

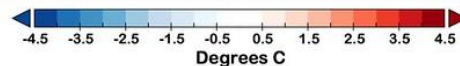
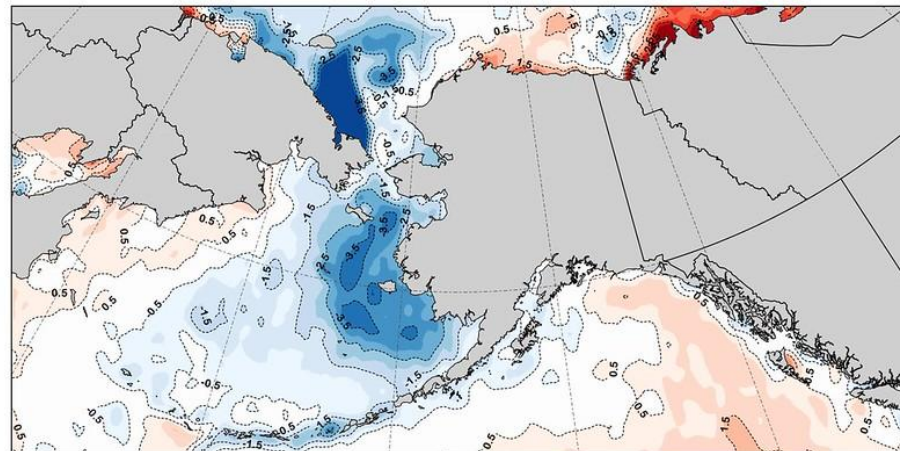
Alaska Climate Overview

NPFMC Crab Plan Team
September 9, 2024



Ivonne Ortiz
Emily Lemagie
Elizabeth Siddon
Bridget Ferriss

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



1991-2020 baseline
OISSIV2.1 courtesy of NOAA/PSL/ESRL



Outline: Climate & Oceanography

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



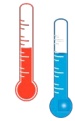
Key Messages



- **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):** Dominant winds from the Arctic with sustained sea ice extent through May, near historic norm.






- **Aleutian Islands (AI):** Strong eastward winds autumn 2023 - summer 2024 opposing regular NP warm water transport through eastern passes to EBS shelf.



- **Gulf of Alaska (GOA):** Shift from multi-year average/cool ocean temperatures to warm winter SST across GOA; EGOA remains warm



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

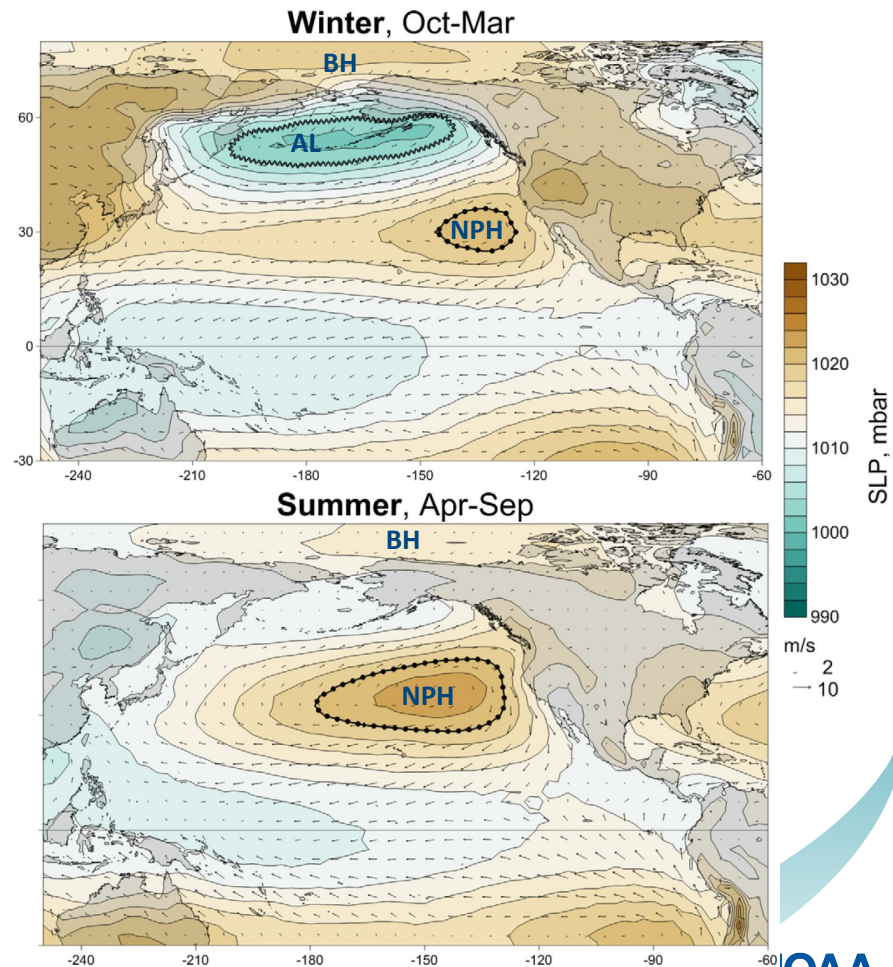


Image modified from Fiedler and Mantua 2017

Interannual variability

Strong AL
One center
Larger size
Stormtrack south of Aleutians

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

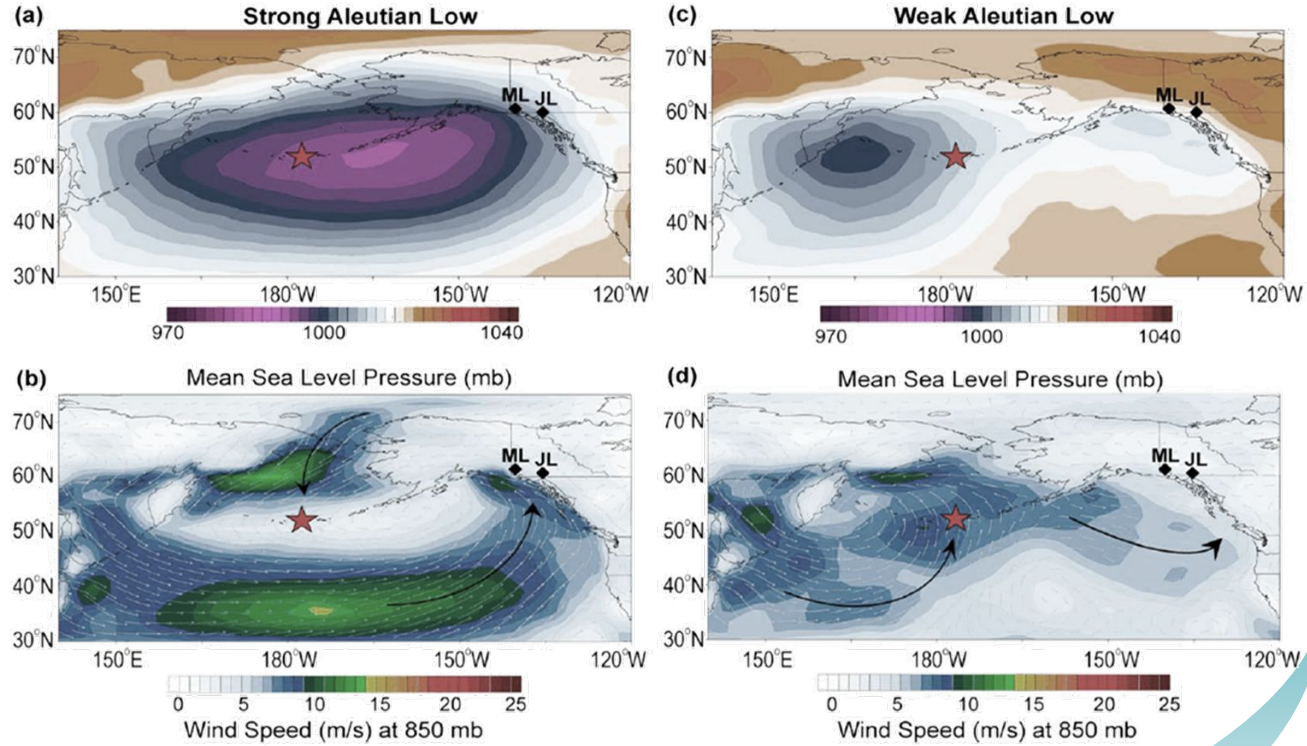


Image modified from Bailey et al. 2015

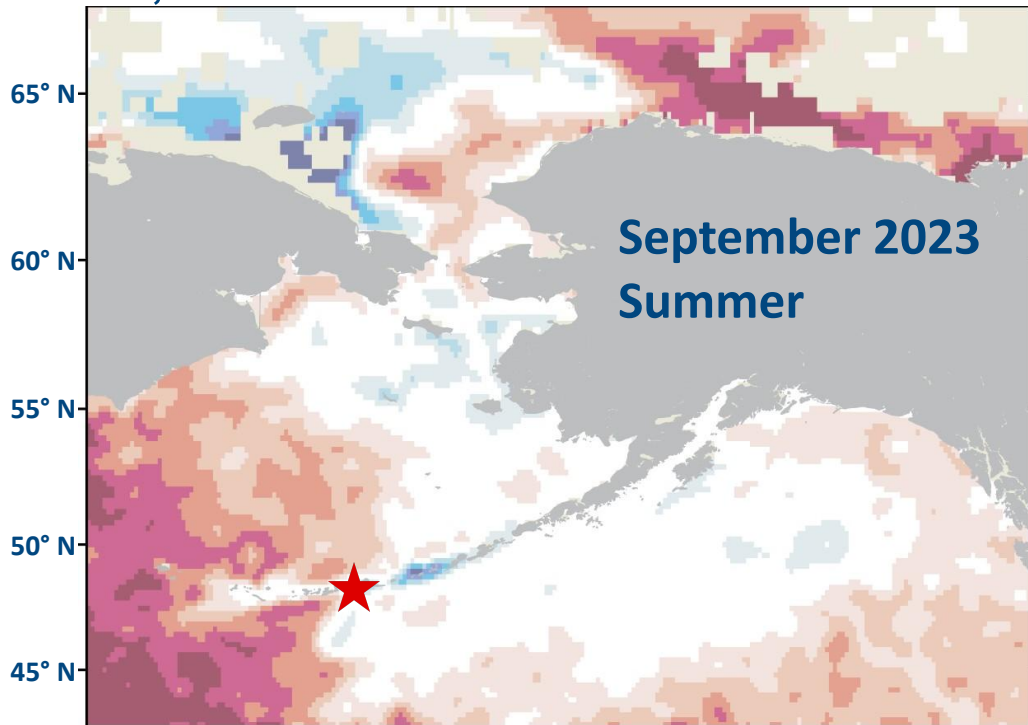
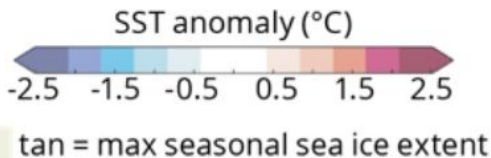
★ Adak
→ Storm track



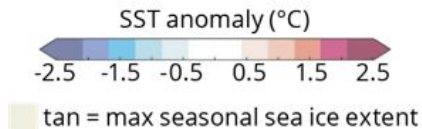
Sea Surface Temperature, Sea Ice & Winds

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
FISHERIES

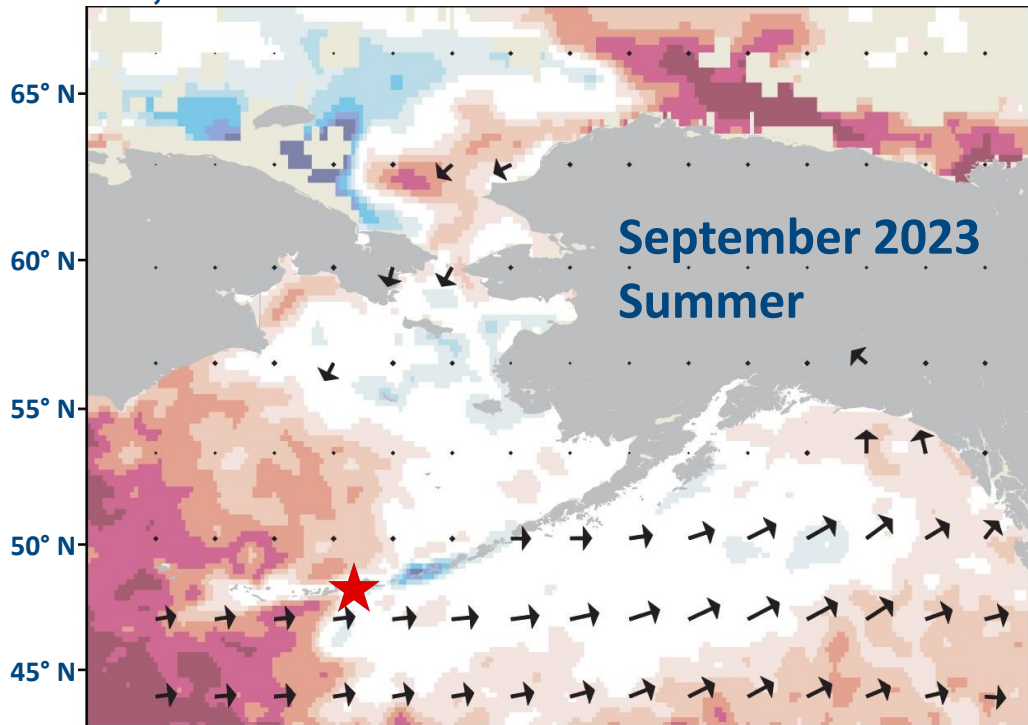
Sea Surface Temperature, Sea Ice & Winds

Lemagie

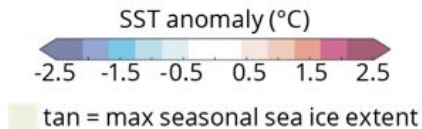
September

~0	<3m/s	3m/s	>3m/s
.	.	→	→→

■ black dots/arrows = climatology winds



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



NOAA
FISHERIES

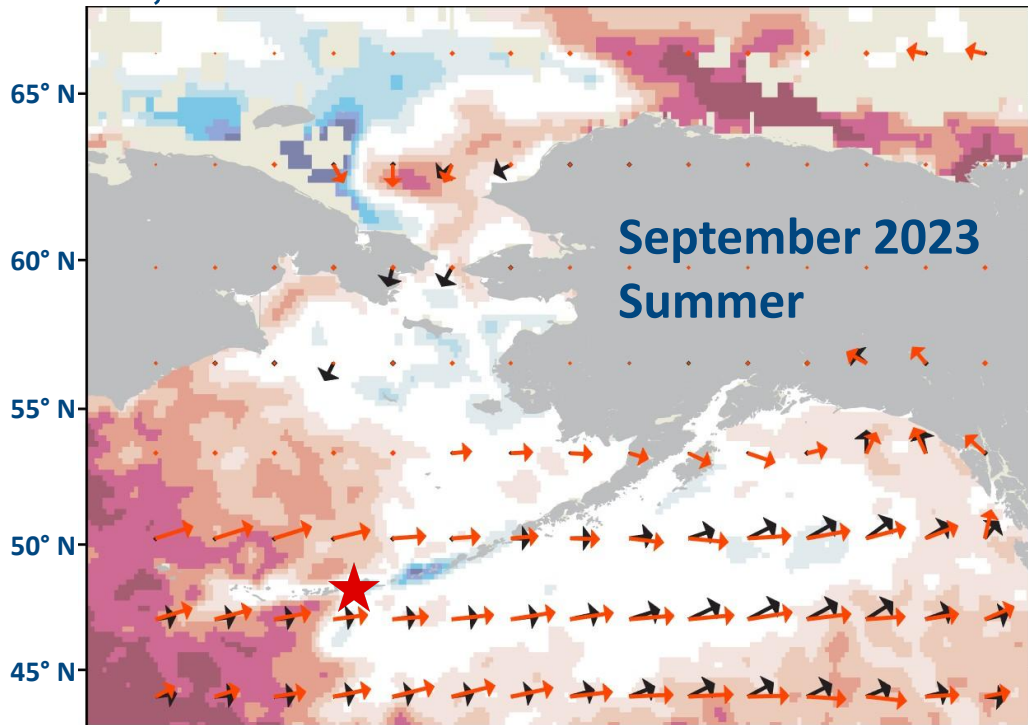
Sea Surface Temperature, Sea Ice & Winds

