

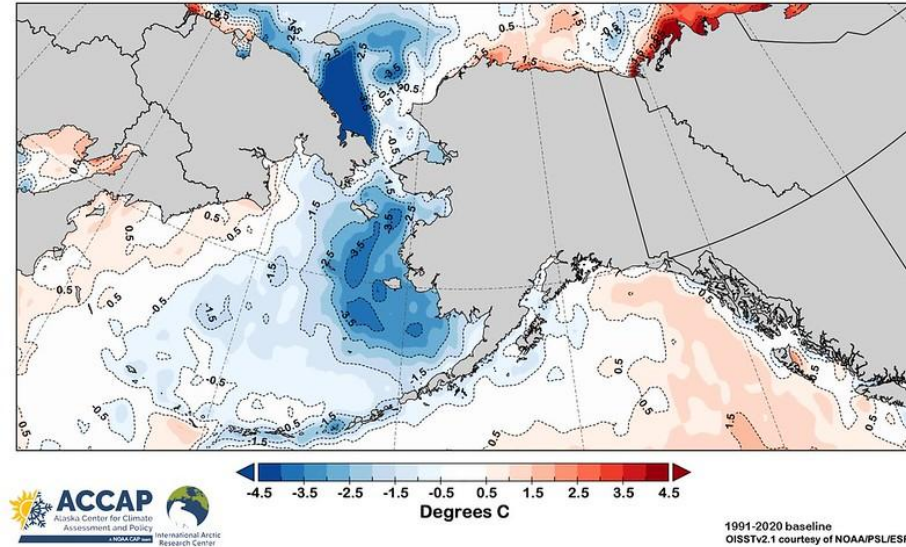
Ecosystem Status Report:

Bering Sea, Aleutian Islands & Gulf of Alaska Climate and Oceanography Update



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Sea Surface Temperature Departure from Normal
August 24-30, 2024



1991-2020 baseline
OISSTv2.1 courtesy of NOAA/PSL/ESRL

NPFMC Groundfish Plan Teams September 17, 2024



Outline: Climate & Oceanography

1. Alaska-wide conditions
 - a. Sea level pressure, sea surface temperature 2023-2024
 - b. SST seasonal projections 2025

2. Large Marine Ecosystem Conditions (2024)
 - Aleutian Islands
 - Eastern Bering Sea
 - Gulf of Alaska



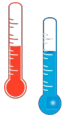
Key Messages



- **N. Pacific:** Started year under El Niño conditions, transitioned to current neutral conditions, expected to move to weak La Niña by mid Fall.



- **Eastern Bering Sea (EBS):** SST anomalies within $\pm 1SD$ of the mean (baseline = 1985-2014); delayed sea ice in fall that eventually reached average extent (baseline = 1991-2020); cold pool extent was near average (baseline = 1982-2024).






- **Aleutian Islands (AI):** Strong eastward winds 2023 - 2024 opposing regular NP warm water transport through eastern passes to EBS shelf. Cooler SST except for winter & WAI



- **Gulf of Alaska (GOA):** Shift from multi-year average/cool ocean temperatures (baseline: 1985-2014) to warm winter SST across GOA; EGOA remains warm; regional variation in temperature and transport

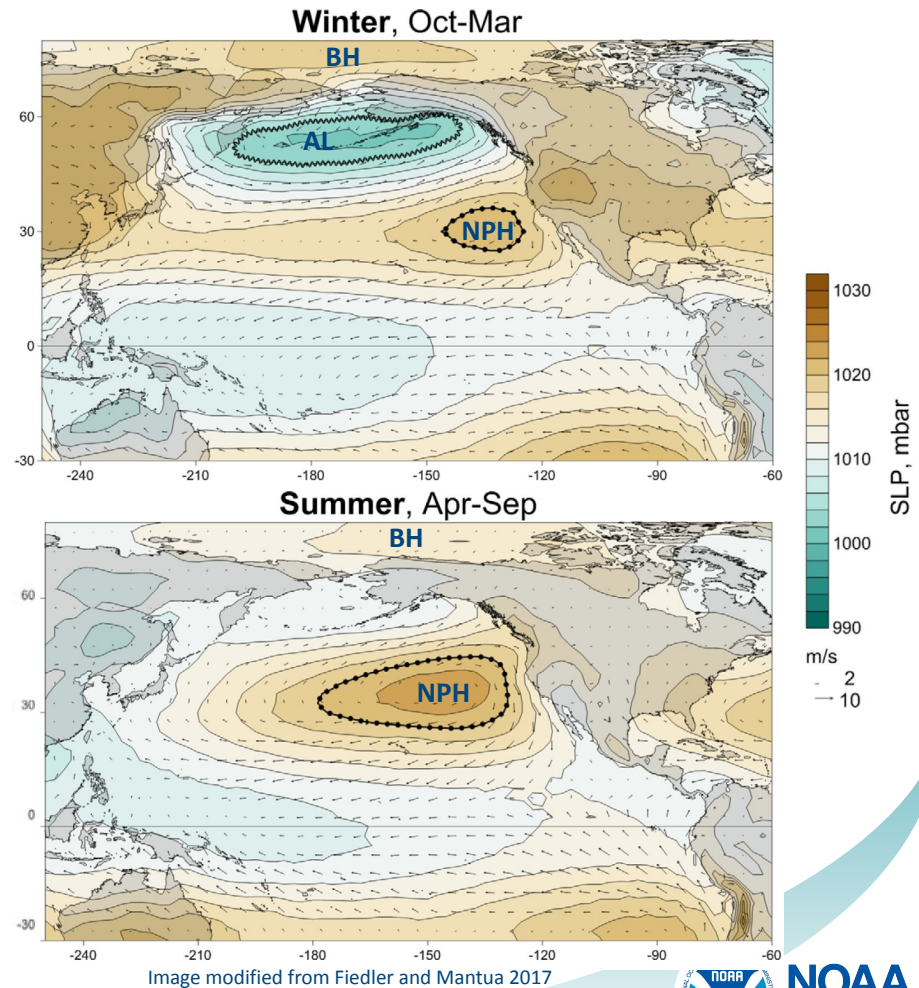


Alaska Climate

- **Three pressure systems:** Beaufort High , Aleutian Low , North Pacific High 
- **Seasonality:** In winter, Aleutian Low and Beaufort High strengthen and North Pacific High weakens (top), opposite in summer (bottom)
- Transport of air from North Pacific to the Arctic is facilitated by strength and position of AL and *modulated* by BH
- Storms tend to travel along the northern edge of the Pacific High

Interannual variability: key features

- Intensity and size: speed of winds
- Lat/long position: wind direction & storm track



Interannual variability

Strong AL
 One center
 Larger size
 Stormtrack south of Aleutians

Weak AL:
 Center can split into two
 Smaller size,
 Stormtrack steered northward

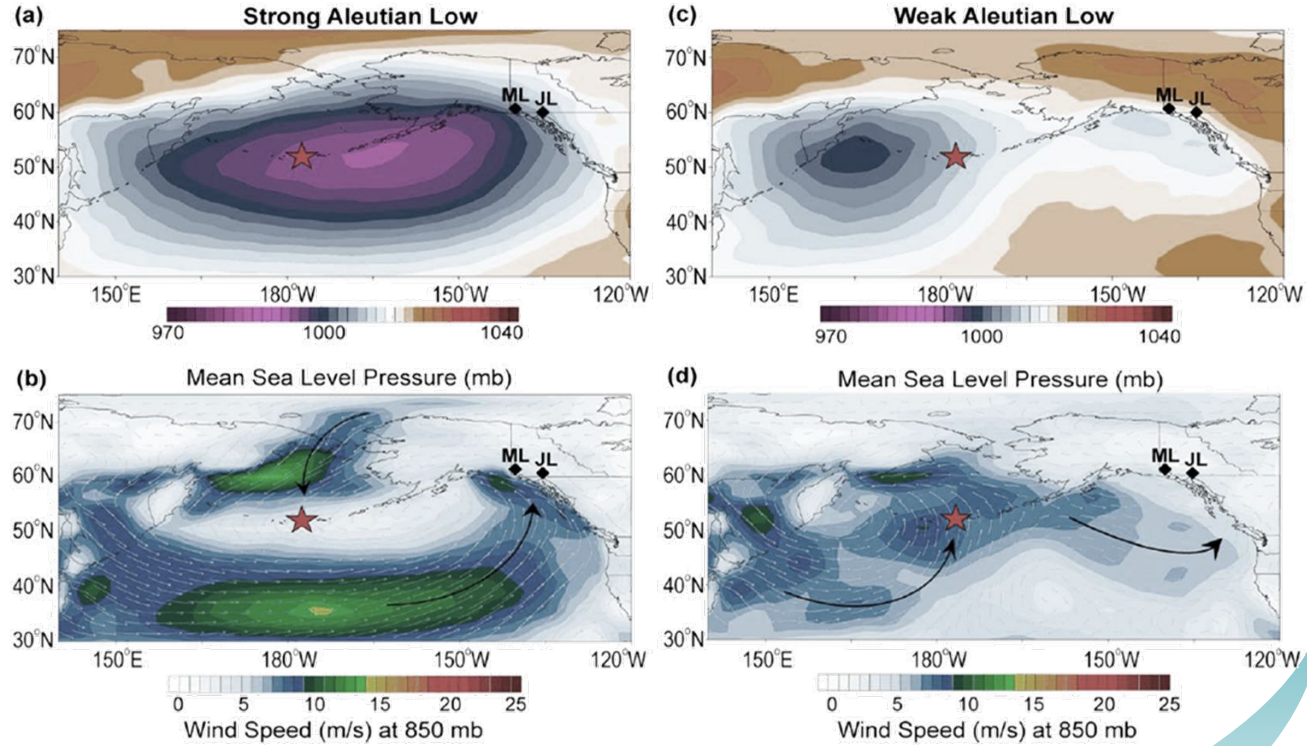
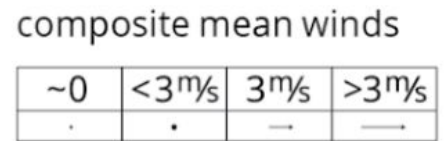
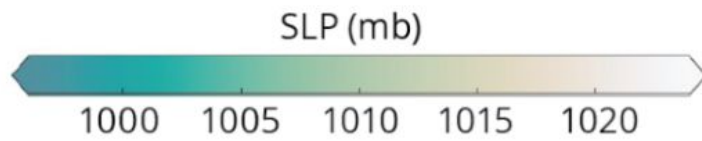
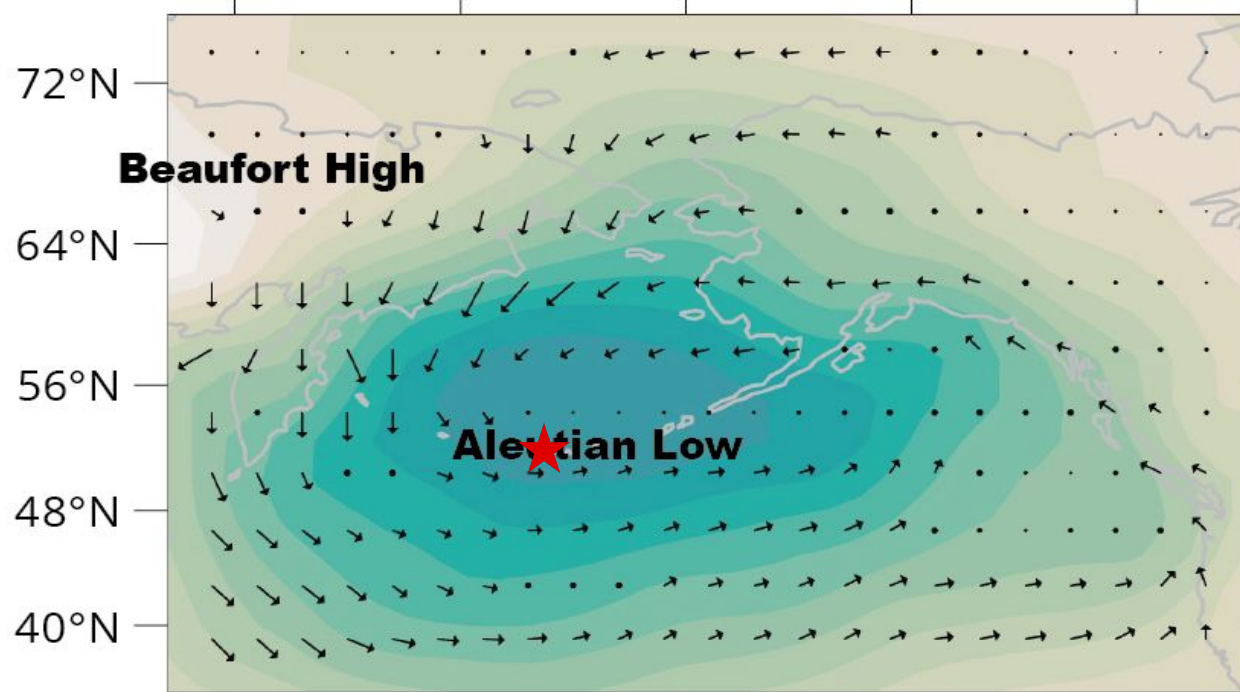


Image modified from Bailey et al. 2015



2024



Interannual variability

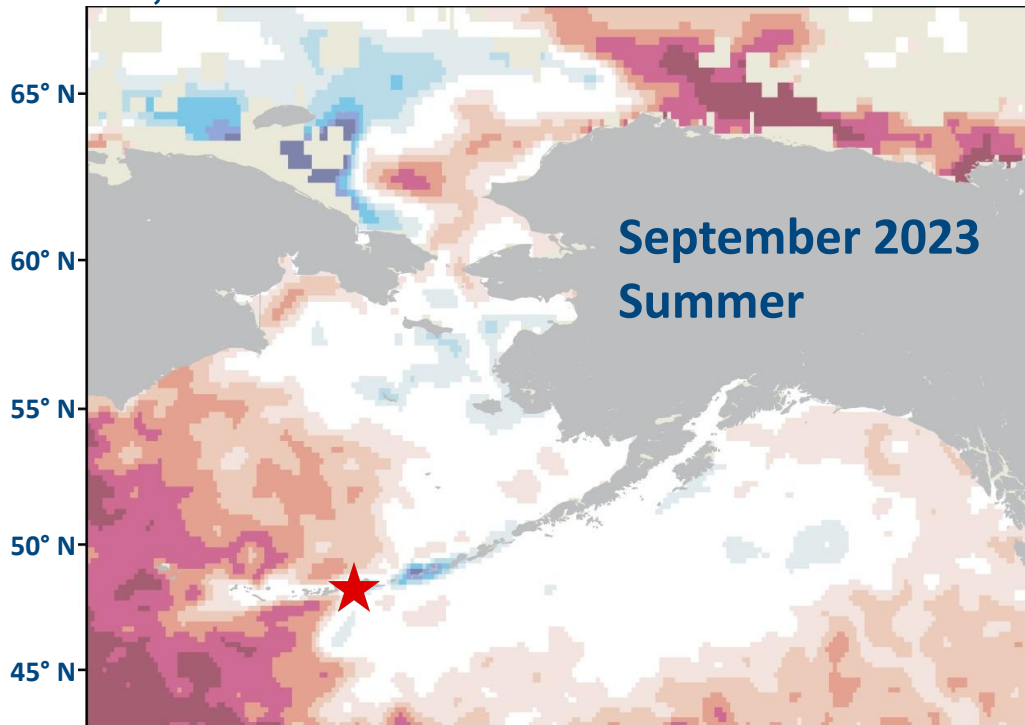
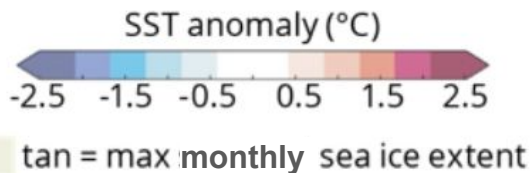
- Strong AL
- One center
- Larger size
- Stormtrack south of Aleutians

- Weak AL:**
- Center can split into two
- Smaller size,
- Stormtrack steered northward

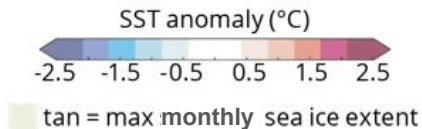
Sea Surface Temperature, Sea Ice & Winds

Lemagie

September



Monthly Wind and SST Anomalies
(1991-2020 Climatology)



~0	<3m/s	3m/s	>3m/s
.	.	→	→

red dots/arrows = monthly mean winds
black dots/arrows = climatology winds
Image modified from Fiedler and Mantua 2017



