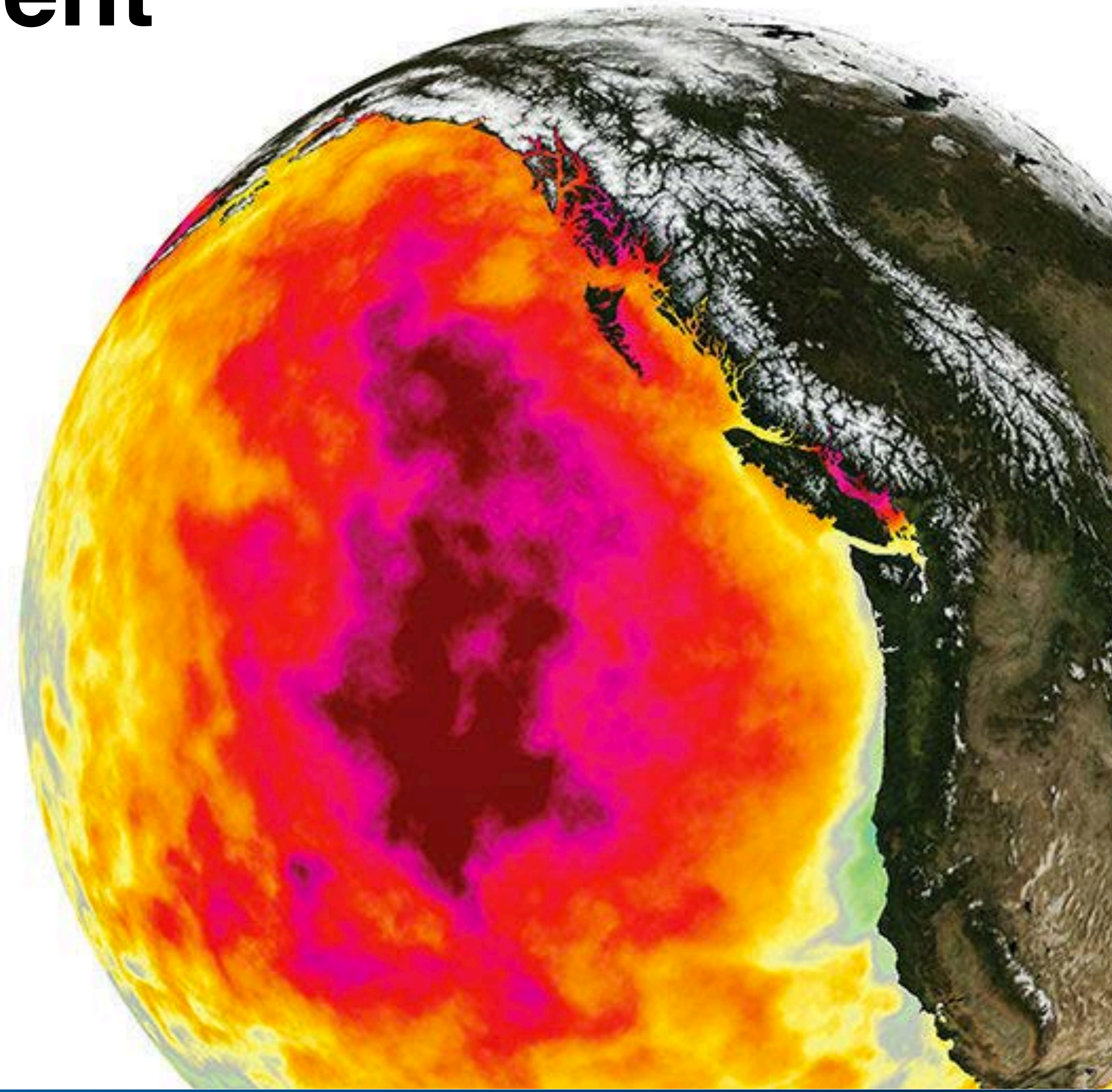
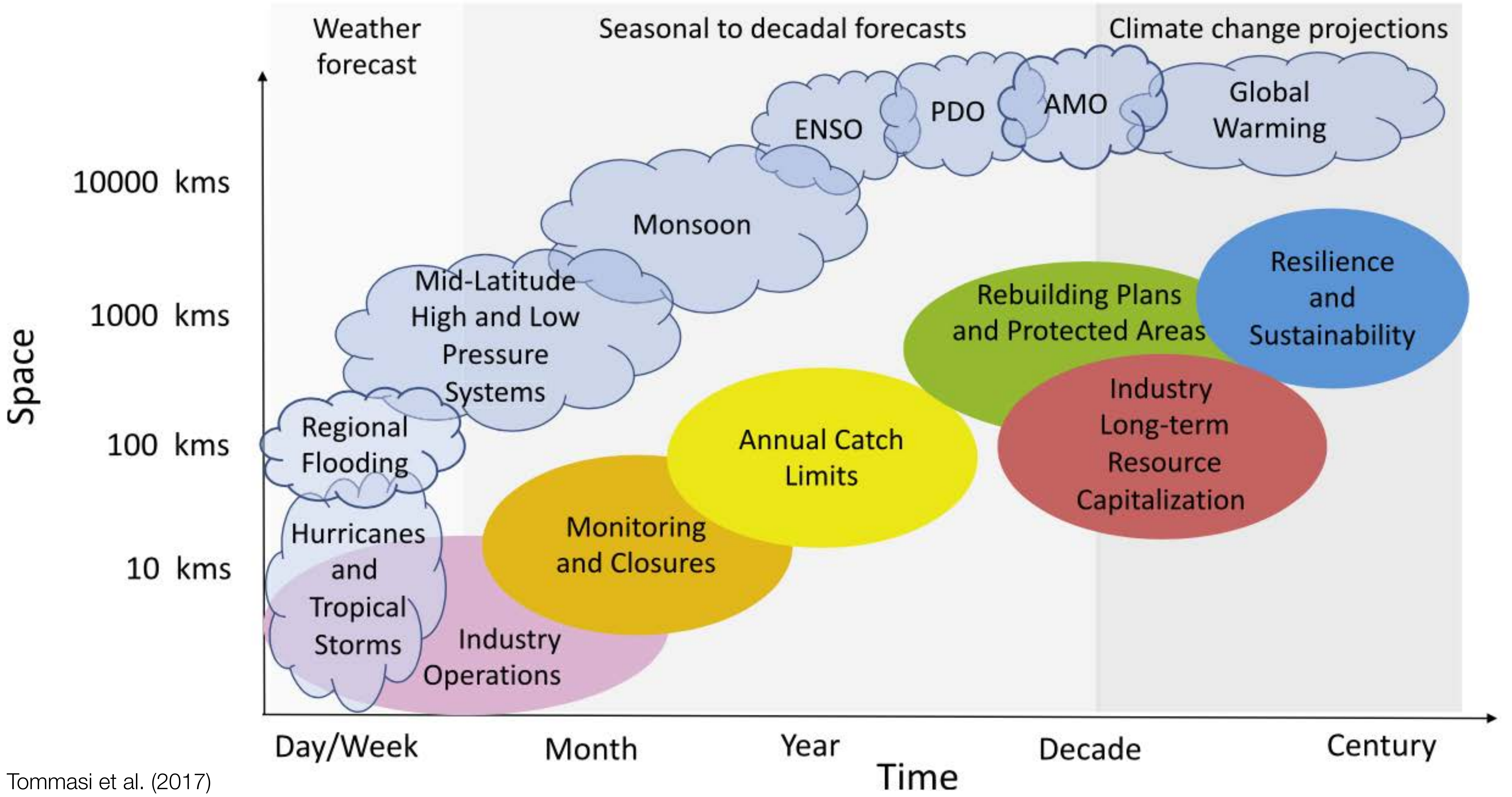
Application of Climate Predictions to Marine Ecosystem Management



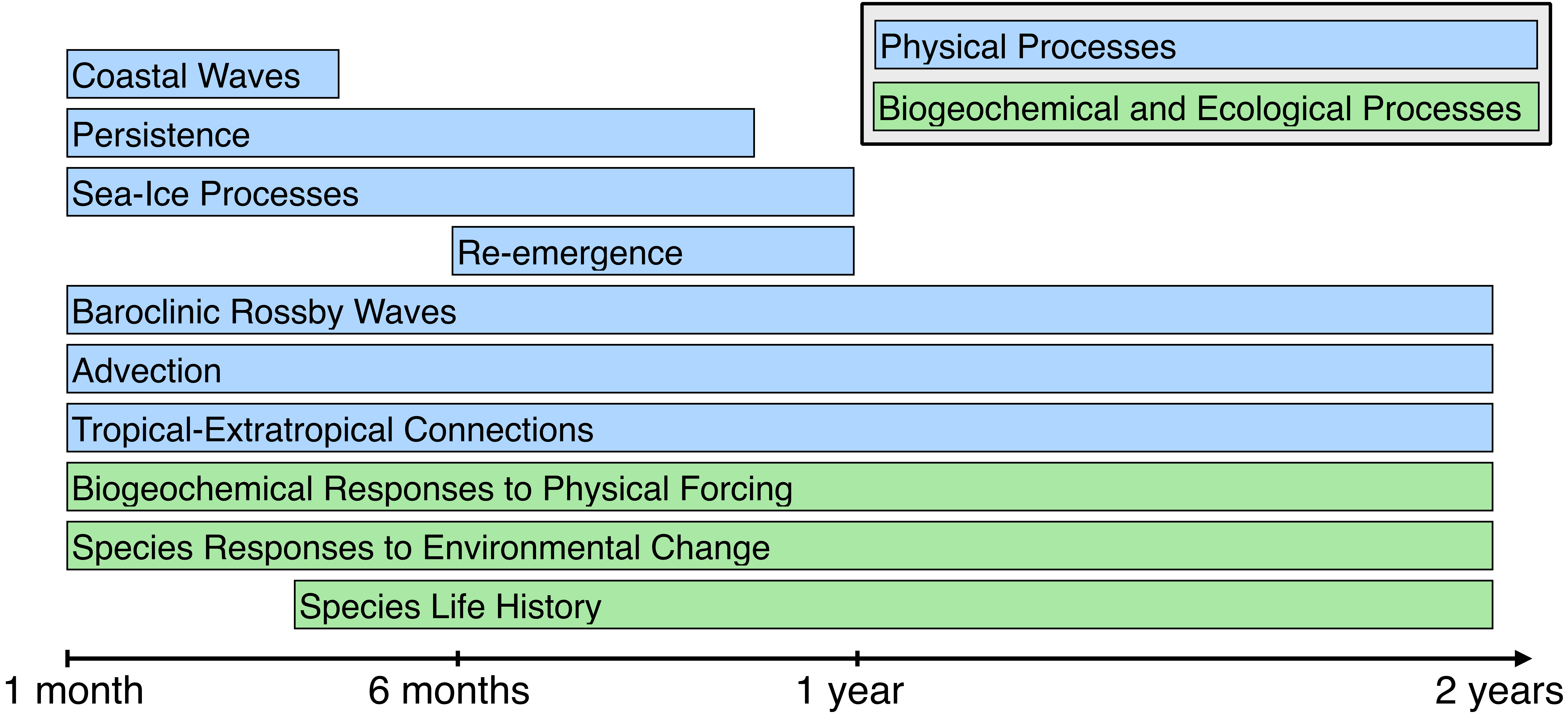
Mike Jacox
NOAA Southwest Fisheries Science Center
NOAA Physical Sciences Laboratory

March 28, 2023
WCRP Symposium
Frontiers in Seasonal to Decadal Prediction



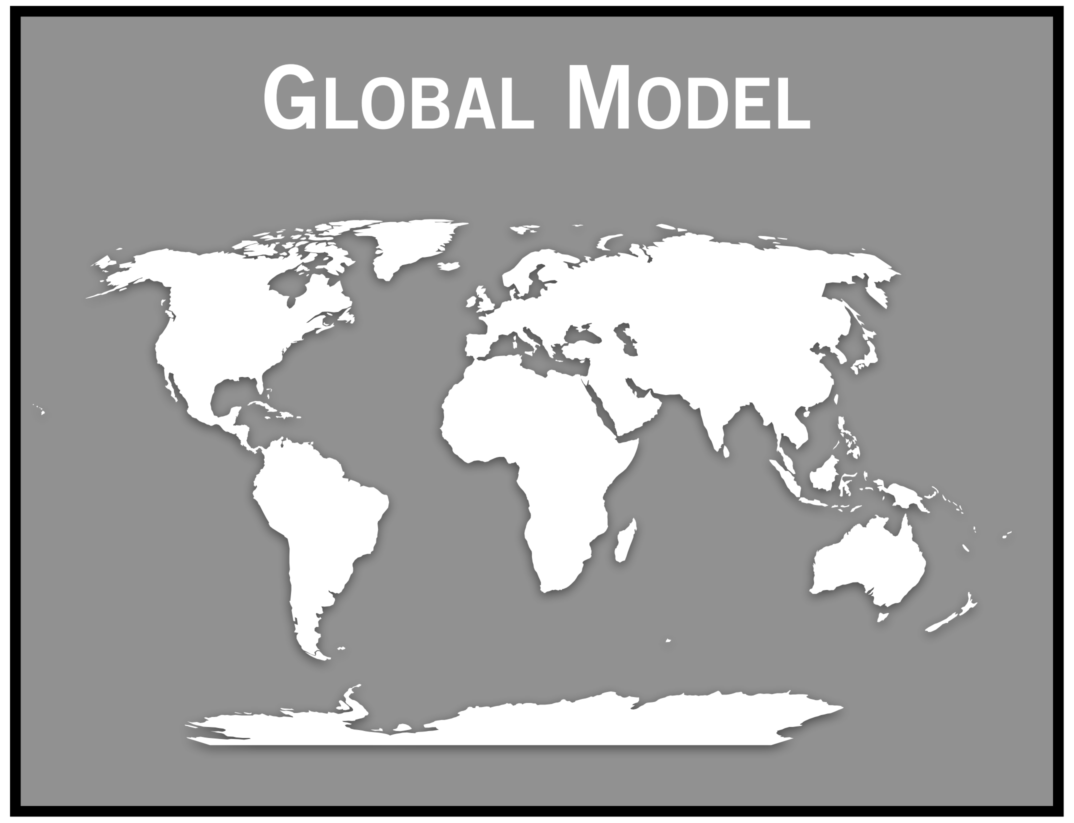
Tommasi et al. (2017)

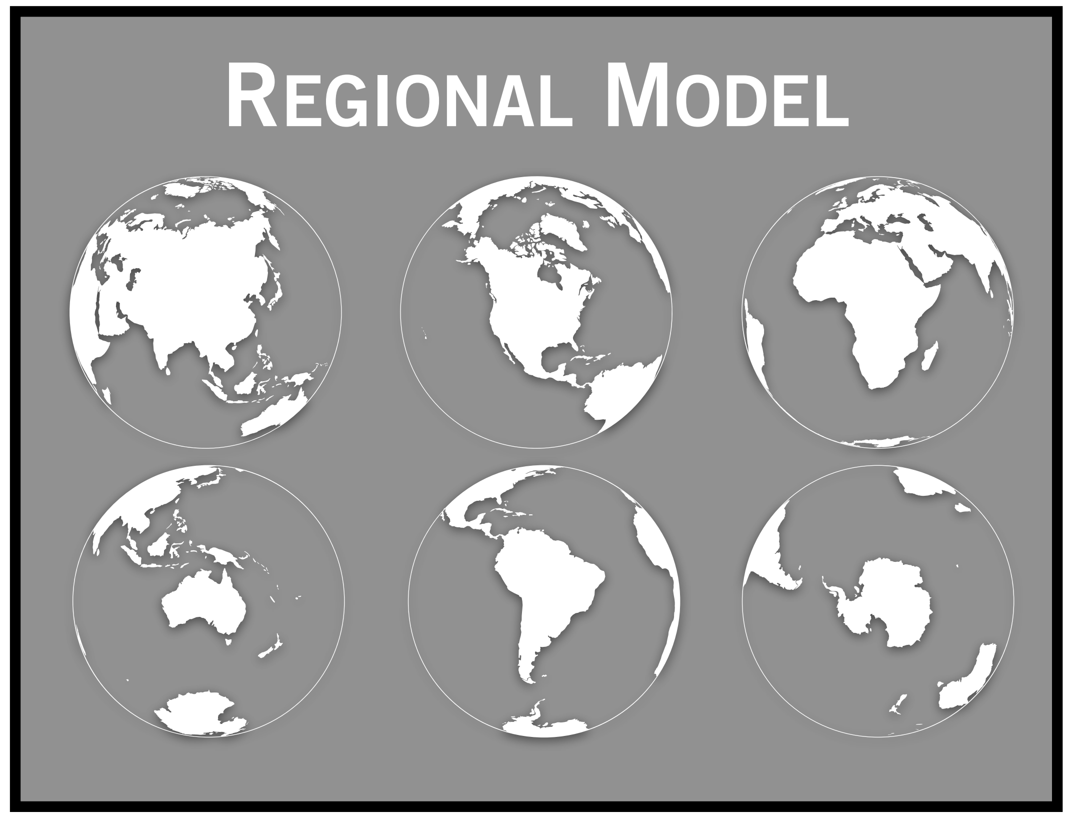
Mechanisms of predictability

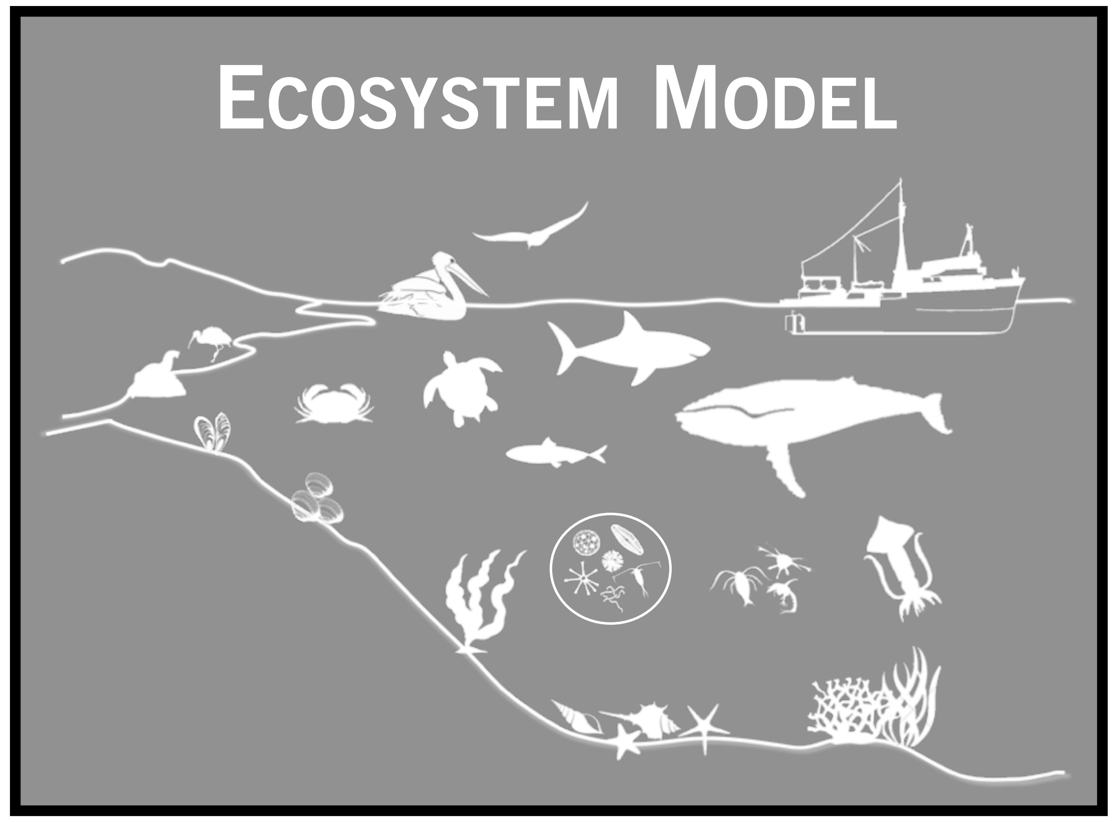


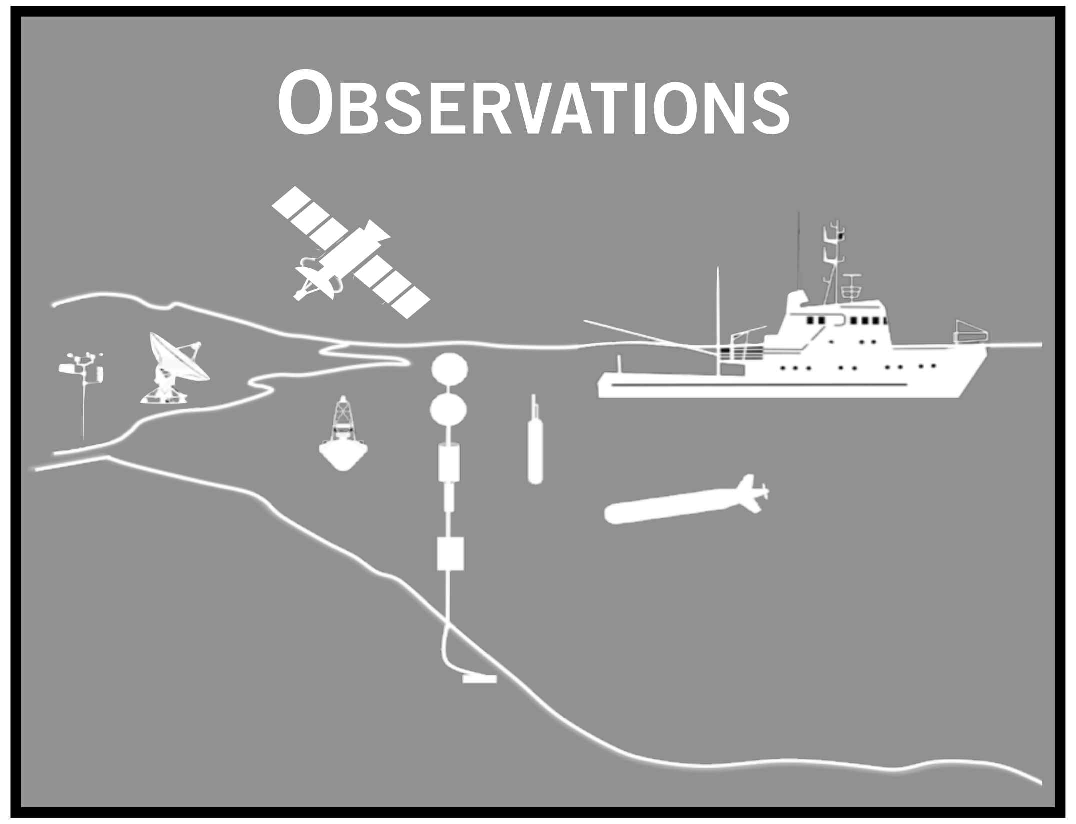
Jacox et al. (2020)

