



NOAA
FISHERIES

Tools and Approaches for Climate-Informed Fisheries Management

**Jay Peterson¹, Nicholas Coleman²,
Wendy Morrison²,
Melissa Karp¹ and Roger Griffis¹**

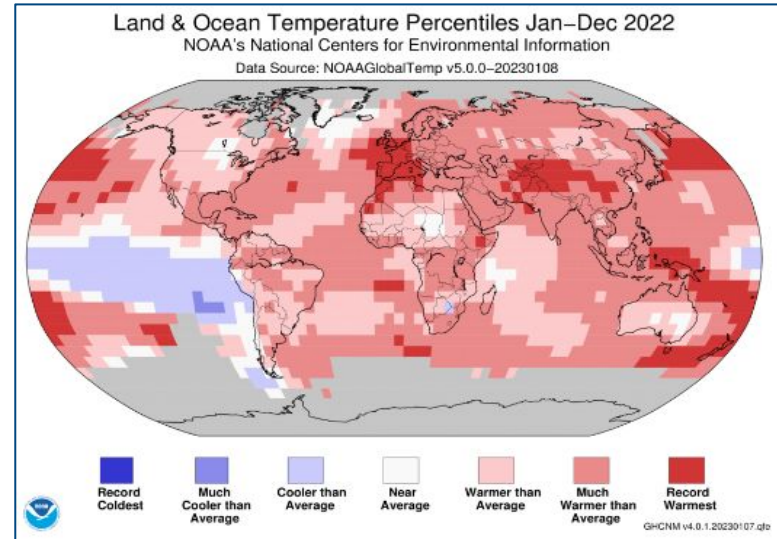
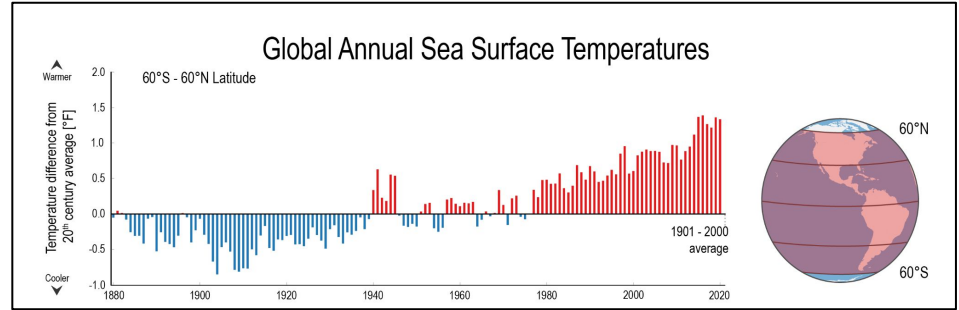
¹NMFS Office of Science and Technology

²NMFS Office of Sustainable Fisheries

New Council Member Training November 14, 2023

Outline

- **Background & Useful Strategies**
- **Tools and Resources**
- **Management Approaches**
 - **Reactive**
 - **Proactive**
- **Key Takeaways**