NOAA
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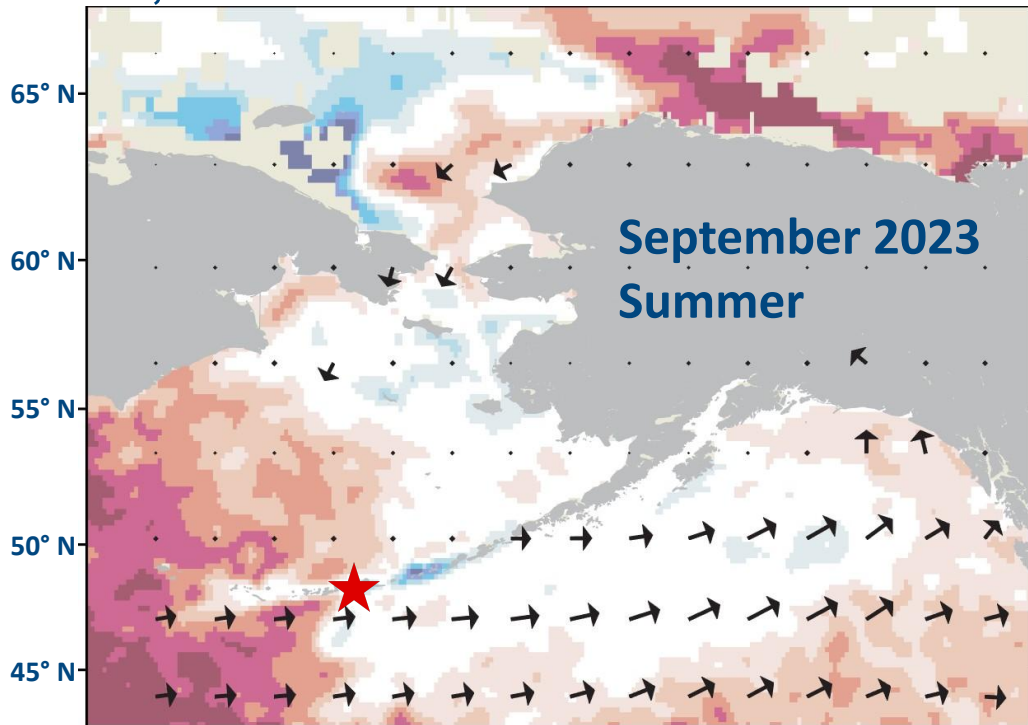
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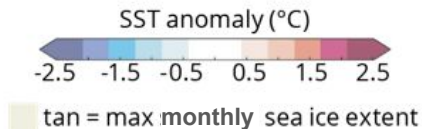
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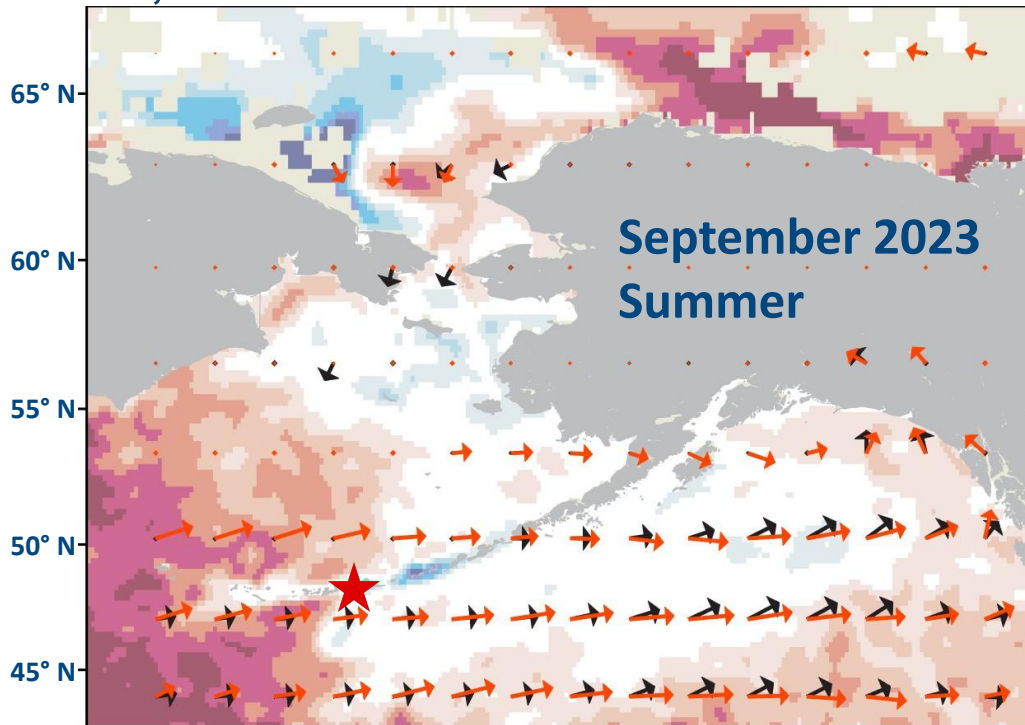
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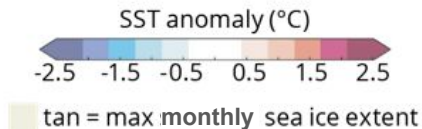
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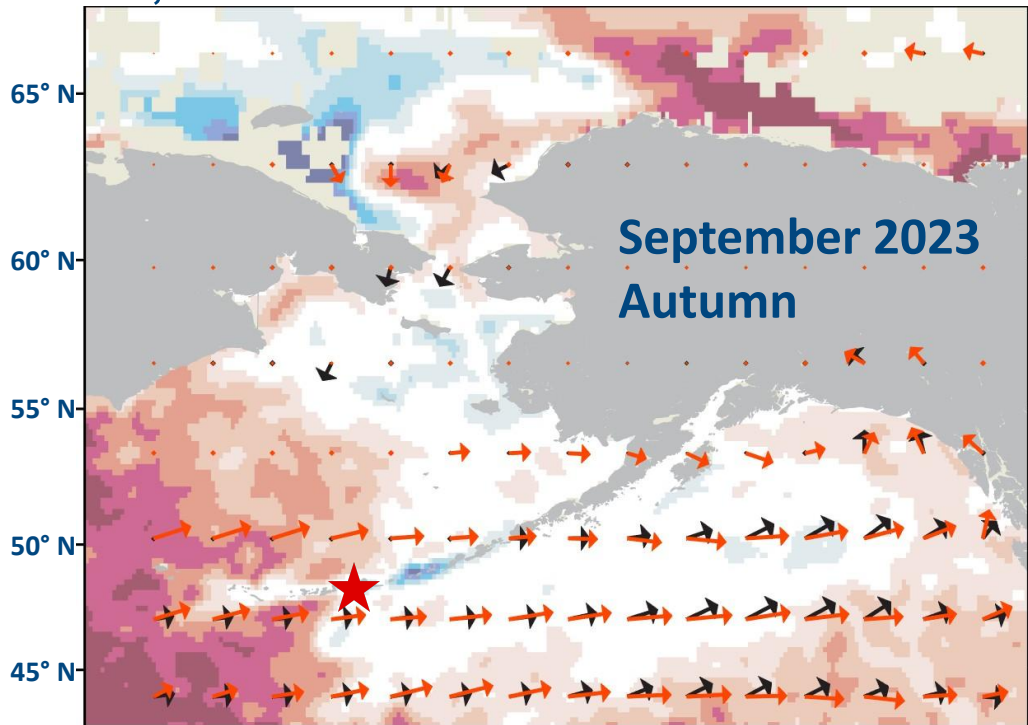


NOAA
FISHERIES

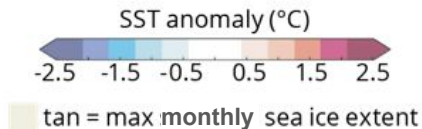
Sea Surface Temperature, Sea Ice & Winds

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Warm SSTs over western
Aleutians and GOA



Monthly Wind and SST Anomalies
(1991-2020 Climatology)



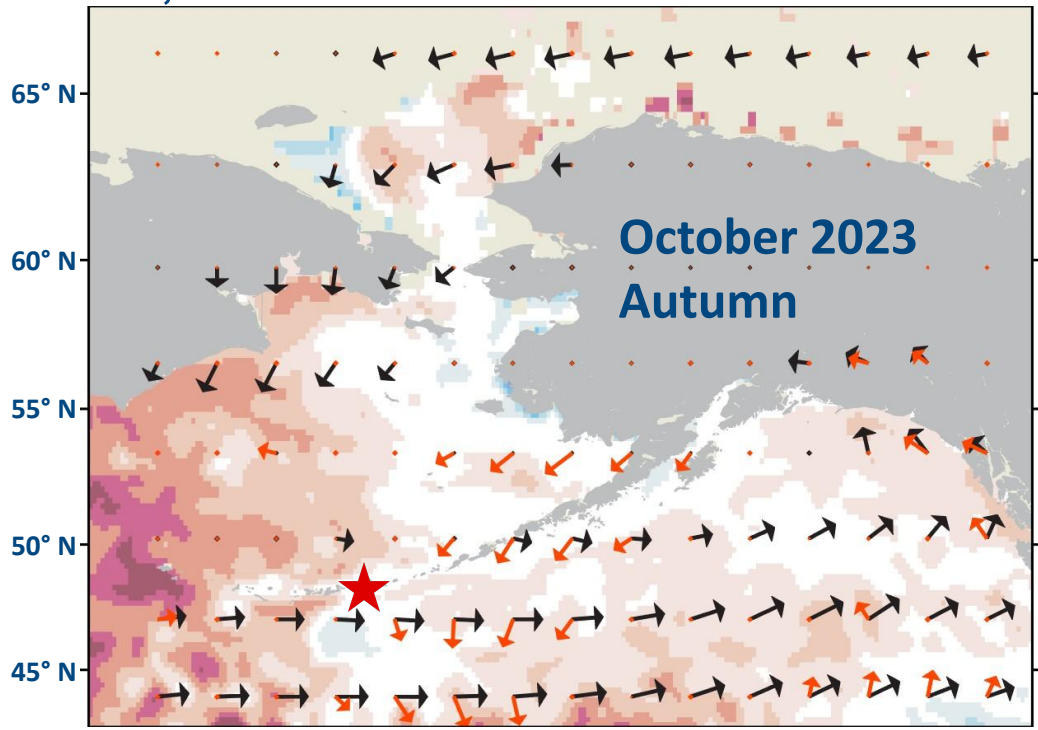
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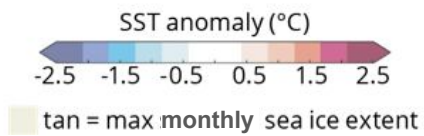
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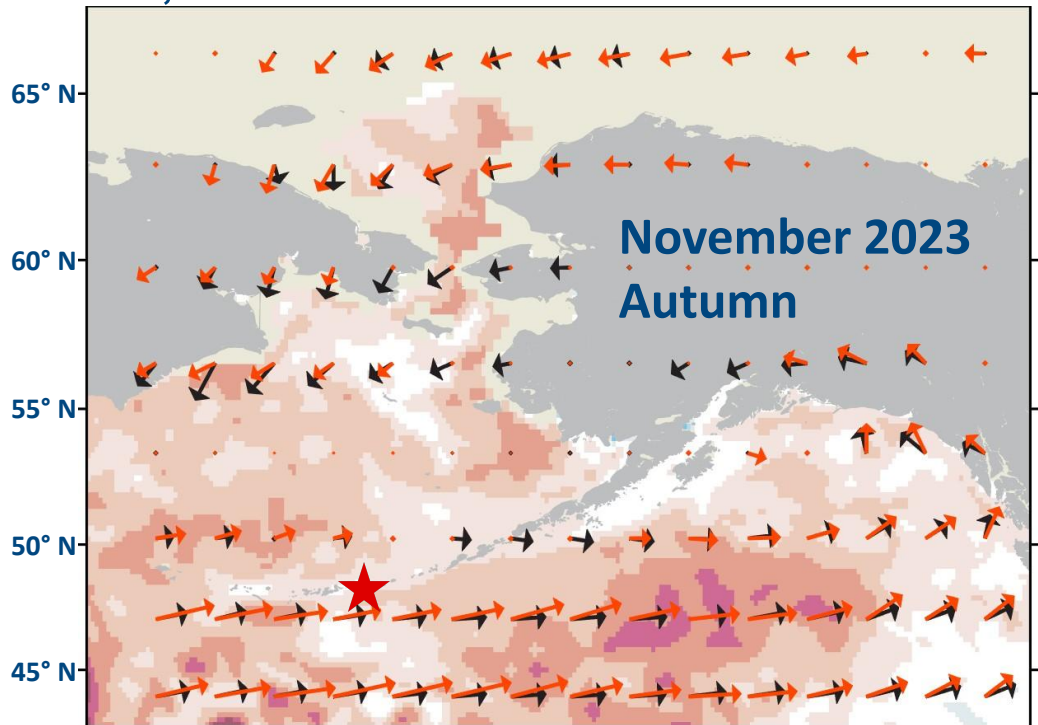
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Sea Surface Temperature, Sea Ice & Winds

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Monthly Wind and SST Anomalies
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Sea Surface Temperature, Sea Ice & Winds

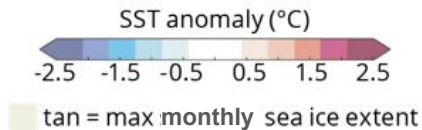
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Aleutian Low this winter:
Weak and small

Winds from Arctic



Monthly Wind and SST Anomalies
(1991-2020 Climatology)



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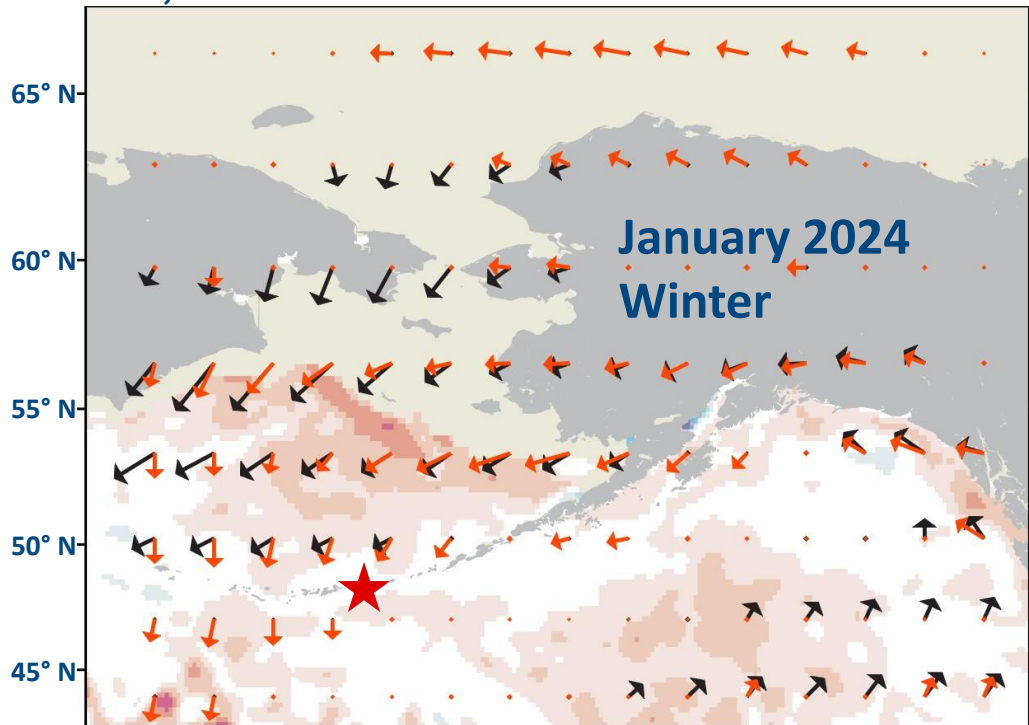
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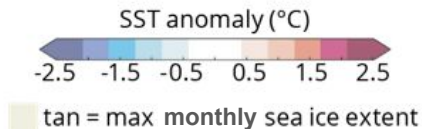
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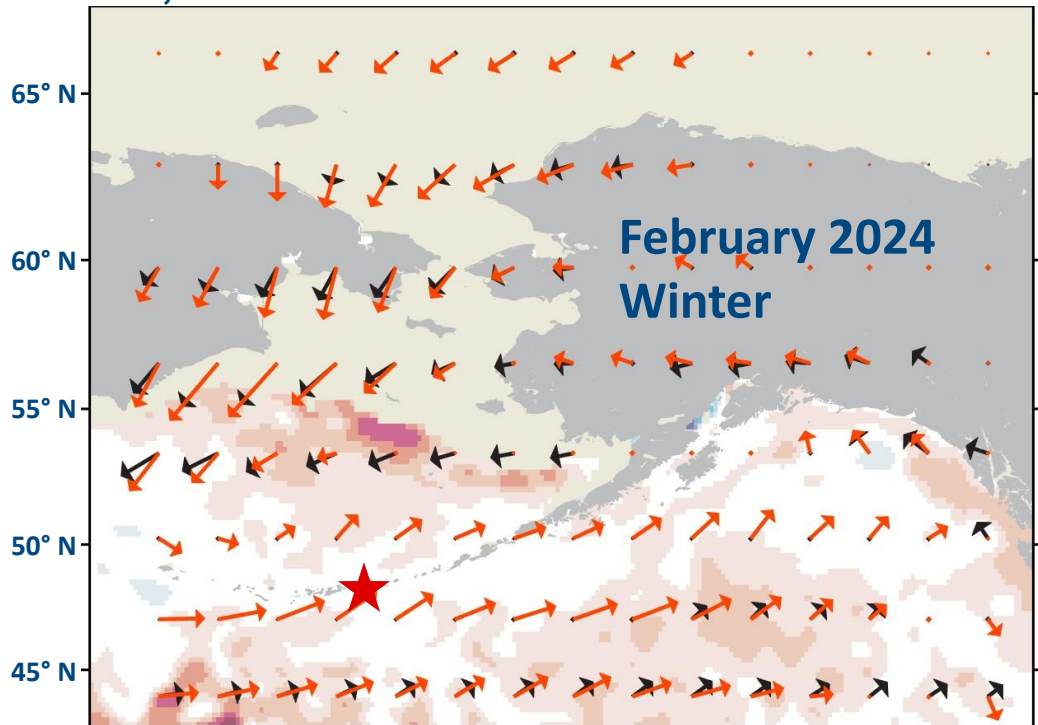
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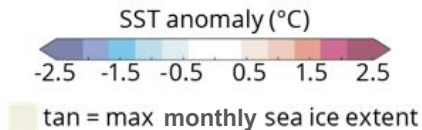
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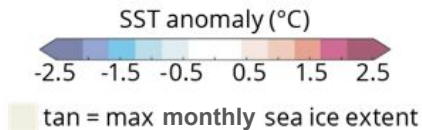
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SST close to long-term mean
across most of Alaska

