

**NOAA  
FISHERIES  
SERVICE**



# **Impacts and Response to Climate Change**

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**January 13, 2011**



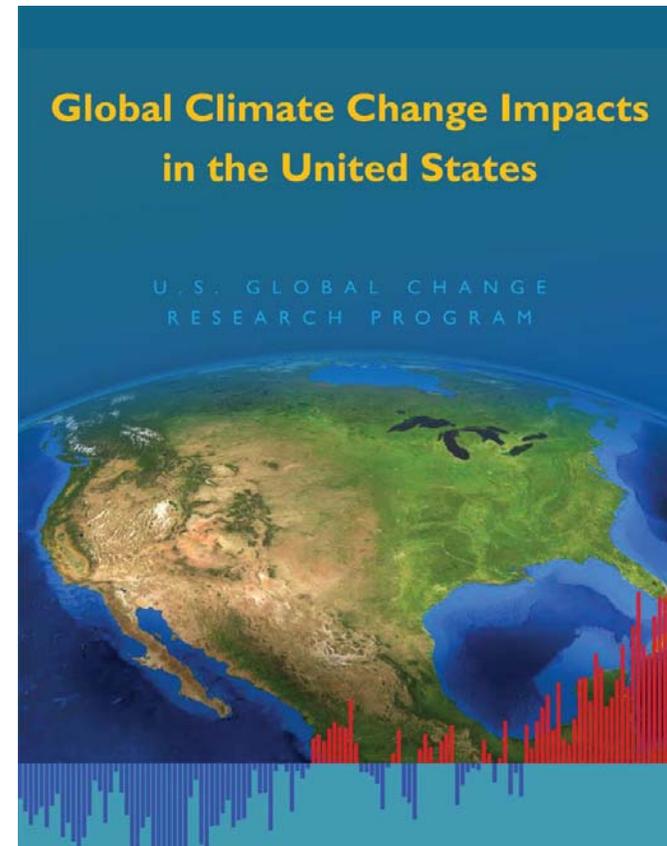
## Purpose

1. **Review impacts** of climate change and drivers to address them.
2. **Summarize some current efforts** to understand and address climate impacts on marine ecosystems.
3. **Describe new opportunities** that may assist.
4. **Get your input** on needs and future directions.



# Our Climate Is Changing

- ***Climate changes are underway*** and expected to grow.
- ***Wide-spread climate-related*** impacts are occurring now & expected to increase.
- ***Thresholds will be crossed***, leading to large changes in climate & ecosystems.
- ***Climate change will exacerbate*** existing stressors in near-shore ecosystems.
- ***High concern for Arctic***, reef systems.
- ***Need to better understand*** and respond to impacts in marine ecosystems.



<http://www.globalchange.gov/>

# Impacts and Implications of Climate Change In Marine Ecosystems

## CLIMATE CHANGE IMPACTS

- **Ocean warming:** impacts on physical features, productivity, species distribution & phenology.
- **Loss of sea ice:** impacts on living marine resources at both poles.
- **Sea level rise:** direct and indirect impacts on coastal habitats.
- **Ocean acidification:** impacts on marine biota
- **Precipitation Changes:** impacts on freshwater supply & nat resources
- **Attribution of climate signals:** long term change vs. natural variability



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## IMPLICATIONS

- Changes in food chain
- Changes in habitats
- Changes in fish stocks
- Changes in fishery allocations, effort
- Impacts on communities and economies
- Changes in protected species populations
- Increased threats to vulnerable species
- Increased invasive species threats



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*Many Unknowns (Direction of change? Pace?  
Magnitude? Interactions? Responses?)*





## Drivers for Incorporating Climate Change Into Mission Areas

### Core mandates (MSA, ESA, NEPA)

- MSA - Optimum Yield “...is prescribed on the basis of maximum sustainable yield as reduced by any relevant economic, social or ecological factor.”
- MSA – Rebuilding Plans especially sensitive to climate-driven ecological changes over longer term that could impact the ability to rebuild or sustain stocks.
- ESA – Listings and recovery plans to consider “the present or threatened destruction, modification, or curtailment of its habitat or range.....and/or other natural or manmade factors affecting its continued existence”.
- NEPA – Consideration of alternatives and decisions in context of changing climate conditions.



## Drivers for Incorporating Climate Change Into Mission Areas

### **NOAA Next Generation Strategic Plan**

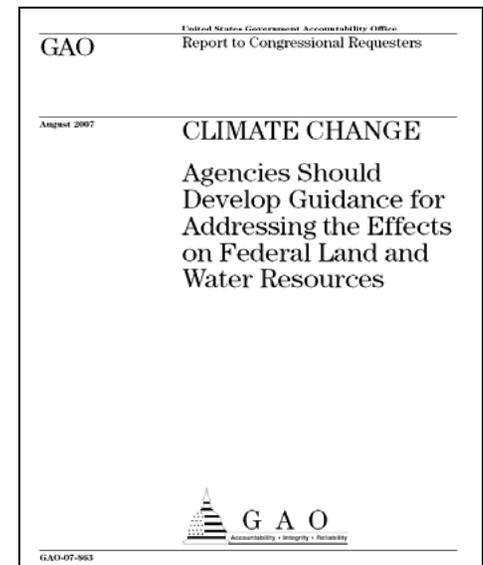
- Ocean Goal: Increase development and use of climate considerations in fishery, protected species and habitat management.
- Ocean Goal: Next-generation stock assessments incorporating habitat, ecosystem and climate information.
- Climate Goal: Living marine resource managers prepare for and respond to climate change impacts.

### **National Ocean Policy Objectives**

- Strengthen resiliency & adaptation of ocean ecosystems

### **GAO and other Assessments**

- Call for federal guidance for addressing climate effects on federal land and water resources





## Key Needs and Responses?

- 1. *Increase understanding*** of current and future impacts of climate change on marine resources.
  - Impacts on physical, chemical features?
  - Impacts on biological features?
- 2. *Increase capacity*** to apply information in resource management.
- 3. *Operationalize*** info delivery and application.

# 1. Increasing Understanding Climate Impacts

**1. Fisheries and the Environment Program (FATE)**

*Increase understanding and forecasts of ecosystem dynamics to improve stock and marine ecosystem assessments.*

**2. Climate Regimes and Ecosystem Productivity Program (CREP)**

*Understand climate patterns and their impact on ecosystem dynamics.*

**3. NOAA Fishery Science Centers**

*Multiple investigators producing significant results.*

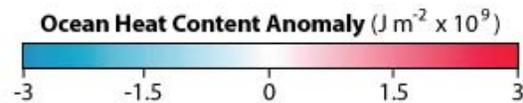
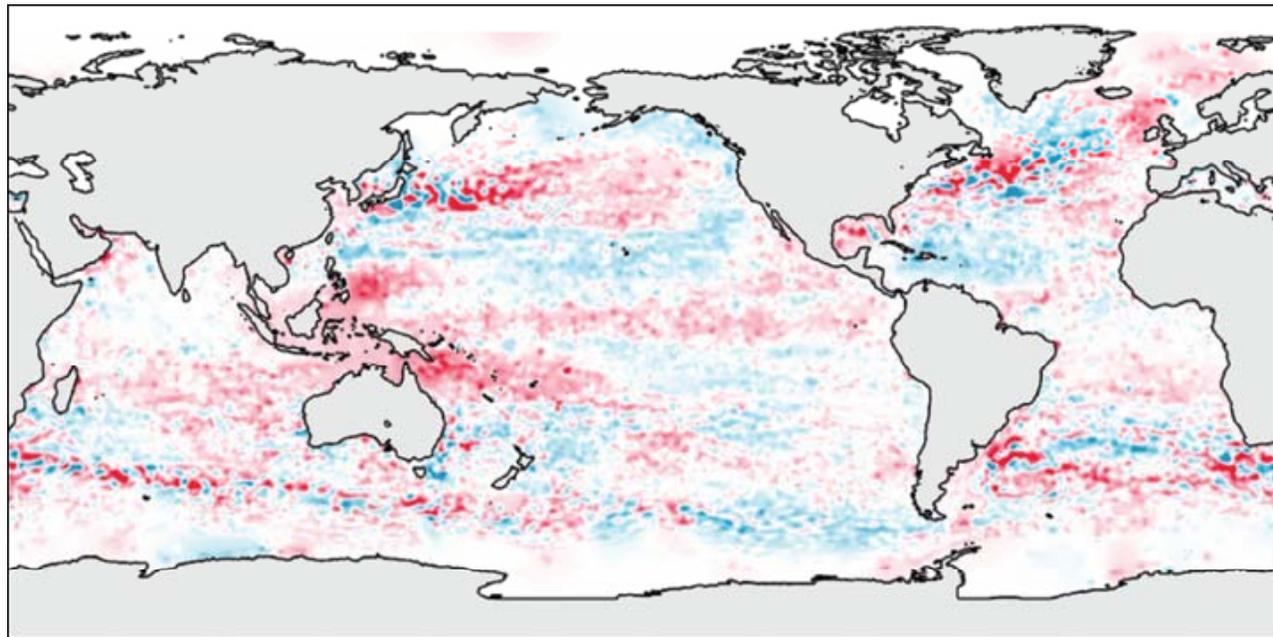
**4. NOAA Ocean Acidification Program**

