Casco Bay Monitoring Plan

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Photo by Jerry Monkman, Ecophotography

Prepared by Casco Bay Estuary Partnership, Casco Bay Monitoring Network, and U.S. Environmental Protection Agency

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Appendix B. REPORTS AVAILABLE ON CBEP'S WEBSITE

In the Monitoring Plan, references to these reports are indicated by (W-capital letter.number.lower case letter), for example (W-B.1.a.) refers to B. Habitats 1. Clam flats a. Friends of Casco Bay 2013 Casco Bay clam flat pH study.

Not all reports listed in Appendix B. and available on CBEP's website are specifically mentioned in the Plan, but are still deemed to be related to monitoring in Casco Bay.

EXECUTIVE SUMMARY OF CASCO BAY MONITORING PLAN

Background

People enjoy Casco Bay because of its clear water, inviting island landscapes, and the marine life, such as fish, seals and cultured oysters that call the Bay home. Yet the Bay is changing. The water is warming, becoming more acidic, and sea level is rising. How do we know this, and why is this important?

We know this because Friends of Casco Bay monitors nutrients and pH in the water. We know this because the Maine Department of Marine Resources has been tracking presence of harmful algal blooms that may pose threats to consuming shellfish like clams and mussels. And, we know this because Casco Bay Estuary Partnership (CBEP) has set out a plan that presents an approach for collaborative and adaptive monitoring in Casco Bay.

U.S. Environmental Protection Agency's National Estuary Program (NEP) requires each NEP, including CBEP, to develop a monitoring plan. The partnership has written two previous plans, in 1996, and 2004. This 2020 Casco Bay Monitoring Plan (Plan) represents a significant update, incorporating up-to-date information on monitoring programs, available data, and management priorities.

The environmental monitoring landscape in Casco Bay and regionally has changed dramatically in the past decade. Use of automated water quality sensors has grown as costs of automation have dropped, and scientists, regulatory agencies, and environmental organizations have grown more proficient in their use. Data collected by national and state agencies are increasingly available online. Technical tools and standard practices for data sharing are more widely available, making regional data collaborations and public-facing data dashboards possible, if not yet simple to implement.

But perhaps the largest change in coastal monitoring has been the evolution of overlapping local- and state-level monitoring collaborations. These programs provide both purpose and context, and sometimes data, to inform Casco Bay monitoring. The region-wide "Integrated Sentinel Monitoring Network (ISMN)" has identified monitoring methods to use to track changes in coastal ecosystems throughout the Northeastern U.S. The City of Portland is finalizing the "Blue Portland" integrated water quality plan, which will include recommendations both for monitoring and for providing synoptic information on City actions to protect water quality and on ambient conditions in the Bay through on-line dashboards. The Maine Ocean and Coastal Acidification Network (MOCA) has built a robust network of scientists, organizations and volunteers working together to understand acidification in Maine waters. The Maine Climate Council has identified monitoring and communication of

environmental data to inform decisions by individuals, business, and groups as a priority for protecting Maine's coastal economy.

The Casco Bay Monitoring Plan has been informed by and in some cases helped inform these interrelated monitoring contexts.

The Plan represents the work of the Casco Bay Monitoring Network (Network), a community of more than 20 scientists and organizations that routinely monitor conditions in Casco Bay and will continue their work in the future. The Network meets regularly to discuss recent observations, changes in monitoring plans and practices, and emerging monitoring needs. This Plan envisions a long-term role for the Network as the stewards of the Plan.

CBEP, through the Monitoring Network, the Monitoring Plan, and periodic State of Casco Bay reports, improves monitoring and enhances understanding of the Bay by setting priorities, sharing information among scientists, providing funding, reducing redundancies, filling gaps in data collection, and pulling together data from multiple sources.

After the first meeting of the Network in December of 2016, we inventoried the state of monitoring in Casco Bay and found an extensive network of scientists, managers and citizens collecting water, seining for fish, analyzing contaminants in shellfish, tracking vegetation changes in salt marshes, and collecting other data. We also cataloged related national and state-level data.

The Monitoring Network worked with CBEP's Management Committee to set monitoring priorities and develop conceptual models of how the Casco Bay ecosystem works. The Plan sets out three overarching questions, embodied in three conceptual models, that address public and scientific questions about the health of the Bay, and provide structure to future monitoring:

> (1) Are anthropogenic nutrients making the Bay less healthy?

The concentration and distribution of nutrients in the Bay is central to understanding status and trends of water quality in the Bay. Eutrophication and eelgrass were selected as starting points for this model because they are both key regulatory endpoints for managing impact of nutrients in coastal waters. Acidification was selected as well because of its close relationship to primary production and significant uncertainties about the impact of acidification on Maine's coastal waters. Causal relationships identified in this conceptual model highlight the need for data on nutrient concentrations in the Bay, nutrient loads entering the Bay, and nutrient sources on land.

> (2) Are coastal habitats of Casco Bay both healthy and abundant enough to support ecosystem processes and protect the vitality of the Bay?

The habitats conceptual model was anchored on the following four focal habitats: fish passage, salt marsh, tidal flats, and eelgrass. The model highlights ways to strengthen existing data collection and make more efficient use of existing data to assess condition of the Bay's coastal habitats.

> (3) Is the food web of Casco Bay changing and does it support marine biodiversity, food production and key ecosystem services?

The food web underlies the ability of a clean and productive Bay to produce seafood and support charismatic megafauna like seals, osprey, and shorebirds. Thus the food web, in loose terms, relates directly to public perceptions of the health of the Bay. This conceptual model was built out from four major categories of a pelagic marine food web: phytoplankton to zooplankton to forage fish to larger fish. We extended the conceptual model to add other important components of the food web, and to reflect public interest in the food web, which focuses on marine harvests and watchable wildlife. Building out the food web conceptual model pointed out significant historic monitoring gaps, especially the lack of long-term consistent monitoring of most organisms inhabiting the Bay. Equally important, it identified data already collected - principally in support of fisheries management - that can provide insight into Casco Bay's ability to support marine harvests.

Plan Priorities

The Casco Bay Monitoring Plan provides a coordinated framework for monitoring of Casco Bay and its watershed. The framework leverages existing data collection programs, identifies emerging information needs, and highlights data gaps. The Plan also identifies ideas for improving monitoring in the next five to ten years. Recommendations prioritized by the Network are summarized here as Programmatic and Monitoring Priorities. Additional recommendations are provided in the full report.

Programmatic Priorities

- Strengthen the Monitoring Network. Link to emerging monitoring frameworks and programs. Facilitate sharing of data and information.
- Identify and advocate for long-term stable funding mechanisms for monitoring programs. Seek funding to track impacts of climate change and address other emerging needs.
- Develop a Casco Bay circulation model to provide context for interpretation of monitoring data.

Monitoring Priorities

- Maintain core of existing monitoring programs.
- Expand emerging monitoring areas, including:
    - tracking freshwater conditions (especially nutrients in rivers and streams);

    - sampling fish communities and other components of the food web;
    - extending eelgrass monitoring;
    - studying impacts of aquaculture on water quality, flora, and fauna.
- Track marine habitat extent and condition, emphasizing long term impacts of climate change.

Conclusion

Data collected under the Casco Bay Monitoring Plan has many uses, including:

- Inform the public regarding the health of Casco Bay, and provide a foundation for periodic State of Casco Bay reports.
- Provide the Monitoring Network with information to assess status and trends in the health of Casco Bay and its watershed.
- Inform decisions for adapting monitoring priorities in response to changing coastal conditions or emerging issues.
- Measure the effectiveness of policies, management actions, and programs implemented under CBEP's Comprehensive Conservation and Management Plan, the Casco Bay Plan.
- Ensure that updates to the Casco Bay Plan are based on the best available data and science.

While completing the Plan, a common refrain was that coastal managers are looking for "sentinel" indicators of change, such as trends in nutrient enrichment, or in fish communities. The role of the Network and CBEP is to see the bigger picture; to look at impacts Bay-wide instead of town-by-town, or program-by-program. How does nutrient enrichment impact habitats such as eelgrass? Is lower pH in bottom water of Casco Bay related to offshore changes or to coastal processes such as river runoff? Will aquaculture result in additional algal growth in the upper Bay? Will changes in temperature yield changes in fisheries?

The 2020 Casco Bay Monitoring Plan will guide the Monitoring Network and Casco Bay Estuary Partnership in addressing these and other emerging questions, in evaluating management actions, in collaborating for funding opportunities, and in communicating to the public about changes to the Bay. These organizations have come together to create a dynamic Plan to ensure the future health and vitality of the critical resource that is Casco Bay.

Section I. INTRODUCTION

The volume and diversity of data available about conditions in Casco Bay is substantial. More than a dozen organizations regularly collect data about the Bay, while numerous state, regional and national data sources shed light on local conditions. Despite the quantity of data available, it can still be difficult to answer important questions about status and trends in Bay and its watershed. A central challenge is that most data collected in and about Casco Bay is collected to address specific institutional or programmatic missions, rather than to fill Bay-wide information needs.

The Casco Bay Monitoring Plan provides a coordinated framework for monitoring of Casco Bay and its watershed. The framework leverages existing data collection programs, identifies emerging information needs, and highlights data gaps.

The need for coordinated monitoring of conditions in Casco Bay has never been greater. Climate change (and its impact on coastal communities, fisheries, and ecosystems) poses significant challenges for public and private actors in the region. Ocean and coastal acidification has raised new questions not addressed by historic monitoring. Innovative approaches to protecting clean water (like Portland's "Blue Portland" integrated water quality planning process) are more dependent than traditional approaches on data to identify cost-effective solutions and demonstrate effectiveness of actions.

The Plan has been written with the assistance of, and on behalf of, the Casco Bay Monitoring Network. The Network is an informal community of individuals, organizations, and agencies involved with monitoring conditions in Casco Bay. It meets on a roughly semi-annual schedule to discuss recent observations, changes in monitoring plans and practices, and emerging monitoring needs. This Plan envisions a long-term role for the Network as the stewards of the Plan. In an era of ongoing changes in Maine's coastal ocean, the Plan needs to be responsive to changing environmental conditions as well as changes in priorities and information needs. The Network provides the institutional mechanism to allow monitoring in Casco Bay to be better coordinated and adaptive to changing circumstances.

A. Purposes

The Casco Bay Monitoring Plan has the following primary purposes:

1) Establish a coordinated monitoring program that will provide data to assess status and trends in the health of Casco Bay and its watershed.
2) Identify gaps in existing monitoring and highlight priorities for improving or expanding monitoring.

3) Delineate a mechanism for adapting monitoring priorities in response to changing coastal conditions or emerging issues without jeopardizing important long-term data series and coordination.
4) Provide a consensus regional context for monitoring that facilitates funding of monitoring programs.
5) Facilitate efforts to share information on the health of the Bay with multiple audiences, including educators, policy makers, the business community, and the general public.

Data collected under this monitoring plan has many uses, including:

1) Inform policy and management decisions.
2) Measure the effectiveness of management actions.
3) Inform the public regarding the health of Casco Bay.
4) Provide a foundation for periodic State of the Bay reports.
5) Evaluate effectiveness of programs implemented under the *Casco Bay Plan*.
6) Update the *Casco Bay Plan* based on best available data and science.

B. Definition of Monitoring

For purposes of this Monitoring Plan, "Monitoring" consists of ongoing data collection efforts undertaken to provide information about status or trends of natural, social, or economic systems over time.

Monitoring overlaps with research, however, research (including social science research) answers specific questions and produces generalizable knowledge, while monitoring collects actionable data about local processes that are used for multiple purposes. The line between research and monitoring is porous. Some short-term monitoring programs answer specific questions about local conditions. Research projects sometimes generate data that is of value outside the context of the original research questions. Research informs monitoring, and vice versa. The individuals engaging in research and conducting monitoring overlap and regularly communicate.

This Plan principally addresses monitoring. It is not a research agenda for Casco Bay.

C. Adaptive Management

This Casco Bay Monitoring Plan is intended to guide monitoring for a period of at least five years, but may well be in force longer.

The history of prior monitoring plans is instructive. The first Casco Bay monitoring plan, "Measuring Progress: The Casco Bay Monitoring Plan," was developed in 1996 by the Casco Bay Estuary Project, and was not updated until eight years later (2004), when "Casco Bay Environmental Monitoring Program," was released. The 2004 document had limited influence

on monitoring practice, yet has not been superseded 16 years later. The two prior plans did not address climate change, invasive species, nutrient pollution, coastal acidification, sea level rise, nor emerging contaminants.

Adaptive management may be especially important over the next few years. Other organizations are engaged in developing monitoring programs and plans that can and should influence and be influenced by the Casco Bay Monitoring Plan. Portland is preparing a plan ("Blue Portland") for integrated water quality management that aims to address multiple Clean Water Act permit obligations. Portland's plan will include recommendations for monitoring water quality protection and water quality. The cities of Portland and South Portland are developing a joint climate action and adaptation plan, "One Climate Future," which may include monitoring of climate change, climate vulnerabilities, and adaptation and mitigation actions. The Maine Climate Council, coordinated by the Governor's Office of Policy Innovation and the Future, is considering recommendations for enhanced data collection and data sharing, regarding fisheries, climate change, and coastal water quality, among others. The Northeast Coastal and Acidification Network (NECAN) and Maine Ocean and Coastal Acidification Partnership (MOCA) continue to discuss ways to optimize monitoring of acidification and coastal carbonate chemistry. The Northeast Regional Ocean Council (NROC) and the Northeastern Regional Association of Coastal Observing Systems (NERACOOS) are collaborating to create an Integrated Sentinel Monitoring Network for the Northeast. Casco Bay monitoring, through the Monitoring Network, should both inform these discussions of coastal monitoring, and also be responsive to the evolving priorities these efforts will identify in coming months and years.

A decade from now, we will look back on this document and wonder that some new concern was not reflected here. New issues will come to the fore, but we cannot be certain what those topics will be. If this document is to play a constructive role guiding regional monitoring for more than a year or two, it must be adaptive. It must incorporate ongoing communication with individuals and organizations involved with monitoring, and incorporate insight into the evolving needs of decision makers.

The Plan must be the basis for ongoing discussion, prioritization and collaboration. The Casco Bay Monitoring Network provides the institutional structure to ensure long-term relevance and support adaptive management. The Monitoring Network can also identify projects that will engage undergraduate and graduate students while addressing emerging monitoring needs.

D. Existing Monitoring

CBEP worked with the Monitoring Network and the Casco Bay Nutrient Council to identify Casco Bay monitoring programs and data sources. We began by reviewing the 2004 and 1996 Casco Bay Monitoring Plans, and the contents of our State of the Bay Reports, to identify data used in the past to characterize conditions in Casco Bay. Working with the Monitoring Network,

we developed a map and a catalog of present-day monitoring programs. We compiled a list of other relevant data sources, using multiple sources ranging from the U.S. Census to Google Earth.

At least ten organizations located in Maine are engaged in significant ongoing monitoring of conditions in Casco Bay. These organizations conduct dozens of separate monitoring programs. These organizations include:

- Bowdoin College;
- Casco Bay Estuary Partnership;
- Department of Environmental Protection, Maine;
- Department of Marine Resources, Maine;
- Friends of Casco Bay;
- Gulf of Maine Research Institute;
- Southern Maine Community College;
- University of Maine;
- University of New Hampshire;
- Wells National Estuarine Research Reserve.

At least seven organizations are engaged in regular monitoring of conditions in fresh water within the Casco Bay watershed. They include:

- Department of Environmental Protection, Maine;
- Lakes Environmental Association;
- Lake Stewards of Maine;
- Long Creek Watershed Management District;
- Portland Water District;
- Presumpscot Regional Land Trust;
- University of Southern Maine.

In addition, U.S. Environmental Protection Agency, National Oceanic and Atmospheric Administration, and U.S. Geological Survey regularly collect information on weather, tides, river flow and more that are essential to understanding the health of the Casco Bay ecosystem.

Any such list is necessarily incomplete and contingent. Local programs are sometimes not widely publicized, and new programs come into being regularly. We invite organizations that regularly collect data about Casco Bay or its watershed to contact Casco Bay Estuary Partnership and participate in the Monitoring Network.

State-level data is becoming increasingly available on-line through centralized archives like the Maine Office of GIS/ Geolibrary and individual departments. Commercial entities such as

Google and ESRI now make important geographic data, such as historical aerial photographs, available, often free of charge.

Section II. SETTING PRIORITIES

Casco Bay is a complex interconnected system. Hundreds of types of information could be incorporated into this Monitoring Plan. But without priorities, a Plan can devolve into little more than a list of existing programs, or worse, a wish list of programs that do not exist and are unlikely to be funded.

A primary purpose of this Plan is to highlight ways that we could be improving monitoring in Casco Bay.

CBEP worked with the Monitoring Network and CBEP's Management Committee on an approach for setting priorities. The process hinged on identifying three Priority Topic areas, and developing graphical Conceptual Models to highlight existing monitoring and identify information gaps. These Priority Topics are:

1) ***Nutrients and Water Quality*** - Track changes in nutrients and related water quality issues in fresh water and in the Bay.

2) ***Habitats*** - Gauge the health and extent of priority habitats, including salt marshes, tidal flats, eelgrass beds, and connected waterways for migratory fish.

3) ***Food Web*** - Monitor how the Casco Bay ecosystem links primary producers like phytoplankton and marine algae to fish and wildlife, charismatic species, and marine harvests.

We used a variation of "Stressor – State – Response" logic to identify how priority areas are interrelated, and what data might inform understanding of each Priority Topic.

For each Priority Topic, we identified a collection of core items (State) we wanted to understand and, using graphical conceptual models, identified upstream (causal, often Stressor) and downstream (consequence, usually Response) metrics. This was an iterative process, with each additional metric generating identification of more upstream and downstream metrics. The resulting Conceptual Models were shared, critiqued, and simplified in conjunction with the Monitoring Network. These Conceptual Models are heuristic devices, not intended to be accurate scientific statements of all cause and effect relationships.

The final Conceptual Models contain dozens of boxes representing potential metrics for each Priority Topic, with considerable overlap. To clarify dominant relationships among our three Priority Topics, we produced a simplified top-level Conceptual Model.

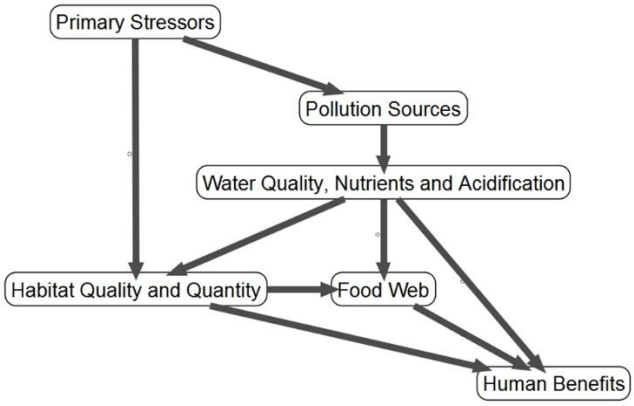

Figure 1: Simplified causal diagram showing relationships among Priority Topics

In this simplified framework, primary (anthropogenic) stressors like population and land use affect Casco Bay indirectly through two main pathways. The first is via effects on coastal and marine habitat, such as loss of wetlands or construction of fish passage barriers. The second is through changes to pollutant loadings to the Bay, which affect water quality. Water quality and habitat condition have ripple effects on each other, the marine food web, and human benefits derived from the Bay.

Human Benefits goes beyond the biophysical responses that are the focus of monitoring Nutrients, Habitats, or the Food Web. The heart of tracking Human Benefits lies in understanding how the Bay provides benefits to the people living along its shores and in its watershed and especially how coastal communities and economies depend on and connect to the Bay. While this Plan does not include Human Benefits as a Priority Topic, it does include a list of data sources that inform our understanding of people's relationship with the Bay. None of these data sources derives from local monitoring programs, but they are used in State of the Bay and Economic Status reporting.

We mapped existing data collection programs onto the Conceptual Models, as a way to evaluate strengths and weaknesses of existing monitoring. As expected, we lack data to address many potential metrics. We lack data entirely for certain topics. In other areas, we are collecting limited data infrequently or from just a few locations. For still other subjects, we have limited historical data from past studies, but no ongoing monitoring.

The results of this exercise are presented in Section III. Each Priority Topic and related Conceptual Model and monitoring programs are discussed, following the framework of Figure 1. This highlights how existing monitoring and available data sources address Priority Topics, but also reveals data gaps and offers the opportunity to evaluate importance of those data.

The Priority Topics segments each conclude with a discussion of Strengths and Drawbacks, which leads to Section IV., Recommendations for Monitoring Priorities 2020-25. Appendix A contains detailed descriptions of 34 monitoring programs, organized into a Catalog. Appendix B

lists related reports that are available on Casco Bay Estuary Partnership's website. Taken together, the Casco Bay Monitoring Plan presents a compilation of monitoring programs, information, and plans as of the 2020 monitoring season.

Section III. PRIORITY TOPICS

A. Nutrients and Water Quality

"Are anthropogenic nutrients making the Bay less healthy?"

