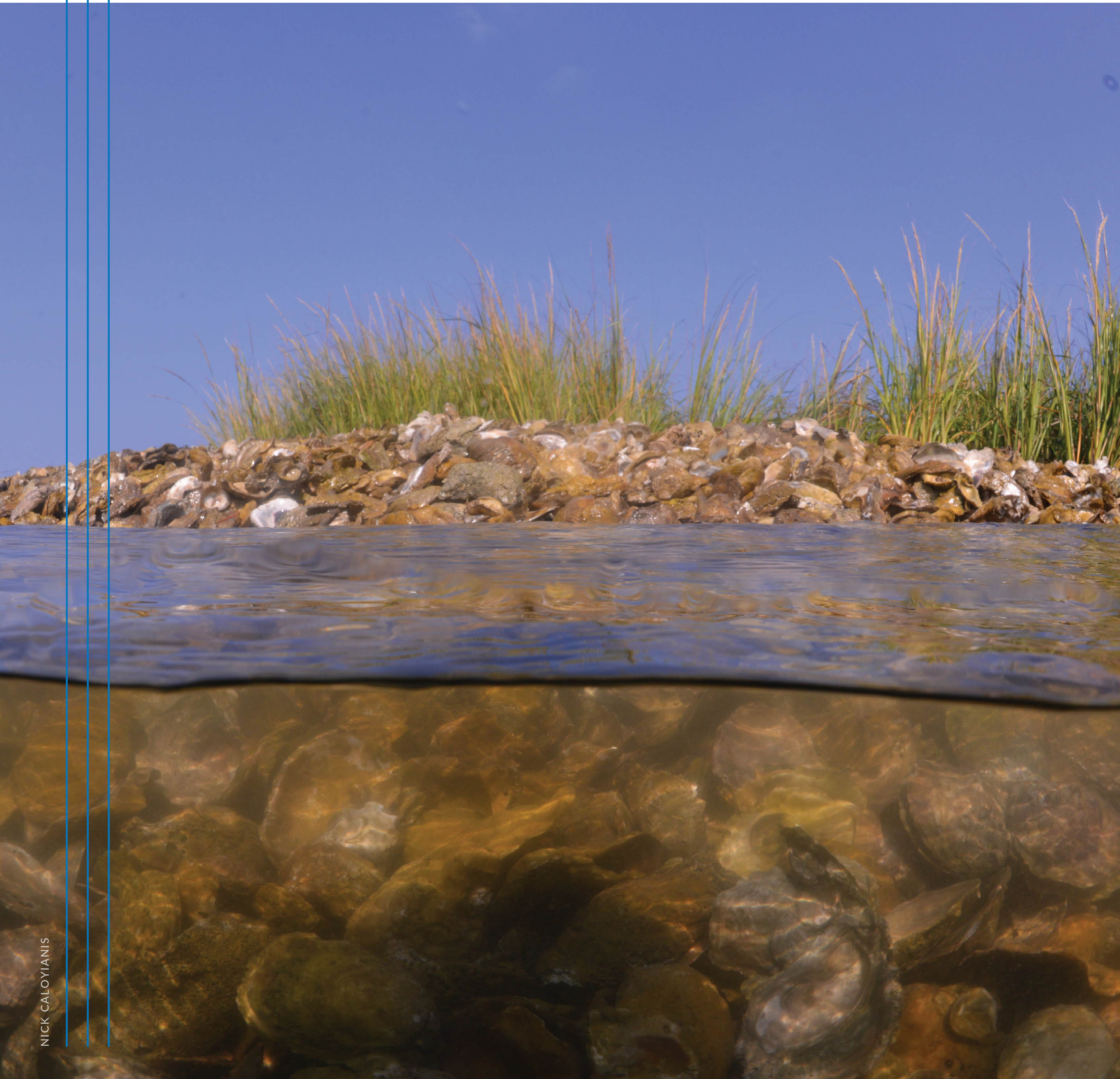
Hope on the Half Shell

Harnessing oysters to build ecological and community resilience

CHESAPEAKE BAY FOUNDATION

Saving a National Treasure



NICK CALOYIANIS

The Chesapeake Bay, spanning 11,600 miles through Maryland and Virginia, faces increased risks due to centuries of oyster reef degradation and climate change threats. Ongoing work is essential to ensure the full potential of oyster restoration in supporting the ecological, economic, and social resilience of the estuary and its communities.

HOPE ON THE HALF SHELL:
Harnessing oysters to build ecological and community resilience

EXECUTIVE SUMMARY

The Chesapeake Bay's shoreline stretches over 11,600 miles through Maryland and Virginia—longer than the entire U.S. West Coast.[1] Home to nearly nine million people,[2] this coastal area is critically important to the social, economic, and environmental fabric of the region. Yet it is increasingly at risk.

Centuries of degradation have diminished one of the Bay's most important natural protections—its oyster reefs. Oyster reefs provide food and shelter to more than 300 other species[3] of fish and invertebrates, and prior to the 19th century, the population could filter the entire volume of water in the Bay in a matter of days.[4] Oyster reefs also served an integral role in the tapestry of natural systems, including underwater grasses, marshes, and maritime forests, that historically buffered the Chesapeake Bay's shorelines from storms. This is an increasingly important service as climate change and rising sea levels are expected to put at risk more than 110,500 homes in Maryland and Virginia, worth $34 billion, by 2100.[5]

The loss of oysters and their reefs has resulted in reduced ecosystem services, species diversity, and economic opportunities for the region. These ecosystem services are extremely valuable. A single acre of restored oyster reef is estimated to provide services worth up to $40,000 in annual economic benefit, not including harvest.[6] Without healthy reefs, local economies suffer, as do other critical estuarine habitats like marshes and submerged aquatic vegetation (SAV). These habitats also provide valuable services, including the mitigation of climate change through storage of blue carbon.[7]

The success of recent large-scale oyster restoration efforts in the Chesapeake Bay,[8] which are among the largest in the world, show that concentrated and coordinated work can bring back oysters and provide many ecological and economic benefits.[9,10,11,12,13]

However, much more must be done. The Bay partnership is moving into the next chapter of oyster restoration as Maryland and Virginia are ramping up efforts to tackle climate change. Now is the time to ensure oyster restoration can realize its full potential to support the ecological, economic, and social resilience of our estuary and vibrant communities where people and nature can thrive together.

To harness the power of this keystone species to achieve six vital outcomes, we recommend taking the following actions to accelerate the pace and scale of oyster restoration, expand oyster aquaculture, and better manage the public oyster resource:

Improved water quality

Accelerate the pace and scale of large-scale oyster restoration of oyster populations and reefs, adding an additional 20 Bay tributaries by 2035.

Invest in regional strategies to secure the substrate necessary for oyster reef restoration.

Implement an accountable nutrient credit program for oysters, ensuring additionality.

Facilitate private investment in oyster recovery.

Equitable economic opportunities for coastal communities

Restore and protect oysters' three-dimensional reef habitat to enhance productivity of commercial and recreational fisheries.

Grow Maryland's oyster aquaculture industry to 50,000 acres under lease and 500,000 bushels harvested annually by 2035.

