A Climate of Change:
Climate Change and New England Fisheries
Observations, Impacts, and Adaptation Strategies

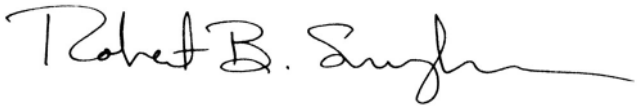
July 31 – August 1, 2013

The Portland Company Complex
58 Fore Street
Portland, Maine

An Island Institute Program

The Island Institute, a non-profit organization, was founded in 1983 with a goal of ensuring balanced use and a healthy future for the islands and waters of the Gulf of Maine. Our mission is to work to sustain Maine's island and remote coastal communities, and to exchange ideas and experiences to further the sustainability of communities here and elsewhere. Many islanders are also fishermen, relying heavily on shifting ocean resources for their livelihoods. Fishermen capture our imaginations because of their dangerous jobs and frontier image. They witness firsthand the changes in the ocean environment. They are storytellers, and they are increasingly willing to speak up about the changes they see on the ocean.

One goal of the Island Institute's Marine Programs is to help fisheries-dependent communities better understand the state of the science and the risks posed by climate change, and to amplify the voices of these stakeholders to help shape sustainable fisheries management. We recognize the critical importance of the fishermen's authentic experience in any discussion of climate change impacts and possible mitigations, and we strive to use the Island Institute's 30-year experience as a science translator, convener and networker to bring together the fishermen with the research scientists and policymakers who will shape our regional and national response to these critically challenging issues. Ultimately, understanding and figuring out the best ways to deal with the shifts facing their communities will help ensure that Maine's island and remote coastal communities endure well into the future.



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Workshop Executive Summary

New England working waterfront communities are at the forefront of experiencing climate change impacts on fisheries and the ocean. Fishermen, scientists and managers across New England are observing ocean conditions and marine life that differ from anything most individuals have previously seen. In some cases, these changes represent extreme and/or record-breaking conditions. The ocean is warmer and the behavior of fish and lobster is changing, most notably the timing of the lobster molt. New species are being caught in nets and traps, some traditional species are no longer present, and other species are showing up at different times.

The reliance on stocks that are at the southern end of their range, coupled with steep temperature gradients, means New England fishermen will continue to experience the impacts of ecosystem shifts as the climate changes. The Gulf of Maine is inherently a low diversity system. With biodiversity so important for economic diversity, the effects of mismanagement and climate change on our commercially important species are felt acutely in this region. Other regions are watching to see how New England's fishermen and fisheries management system adapts to what we all assume will be a less stable future.

In late July 2013, the Island Institute hosted a workshop with approximately 110 fishermen, scientists, managers, policy makers, non-governmental organizations, and others in Portland, Maine. The goal—to discuss the latest science of climate change and the ocean, as well as changes fishermen are seeing at sea. The workshop focused on improving our collective understanding of how climate change is impacting New England fisheries and fishermen. Topics discussed included how our current knowledge of climate change informs our approach to fisheries management, and how we may generate concrete and realistic steps to incorporate the effects of climate change.

Through presentations (many of which are available at www.islandinstitute.org/climateofchange) and small group discussions, workshop participants identified the following overarching theme:

Adapt the Fisheries Management Process

The combination of depleted fish stocks, degraded ocean habitat, and a changing climate presents a serious challenge to the New England region and will require a new approach to fisheries management. This includes understanding the effectiveness of existing management tools in addressing climate change and considering different strategies. We are forced to expect the unexpected, and thus, the current stock assessment approach needs to change in order to respond with more rapidity. It also needs to be built on a scientific framework that doesn't assume a stable ecosystem. There is an urgent need for "nimbleness" in management.

Numerous recommendations were provided to work towards this goal. The top three are as follows:

- **Develop Ecosystem-based Management Approaches**

  Fisheries managers and assessment scientists need to better understand and incorporate the complexity of the environmental interactions into decision-making. Immediate steps can be taken, such as developing indicators to monitor over time and use as triggers for management action. Addressing climate change is a compelling reason to continue to move toward ecosystem-based fisheries management, and significant progress can be made within the current statutory structure of the Magnuson-Stevens Act. The reauthorization of Magnuson-Stevens is an opportunity to clarify how the Councils incorporate ecosystem-based fisheries management within the context of the current single species management approach.

- **Develop Communication Tools**

  Climate changes cross both interstate and international fisheries management boundaries. Effective adaptation to climate changes in fisheries will require better integration of information among fisheries management bodies, including articulating goals and objectives for fisheries policy. Also, enhanced communication between oceanographers, climate scientists, fisheries scientists, and fishermen is necessary. Fishermen have an opportunity to raise greater awareness about climate change and communicate the impacts of these changes on fisheries to the broader public. There should be better outreach and education to the public by a variety of voices.

