



Progress and Prospects for Connecting the Climate and Marine Ecosystem Communities: Predictions, Applications, and Decision-Making

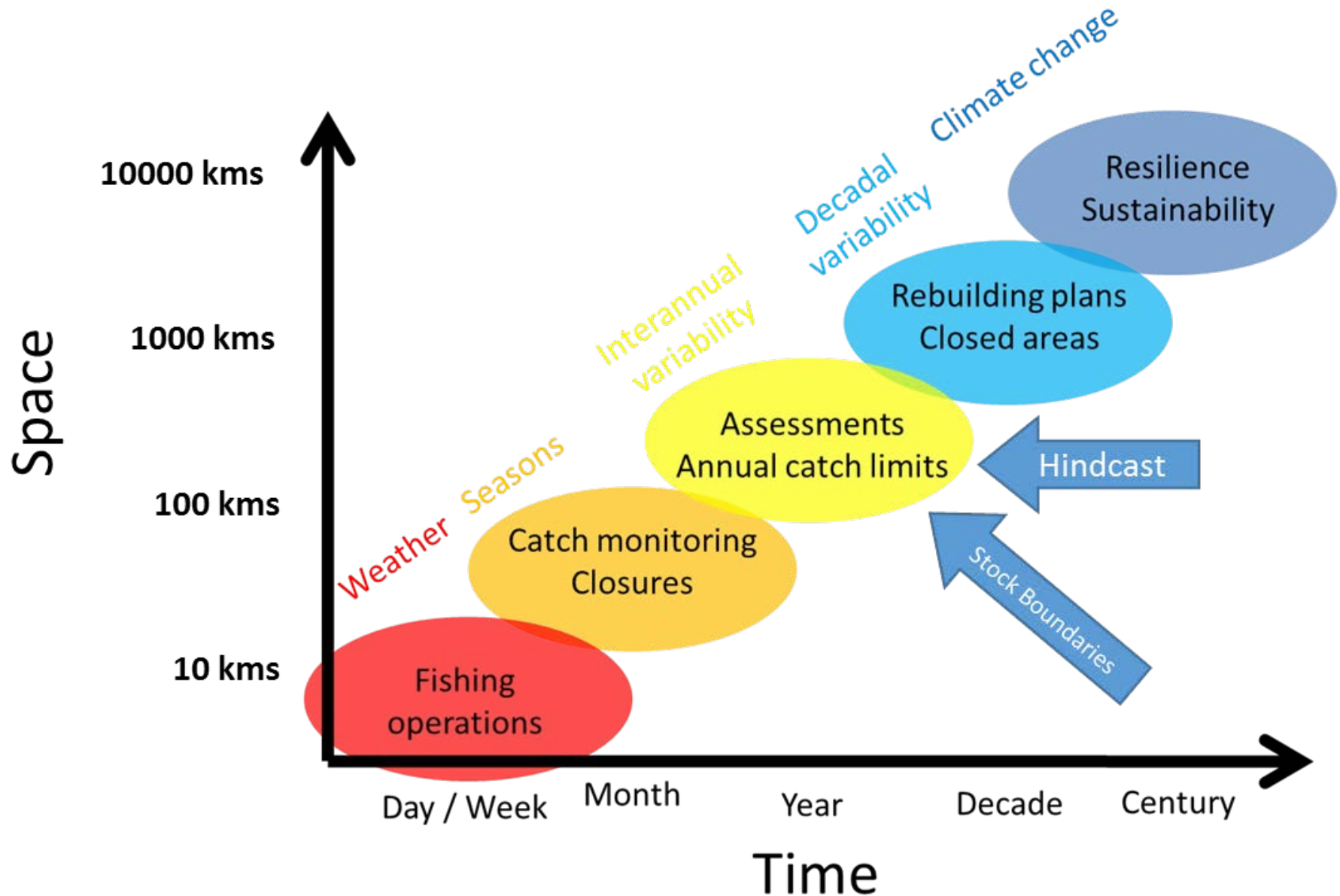
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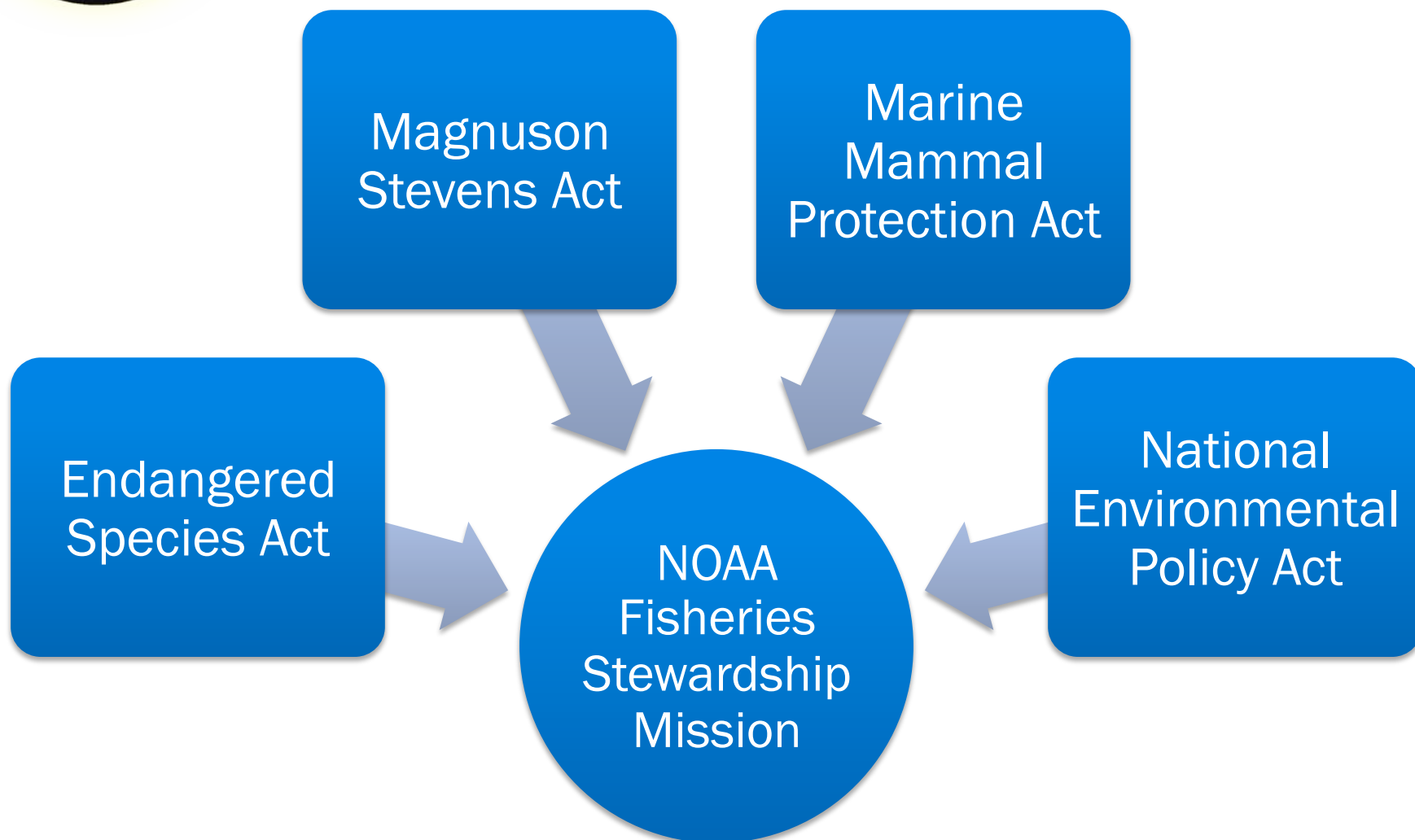