*Cross NOAA effort to understand trends and impacts of ocean acidification on marine ecosystems.*

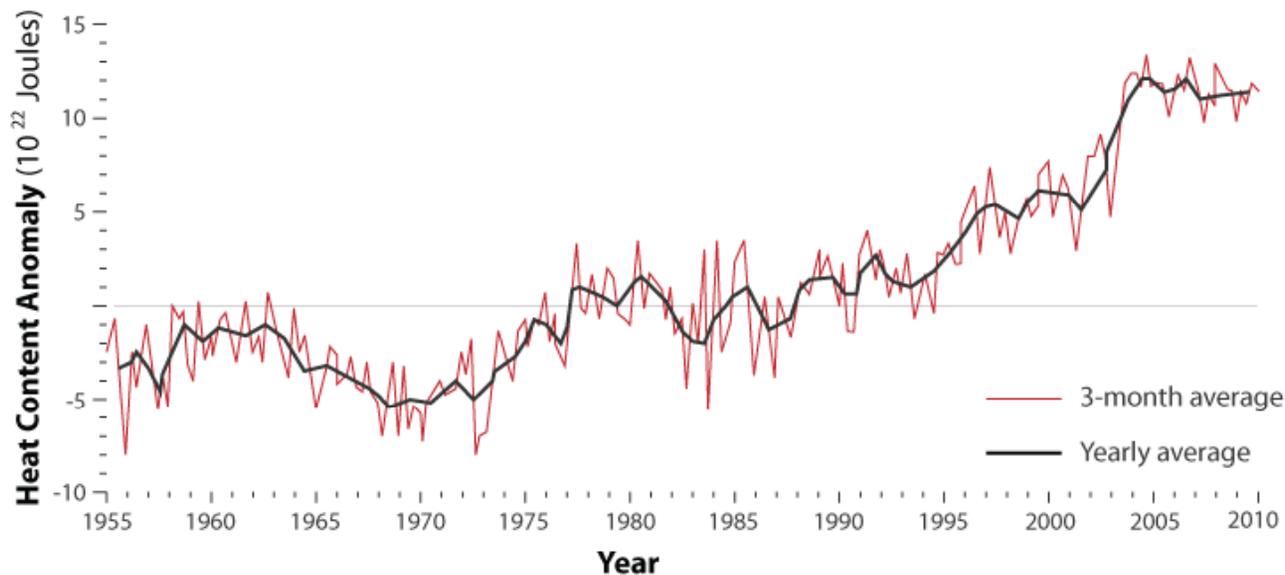
**5. Climate-Marine Modeling Partnership**

*Collaboration with Climate Program (ESRL, GFDL) to advance predictions of climate impacts on marine ecosystems.*

Changes in ocean heat content (1993-2009)

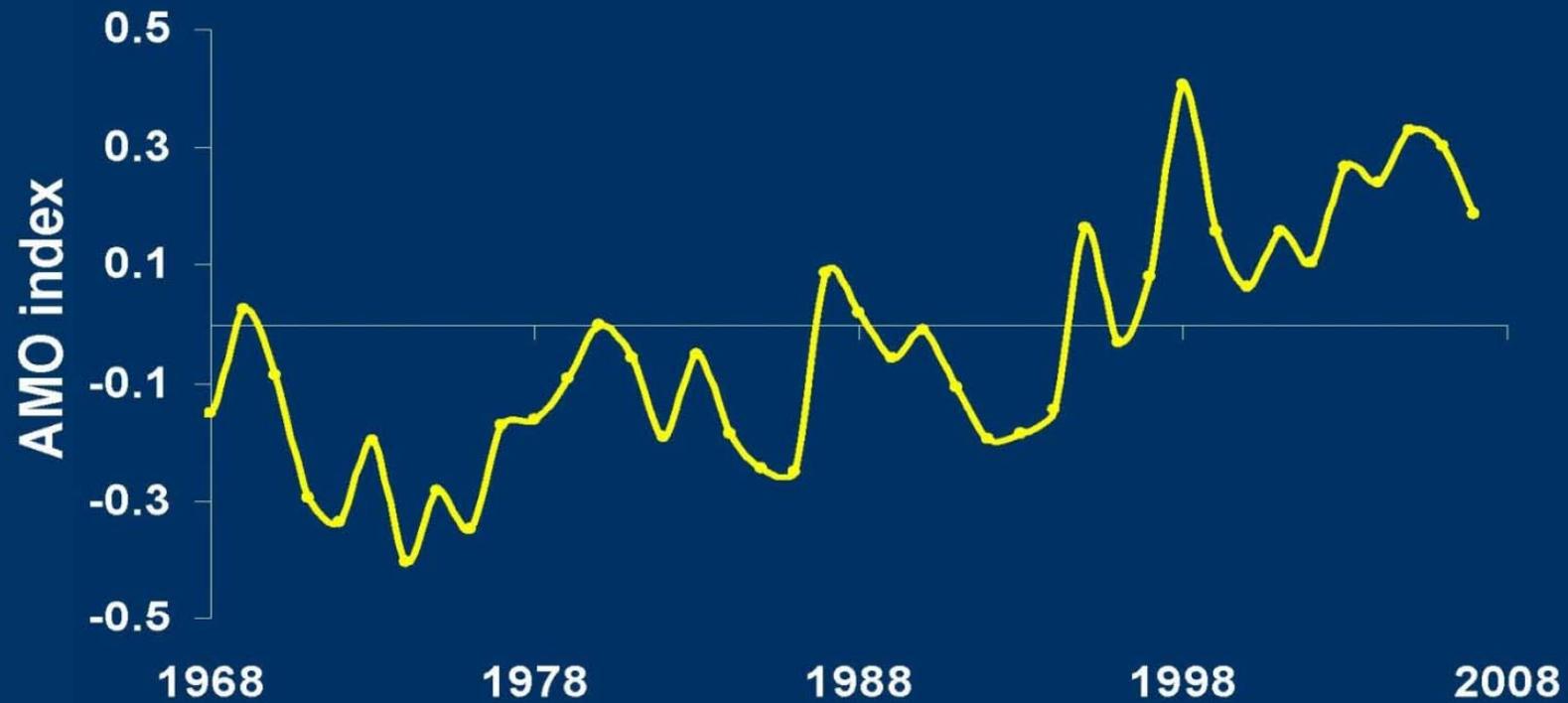


Increasing ocean heat content (1955-2009)