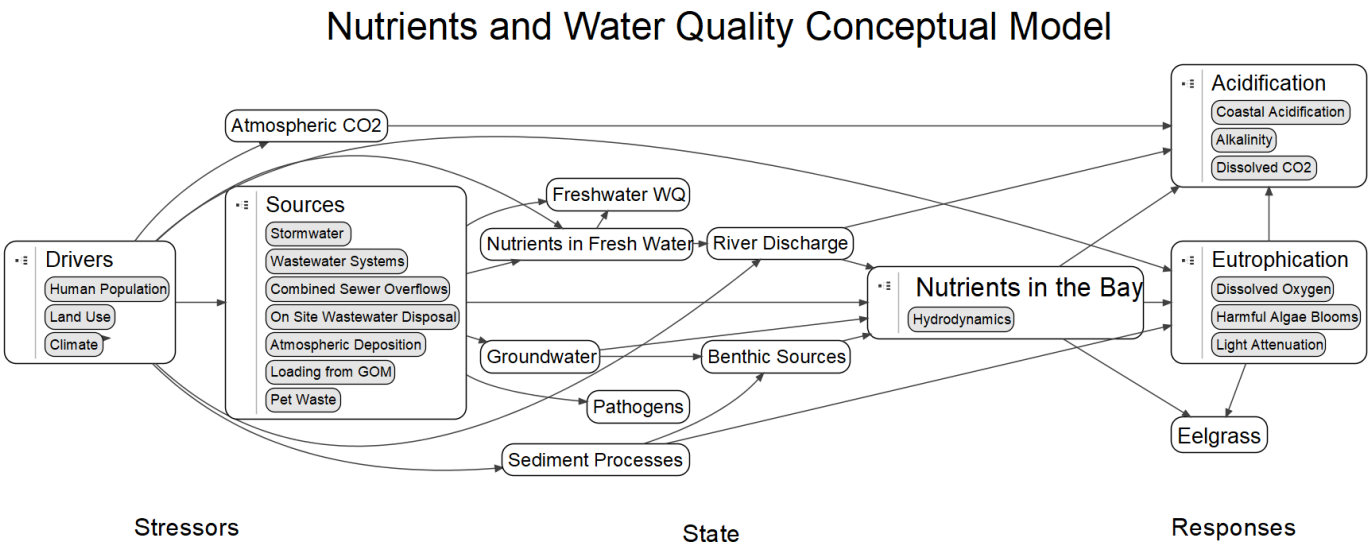

Figure 2: Nutrients and Water Quality Conceptual Model

The conceptual model for this Priority Topic originates from four focal points:

- Nutrients in the Bay;
- Eutrophication;
- Eelgrass;
- Acidification.

The concentration and distribution of nutrients in the Bay is central to understanding status and trends of water quality in the Bay. Eutrophication and eelgrass were selected as starting points for this model because they are both key regulatory endpoints for managing impact of nutrients in coastal waters. Acidification was selected because of its close relationship to primary production and significant uncertainties about the impact of acidification on Maine's coastal waters.

The conceptual model traces those starting concerns upstream to identify dominant sources of nutrients entering the Bay. The sources of nutrients included here are thought to be most important for Casco Bay, but are not comprehensive. As we learn more about nutrient dynamics in Casco Bay, we may want to target monitoring to better understand other nutrient sources.

Additional water quality issues affect both marine and fresh water. Elevated levels of pathogens can put public health at risk. Managing ice and snow on roadways and parking areas through application of sand and salt (de-icing practices), can degrade freshwater ecosystems.

Significant complexity is buried within the conceptual model, which was substantially simplified to facilitate communication. In particular, ecosystem response to nutrient enrichment has been incorporated implicitly as part of Acidification and Eutrophication. Nutrients and water quality also appear as drivers in both the Habitats and Food Web conceptual models, and eelgrass is included in Habitats as well.

1. Nutrients and Water Quality Stressors

Guiding Questions

What are the most important sources of nutrients entering Casco Bay?

What proportion of nutrients entering the Bay are controllable by policy or management interventions?

Are annual nitrogen and phosphorus loads to Casco Bay changing?

Are fresh water inputs to the Bay changing?

Are changes in river flow affecting nutrient delivery to aquatic ecosystems?

How do fresh water inflows affect susceptibility of the Bay to nutrients and acidification?

Population growth directly impacts water quality because more people produce additional waste that must be managed and treated.

Land use, in a broad sense, is also an important driver of nutrient pollution. Urbanization spurs increases in runoff via growth in impervious cover, construction of drainage systems, and changes in vegetation and topography. Suburbanization increases vehicle miles traveled, contributing to both atmospheric deposition of nitrogen and local deposition of nitrogen compounds that contribute to nutrients in runoff. Development also reduces nutrient assimilative capacity (and other ecosystem functions) of the watershed through destruction of wetlands, forests and flood plains. While thought to be less significant than urbanization in the Casco Bay watershed, agriculture may be a locally important source of nutrients and other pollutants including bacteria and sediments.

Climate change both increases nutrient loads entering the Bay and also increases susceptibility of coastal ecosystems to nutrient loads. Increased precipitation is expected to increase runoff,

and river discharge, transporting more pollutants to downstream waters. Higher temperatures accelerate growth of phytoplankton, speed decomposition, and exacerbate thermal stratification, all of which may increase susceptibility of receiving waters to nutrients.

Primary sources of nutrients entering Casco Bay include human waste (entering the Bay principally via sewage), urban and suburban runoff, and atmospheric deposition. Agricultural runoff is not widespread in the Casco Bay watershed, but may be a factor locally, especially in fresh water. On-site (mostly private) wastewater treatment systems are another source of nutrients reaching the Bay. Septic tanks are the most common on-site wastewater treatment systems in our region, and a few hundred overboard discharges ("OBDs"), located principally on the Casco Bay islands, release wastes directly to receiving waters.

Related State of the Bay Indicators

Nutrients and Water Quality Stressors are reported on in the following 2020 State of Casco Bay Report Indicators:

- Population and Land Use;
- Wastewater Disposal;
- Stormwater;
- Combined Sewer Overflows;
- Climate Change.

Throughout this document, monitoring programs and reports are referenced in the following ways:

(C) indicates that a program is described in detail in the Catalog of Monitoring Programs in Appendix A. In the Monitoring Plan, these program descriptions are indicated by their Appendix A listing (C-number), for example (C-1) refers to Bowdoin College Coastal Studies Center Acidification.

Programs with a (W) are the subject of one or more reports that are available on CBEP's Website (https://www.cascobayestuary.org/resources/publications/) and more fully referenced in Appendix B. In the Monitoring Plan, references to these reports are indicated by their Appendix B location (W-capital letter.number.lower case letter), for example (W-B.1.a.) refers to B. Habitats 1. Clam flats a. Friends of Casco Bay 2013 Casco Bay clam flat pH study.

Not all reports listed in Appendix B are specifically mentioned in the Plan, but each is deemed to be related to monitoring in Casco Bay.

Data Sources and Monitoring Programs

Table 1: Data Sources for monitoring nutrients and water quality stressors. Local monitoring efforts are in italics.

Nutrients Stressors	Data Source or Monitoring Program	Comments
Population	U.S. Census American Community Survey	
Climate	National Oceanic and Atmospheric Administration (NOAA), Portland Jetport weather station	Data accessible through the NOAA Climate Data Center.
Bay water temperature	*Friends of Casco Bay, water quality monitoring programs (C-16, C-17)*	
Bay water temperature	*Gulf of Maine Research Institute, CBASS (C-23)*	*Program includes dissolved oxygen.*
Bay water temperature	*Maine Department of Marine Resources, (DMR) Shellfish Sanitation Program, Bacteria (C-11)*	*Shallow water / intertidal temperatures.*
Bay water temperature	*Bowdoin College Coastal Studies Center (C-1, C-2)*	*Temperature data is collected both at the Bowdoin buoy and at the Coastal Studies Center as part of Acidification monitoring.*
Bay water temperature	*Maine DEP (C-6, C-9)*	
Land Use	Coastal Change Analysis Program (CCAP) National Land Cover Dataset (NLCD) Cropland Data Layer	National land cover datasets using consistent methods and categorization. Resolution varies; historic data mostly uses a 30 m pixel.
Land development patterns	Building Permit Data	Provides data only on residential building permits.
Wetland status	National Wetland Inventory	Low resolution characterization of extant wetlands; updated periodically.
Impervious surfaces	Maine Department of Inland Fisheries and Wildlife	High-resolution data layer derived from 2007 aerial imagery.

Nutrients Stressors	Data Source or Monitoring Program	Comments
Permitted discharges	Maine DEP	Data available on permitted discharges, including wastewater treatment facilities, CSOs and OBDs.
River flow	*U.S. Geological Survey river gages on the Royal and Presumpscot Rivers*	*Royal River gage re-installed in 2019.*
Wastewater treatment plant discharges	*Portland Water District (PWD)* *Other treatment plant operators* *Maine DEP*	*All major wastewater treatment plants discharging to Casco Bay or major tributaries now collect periodic data on discharge volume and concentration of nitrogen.*
Combined Sewer Overflows (CSO)	*Portland Water District* *City of Portland* *City of South Portland* *Maine DEP*	*PWD monitors CSO volumes continually. Cities provide storm event discharge totals. DEP provides annual summaries by municipalities.*
Stormwater	*Long Creek Watershed Management District (LCWMD) (C-26)*	*LCWMD collects significant data on water quality in Long Creek, a stream affected by suburban runoff.*
Atmospheric Deposition	*Maine DEP Wolfe's Neck Atmospheric Deposition Monitoring Station (W-C.3.f.,h.,n.,o.,s.,t.,u.)*	*Maine DEP managed monitoring station. Data available through National Atmospheric Deposition Program (NADP).*

Additional Data or Reports:

- Climate change - EcoSystem Indicator Partnership Gulf of Maine Council on the Marine Environment (W-A.3.a.)
- Climate change - University of New Hampshire (W-A-3.c.)
- Climate change vulnerabilities - Waterview Consulting (W-A.3.e.)
- Bay water temperature, salinity - Northeast Coastal Acidification Network, Shell Day
- Impact of development on surface waters, South Portland - Mitchell Center for Environmental and Watershed Research, University of Maine, (W-A.4.k.)
- River flow, Presumpscot River - U.S. Environmental Protection Agency, dye study (W-A.4.o.)
- Watershed survey reports - Cumberland County Soil & Water Conservation District (W-A.5.a.,b.,c.,d.,e.,f.,g.,h.,i.,j.,k.,l.,m.,n.,o.)
- Watershed survey report - Forest Lake Association (W-A.5.p.)
- Watershed survey reports - Friends of the Royal River (W-A.5.q.r.)
- Watershed survey report - Thompson Lake Environmental Association (W-A.5.v.)

2. Nutrients and Water Quality Status

Guiding Questions

What are typical concentrations of major nutrients in Casco Bay?

Are concentrations of major nutrients in the Bay changing?

Are there locations within Casco Bay where elevated nutrient levels are likely to cause water quality problems?

Do winter de-icing practices affect water quality in Casco Bay tributaries?

Do pathogens in the Bay threaten health of swimmers or those eating shellfish?

Efforts to monitor concentration of major nutrients in Casco Bay and in waters within the Casco Bay watershed go back decades. Friends of Casco Bay (FOCB) has managed multiple nitrogen monitoring programs in the Bay for many years, building up what is probably the most comprehensive long-term data on nitrogen concentrations available anywhere in Maine's coastal waters (Cadmus and Saquish Scientific, 2009).[1] U.S. Environmental Protection Agency, Maine DEP, and others have contributed to our understanding of nutrient status of Casco Bay waters through a variety of monitoring programs, often coordinated with the FOCB data

[1] Cadmus Group and Saquish Scientific. 2009. Nutrient criteria development in Maine coastal waters: Review of existing data and preliminary statistical analyses. Report to Maine DEP. Available at: https://www.maine.gov/dep/water/nutrient-criteria/091104_cadmus_saquish_nutrient_criteria_report.pdf

collection programs. Maine DEP maintains a dataset that includes data drawn from these and other sources.

Fresh water monitoring in the watershed is limited but robust. Presumpscot Regional Land Trust (PRLT) has continued the long-running volunteer monitoring of water quality in the Presumpscot River that was begun by Presumpscot River Watch. In recent years, PRLT has added sites on the Stroudwater River to its program. Lakes Environmental Association and Lake Stewards of Maine have established volunteer monitoring programs in Casco Bay watershed lakes and ponds, and conduct complementary continuous monitoring at selected locations. Portland Water District monitors water quality in Sebago Lake and its tributaries, the area's drinking source. Since 2010, the Long Creek Watershed Management District has refined monitoring of this urban stream, which discharges to the Fore River. For several years under the leadership of Professor Karen Wilson, Environmental Science students at the University of Southern Maine have collected winter and early spring data on chlorides (salts) and conductivity in various streams in the watershed.

Related State of the Bay Indicators

Nutrients and Water Quality Status is reported on in the following 2020 State of Casco Bay Report Indicators:

- Inland Water Quality;
- Bay Water Quality;
- Nutrients;
- Swimming Beaches and Shellfish Beds.

Data Sources and Monitoring Programs

Table 2: Data Sources for monitoring status of nutrients & water quality in Casco Bay and other waters in the watershed. Local monitoring efforts are in italics.

Nutrients Status	Data Source or Monitoring Program	Comments
Marine Waters		
Nitrogen concentration in marine waters	*Maine DEP (C-9)* *Friends of Casco Bay (C-17)*	*Long-term data records from grab samples.*
High frequency nitrogen data	*Casco Bay Estuary Partnership, nutrient sensor (C-4)*	*Nitrate and ammonium data, with temperature and conductivity. Future deployments uncertain.*
High frequency nitrogen data & Nutrients in fresh water	*University of Maine, Land/Ocean Biochemical Observatory (LOBO) buoy (C-30)* *Nutrients point samples in association with LOBO buoy (C-31)*	*Nutrients in fresh water sampled at Presumpscot River, Royal River, Nason's Brook.*
Nutrients	*U.S. Environmental Protection Agency, National Coastal Condition Assessment*	*Periodic assessment, relatively few sample locations every three to five years.*
Pathogens in marine waters	*Maine DMR, Shellfish Sanitation Program, Biotoxins in shellfish (C-12)*	*Hundreds of locations, mostly in the Eastern Bay.*
Pathogens at swimming beaches	*Maine DEP, Maine Healthy Beaches Program (C-8)*	*Both freshwater and saltwater beaches included.*
Nitrogen stable isotopes in mussels	*Gulf of Maine Research Institute*	
Lakes and Ponds		
Fresh water quality, Sebago Lake	*Portland Water District (C-27)*	
Fresh water quality, selected lakes & ponds	*Lakes Environmental Association (C-25)*	*Maine DEP aggregates lake water quality data from many sources and makes it available on-line, including phosphorus data, where available.*
Fresh water quality, selected lakes	*Lake Stewards of Maine, Volunteer Lake Monitoring Program*	

Nutrients Status	Data Source or Monitoring Program	Comments
Rivers and Streams		
Fresh water quality, two rivers	*Presumpscot Regional Land Trust, Presumpscot and Stroudwater Rivers (C-29)*	*Emphasis on bacteria, dissolved oxygen, and temperature. No nutrient data currently collected.*
Fresh water quality, Sebago Lake tributaries	*Portland Water District (C-28)*	*Includes phosphorus and bacteria.*
Macroinvertebrates and Algae, rivers and streams	*Maine DEP, Biological Monitoring*	*Includes wetlands.*
Chlorides and Conductivity, stream	*Long Creek Watershed Management District (C-26)*	*Chloride and conductivity data ~ 9 months a year.*
Chlorides and Conductivity	*University of Southern Maine Department of Environmental Science and Policy*	*Student-collected data, mostly winter/spring.*

Additional Data or Reports:

- Nutrient pollution in Casco Bay - Nutrient Council (W-A.1.a.)
- Nutrients, Nitrogen Nab - Friends of Casco Bay
- Hydrodynamics, circulation modeling - Applied Science Associates (W-A.2.a.); and Norwich University (W-A.2.b.); and University of Maine (W-A.2.c.)
- Fresh water quality, Presumpscot River - FB Environmental Associates (W-A.4.a.); and Presumpscot River Watershed Coalition (W-A.4.j.)
- Fresh water quality, Royal River - Friends of the Royal River (W-A.4.b.)
- Fresh water quality, Capisic Brook - Partnership for Environmental Technology (W-A.4.e.f.)
- Nitrogen loading in tributaries, Presumpscot River, Royal River, Capisic Brook - University of Maine, Gray (W-A.4.l.)

3. Nutrients and Water Quality Responses

Guiding Questions

Are nutrients entering Casco Bay having negative effects on water quality?

Are nutrient loads, including phosphorus loads, harming water quality in Casco Bay watershed lakes?

Is water quality in Casco Bay changing?

Is water quality in Casco Bay watershed lakes and rivers changing?

Are salts affecting the invertebrate communities in Casco Bay tributaries?

The Bay is experiencing preliminary ecological effects of excess nutrients including coastal acidification, damage to eelgrass beds, impacts on water quality, shifts in algae communities, and increase in harmful algae blooms. Climate change causes waters to warm which exacerbates certain effects. This combination heightens concern about Casco Bay's long term ability to provide habitat for commercially fished/farmed species and to provide a clean, healthy environment for recreation and tourism.

Conditions in fresh water are more difficult to summarize, since conditions are highly variable from location to location, depending on local watershed conditions, land use, and geochemistry. Observations on fresh water conditions include:

- Water quality in Casco Bay watershed lakes and ponds is often good, but some, like Highland Lake, in Falmouth and Westbrook, have shown signs of stress. While local land use plays a big role in determining water quality, some lakes are more susceptible to problems than others because of their bathymetry or geochemistry.
- While data is limited for streams and rivers in the watershed, water quality in urban streams tends to be poor. Agricultural runoff stresses a handful of streams in our region.

- Certain tributaries of the Presumpscot, and even certain sampling locations, show elevated levels of *E. coli* bacteria, and thus elevated risk of exposure to pathogens.
- Data from Long Creek is showing the importance of winter salt in degrading the health of our freshwater streams. Streams draining forested areas tend to support healthy invertebrate and fish communities.

Related State of the Bay Indicators

Nutrients and Water Quality Responses are reported on in the following 2020 State of Casco Bay Report Indicators:

- Inland Water Quality;
- Bay Water Quality;
- Nutrients;
- Coastal Acidification.

Data Sources and Monitoring Programs

Table 3: Data Sources for monitoring responses of nutrients and water quality in Casco Bay and other waters in the watershed. Local monitoring efforts are in italics.

Nutrients Responses	Data Source or Monitoring Program	Comments
Acidification		
CO_2	NOAA, University of New Hampshire Gulf of Maine buoy D	
Ocean acidification, Continuous	*Bowdoin College Coastal Studies Center, LOBO buoy (C-1)*	*Land/Ocean Biogeochemical Observatory (LOBO) buoy.*
Ocean acidification, Continuous	*Friends of Casco Bay, Cousins Island (C-16)*	*Part of FOCB continuous water quality monitoring suite.*
Eutrophication		
Bay water quality, Seasonal	*Friends of Casco Bay (C-17)*	*Long history of monitoring water quality parameters, such as dissolved oxygen turbidity, temperature, pH and salinity. Current program involves "shore" and "sea" monitoring locations.*
Bay water quality, Continuous	*Friends of Casco Bay (C-16)*	*Part of FOCB continuous water quality monitoring suite.*
Bay water quality	*Maine DEP, Marine water quality(C-9)*	*Program collecting data in Casco Bay in 2020, but future deployments are uncertain.*
Bay water quality	*Bowdoin College Coastal Studies Center, Bowdoin buoy (C-2)*	*LOBO buoy.*
Fresh water quality, lakes and ponds and streams	*Lakes Environmental Association (C-25)* *LCWMD (C-26)* *Portland Water District (C-27, C-28)* *Lake Stewards of Maine*	*See above, under "Status." Lake and stream monitoring programs often track both nutrients and ecological responses to nutrients, like Chlorophyll-A, and water clarity.*
Biotoxins	*Maine DMR, Shellfish Sanitation Program, Biotoxins in shellfish (C-12)*	*See description under Food Web.*

Nutrients Responses	Data Source or Monitoring Program	Comments
Phytoplankton	*Maine DMR, Volunteer phytoplankton monitoring*	*See description under Food Web.*
Ecosystem Health		
Impaired streams	Maine DEP, Waters not meeting state water quality criteria (W-A-4.c.)	"305b" and "302D" lists.
Eelgrass	*Maine DEP (C-6) (W-B.3.a.,b.,c.)*	*Analysis of aerial imagery, dive surveys at selected locations.*

Additional Data or Reports:

- Bay water quality, Citizen Scientists - Friends of Casco Bay (W-A.1.c.,d.,e.,f.,g.,h.)
- Ocean acidification, Continuous (2015-2020) - University of New Hampshire, Southern Maine Community College Pier (C-32; W-A.3.d.)
- Coastal water quality, New Meadows River - MER Assessment Corporation (W-D.2.h.)

4. Strengths and Drawbacks of Nutrients and Water Quality Monitoring

Strengths or Opportunities

- We now have high quality river discharge data for the Bay's two largest tributaries, the Presumpscot River at Westbrook (2016 to present) and Royal River at Yarmouth (1990-2004 and 2019 to present).
- Casco Bay's water quality monitoring programs are approaching thirty years old; which has produced one of the best and most extensive data sets on water quality anywhere in the state or the country. Water quality monitoring in the Bay has a lot on which to build, and robust monitoring programs continue Baywide.
- Casco Bay has a long history of nutrient monitoring, led by Friends of Casco Bay and Maine DEP. This has produced deep institutional experience, and increasing sophistication about nutrient monitoring.
- In recent years, several organizations have expanded the use of "continuous" (really high frequency) monitoring technologies, greatly improving our ability to understand how ecological processes and episodic events affect the Bay.
- Some of the first high frequency, multi-year ocean acidification monitoring in the region occurred in Casco Bay, under the leadership of Friends of Casco Bay, Casco Bay Estuary Partnership, University of New Hampshire, and U.S. Environmental Protection Agency. That has provided a robust foundation for clarifying monitoring needs.
- The Maine Climate Council, and its Coastal and Marine Working Group, have drawn attention to the importance of monitoring for adapting to climate change. This attention may identify new priorities and funding sources for monitoring.

Drawbacks or Vulnerabilities

- Until recently, high resolution land cover data for our region was sporadic, and used changing methodologies, making trend analysis difficult. Federal data sources like CCAP and NLCD use consistent methods, but spatial resolution of older data remains poor.
- Maine produced high resolution (1 meter pixel size) impervious cover data nearly a decade ago, but that is too old to be of much use in understanding present-day water quality conditions. No schedule nor funding mechanism exists for producing updates for high quality impervious cover data. Alternative (national) data sources are much lower resolution.
- Monitoring of alkalinity, which has significant impact on ocean and coastal acidification chemistry, remains limited, both in the Bay and in major tributaries.

