Some Steps Towards Climate-Ready Management of U.S. Fisheries

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Setting the Stage

- Climate change will profoundly impact marine and coastal ecosystems.

- Fish stocks will change.

- Industries and coastal communities will be effected.

- Growing demands, requirements and opportunities for action.

- NOAA Fisheries Service is assessing needs and taking action.

- More action is needed.

- Many challenges and opportunities.

- Rapid learning is critical: Collaborations welcome.
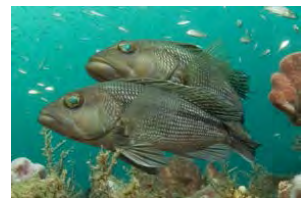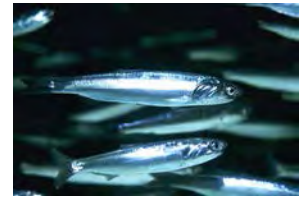
How Get to Climate-Ready Fisheries Management?

1. Assess vulnerabilities
stocks, fisheries, communities

2. Transform our science enterprise
to support climate-informed decisions

3. Build Flexibility and Adaptability
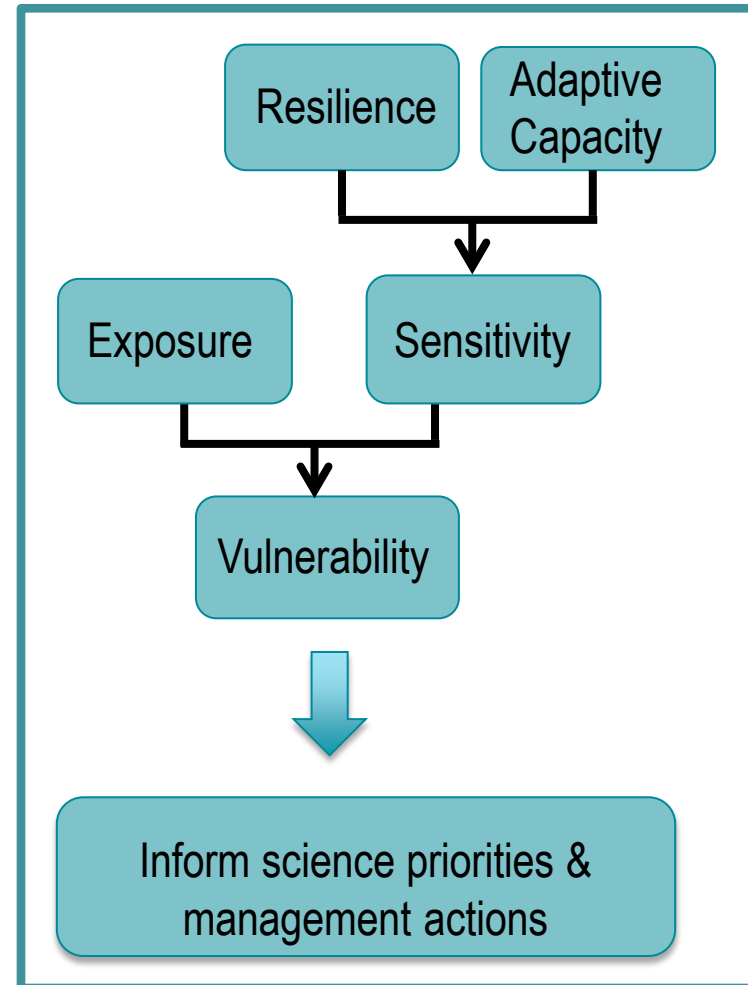In management approaches (e.g. Catch Share Management)

Assess Fish Stock Vulnerability

Goals:

- Determine which stocks are vulnerable and why in all US regions.
- Identify data gaps and research priorities.