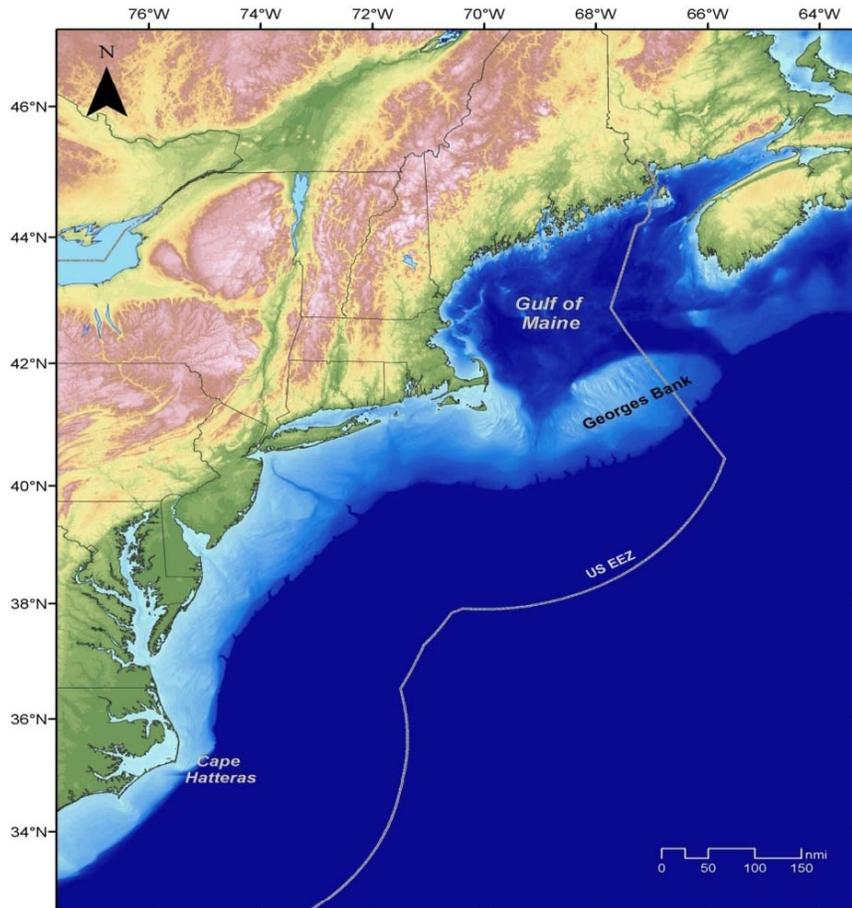


<http://www.climatewatch.noaa.gov/2010/images/newevidence-on-warming-ocean>

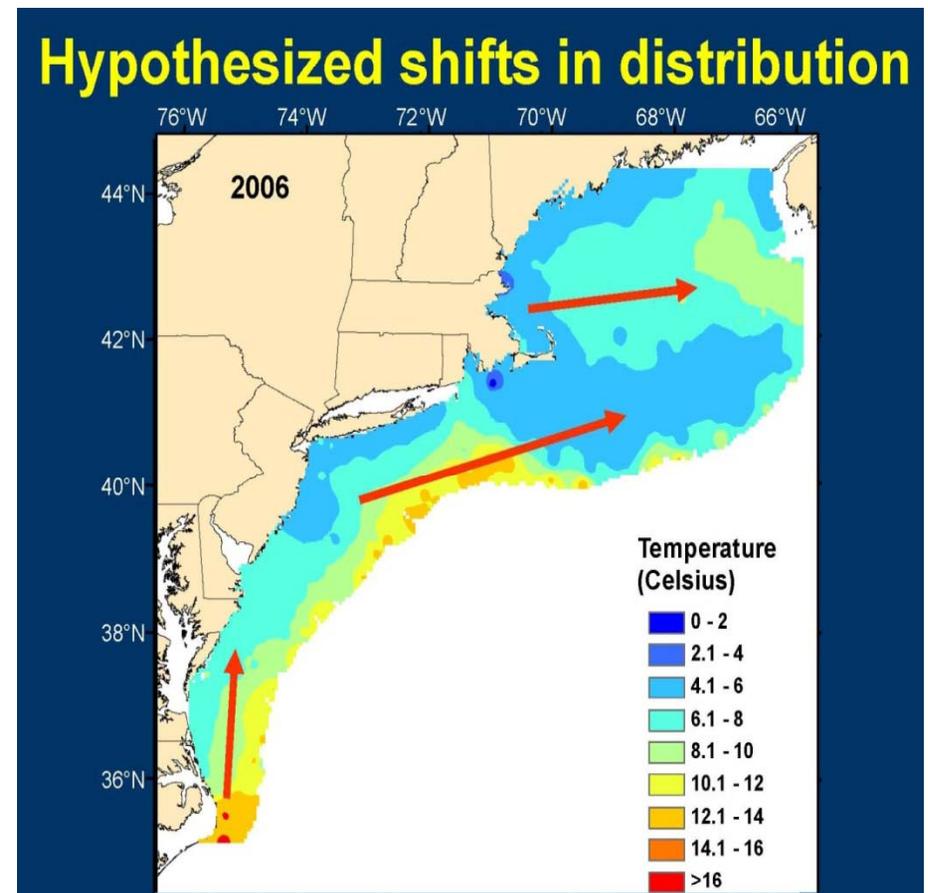
# Warming of Northwest Atlantic



# Hypothesized Shifts in Fish Distributions with Warming Ocean Temperatures Eastern U.S. Waters (Cape Hatteras to Canadian border)

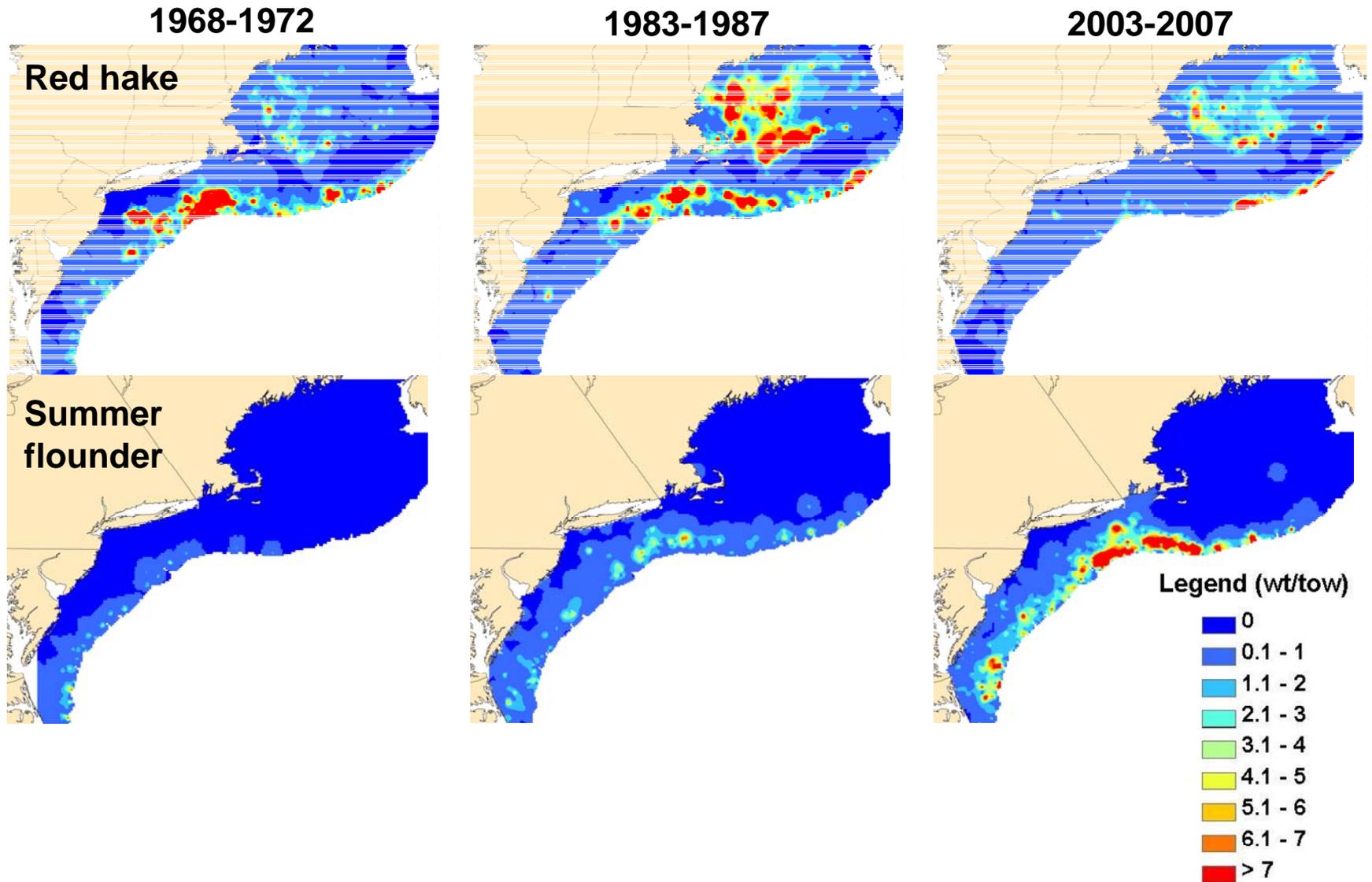


(Credit: Chad Keith, NEFSC/NOAA)



(Credit: Janet Nye, NEFSC/NOAA)

