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Protected Resources and Climate Change Workshop

Second Edition

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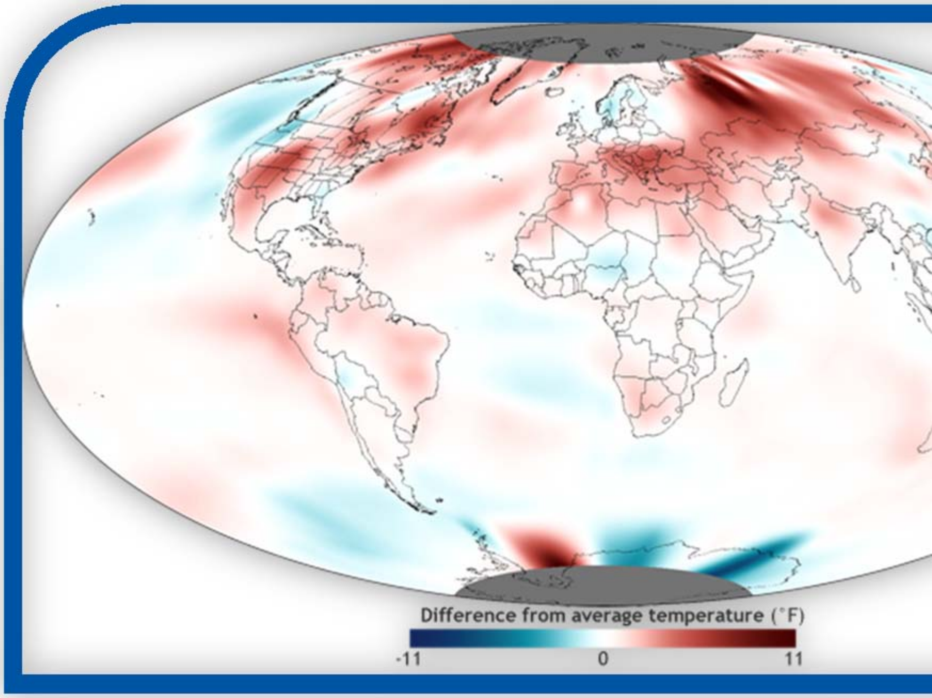

This workshop was supported by the North Atlantic Regional Team. The report will be used for internal purposes to help the National Marine Fisheries Service Northeast Regional Office Protected Resources Division consider climate change in management. Workshop participation was based on expertise, as well as other considerations such as budget.

ABSTRACT

On July 16-17, 2012, the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS), Northeast Regional Office (now called the Greater Atlantic Regional Fisheries Office) brought together scientists and fisheries managers to explore methods to effectively integrate climate change science into management activities within the Northeast Region's Protected Resources Division (PRD). PRD works to manage, conserve, and rebuild species in marine and anadromous waters from Maine to North Carolina. Managers across NMFS are faced with questions on how to best integrate climate change science into their management actions. The workshop focused on bringing together many of the NOAA line offices to exchange information on ongoing and planned climate change research and climate change effects on protected species. NOAA line offices and other federal management agencies also described the status of regional and national efforts to incorporate climate change into natural resources management. Focused discussions were utilized to meet the objectives of: (1) identifying trends and projections for climate change in the Northeast Region (Maine through Cape Hatteras, NC) and outside this area, as appropriate; (2) reviewing projects in which climate science has been incorporated into natural resources management decisions to assist PRD's future consideration of climate change in management; and (3) identifying ways to utilize the best available climate change data in management decisions, including barriers that may hinder such an effort.

KEYWORDS

Climate Change; Protected Species; Endangered Species Act; Marine Mammal Protection Act

Author's note: In 2014, NOAA Fisheries changed the name of the Northeast Regional Office (NERO) to the Greater Atlantic Regional Fisheries Office. NERO is used throughout the report as that was the office name when the workshop was held. The report was first compiled in 2012. Small editorial and clarifications were made in this second edition.

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Introduction

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Protected Resources Management Mandates and Climate Change Challenges (Session 1)

PRD opened the workshop with a discussion of PRD's management mandates and climate change challenges. Kimberly Damon-Randall, Acting Assistant Administrator for Protected Resources, reviewed the mandates and the necessity of considering climate change in management activities. PRD is comprised of three programs: the Marine Mammal and Sea Turtle Program, the Endangered Species Act (ESA) Section 7 Program, and the Salmon, Sturgeon, and Proactive Conservation Program. These programs primarily carry out the mandates of the Marine Mammal Protection Act (MMPA) and the ESA to protect, manage, conserve, and rebuild populations of marine mammals and species listed under the ESA, as well as proactively conserve species of concern. All marine mammals are protected under the MMPA. Species listed under the ESA in the Northeast Region include Atlantic and shortnose sturgeon; the Gulf of Maine Distinct Population Segment of Atlantic salmon; green, hawksbill, Kemp's ridley, loggerhead, and leatherback sea turtles; blue, fin, humpback, right, sei, and sperm whales. Species of concern include, among others, river herring and cusk. These species are also considered candidate species as they are being considered for listing under the ESA.

An overview of the various programs operating within PRD was provided. The Section 7 program is an intra- and inter-agency consultation process for actions that might impact species listed under the ESA. The Marine Mammal/Sea Turtle Program largely focuses on reducing the incidental take of marine mammals and sea turtles in fishing gear, maintains programs for responding to stranded and entangled marine mammals and turtles, and implements other actions for the conservation and recovery of these species. With its Proactive Conservation Program (i.e., Species of Concern), PRD promotes efforts to conserve species for which NMFS has concerns regarding status and threats or has insufficient information available to indicate whether listing under the ESA is warranted.

