A Blueprint for the Bays

Comprehensive Conservation and Management Plan
2023 – 2033

Executive Summary

Massachusetts Bays
NATIONAL ESTUARY PARTNERSHIP

March, 2023

Executive Summary

The legislation that established the National Estuary Program (NEP) in 1987 was unique for its approach to environmental protection, conceived broadly to focus on maintaining the integrity of whole systems — their chemical, physical, and biological properties, as well as their economic, recreational, and aesthetic values. In keeping with this ambitious goal, each NEP is charged with developing Comprehensive Conservation and Management Plans (CCMPs). These are living documents, serving as blueprints for actions that are detailed and implemented in annual workplans, and like all blueprints, they look into the future, describing something that will be realized through over time. And also like all blueprints, there is no guarantee that all will go according to plan. CCMPs must be reality-based, but also aspirational and nimble enough to seize opportunities strategically. CCMPs are required to be updated or revised periodically, at least every 10 years; the program itself is evaluated for progress in achieving goals every five years. MassBays' first CCMP was released in 1996, followed by updates to goals in 2003 and 2013.

The 2023-2033 CCMP for the Ipswich, Massachusetts, and Cape Cod Bays is the product of multiple years of effort, extensive stakeholder input, and the application of innovative methods for ecosystem-based, active management. It highlights recent accomplishments as well as areas where more work is needed – or where approaches must be changed. Impacts and responses to climate change, and engagement in environmental justice are consistent and core strands to the proposed goals, strategies, and actions. We know we cannot predict our successes in the next 10 years, and that even 10 years is not enough time to fix the legacies of past activities or to address the coming impacts of new conditions. But we do know how we propose to spend those next 10 years: prioritizing habitat restoration and protection in the Bays; tracking and reporting on habitat conditions; and building capacity across the region to support this work.

A New Blueprint for the Bays

With this revision, the Management Committee (MC) is updating MassBays' approach to improving and protecting coastal resources, building on MassBays' unique local relationships to build capacity for locally significant efforts that contribute to system-wide improvements in habitat, connectivity, and resilience. Previous CCMPs for our region, dated 1996 and 2003, focused on large projects ("Projects of Regional Scope and Impact") and laid responsibility at the feet of local and state agencies for a wide range of tasks under 17 Action Plans. ***Our new CCMP focuses on achieving specific management and environmental outcomes by means determined at the local level, informed by MassBays' work.***

The principles that guide our day-to-day work will help us to realize the CCMP goals. They include:

- ***Collaboration and Cooperation.*** The complex issues before us cannot be handled by any single entity. We will work with partners in all sectors, engage environmental justice communities, and where there is not already an effort underway, and an issue is identified as a priority through our CCMP, we will build capacity locally – providing technical support, grant writing, and regional connections – that get projects done.
- ***Ecosystem-based Management.*** MassBays seeks fundamental improvement in our estuaries. This requires a holistic approach to problem-solving and decision making. Cross-cutting impacts and implications of any action will be considered before we make significant investments.

- ***Climate Change Resiliency.*** We know that our estuarine systems will be impacted over the coming decades by the multiple manifestations of climate change. MassBays will draw on the most current understanding of those impacts to evaluate proposed actions.
- ***Long-term Sustainability.*** As long as the National Estuary Program exists, MassBays will play a role in meeting the goals of CWA §320. Our ability to do this work requires both Management Committee and staff commitment to implementing well-laid plans – and our success in doing so will set the stage for claiming even more success in the future.

These principles were also incorporated into a new vision and mission statements for MassBays, endorsed by the Management Committee in 2013:

Vision

We envision a network of healthy and resilient estuaries, sustainable ecosystems that support the life and communities dependent upon them.

Mission

To empower 50 coastal communities to protect, restore, and enhance their coastal habitats. To fulfill this mission, MassBays engages local, state, and federal entities to advance the use of scientific information and provide technical support for decision making.

Taken together, our vision and mission drive MassBays' priorities for habitat and management, and serve as the basis for the broad Goals, focusing Strategies, and concrete Actions that we will take up under this CCMP. The ten-year plan described in this document will be implemented through execution of annual workplans, carrying out incremental steps (Activities) according to details vetted by the Local Governance and Management Committees.

Responding to New Conditions

A CCMP is not only a requirement, but it is an important blueprint to guide future actions. In the 20 years since the last CCMP update (in 2003), the context for planning and the universe of environmental conditions, management priorities, and agency capacities have changed significantly. For example:

- ***New programs are in place*** within state agencies, volunteer monitoring capabilities have expanded, and powerful computer tools such as GIS and Shiny for Python and R have become easily accessible.
- ***Programs to protect and improve water quality have been discontinued*** making it imperative to find other ways to address problems holistically.[2]
- ***Regional projects with significant impact have been completed*** (e.g., the Boston Harbor cleanup), and meanwhile addressing localized impacts and restoration has become more important.
- ***Impacts of climate change are incontrovertible and are disproportionally affecting Environmental Justice (EJ) communities.***
- ***New resources are now available and focused on supporting municipal action***, especially with regard to climate change.
- ***Funding for Massachusetts environmental agencies and EPA has declined.***
- ***MassBays' influence on local decision making has increased*** by virtue of 20 years' effort on the part of the RSPs and RCs, staff, and Management Committee.

[2] For example, the Merrimack River continues to be subject to untreated CSO discharges: https://www.epa.gov/merrimackriver/environmental-challenges-merrimack-river#CSO

At the same time, the MC determined the time was right to evaluate MassBays' position within CZM and investigate opportunities to broaden partnerships and outreach. A transparent assessment of host options resulted in the MC 's full endorsement of the program's move to the University of Massachusetts School for the Environment at the Boston campus. The Committee also determined that this CCMP should reflect conditions through June 2022, and that the CCMP Attachments will be updated (Monitoring Framework and Communications Plan in calendar year 2023; Finance Plan by end of calendar year 2024) to incorporate more recent developments, including:

- A new milieu for communications and diversification of funding, with MassBays as a Center within UMass Boston's School for the Environment.
- New opportunities for project implementation with supplemental funding under the Infrastructure Investment and Jobs Act of 2021 (also known as the Bipartisan Infrastructure Law, or BIL). Spending of these funds aligns with corresponding EPA program guidance.

The context established by these changes reflects the impacts of emerging issues, technologies, management frameworks. In response, MassBays' MC worked from 2013 through 2022 to revise our programmatic and organizational goals, bring forward the environmental outcomes those goals supported, and identify strategic actions needed to reach those goals. Section V provides a flowchart and details of the revision process.

Cross-cutting concerns

As we developed this revised CCMP, two cross-cutting concerns in particular provided focus for our work over the next 10 years – addressing environmental injustice and responding to climate change – neither of which had been included in our previous CCMPs.

Environmental justice

In spite of awareness of environmental injustices, highlighted by local communities and officially recognized by President Bill Clinton in 1994, progress in addressing inequities in access to the coast and open space, disproportionate exposures to toxic waste and environmental contamination, and lack of access to arenas where policy and management decisions has been slow. ***Meeting the needs of communities that have routinely borne the brunt of pollution and been excluded from realizing benefits of restoration is critical to sustaining resilient communities.*** MassBays has a role to play in implementing initiatives to respond to these needs, including highlighting the social, economic, and demographic displacements and realignments that climate change will introduce. We will make full use of resources offered by both EPA and EEA's Offices of Environmental Justice to advancing environmental justice in the MassBays study area. The Programmatic Goals detailed in Section VI include means for taking up this work.

Climate change

Emerging and predicted risks from climate change have directly informed MassBays' Programmatic Goals. Massachusetts has conducted comprehensive vulnerability studies and reports with input from local and regional experts, assembled in a web-based clearinghouse, www.resilientma.gov, which provide significant and solid underpinning to this CCMP. Our long-term planning recognizes that past conditions and the current state are not predictive of future conditions. For example:

- ***Sea level rise,*** which will be significant in MassBays' study area compared to other regions, results in marsh subsidence and other changes in coastal habitat extent and distribution.
- ***Warmer water and warmer seasons*** are already changing species distribution and abundance, especially with observed northward migration of aquatic species.

