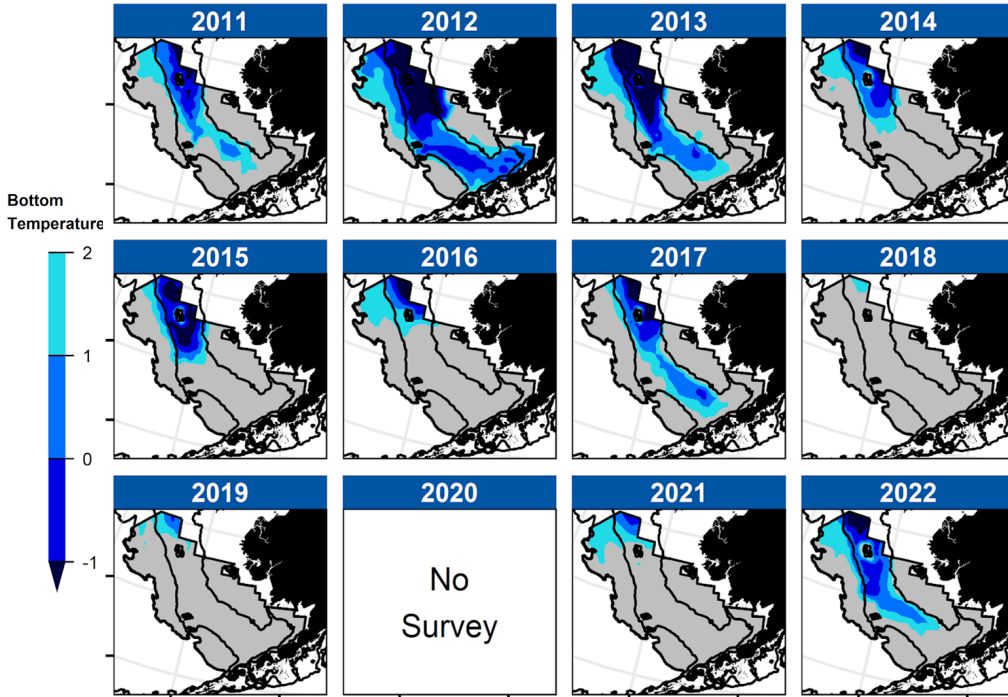


- Bering 10K ROMS hindcast of bottom water temperature, extracted for July 1 of each year.
- 2022 very near the historical average based on the amount of 2°C and 0°C water.
- 2022 resembles other average-to-cool years, most similar to 2017.



Cold Pool

Rohan & Barnett

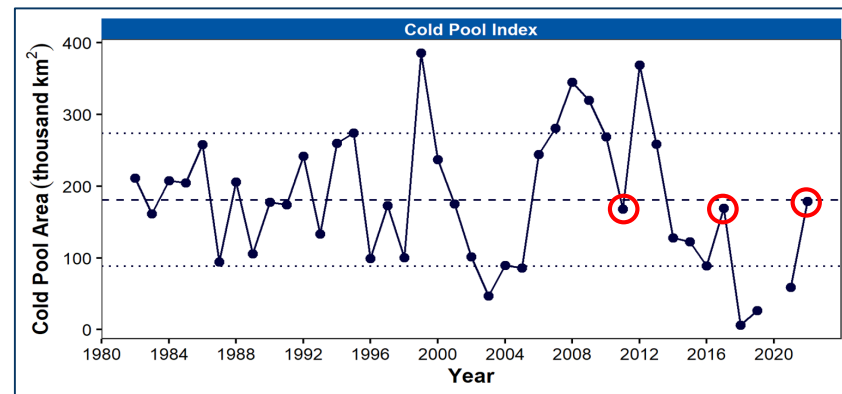
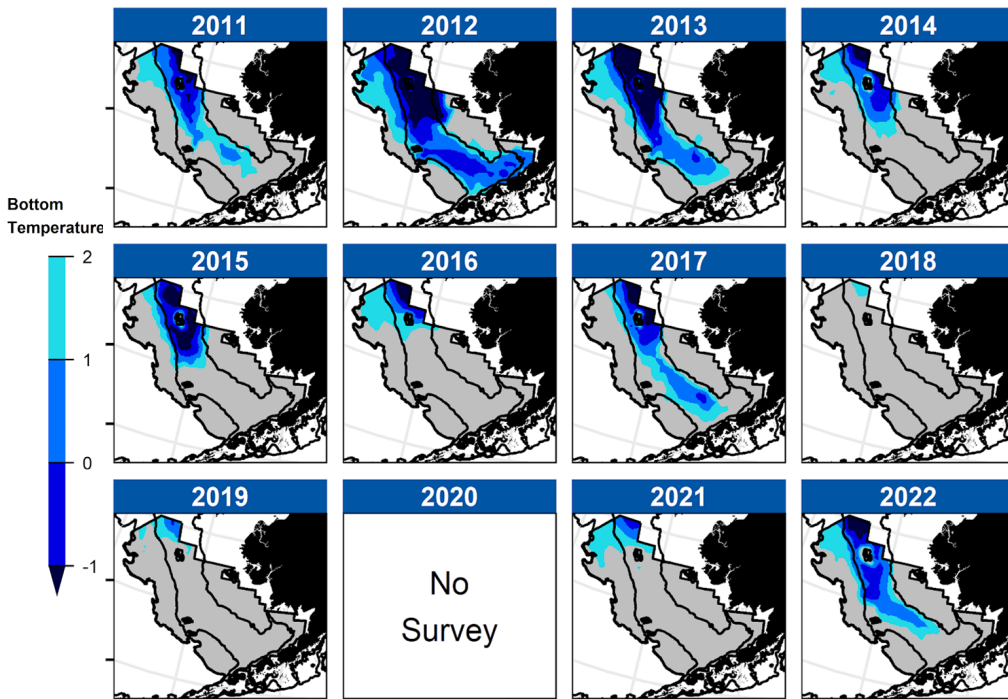


- Cold pool extent was approximately equal to the time series mean.
- Cold pool covered most of the middle shelf north of 57°N .
- Cold pool was similar to 2011 and 2017.



