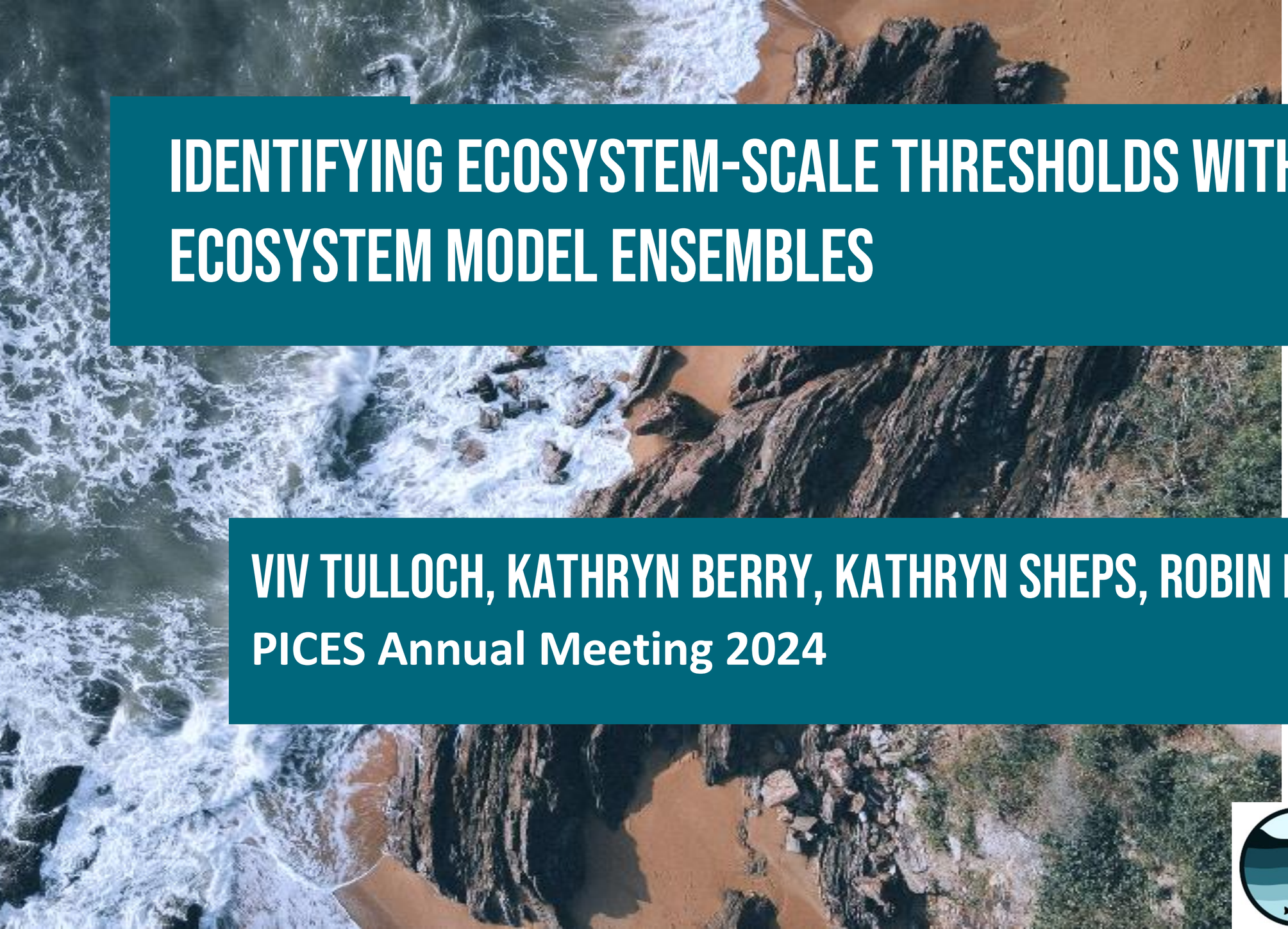

IDENTIFYING ECOSYSTEM-SCALE THRESHOLDS WITH MARINE ECOSYSTEM MODEL ENSEMBLES

VIV TULLOCH, KATHRYN BERRY, KATHRYN SHEPS, ROBIN BROWN

PICES Annual Meeting 2024

BECI
Basin-Scale Events & Coastal Impacts

BACKGROUND

Co-developed by PICES and NPAFC
Hosted by PICES

Endorsed by UNDOS

Funded by BC Salmon Restoration & Innovation Fund

Collaborative partners:

- North Pacific Fisheries Commission
- Pacific States Marine Fisheries Council
- Long Live the Kings
- NOAA
- DFO
- FishMIP

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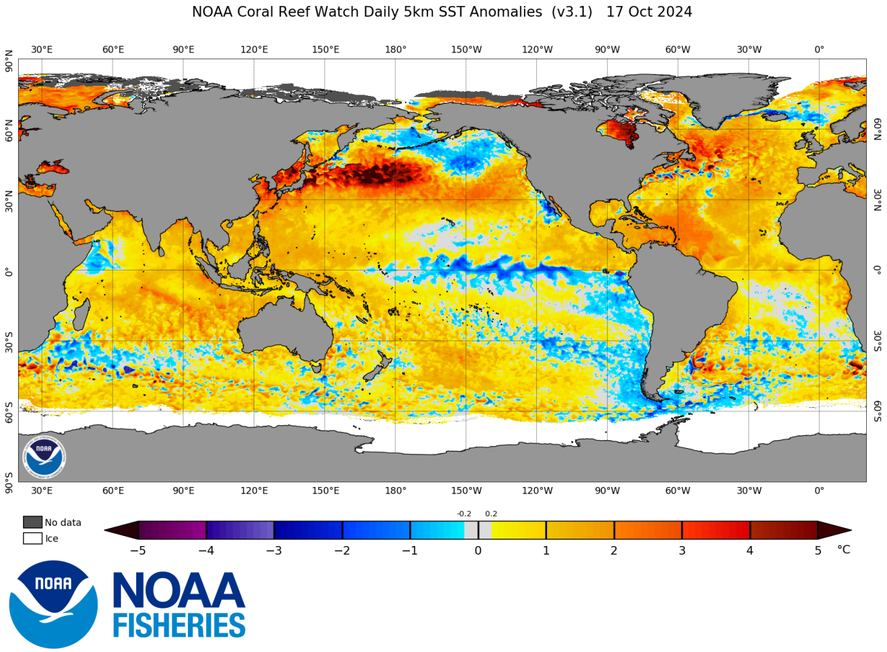
PICES

