

Ecosystem Status Report:

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

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NPFMC Groundfish Plan Teams
September 20, 2021



Outline

1. Climate and oceanography (2021)

- North Pacific
- Bering Sea
- Aleutian Islands
- Gulf of Alaska

2. Sea surface temperature forecasts for North Pacific (2021/22)

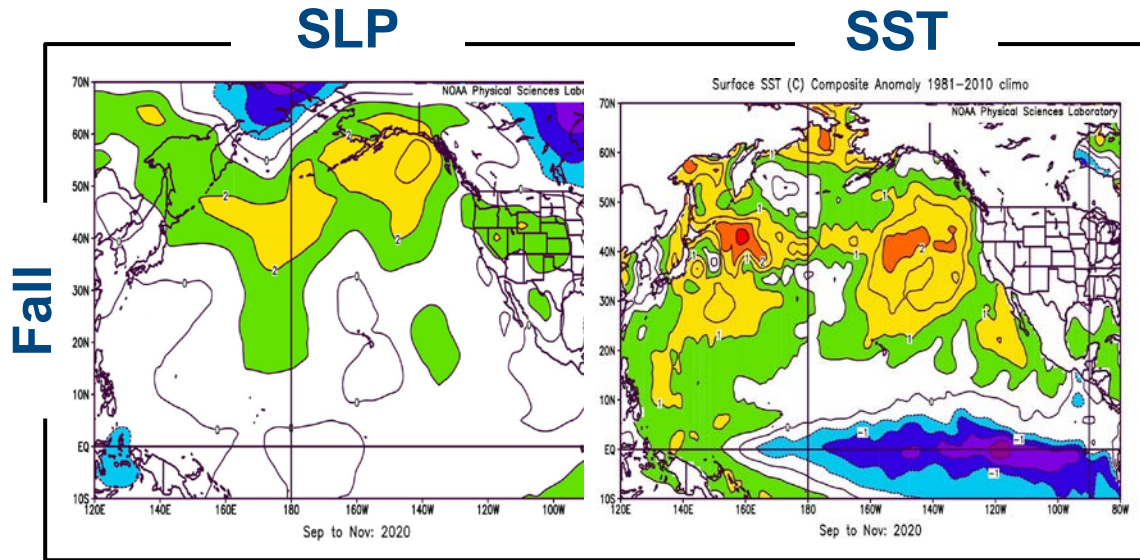


Fall (2020) & Winter (20/21) SLP & SST Anomalies

Bond

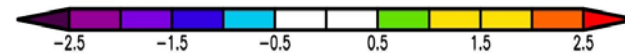
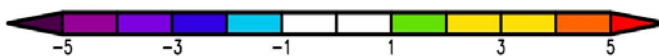
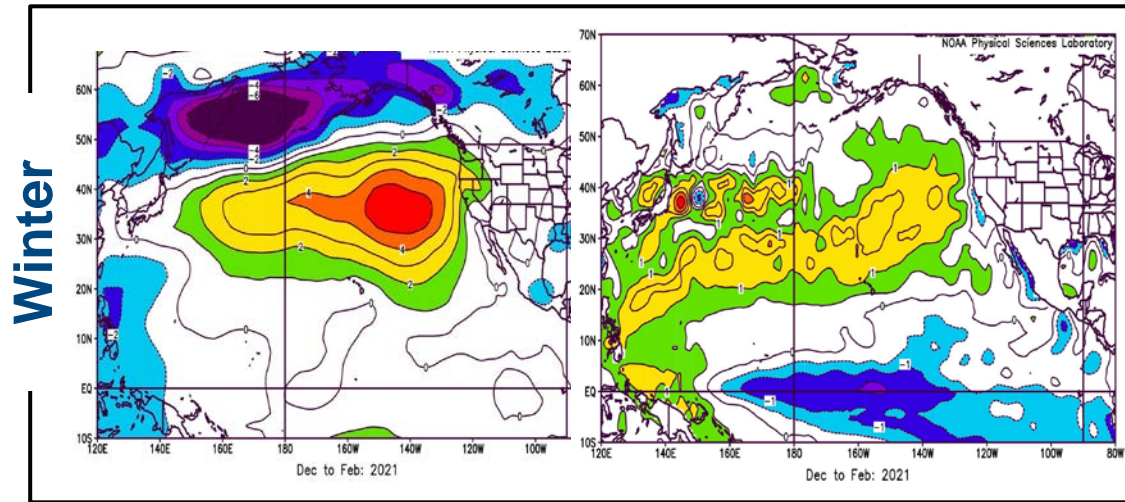
AI & GOA: Positive SLP;
EBS: Winds from the SW and suppressed storminess for the SEBS shelf and GOA

NE Pacific: Warm SST;
Gulf of Anadyr: Anomalies $> 2^\circ$;
 La Niña



SWBS: Negative SLP anomalies with low pressure across AK;
AI & GOA: Westerlies

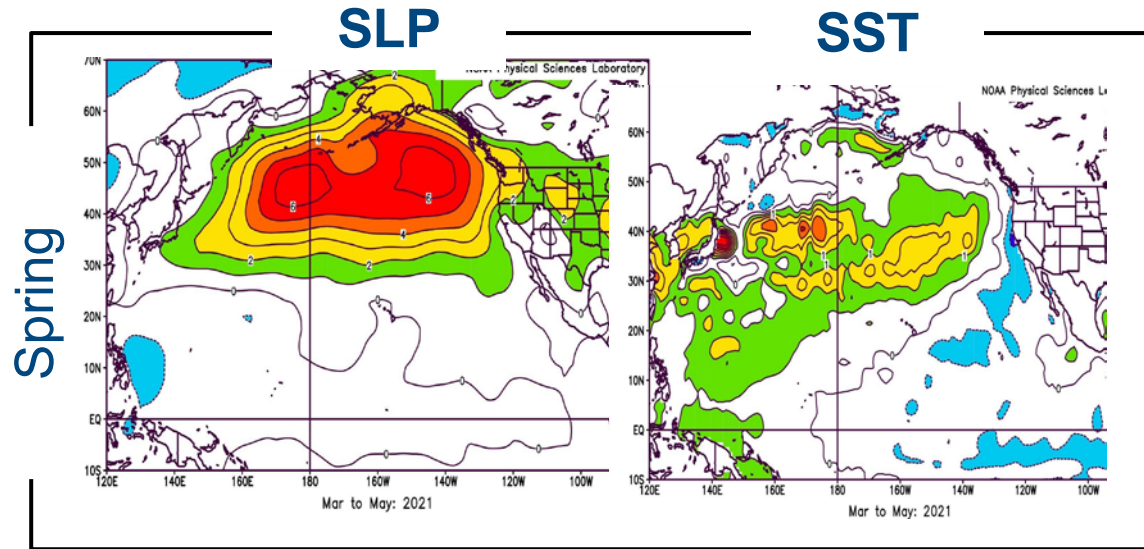
EBS & GOA: Minimal anomalies ($< 0.5^\circ\text{C}$) on the;
 La Niña



Spring (2021) & Summer (2021) SLP & SST Anomalies

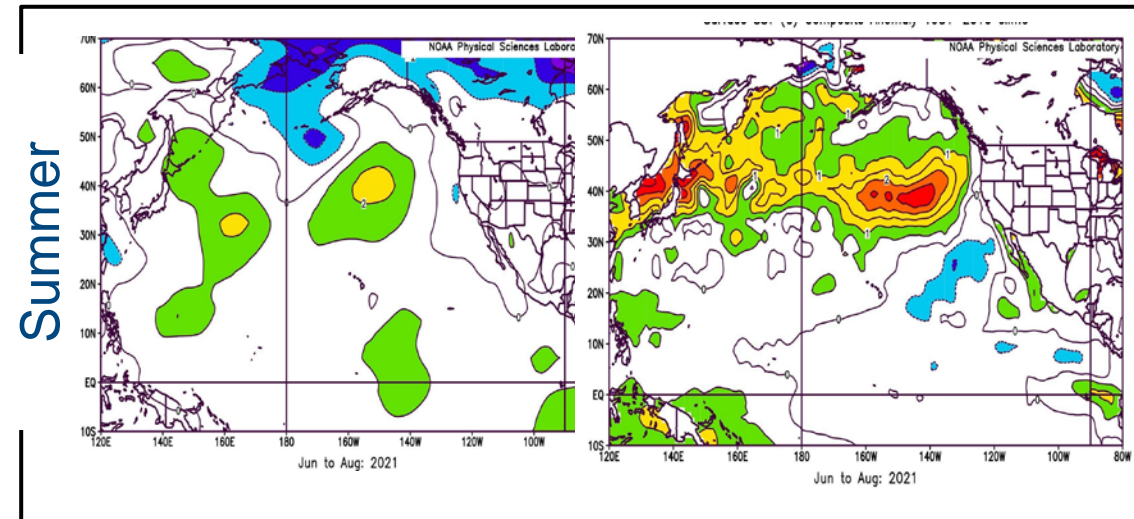
Bond

NE Pac:
Positive SLP
cont.;
EBS & GOA:
westerlies



SEBS: slight
incr. in warmth;
GOA: Minor cold
SST in lower
Cook Inlet

AK: Lower SLP;
NGOA & EGOA:
anticyclonic
(clockwise)
winds;
NBS, Chukchi
WAI: negative
SLP implies
enhanced storm
activity



Western AI:
positive anomalies
of $\sim 1^\circ\text{C}$;
SEBS: minor
warm SST
anomalies;
NGOA near
average

