Advancing Maine's State Climate Action Plan:

GMRI Projects Supporting
Maine Won't Wait

By Dave Reidmiller and Hillary Swimmer
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**Gulf of Maine
Research Institute**

Science. Education. Community.

Introduction

In December 2020, Governor Mills released <u>*Maine Won't Wait*</u>, a 4-year climate action plan for the state that was created by the Maine Climate Council, an entity called for in a 2019 law that is composed of scientists, industry leaders, bipartisan local and state officials, and engaged citizens. The plan prepares the people, communities, and environments of Maine for future climate-related risks, while taking advantage of transformational economic opportunities. The plan is framed around four goals: (1) Reduce Maine's greenhouse gas (GHG) emissions, (2) Avoid the impacts of costs of inaction, (3) Foster economic opportunity and prosperity, and (4) Advance equity through Maine's climate response. The plan outlines 8 different strategies, highlighted below, with more specific objectives and actions falling under each strategy, involving sectors and geographies throughout the state:

A. **Embrace the Future of Transportation in Maine**
B. **Modernize Maine's Buildings: Energy-Efficient, Smart and Cost-Effective Homes and Businesses**
C. **Reduce Carbon Emissions in Maine's Energy and Industrial Sectors through Clean-Energy Innovation**
D. **Grow Maine's Clean-Energy Economy and Protect Our Natural-Resource Industries**
E. **Protect Maine's Environment and Working Lands and Waters: Promote Natural Climate Solutions and Increase Carbon Sequestration**
F. **Build Healthy and Resilient Communities**
G. **Invest in Climate-Ready Infrastructure**
H. **Engage with Maine People and Communities about Climate Impacts and Program Opportunities**

In order for the plan to become a reality, however, action is needed not just by the state government, but by committed, forward-thinking organizations across the state. At the Gulf of Maine Research Institute (GMRI), we pioneer solutions to global ocean challenges. And climate change is the biggest ocean challenge of our time; indeed, climate change represents an existential threat to coastal communities as we know them. But it doesn't have to—by leveraging climate action from the local to the global levels, coastal communities can thrive in a warmer world. A key tool in that cross-scale solution set is *Maine Won't Wait*. In its 20+-year history, GMRI has designed and delivered on scores of projects that advance our understanding of the Gulf of Maine, how it has been changing over time, what that means for the communities that rely on it for our livelihoods and well-being, and—most importantly—what can be done about it.

What follows is a mapping of nearly 100 recent and ongoing projects at GMRI (denoted with ♦) to the strategies, objectives, and actions laid out in *Maine Won't Wait*. While our work does not cover the entire scope of the state's climate action plan (our mission is largely focused on the marine and coastal domains, whereas *Maine Won't Wait* addresses every sector and geographic region of the state), it touches more than half of the strategies, with considerable efforts in (D), (E), and (H) above. Our commitment to executing on ambitious climate action in Maine's coastal and marine domain is clear—we are charting the path forward for coastal communities to thrive for generations to come.

Strategy A:

Embrace the future of transportation in Maine

1. *Accelerate Maine's transition to electric vehicles*
   a. Achieve emissions-reduction goals by putting 41,000 light-duty EVs on the road in Maine by 2025 and 219,000 by 2030.
   b. By 2022, develop a statewide EV Roadmap to identify necessary policies, programs, and regulatory changes needed to meet the state's EV and transportation emissions- reduction goals.
   c. By 2022, create policies, incentives, and pilot programs to encourage the adoption of electric, hybrid, and alternative-fuel medium- and heavy-duty vehicles, public transportation, school buses, and ferries.
2. *Increase fuel efficiency and alternative fuels*
   a. Continue to support increased federal fuel-efficiency standards.
   b. Significantly increase, by 2024, freight industry participation in EPA's SmartWay program.
   c. Increase, by 2024, local biofuel and biodiesel production and use in Maine transportation sectors, especially heavy-duty vehicles (assuming Maine biofuels production becomes viable).
   d. Establish a time-limited incentive program, targeted to low- and moderate-income drivers, to encourage drivers to upgrade to higher-efficiency vehicles in the near term.
3. *Reduce vehicle miles traveled*
   a. Reduce light-duty VMT over time, achieving 10% reductions by 2025 and 20% by 2030.
   b. Reduce heavy-duty VMT by 4% by 2030.
   c. Deploy high-speed broadband to 95% of Maine homes by 2025 and 99% by 2030.
   d. By 2024, establish state coordination, strengthen land-use policies, and use state grant programs to encourage development that supports the reduction of VMT.
   e. Increase public transportation funding to the national median of $5 per capita by 2024.
   f. Relaunch GO Maine to significantly increase shared public commuting options by 2022.

