

Puget Sound, 2045...



The New Normal? Heat Waves and Ocean Blobs, What's Next?



Pacific Marine Environmental Laboratory

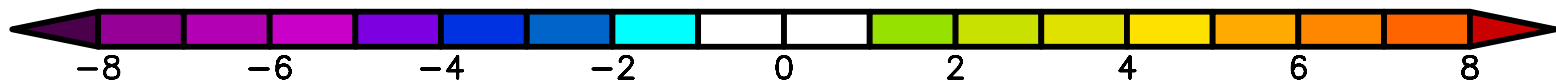
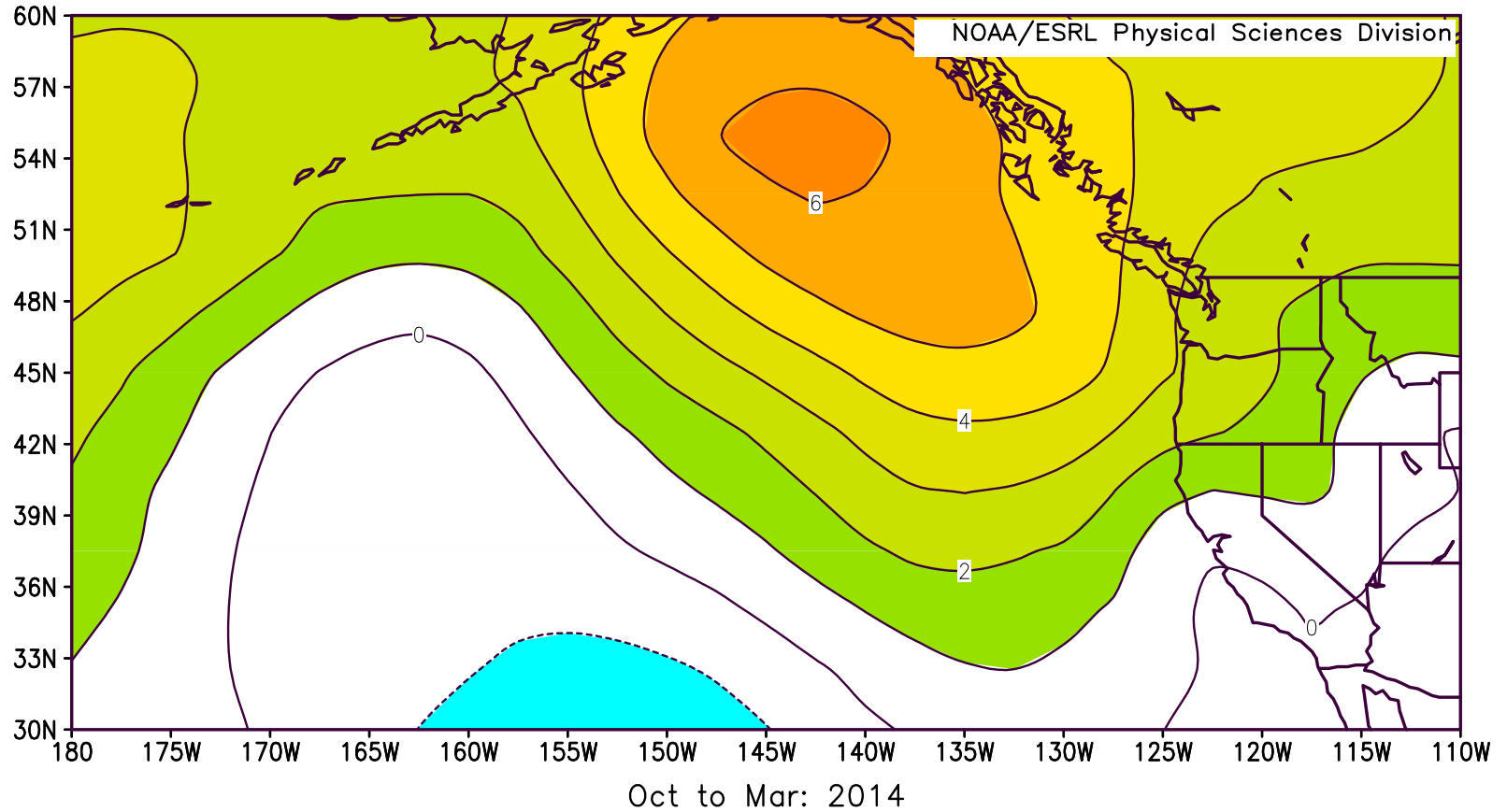
Ocean Climate Stations



Office of the Washington State Climatologist

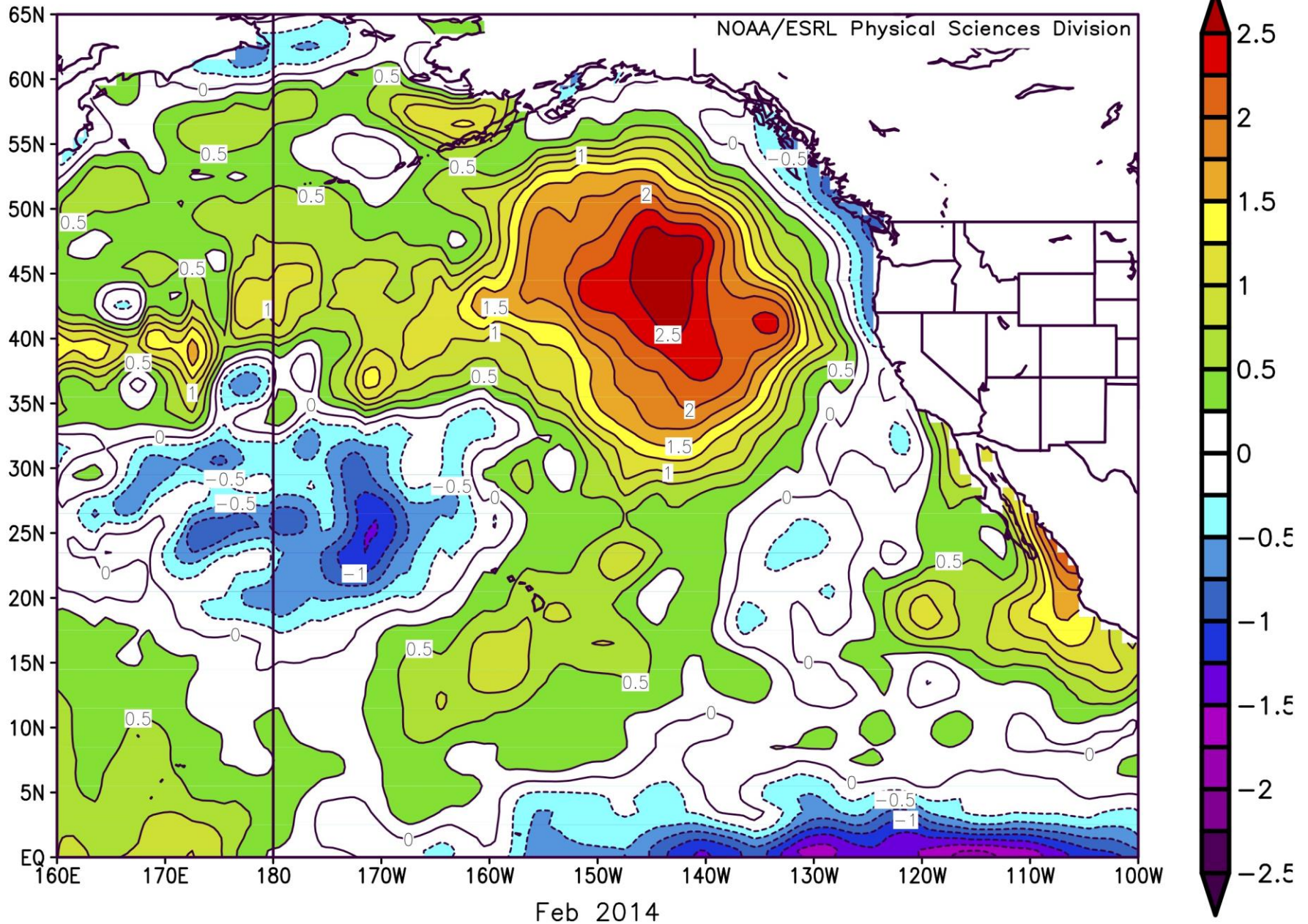
The 2014-16 Event (aka the Blob)
Climate Change Context
Predictability of NE Pacific Waters

NCEP/NCAR Reanalysis
Sea Level Pressure (mb) Composite Anomaly 1981–2010 climo



NOAA OI SST

Surface SST (C) Composite Anomaly 1981–2010 climo



INDESCRIBABLE...
INDESTRUCTIBLE!
NOTHING CAN STOP IT!

THE BLOB

STEVEN
McQUEEN

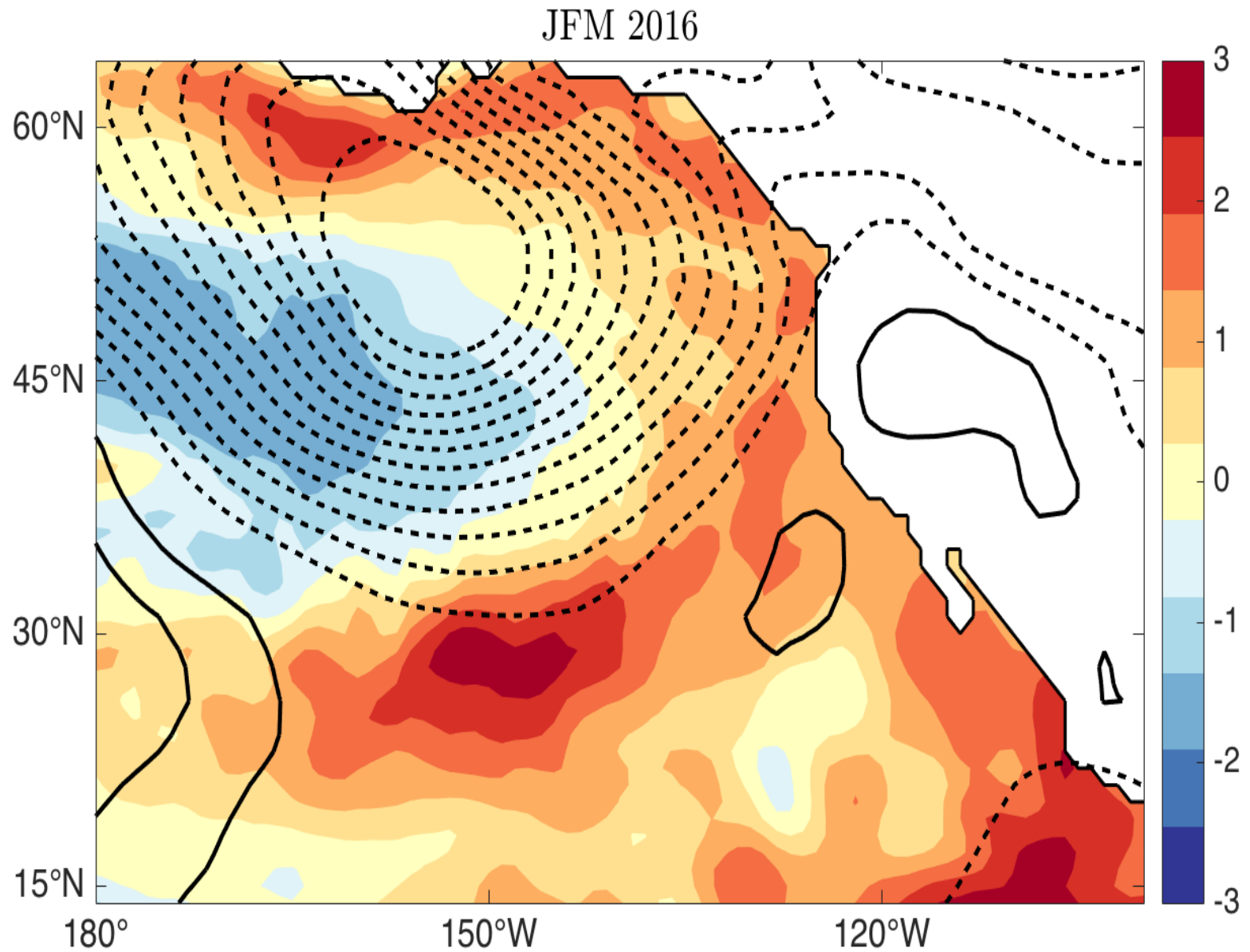
ANITA CORSEAUT - EARL ROWE

PRODUCED BY JACK H. HARRIS - IRVIN S. YEAWORTH, JR. - THEODORE SIMONSON
DIRECTED BY KATE PHILLIPS
SCREENPLAY BY KATE PHILLIPS

