

HABITAT HOTLINE *Atlantic*

2021 Annual Issue



HEALTHY FISHERIES NEED HEALTHY HABITAT

Climate Change and Coastal Habitat Resiliency

It has been another interesting year with a number of challenges brought on by the COVID-19 pandemic. COVID-19 notwithstanding, it is once again my privilege, as Chair of the Atlantic State Marine Fisheries Commission's (ASMFC) Habitat Committee, to share with you the *2021 Habitat Hotline Atlantic*. This has been the second year in a row where nothing came easy and yet so much has been done in the realm of habitat conservation with respect to our East Coast fish stocks. It is with great appreciation that I extend my thanks to all of those who have contributed to the *2021 Habitat Hotline Atlantic*.

This year's issue focuses on climate change and coastal habitat resiliency and what the states are doing in regards to both. So much is changing so quickly. In this day and time, we are being presented with many trials, and just as many opportunities, to focus on these issues and to strategically determine how best to go about facing the challenges ahead. To state the obvious, if we are not able to protect our critically important habitats, we will not be able to protect our fisheries which are so dependent on these habitats. The states are doing some remarkable things to combat the challenges associated with rising seas and other issues related to a changing climate. In this issue, you will be able to see what is being done up and down the Atlantic seaboard.

The articles in this year's *Habitat Hotline Atlantic* demonstrate the commitment of ASMFC's Habitat Committee and their respective state agencies and institutions to addressing climate change and coastal resiliency with some very creative and novel approaches. It is my hope that you enjoy reading this year's edition of the *Habitat Hotline Atlantic*.

Jimmy Johnson
Habitat Committee Chair



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AN OVERVIEW

How Fish Habitats Provide Ecosystem Services to Buffer the Effects of Climate Change

Dean E. Carpenter, North Carolina DEQ

Imagine you are a new advisor of a habitat management team responsible for the protection and restoration of a significant section of coastal landscape and seascape mosaic along the Atlantic seaboard. The team has been guided by a coastal habitat strategic plan whose primary goal is aligned with fish and wildlife benefits, but there is a growing recognition that a more comprehensive accounting of societal benefits could pose a much stronger case to stakeholders for natural-infrastructure conservation. Your assignment is to propose which additional benefits deserve a fuller accounting from a science-based perspective. Are you up to the challenge?

The conservation of coastal habitats does impart multiple ecosystem services to society, or in plain language aids in increasing “nature’s services for people.” A primary service recognized by ASMFC is sustaining the productivity of various fisheries. Yet in conserving the amount and quality of coastal habitats, policy makers, and resource managers are also increasing additional services whose long-term societal benefits will complement their positive impact on fisheries production.

The ecosystem services featured in this issue of *Habitat Hotline Atlantic* are among those additional services. While significant services such as those from cultural/spiritual and biodiversity perspectives should be included in your advisor’s proposal, here we are addressing services collectively improved by “ecosystem resiliency.” Resilience is meant to counter exposure to climate-related stressors that through human actions are increasing in

magnitude, frequency, and/or duration. These stressors whose amplification of extremes have and will pose substantial increases in societal risk include:

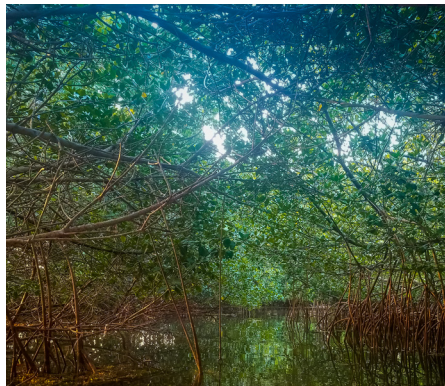
- Precipitation altering hydrologic flows, contaminant loads, and salinity regimes
- Winds altering water-column mixing, currents, tidal surges, sediment resuspension, and contaminant distribution
- Ambient temperatures influencing marine and estuarine surface-water temperatures and stratification
- Relative sea level rise increasing water column depth and elevating wave-height platforms
- Carbon dioxide concentrations impacting marine and estuarine acidification and associated carbonate system dynamics

Resiliency of coastal habitats provides a “natural defense” by reducing exposure to the above stressors. The desired outcomes are risk reductions to people and built structures (buildings, roads, etc.), as well as reduced impacts to the distribution, abundance, productivity, and dispersal of marine and estuarine biota. The resilience capacity to a particular stressor varies by habitat type. Some key habitats and example benefits include:

- Emergent marshes: improvements in water quality through filtering excess nutrients, improved clarity by sediment trapping via



North Carolina coastal wetlands. Image credit NCDMF.



Mangroves in Key West, Florida. Image credit: Shutterstock/Zachary G. Justus.



Salt marsh along Cape Cod Bay. Image credit: Shutterstock/Bob Pool.



reduced flow velocities, and land erosion and subsidence stabilization by increased net sedimentation rates. Interactions at landscape scales between back-barrier marshes and barrier islands will play a role in determining how low-lying coastal ecosystems respond to climate stressors where barrier islands exist.

- Submerged aquatic vegetation (SAV): provide similar water quality improvements qualitatively to that of emergent marshes in terms of nutrient removal and sediment filtration and stabilization. By filtering the water column of pathogens, they reduce contamination in seafood. SAV also oxygenates otherwise hypoxic sediment, thus promoting high microbial activity and nutrient cycling. Their ability to provide local pH buffering has been demonstrated. Furthermore, at landscape scales SAV meadows operate as dynamic sources and sinks of sediment that influence the evolution of coupled marsh and barrier island landforms.
- Oyster reefs: as is the case for other bivalves, oysters' filtration services improve water quality by enhancing nutrient cycling. They abate eutrophication and hypoxia in the water column by reducing organic matter directly and regenerate nutrients that support new production of organic matter, plus enhance sediment processes through biodeposition.
- Living shorelines: the three featured habitats above when adjacent to shore should be considered natural or living shorelines. Yet, here

we refer to habitats where both ecosystem-based and engineering approaches are applied: an “integrated greening of grey infrastructure.” This option may be called for in situations of non-sheltered shoreline exposed to high wave energy, for example in cases where shoreline regression would provide high net societal costs.

While the featured aquatic habitats provide to some degree an important service of coastal protection through wave attenuation, flooding, and storm surge, so too do coastal forests (e.g. mangroves, trees, shrubs), coral reefs, high and low dunes, and additional intertidal vegetation.

Not only are coastal habitats a means of adaptation to a changing climate, they also provide a means of greenhouse gas mitigation by sequestering significant stocks of blue carbon in their biomass and sediment. Yet certain landscape configurations, for example SAV patchiness, appear to reduce the carbon storage capacity. To complement the traditional approach to mitigation by tabulating wedges of habitat amounts for bolstering carbon sequestration, there is potential to increase mitigation effectiveness further by acknowledging interdependencies and connectivity among habitat types.

Sharing these examples of scientific insights on the contributions of different coastal habitats to ecosystem resiliency can motivate coastal management teams to incorporate “co-benefits” in their strategic planning and sets the stage for the following case studies.



Healthy wetland edge. Image credits: ASMFC.



ATLANTIC COASTAL FISH HABITAT PARTNERSHIP UPDATE

Atlantic Coastal Fish Habitat Partnership

Lisa Havel, ACFHP

The Atlantic Coastal Fish Habitat Partnership (ACFHP) has continued to help restore and protect fish habitat in 2021 while working through the challenges of remote collaboration and implementation of America's Conservation Enhancement Act, which codified the National Fish Habitat Partnership (NFHP) into law in FY2021.

On the Ground Conservation

ACFHP has partnered with the U.S. Fish and Wildlife Service (Service) for the 12th consecutive year to fund three new on-the-ground restoration projects in 2021 through National Fish Habitat Action Plan funding. The USS NORTH CAROLINA Battleship Commission is leading [a project in Wilmington, North Carolina](#) to restore 800 linear feet of intertidal shoreline and establish two acres of tidal wetland in order to connect hydrologic function and services to the Cape Fear River for fish habitat and water quality benefits. This work will also reduce nuisance flooding that has both ecological and economic impacts. Species to benefit include federally-managed species, such as shortnose and Atlantic sturgeon.

The Town of Braintree, Massachusetts was funded to [remove the Armstrong Dam](#) on the Monaquot River, the primary barrier to fish passage on the river. The dam removal will restore 36 miles of unimpeded upstream access for river herring and American eel. This project was selected as one of NFHP's [Ten Waters to Watch](#) for 2021.

Finally, Audubon Connecticut is working with partners to restore [39 acres of salt marsh](#) and other intertidal habitat at Great Meadows Marsh in the Stewart B. McKinney National Wildlife Refuge in Stratford, Connecticut. Impacted by land use changes and development, invasive plant species, and sea level rise, the project will restore ecological functions, increase faunal species abundance and diversity, and improve marsh resilience. Restoration activities will provide cover, forage, and spawning habitats for estuarine fish and macro invertebrates, such as Atlantic silverside, winter flounder, horseshoe crab, and other priority ACFHP species.

In the spring of this year, the Florida Fish and Wildlife Foundation, with funding from the FishAmerica Foundation through ACFHP, completed its project to

restore SAV in Moore's Creek, a tributary of the Indian River Lagoon, Florida. Moore's Creek often decreases the Indian River Lagoon water quality, so the Foundation worked with the Florida Fish and Wildlife Conservation Commission and AquaTech to deploy 46 enclosures (28 were paid for by FishAmerica Foundation) of seagrass and pondweed in order to improve water quality and provide fish habitat.

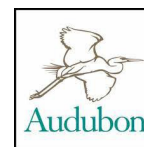
For the third year in a row, ACFHP has received funding from the National Oceanic and Atmospheric Administration (NOAA) Recreational Fishing Opportunity to support restoration and outreach projects on the Atlantic coast. This year, funding was awarded to the Coastal Conservation Association Maryland to highlight and improve two existing recreational fishing resources, the Bill Burton Fishing Pier in Cambridge, Maryland and the existing Maryland Artificial Reef Initiative reef at the pier. In 2014/2015, up to 350 mini-bay sized reef balls were deployed between the Bill Burton Fishing Pier and the Route 50 highway bridge. These reef balls were pre-set with oyster spat and deployed in a way to enhance fishing opportunities at the pier. Unfortunately, after the deployment of the reef balls, no efforts have been made to inform pier anglers and other users that the reef balls exist. This project comprises of a four-part outreach and education effort that uses signage, a live-streaming web camera, multiple reef ball building activities, and the production of a video to share the specifics of this project. The signage, web camera landing site, reef ball builds, and video will all include Spanish and English language/speakers to more effectively reach the diverse recreational fishing community that uses the pier.