Lemagie

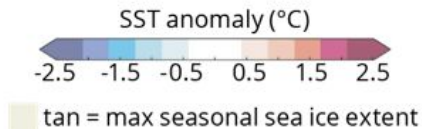
September

~0	<3m/s	3m/s	>3m/s
.	.	→	→

red dots/arrows = monthly mean winds



Monthly Wind and SST Anomalies
(1991-2020 Climatology)



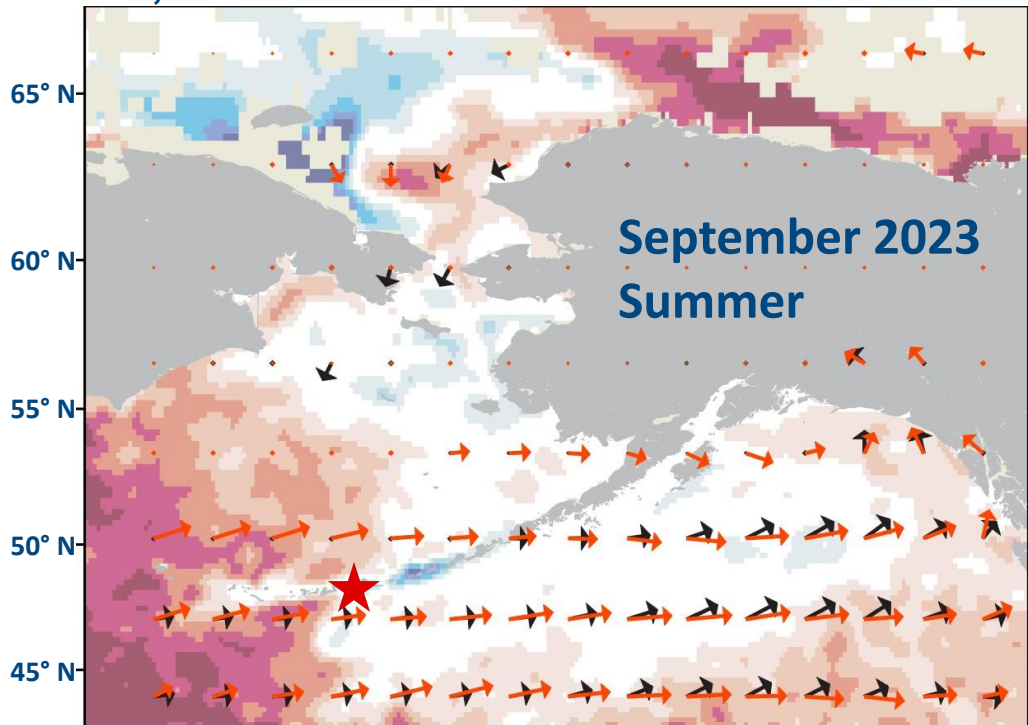
~0	<3m/s	3m/s	>3m/s
.	.	→	→

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

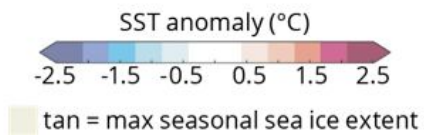
Sea Surface Temperature, Sea Ice & Winds

Lemagie

Warm SSTs over western
Aleutians and GOA



Monthly Wind and SST Anomalies
(1991-2020 Climatology)



~0	<3m/s	3m/s	>3m/s
.	.	→	→

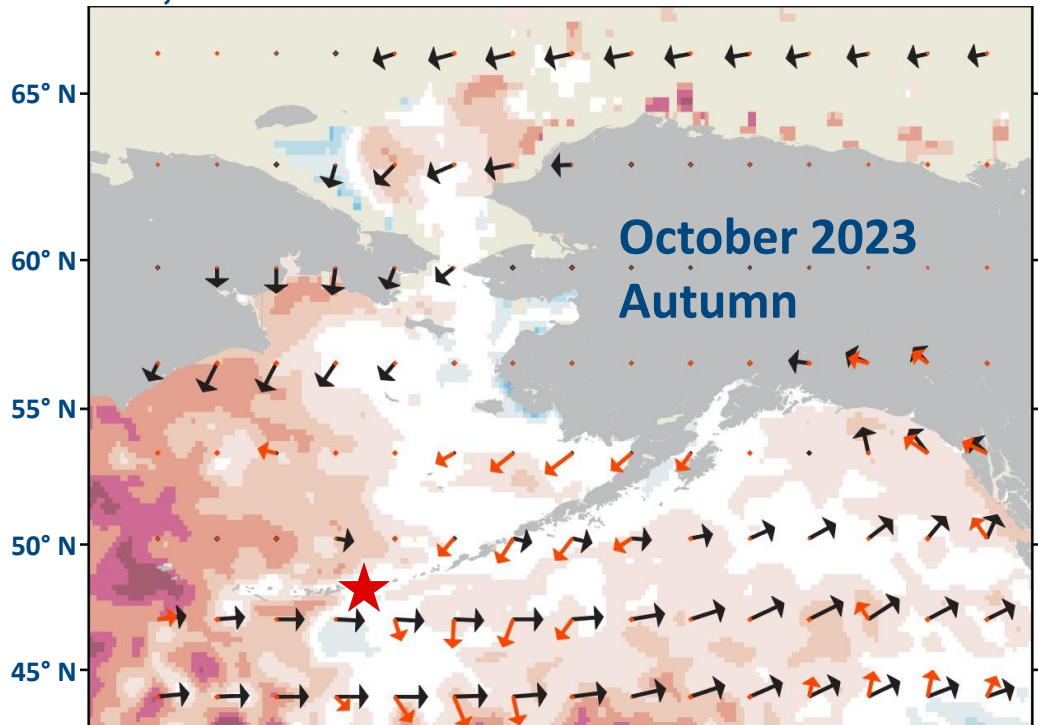
red dots/arrows = monthly mean winds
black dots/arrows = climatology winds



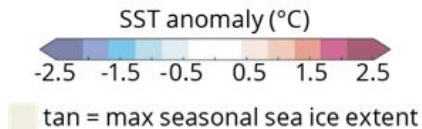
Sea Surface Temperature, Sea Ice & Winds

Lemagie

Warm SSTs over western
Aleutians and GOA



Monthly Wind and SST Anomalies
(1991-2020 Climatology)



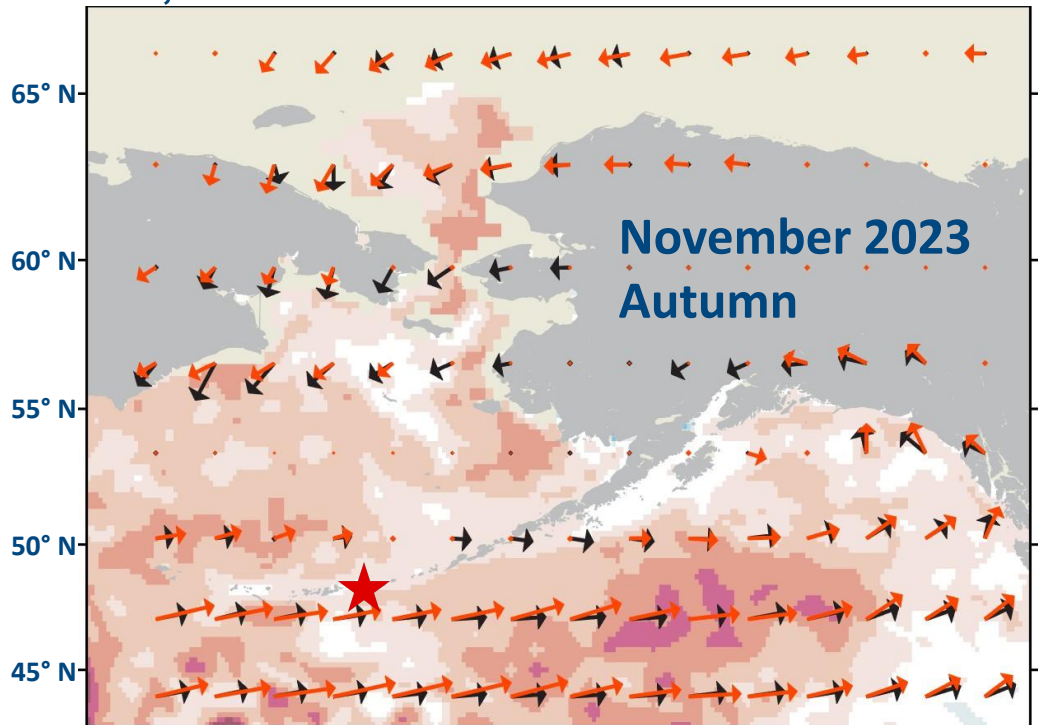
~0	<3m/s	3m/s	>3m/s
.	.	→	→

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

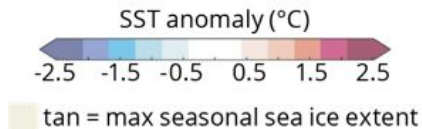
Sea Surface Temperature, Sea Ice & Winds

Lemagie

Warm SSTs over western
Aleutians and GOA



Monthly Wind and SST Anomalies
(1991-2020 Climatology)



~0	<3m/s	3m/s	>3m/s
.	.	→	→

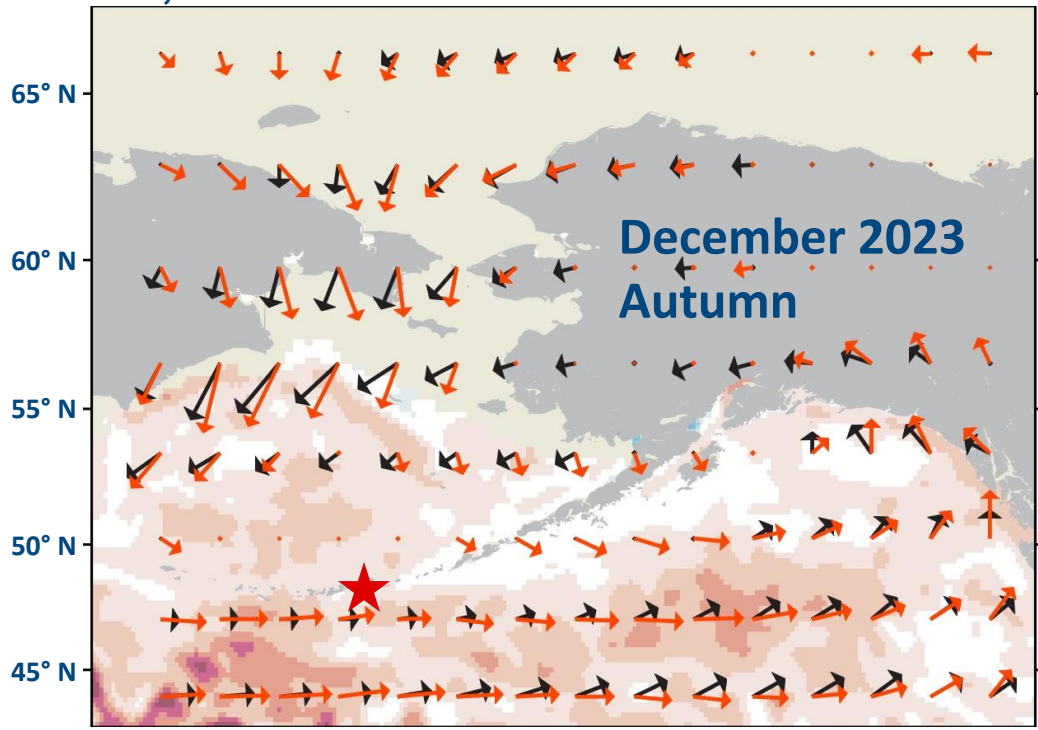
red dots/arrows = monthly mean winds
black dots/arrows = climatology winds

Sea Surface Temperature, Sea Ice & Winds

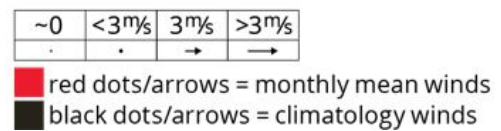
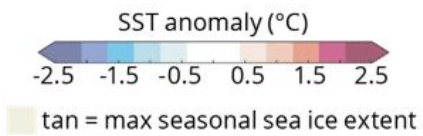
Lemagie

Aleutian Low this winter:
Weak and small

Winds from Arctic



Monthly Wind and SST Anomalies
(1991-2020 Climatology)

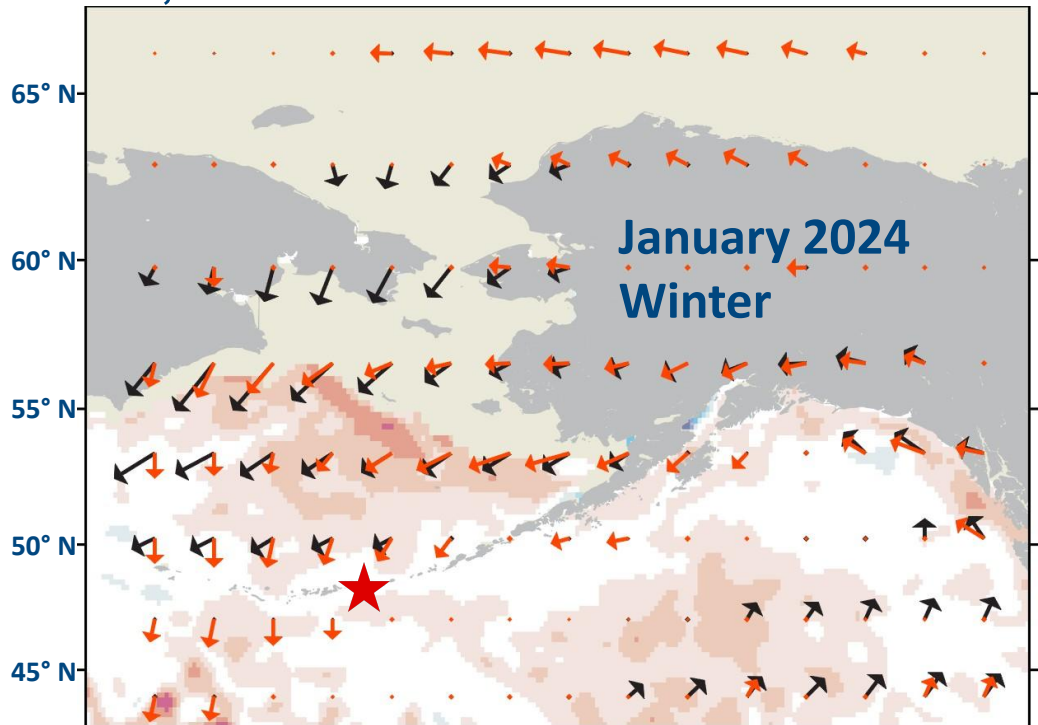


Sea Surface Temperature, Sea Ice & Winds

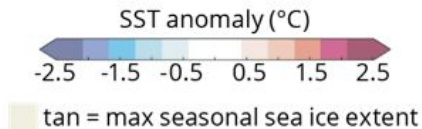
Lemagie

Aleutian Low this winter:
Weak and small

Winds from Arctic



Monthly Wind and SST Anomalies
(1991-2020 Climatology)