In Virginia, ensure aquaculture growth in all regions and increase restoration or rotational growing efforts to ensure that oyster leases are effectively utilized.

Expand equitable opportunities in oyster aquaculture by: increasing access to public waterfront; providing support and funding for capital investments; investing in hatchery infrastructure; prioritizing workforce development; and implementing and supporting programs that provide technical support for entry into the industry.

Promote Chesapeake Bay oyster aquaculture through market development and public communications campaigns.

Reinvigorate the states' artificial reef programs with a renewed focus on incorporating oyster habitat in reef siting and design.

Increased resilience to sea-level rise and storm surge

Increase the use of oysters and oyster habitats in shoreline protection and restoration.

Strengthen laws and regulations requiring living shorelines, which use natural features to protect against erosion.

Subsidize and incentivize the removal of hardened shorelines and their replacement with living shorelines.

Pursue policies that make room for habitat migration to adapt with changing conditions.

Climate change mitigation

Incorporate landscape- and population-scale approaches to restoration strategies and projects to maximize sustainability and the mutual benefits of complex habitats, such as oysters, living shorelines, and SAV.

Identify priority areas for restoration where oyster habitat establishment can slow erosion of existing marsh habitat.

Develop best practices for aquaculture that minimize impacts to SAV in and around lease areas.

Improve aquaculture siting to maximize the co-benefits of blue-carbon habitats.

Modernized fishery management for sustainable harvests

Manage the oyster population to increase oyster abundance by fishing at target harvest rates.

Fully utilize the most up-to-date scientific information and methods to manage oysters, including: initiating an oyster stock assessment in Virginia; implementing harvest quotas; considering spatial variables in management; and electronic harvest reporting.

Manage oyster shell alongside oyster populations, with a primary goal to increase the amount of available shell. Explore alternative substrates for replenishment.

Transparency and accountability in fishery management

Re-center science and improve transparency in decision-making—including better accounting and data-sharing.

Restore confidence in the management process and agency scientists.

Improve navigability and usability of websites and event calendars to ensure full access to public meetings and hearings.

Oysters have shaped the history, culture, and wellbeing of the Bay and its communities for centuries. With our help, they can also play a critical role in shaping the region's future.

Now is the time to ensure oyster restoration can realize its full potential to support the ecological, economic, and social resilience of our estuary and vibrant communities where people and nature can thrive together.

CBF's purpose-built oyster restoration vessel, the *Patricia Campbell*, carries a load of spat on shell oysters to be planted in oyster sanctuaries.

INTRODUCTION

With 11,684 miles of shoreline in Maryland and Virginia—more than the entire U.S. West Coast[1]—coastal ecosystems are an integral part of the Chesapeake Bay region. Comprised of habitats including oyster reefs, tidal saltmarshes, and shallow-water seagrass beds, these areas are home to an astounding diversity of life and provide an array of important services including coastal protection, nursery habitat for fish and wildlife, and food production.[14] The adjoining coastal uplands are also home to nearly nine million people in Maryland and Virginia, and this population is growing.[2]

Unfortunately, coastal areas are also some of the most vulnerable. Climate change is rapidly reshaping the physical, social, and environmental features of the coast and is one of the most urgent threats to shoreline communities in Maryland and Virginia. Sea-level rise in the Chesapeake Bay region is occurring at one of the fastest rates in the nation, threatening nearly 250,000 acres of tidal wetlands[15] and more than 110,500 homes, worth $34 billion, by 2100.[5] Floods at high tide—so-called "sunny-day" floods—are expected to increase as much as seven-fold by mid-century in places like Annapolis, Maryland, and Norfolk, Virginia, which will respectively experience up to 115 and 125 high-tide flood days per year by 2050.[16]

The areas at risk encompass critical infrastructure such as roads, schools, and military bases. They also include 302 hazardous waste sites and wastewater treatment plants across Maryland and Virginia that are regulated by the U.S. Environmental Protection Agency, which could release contaminants into the environment if damaged. Moreover, some of the communities in harm's way are among the least able to adapt and could bear a disproportionate burden from rising seas and floods, including an estimated 39,000 people in Maryland and Virginia who are living with high levels of social vulnerability.[17]

At the same time, climate change—on top of pollution and other stressors—is an existential threat to the Bay's critical coastal habitats,[18] like oyster reefs, saltmarshes, and SAV, which also form the natural infrastructure that protects coastal communities. Saltmarshes and SAV have the ability to store more carbon per unit area than a forest,[7] making them a potent tool to reduce greenhouse gases that drive global climate change.[19] However, these critical "blue-carbon" habitats are being lost across the Bay, despite federal policy meant to ensure no net loss of wetlands and a commitment to restore wetlands and seagrasses in the Chesapeake Bay Watershed Agreement.[20,21]

More frequent, intense storms caused by climate change erode marshes and wash more sediment and pollution into waterways, fueling algal blooms and clouding out the sunlight aquatic plants need to survive. Rising water temperatures and marine heatwaves are placing species such as eelgrass and striped bass, under increasingly stressful conditions. Ocean acidification makes it increasingly difficult for shellfish, like oysters, to create the shells they need to survive and grow. As conditions change, the distribution of species is also changing, with significant implications for both the fishing industry and the ecology of the Bay.[18]

But there is hope. Reviving populations of the Eastern oyster, *Crassostrea virginica*, can be a powerful tool to mitigate and adapt to these challenges. Long the architects of the Chesapeake Bay's coastal environment, oysters build three-dimensional reefs that provide habitat to more than 300 species of fish and invertebrates,[3] support a $56.8 million fishery,[22] and can protect coastal habitats and shorelines from erosion. For example, a study in New York Harbor showed that the loss of historical oyster beds increased wave energy between 30 and 200 percent during Hurricane Sandy and a severe storm in 1992.[23]

The decline of oyster populations in the Bay to a fraction of their historical size has greatly diminished the benefits they can provide.[24] However, holistic actions across three policy sectors—restoration, aquaculture, and fisheries management—can help rebuild the Bay's oyster population while achieving six critical outcomes for coastal communities. These include: improving water quality; growing economic opportunity; increasing coastal resilience; mitigating climate change; bringing 21st century science and management to the oyster fishery; and improving the accountability and transparency of fishery management.

Policymakers, legislators, and communities in Maryland and Virginia have the ability to build on significant investments made to date, including some of the largest and most successful oyster reef restoration projects in the world,[8] to achieve these outcomes. Doing so also represents a key opportunity to align Chesapeake Bay restoration with state climate and coastal resilience plans and the latest science—including the findings of the *Comprehensive Evaluation of System Response* (CESR) report[25] released in 2023 by the Bay Program's Scientific and Technical Advisory Committee.

For example, both the Climate Solutions Now Act in Maryland and the Commonwealth Clean Energy Policy in Virginia set a goal of net-zero emissions by 2045.[26,27] Maryland's Climate Pollution Reduction Plan notes the importance of protecting coastal ecosystems to help reach these emission-reduction goals as well as buffer communities from climate change impacts.[26] Virginia's Coastal Resilience Master Plan encourages the use of natural and nature-based features, such as living shorelines, to reduce erosion and flooding.[28] The CESR report emphasizes the need to focus on both water quality improvements *and* restoring living resources and habitats, like oyster reefs, to bring the Bay back to health.