ACFHP Welcomes Two New Partners

ACFHP was thrilled to welcome [Restore America's Estuaries](#) and [National Audubon Society](#) as our newest partners this year. ACFHP currently has 38 partners representing state, federal, tribal and non-governmental agencies. These fish habitat resource managers, scientists, and communications professionals have established a commitment to work together for the benefit of aquatic resources. To learn more about our partners, visit: [Our Team – Atlantic Coastal Fish Habitat Partnership \(atlanticfishhabitat.org\)](#).



RESTORE
AMERICA'S
ESTUARIES



Audubon



How Do You Like Your Carbon? I'll Take Mine Blue

Phil Colarusso, EPA Region 1

Salt marshes and seagrasses have long been recognized for their value as fishery habitat. In the age of a changing climate, these habitats are now also being valued for ecosystem services that moderate the worst impacts of climate change. Salt marshes and seagrass meadows reduce coastal erosion and provide shoreline protection from coastal storms. Seagrass meadows are thought to serve as a refuge for shellfish from ocean acidification. Science has begun to spend more time on another ecosystem service these habitats provide, carbon sequestration.

Seagrasses, salt marshes, and mangroves are considered blue carbon habitats due to their ability to accumulate and sequester large quantities of carbon. The vast majority of the carbon associated with these habitats exist isolated in the sediments below them. That large reservoir of carbon-rich peat builds up over decades and centuries and will remain sequestered as long as the habitats stay intact. Loss of these habitats risks releasing the stored carbon in the sediments back into the global carbon cycle, exacerbating climate change.

The rapidly growing plants absorb carbon and integrate it into their tissues. Eventually, that tissue senesces, degrades, and the carbon is incorporated into the sediments. However, that is only part of the story. A large percentage of the carbon in the sediments associated with these habitats originates from outside of them. Seagrass meadows and to a lesser extent salt marshes and mangroves function as huge filters. As the tide moves water in and out, the physical presence of the plants results in water currents being slowed, facilitating the settlement of floating organic particles. In seagrass meadows, up to 75% of the carbon in the sediments originates from outside of the meadow itself.

In light of the important role in sequestering carbon that marshes and seagrasses play, the U.S. Environmental Protection Agency (EPA) has led a group of 27 scientists in compiling the

first regional quantification of blue carbon stocks in New England and New York. A compilation of the most current eelgrass and salt marsh maps was created and can be found on the Northeast Ocean Data Portal (<https://www.northeastoceandata.org/>). The group compiled sediment carbon data taken from within these habitats from a variety of sources. These two datasets were combined to generate carbon stock “heat” maps, which by variations in color show where different quantities of carbon may be found.

Natural resource managers can use the carbon heat maps to quantify an important ecosystem service to help inform conservation decisions. As far as we know, this is also the first regional compilation of current salt marsh and seagrass meadow distributions. Both of these habitats serve significant fishery functions, so this work should benefit fishery managers as well. The sediment carbon dataset represents a unique opportunity for additional analysis and potential peer-reviewed journal article publications.



Salt marshes and seagrasses serve as important carbon sinks. Image credits: EPA.



Exploring Blue Carbon Credit through Coastal Resilience Projects that also Support Fish Populations

*Stefanie Simpson, Bo Lusk, and
Lauren Hutch Williams, TNC*

Our increasing understanding of the role nature plays in climate mitigation, coupled with private sector interest to reduce their carbon footprints, have led to an emerging and growing market for natural climate solutions. Aquatic vegetation communities, especially those in estuarine environments, like smooth cordgrass salt marshes, mangrove marshes, and seagrass are especially good at converting atmospheric carbon dioxide, a major greenhouse gas, into organic forms buried in sediments and maintained in plant tissues. Blue carbon strategies have initially focused on terrestrial plant communities (e.g. mangrove forests), however, the exceptional carbon sequestration capacity of coastal marshes and seagrasses are an attractive additional option for market driven carbon offset projects.

Pan to the Volgenau Virginia Coast Reserve on the eastern shore of Virginia, the longest expanse of coastal wilderness on the U.S. East Coast, where The Nature Conservancy (TNC) is exploring a blue carbon offset project. TNC owns

and/or manages 40,000 of these 133,000 acres, which include barrier islands, eelgrass, salt marsh, mudflats, and upland forests. Eelgrass disappeared from the area's coastal bays in the early 1930s due to a pandemic wasting disease. TNC joined partners at the Virginia Institute of Marine Science and University of Virginia to restore eelgrass to the area and further research the ecosystem services it provides. These expansive underwater meadows play an important role in stabilizing adjacent marshes, increasing their natural ability to protect coastlines from erosion. They also support critical shellfish habitat and mitigate the impacts of climate change by capturing and storing carbon in their soils and biomass.

Where blue carbon offsets are generated from quantifying the climate mitigation benefits of coastal wetland projects, resilience credits are generated by quantifying their flood reduction benefits. TNC aims to stack these two credits, to generate blue carbon resilience credits, as a way for invested companies to offset their carbon footprint while simultaneously reducing flooding and enhancing estuarine fish community habitat in vulnerable coastal areas.

TNC is increasing awareness and capacity for developing blue carbon resilience credit projects in Virginia and Texas by working with local partners, private landowners, and state and federal agencies to identify top priority areas for

Welder Flats, a Texas salt marsh. Image credit: Stefanie Simpson, TNC.





coastal wetland restoration and conservation, in addition to assessing the interest and capacity for a supporting market. Using methodologies approved by the Verified Carbon Standard, a global leader in issuing high quality carbon offsets, eelgrass restoration in coastal Virginia will be registered as the world's first blue carbon seagrass offset project, enabling it to sell verified carbon offsets on the voluntary carbon market. The sale of these carbon offsets will support continued research and management efforts to

support this vital habitat now and in the future. In Texas, TNC is kicking off the first blue carbon offset feasibility study for the state, assessing the climate mitigation potential of priority projects and market viability across various sites and restoration and protection approaches. This pre-feasibility study will inform market development and scaling opportunities across Texas and raise the awareness of the blue carbon values provided by Texas coastal landscapes.

Linking NOAA's Habitat Climate Vulnerability Assessment with Managed Species

Michelle Bachman, NEFMC and Jessica Coakley, MAFMC

Essential Fish Habitat (EFH) designations describe fish-habitat associations and distributions for federally-managed fish and shellfish in text and maps. State-managed species habitat use is documented in ASMFC management plans, and the relative importance of various habitats to coastal species was collated through the ACFHP Species-Habitat Matrix project (*Kritzer et al. 2016*). All these products inform fishery management decisions and are considered when assessing the effects of non-fishing projects on marine and coastal environments.

A drawback is that these products are largely static, while both fish and their habitats are continually responding to the significant environmental changes currently occurring on the Northeast U.S. shelf. Managers need tools to understand how both species and habitats are likely to be vulnerable to climate change, which provides important context for management decisions. The NOAA National Marine Fisheries Service (NOAA Fisheries) continues to refine a suite of climate vulnerability assessments to characterize the exposure and sensitivity of both species and habitats to climate. The results of these

assessments provide important decision support and help managers anticipate changes and manage risk.

The New England Fishery Management Council (NEFMC), Mid-Atlantic Fishery Management Council (MAFMC), and NOAA Fisheries are currently co-leading a contract to develop narratives that combine elements of two Northeast assessments: the Fish and Shellfish Climate Vulnerability Assessment (Hare et al. 2016) and the recently completed Habitat Climate Vulnerability Assessment (Farr et al. in review), with EFH designations and the ACFHP Matrix. These narratives will succinctly describe a species' climate vulnerability, its habitat use, and the climate vulnerability of those habitats, allowing managers to quickly identify issues of concern for a particular fish species. The project will also create a web-based decision support dashboard to display information from the various assessments in one place and in combination with other results of the Northeast Fish Habitat Assessment (see NEFMC-MAFMC update for more information on this assessment). The results of this project will be available in summer or fall 2022.

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Kritzer, J. P., M. B. DeLucia, E. Greene, C. Shumway, M. F. Topolski, J. Thomas-Blate, L. A. Chiarella, K. B. Davy, and K. Smith. 2016. The Importance of Benthic Habitats for Coastal Fisheries, BioScience, 66: 274-84.

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UPDATES FROM AROUND THE COAST

MAINE

Claire Enterline, ME DMR

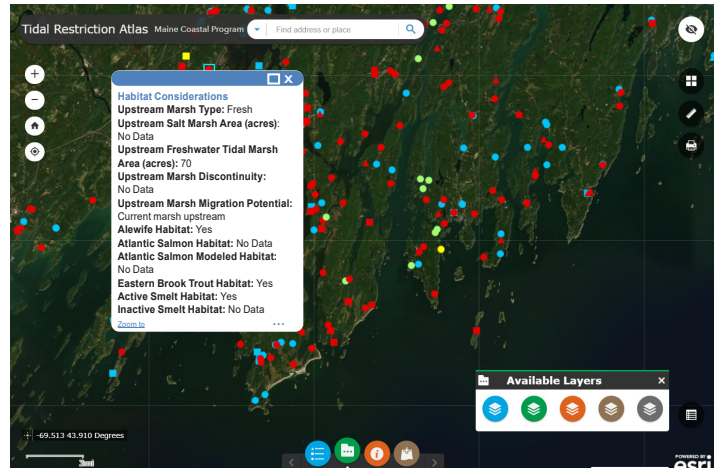
The Development of the CoastWise Approach for Tidal Road Crossings

The services provided by tidal wetlands can include coastal storm and flood damage protection, pollutant break-down, fish and wildlife habitat, and opportunities for commercial harvesting and recreation. Some, like salt marshes, store atmospheric carbon that would otherwise contribute to sea level rise and other climate shifts. To deliver these services, tidal wetlands must remain healthy and resilient to sea level rise. That requires unimpaired tidal flow, but about 90% of Maine's tidal road crossings are tidal restrictions. These crossings put Maine's tidal wetlands at risk, but are also more apt to experience flooding, higher maintenance costs, and interrupted access to emergency services.