~0	<3m/s	3m/s	>3m/s
.	.	→	→

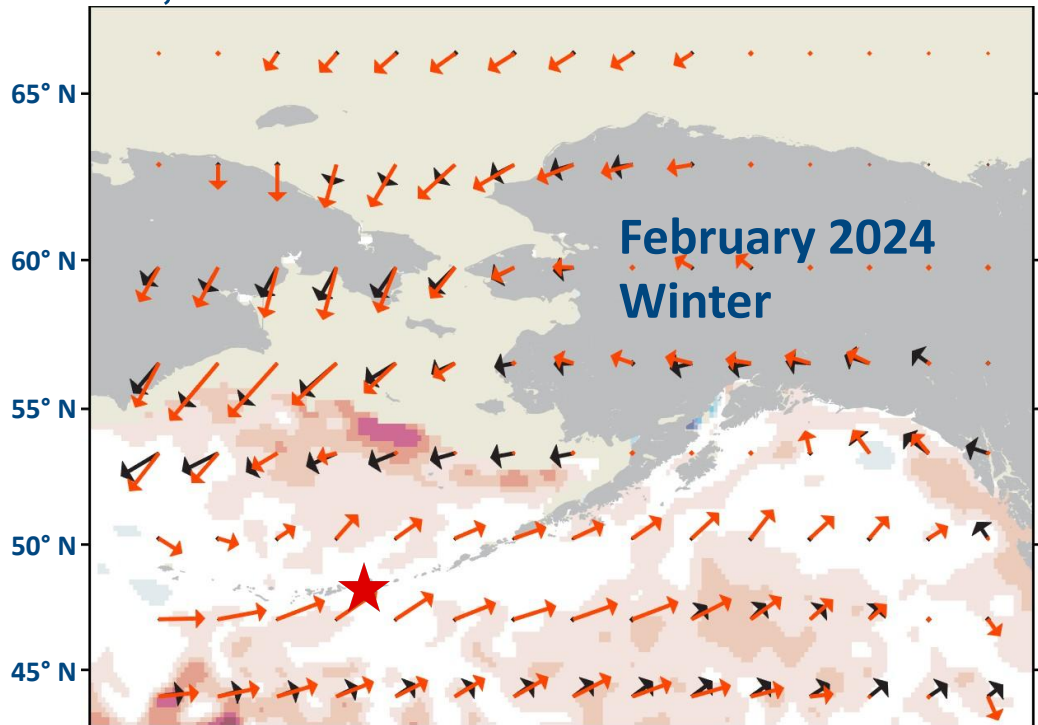
red dots/arrows = monthly mean winds
black dots/arrows = climatology winds

Sea Surface Temperature, Sea Ice & Winds

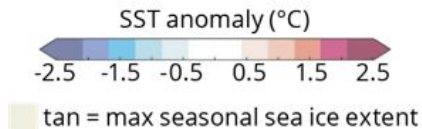
Lemagie

Aleutian Low this winter:
Weak and small

Winds from Arctic



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

Sea Surface Temperature, Sea Ice & Winds

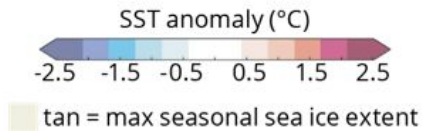
Lemagie

SST close to long-term mean
across most of Alaska

Winds from Arctic



Monthly Wind and SST Anomalies
(1991-2020 Climatology)



~0	<3m/s	3m/s	>3m/s
.	.	→	→→

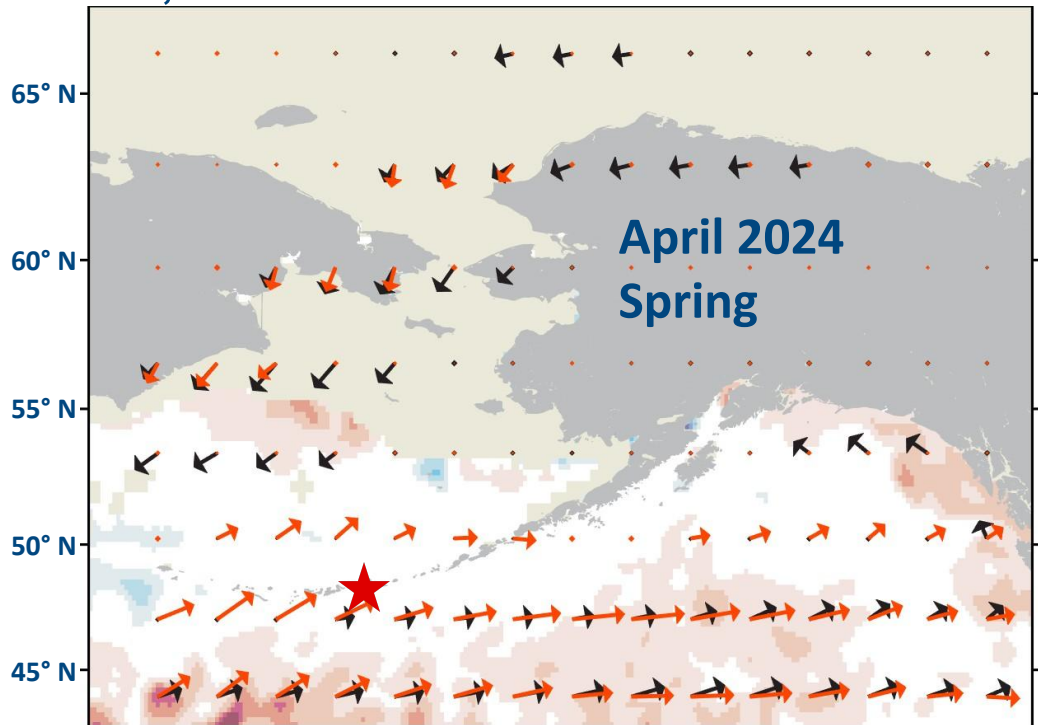
red dots/arrows = monthly mean winds
black dots/arrows = climatology winds

Sea Surface Temperature, Sea Ice & Winds

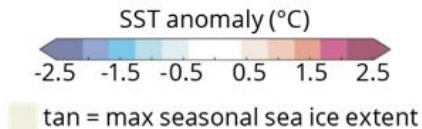
Lemagie

SST close to long-term mean
across most of Alaska

Winds from Arctic



Monthly Wind and SST Anomalies
(1991-2020 Climatology)



~0	<3m/s	3m/s	>3m/s
.	.	→	→

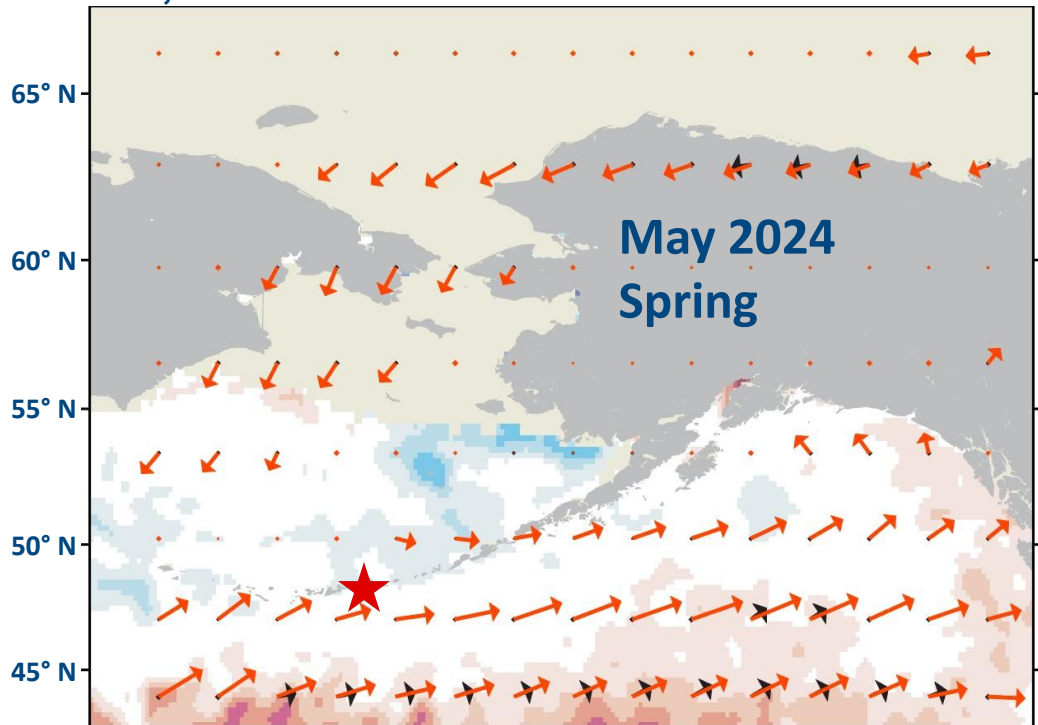
red dots/arrows = monthly mean winds
black dots/arrows = climatology winds

Sea Surface Temperature, Sea Ice & Winds

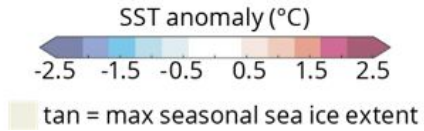
Lemagie

SST close to long-term mean
across most of Alaska

Winds from Arctic



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

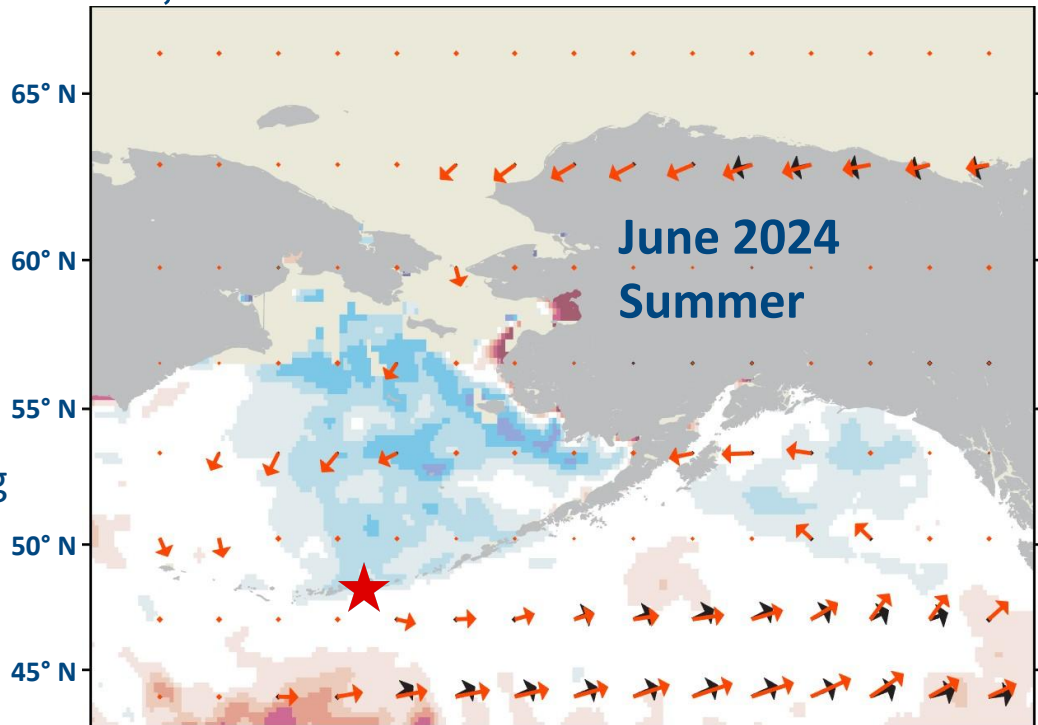


Sea Surface Temperature, Sea Ice & Winds

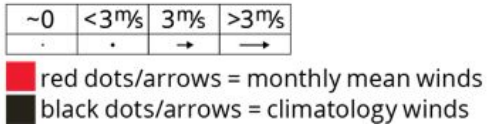
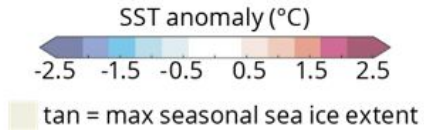
Lemagie

Neutral El Niño conditions

Winds from Arctic weakening



Monthly Wind and SST Anomalies
(1991-2020 Climatology)



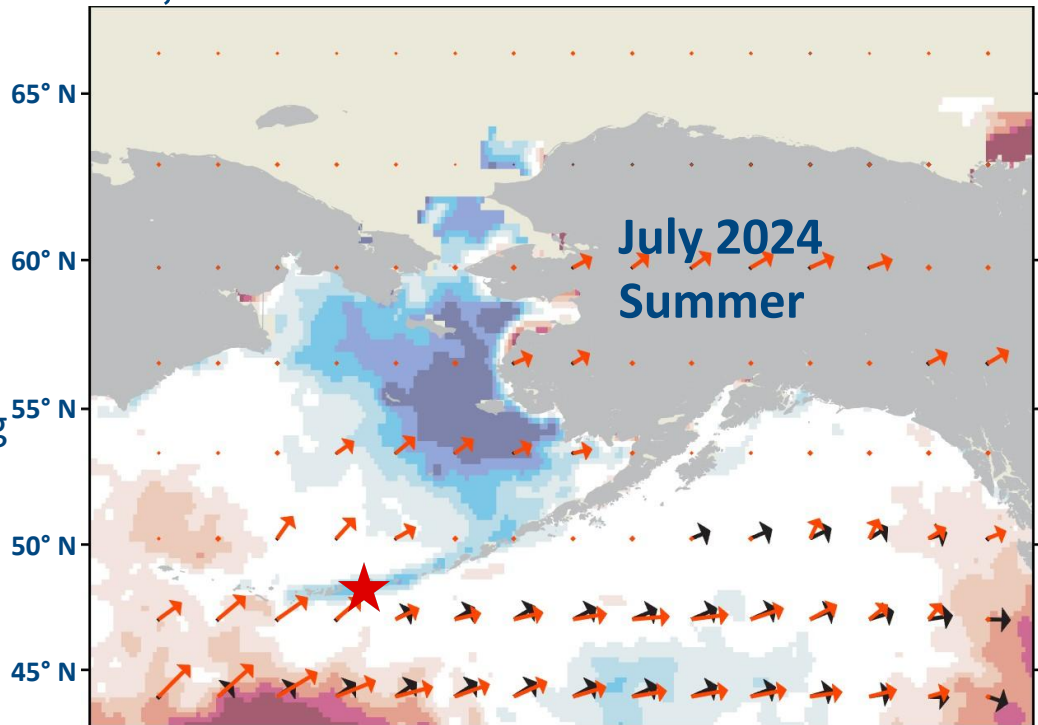
Sea Surface Temperature, Sea Ice & Winds

