
Welcome to
PICES-2026!
Opening Session
Coffee Break
10:20 – 10:50



2025 Zhu-Peterson Award Winner Presentation

!Nbd`mhb`mc @sl nrogdqhb Cqhudqr neL`qhmd
Dbnrxrsdl Oqdchbs`ahksx!

Hyung-Gyu Lim
Chonnam National University, Korea

10:50-11:10AM, October 26, PICES-2026

Oceanic and Atmospheric Drivers of Marine Ecosystem Predictability

Hyung-Gyu Lim (Chonnam National University)

John Dunne, Charles Stock, Paul Ginoux, Jasmin John, John Krasting (NOAA/OAR/GFDL)

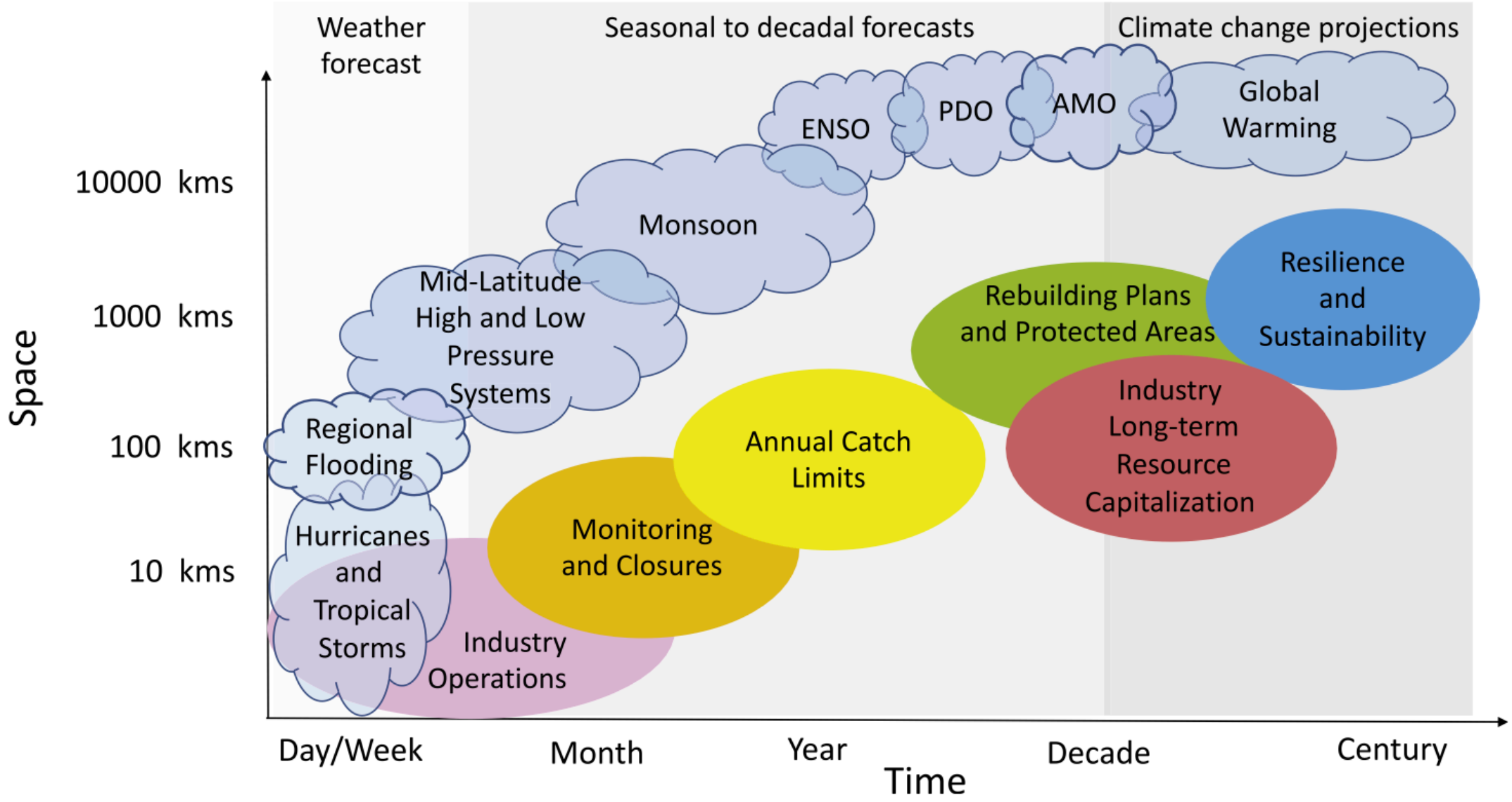
Colleen Petrik (UC San Diego/SIO)

Kristen M. Krumhardt, Mattew C. Long (NCAR/CGD)

Zhuomin Chen, Samantha Siedlecki (University of Connecticut)

Jong-Yeon Park, Eun-Young Kim (Jeonbuk National University)

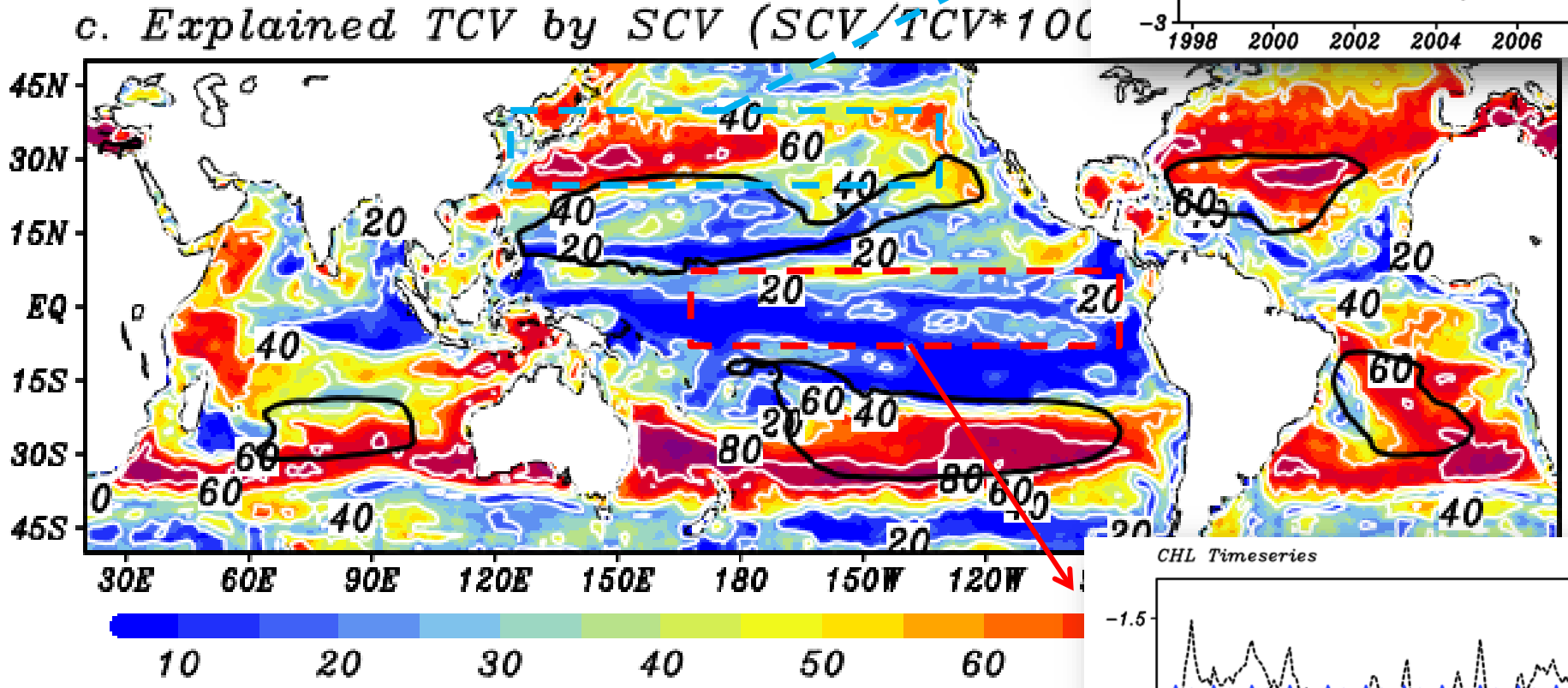
Scales of “oceanic & atmospheric drivers” on marine living resources

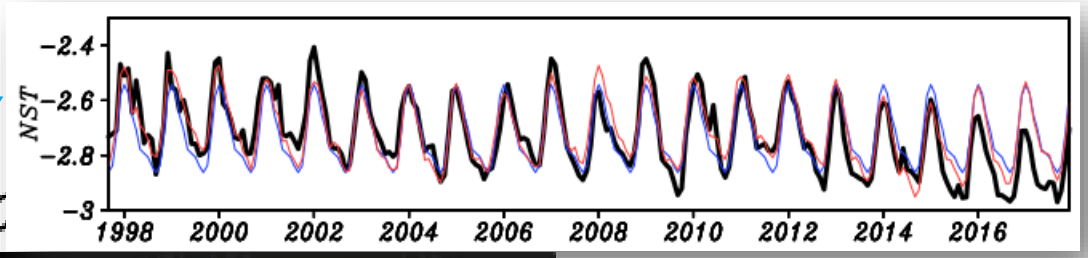


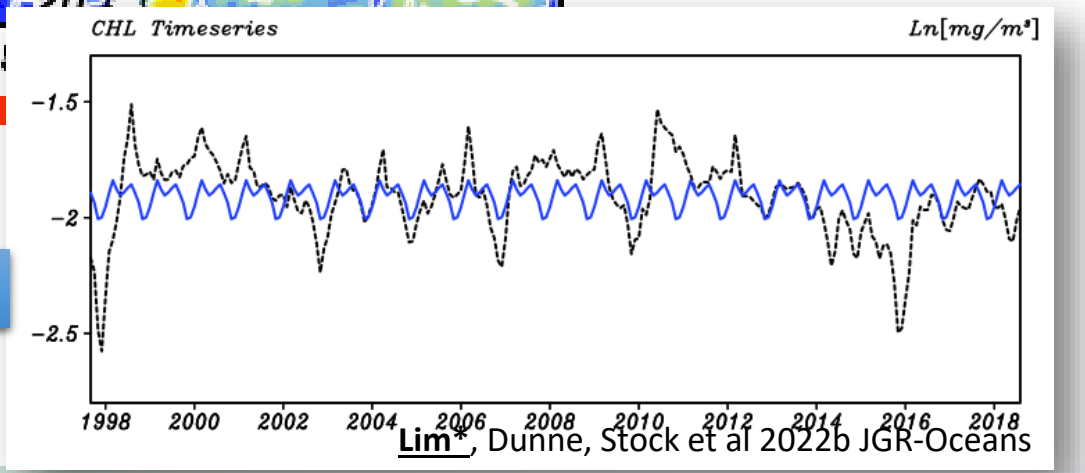
Tommasi et al 2017

Seasonal cycle contribution on Total Chlorophyll Variance

- Seasonal cycle contributes over 60% in midlatitude (~30°)







✓ Strong influence of interannual variability on TCV in tropics

Lim*, Dunne, Stock et al 2022b JGR-Oceans

Delayed climate impacts on CHL anomaly

EP-ENSO

CP-ENSO

PDO

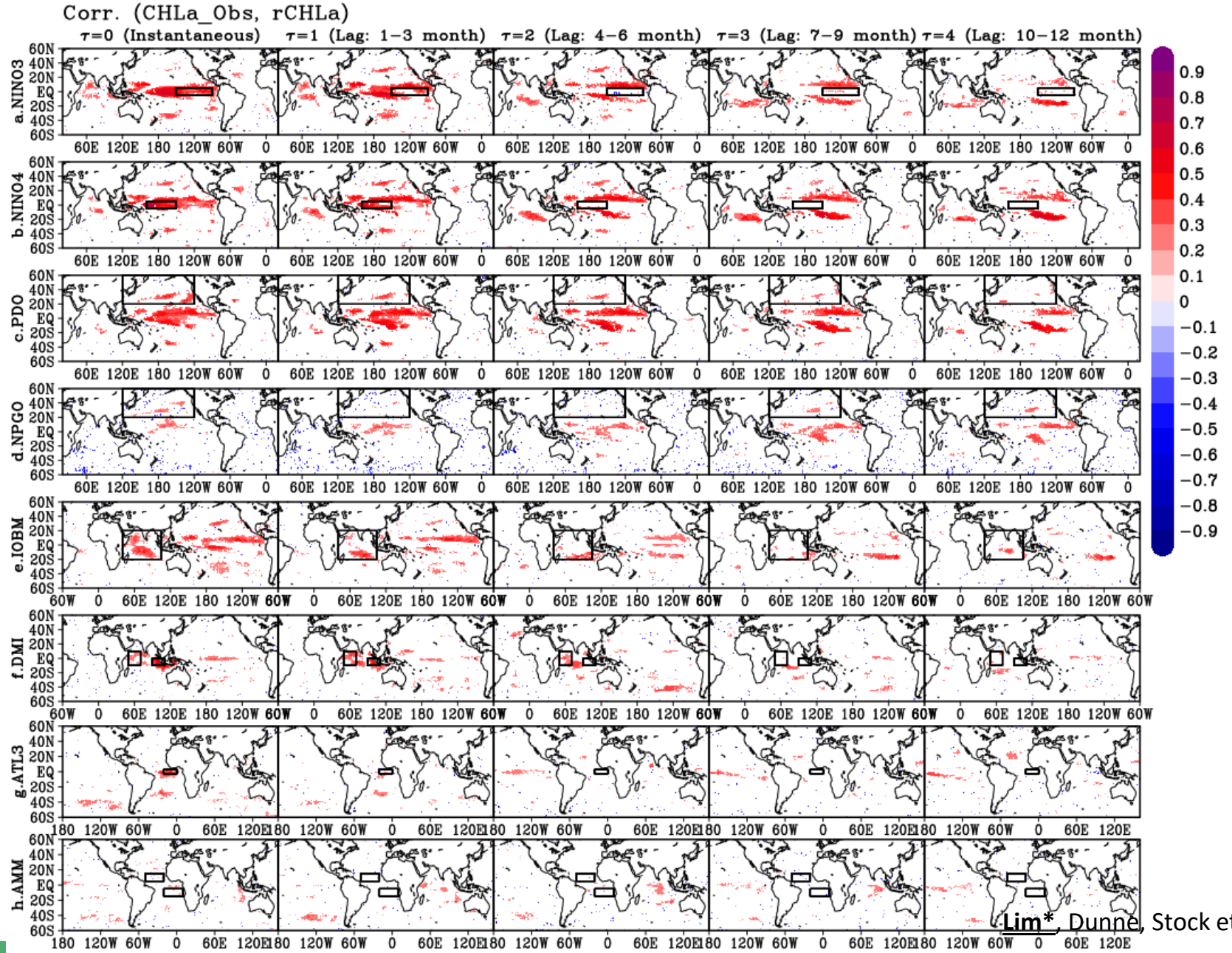
NPGO

IOBM

DMI

ATL3

AMM



Lim*, Dunne, Stock et al 2022b JGR-Oceans

Chlorophyll reconstruction

τ : Lagged time scales of climate indices
$\boldsymbol{\beta}$: Partial Regression coefficients

$$rCHLa_t = \sum_{\tau=0}^{4} (\beta_{1,t-\tau} \cdot NINO3_{t-\tau} + \beta_{2,t-\tau} \cdot NINO4_{t-\tau} + \beta_{3,t-\tau} \cdot PDO_{t-\tau} + \beta_{4,t-\tau} \cdot NPGO_{t-\tau} + \beta_{5,t-\tau} \cdot ATL3_{t-\tau} + \beta_{6,t-\tau} \cdot AMM_{t-\tau} + \beta_{7,t-\tau} \cdot IOBM_{t-\tau} + \beta_{8,t-\tau} \cdot DMI_{t-\tau})$$

$$rTCV = \frac{1}{n} \sum_{t=1}^{n} (rCHLa_t + CHL_SC_t - \mu)^2$$

n : degree of freedom #292
μ : Chlorophyll annual mean
CHL_SC : Chlorophyll seasonal cycle

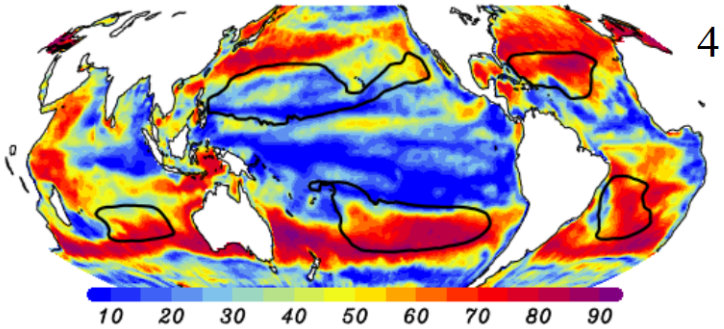
Lim*, Dunne, Stock et al 2022b JGR-Oceans

Attributing chlorophyll variance

Attribution of Total Chlorophyll Variance (%)

Case 1)

Seasonal Cycle



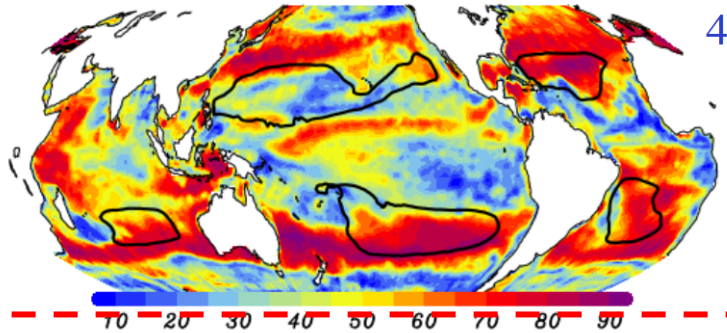
41.6%

Case 2)

Seasonal Cycle

+

Instantaneous climate modes



49.1%

Case 3)

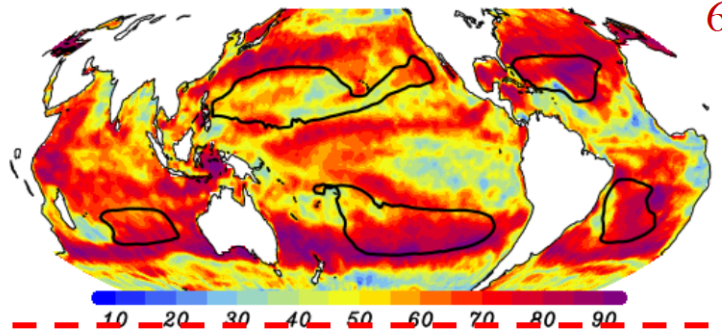
Seasonal Cycle

+

Instantaneous climate modes

+

Delayed climate modes



61.1%

***Critical source in chlorophyll variance and predictability**

JGR Oceans

RESEARCH ARTICLE

10.1029/2022JC019121

Key Points:

- In the mid-latitudes, the seasonal cycle (64.7%) and climate variability (9.6%) combine to explain 74.3% of satellite chlorophyll variance
- In the tropics, the seasonal cycle

Attribution and Predictability of Climate-Driven Variability in Global Ocean Color

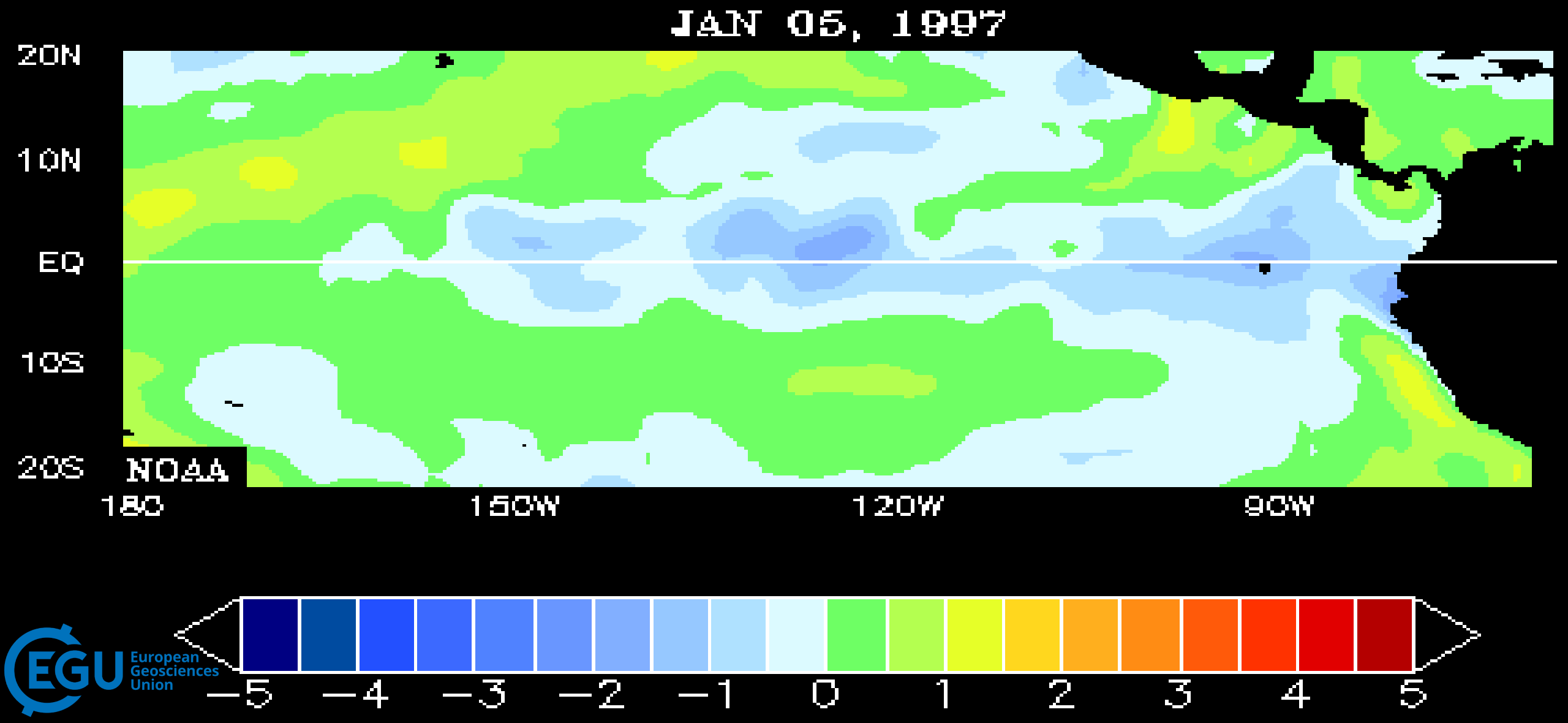
Hyung-Gyu Lim[1,2], John P. Dunne[3], Charles A. Stock[3], and Minho Kwon[4]

[1]Princeton University/Atmospheric and Oceanic Sciences Program, Princeton, NJ, USA, [2]Scripps Institution of Oceanography, University of California San Diego, San Diego, CA, USA, [3]NOAA/OAR/Geophysical Fluid Dynamics Laboratory, Princeton, NJ, USA, [4]Korea Institute Ocean Science and Technology, Busan, South Korea

Adjusting "ocean memory effects"
~ 12 month

Lim*, Dunne, Stock et al 2022b JGR-Oceans

Tropical Pacific SST (°C) anomalies in 1997/1998



European Geosciences Union

97/98 SST, CHL anomalies

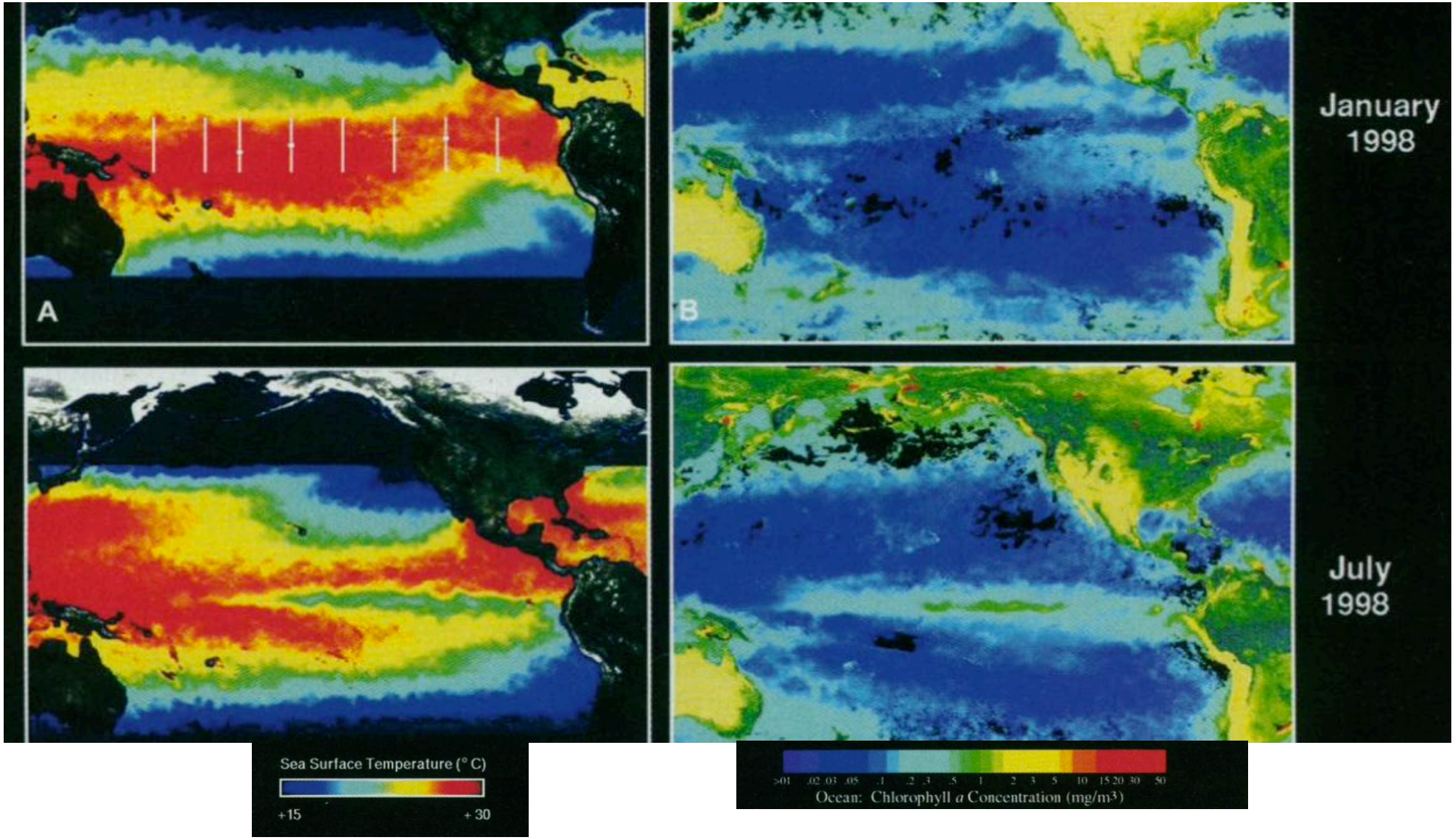
SST

SeaWiFS CHL

El Niño Mature

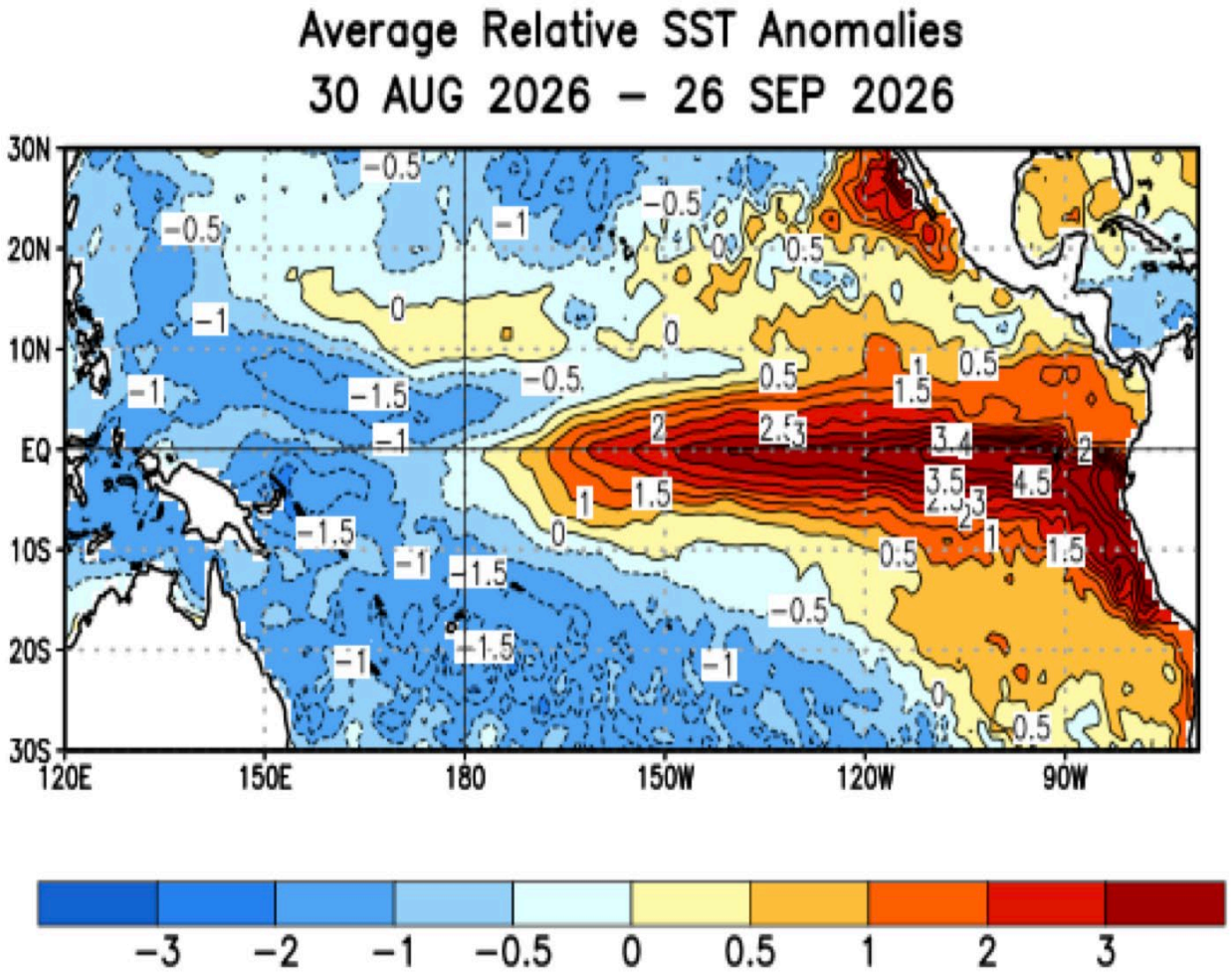
+6m

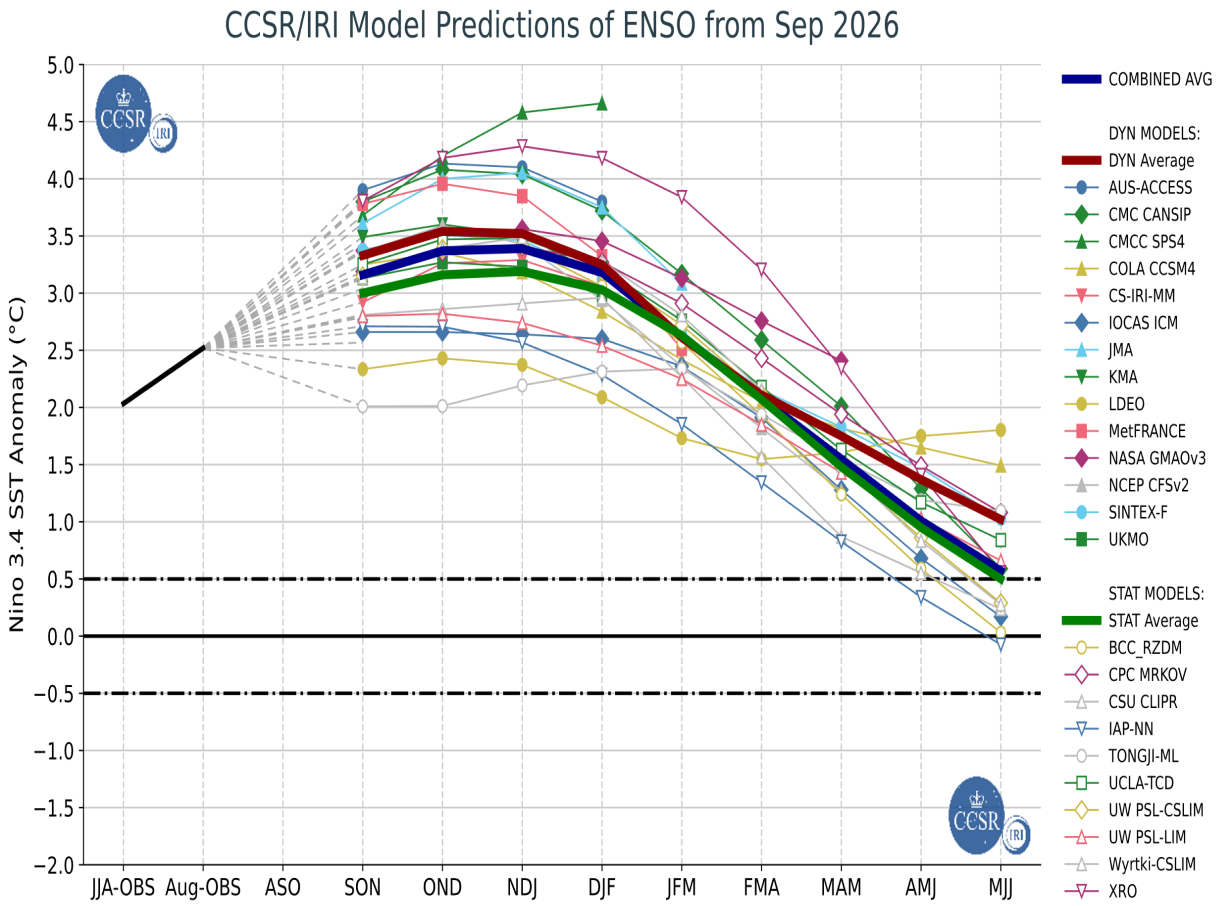
El Niño Decay



Chavez et al 1999 Science

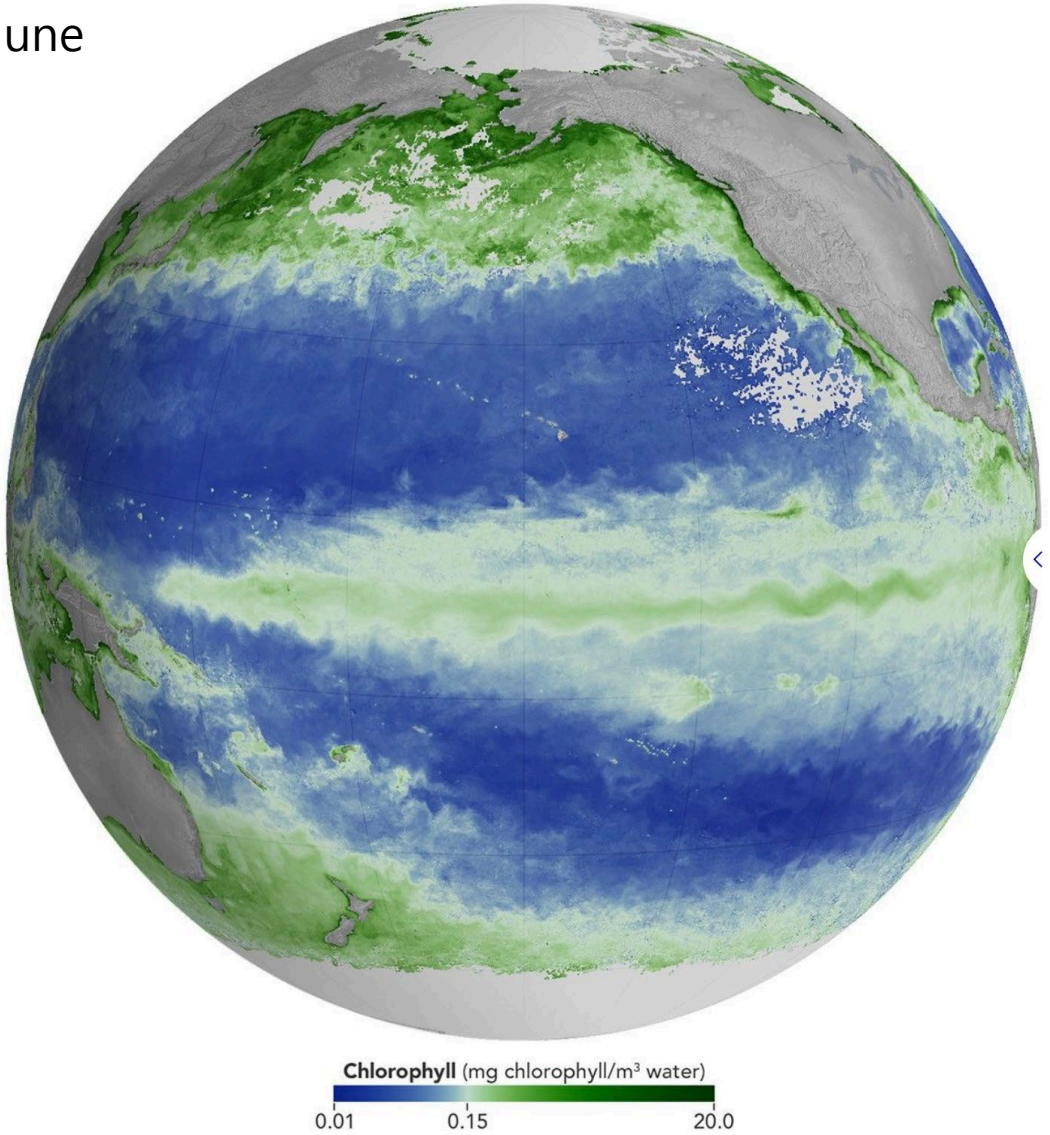
Super El Niño in 2026



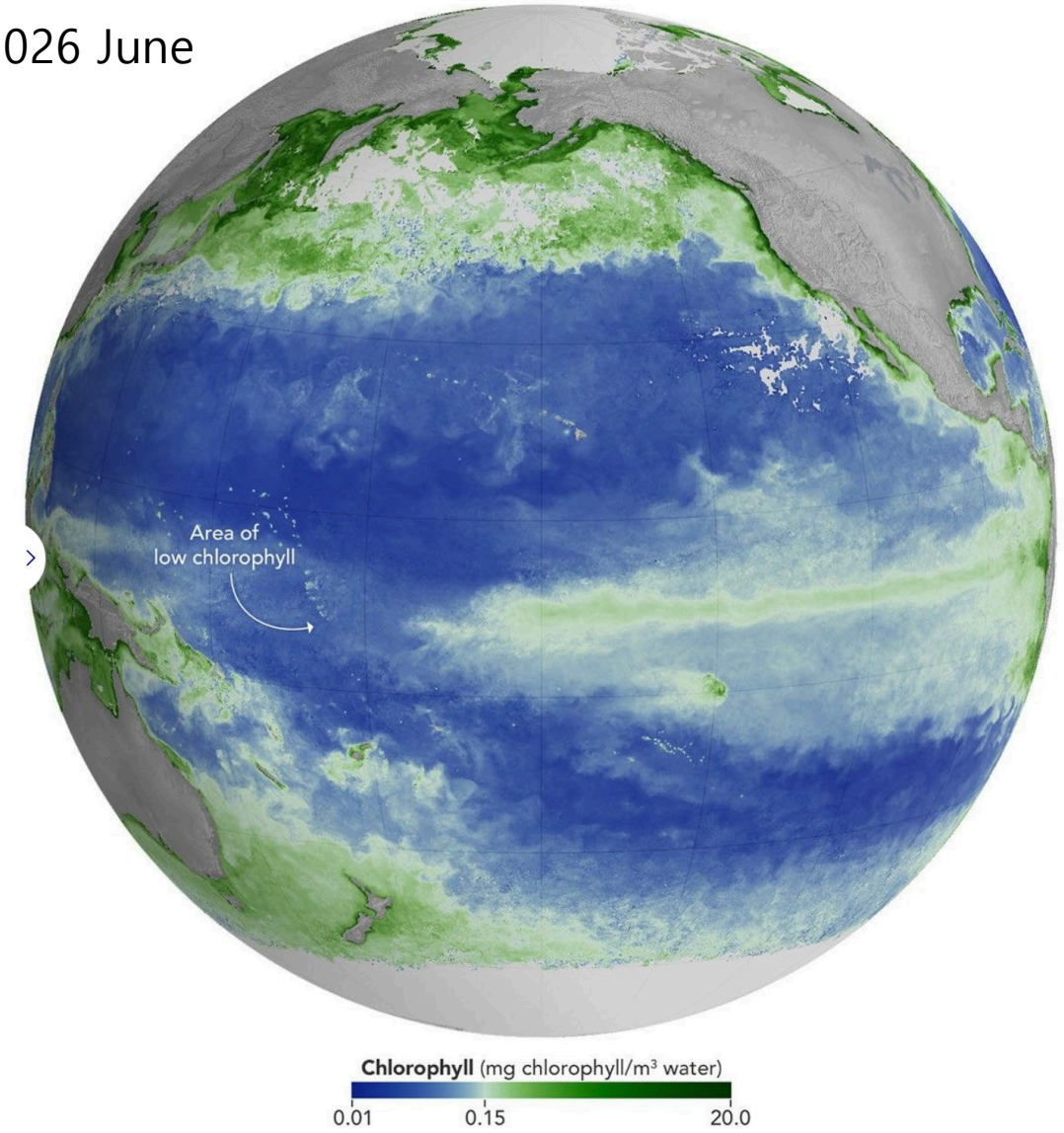


El Niño Alters Marine Life in the Pacific in 2026

2025 June



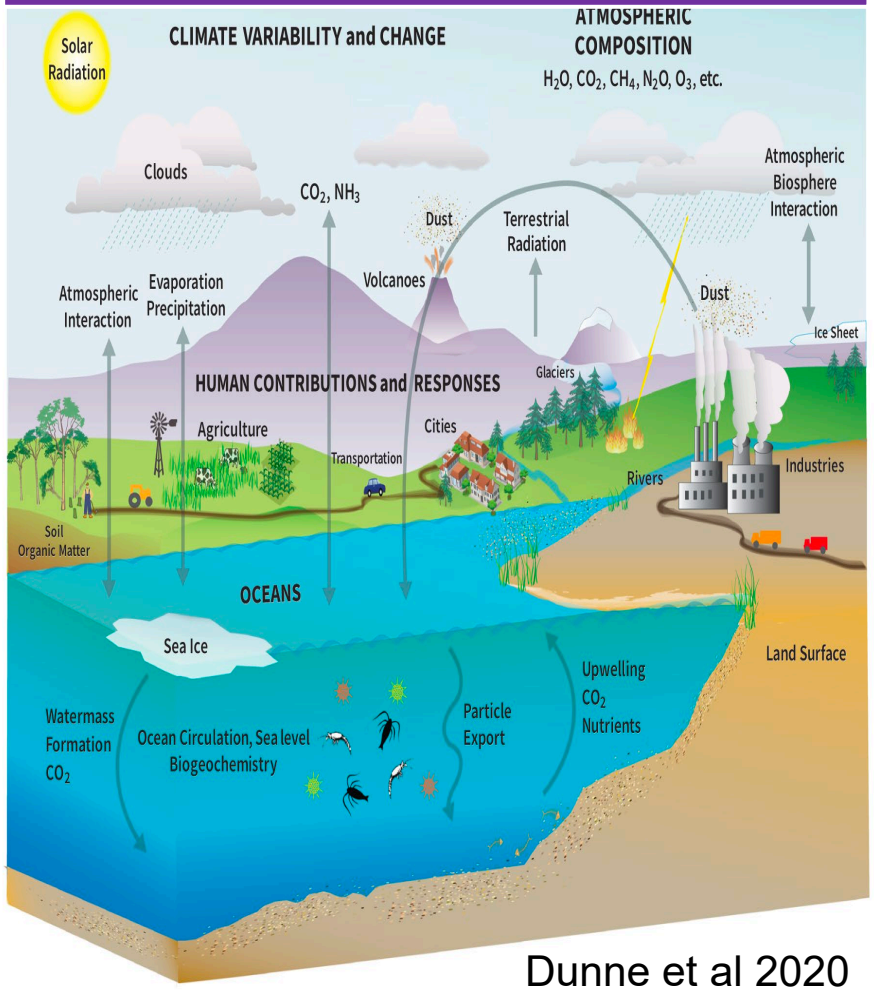
2026 June



https://science.nasa.gov/earth/earth-observatory/el-nino-alters-marine-life-in-the-pacific/

