Atlantic States Marine Fisheries Commission

Habitat Committee Meeting

October 18, 2023; 1:00 p.m. to 5:00 p.m.
October 19, 2023; 08:30 a.m. to 12:00 p.m.
Hybrid Meeting

Webinar Link: https://v.ringcentral.com/join/466405327

Phone: +1 (650) 419-1505; **Meeting ID**: 466405327

Agenda

The times listed are approximate; the order in which these items will be taken is subject to change; other items may be added as necessary.

Day 1: Wednesday, October 18, 2023 (1 – 5 p.m.)

1.	Welcome and introductions (*R. Babb*)	1:00 p.m.
2.	Committee consent (*R. Babb*) • Approval of agenda • Recap of committee activities	1:10 p.m.
3.	Albemarle-Pamlico National Estuary partnership presentation (APNEP, *B. Crowell*) • SAV Monitoring and Assessment Program	1:30 p.m.
4.	Habitat Hotline update (*K. Wilke*) • Topics, authors, future direction	3:00 p.m.
5.	Adjourn Day 1	5:00 p.m.

Day 2: Thursday, October 19, 2023 (8:30 a.m. – 12 p.m.)

1.	Reconvene	8:30 a.m.
2.	Overview of Sackett v. EPA • Discussion on new Supreme Court "wetlands" definition • Impacts to partners and ongoing restoration work	8:45 a.m.
3.	Habitat Management Series update (*R. Babb, K. Wilke, T. Kerns, S. Kaalstad)* • Topics, authors, deadlines (3yr timeline?)	10:00 a.m.
4.	Species assignments & habitat fact sheet update • HC members' species management board updates	11:30 a.m.
5.	Wrap-up, overview, and next steps	11:45 a.m.
6.	Adjourn	12:00 p.m.

The meeting will be held at Beaufort Hotel (2440 Lennoxville Road, Beaufort, North Carolina; 252.728.3000) and via webinar; click here for details

Sustainable and Cooperative Management of Atlantic Coastal Fisheries

HABITAT HOTLINE *Atlantic*

2023 Issue • *Volume 1*

HEALTHY FISHERIES NEED HEALTHY HABITAT

Promoting Resilience in Vegetated Coastal Habitats

As the Chair of the Atlantic States Marine Fisheries Commission's (Commission) Habitat Committee, it is my pleasure to present the 2023 issue of *Habitat Hotline Atlantic*. This issue focuses on continuing efforts to promote resilience in vegetated coastal habitats. The Commission and the broader fishery management community is working to better understand how climate change will influence fish stocks, the fisheries management process, and ultimately, fishing communities. Vegetated coastal habitats are at the vanguard of climate change experiencing both short- and long-term impacts and these impacts can directly influence fisheries productivity.

These remarkable habitats also provide other ecosystem services that often go unnoticed, but in fact, impact all our lives on a daily basis. Beyond their clear habitat importance as nursery and refuge for fish, healthy and resilient coastal habitats provide us with abundant recreational opportunities such as hunting, fishing, boating, and wildlife watching. They also act as a natural cushion to protect coastal communities from flooding and the erosive damage from storm events and serve a vital role in the storage and sequestration of greenhouse gases such as carbon dioxide. Regrettably, studies also show that these "blue" carbon-packed coastal habitats are disappearing at an alarming rate. Now, more than ever, it is of the utmost importance that we better manage and create resilience in and with these habitats.

This edition of the *Habitat Hotline Atlantic* attempts to highlight some of the related climate and habitat modeling work that is underway, it looks at efforts to try to reduce nitrogen at the state level, as well as endeavors to fund nature-based infrastructure projects along the coast. Additionally, it provides examples of some of the state-level efforts that the Commission's partners are making to protect and promote healthy vegetated coastlines. I hope you enjoy reading about some of the ongoing efforts happening along our coast.

Russ Babb
Habitat Committee Chair

In This Issue

Exploring Resiliency in Coastal Habitats

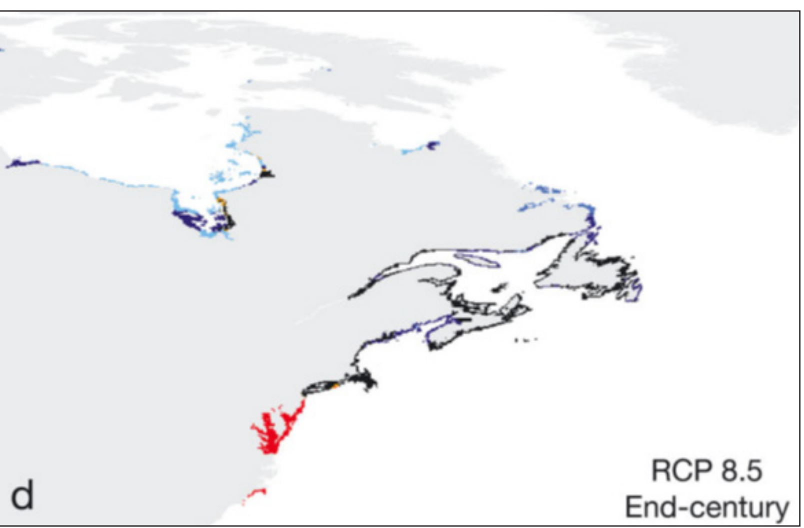
The Possible Future Fate of Eelgrass in the Northwest Atlantic under Climate Change

Phil Colarusso, Environmental Protection Agency

It has become apparent that areas of the Northwest Atlantic are warming faster than any other spots in the world's oceans. Distribution of mobile fauna such as lobsters, blue crabs, and many fish species have changed likely in response to these temperature increases. An important resource management question is "Can we predict future distribution of eelgrass, a rooted plant, in response to warming ocean temperatures?"

Eelgrass is the dominant seagrass species for much of its current range from North Carolina to Atlantic Canada. It thrives in cold clear water and provides critical nursery habitat for many fish and shellfish species. Understanding potential range shifts in this important habitat as a result of climate change has significant implications for fishery management.

A recent paper by Kristen Wilson and Heike Lotze of Dalhousie University provides a prediction of future eelgrass distribution under the "business as usual" scenario. They use modeled water temperature under a variety of carbon emissions scenarios and compare future (end of the century) water temperatures with known eelgrass physiological temperature thresholds. At water temperatures above 25°c, carbon loss due to respiration exceeds carbon gain from photosynthesis. At water temperatures of 30°c, acute mortality occurs. Under the "business as usual" carbon emissions scenario, Wilson and Lotze predict eelgrass will be extirpated from North Carolina up to the south side of Long Island. There would be some eelgrass expansion in Hudson Bay and northern Canada as permanent ice cover is lost. In the figure below, eelgrass loss is represented in red, while gain is in blue. These predicted changes would have a dramatic impact on the ecology of near shore systems and the economics of many coastal fisheries.



Wilson, K.L. and H.K. Lotze. 2019. Climate change projections reveal range shifts of eelgrass Zostera marina in the Northwest Atlantic. Mar Ecol Prog Ser. 620, 47-62. https://doi.org/10.3354/meps12973

How Do We Increase the Thermal Tolerance of Eelgrass in the Face of Warming Ocean Temperatures?

Phil Colarusso, Environmental Protection Agency

A group of scientists from academia, non-profit organizations, and government agencies formed a steering committee and convened a series of three workshops in June to try to answer this question. The steering committee initially reached out to external experts from the coral, shellfish, and terrestrial forestry communities because these groups have already been trying to address these concerns in their ecosystems. The steering committee hoped to learn from the successes and failures from these other ecosystems. In addition to those experts, eelgrass scientists and resource managers from across the country were invited to participate.

Workshop 1 was an opportunity for the external experts to share their experiences and for eelgrass scientists to query them about their approaches with these other systems. Workshop 2 was a brainstorming session to identify as many possible pathways to increasing the thermal tolerance of eelgrass. Workshop 3 was used to narrow the focus to a few of possible pathways and identify opportunities and constraints to progress.

The workshops identified "assisted migration" as the most promising and immediately implementable. Assisted migration involves identifying thermally resistant/resilient populations in the southern portion of the distribution and moving seed stock and shoots to more northern locations

in anticipation of warming seas. Ideally, these would be done with multiple seed/plant sources in common garden experiments. The workshops also identified regulatory hurdles and some ecological risks associated with the interstate movement of plant material. Historically, scientists have moved eelgrass shoots and seeds between both coasts and throughout the Atlantic seaboard. Thus, the ecological risk of further movement of this species is likely to be minimal. Currently, there are several small-scale experiments occurring with eelgrass assisted migration. The workshops identified the need for better coordination between what may quickly become numerous efforts. All participants recognized the urgency in which this science needs to proceed, as an important resource is on the verge of a dramatic range shift with unknown consequences for coastal ecosystems.

For more information, contact Phil Colarusso at Colarusso.Phil@EPA.gov.

Photo credit: Dann Blackwood, USGS

Nitrogen Reduction Efforts on Long Island, New York

Alexa Fournier, New York State Department of Environmental Conservation, Division of Marine Resources

Nitrogen is one of the building blocks of life, critical for growth yet tightly controlled as a limiting element in natural plant communities. In areas of human influence, however, ecosystems may be enriched with excessive nitrogen by runoff from agricultural fields, fertilized lawns, or nutrient-rich wastewater outfalls. Residential septic systems and cesspools contribute to nitrogen loading by discharging wastewater to groundwater, which then flows into surface waters and eventually into the estuaries, bays, and the open ocean. Microscopic plants called phytoplankton or algae can "bloom" or grow and multiply in huge numbers in these nitrogen-rich surface waters, forming mats or discoloring the water and leading to low oxygen conditions, fish kills, and degraded marine habitats.

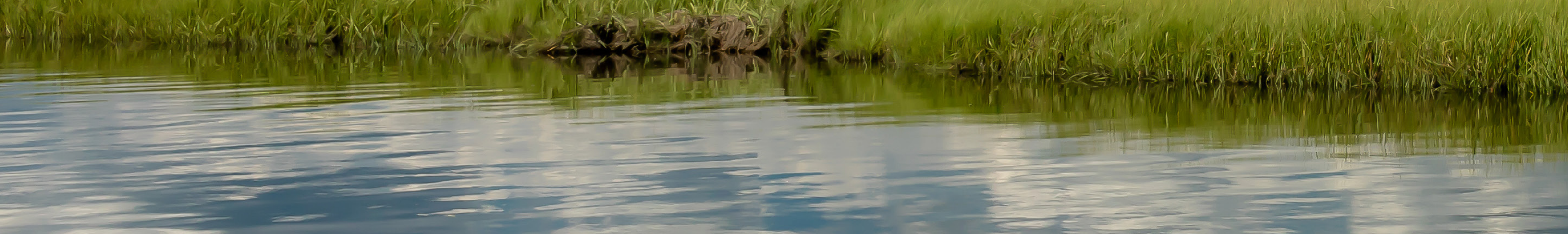
Nitrogen is the leading cause of water quality deterioration of surface and groundwater on Long Island, New York. Excess nitrogen has degraded shellfish populations and impacted marine habitats such as eelgrass beds and salt marshes while also threatening the Island's drinking water aquifers. For these reasons, New York has taken active measures to reduce nitrogen in Long Island's waters via several innovative programs, collaborations, and initiatives.

The Long Island Nitrogen Action Plan

The Long Island Nitrogen Action Plan (LINAP) is a multiyear initiative to reduce nitrogen in Long Island's surface and ground waters through technical, management, regulatory, and policy action. Launched in 2015, it is a collaboration between the New York State Department of Environmental Conservation (NYSDEC), the Long Island Regional Planning Council (LIRPC), Suffolk and Nassau Counties, and numerous environmental organizations, local partners, and stakeholders. The goals of this collaboration are to (1) assess nitrogen pollution in Long Island waters, (2) identify sources of nitrogen to surface waters and groundwater, (3) establish nitrogen reduction endpoints, and (4) develop an implementation plan to achieve reductions. The LINAP management team meets frequently to discuss project updates and plan for future actions, and the group releases a monthly newsletter to share these updates, technical information, and outreach events with the public.

Nutrient Bioextraction Initiative

In 2018, LINAP launched the Nutrient Bioextraction Initiative in partnership with the New England Interstate Water Pollution Control Commission and LIRPC, with funding provided by the Long Island Sound Study. The Nutrient Bioextraction Initiative aims to improve water quality in New York and Connecticut marine waters



by encouraging the cultivation and harvest of seaweed and shellfish, which remove excess nutrients from the surrounding waters as they grow. Because shellfish and seaweed also provide habitat for fish and other marine organisms, nutrient bioextraction could play an important role in improving the overall health of marine waters. The Initiative provides information to decision makers to help them develop guidelines needed to facilitate public and private seaweed and shellfish farming and harvest operations in their coastal waters.

Suffolk County Septic Improvement Plan

More than 360,000 homes in Suffolk County rely on outdated cesspools and septic systems that do not properly treat wastewater to remove nitrogen, and these systems are the largest local source of nitrogen pollution. Under the *Reclaim Our Water Septic Improvement Program*, homeowners who decide to replace their cesspool or septic system with Innovative and Alternative Onsite Wastewater Treatment Systems (I/A OWTS) are eligible up to $30,000 in grants from Suffolk County and the New York State Septic System Replacement Fund to offset the cost of one of the new systems. Funding may be used for the purchase and installation of an approved I/A OWTS and associated engineering and design services. To date the County has awarded over 3,000 grants to homeowners.

To further discourage the use of traditional on-site septic systems, an amendment to the County's sanitary code went into effect on July 1, 2021, requiring I/A OWTS on all new construction and major reconstruction projects. The law was also amended to allow greater flexibility for the use of small sewer plants in downtown business districts, further improving the removal of nitrogen in wastewater.

Sewer Expansion

In 2015, Suffolk County was awarded $390 million in funding through the Governor's Office of Storm Recovery to install sewers in communities that are in unsewered, low-lying areas along the County's south shore that had been inundated by Superstorm Sandy. The sewer projects, known collectively as the Suffolk County Coastal Resiliency

Sugar kelp farmed in New York as part of a bioextraction pilot project in 2020. Photo credit: Nelle D'Aversa

Installation of an Innovative and Advanced Water Treatment System (Fuji Clean CEN7) at a waterfront property in Suffolk County, NY. Photo credit: Bridgewater Environmental Services

Aerial view of the South Shore Water Reclamation Facility, Nassau County, NY. Photo credit: Veolia North America

Initiative, mark the largest investment in water quality infrastructure in the county in more than 40 years and will eliminate over 7,000 cesspools and septic systems in the Carlls River Watershed (North Babylon, West Babylon, Wyandanch), Patchogue River Watershed (Village of Patchogue), the Forge River Watershed (Mastic) and Connetquot River Watershed (Oakdale). These projects will improve water quality, boost economic development, and protect communities against storm surges by strengthening wetlands. Construction began in 2021 and is expected to be completed within five years.

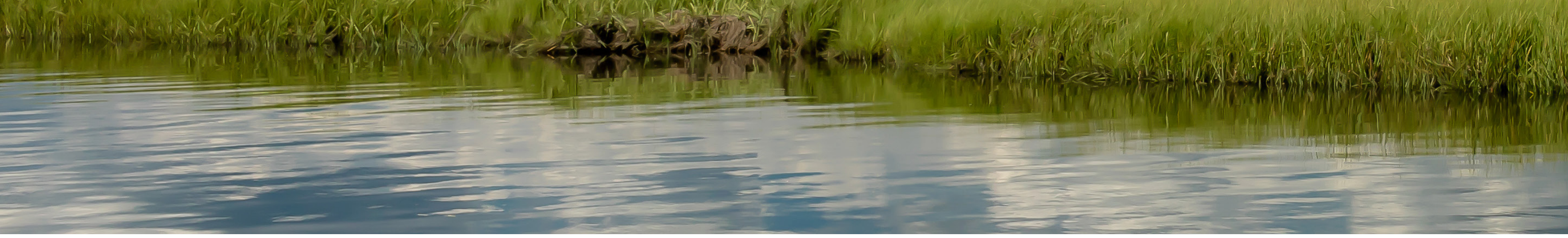
Further west, Nassau County was recently awarded $2 million to conduct a feasibility study to construct sewer infrastructure for the Point Lookout area in the Town of Hempstead as part of a Long Island Regional Economic Development Award. This project aims to convert 500 residential and commercial septic systems to a sewage collection system connected to the Long Beach Water Pollution Control Plant.

Nitrogen Removal at South Shore Water Reclamation Facility (SSWRF)

Nassau County is implementing two projects designed to reduce the nitrogen concentration discharged from the SSWRF. The first project, Biological Nutrient Removal, was granted final completion in October 2021 and eliminates about 40% of the nitrogen discharged from the facility. The second nitrogen reduction project is Sidestream Centrate Treatment. This treatment method is expected to remove up to 85% of the nitrogen in the nitrogen rich liquid produced by the sludge dewatering process. The Sidestream Centrate Treatment project is expected to start performance testing in early 2023.

Together, these upgrades could reduce nitrogen loads in treated water by up to 70%. For more information, contact Alexa Fournier at *Alexa.Fournier@dec.ny.gov.*

These programs are just a sampling of the initiatives that state and local agencies, together with local stakeholders, scientists, and conservation groups, are implementing to improve the quality of New York's waters. While these actions will reduce nutrient loads to our nearshore marine environments and give these critical habitats a better chance to withstand the impacts of climate change, there is still a long way to go. Ongoing investment and public support will be necessary for agencies to expand on successful projects and develop new nitrogen removal technologies to improve water quality and sustain healthy marine habitats into the future.



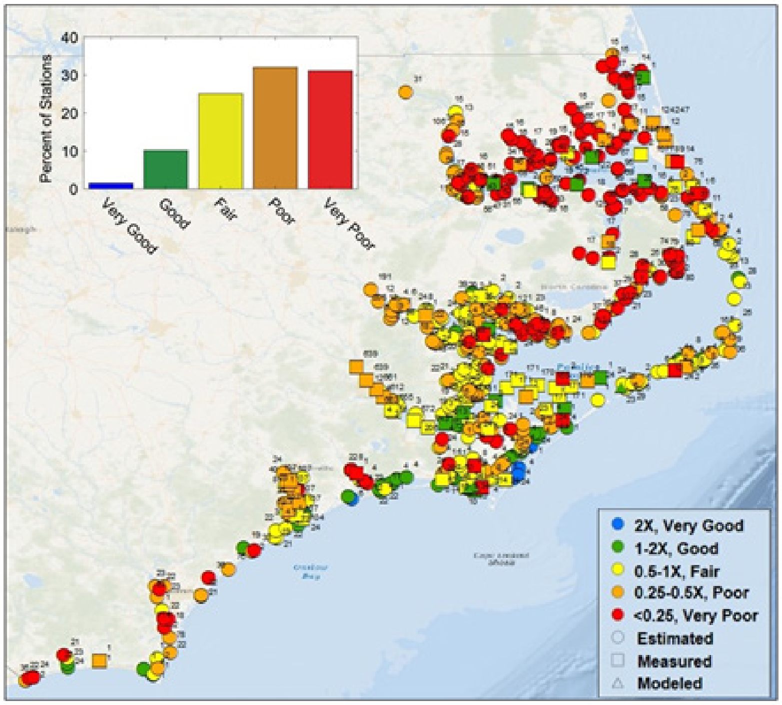
Light Attenuation for SAV

Nathan S. Hall, UNC Chapel Hill, Earth Marine and Environmental Sciences, Institute of Marine Sciences

Submerged aquatic vegetation (SAV) habitats within North Carolina's Albemarle-Pamlico Sound estuarine system (APES) constitute the largest SAV habitat area along the US East Coast and are comprised of a diverse assemblage of SAV including high salinity, meadow forming taxa, and low salinity canopy forming species. North Carolina's estuarine SAV are critical habitats for a host of commercially and recreationally important fish and shellfish resources and also provide important erosion protection and carbon sequestration services. Surveys conducted over the past 20 years have documented declines in both high and low salinity SAV habitats, and credible, anecdotal evidence indicates that current SAV area represents less than half of the historic extent. Declines of SAV habitat within APES have co-occurred with rapid development and population expansion within the watershed which contributes to nutrient and sediment pollution.

Light availability is a primary determinant of the health and long-term survival of SAV, and the elevated phytoplankton biomass due to nutrient pollution and elevated sediment concentrations entering North Carolina's estuarine waters decrease light availability through scattering and absorption. The colored dissolved organic matter (CDOM) of many coastal plain streams additionally absorbs light and can significantly add to the attenuation caused by phytoplankton and sediments. Protection of SAV within North Carolina's estuarine waters is an important goal of the Albemarle-Pamlico National Estuary Partnership (APNEP) and the North Carolina Department of Environmental Quality including its Division of Marine Fisheries (NCDMF) and Division of Water Resources (NCDWR). Through the 2021 amendment to North Carolina's Coastal Habitat Protection Plan ([Coastal Habitat Protection Plan 2021 Amendment (nc.gov)]), North Carolina has proposed water clarity targets to protect high and low salinity SAV. The target light levels for maintaining healthy SAV habitats were adopted from a literature review of SAV light requirements for growth and empirical observations on SAV depth distribution within APES. These adopted clarity targets provide the transmission of 22 and 13% of incident photosynthetically active radiation (PAR) to target depths of 1.7 and 1.5 m for high and low-salinity SAV, respectively. Efforts to implement these water clarity targets as official North Carolina water quality standards are underway, and have placed a strong focus on understanding the current light climate, trends in clarity, and causes of diminished water clarity.

