

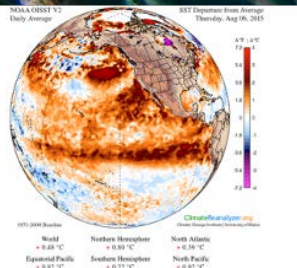


**NOAA
FISHERIES**

Science Updates

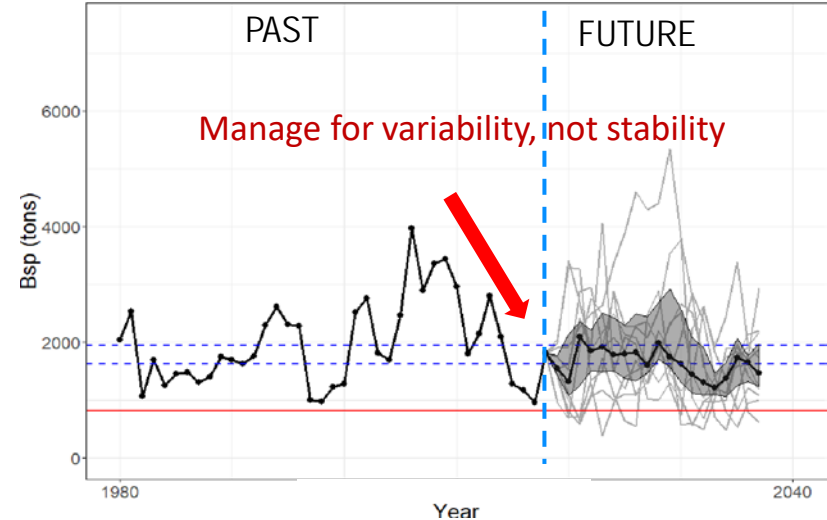
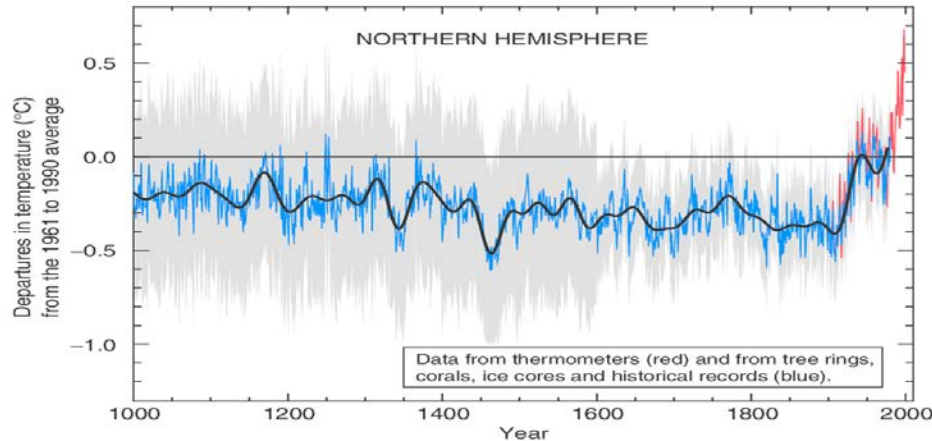
Cisco Werner
NOAA Fisheries
cisco.werner@noaa.gov

MAFAC
Silver Spring
30 November 2022



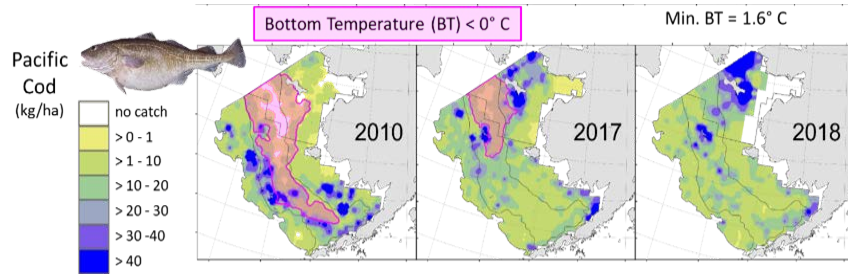
Assessments and Generation of Advice under Non-stationarity and Uncertainty

From *stationarity* to *non-stationarity*



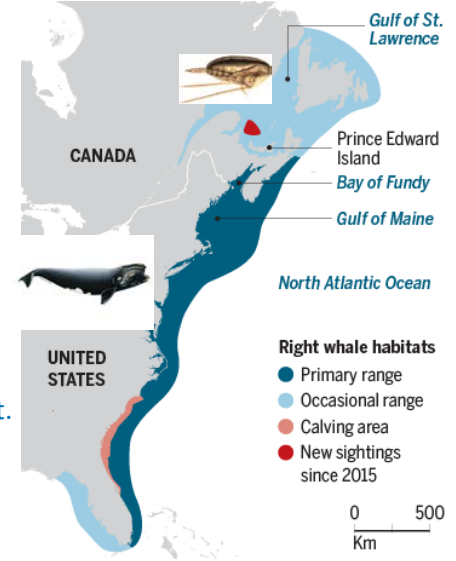
- **Stationarity** – fluctuations within an unchanging envelope of variability.
- **Non-stationarity** – times series whose properties (e.g., mean, variance, etc.) change with time.

Climate impacts on living marine resources

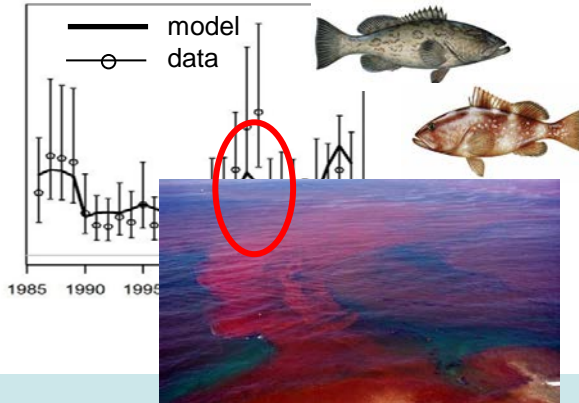


Pacific cod and pollock distribution moved shoreward and northward 1000's of kms as the cold pool (<2°C) was reduced.

