

# Maine Sea Grant Performance Review Panel Report: Program Introduction

More than half of Maine's population of 1.3 million people lives in counties along the state's 5,300-mile coastline. Most are concentrated in the greater Portland area, which is also Maine's economic hub, while sparsely populated eastern coastal counties experience some of the nation's highest poverty rates. According to the National Ocean Economics Program, Maine's ocean economy, which includes coastal and marine-related industry and tourism, contributed more than \$2.4 billion to the state's GDP in 2012. These activities are the lifeblood of many of Maine's coastal communities, particularly in Midcoast and Downeast Maine, where economic activity is less diverse.

Maine Sea Grant is based at the University of Maine, the state's designated land and sea grant college, as well as its largest and oldest research institution. Management and communications teams based in Orono work closely with Maine Sea Grant's Marine Extension Team (MET), a formal partnership between Sea Grant and UMaine Cooperative Extension. The MET serves as a link between stakeholders and the research and policy that affects Maine communities. While each staff member has his or her own expertise and programs, we collaborate daily on crosscutting issues.

Demand for Maine Sea Grant's limited research and program development funds has increased steadily in recent years, as has our status as a trusted source of science-based information, and our focus on improving Maine people's access to the latest science. While our total investments may seem small, our influence is large relative to state capacity. For example, Maine participates in the NSF Experimental Program to Stimulate Competitive Research (EPSCoR), and Maine Sea Grant is a primary player in two current EPSCoR grants focused on sustainable aquaculture and coastal water quality.

As you review our activities and impacts, you will note that we far exceeded most of the targets set for our 2010-2013 strategic plan, which prompted a change in our process for identifying targets in subsequent plans. We have since made them more ambitious.

Here we describe our contributions to science and technology and societal impacts, with an emphasis on areas not covered in the companion report from the National Sea Grant "PIER" database. Where we include additional information on some impacts and accomplishments already reported, numbers in the margins refer to the corresponding statement number.



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# Maine Sea Grant Performance Review Panel Report: Sustainable Coastal Community Development

Of Maine’s 5,300 miles of coast, only 20 miles support water-dependent industries, and the majority of commercial access points are privately owned and vulnerable to conversion. Different parts of the coast have different needs. In rural and remote eastern Maine, many communities are still largely dependent on marine resources but struggle with the loss of resource-based industries and demographic changes. Meanwhile, more urbanized southern Maine deals with coastal development and transportation issues. This focus area also requires a different kind of “science and technology.” Our contributions involve social science, legal research, and participatory processes that engage citizens in making decisions.

## AREAS OF IMPACT

Report  
reference  
numbers

### Working waterfronts

Maine Sea Grant helped to create the National Working Waterfront Network, an outcome of the 2007 and 2010 Working Waterways and Waterfronts National Symposia on Water Access, hosted in Virginia and Maine, respectively. In 2011, the U.S. Department of Commerce Economic Development Administration entered into a \$533,000 cooperative agreement with Maine Sea Grant, National Sea Grant Law Center, Florida Sea Grant, Virginia Sea Grant, Island Institute, Coastal Enterprises Inc., Urban Harbors Institute at University of Mass/Boston, National Marine Manufacturers Association, NOAA, and the Maine Coastal Program to develop and launch the **Sustainable Working Waterfronts Toolkit**, including the following reports:

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State funding for ports: selected state summaries and links to resources

Working waterfronts and the CZMA: defining water-dependent use

Financial Tools for Working Waterfronts

The Tiff over TIF: extending tax increment financing to municipal maritime infrastructure

Economic analysis of working waterfronts in the United States

Best practices for working waterfront preservation: lessons learned from the field

Engaging the legal community in working waterfronts

History, status, and future trends of working waterfronts

Sustainable Working Waterfront Toolkit Final Report, Key Findings, and Recommendations

Working waterfront case studies

Maine’s working waterfront efforts have also influenced legislation at the state and federal level:

US HR 3109 Keep America’s Waterfronts Working Act

VA HB 2263 A Bill to amend the Code of Virginia relating to state and local tax, fee, and regulatory relief for the preservation of commercial fisheries

Maine’s national influence in the working waterfront arena derives from work within the state over the last 12 years. We competed successfully for funding from the National Sea Grant Law Center to support research by legal experts at the University of Maine School of Law Center for Law and Innovation, communicated via [accessingthemaineoast.com](http://accessingthemaineoast.com). The site provides tools for landowners, waterfront users, and government and public entities to facilitate cooperative resolution of local coastal access conflicts. To date, seven states have adapted the Maine resource (AL, FL, HI, MS, NJ, TX, VA).

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6719 An example of impact at the state level is provided by Wolf Tone of the Trust for Public Land, who met a member of Surfrider’s Northern New England chapter at a coastal access forum hosted by Maine Sea Grant in southern Maine. The surfer expressed concern about conflicts over access to a local beach popular with surfers as well as striped fishermen and beach visitors. In 2010, with funding from the Land for Maine’s Future Program, the Trust for Public Land negotiated agreements with landowners and the town, and purchased 12 acres valued at \$1.44 million, securing permanent public access to the beach. Tone credited Sea Grant with providing the format and space for waterfront users to share ideas.

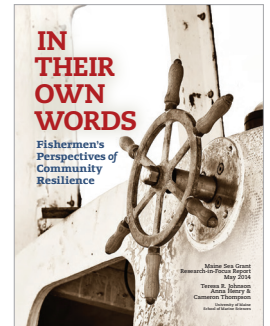
**Fishing communities**

6717 15204 Maine’s fishing communities are experiencing the cumulative effects of fish stock depletion, state and federal regulations, coastal development and demographic changes, and rising fuel and energy costs.

6722 In response to legal mandates and data gaps, social scientists have begun to develop and refine methodological approaches for defining fishing communities and conducting assessments of fishery regulations on communities. In 2010-2012 Maine Sea Grant researchers explored how those living within four Maine fishing communities understand their resilience.

Johnson, T.R., A. Henry, and C. Thompson. 2014. Identifying qualitative indicators of social resilience in small-scale fishing communities: an emphasis on perceptions and practice. *Human Ecology Review* 20(2):97-115.

Johnson, T.R., A. Henry, and C. Thompson. 2014. In Their Own Words: Fishermen’s Perspectives of Community Resilience. Orono, ME: Maine Sea Grant College Program.



18818 Tourism is one way that fishermen and aquaculturists can continue to work on the water while taking advantage of “Maine’s largest industry.” Legal research on barriers to collaboration among and between commercial fishermen, aquaculturists, and tourism providers, funded by the National Sea Grant Law Center, was translated into workshops, a series of fact sheets, and web content. Workshop participants have used information on topics such as insurance and liability, permitting, licensing, and contracting in developing plans to augment their business portfolios and income.

20833 17059 In the last five years, Sea Grant has led the revival and expansion of the Downeast Fisheries Trail, a fishing heritage education and tourism initiative in eastern Maine. The trail has helped to leverage existing tourism resources and attract new interest to Downeast Maine, where tourism provides economic development opportunities.



Springuel, N. 2011. Tourism in regions of natural resource decline: a Newfoundland Case Study. *Tourism in Marine Environments* 7(3/4):191-202.

## Beach communities

Coastal beaches are a significant driver of Maine's economy, attracting the majority of tourists in a state where tourism is the largest industry. More than \$500 million in estimated annual beaches-related spending supports the employment of 8,000 people. Southern Maine "Seacoast" communities are experiencing development pressure and rising home prices as demand increases for coastal living in proximity to Boston. To build the capacity for coastal communities to plan for future housing needs, Maine Sea Grant has worked with the Workforce Housing Coalition of the Greater Seacoast and the U.S. EPA to engage residents in neighborhood-scale planning for workforce housing, zoning changes, and other developments. This work has generated support from local businesses and employers, and led to creation of a training program for citizens in how to facilitate and run effective meetings.