As part of a study funded by APNEP, University of North Carolina Chapel Hill's Institute of Marine Sciences, NCDWR, and NCDMF have collaboratively started addressing some of these questions ([2022 Evaluation of Water Clarity and SAV in the Albemarle-Pamlico Estuary | APNEP (nc.gov)]). Below, we share the results of an assessment of the light climate of APES generated using an extensive compilation of all the known water clarity data collected with APES over the past 20 years.



Map of NC estuarine waters showing light availability for SAV. Symbol colors indicate the median PAR availability at each station expressed as the fraction of the targeted PAR availability at target depths for low and high salinity SAV. For example, "2X" indicates that twice the targeted PAR flux reached the target depth. Symbol shapes represent whether PAR availability at the station were estimated from Secchi depth, directly measured using a PAR sensor, or modeled via the optical model. Small numbers beside each symbol indicate the number of observations from each station. Inset histogram shows the distribution of clarity levels.

Three main types of clarity data were used in the assessment. (1) Most of the water clarity data came from Secchi disk measurements collected by NCDWR's water quality monitoring programs and NCDMF's adult and juvenile fish trawl surveys. Several data sets that contained simultaneous measures of Secchi disk depth and PAR attenuation were used to generate empirical models that estimated PAR attenuation from Secchi disk depth. (2) Measurements of the vertical attenuation of PAR in the water column allowed a direct calculation of PAR penetration to the 1.7 and 1.5 m target depths. (3) Where PAR attenuation was not measured but data on phytoplankton, sediment, and CDOM concentrations existed, an optical model was validated and subsequently used to estimate PAR attenuation. The combination of the three water clarity data sources provided a large data set for assessing the current water clarity of APES in relation to the SAV water clarity targets for areas with high and low-salinity SAV.

Results of the analysis show that water clarity in most areas of North Carolina's estuarine waters does not meet the proposed clarity targets. In particular, for most of the low-salinity SAV habitats in the northern estuarine region comprised by Albemarle and Currituck Sounds, light availability was generally less than 50% of SAV light targets. Clarity was better and low-salinity SAV light requirements were generally met in the lower parts of the Neuse and Pamlico Rivers. For high-salinity SAV habitats along the eastern side of Pamlico Sound, light availability was generally adequate south of Hatteras but moderately inadequate from Hatteras to Bodie Island. Water clarity along the western side of Pamlico Sound was poor to very poor. Only a small area of the central coast comprised of Core Sound and Back Sound generally had adequate clarity. These results indicate that current water clarity is insufficient to maintain SAV at the desired target depths and suggests that poor water clarity is likely a contributor to the observed declines of SAV in North Carolina's estuarine waters. Continuing work will quantify the contributions of phytoplankton biomass, sediments, and CDOM to PAR attenuation and provide the scientific basis for strategies to improve water clarity.

For more information, contact Nathan S. Hall at *shall@email.unc.edu*.

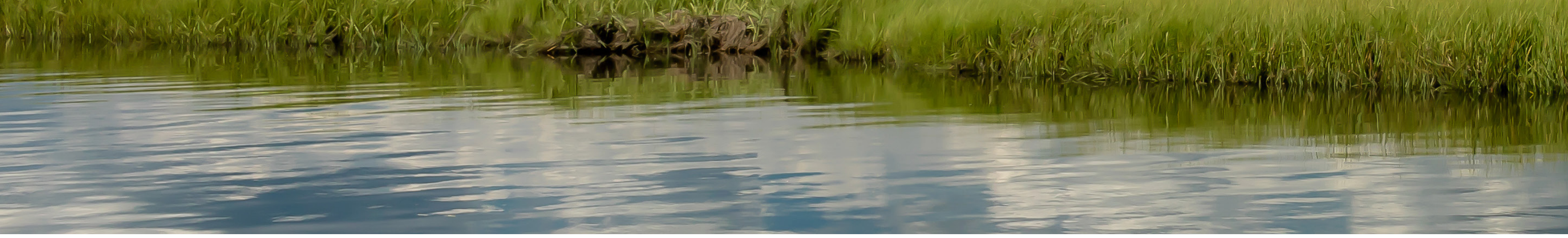
Resilience, Resistance, and Restoration of Seagrass in the Indian River Lagoon

Charles A. Jacoby, Lauren M. Hall, and Lori J. Morris, St. Johns River Water Management District

How does resilience relate to seagrass or other vegetated habitats along the coast? It may help to distinguish resilience (the ability to recover from a perturbation) and resistance (the ability to persist through a perturbation without changing). In this context, a perturbation would be an event or a change that stresses seagrass. There can be pulse perturbations with short durations or press perturbations that act over longer periods. Perturbations that stress seagrass include (1) physical disturbances, (2) extreme salinities, (3) extreme temperatures, and (4) reduced availability of sunlight at the depth where seagrass is growing. In general, seagrass does not resist physical disturbances, but may show resilience by recovering via growth or recolonization. For example, seagrass in the Indian River Lagoon demonstrated both resistance and resilience to press and pulse perturbations involving stressors other than physical disturbances.

The main perturbations affecting seagrass in the lagoon were decreases in the availability of light caused by blooms of single-celled algae or phytoplankton. The dense algae of the blooms in the water column intercepted sunlight before it reached the bottom where seagrass grows, which caused stress due to decreased photosynthetic output. The blooms used nutrients delivered by atmospheric deposition, runoff and groundwater from the watershed, and decomposition of internal stores of organic matter. Loads from all these sources increased from the 1950s to the present as the population around the lagoon increased, so excess loads of nutrients represent a press perturbation that stimulated blooms or pulse perturbations. Concern about this situation prompted development of total maximum daily loads for nitrogen and phosphorus that would not cause harm and basin management action plans for achieving the reductions needed to reach those loads.

Against this backdrop of decades of stress, other pulse perturbations affected the lagoon, as shown by conditions in the Banana River Lagoon (Figure 1). In 2008–2009, salinities were below 23 psu, an empirically determined



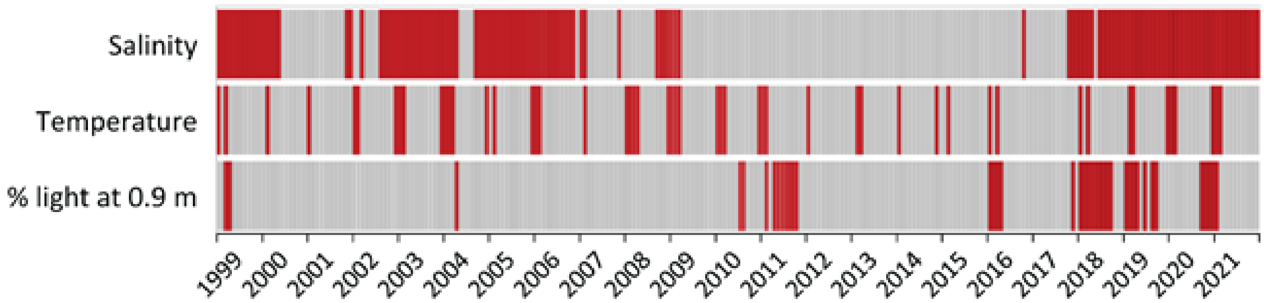


Figure 1. Heat map showing periods of stress (red bars) from low salinities (Salinity), low water temperatures (Temperature), and reduced availability of light at a depth where seagrass grows (% light at 0.9 m = percent of incident sunlight reaching 0.9 meters) in Banana River Lagoon.

threshold for stress on seagrass. Temperatures dropped below a corresponding threshold of 20°C in the winters of 2009 and 2010. In addition, blooms of phytoplankton caused the percent of incident sunlight reaching seagrass in 0.9 meters of water to drop below 27%, which caused stress according to analysis of historical data. A similar set of coincident pulse perturbations occurred from 2018 to 2021. In contrast to these two periods of stress, conditions were more suitable for seagrass from 2012 to 2015.

The response of seagrass to the two periods of stress and to the period of reduced stress appeared as changes in its extent in maps derived from digital aerial photography (Figure 2). The reductions in the extent of seagrass during both periods of stress indicate that the pulse perturbations and the long-term press perturbation combined to overcome the seagrass' resistance. In particular, the reduced availability of light represented a key stressor because seagrass copes better with stress from low salinities and temperatures if sufficient light is available. The increase of approximately 13,000 acres in 2013–2015 provides evidence of resilience. If conditions had continued to support growth, seagrass might have recovered to the level documented in 2009 within 12–17 years. Unfortunately, conditions did not remain favorable, and further losses occurred. Overall, the loss of seagrass and subsequent changes in the ecology of the lagoon, especially the recent manatee unusual mortality event that may be due to starvation, have spurred a great deal of interest in planting seagrass. Guidance for such efforts can come from using the thresholds identified for stress to determine when and where conditions are suitable for the growth of seagrass.

Additional guidance for where planting may be successful comes from examining resistance to change displayed by seagrass. For example, data from the Banana River Lagoon indicate that patches persisted despite declines in seagrass throughout the Indian River Lagoon. Identifying the most resistant patches involved creating an overlay of 12 consecutive maps that covered the span of 26 years from 1996 to 2021 and determining the number of consecutive maps containing each patch (Figure 3). Adding bathymetry to the map of persistence will highlight the depth range that provided the most ideal conditions. The "zone of

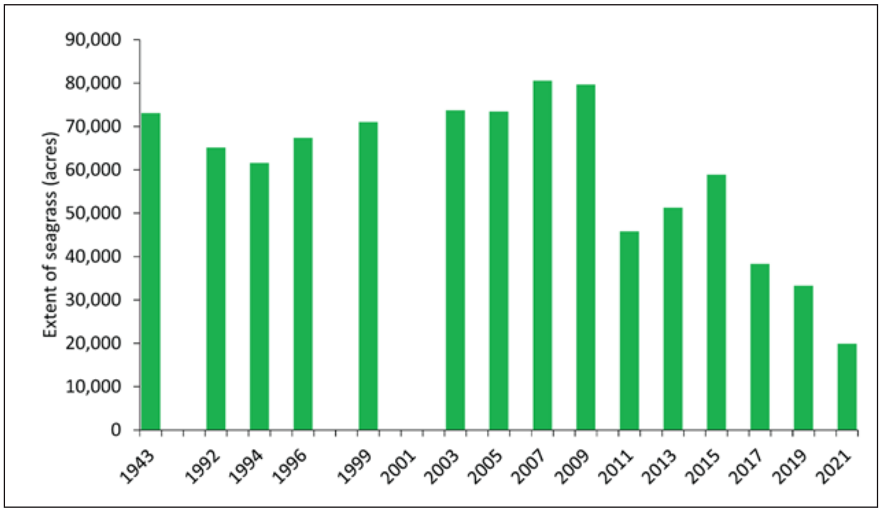


Figure 2. The extent of seagrass in the Indian River Lagoon derived from maps based on interpretation of digital aerial photography.

resistance" identified by patches that persisted across 10–12 maps represents a useful target when selecting sites for planting seagrass.

In the long-term, the health of the Indian River Lagoon will depend on reducing perturbations created when excess loads of nutrients fuel blooms of phytoplankton that reduce the availability of light. There are ways to manage nutrient loads, and efforts to reduce them are underway. Such efforts include improved treatment of stormwater, installation of advanced septic systems that leach fewer nutrients, conversion of septic systems to sewerage, and removal of legacy loads that have accumulated in the system. The goal is to reduce any manageable source of stress on seagrass so that its resistance and resilience will improve to the point where it can cope with meteorological events and other less manageable pulse perturbations. There is evidence that seagrass will respond because it still exhibits resilience. For example, clear water meant light was available for much of 2021 and the beginning of 2022, and surveys in the summer of 2022 showed that the average transect length increased by about four meters and the average percent cover increased by about three-quarters of a percent from the previous year. Overall, the time and dedication needed to restore the health of the lagoon will be worthwhile.

For more information, visit [https://www.sjrwmd.com/#gsc.tab=0.](https://www.sjrwmd.com/#gsc.tab=0)

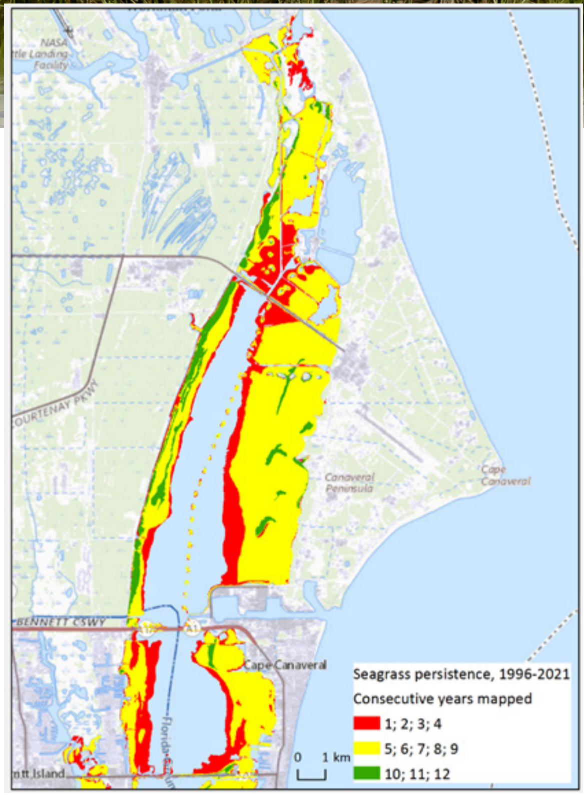


Figure 3. Persistence of seagrass in Banana River Lagoon derived from analyzing an overlay of the 12 maps created from 1996 to 2021.

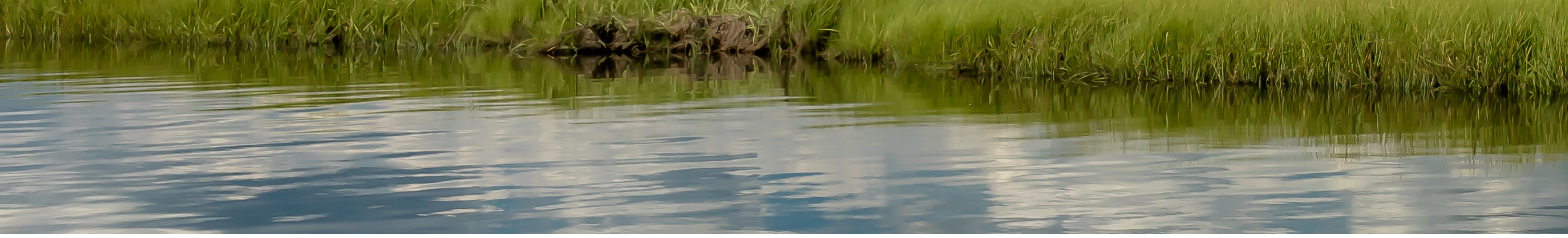
Updates to the Commission's Submerged Aquatic Vegetation Policy

Dr. Lisa Havel, former ASMFC Habitat Committee Coordinator

In 1997, the Commission's Habitat Committee developed a policy to communicate the need for conservation of coastal submerged aquatic vegetation (SAV) resources, and to highlight state and Commission-based activities for implementation of a coastal SAV conservation and enhancement program. The Commission encouraged implementation of this policy by state, federal, local, and cooperative programs that influence and regulate fish habitat and activities impacting fish habitat, specifically SAV. In 2017, the Commission's Habitat Committee conducted a thorough review of the policy, re-evaluating its recommendations and importance, and released an updated policy in 2018.

In 2022, the Habitat Committee updated the policy again to further refine the definition of SAV, and to introduce the Commission's position on living shorelines and nature-based features. Other minor clarifying edits were also included. The goals are still largely unchanged from the 1997 version. The primary goal is to preserve, conserve, and restore SAV where possible, in order to achieve a net gain in distribution and abundance along the Atlantic coast and in tidal tributaries, and to prevent any further losses of SAV in individual states by encouraging the following:

1. Protect existing SAV beds from further losses due to degradation of water quality, physical destruction to the plants, or disruption to the local benthic environment, such as from coastal construction
2. Continue to promote state or regional water and habitat quality objectives that will result in restoration of SAV through natural re-vegetation
3. Continue to promote, develop, attain, and update as needed, state SAV restoration goals in terms of acreage, abundance, and species diversity, considering historical distribution records and estimates of potential habitat
4. Continue to promote SAV protection at local, state and federal levels and when unavoidable impacts to SAV

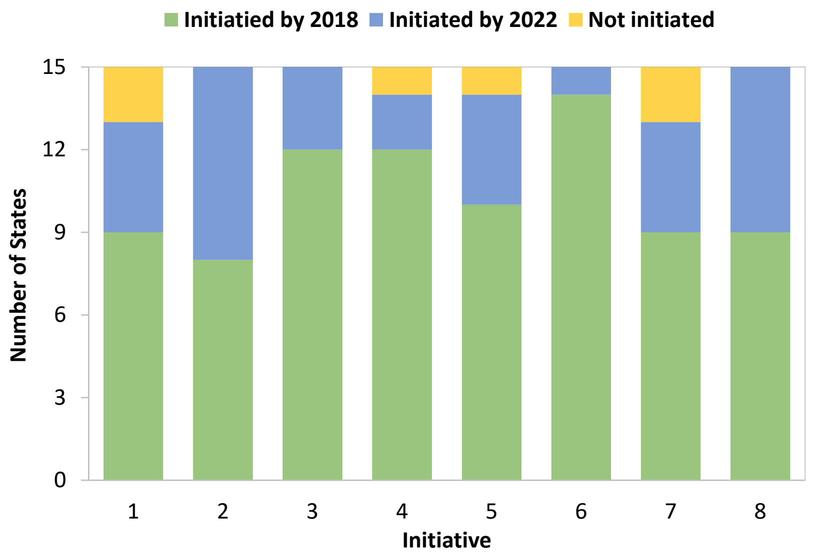


occur from permitted coastal alterations or other unintended actions, agencies should implement compensatory mitigation for the functional and temporal impacts

5. Encourage monitoring and research to address management-oriented information gaps
6. Provide funding for pilot projects and other demonstration restoration areas

There are six key components to achieving the goal of this policy: (1) assessment of historical, current and potential distribution and abundance of SAV; (2) protection of existing SAV and associated habitat; (3) SAV restoration and enhancement; (4) public education and involvement; (5) research; and (6) implementation through pilot demonstration areas. The policy can be found here – [HMS_MgmtSeries15_SAV_PolicyUpdate_Winter2022.pdf (asmfc.org)](HMS_MgmtSeries15_SAV_PolicyUpdate_Winter2022.pdf).

For more information on SAV, visit the Commission website at http://www.asmfc.org/habitat/hot-topics or contact Simen Kaalstad, Habitat Committee Coordinator, at SKaalstad@asmfc.org.



Number of Atlantic coast states carrying out each initiative category in 2022 compared with 2018. Note: data were unavailable for Delaware in 2018 but the state is included in the 2022 data.

ASMFC Releases New Report on State Climate Change Initiatives

Dr. Lisa Havel, former ASMFC Habitat Committee Coordinator

In August 2022, the Commission's Interstate Fisheries Management Program Policy Board approved the publication of the 2022 Report on Atlantic States' Climate Change Initiatives. This report is an updated account of the initiatives that each Atlantic coastal state is taking to reduce their greenhouse gas contribution and address climate change impacts, highlighting the progress made since the last report, released in 2018. Though the focus is on state coastal regulatory planning, many states reference broader initiatives as well.

The report maintains the same categorization of initiatives as the previous report for comparison purposes. They are:

1. Established a working group or legislation to reduce carbon output
2. Established a working group or legislation to respond to climate change threats
3. Produced reports on climate change
4. Assesses and monitors the effects of climate change
5. Has mechanisms in place for collaboration among agencies and other organizations
6. Addresses climate change in planning documents
7. Has responded to climate change on the ground
8. Includes climate change in outreach efforts.

As of 2022, each state has implemented 5-8 of the initiatives categories listed above. Eleven states have practices in place that meet all eight categories, up from four states in 2018.

As evident from the graph, a lot of new work has begun to both reduce the emission of greenhouse gases and respond to the impacts of climate change over the last four years. Details about each initiative, many with links to more resources, can be found in the report.

To read the report, visit: *2022Report_on_AtlanticStates'ClimateChangeInitiatives.pdf (asmfc.org)*. For questions, contact Simen Kaalstad, Habitat Committee Coordinator, at SKaalstad@asmfc.org.

Updates from Around the Coast

MAINE

Claire Enterline, Maine Department of Marine Resources

The CoastWise Approach to Tidal Road Crossings

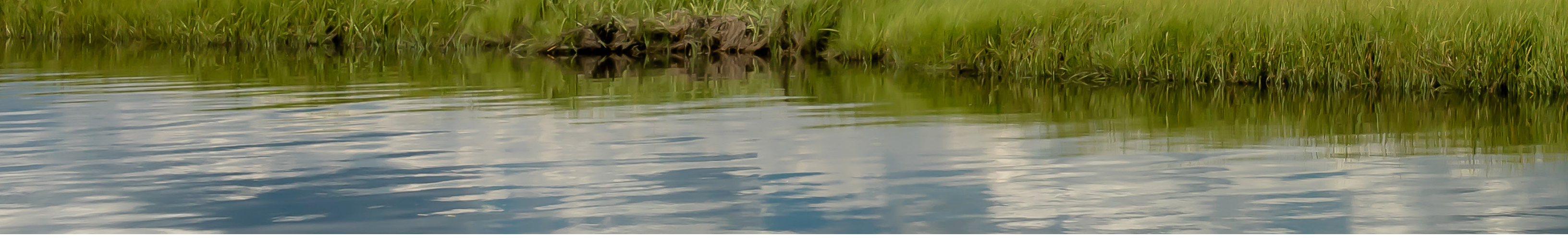
Maintaining roads is a challenge for most communities in Maine, especially in coastal areas that experience rapid changes due to accelerated sea level rise. Where roads cross tidal wetlands at over 800 locations in Maine, the challenges are considerably magnified. Tidal wetlands can provide coastal storm and flood damage protection, pollutant filtration and break-down, fish and wildlife habitat, commercial harvesting, and recreational opportunities. Some wetlands, like salt marshes, store atmospheric carbon that would otherwise contribute to sea level rise and other climate shifts. To deliver these benefits, tidal wetlands must remain healthy and resilient to sea level rise. To do this requires unimpaired tidal flow, but about 90% of Maine's tidal road crossings have 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.