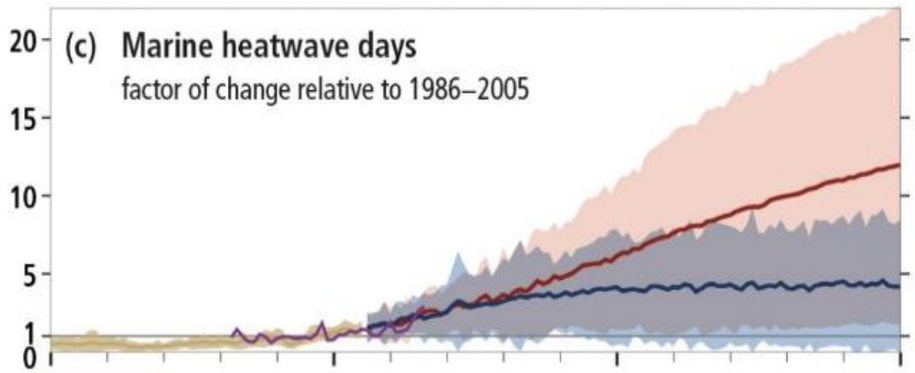
NPAFC

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

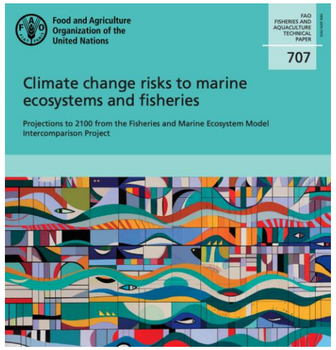
CLIMATE CHANGE IN THE NORTH PACIFIC

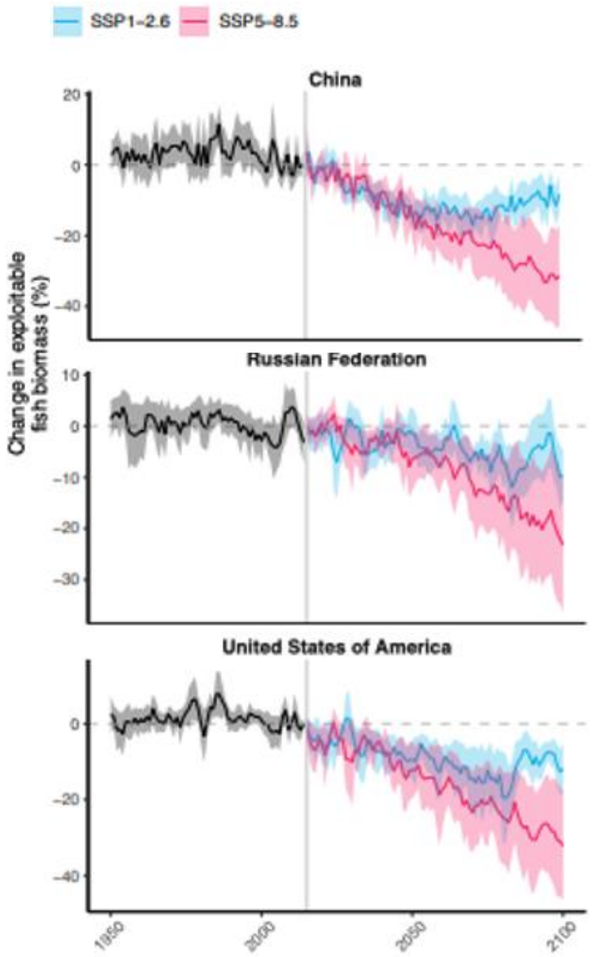
- Significantly impacting the world's oceans and marine resources
- Huge variability spatially and temporally in projections, and predicted impacts
- Exploitable fish stocks are projected to decline for most of the world's ocean regions this century
- Climate and fishing interact in a cumulative manner to impact ecosystems
- **Challenging traditional fisheries management approaches**





IPCC Special Report IPCC 2019. The Ocean and Cryosphere in a Changing Climate, Fig SPM.1