- ***More frequent and more severe storms*** increase the influence of stormwater and combined sewer overflow discharges on water quality, change freshwater/saltwater interfaces, and stress existing stormwater and tidal infrastructure.

Planned responses to these and other climate change impacts are described in Section VI.

Challenges determine Goals and Strategies; Actions result in Outcomes

Figure ES1 diagrams the challenges, goals, and outcomes that frame the CCMP; Figure ES2 provides an "at-a-glance" view of the strategies and actions that comprise MassBays' response to those challenges, and means to realize the outcomes. Each year, our annual workplan will implement activities and tasks under those actions to move us to our ecological and program goals based on priorities vetted with local partners.

Over the next 10 years, and with this CCMP, the MC expects MassBays to consider fundamental questions of what the future should be and work towards two sets of complementary goals depicted in Table ES1, Organizational Goals and Programmatic Goals. Both must be addressed if MassBays is to realize our desired environmental outcomes. The new operational framework provided in this CCMP will enable us and our partners to generate and point to real and substantial improvements in the MassBays ecosystems. And ultimately, the CCMP will help empower our program's 50 coastal communities through a collective investment of partner time, money, and expertise in protecting, restoring, and enhancing our shared coastal habitats.

Table ES1. Goals and Outcomes for the MassBays CCMP

Organizational Goals +	Programmatic Goals →	Environmental Outcomes
MassBays is a primary source for information about conditions and trends in Ipswich Bay, Massachusetts Bay, and Cape Cod Bay.	MassBays provides new resources to support research and management in the Bays.	Locally significant habitats and ecosystems assessed and prioritized for research, assessment, and implementation actions.
MassBays is an important influence on local decision making that recognizes the roles, functions, and values of healthy habitats in the Bays.	MassBays reaches all study-area municipalities with actionable information about coastal habitats.	Ambient water quality supports biodiversity; observed improvements in habitat continuity and hydrological connectivity at the local level.
MassBays is a model program for management and planning that addresses diversity among estuaries.	MassBays provides regular and locally informed State of the Bays reporting that reflects the unique characteristics of MassBays assessment areas, and documents progress toward target conditions.	Locally relevant improvements in water quality, habitat, biodiversity, and resilience.

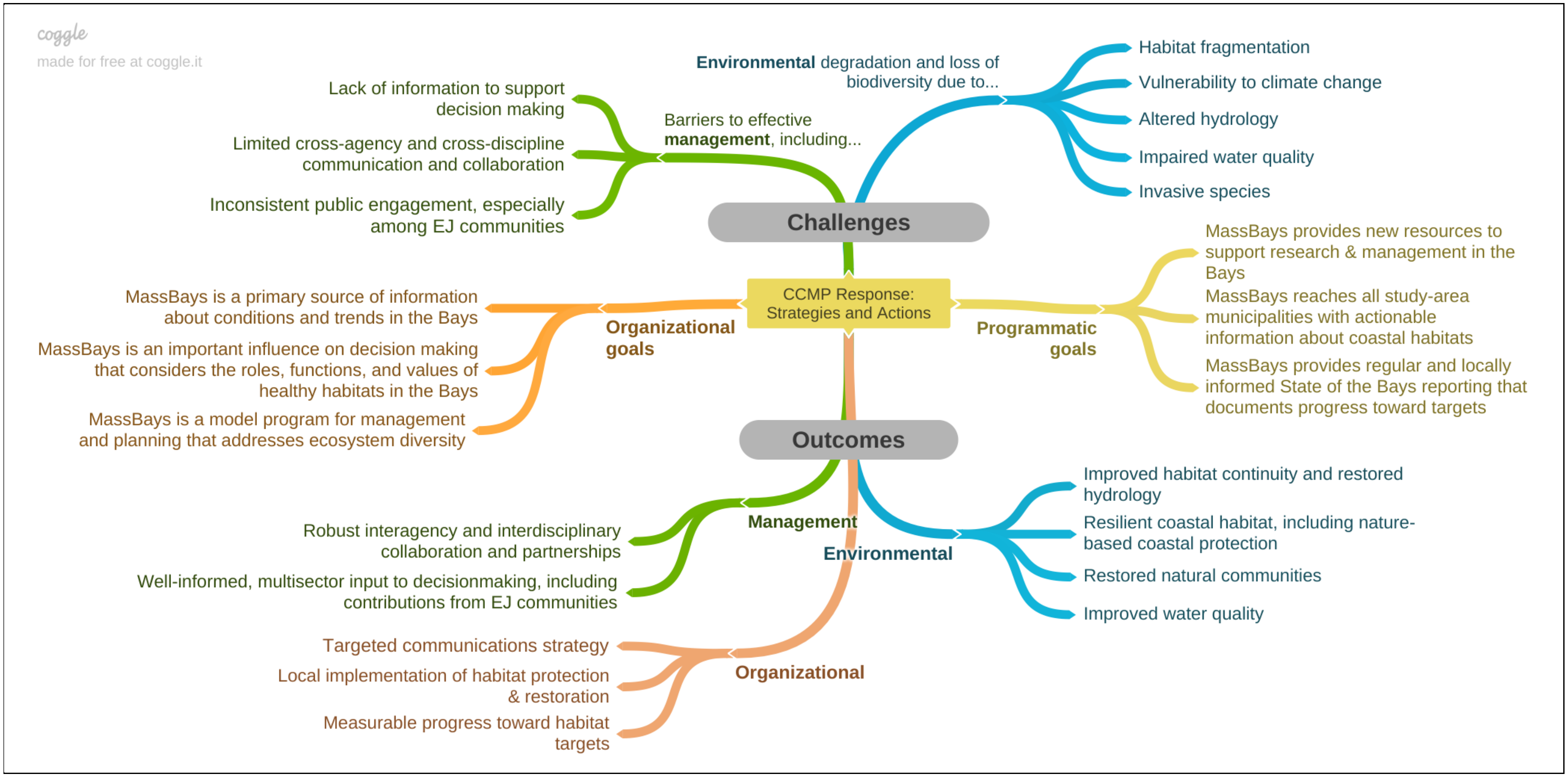

Figure ES1. Relationship between the Challenges in the Bays, the CCMP Goals MassBays will take up with this CCMP, and the anticipated Outcomes resulting from its implementation.

