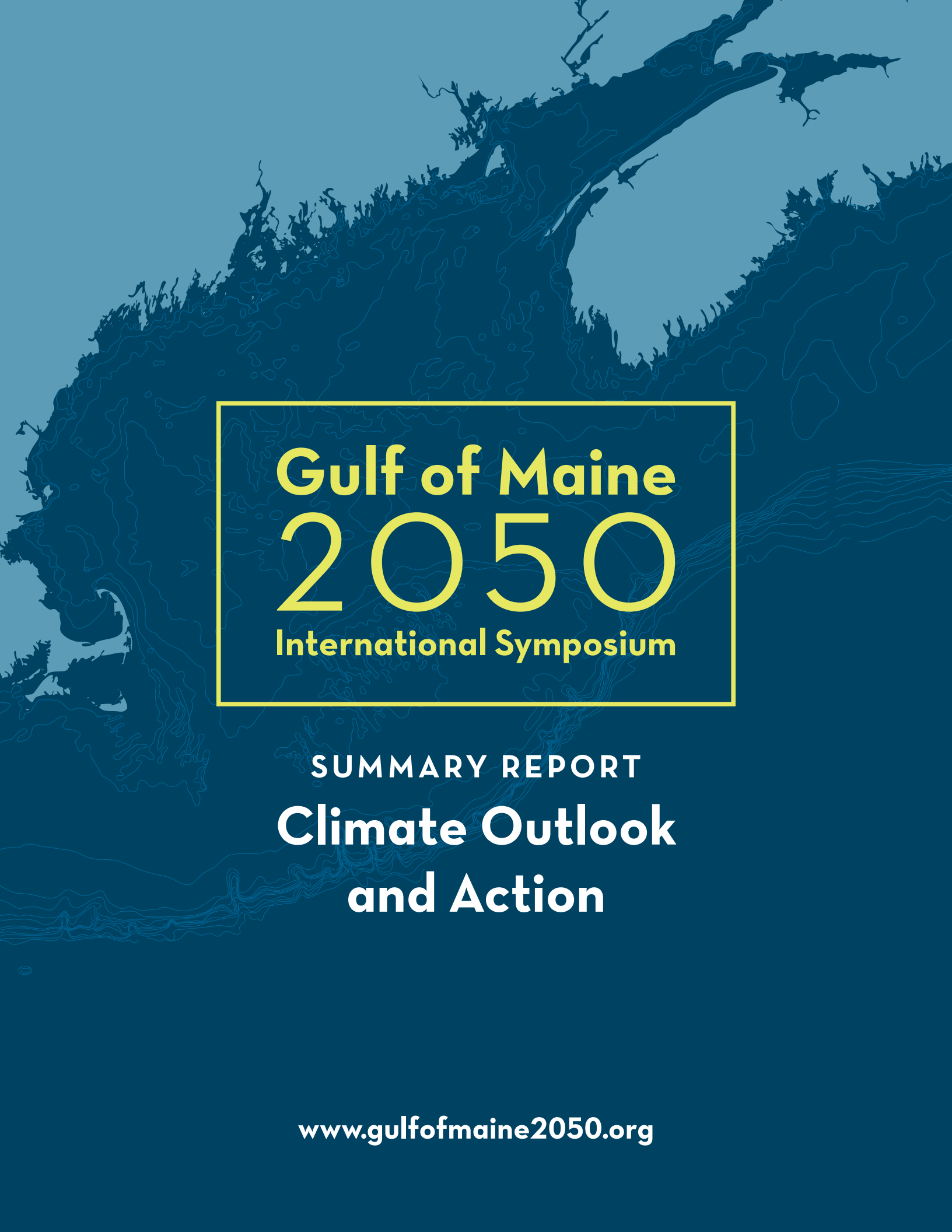

Gulf of Maine 2050 International Symposium

SUMMARY REPORT

Climate Outlook and Action

www.gulfofmaine2050.org

About This Report

The Gulf of Maine 2050 International Symposium in November 2019 was a wonderful example of region-wide climate collaboration. Thank you to the dedicated steering committee and generous sponsors who made this event possible. We are equally grateful to the speakers and participants who came to learn and share insights on challenges and opportunities that lie ahead and examples of innovative solutions already underway. We hope this report inspires you to take action to improve the climate resilience of our ecosystem and coastal communities.