Strategy B:

Modernize Maine's buildings: Energy-efficient, smart, and cost-effective homes and businesses

1. *Transition to cleaner heating and cooling systems, efficient appliances*
   a. Install at least 100,000 new heat pumps in Maine by 2025, ensuring that by 2030, 130,000 homes are using between 1-2 heat pumps and an additional 115,000 homes are using a whole-home heat-pump system. Install at least 15,000 new heat pumps in income-eligible households by 2025.
   b. Implement Maine Appliance Standards requirements by 2022.
2. *Accelerate efficiency improvements to existing buildings*

a. Double the current pace of home weatherization so that at least 17,500 additional homes and businesses are weatherized by 2025, including at least 1,000 low-income units per year.
   b. Weatherize at least 35,000 homes and businesses by 2030.
3. *Advance the design and construction of new buildings*
   a. By 2024, develop a long-term plan to phase in modern, energy-efficient building codes to reach net-zero carbon emissions for new construction in Maine by 2035.
   b. Enhance existing training on building codes and expand these programs to support ongoing education of contractors and code-enforcement officials.
4. *Advance the design and promote climate-friendly building products*
   a. Develop and enhance innovation support, incentives, building codes, and marketing programs to increase the use of efficient and climate-friendly Maine forest products, including mass timber and wood- fiber insulation.
5. *"Lead by example" in publicly funded buildings*
   a. Use procurement rules and coordinated planning efforts for state government to promote high-efficiency lighting, heating, and cooling; climate-friendly construction materials; and renewable energy use for reduced operating costs and emissions reductions. The state will produce a "Lead by Example" plan for state government by February 2021.
   b. Enhance grant and loan programs to support efficiency and renewable energy programs in municipal, tribal, school, and public-housing construction and improvements. Provide recognition programs for those projects making outstanding efforts.
6. *Renewable fuels standard*
   a. Investigate options for establishing a Renewable Fuels Standard (RFS) for heating fuels.
7. *Replace hydrofluorocarbons with climate-friendly alternatives*
   a. Adopt hydrofluorocarbons phase-down regulations in 2021 to be implemented by 2022.

Strategy C:

Reduce carbon emissions in Maine's energy and industrial sectors through clean-energy innovation

1. *Ensure adequate affordable clean-energy supply*
   a. Achieve by 2030 an electricity grid where 80% of Maine's usage comes from renewable generation.
   b. Set achievable targets for cost-effective deployment of technologies such as offshore wind, distributed generation, and energy storage, and outline the policies, including opportunities for pilot initiatives, necessary to achieve these results.
2. *Initiate a stakeholder process to transform Maine's electric power sector*
   a. Establish a comprehensive stakeholder process in 2021 to examine the transformation of Maine's electric sector and facilitate other recommendations of the Maine Climate Council.
3. *Accelerate emissions reductions of industrial uses and processes*

a. Launch an Industrial Task Force to collaboratively partner with industry and stakeholders to consider innovations and incentives to manage industrial emissions through 2030 and reduce total emissions by 2050.

4. *Encourage highly efficient combined heat and power facilities*
   a. Analyze policies, including the potential for long-term contracts, needed to advance new highly efficient combined heat and power production facilities that achieve significant net greenhouse gas reductions.

Strategy D:

Grow Maine's clean-energy economy and protect our natural-resource industries

1. *Take advantage of new market opportunities*
   a. Support the ability of Maine's natural-resource economies to adapt to climate change impacts.
      ♦ **Gulf of Maine Responsibly Harvested**: The Gulf of Maine Responsibly Harvested (GoMRH) label highlights seafood that meets important criteria around responsible harvest. This project works directly with seafood suppliers in the middle of the supply chain, collecting third party traceability information and licensing suppliers to use the GoMRH label when they sell verified species. GoMRH Affiliates provide a way for consumers to choose seafood that is traceable to fishing communities in the Gulf of Maine region and meets important criteria around responsible harvest.
      ♦ **Marine Resource Education Program (MREP)**: This project empowers fishermen with better understanding of how, when, and where to engage effectively in federal fisheries science and management processes. MREP workshops are guided by local fishing industry members, ensuring regional relevance for fishermen attendees.
      ♦ **Aquaculture Workforce Development Strategy**: This project provides a forward-thinking, in-depth analysis that documents the current and future labor needs of Maine's growing aquaculture sector, works to develop the aquaculture industry, and charts a course for Maine to establish a comprehensive workforce training system.
      ♦ **Improving Seafood Quality**: This project updates practices and equipment for quality handling at every step of the local seafood supply chain, provides education and training opportunities about how to achieve premium seafood quality, and brings seafood supply chain stakeholders together to collectively improve seafood quality and the value of seafood in our region. Some of this work is funded through the USDA's Local Food Promotion Program.
      ♦ **Groundfish Stakeholder Engagement**: This project assists the fishing industry to assess, prepare for and thrive under change, serve as impartial conveners to fisheries stakeholders and managers, and facilitate learning experiences to help harbor the future success of fishing communities in the Gulf of Maine.