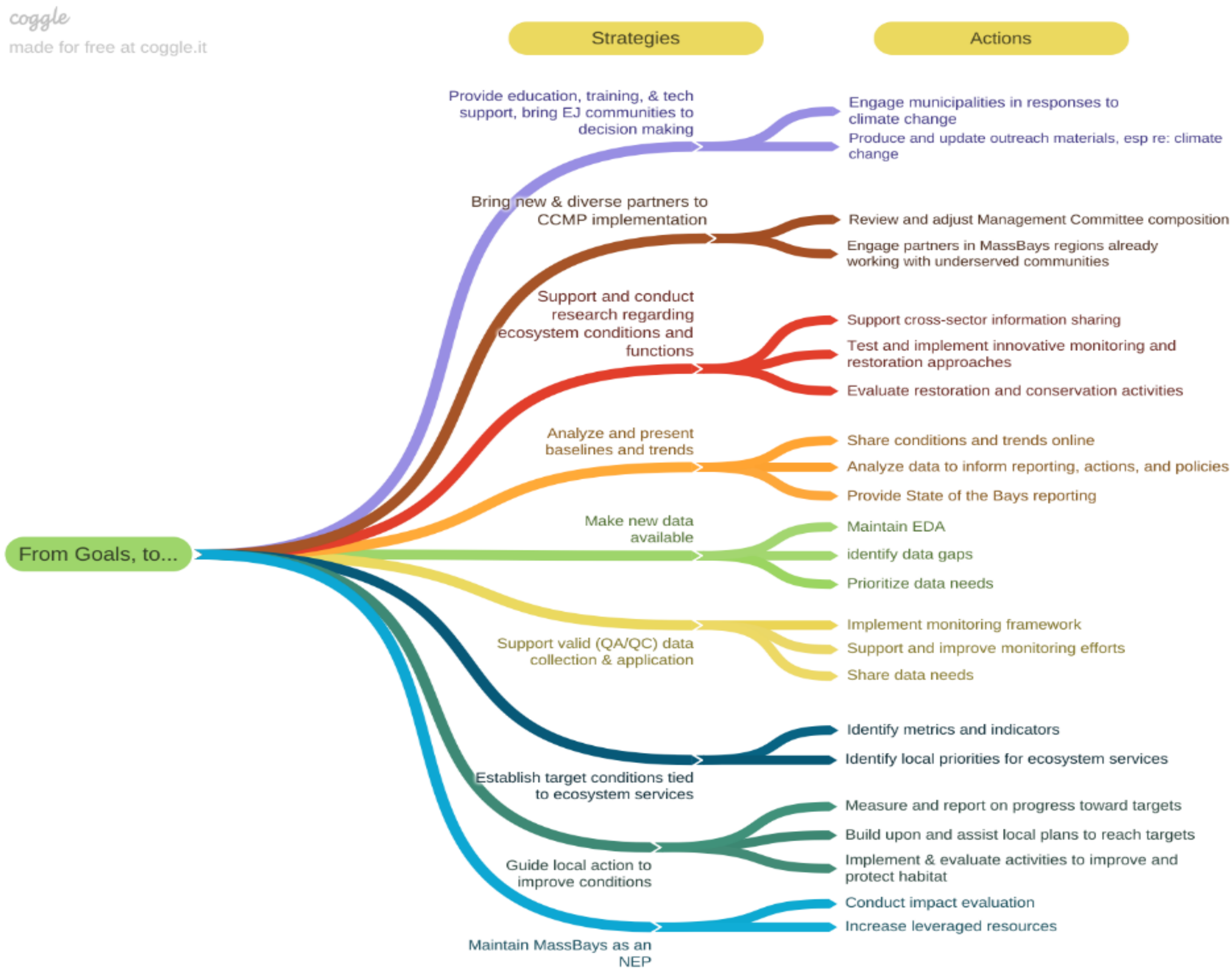

Figure ES2. Compilation of the MassBays CCMP Strategies and Actions planned through 2033.

MassBays' Study Area and Organizational Structure

MassBays was designated an Estuary of National Significance under the NEP on Earth Day in 1990, with an area including 50 coastal communities from Salisbury to Provincetown and more than 1100 miles of coastline around three Bays: Ipswich, Massachusetts, and Cape Cod (Figure ES3).

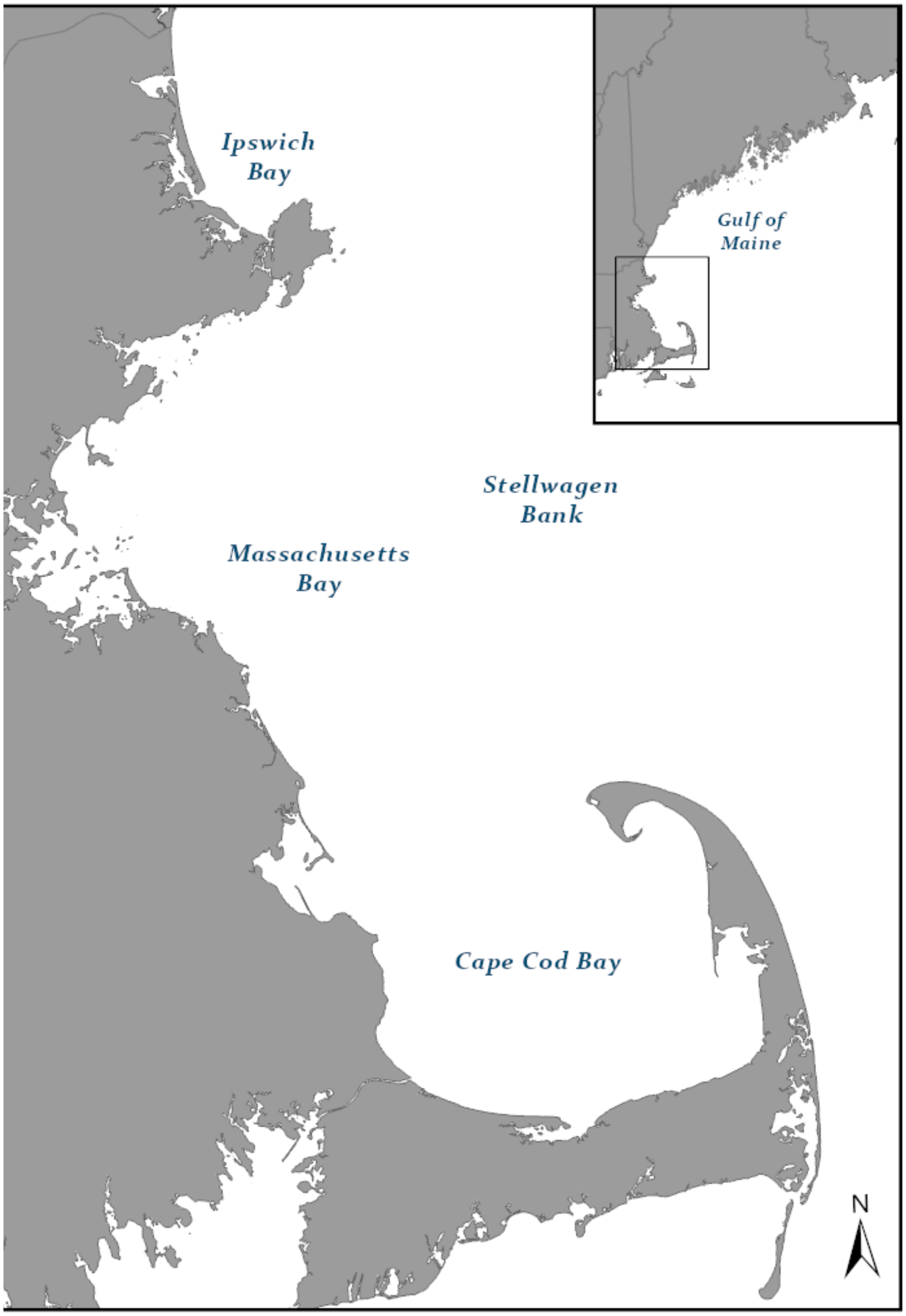

Figure ES3. MassBays' work is focused on Ipswich Bay, Massachusetts Bay, and Cape Cod Bay.

Local expertise to effectively engage stakeholders across this broad study area is critical, and early in its history MassBays engaged Regional Service Providers (RSPs) as MassBays' representatives to provide region-specific technical assistance, outreach to stakeholders, and priority-setting for habitat protection and restoration (Figure ES4). With annual funding from MassBays, each RSP

Figure ES4. MassBays' Regional Service Providers and the municipalities they serve.

designates a Regional Coordinator, who in turn convenes and staffs a Local Governance Committee
to ensure that yearly regional plans are driven by local priorities and capacities, informed by the CCMP (Figure ES5).

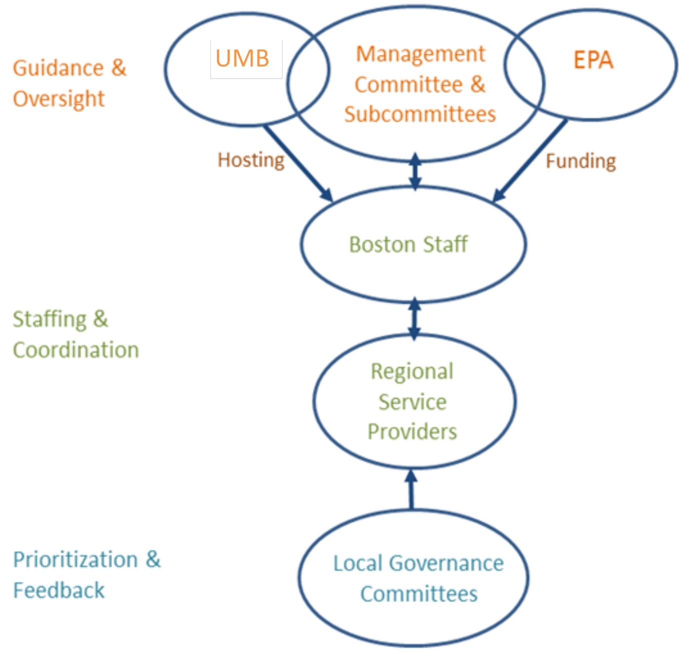

Figure ES5. MassBays' organizational structure.