FROM AN IDEA BY ROYNE H. TULLGATE
A TONY IN PRODUCTION - LEO J. SY DE LORE

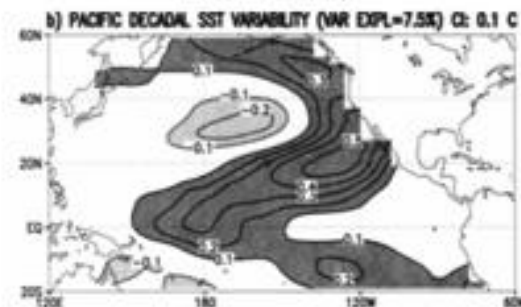
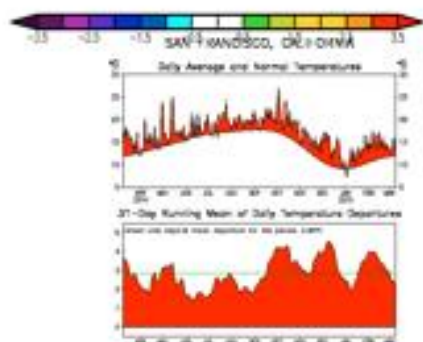
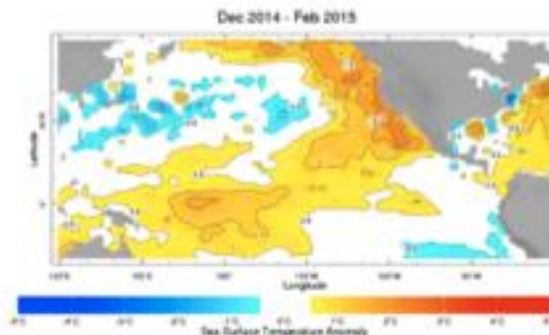
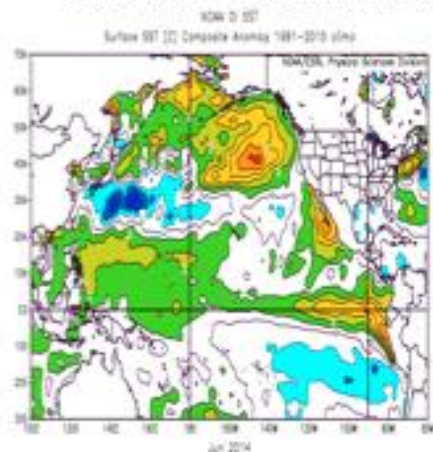


Early 2016 SLP (contours) and SST (color fill) Anomalies



Historic "warm blob"

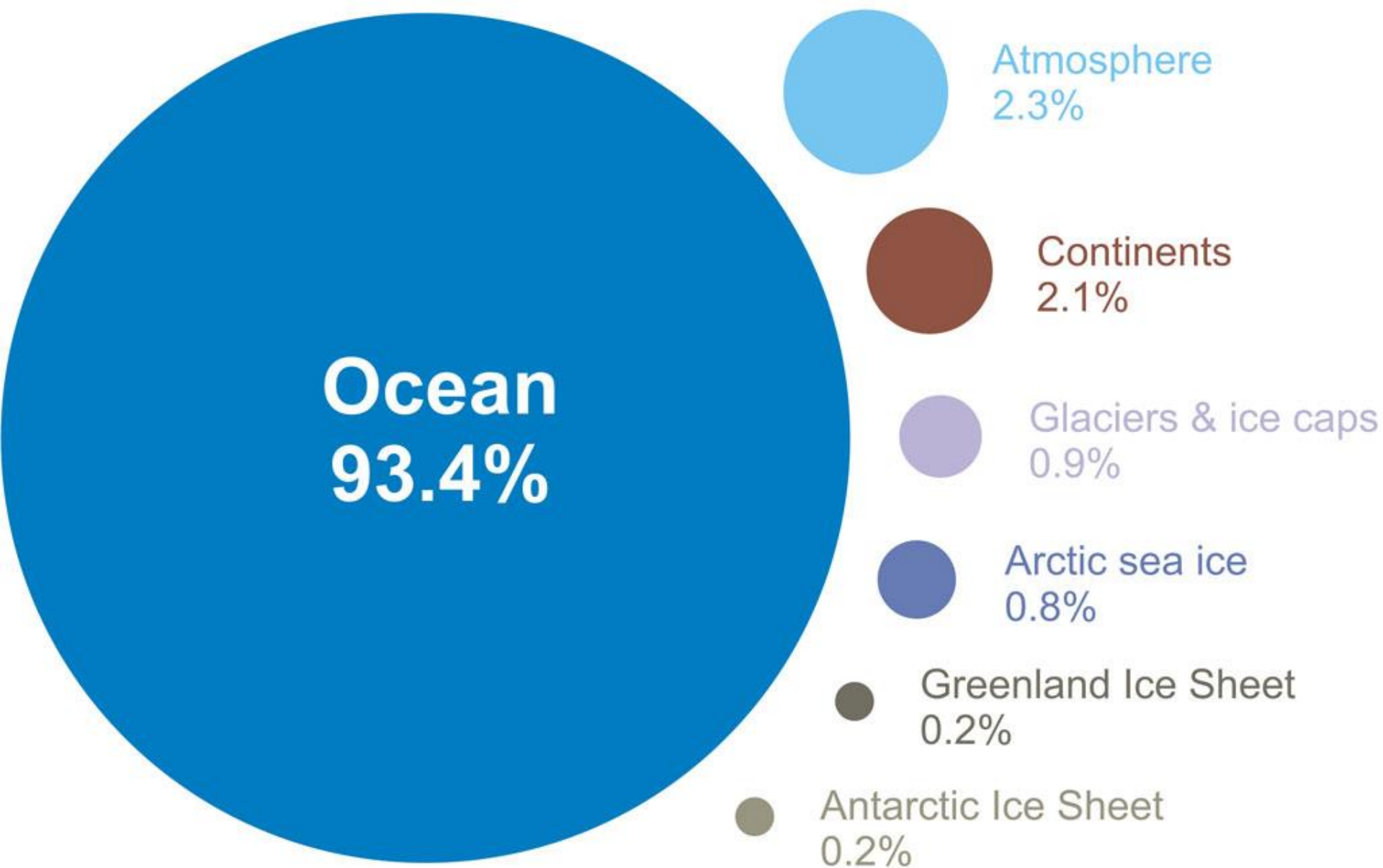
What the hell is going on?!
- Toby Garfield SWFSC



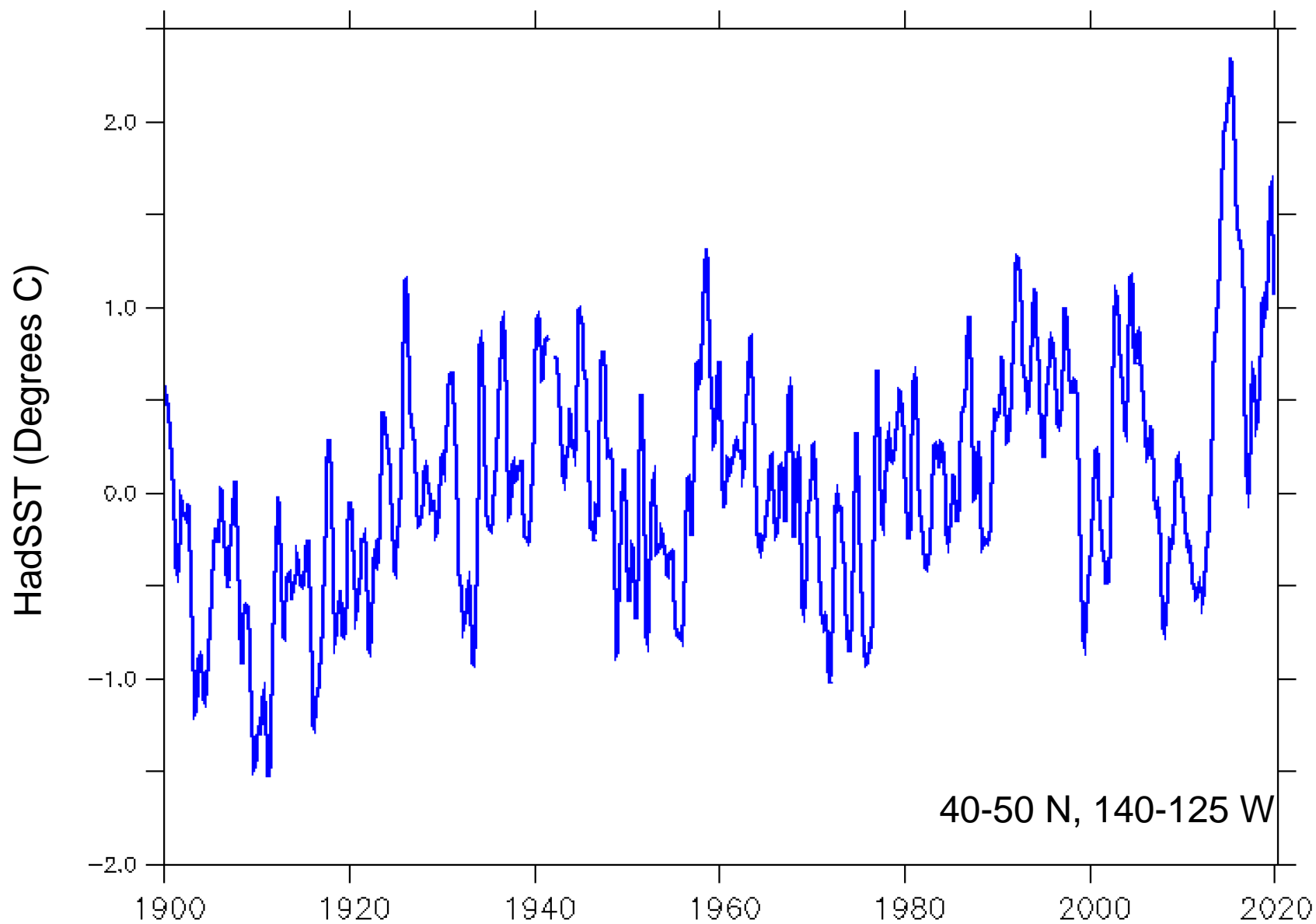
Historic warmth and low snowpack

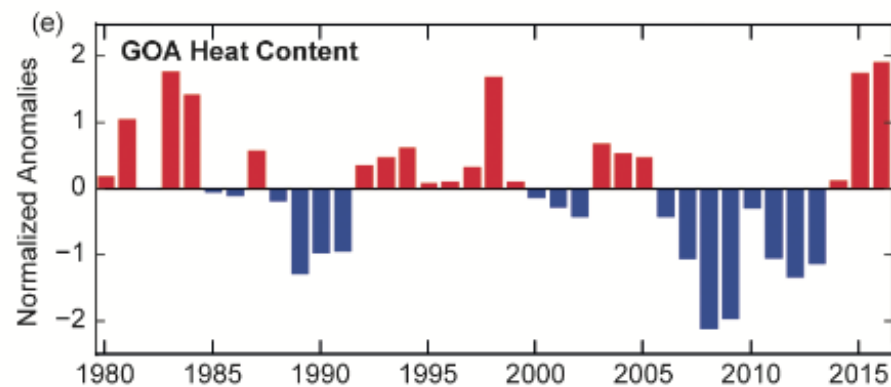
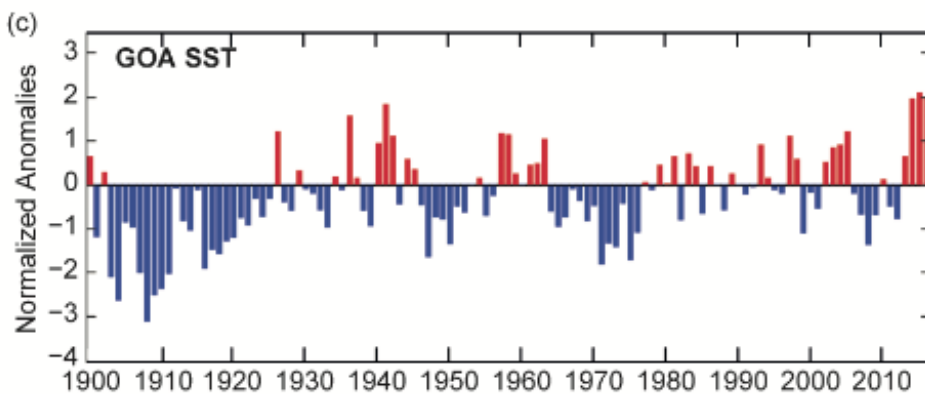
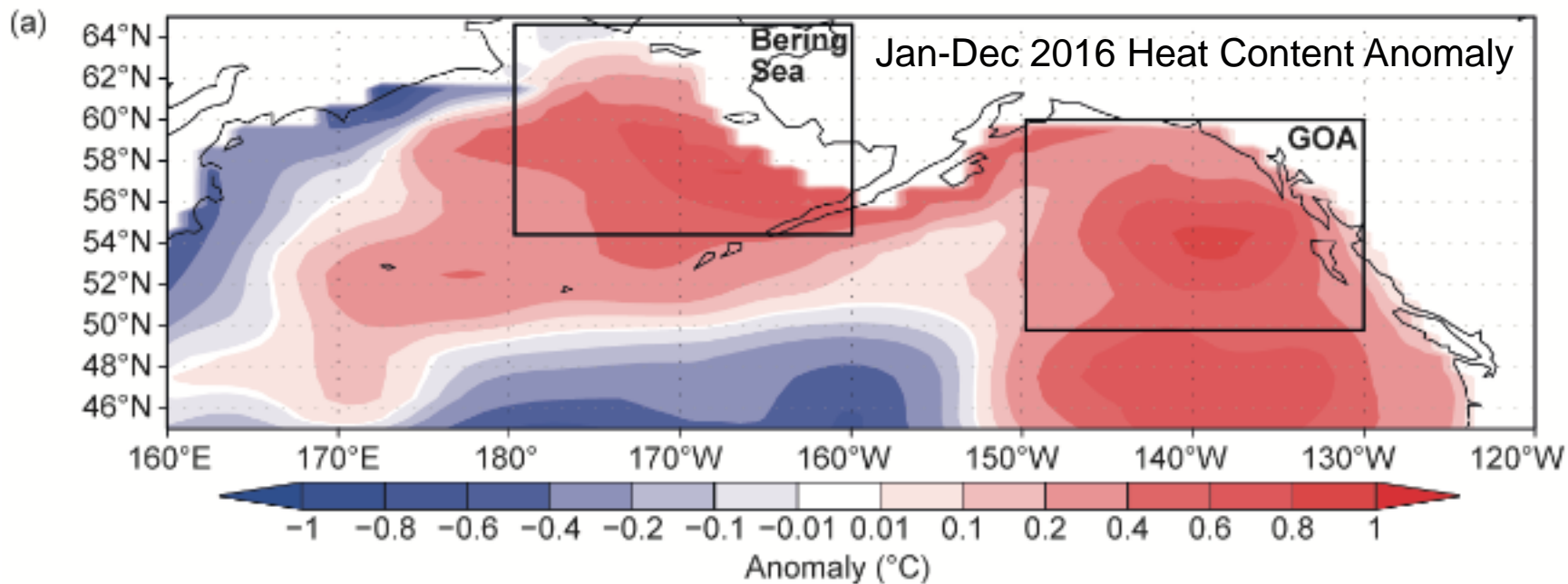