Interactions between Fisheries and Climate





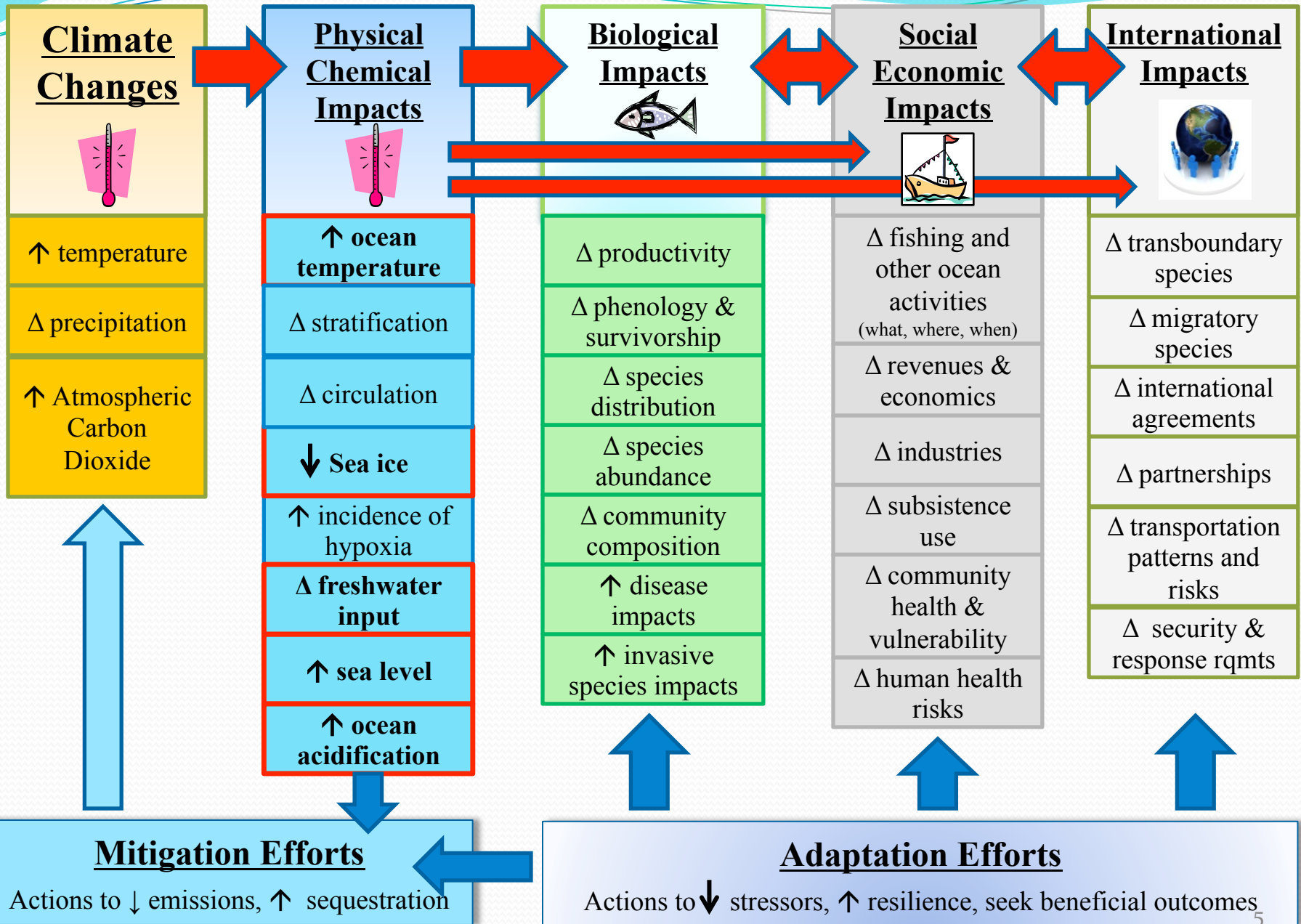
NOAA Fisheries Service Stewardship Drivers



Potential Research Areas

- Basic Research - Observations, Modeling, & theory:
 - Go from index based approach (e.g. correlate fish biomass with the PDO) toward a comprehensive understanding
- Fishery Management: moving from stock assessment to ecosystem based management (EBM)
 - Integrated Ecosystem Assessment (IEA, <http://www.noaa.gov/iea/>)
 - Seasonal to interannual predictions
 - Assess how well relevant ocean variables are predicted
 - e.g. SST, bottom temperature, salinity
 - Climate change => long term planning
 - How will climate-related changes affect NMFS ability to meet its mandates?
- Endangered Species
 - Role of climate change; one of multiple factors (e.g. over fishing)
 - Habitat restoration (impacted by sea level change)

