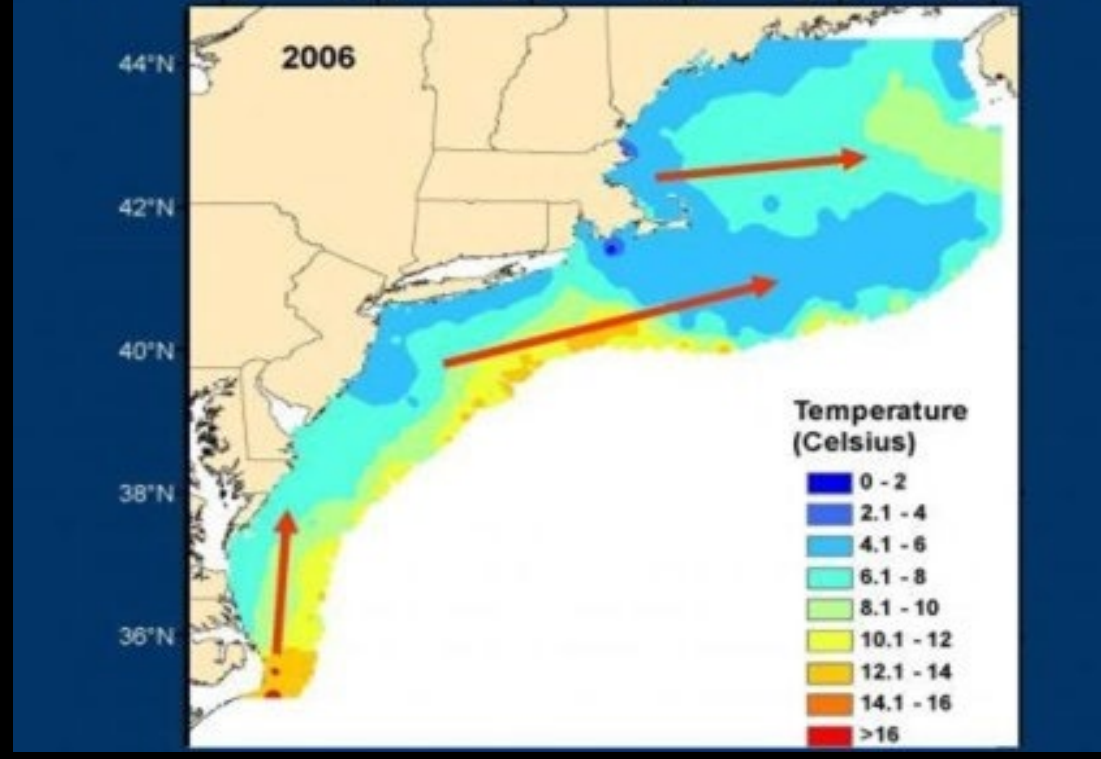

Accounting for shifting distributions and changing productivity in U.S. marine fisheries management: challenges and recommendations

PICES 2019, Victoria, British Columbia, Canada

Melissa Karp*, Jay Peterson, Patrick Lynch, and Roger Griffis *et al.*

*ECS Tech LLC, *in support of*, NOAA Fisheries Office of Science & Technology
Silver Spring, Maryland
melissa.karp@noaa.gov

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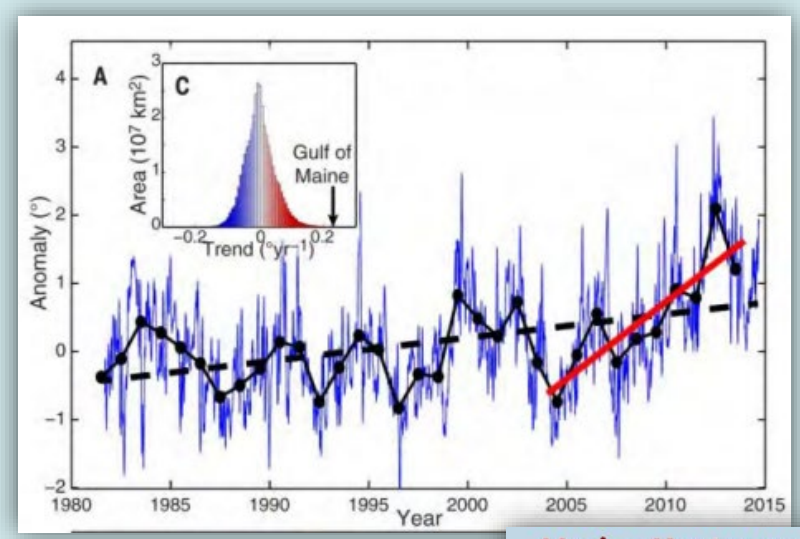
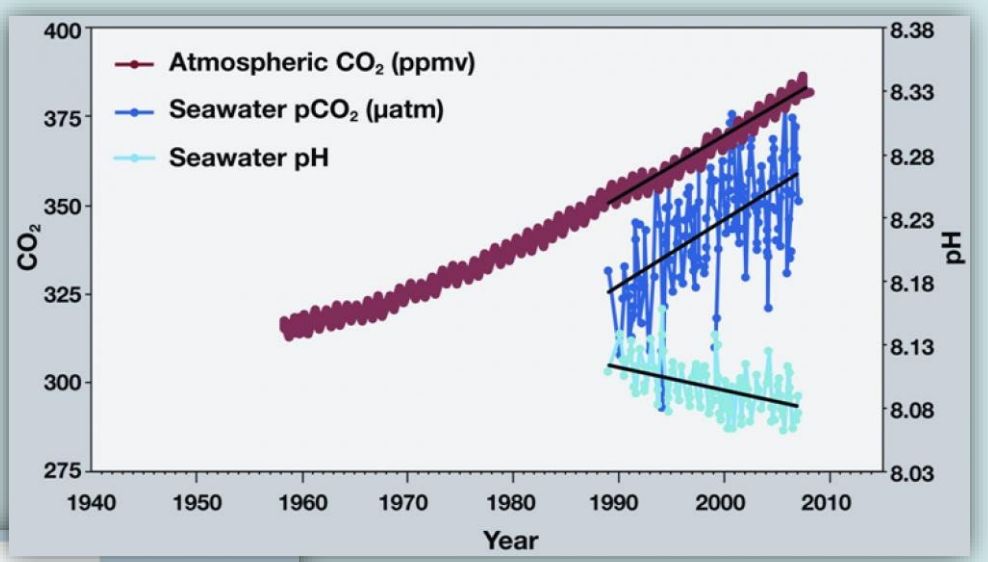
Oceans are Changing