First implementation:

- US Northeast Large Marine Ecosystem.
- 82 species

http://www.st.nmfs.noaa.gov/ecosystems/climate/activities/assessing-vulnerability-of-fish-stocks

Fish Stock Climate Vulnerability Methodology

Vulnerability Assessment Framework

Uses *existing information* to create species profiles

Uses a *combination of sensitivity attributes and climate factors* to assess vulnerability

Species Profiles

Stock Vulnerability Report

Uses species profiles and *expert opinion* to score each stock

A *vulnerability report* for each species will identify key attributes

Multi-Stock Vulnerability Rankings

Stock Scores [low, moderate, high, very high].

Produces multi-stock *vulnerability score ranking* for the region

Fish Stock Climate Vulnerability Assessment

Species Vulnerability

Exposure

- Sea surface temperature*
- Air temperature*
- Salinity*
- Ocean acidification (pH)*
- Precipitation*
- Currents**
- Sea level rise**

modelled results (mean & variance)
*written description only

Sensitivity

- Habitat Specificity
- Prey Specificity
- Sensitivity to Ocean Acidification
- Sensitivity to Temperature
- Stock Size/Status
- Other Stressors
- Adult Mobility
- Spawning Cycle
- Complexity in Reproductive Strategy
- Early Life History Survival and Settlement Requirements
- Population Growth Rate
- Dispersal of Early Life Stages

Fish Stock Climate Vulnerability Assessment

Climate Exposure

CMIP5 ENSMN RCP8.5 anomaly (2006-2055)-(1956-2005)

http://www.esrl.noaa.gov/psd/ipcc/ocn/ccwp.html

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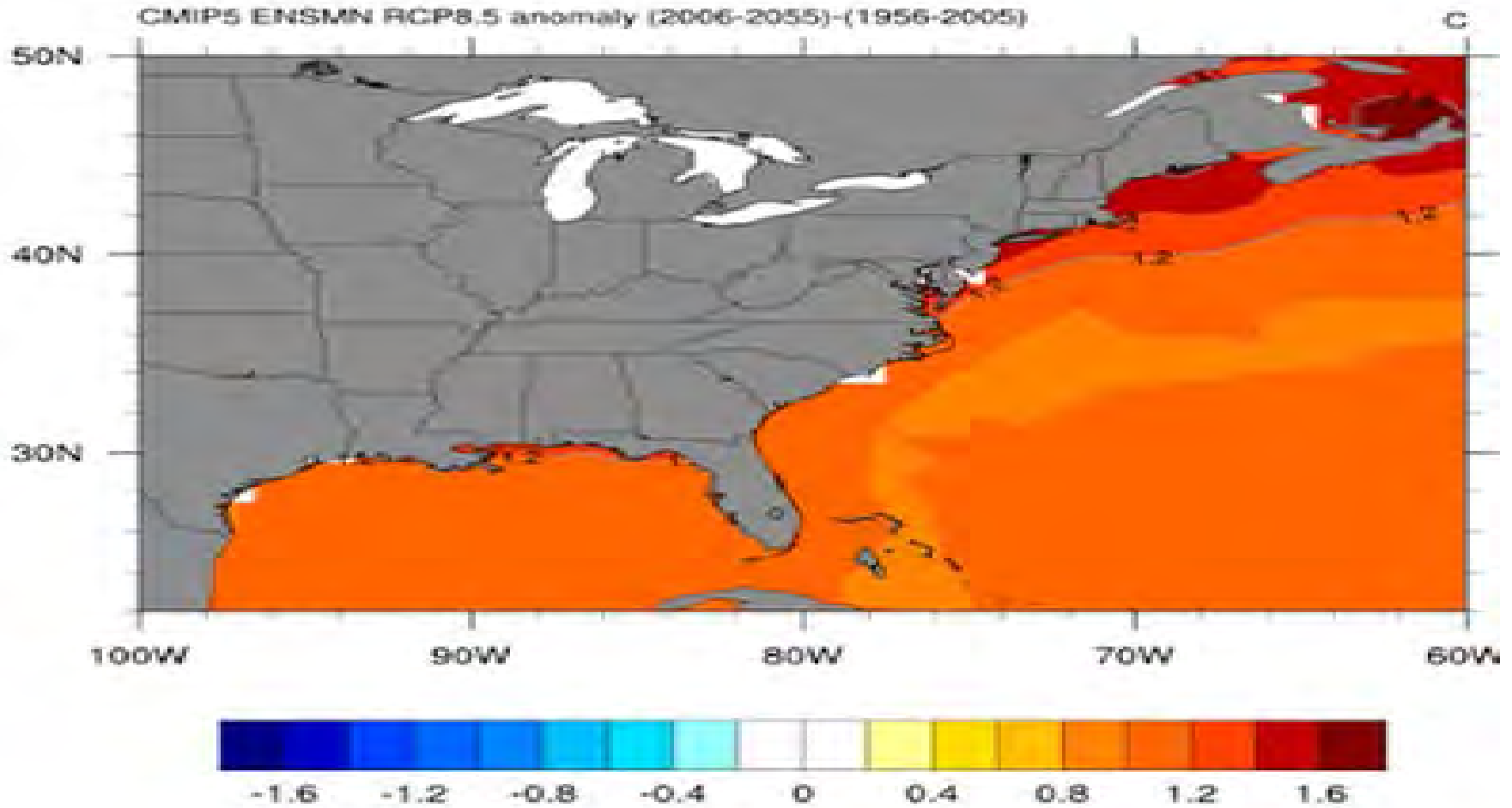
5 Point Tally Scoring System