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Gulf of Maine 2050 was hosted by:

Gulf of Maine Research Institute
Science. Education. Community.

Gulf of Maine Council on the Marine Environment
Canada and the United States working together for a healthy environment

HUNTSMAN Marine Science Centre

This report was produced by the Gulf of Maine Research Institute.

Introduction

In November 2019, several hundred community, governmental, and business leaders from across New England and the Canadian Maritime Provinces joined together with leading scientists to discuss the environmental and societal changes anticipated for the Gulf of Maine as we approach 2050. The Gulf of Maine 2050 International Symposium's focus on the year 2050 was not selected at random — it is around this time that the Intergovernmental Panel on Climate Change's (IPCC) carbon emission scenarios begin to diverge from the most severe climate impacts to lesser, more manageable ones. This means that the choices we make today and over the next several decades have real power in shaping the state of the world we inhabit 30 years from now and beyond. "The decisions that we make between now and 2050 really determine the trajectory that we are on with regard to limiting global warming," says Ko Barrett, Vice Chair of the IPCC.

But global scientific reports alone can't inform those decisions on the local level, Barrett notes. That's why work in the Gulf of Maine is so important to identifying the actions needed in this place at this time to move toward a healthier future.

Taking effective action will also require coordinated and efficient collaboration between groups that may not have typically worked together in the past, says Robert Stephenson, an ecologist with Fisheries and Oceans Canada. "We need to collaborate, we can't do this in our usual way of doing business," he says. "We need to work across silos."

Throughout the Gulf of Maine, groups have already begun to work together to innovate adaptation strategies on the local and regional level. We've highlighted some of their stories here, along with insights and information we think will help move the Gulf of Maine toward a brighter and more manageable 2050.

Section 1: Sea Level Rise & Precipitation

What to Expect

How sea level rise and changes in precipitation will challenge coastal communities

- Floods that cause minor impacts, or "nuisance floods", will increase in depth and frequency, shifting from rare to recurrent and disruptive.
- Rain will become dominant winter precipitation, leading to more extensive road washouts.
- Coastal communities will become isolated when highways flood.
- Ports, piers, fish plants, and other fisheries infrastructure will become more vulnerable to flooding and erosion.

As water warms, it expands. As ice warms, it melts. These are the factors that drive global sea level rise, which could increase by an average of between 6 to 15 inches by 2050. The extent of change globally will depend largely on the fate of the West Antarctic Ice Sheet, a portion of the Antarctic Ice Sheet that measures about twice the size of the state of Maine and could contribute an additional 3.5 feet of sea level rise by the end of this century, depending on how quickly and how much of it collapses and melts into the ocean.

A warmer ocean also contains more energy that feeds severe storms, like hurricanes. An increase in the number and severity of these storms — and the associated precipitation and flooding — will compound the coastal inundation and erosion expected with sea level rise.

Gulf of Maine communities have already begun to experience the challenges associated with rising seas. Cameron Wake, a climate scientist at the University of New Hampshire, recalls 50 eventsin the summer of 2019 when high tide crept so far on shore that coastal residents of Hampton, New Hampshire had to move their cars inland to town-designated parking spots because their driveways had flooded. "We don't even need coastal storms anymore to drive flooding, it's happening during astronomical high tides," Wake says. At first, this "clear-sky flooding" had many community members baffled as to why they were facing floodwaters on such calm, storm-free days. It hadn't occurred to them that they were already facing the impacts of rising sea levels. "It's new," Wake says. "It didn't used to happen."