Winds from Arctic



Monthly Wind and SST Anomalies
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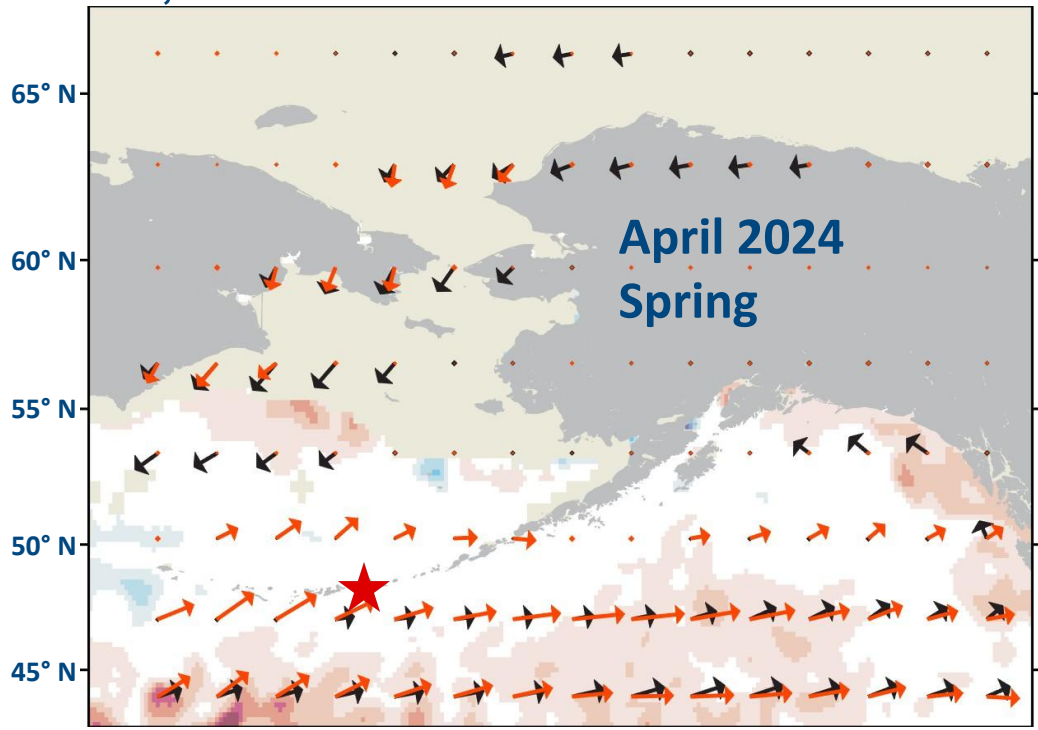
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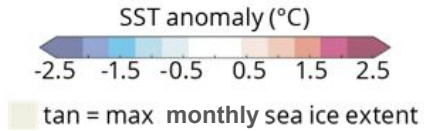
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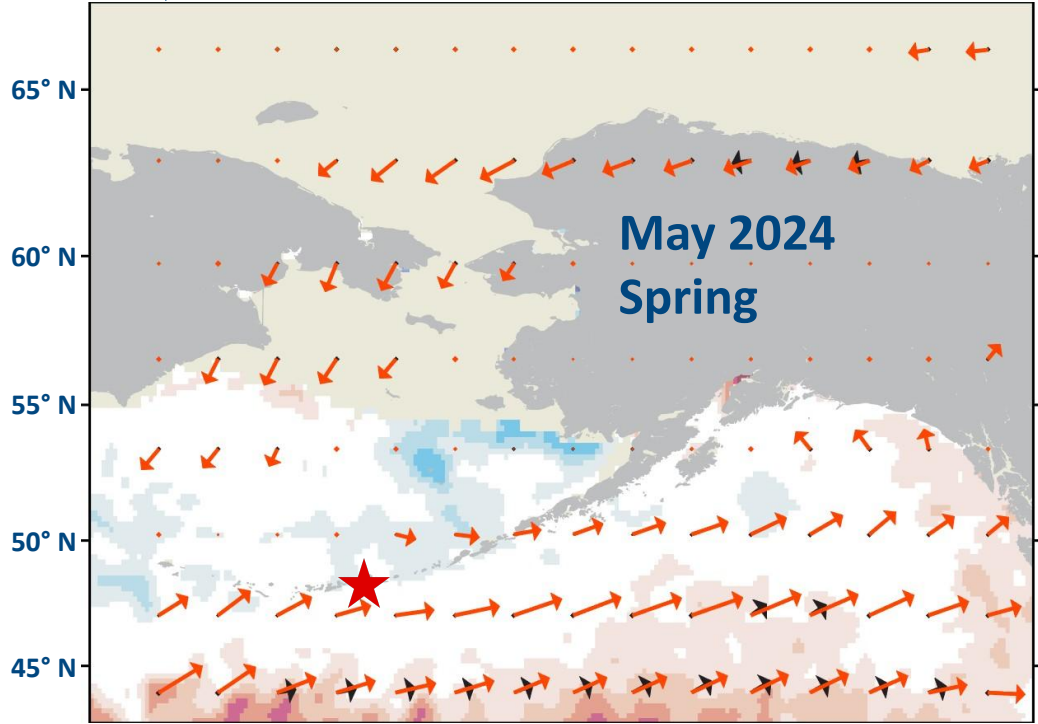


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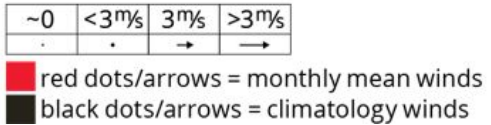
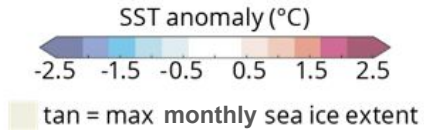
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Monthly Wind and SST Anomalies
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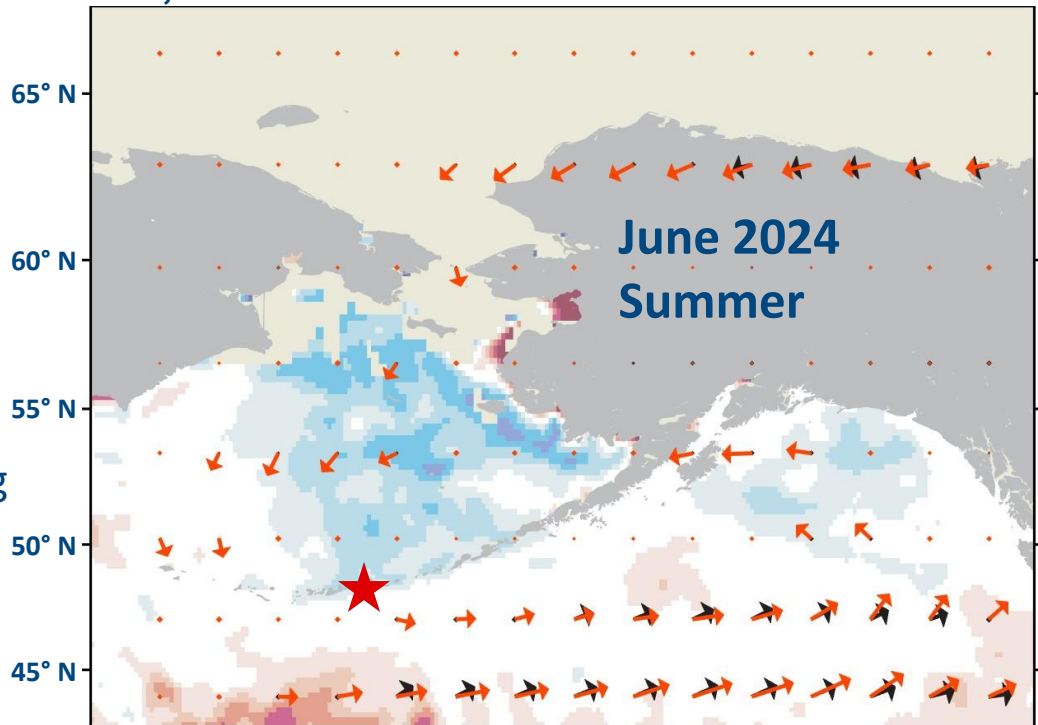


Sea Surface Temperature, Sea Ice & Winds

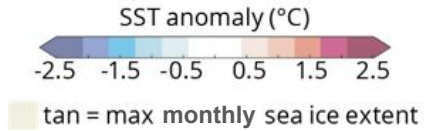
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Neutral El Niño conditions

Winds from Arctic weakening



Monthly Wind and SST Anomalies
(1991-2020 Climatology)



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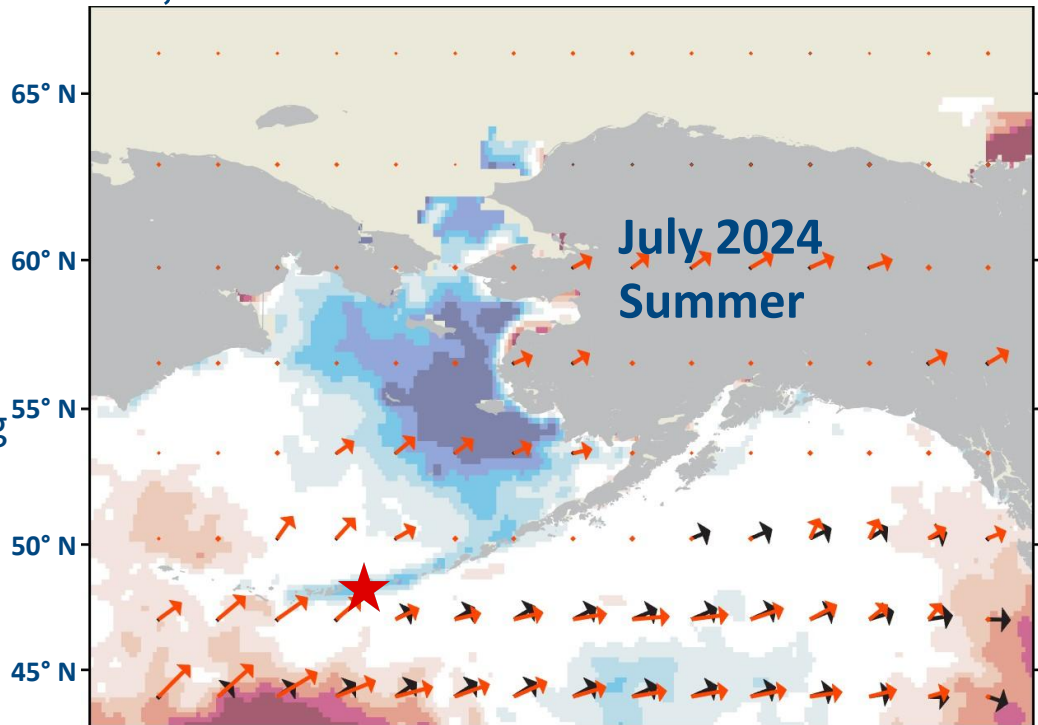
Sea Surface Temperature, Sea Ice & Winds

Lemagie

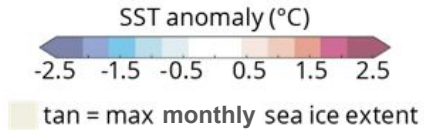
Neutral El Niño conditions

Winds from Arctic weakening

Winds from North Pacific



Monthly Wind and SST Anomalies
(1991-2020 Climatology)



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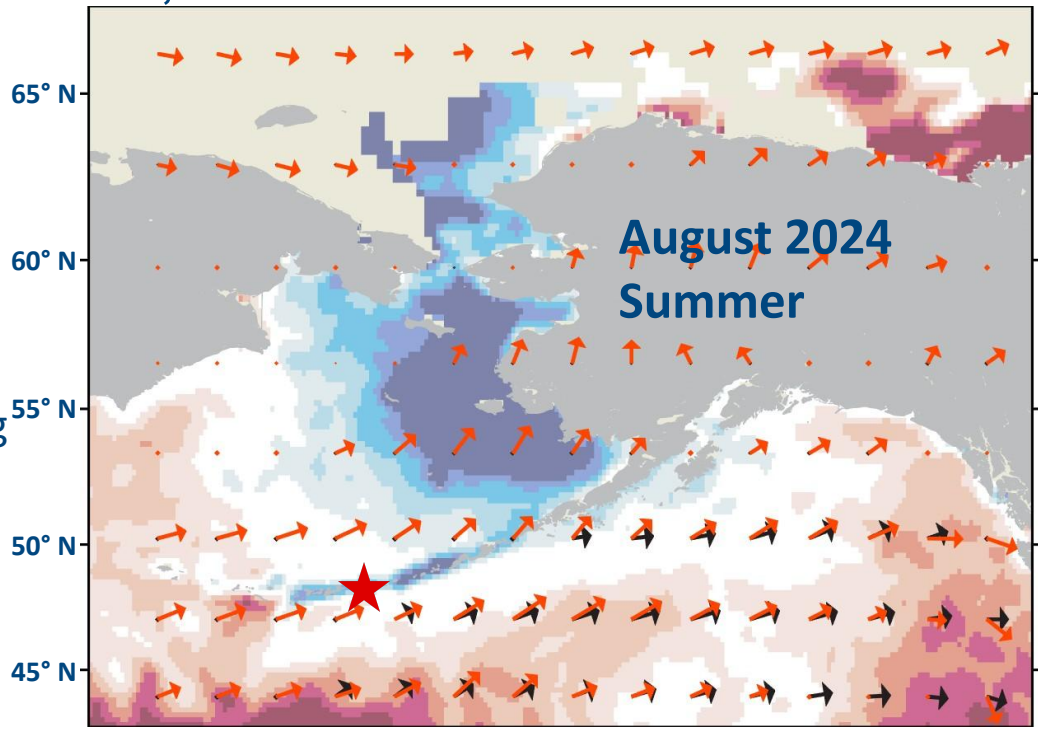
Sea Surface Temperature, Sea Ice & Winds

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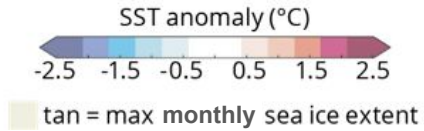
Neutral El Niño conditions

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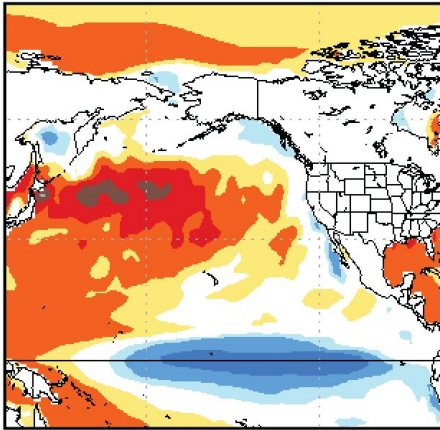
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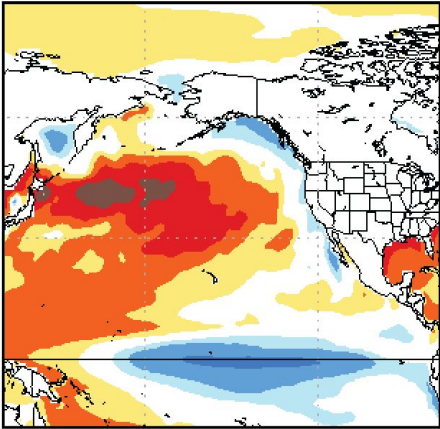
SST Projections from the National Multi-Model Ensemble