The CoastWise Approach

Traditional practices for designing tidal road crossings do not adequately address the unique complexities, uncertainties, risks, or benefits associated with tidal environments. In response, the Maine Coastal Program and the CoastWise Steering Committee convened experts in the field and marshaled the input of over 30 organizations to develop 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. CoastWise Approach principals include:

- **Know your tidal crossings:** Learn which crossings are tidal now or likely to be in the coming decades; use the Maine Coastal Program's *Tidal Restriction Atlas* or other available tools.
- **Start early:** Tidal crossing design is complex and requires ample time to seek funding, collect and analyze diverse data types, establish clear objectives, and develop design alternatives.
- **Ask for advice:** Contact a CoastWise Technical Partner to help with project planning, connecting with the right resources, and providing other support.
- **Engage qualified engineering:** Expertise in data collection, analyses, sea level rise, tidal hydrodynamic modeling, and crossing design specific to tidal environments is the best fit.
- **Encourage local participation:** Crossing design requires value judgements having lasting impact. A transparent, participatory design process facilitates outcomes that serve communities best.
- **Identify risk factors:** Consider wetland condition, vulnerable species, and low-lying infrastructure and resource-uses within the crossing's influence, now and in the future.
- **Plan for coastal change:** Selecting an appropriate sea level rise scenario is essential to effectively plan for flooding, emergency access needs, and long-term cost effectiveness.

Photo credit: Slade Moore, Habitat Restoration Coordinator, Maine Coastal Program



- Establish objectives: Clear, measurable objectives streamline the design process and save costs.
- Size crossings for resilience: To survive, marshes and other tidal wetlands upstream of crossings need unrestricted tidal exchange during the highest tides of the year for the life of the crossing.

For more information and materials, visit the CoastWise webpage at https://www.maine.gov/dmr/programs/maine-coastal-program/coastal-community-support/the-coastwise-approach.

Improving Diadromous Fish Passage

The Maine Department of Marine Resources and multiple partners have implemented a number of dam removals and fish passage improvements to benefit native sea run fish. Some highlights include:

- Removal of a defunct powerhouse and dam just downstream of the 6,000-acre Meddybemps Lake, which could produce more than 2 million alewives annually
- Removal of the Walton Mills Dam on Temple Stream in the Sandy River, restoring over 50 miles of prime climate resilient Atlantic salmon habitat in the Kennebec River watershed
- Removal of two dams on the Sabattus River in the Androscoggin watershed, opening over 25 miles of habitat for multiple sea run fish
- Construction of two nature-like fishways at Seal Cove Pond on Mount Desert Island to improve passage for multiple species
- Implementing fish friendly culvert replacements in Bucksport in the Penobscot watershed.

Major planning and design efforts are underway to remove the Milltown Dam, the first dam on the International St. Croix/Skutik River, in the summer of 2023 and install new state of the art fishways at Woodland and Grand Falls upstream. These lower St. Croix restoration projects could provide improved access to over 600 miles of historic sea-run fish habitat and over 60,000 acres of alewife habitat, which when completed could be the largest alewife restoration project in North America. Governor Janet Mills and other dignitaries welcomed over 700,000 free swimming alewives back to the China Lakes in 2022 after a 200-year hiatus, thanks to the successful completion of the last project in multi-project Alewife Restoration Initiative in 2021.

Supporting Coastal Carbon Habitats, Monitoring, and Research

In 2020, the Maine Climate Council recommended improving our knowledge and conservation of coastal carbon, or blue carbon habitats. These include tidal marshes, eelgrasses, and seaweeds have the potential to sequester and store carbon in addition to their numerous benefits of providing habitat that supports a diversity of species, as well as providing ecosystem services like nutrient reduction and flood resilience.

In response, the Maine Legislature passed LD 559, an Act that restores regular mapping of eelgrass beds throughout the state on a five-year rotational basis, as well as mapping saltmarsh acreage and change over time. The Maine Department of Environmental Protection oversees the new program. Mapping of eelgrass beds in Southern Maine was completed in 2022 through a separate initiative, and the new program will begin collecting information for the Midcoast area within the next five years.

Additionally, researchers, policy advocates, managers, and coastal communications specialists have formed the *Maine Blue Carbon Network* to advance the exchange of information about blue carbon research findings, needs, and how the information can be used to inform policy and management. Over the next two years, the Network will work to inform state carbon accounting using refined carbon sequestration and greenhouse gas emission rates from current Maine-based research, as well as host public workshops to provide a forum for exchange of emerging scientific information and research needs among members of the scientific community and coastal managers.

For more information, contact Claire Enterline at *Claire.Enterline@maine.gov*.

New Hampshire

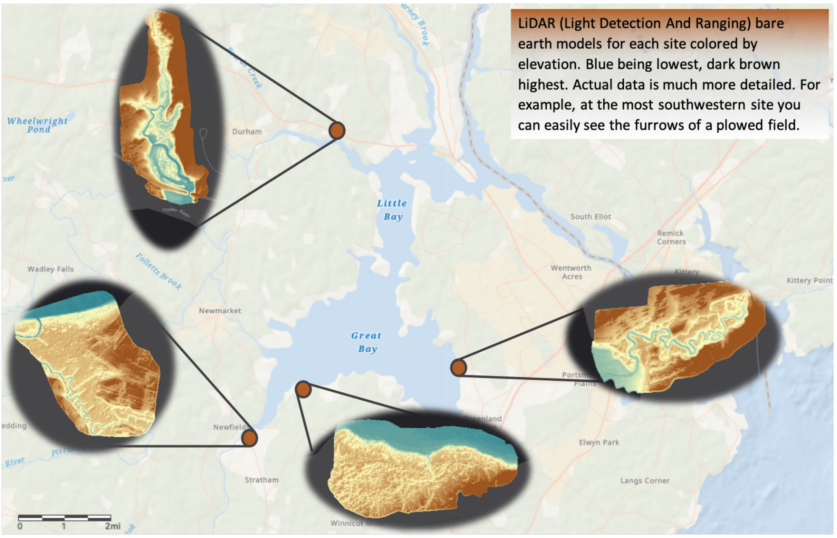
How Drones Are Changing the Way We See the Great Bay

Chris Peter, Rachel Stevens, and Cory Riley, Great Bay National Estuarine Research Reserve

Great Bay National Estuarine Research Reserve (GBNERR) scientists, recently flew a laser-equipped drone in New Hampshire. Although drones were originally designed by the military as weapons capable of delivering remotely guided missiles, the one flying over the Great Bay was on a peaceful mission. Drones are remotely controlled aircraft that are small, light, maneuverable, and used in many different ways. As a fun example, drones were recently deployed for the first time in Austria at one of the most renowned ski races in the world. The drone's vantage point provided stunning and nauseating video footage, chasing ski racers down 2,821 vertical feet at speeds over 85 mph. Remarkably, this was one of the first live ski events captured by drone since 2015, when a drone nearly crashed into one of the top ski racers in world cup history. Other uses of drones include aerial photography to aiding in search and rescue missions, delivering packages, and, as in the case of Great Bay, monitoring impacts from climate change.

GBNERR encompasses over 10,000 acres, including a variety of habitats and creatures such as bald eagles, seabass, horseshoe crabs, salt marshes, seagrasses, and marine mammals. GBNERR is a federal and state partnership between NOAA and New Hampshire Fish and Game (NHFG). NHFG scientists are focused on detecting, understanding, and managing impacts on Great Bay, which brings us back to the skies (not skis) where drones are collecting images and millions of data points that inform us on how salt marshes are being affected by climate change. As the ocean rises more rapidly than ever before, it poses threats not only to our roads and houses but also to rare natural habitats and species. Salt marshes, which are extremely valuable because they provide flood protection, carbon storage, and wildlife habitat, are particularly vulnerable to rising seas because inhabiting plants and animals have harmonized with just the right amount of tidal flooding. Larger increases in flooding could tip this balance towards too much stress and die off.

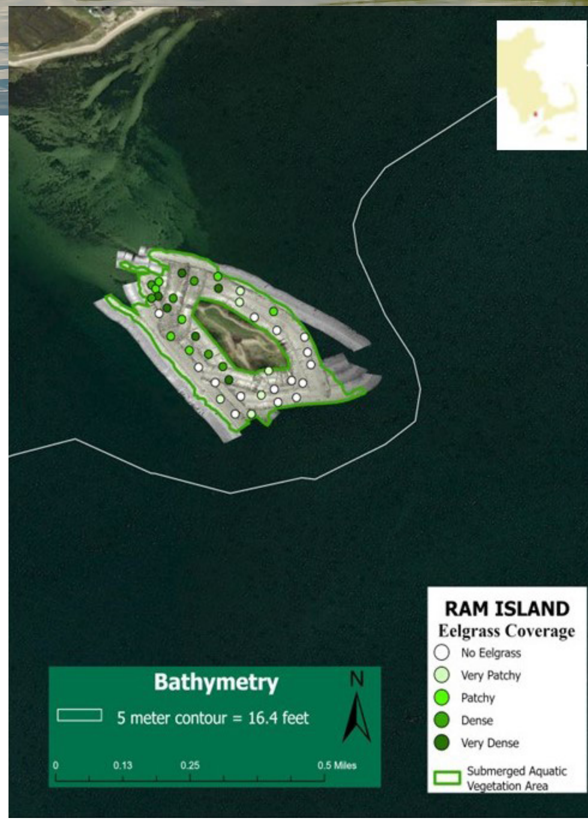
A drone equipped with a specialized laser was flown over several salt marshes of Great Bay to help map the marsh surface elevation, involving a miniaturized light detection and ranging system (LiDAR) to scan the marshes using millions of measurements. Utilizing drones equipped with LiDAR, we can 'see' the microtopography of a marsh on a landscape scale, which we can then analyze with on-the-ground data we collect on plants, tidal water levels, and sedimentation. This allows us to better understand if these crucial habitats are able to keep pace with rising seas, or if they will drown.



GB Map. Photo credit: ARE, Rachel Stevens

Drone Crew. Photo credit: Chris Peter

Why is GBNERR tracking marsh elevation? Unlike uplands, which remain relatively stable, marsh elevations are dynamic and can build upwards or sink. With minor increases in flooding, marshes can build up by trapping mineral sediments that are carried in by the tide and from plant roots from below. However, rapidly rising seas, as seen more recently, can overwhelm this accord between marshes and the tides and kill off the plants, leading to the marsh falling further and further behind the tides. Similar to the infamous ski-drone incident, it's a race the marsh and skier cannot afford to fall behind in, leading to potential death by drowning and "droning." Looking forward, and of course downward, GBNERR not only plans to continue to track the health of Great Bay's marshes using drones but also plans to use images and video to show students and the public a different view of the Great Bay and its incredible ecosystems. With new technologies, the Reserve hopes to expand its research and education programs to bring our collective understanding and appreciation of the Bay to new heights.



Ram Island provides scan sonar and photo groundtruthing surveys. Photo credit: MA DMF

For more information, visit https://greatbay.org/.

Massachusetts

Compiled by Mark Rousseau, Massachusetts Division of Marine Fisheries

Promoting Resilience in Vegetated Coastal Habitats

Ram Island, Mattapoisett

Ram Island, a small, low elevation island in Buzzards Bay, MA, was heavily impacted by the 2003 Bouchard Barge oil spill, which released oil along nearly 100 miles of shoreline in the Bay and nearby Rhode Island waters. The spill resulted in impacts to fringing salt marsh on the Island's periphery, which had played an important role in protecting the Island's interior from erosion. While only approximately 3 acres in size, Ram Island provides critical nesting habitat for both roseate (*Sterna dougallii*) and common (*Sterna hirundo*) terns and supports about 25% of the North American nesting population of the former species. As such, preservation of the Island is critical to the conservation of this endangered species. The Massachusetts Division of Fisheries and Wildlife (MassWildlife), the owner and manager of the Island, is currently developing coastal resilience strategies to restore lost salt marsh, reduce erosion, and preserve existing nesting habitat in the face of rising sea levels.

The nearshore waters bordering Ram Island support extensive eelgrass (*Zostera marina*) meadows. The Massachusetts Division of Marine Fisheries (MA DMF) is providing a supporting role to MassWildlife to map current eelgrass distribution using both side scan sonar and drop

Ram Island provides critical Roseate and Common Tern nesting habitat. Photo credit: MassWildlife

camera methods. Surveys were completed during the 2021 and 2022 growing seasons to provide current data on eelgrass distribution and density. These data will be used in the development of the coastal resilience design and the permitting process to ensure that strategies implemented to protect Ram Island minimize direct and indirect impacts to existing eelgrass habitat.

For more information, contact Dr. John Logan at John.logan@mass.gov.

Salem 2022 – MA DMF and Northeastern University Scientists Investigate Methods to Improve Resilience of Restored Eelgrass

In Massachusetts, eelgrass (*Zostera marina*) is an important marine flowering plant that provides habitat for many fish and invertebrates including commercially and recreationally harvested species such as winter flounder, bay scallop, and American lobster. Widespread eelgrass declines in Massachusetts in recent decades have led to concern and a call for increased restoration efforts. However, to date, many eelgrass restoration efforts in Massachusetts have been unsuccessful, with eelgrass failing to persist more than a season or two following planting. Interestingly, small scale experiments in laboratory and field settings indicate that eelgrass are adapted to local environmental conditions at fine spatial scales. This suggests that the traits of donor eelgrass may strongly influence restoration success. In addition, experimental plantings that incorporate eelgrass with a mixture of traits are more resilient to stress caused by heat waves, algal blooms, and grazing. MA DMF and Northeastern University scientists are working together to investigate whether these experimental findings scale up to affect the resilience of eelgrass in large-scale restoration efforts. Specifically, eelgrass shoots from five natural beds along the North Shore of Massachusetts were harvested and planted individually and in mixture at a ½ acre restoration site in Salem Sound. The fourth year of the planned five-year monitoring program of the restored site was complete via SCUBA this past summer. The final restoration site monitoring is planned for next summer and will involve SCUBA and side scan sonar surveys of the site. These data will then be analyzed to test the effects of eelgrass donor identity and diversity on restoration success. For more information, contact Forest Schenck at Forest.Schenck@mass.gov.

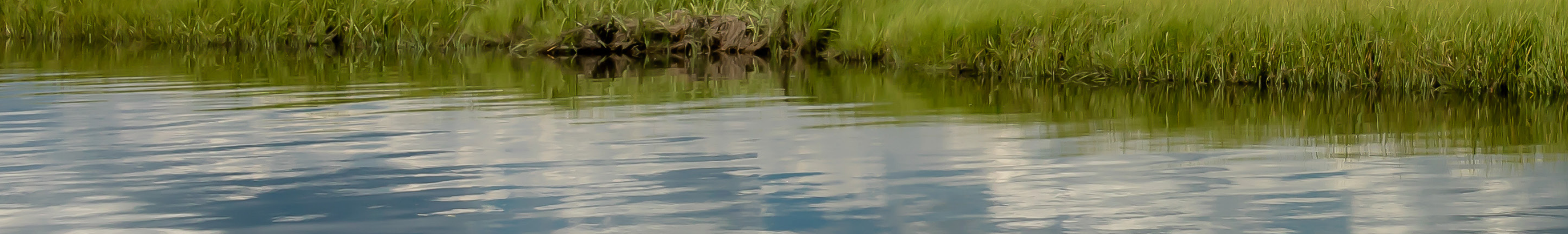
MA DMF Scientific Divers monitor restored eelgrass in Salem Sound. Photo credit: MA DMF

Rhode Island

Eric Schneider, Rhode Island Division of Marine Fisheries

Offshore Wind Development

The Rhode Island Department of Environmental Management (RI DEM), Division of Marine Fisheries (RI DMF) continues to engage in state-water permitting activities and offshore wind energy development project reviews with federal partners. RI DEM is reviewing applications for two projects that propose to install AC power cables within state waters (e.g., Revolution Wind and Mayflower Wind). These reviews and permitting actions are in concert with permit reviews conducted by the Rhode Island Coastal Resource Management Council, NOAA Fisheries, the Environmental Protection Agency (EPA), the Bureau of Ocean Energy Management (BOEM), and other partners. More information is available at RI DEM's website at https://dem.ri.gov/natural-resources-bureau/marine-fisheries/fisheries-science-research/offshore-wind-development.



Shellfish Restoration

Rhode Island continues to develop the planning process for a cohesive, overarching guide for shellfish restoration and enhancement activities that reflects the needs of both stakeholders and managers. The planning processes aims to recognize and incorporate the social, ecological, and economic factors that influence shellfish restoration in Rhode Island. This process builds upon partnerships and collaborations to leverage local knowledge and technical expertise. Primary elements include using stakeholder feedback to help inform restoration goals and applying a social-ecological system approach to identify site-specific restoration opportunities in Rhode Island. The RI Shellfish Restoration and Enhancement Plan is led by RI DMF in partnership with Northeastern University, the Natural Resources Conservation Service of RI, Pew Charitable Trusts, and the University of Rhode Island Coastal Resource Center, with additional support from many other collaborators and entities. The official kick-off meeting occurred in March 2023. More information can be found at http://risrep.org.

Fish Passage and River Connectivity

The RI DEM Division of Fish and Wildlife continues to improve and restore fish passage for diadromous populations of fish in the coastal streams throughout the state via construction of new fishways and dam removals. Previous projects have increased fish passage efficiency and improved river connectivity between freshwater and marine systems. During 2022, the Division of Fish and Wildlife continued participating with various project management teams to assist with the preliminary planning, design, and construction oversight of new fish passage projects on the Annaquatucket, Blackstone, Factory Brook, Kickemuit, Mussachuck Creek, Pawcatuck, Saugatucket, and Ten Mile rivers. For more information, contact Phil Edwards at phillip.edwards@dem.ri.gov.

New York

Alexa Fournier, NYSDEC, Division of Marine Resources

Woodhull Dam Fish Passage Constructed on Peconic River

Last fall, a fish passage project was completed at the Woodhull Dam on the Peconic River in Riverhead, NY. The project restores access to 90 acres of high-quality habitat for river herring and American eel in the Cranberry Bog Preserve and Wildwood Lake upstream. Installation of the fish passage has more than doubled the amount of spawning and maturation habitat available for river herring on the Peconic River, part of the nationally recognized Peconic Estuary System and one of Long Island's premier river herring spawning runs.

The New York State Department of Environmental Conservation (NYSDEC), Suffolk County, the Town of Southampton, and the Peconic Estuary Partnership worked collaboratively to secure nearly $1 million for the design and construction of the fish passage. The design for the fishway includes a series of weirs or "steps" and resting pools to help the fish climb upstream. A separate eel passage with specialized substrate is mounted alongside the fishway to help eels move

Woodhull Dam outfall prior to construction of fish passage. Photo credit: Peconic Estuary Partnership

Side view of eel passage and fishway steps at Woodhull Dam, Riverhead.
Photo credit: Valerie Virgona, Peconic Estuary Partnership

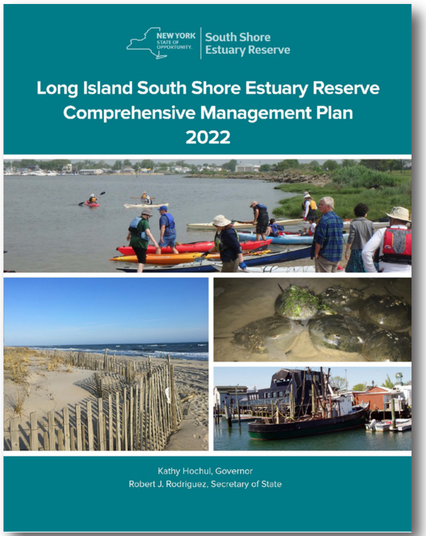
Resting pool at the top of Woodhull Dam fish passage.
Photo credit: Valerie Virgona, Peconic Estuary Partnership

through the passage. These structures were constructed through the existing dam, bypassing the current culvert. In the coming months, project partners will install a video monitoring system near the exit of the fishway to quantify the number of diadromous fish using the fish passage and monitor fish abundance.

Enabling fish passage at Woodhull Dam is a critical step in achieving the goal to restore 300 acres of diadromous fish habitat in the Peconic River. The completion of this and other fish passage projects on the Peconic have the potential to significantly expand river herring and American eel populations. These species are important food sources for many commercially and recreationally important fish species, such as bluefish and striped bass, migratory birds including osprey and herons, river otter, and other mammals.

South Shore Estuary Reserve CMP released

In September 2022, the New York State (NYS) Department of State announced the release of the 2002 Long Island South Shore Estuary Reserve Comprehensive Management Plan update. The plan, [available here](), outlines current priorities for the Reserve such as improving water quality, promoting coastal resiliency and habitat restoration, mitigating the impacts of climate change, and encouraging public use of the estuary. The Reserve covers the 70 miles of bays along Long Island's south shore from western Nassau County to Shinnecock Bay in the Hamptons.