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Three southern Maine towns have implemented Village and Workforce Housing zoning overlay districts.

Southern Maine communities are home to the majority of the state's sandy beaches, which are a top tourist destination yet are vulnerable to erosion and sea-level rise. Maine Sea Grant founded (in 1999) and coordinates the Southern Maine Volunteer Beach Profile Monitoring Program that employs volunteers to gather data on beach erosion and accretion. Within the last four years, participating towns have included program funding in their annual budgets. We created a [Guide to Managing Flooding, Erosion & Other Hazards](#) to help coastal property owners make development decisions. The Maine Geological Survey compiles the data in the [State of Maine's Beaches Report](#), released every two years in conjunction with the Sea Grant-coordinated [Maine Beaches Conference](#), and provides data to other communities and governments to inform decisions. For example:

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Ogunquit formed a beach erosion committee and the town voted to fund an engineering study.

Old Orchard Beach used data that confirmed beach stability to support building renovations and dune restoration at a major resort.

The state passed LD 256, An Act To Amend the Law Regarding Repairing a Structure in a Coastal Sand Dune System.

Maine's beach profile monitoring program has been adopted for application in the Yucatan region of Mexico.

Maintaining and restoring water quality at beaches is critical to the continued vitality of Maine's coastal tourism economy, as well as to the health and well-being of residents and visitors. Maine Sea Grant works with towns and property owners on stormwater and sewer infrastructure issues as part of the [Maine Healthy Beaches Program](#). In the last four years, program data and studies have informed changes in policy, legislation, and resource management at local and state levels, including:

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Kennebunkport implemented a Water Quality Ordinance for Goose Rocks Beach.

Lincolnville created a Sewer District.

Ogunquit passed an amendment to upgrade segments of the Leavitt Stream to include the protection of the entire stream under the Stream Protection District Ordinance; updated official zoning maps; invested in sewer infrastructure improvements and stormwater mapping.

Old Orchard Beach upgraded nearly 11,000 feet of sewer lines and 10,000 feet of stormwater infrastructure, and removed failed and illegal waste disposal systems.

Portland created a Stormwater Program Management Plan.

Rockland has invested approximately \$13 million in infrastructure improvements. This includes correcting illicit connections between storm and sewer, and replacing faulty sewer lines.



Rockport surveyed 54 residences, remediated malfunctioning subsurface wastewater disposal systems, and installed a boat pump-out station in the harbor.

Saco replaced 760 linear feet of sewer lines, developed a Watershed Management Plan and MS4 Community Stormwater Management Plan.

York implemented a Septic System Ordinance.

### Coastal communities in transition

We bring diverse perspectives and skills to our work, and Maine's Marine Extension Team members have developed the convening and facilitation skills necessary to make sure the right people are in the room when stakeholders are faced with difficult questions and decisions. We often help convene and facilitate highly-charged public processes, including working with communities on visioning, planning, and conflict resolution. We worked with UMaine Cooperative Extension to provide a facilitation training series in southern Maine, developing a regional network of 20 trained community facilitators.

In Frenchman Bay, we facilitated a group of organizations, businesses, and individuals as they explored ways to answer important conservation questions, resulting in the formation of Frenchman Bay Partners, an organization that is now developing a conservation plan and collaborative approach to Bay-wide issues.

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In the Bagaduce River, where proposals for new marine aquaculture leases became controversial, Sea Grant facilitated two public meetings attended by nearly 300 people that enabled community members, industry and managers to begin an open dialogue about shellfish farming in the local watershed.

Visioning work takes time. We first began helping the communities of the Schoodic Peninsula in 1996, when the U.S. Navy announced the closure of a base that employed some 350 Navy personnel and 150 civilians, making it the major employer for a rugged and remote stretch of Maine coast. As of 2015, the region now includes:

Schoodic Arts for All, based in a restored historic building.

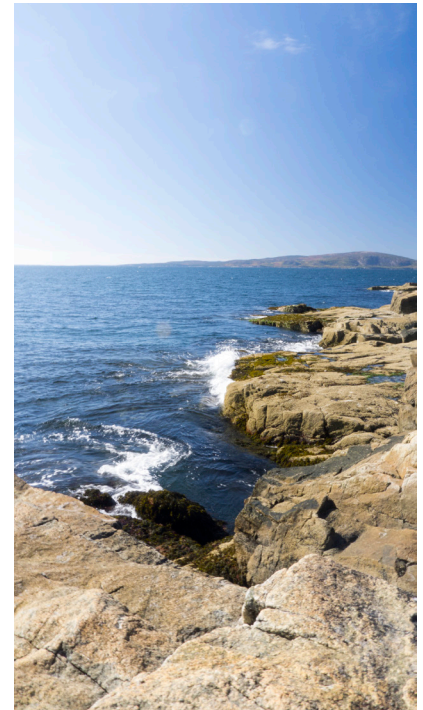
Schoodic National Scenic Byway (including more than \$1 million in associated grant funding).

Schoodic International Sculpture Symposium.

Schoodic Education and Research Center of Acadia National Park and Schoodic Institute (expanded and renovated with more than \$18 million in Congressional appropriations and park user fees).

Protection of 3,200 acres of land previously slated for development, some of which has been transferred to the National Park Service for a new campground and trails.

Follow-up surveys with residents of the region reveal a deep sense of pride in the local community, a sense of neighborliness, a safe environment in which to bring up children, and access to the natural resources of the region, including marine fisheries and the Schoodic portion of Acadia National Park. Respondents revealed their hopes for a future that includes traditional livelihoods as well as new opportunities stemming from the creative economy.



## Sustainable energy

With extensive undeveloped coastline and some of the most promising tidal and offshore wind resources in the U.S., Maine is at the forefront of the emerging ocean energy sector, including hosting the first grid-connected tidal energy device in the United States. Both the private Ocean Renewable Power Company and the Federal Energy Regulatory Commission (FERC) have used Maine Sea Grant's studies of tidal power interactions with fish and birds. FERC has adopted protocols for assessing marine hydrokinetic effects on fish populations, and Maine Sea Grant researchers and graduate students have shared their knowledge in an exchange with Hirosaki University and Hokkaido University in Japan.

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Viehman, H., G.B. Zydlewski, J.D. McCleave, and G. Staines. 2015. Using acoustics to understand fish presence and vertical distribution in a tidally dynamic region targeted for energy extraction. *Estuaries and Coasts* 38(Supp. 1):215-226.

Viehman, H., and G.B. Zydlewski. 2014. Fish interactions with a commercial-scale tidal energy device in the natural environment. *Estuaries and Coasts* 38(Supp. 1):241-252.

The University of Maine is also a leader in ocean-based wind energy research and development, building and testing new floating wind turbine designs for deployment off the central Maine coast. Since April 2013, Maine Sea Grant has coordinated community engagement in the project region, including hosting multiple public forums and meetings with lobster, shrimp, and scallop fishermen. Maine Sea Grant researchers tested acoustic wildlife monitoring equipment in association with development of floating wind turbines. A website, fact sheets, and nautical charts have been developed and shared with stakeholders. Maine Sea Grant's work in communities affected by offshore wind energy research and development have helped to correct misinformation and expand the sphere of engagement, reducing potential conflicts while incorporating more concerns into the development process.