These outcomes and synergies can be achieved through policy reform at the state level, as well as expanding the scale and scope of the large-scale oyster restoration agenda in the federal-state Chesapeake Bay Program partnership and the Chesapeake Bay Watershed Agreement. By seeking solutions that benefit both people and nature, decisionmakers can take actions that go far beyond ecological restoration goals. They will help build lasting, resilient coastal communities where all can benefit from the rich marine resources and way of life that are so integral to our region.

Oysters facilitate the removal of excess nutrients, including nitrogen and phosphorus, the two primary pollutants degrading the Bay's water quality.

WATER QUALITY

Clean water is critical for the thousands of species of plant and animal life in the Chesapeake Bay, as well as the health of communities that depend on coastal waters for recreation, economic opportunities, and food production. However much of the Chesapeake Bay and its tidal rivers remain degraded, with just 28.1 percent of waters meeting water quality standards in the latest reporting period between 2019 and 2021.[29] The Chesapeake Clean Water Blueprint, the federal-state plan to restore water quality in the Bay, was adopted in 2010 and is expected to produce more than $22 billion annually in economic benefits if fully implemented.[30]

Restoring the Bay's oyster population is an important tool to support the water-quality targets in the Blueprint, which the Bay restoration partnership is currently not on track to meet.[31] To meet the targets and sustain water quality over the long term, it is essential to reduce pollution from upstream sources, including wastewater treatment plants and runoff from agricultural, urban, and suburban lands. Reducing this pollution is also important to alleviate stress on oysters and other species, especially as they face increasing pressure from climate change.

However, as filter feeders, oysters facilitate the removal of excess nutrients, including nitrogen and phosphorus, the two primary pollutants degrading the Bay's water quality. They do so through the processes of assimilation and denitrification. Assimilation occurs when oysters feed on algae and store the nutrients they carry in their tissue and shell. When oysters are removed from the water and eaten, the nutrients they filtered from the water and assimilated in their tissues and shell are also removed from the Bay, helping to draw down the excess nutrients that harm water quality. Denitrification is the process by which microbes living on and around oyster reefs turn nitrogen that is dissolved in the water into a harmless nitrogen gas (N_2) that is released into the atmosphere.[32]

Each adult oyster is capable of filtering up to 50 gallons of water per day; historically the Chesapeake's oyster population could filter an equivalent of the entire volume of the Bay in a matter of days.[4] In recognition of the water-quality value provided by oysters through assimilation and denitrification, the Chesapeake Bay Program recently approved a Best Management Practice (BMP) that allows oyster reef restoration and oysters harvested through aquaculture to count toward efforts to meet state pollution-reduction targets for nitrogen and phosphorus.[32,33]

According to the expert panel, oysters 2 to 2.5-inches long can remove 198 pounds of nitrogen and 22 pounds of phosphorus for every one million oysters harvested. Harvesting the largest aquaculture oysters—those bigger than 5.5 inches—removes 683 pounds of nitrogen and 66 pounds of phosphorus per million oysters. In 2022 in Maryland alone, oyster aquaculture harvest removed approximately 5,655 pounds of nitrogen and 943 pounds of phosphorus from Bay waters.[34] Through the restoration of oyster reefs, denitrification can increase the amount of nitrogen removed from the water by as much as 145 pounds per acre per year.[32]

Recent successful large-scale oyster restoration projects show that these efforts can have significant impact. In the 2014 Chesapeake Bay Watershed Agreement, the Chesapeake Bay Partnership set a goal of completing large-scale oyster restoration in 10 tributaries by 2025. As of 2022, work has been completed in eight out of 10 of the selected rivers in Maryland and Virginia and is on track to be completed in the remaining tributaries by the deadline. Virginia has also completed restoration in a sixth "bonus" river.[8]

Monitoring results from these reef restoration projects have been extremely positive, with oyster population density in several rivers exceeding the restoration thresholds.[8] In Harris Creek on Maryland's Eastern Shore, the restored reef is now capable of filtering an equivalent of the entire volume of the creek every 10 days during the summer months.[35]

Additional reef restoration and the growth of the oyster aquaculture industry can facilitate the expansion of these benefits, while providing opportunities for economic growth that preserve the important cultural heritage of working the water. With the passage of the Bipartisan Infrastructure Law, which provided the National Oceanic and Atmospheric Administration (NOAA) more than $3 billion in funding for habitat restoration,[36] and an enhanced focus on the co-benefits of habitat restoration, the opportunity is ripe to accelerate the pace and scale of reef restoration in Chesapeake Bay. As Maryland and Virginia approach the successful completion of the 10 Tributaries Strategy, maintaining momentum will be critical, particularly recognizing the challenges climate change will pose in the future.

Not only has the past decade of large-scale restoration produced astounding results, it has invigorated communities working to restore oysters in their local waterways. By leveraging these efforts and this community support, states can move quickly to achieve restoration targets in additional tributaries. Because oyster aquaculture and reef restoration are now approved BMPs, it also provides incentives for private investment in the recovery of oyster populations at large. These BMPs must be implemented in tandem with complementary efforts to reduce pollution upstream and on land.

ROBERT DILLER

Benefits of Restored Reefs

Studies of large-scale oyster reef restoration projects in the Chesapeake Bay since 2014 found that the recovering reefs have provided many benefits to the surrounding ecosystem. For example, researchers estimate that successfully restored reefs remove seven times as much nitrogen—a primary water pollutant—each day compared to unrestored areas. The 350-acre Harris Creek restoration project on Maryland's Eastern Shore removes approximately 20,000 pounds of nitrogen each year. In addition to improving water quality and clarity, the restored reefs increased the diversity and abundance of invertebrates like sea squirts, worms, shrimp, and small fish that are food for larger fish—services that could improve fishery landings and associated economic benefits by $23 million in the Choptank River region if the oyster reefs are protected from harvest.[10]

Water-Quality Recommendations

To enhance the achievement of water-quality targets through large-scale restoration of the Chesapeake Bay's oyster population, policymakers and resource managers should take the following actions:

Accelerate the pace and scale of large-scale oyster restoration projects, restoring Bay oyster populations and reef habitat in an additional 20 Bay tributaries by 2035 that collectively encompass 4,000 acres or more of restored oyster reef.

With oyster restoration expertise and experience now in place and significant resources available, Maryland and Virginia should build on the success of the 10 Tributaries Strategy to accelerate the pace and scale of Chesapeake Bay oyster restoration. Maintaining the health of oyster reefs in the initial 10 tributaries will be a critical part of this strategy. Restoration approaches should incorporate the best of what has been successful so far, including the 10 Tributary Strategy's focus on large-scale projects, robust monitoring, and the use of alternative substrates to overcome the lack of natural oyster shell.

Invest in regional strategies to secure the substrate necessary for oyster reef restoration.