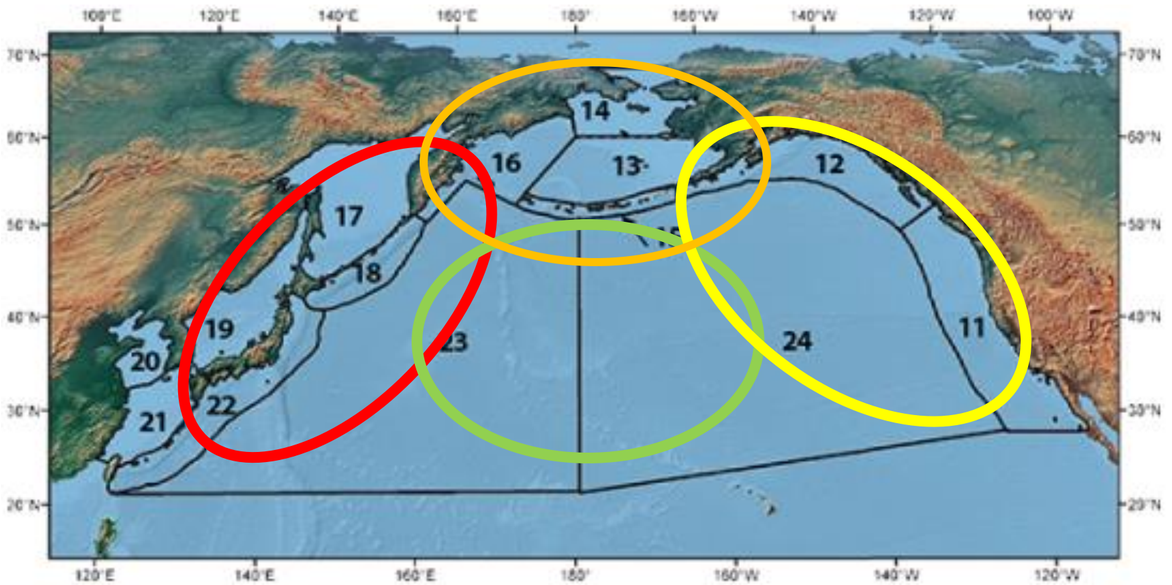


Blanchard et al., 2024

BECI Basin-Scale Events & Coastal Impacts

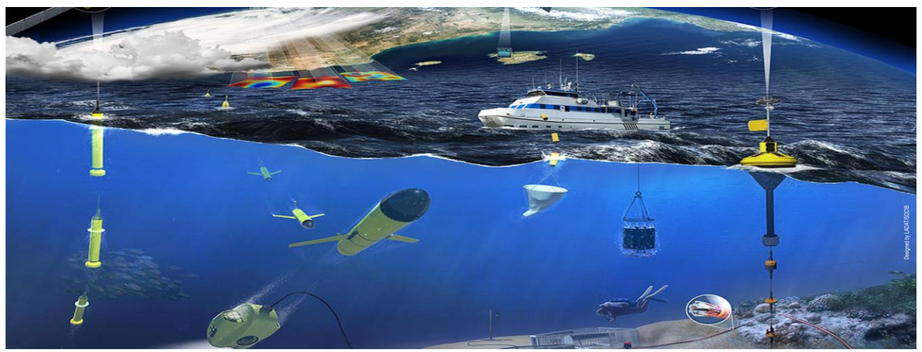
MISSION, SCOPE, OVERARCHING OBJECTIVES

Our mission is to provide researchers, resource managers, and policymakers with comprehensive, actionable information and tools to support climate-informed decision-making



Coordinate international efforts to:

- Assess climate-driven impacts on transboundary and common fishery resources across the North Pacific
- Improve predictions of climate-driven changes at regional and basin scales that account for uncertainty
- Support sustainable resource management, protect marine biodiversity, and enhance ecosystem resilience



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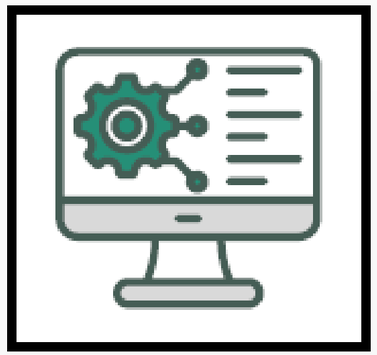
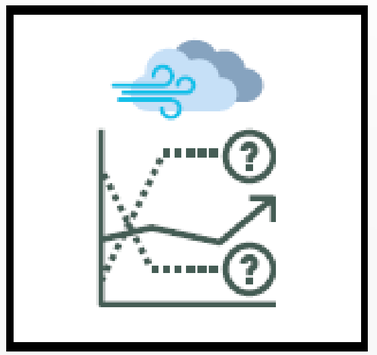
DECISION SUPPORT TOOLKIT AND WORKFLOW

Information Integration & Analytics

Decision Science





International Collaboration & Knowledge Exchange

Engagement with:
RFMOs
NOAA/DFO
FishMIP/ISIMP
Indigenous stewardship

Predictive Modelling

Statistical models
Qualitative models
Expert Elicitation
Risk assessment
Population models
SDMs
Ecosystem models

Structured approach to using data to inform decisions based on values and objectives

Environmental Monitoring & Research

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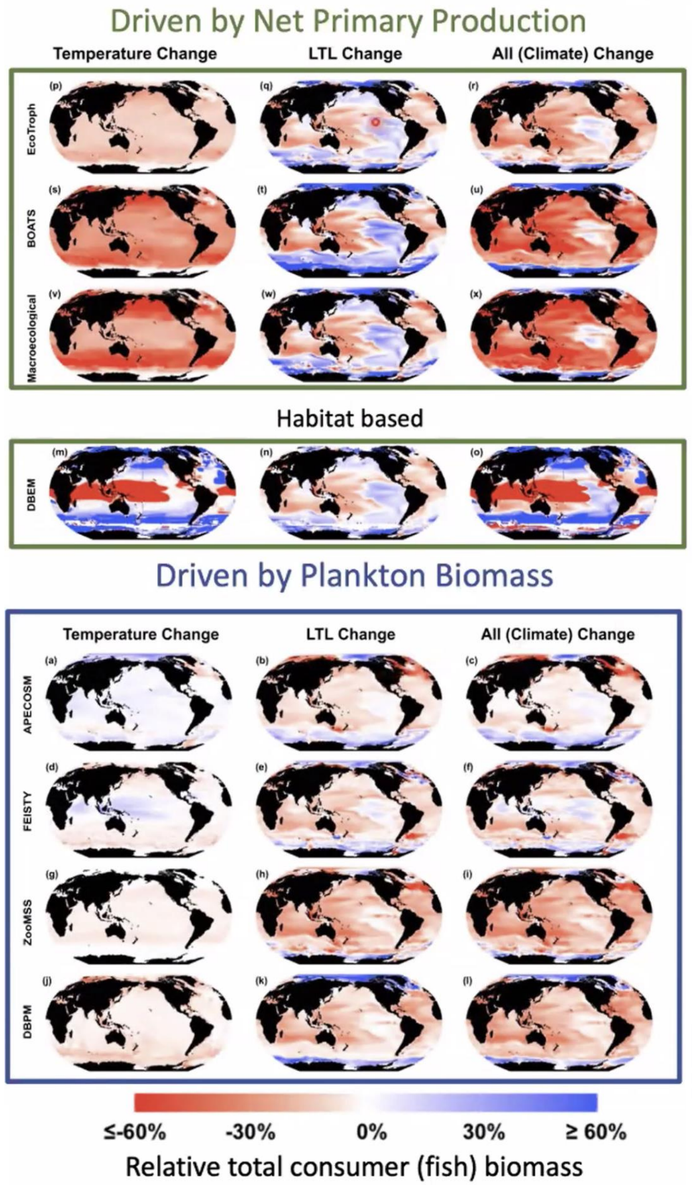
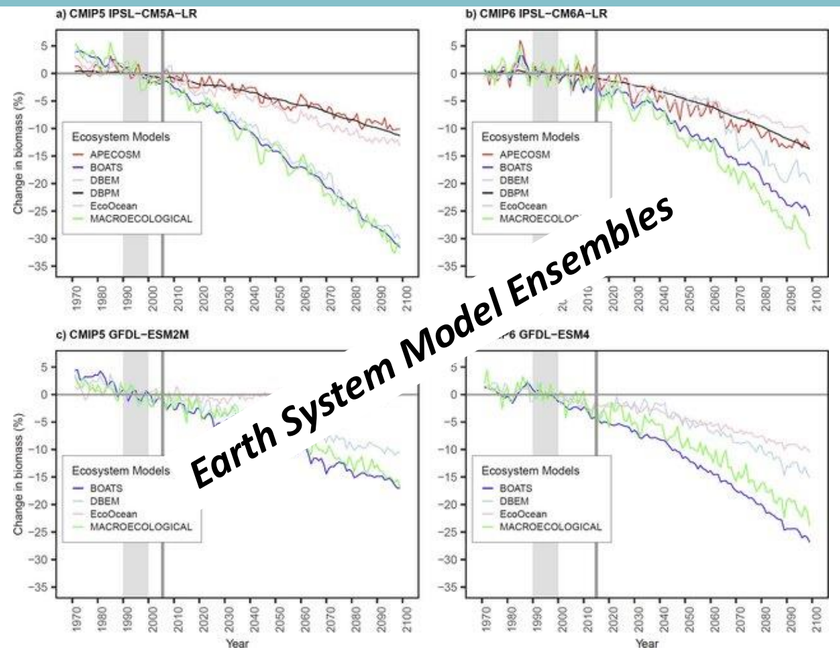
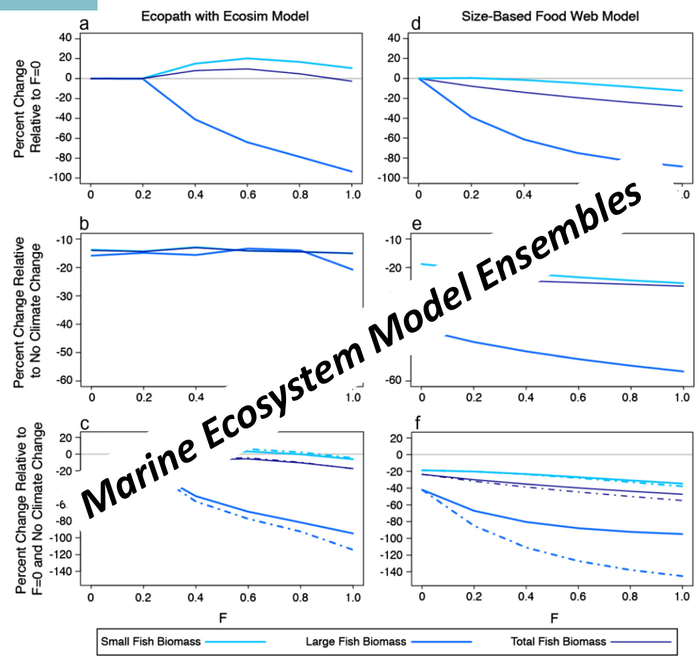
CLIMATE CHANGE VARIABILITY AND UNCERTAINTY