Forecast tools and methods







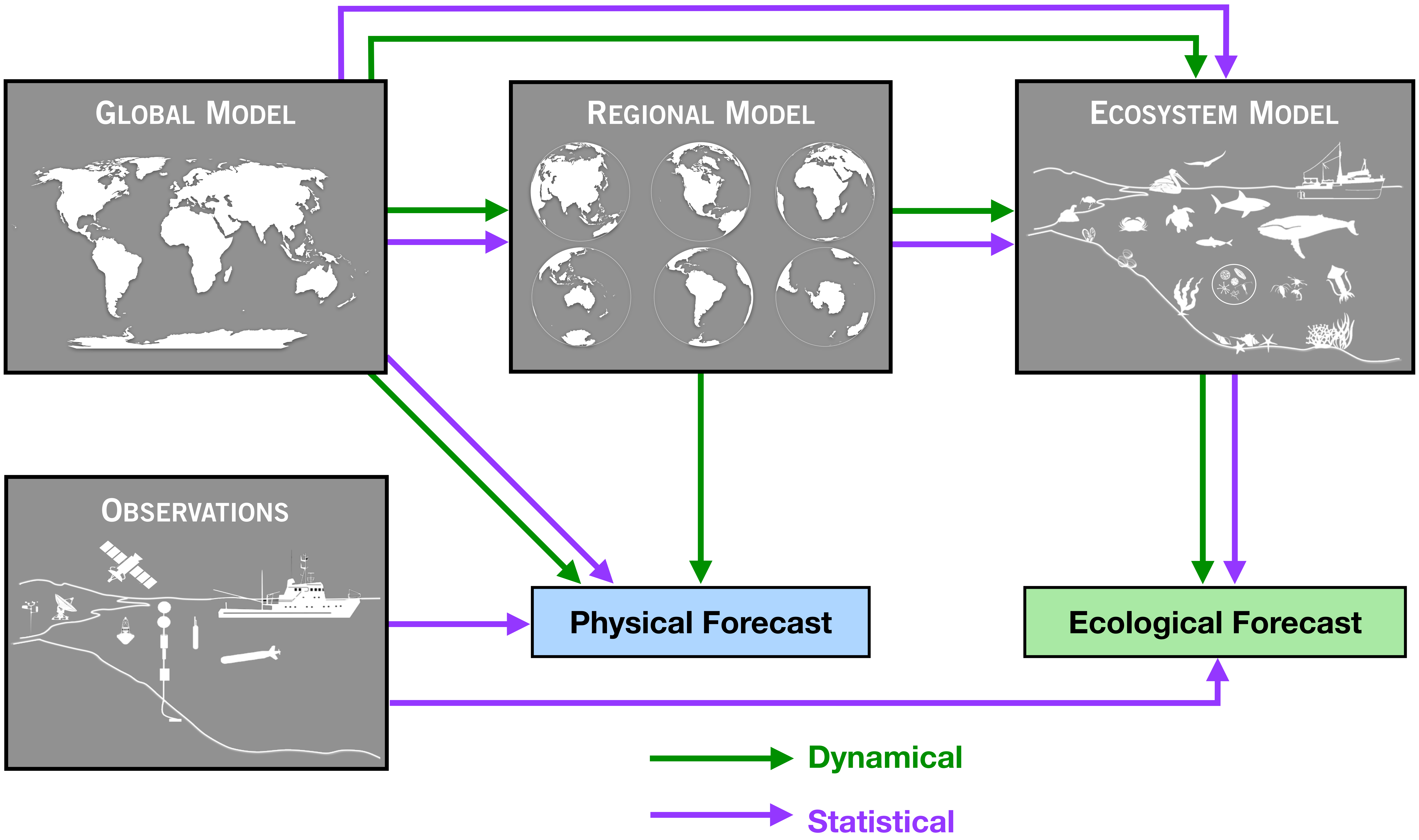


Physical Forecast

Ecological Forecast

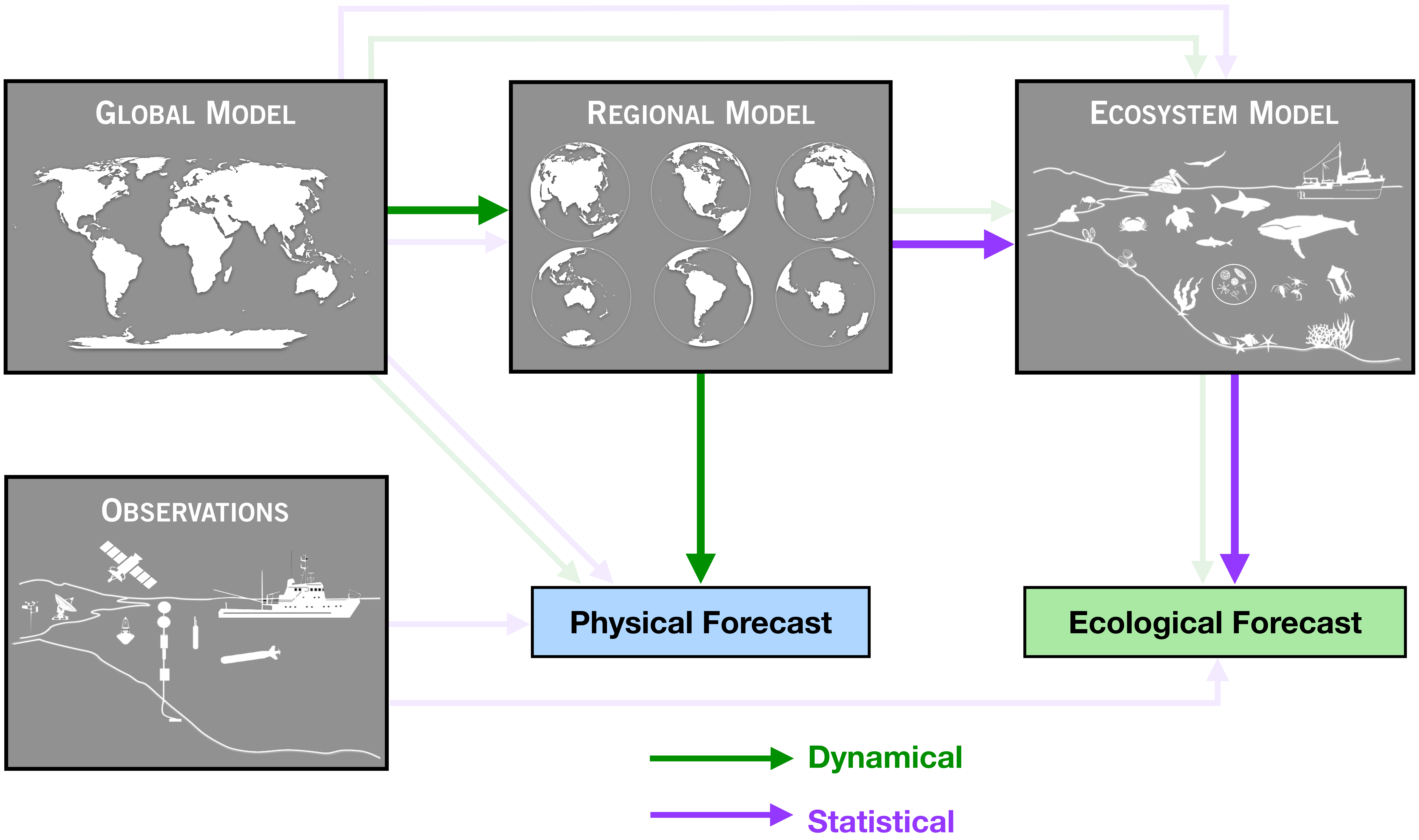
Jacox et al. (2020)

Forecast tools and methods



Jacox et al. (2020)

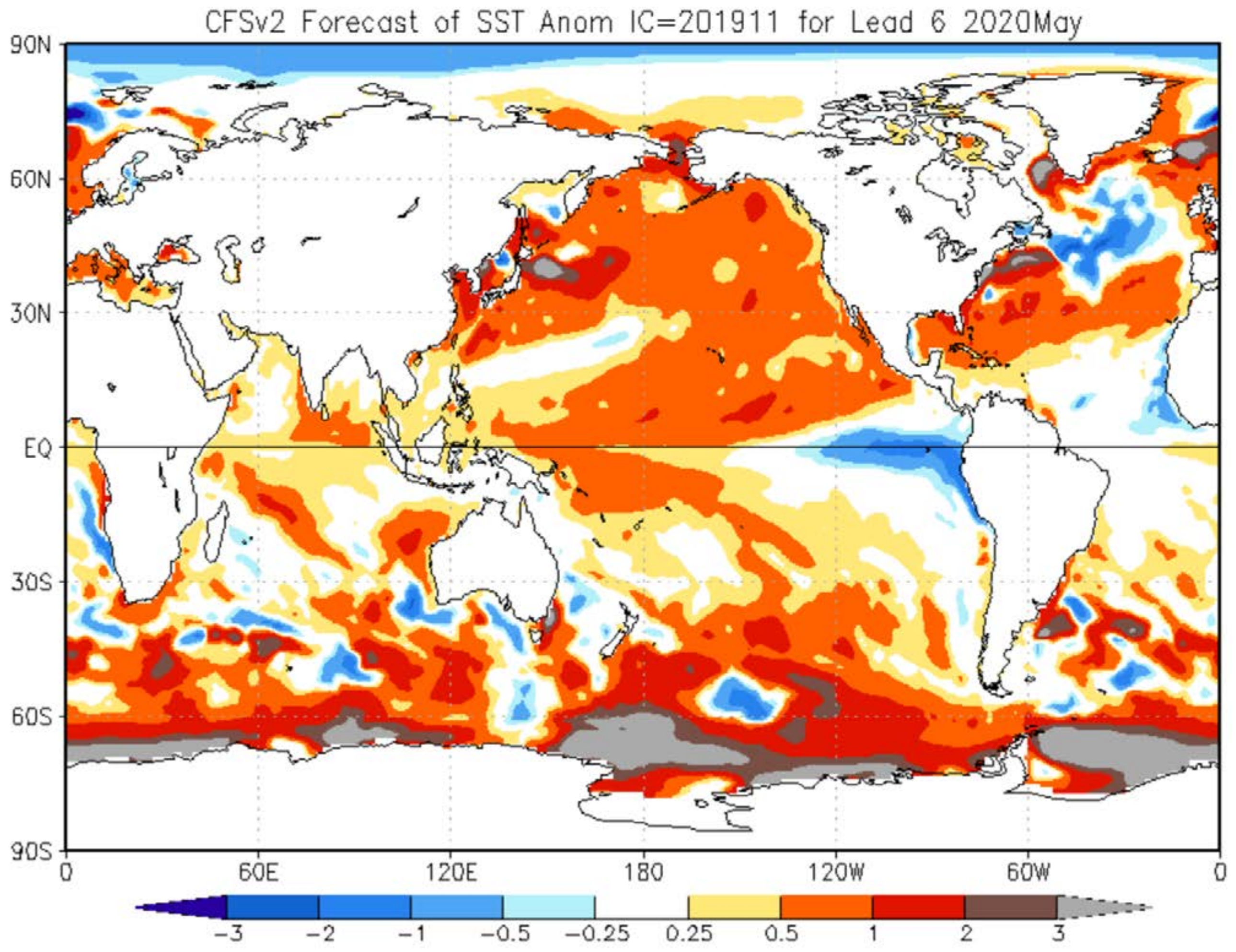
Forecast tools and methods

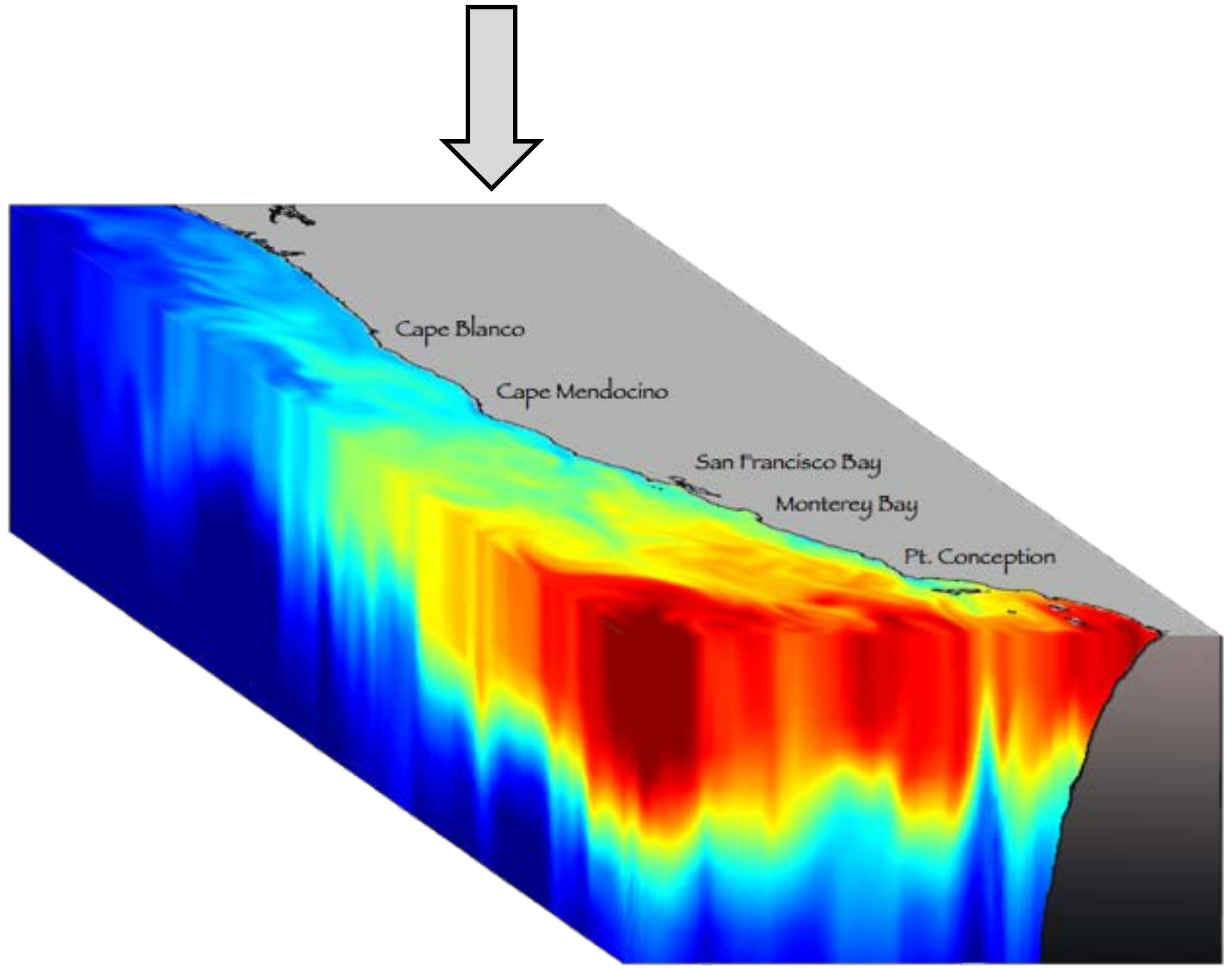


Jacox et al. (2020)

Regional forecasts for the California Current System

Global climate forecasts

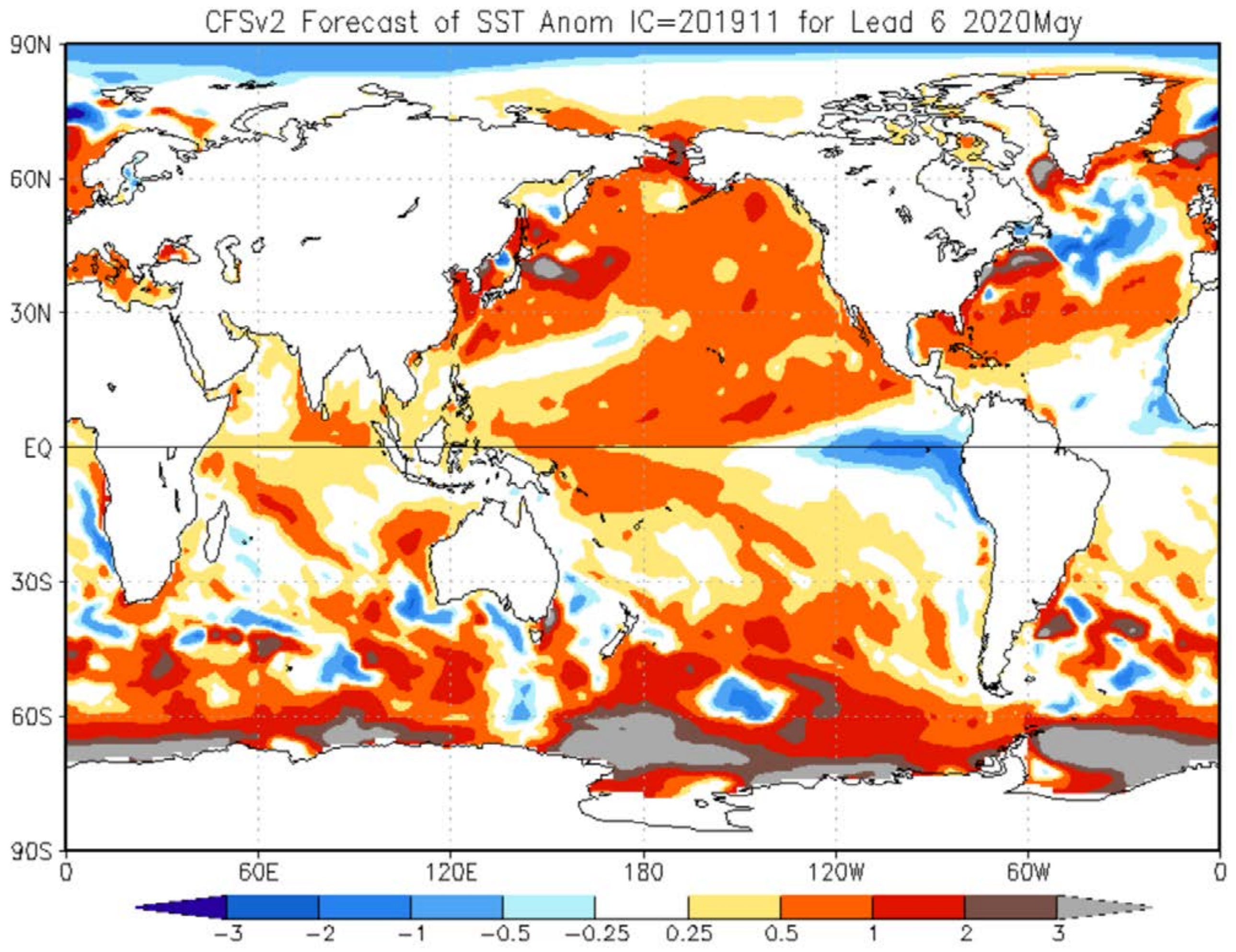


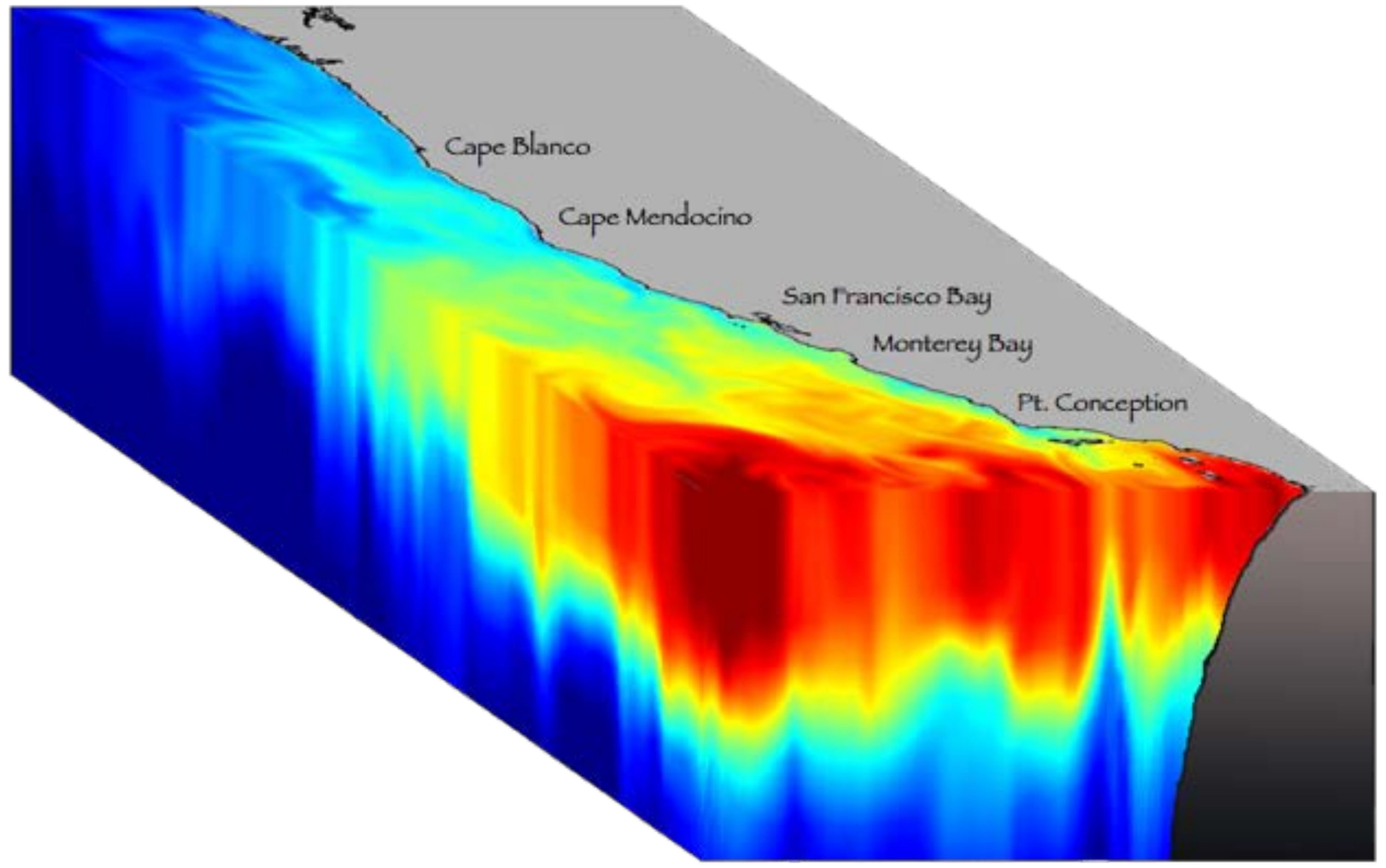


Regional ocean forecasts

Regional forecasts for the California Current System

Global climate forecasts





Regional ocean forecasts

Forecast configuration

Forcing from CanCM4

ROMS California Current domain (0.1° resolution; ~10 km)

Forecasts initialized twice per year (January and July)

