

ECOSYSTEM STATUS REPORT

Climate and Oceanography Update

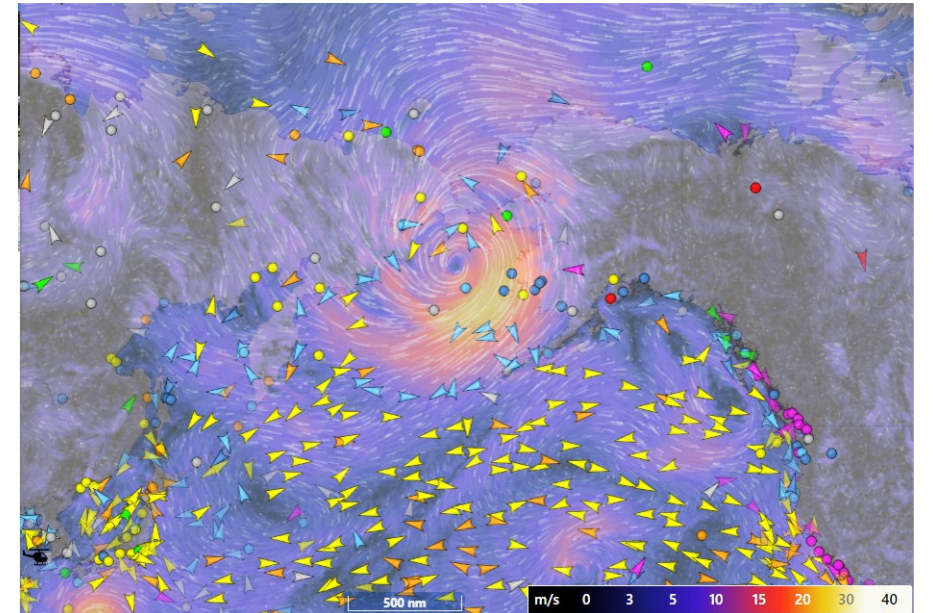
Ivonne Ortiz
Elizabeth Siddon
Bridget Ferriss
Stephani Zador

NPFMC Groundfish Plan Teams
September 19, 2022



Outline

1. Climate and oceanography (2022)
 - North Pacific
 - Bering Sea
 - Aleutian Islands
 - Gulf of Alaska
2. Sea surface temperature forecasts for North Pacific (2022/2023)



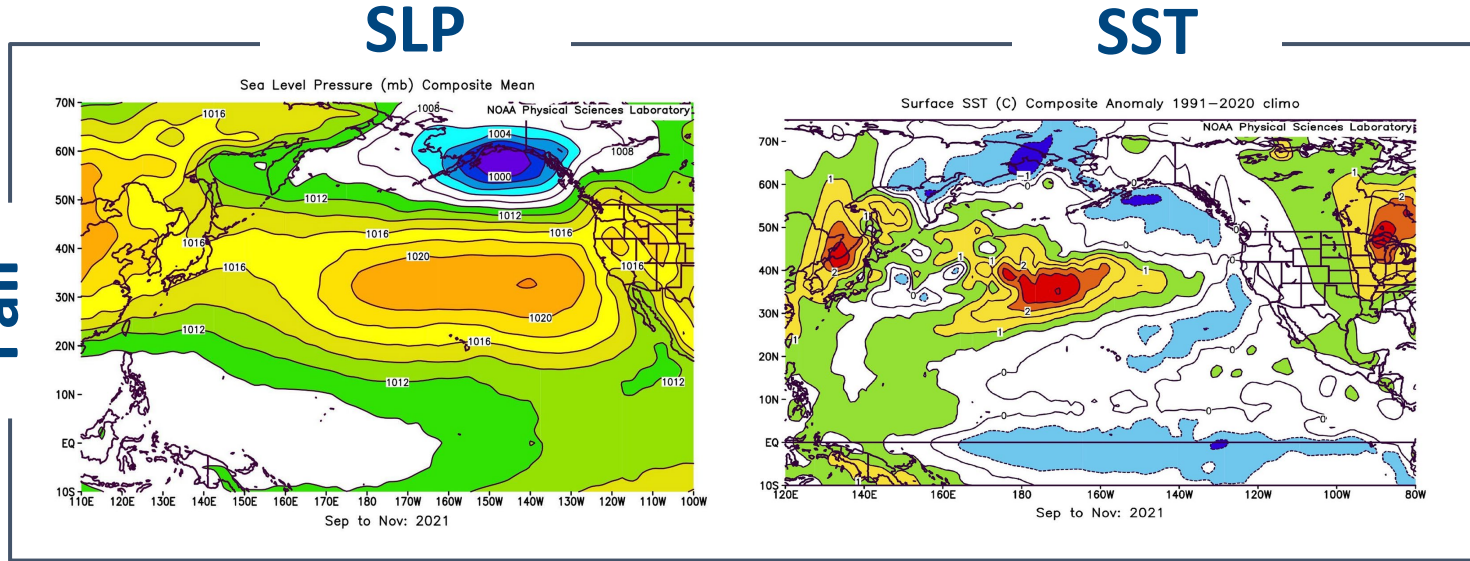
Fall & Winter 2021/2022 SLP & SST

Bond

GOA: Low SLP,
storminess

SEBS: winds from
northwest on shelf

Fall

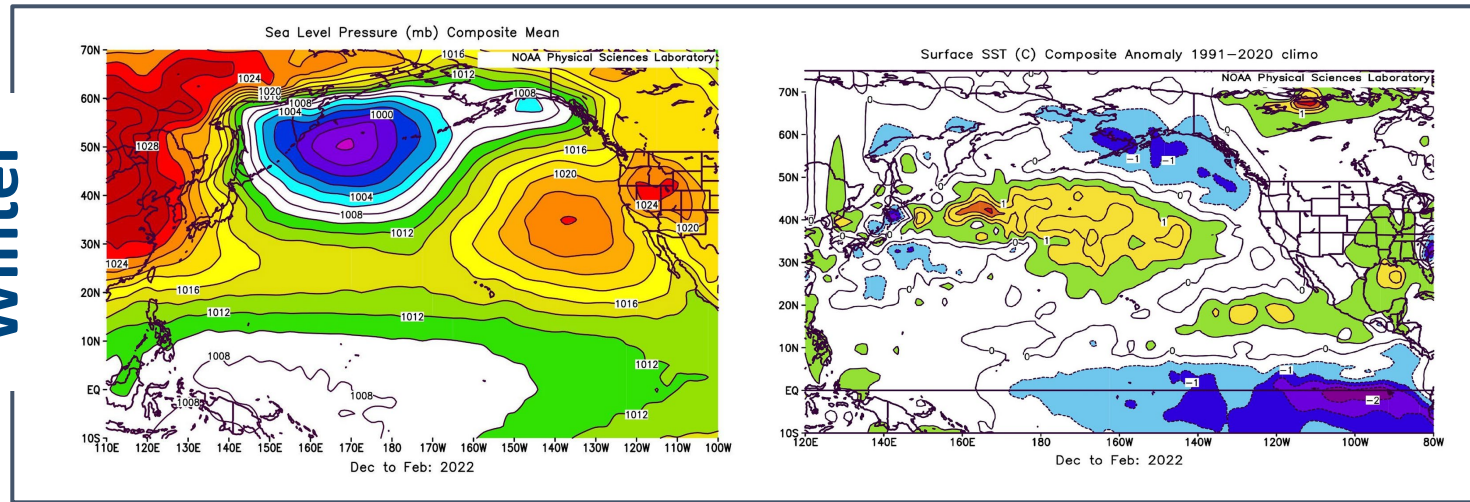


EBS, GOA: Cool
conditions in
middle domain
stretching to GOA,
average outer
domain
CAI, WAI: warm

Weak (split) Aleutian
Low,

GOA: enhanced winds
from the west

Winter

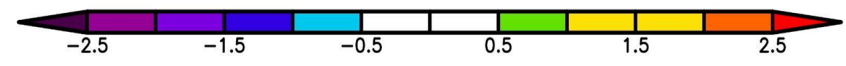
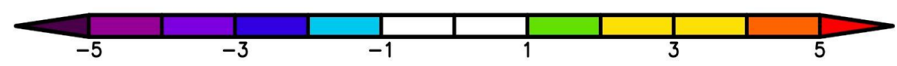
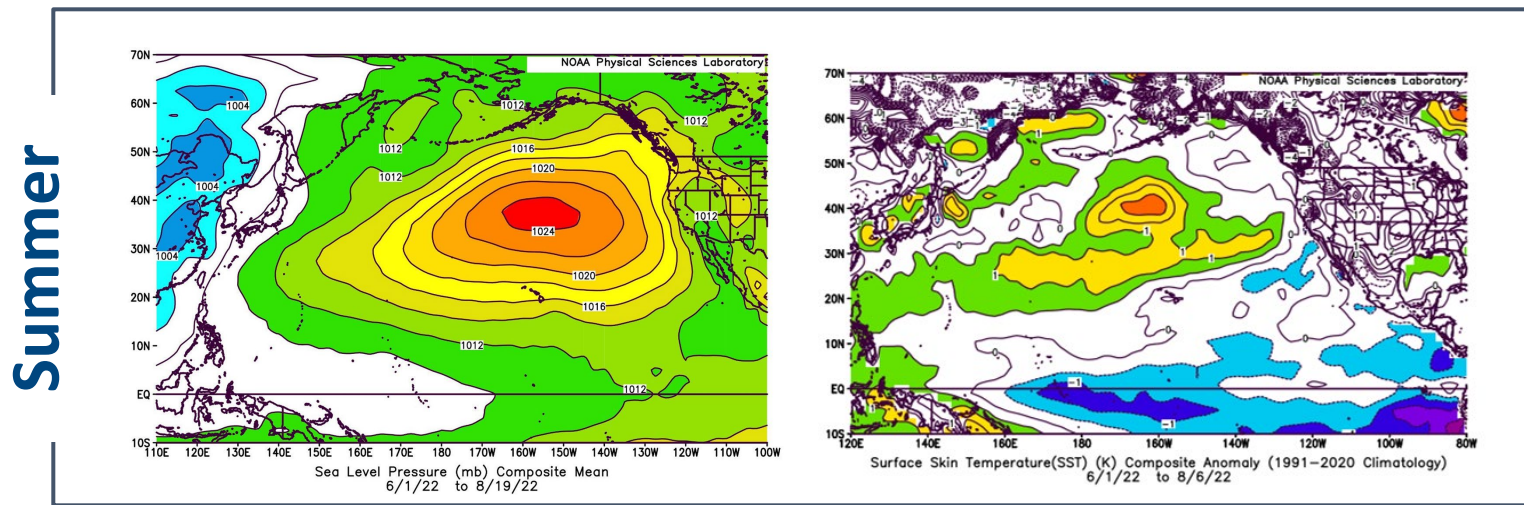
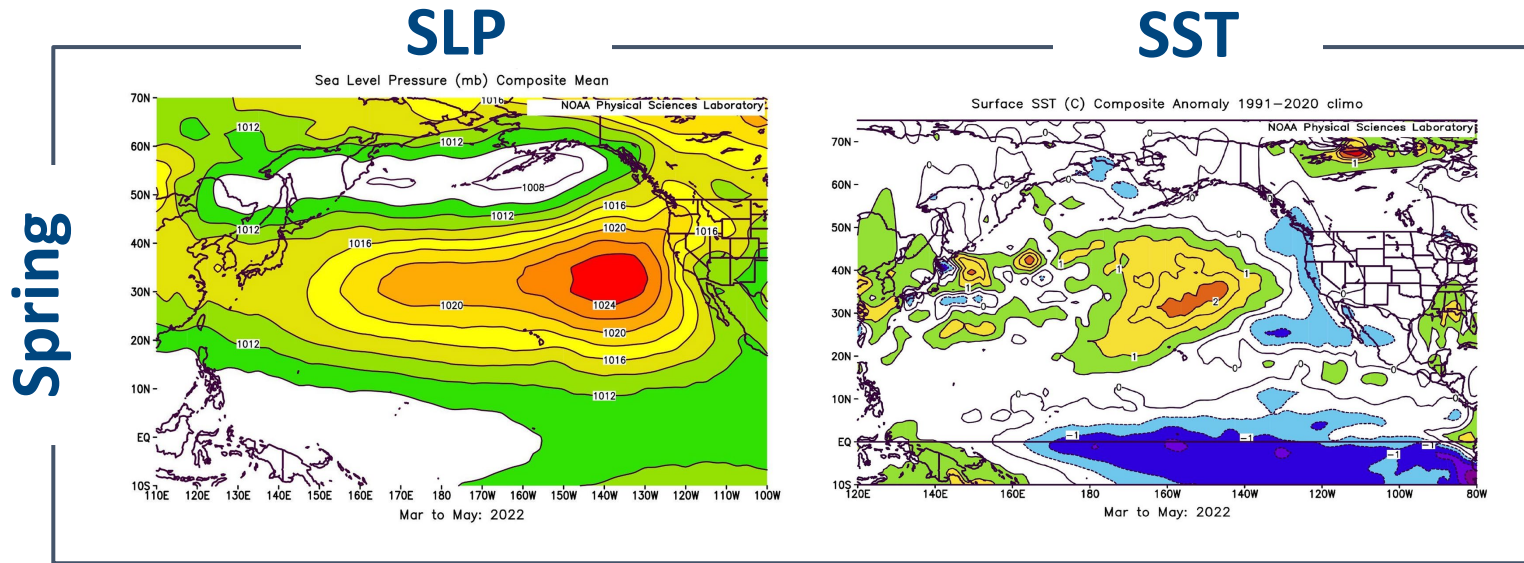


SEBS, GOA: Cold
SSTs in SEBS (inner
shelf >2C below
normal) and GOA,
WAI, CAI: warm



Spring & Summer 2022 SLP & SST

Bond



Higher SLP in NW

SEBS: winds from the north for shelf.

Spring

EBS: Sustained cool conditions over shelf

AI: warm anomalies

EBS, GOA: Weak wind anomalies for the EBS shelf and GOA,

AI winds from northwest

Summer

Modest warming driven by warm air temperatures in coastal Alaska.

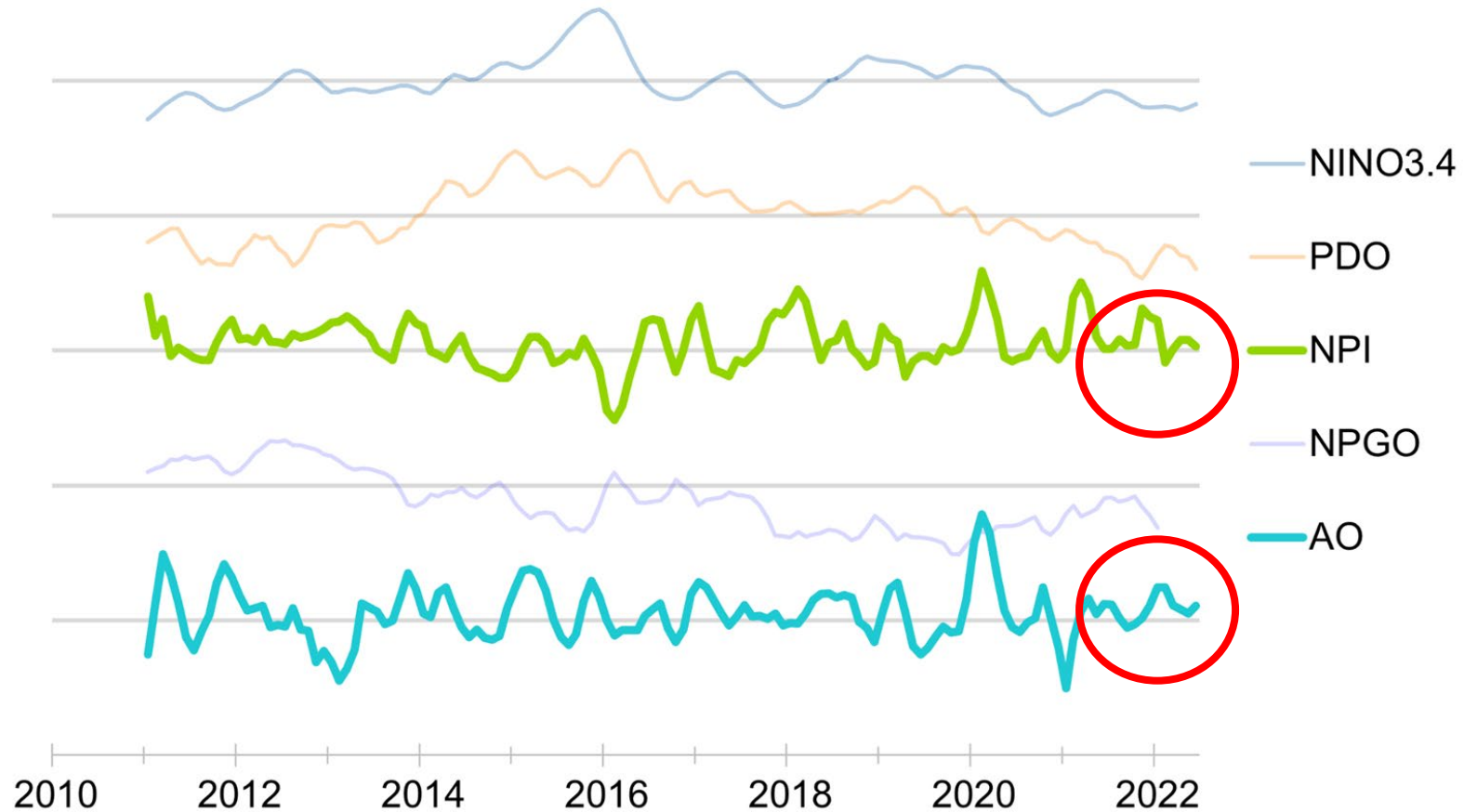
Warm spot over Central NP
GOA, AI:warm

Bering Sea

- **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 temperatures near the long-term average.