- **Examine Methods to Access the Resource**

  Fish and fishermen are moving faster than science and management. Fisheries businesses have to adapt in real time to shifts in fish behavior. Fishermen need flexibility in the permitting process to be responsive to these changes, yet we must ensure overall ecosystem health. Reporting, monitoring, and using caution with harvest levels as fisheries emerge in new areas will be critical.

About the Workshop

Background

Across New England, fishermen and scientists are observing notable shifts in the ecosystem and dramatic changes in the number of fish in the water. Years of harvesting pressure, paired with the effects of warming waters and an ever-changing ocean ecosystem, have led to the crisis we currently face in the groundfish fishery and the unprecedented conditions we are seeing in other fisheries. Scientists, managers, and fishermen have all begun to discuss how we can and should be planning for the inevitable, but unpredictable, climate impacts on the marine ecosystem.

Some interested parties are suggesting major changes to the current fishery management system; others are concerned but uncertain about the best ways to adapt. The Massachusetts Marine Fisheries Institute and the American Institute of Fishery Research Biologists have both held symposia to address environmental changes and fisheries. At the Managing Our Nation's Fisheries Conference in Washington, DC (April 2013), several broad recommendations were suggested to integrate climate change into fisheries management.

In order to expand the dialogue among scientists, fishermen, managers and non-governmental organizations, the Island Institute (Rockland, Maine) hosted a workshop on climate change and fisheries in New England. The Climate of Change workshop was held in Portland, Maine over two days: July 31 and August 1, 2013. Participants came from within and outside the region to share information and discuss observations, impacts and adaption strategies. Please see the Appendices (available for download at www.islandinstitute.org/climateofchange) for the agenda, notes from speaker presentations and panelists' discussions, and a list of participants.

Objectives

- **Improve our collective understanding of how climate change is impacting New England fisheries and fishermen;**
- **Discuss how our understanding of climate change informs how we think about managing our fisheries; and**
- **Generate concrete and realistic steps to incorporate climate change into fisheries management.**

Format

The Climate of Change workshop was designed to be participatory in nature, with active involvement from all the attendees. Panelists gave brief presentations, which were followed by smaller, facilitated discussions at each table. Laura Taylor Singer was the lead facilitator for the two day event. Day 1 of the workshop focused on the state of the science and fishermen's observations from an ecosystem perspective, crossing management boundaries. On Day 2, speakers, panelists, and the audience discussed how existing management strategies could be adapted, and what new and proposed strategies may be effective in the face of climate change. Throughout the workshop, three key overarching questions were considered:

1. **What are the key issues or observations (i.e., what do we know)?**
2. **What other information or key science needs to be addressed?**
3. **What are the potential implications for fishermen and fisheries management?**

Recommendations from the Workshop

Workshop participants were asked to brainstorm a series of science priorities, management priorities, and next steps for consideration. Although these ideas were not prioritized and consensus was not sought, the list presented below represents the collective thinking from the rich mix of scientists, fishermen, managers and non-governmental organizations.

Adapt the Fisheries Management Process

- Understand effectiveness of existing management tools in addressing climate change and consider a different suite of tools that allow us to monitor for surprises.
- Define explicit goals of each [management] measure implemented and, where possible, measure the effectiveness of meeting those goals/objectives. It is important to consider how climate change may affect/interact with the stated goals.
- Evaluate management strategies before implementation (similar to what is done currently in Alaska); consider a Management Strategy Evaluation approach.
- Take a precautionary approach by identifying steps we can take now without needing to directly link cause to effect.
- Discuss uncertainty and risk more explicitly when setting catch limits and using other management tools.
- Consider using indicators to manage fish stocks in addition to setting catch levels.
- Identify indicators at the species level to serve as context when making decisions. (This may be an ideal way to start a cross-jurisdictional effort.)
- Prioritize and fund actions/goals of agencies.
- Prioritize protection of species with high commercial value.
- Increase the speed with which management is responsive and adaptive to science.
- Consider the barriers to adaptation for fishermen and reduce these barriers without getting in the way of sustainable fisheries management.

Develop Ecosystem-based Management Approaches

- Incorporate ecosystem-based management into national ocean policy and coastal zone management.
- Address different goals between different management bodies for effective implementation of ecosystem-based management.
- Clarify how to execute ecosystem-based management under the Magnuson-Stevens Act.
- Broaden the focus of management beyond catch level to include looking at age structure, minimizing bycatch, protecting habitat, etc.
- Manage fisheries based on multiple different species.
- Account for trophic relationships and species interactions in the management process.
- Incorporate primary productivity into management considerations.
- Explore smaller scale management.