Temperatures projected to increase by 2-4°C by end of century

(IPCC, 2014; Pershing et al. 2015, Science)

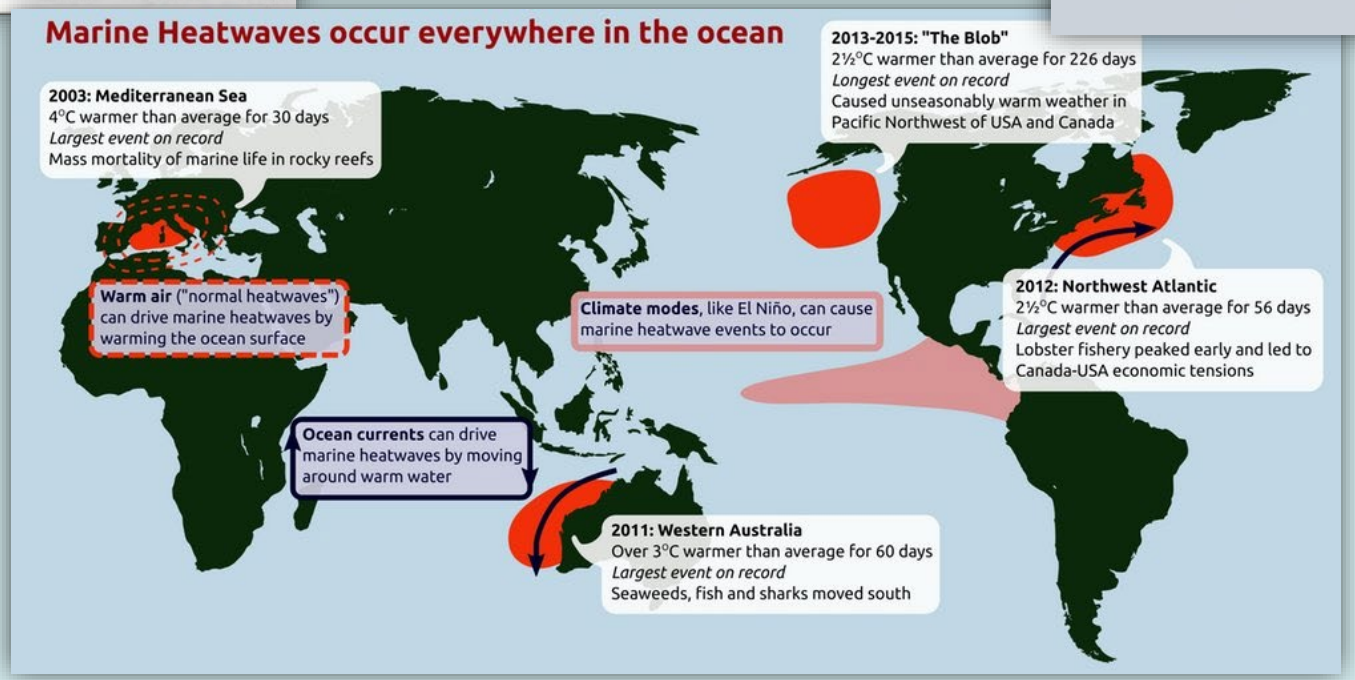


Average surface ocean pH has decreased 0.1 units below pre-industrial average and is projected to further decrease by 0.13 to 0.42 units by 2100

(IPCC, 2014; Pershing et al. 2015, Science)

"Marine heatwaves have become longer and more frequent around the world"

- Eric Oliver, The Conversation



Credit: Eric Oliver/Dalhousie University

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Impacts on Fish and Fisheries

- Species are shifting and their productivity is changing in response
- Potential to significantly impact management
  - Allocation issues
  - Spatial & temporal management
  - Estimates of spawning biomass, MSY, and biological reference points

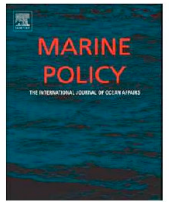
Projecting shifts in thermal habitat for 686 species on the North American continental shelf

PLOS ONE

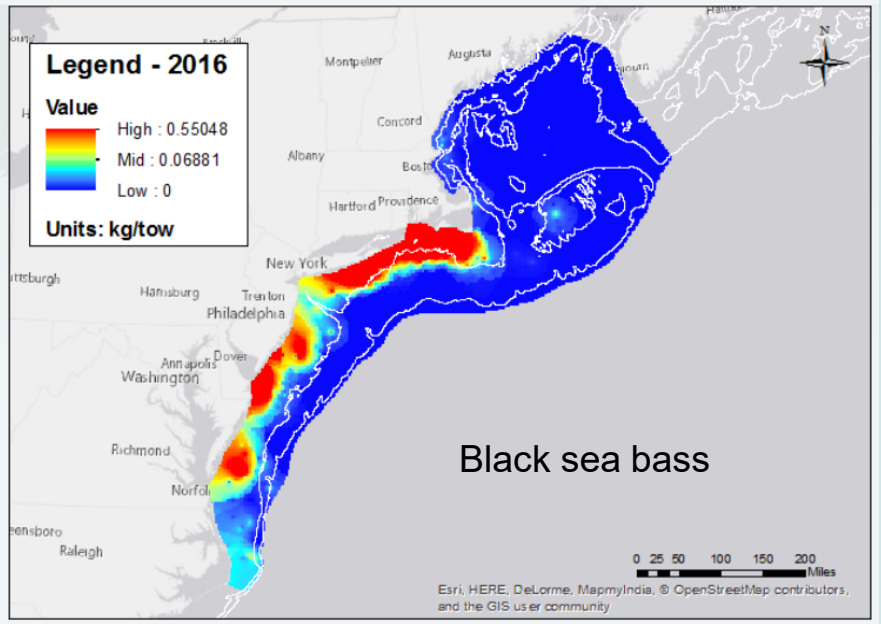
James W. Morley, Rebecca L. Selden, Robert J. Latour, Thomas L. Frölicher, Richard J. Seagraves, Malin L. Pinsky

