MARINE ECOLOGICAL PREDICTABILITY AND FORECASTING

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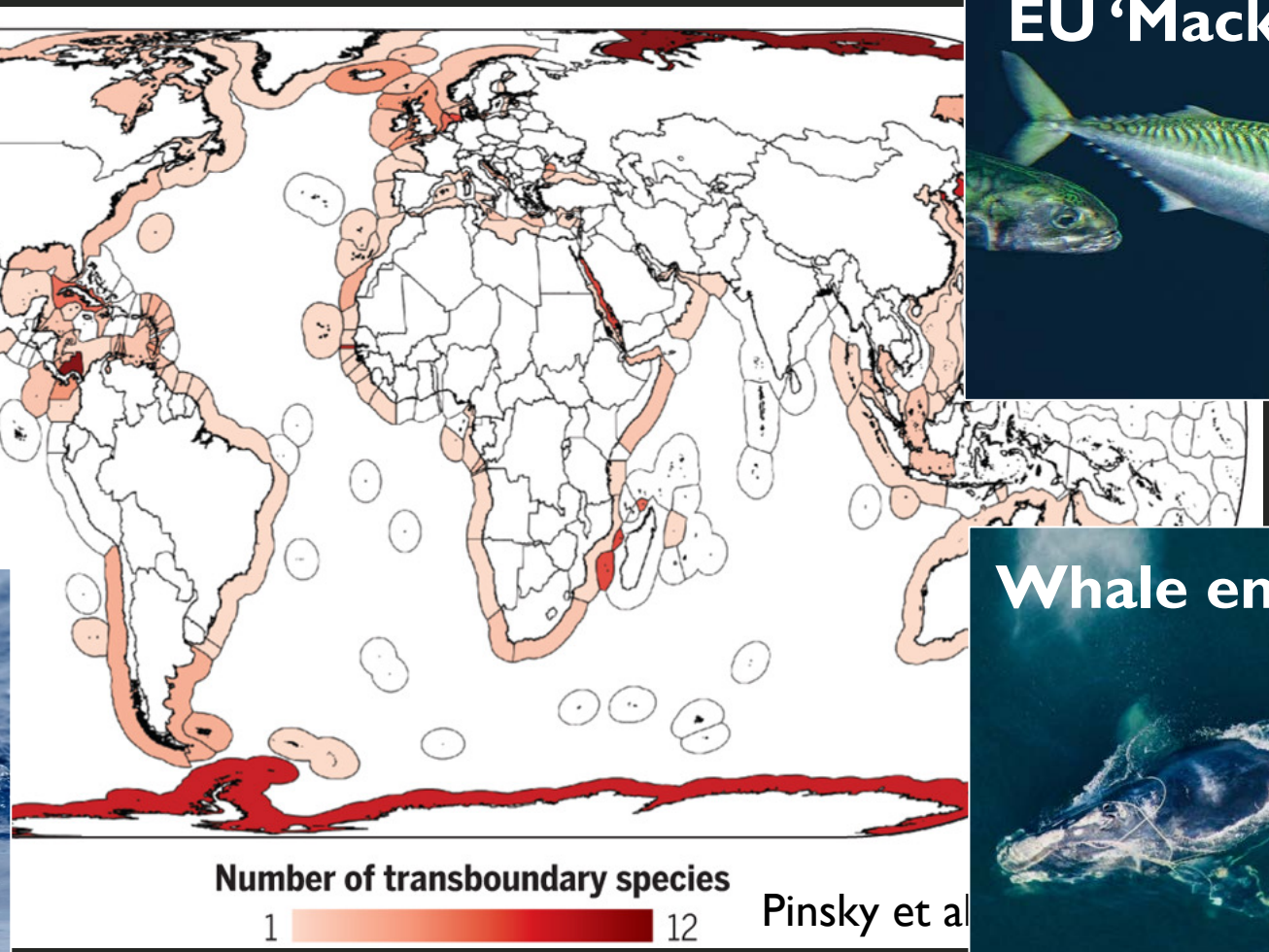
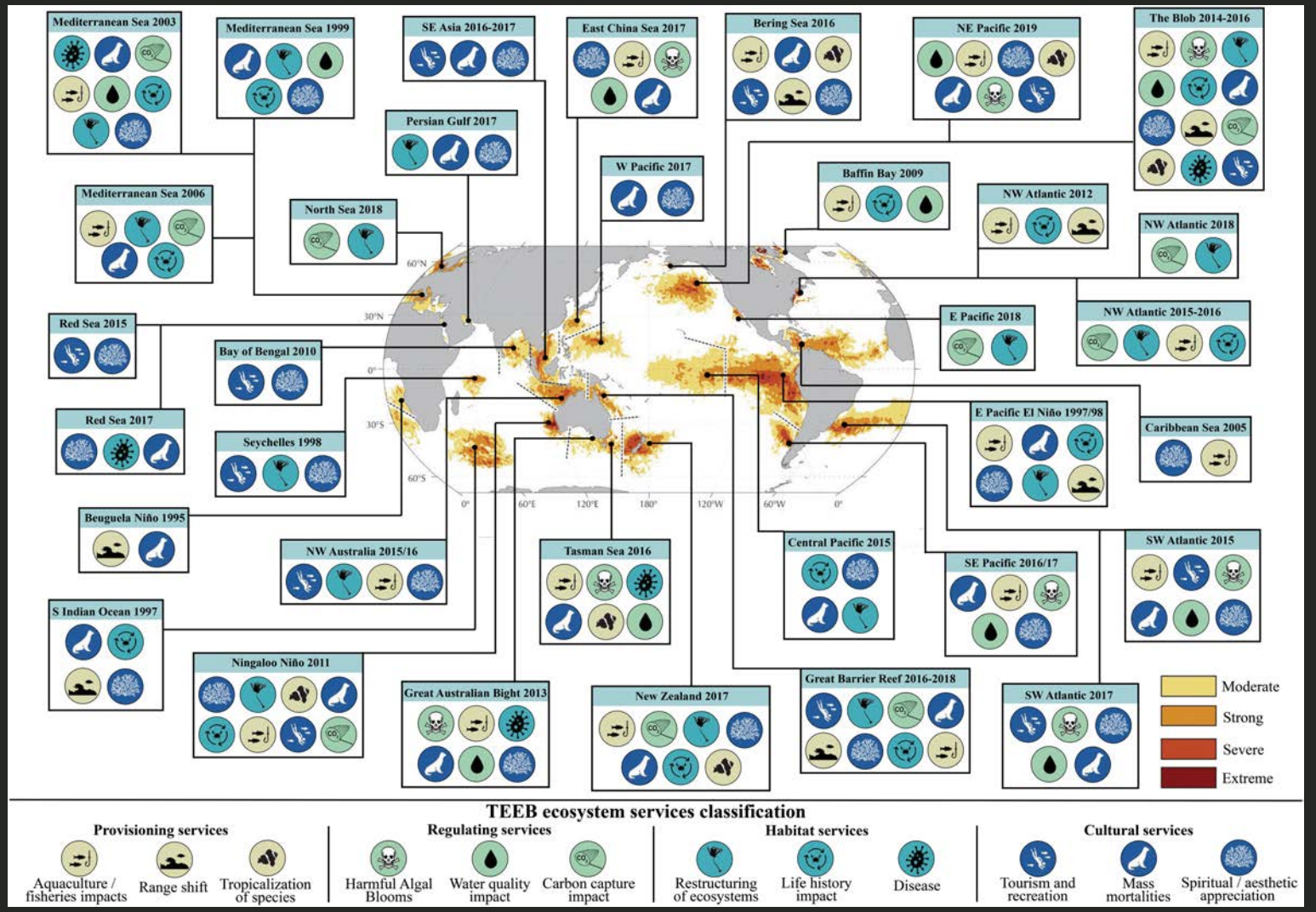
MARINE SPECIES ARE SHIFTING…..