- Right whales feed on a small zooplankton – *Calanus finmarchicus*
- Warming temperature related to fewer *C. finmarchicus* in the Gulf of Maine
- Right whales move to Gulf of St. Lawrence as *C. finmarchicus* in Gulf of Maine decrease



- Including red tide index improves stock assessment fit
- Red tide explains declines of ~8 million grouper (gag and red combined) in 2005



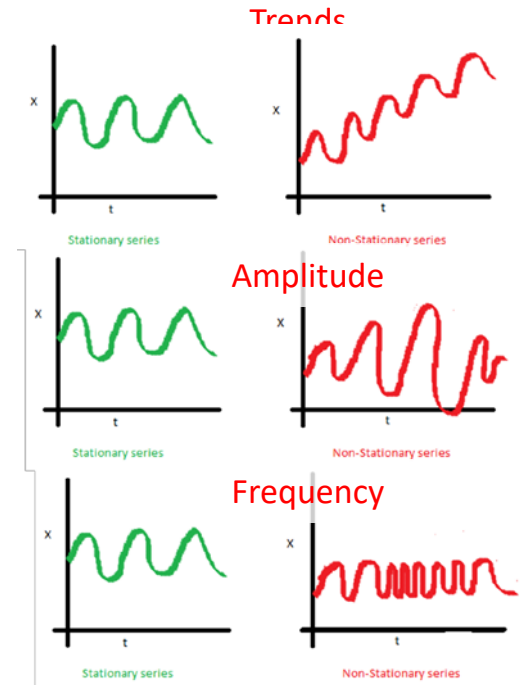
Moving from “nice to know” to “need to know”

Premise: oceanographic processes and ecological interactions affect the population structure and abundance of marine species. Incorporating the variability from the present rapidly changing “non-stationary” environmental signals is required in our provision of advice to management.

Today’s discussion:

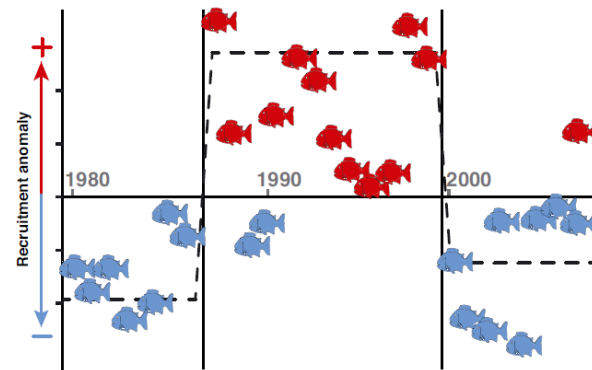
- need to expand collection of oceanographic and fisheries data for evolving, short-term (tactical) **fisheries stock assessments**
- consideration of **longer-term climate, oceanographic, and socioeconomic** projections (e.g., the N. Pacific ACLIM project)
- establishment of the **Climate Ecosystem and Fisheries Initiative (CEFI)**

Stationarity vs. Non-Stationarity



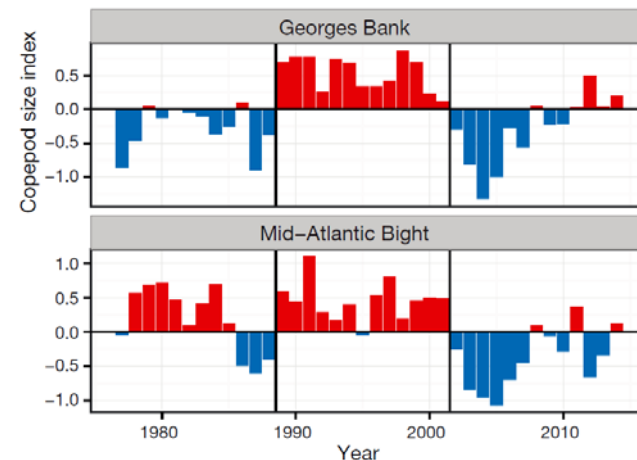
Present models for LMR Management

- In general, no long-term trends, no regime shifts, etc.
- Inclusion of random year-to-year fluctuations with perhaps some autocorrelation
- Reference points and rebuilding targets represent “prevailing environmental conditions”
- More recently, a growing number of MSEs investigate impact of regime shifts and projections of future trends (see ACLIM/CEFI slides later in the presentation)



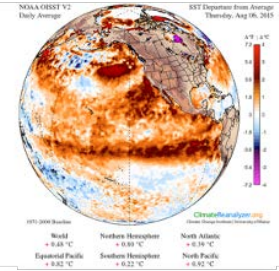
Recruitment success regimes of fish on the Northeast US Continental Shelf.