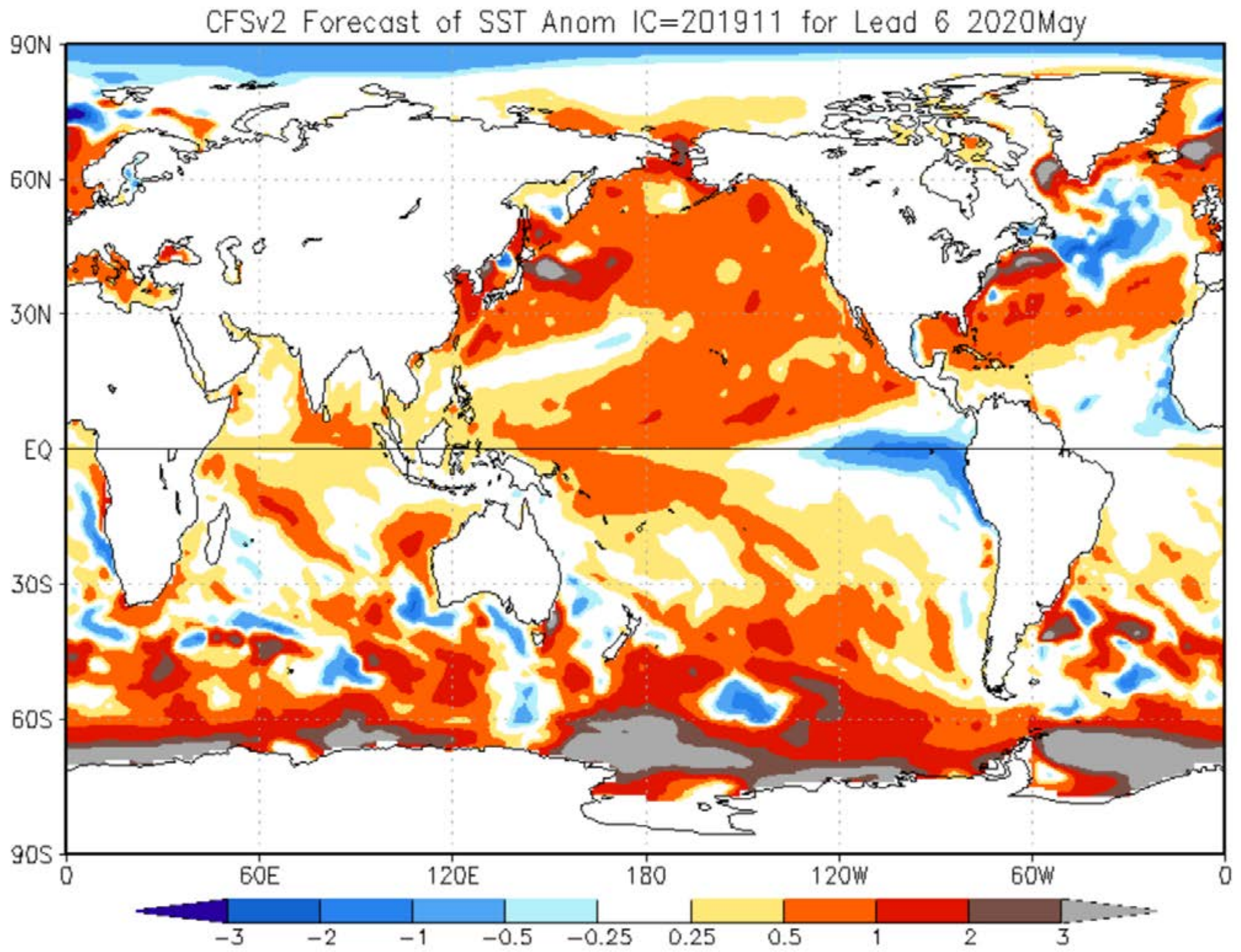
1982 to 2010

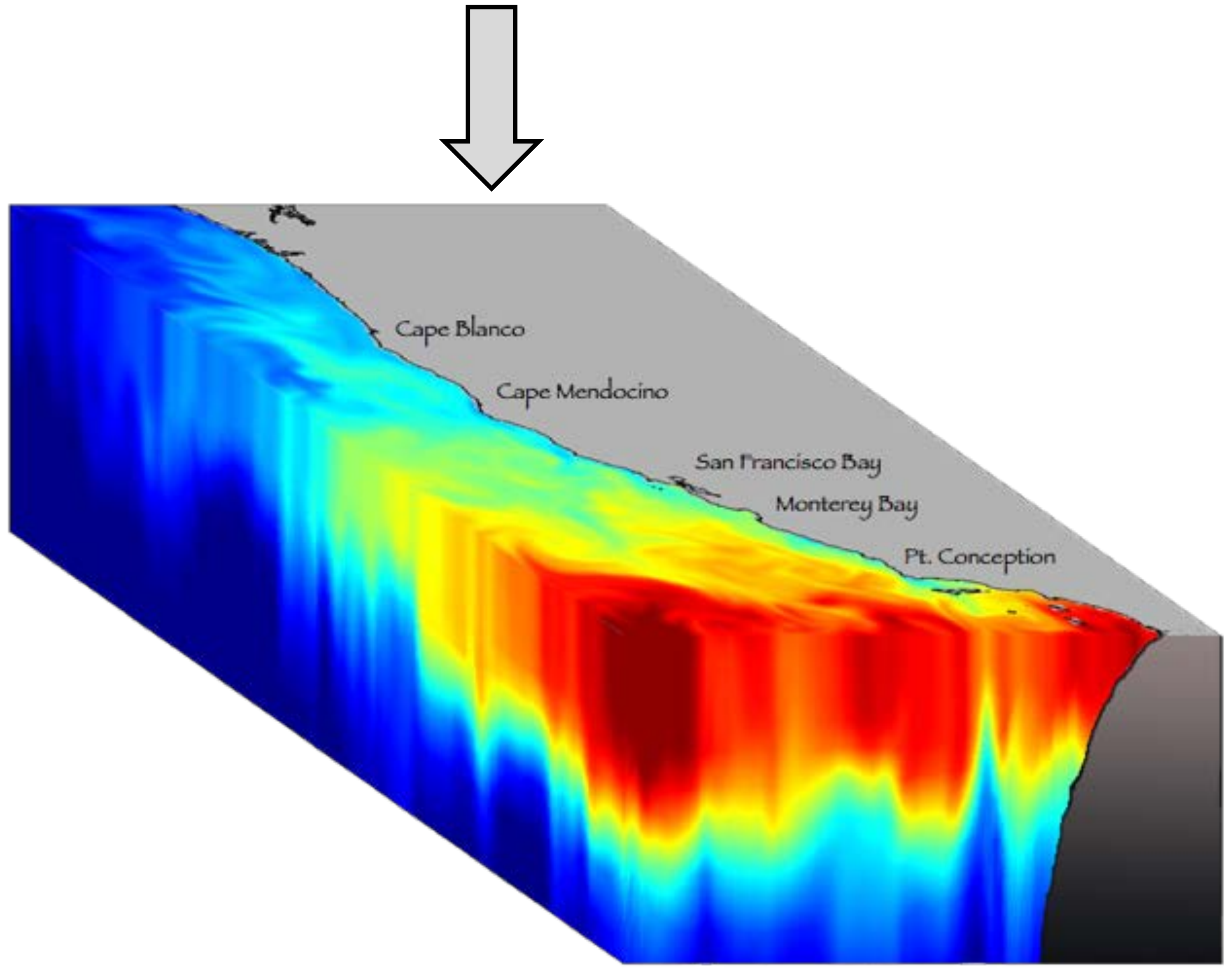
12-month forecasts

Three ensemble members

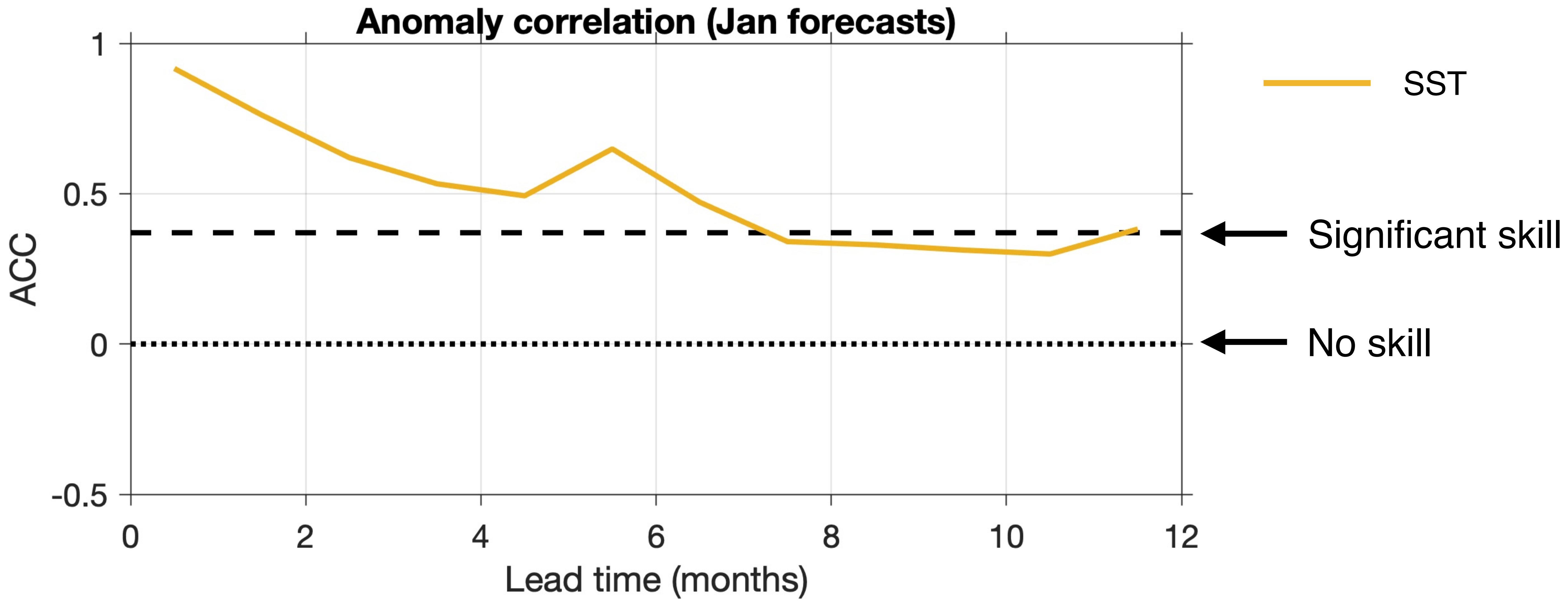
Regional forecasts for the California Current System

Global climate forecasts





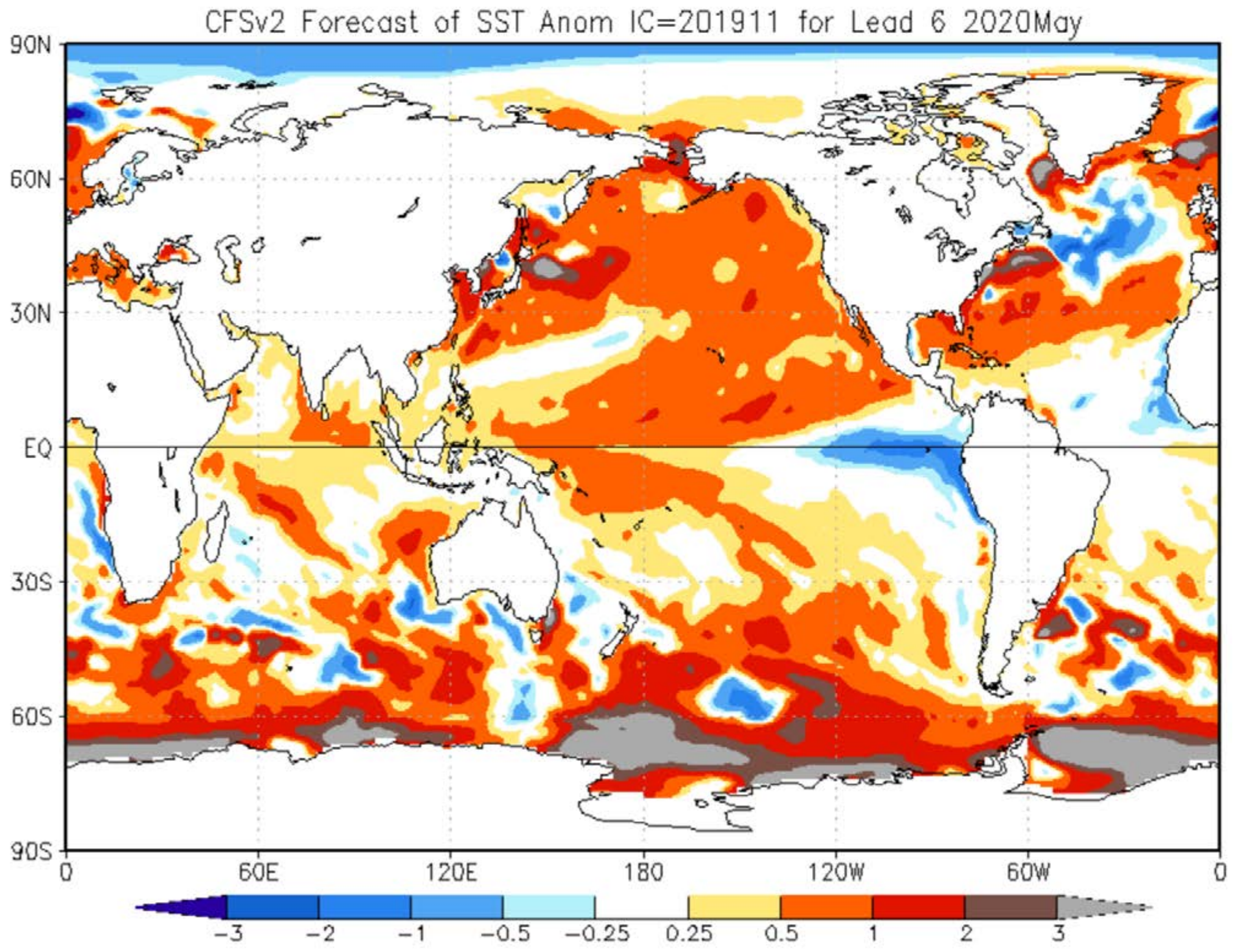
Regional ocean forecasts

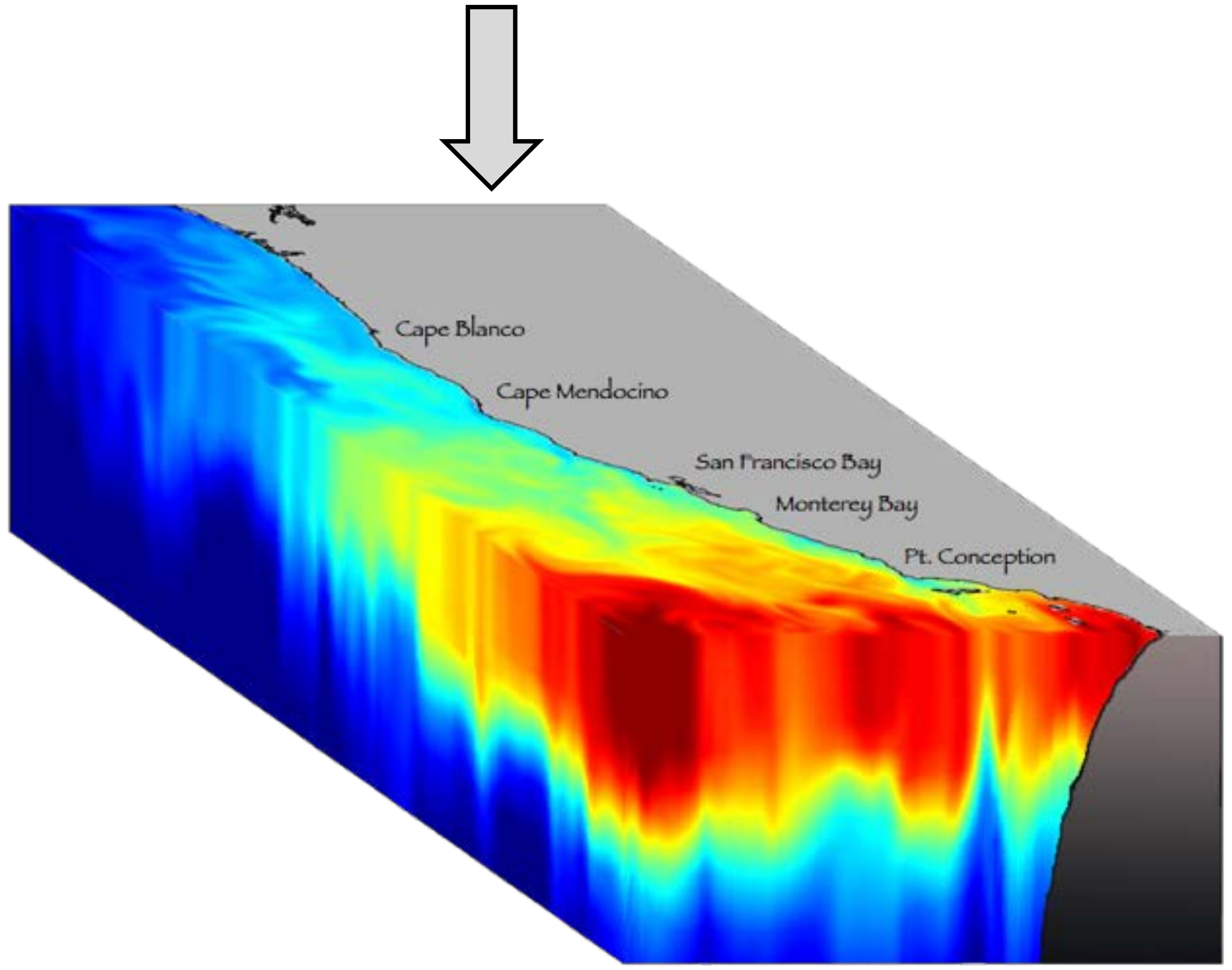


Jacox et al. (in review)

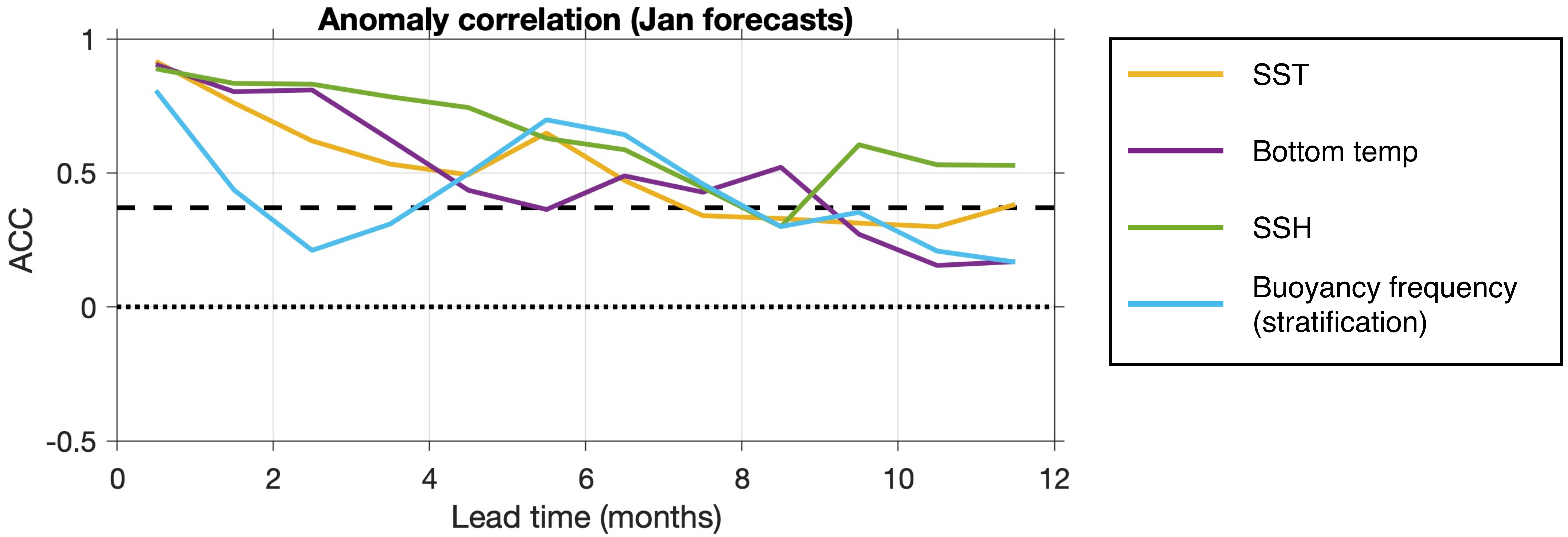
Regional forecasts for the California Current System

Global climate forecasts





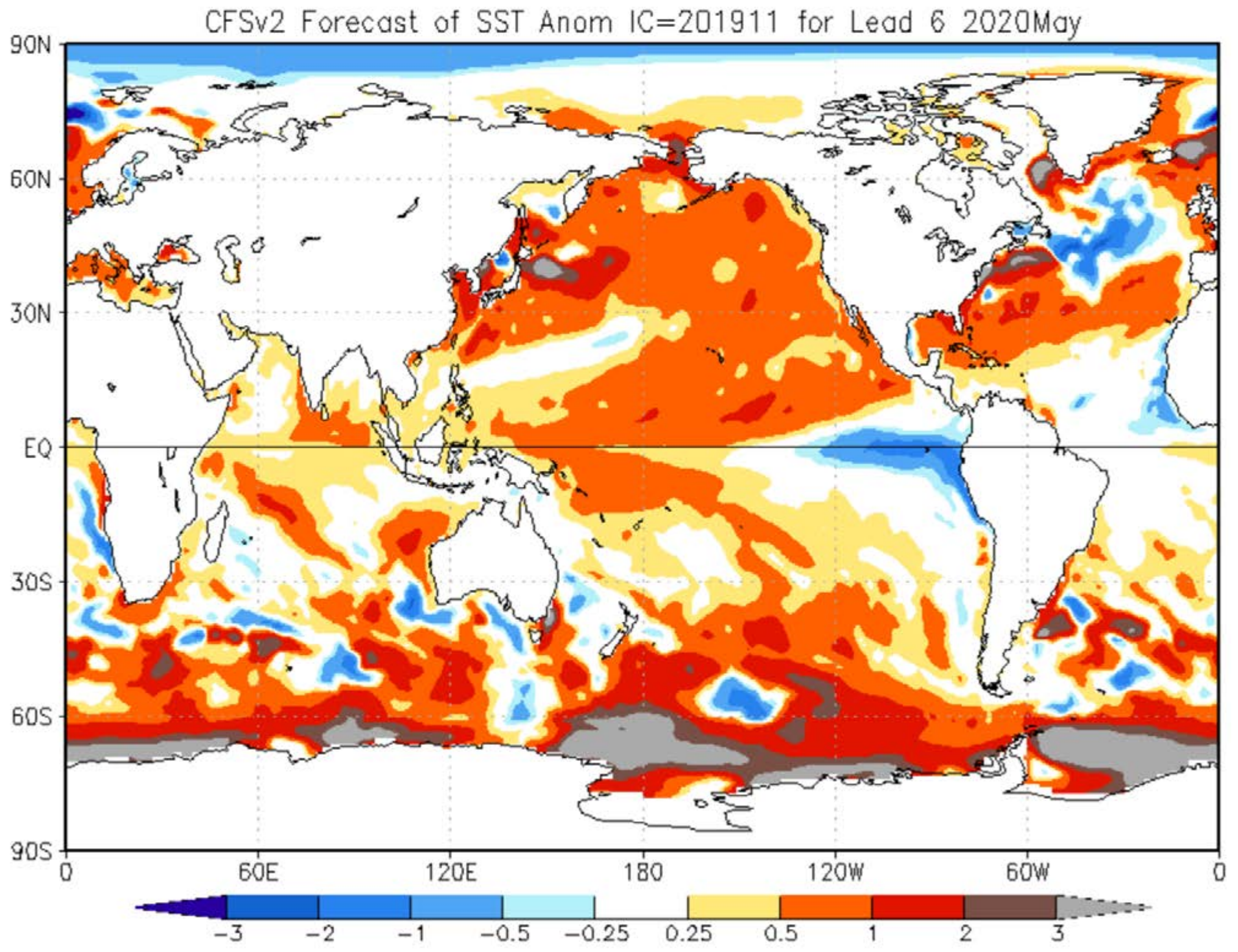
Regional ocean forecasts

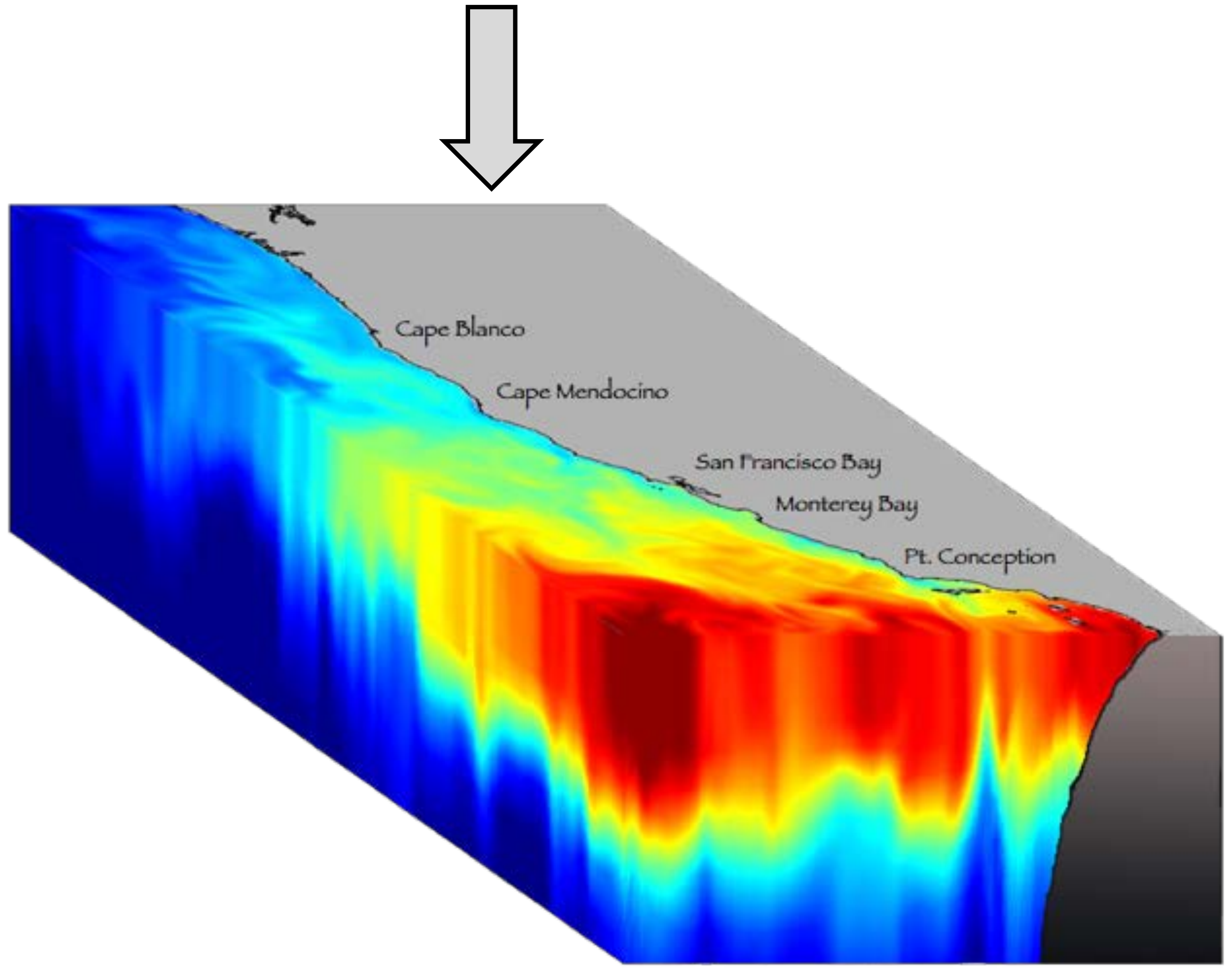


Jacox et al. (in review)

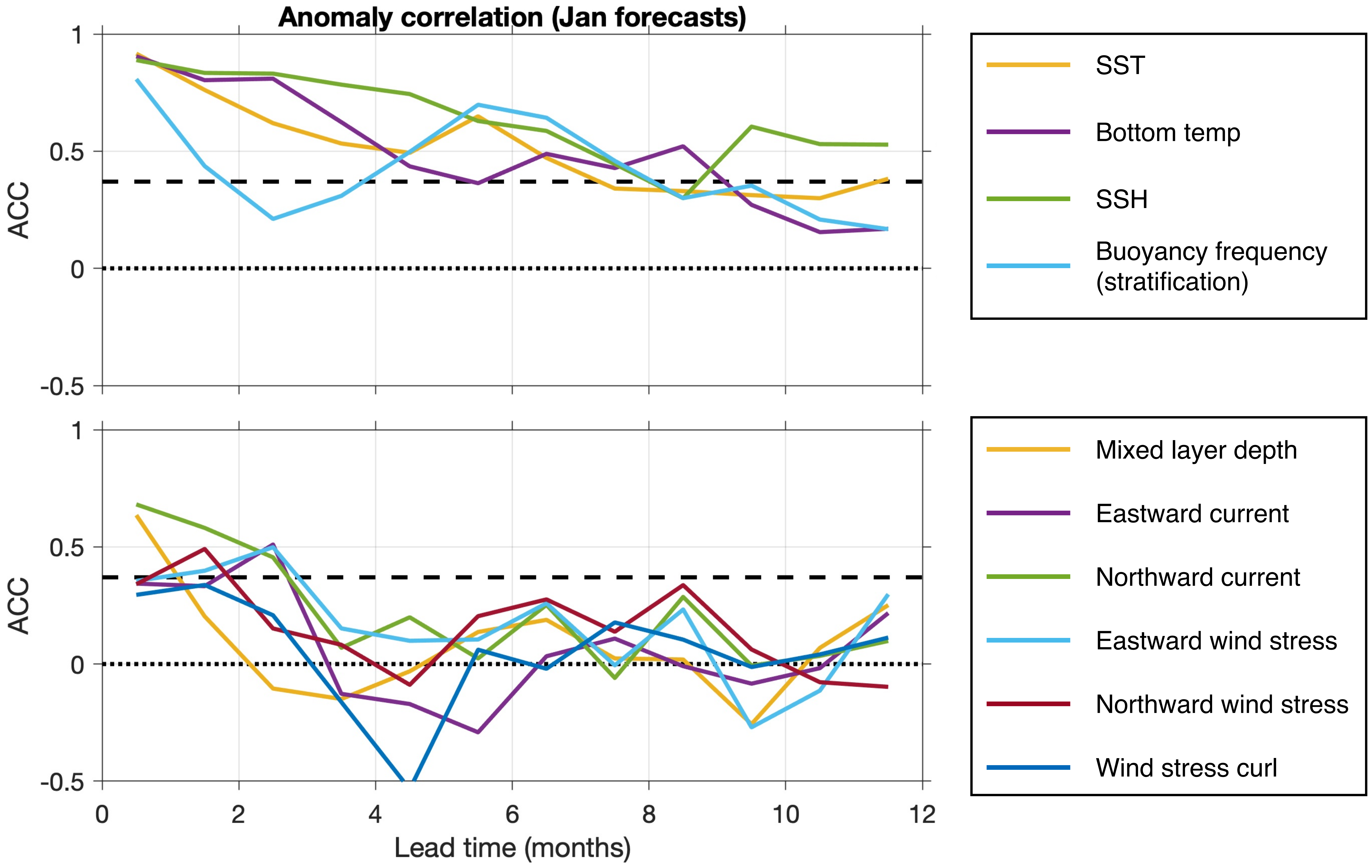
Regional forecasts for the California Current System