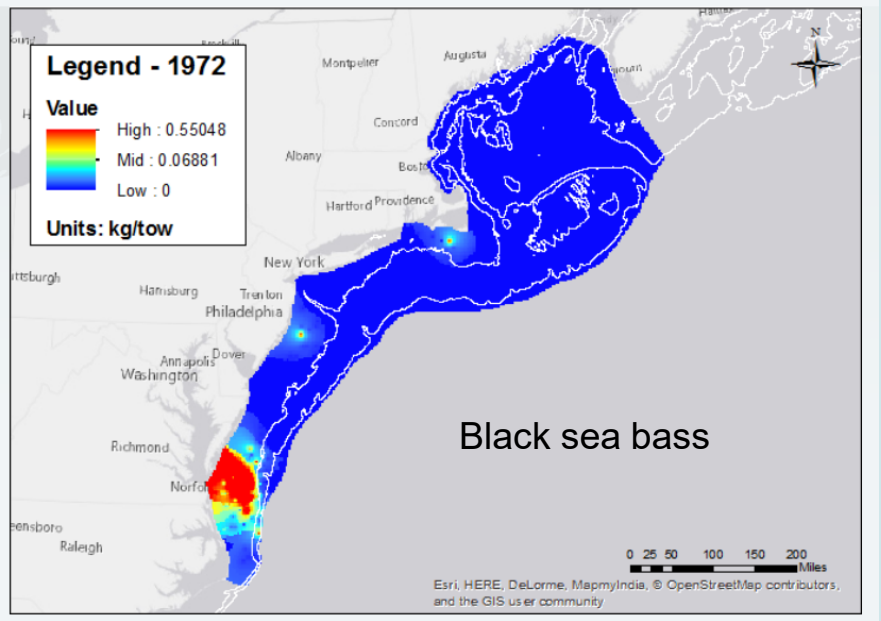
Published: May 16, 2018 • https://doi.org/10.1371/journal.pone.0196127

Governing fisheries in the face of change: Social responses to long-term geographic shifts in a U.S. fishery



Bradford A. Dubik[a,*,1], Elizabeth C. Clark[a,1], Talia Young[b], Sarah Bess Jones Zigler[a], Mikaela M. Provost[c], Malin L. Pinsky[d], Kevin St. Martin[e]





Source: OceanAdapt
https://oceanadapt.rutgers.edu/

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Incorporating Climate and Environmental Information in Fisheries Management Workgroup