At the same time, MassBays' overall planning and programming is guided by a Management Committee, which includes public officials, environmental organizations, business leaders, and scientists. The Management Committee, through a process described by EPA in NEP funding guidance, endorses the CCMP and yearly implementation workplans submitted for EPA's approval, both prerequisites to receiving EPA funding. The Committee provides input through quarterly meetings and participation in subcommittees dedicated to specific needs, such as the Science and Technical Advisory Committee. Appendix L lists the Management Committee members in place during the 2013-2022 CCMP revision process; the process itself is described in Section IV.

All of this expertise – from local experts and advisors – is brought to bear on the work carried out by MassBays' staff, currently 2.8 full-time equivalents, hosted through October 1, 2022 by the Massachusetts Office of Coastal Zone Management, and currently by the University of Massachusetts Boston (UMB) (see "Responding to new conditions," above).

Conditions in the Bays

MassBays' study area is large and diverse, encompassing approximately 1,650 square miles, from coastal wetlands offshore to Stellwagen Bank, 25 miles east of Boston in the Northwestern Atlantic Ocean. The inland watershed covers more than 7,000 square miles. Its 1100-mile coastline from Salisbury to Provincetown is characterized by a diverse and complex geomorphology that has shaped the largest contiguous salt marsh north of Long Island Sound (Great Marsh), expansive shellfish beds, feeding grounds for endangered whales (e.g., North Atlantic Right Whale), and refugia for migrating shorebirds (e.g., endangered Roseate terns). Through a comprehensive Ecosystem Assessment and Delineation (EDA), MassBays has defined 65 assessment units, subwatersheds consisting of 44 estuarine embayments and 21 rocky intertidal areas and barrier beaches (Figure ES6).

Massachusetts Bays support a complex of natural systems, including salt marsh, barrier beaches, dunes, tidal rivers, estuaries, shellfish beds, and mudflats extending from the upper watersheds to the estuaries and the Gulf of Maine. This unique complex of natural systems adds ecological, economic, recreational, and cultural value to the daily lives of both coastal and inland communities where land is connected by river and stream networks. They are home to hundreds of breeding and migratory birds, marine mammals, and fish; serve as nurseries for culturally, recreationally, and commercially valuable fish and shellfish; and provide ecosystem services to millions of people, including their increasingly vital role in blunting the impacts of climate change through nutrient processing and flood protection.

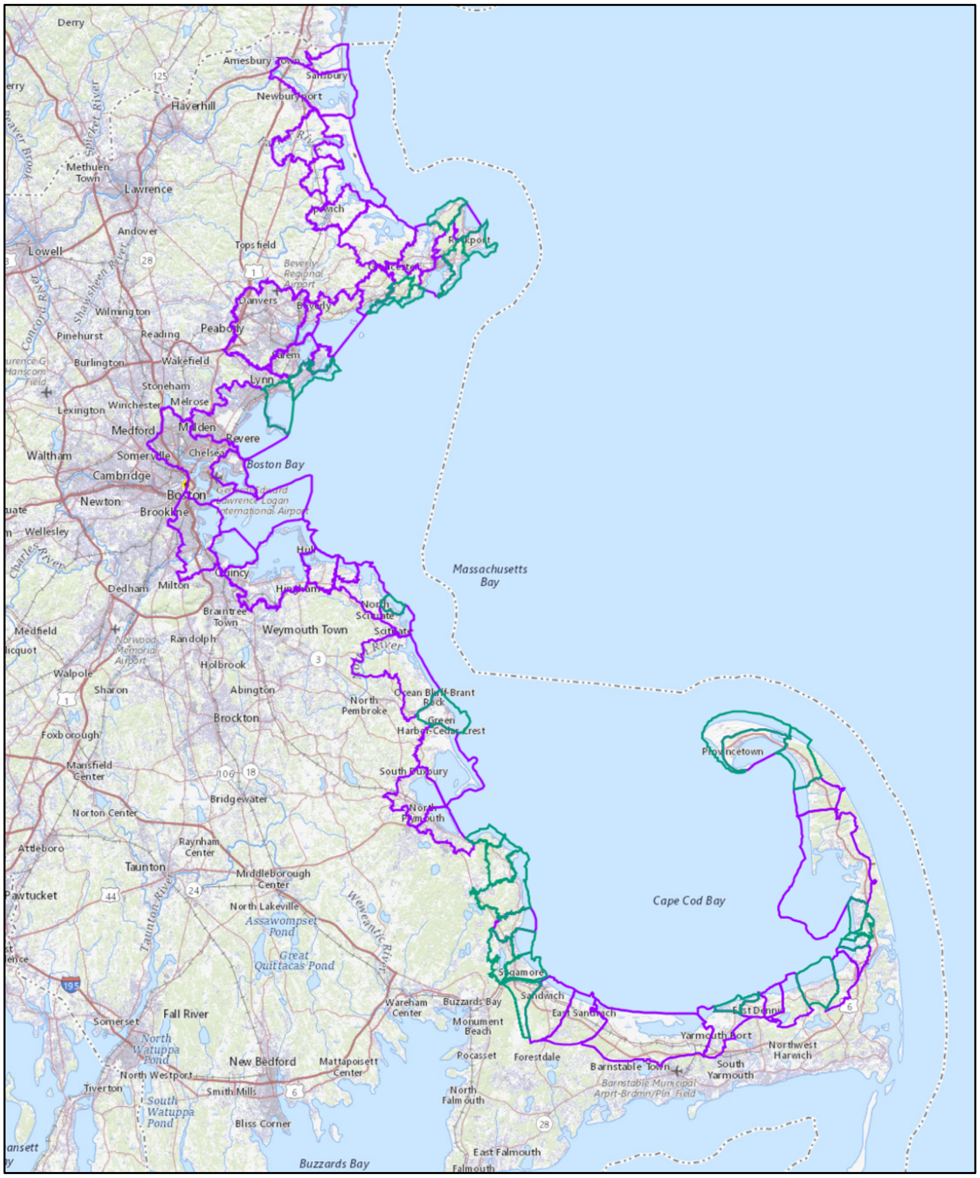

Figure ES6. MassBays has delineated 44 estuarine embayments (purple) and 21 "interestuarine areas," dominated by rocky shores and barrier beaches.

Together these habitats support a varied fishery and aquaculture industry which, along with recreation, shipping, transportation, and tourism, are economic drivers for Eastern Massachusetts if not the entire Commonwealth. Some of these uses and industries are now facing challenges from foreign and domestic competition and the harmful impacts of development patterns and conditions in land use and land cover over time; above all, climate change and its impacts are fundamentally transforming the ecosystems and resources of the Bays, altering conditions as basic as water temperature, pH, and precipitation patterns. Addressing these challenges requires characterizing the system, tracking conditions, and reporting changes to decision makers.

Characterizing the MassBays Ecosystem

Capturing the interplay between physical conditions, water quality, and habitats supported in each assessment area is critical to understanding the status of the study area, from individual embayments to the system as a whole. Section II of the CCMP provides a detailed overview of monitoring mapping programs and their findings for MassBays' study area, summarized here.

Physical characteristics

The Bays form the southern boundary of the Gulf of Maine, and its seascape is a patchwork of mud, sand, gravel, and boulders, with a .[3] general habitat gradient from Ipswich Bay, where salt marshes dominate, to the southern coast of Massachusetts Bay where rocky intertidal habitat mingles with marshes, and finally to Cape Cod Bay, which is dominated by sand beaches, dunes, and tidal flats[4]. The Bays have a tidal range of up to 4.1m (12ft). Although nutrients and pollutants are carried from upland parts of the watershed to coastal wetlands and into Ipswich and Massachusetts Bays, a recent study [5] essentially confirmed that in spite of the many rivers discharging into MassBays, tidal influence vastly exceeds that of freshwater, even with a documented increase in flow from the Merrimack River since the 1960s. Cape Cod Bay, on the other hand, is a dynamic environment that receives most freshwater input from groundwater inflow, a source that is heavily affected by Cape Cod communities' primary reliance on septic systems.

This information, taken together with characterization of water quality and habitat extent and condition described in the following sections, is critical to enabling MassBays to implement adaptive management. This CCMP lays the groundwork for an approach that employs "lumping" and "splitting" of embayments (and the inter-estuarine areas in the future) for generalized education and outreach for example, and for more specific site planning.