- No program collects consistent data on concentrations of nutrients in Casco Bay tributaries, blunting our ability to understand loading of nutrients to the Bay.
- No data provides information on the number, spatial distribution, and current condition of on-site wastewater treatment systems (especially septic tanks).
- Sediment nutrient processes, and especially release of nutrients from Casco Bay sediments, have not been studied in Casco Bay, limiting our ability to understand whether, when, and where the sediments act as sources or sinks for nutrients entering the water column.
- DEP monitoring of nutrients in Casco Bay is scheduled to scale back in 2021. There is currently no clear plan for replacing DEP effort with some sort of long-term monitoring program.
- Management needs in the urbanizing Portland Harbor, especially under a Portland Integrated Water Quality Plan, are likely to require additional monitoring infrastructure to increase both geographic and temporal resolution.
- While nitrogen data is relatively common in Casco Bay, phosphorus data is somewhat less common. Data on other macronutrients and micronutrients are essentially absent. Understanding of nutrient processes in the Bay requires information on prevalence of multiple nutrients.
- Data on health of Casco Bay tributaries is limited principally to periodic biological monitoring, which limits ability to identify relative importance of specific stressors.
- Robust, up-to-date hydrodynamic models of Casco Bay could enhance use of nutrient and water quality data, by connecting observations with explicit causal hypotheses.
- Policy interpretation of data would be further improved with linked watershed, water quality and ecosystem models, providing insight into processes and consequences that are difficult to monitor directly.
- Minimal data available regarding nutrient input to the Bay from the Gulf of Maine and by extension from the currents entering the Gulf of Maine.
- Many existing monitoring programs lack sufficient and secure funding.

B. Habitats

"Are coastal habitats of Casco Bay both healthy and abundant enough to support ecosystem processes and protect the vitality of the Bay?"

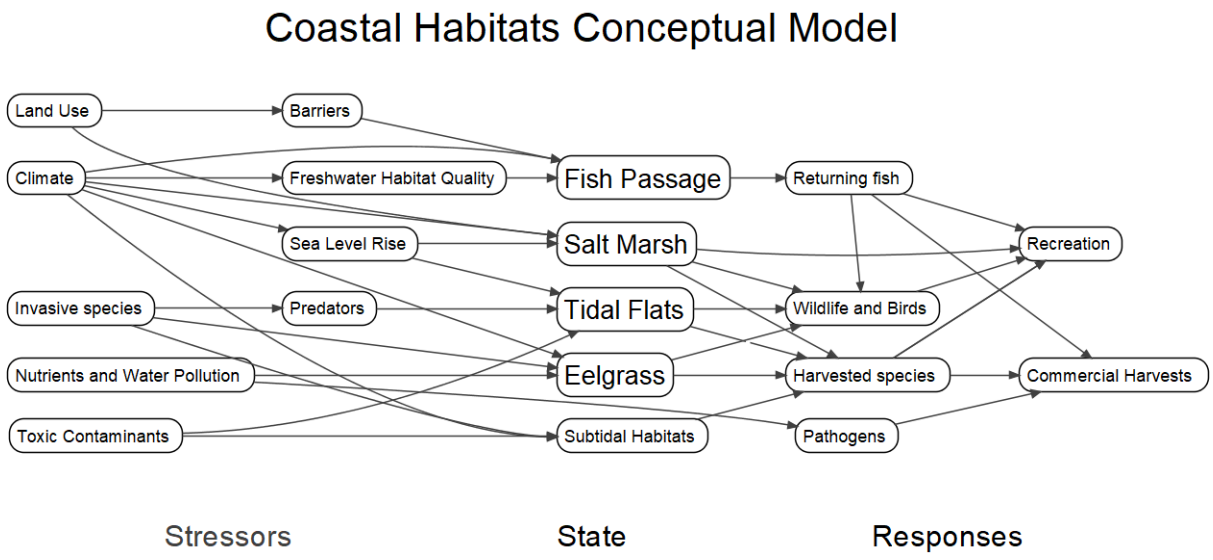

Figure 3: Coastal Habitats Conceptual Model

The Habitats conceptual model was anchored on the following four focal points:

- Fish Passage;
- Salt Marsh;
- Tidal Flats;
- Eelgrass.

These focal points represent three habitat types and a habitat-related issue (fish passage) that have long been areas of concern for the Estuary Partnership, and are explicitly called out in the *Casco Bay Plan 2016-2021*. As the Conceptual Model evolved, the Monitoring Network as a group noted concern about other habitats, including areas of importance to local fisheries like rock ledges, rockweed, and kelp. While these habitats receive little monitoring effort in Casco Bay today, we did not want them to go unrepresented. We have represented them in the model as "Subtidal Habitats." These categories are a reminder that data on less-studied habitats may be important for understanding ecosystem change.

While land use change, road construction, and similar human activities directly threaten some tidal marshes, climate change, sea level rise, poor water quality and invasive species threaten either the extent or the health of all coastal habitats, including those not explicitly identified here.

Responses to changes in habitat include impact on fish populations, fisheries, wildlife, recreation, and water quality.

1. Habitats Stressors

Guiding Questions

How are human activities affecting the health or extent of coastal ecosystems?

How is climate change affecting the health of coastal habitats?

Are sea levels changing in Casco Bay?

How prevalent are invasive species in Casco Bay and how are they affecting the health or extent of coastal ecosystems?

Are toxic chemicals present in Casco Bay at levels of concern?

Centuries of human impacts have compromised the ability of many coastal habitats to sustain functions essential to long-term ecosystem health. Dams and undersized culverts have degraded tidal wetlands and hindered migration of diadromous fish like smelt and alewives. Shellfish dragging and marine moorings have scarred eelgrass beds.

Toxic chemicals from industrial facilities, roadways, and urban lands have deposited contaminants like PCBs (polychlorinated biphenyls), pesticides, and heavy metals into sediments. Toxic contaminants are represented here as a stressor that degrades habitat quality, especially in soft bottom intertidal and subtidal habitats. They are also incorporated in the Food Web Priority Topic as a stressor that affects health of marine organisms and has the potential to biomagnify within marine ecosystems.

Climate change impacts including warming temperatures and increasing precipitation have altered distribution patterns of aquatic species, changed salinity distributions in nearshore waters, and fostered the intrusion of invasives. Rising seas may have already affected rates of shoreline erosion and reduced resilience of tidal marshes. Future rising sea levels may reduce the harvestable area of tidal flats, inundate tidal marshes, and submerge eelgrass beds too deeply for them to persist. Where upslope migration is impossible, area of these habitats may be substantially reduced.

Invasive species are pervasive in Casco Bay's marine environment. Invasives like green crabs have disrupted clam flats and eelgrass beds. Invasives are widespread in intertidal habitats like tidal flats and rocky shores. Certain invasive encrusting organisms like *Didemnum vexillum* (an invasive ascidian) can dominate benthic habitats.

Related State of the Bay Indicators

Habitats Stressors are reported on in the following 2020 State of Casco Bay Report Indicators:

- Invasive Species;
- Bay Water Quality;

- Toxics;
- Coastal Habitats.

Data Sources and Monitoring Programs

Table 4: Data Sources for monitoring stressors affecting health or extent of coastal habitats. Local monitoring efforts are in italics.

Habitats Stressors	Data Source or Monitoring Program	Comments
Land use	See land use data sources described under Nutrients and Water Quality	
Climate	See data sources on climate change identified under Nutrients and Water Quality	
Sea Level Rise	NOAA Portland Tide Gage	
Marine invasives, Casco Bay islands	*Wells National Estuarine Research Reserve, Marine Invaders Monitoring & Information Collaborative (MIMIC) (C-34)*	*Volunteer-based monitoring program looking for common invasives.*
Marine invasives, New England Rapid Assessment Survey (RAS)	*Massachusetts Institute of Technology (W-B.3.d.,e.)* *Massachusetts Office of Coastal Zone Management, (W-B.3.f.,g.)*	*Periodic surveys by professional biologists looking for invasives, including cryptic or difficult to identify species.*
Toxics in sediments	U.S. Environmental Protection Agency, National Coastal Condition Assessment	Limited locations in Casco Bay; probability-based sampling.

Additional Data or Reports

- *Julie N* oil spill - Industrial Economics, Inc. (W-A.1.j.)
- Predators in clam flats - University of Maine-Machias (W-B.1.b.,c.,d.)
- Barriers, Kennebec - Kennebec Estuary Land Trust (W-B.2.e.)
- Diadromous fish surveys, Presumpscot River - Normandeau Associates (W-B.2.f.)
- Stream crossings water quality and flow - Presumpscot River Watershed Coalition (W-B.2.h.)
- Road and stream crossings - Maine Coastal Program, Maine Stream Habitat Viewer
- Aquatic connectivity - U.S. Fish and Wildlife Service Gulf of Maine Coastal program, Stream-Smart
- Tidal restrictions - Maine Coastal Program, Tidal Restriction Atlas (available in fall 2020)
- Damage to eelgrass beds - U.S. Geological Survey (W-B.3.j.)
- Sea Level Rise in wetlands - Casco Bay Estuary Partnership (W-B.4.a.,b.,c.,d.,e.,f.,g.,h., i.,j.,k.)
- Sea Level Affecting Marshes Model (SLAMM) - Casco Bay Estuary Partnership, Warren Pinnacle
- Toxic pollution, Casco Bay - Casco Bay Estuary Partnership (W-B.5.b.)
- Toxics in sediments - Friends of Casco Bay (W-B.5.c.)
- Toxics in sediments - Casco Bay Estuary Partnership (C-5); and Geochemical and Environmental Research Group (W-B.5.d.,e.,f.,g.,h.); and Ramboll Environ (W-B.5.m)
- Toxics in sediments, Portland Harbor Dredge sites - City of Portland/Portland Harbor Commission
- Toxics in sediments, Pesticides - Maine Board of Pesticides Control (W-B.5.j.,k.)
- Tidal restrictions - Conservation Law Foundation, Return the Tides (W-B.6.e.)
- Tidal culverts - Maine Department of Transportation

2. Habitats Status

Guiding Questions

Are key coastal habitats changing in size or health status?

How is sea level rise affecting extent and health of Casco Bay intertidal and shallow subtidal habitats?

What proportion of the Casco Bay watershed is in permanently protected conservation status?

What proportion of high value watershed lands (buffers, shorelines, migration corridors, etc.) are permanently protected by land protection or policy?

Priority habitats including salt marshes, tidal flats, eelgrass beds, and connected waterways are facing challenges, with both extent and health of these habitat types under threat, from multiple stressors.

Tidal marshes provide important habitats for highly visible species like waterfowl and wading birds, as well as essential habitat for salt marsh sparrows and other marsh-dependent species. Tidal marshes have among the highest primary productivity of any ecosystem in Maine. They sequester atmospheric carbon in organic-rich sediments, reducing excess atmospheric CO_2. Tidal marsh productivity also supports coastal ecosystems by harboring juvenile fish, protecting water quality and subsidizing nearshore food webs. Tidal marshes are at risk because of direct disturbance, hydrological alteration (often due to roads or railroads crossing the marsh), declining water quality, and destruction of adjacent forests and other habitats. Tidal marshes in southern New England are already showing signs of stress due to rising seas.

Tidal flats support the softshell clam, quahog, and bloodworm fisheries, and provide important habitat for wading birds, from little “peeps” (small sandpipers) to large waders. Tidal flats are plagued by invasive species such as green crab and milky ribbon worm. Some flats show acidic conditions that reduce settlement of shellfish larvae, and can even cause shells of young shellfish to erode. Sea level rise may drown intertidal flats, reducing harvest ability and shifting species composition.

Eelgrass is a valuable and a vulnerable resource. As a habitat, it provides food for migratory winter waterfowl and serves as nursery habitat for fish and shellfish. It helps sustain water quality by stabilizing sediments and filtering nutrients and suspended particles. Eelgrass is threatened by poor water quality, especially elevated nutrients or poor water clarity and can also be lost or damaged by physical disruption, due either to human activity (moorings, dredging) or invasive species (green crabs).

Connected waterways directly support migratory fish, such as eels, smelt and alewives, but they also support dozens of terrestrial and marine species, from cod to bald eagles, that feed upon the migrating fish. They form an essential connection between marine ecosystems and inland streams, lakes, and rivers. Fish migrating from the Bay to upstream habitats face a gauntlet of passage barriers, like culverts, dams, rock ledges, and beaver dams.

Related State of the Bay Indicators

Habitats Status is reported on in the following 2020 State of Casco Bay Report Indicators:

- Aquatic Connectivity;
- Eelgrass;
- Conserved Lands;
- Coastal Habitats.

Data Sources and Monitoring Programs

Table 5: Data Sources for monitoring status (health and extent) of coastal habitats. Local monitoring efforts are in italics.

Habitats Status	Data Source or Monitoring Program	Comments
Wetlands	U.S. Fish and Wildlife Service, National Wetlands Inventory	Infrequent updates, low resolution (¼ acre). Not designed for tracking of local trends.
Salt marshes	*Casco Bay Estuary Partnership (C-3) (W-B.6.b.,c.,d.)*	*Habitat and stream channel assessments, principally of actual or potential habitat restoration sites.*
Tidal wetland elevation and sedimentation	*Maine DMR, Maine Coastal Program, rSET tables*	*Only one marsh in Casco Bay.*
Eelgrass extent	*Maine DEP (C-6) (W-B.3.a.,b.,c.)*	*Interpretation of aerial photographs.*
Eelgrass health	*Maine DEP (C-6) (W-B.3.a.,b.,c.)*	*Permanent diver transects at three study sites.*
Seafloor and ocean	Maine DMR, Maine Coastal Mapping Initiative (C-13)	Includes benthic epifauna and infauna data, also monitored certain invasives.
Conserved lands	Maine Department of Agriculture, Conservation, and Forestry, Natural Areas Program, Maine Conserved Lands Data	Updated frequently, but not designed principally to track changes in total conserved land over time.

Additional Data or Reports

- Habitats - Maine Department of Agriculture, Conservation and Forestry, Maine Natural Areas Program, Beginning with Habitat
- Conserved lands - U.S. Fish and Wildlife Service
- Eelgrass at Merepoint - MER Assessment Corporation (W-B.3.h.)
- Fringing Salt Marshes - University of New England (W-B.6.g.,h.); and Wells National Estuarine Research Reserve (W-B.6.j.)
- Wetlands, "Blue Carbon" studies - Bates College

3. Habitats Responses

Guiding Questions

Are impacts to habitats affecting populations of selected species of interest, such as species at risk, harvested species, migratory species, or indicator species?

Are habitat changes affecting fisheries and harvests?

How are conservation and management choices (restoration, enhancement, protection) affecting the health or extent of aquatic ecosystems?

The effects of changes in Casco Bay coastal habitats may be reflected in declines in abundance and health of species. Historically, local data collection has focused on a small number of indicator species, including shorebirds, ospreys, salt marsh birds, horseshoe crabs, alewives, and rainbow smelt. However, few programs have persisted. An alternative approach is to rely on fisheries-related data to understand changes in Bay ecosystems. These programs are likely to continue long term, but provide data on a narrow groups of species.

Related State of the Bay Indicators

Habitats Responses are reported on in the following 2020 State of Casco Bay Report Indicators:

- Aquatic Connectivity;
- Coastal Habitats.

Data Sources and Monitoring Programs

Table 6: Data Sources for monitoring responses to changes in coastal habitat health or extent. Local monitoring efforts are in italics.

Habitats Responses	Data Source or Monitoring Program	Comments
Alewives, Highland Lake	*University of Southern Maine Department of Environmental Science and Policy (C-33)*	*Volunteer-based fish count.*
Alewives, Presumpscot River	*Gulf of Maine Research Institute, CBASS, River alewife sampling (C-19)*	
Diadromous Fish, Presumpscot River	*Maine DMR, Cumberland Mills Dam*	*Fish count data collected by Sappi paper mill.*
Salt marsh birds	University of Maine, Saltmarsh Habitat and Avian Research Program (SHARP)	Regional data collection throughout the Northeastern U.S., following standard protocols. No recent data from Casco Bay.
Marine fish communities	Maine DMR, Annual trawl surveys	See discussion under Food Web.
Marine harvests	Maine DMR, Annual catch reporting	Many catch statistics not available at Casco Bay-relevant spatial scales. See discussion under Food Web.

Additional Data or Reports

- Rainbow smelt monitoring - Maine Department of Marine Resources (C-14)
- Rainbow smelt presence/absence - Maine Department of Marine Resources (C-15)
- Salter brook trout - Trout Unlimited

4. Strengths and Drawbacks of Habitats Monitoring

Strengths or Opportunities

- After a significant gap following 2001-2002 eelgrass mapping, eelgrass in Casco Bay was mapped in both 2013 and 2018. DEP's recent efforts to track eelgrass condition at selected sites by collecting detailed data several times a year are providing deeper insight into interacting processes affecting eelgrass in the Bay.
- CBEP monitoring of restored tidal wetlands provides a strong methodological foundation for tracking hydrologic and ecosystem change. Future efforts could emphasize long-term change at sentinel sites rather than tracking restoration.
- The Integrated Sentinel Monitoring Network has led efforts to define sentinel monitoring needs and methods.
- There is great interest in tracking of conditions of coastal habitats, and in particular, the species that use them, both on the part of state agencies and the general public. Habitat monitoring priorities overlap with resource agency plans and programs, such as the Maine State Wildlife Action Plan.

Drawbacks or Vulnerabilities

- State agency capacity to monitor Maine's coastal habitats and associated species is low, particularly relative to the length of its coastline.
- The state of Maine has no mechanism for funding or conducting regular updates to maps of coastal and marine habitats. Some habitats, like wetlands, are tracked by a national program, but data are not optimized for trend analysis and smaller spatial scales. Little mapping of subtidal habitats (with the exception of eelgrass) occurs.
- No structure is in place for monitoring changes in health of key coastal habitats in Casco Bay. In particular, few long-term monitoring sites have been established in Casco Bay, and the institutional and funding structures to ensure long-term data collection have not yet been established.
- High resolution monitoring of sea level rise and sediment deposition using modern state-of-the-art rod sediment elevation tables (rSETs) is currently occurring at only one field site in Casco Bay.
- Maine Department of Environmental Protection collects limited data on anthropogenic toxics, including emerging contaminants such as endocrine disrupters and PFAS (perfluoroalkyl and polyfluoroalkyl substances), however, resources are limited and long-term trends are difficult to discern.
- No program is currently monitoring salt marsh sparrows in Casco Bay tidal wetlands.

- Private ownership to mean low water along Maine's coast complicates monitoring in intertidal habitats.
- No reliable data exists on presence of remnant dams (or other fish passage barriers except culverts) in Casco Bay tributaries.

C. Food Web

"Is the food web of Casco Bay changing and does it support marine biodiversity, food production and key ecosystem services?"

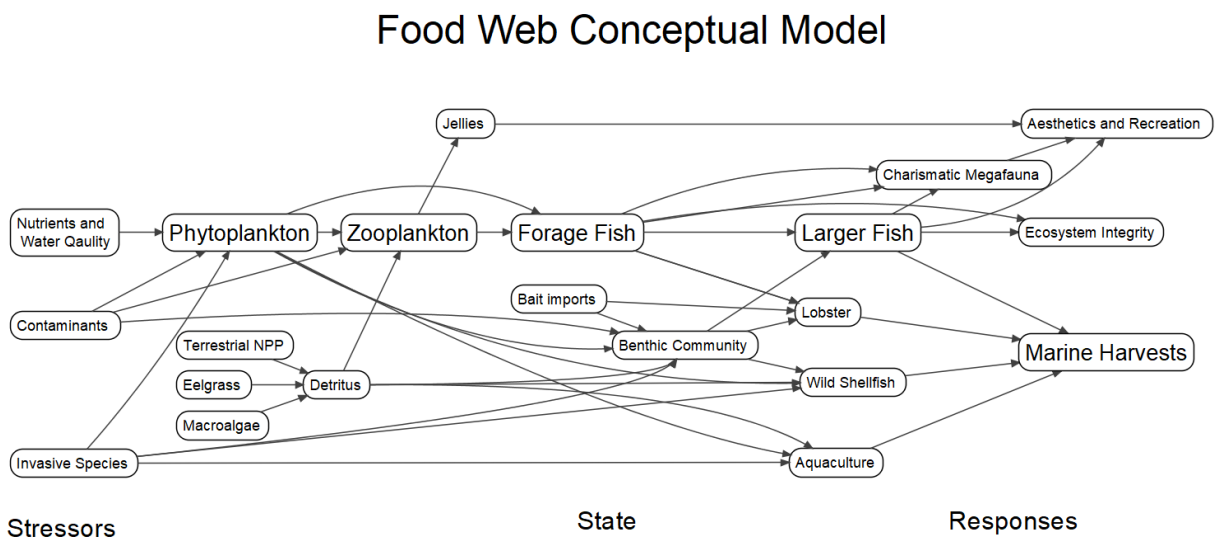

Figure 4: Food Web Conceptual Model

The food web underlies the ability of a clean and productive Bay to produce seafood and support charismatic megafauna like seals, osprey, and shorebirds. Thus the "food web," in loose terms, relates directly to public perceptions of the health of the Bay.

This conceptual model was built out from four major categories of a pelagic marine food web: phytoplankton to zooplankton to forage fish to larger fish. We extended the conceptual model principally to add significant components of the food web, and to reflect public interest in the food web, which focuses on marine harvests and watchable wildlife. Contaminants are incorporated here principally because of their effect on living organisms in the Bay, and widespread appreciation of the potential for biomagnification to exacerbate problems with toxic contaminants at higher trophic levels. Contaminants here complement Toxics in Sediments, which are included under the Habitats Priority Topic.

Nutrient loads and invasive species (each addressed principally in other conceptual models) are incorporated here because of their influence on food web structure and dynamics.

Climate change was not depicted here directly to simplify the graphical model. Climate change will profoundly alter every aspect of the food web, directly or indirectly. It is already incorporated in the water quality and habitat conceptual models, both of which themselves influence the food web. Climate is considered here as a pervasive background process that imposes gradual changes to boundary conditions to which the food web will respond.