Consider Fisheries Habitat

- Explore how physical and chemical factors change the definitions of fish habitat for adults and other life stages.
- Gain a greater understanding of species habitat, particularly for shifting species.
- Investigate the impact of climate change on historical groundfish spawning areas.

Evaluate Data Collection Methods and Monitoring Frequency and Diversity

- Improve data infrastructure to be more efficient and effective.
- Increase the frequency and diversity of data used to make predictions by utilizing existing data, as well as data from fishing vessels and/or other new sources.
- Modify trawl survey protocols to sample more species.
- Fund more instrumentation for monitoring (e.g., NERACOOS).

- Increase the spatial and temporal scale of sampling practices.
- Involve fishermen through collaborative research and by using photographs of what they are seeing. Patterns may indicate shifts in the location of species; however, the traditional management system and data collection methodology isn't sensitive to these changes. Giving different weight to historic data may provide us with a more accurate understanding of how species are moving and where they are most likely to be found.
- Investigate temperature gradient off the coast [of Maine].
- Investigate where marine mammals are going and how they are following forage fish or other food sources.

Refine Stock Assessments

- Improve the current stock assessment approach to more appropriately match species distribution in space and time.
- Reconcile doing more stock assessments with doing better stock assessments.
- Improve estimates of natural mortality—incorporate links to species interactions, trophic interactions, predator-prey interactions, and abiotic factors.
- Identify which life history traits make species resilient or susceptible to climate change by following a single cohort through multiple life stages.
- Develop methods for teasing apart impacts of climate change versus impacts from fishing on species distribution and abundance.
- Explore aspects of climate change on species of concern.

Enhance Predictive Tools and Models

- Use multivariate models for predictions about species susceptibility to climate change and specific events, with an emphasis on valuable or key species of concern.
- Align the scale of the science to the scale of the ecosystem.
- Conduct research on how predator-prey relationships will change in response to climate change.
- Determine methods to distinguish when changes are due to climate signals versus natural variability.
- Monitor for ocean acidification effects and determine which biological processes can be linked quantitatively to temperature or other climate change-related factors, and then begin to predict the effects.
- Investigate how and when ocean acidification impacts calcification in order to better predict the effects on commercially important species such as lobsters and oyster.

Develop Communication Tools

- Improve communication on climate change and ocean acidification—use different voices; crisis is an opportunity.
- Work beyond and between jurisdictional boundaries, management organizations [states, ASMFC, Councils], and scientific disciplines to discuss these issues jointly.

Examine Methods to Access the Resource

- Explore options to equitably allocate access to fisheries that are changing and/or moving.
  - ~ Set aside a certain portion of the TAC for fishermen in regions where the species seem to be migrating or as a conservation approach.
  - ~ Consider changing permit splitting regulations. (Currently, a permit must be bought or sold in its entirety, rather than allowing the sale of allocation of individual species within a permit.)
  - ~ Address entry issues at the federal level.
- Provide flexibility for fishermen to target new species in their area while ensuring overall ecosystem health.
- Take a precautionary approach when starting to fish on stocks that are new to a particular area. There is value in carefully reporting and monitoring overall harvest levels.

Group Discussion Summaries

After each panel, workshop participants participated in a series of facilitated table discussions that focused primarily on the key questions of the workshop:

1. **What are the key issues or observations (i.e., what do we know)?**
2. **What other information or key science needs to be addressed?**
3. **What are the potential implications for fishermen and fisheries management?**

"I've been struck by the extent to which climate change is becoming a crucible for ecosystem-based fisheries management."

~ John Henderschedt, Fisheries Leadership and Sustainability Forum

General Issues and Observations

- Climate impacts and the pace of climate changes are becoming much more apparent; this in turn compounds the impacts fishing has on fish stocks.
- The rate of change is faster than we thought and there is an increased urgency to act.
- Climate change is now showing up on the radar as a major issue in other parts of the country, which may provide opportunities for jointly focused action.
- There is a low level of biodiversity in the Gulf of Maine, which emphasizes the importance of 'getting things right.'
- Climate change is very different from the basic assumption that underlies fisheries management, which assumes a stasis in the environmental conditions.
- Management requirements are mismatched with what science can provide. Science cannot support what management is asking it to do.
- A lot of what we do in an attempt to prepare for climate change is to look at long-term trends. However, extreme events can be as important as or even more disruptive than small-scale changes.
- There is a need to figure out how to make models more localized.
- We don't have a regulatory process that is flexible enough to amend in a responsive time frame.
- Species that are fished shift more rapidly than unfished species.
- NOAA has to respond immediately to legal mandates and sometimes doesn't listen to the Council.
- Maine has a dangerous economic situation, depending upon what happens with the lobster population—fishing communities could disappear. If that happens, they may not return, even if the fish population experiences a resurgence.
- We need to learn how to build the bridge between the climate models and what is happening now on the water (i.e., we need to be able to see these events in real time, as they occur).
- Use our knowledge of the science when possible. What we are currently facing is a management crisis, and the challenge is to incorporate science to improve management measures and ultimately, long-term outcomes.
- If we reduce other stressors, organisms can better adapt to climate change and ocean acidification.
- Ocean acidification is daunting; we need more research to better understand what the impacts might be on fisheries.