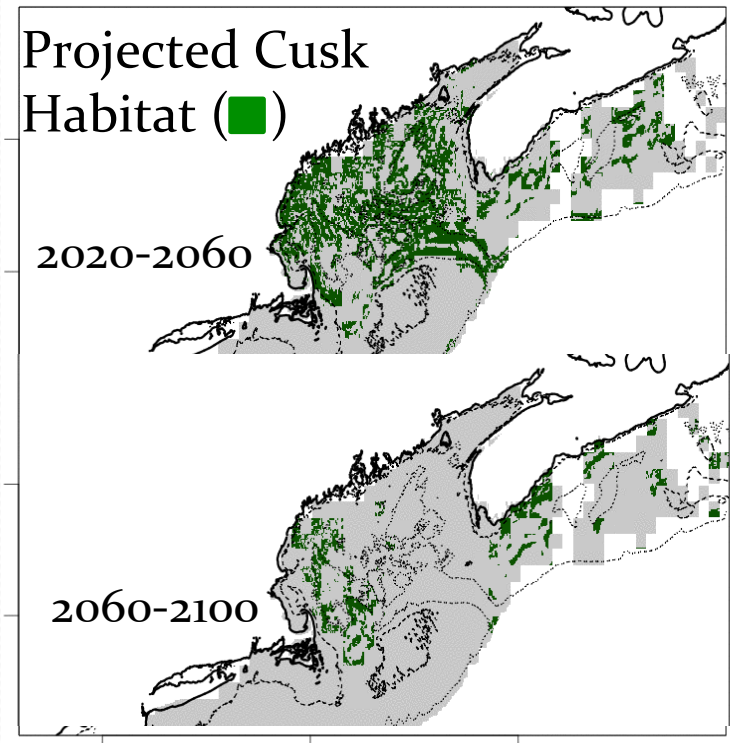
How Will Climate Change Impact Ocean and Coastal Systems?



Projections

Projecting Fish Distributions (A1B) scenario

- Thermal / bottom roughness niche model
- Cusk distribution projected to constrict

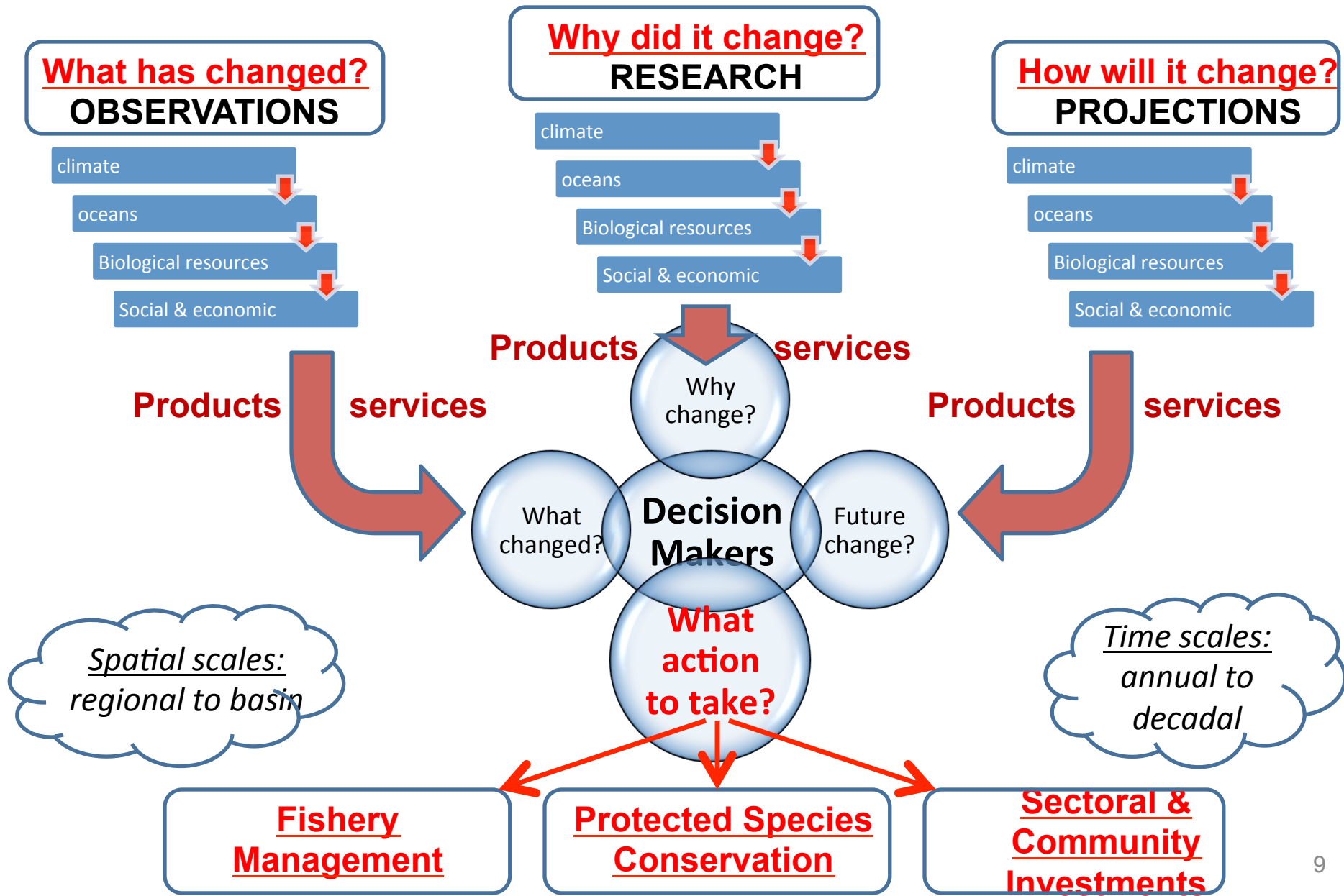


Opportunities & Challenges

- Enhancing communication between climate and marine scientists
 - Organizational contacts
 - Individual scientist contacts
 - Us Learning marine ecology terminology
 - Direct participation in projects => provide expertise on climate variability and change
- Physical Scale ***
 - Climate 100 km; biology 1-10 km (real and perceived)
 - Downscaling
 - Dynamical models Obtaining appropriate boundary conditions & surface fluxes
 - Feasibility of statistical downscaling in the ocean
- Explaining and quantifying uncertainty in the climate forecasts & projections
- Using/enhancing the marine biology in earth system models
- Using, assessing, improving seasonal to decadal prediction for fields relevant to marine ecosystem fisheries
- Developing (web-based) tools for easily accessing and displaying climate information

PPAI session

ESSENTIAL SCIENCE FOR A CLIMATE-READY FISHERIES SERVICE?



Some key questions:

How has/will climate/ocean changes affected ocean productivity?



How has/will these changes affect species abundance and distribution?

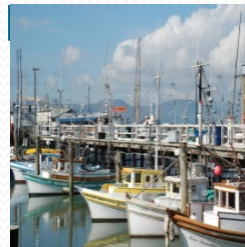


How will fishermen respond to changing fish stocks?



How will communities and economies adapt?

How do we sustainably manage fisheries and other species as systems change (what does climate-ready marine resource management look like?)