- **Assessing Maximum Economic Yield Efforts for Maine's Lobster Fishery**: This project evaluates the amount of effort that will maximize the overall economic benefit from the lobster resources in the Gulf of Maine by combining biological and economic models.
- **Groundfish Management Strategy Evaluation**: This research includes multiple projects that will support economic and ecological resilience by linking environmental changes with the most effective, forward-thinking fishery management strategies.
- **Fisheries Technical Assistance Program**: This project provides a range of technical, convening, and innovation services to New England's commercial fishing industry to promote the long-term prosperity of local fisheries and fishing communities.
- **Sustainable Seafood Consultation**: This project gives consultation to businesses committed to responsible seafood sourcing but that have yet to implement a robust sourcing policy. With a perspective on global marine and seafood business issues, GMRI helps the seafood industry develop and implement plans that contribute to the long-term sustainability of the world's marine resources.
- **Assessing Allocation Strategies for Fisheries Affected by Climate Change**: This project aims to develop guidance and adaptive strategies for fishery managers grappling with climate change induced allocation challenges.
- **Fishery Improvement Projects**: These projects use the power of the private sector to drive changes in a fishery. They are a unique example of seafood supply chain members coming together to push for a fishery to be responsibly managed and supported by good science, all in response to market demand for sustainable seafood.
- **Resilience, Adaptation, and Transformation in Lobster Fishing Communities**: This project draws on lessons from community experiences through a downturn in lobster populations in Southern New England that could help identify conditions and decisions that support resilient fishing communities in the Gulf of Maine as they face potential future changes.
- **Climate Adaptation Strategies for Northeast U.S. Fishing Communities**: This project works with communities to understand their needs and interests in order to develop more community-specific information about expected future species changes, economic impacts, and adaptation strategies in fisheries.
- **SNAPP: Climate Resilient Fisheries Working Group**: This project draws together experts from around the world to identify key features of resilience and approaches to operationalize them in a diverse range of fishery management systems.
- **Using Satellite Data to Support Sustainable Fisheries**: This project works to develop a Fisheries and Climate Toolkit (FaCeT) to track and forecast fisheries-relevant physical and biological ocean features that will inform dynamic ocean management and climate-ready fisheries.
- **Ecosystem Change Indicators for Lobster**: This project develops and tests a suite of ecosystem indicators that can be used to explore connections between lobster biological processes and fishery management strategies.

- ♦ **Multi-scale Forecasts and Analyses for the Maine Lobster Fishery**: This project supports the delivery of multiple forecasts to key Maine lobster fishery stakeholders.
- ♦ **Evaluating Climate Change Adaptation Strategies**: This project works to develop widely applicable general management strategies that promote the conservation of shifting marine fish stocks, and support the ability of fishermen and fishing communities to adapt to changing climates.

b. Grow Maine's forest-products industry through bioproduct innovation, supporting economic growth and sustainable forest management and preservation of working lands.

c. Establish the University of Maine as the coordinating hub for state-applied research on forestry, agriculture, and natural land-related climate concerns, including research and development of climate-friendly bio-based wood-market innovation; and research around climate-friendly agricultural practices.

d. Increase the amount of food consumed in Maine from state food producers from 10% to 20% by 2025 and 30% by 2030 through local food system development.

- ♦ **Advancing Aquaculture**: This project works collaboratively with industry leaders, farmers, researchers, the business community, and other nonprofits to identify and pursue opportunities to expand the sustainable aquaculture sector.
- ♦ **Maine Farmed Shellfish Market Analysis**: This project produces a data-driven, quantitative market assessment to inform industry leaders and business owners about the potential scale and scope of markets for farmed shellfish and to facilitate strategic growth in the industry.
- ♦ **Split The Seafood Bill Day**: This project, took place on six separate days (December 16th, 2020, and February 18th, 25th, March 4th, 11th and 18th, 2021) and in support of our Culinary Partners (and ultimately our local coastal communities), offered to split the cost of takeout or dine-in orders when a person ordered a seafood dish with 500 community members.
- ♦ **Culinary Partners**: GMRI partners with area restaurants that commit to sourcing at least 20% Gulf of Maine seafood and promote responsibly harvested seafood from fishermen and purveyors in the Gulf of Maine.
- ♦ **The Maine Aquaculturist: An Aquaculture Knowledge Portal**: This project is a free-to-use aquaculture knowledge portal, a comprehensive, accessible, and practical information portal that assists commercial aquaculture businesses in understanding and utilizing business-relevant aquaculture resources.
- ♦ **Aquaculture Top Gun**: This program is a partnership with MCE that tailors Top Gun to support early-phase aquaculture businesses in Maine by teaching aquaculture-specific content around business fundamentals and providing one-on-one mentoring.
- ♦ **Commercial Oyster Farm Demo Model**: This project documents the growth of a small oyster farm as it scales to commercial level operations, can provide guidance to other small farms, and promote the growth of Maine's aquaculture industry.
- ♦ **South Portland Pier Aquaculture & Fishing Needs Assessment**: This project conducts a needs assessment that provides the City with critical information to help guide them towards fully utilizing the pier in support of Portland Harbor's commercial fishing and aquaculture businesses.

- ♦ **Gulf of Maine Responsibly Harvested**: The Gulf of Maine Responsibly Harvested (GoMRH) label highlights seafood that meets important criteria around responsible harvest. This project works directly with seafood suppliers in the middle of the supply chain, collecting third party traceability information and licensing suppliers to use the GoMRH label when they sell verified species. GoMRH Affiliates provide a way for consumers to choose seafood that is traceable to fishing communities in the Gulf of Maine region and meets important criteria around responsible harvest.
- ♦ **Sustainable Seafood Program**: This project works with industry leaders across the supply chain to build market demand and empower consumers to find and buy Gulf of Maine seafood. The industry leaders include: retailers, restaurants, seafood dealers, fishermen, and other stakeholders.
- ♦ **Expanding Maine's Blue Economy**: This project aims to support Maine's aquaculture industry by identifying barriers and opportunities to expand consumption of aquaculture products from Maine.
- ♦ **Gulf of Maine Sashimi**: This project was founded to realize the maximum potential for seafood from the New England region through advanced quality handling and processing techniques.
- ♦ **USDA Grant-Farm to School**: This project is focused on working with 10 school districts across northern New England to increase regional seafood consumption in K-12 schools.
  - e. Launch the Maine Seafood Business Council by 2022.
2. Clean-energy jobs and businesses in Maine
   - a. Launch a workforce initiative by 2022 that establishes ongoing stakeholder coordination between industry, educational, and training organizations to support current and future workforce needs.
   - b. Establish programs and partnerships by 2022 for clean-tech innovation support to encourage the creation of clean-energy and climate solutions.