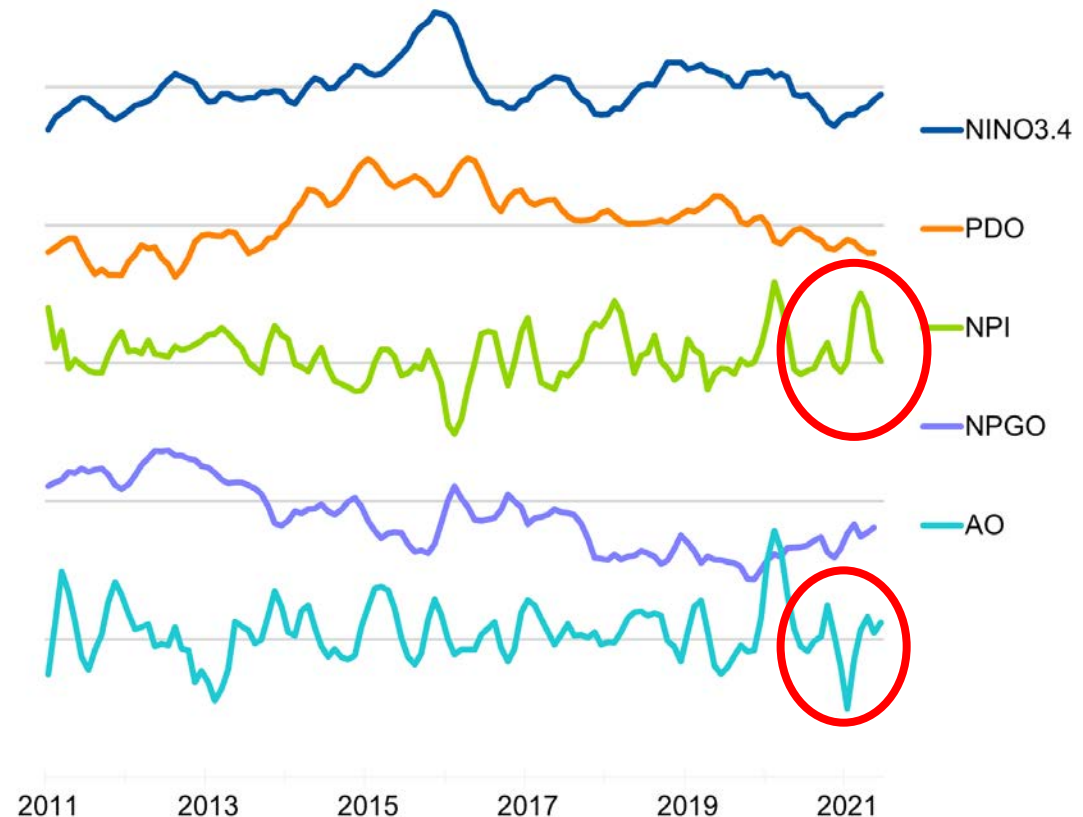


North Pacific Climate Indices

Bond

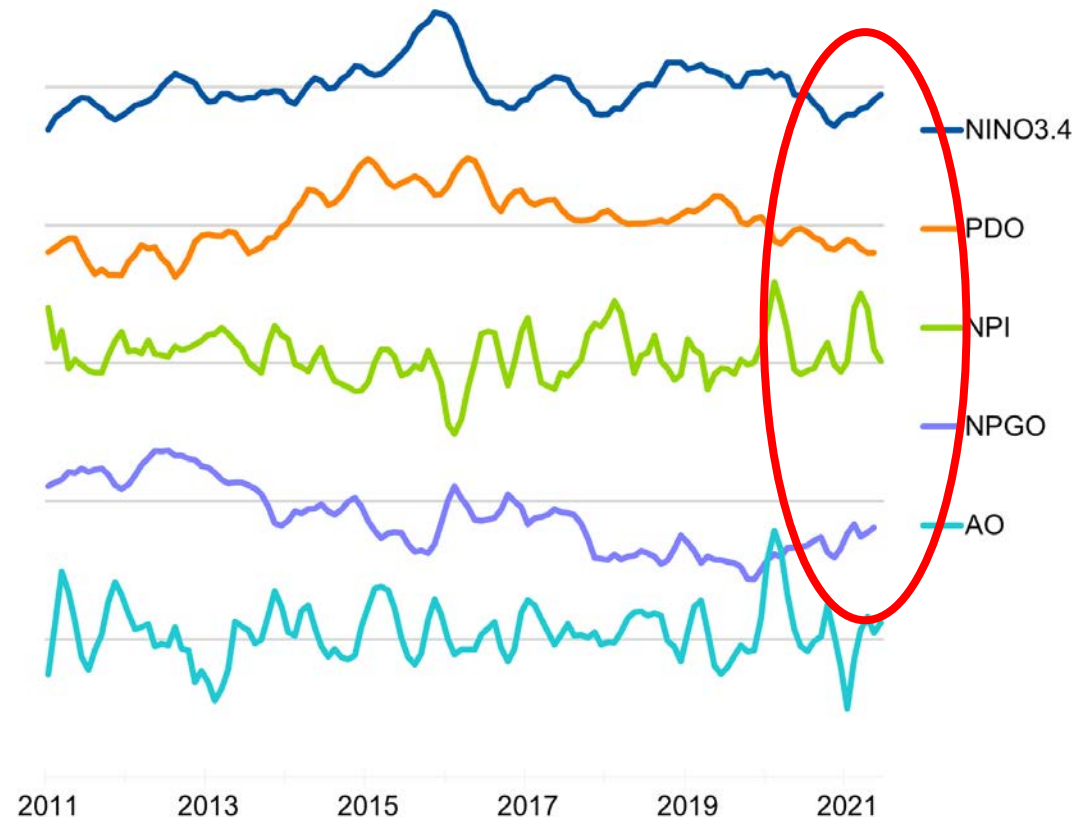
Bering Sea

- **NINO3.4** negative (La Niña) spring 2020-summer 2021
- **PDO** moderately negative state
- **NPI** strongly positive winter 20/21 (high AL); near-neutral in summer 2021
- **NPGO** negative but reduced intensity from 2020
- **AO** monthly variability; strongly positive early 2020 to negative winter 20/21 to positive spring & summer 2021

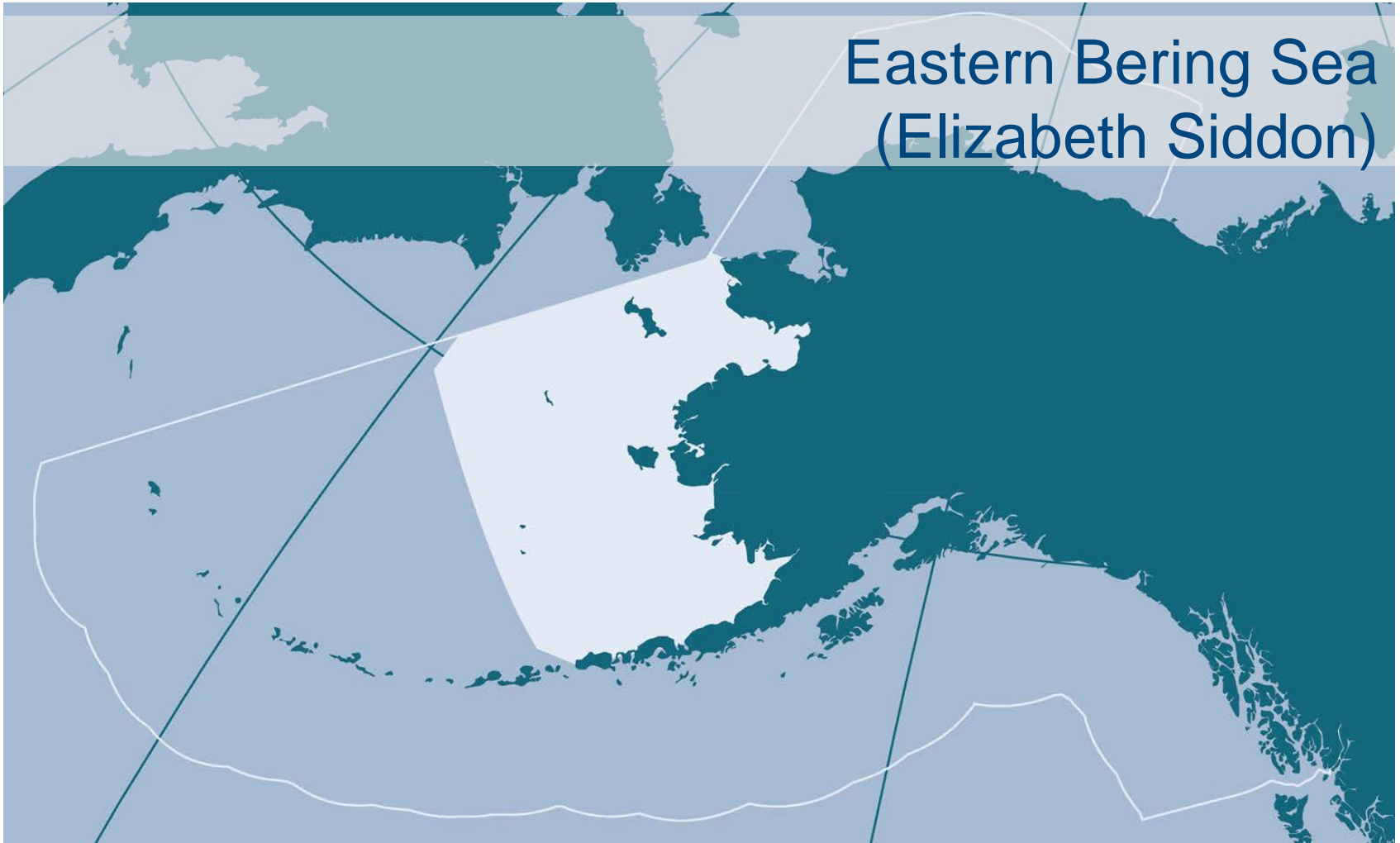


AI & GOA

- **NINO3.4** negative (La Niña) spring 2020-summer 2021
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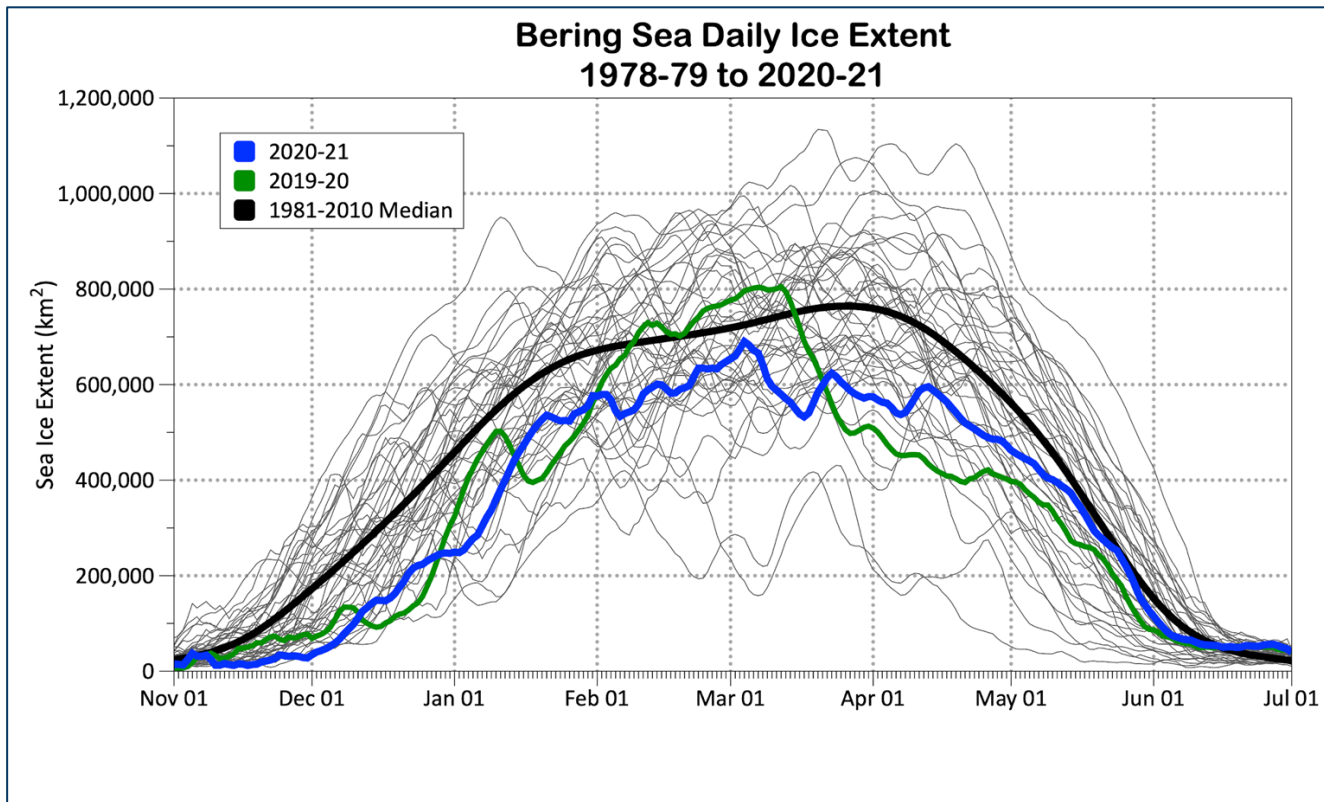


Eastern Bering Sea (Elizabeth Siddon)



Bering Sea Ice Extent

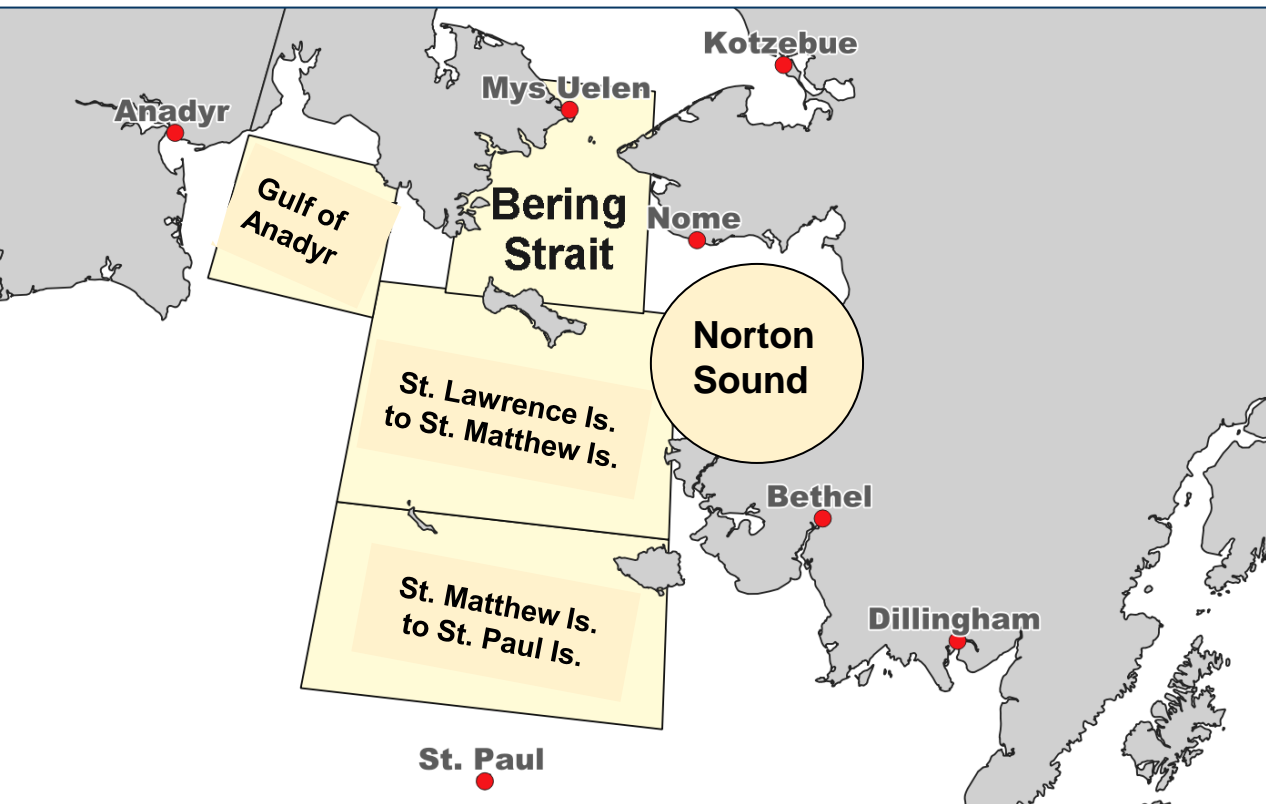
Thoman



- Residual warmth delayed freeze-up into winter.
- Cooling in late winter resulted in a rapid build-up of sea ice.
- Ice advance stalled at end of January.
- Ice was steady from February through early April.