Water column conditions

MassBays follows four primary elements of water quality: temperature, dissolved oxygen, nutrients, and phytoplankton. All of these are shifting rapidly due to climate change, and those shifts are likely to have significant impacts on the habitats, species, and uses of the bays in the future.

Temperature

Continuous surface and bottom sea temperature data for areas north of Cape Cod from 2001-2020 show that the temperature of Massachusetts Bays is on a rising trend.[6] Sea temperatures recorded in 2012 were the warmest since 2000, causing early molting in American lobster (*Homarus americanus*) in the Gulf of Maine.[7] Another notable maximum was observed in 2015 in the winter sea surface temperature (45.6˚F), and again in 2016 a maximum was recorded in 2016 for annual sea bottom temperature (45.8˚F). A longer continuous time series for northern Massachusetts waters is required before long-term trends can be confidently described.[8] However, variations in water temperature at different depths create "layers" or thermocline in ocean waters; depending on the temperature, the water column above and below the thermocline can store oxygen and nutrients differently, impacting microbial growth and concentrations over time.

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[3] Knebel, H., R. Rendings, and M. Bothner. Modern Sedimentary Environments in Boston Harbor, Massachusetts. Journal of Sedimentary Petrology, 61(5): 791-804.
[4] Massachusetts Ocean Management Plan Volume 2. Commonwealth of Massachusetts 2021. https://www.mass.gov/files/documents/2022/02/25/ma-ocean-plan-2021-vol-2a.pdf
[5] Woods Hole Group Inc., 2019. MassBays Water Transport Times Estimation Project. Report prepared for MassBays National Estuary Partnership.
[6] http://neracoos.org/datatools/climatologies_display
[7] Pershing, A. et al. 2015. Slow adaptation in the face of rapid warming leads to collapse of the Gulf of Maine cod fishery. Science V. 350 (6262): 809-812.
[8] Massachusetts Ocean Management Plan Volume 2. Commonwealth of Massachusetts 2021. https://www.mass.gov/files/documents/2022/02/25/ma-ocean-plan-2021-vol-2a.pdf

Dissolved Oxygen

Massachusetts Bay and Cape Cod Bay both follow a seasonal dissolved oxygen (DO) cycle.[9] Massachusetts Bay experiences its highest DO concentrations during the spring and its lowest during the fall; those for Cape Cod Bay are higher in May-September. The cycle of warmer water temperatures and higher microbial activity in summer contributes to the reduced concentration of DO in bottom waters, and to the formation of hypoxic areas of depleted oxygen. Reduced DO can impact fish and other biota, with extreme oxygen depletion (<2 mg/L) resulting in fish kills.[10] In 2019 an unusually intense thermocline created hypoxic conditions, with DO < 1 mg/L in the bottom nearshore waters of Cape Cod Bay, resulting in the death of trapped lobsters and crabs.[11] These anoxic and hypoxic episodes in Cape Cod Bay prompted further investigation, including monitoring to catch signs of deleterious effects on fauna in Cape Cod Bay and other areas. Results of a 2022 study to identify the primary influences on water quality in Cape Cod Bay are pending.

Nutrients

Excessive nutrient inputs to coastal waters – primarily nitrogen from land-side sources like stormwater runoff and wastewater treatment plant discharges – often result in algal blooms in coastal systems. To date, MassBays has relied on data from MWRA and the Center for Coastal Studies for information about nutrient loading in Massachusetts Bay and Cape Cod Bay (both programs date from the construction of the Deer Island treatment plant to serve 43 cities and towns in Eastern MA). Nitrogen discharges have exceeded the "caution" level set in 1996 based on modelling data for 2020 only once, in 2019,[12] with no evident decrease in water quality in the vicinity of the treatment plant outfall. Otherwise, discharge concentrations of nutrients have been steady over time, and decrease with distance from the outfall. Data showed normal and improving total nutrient concentrations in Cape Cod Bay.

Phytoplankton

The MassBays study area experiences annual Spring and Fall phytoplankton blooms. MWRA monitoring in Massachusetts Bay indicates that during the Spring bloom (which coincides with freshwater flow from spring rains and snowmelt), chlorophyll averages just about 2.5 mg/L. Surface concentrations decrease to less than 2 mg/L during the summer, and then spike in September through November to about 4 mg/L (after nutrients are replenished when layers mix, bringing the end to stratification).[13] MWRA monitoring stations found that total dinoflagellate concentration increased substantially from 2018 to 2019, with the 2019 concentration ranking third highest in 28 years of monitoring.[14] Some blooms can be harmful or even toxic, requiring shellfish closures; they can also cause and turbidity and consequent loss of eelgrass.

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[9] Xue P., Chen C., Qi J., Beardsley RC., Tian R., Zhao L., Lin H. 2013. Mechanism studies of seasonal variability of dissolved oxygen in Mass Bay: A multi-scale FVCOM/UG-RCA application. *Journal of Marine Systems* 131, 102-119. https://www.sciencedirect.com/science/article/abs/pii/S0924796313002935?via%3Dihub

[10] https://www.epa.gov/nutrient-policy-data/documented-hypoxia-and-associated-risk-factors-estuaries-coastal-waters-and

[11] Scully, M. E., Geyer, W. R., Borkman, D., Pugh, T. L., Costa, A., and Nichols, O. C.: Unprecedented summer hypoxia in southern Cape Cod Bay: an ecological response to regional climate change? Biogeosciences, 19, 3523–3536, https://doi.org/10.5194/bg-19-3523-2022

[12] https://www.mwra.com/harbor/enquad/pdf/2020-11.pdf; pg. vi

[13] Geyer W., G.B. Gardner, W. Brown, J. Irish, B. Butman, T. Loder, and R.P. Signell. 1992. Physical Oceanographic Investigation of Massachusetts and Cape Cod Bays, Technical Report MBP-92-03. Massachusetts Bays Program, Boston, Massachusetts.

[14] https://www.mwra.com/harbor/enquad/pdf/2020-11.pdf; pg. 20

Habitat status

Salt marsh

There are approximately 34,000 acres of salt marsh in the MassBays study area (DEP Wetland data MassGIS 2005). The Great Marsh, a full 25,000 acres in the northern region, the largest contiguous salt marsh in New England, is an internationally recognized Important Bird Area, supporting more than 300 species of breeding and migratory birds. Other large salt marshes are located in Scituate/Marshfield and Duxbury Bay on the South Shore, and in Barnstable on Cape Cod. Historically, salt marshes ringed the Boston Harbor region and extended well into the Saugus, Mystic, Charles, and Neponset watershed.[15] Now only a fraction of those historic marshes remain, namely Rumney Marsh and Belle Isle Marsh (areas where MassBays continues to support assessment and restoration). It is estimated that salt marsh loss in the Boston Harbor region is close to 81% since pre-colonial times (see Appendix 1, title here). These losses are largely due to placement of fill during the 19th century,[16] but are also a result of salt marsh ditching and restriction of marsh-supporting tidal inundation with dams and tide gates – structures that remain to this day. Sea level rise and the impacts of development adjacent to marshes add modern challenges to the health of salt marshes in the MassBays study area.