North Pacific Climate Indices

Bond

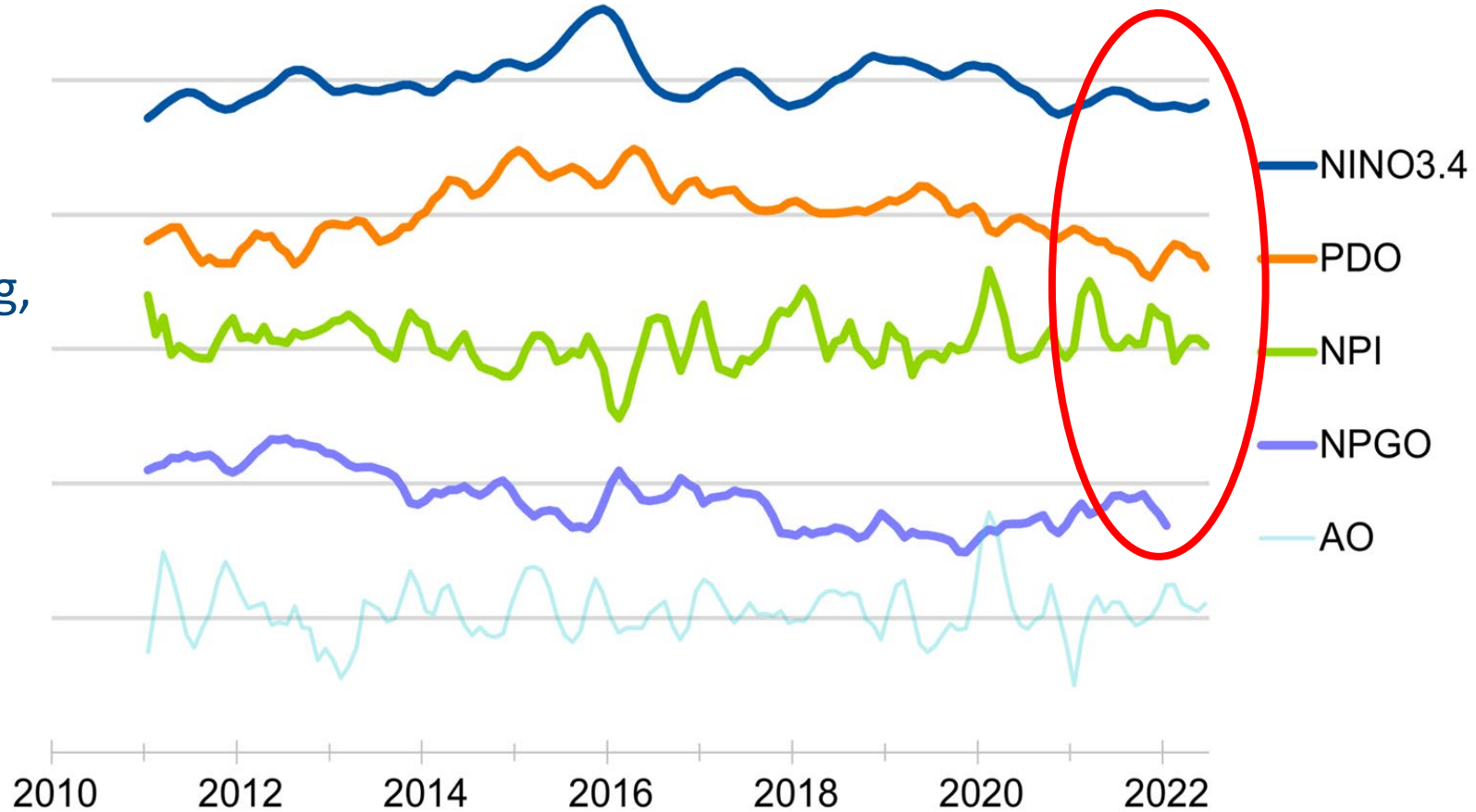


AI & GOA

North Pacific Climate Indices

Bond

- **NINO3.4** negative (La Niña) spring 2020-summer 2022. Wet summer & strong winds
- **PDO** moderate negative in spring, stronger in summer 2022
- **NPI** strongly positive winter 20/21 (weak AL); near-neutral in summer 2021
- **NPGO** negative but reduced intensity from 2020

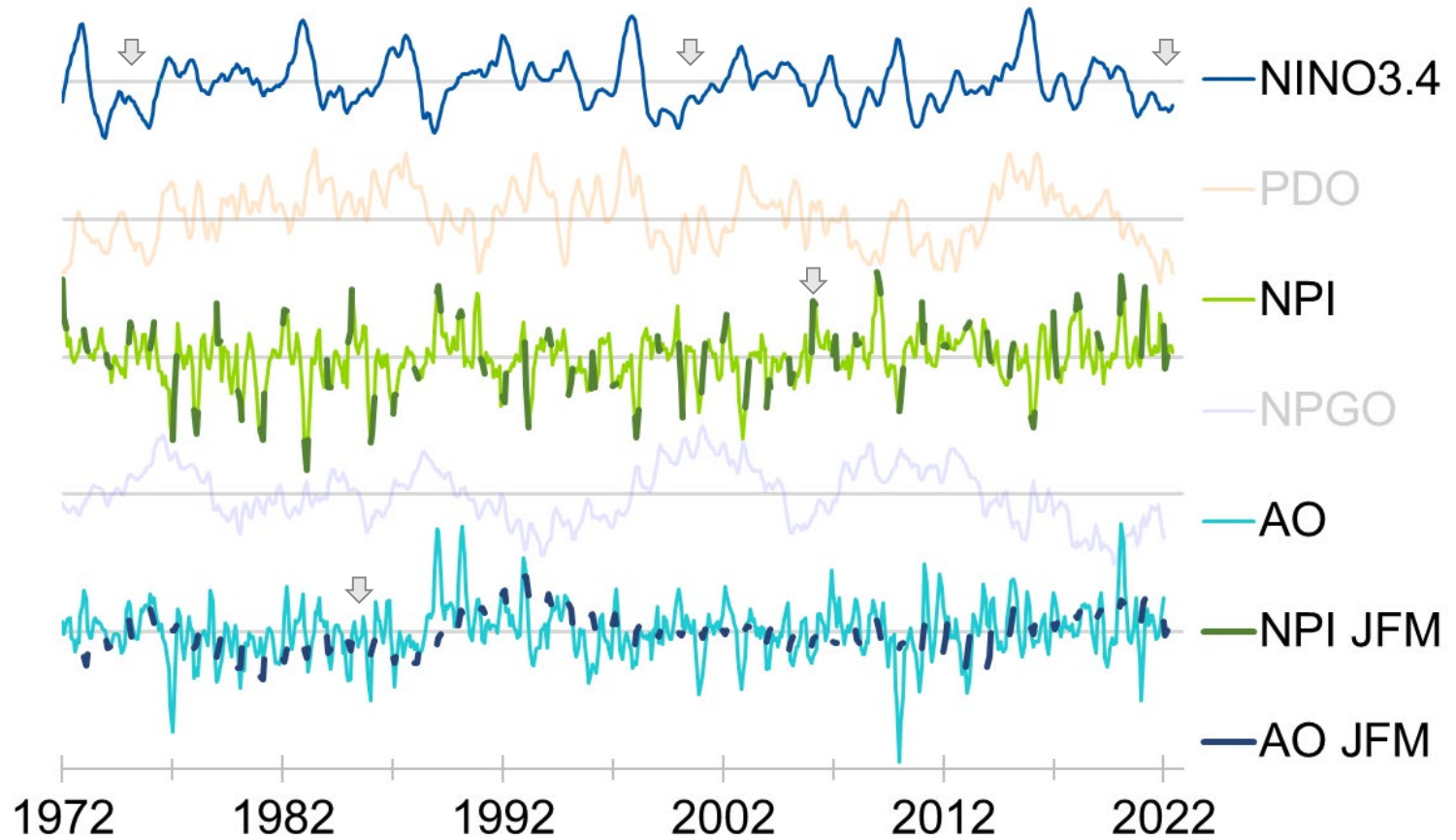


Long-term trend

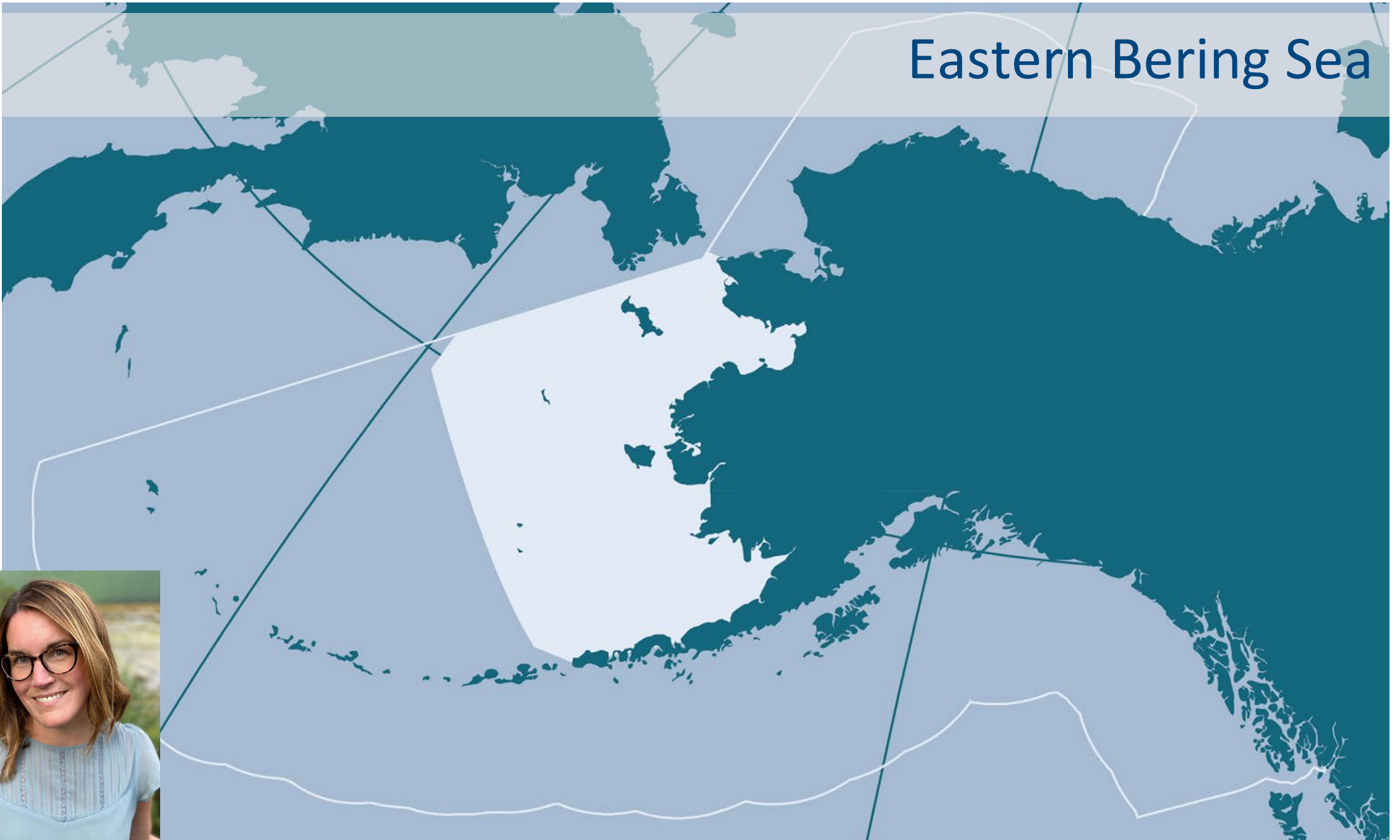
- NINO3.4 Predicted third La Niña in a row, previous in 1973-76, 1998-2001
- NPI: 5 out of 6 last winters positive, largely positive since 2006
- AO: 5y JFM average neutral/positive since 1985
+AO favors average - colder temperature in AK

North Pacific Climate Indices

Bond

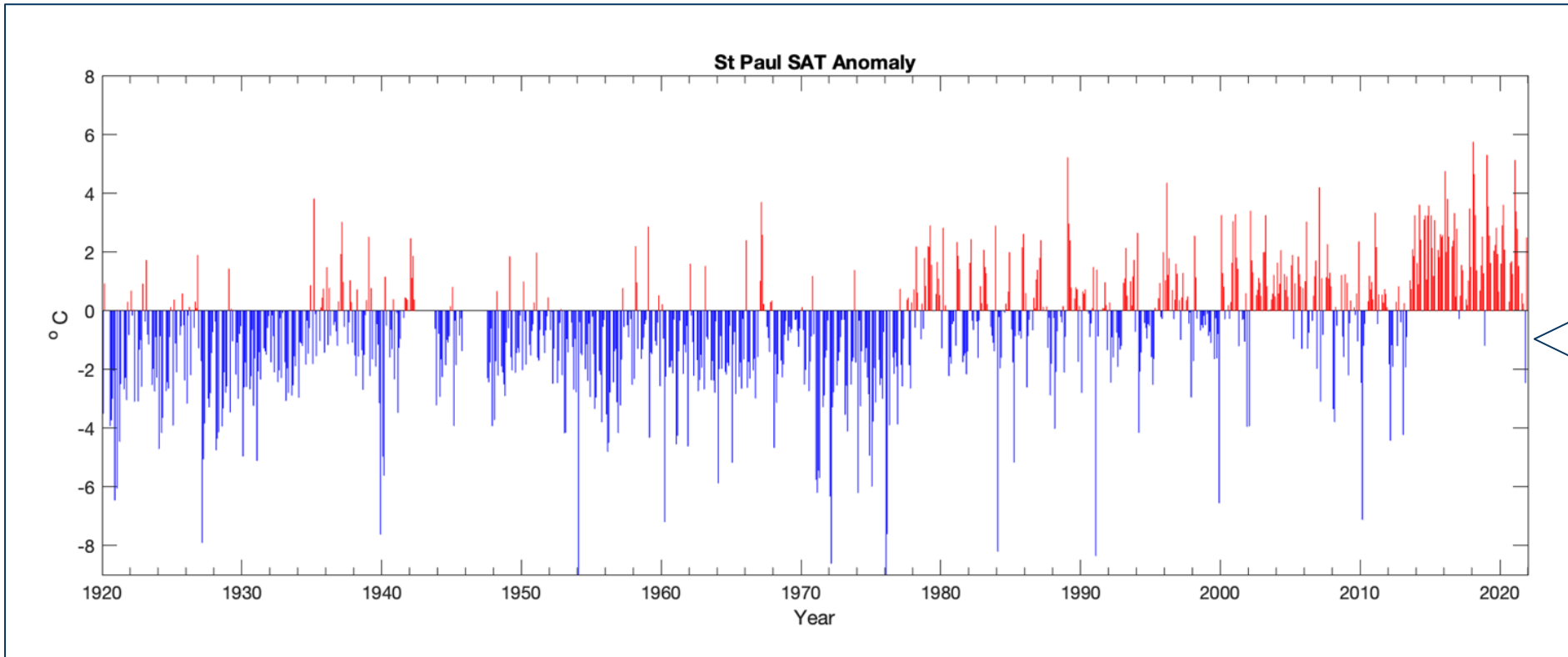


Eastern Bering Sea



Air Temperature Anomalies

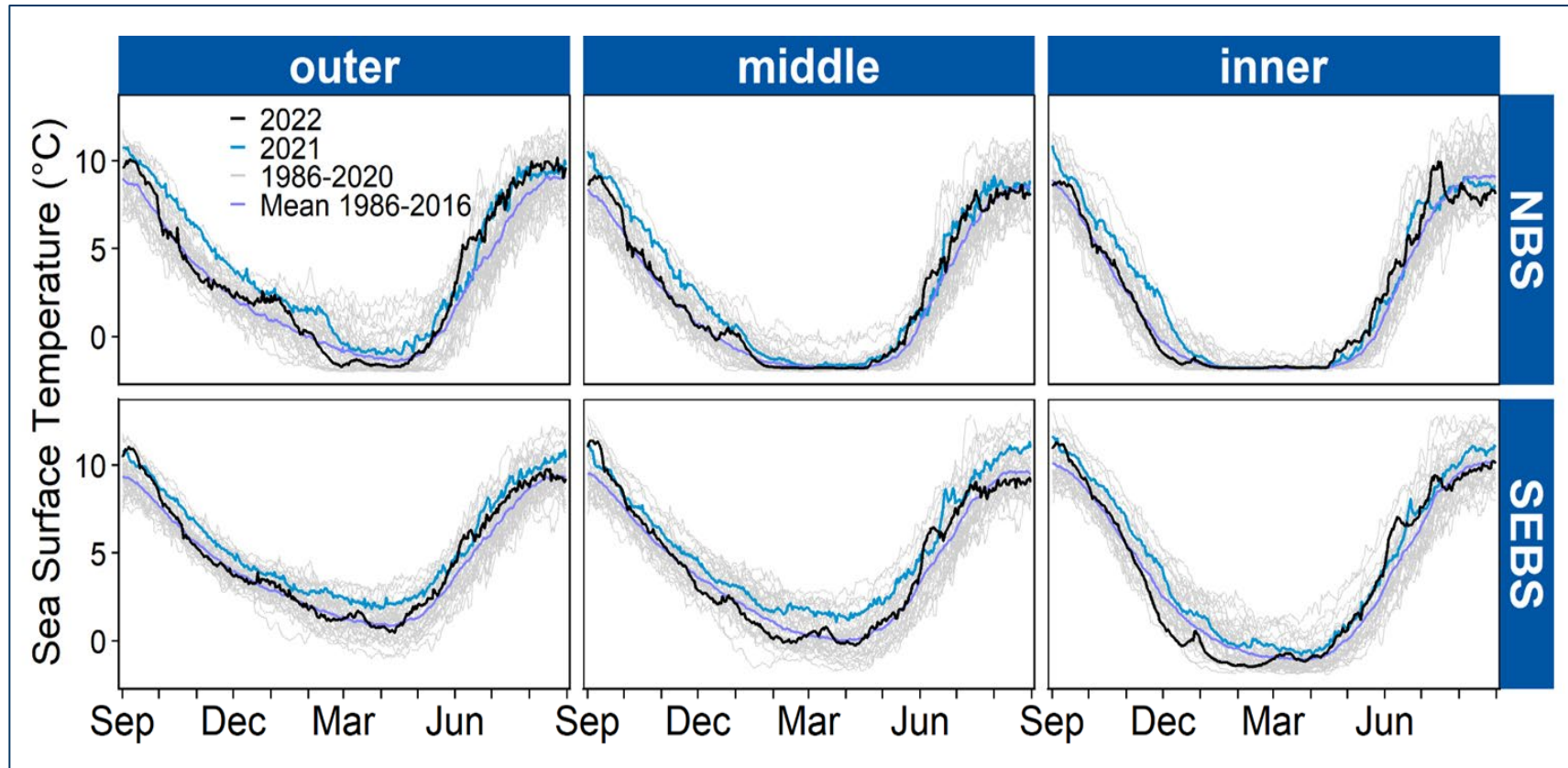
Overland & Wang



Cold spring (May)