Lemagie

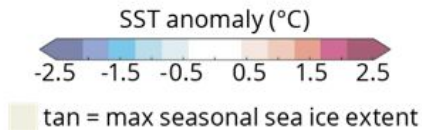
Neutral El Niño conditions

Winds from Arctic weakening

Winds from North Pacific



Monthly Wind and SST Anomalies
(1991-2020 Climatology)



~0	<3m/s	3m/s	>3m/s
.	.	→	→

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

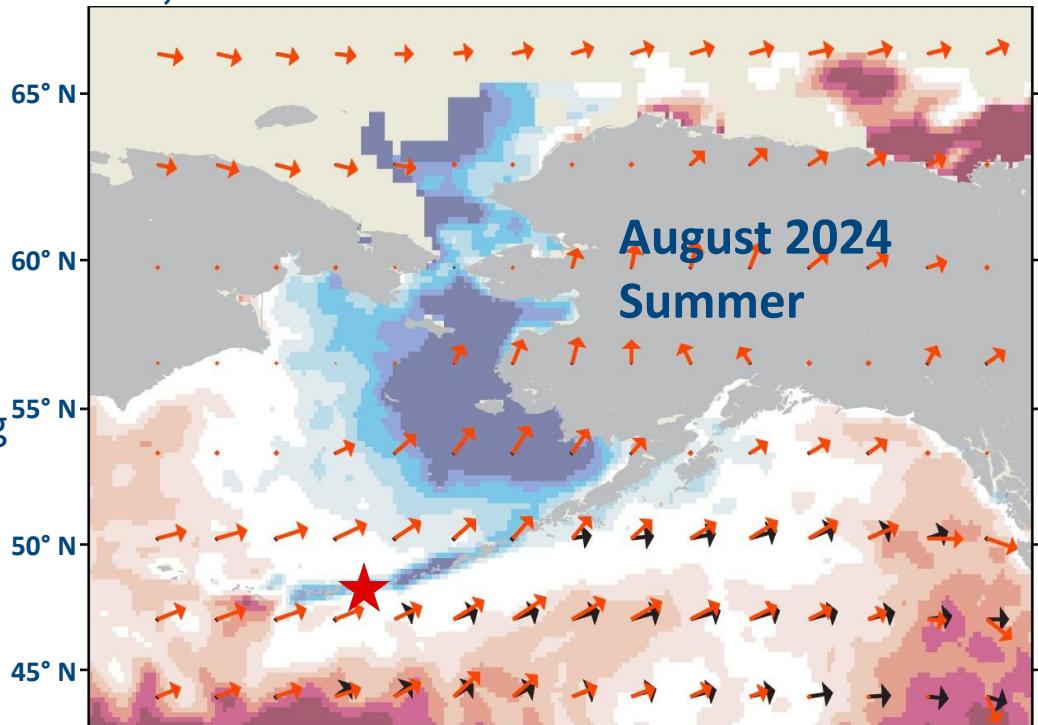
Sea Surface Temperature, Sea Ice & Winds

Lemagie

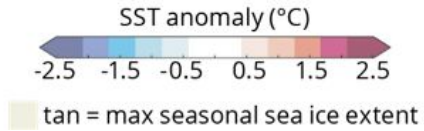
Neutral El Niño conditions

Winds from Arctic weakening

Winds from North Pacific



Monthly Wind and SST Anomalies
(1991-2020 Climatology)



~0	<3m/s	3m/s	>3m/s
.	.	→	→

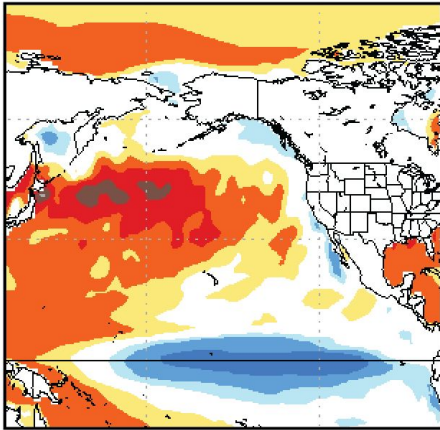
red dots/arrows = monthly mean winds
black dots/arrows = climatology winds



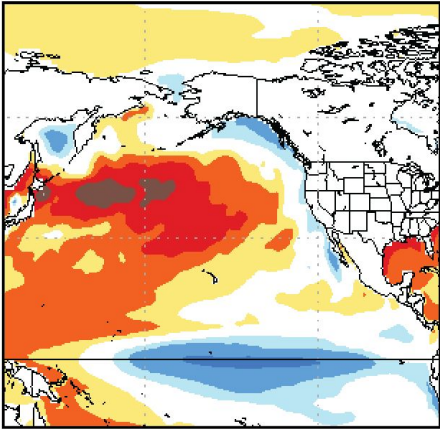
SST Projections from the National Multi-Model Ensemble

Lemagie

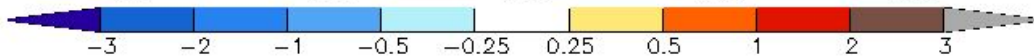
Nov 24 -
Jan 25



Jan - Mar
2025

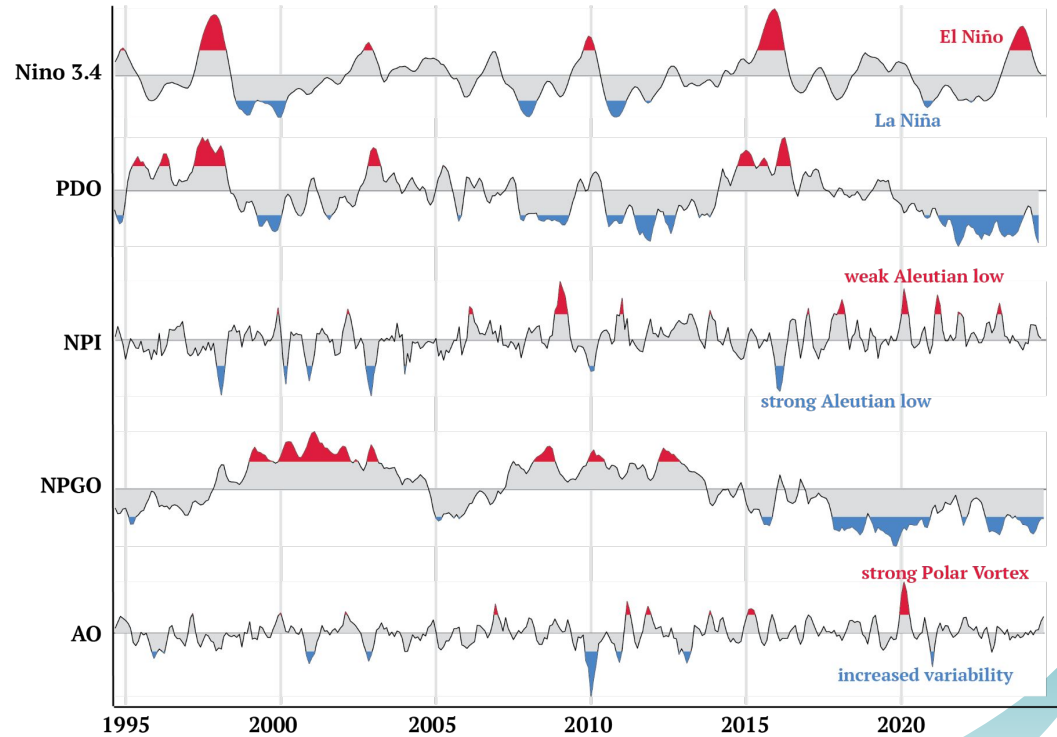


- Synopsis: ENSO-neutral is expected to continue for the next several months, with La Niña favored to emerge during September-November (66% chance) and persist through the Northern Hemisphere winter 2024-25 (74% chance during November-January).
- Nov-Jan and Jan-Mar, near-normal surface temperatures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



Climate indices

- **NINO3.4** El Niño Jan-May 2024; neutral since Apr-May-June 2024
- **PDO** negative since winter 2019/2020
- **NPI** positive since 2020 . String of weak AL; near-neutral in summer
- **NPGO** decline since 2012; neg. since 2017
- **AO** positive since April - colder air confined across polar regions



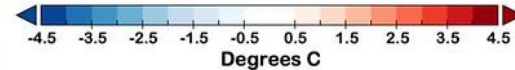
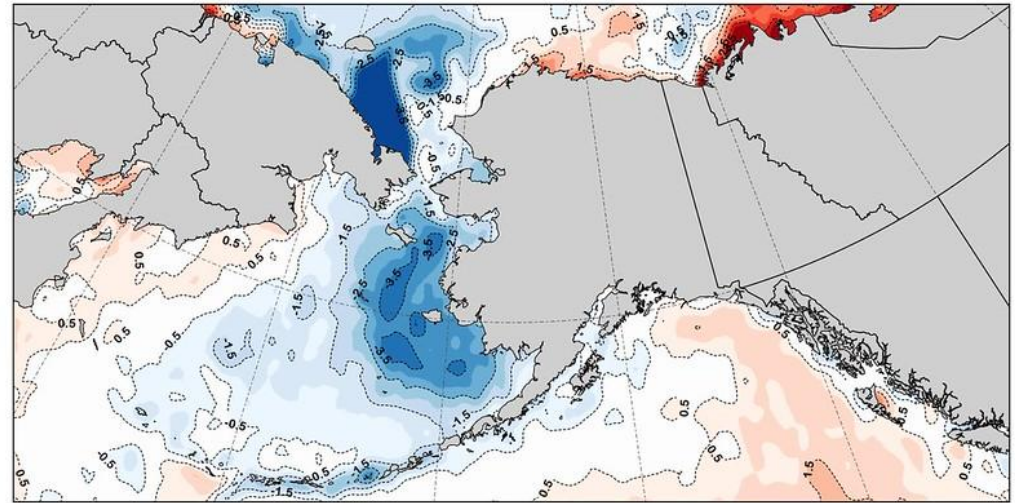
Aleutian Islands

ECOSYSTEM STATUS REPORT

NPFMC Crab Plan Team
September 9, 2024

Ivonne Ortiz
Stephani Zador

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



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

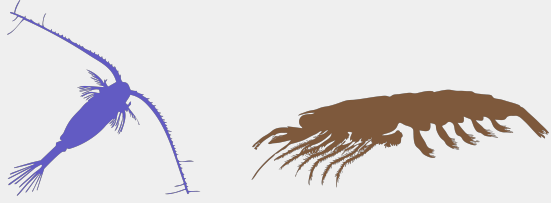


Crab-relevant ecosystem information

- Pelagic and benthic stages
- Environmental processes, prey, competitors, predators
- 2024 (where available) in context

Pelagic larval indicators

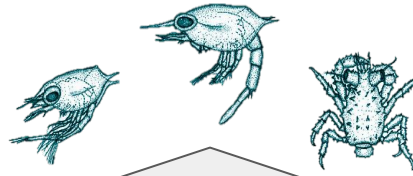
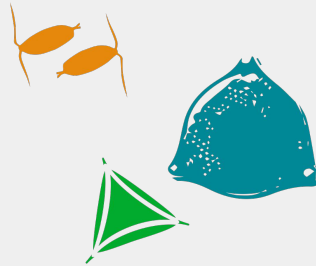
COMPETITORS



PREDATORS



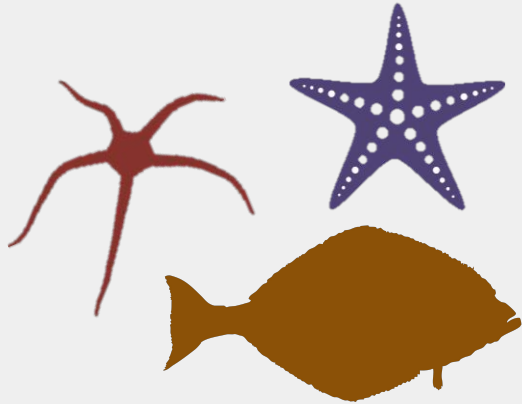
PREY



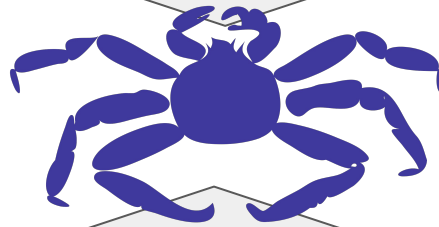
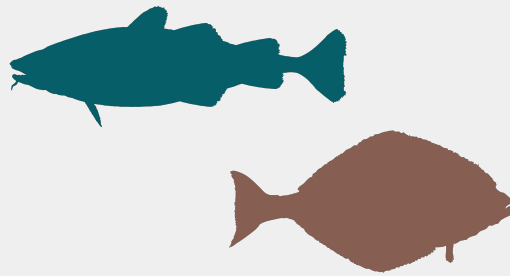
ENVIRONMENTAL PROCESSES

Benthic juvenile/adult indicators

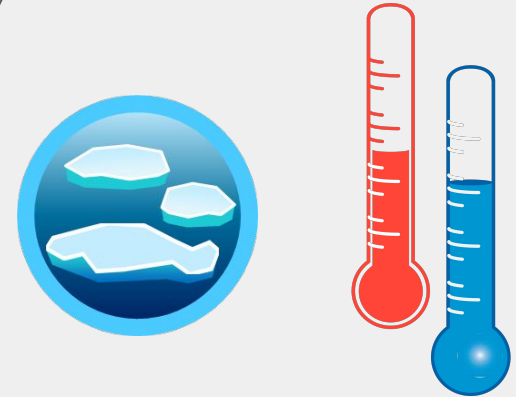
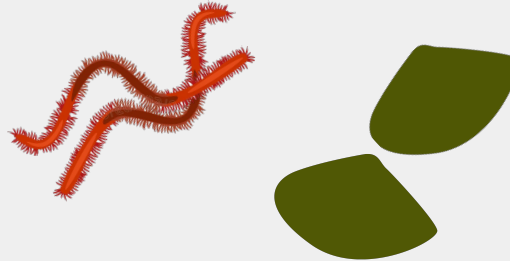
COMPETITORS