A further simplification in this model is that we include marine harvests here solely as a response. We also recognize that harvests have a profound effect on the Bay food web.

1. Food Web Stressors

Guiding Questions

Are water quality challenges affecting the Casco Bay food web?

Are invasive species affecting the Casco Bay food web?

Are changes in climate affecting the Casco Bay food web?

Are stressors cumulatively likely to affect Casco Bay marine harvests?

How are contaminants like persistent toxics, emerging contaminants, or microplastics affecting the health of organisms in the Bay?

The biota in the marine food web are threatened by changes in water temperature, increase in invasive species, declining water quality, and a variety of contaminants. Climate change will lead to range shifts for many marine organisms, including harvested species. Cumulative effects may significantly alter species composition with implications not only for ecosystem health and harvesters, but also for shore-side processing and support industries.

Marine organisms are exposed to a range of contaminants, including persistent toxics, like metals, PCBs and organochlorine pesticides. Less persistent contaminants, like perflourinated compounds, are found both in the marine environment and in tissue of marine organisms. The role of microplastics in the marine environment is an area of active research, regarding not only their prevalence and distribution, but also their effects. Ingestion of microplastics by zooplankton, a crucial food source for many secondary consumers, may provide a pathway for transfer up trophic levels. Biotoxins derived from harmful algae can affect marine organisms directly, but they are also of high importance for marine harvests because they contaminate shellfish, posing significant public health risks.

Related State of the Bay Indicators

Food Web Stressors are reported on in the following 2020 State of Casco Bay Report Indicators:

- Bay Water Quality;
- Living Resources;
- Swimming Beaches and Shellfish Beds.

Data Sources and Monitoring Programs

Table 7: Data Sources for monitoring stressors that affect the food web or food production in Casco Bay. Local monitoring programs are in italics.

Food Web Stressors	Data Source or Monitoring Program	Comments
Climate change	See discussion of climate change and sea level rise tracking in prior sections	
Water quality	See discussion under Nutrients and Water Quality	
Invasive species	See discussion under Habitats	
Mercury deposition	*Maine DEP, Wolfe's Neck Atmospheric Deposition Monitoring Station (W-C.3.f.,h.,n.,o.,s.,t.,u.)*	*Local data, but part of national air deposition monitoring programs.*
Toxics in sediments	U.S. Environmental Protection Agency, National Coastal Condition Assessment	Limited locations in Casco Bay; probability-based sampling.
Toxics in shellfish, soft shell clams, mussels, lobsters	*Maine DEP, Surface water ambient toxics (SWAT) (C-10) (W-C.3.j.,k.,l.)*	
Toxics in shellfish, mussels	National Oceanic and Atmospheric Administration, Mussel Watch	Infrequent samples from a handful of locations only.
Toxics in shellfish, mussels	Maine DEP, GulfWatch (C-7)	No new samples collected recently. Program was discontinued but future collaboration with NOAA may be possible.
Bacteria in marine waters	*Maine DMR (C-11)*	*Hundreds of locations, mostly in the Eastern Bay. See discussion under Nutrients and water quality.*

Additional Data or Reports

- Bacteria in clam flats - Normandeau Associates, Inc. (W-C.1.h.,i.,j.,k.)
- Toxics in osprey eggs - Biodiversity Research Institute (W-C.3.c.,d.,e.)
- Toxics in mussel tissue - Ecosystem Indicator Partnership GulfWatch (W-C.3.g.); and Maine Bureau of Health (W-C.3.i.); and Maine Department of Environmental Protection (W-C.3.m.)
- Human exposure to toxics - Menzie-Cura & Associates (W-C.3.q.)
- Microplastics - Friends of Casco Bay

2. Food Web Status

The primary indicators of food web status are the health, abundance, and distribution of plant and animal life throughout the Bay and the watershed. (Many of these are also "response" indicators in the Habitats conceptual model.) Conceptually, studying the food web involves determining who eats whom. Direct studies of diet of marine organisms are labor intensive and are usually considered beyond the scope of monitoring. Stable isotope methods offer an alternative not previously considered in Casco Bay monitoring plans.

At the bottom of the marine/fish food web are phytoplankton, but also other primary producers like eelgrass and macroalgae, as well as terrestrial net primary production (NPP) inputs (included in the conceptual model via the "detritus" category). Phytoplankton and detritus are consumed principally by zooplankton, shellfish, and small fish. Moving up the food chain, forage fish serve as food for larger fish and megafauna; and are directly harvested by humans (often for bait). Larger fish, in turn, provide harvesting opportunities for humans and food for marine mammals and birds.

The primary method of tracking the status of the Casco Bay food web will be to document the dominant species present in the Bay at different trophic levels. This provides information that informs understanding of how the Bay functions today, and also provides baseline information for understanding how the Bay is changing in the face of climate change and other stressors. Traditional biological sampling tends to be labor intensive. It is based on capturing and identifying organisms from the marine environment. That requires boats, specialized gear, time, and trained specialists able to identify marine species.

In recent years, significant advances have been made using environmental DNA (eDNA) and related technologies to document presence, and in some cases, relative abundance of certain species in the coastal environment. The potential exists for eDNA, in the next few years, to provide cost-effective alternatives for monitoring presence, distribution and abundance of marine organisms, from invasive species to commercially important species like cod. Demonstration studies in Casco Bay have already shown the value of eDNA for detecting presence of migratory fish.

Guiding Questions

What are the major components of the Casco Bay food web?

Are the dominant species at different trophic levels in Casco Bay changing?

Are dominant pathways in the Casco Bay food web – who eats whom – changing over time?

How does the Casco Bay food web support species of interest like charismatic species, and harvested marine organisms?

Related State of the Bay Indicators

Food Web Status is reported on in the following 2020 State of Casco Bay Report Indicators:

- Living Resources;
- Swimming Beaches and Shellfish Beds.

Data Sources and Monitoring Programs

Table 8: Data Sources for monitoring status of the Casco Bay food web. Local monitoring programs are in italics.

Food Web Status	Data Source or Monitoring Program	Comments
Biotoxins, Harmful algae blooms (HABs)	*Maine DMR, Shellfish Sanitation Program, Biotoxins in shellfish (C-12)*	*Phytotoxin monitoring program.*
Harmful algae blooms	Woods Hole, Casco Bay Red Tide/Paralytic Shellfish Poisoning (PSP) Monitoring Buoys	Not clear whether data are available, nor what the future deployment plans are.
Phytoplankton	*Maine DMR*	*Volunteer phytoplankton monitoring and identification program supporting Biotoxins monitoring.*
Chlorophyll-A	*Bowdoin College (C-2)* *Maine DEP (C-9)* *Friends of Casco Bay (C-16)* *University of Maine (C-30)*	*Chlorophyll-A is monitored by several automated sensor systems in Casco Bay, managed by Bowdoin College, DEP, FOCB, and UMaine.*
Marine biota	*Gulf of Maine Research Institute, CBASS programs:* • *Acoustic fish survey (C-18)* • *Beach seine fish survey (C-20)* • *Jig groundfish survey (C-21)* • *Zooplankton via Oceanographic survey (C-22)* • *Trap survey (C-24)*	*The CBASS program is our only local, targeted program looking at most food web components.*
Marine fish communities	Maine DMR	Annual trawl surveys provide regional data on finfish in Maine and New Hampshire. Surveys include data from a small number of locations within Casco Bay. Locations are based on a probability sample each year, prioritizing regional population estimation over detection of trends.
Lobster settlement	*University of Maine, Wahle Lab (W-C.1.l.)*	*Annual survey of abundance of juvenile lobsters in near-shore habitats, including locations in Casco Bay.*

Additional Data or Reports

- Horseshoe crab populations - Bar Mills Ecological (W-C.1.a.)
- Horseshoe crab spawning - Bar Mills Ecological (W-C.1.b.,c.,d.)
- Brook floater (fresh water mussel) - biodrawversity (W-C.1.e.)
- Lobsters - MER Assessment Corporation (W-C.1.g.)
- eDNA, rainbow smelt - Wells National Estuarine Research Reserve (W-C.1.m.)
- Osprey nest abundance and reproductive success - Biodiversity Research Institute (W-C.2.a.,b.,c.)
- Shorebirds - Biological Conservation, LLC (W-C.2.d.,e.,f.)
- Terns on Jenny Island - Gulf of Maine Seabird Working Group (W-C.2.g.)
- Common eiders on Flag Island - Maine Department of Inland Fisheries and Wildlife (W-C.2.h.)
- Terns on Outer Green Island - National Audubon (W-C.2.i.,j.)
- Beach seine subtidal species - Southern Maine Community College
- Red Tide/PSP - Battelle (W-C.3.a.,b.); and MER Assessment Corporation (W-C.3.r.)
- Seals - Marine Environmental Research Institute (W-C.3.p.)
- IF&W waterfowl surveys (reported in State of the Bay reports, W-D.2.a.,c.,d.,e.)
- Water Reporter photographs - Friends of Casco Bay

3. Food Web Responses

Guiding Questions

Are Casco Bay marine harvests changing in biomass, value, or composition?

About how many people work as marine harvesters in the largest Casco Bay fisheries?

Is abundance of "watchable wildlife" in the Bay changing?

Do changes in species composition of Casco Bay marine ecosystems suggest declines in ecosystem health, integrity or resilience? Are there other direct measures of ecosystem health and integrity?

Here, we track "Responses" to the marine food web of Casco Bay principally in terms of human benefits. There is a certain symmetry to that, as ability of the Bay to provide a sustainable environment for aesthetics and recreation, resilient ecosystems, and marine harvests is partially dependent on human behavior. Reducing the inflow of nutrients and contaminants to the Bay will resonate through the food chain and produce more robust populations of harvestable species. Equally important, it will result in a coastal marine food web better able to respond to climate change, invasive species, and other stressors while continuing to produce harvestable protein (even if the mix of harvested species may change in coming decades). System resilience will also depend on responsible harvesting in terms of both species composition and total biomass. Additional detail on ways of tracking human benefits derived from the Bay are discussed below.

Related State of the Bay Indicators

Food Web Responses are reported on in the following 2020 State of Casco Bay Report Indicator:

- Living Resources.

Data Sources and Monitoring Programs

Table 9: Data Sources for monitoring responses to the condition of the Casco Bay food web. Local data collection programs are in italics.

Food Web Responses	Data Source or Monitoring Program	Comments
Lobster harvests	Maine DMR	
Shellfish harvests	Maine DMR	
Aquaculture harvests	Maine DMR	
Other marine harvests	Maine DMR	DMR tracks information on harvests of finfish species, as well as other marine resources. While value of harvest of other species in 2019 was small compared to lobster or shellfish, they are cumulatively important, and long-term trends may be important to document.
Lobster licenses	Maine DMR	
Softshell clam licenses	*Southern Maine Conservation Collaborative, Casco Bay Regional Shellfish Working Group*	*Numbers collected from municipal governments.*
Aquaculture licenses	Maine DMR	

Additional Data or Reports

- Harvests - Island Institute, Waypoints report, 2018

4. Strengths and Drawbacks of Food Web Monitoring

Strengths or Opportunities

- Historic and present-day water quality monitoring in Casco Bay has largely been designed to provide summary information on eutrophication, which is directly tied to system metabolism. Core monitoring infrastructure therefore provides information that can be used as synoptic indicators of net primary production and respiration. The quality and broader utility of these data has only been improved by expansion of efforts to monitor coastal acidification.
- The design of GMRI's Casco Bay Aquatic System Survey (CBASS) program was intended to link food webs to fisheries. If adequately funded, and expanded to address other species and other portions of the Bay, it would provide a structured starting place for understanding Casco Bay's marine food web.
- The Maine EPSCOR eDNA program could provide an avenue to expand use of eDNA techniques to characterize presence and abundance of selected marine species in Casco Bay.
- GMRI and Bates College have used stable isotope analysis to characterize nutrient sources in different parts of Casco Bay (See the Nutrients and Water Quality Priority Topic). Stable isotope analyses of selected sentinel species might provide a way to track long-term change in marine food webs.

Drawbacks or Vulnerabilities

- While numerous studies over the years have looked at components of the marine food web in Casco Bay, we are unaware of any effort at systematic data collection to facilitate understanding of ecosystem structure or detect long-term change.
- Estuary and Bay faunal communities haven't been recently characterized to understand how the resident community is changing over time and with proximity to pollution sources.
- While coastal birds have been monitored repeatedly over the past 25 years, methods, and even target species, have changed repeatedly, making long-term comparisons impossible.
- We have uncovered no programs monitoring numbers of marine mammals in Casco Bay that are designed to provide reliable estimates at the Bay or local scale.
- DMR monitoring of HABs is thorough, but narrowly focused. Data provides only limited information about primary producers generally. These data alone cannot document shifts in relative abundance of major groups during seasonal events like the spring phytoplankton bloom.
- Zooplankton data is very rare in Casco Bay.

- Monitoring of fish communities in Casco Bay samples few locations, thus obscuring spatial patterns and variation.
- Benthic communities, both intertidal and subtidal, are not regularly studied, despite their importance for commercial fisheries in the region. Monitoring, itself often opportunistic, tends to focus on harvestable species, not community structure.
- DMR data on fisheries and marine harvests is comprehensive, but data collection and reporting are often not designed for analysis at Casco Bay scale.
- No program in Casco Bay is tracking changing abundance of jellies, including ctenophores, hydromedusae and scyphomedusae.
- Monitoring for persistent contaminants is expensive, and has declined in recent years.

D. Human Benefits

"How do humans derive material and cultural benefits from the Bay?"

The Monitoring Plan provides no separate graphical conceptual model of human benefits derived from the Bay, as these benefits are direct outcomes of the health and productivity of the Bay. Thus the three previous conceptual models provide the analytic structure for understanding how the Bay provides benefits to the people living along its shores and in its watershed. The challenge with developing indicators of human benefit derived from the Bay lies principally in the difficulty of capturing the many different ways that humans receive benefit from living in a coastal area.

Previous CBEP Monitoring Plans made no effort to evaluate human benefits derived from Casco Bay. This plan highlights the need to understand, track, and report on such benefits. This is a new area for Casco Bay monitoring, and one that will continue to evolve as we gain more experience with related metrics.

Human Benefits include both market and non-market values. Thus metrics describing human benefits derived from the Bay should incorporate both analyses of the Casco Bay economy, and also other measures of the importance of the Bay to our communities. Econometric "input-output" tools can readily capture the size of market transactions (price times quantity) and number of jobs supported by Bay-related commercial activities, such as fisheries, boat yards, and marine construction (See CBEP's 2017 Economic Analysis, W-D.1.i.). Such analyses should be complemented with metrics that speak more directly to people's experience of the Bay, and the social, existence, heritage, and aesthetic values that it supports.

Areas of interest include, but are not limited to:

- The coastal economy;
- Commercial fisheries;
- Aquaculture;
- Recreation;
- Property values;
- Heritage values;
- Educational values.

Guiding Questions

How large is Casco Bay's Marine Economy? What are its most important components?

How many people fish, hunt, boat and play on the Bay?

How many people work harvesting the bounty of the Bay?

How many people travel to the Bay's islands seasonally?

How do people learn about and teach about Casco Bay and its watershed?

Related State of the Bay Indicators

Human Benefits are reported on in the following 2020 State of Casco Bay Report Indicators:

- Economics;
- Education;
- Stewardship;
- Climate Preparedness.

Data Sources and Monitoring Programs

The following data sources are not the subject of regular monitoring programs but are used in State of the Bay and Economic Status reporting.

Table 10: Data Sources for information on human benefits

Benefit	Data Source	Comments
Bay economics	USM Maine Center for Business and Economic Research, Economic Modeling Specialists International economic analyses (W-D.1.i.)	Including gross regional product, employment, average earnings, in selected coastal and marine business sectors.
Ocean economy	Middlebury Institute Center for the Blue Economy, National Ocean Economics Program	County estimates of gross regional product, employment, average earnings, in selected coastal and marine business sectors.
Ferry ridership	Casco Bay Lines	CBEP analysis of data.
Casco Bay boat launches	Maine Department of Agriculture, Conservation and Forestry	Includes "official" state boat launches only, not local, commercial, and informal facilities.
Recreational fishing licenses	Maine Department of Inland Fisheries and Wildlife	Allocation to fishing location is not possible.
Marine harvests	Maine DMR	Data currently reported by landing port.
Marine harvesting and aquaculture licenses	Maine DMR	Difficult to assign harvests or landings to specific locations.
Casco Bay marine moorings	Harbor masters	CBEP analysis of data.
Educational programs	Selected educational providers	CBEP analysis of data.
Stewardship activities	Selected organizations	CBEP analysis of data on citizen science, bay cleanup events, etc.

Additional Data or Reports

- Population trends - Maine State Office of Policy and Management
- Economic impact of clam industry - MER Assessment Corporation (W-D.1.e.)
- Economic value of Casco Bay - University of Southern Maine (W-D.1.h.)
- Ocean uses - Northeast Regional Ocean Council, Northeast Ocean Data Portal
- Economic impact of tourism - Maine Office of Tourism Partners
- State of the Bay - Casco Bay Estuary Partnership (W-D.2.a.,b.,c.,d.,e.)
- State of the Bay - Friends of Casco Bay (W-D.2.f.)
- State of the Gulf of Maine - Gulf of Maine Council on the Marine Environment (W-D.2.g.)

2. Strengths and Drawbacks of Data Sources for Human Benefits

Strengths or Opportunities

- The 2017 econometric analysis of Casco Bay economy has shown tracking of the economic importance of the Bay can be conducted cost-effectively based on available data, and following standard protocols.

Drawbacks or Vulnerabilities

- We need continued identification and development of solid, cost effective Human Benefits metrics.
- Many fisheries statistics are not readily available at Casco Bay scale.
- Human Benefits metrics outside those directly tracked for fisheries regulation are difficult and expensive to gather or access.

Section IV. RECOMMENDATIONS FOR MONITORING PRIORITIES 2020-25

A. Programmatic recommendations - in order of priority rankings by Monitoring Network

1. The Casco Bay Monitoring Network provides the core adaptive management structure for ongoing monitoring of Casco Bay. The Monitoring Network will meet regularly to share data; and to discuss our understanding of the Bay, evolving monitoring needs, developing technologies, and collaborative opportunities.
2. The Casco Bay Monitoring Network needs to strengthen both formal and informal connections with Casco Bay monitoring programs and other local and regional monitoring efforts. Possible linkages include the following:
    a. Blue Portland;
    b. One Climate Future;
    c. Maine Climate Council;
    d. MOCA;
    e. NECAN;

f. NERACOOS;
g. Northeast Integrated Sentinel Monitoring Network.

Coordination can align Casco Bay monitoring with priorities these other groups identify, and leverage outside resources to address (ideally, fund) Casco Bay monitoring needs.

3. Stable and adequate funding is essential for sustained monitoring. The Monitoring Network should work together to identify and advocate for long-term funding mechanisms.
4. The Monitoring Network and CBEP staff should facilitate sharing of data among Monitoring Network participants. This includes encouraging state agencies to make their data more readily available.
5. CBEP and partners need to continue to reach out to groups involved with or beginning to get involved with monitoring, including monitoring of fresh water, and invite their participation in the Monitoring Network.
6. Geographic Priorities - monitoring should emphasize collection of data in and around specific focus areas, including Eastern Bay.

B. Programs to continue on current basis

These programs form the core of Casco Bay monitoring. Their current structure addresses Casco Bay needs well. Loss of these programs would leave a significant hole in our ability to track conditions in Casco Bay. While programs can always continue to improve, these programs are already an essential long-term part of Casco Bay monitoring.

1. Nutrients and Water Quality

    C-1. Bowdoin College acidification
    C-2. Bowdoin College buoy
    C-6. DEP eelgrass monitoring
    C-8. DEP Maine Healthy Beaches
    C-9. DEP marine water quality monitoring
    C-17. FOCB Bay water quality and nutrients, seasonal monitoring
    Lake Stewards of Maine lakes water quality monitoring
    C-25. LEA lakes and ponds water quality monitoring
    C-26. Long Creek WMD stream monitoring
    C-27. PWD Sebago Lake water quality monitoring
    C-28. PWD Sebago Lake tributaries monitoring
    DEP biomonitoring of streams and rivers
2. Habitats

    C-6. DEP Eelgrass
    C-13. DMR Maine Coastal Mapping Initiative
    C-33. USM Alewives in Highland Lake

C-34. Wells NERR “MIMIC” marine invasive species monitoring

3. Food Web

C-10. DEP Surface Water Ambient Toxics
C-11. DMR bacteria in marine waters
C-12. DMR biotoxins in shellfish and phytoplankton monitoring
DMR fisheries landings and licenses
DMR trawl survey

C. Program to discontinue

1. UNH ocean acidification (superseded by expanded FOCB ocean acidification monitoring); C-32.

D. Programs to expand - in order of priority rankings by Monitoring Network

These are monitoring programs that are an important part of Casco Bay monitoring, and for which the Monitoring Network has identified value in expanding or refining the existing programs. The Monitoring Network should provide support for expansion of these programs.

1. PRLT Presumpscot and Stroudwater River freshwater monitoring - add nitrogen; C-29.
2. GMRI CBASS - clarify priority components for long-term, expand locations as funding is available; C-18, 19, 20, 21, 22, 23, 24.
3. FOCB Bay water quality and acidification, continuous monitoring - add stations in Portland Harbor and Eastern Bay; C-16.
4. Marsh monitoring – incorporate sentinel monitoring sites, which should be the same as DMR rSET sites; C-3.
5. DMR phytoplankton – expand monitoring to track additional species and locations.
6. DMR rSETS - add sites; integrate with vegetation, hydrologic, and other sentinel monitoring.

These are programs with the potential to fill important data gaps, but for which we have not identified stable funding sources. The Monitoring Network should advocate for funding.