Efforts to Prepare and Adapt

Groups at the local, state, federal, and international level have begun to collaborate to prepare for rising sea levels and to help make the threats of increased flooding tangible and meaningful to coastal residents. The Gulf of Maine King Tides Project, for example, has encouraged U.S. and Canadian communities to snap pictures of particularly high tides to illustrate what the new normal might look like later this century and to highlight areas most vulnerable to flooding. In Nova Scotia, the city of Halifax has created an interactive map where locals can record damage they've observed from storm surge and flooding, to help keep tabs on especially vulnerable locations. And the U.S. Federal Highway Administration recently funded a regional project that allowed Maine and New Hampshire Departments of Transportation

to work together to pinpoint areas along coastal highways that are especially susceptible to flooding, and to find nature-based solutions to prevent that flooding. These are just a few examples of the ways groups are coming together to prepare for inevitable inundations associated with climate change.

Case Study: Using Nature-Based Approaches to Stabilize Shorelines

Interview with Julia Knisel, Coastal Shoreline and Floodplain Manager, Massachusetts Office of Coastal Zone Management

After a series of severe storms hit the northeastern U.S. between 2012 and 2014, Julia Knisel and colleagues across New England felt a sense of urgency to address the mounting threats of coastal erosion and flooding brought on by these increasingly common events. So in 2015, they formed a partnership through the Northeast Regional Ocean Council to assess how natural materials could help stabilize shorelines against the impacts brought on by these storms, in ways that seawalls and other traditional hard structures have fallen short.

The nature-based solutions Knisel and her colleagues have since explored include planting dune and salt marsh grasses and other native vegetation to help stabilize sediment and soil; laying down biodegradable materials like coconut fibers to help hold this vegetation in place until roots take hold; bringing in sediments to add to the material available for buffering storms; and using native shellfish to further stabilize those sediments and break waves. In the Massachusetts Office of Coastal Zone Management where she works, Knisel helps manage a grant program that supports these types of living shoreline projects across the coast of Massachusetts.

Interest in these approaches has grown over the years as the threats of flooding and storm surge have become more tangible for residents and local officials. Last summer, her team successfully completed a project at Collins Cove in Salem, MA where more than 100 volunteers helped plant 15,000 seedlings of salt marsh grasses and other vegetation through a coconut fiber blanket laid down to help those plants take hold. In addition to stabilizing the shoreline against erosion, these approaches can also benefit the environment in a variety of ways including by improving water quality and bolstering coastal fish and wildlife habitats. These added benefits have been especially appealing to the community members who have stepped up to volunteer and take part in these projects, says Knisel. “You’re bringing the birds back, you’re providing a more beautiful setting,” she says. “There are some real tangible amenities to the community.”

In this way, the benefits of these nature-based approaches surpass those of hard structures like seawalls that don’t provide the same high quality habitat and often contribute to erosion rather than protect against it. “There is a real opportunity to try to be more responsible and help out the natural system while protecting vulnerable areas of the community,” Knisel says.

Section 2: Ocean Acidification

What to Expect

How acidification challenges Gulf of Maine fisheries

- The eggs, larvae, and juveniles of some commercial shellfish grow more slowly and are less likely to survive in more acidic waters.
- Lobsters and other species experience negative impacts that may be compounded by other stressors associated with climate change, including warming waters and changes in food availability.
- The need for a robust aquaculture industry increases with acidification to make up for losses within wild fisheries.

As carbon dioxide in the atmosphere enters the ocean, it dissolves to form carbonic acid. This is one reason why global oceans have become more acidic as they have absorbed more carbon dioxide from fossil fuel emissions. Along coastlines, other materials can add to this acidification, including acidic precipitation, river discharge, agricultural waste runoff, and other human materials that flow from the land into the ocean. Together, these contribute to what's called coastal acidification.

The Gulf of Maine receives ample doses of these sources of acidification but is not currently acidifying as quickly as other regions of the global ocean. This can be explained, in part, by the unusually fast pace this region is warming compared to the rest of the global ocean, says Samantha Siedlecki, an oceanographer at the University of Connecticut who studies acidification in the Gulf of Maine. "Warm water holds less gas," Siedlecki explains. "Because carbon dioxide is a gas, its absorption by the ocean is sensitive to those changes."