## Planning for ocean uses

Wind is one of several potential competing uses of the Gulf of Maine. Coastal and marine planning initiatives require spatial data. Local and regional-scale uses of the ocean by humans are not as readily available to planners, and can be overlooked during state and federal planning efforts. As part of a pilot study, Maine Sea Grant researchers inventoried and mapped local fishing-related uses of the marine environment, engaging communities directly in the collection and use of baseline spatial data through interviews with fishermen from three communities. The results were leveraged for an additional \$242,500 from a variety of federal, state, and private sources. To date, the maps have been used by the Maine Coastal Program, the Maine Department of Marine Resources, the Northeast Regional Ocean Council, and StatOil.

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# Maine Sea Grant Performance Review Panel Report: Hazard Resilient Coastal Communities



The majority of Maine’s coastline is rocky, with cliffs and headlands that have been battered by waves for millennia. However, hurricanes and storms are major hazards in the parts of our coast that are made of softer materials, like bluffs, beaches, and wetlands. Maine’s coastal communities developed around their waterfronts, which are vulnerable to rising sea levels and storm surge. All of Maine is experiencing increasing temperatures and more frequent and intense precipitation events.

While some of Maine Sea Grant’s longstanding programs fall within this focus area, the majority of work is relatively recent, having begun just before this strategic plan cycle. Therefore, newer projects and programs have not yet yielded the kind of impacts as have longer-running efforts like the beach profiling program. We have, however, been able to leverage existing programs in our new initiatives.

## Areas of Impact

*Report reference numbers*

### Increasing knowledge of Maine’s changing shorelines

Southern Maine communities are home to the majority of the state’s sandy beaches, which are a top tourist destination yet are vulnerable to erosion and sea-level rise. Maine Sea Grant founded and coordinates a **beach profile monitoring program** that employs volunteers to gather data on beach erosion and accretion. Participating towns have included program funding in their annual budgets, and in 2013 the program expanded to three new beaches. The Maine Geological Survey compiles the data in the **State of Maine’s Beaches Report**, released every two years in conjunction with the Sea Grant-coordinated **Maine Beaches Conference**, and provides data to other communities and governments to inform decisions. For example:

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Ogunquit formed a beach erosion committee and the town voted to fund an engineering study.

Old Orchard Beach used data that confirmed beach stability to support building renovations and dune restoration at a major resort.

Wells evaluated the effectiveness of a \$1.4 million beach nourishment effort.

The state passed LD 256, An Act To Amend the Law Regarding Repairing a Structure in a Coastal Sand Dune System.

In 2012 the National Weather Service began using program volunteers as “storm teams” to conduct rapid pre- and post-storm profiling to determine the extent of short-term beach erosion and understand beach resilience dynamics.

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Maine’s beach profile monitoring program has been adopted for application in the Yucatan region of Mexico.

Maine Sea Grant researchers are studying the dynamics of sea-level rise in coastal wetland environments, for example where salt marshes and beaches abut freshwater bogs. In one location, wetland loss threatens a state road that provides the only means of access to a remote peninsula. Researchers are working with the state Department of Transportation to evaluate options.

17012

Kelley, J.T., D.F. Belknap, and M.E. Mansfield. 2015. **Encroachment of rising sea level upon raised freshwater wetlands, Lubec and Jonesport**. Maine Geological Survey Geologic Site of the Month, January.

## Building a resilient coast

Much of our work in this focus area continues outreach based on research conducted in 2008-2010 as part of a NOAA-funded project with Oregon Sea Grant, **Coastal Community Resilience: Building and testing a model of state-based outreach**. The results led to two lines of continued research and outreach.

### Adaptation Strategies in a Changing Climate (NSF EPSCoR, National Sea Grant)

- Study vulnerabilities and assets related to extreme precipitation events in Maine communities.
- **Culvert Operations** video, with Maine Public Broadcasting Network.
- Working with one municipality, develop user-friendly GIS and Google Earth models to show **stormwater infrastructure vulnerabilities and help the community assess and prioritize emergency management needs**. This work was cited in the **2014 National Climate Assessment**.
- Culvert inventory and assessment tool now being used by two additional communities (Damariscotta and Newcastle).

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### Coordinating and Enhancing Coastal Resiliency (National Sea Grant)

- **Building a Resilient Coast: Maine Confronts Climate Change DVD**. 6732
- Maine Property Owner's Guide to Flooding, Erosion & Other Coastal Hazards. 18778  
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- Resilient Coastal Property Demonstration Tours.
- Resilient building techniques training for municipal officials. 17062
- Southern Maine Volunteer Beach Profile Monitoring Program (see above).
- The Sandy Dialogues, an exchange between southern Maine coastal towns and New Jersey towns hit by Superstorm Sandy. 20839

Cone, J. 2013. Creating research-based videos that can affect behavior. *Journal of Extension* 51(2):2IAW2.

Cone, J., S. Rowe, J. Borberg, E. Stancioff, B. Doore, and K. Grant. 2013. Reframing engagement methods for climate change adaptation. *Coastal Management* 41(4):345-360.

Additional climate change adaptation projects are focused on specific sectors, such as fishing communities. Based on findings from a 2012 NOAA-funded research project focused on **promoting climate change awareness and adaptation planning in Atlantic fisheries communities**, we are developing decision-making tools and other resources for lobster fishermen in Midcoast Maine to help them “fish smarter, not harder.”

We are also sharing Maine's experiences with other Northeast states to **raise awareness of best practices** in climate change adaptation.

## Engaging citizens in climate science

The beach profile monitoring program described above is one of several “citizen science” programs that contribute data to research efforts while educating Maine residents and visitors about Maine's changing environment.

Increasing frequency and intensity of precipitation events affects water quality at Maine's beaches. The EPA-funded **Maine Healthy Beaches Program**, coordinated by Sea Grant and University of Maine Cooperative Extension, involves 55 beach management areas routinely monitored by teams of volunteers and posted with advisories according to established bacteria standards for marine recreational waters. Participants include towns, state and national parks, and private beach associations. Citizen volunteers and municipal or park staff are trained annually in the program's field methods. Special studies in communities where bacteria levels exceed federal standards draw connections between rainfall events, stormwater runoff, and beach water quality. Remediation efforts have resulted in infrastructure improvements and restored shellfish habitat. For example:

Old Orchard Beach upgraded nearly 11,000 feet of sewer lines and 10,000 feet of stormwater infrastructure, and removed failed and illegal waste disposal systems.

Portland created a Stormwater Program Management Plan.



Rockland has invested approximately \$13 million in infrastructure improvements. This includes correcting illicit connections between storm and sewer, and replacing faulty sewer lines.

Rockport surveyed 54 residences, remediated malfunctioning subsurface wastewater disposal systems.

Saco replaced 760 linear feet of sewer lines, developed a Watershed Management Plan and MS4 Community Stormwater Management Plan.

The Signs of the Seasons New England Phenology Program engages citizens in monitoring seasonal changes in their backyards. In 2014, more than 300 volunteers contributed 2,600 hours and more than 150,000 observations to the National Phenology Network database, which is used by scientists to track changes in ecologically and economically important species including spring leaf-out and reproductive stages of sugar maple, reproductive timing of rockweed, and other plant and animal life cycle events.

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Posthumus, E.E., L. Barnett, T.M. Crimmins, G.R. Kish, W. Sheftall, E. Stancioff, and P. Warren. 2013. Nature's Notebook and extension: engaging citizen-scientists and 4-H youth to observe a changing environment. *Journal of Extension* 51(1):11AW1.

