

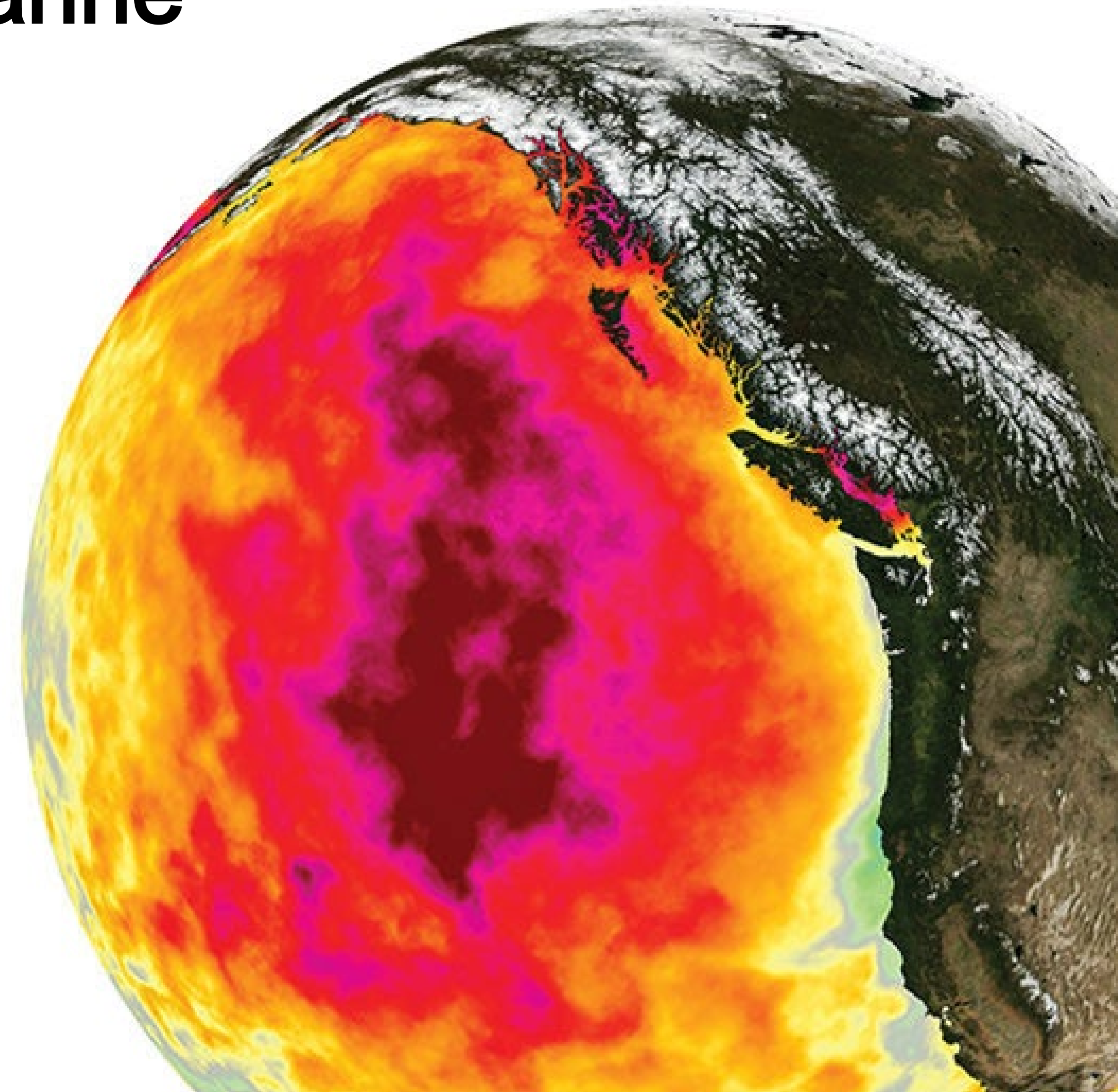
Leveraging the NMME for Marine Ecosystem Prediction

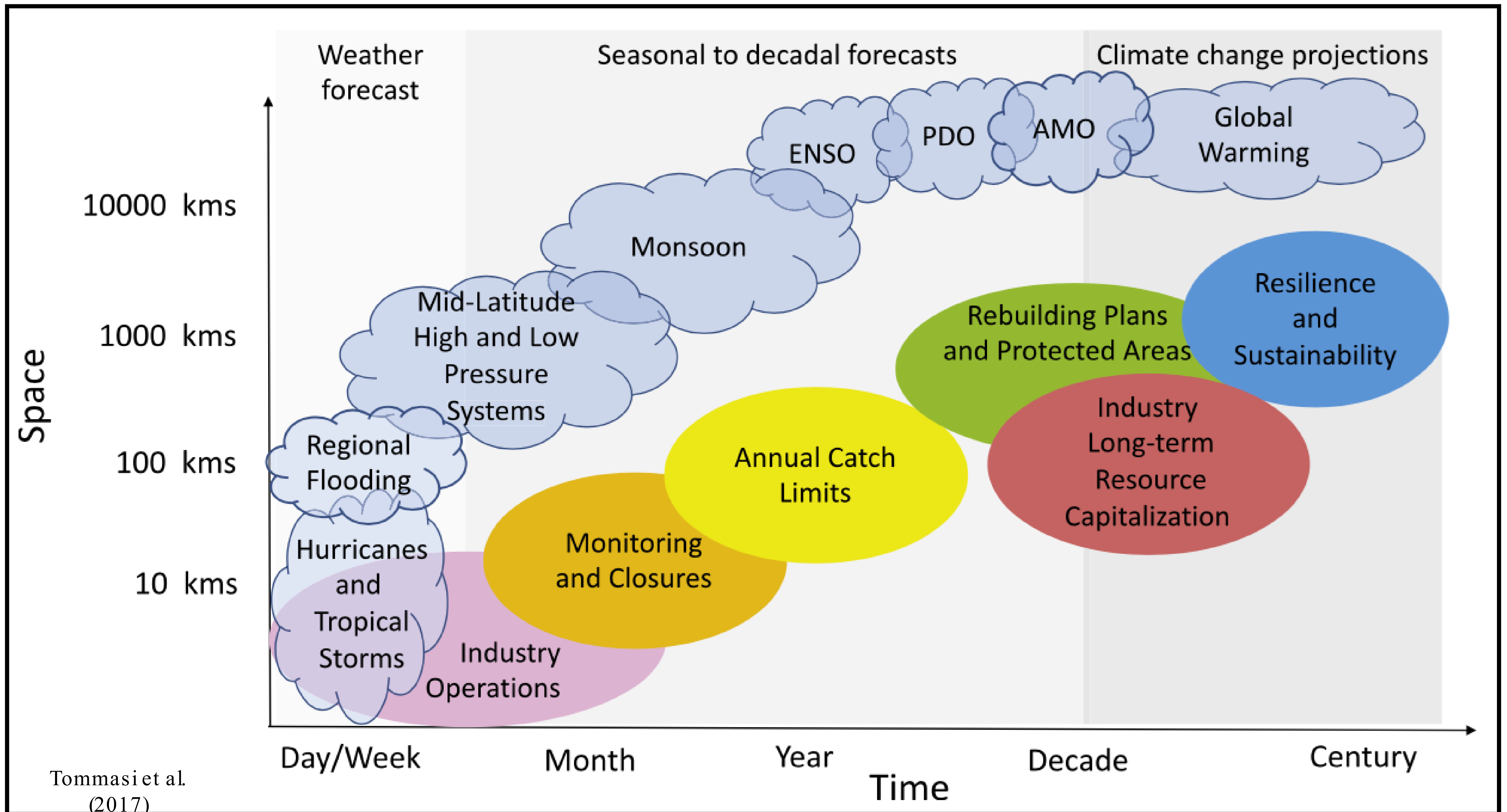
Mike Jacox

NOAA Southwest Fisheries Science Center
NOAA Physical Sciences Laboratory

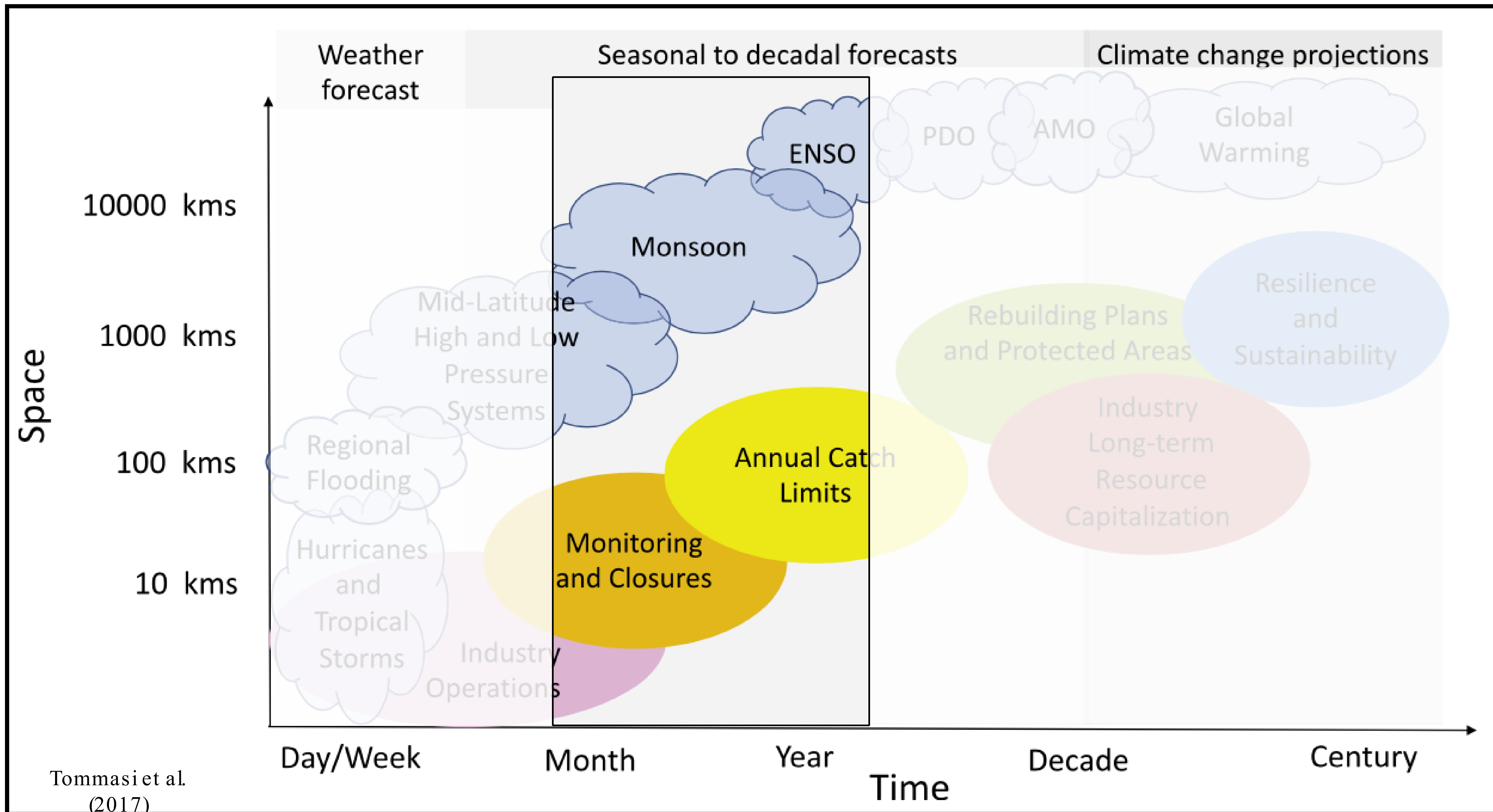
With lots of help from

Mer Pozo Buil, Steph Brodie, Steven Bograd, Elliott Hazen,
Desiree Tommasi, Mike Alexander, Dillon Amaya, Emily Becker,
Chris Edwards, Jerome Fiechter, Heather Welch



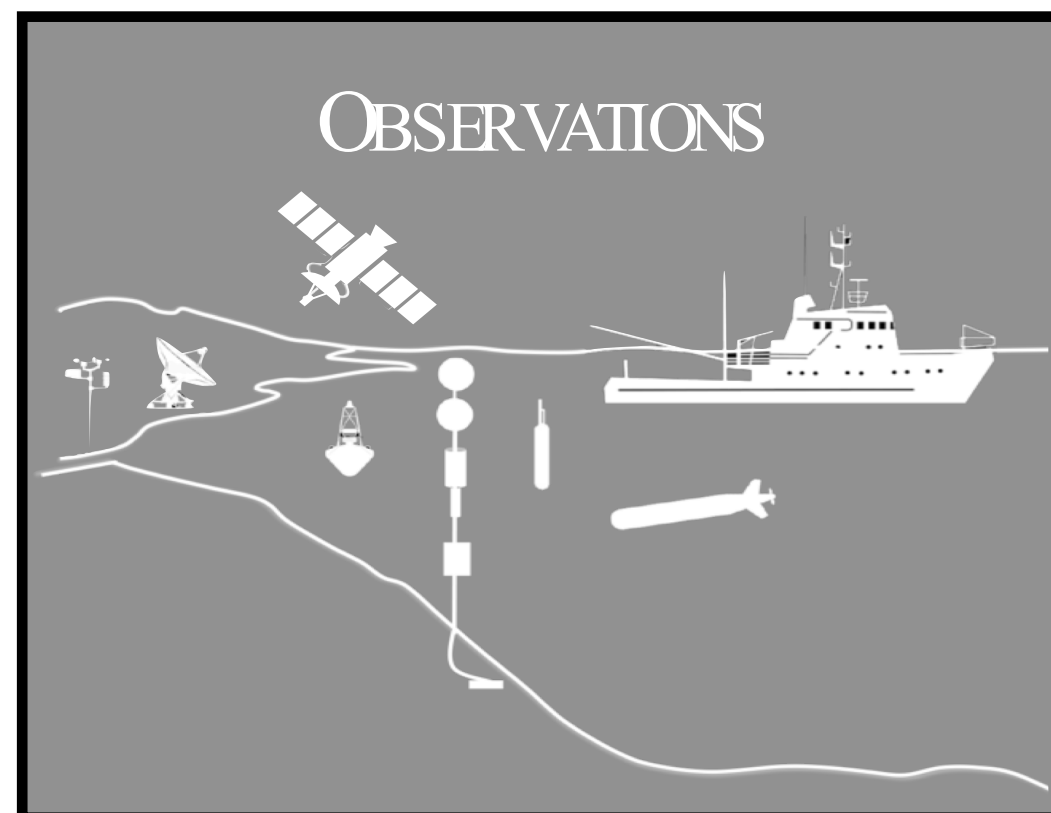
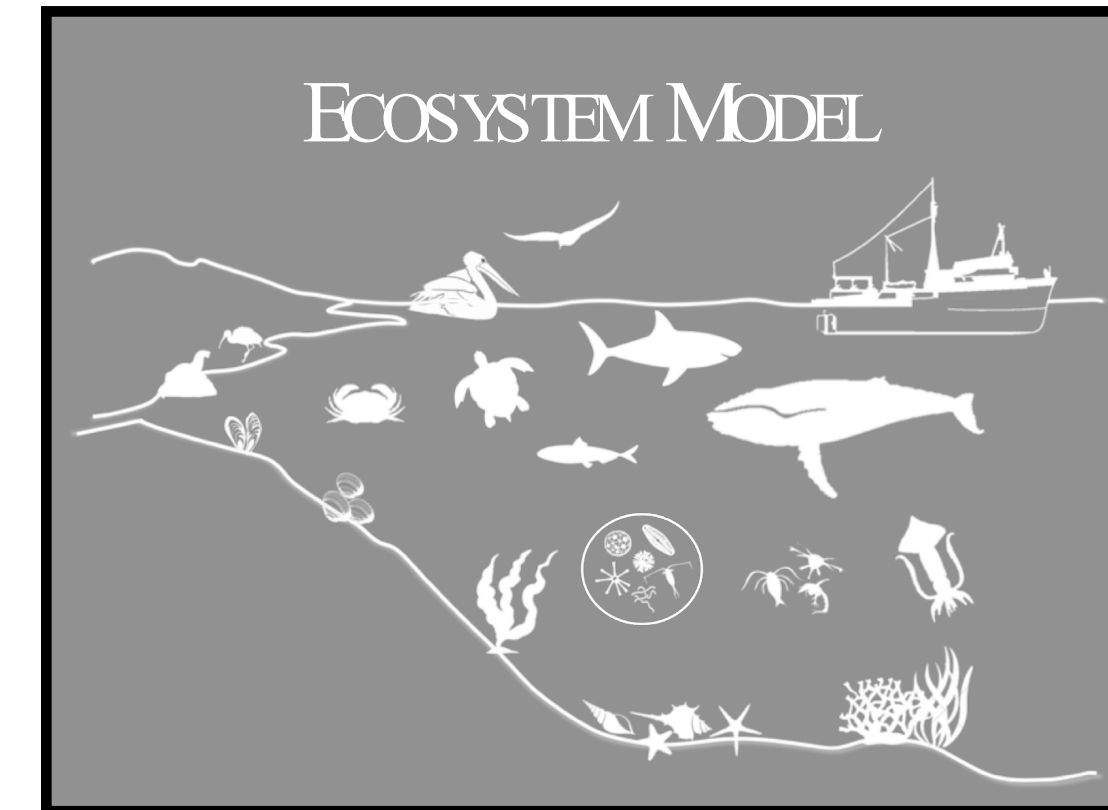
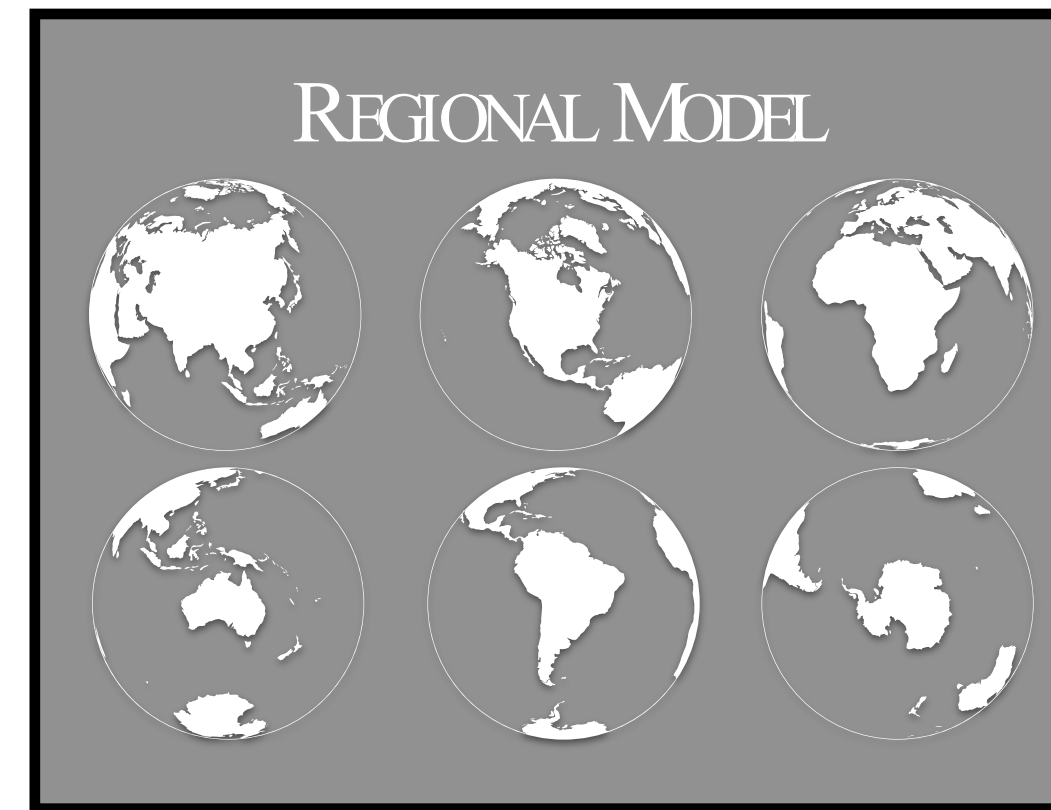
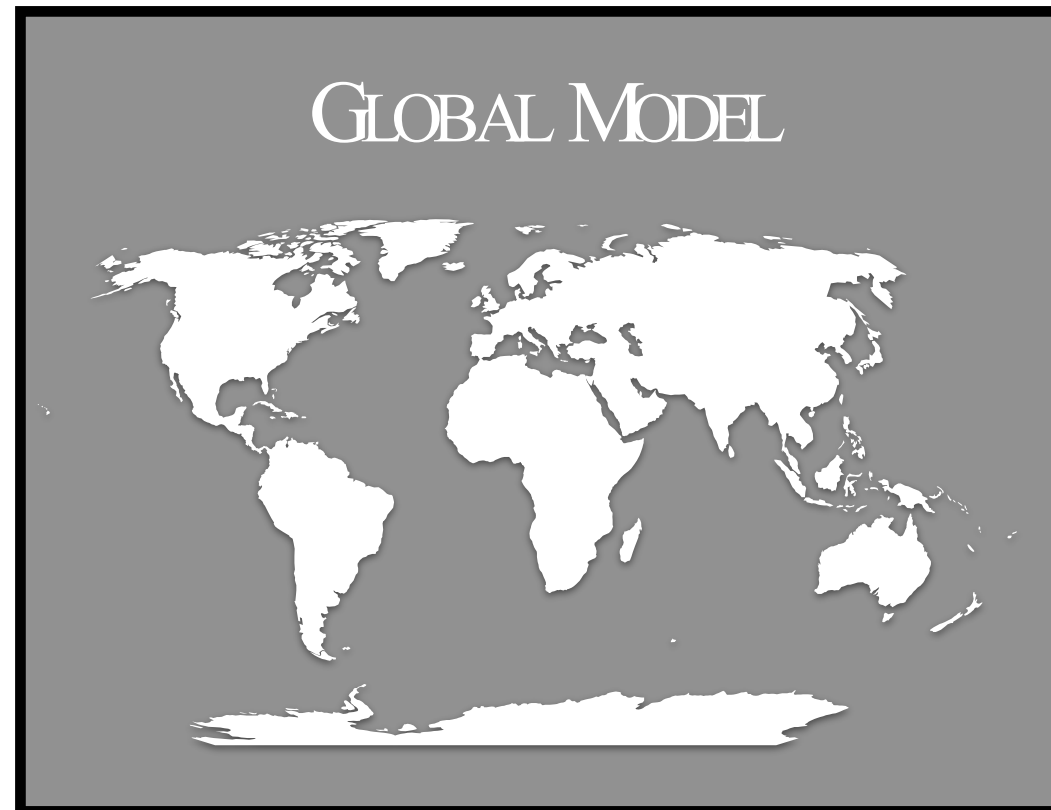