Where is global warming going?

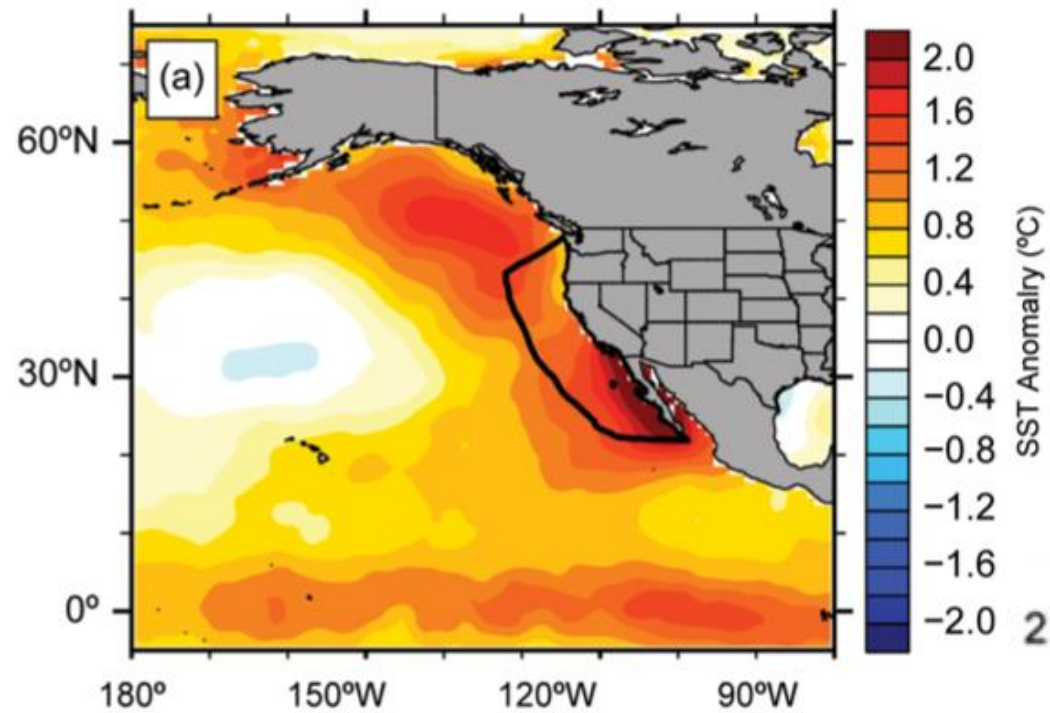


SST Anomalies Offshore of the Pacific NW

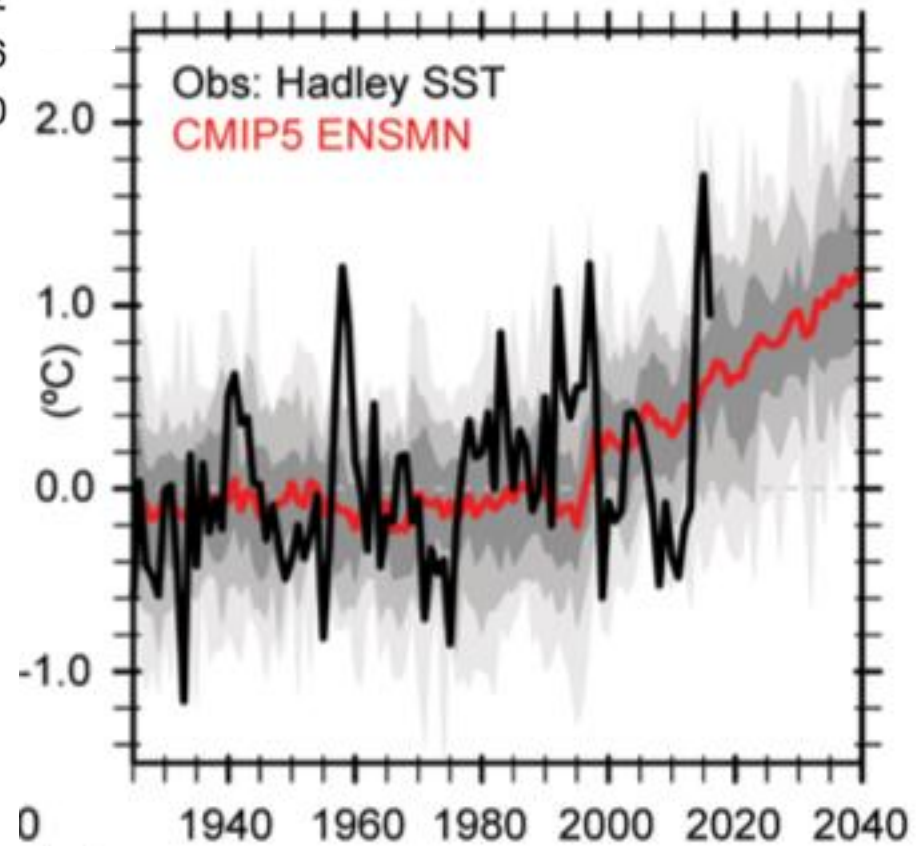




Jacox et al. (2018)



2014-16 SST Anomaly



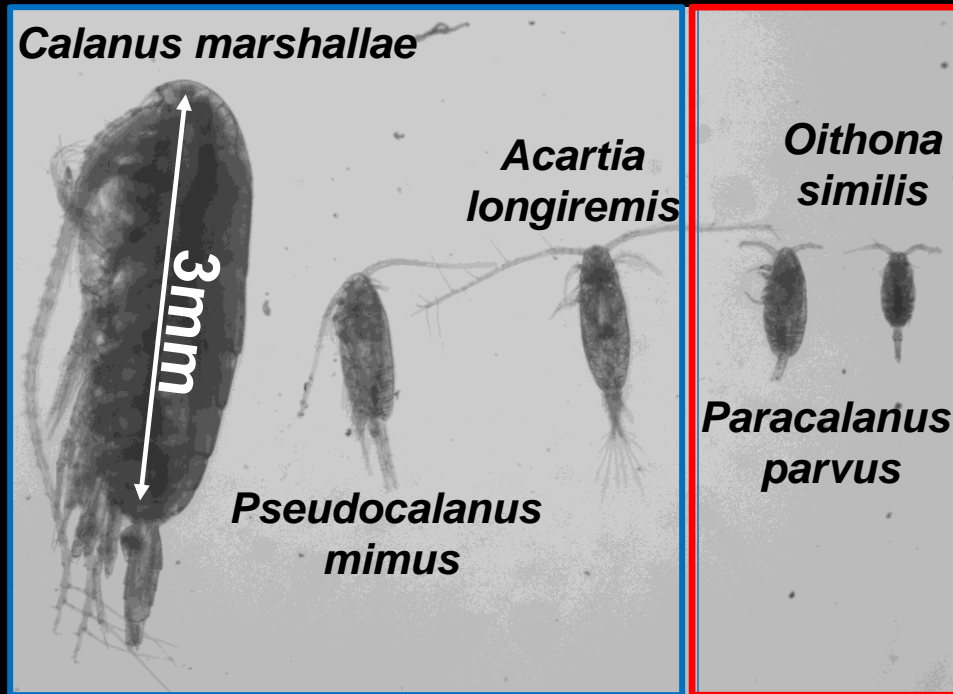
RECENT OCEAN CONDITION INDICATORS TREND

good fair poor

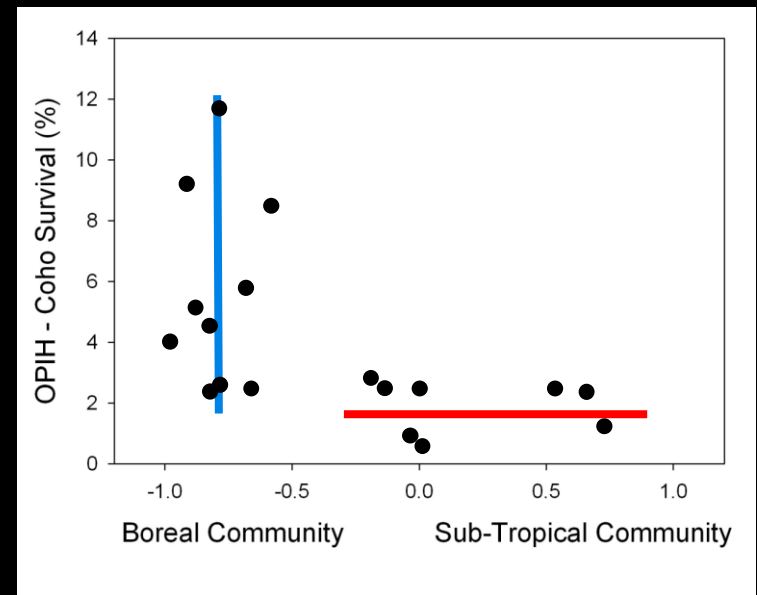
ECOSYSTEM INDICATORS		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
CLIMATE & ATMOSPHERIC	PDO (SUM; Dec-Mar)	good	fair	fair	poor	poor	poor	fair	poor	fair	good
	PDO (SUM; May-Sep)	good	fair	poor	poor	poor	poor	fair	poor	fair	good
	ONI (AVG; Jan-Jun)	good	fair	fair	poor	poor	fair	good	poor	poor	good
LOCAL PHYSICAL	SST NDBC Buoys (°C; May-Sep)	fair	poor	poor	poor	poor	fair	poor	poor	fair	good
	Upper 20 m T (°C; Nov-Mar)	good	fair	good	poor	poor	poor	fair	poor	good	good
	Upper 20 m T (°C; May-Sep)	good	poor	poor	poor	fair	fair	fair	poor	poor	good
	Deep Temp (°C; May-Sep)	good	fair	poor	poor	fair	poor	poor	poor	poor	good
	Deep Salinity (May-Sept)	fair	fair	poor	poor	fair	fair	good	fair	poor	good
LOCAL BIOLOGICAL	Copepod richness	good	good	fair	poor	poor	poor	fair	fair	good	good
	N copepod biomass	good	good	good	poor	poor	poor	fair	good	good	good
	S copepod biomass	fair	good	fair	poor	poor	poor	fair	fair	fair	good
	Biological transition	fair	good	good	poor	poor	poor	fair	fair	good	fair
	Nearshore Ichthyoplankton	good	fair	poor	fair	poor	fair	fair	poor	good	good
	Nearshore & offshore Ichthyoplankton	good	good	fair	poor	poor	poor	poor	poor	poor	fair
	Chinook salmon juvenile catch	good	good	fair	fair	poor	poor	fair	fair	poor	fair
	Coho salmon juvenile catch	poor	good	fair	fair	fair	poor	good	fair	fair	fair
MEANS & RANKS	Mean of ranks	6.6	9.3	14.2	20.4	19.8	18.3	13.4	17.3	13.2	6.0
	Rank of the mean rank	good	fair	fair	poor	poor	poor	fair	poor	fair	good

Not all copepods are tasty and filling!