Heneghan et al. 2021



Tittensor et al. 2021 Nat. Clim. Chng



Woodworth-Jefcoats et al. 2015

Climate change = high uncertainty, huge variability

Model ensembles/multi-model approaches help identify structural uncertainties, characterize confidence in projections, understand internal variability

FishMIP
Fisheries & Marine Ecosystem Model Intercomparison Project

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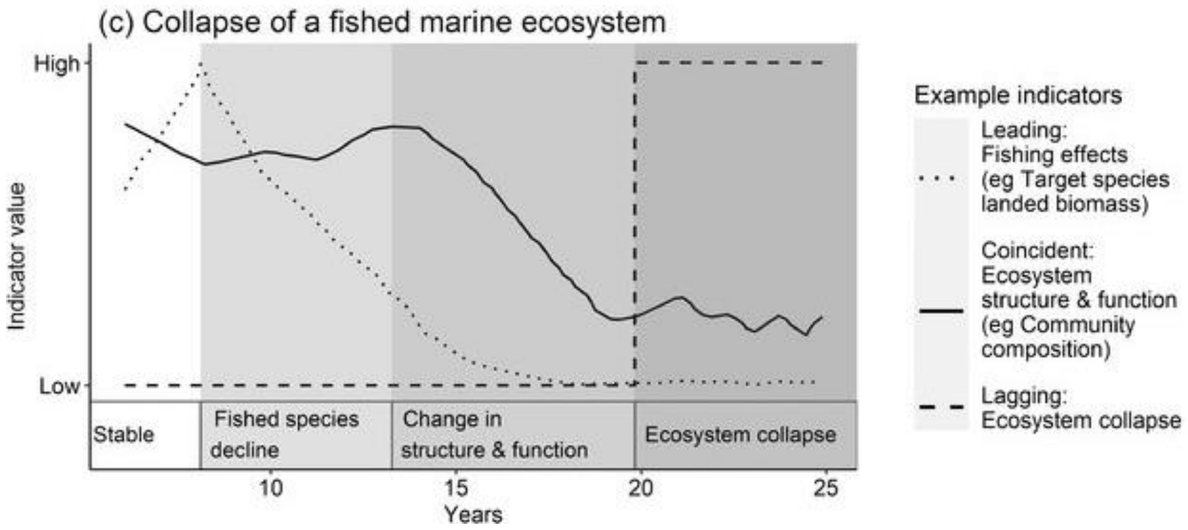
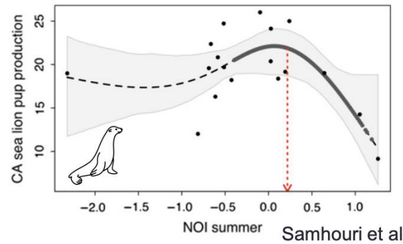
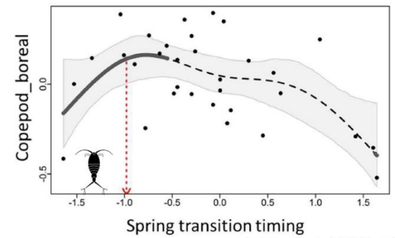
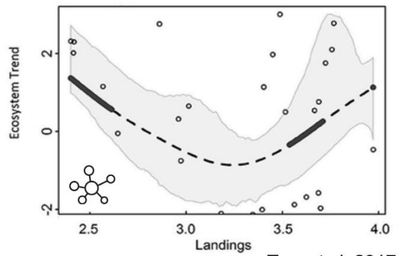
ECOLOGICAL THRESHOLDS AND UNCERTAINTY

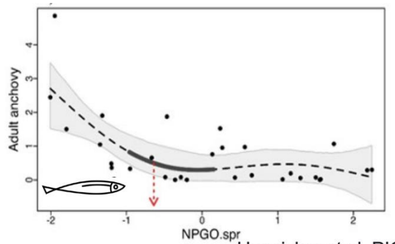
Ecosystem-scale thresholds











Addressing uncertainty in ecological thresholds?

Hunnisker - ICES-PICES Small Pelagic Fish Symposium November 2022

How can we improve our confidence in identifying species- and ecosystem-scale thresholds in the North Pacific?