### Informing policy discussions

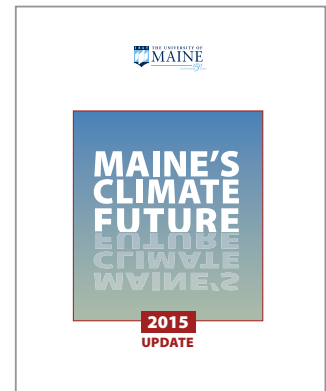
In 2009, Maine Sea Grant and the UMaine Climate Change Institute published **Maine's Climate Future**, a Maine-specific climate modeling and assessment effort by more than 70 scientists from across the state. The initial assessment continues to be widely cited and has positioned the University of Maine as the best source of information on climate change in Maine. The report led directly to the following outcomes:

**A Climate Change Stakeholder Adaptation Committee**, led by Maine state government, and resulting report.

Additional fact sheets and articles on specific topics, such as **sea-level rise**.

**Maine Climate News**, an online newsletter featuring quarterly updates from the state climatologist.

**Maine's Climate Future 2015**, featuring new temperature and precipitation modeling results and updated information on how Maine communities are already experiencing the effects of a changing climate.



Included in the Maine's Climate Future report is Sea Grant research on juvenile lobster settlement that has shown a northward shift in North Atlantic lobster populations.

Pershing, A., R.A. Wahle, P. Meyers, and P. Lawton. 2013. Large-scale coherence in New England lobster settlement associated with regional weather. *Fisheries Oceanography* 21:348-362.

Marine Extension Team members are positioned to assist Maine's fisheries and aquaculture stakeholders as they begin exploring issues related to ocean acidification and other climate-related changes in Maine's coastal waters, including participation in the **Northeast Coastal Acidification Network**. Since November 2013, NECAN has sponsored a **series of 16 webinars** on topics related to regional coastal and ocean acidification. Following the webinars, we conducted a two-day Ocean Acidification State of the Science workshop to summarize the relevant ocean acidification-related science in the region, and developed information that was the basis for stakeholder engagement workshops throughout New England and implementation planning.

Sea Grant program development funds supported an effort to develop statewide **research priorities**, and a **statewide taskforce on ocean acidification**, which released a report in January 2015. Maine is now forming an ongoing ocean acidification council to address the recommendations from the task force in order to maintain a sustained and coordinated focus on ocean acidification in the state.

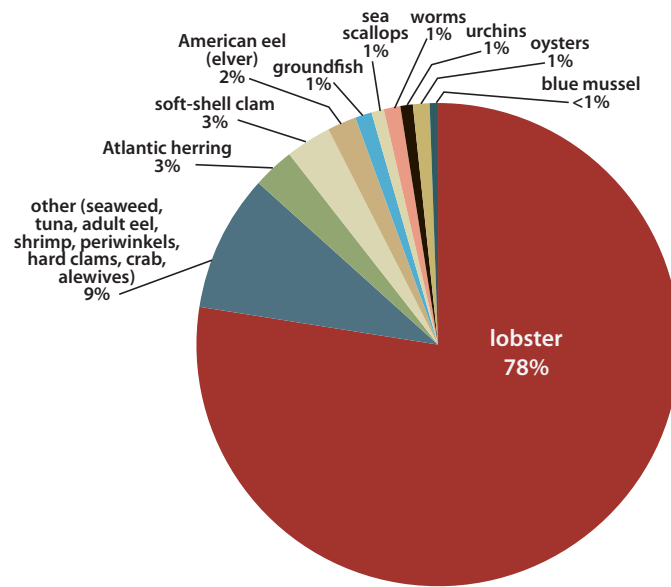
20852

Gledhill, D.K., et al. 2015. Ocean and coastal acidification off New England and Nova Scotia. *Oceanography* 28(2):182-197.

# Maine Sea Grant Performance Review Panel Report: Safe & Sustainable Seafood



Maine’s coastal communities rely on the sea for their economic and cultural livelihood. According to the National Marine Fisheries Service, the proportion of Maine workers employed in commercial fishing industries is more than ten times the national percentage, and commercial fisheries and aquaculture businesses in Maine are predominantly owner-operated. Yet Maine has lost most of its groundfish fleet and related infrastructure since 1980, and today a once-diverse fishing culture is overwhelmingly dependent on lobster, a vulnerable situation that one scientist has called “a gilded trap.”



Maine 2014 Seafood Landings by Ex-Vessel Value  
Total value= \$585,348,370

Report reference numbers

New seafood businesses created with Maine Sea Grant assistance:

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- 1 lobster pounding business
- 5 seaweed farms
- 6 shellfish aquaculture businesses

Businesses sustained:

- 1 international salmon aquaculture company
- 3 seaweed farms
- 10 shellfish aquaculture businesses
- 12 independent fishermen retained through fisheries/aquaculture income diversification.
- 130 lobster fishing families estimated to have stayed in business as a result of the Trade Adjustment Assistance Program

## Managing commercial fisheries

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Our work in this area is focused on fisheries managed at the state and/or community level, a scale at which our fishermen can get involved in science, monitoring, and management, and where communities can realize direct benefits from our work. Maine Sea Grant researchers have informed fisheries management through applied research in population dynamics, stock assessment, and sampling methodology.

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Brewer, J. 2011. Paper fish and policy conflict: catch shares and ecosystem-based management in Maine's groundfishery. *Ecology and Society* 16(1):15.

Brewer, J. 2014. Hog Daddy and the Walls of Steel: Catch shares and fish stories in the New England groundfishery. *Society and Natural Resources* 27(7):724-741.

Brewer, J. 2014. Harvesting a knowledge commons: collective action, transparency, and innovation at the Portland Fish Exchange. *International Journal of the Commons* 8(1):155-178.

Cao, J., Y. Chen, J.-H. Chang, and X. Chen. 2014. An evaluation of an inshore bottom trawl survey design for American lobster (*Homarus americanus*) using computer simulations. *Journal of Northwest Atlantic Fisheries Science* 46:27-39.

Cao, J., S.B. Truesdell, and Y. Chen. 2014. Impacts of seasonal stock mixing on the assessment of Atlantic cod in the Gulf of Maine. *ICES Journal of Marine Science: Journal du Conseil* 71(6): 1443-1457.

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Maine Department of Marine Resources and Plan Development Team. Fishery Management Plan for Rockweed (*Ascophyllum nodosum*), final report prepared for review by the Joint Standing Committee on Marine Resources of the 126th Maine Legislature, January 2014. Augusta, ME.

6724

McCarron, P., and H. Tetreault. 2012. Lobster pot gear configurations in the Gulf of Maine. Kennebunk, ME: Maine Lobstermen's Association, Consortium for Wildlife Bycatch Reduction, and New England Aquarium.

McMahan, M., D.C. Brady, D.F. Cowan, J.H. Grabowski, and G.D. Sherwood. 2013. Using acoustic telemetry to observe the effects of a groundfish predator (Atlantic cod, *Gadus morhua*) on movement of the American lobster (*Homarus americanus*). *Canadian Journal of Fisheries and Aquatic Sciences* 70:1625-1634.

Willis, T.V., K.A. Wilson, K.E. Alexander, and W.B. Leavenworth. 2013. Tracking cod diet preference over a century in the northern Gulf of Maine: historic data and modern analysis. *Marine Ecology Progress Series* 474:263-276.

Ying, Y., Y. Chen, L. Lin, and T. Gao. 2011. Risks of ignoring fish population spatial structure in fisheries management. *Canadian Journal of Fisheries and Aquatic Sciences* 68:2101-2120.

Zhao, J., J. Cao, S. Tian, Y. Chen, S. Zhang, Z. Wang, and X. Zhou. 2014. A comparison between two GAM models in quantifying relationships of environmental variables with fish richness and diversity indices. *Aquatic Ecology* 48:297-312.