Bering Sea Ice Thickness

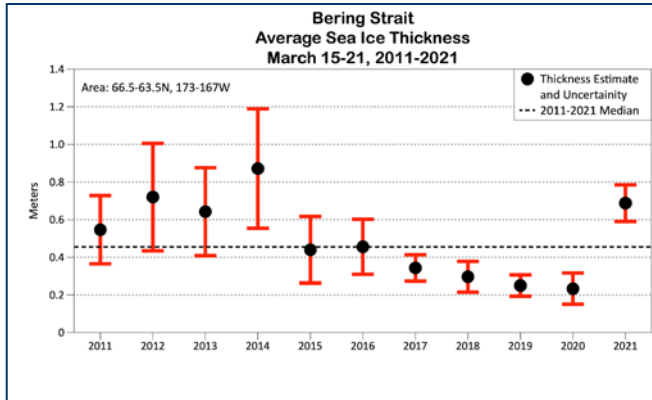
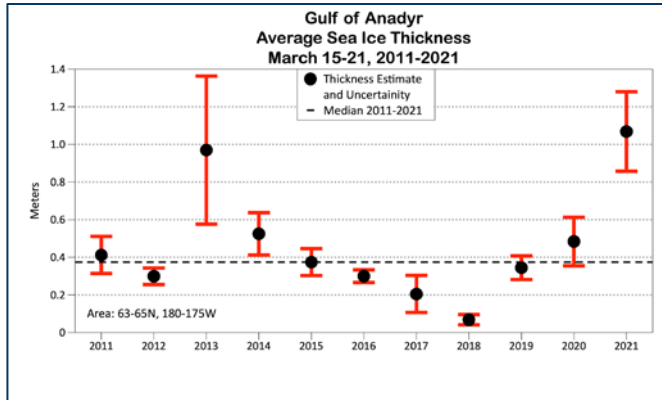
Thoman



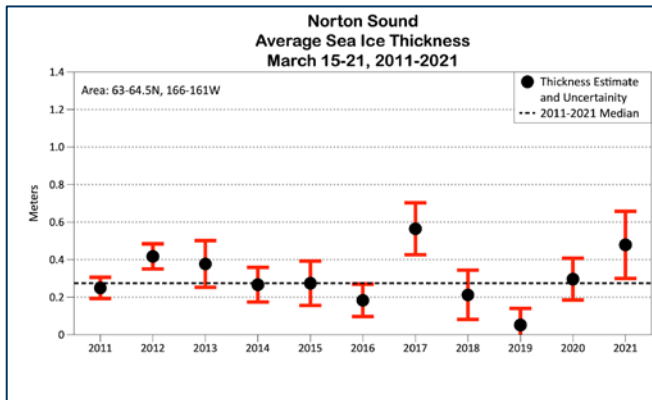
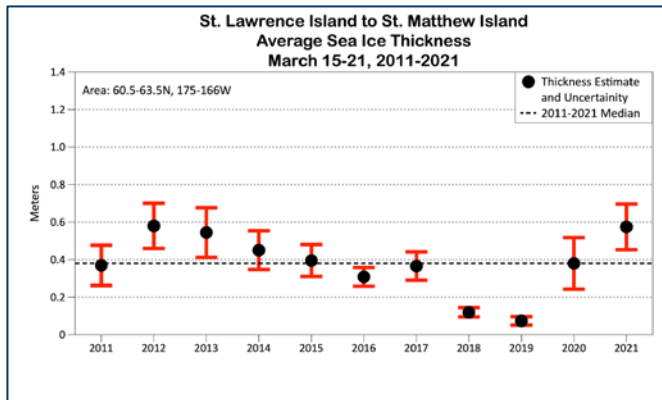
- 3rd week of March.
- Ice thickness is related to duration or residency of ice over the shelf.
- Abundance of ice-associated algae correlated to ice duration?

Bering Sea Ice Thickness

Thoman

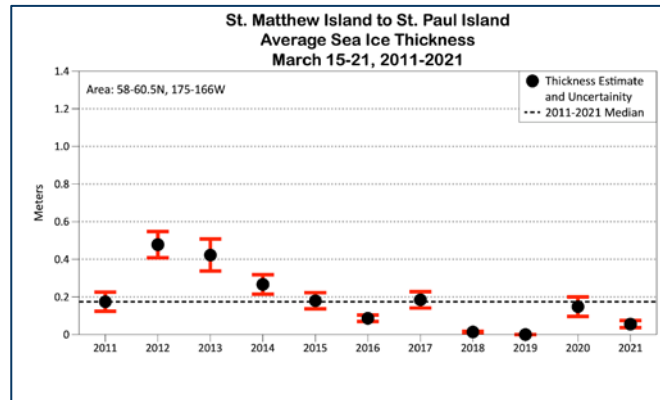
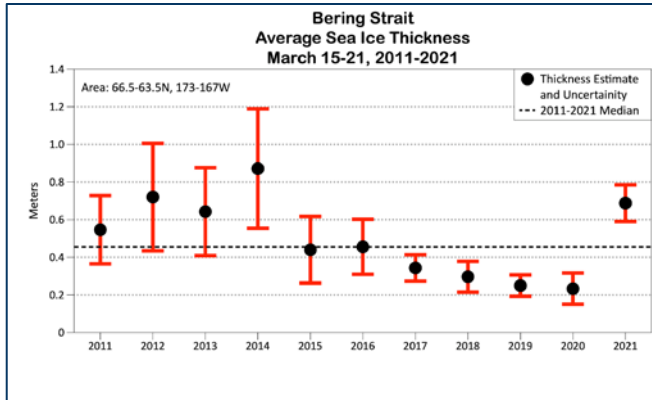
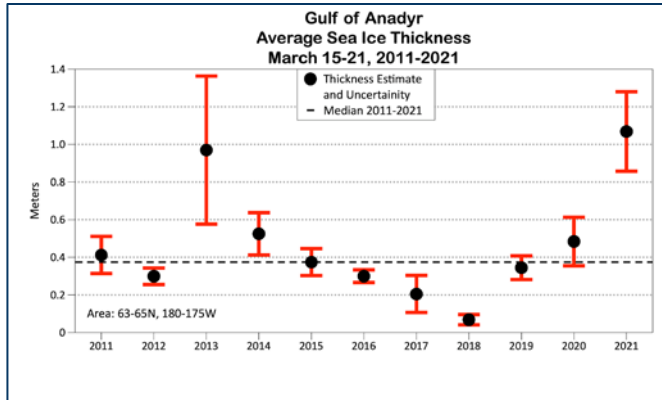


- Northern and western areas: ice thickness increased in 2021.



Bering Sea Ice Thickness

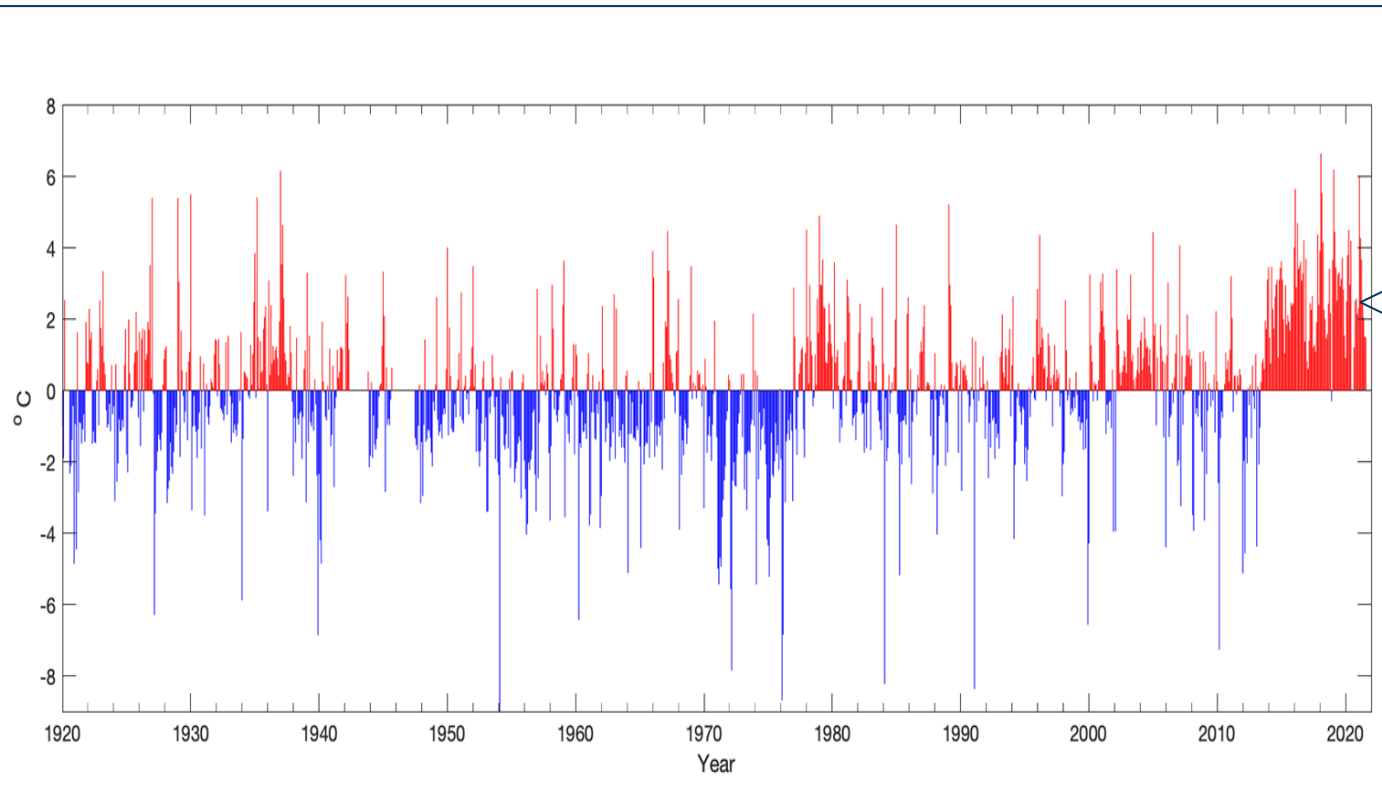
Thoman



- Northern and western areas: ice thickness increased in 2021.
- South of St. Matthew: ice thickness remained very low in 2021.
- Unusual weather pattern in Jan-Mar allowed ice in NBS to thicken, but prevented ice from moving south.

St. Paul Air Temperature Anomalies

Wang



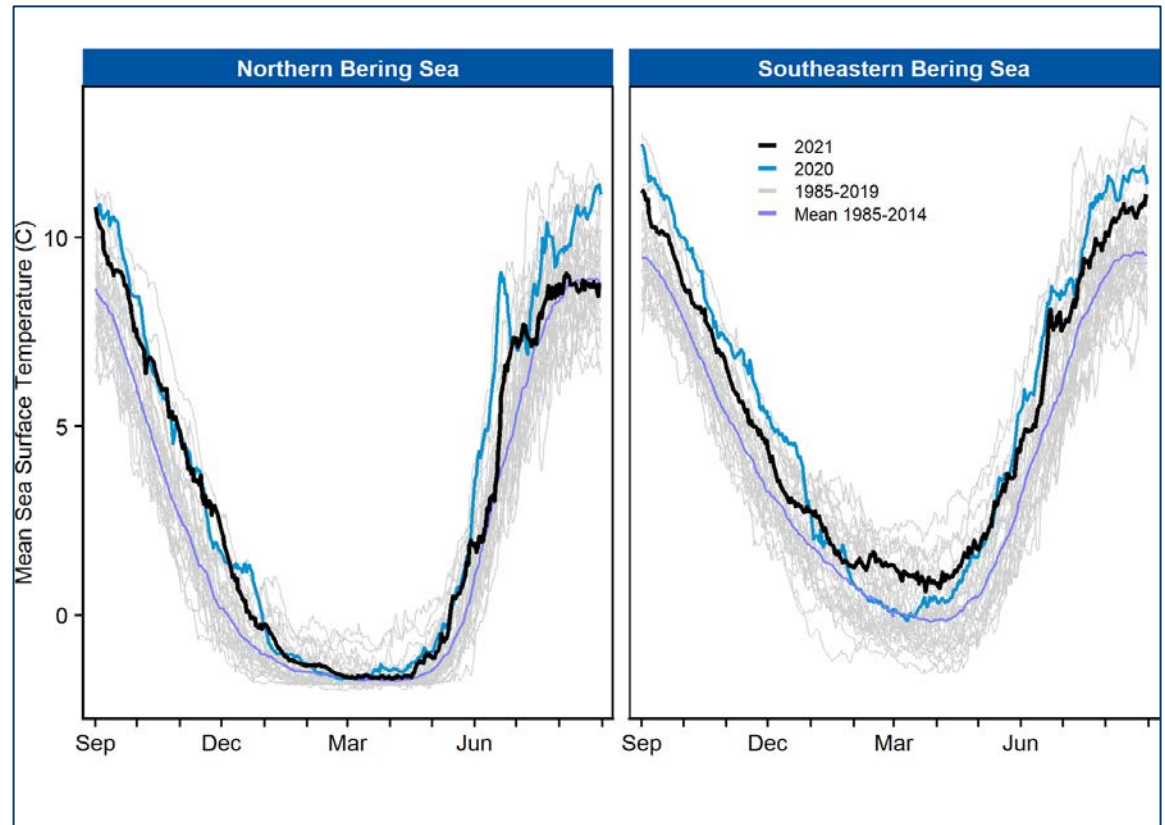
Increased duration and magnitude of current warm period.