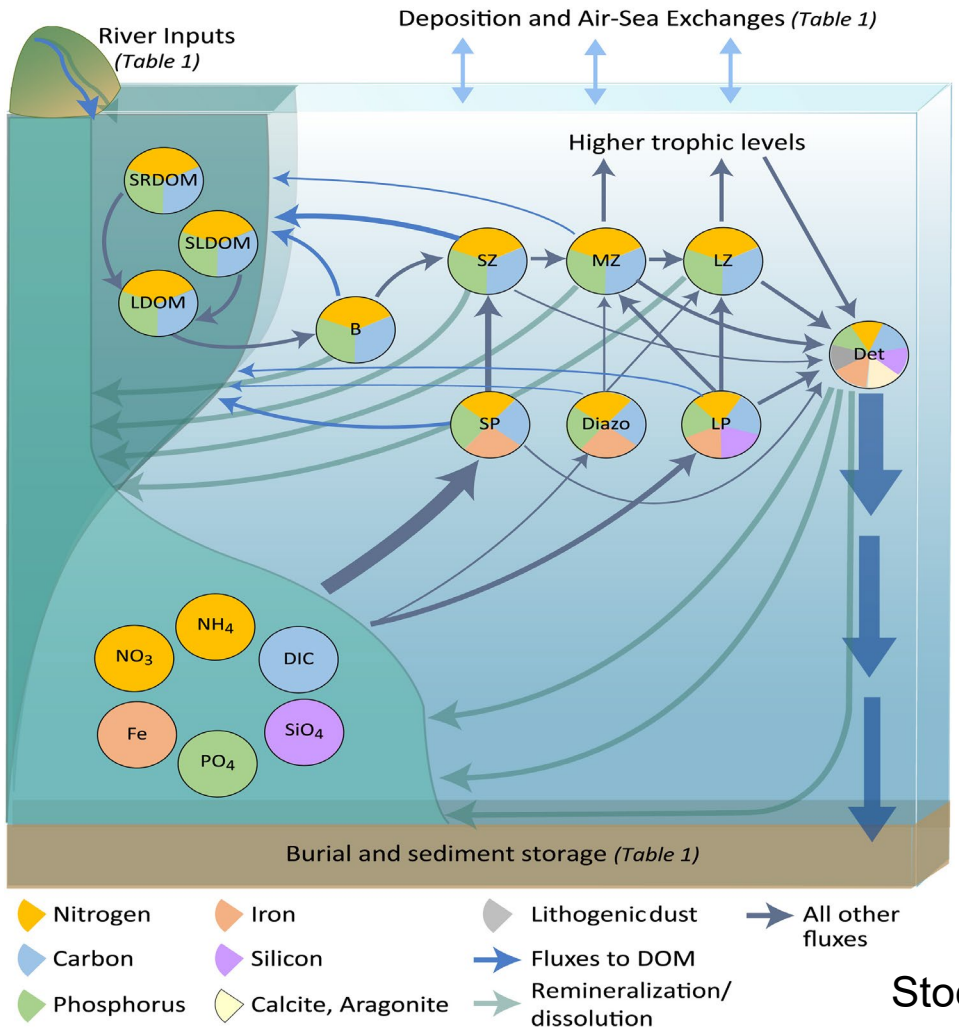
Climate model coupled with marine biogeochemistry - lower trophic levels (planktons)

Earth system model:
general ocean circulation, air-sea interaction, lithogenic nutrient flux



Dunne et al 2020

Biogeochemistry - low trophic level of marine ecosystem model

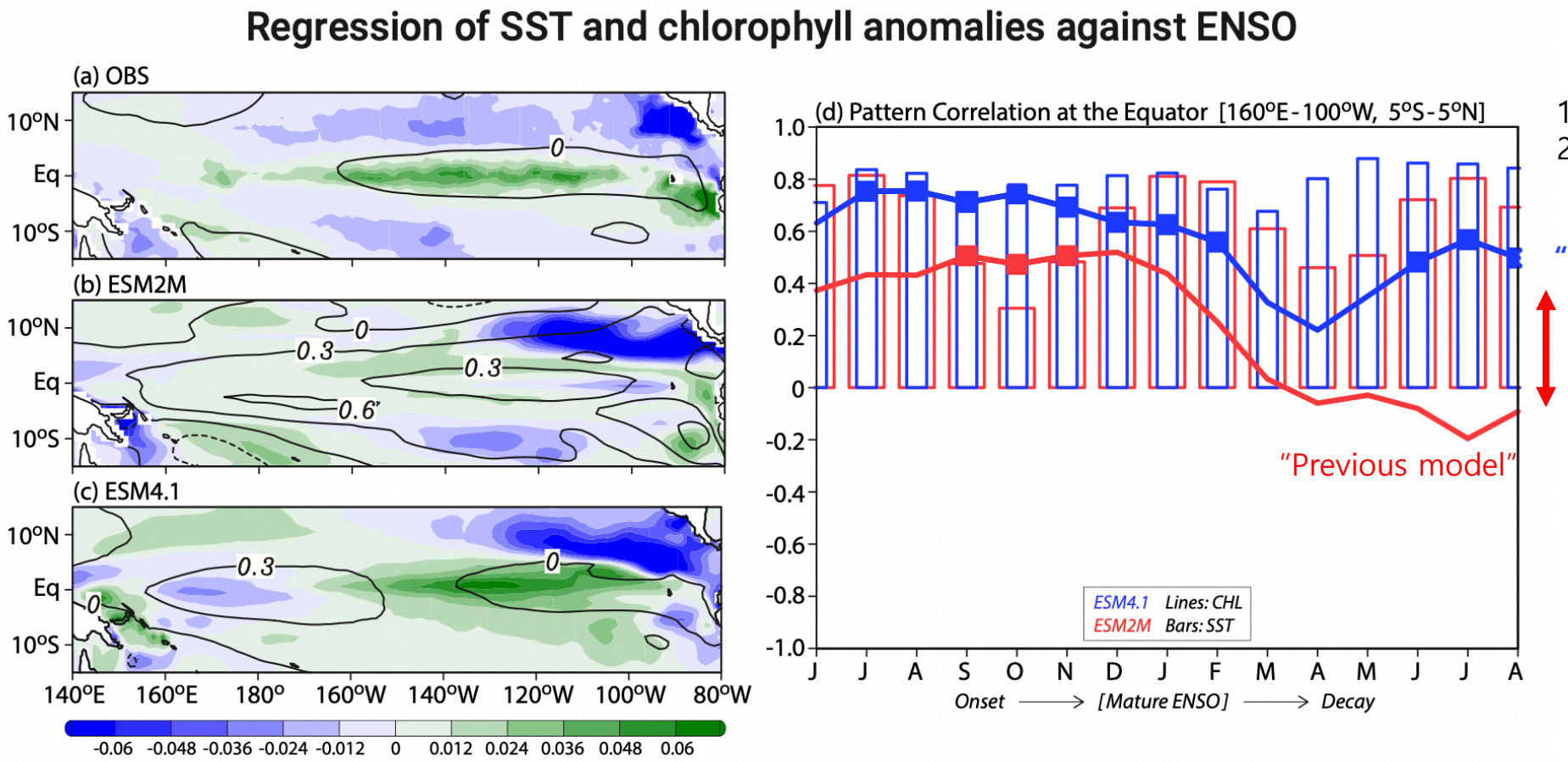


Stock et al 2020

Oceanic physical phenomena

Marine ecosystem

“El Niño – Southern Oscillation” on chlorophyll evolution



1) Oceanic Iron transport*
2) Atmospheric mineral dust

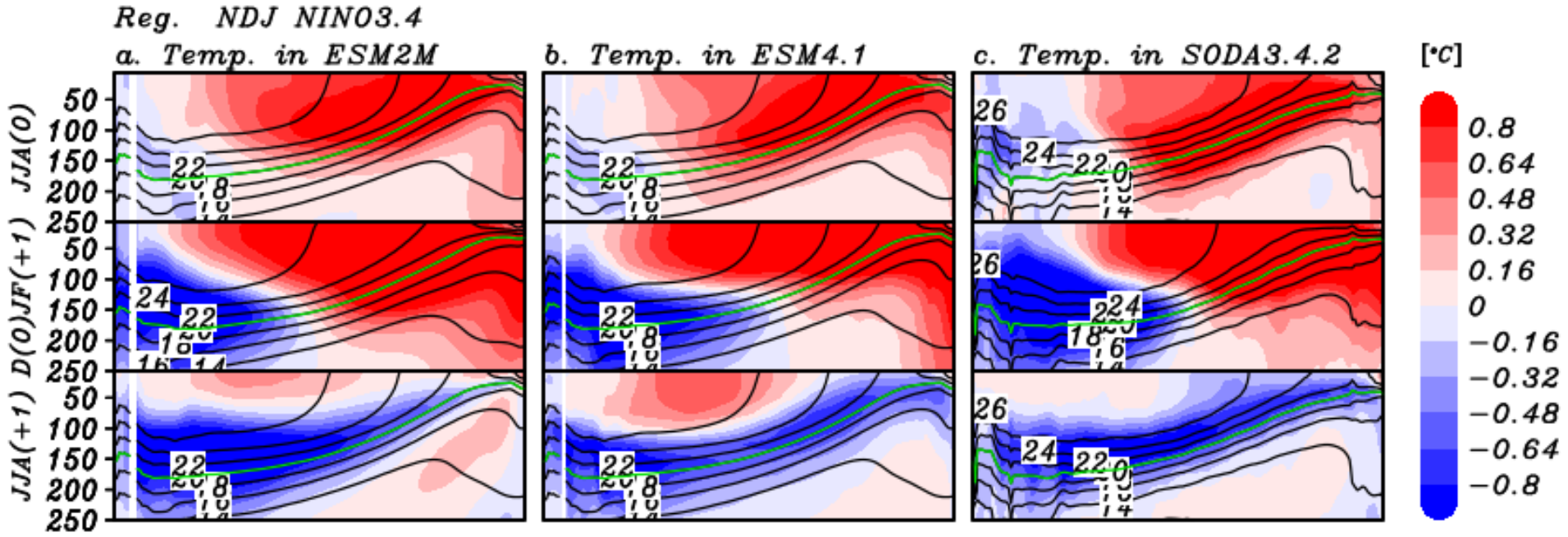
Spatially resolved ENSO-regression of temperature (contours, °C/°C) and chlorophyll concentration (shading, mgm3/°C) anomalies against ENSO in (a) satellite, Simple Ocean Data Assimilation (SODA), (b) ESM2M, and (c) ESM4.1.

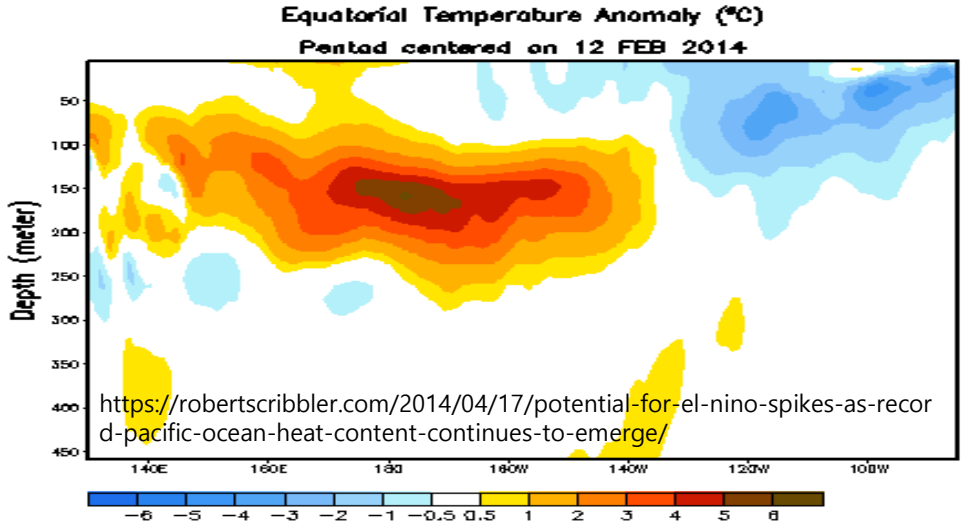
Values are shown for the ENSO decay state one year after the peak (JJA+1); (d) pattern correlations of ESM2M (red) and ESM4.1 (blue) regression coefficients (i.e., panels (b) and (c)) with SODA (bars) and satellite chlorophyll (lines; square symbols denote the Student’s t-test statistical significance at 95% confidence level) regression coefficients (i.e., panel (a)) in the EP (160°E–100°W, 5°N–5°S).

Lim*, Dunne, Stock et al 2022a GRL

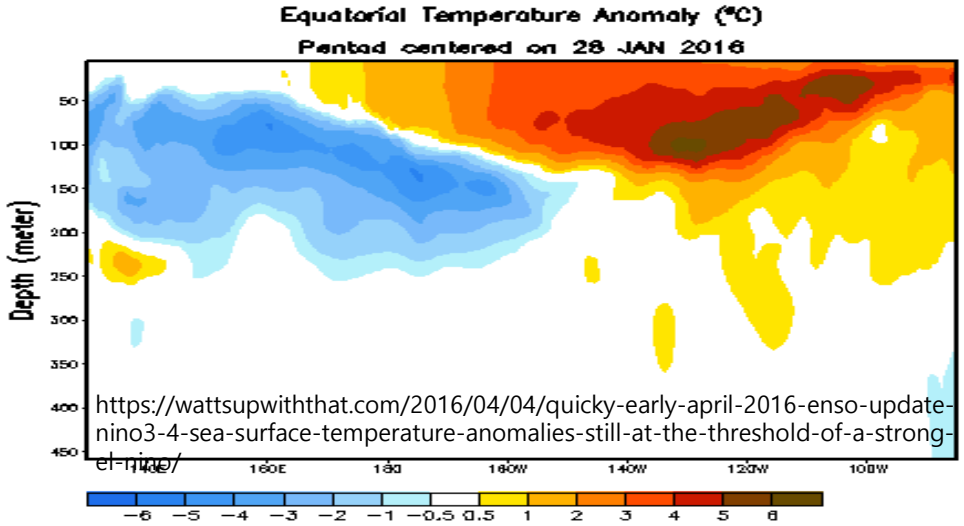
Ocean Driver: Vertical temperature and iron responses at Eq (2oN-2oS)

Temperature





https://robertscribbler.com/2014/04/17/potential-for-el-nino-spikes-as-record-pacific-ocean-heat-content-continues-to-emerge/

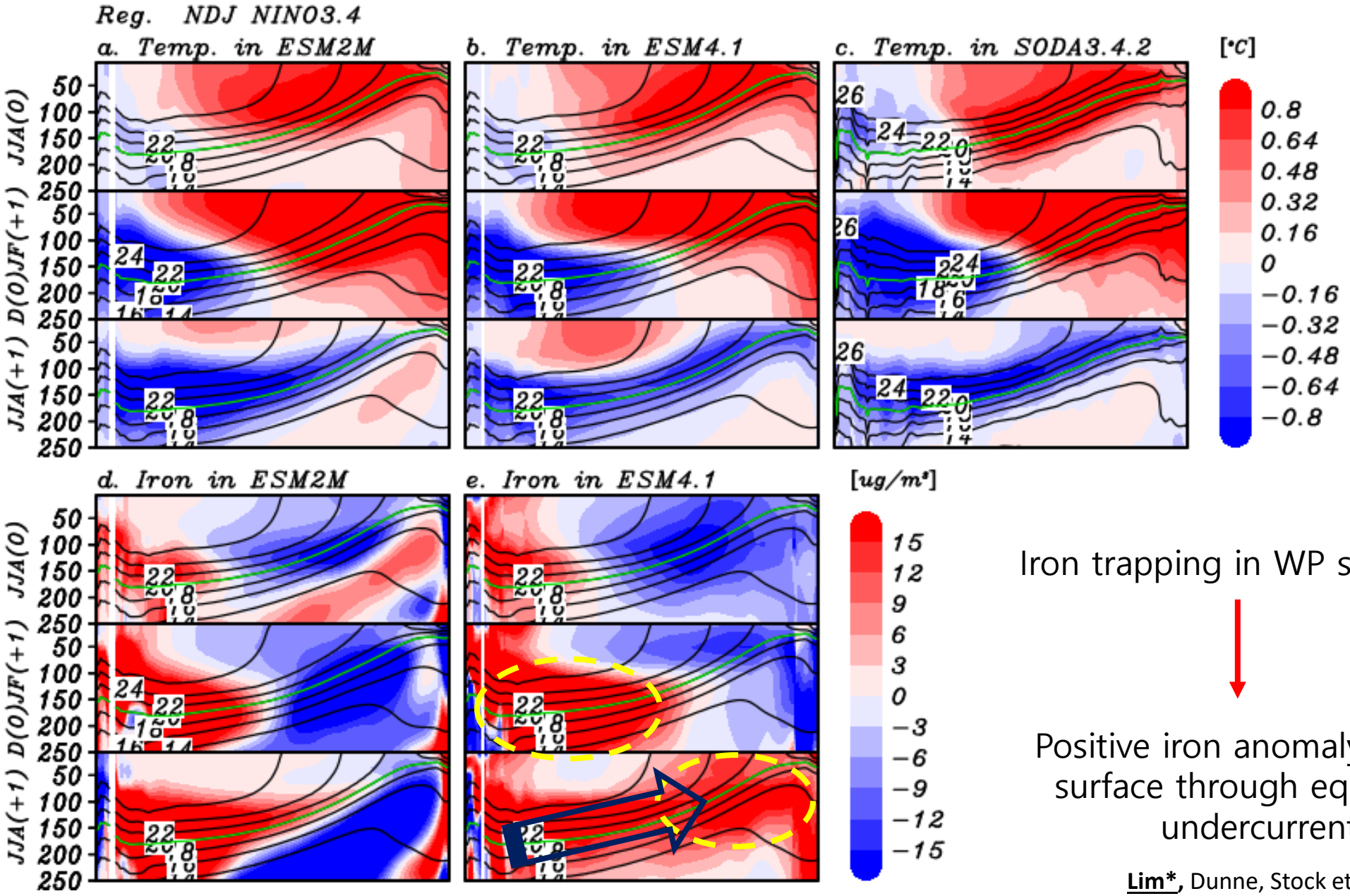


https://wattsupwiththat.com/2016/04/04/quicky-early-april-2016-enso-update-nino3-4-sea-surface-temperature-anomalies-still-at-the-threshold-of-a-strong-el-nino/

Ocean Driver: Vertical temperature and iron responses at Eq (2oN-2oS)

Temperature

Dissolved Iron

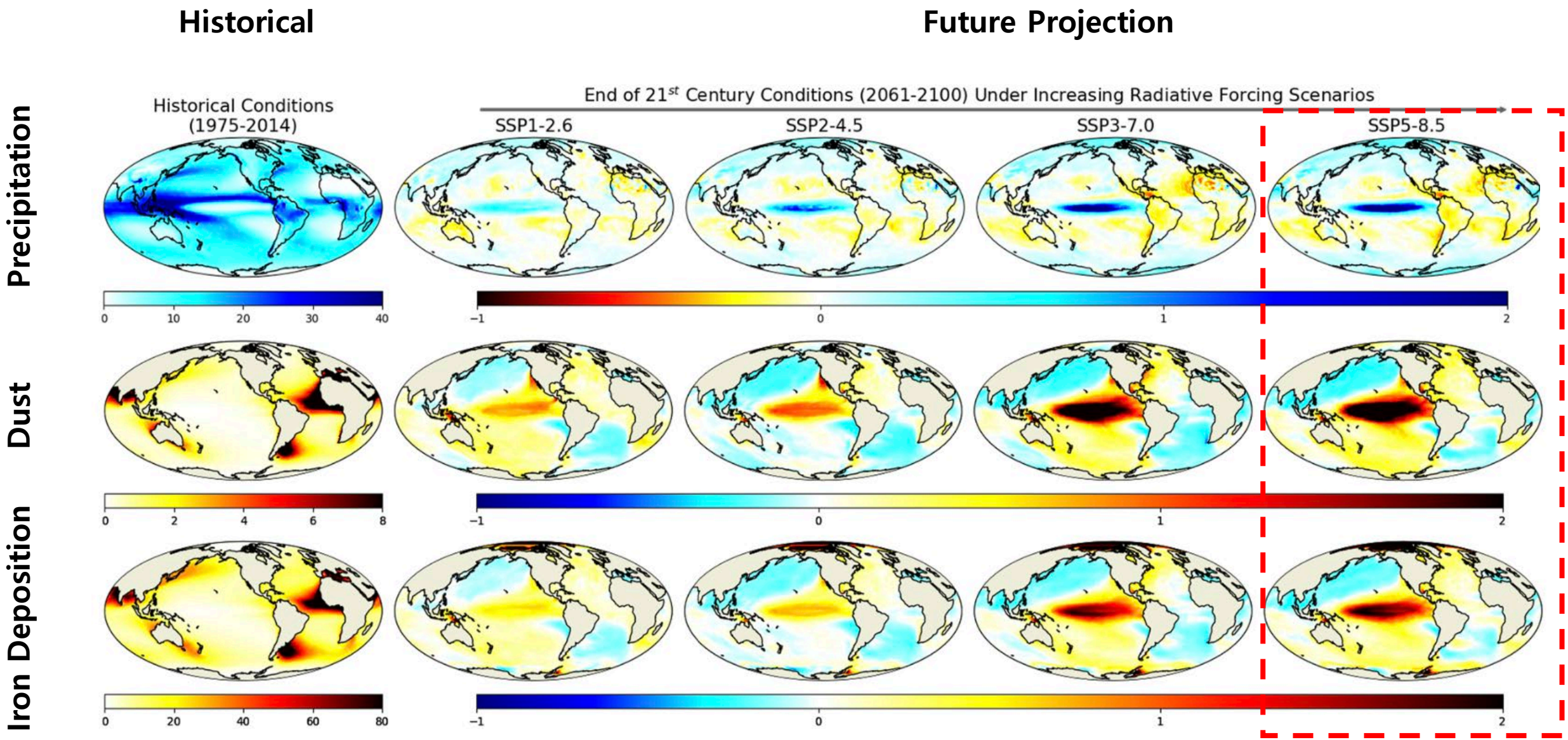


Iron trapping in WP subsurface

Positive iron anomaly into EP surface through equatorial undercurrent

Lim*, Dunne, Stock et al 2022a GRL

Iron-deposition in future projections



Drenkard, John, Stock, **Lim** et al 2023 GRL

“Anthropogenic nitrogen amplifying the Arctic warming”

Human-induced N fertilization in Arctic Ocean

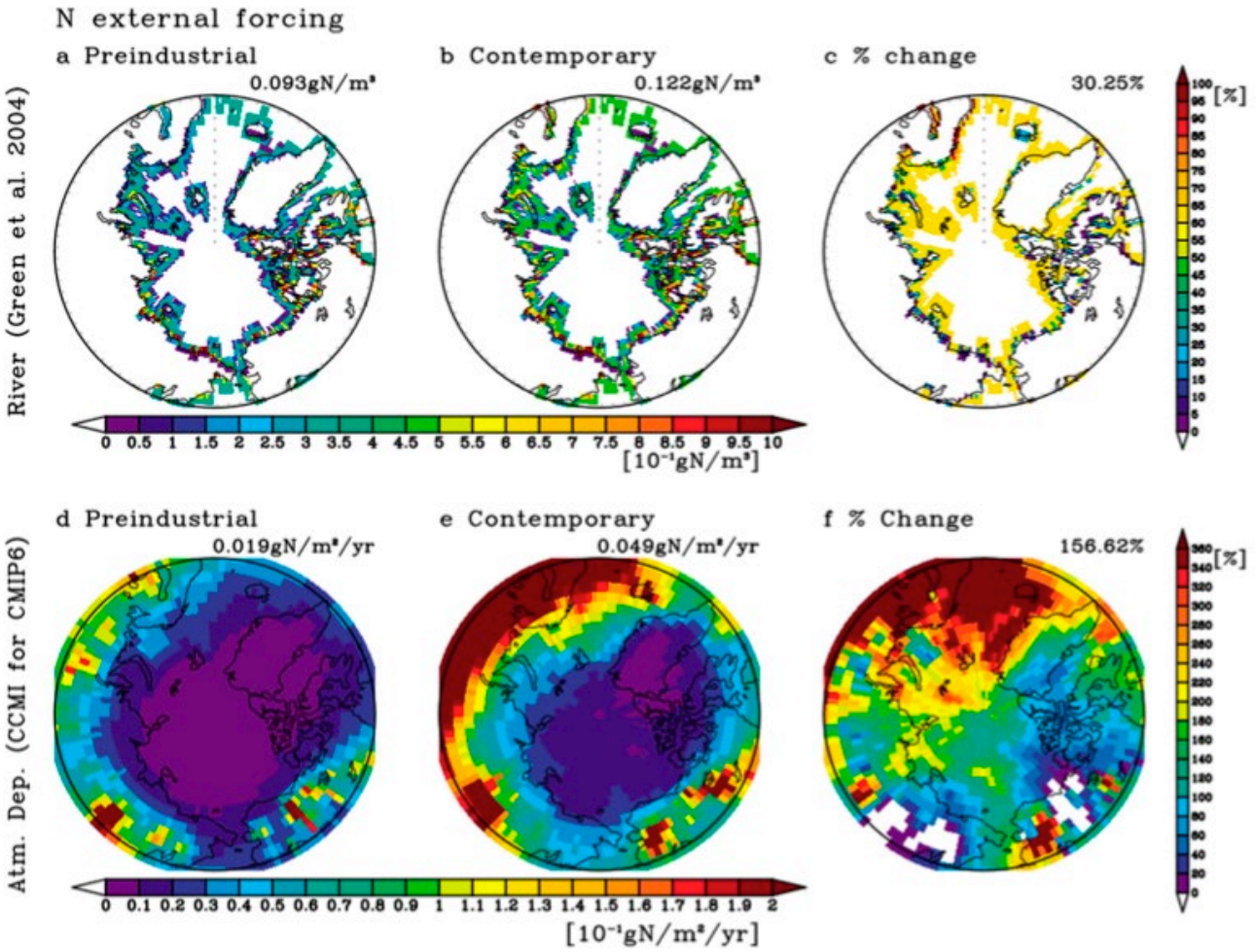


FIG. 1. External forcing N used in present study: (left) preindustrial, (center) contemporary, and (right) percentage change between preindustrial and contemporary amounts through (top) river and (bottom) atmospheric depositions and their quantities averaged for the pan-Arctic (top-right value in each panel).

Experimental Design

	$1xCO_2$	$2xCO_2$ (rising CO_2 1%/yr until doubled)
Preindustrial N (river+deposition)	N_{pi}-$1xCO_2$ “Control”	N_{pi}-$2xCO_2$ “Greenhouse warming”
Anthropogenic N (river+deposition)	N_{1990}-$1xCO_2$ “High N supply”	N_{1990}-$2xCO_2$ “High N supply + Greenhouse warming”

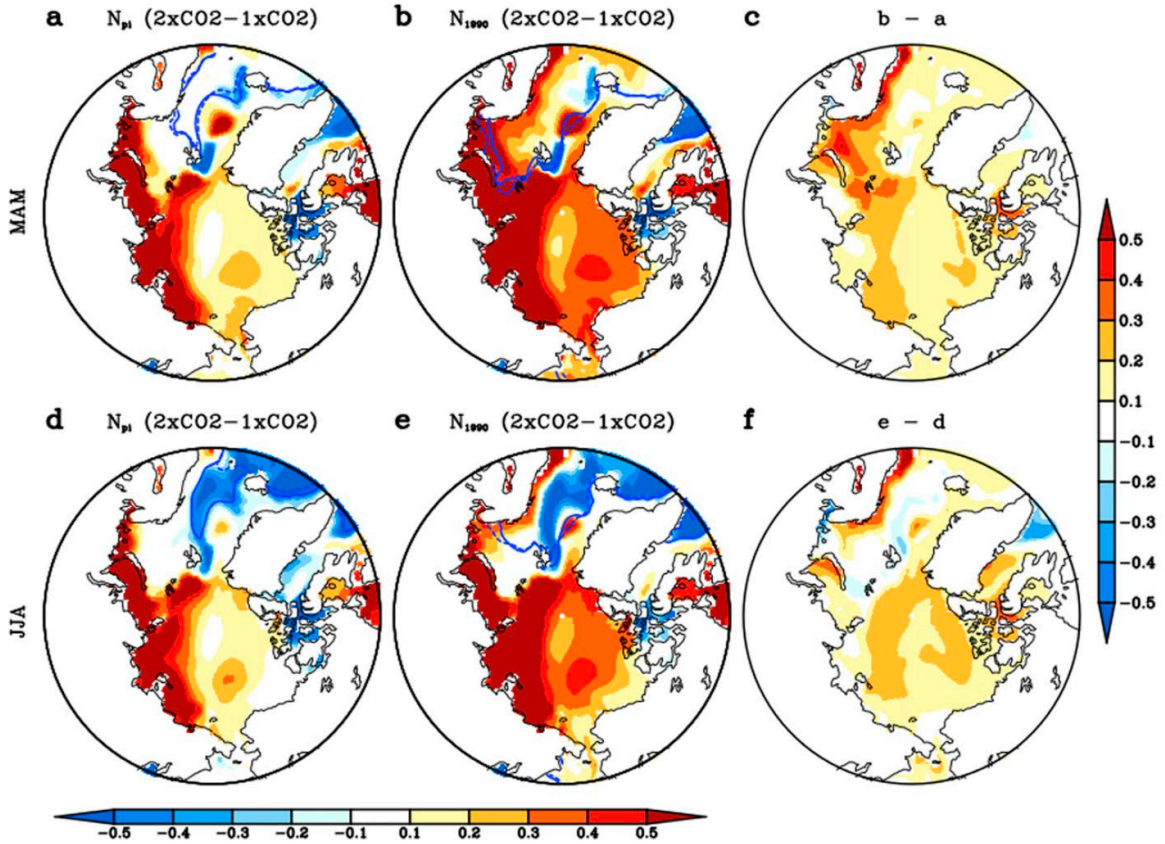
*Impact of anthropogenic N forcing under greenhouse warming

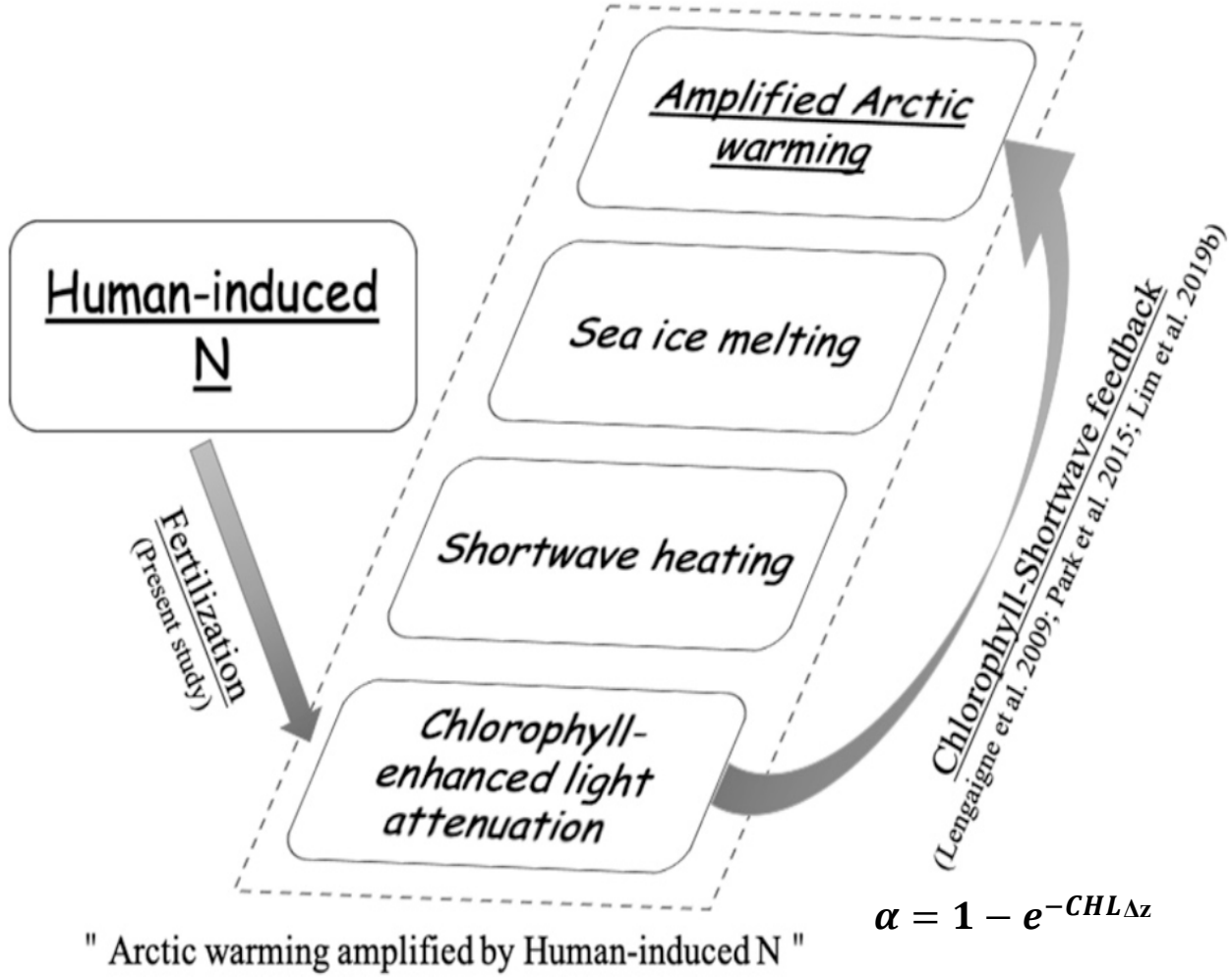
= (N_{1990}-$2xCO_2$ - N_{1990}-$1xCO_2$) - (N_{pi}-$2xCO_2$ - N_{pi}-$1xCO_2$)

Lim, Park, Dunne, Stock et al. 2021 JC

“Anthropogenic nitrogen amplifying the Arctic warming”

Increased N* = $[NO_3] - 16*[PO_4]$





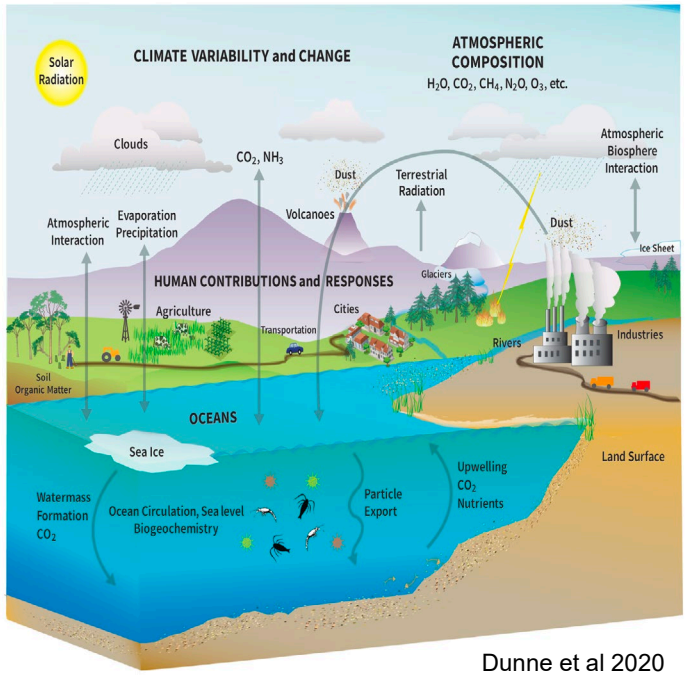
Nitrate Bias correction by human-induced N flux

	N_{pi}-1xCO_2	N_{1990}-1xCO_2	WOA13, GLODAPv2	ESA-CCI-v3	HadISST
SIC (%)	56.1 (−11.8)	56.2 (−11.8)			67.9
SIE (millions of km^2)	8.34 (+0.62)	8.35 (+0.63)			7.72
Nitrate (μmol kg^{-1})	2.95 (−0.52,−0.29)	3.51 (+0.04,+0.27)	3.47, 3.24		
Chlorophyll (mg m^{-3})	0.35 (−0.3)	0.37 (−0.28)		0.65	