Boreal species =
larger and lipid filled



Copepod Community
relates to salmon survival:



← Cold years → Warm years

Julie Keister UW

The Ocean and Cryosphere in a Changing Climate

This Summary for Policymakers was formally approved at the Second Joint Session
of Working Groups I and II of the IPCC and accepted by the 51th Session of the IPCC,
Principality of Monaco, 24th September 2019

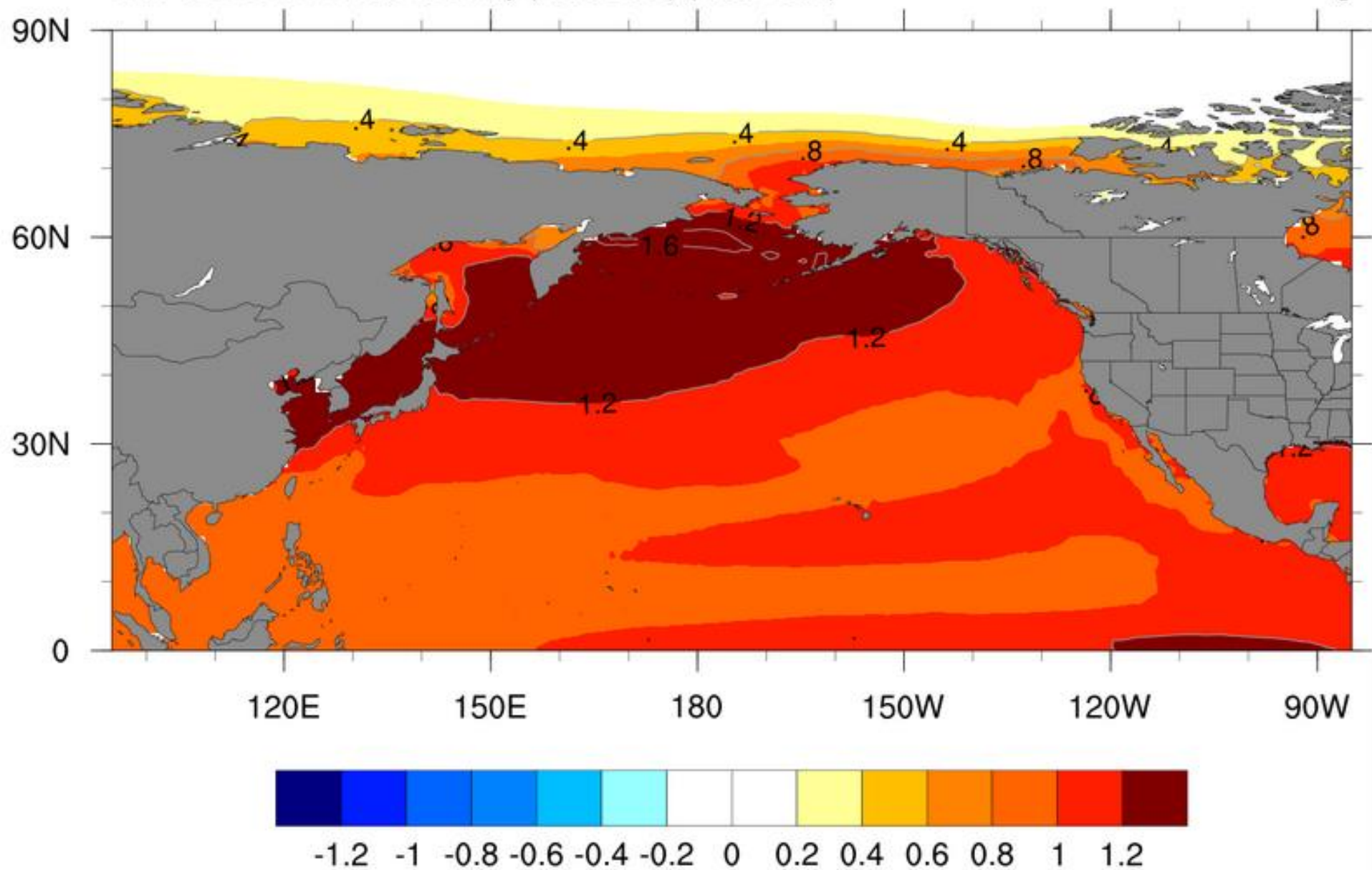
Summary for Policymakers



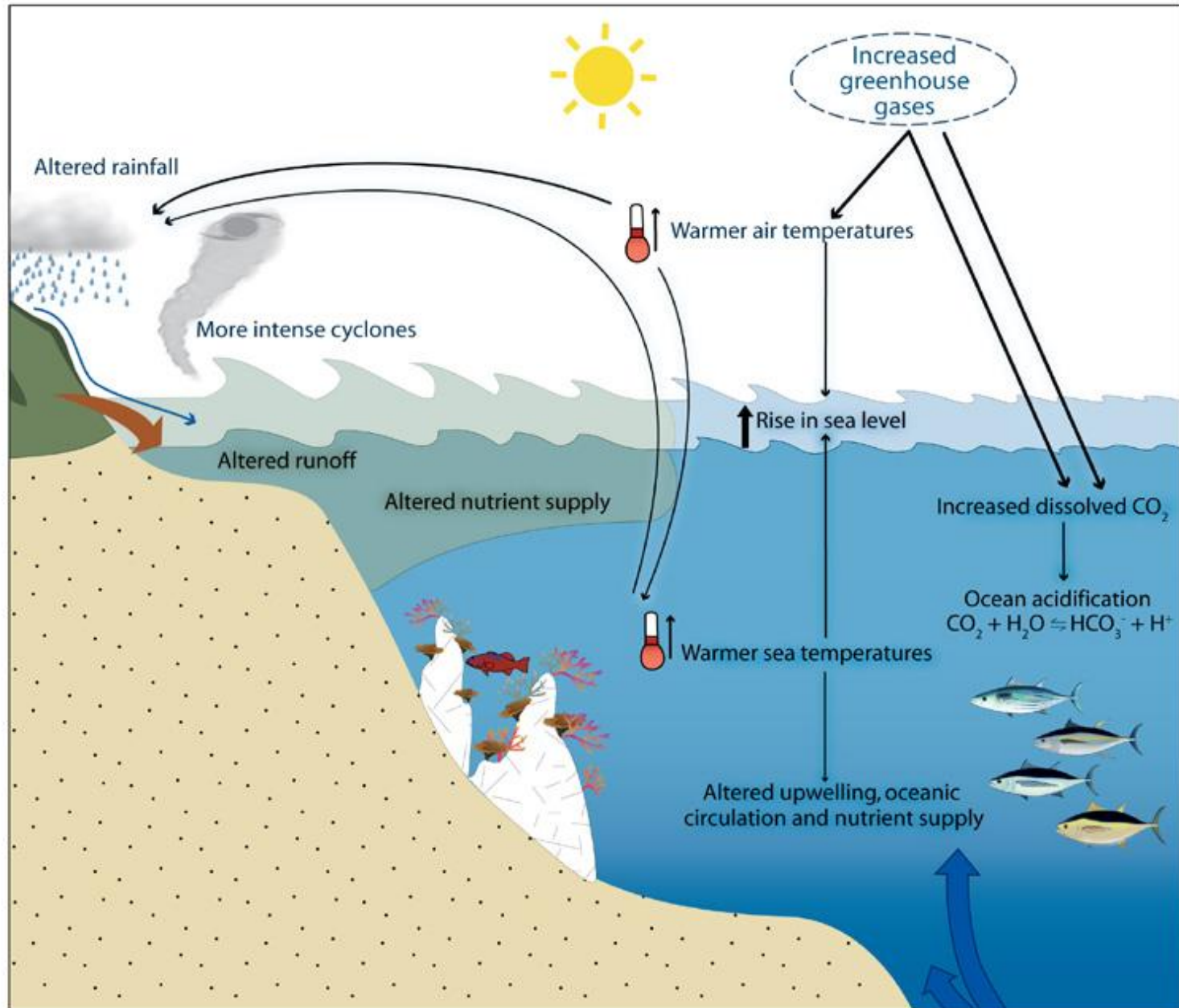
Projected Change in SST (Ensemble Model Average)

CMIP5 ENSMN RCP8.5 anomaly (2006-2055)-(1956-2005)

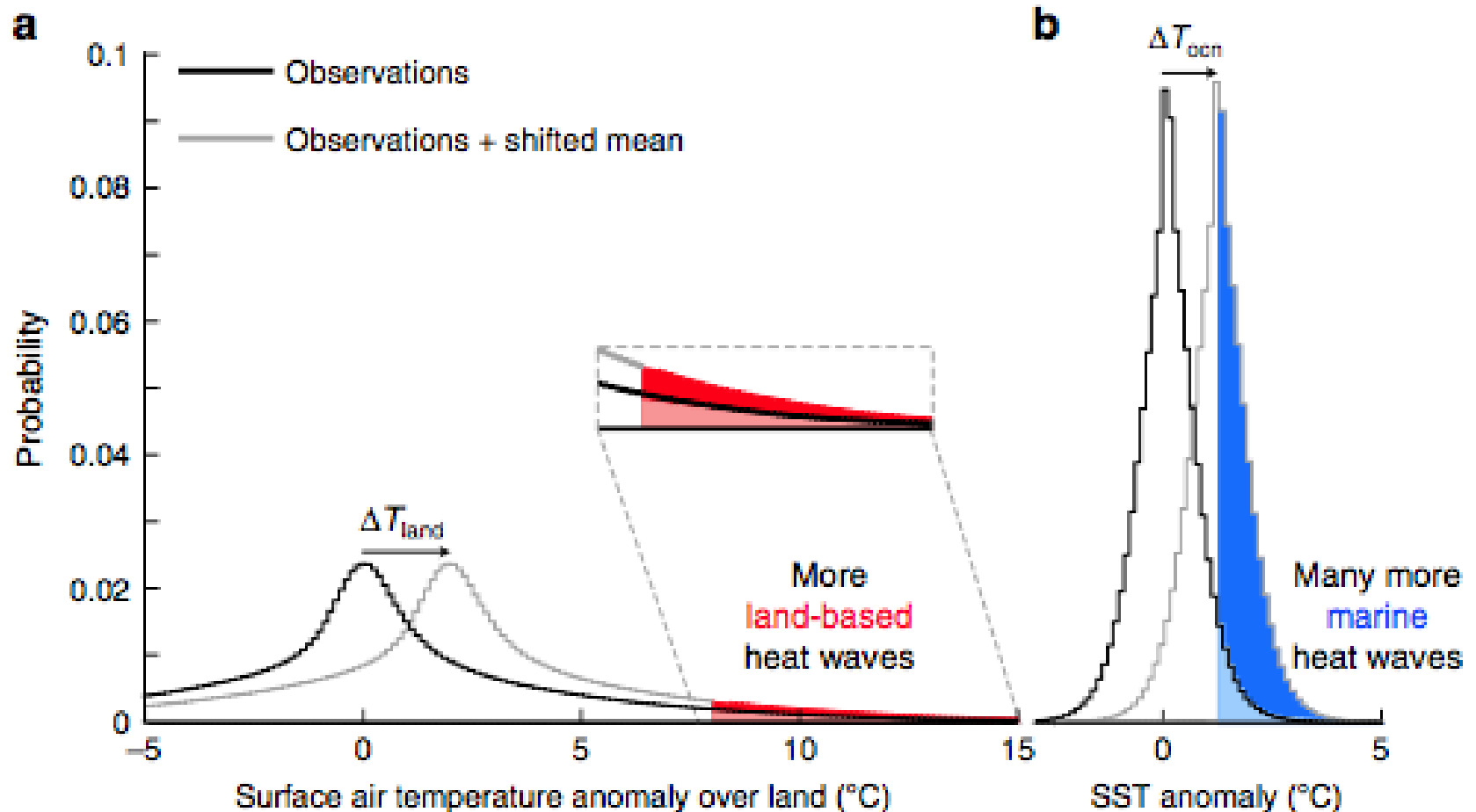
C



Temperature is not all that is changing for the ocean!

