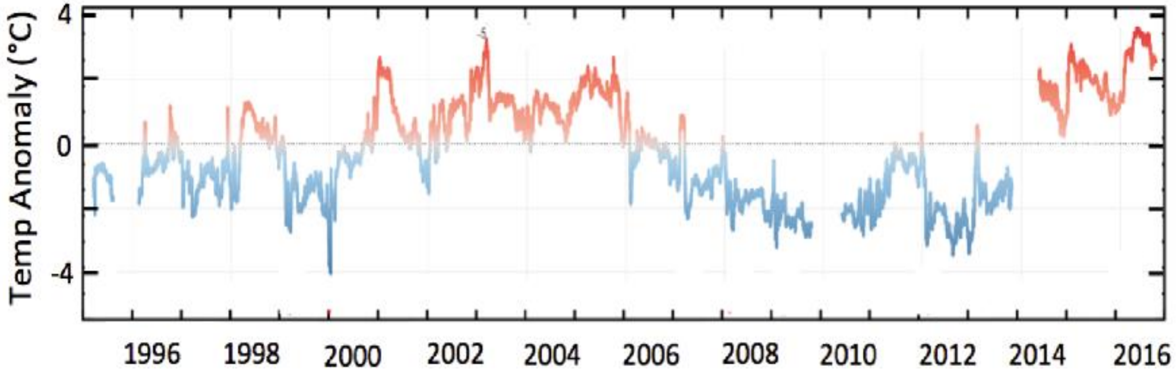
Red-shifted temperature variability in Alaskan marine ecosystems: implications for climate tipping points

Emily Ryznar and Mike Litzow
NOAA – AFSC Kodiak Laboratory

PICES October 2024

North Pacific sea surface temperatures have shifted to multi-year stanzas



Stabeno et al. 2017

FISHERIES OCEANOGRAPHY

Changes in the vertical distribution of age-0 walleye pollock (*Gadus chalcogrammus*) during warm and cold years in the southeastern Bering Sea

Adam Spear[1] | Alexander G. Andrews III[2] | Janet Duffy-Anderson[1] | Tayler Jarvis[2] | David Kimmel[1] | Denise McKelvey[1]

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https://doi.org/10.3354/meps13317
MARINE ECOLOGY PROGRESS SERIES
Mar Ecol Prog Ser
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Time-series of direct primary production and phytoplankton biomass in the southeastern Bering Sea: responses to cold and warm stanzas

Michael W. Lomas[1,*], Lisa B. Eisner[2,3], Jeanette Gann[3], Steven E. Baer[4], Calvin W. Mordy[5,6], Phyllis J. Stabeno[5]

ICES Journal of Marine Science

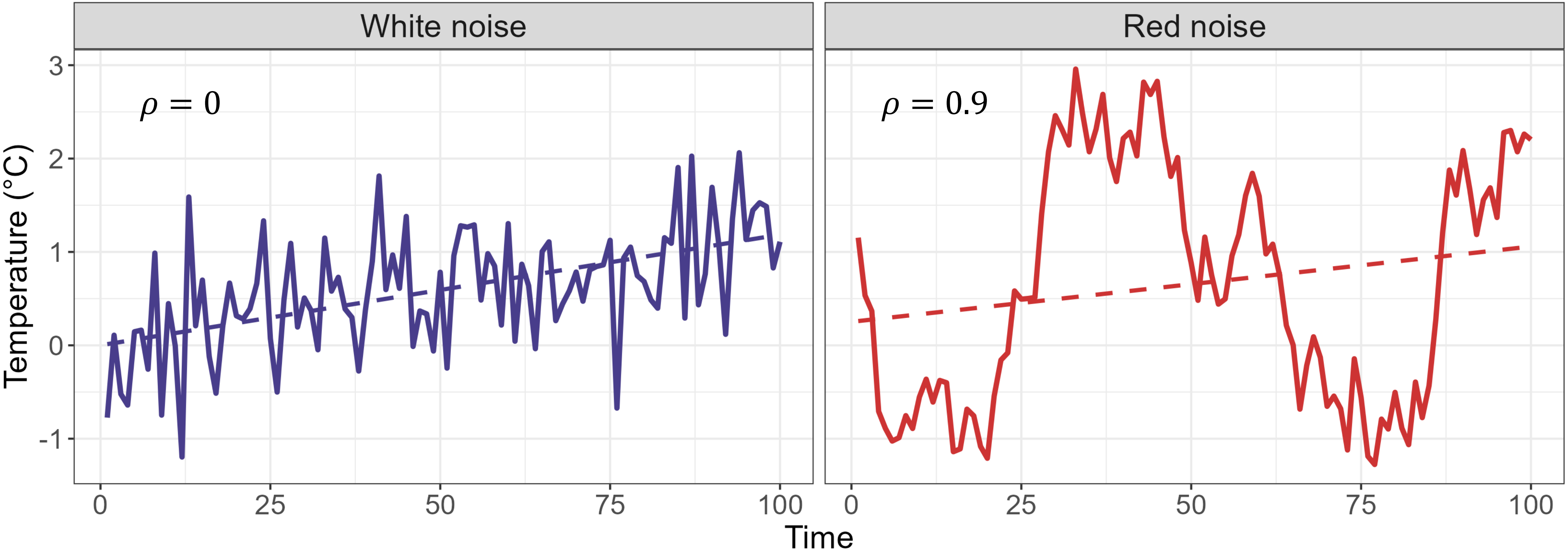
ICES CIEM

Original Article

Contrasting the variability in spatial distribution of two juvenile flatfishes in relation to thermal stanzas in the eastern Bering Sea