AND SHIFTING FASTER THAN TERRESTRIAL SYSTEMS

CHALLENGES FOR MANAGEMENT & GOVERNANCE



CLIMATE VARIABILITY THREATENS ECOSYSTEM SERVICES



Review of 34 MHW impacts since 1995

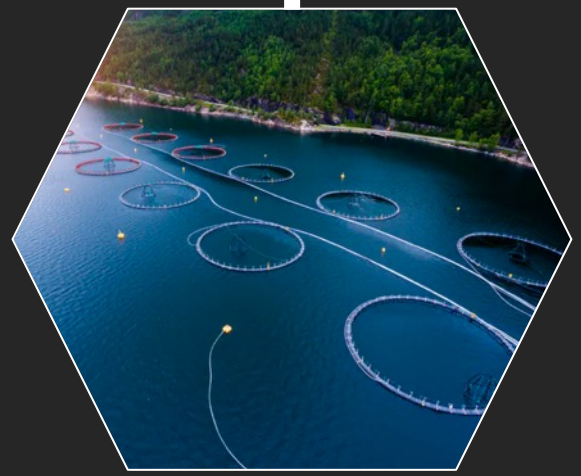
Smith et al., 2021 Science

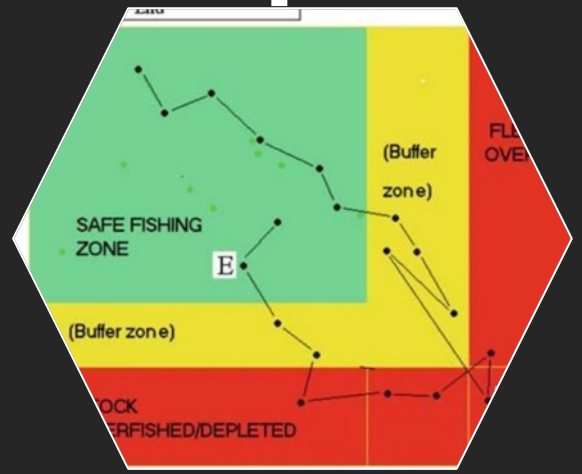
We need accurate predictions across all forecast horizons

0-10 days | Weeks - Months | Year - Decade | Decades - Century

Societally-relevant decisions change across time-scales

0-10 days | Weeks - Months | Year - Decade | Decades - Century





Decisions change across time-scales

Forecasting ecology relies on ecology being predictable

Where can ecological predictability come from?