PRD actions include: determining whether species listing on the ESA is warranted, designating critical habitat for ESA listed species, implementing ESA recovery plan actions, issuing regulations to address take, consulting on federal actions, coordinating the regional stranding and disentanglement networks, and carrying out other conservation and recovery activities. Climate change will likely impact or is already impacting all the species managed by PRD in some manner. Thus, PRD has a need to identify how changes in climate directly and indirectly affect (including cumulatively) these species and their habitats. The information gained through the workshop will be used to guide and inform management decisions with respect to protected species. It will also be utilized to inform consultations by factoring in known or possible climate change effects on protected species when biologists consider the cumulative effects of the action, climate change, and other factors on the species managed.

Deirdre Casey, NOAA Office of General Counsel, described the legal context in which climate change considerations arise. There are three main sources of legal requirements: statutes, Executive Orders, and judicial decisions. Select key statutes relevant to protected resources management (including procedural and protective) with respect to climate change include the Administrative Procedure Act (APA), ESA, MMPA, Magnuson-Stevens Fishery Conservation and Management Act, National Environmental Policy Act (NEPA), and the National Marine Sanctuaries Act. Executive Order 13514 created an Interagency Climate Change Adaptation Task Force to identify a national climate change adaptation strategy.

Ms. Casey discussed three cases in which the impacts of climate change on protected species were at issue. The APA authorizes courts to review certain final agency determinations, and set aside or remand decisions that are “arbitrary, capricious, or contrary to law.” In considering climate change impacts, the agency must consider all relevant issues, explain its rationale, demonstrate support for the decision, and document the weight given to various sources, including an explanation of how uncertainty was resolved or why certain information was or was not used. Relevant climate change considerations must be adequately considered in such actions as listing decisions, ESA Section 7 consultations and biological opinions, ESA Section 10

Habitat Conservation Plans, and MMPA incidental take authorizations. In listing decisions, of the five listing factors (ESA Sec. 4(a)(1)), factors, A, C, and E (and possibly D) have been challenged in relation to climate change.[1] Under NEPA, climate change is considered when describing environmental impacts (direct, indirect and cumulative) of the proposed action and in consideration of the alternatives, particularly where a proposed action may contribute to climate change. Under the ESA, a species is considered threatened if it is likely to become an endangered species within the foreseeable future. While not defined in the ESA, the Department of the Interior has adopted a written policy that states “foreseeable future” is an ambiguous term and, thus, is considered on a case-by-case basis depending on the species. An agency making a listing determination needs to explain and justify what it considers the “foreseeable future,” including when climate change is considered, in the listing decision. For example, for the recent listing by the U.S. Fish and Wildlife Service (USFWS) of polar bears as threatened, the agency considered climate models that predicted out to 50 years, stating that this time frame provided the best available information and citing the high level of uncertainty regarding climate change effects after 50 years.

During this session, there was a brief discussion on what the best available data is and how courts handle the evolution of climate change science, with new data just coming online. It was noted that the new science must be considered, but there is not a requirement to commission new research. The agency, as the decision-maker, must consider the data available to it. It was also noted that it is difficult to tailor the available research to a specific management issue. The Court noted, however, that it is not enough to say because of uncertainty, we will not consider the effects of climate change. The translation of this data into something that can be used by the managers will be important to effectively consider climate change.

Understanding Climate Change (Session 2)

Session 2 was dedicated to identifying trends and projections of climate change, with a focus on key ecosystem components relevant to protected species managed by the Northeast Region. Prior to the workshop, PRD staff met to identify the key presentation topics. These included climate models and scenarios, climate change response along the east coast of North America, temperature (both water and air), ocean acidification, sea level rise, primary and secondary production, and stream flow. Presentations on the current science for each of these were delivered by climate experts within and external to NOAA.

[1] The five listing factors are: A) present or threatened destruction, modification, or curtailment of its habitat or range; B) overutilization for commercial, recreational, scientific, or educational purposes; C) disease or predation; D) inadequacy of existing regulatory mechanisms; and E) other natural or manmade factors affecting its continued existence.

Climate models and climate scenarios — Dr. Mike Alexander (NOAA, Earth System Research Laboratory [ESRL])

Dr. Mike Alexander reviewed climate models and scenarios as a means to investigate future climate changes, and discussed what climate models can and cannot do. Very sophisticated models of the atmosphere, ocean, land, and sea ice are available, with most current coupled models having a horizontal resolution of ~100-300 km. Climate model metrics are used to simulate mean climate features, simulate natural variability, and model response to observed forcing. While the models are adept at simulating mean climate features (e.g., get large scale features "correct"), it is more difficult to model specific regional-scale features. A comparison of the models to nature (e.g., specific areas, points in time) cannot be directly made, though the averages over time can be compared. For example, a model may have a tendency to make certain areas too cold/too hot. However, the model may represent the global response well.

A number of climate models, their workings, and methods of validating the models were presented. Sources of uncertainty include changes in forcing, model sensitivity, and natural variability. In modeling, we do not know how human behavior will change (e.g., use of fossil fuels), and these behavioral changes are affected by factors such as economics, sociology, etc. In addition, different models respond differently to forcing due to differences in parameterizations of sub-grid scale physical processes, resolutions, etc. Climate models are adept at predicting at a global scale, but the natural variability results in an increase in model discrepancies at smaller scales. These models may incorporate simulations of natural variation, and some uncertainties within the model can be addressed by running the model with various forcings included or excluded.

Regardless of scale, a simple bias correction can be performed by taking the difference between period averages (where one of the periods is often from the future and the second from the present day) and then adding this difference to the mean value obtained from observed data from present day. Current global climate models lack some key features (e.g., estuaries). Increased resolution can be considered, but not all biases are improved. In general, dynamical downscaling can be used with global climate change models to obtain finer scales that can be utilized in regions where boundary conditions are provided by available global models. Alternatively, statistical downscaling uses the global climate change model output and statistical relationships to address regional issues. This approach has a low computation cost, but assumes stationarity in statistics, requires robust long-time series, and can perpetuate errors, exaggerating errors in the downscaled version.