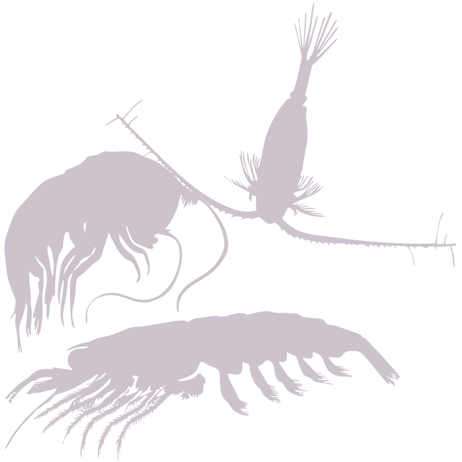
Cynthia Yeung * and Daniel W. Cooper

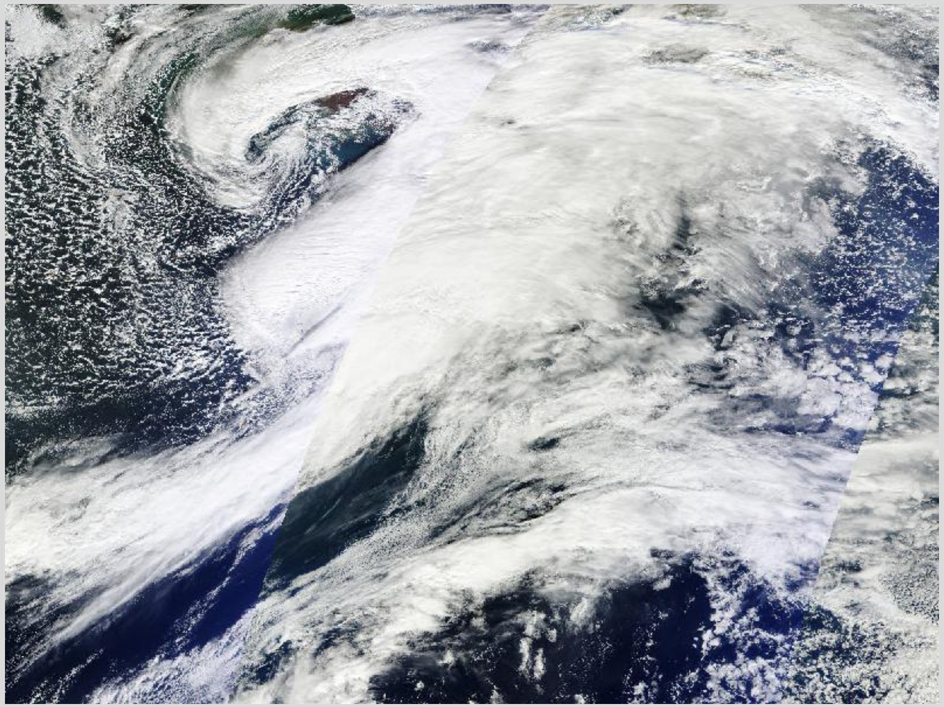
Multi-year stanzas → climate reddening

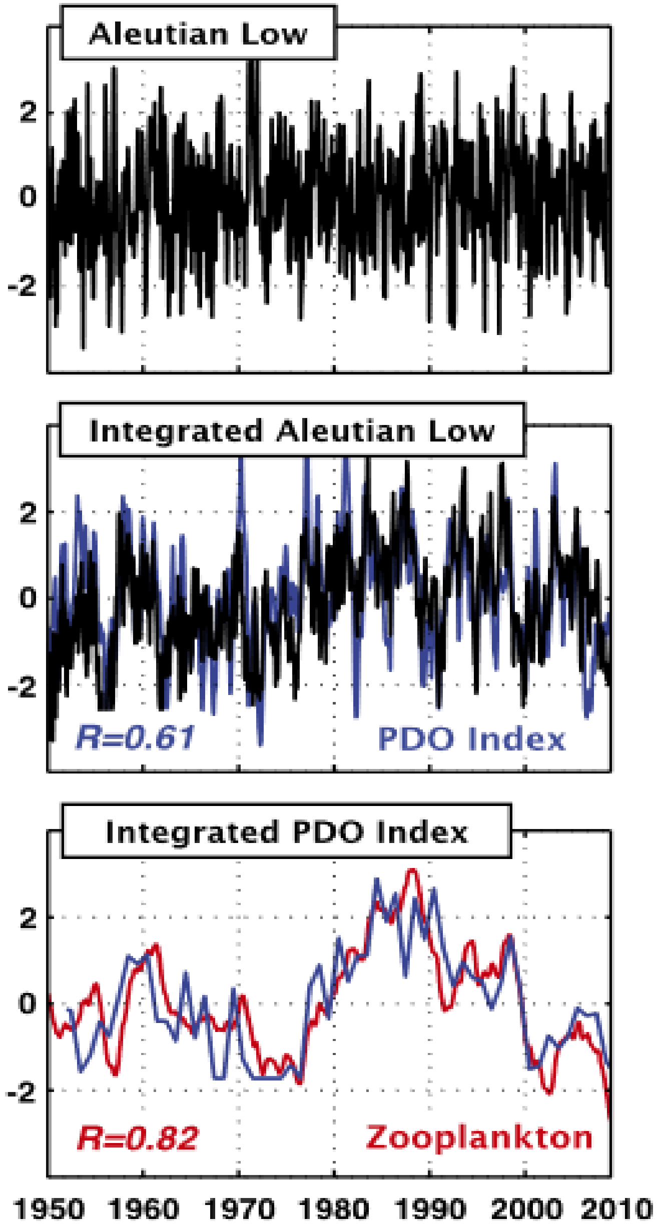


Uncorrelated random variability ***Correlated random variability***

Reddening and associated ecological responses can result from random white noise







PNAS

A double-integration hypothesis to explain ocean ecosystem response to climate forcing

Emanuele Di Lorenzo[a,1] and Mark D. Ohman[b]

[a]School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA 30332; and [b]Integrative Oceanography Division, Scripps Institution of Oceanography, University of California at San Diego, La Jolla, CA 92093

Why is reddening important?

→ It increases the chance of abrupt, random climate tipping points with ecosystem implications

→ It can also coincide with increasing variability

PNAS

Slowing down of North Pacific climate variability and its implications for abrupt ecosystem change

Chris A. Boulton[1] and Timothy M. Lenton[1]

PERSPECTIVE
https://doi.org/10.1038/s41558-018-0160-7
nature climate change

Climate reddening increases the chance of critical transitions

Bregje van der Bolt*, Egbert H. van Nes, Sebastian Bathiany, Marlies E. Vollebregt and Marten Scheffer

PNAS

Slowing down as an early warning signal for abrupt climate change

Vasilis Dakos*, Marten Scheffer*†, Egbert H. van Nes*, Victor Brovkin‡§, Vladimir Petoukhov‡, and Hermann Held‡

C. Lescher

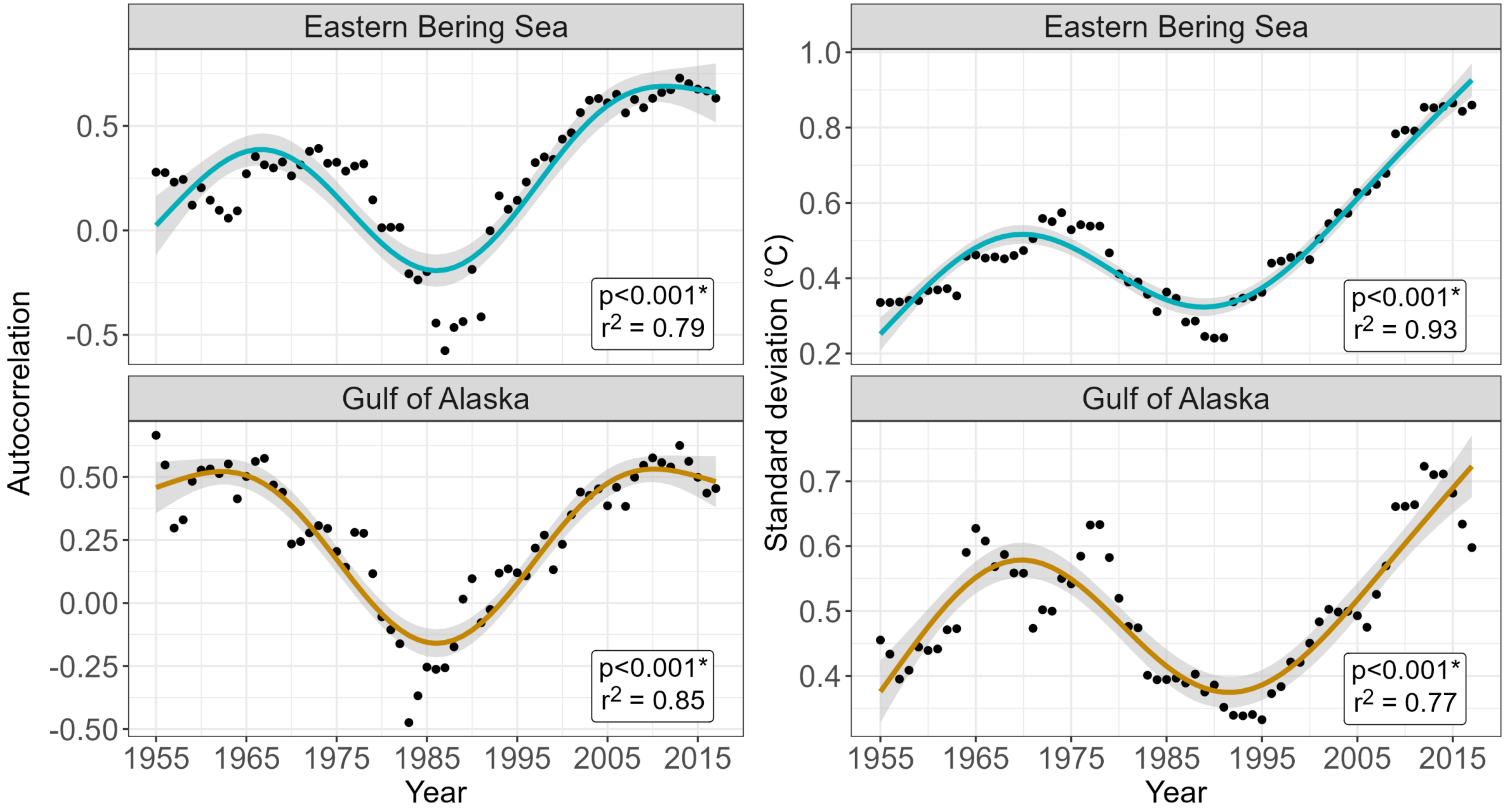
Questions:

1. Is sea surface temperature reddening in the Eastern Bering Sea and Gulf of Alaska?

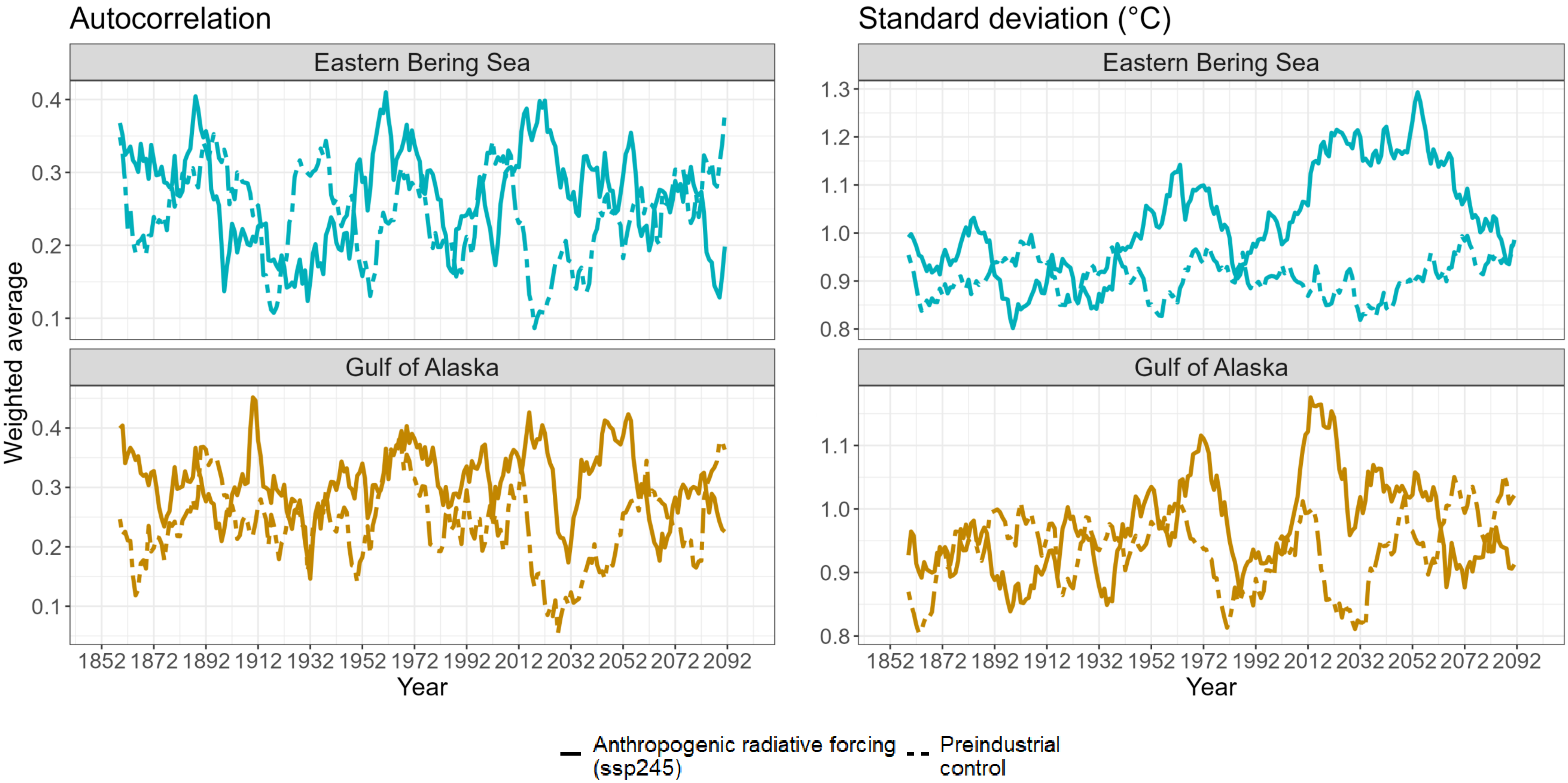
2. If so, why is it occurring?

3. How likely climate tipping points with reddening, and what are the potential consequences?

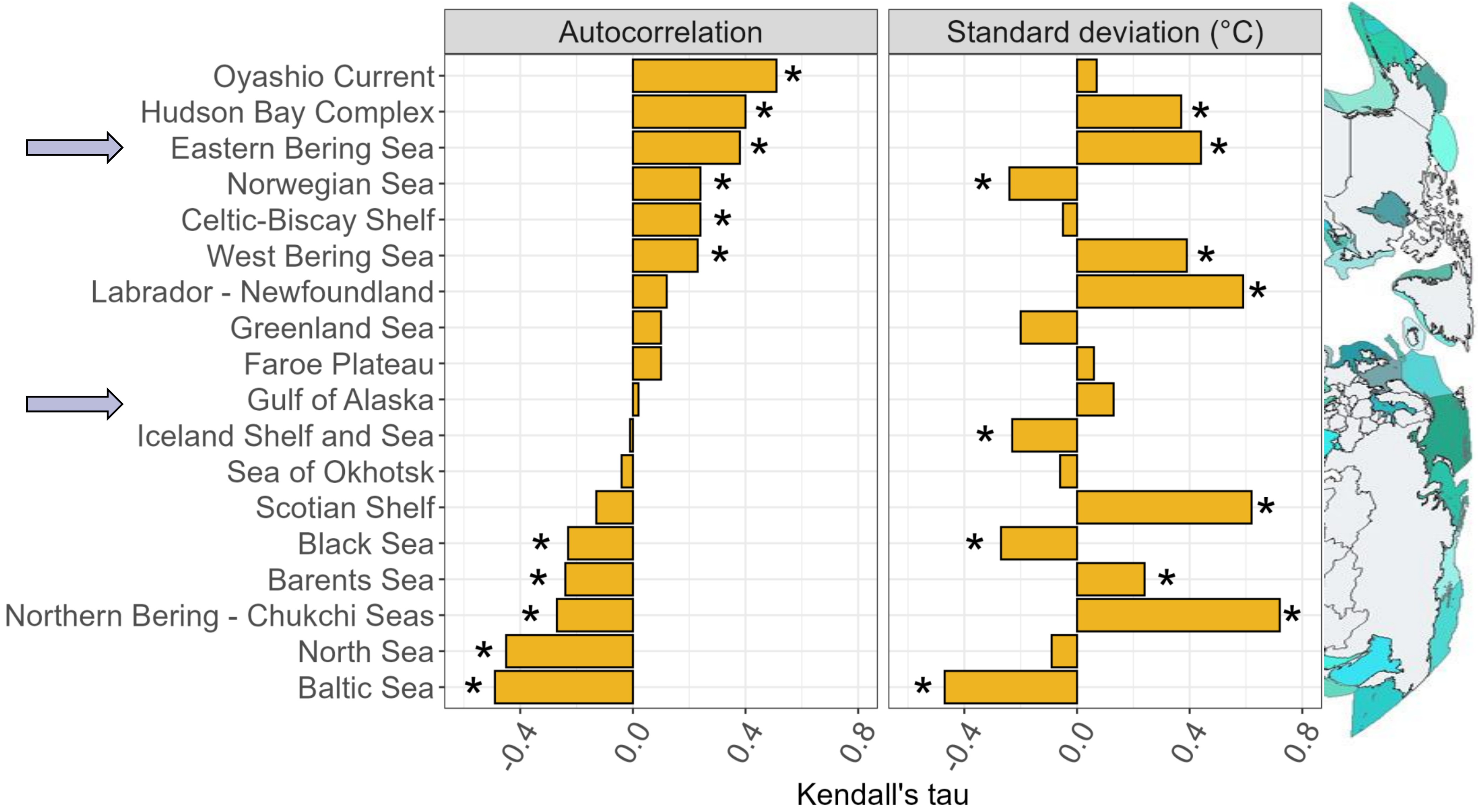
Q1: SST is becoming more red and variable with time