Lemagie

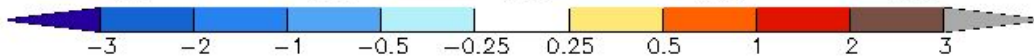
Nov 24 -
Jan 25



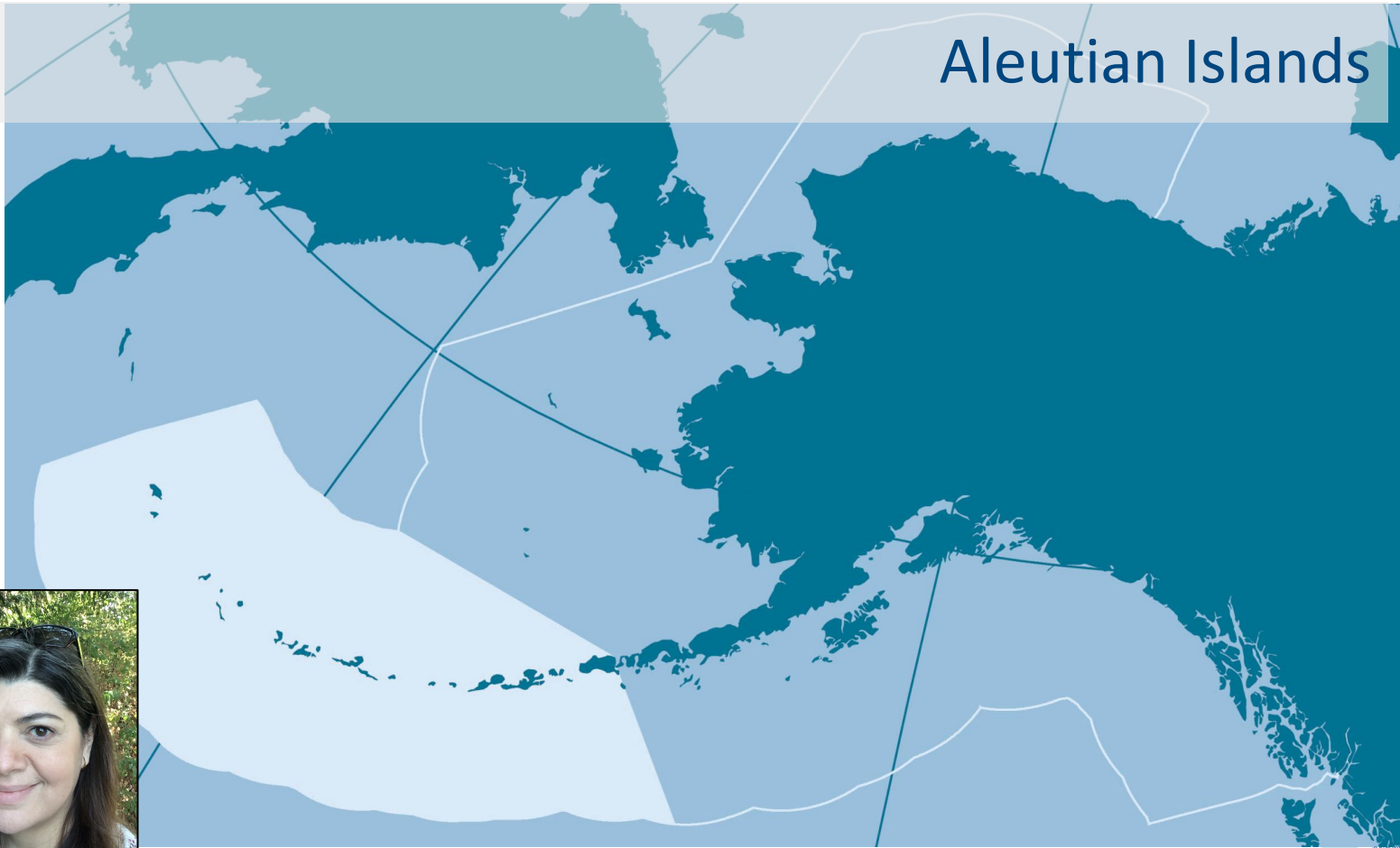
Jan - Mar
2025



- Synopsis: ENSO-neutral is expected to continue for the next several months, with La Niña favored to emerge during September-November (66% chance) and persist through the Northern Hemisphere winter 2024-25 (74% chance during November-January).
- Nov-Jan and Jan-Mar, near-normal surface temperatures predicted across most of Alaska's marine ecosystems with cool anomalies over the eastern GOA in winter, expanding into the western GOA in spring.



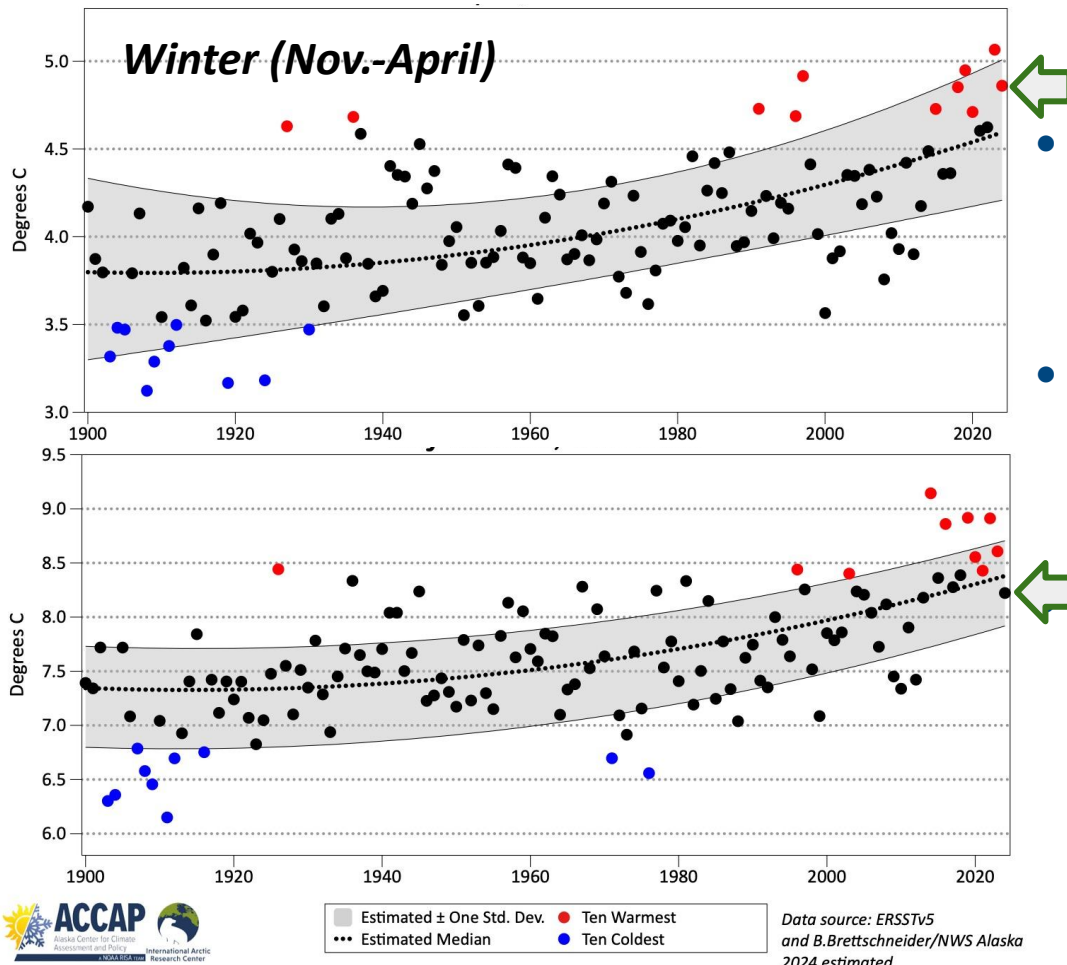
Aleutian Islands



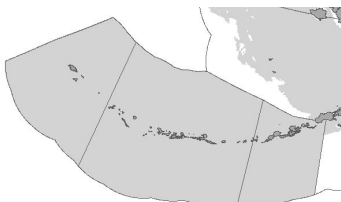
NOAA
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Long-Term AI Sea Surface Temperature

Thoman

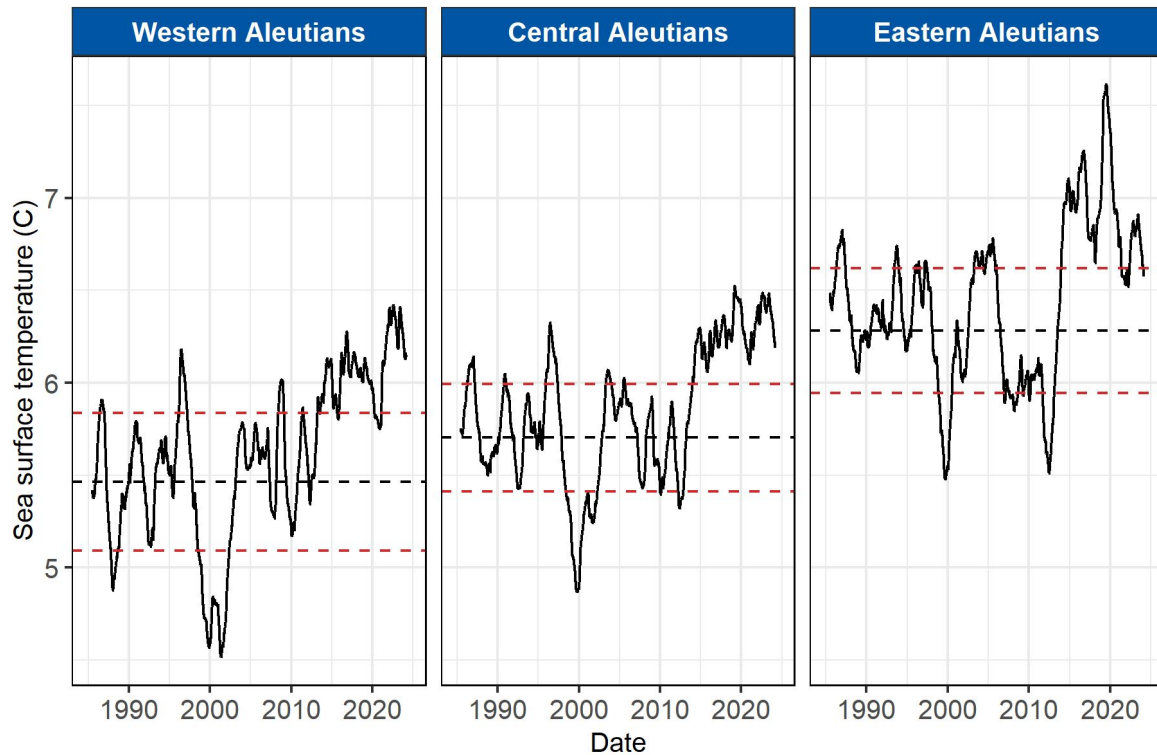


- AI NMFS area shelf SST (NOAA's Extended Reconstructed SST, ERSSTv5) with B-spline regression $\pm 1SD$
- Winter (Nov.-April '23/'24) among 10 warmest on ERSSTv5 record; warming long-term trend $\sim 0.75^{\circ}C$
- Summer (May-Oct. '24) colder than long term trend with overall increasing trend $\sim 1^{\circ}C$
 - Summer 2024 data point is preliminary



AI SST & Marine Heatwaves 2024

Lemagie, Callahan



Trend (does not include 2024)
seasonality and noise removed

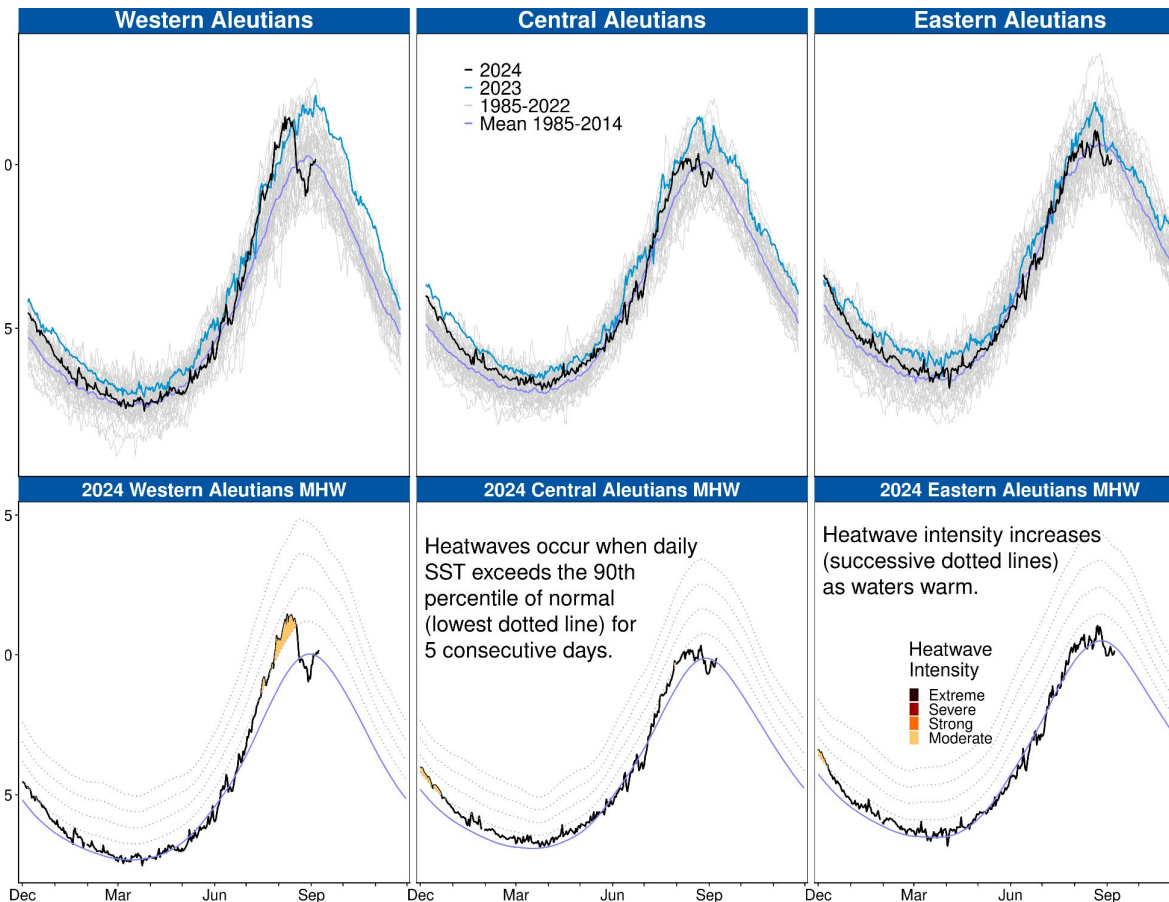
- Continued warm temperature above 1985-2014 mean
- All three regions have trended anomalously warm ($> 1\text{sd}$ above mean) for last 10 years

- - - mean

- - - ± 1 standard deviation

AI SST & Marine Heatwaves 2024

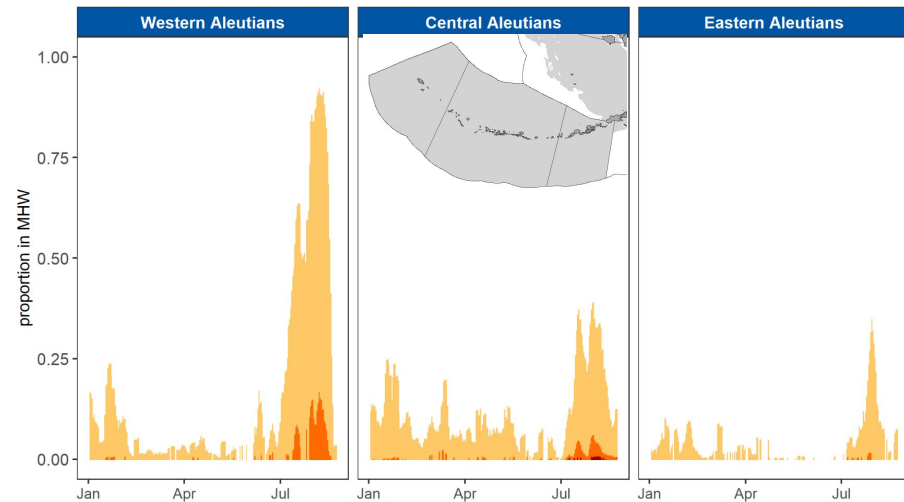
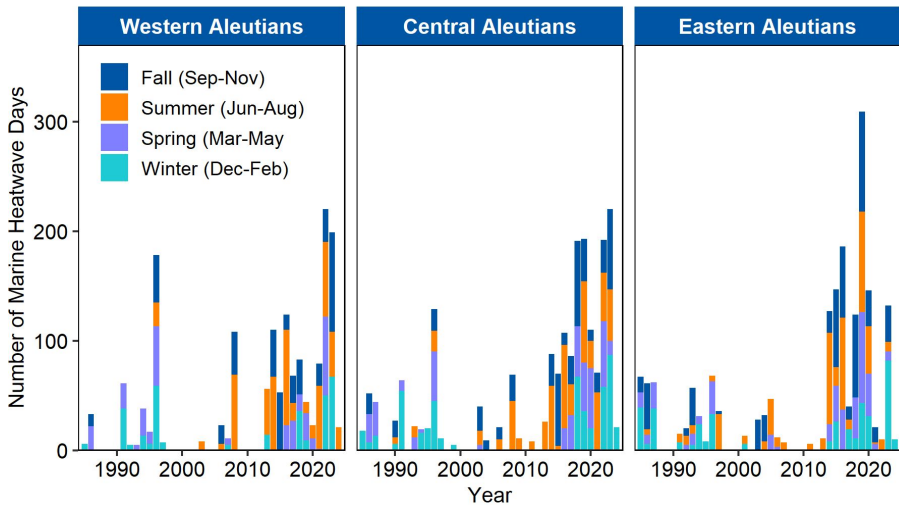
Lemagie, Callahan