Lim, Park, Dunne, Stock et al. 2021 JC

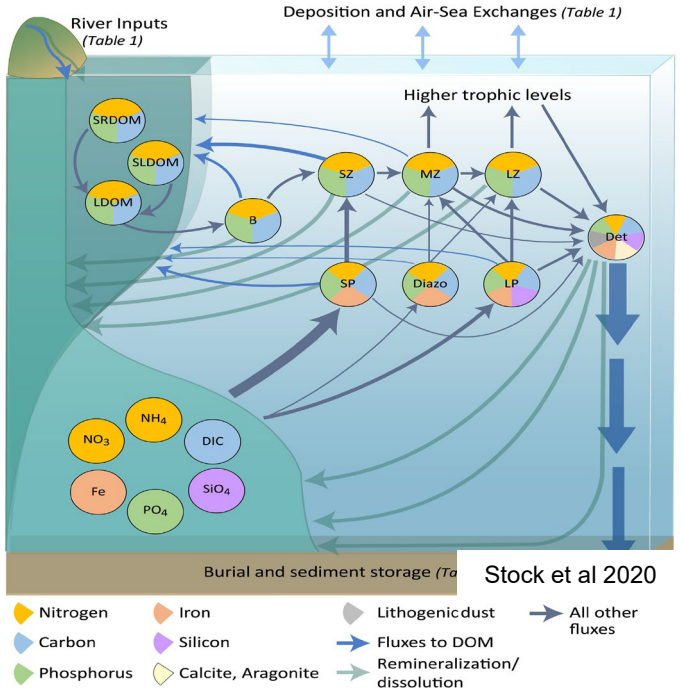
Ecosystem-based fishery management modeling:
Biogeochemistry - lower trophic levels (plankton) -> Higher trophic levels (fisheries)

Earth system model:
general ocean circulation, air-sea interaction, lithogenic nutrient flux



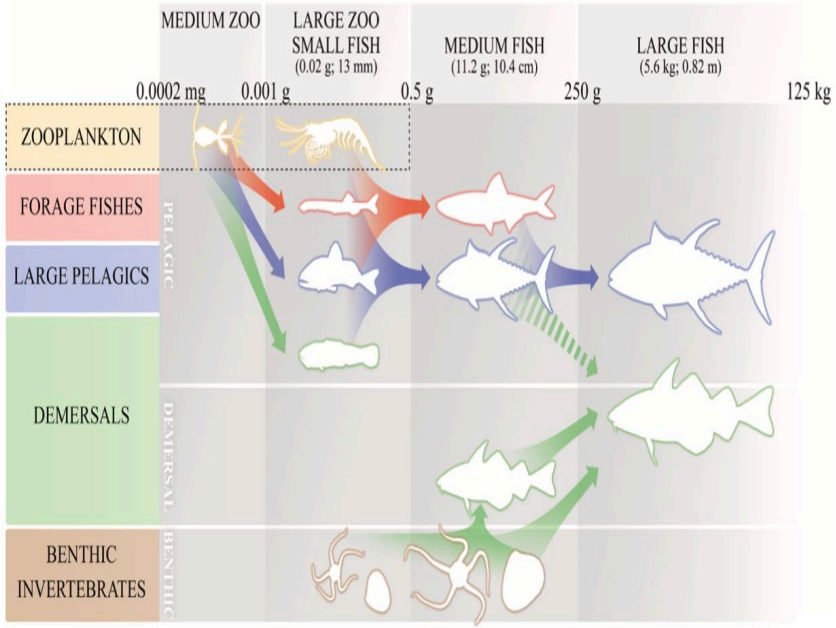
Dunne et al 2020

Biogeochemistry - low trophic level
of marine ecosystem model



Stock et al 2020

High trophic level of marine ecosystem
- FEISTY: forage fishes, pelagics, demersals



Petrik et al 2019

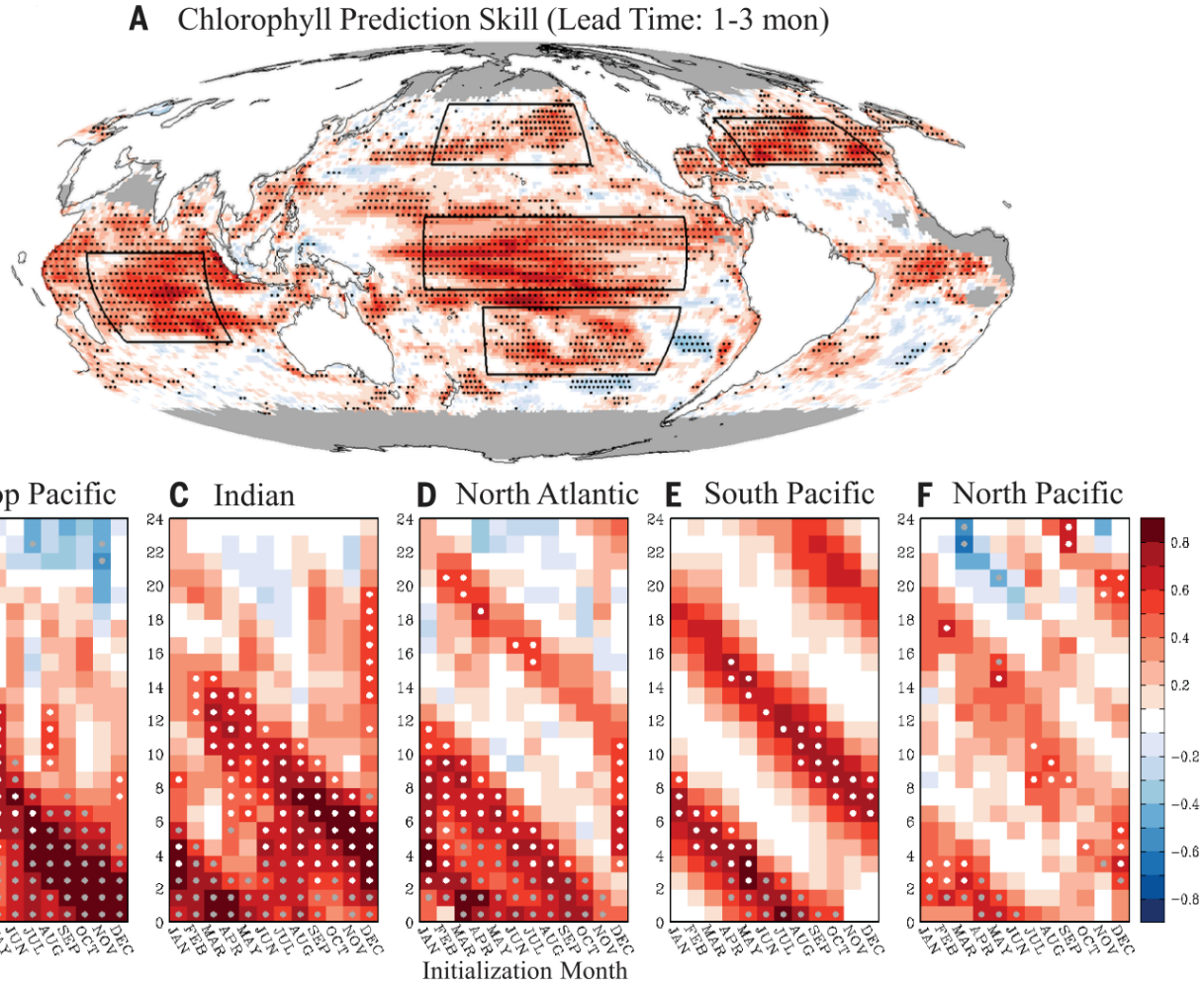
Oceanic physical phenomena

Marine ecosystem

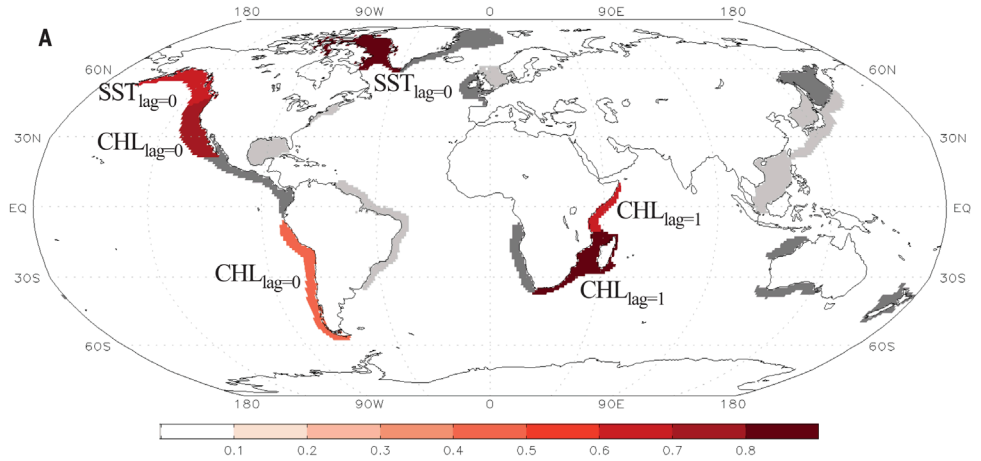
Simulating fisheries and its predictability

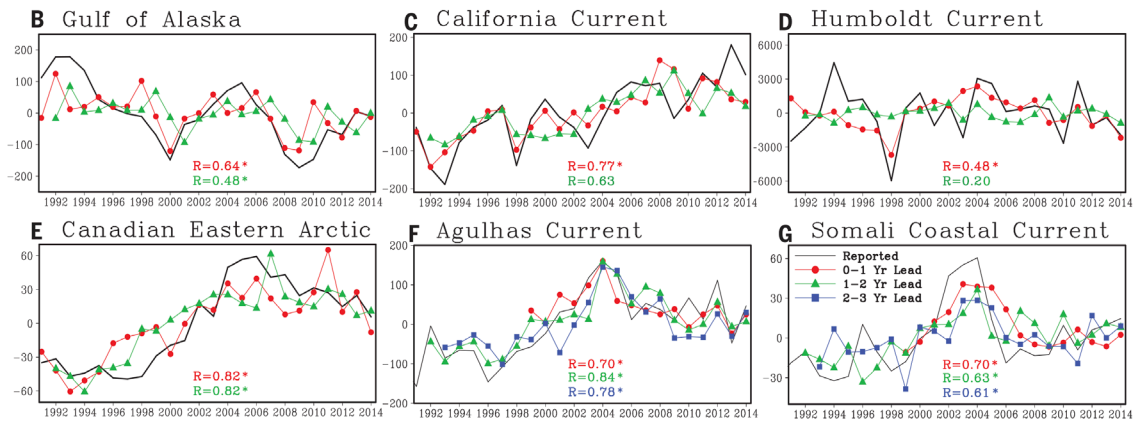
Skillful chlorophyll prediction

*Chlorophyll, pH, Oxygen



Fish catch prediction



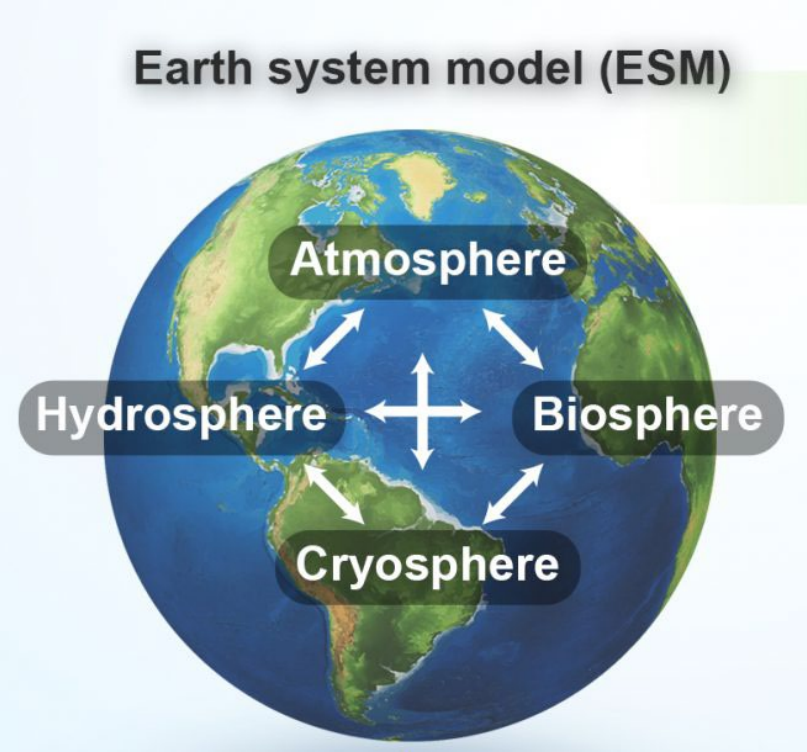


*Comprehensive fully coupled earth system model development to represent marine ecosystem variability

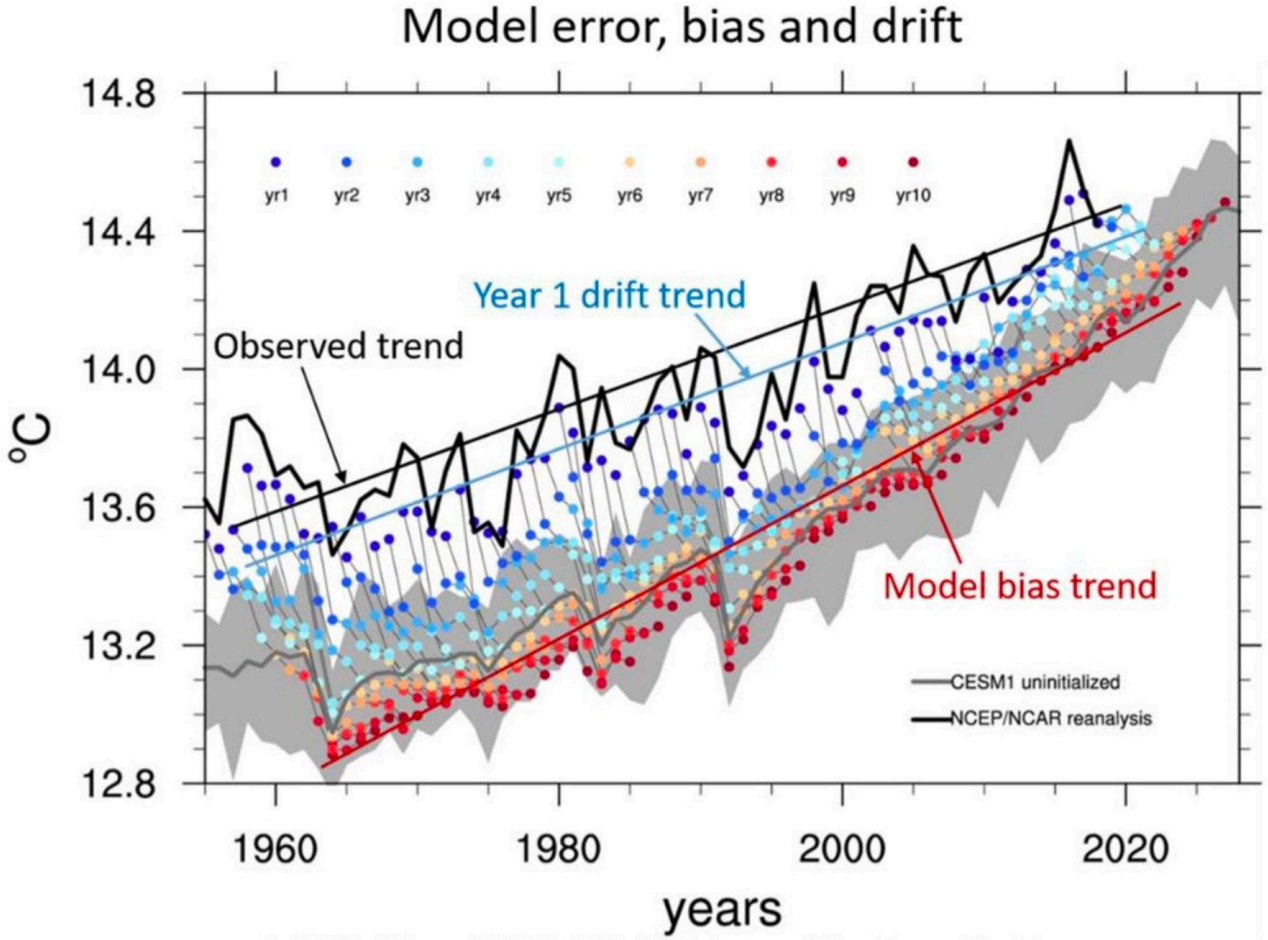
Park, Stock, Dunne et al 2019 Science

How can we predict global environmental bottom-up drivers?

The NCAR CESM Decadal Prediction Large Ensemble (**DPLE**) is a set of simulations for near-term Earth System prediction (Yeager et al 2018).



Initializing the ocean from historical atmospheric state and flux fields "forced ocean sea ice (**FOSI**)"



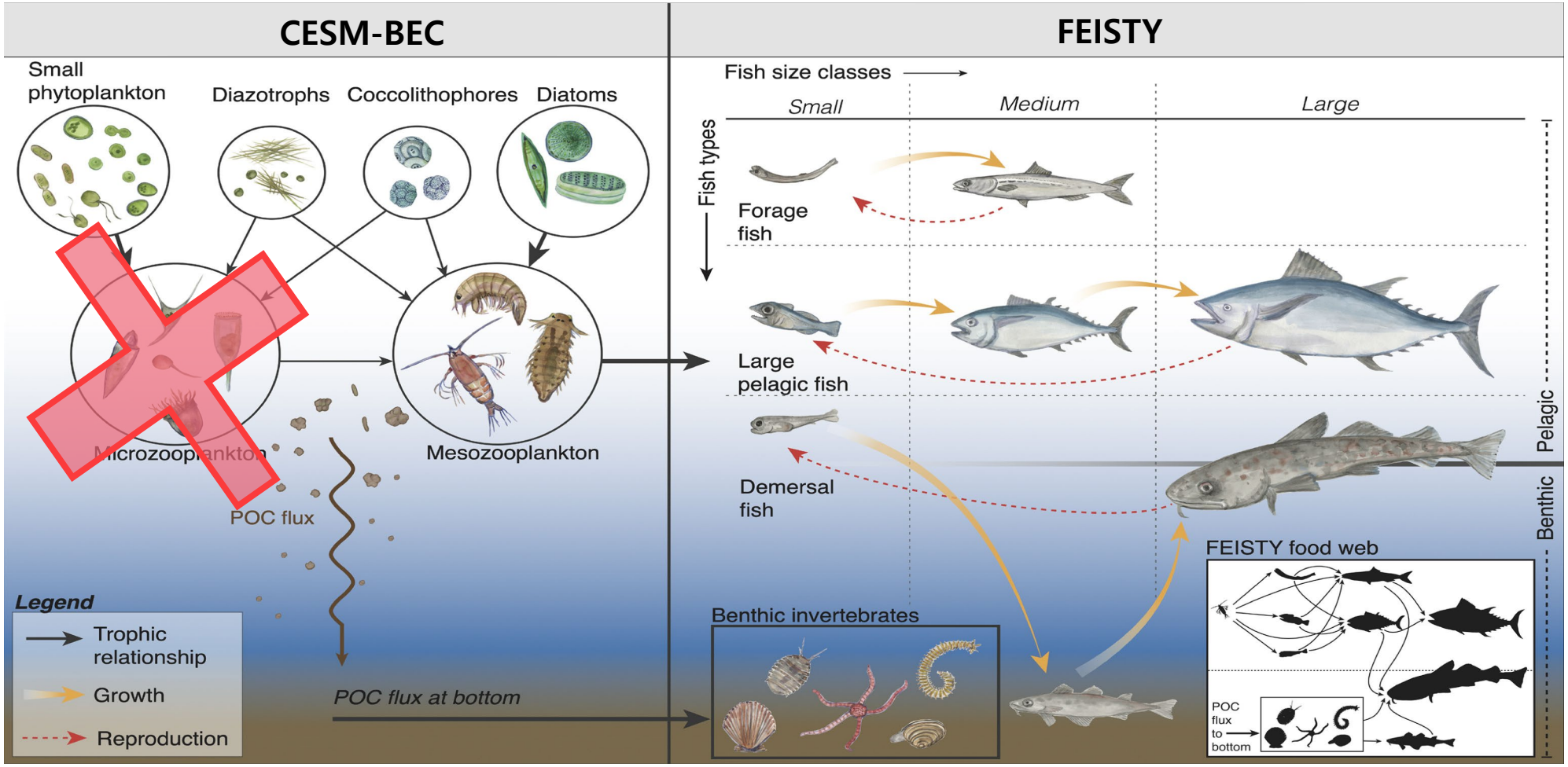
CESM1 LE and DPLE Global Annual Surface Air Temperature

*SST, NPP, Upper Ocean Heat Content are predictable (Yeager et al 2018; Krumhardt et al 2020)

CESM + **FEISTY** (FishErIes Size and functional TYpe model)

CORE,JRA55-do ⟶ FOSI reconstruction
DPLE Decadal Prediction

FOSI-FEISTY reconstruction
DPLE-FEISTY decadal prediction

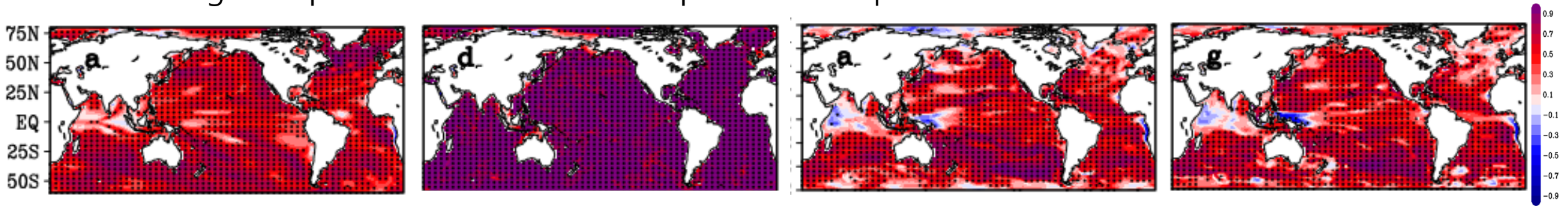


(Krumhardt et al. 2024)

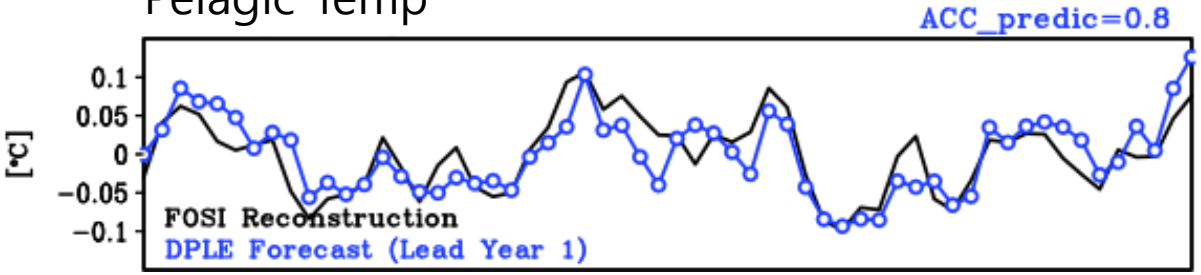
1. bottom-up drivers (ACC_predic, Lead time: 1-3yr)

$$* ACC_predic\ (\tau) = \frac{\sum_{i=1}^{N} F'(\tau) \cdot R'_{i+}}{\sqrt{\sum_{i=1}^{N}\left(F'(\tau)\right)^2} \cdot \sqrt{\sum_{i=1}^{N}(R'_{i+\tau})^2}}$$

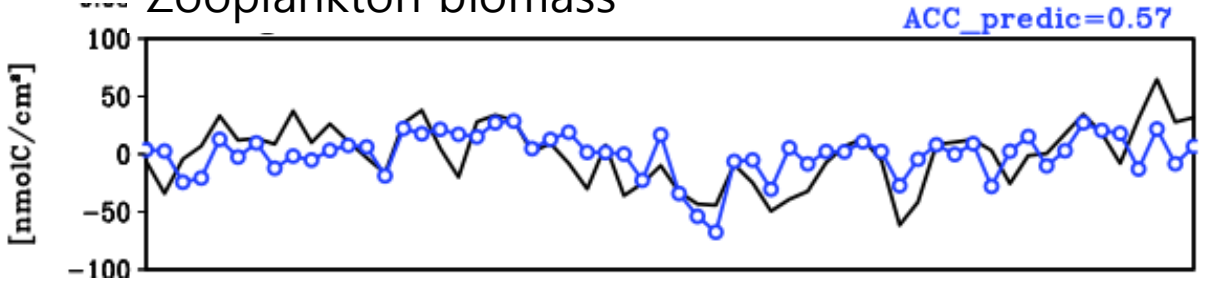
Pelagic temp | Bottom temp | Zooplankton biomass | POC Flux to bottom



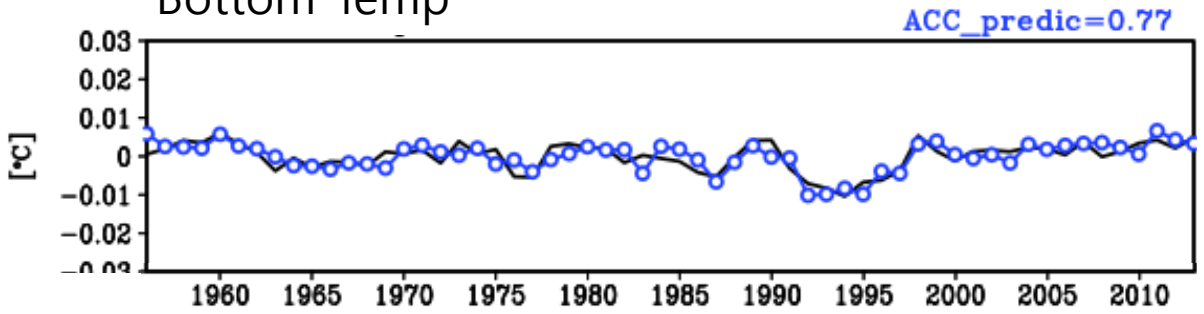
Pelagic Temp



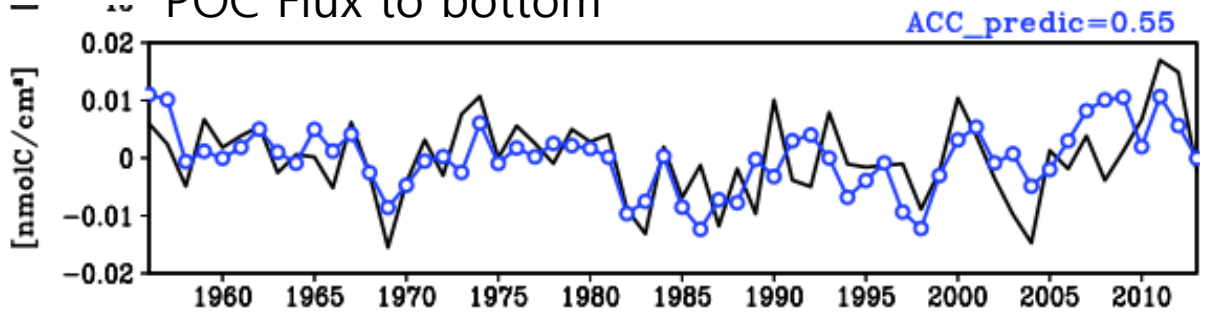
Zooplankton biomass



Bottom Temp



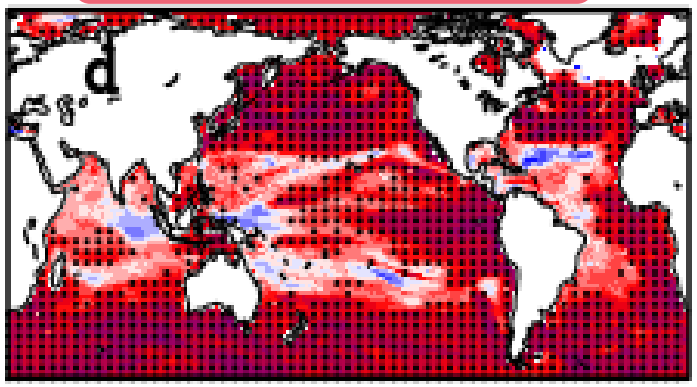
POC Flux to bottom

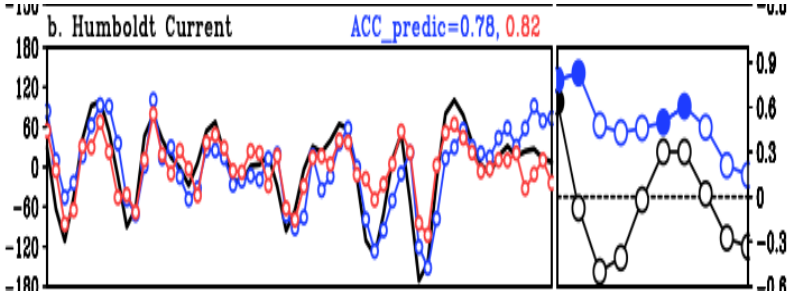


2. Fish biomass (ACC_predic, Lead time: 1-3yr)

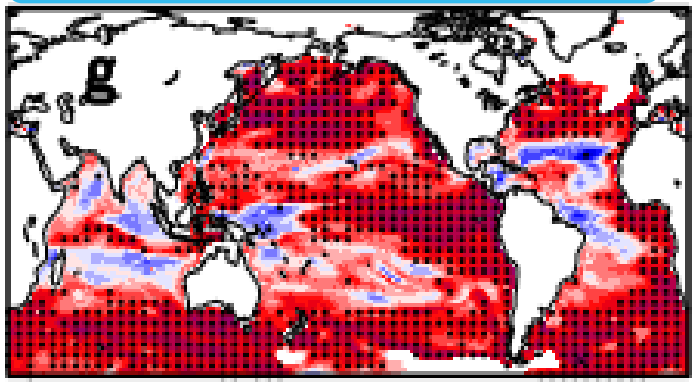
$$* ACC_predic\ (\tau) = \frac{\sum_{i=1}^{N} F'(\tau) \cdot R'_{i+}}{\sqrt{\sum_{i=1}^{N} \left(F'(\tau)\right)^2} \cdot \sqrt{\sum_{i=1}^{N} (R'_{i+\tau})^2}}$$

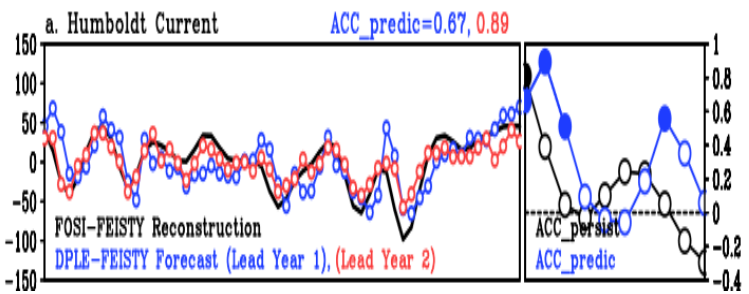
Forage



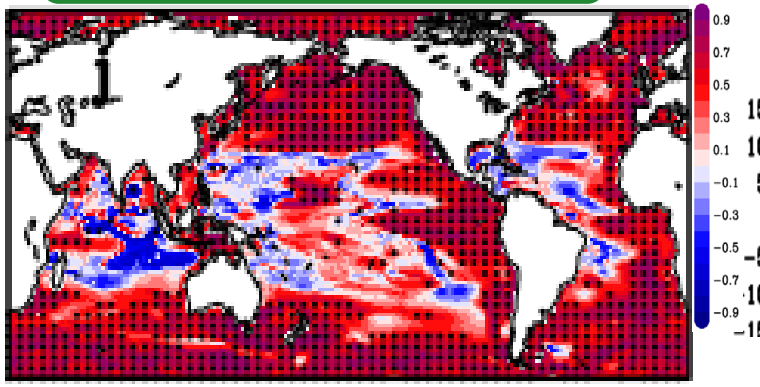


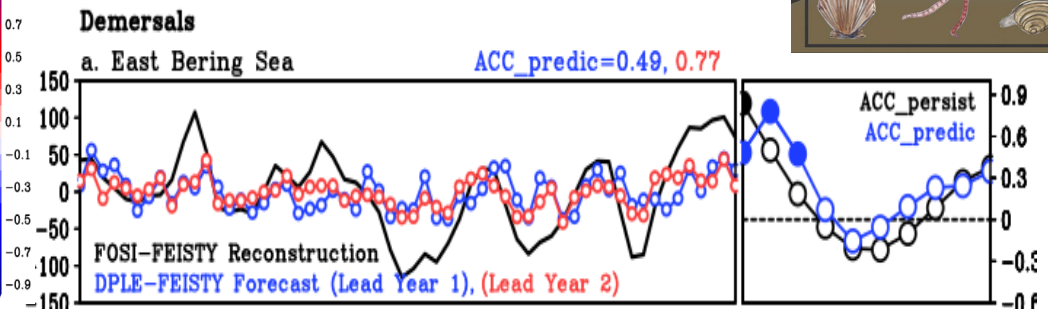
Large Pelagic

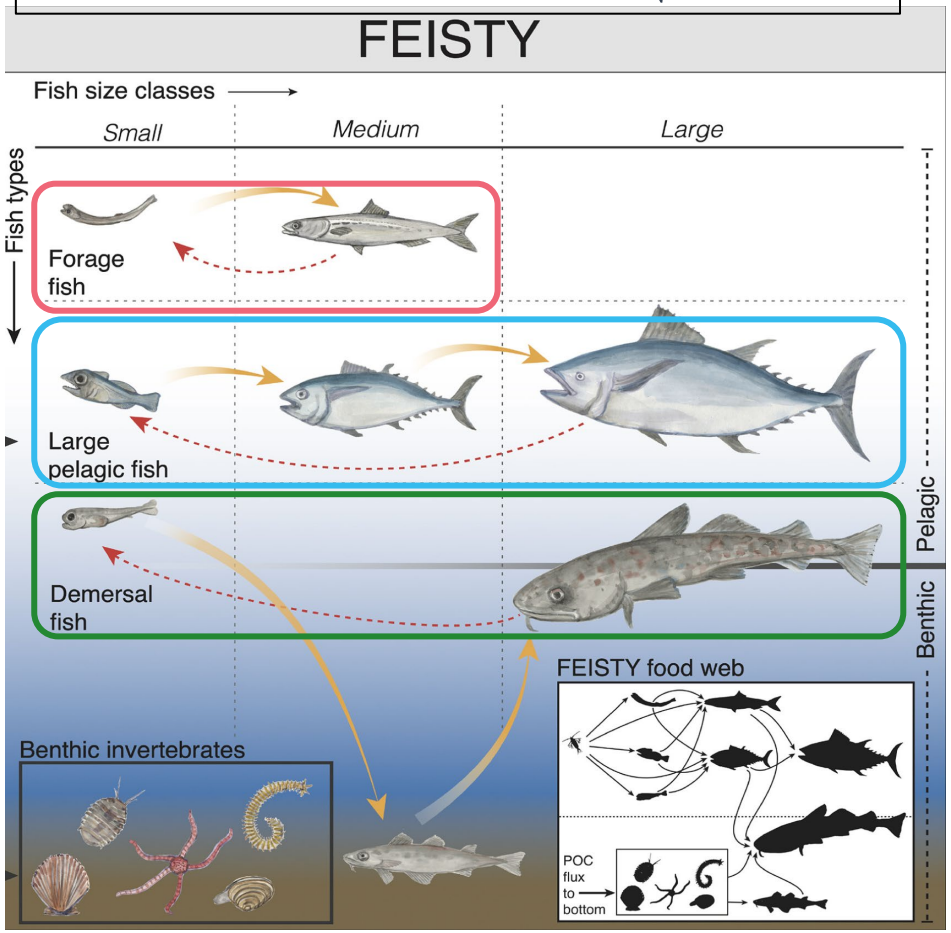




Demersal



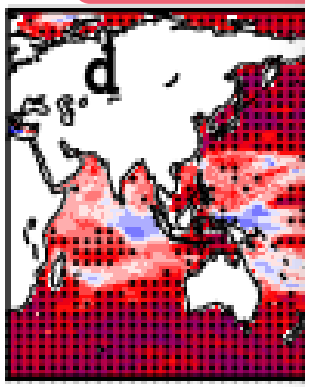


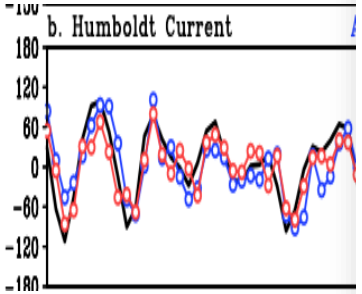


2. Fish biomass (ACC_predic, Lead time: 1-3yr)

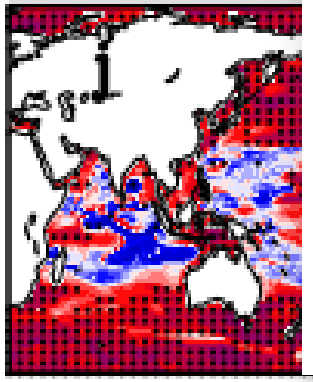
$$* ACC_predic\ (\tau) = \frac{\sum_{i=1}^{N} F'(\tau) \cdot R'_{i+}}{\sqrt{\sum_{i=1}^{N} \left(F'(\tau)\right)^2} \cdot \sqrt{\sum_{i=1}^{N} (R'_{i+\tau})^2}}$$