“Is the Bering Sea more vulnerable to continued change with thinner and less sea ice?” - Jim Overland

EBS Sea Surface Temperature

Watson

- Both regions continued to experience SSTs warmer than baseline (1985-2014).

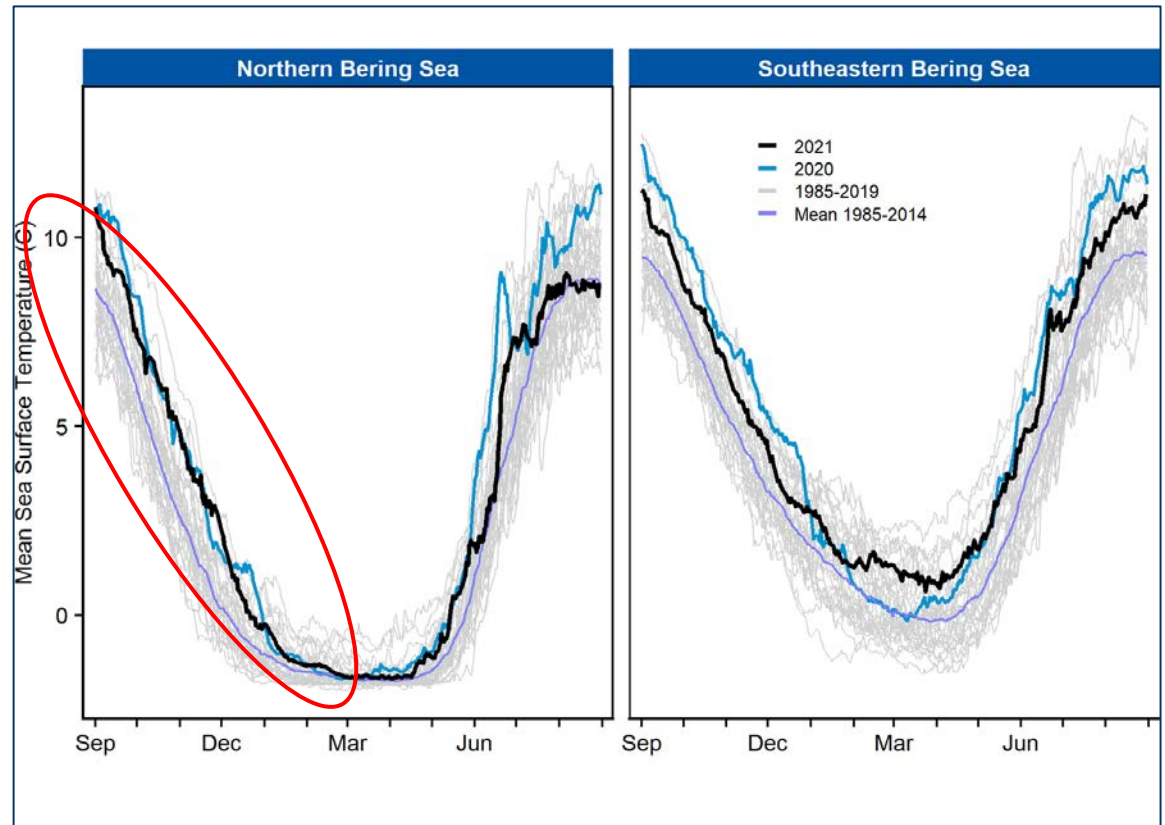


North of 60°N ← → South of 60°N

EBS Sea Surface Temperature

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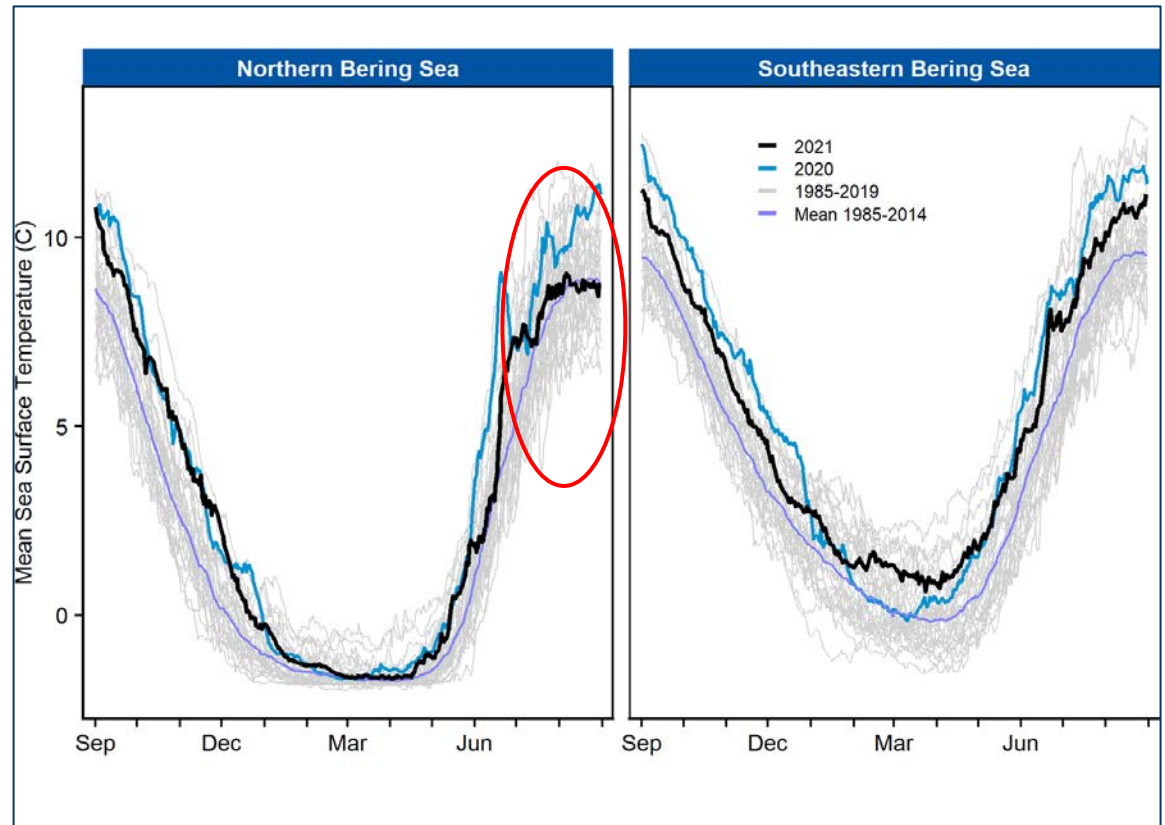


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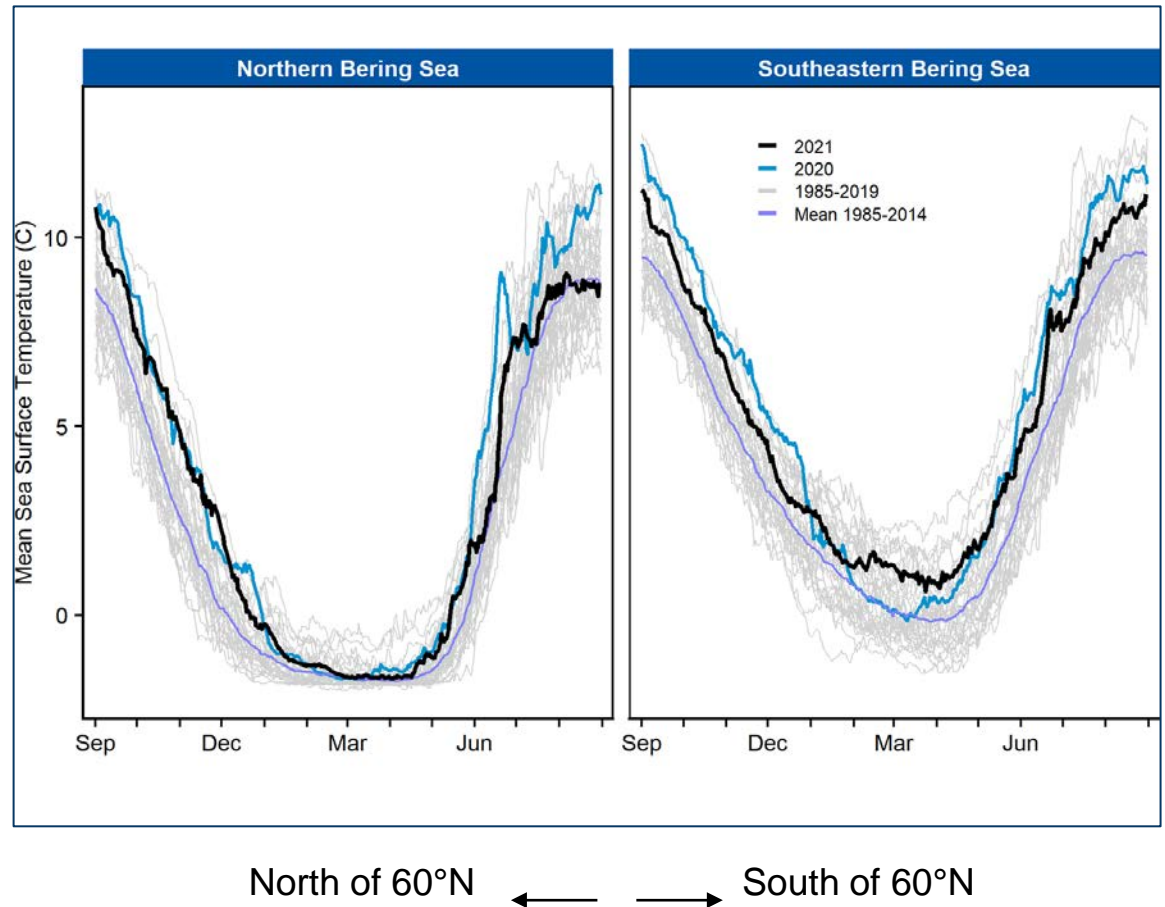


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EBS Sea Surface Temperature

Watson

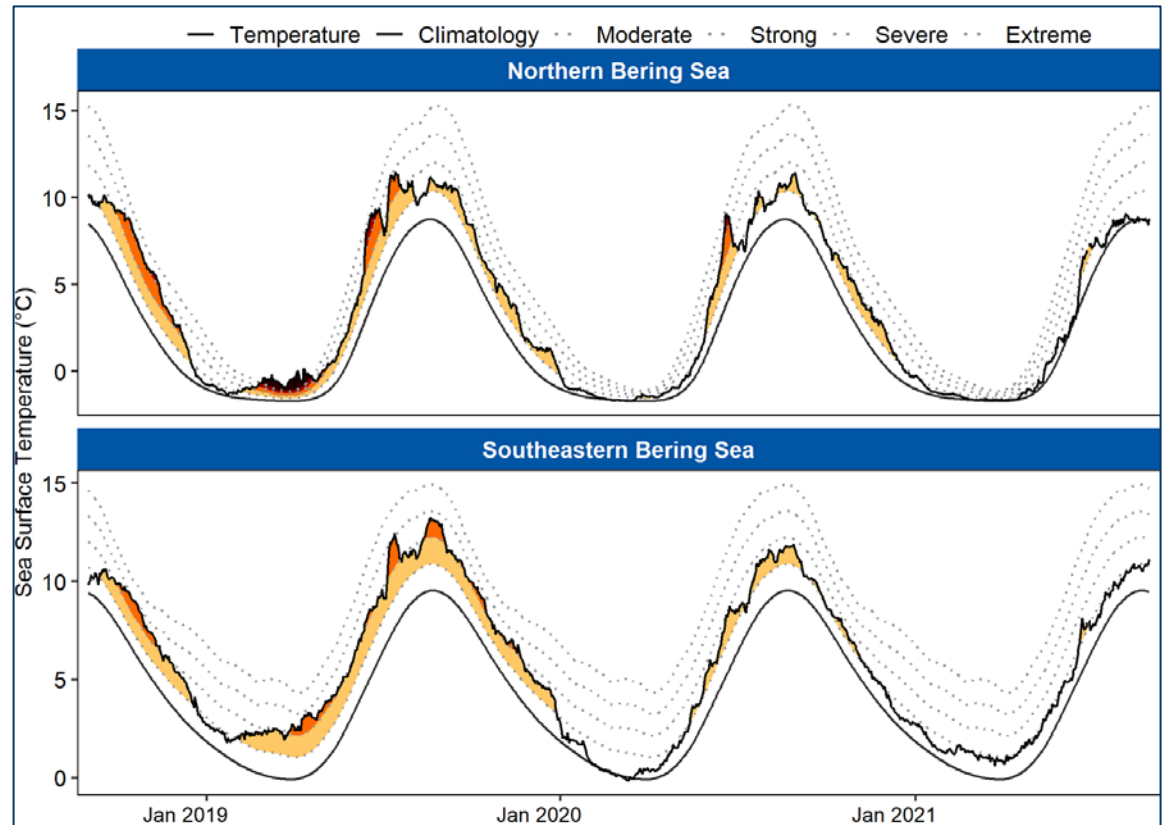
- Both regions continued to experience SSTs warmer than baseline (1985-2014).
- NBS: fall and winter similar to previous year; summer 2021 has been cooler.
- SEBS: generally cooler than previous year.