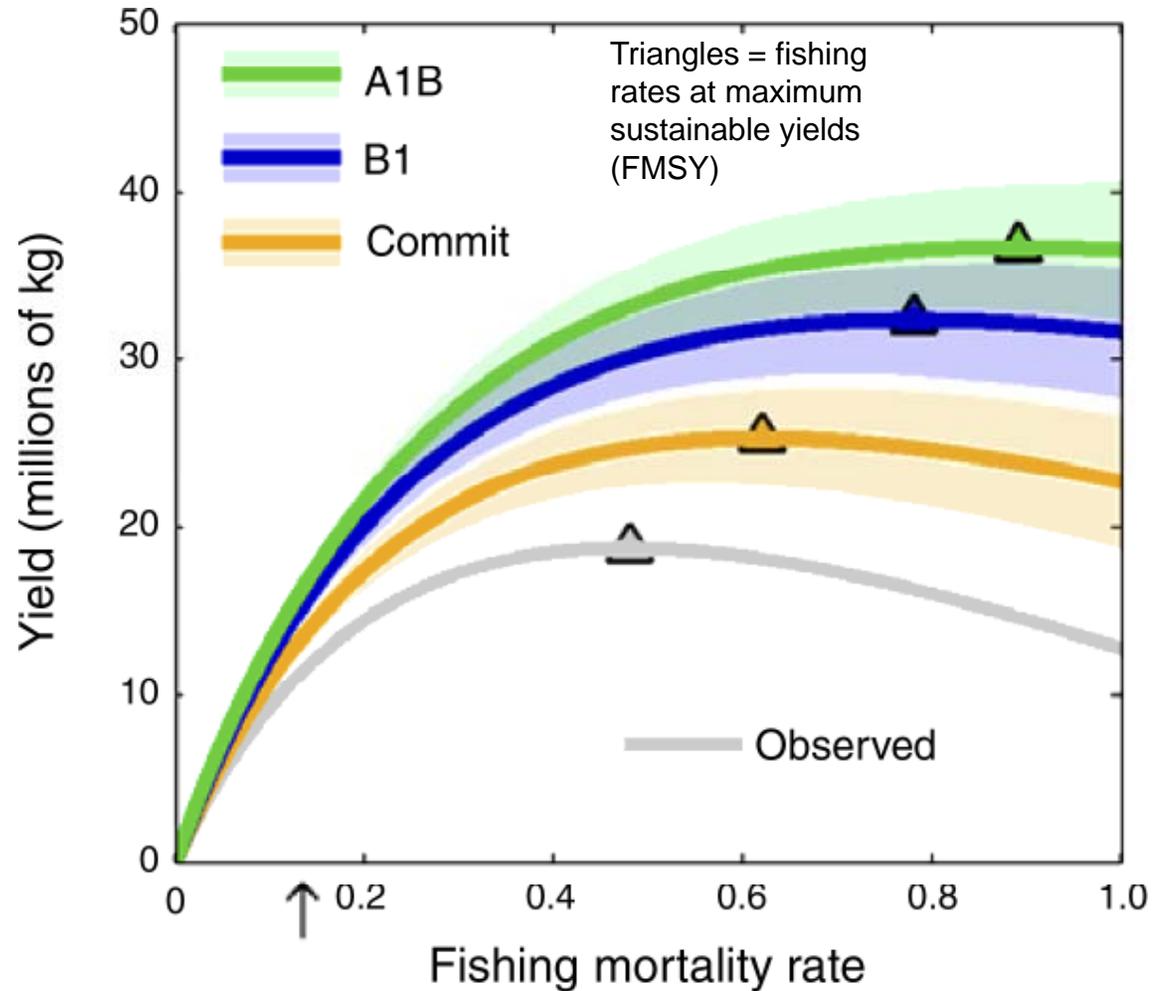
# Shifts in spatial distribution of Northeast US fish



# Resource levels under future climate conditions?



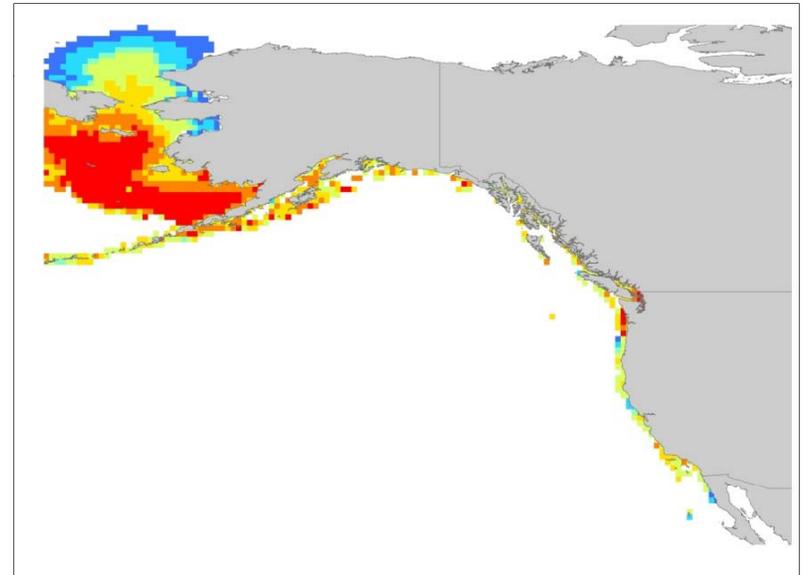
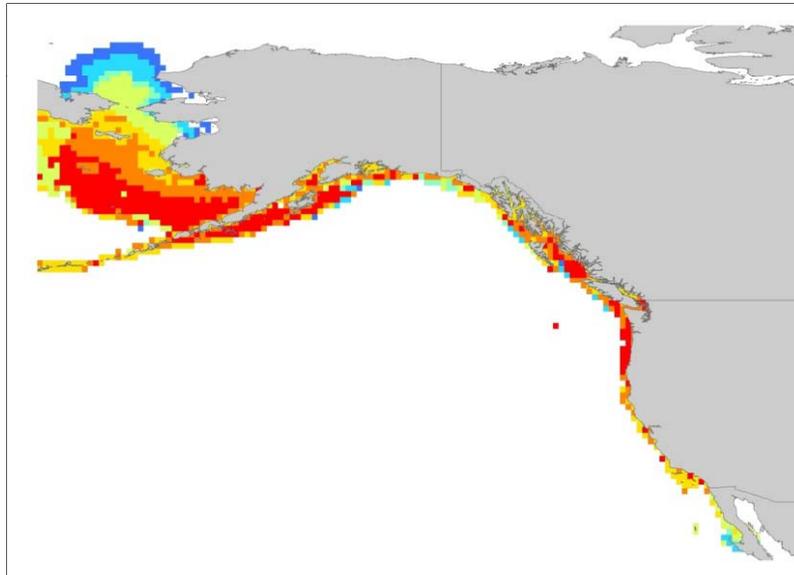
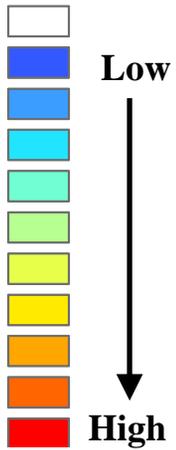
FIG. 7. Atlantic croaker fishery yield as a function of fishing mortality rate based on the temperature-dependent stock–recruitment model and ensemble multimodel mean of three climate scenarios (A1B, B1, and commit). (Hare et al 2010)



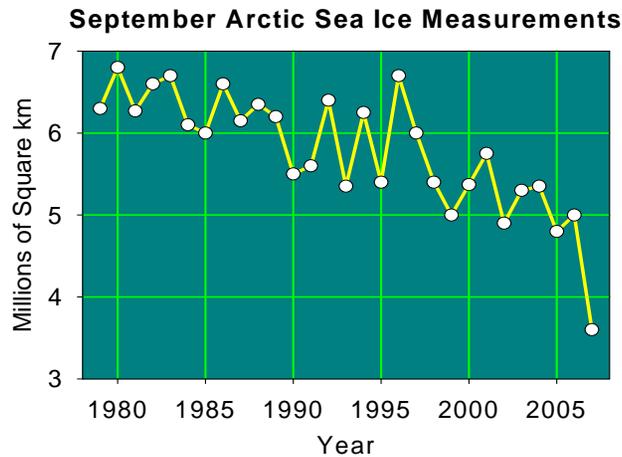
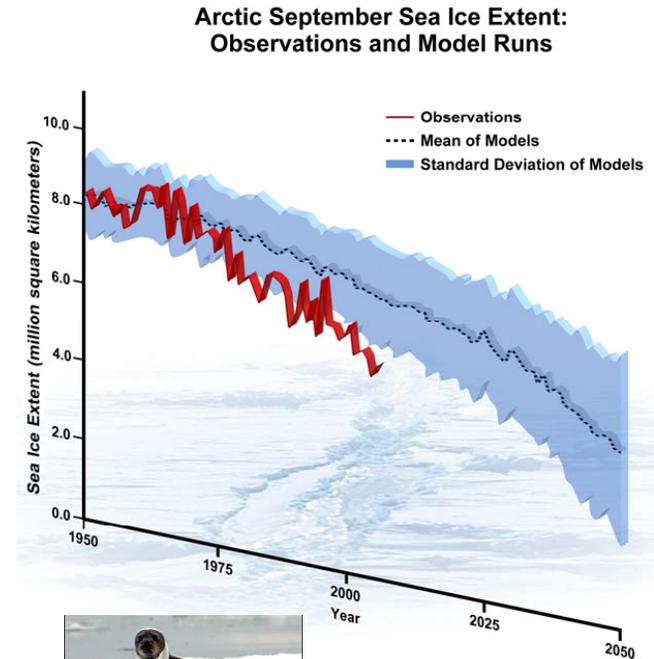
# Chinook salmon