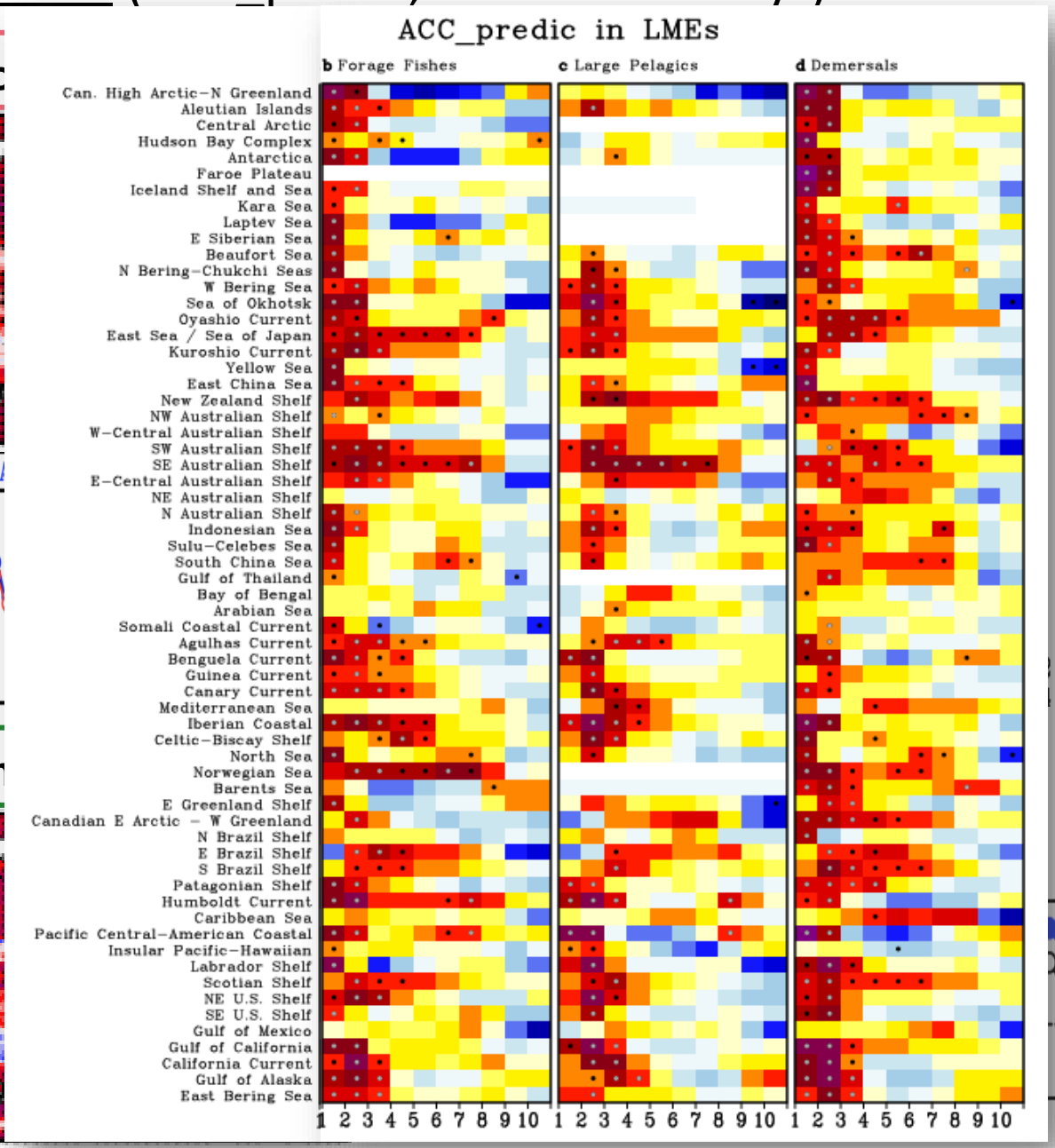
Fo

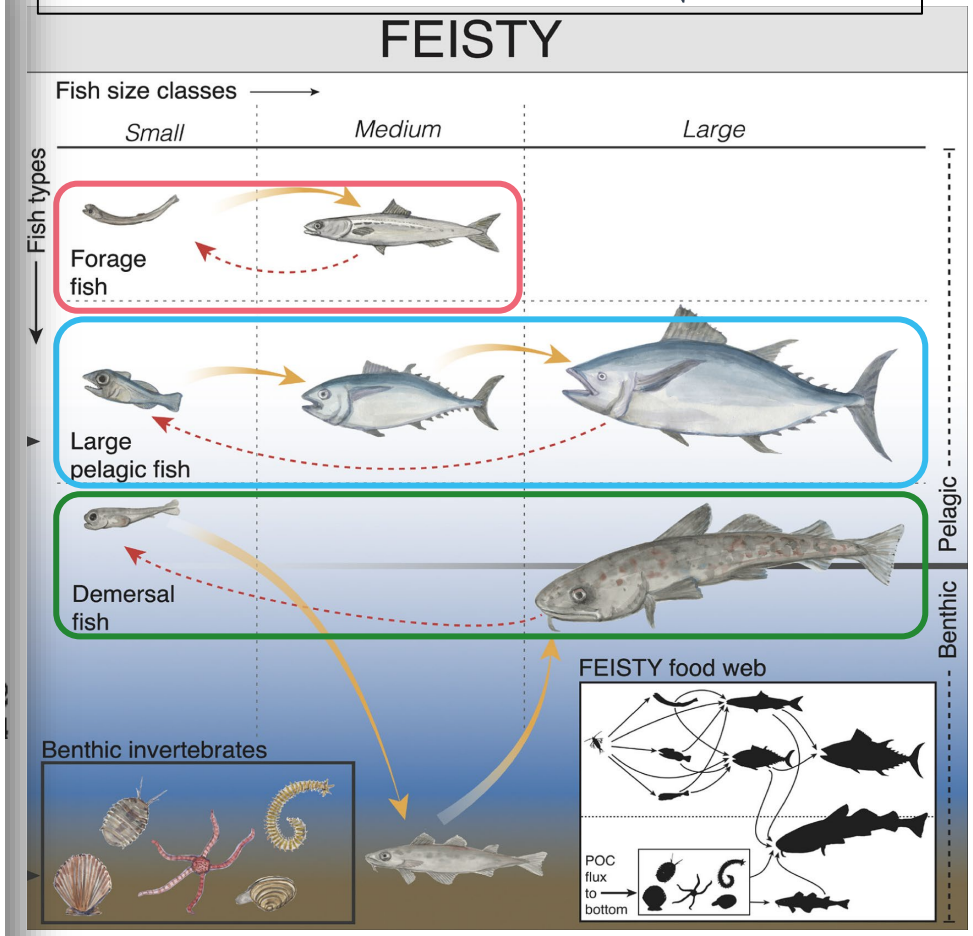


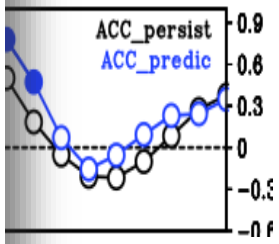


Der



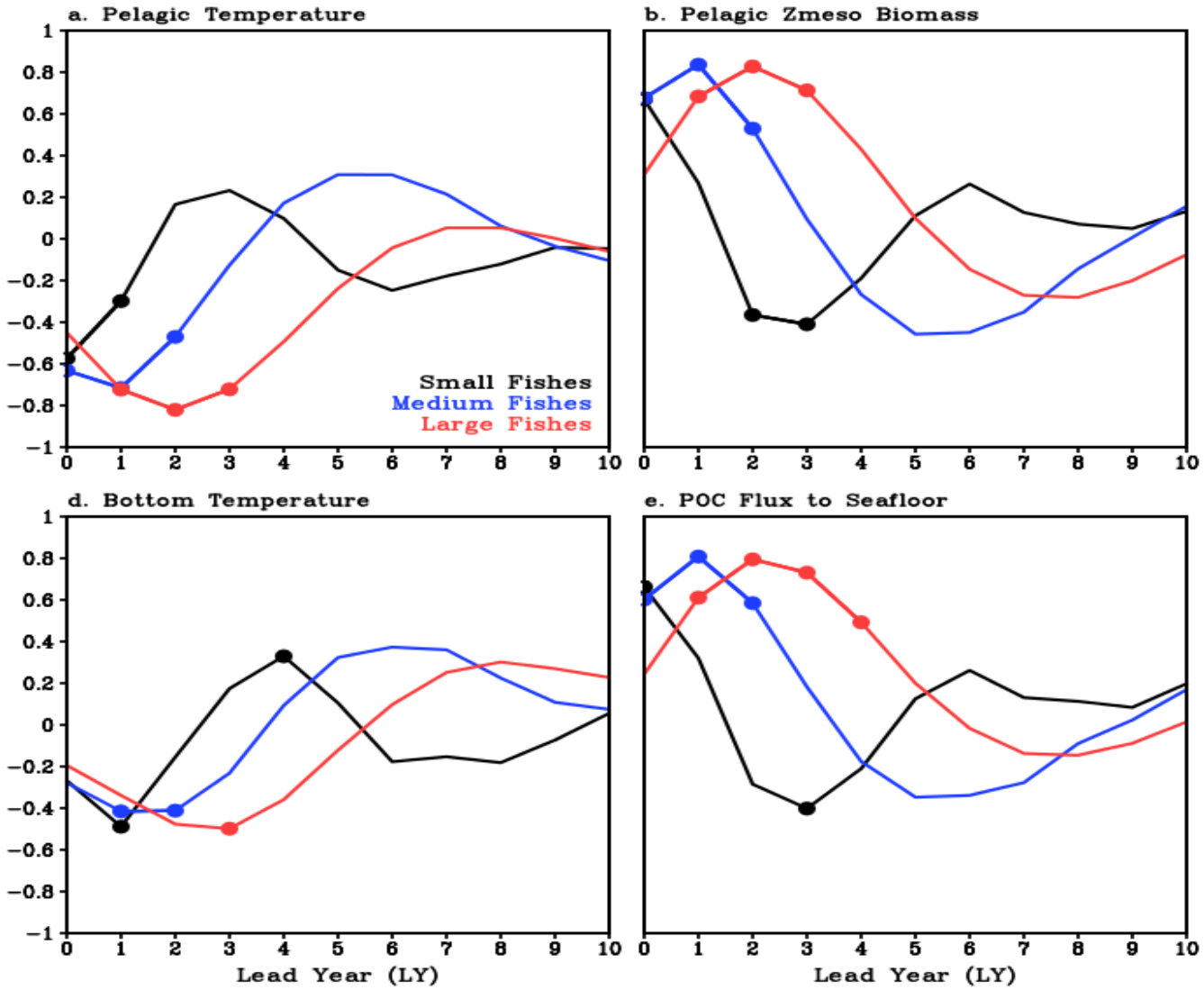


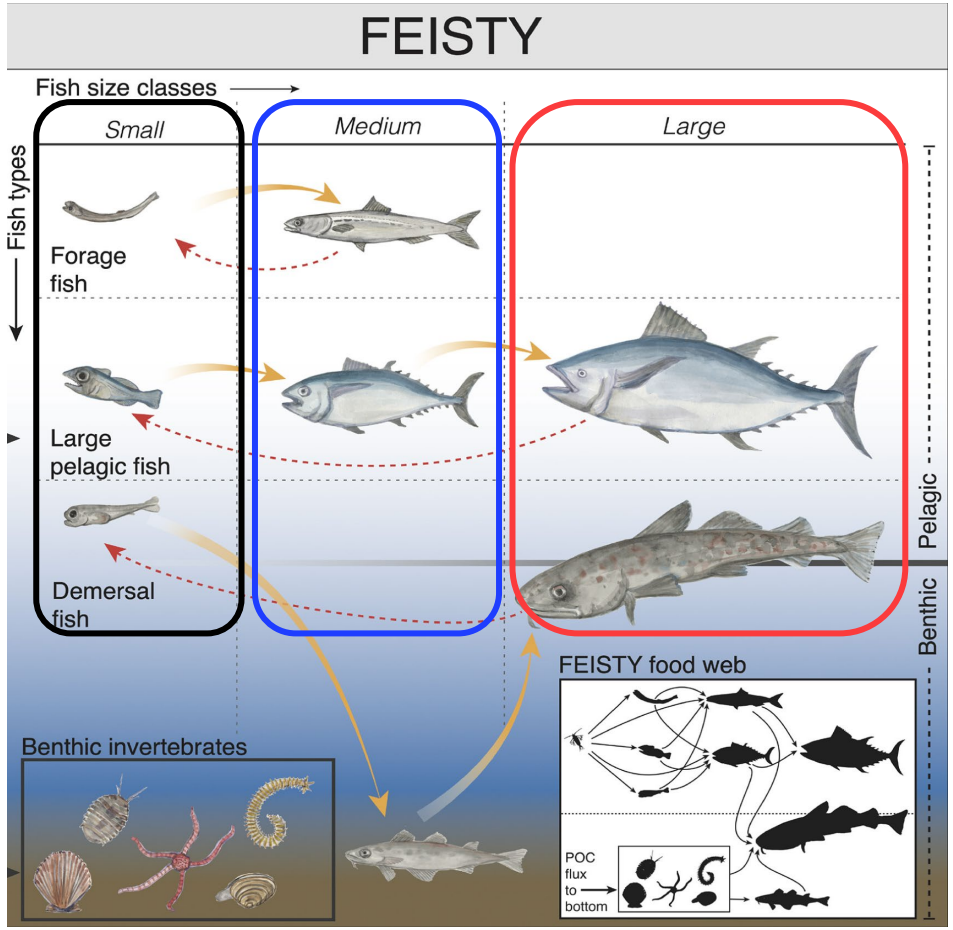




3. Source of Predictability (Size Classes)

1) delayed bottom-up impact





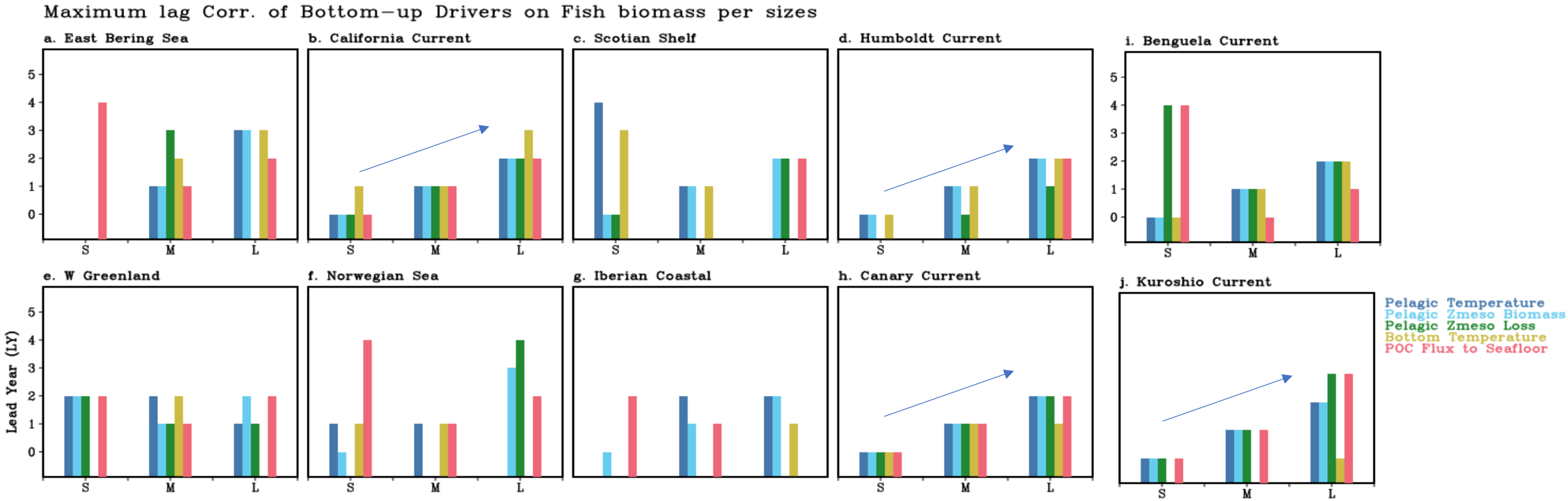
3. Source of Predictability (Multiple Linear Regression model)

1) Bottom-up drivers

2) Autocorrelation of fish biomass

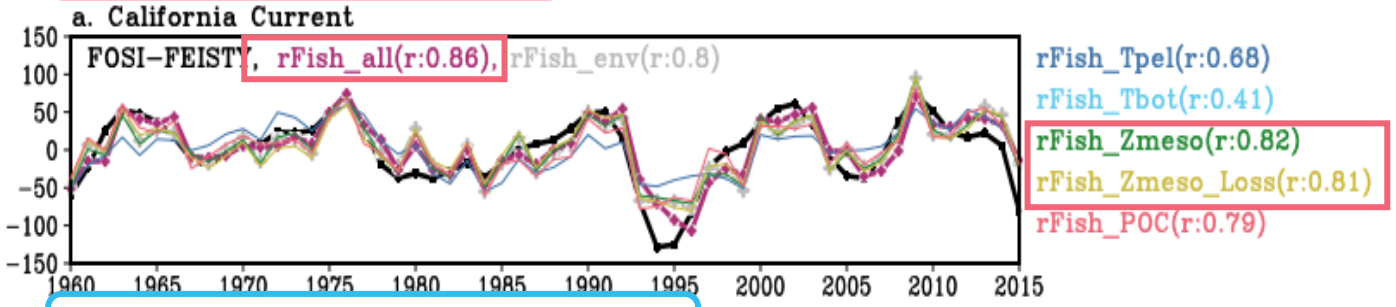
*τ: *Maximum Lag Correlation* (yr)

$$Fish_all'_t = \beta_1 \cdot Tpel'_\tau + \beta_2 \cdot Tbot'_\tau + \beta_3 \cdot POC'_\tau + \beta_4 \cdot Zmeso'_\tau + \beta_5 \cdot Zmeso_loss_\tau{}' + \beta_6 \cdot Fish'_{t-1}$$

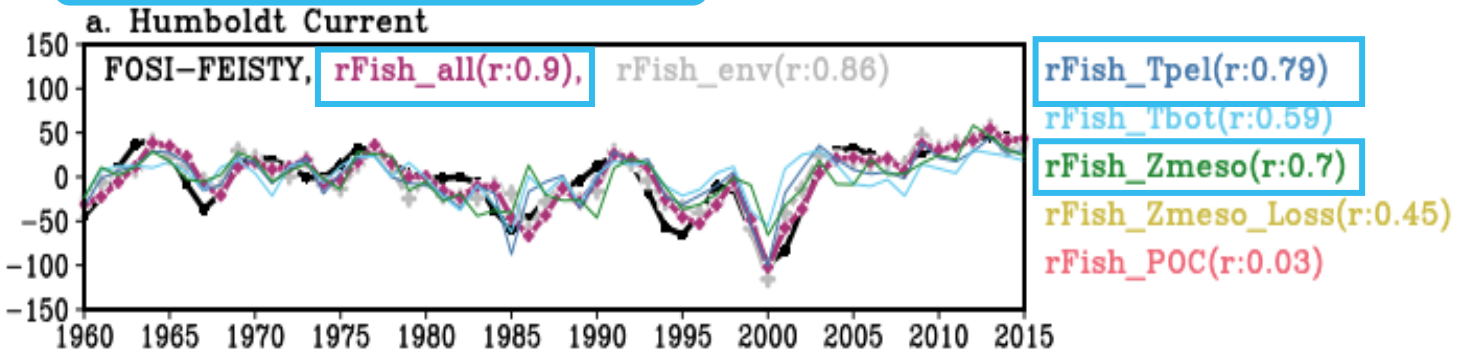


3. Source of Predictability (Multiple Linear Regression model)

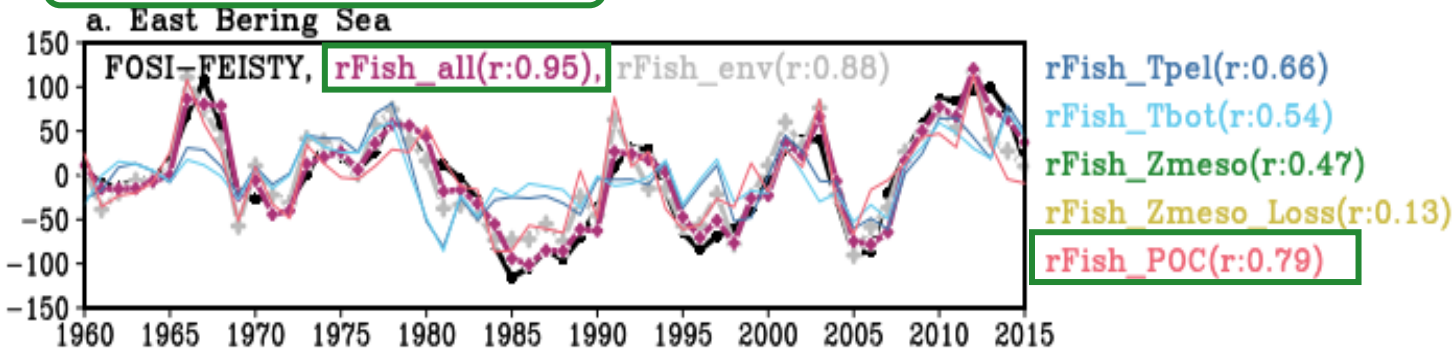
Forage

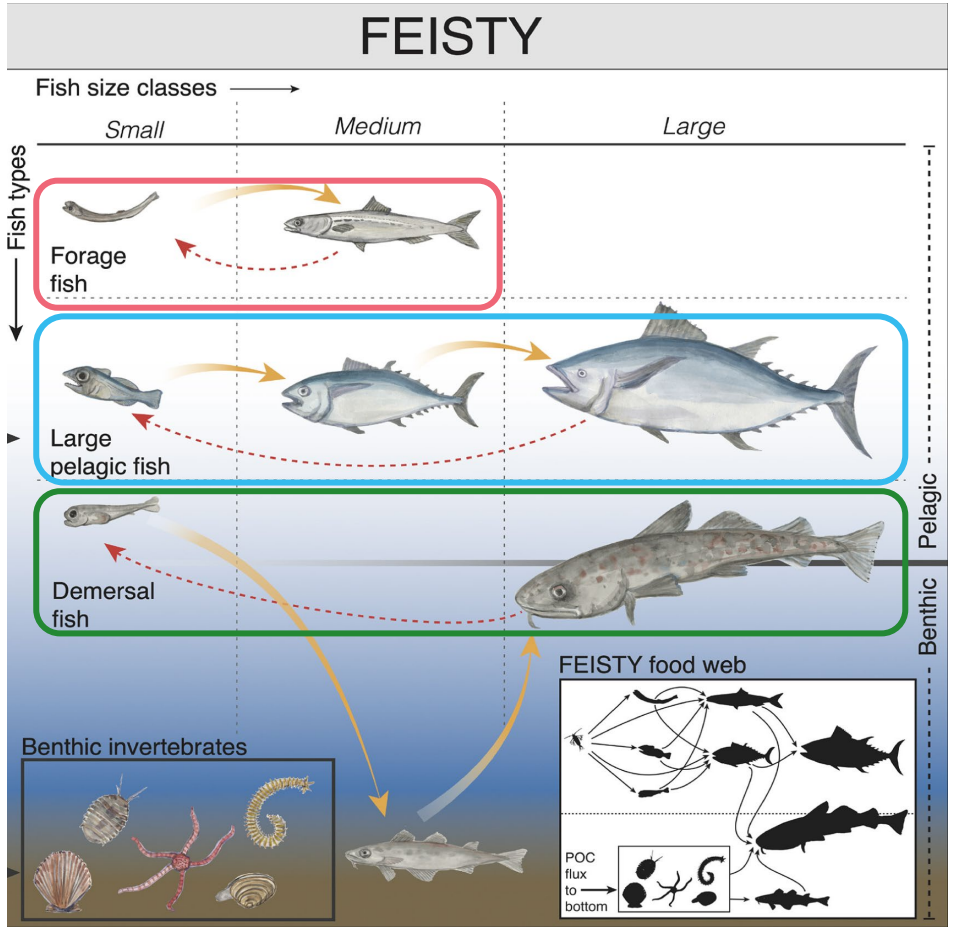


Large Pelagic

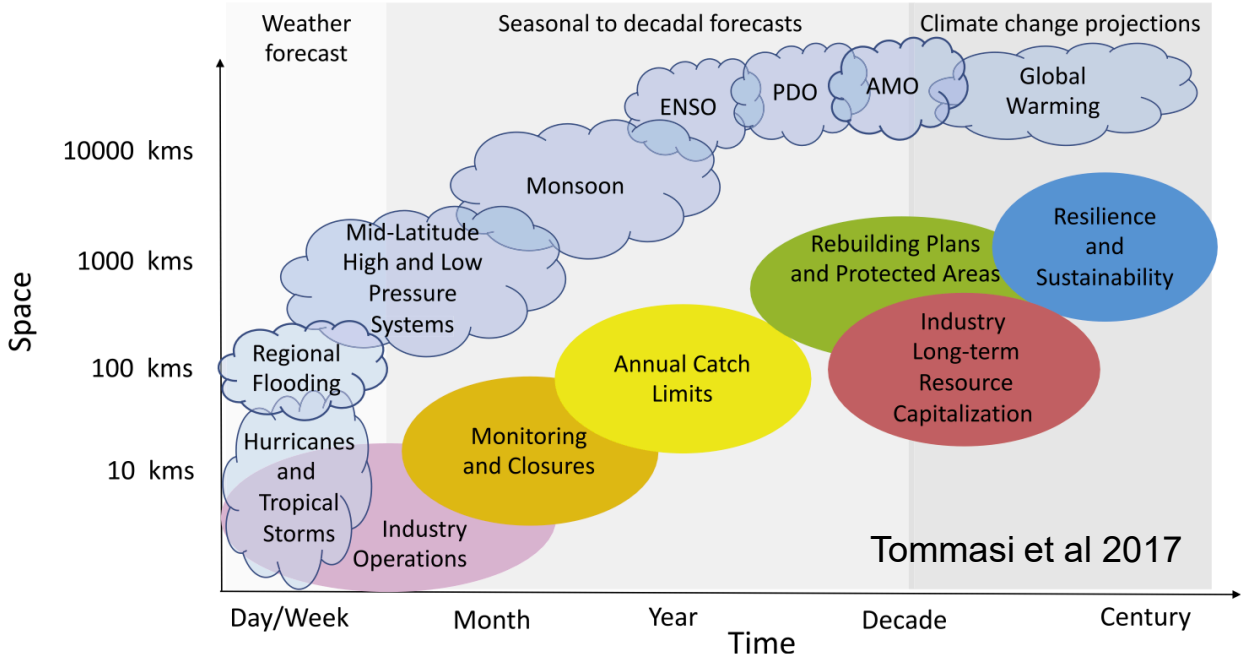


Demersal





Conclusion



Understanding multiscale oceanic and atmospheric drivers on marine ecosystem

↓ ↑

Forecasting marine living resources

Thank you

hglim01@jnu.ac.kr

Iron limitation in Tropical Pacific

Observation

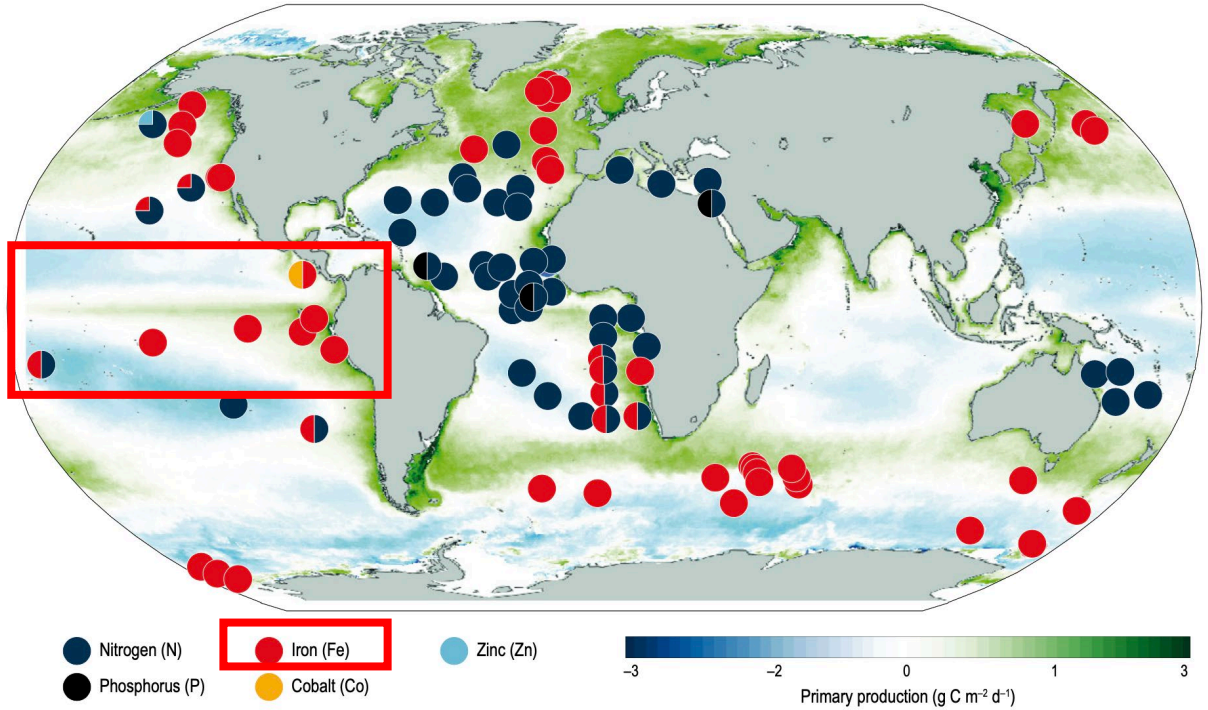
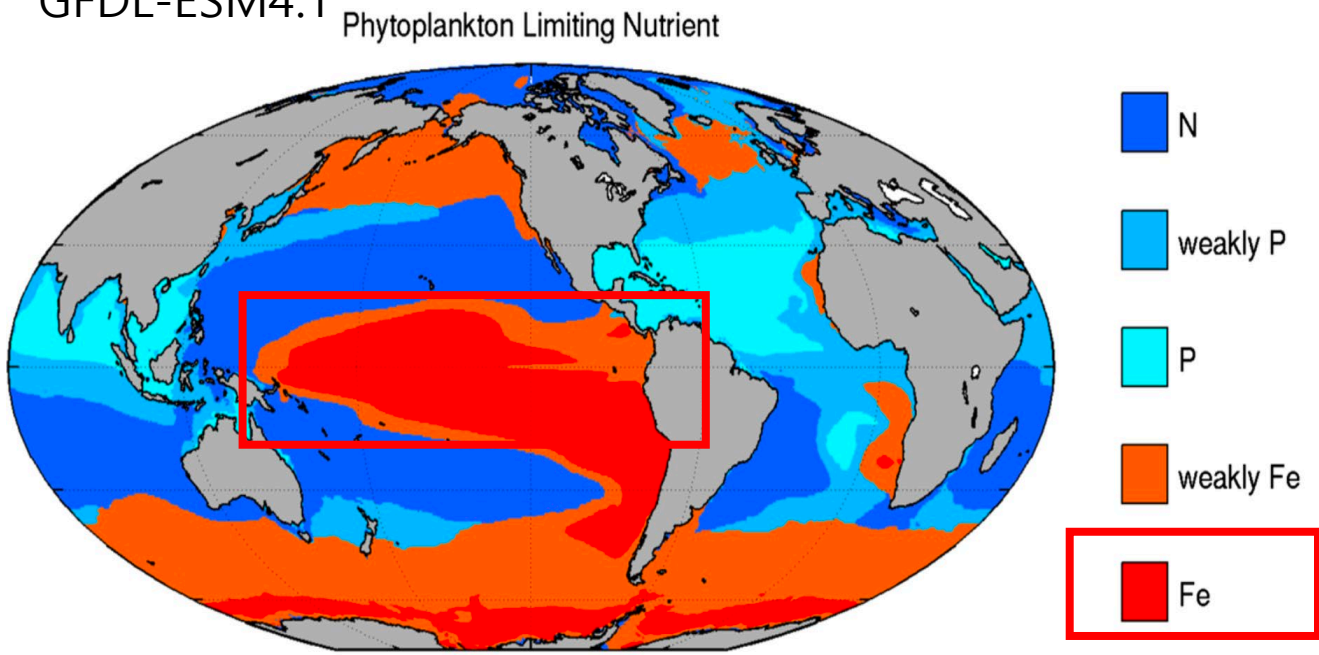


Figure 5.11 | Map of the dominant limiting resource (Moore et al. 2013), updated to include new experiments from the north Pacific, tropical Atlantic and south east Atlantic (Browning et al. 2017; Shilova et al. 2017). The background is depth integrated primary productivity using the Vertically Generalized Production Model algorithm. Colouring of the circles indicates the primary limiting nutrients inferred from chlorophyll and/or primary productivity increases following artificial amendment of: N (blue), P (black), Fe (red), Co (yellow) and Zn (cyan). Divided circles indicate potentially co-limiting nutrients, for example, a red-blue divided circle indicates Fe-N co-limitation.

Changing Ocean, Marine Ecosystems, and Dependent Com munities (IPCC Special Report on the Ocean and Cryos phere in a Changing Climate Ch.5.)

GFDL-ESM4.1



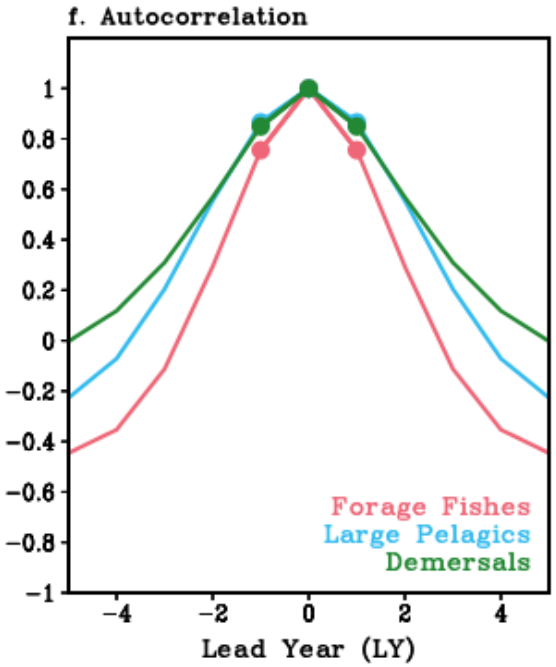
Stock et al. 2020

3. Source of Predictability

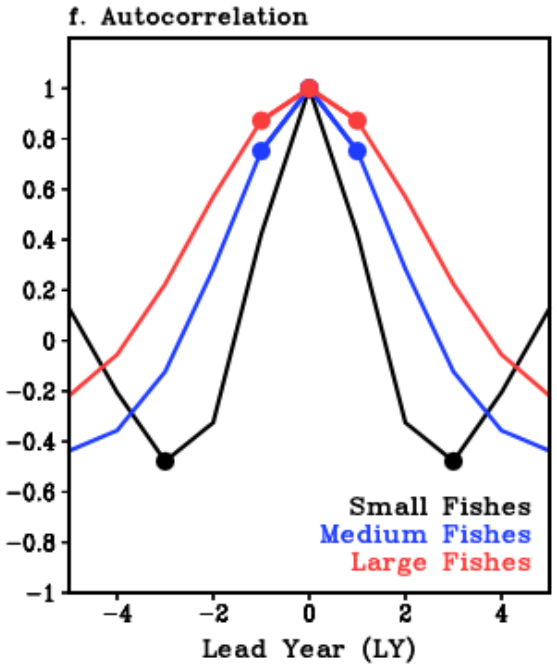
1) delayed bottom-up impact

2) Turnover rates of fish biomass (consistency with time)

Functional



Size



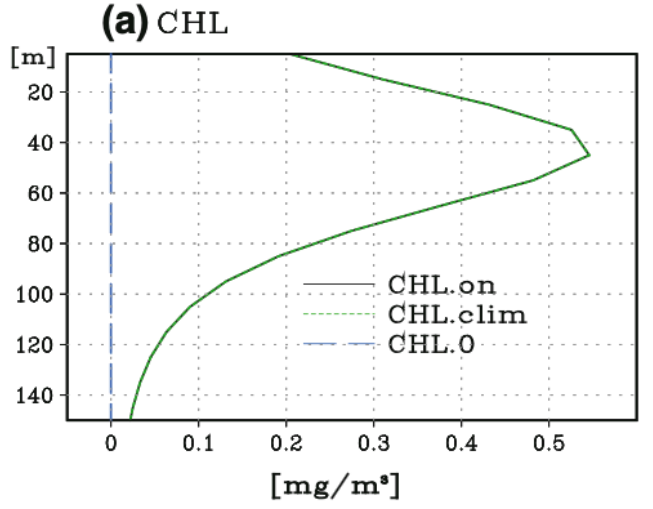
Residence time (I/O biomass flux: recruitment, energy gain, reproduction, natural, predation mortality)

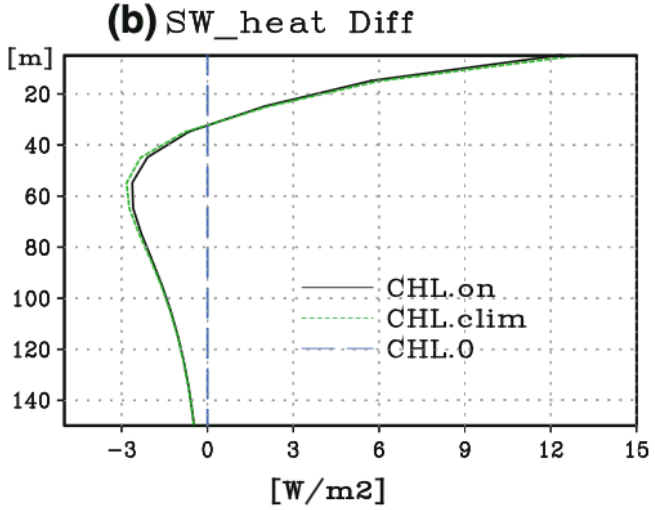
	Residence time of fish biomass (months)					
Large Marine Ecosystems	Small	Medium	Large	Forage	Large Pelagics	Demersals
East Bering Sea	0.65	4.28	19.82	2.22	7.89	8.77
California Current	0.37	4.61	20.24	1.40	6.68	10.87
Scotian Shelf	0.55	3.19	17.81	1.86	7.27	7.10
Humboldt Current	0.33	4.16	19.41	1.20	6.24	10.39
West Greenland Shelf	1.11	5.76	22.01	3.66	10.92	8.18
Norwegian Sea	0.80	5.58	21.41	2.78	NA	9.54
Iberian Coastal	0.36	3.95	19.60	1.28	6.47	10.06
Canary Current	0.28	3.26	19.08	1.14	6.49	9.01
Benguela Current	0.29	3.56	19.16	1.07	6.19	9.73
Kuroshio Current	0.26	3.45	19.89	1.17	6.89	9.29
Average	**0.5**	**4.18**	**19.84**	**1.78**	**7.23**	**9.29**

Chlorophyll: attenuation of shortwave heating

+ Self-shading effect

- **Heat redistribution**





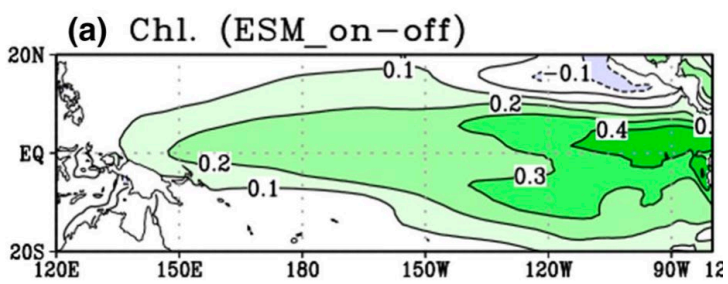
- **Manizza et al (2005)**

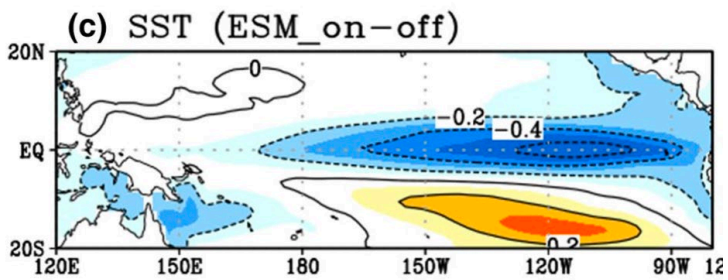
$$I_{(z)}=I_{IR}\cdot(1-e^{-k_{IR}z}) + I_{RED(z-1)}\cdot(1-e^{-k(r)\Delta z}) + I_{BLUE(z-1)}\cdot(1-e^{-k(b)\Delta z})$$

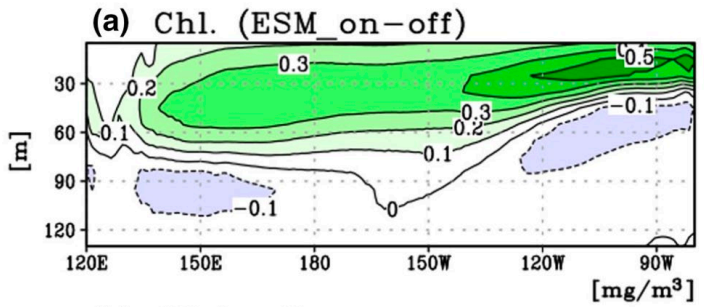
Visible light attenuation coefficient

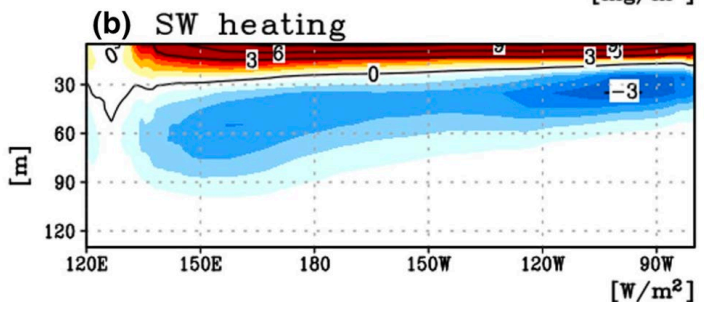
$$k_{(\lambda)}=k_{sw(\lambda)} + \chi_{(\lambda)}\cdot[CHL]^{e(\lambda)}$$

- **Overestimated Chlorophyll conc. -> cold SST mean state**









Park et al 2014;**Lim** et al 2018

ENSO-Chlorophyll feedbacks

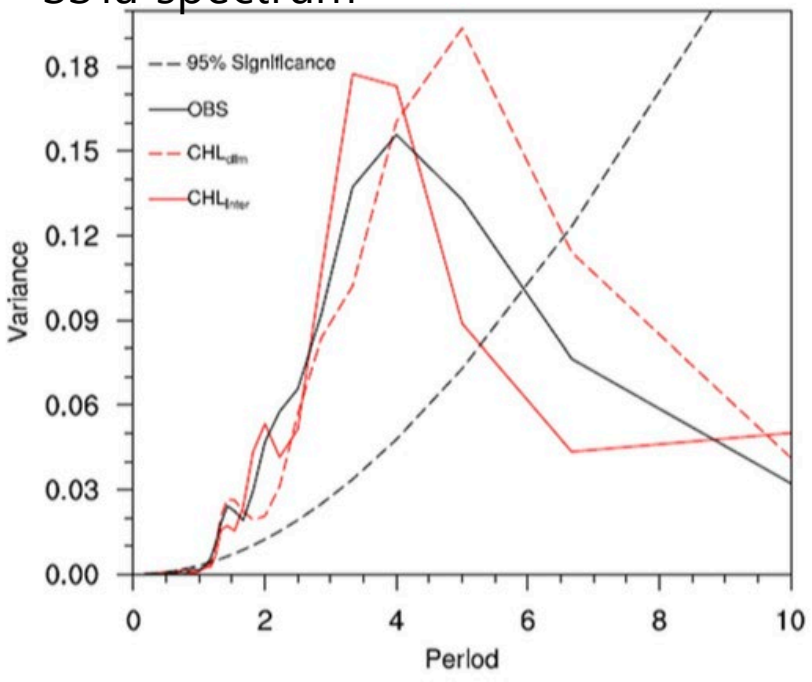
El Nino prediction → CHL ↓ → MLD deepening → Warming intensify

Fast → **Less surface heating** → **Warming reduce**

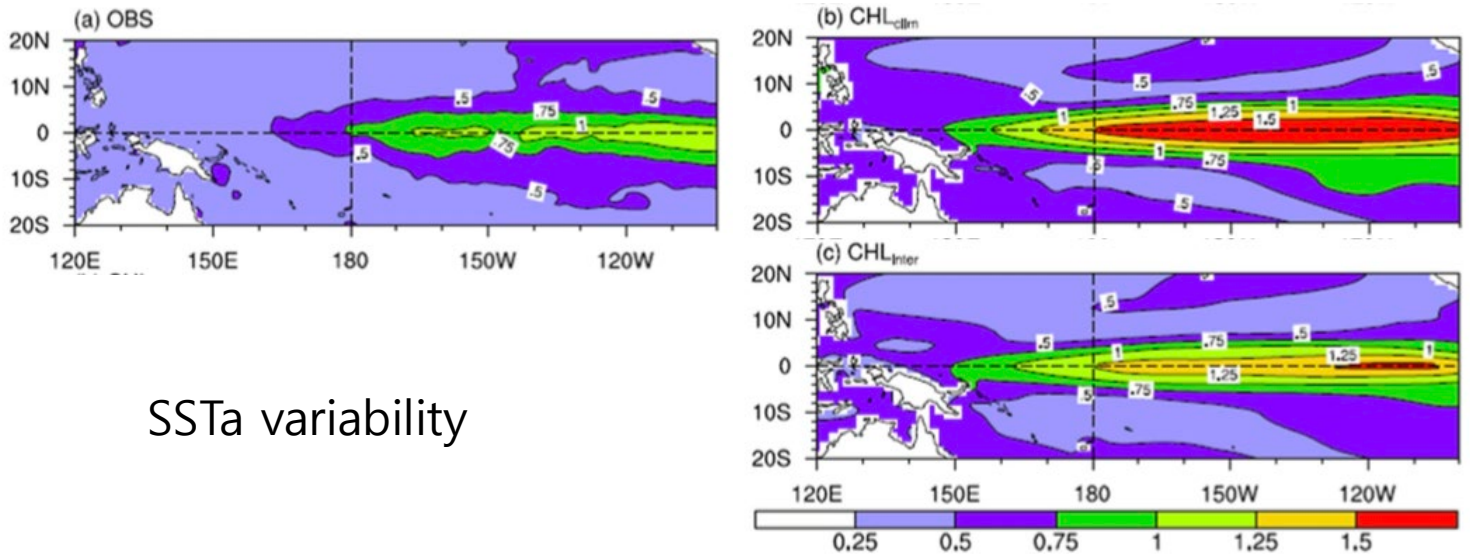
La Nina prediction → CHL ↑ → Slow → MLD shoaling → Cooling intensify

Fast → **more surface heating** → **cooling reduce**

SSTa spectrum



SSTa variability



Kang et al 2017



FUTURE SEES
Award Winner Presentation

Meaghan Efford
University of British Columbia
Vancouver, BC, Canada

2026 FUTURE ECOP SEES Award Winner

Award Objective: Encourage the recognition and application of the Social-Ecological-Environmental-System (SEES) framework and engage early career scientists in PICES.