1. DEP eelgrass aerial surveys - expand.
2. University of Maine LOBO buoy continuous monitoring - continue; C-30.
3. New England marine invasive species Rapid Assessment Survey: survey is conducted every three to four years; CBEP has provided partial funding for almost a decade - continue to fund.
4. DEP GulfWatch program - restore consistency of sampling; C-7.
5. Inshore continuous nitrogen monitoring (CBEP NuLAB or similar) - re-activate; C-4.

E. Programs to consider - in order of priority rankings by Monitoring Network

These are programs that could provide data of high value but for which existing efforts are absent or lacking. The Monitoring Network should consider how to initiate these programs.

1. Monitor nutrients in freshwater and delivery of nutrients to coastal waters via rivers and streams.
2. Establish sentinel monitoring of selected coastal and nearshore habitats to track impacts of climate change; for example, include species that might not typically be monitored.
3. Monitor impacts of aquaculture operations on water quality, flora, and fauna.
4. Track marine habitat extent and condition.
5. Develop a Casco Bay circulation model to provide context for interpretation of monitoring data.
6. Use eDNA to track presence / abundance / location of selected aquatic species like anadromous fishes or invasive species.
7. Collect high resolution impervious cover data on a regular schedule.
8. Monitor sediment nutrient fluxes.
9. Establish methods for tracking number, location and condition of septic tanks, especially in shoreline areas.
10. Supplement existing acidification monitoring by adding: (a) additional locations; and (b) additional parameters.
11. Establish a microplastics monitoring effort.
12. Establish freshwater monitoring of harmful algae blooms (HABs).
13. Use stable isotopes in indicator species to enhance understanding of trophic relationships in the Bay.

Appendix A. CATALOG OF MONITORING PROGRAMS

A. Surveys of monitoring programs

In 2016, CBEP and EPA created a Casco Bay Monitoring Network to identify shared monitoring priorities among the growing number of entities who are monitoring the waters within Casco Bay and its watershed. In 2016-2017, 14 organizations were surveyed on monitoring information for each of their programs and the parameters collected within Casco Bay.

The information is available in Microsoft Access, ESRI Shapefile, and Google Earth (kmz) format. Map data, including a map graphic, shapefiles, and kmz files are available on CBEP's website (cascobayestuary.org). A table providing a matrix of information on 32 monitoring programs and whether they were collecting information in six parameter groupings (biota, nutrients, sediments, tidal wetlands, toxics, and water quality) is also available on the website.

In 2020, the survey responses were updated and added to by the Monitoring Network and compiled into the following catalog of monitoring programs. The primary focus of the catalog is on on-going programs, but certain historically important programs that have been discontinued are also described. These are noted as Discontinued.

The monitoring organizations and their programs are described in alphabetical order and contain a reference to the Priority Topics of the Casco Bay Monitoring Plan to which they are related.

The catalog descriptions also include a reference to the Goals of the *Casco Bay Plan 2016-2021* addressed by each monitoring program. Those goals are:

- Goal 1: Protect, restore and enhance key habitats that sustain ecological health;
- Goal 2: Reduce nutrient pollution and its impacts, including coastal acidification;
- Goal 3: Foster resilient communities and their connections to Casco Bay;
- Goal 4: Mobilize collective knowledge and resources to support Casco Bay.

At its annual Spring meeting, the members of the Monitoring Network share the results of their monitoring programs from the prior year. PowerPoints of these presentations on 2018 and 2019 monitoring are available on CBEP's website (http://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/).

B. Descriptions of monitoring programs

C-12 Dept. of Marine Resources - Biotoxins in shellfish
C-13 Dept. of Marine Resources - Maine Coastal Mapping Initiative
C-14 Dept. of Marine Resources - Rainbow smelt monitoring - Discontinued
C-15 Dept. of Marine Resources - Rainbow smelt presence - Discontinued
C-16 Friends of Casco Bay - Bay water quality & Acidification, Continuous
C-17 Friends of Casco Bay - Bay water quality & Nutrients, Seasonal
C-18 GMRI - Casco Bay Aquatic System Survey, Acoustic fish survey
C-19 GMRI - Casco Bay Aquatic System Survey, Alewives in Presumpscot River
C-20 GMRI - Casco Bay Aquatic System Survey, Beach seine fish survey
C-21 GMRI - Casco Bay Aquatic System Survey, Jig groundfish survey
C-22 GMRI - Casco Bay Aquatic System Survey, Oceanographic survey
C-23 GMRI - Casco Bay Aquatic System Survey, Temperature & DO
C-24 GMRI - Casco Bay Aquatic System Survey, Trap survey
C-25 Lakes Environmental Association - Lakes and Ponds
C-26 Long Creek Watershed Management District - Stream
C-27 Portland Water District - Sebago Lake
C-28 Portland Water District - Sebago Lake tributaries
C-29 Presumpscot Regional Land Trust- Presumpscot & Stroudwater Rivers
C-30 Univ. of Maine - Land/Ocean Biogeochemical Observatory (LOBO) buoy
C-31 Univ. of Maine - Nutrients in fresh water
C-32 Univ. of New Hampshire - Ocean Acidification, Continuous
C-33 Univ. of Southern Maine - Alewives in Highland Lake
C-34 Wells NERR - Marine Invaders Monitoring & Information Collaborative

(C-1) Bowdoin College Coastal Studies Center - Acidification

Contact: Steven Allen, sallen@bowdoin.edu
Website: https://www.bowdoin.edu/coastal-studies-center/
Program Description: The Schiller Coastal Studies Center provides a sentinel site at the edge of the Gulf of Maine to understand the impact of climate change on coastal systems, and to monitor key aspects of physical and biological environments that are changing rapidly. A coastal acidification monitoring program that collects data on related parameters from the Center's pier began in 2017. Additional monitoring includes a continuous temperature logger located adjacent to the Coastal Studies Center pier.

Monitoring Plan Priority Topic: Nutrients
Casco Bay Plan Goals: Goal 2; Goal 4
Habitat Type: Estuary

Collectors: Students; Professional Staff
Collection Method: Automated monitoring equipment
Equipment: A pier-mounted instrument array that streams seawater temperature, salinity, pH, O2, and pCO2 data to a global research community 365 days a year. As well as HOBO temperature logger and YSI sonde.

Principal Parameters:

Water Quality: Dissolved Oxygen; Salinity; Temperature
Acidification: Carbon Dioxide Partial Pressure (PCO2); pH (and related carbonate parameters by calculations)

Number of Stations: 1
Monitoring Location: Harpswell Sound, Orr's Island

Program Start Date: 2017
Anticipated Program End Date: Ongoing
Program changes over time: Developed a continuous monitoring platform at Bowdoin's Coastal Studies Center. Other monitoring is on a continuous temperature logger located adjacent to the Coastal Studies Center Pier.
Future plan for program:

Data Collection Intervals: Continuous
Data Location: Bowdoin
Data QA/QC Method: Bowdoin SOP

Data Reporting Audience: Public
Data Availability:
Data Reporting Frequency: Monthly; Annual

Program Summary Reports Audience:
Program Summary Reports Public Availability:
Program Summary Reports Frequency:

Long Term Program Sustainability/Funding: Bowdoin anticipates maintaining this program long-term.

(C-2) Bowdoin College Coastal Studies Center - Bowdoin buoy

Contact: Steven Allen, sallen@bowdoin.edu
Website: https://www.bowdoin.edu/coastal-studies-center/
Program Description: The Schiller Coastal Studies Center monitors oceanographic conditions in Harpswell Sound via the "Bowdoin Buoy." The buoy has been deployed seasonally, May through November since 2014. The buoy monitors water quality and the physical environment of Harpswell sound.

Monitoring Plan Priority Topic: Nutrients
Casco Bay Plan Goals: Goal 2; Goal 4
Habitat Type: Estuary

Collectors: Students; Professional Staff
Collection Method: Automated monitoring equipment
Equipment: The buoy is a "BayLOBO" buoy, equipped with multiple sensors to track the physical environment, including irradiance and current velocities; nitrate and chlorophyll concentrations; colored dissolved organic matter (CDOM); and turbidity. Data is telemetered, providing near-real time access to preliminary data.

Principal Parameters:

Water Quality: Chlorophyll-A (CLA); Chlorophyll Fluorescence; Colored Dissolved Organic Matter; Dissolved Oxygen; Irradiance; Salinity; Temperature; Turbidity
Nutrients: Nitrate
Hydrology: Current velocity profile

Number of Stations: 1
Monitoring Location: Harpswell Sound

Program Start Date: 2014
Anticipated Program End Date: Ongoing
Program changes over time:
Future plan for program:

Data Collection Intervals: Continuous
Data Location: Bowdoin
Data QA/QC Method: Bowdoin SOP

Data Reporting Audience: Public
Data Availability: Recent and archived data are available via loboviz portals and related APIs at http://bowdoin.loboviz.com/
Data Reporting Frequency: Continuous as collected

Program Summary Reports Audience:
Program Summary Reports Public Availability:
Program Summary Reports Frequency:

Long Term Program Sustainability/Funding: Bowdoin anticipates maintaining this program long-term.

(C-3) Casco Bay Estuary Partnership (CBEP) - Marshes

Contact: Matt Craig, matthew.craig@maine.edu
Website: https://www.cascobayestuary.org/
Program Description: CBEP conducts pre- and post-restoration monitoring of tidal wetland restoration projects as well as baseline condition assessments

Monitoring Plan Priority Topic: Habitats
Casco Bay Plan Goals: Goal 1
Habitat Types: Tidal Marsh; Wetland

Collectors: Professional staff; Part-time seasonal staff; Students; Collaborators on an opportunistic basis
Collection Method: Surveying; Automated Monitoring; Grab Sample-Water; Handheld Equipment; Observation; Field specimens
Equipment: Surveying equipment (total station, auto level/stadia rod, GPS); Onset Hobo water level, conductivity, and barometric pressure loggers; Xylem/YSI handheld conductivity sampling system; handheld refractometer; tape reel; quadrat; etc.

Principal Parameters:

Water Quality: Conductivity; Level/depth; Salinity of surface water and groundwater; Temperature
Tidal Wetland: Channel Morphology; Elevation-Marsh surface; Hydrology Signal; Salinity-Pore water; Salinity-Surface water; Soil and Sediments; Temperature; Vegetation; Water Level; Wildlife
Invasive Plants, species of concern: *Phragmites australis; Typha angustifolia; Lythrum salicaria*

Number of Stations: Pre/post monitoring five sites, approximately 10 stations per site; Assessments at another ~20 sites
Monitoring Locations: Pre/post monitoring: Eastern Bay, Brunswick, Harpswell and Phippsburg - Appletree Marsh; Head of Mill Cove; Long Marsh; Thomas Bay Marsh; Small Point Marsh

Program Start Date: 2009
Anticipated Program End Date: Ongoing
Program changes over time: Equipment changes (surveying, continuous monitoring, handheld instrument, refractometer); Sampling locations have changed over time; Methods have remained consistent
Future plan for program: Anticipate adding new parameters, changing locations, and tweaking some of the existing methodology

Data Collection Intervals: Irregular, varies by parameter
Data Location: CBEP files - paper and digital
Data QA/QC Method: EPA-approved QAPP, generally follows the GPAC protocols for monitoring salt marsh restoration projects. Agency approved monitoring plans have been developed at three of the sites.

Data Reporting Audience: EPA, DEP, ACOE, NOAA, DOT
Data Availability: By request to CBEP
Data Reporting Frequency: Annual

Program Summary Reports Audience: Funders, Monitoring Network; Public

Program Summary Reports Public Availability: CBEP website, https://www.cascobayestuary.org/resources/publications/;
PowerPoints presented to the Casco Bay Monitoring Network on 2018 and 2019 monitoring are available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: CBEP anticipates maintaining a limited version of this program long-term.

(C-4) Casco Bay Estuary Partnership (CBEP) - Nutrients

Contact: Curtis Bohlen, curtis.bohlen@maine.edu
Website: https://www.cascobayestuary.org/
Program Description: A NuLAB high throughput nitrogen analyzer from Green Eyes in Maryland was deployed on a pier in South Portland from late June to mid-October 2019. The device was configured to collect data on nitrate + nitrite and ammonium (and thus dissolved inorganic nitrogen or DIN) every two hours. Ammonium data from 2019 were considered unreliable due to technical problems. The device was co-located with a HOBO conductivity and temperature logger. Periodic grab samples were taken to provide QA/QC checks on the instrumental results.

Monitoring Plan Priority Topic: Nutrients
Casco Bay Plan Goal: Goal 2
Habitat Type: Near Shore

Collectors: Student, Staff
Collection Method: Automated Monitoring; Grab Sample-Water
Equipment: Two channel NuLAB system for continuous aqueous detection of dissolved nitrate/nitrite and ammonia/ammonium; HOBO conductivity/temperature data logger

Principal Parameters:
Water Quality: Conductivity; Salinity; Temperature
Nutrients: Ammonia (NH3); Ammonium (NH4); Dissolved Inorganic Nitrogen (DIN); Nitrate + Nitrite
Number of Stations: 1
Monitoring Location: Portland Street Pier, South Portland

Program Start Date: June 26, 2019
Anticipated Program End Date: Equipment removed in mid-October, 2019; uncertain if/when it will be re-deployed
Program changes over time: Secure deployment location is difficult to find
Future plan for program: Uncertain

Data Collection Intervals: Every two hours
Data Location: CBEP archives
Data QA/QC Method: EPA-approved QAPP

Data Reporting Audience: CBEP partners, EPA
Data Availability: By request to Curtis Bohlen
Data Reporting Frequency: Annual

Program Summary Reports Audience: EPA, Monitoring Network, Public
Program Summary Reports Public Availability: PowerPoint presented to the Casco Bay Monitoring Network on 2019 monitoring is available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: Annual when equipment is deployed

Long Term Program Sustainability/Funding: Uncertain

(C-5) Casco Bay Estuary Partnership (CBEP) - Sediments - Discontinued

Contact: Curtis Bohlen, curtis.bohlen@maine.edu
Website: https://www.cascobayestuary.org/
Program Description: From 1991 through 2011 CBEP conducted a monitoring program to track the concentrations of certain pollutants in sediments throughout Casco Bay.

Monitoring Plan Priority Topic: Habitats
Casco Bay Plan Goals: Goal 1; Goal 4
Habitat Types: Estuary; Near Shore; Outer Bay

Collectors: Professional Staff; Contractors
Collection Method: Grab Sample-Sediment
Equipment: Ponar and VanVeen dredges; some historical shallow water samples collected by hand

Principal Parameters:

Toxics: Dioxins; Lead (Pb); Mercury (Hg); Metals; PAH; PCB; Pesticides
Sediments: Arsenic; Butyltins; Cadmium; DDT; Dioxins and Furans; Grain Size; Hydrocarbons; Lead (Pb); Mercury (Hg); Metals; PAH; PCB; Pesticides; Selenium; Silver; Total Organic Carbon (TOC); Zinc

Number of Stations: Varied by year; ~ 70 locations sampled in 2010-2011
Monitoring Locations: Sample locations were evenly distributed throughout Casco Bay and assigned to one of the following five regions in the Bay – Inner Bay; Outer Bay; West Bay; East Bay; Cape Small

Program Start Date: 1991
Anticipated Program End Date: 2011
How program has changed over time: Sample locations changed somewhat, but a large proportion remained the same. Analytic methods changed over time, with different method detection limits, etc.
Future plan for program: Program has been dropped; if it were re-started, the future plan would be to scale back on sampling, reducing number of samples and shortening the list of chemicals sought in the samples.

Data Collection Intervals: Roughly every 10 years
Data Location: CBEP archives
Data QA/QC Method: EPA QAPP. Sample locations checked, track sample custody. Field duplicates. Laboratory blanks, duplicates, spikes. Certified labs. Data by EDD. Hand check of data consistency, 100% review of data with paper records.

Data Reporting Audience: Public
Data Availability: www.cascobayestuary.org
Data Reporting Frequency: After each sampling event

Program Summary Reports Audience: Public
Program Summary Reports Public Availability: CBEP website, https://www.cascobayestuary.org/resources/publications/
Program Summary Reports Frequency: Roughly every 10 years

Long Term Program Sustainability/Funding: This program has been discontinued.

(C-6) Department of Environmental Protection (DEP) - Eelgrass

Contact: Angela Brewer, angela.d.brewer@maine.gov
Website: https://www.maine.gov/dep/water/monitoring/coastal/index.html, https://www.maine.gov/dmr/science-research/species/eelgrass/
Program Description: The eelgrass monitoring program tracks the variations in area, density, percent cover, and shoot length of three Portland-area eelgrass beds seasonally and interannually. The program additionally includes biennial summer aerial mapping of bed extent, and annually, May-October measurements of water quality parameters including nutrients, chlorophyll and suspended solids, and light availability. DEP acquired Casco Bay-wide aerial imagery most recently in June 2018. Images were interpreted and ground truthed, producing Bay-wide low tide imagery and maps of eelgrass presence and percent cover. Also occurring exclusively in 2018 was an eelgrass mapping methods comparison project, which utilized multispectral drone imagery, and side scan and multibeam sonar to test sampling scale efficiencies.

Monitoring Plan Priority Topics: Nutrients; Habitats
Casco Bay Plan Goals: Goal 1; Goal 4
Habitat Type: Near Shore

Collectors: Professional Staff, Contractors
Collection Method: Observation, Measurement, Automated Monitoring, Grab Sample-Tissue, Grab Sample-Water, Aerial Photography, Videography
Equipment: Quadrats, Transect Tapes, Underwater Cameras, Water Quality Sondes, Light Meters, Grab Sample Bottles, Secchi Disk, Georeferenced Cameras for Aerial Photography

Principal Parameters

Water Quality: Chlorophyll; Chlorophyll-A (CLA); Colored Dissolved Organic Matter (CDOM); Depth; Dissolved Oxygen; Irradiance; Salinity; Secchi Depth; Temperature; Total Suspended Solids; Turbidity
Acidification: pH
Nutrients: Ammonium (NH4); Dissolved Inorganic Nitrogen (DIN); Nitrate + Nitrite; Orthophosphate; Total Nitrogen (TN); Total Phosphorus (TP)
Biota: Eelgrass, Epiphyte
Sediment: Grain Size

Number of Stations: 3
Monitoring Locations: East End vicinity (Portland and Falmouth) - Clapboard Island; East End; Fort Gorges; Great Diamond Island (suspended); Mackworth Island (aerial and areal determination only)

Program Start Date: 2017
Anticipated Program End Date: Ongoing
Program changes over time: Aerial photography acquired in 2013, 2014, 2017, and 2018 for 4 eelgrass areas enables areal coverage calculations and % cover estimations. Three of these 4 areas were the locations of long term monitoring site establishment in 2018. In addition to on-going diver-based monitoring at the three eelgrass sites in the Portland area, anticipated program modifications in 2020 include quantification of eelgrass biomass and epiphyte, shoot stable isotope data collection, and pilot deployment of wiped irradiance loggers.
Future plan for program: See above

Data Collection Intervals: Annually (June and September), Continuous (July-Aug. index period for temperature, light)
Data Location: DEP server and DEP Environmental and Geographic Analysis Database (EGAD)
Data QA/QC Method: DEP Quality Assurance Project Plan; DEP Sampling and Analysis Plan; Eelgrass delineation is groundtruthed by diver and underwater video, areal extent and percent cover values are compared with values generated by Angela Brewer or eelgrass delineation expert, Seth Barker (retired Maine DMR)

Data Reporting Audience: DEP and externally as requested
Data Availability: Data available by request
Data Reporting Frequency: Biannually

Program Summary Reports Audience: Monitoring Network, Public
Program Summary Reports Public Availability: PowerPoints presented to the Casco Bay Monitoring Network on 2018 and 2019 monitoring are available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: Program is an agency program likely to continue, although dependent upon annual federal funding allocation.

(C-7) Department of Environmental Protection (DEP) - GulfWatch - Discontinued

Contact: James Stahlnecker, james.stahlnecker@maine.gov
Website: http://www.gulfofmaine.org/public/gulfwatch-contaminants-monitoring/
Program Description: GulfWatch was a regional chemical contaminants monitoring program, organized and administered by the Gulf of Maine Council on the Marine Environment (GOMC) since 1991. DEP's Marine Unit coordinated the Maine sampling of blue mussels (*Mytilus edulis*) to assess the types and concentrations of contaminants in the nearshore marine environment.

Monitoring Plan Priority Topic: Food Web
Casco Bay Plan Goals: Goal 1; Goal 4
Habitat Type: Rocky Shore

Collectors: Professional Staff
Collection Method: Observation; Tissue Sample
Equipment: Blue mussels were collected at low tide by hand picking. Pertinent site features were noted by visual observation. Tissue analysis occurred at contracted laboratories.

Principal Parameters
Biota: Mussels
Toxics: Dioxins; Lead (Pb); Mercury (Hg); Metals; PAH; PBDE; PCB; coplanar PCB; Pesticides; PFC
Number of Stations: 5
Monitoring Locations: Broad Cove; Fore River (outer); Portland Harbor; Presumpscot River (mouth); Royal river (mouth). MEFR is colocated with CBFRMR from SWAT.

Program Start Date: 1988
Anticipated Program End Date: GOMC has ceased funding, including sample analysis and program coordination. Samples were collected in 2014-15 by cooperating jurisdictions, who also collected NOAA Mussel Watch blue mussel samples. NOAA funded lab analysis of the Gulfwatch samples. Some jurisdictions did not collect samples in 2016, and only Maine and New Hampshire collected samples in 2017. Samples are currently archived with an eye to future funding of lab analyses. Hope to continue collaboration with NOAA Mussel Watch, although no plan is currently in place.
Program changes over time: Some emerging contaminants were added. Recent (2016) cooperative lab analysis with NOAA Mussel Watch will provide some newer analytes. Some sites shifted due to low blue mussel numbers. Tissue not analyzed from 2009-2015.
Future plan for program: Continue collaboration with NOAA Mussel Watch, if possible

Data Collection Intervals: Most stations monitored every three years
Data Location: DEP Environmental and Geographic Analysis Database (EGAD) or in raw Excel files on State server
Data QA/QC Method: DEP SOP; QAPP pending; Field data are proofed when entered into database, lab results include QA checks as required by DEP guidelines

Data Reporting Audience: DEP, occasional GW reports
Data Availability: Gulf of Maine Council on the Marine Environment webpage at http://www.gulfofmaine.org/public/gulfwatch-contaminants-monitoring/

Data Reporting Frequency: Some yearly data reports and some intermittent, more comprehensive program reviews

Program Summary Reports Audience: Public
Program Summary Reports Public Availability: Related reports are available on GOMC webpage at http://www.gulfofmaine.org/public/gulfwatch-contaminants-monitoring/data-reports/
Program Summary Reports Frequency: Some annual

Long Term Program Sustainability/Funding: Program is no longer funded by GOMC, with lab analysis paid by NOAA for the 2015 collections. There is no funding for a coordinator position to assist the program. Some future collaboration with NOAA may be possible.