Tommasi et al. (2017)



Tommasi et al.
(2017)

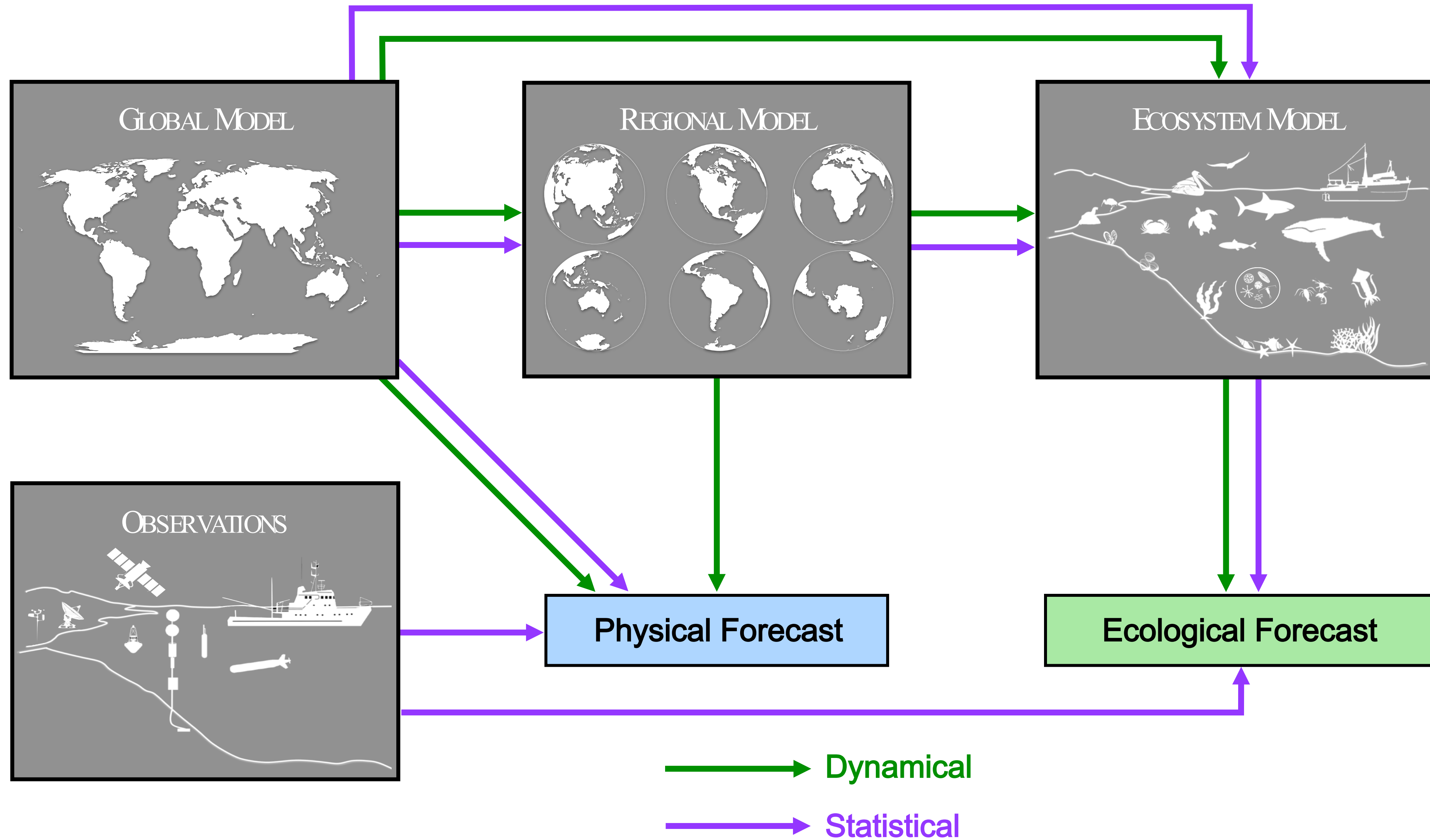
Forecast tools and methods



Physical Forecast

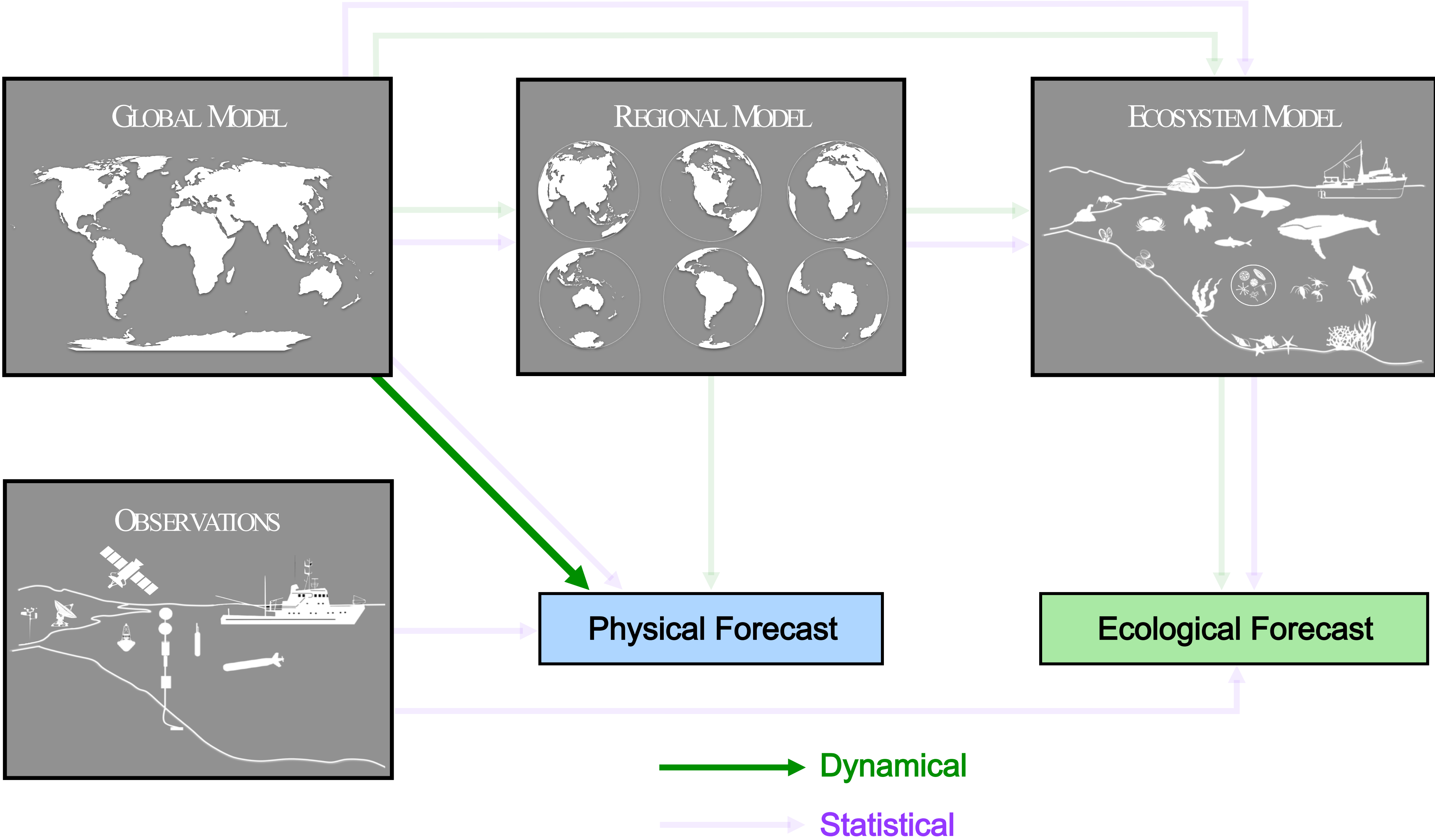
Ecological Forecast

Forecast tools and methods

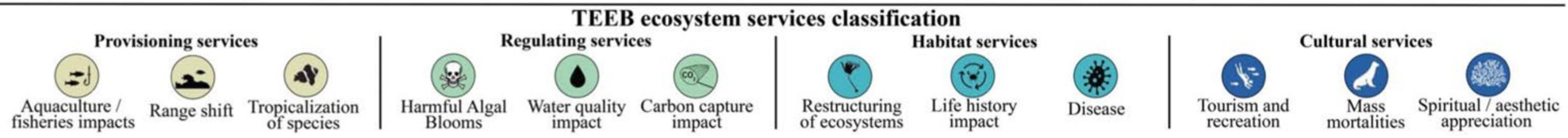
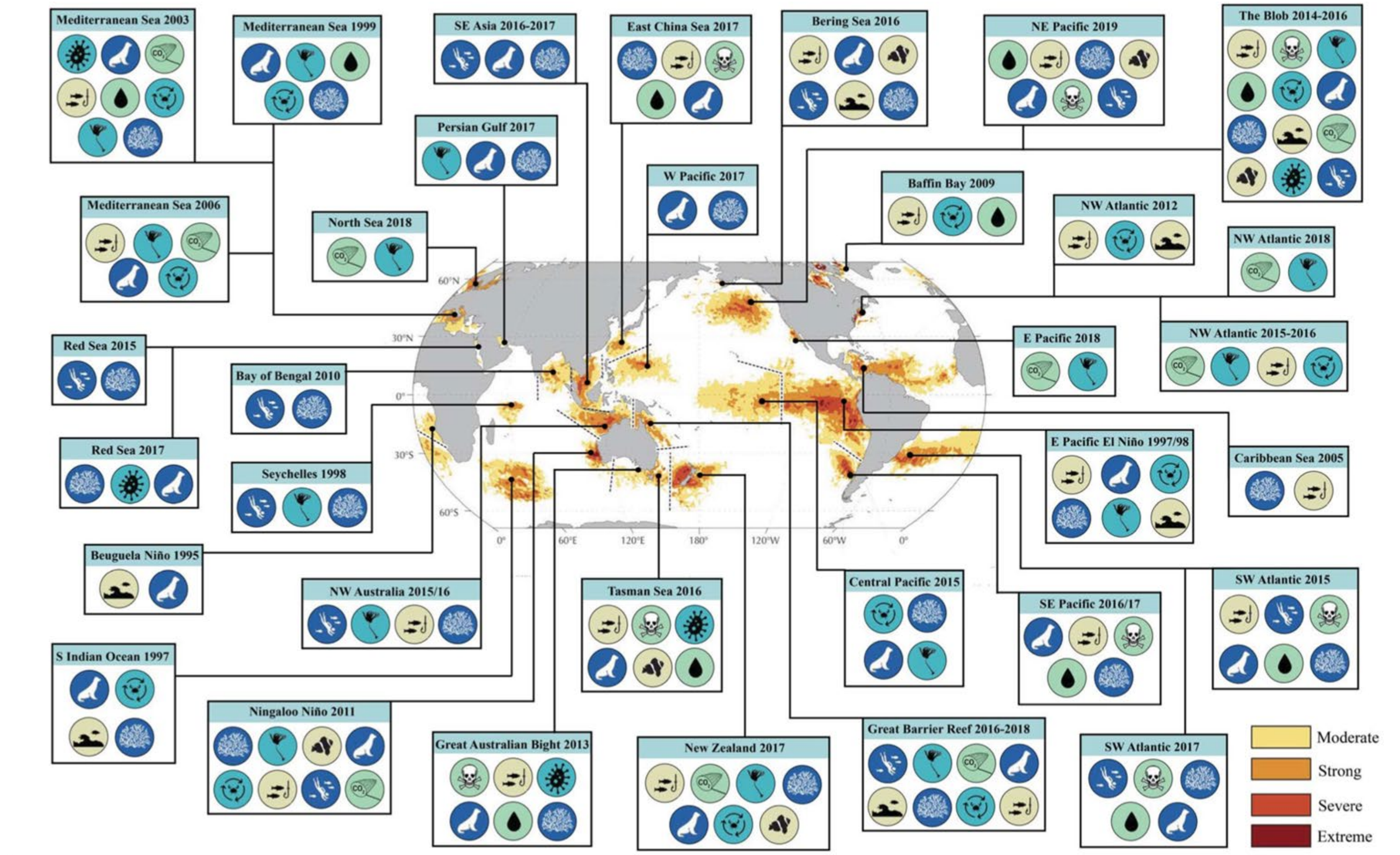


Jacox et al. (2020)

Forecast tools and methods



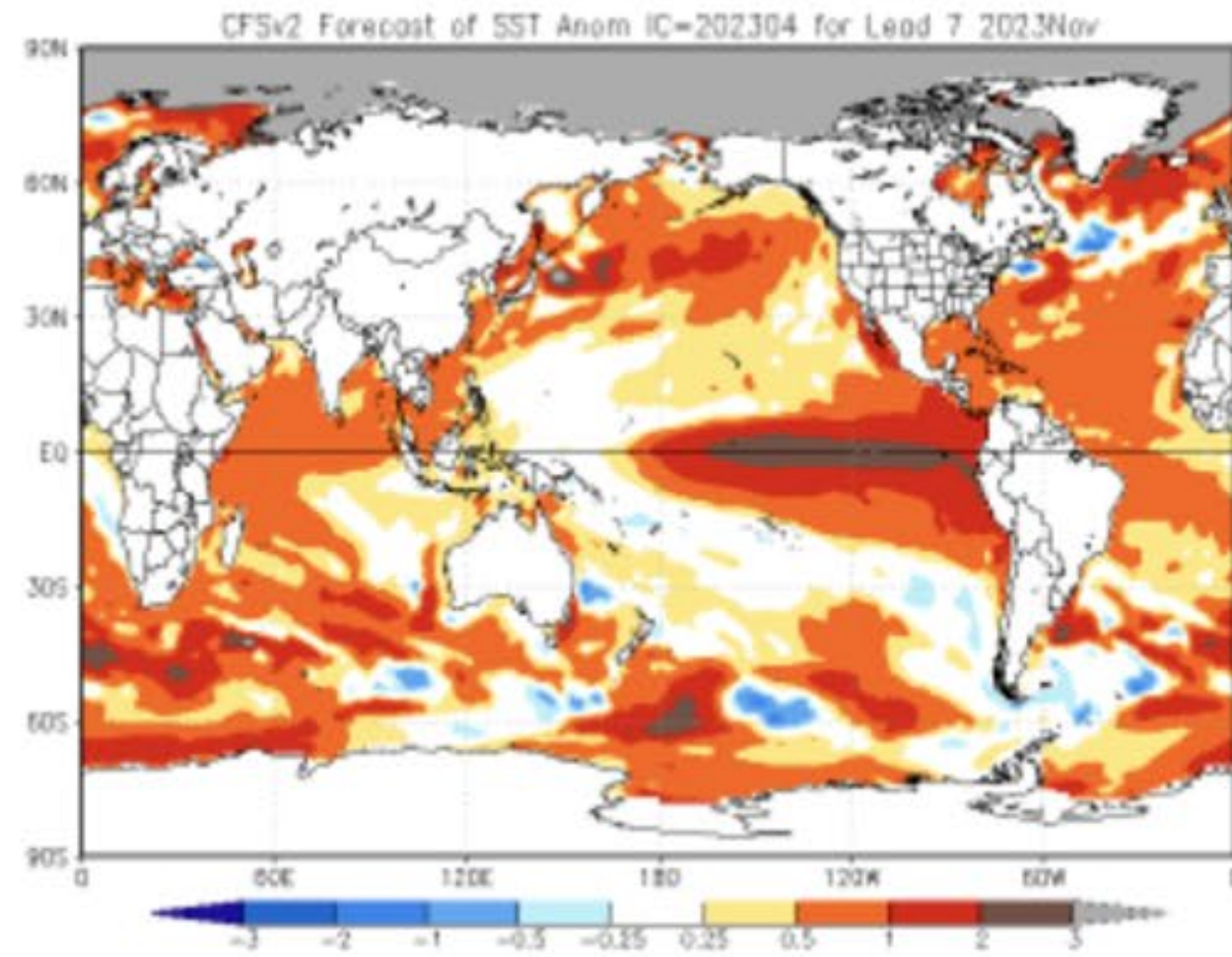
Marine heatwaves



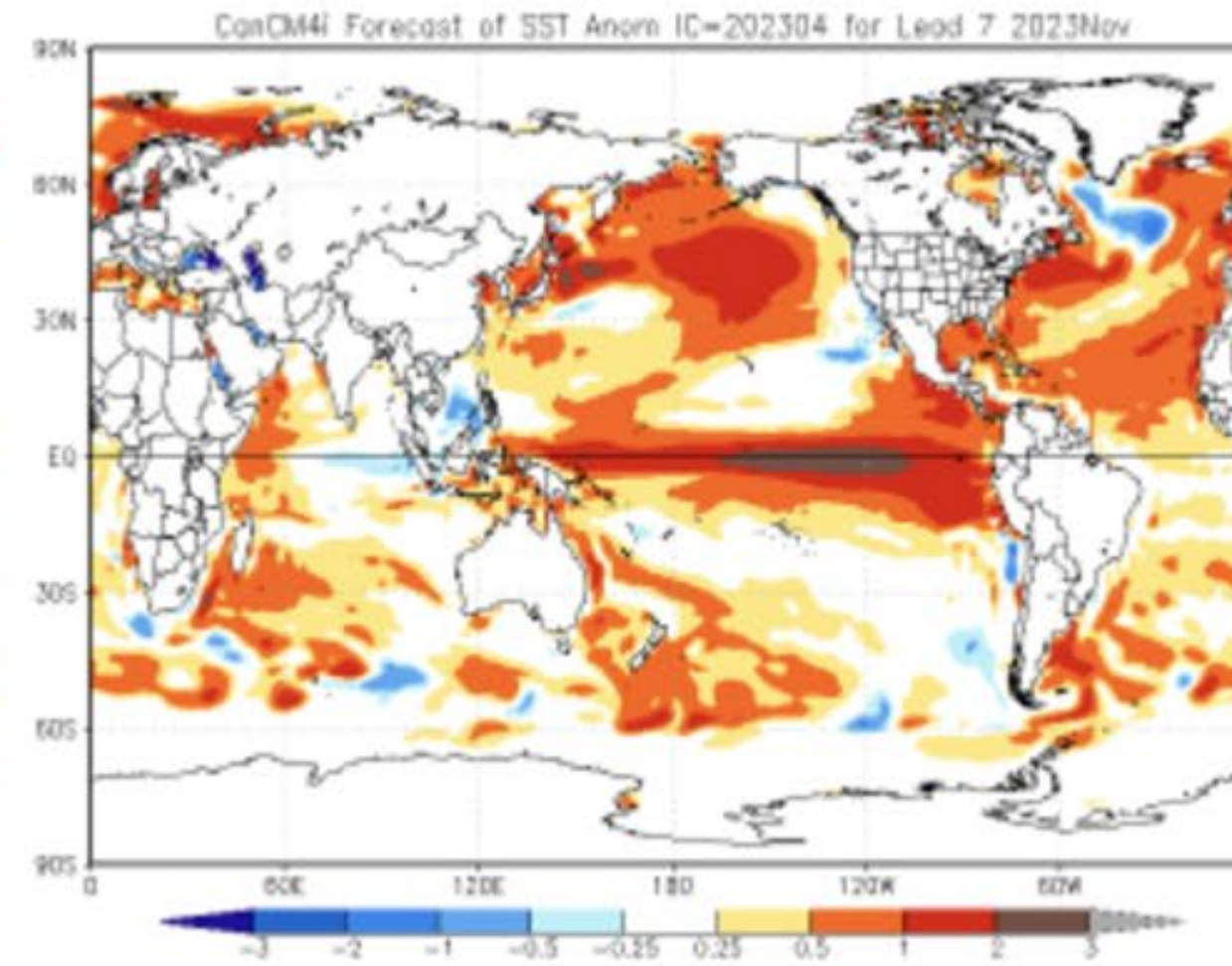
Smith et al. (2021)

Leveraging forecasts in the North American Multimodel Ensemble...