Strategy E:

Protect Maine's environment and working lands and waters: Promote natural climate solutions and increase carbon sequestration

1. *Protect natural and working lands and waters*
   a. Increase by 2030 the total acreage of conserved lands in the state to 30% through voluntary, focused purchases of land and working forest or farm conservation easements.
      i. Additional targets should be identified in 2021, in partnership with stakeholders, to develop specific sub-goals for these conserved lands for Maine's forest cover, agriculture lands, and coastal areas.
   b. Focus conservation on high biodiversity areas to support land and water connectivity and ecosystem health.
      ♦ <u>**Re-evaluating ecosystem services through community perspectives**</u>: This project aims to assess how Maine's coastal ecosystem (e.g., soft-shell clam and its habitat) contributes to coastal communities' well-being by operationalizing the notion of "nature's contribution to people" and "relational values", the two concepts being discussed by IPBES.
   c. Revise scoring criteria for state conservation funding to incorporate climate mitigation and resiliency goals.
   d. Develop policies by 2022 to ensure renewable energy project siting is streamlined and transparent while seeking to minimize impacts on natural and working lands and engaging key stakeholders.
2. *Develop new incentives to increase carbon storage*
   a. DEP will conduct a comprehensive, state-wide inventory of carbon stocks on land and in coastal areas (including blue carbon) by 2023 to provide baseline estimates for state carbon sequestration, allowing monitoring of sequestration over time to meet the state's carbon neutrality goal.
   b. Establish by 2021 a stakeholder process to develop a voluntary, incentive-based forest carbon program (practice and/or inventory based) for woodland owners of 10 to 10,000 acres and forest practitioners.
   c. Engage in regional discussions to consider multistate carbon programs that could support Maine's working lands and natural- resource industries, and state carbon- neutrality goals.
3. *Expand outreach to offer information and technical assistance*
   ♦ **Building Capacity of Rural Communities to Plan and Prepare for Coastal Resilience:** Through state, regional, and local partnerships, this project convenes and facilitates regional trainings by which Maine's rural coastal communities can increase their capacity to plan and prepare for coastal climate impacts by developing the knowledge, skills, and relationships necessary to create data- and community- informed climate resilience plans.

- **Climate Change Education Collaborative**: Through a collaboration led by Shelburne Farms, this partnership across the Northeast leverages the collective expertise across 21 organizations to increase climate change education capacity regionally.
- **Regional Teacher Communities**: GMRI supports fifth through eighth grade STEM educators to come together and learn with and from one another as they work to engage their learners in authentic STEM experiences. As these communities continue to grow, we seek to support the development of connected learning ecosystems that focus on bringing these formal educators together with informal educators from across the state of Maine.
- **Integrated Sentinel Monitoring Network (ISMN)**: This work develops an Integrated Sentinel Monitoring Network (ISMN) in partnership with NERACOOS, the Northeast Regional Ocean Council (NROC), and other partners in the region that will integrate data from long-term research efforts and extend observations in the Gulf of Maine with a focus on filling gaps in understanding regarding marine biodiversity and ecosystem functions. This project is part of the larger Marine Biodiversity Observation Network (MBON).
- **Northeastern Regional Association of Coastal and Ocean Observing Systems (NERACOOS)**: This work is to lead the data management and cyberinfrastructure efforts for ocean observing in the Northeast region as a key partner in NERACOOS, includes data management; integration of data from near real-time buoys, remote sensing satellites, and ocean conditions forecast models; and the development of information products for stakeholders to access near-real time data, forecasts of ocean conditions, and long term historical data and climatology trends.
- **Ocean and Coastal Acidification Threshold**: NERACOOS and partners are expanding the capacity to predict changes in ocean chemistry, and better understand trends in coastal acidification. Using feedback from the aquaculture industry and water quality managers, the project will introduce users to new OA forecasting models, and demonstrate ways through which industry members could use model predictions to prepare for acidification events.
- **Coastal and Ocean Model Testbed (COMT)**: This project is a part of the Coastal Ocean Model Testbed (COMT), a national program of federal and regional modeling research communities working to develop comprehensive forecasting models to improve prediction of short-term impacts from coastal storms and longer-term sea level rise projections. Improved model forecasts will be distributed through NERACOOS data products.
- **Climate and Fisheries Data Dashboard**: This work develops a web-based application for fisheries stakeholders in the Northeast which makes complex, climate-relevant data more accessible and easier to understand. The dashboard tools enable users to quickly assess and evaluate ocean conditions in the context of past and projected changes. The dashboard will continue evolving to host new products for fisheries (e.g. phenology tools, fish distributions, ecosystem forecasts) currently in development.
- **Groundfish Management Strategy Evaluation**: This research includes multiple projects that will support economic and ecological resilience by linking environmental changes with the most effective, forward-thinking fishery management strategies.
- **Northeast Climate Integrated Modeling to Meet Ocean Decision Challenges**: This project will develop both natural and human systems scientific knowledge through the development of integrated models, to help enable effective adaptation measures in fisheries in the Northeast.

     a. Increase technical service provider capacity by 2024 to deliver data, expert guidance, and support for climate solutions to communities, farmers, loggers, and foresters at the Department of Agriculture, Conservation and Forestry, Maine Forest Service, Department of Inland Fisheries and Wildlife, the Department of Marine Resources, and the University of Maine.

     b. Launch the Coastal and Marine Information Exchange by 2024.