Ocean conditions are changing

Extreme Events



Long term change

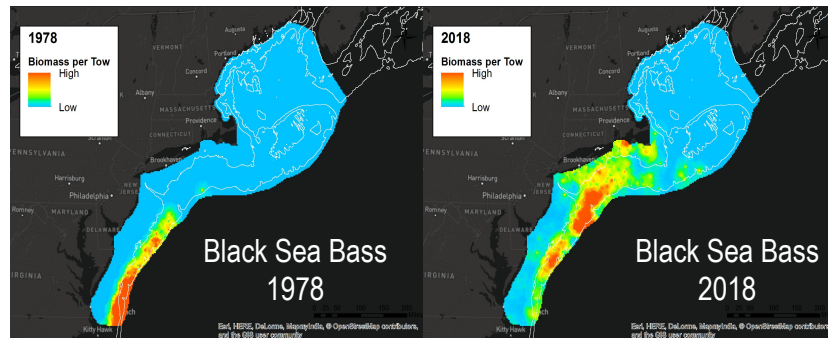


Growing Challenges for Effective Resource Management

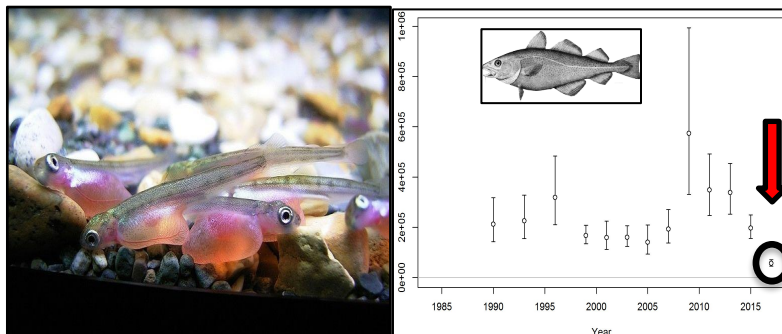
Changing Habitats



Shifting Distributions



Changing Abundance



Changing Interactions

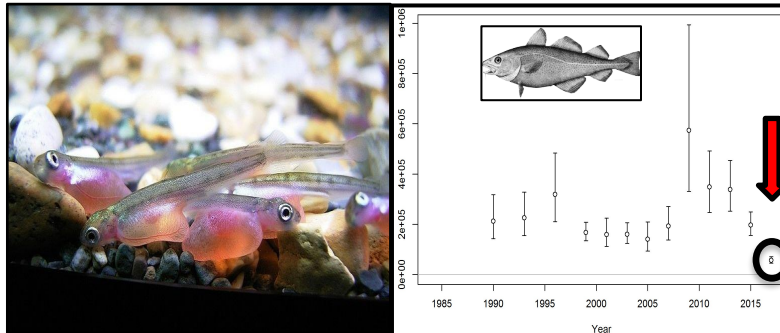


Fisheries Management Issues

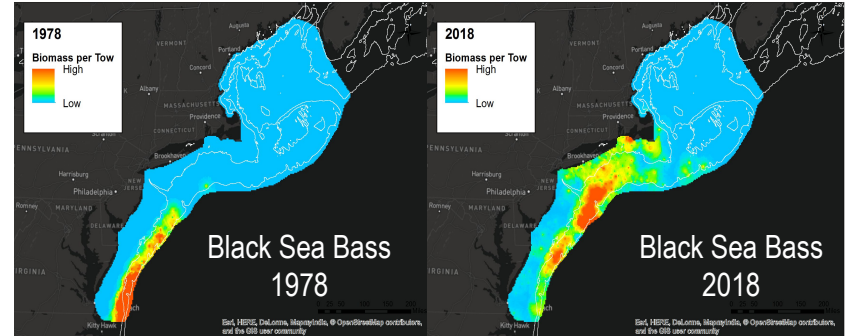
Changing Habitats

- *Impacts on essential fish habitats and protected areas?*

Changing Abundance



Shifting Distributions



Changing Interactions



There is much at risk

High Demand for Information and Action

Marine Resources

1.7 Million Jobs

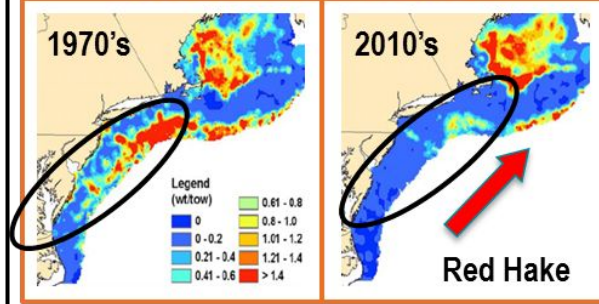
\$350+ Billion in economic activity

Tourism & Recreation

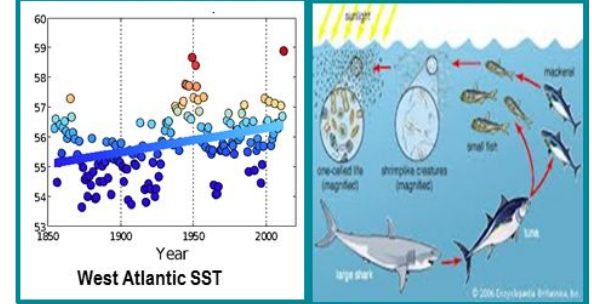
Fishing Communities

Cultural Heritage

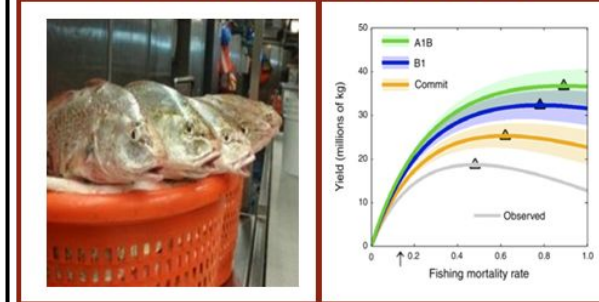
WHAT IS CHANGING?



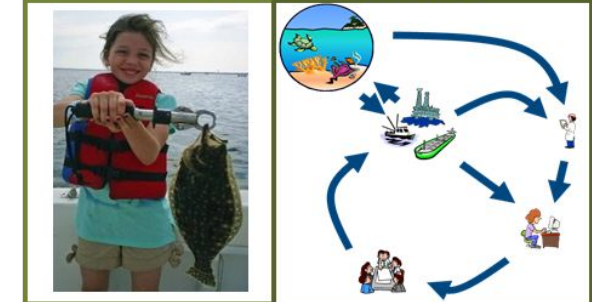
WHY IS IT CHANGING?



HOW WILL IT CHANGE?

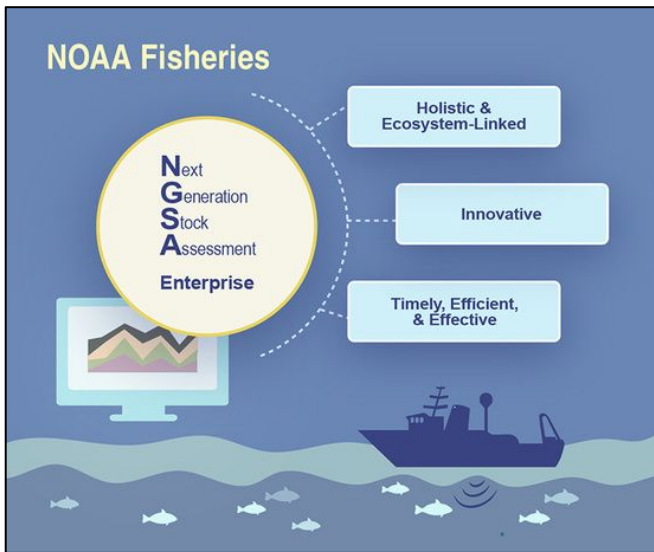


HOW TO RESPOND?



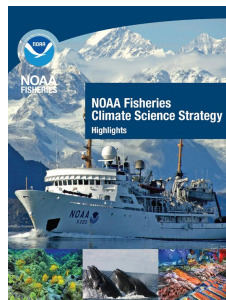
NOAA Fisheries Strategic Plans

Next Generation Stock Assessment Improvement Plan



Ecosystem-based Fisheries Management Policy & Roadmap

Levels	Scientific Advice	Management Framework
EBM Ecosystem Based Management		Regional Ocean Plans
EBFM Ecosystem Based Fisheries Management		Fisheries Ecosystem Plan
EAFM Ecosystem Approach to Fisheries Management		Fishery Management Plan
SS Single Species		Fishery Management Plan



Climate Science Strategy Objectives



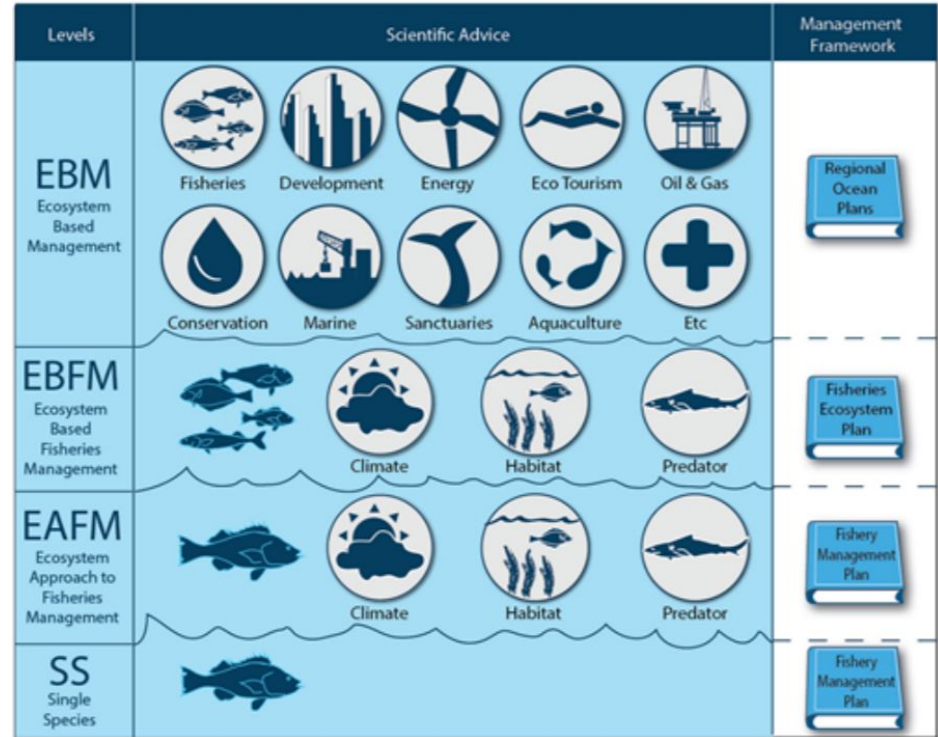
What are we doing about it?

Tools & Resources



Ecosystem Based Fisheries Management (EBFM)

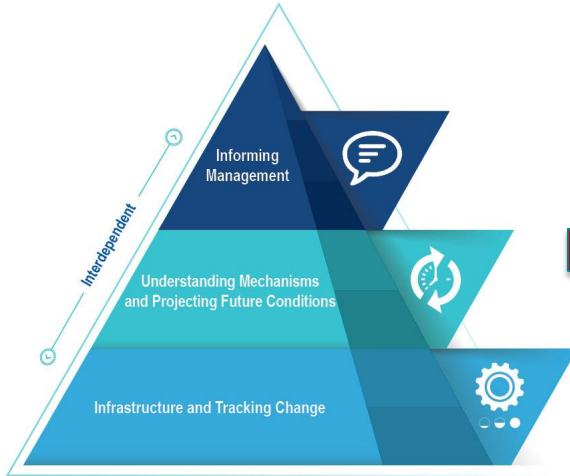
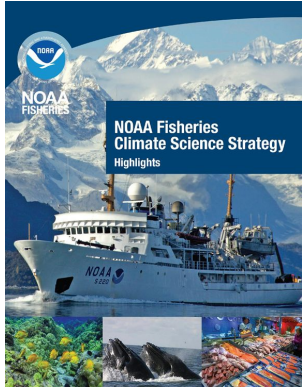
- Holistic approach to fisheries management
- Considers multiple ecosystem components
- Climate-informed
- Goals:
 - Reduce risks
 - Better decisions
 - Effective management