(C-8) Department of Environmental Protection (DEP) - Maine Healthy Beaches

Contact: Meagan Sims, meagan.sims@maine.gov
Website: http://www.mainehealthybeaches.org/index.html (Program information)
http://www.mainecoastdata.org/public/CurrentBeachStatus.aspx
http://www.mainecoastdata.org/public/ (Historical data)
https://www.maine.gov/dep/gis/datamaps/lawb_healthy_beaches/lawb_healthy_beaches.html (geographic data on sampling locations)
Program Description: The Maine Healthy Beaches (MHB) program is a statewide, public health-focused, bacteria program with six locations in Casco Bay. Weekly samples are taken from Memorial Day to Labor Day. Factors considered in determining the health of a beach include water quality history, potential or actual sources of pollution, current conditions and water test results. Tools used for assessing conditions at a beach include routine monitoring and data analysis, a Risk Assessment Matrix, special studies, and sanitary survey work. Environmental impacts considered include nearby waste disposal, stormwater runoff, public restroom facilities, the presence of dogs or wildlife on the beach, beach usage, boating activity, etc.

Monitoring Plan Priority Topic: Nutrients
Casco Bay Plan Goals: Goal 2; Goal 4
Habitat Type: Beach

Collectors: Volunteers-General; Other
Collection Method: Grab Sample-Water; Handheld Equipment; Observation
Equipment: Whirlpak bag/tongs, refractometer, thermometer

Principal Parameters

Water Quality: Salinity; Temperature; Turbidity
Bacteria: Enterococci (Fecal coliform)

Number of Stations: 6 in Casco Bay
Monitoring Locations: East End Beach (Portland); Willard Beach (South Portland); Broad Cove Reserve (Cumberland); three monitoring sites in Harpswell, including Mackerel Cove (Harpswell); Stover Point Preserve (Harpswell); Mitchell Field Beach (Harpswell)

Program Start Date: 2002 (2 pilot beaches); 2003 in Casco Bay
Anticipated Program End Date: Ongoing; Contingent on annual grant funds issued by EPA
Program changes over time: In 2018 added three sites in Harpswell. East End Beach previously tested 3 times/week, now 2/week; Willard had 3 sample locations, now 1. Have partnered with South Portland to collect optical brighteners and other pollution source tracking parameters on Willard Beach and upland stormwater drainage network (ongoing). As of 2019, program is coordinated through the Maine Department of Environmental Protection (previously through University of Maine Cooperative Extension).
Future plan for program: No changes anticipated

Data Collection Intervals: 2/week at East End Beach, Willard Beach; 1/week at Broad Cove-Cumberland; 1/week at Mackerel Cove, Stover Point Preserve, Mitchell Field Beach
Data Location: MHB website; Maine DEP; EPA

Data QA/QC Method: EPA QAPP; Agency SOP; 3rd party lab supply testing; state lab certification and/or MHB QA/QC lab checklist; field/lab equipment routine testing; field/lab duplicates; relative % difference calculation; annual field/lab trainings; observation/follow-up trainings; SOPs, etc.

Data Reporting Audience: Public; Maine DEP; EPA
Data Availability: MHB website; Maine DEP; EPA. All data is current and available to the public. At the DEP website, data can be requested from EGAD. Downloads in a more user friendly format can be made by the public by request to the contact person.
http://www.mainecoastdata.org/public/ (Historical data)
https://www.maine.gov/dep/gis/datamaps/lawb_healthy_beaches/lawb_healthy_beaches.html (geographic data on sampling locations)
Data Reporting Frequency: Annual

Program Summary Reports Audience: EPA, Maine DEP, Monitoring Network, Public
Program Summary Reports Public Availability: http://www.mainehealthybeaches.org/resources.html
PowerPoint presented to the Casco Bay Monitoring Network on 2019 monitoring is available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: Program is a regular agency program closely tied to public health, and so is likely to continue-contingent on annual grant funds issued by EPA.

(C-9) Department of Environmental Protection (DEP) - Marine water quality

Contact: Angela Brewer, angela.d.brewer@maine.gov
Website: https://www.maine.gov/dep/water/monitoring/coastal/index.html
Program Description: Maine DEP's Marine Unit implements water quality monitoring under the Clean Water Act and state law, in order to identify those waters that do not meet their water quality classifications. Maine's Marine Environmental Monitoring Program (MEMP) was established in 1991 to monitor the "extent and effect of industrial contaminants and pollutants on marine and estuarine ecosystems and to determine compliance with and attainment of water quality standards." Monitoring efforts are focused on ambient water quality, nutrients, and eutrophication indicators, in particular near wastewater discharges.

Monitoring Plan Priority Topic: Nutrients
Casco Bay Plan Goals: Goal 2; Goal 4
Habitat Types: Estuary; Head of Tide; Near Shore; Outer Bay; Riverine

Collectors: Professional Staff, Contractors
Collection Method: Observation; Handheld Equipment; Automated Monitoring; Grab Sample-Water; Sediment; Benthic Fauna; Periphyton Sampling
Equipment: Water quality sondes, light meters, Secchi disk, Van Dorn sampler and bucket-water; Ponar grab and sieves-sediment

Principal Parameters

Water Quality: Chlorophyll; Chlorophyll A (CHLA); Colored Dissolved Organic Matter (CDOM); Conductivity; Depth; Dissolved Oxygen; Irradiance; Salinity; Secchi Depth; Temperature; Total Suspended Solids; Turbidity
Acidification: pH
Nutrients: Ammonia (NH3); Ammonium (NH4); Dissolved Inorganic Nitrogen (DIN); Nitrate + Nitrite; Orthophosphate; Total Nitrogen (TN); Total Phosphorus (TP)
Biota: Infauna

Number of Stations: Variable depending on year
Monitoring Locations: Anthoine Creek, Broad Cove; Cousins Island; Cousins River; Fore River; Great Diamond Island; Harraseeket River; International Seafood Trading; Little Chebeague Island; Littlejohn Island; Long Creek; Mackworth Island; Maquoit Bay; Mussel Cove; Potts Harbor; Presumpscot River; Presumpscot River Estuary; Quahog Bay; Reed Cove; Royal River Estuary; Royal River; Simonton Cove; Simpsons Point; Trout Brook; Walton Park; Widgeon Cove

Program Start Date: 1995
Anticipated Program End Date: Ongoing
Program changes over time: Unattended sonde and light attenuation data collection, total suspended solids, and Colored Dissolved Organic Matter (CDOM) were added in 2015, 2016, and 2020, respectively. Sampling locations vary on an annual basis depending on the need, with priority given to locations with proximity to wastewater outfalls. Addition of benthic grab sampling for infaunal composition and quantification is anticipated to begin in 2020 on a pilot study basis.
Future plan for program: Possible addition of long term monitoring sites, benthic infauna characterizations, ocean acidification parameters, sediment particle size analysis

Data Collection Intervals: May-October, frequency dependent on project

Data Location: DEP server and DEP Environmental and Geographic Analysis Database (EGAD)
Data QA/QC Method: DEP Quality Assurance Project Plan and EGAD

Data Reporting Audience: EPA, external organizations and public (as requested)
Data Availability: Raw data available
Data Reporting Frequency: Biannual, variable depending on requests

Program Summary Reports Audience: EPA, Monitoring Network, Public
Program Summary Reports Public Availability: Reporting atypical but raw data available. DEP summarizes attainment/impairment information based on raw data in biennial report to EPA (Integrated Water Quality Monitoring and Assessment Report)
PowerPoints presented to the Casco Bay Monitoring Network on 2018 and 2019 monitoring are available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: Biannual

Long Term Program Sustainability/Funding: Program is an agency program that is likely to continue, although dependent upon annual federal funding allocation. Presence in Casco Bay is largely dependent upon increase in future staff resources and wastewater licensing needs.

(C-10) Department of Environmental Protection (DEP) - Surface Water Ambient Toxics (SWAT)

Contact: James Stahlnecker, james.stahlnecker@maine.gov
Website: https://www.maine.gov/dep/water/monitoring/toxics/swat/index.htm
Program Description: Maine's Surface Water Ambient Toxics monitoring program was established in 1993 to determine the nature, scope and severity of toxic contamination in the surface waters and fisheries of the State. DEP's Marine Unit monitors for the presence of toxic contaminants in tissues from softshell clams (*Mya arenaria*), blue mussels (*Mytilus edulis*), and lobster (*Homarus americanus*), among other species. Sites are resampled based on prior results of concern or from sites not sampled in many years. Sampling of new analytes and various matrices can complicate the results.

Monitoring Plan Priority Topic: Habitats
Casco Bay Plan Goals: Goal 1; Goal 2; Goal 4
Habitat Types: Rocky Shore; Tidal Flats

Collectors: Professional Staff
Collection Method: Tissue sample
Equipment: Bivalves are hand collected, with lobsters trapped in traditional pots

Principal Parameters

Biota: Clams-softshell; Lobsters; Mussels
Toxics: Dioxins/furans; Metals including Lead (Pb) and Mercury (Hg); PAH; PBDE; PCB; coplanar PCB; Pesticides; PFC

Number of Stations: 24 stations for blue mussels, 6 for softshell clams, multiple lobster collection stations over several years (roughly 5-year intervals, and 2016 and 2018)
Monitoring Locations: Back Bay; Great Diamond Island Cocktail Cove & southwest end; Cousins Island thoroughfare; DMR Lobster Management Zones; East End Beach; Falmouth anchorage; Falmouth flats; Fore River (inner, middle, outer), Harraseeket River; Jewel Island punchbowl; Little River; Long Island; Maquoit Bay; Mare Brook/Harpswell Cove; Middle Bay (outer); Mill Creek; Navy pier; Presumpscot River (mouth); Quahog Bay; Royal River (mouth); Spring Point South Portland; Strawberry Creek
Monitoring Locations for blue mussels by year:

2011: East End Beach & Mill Creek
2012: Spring Point & Scarborough River
2013: East End Beach
2014: Mill Creek & Mare Brook
2015-2016: East End Beach, Spring Point, Scarborough River & Mare Brook
2017-2018: Mill Creek & East End Beach
2019-2020: East End Beach, Outer Fore River, Middle Fore River, Inner Fore River, Presumpscot River, Back Cove, Long Island, Royal River, Cousins Island Thorofare

Program Start Date: 1988
Anticipated Program End Date: Ongoing
Program changes over time: Blue mussels remain a centerpiece, with softshell clams, lobsters, sediments, and cormorants also sampled less frequently. Newer suites of analytes have been examined through the years, including PFCs, PBDEs, several groups of pesticides.
Future plan for program: New matrices (species or tissue types) and analytes will be investigated as needed. Lobster tissue will continue to be of great importance for toxic monitoring in the future based on human

health concerns and the market value of the fishery. Future work is likely to include lobster tissue analyses, part of a regular statewide effort, and continued blue mussel and softshell clam testing.

Data Collection Intervals: Annually, some sites every three years, some sites/matrices less frequently
Data Location: DEP Environmental and Geographic Analysis Database (EGAD)
Data QA/QC Method: DEP SOP; QAPP pending

Data Reporting Audience: Public
Data Availability: Data in EGAD database is available by request
Data Reporting Frequency: As entered in EGAD database

Program Summary Reports Audience: DEP; legislature via DEP authored report
Program Summary Reports Public Availability: DEP website for most recent years;
Reports are available at https://www.maine.gov/dep/water/monitoring/toxics/swat/index.htm
Program Summary Reports Frequency: SWAT report is now biennial

Long Term Program Sustainability/Funding: Program is a regular agency program, likely to continue.

(C-11) Department of Marine Resources (DMR) - Bacteria in marine waters

Contact: Bryant Lewis, bryant.j.lewis@maine.gov
Website: https://dmr-maine.opendata.arcgis.com/
Program Description: Data on abundance of fecal coliform bacteria in surface waters are needed to regulate shellfish growing areas to ensure that only pollution-free areas are open to harvesting. Samples are collected six times per year (with a few exceptions) based on a systematic random sampling schedule. Reopening samples are required following a two-inch "flood" closure. Water samples are analyzed by membrane filtration using mTEC media (FC/100ml).

Monitoring Plan Priority Topic: Food Web
Casco Bay Plan Goals: Goal 1; Goal 4
Habitat Types: Beach; Island; Near Shore; Rocky Shore; Shoreline; Tidal Flats

Collectors: Professional Staff; Volunteers-general
Collection Method: Grab Sample-Water
Equipment: Tongs, thermometer, compass, whirl-pak bags

Principal Parameters:
Water Quality: Salinity; Temperature
Bacteria: Fecal Coliform
Number of Stations: 150-200
Monitoring Location: Casco Bay

Program Start Date: 1950
Anticipated Program End Date: Ongoing
Program changes over time: Sampling stations can change over time particularly if areas need to be investigated for possible new pollution sources. In 2006, DMR switched from multiple tube fermentation (MPN method) to membrane filtration for testing growing area waters for fecal coliforms.
Future plan for program:

Data Collection Intervals: Weekly to monthly, based on a systematic random sampling (SRS) schedule. SRS entails scheduling sample collection a year in advance with the goal of equally spacing sampling efforts per station throughout the year to avoid biasing samples based on season, weather conditions, etc. Sampling occurs at pre-defined sampling stations.
Data Location: DMR archives; P90 for each station is available on the DMR website
Data QA/QC Method: DMR SOP. Staff member QC's bench sheets and field sheets, data entry is QC'd by another staff member, and monthly QC of data entry is also done. FDA audits files periodically.

Data Reporting Audience: Public; Town shellfish committees or by request. P90 scores are posted on DMR website for all stations.
Data Availability: Annual "P90" data (the 90th percentile of observed fecal coliform levels) are available online for years 2013 to the present at
https://gis.maine.gov/arcgis/rest/services/dmr/DMR_Public_Health_Historical_Bacteria_Data/MapServer
Raw data available by request of the program's Growing Area Supervisor. Supervisor contact information for the eastern and western Maine growing area classification programs can be found at:

https://www.maine.gov/dmr/shellfish-sanitation-management/programs/growingareas/index.html.
Data Reporting Frequency: Annual

Program Summary Reports Audience: Monitoring Network, Public
Program Summary Reports Public Availability: PowerPoints presented to the Casco Bay Monitoring Network on 2018 and 2019 monitoring are available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: Program is an agency program related to public health and shellfish harvesting, and thus likely to continue indefinitely.

(C-12) Department of Marine Resources (DMR) - Biotoxins in shellfish

Contact: Bryant Lewis, bryant.j.lewis@maine.gov
Website: https://www.maine.gov/dmr/shellfish-sanitation-management/programs/biotoxininfo.html
Program Description: The Biotoxin Monitoring Program is administered by the Department's Bureau of Public Health. It uses the standards outlined in the National Shellfish Sanitation Program (NSSP) to monitor levels of PSP-related ("Red Tide") and other marine biotoxins in the shellfish of the State of Maine. Shellfish samples are collected statewide between March and December and evaluated at the biotoxin laboratory in Boothbay Harbor. Data are then interpreted and appropriate closures are made when necessary in order to protect public health.

As of May 2014, the Biotoxin Program transitioned from the traditional mouse bioassay to a high-performance liquid chromatography (HPLC) method for detecting PSP-related biotoxins in most species of bivalve shellfish (clams, mussels, oysters). Sample processing is done through a partnership with Bigelow Laboratory for Ocean Sciences, which was successfully evaluated by the U.S. Food and Drug Administration in March 2014.

Aquaculture operations with a Memo of Understanding (MOU) with DMR receive data on conditions at their lease sites. Data on research stations are provided on a listserv regularly**.** Research stations are pre-selected sampling stations that are collected routinely for PSP and are used by external agencies for investigative purposes such as predictive modelling. Most biotoxin sampling station data is not immediately available to the public.

Monitoring Plan Priority Topic: Food Web
Casco Bay Plan Goals: Goal 1; Goal 4
Habitat Types: Near Shore; Shoreline; Tidal Flats

Collectors: Other; Professional Staff
Collection Method: Grab Sample-Water; Tissue Sample
Equipment: Water bucket, 20um sieve, 50mL test tubes for phytoplankton and hand collection/clam rakes for shellfish

Principal Parameters:

Toxics: Biotoxin; Domoic Acid (Amnesic Shellfish Poisoning); Harmful Algal Bloom (HAB); Saxitoxin or Red Tide (Paralytic Shellfish Poisoning); Okadaic Acid (Diarrhetic Shellfish Poisoning)

Number of Stations: 10-15
Monitoring Location: Casco Bay

Program Start Date: 1958
Anticipated Program End Date: Ongoing
Program changes over time: Sampling locations have changed, added phytoplankton stations from start of program
Future plan for program: If new aquaculture lease sites develop these could be added to sampling locations

Data Collection Intervals: Weekly to monthly
Data Location: DMR archives

Data QA/QC Method: DMR SOP; FDA. Our QA plan is kept on the DMR server. If any specific protocol was requested it could be provided. Bench sheets are QC'd by another staff member before analysis of samples and data entry is QC'd by staff. All documents are available for FDA periodic audits.

Data Reporting Audience: Aquaculture with an MOU receive data on their lease sites. Representative "research" stations are provided on a listserv regularly.
Data Availability: Data can be requested from DMR. A listserv provides research station results only.
Data Reporting Frequency: Monthly

Program Summary Reports Audience: Monitoring Network, Public
Program Summary Reports Public Availability: PowerPoints presented to the Casco Bay Monitoring Network on 2018 and 2019 monitoring are available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: Program is an agency program related to public health and shellfish harvesting, and thus likely to continue indefinitely.

(C-13) Department of Marine Resources (DMR) - Maine Coastal Mapping Initiative (MCMI)

Contact: Claire Enterline, claire.enterline@maine.gov
Website: https://www.maine.gov/dmr/mcp/planning/mcmi/index.htm
Program Description: The Maine Coastal Mapping Initiative (MCMI), created by the Maine Coastal Program (MCP) in 2012, acquires data about the seafloor and oceanic environment, including bathymetry (seafloor depth), sediment information, fauna type and abundance, and water column information. This hydrographic data collection program supports regional ocean planning and habitat modeling. The team characterizes substrate, biological communities, habitat and infauna at submerged glacial paleodeltas on the inner and outer continental shelf using multibeam sonar, benthic infauna analysis, and sediment surveys.

Monitoring Plan Priority Topic: Habitats
Casco Bay Plan Goals: Goal 1; Goal 4
Habitat Types: Near Shore; Outer Bay

Collectors: Professional Staff
Collection Method: Acoustics, Grab Sample-Sediment, Grab Sample-Water
Equipment: Bathymetric mapping with grab samples for sediment, water quality, and benthic fauna

Principal Parameters:

Water Quality: Chlorophyll; Conductivity; Depth; Dissolved Oxygen; Salinity; Temperature
Acidification: pH
Biota: Clams-softshell; Clams-quahog; Fish community; Mussels; Benthic Epifauna; Benthic Infauna; Species of Concern

Number of Stations: 18
Monitoring Location: Eastern Casco Bay

Program Start Date: 2014
Anticipated Program End Date: 2024
Program has changes over time: Methodology remains the same, but sample locations change each year
Future plan for program: Change in sampling locations

Data Collection Intervals: Irregular
Data Location: MCP
Data QA/QC Method: DMR SOP; BOEM and NOAA hydrographic quality survey protocols

Data Reporting Audience: NOAA, BOEM, Agency Reports, public
Data Availability: At MCP - available by request. Will be online.
Data Reporting Frequency: Annual

Program Summary Reports Audience: Monitoring Network, Public
Program Summary Reports Public Availability: PowerPoints presented to the Casco Bay Monitoring Network on 2018 and 2019 monitoring are available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: Program is an agency program, planned to continue at least five years.

(C-14) Department of Marine Resources - Rainbow smelt monitoring - Discontinued

Contact: Sean Ledwin, sean.ledwin@maine.gov
Website: https://www.maine.gov/dmr/science-research/species/smelt/index.html
Program Description: Maine, Massachusetts and New Hampshire worked together to understand rainbow smelt status and threats, and to plan a regional conservation effort for the species. Monitoring focused on the status of the smelt population and the condition of spawning areas in streams, which may be a key factor in their decline.

Monitoring Plan Priority Topic: Habitats
Casco Bay Plan Goals: Goal 1; Goal 4
Habitat Type: Head of Tide

Collectors: Professional Staff
Collection Method: Grab Sample-Water; Periphyton Sampling; Trap
Equipment: YSI sondes, water sample grab for TN/TP and metals, fyke net

Principal Parameters

Water Quality: Conductivity; Depth; Dissolved Oxygen; Salinity; Temperature; Turbidity
Acidification: pH
Nutrients: Total Nitrogen (TN); Total Phosphorus (TP)
Biota: Fish community; Rainbow smelt
Toxics: Lead (Pb); Mercury (Hg); Metals
Hydrology: Water Velocity

Number of Stations: 18
Monitoring Location: Eastern Casco Bay

Program Start Date: 2008
Anticipated Program End Date: 2015
Program changes over time: Added one location in 2009
Future plan for program: Discontinued

Data Collection Intervals: Daily March-June
Data Location: DMR
Data QA/QC Method: DMR SOP; Standardized methodology adopted by regional monitoring group (http://www.mass.gov/eea/docs/dfg/dmf/publications/tr-42.pdf)

Data Reporting Audience: NOAA, public
Data Availability: http://www.maine.gov/dmr/science-research/species/smelt/index.html
Data Reporting Frequency: One time report, on demand

Program Summary Reports Audience:
Program Summary Reports Public Availability:
Program Summary Reports Frequency:

Long Term Program Sustainability/Funding: This program has been discontinued.