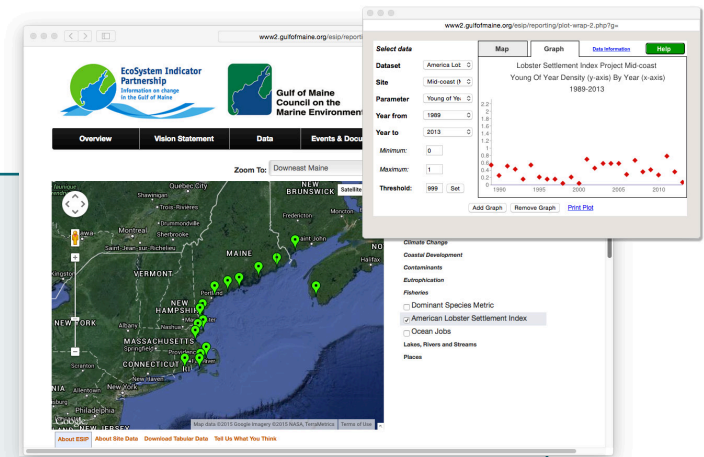
Zhang, Y., D. Brzezinski, J.H. Chang, K. Stepanek, and Y. Chen. 2011. Spatial structuring of fish community in association with environmental variables in the coastal Gulf of Maine. *Journal of North Atlantic Fisheries Science* 43:47-64.

Zhang, Y., and Y. Chen. 2012. Effectiveness of harvest control rules in managing American lobster fishery in the Gulf of Maine. *North American Journal of Fisheries Management* 32(5):984-999.

Zhang, Y., Y. Li, and Y. Chen. 2012. Modeling the dynamics of ecosystem for the American lobster in the Gulf of Maine. *Aquatic Ecology* 46:451-464.

Zhang, Y., Y. Chen, and C. Wilson. 2011. Developing and evaluating harvest control rules with different biological reference points for the American lobster (*Homarus americanus*) fishery in the Gulf of Maine. *ICES Journal of Marine Science* 68:1511-1524.

Maine Sea Grant researchers created the **American Lobster Settlement Index**, a measure of juvenile lobster populations throughout the North Atlantic, 25 years ago. The Index is used by state/provincial and national regulatory agencies in the United States and Canada to assess and manage the lobster stock. Recent Sea Grant funding supported development of a web portal for data viewing and analysis, and a tool for forecasting the fishery.



Burdett-Coutts, V.H.M., R.A. Wahle, P.V.R. Snelgrove, and R. Rochette. 2014. Spatial linkages between settling young-of-year and older juvenile lobsters. *Marine Ecology Progress Series* 499:143-155.

Pershing, A., R.A. Wahle, P. Meyers, and P. Lawton. 2013. Large-scale coherence in New England lobster settlement associated with regional weather. *Fisheries Oceanography* 21:348-362.

Sigurdsson, G.M., B. Morse, and R. Rochette. 2014. Light traps as a tool to sample pelagic larvae of American lobster (*Homarus americanus*). *Journal of Crustacean Biology* 34(2):182-188.

Wahle, R.A., C.E. Bergeron, J. Tremblay, C. Wilson, V. Burdett-Coutts, M. Comeau, R. Rochette, P. Lawton, R. Glenn, and M. Gibson. 2013. The geography and bathymetry of American lobster benthic recruitment as measured by diver-based suction sampling and passive collectors. *Marine Biology Research* 9:42-58.

In 2012, Maine Sea Grant coordinated and hosted an **international symposium on the American lobster**, attended by 150 researchers, students, fishermen, and managers. The symposium led to nine papers in a special issue of the *Canadian Journal of Fisheries and Aquatic Sciences*, new research collaborations, and a second symposium to be held in Prince Edward Island this fall.



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Maine is home to 11 species of diadromous or sea-run fish, some of which still support commercial fisheries. As a result, Maine is a leader in restoring habitat for migratory fish. Our work in this area has informed research and management within and outside of Maine. For example, NOAA contracted with Maine Sea Grant to coordinate a series of **workshops on Atlantic salmon in the marine environment**. We convened and facilitated a multidisciplinary team of scientists and wrote the final synthesis report, which led to numerous research projects on endangered Atlantic salmon and a new estuarine survey effort by NOAA Fisheries.

Anderson, P., and C. Schmitt (eds). Marine Ecology of Gulf of Maine Atlantic Salmon, summary document from a 2008-2010 series of workshops, MSG-TR-12-01. Orono, ME: Maine Sea Grant College Program.

We conducted field work and coordinated volunteers whose data enabled a statewide **assessment of rainbow smelt**, a federal species of concern.

Enterline, C.L., B.C. Chase, J.M. Carloni, and K.E. Mills. 2012. A regional conservation plan for anadromous rainbow smelt in the U.S. Gulf of Maine. Augusta, ME: Maine Department of Marine Resources.

Kovach, A.I., T.S. Breton, C. Enterline, and D.L. Berlinsky. 2013. Identifying the spatial scale of population structure in anadromous rainbow smelt (*Osmerus mordax*). *Fisheries Research* 141:95-106.



A Maine Sea Grant **study of dam removal** in a tributary of the Penobscot River has informed river restoration efforts throughout the state, results which have been shared nationally and which contributed to our involvement in NOAA's **Penobscot River Habitat Focus Area**.

Demi, L.M., K.S. Simon, S.M. Coghlan Jr., R. Saunders, and D. Anderson. 2012. Anadromous alewives in linked lake-stream ecosystems: do trophic interactions in lakes influence stream invertebrate communities? *Freshwater Science* 31(3):973-985.

Gardner, C., S.M. Coghlan Jr., J. Zydlewski, and R. Saunders. 2011. Distribution and abundance of stream fishes in relation to barriers: implications for monitoring stream recovery after barrier removal. *River Research and Applications* DOI:10.1002/rra.1572.

Gardner, C., S.M. Coghlan Jr., and J. Zydlewski. 2012. Distribution and abundance of anadromous sea lamprey spawners in a fragmented stream: current status and potential range expansion following barrier removal. *Northeastern Naturalist* 19(1):99-110.

Hogg, R., S.M. Coghlan Jr., J. Zydlewski, and K.S. Simon. 2014. Anadromous sea lampreys (*Petromyzon marinus*) are ecosystem engineers in a spawning tributary. *Freshwater Biology* 59(6):1294-1307.

Hogg, R., S.M. Coghlan Jr., and J. Zydlewski. 2013. Anadromous sea lampreys recolonize a Maine coastal tributary after dam removal. *Transactions of the American Fisheries Society* 142(5):1381-1394.

## Advancing sea vegetable and shellfish industries

Maine Sea Grant has served as a trusted leader in aquaculture research and development in Maine since we helped to establish the oyster aquaculture industry beginning in the 1970s. Our work in aquaculture has evolved and expanded with the growth of the industry, and includes continued development of new culture techniques and target species (scallops, razor clams, soft-shelled clams, Artic surf clams) , as well as marketing and industry support.

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Over the past four years, we have maintained our role as technical advisors, group decision-making process facilitators, and coordinators of shellfish and seaweed aquaculture working groups. In 2011, we expanded our capacity with a National Sea Grant Aquaculture Extension National Strategic Initiative grant that enabled hiring of an extension associate with expertise in marine macroalgae, with the resulting impacts described in the companion report.

Developing culture methods for sea vegetables involves learning more about the basic biology and genetics of native algae species. We have funded basic research along these lines, with related efforts to **develop new seaweed culture nursery capacity** at the UMaine Center For Cooperative Aquaculture Research.