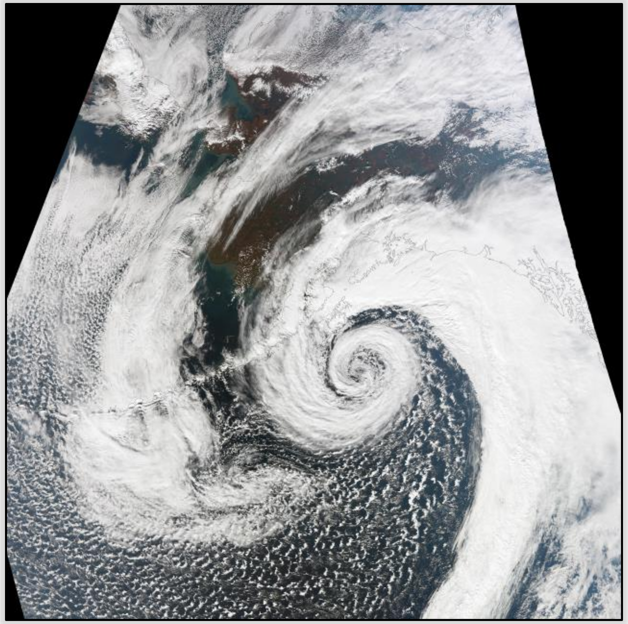
Q2: Climate change is not a driver of SST reddening



Q2: Reddening is not consistent across high-latitude large marine ecosystems → climate change is not a driver



Q2: The Aleutian Low can drive SST, but does it drive SST reddening?

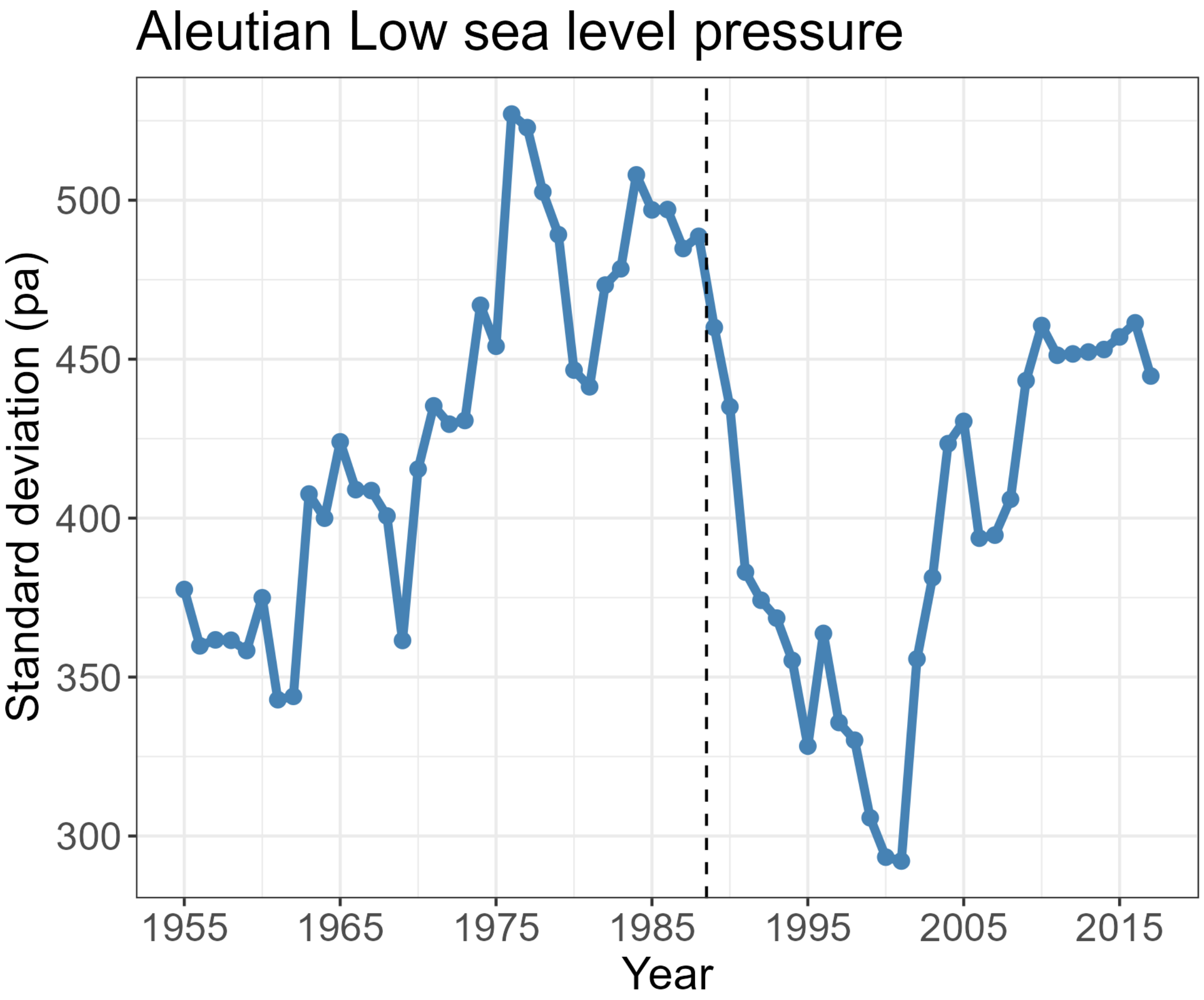


The changing physical and ecological meanings of North Pacific Ocean climate indices

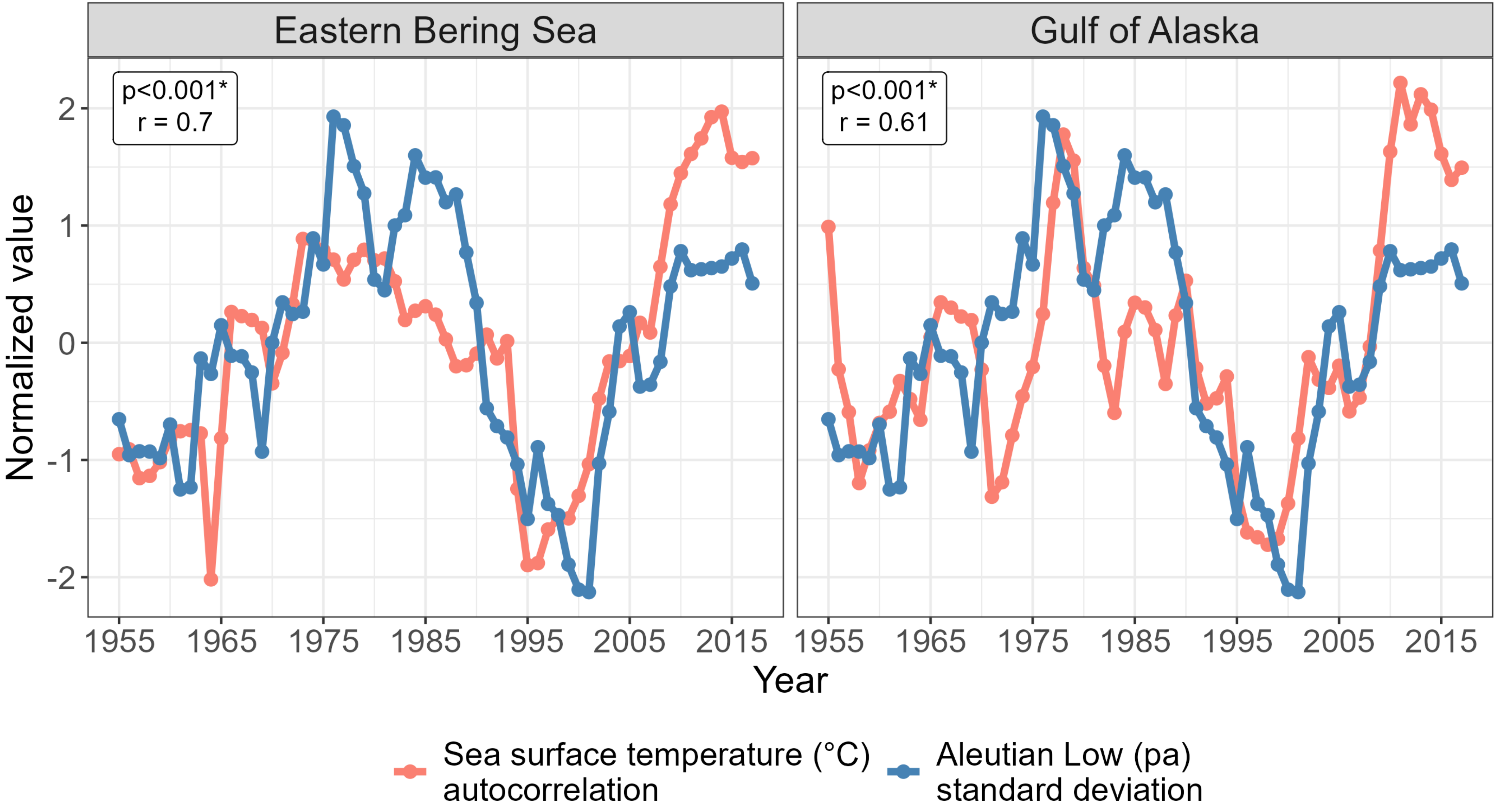
Michael A. Litzow[a,1], Mary E. Hunsicker[b], Nicholas A. Bond[c], Brian J. Burke[d], Curry J. Cunningham[e], Jennifer L. Gosselin[f], Emily L. Norton[c], Eric J. Ward[d], and Stephani G. Zador[g]