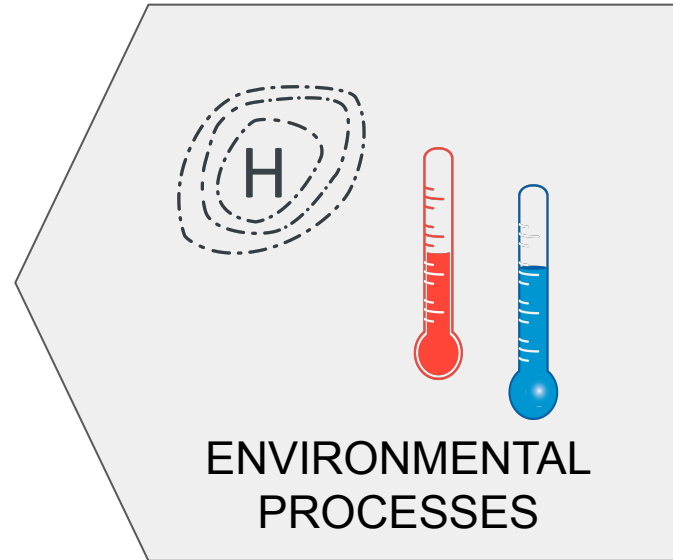
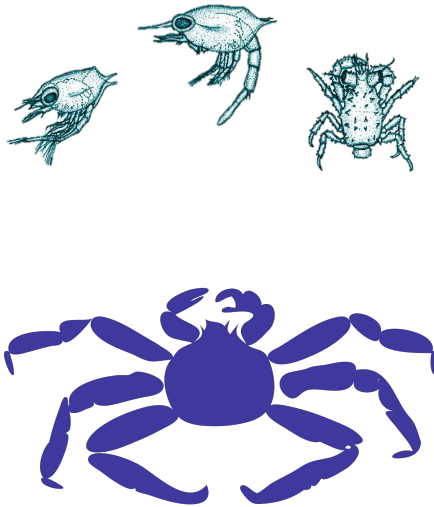
PREDATORS



PREY



ENVIRONMENTAL
PROCESSES

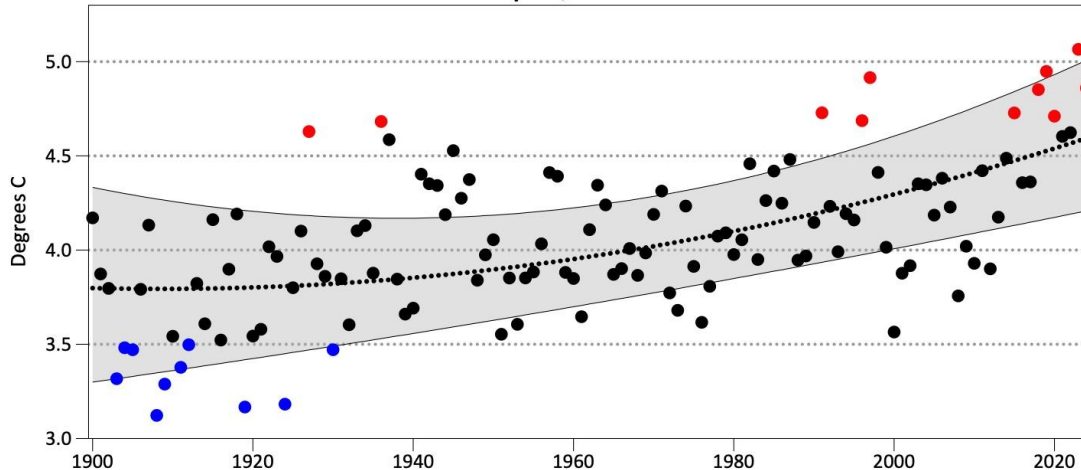




Long-term Sea Surface Temperature

Thoman

**Aleutians Sea Marine Management Areas
Average Sea Surface Temperature
November-April, 1900-01 to 2023-24**



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

Data source: ERSSTv5
and B.Brettschneider/NWS Alaska

Winter

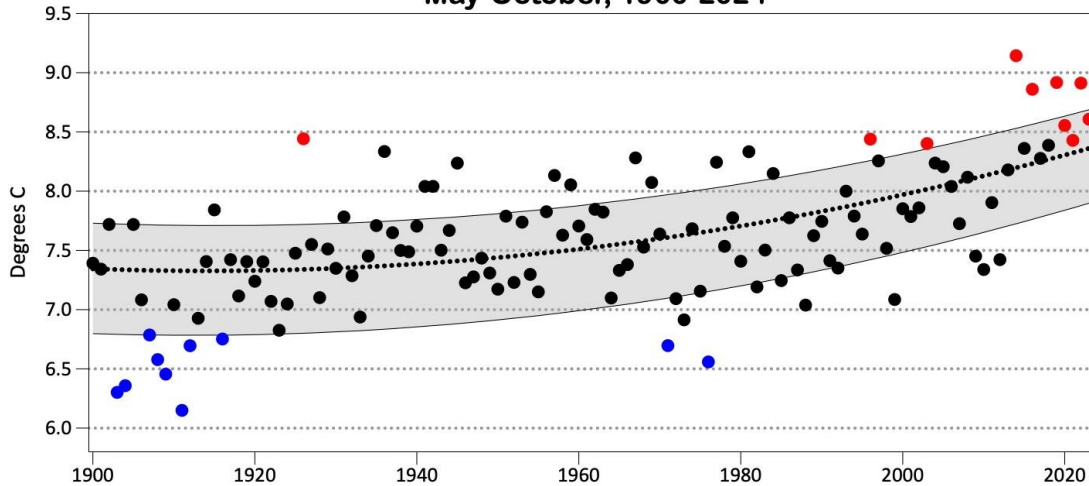
- SSTs winter lower than last year but still among 10 warmest



Long-term Sea Surface Temperature

Thoman

**Aleutians Sea Marine Management Areas
Average Sea Surface Temperature
May-October, 1900-2024**



Summer

- SSTs close to long-term mean, slightly below



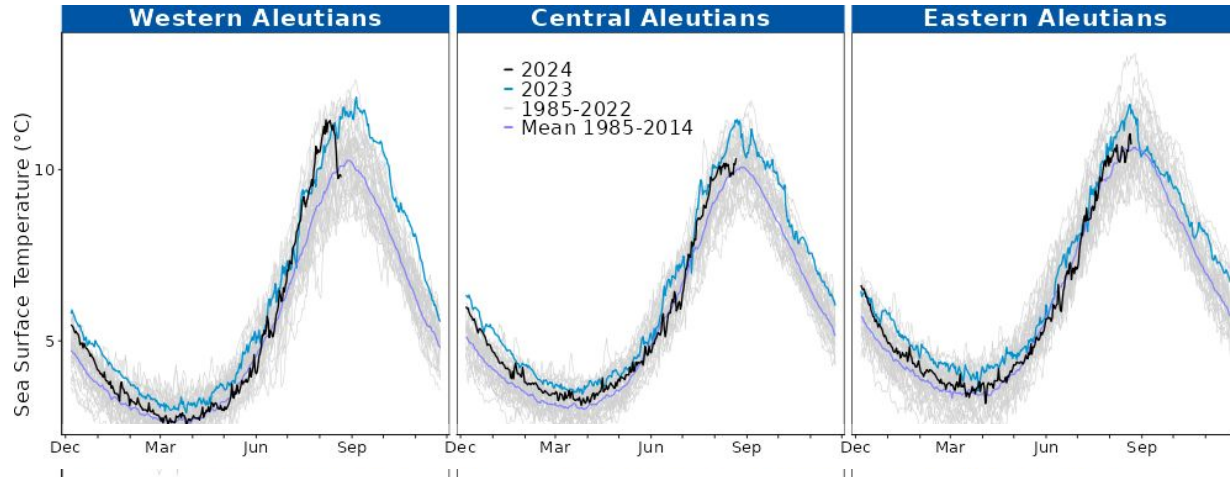
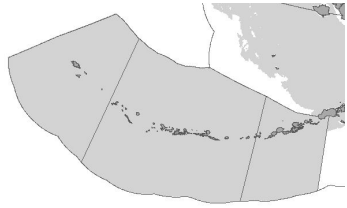
■ Estimated \pm One Std. Dev. ● Ten Warmest
●● Estimated Median ● Ten Coldest

Data source: *ERSSTv5*
and *B. Brettschneider/NWS Alaska*
2024 estimated



Sea Surface Temperature and Marine Heat Wave

Lemagie & Callahan

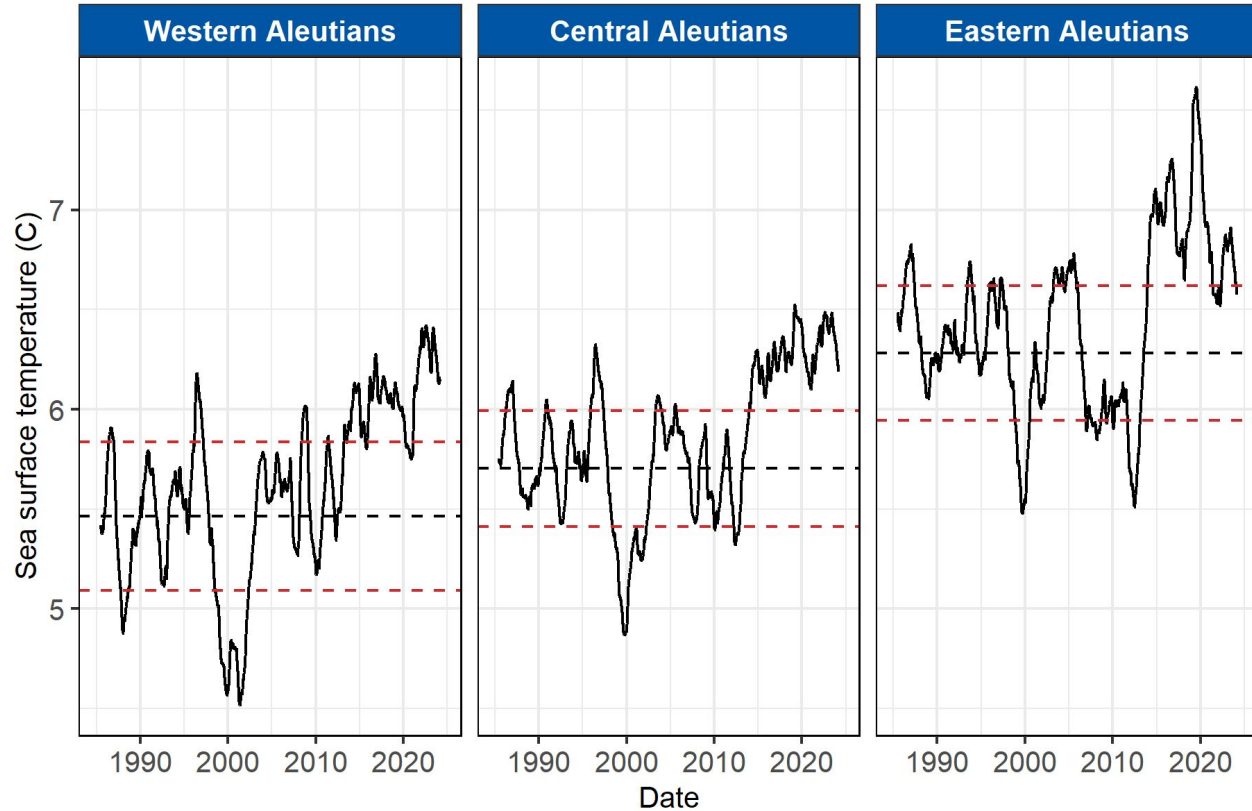


- WAI-CAI: SST above long-term mean in winter and summer
- EAI: SSTs above long-term average in winter, near mean through fall



Sea Surface Temperature Trend

Lemagie & Callahan

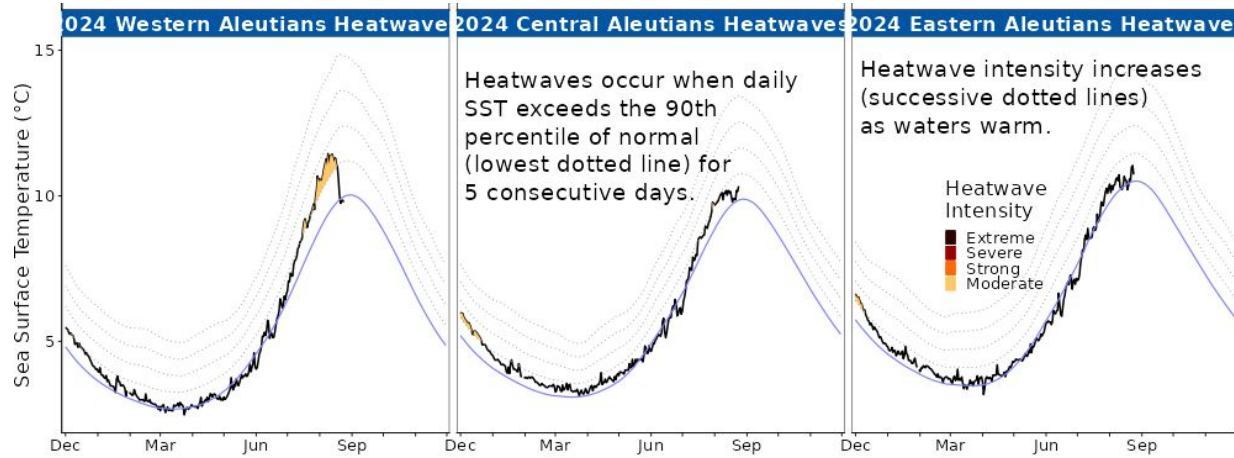


- Through May 2023
- Step-increase in 2014
- SST above 1 std. dev.