Graphic: C. Perretti and S. Schüller



Pivotal Point in Ocean and Fisheries Science

- **Climate change & non-stationarity** - the oceans' physics, biogeochemistry, and ecosystems are changing at unprecedented rates
 - The greater the non-stationarity, the harder it is to project future changes, requiring closer monitoring of the unpredictable changes
- **Rapid changes also taking place in traditional and emerging ocean use-sectors** (e.g., offshore wind energy, aquaculture, etc.)
- Data, and the information they provide, are an essential currency of **fisheries and protected resource management**



Next-Generation Data Acquisition Plan (NG-DAP)

Process followed:

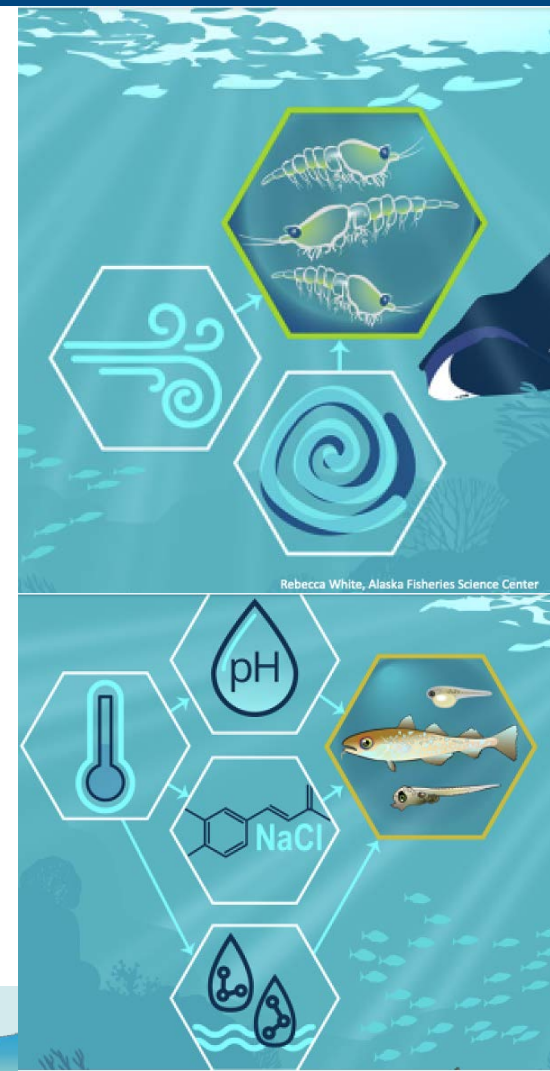
- Reviewed literature
- Questionnaire, listening sessions, workshops and expert focus groups that captured information from internal and external stakeholders (over 400 participants)
- Identified current and future data needs and priorities
- Draft recommendations document currently under internal review



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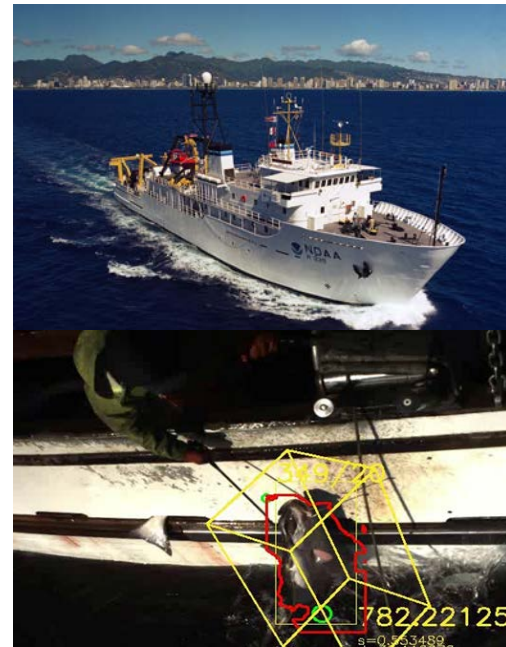
Emerging NG-DAP recommendations include:

- Uncrewed systems (UxS)
- Automated sampling and processing
- Remote sensing
- Acoustics
- Molecular tools
- Electronic monitoring and reporting
- Citizen science

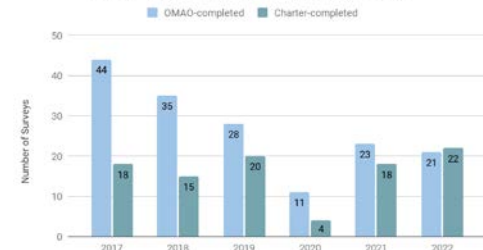


Present Challenges and Opportunities

- Increased identified data acquisition needs
- Shrinking Days-at-Sea – DAS (down ~60% from 2015)
- End of Service Life for 3 of 8 vessels by 2030
- "Class C" replacements evaluation and schedule in development
- Advanced technologies, while very promising, are not yet operational in many surveys/management
- Data acquisition is only "Step 1" in our processes (Artificial Intelligence, Big Data, management models, etc.)



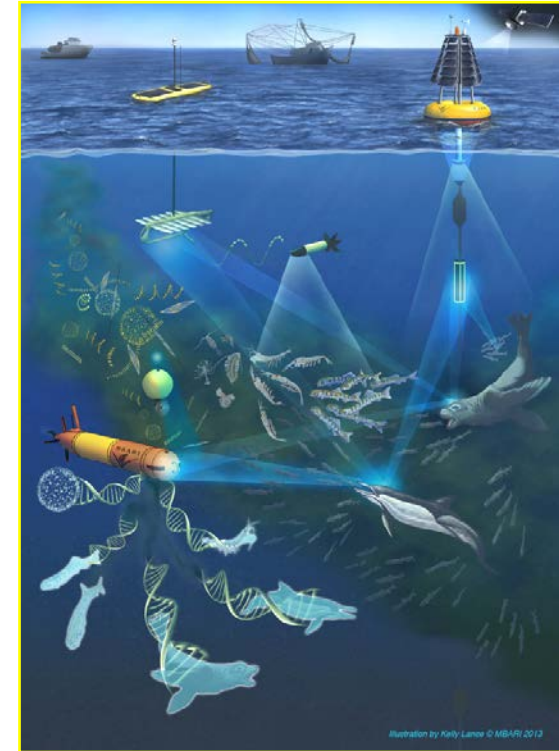
FY2017-2022 Number of Completed Surveys*