Sea Surface Temperature

Lemagie & Callahan

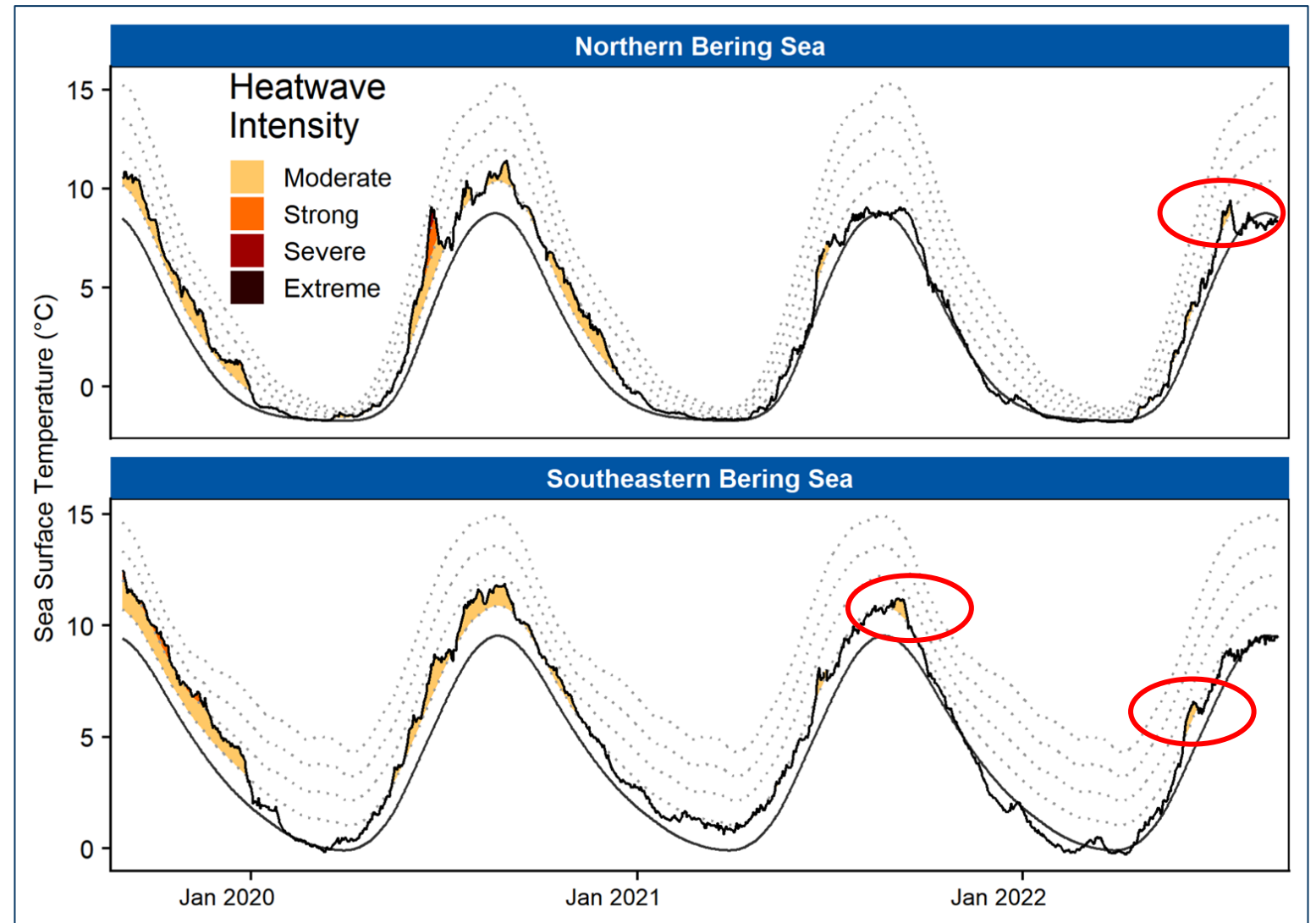


- SSTs largely similar to (and in some cases below) the long-term mean in fall, winter, and spring.
- SSTs were slightly above average in summer.

Marine Heatwave Index

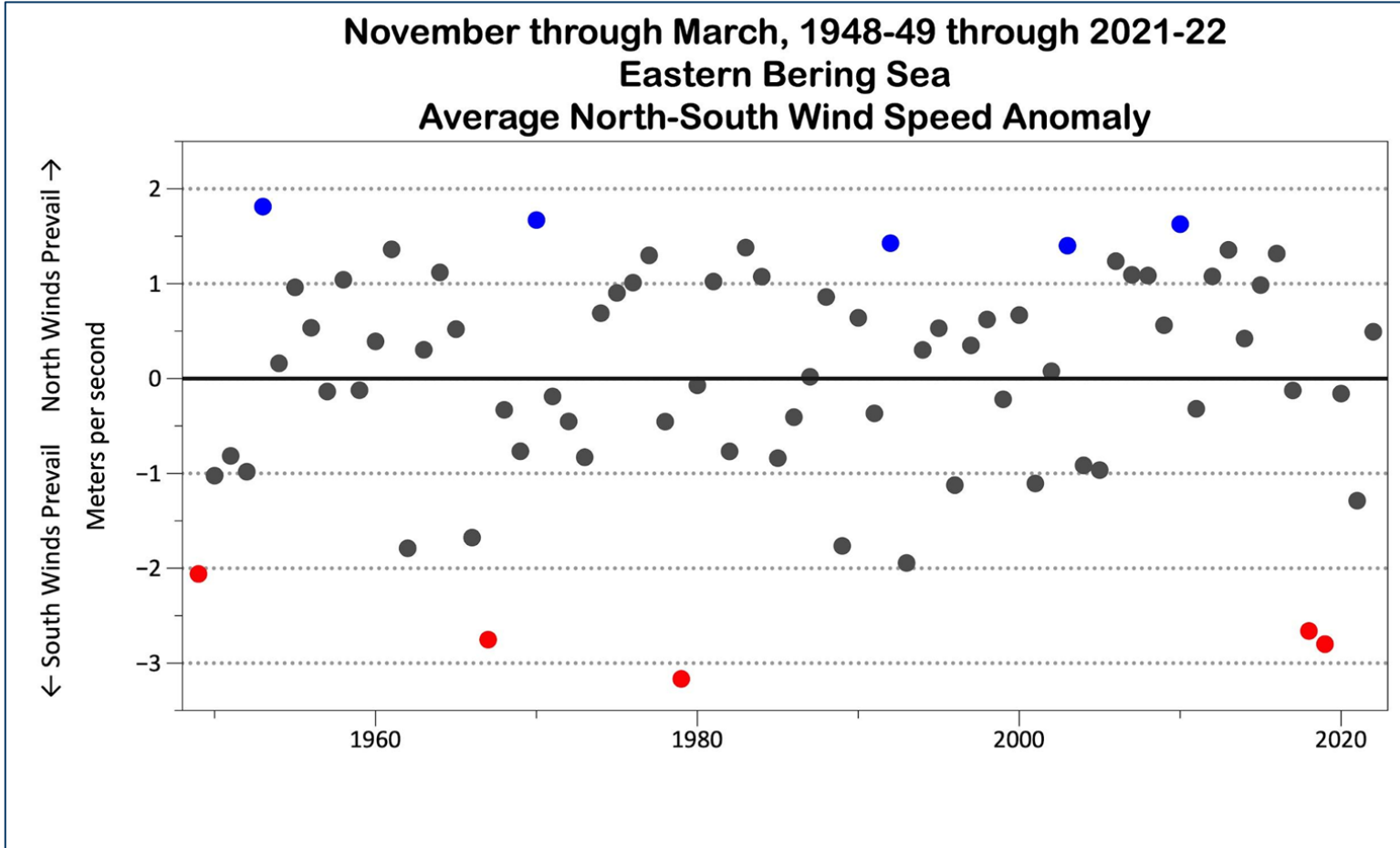
Lemagie & Callahan

- 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

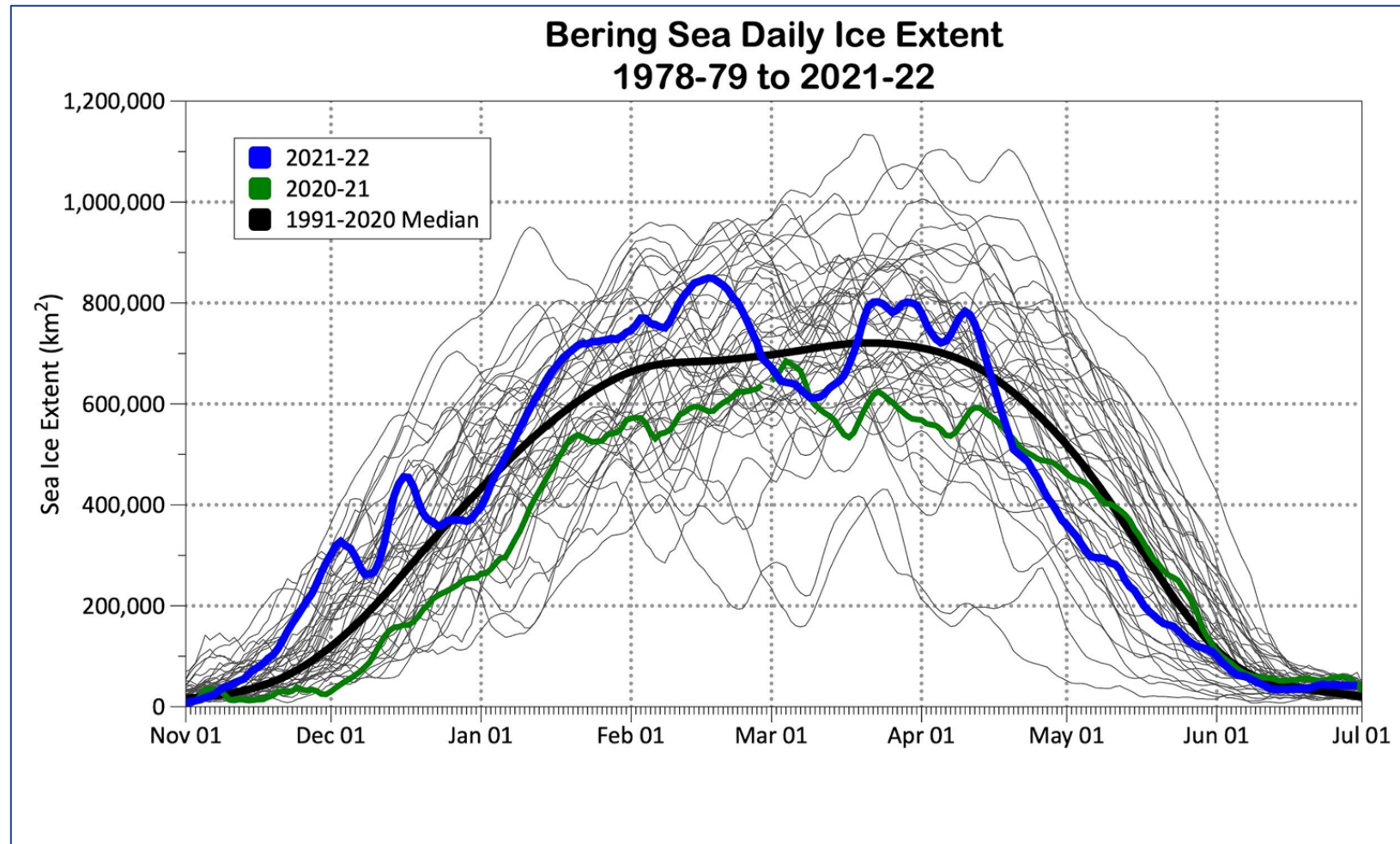
Thoman



- 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).

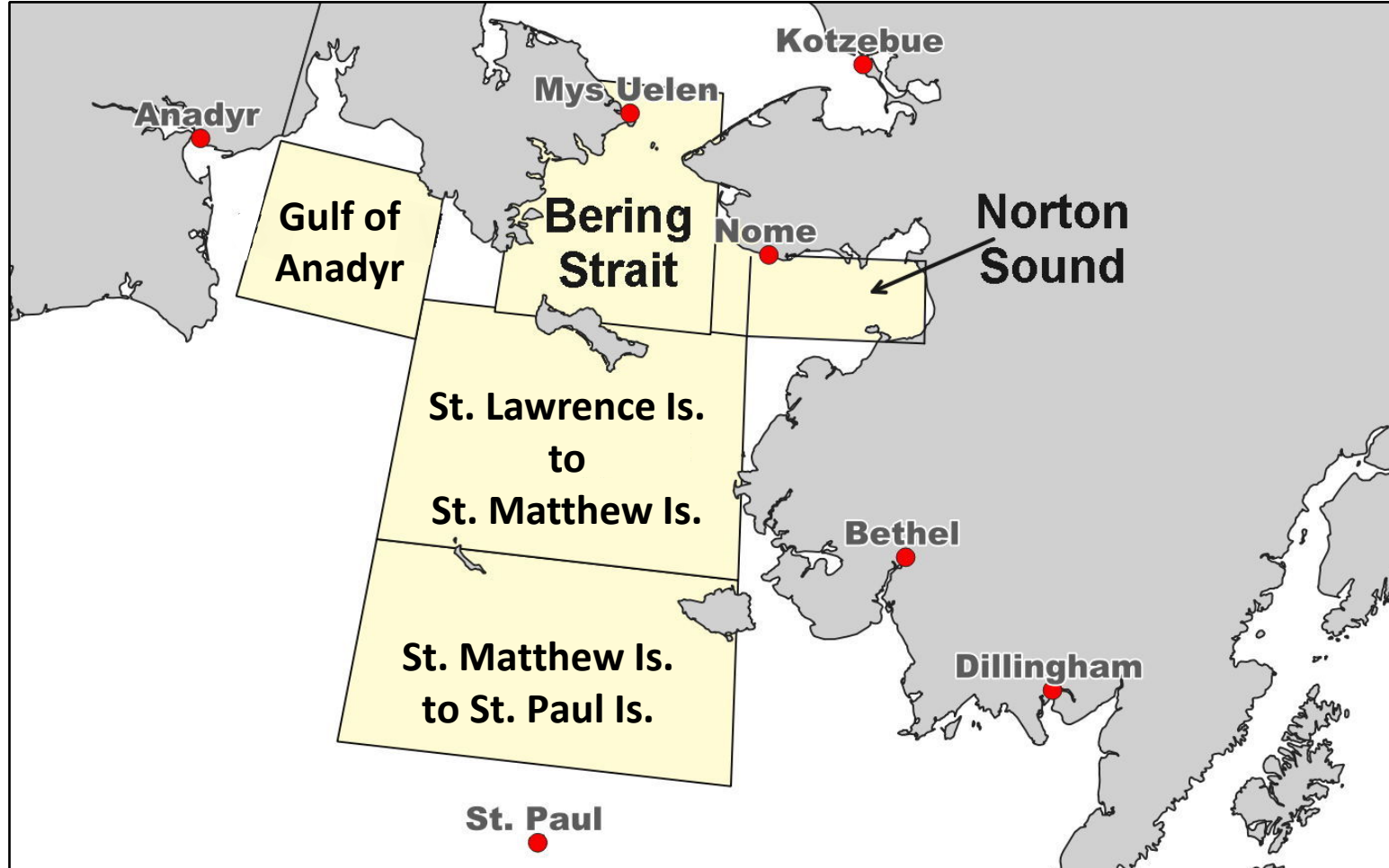
- Winters ending in 2018 and 2019 were among 5 years with the strongest south winds, which contributed to low sea ice extent in those years.