There is currently not one accepted climate model or a method regarding the use of the different models and how they should be weighted. However, one approach would be to eliminate the model if it doesn't replicate observations for parameters that could strongly influence its sensitivity to climate change. Ensemble approaches utilize a set of simulations with the same forcings, but different initial conditions, and are frequently used in modeling. Responding to questions, it was noted that climate science is more comfortable attributing a phenomena to changing climate rather than attributing a specific event to changing climate. For example, the occurrence of heat waves may be more frequent due to changing climate. However, one specific heat wave event may or may not be directly attributable to changing climate.

General climate responses along the east coast of North America – Dr. Michael Alexander (NOAA, ESRL)

Dr. Alexander also presented on climate change in relation to the Northeast United States and North Atlantic. Notable changes in the marine environment include:

- Over the Northeast United States, air temperature is projected to rise by 2-6°C by the end of the 21st century.
- Sea surface temperatures (SSTs) are expected to warm, but not as greatly as predicted increases for air temperatures.
- Less temperature change is predicted in areas south of Greenland.
- Across most of the North Atlantic, an increase in temperature is also predicted at 200 m depth, although it should be smaller than the changes in surface temperature.
- Surface-intensified ocean warming will likely result in increased stratification (due to temperature (primarily) and salinity changes), enhanced salinity in the sub-tropics, and global sea level rise. Increased stratification has implications for nutrients and circulation.
- In the subtropics, surface salinities are projected to increase, while waters in the Arctic are projected to get fresher.
- The global sea level is projected to rise 22 mm in the North Atlantic by the end of the 21st century. Climate models currently can include the changes due to thermal expansion, and that effect is projected to increase sea level globally by 100-400 mm. Sea levels will also rise due to melting of glaciers and ice on Greenland and Antarctica.
- It is unclear if climate change will substantially impact the North Atlantic Oscillation, a north-south dipole in sea level pressure.
- Precipitation is expected to increase by roughly 10% over the northeast United States during winter. However, projected precipitation changes are more uncertain than those in temperature.
- There are expected to be more evaporation and more extreme precipitation events.

Over land, expectations are for:

- Higher minimum and maximum temperatures, and an increase of heat index.
- There are expected to be more hot days, fewer cold days, and a contraction of the diurnal temperate range over most land areas,

Temperature – air and water – Dr. Jon Hare (NOAA NMFS, Northeast Fisheries Science Center)
Temperature is a dominant factor affecting organisms. This factor may be a lethal (e.g., thermal limits), limiting (e.g., rate processes such as metabolism growth), or directive (e.g., behavior, metabolic, and ecological responses). In climate models, temperature is predictable compared to some of the other factors that are evaluated. With changes in temperature, species may (1) assume the benefits and costs associated with the change (i.e., "deal with it"); (2) move actively through migration or passively through changes in distribution; or (3) adapt. Temperature changes are relevant to ESA-listed species in how these species will react, move or adapt, and whether adaptation can occur at the same pace as climate change.

Air and water temperature are related, and air temperature can be used as a proxy for water temperature in estuarine and stream systems. As with other parameters, natural variability is also observed with temperature. Currently, SSTs are equal to (or nearly equal to) the warmest observed since the 1880s. By the end of the century, mean temperatures are expected to be 2-3 °C greater than the maximum recorded. Both temperatures (air, streams, estuaries, and oceans) and the rate of warming are increasing, and the difference between summer and winter temperatures (the seasonal range) is increasing. There is also evidence of changes to salinity: a decrease in salinity of 0.3 was observed between 1977 and 2007.

Ongoing needs include continued observational data, more access to historical processes, better understanding of processes such as advection and convection, improved decadal projections, and a better understanding of ecological and evolutionary species response to changes.

Ocean acidification – Dr. Beth Phelan (NOAA NMFS, Northeast Fisheries Science Center)
Dr. Phelan presented information on how ocean acidification refers to the chemical changes in the ocean as a result of the absorption of carbon dioxide (CO_2). NMFS Northeast Fisheries Science Center's (NEFSC) ocean acidification program focuses, particularly with respect to commercially important species, on acidification as it relates to oceanic conditions, although some experimental pilot studies are being conducted in estuarine environments.

The ocean absorbs about one quarter of the CO_2 released into the atmosphere each year. Thus, increasing atmospheric CO_2 levels lead to increasing oceanic CO_2 levels. A decline in pH, which is dependent on both CO_2 and temperature, of 0.02 has been observed over the last decade as has a decline of 0.10 since pre-industrial records. Nitrous and sulfur oxides can also locally affect ocean acidification. Predictions indicate that CO_2 will increase, and pH will continue to decrease. This may result in reduced calcification rates, shifts in phytoplankton diversity, reduced sound absorption, and reduced homing ability, among other impacts. The capacities for acclimation and adaptation by marine species are unknown. It is expected that food webs will be affected and that ecosystem services (e.g., fisheries) will change. The uncertainties around these impacts are great and more research is needed. Dr. Phelan also noted that there are multiple stressors, including temperature and pCO_2[2] on marine communities. Ocean acidification is occurring and is increasing; is known to cause physiological stress; and will only be mitigated with decreased CO_2. Under the Federal Ocean Acidification Research and Monitoring Act of 2009 (FOARAM), NOAA is mandated to establish an ocean acidification program to assess regional impacts, research adaptation strategies, and ensure a comprehensive interagency plan. In response to a question regarding whether there were periods in the Earth's history with high CO_2 and low pH that could help us better understand ecosystem effects, it was indicated that these periods have occurred.