Proposed Ways Forward - NMFS' Future Survey Enterprise

We need 21st century solutions to address an increasingly complex ocean environment

- Using **innovative technologies** (e.g., UxS, 'Omics) that increase efficient and effective observational data collection
- **Diversifying** observational platforms beyond white hulls
- **Modernizing fishery information** collection, management, and dissemination systems
- Artificial Intelligence/Machine Learning (**AI/ML**) capabilities to accelerate predictive analytics of multiple large data sets
- Developing **next generation analytical and modeling tools** to forecast ecosystem changes and associated LMR and socioeconomic impacts



NOAA Fisheries' Survey Vision for the Future

- **Sustain** core strength while we build the **additional capacity** needed to face the ever-growing challenges of climate change
- **Modernize** - Evaluate and implement **new technology platforms** for collecting data and enhancing workforce proficiency
- **Strengthen** survey **planning, prioritization, and management** of survey resources to optimize return on investment

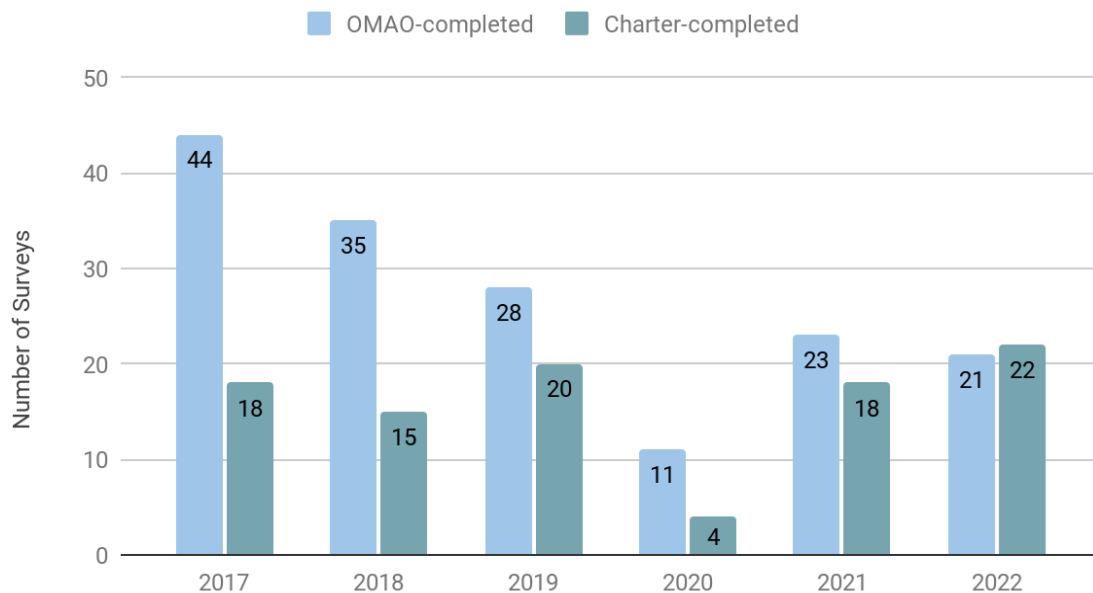


Sustaining Current Survey Enterprise

The **FY 2022 Budget** addition of \$8M increase supports NMFS' **immediate** actions to:

- Restore/sustain capacity
- Expand regional coverage
- Continue advanced technology initiatives
- Increase staff proficiency

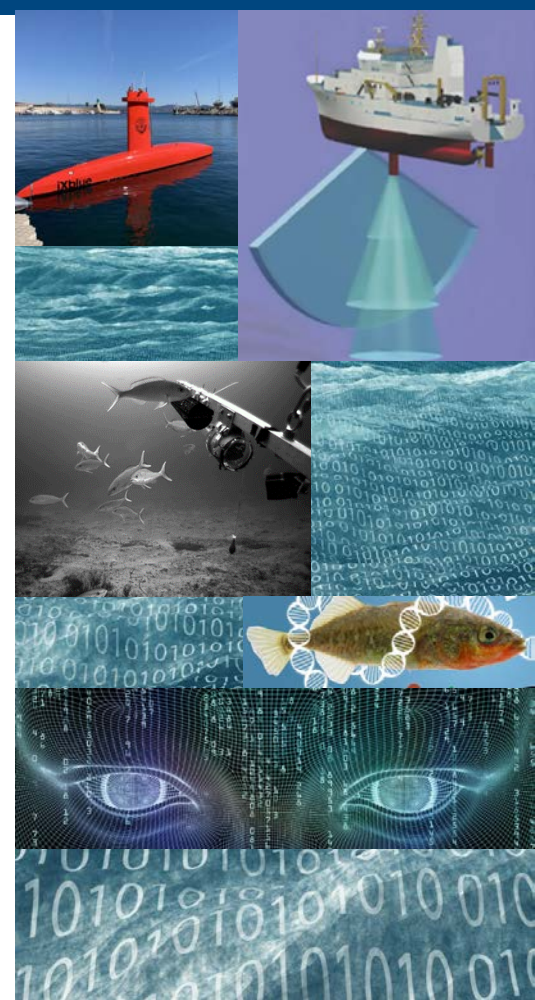
FY2017-2022 Number of Completed Surveys*



Modernize the enterprise

Surveys will need to expand to collect essential data about our “new ocean”

- This requires a suite of new operational approaches: Next-Generation Data Acquisition Plan (**NG-DAP**), **Fleet Recapitalization Plan**
- Rapid increase in acquired data volume will require modernized data management and analysis: **FIMM**, **NMFS Data Vision 2022**
- Survey enterprise supports assessments, as well as ecosystem forecasts and societal needs: **CEFI**, **HPC**, **EJ**
- Advance workforce proficiency (training and new hires)