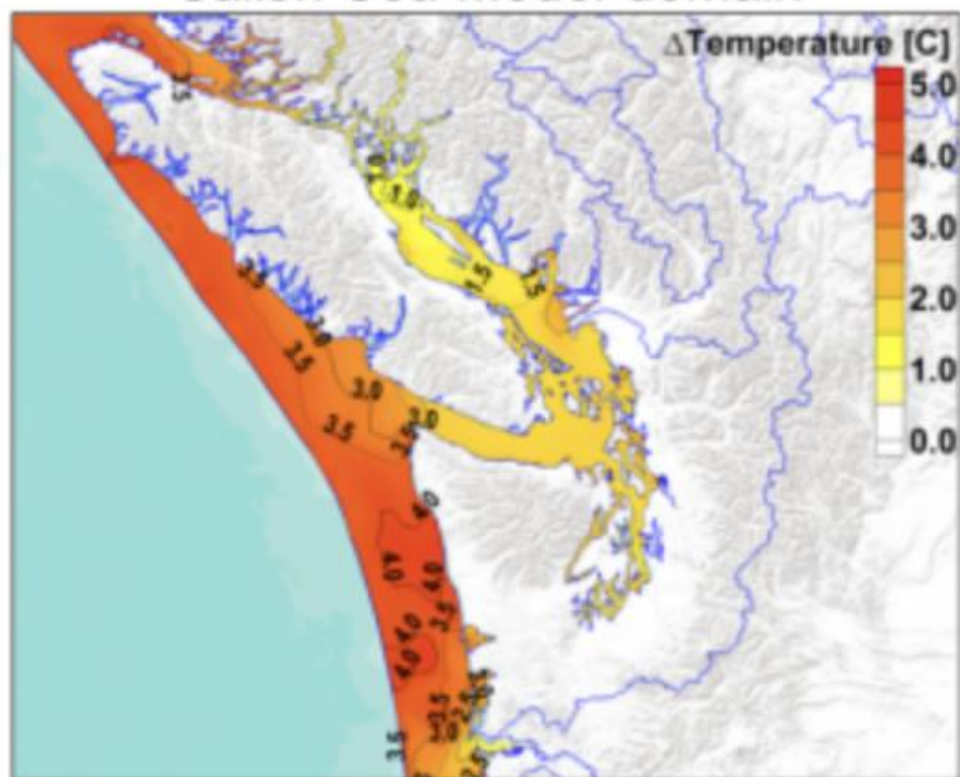


Heat waves (temperatures exceeding 95th percentile level of the present climate) are apt to occur more frequently in the ocean

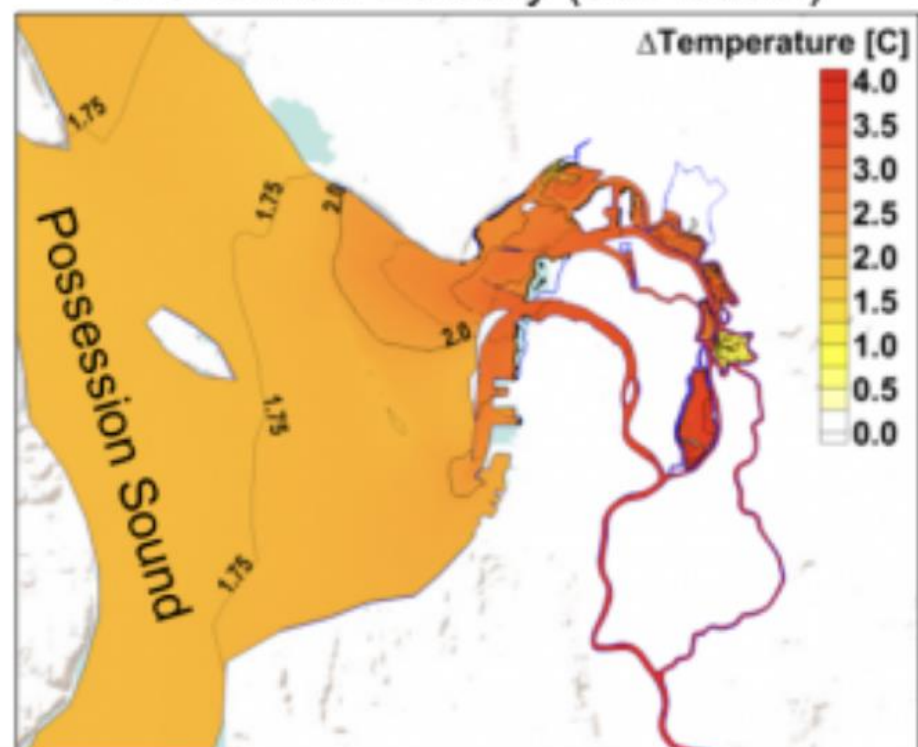


Emerging Risks from Marine Heat Waves - Frolicher and Laufkötter (2018)

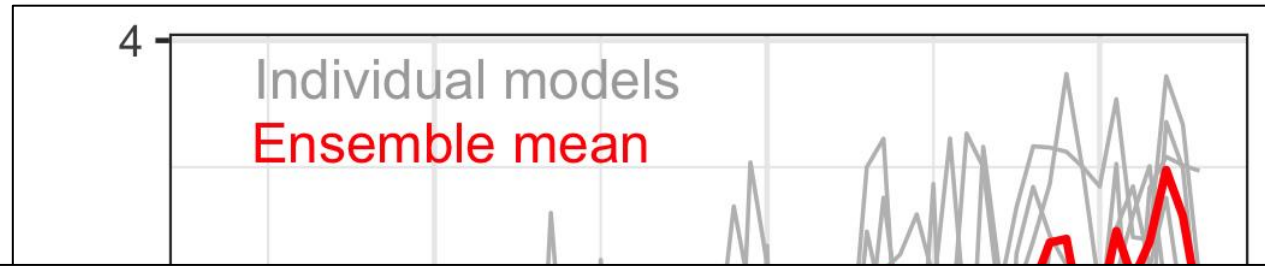
Δ Surface Temperature
RCP 8.5 (2095) - Historical (2000)
Salish Sea Model domain



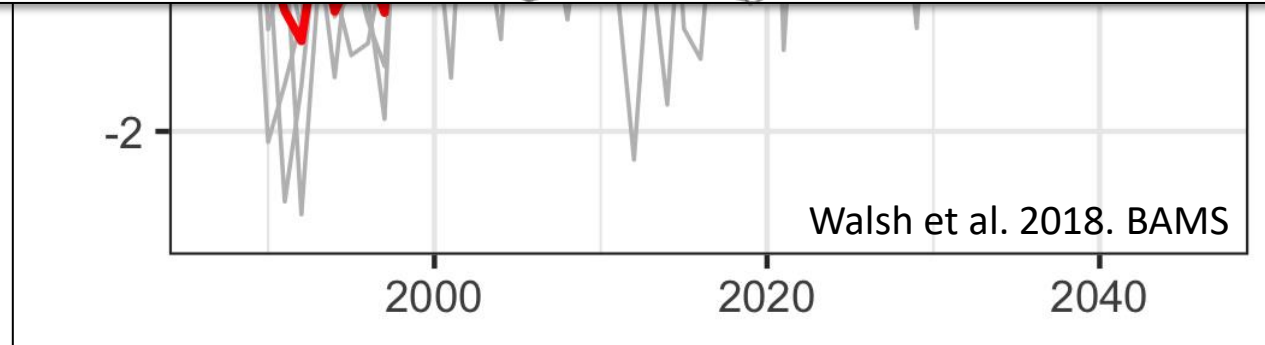
Snohomish Estuary (sub-basin)



NE Pacific Sea Surface Temperatures Historical and Projected

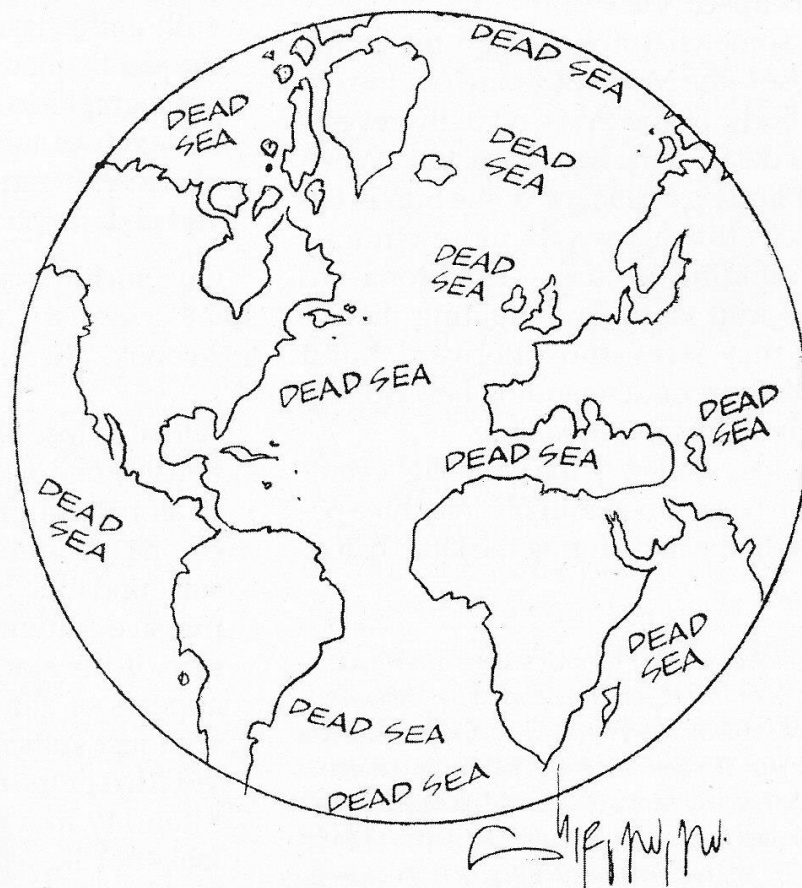


Novel climates = new combinations of climate variables





TODAY

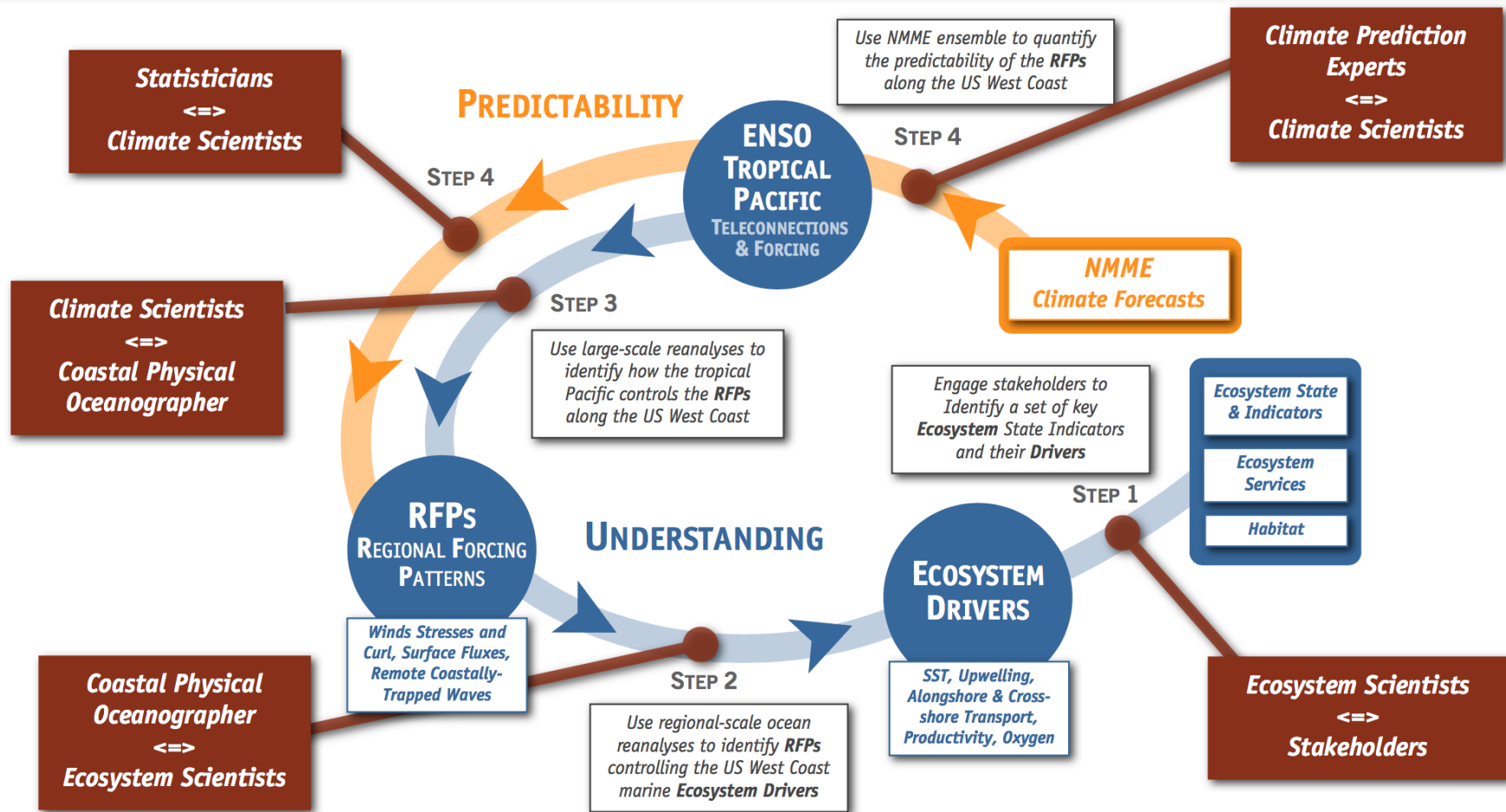


TOMORROW?