Dolan et al 2015

<https://www.fisheries.noaa.gov/national/ecosystems/ecosystem-based-fisheries-management>

Regional Climate Action Plans



CLIMATE SCIENCE STRATEGY OBJECTIVES



Federal waters (generally extend 100 to 200 nautical miles off the coast)
Sources: National Marine Fisheries Service, Fisheries of the United States, 2014 (data); Map Resources (map). | GAO-16-827

National to Regional

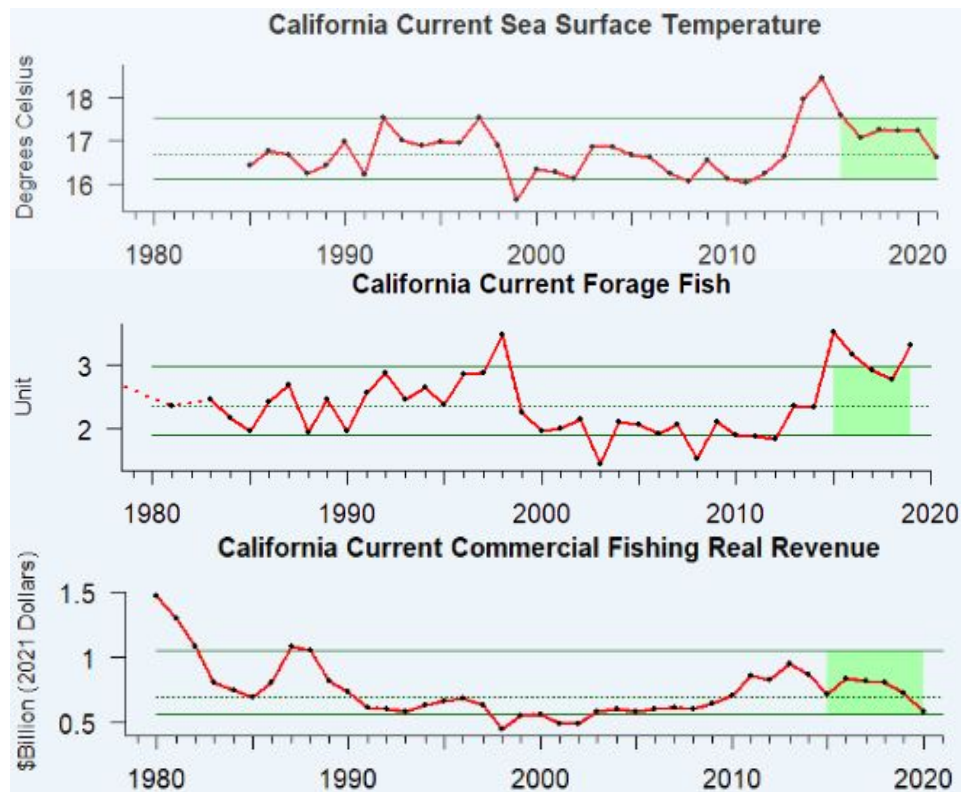
*Climate-related Information
Decision-maker Capacity
Climate-Ready Management
Resilience and Adaptation*

Climate Ready NMFS

Ecosystem Status Reports (ESRs) - What is changing?

Provide trends in a variety of indicators

- physical (e.g., temperature)
- chemical (e.g., oxygen)
- biological (e.g., forage, predators)
- Socio-economic (e.g., landings, market diversity)

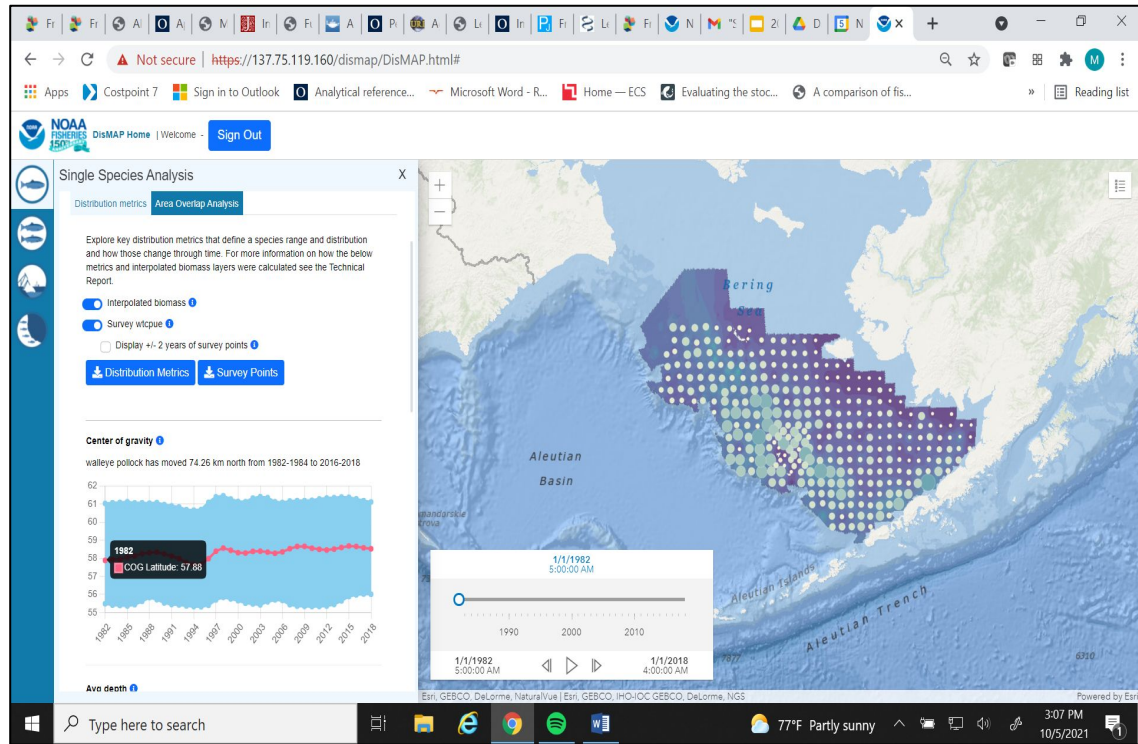


<https://www.integratedecosystemassessment.noaa.gov/Ecosystem-Status-Reports>

<https://ecowatch.noaa.gov/>

Understanding Shifting Distributions – DisMAP portal

- Launched April 2022!
- Nationwide portal
- Distributions and analysis tools for 400+ species of marine fish and invertebrate species in U.S. marine waters.
- User-friendly tool to help in climate-ready decision making.