For each attribute:

- experts assign 5 tallies within the 4 scoring bins

- experts express uncertainty in their score

- experts estimate data quality (0= no data, 1= expert knowledge, 2= limited data, 3 = good data)

Example:

Expert Scores - Low uncertainty scenario			
Low	Moderate	High	Very High
	5		

Expert Scores - Moderate uncertainty			
Low	Moderate	High	Very High
		3	2

Expert Scores - Higher uncertainty scenario			
Low	Moderate	High	Very High
1	1	2	1

Sensitivity and Exposure Scoring Rubric

Attribute Score = Weighted Average of Tallies

Sensitivity or Exposure Component Score =
- Very **high** = # attribute scores ≥ 3.5
- **High** = # attribute scores ≥ 3.0
- Moderate = # attribute scores ≥ 2.5
- Low = rest

Vulnerability = Sensitivity and Exposure
$$= VH + VH = VH$$

Results
Overall

- Exposure to climate change in Northeast U.S. is high to very high

- Sensitivity higher for diadromous and shellfish; lower for groundfish and pelagics

Climate vulnerability matrix with EXPOSURE on the x-axis (Low, Moderate, High, Very High) and SENSITIVITY on the y-axis (Low, Moderate, High, Very High):

- Very High sensitivity, High exposure: 2 shellfish
- Very High sensitivity, Very High exposure: 1 shellfish, 1 diadromous
- High sensitivity, High exposure: 6 groundfish, 4 elasmobranchs, 4 shellfish
- High sensitivity, Very High exposure: 8 shellfish, 7 diadromous, 3 coastal
- Moderate sensitivity, High exposure: 5 groundfish, 3 elasmobranchs, 1 pelagic, 2 shellfish
- Moderate sensitivity, Very High exposure: 2 diadromous, 3 coastal
- Low sensitivity, High exposure: 8 groundfish, 5 elasmobranchs, 8 pelagics, 1 shellfish
- Low sensitivity, Very High exposure: 8 coastal

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Results

Spanish Mackerel

Bootstrap Expert scores:

0	Very High
3	High
97	Moderate
0	Low

Spanish mackerel - *Scomberomorus maculatus*
Overall vulnerability rank = Moderate
Sensitivity = Low
Exposure = Very High
Data Quality = 0.79