Traditional practices for designing tidal road crossings have not adequately addressed the unique complexities, uncertainties, risks, or benefits associated with tidal environments. In response, Maine Coastal Program and over 30 organizations have developed the CoastWise Approach for tidal crossing design. CoastWise provides a voluntary set of best practices, decision-making tools, and path for designing safe, cost-effective, ecologically-supportive, and climate-resilient tidal crossings. Tidal crossings require a design approach that adequately addresses complexity and risk, now and in the future.

Principles of the CoastWise Approach include:

- Providing tools to show which crossings are tidal now or likely to be in the coming decades through the [Tidal Restriction Atlas](#)
- Planning for the complexity of tidal projects
- Working with a CoastWise Technical Partner to help with project planning and other support; engaging qualified engineering with expertise in sea level rise, tidal hydrodynamic modeling, and tidal environments
- Encouraging local participation
- Identifying risk factors like wetland condition, vulnerable species, and low-lying infrastructure
- Planning for appropriate sea level rise scenarios based on likelihood of flooding, emergency access needs, and long-term cost effectiveness



A screenshot of the Tidal Restriction Atlas. Figure credit: Maine Coastal Program.

- Sizing crossings for climate resilience and, if possible, unrestricted tidal exchange

The CoastWise Approach will provide outreach, training modules for road owners, and technical support, in addition to a set of best management practices.

Living Shorelines Decision Support Tool for Casco Bay and Demonstration Projects

There has been an increased interest by the State and many Maine municipalities to explore employing living shoreline techniques, especially in coastal bluff environments, to help curtail erosion while still maintaining the natural continuity of the land-water interface and providing habitat value. The Maine Geological Survey developed the Living Shorelines Decision Support Tool for Casco Bay map viewer to provide generalized information regarding the potential suitability of living shoreline approaches for sections of shoreline in Casco Bay. Each point is a combined (cumulative) score of different key factors that influence the suitability of the shoreline for green infrastructure approaches using the scoring system. Factors include:

- Annualized fetch (the dominant direction and percent time over the year the wind comes from that direction)
- Nearshore bathymetry (the depth of water within 30 meters of the shoreline)
- Landward shoreline type (the dominant landward shoreline type)



- Seaward shoreline type (the dominant seaward shoreline type)
- Relief (the relief of the shoreline 50 feet landward of the mean high water line)
- Percent slope (the percent slope of the shoreline 50 feet landward of the mean high water line)
- Aspect (the direction which the shoreline faces)

Maine has also been part of a two-year NOAA-funded Regional Resilience Grant which focused on identifying the challenges of implementing living shorelines in New England. In Maine, a large team of state, local, and regional partners used the Living Shorelines Decision Support tool to select three pilot project sites where there was evidence of eroding bluffs or marsh toes. Led by Casco Bay Estuary Partnership, the partners will conduct monitoring for five years to determine the efficacy of the different installations in curtailing erosion, the impacts of the treatments to surrounding habitats, survivability of the different installations in Maine's harsh winter climate, and compare and contrast the synthetic vs. biodegradable installations.

Offshore Wind Developments, Roadmap, and Research Lease Application

Through the Maine Offshore Wind Initiative, launched in June 2019 by Governor Janet Mills, the state will explore opportunities for thoughtful development of offshore wind energy in the Gulf of Maine and determine how to best position Maine to benefit from an industry expected to generate \$1 trillion in global investment by 2040. The Initiative aims to balance this industry development with our state's maritime heritage and existing marine uses to ensure sustainable preservation of the natural resources in the Gulf of Maine. Maine is also working closely with neighboring states and the federal government to evaluate regional opportunities in offshore wind energy in collaboration with maritime interests in the Gulf of Maine, particularly the fishing industry.

Aspects of the Initiative include the formation of Maine Offshore Wind Roadmap and a recent (September 2021) application to Bureau of Ocean Energy Management (BOEM) to lease a 15.2-square-mile area nearly 30 miles offshore in the Gulf of Maine for the nation's first floating offshore wind research site in federal waters. The State hopes to deploy a small-scale research array of 12 or fewer wind turbines on innovative floating hulls designed at the University of Maine. The lease area was selected following an extensive public outreach process led by the Governor's Energy Office, which included [an analysis by the Maine Department of Marine Resources \(ME DMR\)](#) that helped identify areas that minimized known potential impacts on the fishing industry. This effort will be advanced under the guidance of a Maine offshore wind research consortium, which will include members of Maine's fishing industry, marine scientists, offshore wind industry experts, and others to oversee research priorities for the array. By addressing fundamental questions about how offshore wind can exist in the Gulf of Maine, the intent of the research array is to advance the development of Maine's offshore wind economy while informing the responsible growth of floating offshore wind.

Other elements of the Offshore Wind Initiative include a comprehensive economic plan for an offshore wind industry in Maine, the [Maine Offshore Wind Roadmap](#);



Living shoreline installation in Brunswick, ME. Image credit: P. Slovinsky, Maine Geological Survey.

a study of port infrastructure to support offshore wind [focusing on Searsport](#); regional collaboration through the [Gulf of Maine Task Force](#); and forging offshore wind research and development partnerships. The Governor's Energy Office invites involvement in planning Maine's offshore wind future by engaging in the development of the Roadmap. For details on upcoming meetings, please visit www.maineoffshorewind.org.

Additions to the Maine Department of Marine Resources Environmental Monitoring Program

ME DMR Environmental Monitoring Program in West Boothbay Harbor maintains one of the longest continuous records of sea surface temperature in the Northwest Atlantic with daily measurements dating back to 1905. The station has also recorded observations of air temperature, barometric pressure, relative humidity, wind speed, and wind direction since 2012. In 2020, ME DMR researchers expanded the capacity of this program by deploying pH, dissolved oxygen, and partial pressure of carbon dioxide sensors at the station. Since these deployments ME DMR has collaborated with universities and other researcher institutions across Maine to ensure the quality and accessibility of these data. All ME DMR station data is available on the [ME DMR website](#) and upon request to jesica.d.waller@maine.gov.



A tern with a fish. Image credit: University of New Hampshire.

have changed since the 1970s and will make projections of future fish diets as waters warm. Many fish species have moved up the coast with climate change but each species' shift is unique, leading to potential changes in predator-prey relationships and diets of groundfish. While groundfish can slowly react to changes in ocean temperatures by seeking new habitats, breeding seabirds remain on islands during the summer to raise their chicks. In response, the Lab (supported by New Hampshire Sea Grant and led by Dr. Elizabeth Craig of Shoals Marine Laboratory) is exploring the use of common terns for monitoring juvenile fish communities in the Gulf of Maine. Terns are effective at capturing fish that are hard to assess with traditional methods: small, juvenile fish that use

open-water habitats. The team is using data describing fisheries productivity and the fishes captured by terns for their chicks at the Isles of Shoals from 1999 to present to identify the fish species for which seabirds serve as good indicators. With this information, the team can explore shifts in the productivity and community structure of juvenile fishes under climate change. Across these two projects, the research team hopes to provide relevant linkages between fish and seabird diet to fisheries productivity and environmental conditions to aid

in the proper management of resources and improved predictions of the continued impacts of climate change.

NEW HAMPSHIRE

How Does Climate Change Affect Feeding by Fishes and Seabirds?

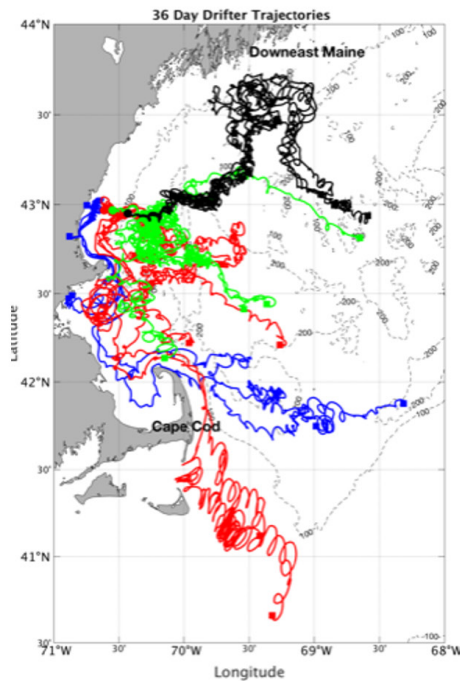
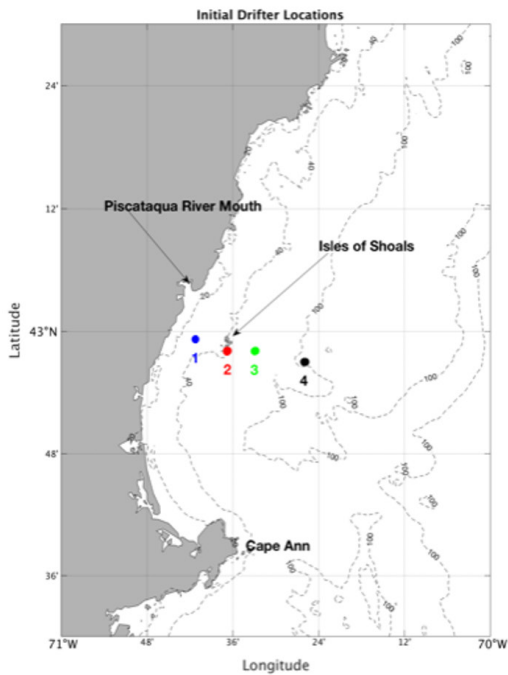
Aliya Caldwell, Nathan Hermann, and Nathan Furey, University of New Hampshire Fish and Movement Ecology Lab