Original (static) distribution

Distribution after 50 years  
(Climate projection from NOAA/GFDL CM 2.1)



# Loss of Arctic Sea Ice: Ecological Implications for NOAA-Managed Species



Variety of impacted NOAA Trust Resources (MMPA, ESA, MSA)



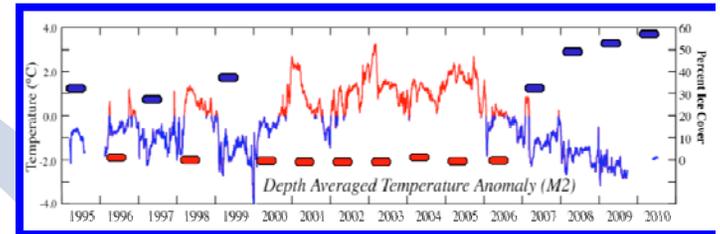
Ringed,  
Ribbon,  
Spotted,  
Bearded  
Seals  
+ Arctic FMP



# ADAPTIVE MANAGEMENT OF ALASKA MARINE FISHERIES IN A CHANGING CLIMATE



5 SSC supports recommendations to reduce pollock harvest based on assessment and continuation of poor (warm) environmental conditions



NPCREP - Mooring 2

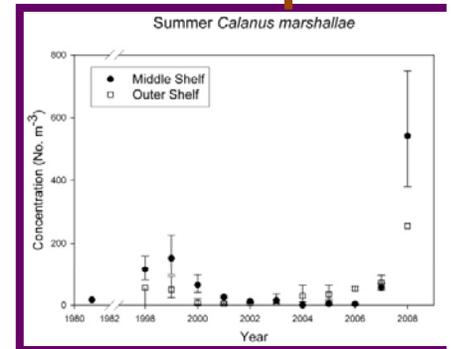
1 2005 moored temperature and zooplankton data reveal unfavorable ocean conditions for recruitment

4 Fishery Management Council's Science and Statistical Committee (SSC) receives warning

## INFORMATION PATHWAY

2 Stock assessment model reveals low/declining recruitment

3 NPCREP warning of poor environmental conditions reported in assessment documents

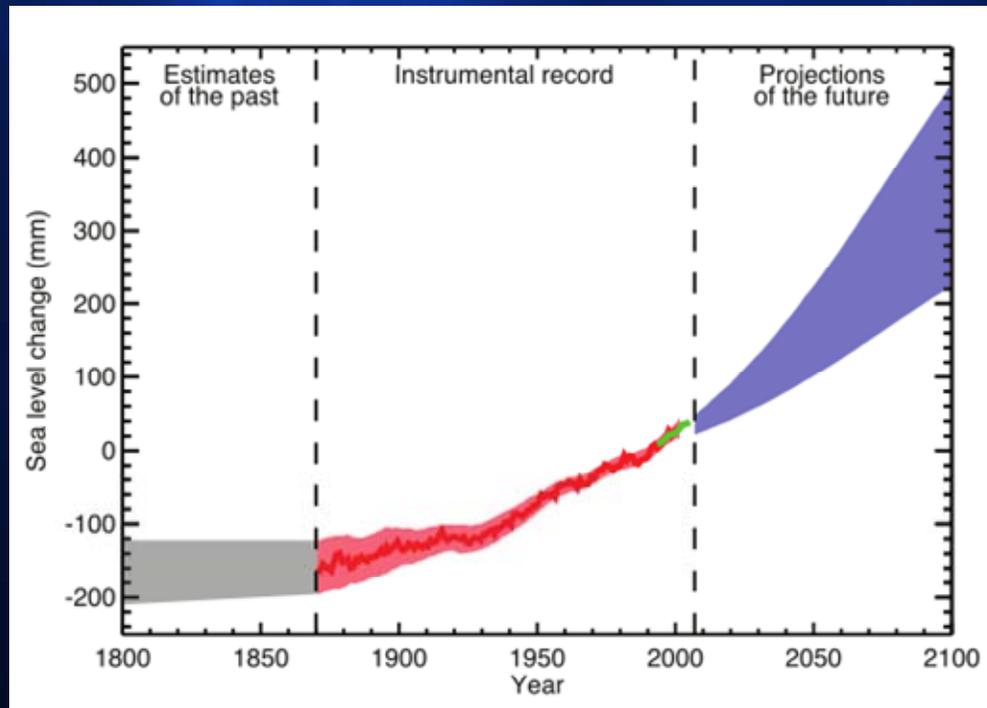


# Recent Research Suggests Global Sea-Level Rise Is Accelerating

Due to

- 1) Thermal expansion
- 2) Melting from glaciers on land
- 3) Melting ice sheets