Scomberomorus maculatus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Stock Status	1.9	2.2	
Other Stressors	2.1	1.8	
Population Growth Rate	1.7	2.6	
Spawning Cycle	2.4	2.8	
Complexity in Reproduction	2.1	2.6	
Early Life History Requirements	2.3	1.2	
Sensitivity to Ocean Acidification	1.1	2.2	
Prey Specialization	1.3	2.8	
Habitat Specialization	1.6	3.0	
Sensitivity to Temperature	1.3	3.0	
Adult Mobility	1.3	2.4	
Dispersal & Early Life History	2.0	2.6	
Sensitivity Score	Low		
Sea Surface Temperature	4.0	3.0	
Variability in Sea Surface Temperature	1.0	3.0	
Salinity	3.1	3.0	
Variability Salinity	1.2	3.0	
Air Temperature	4.0	3.0	
Variability Air Temperature	1.0	3.0	
Precipitation	1.2	3.0	
Variability in Precipitation	1.3	3.0	
Ocean Acidification	4.0	2.0	
Variability in OA	1.0	2.2	
Currents	2.0	1.0	
Sea Level Rise	1.2	1.5	
Exposure Score	Very High		
Overall Vulnerability Rank	Moderate		

Legend:
- Low
- Moderate
- High
- Very High

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Draft National Climate Science Strategy

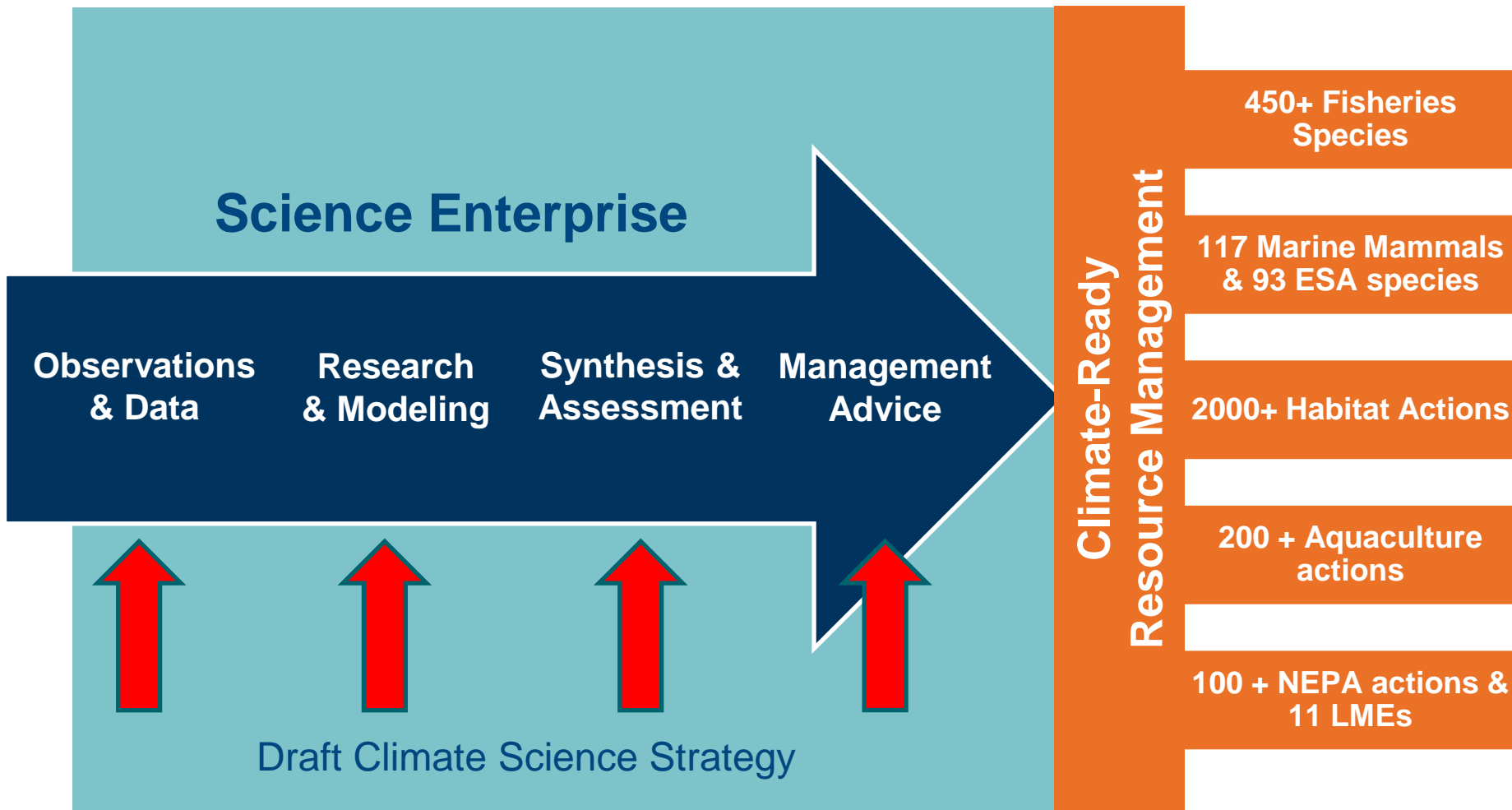|	
GOAL	Increase the production, delivery and use of climate-related information to support NOAA Fisheries and stakeholder decisions.
CONTENT	Identifies 7 key objectives to meet NOAA Fisheries information requirements for resource management in a changing climate.
INTENDED USE	Help guide development of NOAA Fisheries science enterprise at national to regional levels (e.g., regional action plans).