[a]College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Kodiak, AK 99615; [b]Northwest Fisheries Science Center, National Marine Fisheries Service, Newport, OR 97365; [c]Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle, WA 98105; [d]Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, WA 98112; [e]College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Juneau, AK 99801; [f]School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA 98105; and [g]Alaska Fisheries Science Center, National Marine Fisheries Service, Seattle, WA 98115

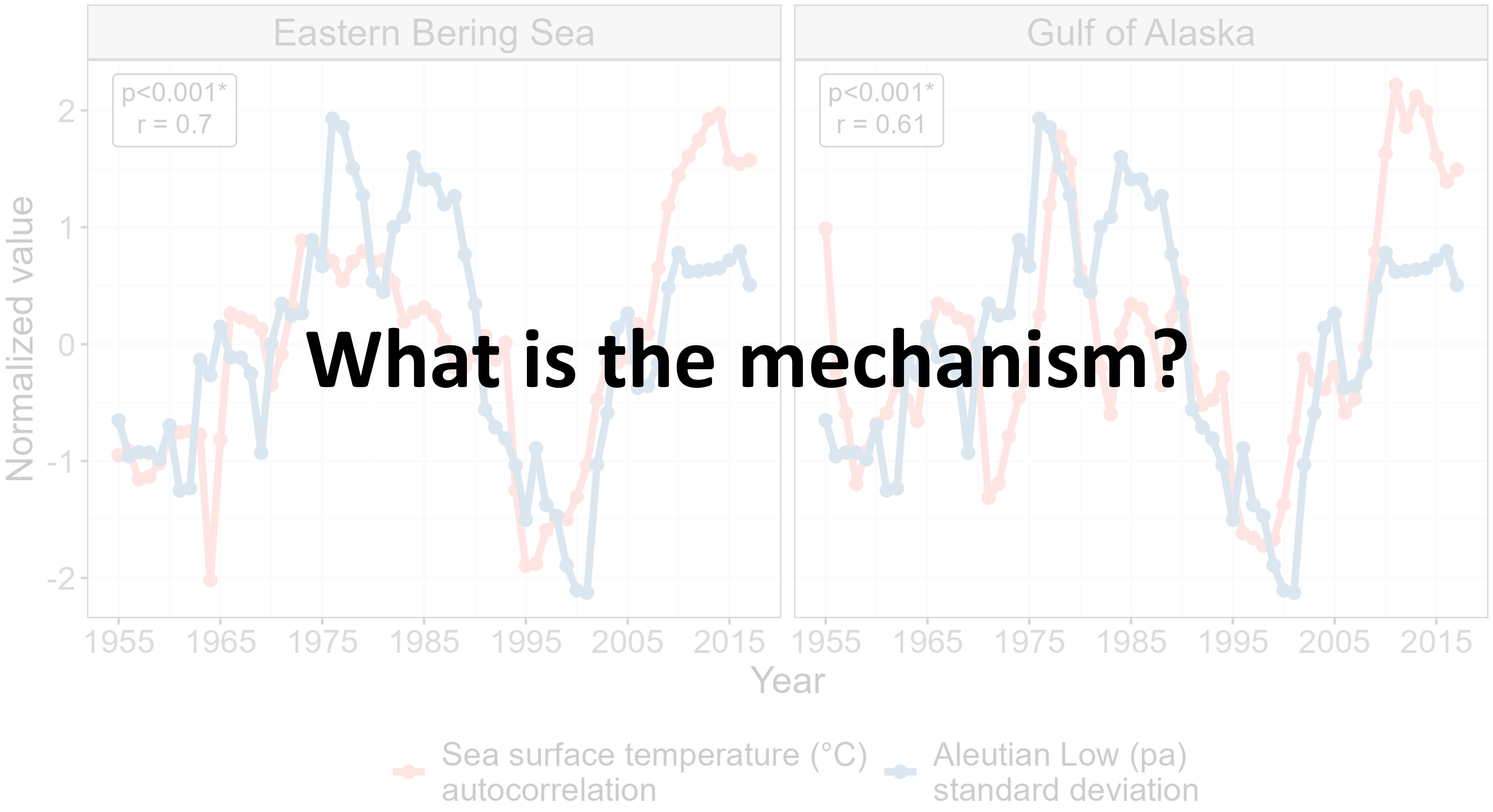
Edited by Nils Chr. Stenseth, University of Oslo, Oslo, Norway, and approved February 19, 2020 (received for review December 4, 2019)



Q2: Aleutian Low variability explains SST reddening.

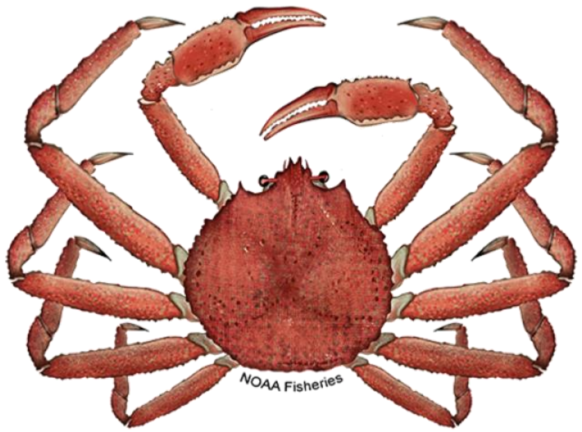


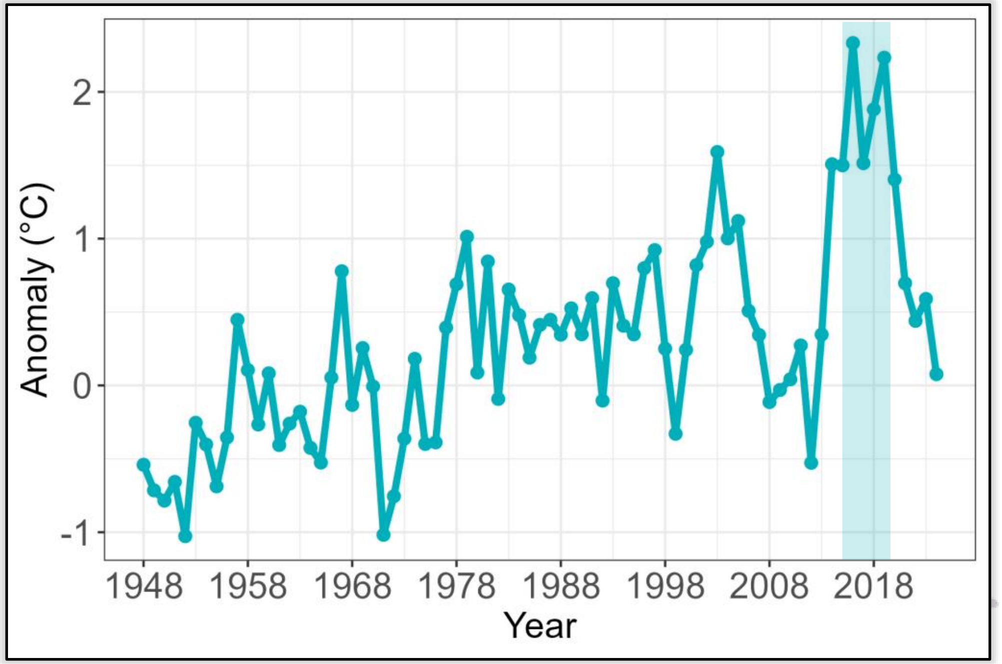
Q2: Aleutian Low variability explains SST reddening.