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NORTH PACIFIC MULTI-MODEL ENSEMBLES - NOMEME

North Pacific Ocean Marine Ecosystem Model Ensemble (NOMEME)

Develop a North Pacific Ocean Marine Ecosystem Model Ensemble (NOMEME) at the basin scale, linked to earth system models (ESMs), to inform transboundary fisheries management across the Northeast Pacific, and outline protocol for expansion to Northwest Pacific.

- **Bringing together modellers, researchers and practitioners** in the North Pacific who understand the climate-fisheries landscape and can guide objectives and initiatives;
- **Review of modelling tools, approaches and initiatives** currently operational to incorporate the effect of climate change and fisheries management on ecosystems of the North Pacific Ocean;
- **Develop a protocol** for combining disparate ecosystem-scale models;
- Identification of **appropriate environmental forcing variables** for North Pacific Ocean regions, and potential ensemble ESMs to address model and climate uncertainty;
- **New ensemble simulations that address knowledge gaps** for focal fish and associated fisheries management or conservation problems in an ensemble of candidate regional MEMs.

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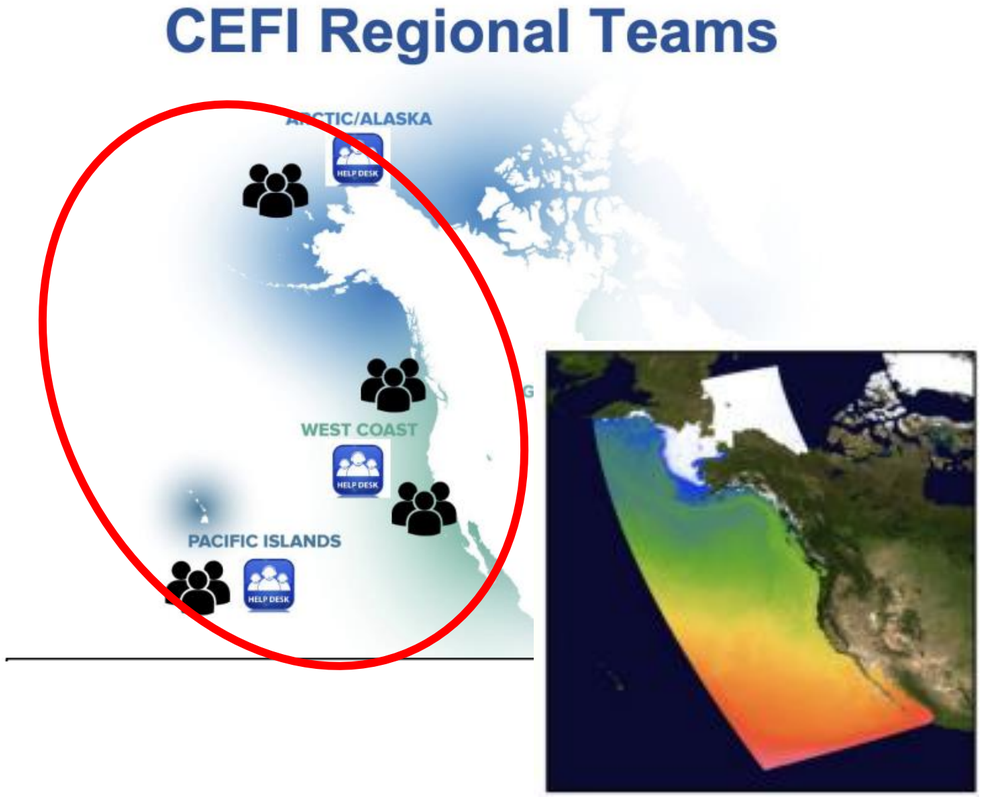
BUILDING ON EXISTING INITIATIVES

Climate, Ecosystems and Fisheries Initiative (CEFI)