New estimates:  
0.75-1.9m  
by 2100\*



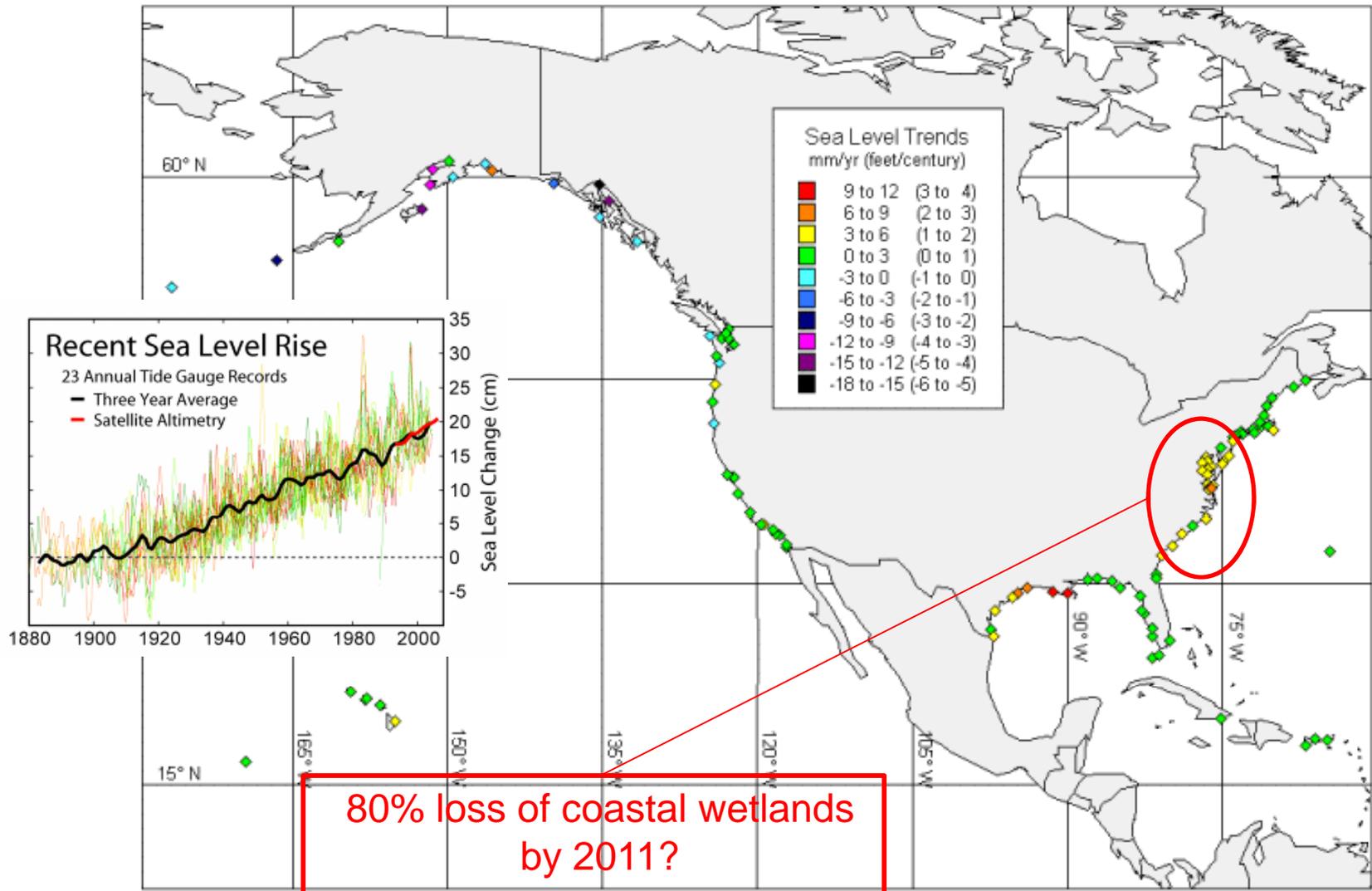
IPCC 2007

Impacts of Climate Change on Oceans \*Vermeer and Rhamstorf 2009

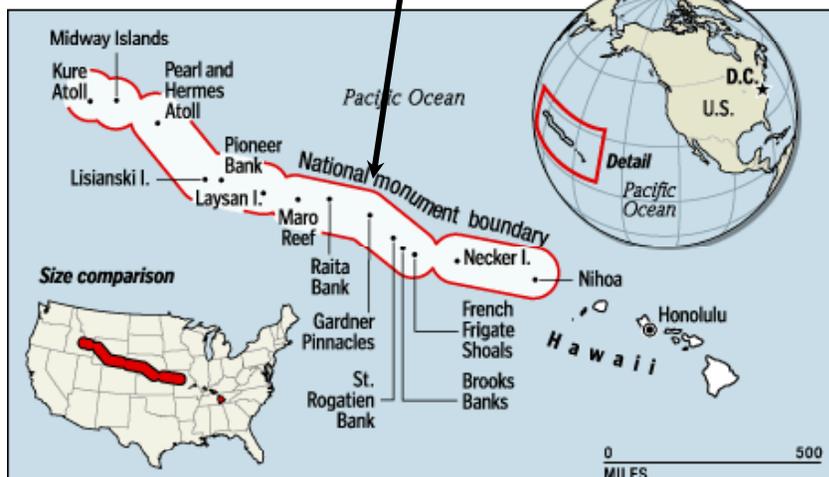


- **Figure 2 New research estimates suggest sea level rise is accelerating due to global warming.** (Vermeer and Rhamstorf, 2009, Global sea level linked to global temperature. PNAS, published Dec. 7, 2009)

# Trends in Sea Level Rise & Resource Impacts



## Example: How will Protected Species critical habitats change with SLR in the Pacific Islands?

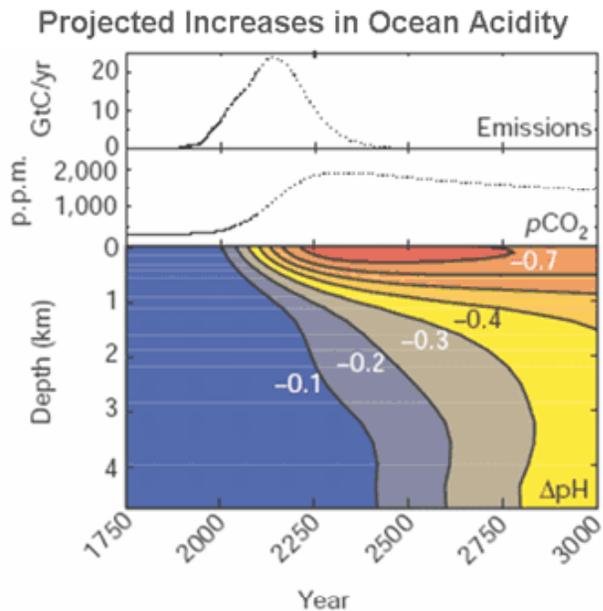


2006 study published by NOAA scientists in the Journal Biological Conservation (Baker et al. 2006)

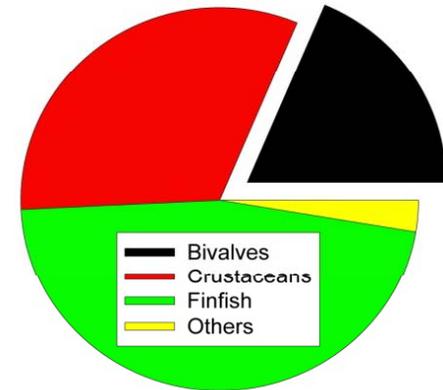
- Once an important nesting island for Hawaiian green sea turtles and a primary pupping site for endangered Hawaiian monk seals
- What would be the impacts of observed rates of SLR on Protected Species breeding and nesting habitat?
- Projected maps at mean low water (MLW) with minimum (9 cm), median (48 cm) and maximum (88 cm) predicted sea-level rise by 2100 (IPCC, 2001).
- Conclusion: as much as 40% loss in protected species breeding & nesting areas



# Ocean Acidification



2005 Fishery Landings Value = \$3.933 Billion  
(First Sale)



## Potential impacts on

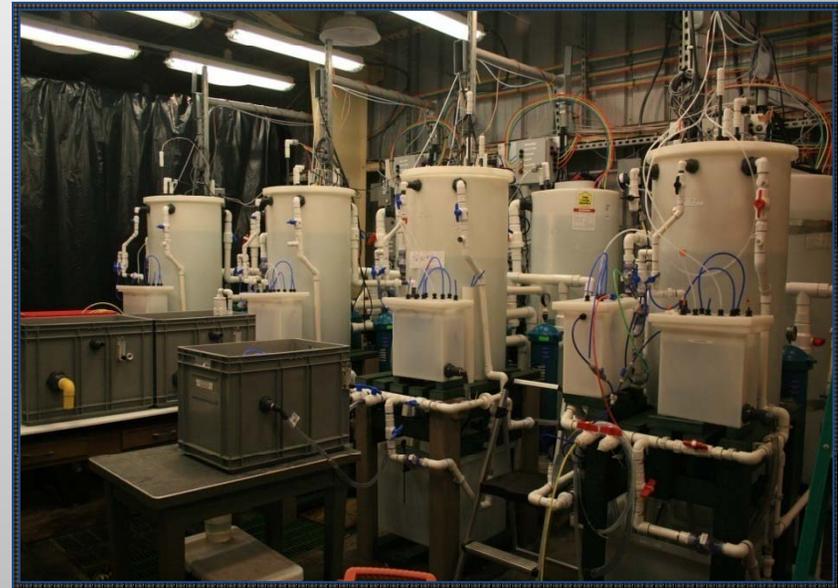
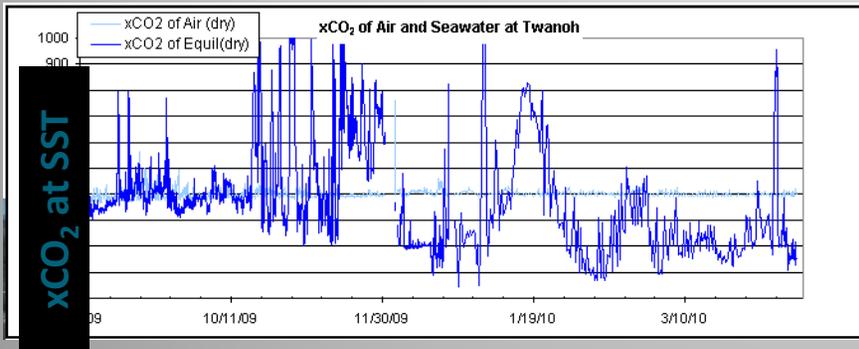
- shelled plankton
- coral reefs (shallow and deep)
- bivalves and crustaceans
- food chains

## Valuable Resources:

- Bivalves: \$732M ex-vessel commercial value
- Crustaceans: \$1,265M ex-vessel commercial value
- Combined : \$1,997M ex-vessel commercial value (51% of commercial catch by \$)

# NWFSC OA Research Focus: Species Response

- NWFSC Facility
  - Control CO<sub>2</sub>, DO, temp. and food
  - Vary temporal pattern



- Multiple species simultaneously



Krill



Copepods



Oyster



Abalone



Dungeness Crab



Geoduck



Sablefish



Rockfish

# WHERE TO TARGET HABITAT RESTORATION FOR SALMON IN CHANGING CLIMATE?

- 2 Downscaled climate projections for 2050 (GFDL, HadCM3).