The South Shore Estuary Reserve (SSER), administered by the NYS Department of State, was established in 1993 through the Long Island South Shore Estuary Reserve Act which called for the protection and prudent management of Long Island's South Shore bays and upland watershed areas. SSER brings together state and local governments, not-for-profit organizations, academia, local business interests and the public to preserve, protect and enhance the natural, recreational, economic and educational resources of the estuary.

DEC Announces Completion of New Shellfish Microbiology Laboratory

In June 2022, NYSDEC Commissioner Basil Seggos announced the completion of the federal evaluation under the National Shellfish Sanitation Program (NSSP) of the state's new shellfish microbiology laboratory. The state-of-the-art laboratory is located at the new headquarters of NYS DEC's Division of Marine Resources in Kings Park, which was completed in the fall of 2022. The laboratory features advanced equipment for processing and analyzing thousands of plankton, shellfish, and water samples annually, to ensure that shellfish harvested from certified areas in New York are safe for consumers in support of the state's commercially important shellfish industry. NYSDEC operates the only US Food and Drug Administration (FDA)-evaluated and conforming (approved) laboratory in the state for processing water samples to certify shellfish harvest areas under the National Shellfish Sanitation Program (NSSP).

View of the new shellfish laboratory at DEC's Division of Marine Resources, Kings Park, NY. Photo credit: Alexa Fournier, NYSDEC

NYSDEC's Shellfish Microbiology Laboratory analyzes approximately 13,000 water samples year-round to monitor trends in water quality from waterbodies across Long Island. Water samples are used to determine if areas meet strict sanitary standards for consumers under guidance by the FDA and the NSSP.

In addition to year-round water sampling analysis, the laboratory processes hundreds of blue mussel samples and phytoplankton samples annually. Each spring NYSDEC deploys mussel samples in various waterbodies around Long Island to monitor for the presence of potential marine biotoxins that can accumulate in shellfish and make them dangerous for consumption. Phytoplankton are identified and photographed as an early warning sign for harmful algae blooms that may accumulate in shellfish and pose a risk to consumers.

Enhancements provided at the new laboratory support NYSDEC's continued commitment to expand open shellfish harvests and increase shellfish harvesting opportunities for commercial and recreational shellfish harvesters as water quality conditions warrant.

The new headquarters of NYSDEC's Division of Marine Resources located within Nissequogue River State Park, Kings Park, NY. Photo credit: Alexa Fournier, NYSDEC

Headgates Dam. Photo credit: NOAA

NEW JERSEY

Russ Babb, New Jersey Department of Environmental Protection

NJDEP Plans to Remove Dam Using Natural Resource Damages Funds

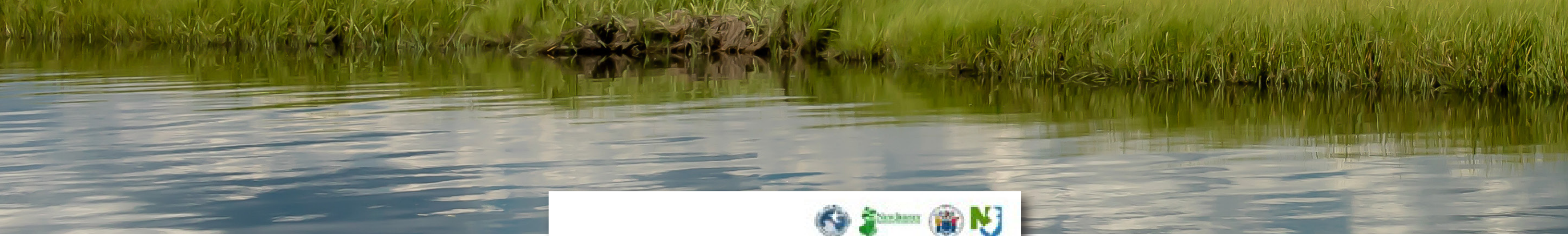
The New Jersey Department of Environmental Protection (NJDEP) announced that the obsolete Headgates Dam on the Raritan River in Somerset County will be removed using natural resource damages funds secured by the state, opening significant stretches of the river's North and South branches to fish passage for the first time in nearly two centuries. The Raritan River is part of an estuary ecosystem that historically provided spawning habitat for migratory fish such as shad, river herring, and striped bass. The Headgates Dam and Raritan Water Power Canal were built in 1842 to spur economic development in the region. At its peak, the dam, served a gristmill, machine shop and foundry, a paint works, flour mills, the Somerville Water Co., and the Raritan Woolen Mills.

Over the past decade, three dams downstream of the Headgates Dam and another on the Millstone River have been removed. When the Headgates Dam is removed, the only dam remaining on the mainstem Raritan will be the Island Farm Weir Dam, near the confluence of the Millstone River. The Island Farm Weir Dam, equipped with a fish ladder since its construction in the 1990s, is not a candidate for removal because it supports public drinking-water intakes operated by the New Jersey Water Supply Authority. However, the NJDEP is working on ways to improve fish passage at this dam. Over the history of the NJDEP's natural resource damages program, the state has recovered more than $800 million from polluters covering some 7,000 sites and has restored more than 1,000 acres of habitats.

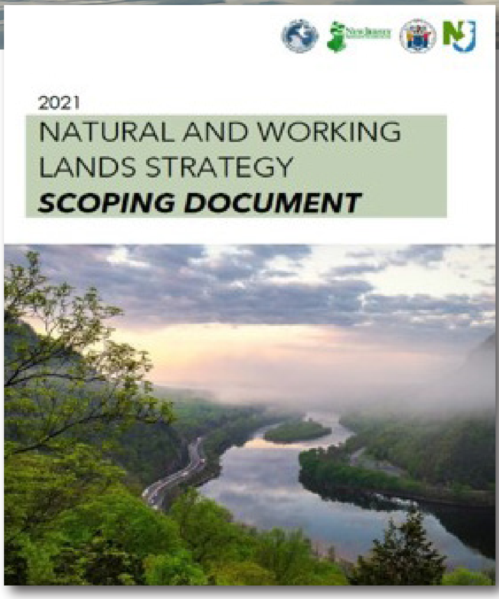
Removal of dams and restoring the flow of the waterways within the Raritan watershed to a more natural state to help rebuild fish populations is a priority for multiple government and non-profit organizations, including the NJDEP, NOAA and the US Fish and Wildlife Service. In addition to blocking fish passage, dams create stagnant stretches along rivers that can be low in dissolved oxygen that aquatic life needs. They also exacerbate excessive algae growth that diminishes recreational and scenic enjoyment. Migratory fish that are benefitting from dam removals include American shad, alewife, blueback herring, and striped bass – species that live most of their lives in the ocean but need freshwater rivers and streams to spawn. Another species that is benefitting is American eel, which spends much of its life in fresh water but migrates into the ocean to spawn. Populations of these species are stressed in the Mid-Atlantic region for a number of reasons, including blocked access to freshwater habitat due to dams. Fish are known to naturally start using these waterways soon after dams are removed. The commencement of work is pending approval from all partners, securing of all required permits and other logistical considerations.

NJDEP Advances Efforts to Sequester Carbon, Fight Climate Change through Management of Natural and Working Lands Program

Complementing the NJDEP's efforts to reduce greenhouse gas emissions and build greater climate resilience, NJDEP and the NJ Department of Agriculture initiated a strategy for managing natural and working lands that is intended to reduce the amount of carbon in the atmosphere contributing to global warming.



The release of the Natural and Working Lands Scoping Document follows the NJDEP's issuance of the [*Global Warming Response Act 80x50 Report*] in 2021, which details the legislative, policy, public, and private actions necessary for New Jersey to reach its global warming goals of reducing emissions by 80% below 2006 levels by 2050. Increasing the state's ability to sequester carbon through the improved management of natural and working lands is critical to achieving the 80x50 goals and warding off some of the worst impacts of climate change.


2021
NATURAL AND WORKING LANDS STRATEGY
SCOPING DOCUMENT

The strategy will ultimately present a set of statewide policies and recommendations for the management of natural and working lands, the actions necessary to implement those recommendations within a proposed timeframe, and the associated carbon sequestration benefits. These land management efforts can and should reduce carbon dioxide in the environment through long-term accumulation in vegetation and soils. Sequestering carbon in this way would have multiple additional benefits, such as providing habitat for wildlife, contributing to the health and resilience of communities, including overburdened communities and strengthening the economy.

Natural and Working Lands include:

A good deal of attention from the Natural and Working Lands initiative has been spent on coastal wetlands and coastal aquatic resources and habitats (with particular focus on submerged aquatic vegetation). After incorporating input collected during stakeholder sessions, a final strategy document is anticipated in 2023.

NJDEP Makes $15M Investment in Nature-Based Infrastructure to Fight Climate Change

NJDEP launched a new blue and green carbon grant program that will invest $15 million in projects across New Jersey that create, restore and enhance salt marshes, submerged aquatic vegetation habitat, forests, and urban parks that sequester atmospheric carbon in the fight against climate change. Through this program, New Jersey became one of the first states to invest proceeds from Regional Greenhouse Gas Initiative (RGGI) auctions into natural resource restoration and enhancement projects.

The program provides local governments, academic institutions, nonprofits and others with a funding opportunity by restoring and enhancing coastal, woodland and urban ecosystems to reduce the greenhouse gases that cause climate change. The grant program is funded through auction proceeds the state has received through RGGI, a collaboration of Mid-Atlantic and New England states that works to reduce carbon emissions from power plants. States receive auction proceeds through this cap-and-trade program to fund a variety of initiatives that reduce emissions of greenhouse gases that contribute to climate change. New Jersey rejoined RGGI under Governor Murphy's leadership in 2020. Restored tidal wetlands provide important wildlife and fisheries habitat and can increase the resilience of coastal areas.

Project grant awards will range from $250,000 to $5 million. Applicants for blue and green carbon grants were required to demonstrate that the projects will reduce greenhouse gas emissions by increasing carbon storage capacity in biomass (i.e., trees and plants) and soils, will reduce methane and nitrous oxide emissions caused by increasing salinity of coastal waters or changing land use, and will reduce carbon dioxide emissions by preventing soil loss. Some eligible projects include those that prevent erosion of carbon rich soils in littoral (nearshore zones) of the

New Jersey coastal salt marsh. Photo credit: New Jersey Fish and Wildlife

state, including tidal wetlands, restore tidal flows to salt marshes, with a focus on increasing salinity to decrease production of methane, and increase the cover of native salt marsh vegetation in brackish and salt water tidal wetlands to sequester carbon.

For more information, contact Russ Babb at Russell.Babb@dep.nj.gov.

Delaware

Margaret Conroy and Mike Stangl, Delaware Division of Fish and Wildlife

Monitoring Fish Ladders

The Delaware River runs 330 miles from Hancock, New York to the Delaware Bay. While the Delaware River is the United States' largest undammed river east of the Mississippi, many of its tributaries are dammed. These dams impede passage of many fish species, including alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*), both commonly grouped as "river herring." River herring have been listed by the National Marine Fisheries Service as a "Species of Concern" since 2006. In order to monitor the restoration of river herring in the State of Delaware, the Delaware Division of Fish and Wildlife (DE DFW) has been collecting adult river herring data and analyzing trends related to fish ladders installed and maintained in the state.

Between 2000 and 2016, PSEG Nuclear, LLC was required to install fish ladders on 8 tributaries of the Delaware River estuary. From 2017 onward, DE DFW assumed operation, maintenance, and monitoring of those 8 fish ladders in addition to constructing 2 additional fish ladders. The goal of the fish ladders it to provide river herring access to habitat upstream of the ponds for spawning. Adult river herring abundance has been tracked at the ten fish ladders since 2017, and the data recently analyzed for the 2017-2021 period.

Fish ladders are opened seasonally. The ladders are first opened in early spring, as water temperatures begin to rise. The ladders are closed during the summer, and then reopened in late fall to allow emigration of age-0 river herring to below the ladder. DE DFW has added exit traps at the top of each ladder to monitor fish passage going into the ponds. These traps are monitored and maintained while they are in place.

The data for the past five years indicates that the total number of fish passing through the fish ladders is variable across years. Looking specifically at river herring, alewife, although much lower in number passed, have shown a downward trend in the 5-year period and blueback herring have been variable, exhibiting no clear trend across years.

The fish ladder traps have shown that there are many other species besides river herring using the fish ladders. Combining all ten fish ladder locations during the 5-year time period, gizzard shad and white perch were found in the highest abundance, with brown bullhead, white catfish, bluegill, pumpkinseed, black crappie, and common carp following. Occasional striped bass, largemouth bass, yellow perch, chain pickerel, yellow bullhead, redear sunfish, redbreast sunfish, redhorse sucker, northern hogsucker, and green sunfish were found in the traps. A single sea lamprey was found.

Collecting data from the fish ladders provided information on the fish that pass up the ladder but could not categorize the fish species abundance or trends on the river system as a whole, or provide data on the abundance, size and sex of fish that reach the spill pools below the ladder. The efficiency of each ladder in allowing fish passage is unknown, as is if individual ladder efficiency is variable by year. The analysis on 5 years of data does show that passage of fish varies strongly by ladder among the 10 fish ladders monitored by DE DFW. Additional years of monitoring and gathering data on the fish ladders will help to provide more information on abundance, length, and sex data for river herring using the ladders in these systems.

For more information, contact Margaret Conroy at Margaret.Conroy@Delaware.gov or Mike Stangl at Michael. Stangl@delaware.gov.

Information from: Final Performance Report for Project Number F20AF00154; Anadromous Species Investigations; Study 2: Shad and Herring Research; Activity 5: Delaware Fish Ladder Operation, Maintenance and Biological Monitoring

Maryland

Marek Topolski, Maryland Department of Natural Resources (MD DNR)

MD DNR Partners with GMU and TNC to Quantify the Benefits of Natural and Nature-based Features to Mitigate Effects of Sea Level Rise

Maryland submerged aquatic vegetation (SAV) staff are conducting a pilot study to run a before-after-control-impact assessment of the impacts of living shorelines on SAV. The project is assessing three sites and includes a restoration component. Knowledge gained will inform how to begin working SAV restoration into living shoreline designs. In a similar vein, MD DNR is collaborating with George Mason University (GMU) and The Nature Conservancy (TNC) to quantify benefits of natural and nature-based features for mitigation of effects of sea level rise. For example, assessing the value of SAV along shorelines affected by sea level rise.

A fish ladder and exit trap at Garrison's Lake, north of Dover, DE. Photo credit: Mike Stangl

MD DNR staff have been engaged in Chesapeake Bay Program (CBP) SAV Workgroup actions. The CBP SAV Workgroup recently published a guide to Chesapeake Bay SAV restoration (*https://d38c6ppuviqmfp.cloudfront.net/channel_files/44657/chesapeake_bay_sav_restoration_manual_cbp_sav_wg_online.pdf*). The idea is to promote small-scale SAV restoration projects and mitigation in Chesapeake Bay, particularly in the fresh and mesohaline waters where restoration success is higher.

The CBP SAV Workgroup is developing a third tier to their CBP SAV monitoring effort–an SAV Sentinel Site Program designed specifically to track climate impacts to SAV throughout the Chesapeake Bay. The data will also be used to train algorithms for artificial intelligence interpretation of satellite imagery to automate SAV delineation. Details on the three-tiered SAV monitoring approach can be viewed at: *https://www.chesapeakebay.net/what/programs/monitoring/sav-monitoring-program*.

Additionally, a project (contracted with the Virginia Institute of Marine Science) has been funded to assess the impacts of climate change on Chesapeake Bay SAV; and pending funding, a social marketing campaign is planned to promote the maintenance and stewardship of Chesapeake Bay SAV by waterfront land owners.

For more information, contact Marek Topolski at Marek.Topolski@maryland.gov.

North Carolina

Promoting Resilience in Vegetated Coastal Habitats

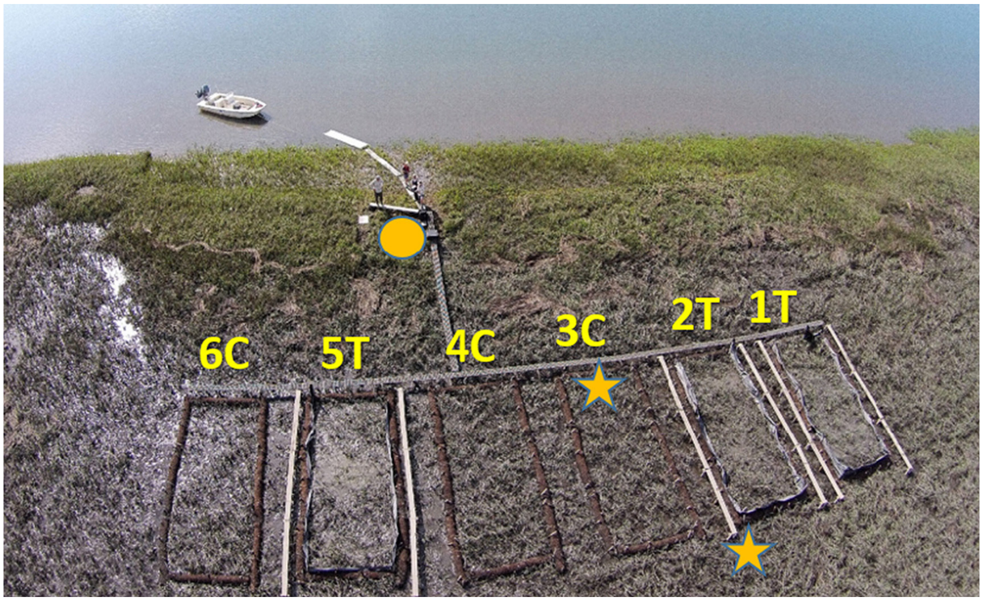
Jimmy Johnson, Coastal Habitats Coordinator, Albemarle-Pamlico National Estuary Partnership

"The salt marshes that fringe our coastal waters are some of the most productive and valuable natural habitats in the world. And North Carolina's got them — more than 3,000 square miles of them."- North Carolina Coastal Federation

The saltwater marshes of North Carolina have become especially vulnerable to the impact of rising seas. Several projects have been undertaken recently to find ways to help the marshes survive and keep from being inundated. One such project entitled, "Effective use of thin layer sediment application in Spartina alterniflora marshes is guided by elevation-biomass relationship" used thin layer application of dredged material as a means of helping marshes that are not increasing in elevation fast enough to keep pace with sea level rise. This study, conducted at the National Centers for Coastal Ocean Science (NCCOS) in Beaufort, NC, showed that thin layer application of sediment could indeed be beneficial in promoting vegetation growth of low-lying marshes while building elevation.

Sediment can be deposited on a marsh by either a high-pressure hose to spray the sediment across the landscape or by using a pipe to deliver a low-pressure slurry across the sediment site. This project used the latter of the two application methods so that it could be easily reproduced. "This method when combined with sediment sourced from routine navigation channel maintenance, can help retain sediment in coastal systems that would otherwise be placed in upland containment facilities or in offshore disposal areas, and benefit marshes that are not increasing in elevation fast enough to keep pace with sea level rise," the study reports.

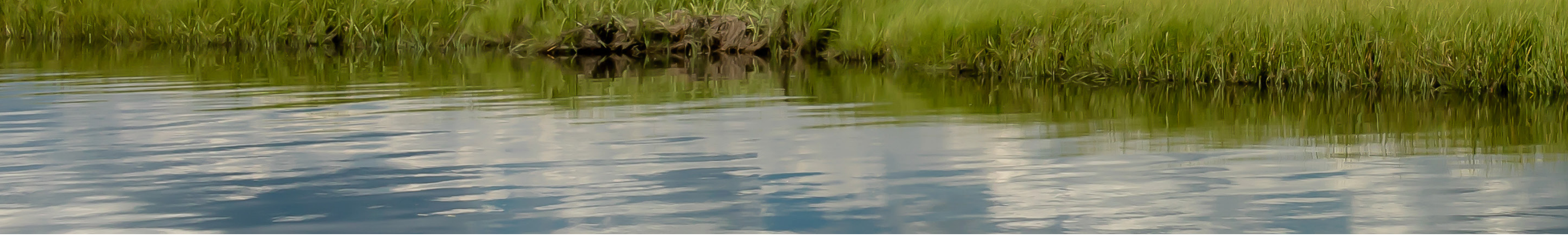
A significant increase in marsh vegetation was measured following the first growing season and that increase has lasted for four years. This demonstrates that the marsh now has an increased capacity to build further elevation on its own. Sediment application can result in making marshes more resilient to sea level rise. However, it was noted by Dr. Jenny Davis, NCCOS Research Ecologist and lead author of the study, that this method of thin layer sediment placement would be difficult to achieve across large areas of marsh until advances were made in the placement technology. The study may be accessed here: [*Davis, J., Currin, C., and Mushegian, N. 2022. Effective use of thin layer sediment application in Spartina alterniflora marshes is guided by elevation-biomass relationship. Ecological Engineering, 177; 106566. https://doi.org/10.1016/j.ecoleng.2022.106566*](https://doi.org/10.1016/j.ecoleng.2022.106566)



Plots 1, 2 and 5 were treated with dredged sediment. Plots 3, 4 and 6 were controls. Orange stars indicate water level logger locations and orange circle indicates position of the elevation benchmark. Image was taken halfway through the sediment application. Photo credit: NOAA

Submerged Aquatic Vegetation

The Albemarle-Pamlico Estuarine System has more than 100,000 acres of submerged aquatic vegetation (SAV), the most of any single state on the Atlantic Seaboard. Over the past year and a half, the Albemarle-Pamlico National



Estuary Partnership (APNEP) has contracted with the University of North Carolina at Chapel Hill Institute of Marine Sciences "to establish scientifically defensible chlorophyll a (Chla) and turbidity thresholds that are protective of SAV for high-and low-salinity zones of the Albemarle-Pamlico Estuarine System (APES)." This research was led by Dr. Nathan Hall and the report he authored is entitled, "Evaluation of water clarity metrics for protection of submerged aquatic vegetation in the Albemarle-Pamlico Estuarine System." It may be accessed at *https://apnep.nc.gov/media/1985/open*.