Life History

Anderson et al. 2014

Phenology

Hazen et al., 2016

Distribution

Brodie et al., 2021

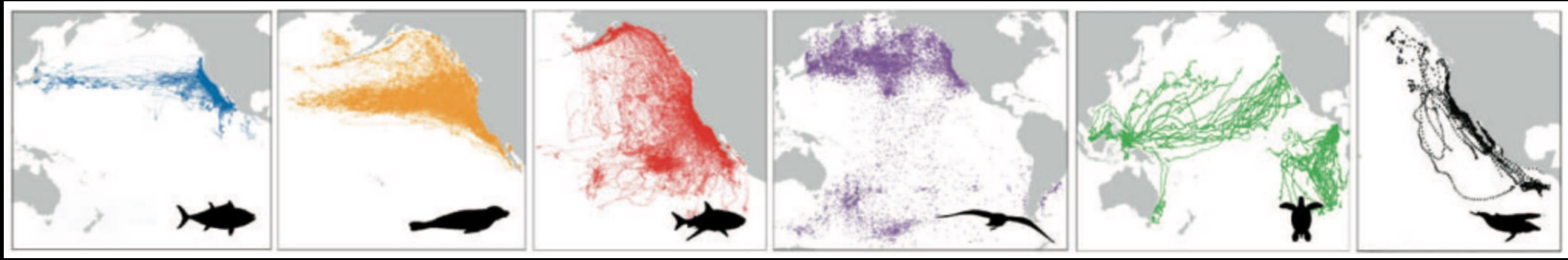
Welch et al., 2018

Persistence

Cimino et al., 2021

Advection

Animal movements are a function of multiple scales of environmental variability



Basin-scale migrations

Fine-scale movements

Figure from Block et al. 2011

Scales of Movement

Diel vertical migration

Occurrence integrates across all

es

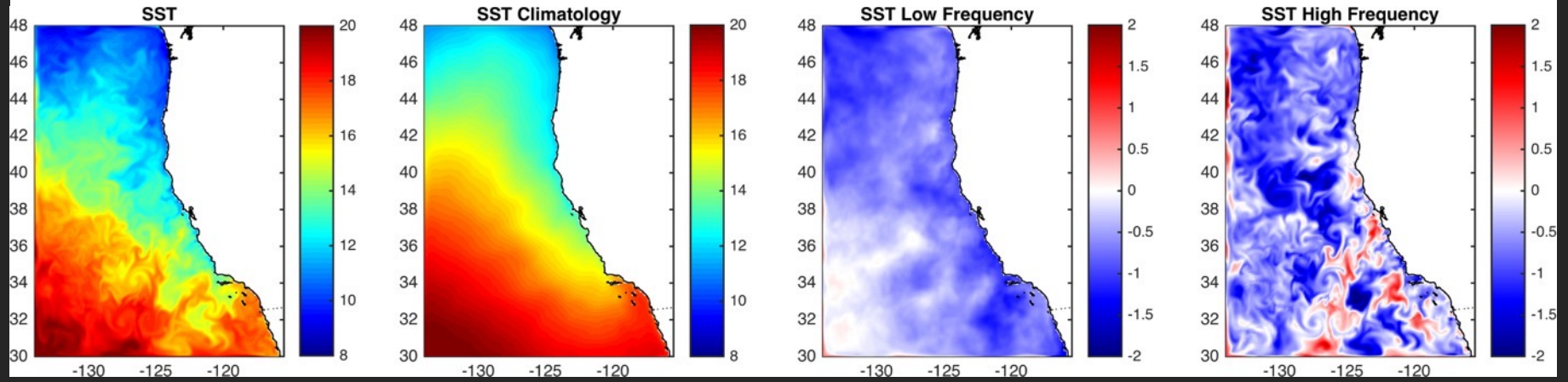
Which temporal scales of environmental variability provide predictability?