Just as a carbonated beverage holds fewer bubbles when its warm than when its iced, seawater holds less carbon dioxide when it heats up — so the Gulf of Maine is absorbing less carbon dioxide than other regions of the ocean that have maintained cooler waters.

But this doesn't mean acidification won't become a more pressing issue in the Gulf of Maine as we approach 2050, says Siedlecki. "We should not get comfortable," she says. By 2050 under the most severe emissions scenario, waters in this region will continue to absorb more carbon dioxide as emissions continue to climb, and the impacts of acidification will ripple across the Gulf of Maine despite the warming. This will challenge marine life in a variety of ways. In more acidic waters, organisms may struggle to build and maintain shells, their growth rates may slow down, and some may begin to lose their sense of smell and ability to find prey. This will present new challenges and vulnerabilities to fisheries across the Gulf of Maine.

Efforts to Prepare and Adapt

There are steps that we can take to lessen the severity of ocean acidification and its impacts on fisheries and marine ecosystems in the Gulf of Maine. Aside from curbing fossil fuel emissions — the most important step in slowing the rate of acidification — research has also shown that kelp beds can

consume dissolved carbon dioxide and raise the pH of seawater. Establishing farmed kelp beds along coastlines could help counter the effects of acidification, at least on a local level. Innovations in shellfish aquaculture could generate technologies to raise species like blue mussels and sea scallops that have previously been harvested as juveniles in the wild, but that may be more effectively raised in hatcheries moving forward. Commercial broodstock programs for these shellfish hatcheries can begin to select for offspring that are more tolerant of stressors like acidification, to help strengthen the aquaculture industry as it steps up to take a more prominent role in regional fisheries.

Case Study: Proactively Preparing an Oyster Hatchery For Environmental Change

Interview with Meredith White, director of research and development at Mook Sea Farm

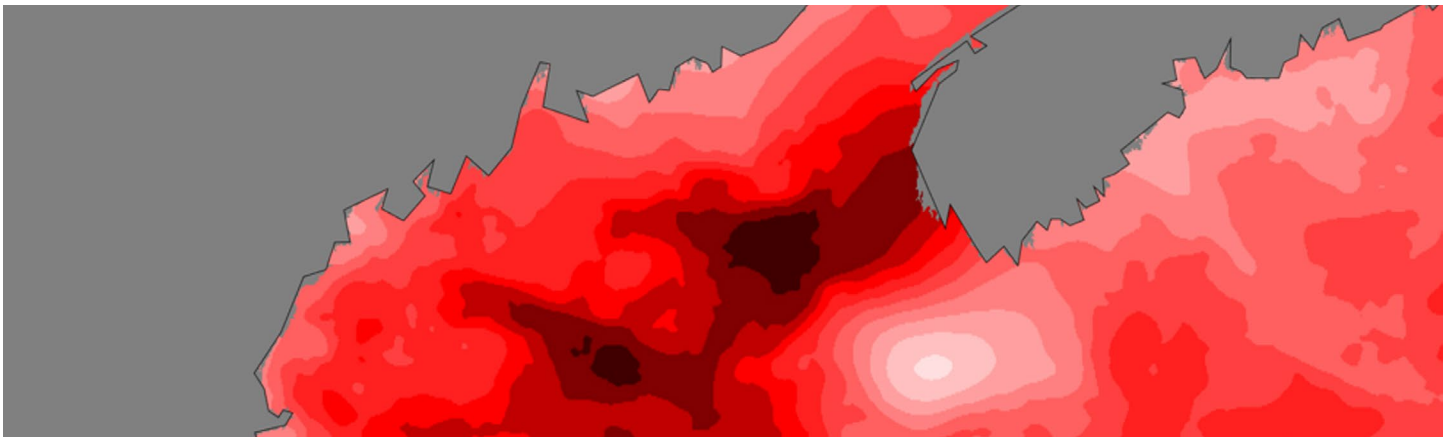
Mook Sea Farm, an oyster farm and hatchery in Walpole, Maine, has taken proactive steps to assess how ocean acidification may impact their business now and in the future. Meredith White, the farm's director of research and development, has conducted experiments to explore the vulnerability of their juvenile oysters (between 1 to 3 years old) compared to larval oysters (0 to 1 year old) to acidic seawater. The results of these experiments indicated that juvenile oysters aren't as sensitive to acidification as larval oysters are — in part because larval oyster shells are made of aragonite, a more soluble form of calcium carbonate than the shells of juvenile oysters. Other studies have shown that shellfish with thinner shells than oysters, such as mussels, tend to be more vulnerable to acidification, so each species must be assessed on a case by case basis.