- 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 next)
 - Storminess
- Maximum ice extent occurred February 17, almost a month earlier than the median.



Bering Sea Ice Thickness

Thoman

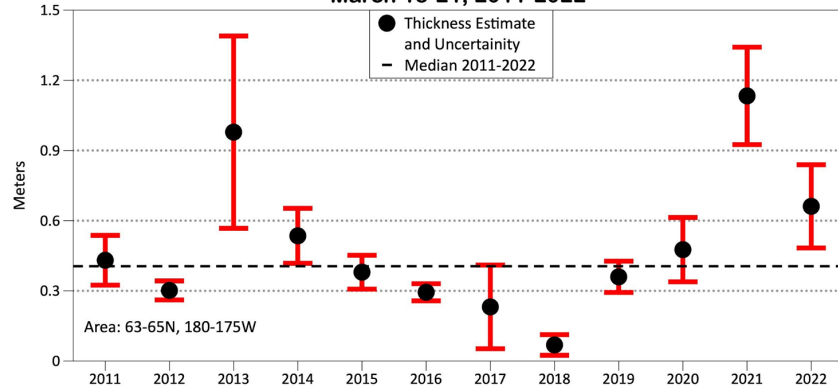


- 3rd week of March.
- Ice thickness is related to duration or residency of ice over the shelf.
- Abundance of ice-associated algae correlated to ice duration?

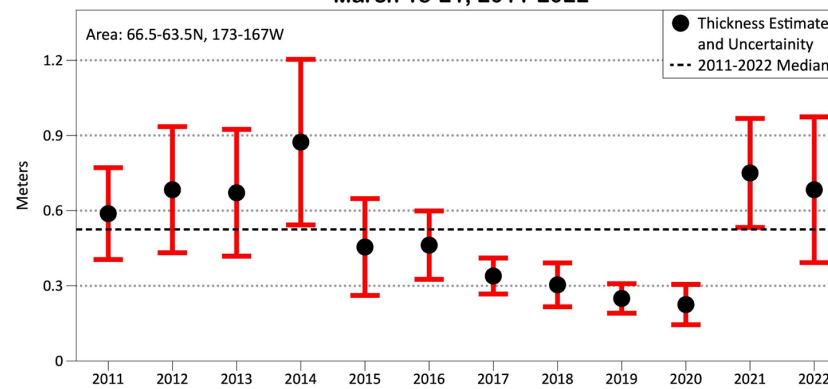
Bering Sea Ice Thickness

Thoman

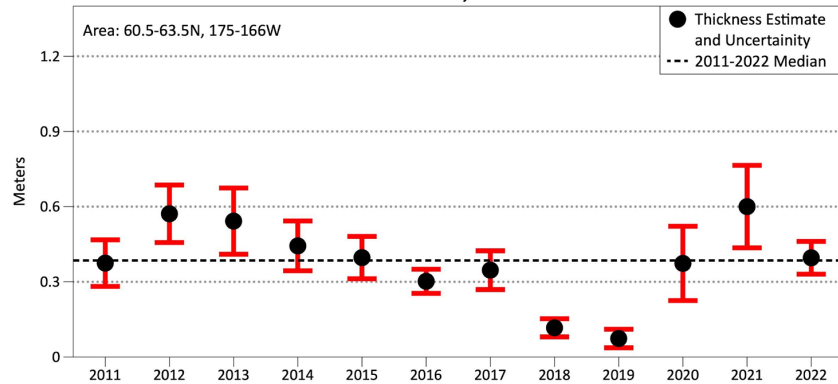
Gulf of Anadyr
Average Sea Ice Thickness
March 15-21, 2011-2022



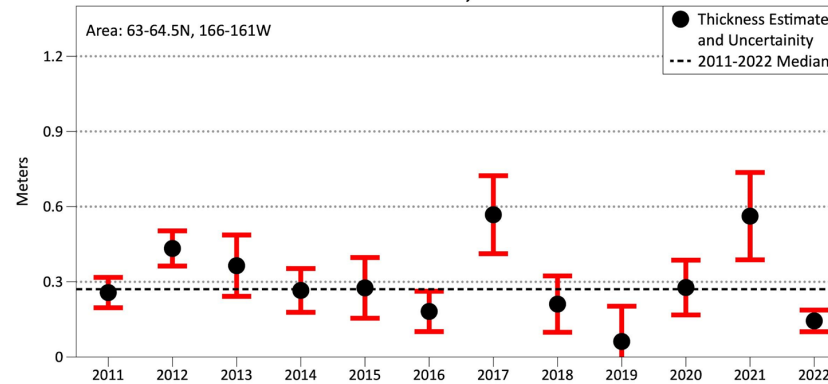
Bering Strait
Average Sea Ice Thickness
March 15-21, 2011-2022



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

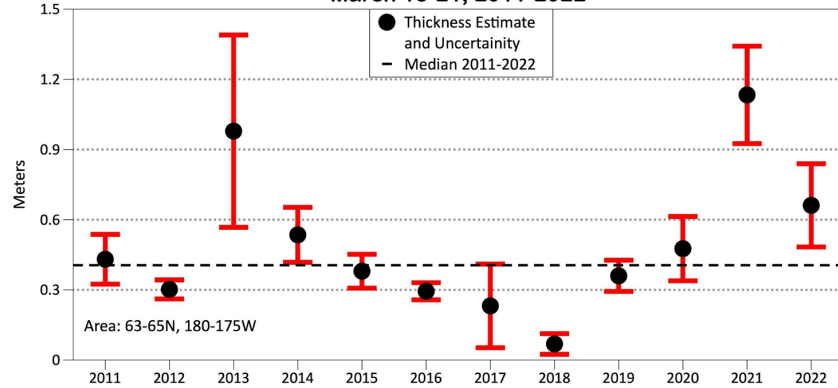


- Ice *extent* was higher than recent years.
- Ice *thickness* was lower than 2021 in all NBS areas.
- Norton Sound ice thickness was 2nd lowest of record.

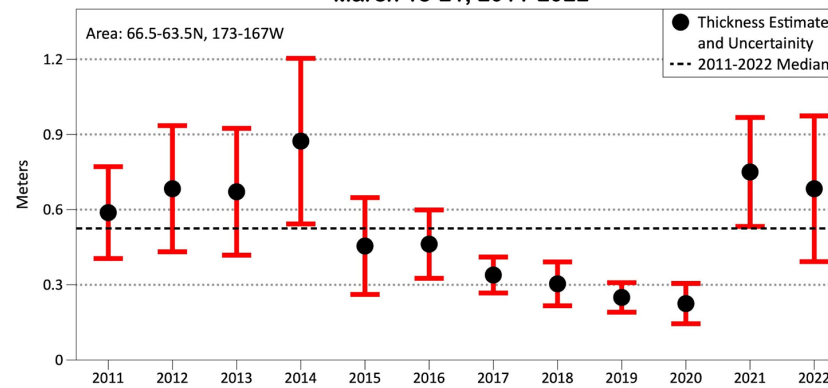
Bering Sea Ice Thickness

Thoman

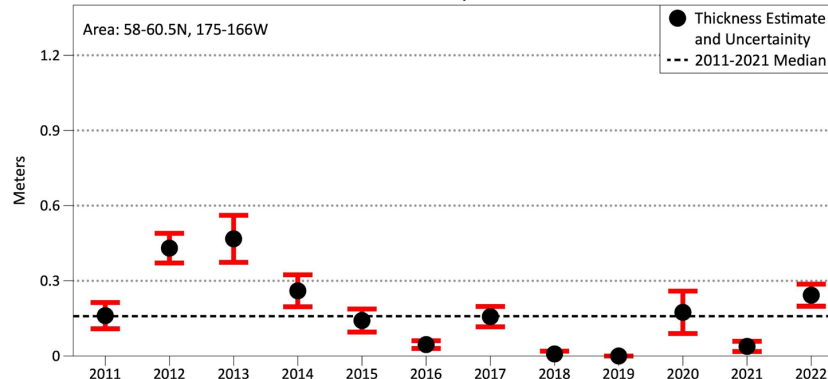
Gulf of Anadyr
Average Sea Ice Thickness
March 15-21, 2011-2022



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



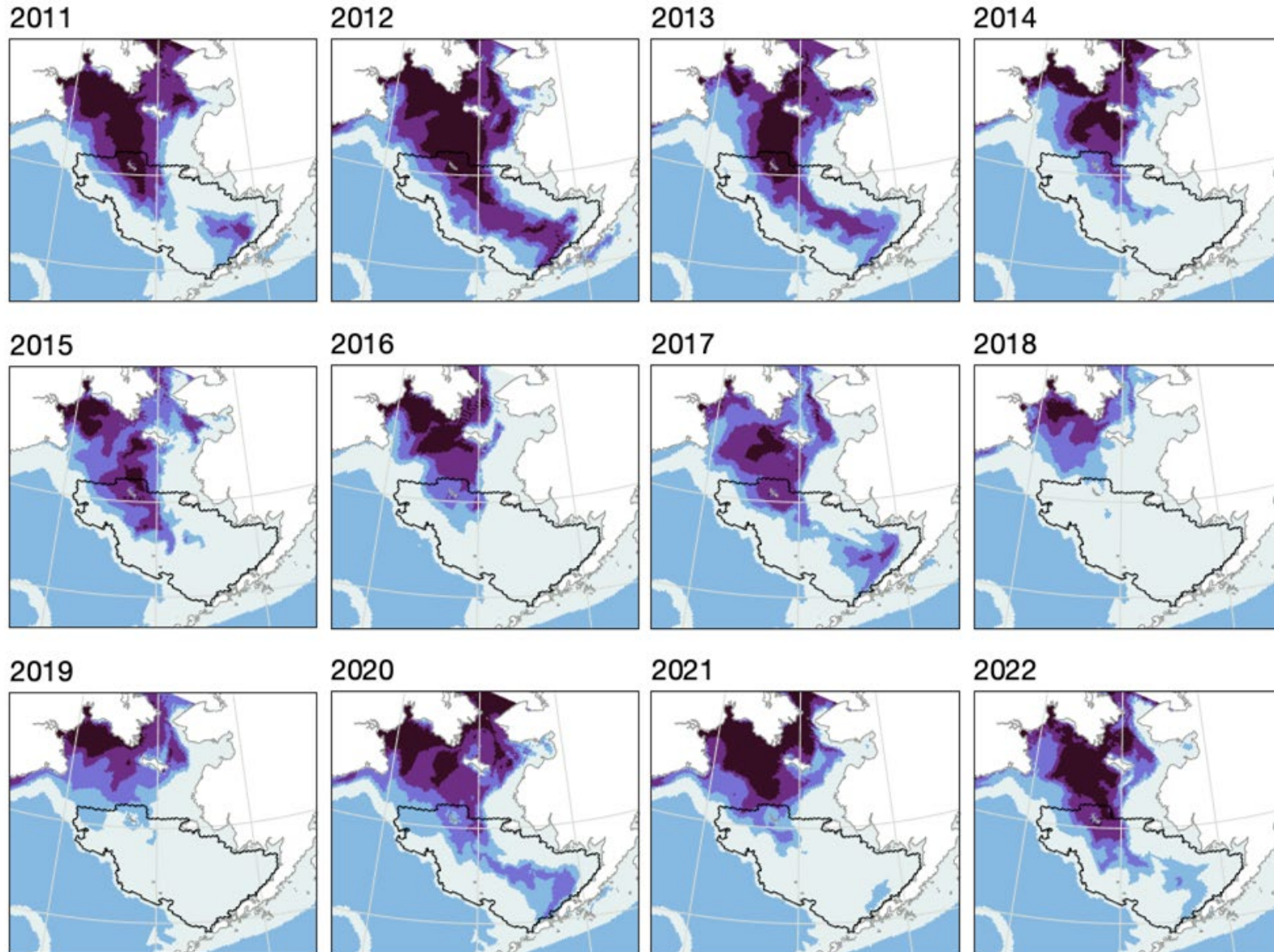
St. Matthew Island to St. Paul Island
Average Sea Ice Thickness
March 15-21, 2011-2022