Scientific Themes

Monitoring Data and Surveys:
Many noted that there is a need to have long-term monitoring data, but that this should be balanced with real-time information to develop the capacity for rapid response and flexibility. The Northeast Regional Association of Coastal and Ocean Observing Systems (NERACOOS) is working toward learning more about the management process in order to develop a rapid response and review of data and customize data analysis for managers. Dynamic maps that continually update what species are new in an area would be useful. Improvements to software infrastructure to put biological data on public websites should be considered. Data collection and monitoring should engage on-the-water resource users and facilitate communication to ensure management can respond quickly.

In order to better assess the impact of climate change on fisheries, there is new information to be gathered, but also a need for better coordination and synthesis of current data. Information on topics such as temperature at depth and climate change implications for lower trophic levels should be improved. All the factors that influence recruitment and survivability of the animals—such as coastal pollution and loss of estuarine habitat—need to be better understood and considered. Existing datasets (e.g., inshore and offshore trawl surveys) should be examined to see how they can be integrated and used in new ways. Some participants remarked that the new NOAA survey vessel is larger than the previous vessel and therefore cannot monitor shallower inshore waters. It was also noted that there should be increased funding and a greater federal investment in environmental monitoring.

Several participants advocated for information at a finer scale to feed into the larger system. The fine-scale stock structure is more nuanced than current sampling can address. Year-to-year changes may require enhancement in data collection. Higher resolution information in both space and time is needed to determine species' diversity and numbers, based on location and time of year. For example, fine-scale detail is needed to assess the lobster populations within Maine's lobster zones.

The stratified random sample of the trawl survey is based on the concept of a contained system. Do we need to re-evaluate, and provide complementary surveys to target specific fisheries? Do we need to rethink our surveys? Do we need biomass surveys that cover species in their current geographic range, rather than the entire area (e.g., squid and herring acoustic survey)?

"The Gulf of Maine is at the doorstep of one of the largest temperature gradients on the planet. Lobsters are experiencing two sides of the climate story—in southern New England they are declining, and in northern New England the populations are expanding."

~ Dr. Rick Wahle, University of Maine

Collaborative Research:
Several breakout groups highlighted the value of continuing and expanding work with the fishing industry and use of fishing vessels as platforms of opportunity. For example, this could allow for more observations of temperature, nutrients and pH. Fishermen's knowledge can be very spatially constrained, but also of very high value. There were questions raised about how best to integrate fishermen's observations into the science/management process.

One program highlighted was the use of electronic monitoring systems which use video cameras to film the conveyors on fishing vessels and identify and measure catch. The Northeast Fisheries Science Center has been conducting a pilot electronic vessel monitoring program. In British Columbia, video monitoring has been used effectively to replace on-board observers.

Enhanced collection of social science data and greater collaboration among scientific disciplines was also raised. There is a need to connect scientific uncertainty with social sciences and management into the future. More data collection on how fishermen adapt to changes was also mentioned.

Ocean Acidification:
The presentation on ocean acidification left participants with several questions and concerns. The Gulf of Maine is uniquely susceptible to ocean acidification because of its cold water and abundance of freshwater input from rivers. In addition to oysters, other shellfish, lobsters, and finfish fisheries may also be affected by ocean acidification. Investigations of the impacts of ocean acidification should also look

at other species that do not have shells. The groups stressed the need for additional funding to improve the affordability of technology, increased monitoring, and laboratories suitable for measuring impacts of multiples stressors on species. There was limited discussion among the participants about management changes to adapt to ocean acidification. It was recognized that there is very little conversation about ocean acidification happening at the Council level. One surprising realization was that while it was not clear how to directly manage for ocean acidification beyond the reduction of global CO_2 emissions and monitoring, it was noted that if other ecosystem stressors are reduced, organisms may have a better chance of adapting to changing water chemistry. An ecosystem-based approach to management will help improve ecosystem function at all trophic levels, thereby reducing other stressors on the ecosystem. This, in combination with reduced emissions and nutrient runoff, can help us mitigate the impacts of ocean acidification.