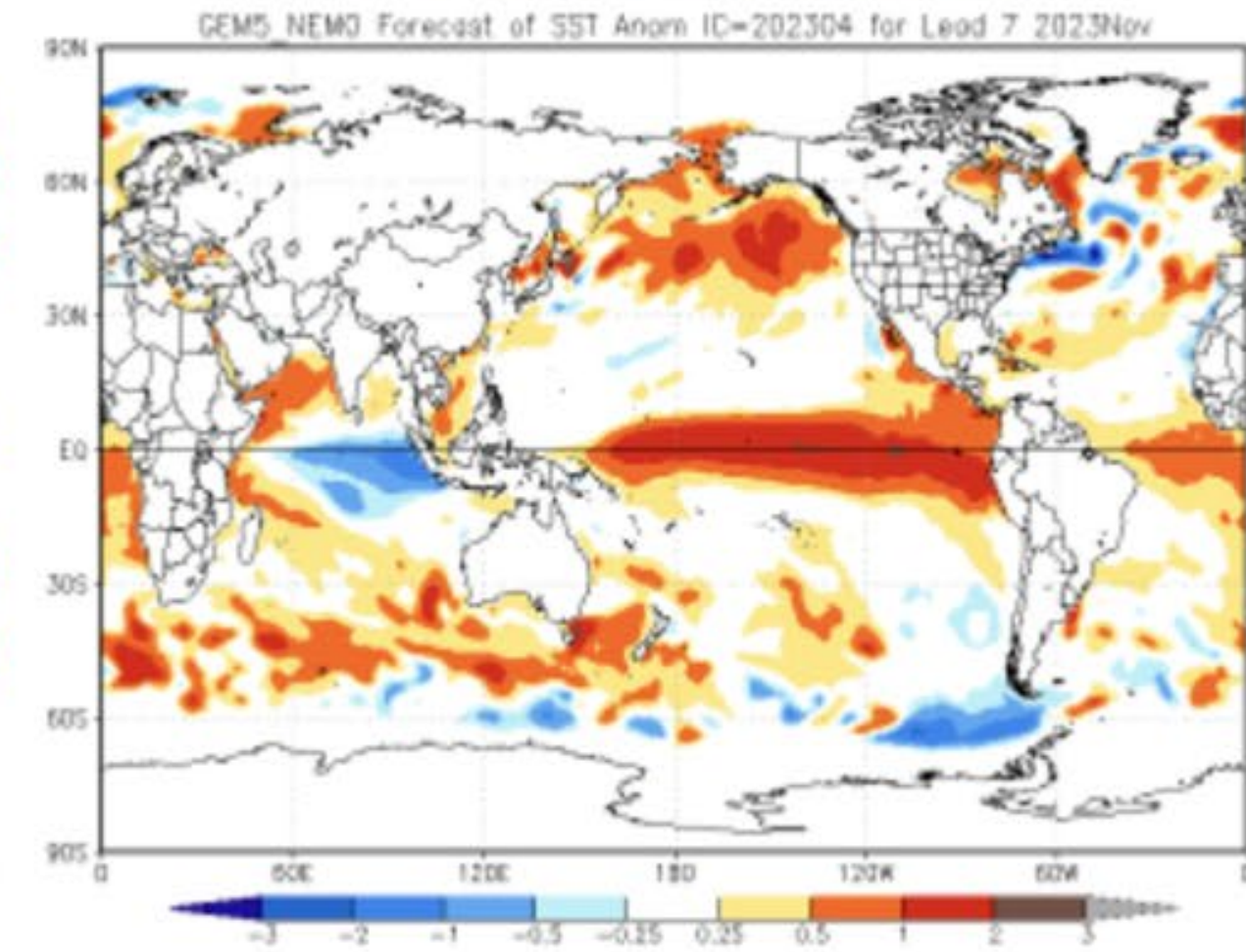
NCEP CFSv2



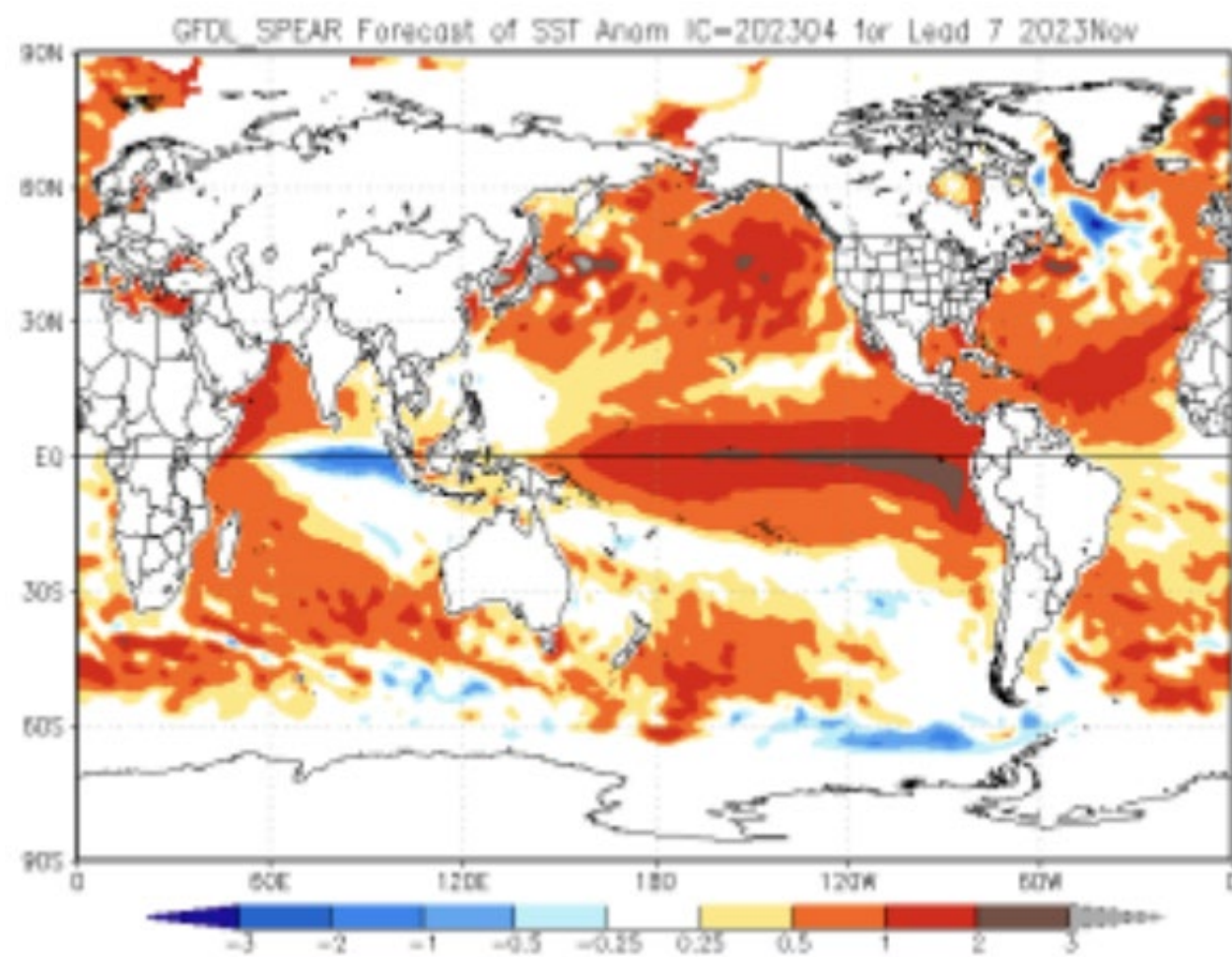
CanCM4i



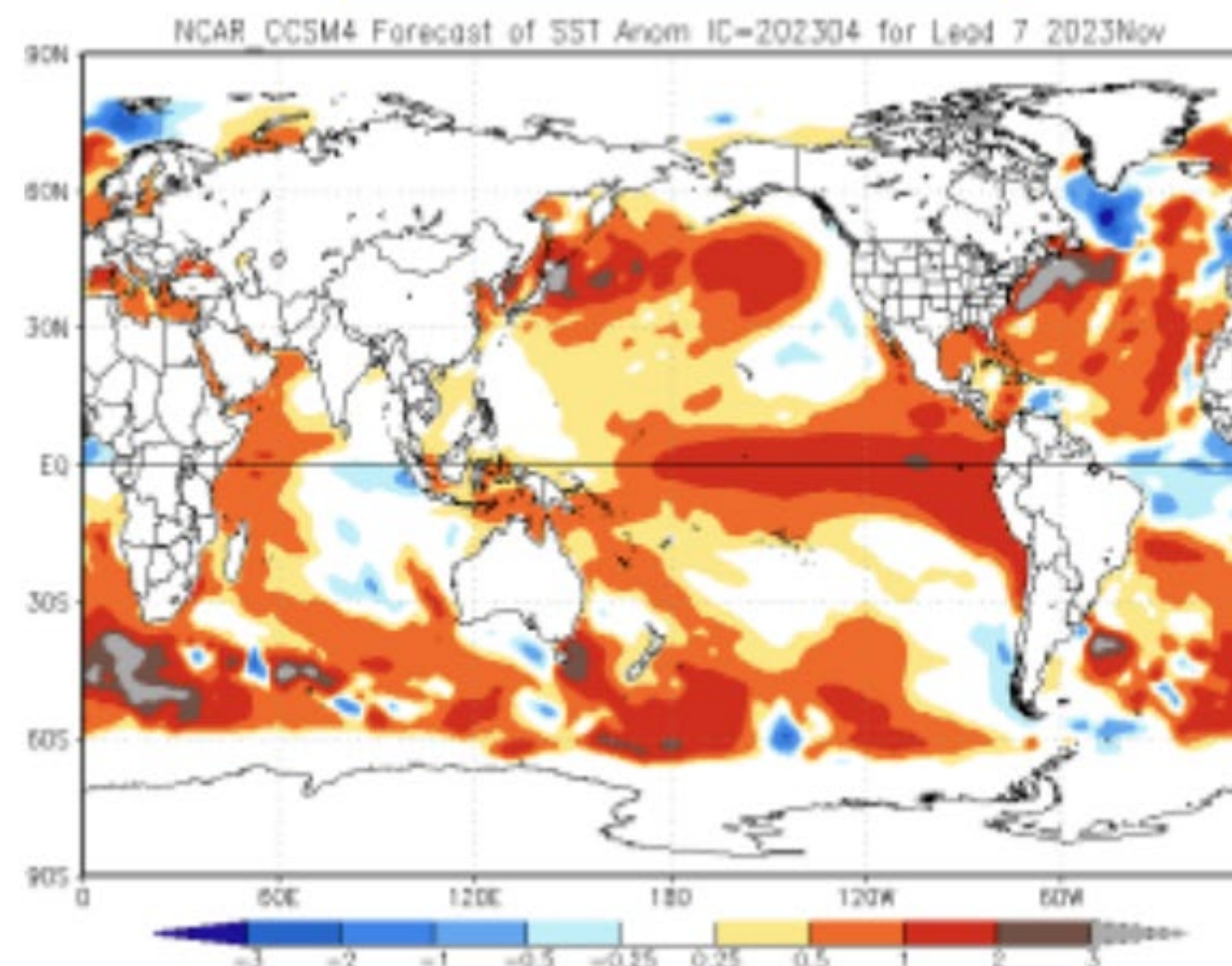
GEM5 NEMO



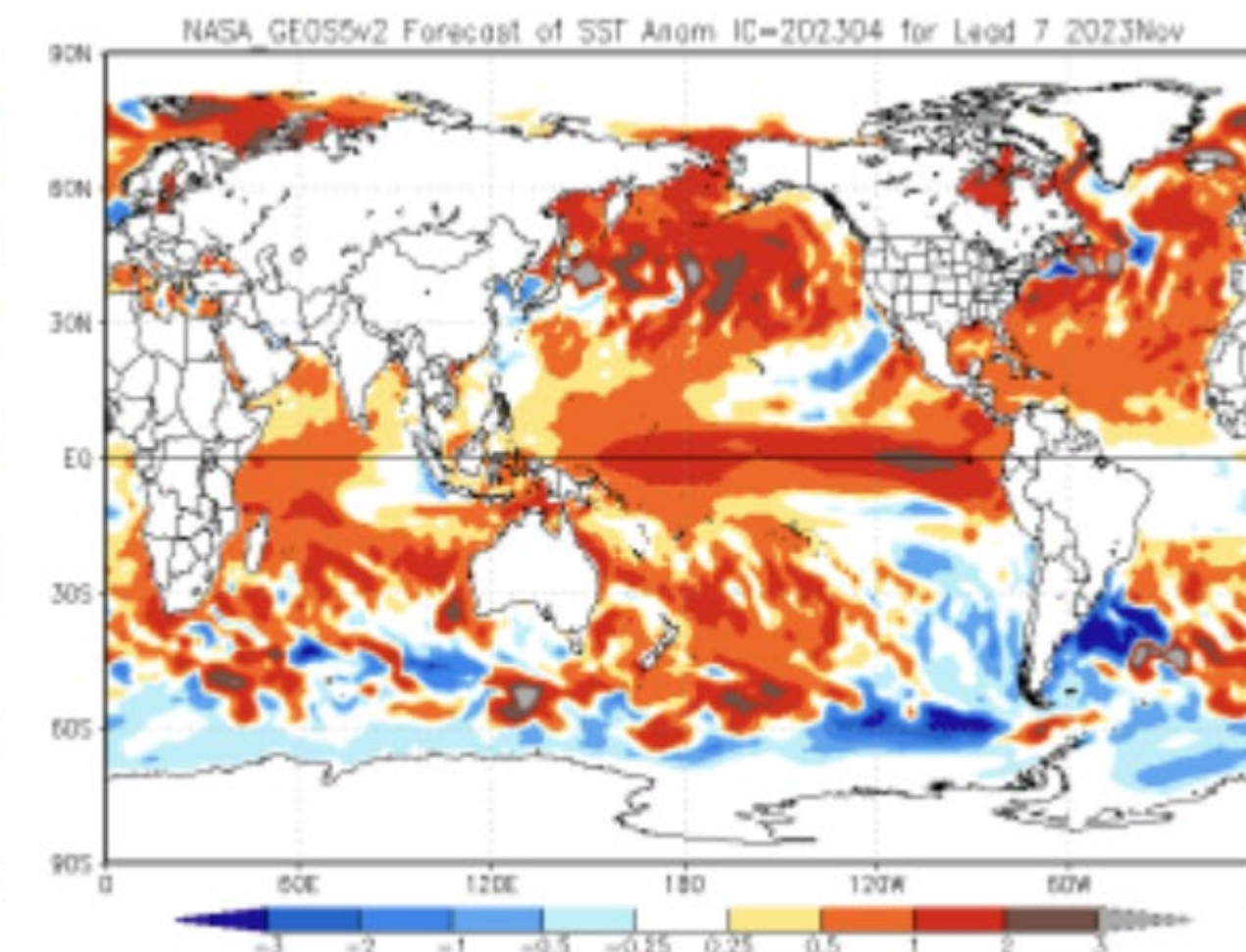
GFDL SPEAR



NCAR CCSM4

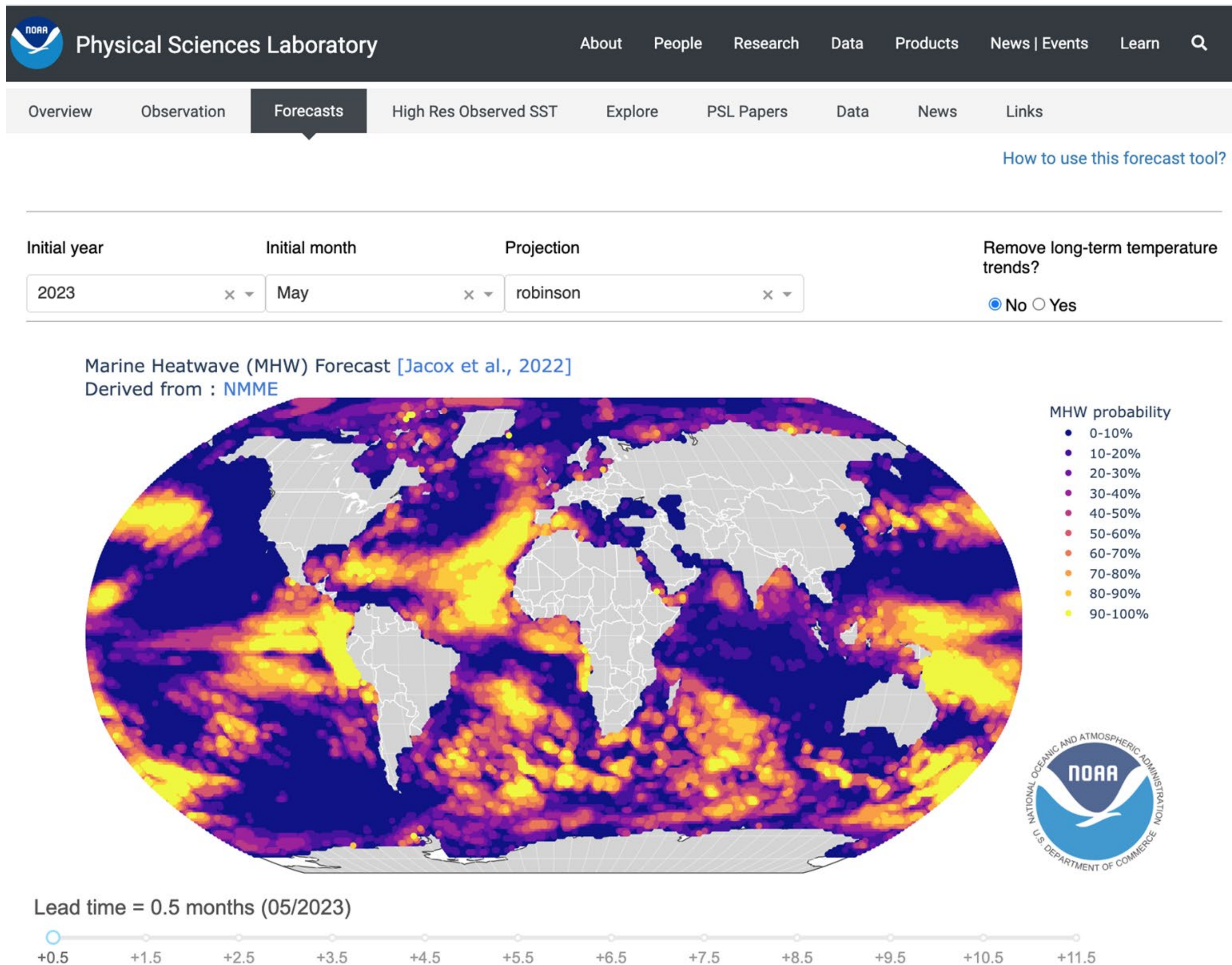


NASA GEOS5v2



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

..to create seasonal marine heatwave forecasts



Global Monthly Forecasts

Built on output from the North American Multi-model Ensemble

>70-member ensemble, using six global climate models

Forecasts issued monthly

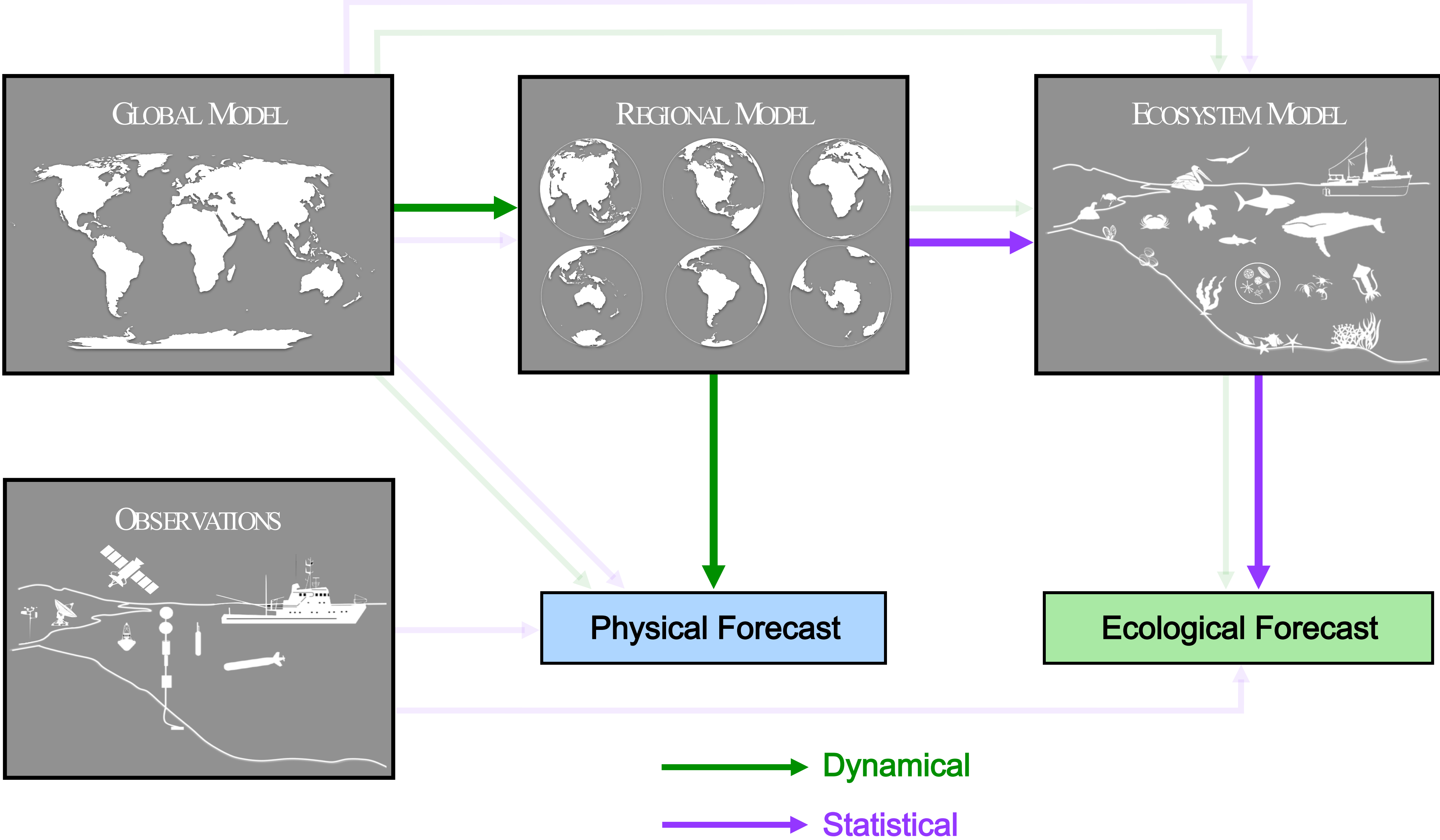
Lead times up to one year

Current and past forecasts online

Forecast methods and skill described in Jacox et al. (2022)