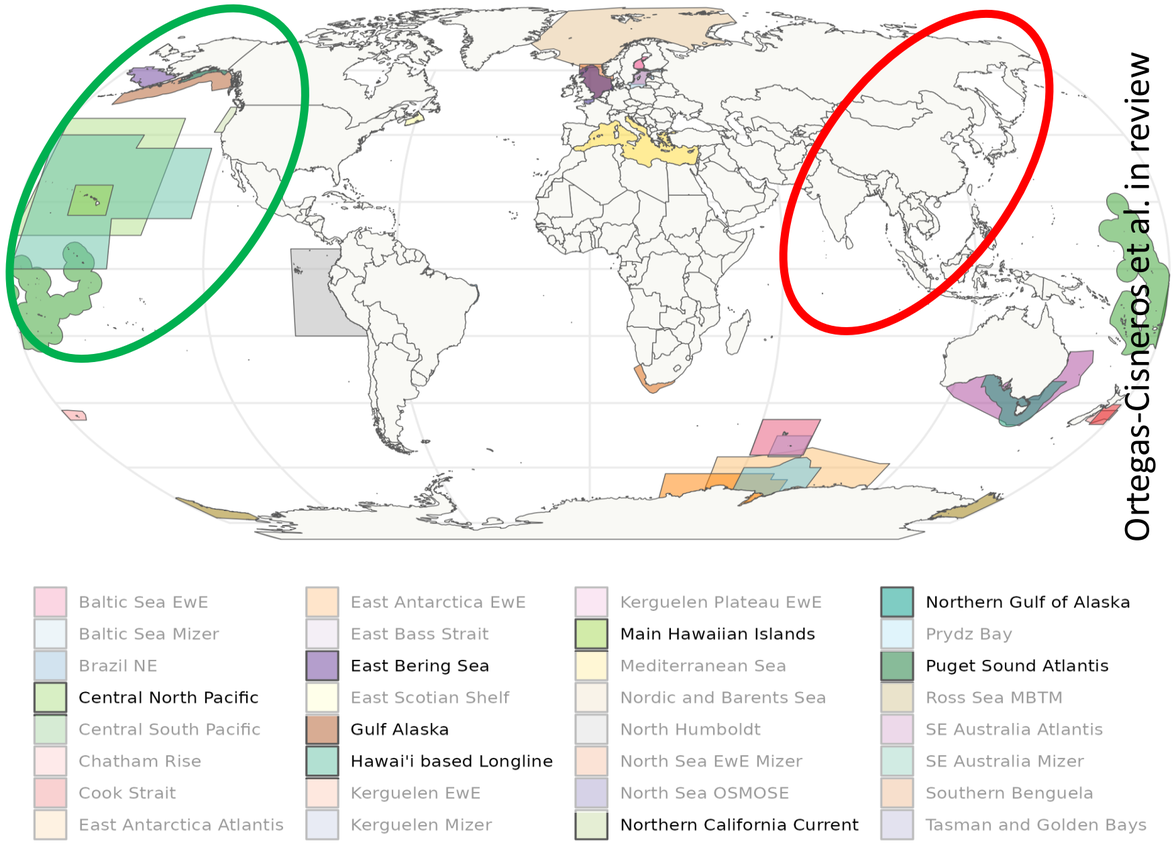
- ACLIM/GOACLIM/West Coast



High resolution MOM6

FishMIP

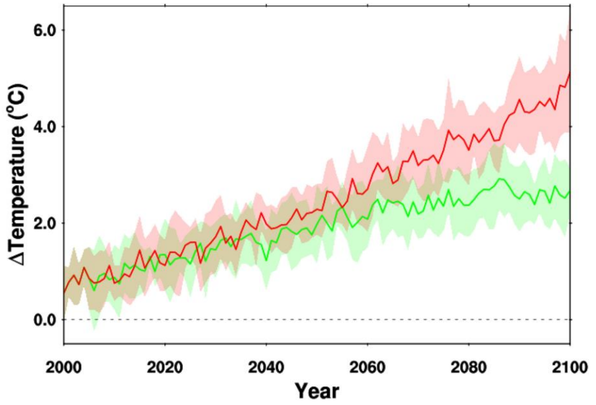
- Global-to-Regional Modelling Protocol
- SOMEME Protocol (Southern Ocean Marine Ecosystem Model Ensemble)

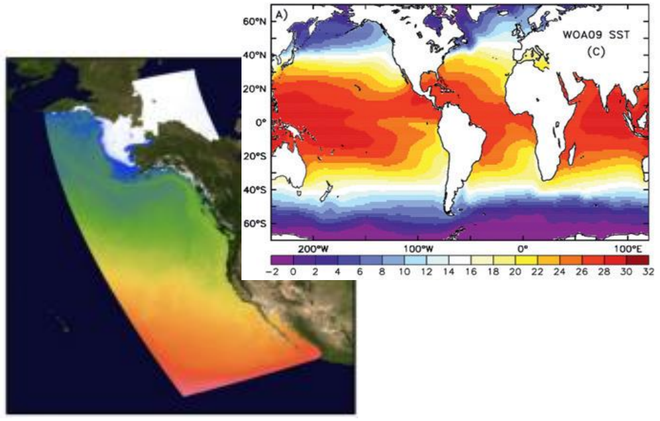


Ortegas-Cisneros et al. in review

MULTI-MODEL ENSEMBLES TO RESOLVE UNCERTAINTIES

Multiple ESMs – resolve climate uncertainties





Multiple MEMs - resolve functional/structural uncertainties

Atlantis

State-space

Global (BOATS/FEISTY)