SAV provide a host of ecosystem services including nursery and feeding areas for important fisheries resources, sediment stabilization, and carbon sequestration and they are identified as a critical habitat by the North Carolina Coastal Habitat Protection Plan (CHPP). SAV are also useful and sensitive indicators of water quality, particularly water clarity changes related to eutrophication. Protection of SAV within North Carolina's estuarine waters is an important goal of APNEP and the North Carolina Department of Environmental Quality including its Division of Marine Fisheries, Division of Coastal Management and Division of Water Resources.

The purpose behind the project was to answer three important management related questions. The answer to these questions will help to better understand the links between eutrophication, photosynthetically active radiation (PAR) attenuation, and SAV health across the APES. The three questions were:

1. What threshold levels of phytoplankton biomass measured as chlorophyll a (chla) and non-algal particulates measured as turbidity are compatible with maintaining sufficient light availability for high-and low-salinity SAV growth in APES?
2. How do those SAV related chla and turbidity thresholds compare to the current water quality standard for North Carolina's estuarine waters, and to the current chla and turbidity concentrations observed in APES waters?
3. How does current water clarity compare to clarity targets for SAV expressed as a PAR attenuation coefficient across different high-and low-salinity regions of APES?

From Dr. Hall's report we read, "Answers to these questions will help establish scientifically defensible chla and turbidity thresholds that are protective of SAV for high-and low-salinity zones of APES. This information is needed for the process of numeric nutrient criteria development for North Carolina estuarine waters as part of the NC Nutrient Criteria Development Plan (NCDP) and will provide information for conservation and management of SAV habitats under APNEP's Comprehensive Conservation and Management Plan and NCDEQ's 2021 amendment to the North Carolina Coastal Habitat Protection Plan (CHPP)." APNEP continues to contract with Dr. Hall and the Division of Water Resources to improve this work by recalibrating the model for more reliable application to low-salinity systems.

Photo credit: APNEP

Photo credit: APNEP

Florida

Kent Smith, Florida Fish and Wildlife Conservation Commission

FWC Implements $8 million in estuarine habitat restoration projects

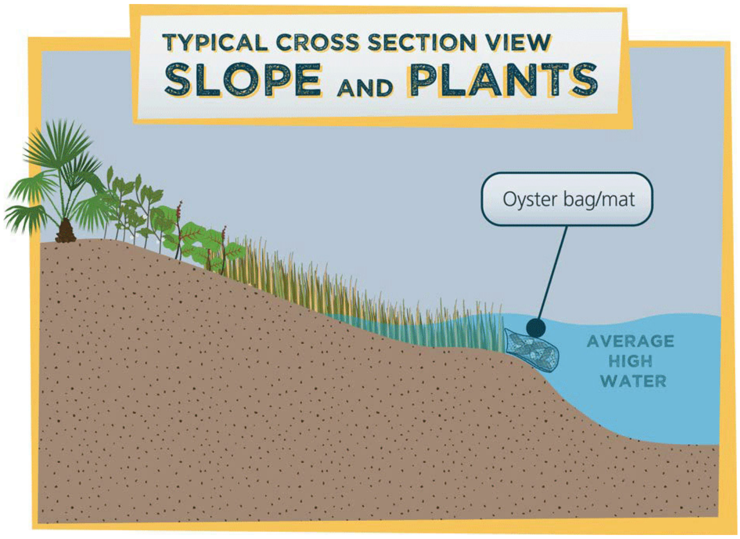
The Florida Fish and Wildlife Conservation Commission (FWC) is working with partners to implement $8 million in state funding for habitat enhancement and restoration projects supporting restoration of habitat in spring systems and in areas along the Atlantic coastal estuaries of Florida. The goal of these projects it to improve conditions for warm water and seagrass habitat used by manatees throughout the state. The list of projects includes enhancing and expanding a network of seagrass nurseries, restoration of hard clam and seagrass populations throughout the Indian River Lagoon, establishing estuarine habitat islands in lower Lake Worth Lagoon, and enhancing oyster, seagrass, and saltmarsh communities in the Mosquito Lagoon. These projects will result in supporting the re-establishment of hundreds of acres of a mosaic of integrated habitats supporting numerous ASMFC-managed fish species along the central to south Atlantic coast in the state. Information regarding the individual projects can be found at *https://myfwc.com/wildlifehabitats/habitat/ahcr/manatee-projects/*.

Public Access and Outreach for Nature-Based Resilience Projects

Florida is on the front line of experiencing the effects of climate change related to sea level rise and magnification of tropical cyclones. Use of nature-based infrastructure to address creating shoreline resilience to these effects is a focal activity on the part of state, federal and non-governmental agencies and organizations working on resource management projects. A coalition of partners in Florida have developed a Florida living shorelines website (*https://floridalivingshorelines.com/*) designed to disseminate information about the latest technology, design and permitting details to shoreline property owners and public resource managers. This, in concert with the Florida Department of Environmental Protection Office of Resilience and Coastal Protection's newly developed Living Shoreline Outreach Story Map and project tracker (*https://floridadep.gov/rcp/resilient-florida-program/content/resilient-florida-program-living-shorelines*), seek to engage and connect the public, consultants, and resource managers to expand the use of this approach to creating coastal resiliency that can adapt to our changing climate conditions and benefit fishery species. Integrating oyster reef and coastal marsh community (saltmarsh and mangroves) into these designs expands the area and ecological services, such as use by fish species as nursery habitat, of these communities in estuarine waters. Interest in nature-based shoreline resiliency has led to a dramatic increase in the installation of these projects around the state, thereby enhancing fish habitat in affected estuaries.

Photo credit: L. Walters, University of Central Florida

For more information, contact Kent Smith at *Kent.Smith@myfwc.com*.



FloridaLivingShorelines.com/types-of-living-shorelines

ACFHP Partnership Updates

Dr. Lisa Havel, former Atlantic Coastal Fish Habitat Partnership Director

The Atlantic Coastal Fish Habitat Partnership (ACFHP or Partnership) has continued to help restore and protect fish habitat in 2022 and has welcomed in-person collaboration again during multiple Steering Committee meetings throughout the year.

On the Ground Conservation

ACFHP has partnered with the US Fish and Wildlife Service (USFWS or Service) for the 13th consecutive year to fund five new on-the-ground restoration projects in 2022 through National Fish Habitat Partnership (NFHP) funding. The *Baskahegan Lake and Crooked Brook Flowage Fish Passage Project*, led by the Atlantic Salmon Federation, will restore access to 8,960 acres and 137 miles of stream habitat for alewives and other diadromous fish species through the installation of a pool and weir fishway at the Baskahegan Dam. Over time, a self-sustaining run of more than two million alewives is anticipated to have far-ranging, positive ecological, social, and economic benefits throughout the watershed all the way down to Penobscot Bay and the Gulf of Maine.

The Town of Braintree is leading the *Ames Pond Dam Removal and Fishway Construction Project* on the Monatiquot River in Massachusetts. With this funding, the Town of Braintree will remove the Ames Pond Dam and install a pool-and-weir fishway around the Rock Falls to restore 36 miles of unimpeded upstream access to 180 acres of habitat for river herring and American eel. The Ames Pond Dam and Rock Falls are two of three fish passage barriers on the Monatiquot River. The third barrier, the *Armstrong Dam*, was funded for removal by ACFHP in 2021.

Save the Sound is leading the Dam Removal and Diadromous Restoration of the *Norwalk River Watershed at Merwin Meadows Park* in Wilton, Connecticut. Through complete removal of the dam in Merwin Meadows Park, partial channel construction, partial channel realignment, and beneficial on-site sediment use, Save the Sound will restore fish passage and ecological connectivity to 6.5 upstream river miles, forming a free-flowing 17 mile stretch of the Norwalk River to Long Island Sound. The work will also remove a safety hazard; reconnect 1.13 acres of heterogeneous floodplain; reduce thermal, chemical, and other physical impacts to 1/4 mile of the Norwalk River; and educate visitors through volunteer events and interpretive signs.

The Nature Conservancy is working with partners on the *Paulina Dam Removal, Paulins Kill, New Jersey*. The dam is an obstruction to American shad, American eel, and sea lamprey passage, which are found below the dam. Removal of this dam, along with the earlier removals of the *Columbia* and *County Lines Dams* (both partially funded by ACFHP) will open and improve a total of 45 miles of mainstem and tributaries to migratory and resident fish.

Finally, the Chesapeake Bay Foundation is leading the *Comprehensive South River and Herring Bay Tributary*

Ames Pond Dam looking upstream. Photo credit: Town of Braintree

[Scale Oyster Restoration Project](#) in the Chesapeake Bay, Maryland. This project will augment existing hard bottom within two existing protected oyster sanctuaries along the mainstem and in a tidal tributary of Chesapeake Bay. Herring Bay will increase from 0.68 acres to 2 acres, and Glebe Bay (South River) will increase from 0.86 acres to 3 acres. Restoration of reefs in this area is designed to combat the threat of historic overfishing and sedimentation and add live native oysters to suitable reef substrate supporting the oysters themselves, adjacent aquaculture operations, and the broader estuarine food web. Chesapeake Bay Foundation will engage two communities through their existing local partnerships to expand oyster gardening efforts, design a tributary-scale oyster restoration plan, inform the process with surveying, and produce permitting documents for larger scale restoration.

For the third year, ACFHP has assisted the FishAmerica Foundation in funding projects to improve sport fish populations, aquatic habitat, and water quality. This year, funding was awarded to the Florida Fish and Wildlife Foundation to improve fisheries at Mary Holland Park in Lakeland, Florida. The project will provide habitat in lakes with limited SAV and natural habitat structure, and create a new urban fishing opportunity in Polk County, Florida. Funding was also awarded to The Nature Conservancy New Hampshire's Oyster Conservationist Program to support volunteers in their oyster restoration efforts. This involves growing oysters for restoration and collecting data on survival and growth. The community oyster gardens are used to educate community members about the Great Bay Estuary and the importance of oysters to this ecosystem.

Operations Updates

ACFHP was proud to release its Inclusion and Diversity Statement in April 2022, which was led by ACFHP Steering Committee member and former ACFHP Coordinator, Jessie Thomas-Blate of American Rivers. The statement can be viewed on the ACFHP website's at: *Mission, Vision, and Inclusion and Diversity Statement – Atlantic Coastal Fish Habitat Partnership (atlanticfishhabitat.org)*. We at ACFHP are committed to making fish habitat conservation welcoming and accessible for all, and look forward to the work ahead. Our first step is to thoughtfully and honestly examine our operations, culture, and conservation work during our strategic and action plan development, which has been taking place this year. Our new strategic and action plans will be released in mid-2023.

For more information, contact Simen Kaalstad, ACFHP Director, at *SKaalstad@asmfc.org*.

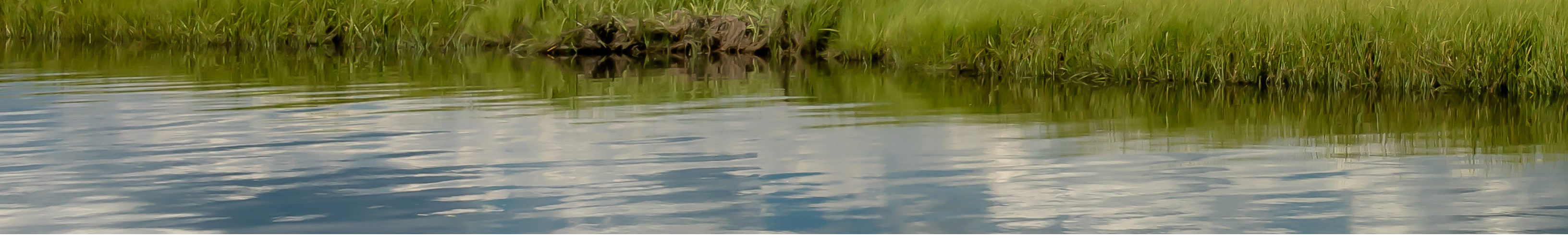
The Melissa Laser Fish Habitat Conservation Award

Tom Twyford - 2022

Executive Director of the West Palm Beach Fishing Club

Tom Twyford, the Executive Director of the West Palm Beach Fishing Club (Club) was presented the Atlantic Coastal Fish Habitat Partnership's (ACFHP) Melissa Laser Fish Habitat Conservation Award on November 16, 2022 at the Annual Lake Worth Lagoon Science Symposium in West Palm Beach, Florida. Tom accepted the award on behalf of his team of dedicated volunteers and staff members, who have partnered with Palm Beach County and the Florida Fish and Wildlife Conservation Commission (FWC) in their estuarine habitat conservation, innovation, and education efforts. Through Tom's outstanding leadership, the Club has aided in projects that have resulted in the restoration of approximately 250 acres of mangrove, seagrass, and oyster reef habitat. Additionally, Tom has been one of Palm Beach

Tom (center) and his two sons, Tommy (left) and Eddie (right), bagging oyster shells for future oyster reef restoration. Photo credit: Tom Twyford



County's leading ambassadors of sport fishing and a pillar for the community. His education and outreach programs have connected thousands of people (of all ages) and introduced them to the wonders of the estuarine environment and the importance of habitat conservation and restoration.

Tom's hard work and dedication exemplifies ACFHP's mission of accelerating restoration of native estuarine habitats. His unrivalled passion and extensive knowledge have brought his community closer together and provided support to local, regional, and state-level conservation projects.

Tom (left) and Tommy "Buzz" Bzura (right) participating in mangrove habitat restoration at Tarpon Cove. Photo credit: West Palm Beach Fishing Club

Wenley Ferguson - 2021, *Save the Bay - Narragansett Bay*
Andrew Goode - 2020, *Atlantic Salmon Federation*

After multiple postponements of the 2020 and 2021 Melissa Laser Fish Habitat Conservation Award presentations due to the COVID-19 pandemic, ACFHP was pleased to present Andrew Goode of the Atlantic Salmon Federation and Wenley Ferguson of Save the Bay – Narragansett Bay with the 2020 and 2021 awards, respectively, during a virtual ceremony on March 3, 2022. The ceremony was led by Kent Smith, ACFHP Chair, and attended by the ACFHP Steering Committee and friends and colleagues of Mr. Goode and Ms. Ferguson. Jeremy Bell, Climate Adaptation Program Director at The Nature Conservancy in Maine; Patrick Keliher, Maine Department of Marine Resources Commissioner; and Dan Kircheis, NOAA Fisheries Penobscot Bay Salmon Recovery Coordinator, gave remarks on Mr. Goode's successful career restoring fish passage in Maine. Chris Powell, ACFHP Steering Committee member (Rhode Island Department of Environmental Management, retired); and Jonathan Stone, Executive Director of Save the Bay – Narragansett Bay spoke about Ms. Ferguson's accomplishments in restoring Narragansett Bay.

Andrew Goode of the Atlantic Salmon Federation

Mr. Goode is responsible for leading the negotiation and implementation of dam removals on the Penobscot and Sheepscot Rivers in Maine. He recognized the important work Dr. Laser started on Coopers Mills and Head Tide Dams and committed to seeing them through to completion. Mr. Goode developed a solution at each site that restored fish passage to over 50 miles of river and tributary habitat for Atlantic salmon, alewife, American shad, striped bass, American eel, sea lamprey, and sea run brook trout. As a river with a longstanding and historic commercial alewife harvest, his efforts increased the sustainability of the Sheepscot River harvest for future generations.

Wenley Ferguson of Save the Bay - Narragansett Bay

Ms. Ferguson facilitated community-based restoration projects by working with towns, cities, and other partners to improve water quality and habitat in Narragansett Bay. Her recent efforts have focused on studying

salt marsh response to sea level rise and working with federal, state, and local partners on adaptive management strategies to improve resilience of these habitats. She has built coalitions and constituencies to envision, plan, implement, and secure millions of dollars in funding for dam removal, eelgrass restoration, salt marsh restoration, and coastal adaptation. Ms. Ferguson has organized, led, partnered, and promoted fish passage projects in Rhode Island, including projects on the Mussachuck Creek; and the Ten Mile, Pawtuxet, Pawcatuck, and Kickimuit Rivers. For more information on the Melissa Laser Award, please visit: [https://www.atlanticfishhabitat.org/ melissa-laser-fish-habitat-conservation-award/.](https://www.atlanticfishhabitat.org/melissa-laser-fish-habitat-conservation-award/)

New England and Mid-Atlantic Fishery Management Councils

Michelle Bachman, NEFMC and Jessica Coakley, MAFMC

The New England and Mid-Atlantic Fishery Management Councils (NEFMC and MAFMC, respectively) and partners have launched a Habitat Data Explorer as part of a collaborative, multi-disciplinary project to develop decision support products for marine fish habitat management. This online tool allows users to explore information on fish distribution and survey abundance, species life history, essential fish habitat (EFH), fish vulnerability to climate change, and much more – all on one website: *Northeast Regional Habitat Assessment Data Explorer*.

Photo credit: David Dixon, Wikimedia Commons

ACFHP Seeks Nominations for 2023 Melissa Laser Fish Habitat Conservation Award

The Melissa Laser Fish Habitat Conservation Award is bestowed by the Atlantic Coastal Fish Habitat Partnership upon individuals deemed to further the conservation, protection, restoration, and enhancement of habitat for native Atlantic coastal, estuarine-dependent, and diadromous fishes in a unique or extraordinary manner.

The award was established in memory of Dr. Melissa Laser who passed away unexpectedly on April 27, 2010. Melissa was a biologist with the Maine Department of Marine Resources where she worked tirelessly to protect, improve, and restore aquatic ecosystems in Maine and along the entire Atlantic Coast.

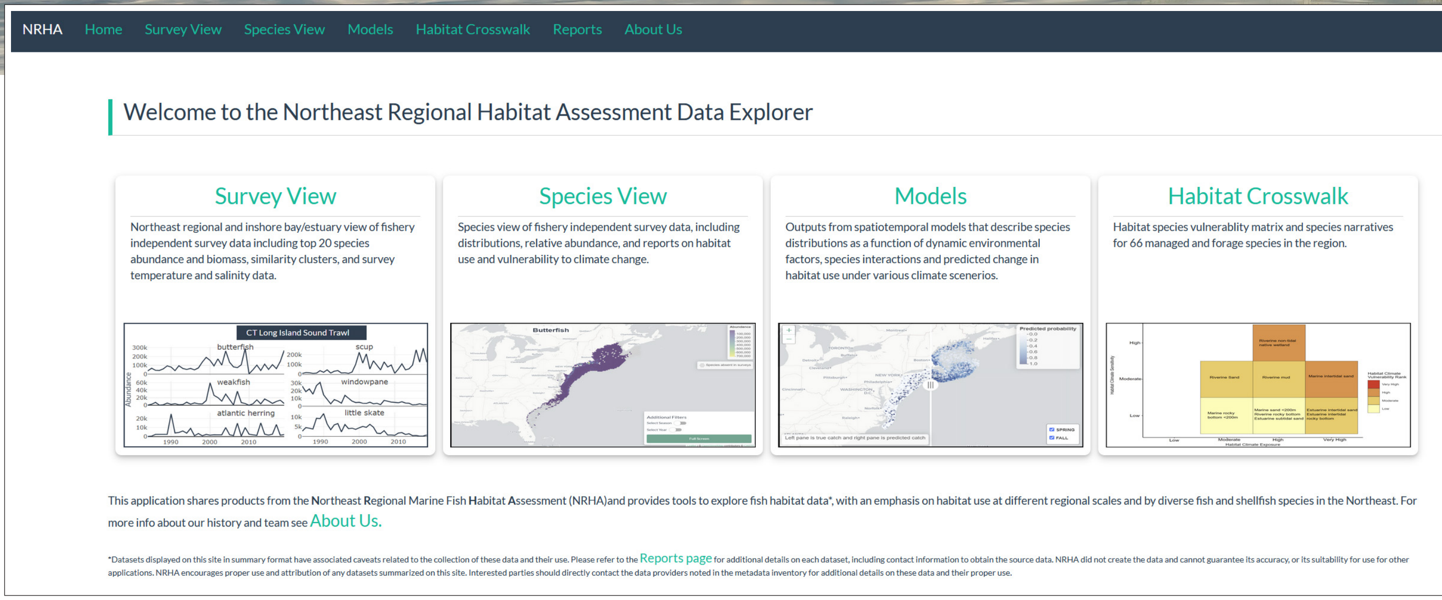
As an astute strategic thinker and leader, Melissa edited and coordinated the Strategic and Operational Plan for the Restoration of Diadromous and Resident Fishes to the Penobscot River. She coordinated fish passage projects, managed and oversaw the biological field staff for the Maine Western Region, and was the Bureau of Sea Run Fisheries and Habitat Program lead for habitat restoration studies and projects. She was also an effective champion for Atlantic salmon, directing and coordinating Endangered Species Act-related actions pertaining to the species.