Sea level rise – Dr. Robert Beardsley (Woods Hole Oceanographic Institution)

Dr. Beardsley described inundation modeling and regional sea level rise in New England. The application of FVCOM, an unstructured grid, finite-volume coastal model, and its application were detailed. The Northeast Coastal Ocean Forecasting System (NECOFS) developed a three-day operation forecast for the NE region and piloted the "end-to-end" inundation forecast capability at two pilot sites: Scituate, Massachusetts, and Hampton-Seabrook, New Hampshire. As there are few tide stations in the Northeast, tide gauges needed to be installed to acquire the needed data. FVCOM was used in NECOFS for the forecasts predicting surface weather, waves, elevation, three-dimensional currents, temperature, and salinity. In the Scituate models, the models were strongly affected by wave-current interaction which made a difference in the flooding and erosion that was predicted. With the wave-current interaction included, the model could simulate inundation within the harbor. This model is currently being expanded to other Massachusetts coastal communities by MIT Sea Grant.

Dr. Beardsley also reviewed regional climate change and implications for future inundation in the Bay of Fundy and Gulf of Maine marine systems. Recent changes in sea level are attributed in part to post-glacial rebound, giving rise to increasing tides. Without climate change, tidal high water in the Bay of Fundy/Gulf of Maine region is expected to increase ~0.3 m by the end of the next century. Combined with climate change, the increase expected is ~0.5 m in the next 50 years and ~1 m by the end of the next century. Increased inundation is predicted due to the combination of (1) increased tidal range due to present and global warming-induced sea level rise and (2) increased storm surge due to climate change-caused increases in storm intensities. These predictions do not account for sea level rise associated with glacial melting. The academic interest in downscaling is growing, which may be important for regional projections in the Northeast.

[2] The partial pressure of CO_2= pCO_2

Primary and secondary production – Dr. Charlie Stock (NOAA, Geophysical Fluid Dynamics Laboratory)

Factors determining net primary production include light availability, nutrients (from mixing and upwelling), and temperature. Nutrients are brought to the surface through mixing and upwelling. Within the North Atlantic, there are areas of deep mixing. Atmospheric deposition is also a significant nutrient source, particularly for iron. Sea surface reconstructions for the last 60 years suggest a "fresh gets fresher, salty gets saltier" pattern consistent with projected hydrological cycles. Increased warming leads to increased stratification that can decrease mixing and, subsequently, primary productivity. The projected impact of increased stratification on net primary production varies by latitude.

Climate variability can mask trends with at least 15 years of data required to detect a change, and time series of 50-60 years are needed in many places. Detecting climate change driven trends in net primary production is difficult because the time series required are long, measurements are difficult, and model-based estimates vary. It is generally agreed that there will be a modest to moderate decrease in global net primary production, and that significant regional differences will occur. Net primary production is also projected to decline in the North Atlantic likely due to freshening of the water resulting in increased stratification and less nutrients being brought up. In addition, spring blooms may also occur earlier annually in response to climate changes. Salinity changes offer the strongest correlation with spring blooms. Climate change may impact different size classes of phytoplankton differently, with larger phytoplankton production decreasing more than smaller phytoplankton production. With respect to higher trophic levels, net primary production has been shown to be a poor predictor of fisheries yields. This is due, in part, to complex planktonic food webs with dynamic trophic conditions. Fish can respond strongly to the timing of seasonal transition. Various species may respond to climate changes in unique ways, so we should consider creating species-specific models. For example, negative impacts on the eastern Pacific leatherback are predicted due to lower hatching and emergence rates with increasing temperature. Northward shifts in nesting are unlikely due to the extremely dry conditions in the sub-tropics.

Stream flow – Dr. Robert Lent (USGS, Maine Water Science Center)

Dr. Lent reviewed hydrologic climate responses in New England. New England hydrology is sensitive to climate, especially in the winter and spring, and spring runoff dominates the annual hydrograph. In recent years, spring runoff has occurred significantly earlier in northern New England regions, with the timing related to changes in air temperature. Variations are also seen in runoff quantity. In the St Johns River at Ft. Kent, Maine, the spring runoff occurred earlier in the year and with decreased flow. Geographic distinction in runoff changes are seen north (Maine) to south (CT) in both timing and quantity. It was recognized that different areas, even those that are adjacent, may have different key variables, and different variables may be appropriate at different scales. These differences are important to understand when considering a regional climate network. Other variations may include frequency of events, intensity of events, and changes to the hydrologic system. The intent of recent projects has been to identify and define hydrologic variables sensitive to climate change, characterize regional responses to climate variations, and evaluate the implications of variations on hydrologic processes. Implications for the near and far future were discussed. Watershed responses across 14 basins within the United States, using three IPCC scenarios, are available. These models used statistical downscaling to represent future conditions. The hydrologic variables evaluated display consistent trends, both temporally and geographically. There is a strong relationship between climate and hydrologic processes such as annual flow and winter/spring runoff, and future climate changes could have a large impact on these processes in New England. Publications addressing these topics in more detail are available at http://me.water.usgs.gov/publications/climate.html. Discussion following the talk again noted the importance of having long time scales as changes happen at different scales, and the observational record is a combination of both natural and anthropogenic forcing.

Putting It All Together (Session 3)

The objective of this session was to understand how different ecosystem components interact with respect to climate change and potential impacts to protected species as well as to identify data gaps. During the presentations/discussion throughout Session 2 (see above), this objective was addressed. Therefore, discussions focused on increasing common understandings of the science as well as clarifying the goals and purpose of the workshop. PRD's needs in considering climate change were also explored. Generally, participants from outside of NERO had an understanding of the overall workshop goals, but were less clear of the questions to address when it came to specific species and for what purpose PRD needed climate science information. It was noted that this workshop is a first step in understanding the latest information in climate change science, how this information can and should be considered and incorporated into management-related documents and management measures for protected species, and the potential impacts of climate change on protected species. To clarify the type of information necessary for protected species management, PRD staff provided examples of specific climate-related topics that are considered in management or have been raised during various discussions in the region. These questions vary greatly depending on the species and factors being considered. A few examples are highlighted here:

- During ESA Section 7 consultations, biologists must evaluate the effects of not only the action being considered (e.g., a bridge construction), but other potential factors, including climate change, impacting ESA-listed species to determine the cumulative effects to the listed species.