<https://apps-st.fisheries.noaa.gov/dismap/DisMAP.html>

Understanding Vulnerability – Climate Vulnerability Analyses

Fish Stocks



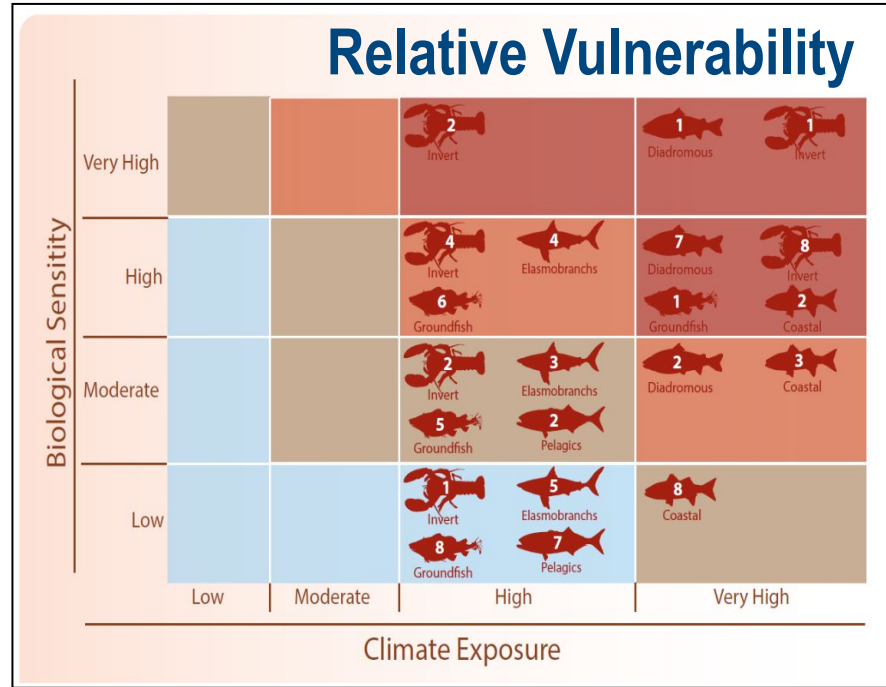
Fishing Communities



Protected Species



Habitats



Online Tool -

<https://www.fisheries.noaa.gov/data-tools/climate-vulnerability-assessment-tool>

Evaluating Risks - MAFMC Example

- Management elements with associated management objectives
 - ecological
 - economic
 - social
- Indicators for each element
- Annual updates on the status and risk of not meeting management objectives.

Species	Assess	Fstatus	Bstatus	FW1Pred	FW1Prey	FW2Prey
Ocean Quahog	l	l	l	l	l	l
Surfclam	l	l	l	l	l	l
Summer flounder	l	l	lm	l	l	l
Scup	l	l	l	l	l	l
Black sea bass	l	l	l	l	l	l
Atl. mackerel	l	h	h	l	l	l
Chub mackerel	h	lm	lm	l	l	l
Butterfish	l	l	lm	l	l	l
Longfin squid	lm	lm	lm	l	l	lm
Shortfin squid	lm	lm	lm	l	l	lm
Golden tilefish	l	l	lm	l	l	l
Blueline tilefish	h	h	mh	l	l	l
Bluefish	l	l	h	l	l	l
Spiny dogfish	lm	l	lm	l	l	l
Monkfish	h	lm	lm	l	l	l
Unmanaged forage	na	na	na	l	lm	lm
Deepsea corals	na	na	na	l	l	l

Risk to achieving Optimum Yield.
 Low, Medium, High

Example from MAFMC Risk Assessment: https://www.mafmc.org/s/d_MAB_RiskAssess_2022update.pdf

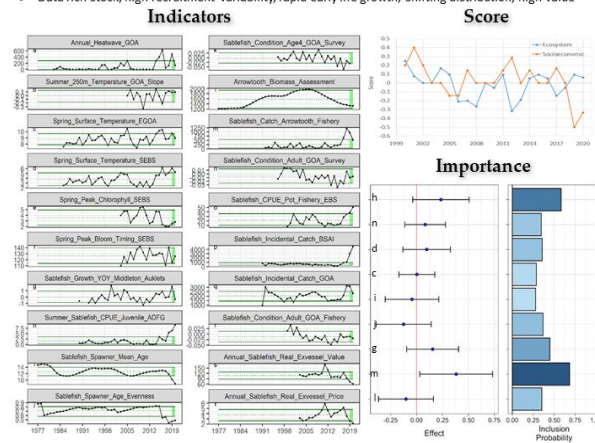
Understanding Changes - Ecosystem and Socioeconomic Profiles (ESPs)

- Stock-specific ecosystem and socioeconomic info.
- In use in Alaska and NE.
- Development and Pilots in other regions (PI).
- Proposal to expand nationally.



Sablefish (*Anoplopoma fimbria*)

- Data rich stock, high recruitment variability, rapid early life growth, shifting distribution, high value



- Presence of 2016 and 2019 year class in ADF&G survey, age 4 fish generally in poor condition, higher spatial overlap with arrowtooth in fishery, physical + but < from 2019, lower stable, upper slight >
- Incidental catch < in GOA, > in BSAI indicates expanding habitat, ex-vessel value and price/pound on recent decline, community analysis in progress

Research Model Performance (hypothetical)

Model	ABC	OFL	Cross Validation	Retrospective	Recruitment Comparison	SSB Comparison
SAFE	26,250	30,000	28% +/- 6%	+0.19	0.5	0.5
Eco	23,625	27,000	46% +/- 12%	+0.07	0.65	0.3

ESP: <https://www.afsc.noaa.gov/REFM/Docs/1YEARI/GOASablefish.pdf> Contact: Kalei.Shotwell@noaa.gov

Climate scenarios

Global Climate Models (x 7)

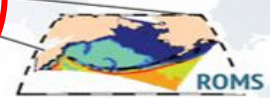
- ECHO-G
- MIROC3.2 med res.
- CGCM3-t47
- CCSM4-NCAR-PO
- MIROCESM-C-PO
- GFDL-ESM2M*-PO
- GFDL-ESM2M*-PON

Projection Scenarios (x3)

- AR4 A1B
- AR5 RCP 4.5
- AR5 RCP 8.5

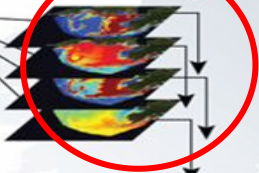


Physical downscaling



Ocean scenarios

Biological downscaling



Bering Sea 10K Model

Q: What are effective management options for changing oceans?

Fishery Management and Adaptation scenarios

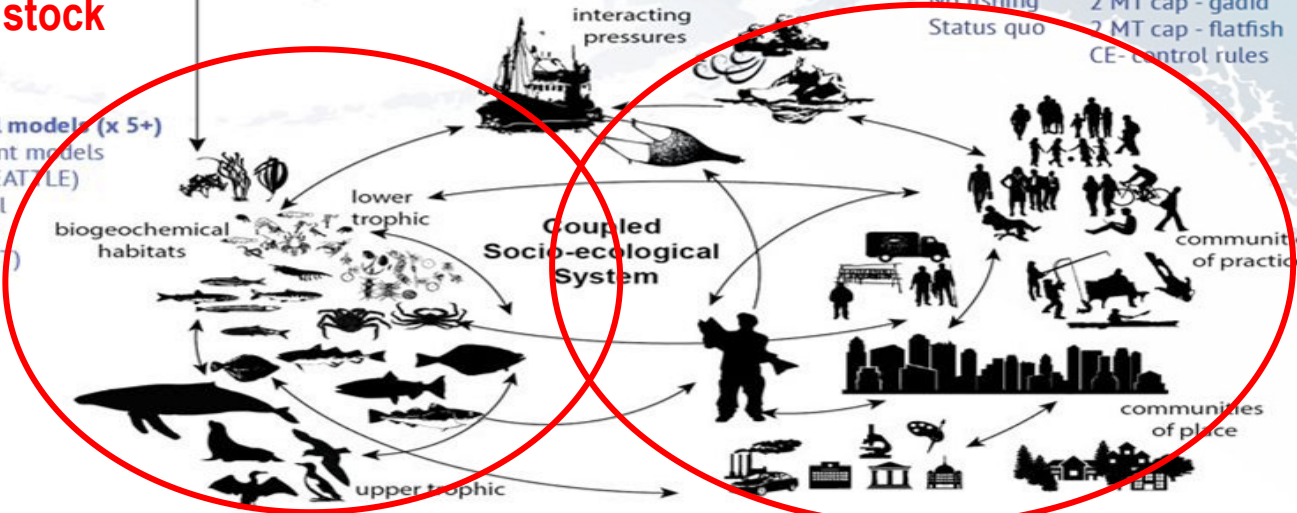
Ecosystem and stock scenarios

Social & economic / harvest strategies (x 5+)