Marine Heatwave Index

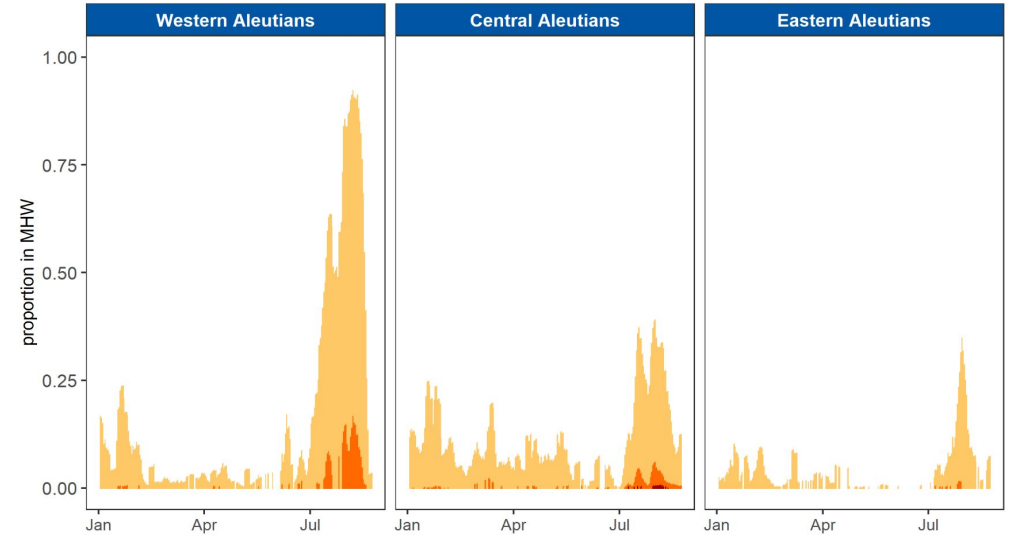
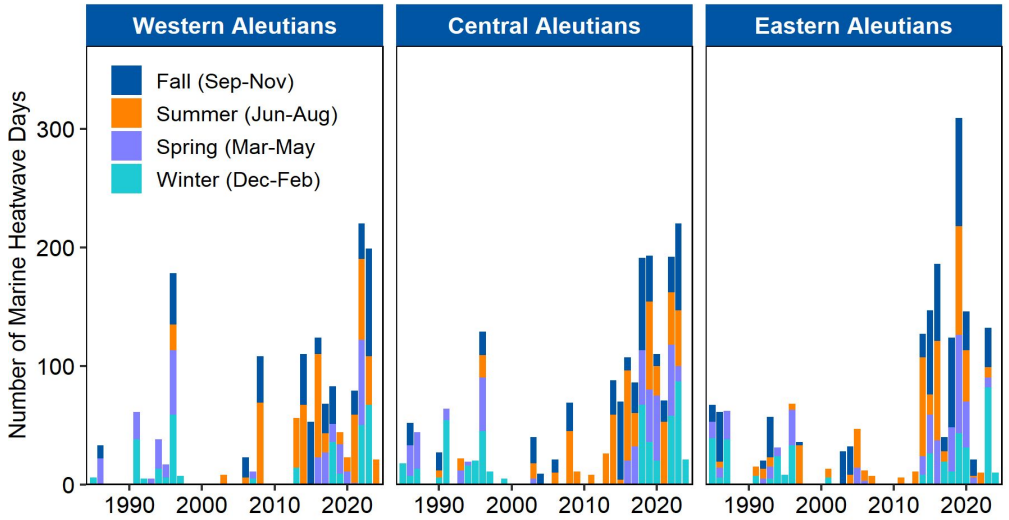
Lemagie & Callahan



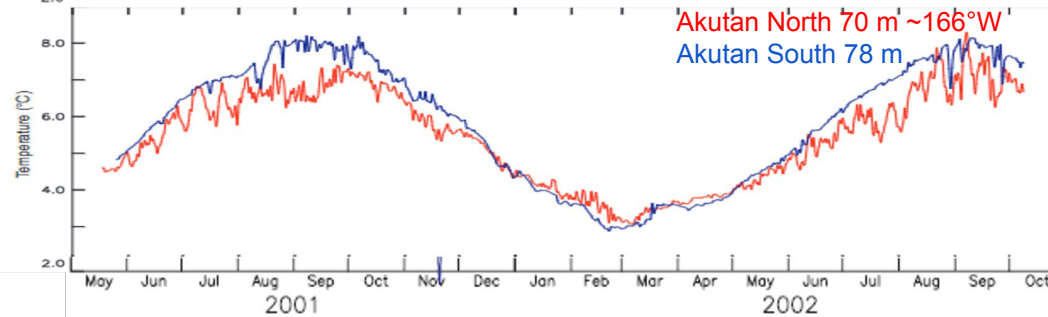
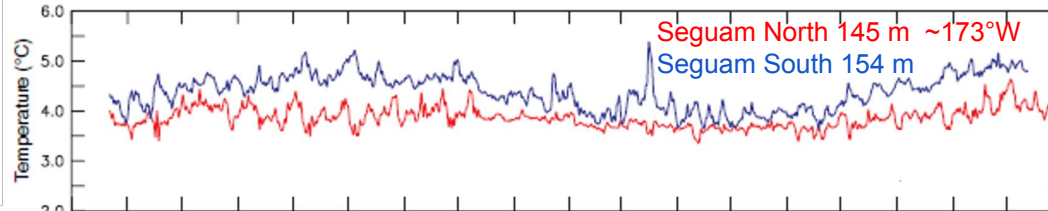
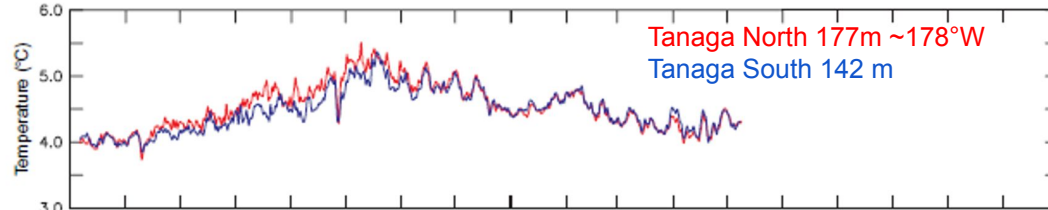
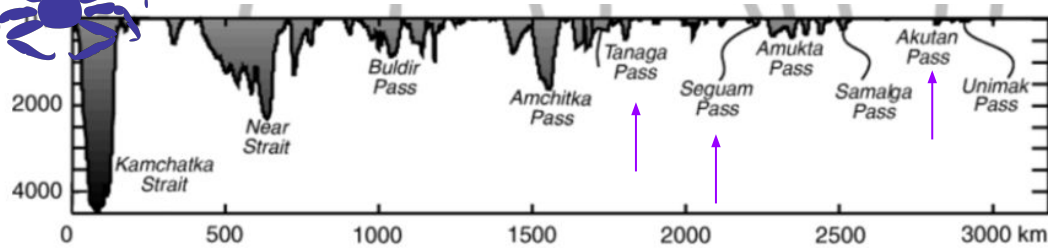
- MHWs moderate events in winter & summer

Marine Heatwave Index

Lemagie & Callahan



- TOP panel: number of days under MHW
- WAI in summer, CAI and EAI in winter
- Bottom panel: proportion of NMFS region under MHW
- MHWs more extensive in west, smaller towards east



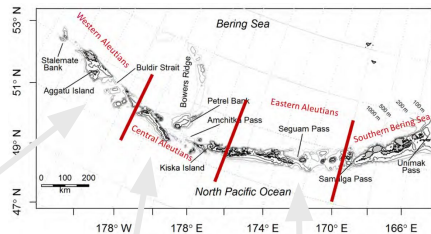
Bottom temperature O'Leary and Laman

Bottom temperature seasonality

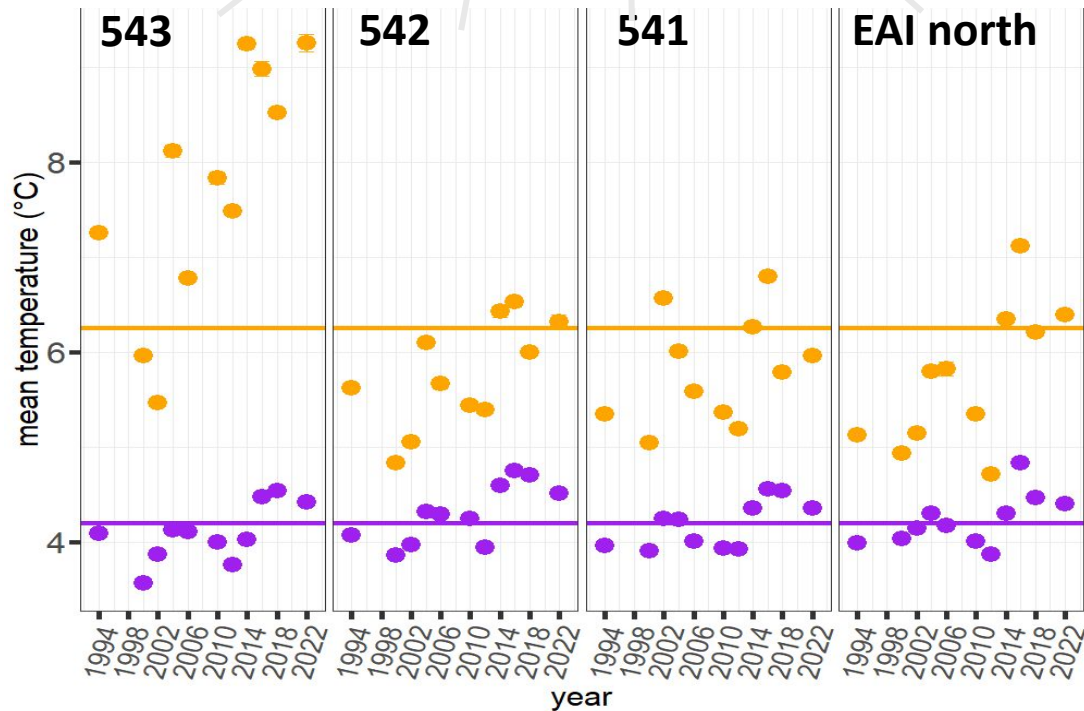
Top panel
depth profile of Aleutian passes:

shallower narrower towards east

- east: shallow and narrow
- west: deeper and wider
- warmest on WAI 543



Bottom temperature O'Leary and Laman

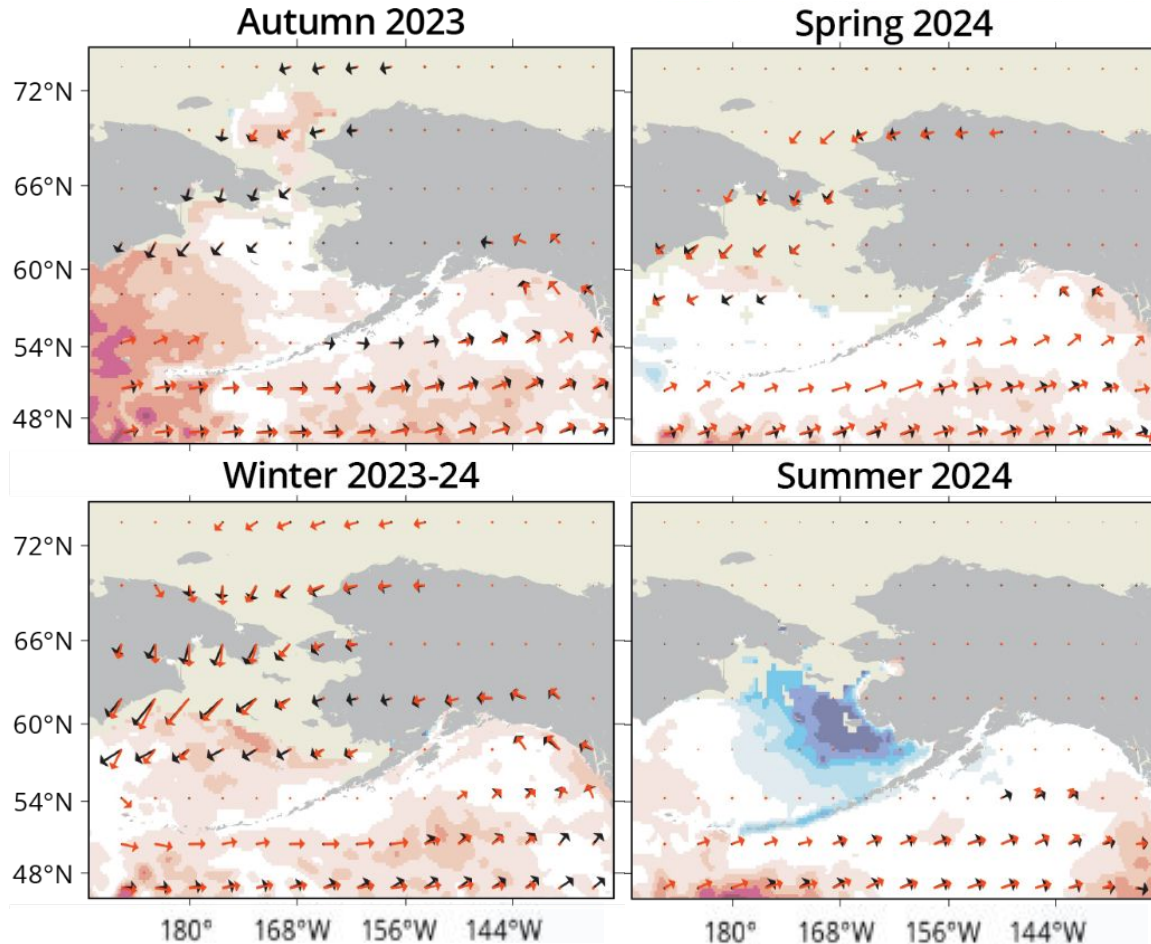


Bottom survey data

- Surface temperatures warming trend in summer
- warmest on WAI 543
- Bottom temperatures step change in 2014

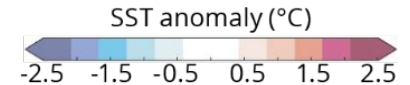


Winds Lemagie



- Dominant eastward winds south of the Aleutian Islands
- southward transport opposes mean currents over eastern Aleutian Islands

Seasonal Wind and SST Anomalies (1991-2020 Climatology)

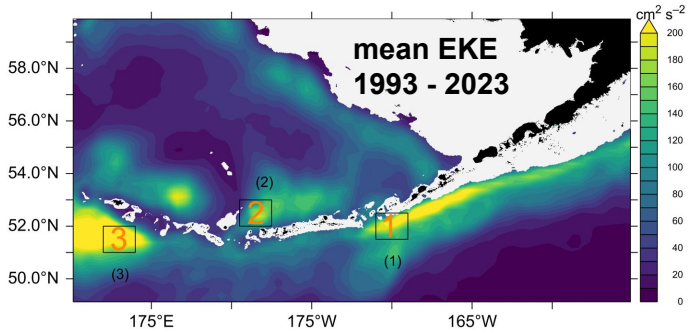


tan = max seasonal sea ice extent

~0	<3m/s	3m/s	>3m/s
.	.	—	—

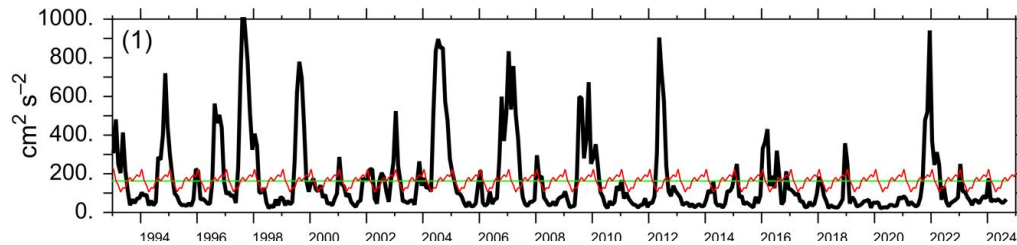
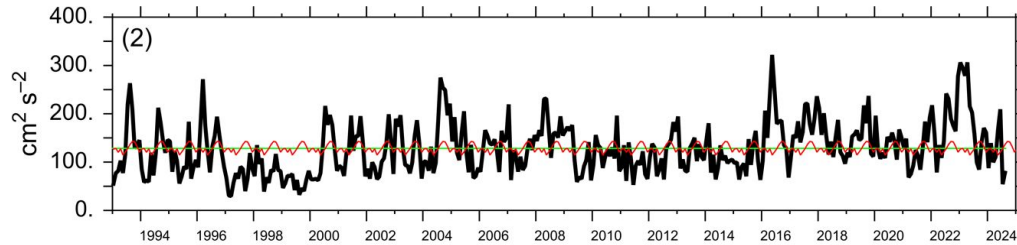
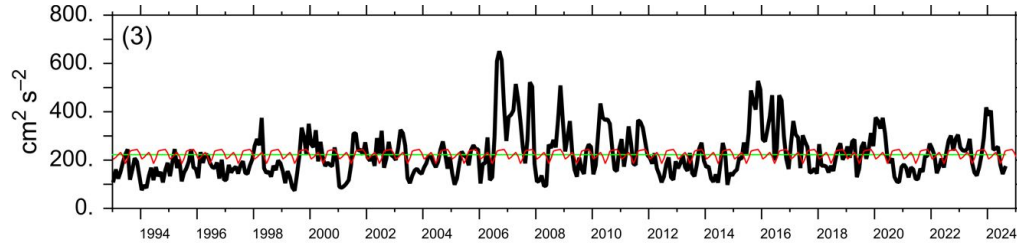
red dots/arrows = seasonal mean winds

black dots/arrows = climatology winds



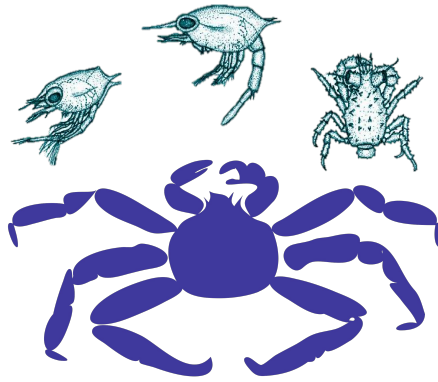
Eddy Kinetic Energy

Cheng



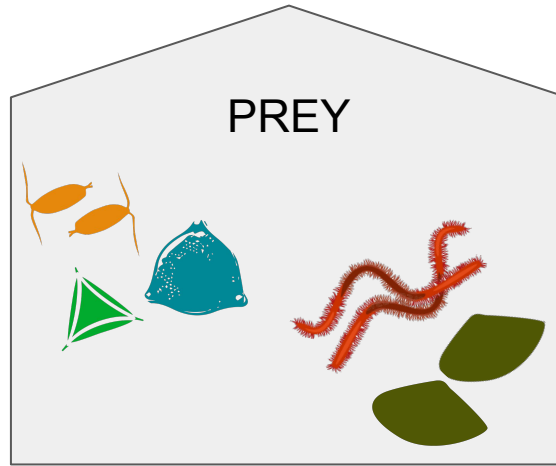
- EKE around or below long-term mean across chain
- average transport of heat, nutrients and salinity