Stock Assessments and Models:
All the groups discussed potential changes to the current fisheries stock assessments, including both the information and the process used. More flexibility is needed to incorporate temperature and other factors into stock assessments. Suggestions were made to gain higher resolution of life history processes to learn the biology of species in an area. How are environmental stressors such as warmer temperatures and acidification affecting fish reproduction, growth, and survival? There are challenges in estimating natural mortality and how it changes over time that need to be resolved. If you assume fixed values for emigration and natural mortality, then fishing mortality (F) is the only factor that can be changed. Understanding these exchanges between stocks and getting a better handle on natural mortality has very important management implications.

There is also a need to perform assessments without catch history. Assessments should be completed on an annual basis, and other decentralized assessments should be considered. We need integrated information at multiple scales of the ecosystem. Spatially and temporally, we need to bring science more in tune with the ecosystem. For example, there are differences in oceanography and population structure between eastern Maine and western Maine that need to be recognized. However, the need for science and data can't drive us to a point where we cannot make decisions or ask for a level of precision that the science can't accommodate. Scientists are just beginning to learn how to adjust stock assessments based on climate changes. It was recognized that there is a long history of stock assessment science and changes may be difficult to implement.

Several new methods have been developed to separate the impacts of fishing pressure from the impacts of climate changes. These should be incorporated into stock assessments.

Questions were raised about detecting shifts in species ranges. Are the species moving as a whole, or will the species expand their range and grow? How do you separate expanding populations with shifting range? Are they establishing a population and breeding in a new area? What information

do we really need to better inform stock assessments that more effectively capture the total biogeographic range covered by the fishery as stocks move north?

Participants suggested increased predictive-based modeling to distinguish between pulses and trends in the system and to outline likely scenarios for the region from an oceanographic perspective. How stable is the change? Are we still changing or are we at a new steady state? When fishermen see a species change, how do we tell whether the changes are due to long-term trends or year-to-year changes that are likely to revert? Participants want to be able to be more predictive about how climate trends will affect catch. There were also advocates for making climate models more refined and conducted at a finer spatial scale. Climate models and predictions are very broad and do not output specific fish species' movement.

Predator/Prey Interactions:
There were several conversations about new trophic interactions that may result from changes in ocean temperatures and changes to species abundance. More science research is needed on how southern species will interact with present species as they move into the Gulf of Maine. Others noted that more information is needed on the key forage stocks—including those that don't have direct fisheries (e.g., sand lance). Research should focus on new trophic interactions and their durability versus vulnerability.

The impacts of changes in physical oceanography should also be considered, especially as it may be affecting zooplankton dynamics. How are seasonal cycles and distribution of energy rich plankton going to be affected by climate shifts and circulation? Recommendations were made to look specifically at how temperature-driven species such as zooplankton have changed in relation to historical temperature changes. Have those changes impacted cod recruitment? If so, the relationships could be used to project future cod recruitment based on temperature changes. Additionally, there is a need to better understand the distribution of other prey like herring and krill through acoustical methods, and to better understand what factors influence the predator/prey relationships and how those may change with changes in climate.

The green crab invasion in Maine was one example of climate change affecting predator/prey relationships in a way that allows them to fully exploit their new niche. Green crabs are decimating the commercially important soft shell clam populations in Maine. Participants suggested finding markets for green crabs such as for compost, fertilizer, or feed in aquaculture. Others suggested use of green crabs for lobster bait or to replace horseshoe crabs as whelk bait. Yet, it was noted that green crabs have been around for 150 years and no one has found a use for them yet!

Habitat:
What is the relationship between habitat and fishery productivity? In order to consider how fisheries may be affected by climate change, we need to understand 1) the inter-relationship between where species might be moving; and 2) which benthic habitat will be available for specific fish species in regions that will have appropriate temperatures in the future. There is a need for better data on preferred habitat, temperature thresholds and other factors to understand where species will go. Additional factors that need to be explored include appropriate gravel size for cod, size of zooplankton, and sufficient abundance of invertebrates for larval fish to eat, salinity, and biophysical interactions. Nursery habitats must also be understood more fully, as this is the key for southern species to gain a foothold.

Fisheries Management Themes

Flexible/Adaptive Management:
A key theme echoed among the groups was the need for management to be more flexible and adaptable. The impending changes as a result of climate change could lead to regulatory conflict and there is a need for more adaptive management entities. Managers will need to be able to act in real time, and to do this, will require real-time data. Examples include management triggers based on catch per unit effort (CPUE). The fishing year begins with a target for catch levels, but if CPUE is too low, in-season adjustments can be made to adjust catch levels to the targets. However, there was concern that a CPUE-based trigger doesn't work when the stock area is too big relative to the scale of a small fish population level.

Climate change is not a crutch or an excuse. We will need to reevaluate what is possible. We can not back off from our commitment to rebuild. We can't throw in the towel before we throw a decent punch."