Global climate forecasts





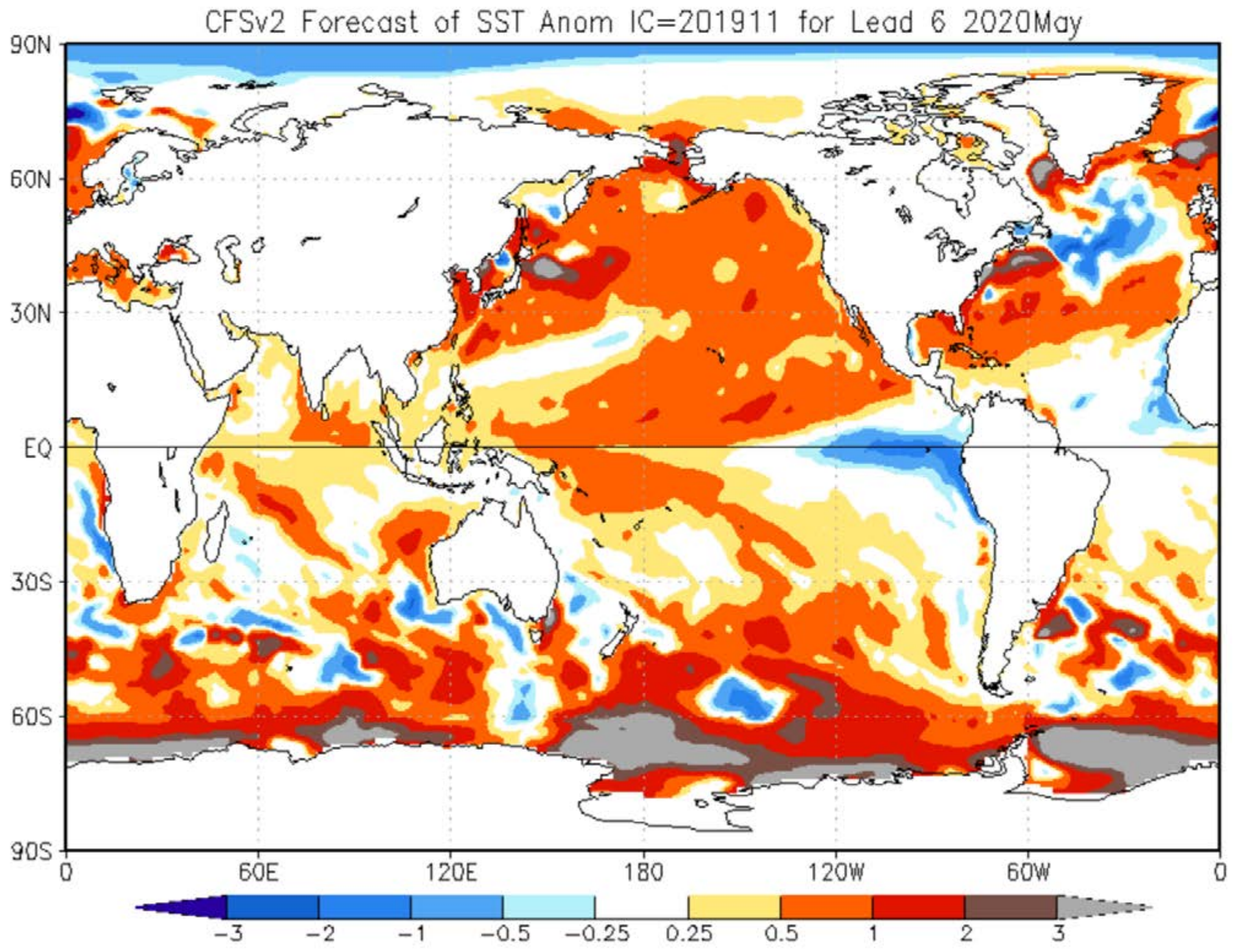
Regional ocean forecasts

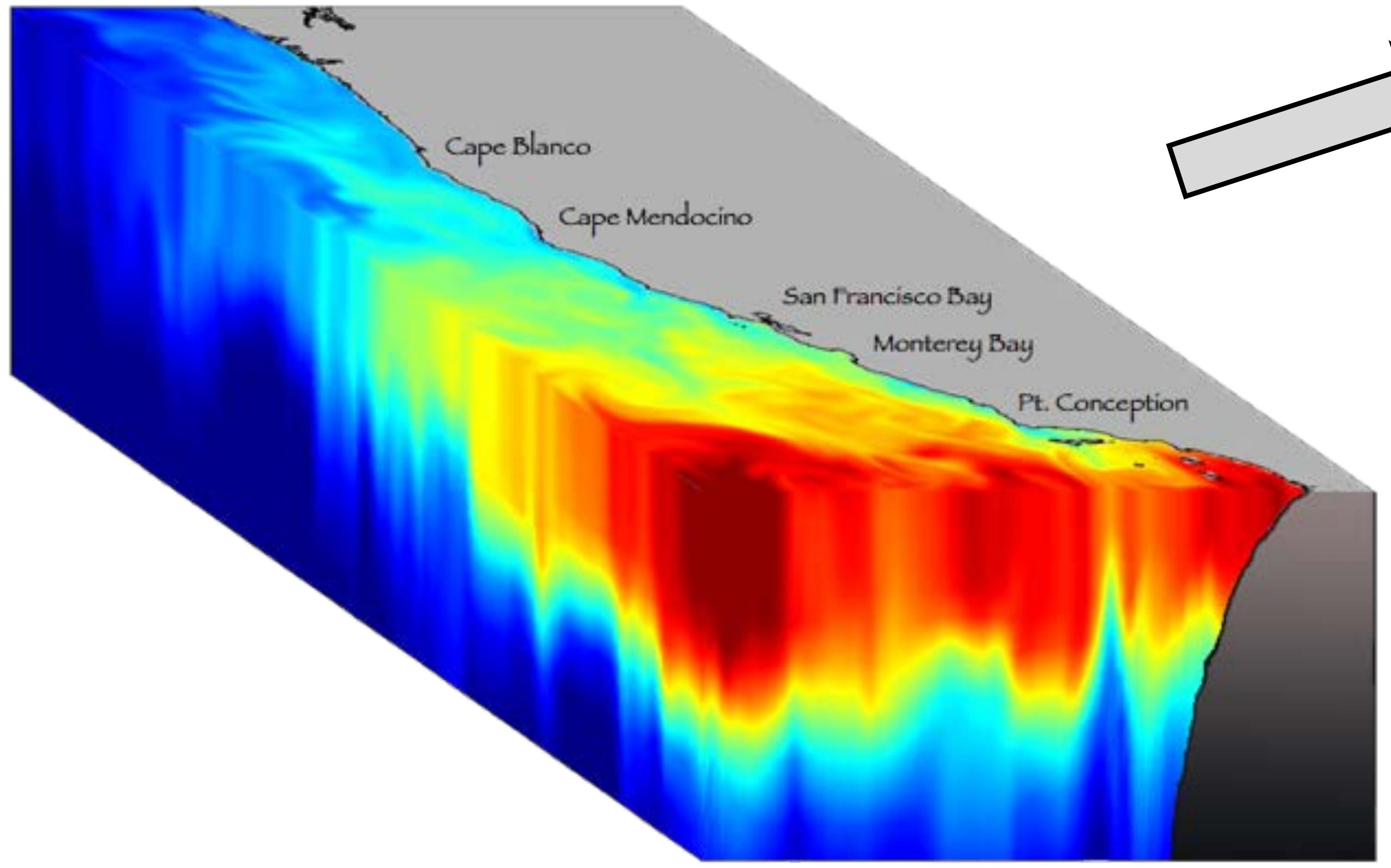


Jacox et al. (in review)

Connecting physical forecasts to ecological forecasts

Global climate forecasts





Regional ocean forecasts

Contents lists available at ScienceDirect

Ecological Indicators

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ELSEVIER

Original Articles

Environmental indicators to reduce loggerhead turtle bycatch offshore of Southern California

Heather Welch[a,b,*], Elliott L. Hazen[a,b], Dana K. Briscoe[a,c], Steven J. Bograd[a,b], Michael G. Jacox[b,d], Tomoharu Eguchi[e], Scott R. Benson[f,g], Christina C. Fahy[h], Toby Garfield[e], Dale Robinson[a,i], Jeffrey A. Seminoff[e], Helen Bailey[j]

Received: 21 December 2018 | Revised: 15 April 2019 | Accepted: 5 May 2019

DOI: 10.1111/ddi.12940

EDITOR'S CHOICE

BIODIVERSITY RESEARCH

WILEY Diversity and Distributions

Dynamic ensemble models to predict distributions and anthropogenic risk exposure for highly mobile species

Briana Abrahms[1] | Heather Welch[1,2] | Stephanie Brodie[1,2] | Michael G. Jacox[1,3] | Elizabeth A. Becker[2,4] | Steven J. Bograd[1,2] | Ladd M. Irvine[5] | Daniel M. Palacios[5] | Bruce R. Mate[5] | Elliott L. Hazen[1,2]

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ELSEVIER

Habitat compression indices for monitoring ocean conditions and ecosystem impacts within coastal upwelling systems

Isaac D. Schroeder[a,b], Jarrod A. Santora[c,d,*], Nate Mantua[c], John C. Field[b,c], Brian K. Wells[c], Elliott L. Hazen[a,b], Michael Jacox[a,b], Steven J. Bograd[a,b]

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Research

Check for updates

Cite this article: Fennie HW et al. 2022 An anchovy ecosystem indicator of marine

An anchovy ecosystem indicator of marine predator foraging and reproduction

H. William Fennie[1,2], Rachel Seary[1,3], Barbara A. Muhling[1,2], Steven J. Bograd[3], Stephanie Brodie[1,3], Megan A. Cimino[1,3], Elliott L. Hazen[3], Michael G. Jacox[3,4], Elizabeth A. McHuron[5], Sharon Melin[6], Jarrod A. Santora[7,8], Justin J. Suca[1,3], Julie A. Thayer[1,9], Andrew R. Thompson[2], Pete Warzybok[10] and Desiree Tommasi[1,2]

SCIENCE ADVANCES | RESEARCH ARTICLE

ECOLOGY

A dynamic ocean management tool to reduce bycatch and support sustainable fisheries

Elliott L. Hazen,[1,2,3]* Kylie L. Scales,[2,4] Sara M. Maxwell,[5] Dana K. Briscoe,[2] Heather Welch,[2] Steven J. Bograd,[1,2] Helen Bailey,[6] Scott R. Benson,[1,7] Tomo Eguchi,[1] Heidi Dewar,[1] Suzy Kohin,[1] Daniel P. Costa,[2] Larry B. Crowder,[8] Rebecca L. Lewison[9]

MUHLING ET AL.: DYNAMIC HABITAT USE OF ALBACORE AND THEIR PRIMARY PREY SPECIES IN THE CALIFORNIA CURRENT SYSTEM
CalCOFI Rep., Vol. 60, 2019

DYNAMIC HABITAT USE OF ALBACORE AND THEIR PRIMARY PREY SPECIES IN THE CALIFORNIA CURRENT SYSTEM

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Ocean Sciences Department
University of California, Santa Cruz, CA

YI XU
Department of Fisheries and Oceans
Delta, British Columbia, Canada

STEPHANIE SNYDER
Thomas More University,
Crestview Hills, KY

Connecting physical forecasts to ecological forecasts

Application	Region	Key physical variables	Forecast months
Habitat compression (whale entanglement	Central/Northern California	SST	Mar-Nov
TOTAL (loggerhead bycatch)	Southern California	SST	Dec-Jul
WhaleWatch (ship strike risk)	Southern California	Full suite *	May-Nov
Sardine spawning habitat and recruitment	Southern California	SST, SSH	Mar-May
EcoCast (bycatch risk)	Entire Coast	Full suite *	Aug-Jan
Albacore distribution	Oregon/Washington	Full suite *	Jun-Nov
Anchovy Ecosystem Indicator (top predator foraging and reproduction)	Central/Northern California	Full suite *	Apr-Jul

*Full suite
SST
SSH
Surface currents (u,v)
Wind Stress (u,v,curl)
Mixed layer depth
Stratification

Jacox et al. (in review)

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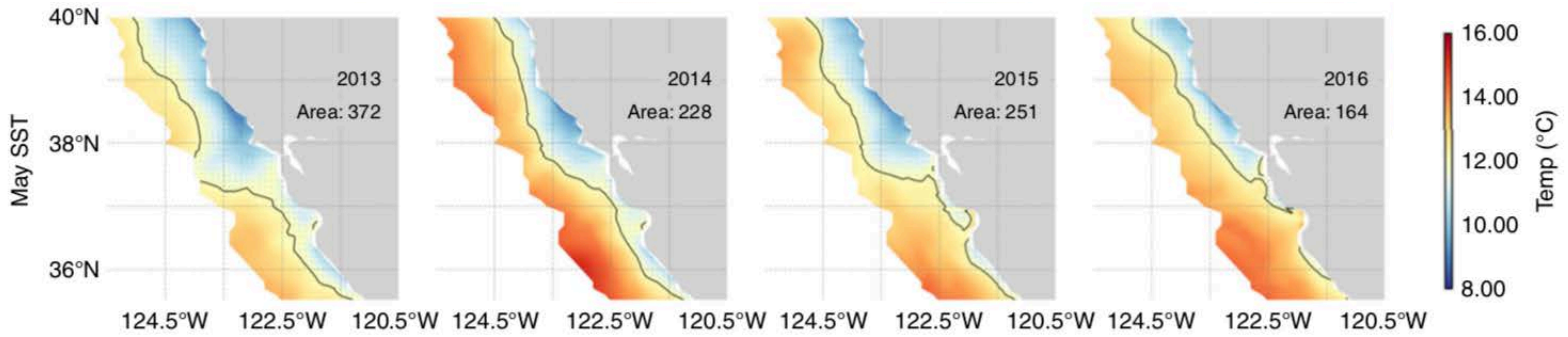
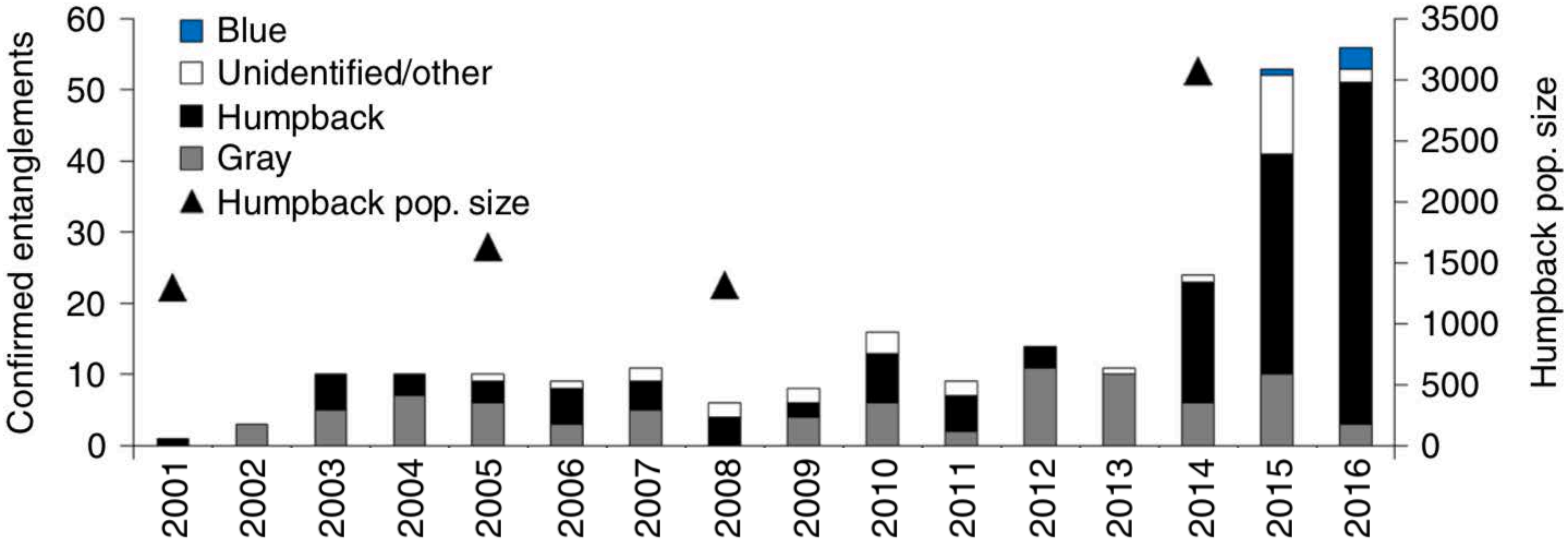
*Full suite
SST
SSH
Surface currents (u,v)
Wind Stress (u,v,curl)
Mixed layer depth
Stratification

Jacox et al. (in review)

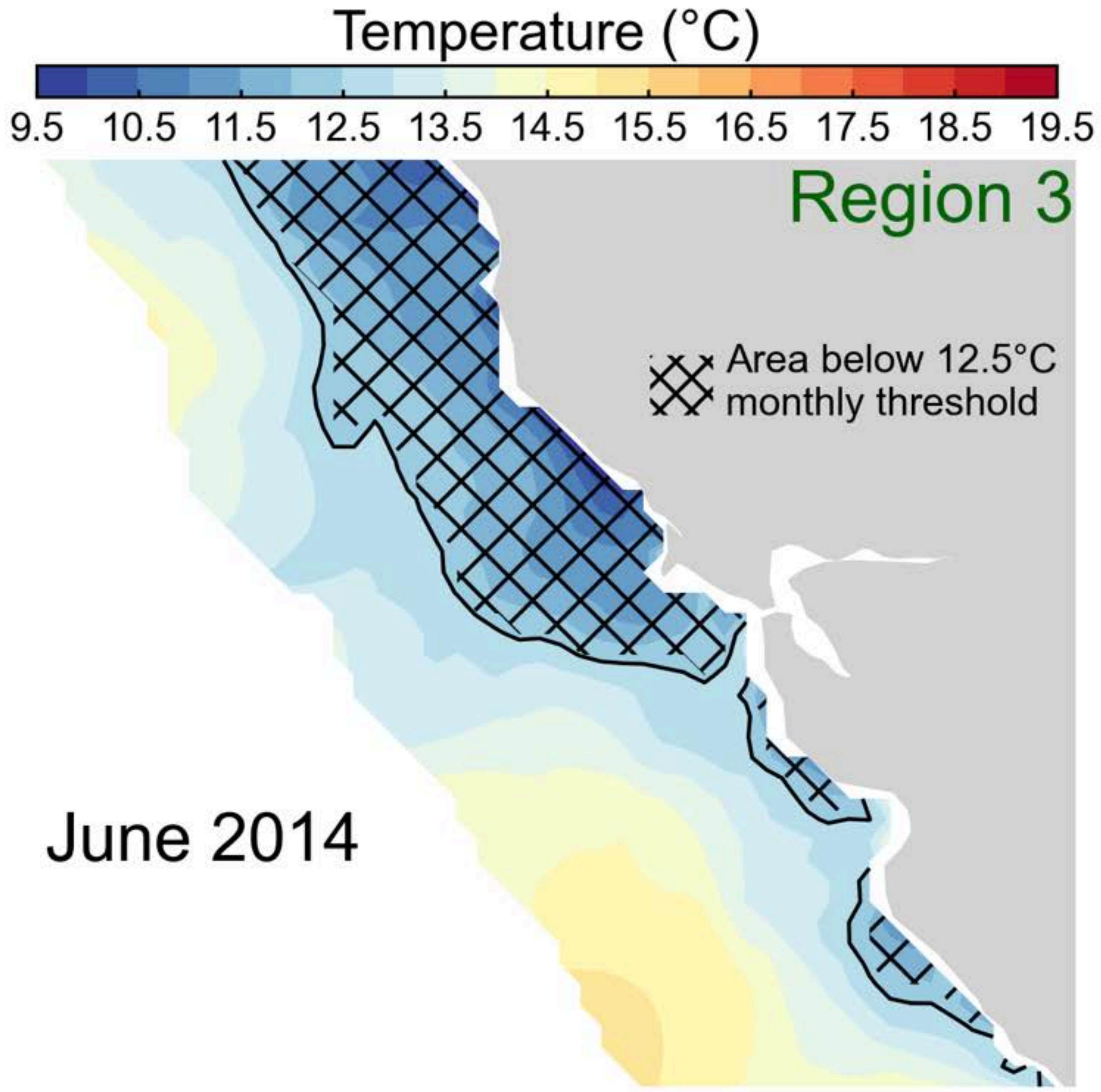
Habitat compression index (HCI)





Santora et al. (2020)

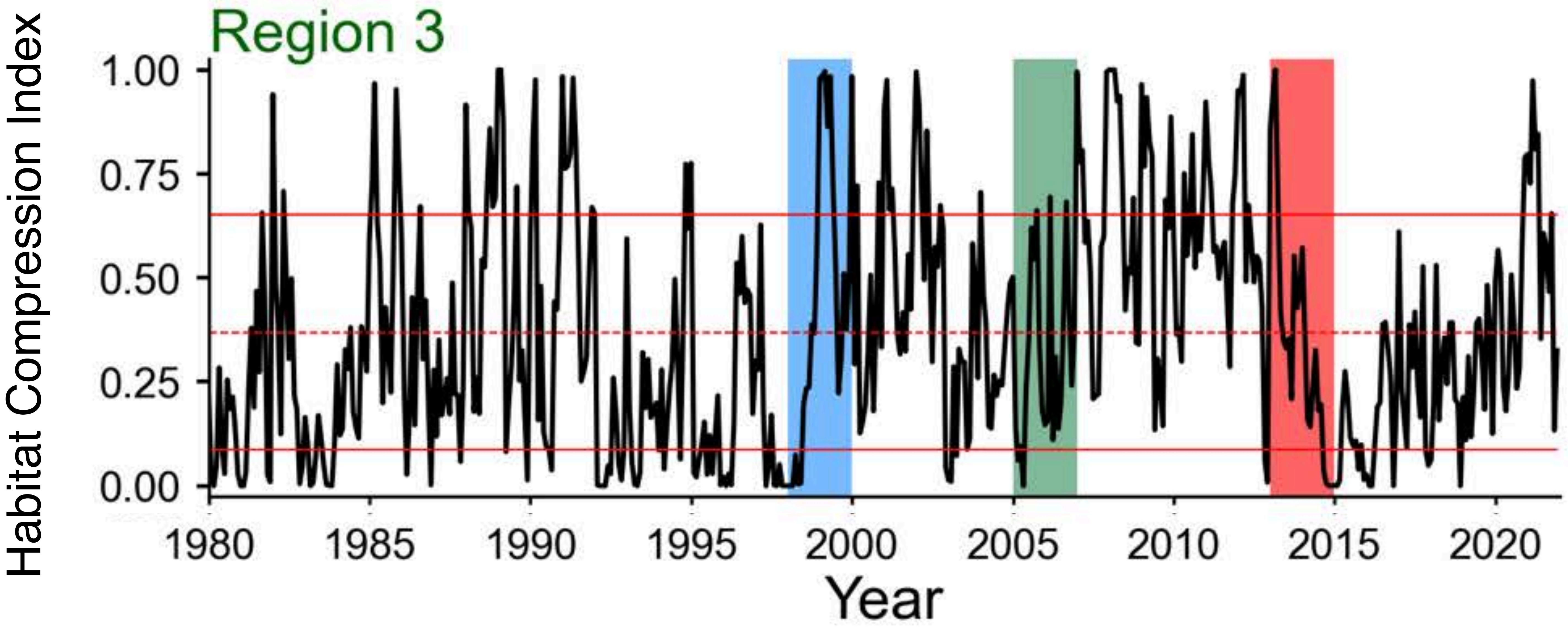
Habitat compression index (HCI)



Area below threshold = 29177 km^2

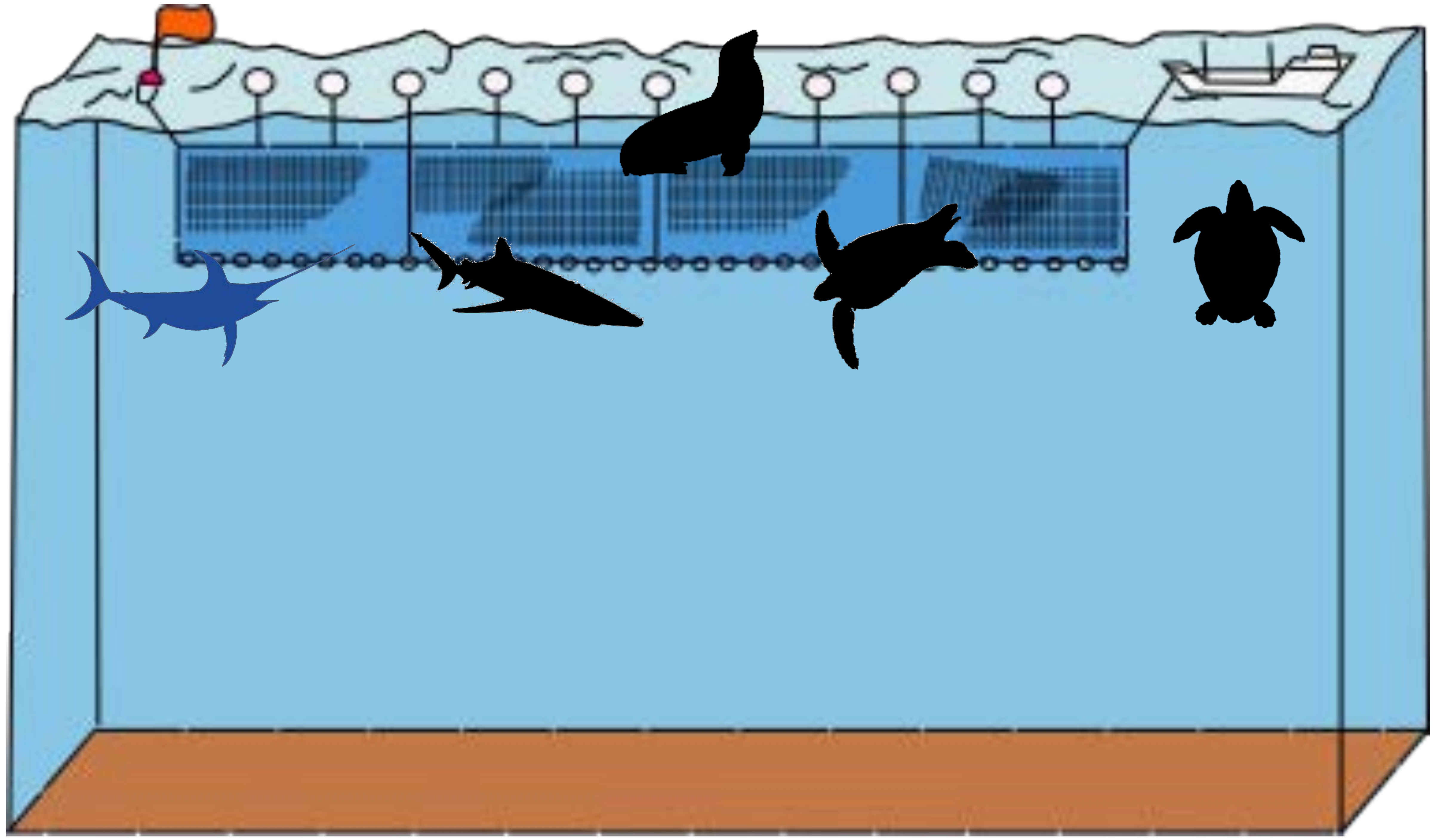
Total area = 89418 km^2

$$HCI = \frac{29177\ km^2}{89418\ km^2} = 0.33$$



Schroeder et al. (2022)