Melissa brought her smiling dedication and enthusiasm to the Atlantic States Marine Fisheries Commission's Habitat Committee and Atlantic Coastal Fish Habitat Partnership's Steering Committee, catalyzed by the Commission in 2006. Her contributions to these committees and to her home state were tremendous. She is deeply missed.

View the *instructions* on how to submit a 2023 nomination, or to see a list of past award recipients, visit: https://www.atlanticfishhabitat.org/melissa-laser-fish-habitat-conservation-award/

Please send nominations to Simen Kaalstad, ACFHP Director (*SKaalstad@asmfc.org*), by **May 29, 2023**.

We plan to present the 2023 award at the Atlantic States Marine Fisheries Commission Annual Meeting this fall.



MAFMC approved an Aquaculture Policy in 2022, using the NEFMC policy (approved in 2020) as a starting point. The policy and other information on aquaculture in the Mid-Atlantic region are available at: *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 (*https://www.rosascience.org/*), which is dedicated to research, communication, and regional collaboration on offshore wind development and fisheries.

In response to offshore wind development pressures in Southern New England, NEFMC developed a *Habitat Area of Particular Concern (HAPC) designation* that highlights the occurrence of cod spawning and complex seafloor habitats in a location where multiple offshore wind projects are planned. The designation was approved by the Council in June 2022 and should be effective in late 2022 or early 2023 assuming approval by NOAA Fisheries. HAPCs direct focus towards important and vulnerable habitat types throughout project development are an important tool for EFH consultations.

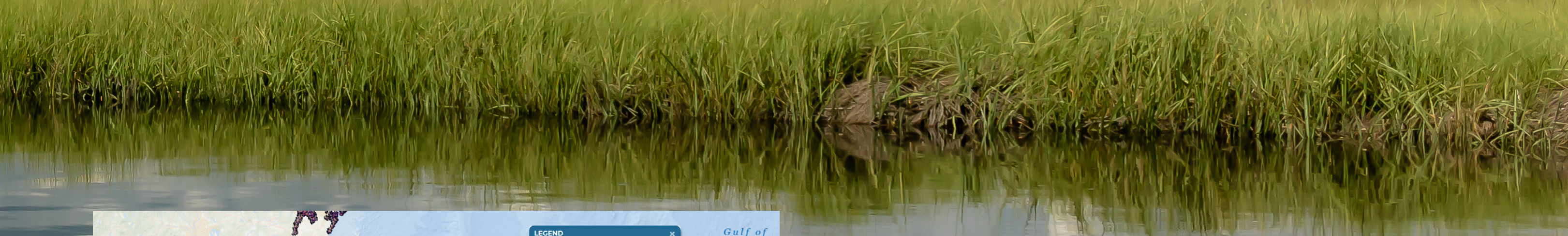
The East Coast Climate Change Scenario Planning Initiative, being coordinated by the New England, Mid-Atlantic, and South Atlantic Fishery Management Councils, Atlantic States Marine Fisheries Commission, and NOAA Fisheries, is exploring multiple plausible future scenarios related to climate change and shifting fishery stocks and considering how to best adapt to them. In early 2023, the project hosted a summit that brought East Coast fishery managers together to identify solutions that will promote resilience and adaptation in the face of these alternative futures. For more information visit *https://www.mafmc.org/climate-change-scenario-planning*.

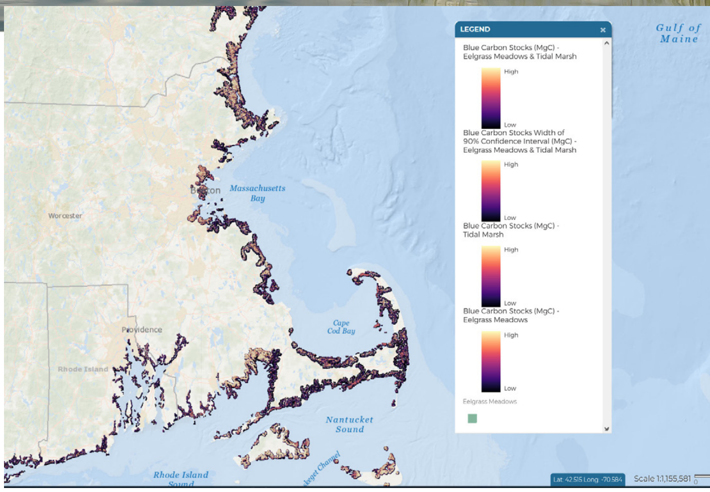
EPA Update

Phil Colarusso, Environmental Protection Agency

The Environmental Protection Agency (EPA) is finalizing a report on blue carbon resources from Maine to New York. This report was completed with the assistance of 29 scientists from academia, non-profit organizations, and state and federal government agencies. It creates a quantifiable baseline of blue carbon in the Maine to New York geographic region. The mapping working group compiled the most up to date eelgrass and salt marsh maps to create a regional habitat map. This map is publicly available on the Northeast Ocean Data Portal (*https://www.northeastoceandata.org/*).

The Carbon Working Group collected sediment carbon data associated with salt marsh and eelgrass meadows from a wide variety of sources. Bringing the disparate datasets into a coherent single database required significant analyses and multiple judgement decisions. The results of the carbon working group were brought together





Sediment Carbon Heat Map. Photo credit: Northeast Ocean Data Portal

with the habitat maps to create multi-colored sediment carbon "heat" maps. Those maps can be used to identify locations of high carbon storage to help inform future management decisions. An example is provided above.

North Carolina Coastal Federation

By Erin Fleckenstein, Wilson Laney and Todd Miller

The North Carolina Coastal Federation (NCCF), partnering with the Pew Charitable Trust (Pew) and the NC Division of Marine Fisheries (NCDMF), sponsored the North Carolina Coastal Water Quality Summit: Stakeholders Driving Solutions. The Summit was held October 19, 2022 in New Bern, North Carolina. The purpose of the Summit was to convene stakeholders and decision-makers to identify and organize voluntary actions that protect and restore coastal water quality. Participants, which included the three authors of this article, were presented a "Call to Collaboration" from North Carolina agency leadership and a "Call to Action" from key field personnel of the NCDMF Habitat and Enhancement Section, and Pew.

Informative presentations were given to aid in an understanding of water quality and habitat challenges facing North Carolina estuaries; explain how participants could build on existing programs through the North Carolina Coastal Habitat Protection Plan (CHPP); and how to engage stakeholders in CHPP water quality actions. Post-lunch working sessions were held with four breakout groups in three topic areas:

1. improving water quality through living shorelines and salt marsh conservation;
2. improving water quality through working lands and waters; and
3. improving water quality through community and ecosystem resiliency planning.

The Summit was well-attended (over 100 participants) and well-covered by local media (i.e., see: https://www.witn.com/2022/11/02/summit-new-bern-looks-improve-water-quality-coastal-ecosystems/).

Volunteers were identified in each of the breakout sessions for those interested in forming working groups, so that stakeholder participation will continue and the recommendations generated by the NCCF/Pew Stakeholder Workgroup Report, which was included in Appendix of the CHPP 2021 Amendment, will be implemented. The Summit is just one of a myriad of projects ongoing under the auspices of NCCF.

For more information, visit the NCCF website at https://www.nccoast.org/.


Egret. Photo credit: USFWS

Comings & Goings

DR. LISA HAVEL

In October 2022, Dr. Lisa Havel stepped down as the Director of the Atlantic Coastal Fish Habitat Partnership (ACFHP) and Coordinator of the Commission's Habitat and Artificial Reef Committees to become Grants Director at the Coastal Bend Bays and Estuaries Program, a non-profit dedicated to researching, protecting, and restoring the bays and estuaries in the Texas Coastal Bend and part of the EPA's National Estuary Program. When Lisa started at the Commission, ACFHP was just a fledgling program, but under her 8 years of leadership and hard work, the Partnership has seen incredible growth and, with increased federal funding, the Partnership has been able to support multiple habitat restoration projects benefiting Atlantic diadromous, estuarine, and coastal fish. Lisa strongly guided the Habitat and Artificial Reef Committees through the annual publication of Habitat Hotline Atlantic, and multiple habitat management series and reports focusing on aquaculture, living shorelines, sciaenid fish habitat, habitat bottlenecks, and artificial reef development.

SIMEN KAALSTAD

Simen Kaalstad has joined the ASMFC Commission staff as Director for the Atlantic Coastal Fish Habitat Partnership and Coordinator for the Habitat Committee and Artificial Reef Subcommittee. In those roles, he will be leading the ACFHP Steering Committee and its subcommittees in implementing the new ACFHP Strategic Plan, among other things, and will work with the Habitat and Artificial Reefs Committees to provide individual species habitat information to Commission fishery management plans, and publish the next installment in the habitat management series.

Simen joins us from the Gulf Coast, where his previous work and graduate research focused on mangrove ecology and restoration. He has a Master of Science in Fisheries and Mariculture from Texas A&M University-Austin, and a Bachelor of Science in Marine and Freshwater Biology from the University of Texas at Austin.

ACKNOWLEDGEMENTS

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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PUBLICATION 2023 (Volume 1)

This publication of Habitat Hotline Atlantic was made possible by the contributions of many, but the Habitat Committee would like to specifically acknowledge the efforts of the 2023 Editors:

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Simen Kaalstad (ASMFC)
Madeline Musante (ASMFC)

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The views expressed in the Habitat Hotline Atlantic are those of the authors and do not necessarily reflect the views of the Atlantic States Marine Fisheries Commission.

Funding provided by Sport Fish Restoration

Banner photo: salt marsh, Manahawkin, New Jersey
Photo credit: Shutterstock/Anthony Tucci

Anthropogenic Noise Impacts on Spawning and Ecology of Atlantic Fisheries: Implications for Managers and Long-Term Fishery Productivity.

REVISED BY R. GRANT GILMORE, JR., PH.D.

Commented [1]: need consensus on authors and acknowledgements

Report Objective:

It is well documented that sources of human-generated noise impact coastal and marine fishes through disruption of physiological processes and interruption of fish auditory communication. In turn, fish health and behavior are impacted. These impacts can range from short-term to long-term, however both can lead to changes in fish aggregations, habitat use, spawning success, and mortality. The purpose of this report is to summarize the important of sound and the impacts of anthropogenic noise to fishes managed by the Atlantic States Marine Fisheries Commission.

While there is vast literature on the production and use of sound by marine mammals, including the effects of human-generated sound on these species, this is beyond the scope of this report, given ASMFC's fisheries management focus.

I. Introduction

The oceans are full of both natural and anthropogenic sounds. The auditory system is the most important sensory system for many aquatic organisms, including most fishes (Tavolga 1960, 1980; Richardson et al, 1995; Stocker 2002; Au and Hastings 2008; Staaterman et al. 2013, 2014). Because water is denser and more viscous than air, the propagation of light and the diffusion of chemicals are both severely inhibited. In contrast, sound can move over four times faster and travel farther with less transmission loss underwater than it can through the air (Rogers and Cox 1988; Ward 2015).

Unfortunately, many human activities occurring in coastal and marine habitats add noise to the natural soundscape, and these noises affect aquatic organisms and their interactions with one another (Duarte et al 2021). For example, as rates of sound production correlate to rates of spawning and reproductive success, any disruptions to the effective communication range for fish and invertebrate species has the potential to reduce reproductive output and recruitment.

This Report aims to provide general information about the importance of sound to marine species, focusing on those managed by ASMFC, the impacts that anthropogenic noise can have on marine species, and the characteristics of natural sounds and anthropogenic noise. The report provides case studies for selected ASMFC managed species demonstrating the effect of anthropogenic noise on spawning and communication. The following section describes mitigation measures for certain human-induced noise are provided where they are known. Finally, the report provides a list of data gaps and research needs to improve our understanding of the impact of noise on ASMFC managed species.

II. The natural soundscape and its importance to fishes

Because the movement of light and chemicals can be diffuse in the marine environment, whereas sound propagates quickly and for long distances in water, marine animals have evolved a wide array of physiological and behavioral mechanisms to detect and use sound.

The natural soundscape of the ocean environment includes tectonic activity, sea surface agitation, and sea ice activity. These sounds range from <10 Hz to >150,000 Hz with varying intensities and intermittency. Ocean waves and seismic activity produce constant low frequency noises of a moderate intensity, while dramatic seismic events, such as earthquakes or volcanic eruptions, produce relatively short bursts of very loud sounds. Weather, such as precipitation or high wind speeds, contributes to surface agitation causing increased abundance of 100-10,000 Hz noise (Martin et al 2014; Nowacek 2007; Peng 2015). Most abiotic, natural sounds are caused by surface agitation such as bubbles or spray impacting the water's surface. Weather conditions contribute to agitation, causing increased abundance of 100-10,000 Hz noise from precipitation or high wind speeds for the duration of the event (Martin et al. 2014; Nowacek 2007; Peng 2015).

Fishes and other marine animals produce sound intentionally as part of their communication, reproduction, predator avoidance, foraging, and navigation and orientation (Peng 2015), as well as unintentionally they move, forage, and release gas (Paxton et al. 2017). Field and laboratory studies of fish physiology and behavior indicate that sound is a preferred sensory mechanism to detect predators or prey, find suitable habitat, orient, migrate, communicate, attract mates, and coordinate spawning (Putland et al. 2018). Not only do many species use sound to locate reproductive partners or indicate reproductive intent (Bass et al. 1997; Maruska and Mensinger 2009; Lamml and Kramer 2005; Montie et al. 2016, 2017), but some species, like the Pacific marine toadfish *Porichthys notatus*, become more sensitive to particular frequencies or their counterpart's sounds during periods of reproductive availability (Sisneros 2009; Maruska et al. 2012). Rates of sound production correlate to rates of spawning and reproductive success. Territorial species use aggressive, threatening calls to delineate an individual's territory and intimidate or deter competitors or predators (Ladich 1997; Vester et al. 2004; Maruska and Mensinger 2009**)**. Other uses of sound include navigation and orientation, especially for planktonic larval stages of fishes and invertebrates (Radford et al. 2011; Vermeij et al. 2010), avoidance of predators (Remage-Healey et al. 2006; Hughes et al. 2014), communication (Buscaino et al. 2012; Janik 2014; van Oosterom 2016), and the determination of suitable habitats for settlement (Simpson et al. 2004).

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III. Sources of anthropogenic noise in the oceans

Noise (unwanted sound) generated from human activities covers the full frequency of sound energies used by marine fishes (Duarte et al 2021). The contribution of human noise to ocean acoustics has increased over time as activities such as shipping, mineral and oil mining, and coastal construction have grown in their scale (Pijanowski et al 2011). More recently and emerging sources of sound, such as offshore aquaculture and renewable energy development will contribute noise in their construction, maintenance, and operation.

Anthropogenic sources of ocean noise are acute (episodic) and chronic (ongoing or continuous). Both types may occur within estuaries, on the continental shelf, or in open-ocean regions. Acute sources include pile driving, dredging, cable laying, bridge removal, and seismic surveys. Chronic sources include commercial and recreational boating, shipping activities, and operation of wind turbine generators. These activities and their impacts are summarized below.

Below, Figure 1 from Duarte et al. 2021 shows the duration and spatial scale of both natural sounds and anthropogenic noise in the ocean as well as the sound frequencies of marine animal sound production and hearing ranges together with anthropogenic noise sources. These visual displays demonstrate that the scale, frequency, and extent of anthropogenic noise overlaps with the activity of marine animals' behavior in different ways.

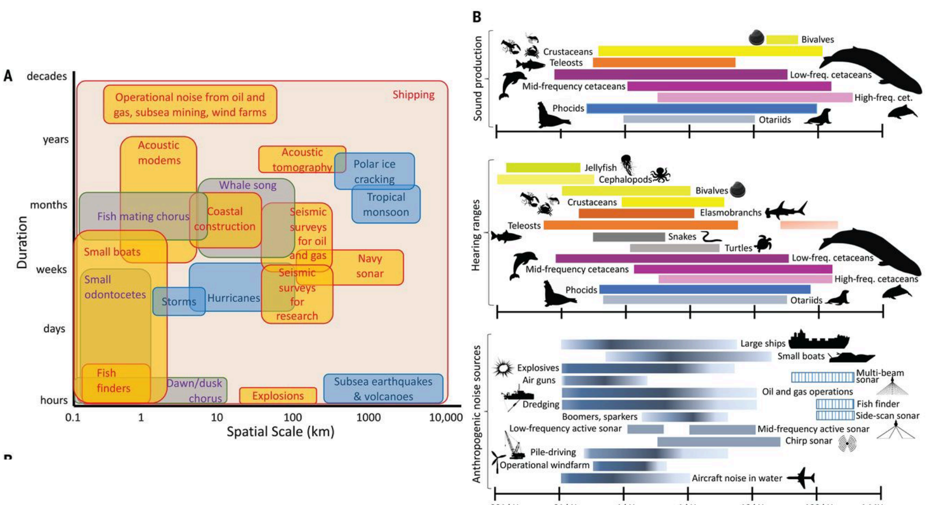


Figure 1 (from Duarte et al 2021). (A) Extent and duration of selected biophony (rounded gray squares), geophony (rounded blue squares), and anthrophony (rounded yellow squares) events. Events (rounded squares) reflect the spatial and temporal period over which signals or bouts of signals typically occur. (B) Approximate sound production and hearing ranges of marine taxa and frequency ranges of selected anthropogenic sound sources. These ranges represent the acoustic energy over the dominant frequency range of the sound source, and color shading roughly corresponds to the dominant energy band of each source. Dashed lines represent sonars to depict the multifrequency nature of these sounds.

Ongoing/Chronic Activities

Marine Transport and Other Vessel Activity

Watercraft of all kinds produce very loud undersea noise and are the most common sources of anthropogenic noise in coastal waters (Stocker 2002). These sources of noise can be amplified by complex reflected paths due to both surface and seafloor reflections, scattering and reverberating because of the geography and geology of the submerged shoreline and bottom. Watercraft generate sound primarily from propeller action, propulsion machinery, generators, and water flow over the hull (Hildebrand 2005). Combined, the sounds generated from a large container vessel can exceed 190 decibels (dB)[1] at the source (Jasny 1999; see the case study below). Metropolitan areas and ports contain a diverse array of watercraft which constitute the dominant human derived soundscape: commercial and private fishing boats, recreational watercraft, coastal industrial vessels, public transport ferries, military craft, personal watercraft, and many others. Significant underwater sound production can also be generated from bridge automobile traffic, particularly during peak traffic periods.

Additionally, most vessels have sonar systems for navigation, depth sounding, and “fish finding” that may cause acute or episodic noise disturbance. Some commercial fishing boats also deploy various acoustic deterrent devices (pingers) to keep dolphins, seals, and turtles from running afoul of the nets (Stocker 2002). There is little information on the effects of acoustic deterrent devices on fish, however.

Offshore Energy Operations

Renewable energy has been a growing segment of the nation’s energy portfolio due to concerns over energy security and environmental change (Dincer 1999; Pimentel et al. 2002; Chow, Kopp & Portney 2003; Valentine 2011). While the United States’ renewable energy portfolio has to date been composed almost exclusively of land-based technologies, coastal and marine energy sources in the form of tides, currents, waves and offshore wind have the potential to provide a large amount of predictable energy (Pelc & Fujita 2002). These energy sources, however, are not without impacts to marine fish health, movements, and behavior. Specifically, the noise produced during construction of energy systems that require pile driving and those that produce significant noise during their operation have been documented to cause negative or disruptive physiological and behavioral effects. Of central concern is the impact of offshore wind, an industry that is planned for rapid advancement along the Atlantic coast.

The impacts of offshore wind areas on the marine environment have been widely discussed in recent years, though because the few constructed sites have been in operation for only a short period of time, the actual downstream and long-term effects are still being determined. The impact of noise produced by wind farms can occur during construction, operation, maintenance, and decommissioning. The most noise disturbance is thought to occur during the construction phase when the impact pile driving (for fixed turbines), shipping, and other associated activities (geological and geophysical surveys as discussed

[1] Note that dB in air and water are different. For more information, visit: How does sound in air differ from sound in water? – Discovery of Sound in the Sea (dosits.org).

in the section below) will impact both animal behavior and survival (Bergstrom et al. 2014). Once wind farms are in operation, marine animals may be impacted by underwater noise from the turbines (Gill 2005). The impact of noise generated by pile driving associated with offshore wind construction is discussed in the section below on acute sources of noise.

During operation, studies have that the noise generated by both the turbines and increased boat traffic for maintenance exceeded the natural sounds typical at similar deep-water locations (Nedwell et al. 2003, Tougaard et al. 2012). Measuring noise at wind farms in the UK documented that the overall sound pressure level was significantly higher during the daytime due to more vessel traffic. The noise levels were found to be higher at low wind speeds, in contrast to the assumption that the turbine-generated noise would be greater with increasing wind speed (Nedwell et al 2003). Turbine operation has been measured between 120 – 142 dB with dominant frequencies at 50, 160, and 200 Hz at wind speeds of 12 m/s (Thomsen et al. 2003). It is estimated that operational noise of wind turbines is within the perception range of cod (*Gadus morhua*) and Atlantic herring (*Clupea harengu*s) up to a distance of approximately 4 km, while for dab (*Limanda limanda*) and Atlantic salmon (*Salmo salar*) up to 1 km.