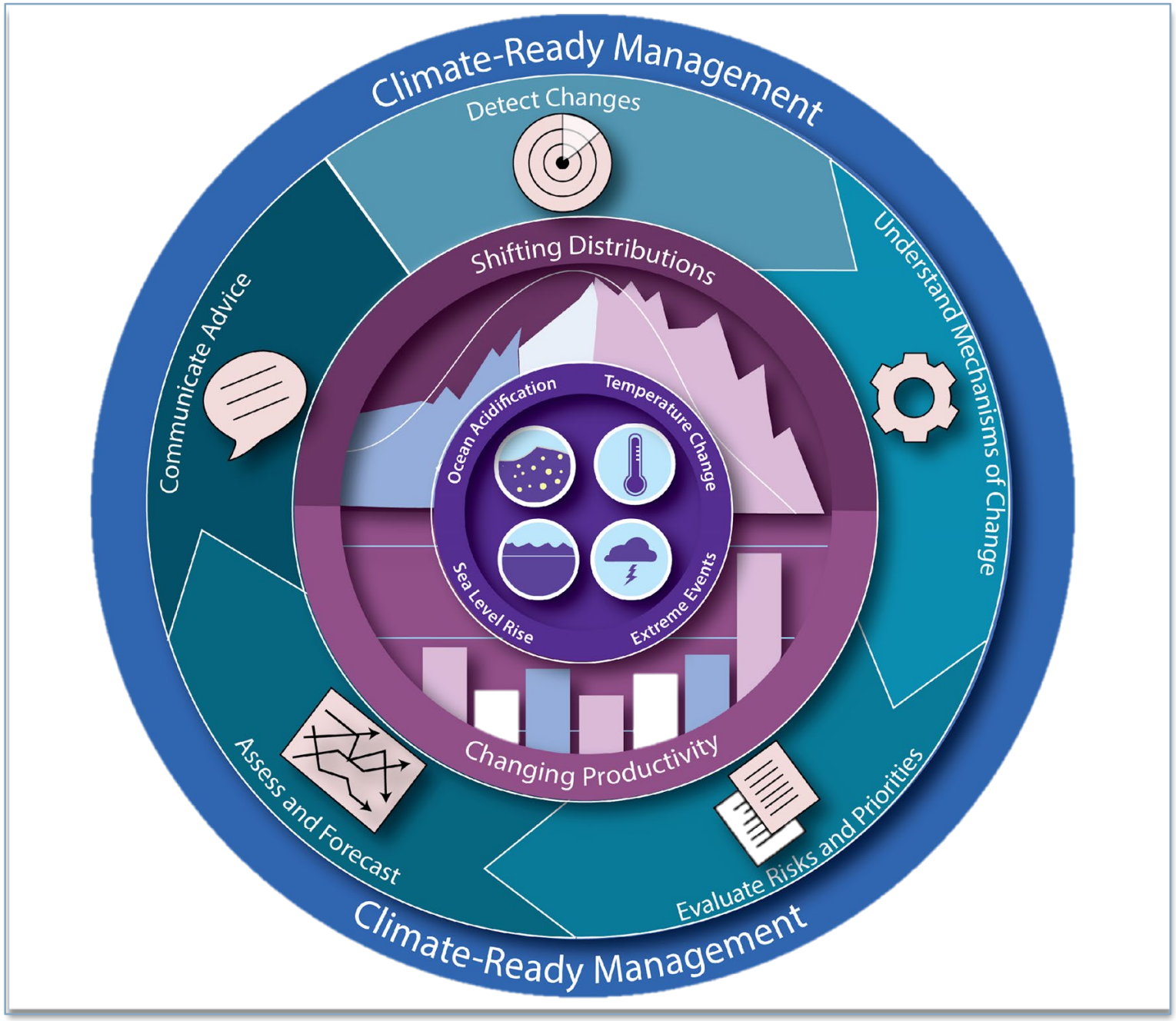
Note: not all participants are in photo

Charge:

- ***Develop specific, actionable recommendations*** to better incorporate environmental and climate information into the fisheries management process.
- ***Focus on Responding to Two Issues***:
  - Shifting species distributions
  - Changing stock and system productivity

Participants:

- Representatives from each Science Center and Regional Office, S&T, and SF



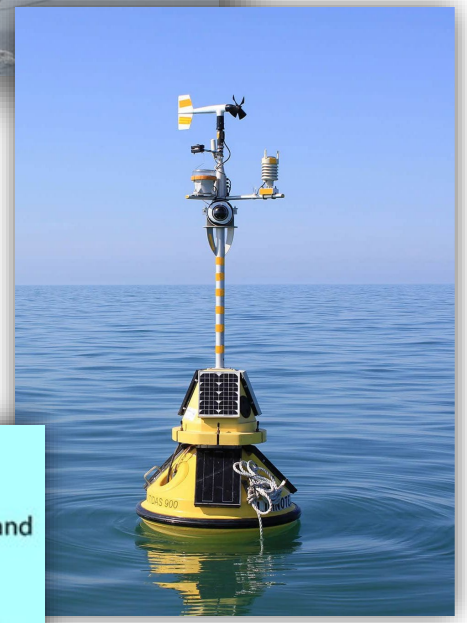
Components of Climate-Ready Fisheries Management

- What is changing?
- Why is it changing?
- What is vulnerable to change?
- How will it change?
- How to deliver and use key information/advice?
- How to prepare and respond to changes?

Karp et al. 2019, *ICES J. Mar. Sci.*, doi:10.1093/icesjms/fsz048

1. Detect Changes

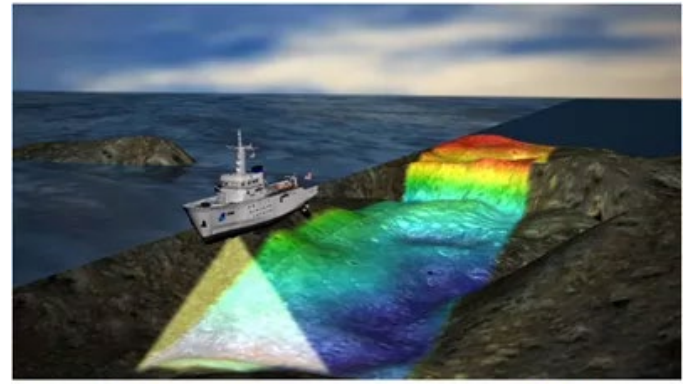
- Expand the spatial and temporal coverage of surveys
  - Facilitate survey flexibility to track changes in species distributions
    - e.g., Pacific Sardine surveys
  - Engage and leverage capacity of fishermen and other stakeholders
- Use Integrated Ocean Observing System (IOOS) and other advanced sampling technologies
- Coordinate research and survey efforts across adjacent jurisdictions
- Track and monitor indicators that can serve as early warnings of change

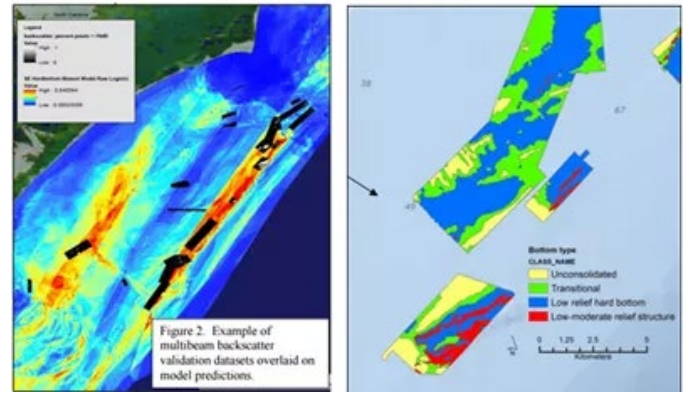


http://www.fisherycouncils.org/

2. Understand Mechanisms of Changes

- Collect oceanographic, habitat, and multispecies information on all standard surveys
- Evaluate stock availability to survey and fishing gear (catchability)
- Conduct process oriented research that can improve modeling and assessments
  (e.g., temp and OA effects on mortality, growth, etc.)