Temperature observations to avoid loggerheads (TOTAL) tool



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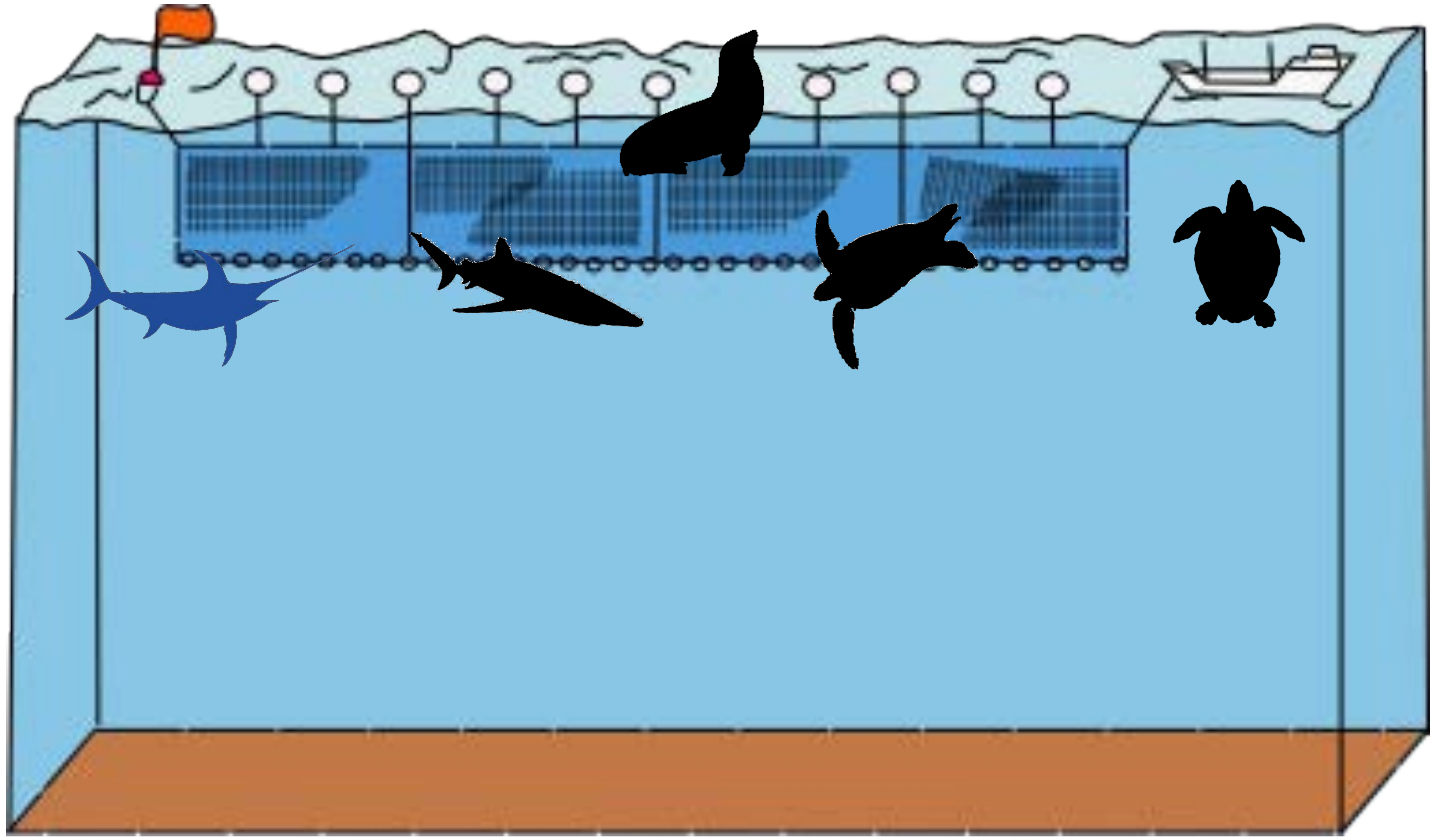
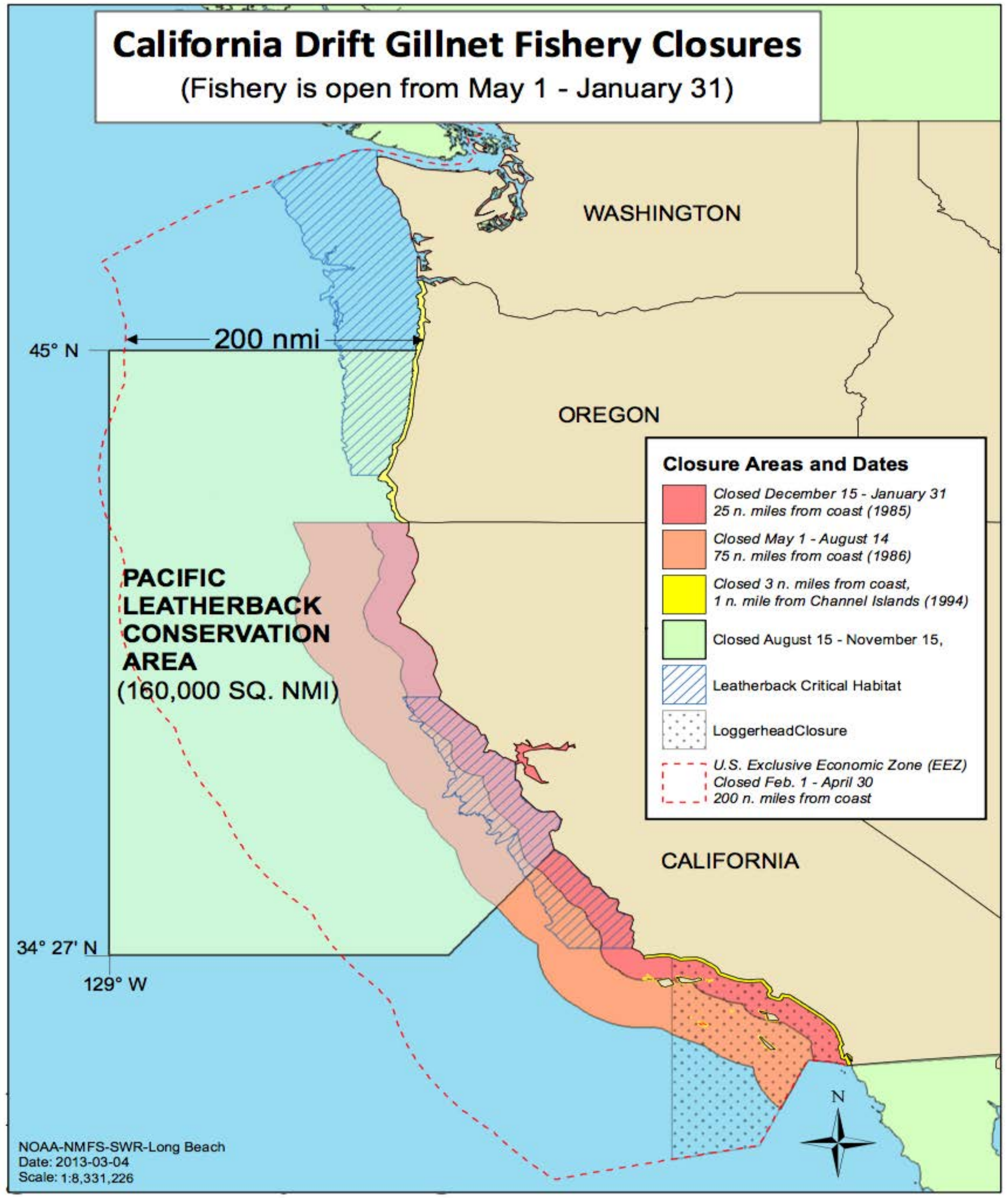
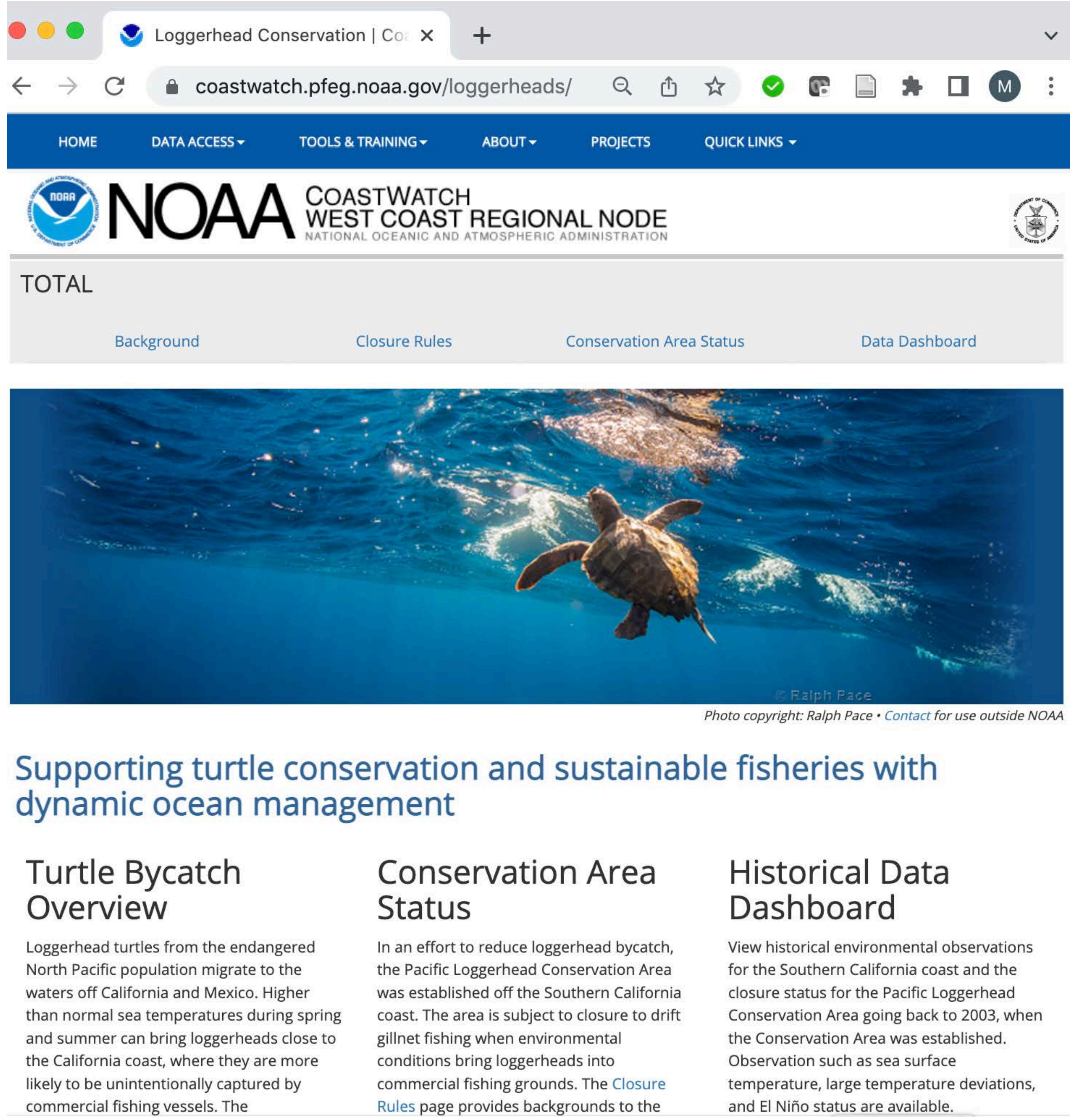
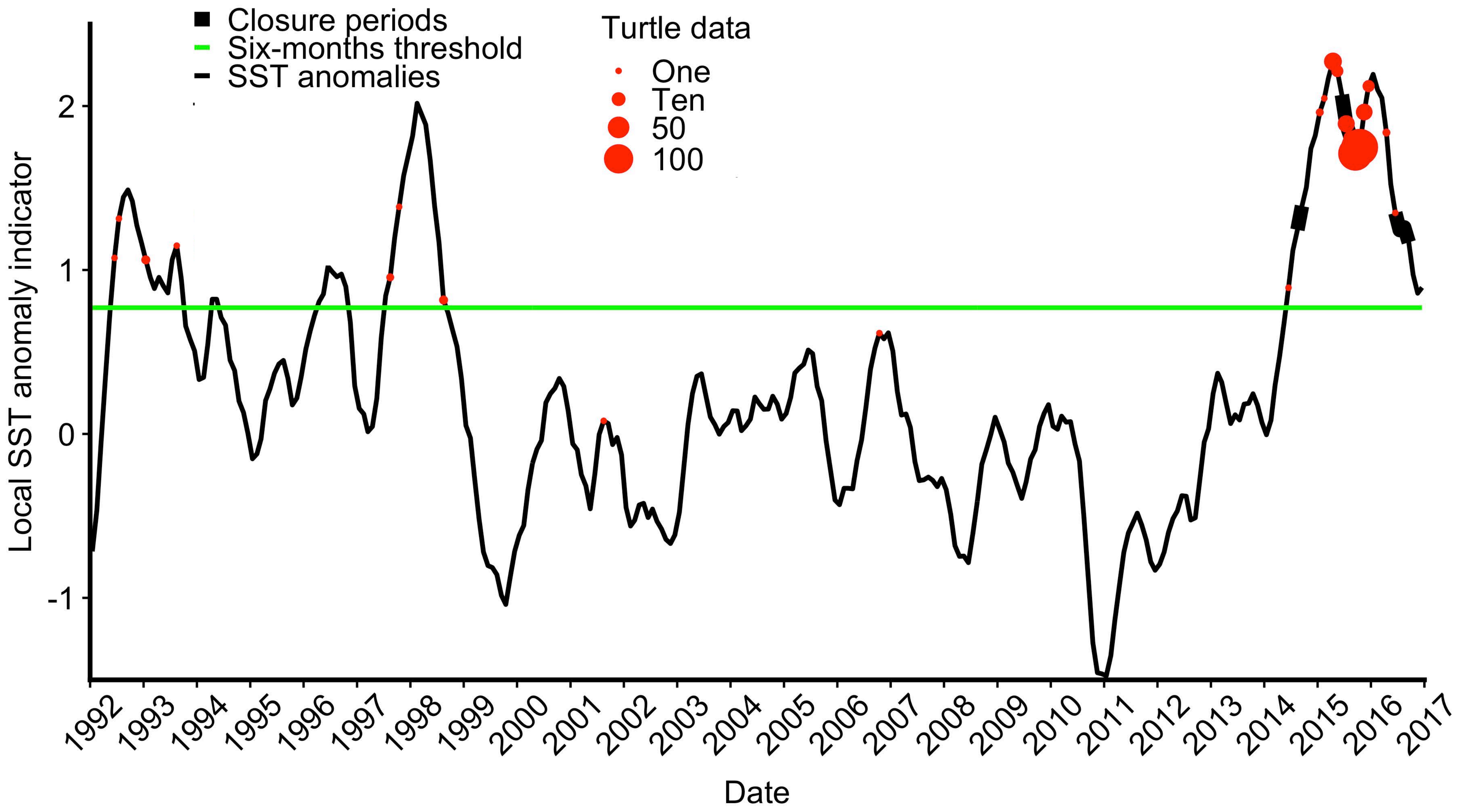




Bycatch dropped significantly, but at large economic cost to the fishery

Temperature observations to avoid loggerheads (TOTAL) tool

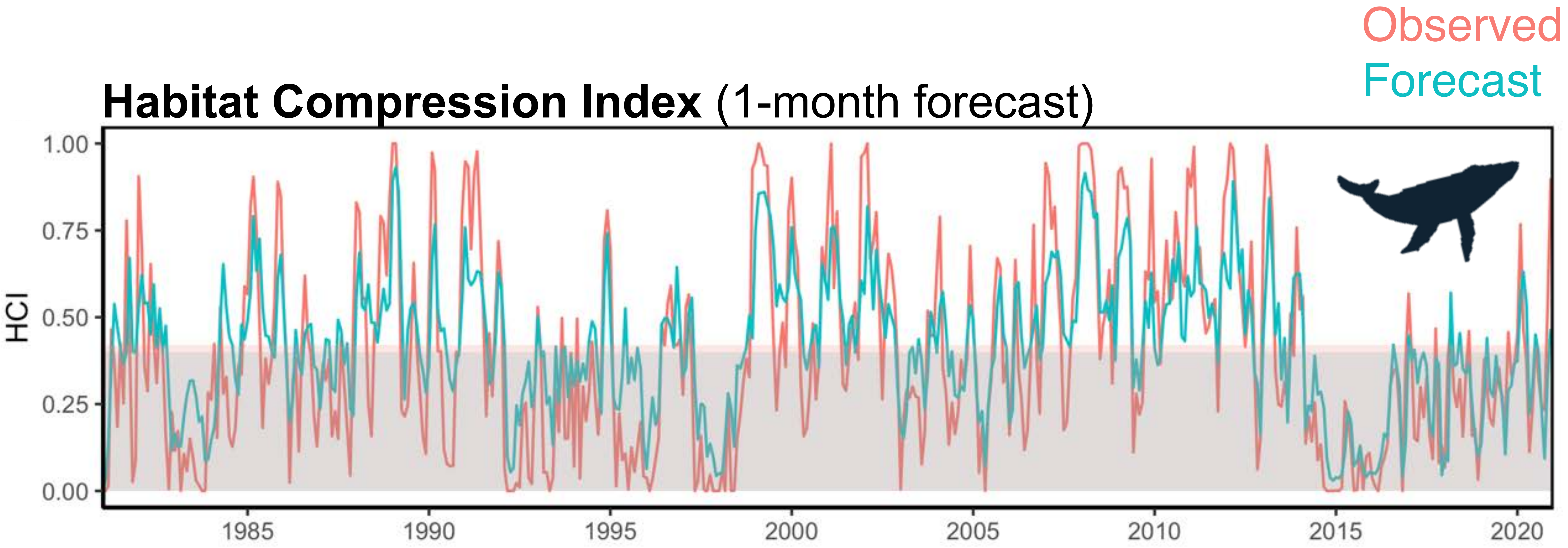




Welch et al. (2018)

https://coastwatch.pfeg.noaa.gov/loggerheads/

Moving TOTAL and HCI from nowcast to forecast

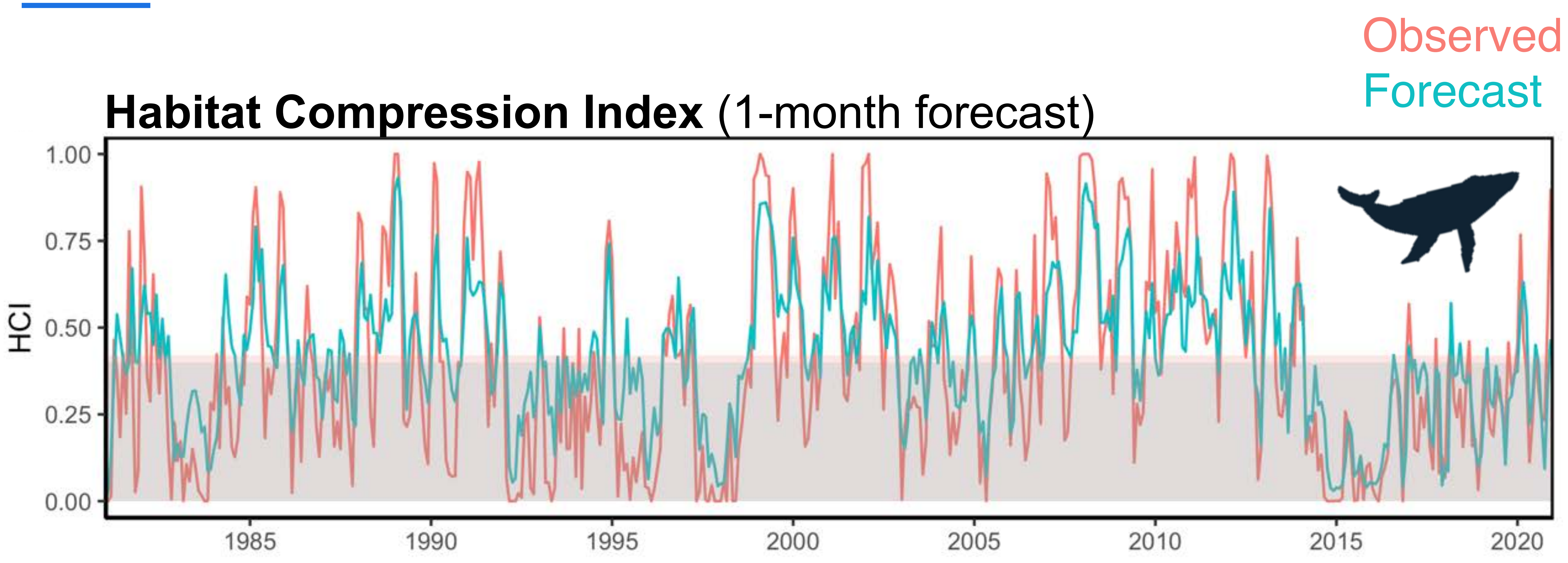


High compression in 2005 could have been predicted 1-2 months in advance.

Persistent habitat compression 2014-2016 was predictable months in advance.

Brodie et al. (in prep)

Moving TOTAL and HCI from nowcast to forecast



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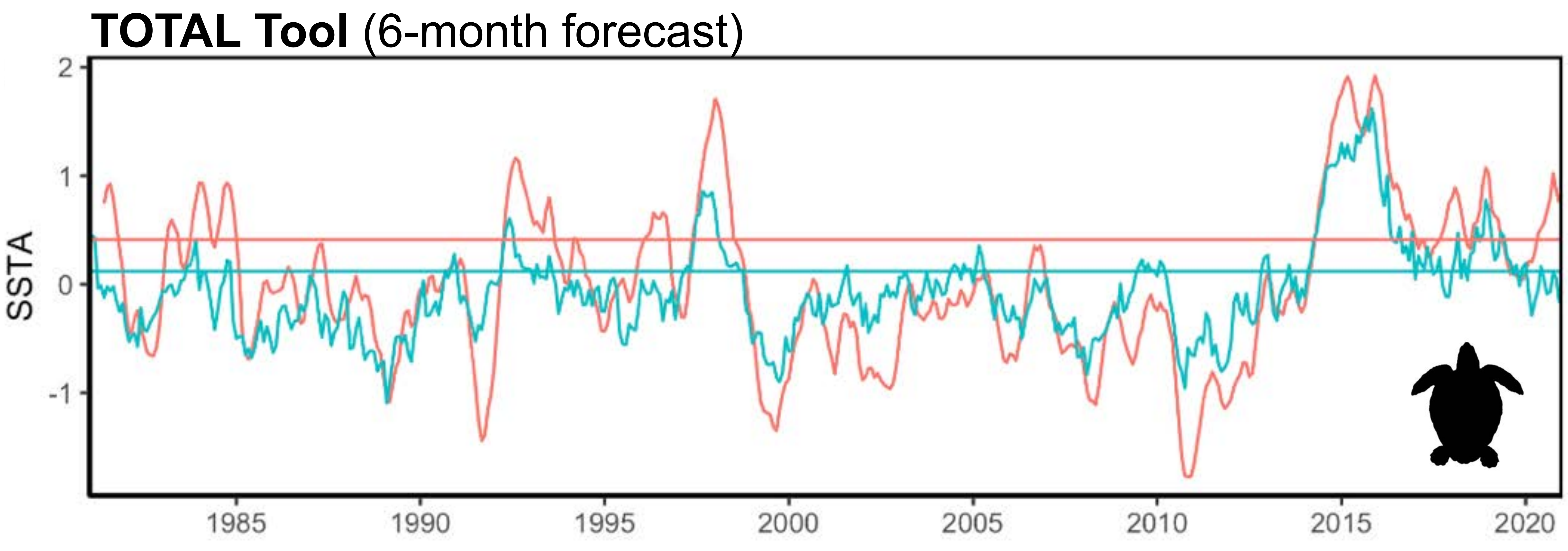
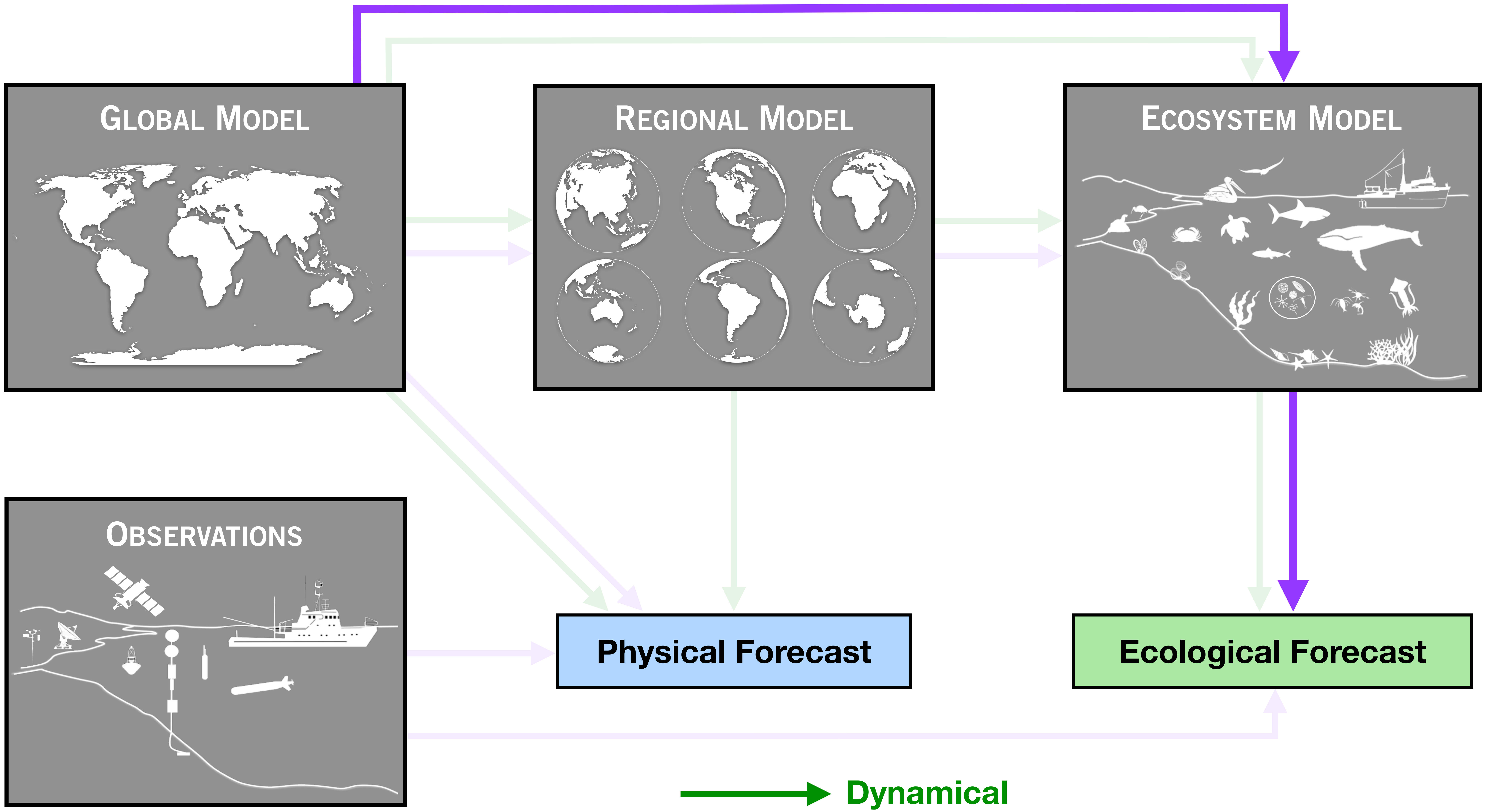


Closures were enacted in the summers of 2015 and 2016.