Cold Pool

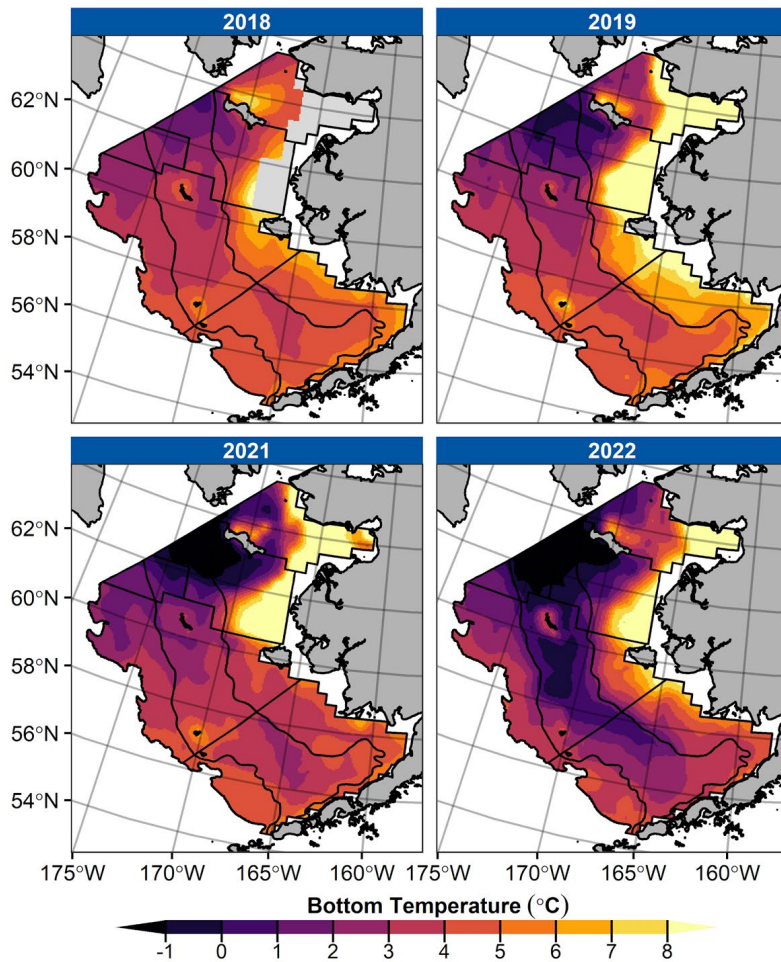
Rohan & Barnett





Cold Pool

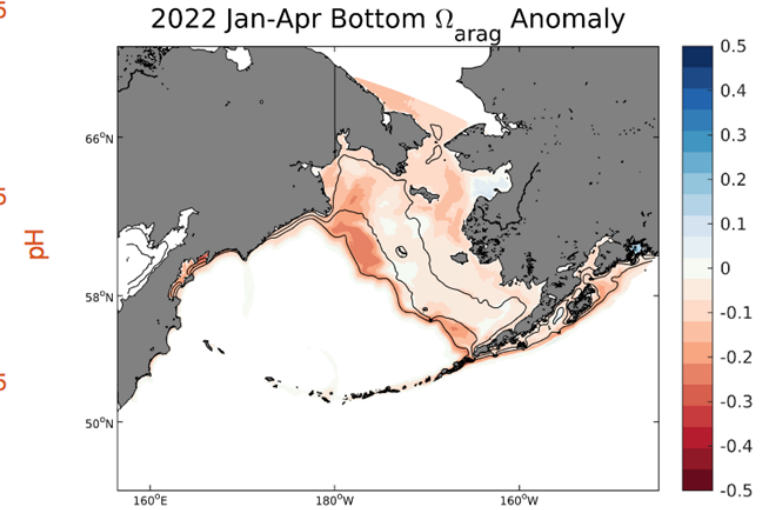
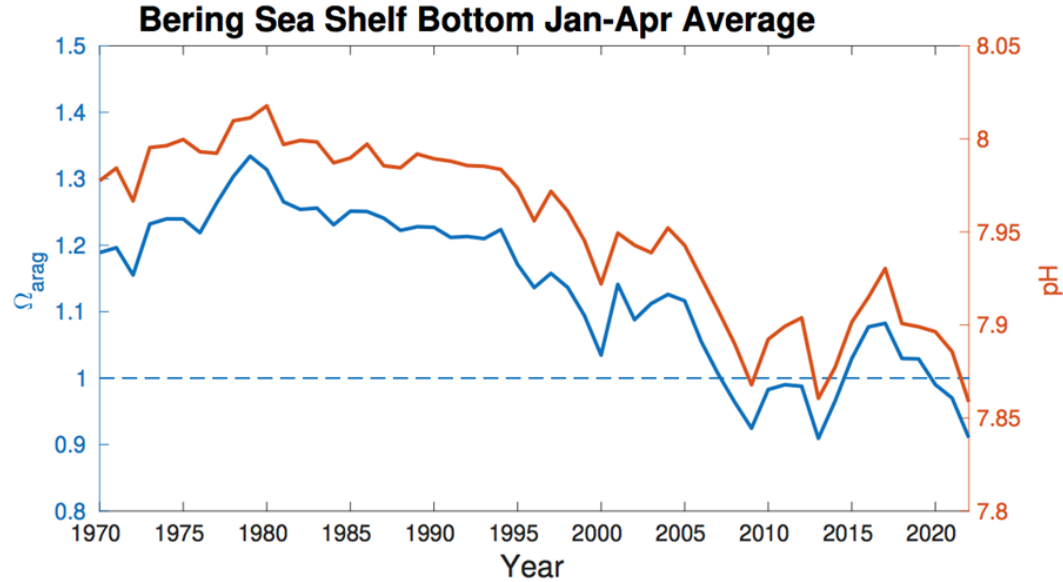
Rohan & Barnett



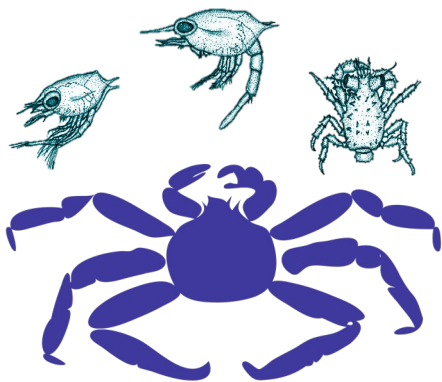
- Bottom temperatures over EBS and NBS survey areas.
- 2019 had extremely warm inner domain waters.
- 2022 cold pool extended over middle domain of EBS and NBS shelves.