Strategy designed to meet climate-related information requirements across mission areas

Science Enterprise

Observations & Data → Research & Modeling → Synthesis & Assessment → Management Advice → Climate-Ready Resource Management

Draft Climate Science Strategy

- 450+ Fisheries Species
- 117 Marine Mammals & 93 ESA species
- 2000+ Habitat Actions
- 200 + Aquaculture actions
- 100 + NEPA actions & 11 LMEs

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Draft Climate Science Objectives
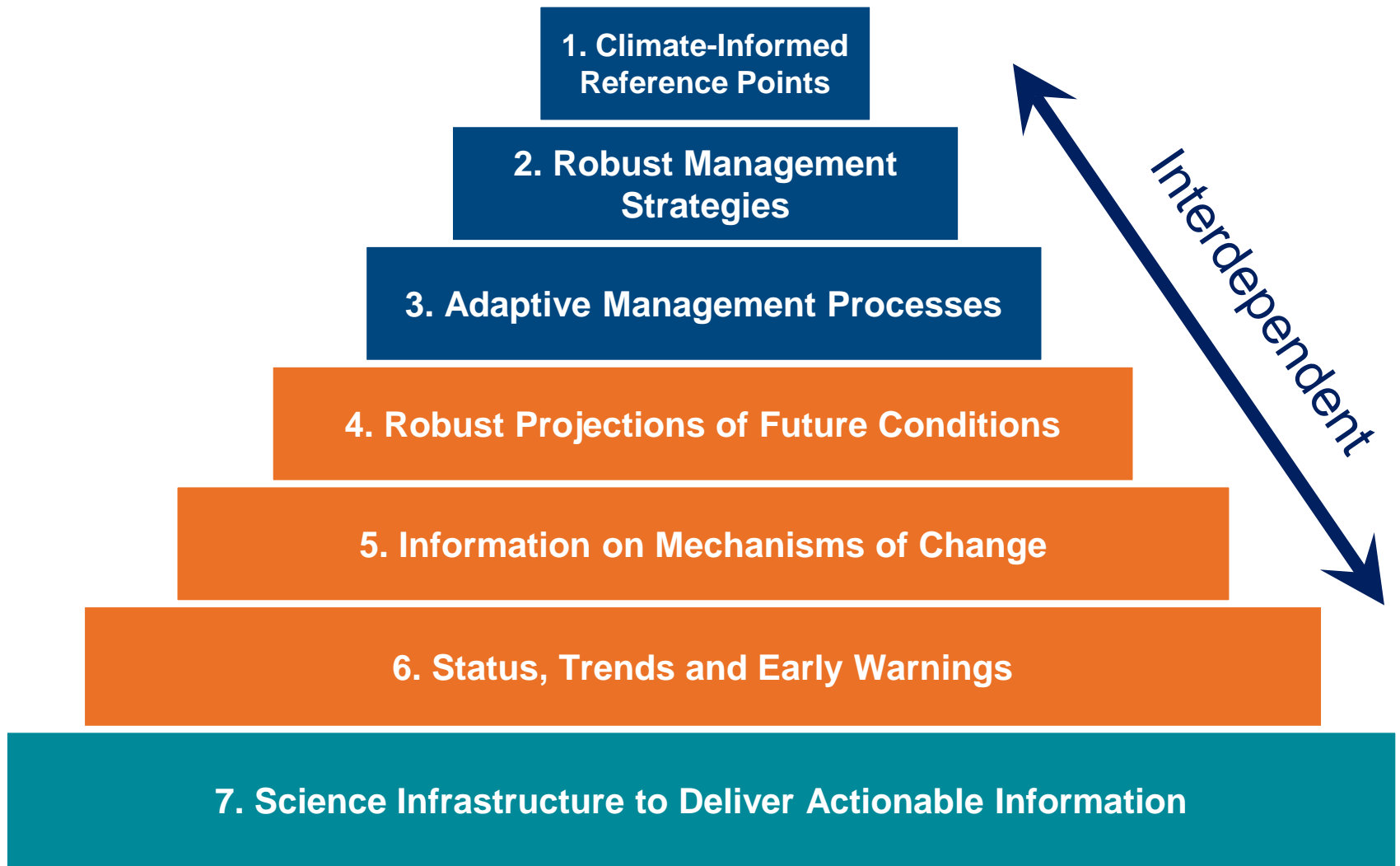
1. Climate-Informed Reference Points

2. Robust Management Strategies

3. Adaptive Management Processes

4. Robust Projections of Future Conditions

5. Information on Mechanisms of Change

6. Status, Trends and Early Warnings

7. Science Infrastructure to Deliver Actionable Information

Interdependent

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Climate Smart Fisheries Management Will Need to be *Flexible* and *Adaptable*