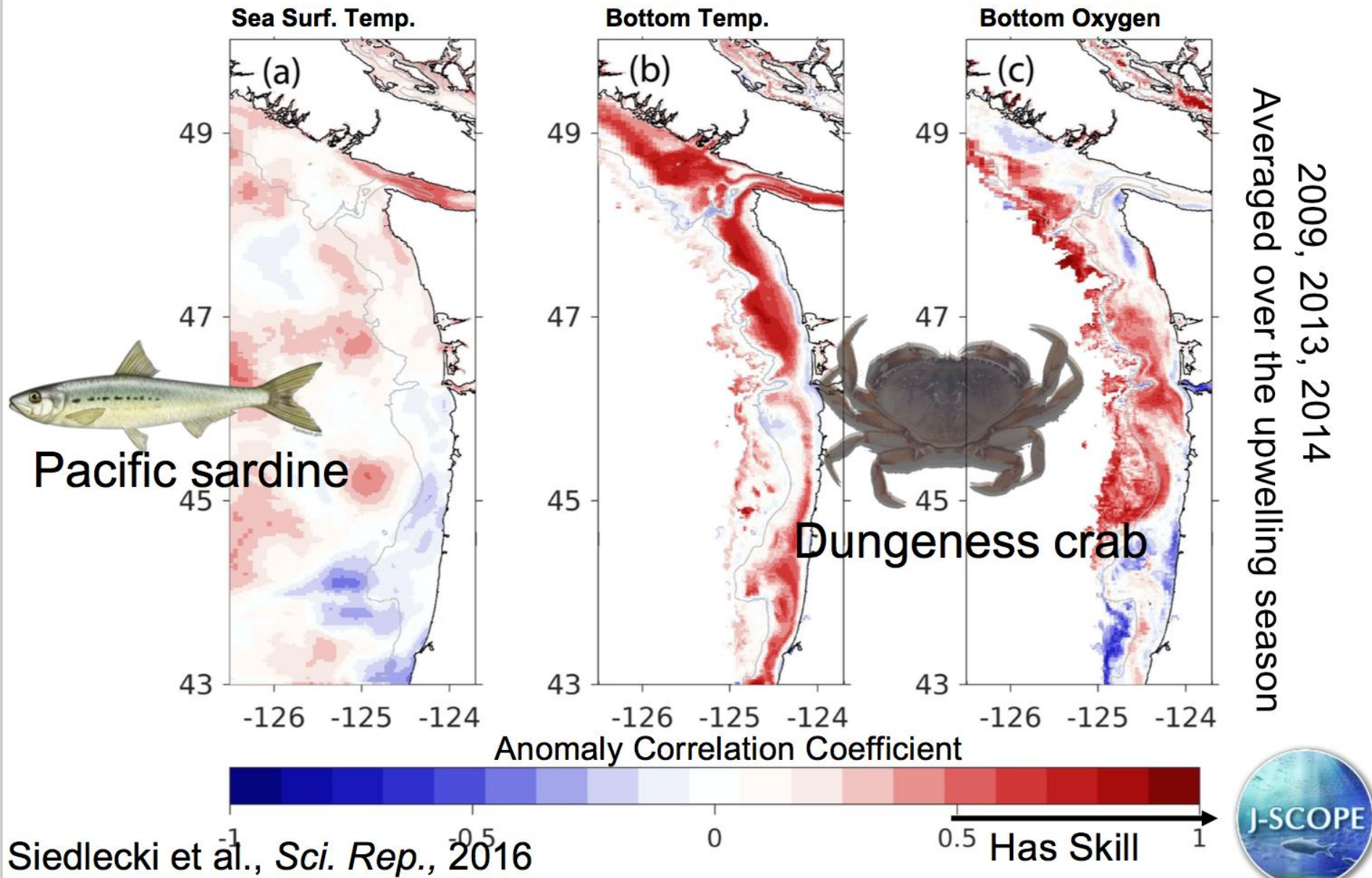
Could the Blob have been
predicted?

New Efforts to Provide Seasonal Marine Ecosystem Predictions

FRAMEWORK FOR PREDICTABILITY & UNDERSTANDING OF MARINE ECOSYSTEMS ALONG THE U.S. WEST COAST

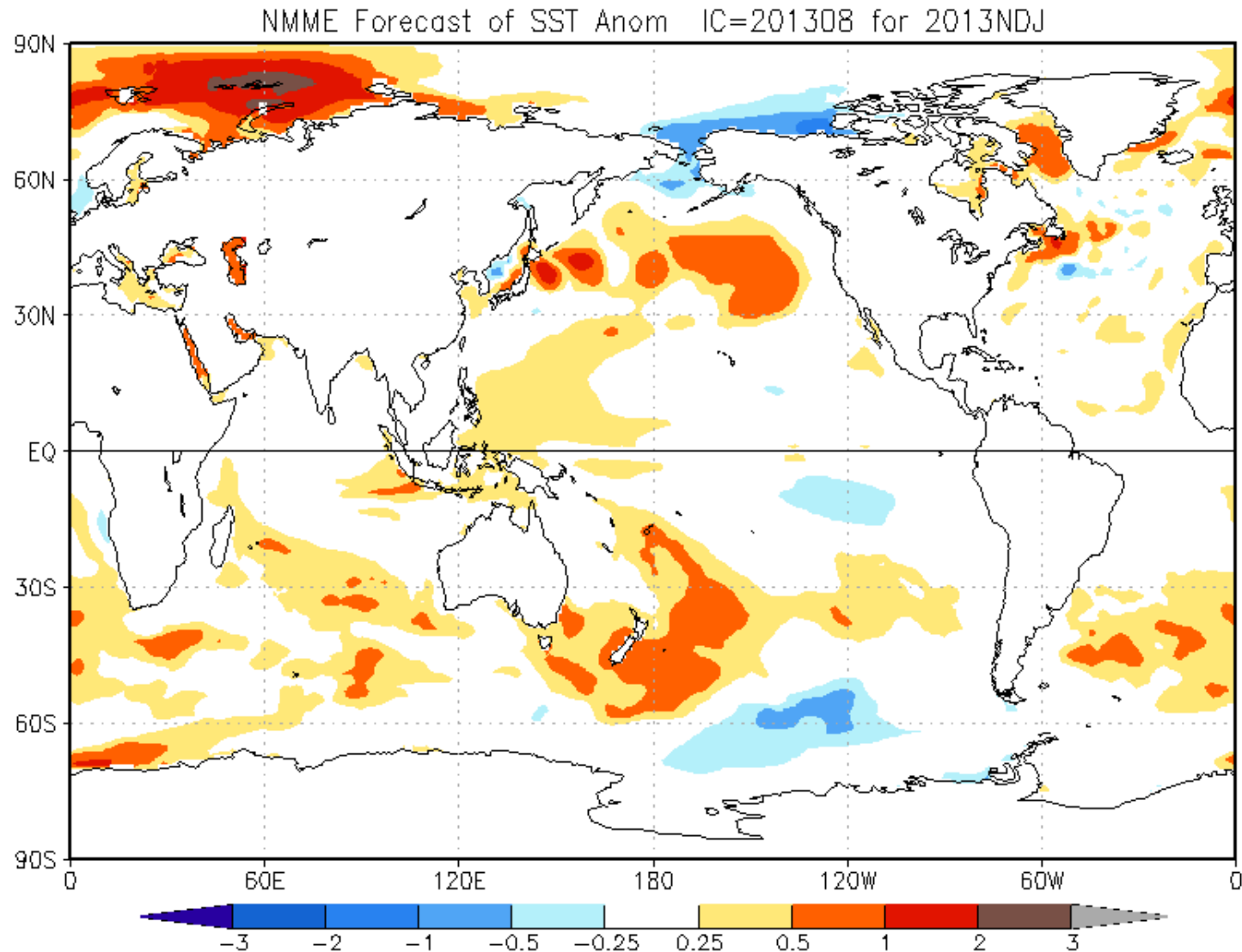


Forecasts show ocean conditions are predictable on seasonal timescales

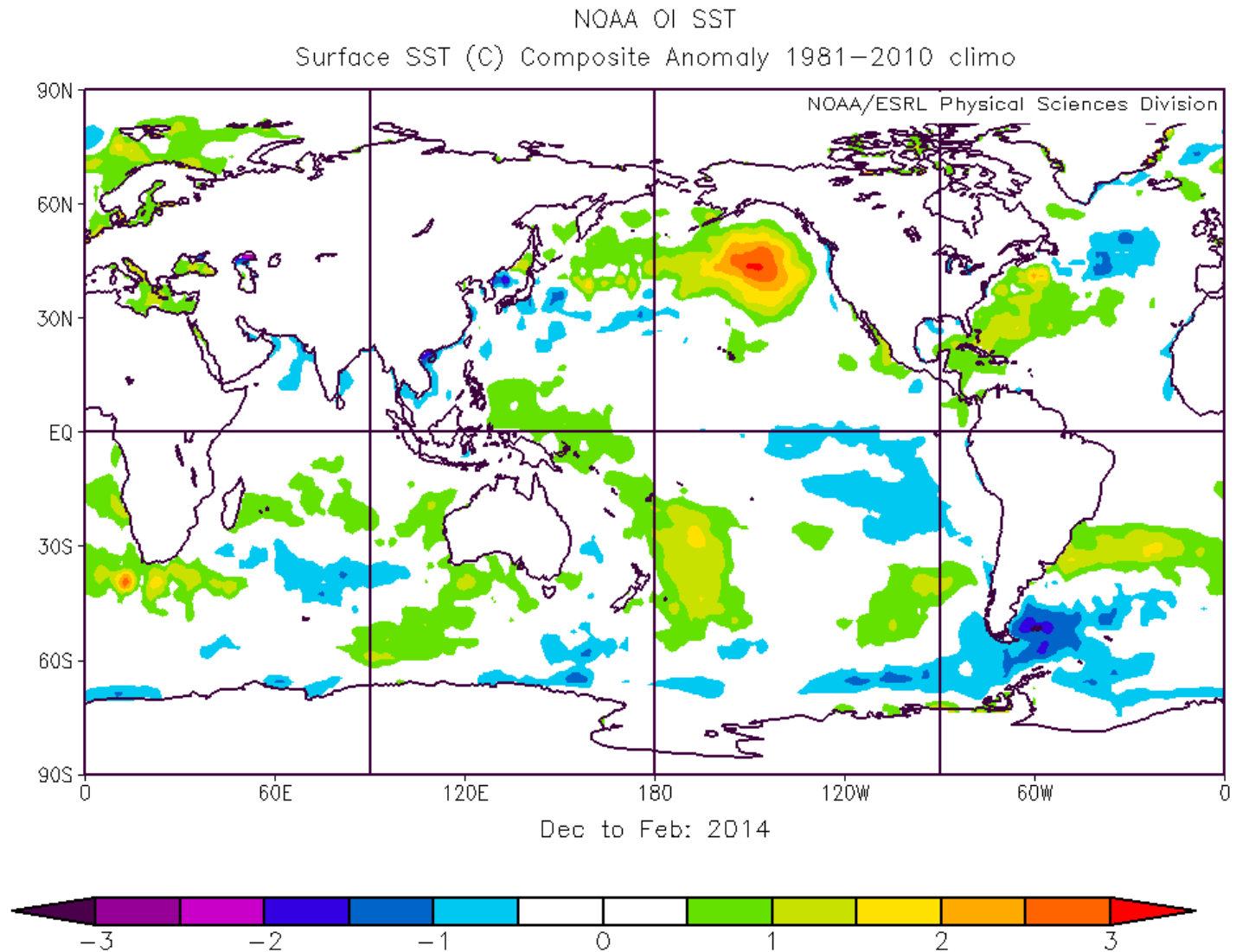


NMME SST Anomalies

August 2013 for DJF 2013-14

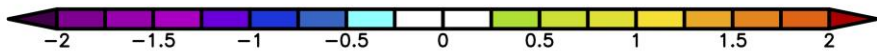
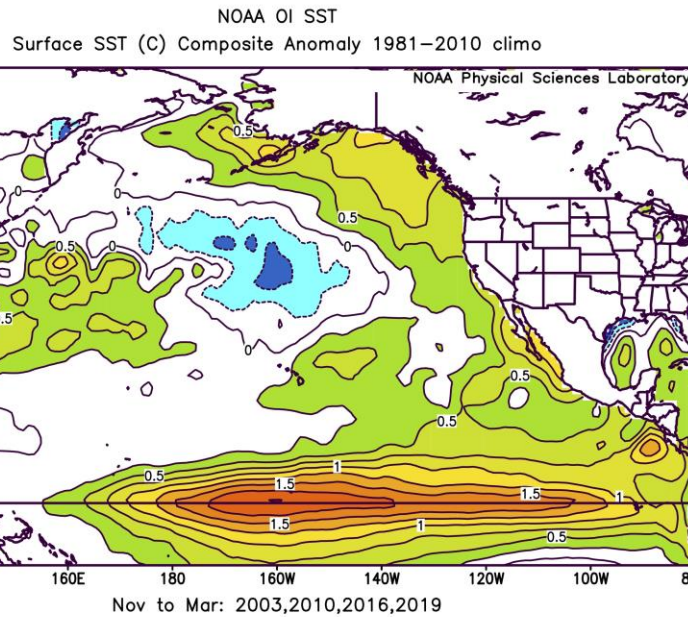