Annual Sp

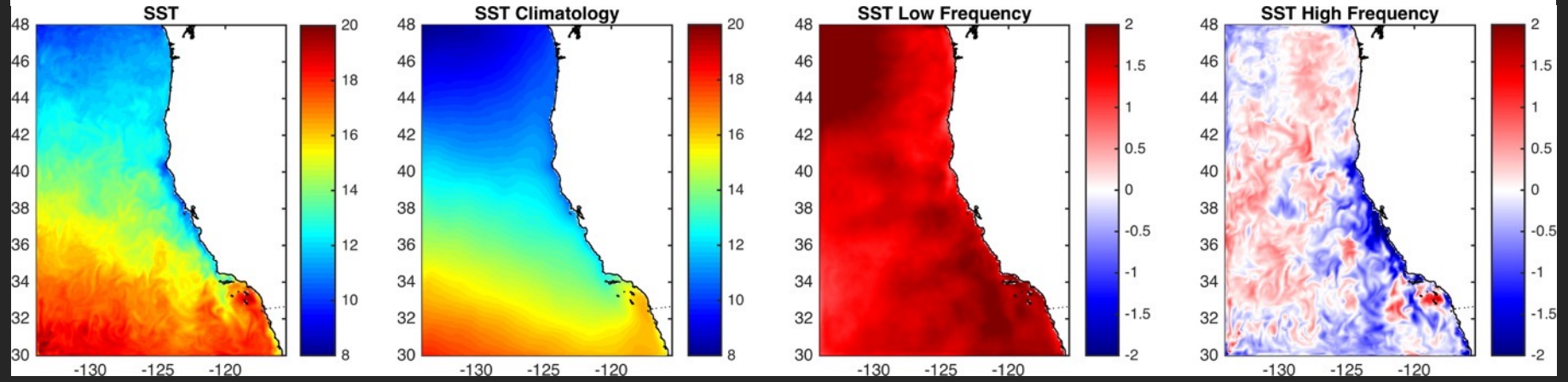
following migration

Temporal Decomposition of SST

23 November 2007



15 April 2015

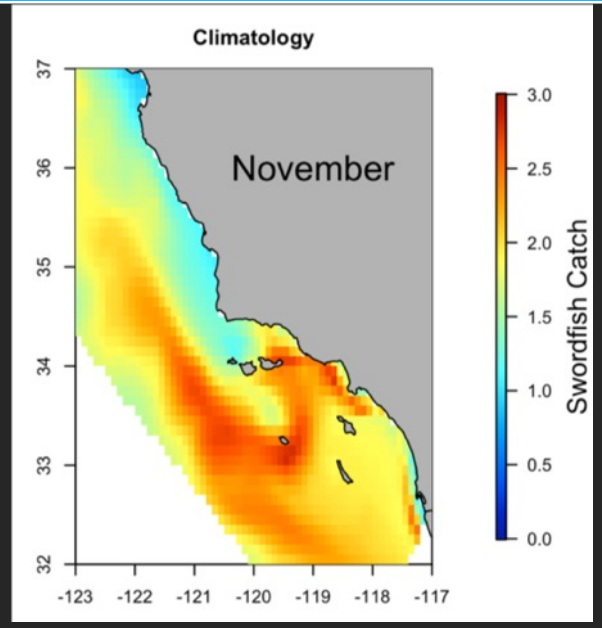


Variables Decomposed:
SST
Chl-a
MLD

Brodie et al., 2021

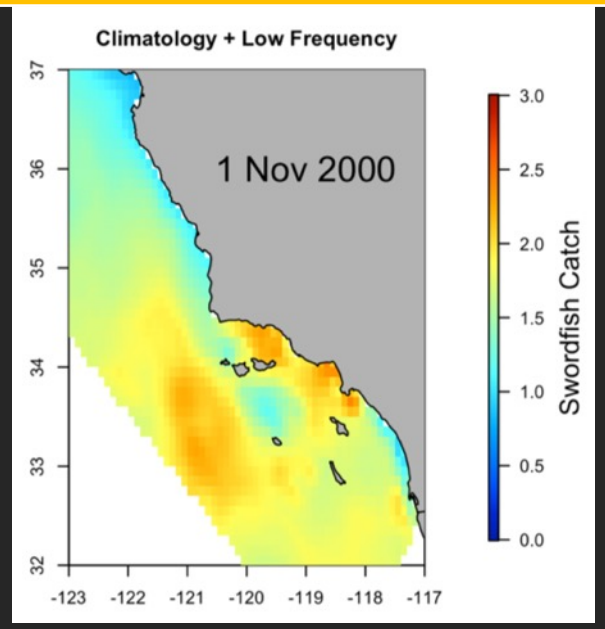
Swordfish Catch Models

Model 1: Climatology



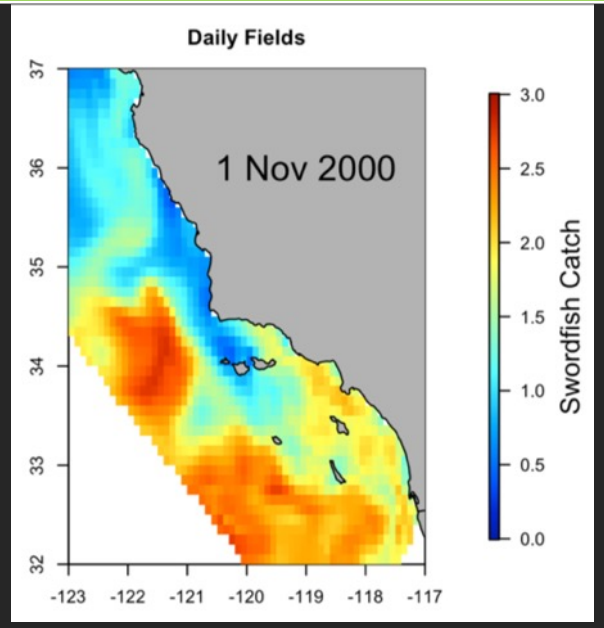
Performed worst
(e.g. %dev = 48.5)

Model 2: Clim. + low frequency



Intermediate performance
(e.g. %dev = 48.7)