B–metro.com

IT IS NOT THE STRONGEST OF THE SPECIES THAT SURVIVES, NOR THE MOST INTELLIGENT. IT IS THE ONE THAT IS MOST ADAPTABLE TO CHANGE.
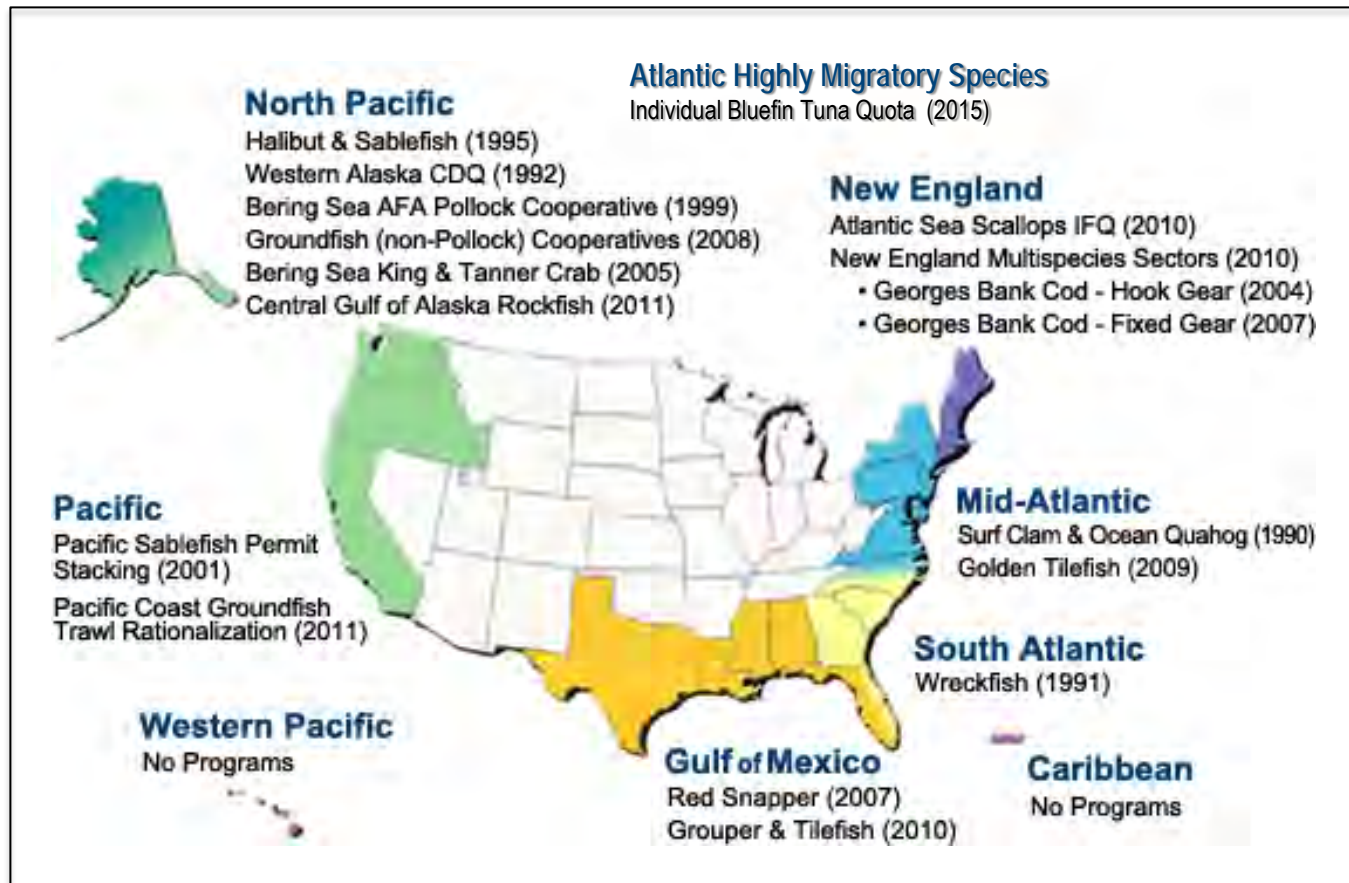
french by design blog

– CHARLES DARWIN

U.S. Catch Share Programs

In the United States, approximately

33% (160 out of 478 stocks)

of federally managed fish stocks are managed under catch share programs.

Atlantic Highly Migratory Species
Individual Bluefin Tuna Quota (2015)

North Pacific
Halibut & Sablefish (1995)
Western Alaska CDQ (1992)
Bering Sea AFA Pollock Cooperative (1999)
Groundfish (non-Pollock) Cooperatives (2008)
Bering Sea King & Tanner Crab (2005)
Central Gulf of Alaska Rockfish (2011)

New England
Atlantic Sea Scallops IFQ (2010)
New England Multispecies Sectors (2010)
• Georges Bank Cod - Hook Gear (2004)
• Georges Bank Cod - Fixed Gear (2007)

Pacific
Pacific Sablefish Permit Stacking (2001)
Pacific Coast Groundfish Trawl Rationalization (2011)

Mid-Atlantic
Surf Clam & Ocean Quahog (1990)
Golden Tilefish (2009)

South Atlantic
Wreckfish (1991)

Western Pacific
No Programs

Gulf of Mexico
Red Snapper (2007)
Grouper & Tilefish (2010)

Caribbean
No Programs

Do Catch Shares Improve Flexibility?