Strengthen National Survey Program Management

- Elevate the **national program management model** (e.g., produce annual survey and stock assessment priority list)
- Continue national survey program **cost analysis**
- Improvement of national survey **prioritization**, budget formulation, and execution
- Continual attention to emerging **gaps** in NMFS' survey vision



Moving from *Present State* to *Future State*

Present State

Strong reliance on white hull-like ships

Strong survey<->specific vessel ties

Several Advanced Tech R&D Projects

Surveys->Assessments->Management

Fair National Coordination/Accounting

Future State

Diversified observation portfolio

Vessel/Platform flexibility in Planning

Operational Advanced Tech + new R&D

Management->Assessment Gaps-> Surveys

Strong National Coordination/Accounting

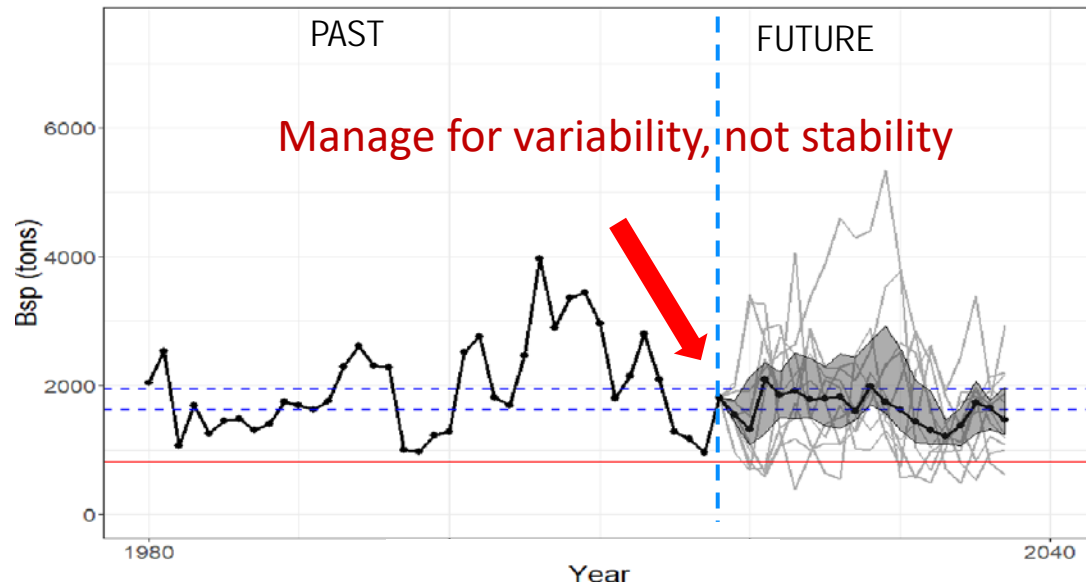


Climate and Fisheries Initiative

Climate, Ecosystems, and Fisheries Initiative (CEFI): forecasts in support of fisheries management and adaptation strategies

- Provide a national capacity for sustained provision of regional ocean and climate information **across LMR management time scales**.
- Provide a national capacity to translate this information to **improved management and stakeholder decisions**.

Generation of Advice under Non-stationarity: Uncertainty, and Scenario Planning



How do we get to climate-ready resource management?

Today

1. No regular delivery of ocean forecasts and projections.
2. No operational system to link ocean forecasts to ecosystem scenarios, risk assessments & management advice.
3. Low capacity to use climate-informed advice to reduce risks, increase resilience, and link with human dimensions.
4. Limited planning for extreme events and longer term changes.



With CEFI

1. **Regular delivery** of robust ocean forecasts and projections.
2. **Operational delivery** of linked ocean forecasts and management advice.
3. **High capacity** to use climate-informed advice to reduce risks, increase resilience, and link to human dimensions.
4. **Improved planning** for extreme events and longer term changes.

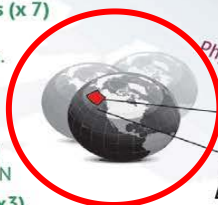
Climate scenarios

Global Climate Models (x 7)

ECHO-G
MIROC3.2 med res.
CGCM3-t47
CCSM4-NCAR- PO
MIROCESM-C- PO
GFDL-ESM2M* PO
GFDL-ESM2M* PON

Projection Scenarios (x3)

AR4 A1B
AR5 RCP 4.5
AR5 RCP 8.5



Physical downscaling

ROMS



NPZ
Bering Sea 10K Model

Alaska Climate Integrated Modeling (ACLIM) Project

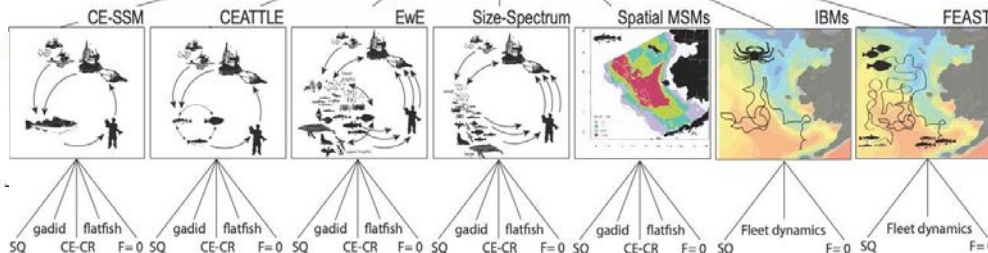
Ocean scenarios

Biological downscaling

Bering Sea Models

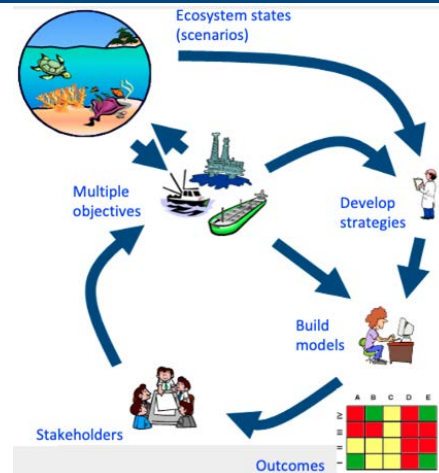
Climate Enhanced Biological models (x 5)