The Fish and Movement Ecology Lab directed by Dr. Nathan Furey at the University of New Hampshire is researching how climate change will impact the Gulf of Maine ecosystem through the perspectives of both fish and seabirds. First, a National Science Foundation-funded project in collaboration with the Gulf of Maine Research Institute is determining how groundfish diets

Potential Impacts of Climate Induced Changes in Temperature on the Movement of Egg Bearing Lobsters and Recruitment in the Gulf of Maine

Jason Goldstein, Wells National Estuarine Research Reserve, and Joshua Carloni, NHF&G

In collaboration with Wells National Estuarine Research Reserve in Maine, New Hampshire Fish and Game (NHF&G), the University of New Hampshire, and St. Joseph's College of Maine, are conducting research on American lobster with funds awarded from National Sea Grant's American Lobster Research Initiative. The goals for this multiyear project are three-fold: 1) Assess the thermal preferences of ovigerous (egg-bearing) female lobsters over their full course of egg development in the



Trajectories for drifters released off the coast of New Hampshire at 4, 11, 16 and 26 kilometers from shore over 36 days. Six drifters were released at each location. The two release locations closest to shore tended to move in a southwest direction along the shore towards Cape Cod, while the two offshore locations tended to stay in deeper water farther away from shore. Figure credit: University of New Hampshire.

lab; 2) Measure and document post-larval swimming performance and nutritional condition under different temperature scenarios; and 3) Model larval dispersal based on changes in temperature patterns in the southern Gulf

of Maine coastal waters. Our team hopes to use and report on these data to better understand the thermal preferences of ovigerous lobsters, how these preferences may influence their present and future distribution, and how a change in their distribution might impact the ability of post-larvae to recruit to their nursery grounds. Similar to what has been observed in Southern New England, our assumption is that ovigerous females will move farther offshore to hatch their eggs as temperatures continue to rise in Gulf of Maine waters. Using ocean surface drifters and advanced oceanographic modeling, we can begin to determine the location where larvae will metamorphose from passive drift (i.e. Stages I-III) to the active swimming post-larval Stage IV. We can then use the results from our lab experiments on the swimming performance and speed of post-larvae to model their ability to recruit to inshore areas from these locations under different environmental conditions.



Ocean drifter assembly crew poses onboard the NHF&G's R/V Endeavor. Pictured from left to right: Amanada Giacchetti, Laura Crane, Erin Pellitier, Phoebe Oehmig, Tom Lippmann, Josh Carloni, Ben Gutzler, Jason Goldstein, and Jang-Geun Choi. Not pictured: Win Watson. Image credit: NHF&G.



Ocean drifters floating after being released from R/V Endeavor. Drifters include a GPS device, solar powered light, and contact information. Image credit: Wells National Estuarine Research Reserve.

MASSACHUSETTS

Mark Rousseau, MA DMF

Ocean Acidification Commission

The Massachusetts Division of Marine Fisheries (MA DMF) participated in the Massachusetts Ocean Acidification (OA) Commission. In 2018, “An Act Promoting Climate Change Adaptation, Environmental and Natural Resource Protection, and Investment in Recreational Assets and Opportunity” was passed by the Massachusetts State Legislature, creating a special legislative commission to investigate and study ocean acidification. The 17 member Commission panel released its [Report on Ocean Acidification Crisis in Massachusetts](#) in February 2021, focusing on available science to help understand and mitigate the impacts of OA. The report notes that Massachusetts will be disproportionately affected by ocean acidification given the relative importance of its coastal economies and environments. The report lists several recommendations aimed at protecting important coastal fish habitats from climate change impacts, including developing best practices for shell fishing and marine industries, improving acidification monitoring along the coastline, and updating nutrient pollution regulations to reflect the impact of acidification due to eutrophication. Over the next five years, priorities to address include establishing a broad, sensitive OA monitoring system, increasing funding to existing programs to address coastal stressors, assessing the

effects of OA on commercially important marine species, and developing a set of best practices for the shellfish and marine industry.

MA DMF Bottom Temperature Data

Time-series datasets are vital in assessing impacts to fisheries and habitats impacted by climate change. MA DMF began collecting sea bottom temperature data in Buzzards Bay in 1986 and has gradually expanded active monitoring locations to 54 stations in Massachusetts coastal waters. Temperature sensors are fixed to the

seafloor and programmed to collect data at set time intervals. Sensors are replaced annually, and data is loaded into a database containing more than 2 million temperature records.

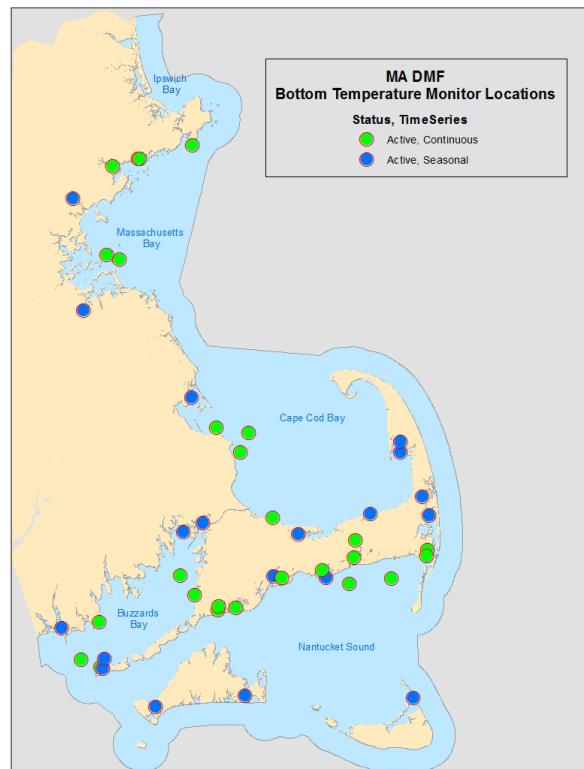
Internally, the data are used by multiple projects to address climate related questions ranging from how ocean warming

affects managed species such as northern shrimp and lobster, to regional changes to eelgrass habitats resulting from climate change, to monitoring the potential impact of climate change on *Vibrio parahaemolyticus*, a pathogenic marine micro-organism responsible for foodborne illnesses in Massachusetts.

MA DMF has provided data to the Massachusetts Office of Coastal Zone Management Baseline Assessment and Science Framework for the 2021 Massachusetts Ocean Plan, and researchers from Massachusetts Institute of Technology Sea Grant used the data as part of a project using diverse multi-fidelity measurements to predict and map temperature.



Mass OA Commission Report. Figure credit: Massachusetts OA Commission.



MA DMF Bottom Temperature Monitoring Stations. Figure credit: MA DMF.



Their model is intended to help decision makers evaluate the potential of existing data-acquisition systems, and improve the efficiency of system monitoring and predictive capabilities.

MA DMF continues to explore enhancing data accessibility and expanding efforts to collect data needed to explore long-term fisheries management strategies at local and regional scales.

RHODE ISLAND

Eric Schneider, RI DEM, DMF

The Rhode Island Department of Environmental Management, Division of Marine Fisheries (RI DEM, DMF) in partnership with Northeastern University and the Pew Charitable Trusts is initiating a planning process in early 2022 that will engage stakeholders to inform the development of a Rhode Island Shellfish Restoration and Enhancement Plan. The initial focus is to guide restoration and enhancement of Eastern oyster (*Crassostrea virginica*) in Rhode Island state waters; however, spatial and user information on all shellfish species will be considered in the process. The process will provide multiple opportunities for stakeholders and partners to inform restoration goals, targets, and priority locations. The plan also includes updated information on natural oyster populations and an oyster habitat suitability index model, supported by the Southeast New England Program Watershed Grant Program funded by the EPA through a collaboration with Restore America’s Estuaries. The Shellfish Restoration and Enhancement Plan will be a living document that can be updated as new information and science becomes available. For more information contact Eric Schneider at eric.schneider@dem.ri.gov.

New York

Alexa Fournier, NYSDEC

Legislative Updates Promote Resiliency Measures

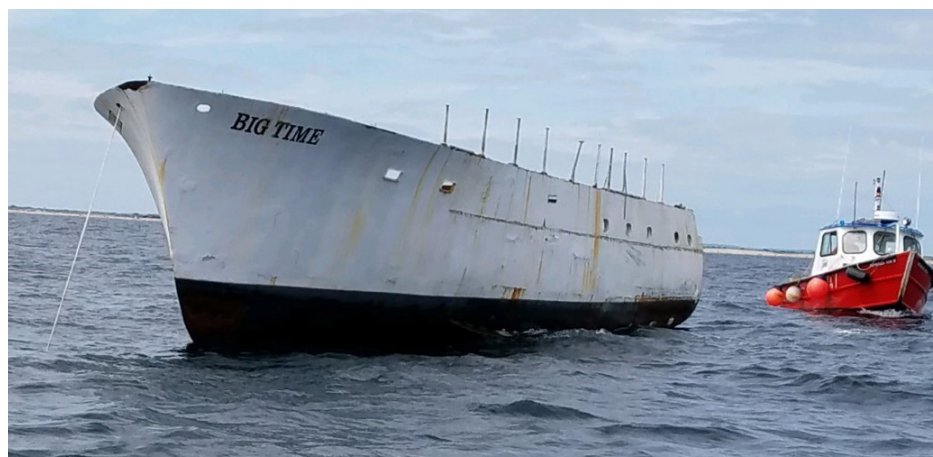
The protection and restoration of coastal fish habitats (such as salt marshes, seagrass beds, and oyster reefs) are key priorities in New York’s coastal resiliency strategy. Natural resilience

measures are actions that conserve, restore, or mimic natural landforms and processes to reduce climatic risks. In November 2020, the New York State Department of Environmental Conservation (NYSDEC) and Department of State released a document, [Using Natural Measures to Reduce the Risk of Flooding](#) to serve as a guide to the selection and planning of natural resilience measures.