- No fishing
- Status quo
- 2 MT cap - gadid
- 2 MT cap - flatfish
- CE- control rules

Climate Enhanced Biological models (x 5+)

- CE- single-spp assessment models
- CE- multi-spp model (CEAT/LE)
- CE - Size spectrum model
- CE- Ecopath with Ecosim
- End-to-End model (FEAST)
- CE- spatial MICE model
- CE - IBM (crab)

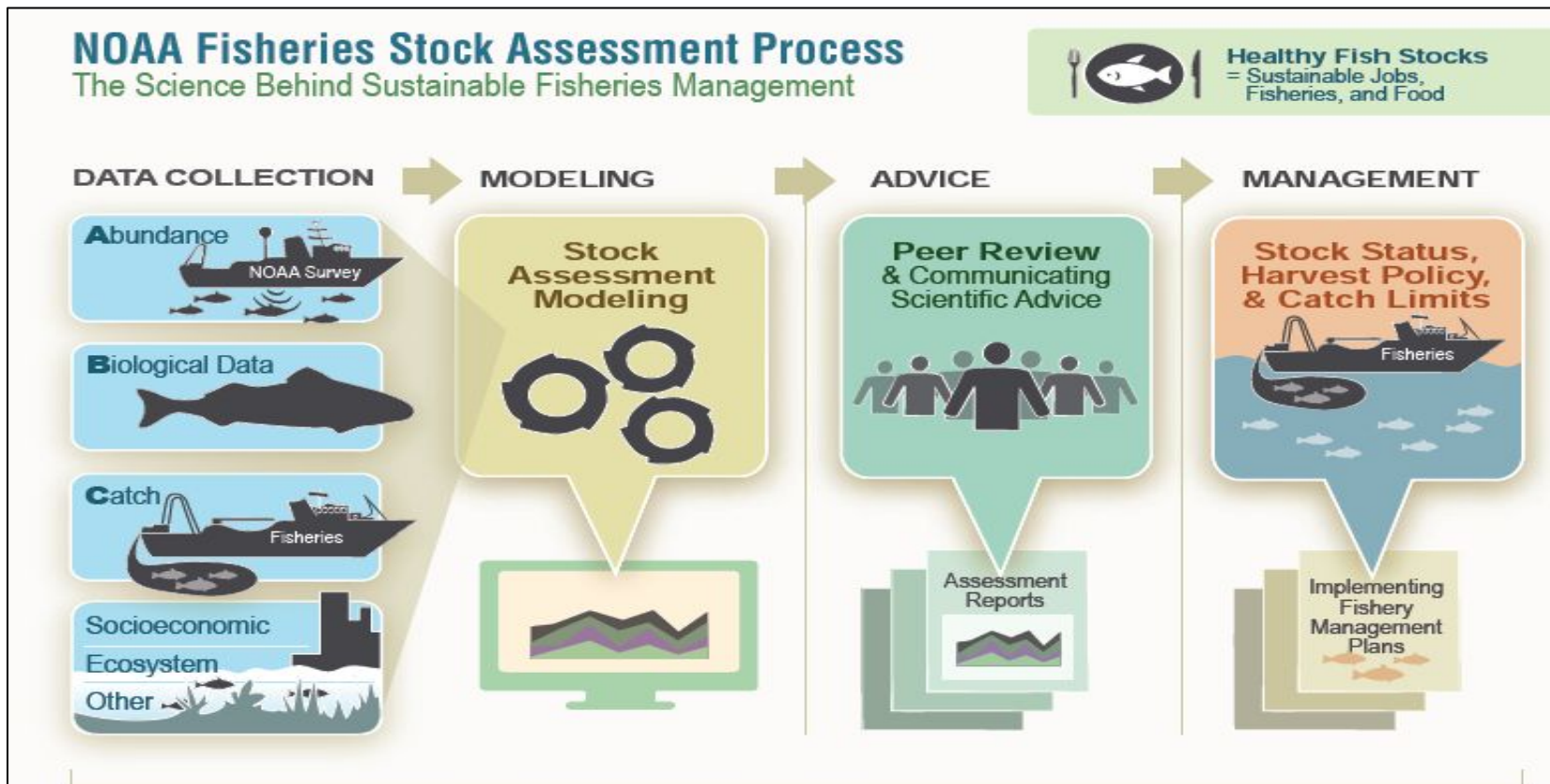


Management Approaches



Link et al. 2019 ICES

How to incorporate climate information?



Management Challenges

- Focus on sustainability & decreasing overcapitalization = policies that resulted in fishermen being less adaptable
- Many historical approaches are based on scientific assumptions that are no longer valid
- Updating science is not enough, we also need to update management to be more adaptable



Adapting Fisheries Management – Need Two - Pronged Approach

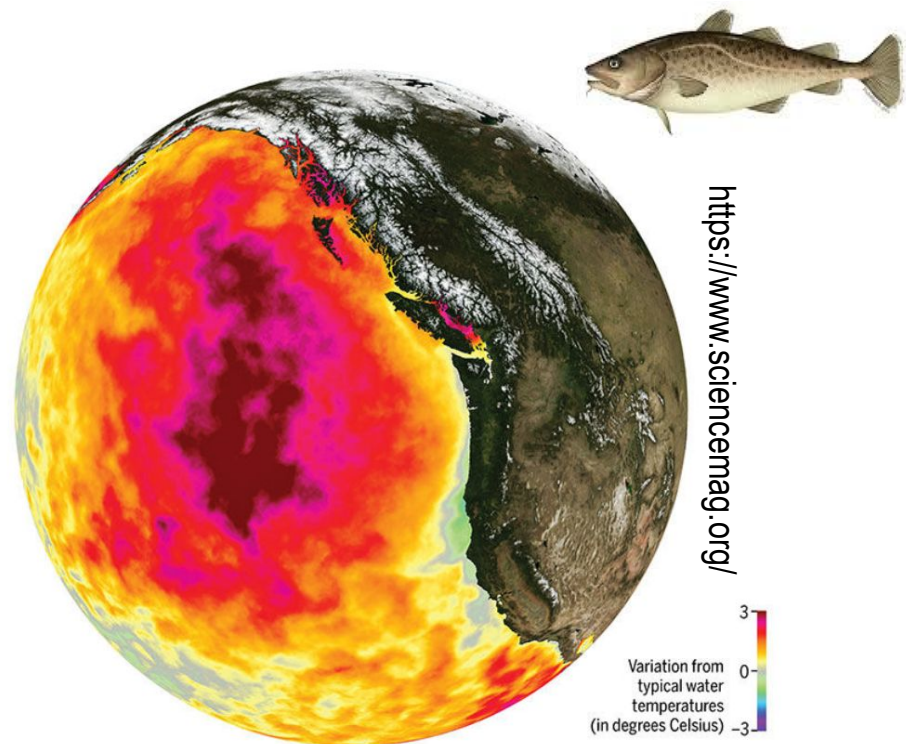
- Reactive Management
- Proactive Management



<https://www.fisheries.noaa.gov/resource/document/review-potential-approaches-managing-marine-fisheries-changing-climate>

Reactive - Adjusting Catch Limits as Abundances Change

- Marine heatwave anomaly coincided with reduction in Gulf of Alaska Pacific Cod biomass
- Management responded with severe cuts to catch limits and declared the 2018 fishery a fishery disaster
- Emphasizes the importance of observational data to facilitate reactive management response