~ Tom Dempsey, Cape Cod Commercial Fishermen's Alliance

Although flexibility in the management process is a significant need, there are barriers to obtaining it. Some changes that could be considered are management personnel changes, regulatory changes, and improved communications. The litigious nature of fisheries decisions was also discussed. Perhaps making it more difficult to go to court would improve the ability of the agency to be flexible. However, some questioned whether additional flexibility would jeopardize the long-term health of the fishery.

Fisheries groups and fishermen need a mechanism to raise flags to ensure that management can respond better to what fishermen are seeing on the water. The management system also needs to consider economic and social implications of fish as protein for the country.

Coordination and Scale of Management:
Adapting to climate change will require more interaction and coordination among management bodies such as the ASMFC, the councils, and Canadian management bodies. A disconnect currently exists between state and federal management. The ASMFC has more flexibility than the fisheries management councils because they are not subject to the Magnuson-Stevens Act. The councils need a formal process to transfer knowledge to each other. Some suggested a structure analogous to ASFMC. Some states have already learned how to trade fisheries quota. For example, dogfish quota is regularly traded between Delaware and Maryland. However, with black sea bass, northern states are catching more while they are reducing quota in southern states. Management has to change so there is sufficient interaction between the councils. Interstate and international negotiations will also be needed to ensure species aren't overfished on their way north, which would in turn preclude a productive fishery on that species in an area farther north.

In order to adapt to climate changes in fisheries, many participants suggested that modifications will need to be made to the spatial scale of management and the ability to respond rapidly to changes. When management is at a large scale, it is hard to determine if discrete populations are overfished and to understand how those populations reestablish themselves in a new management regime. Multiple scales of management are necessary to match data to the scale needed for each species. A rapid exchange of information among scientists, managers and fishermen is needed in order to be dynamic. Information needs to be evaluated on both the short term and long term perspective. How do we align changes that we see on a yearly basis to management timeframes?

Decentralization of fisheries management and adoption of more co-management approaches was suggested as a promising approach. The capacity to see these changes in real time among fishermen is much better than the ability for the current fisheries science and fisheries management system to react. Local scale, self-enforced management appears to work well along the coast of Maine for the lobster fishery and it should be considered to determine if it could

work on a smaller scale for protecting spawning aggregations with triggered closures throughout the region.

Emerging Fisheries and Access:
As climate changes take place in the Gulf of Maine, species will shift and fisheries will emerge in new areas. We should be investigating emerging fisheries and stock rebuilding. What environmental conditions/habitat are we going to have in the Gulf of Maine, and which species could possibly live here? How can we get that story together and translated so that industry knows which sets of species they should be focused on keeping in the region.

Knowing how to take advantage of these new fishing opportunities in a way that comes from a good understanding of the stocks is going to be a challenge. A fish population that is being established in a new region is more vulnerable to fishing than one that has been in stasis. There is a need to get science and management ahead of exploitation and avoid managing emerging fisheries retrospectively after problems arise. As the exploitation of new species occurs, data collection from unexploited species is crucial in order to establish baselines before harvest occurs on a large scale.

Access to fisheries as they shift is a significant challenge that needs to be addressed. How will new entrants be able to pursue new species that have not heretofore been regulated under the management regime? Can fisheries management adjust to allow new fisheries as the species show up in an area? Who will be allowed into those fisheries? For example, most permits for longfin squid are based in the Mid-Atlantic because that's where species distribution has been centralized. However, fishermen see changes to that distribution. How do we allocate or reallocate shifting species' annual catch limits or quota?

Almost all fisheries in New England are limited access fisheries. In order to access a new species, fishermen may need to buy the permits. However, there are regulatory hurdles to transferring permits. There may be a need to decouple or split permits, and to consider packaging permits in different ways. It may be necessary to revisit the historical landings requirements for species if they have shifted into a new area. Issues of latent effort within the fisheries and the speed with which the states and federal government permit were also raised. Permit banks for species that are shifting should be investigated as well.

Dogfish were raised as a specific example of an emerging fishery that was not managed proactively. Dogfish are extremely prevalent now and there is a need for a domestic market for dogfish. Would a commodity program for dogfish run by the government help in the same way that the canned salmon commodity program worked?

Closed Areas:
Closed areas have been used as a management tool in the Gulf of Maine for decades. There are both year-round closures and rolling closures, in which an area may be closed only to certain gear rather than closed to all fishing pressure. In the Gulf of Maine there are only two types of protected areas where dynamic in-season closures triggered by the animals showing up are seen, or by the animals showing up and displaying spawning activity. These are the herring spawning protection and large whale protection areas. All other closures occur at set times and/or in set locations that aren't changed based on real time, or even recent data on where/when the animals are there.