Model 3: Daily values

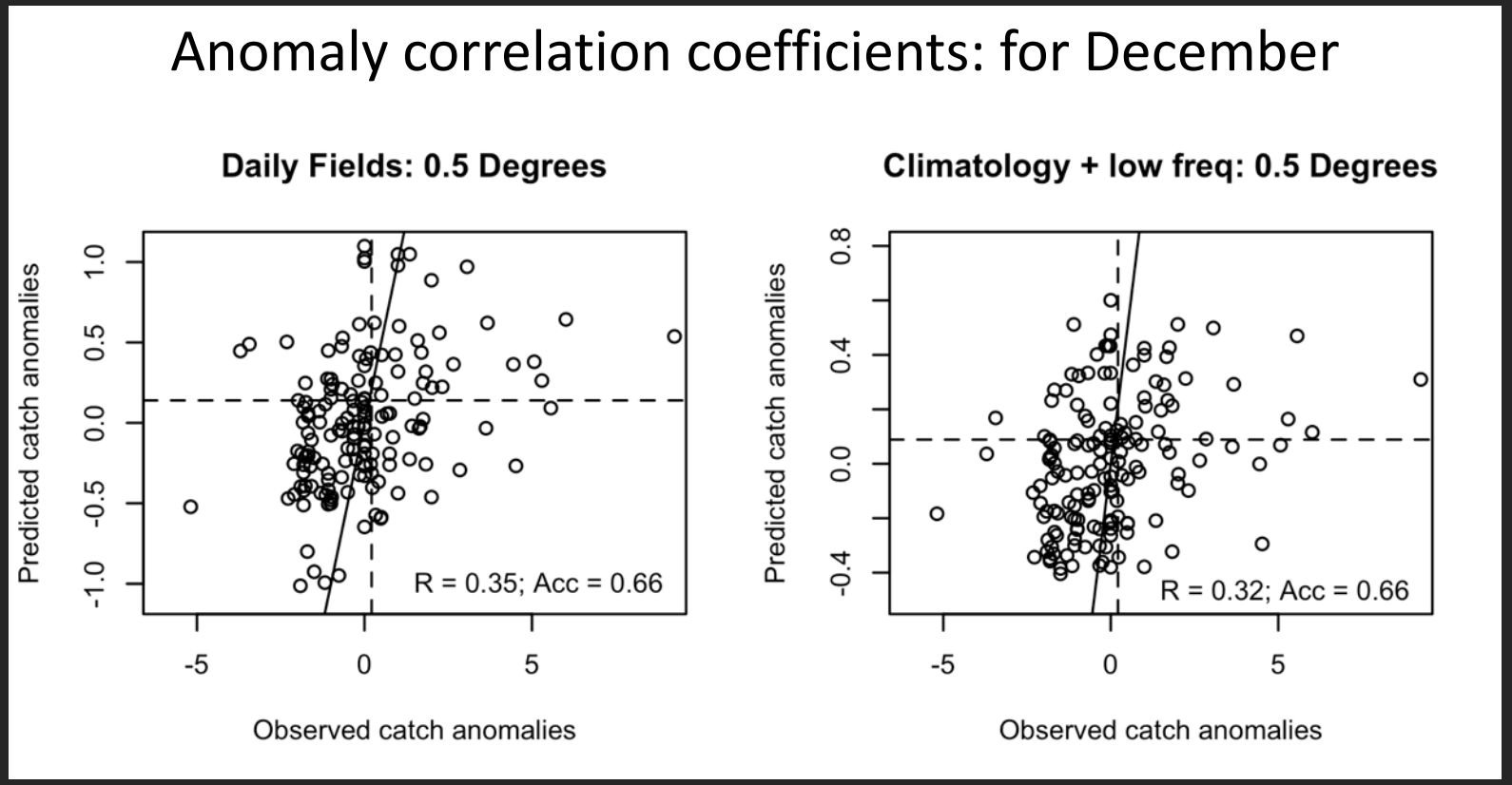


Performed best
(e.g. %dev = 49.3)

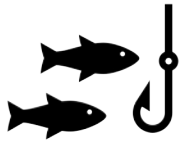
Brodie et al., 2021

Model Validation: catch anomalies

Can we predict when swordfish catch is anomalously high or low? Yes



Swordfish Catch Models



Model 1: Climatology

Climatology is dominant source of predictability

Model 2: Clim. + low frequency

Low frequency adds ability to detect *anomalous* catch

Model 3: Daily values

High frequency added minor improvement

Swordfish S2S forecast likely viable…and maybe even S2D?

