GOALS	RECOMMENDATIONS	Action to Date	Future Action
1. Invest in Maine's Capacity to Monitor and Investigate the Effects of Ocean Acidification and Determine Impacts of Ocean Acidification on Commercially-Important Species and the Mechanisms Behind Those Impacts	*1.1. Enhance monitoring and create a database sufficient to support the development of regulatory and non-regulatory approaches to reduce and limit nutrients and organic carbon from sources that are contributing significantly to acidification of Maine's marine waters. Enhanced monitoring should begin in one or more pilot estuaries where impacts are presently occurring.*	1.1.1 Acquired and deployed high-frequency and precision OA monitoring sensors and collected nutrient water quality samples inside and outside of natural and aquacultured kelp beds (carbon sinks) in collaboration with Island Institute, UNH, and Atlantic Sea Farms in Casco Bay and the Damariscotta River Estuary with NOAA funding; data contributed to CBEP working group 1.1.2 Deployed high-frequency and precision OA monitoring sensors and collected nutrient water quality samples in collaboration in collaboration with USGS in Casco Bay on eelgrass beds (carbon sinks) with TNC funding; data contributed to CBEP working group 1.1.3 Worked with ME DMR to do rapid assessments of HABs and water quality in 2018 1.1.4 Bigelow hosts a high performance computing facility and data warehouse capable of storing over 200TB of data	1.1.1 Bigelow strategic plan includes a Big Data Discovery initiative, including geospatial datasets on ocean water quality, to integrate new data types (e.g., copepod distribution, HABs, nutrients, etc.) and unlock new insights – and in the case of ocean acidification, new remediation strategies. 1.1.2 Continued fundraising from state, federal, and philanthropic sources to support ongoing monitoring and data quality control, storage, and sharing efforts

	1.2. Expand monitoring of ocean acidification to establish its natural variability and to detect trends in water chemistry and related biological responses.	1.2.1 Deployed high frequency-precision instruments with FOCB equipment to cross calibrate less expensive citizen science sensor packages and validate trend data gathered at the FOCB long-term monitoring site 1.2.2 Maintain the GNATS database of ship-board measurements of several water quality parameters (including nutrient concentration and acidity) in the Gulf of Maine for the past four decades via support from NASA 1.2.3 One of the only groups to maintain nearshore *and* offshore monitoring stations through the winter months to gather data when acidity is seasonally peaking 1.2.4 Sharing of protocols with EPA, DMR, and local water testing companies to ensure quality statewide quality control	
	1.3. Develop new tools with which to assess and understand acidification and its impacts in Maine waters.	1.3.1 Recently upgraded the Bigelow Seawater Suite with philanthropic funds for OA and nutrient loading experimentation purposes	1.3.1 New funding acquired from NOAA MERHAB program to support development of a nearshore georeferenced modeling tool to predict HAB

		1.3.2 Refurbishment of an alkalinity titration system and investment in a high throughput spectrophotometric system for very accurate pH measurements with NSF funding	toxicities using buoy water quality data (including nutrient loading and acidification) for DMR
	1.4. Determine the causes and relative importance of acidification in the waters and sediments of Maine.		
	1.5. Identify the impacts of acidified waters and sediments on Maine's commercial species.	1.5.1 Ongoing experimentation of on the biological impacts of acidification and warming on oysters and their parasites, many species of commercialized seaweeds, mussels, lobsters, and the copepods, phytoplankton and microbes that are the base of the fisheries foodweb via funding from several state and federal resources and using our seawater facility; in collaboration with UMaine, Mook Sea Farm, Bangs Island Mussels, and others	

2. Reduce Emissions of Carbon Dioxide	*2.1. Strengthen coordination and continue participation with existing national, state, and regional initiatives regarding the reduction of atmospheric CO_2 levels.*	2.1.1 Service on the Seaweed Fisheries Advisory Council and recommending coordination with the Climate Panel to consider a Blue Carbon Initiative and accounting for carbon sequestration of our intertidal algae, eelgrass, and salt marshes 2.1.2 Membership with MOCA! And hosting MOCA meetings using Bigelow facilities 2.1.3 Membership with MCOA, NECAN, NeCSA, and KEEN – all statewide or regional working groups to assess water quality and shifting distributions or phenology as a result of climate change	2.1.1 Anticipated publication of a NOAA Tech Memo on the ecosystem services of seaweed cultivation, including carbon uptake, within the coming weeks

	2.2. Encourage key leaders and policymakers to synchronize in establishing a comprehensive and unified strategy to reduce carbon dioxide emissions.	2.2.1 Visits to Maine State delegation in DC twice annually, at minimum – the last of which resulted in all four senators and reps supporting an Ocean Acidification Bill 2.2.2 Testimony to Senate and House of Representatives on need for climate action NOW 2.2.3 Service with the Union of Concerned Scientists to encourage development of renewable energy resources 2.2.4 Service on an international steering committee to develop algae feed for ruminants that will suppress methane emissions	2.2.1 Host an invitation only international workshop in November 2019 to develop universal and informed roadmap to develop algae feed for ruminants that suppresses methane emissions and meet regulatory needs
	2.3. Expand actions at the state and local levels that may help in reducing CO_2 emissions.		