These closures could have been predicted at least 6 months in advance.

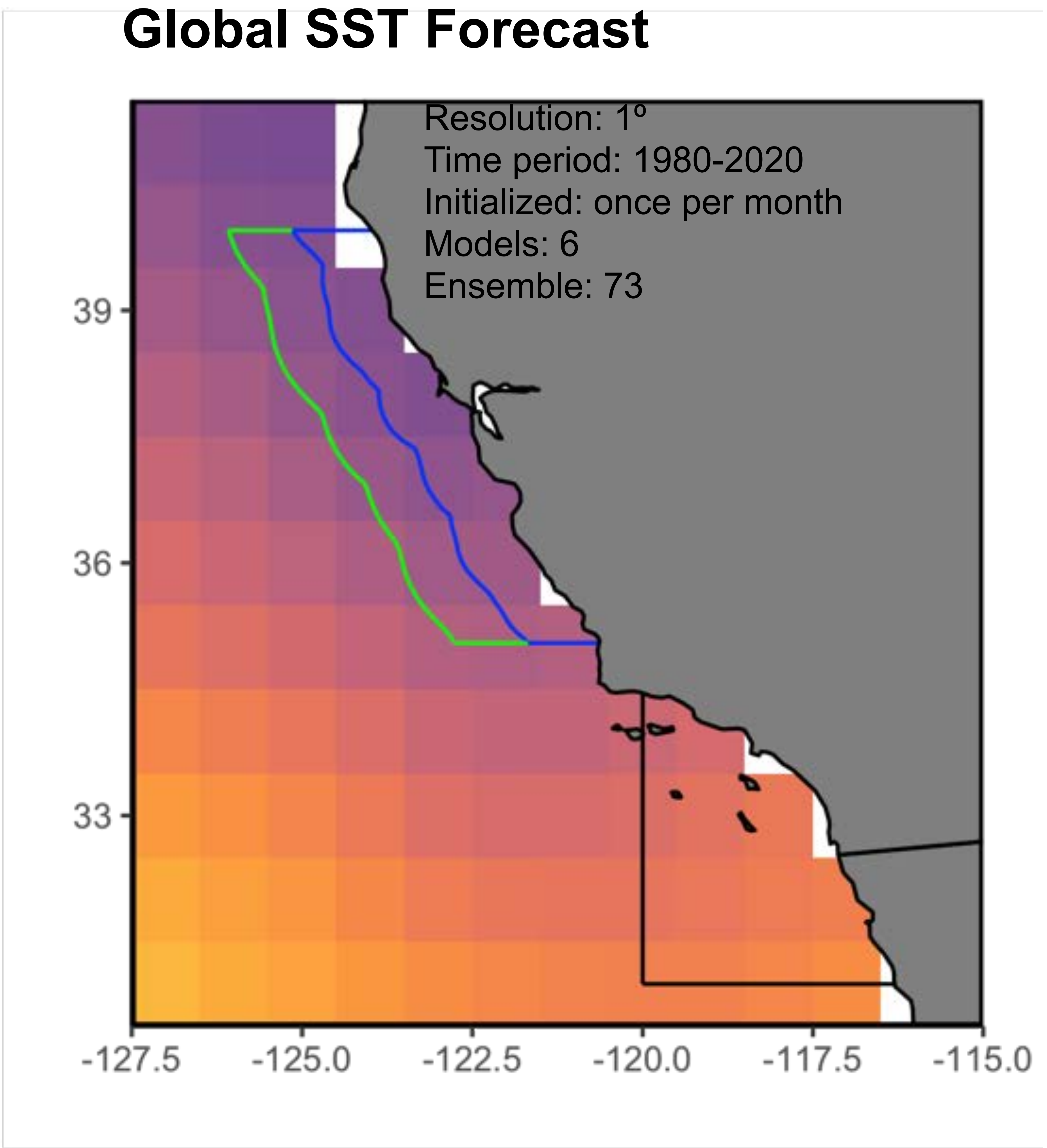
Brodie et al. (in prep)

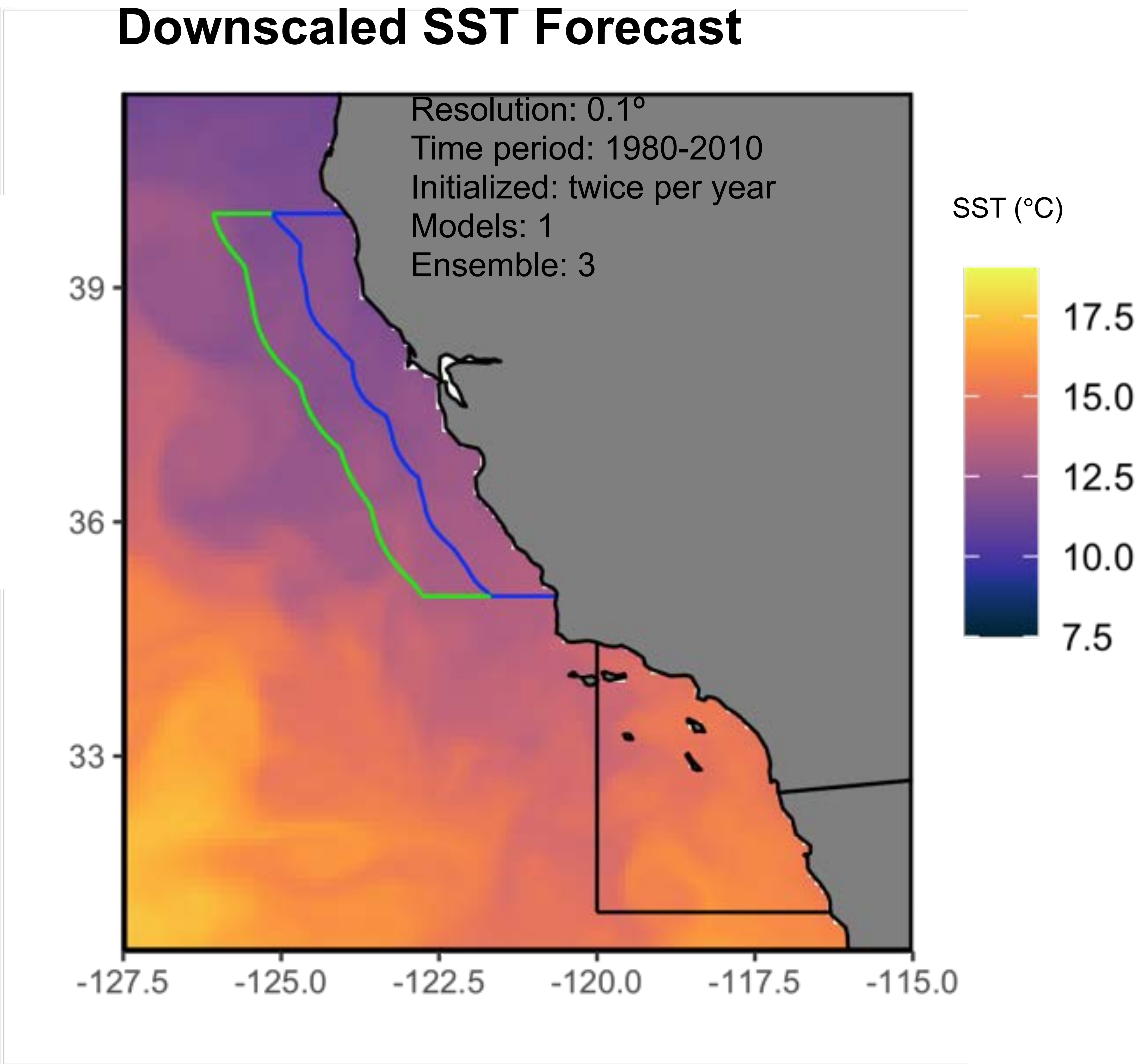
Moving TOTAL and HCI from nowcast to forecast



Jacox et al. (2020)

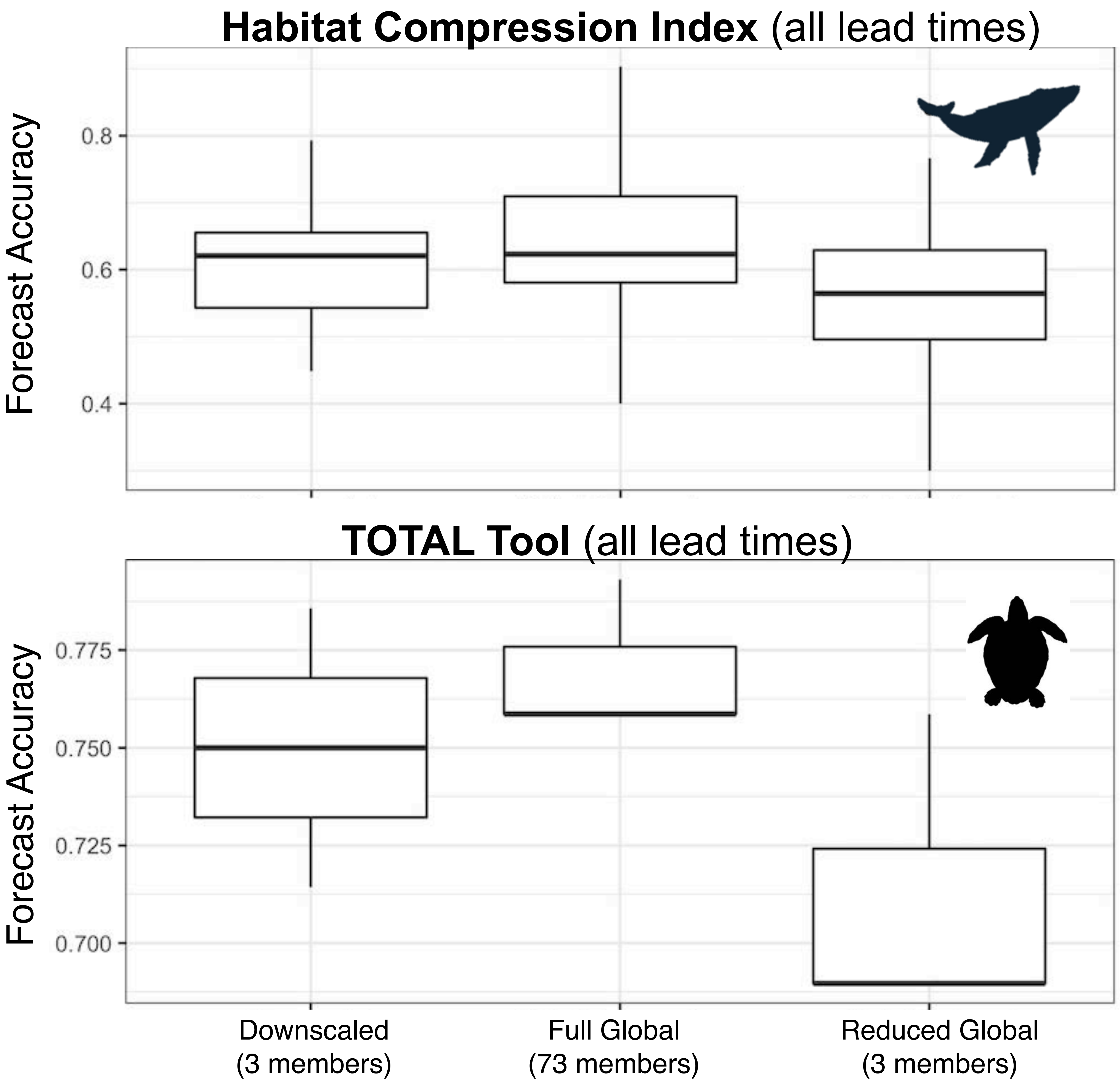
Comparing global and regional forecasts





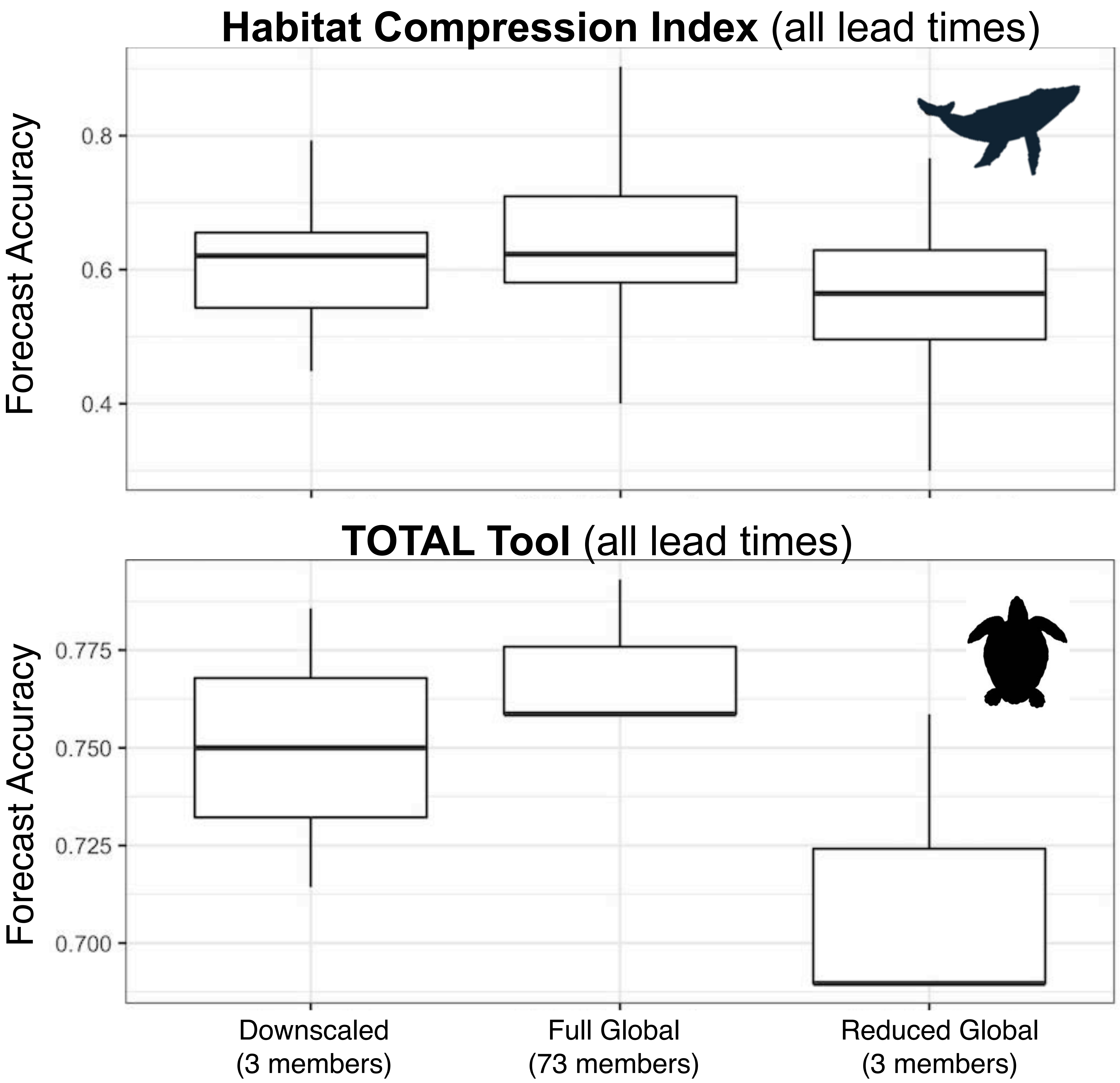
Brodie et al. (in prep)

Comparing global and regional forecasts



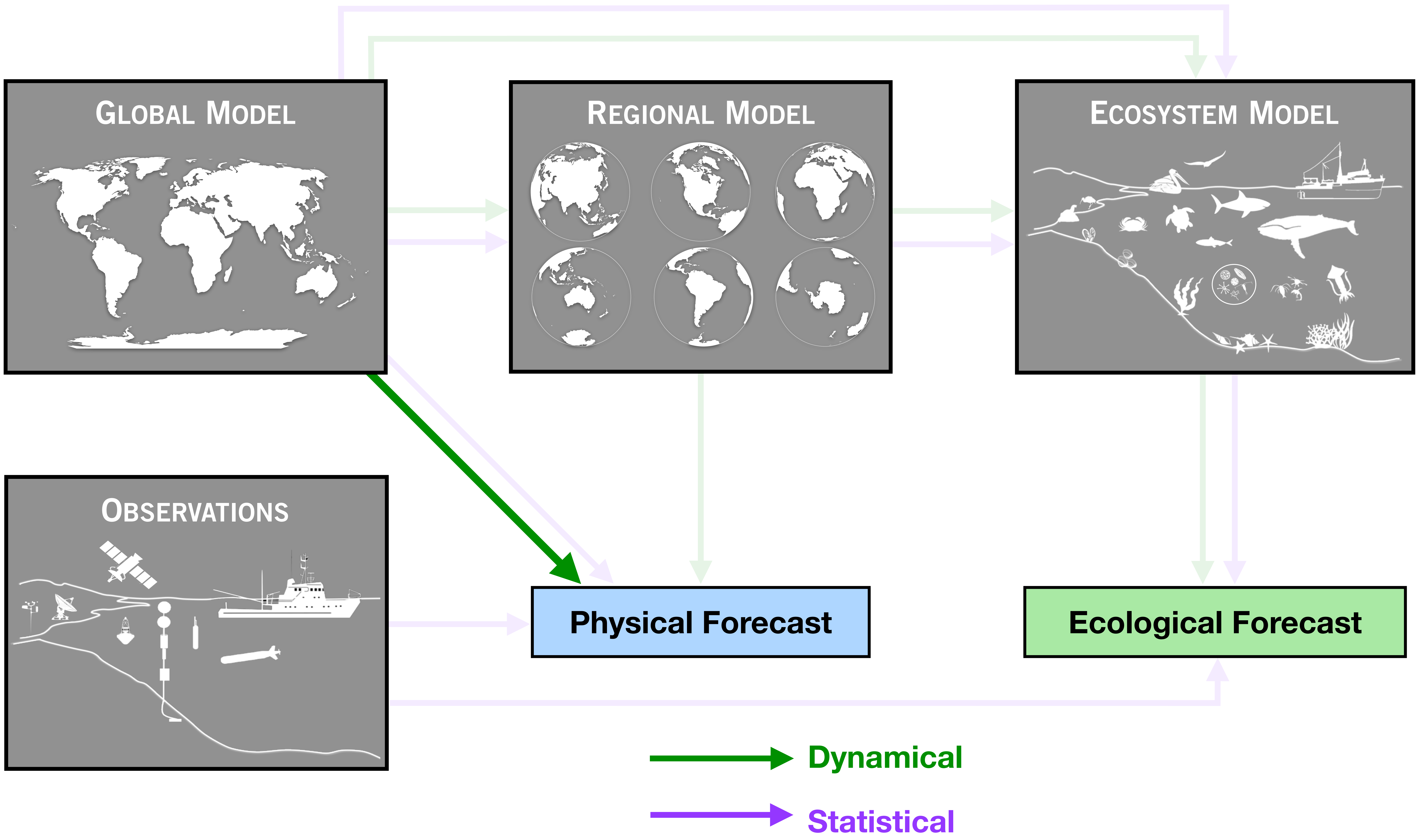
Brodie et al. (in prep)

Comparing global and regional forecasts



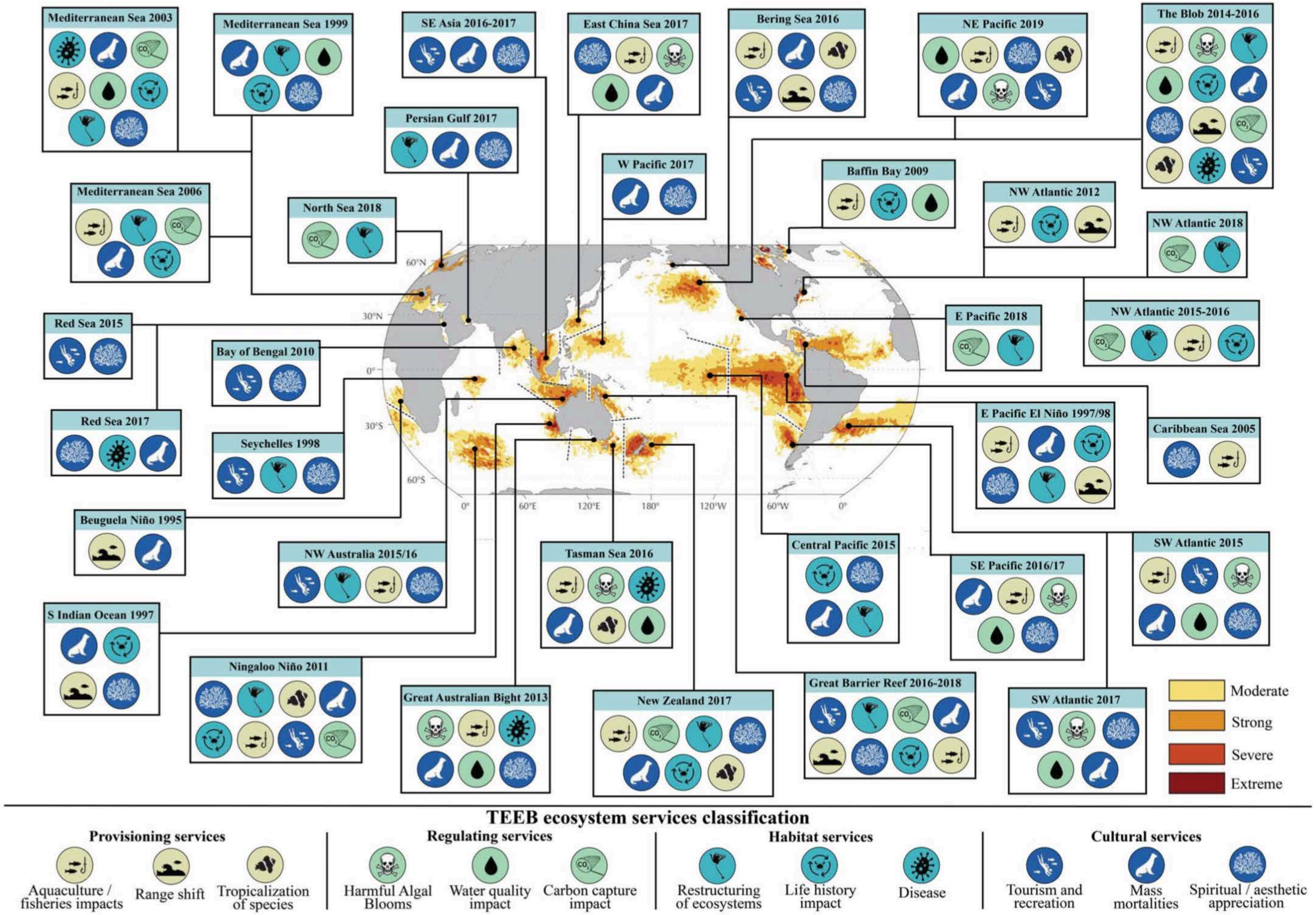
Downscaling improves skill,
BUT global forecasts are also skillful
and can even be better due to
availability of much larger ensembles.