- 2 restoration scenarios:

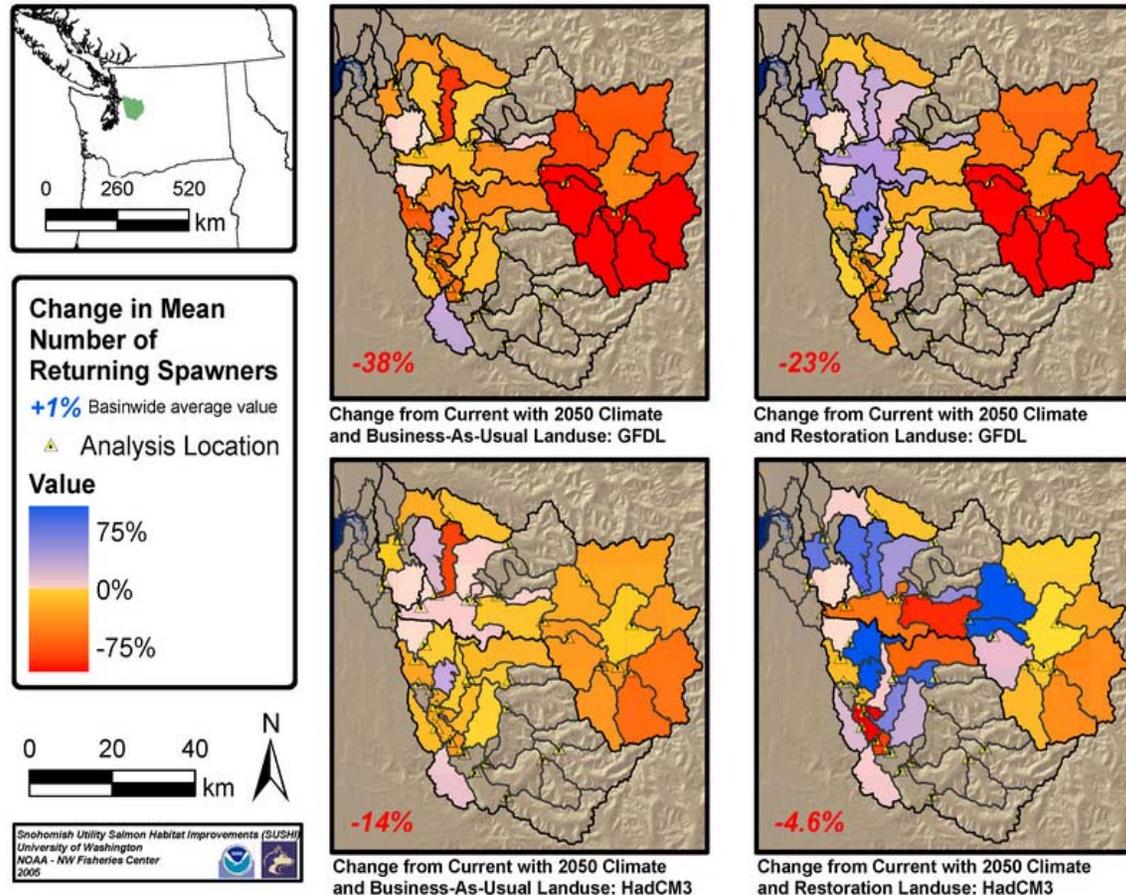
Scenario 1: Business-as-usual  
Result: 14.0-38% declines in salmon returns

Scenario 2: Stream restoration  
Result: 4.6 -23% declines

Conclusions:

Best improvements in salmon returns are projected when restoration of stream conditions occurs in middle and lower-elevation parts of the watersheds.

*Snohomish River: Climate and Landuse Change Impacts by Subbasin, Year 2050*



*Predicted salmon population change: 2000-2050*

Puget Sound: Snohomish River

## 2. Building Capacity To Address Impacts

Some Tools and Trainings:

- **Coastal habitat conservation in changing climate**  
(Regional Trainings)(OHC/Climate/others).
- **Assessing natural resource vulnerability**  
(Guide & Trainings) (OHC/ST /Climate/others).
- **“Climate-smart” habitat restoration**  
(Guidelines, funding)(OHC).
- **Using Down-scale Climate Projections**  
(Guide, Trainings)(ST/Climate/others).
- **Assessing fisheries vulnerability**  
(Proposed guide)(SF/ST).
- **Regional Workshops to Assess Needs/Approaches**  
(NWFSC/Sea Grant/others)

## 2. Building Capacity To Address Impacts

Developing approaches/guidance on incorporating climate change into mission areas:

- Habitat protection activities (OHC, regions).
- Habitat restoration activities (OHC, regions).
- ESA activities (PR/ST/regions/Science Centers).



# Some Opportunities

## NOAA Climate Service

- Marine ecosystems one of four priority focus areas.
- Establishing regional framework to serve clients.
- Current effort to
  - identify core needs for marine resource management
  - Operationalize product development and delivery with NMFS and partners





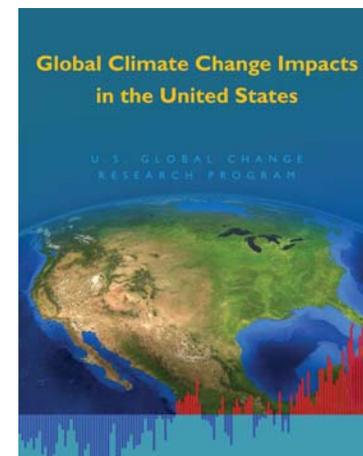
## Some Opportunities

### National Climate Assessment



United States Global Change Research Program  
National Climate Assessment

- Led by USGCRP
- Assessment of climate impacts on U.S.
- Assessment of needs to address impacts.
- Previous assessments 2000, 2009
- Due 2013 (and every 4 yrs)
- Opportunity for increased focus on marine and coastal ecosystems

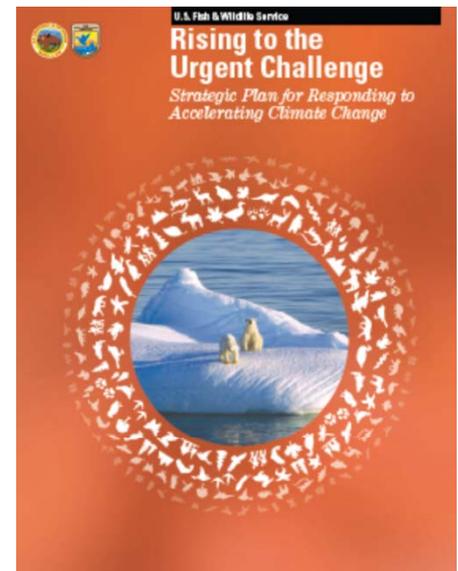




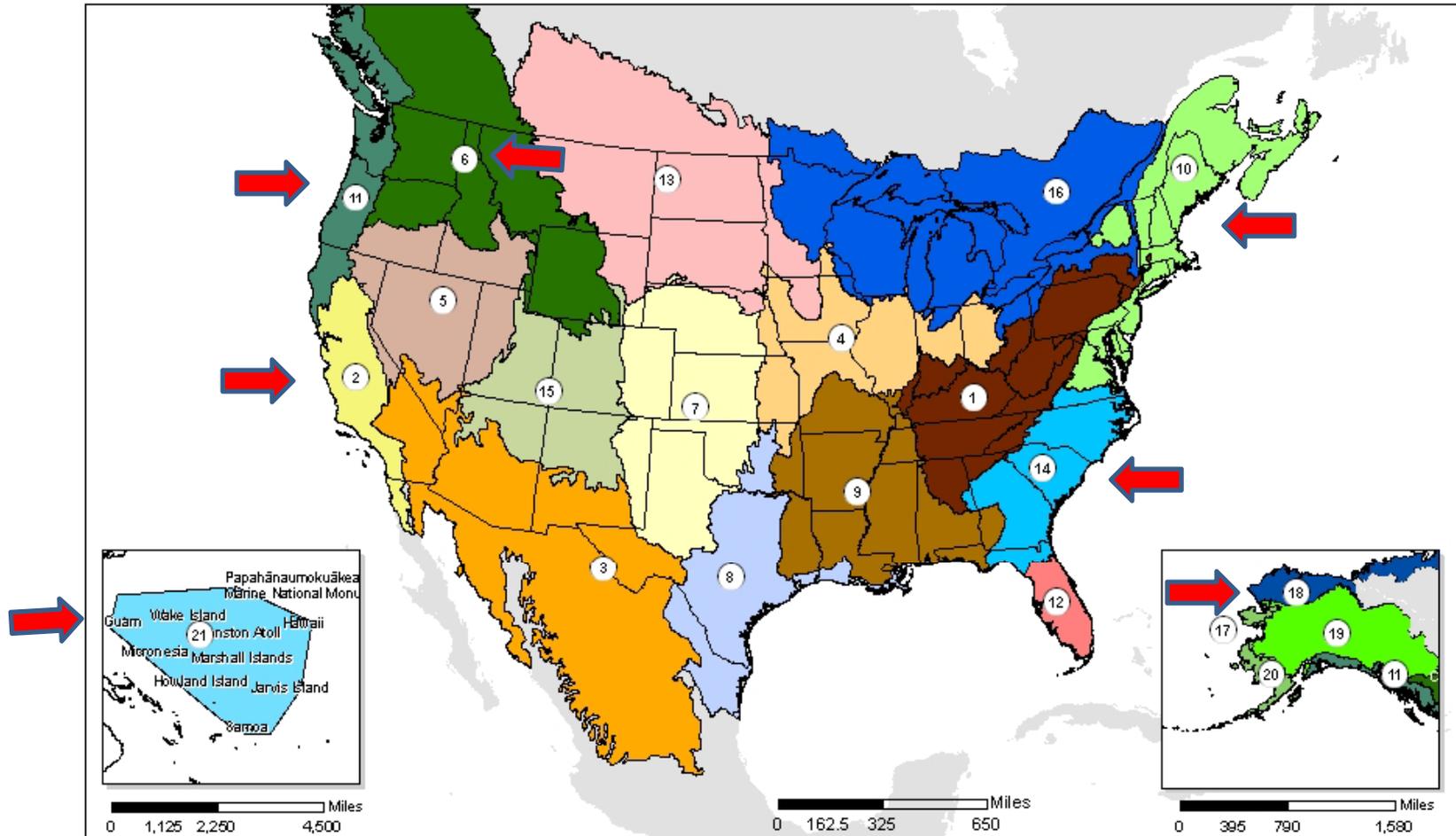
## Some Opportunities

### DOI Interior National Climate Response Framework:

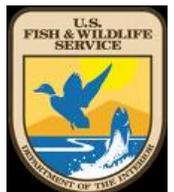
- Nation-wide framework for collaborative response
- Landscape Conservation Cooperatives
- Climate Science Centers
- Funding for science, vulnerability assessments
- Request for NOAA and others to engage
- Opportunity to influence priorities, contribute to and benefit from efforts
- Discussions on how to include marine areas