- Some Section 7 consultations evaluate longer-term projects (e.g., 50 yrs) and, thus, biologists must evaluate climate change impacts on listed species over the course of the duration of the project.
- In listing decisions, PRD must address the factors that contribute to a species decline, including climate change. For example, climate change was identified as a factor for the decline of river herring in a recent petition to NMFS to list them as a threatened species under the ESA.
- In protected species management of commercial fisheries, management areas are defined spatially and temporally to coincide with periods of overlap between the animals and the fisheries. If climate change affects the distribution of the animals (either directly or indirectly through shifts in prey distribution), this could lead to shifts in distribution to other areas that may make management measures ineffective.

Conversely, PRD staff highlighted their confusion about the many different sources of climate change information and difficulty in identifying the correct information that should be used (e.g., what is the most appropriate climate scenario model). Perhaps a method can be developed to ensure that climate change data are collected and/or provided in a more useable format for PRD purposes. Several participants observed that there is a need for increased communication between protected species managers and climate science experts, and that the questions to be addressed need to be clearly articulated and detailed before tools can be developed to help answer them. Given the wide range of protected species with varying life histories and distributions, additional focused discussions and research will be needed to understand impacts to these species.

While models and assessments have been developed to examine climate change efforts on a few protected species (e.g., cusk, river herring), there is a need to develop methods to evaluate species groups, as addressing impacts on a species-by-species basis is logistically challenging given the time needed to develop the models and the limited resources available. This might be alleviated to an extent by considering groupings of species, such as sea turtles, large cetaceans, small cetaceans, pinnipeds, etc. A need to bring ecologists and modelers into the process was identified, as this expertise is required to help make the link between the climate change data and the anticipated impacts on protected species. It was also noted that this communication is essential to ensuring that the science is being used appropriately in assessing impacts to protected species. In order to understand these impacts, it is also necessary to downscale the global climate change models to specific sub-regions. Other types of studies may include controlled pCO_2 laboratory studies at different life history stages for commercial fish and shellfish species, identification of synergies at different scales, and data discovery and interpolation (e.g., from hydrology information system). There is also a need to have an understanding of the basic biology of species response, without which it is challenging to incorporate the climate change information into management actions for protected species. Resources were identified as a limitation to completing this work.

Agency Case Studies and/or Climate-Related Policy Efforts (Session 4)

This session focused on providing an overview of projects that have moved climate change science into natural resource management decisions. This overview was used to help participants identify ways to effectively use the best available climate change data and lessons learned from the case studies in protected species management decisions, as well as barriers that might hinder such an effort. The session opened with a series of presentations on management projects with a climate change component.

NMFS' ESA and Climate Change Initiative — Dr. Roger Griffis (NOAA NMFS, Office of Science and Technology)

Within NMFS, there is an ESA-Climate Change working group, led by Michelle McClure and consisting of approximately 24 people from the science centers, regional offices, headquarters offices, and general counsel's office. In addition, USFWS and the University of Washington participate in the working group. The goal of the working group is to establish guidelines for incorporating climate change into ESA actions. The project consists of eight case studies including the listing of ice seals, listing of corals, listing of cusk, sea turtle recovery planning, Pajaro steelhead recovery planning, Pacific Northwest species in Section 7, and two projects on Pacific salmon in Section 7. Key issues being addressed include:

- which climate change projections (e.g., scale, emissions scenarios) should be used/considered in ESA activities,
- how to address uncertainties,
- what time horizon to consider,
- how to predict and mitigate future greenhouse gas emissions,
- how to consider currently unoccupied habitats,
- how to incorporate population diversity into resilience,
- how to weight potential positive effects,
- how to design projects, and
- how to manage adaptively.

The working group has identified that guidance should be developed on all of these to varying extents, with the exception of project design issues. Guidance related to project design could be at the regional level, but some working group members believe national guidance would be helpful. The next steps in this process are to publish the case studies in a special issue of *Biological Conservation* as well as to develop a technical memo and agency memo; continue to develop guidance and tools; and to identify and secure climate information at regional and local scales required to implement the ESA.

Consideration of climate change in ESA status reviews and NMFS Fish Stock Vulnerability Assessment — Dr. Jon Hare (NOAA NMFS, Northeast Fisheries Science Center)

In 2007, NMFS proactively initiated a status review for cusk (*Brosme brosme*). Cusk is a transboundary fish stock, and Canada had also initiated a review of its status. This project is one of the eight projects in the NMFS Climate Change Initiative described above. These pilot projects have been time consuming and resource intensive. The objective of this study was to project shifts in the distribution of cusk using a coupled habitat distribution-climate model. The study linked a niche model (using bottom temperature and bottom type) to downscaled climate models to project future population dynamics. In the niche model, bottom type was considered static, but information from this workshop indicates this may need to be reconsidered. One presentation suggested sea level rise could change the tidal characteristics of the Gulf of Maine and potentially affect sediment characteristics. This potential needs to be investigated further. With increasing temperature, a decrease in habitat was projected. The model suggests that suitable habitat availability might increase farther north as water temperature increases. In the Gulf of Maine, a decrease in suitable habitat, but not extirpation of cusk, is projected by the end of the century. In addition to a decrease in availability of habitat, habitat is becoming more fragmented, indicating a need to better understand connectivity for cusk.