- 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

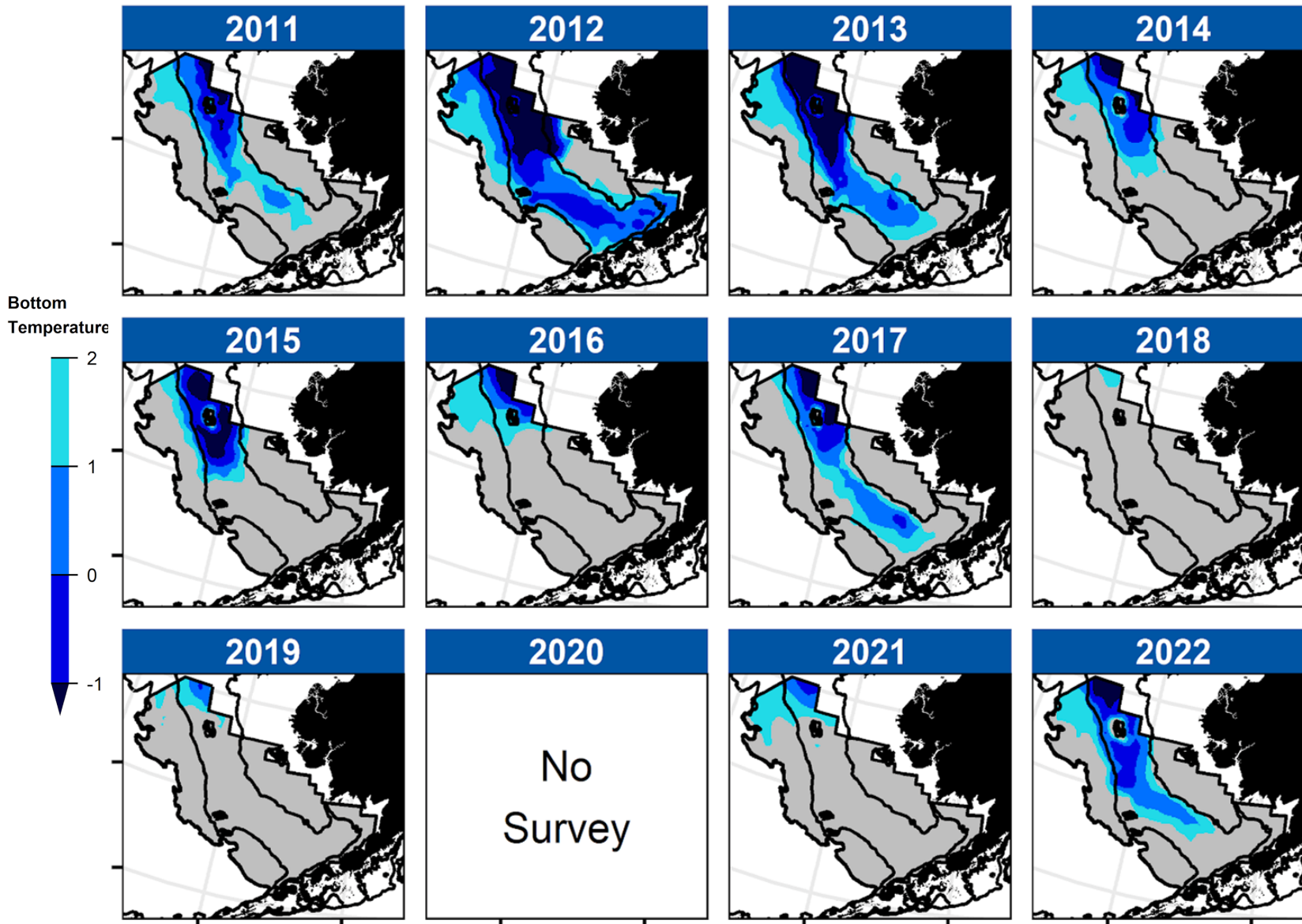
Kearney



- 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

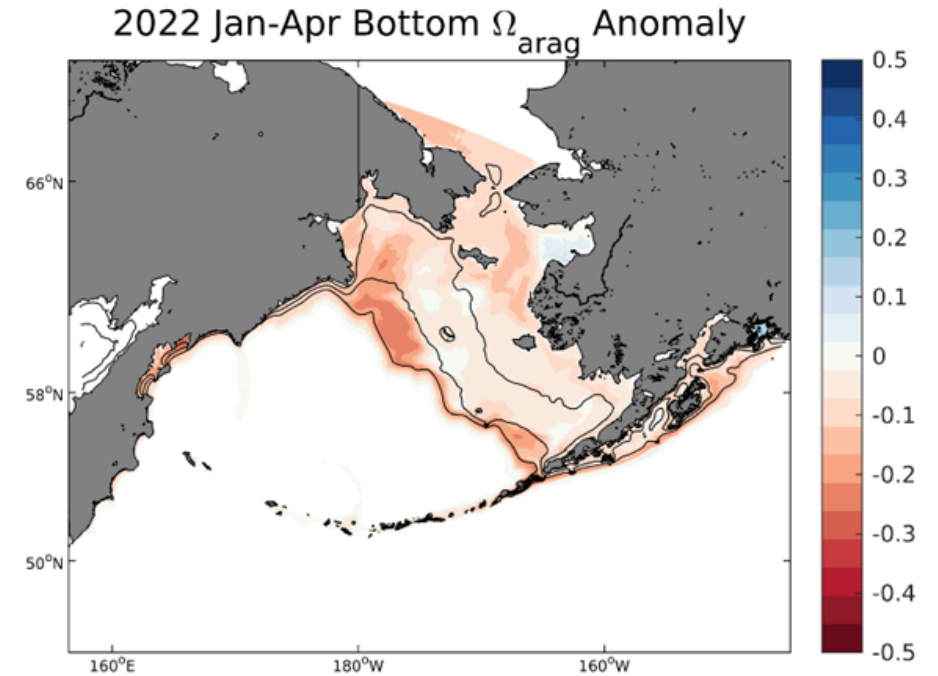
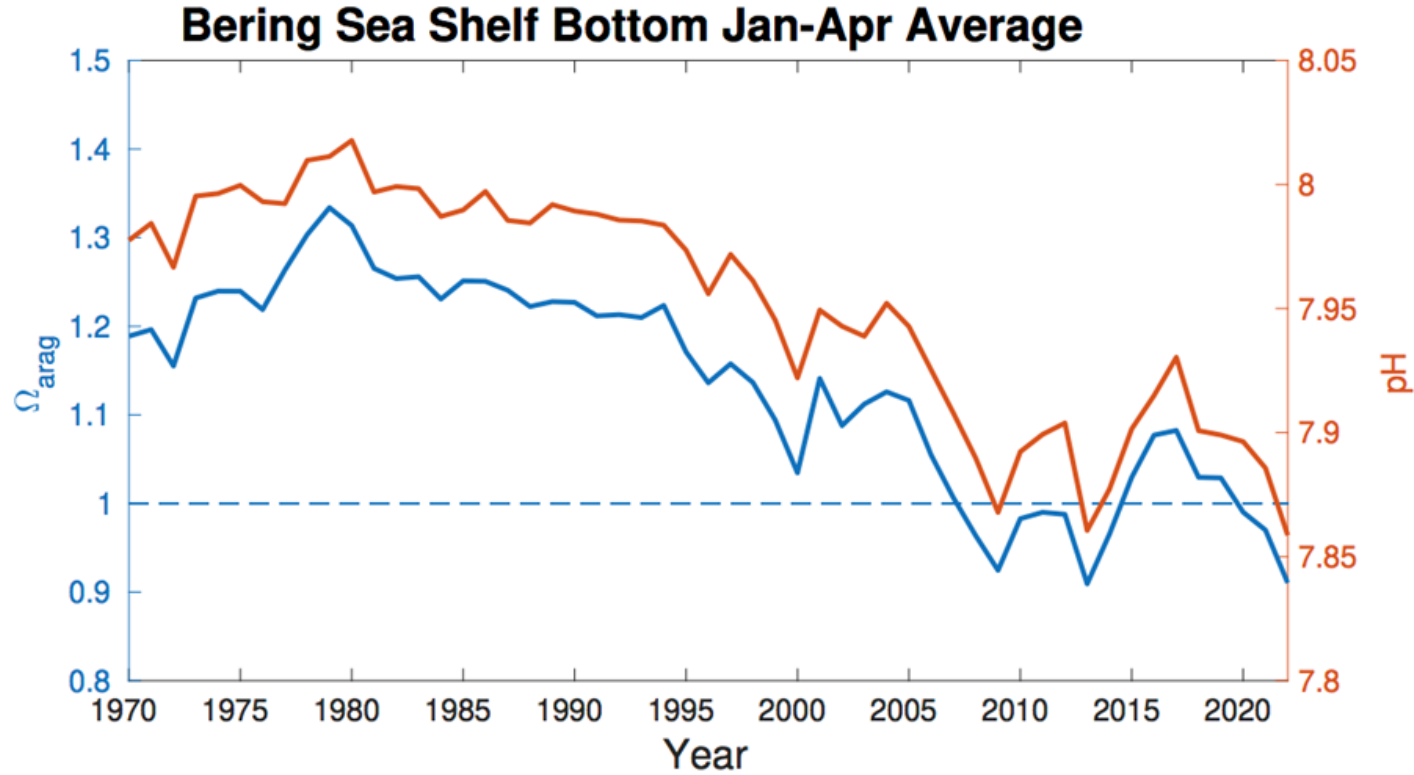
Rohan & Barnett



- 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.

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.

EBS Climate & Oceanography

Sea Surface Temperature (SST)

- SEBS and NBS had near-normal SSTs in fall through spring, with moderate warming in summer.
- MHWs infrequent and brief compared to recent past.

Moderation of SSTs to near-normal levels

Sea ice

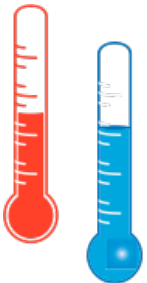
- Rapid ice growth in November; rapid retreat in April.
- Ice extent exceeded median for much of the winter, but ice thickness was generally lower than 2021.

Sea ice impacts stratification and production of ice algae

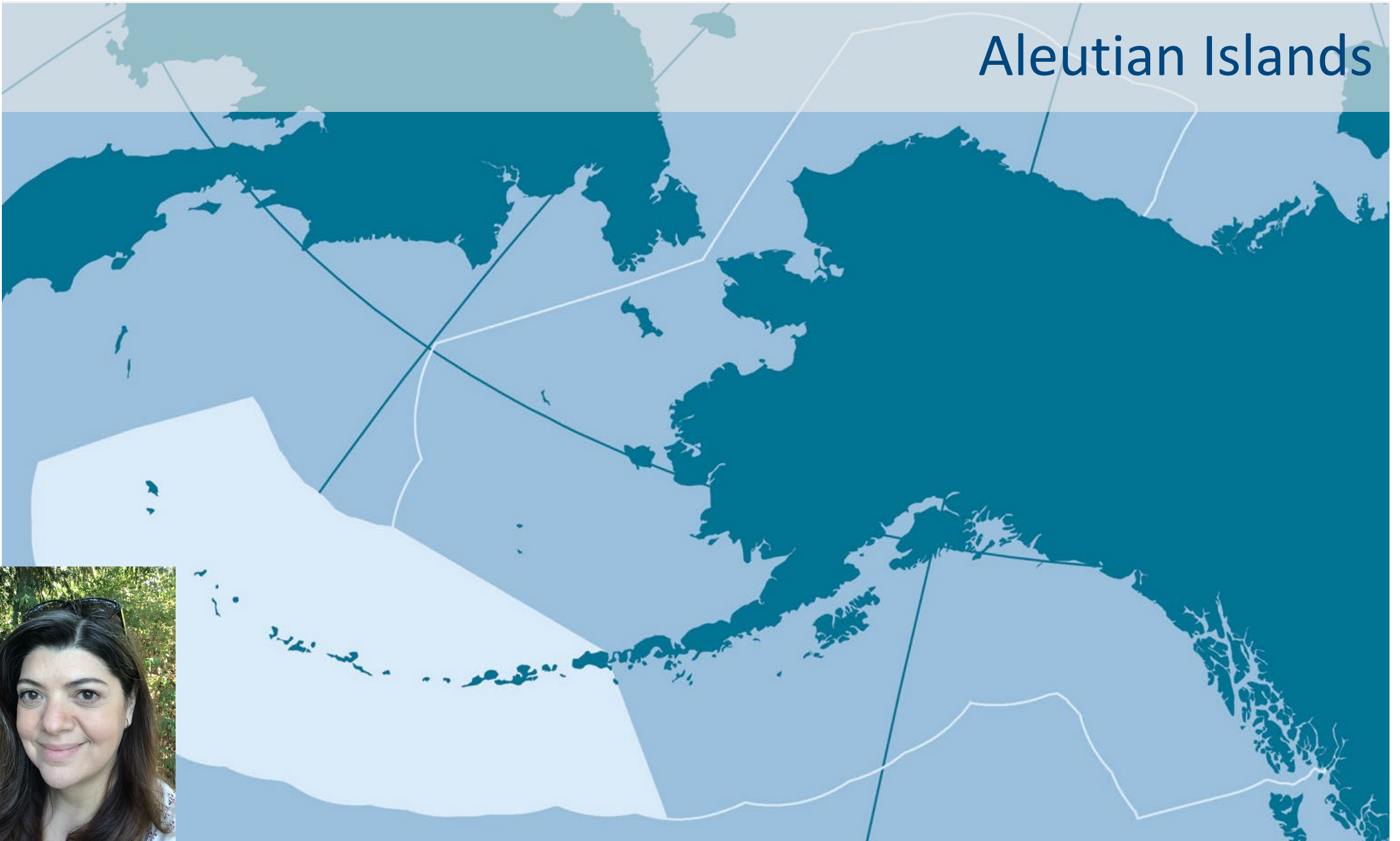
Cold pool

- 2022 cold pool extent was near the historical average.
- 2022 resembles other average-to-cool years (e.g., 2011 & 2017).

Cold pool extent impacts distribution and movement of fish and crab stocks

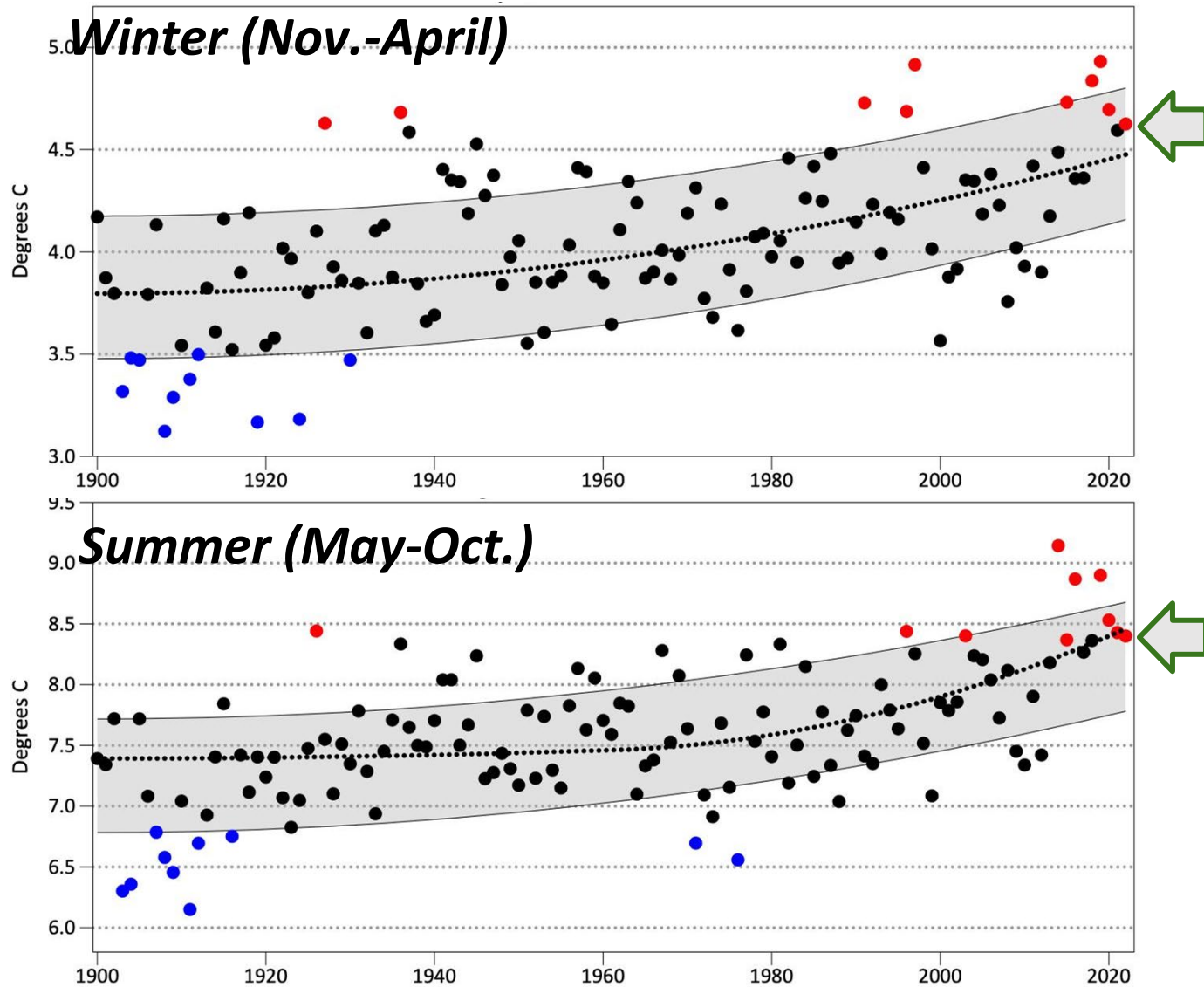


Aleutian Islands



Long-Term AI Sea Surface Temperature

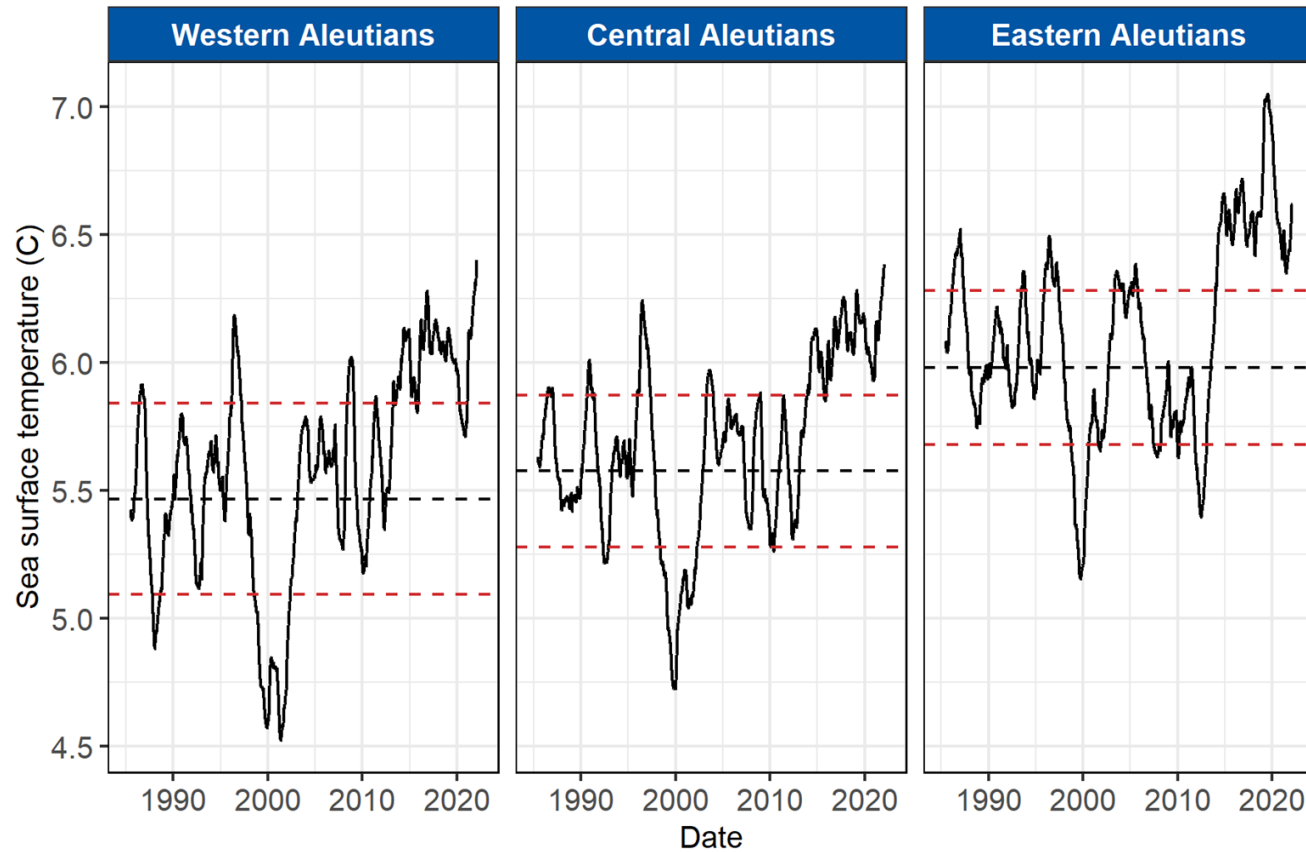
Thoman



- AI NMFS area shelf SST (NOAA's Extended Reconstructed SST, ERSSTv5) with B-spline regression $\pm 1SD$
- Winter (Nov.-April '21/'22) SST among ten warmest; warming long-term trend $\sim 0.75^{\circ}C$
- Summer (May-Oct. '22) again among ten warmest SST and increasing trend over long-term $\sim 1^{\circ}C$
 - Summer 2022 data point is preliminary