- *Archaeologist and historical ecologist whose research advances scientific understanding of people–place relationships across centennial and millennial timescales.*
- *Contributed to a coastal archaeology and historical ecology project with Huu-ay-aht Nation and Tseshaht Nation, and supported Tsleil-Waututh Nation's Cumulative Effects Monitoring Initiative.*
- *Leader of EcoPast program, helping shift ecosystem modelling toward incorporating diverse knowledge systems and data on past ecosystem states.*

Award Presentation

"Integrating Indigenous Knowledge, archaeological data, and historical records into ecosystem models of marine and coastal change"



Dr. Meaghan Efford
University of British Columbia (Canada)



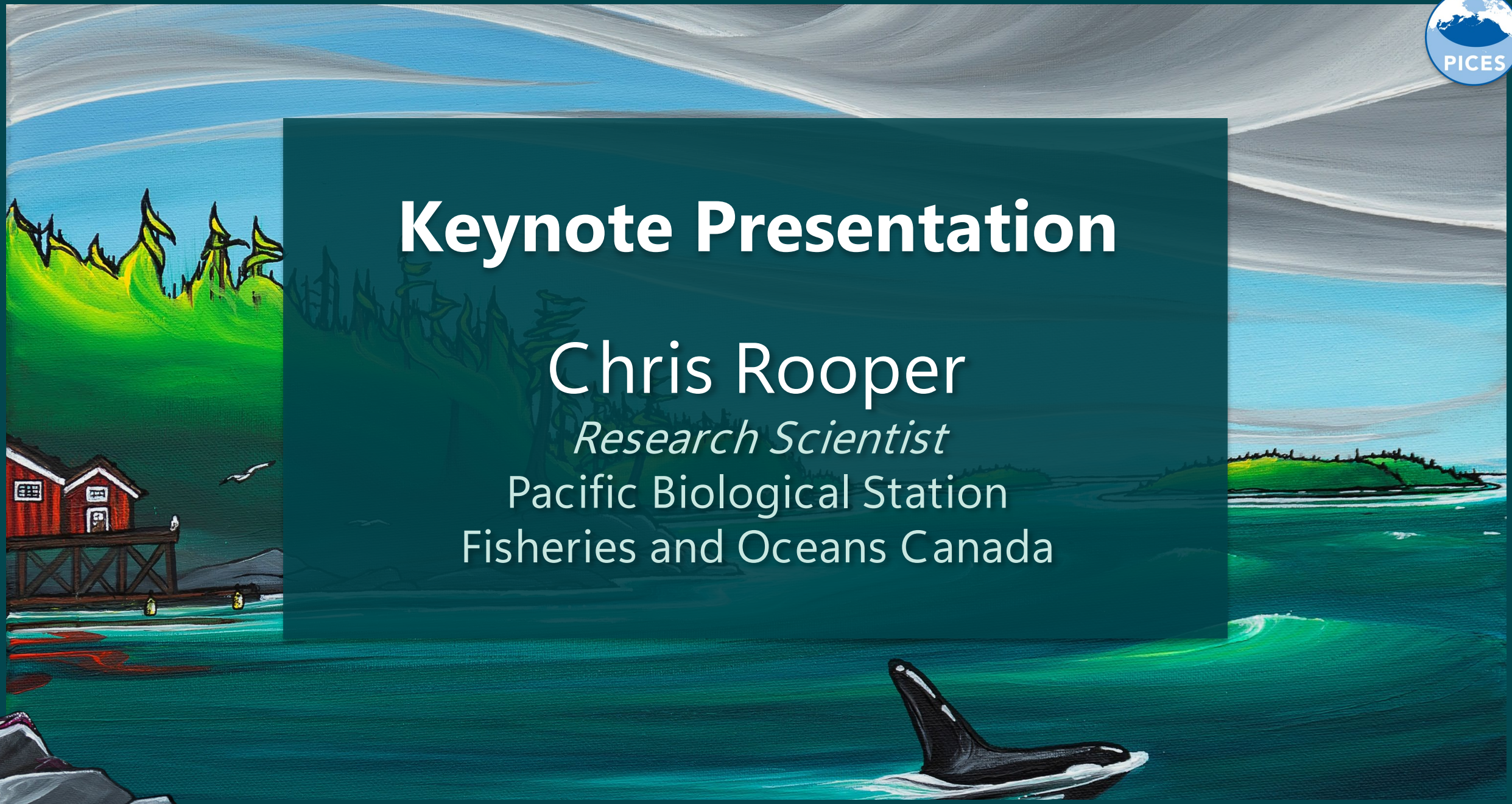
Integrating Indigenous knowledge, archaeological data, and historical records into ecosystem models of marine and coastal change

Dr. Meaghan Efford

University of British Columbia

PELAGIC ECOSYSTEMS LABORATORY

IOF | UBC THE UNIVERSITY OF BRITISH COLUMBIA
Institute for the Oceans and Fisheries



Keynote Presentation

Chris Rooper

Research Scientist

Pacific Biological Station

Fisheries and Oceans Canada

Evolution of a scientist's career



Labourer - building foundational knowledge



Building a flock– build research programs and collaborations



Training the border collie - overseeing science





SALUS

OREGON STATE
UNIVERSITY


OREGON STATE

Dr. Chris Rooper - Current Research

Research Scientist, Fisheries and Oceans Canada



- Study of **fish habitat, relationships of fish and invertebrates to ecosystem and climate drivers**
- Development of new methods to **estimate and model the abundance and distribution fish and invertebrates**
- Application of **advanced technologies** to conduct in situ habitat research
- Study of **fisheries beyond national jurisdictions**
- Chair of the North Pacific Fisheries Commission **Bottom Fish and Marine Ecosystems** Scientific Committee
- Co-Chair of the joint PICES-ICES Working Group on **Small Pelagic Forage Communities** (WG53/WGSPF)
- Member of PICES' **FIS Committee** and expert groups on **seamounts and biogenic habitats**

PICES-2026

Actionable Science for a Changing Ocean

Oct 24-30, 2026 | Nanaimo, Canada

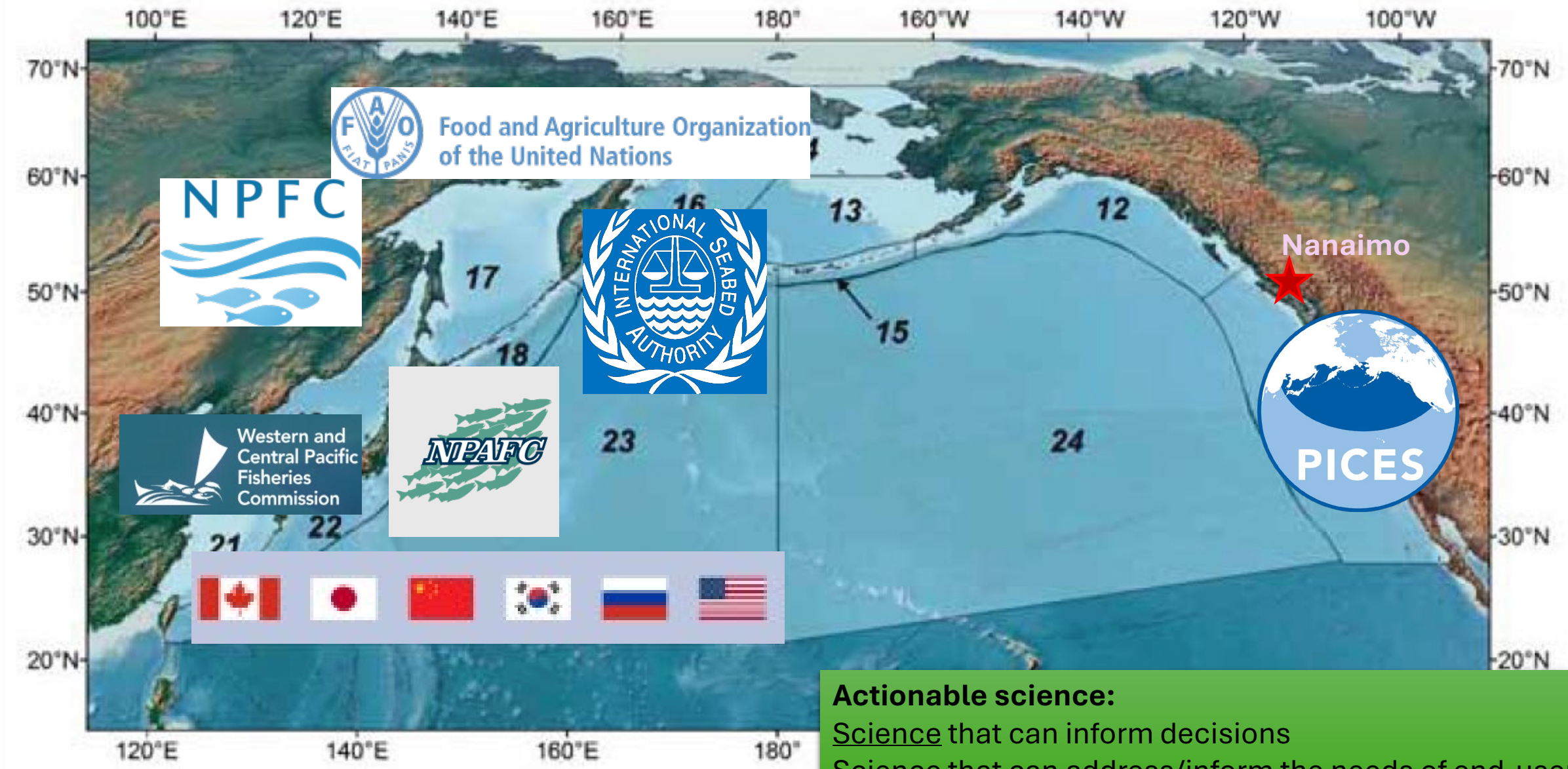


Advancing Actionable Science Advice: PICES collaborations and knowledge exchange in a rapidly changing North Pacific Ocean

Chris Rooper – Pacific Biological Station, DFO

Fisheries and Oceans Canada | Pêches et Océans Canada

Canada



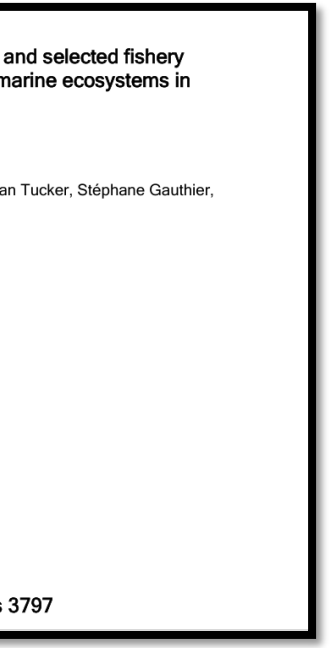
Actionable science:

Science that can inform decisions

Science that can address/inform the needs of end-users (resource managers, policy makers, community leaders, local decision makers and ordinary people)

Highly variable and changing

- Underlying warming trends
- Higher frequency of hypoxia in near-bottom waters
- More frequent and intense marine heatwaves


State of the physical, biological and selected fishery resources of Pacific Canadian marine ecosystems in 2025

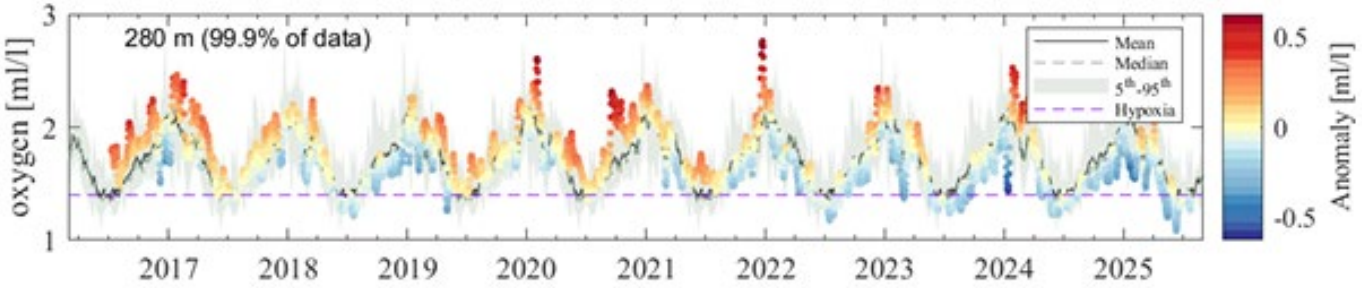
Jennifer L. Boldt, Elizabeth Joyce, Strahan Tucker, Stéphane Gauthier, and Jennifer Jackson (Editors)

Fisheries and Oceans Canada
Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, B.C. V9T 6N7

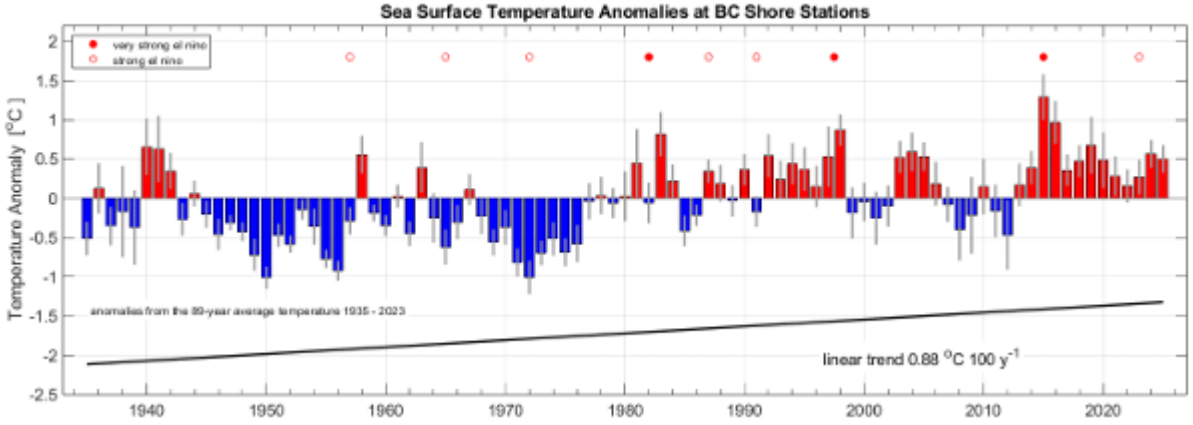
2026

Canadian Technical Report of
Fisheries and Aquatic Sciences 3797

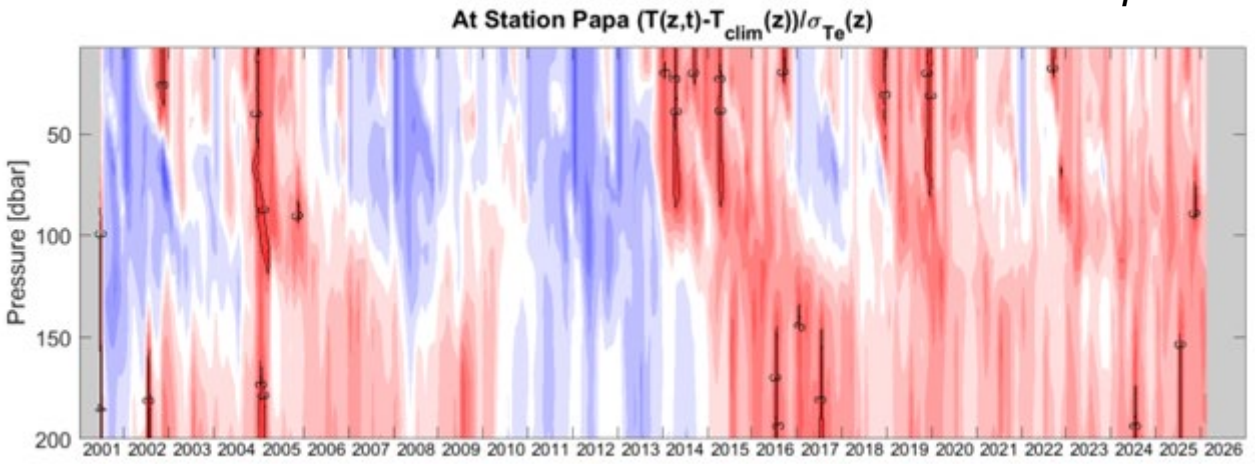
Bluteau et al. 2026 – *State of the Pacific Ocean Report*



Jackson et al. 2026 – *State of the Pacific Ocean Report*



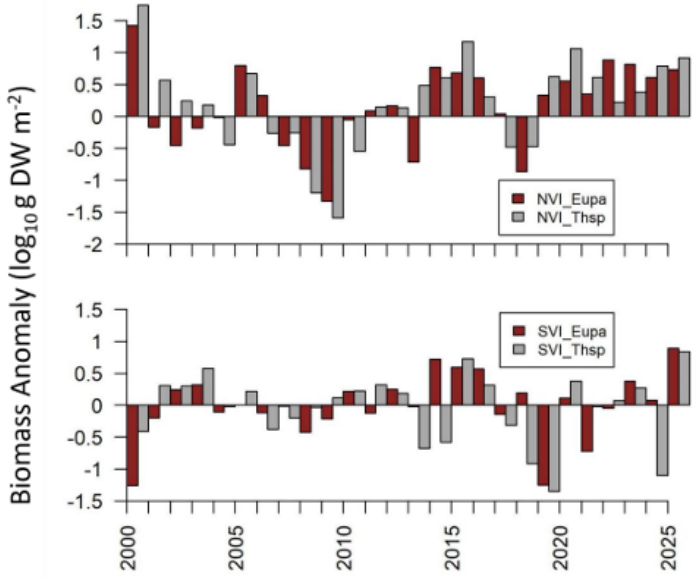
Ross et al. 2026 – *State of the Pacific Ocean Report*



Changes in Biology

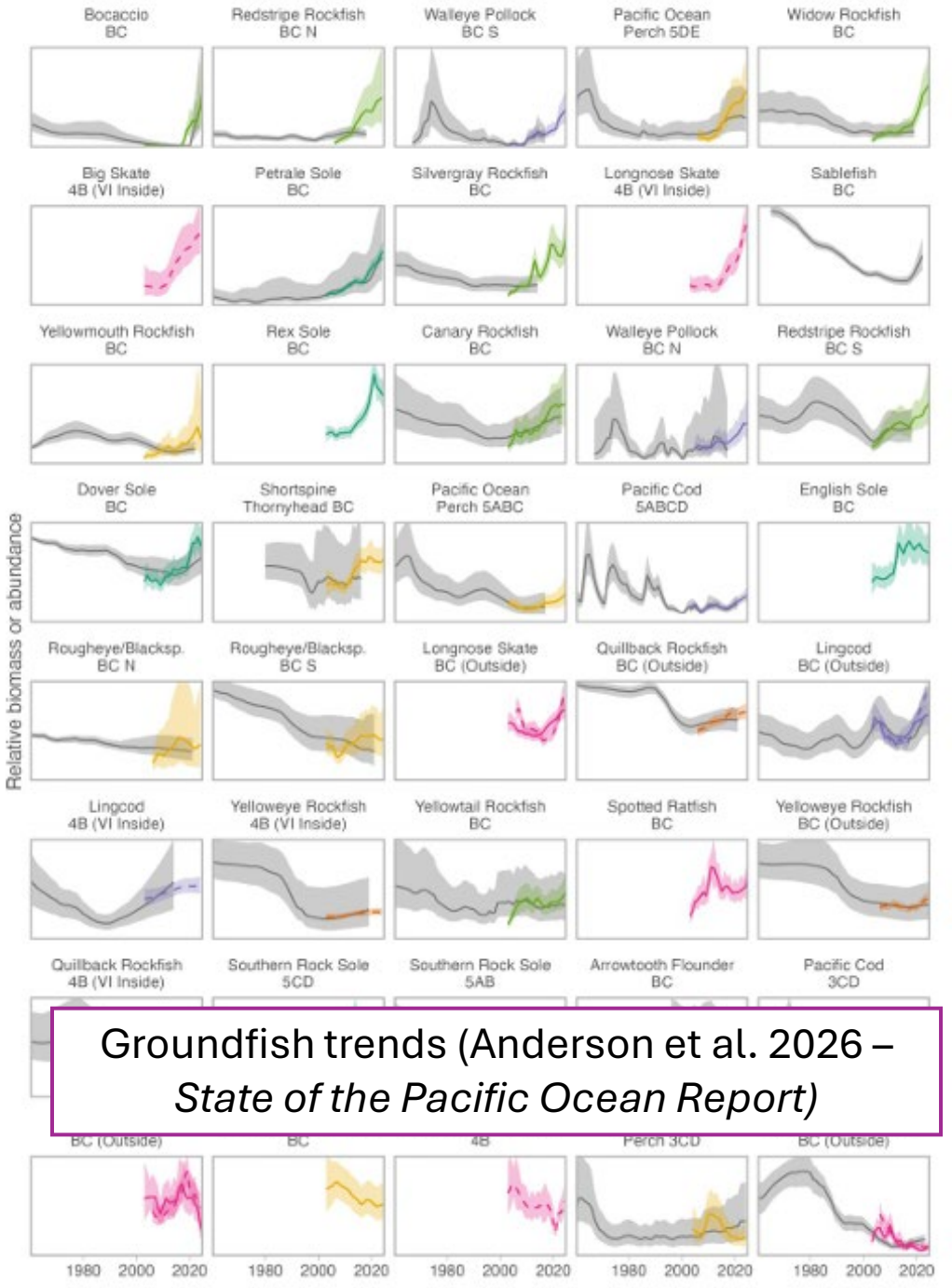
- Changing primary & secondary productivity
- Distribution and abundance of fish and invertebrates
- Mass mortality of marine mammals & birds

Euphausiid biomass (Sastri et al. 2026 – *State of the Pacific Ocean Report)*





Mortality of ~400k Cassin's auklets in 2014-15 (Jones et al. 2024)

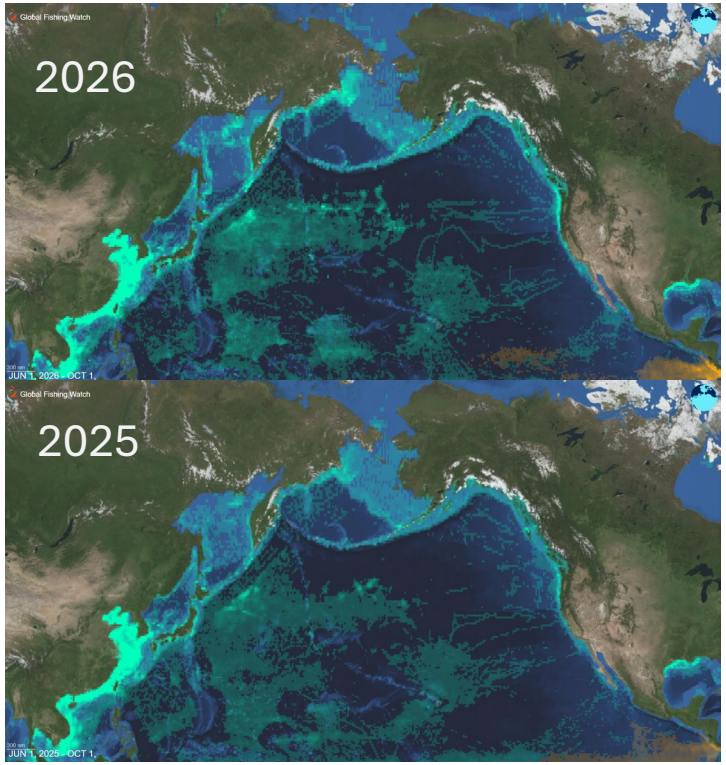


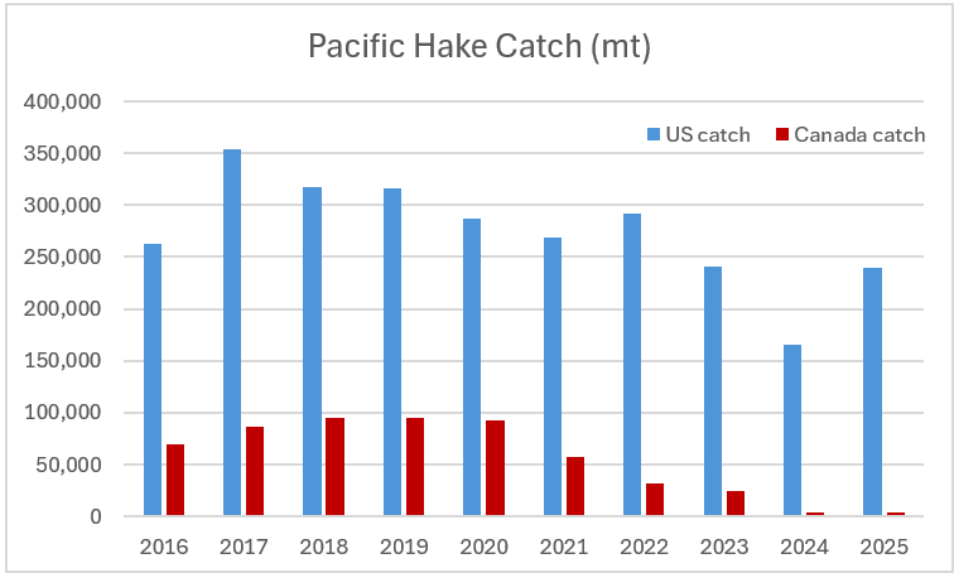
Groundfish trends (Anderson et al. 2026 – *State of the Pacific Ocean Report)*

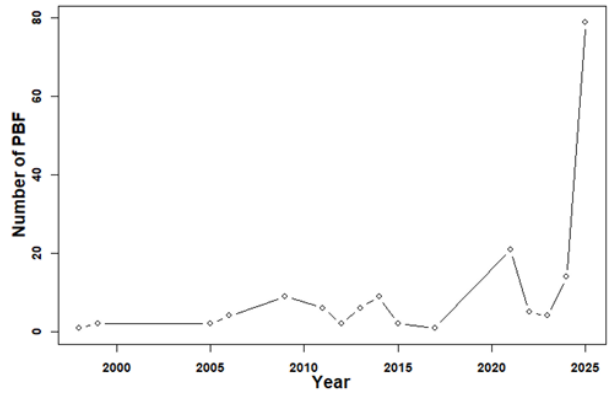
Disruptions in fisheries and sustainable management

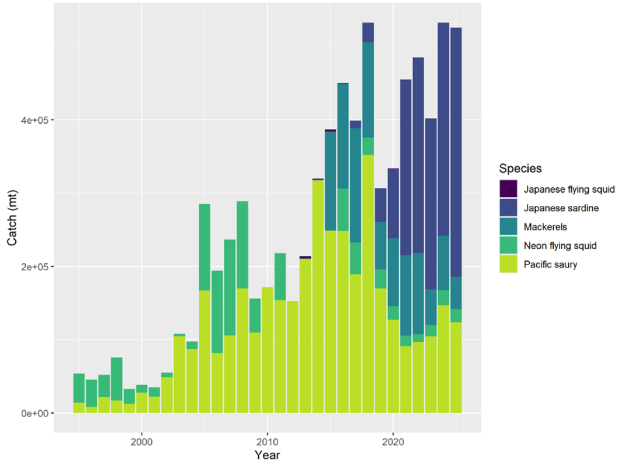
- Hake, Pacific Saury & Japanese Sardine catches
- Changes in fisher distribution on high seas and in domestic waters
- Expansion of some species (recent bluefin and swordfish catch in Canada)











2026 El Niño!!!!



TOKYO — JAPAN.co.jp Climate & Weather Desk / July 17, 2026

The forecast in one careful sentence

British Columbia

Meteorologists are forecasting a 'super' El Niño. What does that mean for B.C.?

Event 'may exceed anything we've seen at least for the past 100 years,' meteorologist says

CBC News · Posted: Aug 16, 2026 11:00 AM EDT | Last Updated: August 16

ENVIRONMENT

'Very strong' El Niño to bring warmer winter, with scorching ocean water for marine life

The weather system is moving up the Oregon coast, bringing with it a warm ocean heat blob

BY ALEX BAUMHARDT - SEPTEMBER 6, 2023 5:45 AM

Effect on ocean

The warmer water that El Niño brings has more volume, likely causing higher tides and the potential for coastal flooding, according to Jack Barth, a physical oceanographer and executive director of the Marine Studies Initiative at Oregon State University. Barth and other scientists expect the sea level off the Oregon coast to rise this winter due to El Niño.

Korea JoongAng Daily

Korea Business Lifestyle Entertainment Sports Opinion World

Korea | Politics Social Affairs North Korea Diplomacy Defense Environment K-campus

A storm is brewing: 'Super El Niño' could put Korea right in the crosshairs

Forecasters warn of a potentially record-strength El Niño that could bring even more powerful peninsula.

News Team

PUBLISHED August 20, 2026 - 7:00 a.m. MODIFIED August 20, 2026 - 2:17 p.m.

The Moscow Times

30 YEARS INDEPENDENT NEWS FROM RUSSIA

NEWS UKRAINE WAR REGIONS BUSINESS OPINION ARTS & LIFE PODCASTS ARCHIVE

What Could the 'Super' El Niño Bring to Russia?

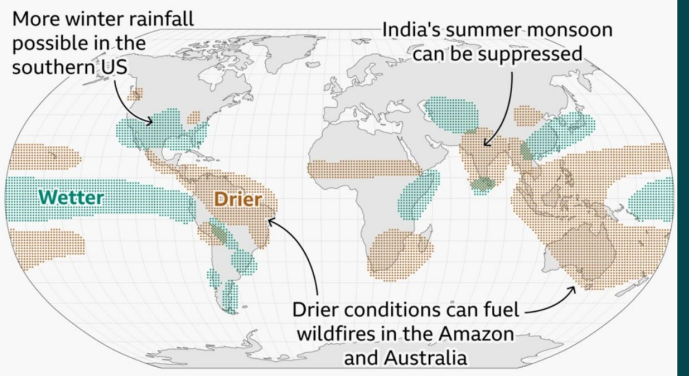
By Mack Tubridy
Sep. 22, 2026

China warns of super El Niño rivaling one of history's strongest

Earth • 12:43, 11-Jul-2026

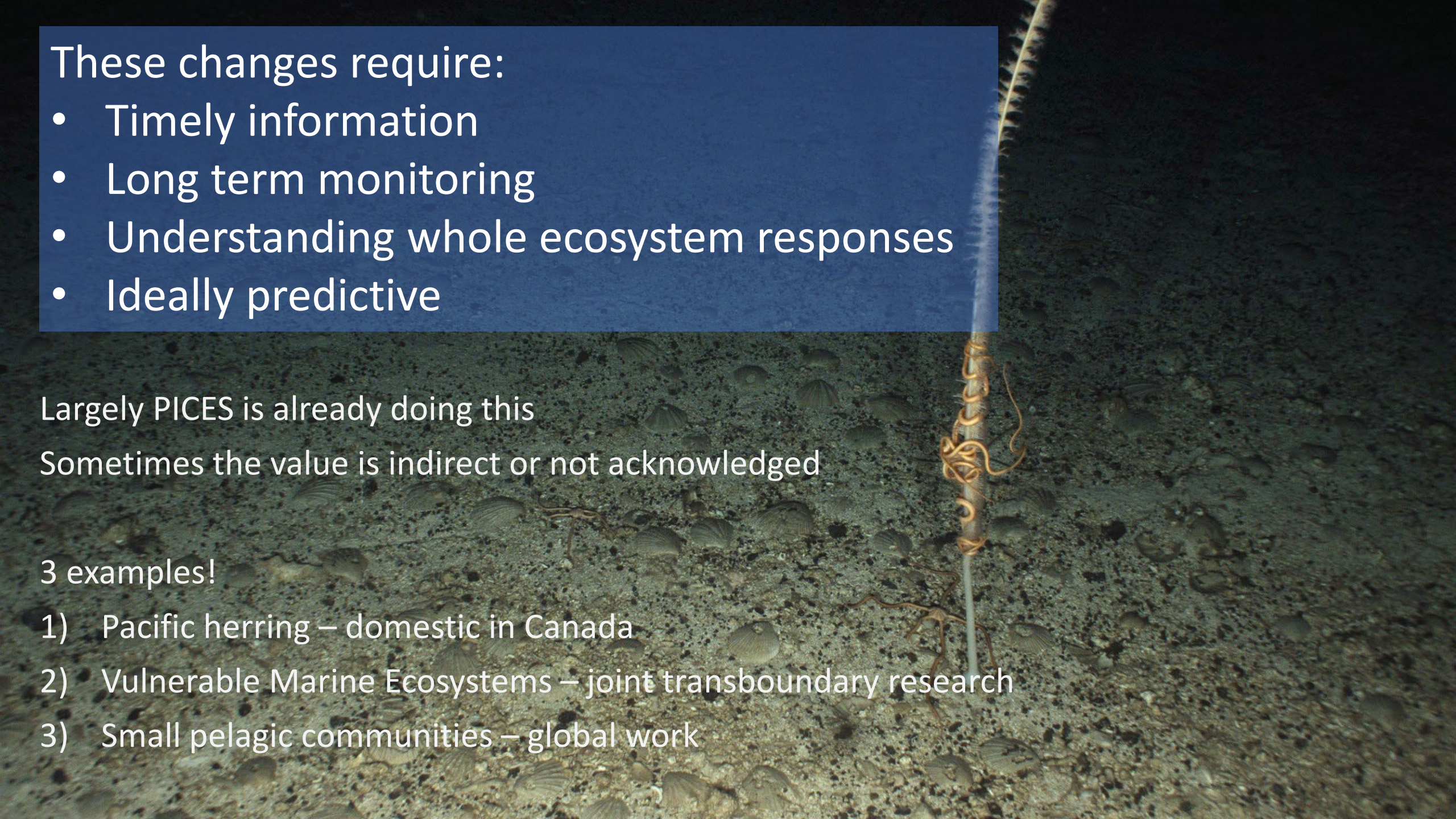
Chen Mengfei

How El Niño affects rainfall patterns



Note: Each El Niño event is different and the effects may vary between seasons

Source: Lenssen, Goddard and Mason, 2020, Weather and Forecasting BBC



These changes require:

- Timely information
- Long term monitoring
- Understanding whole ecosystem responses
- Ideally predictive

Largely PICES is already doing this

Sometimes the value is indirect or not acknowledged

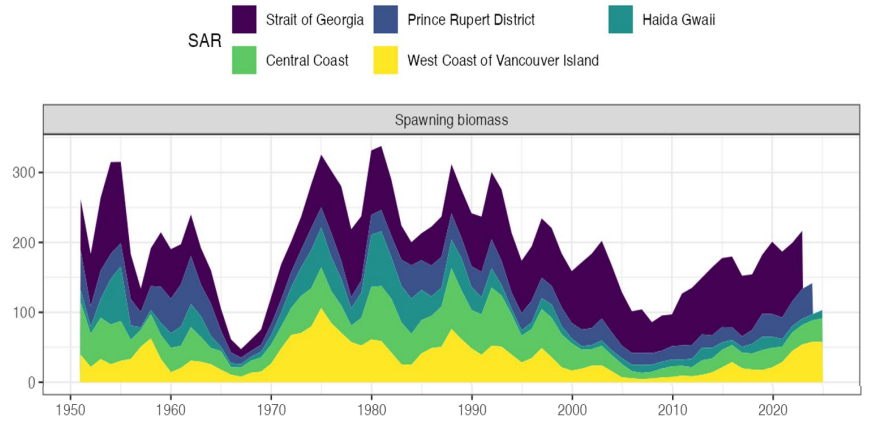
3 examples!