EBS Ocean Acidification

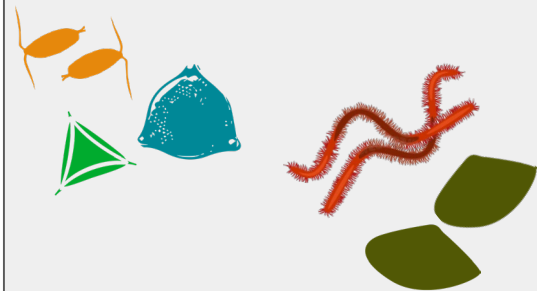
Pilcher & Cross

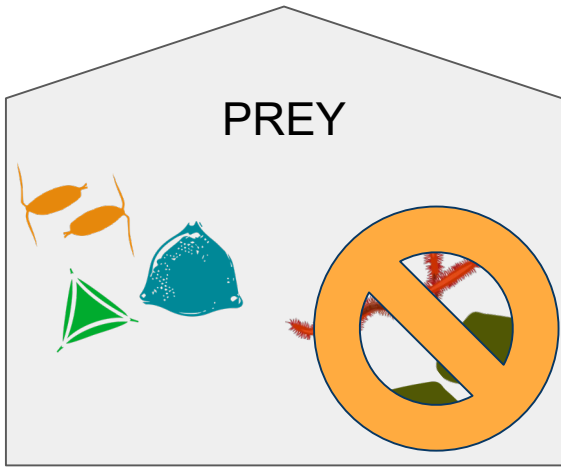
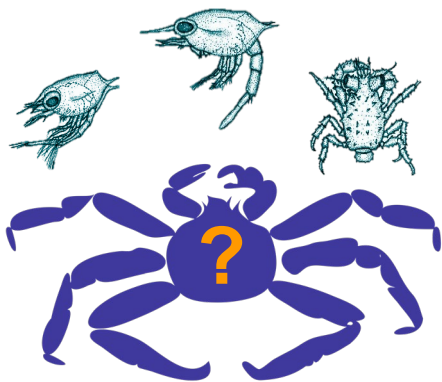


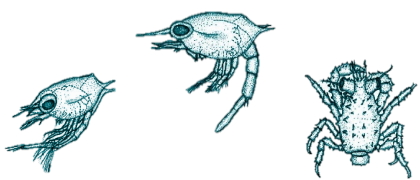
- Through April 2022, Ω_{arag} is 2nd lowest over hindcast and pH is the lowest.
- Low anomalies throughout most of shelf, but particularly strong on outer shelf.



PREY

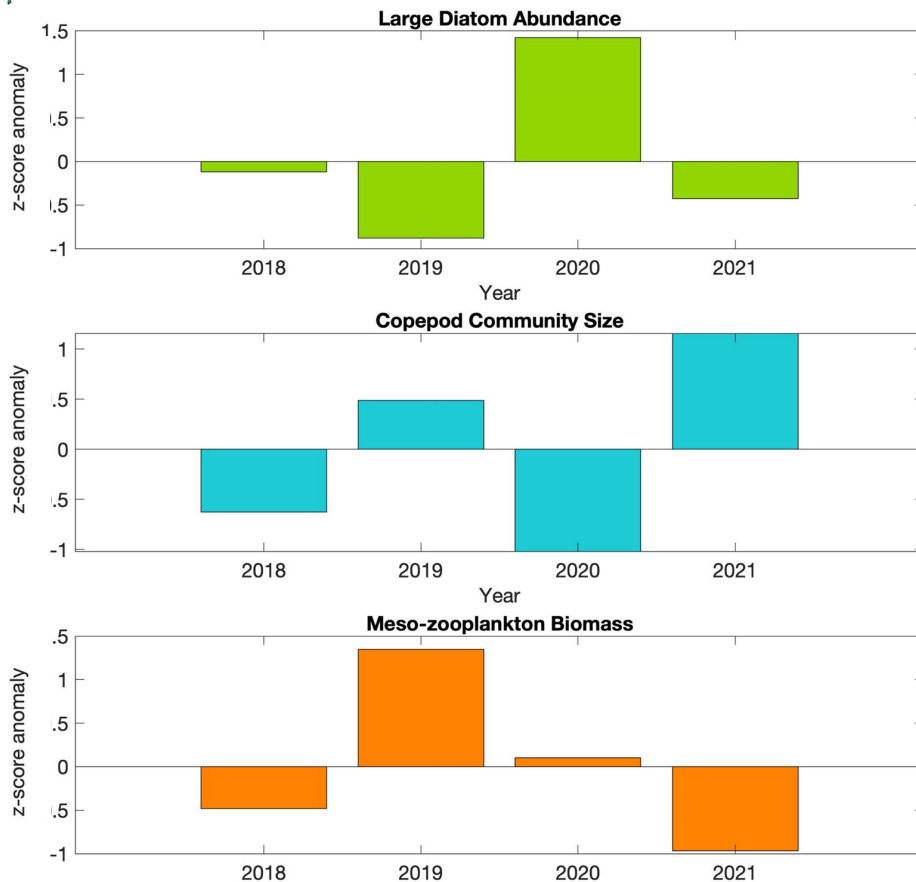
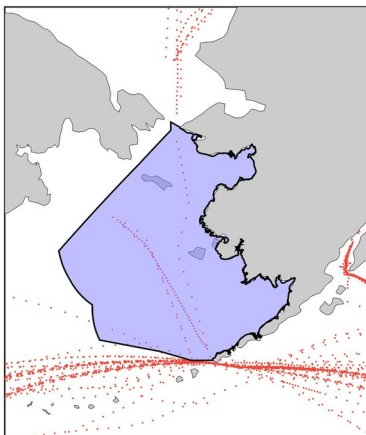






2021 Continuous Plankton Recorder

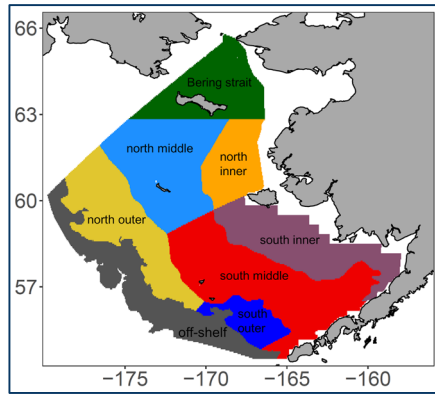
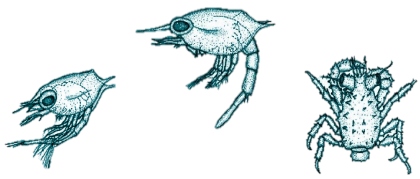
Ostle & Batten