0-10 days → Weeks to Months → Decades to Centuries

Harnessing ecological predictability for forecasting

Option A

Use physical environment

e.g. temperature

Temperature observations predict lobster migration

Mills et al., 2017 FMARS

Option B

Use ecological observations

e.g. autoregression or life-history

Autoregressive models predict distribution shifts

Thorson et al. 2018 GHOTI

Option C

Couple ecology with physical forecast system

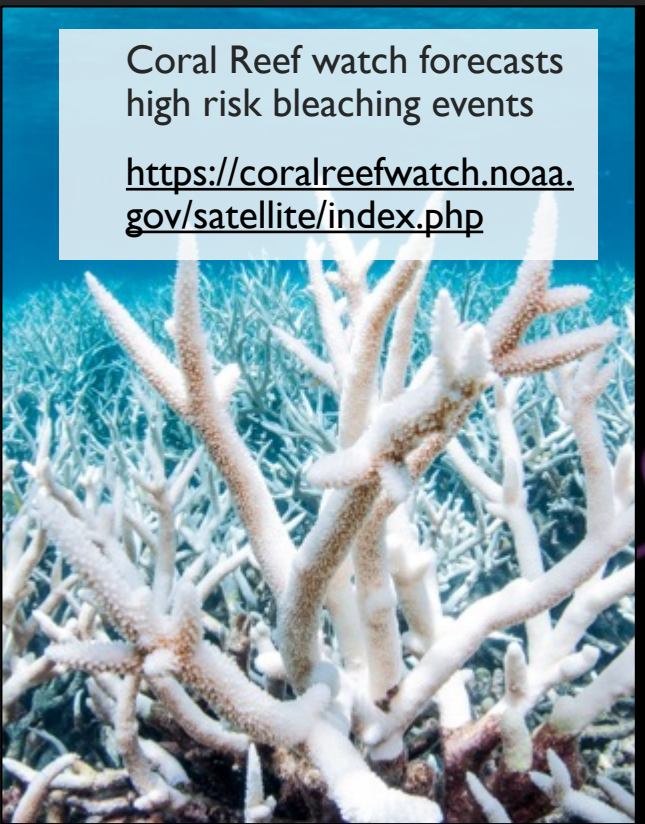
e.g. species distribution or ecosystem model

Timing of tuna migrations for ranching

Eveson et al., 2015

ECOLOGICAL FORECASTING: **OPERATIONAL** NOAA EXAMPLES

0-10 days | Weeks - Months | Year - Decade | Decades - Century

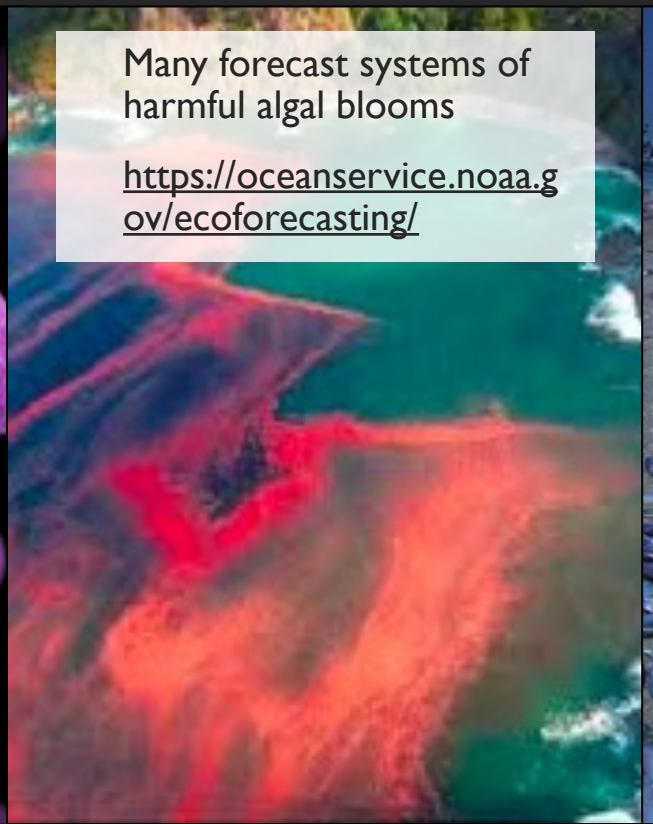


Coral Reef watch forecasts high risk bleaching events

https://coralreefwatch.noaa.gov/satellite/index.php

Pathogen forecasts predict when shellfish become toxic

https://oceanservice.noaa.gov/ecoforecasting/



Many forecast systems of harmful algal blooms

https://oceanservice.noaa.gov/ecoforecasting/

Forecasting dead zones for watershed management

https://oceanservice.noaa.gov/ecoforecasting/

ECOLOGICAL FORECASTING: **OPERATIONAL** FISHERIES EXAMPLES

0-10 days | Weeks - Months | Year - Decade | Decades - Century

Nowcasts to reduce fisheries bycatch.

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

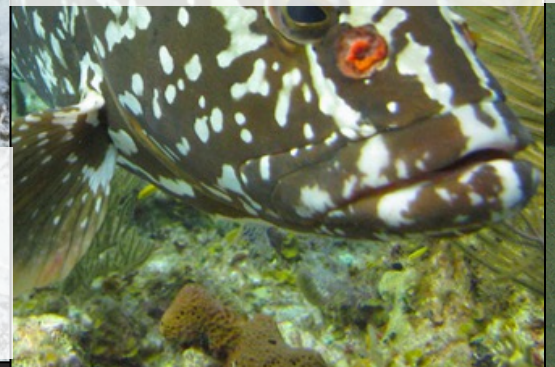
Nowcast to reduce turtle bycatch.

https://oceanwatch.pifsc.noaa.gov/turtlewatch.html

Forecasting salmon returns:
https://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/g-forecast.cfm