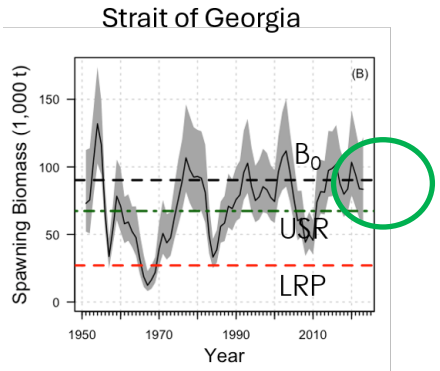
1) Pacific herring – domestic in Canada
2) Vulnerable Marine Ecosystems – joint transboundary research
3) Small pelagic communities – global work

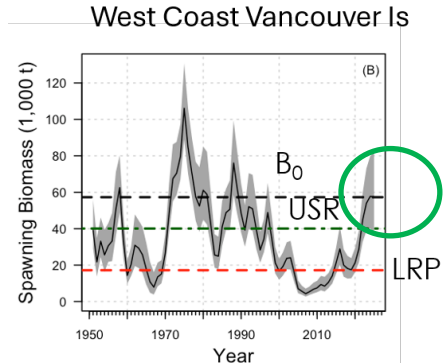
Moving Pacific Herring towards EBFM in British Columbia

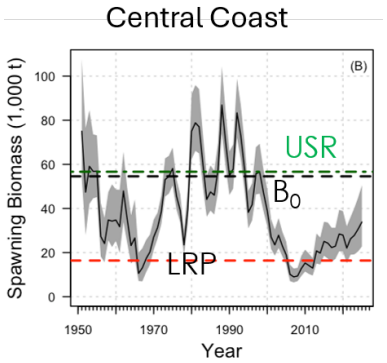
DFO invests in herring research (spawn surveys, juvenile surveys, adult sampling, ecosystem research)

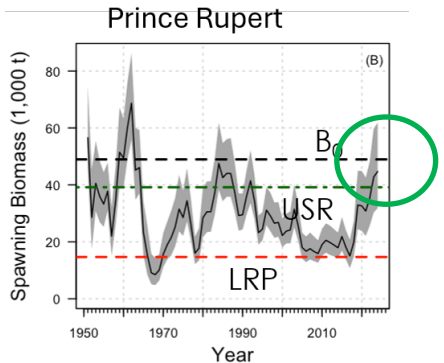
- One of three non-tuna MSEs in the north Pacific
- Developing ecosystem support tools
- Applying advanced technology (seasonal patterns)

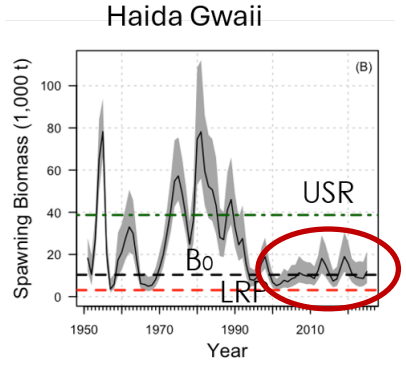










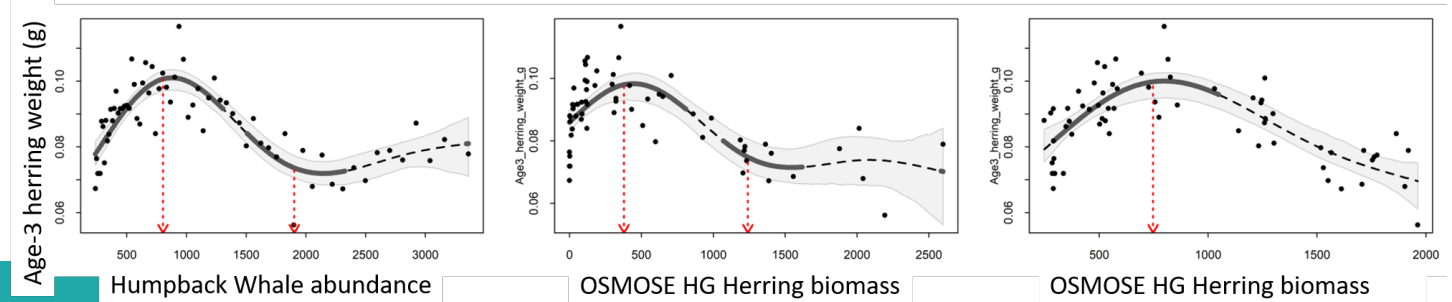


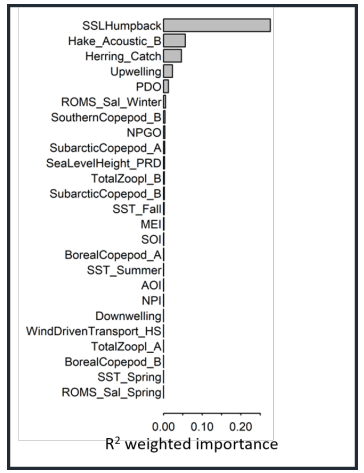
Exploratory Analyses of Pressure-Response Relationships

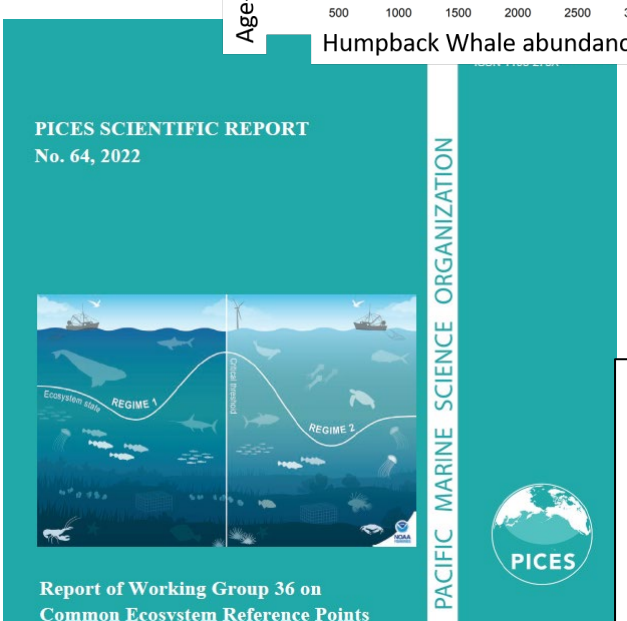
(WG 36 – Common Ecosystem Reference Points)

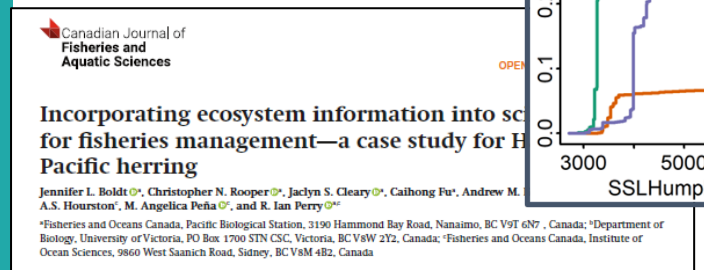
- Single pressure-response models: linear, LMAC, GAMM, or GAM (nonlinearities, thresholds)
- Multi-factor regression approach: Gradient Forest analysis (nonlinearities, thresholds)
- Multivariate analyses: Dynamic Factor Analysis with and without covariates

GAMs

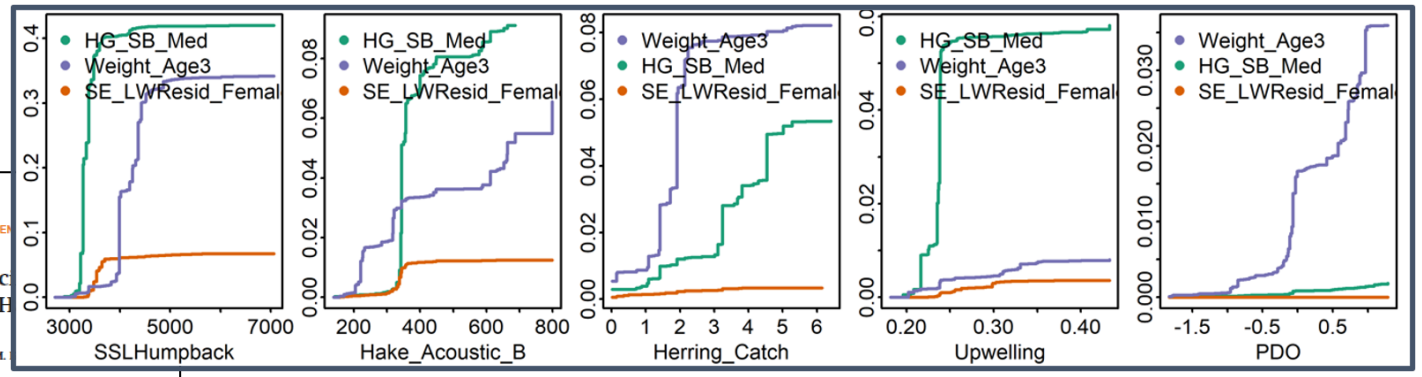






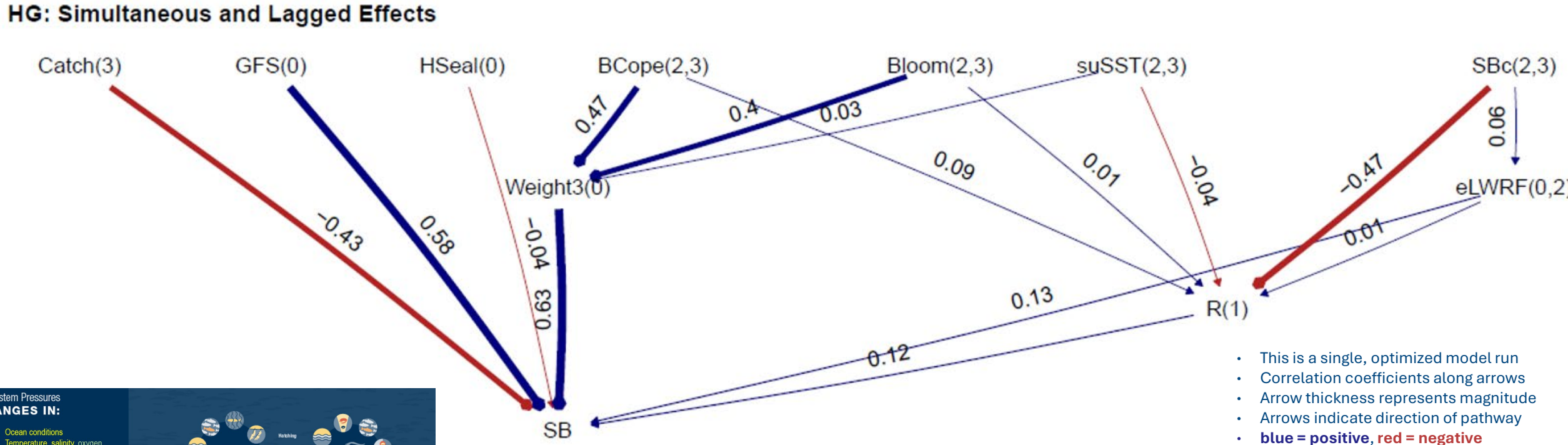


Gradient Forest

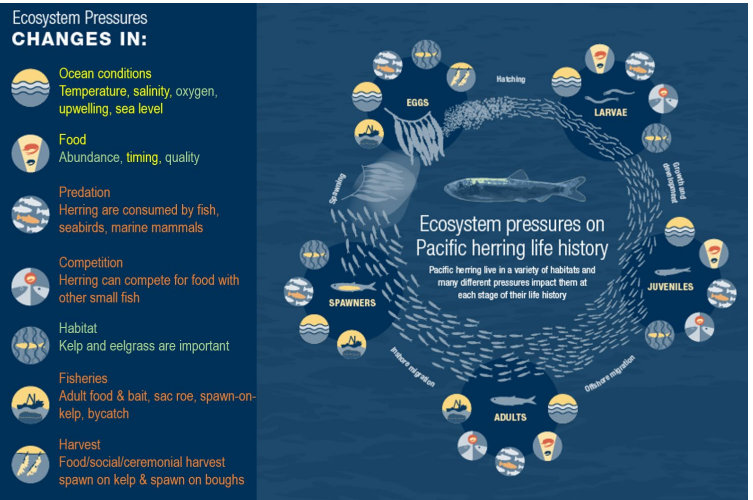


Best-performing model, Haida Gwaii herring

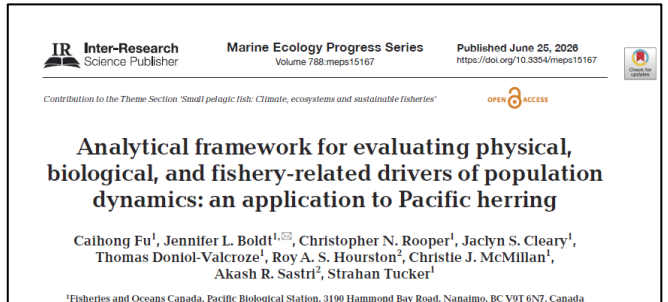
Dynamic Structural Equation Modeling (Thorson et al. 2024)



- This is a single, optimized model run
- Correlation coefficients along arrows
- Arrow thickness represents magnitude
- Arrows indicate direction of pathway
- **blue = positive**, **red = negative**

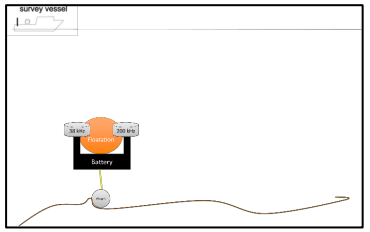


Spring bloom date
Boreal copepod biomass
Predatory fish biomass
Physical drivers (SST)



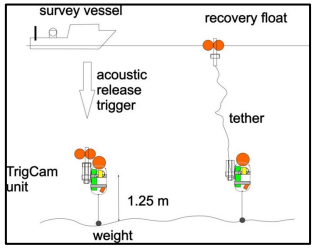
Habitat, spawning, recruitment and seasonal distribution

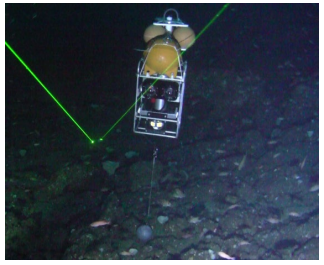
- Herring present throughout the year
- Spawn timing set by biology & environment
- Predators always hungry



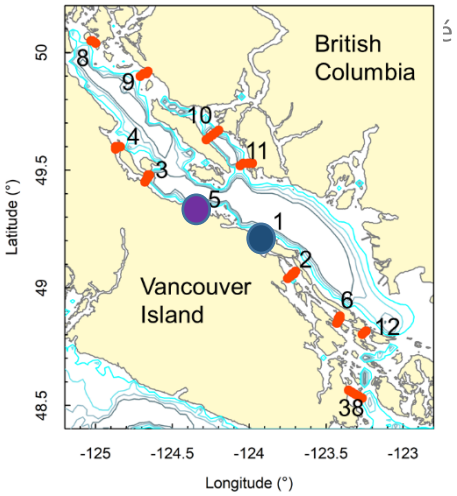


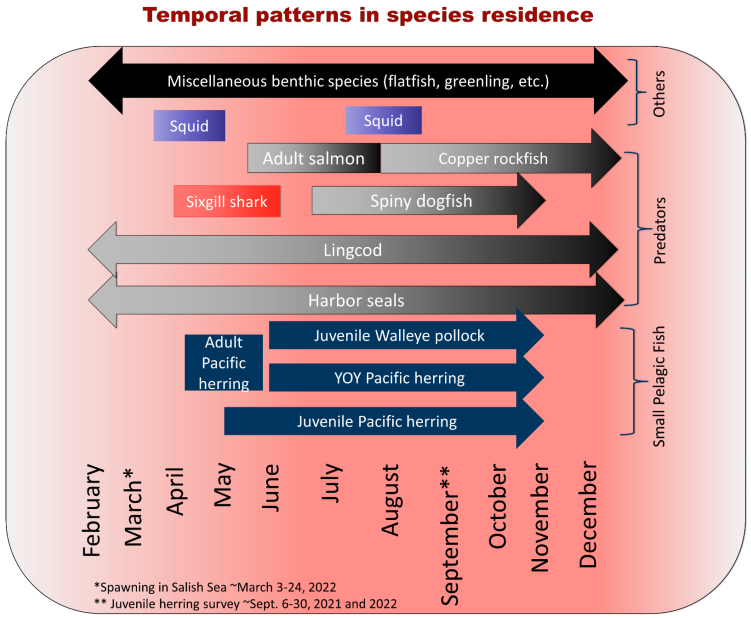
Acoustic moorings

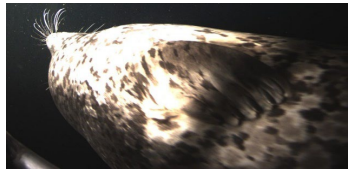


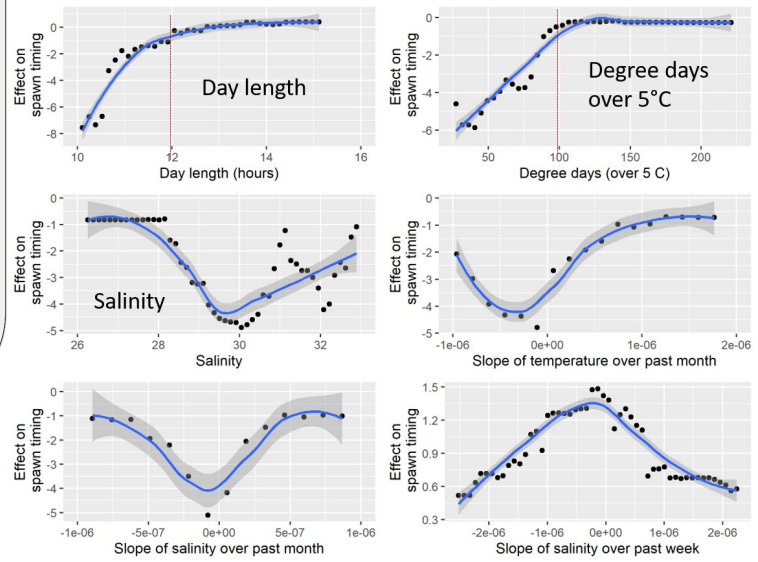


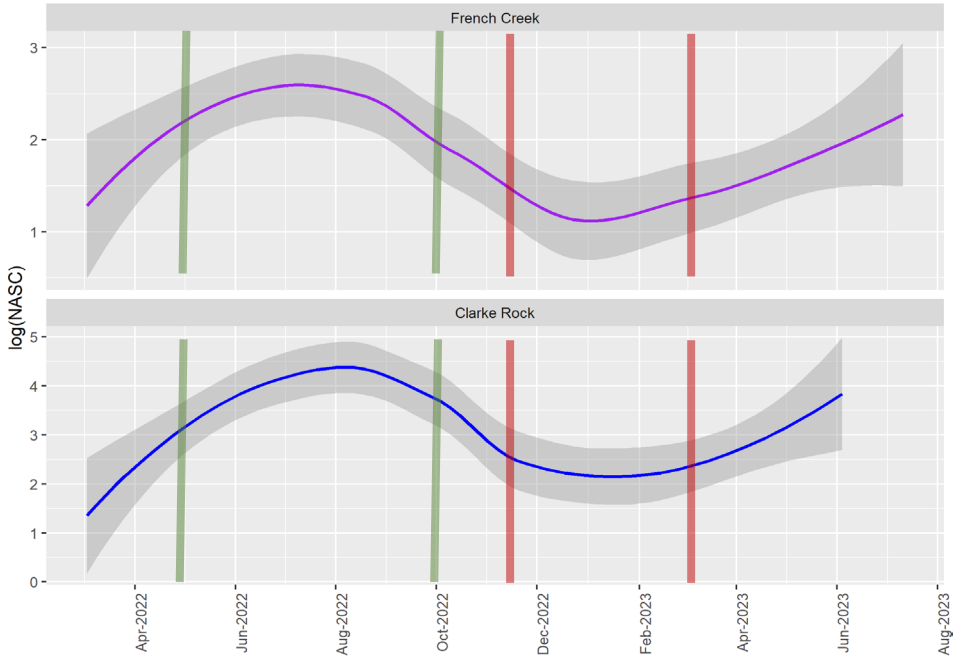
Stereo cameras





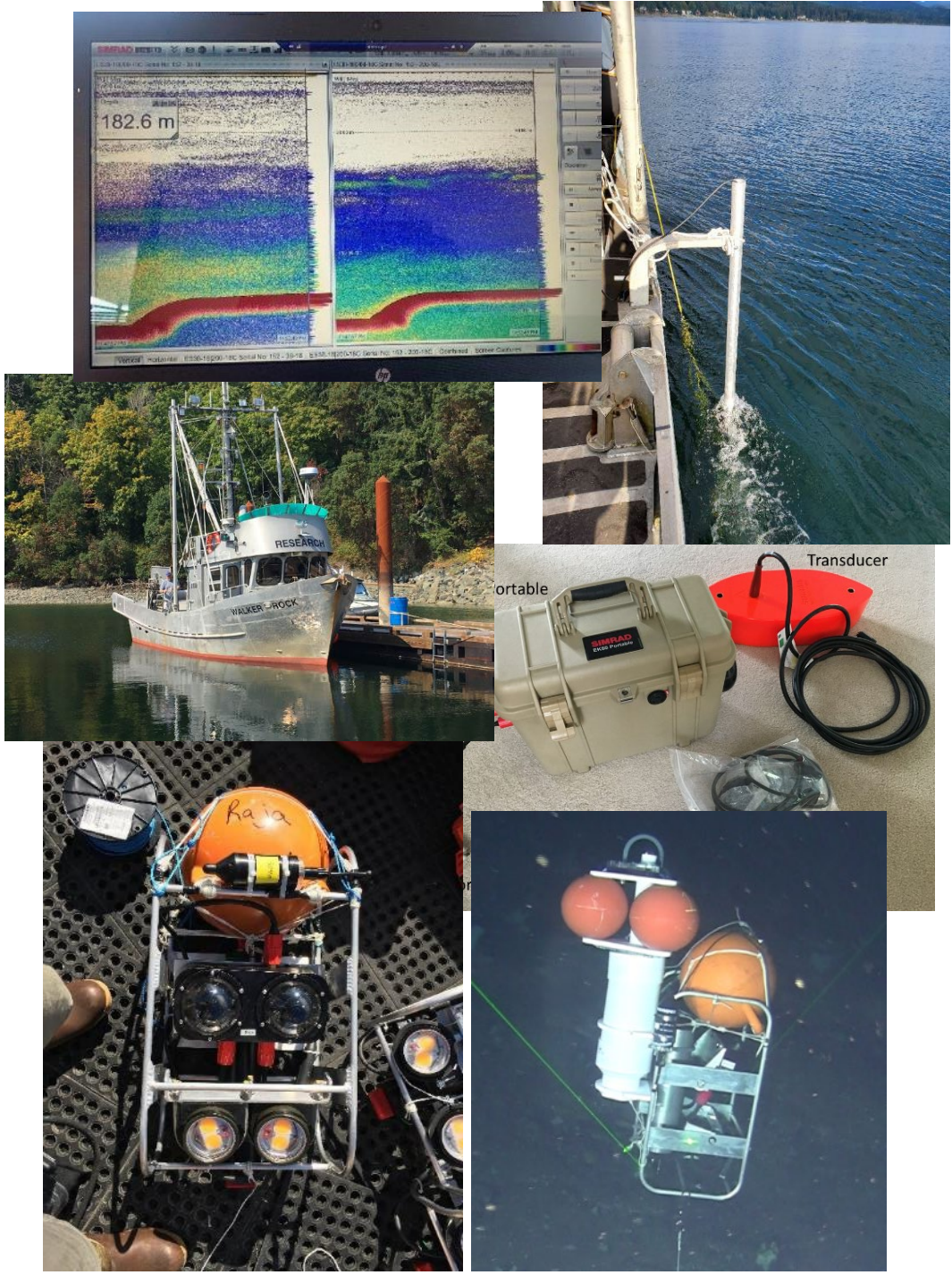






Pacific herring ecosystem research

- **Provides context for decision makers**
  - **How is ocean changing**
  - **What are warning indicators**
- **Identify key habitat & seasonal patterns**
  - **Potential sources of ELH mortality**
  - **Anthropogenic impacts (beyond fishing)**
- **Including results into MSE framework for next round**
- **Linkages to stock productivity**



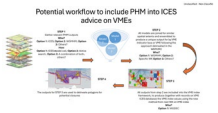
Timeline of PICES & deep-sea coral work







FAO Ecosystem Management Workshop



ICES WKPHM

ICES WKPHM2

Joint Canada-US

WG 56

S14 - *Seamount biodiversity: vulnerable marine ecosystems (VMEs) and species associated with seamounts in the North Pacific Ocean*

NPFC VME workshop

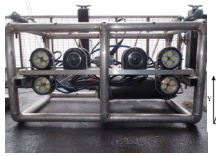
W3 - *Distributions of habitat-forming coral and sponge assemblages in the North Pacific Ocean and factors influencing their distributions*

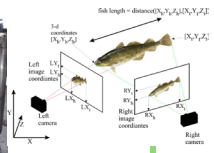
S2 *Strengths and limitations of habitat modeling: Techniques, data sources, and predictive capabilities*

Modeling approaches
Survey methods
Ensembling
Model validation
Best practices
Camera technology
Spatial planning analysis



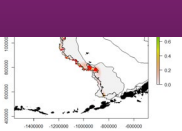
Aleutian Islands bottom trawl survey





Stereo-camera development

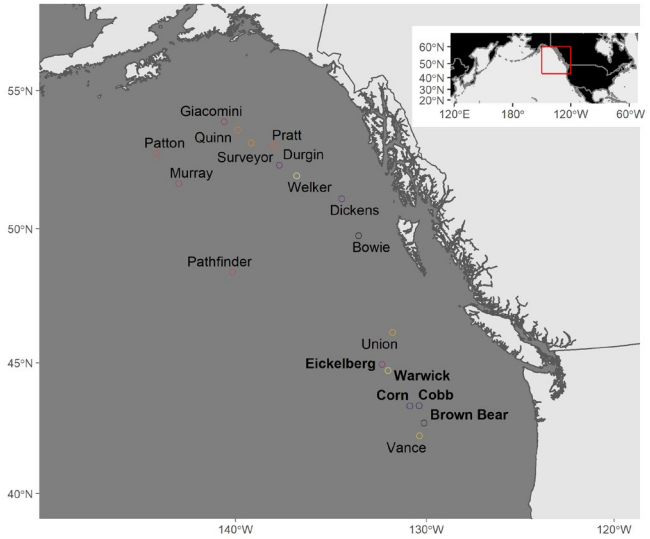




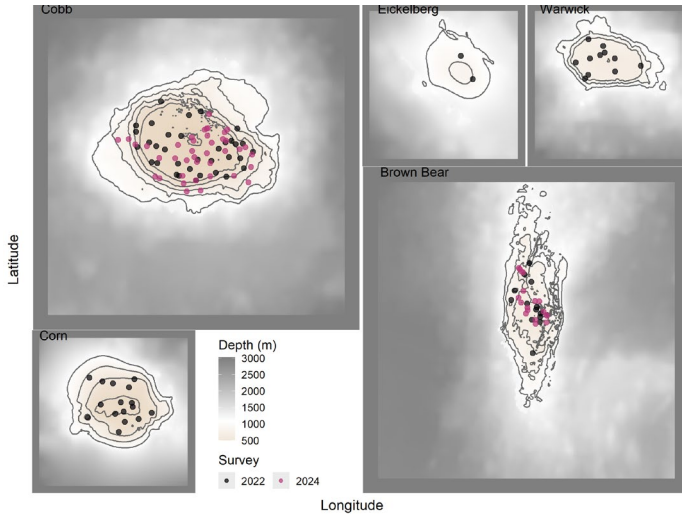
Alaska modeling & camera surveys

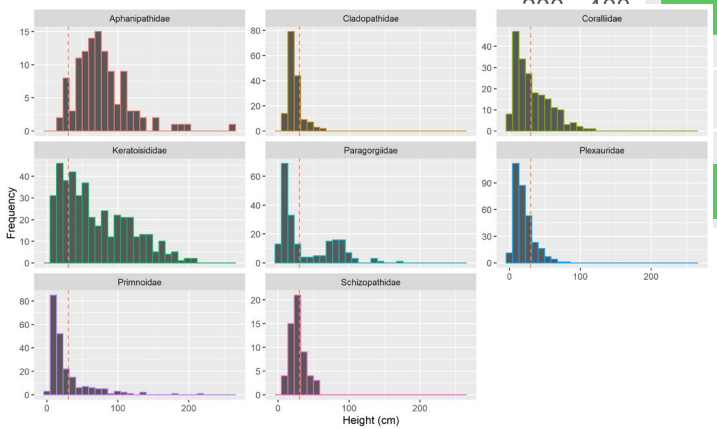
2000 2005 2010 2015 2020 2025

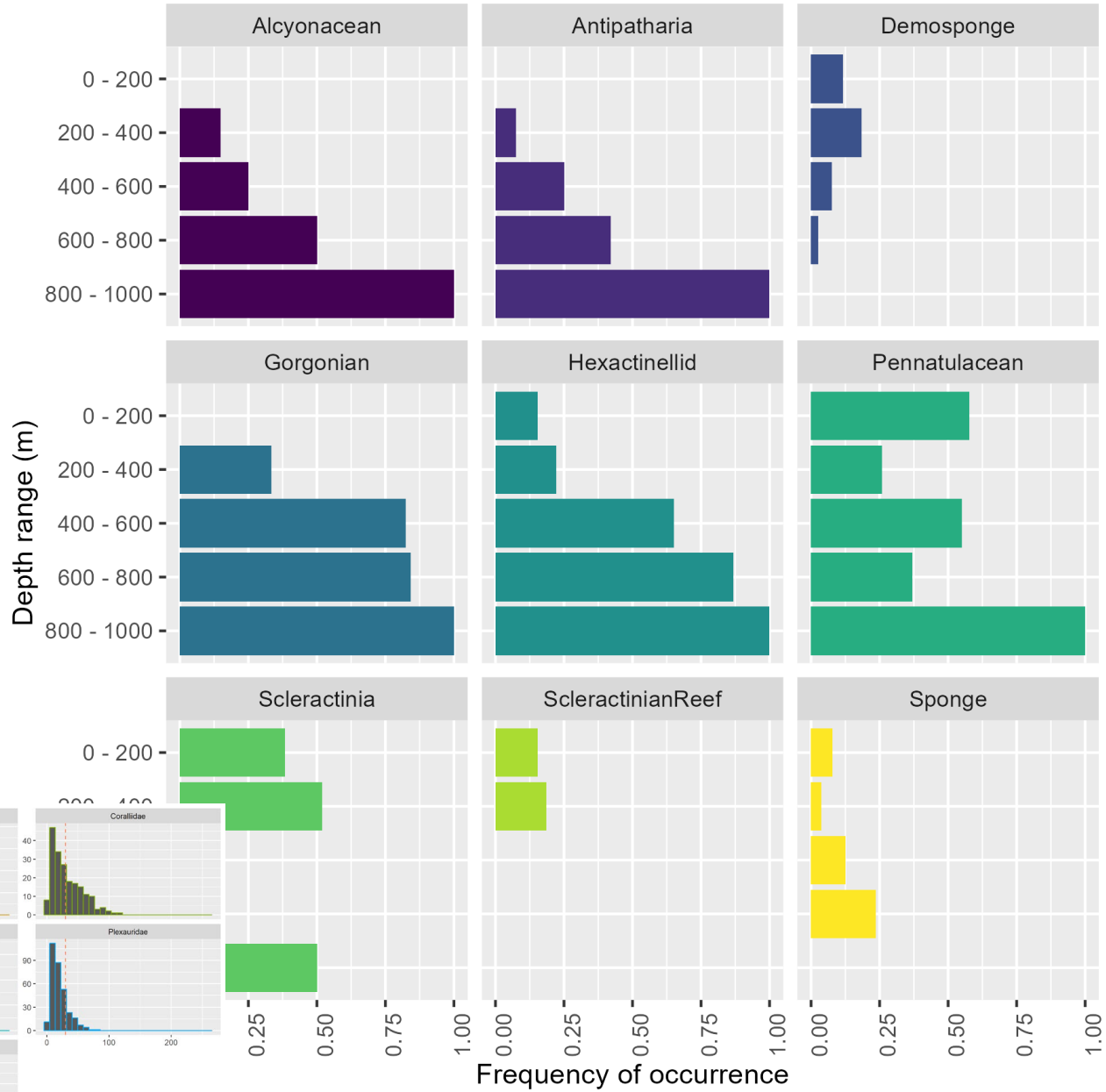
Depth Stratified Random Survey Design
2022 (n = 77)
2024 (n = 56)







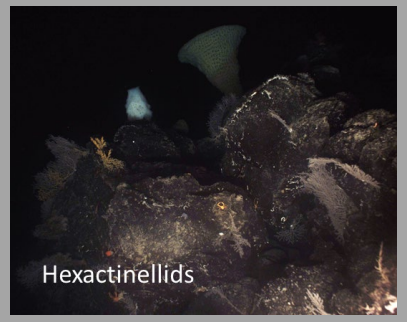


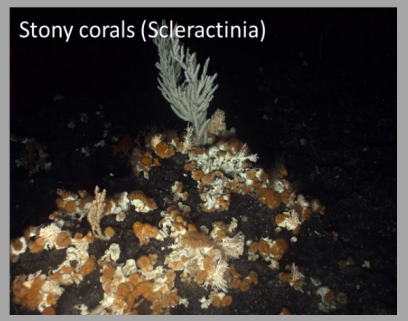


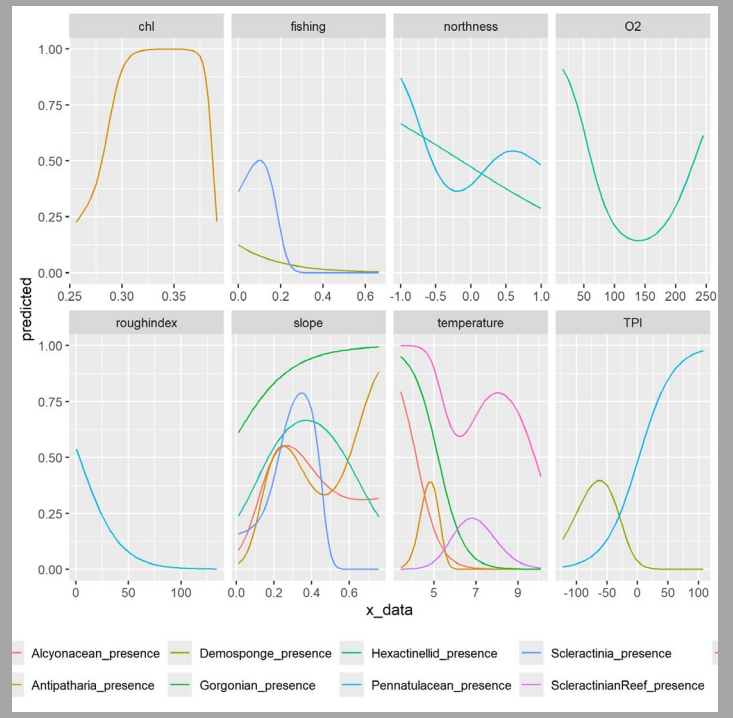
Species distribution models

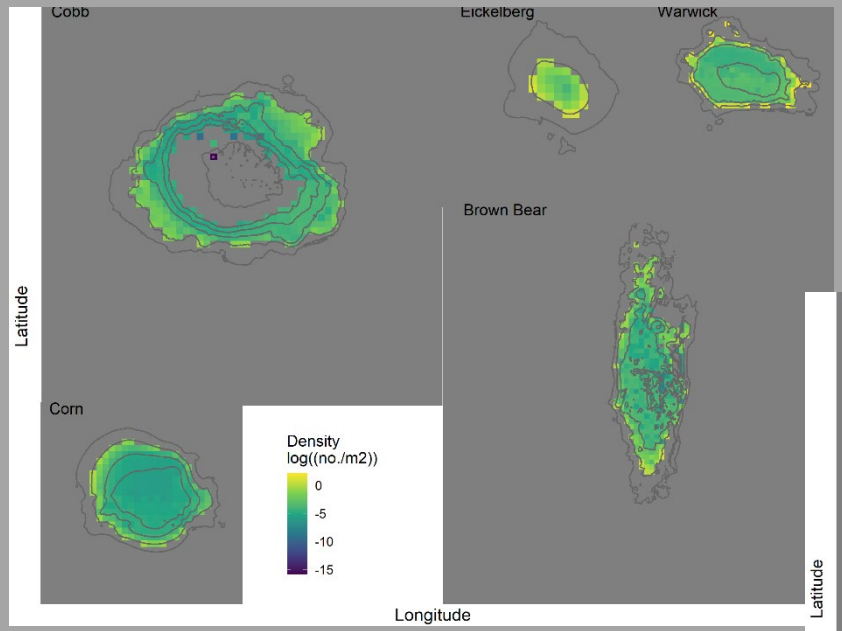
- each VME indicator taxa
- combined VME indicator taxa
- Presence/absence
- Density
- Height