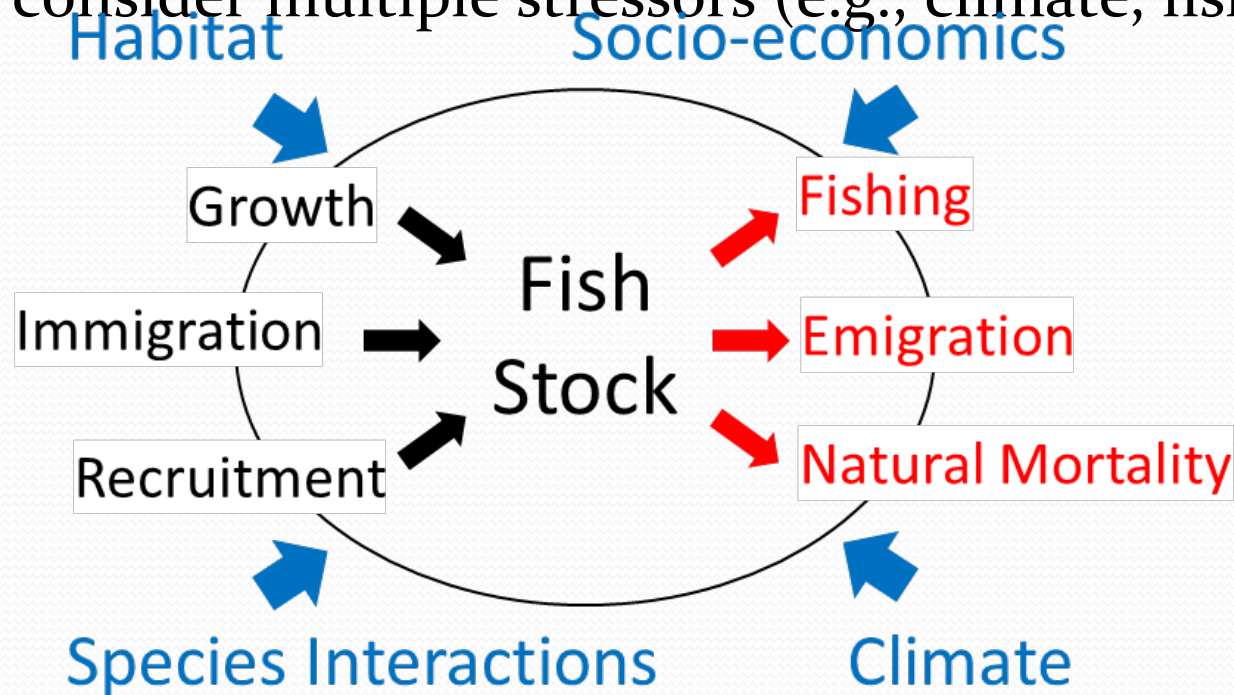


NMFS Climate Science Strategy Priority Objectives

- Objective 1: Identify appropriate, climate-informed reference points for managing LMRs.
- Objective 2: Identify robust strategies for managing LMRs under changing climate conditions.
- Objective 3: Design adaptive decision processes that can incorporate and respond to changing climate conditions.
- Objective 4: Identify future states of LMRs and LMR -dependent human communities under climate change.
- Objective 5: Identify the mechanistic “how and why” of changing climate effects on LMRs and LMR-dependent human communities.
- Objective 6: Track trends in LMRs and LMR-dependent human communities and provide early warning of change.
- Objective 7: Build and maintain the science infrastructure needed to fulfill NMFS mandates with changing climate conditions.

Some conclusions

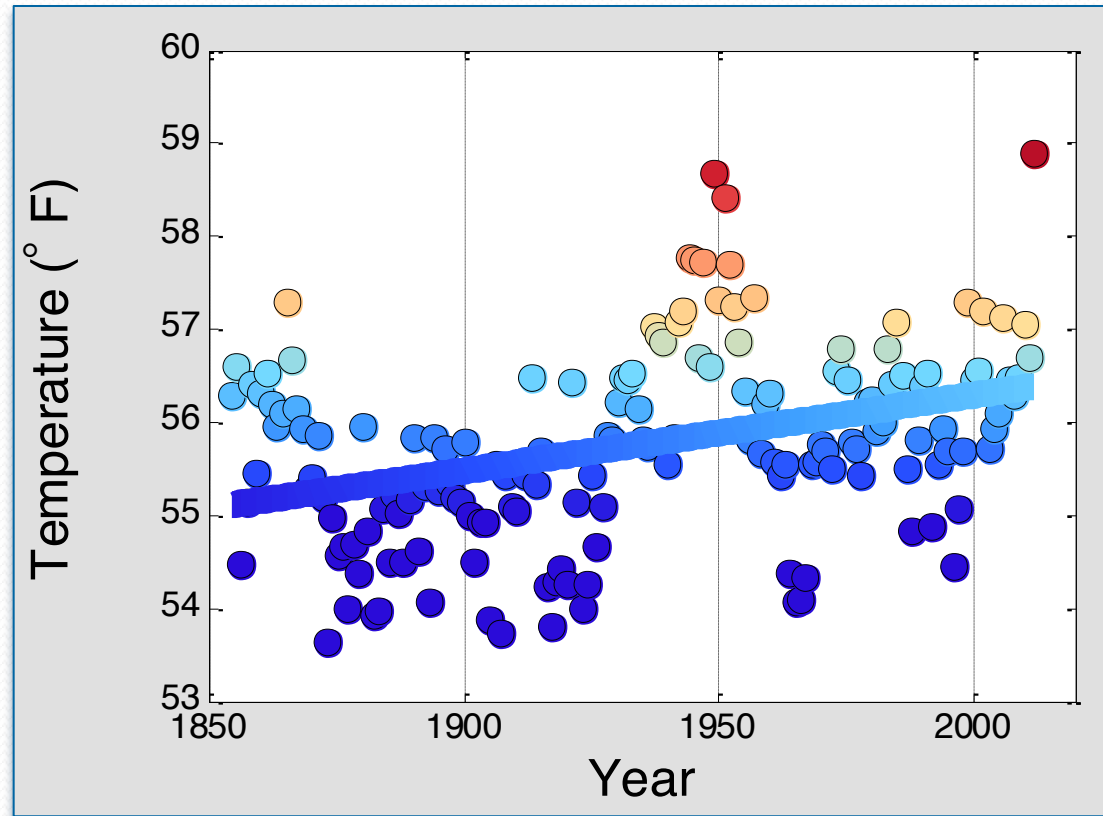
- Biological reference points are not static (climate impacts)
- Marine resource boundaries are not fixed (climate impacts)
- Trophic interactions / communities are changing (climate etc)
- Need to consider multiple stressors (e.g., climate, fishing etc)