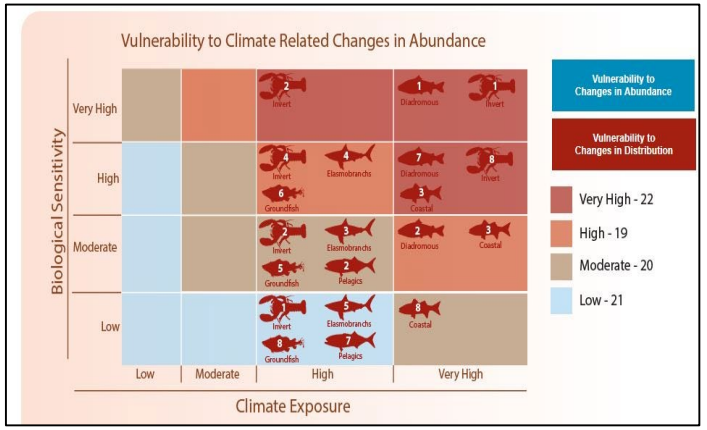
3. Evaluate Risks and Priorities

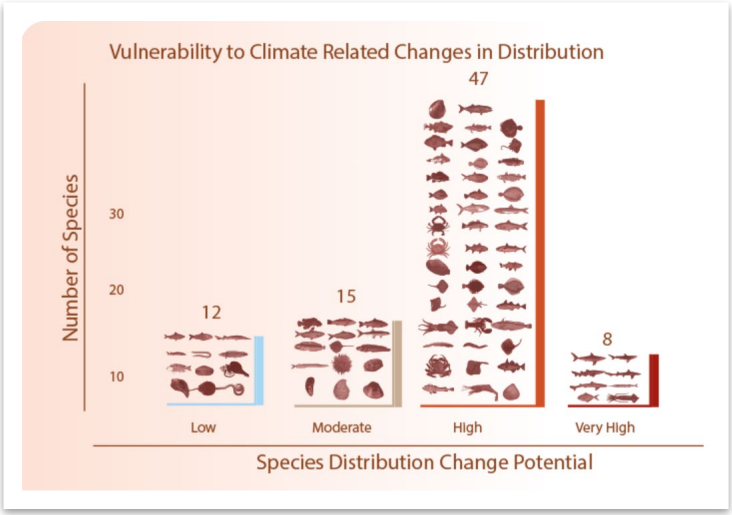
- Evaluate the magnitude and relative importance of distribution shifts and changes in productivity
  - Spatial analysis techniques
  - Sensitivity analysis
- Vulnerability assessments, tiered risk assessments
- Prioritize species at risk

RESEARCH ARTICLE

A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf

Jonathan A. Hare[1]*, Wendy E. Morrison[2], Mark W. Nelson[2], Megan M. Stachura[3¤a], Eric J. Teeters[2], Roger B. Griffis[4], Michael A. Alexander[5], James D. Scott[5], Larry Alade[6], Richard J. Bell[1¤b], Antonie S. Chute[6], Kiersten L. Curti[6], Tobey H. Curtis[7], Daniel Kircheis[8], John F. Kocik[8], Sean M. Lucey[6], Camilla T. McCandless[1], Lisa M. Milke[9], David E. Richardson[1], Eric Robillard[6], Harvey J. Walsh[1], M. Conor McManus[10¤c], Katrin E. Marancik[10], Carolyn A. Griswold[1]





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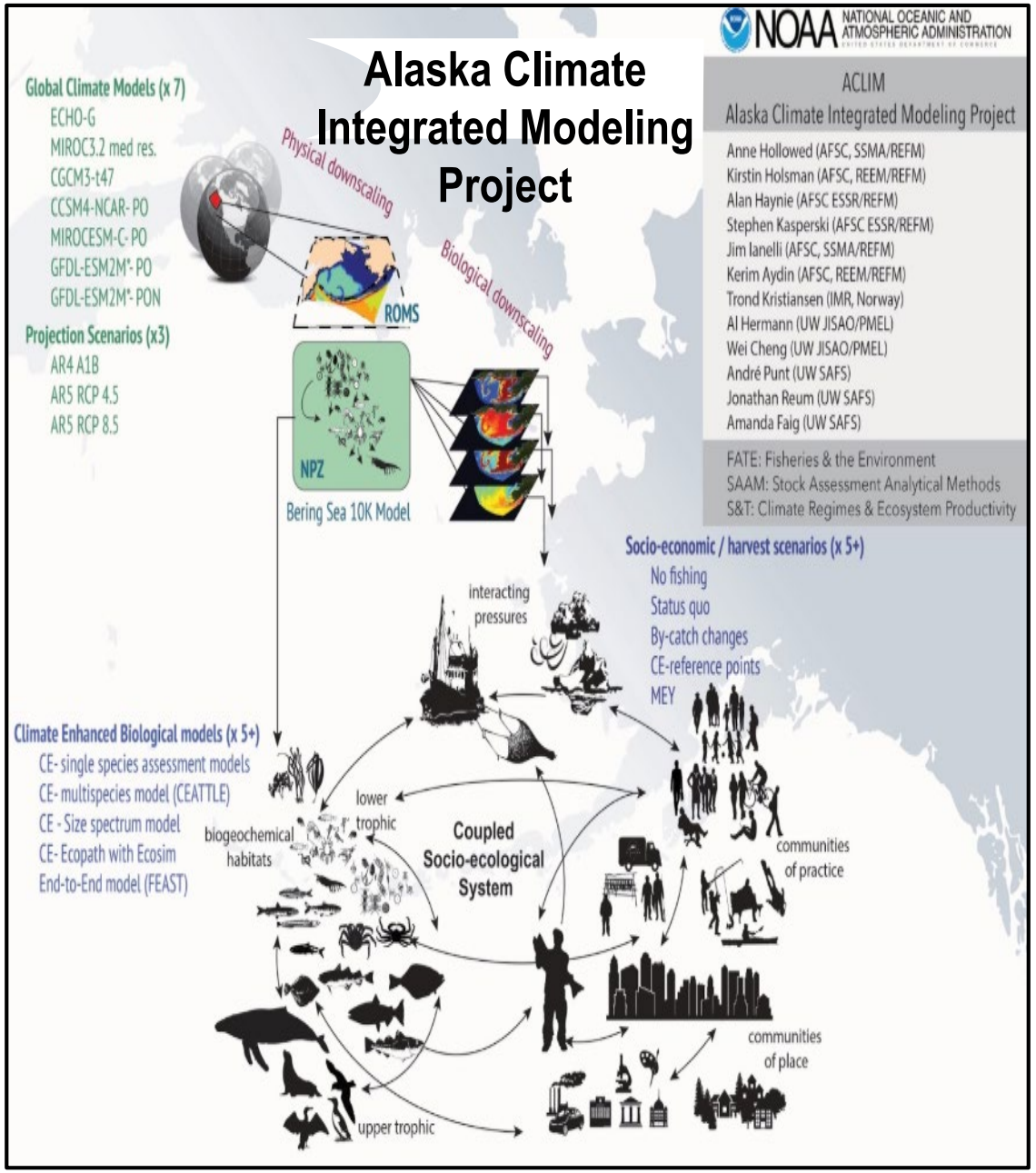
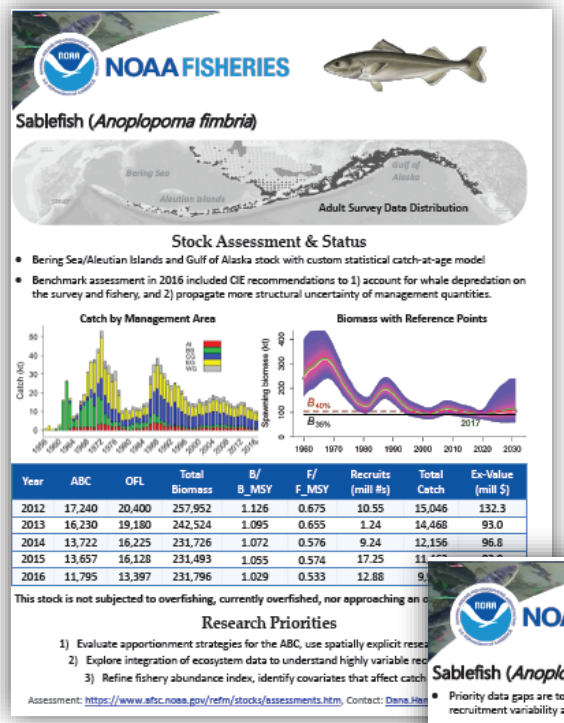
4. Assess and Forecast