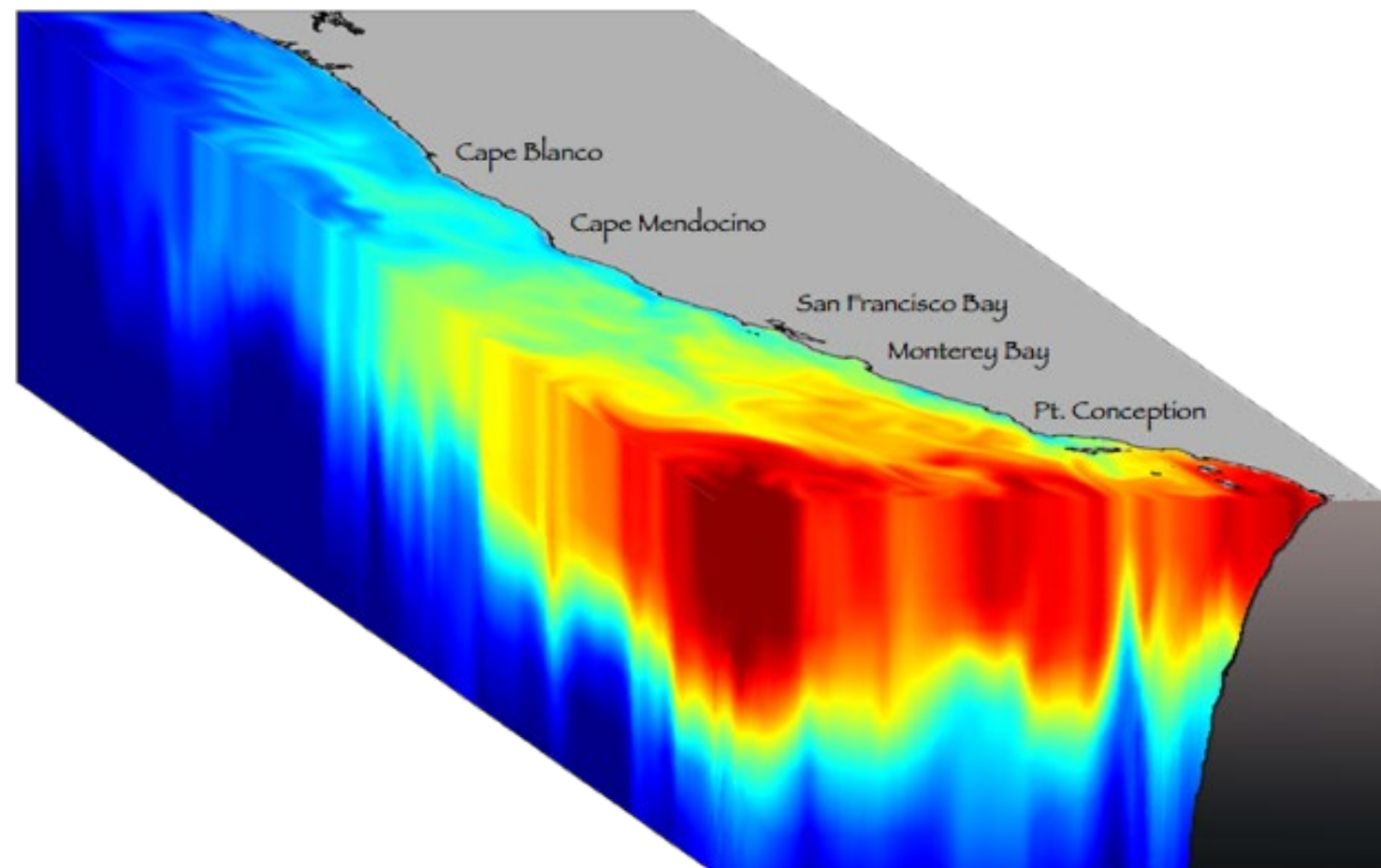
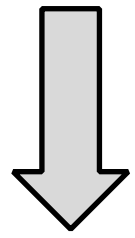
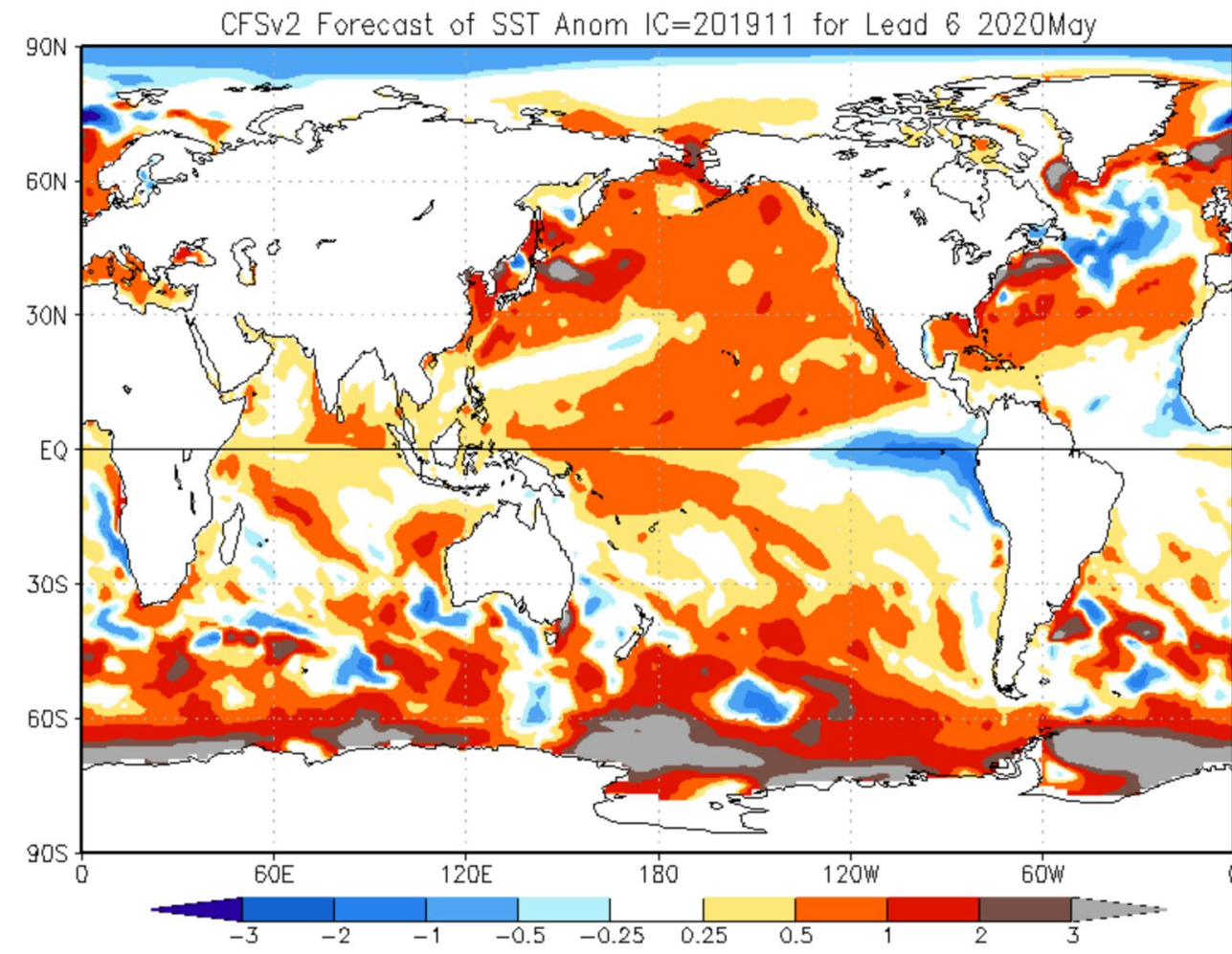
<https://psl.noaa.gov/marine-heatwaves>

Forecast tools and methods



Regional forecasts for the California Current System

Global climate forecasts

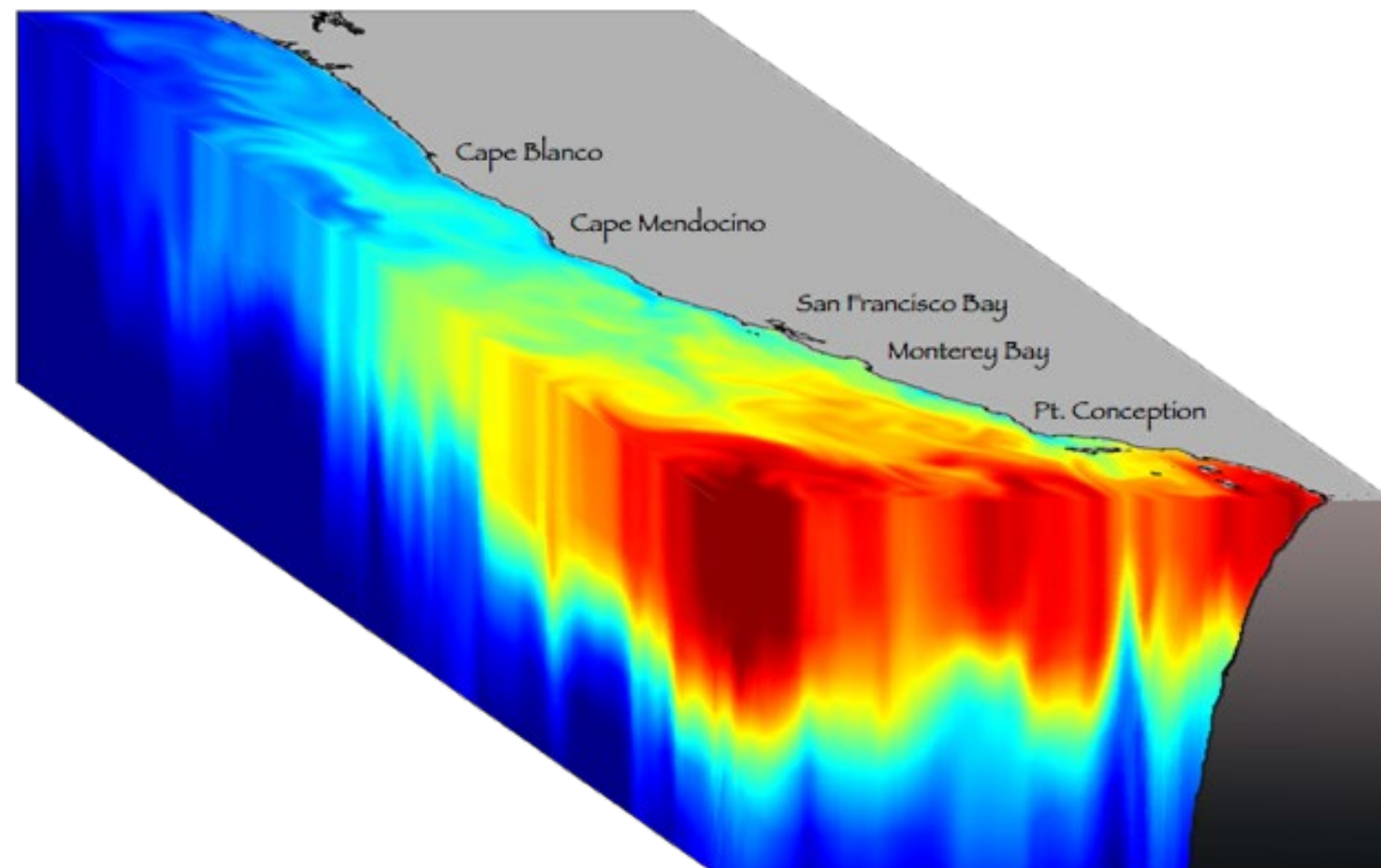
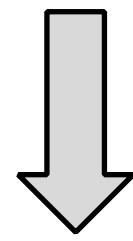
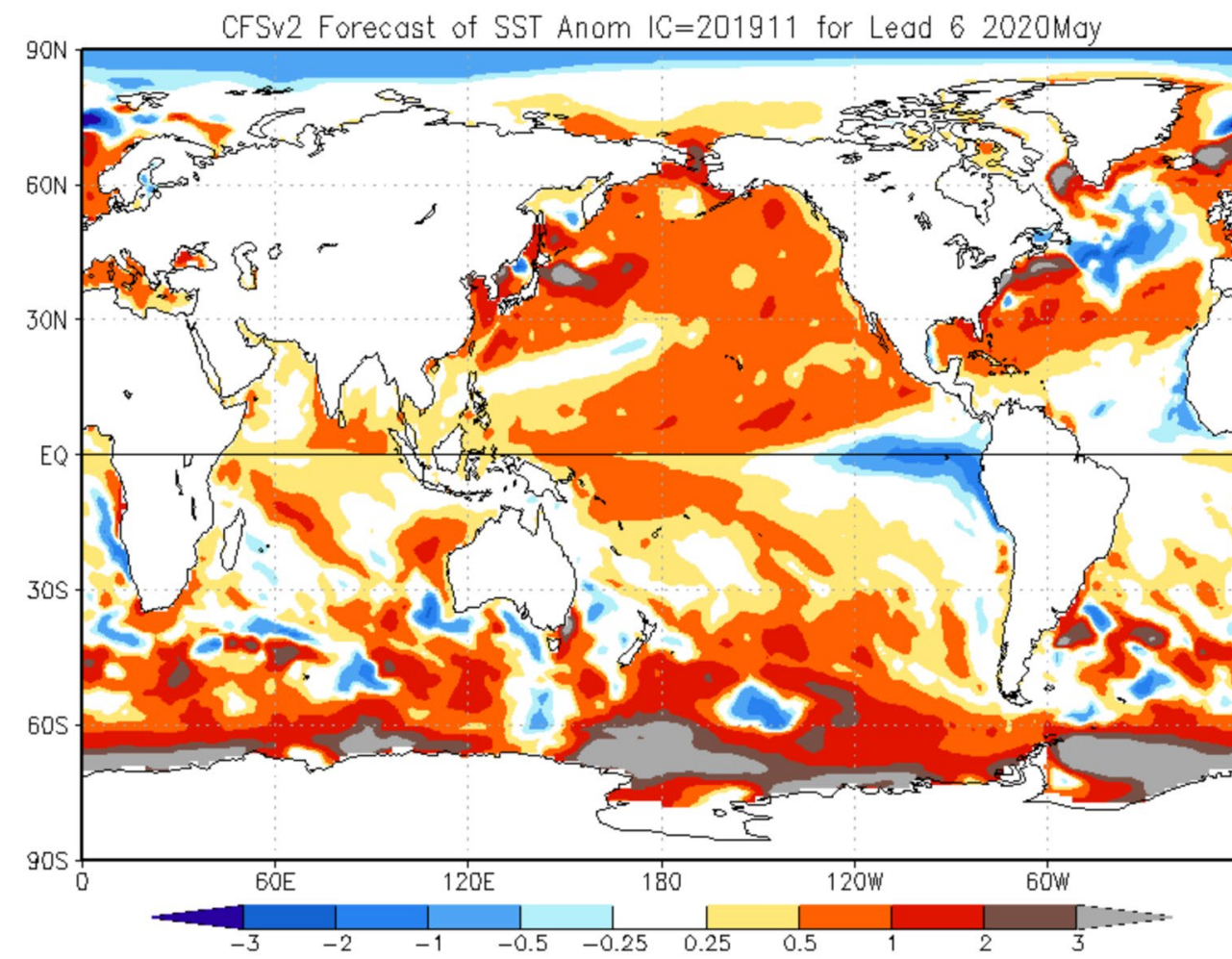


Regional ocean forecasts

Regional forecasts for the California Current

System

Global climate forecasts



Forecast configuration

Forcing from global climate model (CanCM4)

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

Forecasts initialized twice per year (January and July)