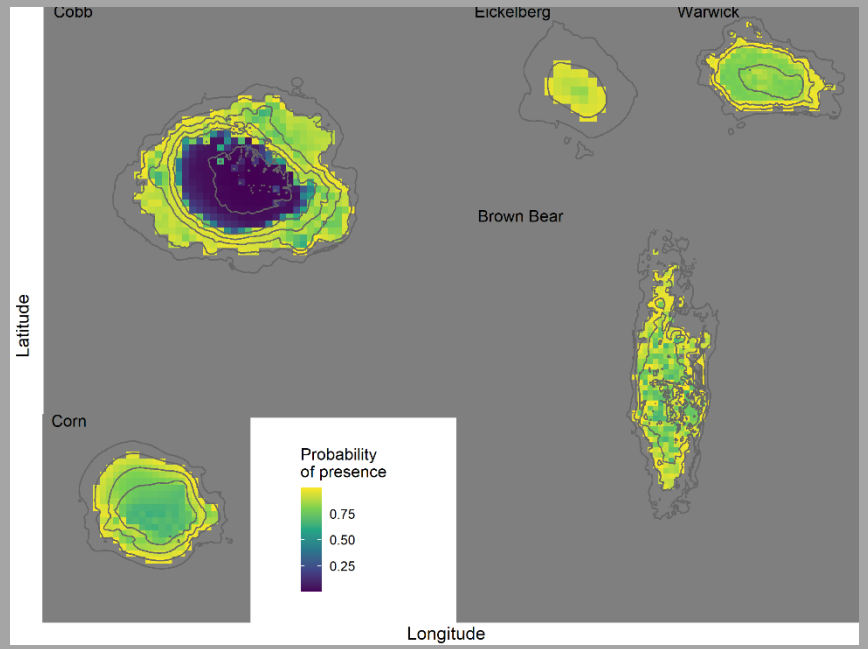
n = 19 models

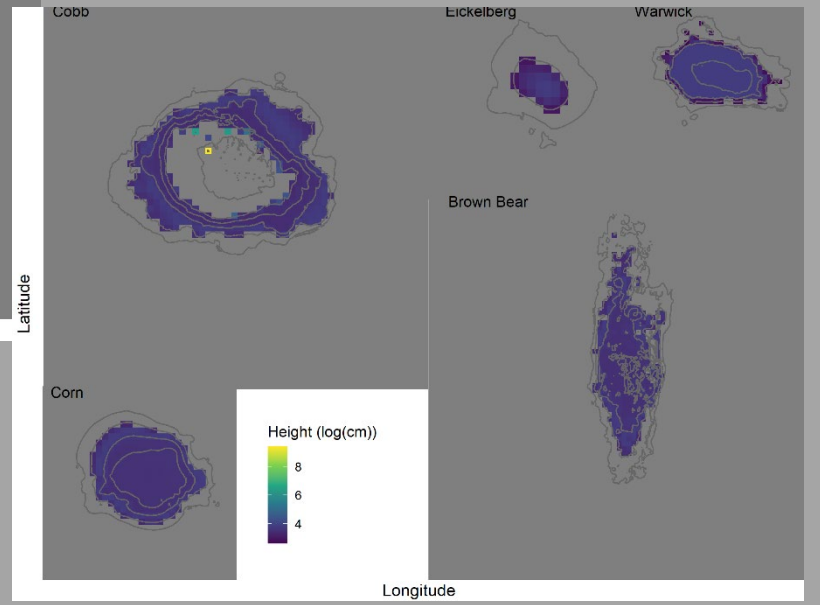






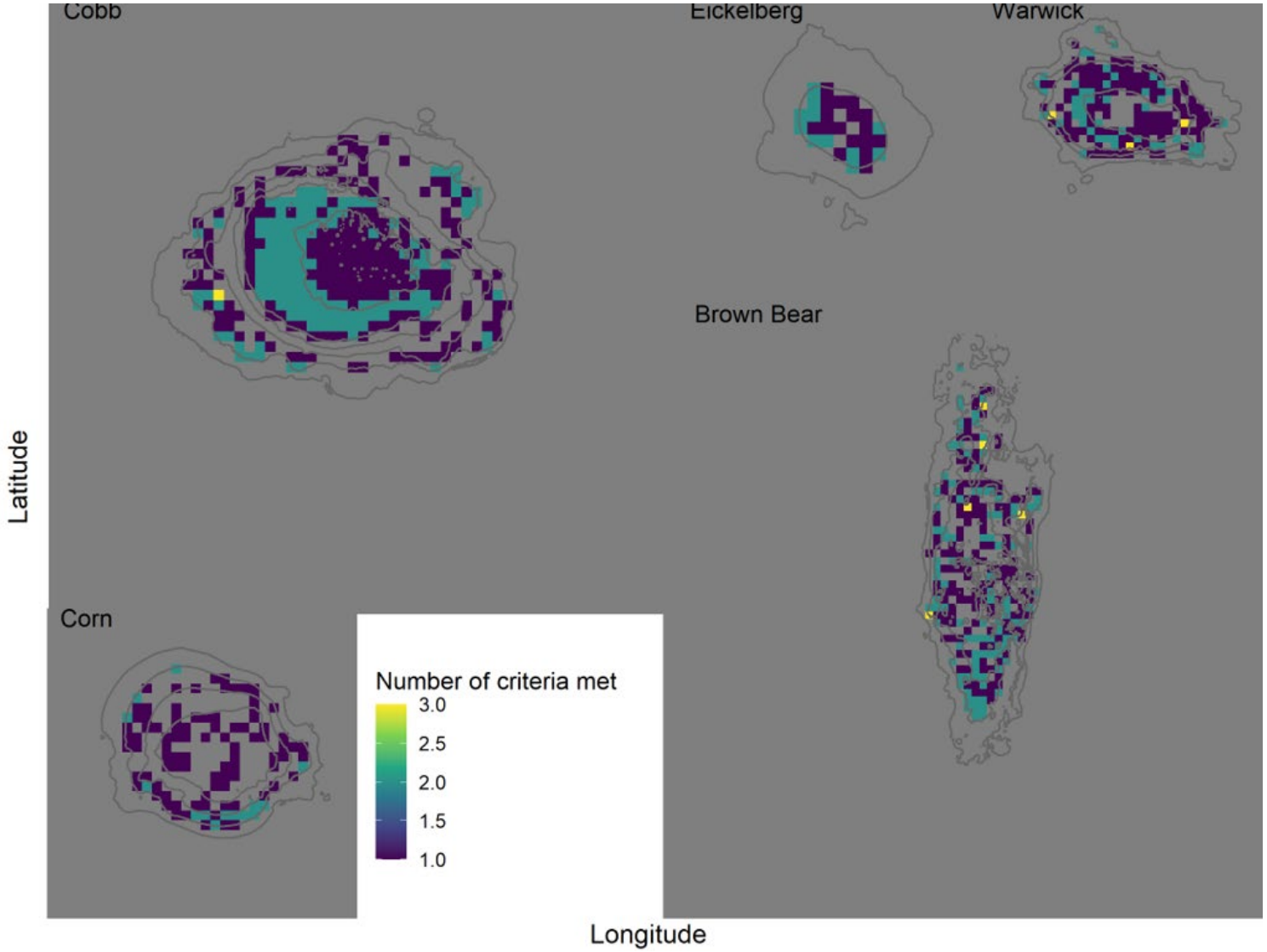




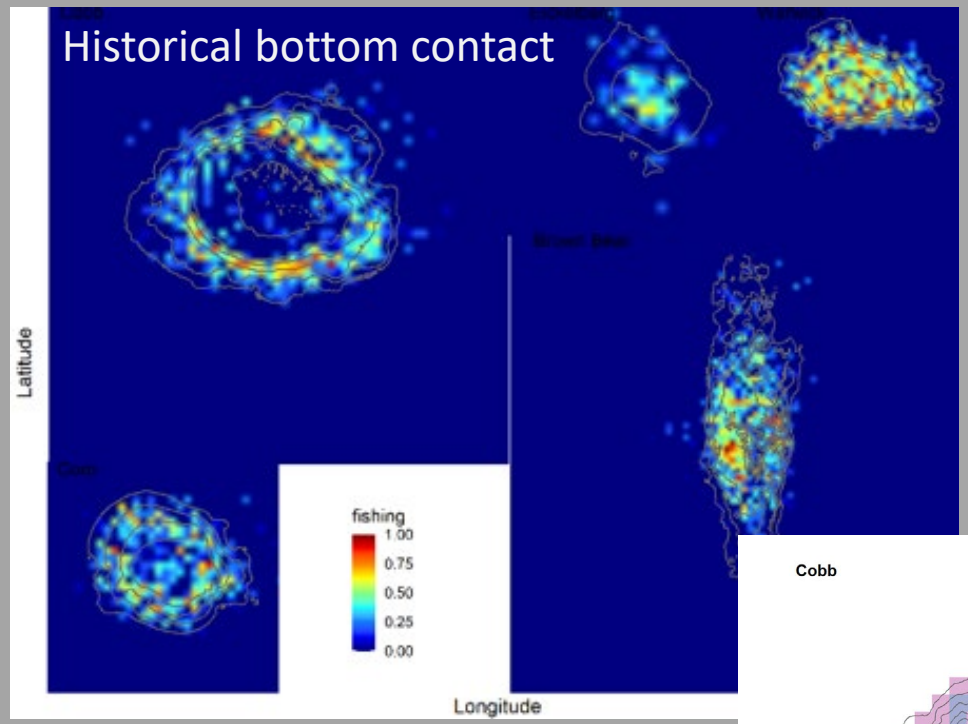


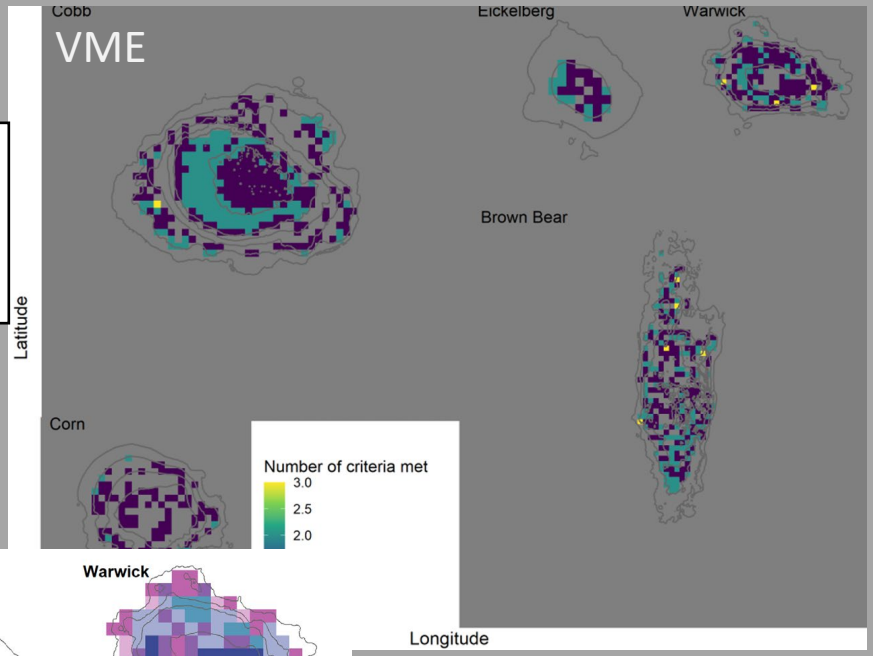
Number of VME criteria (FAO) met

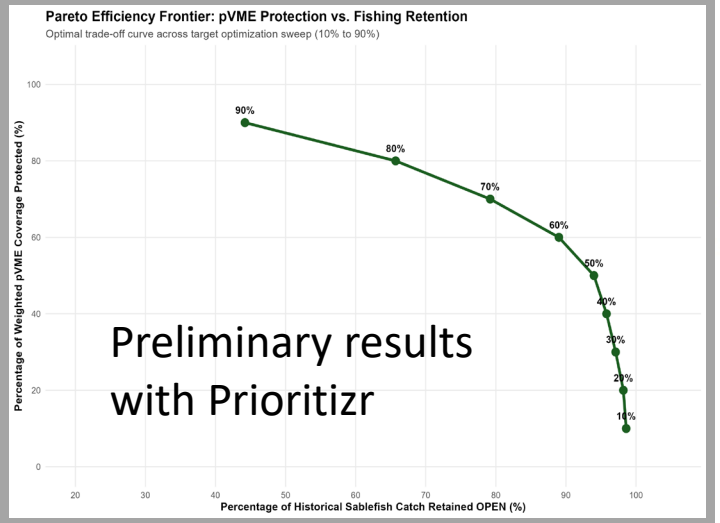
FAO Criterion	Characteristics	Definition used in this analysis
1. Uniqueness or rarity	Rare or unique populations	VME indicator taxa groups that **occur in < 10% of transects**
2. Functional significance of the habitat	Create a habitat that is used by other taxa, usually indicated by species associations or forming spawning or feeding habitats important for other taxa survival and growth	**Upper quantile (10%) of density** predictions for each VME indicator taxa
3. Structural complexity	Contribute to forming complex seafloor structure that supports biodiversity	Predicted **density of combined VME indicator taxa > 0.58 VME** indicator taxa * m^{-2}
4. Fragility	Susceptible to damage from physical processes or bottom contacting fishing gear	**Upper quantile (10%) of height** predictions for each VME indicator taxa
5. Life history traits that make recovery difficult	Longevity, slow growth, low reproductive rates, limited larval dispersal	All VME indicator taxa exhibit one or more of these characteristics, so these are contained within the criteria 2 & 4.

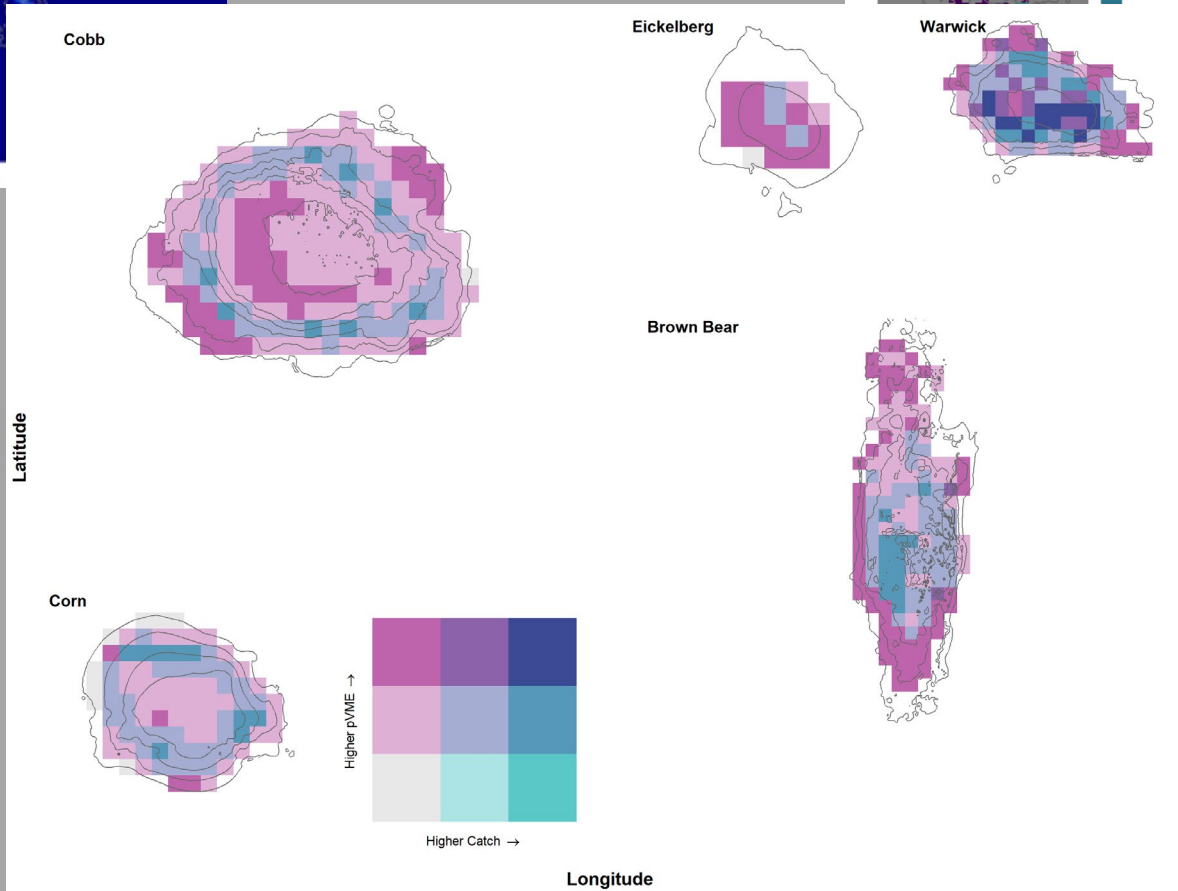


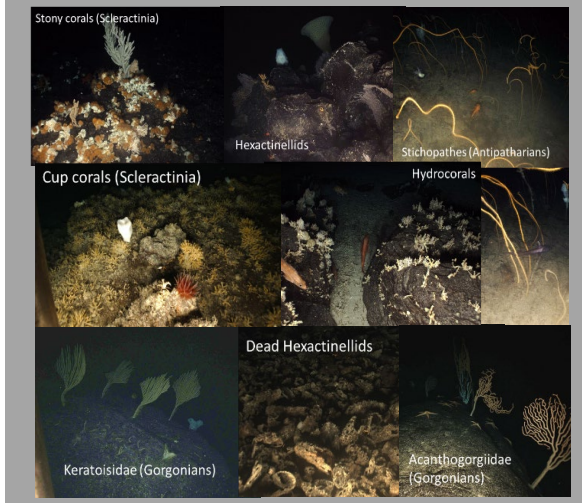
Trade-off analysis (D. Warawa)







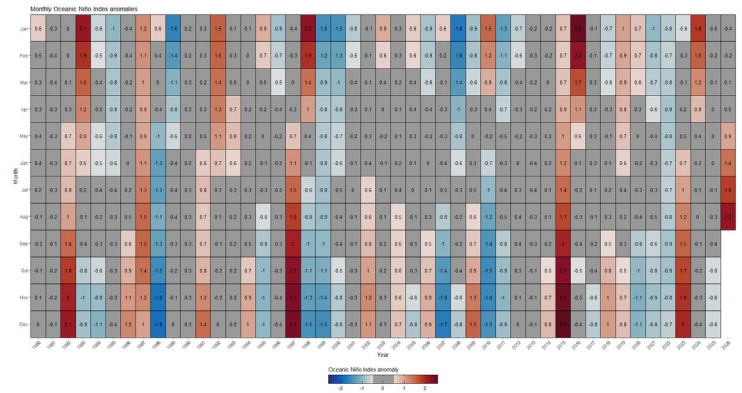




Deep Sea coral and sponge research

- **Provides tools for spatial management**
  - **Distribution, abundance, size structure**
  - **Spatial predictions**

- **Identify key risks**
  - **Avenue for mitigation & recovery**
  - **Long-term consequences of current management**
  - **Climate change impacts**

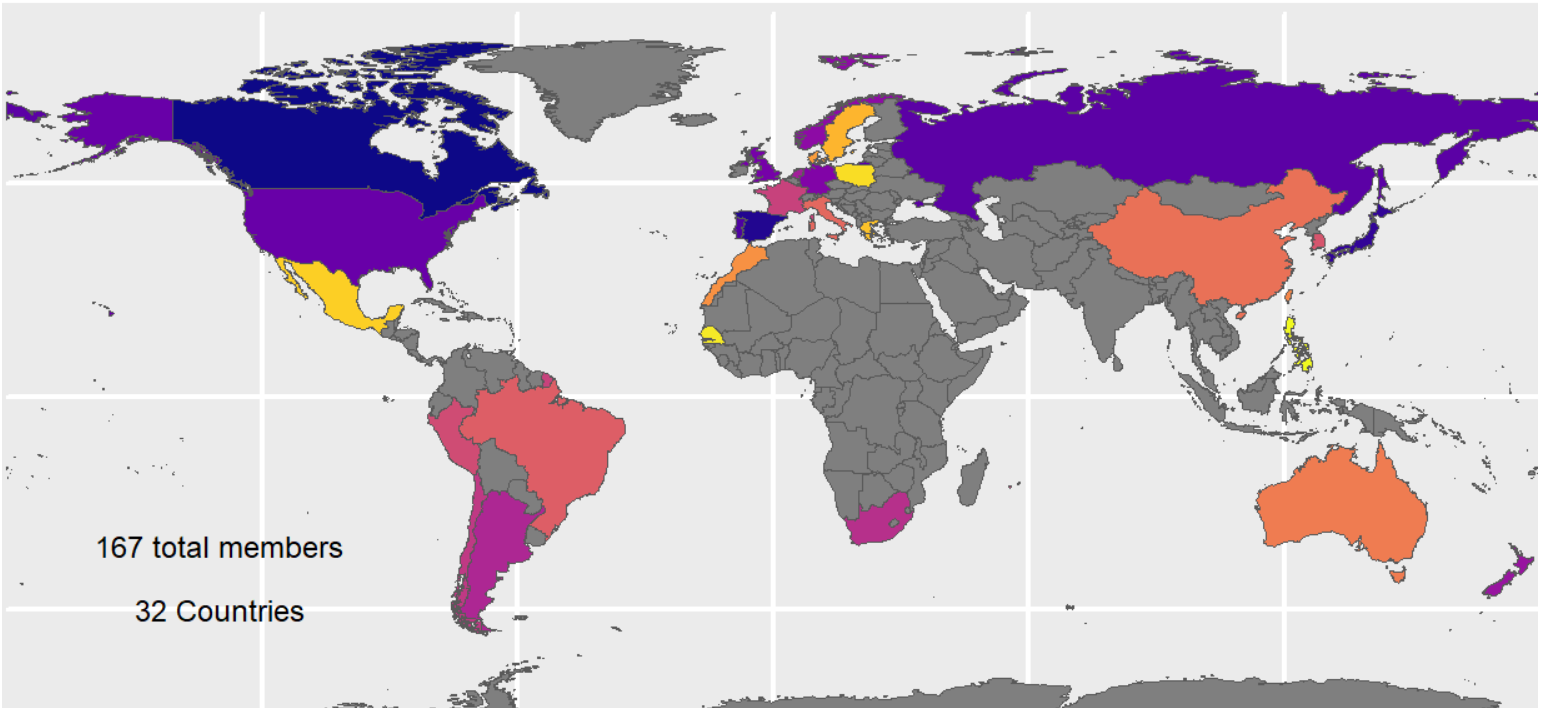




Joint PICES-ICES *Working Group on Sustainable Pelagic Forage Communities* (WG53/WGSPF)



2020-2024, 2025-2028



PICES Members

Canada (6): Rooper C*, Boldt JL, Cleary J, Hunt B, Juanes F, Murphy H

Japan (6): Takahashi M*, Itoh S, Miyamoto H, Sakamoto T, Takasuka A, Watai M

China (6): Jin Y, Ma S, Tian Y, Yu W, Zhang H, Zhang K,

Korea (5): Choi H, Choi M, Ji H, Kang H, Sohn D

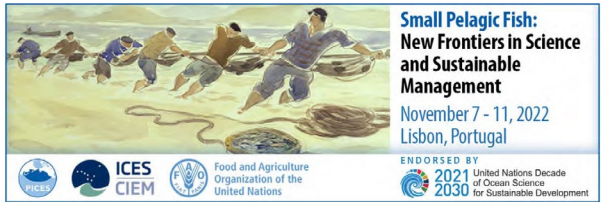
Russia (3): Antonenko D, Dederer N, Radchenko VI

USA (7): Baker M, Brodeur RD, Erisman B, Essington T, Kaplan IC, Rykaczewski RR, Siple M

Ex-officio (3): T. Kitakado (NPFC), K. Oshima (NPFC), A. Somov (NPAFC)

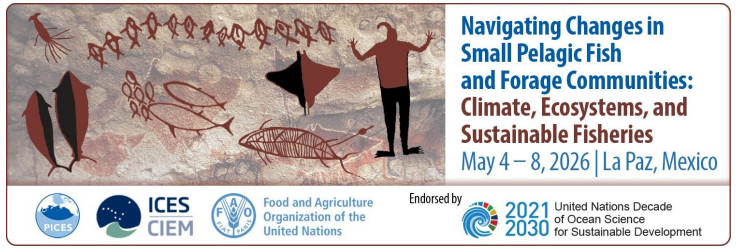
Goals

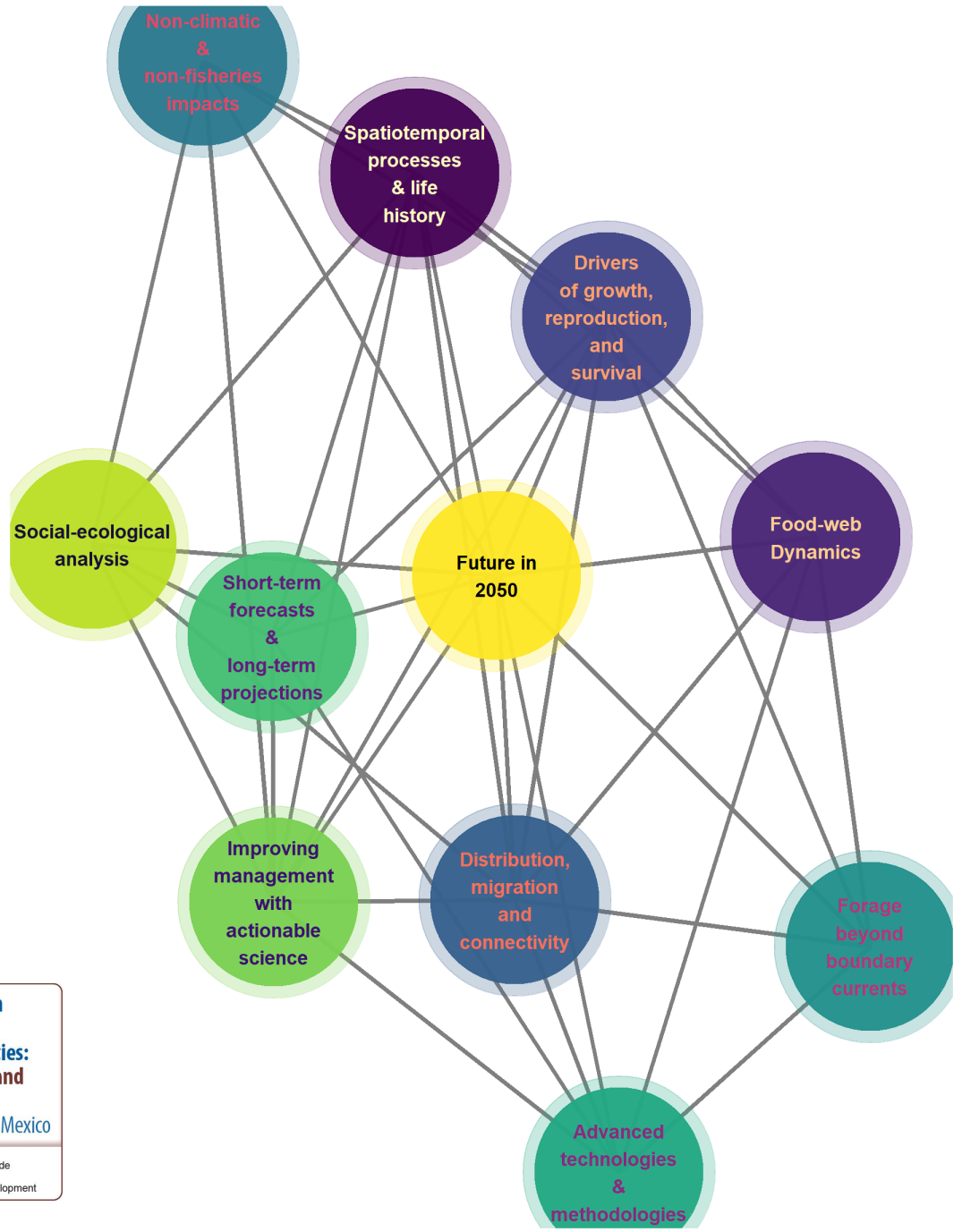
- Foster international and interdisciplinary collaboration
- Understand fluctuations of forage species
- Prioritize, and recommend research to forecast ecosystem responses
- Describe impacts of climate change, variability & other anthropogenic factors
- Improve ecosystem-based management for forage species











Testing paradigms across ecosystems

Takasuka *et al.* Title

Exploring hypotheses of mechanisms behind population dynamics of small pelagic fish: perspectives for compara… and collaborative resea…

Akinori Takasuka

Graduate School of Agricultural and Life Sc…
The University of Tokyo, Japan

"Small Pelagic Fish" Symposium
La Paz, Mexico, May 4–8, 2026
Plenary Session, May 6 (Wednesday)

Takasuka *et al.*

Hypotheses

Major hypotheses

Approximately 50 ideas were extracted from literature and the SPF symposia.

1. **Environmental factors**
   Food availability, Match/mismatch, Trophic dissimilarity, Optimal temperature, Oxygen limitation, Habitat suitability, Spawning habitat, Primary productivity, Climate periodicity, Ocean triads (enrichment, concentration, and retention), Advection and retention, Hydrodynamic forcing
2. **Population and life-history processes**
   Critical period, Starvation, Density dependence, Growth–survival/mortality, Bigger is better, Stage duration, Growth-selective predation, Juvenile mortality, Maternal effects, Reproductive success
3. **Trophic interactions**
   Top-down control, Bottom-up control, Wasp-waist control, Predation, Interspecific competition, Inter- and intra-guild competition, Trophody…
4. **Spatial dynamics and population structure**
   Spatial dynamics, Movement, Metapopulation, Homing, Member–vag… Frontal eddy, Spatial partitioning, Diel vertical migration, MacCall's ba…
5. **Emergent patterns**
   Boom and bust cycles, Regime shifts, Alternating dominance, Global… Winners and losers

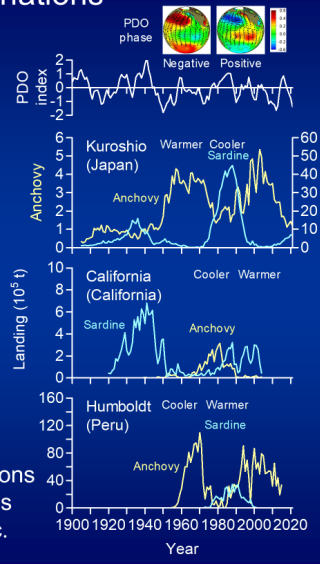
Takasuka *et al.*

Species alternations

Different current systems

Anchovy *Engraulis* spp.
Sardine *Sardinops* spp.





The species alternations tended to be synchronous among the Pan-Pacific regions despite the reversed temperature regimes between the opposite sides of the Pacific.

M. Huret – Decreasing size in Sardine
S9 – Thursday AM

Eye lens isotope tag reveal migration as a driver of Japanese sardine synchrony

Authors
Tatsuya Sakamoto[1,2*], Motomitsu Takahashi[1], Kotaro Shirai[3], Satoshi Kitajima[1], Toyoho Ishimura[4]

1. Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Nagasaki, Japan
2. The Hakubi Center for Advanced Research, Kyoto University, Kyoto, Japan

Progress in Oceanography 247 (2026) 103781

Contents lists available at ScienceDirect

Progress in Oceanography

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

Different migration patterns of European anchovy and sardine around Iberian Peninsula revealed by eye lens isotopes

Tatsuya Sakamoto [a,b,*], Susana Garrido [a]

[a] Instituto Português do Mar e da Atmosfera, Lisbon, Portugal
[b] The Hakubi Center for Advanced Research, Kyoto, Japan

ARTICLE INFO

Keywords:
Eye lens
Stable isotope
Migration
Population structure
Anchovy
Sardine
Fishery management

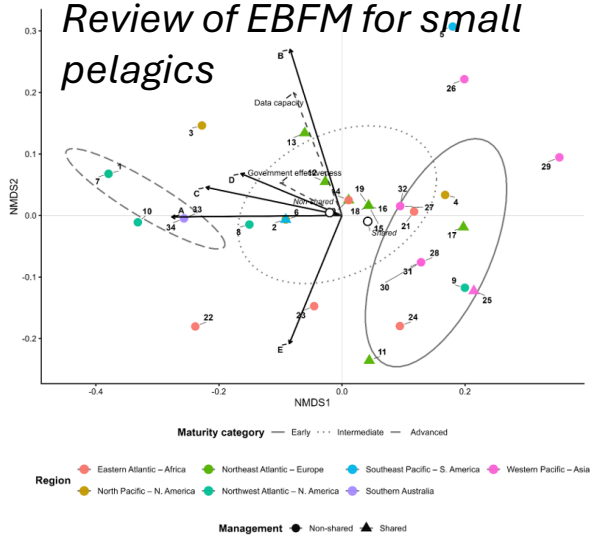
ABSTRACT

Small pelagic fish are key components of productive coastal ecosystems, yet their migration ecology remains poorly understood, causing challenges for management. We applied stable carbon and nitrogen isotope ($\delta^{13}C$ and $\delta^{15}N$) analyses of eye lenses to investigate movements of European anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) around the Iberian Peninsula. Muscle isotopes showed strong spatial heterogeneity, largely consistent between species and reflecting differences in baseline values. Eye lens centres of small anchovy, and to a lesser extent sardine, showed clear geographic variation: higher $\delta^{15}N$ off the Atlantic south coast, lowest $\delta^{15}N$ in the Alboran Sea, and lower $\delta^{13}C$ off the west coast. These patterns persisted across years and fish sizes in anchovy, with only minor outliers, suggesting limited cross regional migration. An exception was the overlap

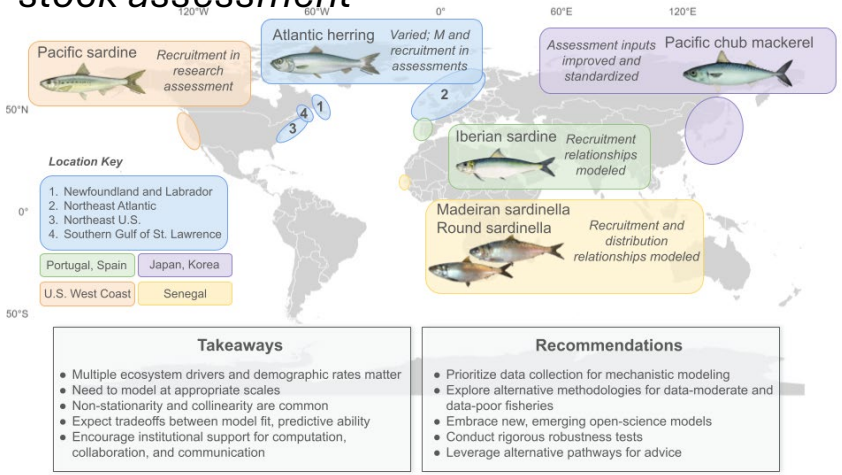
Collaboration and knowledge exchange

- Methods to detect migration in Japanese Sardine applied to Iberian sardine stocks (*Sakamoto & Garrido 2026*)

Szalaj et al. in review – *Review of EBFM for small pelagics*



Jensen et al. in review – *Best practices for including environmental variables in stock assessment*



Comparative reviews with recommended best practices

Collaborative papers on bigger questions



Progress in Oceanography 191 (2021) 102494

Contents lists available at ScienceDirect

Progress in Oceanography

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

Small pelagic fish in the new millennium: A bottom-up view of global

REVIEWS IN FISHERIES SCIENCE & AQUACULTURE
2025, VOL. 33, NO. 4, 497–558
https://doi.org/10.1080/23308249.2025.2458869

Taylor & Francis

OPEN ACCESS

Worldwide Appraisal of Knowledge Gaps in the Space Usage of Small Pelagic Fish: Highlights Across Stock Uncertainties and Research Priorities

Ignacio A. Catalán[a], Noelle M. Bowlin[b], Matthew R. Baker[c], Florian Berg[d], Aaron Brazier[a], Timothée Brochier[f], Jana M. Del Favero[g], Susana Garrido[h], Douglas F. M. Gherardi[g], Stefanie Haase[j], Martin Huret[l], Matthias H. F. Kloppmann[k], Jeroen van der Kooij[e], Luiz Eduardo de Souza Moraes[i], Marta Moyano[m,n], Richard D. M. Nash[e], Carolina Parada[o], Myron A. Peck[p], Patrick Polte[i], Isabel Riveiro[q], Motomitsu Takahashi[r], Mariano Gutiérrez[s], Sebastián I. Vásquez[t,u] and Andrés Ospina-Álvarez[a]

[a]Mediterranean Institute for Advanced Studies, (IMEDEA, CSIC-UIB), Esporles, Balearic Islands, Spain; [b]NOAA Southwest Fisheries Science Center, USA; [c]North Pacific Research Board, Anchorage, AK, USA; [d]Institute of Marine Research (IMR), Bergen, Norway; [e]Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Lowestoft, UK; [f]IRD, Sorbonne Université, UMMISCO, Bondy, France; [g]Laboratory of Ocean and Atmosphere Studies (LOA), Earth Observation and Geoinformatics Division, National Institute for Space Research (INPE),

FISH and FISHERIES

ORIGINAL ARTICLE OPEN ACCESS

Advancing Ecological Understanding and Sustainable Management of Small Pelagic Fish

23 authors - 11 nations

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Correspondence: Myron A. Peck (myron.peck@nioz.nl)

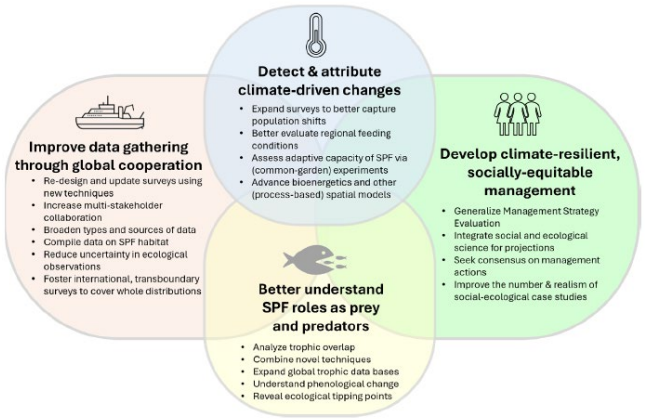
Received: 3 February 2025 | **Revised:** 11 March 2026 | **Accepted:** 29 March 2026

ABSTRACT

Small pelagic fish (SPF) are critical to the trophodynamic structure and function of marine systems and support some of the most valuable and socially important fisheries worldwide. Their "boom and bust" population dynamics, shifts in distribution, and importance as forage resources for other fish stocks place unique challenges to assessing and managing SPF. In response to these challenges, an international working group was formed in 2019 to foster collaboration aimed at closing key knowledge gaps in the ecology and sustainable management of SPF. Here, that group reviews progress made over the last ~10years and identifies priorities for the next stage of coordinated international collaboration. Key research needs include: (i) enhancing monitoring programs to capture shifts in SPF distribution and incorporating new technologies, from molecular tools and digital imaging to biophysical and ecological modelling, (ii) improving data sharing to better understand life-history bottlenecks and cross-regional population dynamics, (iii) advancing process-based studies on oceanic and trophodynamic interactions to clarify the ecological roles of SPF as both predators and prey, and (iv) conducting bioeconomic and risk analyses to assess the vulnerability of fishing-dependent human communities to environmental and fish population fluctuations. A key pathway forward involves integrating mechanistic ecological knowledge, ecosystem and bioeconomic modelling, and social-ecological frameworks into real-time, adaptive, and equitable management approaches. This integration will be essential for developing resilient, ecosystem-based

https://doi.org/10.1111/faf.70086

Synthesis and Recommendations (2020 to 2024)





La Paz, February 2024

Recommendations for future work

In the short-term (1–5 years)

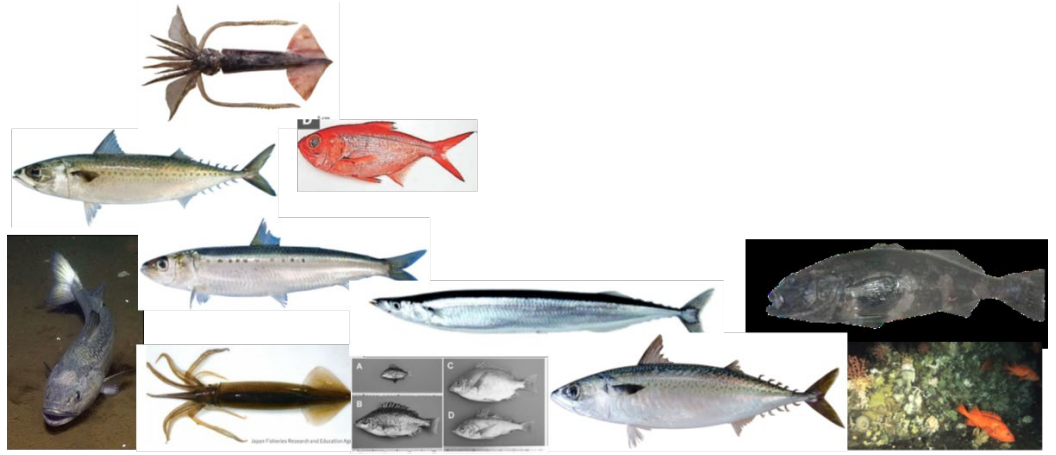
1. Investigate robustness of assessment models and management advice to bias and uncertainty in survey observations and ecological processes to improve fishery resilience as marine economies and ecosystems change due to global drivers.
2. Investigate bottom-up forcing of SPF dynamics through planktonic prey interactions by integrating the fields of fisheries oceanography, physiology, and population dynamics and by using innovative technologies (e.g., eDNA, fatty acid tracer analyses, autonomous observation platforms, AI, etc.) as they develop.

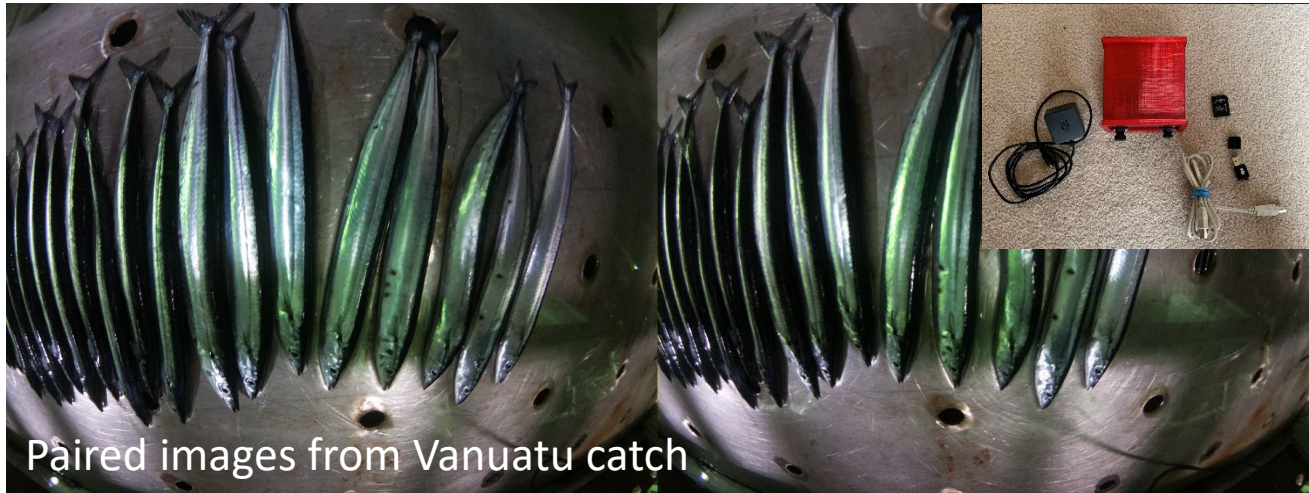
In the longer-term (5+ years)

3. Redouble efforts to increase coverage and resolution of socioeconomic and natural history datasets to improve mechanistic understanding of the roles SPF play in socioecological systems and achieve closure of their life history.
4. Establish responsive, effective management frameworks to quickly and nimbly observe, assess, and respond to changes in SPF dynamics to ensure equitable and sustainable harvests.