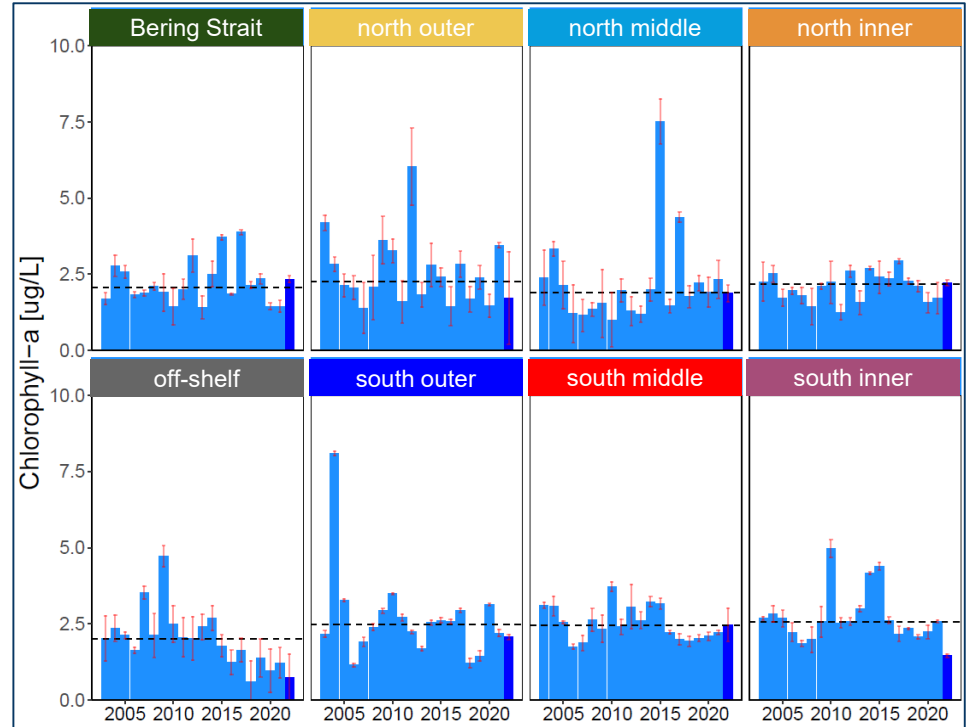
- The mean diatom abundance was negative in 2021.
- Copepod community size was positive in 2021, where it had been negative in 2020.
- Meso-zooplankton biomass was negative in 2021, where it had been positive in 2020.

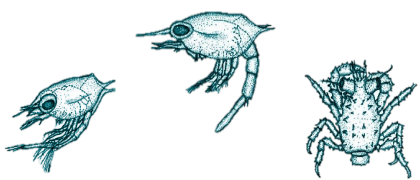
2022 Spring Bloom

Nielsen



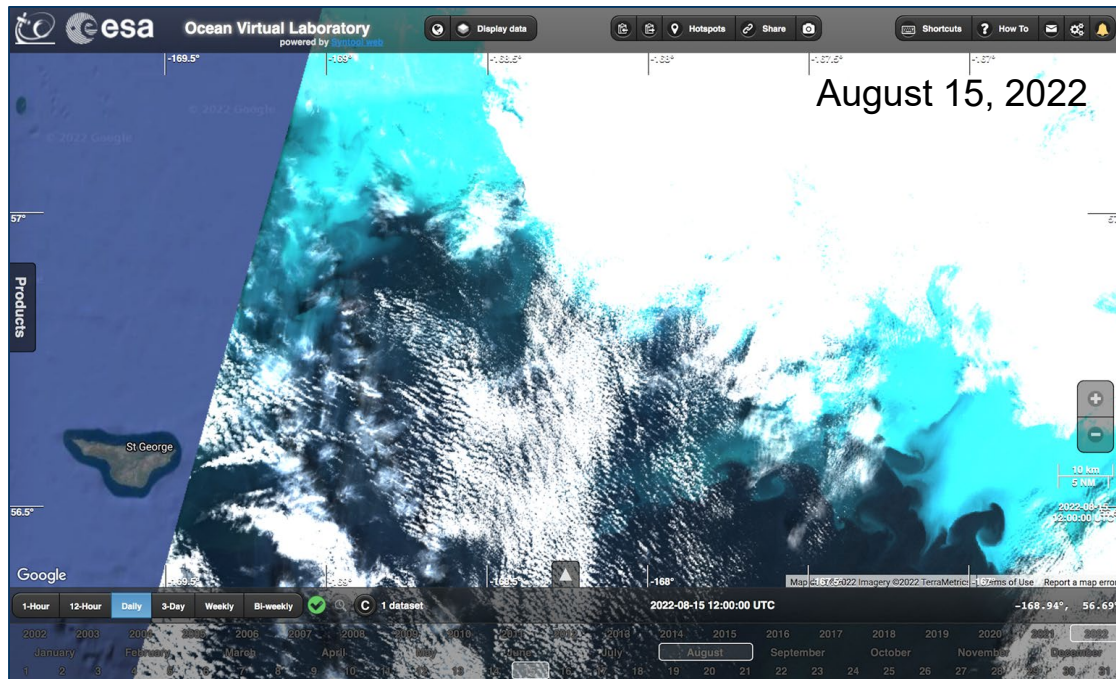
- *Preliminary interpretation:*
- Chl-a biomass trends are close to the long term average.
- Exceptions are the **south inner**, **south outer**, and the off-shelf (which continues a low trend).
- Bloom timing (*figure not shown*) appears average.