1982 to 2010

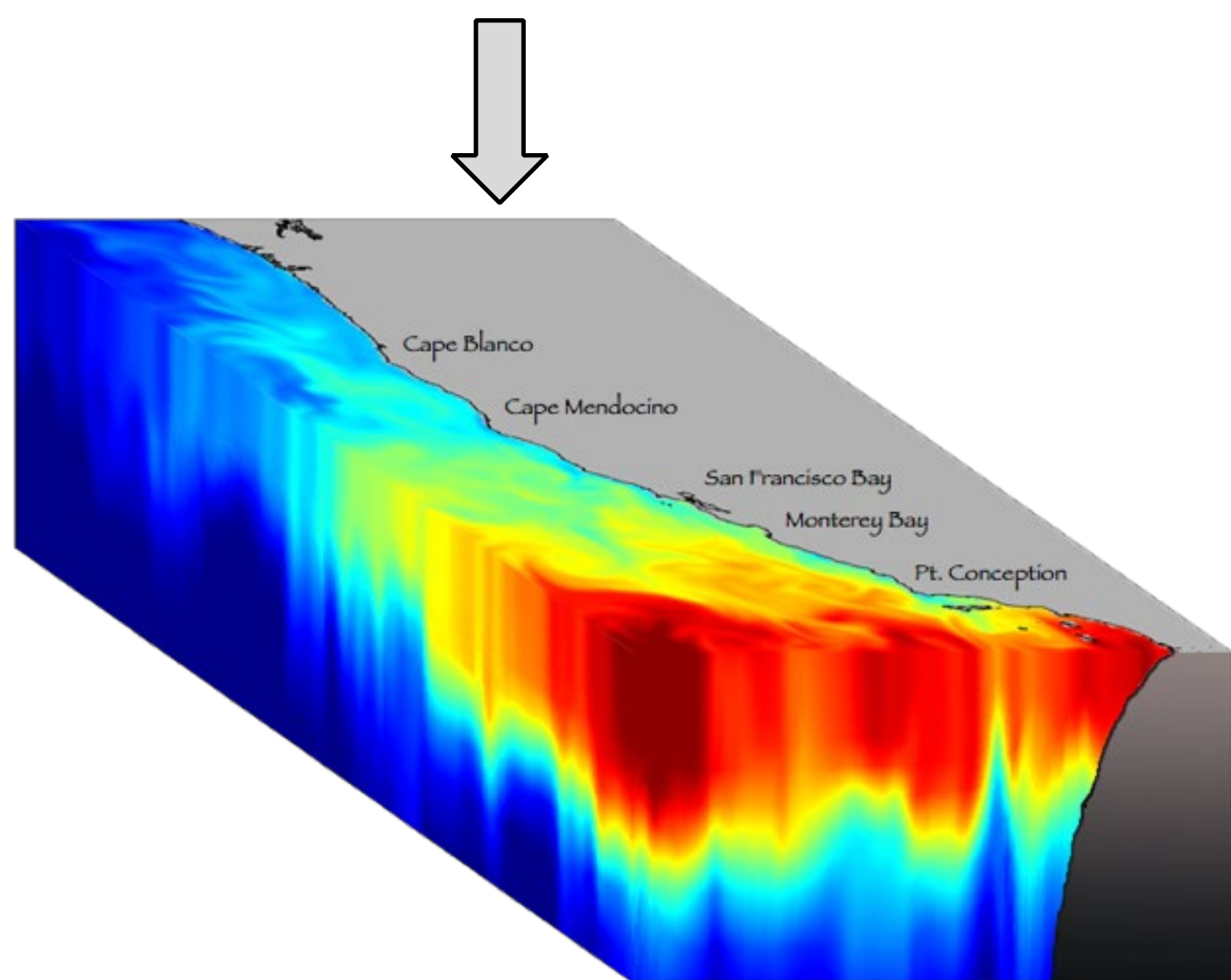
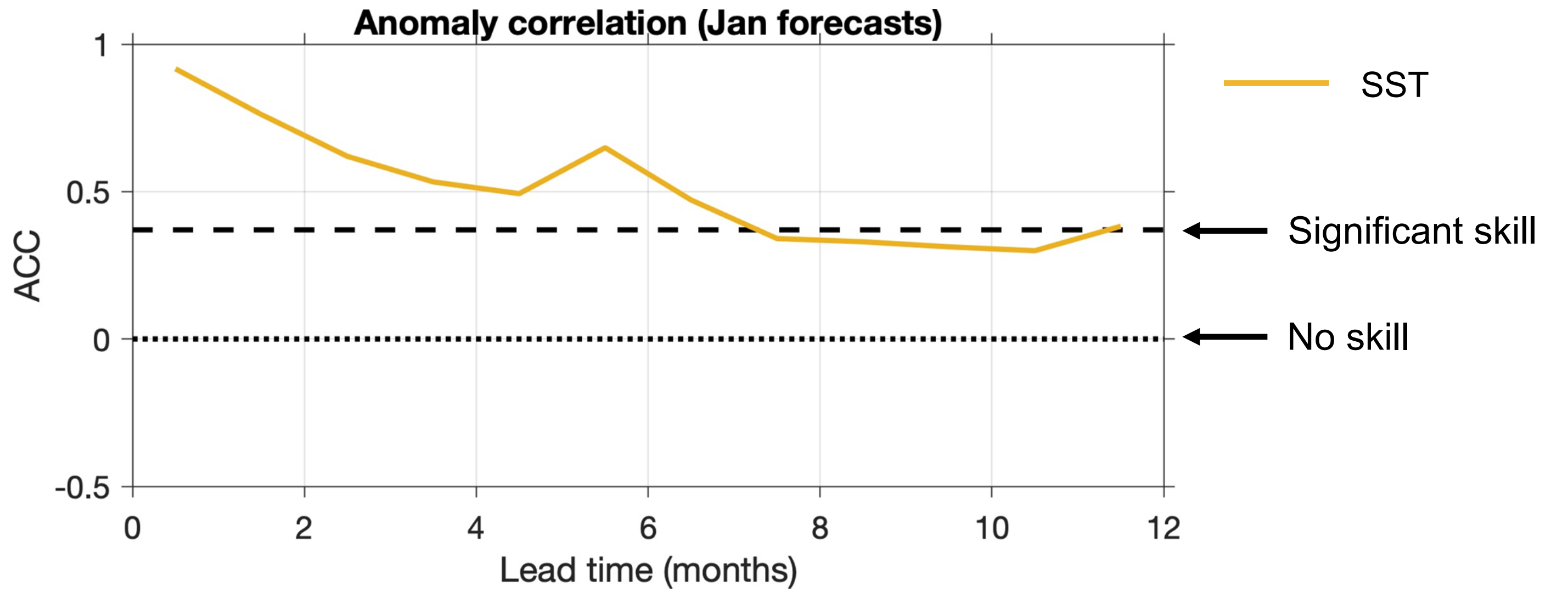
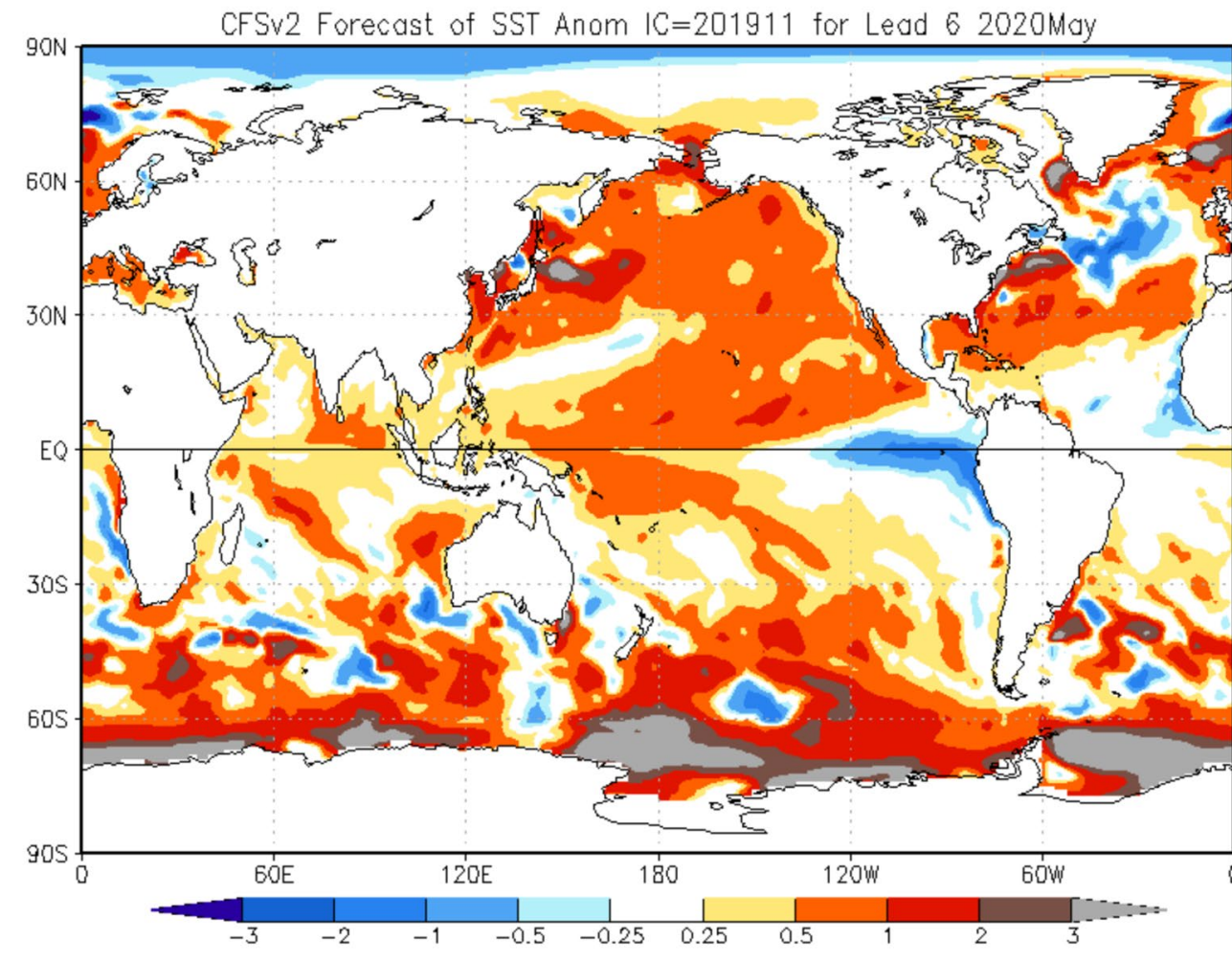
12-month forecasts

Three ensemble members

Regional ocean forecasts

Regional forecasts for the California Current System

Global climate forecasts

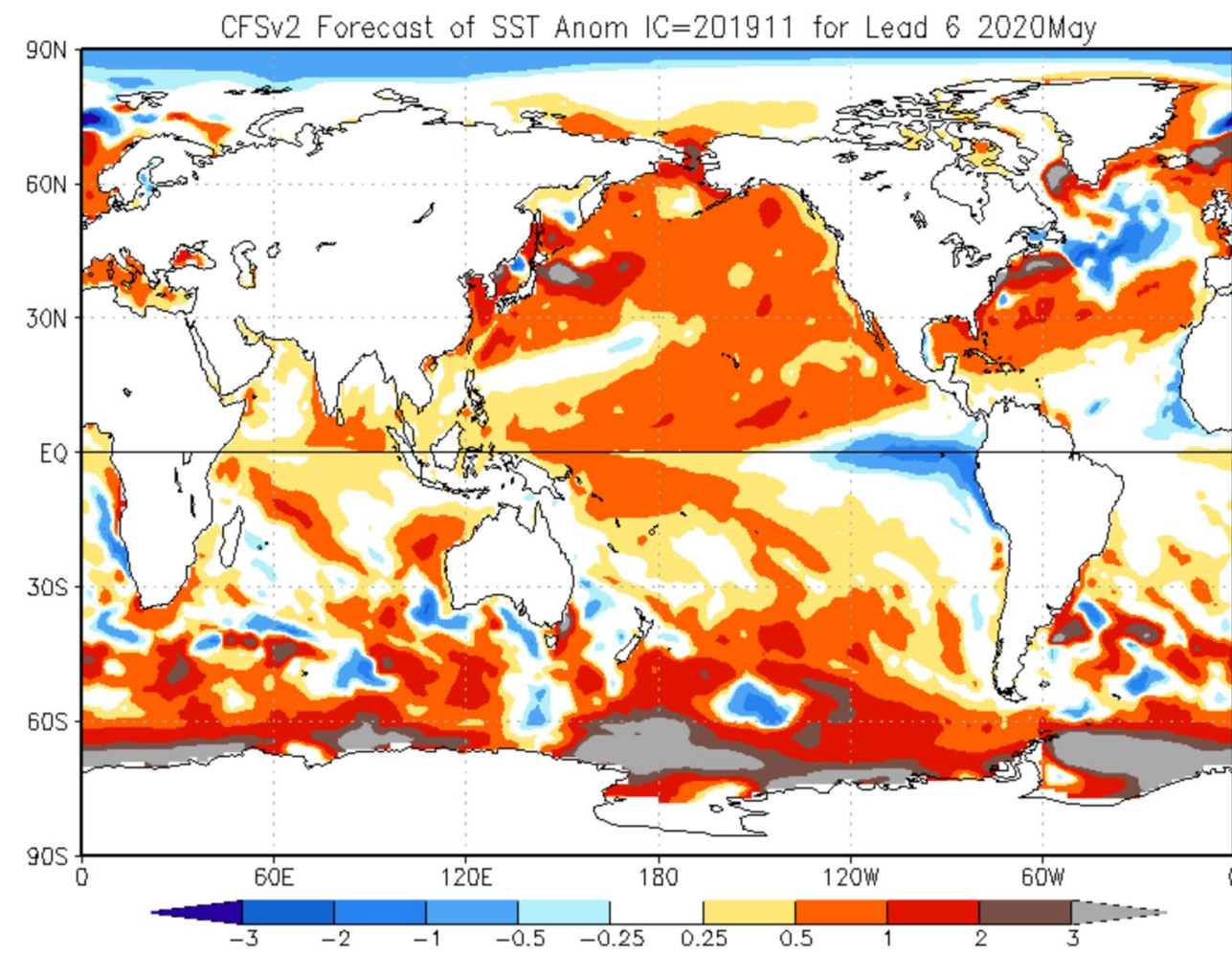


Regional ocean forecasts

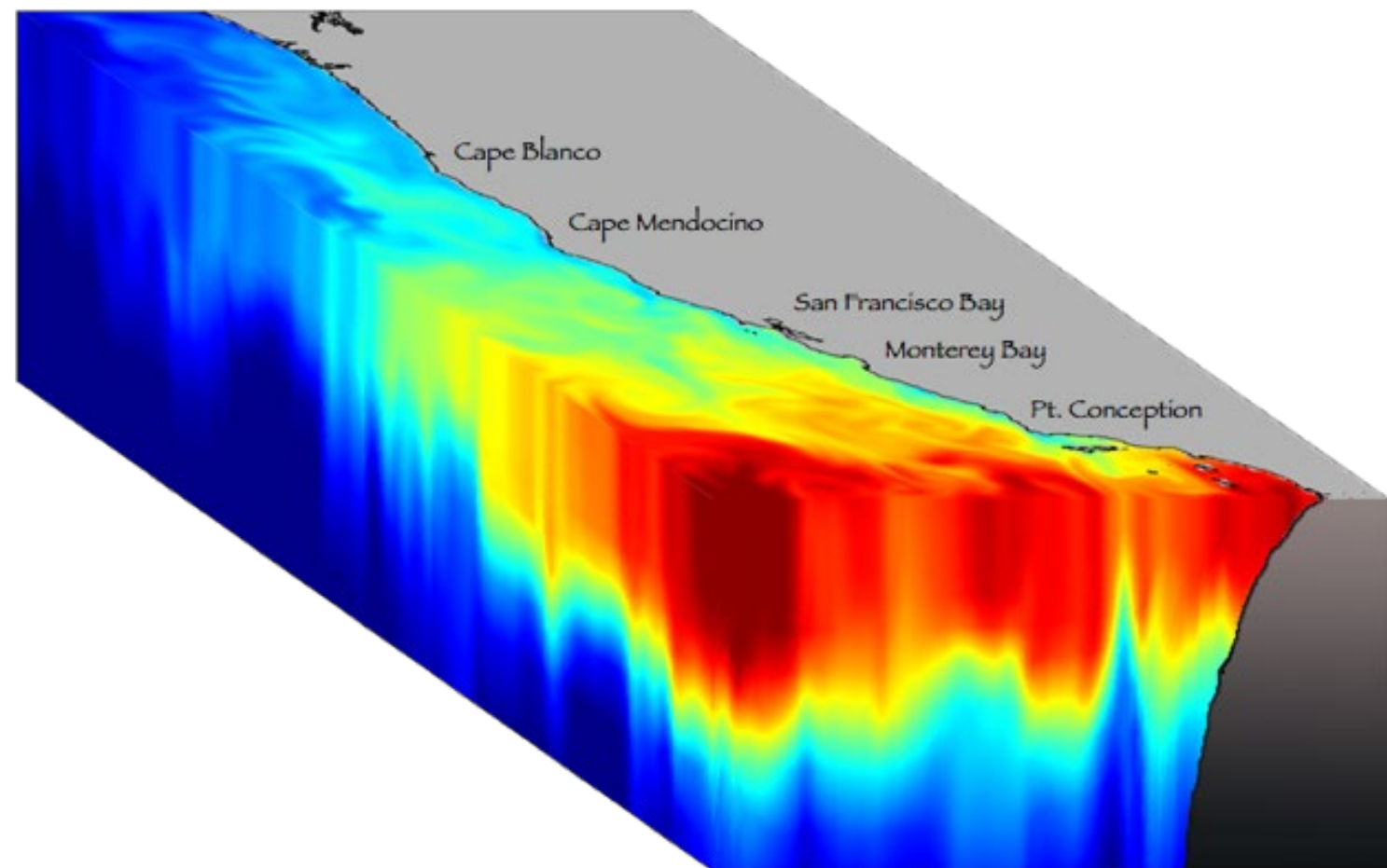
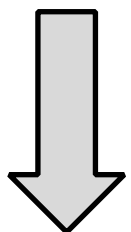
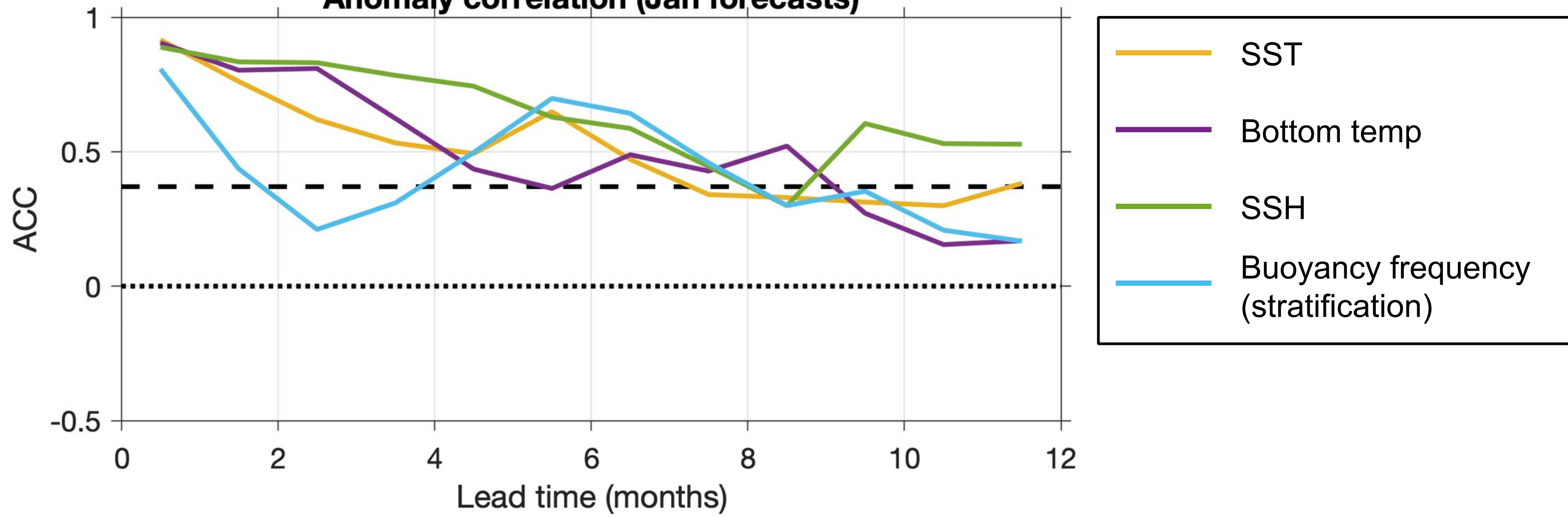
Jacox et al. (in review)

Regional forecasts for the California Current System

Global climate forecasts



Anomaly correlation (Jan forecasts)