Climate Conditions

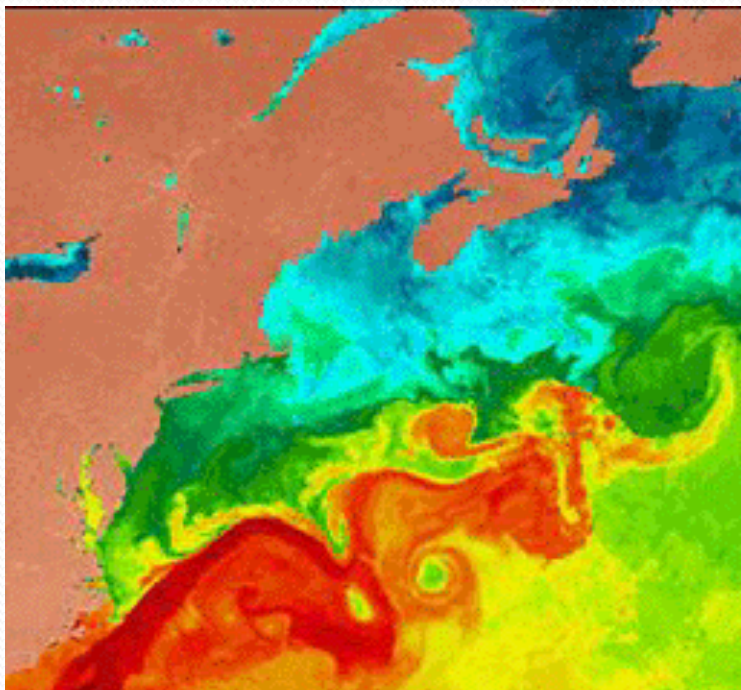
Northeast US Shelf Temperature

- ~ 1.25 °C increase
- Substantial inter-annual and decadal variability



Climate Conditions

- **Physical ecosystem is variable and changing over the long-term**



Salinity decrease (EcoAp 2012)

Ocean acidification (Rebuck et al. in prep)

Wind patterns – Archer and Calderia (2008)

Precipitation and streamflow – Hayhoe et al. (2007)

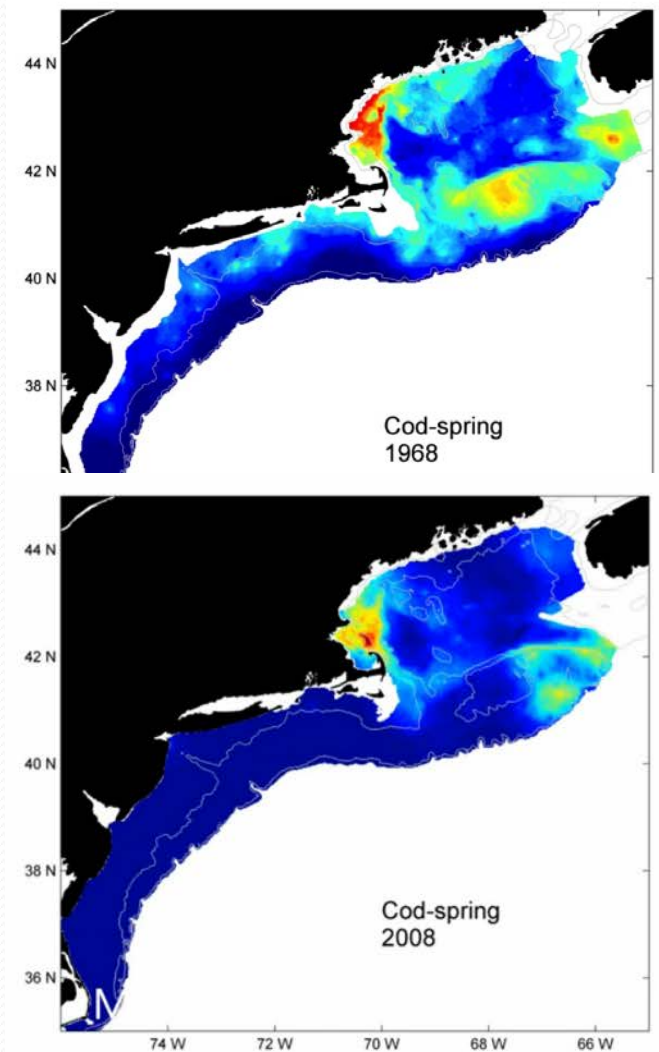
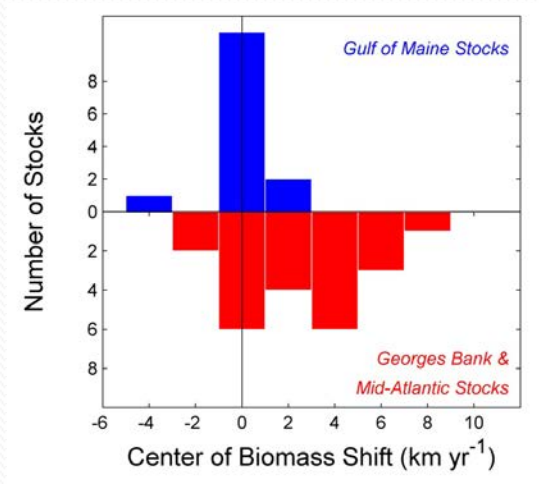
Nutrients – Townsend et al (2010)

And more

Biological Conditions

Northeast U.S. Fisheries

- 24 of 36 stocks shifted poleward and/or deeper



Nye JA et al. (2009) MEPS 393:111-139

Richardson DE <http://www.nefsc.noaa.gov/epd/ocean/MainPage/ioos.html> fish distribution movies

Biological Conditions

- **Biological ecosystem is variable and changing over the long-term**



Zooplankton and phytoplankton changes (Kane 2009)

Mackerel distribution - Overholtz et al. (2011)

Atlantic salmon- Friedland et al. (2003)

Shellfish – Weinberg (2005), Talmage and Gobler (2010)

Phytoplankton – Balch et al. (2012)

And more ...

NOAA's Scale of Information- What can we do?