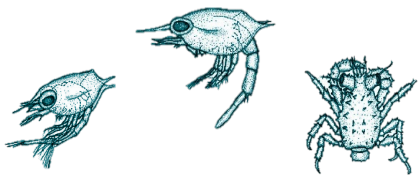


2022 Coccolithophores

Gann & Lange

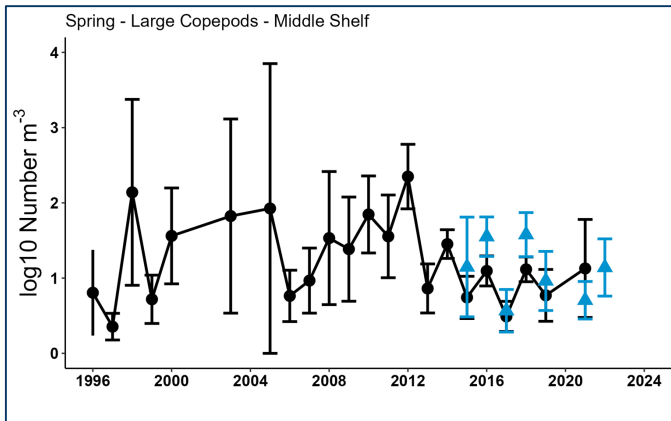
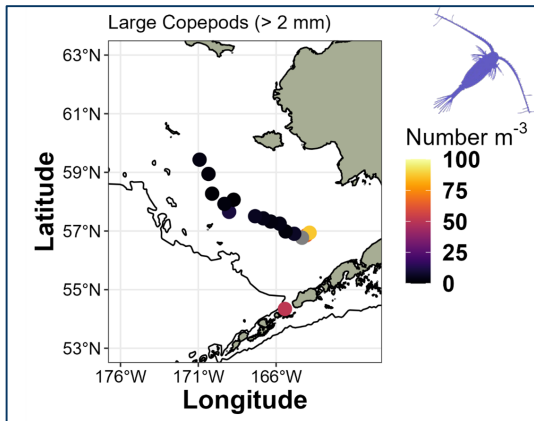
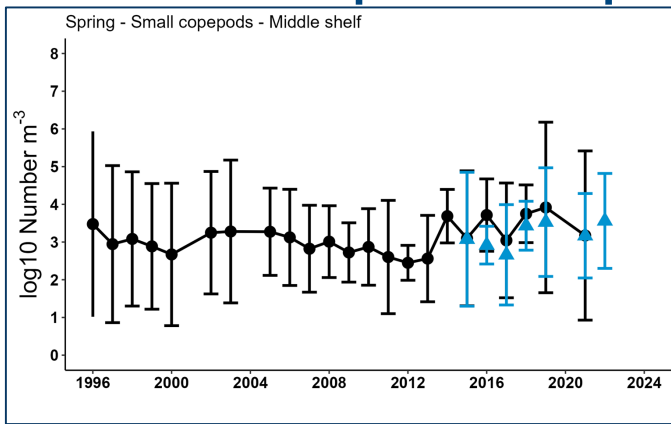
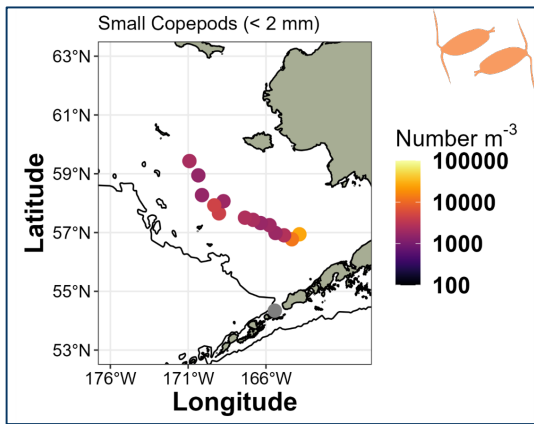


- Coccolithophore bloom index was low in 2018 and 2019, but higher in 2020 and 2021.
- 2022: a noticeable coccolithophore bloom (full index available in October).
- *Implications:* coccolithophores result in longer trophic chains, may be a less desirable food source, and can reduce foraging success for visual predators.



Spring 2022 Rapid Zooplankton Assessment

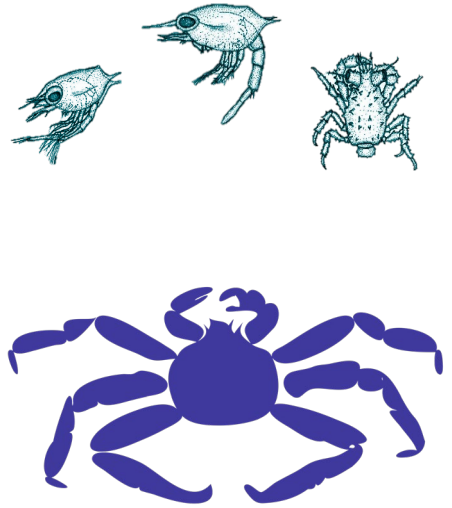
Kimmel



- Copepods were more abundant than 2021, particularly small copepods.

- *Calanus* (a large copepod) were low in lipid.

COMPETITORS

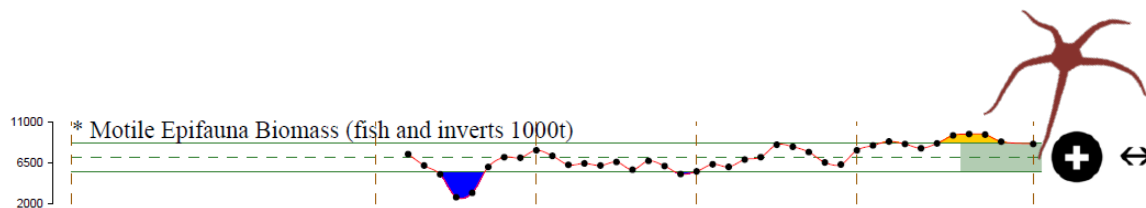




2021 Motile Epifauna and Benthic Foragers

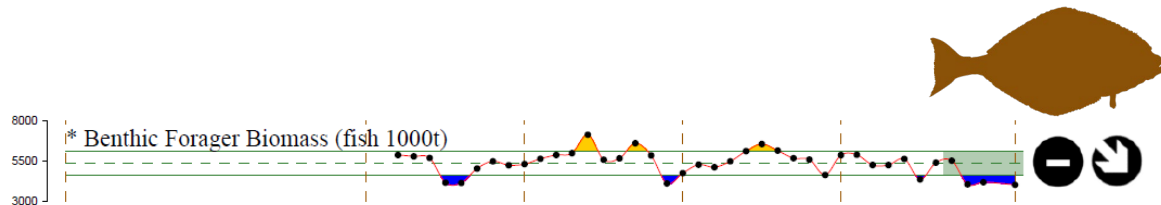
Whitehouse

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



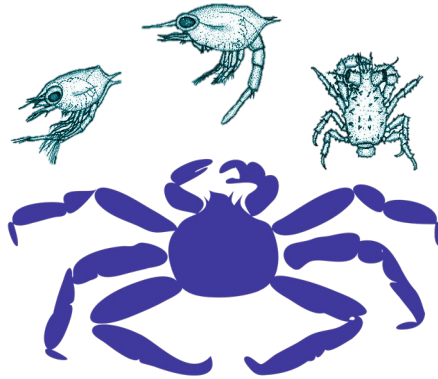
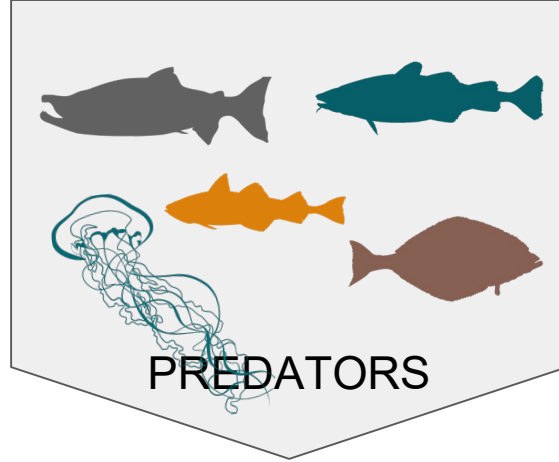
Indicates benthic productivity

- Motile epifauna biomass peaked in 2017 and remained above the long-term mean in 2021.