CE- single species assessment models
CE- multispecies model (CEATTLE)
CE- Size spectrum model
CE- Ecopath with Ecosim
End-to-End model (FEAST)



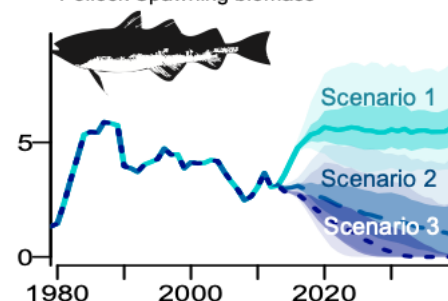
explicit drivers of population variability (climate & food-web); high computational demand

implicit drivers of population variability (random error); low computational demand & multiple iterations

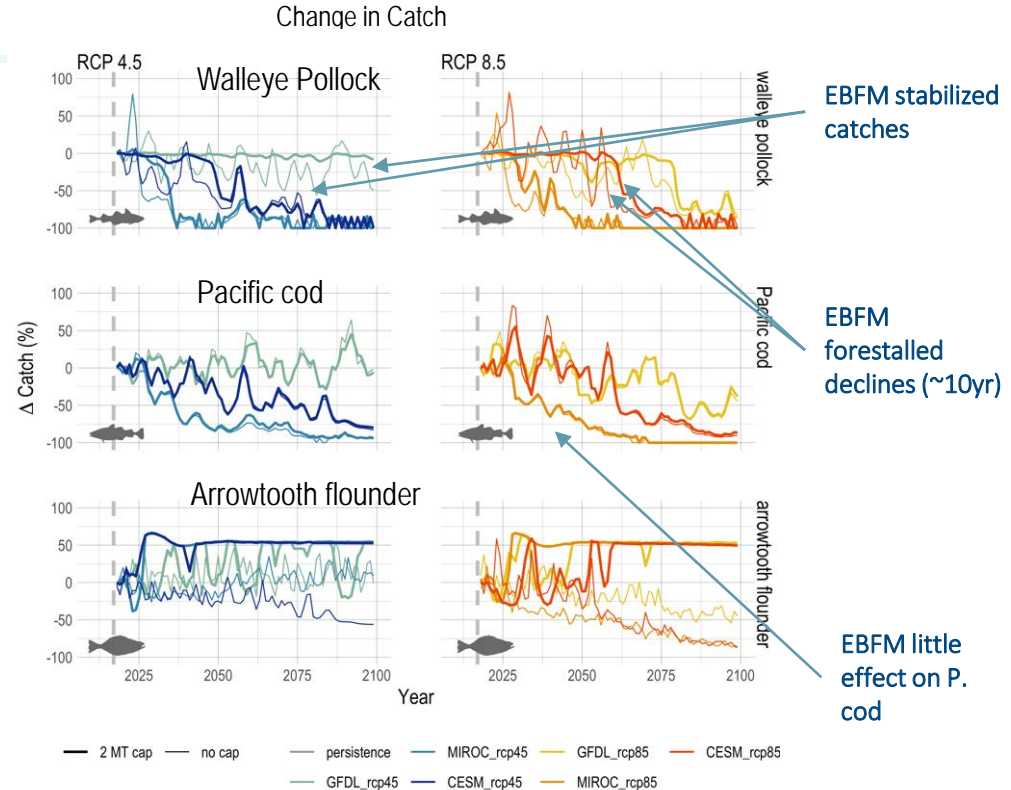
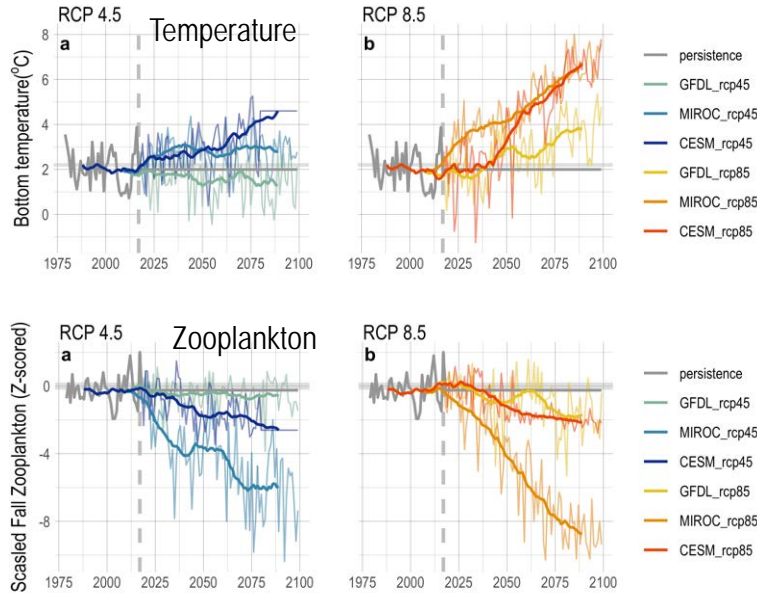


Fishery and Management scenarios

Pollock Spawning biomass



EBFM vs non-EBFM cap



Holsman, K.K., Haynie, A.C., Hollowed, A.B. et al. Ecosystem-based fisheries management forestalls climate-driven collapse. *Nat Commun* 11, 4579 (2020). <https://doi.org/10.1038/s41467-020-18300-3>

Regional Ocean Modeling Teams

Providing Ocean Hindcasts and Forecasts



Five Regional Ocean Modeling Teams, composed of scientists from across NOAA Line Offices and academic partners, will provide the deep knowledge of the ocean and biogeochemical dynamics shaping each region that is needed to appropriately configure models for LMR applications.