Tidal flats

There are roughly 28,000 acres of tidal flats in MassBays. About 40% are located along Cape Cod Bay and constitute the largest flats in North America, extending 9.7 miles along the shore from Brewster to North Eastham.[17] Duxbury and Plymouth Bays on the South Shore, and Ipswich Bay on the North Shore, also contain extensive tidal flats.[18] Conditions in intertidal flats are variable given the unconsolidated nature of the sediment, changes in temperature, and presence or absence of water related to tides. Despite the variability, or maybe because of it, tidal flats support a high degree of biodiversity. Like salt marshes, coastal dunes, barrier beaches, and other coastal habitats, tidal flats are protected by the Wetlands Protection Act as "likely to be significant to storm damage prevention and flood control." Yet erosion poses an important threat to tidal flats and the beaches behind them. Sea level rise also poses a threat to tidal flats from complete submergence, putting organisms they support – like shorebirds, shellfish, and crustaceans – at risk.[19]

Eelgrass

Measuring the extent of eelgrass (*Zostera marina)* in Massachusetts' coastal waters is challenging due to cost, availability of resources, and variable methods used. MassDEP established the Eelgrass Mapping Project in 1995, the most comprehensive eelgrass survey effort in the state. The project involves mapping embayments across the state with a combination of aerial photography, digital imagery, and ground truth verification through diving. Findings of the first 12 years of the project

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[15] Carlisle, B.K., et al. 2005. *100 Years of Estuarine Marsh Trends in Massachusetts (1893 to 1995): Boston Harbor, Cape Cod, Nantucket, Martha's Vineyard, and the Elizabeth Islands*. Massachusetts Office of Coastal Zone Management, Boston, MA; U.S. Fish and Wildlife Service, Hadley, MA; and University of Massachusetts, Amherst, MA. Cooperative Report. https://www.mass.gov/files/documents/2016/08/or/ma-estuarine-trends.pdf

[16] https://www.hiddenhydrology.org/bostons-made-land/

[17] Setterlund, C. 2016. "The Changing Shape of the Cape & Islands: The tidal flats of Brewster, Orleans, & Eastham." *Cape Cod Life*, September/October accessed 12/20/2018 at https://capecodlife.com/the-changing-shape-of-the-cape-islands-the-tidal-flats-of-brewster-orleans-eastham/

[18] Hankin, A. L. et al. 1985. Barrier Bleachers, Salt Marshes, and Tidal Flats. An Inventory of the Coastal Resources of the Commonwealth of Massachusetts. CZM publication 13899-27-600-1-85 C.R.

[19] Galbraith et al. 2005. Global Climate Change and Sea Level Rise: Potential Losses of Intertidal Habitat for Shorebird. USDA Forest Service Gen. Tech. Rep. PSW-GTR-191. 2005.

are documented in Costello and Kenworthy[20] revealing increased eelgrass coverage in only three embayments and documenting an overall loss of 1,865 acres of eelgrass. Since 1995, Duxbury-Kingston-Plymouth Bays in western Cape Cod Bay collectively lost 54% of its eelgrass. Large losses have also been documented from other embayments such as Wellfleet (eastern Cape Cod Bay). Plum Island Sound, in Ipswich Bay, used to have extensive beds that disappeared decades ago. Surveys of this area were conducted by MassDEP in 2021 and results are still pending.

In spite of ongoing research, spatial fluctuations in eelgrass location and extent from year to year have not yet been fully explained. Major threats to eelgrass come from wastewater and stormwater discharge causing turbidity and eutrophication, and from physical damage and increase in turbidity caused by certain fishing gear, moorings, dredging, aquaculture, and boating activities. Eelgrass is also vulnerable to population fluctuations resulting from intense coastal storms, wasting disease, epifauna and impacts from invasive species including green crabs.

Rocky shores, Barrier Beaches and Dunes

Rocky intertidal shorelines are prevalent in the North Shore region extending from Nahant through Cape Ann. Several rocky shorelines are also found around areas of Salem Sound and around Boston Harbor. There are approximately 105 acres of rocky intertidal habitat in the Boston Harbor area, both natural and manmade (DEP Wetland Layer MassGIS 2005). Most of the natural rocky intertidal shorelines occur on the Boston Harbor Islands, with a total of almost 800 acres of rocky intertidal area across the study area. This habitat is vulnerable to human development which has often resulted in degradation, including development of shoreline protection structures such as seawalls, jetties, and riprap.

MassBays' study area includes more than 100 miles of beach, primarily in the Upper North Shore along Plum Island Sound, along Duxbury Bay on the South Shore, and along most of Eastern Cape Cod Bay. In terms of area, there are 11,000 acres of dunes and sandy beaches in MassBays' study area, nearly every one vulnerable to impacts of climate change and development. Construction of hard structures such as groins and jetties is often seen as a solution to protect eroding beaches and the land and communities behind it. However, appropriate design and maintenance of these structures is important for preventing more damage to the beach morphology that naturally maintains habitat values.

Fish runs and spawning areas

The MassBays study area has hosted spawning areas and migration routes for diadromous fish including American shad (*Alosa sapidissima*), alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), striped bass (*Morone saxatilis*), and rainbow smelt (*Osmerus mordax*). Fish populations and associated habitat have diminished over the past centuries because of dams, habitat alterations, pollution, and overfishing. MassBays' study area includes more than 200 potential, in-process, or completed fish run restoration sites along migration routes for herring, smelt, and American eel. [21]

Shellfish beds

Shellfish habitat is found across all MassBays with hotspots on the south shore and around Cape Cod Bay. The Massachusetts coast is characterized by quahogs (*Mercenaria mercenaria*), soft shell clams (*Mya arenaria*), blue mussels (*Mytilus edulis*), razor clams (*Ensis directus*), oysters

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[20] Costello, C. and W.J. Kenworthy (2011) Twelve-year mapping and change analysis of eelgrass (*Zostera marina*) areal abundance in Massachusetts (USA) identifies statewide declines. Estuaries and Coasts 34(2):232-242. DOI 10.1007/s12237-010-9371-5.

[21] https://www.mass.gov/info-details/massgis-data-diadromous-fish

(*Crassostrea virginica*), and bay scallops (*Argopecten irradians*). Areas within MassBays with vulnerable shellfish resources include: Cape Cod Bay (ocean quahogs and sea scallops), and the North Shore (sea scallops). Shellfish beds are threatened by pollution from land, harmful algal blooms, and construction, among others.

Setting habitat goals

A central component informing MassBays' new CCMP was the establishment of specific goals for habitat condition and extent across the entire study area. Setting goals for 68 embayments, rocky shores, and barrier beaches is a daunting task, however, and one that could take the entire 10 years' timeline for its implementation. Instead, MassBays undertook a stepwise process, beginning in 2018 that involved sorting the 44 delineated estuarine embayments according to their physical and chemical characteristics, and then setting habitat goals for each grouping informed by local priorities. This multi-year effort is detailed in Appendix A. Goal 3 of the CCMP calls for similar analysis and goal-setting for habitats in rocky shore and beach areas.

Defining ecotypes

To establish similarities and differences across the embayments and support resource management and planning, MassBays and EPA researchers undertook a detailed assessment of the hydrogeology and other physical characteristics. The analysis revealed four embayment ecotypes, depicted in Figure ES7 and referred to as Yellow, Orange, Green, and Blue. Only one embayment falls into the Blue category: Rockport Harbor, at the border between Ipswich Bay and Massachusetts Bay.

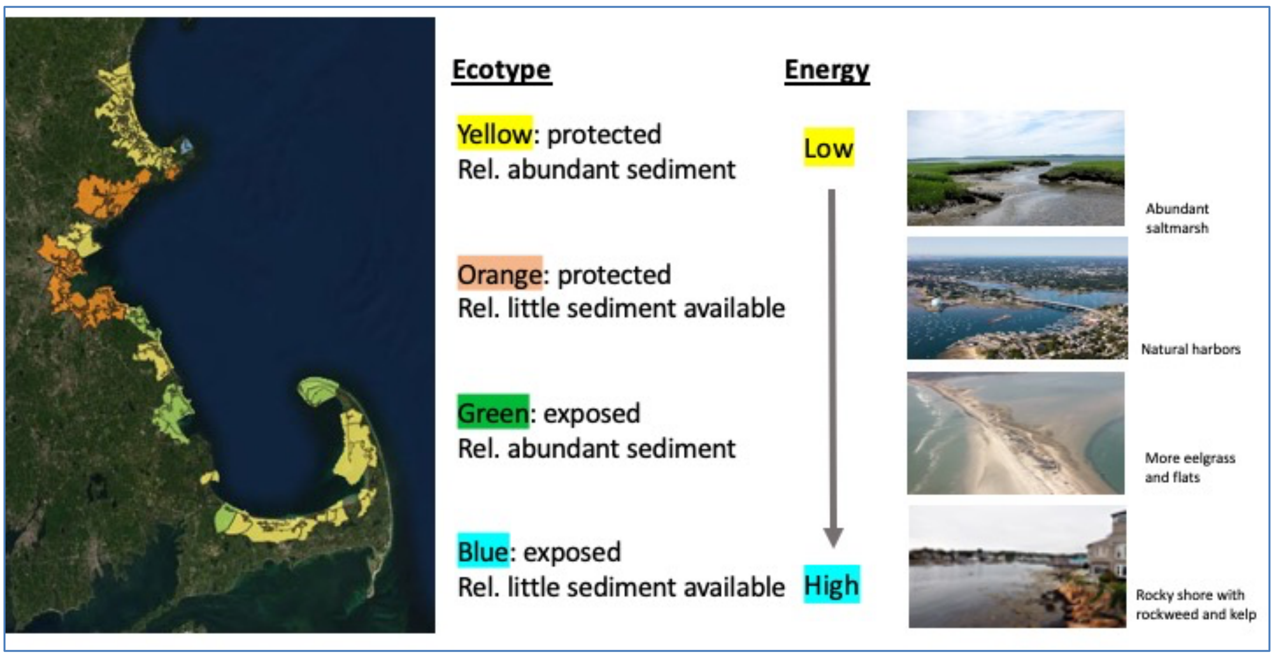

Figure ES7. MassBays' embayments were classified into four ecotypes based on physical characteristics including exposure to wind and wave action, velocity of tidal exchange (energy), and sediment abundance. Photographs illustrate the dominant habitats supported by each ecotype.