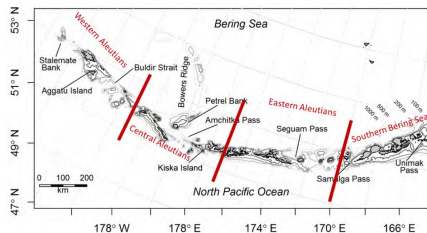
- Warm winter across AI with minor moderate MHW
- Spring temperatures near long-term average, few MHW in CAI & EAI
- Welcome cooling overall, except for WAI with warm summer above 1985-2014 mean & MHWs

AI SST & Marine Heatwaves 2024

Lemagie, Callahan



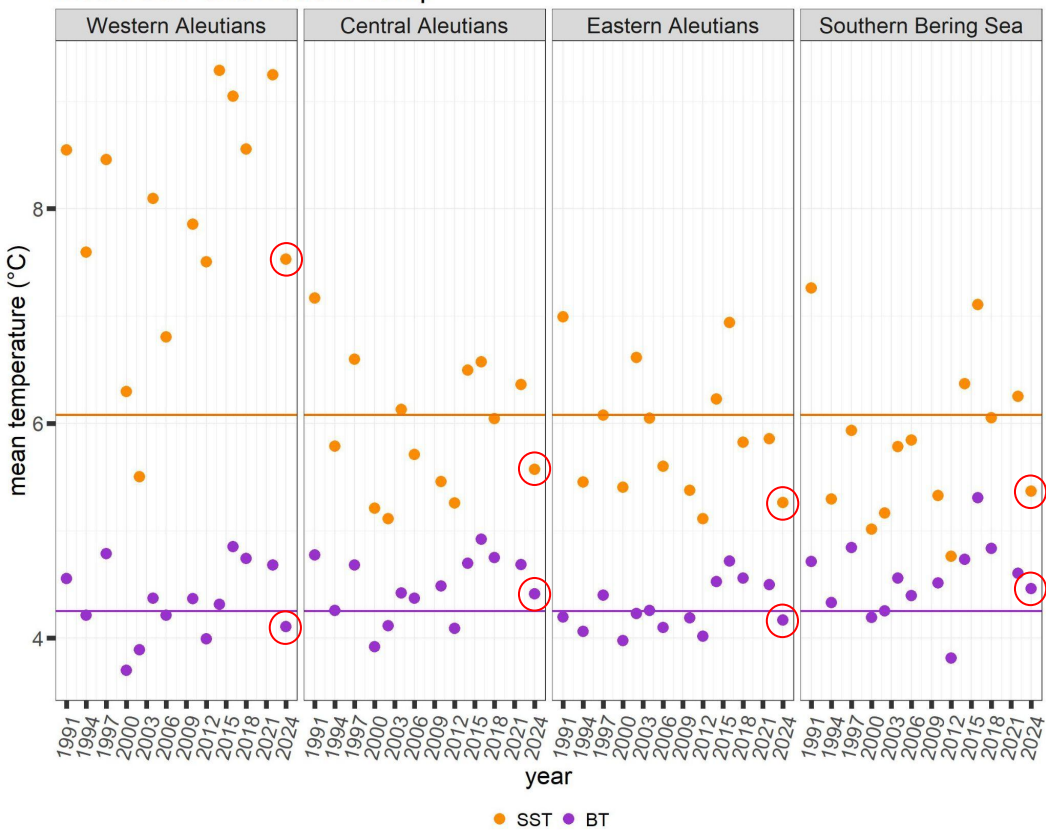
- Less area in MHW than last year
- EAI, CAI in general less than 25% area in MHW throughout the year
- WAI: at times 75% area in MHW status



AI Bottom Temperature 2024

Howard, Laman, McDermott

Mean SST and Bottom Temp

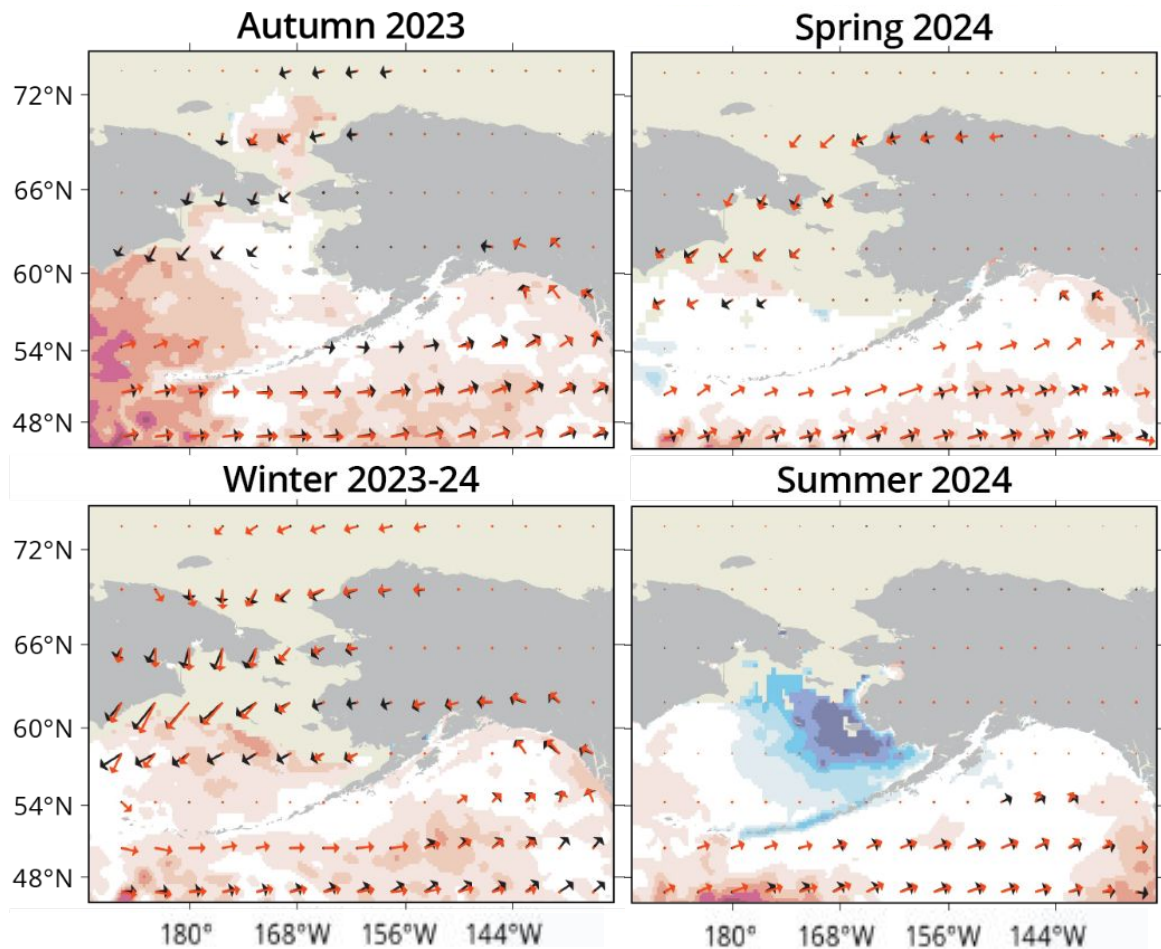


historical overall mean based on 1991-2012, not full time series

- Overall cooling, close to long term overall mean
- Seasonal pattern: Stronger seasonal pattern towards east, weaker towards west (i.e. winter T similar to summer in WAI)

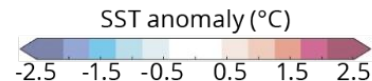
Winds

Lemagie



- Dominant eastward winds south of the Aleutian Islands
- southward transport caused by wind opposes mean currents over eastern Aleutian Islands
- Reduced northward heat through eastern passes

Seasonal Wind and SST Anomalies (1991-2020 Climatology)

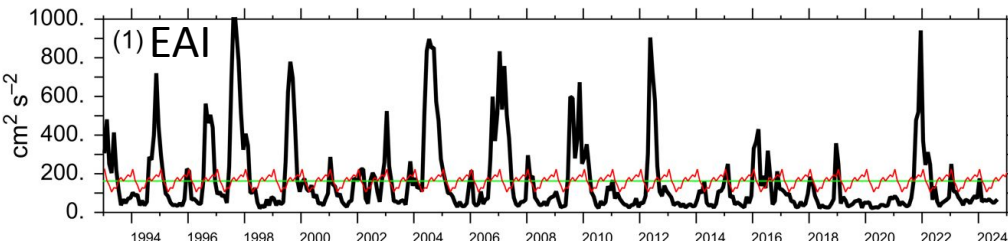
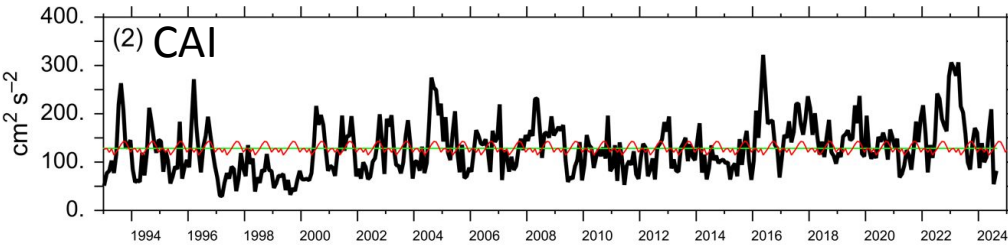
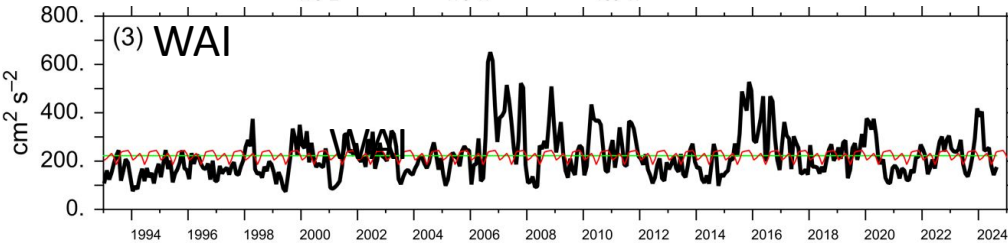
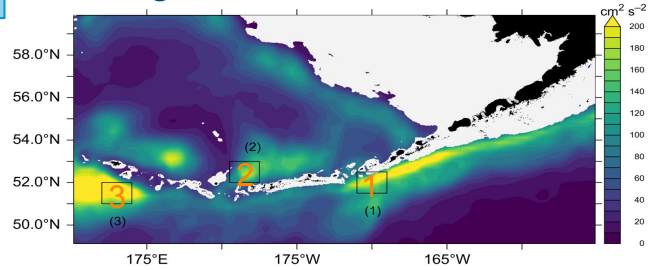


tan = max monthly sea ice extent

~0	<3m/s	3m/s	>3m/s
.	.	—	—

red dots/arrows = seasonal mean winds
black dots/arrows = climatology winds

Average EKE Jan 1993 - Dec 2023



Eddy Kinetic Energy in the AI

Cheng

EKE indicates strength and frequency of eddies, which can influence flow and transport of heat, salinity, and nutrients

- Monthly climatology in red, 1993-2023 mean in green
- WAI above long-term mean in early 2024
- Currently near or below long term mean across the chain
- Potentially lower flow of heat, salinity and nutrients through passes

AI Climate & Oceanography

Sea Surface Temperature (SST)



- Among ten warmest winters on record
- Cooling in spring and summer with near/ long-term mean SST except WAI
- Sustained SST above average across AI for last 10 years

Bottom Temperature (BT)

- Cooler than past years, near or below long-term mean

Cooling in current year offers a reprieve from past years with sustained warmer SST, BT which may have longer impacts on phenology, productivity

Transport

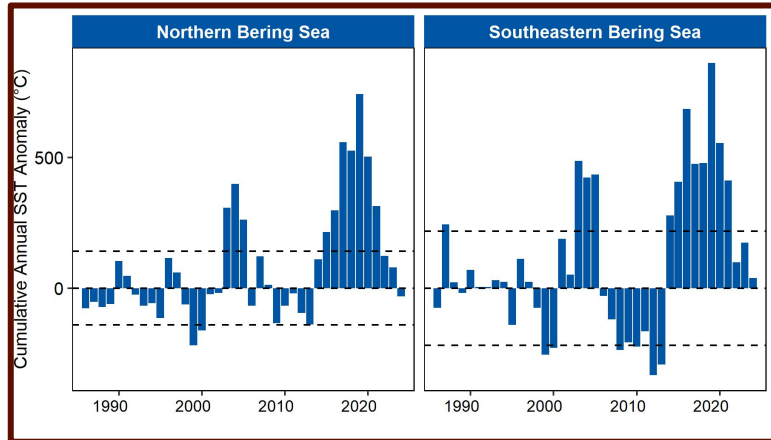
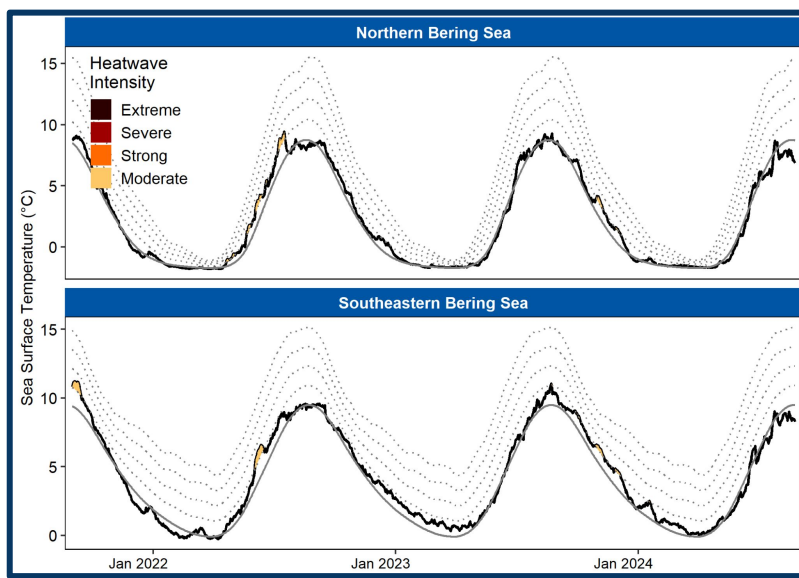
- WAI: Above long-term mean beginning 2024
- Currently near or below long-term mean throughout the chain