- Include ecosystem considerations in Terms of Reference in each regional stock assessment process
- Capitalize on advancement in spatial-temporal and physical-ecosystem-economic models
- Explore the use of ensemble modeling and multi-mode inferences
- Evaluate model diagnostics and the predictive skill of forecasts



5. Communicating Advice

- Establish routine reporting and standardized templates to report information on ecosystem dynamics, species distributions, and productivity
  - e.g., Ecosystem-Socioeconomic Profiles and APECS (Shotwell, pers. communication)
- Utilize and include decision support tools in stock assessment reports
  - e.g., decision tables and decision trees to communicate risk and tradeoffs
- Facilitate regular engagement between scientists and managers through regular and open dialogue at workshops and debriefs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Sablefish (*Anoplopoma fimbria*)

Adult Survey Data Distribution

Stock Assessment & Status

- Bering Sea/Aleutian Islands and Gulf of Alaska stock with custom statistical catch-at-age model
- Benchmark assessment in 2016 included CIE recommendations to 1) account for whale depredation on the survey and fishery, and 2) propagate more structural uncertainty of management quantities.

Catch by Management Area

Biomass with Reference Points

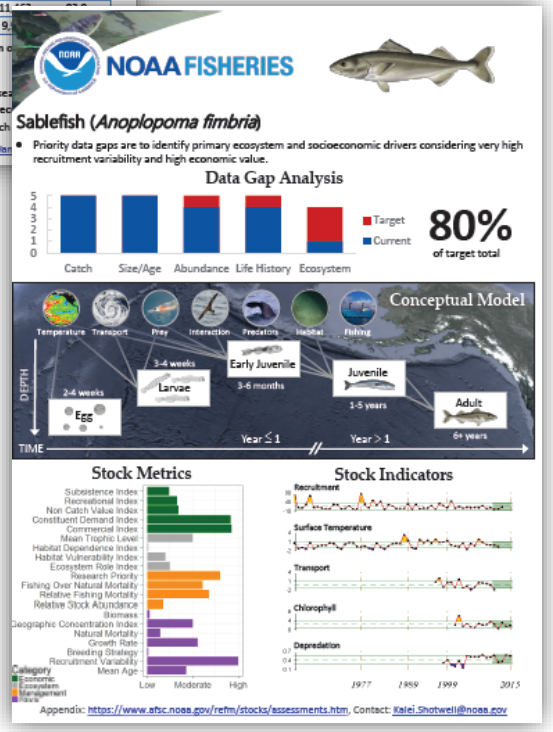
Year	ABC	OFL	Total Biomass	B/ B_MSY	F/ F_MSY	Recruits (mill #s)	Total Catch	Ex-Value (mill $)
2012	17,240	20,400	257,952	1.126	0.675	10.55	15,046	132.3
2013	16,230	19,180	242,524	1.095	0.655	1.24	14,468	93.0
2014	13,722	16,225	231,726	1.072	0.576	9.24	12,156	96.8
2015	13,657	16,128	231,493	1.055	0.574	17.25	11,[illegible]	[illegible]
2016	11,795	13,397	231,796	1.029	0.533	12.88	9,[illegible]	[illegible]

This stock is not subjected to overfishing, currently overfished, nor approaching an [illegible]

Research Priorities

1) Evaluate apportionment strategies for the ABC, use spatially explicit rese[illegible]
2) Explore integration of ecosystem data to understand highly variable rec[illegible]
3) Refine fishery abundance index, identify covariates that affect catch[illegible]

Assessment: https://www.afsc.noaa.gov/refm/stocks/assessments.htm, Contact: Dana Hen[illegible]


NOAA FISHERIES

Sablefish (*Anoplopoma fimbria*)

- Priority data gaps are to identify primary ecosystem and socioeconomic drivers considering very high recruitment variability and high economic value.