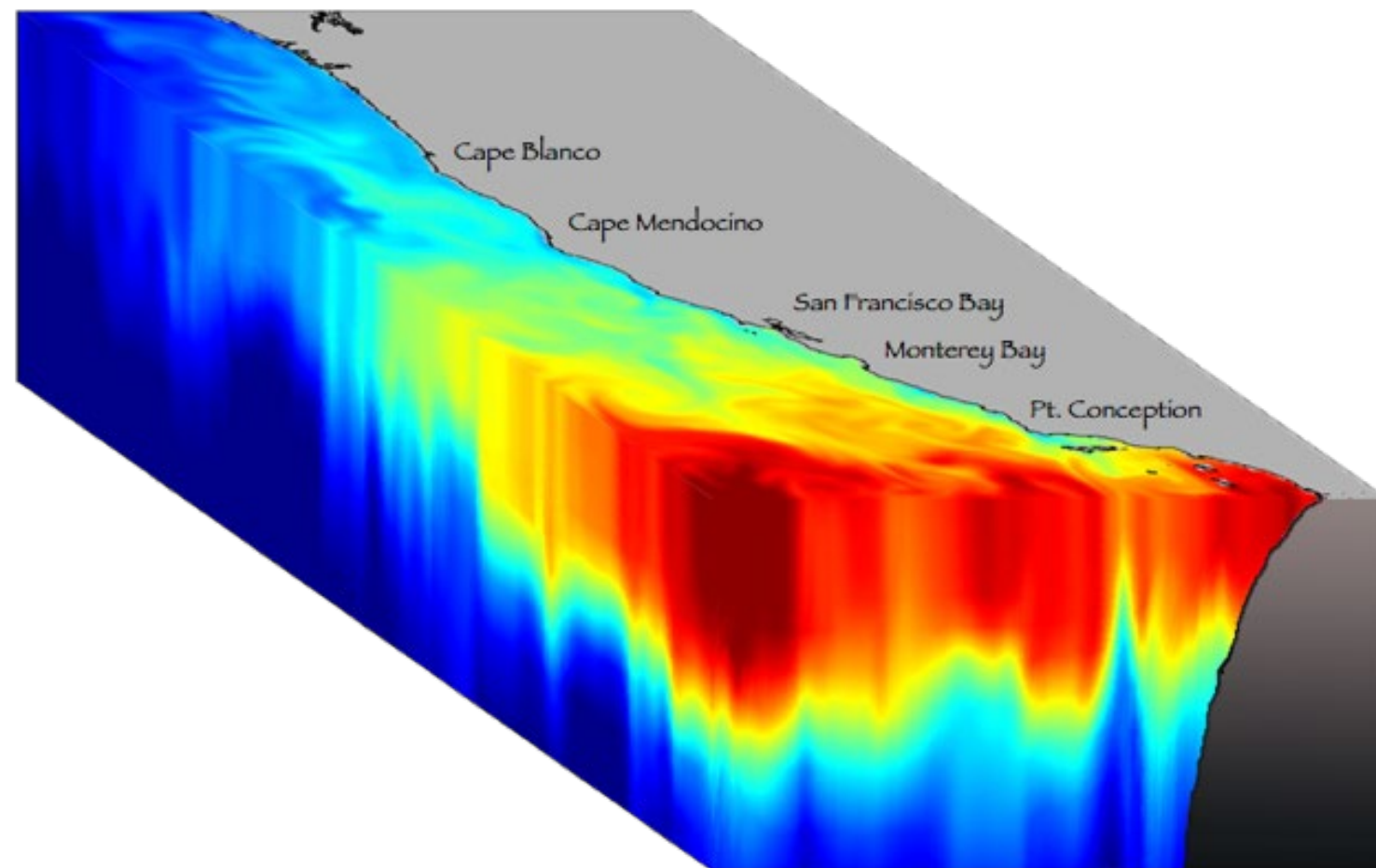
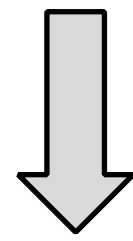
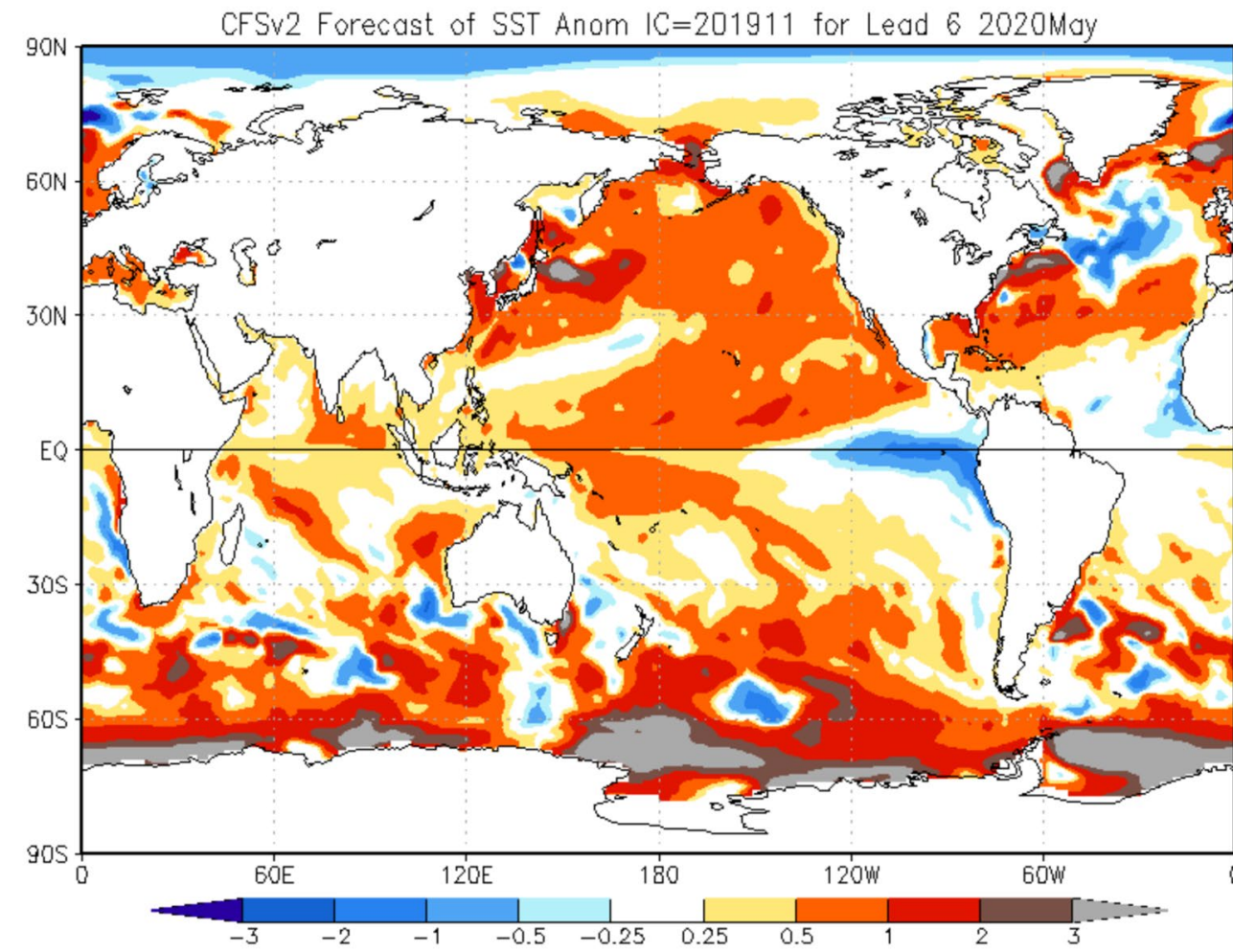


Regional ocean forecasts

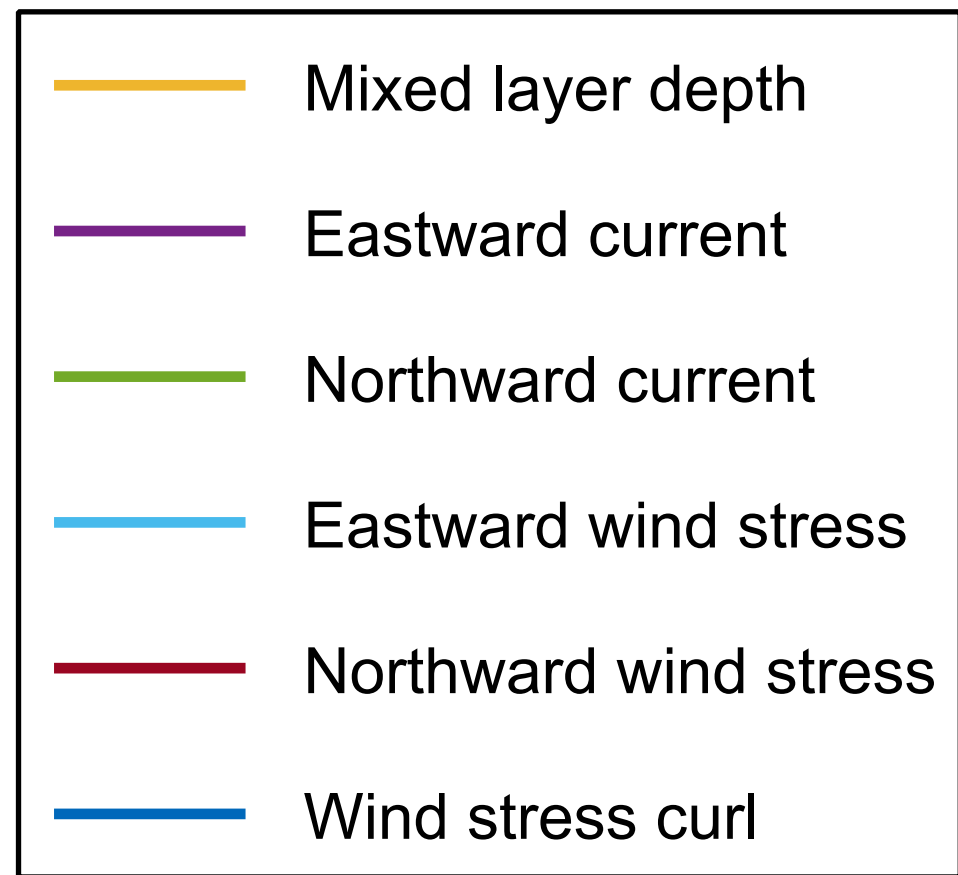
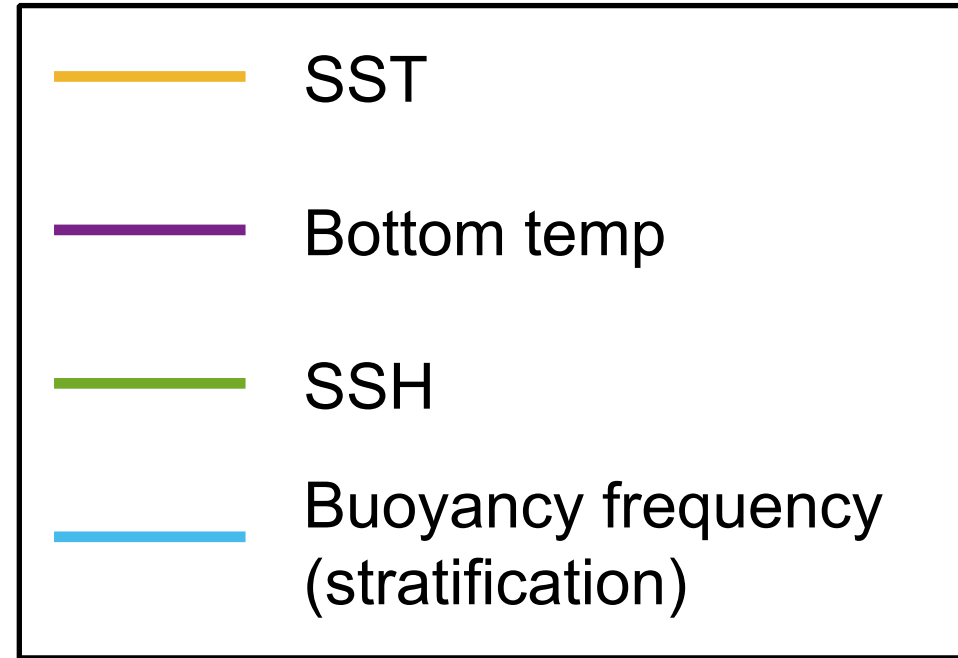
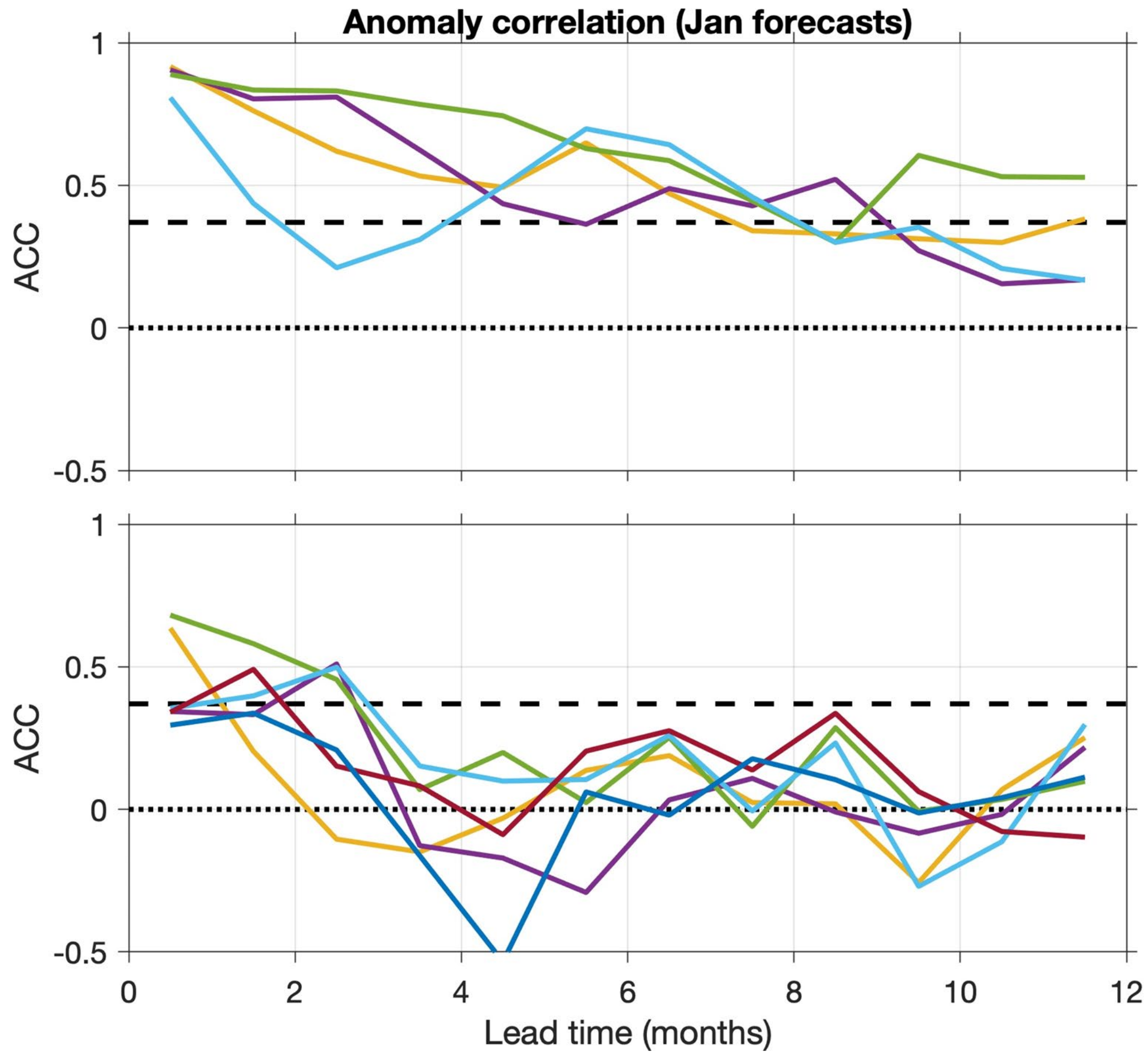
Jacox et al. (in review)

Regional forecasts for the California Current System

Global climate forecasts



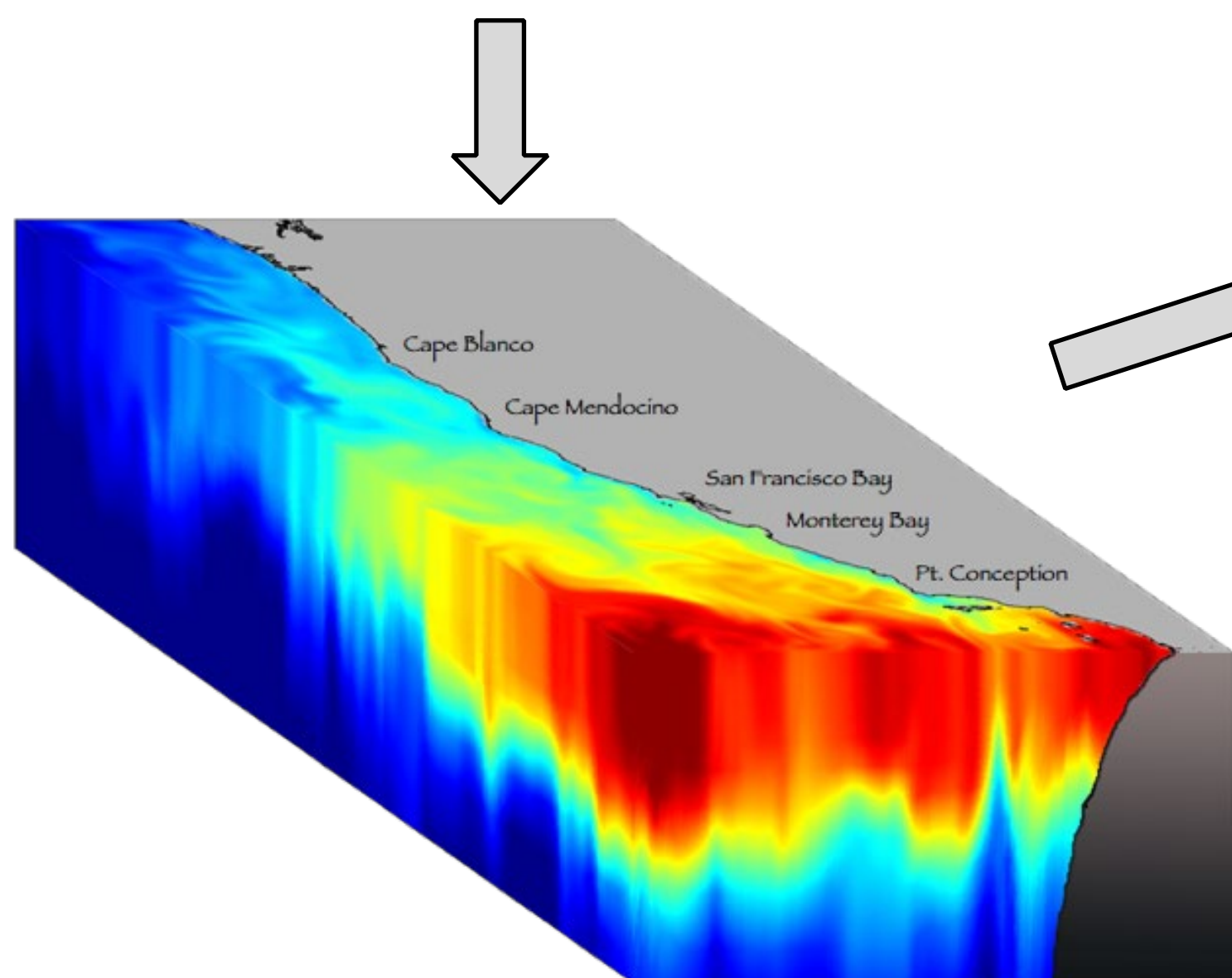
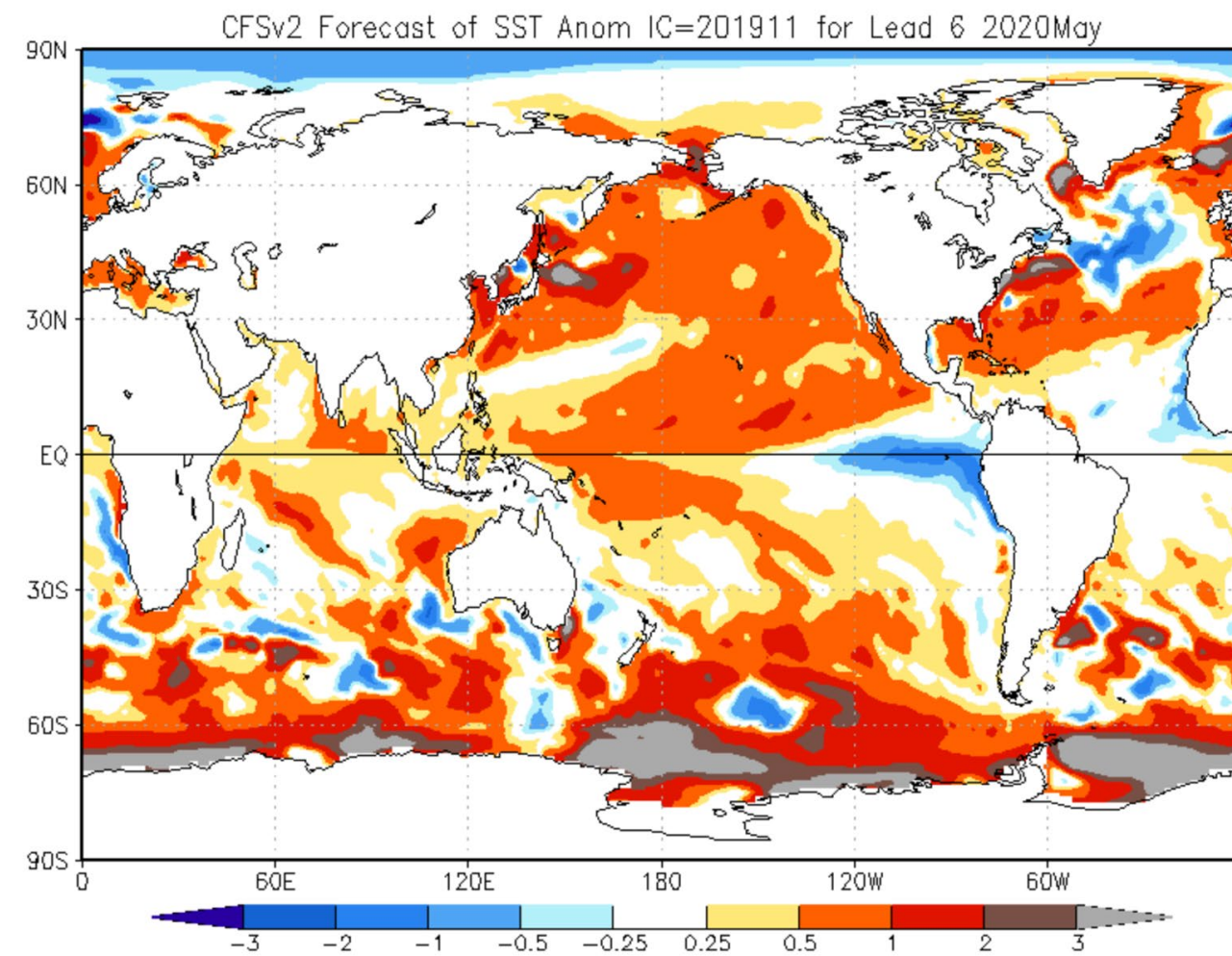
Regional ocean forecasts