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



Eastern Bering Sea





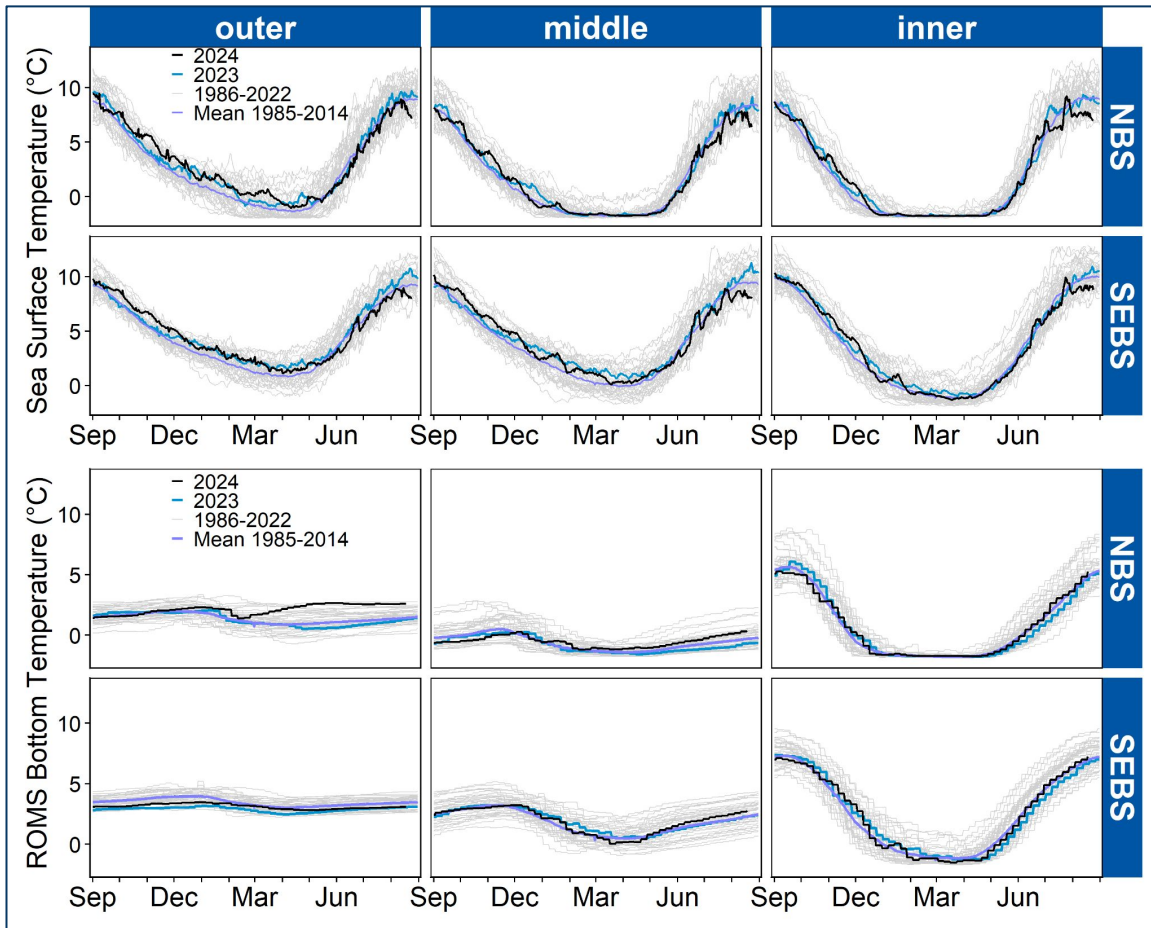
Sea Surface Temperatures

Callahan, Lemagie

- Marine heatwaves have been brief and infrequent since 2021
- SST anomalies continued to be within $\pm 1SD$ of the mean (baseline = 1985-2014)

Sea Surface & Bottom Temperatures

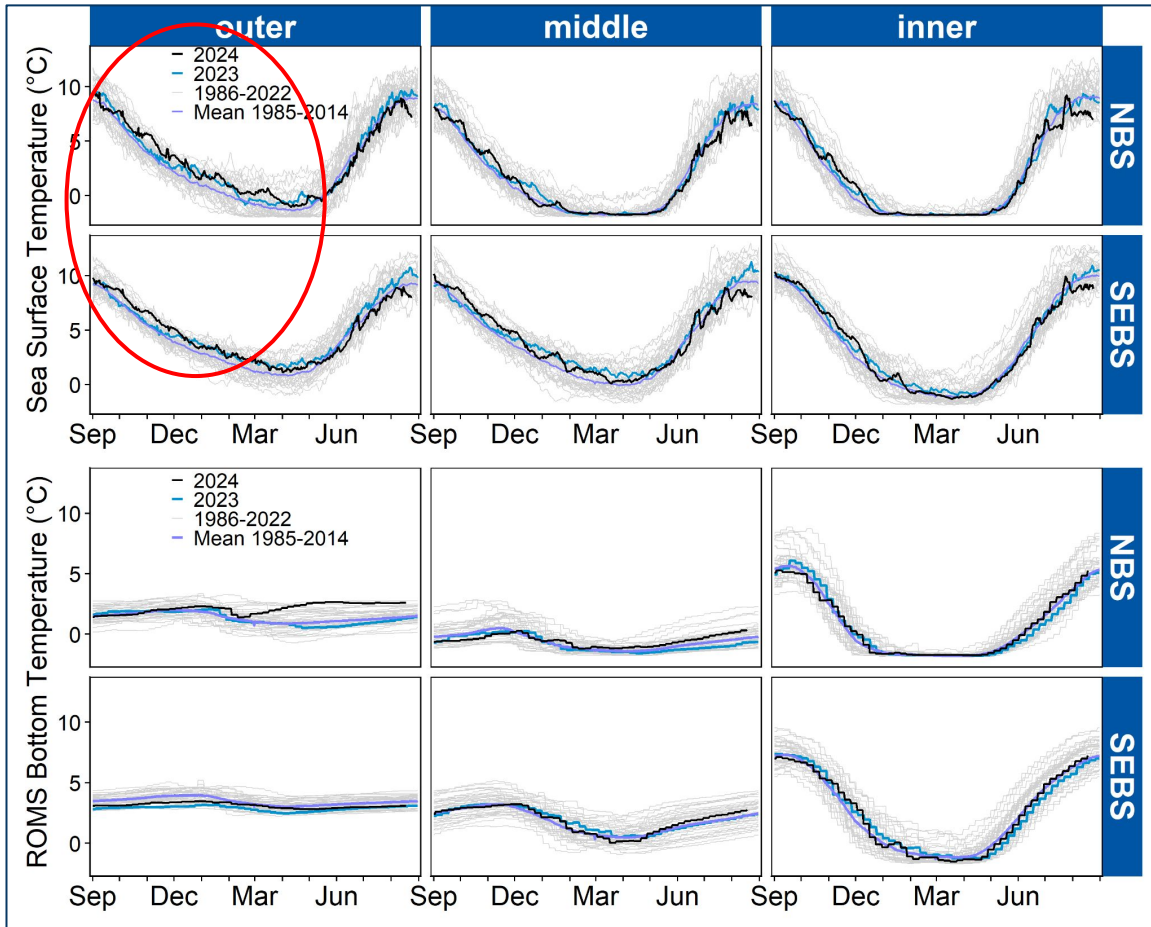
Callahan, Lemagie, Kearney



Sea Surface & Bottom Temperatures

Callahan, Lemagie, Kearney

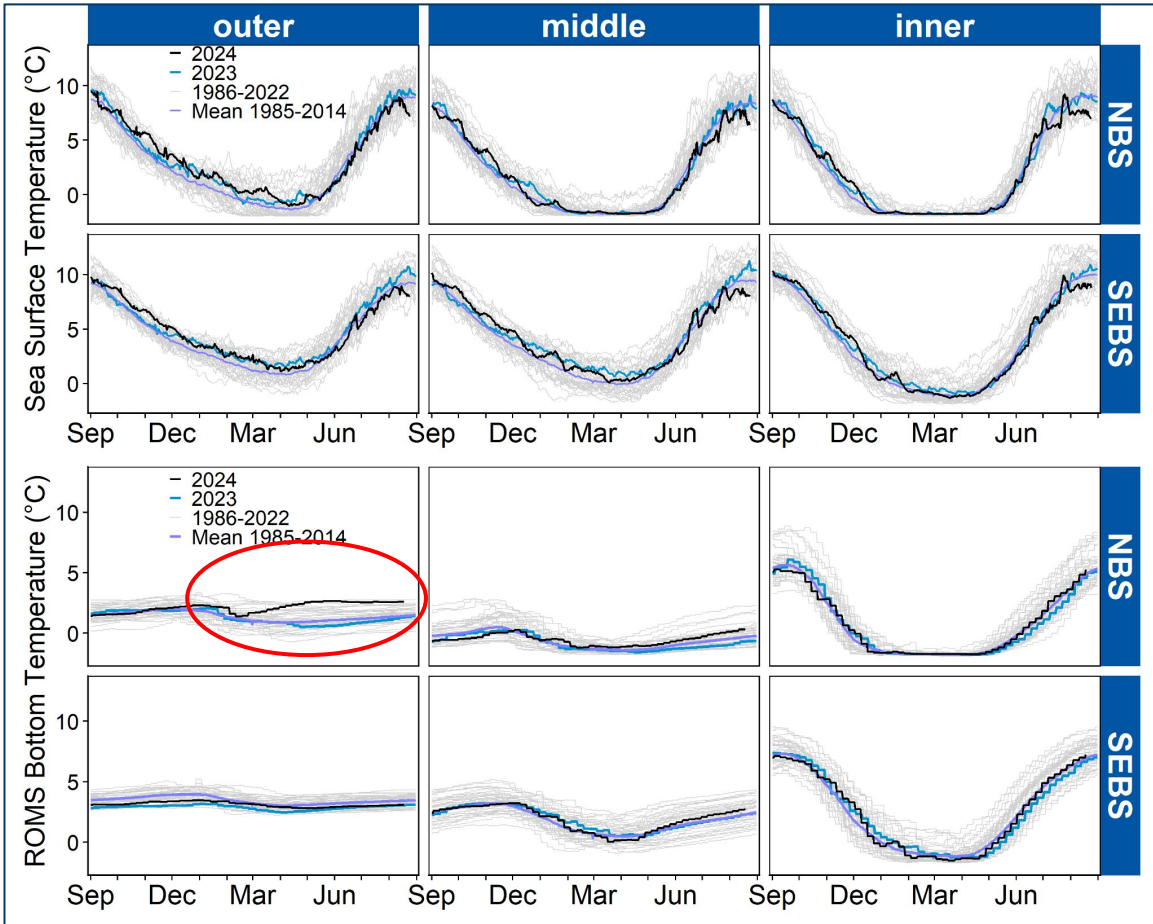
- SSTs were warm in the outer domain in fall → spring; near the long-term mean in all regions by summer



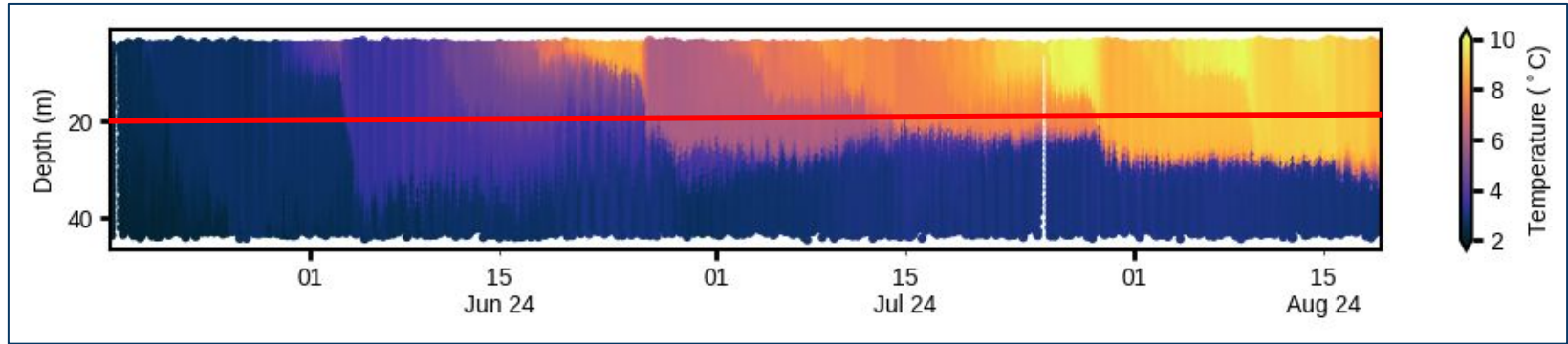
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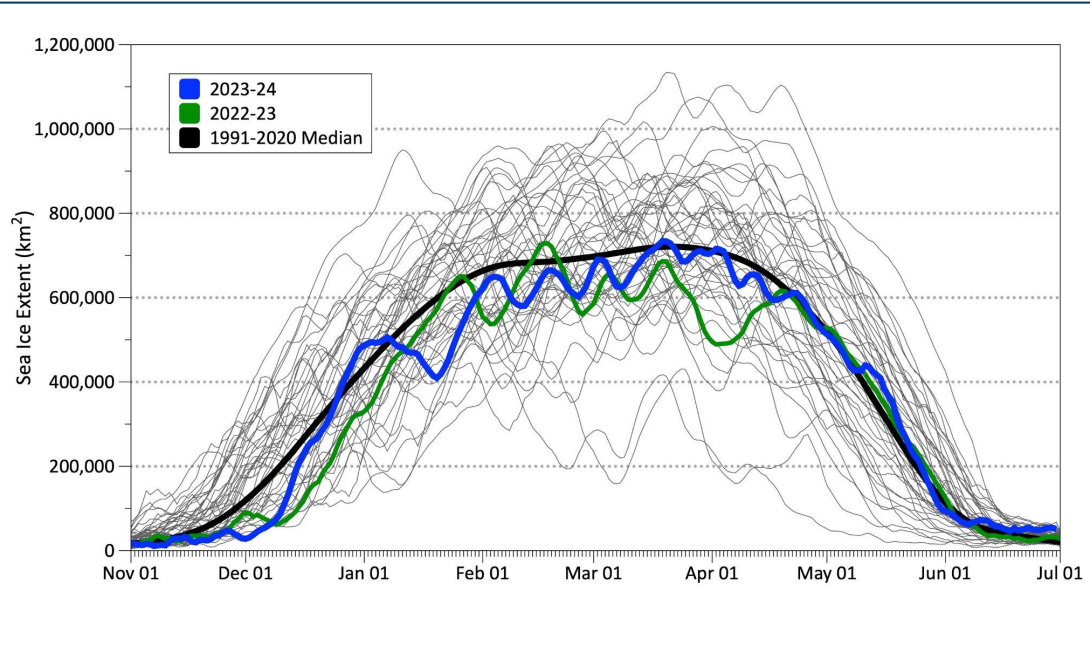
- SSTs were warm in the outer domain in fall → spring; near the long-term mean in all regions by summer
- Unusually warm bottom temperatures in the NBS outer domain started in spring



Water-column temperatures at M2 Stabeno



- SSTs are cooler because the mixed layer depth (MLD) is deeper
- The heat content of the water is spread over more (deeper) water
- Deeper MLD due to persistent storms
- Implications for productivity (more on this in November)



- Delayed sea ice growth in fall
 - Early season ice extent has decreased 63% since 1979
- Winter “wiggles” due to short-term variability in weather patterns
- Maximum ice extent occurred in late March; sea ice reached St. Paul Island for 2 days
- Sea ice thickness at or above average (2011-2024); slightly lower than 2023



Motivation

- Provide sea ice satellite data for use in fisheries management
- Provide a tool for monitoring real-time sea ice changes

Product:

- Daily sea ice extent time series
- Sea ice extent anomalies
- Data tables and plots
- Code in R and Python

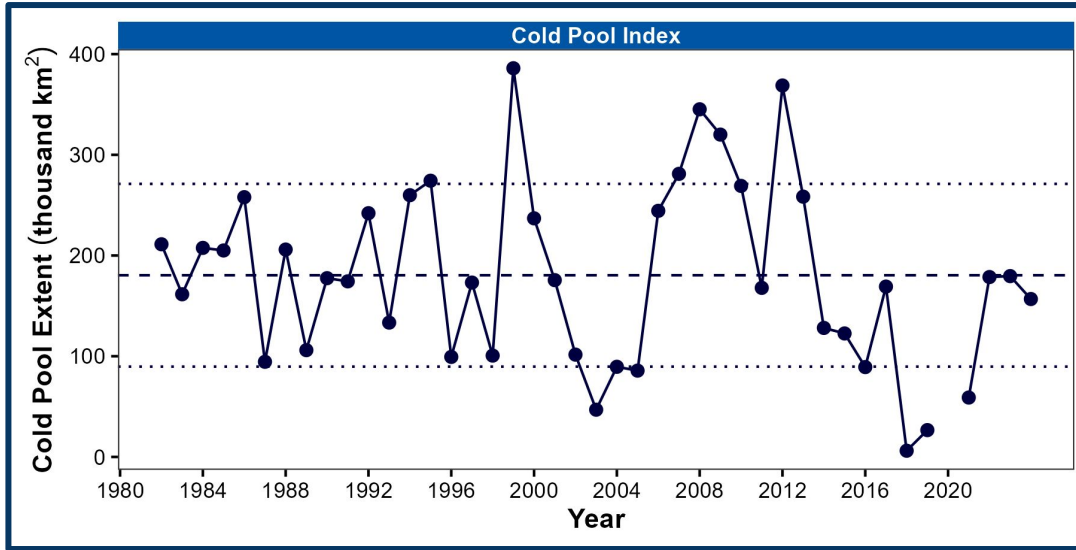
Data access and method description

The chart data is available for download, and the data sources and calculation methods can be found on the methods page:

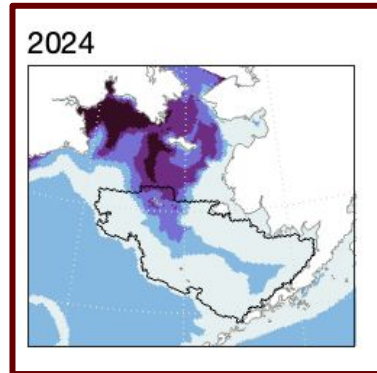
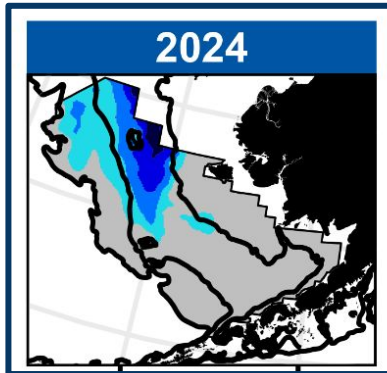
- [Methods](#)
- [Daily sea ice extent baseline time series \(1985-2015\), metadata](#) [csv format]
- [Daily sea ice extent time series \(current, last year\), metadata](#) [csv format]
- [Daily sea ice concentration satellite data \(CDR\), metadata](#) [link to data portal]
- [Daily sea ice concentration satellite data \(Near-Real-Time\), metadata](#) [link to data portal]