Data Gap Analysis

Target
Current

80%
of target total

Catch, Size/Age, Abundance, Life History, Ecosystem

Conceptual Model

Temperature, Transport, Prey, Interaction, Predators, Habitat, Fishing

Egg, Larvae, Early Juvenile, Juvenile, Adult

DEPTH, TIME, Year ≤ 1, Year > 1

Stock Metrics

Stock Indicators

Recruitment, Surface Temperature, Transport, Chlorophyll, Depredation

Appendix: https://www.afsc.noaa.gov/refm/stocks/assessments.htm, Contact: Kalei.Shotwell@noaa.gov

6. Climate-Ready Management Actions

- Plan for future scenarios
  - Structured scenario planning and Management Strategy Evaluations (MSE)

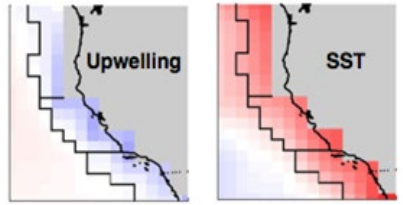
Photo Credit: Bas Kohler; Scheffers and Pecl 2019

6. Climate-Ready Management Actions

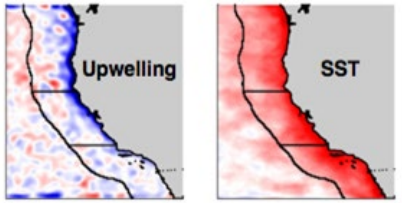
- Plan for future scenarios
- Re-evaluate spatial management approaches
  - Use more 'responsive ocean management' to evaluate and adjust spatial/temporal management approaches using near real-time biological, social, economic, ecological data

EcoCast
An Eco-informatic Tool for Fisheries Sustainability

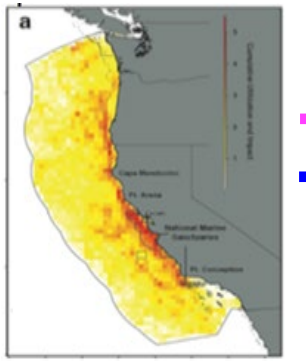
Global Climate Forecast



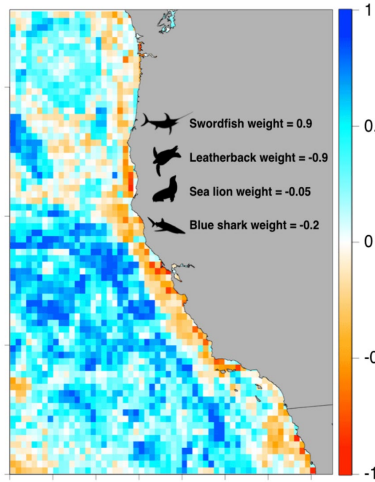
Regional Ocean Model



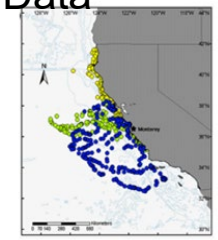
Species Distribution Models



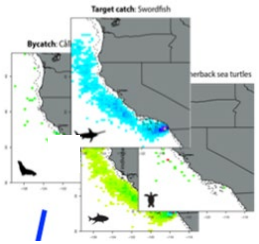
EcoCast Product



Tracking Data



Fishery Observer



Hazen et al., Welch et al.

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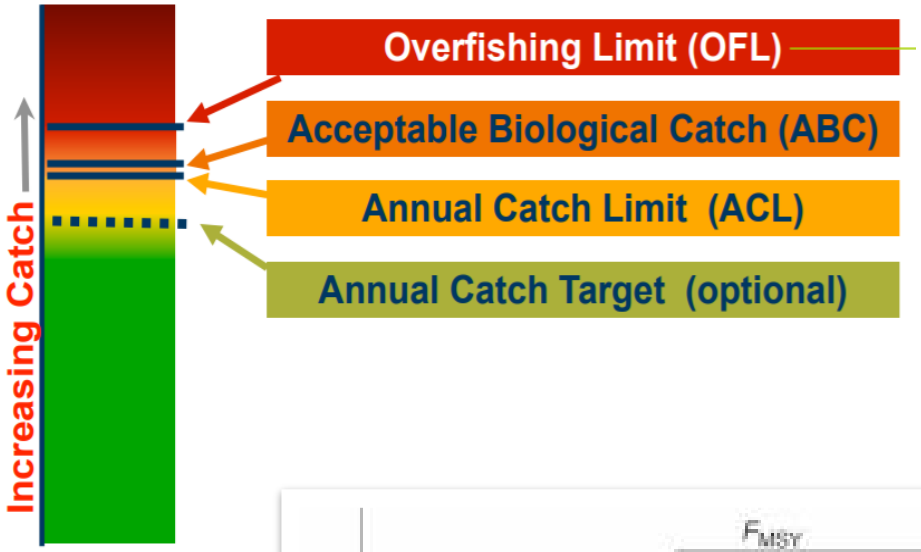
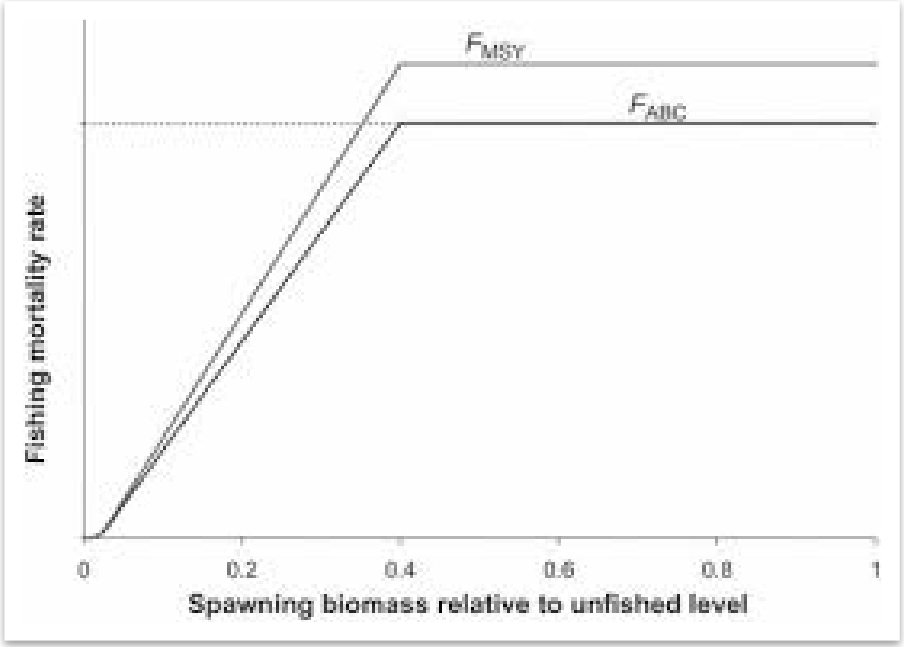
6. Climate-Ready Management Actions