DJF 2013-14 observed SST Anomalies

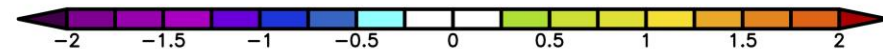
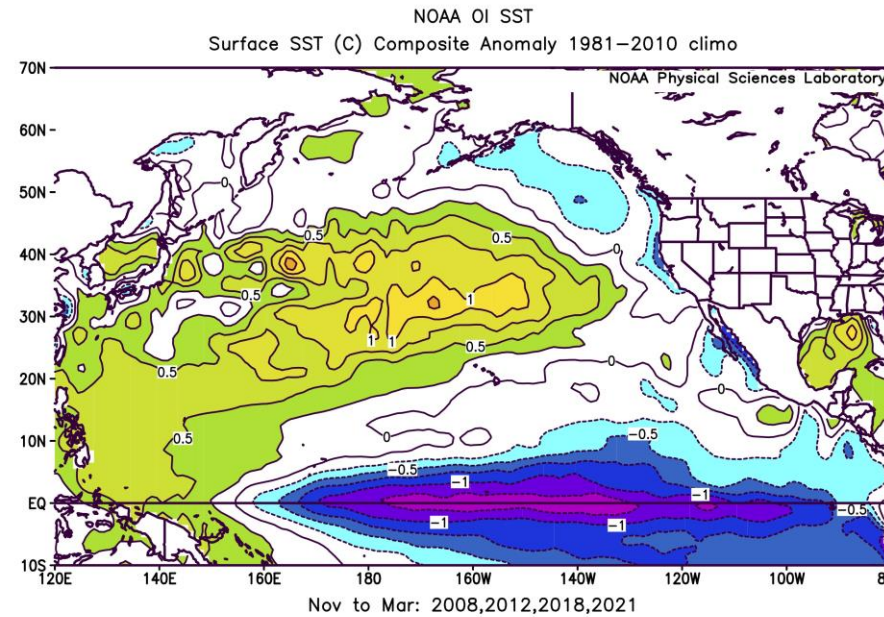


Composite Sea Surface Temperature Anomalies

El Nino (last 4)



La Nina (last 4)



Final Remarks

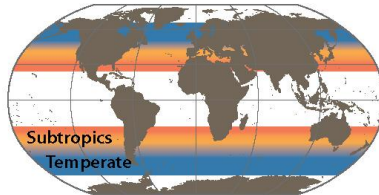
- A marine heat wave (MHW) of unprecedented intensity and duration occurred in the NE Pacific during 2014-16.
- It was especially severe because of the baseline warming that has occurred; comparable events are apt to become increasingly frequent in future decades.
- There appears to be *some* predictability for the waters of the NE Pacific on time horizons as long as 6-12 months.

Back-Up Slides

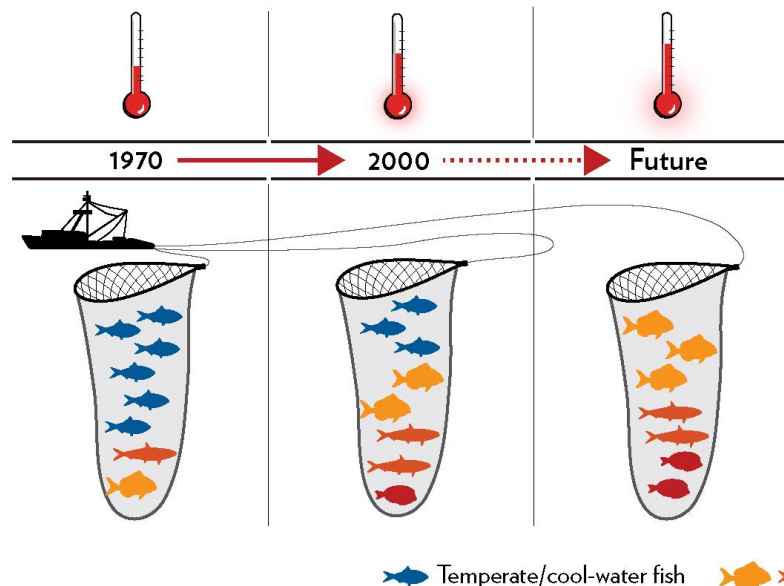
Warming Oceans Are Reshaping Fisheries

Marine species are gradually moving away from the equator into cooler waters, and, as a result, species from warmer waters are replacing those traditionally caught in many fisheries worldwide. Scientific studies show that this change is related to increasing ocean temperatures.

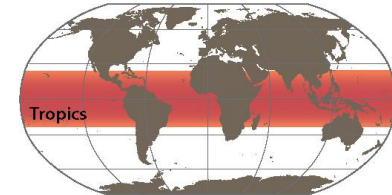
Subtropic and temperate ocean



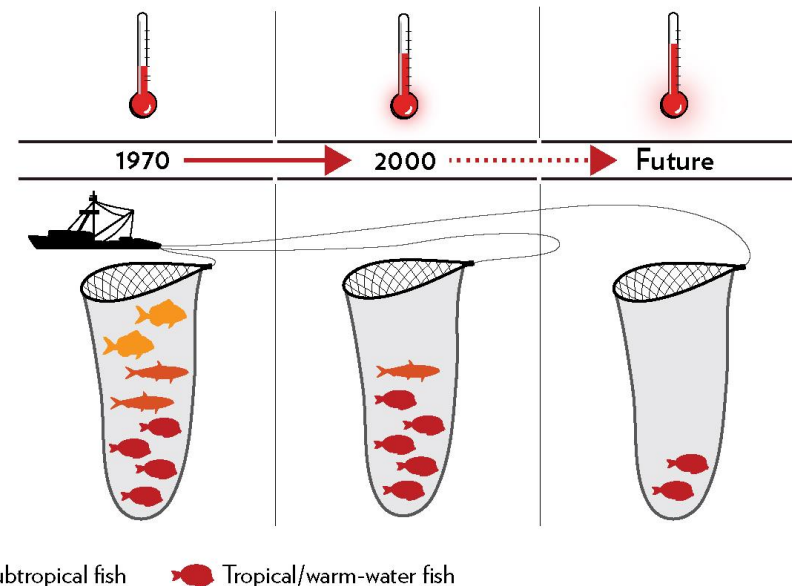
From 1970 to 2006, as open temperatures were rising, catch composition in the subtropic and temperate areas slowly changed to include more warm-water species and fewer cool-water species.



Tropics



In the tropics, the catch composition changed from 1970 to 1980 and then stabilized, likely because there are no species with high enough temperature preferences to replace those that declined.



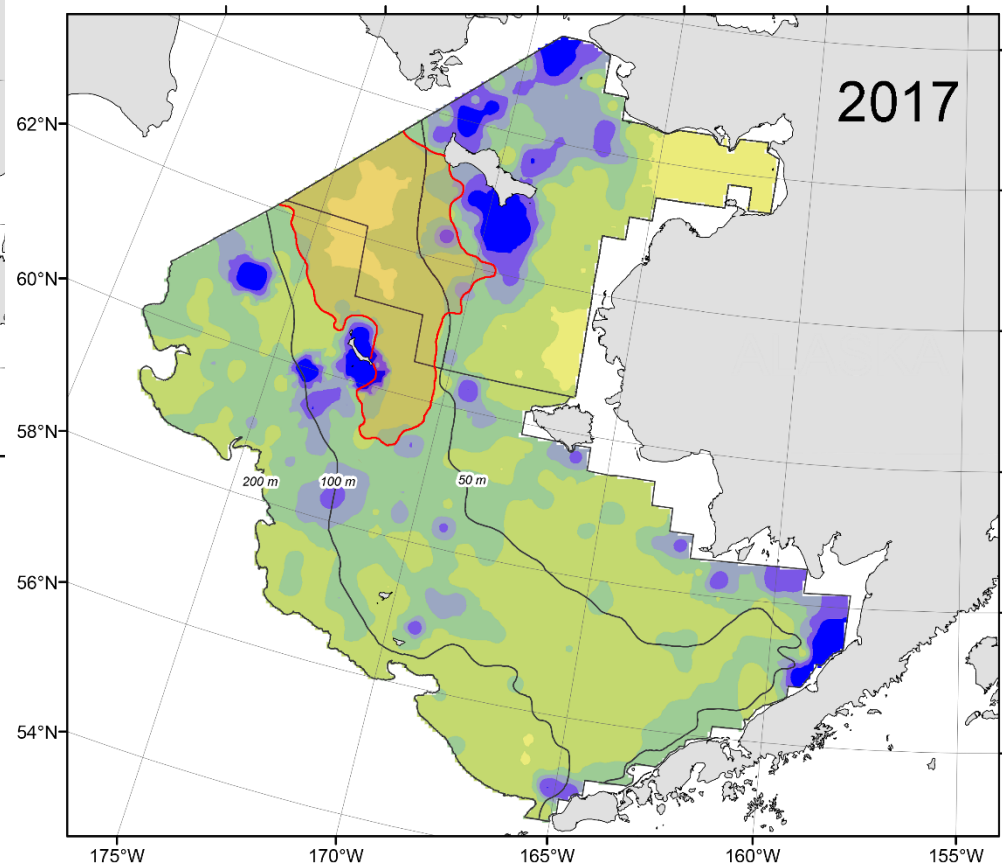
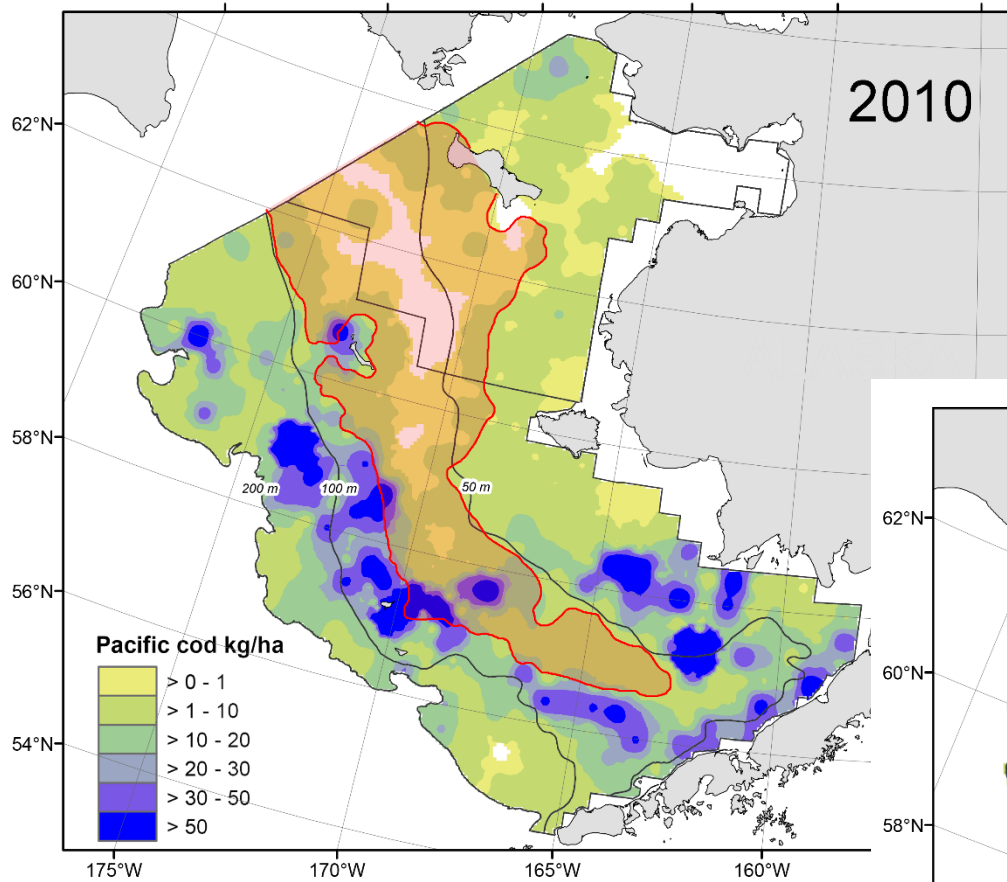
These shifts could have negative effects including loss of traditional fisheries, decreases in profits and jobs, conflicts over new fisheries that emerge because of distribution shifts, food security concerns, and a large decrease in catch in the tropics.