AI SST & Marine Heatwaves 2022

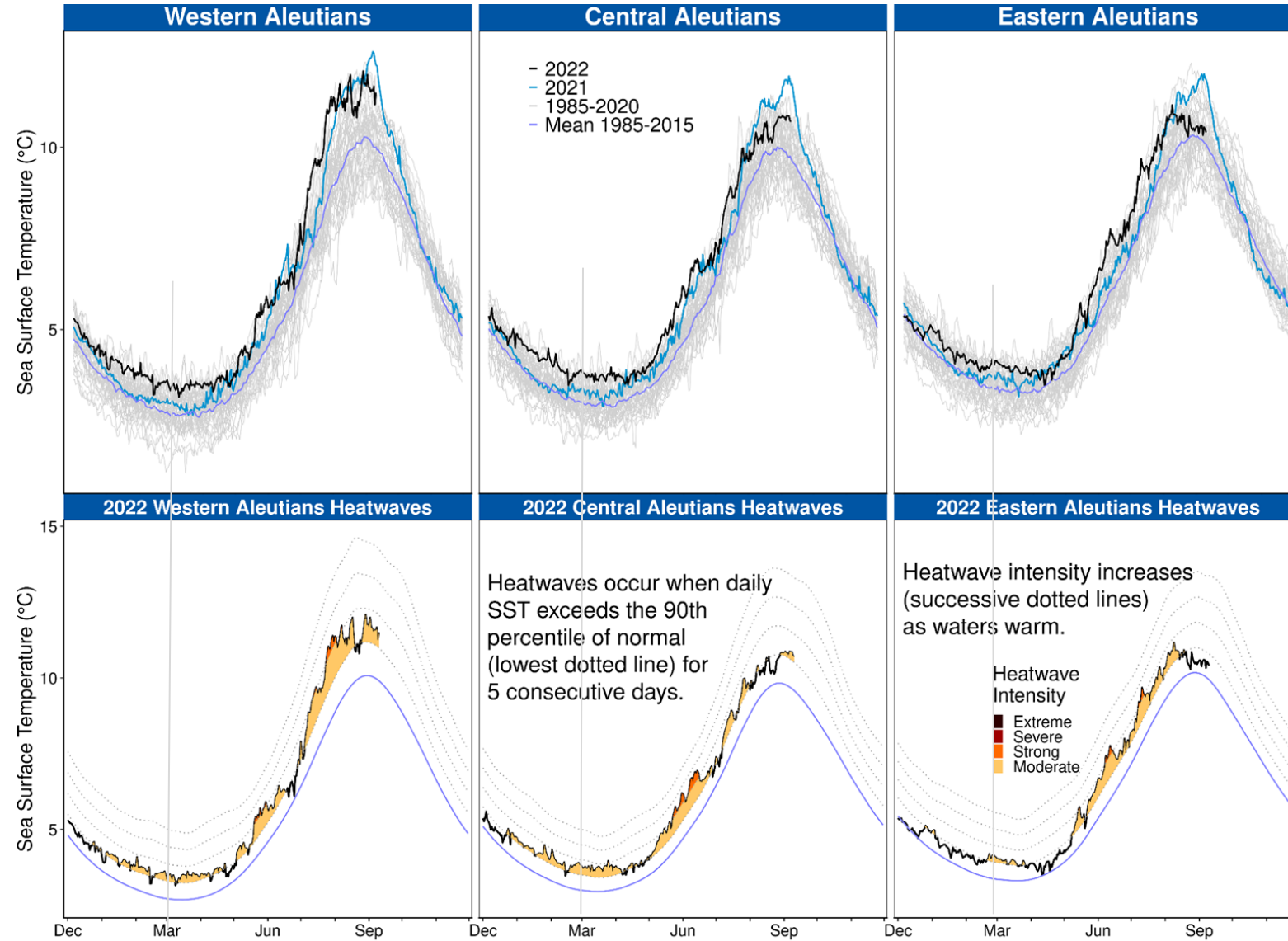
Lemagie, Callahan



- Continued warm temperature above long term mean

AI SST & Marine Heatwaves 2022

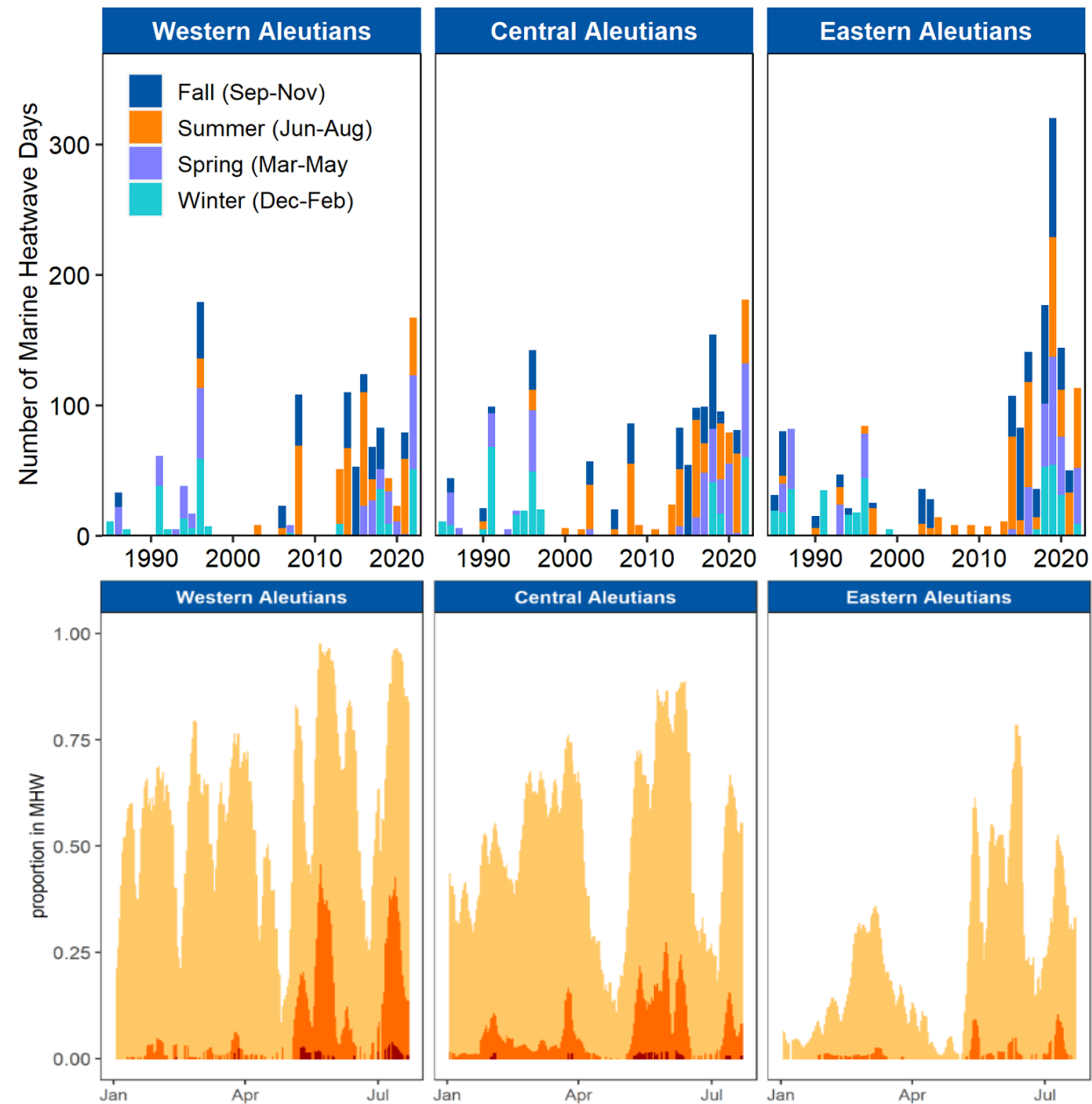
Lemagie, Callahan



- Continued warm temperature above long term mean
- Warm winter across AI particularly WAI and CAI
- Summer temperatures same or above last year
- Sustained moderate MHW in WAI reaching strong category at times

AI SST & Marine Heatwaves 2022

Lemagie, Callahan

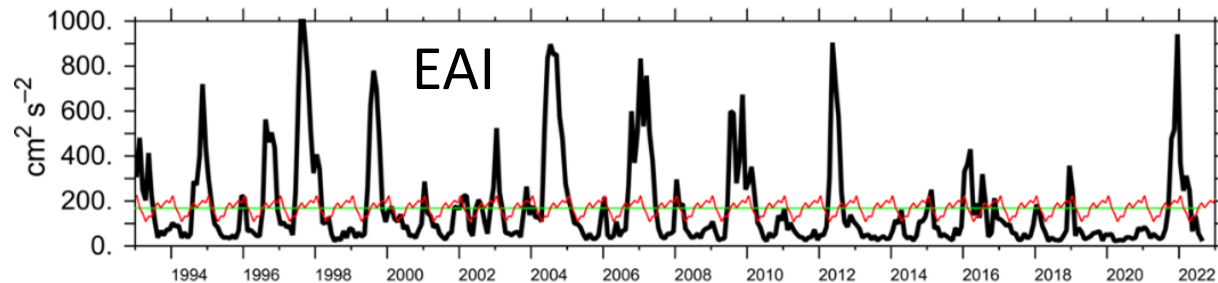
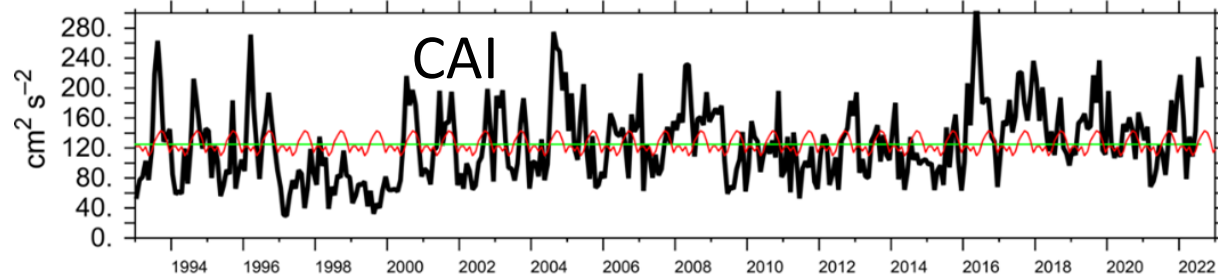
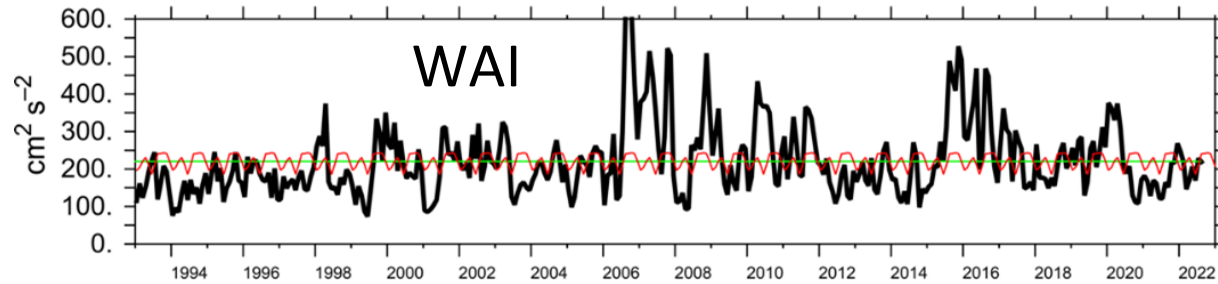
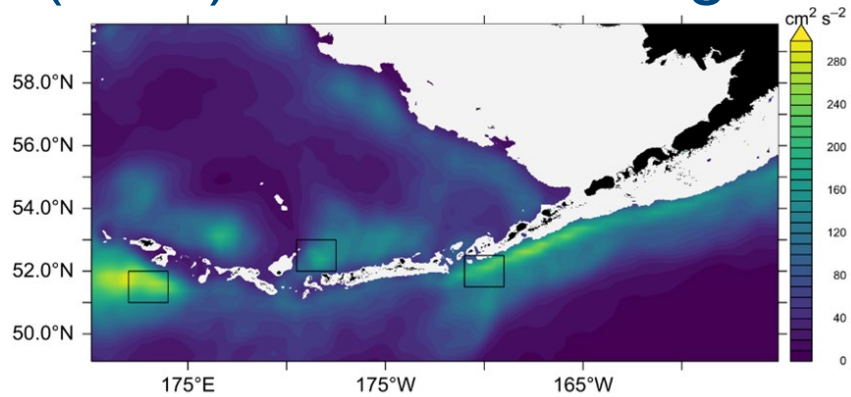


- 2022 increased length of heat wave in WAI and CAI, not as long in EAI
- WAI, CAI Heatwave in all seasons
EAI mostly only Summer & Spring
- WAI: Over half the area under heatwave, past 75% in summer;
CAI often 50% on heatwave too, lower intensity

Average Eddy Kinetic Energy (EKE) Jan 1993 - Aug 2022

Eddies in the AI

Cheng & Ladd



- Monthly climatology in red, 1993-2021 mean in green
- WAI close to long term mean
- CAI sustained increased activity since 2016
- EAI second highest on record, below 1997, from 2nd half 2021 to 1st half 2022. First significant increase since 2012

update



AI Climate & Oceanography

Surface Temperature

- Year long MHW in WAI, CAI; summer in EAI
- Warming winters in WAI, CAI
- Sustained SST above average across AI now 10 years in a row

Impacts of MHW depending on magnitude and duration of heatwave

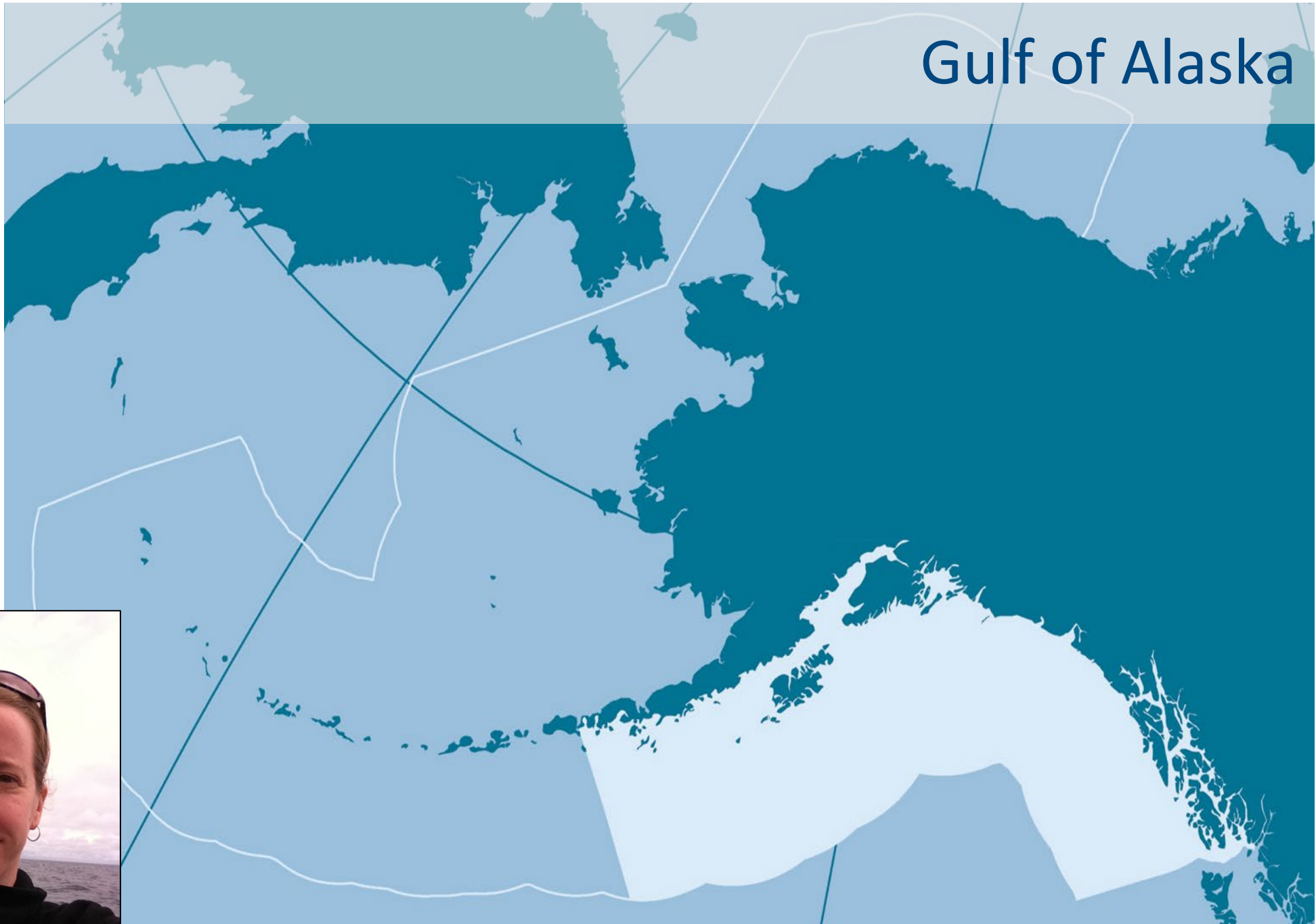
Transport

- Unimak Pass: Second strongest EKE, first strong event since 2012
- CAI: Continued above average EKE since 2016
- Low EKE in WAI

Likely lower than average volume, heat, salt and nutrient fluxes to the Bering Sea