Identifying stressor-resource categories

Simply referring to historic habitat conditions for goal-setting is not a defensible position for systems like MassBays' study area, which has been impacted over centuries by increasing development. To set habitat goals that acknowledge existing local conditions, stressors and resources were quantified for each embayment (Table ES3). Then, Northeastern University's Marine Science Center conducted statistical analysis to group the 44 estuarine embayments into categories based on similarities (Figure ES8). With this information in hand, MassBays could proceed to define habitat goals for each ecotype-category combination, avoiding a situation where a more rural or shallow embayment might be compared with an embayment characterized by dense development and a protected harbor.

Table ES3. Attributes analyzed for each embayment in the MassBays study area.

Estuarine Resources	***Eelgrass, salt marsh (% shoreline length), salt marsh (areal extent), tidal flats, rocky intertidal (natural unhardenable shoreline),***
Stressors	*High-intensity land use, annual stormwater discharge, population density, % population using septic systems, 303(d) impairments estuaries (bacteria & nutrients), septic system use; tidal restrictions, extent of hardened shoreline*

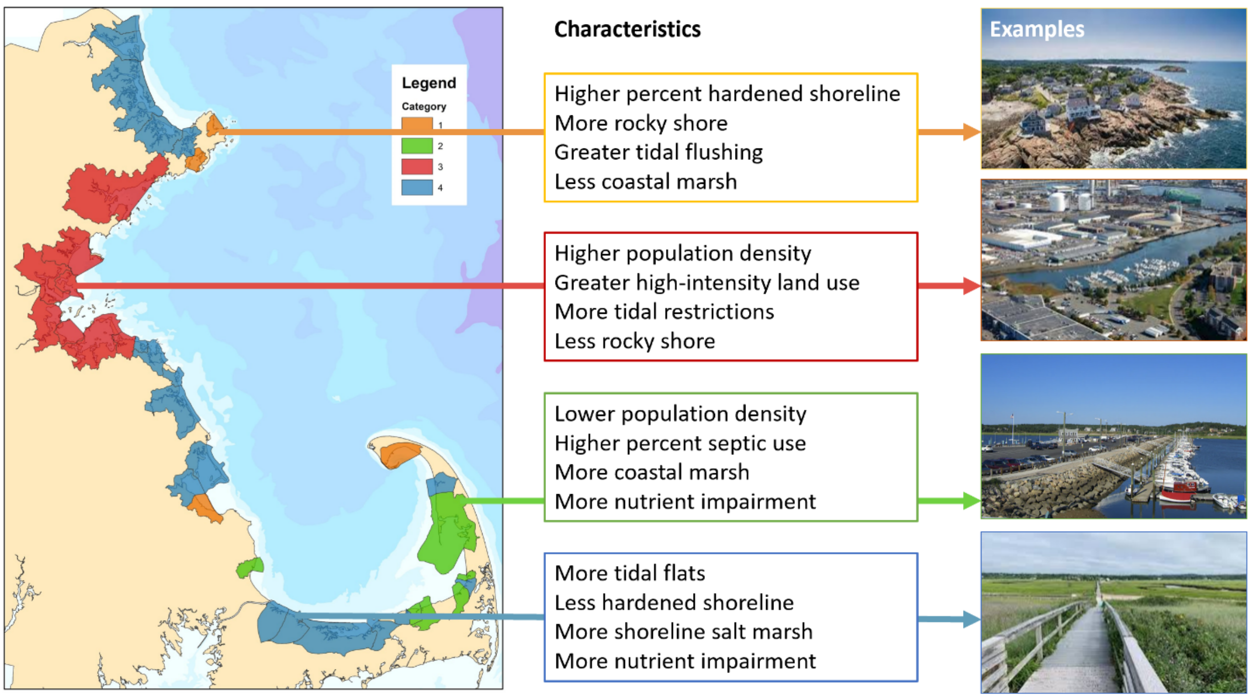

Figure ES8. Stressor-resource categories 1 through 4, with their signature characteristics. Photographs provide an example of each category.

Applying the Biological Condition Gradient approach

The Biological Condition Gradient process begins with defining the ideal, unimpacted habitat condition (represented by historical conditions) and estimates conditions that can be attained going forward under different scenarios: increased conservation and restoration, some conservation, or business as usual (Figure ES8).

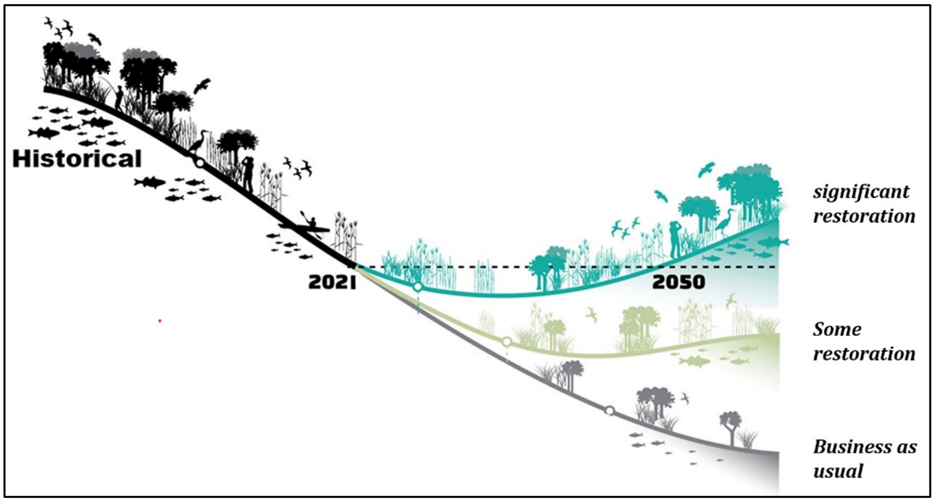

Figure ES8. The Biological Condition Gradient. Illustration courtesy of Emily Shumchenia using Integration and Application Network vector graphics (ian.umces.edu/media-library)

Step 1. Examine historical habitat extent and condition

A team from EPA's Office of Research and Development and Office of Science and Technology used maps from the 1770s to 2021 to assess changes in habitat extent for the entire planning area. In some cases, coastal change would preclude returning to those conditions (the filling of Boston Harbor tidelands to create the modern waterfront is the most dramatic example), but in others this information provided valuable insights for our goal-setting. Analysis of these data summarized in Table ES2 also provides evidence that the ecotypes defined for MassBays can accurately be associated with distinct habitats and their distribution as depicted in Figure ES7.

Table ES2. Summary of habitat loss in MassBays' study area over time

	Acres lost	% Lost	Data quality	
Salt marsh 1700s-2005	16125	36	Good	Significant losses will have occurred after 2005 with increasing stressors including Sea Level Rise, population density, nutrient pollution; new surveys are needed.
Tidal flats 1700s-2005	5030	22	Fair	
Eelgrass 1995-2017	5510	46	Excellent	Reflects huge seagrass loss in Wellfleet Harbor
Eelgrass 1995-2017 (Wellfleet excluded)	1827	33	Excellent	MassBays lost 33% of eelgrass over 22 yrs The rate of eelgrass loss from 2012 to 2017 was twice that of the previous 17 years.