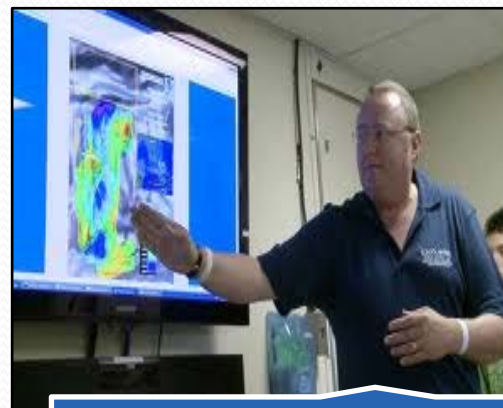
Research



Observations



Decision Support Tools



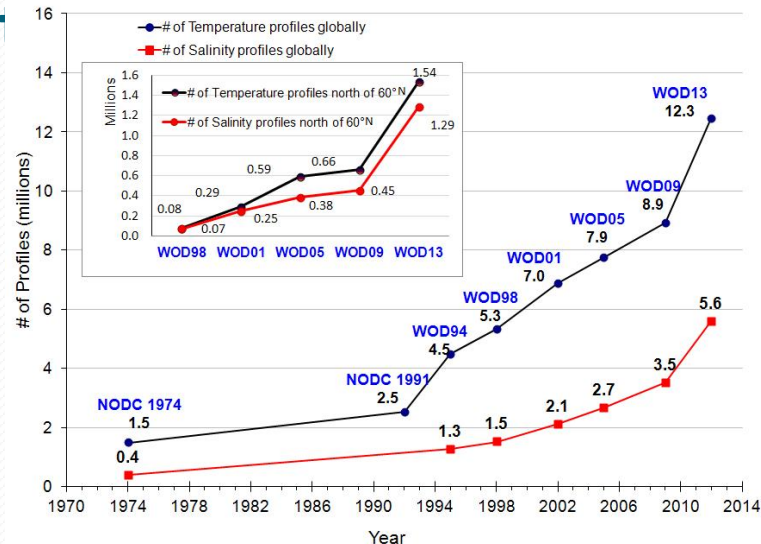
Information Transfer

High-Resolution NODC Climate

Ocean climatologies in the format of *World Ocean Atlas* (WOA) have been generated and published at the *NODC Ocean Climate Laboratory* since 1982 and are based on the NODC flagship product *World Ocean Database*—the largest quality-controlled oceanographic database to date.

- **Ocean climatology** is a compendium of objectively analyzed, quality controlled, arranged on a regular geographical grid and time-averaged fields of essential oceanographic variables, such as temperature, salinity, oxygen, etc.
- All revisions of **WOA**, including the latest edition published in 2013, provide 102 standard levels from surface to 5,500 m.

The new *NODC Ocean Regional Climatologies* project aims at creating high-resolution regional climatologies in the key areas where data allow sub-one-degree resolution on 102 standard data levels.



NODC data holdings for the *World Ocean* and *Arctic Region* (north of 60°N; insert).

New edition of *World Ocean Database* (WOD₁₃) was published on September 31, 2013.

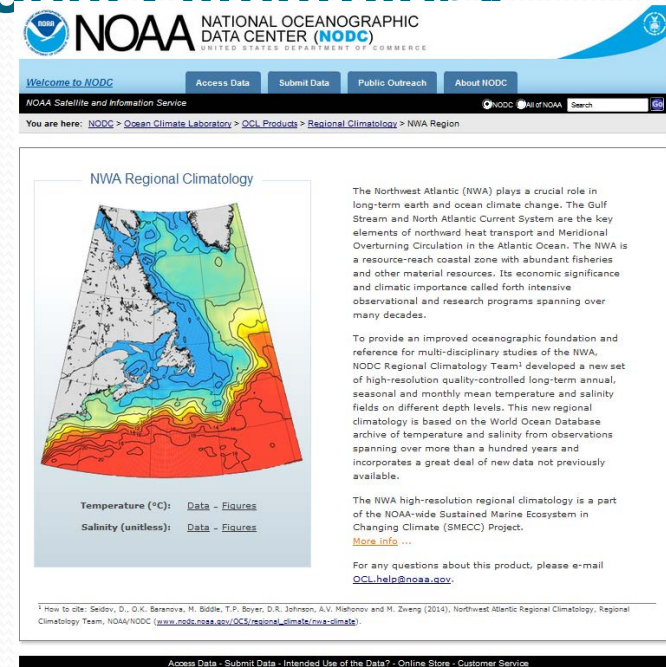
Northwest Atlantic (NWA) Regional Climatology

(SMECC; FY14 - work in progress)
The NWA high-resolution regional climatology is a part of the cross-NOAA Sustained Marine Ecosystem in Changing Climate (SMECC) Project.

NODC Regional Climatology Team¹ developed a new set of high-resolution quality-controlled long-term annual, seasonal and monthly mean temperature and salinity fields on different depth levels.

This new regional climatology is based on the World Ocean Database 2013 archive of temperature and salinity from observations spanning over more than a hundred years and incorporates a great deal of new data not previously available.

High-resolution NWA regional climatology provides quality-controlled temperature and salinity on 87 depth levels with $1/10^\circ \times 1/10^\circ$ grid resolution.



NODC NWA web site screenshot (web site is under construction).

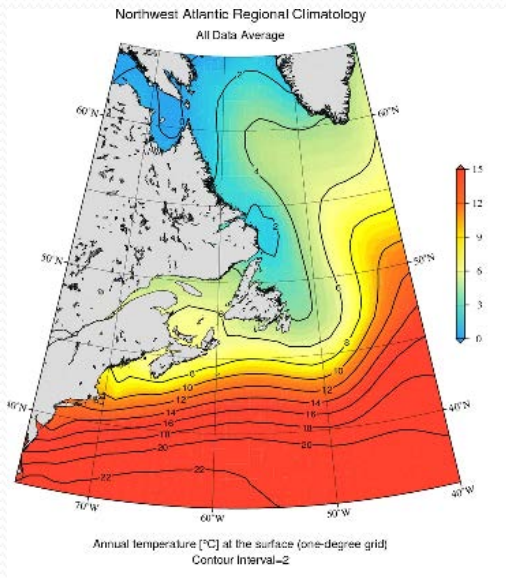
NODC Regional Climatology Team: Seidov, D., O.K. Baranova, M. Biddle, T.P. Boyer, D.R. Johnson, A.V. Mishonov and M. Zweng

High-resolution “all-time” NWA climatology

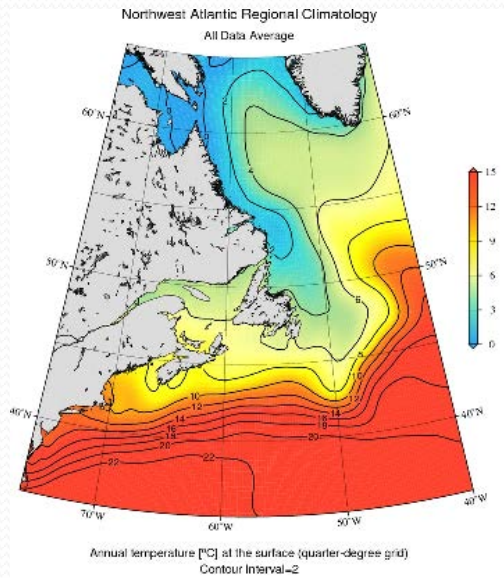
At the moment, the “all-time” NWA climatology has been completed on $1/10^\circ \times 1/10^\circ$ grid. “All-time” means the climatology was compiled using all available data. There will be decadal climatologies compiled for six decades from 1955-1954 to 2005-2012 (the last “decade” has only eight years of data). The decades 1995-2004 and 2005-2012 will be completed by the end of FY14, while earlier decades are due in FY15.