Indirect indicator of infauna

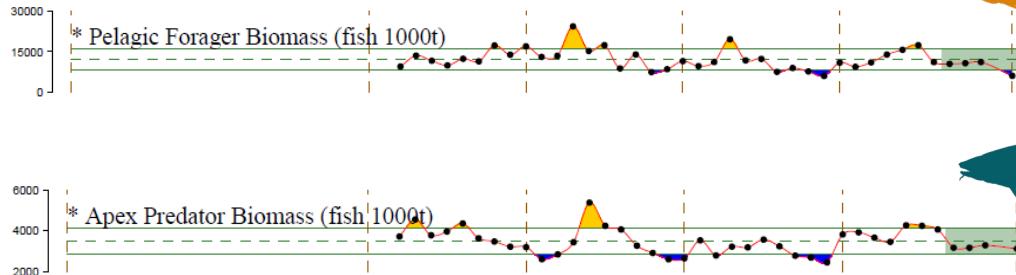
- Benthic foragers biomass was at the **lowest level in the time series** in 2021.



2021 Pelagic Foragers and Apex Predators

Whitehouse

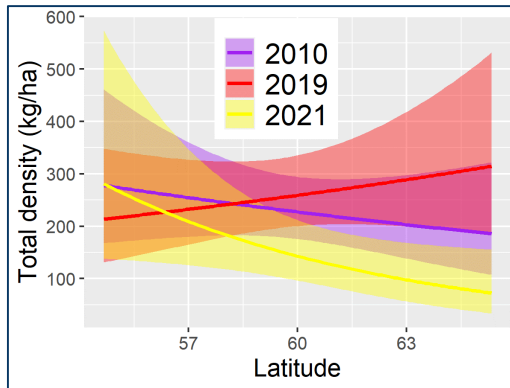
Pelagic foragers are predators of larvae while apex predators consume small benthic crab stages.



- Pelagic foragers (pollock and jellyfish) dropped to 2nd lowest in time series in 2021.

- Apex predators (P. cod and ATF) were within 1SD in 2021.

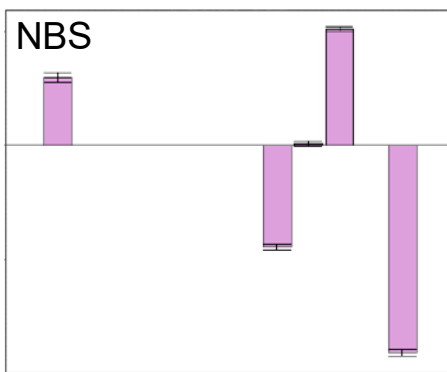
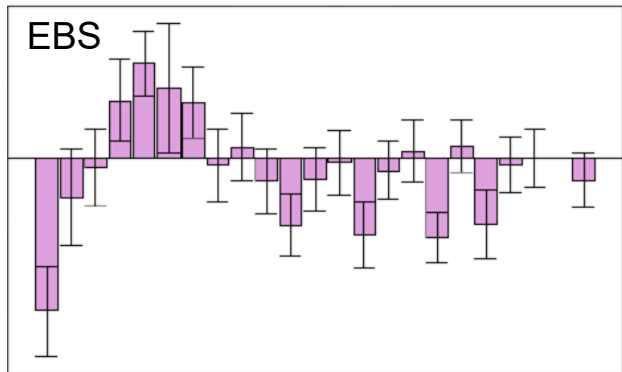
- Northward shift of the fish community reversed in 2021; CPUE in NBS decreased from 2019 to 2021.





2021 Adult Pacific Cod Condition

Rohan & Prohaska, Holsman

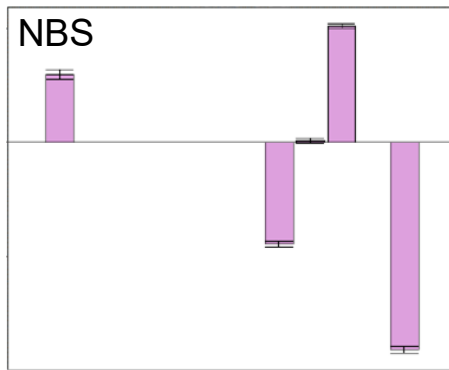
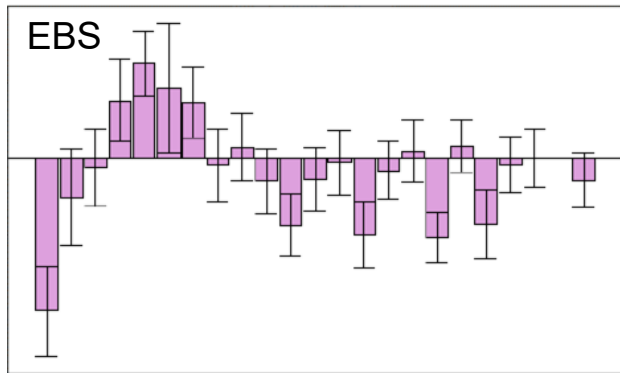


- EBS: PCod condition was negative (95%CI incl. mean) and across all strata
- NBS: PCod condition was negative.