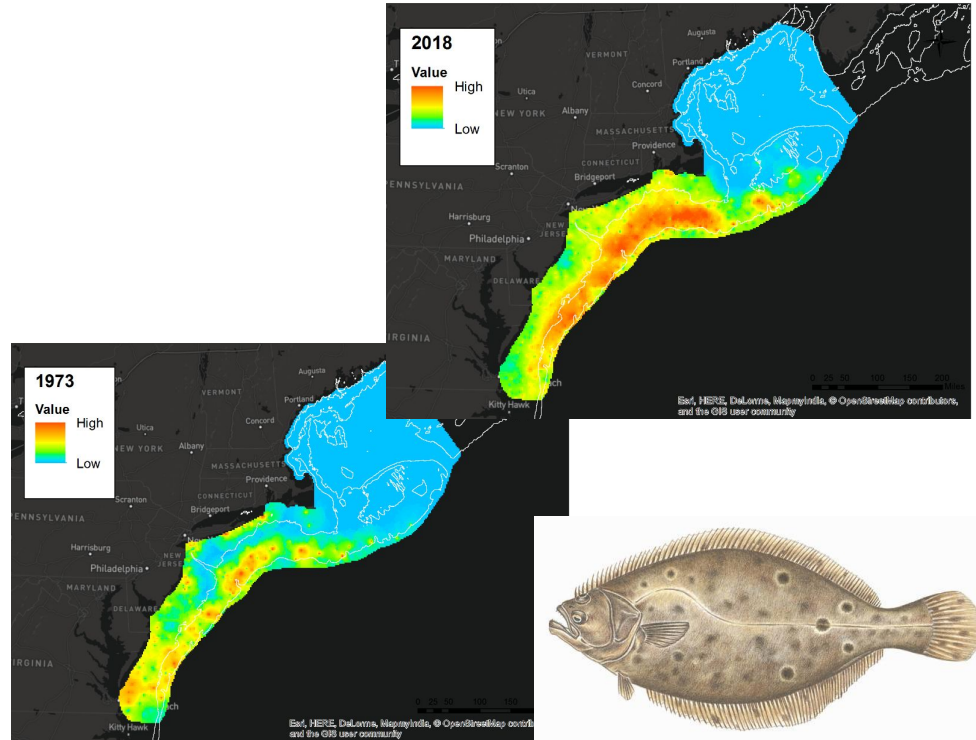


By early 2015, the unusually warm water known as The Blob covered a vast swath of the Pacific Ocean.
GENTEMANN, C., ET AL. *GEOPHYSICAL RESEARCH LETTERS* 44, 1, 312, (2017)

<https://www.frontiersin.org/articles/10.3389/fmars.2020.00703/full>

Reactive - Adjusting Fishing Allocations as Distributions Change

- Summer Flounder have extended their range north
- New rule revises percent allocations for quota greater than 9.55 mill lb
- Management needs to balance historical use with new fishing opportunities



Summer Flounder (Fluke)

Reactive - Adjusting Fishing Practices as Interactions Change

- Dungeness crab fishery delayed and overlapped with northern migration of gray and humpback whales
- High number of whales entangled in crab lines
- Management exploring changes in gear and timing of season



Proactive – Add Future Flexibility

Ocean
EXTREMES
and their
impact

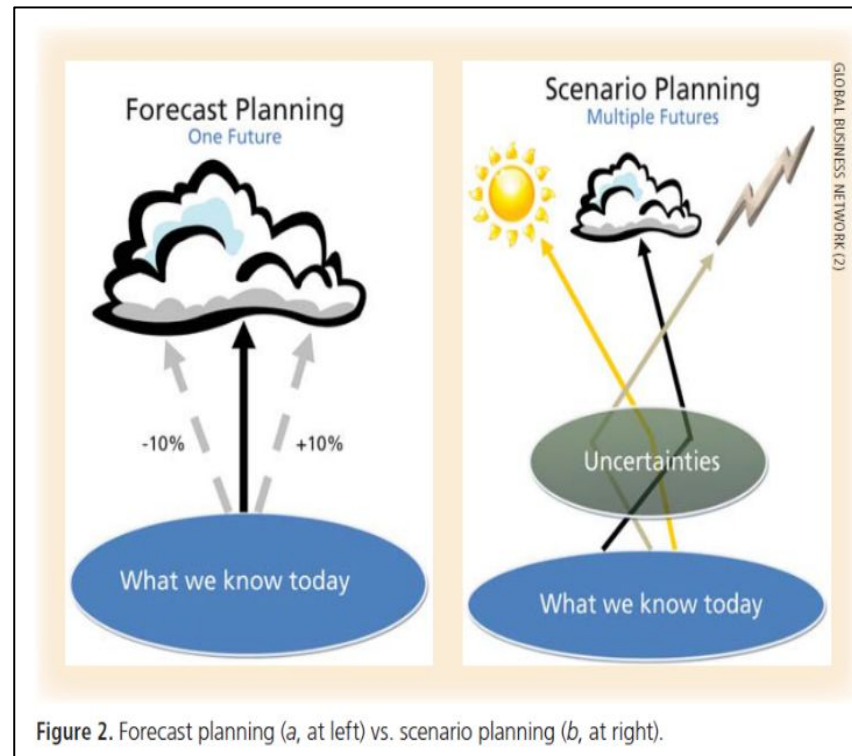
expect the
unexpected!



Link et al. 2019 ICES






Proactive – Scenario Planning Tool

- Identifies options to reduce risks and meet goals under multiple likely futures
- Identify actions for adaptability
- Prepares for future reactive management



Weeks et al. 2011, Park Science

Benefits from Scenario Planning

-  *Flexibility to react quickly to a changing world*
-  *More robust decisions and plans*
-  *Innovative ideas*
-  *Early and broad risk identification*
-  *Alignment towards a common vision*

Source: Scenario Insight

Proactive – Increase Resilience of Stocks, Ecosystems

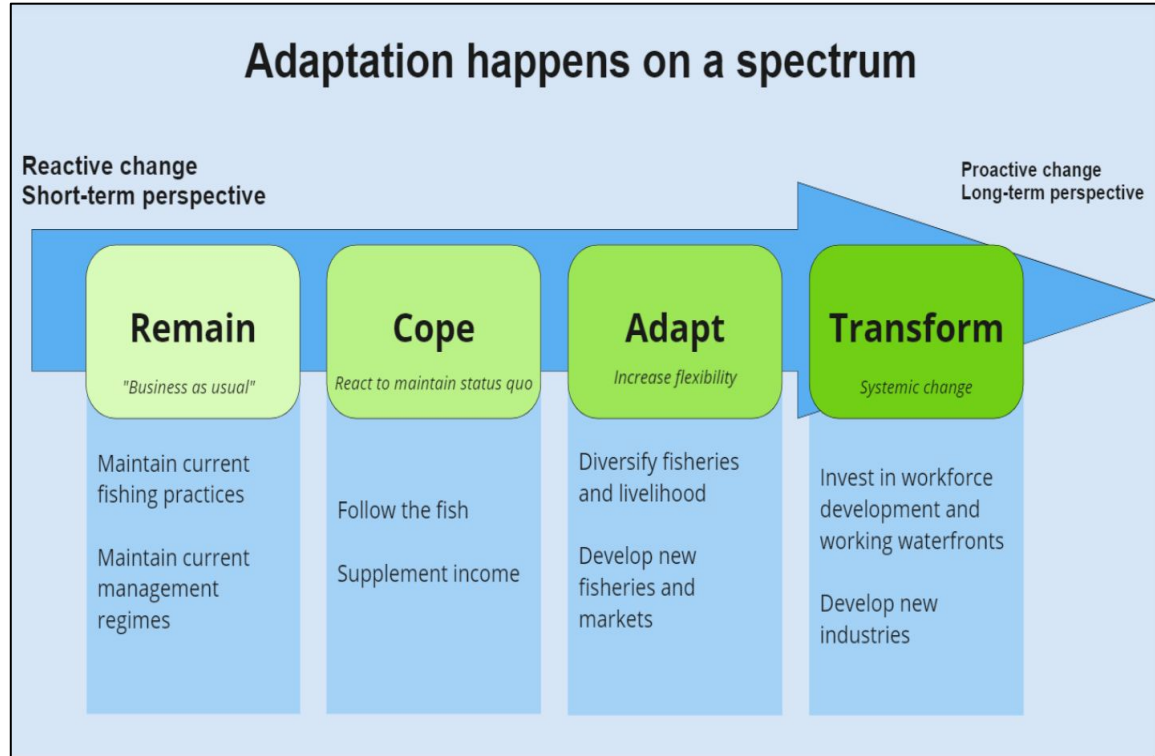
- Protect old females (BOFFs).
- Protect key habitats or species.
- Evaluate Council risk policies (more and less risk).