Jacox et al. (in review)

Connecting physical forecasts to ecological forecasts

Global climate forecasts



Turtle bycatch

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

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

Whale ship strikes

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

DOI: 10.1111/ddi.12940

BIODIVERSITY RESEARCH WILEY **Diversity and Distributions** EDITOR'S CHOICE

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

Briana Abrahms¹ | 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. Irvine⁵ | Daniel M. Palacios⁵ | Bruce R. Mate⁵ | Elliott L. Hazen^{1,2}

Whale entanglement

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

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}

Bird and marine mammal populations

PROCEEDINGS B

royalsocietypublishing.org/journal/rspb

Research Check for updates

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. Bograd³, Stephanie Brodie^{1,3}, Megan A. Cimino^{1,3}, Elliott L. Hazen³, Michael G. Jacox^{3,4}, Elizabeth A. McHuron⁵, Sharon Melin⁶, Jarrod A. Santora^{7,8}, Justin J. Suca^{1,3}, Julie A. Thayer^{1,9}, Andrew R. Thompson², Pete Warzybok¹⁰ and Desiree Tommasi^{1,2}

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

Turtle and marine mammal bycatch

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. Maxwell⁵, Dana K. Briscoe², Heather Welch², Steven J. Bograd^{1,2}, Helen Bailey⁶, Scott R. Benson^{1,7}, Tomo Eguchi¹, Heidi Dewar¹, Suzy Kohin¹, Daniel P. Costa², Larry B. Crowder⁸, Rebecca L. Lewison⁹

Fish distributions

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

BARBARA MUHLING, STEPHANIE BRODIE, OWYN SNODGRASS, DESIREE TOMMASI
University of California, Santa Cruz
Institute for Marine Science
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MICHAEL JACOX
NOAA Earth System Research Laboratory
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CHRISTOPHER A. EDWARDS
Ocean Sciences Department
University of California, Santa Cruz, CA

BARBARA MUHLING, OWYN SNODGRASS, HEIDI DEWAR, DESIREE TOMMASI, JOHN CHILDERS
NOAA Southwest Fisheries Science Center
San Diego, CA

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

STEPHANIE BRODIE, MICHAEL JACOX
NOAA Southwest Fisheries Science Center
Monterey, CA

STEPHANIE SNYDER
Thomas More University,
Crestview Hills, KY

Regional ocean forecasts

Temperature observations to avoid loggerheads (TOTAL) tool

Turtle bycatch

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Loggerhead Conservation | Coastwatch

coastwatch.pfeg.noaa.gov/loggerheads/

HOME DATA ACCESS TOOLS & TRAINING ABOUT PROJECTS QUICK LINKS

NOAA COASTWATCH WEST COAST REGIONAL NODE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

TOTAL

Background Closure Rules Conservation Area Status Data Dashboard

Photo copyright: Ralph Pace • Contact for use outside NOAA

Supporting turtle conservation and sustainable fisheries with dynamic ocean management

Turtle Bycatch Overview

Loggerhead turtles from the endangered North Pacific population migrate to the waters off California and Mexico. Higher than normal sea temperatures during spring and summer can bring loggerheads close to the California coast, where they are more likely to be unintentionally captured by commercial fishing vessels. The

Conservation Area Status

In an effort to reduce loggerhead bycatch, the Pacific Loggerhead Conservation Area was established off the Southern California coast. The area is subject to closure to drift gillnet fishing when environmental conditions bring loggerheads into commercial fishing grounds. The [Closure Rules](#) page provides backgrounds to the

Historical Data Dashboard

View historical environmental observations for the Southern California coast and the closure status for the Pacific Loggerhead Conservation Area going back to 2003, when the Conservation Area was established. Observation such as sea surface temperature, large temperature deviations, and El Niño status are available.

Temperature observations to avoid loggerheads (TOTAL) tool

Loggerhead Conservation | Co... x

coastwatch.pfeg.noaa.gov/loggerheads/

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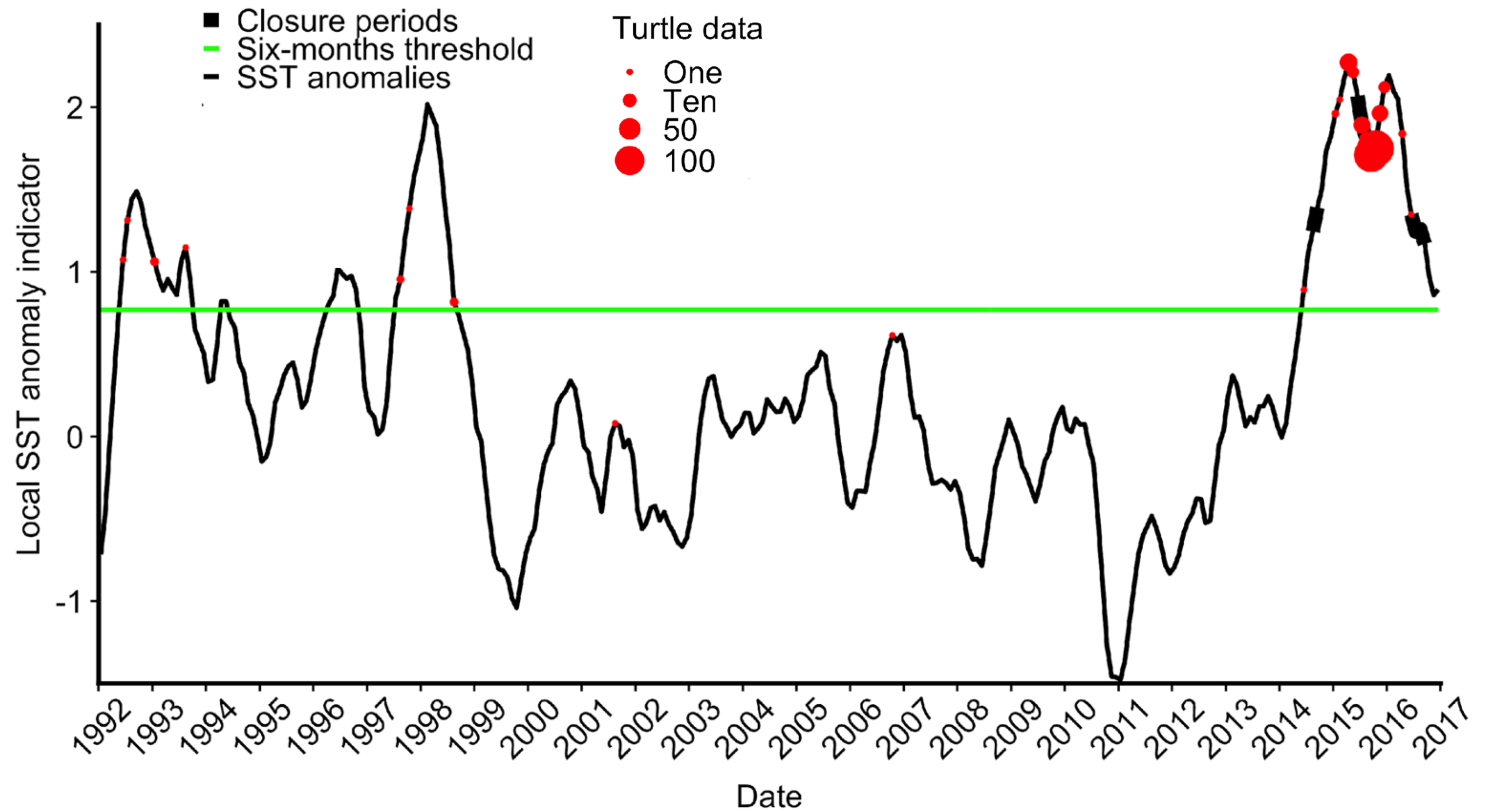
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Supporting turtle conservation and sustainable fisheries with dynamic ocean management

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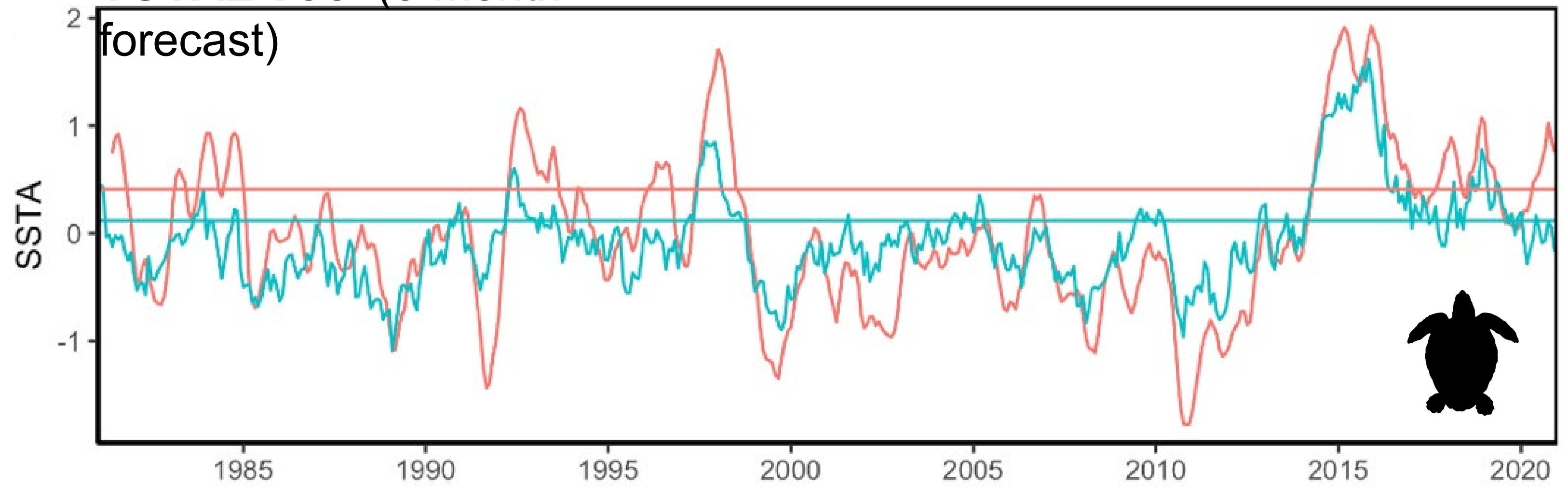
Welch et al. (2018)

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

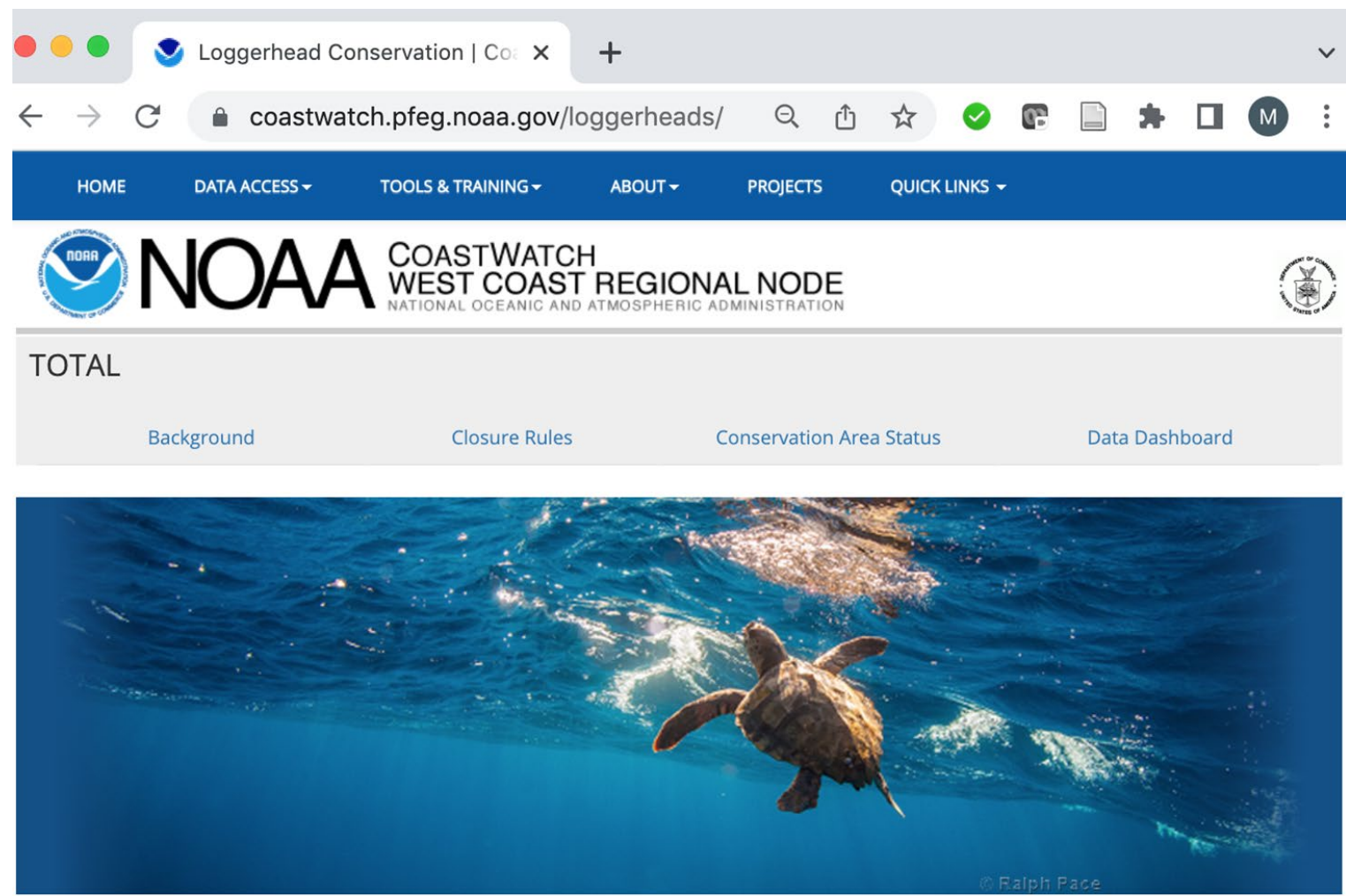
Moving TOTAL from nowcast to forecast

Observed
Forecast

TOTAL Tool (6-month forecast)



Closures were enacted in the summers of 2015 and 2016. These closures could have been predicted 6 months in advance.