Cold Pool

Rohan & Barnett, Kearney

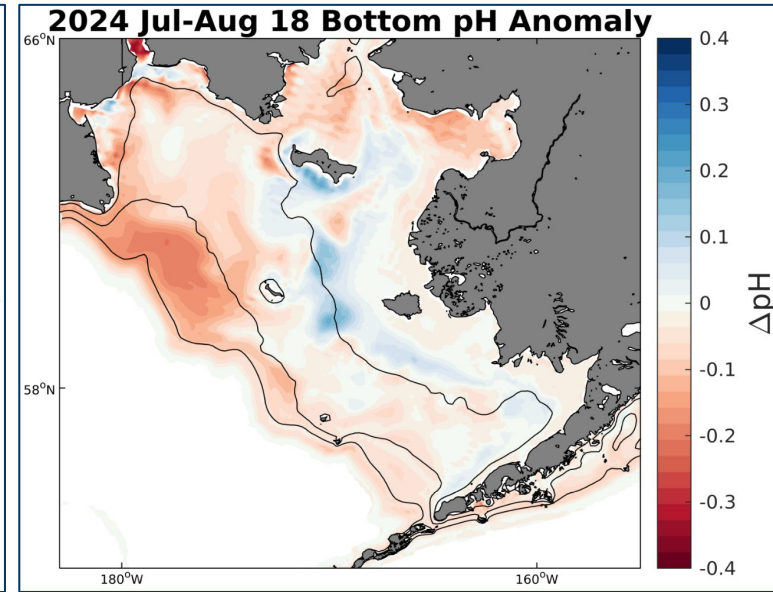
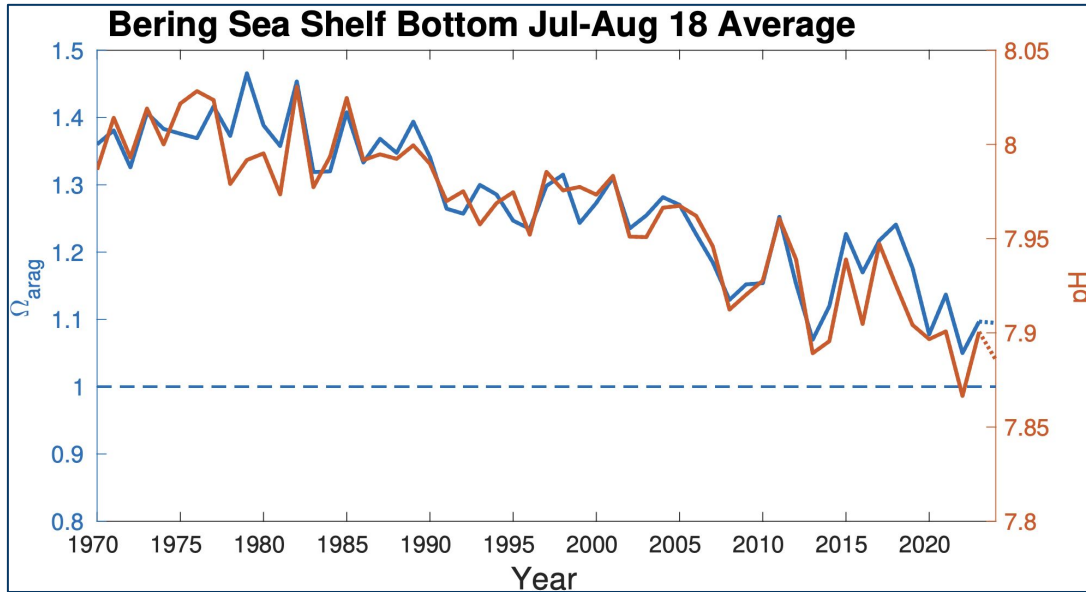


- 2024 bottom temperatures were near the time series average (std grid; 1982-2024)
- 2024 cold pool extent (<2°C; km²) was near the time series average (std grid; 1982-2024)
- Narrow tongue of <2°C water along the middle shelf (ROMS model)



Ocean Acidification

Pilcher & Monacci



- Summer 2024 bottom Ω_{arag} similar to 2023, pH slightly lower
- Multi-year outer shelf low pH anomaly still present, most prominent in northwest
- Bottom waters near 50m isobath have slightly higher pH values

EBS Physical Oceanography

Sea Surface Temperatures (SSTs)



- MHWs have been brief and infrequent since 2021
- SST anomalies within $\pm 1SD$ of the mean
- SSTs cooled to average by summer 2024; deeper MLD

Continued average temperature conditions over the EBS shelf

Sea ice



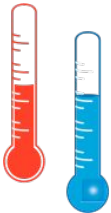
- Delayed freeze-up; winter “wiggles” due to weather; later melt-out
- Max ice extent occurred in late March
- Ice thickness was at or above average, but slightly lower than 2023

Sea ice impacts stratification, production of ice algae, and the cold pool

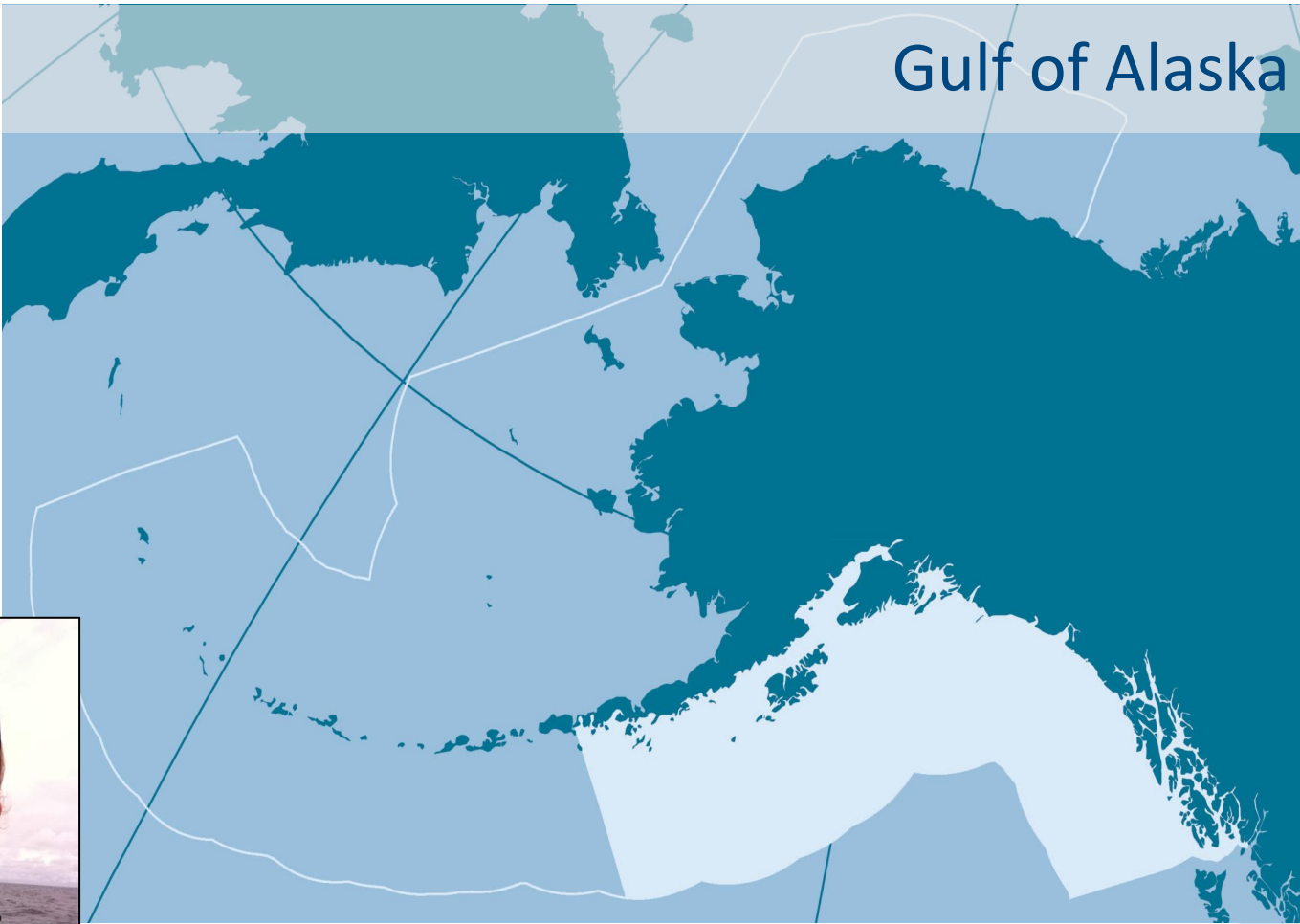
Cold pool

- 2024 cold pool extent was near average; slightly smaller than 2022 & 2023
- Narrow cold tongue along the middle shelf

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



Gulf of Alaska



NOAA
FISHERIES

GOA 2024 Climate & Oceanography Big Picture

- GOA experienced El Niño winter conditions after 3 years of cooler La Niña; predicted to return to La Niña in winter 2025
- El Niño was strong but moderated in GOA

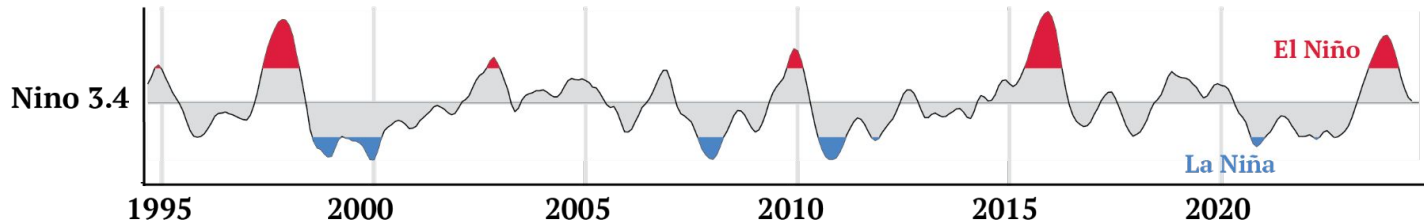
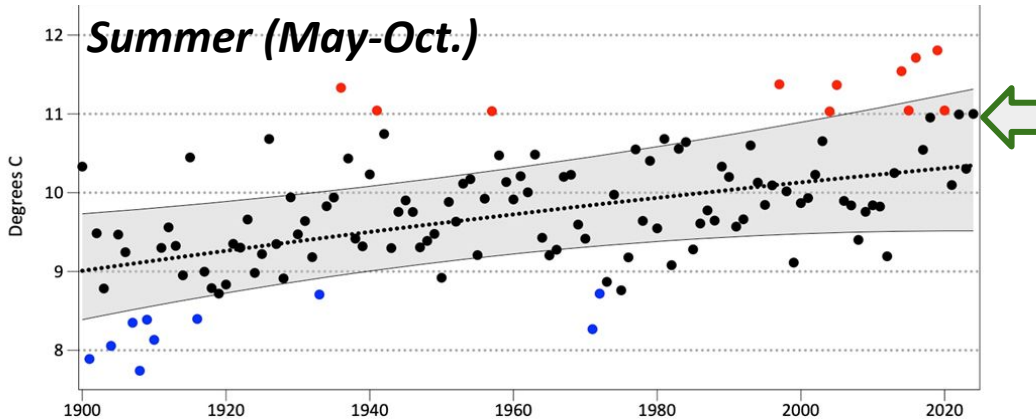
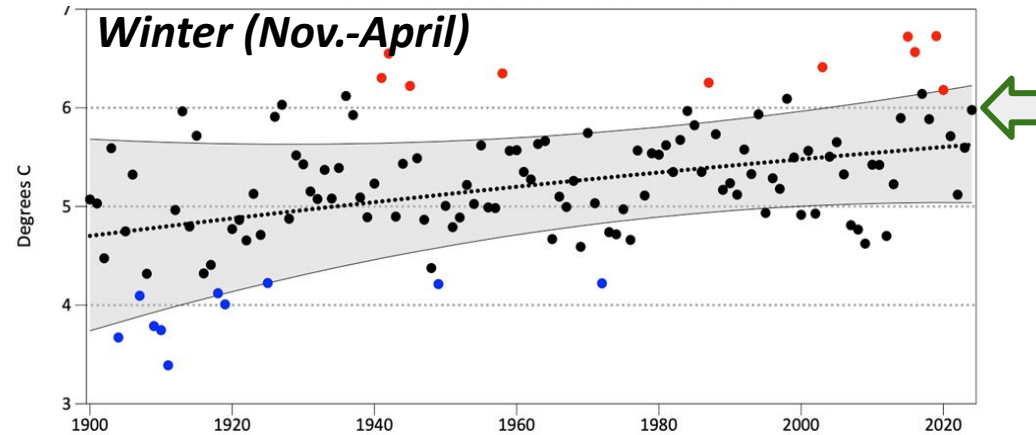


Figure: E. Lemagie

Long-Term GOA Sea Surface Temperature

Thoman

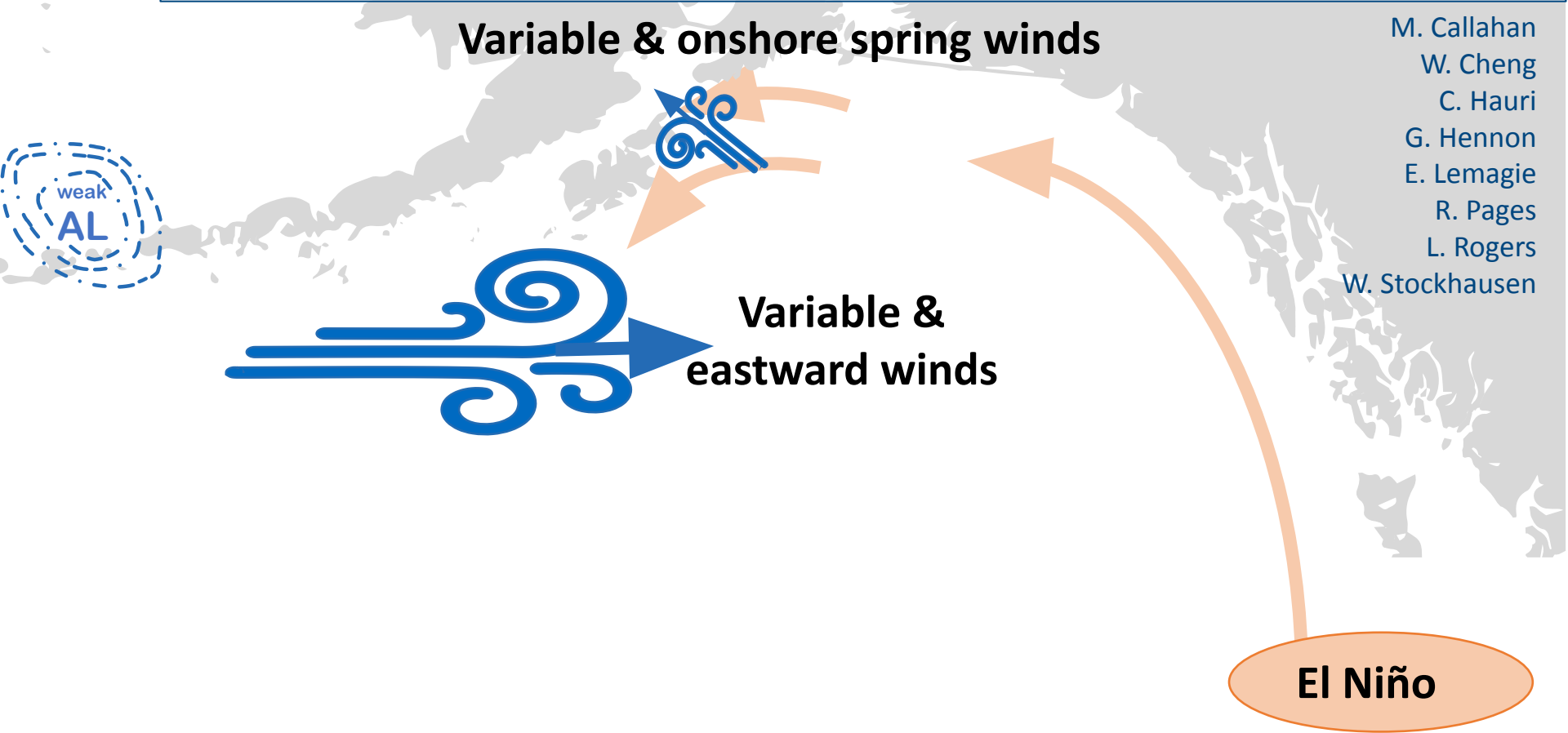


- GOA shelf SST (NOAA's Extended Reconstructed SST, ERSSTv5) with B-spline regression $\pm 1SD$
- Winter (Nov.-April '23/'24) above median SST of increasing trend
- Summer (May-Oct. '24) above median SST of increasing trend (driven by warmer EGOA)
 - Preliminary summer 2024 data point