CEATTLE

DBPM

Ecopath with Ecosim, EcoTran

MICE

Mizer/thermizer

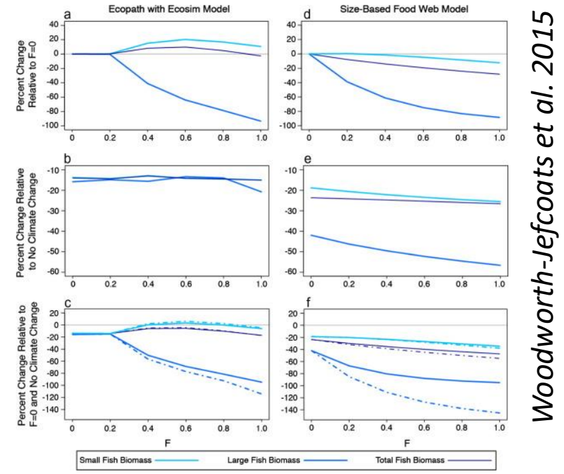
OSMOSE

NEMURO.FISH

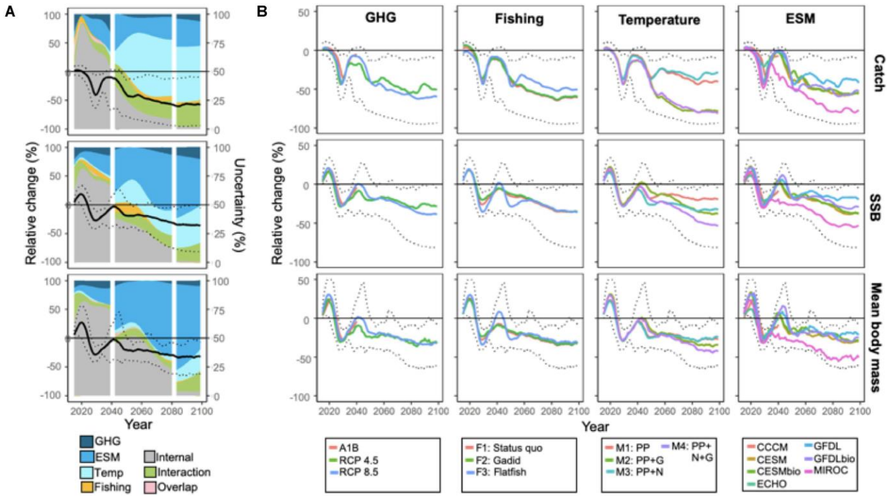
tinyVAST

CVA

Compare outputs – resolve threshold uncertainty

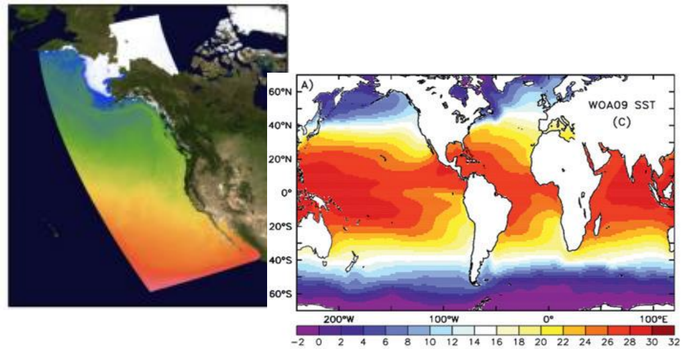


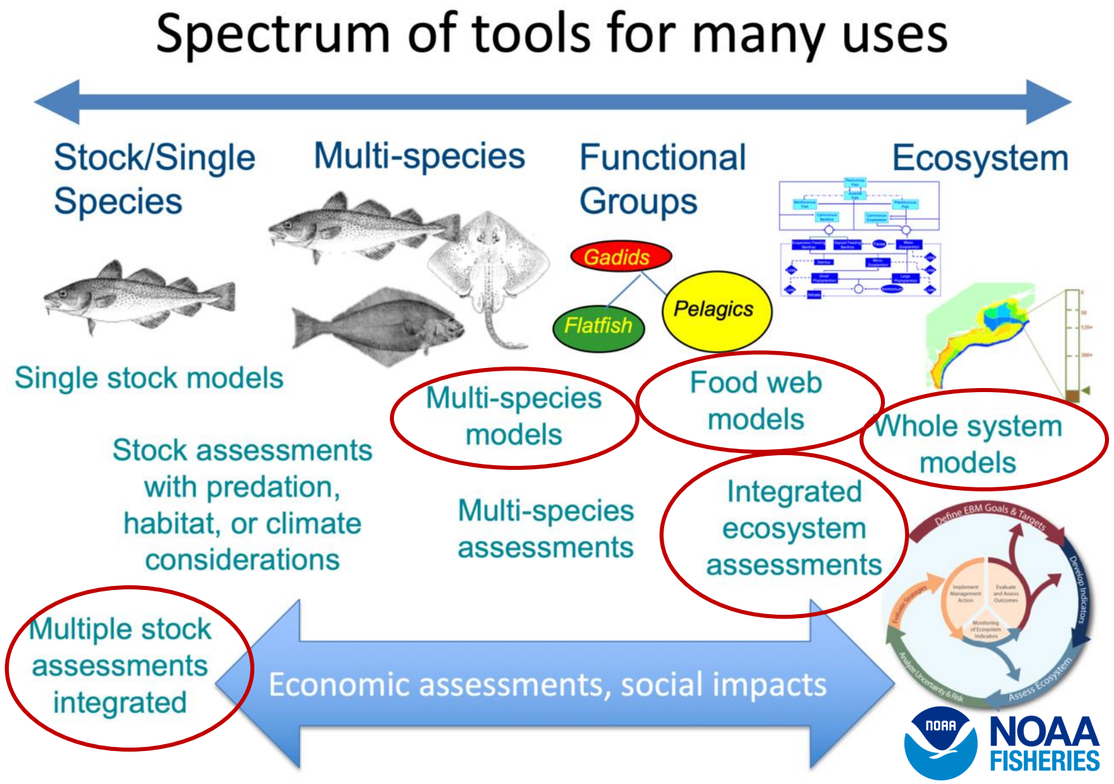
Woodworth-Jefcoats et al. 2015



Reum et al. 2020

ECOSYSTEM-SCALE: MATCHING INDICATORS TO NEEDS





ESM/scenario ensembles = uncertainty and variability

MEM ensembles = functional benchmarks (single and multiple species)

Model ensembles can be used to quantify variability and find thresholds where one model was unsuccessful

Species and ecosystem indicators:

Population

Productivity

Functional

Trophic

"Resilience"

Fisheries

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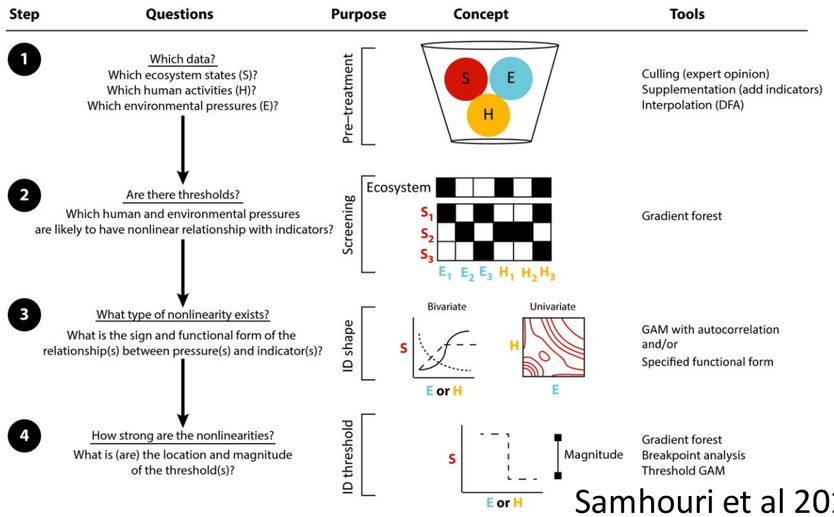
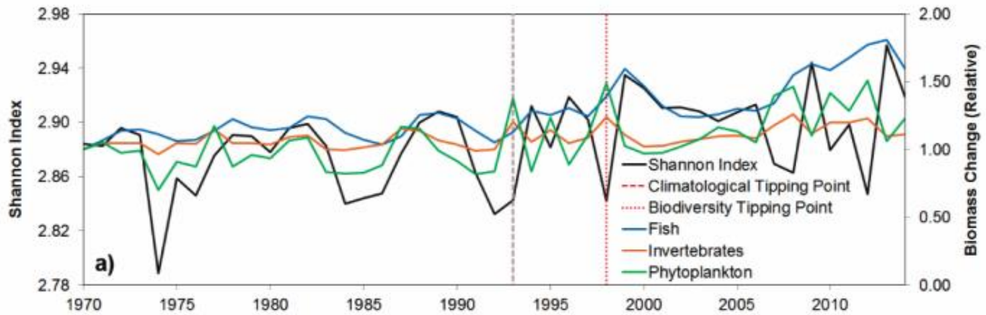
MULTI-MODEL ECOSYSTEM-SCALE INDICATORS

Multi-model approaches to identifying thresholds of ecological indicators to fishing pressure under climate change

1. **Driver thresholds for ind. species** – thresholds/tipping points from nonlinear statistical relationships btw catch (response) and temperature (pressure) (Holsman et al. 2020, Samhouri et al. 2017)
2. **Ecosystem-scale indicators-** Statistically significant tipping points in whole-ecosystem biodiversity using statistical analysis of ecological indicators e.g. Shannon Index (Suprenand et al. 2018)
3. **Addressing uncertainty -** Using generalized additive models (GAMs) fitted to outputs from a multi-ecosystem, multi-model simulation experiment (Fu et al. 2019;