(C-15) Department of Marine Resources (DMR) - Rainbow smelt presence - Discontinued

Contact: Sean Ledwin, sean.ledwin@maine.gov
Website: https://www.maine.gov/dmr/science-research/species/smelt/index.html
Program Description: Monitoring focused on the presence or absence of the smelt population

Monitoring Plan Priority Topic: Habitats
Casco Bay Plan Goals: Goal 1; Goal 4
Habitat Type: Head of Tide

Collectors: Volunteers-trained
Collection Method: Observation
Equipment: Observation

Principal Parameters
Biota: Rainbow smelt; Species of concern
Number of Stations: ~30
Monitoring Location: Casco Bay

Program Start Date: 2005
Anticipated Program End Date: 2010
Program changes over time: Locations monitored sporadically for presence/absence
Future plan for program: There is interest in renewing the presence/absence surveys

Data Collection Intervals: Irregular March-June
Data Location: http://maine.gov/dacf/mcp/environment/streamviewer/index.htm
Data QA/QC Method: Volunteer guidance; Spot checks by DMR biologist

Data Reporting Audience: DMR, Maine Stream Connectivity Work Group
Data Availability: Spatial data mapped through:
http://maine.gov/dacf/mcp/environment/streamviewer/index.htm
Data Reporting Frequency: Every ten years

Program Summary Reports Audience:
Program Summary Reports Public Availability:
Program Summary Reports Frequency:

Long Term Program Sustainability/Funding: This program has been discontinued but there is interest in renewing the presence/absence surveys.

(C-16) Friends of Casco Bay (FOCB) - Bay water quality & Acidification, Continuous

Contact: Mike Doan, mdoan@cascobay.org
Website: https://www.cascobay.org/our-work/science/continuous-monitoring-station/
Program Description: FOCB maintains an unattended continuous water quality monitoring station in Casco Bay at Cousins Island in class SB water. High frequency data (hourly) are collected at the site to detect how climate change and other coastal stressors may (or may not) be affecting the Bay. The sensors are housed in a lobster trap, called "The Cage of Science," attached to a pier. Grab samples are collected periodically to measure nutrient concentrations. FOCB anticipates expanding continuous monitoring to additional locations as funding becomes available.

Monitoring Plan Priority Topic: Nutrients
Casco Bay Plan Goals: Goal 2; Goal 4
Habitat Type: Outer Bay

Collectors: Professional staff
Collection Method: Automated Monitoring; Grab Sample-Water
Equipment: YSI data sonde, C-Sense pCO2 sensor, water samples for nutrients

Principal Parameters

Water Quality: Chlorophyll-A (CLA); Chlorophyll Fluorescence; Dissolved Oxygen; Salinity; Secchi Depth; Temperature; Turbidity
Acidification: Carbon Dioxide Partial Pressure (PCO2); Dissolved Inorganic Carbon (DIC); Omega Aragonite; pH; Total Alkalinity
Nutrients: Ammonium (NH4); Nitrate + Nitrite; Total Nitrogen (TN)

Number of Stations: 1
Monitoring Location: Cousins Island

Program Start Date: 2016
Anticipated Program End Date: Ongoing
Program changes over time: None
Future plan for program: The Cousins Island program will continue indefinitely, and additional stations in Portland Harbor and Eastern Casco Bay will be deployed.

Data Collection Intervals: Hourly
Data Location: FOCB server
Data QA/QC Method: EPA QAPP; frequent calibration and maintenance of equipment

Data Reporting Audience: CBEP; public
Data Availability: By request to FOCB; daily and monthly means graphs are produced regularly and uploaded to the FOCB website, www.cascobay.org
Data Reporting Frequency: Annual

Program Summary Reports Audience: Monitoring Network, Public
Program Summary Reports Public Availability: PowerPoints presented to the Casco Bay Monitoring Network on 2018 and 2019 monitoring are available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/

Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: FOCB is committed to long-term monitoring of water quality in Casco Bay. Scope and extent of the program may depend on available funding. Casco Bay Estuary Partnership plans to continue providing funding to this program.

(C-17) Friends of Casco Bay (FOCB) - Bay water quality & Nutrients, Seasonal

Contact: Mike Doan, mdoan@cascobay.org
Website: https://www.cascobay.org/seasonal-sampling-across-casco-bay/
Program Description: FOCB conducts seasonal water quality monitoring of nitrogen levels and ancillary parameters in Casco Bay. Staff conducts water column profile trips to 8 sites using FOCB's boat and conducts land-based monitoring at 14 sites. Seasonal monitoring takes place every few weeks from April through October.

Monitoring Plan Priority Topic: Nutrients
Casco Bay Plan Goals: Goal 2; Goal 4
Habitat Types: Estuary; Outer Bay

Collectors: Professional Staff
Collection Method: Automated Monitoring; Grab Sample-Water
Equipment: YSI data sonde, sample jar, Secchi disk

Principal Parameters

Water Quality: Conductivity; Depth; Dissolved Oxygen; Salinity; Secchi Depth; Temperature
Acidification: pH
Nutrients: Ammonium (NH4); Dissolved Inorganic Nitrogen (DIN); Nitrate + Nitrite; Orthophosphate; Silicate; Total Nitrogen (TN)

Number of Stations: 22
Monitoring Locations: Profile sites include the Fore River, Portland's East End, head of tide in the Presumpscot River, the New Meadows River, the Harraseeket River, and several off shore sites. Land-based sites are along the coast from South Portland to Harpswell.

Program Start Date: 1992
Anticipated Program End Date: Ongoing
Program changes over time: Formerly some land-based monitoring was conducted by volunteers as part of FOCB's Citizen Scientists monitoring program. With move to professional staff only, the number of sampling locations was reduced by roughly half, but the overall data accuracy is improved and the number of measured parameters has increased.
Future plan for program: This program will continue indefinitely

Data Collection Intervals: Every 3-4 weeks May to October
Data Location: FOCB server
Data QA/QC Method: EPA QAPP; frequent calibration

Data Reporting Audience: Maine DEP; CBEP; Public
Data Availability: FOCB website. Data is uploaded to mapping tool a few days after each sampling event.
Data Reporting Frequency: Annually to Maine DEP; as available to the public

Program Summary Reports Audience: Public, Monitoring Network
Program Summary Reports Public Availability: CBEP website, https://www.cascobayestuary.org/resources/publications/;

PowerPoints presented to the Casco Bay Monitoring Network on 2018 and 2019 monitoring are available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: 1993-2007

Long Term Program Sustainability/Funding: FOCB is committed to long-term monitoring of water quality in Casco Bay. Scope and extent of the program may depend on available funding.

(C-18) Gulf of Maine Research Institute (GMRI) - Casco Bay Aquatic System Survey (CBASS) - Acoustic fish survey

Contact: Graham Sherwood, gsherwood@gmri.org
Website: https://www.gmri.org/our-work/research/projects/casco-bay-aquatic-system-survey
Program Description: Acoustic transducers provide detailed information on fish schools and plankton abundance along a 45 mile long zig-zag transect in outer Casco Bay. Acoustic transducers are sophisticated, recording versions of the "depth sounders" or "fish finders" used by recreational boaters. The transducers emit sound waves towards the seabed and record the echoes reflected back by organisms in the water column. The data are used to monitor fish and zooplankton biomass, spatial and temporal variation in schooling behavior, and spawning ground identification. The survey monitors fish out to four miles offshore.

Monitoring Plan Priority Topic: Food Web
Casco Bay Plan Goals: Goal 3; Goal 4
Habitat Types: Near Shore; Outer Bay

Collectors: Graduate Students, Professional Staff, Students
Collection Method: Acoustics
Equipment: Simrad acoustics

Principal Parameters
Biota: Fish community
Number of Stations:
Monitoring Location: Western Casco Bay

Program Start Date: 2014
Anticipated Program End Date: Although program is expected to continue until 2024, it was last conducted in 2015
Program changes over time: No changes
Future plan for program: No changes

Data Collection Intervals: June to September biweekly
Data Location: GMRI website
Data QA/QC Method: This is a different question for acoustics and fish monitoring than it is for water quality monitoring

Data Reporting Audience: Public
Data Availability: GMRI website
Data Reporting Frequency: Annual

Program Summary Reports Audience: Monitoring Network, Public
Program Summary Reports Public Availability: PowerPoints presented to the Casco Bay Monitoring Network on 2018 and 2019 monitoring are available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: GMRI is committed to continuing the monitoring program through 2024. Scope of monitoring may depend on future levels of funding.

(C-19) Gulf of Maine Research Institute (GMRI) - Casco Bay Aquatic System Survey (CBASS) - Alewives in Presumpscot River

Contact: Graham Sherwood, gsherwood@gmri.org
Website: https://www.gmri.org/our-work/research/projects/casco-bay-aquatic-system-survey
Program Description: Sampling alewife at the lower falls of the Presumpscot River to monitor timing of migrations and energetic condition of migrating fish. Data collected includes information on length, weight, and age of in-migrating adult alewives during the spring spawning migration.

Monitoring Plan Priority Topic: Habitats
Casco Bay Plan Goals: Goal 1; Goal 4
Habitat Types: Freshwater; Riverine

Collectors: Graduate Students, Professional Staff, Students
Collection Method: Handheld equipment
Equipment: Cast net, dip net, thermometer

Principal Parameters
Water Quality: Temperature
Biota: Alewives
Number of Stations: 1
Monitoring Location: Presumpscot River at lower falls

Program Start Date: 2014
Anticipated Program End Date: 2024
Program changes over time: No changes
Future plan for program: No changes

Data Collection Intervals: Mid-May to mid-June, few times a week
Data Location: GMRI website
Data QA/QC Method: This is a different question for acoustics and fish monitoring than it is for water quality monitoring

Data Reporting Audience: Public
Data Availability: GMRI website
Data Reporting Frequency: Annual

Program Summary Reports Audience: Monitoring Network, Public
Program Summary Reports Public Availability: PowerPoints presented to the Casco Bay Monitoring Network on 2018 and 2019 monitoring are available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: GMRI is committed to continuing the monitoring program through 2024. Scope of monitoring may depend on future levels of funding.

(C-20) Gulf of Maine Research Institute (GMRI) - Casco Bay Aquatic System Survey (CBASS) - Beach seine fish survey

Contact: Graham Sherwood, gsherwood@gmri.org
Website: https://www.gmri.org/our-work/research/projects/casco-bay-aquatic-system-survey
Program Description: GMRI manages beach seining efforts at various locations around the Bay to describe very nearshore fish community structure and dynamics. The nearshore fish community includes forage fish as well as juveniles and occasional adults of commercially important species. In 2020 GMRI began working with ME-eDNA, a multi-institutional collaboration led by the University of Maine to build capacity for eDNA (environmental DNA) research, by leveraging seine and river sampling results to help validate eDNA signals.

Monitoring Plan Priority Topic: Food Web
Casco Bay Plan Goals: Goal 3; Goal 4
Habitat Types: Estuary; Near Shore; Tidal Flats

Collectors: Graduate Students, Professional Staff, Students
Collection Method: Seine
Equipment: 150 foot by 6 foot beach seine

Principal Parameters
Biota: Fish community; Shellfish
Number of Stations: 14 seine sites
Monitoring Location: Western Casco Bay

Program Start Date: 2014
Anticipated Program End Date: 2024
Program changes over time: No changes
Future plan for program: No changes

Data Collection Intervals: June to September biweekly
Data Location: GMRI website
Data QA/QC Method: This is a different question for acoustics and fish monitoring than it is for water quality monitoring

Data Reporting Audience: Public
Data Availability: GMRI website
Data Reporting Frequency: Annual

Program Summary Reports Audience: Monitoring Network, Public
Program Summary Reports Public Availability: PowerPoints presented to the Casco Bay Monitoring Network on 2018 and 2019 monitoring are available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: GMRI is committed to continuing the monitoring program through 2024. Scope of monitoring may depend on future levels of funding.

(C-21) Gulf of Maine Research Institute (GMRI) - Casco Bay Aquatic System Survey (CBASS) - Jig groundfish survey

Contact: Graham Sherwood, gsherwood@gmri.org
Website: https://www.gmri.org/our-work/research/projects/casco-bay-aquatic-system-survey
Program Description: A random jig fishing survey is carried out every two weeks during the summer months in waters in and adjacent to the Bay. The survey monitors relative abundance and distribution of commercially and ecologically important groundfish (e.g. cod). Data collected includes information on species, number, age, size, and condition of captured fish.

Monitoring Plan Priority Topic: Food Web
Casco Bay Plan Goals: Goal 3; Goal 4
Habitat Types: Outer Bay

Collectors: Graduate Students, Professional Staff, Students
Collection Method: Jig
Equipment: Hook-and-line

Principal Parameters
Biota: Fish community
Number of Stations: 20 jig sites
Monitoring Location: Western Casco Bay

Program Start Date: 2014
Anticipated Program End Date: Although program is expected to continue until 2024, it is being conducted sporadically
Program changes over time: No changes
Future plan for program: No changes

Data Collection Intervals: June to September biweekly
Data Location: GMRI website
Data QA/QC Method: This is a different question for acoustics and fish monitoring than it is for water quality monitoring

Data Reporting Audience: Public
Data Availability: GMRI website
Data Reporting Frequency: Annual

Program Summary Reports Audience: Monitoring Network, Public
Program Summary Reports Public Availability: PowerPoints presented to the Casco Bay Monitoring Network on 2018 and 2019 monitoring are available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: GMRI is committed to continuing the monitoring program through 2024. Scope of monitoring may depend on future levels of funding.

(C-22) Gulf of Maine Research Institute (GMRI) - Casco Bay Aquatic System Survey (CBASS) - Oceanographic survey

Contact: Graham Sherwood, gsherwood@gmri.org
Website: https://www.gmri.org/our-work/research/projects/casco-bay-aquatic-system-survey
Program Description: The CBASS oceanographic survey collects basic physical parameters of seawater and information on zooplankton abundance and composition.

Monitoring Plan Priority Topics: Nutrients; Food Web
Casco Bay Plan Goals: Goal 2; Goal 4
Habitat Types: Near Shore; Outer Bay

Collectors: Graduate Students, Professional Staff, Students
Collection Method: CTD probe
Equipment: CTD probe

Principal Parameters

Water Quality: Conductivity; Depth; Temperature
Biota: Zooplankton

Number of Stations: 3 CTD sites
Monitoring Location: Western Casco Bay

Program Start Date: 2014
Anticipated Program End Date: 2024
Program changes over time: No changes
Future plan for program: No changes

Data Collection Intervals: 3-4 times/summer
Data Location: GMRI website
Data QA/QC Method: This is a different question for acoustics and fish monitoring than it is for water quality monitoring

Data Reporting Audience: Public
Data Availability: GMRI website
Data Reporting Frequency: Annual

Program Summary Reports Audience: Monitoring Network, Public
Program Summary Reports Public Availability: PowerPoints presented to the Casco Bay Monitoring Network on 2018 and 2019 monitoring are available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: GMRI is committed to continuing the monitoring program through 2024. Scope of monitoring may depend on future levels of funding.

(C-23) Gulf of Maine Research Institute - (GMRI) - Casco Bay Aquatic System Survey (CBASS) - Temperature & Dissolved Oxygen

Contact: Graham Sherwood, gsherwood@gmri.org
Website: https://www.gmri.org/our-work/research/projects/casco-bay-aquatic-system-survey
Program Description: Monitoring of temperature using automated data loggers, and dissolved oxygen, and relationship between the two.

Monitoring Plan Priority Topic: Nutrients
Casco Bay Plan Goals: Goal 2; Goal 4
Habitat Types: Beach; Estuary; Island; Near Shore; Rocky Shore; Shoreline; Tidal Flats

Collectors: Graduate Students, Professional Staff, Students
Collection Method: Automated Monitoring, Handheld Equipment
Equipment: HOBO T-loggers

Principal Parameters
Water Quality: Dissolved Oxygen; Temperature
Number of Stations: 7 Hobo sites
Monitoring Location: Western Casco Bay

Program Start Date: 2014
Anticipated Program End Date: 2024
Program changes over time: No changes
Future plan for program: No changes

Data Collection Intervals: Biweekly
Data Location: GMRI website
Data QA/QC Method: This is a different question for acoustics and fish monitoring than it is for water quality monitoring

Data Reporting Audience: Public
Data Availability: GMRI website
Data Reporting Frequency: Annual

Program Summary Reports Audience: Monitoring Network, Public
Program Summary Reports Public Availability: PowerPoints presented to the Casco Bay Monitoring Network on 2018 and 2019 monitoring are available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: GMRI is committed to continuing the monitoring program through 2024. Scope of monitoring may depend on future levels of funding.

(C-24) Gulf of Maine Research Institute (GMRI) - Casco Bay Aquatic System Survey (CBASS) - Trap survey

Contact: Graham Sherwood, gsherwood@gmri.org
Website: https://www.gmri.org/our-work/research/projects/casco-bay-aquatic-system-survey
Program Description: Trapping efforts to further describe fish and invertebrate communities from the point of view of a lobster trap.

Monitoring Plan Priority Topic: Food Web
Casco Bay Plan Goals: Goal 3; Goal 4
Habitat Types: Beach; Estuary; Island; Near Shore; Rocky Shore; Shoreline; Tidal Flats

Collectors: Graduate Students, Professional Staff, Students
Collection Method: Trap
Equipment: Trap

Principal Parameters
Biota: Fish community; shellfish
Number of Stations: 5 trap sites – Alewife Cove, Great Diamond Island, Mackworth Island, Mussel Cove, Willard Beach
Monitoring Location: Western Casco Bay

Program Start Date: 2014
Anticipated Program End Date: 2024
Program changes over time: No changes
Future plan for program: No changes

Data Collection Intervals: Biweekly
Data Location: GMRI website
Data QA/QC Method: This is a different question for acoustics and fish monitoring than it is for water quality monitoring

Data Reporting Audience: Public
Data Availability: GMRI website
Data Reporting Frequency: Annual

Program Summary Reports Audience: Monitoring Network, Public
Program Summary Reports Public Availability: PowerPoints presented to the Casco Bay Monitoring Network on 2018 and 2019 monitoring are available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: GMRI is committed to continuing the monitoring program through 2024. Scope of monitoring may depend on future levels of funding.

(C-25) Lakes Environmental Association (LEA) - Lakes and Ponds

Contact: Colin Holme, colin@mainelakes.org
Website: www.mainelakes.org
Program Description: Routine and advanced lake and pond monitoring.

Monitoring Plan Priority Topic: Nutrients
Casco Bay Plan Goals: Goal 2; Goal 4
Habitat Type: Lake

Collectors: Students; Professional Staff; Volunteers-General
Collection Method: Automated Monitoring; Grab Sample-Sediment; Grab Sample-Water; X Handheld Equipment; Observation
Equipment:

Principal Parameters:

Water Quality: Chlorophyll-A (CLA); Chlorophyll Fluorescence; Clarity; Color; Conductivity; Depth; Dissolved Oxygen; Secchi depth; Temperature; Turbidity
Acidification: pH; Total Alkalinity
Nutrients: Program has the capability to do Nitrogen but we have not done it yet.
Biota: Program has done algae monitoring in the past but not in 2019 or 2020
Toxics: Mercury (Hg): Program has done mercury in fish tissue in the past and currently collects Mercury in precipitation via NADP site

Number of Stations: 41 lakes, 2 have three regular monitoring sites, some studies go beyond the monitoring sites
Monitoring Location:

Program Start Date: 1970-1995
Anticipated Program End Date: Ongoing
Program changes over time: Some
Future plan for program: Add more biological monitoring, more shoreline monitoring

Data Collection Intervals: Varies - larger lakes (around 22) every two weeks, smaller lakes annually, other monitoring depends on the project
Data Location:
Data QA/QC Method: In-house, DEP and Lake Stewards of Maine

Data Reporting Audience: Members, Public
Data Availability: By request
Data Reporting Frequency: Annual

Program Summary Reports Audience: Public, Town officials, Lake associations
Program Summary Reports Public Availability: Sent to town officials and lake associations, available on-line
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: Members

(C-26) Long Creek Watershed Management District (LCWMD) - Stream

Contact: Peter Carney, pcarney@restorelongcreek.org
Website: www.restorelongcreek.org
Program Description: Comprehensive stream monitoring program in an urbanized stream. A combination of continuous monitoring, grab samples, and short term investigations evaluate water quality measuring both chemical and biological parameters. The program evaluates water quality conditions in Long Creek in accordance with the Long Creek Watershed Management Plan, to guide future management actions.

Monitoring Plan Priority Topic: Nutrients
Casco Bay Plan Goal: Goal 2
Habitat Types: Freshwater stream

Collectors: Professional staff
Collection Method: Grab samples, continuous monitoring, hydrology and flow, "rock basket" biological monitoring
Equipment: Sondes, sample bottles

Principal Parameters

Water Quality: Chlorides; Conductivity; Dissolved Oxygen; Hardness, Percent Saturation; Temperature
Nutrients: Phosphorus
Biota: Stream invertebrate community; Fish
Toxics: Metals
Hydrology: Water Level; Discharge

Number of Stations: Six "primary monitoring locations" plus supplementary data from ten other sites
Monitoring Location: Long Creek

Program Start Date: 2010
Anticipated Program End Date: Ongoing
Program change over time: Monitoring design has shifted to reduce collection of data that has proven uninformative, such as data on presence of organic contaminants.
Future plan for program:

Data Collection Intervals: Continuous data collection except during winter; multiple grab samples annually, under different flow conditions
Data Location: Long Creek Watershed Management District, and LCWMD monitoring contractor
Data QA/QC Method: QAPP

Data Reporting Audience: Long Creek Watershed Management District stakeholders, including participating landowners
Data Availability: Data available to the public by request
Data Reporting Frequency: Annual

Program Summary Reports Audience: Long Creek Watershed Management District stakeholders, including participating landowners
Program Summary Reports Public Availability: Summaries available online via Annual Meeting Presentations
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: Program is funded by participating landowners through the Long Creek Watershed Management District. Expansion of monitoring beyond permit requirements would require external funding.