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

Data source: ERSSTv5 and B.Brettschneider/NWS Alaska

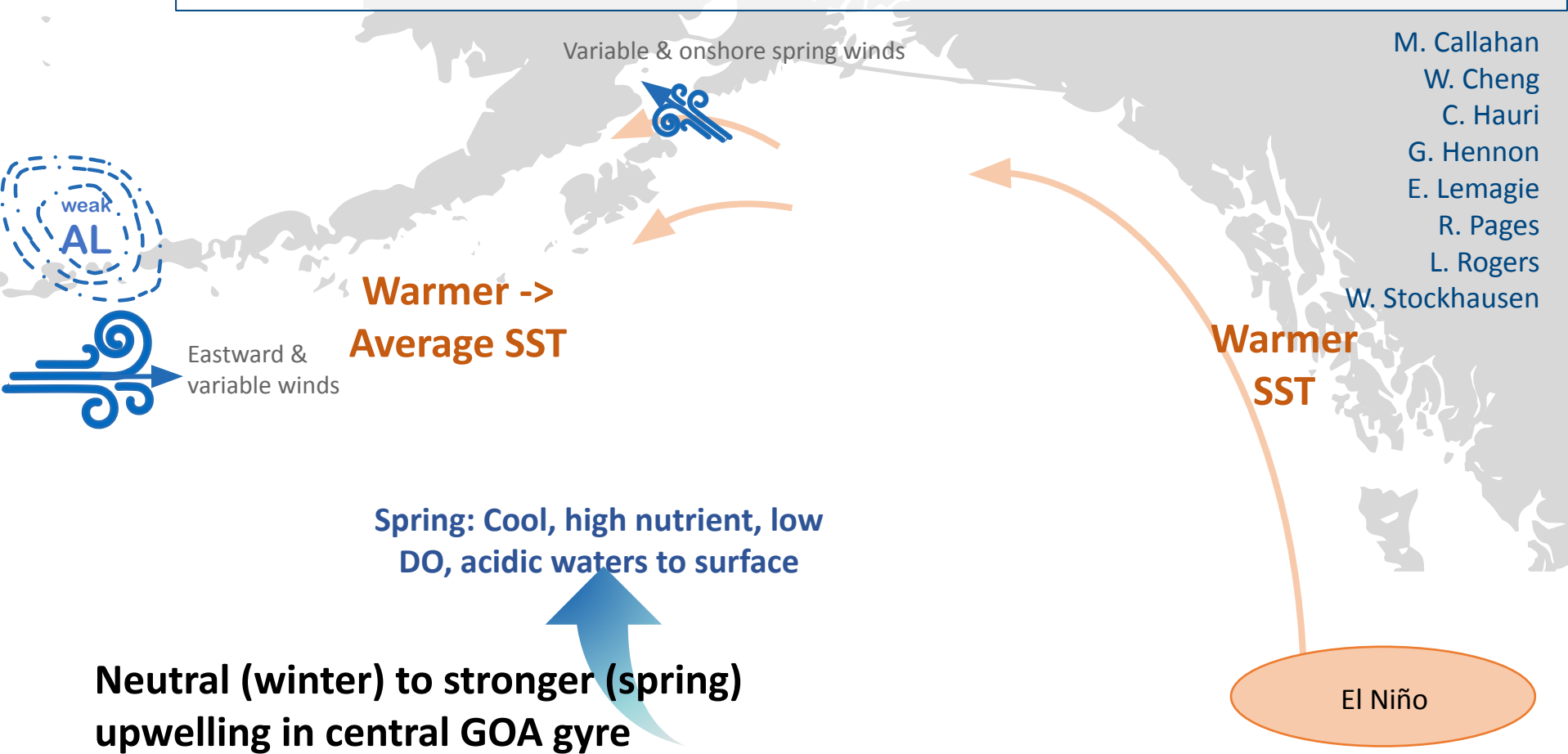
Winter/Spring 2024: Strong El Niño moderated by weak Aleutian low and eastward and variable winds



- M. Callahan
- W. Cheng
- C. Hauri
- G. Hennon
- E. Lemagie
- R. Pages
- L. Rogers
- W. Stockhausen

El Niño

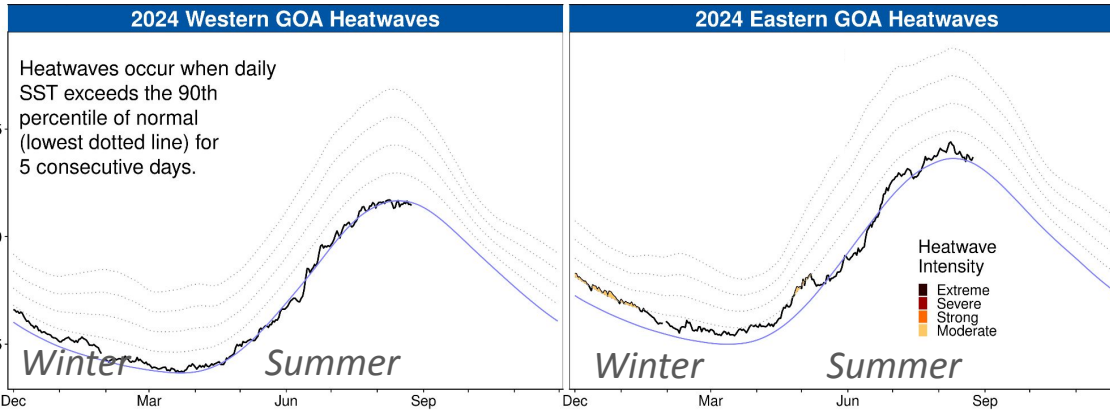
Winter/Spring 2024 (Temperature): Warm surface waters across GOA shelf; EGOA warm at depth? Spring upwelled cooler waters in central gyre



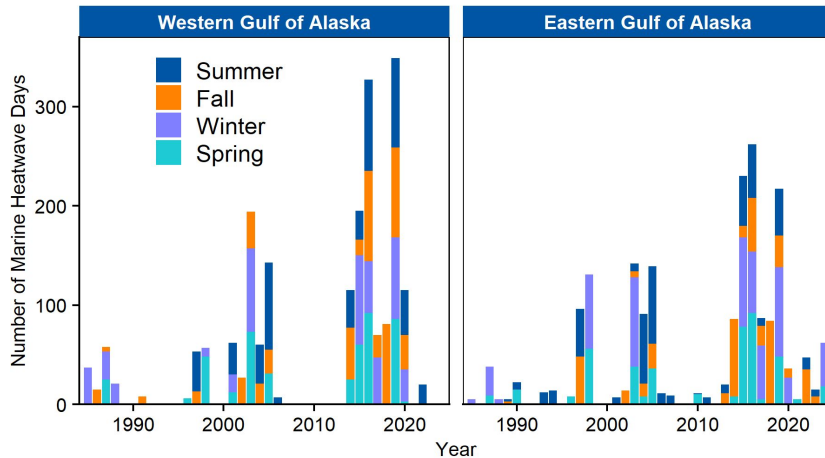
- M. Callahan
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GOA SST & Marine Heatwaves 2024

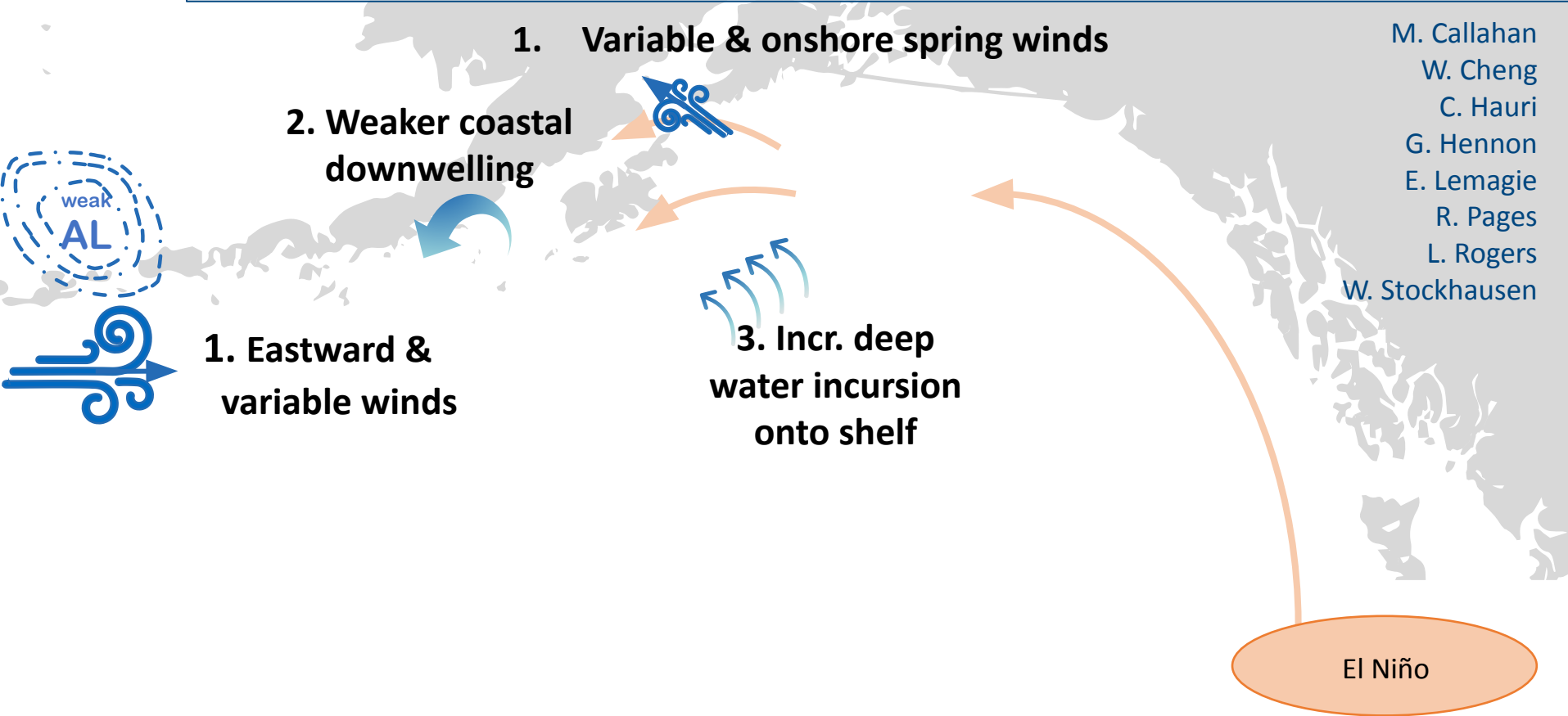
Lemagie, Callahan



- WGOA
 - Winter warm but not marine heatwave status (trend since 2020)
 - Summer average SST
- EGOA
 - Winter/spring in or near marine heatwave status (up to ~75% area)
 - 2022/2023 MHW days in summer & fall
 - Warm summer
- *1985-2014 baseline*

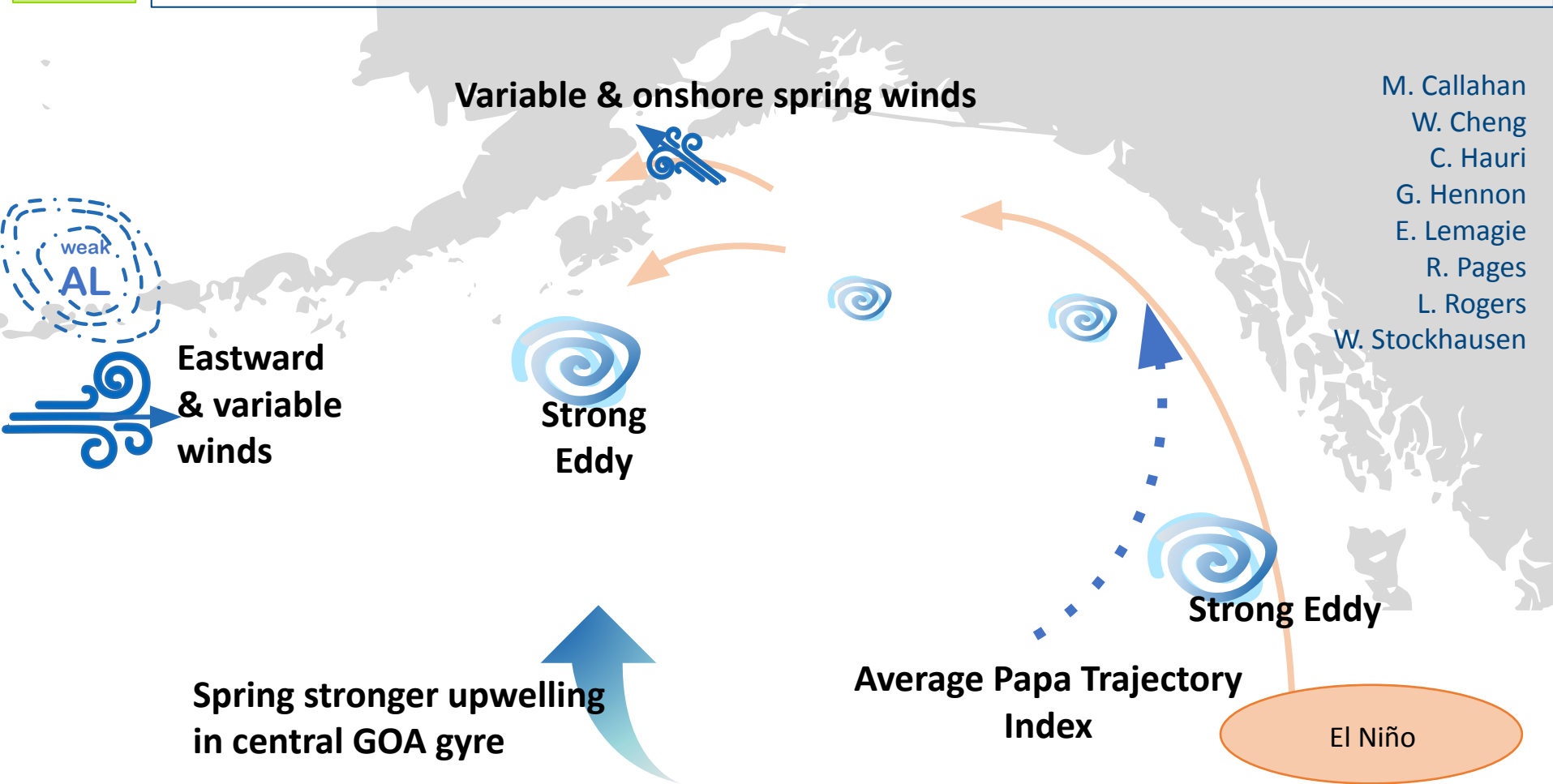


Winter/Spring 2024 (Transport): Weakened coastal downwelling, increased deep water incursion from slope onto shelf bottom



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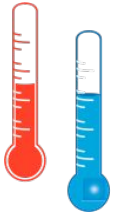
Winter/Spring 2024 (Transport): Regionally variable surface transport



GOA Climate & Oceanography 2024



- Shift from multi-year average/cool ocean temperatures to a warm winter (WGOA)/ year (EGOA); predicted to cool in 2025
- Strong El Niño was moderate in the GOA but some associated oceanographic responses



- WGOA warm winter/spring surface temperatures; average at depth?
- EGOA MHW status Dec-May; warm summer; heat at depth?



- Regionally variable surface transport on shelf; spring upwelled cooler waters in central gyre



- Potential for weakened winter coastal downwelling, increased deep water incursion from slope onto shelf bottom

Potential for positive larval survival: rockfish, s. rocksole, rex sole, halibut, arrowtooth

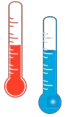
Key Messages



- **N. Pacific:** Started year under El Niño conditions, transitioned to current neutral conditions, expected to move to weak La Niña by mid Fall.



- **Eastern Bering Sea (EBS):** SST anomalies within $\pm 1SD$ of the mean (baseline = 1985-2014); delayed sea ice in fall that eventually reached average extent (baseline = 1991-2020); cold pool extent was near average (baseline = 1982-2024).



- **Aleutian Islands (AI):** Strong eastward winds 2023 - 2024 opposing regular NP warm water transport through eastern passes to EBS shelf. Cooler SST except for winter & WAI



- **Gulf of Alaska (GOA):** Shift from multi-year average/cool ocean temperatures (baseline: 1985-2014) to warm winter SST across GOA; EGOA remains warm; regional variation in temperature and transport



Thank You

Alaska Fisheries Science Center Ecosystem Status Reports

<https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands>



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