Maryland and Virginia should work together to find regional solutions for securing substrate material. This material is critical for oyster reef restoration as oysters require a hard substrate to attach to as they grow. In nature they grow on other oysters or old shell, but the decimation of the Bay's historical oyster population and the removal of large quantities of oysters for consumption has reduced the amount of shell available.[37] By working together to source shell and alternative substrates, Maryland and Virginia can create economies of scale to reduce the cost of restoration projects.

Implement an accountable nutrient credit program for oysters, ensuring additionality.

The trading of nutrient credits—which are earned by implementing practices that remove nitrogen and phosphorus pollution—can help ensure cost-effective pollution reductions when programs function well. Realizing these reductions, however, requires that the program ensures robust accountability and additionality—meaning the practices demonstrate an additional benefit that is maintained over time.

Facilitate private investment in oyster recovery.

Pay-for-performance programs and markets have the potential to play a positive role in restoration by allowing state and local governments to purchase environmental outcomes from the private sector, for example through investment in "blue infrastructure" like oyster reefs. Legislation like Maryland's recently enacted Conservation Finance Act[38] provides avenues for public-private partnership to achieve environmental results on an expedited timeline.

Growing the Bay's oyster population and reef habitat increases fisheries productivity and supports local economies.

ECONOMIC OPPORTUNITY

The Chesapeake Bay, for many people who live in this region and abroad, is synonymous with its famous seafood. The commercial seafood industry has long been a mainstay of the region's economy as well as the culture of many communities who live along the Bay's shores. Chesapeake Bay at one time supplied 75 percent of the nation's blue crabs[39] and was the world's largest producer of oysters.[24] Its waters still produce an annual seafood harvest of approximately 500 million pounds,[40] and the seafood industry generates over $1 billion in sales in Maryland and Virginia.[41]

Oysters alone brought in more than $56.8 million in revenue in Maryland and Virginia in 2022.[22] While this represents the second-highest-value fishery—behind blue crabs—oysters and their reefs are also the foundation of many other commercially and recreationally important fisheries in the Bay region. The Atlantic States Marine Fisheries Commission, the regional body that manages fisheries along the East Coast, found that 22 of the 27 species it manages use reef habitat created by shellfish at some point in their lives.[42] Oyster reefs, for example, support American eel, Atlantic croaker, Atlantic menhaden, bluefish, red drum, spot, striped bass, and weakfish, among over 300 other species.[3]

The health of many of these fisheries, and the jobs and industries they support, is therefore tied to the health of oyster reefs. Yet oysters and oyster reefs have undergone more than 150 years of degradation due to overfishing, disease, pollution, and habitat loss. They remain at just a fraction of their historical extent. Populations of striped bass—locally called "rockfish"—

comes from their association with oyster reefs or "rock," have also shown worrying signs in recent years, according to annual surveys.[43]

Rapidly changing conditions due to climate change are also placing new pressures on species and shifting their distribution.[18] Water temperatures in the Chesapeake Bay have risen nearly two degrees Fahrenheit on average over the last 30 years.[44] The Bay is also increasingly subject to marine heatwaves,[45] which can be deadly for cool-water species like striped bass that are already squeezed by low-oxygen dead zones and intense fishing pressure. Restoring the Bay's oyster population and oyster reefs is a critical part of supporting these fisheries and preserving the industries and jobs that depend on them by improving habitat and water quality.

A key component of this effort should be oyster aquaculture. In Virginia, oyster aquaculture has become an important part of the commonwealth's oyster industry. Private oyster leases currently cover approximately 130,000 acres of bottom, and aquaculture produced over 370,000 bushels of oysters in 2021.[46] In Maryland, the industry is more nascent, but growing rapidly, from less than 5,000 bushels harvested in 2013 to more than 94,000 bushels harvested in 2022 with an economic impact of more than $13.3 million.[34] Maryland's aquaculture industry growth is more recent than Virginia's due to centuries of legislation that curtailed aquaculture's development.[9]

Beyond its direct economic impacts, oyster aquaculture offers many additional benefits to local economies and ecosystem services. For example, one recent study found that the additional fish produced due to the habitat created by oyster aquaculture farms had a value to commercial fisheries of $5,267 per hectare (2.47 acres).[47] The study also noted the benefits associated with oyster farming's production of nutrient-rich food with a relatively low carbon footprint, as well as the opportunities it can provide for ecotourism and farm-to-table tourism.

Nonetheless, significant barriers of entry to oyster aquaculture still exist. One of the most concerning is the extremely long time it takes to get aquaculture lease applications approved. It takes 34 months on average in Maryland, the longest time from application to lease execution in the country.[48] It can also be difficult for oyster farmers to secure funding to enter this capital-intensive industry, in which growers must wait two to three years after planting their first oysters for their first sale. The industry and the economic opportunities it could provide Chesapeake Bay communities has therefore not reached its full potential.

Beyond aquaculture, reinvesting in oyster restoration efforts will also bring a significant number of jobs and economic benefits. In 2019, researchers at Morgan State University estimated that oyster reef restoration in the Chesapeake Bay would lead to a $10 million increase in commercial fishing revenues annually, driving regional sales of $20 million as the dollars are re-spent, due to significant increases in harvests of blue crabs and species like white perch.[49] Restoration itself also creates and supports a variety of jobs as projects are planned, constructed, and monitored. In 2017, the National Oceanic and Atmospheric Administration (NOAA) reported that for every $1 million spent on restoration projects, an average of 15 jobs were supported. Labor-intensive projects like oyster reefs supported up to 30 jobs per $1 million spent.[13]

Due to the local, place-based nature of oyster restoration work, the jobs and economic benefits stay in the region. Growing these opportunities will not only help ensure oyster recovery and vibrant coastal ecosystems, it will also support jobs and industries that maintain the region's cultural heritage and connections to the water.

Growing Equitable Opportunities

From early colonial times, Black watermen have played an integral role in the establishment of the Bay's oyster industry. Black people who were enslaved in the Chesapeake region were often relied on to harvest oysters and fish due to their knowledge of the water, and after emancipation, many Black communities in the 19th century turned to the water to earn a living through harvesting and shucking oysters. However, discriminatory laws, policies, regulations, and actions drastically curtailed these watermen's access to oyster licenses, boats, capital, and other resources necessary to sustain their businesses. The legacy of this discrimination is still felt today. The modern-day oyster industry lacks diversity and many barriers still exist to equitable economic opportunities.[85] Addressing these inequities is a critical part of efforts to grow the industry moving forward.

Economic Opportunity Recommendations

To grow economic opportunities in coastal communities and industries while supporting the restoration of the Bay's oyster population, policymakers and resource managers should take the following actions:

Restore and protect oysters' three-dimensional reef habitat to enhance productivity of commercial and recreational fisheries.

Grow Maryland's oyster aquaculture industry to 50,000 acres under lease and 500,000 bushels of oysters harvested annually by 2035.

Lease application processing times should be reduced to six months or less, and the lease protest process should be re-evaluated to prevent significant delays in the process. Spatial management delineations that are outdated, unused, or function solely to exclude aquaculture—such as pound net sites and public shellfish fishery areas—should be removed.

In Virginia, ensure aquaculture growth in all regions and increase restoration or rotational growing efforts to ensure that oyster leases are effectively utilized for maximum oyster productivity.