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Blouin, N.A., and S.H. Brawley. 2012. An AFLP-based test of clonality in widespread, putatively asexual populations of *Porphyra umbilicalis* (Rhodophyta) in the Northwest Atlantic with an in silico analysis for bacterial contamination. *Marine Biology* 159:2723-2729.

Blouin, N.A., J.A. Brodie, A.C. Grossman, P. Xu, and S.H. Brawley. 2011. *Porphyra*: a marine crop shaped by stress. *Trends in Plant Science* 16(1):29-37.

Brawley, S., S. Redmond, and N. Brown. Pilot production of native *Porphyra* for land and sea-based IMTA, Final Report, Project No. 12-06. Orono, ME: Maine Aquaculture Innovation Center.

Chan, C.X. et al. 2012. *Porphyra* (Bangioophyceae) transcriptomes provide insights into red algal development and metabolism. *Journal of Phycology* 48:1328-1342.

Chan, C.X. et al. 2012. Analysis of *Porphyra* membrane transporters demonstrates gene transfer among photosynthetic eukaryotes and numerous sodium-coupled transport systems. *Plant Physiology* 158:2001-2012.

Stiller, J.W. et al. 2012. Major developmental regulators and their expression in two closely related species of *Porphyra* (Rhodophyta). *Journal of Phycology* 48:883-896.

Although MSX, a disease caused by a single-celled Protozoan parasite, has been present in Maine before, in 2010 **a large-scale outbreak occurred in the Damariscotta River**, the heart of Maine's oyster growing industry. With funds from both Maine Sea Grant and the National Sea Grant Office, the industry, the state, the university, and a private laboratory worked together immediately to develop and implement a surveillance program, including testing of oyster operations coastwide. The results served to ease the concerns of growers outside of the Damariscotta River by confirming that MSX was in fact contained within that one estuary. Additionally, baseline surveillance data for the natural and farmed populations in the Damariscotta River has been established, preventing the spread of MSX and limiting the economic impact on growers.



Larsen, P.F., K.A. Wilson, and D.L. Morse. 2013. Observations on the expansion of a relict population of Eastern oysters (*Crassostrea virginica*) in a Maine estuary: implications for climate change and restoration. *Northeastern Naturalist* 20(4):N28-N32.

Messerman, N.A., K.E. Johndrow, and T.J. Bowden. 2014. Prevalence of the protozoan parasite *Haplosporidium nelsoni* in the Eastern oyster, *Crassostrea virginica*, within the Damariscotta River Estuary, in Maine, USA in 2012. *Bulletin of the European Association of Fish Pathologists* 34(2):54-62.

20864 We supported the Gulf of Maine’s nearshore scallop fishery through collaborative research that engaged industry members in developing, refining, and improving hatchery **production and nursery techniques for cultured sea scallops** and to develop baseline data on biotoxin loads of cultured scallops.

### Building resilient fishing communities

6717 Maine’s fishing communities are experiencing the cumulative effects of fish stock depletion, state and  
6722 federal regulations, coastal development and demographic changes, and rising fuel and energy costs.

To help state and federal agencies assess fishery regulations on communities, Maine Sea Grant researchers explored how those living within **four Maine fishing communities understand their resilience**.

Johnson, T.R., A. Henry, and C. Thompson. 2014. Identifying qualitative indicators of social resilience in small-scale fishing communities: an emphasis on perceptions and practice. *Human Ecology Review* 20(2):97-115.

Johnson, T.R., A. Henry, and C. Thompson. 2014. In *Their Own Words: Fishermen’s Perspectives of Community Resilience*. Orono, ME: Maine Sea Grant College Program.

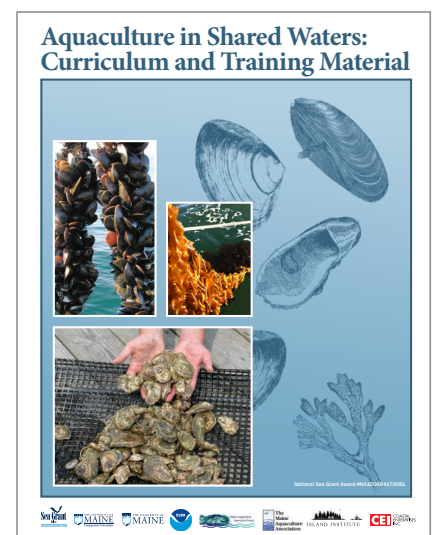


15200 With such a large percentage of communities dependent on marine resources, Maine Sea Grant was an early leader in state and national efforts to maintain and protect working waterfront assets and access to the shoreline. We helped to create the National Working Waterfront Network, an outcome of the 2007 and 2010 Working Waterways and Waterfronts National Symposia on Water Access, hosted in Virginia and Maine, respectively. In 2011, the U.S. Department of Commerce Economic Development Administration entered into a \$533,000 cooperative agreement with Maine Sea Grant, National Sea Grant Law Center, Florida Sea Grant, Virginia Sea Grant, Island Institute, Coastal Enterprises Inc., Urban Harbors Institute at University of Mass/Boston, National Marine Manufacturers Association, NOAA, and the Maine Coastal Program to develop and launch the **Sustainable Working Waterfronts Toolkit**. Our working waterfront efforts have also influenced legislation at the state and federal level.

Diversification and business training are other aspects of building resilient fishing communities. We coordinated the process of organizing and implementing the USDA’s **Trade Adjustment Assistance Program for the lobster fishery** in five Northeastern states, which delivered business training and technical and financial assistance to more than 4,000 lobster fishing families in the region, and 1,328 individuals completed in-depth business plans.

20846 We developed and delivered a 12-week **aquaculture training for commercial fishermen** interested in business diversification, and identified best practices for continuing this effort in 2015 through social science research conducted by UMaine investigators and students.

15215 Fishermen can stay in business by finding new ways to connect to consumers. We provided financial and planning support for the **National Summit on Community Supported Fisheries**, organized by New Hampshire Sea Grant, which brought together 75 CSF organizers, fishermen, and community leaders to explore the challenges and opportunities associated with the emerging model.





Tourism is one way that fishermen and aquaculturists can continue to work on the water while taking advantage of “Maine’s largest industry.” Legal research on barriers to collaboration among and between commercial **fishermen, aquaculturists, and tourism** providers, funded by the National Sea Grant Law Center, was translated into workshops, a series of fact sheets, and web content. Workshop participants have used information on topics such as insurance and liability, permitting, licensing, and contracting in developing plans to augment their business portfolios and income.

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In the last five years, Sea Grant has led the revival and expansion of the **Downeast Fisheries Trail**,

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a fishing heritage education and tourism initiative in eastern Maine. Through collaboration with the 45 sites on the Trail, we installed 12 new interpretive panels, produced an oral history video series highlighting harvester knowledge of eel and alewife fisheries, and published an annual online literary journal focused on the region’s fisheries heritage. Collaborations between Downeast Fisheries Trail and Experience Maritime Maine, Two Nation Vacation, and Downeast and Acadia Regional Tourism are enabling travellers to connect with fisheries and aquaculture heritage in ways that were previously unavailable.

Sometimes fishery rule changes resulted in behaviors that affect the safety of fishermen. Maine Sea Grant **research on fishing safety** has influenced safety training requirements and apprenticeship programs for multiple fisheries. We supported a NOAA survey crew mapping of an area of Cobscook Bay that experiences high rates of fishing fatalities, and provided funding and staff coordination for a U.S. Coast Guard-approved Fishing Vessel Drill Conductor Certification course for commercial fishermen.

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Backus, A., and M.E. Davis. 2011. Occupational safety and compliance in the Maine commercial fishing industry: status report and policy recommendations, July 2011. Medford, MA: Tufts University.