Supporting turtle conservation and sustainable fisheries with dynamic ocean management

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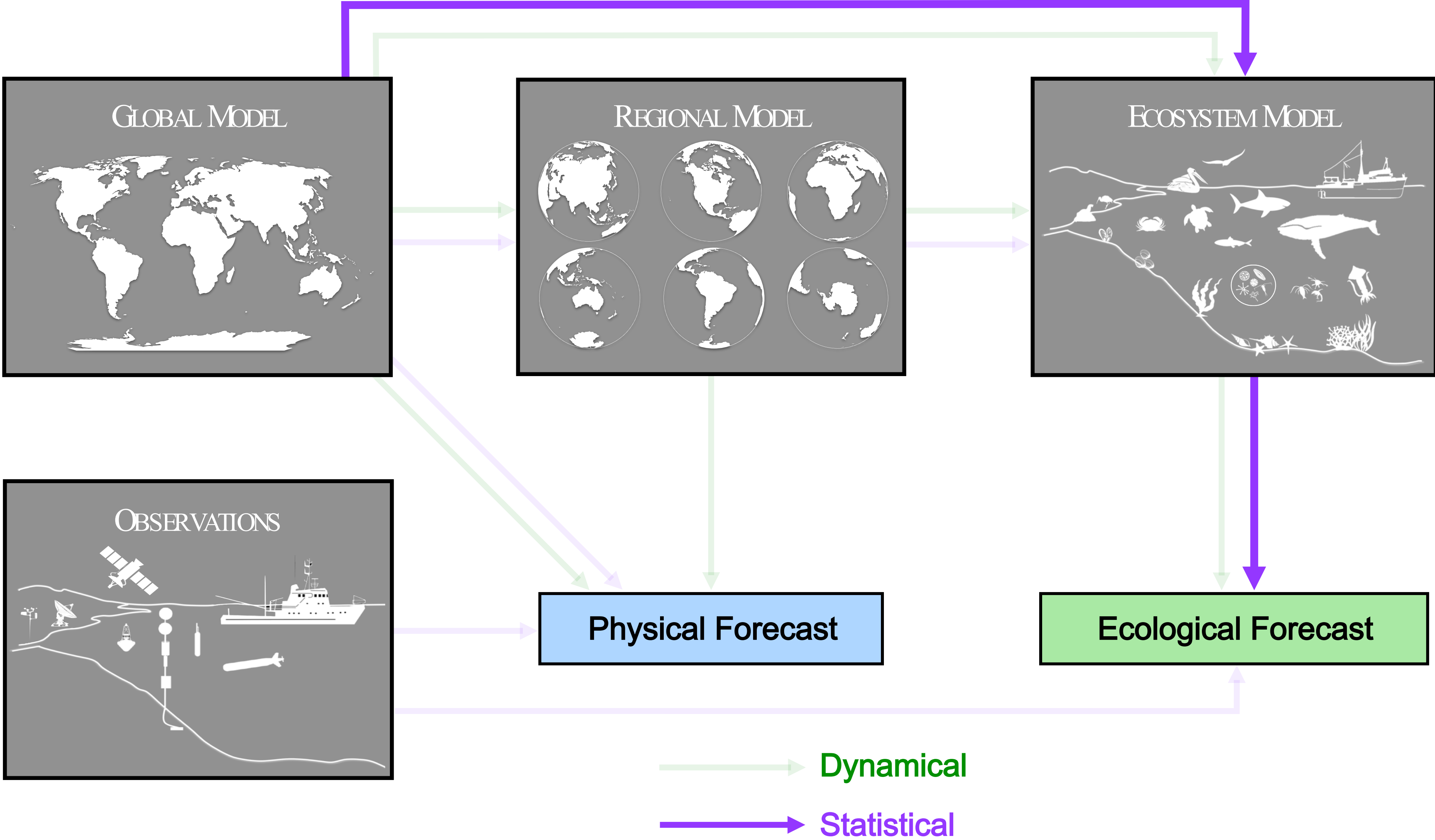
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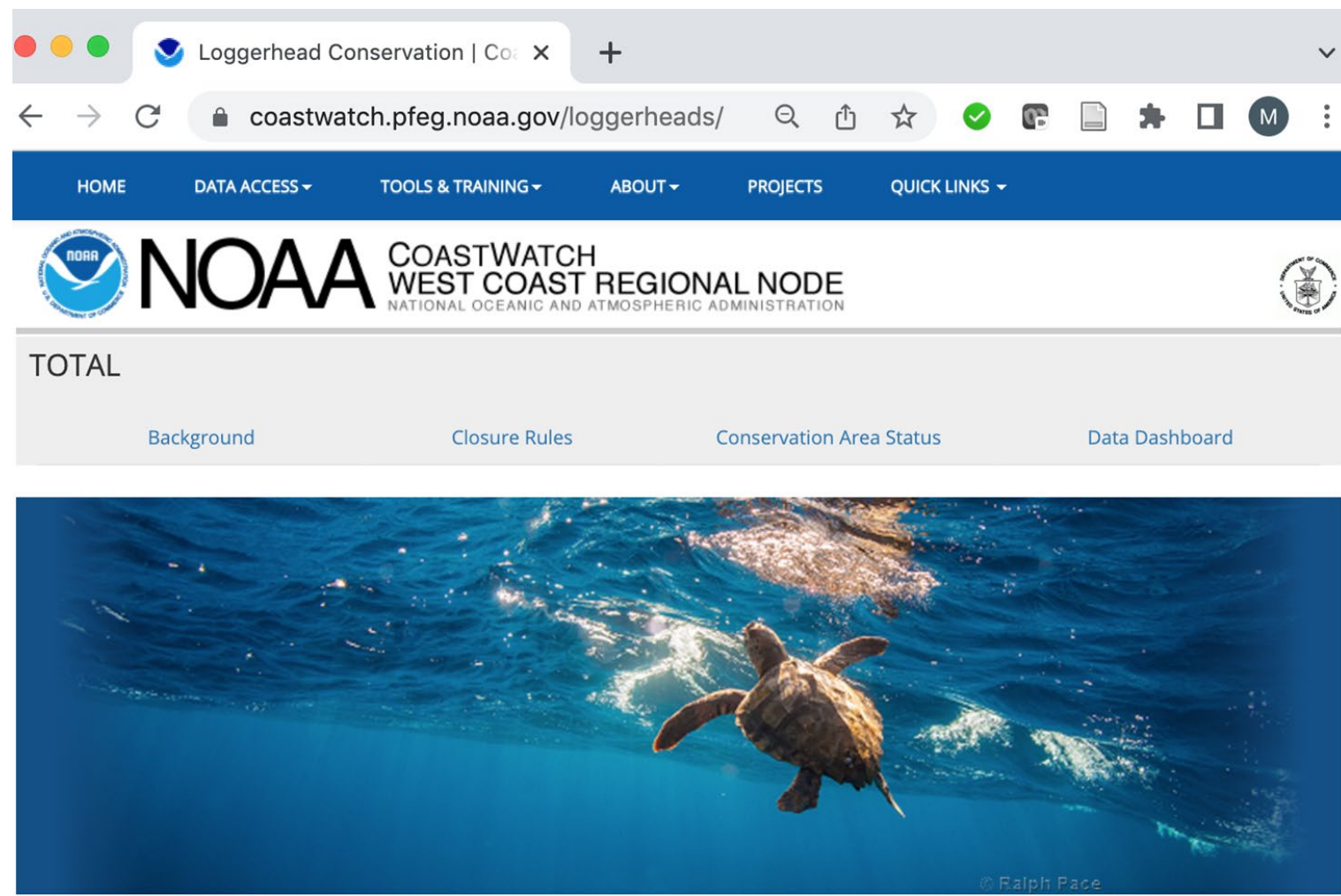
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Forecast tools and methods



Comparing global and regional forecasts



Supporting turtle conservation and sustainable fisheries with dynamic ocean management

Turtle Bycatch Overview

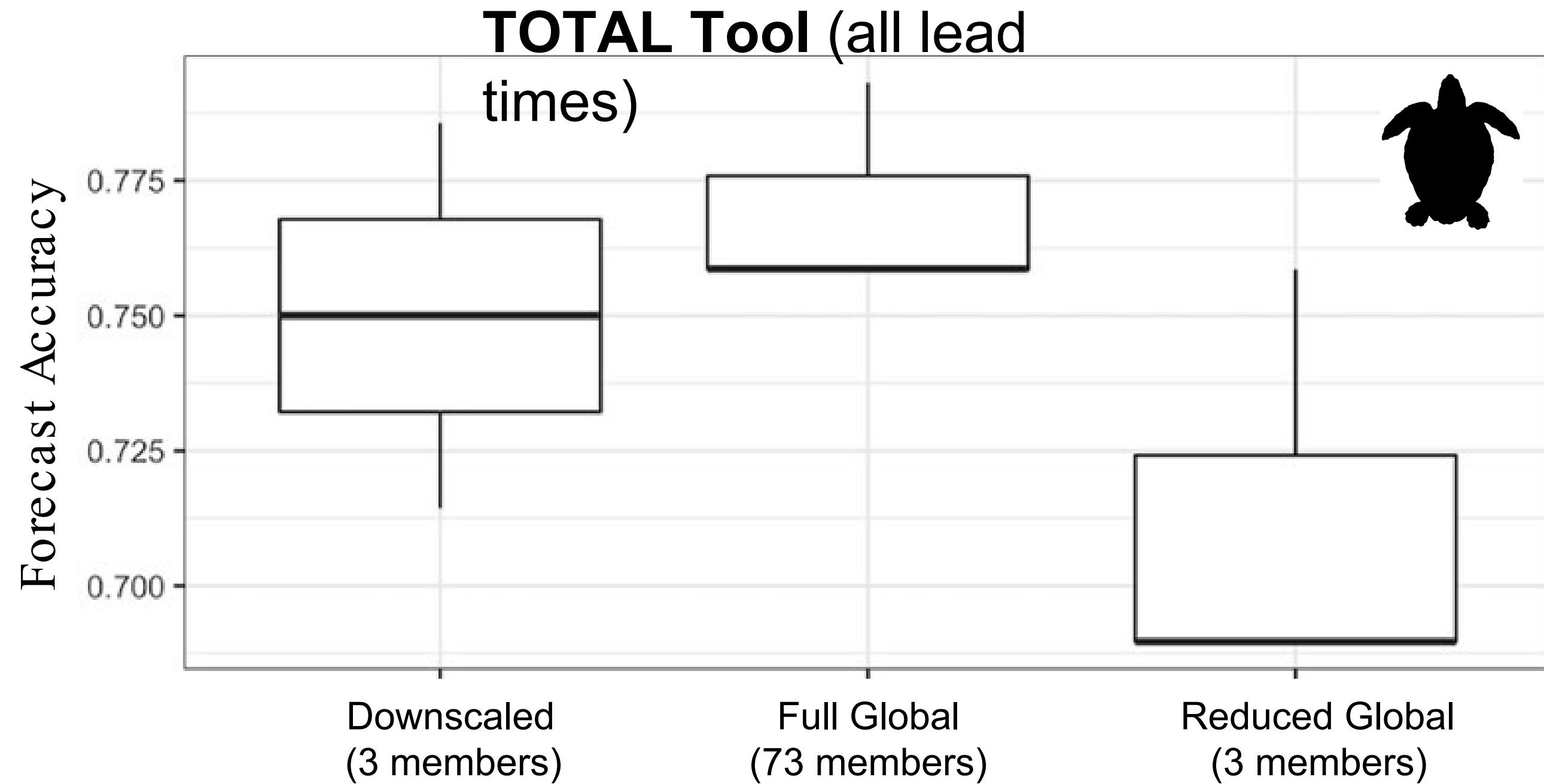
Loggerhead turtles from the endangered North Pacific population migrate to the waters off California and Mexico. Higher than normal sea temperatures during spring and summer can bring loggerheads close to the California coast, where they are more likely to be unintentionally captured by commercial fishing vessels. The

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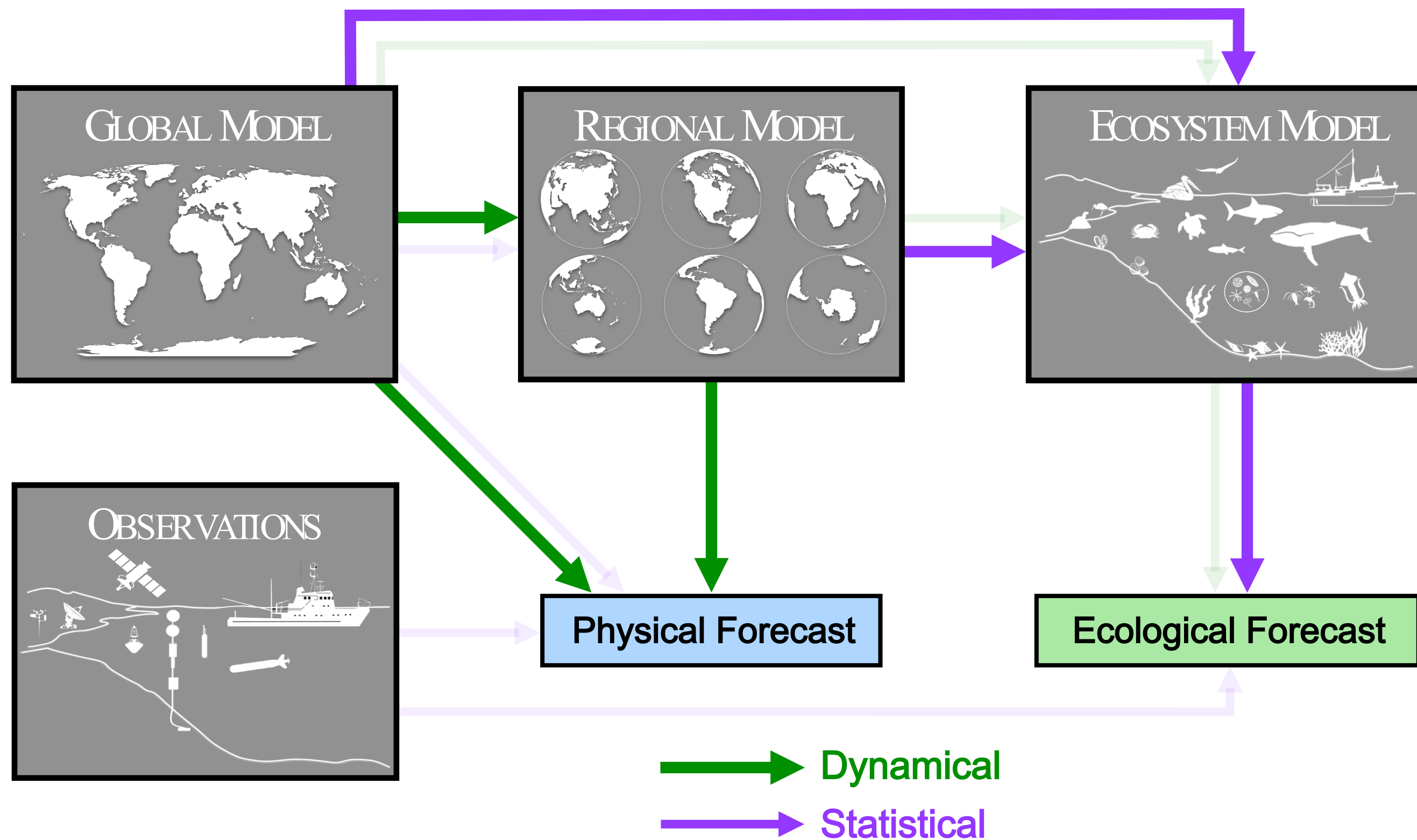
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Downscaling improves skill, BUT global forecasts are also skillful and can even be better due to availability of much larger ensembles.

Summary



Current Uses

Derived products (e.g., MHW forecasts)

Direct forcing of ecological models (SST only)

Forcing regional ocean models (historical only, select models)

Helpful additional information from existing runs

Output of more ocean variables (e.g., SSH, MLD)

Guidance on climatology adjustments

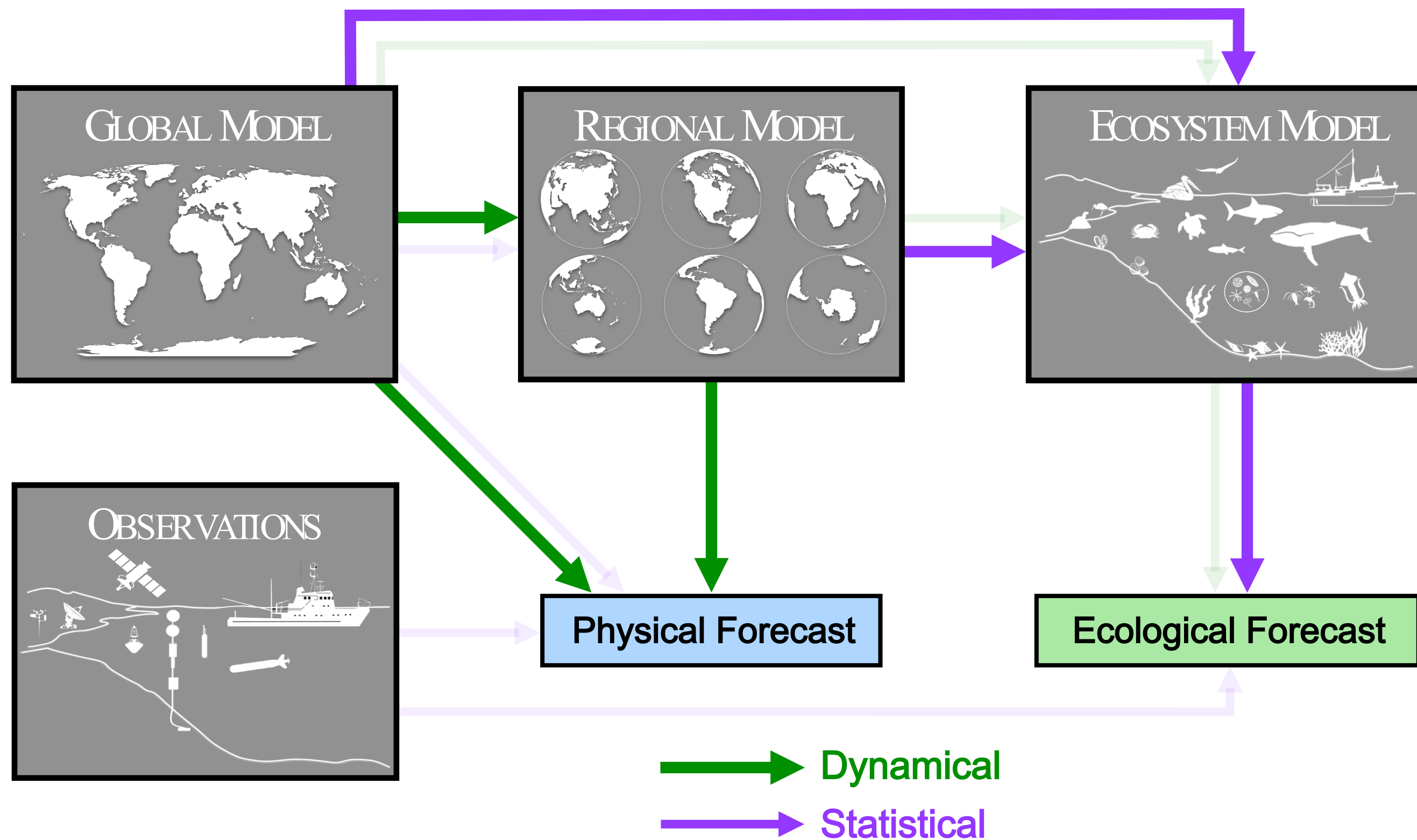
Output variables for regional downscaling

Helpful forecast extensions/additions

Year 2

Biogeochemistry

Summary



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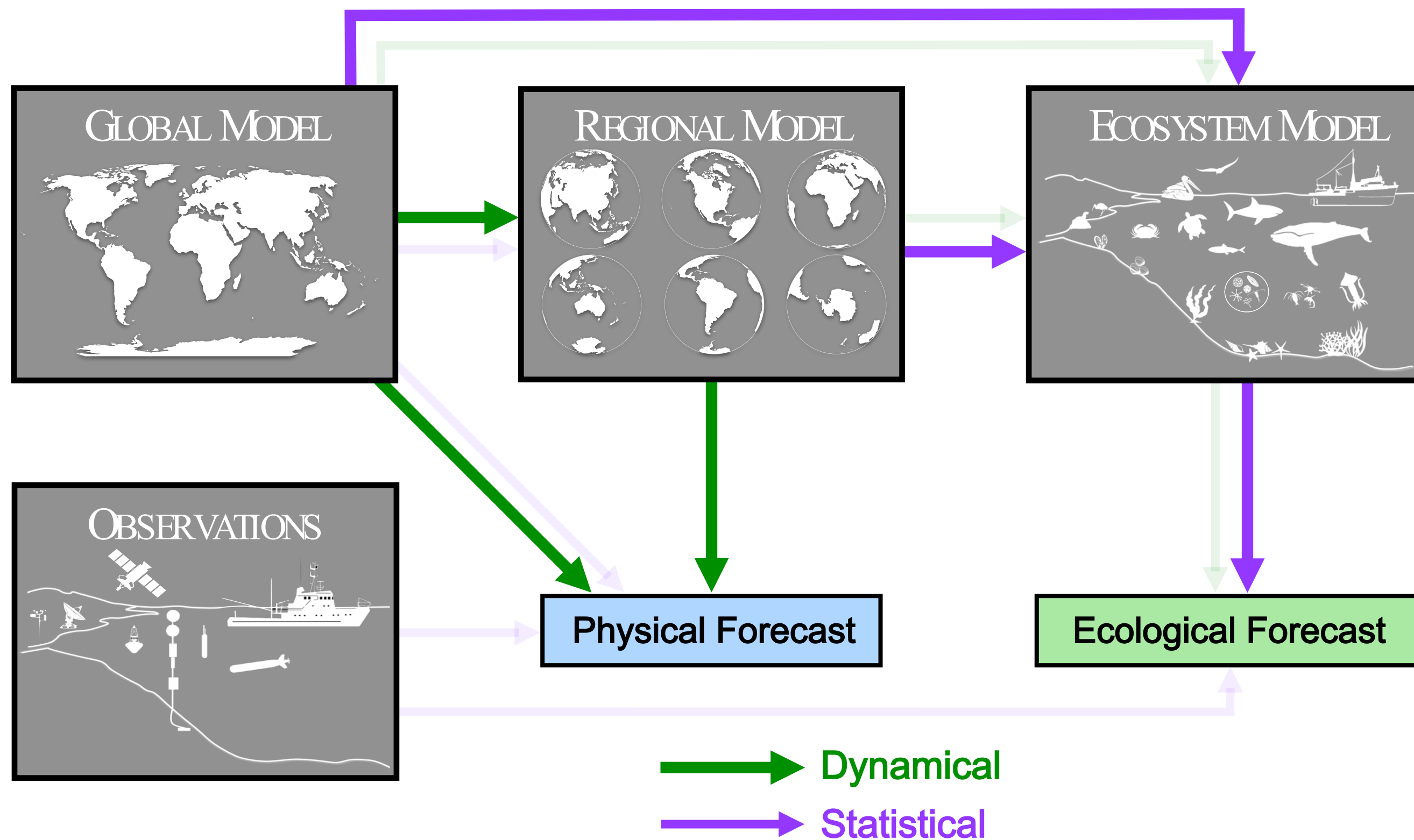
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