What is the mechanism?

Q3: How likely are tipping points with SST reddening in the Bering Sea?





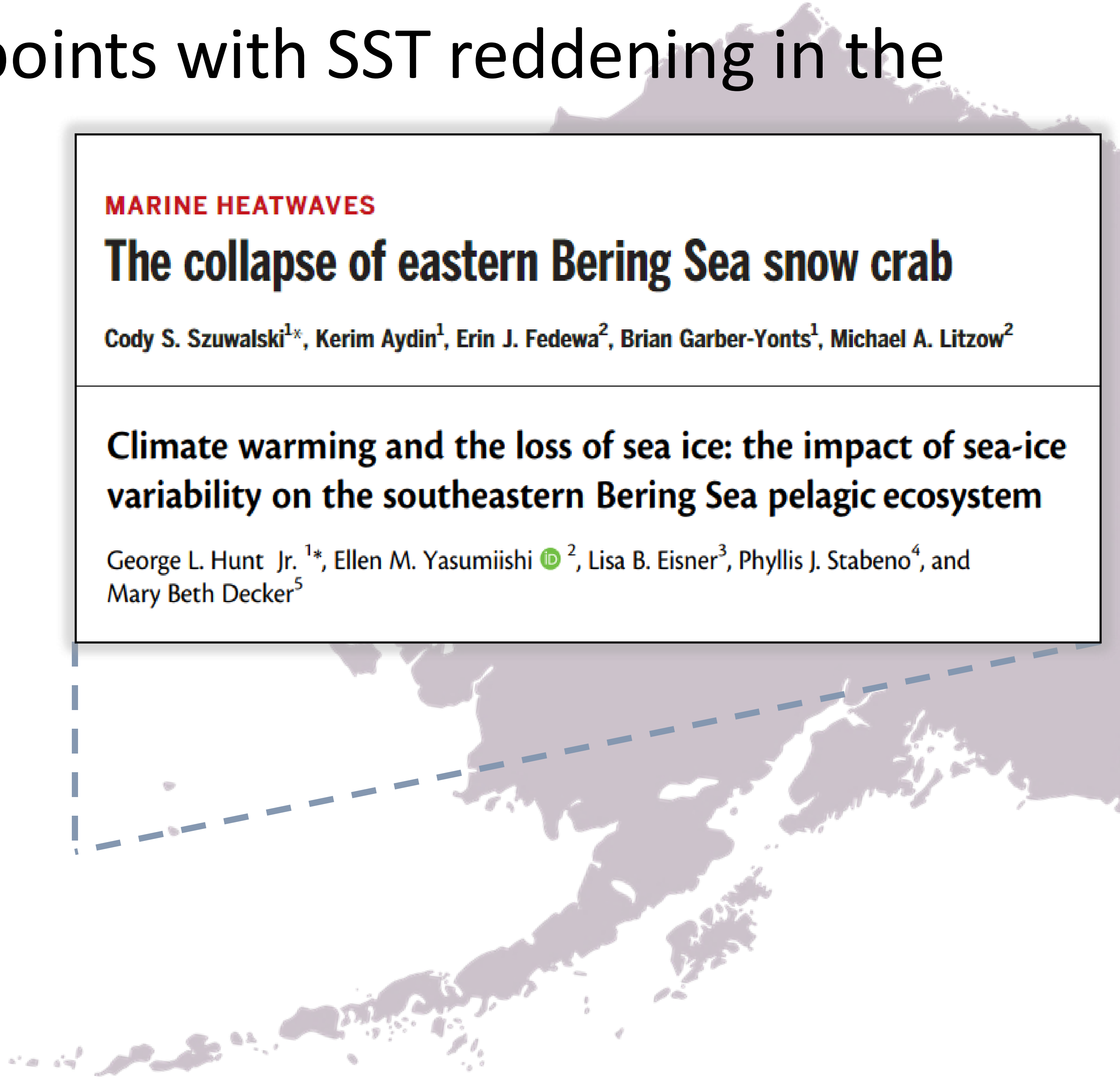
MARINE HEATWAVES

The collapse of eastern Bering Sea snow crab

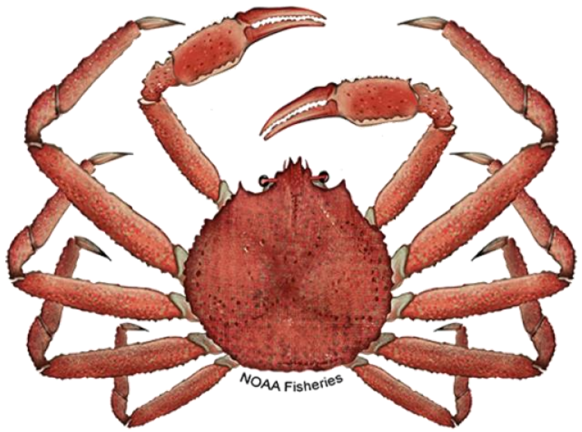
Cody S. Szuwalski[1*], Kerim Aydin[1], Erin J. Fedewa[2], Brian Garber-Yonts[1], Michael A. Litzow[2]

Climate warming and the loss of sea ice: the impact of sea-ice variability on the southeastern Bering Sea pelagic ecosystem

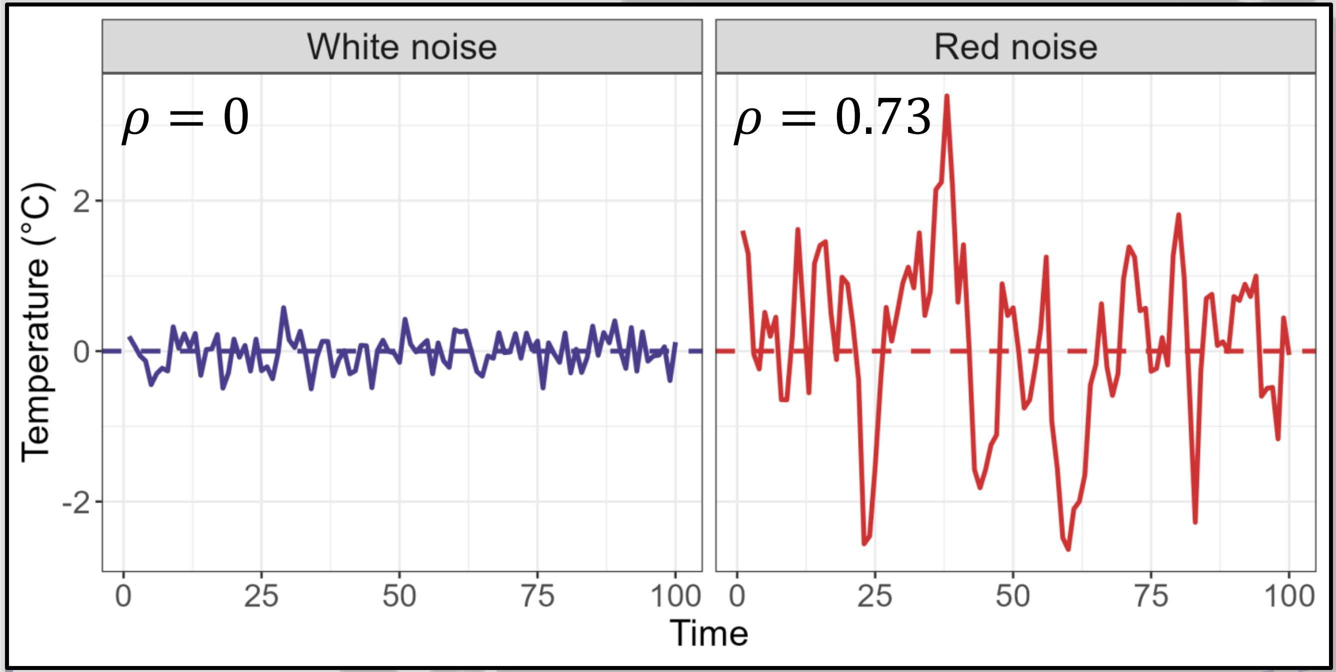
George L. Hunt Jr. [1*], Ellen M. Yasumiishi [2], Lisa B. Eisner[3], Phyllis J. Stabeno[4], and Mary Beth Decker[5]