Lease renewals intended to block others from productive use of the resource should be dissuaded, and states should address "not-in-my-backyard" objections to the siting of aquaculture operations based on aesthetics—especially when no such objections are raised to operations elsewhere.

Remove barriers to entry to the oyster aquaculture industry.

States should reinvest in agency aquaculture programs and designate a staff liaison to help prospective oyster farmers navigate the regulatory process and procedures.

Update and modernize reporting and regulatory frameworks to make operations and compliance less burdensome for industry members.

Whole-of-industry annual reporting causes significant delays alongside antiquated and redundant reporting and tracking systems. These regulatory inefficiencies create more work for industry members and for state agencies overseeing them. Maryland and Virginia, in collaboration with aquaculturists, should identify key pinch points in current regulations and work to adopt new policies that maintain the safety and accountability of the industry while allowing commonsense reforms to ease enforcement and industry compliance.

Develop priority oyster aquaculture areas.

These areas should be designed to maximize economic and ecological benefits, including consideration of ecological deficits, environmental conditions, and areas that would reduce social conflicts. In Virginia, there is opportunity to build support and plan for aquaculture expanding into newly available bottom due to the updated Virginia Marine Resources Commission lease-renewal guidelines that address unproductive leases.

Expand equitable opportunities in oyster aquaculture by: increasing access to public waterfront; providing support and funding for capital investments; investing in hatchery infrastructure; prioritizing workforce development; and supporting programs, like Minorities in Aquaculture, that provide technical support for entry into the industry.

Trainings and programs should be developed that build the skills needed for the aquaculture industry. There should also be a specific focus on providing access to underrepresented groups and those who have been previously excluded from the fishing industry, including Black watermen. In addition to these efforts, Maryland should conduct a disparity study of its aquaculture and fishing industries to document how historic discrimination and bias have perpetuated the current lack of access to seafood industry opportunities today.

Promote Chesapeake Bay oyster aquaculture through market development and public communications campaigns that highlight the benefits of aquaculture to reduce conflicts and concerns over aquaculture siting.

Reinvigorate the states' artificial reef programs with a renewed focus on incorporating oyster reef habitat in reef siting and design.

Recreational fishing is a tremendous economic driver which stands to benefit significantly from enhanced fish productivity resulting from reef restoration. State-run programs that create artificial reefs for recreational fisheries enhancement should strive to incorporate, wherever appropriate, oyster reef habitat in their design to achieve ecological co-benefits while supporting the Bay's recreational fishing industry.

SUE MANGAN

Living shorelines are a natural approach to protecting tidal shorelines from erosion. Compared to hardened shorelines lined with riprap, bulkheads, and concrete, living shorelines are created by planting native wetland plants, wetland grasses, shrubs, and trees.

COASTAL RESILIENCE

Sea-level rise, driven by climate change and land subsidence, is occurring in the Chesapeake Bay region at one of the fastest rates in the country[50] presenting a significant and urgent threat to coastal communities. The average sea level in Maryland will likely be approximately one to two feet higher by 2050 and more than four feet higher by 2100 under current commitments to reduce greenhouse gas emissions—and higher if those commitments are not met.[51] In Virginia, the commonwealth anticipates sea-level rise of approximately 2.7 feet by 2060 and 4.6 feet by 2080. Higher seas will also increase the risks from storm surge. For example, a 100-year flood occurring in Norfolk in 2020 would have pushed floodwaters to nearly eight feet, but the same flood in 2060 could push the water level closer to 11 feet.[28]

Already many communities are experiencing much more frequent "sunny-day" flooding, when water at high tide flows back through storm drains and overwhelms roads, businesses, and residences. These floods are expected to occur up to 115 days per year in Annapolis and 125 days per year in Norfolk by 2050, more than a seven-fold increase from current conditions.[16]

Fish Decline as Shorelines Harden

Currently, approximately 14 percent of Chesapeake Bay shorelines in Maryland and 11 percent in Virginia are considered "hardened" by shoreline protections like bulkheads and revetments.[60] These features sever the connection between land and sea, which has a direct negative impact on important commercial and recreational fish species and their prey. In an analysis of seven species in the Bay—spot, croaker, blue crab, menhaden, bay anchovy, hogchoker, and silversides—all declined in abundance when between 10 and 30 percent of nearby shorelines were hardened. All of these species either directly support commercial and recreational fisheries or are important prey for fisheries species. Blue crabs, spot, croaker, and Bay anchovy were the most sensitive, with blue crabs declining 0.4 percent for every 1 percent increase in hardened shorelines.[61]

GREG KAHN

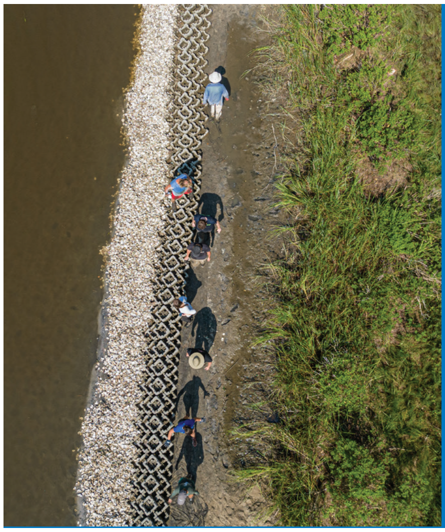
The combination of these factors is projected to threaten more than 110,500 homes in Maryland and Virginia, worth $34 billion, by 2100.[5] Also at risk is critical infrastructure, including major military installations, power plants, and ports whose operation is critical to commerce and national security. In Maryland, this infrastructure includes 1,488 miles of road, three power plants, and 154 EPA-listed sites such as hazardous waste sites and wastewater plants. In Virginia, 1,469 miles of road, one power plant, and 148 EPA-listed sites are at risk, as well as significant portions of military installations including Norfolk Naval Station, Norfolk Naval Shipyard, and Joint Base Langley-Eustis. Moreover, approximately 14,000 people in Maryland and 25,000 people in Virginia who are at risk have high levels of social vulnerability, meaning they are less able to prepare and recover from hazardous events.[17]

At the same time, the ecological resources of coastal areas are also at grave risk. The marshes, nearshore oyster reefs, and SAV were once some of the most productive areas in the Bay, providing refuge and nursery areas for many kinds of fish and shellfish—including striped bass, blue crabs, and Bay scallops. These coastal habitats also serve as a critical stopover point for nearly one million waterfowl and other birds migrating along the Atlantic Flyway each year.[52]

This critical transition area between land and sea has already been significantly degraded in many places by waterfront development, shoreline hardening, and polluted stormwater runoff. Climate change is placing it under even more intense pressure. For example, as sea levels rise, nearly 250,000 acres of tidal wetlands and coastal lands in the region may be lost.[15] Rising water temperatures, driven by climate change, will also place increasing pressure on sensitive species such as eelgrass and striped bass.[18] Without these important habitats and nursery areas, many of the Bay's iconic fisheries and the industries they support are at risk, as is the natural protection from storms that coastal areas provide.