Yes and No. It depends on Program Design

Designs that limit flexibility:

- Quotas distributed by area (= limited flexibility to follow fish)
- Geographic landing requirements (=limited spatial flexibility)
- Single species permits (=limited flexibility to shift species)
- High entrance costs or quota costs (=limited flexibility to shift species)

Do Catch Shares Improve Flexibility?

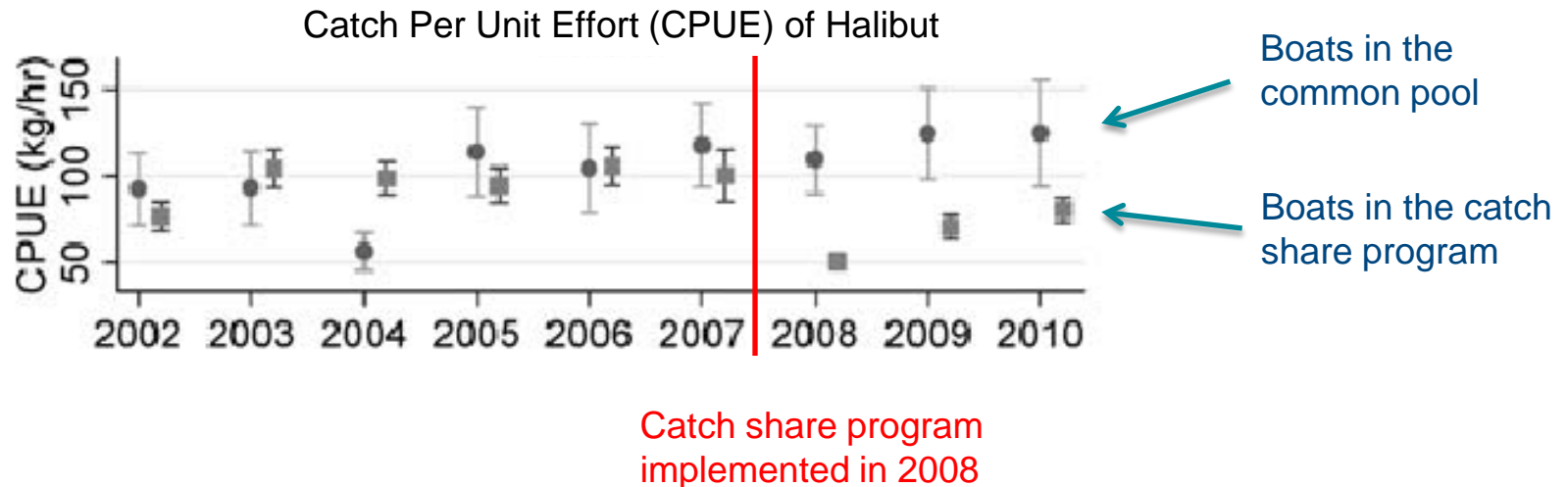Yes and No. It depends on Program Design

Actions that increase flexibility:

- Incentives to match catches to abundances as they change (i.e. flexibility to avoid "choke" species)
- Quota transferability provides opportunity for fishermen to build a portfolio of harvest privileges & decrease income risk
- Distribute quotas to communities

Do Catch Shares Improve Flexibility?

Yes: catch share programs can create incentives to change fishing behavior to reduce bycatch of a limiting species.

Catch Per Unit Effort (CPUE) of Halibut

Boats in the common pool

Boats in the catch share program

Catch share program implemented in 2008

In the Bering Sea, halibut is a "choke" species in the groundfish fishery.

Abbott et al. 2015. Land Economics

Take Home Messages

Climate change will profoundly impact marine and coastal ecosystems.

- Determining vulnerabilities is key first step to:
  - Prioritize resources
  - Advance dialog about climate change
- Increasing production and use of climate-related science is critical to climate-ready fisheries management.
- Need flexible and adaptable management.
- Testing and collaborations welcome and needed.