Forecasting when catch limits will be met

https://www.fisheries.noaa.gov/southeast/2019-and-2020-gulf-mexico-recreational-landings-and-annual-catch-limits-acls-and-annual

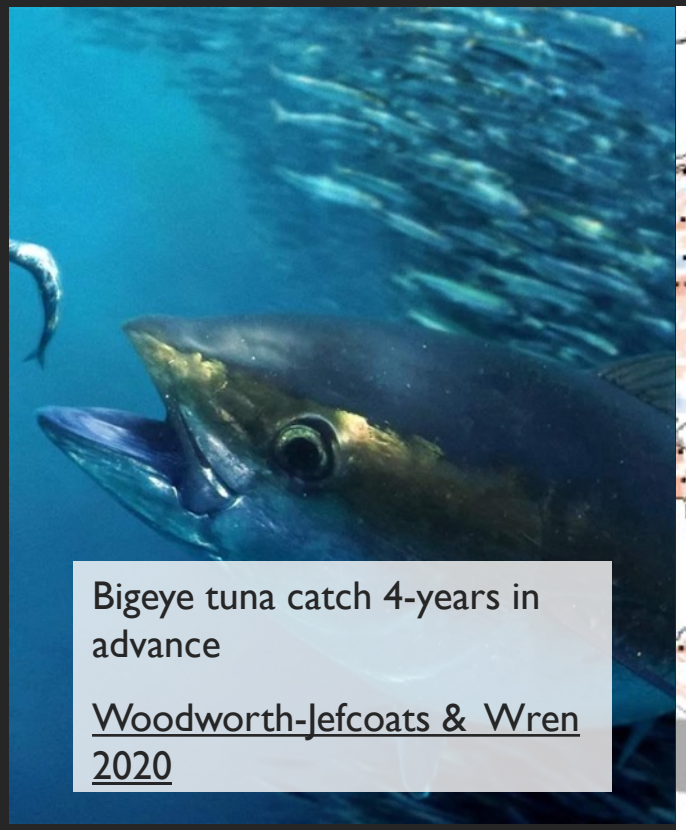


Forecasting hake distribution

http://www.nanoos.org/products/j-scope/forecasts.php?forecast=2021-01&var=hake

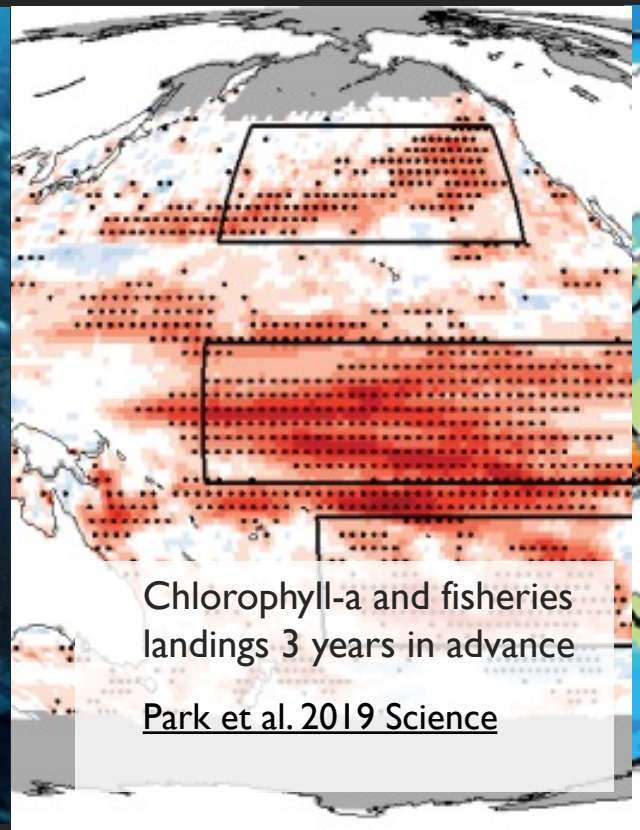
ECOLOGICAL FORECASTING: THE NEXT FRONTIER