Setting aside some closed areas to harbor long-lived individuals may be increasingly important to allow species to recover after significant climate events. It becomes more imperative to have successful recruitment in the face of climate change. Recent work by Graham Sherwood shows there is an effect on age and population structure that should be considered when evaluating closed areas. How do we evaluate whether closed areas

are effective as fish move? Creating standards for re-evaluation every other year, rather than every five or ten or fifteen years, should be considered to adapt to climate changes, especially to better match how spawning aggregations may be changing and to establish trigger mechanisms to close or open areas. Recreational fishing impacts on rolling closures also need to be considered.

The closed areas in the Gulf of Maine tend to be more shallow, bank areas that will warm up quicker. We haven't looked at cold, deeper water for migration corridors, such as extending the Cashes Ledge closure to the south. Perhaps this should also be considered.

Risk Management:
Fisheries management will need to manage for uncertainty due to the impact of climate changes and accept and acknowledge the lack of predictability. Planning for multiple scenarios based on different climatic regimes may assist with risk management strategies. Management strategies typically require inaction until certainty, and that is almost always too late. Should management act sooner based on less certain science?

One suggestion was to develop a set of indicator species, along with stock assessments, that can be used to evaluate the health of the fishery and ecosystem. If the timing or abundance of a specific forage fish, or temperature, or plankton element is significantly outside its normal range, this information could be used to trigger a closure, adjust the quota, or make some other real-time management adjustment. Managers could slowly start using indicators as an additional tool. However, work will need to be done to determine the appropriate indicators and the scale of each indicator.

Another method to consider is the management strategy evaluation approach, which has been used overseas in places such as New Zealand. This approach uses a management procedure that is adaptive and allows for considering a variety of management scenarios and options.

Ecosystem-based Fisheries Management:
Mike Fogarty's presentation raised several issues regarding the value of ecosystem-based fisheries management in adapting to climate change. One person remarked that it is difficult to separate the discussions around ecosystem-based fisheries management and climate-driven approaches to management.

It is important to look at both top down and bottom up forcing within the ecosystem. Top down forcing is through perturbation through the system. Harvesting on one part of the system causes cascading effects. How open or closed a system is matters. The more closed the system, the more strongly the effects disrupt it. While ecosystem models seem daunting, they may be able to reduce the burden. A properly-executed ecosystem approach should actually reduce the overall economic investment in monitoring and science.

> *"If no one had thought about the need for EBFM before, we would be inventing it now in order to deal with climate change."*
>
> ~ Roger Griffis, NOAA

Ecosystem-based fisheries management requires taking a broader look beyond catch levels to include factors such as age structure, minimizing bycatch, protecting habitat, etc., and may be more appropriate for adaptation to climate change. However, this approach is always set aside by fisheries managers to address something they consider to be more urgent. The Council needs to implement deliberate planning and follow through on ecosystem-based fisheries management. Fishermen and their knowledge are an important part of that conversation. It was recognized that addressing different goals between different management bodies is a huge challenge to effective implementation of ecosystem-based fisheries management.

With regard to the lobster fishery, an ecosystem-based fisheries management approach would include evaluating the impact of the seal population on the fishery. Seals are a major predator on the lobster population, but are not considered in the management of the fishery.

Changes to Magnuson-Stevens Act:
The federal Magnuson-Stevens Act (MSA) is undergoing reauthorization. Participants made some suggestions for changes to MSA in order to allow fisheries to better adapt to climate changes. Conversations centered specifically on improvements to rebuilding plans and reference points. Changing reference points should be explicitly addressed in reauthorization of MSA so that it is more a fundamental part of stock assessments. It is important to incorporate ecological value/ecosystem services into management, not just fishing mortality (F).

In reference to Atlantic cod, with a shift in species composition in the Gulf of Maine, what does cod recovery look like and what level is possible under the current or future environmental conditions? Several people noted that managing each species to its maximum sustainable yield (MSY) was not feasible or practicable.