Step 2. Collect information on local priorities

MassBays Each coastal habitat offers unique benefits to people as well as the creatures that rely on those habitats for food and protection. EPA researchers analyzed municipal planning documents for local priorities, while MassBays worked with University of Massachusetts Boston researchers to ask local experts – residents of representative communities – which benefits they consider most important to future generations.

Step 3. Consult with scientists on the potential for future restoration

Multiple factors influence habitat restoration potential. Sea level rise, coastal erosion, and temperature changes associated with climate change; development that hems in salt marshes and shoreline hardening with seawalls; water pollution; invasive species; dredging; and poor fishing and boating practices all impact the ability of coastal habitats to thrive. These factors were taken into account when setting out possibilities for 2050 (Table ES3).

The resulting targets are visualized as "habitat goals" in MassBays' Ecohealth Tracking Tool (ETT), a web-based State of the Bays reporting platform launched in 2022. The targets are described in terms of "healthy acres" of each habitat and are based primarily on the suitability for the habitat offered by geophysical conditions (exposure, coastal geology, and shallow-water habitat area) and not influenced by anthropogenic factors. with two take-home considerations:

- Goals for salt marsh and tidal flat extent are equal to "current" acreage as of June 2005. Due to sea level rise and existing development and infrastructure encroaching along the coastline, it is unclear whether those habitats have the potential to expand, so MassBays' goals for salt marsh and tidal flats are focused on maintaining and improving the health of existing habitat rather than expansion. As we look forward (see Goal 3), we will develop additional information regarding potential for habitat expansion and improved health in terms of water quality using Habitat Potential Indices (HPIs). We will thus be able to track progress toward our environmental outcomes: expanded coastal habitat, improved habitat continuity and hydrology, restored natural communities, and improved water quality through implementation of our monitoring framework (Attachment 3).
- Some embayments are already meeting or exceeding habitat goals. MassBays set the habitat goals using a process that looks across embayment ecotypes (described above) in an effort to compare like-with-like, thus individual embayments might be in better condition compared to similarly categorized embayments. In addition, habitat maps are a snapshot of habitat extent, and change in area can shift dramatically from year to year; there are also limitations to the remote sensing data used.

Table ES3. Habitat goals for MassBays estuarine embayments

Ecotype	Habitat	Goal by 2050	Acres to restore/maintain	Associated ecosystem benefits
Green	Eelgrass	Increase acres, improve quality	2,040	• Habitat for fish, birds, invertebrates • Improved water quality • Nitrogen uptake • Carbon sequestration • Shoreline protection & erosion control • Aesthetics • Shellfish production • Food sources • Recreational opportunities
	Salt Marsh	Maintain acreage, improve quality	2,800	
	Tidal flats	Maintain acreage, improve quality	4,060	
Yellow	Eelgrass	Increase acres, improve quality	4,560	
	Salt Marsh	Maintain acreage, improve quality	27,170	
	Tidal flats	Maintain acreage, improve quality	11,720	
Orange	Eelgrass	Increase acres, improve quality	10	
	Salt Marsh	Maintain acres, improve quality	1,730	
	Tidal flats	Maintain acres, improve quality	3,270	
Blue	Eelgrass	Maintain acreage, improve quality	2	
	Salt Marsh	Maintain acreage, improve quality	0	
	Tidal flats	Maintain acreage, improve quality	4	

MassBays' Role into the Future

Despite the 81 universities and colleges and at least 60 nonprofit organizations working within 25 miles of Boston, MassBays is the only entity that has taken up the challenge of characterizing the habitats and water quality in each coastal subwatershed, from Salisbury to Provincetown, across three bays. MassBays' efforts to drive improvements in habitats and water quality across our study area will be informed by site-specific targets.

Our regional purview places MassBays in a unique position to look across individual data sets to identify common challenges and opportunities. Reporting from the Regional Coordinators, insights from members of our Management Committee and Science and Technical Advisory Subcommittee, and access to an extensive network of state, federal, and local partners and collaborators provide MassBays with the context needed to respond to emerging concerns.

At the same time, NEPs' non-regulatory mandate under the Clean Water Act allows MassBays to bring together disparate stakeholders as a neutral convener, and to provide direct assistance to local implementers. This role becomes even more important as federal and state governments direct investments in infrastructure and responses to climate change, revealing the need for increased capacity among communities. MassBays has taken up this task, providing training, tools, and one-on-one support to efforts by municipalities, and local and regional nonprofit organizations.

Finally, aligned with the NEP focus on coastal habitat protection and restoration, MassBays identifies, develops, and implements investigations and programs that incorporate holistic, ecosystem-based solutions. This approach acknowledges the interconnectedness of human and coastal systems, a concept that will be integral to our work with communities and decision makers, while also taking into account the need for long-term, adaptive response to current conditions.

Tracking and Reporting

The new operational framework provided in this CCMP will enable us and our partners to generate and point to real and substantial improvements in the MassBays ecosystems, including:

- Greater habitat continuity and hydrological connectivity at the local level.
- Local investment in and long-term maintenance of natural systems for coastal resilience.
- Spatial expansion of natural communities.
- Ambient water quality that supports biodiversity.

To document these changes, and as required under the Clean Water Act, MassBays will produce a State of the Bays report or conference every five years. To now, the scope of that reporting has been limited by the availability of data for such assessments, especially for water quality data outside Boston Harbor and Cape Cod Bay, and for habitat and species information. With the new blueprint for the bays, we will be able to provide more granular documentation of trends and conditions, as compared to the targets described above. MassBays' tools for tracking and sharing this information include:

- A ***Monitoring Framework*** that builds on governmental and nongovernmental monitoring programs, using data gathered by community-based groups that may be overlooked. (The 2021 version is included as Attachment 3).
- ***Ecohealth Tracking Tool,*** an online data visualization tool providing access to long-term data sets relevant to MassBays' targets for coastal habitats and relevant water quality data. Data trends and conditions are currently available at the embayment level for eelgrass, salt marshes, and tidal flats along with progress towards habitat targets, as well as a suite of water quality parameters. Work under this CCMP will continue to expand the coverage of

the ETT to include diadromous fish runs and spawning habitat, barrier beaches and dunes, rocky shores, and benthic health.

- ***Ecosystem Delineation and Assessment***, and an interactive Story Map online at https://bit.ly/3QDi8P9, which provides geolocated data from the full assessment, everything from the locations of shellfishing areas and wastewater discharge pipes to upland population density and land use.
- MassBays also developed two tools for use by partners: ***AquaQAPP,*** a "wizard"-like online application that helps users build Quality Assurance Project Plans to guide their monitoring and improve project outputs (www.aquaqapp.com); and ***MassWateR***, a package of R-based tools for data analysis, including generating a QA/QC report and data suitable for upload to EPA's Water Quality Portal (https://massbays-tech.github.io/MassWateR/index.html).

Goals, Strategies, and Actions: 2023 through 2033

Section VI of the CCMP presents the adaptive and nimble approach MassBays will use to meet the Environmental and Management Challenges in the Bays. Activated by year-by-year implementation of Activities specified in annual workplans, this structure, characterized by broad Goals, focusing Strategies, and concrete Actions, provides flexibility to take advantage of opportunities for projects with the highest likelihood of success given funding, local support, and complementary efforts by other entities that may join us in advancing CCMP implementation. A sample workplan (Appendix M) for FFY2022 illustrates the tight connection between the CCMP and yearly activities.

In Section VI, three sets of Organizational and Programmatic Goals provide the context for Strategies to be employed, with Actions and Activities identified through the CCMP development process, presented in the following layout:

Description of **Organizational Goal**
Description of associated **Programmatic Goal**
  Description of **Strategy [1]**
    Description of **Action [1.1]**
    List of **Activities**
    Description of **Environmental Outcomes expected**
    Estimate of **Resources Required**
    List of **Outputs**
    List of **Measures**
    Estimated **Timeline**
    List of anticipated **Partners** *and their* **[Roles]**

We encourage you to review the range of Actions and Activities included in the full CCMP, and to join us in our work toward realizing significant environmental outcomes.