0-10 days | Weeks - Months | Year - Decade | Decades - Century



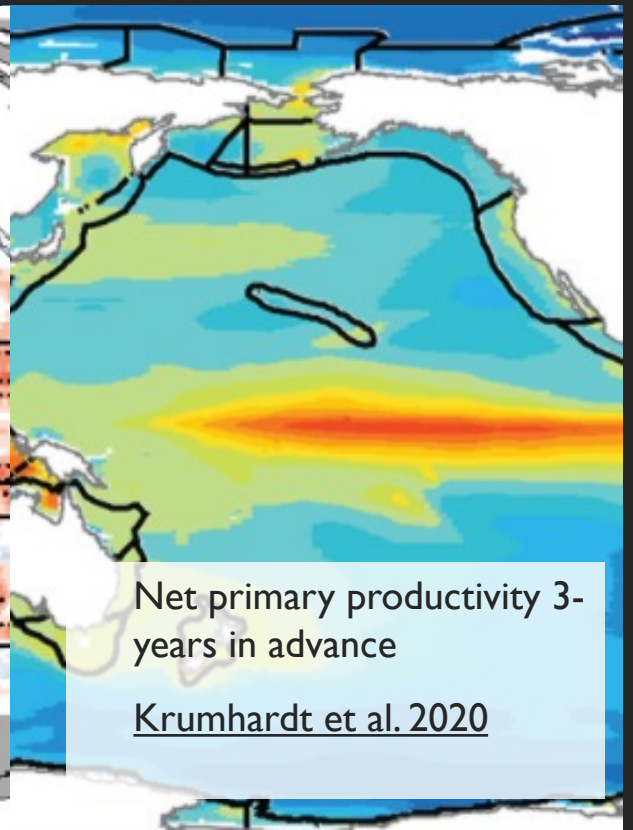
Bigeye tuna catch 4-years in advance

Woodworth-Jefcoats & Wren 2020



Chlorophyll-a and fisheries landings 3 years in advance

Park et al. 2019 Science



Net primary productivity 3-years in advance

Krumhardt et al. 2020

ECOLOGICAL FORECASTING: THE NEXT FRONTIER

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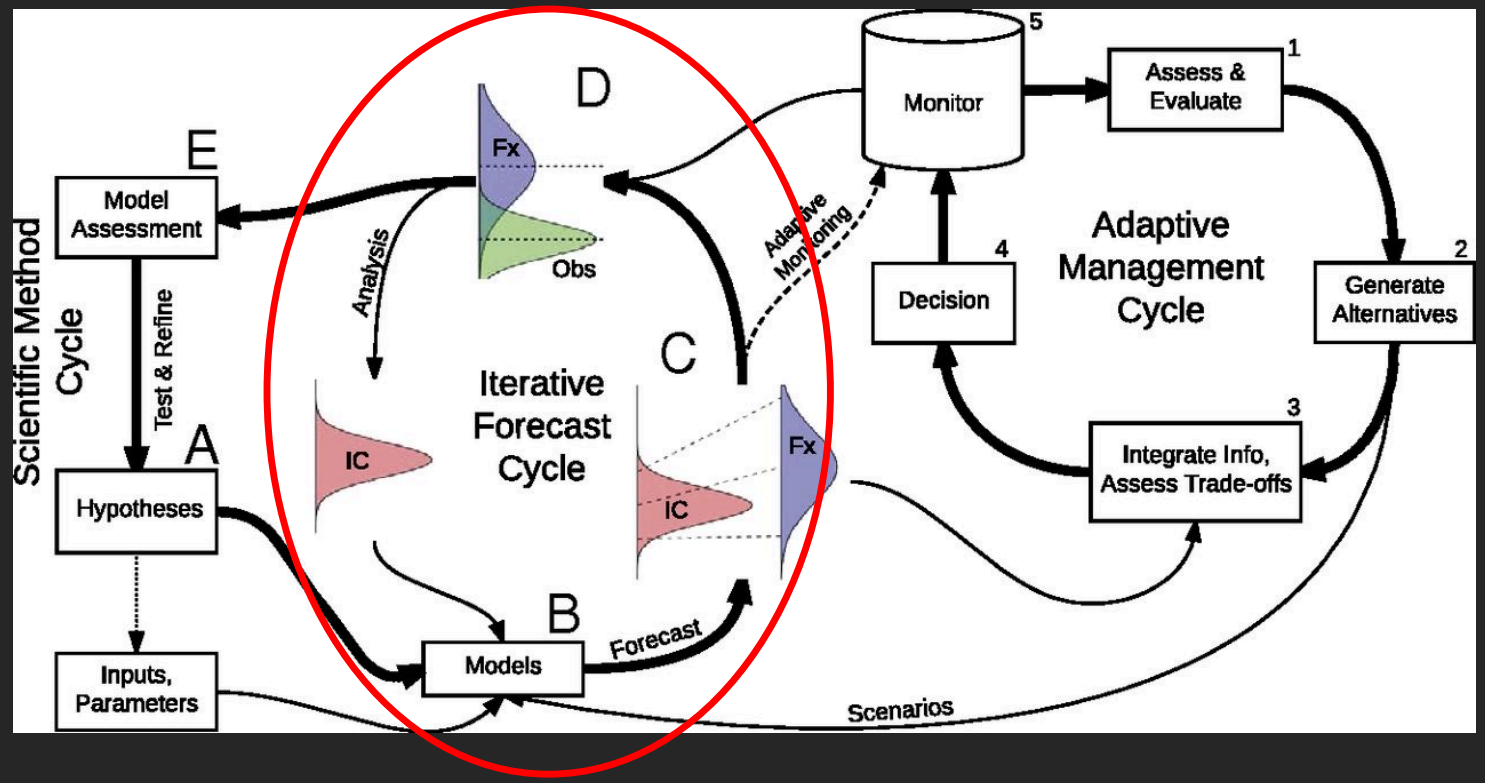

Dietz et al. 2018 PNAS

A PATH FORWARD

Key Needs:

- Foster a community of researchers engaged in this space
- Best practices for stakeholder engagement and end-user uptake
- Transitioning from research to operations
- Understand which physical variables are skillful and at what lead times
- Communicate which variables are needed for downstream users

ACKNOWLEDGEMENTS

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