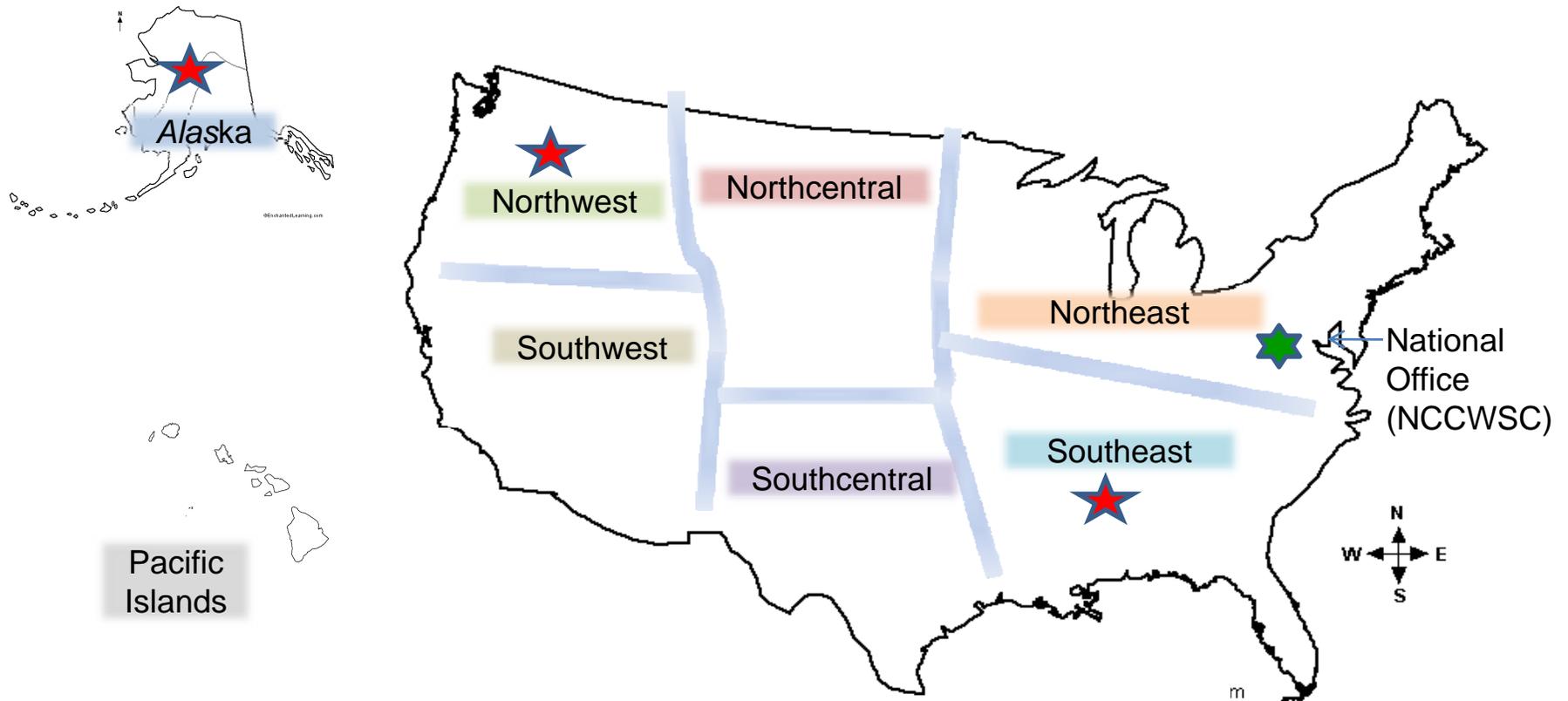
# DOI Landscape Conservation Cooperatives



- |                                             |                                   |                                     |                               |
|---------------------------------------------|-----------------------------------|-------------------------------------|-------------------------------|
| 1. Appalachian                              | 7. Great Plains                   | 13. Plains and Prairie Potholes     | 19. Northwest Interior Forest |
| 2. California                               | 8. Gulf Coast Prairie             | 14. South Atlantic                  | 20. Western Alaska            |
| 3. Desert                                   | 9. Gulf Coastal Plains and Ozarks | 15. Southern Rockies                | 21. Pacific Islands           |
| 4. Eastern Tallgrass Prairie and Big Rivers | 10. North Atlantic                | 16. Upper Midwest and Great Lakes   | Unclassified                  |
| 5. Great Basin                              | 11. North Pacific                 | 17. Aleutian and Bering Sea Islands |                               |
| 6. Great Northern                           | 12. Peninsular Florida            | 18. Arctic                          |                               |



# New DOI Climate Science Centers (9)



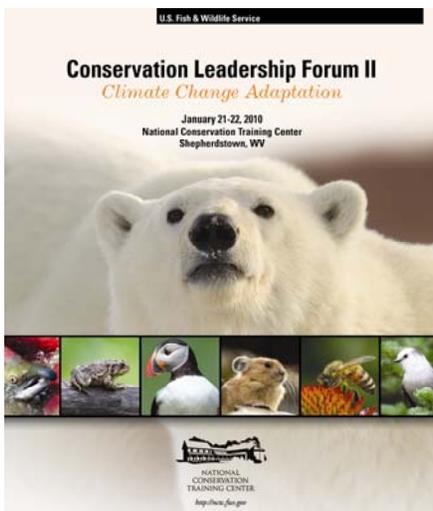
Purpose:  
Provide Resource Managers with Data and Information  
on Climate Change and Natural Resources



# Some Opportunities

## National Fish Wildlife Plant Climate Adaptation Strategy

- Develop blueprint to increase resilience and adaptation of nation's living natural resources by 2012
- Congressional mandate
- Co-led by USFWS, NOAA and State of NY
- Intergovernmental Steering Committee (fed, state, tribal)
- Identify gaps and solutions by major ecosystems (e.g., marine, coastal).
- **Opportunity to highlight needs and strategies to incorporate climate change in marine resource management.**





## Summary

- Variety of efforts underway to better understand and incorporate climate change into marine resource management.
- Significant needs remain:
  - regional scale climate change information
  - operationalize delivery of products and services
  - forecast ecological & soc/econ impacts
  - build capacity to use information in management process
- Some opportunities to highlight needs and strategy
- Need your input on needs and future directions.

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# Backup

### Examples of Private and Public Sector Concerns

Energy and water demands, food quality and quantity, reliable infrastructure during extremes of climate, insurance protection, international trade, economic resiliency, plant and animal range, ocean productivity, and other concerns, as affected by climate variability, global warming, heat waves, cold snaps, drought, fires, heavy downpours, blizzards, floods, sea-level rise, storm surge, sea-ice and glacier loss, snow cover, and other physical variables.

### Initial Science and Service Priorities of the Climate Service to Meet Private and Public Sector Challenges

Sustainability of Marine Ecosystems

Coasts and Climate Resilience

Climate Impacts on Water Resources

Changes in Extremes of Weather & Climate



### Basic climate services are provided in these example sectors

Agriculture    Energy    Health    Transportation    Trade    Finance    Economic Development    Natural Resources

## Key Issues to Move Forward

- **Establish integrated regional frameworks for observations, research, modeling and decision support in all LMEs** (e.g., NMFS-NCS service-level agreement, investments in NPCREP, GFDL partnership, OA, CCLME etc).
- **Produce regional predictions and projections of climate change impacts on ocean resources & services.**
- **Develop decision support tools** to assess marine resource vulnerability and develop/evaluate management options.
- **Build capacity** to deliver and use information in decisions.
- **Increase understanding** of social and economic impacts.
- **Increase coordination** across NMFS, NOAA, Councils?