Brodie et al. (in prep)

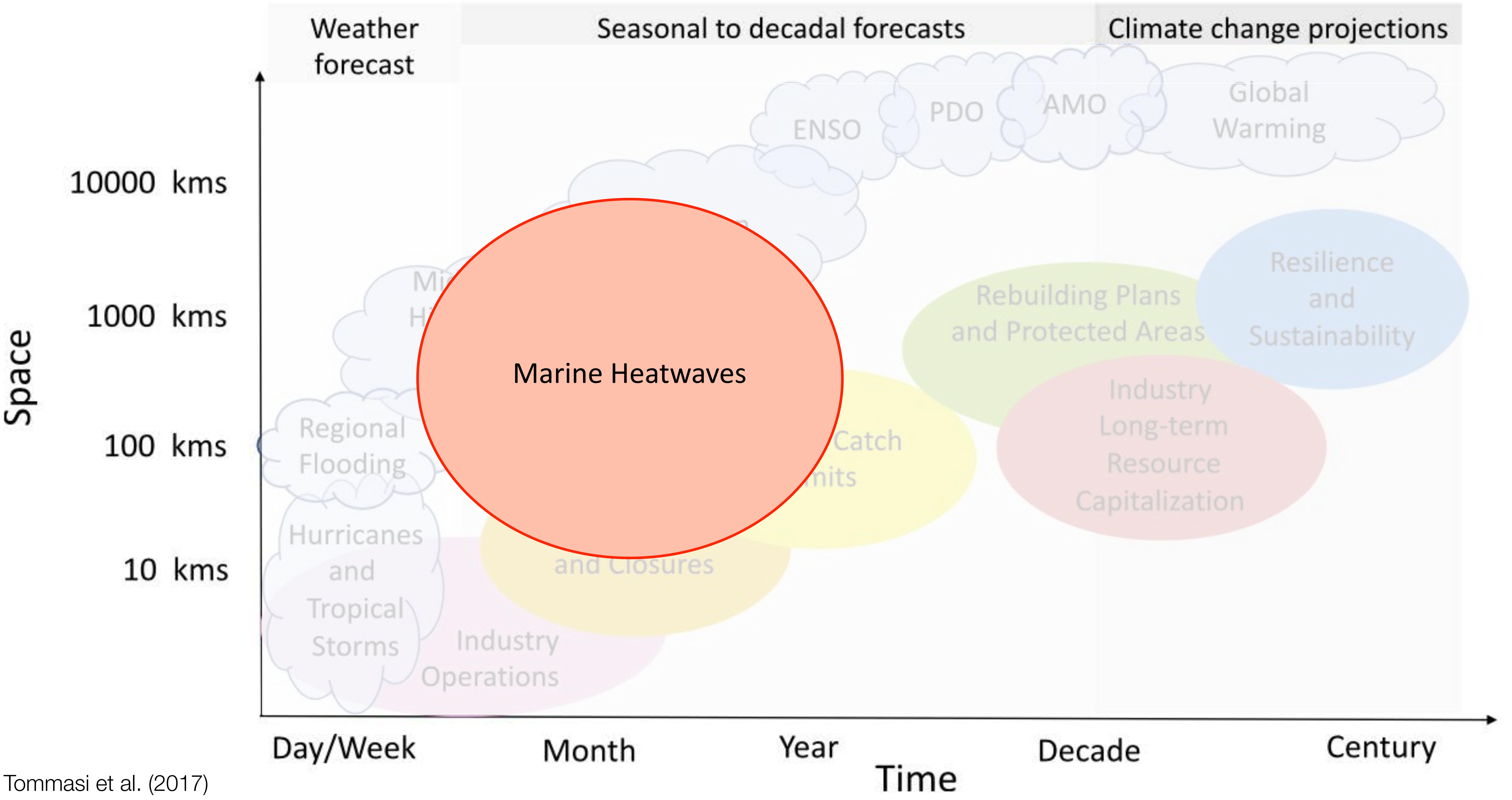


Jacox et al. (2020)

Widespread impacts of marine heatwaves



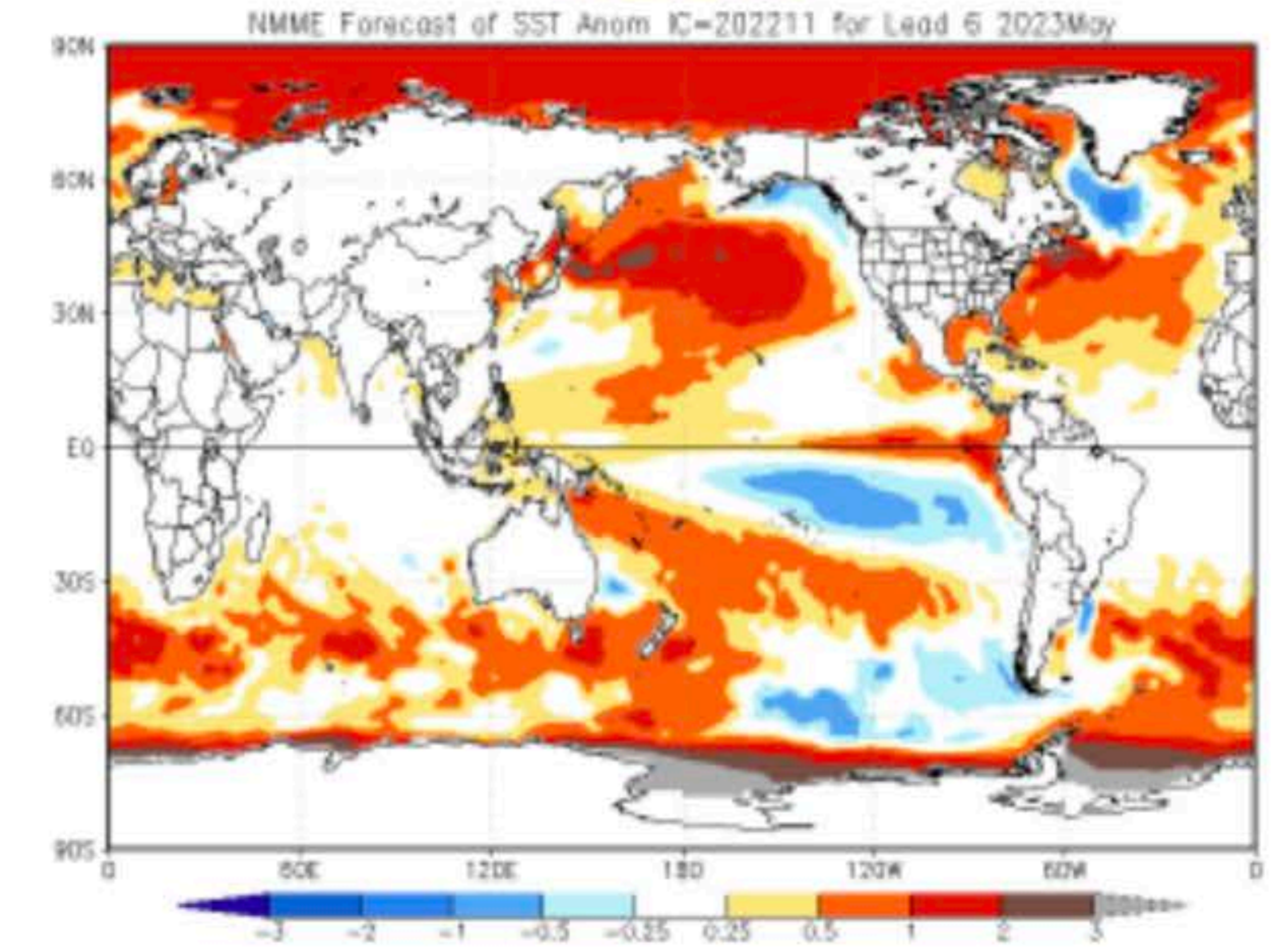
Smith et al. (2021)



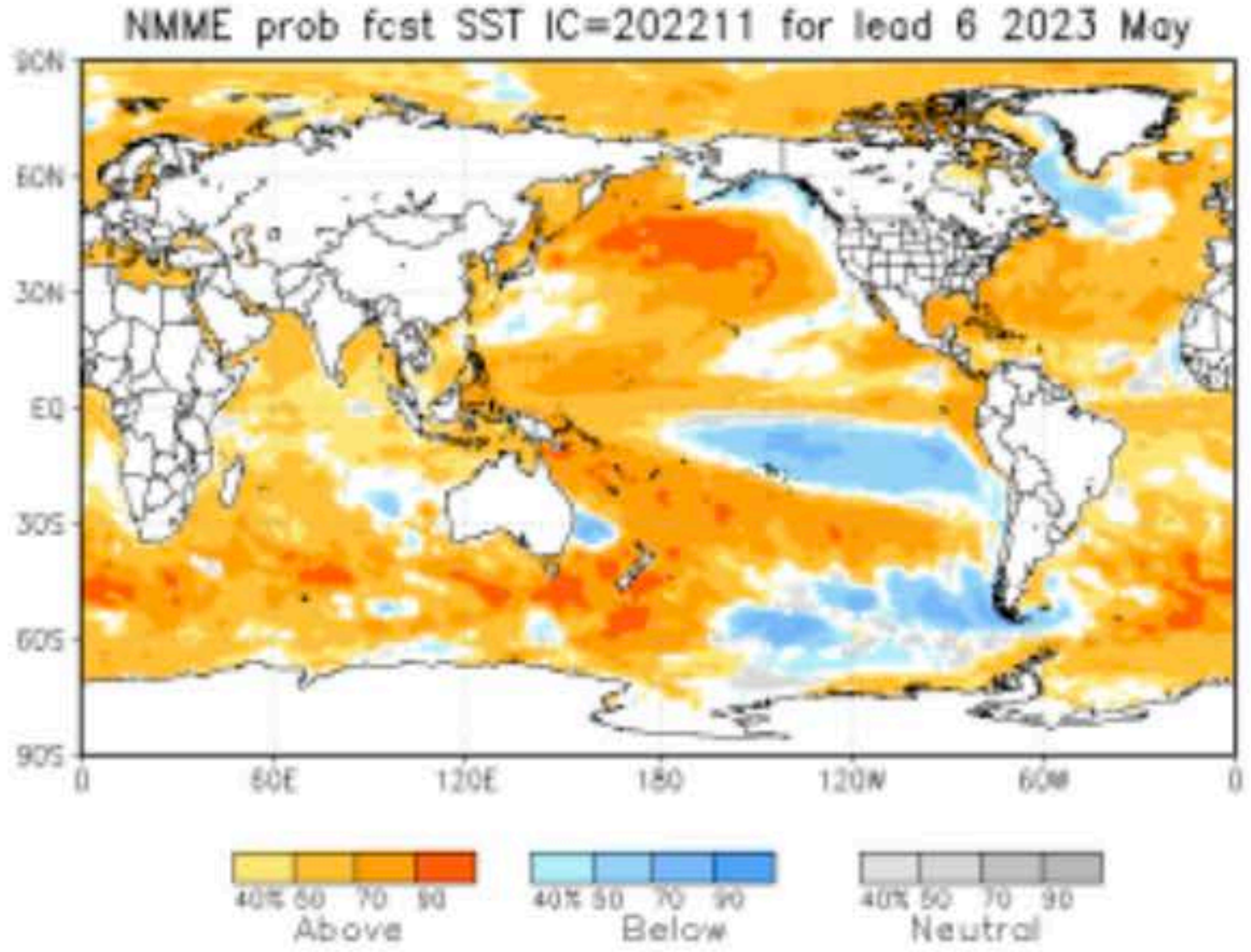
Tommasi et al. (2017)

Leveraging forecasts in the North American Multimodel Ensemble…

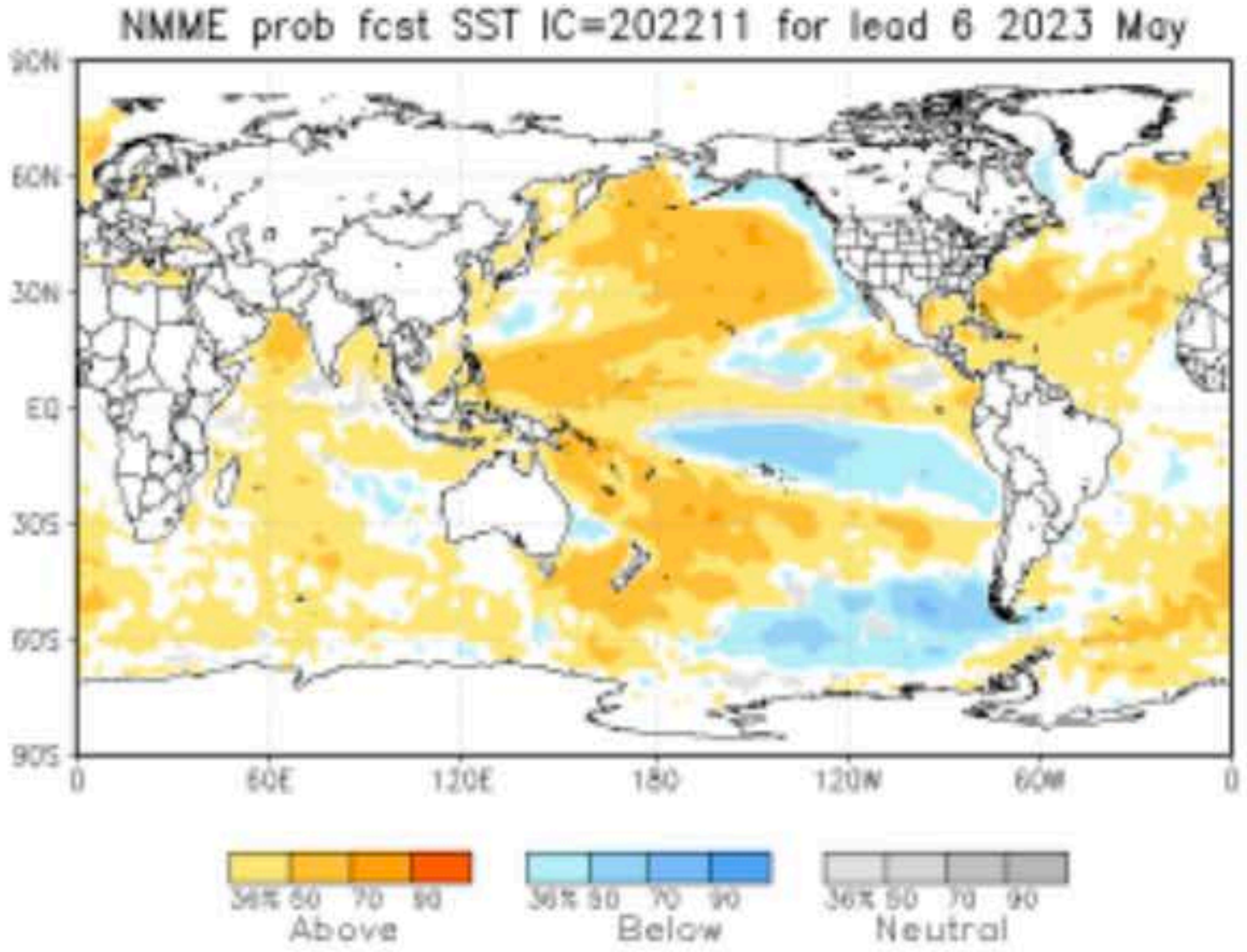
NMME



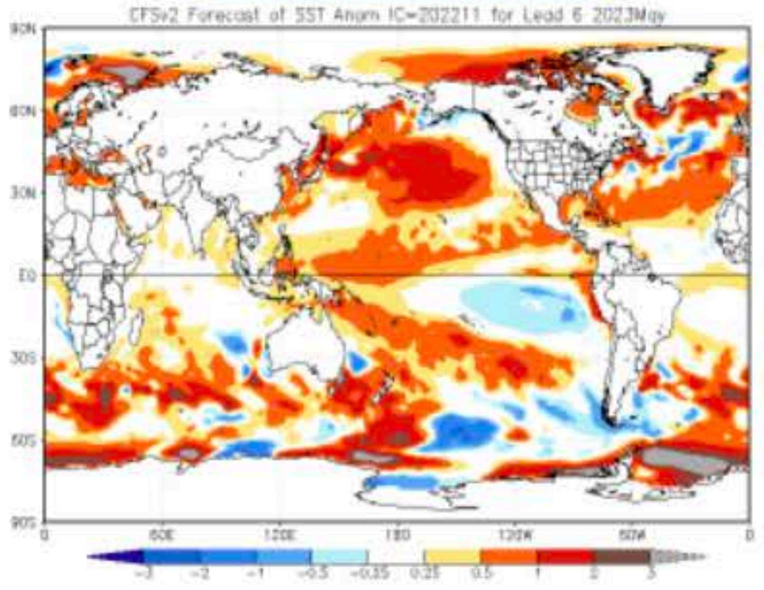
Prob fcst



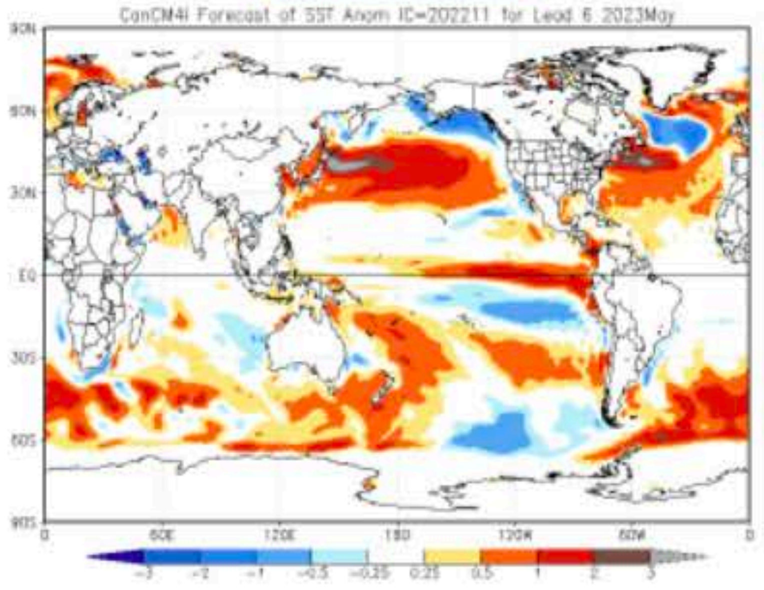
PAC calib. prob fcst



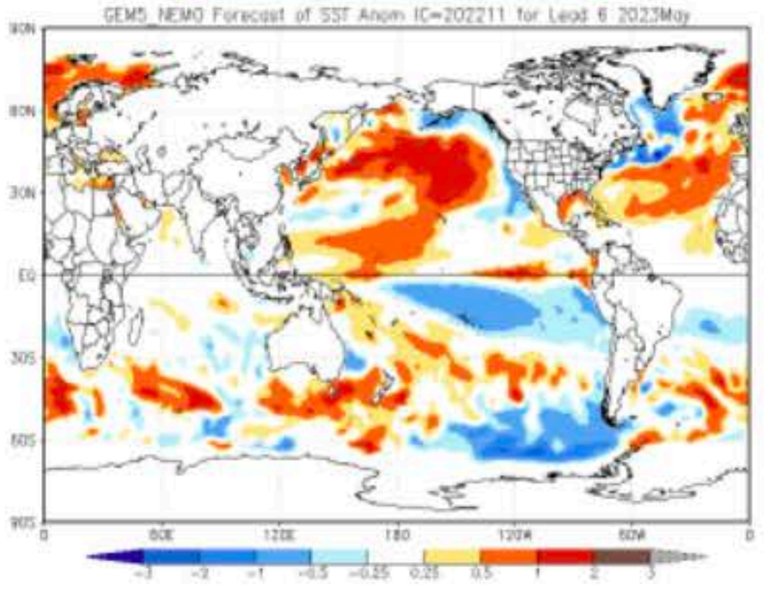
NCEP_CFSv2



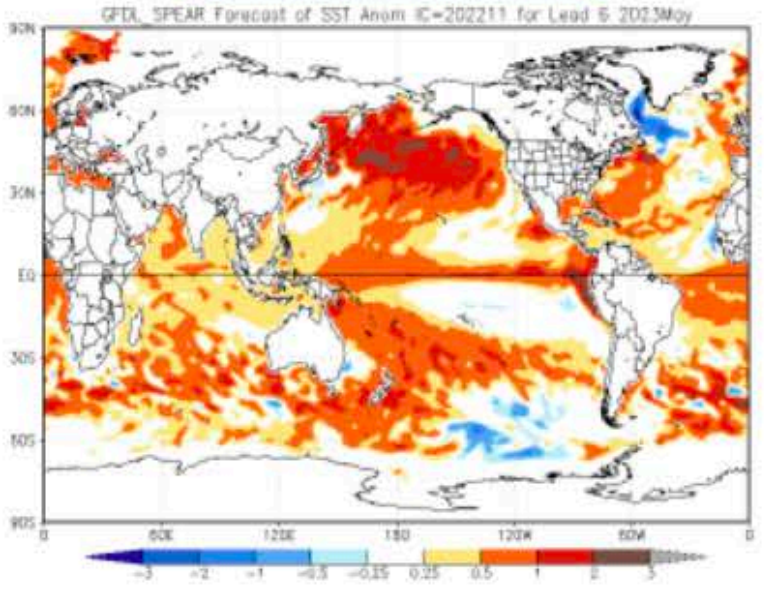
CanCM4i



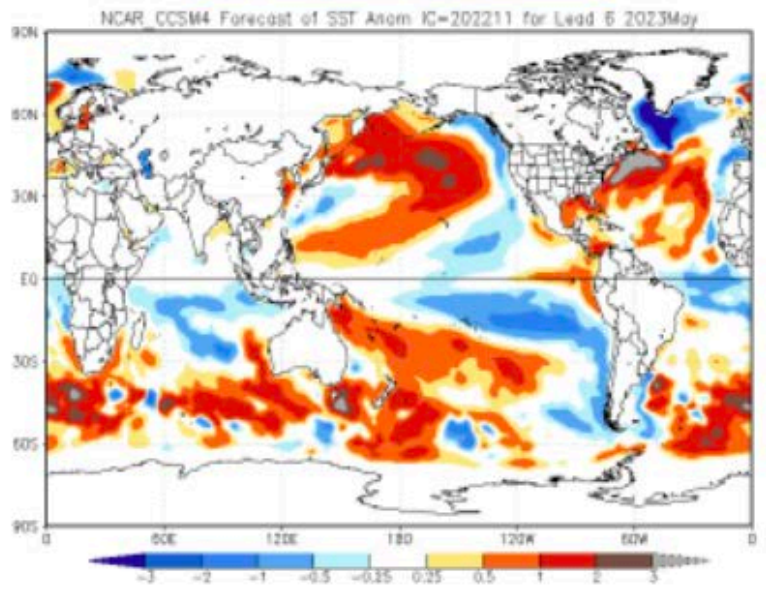
GEM5_NEMO



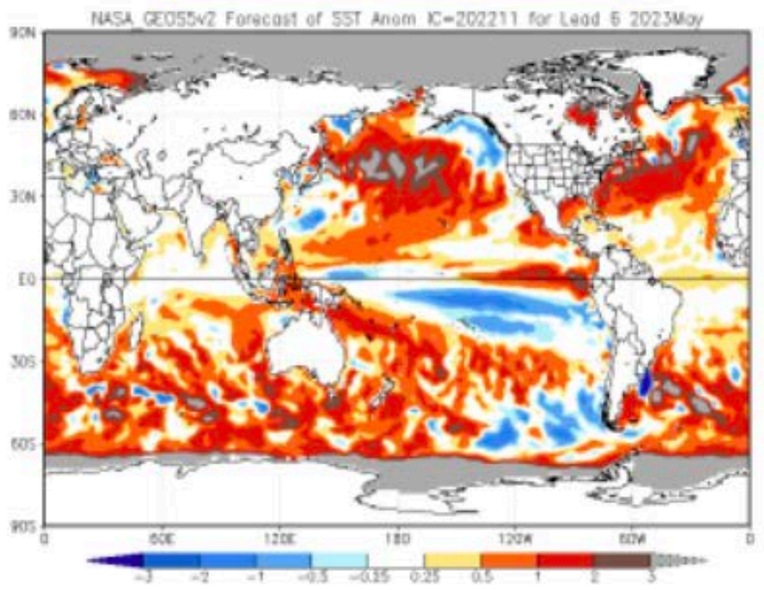
GFDL_SPEAR



NCAR_CCSM4



NASA_GEOS5v2



https://www.cpc.ncep.noaa.gov/products/NMME/

...to create seasonal marine heatwave forecasts

Seasonal SST forecasts (1991-2020)

↓

Remove lead- and initialization-dependent model mean climatology from each ensemble member to get SSTa

↓

(Detrend SSTa)

↓

Calculate MHW thresholds
(90th percentile of forecast SSTa from all ensemble members)

↓

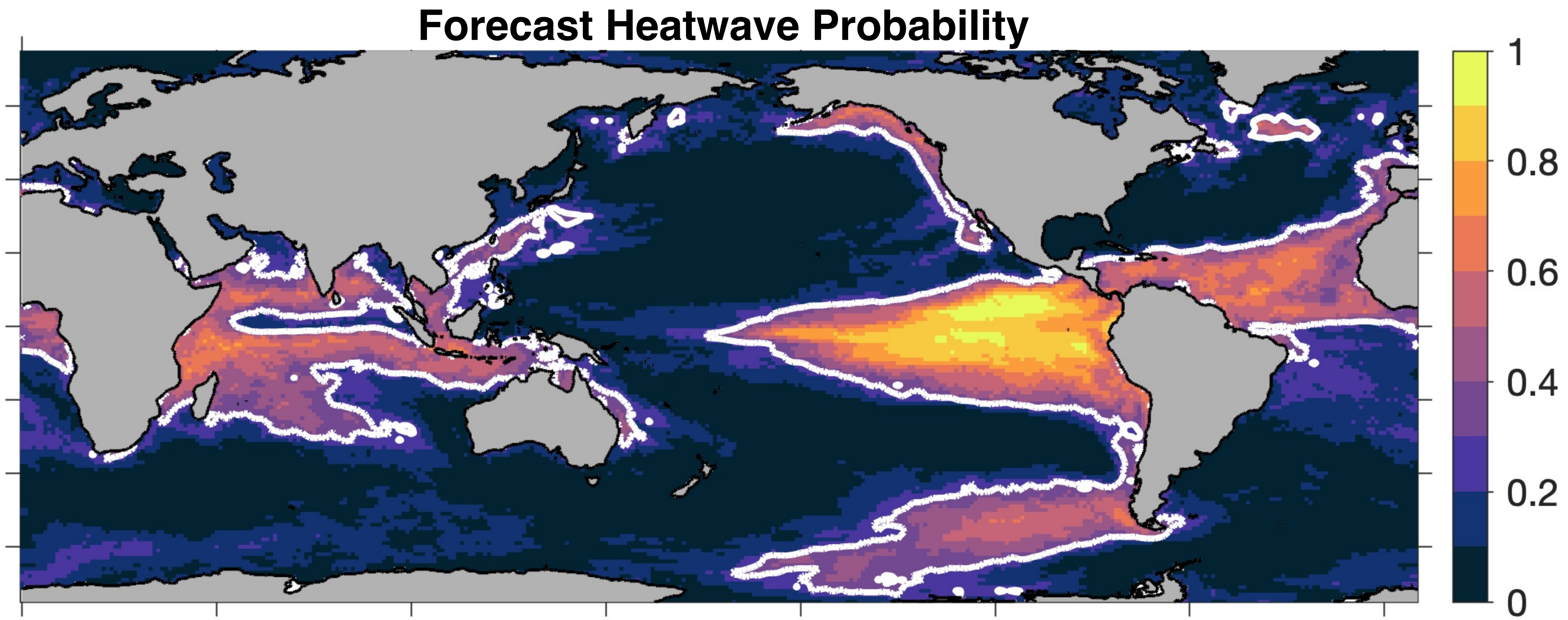
Identify forecast MHWs

Repeat for each of six models → ~70 member monthly MHW forecast

Evaluate with OISSTv2.1 SST

Jacox et al. (2022)