Future work needed includes developing valid population assessments and projections with population dynamics incorporated. Additionally, a fisheries vulnerability assessment, focusing on managed fish species including the protected species cusk and Atlantic sturgeon, is currently being developed. The three categories of vulnerability incorporated in the assessment are exposure (climate-related), sensitivity (biological attribute), and adaptive capacity (biological attribute). Life history traits are used to place species in a relative ranking of sensitivity to climate change. As this ranking is relative, species must be considered at the same time, or the assessment must be re-run. This fisheries vulnerability assessment could be adapted to inform a similar process for protected species. As these assessments are currently tailored to fish life histories, they would need to be adjusted to allow for an assessment to be conducted for other protected resources species groups such as marine mammals and sea turtles.

Consideration of climate change in refuge management, landscape conservation cooperatives — (United States Fish and Wildlife Service)

Unfortunately, the USFWS was unable to participate in the workshop. Therefore, this agenda item was not discussed.

Consideration of climate change in coastal management through the Climate Ready Estuaries Program — Mel Coté (Environmental Protection Agency, Region 1)

The Environmental Protection Agency's (EPA) Climate Ready Estuaries (CRE) program works with the National Estuary Programs and other coastal managers to: 1) assess climate change vulnerabilities, 2) develop and implement adaptation strategies, 3) engage and educate stakeholders, and 4) share the lessons learned with other coastal managers. The CRE program currently focuses its goals on the EPA's mandates under the Clean Water Act (CWA). There are 28 National Estuary Programs (NEPs) across the country, six of which are in New England. Starting in 2008, EPA has funded 31 CRE projects with 19 NEPs, including nine projects with five of the New England NEPs. These projects are intended to identify climate change adaptation best practices and inform updates to each NEP's Comprehensive Conservation and Management Plan. Several regional projects were introduced. The Piscataqua Region Estuaries Partnership in New Hampshire evaluated culverts on the Oyster River to identify those most vulnerable to flooding. This helps inform watershed management and future development by showing connectivity in the watershed. Projects such as the Delaware Estuary project incorporate a Climate Ready Water Utilities component. This component is designed to improve resilience to drinking water and waste water infrastructure by evaluating precipitation, sea level rise, coastal flooding, and salt water intrusion. Other projects address nutrient enrichment, water quality, and ecological integrity as well as increasing community understanding of climate change and how it affects their community. The program has also developed decision support tools to help assess such things as vulnerability to climate change. There are several publications underway related to this program. These include a vulnerability assessment approach, lessons learned, progress report, and climate change adaptation in support of the CWA goals. In response to questions, Mr. Coté indicated that there is a general construct for thinking about vulnerability assessments, but that the assessment must be tailored to meet needs.

Consideration of climate change and climate forcing in ESA Section 7 consultation effects analysis – Mr. Patrick Opay (NOAA NMFS, Pacific Islands Regional Office)

The NMFS Pacific Islands Regional Office (PIRO) is addressing the issue of climate change in its Biological Opinions. However, there are many challenges in considering climate change. This talk focused on specific examples for sea turtles. Climate change may affect one or more sea turtle species or species life stages, but may not affect all species or life stages in exactly the same manner. Some impacts may be positive while others may be negative. In addition, populations in different regions or ocean basins may also be impacted differently. Other challenges to addressing impacts include a lack of information for specific areas and uncertainties around adaptation of the species to climate change. The talk introduced a climate forcing model developed by Van Houtan and Halley (2011) that uses basin-scale climate indices and regional surface temperatures to estimate loggerhead sea turtle nesting. The modeling suggests that sea turtle populations in some areas may be regionally synchronized and correlated to ocean conditions, and the model may be of some use in forecasting population changes. This model was adapted and used in a Biological Opinion (projecting 25 years in the future) on the Hawaii-based shallow set longline fishery. Two life stages, neonates and breeding females, were considered. This model gave very different results from the classical population viability assessment model. It should be noted that a complete picture of the population is not achieved as only two life stages were incorporated in the model. The Biological Opinion used both quantitative and qualitative evaluations, considering general direction and magnitude of trends rather than strict numerical determinations. The model results were considered in the context of other relevant sources of information, and the multiple layers of uncertainty were also noted.

Session Discussion

The discussion during this section focused on the need to synthesize available data. It was noted that there are opportunities to utilize the NEFSC for information on the environment and climate. With the move towards ecosystem-based management, there may be more opportunities to collaborate efforts and leverage funds, and these opportunities should be explored. Edge matching, realization of where one agency's responsibilities begin and another's end, and improved communication across and among agencies will help in identifying these opportunities. In addition, the data should be made readily available, and users should understand the different scales and levels of information. Providing training on climate may also help the Protected Resources and Habitat Conservation Divisions staff in completing consultations. Again, resources were noted as a limitation. The idea of communities of practice or small action teams was introduced.

It was noted that there are not many stations for gathering data on rivers, and there is a need to look inland to these systems in order to assess impacts to anadromous species. The Consortium of Universities for Hydrologic Systems (HIS) is identifying available river data from different universities and sources. Synthesizing data from different sources can be challenging in that it can exist in different forms, have varying degrees of quality and possess different tolerances. Portals for data access should be established, and existing portals should be reviewed for ease of use and accessibility. At this time, there is not agreement on data standards.

Potential solutions to some of the issues facing PRD were proposed. As a first step, PRD is currently developing a white paper synthesizing the literature related to impacts of climate change to protected species and conducting an analysis on where there are gaps in the information available. There may be a need to host workshops specific to species groups (e.g., large whales, small cetaceans, pinnipeds, sea turtles, anadromous fish, etc.) to bring managers together with species biologists/ecologists and climate scientists to begin assessing known or potential impacts of climate change on protected species. This may be accomplished through establishing a community of practice. There was interest in developing a vulnerability assessment for protected species, perhaps through adaptation of the fisheries assessment to protected species life histories. A clearinghouse of climate science and data would help identify where information is available. Several at the workshop noted that there is not one lead agency for climate science, which may sometimes result in confusion on where to acquire information.