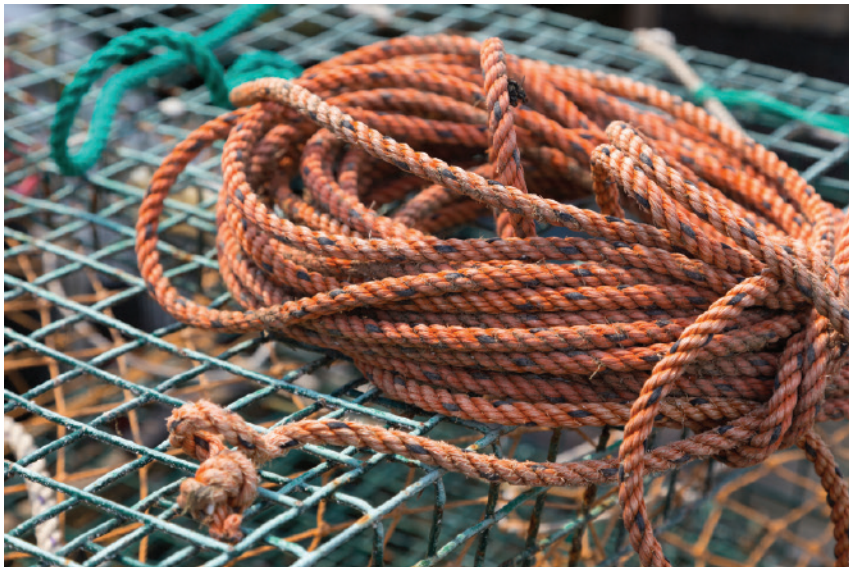
There was some discussion on whether ecosystem-based fisheries management required changes to the MSA framework versus how MSA is implemented and interpreted. It is important to differentiate between what MSA says and how the National Marine Fisheries Service (NMFS) interprets it through the National Standards. Some believe that NMFS can go a long way toward accomplishing ecosystem-based fisheries management without revising MSA. The guidelines refer to buffers and acknowledge that not all stocks can be at MSY all the time. However, language in Amendment 16 requiring rebuilding of every stock and aggressive timelines was recently upheld. MSA recommends an ecosystem approach but also requires fisheries to be managed on an individual stock basis. It was recommended that MSA explicitly prioritize ecosystem-based fisheries management over single-species management.

Markets and Communication Themes

Finally, the themes of markets and communication were raised throughout workshop discussions. Markets are more fickle than the fish or fisheries. There are issues with distribution, processing, and the desire for a consistent steady product. With record landings, the lobster industry has suffered with low lobster prices but has been unable to organize collectively without legal implications for price collusion.

Fisheries entering or leaving a fishing community cause adjustments to be made in business strategies. Tools to assist fishermen become better businesspeople and help them diversify their businesses will be necessary. There is deep concern about how fishing communities will be affected by changes to fish populations. Those that fish migratory species might need to consider redefining the scope of their community. Communities could embrace the need for flexibility and may need to diversify how a community creates its own sociocultural identity.

The story of how climate change impacts fisheries is compelling. This information should be used to make it part of the public discussion about carbon policy. Environmental and fisheries groups could come together on climate change and carbon policy to create a public outreach and education campaign. This could focus on responsible fisheries management and climate policy at the same time, and should include the recreational fishery as well.



Suggested Next Steps:

Participants in the workshops identified a number of potential actions that could be undertaken at the regional and national level, including:

- Establish a mechanism for various agencies to articulate different short-term and long-term goals (including steps that are attainable now), generally and with specific regard to addressing climate change.
- Include climate change considerations in Fisheries Management Plans.
- Create a dialogue with scientists about how to transition to ecosystem-based fisheries management (EBFM).
- Re-establish the EBFM planning development team (PDT) within the New England Fisheries Management Council.
- Downscale global climate models to specific regions to allow for projections of what species will be available in certain areas and design management appropriately.
- Create a cross-jurisdictional advisory body that bridges the gap between state and federally managed fisheries.
- Continue to build partnerships between scientists and industry as well as between different disciplines of fishermen and scientists.
- Empower industry to become advocates for climate change and ocean acidification research, as well as the incorporation of research findings into management.
- Increase science translation about climate change and ocean acidification and convey to the public.
- Keep conversation about climate change and fisheries current and incorporate new information as needed.
- Seek funding to maintain and improve monitoring of environmental parameters such as ocean acidification.
- Move beyond single species management at the state level [Maine] with the opportunity to develop fisheries management plans.
- Establish a Blue Ribbon Panel for ecosystem-based management at the state level [Maine].
- Be prepared to accept tough decisions (i.e., may be hardships for fishermen, seals, etc.).

Conclusion

Climate change and the potential impacts of shifts in the marine ecosystem could be devastating to the island and coastal communities of Maine. Understanding what is already occurring and the impacts of potential future shifts allows the region to start preparing for a sustainable future now.

We feel that the Climate of Change workshop moved the conversation in the region forward in a productive way. We hope this summary will do the same. The Island Institute would like to thank all of our partners who participated in the event and shared their knowledge and experience. In particular, we would like to thank the fishermen who took time off the water to attend and contribute to the workshop.

Understanding how climate change is going to impact fisheries in New England is a huge undertaking. We look forward to working with others in the region to better understand the ongoing scientific developments, what fishermen are seeing in the ecosystem, and how management can be improved to better incorporate this understanding.

See the Appendices to this report at islandinstitute.org/climateofchange.

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