Samhouri et al 2017



Suprenand et al. 2018

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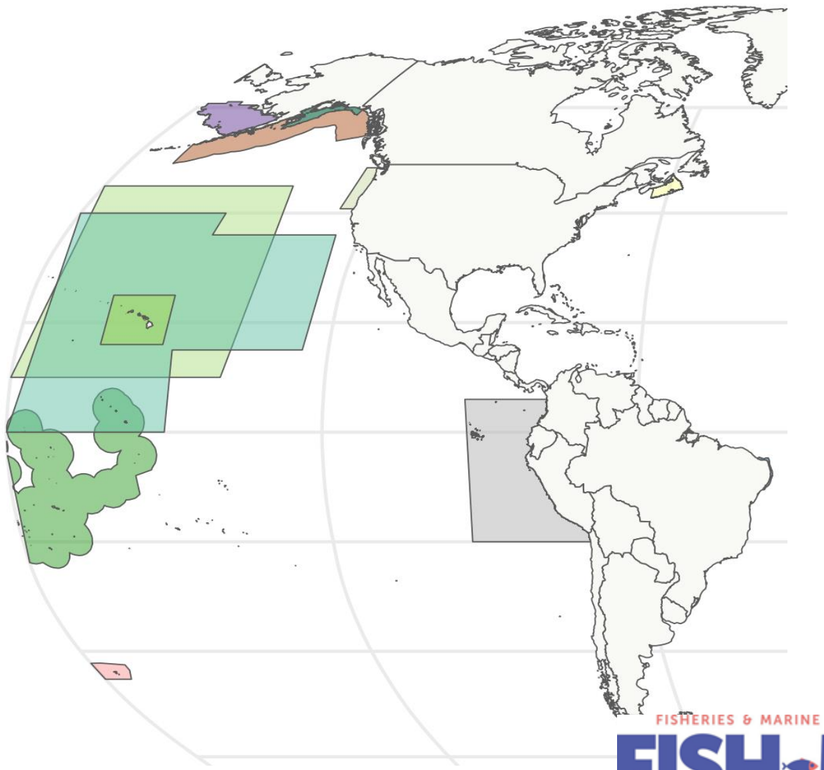
Basin-Scale Ecosystem Cumulative Impacts

Stevenson et al 2020

COMPARING THRESHOLDS AT MULTIPLE SCALES

Multi-model approaches to identifying thresholds of ecological indicators to fishing pressure under climate change

1. Comparing across model outputs to address uncertainties = improving predictions of thresholds
2. Comparing ecosystem outputs across space = early warnings for different regions
3. Retrospective and forecasting analyses = identify potential points of concern in the future under uncertainty



FISHERIES & MARINE ECOSYSTEM
FISH-MIP
MODEL INTERCOMPARISON PROJECT

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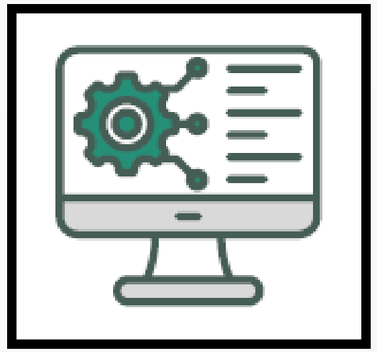
Basin-Scale Ecosystem Climate Impacts

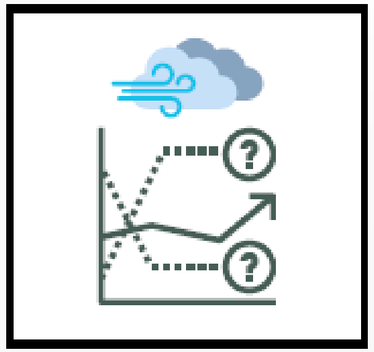
Stevenson et al 2020

DECISION SUPPORT TOOLKIT AND WORKFLOW

International Collaboration
&
Knowledge Exchange

Information Integration &
Analytics





Predictive Modelling

Decision Science

Environmental Monitoring
& Research

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Basin-Scale Events & Coastal Impacts

NEXT STEPS AND ONGOING COLLABORATION

- Workshop just held at PICES Annual Meeting 26 October 2024 – workshop report soon
- Upcoming webinar with SUPREME/FUTURE to progress collaboration with FishMIP and lead into next workshop – 20 November 2024
- Online discussion group for ensemble ecosystem modelling in the Nth Pacific and follow-up workshops TBA

We are building a community of practice!

We invite interested folks to contact us if you are keen to join the NOMEME working group, salmon-focused initiatives, information integration, or to find out more!

BECI Special Workshop
Bringing together models for fisheries management under climate change – multiple model ensembles and inference to guide decision-making

Duration:
TBD

Convenors:
Vivitskaia Tulloch (Canada), *corresponding*
Kathryn Berry (Canada)

Invited Speakers:
TBD

Due to its structure, the workshop does not have an open call for abstracts for oral presentations.

The Basin-scale Events to Coastal Impacts (BECI) project is a UN Ocean Decade program led by the North Pacific Marine Science Organization (PICES) and North Pacific Anadromous Fish Commission (NPAFC), with goals of providing decision support to detect and predict ecosystem impacts and inform fisheries management under climate change.

The primary goal of this workshop is to enhance regional marine ecosystem

Monday, September 30, 2024 1:00 PM (PDT)

Sept Webinar: Topics at the nexus of climate change, fisheries & blue foods

View event details

Topics at the nexus of climate change, fisheries, and blue foods

A webinar series highlighting the impact of climate change on fisheries, aquaculture, and the communities who depend on them

This webinar series is jointly hosted by the UN Ocean Decade endorsed programs Blue Food Futures, FishSCORE, SmartNET, SUPREME, and as of August 2024, FishMIP and Basin-Scale Events to Coastal Impacts (BECI). This webinar series highlights current efforts and challenges at the climate-fisheries nexus. Presentations and discussions will range from data-driven efforts to better understand oceanographic and biological changes affecting fisheries, to how the results can be used to inform fisheries management, aquaculture, and sustainable food decisions, to the many ways people and broader communities are being impacted by and adapting to changes in marine ecosystems and marine resource use.

Organized by
Gulf of Maine Research Institute

Follow Contact

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Basin-Scale Events & Coastal Impacts

BASIN SCALE EVENTS AND COASTAL IMPACTS

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Acknowledgements:

Phoebe Woodworth-Jefcoats (NOAA), Kirstin Holsman (NOAA), Kieran Murphy (UTAS), Julia Blanchard (UTAS), Kelly Ortega-Cisneros (CU), Hem Morzaria-Luna (Long Live the Kings), Isaac Kaplan (NOAA), Beth Fulton (CSIRO), Eva Plaganyi (CSIRO), Jon Reum (NOAA), Robin Brown (BECI), Josep Planas (IPHC), Cheryl Harrison (LSU) and others!

BECI
Basin-Scale Events & Coastal Impacts

PICES Annual Meeting 2024, Hawaii

PICES

NPAFC

2021 2030 United Nations Decade of Ocean Science for Sustainable Development