- Plan for future scenarios
- Re-evaluate spatial management approaches
- Develop responsive harvest strategies and control rules
  - Adjust risk policy
  - Empirical management procedures to adjust HCR
  - Explicitly incorporate environmental information into the HCR





Conclusions

- ***Traditional methods and assumptions* may need to change** to account for changing species distribution and productivity.
- ***Additional focused efforts are needed*** to reduce risks.
  - **Explore future scenarios**, re-evaluate spatial and temporal management procedures, and develop responsive HCR.
  - **Improve collaboration and communication** between scientists and managers to increase flow and use of information.
  - **Improve capabilities** to detect changes, understand mechanisms, forecast future changes, evaluate best management strategies and respond to change.

Collaborators

NMFS, Office of Science & Technology

Jay Peterson
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Roger Griffis
Jane DiCosimo

NMFS, Office of Sustainable Fisheries

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Erin Schnettler

NMFS HQ

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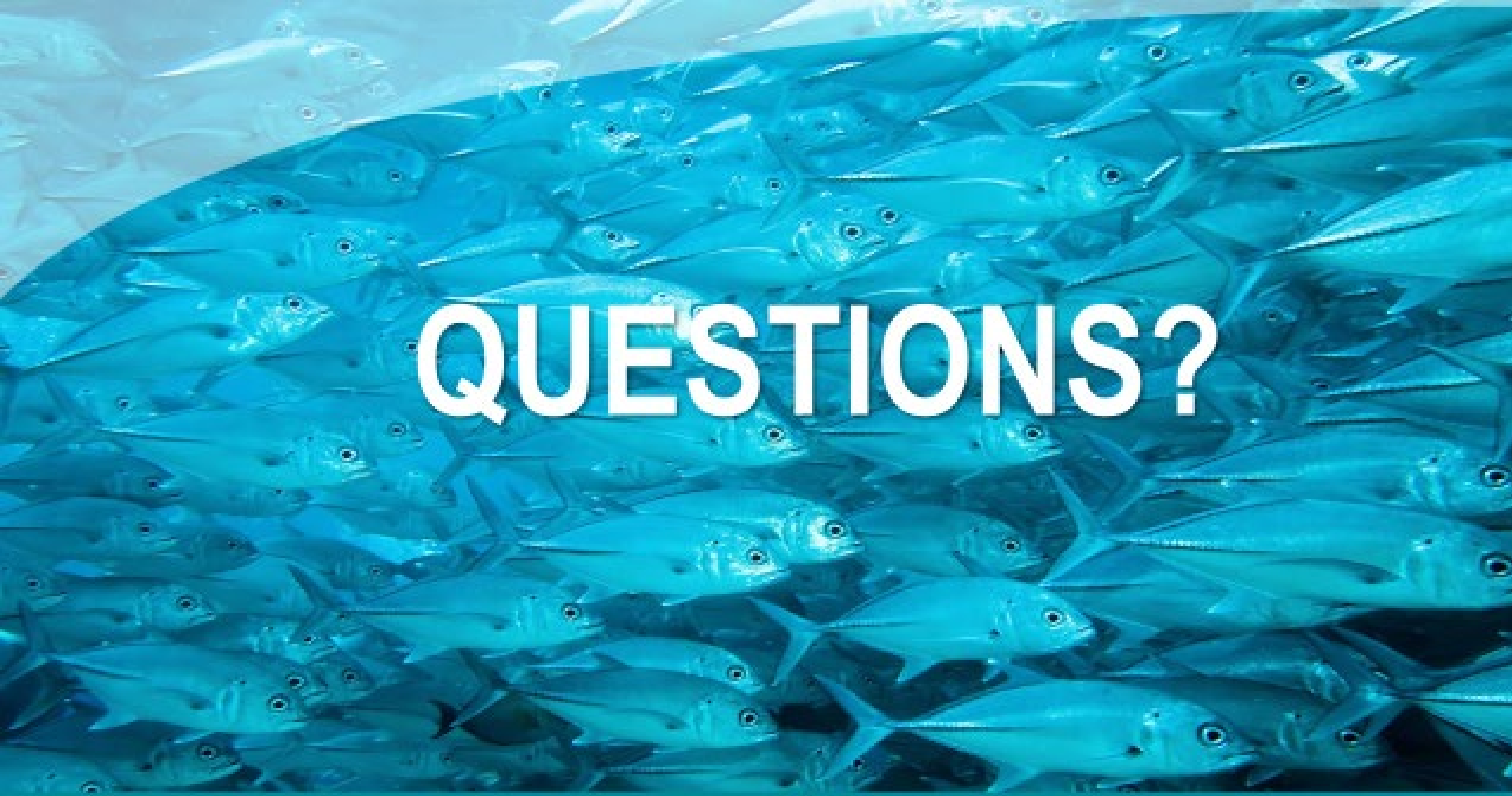
Michelle McClure	PMEL (previously NWFSC)


QUESTIONS?