The Climate Leadership and Community Protection Act (CLCPA), signed into law by Governor Cuomo in July 2019, is the most aggressive climate and clean energy initiative in the nation, calling for an orderly and just transition to clean energy that creates jobs and continues fostering a green economy as New York State recovers from the COVID-19 pandemic. CLCPA amended the Climate Risk and Resiliency Act of 2014 to expand the list of state permit programs covered by the law, as well as the scope of climate hazards that must be considered in these permit programs. CLCPA explicitly recognizes that protecting and restoring natural features and promoting the use of nature-based features in state and local decisions will contribute to resilience and reduction of risk from flooding and erosion.

New York Bay Scallop 2019/2020 Fishery Disaster Declarations

The Secretary of Commerce, working with NOAA Fisheries, has declared that New York’s bay scallop fishery in 2019 and 2020 meets the requirements of a fishery resource disaster under section 312(a) of the Magnuson-Stevens Fishery Conservation and Management Act and section 308(d) of the Interjurisdictional Fisheries Act. This determination makes New York’s bay scallop fishery eligible for fishery disaster assistance.



DEC Deploys Vessel “Big Time” to Enhance Artificial Reef. Image credit: NYSDEC.



Reduced biomass and access to the bay scallop fishery in the Peconic Bay Estuary of eastern Long Island has largely been attributed to high summer water temperatures, low dissolved oxygen, physiological stress of adult scallop spawning, and an outbreak of a coccidian parasite – all of which are beyond the control of fishery managers. Predation by cownose rays is also considered to be a contributing factor in the mortality of adult scallops.

The Department of Commerce will determine an allocation of funds for this fishery disaster and provide more information regarding the award process and requirements for these funds.

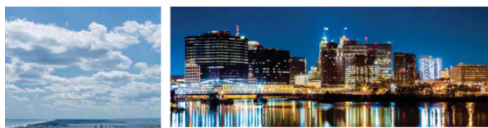
In August 2021, NYSDEC announced the deployment of the vessel “Big Time,” a 55-foot steel luxury Feadshipcruiser Showboat built in 1956, on the Fire Island Reef as part of the state’s ongoing efforts to expand New York’s network of artificial reefs. This sustained effort is developing a stronger, more diverse marine ecosystem and providing shelter for fish and other marine life off New York’s shores.

In November 2020, the Artificial Reef Program deployed 16, 75-foot steel rail cars donated by Wells Fargo on Fire Island Reef; 59 additional rail cars were deployed on five other reef sites.

To date, New York’s Artificial Reef Program has deployed a total of 4,700 tons of jetty stone, 1,810 cubic yards of Tappan Zee Bridge materials, three New York Canal Corporation steel barges, Erie Canal lift bridges and miter gates and pontoons, New York State Department of Transportation steel bridge girders, trusses and pipe, and the U.S. Army Corps of Engineers research vessel



New York’s bay scallop fishery has been declared a disaster for 2019 and 2020. Image credit: NYSDEC.



New Jersey’s Climate Change Resilience Strategy. Figure credit: NJDEP Marine Fisheries Administration.

“M/V Hudson” on Fire Island Reef. All materials were deployed under the guidance of the Reef Program to ensure they are safely cleaned of contaminants prior to joining the reef.

The benefits of constructing New York’s artificial reefs include improving existing habitats to increase local marine biodiversity, stimulating more productive and diverse aquatic ecosystems, and promoting environmental sustainability. Concrete and steel surplus bridge materials have proven to be both stable and durable reef-building material while providing shelter and forage opportunities for finfish and crustaceans that inhabit these underwater structures, such as tautog, fluke, black sea bass, scup, and lobsters.

NEW JERSEY

Russ Babb, NJDEP

New Jersey Releases First Climate Change Resilience Strategy

In October 2019, New Jersey’s Governor Murphy signed [Executive Order 89](#), which appointed the state’s first Chief Resilience Officer, established an [Interagency Council on Climate Resilience](#), and directed the Department of Environmental Protection (NJDEP) to develop a Climate Change Resilience Strategy. The Strategy outlines six state priorities, each of which includes

recommendations to guide state and local government efforts to protect vulnerable communities, infrastructure, businesses, and the environment from the devastating effects of climate change. Over the past 18+ months, the Interagency Council on Climate Resilience has worked collaboratively to develop the Strategy, which includes over 100 recommendations to strengthen New Jersey against climate impacts, including the state’s unique risks from



sea level rise, chronic flooding, rising temperatures, and more frequent and intense storm events. The draft Strategy follows the June 2020 release of the first-ever [Scientific Report on Climate Change](#), which documents the specific impacts of climate change to New Jersey and serves as an important scientific basis for decision-making.

The statewide Climate Change Resilience Strategy's six priorities are:

1. Build resilient and healthy communities
2. Strengthen the resilience of New Jersey's ecosystems
3. Promote coordinated governance
4. Invest in information and increase public understanding
5. Expand resilience funding and financing
6. Development of an overall coastal resilience plan.

For more information, please visit <https://www.nj.gov/dep/climatechange/resilience.html>.

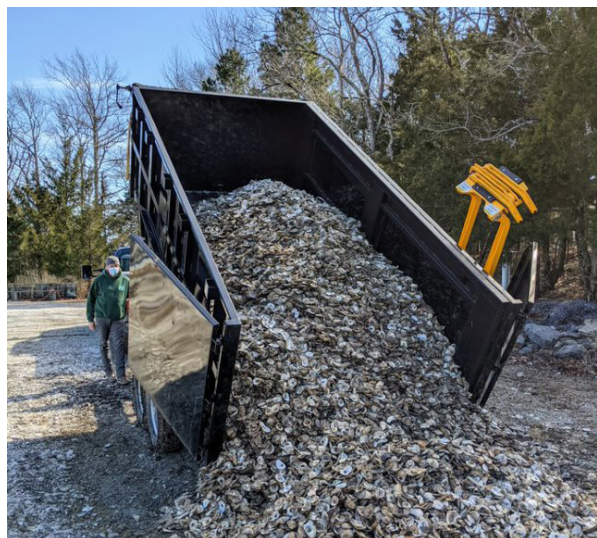
State Shell Recycling Program Grows

Since February of 2019, NJDEP's Marine Fisheries Administration (MFA) in partnership with the Jetty Rock Foundation, Stockton University, and Rutgers Cooperative Extension, has been collecting shell from Atlantic City restaurants through the MFA Shell Recycling

Program. MFA staff picks up shell on a weekly basis from participating venues and transports the shell back to the Nacote Creek Research Station for storage and curing. The shell will cure for a minimum of six months prior to placing it back in the water to rid it of any potential diseases that can be harmful to native oyster populations (not human consumers). The collected shell is then used in oyster reef enhancement efforts along New Jersey's coastline, with an initial focus on the Mullica River oyster reefs, which is home to one of the last self-sustaining oyster populations on New Jersey's Atlantic coast. These oyster reefs are very resilient, having survived freshwater flooding events, disease outbreaks, and the impacts of climate change, making them the perfect candidate to enhance and expand.

In June and July of 2021, the MFA executed the first annual shell plant on the Mullica River oyster reefs using recycled shell. Shell was loaded at the Nacote Creek Research Station onto a barge and transported to the reefs where staff used high-pressured water cannons to deploy the shell back onto the reefs. In total, 70 tons of shell: 55 tons of recycled oyster and clam shell and 15 tons of surf clam shell from additional shell sources was deployed over a two-acre parcel. Despite impacts from COVID-19, the program continues to expand and now collects shell from the Hard Rock Cafe, Dock's Oyster House, and the Knife & Fork Inn with pressing interest from additional casinos and restaurants. To learn more about this program, please visit https://www.njfishandwildlife.com/shell_recycling_prog.htm.

Dropping shell off for storage and curing. Image credit: NJDEP MFA.



Using water cannons to deploy shell onto reefs. Image credit: NJDEP MFA.





Aerial view of shell deployment. Image credit: NJDEP MFA.



Material for deployment on the Manasquan Inlet reef site. Image credit: NJDEP MFA.

New Jersey Expands Artificial Reef System

New Jersey’s artificial reef network was significantly expanded through a deployment of 6,000 tons of concrete on the Manasquan Inlet reef site. Material for the first deployment consisted of 74 concrete forms, measuring 40 feet x 8 feet x 1.5 feet each, donated by Maher Terminals in Elizabeth, Union County. Another 77 forms were later deployed. The forms, once used by U.S. Customs to scan shipping containers, were no longer needed and were slated to be recycled.

This was an example of a beneficial collaboration that gives new life to these materials, keeping them out of landfills and providing habitat for a wide array of marine life, including species important to New Jersey’s prominent commercial and recreational fishing sectors.

Artificial reefs are typically made up of concrete, steel, and decommissioned ships and barges, and provide a habitat for a variety of marine life. NJDEP studies have shown that these materials are colonized quickly with organisms such as algae, barnacles, mussels, sea stars, crabs, sponges, and corals.

Encompassing a total of 25 square miles of ocean floor, the New Jersey Artificial Reef Program began in 1984, and currently consists of four reefs in New Jersey waters and 13 in federal waters. The program is administered by NJDEP’s

MFA. The program is sustained largely by donations of reef materials from private organizations and companies. The Manasquan Inlet reef is approximately two miles east of the inlet and is one of the newest reefs in the artificial reef system. The new material adds nearly 1.25 acres of artificial reef habitat on what was formerly featureless sand bottom. Earlier in 2020, New Jersey deployed a 150-foot long caisson gate on the Deepwater reef site, a tugboat on the Sandy Hook reef site, and a memorial reef on the Atlantic City reef. For videos of the deployments, visit the Manasquan Inlet reef site at: <https://youtu.be/7ntTlvSTiJ4>.

PENNSYLVANIA

David Dippold, Pennsylvania Fish and Boat Commission

Pennsylvania continues to improve habitat quality and restore fish passage for diadromous fishes in the state. During 2019 and 2020, 18 dams were removed across the state, with many located in Atlantic Slope drainages. Additionally, work continues in the Susquehanna River to restore fish passage and migratory fish populations. Specifically, fish passage work continues for eel, shad, and river herring in the watershed, including the design and construction of fishways as well as the transport of fish around the major dams on the river.