Building the combined resilience of these interconnected coastal systems—human and environmental—is therefore urgent and critical. A holistic approach that re-establishes a more natural transition between the shoreline and the built environment can be a potent tool to further this goal. Oyster reefs, in conjunction with other Natural and Nature-Based Features (NNBF) like marshes and living shorelines, are an important component because they can further reduce vulnerability to waves and protect adjacent marshes from erosion.[23,53,54]

In many cases, NNBF, also called natural infrastructure, can protect coastal resources more effectively than built infrastructure. For example, a study in North Carolina found that living shorelines protected saltmarshes better after hurricanes than hardened shorelines.[55] In the aftermath of Hurricane Sandy, communities chose to rebuild natural infrastructure over replacing built infrastructure that was damaged in the storm.[56] The federal Hurricane Coastal Resilience Program created approximately 53,000 feet of living shorelines that restored marshes, beaches, oyster reefs, and aquatic vegetation after the storm. An analysis of these projects in 2019 found they were more cost-effective for erosion protection than stone revetments.[57]



BARB HAYS

Living Shorelines

Living shorelines are a natural approach to protecting tidal shorelines from erosion. Compared to hardened shorelines lined with riprap, bulkheads, and concrete, living shorelines are created by planting native wetland plants, wetland grasses, shrubs, and trees. Plantings are often paired with carefully placed bioengineering materials, such as manmade coconut-fiber rolls. Where viable, oysters can be included as well.

An added benefit of natural infrastructure is its ability to grow and adapt. For example, oysters, when located in the ideal tidal range, can keep up with sea-level rise and protect marshes, even as water levels increase.[86] Marshes can also recover from damage and grow, which can make living shorelines more resilient to storms and require less repair than built infrastructure like bulkheads that are static.[55]

By strengthening living shoreline policies to reduce shoreline hardening and incorporating oyster habitat as a key component, it is possible to recreate the continuous, interconnected natural systems that historically protected coastal areas against storms and erosion. Doing so will also provide many additional benefits for the resilience of coastal species, habitats, and economies.

Coastal Resilience Recommendations

To leverage oysters in conjunction with other natural features to begin building back the resilience of communities and ecosystems, policymakers and resource managers should take the following actions:

Increase the use of oysters and oyster reefs in shoreline protection and restoration.

Living shorelines must include biological components such as oysters, underwater grasses, and marsh plantings that are suitable for the site—not just rock and sand fill.

Strengthen laws and regulations requiring living shorelines, which use natural features to protect against erosion.

Although both Maryland[58] and Virginia[59] have laws requiring the use of living shorelines for new shoreline protection projects, shoreline armoring continues in both states. It is imperative to increase the rate of compliance with living shorelines laws and reduce hardening of shorelines in areas that are suitable for living shorelines.

Subsidize and incentivize the removal of hardened shorelines and their replacement with living shorelines.

As noted above, 14 percent of shorelines in Maryland and 11 percent of shorelines in Virginia are already hardened[60] which is above the threshold causing impacts to important species, like blue crabs.[61] Therefore, reducing existing hardened shorelines is critical.

Pursue policies that make room for habitat migration to adapt with changing conditions.

It is important that local zoning ordinances and state regulations, such as Maryland's Critical Area policies, provide space for marshes and nearshore oyster reefs to grow over time as sea levels rise. This provides protection that adapts with changing shoreline conditions.

Oyster reefs buffer shoreline habitats like tidal marshes from erosion, helping to stabilize and maintain carbon sequestered in the sediment.

CLIMATE CHANGE MITIGATION

In addition to their ability to work in concert with other natural features to protect shorelines and coastal communities, healthy oyster reefs can also help protect the coastal habitats that capture and store carbon. Therefore, in addition to helping coastal ecosystems adapt to climate change, oysters are an important part of efforts to mitigate the greenhouse gas emissions that drive climate change.

Tidal saltmarshes and SAV are some of the most powerful carbon "sinks" in the world, with the ability to store more carbon per unit area than a forest.[7] They are among the coastal and marine ecosystems known as "blue-carbon habitats" because they can both sequester carbon—remove it from the atmosphere—and store it for long periods of time. Globally, seagrasses can remove an estimated 19.1 million metric tons of carbon per year, while tidal marshes can remove an estimated 8.6 million metric tons of carbon per year. The total global emissions avoided by protecting these ecosystems are estimated at 59.5 to 758.9 million metric tons of carbon and 91.4 to 587.9 million metric tons of carbon per year for seagrasses and tidal marshes, respectively.[62]

Unfortunately, many tidal marshes have been lost in the Chesapeake Bay region. By 1990, approximately 50 percent of wetlands had been lost in the three centuries since European colonization, with roughly 500 acres of saltmarsh lost per year between the 1950s and 1980s due to dredging and filling.[63] In addition, underwater grasses cover just over 76,000 acres of the Bay, far short of the target of 130,000 acres by 2025, according to the Chesapeake Bay Program.[64] This not only degrades the region's carbon storage capacity, but further loss of marshes and seagrasses could contribute additional emissions—contrary to the states' climate goals. A study of habitat change driven by sea-level rise in six Atlantic Coast states, including Maryland and Virginia, found that 83 percent of existing coastal marshes and 26 percent of existing seagrasses could be lost by the end of the century. The loss would transform these habitats from carbon sinks to a source of carbon emissions.[65]

Restoration of the Bay's oyster population and reef systems goes hand in hand with the protection and enhancement of these critical blue-carbon habitats. Oysters can facilitate the growth and expansion of saltmarshes and underwater grasses by buffering them from the impact of waves, protecting against erosion and marsh retreat. Oysters also filter sediment and algae from the water, increasing the clarity that is needed for SAV to receive enough sunlight, while at the same time depositing nutrient-rich organic matter on the bottom that supports growth.[6] Finally, oyster reefs may also increase the amount of carbon stored in sediments by nearby SAV.[66]

Co-locating the restoration of marshes, SAV, and oyster reefs may also mitigate the impact of ocean acidification on oysters.[67] Acidification is being driven by the same greenhouse gas emissions causing global climate change. Carbon dioxide from the atmosphere dissolves into the ocean and mixes with water, forming a weak carbonic acid that impacts the ability of oysters to build their calcium carbonate shell. Oysters and other shell-creating creatures therefore have to work harder to build shell faster than it is broken down by their acidic environment.

Globally, more than 95 percent of the ocean surface has acidified beyond natural levels due to human-caused emissions, according to the Intergovernmental Panel on Climate Change (IPCC).[19] These same effects of acidification have already been observed in the Chesapeake Bay.[68] A recent scientific study has shown that underwater grasses can actually mitigate this impact through a process called calcification—essentially, the vegetation acts as an "antacid" for the Bay.[69] This may also help create a virtuous cycle by which healthy oyster reefs also perform calcification and further buffer against acidification. Co-locating SAV and oysters has also been suggested as a strategy for building the resilience of nearshore habitats to the Bay's rising water temperatures.[70]

Because acidification and other pressures will continue to worsen with climate change and make it increasingly difficult for oysters to grow, there is an urgent need to focus resources on rebuilding oyster populations as much as possible now. Additional monitoring and research are also critically needed to better understand the impacts of acidification on the Bay's existing wild oyster population, as well as on the growing aquaculture industry, in order to mitigate acidification's effects on this keystone species and the region's economy.