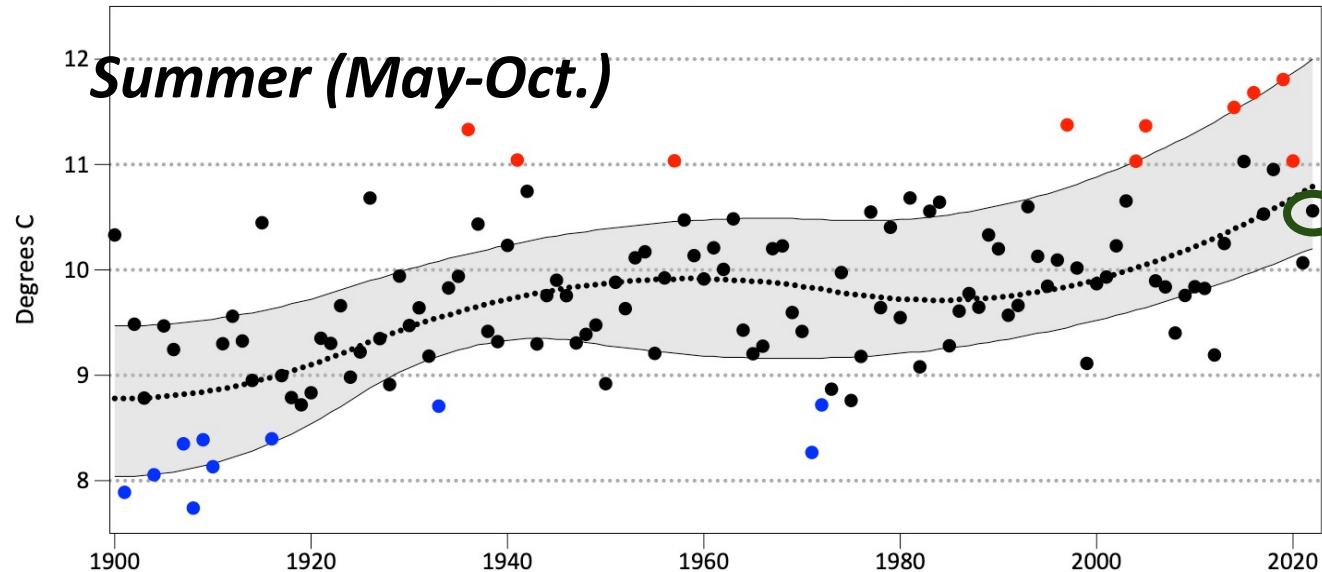
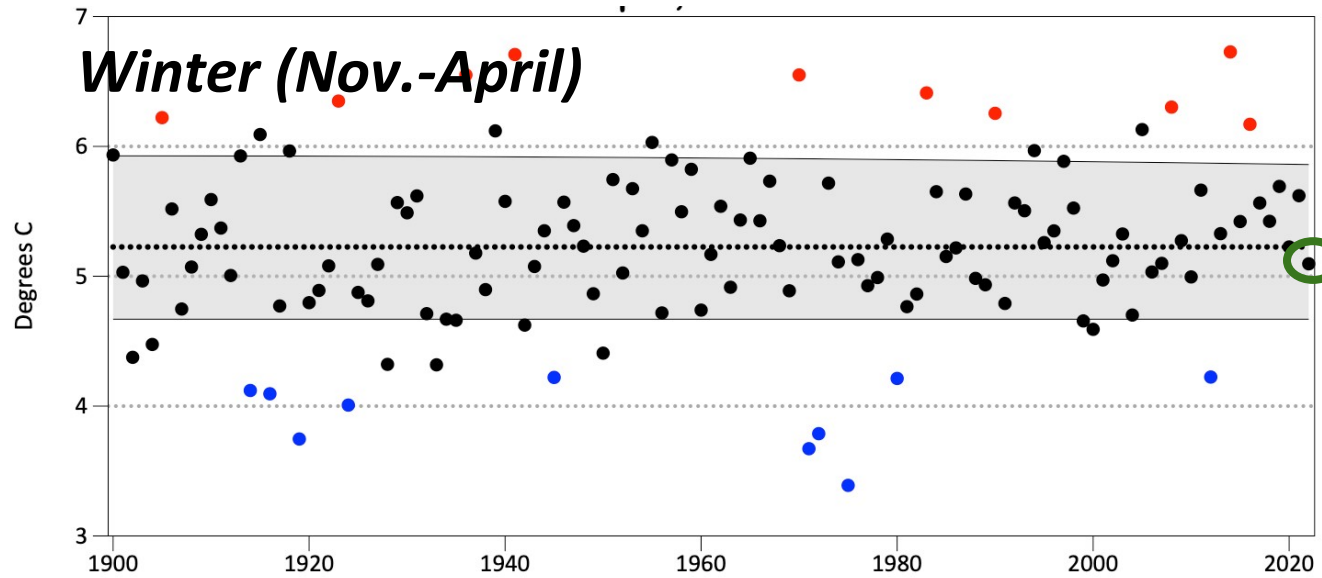


Gulf of Alaska



Long-Term GOA Sea Surface Temperature

Thoman



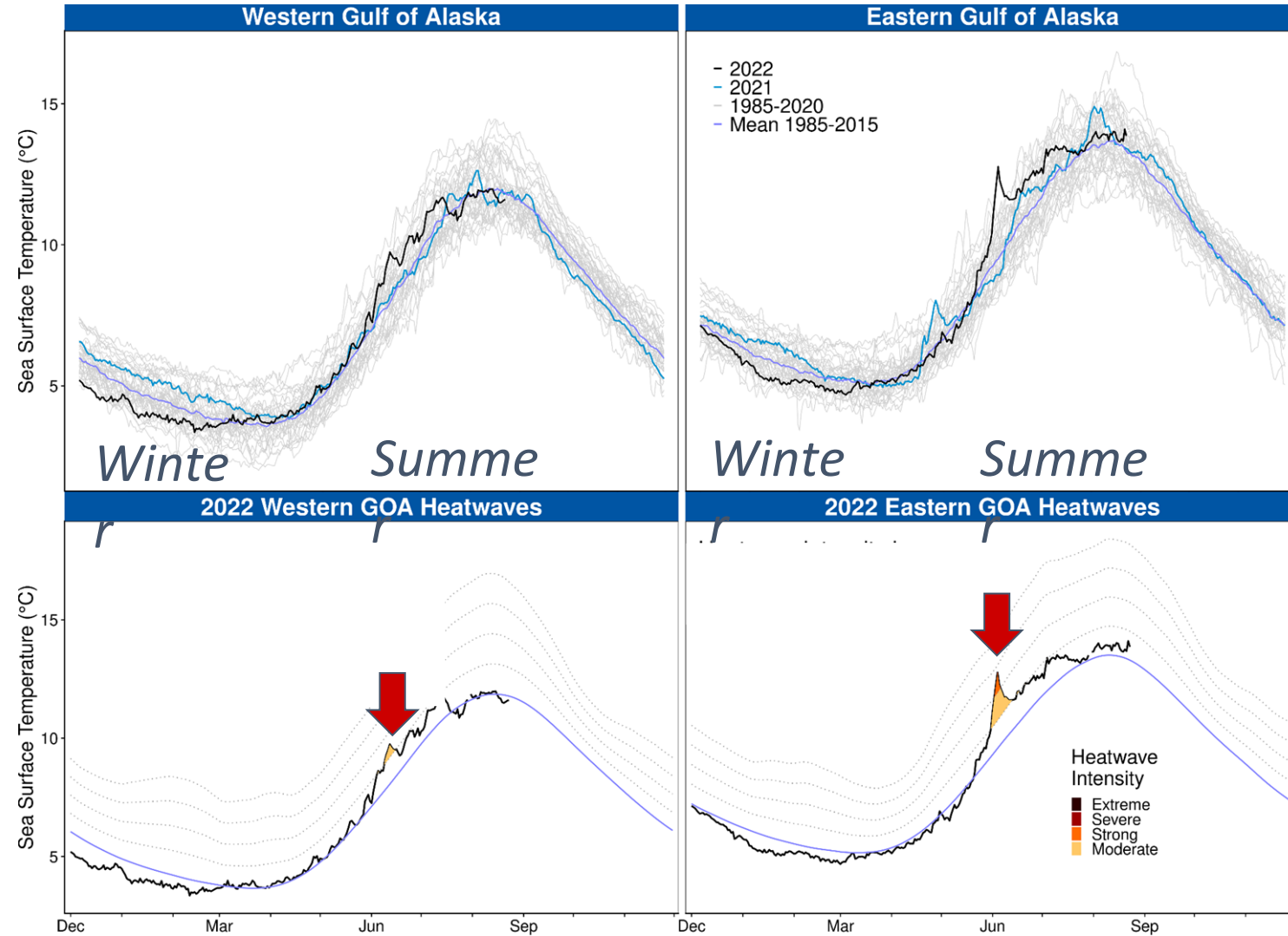
Estimated \pm One Std. Dev.
 Ten Warmest
 Ten Coldest

Data source: ERSSTv5 and
B. Brettschneider/NWS Alaska
2022 estimated

- GOA shelf SST (NOAA's Extended Reconstructed SST, ERSSTv5) with B-spline regression $\pm 1SD$
- Winter (Nov.-April '21/'22) SST close to median; no long-term trend
- Summer (May-Oct. '22) approximately median SST of increasing trend over long-term
 - Summer 2022 data point is preliminary

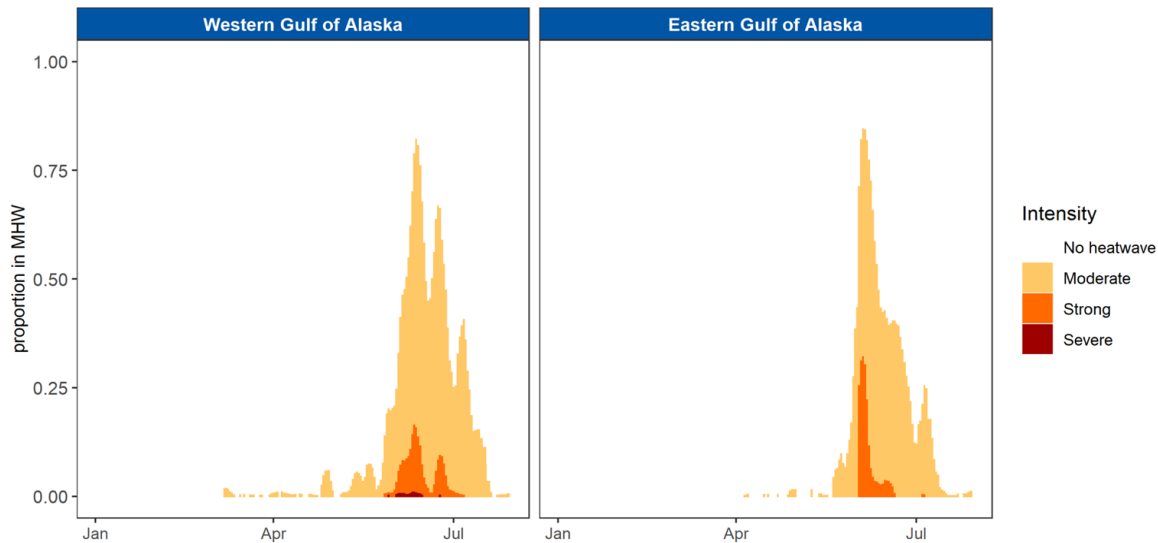
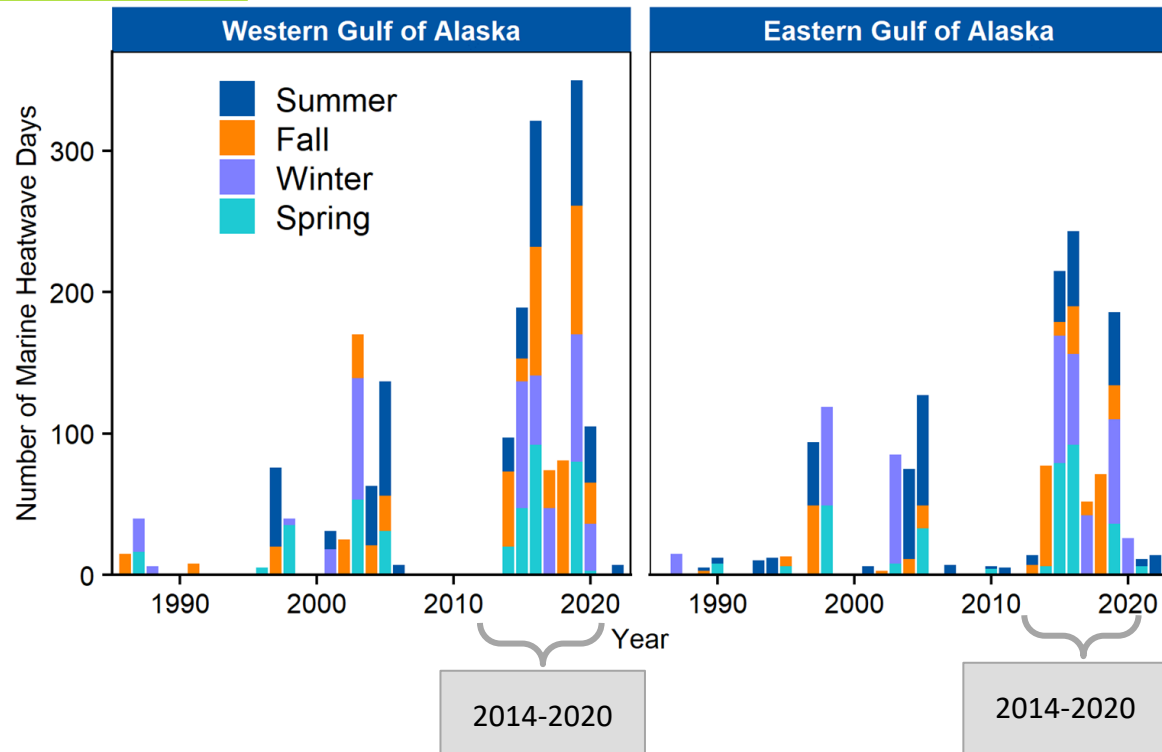
GOA SST & Marine Heatwaves 2022

Lemagie, Callahan



- WGOA & EGOA 2022 SST (black) generally cold during winter, near average during spring, and warm during summer (*1985-2015 baseline*)
- Persistently cooler and closer to the long-term mean than the previous few years
- EGOA MHW was brief/strong and covered >99% EGOA area

Temperature



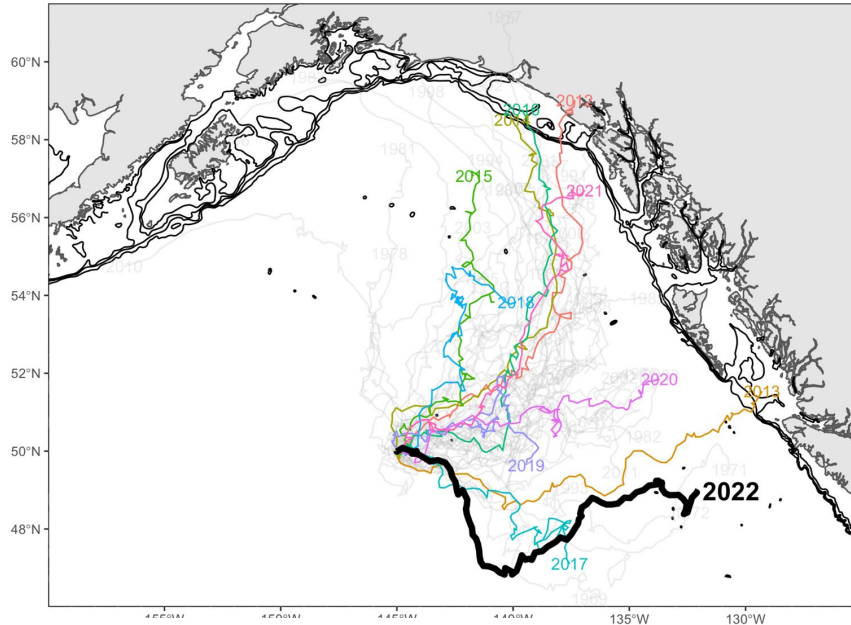
GOA Marine Heatwaves cont.