Review of Fishery Management Approaches to Changing Climate - <https://www.fisheries.noaa.gov/resource/document/review-potential-approaches-managing-marine-fisheries-changing-climate>



Proactive – Increase Resilience of Communities & Businesses

- Identify risks
- Diversify catch
- Consider supply chains
- Engage communities
- Plan for adaptation








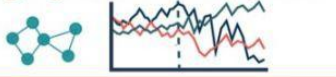
Source image: Marysia Szymkowiak (NMFS AFSC)

On Ramps for Climate Information

Climate informed stock assessments and advice

Climate information in near term management targets

Climate information in long term management targets and design

<p>On-ramp 1</p> 	<p>Tactical Near-term Advice (<2 yr)</p> <p>Climate change information incorporated into stock assessment models, stock-specific indicators (ESPs), stock-specific risk tables (as appropriate).</p> <p>E.g., ABC based on climate forecasts</p> 
<p>On-ramp 2</p> 	<p>Strategic Near-term Advice (<2 yr)</p> <p>Climate change context for observed changes in social, ecological, & oceanographic conditions relevant for harvest advice and targets.</p> <p>E.g., Forecasts of climate-driven distributions, tipping points, & thresholds</p> 
<p>On-ramp 3 (new)</p> 	<p>Strategic & Long-term Advice (>2 yr)</p> <p>Climate - informed long-term strategic decision making & planning informed by IK, LK, and climate & management scenario evaluations, risk assessments, & adaptation efficacy & feasibility evaluations.</p> <p>E.g., Targets based on climate projections</p> 

<https://www.npfmc.org/climatechangetaskforce/>

Unique Opportunity – Inflation Reduction Act (IRA) Funding

- + \$349 million to advance Climate-Ready Fisheries:
 - Expand and Modernize Stock Assessments
 - Regional Fishery Management Councils
 - Climate Ecosystems and Fisheries Initiative (CEFI)
 - Focus on specific challenges including North Atlantic Right Whale, Red Snapper, Pacific Salmon, Protected Resources recovery.
- + \$784 million for hatcheries and habitat conservation



<https://www.fisheries.noaa.gov/national/climate/helping-america-prepare-and-respond-climate-change-under-inflation-reduction-act>
<https://www.fisheries.noaa.gov/topic/climate-change/climate,-ecosystems,-and-fisheries>

Key Take-aways (1)

- Changing climate and ocean conditions are impacting fisheries, fisheries management & fishing communities.
- There are a number of tools available to help track change, assess risks and identify effective management strategies.
- NOAA is working to increase the production, delivery and use of climate information in fisheries management.



Key Take-Aways (2)

- Decision makers need to be ***both proactive and reactive***
- We can expect the need for reactive responses to increase in the future
- There are proactive things we can do now to improve our reactive responses in the future (e.g. **Scenario planning**)



For more information (1)

- NOAA Fisheries Climate Science Strategy and Regional Action Plans - <https://www.fisheries.noaa.gov/national/climate/noaa-fisheries-climate-science-strategy>
- Next Generation Stock Assessments - <https://spo.nmfs.noaa.gov/sites/default/files/TMSPO183.pdf>
- Accounting for shifting distributions and changing productivity in Fisheries Management - <https://spo.nmfs.noaa.gov/sites/default/files/TMSPO188.pdf>
- Integrated Ecosystem Assessments - <https://www.integratedecosystemassessment.noaa.gov/>
- NOAA Climate, Ecosystems and Fisheries Initiative (CEFI) - <https://www.fisheries.noaa.gov/topic/climate-change#noaa-climate-and-fisheries-initiative>
- NMFS EBFM Policy and Road Map - <https://www.fisheries.noaa.gov/national/ecosystems/ecosystem-based-fisheries-management>

For more information (2)

- Review of Fishery Management Approaches to Changing Climate - <https://www.fisheries.noaa.gov/resource/document/review-potential-approaches-managing-marine-fisheries-changing-climate>
- East Coast Scenario Planning <https://www.mafmc.org/climate-change-scenario-planning>
- Scenario Planning for Fisheries Managers - <https://www.fisheries.noaa.gov/resource/document/scenario-planning-introduction-fishery-managers>
- Proposed Business Rules to Incorporate Climate-Induced Changes in Fisheries Management <https://academic.oup.com/icesjms/article/78/10/3562/6425783>
- Linking Knowledge and Action for Climate-Ready Fisheries: Emerging Best Practices Across the U.S. <https://www.sciencedirect.com/science/article/pii/S0308597X23002919>

Thank you!

Questions?