MARYLAND

Marek Topolski, MD DNR

Maryland's Stateside Program Open Space scorecard has been updated with criteria for coastal community resilience to climate change benefits when evaluating potential property acquisition. Climate change benefits are provided to coastal communities by adjacent shoreline properties having natural habitats, such as marshes and coastal forests, that reduce the impact of coastal hazards by dampening waves, stabilizing sediment, and absorbing water. This enhancement to the scorecard builds on existing land conservation criteria that avoids conserving lands subject to inundation by sea level rise and targets adaptation areas such as those providing for wetland migration. The Maryland Board of Public Works relies upon the Stateside Program Open Space scorecard to provide ecological, resiliency, and management justification necessary to approve property acquisitions.

With funding from NOAA through Maryland Department of Natural Resources (MD DNR), the University of Maryland Center for Environmental Science - Integration and Application Network has developed a suite of adaptation indicators. These adaptation indicators will be released as a Maryland Coastal Adaptations Report Card which will assess where Maryland is on adaptation efforts and provide a system to track progress in the years to come. The approach involved a series of stakeholder workshops and feedback to identify which indicators are of highest priority for Marylanders, what data sources are available, and best practices for establishing the thresholds for measurement. The indicators and report card overall will provide the Maryland Commission on Climate Change, its working groups, state agencies, and others with an assessment tool for adaptation actions in the state moving forward.

MD DNR is participating as one of eight National Estuarine Research Reserves to test the use of thin-layer placement across diverse marsh plant communities. The project team assessed the impact of elevation, sediment type, and layer thickness on the success of this marsh adaptation technique. Greenhouse experiments that explored the effect of sediment texture and the addition of biochar as a soil amendment complemented these field studies. To support future use of thin-layer placement, the project team along with an advisory committee of coastal managers at state and federal agencies and

nonprofit groups created a suite of guidance documents including a consensus statement on thin-layer placement in tidal marsh ecosystems, a guide to navigating the permitting process, and a monitoring strategy for thin layer placement. The monitoring guidance developed as part of this study is now being used to inform a marsh enhancement project with the Army Corps of Engineers on the Deal Island Wildlife Management Area. These project outcomes represent significant progress toward a national framework to enhance tidal marsh resilience through broadly applicable adaptation strategies.

Maryland has implemented an Ecological Effects of Sea Level Rise Project to monitor and model wave attenuation and flood reduction benefits of marshes, SAV, and other nature-based features. Wave, water level, and current sensors were deployed at three sites in the summer of 2020 and have collected data throughout 2021. This three-year project will quantify the protective services of Maryland's natural features and explore how protective services may change as sea levels rise. This study will assist managers in determining appropriate restoration needs and priorities for areas where natural features can enhance community resiliency to impacts of climate change. MD DNR has engaged state, federal, and local partners through a Management Transition Advisory Group.

The Adaptation and Resiliency Working Group (ARWG) of the Maryland Commission on Climate Change continues to support the State's effort to develop a long-term portfolio of natural infrastructure projects that optimize water quality, living resources, greenhouse gas reduction, and other health and environmental benefits in coastal and estuarine shorelines. ARWG will continue to convene partners around opportunities that promote the use of natural infrastructure to build resilience to climate impacts. These efforts will include expanded use of developing Resiliency Opportunity Zones, Restoration and Resiliency Portfolios and other water quality, natural infrastructure, and climate resiliency opportunities.

Maryland Commission on Climate Change and external partners (COMPASS and Restore America's Estuaries) are exploring opportunities associated with blue carbon for carbon sequestration, protecting shorelines, and enhancing tidal ecosystems. Blue carbon refers to the carbon that accumulates in vegetated, tidally influenced ecosystems such as tidal forests, tidal marshes, and intertidal to subtidal SAV meadows. Blue carbon represents a



mitigation and adaptation mechanism to the adverse impacts of climate change through the multiple benefits of sustaining wetlands, enhancing coastal resilience, reducing flood risks, and protecting infrastructure. Three events have been planned for fall 2021: a blue carbon accounting webinar, a conservation finance webinar, and a living shoreline online workshop.

VIRGINIA

Rachael Peabody, VMRC

Increasing Nature-Based Solutions and Habitat Restoration in Virginia

Since 2011, Virginia has continued to increase its focus on promoting, mandating, and protecting natural and nature-based strategies for shoreline protection, water quality, and resilience projects. Virginia's regulatory agencies have strengthened regulations within the tidal wetland, riparian buffer, and storm water regulatory programs and are building innovative partnerships and funding to support restoration efforts. In support of oyster habitat restoration, state funding for oyster restoration has been growing and is at an all-time high. The year 2021 marks the first time capital funding was used in the Commonwealth for a natural resource restoration project. Research shows this funding is paying off. Based on the most recent data collected as part of a [long running survey](#) of public oyster grounds, the population density of oysters in Virginia waters is at its highest point in more than 30 years and the reef area is stable or increasing in almost all portions of Virginia waters.

In support of living shorelines and increased wetland protection, Virginia's Marine Resources Commission (VMRC) has taken several steps to streamline the living shoreline regulatory review process by creating two expedited living shoreline [general permits](#). Additionally, Virginia [law](#) now states that only living shoreline approaches to shoreline management are permissible unless the best available science shows that such approach is not suitable. The newly updated [Tidal Wetland Guidelines](#) incorporate resilience in the updated design standards and give greater regulatory strength to non-vegetated wetlands as an equally integral part of a functioning wetland system. The guidelines state that projects may only be approved if the proposal does not contribute "to the cumulative net loss of tidal wetlands."

Recent updates to [riparian buffer regulations](#) include increased protection of large trees, requirements for nature-based solutions within the 50-foot buffer, and integration of sea level rise in all permit decisions.

Finally, Virginia finalized its [Watershed Implementation Plan, Phase 3](#) to achieve substantial water quality goals by 2025. This water quality plan update increases support for shoreline and buffer restoration in agricultural lands, advances the implementation of nature-based storm water solutions, and retains existing natural shorelines in light of sea level rise.

Building Natural Resource Resilience to Climate Change

Building resilience capacity at the state, regional, and local levels is key to Virginia's approach to adapting to climate change impacts and protecting our natural resources in the future. Virginia is committed to taking proactive steps to ensure its assets and communities are as resilient as possible to the impacts of natural hazards as well as climate change. In 2018, Governor Ralph Northam issued [Executive Order 24](#) "Increasing Virginia's Resilience to Sea Level Rise and Natural Hazards," which set the Commonwealth on a course toward addressing its risk and resilience to natural hazards, including flooding in all of its regulatory programs. Executive Order 24 designated the Commonwealth's first Chief Resilience Officer (Secretary of Natural Resources, Matthew Strickler). The Order also directed the integration of unified sea level rise projections (2017 NOAA-Intermediate Curve), and Federal Emergency Management Agency storm data in all permit decisions. Importantly, the Order directed the Chief Resilience Officer and the Special Assistant to the Governor for Coastal Adaptation (Rear Admiral Ann Phillips, U.S. Navy) to develop the [Virginia Coastal Resilience Master Planning Framework](#), published in October 2020. This Framework lays out the Commonwealth's approach to coastal protection and adaptation and is being utilized to create the [Coastal Resilience Master Plan](#). The Master Plan incorporates natural and nature-based infrastructure and flood control whenever possible, resulting in expanded buffers and reduced runoff to the Chesapeake Bay and its tributaries. Virginia has also joined the [Regional Greenhouse Gas Initiative](#), a regional cap-and-trade program designed to reduce climate pollution. Proceeds generated from the program will fund resiliency projects recommended through the Coastal Resilience Master Plan.



NORTH CAROLINA

Jimmy Johnson, APNEP/NC DEQ and Trish Murphey, NC DMF

Executive Order 80

Throughout North Carolina, impacts from climate change, including sea level rise, will affect all coastal habitats and species. In 2018, after the devastation brought about by Hurricane Florence, North Carolina's Governor Roy Cooper signed [Executive Order 80](#) – “North Carolina's Commitment to Address Climate Change and Transition to a Clean Energy Economy” (EO80), directing all cabinet agencies to integrate climate adaptation and resiliency planning into their policies, programs, and operations. As part of this Executive Order, the Climate Change Interagency Council was created including members from all of the cabinet agencies. The North Carolina Department of Environmental Quality (NC DEQ) was tasked to serve as the lead agency with the Secretary of NC DEQ serving as Climate Change Interagency Council chair. Staff from all NC DEQ divisions actively participated on the Climate Change Interagency Council and associated working groups.

These working groups, along with federal and university partners, developed a state-specific North Carolina Climate Science Report, assessed hazards and risks associated with climate change, and compiled a Natural Working Lands Report. These efforts were incorporated into the [2020 North Carolina Risk Assessment and Resilience Plan](#) to increase carbon sequestration and resiliency of coastal habitats and communities. In 2021, North Carolina began implementing this overarching and aggressive plan. Governor Cooper's EO80 is the driving force behind much of North Carolina's approach to coastal resiliency.

Coastal Habitat Protection Plan

North Carolina's Coastal Habitat Protection Plan (CHPP) is undergoing its five-year review and an amendment to the Source Document is almost through the process. It is expected to be approved by the state's Coastal Resources Commission, Environmental Management Commission, and Marine Fisheries Commission and adopted by year's end. The amendment focuses on five important issues, several of which have implications regarding climate change and sea level rise. The five priority issues are: 1) SAV protection and restoration through water quality improvements, 2) Wetland protection and restoration through nature-based solutions, 3) Environmental rule

compliance to protect coastal habitats, 4) Wastewater infrastructure solutions for water quality improvement, and 5) Coastal habitat mapping and monitoring to assess status and trends. For more information about the amendment, the source document from 2016, and the process, go to: <https://deq.nc.gov/about/divisions/marine-fisheries/habitat-information/chpp>.

SAV Surveys

With the Albemarle-Pamlico National Estuary Partnership (APNEP) taking the lead, flights, or Tier 1 sampling, were flown in the spring and fall to photograph SAV. These photographs will be used to survey the abundance and condition of the seagrasses in North Carolina's estuarine waters. Boat-based, or Tier 2, sampling was conducted during the flight windows of both the spring and fall growing seasons to corroborate what was seen from the air and in the photographs. Previous Tier 1 sampling can be viewed at: <https://apnep.nc.gov/our-work/monitoring/submerged-aquatic-vegetation-monitoring>.