4. *Enhance monitoring and data collection to guide decisions*

- **Atlantic salmon in a changing Northwest Atlantic ecosystem**: This research seeks to identify key drivers in the Northwest Atlantic marine ecosystem that are the likely culprits for population declines and understand the mechanisms by which changing ecosystem conditions influence Atlantic salmon population outcomes.

- **Ecosystems Impacts of Warming**: This project documents how plankton and fish communities have changed and uses computer models to better understand how marine ecosystems respond to warming.

- **Northeast Climate Integrated Modeling to Meet Ocean Decision Challenges**: This project will develop both natural and human systems scientific knowledge through the development of integrated models, to help enable effective adaptation measures in fisheries in the Northeast.

- **Climate Decision Theater**: This project develops an interactive learning environment and workshop experience for fishery stakeholders, to learn how to understand and use models that lead to more informed fishery management decisions as the climate continues to change.

- **Casco Bay Aquatic Systems Survey (CBASS)**: CBASS, a long-term monitoring effort led by GMRI, helps to gain a better understanding of the pace and direction of these changes taking place in the coastal marine fishery ecosystems that support the region.

- **Environmental DNA Validation**: This work advances the reliable use of eDNA in the ocean. A validation study is conducted using acoustic technologies for quantifying fish to provide insights into the factors that may influence fish eDNA in marine settings.

- **Improving Science and Management of Highly Migratory Species in the Atlantic**: This project improves understanding of highly migratory species in the northwest Atlantic allowing us to enact measures to rebuild their populations and improve their status.

- **Evaluating Age Structure, Aging Bias and Mixed Stock Composition of Atlantic Bluefin Tuna in the Northwest Atlantic**: This project invests substantial time and funding to studying the life history of bluefin tuna to learn more about their biology, improve the ability to assess the status of their stocks, and ultimately improve their sustainability.

- **Integrated Sentinel Monitoring Network (ISMN)**: This work develops an Integrated Sentinel Monitoring Network (ISMN) in partnership with NERACOOS, the Northeast Regional Ocean Council (NROC), and other partners in the region that will integrate data from long-term research efforts and extend observations in the Gulf of Maine with a focus on filling gaps in understanding regarding marine biodiversity and ecosystem functions. This project is part of the larger Marine Biodiversity Observation Network (MBON).

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products for stakeholders to access near-real time data, forecasts of ocean conditions, and long term historical data and climatology trends.

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- **Spatio-temporal Associations of Western Bluefin Tuna Indices of Abundance with Ocean Climate Conditions:** This project examines atmospheric and oceanographic changes that may have impacted the distribution of giant bluefin tuna in the Gulf of Maine, critical to understanding whether or not declines in landings equate to declines in population abundance, or if those declines represent distribution shifts.
- **Evaluating the Importance of Chub Mackerel in the Diet of Highly Migratory Species:** The project seeks to investigate the foraging ecology of marlins (blue, white, round-scale spearfish) and tunas (bigeye, yellowfin) along the East Coast to identify the most important components of their forage base, with a strong focus on chub mackerel.
- **The Open Knowledge Network to Meet Ocean Decision Challenges (OceanOKN):** This works enables a transformative approach to forward-looking, climate-informed decision making in fisheries.
- **Snap-a-Striper:** This project partners with the Maine chapter of The Coastal Conservation Association to launch a citizen science initiative.
- **Evaluating Age Structure and Foraging Ecology of Yellowfin and Bigeye Tuna in the Northwest Atlantic:** This research seeks to fill in those knowledge gaps of yellowfin and bigeye tuna's life history and improve the ability to manage these species more effectively.
- **Evaluating the life history and stock structure of yellowfin tuna (Thunnus albacares) in the northwest Atlantic Ocean:** This research seeks to improve knowledge on the biology of yellowfin tuna, especially key inputs like age, stock structure and spawning.
- **Foraging Ecology of Atlantic Bluefin Tuna in the Northwest Atlantic:** This project analyzes Atlantic bluefin tuna's foraging habits that can provide insights into how the ecosystem is responding to temperature changes, and the possible impacts it may have on top predators in the region.
- **Regional and National Climate Advisory Activities:** This project places GMRI scientists among hundreds of leading national experts to assess the science and impacts of climate change in the Gulf of Maine, throughout the Northeast region, and across the nation.

These scientific assessments provide decisionmakers with critical information to underpin climate policies and action.

♦ **Monitoring Pollution with Mussels**: This research constructs more complete maps of human-associated nitrogen loading to marine ecosystems, it measures nitrogen stable isotopes in mussels from numerous coastal sites because mussels continuously filter food from the water, and in the process intake nitrogen that can be linked to humans or natural sources.

♦ **Atlantic Ocean Tropical Tuna Tagging Program**: The International Commission for the Conservation of Atlantic Tunas, partnered with UMaine and GMRI, to tag tropical tunas in the northwest Atlantic through the Atlantic Ocean Tropical Tuna Tagging Program to learn more about the migratory pattern of these fish and how to improve their management and long-term sustainability.

♦ **Ecosystem Change Indicators for Lobster**: This work develops and tests a suite of ecosystem indicators that can be used to explore connections between lobster biological processes and fishery management strategies.