Global Climate Models (x7)

ECHO-G
MIROC3.2 med res.
CGCM3-147
CCSM4-NCAR-PO
MIROCESM-C-PO
GFDL-ESM2M-PO
GFDL-ESM2M-PON

Projection Scenarios (x3)

AR4 A1B
AR5 RCP 4.5
AR5 RCP 8.5

Alaska Climate Integrated Modeling Project



NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

ACLM

Alaska Climate Integrated Modeling Project

Anne Hollowed (AFSC, SSMA/REFM)
Kirstin Holzman (AFSC, REEM/REFM)
Alan Haynie (AFSC, ESSR/REFM)
Stephen Kasperski (AFSC, ESSR/REFM)
Jim Iannelli (AFSC, SSMA/REFM)
Kerim Aydin (AFSC, REEM/REFM)
Trond Kristiansen (IMR, Norway)
Al Hermann (UW, JSAO/PMEL)
Wei Cheng (UW, JSAO/PMEL)
Anders Havn (UW, JSAO/PMEL)
John M. Menden-Deuer (UW, JSAO/PMEL)
Franka Faig (UW, JSAO/PMEL)

FATE: Fisheries & the Environment
SAAM: Stock Assessment Analytical Methods
S&T: Climate Regimes & Ecosystem Productivity

Scenario / harvest scenarios (x5+)

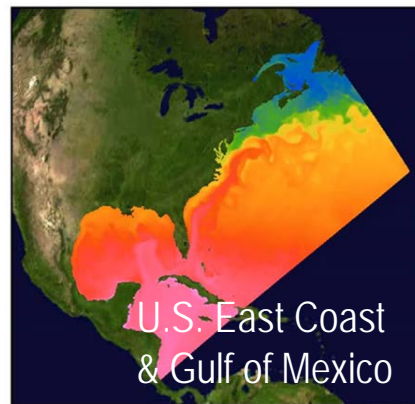
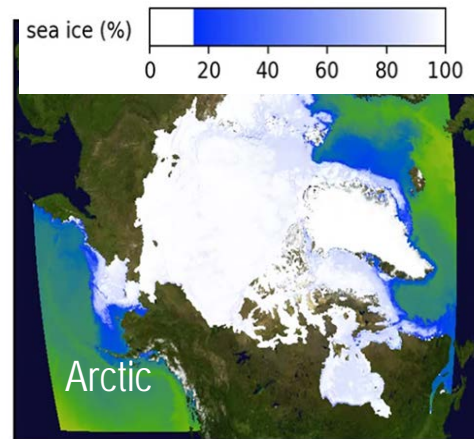
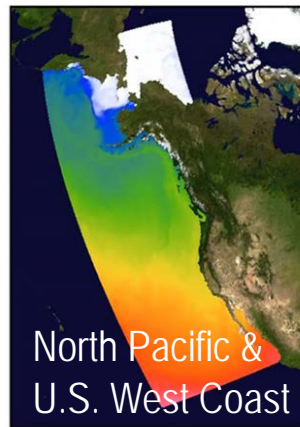
No fishing
Status quo
By-catch changes
CE-reference points
MEY

Climate Enhanced Biological models (x5+)

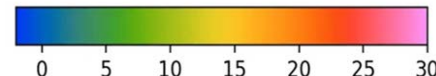
CE- single species assessment models
CE- multispecies model (CEATTLE)
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CE- Ecopath with Ecosim
End-to-End model (FEAST)



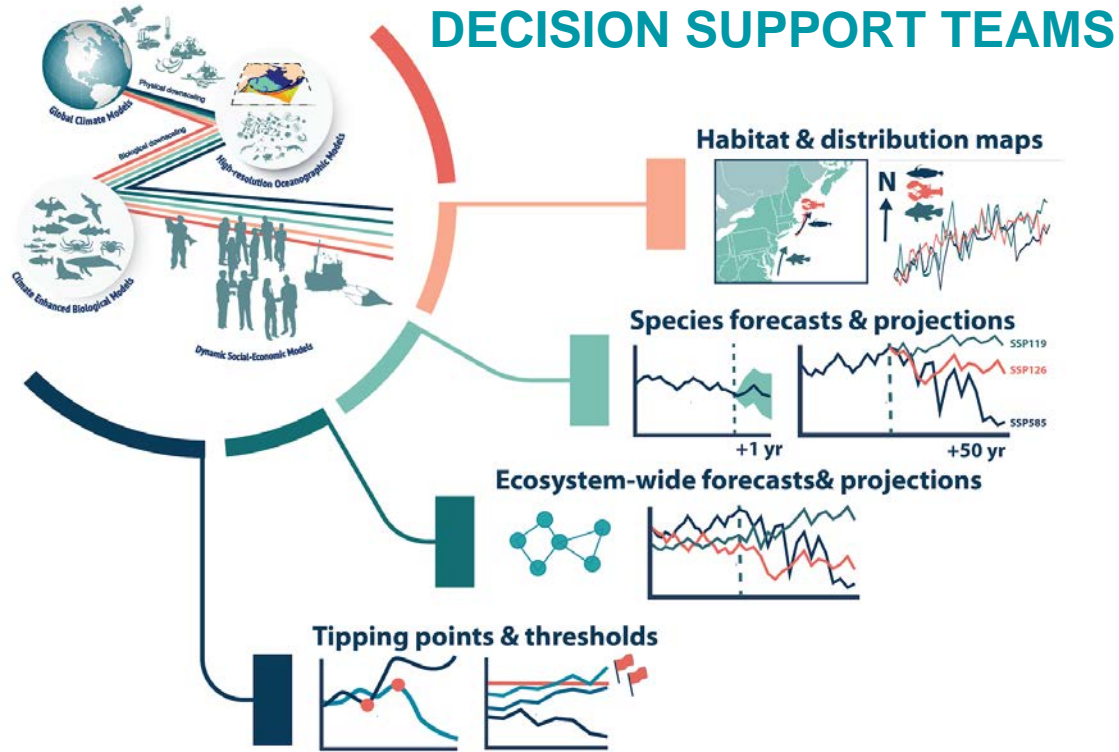
Expand successful Climate-Fisheries efforts nationally