Climate Change Mitigation Recommendations

To leverage oysters to protect and enhance the capacity of the Chesapeake Bay's blue-carbon habitats to mitigate climate change and the impacts of ocean acidification, policymakers and resource managers should take the following actions:

Incorporate a landscape-scale approach to restoration strategies and projects to maximize the mutual benefits of complex habitats, such as oysters, living shorelines, and SAV.

Opportunities should be pursued to create multiple, co-beneficial habitat improvements that incorporate oyster reefs, SAV, and marshes to maximize the blue-carbon potential of coastal ecosystems. In places where none exist, a dedicated restoration program for SAV should be considered in addition to existing agency programs.

Identify priority areas for restoration where oyster habitat establishment can slow erosion of existing marsh habitat.

Despite state and federal law meant to curb the loss of marshes, wetlands loss continues to outpace gains due to sea-level rise, erosion, and other direct impacts. Restoration of fringing oyster reefs along marshes can help buffer wave energy and reduce erosion, helping to preserve the habitat value and carbon sequestration function of these important habitats.

Work with the aquaculture industry to develop best practices that minimize impacts to SAV in and around lease areas.

Oyster aquaculture is a growing industry in Maryland and Virginia and provides important economic and ecological services. These best practices should therefore seek to protect fragile environments while still allowing oyster cultivation where appropriate. Research is also needed into the possible co-cultivation of SAV and how oyster aquaculture gear could provide wave attenuation benefits to protect marshes.

Improve aquaculture siting and operations to maximize the co-benefits in, around, or near blue-carbon habitats.

Co-locating oyster aquaculture with marshes and SAV could help further amplify their mutual benefits. These include the protection of marshes and communities from erosion, the enhancement of fishery production, and the provision of a diversity of nearshore habitats to support biodiversity. Policies and programs that incentivize aquaculture practices to maximize these ecosystem services should be established.

Despite significant advances in fisheries management techniques and approaches, oyster fisheries in Chesapeake Bay are still managed under the types of rules that have been in place for more than two centuries.

MODERN FISHERY MANAGEMENT

The fisheries of the Chesapeake Bay have supported human populations for thousands of years, beginning with the region's Indigenous communities. They harvested at levels that were sustainable over many years, as evidenced by the long record of middens where oyster shells were deposited after harvest.[71]

DAVE HARP

Cues from the Past: Sustainable Oyster Harvest by Indigenous Peoples

Chesapeake Bay oysters have been a food source for human communities for millennia, with harvests by Indigenous peoples stretching back more than 13,000 years. Studies of historical oysters suggest these harvests were sustainable until the colonial period. They also show that the size and lifespan of oysters in the Bay has declined in modern times, in part due to harvest practices.[87] In contrast to modern harvests, Indigenous harvests were more focused on shallow nearshore reefs rather than reefs in deeper water, and hand collection likely left reefs intact compared to modern gear—helping oysters naturally replenish.[88] While oysters today face additional challenges, including more pollution, disease, and a higher human population, these historical harvest methods could help inform future management efforts.

When European colonists arrived in the 17th and 18th centuries, they made note of the incredible bounty of the Bay's fisheries. Oyster reefs, according to the journals of some visitors, were so large that they posed navigational hazards to ships, and by the end of the 19th century Maryland was the world's largest oyster producing region.[24] However, even during the 1800s, scientists including W.K. Brooks were already recording overfishing and depletion of populations.[72] This followed the overexploitation of oyster fisheries in New England, which collapsed earlier and pushed additional fishing pressure from Northern states into the Chesapeake Bay.[73]

At the same time, the conversion of large areas of forest to farmland also contributed significant amounts of sediment flowing into the Bay that silted over oyster reefs and river bottoms.[74] Together these factors placed enormous pressure on the Bay's oyster populations. Yet while disease and pollution also contributed to the decline of oysters throughout the 20th century, the decimation of oysters and their reefs by overfishing has been identified as the primary cause of the population's initial collapse.[75]

Management of the fishery is therefore critical to restoring the Bay's oyster population. In the early years of regulation, much of the management focused on the gear used to harvest oysters, as industrialization brought new vessels and gear that allowed the exploitation of deeper oyster beds. Oyster dredges facilitated large harvests by dragging the equipment along the bottom, but in doing so they destroyed the reefs needed for the population to survive. Virginia banned oyster dredging in 1811 and Maryland followed suit in 1820, but dredges were re-legalized in 1865 and are now the most frequently used gear in Maryland and Virginia.[24,71,75] These regulations were followed by efforts to put in place minimum size limits for harvestable oysters and limits on the number of bushels of oysters that watermen could harvest daily.

Yet despite incredible gains in the understanding of oysters, their ecology, and fisheries science since the turn of the 20th century, this is the same approach to management that state fishery managers use today. For example, in 2018, Maryland began implementing one of the most advanced stock assessments for oysters anywhere in the world, providing more data than ever about the current state of the oyster population. However, management of the fishery has not modernized to reflect this new knowledge or advancements in technology that would make management more accountable and targeted.

Bringing management of the Bay's oysters into the 21st century would allow oyster populations to recover and grow, fulfilling their critical keystone role in the ecosystem while also maintaining a valuable fishery. Under current management approaches, this has not been possible.[76] However, other examples exist of fisheries both regionally and globally where new approaches have been successfully implemented to achieve restoration of the population and a sustainable harvest.

In Limfjorden, Denmark, the fishery for the European flat oyster, *Ostrea edulis*, was facing many of the same challenges. Overexploitation, disease, and pollution eventually resulted in the total ban of fishing between 1982 and 1991. However, the fishery was reopened in 2003 and implementation of an adaptive management strategy has ensured the survival of the oyster population, and a stable harvest, even when the population has been low. Management relies heavily on annual stock assessments that provide the fundamental knowledge of total population size, density, and population structure. Based on this knowledge, managers implement a Total Allowable Catch (TAC) that can be set for specific areas as well as specific time periods. The number of fishing vessels in each area can also be limited, certain areas to protect broodstock may be closed, and logbook reporting and the installation of "black box" devices to protect closed areas from poaching are mandatory.[77]

In New Jersey's Delaware Bay, management of the oyster fishery is grounded in principles of cooperative management among watermen, government agencies, and researchers, incorporating science as a bedrock component. The fishery has long depended on the harvest of seed oysters from natural beds farther up the Bay—where they are less susceptible to disease—to leased bottom areas in the lower Bay where they are grown to market size. To ensure this harvest is sustainable, the seed beds are sampled by researchers to determine population characteristics each winter. This information is then used by members of a shellfish council, comprised of industry members appointed by the governor, to determine if harvest is allowable, where it should take place, and for how long. The recommendations are submitted to the state management agency for final approval.[78]

Another important aspect of managing oyster fisheries to ensure a sustainable population is the consideration of oyster shell. Fishing pressure not only removes live oysters from the water, but also removes their shells. This can be problematic if too much shell is removed because it is necessary to form the substrate upon which juvenile oysters attach and grow, which in turn sustain oyster populations and their reef habitat. A study examining this issue in Delaware Bay was able to create reference points for sustainable levels of harvest that would protect the shell resource, while also taking into account mortality from disease.[79] While Maryland's oyster stock assessment includes oyster habitat as a component, resource managers have not moved to align management of the species with the reference points that would support a sustainable amount of shell, known as a shell budget, over time.