A website synthesis of key fisheries variables to distill climate data and provide access was also suggested. Other potential solutions include focusing research at the intersection of fisheries and climate and making ecosystem status reports and data more accessible. Many of these require significant resources, and it was again noted that there would be a need for a commitment to the funding in order to accomplish these.

“Take home” points identified at the conclusion of the workshop included, in part, the need to keep headquarters offices informed of and involved in discussions of the need for regional action plans; improved coordination, cooperation, and information sharing is critical to continue moving forward; and baseline capacities need to be improved. There is a need to merge atmospheric and oceanic data and move towards ecosystem-based management. Climate change should be incorporated into studies and not considered a factor alone. It will be important to clearly define the questions to be asked and, once asked, to identify the best approach to address the questions. It was also noted that it can be difficult to identify the right questions to be asked, and the process will likely be iterative. The exchange of ideas cannot end with the workshop, if climate science is to be successfully incorporated into future management actions focusing on the protection and conservation of protected species.

Appendix I – Agenda

NMFS Northeast Regional Office Protected Resources Division
Climate Change Workshop

July 16-17, 2012
Gloucester, MA
Agenda

Goal:
Funded by the North Atlantic Regional Team (NART), this workshop brings together NOAA's line offices, along with other scientists and managers, to explore methods to effectively integrate climate change science into management activities within the Northeast Region's (NERO) Protected Resources Division (PRD) under the Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA), and to identify gaps in information that could be filled by NOAA. The workshop will focus on an exchange of information regarding ongoing and planned climate change research, as well as climate change effects on protected species and the status of regional and national efforts to incorporate climate change into natural resource management. Major objectives include:

- Identifying trends and projections for climate change in the Northeast Region (through Cape Hatteras, NC);
- Reviewing projects/cases in which climate science has been incorporated into natural resource management decisions to assist PRD's future consideration of climate change in management; and,
- Identifying ways to utilize the best available climate change data in management decisions, including barriers that may hinder such an effort.

The workshop outcome will be a report summarizing the discussions and recommendations, including identification of additional research needs.

DAY 1

9:00[3]	**Purpose of Workshop & Introductions (incl expectations for the mtg)**
9:30	**PRD's Management Mandates and Climate Change Challenges** **Objective 1:** Achieve a common understanding among workshop participants of NERO PRD's mandates under the ESA and MMPA, and current challenges associated with addressing climate change in management activities **Objective 2:** Achieve a common understanding of legal requirements to consider regarding climate change within the framework of our current mandates (e.g., ESA, MMPA, National Environmental Policy Act [NEPA], etc) **Format:** Presentations (PRD and General Counsel [GC]) followed by question/answer session • PRD Management Overview (10-15min, PRD Presentation- Kim Damon-Randall Acting Asst RA) o Protected species overview o Mandated requirements under the ESA and MMPA o Current challenges associated with addressing climate change • Legal Requirements to Consider Regarding Climate Change (GC Presentation- Deirdre Casey, NOAA/NERO GC)
10:15 – 5:00	**Understanding Climate Change** **Objective**: Identify trends/ projections of climate change focusing on key ecosystem components in the Northeast. Each section to include:

[3] All times are approximate.

	- Presentation of available science, including current state and predicted trends (30 minutes each). - Discussion on known and/or anticipated impacts, including biological and habitat factors, with a focus on impact to protected species. - Identification of data gaps and needs.
10:15-11:00 *11:15-12:00* *12:00-12:45*	**Format: Presentations and discussions** • *Climate models and climate scenarios (i.e., different emissions scenarios)(Mike Alexander, NOAA OAR)* • *BREAK (11:00-11:15)* • *General climate responses along the east coast of North America (Mike Alexander and Charlie Stock, NOAA OAR)* • *Temperature – air and water (Jon Hare, NOAA NMFS)*
12:45	**Lunch (Costco, BBQ, $10 each)**
1:45-2:30 *2:30-3:15* *3:30-4:15*	**Understanding Climate Change (cont)** • *Ocean acidification (Beth Phelan, NOAA NMFS)* • *Sea level rise (Robert Beardsley, WHOI)* • *BREAK (3:15-3:30)* • *Primary and Secondary Production (Charlie Stock, NOAA OAR)*
4: 30	**Wrap-up and Next Steps (review and add deliverables)**
5:00	**Adjourn**

DAY 2

9:00	**Brief Review**
9:15-10:15	**Understanding Climate Change (continued from Day 1)** • *Stream Flow (Robert Lent, USGS)*
10:15-11:30	**Putting It All Together** **Objective**: Understanding of how these different ecosystem components interact with respect to climate change and the potential impacts to protected species. Characterize any additional data gaps (i.e., not already discussed or fully captured during Day 1) in the available science and needs from a protected species standpoint. **Format:** Group Discussion
11:30	**Lunch (order from Mike's and deliver)**
12:30 -4:30 *12:30-12:45* *12:45-1:15*	**Agency Case Studies and/or Climate-Related Policy Efforts** **Objective 1:** Provide a broad overview of projects conducted that have moved climate science into natural resource management decisions. **Objective 2**: Identify ways to effectively utilize the best available climate change data, including lessons learned from case studies, in protected species management decisions, including barriers that may hinder such an effort. **Format:** Presentations and group discussion **Deliverables:** Identified mechanisms or next steps to better consider climate change in protected species management. List of additional research needs. Established open lines of communication between managers and climate scientists. • NMFS' ESA and Climate Change initiative (NMFS F/PR and S&T- Roger Griffis) o Status o Lessons learned & policy outcomes • Case Studies o NOAA/EPA/UCONN (cusk) (Jon Hare)