- monthly EKE time series
- monthly climatology of EKE
- long-term (1993-2022) average of EKE



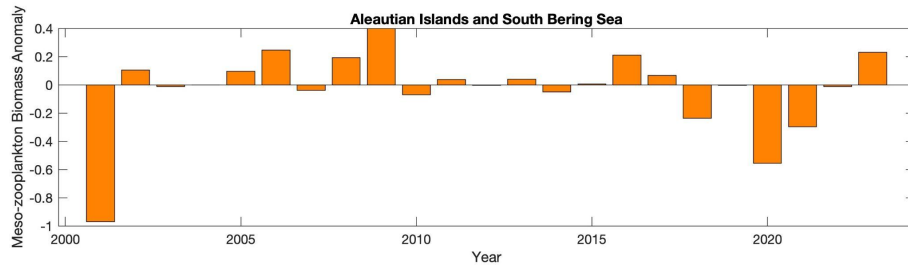
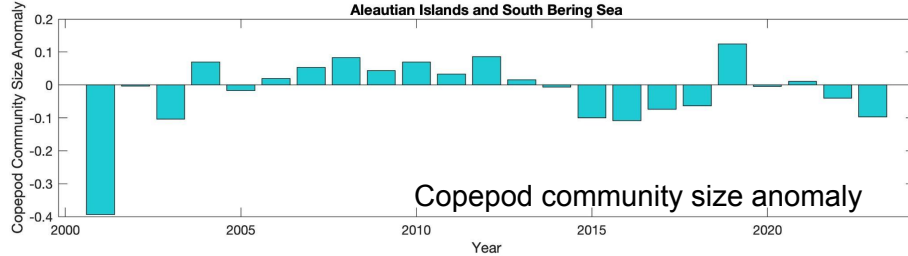
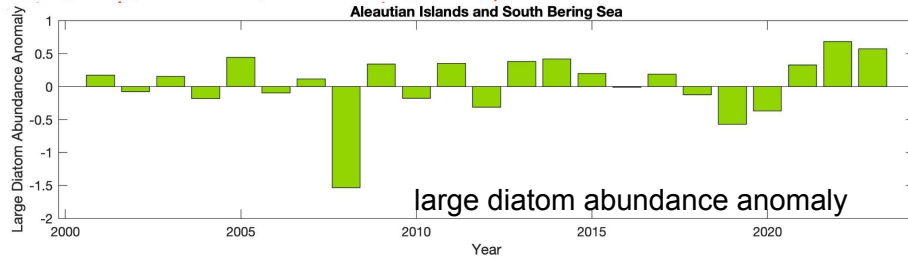
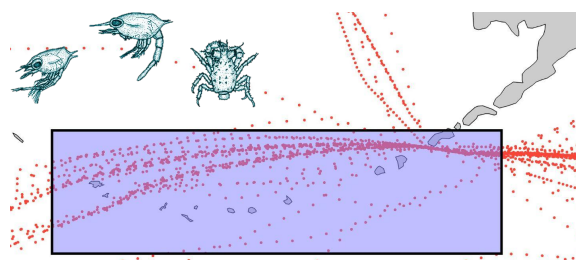
larvae do not feed, they have yolk sac

They do not need to synchronize hatch time with planktonic food availability but do need energy reserves to develop to the first crab stage (Long and Van Sant, 2015)



2023 Continuous Plankton Recorder

Ostle & Batten

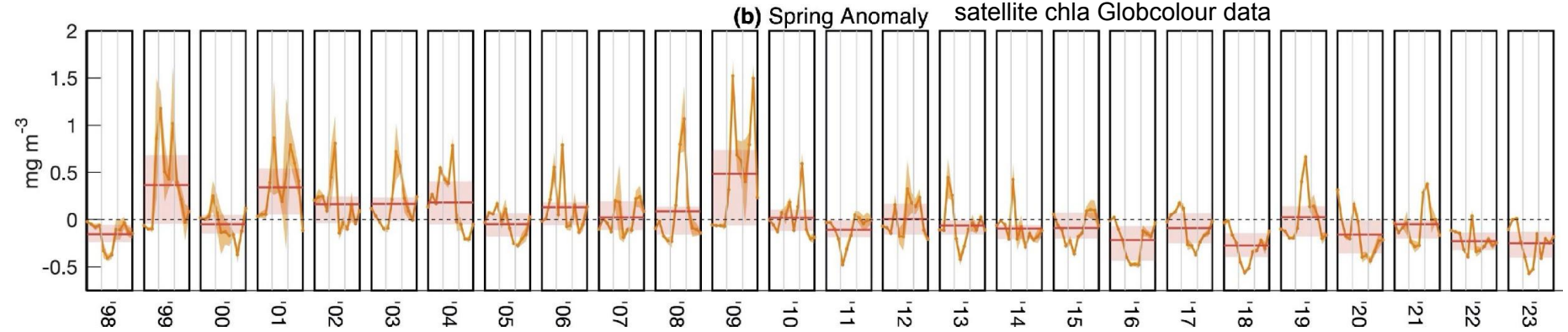


- Samples Apr-Sep crossing north to BS a Unimak Pass and south to NP west of Attu Is.
- The mean large diatom abundance was positive in 2023
- Copepod community size negative tendency may indicate true increase in abundance of smaller species of copepods
- Meso-zooplankton biomass was positive in 2023



2023 Spring Bloom

Pelland, Callahan

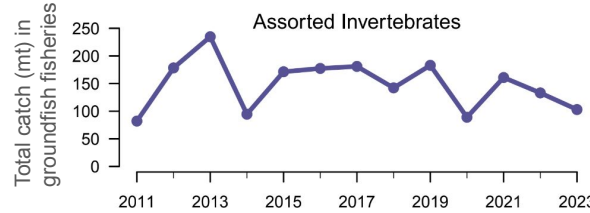
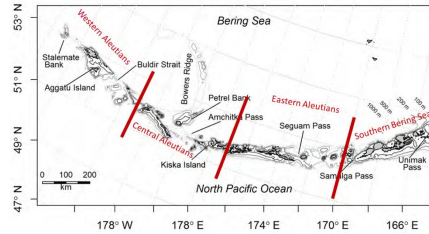


- Chl-a proxy for phytoplankton biomass
- 2023 was below the long term average (dashed black dots); mostly negative anomalies are evident since 2016
- A strongly above-average spring bloom has not been observed since 2009
- Biennial pattern might be influenced by eastern Kamchatka pink salmon

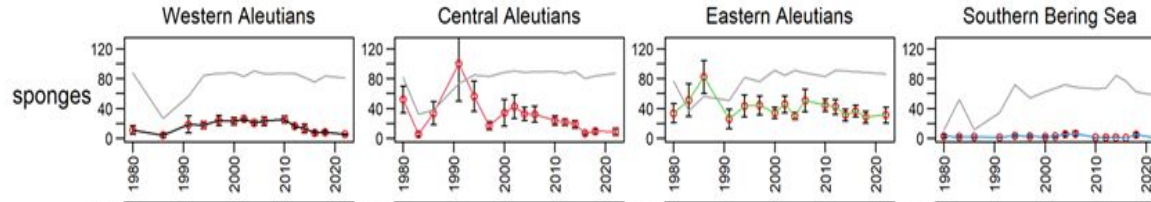


2022 Sponges, Echinoderms, 2023 Invertebrates

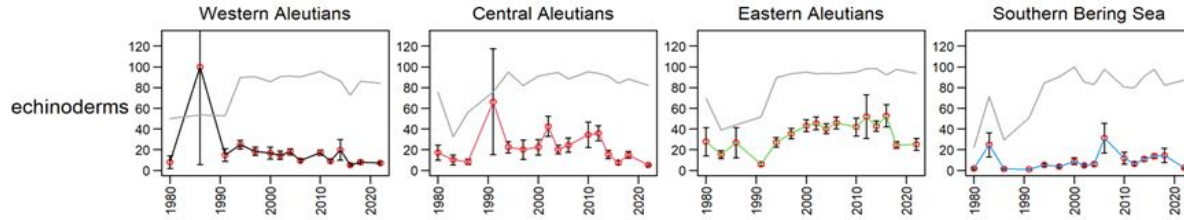
Laman and Whitehouse



- Groundfish fisheries: Assorted invertebrates (bivalves, brittle stars, sea stars)

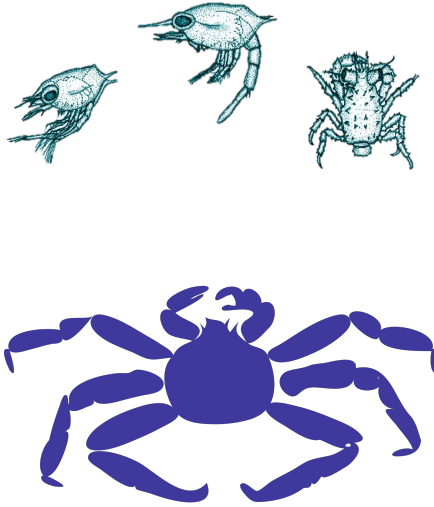
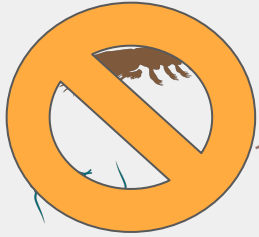


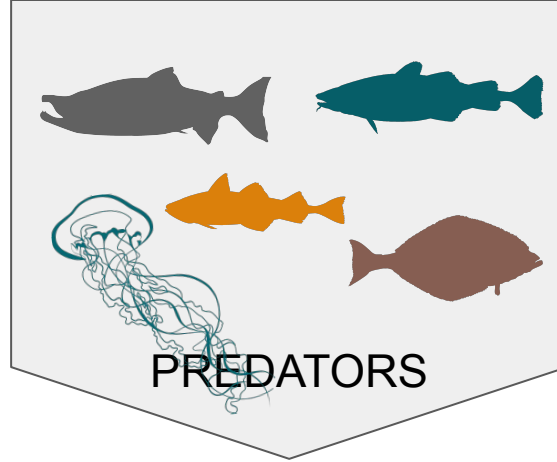
- Survey data: Higher abundances in Eastern and Central Aleutians



- decreasing trends in all time series might indicate true decrease

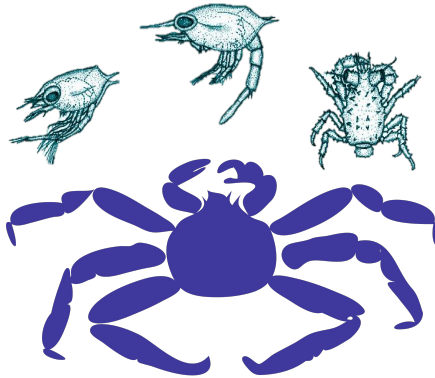
COMPETITORS





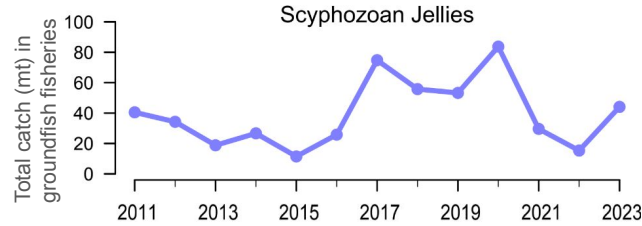
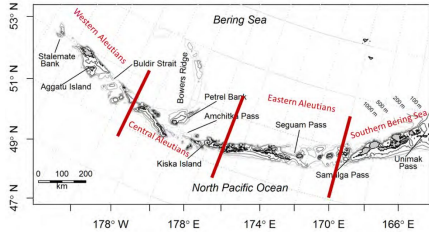
From foodlab database (golden king crab and/or king crab (genus only):

- Shortspine thornyheads
- Pacific cod
- Great sculpin
- Yellow Irish Lord
- Pacific halibut
- white blotched skate, walleye pollock, darkfin sculpin



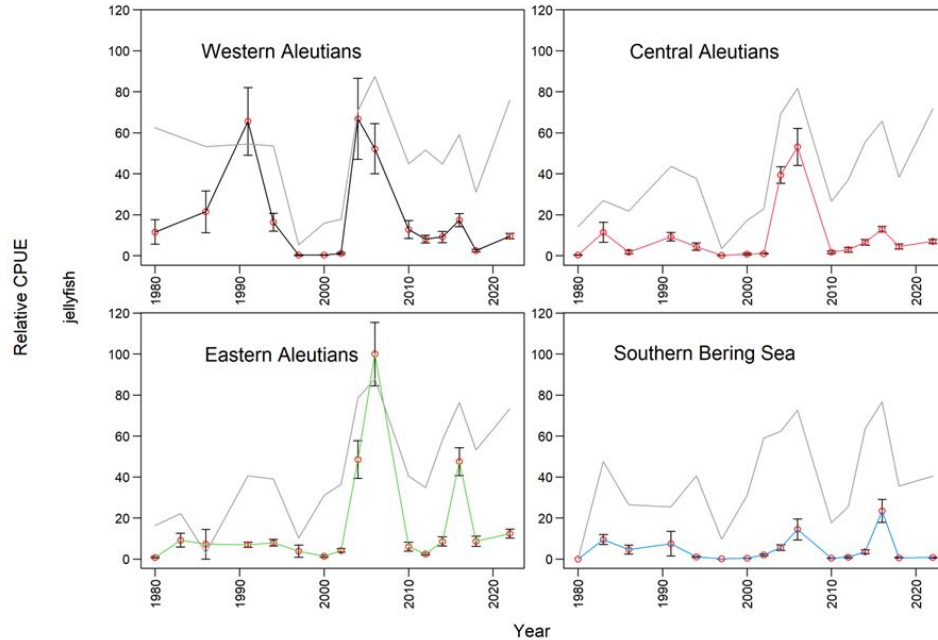


2022 & 2023 Jellyfish Laman and Whitehouse



- Groundfish fisheries: Scyphozoan Jellies increasing
- Survey data: Higher abundances east of Samalga Pass
- Trend uncertain