This graphic presents concepts from: Cheung, WWL., R. Watson and D. Pauly. 2013. Signature of ocean warming in global fisheries catch. *Nature*. DOI:10.1038/nature12156.

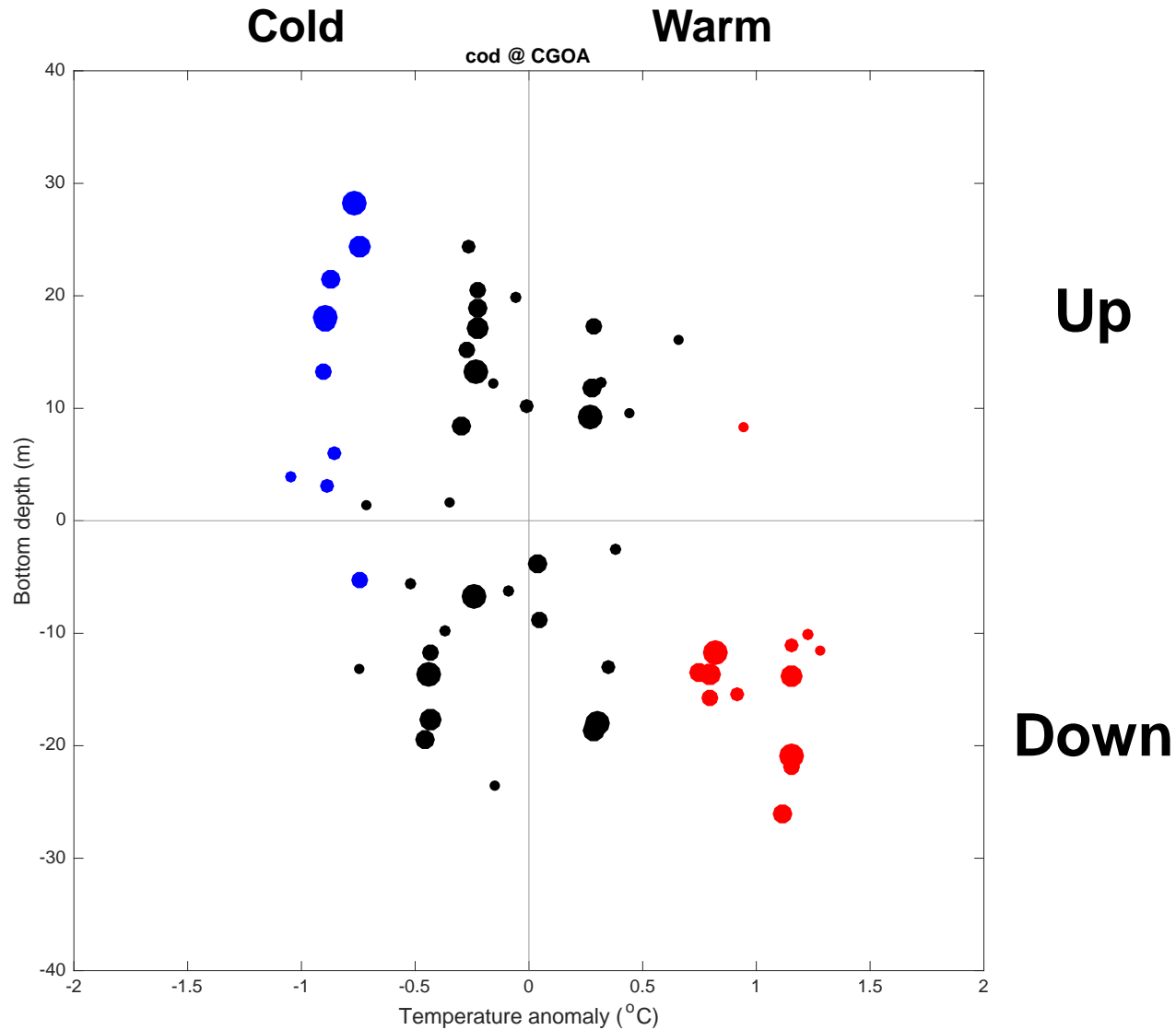
The thermometers are representative of trends in ocean temperature over time and the fish are representative of trends in catch composition over time. They do not represent specific values. Please consult the results section of Cheung et al. (2013) for exact data points.

Graphic by The Pew Charitable Trusts' ocean science division, www.pewenvironment.org/research-programs

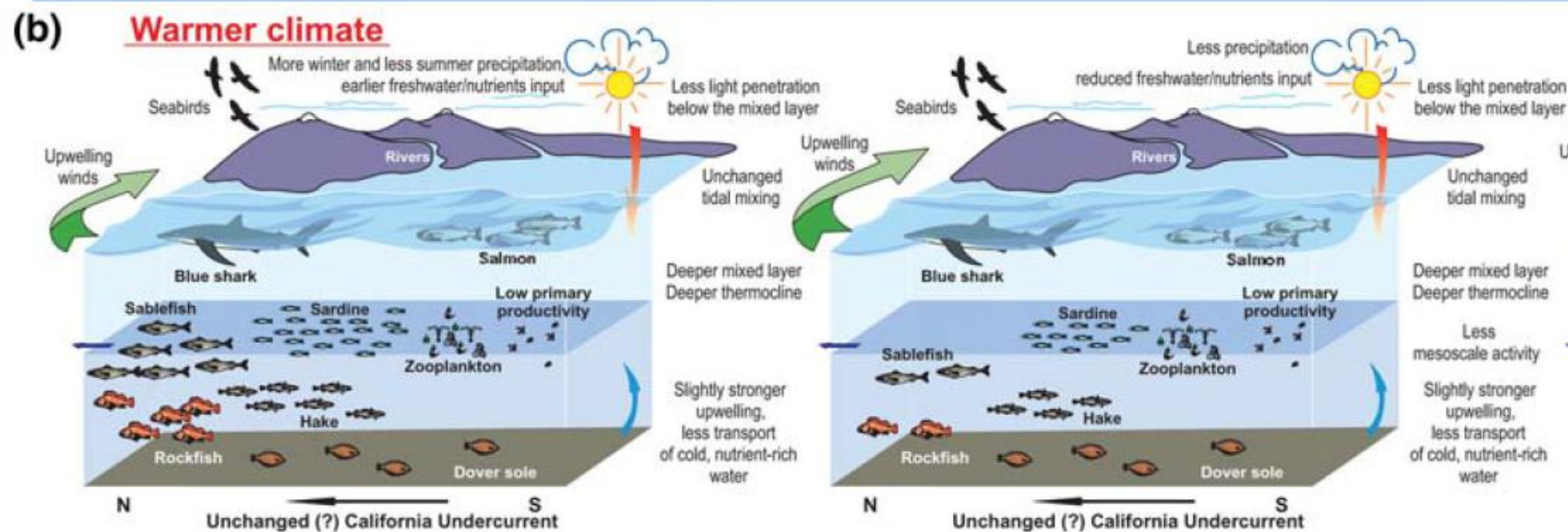
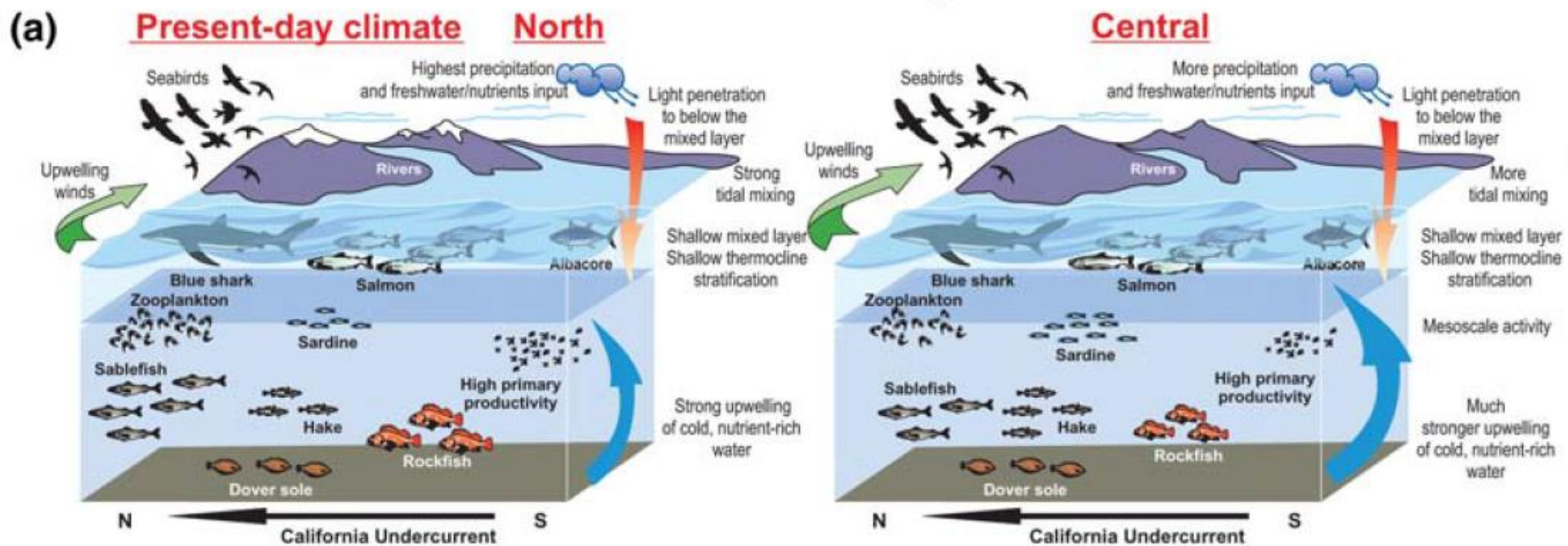
Pacific Cod Distribution



Pacific Cod and their Vertical Displacements in the Central GOA (near Kodiak Is.)

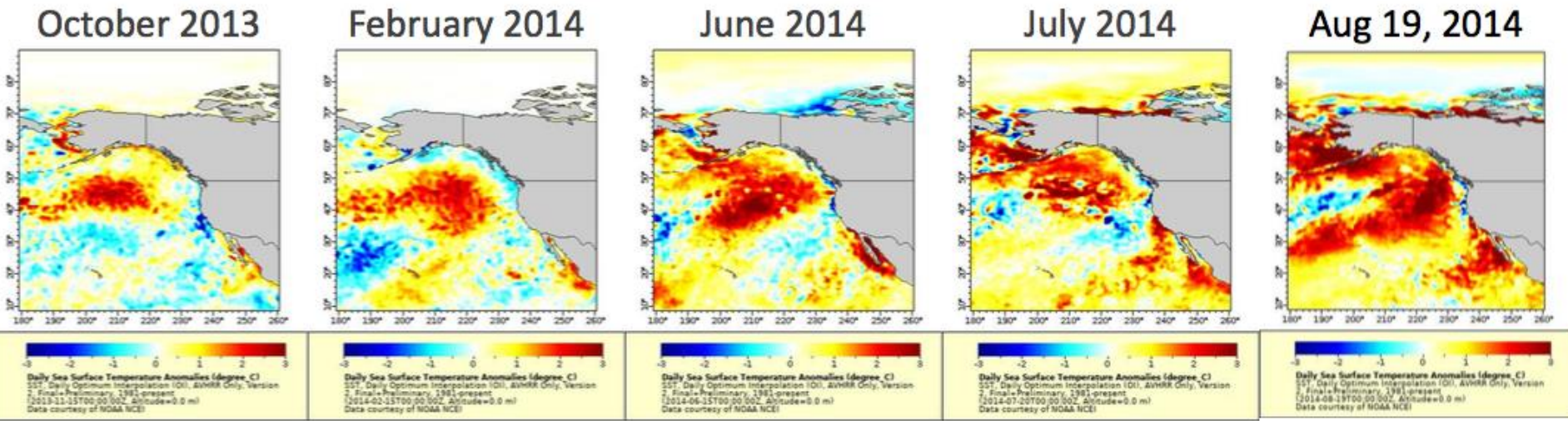


The bigger the dot, the bigger the fish (10 to 70+ cm) Yang et al. (2019)



MHW of 2019 versus “The Blob”: SST Anomalies

The Blob



2019 MHW