Oil and Gas Extraction Operations

Mineral extraction in marine waters produces chronic noise disturbance often dominated by vessel noise (the impacts of vessel noise are described above), however noise is also produced by the operation at platforms vary depending on the platform type. A comprehensive study of noise generated by oil and gas extraction found that fixed platforms had lower underwater radiated noise levels than floating platforms, and gravel islands appear to have the lowest source levels of any oil and gas industry activity. Semisubmersible platforms were found to generate the most underwater noise which was highest when thrusters were operating and drilling was occurring. Levels were measured at 20-50+ dB in the frequency range of 20 – 1000 Hz during drilling operations, with the dominant frequencies at 130, 200, 350, and 600 Hz (Spence et al. 2007). On all platform types, noise from large power generation equipment is likely to be a dominant cause of underwater noise, for example from the operation of turbines, compressors, and large pumps (e.g. mud pumps). This noise is thought to be more significant when equipment is hard mounted directly to the platform (Spence et al 2007).

Acute/Episodic Activities

Coastal and Marine Construction

Inshore industrial and construction activities drastically alter the aquatic soundscape and have caused documented mortality and severe behavioral change in fishes and other marine animals. Underwater blasting with explosives is typically used for dredging new navigation channels in rocky substrates; decommissioning and removing bridge structures and dams; and construction of new in-water structures such as gas and oil pipelines, bridges, dams, and wind turbines. The potential for injury and death to fish from underwater explosives has been well-documented (Hubbs and Rechnitzer 1952; Teleki and Chamberlain 1978; Linton et al. 1985; Keevin et al. 1999). Pile driving activities, which

Commented [EC3]: Add sentence about sturgeon in Hudson or pull out ASMFC species from the citations in this paragraph typically occur at frequencies below 1000 Hz, have also led to fish kills (Hastings and Popper 2005). Intensity levels of pile driving have been measured up to 193 dB in certain studies (Hastings and Popper 2005).

Construction of Offshore Wind Farms

Of the studies performed to assess these impacts, construction noise, specifically, pile driving has produced high levels of sound pressure and acoustic particle motion in the water as well as within the seabed (Nedwell et al. 2003, Thomsen et al. 2006, Tougaard et al. 2012)). During pile driving, the broadband peak sound pressure level has been measured at 189 dB at 400 m and a modeled level of 228 dB at 1m with a dominant frequency of 315 Hz, however these levels will depend on the size and diameter of the piles and have been modeled to be higher with larger pile diameters (Thomsen et al. 2006, Tougaard et al. 2012). These noise levels are within the perception ranges of cod (*Gadus morhua*), dab (*Limanda limanda*), Atlantic salmon (*Salmo salar*), and herring (*Clupea harengu*s) at large distances, estimated at up to 80 km from the source (Thomsen et al. 2006). Documented behavioral reactions in cod (*Gadus morhua*) and sole (*Solea solea*) were observed up to tens of kilometers from the source (Andersson 2011). In the same study, noise produced during power production generated noise within specific frequencies which were detectable by sound pressure sensitive fish at a distance of several kilometers, however species sensitive to motion (as opposed to pressure) were found to be affected within tens of meters (Andersson 2011). Close to the source of pile driving, injury and mortality are likely. Mitigation measures for pile driving are discussed in Section VI of this report.

To date, most offshore wind installations have been fixed turbines. Floating offshore wind technology is in its nascent stages and thus there is less known about whether the ongoing noise produced by turbines will be similar to the levels and frequencies measured for fixed turbines. There is some evidence that jacketing monopile turbines reduces the chronic noise from operation (Thomsen et al. 2015), however to date, actual noise levels emitted by floating platforms has not been documented. As this technology advances, there is a need to determine the noise levels and frequencies different floating platform types emit and at what distances.

Geological and Geophysical Surveys

Geological and geophysical (G&G) surveys are performed to gather information about the seafloor including bathymetry, surficial sediment, sub-surface sediment, and the topology of an area. These surveys are performed for a multitude of uses including resource extraction and wind power siting. Not all G&G surveys produce noise that is known to be within the hearing range of marine animals.

Sonar systems are used for a wide variety of civilian and military operations. Active sonar systems send sound energy into the water column. Sonar systems can be classified into low (<1,000 Hz), mid (1,000 – 20,000 Hz), and high frequency (>20,000 Hz).

Low and mid frequency systems emit sound that overlap with the acoustic detection of many marine animals. Sub-bottom profilers are a type of high-resolution seismic system that produce imaging of the seafloor's sub-surface. These can be shallow penetration (2–20 m) or deep penetration systems and operate at a wide range of frequencies (400 – 24,000 Hz) and produce varying levels of peak sound (212-250 dB; Mooney et al. 2020). Seismic airguns are used for a deeper penetration of acoustic sound into the seafloor and are used primarily for oil and gas exploration and siting of offshore cables. Airguns generally produce sound at 200-210dB at a range below 100 Hz. While morbidity has not been associated with airgun exposure, changes in behavior have been observed. Following exposure in a laboratory setting, American lobster (*Homarus americanus*) changed their feeding levels, and physiological changes were also measure.

Studies investigating the effect of full-scale G&G surveys on wild fish populations have shown effects in some cases. Atlantic herring (*Clupea harengus*) schools in the wild were not observed to change their swimming speed, swimming direction, or school size during exposure to a full-scale seismic survey (Pena et al. 2013). However, other studies have found that trawl and long-line fish catches during full-scale G&G surveys decreased within the area of the seismic survey and at ranges of up to 33 kilometers (Engas et al. 1996). When catch rates and behavior were observed to change during seismic surveys, fish were observed to return to the site of the survey within hours or days after the survey completion (Lokkeborg et al. 2012).

High frequency sonar telemetry is associated with vessel positioning, locating, steering, and remotely operated vessel control. Ultrasonic frequencies (generally 200,000 - 400,000 Hz), also known as multibeam echosounders, are used for sonar mapping. These ultrasonic frequencies are generally outside of the known range of acoustic detection by marine animals. Multibeam echosounder surveys collect bathymetry and seafloor hardness information that nautical chart updates, benthic habitat characterizations and fisheries habitat modeling, and surficial sediment analysis.

Oil Drilling and Mining

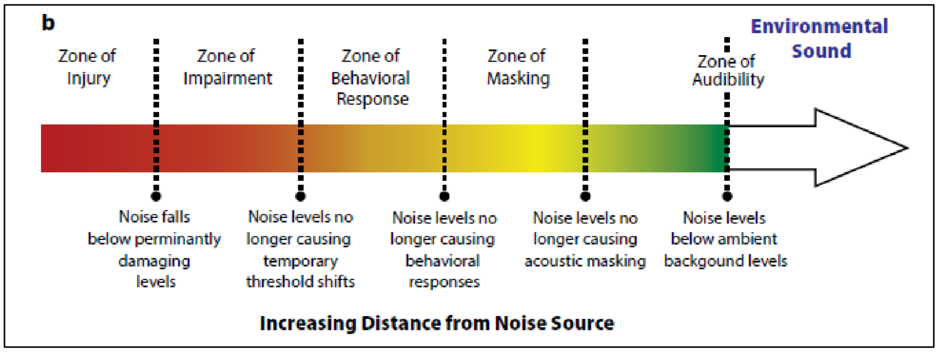
Some of the loudest anthropogenic noises are generated by marine extraction industries such as oil drilling and mineral mining (Stocker 2002). The most common source of sounds is from air guns used to create and read seismic disturbances (Popper and Hastings 2009; Popper et al. 2005, 2014; NOAA 2016; Popper and Hawkins 2016). Air guns are used to generate and direct huge impact noises into the ocean substrate. The sound pressure wave created aids in reflection profiling of underlying substrates for oil and gas exploration. Peak source sound levels typically are 250-255 dB. Following the exploration stage; drilling, coring, and dredging are performed during extraction. Each of these activities also generates loud noises.

IV. Impacts of anthropogenic noise on fishes

Sound energy is transmitted through both sound pressure and water particle motion. Thus, to understand whether and how noises are likely to impact fishes, we need to understand their sensitivity to both sound pressure and particle motion. Fishes as a group have very complex and diverse interactions with sound and how they perceive it. Hearing systems and capabilities vary based on anatomy, including presence of a swim bladder or other gas filled organs and position relative to the inner ear, as well as other factors (Popper and Hawkins 2018). Sensitivity varies by species and among larval, juvenile, and adult stages (Wright et al. 2010). Many species have the same hearing frequency sensitivity that humans do (10 to 20,000 Hz; Tavolga 1960, 1980; Fine et al 1977; Fay et al. 2008; Popper and Hastings 2009; Popper and Fay 2011), and most fish produce sounds below 200,000 Hz (Tavolga 1960, 1980; Fine et al 1977; Fay et al. 2008). Sound frequencies below 100,000 Hz scatter and dissipate least, travel farthest underwater (Wenz 1962; Au and Hastings 2008; Ward 2015), and are the frequencies fish typically use for communication (Bass et al. 1997; Au and Hastings 2008; Popper and Fay 2011). Certain groups of fish, such as the herrings, sardines, and menhaden (clupeids), can detect ultrasound frequencies above 100,000 Hz (Fine et al. 1977b; Nestler et al 1992; Mann et al. 1997, 2001; Narins et al. 2013), however the strongest response has been documented at 40,000 Hz (Wilson et al. 2009).

The frequency at which different species perceive sound is highly variable (Monczak et al. 2017), however for most fishes, sound production and habitat soundscape acoustic signatures are at frequencies below 5,000 Hz (Fish and Mowbray 1970; Zelick et al. 1999; Myrberg and Fuiman 2002). For example, black drum (*Pogonias cromis*) were found to have the highest neurological response to sounds at 82, 166, and 249 Hz (Monczak et al. 2017). This is also the range of frequencies where underwater sound propagates best. Most human-generated chronic noise is also below 5,000 Hz (Richardson et al. 1995; Au and Hastings 2008), which is of concern as fish are very sensitive to intense sounds below 1,000 Hz.

Figure 2. The potential effects of noise with distance from source. Generally, noise and impact on individual animals may be greater closer to the source. Effects change with increasing distance from the source because acoustic signals change, for example decreased dB. Figure from Mooney et al. 2012, modified from Dooling and Blumenrath (2013).



Particle Motion versus Sound Pressure

Describe the difference.

Although there is growing evidence that fish and invertebrates are sensitive to the particle motion caused by underwater noise (Casper and Popper 2010; Mooney et al. 2010; Mueller-Blenkle et al. 2010; Nedelec et al. 2016; Hawkins and Popper 2017; Sole et al. 2017; Popper and Hawkins 2018), it is technically challenging to measure. This difficulty has led to poor assessments of the impacts of particle motion on fish and invertebrates (Popper and Hawkins 2018). There is more information and research on effects of sound pressure in bony fishes and to a lesser extent invertebrates. As such, much of the information discussed below describe the impact of sound pressure.

Physiological Effects

Physiological impacts to fish include damage to ear, nerve, and lateral line tissue that can lead to sound sensing loss or threshold shifts in hearing (Jasny 1999; Heathershaw et al. 2001; Hastings and Popper 2005). Threshold shifts result from exposure to low levels of sound for a relatively long period of time or high levels of sound for shorter periods, which may be temporary or permanent. Recovery from threshold shifts appears to require more time for fish species that vocalize (Amoser and Ladich 2003). Threshold shifts can impact a fish's ability to carry out its life functions. Any organ with a markedly different density to seawater (e.g. swim bladder) may be susceptible to pressure-related impacts. Some of the resulting effects on fish include rupturing of organs and death (Hastings and Popper 2005).

Commented [4]: From Eric Montie: Some other important papers to review and include in this section:

McCauley R.D., Fewtrell J., Popper A.N. (2003). High intensity anthropogenic sound damages fish ears. The Journal of the Acoustical Society of America 113:638-642.

Halvorsen MB, Casper BM, Matthews F, Carlson TJ, and Popper AN. (2012). Effects of exposure to pile-driving sounds on the lake sturgeon, Nile tilapia, and hogchoker. Proc. R. Soc. B 279:4705-4714.

Near field (close proximity) percussion events produced by pile driving and explosions can have a lethal impact on fish through particle motion and sound wave compression. However, the distance from the disturbance and environmental setting (water density, turbulence, etc.) undoubtedly have major influences on potential physiological effects of particle motion and need further study before they can be treated in detail (Kevin et al. 1999; Thomson et al. 2015). The lethality of underwater blasts on fish is dependent upon the intensity of the explosion; however, a number of other variables may play an important role including the size, shape, species, and orientation of the organism to the shock wave; the amount, type, and detonation depth of explosive; water depth; and bottom type (Linton et al. 1985). Fish with swim bladders are the most susceptible to underwater blasts due to the effects of rapid changes in hydrostatic pressures on this gas-filled organ. The kidney, liver, spleen, and sinus structures are other organs typically injured after underwater blasts (Linton et al. 1985). Smaller fish are more likely to be impacted by the shock wave of underwater blasts than are larger fish, and eggs and embryos tend to be particularly sensitive (Wright 1982). However, early fish larvae tend to be less sensitive to blasts than eggs or post-larval fish, probably because the larval stages do not yet possess swim bladders (Wright 1982). Cephalopods can experience significant trauma to their statocysts, structures necessary for balance and position, at cellular and subcellular levels (André et al. 2011). Additionally, playback of seismic air gun recordings induced delayed development and malformation of New Zealand scallop larvae (de Soto et al. 2013).

Effect of anthropogenic noise on zooplankton is a relatively recent topic of interest. These physiological impacts of noise affect fishes indirectly since many species feed on zooplankton. Abundance of dead larval and adult zooplankton increases two to threefold within one hour after passage of an active seismic air gun; elevated mortality extended at least 1.2 km from the air gun signal (McCauley et al. 2017). Simulations based on the McCauley et al. (2017) findings estimate a 22% reduction of zooplankton population within the survey area and declining to 14% within 15 km and 2% within 150 km (Richardson et al. 2017). In contrast, the copepod *Calanus finmarchicus* was only negatively affected when in close proximity (≤ 10 m) to an active seismic air gun (Fields et al. 2019).

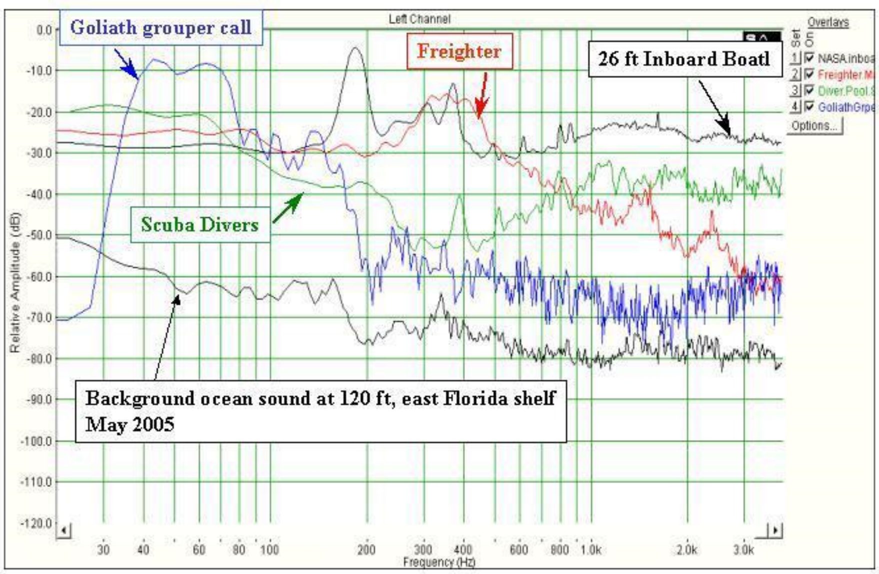


Figure 3. Illustration of the spectrum of various human activity generated and fish (Goliath grouper, *Epinephelus itajara*) sound sources. Note the low frequency sound region where most biologically important sounds are produced (<3 kHz.)

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Behavioral Effects

Anthropogenic noise that falsely trigger fish responses may cause animals to expend energy without benefits (Stocker 2002). Masking biologically significant sounds may compromise feeding, breeding, community bonding, and schooling synchronization. For species in which males broadcast calls to attract females to a spawning location (e.g. oyster toadfish, silver perch, black drum, spotted seatrout, red drum), masking of these acoustic signals by noise may interfere with reproduction through various mechanisms (Smott et al. 2018). Further, the effect of noise on each of these behaviors is compounded when considering that the behaviors are inter-related; for example a change in the ability or desire to feed compounded with reduced communication may lead to a higher reduction in spawning success.

Behavioral response of fishes to noise is varied and dependent on the species sound perception and the characteristics of the source of noise. While not a comprehensive list, the following provide some examples of behavioral responses.

- When exposed to noise from piling installation, Atlantic cod (*Gadus morhua*) initially responded by freezing in place. Following the initial onset of noise, cod and sole (*Solea solea*) increased swimming speed for the duration of the piling installation activity. In contract, other fish species appeared to habituate to the repetitive noise (Andersson 2011).
- Elasmobranch species that are more active swimmers appear to be more sensitive to sound than more sedentary species. Elasmobranchs have been shown to be sound curious, often seeking out the source. Sudden noises that are ~20-30 dB above ambient sound can induce a startle response, but habituation over time has been known to occur (Casper and Popper 2010).
- Turbine and tidal turbine noise can obscure sounds associated with mudflats resulting in delayed metamorphosis of estuarine crabs (Carroll et al. 2017).
- Increased ambient noise created by watercraft activity potentially reduces the ability of marine organisms, particularly larval forms, to receive the appropriate sound cues to settle in critical habitats (Jasny 1999; Scholik and Yan 2002; Hastings and Popper 2005; Stanley et al. 2012; Holles et al. 2013; Simpson et al. 2016; Staaterman et al. 2014, Lillis et al. 2016).

Cumulative Effects

The most chronic and pervasive impacts on regional fish stocks occur when human generated sounds cause behavioral changes that affect critical life history activities required to maintain healthy populations. Several studies have indicated that increased background noise and sudden increases in sound pressure can lead to elevated levels of stress in many fish species (Hastings and Popper 2005). Chronic noise levels ≥123 dB can elicit physiological (weight loss, decreased condition, and elevated and variable heterophil:lymphocyte ratio), behavioral (increased piping and tail adjustments and reduced stationarity), and vocal (increased clicking) stress responses in the lined seahorse (*Hippocampus erectus*) (Anderson et al. 2011). Similarly, scallops exposed to seismic air gun signals resulted in altered physiology (hemolymph biochemistry) and behavior (development of a flinch response and increased recessing reflex) which intensified with repeated exposure (Day et al. 2017).

These examples, as well as others described in this report, demonstrate that noise impacts key life events (e.g. foraging, navigation, and spawning) in many species. This can produce cumulative impacts as many scales. Animals that are exposed to acute noise impacts multiple times, to chronic noise, or most likely to acute impacts followed by chronic noise may have cumulative physiological impacts that in turn reduce their fitness, spawning success, navigation abilities, use of a certain key areas, larval dispersal success, and other impacts. This can lead to population level effects over time if, for example,

Commented [6]: This section needs a little more. There are cumulative impacts from the culmination of multiple sources of noise. But there is also a difference between impacts to individual fish from noise vs. population-level impacts related to effects on important life history events such as spawning. I'm thinking about the case of offshore wind in particular, a fish may be exposed to noise related to construction of one or multiple turbines. Also populations of fish will be exposed to construction of multiple turbines and multiple wind projects over time. If construction noise interferes with, say spawning aggregations over multiple times and locations, then population level effects may result. Effects to individual fish may be less concerning than population-level effects.

Commented [7]: From Eric Montie: Kate provides an important point. As I mentioned previously, masking could severely impact reproduction, which over generations could impact populations. This phenomena could occur in areas where noise is chronic, such as estuaries and coastal oceans near Ports where commercial vessels are constant and loud.

Commented [8]: Again, give Hz range if paper provides one spawning success or aggregations are interrupted on a multi-generational scale. This phenomena could occur in areas where noise is chronic, such as estuaries and coastal oceans near ports with repeated in-water coastal construction, ubiquitous vessel traffic, or offshore areas where seismic surveys, construction, vessel traffic, and operational noise result in years of noise interruption in an area.

Effects on Biogenic Habitats

Alteration of the soundscape has the potential to impact biogenic fish habitats. Oyster larval settlement increased in the presence of oyster reef habitat sounds (Lillis et al. 2013). In response to sediment vibrations blue mussel respiration rates decreased resulting in altered valve gape, oxygen demand, and waste removal (Roberts et al. 2015). Unlike shellfish, Scleractinian corals appear resistant to soft tissue and skeletal damage after repeated exposure to a 3D seismic survey (Heyward et al. 2018). Seagrass meadows, which provide not only a structural habitat for species to forage and avoid predators, but also act as an acoustic refuge for prey species including fishes by attenuating high frequency sounds (100,000 Hz) such as those used by bottlenose dolphin (Wilson et al. 2013), may be impacted by noise. Submerged aquatic vegetation exposed to low frequency sounds (50-400 Hz at 157 ± 5 dB re 1 μPa^2) can develop physical damage to root and rhizome cellular structures; specifically amyloplasts responsible for starch production and storage, gravity sensing, and vibration reception; as well as fungal symbionts (Solé et al. 2021).