Annual temperature at the surface from NWA regional climatologies with $1^\circ \times 1^\circ$, $1/4^\circ \times 1/4^\circ$ and $1/10^\circ \times 1/10^\circ$ grid resolution show dramatic improvements provided by high-resolution climatology.

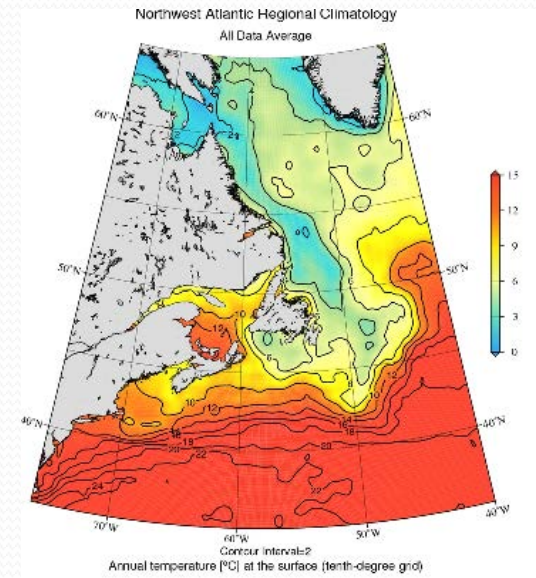
$1^\circ \times 1^\circ$



$1/4^\circ \times 1/4^\circ$



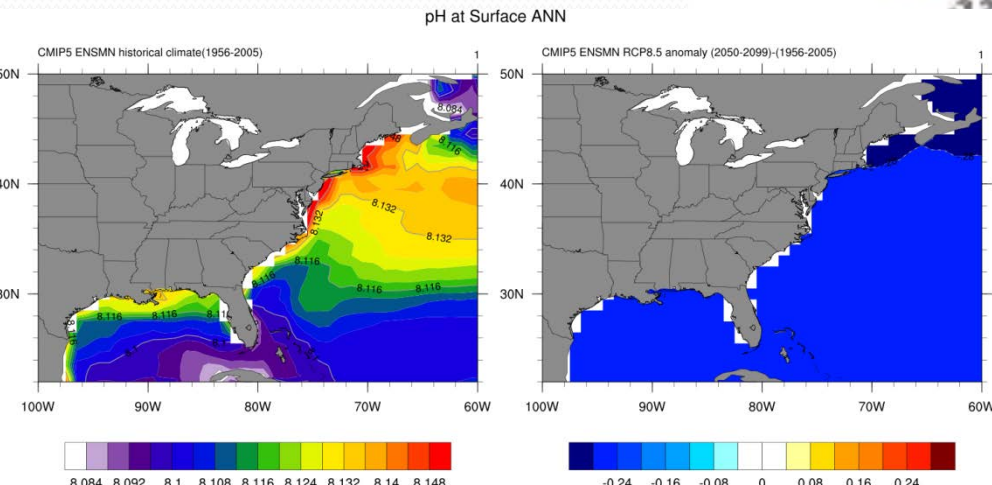
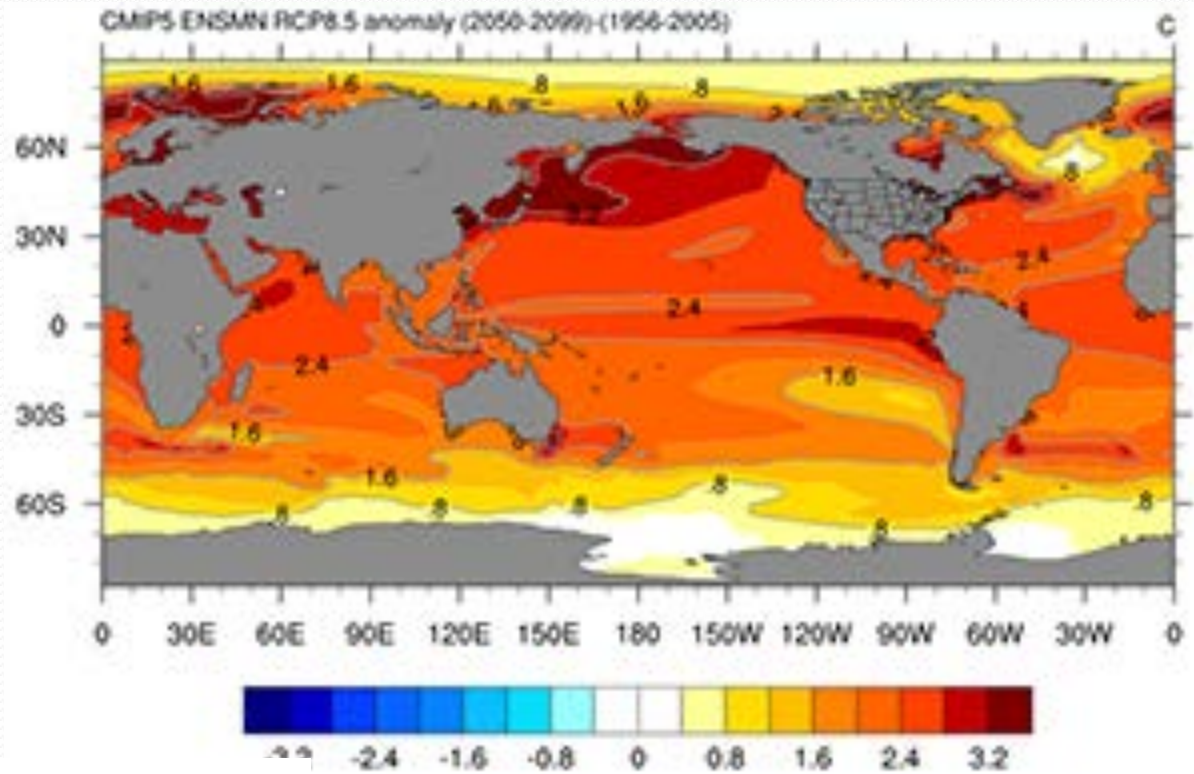
$1/10^\circ \times 1/10^\circ$



Annually-averaged Climatological Sea Surface Temperature (°C)