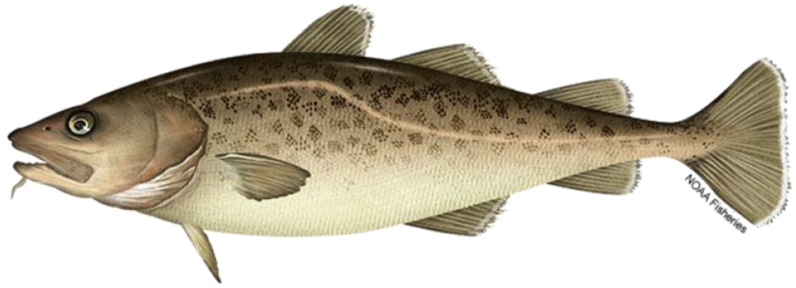
Q3: Increasing reddening → increased risk of tipping points

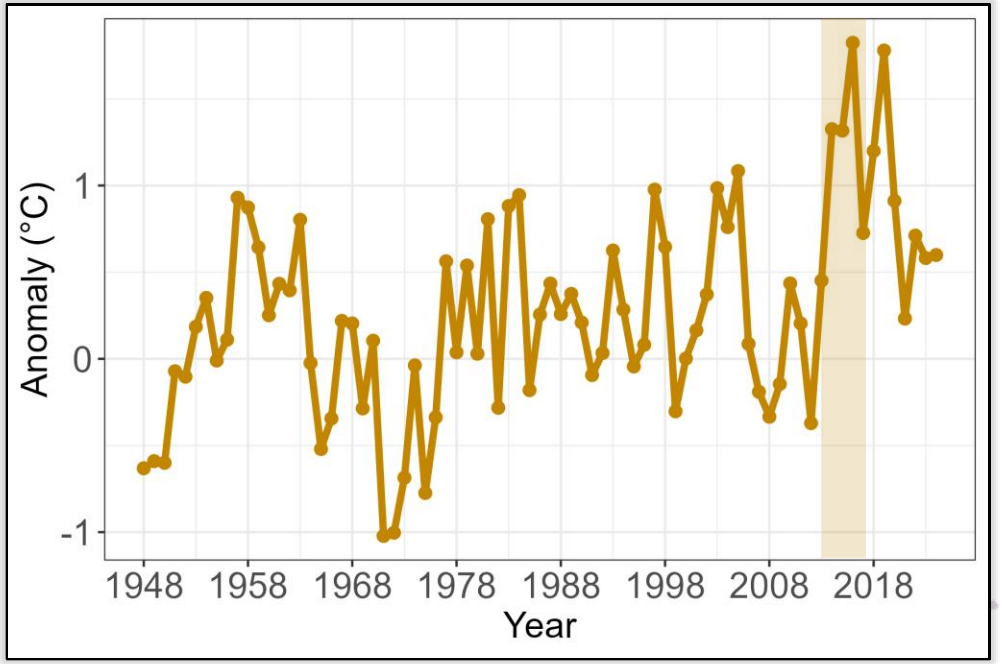


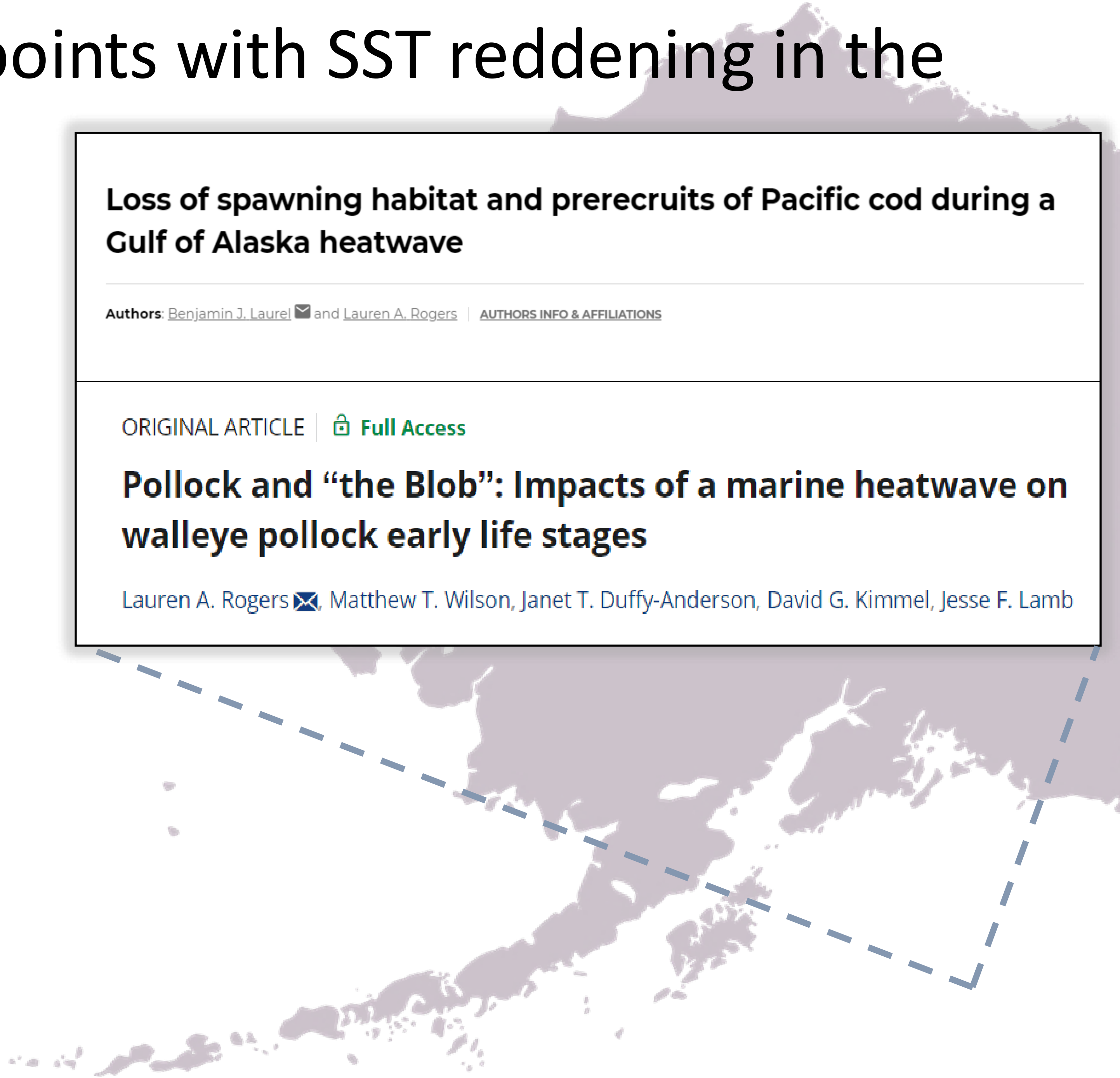
Probability of 2016-2019 tipping point conditions are predicted to occur **17% of the time with red noise** and **0% of the time with white noise**



Q3: How likely are tipping points with SST reddening in the Gulf of Alaska?