♦ **Crossing boundaries: understanding and projecting distribution shifts for species that span U. S. and Canadian waters**: This research develops models of species distributions over the Northeast Shelf and Scotian Shelf and projects them forward under future climate conditions.

♦ **Marine and coastal phenology: temperature, phytoplankton, and fish**: This project determines how the timing of seasonal ocean warming and cooling is changing and how these changes relate to the timing of life history events in diadromous fish, including the return migration of Atlantic salmon to the Penobscot River.

♦ **Nutritional ecology of climate change**: This project investigates how warming-related species distribution shifts affect predator-prey overlap, diet composition, and energy content of diets for fish communities on the Northeast Shelf.

♦ **Updating and improving spatial distribution projections for lobster**: This project will advance lobster distribution models and develop expert consensus on communicating results and uncertainty across multiple modeling efforts.

♦ **Evaluating climate impacts in Maine's Coastal Waters**: This project examines climate impacts on biodiversity and community structure in coastal Maine waters and places them in the context of greater Northeast U.S. waters.

♦ **Coastal Flooding Citizen Science**: GMRI partners with municipalities to engage their communities in a citizen science project that guides them in contributing observations to formalize local knowledge of where flooding, erosion, and splash-over happens, and under what conditions, as well as quantifying the impacts these flood events have on their community.

♦ **Gulf of Maine Temperature Trends**: This project uses satellite data to assess in near-real-time the temperature conditions in the Gulf of Maine. In recent years, this work revealed that the Gulf of Maine was warming faster than 99% of the world's ocean waters.

♦ **Ecosystem Impacts of Warming**: This research documents how plankton and fish communities have changed and uses computer models to better understand how marine ecosystems respond to warming.

♦ **NASA Citizen Science Community Workshops**: This project gathers practitioners, scientists, civil servants, and partners involved in NASA citizen science work intended to promote exchange of scientific and engagement practices that make citizen science projects effective.

a. Establish a "coordinating hub" with state and non-state partners for key climate change research and monitoring work to facilitate statewide collaboration by 2024.
b. Create the framework and begin pilot for a coordinated, comprehensive monitoring system by 2024.
c. Incorporate climate research and climate change-related technologies into Maine's research and development priorities such as those developed by the Maine Innovation Economy Advisory Board and the Maine Technology Institute.

Strategy F:
Build healthy and resilient communities

1. *Empower local and regional community resilience efforts*
   ♦ **Building Capacity of Rural Communities to Plan and Prepare for Coastal Resilience:** Through state, regional, and local partnerships, this project convenes and facilitates regional trainings by which Maine's rural coastal communities can increase their capacity to plan and prepare for coastal climate impacts by developing the knowledge, skills, and relationships necessary to create data- and community- informed climate resilience plans.
   ♦ <u>**Ecosystem Investigation Network**</u>: This project brings stories of climate-driven changes happening in the Gulf of Maine and its watershed together to reveal new patterns of change and new connectedness across our region.
   ♦ <u>**Resilience, Adaptation, and Transformation in Lobster Fishing Communities**</u>: This project draws on lessons from community experiences through a downturn in lobster populations in Southern New England that could help identify conditions and decisions that support resilient fishing communities in the Gulf of Maine as they face potential future changes.
   ♦ <u>**Climate Adaptation Strategies for Northeast U.S. Fishing Communities**</u>: This project works with communities to understand their needs and interests in order to develop more community-specific information about expected future species changes, economic impacts, and adaptation strategies in fisheries.
   ♦ <u>**Regional Teacher Communities**</u>: GMRI supports fifth through eighth grade STEM educators to come together and learn with and from one another as they work to engage their learners in authentic STEM experiences. As these communities continue to grow, we seek to support the development of connected learning ecosystems that focus on bringing these formal educators together with informal educators from across the state of Maine.
   ♦ <u>**Climate Change Education Collaborative**</u>: Through a collaboration led by Shelburne Farms, this partnership across the Northeast leverages the collective expertise across 21 organizations to increase climate change education capacity regionally.
   a. Provide state leadership for robust technical assistance and funding to communities by 2024 to support local and regional climate-resilience initiatives.
2. *Adopt official sea-level rise projections*
   ♦ <u>**Mapping Coastal Community Flood Hazards**</u>: This project increases public understanding of the complex and compounding impacts of coastal flooding to a community's economic, environmental, and social assets through a mapping tool that

illuminates the complex impacts of coastal flooding by aggregating and geo-referencing currently disconnected data sources.

   a. Incorporate official state sea-level rise projections into regulations by 2022 and require regular updates to ensure the projections utilize the latest scientific data.

3. *Emphasize resilience through land-use planning and legal tools*
   a. Develop and implement updated land-use regulations, laws, and practices by 2024 in order to enhance community resilience to flooding and other climate impacts.

4. *Strengthen public-health monitoring, education, and prevention*
   - ♦ **Mapping Coastal Community Flood Hazards**: This project increases public understanding of the complex and compounding impacts of coastal flooding to a community's economic, environmental, and social assets through a mapping tool that illuminates the complex impacts of coastal flooding by aggregating and geo-referencing currently disconnected data sources.
   - ♦ **Monitoring Pollution with Mussels**: This research constructs more complete maps of human-associated nitrogen loading to marine ecosystems, it measures nitrogen stable isotopes in mussels from numerous coastal sites because mussels continuously filter food from the water, and in the process intake nitrogen that can be linked to humans or natural sources.
   a. Develop and implement more robust public-health monitoring, education, and prevention practices by 2024 to achieve better health outcomes against climate change impacts.