EBS Marine Heatwave Index

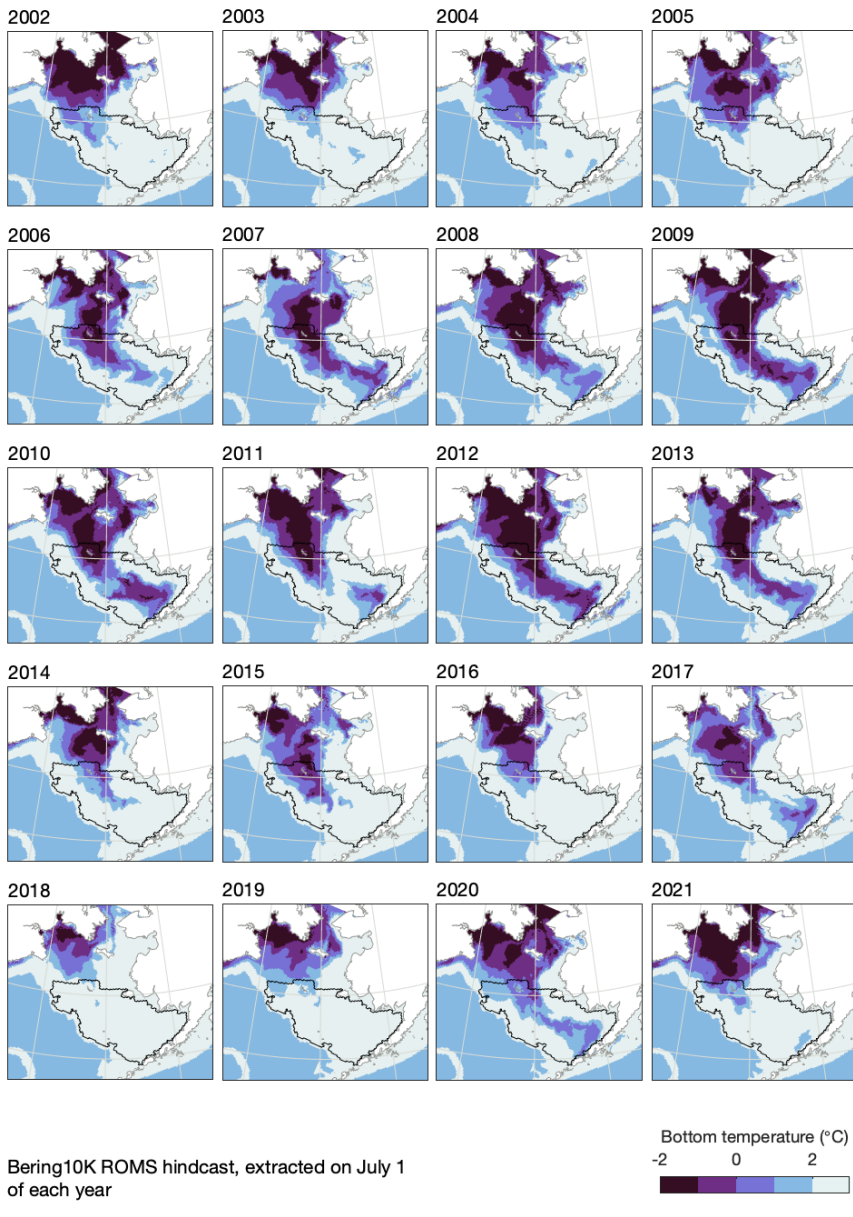
Watson

- MHWs have been minor compared to recent years; not triggered as often or as severely during 2021.
- However, temperatures hovered just below the threshold, yielding cumulatively warm SST conditions.



EBS Bottom Temperatures and Cold Pool Extent

Kearney



- 2021 was a warm year, but not excessively warm.
- 2021 cold pool extent is similar to previous warm years of 2002-2005.

EBS Climate & Oceanography

Sea ice



- Ice extent remained below the median the entire season
- Stable ice in NBS allowed for thicker ice compared to SEBS

Stable ice in NBS impacts stratification and production of ice algae

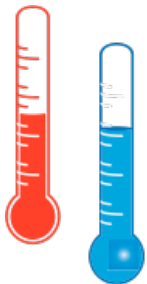
Sea Surface Temperature (SST)



- Both SEBS and NBS had warm SSTs
- SSTs cooled in the NBS; SEBS cooler than 2020, but currently in MHW

Protracted warming impacts metabolism, growth rates, and prey demands.

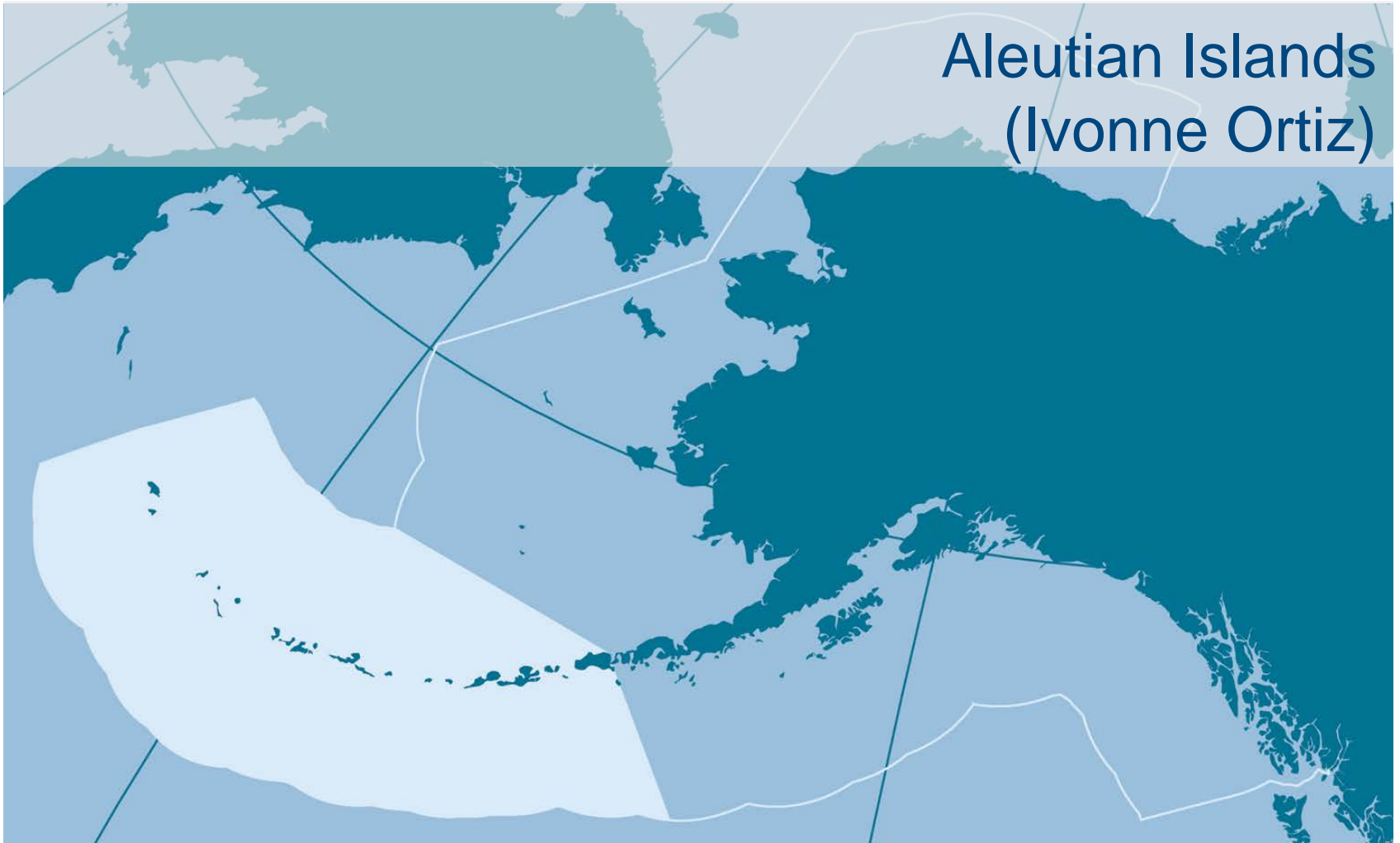
Cold pool



- 2021 cold pool extent is similar to previous warm years of 2002-2005

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

Aleutian Islands (Ivonne Ortiz)

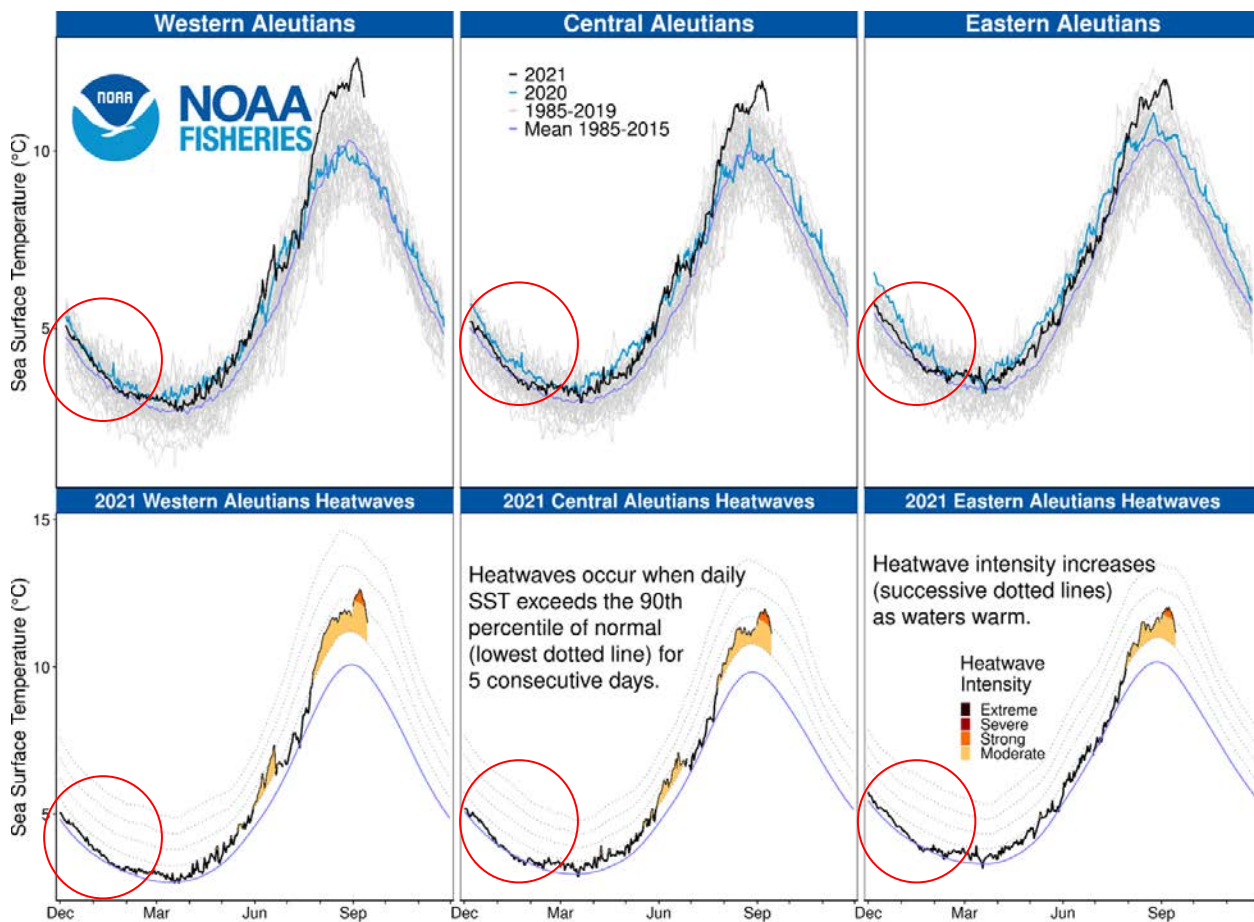


SST and Marine Heatwaves

Jordan and Callahan

Winter (Dec-Feb)

- SST slightly above average
- No MHW
- Stormy (good mixing)
- Mean wind anomalies associated with suppressed northward flow through Unimak Pass