— percentage of non zero catches



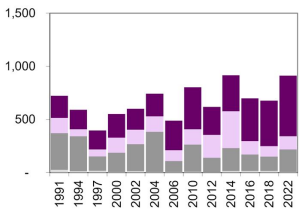


2022 Pelagic Foragers and Apex Predators

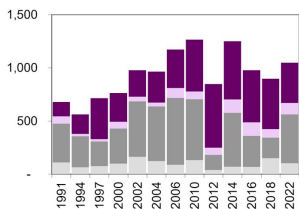
Ortiz

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

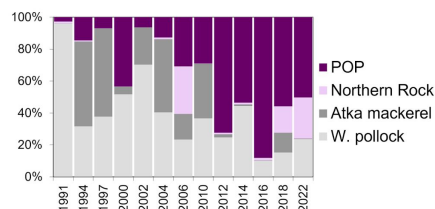
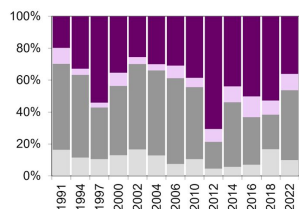
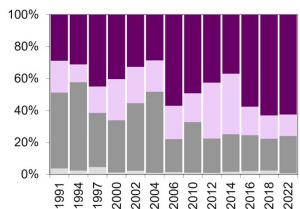
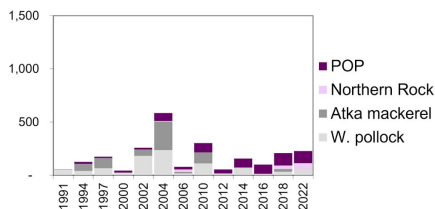
Pelagic Foragers: Western AI



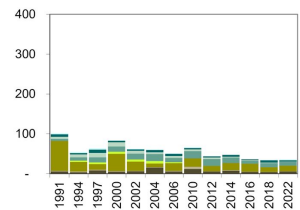
Central AI



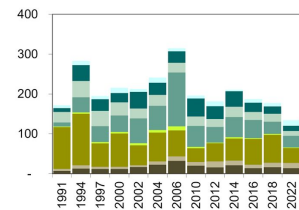
Eastern AI



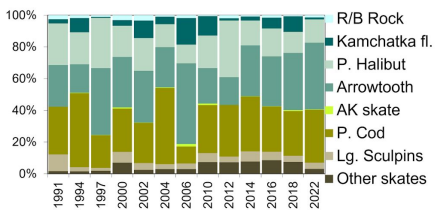
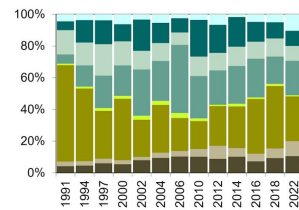
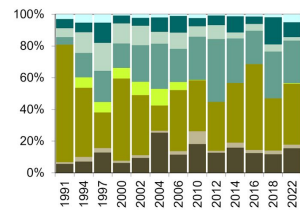
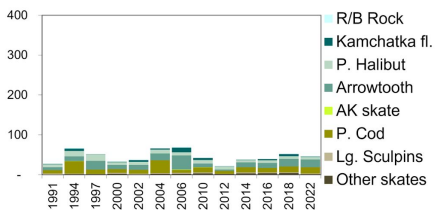
Apex Predators: Western AI



Central AI



Eastern AI

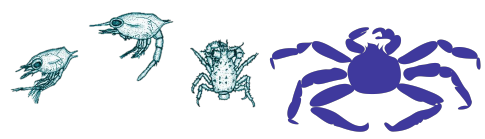


Pelagic Foragers Biomass

- Rockfish dominate
- Atka mackerel did increase in WAI-CAI
- Pollock increased in EAI

Apex Predator Biomass

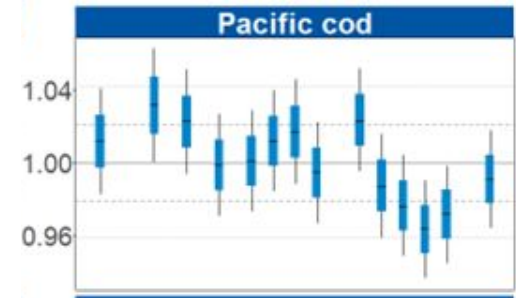
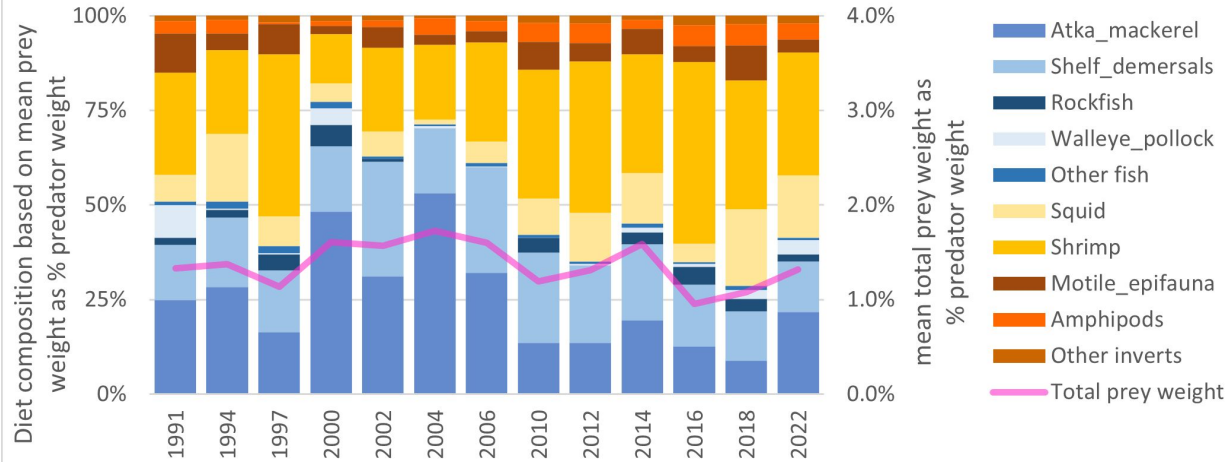
- Large flatfish, Pacific cod decreased
- Large sculpins increased



2022 Adult Pacific Cod Diet & Condition

Rohan & Prohaska, Aydin & Ortiz

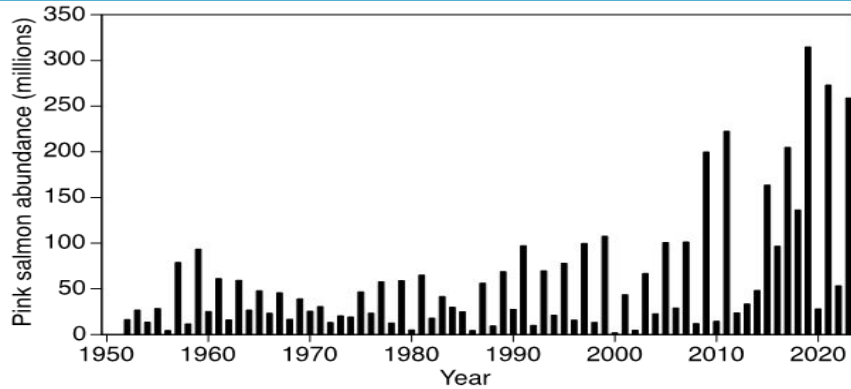
Pacific cod diets in AI areas NMFS 543, 542, 541



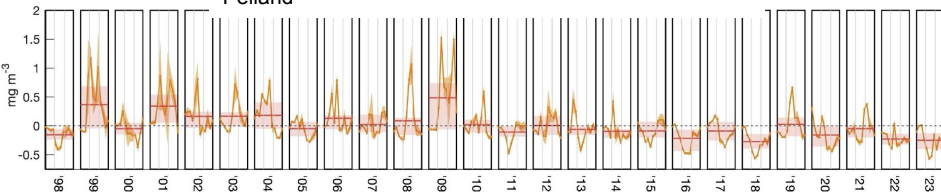
- Pacific cod diets: Apparently more invertebrates but really eating less fish (less Atka mackerel)
- Overall consuming less prey and lower fish condition
- Combined effect of higher bioenergetics due to warmer temperatures and/or lower availability of prey (lower prey abundance or higher competition)

Eastern Kamchatka pink salmon in odd years

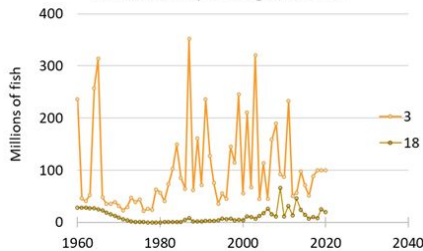
Multi-year patterns



Spring (Apr-Jun) satellite chla anomaly GlobColour, Pelland



Pacific Ocean perch Age 3 and 18

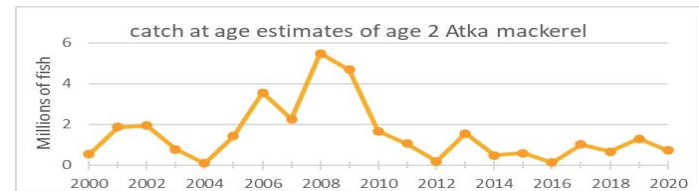
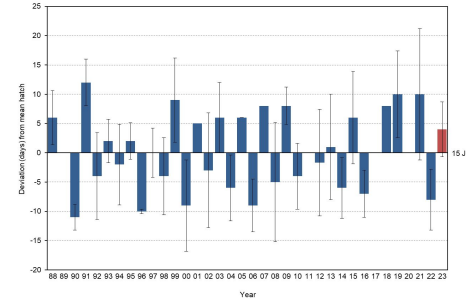


Spencer et al. 2020

Eastern Kamchatka pink salmon

- Continued high level for a low abundance year
- Biennial pattern at several trophic levels from diverse sources
- No statistical analysis has been conducted
- Potential thresholds: 2009 for high abundance years

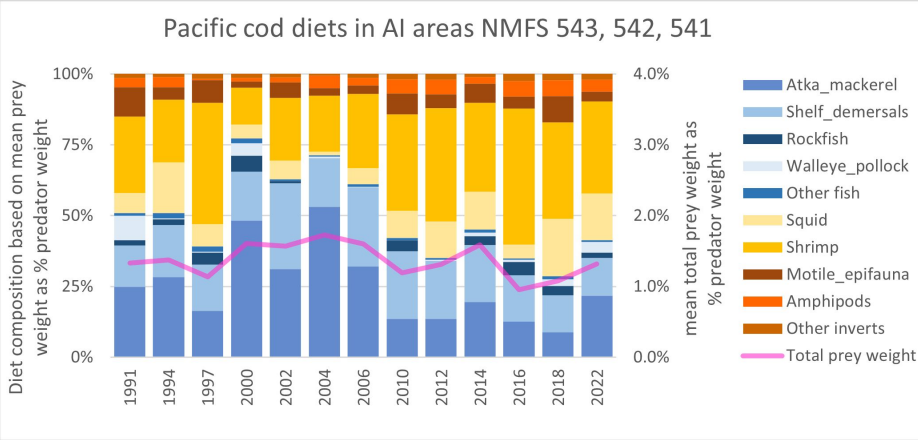
Tufted puffin hatch date anomaly at Buldir, Rokek et al.
no effect on reproductive success



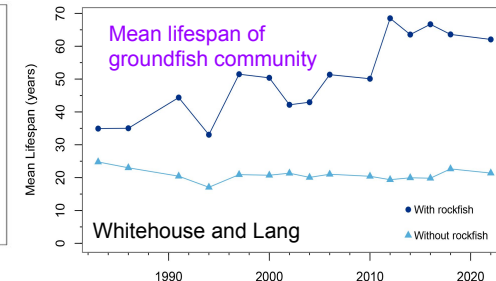
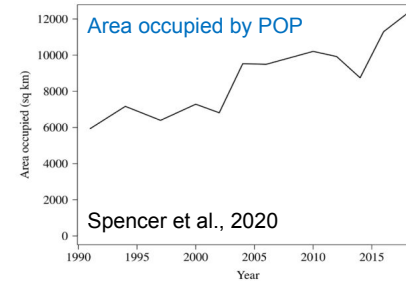
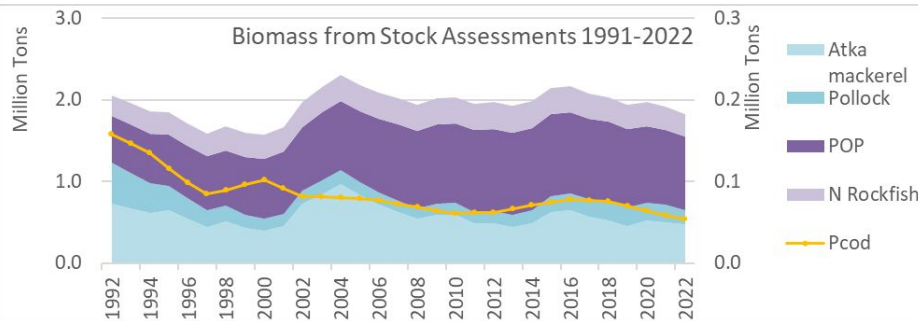
Lowe et al. 2021

POP and Northern Rockfish as main pelagic foragers

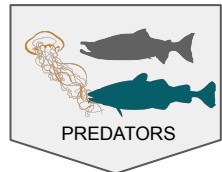
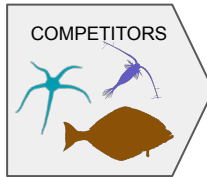
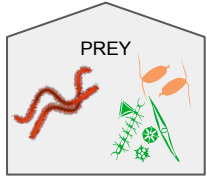
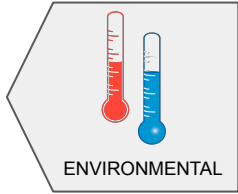
Multi-year patterns









- Increased competition with other fish feeding on zooplankton, changes in cod diet may be due to decreasing Atka mackerel
- POP expanding area occupied
- Longer mean lifespan of groundfish community (35 to 60 years) means a slower turnover rate & dampened effects of environmental variability (increased ecological stability)
- Spatial competition with Atka mackerel, pollock?



Summary



<ul style="list-style-type: none"> • El Niño to La Niña transition • SST cooled to average conditions • Consistent eastward winds would advect larvae in that direction 	<ul style="list-style-type: none"> • El Niño to La Niña transition • BT above long-term mean since 2014 
<ul style="list-style-type: none"> • Continued low chl-a biomass; • Higher small copepod abundance 	<ul style="list-style-type: none"> • <i>Potential decrease</i> of invertebrates 
<ul style="list-style-type: none"> • Unknown trend of jellies • 	<ul style="list-style-type: none"> • Lower biomass of Pacific cod • increased sculpins but low overall biomass • Higher abundance of rockfish that don't feed on golden king crab) 



Questions?

Feedback?