1980-04-16 sea surface temperature (°C)



Decision Support Teams: Provide Key Products & Services



- Expert Teams at Science Centers
- Work with existing programs & partners
- Catalyze efforts
- Dedicated products
- Operational delivery
- Scalable
- Working using open science frameworks



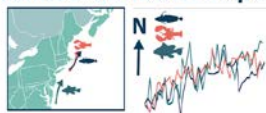
Improved Delivery and Use of Climate-Informed Advice

Ocean Predictions



Decision Support Teams

Habitat & distribution maps



Species forecasts & projections



Ecosystem-wide forecasts & projections



Tipping points & thresholds



Applications (on-ramps)



Scenario Planning



Stock & Risk Assessments



Rapid Responses



Consultations



Management Strategies



Rebuilding & Recovery Plans

Across NOAA Fisheries Mission

Fisheries

Aquaculture / Seafood

Protected Species

Habitat

Ecosystems

Human Communities

International Activities

CFI Integrated Ocean Modeling and Decision Support System

► Advancing Climate, Ocean, and Ecosystem Understanding



► Operational Decision Support Systems



► Climate Ready Decision Making



- Enhanced Observations
- Targeted Applied Research
- Build a system of high-resolution regional climate models

- Harness computing to deliver ocean predictions
- Expand National Ocean Climate Model Portal
- Develop Applications to Meet the Needs of Decision Makers

- Develop Climate Decision Support Tools
- Increase Capacity with resource managers
- Provide Coordinated Science and Advice

“Shadow assessments” ...

Run assessments in parallel to present stock assessments:

- establishes partnerships between the ecosystem modeling groups and the assessment teams, and
- links the ecosystem modeling teams with analysts to jointly establish annual biological reference points.

2018 Climate-enhanced multi-species Stock Assessment for walleye pollock, Pacific cod, and arrowtooth flounder in the Eastern Bering Sea

Kirstin K. Holsman, James N. Ianelli, Kerim Aydin, Ingrid Spies, Grant Adams, Kelly Kearney

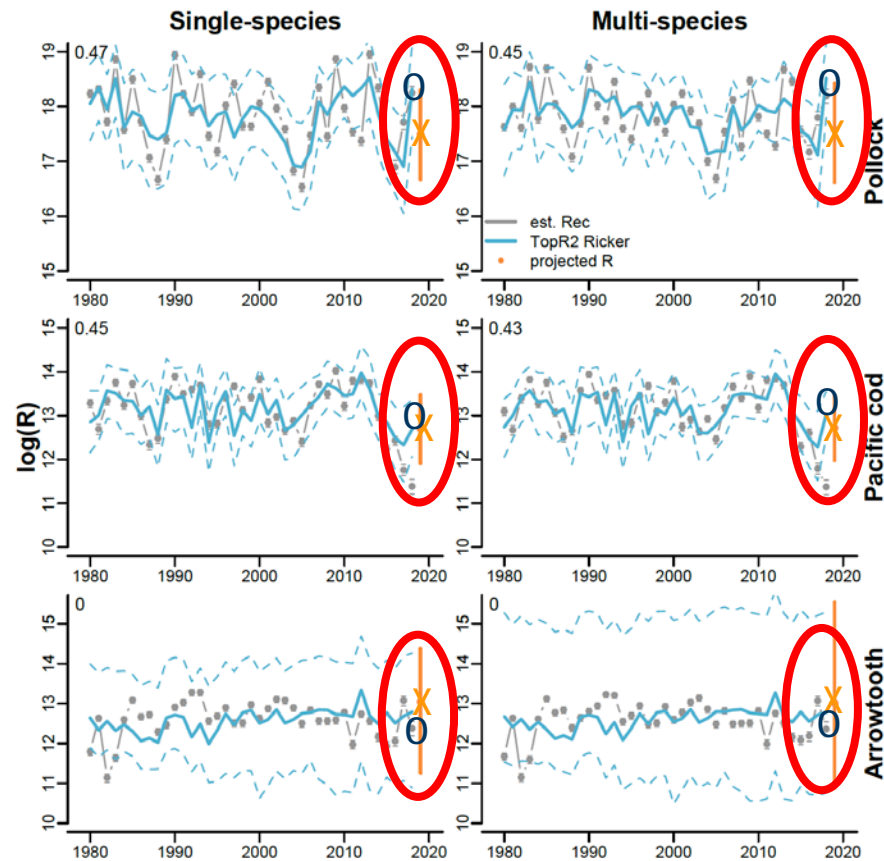


Figure 21: Climate-enhanced recruitment (log) fits and 2019 forecasted recruitment given 2018 SSB and environmental conditions.

Summary

- **Non-stationarity:** nice to know to need to know
- Need to **evolve our data collection** (NG-DAP)
- Need to **evolve our advice** to management (CEFI)