Example forecasts



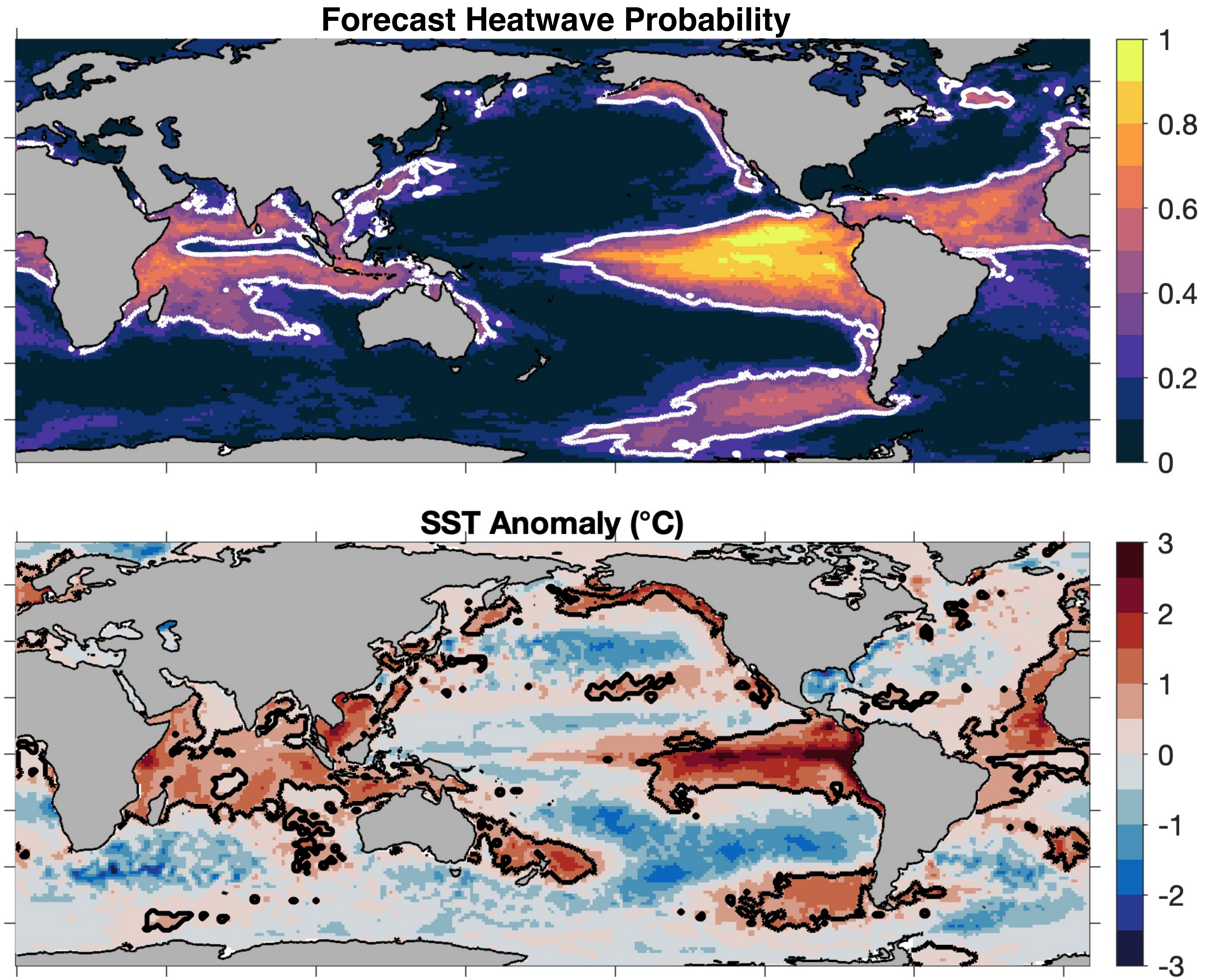
July 1997 forecast

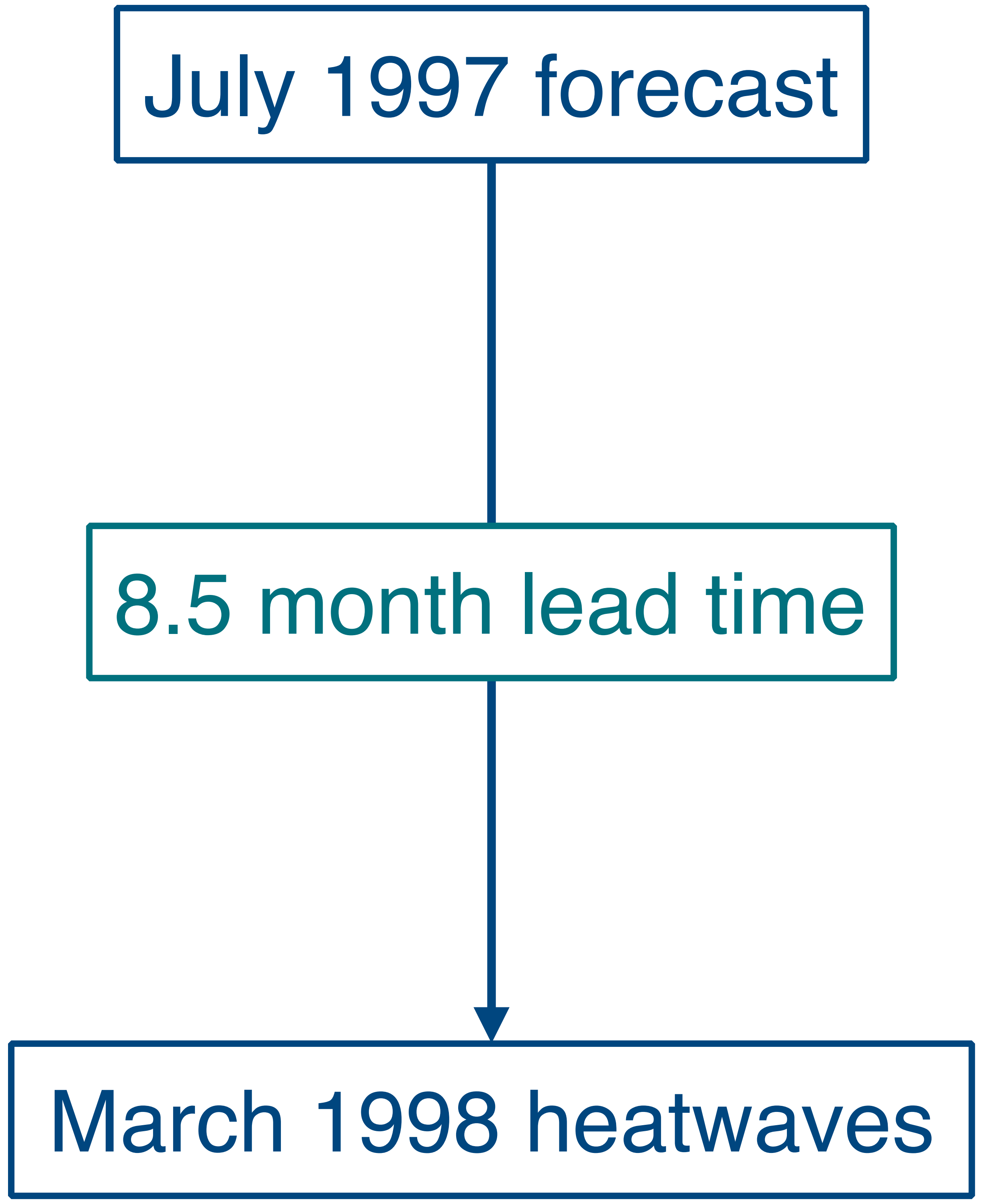
8.5 month lead time

March 1998 heatwaves

Jacox et al. (2022)

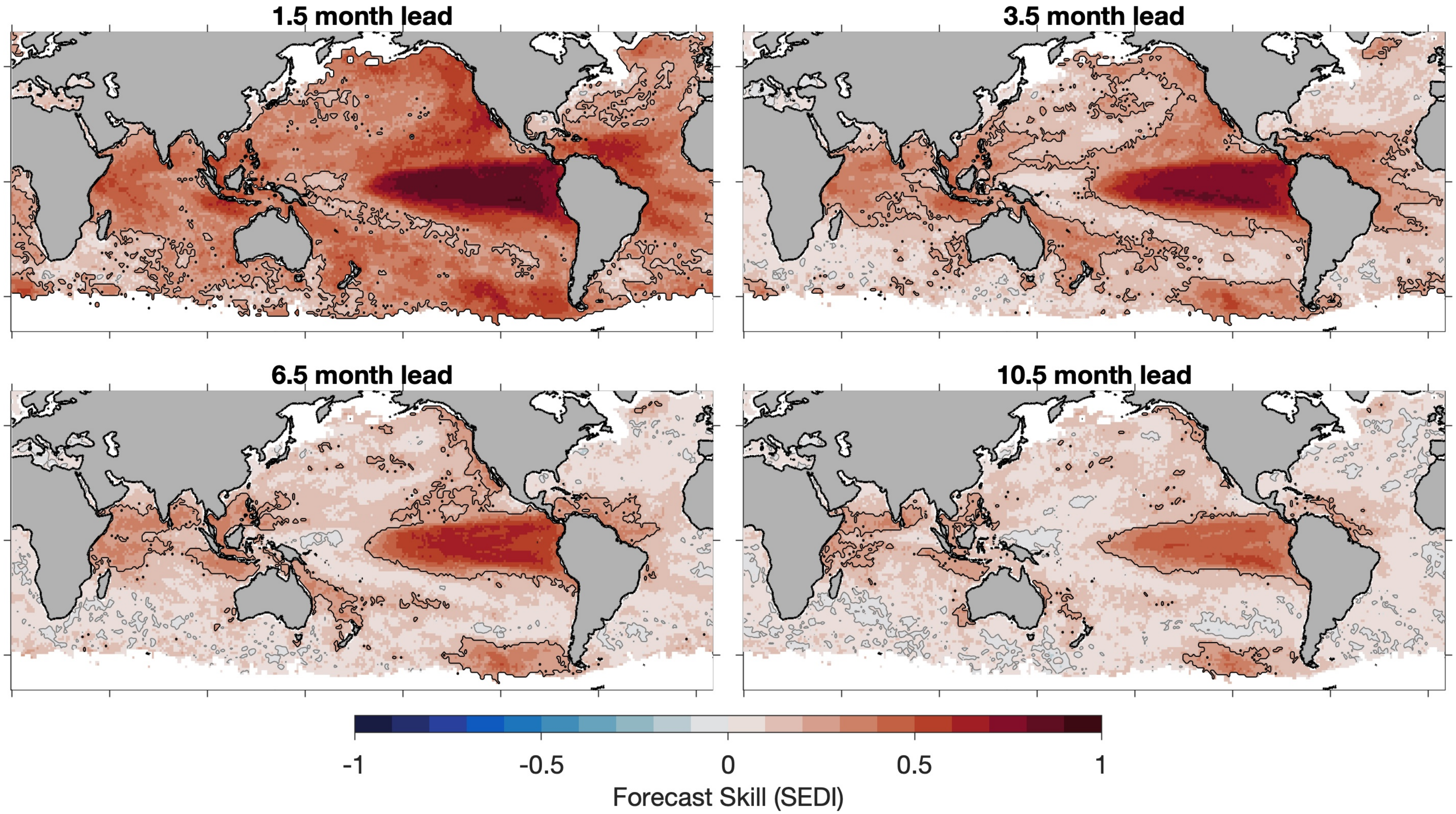
Example forecasts





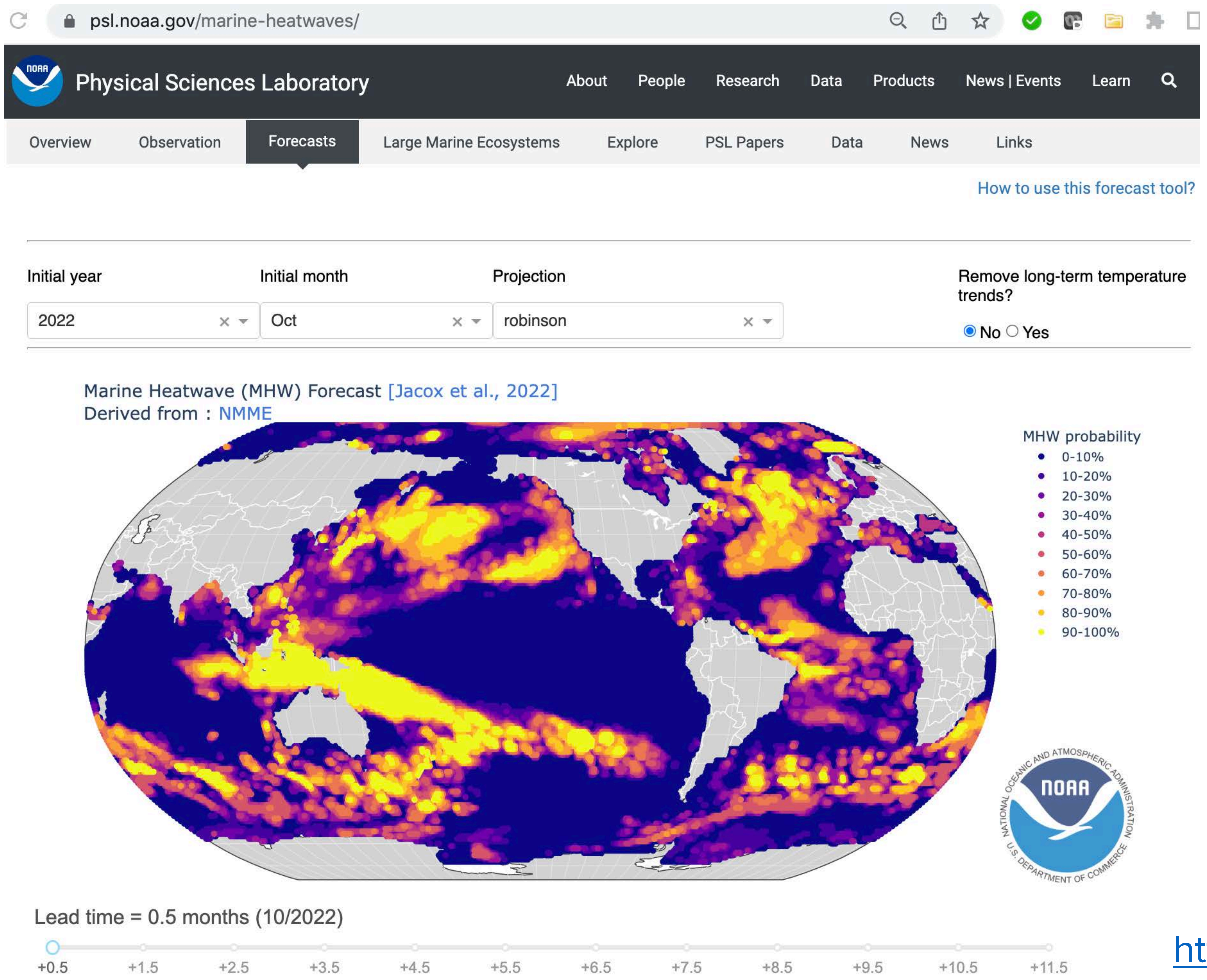
Jacox et al. (2022)

Marine heatwave forecast skill



Jacox et al. (2022)

Web-based marine heatwave forecasts



Built on output from the North American Multi-model Ensemble

>70-member ensemble, using six global climate models

Forecasts issued monthly

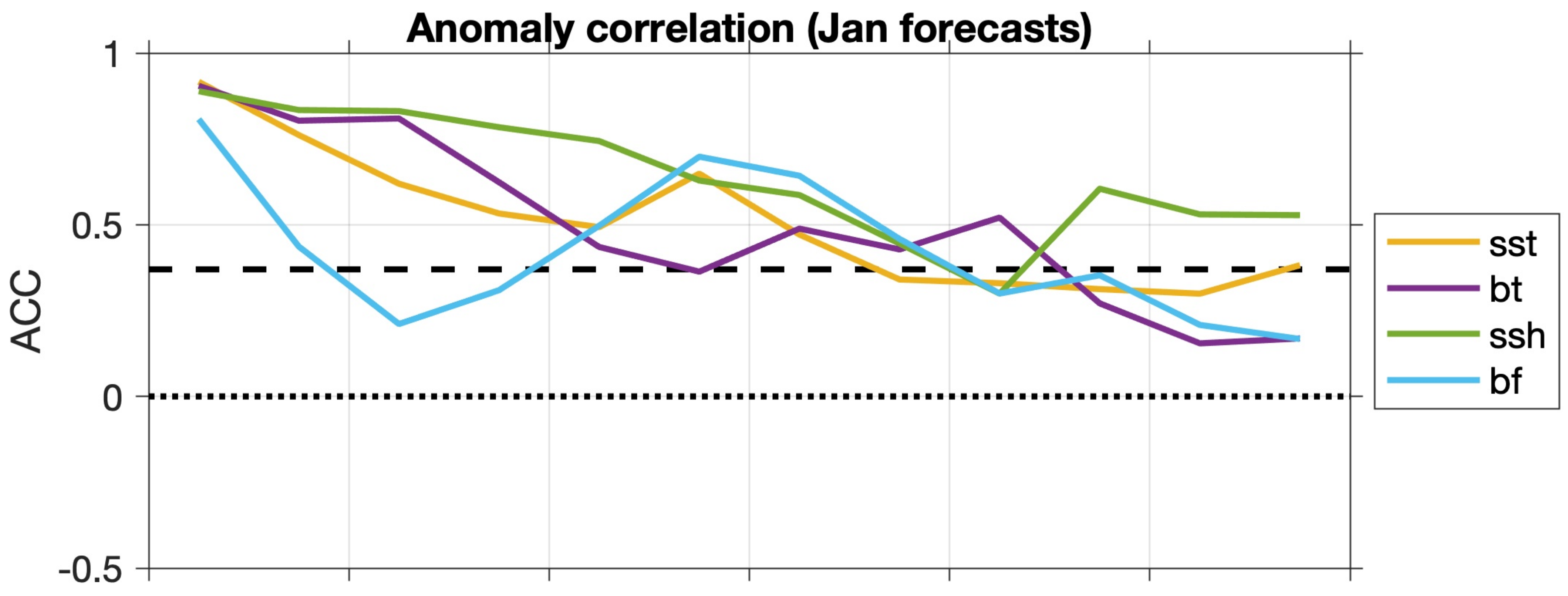
Lead times up to one year

Current and past forecasts online

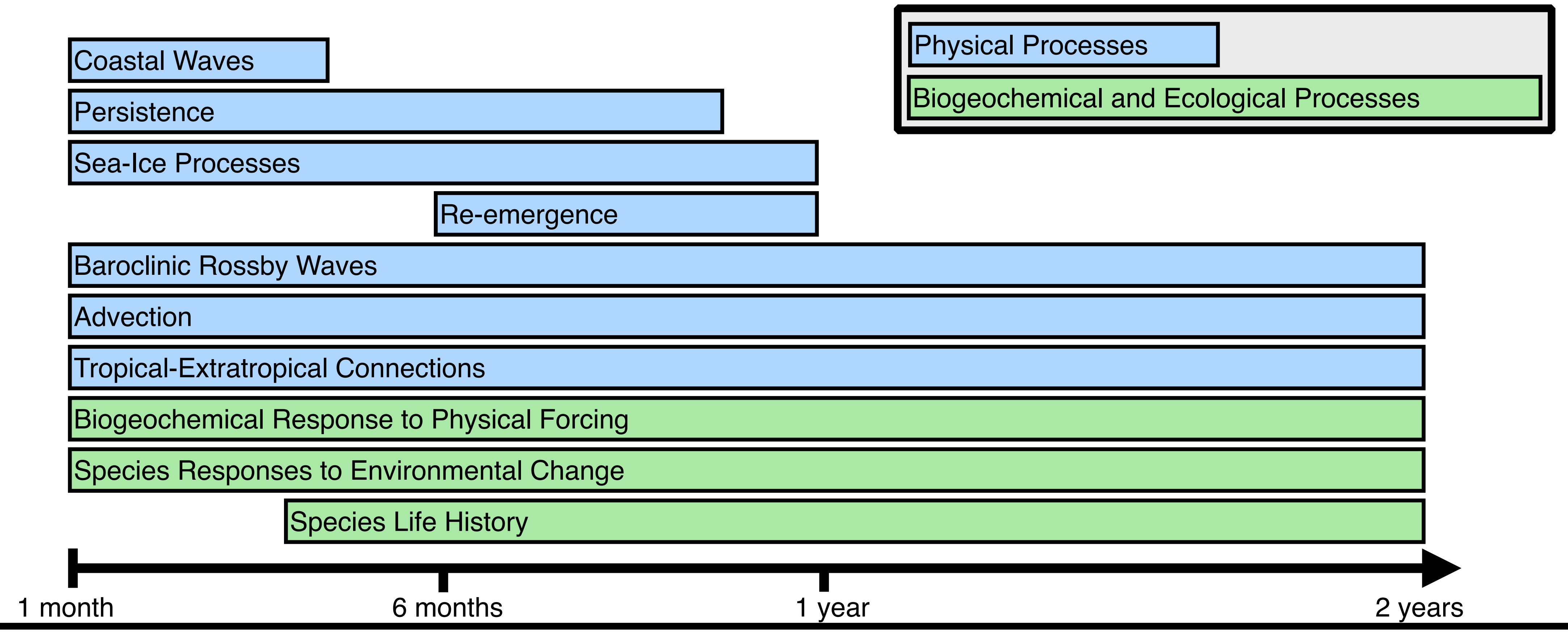
https://psl.noaa.gov/marine-heatwaves/#forecasts

Priority advancements in forecasting for marine ecosystem management

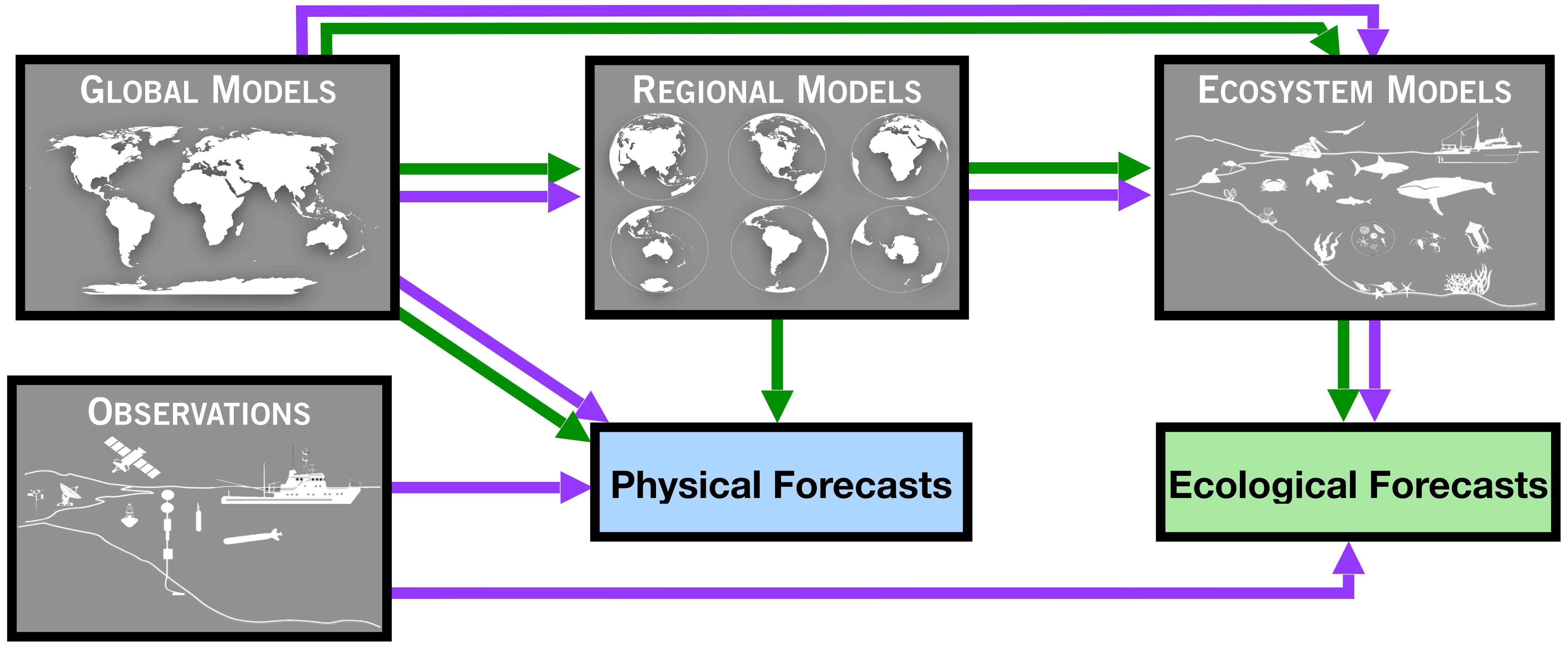
Evaluate forecast skill and uncertainty



Improve mechanistic understanding



Develop and improve forecasts



Facilitate uptake of climate information