 1:15-1:45 *1:45-2:15*	▪ Consideration of climate change in ESA status reviews & NMFS Fish Stock Vulnerability Assessment o USFWS (Region 5) (TBD) ▪ Consideration of climate change in refuge management, Landscape Conservation Cooperatives (LCCs), and under the ESA o EPA (Region 1) (Mel Cote) ▪ Consideration of climate change in coastal management through the Climate Ready Estuaries Program
2:15-2:30	**Break**
2:30-3:00 *3:00-4:00*	o NMFS Pacific Islands Regional Office (sea turtle) (Pat Opay) (CALL-IN) ▪ Consideration of climate change and climate forcing in ESA Section 7 consultation affects analysis • Group Discussion o Discuss & identify mechanisms or next steps to better consider climate change in protected species management (both within and outside of NMFS) o Identify gaps between science and its use in management, including research needs. o Identify barriers that may prevent managers from fully utilizing this in their assessments. o Identify ways to improve communication and translation of science into management.
4:00	• Wrap-up, Next Steps
4:30	• Adjourn

Appendix II – Workshop Participation

Facilitator

Ellen Mecray – NOAA/NESDIS/National Climatic Data Center

Participants

Northeastern Regional Association of Coastal and Ocean Observing Systems (NERACOOS)

Tom Shyka

Peter Moore

NOAA/NMFS/ Northeast Regional Office

Protected Resources Division

Diane Borggaard
Kimberly Damon-Randall
Amanda Johnson
Ellen Keane
John Kenney
Dan Kircheis
Lynn Lankshear
Patrick Lynch
Carrie Upite

Habitat Conservation Division

Matt Collins
Mike Johnson
Bill McDavitt

National Environmental Policy Act Division

Sarah Biegel

Sustainable Fisheries Division

Tobey Curtis

NOAA/NMFS/ Northeast Fisheries Science Center

Heather Haas
Jon Hare
Chris Orphanides
Beth Phelan

NOAA/NMFS/Office of Science and Technology

Roger Griffis

NOAA/NMFS/ Pacific Island Regional Office

Pat Opay

NOAA/NMFS/Northwest Fisheries Science Center

Michelle McClure

NOAA/OAR/Earth System Research Lab

Mike Alexander

NOAA/OAR/Geophysical Fluid Dynamics Lab

Charlie Stock

NOAA Office of General Counsel

Deirdre Casey

Julie Williams

Environmental Protection Agency, Region 1

Mel Coté
Janet Nye

United States Geological Survey

Bob Lent

University of Maine School of Marine Sciences

Andrew Pershing
Kathy Mills
Carrie Byron

Woods Hole Oceanographic Institution

Bob Beardsley

Appendix III – Relevant Websites

Website	Link
Environmental Protection Agency	http://www.epa.gov/
Climate Change	http://www.epa.gov/gateway/science/climatechange.html
Climate Ready Estuaries Program	http://water.epa.gov/type/oceb/cre/index.cfm
National Oceanic and Atmospheric Administration	http://ww.noaa.gov/
Earth System Research Laboratory (ESRL)	http://www.esrl.noaa.gov/
ESRL Products and Services (including climate products)	http://www.esrl.noaa.gov/research/products/
Geophysical Fluid Dynamic Lab	http://www.gfdl.noaa.gov/
National Climatic Data Center's Climate Monitoring	http://www.ncdc.noaa.gov/climate-monitoring/
National Marine Fisheries Service (NMFS)	http://www.nmfs.noaa.gov/
Northeast Regional Office Protected Resources Division	http://www.nero.noaa.gov/prot_res/
Northeast Fisheries Science Center – Protected Species Brach	http://www.nefsc.noaa.gov/psb/
Northeast Fisheries Science Center – Ecosystems Processes Division	http://www.nefsc.noaa.gov/epd/
Northeast Fisheries Science Center – Ecology of the Northeast U.S. Continental Shelf (includes climate)	http://www.nefsc.noaa.gov/ecosys/ecology/index.html
Northeast Fisheries Science Center – Oceanography Branch	http://na.nefsc.noaa.gov/ecosystem.html
Northeast Fisheries Science Center Publications	http://www.nefsc.noaa.gov/publications/
United States Geological Survey (USGS)	http://www.usgs.gov
Maine Water Science Center (includes link to publications)	http://me.water.usgs.gov/
Ocean Observing and Modeling	
Northeastern Regional Association of Coastal and Ocean Observing Systems	http://www.neracoos.org/
Sea-viewing Wide Field-of-view Sensor (SeaWiFS)	http://oceancolor.gsfc.nasa.gov/SeaWiFS/
Northeast Coastal Ocean Forecast System (NECOFS)	http://fvcom.smast.umassd.edu/research_projects/NECOFS/index.html
U.S. Integrated Ocean Observing System (IOOS)	http://www.ioos.gov/
Relevant Statutes	
Administrative Procedure Act	http://www.nmfs.noaa.gov/pr/pdfs/laws/apa.pdf
Endangered Species Act	http://www.nmfs.noaa.gov/pr/laws/esa/
Magnuson-Stevens Fishery Conservation and Management Act	http://www.nmfs.noaa.gov/sfa/magact/MSA_Amended_2007%20.pdf
Marine Mammal Protection Act	http://www.nmfs.noaa.gov/pr/laws/mmpa/
National Environmental Policy Act	http://www.nero.noaa.gov/nepa/

National Marine Sanctuaries Act	http://sanctuaries.noaa.gov/about/legislation/
Other	
Intergovernmental Panel on Climate Change	http://www.ipcc.ch/
Climate Central	http://www.climatecentral.org/
Ocean Motion	http://oceanmotion.org/html/introduction-general.htm

Appendix IV – Workshop Presentations

To request a copy of a presentation, please contact Ellen Keane at ellen.keane@noaa.gov or 978-282-8476.