APNEP also provided funding for an interdisciplinary team of researchers at North Carolina State University and Duke University to research and publish a [report](#) that estimated the market and nonmarket economic losses from declines in SAV in the Albemarle-Pamlico estuary. Focusing on the losses to commercial and recreational fisheries, residential property values, and carbon sequestration, the team conservatively estimates aggregate losses of \$1,290 per acre over the next decade.

Alternative Methods to Map Shell Bottom

The Division of Marine Fisheries continues to explore the use of remote sensing technology, such as drones and sonar, as alternative means of mapping shell bottom. The Estuarine Bottom Habitat Mapping Program is using drones to map intertidal oysters and modifying parameters to establish sentinel sites for more frequent and rapid mapping and monitoring. These changes will greatly increase the usefulness of the Estuarine Bottom Habitat Mapping Program and allow more timely trend assessments of the intertidal oyster population. To enhance subtidal oyster habitat mapping, a position was repurposed to create a position used to focus on using side scan sonar in order to map priority subtidal areas for the Oyster Sanctuary and Cultch Planting Programs with primary focus in Pamlico Sound.



Wetlands Monitoring

This year, North Carolina's Division of Water Resources began sampling for an EPA grant called "The Assessment of Change in North Carolina Coastal Plain Wetlands."

This assessment will be looking at new wetland sites as well as known sites surveyed five, 10, and 30 years ago. In addition, North Carolina State University continued the long-term monitoring of a few sites previously monitored by the Division of Water Resources from 2014 through 2018/2019. The Division of Water Resources is currently awaiting funds from the EPA to initiate a statewide wetland mapping project and a more accurate, publicly available wetland mapping tool for North Carolina.

Living Shorelines

APNEP is co-lead with the North Carolina Coastal Federation (Federation) on the North Carolina Living Shoreline Steering Committee. This Committee was established in 2018 and acts as APNEP's Living Shoreline Action Team. The committee brings together federal and state agencies, non-governmental organizations, and universities to communicate and collaborate on education and outreach, research, and implementation of living shorelines. This committee recently promoted its partner's accomplishments at: <https://bit.ly/3l2SDIF>.

Coastal Resiliency

APNEP is collaborating as a project partner on a NOAA Coastal Resilience Grant awarded to the Virginia Institute of Marine Science. The project is focused on increasing the use of natural and nature-based features to increase resilience of coastal communities to flooding caused by storms and extreme weather events. The project is designed to include interaction with local government officials as the target audience for project generated data and guidance. APNEP staff are working with Wetlands Watch to solicit feedback from North Carolina agency personnel, local governments, and other partners to develop an evaluation of opportunities and limitations to extension of the project outputs beyond Virginia in 2021. You may view the project website at: https://www.vims.edu/ccrm/research/climate_change/adaptation/nmbfs/index.php.

SOUTH CAROLINA

Graham Wagner, SCDNR, Marine Resources Research Institute

Global climate change is resulting in sea level rise as well as increased storm frequency and intensity. One of the synergistic effects of storm impacts and sea level rise is the loss of shoreline habitat through erosion. The erosional impacts of such storms can be mitigated by the installation of structures that attenuate wave energy and capture sediment, without the resulting negative impacts to surrounding habitats associated with hardened structures like bulkheads and seawalls. In recent years, multiple coastal states including South Carolina have directed research efforts towards natural, "greener" approaches to shoreline protection and stabilization. These natural alternatives are collectively referred to as "living shorelines" due to their incorporation of living resources, such as marsh grasses and oyster reefs, that support ecosystem services, such as the provision of EFH, and the maintenance of the land-water continuum that gives shorelines the potential to adapt to changing environments. South Carolina Department of Natural Resources (SCDNR) has been constructing living shorelines for coastal management, conservation, and educational outreach purposes since the late 1990s.

In May 2021, in response to increasing interest in living shorelines among coastal property owners, the South Carolina Department of Health and Environmental Control's Office of Ocean and Coastal Resource Management (SCDHEC OCRM) established a [regulatory definition and project standards](#) for permitting living shorelines. These regulations and standards were based in part on findings from a [multi-year research project](#) funded by NOAA's National Estuarine Research Reserve System Science Collaborative, which was designed to evaluate the effectiveness of a variety of living shoreline approaches in South Carolina. This research was conducted by SCDNR in partnership with the ACE Basin National Estuarine Research Reserve, North Inlet Winyah Bay National Estuarine Research Reserve, and SCDHEC OCRM. The project involved monitoring existing living shoreline installations, as well as installing and monitoring new and existing technologies in a diverse set of estuarine habitat types.



Wire-based living shoreline at Brittlebank Park in downtown Charleston. Other living shorelines at Brittlebank Park have demonstrated successful marsh grass recruitment and sediment accumulation which provides shoreline protection and wave attenuation. Image credit: SCDNR.

Wire-based living shoreline installed on Lockwood Blvd. Note that a small section of marsh is the only barrier separating the road from the Charleston Harbor. During Hurricane Irma in September 2017, this portion of Lockwood Blvd. experienced severe flooding caused by storm surge from Charleston Harbor. Image credit: SCDNR.

Clemson Cooperative Extension recently established a [website with information and resources pertaining to living shorelines in South Carolina](#), including case studies highlighting the use of different materials, one of which is described in more detail below.

Using Wire-Based Living Shorelines to Provide Fish Habitat and Mitigate Erosional Impacts of Changing Climate


SCDNR has been evaluating a variety of living shoreline materials since 2011 and is currently conducting a shoreline restoration project funded by a NOAA Fisheries Community-Based Restoration Program Coastal and Marine Habitat Restoration Grant. This three-year (2019-2022) project will install and monitor living shorelines at 14 sites throughout the heavily urbanized Charleston County watershed in coastal South Carolina. One of the most successful materials used in such installations has been purpose-built wire structures known as manufactured wire reefs (MWRs).

The development of MWRs was inspired both by observations of derelict wire crab traps in coastal habitats that over time become encrusted with wild oysters, as well as previous research projects to retrieve, repurpose, and deploy such materials as reef-building substrate. These modular MWR structures are installed

in the intertidal zone to recruit wild oysters (*Crassostrea virginica*) and capture sediment, both of which promote the expansion of existing marsh habitat (primarily smooth cordgrass, *Spartina alterniflora*). SCDNR staff have designed and built MWRs to provide extensive surface area for oyster growth, which in turn provides natural wave attenuation and facilitates the growth of marsh grasses on the landward side of the deployed structures. Additionally, these MWRs, and the oyster reef and marsh



Dense oyster growth on MWRs at Fort Johnson approximately 11 months after installation. The rapid recruitment of oysters to the wire structures demonstrates how quickly living shorelines can become established in the environment and provide essential fish habitat as well as shoreline protection. Image credit: SCDNR.



grass habitats that they support, provide essential habitat for many commercially- and recreationally-important species such as red drum, flounder, blue crabs, and penaeid shrimp.

Through the ongoing NOAA Fisheries shoreline restoration project described above, the SCDNR has installed approximately 650 linear feet of wire-based living shorelines at five locations around Charleston, including Brittlebank Park, Lockwood Boulevard, and Fort Johnson. These locations represent shorelines that are experiencing active habitat loss from erosion and are often the only barrier separating urbanized infrastructure from coastal waterways subject to sea level rise and storm surge. The MWRs at these locations have already begun to recruit oysters and marsh grasses, demonstrating the early stages of successful shoreline restoration and stabilization. Moving forward, SCDNR staff will monitor these installations for several metrics of success in order to quantify the benefits that MWRs provide to threatened shorelines and to increase our understanding of how living shorelines can persist and adapt within a dynamic coastal environment.

New England and Mid-Atlantic Fishery Management Councils

Michelle Bachman, NEFMC and Jessica Coakley, MAFMC

Both the NEFMC and MAFMC are continuing their collaborative work with multiple fisheries management organizations, federal agencies, and academic researchers to assess the quality and quantity of fish habitat in the Northeast region. The Northeast Regional Marine Fish Habitat Assessment will conduct investigations to assess habitat use for key marine fish and shellfish species in the changing environment of the Northeast Shelf Large Marine Ecosystem. Just one of many key products will be spatiotemporal models that describe species distributions (presence/absence and/or abundance) as a function of dynamic environmental factors as well as species covariances with one another. These models can then be informed with the outputs of climate models to project how fish communities and their use of space might be altered under different environmental change scenarios. This habitat research will provide information to be used in the future to support federal EFH assessments and consultations.

In December 2020, NEFMC approved an Aquaculture Policy and a Submarine Cable Policy, which highlights the Council's position on these issues related to habitat; the Council is in the process of updating its Offshore Wind Policy as well. For more information on the policies see the Quick Links section of <https://www.nefmc.org/management-plans/habitat>. MAFMC is in the process of developing a complementary Aquaculture Policy and has developed an aquaculture webpage to connect fisheries stakeholders and managers with useful regional information on the topic: <https://www.mafmc.org/aquaculture>.

Both Councils have been actively working to stay ahead of wind energy development issues in their respective regions, by submitting comment letters, receiving briefings on ongoing activities, and keeping their joint wind web page up to date: <https://www.mafmc.org/northeast-offshore-wind>. In addition, the Councils are members of the Responsible Offshore Science Alliance (ROSA, <https://www.rosascience.org/>), which is dedicated to research, communication, and regional collaboration on offshore wind development and fisheries.

Through the East Coast Climate Change Scenario Planning Initiative, fishery scientists and managers are working collaboratively to explore jurisdictional and governance issues related to climate change and shifting fishery stocks. Scenario planning is a tool that managers can use to test decisions or develop strategy in a context of uncontrollable and uncertain environmental, social, political, economic, or technical factors. It is a structured process to explore multiple plausible futures and consider how to best adapt and respond to them. The New England, Mid-Atlantic, and South Atlantic Fishery Management Councils are collaborating with ASMFC and NOAA Fisheries on this initiative. For more information visit <https://www.mafmc.org/climate-change-scenario-planning>.