Strategy G:
Invest in climate-ready infrastructure

1. *Assess climate vulnerability and provide climate-ready design guidance*
   - ♦ **Building Capacity of Rural Communities to Plan and Prepare for Coastal Resilience:** Through state, regional, and local partnerships, this project convenes and facilitates regional trainings by which Maine's rural coastal communities can increase their capacity to plan and prepare for coastal climate impacts by developing the knowledge, skills, and relationships necessary to create data- and community- informed climate resilience plans.
   - ♦ **Mapping Coastal Community Flood Hazards**: This project increases public understanding of the complex and compounding impacts of coastal flooding to a community's economic, environmental, and social assets through a mapping tool that illuminates the complex impacts of coastal flooding by aggregating and geo-referencing currently disconnected data sources.
   a. Complete a statewide infrastructure-vulnerability assessment by 2023, as well as develop and implement design standards for resilience in infrastructure projects.

2. *Establish the state infrastructure adaptation fund*
   a. Launch a State Infrastructure Adaptation Fund and predevelopment assistance program in 2021, designed to leverage federal recovery support in the short term, and in the long term to address the significant and ongoing infrastructure adaptation needs.

Strategy H:

Engage with marine people and communities about climate impacts and program opportunities

- **<u>Strategic Partners</u>:** This project builds strategic partnerships with regional leaders in the blue tech sector to support access to capital, technical expertise, and incubation and acceleration capacity for innovative startup companies.
- **<u>Re-evaluating the Cultural Value of Fisheries and Working Waterfronts</u>:** This project introduces currently missing perspectives to international discussions focused on defining the concept of Ecosystem Services by conducting case studies in Japan and the US that more closely examines the relational values that local populations develop as they work with their surrounding ecosystems to maintain livelihoods.
- **<u>Integrated Sentinel Monitoring Network (ISMN)</u>:** This work develops an Integrated Sentinel Monitoring Network (ISMN) in partnership with NERACOOS, the Northeast Regional Ocean Council (NROC), and other partners in the region that will integrate data from long-term research efforts and extend observations in the Gulf of Maine with a focus on filling gaps in understanding regarding marine biodiversity and ecosystem functions. This project is part of the larger Marine Biodiversity Observation Network (MBON).
- **<u>Northeastern Regional Association of Coastal and Ocean Observing Systems (NERACOOS)</u>:** This work is to lead the data management and cyberinfrastructure efforts for ocean observing in the Northeast region as a key partner in NERACOOS, includes data management; integration of data from near real-time buoys, remote sensing satellites, and ocean conditions forecast models; and the development of information products for stakeholders to access near-real time data, forecasts of ocean conditions, and long term historical data and climatology trends.
- **Ocean and Coastal Acidification Thresholds:** NERACOOS and partners are expanding the capacity to predict changes in ocean chemistry, and better understand trends in coastal acidification. Using feedback from the aquaculture industry and water quality managers, the project will introduce users to new OA forecasting models, and demonstrate ways through which industry members could use model predictions to prepare for acidification events.
- **<u>Climate and Fisheries Data Dashboard</u>:** This work develops a web-based application for fisheries stakeholders in the Northeast which makes complex, climate-relevant data more accessible and easier to understand. The dashboard tools enable users to quickly assess and evaluate ocean conditions in the context of past and projected changes. The dashboard will continue evolving to host new products for fisheries (e.g. phenology tools, fish distributions, ecosystem forecasts) currently in development.

1. Raise awareness about climate change impacts and opportunities
   - **<u>Climate Adaptation Strategies for Northeast U.S. Fishing Communities</u>:** This project works with communities to understand their needs and interests in order to develop more community-specific information about expected future species changes, economic impacts, and adaptation strategies in fisheries.
   - **<u>Ecosystem Change Indicators for Lobster</u>:** This project develops and tests a suite of ecosystem indicators that can be used to explore connections between lobster biological processes and fishery management strategies.

- ♦ **Coastal Flooding Citizen Science**: GMRI partners with municipalities to engage their communities in a citizen science project that guides them in contributing observations to formalize local knowledge of where flooding, erosion, and splash-over happens, and under what conditions, as well as quantifying the impacts these flood events have on their community.
- ♦ **Preparing Coastal Communities for Sea Level Rise**: This project is a community education event that builds participant knowledge in sea level rise science, future projections, and local impacts through data from local history and case studies.
- ♦ **Mapping Coastal Community Flood Hazards**: This project increases public understanding of the complex and compounding impacts of coastal flooding to a community's economic, environmental, and social assets through a mapping tool that illuminates the complex impacts of coastal flooding by aggregating and geo-referencing currently disconnected data sources.
- ♦ **Groundfish Management Strategy Evaluation**: This research includes multiple projects that will support economic and ecological resilience by linking environmental changes with the most effective, forward-thinking fishery management strategies.
- ♦ **Learning Ecosystems Northeast**: This NASA-funded effort will develop regional communities of informal and formal educators, youth, and other community stakeholders to identify and pursue investigations of locally relevant climate impacts.
  a. Launch a multifaceted, ongoing communications effort in 2021 based on the Climate Action Plan to raise public awareness and understanding about climate change in Maine, the state's climate-response actions, and climate-related programs and opportunities.