After centuries of decline, these examples show that a different path is possible. Without significant changes to management, the Bay's oyster populations will continue to struggle and stocks will consistently be on the edge of exhaustion. This is not only detrimental to coastal ecosystems. It damages the long-term viability of the oyster fishery itself and the communities that depend on the harvest of oysters as a way of life and an important cultural touchstone.

Modern Fishery Management Recommendations

To grow and maintain the Bay's oyster populations so they are abundant enough to support a sustainable fishery while also serving their critical ecological role and providing many co-benefits to the ecosystem, policymakers and resource managers should take the following actions:

Manage the oyster population to increase oyster abundance by fishing at target harvest rates.

Fully utilize the most up-to-date scientific information and methods to manage the oyster resource, including:

Initiating an oyster stock assessment in Virginia.

Based on this science, management should be designed to enhance both the ecological function of oysters and their economic value, recognizing the many additional co-benefits that oysters and their reefs provide.

In Virginia, reevaluate the total area designated as Baylor Ground and advocate for 50 percent of the public bottom to be in rotational harvest. In addition, implement pilot programs for short-term use on unproductive Baylor Grounds.

The Baylor Grounds, delineated by the Baylor Survey in 1894, refer to the area set aside exclusively for the public oyster fishery in Virginia. These areas currently may not be leased for private aquaculture. However, many of these grounds have become unproductive. Reevaluating these areas and allowing managed beneficial uses in unproductive areas, such as aquaculture, could help improve oyster productivity overall.[80]

Update fishery management statutes to reflect modern methods and management approaches and nomenclature.

These include the use of stock assessments, reference points, spatial management, electronic harvest reporting, and optimum yields.

Implement harvest quotas and other harvest control methods.

Quotas should prevent overharvesting of oysters and limited entry programs help to address the issue of latent effort, which refers to the possible flood of new participants in the oyster fishery that occurs in abundant years. This effort often undermines any gains in oyster productivity and the potential for long-term recovery, however current regulatory frameworks do not always effectively control it.

Include spatial considerations in management that reflect the variable reproduction, persistence, and success of oysters along the Bay's salinity gradient.

Implement electronic harvest reporting that includes hail-in/out requirements and vessel monitoring systems.

With accountability measures and sufficient enforcement, this can ensure the timely and accurate data collection necessary to implement management measures.

Manage oyster shell alongside oyster populations, with a primary goal to increase the amount of available shell.

Oyster populations cannot be restored or sustained without adequate amounts of oyster shell, which is currently scarce. Management utilizing shell-based reference points or shell budgets is essential to ensure the long-term sustainability of oyster populations.[37]

In Virginia, experiment with alternative substrates for replenishment.

In order to sustain the productivity of public oyster grounds, Virginia currently operates a replenishment program that plants recycled and fossil oyster shells, providing a substrate for juvenile oysters to grow. Because shell is a limited resource that is increasingly expensive, alternative substrates should be considered for replenishment efforts.[81]

Living shorelines, like this one in Portsmouth, Virginia, are low-cost, big-impact projects that stabilize beaches and waterfront properties and create oyster and aquatic habitat.

ACCOUNTABILITY AND TRANSPARENCY

Underlying achievement of all of the outcomes and goals listed above is the need for policies and management structures built on a strong foundation of collaboration and trust. Management of the Bay's oyster has long been fraught with deep divisions, dating back to the Oyster Wars of the 19th century.[82] In more recent history, tensions often arise between stakeholders concerned with maximizing the immediate economic value of oyster populations and those who are concerned with the long-term viability of oyster populations and their ability to sustain the critical ecological services oyster reefs provide to coastal ecosystems and communities.

Rebuilding trust in managers and agencies is critical to bridge these divides. Managers must convince stakeholders that the states will uphold their mission to steward public resources and respond genuinely to concerns. As noted above in the example of Delaware Bay,[78] trust among industry members, government, and scientists is essential to ensure the success of efforts to sustain oyster populations for ecological and economic values.

As the preceding sections of this report show, oysters are at the heart of achieving many benefits for the ecological, social, and economic wellbeing of the Chesapeake Bay, particularly in a changing climate. Only by repairing trust, accountability, and transparency can the many stakeholders involved in achieving these outcomes fully realize the potential of oysters to build a more resilient future.

Accountability and Transparency Recommendations

To rebuild trust in state agencies and fishery managers in order to bridge stakeholder divisions and successfully manage the Bay's oyster populations for the benefit of coastal ecosystems and communities, policymakers and resource managers should take the following actions:

In Maryland:

Re-center science in natural resources decision-making and restore the confidence of agency scientists.

Previous agency actions deeply eroded trust and morale among staff and external stakeholders, which must be rebuilt.

Improve transparency in decision-making.

This can be achieved by providing summaries of comments received on agency actions, rationale for agency decisions, and clear communication on the scientific basis for decisions and how managers incorporated scientifically supported comments.

Reform advisory commissions to be more diverse and inclusive of the full suite of stakeholders with interest in the resource.

For oysters, specifically, reform the antiquated and duplicative committee structure that includes county oyster committees, statewide oyster committee, the Tidal Fisheries Advisory Commission, and Oyster Advisory Commission.

Improve navigability and usability of the Department of Natural Resources website and event calendar to ensure full access to public meetings and hearings.

Agencies should also continue to offer hybrid and virtual meetings to maximize participation and improve equitable access to participation.

In Virginia:

Implement better accounting and data-sharing about how many oyster-lease acres are active and productive versus fallow.

Despite recent increases in the area of bottom leased for oyster aquaculture, many of these leases remain under or unused for oyster production. This has been noted as an impediment to the growth of Virginia's oyster industry and may be driven by a number of factors, including the acquiring of leases in order to exclude oyster aquaculture.[83, 84]

In addition to completing a Virginia oyster stock assessment, the public should be allowed to participate in recommending how the oyster fishery operates.

Projects like building new artificial oyster reefs for fish habitat in designated recreational fishing areas demonstrates the power of oyster restoration to achieve multiple economic and social benefits.

CONCLUSION

Over the past 150 years, the diminishment of the Chesapeake Bay's oysters through water pollution, overharvesting, disease, and habitat loss has resulted in lost opportunities to drive the prosperity and productivity of our region. A holistic approach to oyster restoration and management can revive our coastal ecosystems in a way that reduces the impacts of climate change, improves water quality, and expands economic opportunities in the region while ensuring these resources and opportunities are managed sustainably, transparently, and equitably.

As the Bay partnership moves into the next chapter of oyster restoration and states confront the existential threat of climate change, the decisions being made today will shape the future of the Bay's oysters and the many economic and ecosystem services they provide for decades to come. Now is the time to ensure oyster restoration can realize its full potential to support the ecological, economic, and social resilience of our estuary. Doing so will support vibrant communities where people and nature can thrive together.

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