Effects on Fisheries Catch Rates

Anthropogenic noise has been demonstrated to affect catch rates. Several studies indicate that catch rates of fishes decreased in areas exposed to seismic air gun blasts (Engås et al. 1996; Hastings and Popper 2005, Paxton et al. 2017); abundance and catch rates for cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) did not return to pre-disturbance levels during the five-day monitoring period (Engås et al. 1996). These results imply that fish relocate to areas beyond the impact zone (area of highest sound intensity), which have been corroborated with visual studies on fish abundance before and after seismic surveys (Paxton et al. 2017). One study indicated that catch rates increased 30-50 km away from the noise source, showing that redistribution of fish populations can occur over broad areas (Hastings and Popper 2005). Seismic surveys may have positive, no change, or negative effect on fishery catch rates due to variable responses among fish species such as no response, dispersal, avoidance, and decreased responsiveness to bait (Carroll et al. 2017). While fish abundance can decrease due to increased anthropogenic noise, such as from wind farm operation, it is unclear the extent to which the increased noise from wind farm operation affects individual behaviors (Mooney et al. 2020).

Commented [9]: We could definitely cite a personal communication here from Capt. Monty Hawkins, if we wanted to do so, based on his personal observations for Black Sea Bass.

Commented [10]: Monty's observations are specific to sub-bottom profiler sound. We would need to make that distinction regarding sound source. I do not recall seeing an papers provided that assess sub-bottom profiler sound effects. Not sure we want to include anecdotal observations. I am not discounting Monty's observations which are compelling, but the correlation has not been studied (at least in that specific example).

- Resulting impacts to fisheries
    - Loss of fish on fishing grounds and resultant redistribution of fishing effort, increasing costs and possibly interactions with other types of fishing or other activities
    - Also reference direct biological impacts to fish tissues, etc., although I think we want to keep our focus on effects related to habitat
    - Potential local/regional population effects (tied to repeated reproduction impacts)

V. Case Studies: the importance of sound to species managed by ASMFC

Case Study 1: Ultrasound may impact clupeid spawning migration

As noted above, fishes are impacted by sound both physiologically and behaviorally. Physiological responses are somewhat consistent across families. However, behavioral responses can vary depending on species-specific hearing and sensitivity to sound. Within the family Clupeidae, the subfamily Alosinae (alewife, blueback herring, menhaden, shad) have evolved the ability to hear in the ultrasound range of frequencies (25,000 – 180,000 Hz) Mann et al. 1997). The ability may have evolved as an avoidance mechanism to hear echolocating predatory toothed whales (Narins et al. 2013).

Alewife responded to high frequency pulsed sound at 110,000 – 150,000 Hz above 157 dB (Dunning et al. 1992), while menhaden can detect sound at 40,000 – 80,000 Hz (Mann et al. 2001)--all within the range of ultrasonic frequency. Ultrasound pulses have been used to deter alosines from power plant intakes (Narins et al. 2013).

Because sound intensity above the clupeid sensitivity threshold of 145 dB and within the ultrasound range could impact behavior of the fish, there is concern that certain anthropogenic activities, for example, the use of Acoustic Deterrent Devices for marine mammals near pile driving activities, could impact spawning migration (Boyle & New 2018).

Case Study 2: Long-term monitoring of human interference with biological sound production in Horseshore Reef, East Florida

Long term deployment of hydrophones in East Florida freshwater tributaries, estuaries, and continental shelf reef formations was used to isolate specific fish spawning sites for long term monitoring and continuous acoustic assessment (Gilmore 2002; Gilmore et al. 2003). The hydrophone array allowed for monitoring the impact of single freighter engine/propeller noise on subtropical reef fish. A complex, high relief (2-8 m) rock reef formation known locally as "Horseshoe Reef" was chosen for a multiple day deployment of three "Passive Acoustic Monitoring Systems" (PAMS) (Gilmore et al. 2003). PAMS were deployed on July 9, 2004 for a period of 72 hrs to continuously record all sounds between 10 and 20,000 Hz (Gilmore et al. 2003). The monitoring system documented vessel noise interference with biological sounds (Figures 2 & 3) on a mid-continental shelf reef where fishery species are known to spawn: groupers (Goliath grouper, *Epinephelus itajara*; gag, *Mycteroperca microlepis*; scamp, *M. phenax*; red grouper, *Epinephelus morio*), black sea bass, *Centropristis striatus*, and various snappers (red, *Lutjanus campechanus*; mutton, *L. analis*; and lane, *L. synagris)*. Each of these species uses acoustic signals during mating events (Mann 2006; Mann et al. 1997, 2007, 2009, 2010; Locascio and Mann 2005, 2008, 2011). What is the conclusion?

Case Study 3: Add another regarding wind turbine installation and/or operation from Block Island Studies

Commented [11]: https://prod-drupal-files.storage.googleapis.com/documents/resource/public/ORJIP%20Piling%20Study%20Final%20Report%20Aug%202018%20%28PDF%29.pdf

Commented [12]: Here or above in section III it would be good to define the difference between passive and active acoustics.

Commented [13]: This paragraph leaves the reader hanging. Vessel noise interfered with biological sounds. The species use signals during mating. What is the conclusion? (I don't know enough to add the right text) Vessel noise may interfere with mating events, possibly decreasing successful reproduction? or More research is needed to understand potential population level effects of vessel noise?

Commented [14]: From Eric Montie: Yes, what are the conclusions? Was this a soundscape study that defined the different sound-producing fish? Did the freighter noise disrupt fish sound production?

Soundscape studies are excellent to perform. They define organisms that produce sound and explain their temporal patterns. Then, anthropogenic noise events can be counted and quantified. By comparing quieter vs noisy sites and in collaboration with fishery-independent surveys, we can then begin to understand how noise may impact fish populations. Some examples of soundscape studies that we've performed and that could be cited include:

Monczak A., McKinney B., Mueller C., Montie E.W. (2020). What's all that racket! Soundscapes, phenology, and biodiversity in estuaries. PLoS ONE 15(9): e0236874. https://doi. org/10.1371/journal.pone.0236874

Mueller C, Monczak A, Soueidan J, McKinney B, Smott S, Mills T, Ji Y, Montie E.W. (2020). Sound characterization and fine-scale spatial mapping of an estuarine soundscape in the southeastern USA. Marine Ecology Progress Series 645:1-23

Monczak A., Mueller C., Miller M.E., Ji Y., Borgianini S.A., Montie E.W. (2019). Sound patterns of snapping shrimp, fish, and dolphins in an estuarine soundscape of the southeastern USA. Marine Ecology Progress Series 609:49-68.

Monczak, A., Berry A., Kehrer C., Montie E.W. (2017). Long-term acoustic monitoring of fish calling provides baseline estimates of reproductive timelines in the May River estuary, southeastern USA. Marine Ecology Progress Series 581, 1-19.

Add another for G&G impacts

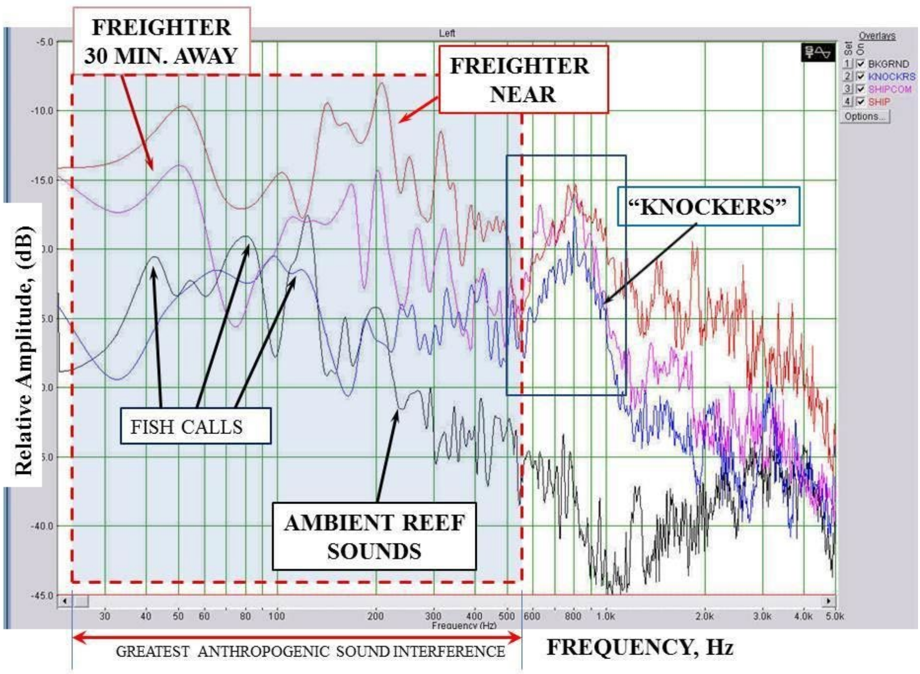

Figure 4 (Case Study 2). Spectral curves for diurnal ambient reef sounds produced on Horseshoe Reef, Florida (black curve) are compared to nocturnal biological sounds produced by an unidentified organism, labeled as "knockers", whose acoustic pulses center around 1,000 Hz, and fish calls (grouper/snapper) below 300 Hz (blue curve) with an approaching freighter 30 min away (purple curve), and same vessel nearby (red curve). Note that the greatest anthropogenic interference is below 600 Hz.

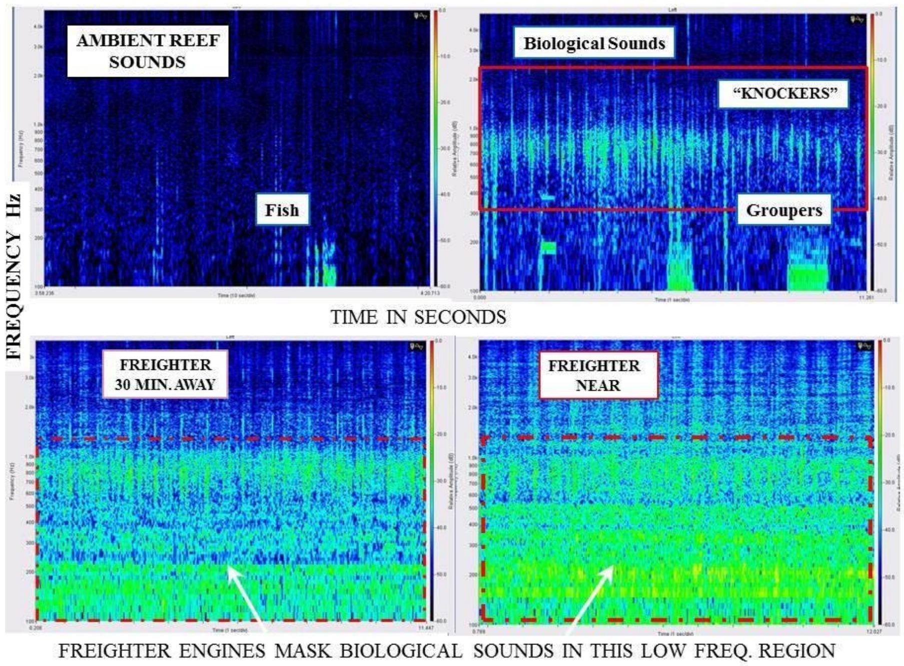

Figure 5 (Case Study 2). Horseshoe Reef, Florida sonogram depicting the same acoustic signals presented in Figure 2, revealing the greatest anthropogenic interference is from highly energetic sounds, engine and propeller noise below 600 Hz.

VI. Mitigation

Several measures could be implemented to mitigate anthropogenic acoustic impacts. New technologies are available to reduce vessel noise making them less acoustically intrusive. As technology allows, use of alternative propeller design and propulsion systems such as diesel-electric hybrid, electric motors, LNG pumps, and rotor sails that are quieter than internal combustion engines can be employed. Ship generators are also a substantial source of underwater noise. Insulated or sound proofed ship hulls may be necessary in major shipping industries to further reduce acoustic impacts. When in port, vessels should connect to on-shore power systems when possible.

Commented [15]: From Eric Montie: This is all great to do, but it is challenging to measure source levels of commercial vessels in shallow water environments. See the following paper:

Ainslie M.A., Martin S.B., Trounce K.B., Hannay D.E., Eickmeier J.M., Deveau T.J., Lucke K., MacGillivray A.O., Nolet V., Borys P. (2022). International harmonization of procedures for measuring and analyzing of vessel underwater radiated noise. Marine Pollution Bulletin 174:113124.

Regulations and permitting, informed by biological information and marine spatial planning, can be used to manage location and timing of when damaging sounds are generated. Acoustic transects can be used to isolate and map specific sites based on sound production of fishery aggregations (Gilmore 1994, 1996, 2002; Luczkovich et al. 1999; Rountree et al. 2003) as well as the broader ambient soundscape (Chou et al. 2021). For example, critical spawning and aggregation sites can be designated as off limits to vessels,

Commented [16]: From Eric Montie: Understanding the temporal rhythms of fish sounds associated with reproductive activity is key. Then, as stated, more informed management can follow. See the soundscape papers cited above as specific examples for Southeastern estuaries.

dredging, seismic, construction, and other sound generating activities at night which is when spawning chorus events typically occur. These sites can be remotely monitored with vessel tracking technologies, currently in use, allowing for violating vessels to be identified.

Alternate seismic survey methods including higher sensitivity hydrophones, benthic stationary fiber-optic receivers, parabolic reflectors, and non-impulsive, very low frequency marine vibroseis are being studied (Chou et al. 2021).

Construction that requires pilings or some form of foundation can benefit from installation technologies such as pulse prolongation, vibropiling, foundation drilling, gravity base foundation, suction bucket jacket, mono bucket foundation, and floating foundation (Koschinski and Lüdemann 2020). When possible, one or more sound dampening measures such as bubble curtains, isolation casings, hydro sound dampers, dewatered cofferdams, and double/mandrel piles should be used (Koschinski and Lüdemann 2020). Multiple sound exposure level metrics such as cumulative, peak, single-strike, and number of strikes should be considered when evaluating the potential effect of pile driving and other impulsive sounds and establishing allowable exposure criteria (Halvorsen et al. 2011). Furthermore, deterrence strategies such as soft-start and ramp-up are intended to scare away mobile species as noise levels are gradually increased to levels that are damaging (Andersson 2011 and Chou et al. 2021).

VII. Data gaps and research needs

There are still many unknowns about the impact of anthropogenic noise on the physiology and behavior of fishes. Some of these include species-specific effects, the impact on fishing catch rates, synergistic impacts of multiple sources of anthropogenic noise, and many other questions. The following topics have been identified by researchers in the field and the ASMFC Habitat Committee as important data gaps and research that is needed to inform our understanding of anthropogenic noise on ASMFC species and their management.

- There is little long-term data on the effect of chronic, cumulative, anthropogenic sounds from watercraft and wind turbine generators on the behavior of invertebrates and fish, particularly at spawning sites (Hawkins and Popper 2016, 2017) and monitoring programs should be developed.

- Effects from various types of anthropogenic noise including duration of and recovery from noise should be studied to determine if population level impacts exist which could affect fisheries catch rates (Carroll et al. 2017).

- Anthropogenic noise may act in combination with other non-noise stressors to affect a biological response or outcome (Carroll et al. 2017). Synergistic effect of noise and non-noise stressors should be examined.

Commented [17]: Do we have any examples of where a "noise exclusion window" has been put in place to protect a spawning aggregation or spawning behavior? Would be good to cite if we do have one or more examples.

Commented [18]: that create less noise interference? that have less of an impact on fish?

Commented [19]: spelling?

Commented [20]: Go through Popper and Hawkins 2019 for an overview of data gaps.

- Sounds important to biological processes may be masked by anthropogenic sounds and the consequences of this disruption should be studied (Carroll et al. 2017 and Hawkins et al. 2015).

- Identify the noise exposure limits and acoustic impact thresholds for various life history stages of species (Chou et al. 2021).

- Subtle and long-term effects on behavior or physiology could result from persistent exposure to certain noise levels leading to an impact on the survival of fish populations (Jasny 1999; Hastings and Popper 2005). It is important to conduct integrated laboratory, behavioral, and physiological experiments under a variety of acoustic conditions, and coordinate these lab studies with field studies using the same organism. This is of critical importance as chronic sound has the potential to directly impact periodic spawning events at specific locations.

Commented [21]: From Eric Montie: There is also the possibility of adaptation and the Lombard Effect.

- Long-term acoustic listening stations should be deployed at spawning sites where significant human activities occur to determine if mitigation measures are needed. Identifying and mapping these critical areas to create management areas limiting human generated noise~~sound~~ is also needed.

Commented [22]: From Eric Montie: Hard to do on a large spatial scale. First, you need to identify the spawning sites which can be challenging for both inshore and offshore species. For fish species in which courtship calls are integral in reproduction, the best approach is defining temporal rhythms of chorusing. Then, you can perform more in depth spatial studies focusing on these time periods with gliders or other autonomous vehicles.

- More information on the impacts and importance of sound to fish larvae and eggs, as well as invertebrates at all life stages, is needed.

- Impact of noise exposure on fish habitat development, specifically reef formation and submerged aquatic vegetation beds, is poorly understood and in need of study.

- Mining the tens of thousands of hours of long duration historical recording data made by various aquatic bioacoustic investigators whose literature contributes to this review should be conducted to further identify and characterize potential human acoustic interference.

Commented [23]: From Eric Montie: Machine learning techniques are needed. It takes our Team a very long-time to review acoustic files. Nonetheless, when describing a new soundscape, you need to manually review acoustic files to understand the different sound-producing organisms and build a training dataset.

- Several important data collection needs to resolve include standardization of terminology and measurement of sound exposure (Carroll et al. 2017 and Hawkins et al. 2015), a methodology for measuring particle motion in the field (Hawkins et al. 2015, Popper and Hawkins 2018), determination of appropriate particle motion metrics, improvement of particle motion sensors and mounting systems, and standards for particle motion and sound pressure sensors (Popper and Hawkins 2018).

Commented [24]: I paraphrased some of the Popper & Hawkins 2018 recommendations (double check me, see references for DOI to search paper).

- Improved understanding of how sound pressure and particle motion effects may differ for and among species and life history stages (Popper and Hawkins 2018).

Commented [25]: Should also add to this section research into 1) technologies that perform the same functions but with reduced noise impact (as referenced above by Chou et al. 2021) and 2) roadblocks to implementing changes to existing acoustically-damaging practices.

For more information, the NYSERDA/RWSE working group wrote an extensive document on research and monitoring related to sound and vibration effects on fishes and invertebrates.[2]

VIII. Additional information

Commented [26]: Can link to other webpages, reports, etc.

Commented [27]: Popper has a good web site for which we can include a link.

The Discovery of Sound in the Sea website, https://dosits.org/ introduces users to the science and uses of Sound in the Sea. There are several major sections on the site such as The Science of Sound in the Sea, People and Sound in the Sea, and Animals and Sound in the Sea. This page focuses on resources for decision makers.

IX. Literature Cited

Commented [28]: This has not been checked yet.

Commented [29]: Lisa, one way to perhaps proceed is to separate Literature Cited from a Bibliography of other references which our readers may find useful, but which we didn't cite. I'd be willing to assist you in ferreting out which ones go where. Just let me know. I also can check my hard drive acoustic literature files against what we have included here, and then add any we missed to the Bibliography, if you want.

Commented [30]: I made a first pass at standardizing format and adding DOIs where possible. I made comments where there is an issue with the reference that I was not able to resolve with certainty. Yes, there are literature cited that are not referenced in the document which needs to be resolved.

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[2] https://www.nyetwg.com/_files/ugd/78f0c4_275f9f2ac5e84b07ae420e0cf5b5b2eb.pdf

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BY COMMITTEE MEMBER

Member	Species Assignments
Russ Babb	spiny dogfish AND black drum
Michelle Bachman	Atlantic herring
Josh Carloni	Jonah crab AND American lobster
Lou Chiarella	coastal sharks
Jessica Coakley	summer flounder AND scup
Dave Dippold	American eel
Claire Enterline	Northern shrimp AND Atlantic herring
Ginny Fay	spotted seatrout
Alexa Fournier	weakfish AND tautog
Jimmy Johnson	red drum AND weakfish
Wilson Laney	striped bass AND American eel AND shad and river herring
Robert LaFrance	horseshoe crab, menhaden
Paul Medders	spotted seatrout AND red drum
Rachael Peabody/Tiffany Birge	shad and river herring
Mark Rousseau	horseshoe crab
Sharleen Johnson	spot AND Atlantic croaker
Eric Schneider	winter flounder AND Atlantic sturgeon
Graham Sherwood	Northern shrimp AND Atlantic herring
Kent Smith	Spanish mackerel AND cobia
Zina Hense	tautog
Marek Topolski	black sea bass AND striped bass
Kate Wilke	bluefish AND menhaden

BY SPECIES

Species	Member
American eel	Wilson Laney AND Dave Dippold
American lobster	Josh Carloni
Atlantic croaker	Sharleen Johnson
Atlantic herring	Michelle Bachman, Graham Sherwood, Claire Enterline
Atlantic sturgeon	Eric Schneider
black drum	Russ Babb
black sea bass	Marek Topolski
bluefish	Kate Wilke
coastal sharks	Lou Chiarella
cobia	Kent Smith
horseshoe crab	Mark Rousseau AND Robert LaFrance
Jonah crab	Josh Carloni
menhaden	Kate Wilke AND Robert LaFrance
Northern shrimp	Graham Sherwood AND Claire Enterline
red drum	Jimmy Johnson AND Paul Medders
scup	Jessica Coakley
shad & river herring	Wilson Laney AND Rachael Peabody/Tiffany Birge
Spanish mackerel	Kent Smith
spiny dogfish	Russ Babb
spot	Sharleen Johnson
spotted seatrout	Ginny Fay AND Paul Medders
striped bass	Marek Topolski AND Wilson Laney
summer flounder	Jessica Coakley
tautog	Alexa Fournier AND Zina Hense
weakfish	Jimmy Johnson AND Alexa Fournier
winter flounder	Eric Schneider