CMIP5 Model Runs

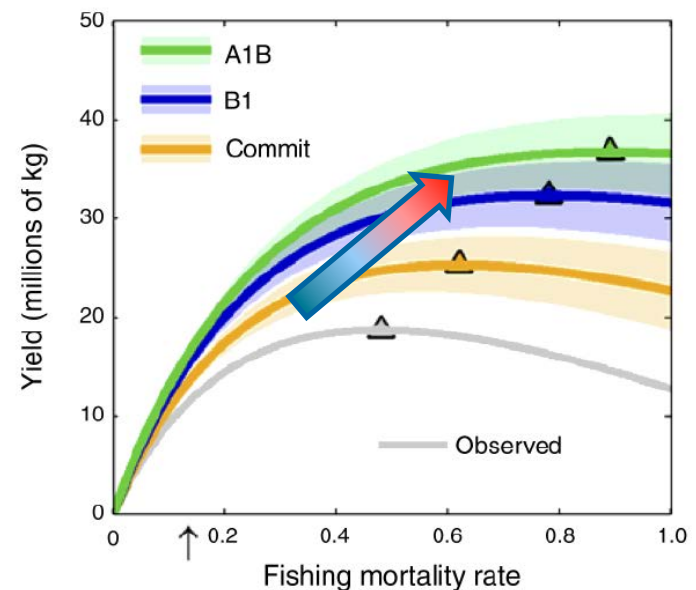
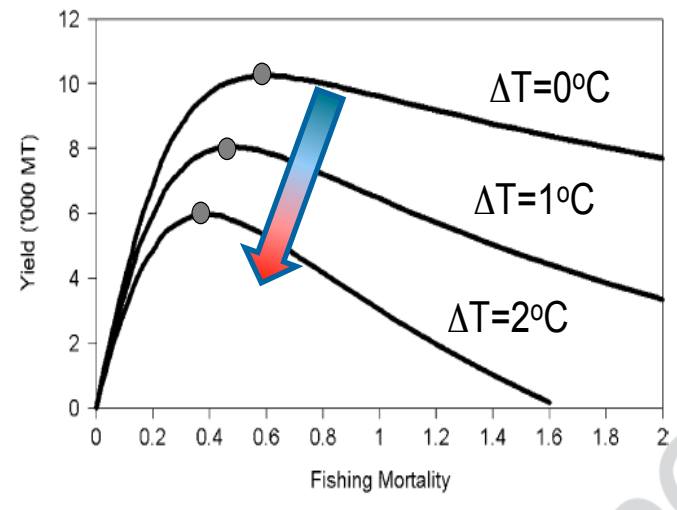
- Projected increase in SST by 3deg C
- Projected decrease in sea surface pH by >0.24



<http://www.esrl.noaa.gov/psd/ipcc/ocn/>

Projecting Fishery Yields

- Atlantic cod productivity projected to decrease
- Atlantic croaker productivity projected to increase
- Temperature-modified recruitment functions
- In a given region (e.g., the Northeast U.S. Continental Shelf), there will be winners and losers



NEclimateUS.org

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nexus ['neksəs] n pl nexuses

1. a means of connection between members of a group or things in a series; link; bond
2. a connected group or series [from Latin: a binding together, from nectere to bind]



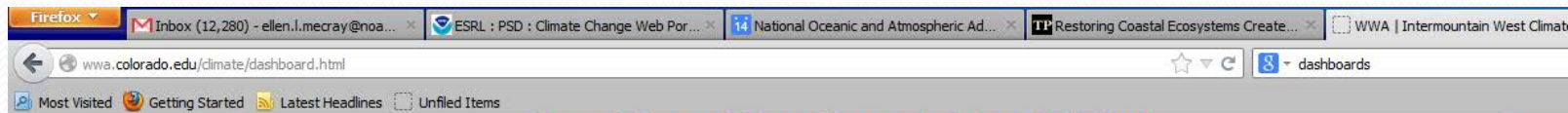
This website was developed through the collaborative efforts of NOAA, NALCC, NWF and EPA.

NEclimateUS.org (a.k.a. 'neXus') is a searchable online database that provides a gateway to climate information for the Eastern US. It summarizes needs for climate information as articulated in publications; identifies available data, products and services; and captures planned and on-going projects. The goal is to offer a tool to search for regionally relevant climate information, and to facilitate collaborative opportunities across the network of climate-focused programs and partners in the Eastern US. NEclimateUS.org is in its early stages of development. Content will change with time to reflect developments in climate work within the region, and in response to individual sector needs when necessary. For detailed information about the content of NEclimateUS.org and tips for using the site, please visit [about NEclimateUS.org](#).



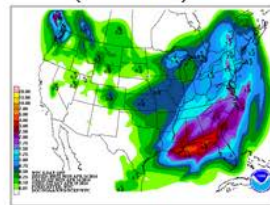
New product coming in FY14-15

- Fisheries/climate indicators in Dashboard format



Precipitation and Snow Forecasts, Drought Outlook

5-Day Quant. Precip Forecast (NOAA HPC)



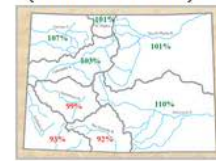
(updated daily)

Experimental Seasonal Precip Guidance (SWcast) (NOAA ESRL PSD)



(updated every ~2months)

Experimental Colorado April 1 SWE Forecast (NOAA ESRL PSD)



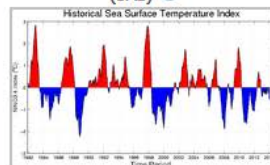
Seasonal Drought Outlook (NOAA CPC)



(updated twice-monthly)

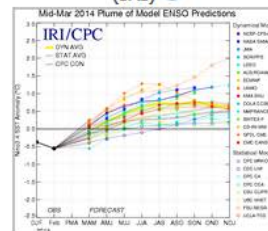
ENSO Conditions & Forecasts

Nino 3.4 Sea Surface Temps, 1982-present (IRI)



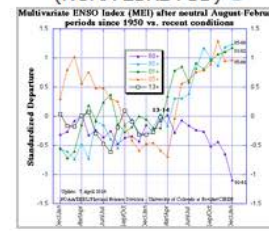
(updated monthly)

ENSO Prediction Plume (forecasts of Nino 3.4 SST) (IRI)



(updated monthly)

Current Multivariate ENSO Index (MEI) vs. past events (NOAA ESRL PSD)



(updated monthly)

- NERACOOS
- Phytoplankton
- Zooplankton
- Satellite SST
- Oleander LT obs
- NODC
- climatology
- ESRL projections
- Frontal boundary
- Landings
- Ocean acidification