PICES-ICES JOINT WORKING GROUP RESEARCH

- **Provides direction**
  - **For researchers**
  - **For agencies**
- **What are the main knowledge gaps**
  - **Where should time/effort be spent**
  - **Technology/methods transfer**
- **Best practices**
- **Synthesis of global knowledge!**







Conclusions and key thoughts

- Expansion of participation is needed (both individuals and themes)
- PICES is a venue for collaboration across systems/technologies
- PICES supports enhanced and continued monitoring
- Integration of products into management (particularly in RFMOs)
- Better communication of where we can and do contribute to actionable science

Acknowledgements

Thank you to:

- Jennifer Boldt
- Sarah Hawkshaw
- Jaclyn Cleary
- Hilari Dennis-Bohm
- Matt Thompson
- Janelle Curtis
- Devon Warawa
- Christina Conrath
- Pam Goddard
- Lauri Sadorus
- Kim Rand
- Jackie King
- Rick Towler
- Canada's NPFC Delegation
- Andrew Edwards
- Dorota Szalej
- Alexander Jensen
- Sean Anderson
- Jim Thorson
- Kresimir Williams
- Myron Peck
- Akinori Takasuda
- Susana Garrido
- Rebecca Asch
- Motomitsu Takahashi
- Cynthia Bluteau
- Tetjana Ross
- Jennifer Jackson
- Akash Sastri
- Caihong Fu
- Stéphane Gauthier

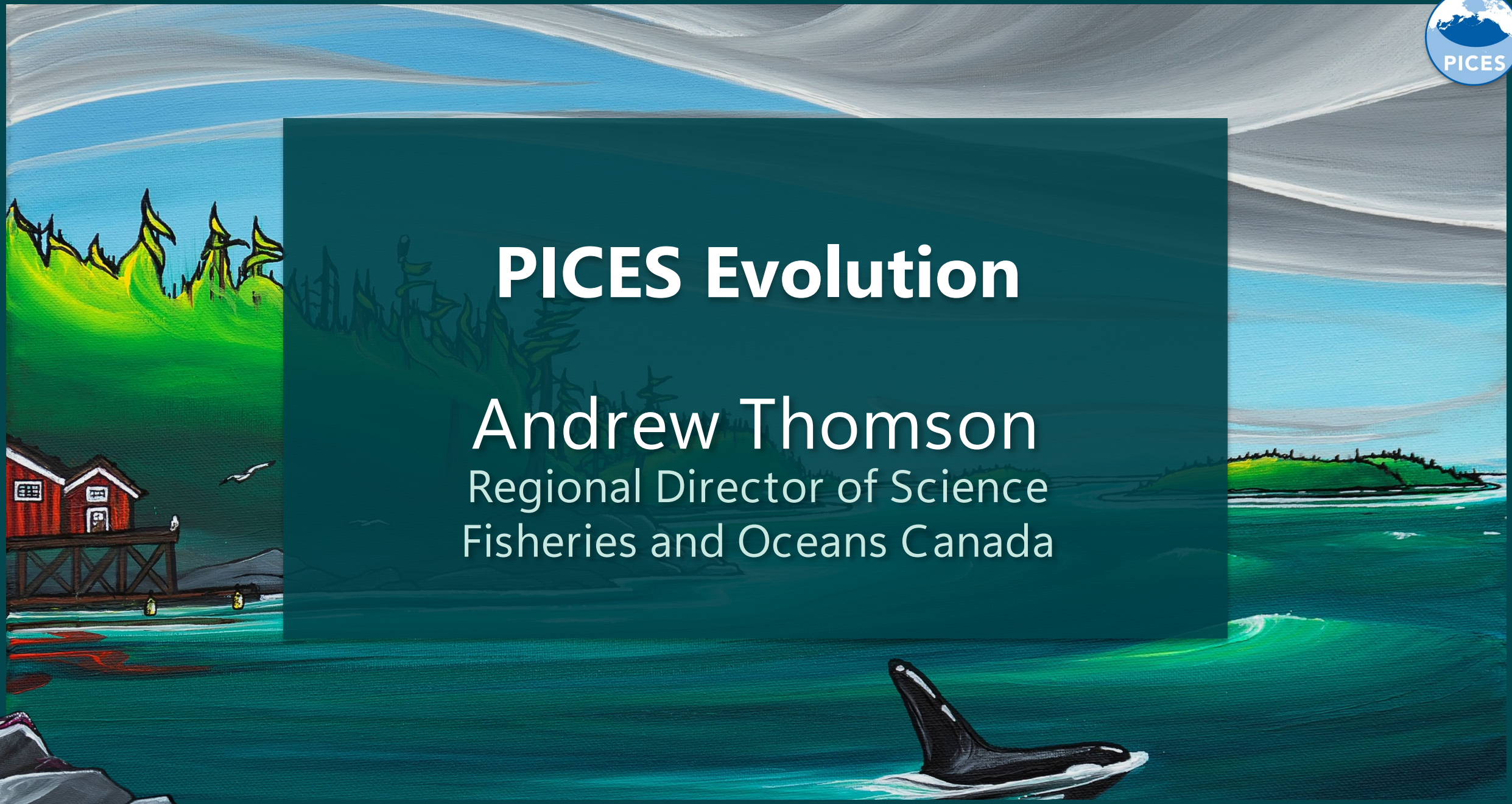


Contact information:

Chris.Rooper@dfo-mpo.gc.ca

011-250-327-4857

This research was completed on the traditional and unceded territory of the Coast Salish Peoples, mostly on the traditional territory of the Snuneymuxw First Nation.



PICES Evolution

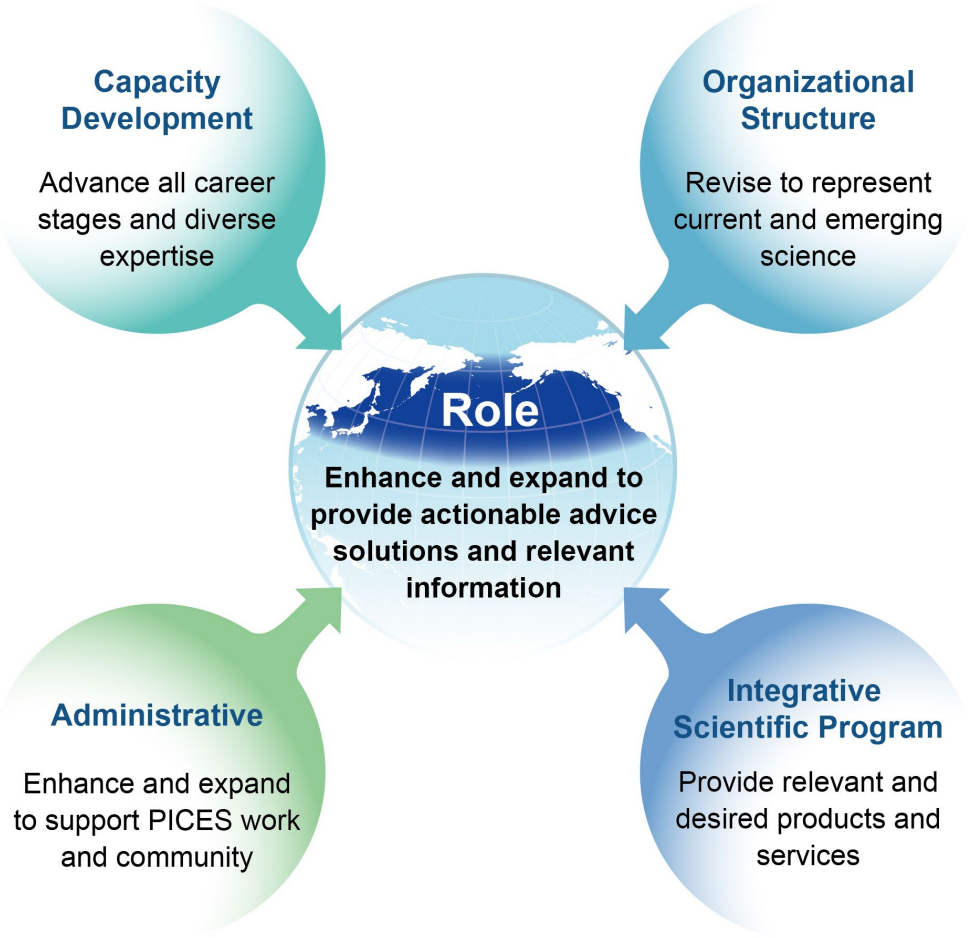
Andrew Thomson

Regional Director of Science
Fisheries and Oceans Canada

PICES evolution

Progress on the response to PICES external review





Recap - history and timeline



PICES-2025 Town hall

External Review agreed

Report & recommendations presented

Mission statement revised

WG-58 (Strategic Plan revision) created

2022 | 2023-2024 | Late 2024 | PICES-2024 | PICES-2025 | 2026+

Review Panellists invited, Panel formed, attended PICES-2023, visited Secretariat, many interviews.

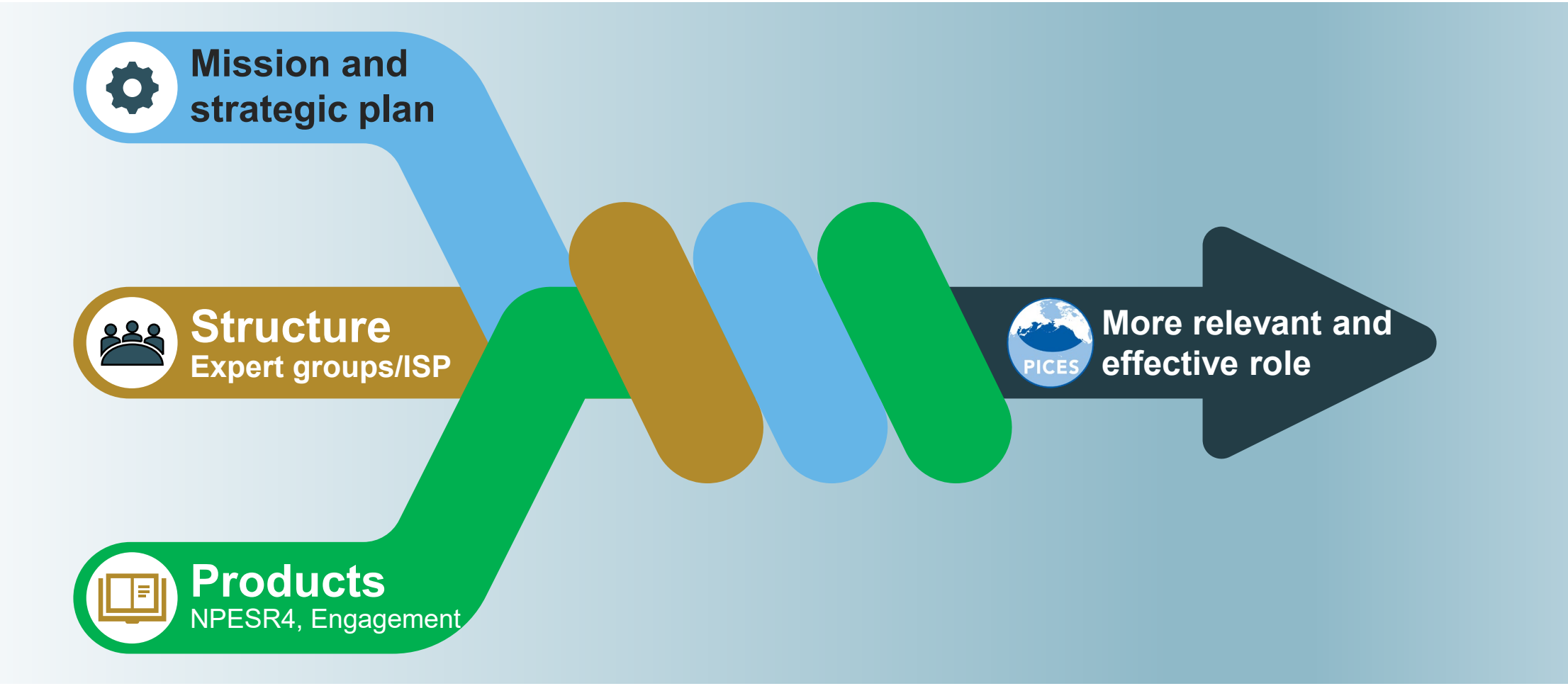
Panel at PICES-2024, solicited comments from community & partners, SG-ERRR created

Now we are here….

The Panel's recommendations had five main themes:

Role	• Enhance and expand to focus on relevant and actionable science
Structure	• Revise Expert Group structure as needed to deliver new role, and reflect current and emerging science
Integ. Science Prog	• Review FUTURE at its conclusion • Plan and implement a new ISP that reflects new Role
Admin	• Annual meeting changes in response to feedback • Secretariat support – explore new methods
Capacity dev	• Strategic partnerships and engagement • Advance all career stages

One challenge in addressing these recommendations is that it involves a number of simultaneous activities that inform each other :



PresentationGO.com

Some (easier) things have been completed……..



PICES conducts and coordinates marine research and the exchange of knowledge across the North Pacific Ocean to provide member states with actionable information on the current and future conditions of the ocean environment and its resources, including the interactions among the atmosphere, ocean, marine ecosystems and human dimensions. PICES brings together academic researchers, government scientists and managers, and organizations responsible for the protection and sustainability of the North Pacific Ocean to inform decisions and actions.

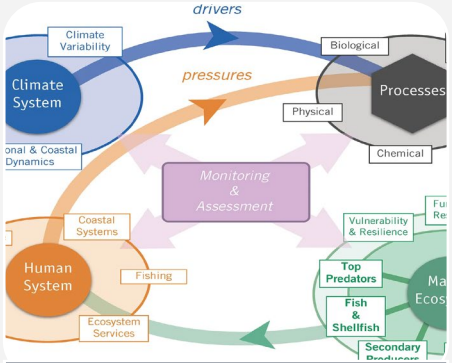
New Mission Statement adopted at PICES-2025.





Annual meetings are shorter now, with some format changes.

.....and others are in progress



FUTURE is ending at PICES-2026

There will be a review and a proposal for a new study group to develop the next ISP



A Study Group was created in 2025 and is planning the 4th edition of the North Pacific Ecosystem Status Report

A Working Group is focused on revising the Strategic Plan, based on detailed responses from

1. member countries
2. partner organizations

The Study Group on the next North Pacific Ecosystem Status Report (NPESR4) has……

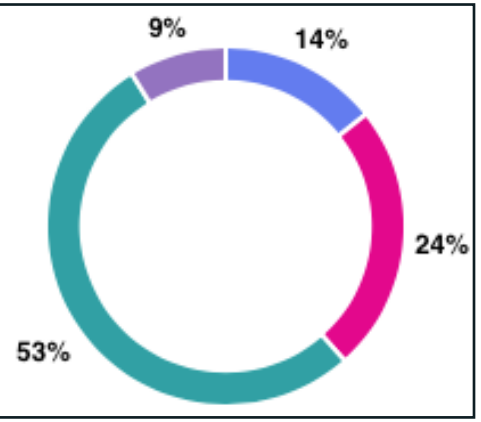
Reviewed NPESR3 and other reports

Held a survey of the PICES community on what they want for NPESR4

Will prepare a draft structure and ideal outputs for this meeting

Finalize implementation plan for next spring

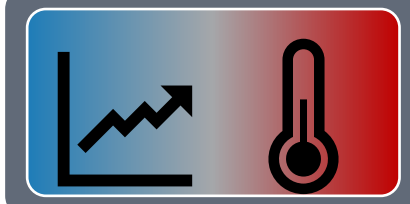
A synthesis report only (with optional ad-hoc reports on specific regional events)	13
A synthesis report and Regional sub-reports describing changes in physical, biogeochemical,…	22
A synthesis report and "Thematic sub-reports" (e.g., on climate, oceanography, ecosystem, fisheries,…	48
Other	8



WG on Strategic Plan Revision progress

A letter was sent to member countries, requesting priority and upcoming needs from PICES.
Multiple agencies and departments have been consulted.
Four national responses received (two are in final stages of synthesis and will be added soon)

Already, clear commonalities exist:



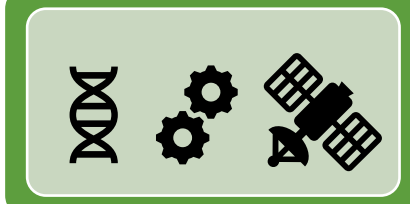
Climate impacts, ocean warming and adaptation

- “Forecasting hemispheric heat waves”
- “Monitoring Ocean warming, acidification, deoxygenation and sea-level rise”
- “Enhancing resilience to climate-related risks”



Sustainable fisheries and ecosystem-based management

- “Adapt management to changing ecosystems”
- “Providing scientific data for ecosystem-based management”
- “Predict food distribution and fish stock changes”



Emerging technologies, data Integration and shared observations

- “Leveraging AI, big data…promote data sharing”
- “Integrate ‘omics, AI, satellite sensing”
- “Joint research and information exchange…..ecosystem modeling”

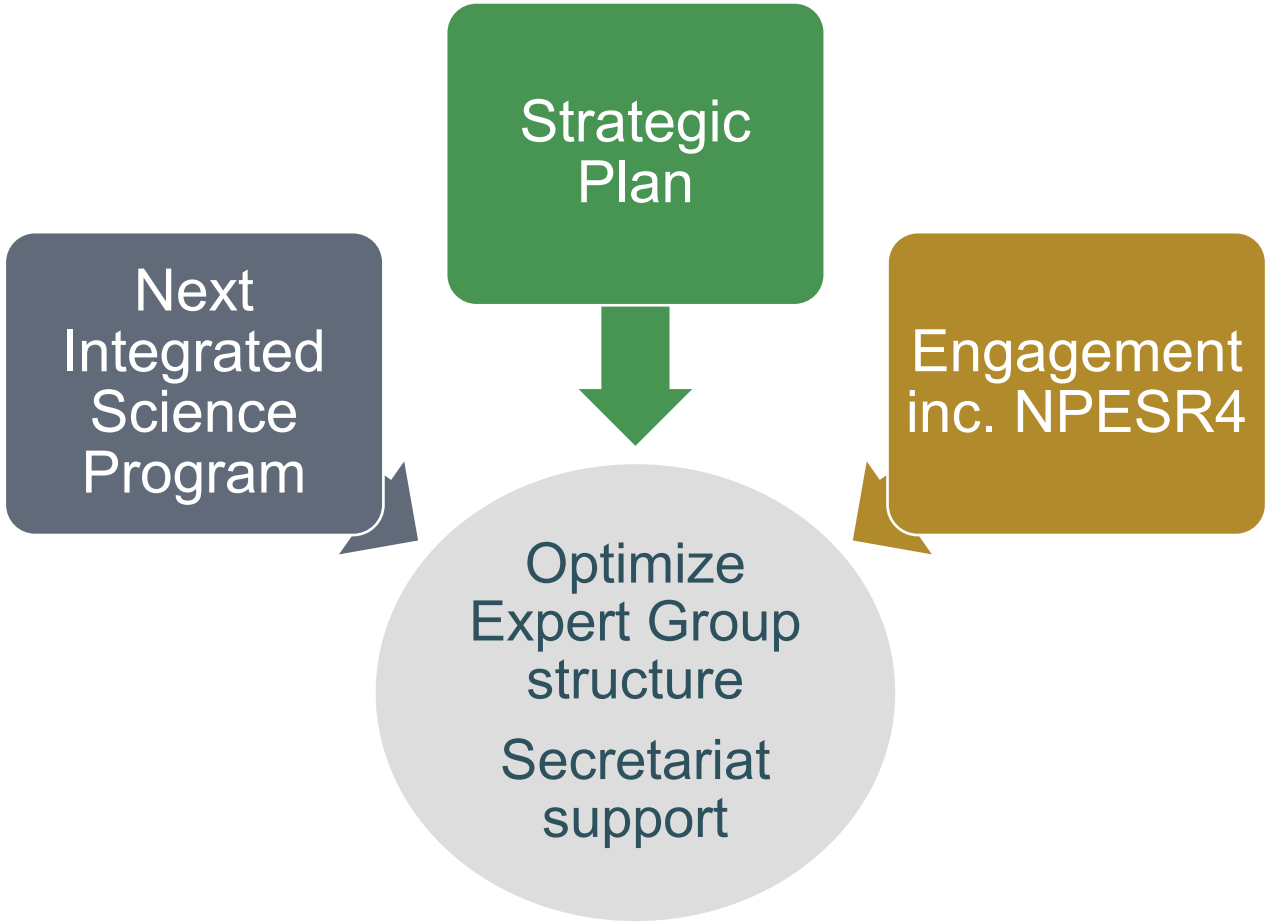


Marine ecosystem health (pollution and habitat degradation) and biodiversity

- “Scientific efforts are directed toward conserving marine biodiversity beyond national jurisdictions”
- “Research marine debris, especially plastics”
- “Understanding trends and drivers affecting key species and habitats”

So, this is very much a work in progress!

Multiple efforts focusing now on what PICES *SHOULD* do



And then next we will determine the *HOW*….

Questions?

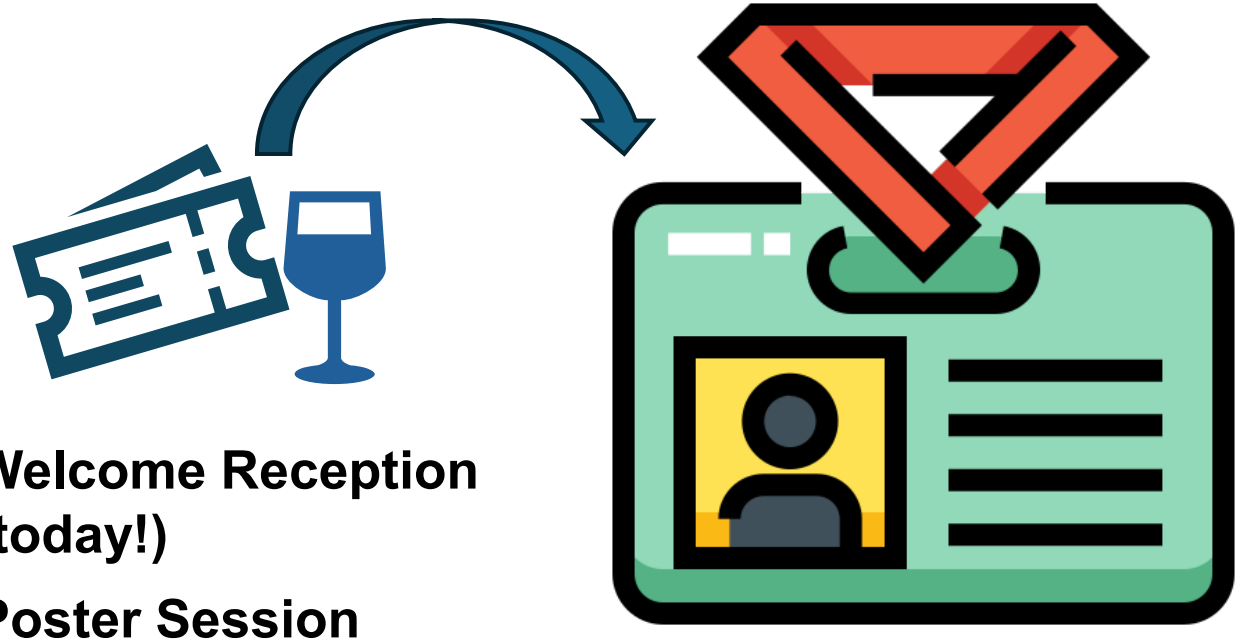
Logistics Announcement

Tips to make your days easier at PICES-2026

Sanae Chiba
PICES Deputy Executive Secretary

Essentials to Survive

Your name tag is your passport



Welcome Reception (today!)

Poster Session (Wednesday)

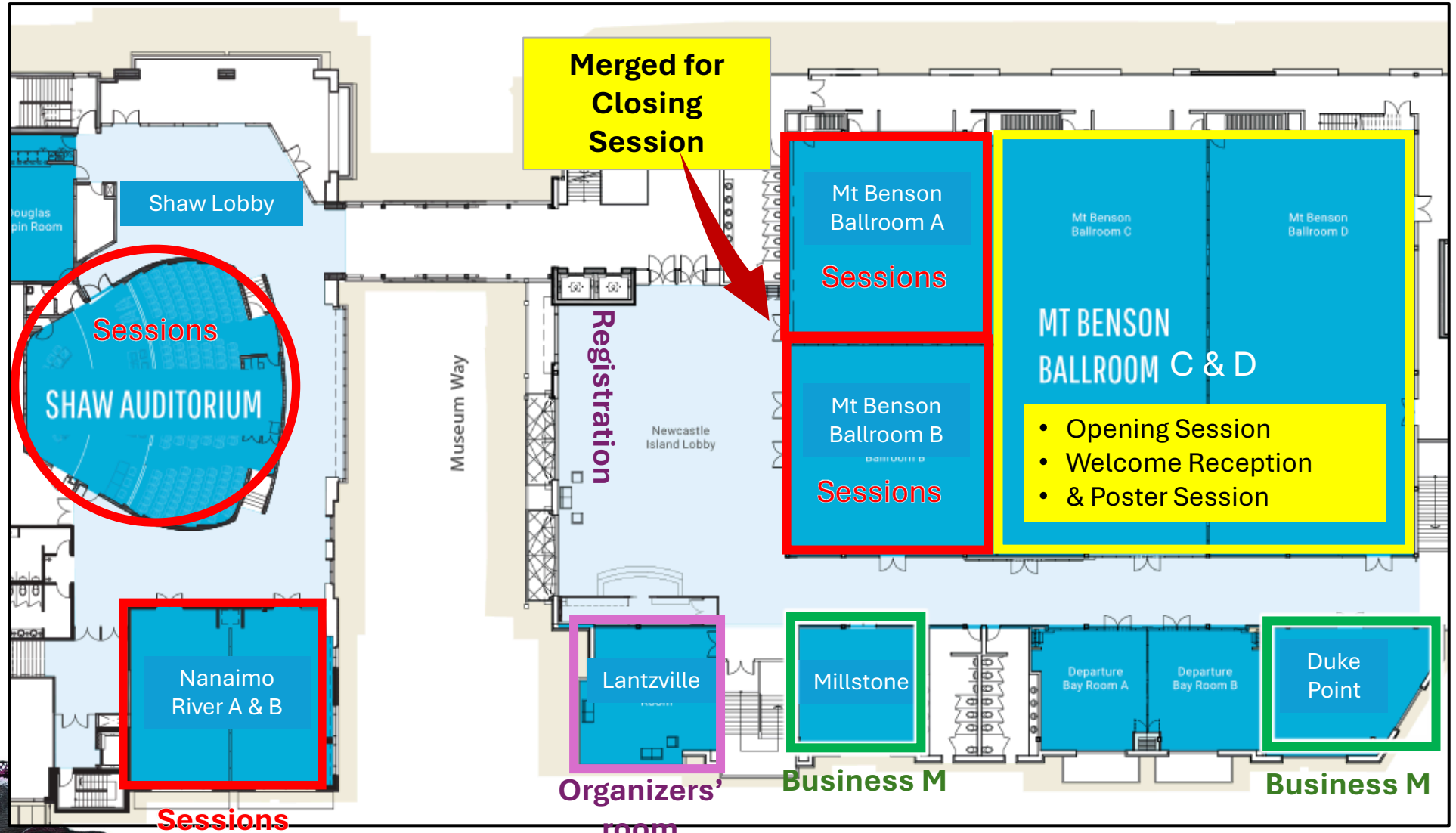
Ware your name tag in the Venue and at the social and side event venues



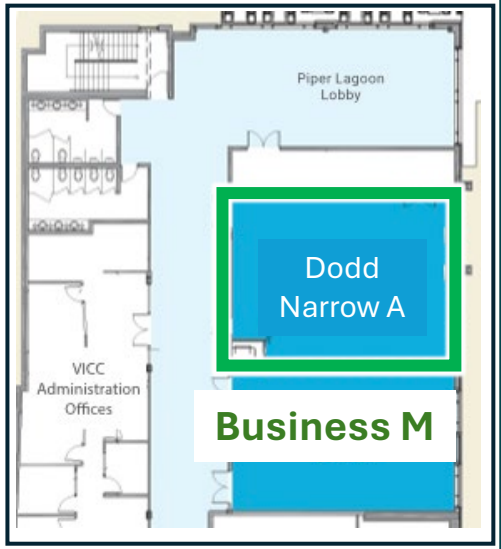


Floor Map

Upper level



Lower level



Venue Policy for Outside Food

Please note…

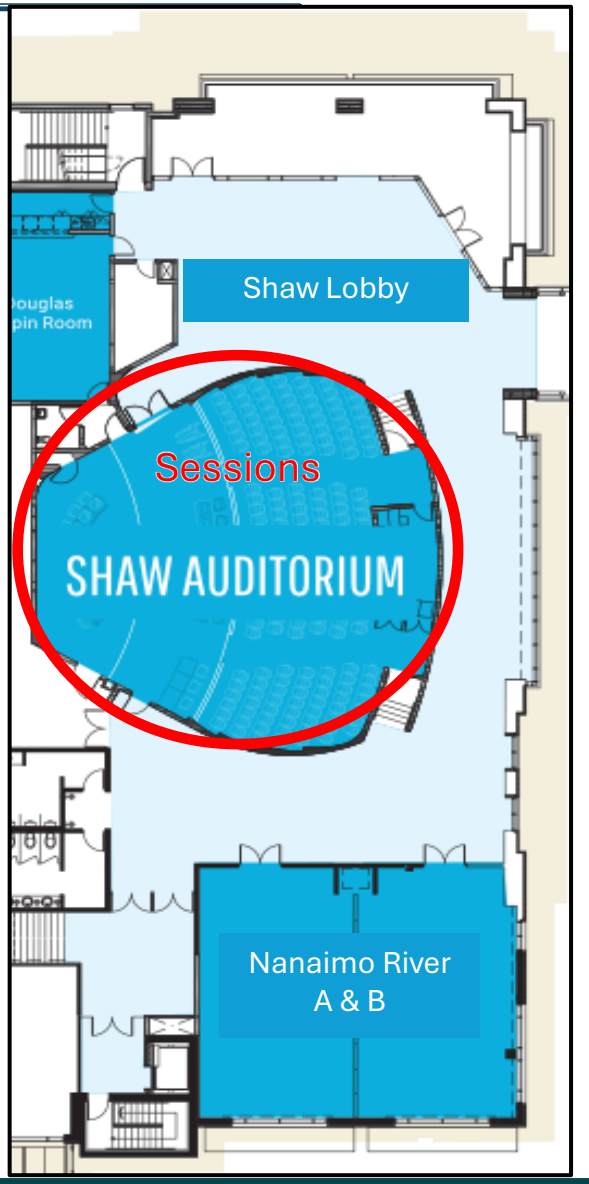
Bringing and eating takeout food inside the conference centre is not permitted.



Explore local Nanaimo gourmet dining!



A limited amount of light food will be available to purchase during lunchtime at a location behind the Shaw Auditorium.



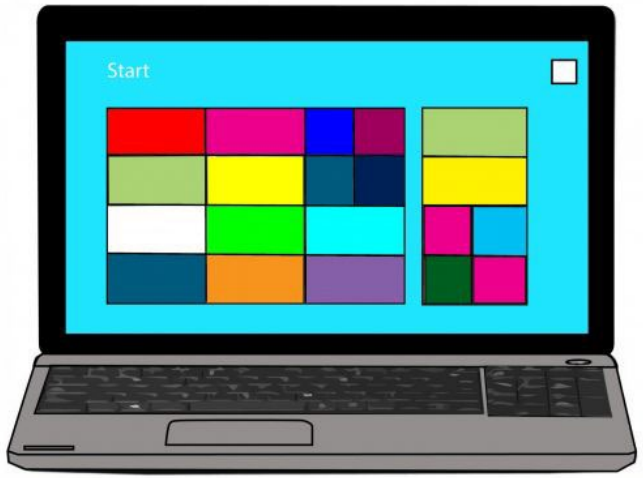
Whova Helps

Use **Whova** for planning your schedules, latest updates, social events, side events, session poll etc.





Or



Take candid photos, and post them on 

Welcome Reception

This evening!

Ballroom C&D

18:00 - Welcome by Andrew Thomson, Regional Director of Science, DFO

18:05 - Cultural Performance by Qwam Qwum Stuwixwulh Singers and Dancers of Snuneymuxw First Nation

Ballroom C&D and lobby area

18:30: Reception continues with Food and refreshments



Qwam Qwum Stuwixwulh Singers and Dancers of Snuneymuxw First Nation

PICES Sports Event

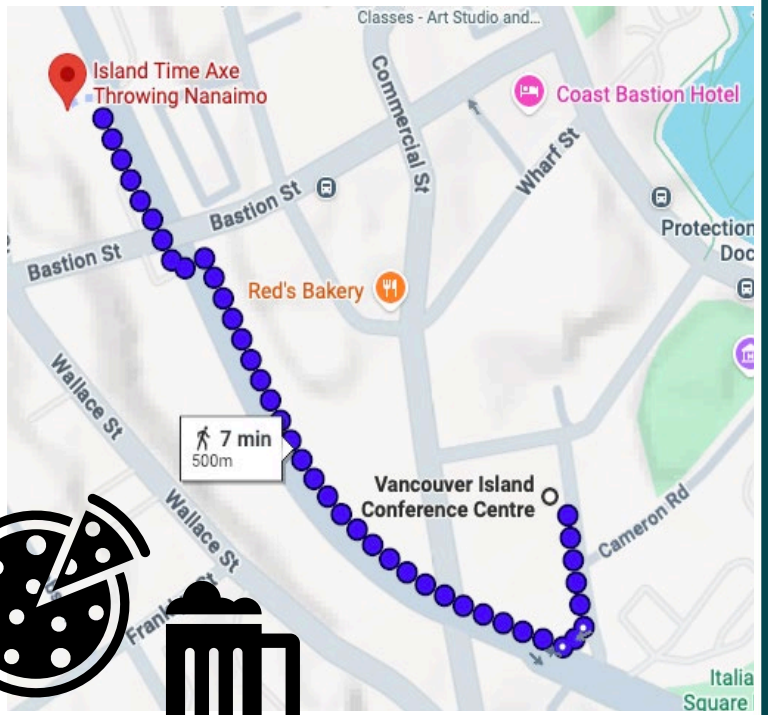
October 27 (Tue) at Island Time Axe Throwing

18:00 and 20:00 (2 sessions)



- **48** participants for each session
- Sign-up sheets and waivers are at the registration desk in PM today
- Participants to meet at the registration desk **15 min before** the session for a guided walk (on Gordon St)
- Pizza & beer will be served

500 m from VICC



Poster Session

It's Wednesday!!

18:00-20:30, October 28 (Wed) at Mt Benson Ballroom C&D

Light snacks and drinks are served



Don't forget your drink tickets!

Poster Presented for;

Oct 27 (1400-2030)
Oct 28 (0900-2030)
Oct 29 (0900-1530)



Poster Presentation

- Mount your poster from **14:00 -** on Oct 27 (Tue)
- Attend at your poster for **18:30 - 19:30 during Poster Session** on Oct 28 (Wed)
- Take down the poster before **15:30** on Oct 29 (Thu)



Side Events

October 29 (Thur), Tour of the Pacific Biological Station (PBS): AM and PM tours

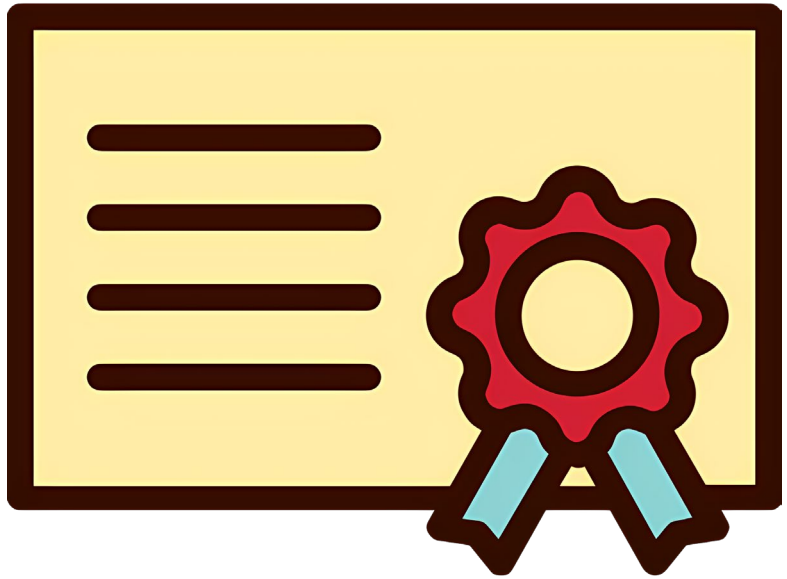
- **50** participants for each session
- Sign-up sheets and waivers are at the registration desk in PM today
- Bus starts at VICC entrance on Gordon St.

	AM Tour	PM Tour
Meat at the bus in front of VICC	9:45	12:45
Arrive at PBS	10:00	13:00
Leave PBS	12:00	15:00
Arrive at VICC	12:20	15:20



Closing Session

16:00 – 17:00: Oct 29 (Thur)

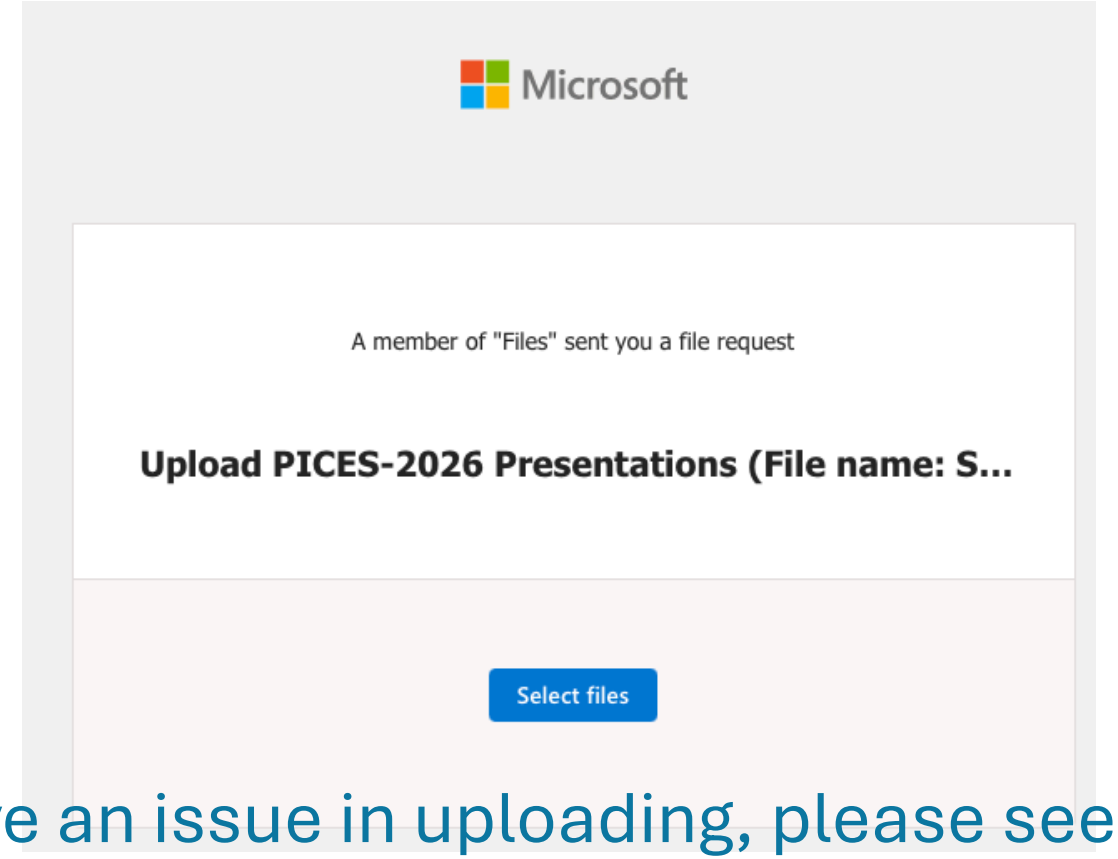


Don't miss!

ECOP Presentation Awardees will be announced!

Upload Your Presentation File

Upload your presentation file **48 hr** before your Session through the link mailed to you.



If you have an issue in uploading, please see Ms. Julia Yazvenko in the Secretariat Room (Lantzville)

We are Family, We are PICEAN





Celebrate diversity
and
Communicate thoughtfully





Lunch time ☺



Enjoy lunch
and be back before
the afternoon
Sessions start!