To help support their larval oysters, White's team adjusts the chemistry of their seawater in their hatchery to make it less acidic. This suffices for now. But White points out that their studies of juveniles didn't take into account other possible compounding effects of climate change that will intensify in the future, such as changes in food supply for the oysters. "It's very possible that in the future, if there is less food available to them due to other aspects of climate change, that they might not be able to cope with acidification to the same extent because they don't have as much energy available to them," she says.

Aside from food availability, changes in the occurrence of harmful algal blooms could also compound the effects of acidification, as these may become more common in warmer waters. "Trying to understand that interaction more is really important to us," White says.

As an industry, White notes that breeders have historically selected for qualities like disease resistance and appearance. Mook Sea Farm has begun selecting for resistance to environmental stressors and recommends that other hatcheries do the same. "In conversations with larger oyster breeding groups, we are vocal about our recommendation," she says. "It would be beneficial to the industry overall if breeding programs included selection for resistance to environmental stressors."

Section 3: Temperature and Circulation



What to Expect

How changes in temperature and circulation challenges Gulf of Maine fisheries

- Ocean warming could modify the habitats of more than three-quarters of the target fishery species in Canada and the United States, with some habitats expanding but the majority contracting.
- Habitats for key fishery species will become more fragmented, making it difficult for fish to find their preferred conditions.
- Invasive species like green crabs more easily outcompete native species in warmer waters.
- The Gulf of Maine system will shift to become more temperate, pushing subarctic communities of marine life out of this region.

Through 2019, the Gulf of Maine has warmed faster than roughly 99 percent of the rest of the ocean — with temperatures increasing 7 times faster here than elsewhere in the world this century. A few qualities of the Gulf of Maine make this region especially susceptible to this rapid change. First, the Gulf of Maine sits at the meeting point of two opposing ocean currents — the Labrador Current that pulses cold water down from the Arctic, and the Gulf Stream that flows much warmer water up from the south. The dynamics of these two currents determines whether the Gulf of Maine receives cold, Arctic water or warmer water coming up from the south. As ice melts in the Arctic, the northern North Atlantic Ocean is becoming fresher. This causes the Gulf Stream to shift its path and allows more warm water to surge into the Gulf of Maine where the Labrador Current once dominated.

"In years where the Labrador Current is really strong, you can detect water that clearly has this Labrador origin all the way south of New York," says Andrew Pershing, chief scientific officer at GMRI who has spearheaded research on the Gulf of Maine warming. "In other years where that flow is really weak, that signal gets much more muddied and those waters look more temperate or subtropical."

Once that warm water arrives, it can become trapped in place due to the relatively shallow, protected, and bathtub-like quality of the Gulf of Maine.

Increasingly, these warmer waters have brought warm-adapted species like longfin squid further north into the Gulf of Maine than they have typically swum in the past. These new arrivals and changes in Gulf of Maine habitats have challenged the ways fisheries managers have traditionally made decisions, says Pershing. "Many decisions in fisheries are based on your 30 year average, on your history," he says. "Rather than thinking about where you are going, the discussion is often about where you have been."

Moving forward, ongoing shifts in temperature and circulation will generate uncharted territory that will require future-focused decisions and innovations.