Jay Peterson - jay.peterson@noaa.gov

Nicholas Coleman - nicholas.coleman@noaa.gov

Wendy Morrison - wendy.morrison@noaa.gov

Melissa Karp - melissa.karp@noaa.gov

Roger Griffis - roger.b.griffis@noaa.gov



Extra Slides



Environmentally Linked Stock Assessments






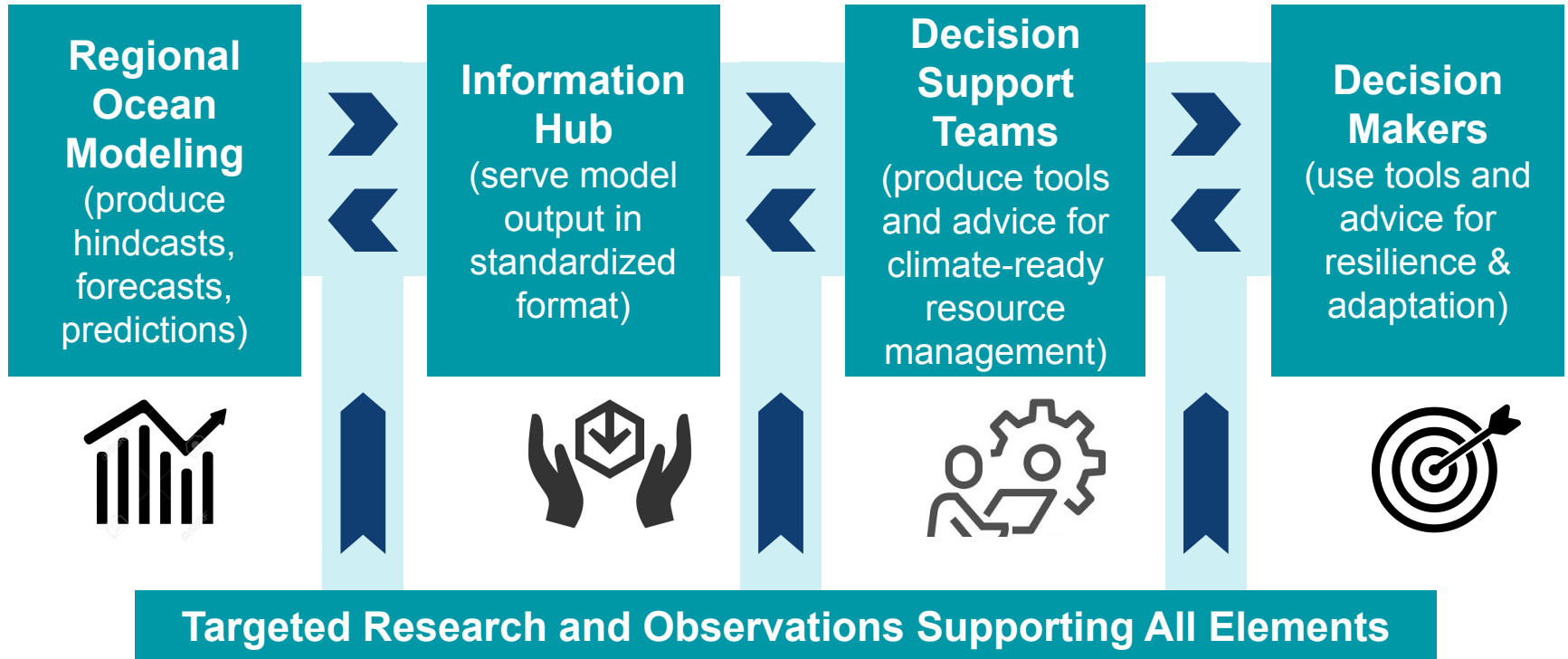
Model term	Factors	Example Species
Catchability	Temperature-dependent	
Catch	Temperature-dependent assignment	
Productivity/ Recruitment	Environmental indicators	
Growth	Time-varying with PDO regime	
Mortality	Harmful algal bloom indicator	

Table credit: Kristin Marshall

CEFI is an end-to-end decision support system for climate-ready decision making

- **Cross-NOAA effort to provide climate-informed advice** and increased capacity for effective resource management.
- **Leverages existing NOAA investments** in research, modeling, observations and decision-making.
- **End-to-end decision support system** addressing four core requirements:
 - **Reliable delivery** of robust ocean forecasts and projections
 - **Operational production** of climate-informed ecosystem projections, risk assessments and adaptation strategies
 - **Decision maker capacity** to use climate advice
 - **Targeted research & observations** for innovation

CEFI Decision Support System



Proactive - Adjusting Catch Limits to account for Uncertainty (Risk Tables)

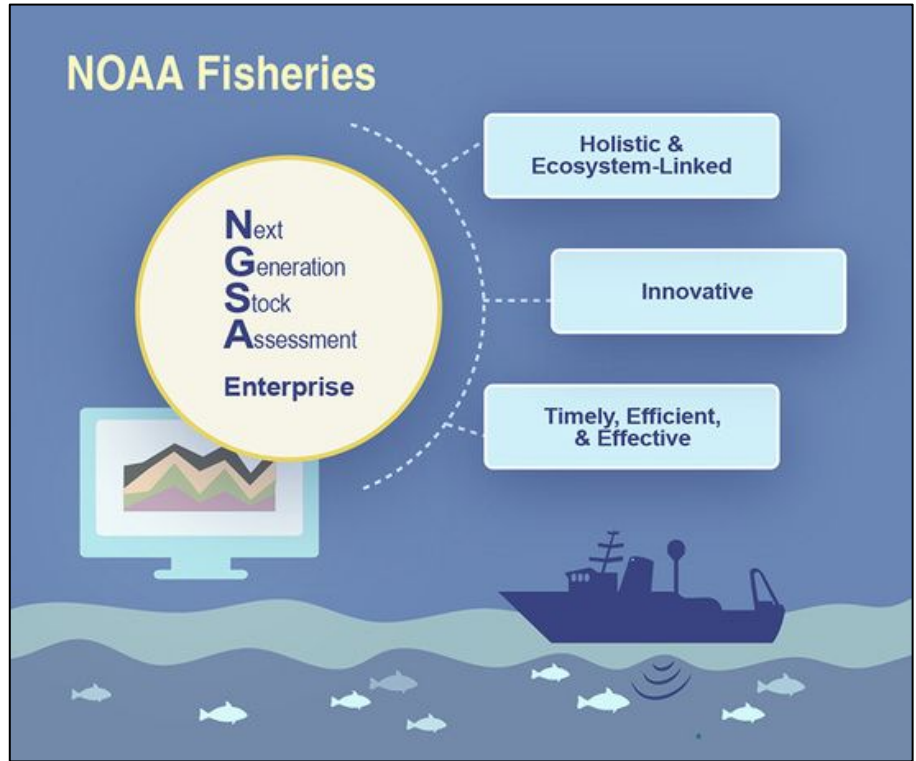
Table 1. Risk classification table for assessment, population dynamics, and environmental/ecosystem considerations.

	Assessment-related considerations	Population dynamics considerations	Environmental/ecosystem considerations
Level 1: Normal	Typical to moderately increased uncertainty; minor unresolved issues in assessment.	Stock trends are typical for the stock; recent recruitment is within normal range.	No apparent environmental/ecosystem concerns.
Level 2: Substantially increased concerns	Substantially increased assessment uncertainty or unresolved issues.	Stock trends are unusual; abundance increasing or decreasing faster than has been seen recently, or recruitment pattern is atypical.	Some indicators showing an adverse signals but the pattern is not consistent across all indicators.
Level 3: Major Concern	Major problems with the stock assessment; very poor fits to data; high level of uncertainty; strong retrospective bias.	Stock trends are highly unusual; very rapid changes in stock abundance, or highly atypical recruitment patterns.	Multiple indicators showing consistent adverse signals a) across the same trophic level, and/or b) up or down trophic levels (i.e., predators and prey of stock)
Level 4: Extreme concern	Severe problems with the stock assessment; severe retrospective bias. Assessment considered unreliable.	Stock trends are unprecedented. More rapid changes in stock abundance than have ever been seen previously, or a very long stretch of poor recruitment compared to previous patterns.	Extreme anomalies in multiple ecosystem indicators that are highly likely to impact the stock. Potential for cascading effects on other ecosystem components.

Dorn and Zador, 2020

Next Generation Stock Assessments Improvement Plan

- Expand the scope of stock assessments to be more holistic.
- Use innovative science and advanced technologies
- Establish a more timely, efficient and effective SA process



Published June 2018. <https://www.fisheries.noaa.gov/topic/population-assessments#fish-stocks>

Proactive - Adjusting Catch Limits to account for Uncertainty (Risk Tables)

*“In summary, while there are clearly positive signs of strong incoming recruitment, concerns exists regarding the lack of older fish contributing to spawning biomass, the uncertainty surrounding the estimates of the strength of the 2014, 2016, and 2017 year classes, and ambiguity related to how existing environmental conditions may affect the success of these year classes in the future. **These concerns warrant additional caution when recommending the 2021 and 2022 ABCs.**”*



Table. Risk table summary.

Assessment Related Considerations	Population Dynamics Considerations	Environmental and Ecosystem Considerations	Fishery Performance Considerations
Level 3: Major concern	Level 3: Major concern	Level 2: Substantially increased concern	Level 3: Major concern