North Carolina Coastal Federation

Erin Fleckenstein, Michael Flynn, R. Wilson Laney, and Todd Miller, NCCF; and Trish Murphey, APNEP

The Federation continued to be very active in coastal conservation activities during 2021 despite constraints imposed by the ongoing COVID-19 pandemic (<https://www.nccoast.org/>). Formed in 1982 by Executive Director Todd Miller, the 39-year-old non-profit organization continues to engage in conservation, restoration, and



education regarding North Carolina's public trust estuarine and adjacent terrestrial natural resources.

An especially significant activity throughout 2021 was the Federation's participation and partnership in updating the North Carolina CHPP (for more details see the North Carolina update). The Federation partnered with The Pew Charitable Trust to form a stakeholder workgroup to consider the five issues being addressed in the Draft 2021 CHPP Amendment and develop recommendations for each of them. The report of the workgroup is included in the draft CHPP Amendment in Appendix A, Public Comment. The 2021 CHPP Amendment was out for public review with comments due October 21. The 2021 CHPP may be accessed at: <https://tinyurl.com/msauj48z>.

The Federation continued its significant engagement in conservation and restoration activities in North Carolina coastal watersheds along the entire coast. Its staff were instrumental in the development of the watershed management plan for Lake Mattamuskeet (see the [2020 Habitat Hotline Atlantic](#) for details), an important spawning and nursery habitat for ASMFC-managed species such as alewife (spawning and nursery habitat) and American eel (nursery habitat), and continues engagement for the plan's implementation. Additional watershed restoration projects completed in past years include those conducted for the Mattamuskeet Association (2012), in Bradley and Hewitt's Creeks (2007), Beaufort (2016-2017), Lockwood Folly (2007), Swansboro (2017), and the White Oak River Watershed (2006 with work continuing into 2017).

Two additional watershed plans were initiated in 2021. The [Stump Sound Watershed Protection Plan](#) entails ten specific goals. The Town of Atlantic Beach Watershed Restoration Plan was approved in 2021 by the Town Council, with the key goal of the plan being reduction of the volume of runoff contributing to flooding and water quality impairment after heavy rains. Further work in the Beaufort Watershed continued in 2021 with a project to complete an innovative stormwater project. This project, funded in part by the North Carolina Land and Water Fund, transformed Orange Street in Beaufort into a stormwater treatment device. The importance of local, community-based, watershed conservation and restoration projects cannot be understated and is a major key to the restoration, protection, and sustainability of North Carolina's estuarine and coastal riverine water quality.

The Federation continued its partnership with the Natural Resources Conservation Service to restore approximately 8,000 acres of prior converted cropland in eastern North Carolina. Projects undertaken as part of this work are in Hyde, Halifax, Carteret and Bladen counties. The Federation is also partnering with the U.S. Fish and Wildlife Service, EPA, NOAA, and the U.S. Navy to identify and pursue some new additional large-scale wetland restoration projects in coastal counties.

Important engagement continued with respect to restoration and development of additional Eastern Oyster (*Crassostrea virginica*) habitats within North Carolina estuarine waters. In April, the Federation announced the release of the [North Carolina Oyster Blueprint for 2021-2025](#), which is designed to advance restoration, protection, and harvest of oysters. This is the fourth iteration of the plan, which was originally issued in 2003. During 2021, the Federation worked with the North Carolina Division of Marine Fisheries to build five acres of reefs at the new Cedar Island Oyster Sanctuary and added to the existing Swan Island Oyster Sanctuary. One acre of oyster sanctuary supports nearly one million oysters in Pamlico Sound. Oyster sanctuaries make up approximately six percent of all oyster reefs in Pamlico Sound but contribute nearly 40% of the oyster population. The Federation is also beginning a cohesive oyster shell recycling program along the coast of North Carolina and in specific inland areas. The goal is to provide five percent of material needed to support oyster habitat restoration projects, and to identify priority reef projects to build with recycled shell, with a target to build 20 acres of new reef. Shell recycling drop-off sites are located at the Federation's three regional offices and in seven of North Carolina's 20 coastal counties. A map of the sites is provided on the Federation's website at: <https://www.nccoast.org/project/oyster-shell-recycling-program/>.

The Federation's involvement in and promotion of living shorelines as an alternative to traditional, less environmentally-appropriate shoreline stabilization methods continued with more than a mile of shorelines constructed this year. [One project](#) entails the protection of 2,100 feet of shoreline at the US Department of Defense's Marine Air Corps Station, Cherry Point. The project is being funded by a \$400,000 grant to the Federation from the North Carolina Land and Water Fund, and an additional one million dollar grant secured by Cherry Point staff from the Department of Defense Readiness

and Environmental Protection Integration Challenge Program. This is probably the largest contiguous living shoreline project the Federation has engaged in to-date. In addition to the 2,100-foot living shoreline currently being funded, base personnel have also secured eight million dollars in emergency funding for repairs from Hurricane Florence in 2018. The money will be used to build an additional 6,000 feet of living shoreline at other portions of the Base's shoreline along the estuary. In addition to its direct involvement in living shoreline construction through securing funding and assisting in emplacement, the Federation also conducts an [educational program](#) about living shorelines, targeting students and schools as potential users.

Finally, multiple additional Federation educational efforts continued, with one significant outreach mechanism being daily Coastal Review articles that address many topics of interest. [CoastalReview.org](#) is the Federation's award-winning, daily, news service covering environmental news of the North Carolina coast. This year it will reach approximately 800,000 readers. Coverage includes science breakthroughs; government and regulatory actions and education; as well as the environment, culture, and history of the state's 20 coastal counties. Written by professional journalists, *Coastal Review* strives to provide thorough coverage of coastal issues and meet the highest standards of fairness and accuracy. In 2021, the North Carolina Press Association recognized *Coastal Review* with a first-place award for public service, along with a first-place award for appearance and design and second-place awards for community coverage and general excellence.

THE NATURE CONSERVANCY

Compiled by Kate Wilke, TNC

Wetlands and Oyster Reefs Promote Resiliency in the Panhandle

Christine Shepard, TNC Florida

TNC is working with the Northwest Florida Water Management District alongside local, regional, and university partners to conduct a two-year project to identify and promote nature-based solutions, such as wetlands and oyster reefs, for resiliency in the panhandle. This project, called Scaling Up Nature Based Solutions, will focus on Bay, Gulf, and Franklin counties and is supported with funding from the National Fish and Wildlife Foundation's National Coastal Resilience Fund. For more information visit www.nature.org/suns.

Flood Reduction Benefits of Mangroves

Laura Geselbracht, TNC Florida

As follow-on work to the post-Hurricane Irma study, [Valuing the Flood Risk Reduction Benefits of Florida's Mangroves](#), analysts and scientists are now quantifying the flood reduction benefits of mangroves where they occur in Florida, the Yucatan area of Mexico, and the Bahamas. This avoided-damages information, now under development, will be used to inform the implementation of pilot mangrove insurance products in the three geographies. TNC staff is currently collecting data on recent mangrove restoration projects to characterize cost by type of project and speaking to entities (e.g. local governments, etc.) potentially interested in purchasing a mangrove insurance policy.

Kayaking among mangroves. Photo credit: FL FWC.





ACRONYMS

ACFHP or Partnership - Atlantic Coastal Fish Habitat Partnership
 APNEP – Albemarle-Pamlico National Estuary Partnership
 ARWG – Adaptation and Resiliency Working Group
 ASMFC – Atlantic States Marine Fisheries Commission
 BOEM – Bureau of Ocean and Energy Management
 CHPP – Coastal Habitat Protection Plan
 CLCPA – Climate Leadership and Community Protection Act
 EFH – Essential Fish Habitat
 EO80 – Executive Order 80
 EPA – Environmental Protection Agency
 Federation – North Carolina Coastal Federation
 MA DMF – Massachusetts Division of Marine Fisheries
 MAMFC – Mid-Atlantic Fishery Management Council
 MD DNR – Maryland DNR
 ME DMR – Maine Department of Marine Resources
 MFA – Marine Fisheries Administration
 MWR – manufactured wire reefs
 NC DEQ – North Carolina Department of Environmental Quality

NEFMC – New England Fishery Management Council
 NFHP – National Fish Habitat Partnership
 NHF&G – New Hampshire Fish and Game
 NJDEP – New Jersey Department of Environmental Protection
 NOAA – National Oceanic and Atmospheric Administration
 NOAA Fisheries – NOAA National Marine Fisheries Service
 NYSDEC – New York State Department of Environmental Conservation
 RI DEM – Rhode Island Department of Environmental Management
 RI DMF – Rhode Island Division of Marine Fisheries
 SAV – submerged aquatic vegetation
 SCDNR – South Carolina Department of Natural Resources
 Service – U.S. Fish and Wildlife Service
 TNC – The Nature Conservancy
 VMRC – Virginia Marine Resources Commission

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HABITAT PROGRAM MISSION

To work through the Commission, in cooperation with appropriate agencies and organizations, to enhance and cooperatively manage vital fish habitat for conservation, restoration, and protection, and to support the cooperative management of Commission managed species.

REPRODUCTIONS

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Claire Enterline (ME DMR),
 Lisa Havel (ASMFC),
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PARTNER CONTRIBUTORS:

Lisa Havel, Stefanie Simpson, Bo Lusk, Lauren Hutch Williams, Aliya Caldwell, Nathan Hermann, Nathan Furey, Jason Goldstein, Trish Murphey, Graham Wagner, Erin Fleckenstein, Michael Flynn, Todd Miller, Christine Shepard, Laura Geselbracht, and Dean Carpenter

HABITAT COMMITTEE MEMBER CONTRIBUTORS:

Jimmy Johnson, Phil Colarusso, Michelle Bachman, Jessica Coakley, Claire Enterline, Joshua Carloni, Mark Rousseau, Eric Schneider, Russ Babb, David Dippold, Marek Topolski, Rachael Peabody, R. Wilson Laney, and Kate Wilke

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Banner photo: salt marsh, Manahawkin, New Jersey
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