Efforts to Prepare and Adapt

Shifts in fisheries will have cultural, economic, and emotional impacts in communities across the Gulf of Maine. People within these communities not only lose a source of income with these changes, but also an element of their heritage and identity that may have been passed down for several generations or, in the case of tribal nations, for millennia.

But these changes also offer new opportunities. Lobster fishers along Cape Cod, for example, have begun to harvest and sell Jonah crabs, a species that used to be considered bycatch in lobster traps but have recently gained popularity for their sweet and juicy claw meat. As lobsters move offshore in warmer waters and become harder to come by, the emerging Jonah crab fishery could soften the blow, says Aubrey Ellertson, a research biologist with the Commercial Fisheries Research Foundation in Rhode Island who works with fishermen making this shift. "It's a new hot delicious thing that you can get from restaurants now," she says. "The emergence of this fishery has really provided lobstermen with an option to diversify and reduce their dependence on lobster."

Still, while humans have this opportunity to pivot and shift their diets, marine life may struggle to do the same.

Case Study: Seabird Communities Struggle to Adapt to Warming Gulf of Maine Waters

Interview with Heather Major, biologist at the University of New Brunswick

Heather Major has been studying seabird colonies on Machias Seal Island since 2016. Research on this island, which lies in disputed waters between the Gulf of Maine and the Bay of Fundy, has been ongoing for 25 years, providing an unusually long and detailed dataset for this region. "Having this kind of information on a top predator is really important to try to tease out what's happening in this system," she says.

Since the 1990s, researchers have observed a rise in sea surface temperature around the island and associated changes in the arrival of Atlantic puffins and razorbills — both cold-adapted members of the auk family that flock to the island to raise their chicks.

The shifts in arrival times have not been consistent between the two species: Atlantic puffins are arriving between 10 to 14 days later than they were 25 years ago, whereas razorbills are arriving roughly 5 days earlier, Major says. Her team doesn't know exactly what accounts for this difference, but she suspects it has to do with changes in food availability for the birds. In the mid-1990s, both species brought in large quantities of Atlantic herring to feed their chicks. Today, razorbills are bringing less than they once did, and puffins are hardly bringing in any at all. "The amount of prey in the system is changing, so it's taking them longer to have the energy to produce an egg," Major says.

Over the past five years, she has observed large swings in the reproductive success in the colonies. The 2016 nesting season held the lowest reproductive success ever recorded, 2017 held one of the best years recorded, and ups and downs have continued since. "Those really big fluctuations are really worrying from a population biology standpoint," she says. "Often this signals a decrease in population."

They haven't seen that drop yet — overall population sizes are the same as they were 25 years ago. But if warming continues on this trajectory, Major thinks this will change. These are cold adapted species breeding at the southern edge of their range, and they may shift their range northward if the climate becomes too inhospitable here. "If temperature continues to warm as it is right now," she says, "then we might not see them anymore."

Section 4: The Power of Collaboration and Communication

Climate change is an emotionally fraught issue. The implications of what's to come have deep economic, societal, health, and environmental repercussions that will change the lives of billions of people across the planet by 2050. While science can help address many facets of these mounting issues, scientific findings alone can't move society forward. Those findings must be communicated clearly so that policy makers and other members of the general public can use that information to make informed decisions at the local level. Researchers must also take into account the needs and knowledge of people outside scientific spheres to make sure that they're asking the most relevant research questions.

"The scientific community can think of itself as off on its own and not a part of these systems," says Lindsey Williams, a social scientist and marine policy specialist at the University of New Hampshire who studies coastal issues. "But we are not on the side of these systems — we are active participants in them."

When scientists engage with communities who might be affected by the outcomes of their research early and often and in the scientific process, Williams says, they bridge gaps and improve the flow of knowledge in ways that ultimately strengthen the science itself.