2. *Increase public education offerings related to climate and energy*
   - ♦ **Research Experience for Undergraduates**: This project provides students from diverse backgrounds the chance to immerse themselves in a genuine research culture and to conduct independent research project on aspects of fisheries, marine ecology and climate change in the Gulf of Maine (official REU site name: Integrated studies in a rapidly warming fishery ecosystem").
   - ♦ **Teaching and Learning Ecosystem Modeling**: This work investigates the development of middle-school students' understandings and practices of modeling in the context of investigations of variability and change in ecosystems.
   - ♦ **Developing Socioecological Literacy**: This work advances efforts to better understand and promote practices that broaden access to and interest in Maine's aquaculture industry through hands-on learning experiences at active farms, the construction and revision of computational models of natural systems, and engagement with choice-based virtual economic games.
   - ♦ **GMRI Home Delivery**: This project was created to adapt to modern challenges to provide teachers, students, and parents with virtual education options which mirror our traditional offerings.
   - ♦ **Scientists To Go**: This project delivers a series of biweekly lectures focused on the day-to-day workings of active scientists in the marine space to middle school classrooms.
   - ♦ **Climate Change Education Collaborative**: Through a collaboration led by Shelburne Farms, this partnership across the Northeast leverages the collective expertise across 21 organizations to increase climate change education capacity regionally.
   - ♦ **Regional Teacher Communities**: GMRI supports fifth through eighth grade STEM educators to come together and learn with and from one another as they work to engage their learners in authentic STEM experiences. As these communities continue to grow, we

seek to support the development of connected learning ecosystems that focus on bringing these formal educators together with informal educators from across the state of Maine.

- **LabVenture**: GMRI hosts nearly 10,000 Maine middle schoolers in its LabVenture program — a hands-on, interactive, authentic investigation of the changing Gulf of Maine ecosystem.
- **Systemic Impacts of LabVenture**: This project investigates the short-term and long-term impacts of the LabVenture program on Maine's students, families, and learning communities in terms of their perception of and participation in formal and informal science learning.
- **Modeling Change:** This project is an interactive experience for public audiences focused on climate impacts in the Gulf of Maine based on the LabVenture program content.
- **Educator Professional Development**: This work supports educators with professional learning opportunities that help them engage students in authentic science learning experiences like the process of scientific inquiry, working with data, and current science research about climate and ecosystem change in the region.
- **Findings from the Field**: This project is growing a community of middle school ecosystem scientists across the region, and supporting them in deepening their scientific thinking.
- **Real World, Real Science**: This NASA-funded project enables students to explore the local impacts of global climatic trends and builds connections in STEM learning across formal and informal education environments.
- **Building Climate Literacy Among Frontline Communities**: This NASA and NOAA effort supports the engagement of multigenerational immigrant, refugee, and Tribal communities in the work of youth/educator-led investigations into climate impacts on ecosystems.
- **Science Center Community of Practice**: This NASA-funded project develops ways to engage science center visitors in data-rich investigations of changing ecosystems using locally relevant examples. The Community of Practice will also create learning ecosystems regionally as infrastructure for climate change conversations and investigations.
- **Curriculum Resources**: Across all of GMRI's educational efforts, this project creates compelling curriculum resources targeting middle school learners.
- **Extending LabVenture into the Classroom**: This project creates a suite of classroom and teacher professional development activities to extend students' explorations of the local impacts of climate change into classrooms across the state and across ecosystems.
- **Sea Level Rise High School Curriculum**: GMRI developed a sea level rise curriculum for high school students that gives them the knowledge, skills, and confidence to engage their communities in understanding local sea level rise impacts.
- **Citizen Science in Classrooms**: In this project, students partner with scientists and resource managers in real scientific research to understand local ecosystems and climate change.
- **Ecosystem Investigation Network**: This platform and network for community-based citizen science aims to gather stakeholders in co-investigation of ecosystem change across Maine.
- **Lunch and Learn**: On the first Thursday of each month, GMRI hosts a Lunch & Learn tour of the facility on the Portland waterfront where participants can learn more about GMRI's work and role in the community.

- **Science Café**: Every few months, members of the public are invited to GMRI to grab a drink, pull up a chair, and join GMRI for an informal presentation and discussion about current research related to the Gulf of Maine.
- **Sea State Series**: This series features expert speakers, such as scientists, seafood experts, fishermen, on topics central to the Gulf of Maine ecosystem and economy.
- **Preparing Coastal Communities for Sea Level Rise**: This community education event that builds participant knowledge in sea level rise science, future projections, and local impacts through data from local history and case studies.
- **Trawl to Table**: These workshops bring together players from throughout the seafood supply chain to learn and share information. The workshops dig into the challenges and opportunities for sourcing more seafood from the Gulf of Maine by connecting those directly involved in buying and selling seafood.
  a. Develop enhanced educational opportunities for climate science and clean energy careers in Maine public schools to meet increasing interest from students and educators. Launch a process in 2021 to engage key stakeholders including students, older youth, educators, and state leaders in next steps.

3. *Start the "Marine Climate Corps" for climate-related workforce development*
   a. Partner with service-learning organizations and nonprofit organizations to launch a Maine Climate Corps program by 2023.
4. *Recognize climate leadership by Maine businesses and organizations*
   a. Launch the Governor's Climate Leadership Council in 2021 to increase private sector commitment toward voluntary climate actions.