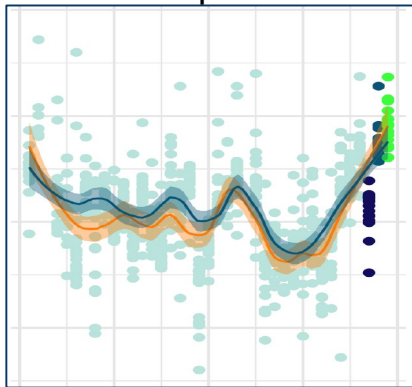


2021 Adult Pacific Cod Condition

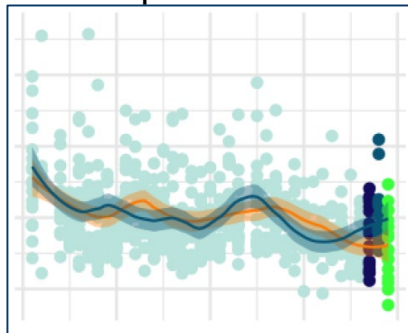
Rohan & Prohaska, Holsman



Thermal experience



Growth potential



- EBS: PCod condition was negative (95%CI incl. mean) and across all strata.
- NBS: PCod condition was negative.
- Bioenergetics through 2019 indicate increased temperature led to increased metabolic demand while foraging rates and prey energy decreased.
- This resulted in a decline in growth potential

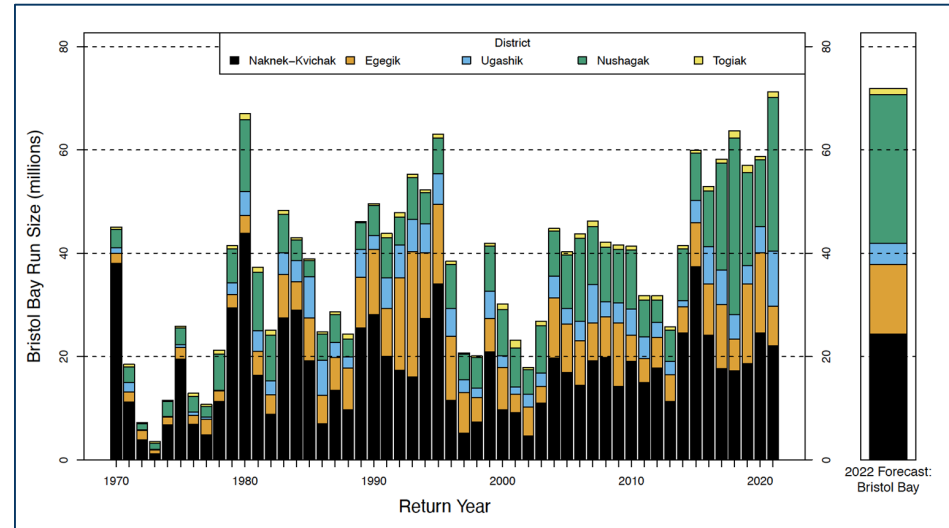


2022 Bristol Bay Sockeye Salmon

Cunningham

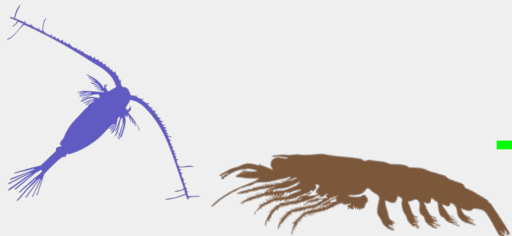


- 2022 was largest run on record (>78 mil).
- Small size at age (density-dependent growth).
- Higher than expected proportion of 1.3 fish.
- Juvenile sockeye feed on zooplankton and age-0 pollock in warm years; adults feed on zooplankton and krill.
- Are there system-wide impacts?



2022 Summary & Larval Implications

COMPETITORS



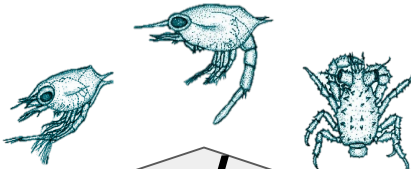
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PREDATORS
(2021)

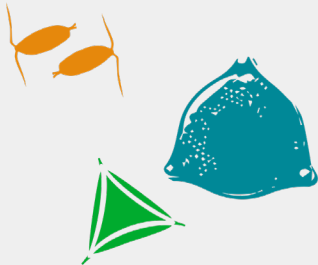


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PREY



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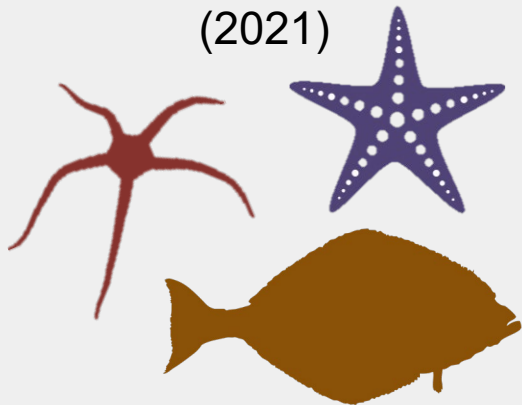
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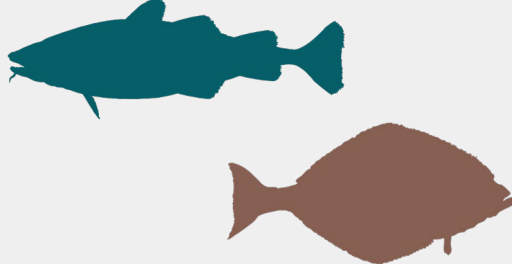
ENVIRONMENTAL
PROCESSES

2022 Summary & Adult Implications

COMPETITORS
(2021)



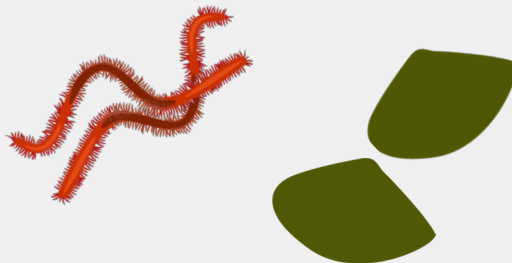
PREDATORS
(2021)



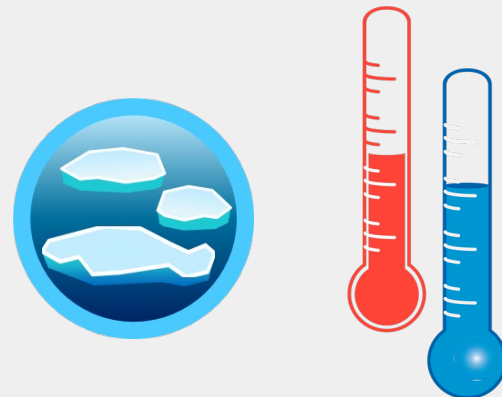
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PREY