Thinking Creatively: Theatre Approaches to Addressing Climate Issues

Cameron Wake, a climate scientist at the University of New Hampshire, has taken a creative approach to addressing climate issues by collaborating with a theatre group at the University of New Hampshire called Power Play. Together, they are addressing the emotionally charged issue of managed retreat — the proactive movement of coastal households and businesses inland as sea levels rise. The hope of the collaboration is to help scientists who study sea level rise better understand the concerns and emotions of those directly affected by it. "Just going in with the science logic turns out to be not a great approach to engaging people in a meaningful conversation," Wake says.

The Power Play theatre program includes a series of short intertwining monologues from three characters — a climate scientist, a town planner, and a coastal property owner — followed by a facilitated conversation with the audience about their emotional reaction to the piece. The actors have tailored this program to the Gulf of Maine and informed their roles through more than 30 interviews with people living this region. But Wake sees this program as one that could be re-created in other regions as well, and he hopes to see this and other iterations of the arts become more creatively incorporated within climate communication moving forward.

"If we want to make a difference in society, we need to do way more than just do good science and publish our science," Wake says. "We must start thinking out of the box and be innovative about it."

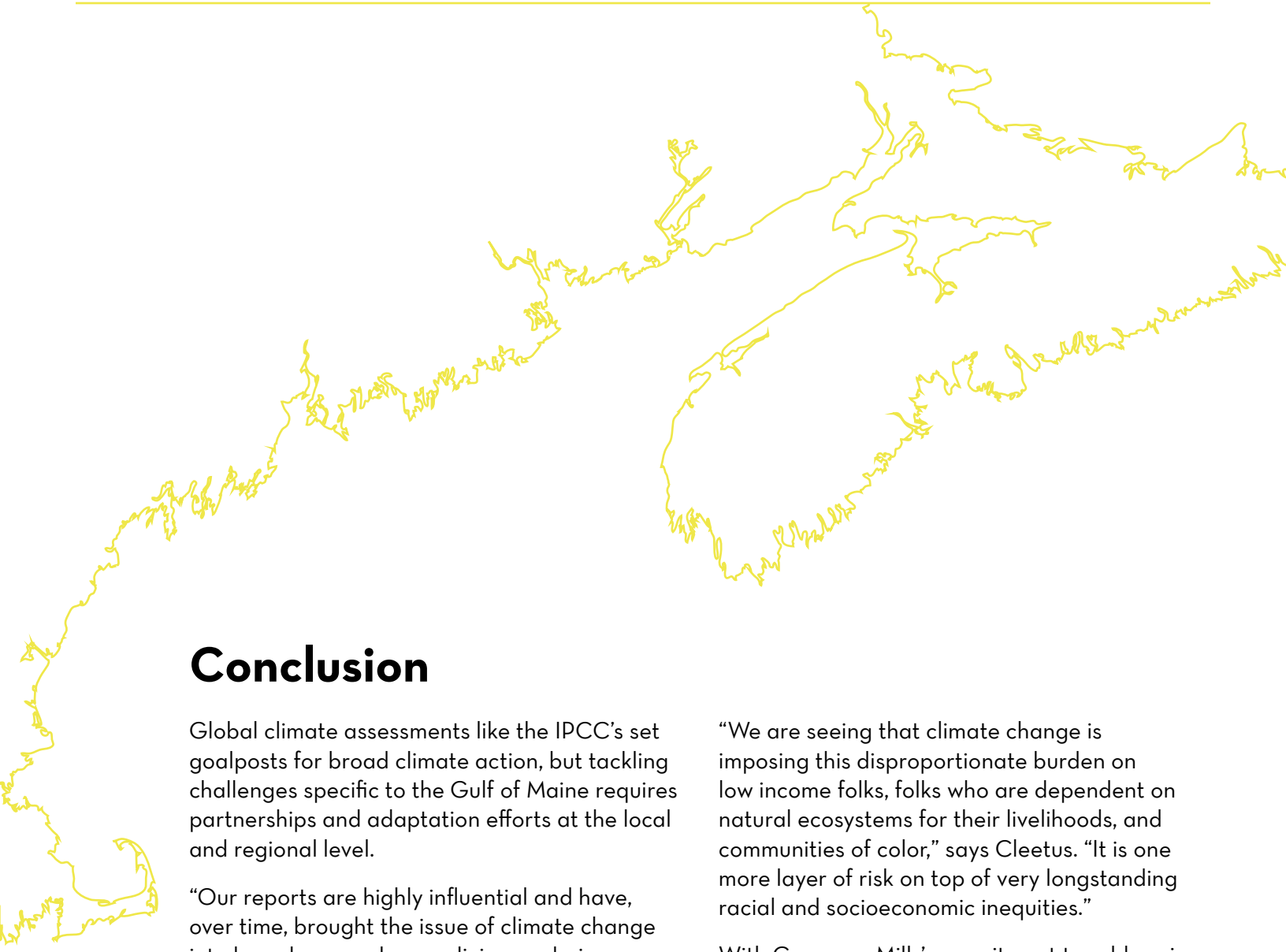
Working Across Silos: Data Collection on Fishing Vessels