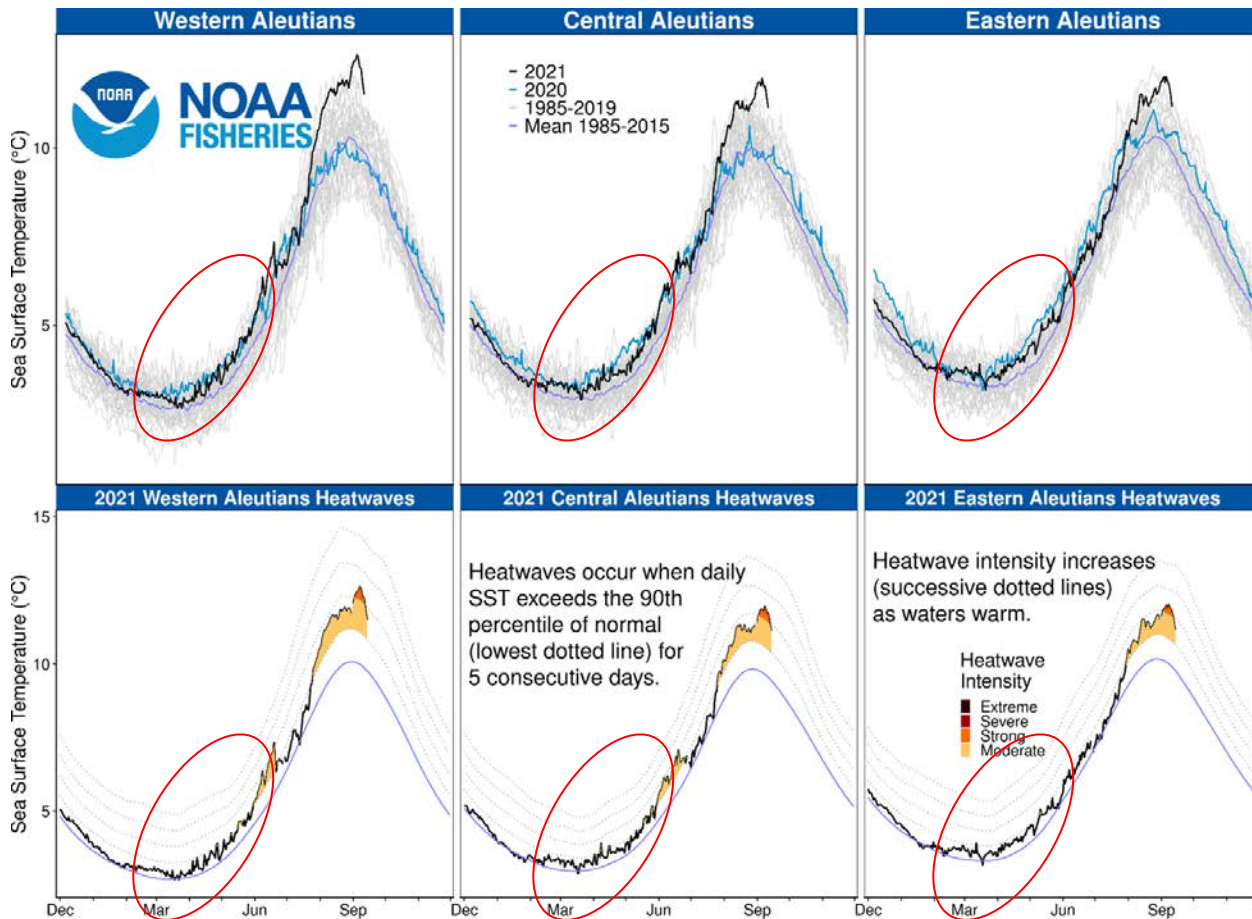
NOAA Coral Reef Watch data, courtesy NOAA Pacific Islands Ocean Observing System (Updated: 09-14-2021)
Data are modeled satellite products and periodic discrepancies or gaps may exist across sensors and products.
Contact: Jordan.Watson@noaa.gov, Alaska Fisheries Science Center

SST and Marine Heatwaves

Jordan and Callahan

Spring (Mar-May)

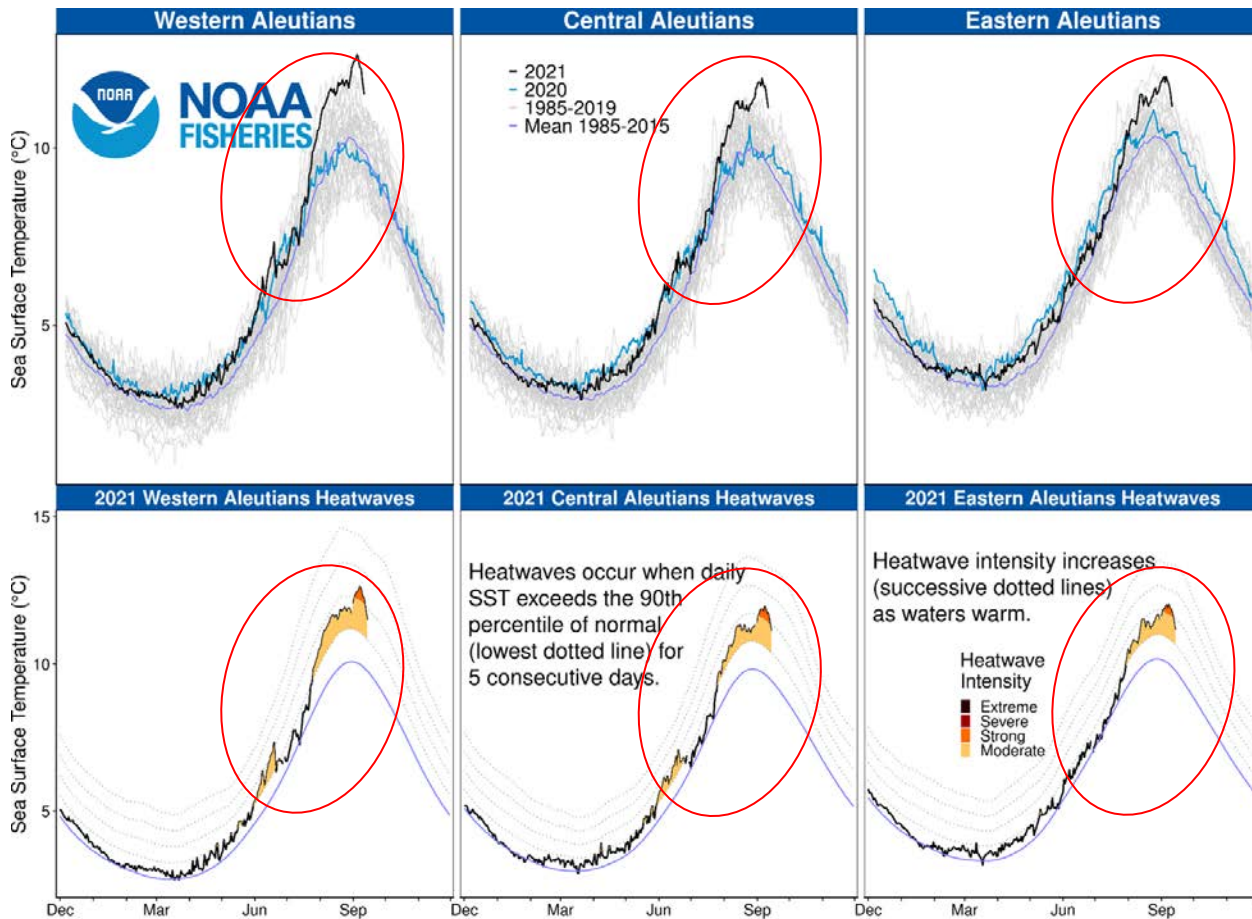
- SST slightly above average
- Relatively calm period in spring
- No MHW



NOAA Coral Reef Watch data, courtesy NOAA Pacific Islands Ocean Observing System (Updated: 09-14-2021)
Data are modeled satellite products and periodic discrepancies or gaps may exist across sensors and products.
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SST and Marine Heatwaves

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Summer

- Warming seen in SST map shows up in time series
- Moderate short MHW in June in WAI and CAI, Aug, all AI

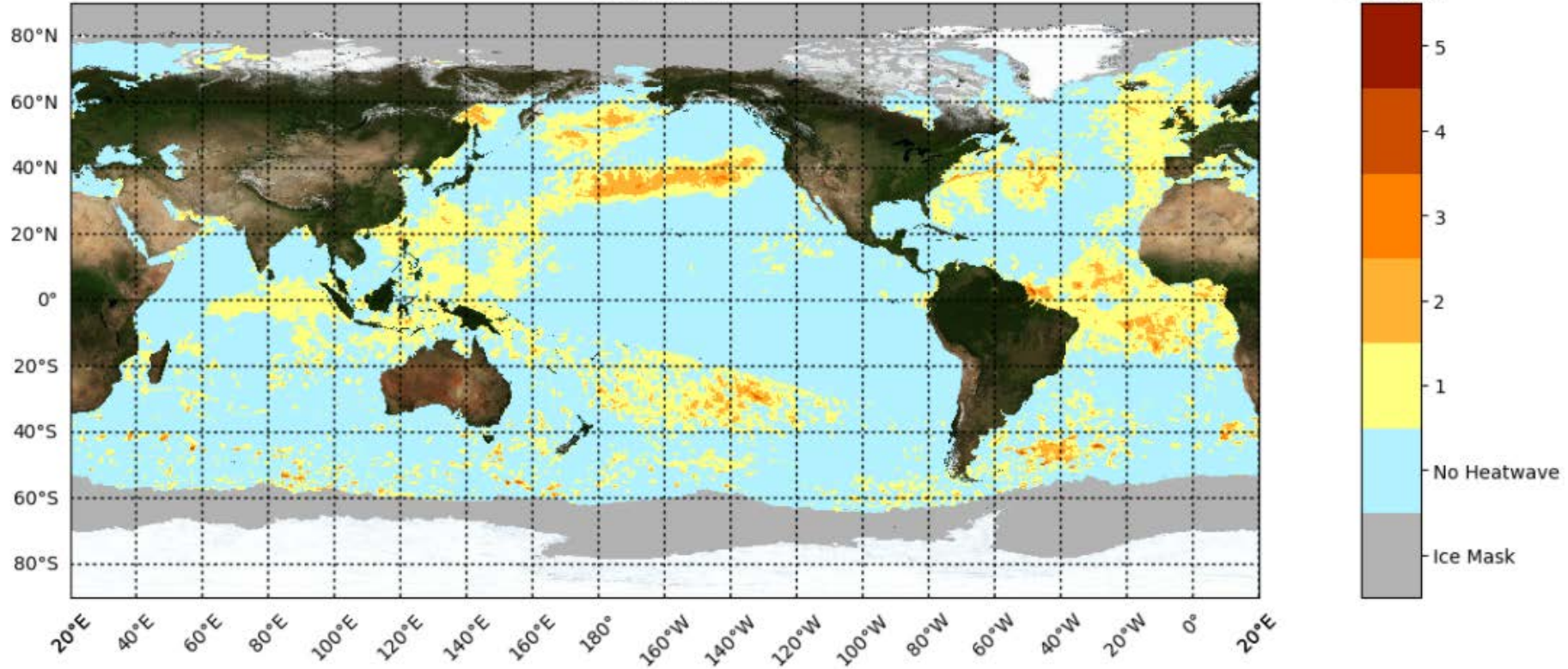
Fall - Sep - Nov

- Warmest temperatures observed in WAI and CAI
- Strong MHW based on international standards (Hobday et al. 2018)
- November update will inform on intensity and duration of current MHW

Marine Heatwave Watch

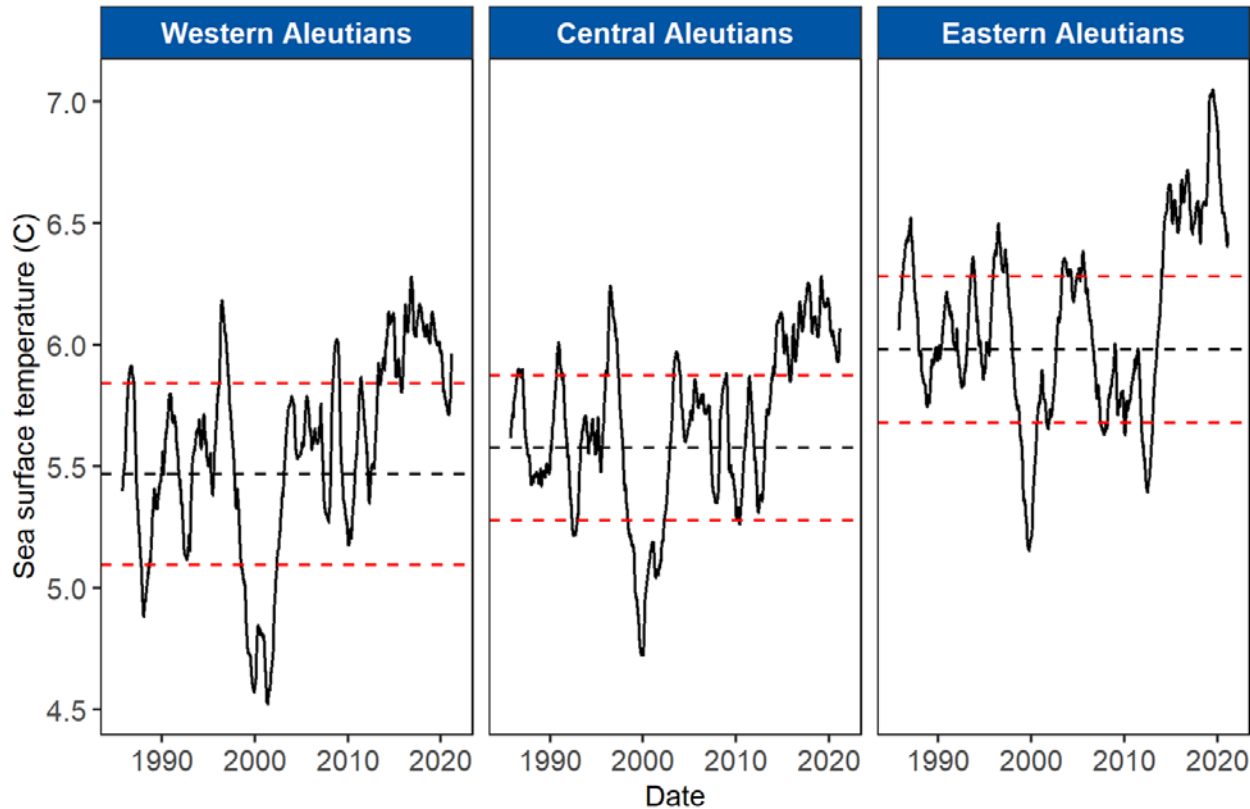
Coral Reef Watch
For context only - not part of ESR