3. Identify and Reduce Local Land-Based Nutrient Loading and, Organic Carbon Contributions to Ocean Acidification and Freshwater Runoff by Strengthening and Augmenting Existing Pollution Reduction Efforts and Making Groundwater Recharge a Land Use Priority.	*3.1. Identify and reduce nutrient loading and organic carbon from point source and nonpoint discharges determined to cause or contribute to ocean acidification.*		3.1.1 Proposal pending with DOE to support tool development to implement standardized evaluation of cultivated micro or macroalgae capacity for bioextraction of nutrients and carbon, particularly within or at waste water treatment system discharge points. Will work with Boothbay wastewater managers and Nordic Aqua Farms to identify test sites
	3.2. Assess the need for water quality criteria relevant to ocean acidification.		
	3.3. Ensure that state staff and other practitioners are working with the best information and most effective technology.	3.3.1 Try to maintain regular communication with DEP and DMR and various working groups (seaweed, shellfish, etc.) about conclusions drawn from various research initiatives AND coordinate sampling	

		efforts/trainings where it makes sense to do so	
	3.4. Investigate incentive programs for pollution and freshwater runoff reduction.		
	3.5. Support and reinforce current planning efforts and programs that address the impacts of nutrients and organic carbon and freshwater runoff into coastal waters.		
	3.6. Enhance education and outreach programs that provide landowners with information about best practices for reduction of nutrient pollution.		

4. Increase Maine's Capacity to Mitigate, Remediate and Adapt to the Impacts of Ocean Acidification	*4.1. Preserve, enhance and manage a sustainable harvest of kelp, rockweed and native algae in bivalve areas and adjacent shoreline, and preserve and enhance eelgrass beds.*		4.1.1 Pending proposal with TNC to develop drone technology to rapidly assess extent, biomass, and carbon sequestration potential of intertidal macrophytes like rockweed, eelgrass, and salt marsh grasses along the Maine coastline, in coordination with citizen science efforts at UMaine and Schoodic and eelgrass mapping at DEP
	4.2. Encourage bivalve production to support healthy marine waters.	4.2.1 Participate in the Damariscotta River Estuary Oyster Celebration and Seaweed events in Portland and Midcoast Region to educate public about the restorative nature of shellfish and seaweed aquaculture 4.2.2 Participate in the Aquaculture Business Development and the Aquaculture in Shared Waters courses to educate would-be farmers about the benefits of co-cultivation of kelp and shellfish to water quality	

Comment [NNP1]: And seaweed! 4.1 seems geared toward wild population management

	4.2.3 Participate in the Aquaculture Workforce Development Steering Committee	
4.3. Spread shells or other forms of calcium carbonate ($CaCO_3$)in bivalve areas to remediate impacts of local acidification.	4.3.1 Ongoing research with Mook Sea Farm supported by CBEP and EPA to explore the utility of strategic placement of ground shells in oyster nursery (the stage AFTER hatchery) upweller systems to act as an antacid for acidified coastal seawater	
4.4. Increase the capacity of the fishing and aquaculture industries to adapt to ocean acidification.	4.4.1 Ongoing research with Atlantic Sea Farm, Island Institute, UNH, and Bangs Island Mussels supported by NOAA SK and philanthropy to explore the utility of the 'halo' effect of growing kelp and mussels together to protect shellfish from rising seawater acidity and communicating results to practitioners and policy-makers	4.4.1 Pending proposal at USDA Aquaculture program to develop lease-site specific predictive models about rate of warming and acidification and to compare cost-effectiveness of localized mitigation strategies
4.5. Identify refuges and acidification hotspots to prioritize protection and remediation efforts.	4.5.1 Ongoing underway mapping of CO_2 hot and cool spots in coastal waters with UNH	See 4.1.1 and 4.4.1

	4.6. Encourage the enhancement and creation of research hatcheries.	4.6.1 Developed a seaweed nursery and cryopreservation services to help support the growing Maine seaweed industry with internal funding from Bigelow and our National Center for Marine Algae and Microbiota	

5. Inform Stakeholders, the Public, and Decision-Makers about Ocean Acidification in Maine and Empower Them to Take Action.	*5.1. In addition to providing the commission's report, its key findings should be communicated to the Governor, Maine's legislative leaders, Maine's Congressional delegation, the press and the general public in a series of briefings by commission members.*		5.1.1 Bigelow can use our communications team, social media platforms, and media contacts to assist with echoing these messages
	5.2. Continue efforts to increase the understanding of ocean acidification among key stakeholders, targeted audiences and local communities to help implement the commission's recommendations.		5.2.1 Bigelow, with Island Institute, needs to convene a final stakeholder meeting for the current 'halo' project that is coming to a close within the next 12 months

	5.3. Enhance the existing communication network of engaged stakeholders, state agency representatives and the research community.	5.3.1 Bigelow uses its new Shimmield Residence facility built in 2017 to host educational and stakeholder meetings at no cost to conveners or participants when coordinated through the Center for Seafood Solutions	**See 1.1.1**
	5.4. Develop, adapt and use curricula on ocean acidification in K-12 schools and institutes of higher education and increase interdisciplinary university programs to equip young leaders with the skills to find solutions to complex multidisciplinary problems such as ocean acidification.	5.4.1 Ocean acidification is a large part of the Bigelow Research Experience for Undergraduates program, the Keller Bigelow Orders of Magnitude (BLOOM) high school program, the BLOOM middle school teacher education program, and our Colby Semester Program 5.4.2 The Boothbay Sea and Science Center and Edgecomb Eddy School both visit Bigelow to learn about ocean acidification and grow seaweed to test the 'halo' theory in their classrooms	

6. Maintain a Sustainable and Coordinated Focus on Ocean Acidification.	*6.1. Create an on-going ocean acidification council.*	6.1.1 Participant in MOCA since 2015 and steering committee member since 2017	

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