As a research biologist with the Commercial Fisheries Research Foundation in Rhode Island, Aubrey Ellerston works to connect fishermen with scientists and fishery managers so that all parties can collaborate together on the research that informs fishery stock assessments.

Since 2013, Ellerston's team has outfitted a fleet of 19 lobster and crab fishing vessels with scientific data collection tools to record biological, temperature, and environmental data from gear hauls. Three times per month, fishermen use tablets to collect data out at sea and send that data back to Ellerston once they return to dock.

"They are seeing what's happening on the water every day, they are witnessing changes that scientists may not be able to see," Ellerston says. This not only moves fisheries research forward, but gives fishermen access to data they may not have had access to before, and strengthens relationships amongst all the parties involved. "Once they feel that scientists and managers are backing them up, it builds this community of collaboration," Ellerston says.

The fleet she manages is the only one dedicated to Jonah crab research in the northeast and will be instrumental in the first Jonah crab stock assessment set to come out in 2023. As this fishery could prove to be one viable alternative to the lobster fishery as lobsters move offshore in warming Gulf of Maine waters, Ellerston hopes their collaborative and productive efforts demonstrate the value of working together across silos. "It really builds this community of trust and transparency, and that's the key to fishery science as we continue to think toward the future," she says.



Conclusion

Global climate assessments like the IPCC's set goalposts for broad climate action, but tackling challenges specific to the Gulf of Maine requires partnerships and adaptation efforts at the local and regional level.

"Our reports are highly influential and have, over time, brought the issue of climate change into boardrooms where policies are being considered, into classrooms where science is furthered, and into dining rooms where debate among family and friends seeds individual action," says Ko Barrett, Vice Chair of the IPCC. "But eventually the conversations in all of these rooms turn to the need for tailored information to regional and local contexts."

Rachel Cleetus, policy director with the Climate and Energy program at the Union of Concerned Scientists, similarly emphasizes the need for work at local levels, and says that this type of work is becoming ever more feasible as science advances and allows for more localized data collection. These advancements could help meet the needs of the Gulf of Maine communities hit hardest by the climate crisis, she says.

"We are seeing that climate change is imposing this disproportionate burden on low income folks, folks who are dependent on natural ecosystems for their livelihoods, and communities of color," says Cleetus. "It is one more layer of risk on top of very longstanding racial and socioeconomic inequities."

With Governor Mills' commitment to addressing the climate crisis by joining a coalition of 24 states within the U.S. Climate Alliance, Maine is positioned to proactively address this crisis and its inherent inequities. "We're seeing states really step up and recognize that they have a powerful role to play in driving forward the changes we are going to need to see," Cleetus says.

This report showcases examples of partnerships that are already instigating these types of changes and preparing Gulf of Maine communities for a more sustainable 2050. "When you see a group of people come together guided by the science, motivated to help solve the problem," says Cleetus, "it's very inspiring."

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- Bay of Fundy Ecosystem Partnership
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