NOAA Coral Reef Watch Daily 5km Marine Heatwave Watch
(Version 1.0)
16 Sep 2021



SST and Marine Heatwaves

Jordan and Callahan



Longer-term context

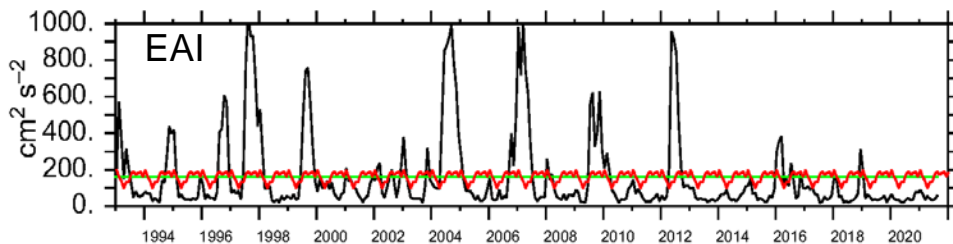
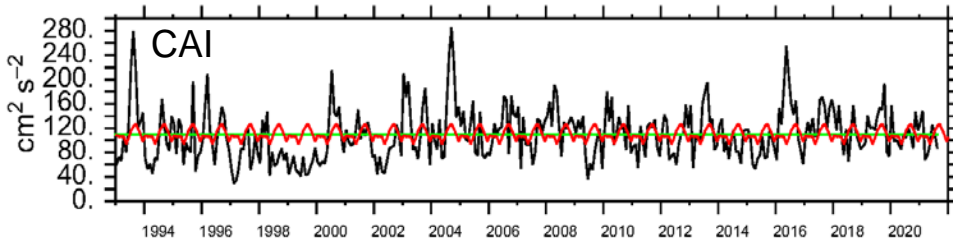
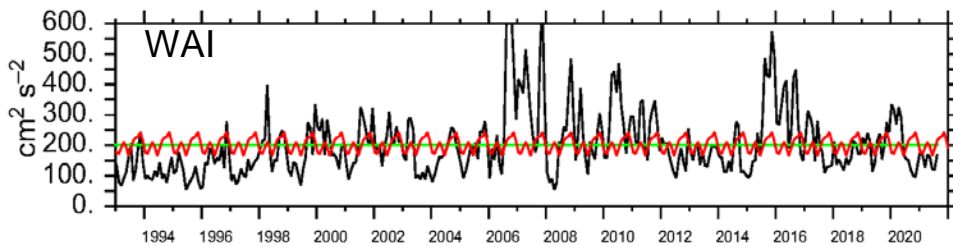
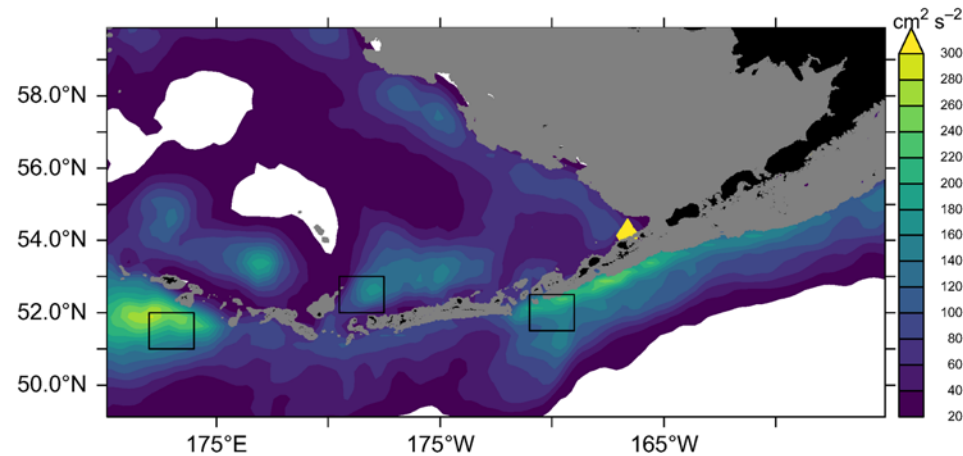
- Sustained SST above average starting 2013 across the chain
- Note Sep not included in plot yet

Eddies in Aleutian Islands

Cheng & Ladd

Eddy Kinetic Energy

- Overall, EKE near average or below average across the chain
- WAI: “Aleutian eddies” EKE; low since 2017
- CAI: Lowest mean EKE in AI; low since 2016
- EAI: Amukta Pass - high episodic EKE ; low since fall 2012
- Likely smaller fluxes through passes of heat, nutrients and salt
- Causes of variability in EKE unclear



AI Climate & Oceanography



Surface Temperature

- September SST warmest recorded in western and central Aleutians - ongoing
- MHW in summer and ongoing across all three regions
- Sustained SST above average across AI now 9 years in a row

Impacts of MHW depending on magnitude and duration of heatwave

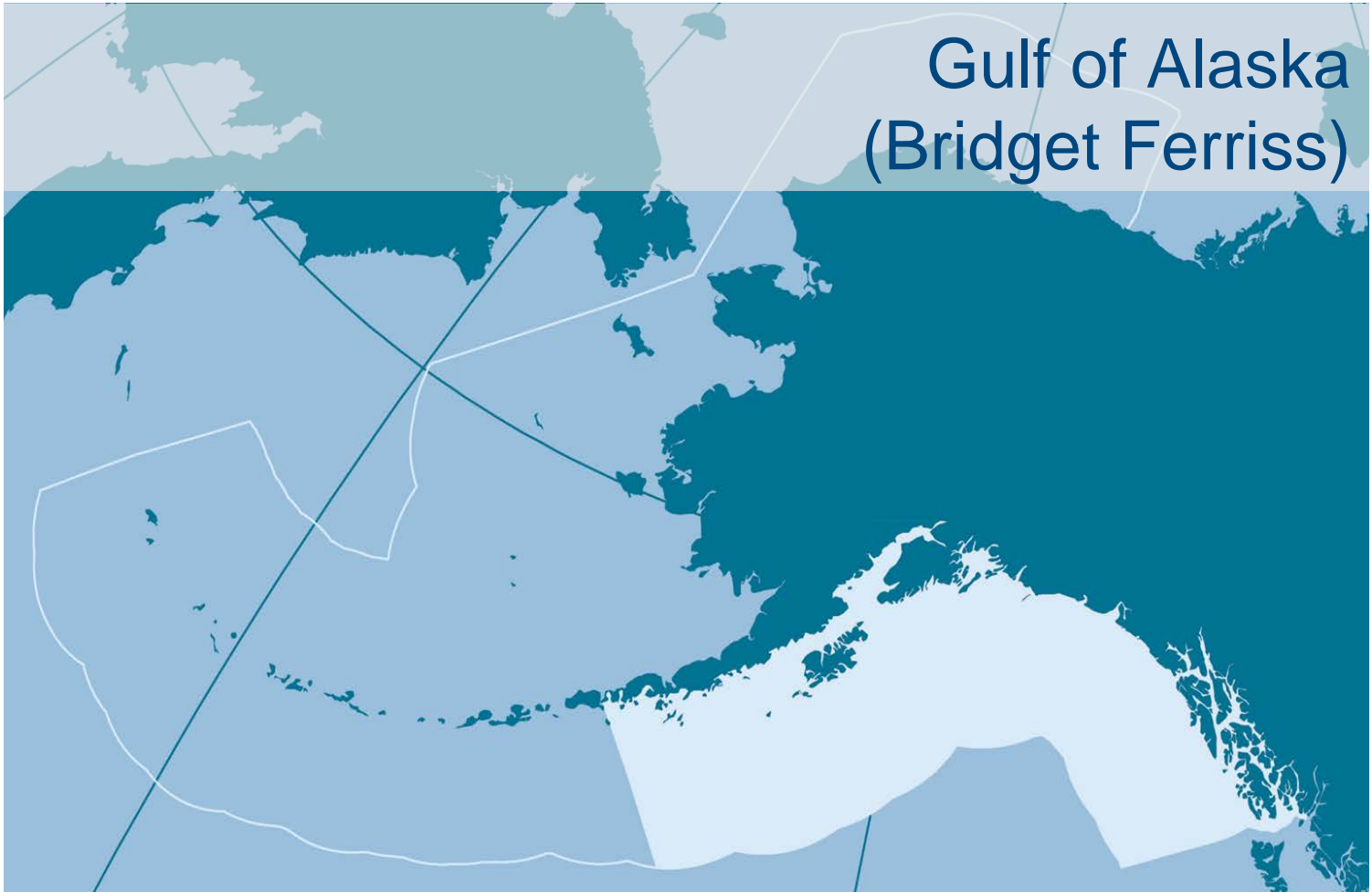


Transport

- Unimak Pass: weak flow northward through pass
- Continuing low EKE south of Amukta Pass (EAI)
- Low EKE in WAI and CAI since 2017 and 2016 respectively

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

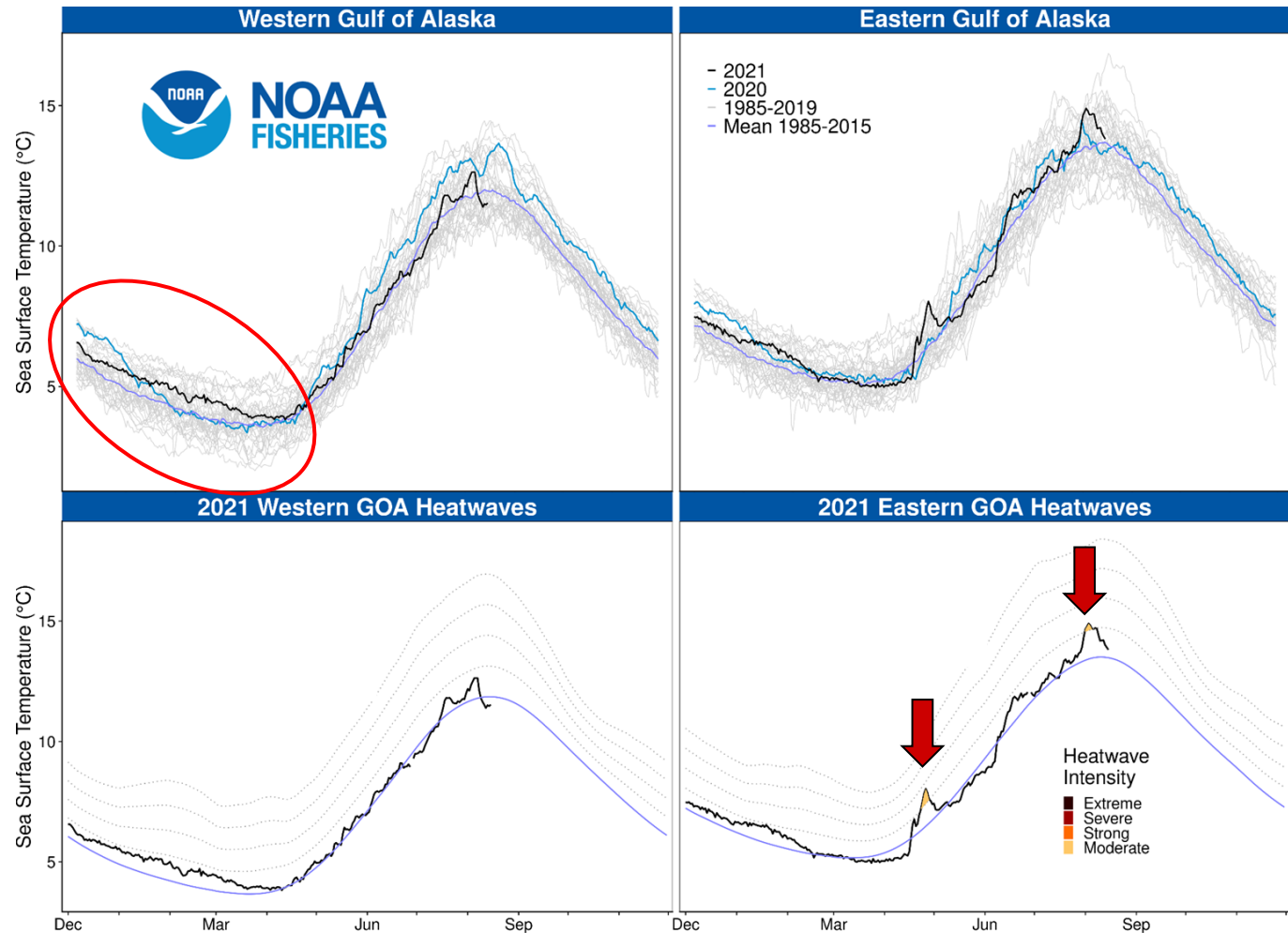
Gulf of Alaska (Bridget Ferriss)