Davis, M.E. 2011. Occupational safety and regulatory compliance in US commercial fishing. *Archives of Environmental and Occupational Health* 66(4):209-216.

Davis M.E. 2012. Perceptions of occupational risk by US commercial fishermen. *Marine Policy* 36:28-33.



# Maine Sea Grant Performance Review Panel Report: Healthy Coastal Ecosystems

Maine’s extensive and diverse coastline supports commercial, recreational, and subsistence fisheries as well as tourism, all of which depend on clean water, plentiful marine resources, and diverse wildlife. Compared to other Eastern states, Maine’s population is small (1.3 million people) and our coastal ecosystems are relatively intact, a situation that presents challenges—how can we keep this place healthy and beautiful?—as well as opportunities for innovative resource management, restoration, and student engagement.

Report  
reference  
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Our work in this focus area informs and improves state and community-based ecosystem management efforts through research, and providing facilitation and coordination for habitat and ecosystem management initiatives. We have a history of developing and supporting diverse and often unconventional partnerships to leverage resources and expertise that would not otherwise be available for our work in this focus area.

## AREAS OF IMPACT

### Healthy beaches, bays, and shellfish beds

Maintaining and restoring coastal swim beach water quality is critical to the continued vitality of Maine’s coastal tourism economy. Water quality is also vitally important to Maine’s valuable seafood industry, supporting production of clams, mussels, oysters, and scallops. The **Maine Healthy Beaches Program** is coordinated by Maine Sea Grant and University of Maine Cooperative Extension in partnership with the Maine Department of Environmental Protection and U.S. EPA. Because Maine has thousands of miles of coastline and limited financial and human resources available for monitoring, the Maine Healthy Beaches Program is designed to build and maintain local capacity for pollution prevention. This partnership approach has helped to identify and fix sources of bacteria polluting beaches, reducing the number of beach advisories in some areas. The program trains some 200 citizens annually, educating and empowering citizens to take action. Motivated by their experience and increased knowledge, participants have pressed towns to look for and fix problems, pass stringent water quality ordinances, setback requirements, etc. The program coordinator routinely works with researchers in water quality and coastal resource management fields in other states to conduct watershed bacterial pollution surveys, learn and share new water quality field methods and sources of data, and provide updates and reports to participating communities.

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### Contributions to science & technology:

**Municipal Guide to Clean Water: Conducting Sanitary Surveys to Improve Coastal Water Quality**, produced in 2010, has been used by hundreds of towns, land trusts, and watershed management agencies across the country. The national Center for Watershed Protection has used this comprehensive guide to develop training modules for webinars as an international resource.

**Maine Healthy Beaches: a unique partnership to keep Maine beaches clean, status and trends 2005-2010**, summarizes data for the 55 participating beaches.

Pollution source identification tools have been developed with EPA.

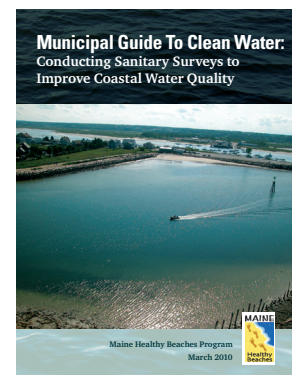
Microbial source tracking to identify human sources of fecal contamination, conducted in partnership with UMaine at Fort Kent and University of New Hampshire.

Sharing of library-based DNA Ribo-type source tracking methods.

Contribution to larger watershed restoration efforts, such as Clean Water Act Section 319 planning and implementation.

Development of a molecular technique using real-time (q)PCR to detect mammalian host mitochondrial DNA (mtDNA) in environmental surface water samples.

Use of bacteria-sniffing canine units to identify pollution sources.



One of Maine's water quality challenges is aging sewer and stormwater infrastructure, with increased use and stress on existing systems. Healthy Beaches Program data and studies have informed changes in policy, legislation, and resource management at local and state levels. Recent examples include:



Bar Harbor included a water resource protection chapter in its Open Space Plan.

Camden's Boater Education Campaign and pollution remediation efforts helped remove Rock Brook from the state's list of impaired waters. Camden also fixed four illicit cross connections and two broken sewer lines, and replaced their pump station.

Kennebunkport implemented a Water Quality Ordinance for Goose Rocks Beach.

Lincolntonville created a Sewer District.

Ogunquit passed an amendment to upgrade segments of the Leavitt Stream to include the protection of the entire stream under the Stream Protection District Ordinance; updated official zoning maps; invested \$50,000+ in sewer infrastructure improvements and stormwater mapping, passed an ordinance banning the use of pesticides on town property, and acquired 56 acres of green space and wetlands to help protect the Ogunquit River Watershed and Ogunquit Beach.

Old Orchard Beach upgraded nearly 11,000 feet of sewer lines and 10,000 feet of stormwater infrastructure, and removed failed and illegal waste disposal systems.

Portland created a Stormwater Program Management Plan.

South Portland fixed a sewer-stormwater cross connection.

Rockland has invested approximately \$13 million in infrastructure improvements. This includes correcting illicit connections between storm and sewer, and replacing faulty sewer lines.

Rockport surveyed 54 residences, remediated malfunctioning subsurface wastewater disposal systems, and installed a boat pump-out station in the harbor.

Saco replaced 760 linear feet of sewer lines, developed a Watershed Management Plan and MS4 Community Stormwater Management Plan.

York implemented a Septic System Ordinance.

Other states (MI, MA, WA, CA, OR and others) have adopted the Maine Healthy Beaches model to improve their own public outreach, and use our training materials and resources to facilitate better cooperation at the local level.

Sea Grant program development funds have supported other water quality work, including monitoring.

Disney, J., J. Charabati, and A. Farrell. 2014. Bar Harbor Cruise Ship Monitoring Report 2014, final report to the Bar Harbor Town Council. Salisbury Cove, ME: Environmental Health Laboratory MDI Biological Laboratory.

Dwyer, M. 2012. Microplastics in Blue Hill Bay: monitoring pilot project report. Blue Hill, ME: Marine Environmental Research Institute.



## Restoring important species & habitats

We have supported an eelgrass restoration experiment that developed new biodegradable grids for easy transplanting by students and volunteers, and studies of Maine's native "wild" oyster populations. 18713

Fox, E., S. White, G. Sato, M. Miller, G. Kidder, J. Hauck, and J.E. Disney. 2013. Effects of slow release nutrients on eelgrass (*Zostera marina* L.) morphometrics and water quality. *Bulletin of the Mount Desert Island Biological Laboratory* 52:34-36.

Kidder, G.W., and J.E. Disney. 2013. A comparison of transplant methods for eelgrass (*Zostera marina* L.) restoration in Frenchman Bay. *Bulletin of the Mount Desert Island Biological Laboratory* 52:37-39.

Larsen, P.F., K.A. Wilson, and D.L. Morse. 2013. Observations on the expansion of a relict population of Eastern oysters (*Crassostrea virginica*) in a Maine estuary: implications for climate change and restoration. *Northeastern Naturalist* 20(4):N28-N32.

White, S., S. Bleicher, E. Peirce, G.W. Kidder, and J.E. Disney. 2012. Lobster (*Homarus americanus*) size distribution in relation to proximity to eelgrass (*Zostera marina*) beds in Frenchman Bay. *Bulletin of the Mount Desert Island Biological Laboratory* 51:35-38.