Lemagie, Callahan

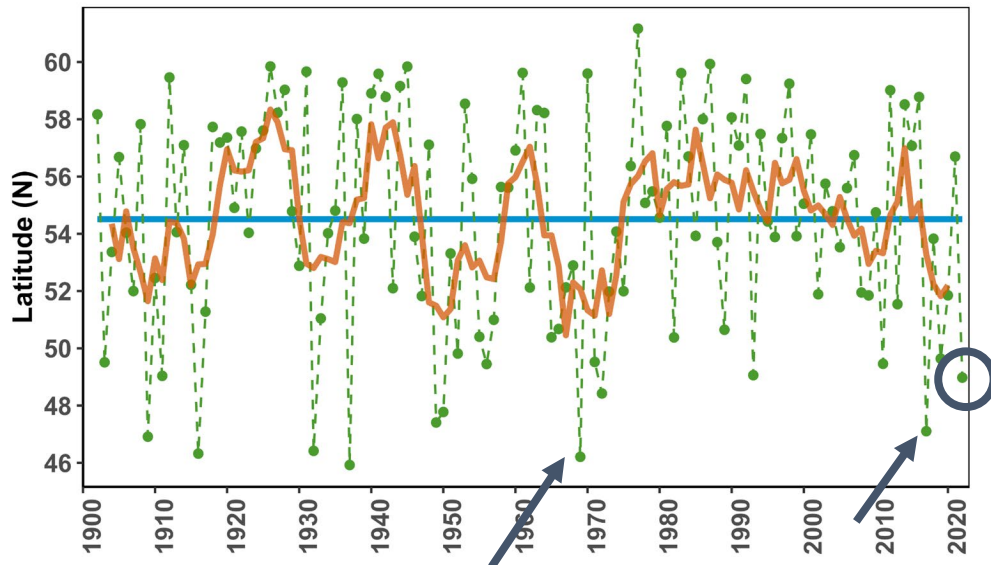
- 2022 is third consecutive year of no persistent MHW conditions
- Continue trend from 2021 as few MHW days relative to 2014-2020
- Brief MHWs in summer in WGOA and EGOA
- MHWs were brief/strong/covered >75% area at their peak

Winter GOA Ocean Surface Currents: Papa Trajectory Index

Stockhausen

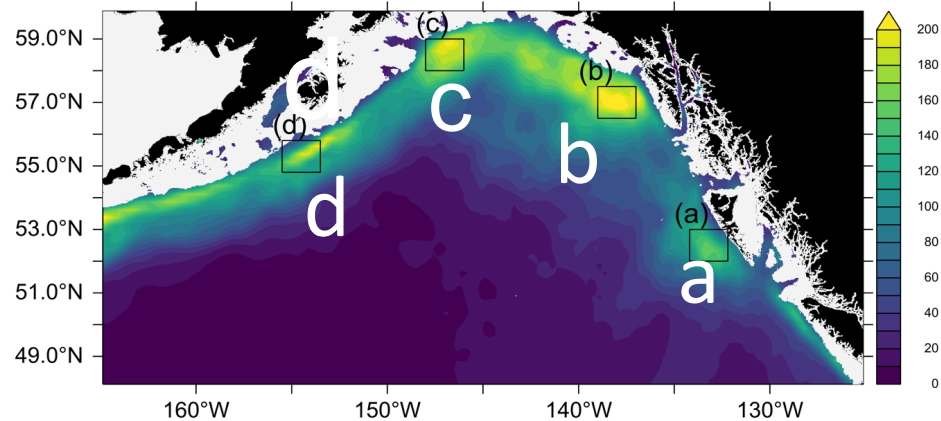


— L-T-M ● PTI — 5-Yr Running



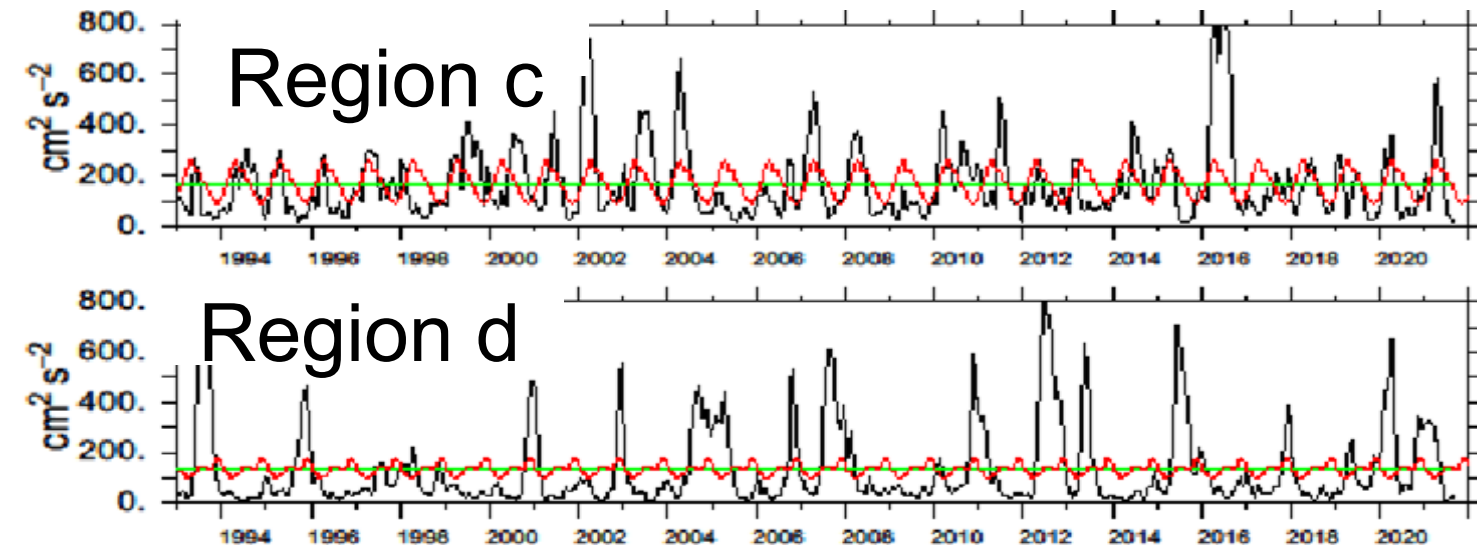
- Simulated surface drifter released from Ocean Station Papa on Dec 1, 2021, for 90 days.
- 2021/2022 PTI extended southeast (ended 2nd most southerly since early 1970s)
- 2022 PTI similar to 1968/70, 1970/71, 1971/72, and 2016/17
- Reflects surface winds from west (east and south transport) associated with the high pressure system and westerlies in winter 2021/22

Average Eddy Kinetic Energy (EKE) Jan 1993 - Aug 2022



Eddies in the GOA Cheng & Ladd

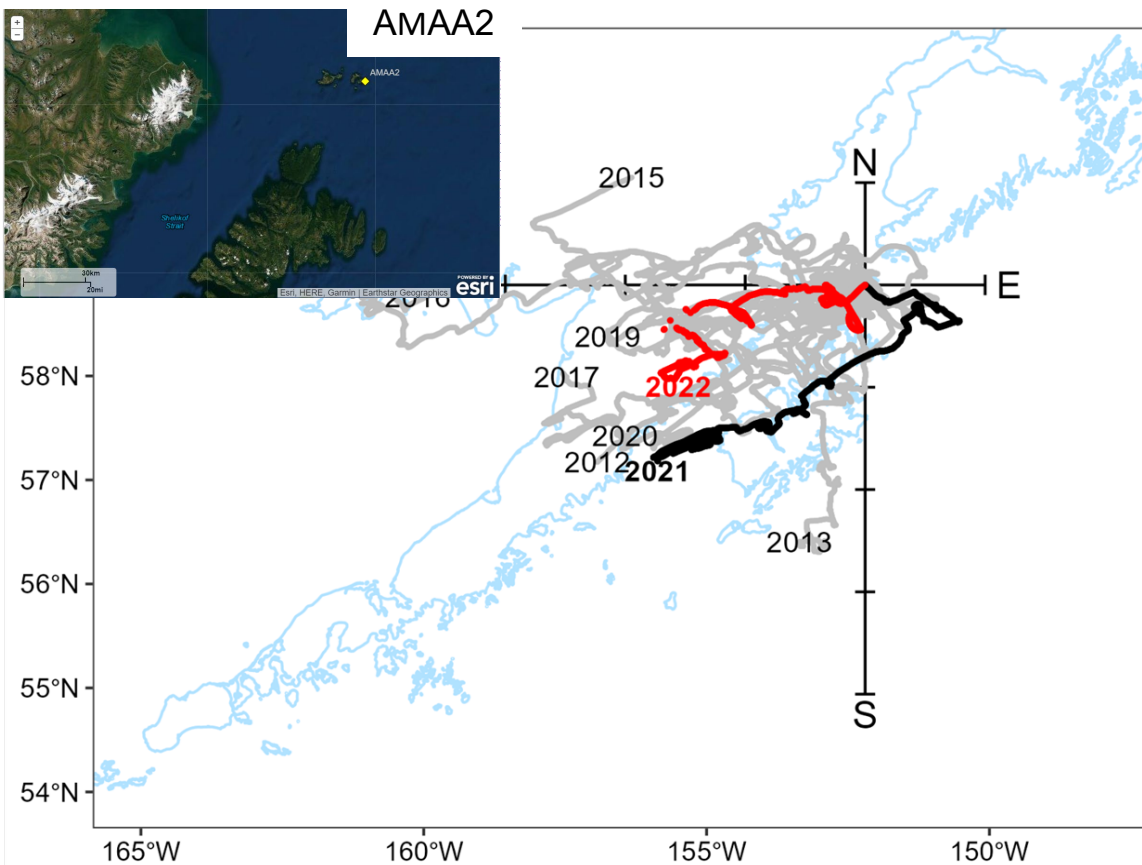
- 2022 eddy kinetic energy (EKE) in all regions is close to climatology
- EKEs in western regions (c and d) reduced from high 2020/2021.
- EKE in eastern regions (a and b), this “slightly low to average” (since the late 2010s)
- EKE related to strength of cross-shelf transport of heat, salinity, and nutrients.



Shelikof Spring Wind

M. Wilson, L. Rogers

Shelikof Spring Wind Direction



- Spring (April-May) surface winds off NE Kodiak Archipelago indicating the direction of coastal flow
- 2022(red): Downwelling-favorable northeasterly spring winds (i.e., down Shelikof Strait) (similar to 2021: black, 2014, 2012)
- Predict good recruitment of 2023 pollock age-1 year class (correlation of southwest wind direction with estimates of age-1 pollock abundance)
- Retention of larval and juvenile pollock in favorable habitat

GOA Climate & Oceanography

Continued multi-year period of similar ocean conditions

Climate

- Continued period of negative PDO, La Niña, weak Aleutian Low (positive NPI)
- Long-term summer SST warming



Surface Temperature

- Cool winter across GOA shelf, average spring, and warm summer
- 3rd consecutive year of no persistent MHW conditions (but brief summer MHW)

Transport

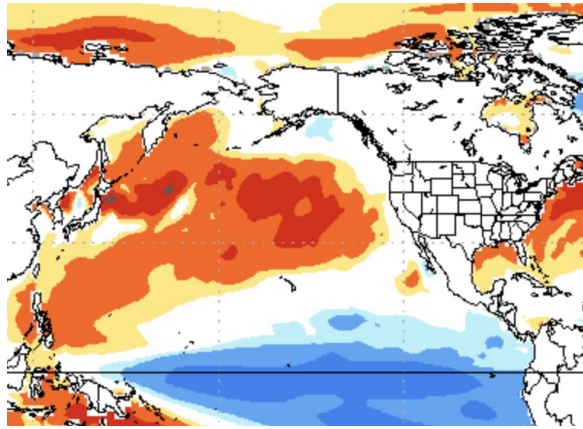
- Fall '21/Winter '22: winds from west results in east and southward surface transport (reduced northward/westward transport)
- Spring/Summer '22:
 - Winds return to counterclockwise, downwelling
 - Shelikof Strait spring winds from northeast down the Strait
 - Average cross-shelf transport of heat, salinity, and nutrients from eddies



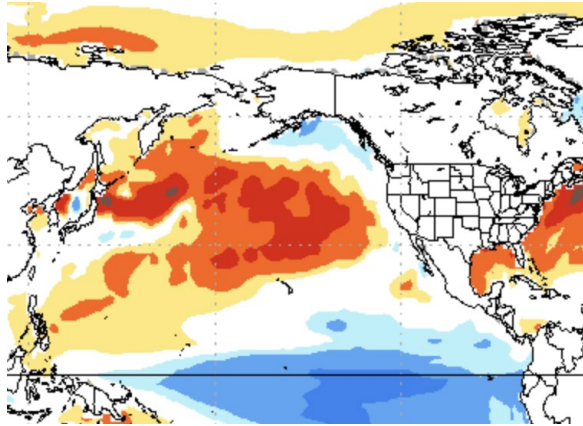
SST Anomalies Projections from the National Multi-Model Ensemble

Bond

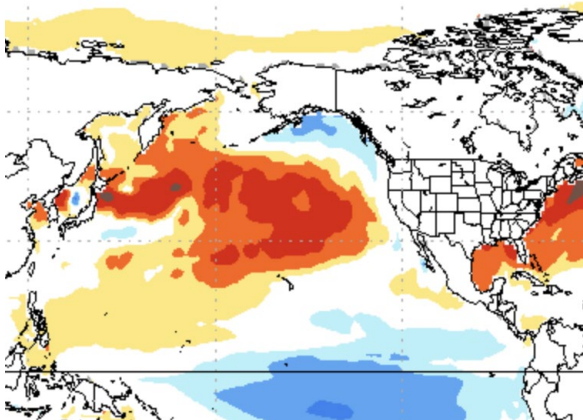
Oct - Dec
2022



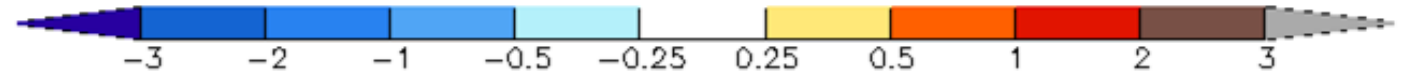
Dec 22 -
Feb 23



Feb - April
2023



- **Fall '22:** Continued warm water over Central North Pacific
- **Winter '22/'23:** Continued La Niña conditions, cooling in GOA
- **Spring '23:** Expected average conditions.



WEATHER

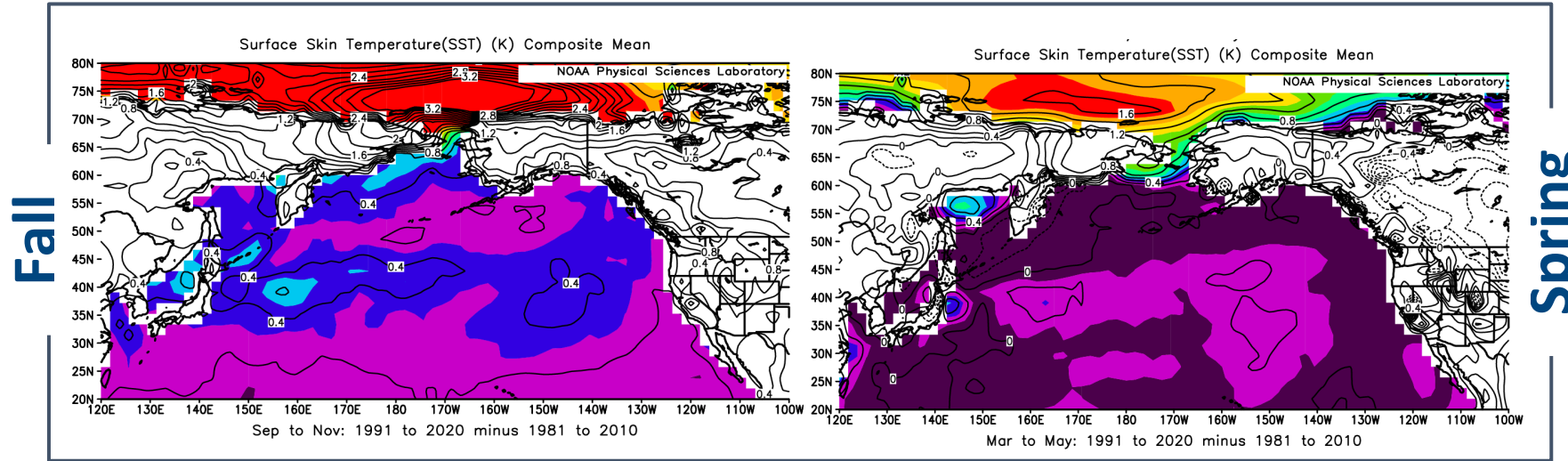
The 'triple-dip La Niña' explained – and how it affects the weather in your area

September 12, 2022 · 5:00 AM ET

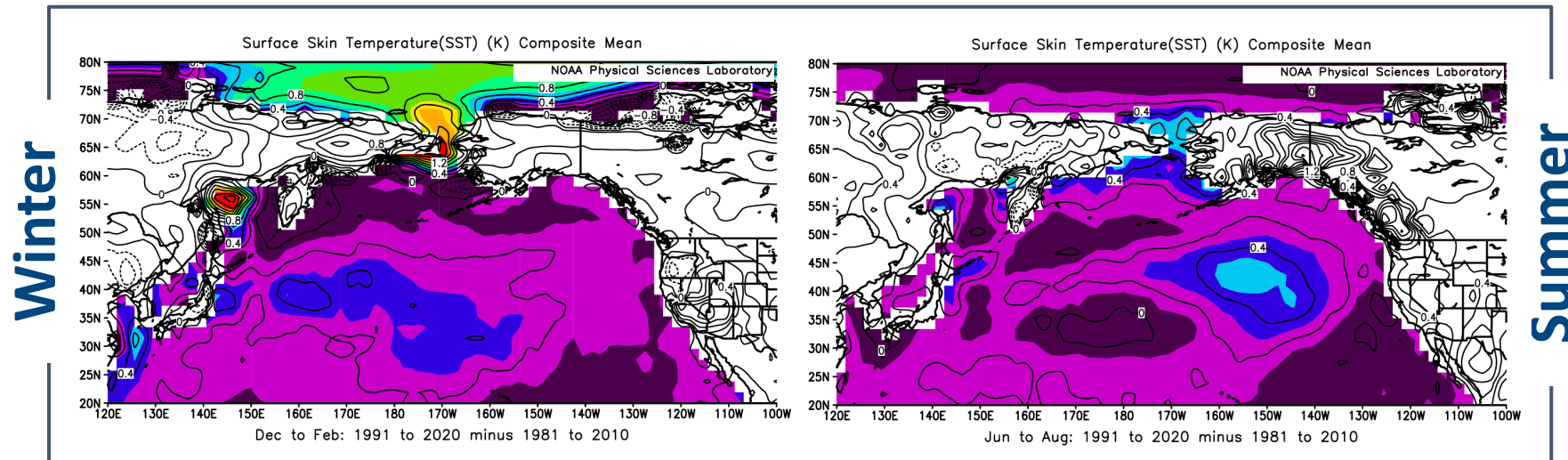
JOE HERNANDEZ 



Differences in SST Climatology baseline 1981-2010 vs 1991-2021



Cool conditions in middle domain stretching to GOA, average outer domain, warm CAI, WAI.



Cold SSTs in SEBS (inner shelf >2C below normal) and GOA, warm in AI.