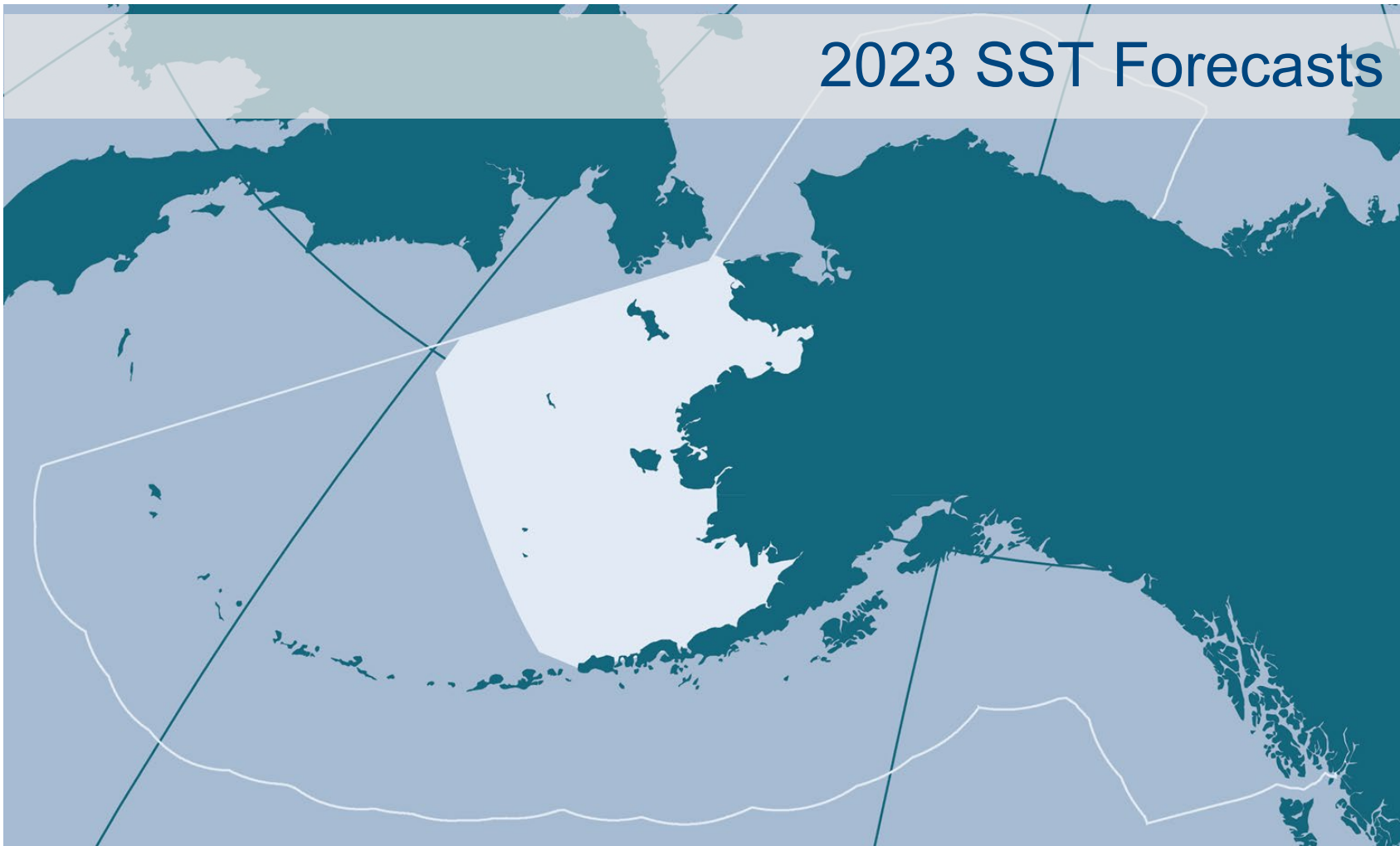


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ENVIRONMENTAL
PROCESSES

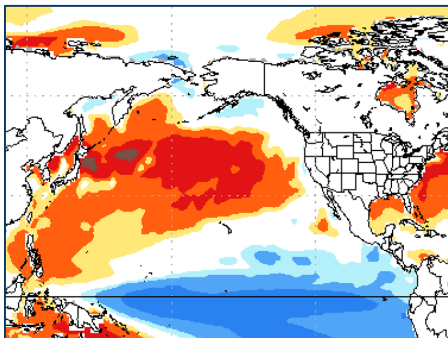
2023 SST Forecasts



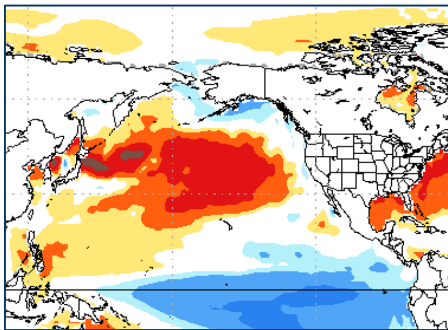
SST Projections from the National Multi-Model Ensemble

Bond

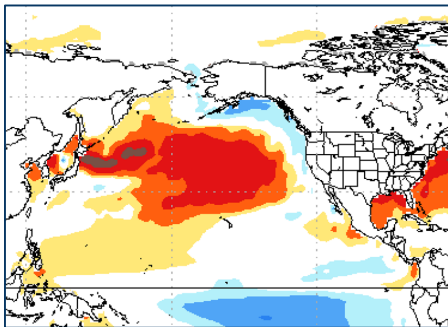
Oct - Dec
2022



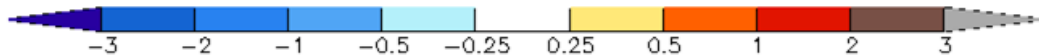
Dec 22 -
Feb 23



Feb -
April
2023



- **TOP:** Near-normal temperatures are predicted for Alaskan waters (except WAI has positive anomalies).
- **MIDDLE:** Similar to previous period. A weak-moderate La Niña is projected.
- **BOTTOM:** Forecasts for the EBS shelf range from moderately below to moderately above normal temperatures. Most of the models suggest reasonably normal conditions that would result in ice extending south of 60°N and as far south as Bristol Bay.





Questions?

Feedback?

Full presentation to the Groundfish Plan Teams is available at:

[ESR Climate Overview](#)

- North Pacific: slides 1-7
- EBS: slides 8-20
- AI: slides 21-27
- GOA: slide 28-35