Maine is home to 11 species of diadromous or sea-run fish, some of which still support commercial fisheries. Our work in this area has informed research and management within and outside of Maine. For example, NOAA contracted with Maine Sea Grant to coordinate a series of workshops on Atlantic salmon in the marine environment. We convened and facilitated a multidisciplinary team of scientists and wrote the final synthesis report, which led to numerous research projects on endangered Atlantic salmon and a new estuarine survey effort by NOAA Fisheries. 18720

Anderson, P., and C. Schmitt (eds). Marine Ecology of Gulf of Maine Atlantic Salmon, summary document from a 2008-2010 series of workshops, MSG-TR-12-01. Orono, ME: Maine Sea Grant College Program. 15212

We conducted field work and coordinated volunteers whose data enabled a statewide assessment of smelt. 17056

Enterline, C.L., B.C. Chase, J.M. Carloni, and K.E. Mills. 2012. A regional conservation plan for anadromous rainbow smelt in the U.S. Gulf of Maine. Augusta, ME: Maine Department of Marine Resources.

Kovach, A.I., T.S. Breton, C. Enterline, and D.L. Berlinsky. 2013. Identifying the spatial scale of population structure in anadromous rainbow smelt (*Osmerus mordax*). *Fisheries Research* 141:95-106.



A Maine Sea Grant study of dam removal in a tributary of the Penobscot River has informed river restoration efforts throughout the state, results which have been shared nationally. 17016  
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Demi, L.M., K.S. Simon, S.M. Coghlan Jr., R. Saunders, and D. Anderson. 2012. Anadromous alewives in linked lake-stream ecosystems: do trophic interactions in lakes influence stream invertebrate communities? *Freshwater Science* 31(3):973-985.

Gardner, C., S.M. Coghlan Jr., J. Zydlewski, and R. Saunders. 2011. Distribution and abundance of stream fishes in relation to barriers: implications for monitoring stream recovery after barrier removal. *River Research and Applications* DOI:10.1002/rra.1572.

Gardner, C., S.M. Coghlan Jr., and J. Zydlewski. 2012. Distribution and abundance of anadromous sea lamprey spawners in a fragmented stream: current status and potential range expansion following barrier removal. *Northeastern Naturalist* 19(1):99-110.

Hogg, R., S.M. Coghlan Jr., J. Zydlewski, and K.S. Simon. 2014. Anadromous sea lampreys (*Petromyzon marinus*) are ecosystem engineers in a spawning tributary. *Freshwater Biology* 59(6):1294-1307.

Hogg, R., S.M. Coghlan Jr., and J. Zydlewski. 2013. Anadromous sea lampreys recolonize a Maine coastal tributary after dam removal. *Transactions of the American Fisheries Society* 142(5):1381-1394.

### Protecting Maine's marine resources from invasive species

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Maine's location at the northeastern corner of the United States with cooler ocean water temperature and low population density, has helped to limit damage caused by marine invasive species. However, given the state's reliance on natural resources, Maine has been vigilant about monitoring and awareness of the threat. One species that is here, the European green crab, recently exploded in abundance with impacts on the soft-shelled clam, which supports one of Maine's most valuable commercial fisheries. Maine Sea Grant's responses include:

Support for a statewide green crab population density survey led by the Department of Marine Resources.

Coordination of a December 2013 Maine Green Crab Summit attended by 600 industry, agency staff, researchers, students, and other stakeholders.

Supported several green crab-related applied research and monitoring projects.

We also coordinate the Maine Marine Invasive Species Collaborative of researchers, state and federal agency staff, educators, environmental monitoring groups, and industry members. Meetings are typically attended by researchers and state and federal agency staff from New Hampshire and Massachusetts, in addition to those from Maine.

Leeuw, T., S.O. Newburg, E.S. Boss, W.H. Slade, M.G. Soroka, J. Pederson, C. Chryssostomidis, and F.S. Hover. 2013. Remote identification of the invasive tunicate *Didemnum vexillum* using reflectance spectroscopy. *Applied Optics* 52:1758-1763.



### Informing ecosystem-based management

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Much of the research funded by Maine Sea Grant in the realm of fisheries falls into this focus area because the results contribute to "ecosystem-based management." Maine Sea Grant researchers work closely with the state Department of Marine Resources and Atlantic States Marine Fisheries Commission to improve understanding, assessment, and management of commercial marine species, many of which are coastal fisheries managed at the state level. Here we include recent peer-reviewed articles and reports that demonstrate our contributions to science in this area.

Burdett-Coutts, V.H.M., R.A. Wahle, P.V.R. Snelgrove, and R. Rochette. 2014. Spatial linkages between settling young-of-year and older juvenile lobsters. *Marine Ecology Progress Series* 499:143-155.

Cao, J., S.B. Truesdell, and Y. Chen. 2014. Impacts of seasonal stock mixing on the assessment of Atlantic cod in the Gulf of Maine. *ICES Journal of Marine Science: Journal du Conseil* 71(6):1443-1457.

Cao, J., Y. Chen, J.-H. Chang, and X. Chen. 2014. An evaluation of an inshore bottom trawl survey design for American lobster (*Homarus americanus*) using computer simulations. *Journal of Northwest Atlantic Fisheries Science* 46:27-39.

Jury, S.H., and W.H. Watson III. 2013. Seasonal and sexual differences in the thermal preferences and movements of American lobsters. *Canadian Journal of Fisheries and Aquatic Sciences* 70:1650-1657.

Maine Department of Marine Resources and Plan Development Team. Fishery Management Plan for Rockweed (*Ascophyllum nodosum*), final report prepared for review by the Joint Standing Committee on Marine Resources of the 126th Maine Legislature, January 2014. Augusta, ME.

McMahan, M., D.C. Brady, D.F. Cowan, J.H. Grabowski, and G.D. Sherwood. 2013. Using acoustic telemetry to observe the effects of a groundfish predator (Atlantic cod, *Gadus morhua*) on movement of the American lobster (*Homarus americanus*). *Canadian Journal of Fisheries and Aquatic Sciences* 70:1625-1634.

Steneck, R.S., and R.A. Wahle. 2013. American lobster dynamics in a brave new ocean. *Canadian Journal of Fisheries and Aquatic Sciences* 70:1612-1624.

Wahle, R.A., A. Battison, L. Bernatchez, S. Boudreau, K. Castro, J.H. Grabowski, S.J. Greenwood, C. Guenther, R. Rochette, and J. Wilson. 2013. The American lobster in a changing ecosystem: a US-Canada science symposium, 27-30 November 2012, Portland, Maine. *Canadian Journal of Fisheries and Aquatic Sciences* 70:1571-1575.

Willis, T.V., K.A. Wilson, K.E. Alexander, and W.B. Leavenworth. 2013. Tracking cod diet preference over a century in the northern Gulf of Maine: historic data and modern analysis. *Marine Ecology Progress Series* 474:263-276.

Ying, Y., Y. Chen, L. Lin, and T. Gao. 2011. Risks of ignoring fish population spatial structure in fisheries management. *Canadian Journal of Fisheries and Aquatic Sciences* 68:2101-2120.

Zhang, Y., D. Brzezinski, J.H. Chang, K. Stepanek, and Y. Chen. 2011. Spatial structuring of fish community in association with environmental variables in the coastal Gulf of Maine. *Journal of North Atlantic Fisheries Science* 43:47-64.

Zhang, Y., Y. Li, and Y. Chen. 2012. Modeling the dynamics of ecosystem for the American lobster in the Gulf of Maine. *Aquatic Ecology* 46:451-464.

While most of our climate change related work falls within the “Hazard Resilience in Coastal Communities” focus area, there are obvious overlaps with building and maintaining healthy ecosystems. Based on findings from a 2012 NOAA-funded research project focused on promoting climate change awareness and adaptation planning in Atlantic fisheries communities, we are developing decision-making tools and other resources for lobster fishermen in Midcoast Maine to help them “fish smarter, not harder.”