GOA Sea Surface Temperature

Watson, Callahan

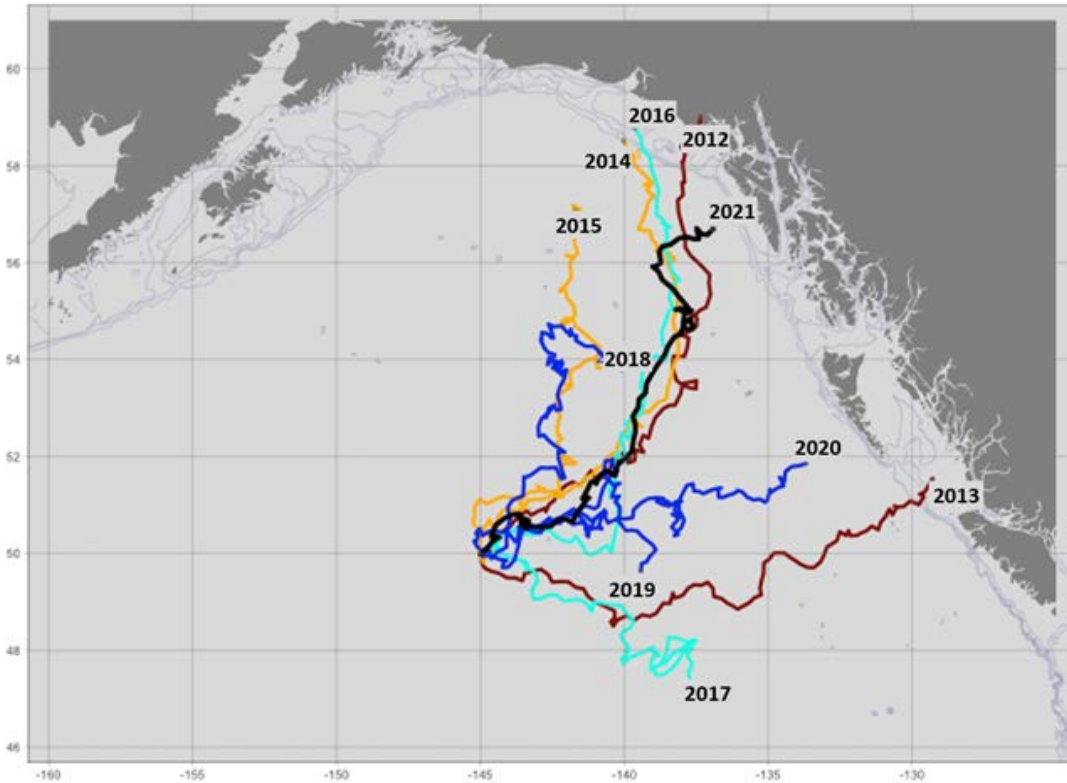
- WGOA
winter/early
spring warmth
then close to
long-term
mean (1985-
2010)
- EGOA
moderate
SST; 2 brief
marine
heatwave
periods in
spring and
summer



Winter GOA Ocean Surface Currents

Papa Trajectory Index

Stockhausen



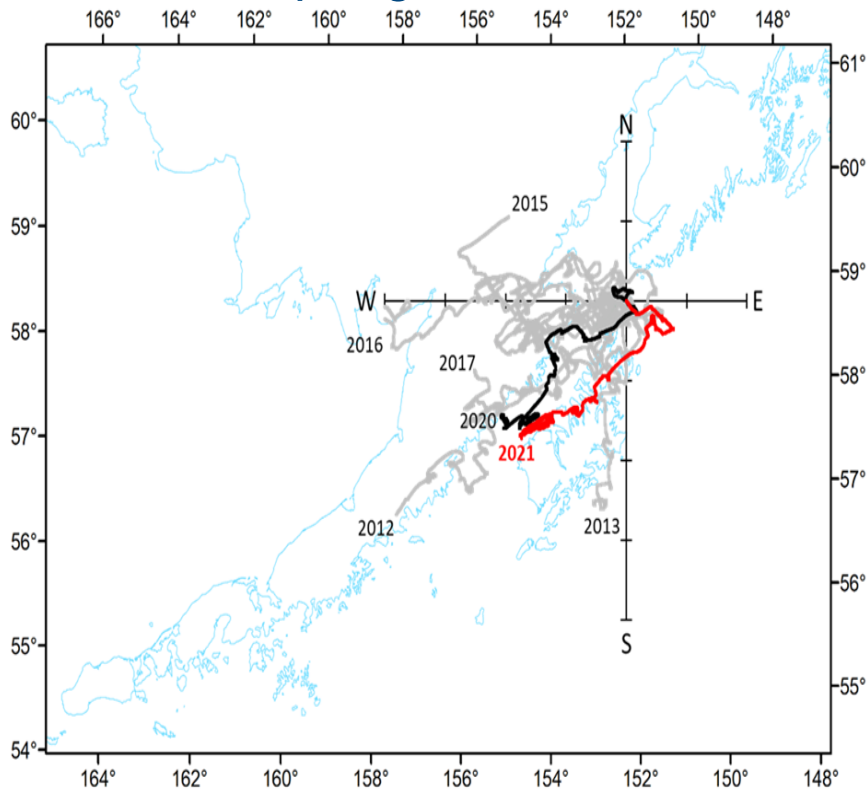
- Simulated surface drifter released from Ocean Station Papa on Dec 1 for 90 days.
- 2021 PTI extended further north than the long-term mean.
- 2021 PTI similar to 2012, 2014, 2016
- Reflects southerly surface winds (northward transport) associated with the low pressure system in Dec 2020 and developing westerlies in winter 2021.

Shelikof Spring Wind

M. Wilson, L. Rogers



Shelikof Spring Wind Direction

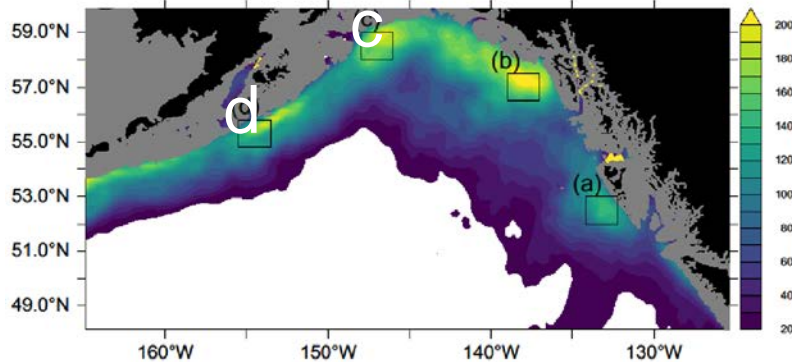


- Spring (April-May) surface winds off NE Kodiak Archipelago indicating the direction of coastal flow
- 2021(red): Downwelling-favorable northeasterly spring winds (i.e., down Shelikof Strait) (similar to 2020)
- Predict good recruitment of 2022 pollock age-1 year class (correlation of southwest wind direction with estimates of age-1 pollock abundance)
- Retention of larval and juvenile pollock in favorable habitat

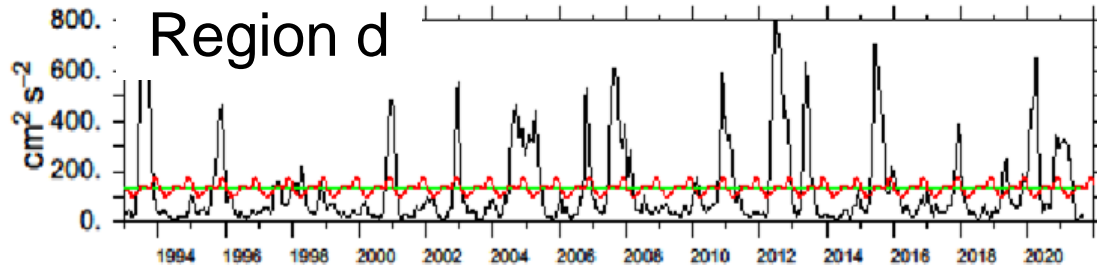
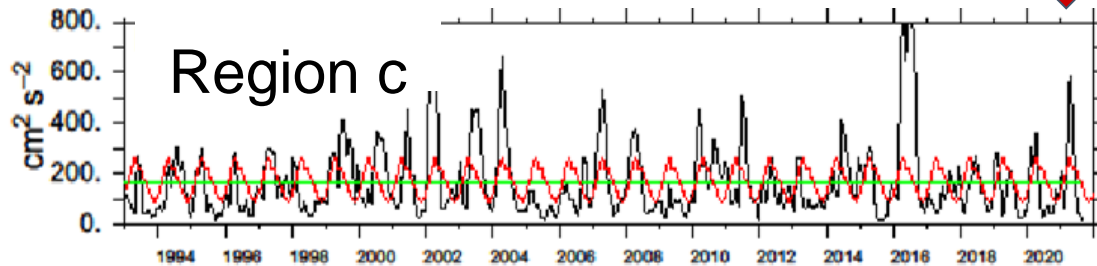
Eddies in the GOA

Cheng & Ladd

Average Eddy Kinetic Energy (EKE) Jan 1993 - Aug 2021



- 2021 EKE in region a and b is close to climatology;
- EKEs in region c and d are higher than climatology from late 2020 to early 2021.



Potential implications for Region d

- Winter 2021: Stronger cross-shelf transport of heat, salinity, and nutrients.

GOA Climate & Oceanography



Surface Temperature

- Warm late winter/spring in WGOA and MHW spikes in EGOA spring and summer but otherwise moderate temperatures

Potential to affect late winter/early spring shelf spawners (P. cod, walleye pollock, northern rock sole)



Transport

- Mixed but favorable?
- Early winter: northward surface transport
- Winter/Spring:
 - Winds from west reduce northward transport & lead to upwelling conditions
 - Shelikof Strait northeasterly spring winds (downwelling)
 - Stronger cross-shelf transport of heat, salinity, and nutrients in CGOA

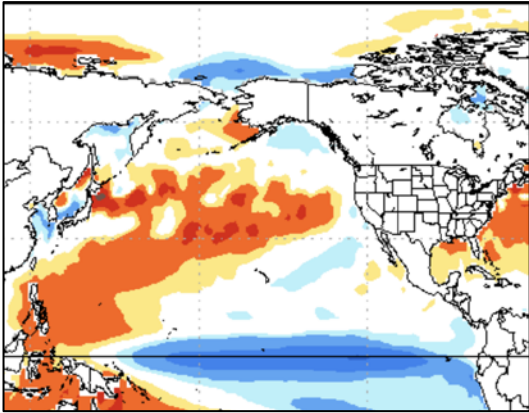
Temporal and spatial mixture of transport conditions but potentially favorable overall

Looking ahead...



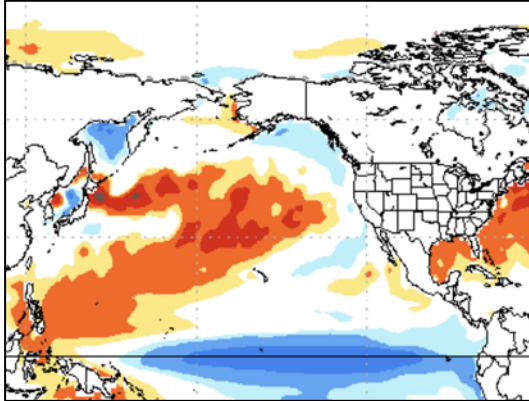
SST Projections from the National Multi-Model Ensemble

Bond



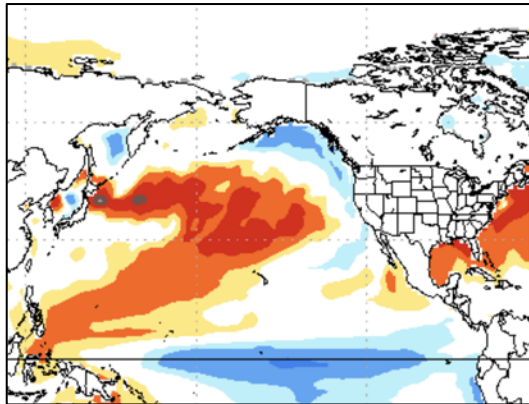
Oct - Dec 2021

- SEBS & AI warmer
- North of Bering Strait colder
- GOA: average to colder



Dec '21 - Feb '22

- SEBS decr. warmth (high SLP over western Bering)
- GOA continued cooling of GOA
- Moderate La Niña



Feb - Apr 2022

- Continued trends
- BS and AI near average SST (maybe)
- GOA: colder (maybe)
- Neutral ENSO