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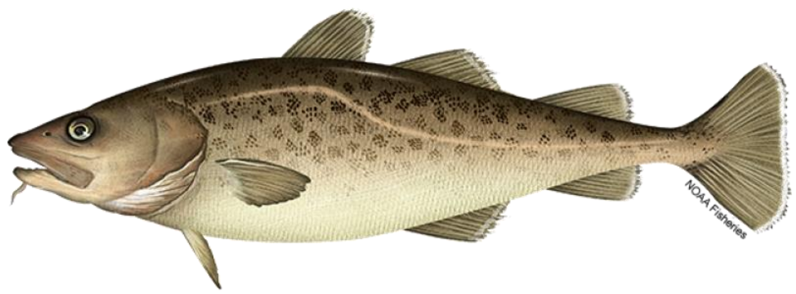
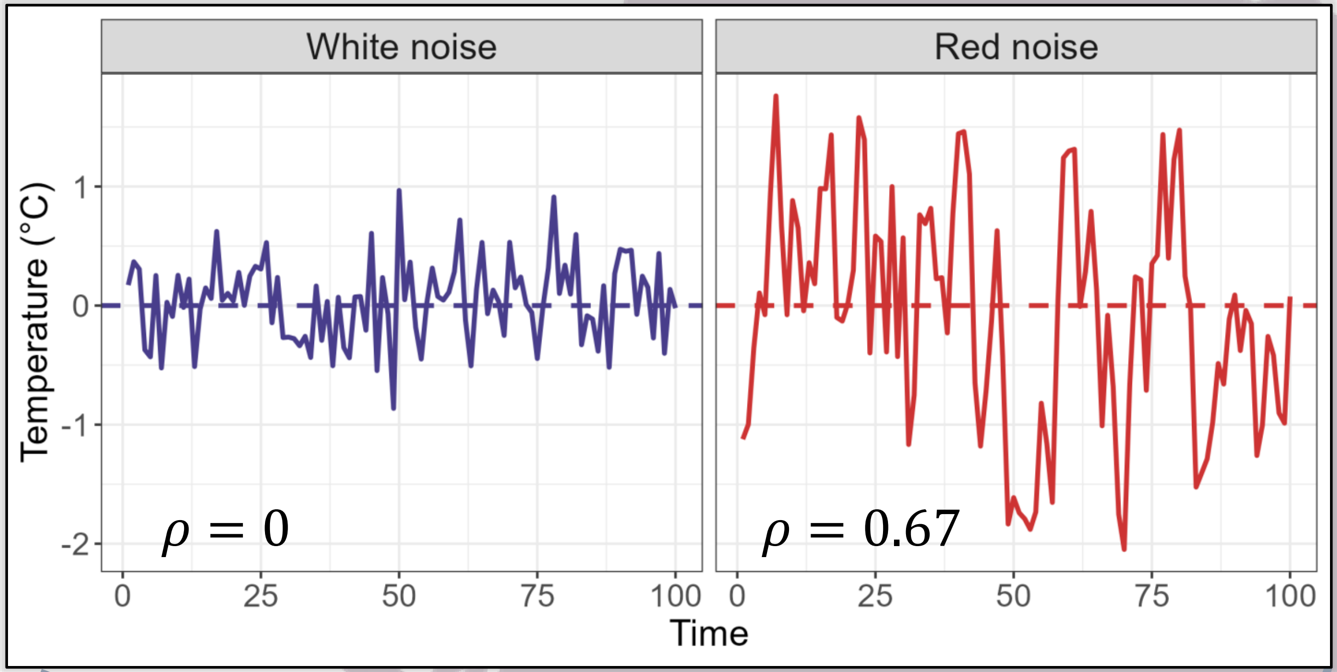




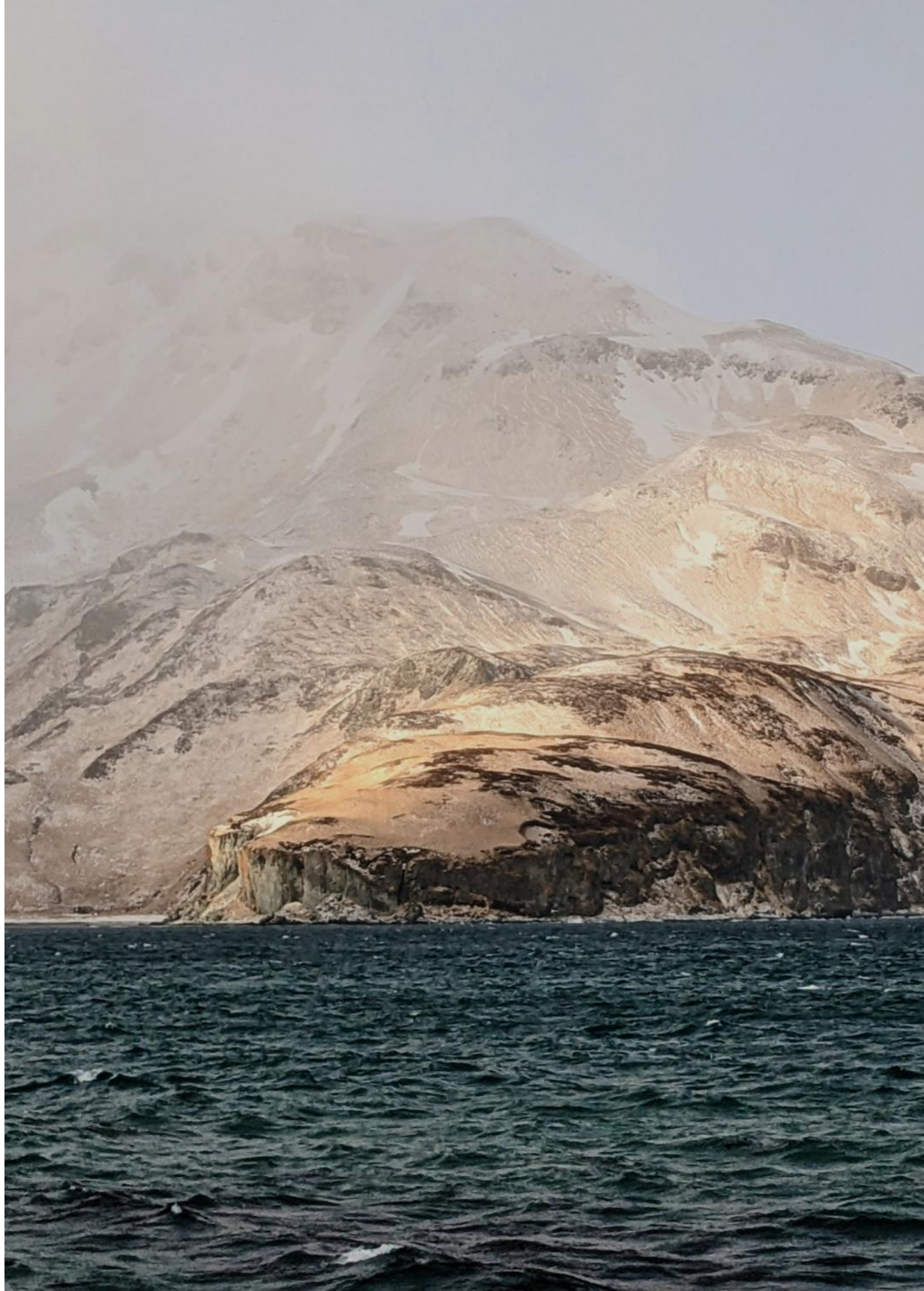
Probability of 2014-2016 tipping point conditions are predicted to occur **10% of the time with red noise** and **<0.01% of the time with white noise**

Summary

1. **Is sea surface temperature reddening in the Eastern Bering Sea and Gulf of Alaska?**
   - Yes, though less pronounced in the Gulf.

2. **If so, why is it occurring?**
   - Not climate change → reddening is not widespread nor predicted in climate projection models
   - Aleutian Low variability is driving reddening in these systems, but what is the mechanism?

3. **How likely are climate tipping points with reddening, and what are the consequences?**
   - Historic and catastrophic tipping point conditions are predicted to occur more frequently




Questions?
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