(C-27) Portland Water District (PWD) - Sebago Lake

Contact: Nate Whalen: nwhalen@pwd.org
Website: https://www.pwd.org/lake-water-quality
Program Description: Classical lake monitoring

Monitoring Plan Priority Topic: Nutrients
Casco Bay Plan Goals: Goal 2; Goal 4
Habitat Type: Lake

Collectors: Professional Staff
Collection Method: Handheld Equipment
Equipment: YSI Pro ODO meter, core tube, Secchi disk

Principal Parameters:

Water Quality: Chlorophyll-A (CLA); Clarity; Depth; Dissolved Oxygen; Secchi depth; Temperature
Nutrients: Total Phosphorus (TP)

Number of Stations: 3
Monitoring Location: Deep Basins of Sebago Lake (Big Bay, Jordan Bay, Lower Bay)

Program Start Date: Spring 1976
Anticipated Program End Date: None
Program changes over time: Sample locations have been added and removed
Future plan for program: Maintain existing program

Data Collection Intervals: Once per month from April to October
Data Location: PWD server
Data QA/QC Method: Lake Stewards of Maine yearly certification; Samples analyzed in State certified laboratory

Data Reporting Audience: Public
Data Availability: Public information, online
Data Reporting Frequency: Annual report

Program Summary Reports Audience: Public
Program Summary Reports Public Availability: Public information, online
Program Summary Reports Frequency: Annual report

Long Term Program Sustainability/Funding: Water quality conditions in the lake show cyclical changes over time with a stable trend since 1976.

(C-28) Portland Water District (PWD) - Sebago Lake tributaries

Contact: Kirsten Ness, kness@pwd.org
Website: www.pwd.org
Program Description: Monthly monitoring program that samples 11 tributaries that drain to Sebago Lake. In a separate program, the Crooked, Northwest, and Muddy Rivers are monitored yearly for aquatic insects.

Monitoring Plan Priority Topic: Nutrients
Casco Bay Plan Goals: Goal 2; Goal 4
Habitat Types: Fresh water; Stream

Collectors: Professional Staff
Collection Method: Grab Sample-Water
Equipment: Sampling "dipper" used to lower sample bottles into tributary. Samples collected monthly in 500ml sterile bottles for turbidity and *E. coli* bacteria. Acid washed glass flasks are used to collected total phosphorus samples 4 times per year (April, June, August, and October).

Principal Parameters:

Water Quality: Turbidity
Nutrients: Total Phosphorus (TP)
Biota: Insects
Bacteria: *E. coli*

Number of Stations: 11
Monitoring Locations: Tributaries - Muddy River, Northwest River, Panther Run, Rich Mill outlet, Saint Joe's stream, Sebago Lake State Park, Smith Mill, Songo River, Standish Brook, Sticky River, 1952 Brook
Aquatic insects - Crooked River, Northwest River, Muddy River

Program Start Date: Ongoing
Anticipated Program End Date: Ongoing
Program changes over time: None planned at the current time
Future plan for program: Plan to continue monitoring as we currently are

Data Collection Intervals: Monthly for turbidity and *E. coli*, 4 times per year for total phosphorus (April, June, August, and October)
Data Location: PWD Hach WIMS Database
Data QA/QC Method: Samples analyzed by PWD state certified laboratory

Data Reporting Audience: PWD staff, Public
Data Availability: Available upon request
Data Reporting Frequency: Internally distributed to staff monthly, summarized for the general public annually

Program Summary Reports Audience: Public
Program Summary Reports Public Availability: https://www.pwd.org/lake-water-quality
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: Program has been in existence since 1977 and continues to be funded in PWD's annual operating budget.

(C-29) Presumpscot Regional Land Trust (PRLT) - Presumpscot & Stroudwater Rivers

Contact: Toby Jacobs, toby@prlt.org
Website: https://www.prlt.org/
Program Description: Volunteers collect data on bacteria, dissolved oxygen, temperature and conductivity at thirty to forty locations annually on the Presumpscot River, its major tributaries, and the Stroudwater River.

Monitoring Plan Priority Topic: Nutrients
Casco Bay Plan Goals: Goal 2; Goal 3
Habitat Types: Riverine; Streams

Collectors: Volunteers
Collection Method: Grab samples, dissolved oxygen meters
Equipment: Dissolved oxygen meters

Principal Parameters

Water Quality: Conductivity; Dissolved Oxygen; Percent Saturation; Temperature

Bacteria: *E. coli* concentrations (Colony forming units per 100ml) as estimated by the MPN method

Number of Stations: 47 sites since 2009; number varies each year
Monitoring Location: Presumpscot River watershed and Stroudwater River, from river banks, bridges and other access points

Program Start Date: Prior to 2009, but data has only been retained and fully QA/QC'd since 2009
Anticipated Program End Date: Ongoing
How program has changed over time: Site selection changes; Program was run by all-volunteer Presumpscot River Watch until it merged with PRLT in 2017
Future plan for program: Continue

Data Collection Intervals: Every other Saturday from mid-May through mid-September for total of 10 sampling events
Data Location: Long-term archive with DEP's EGAD database; Also available by request from PRLT
Data QA/QC Method: Maine Volunteer River Monitoring QAPP

Data Reporting Audience: DEP; Public
Data Availability: By request from DEP or from PRLT; Available to the public in distilled/summarized form via interactive maps on the PRLT website
Data Reporting Frequency: Annual

Program Summary Reports Audience: Town officials; Natural resource professionals
Program Summary Reports Public Availability: Summaries shown on PRLT web site
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: Casco Bay Estuary Partnership has funded this program since at least the mid-2000s and plans to continue providing funding.

(C-30) University of Maine (UMaine) - Land/Ocean Biogeochemical Observatory (LOBO) buoy

Contact: Damian Brady, damian.brady@maine.edu
Website: http://maine.loboviz.com/
Program Description: UMaine provides monitoring via the Sustainable Ecological Aquaculture Network (SEANET). The buoy network consists of four Land/Ocean Biogeochemical Observatories (LOBOs), two Gulf of Maine Observing buoys, and a suite of small sensors, which are deployed in two to three estuaries per year. Each network is deployed for a year to collect environmental data during the full course of a bivalve growing season.

Monitoring Plan Priority Topic: Nutrients
Casco Bay Plan Goals: Goal 2; Goal 4
Habitat Type: Estuary

Collectors: Graduate Students; Students; Professional Staff
Collection Method: Automated Monitoring; Grab Sample-Water; Handheld Equipment
Equipment: maine.loboviz.com gives a description of the buoy data. Protocols for measuring discharge and nutrient samples for nutrient loading calculations are available upon request.

Principal Parameters

Water Quality: Chlorophyll; Chlorophyll-A (CLA); Color; Conductivity; Depth; Dissolved Oxygen; Salinity; Secchi Depth; Temperature; Turbidity
Acidification: pH
Nutrients: Ammonia (NH3); Dissolved Inorganic Nitrogen (DIN); Total Nitrogen (TN);

Number of Stations: 2
Monitoring Locations: Bombazine buoy; Sandy Cove buoy; East End

Program Start Date: 2015
Anticipated Program End Date: unknown
Program changes over time: Buoys were deployed and point samples taken in the Casco Bay region, including the New Meadows estuary during 2017. The buoy was deployed off East End beach in Portland in 2019.
Future plan for program: Some sampling may continue, particularly related nutrient loading, depending on funding

Data Collection Intervals: Irregular
Data Location: http://maine.loboviz.com/
Data QA/QC Method: Organization SOP; Buoy data does not necessarily have QAQC procedures, but data is visually inspected by graduate students for consistency, drifting measurements or erratic behavior. Samples are obtained every two weeks and compared with buoy measurements.

Data Reporting Audience: Public
Data Availability: http://maine.loboviz.com/
Data Reporting Frequency: As collected

Program Summary Reports Audience:
Program Summary Reports Public Availability:
Program Summary Reports Frequency:

Long Term Program Sustainability/Funding: CBEP may provide partial funding to continue monitoring in Casco Bay.

(C-31) University of Maine (UMaine) - Nutrients in fresh water

Contact: Damian Brady, damian.brady@maine.edu
Website:
Program Description: UMaine provides monitoring via the Sustainable Ecological Aquaculture Network (SEANET). Point samples are collected every two weeks and compared with buoy measurements.

Monitoring Plan Priority Topic: Nutrients
Casco Bay Plan Goals: Goal 2
Habitat Type: Fresh water

Collectors: Graduate Students; Students; Professional Staff
Collection Method: Grab Sample-Water, Handheld Equipment
Equipment: Protocols for measuring discharge and nutrient samples for nutrient loading calculations are available upon request

Principal Parameters

Nutrients: Ammonium (NH4); Nitrate (No3); Total Nitrogen (TN);

Number of Stations: 3
Monitoring Locations: Royal River (Grist Mill Park), Presumpscot River (Sappi Paper Mill), Nason's Brook (Capisic Pond Trail)

Program Start Date: 2015
Anticipated Program End Date: 2019
Program changes over time: Point samples were taken in the Casco Bay region during 2017
Future plan for program: May continue if buoy is deployed

Data Collection Intervals: Irregular
Data Location: http://maine.loboviz.com/
Data QA/QC Method: Organization SOP; Buoy data does not necessarily have QAQC procedures, but data is visually inspected by graduate students for consistency, drifting measurements or erratic behavior. Samples are obtained every two weeks and compared with buoy measurements.

Data Reporting Audience: Public
Data Availability: http://maine.loboviz.com/
Data Reporting Frequency:

Program Summary Reports Audience:
Program Summary Reports Public Availability:
Program Summary Reports Frequency:

Long Term Program Sustainability/Funding: CBEP may provide partial funding to continue monitoring.

(C-32) University of New Hampshire (UNH) - Ocean Acidification, Continuous

Contact: Dr. Joe Salisbury, joe.salisbury@unh.edu; Chris Hunt, chunt@unh.edu
Website: https://seagrant.unh.edu/ocean-acidification
Program Description: EPA initiated an Ocean Acidification (OA) monitoring program utilizing technically advanced equipment to support planning for climate change in Casco Bay. OA parameters are collected hourly by automated sensors, discrete pH, DIC, and alkalinity samples are collected on a monthly basis when staff manually downloads the data and cleans the equipment.

Monitoring Plan Priority Topic: Nutrients
Casco Bay Plan Goals: Goal 2; Goal 4
Habitat Types: Estuary; Near Shore

Collectors: Professional staff
Collection Method: Automated Monitoring; Grab Sample-Water
Equipment: SAMI CO2, SeaFET pH, Optode oxygen sensors, Seabird salinity

Principal Parameters

Water Quality: Dissolved Oxygen; Salinity; Temperature
Acidification: Carbon Dioxide Partial Pressure (PCO2); Dissolved Inorganic Carbon (DIC); pH; Total Alkalinity

Number of Stations: 1
Monitoring Locations: Southern Maine Community College (SMCC) pier, approximately 100 yards offshore; equipment is housed in a metal frame that sits on the bottom and equipment is about one-half meter off the bottom; water is about 20 feet deep at high tide

Program Start Date: 2015
Anticipated Program End Date: 2020
Program changes over time: No changes
Future plan for program: Unknown

Data Collection Intervals: Hourly
Data Location: UNH
Data QA/QC Method: EPA QAPP; calibration in lab and by manufacturer

Data Reporting Audience: CBEP; EPA
Data Availability: Upon request to CBEP
Data Reporting Frequency: Annual

Program Summary Reports Audience: EPA, CBEP, Monitoring Network, Public
Program Summary Reports Public Availability: PowerPoints presented to the Casco Bay Monitoring Network on 2018 and 2019 monitoring are available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: Unknown; Program funding by CBEP is being discontinued in 2020

(C-33) University of Southern Maine (USM) - Alewives in Highland Lake

Contact: Karen Wilson, karen.wilson@maine.edu; Theo Willis, theodore.willis@maine.edu
Website: http://www.highlandlakemaine.org/
Program Description: Yearly monitoring of the searun alewife spawning run in Highland Lake (Windham) in collaboration with Presumpscot Regional Land Trust (PRLT) and the Highland Lake Association. Volunteers do hand counts, and, when possible, video is used by USM to confirm hand counts.

Monitoring Plan Priority Topic: Habitats; Food Web
Casco Bay Plan Goals: Goal 1; Goal 4
Habitat Types: Fresh water; Lake; Riverine

Collectors: Volunteers-General; Since 2018, effort is coordinated by summer intern working with Drs. Wilson and Willis and PRLT; previously USM did most of the coordination of volunteers (and back up monitoring)
Collection Method: Observation; Photography/Aerial photography/Videography
Equipment:

Principal Parameters:
Water Quality: Temperature
Biota: Alewives
Number of Stations: 1
Monitoring Location: Highland Lake fish ladder, Windham

Program Start Date: 2014
Anticipated Program End Date: Hope to keep going indefinitely
Program changes over time:
Future plan for program:

Data Collection Intervals: Once per year, from approximately May 15 to June 25
Data Location: USM, shared widely
Data QA/QC Method: Video, review of volunteer datasheets

Data Reporting Audience: Highland Lake Association, DMR, volunteers
Data Availability: Shared widely
Data Reporting Frequency: Annual

Program Summary Reports Audience:
Program Summary Reports Public Availability:
Program Summary Reports Frequency:

Long Term Program Sustainability/Funding: Mostly volunteer run – usually $3000 goes toward intern; every 4 years or so need to update video equipment (~$5000). Casco Bay Estuary Partnership has funded purchases of equipment.

(C-34) Wells National Estuarine Research Reserve (Wells NERR) - Marine Invader Monitoring and Information Collaborative (MIMIC)

Contact: Jeremy Miller, jmiller@wellsnerr.org
Website: https://www.mass.gov/marine-invasive-species-program; https://www.mass.gov/service-details/story-map-of-marine-invasive-species-monitoring-data
Program Description: MIMIC (The Marine Invader Monitoring and Information Collaborative) works with citizen scientists to collect data on presence and relative abundance of selected invasive marine species along the New England Coast. The Wells NERR coordinates the MIMIC program for the State of Maine supporting volunteer coordination as well as confirming species ID and data quality. Within Casco Bay, there are eight MIMIC sites, including sites on Peaks, Chebeague, and Long Islands.

Monitoring Plan Priority Topic: Habitats
Casco Bay Plan Goals: Goal 1; Goal 4
Habitat Types: Island, Rocky Shore, Shoreline, Tide Pools

Collectors: Graduate Students, Students, Professional Staff, Volunteers-trained
Collection Method: Handheld Equipment; Observation
Equipment: Handheld refractometer, thermometer, magnifying glass, identification cards, dissecting tray, dip net

Principal Parameters

Water Quality: Salinity; Temperature
Invasives: Invasive Animals, list of species*: Botrylloides violaceus, Botryllus schlosseri, Carcinus maenas, Hemigrapsus sanguineus, Ascidiella aspersa, Styella clava, Diadumene lineata, Caprella mutica, Bugula neritina, Didemnum vexillium, Palaemon elegans, Diplosoma sp., Ostera edulis, Membranipora membranacea*
Invasive Plants, list of species: *Codium fragile, Colpomenia peregrine, Grateloupia turuturu*

Number of Stations: 9
Monitoring Locations: Chebeague stone pier; Fowler's Beach; Long Island ferry dock; Peaks Island dock; Peaks Island tidepool; Segal's Reef; SMCC dock, Spring Point Marina

Program Start Date: 2008 state wide
Anticipated Program End Date: Ongoing
Program changes over time: Sites have been added as community involvement has increased. Monitored species were updated as of 2019 to better represent potential invasive species to the region.
Future plan for program: Sites may be added as interest and time allow. Monitored species may change.

Data Collection Intervals: Once per month, May to October
Data Location: Wells NERR; MORIS - Massachusetts Ocean Resource Information System; Massachusetts Office of Coastal Zone Management; Maine iMap Invasives Portal
Data QA/QC Method: EPA QAPP; Volunteers are trained on sampling protocols and species ID. State lead (Jeremy Miller) confirms any suspect identifications with the help of the New England Aquatic Nuisance Species Panel. Refractometers are calibrated with DI every 2 months.

Data Reporting Audience: Public; Massachusetts Office of Coastal Zone Management; Maine iMap Invasives Portal

Data Availability: Data and program information are available to the public through Massachusetts Coastal Zone Management's MIMIC interface known as a "storymap." Data from 2008 through 2017 can be viewed and accessed at: https://www.mass.gov/service-details/story-map-of-marine-invasive-species-monitoring-data;
Spatial data is available on the Maine iMap Invasives Portal at https://login.imapinvasives.org/meimi/map/
Data Reporting Frequency: Annual

Program Summary Reports Audience: Monitoring Network, Public
Program Summary Reports Public Availability: PowerPoint presented to the Casco Bay Monitoring Network on 2018 monitoring is available on CBEP's website, https://www.cascobayestuary.org/casco-bay-monitoring-network-2017-programs/
Program Summary Reports Frequency: Annual

Long Term Program Sustainability/Funding: Future monitoring in Maine depends on the ability of the Wells National Estuarine Research Reserve to provide staff support. Casco Bay Estuary Partnership plans to continue providing funding to this program to support monitoring in Casco Bay.

Appendix B. REPORTS AVAILABLE ON CBEP'S WEBSITE

The following reports are available by searching Publications on the Resources dropdown of CBEP's website, https://www.cascobayestuary.org/resources/publications/

They are also available at the University of Southern Maine Library's Digital Commons website, https://digitalcommons.usm.maine.edu/

In the Monitoring Plan, references to these reports are indicated by (W-capital letter.number.lower case letter), for example (W-B.1.a.) refers to B. Habitats 1. Clam flats a. Friends of Casco Bay 2013 Casco Bay clam flat pH study.

Not all reports listed in Appendix B are mentioned in the body of the Monitoring Plan. This list offers a more complete compilation of reports related to monitoring in Casco Bay available through the CBEP archives for reference.

A. Nutrients and Water Quality

1. Bay water quality

a. Casco Bay Nutrient Council, & CBEP. Nutrient pollution in Casco Bay, Maine, State of the science and recommendations for action (2019)

b. Conservation Law Foundation, Paul Hauge. Troubled waters: report on the environmental health of Casco Bay (1988)

c. Friends of Casco Bay, Battelle. State of the water quality of Casco Bay, an analysis of six years of water quality data, 1993-1998 (2002)

d. Friends of Casco Bay, Battelle. Twelve-year water quality data analysis: 1993-2004 report (2005)

e. Friends of Casco Bay. Final report 2003 dissolved oxygen monitoring project (2005)

f. Friends of Casco Bay. Final report 2004 dissolved oxygen monitoring project (2005)

g. Friends of Casco Bay. Final report 2005 dissolved oxygen monitoring project (2006)

h. Friends of Casco Bay. Final report 2006 dissolved oxygen monitoring project (2007)

i. Friends of Casco Bay. Summary statistics for the Portland Harbor/Presumpscot River nitrogen monitoring project (2009)

j. Industrial Economics, Inc., Timothy J. Reilly. *Julie N* preassessment data report (1998)

k. U.S. EPA, Tim Bridges. Measurement of sediment oxygen demand in the Royal River estuary (2006)

l. U.S. EPA, Tim Bridges. Measurement of sediment oxygen demand in upper New Meadows River and Quahog Bay estuarine areas, Maine (2009)

m. Wells National Estuarine Research Reserve. Nutrients and dissolved oxygen in Maine estuaries and embayments (1997)

2. Bay hydrodynamics and circulation

a. Applied Science Associates, Malcolm L. Spaulding. Review of circulation studies and modeling in Casco Bay (2011)

b. Norwich University, Ernest D. True, & Northeast Fisheries Science Center, James P. Manning,. Modeling wind and tidal circulation in Casco Bay, Maine: a preliminary study (2005)

c. University of Maine, Bryan Pearce, Neal Pettigrew, et al. Casco Bay Maine: circulation modeling (1996)

3. Climate change

a. Ecosystem Indicator Partnership of the Gulf of Maine Council on the Marine Environment. Climate change in the Gulf of Maine (2011)

b. Natural Choices, Marina Schauffler. Climate trends in the Casco Bay region (2015)

c. University of New Hampshire, Cameron Wake, Elizabeth Burakowski, et al. Climate change in the Casco Bay watershed: past, present, and future (2009)

d. University of New Hampshire, Christopher Hunt, Melissa Meléndez. Ocean and coastal acidification in Casco Bay, Draft final data report 2015-2020 (2020)

e. Waterview Consulting, Peter Taylor. Casco Bay climate change vulnerability report (2017)

4. Fresh water quality

a. FB Environmental Associates. 2010 Presumpscot River lower main stem monitoring (2011); 2010-11 Presentation

b. Friends of the Royal River. Royal River watershed, Maine water quality monitoring reports 1993-1999 (2001)

c. Maine Department of Environmental Protection. Rivers and streams in the Casco Bay watershed that are considered impaired (2010)

d. Midwest Biodiversity Institute, Chris Yoder, Lon E. Hersha. Fish assemblage and habitat assessment of the Presumpscot River (2009)

e. Partnership for Environmental Technology, Susanne Meidel, & Maine Department of Environmental Protection. Urban streams nonpoint source assessments in Maine final report, Birch Stream, Trout Brook, Barberry Creek, Capisic Brook (2005)

f. Partnership for Environmental Technology, Susanne Meidel, & Maine Department of Environmental Protection, Leon Tsomides. Preliminary survey of existing biological monitoring data from Capisic Brook in Portland, Maine (2004)

g. Presumpscot River Management Plan Steering Committee. A plan for the future of the Presumpscot River, Introduction and overview (2003)

h. Presumpscot River Management Plan Steering Committee. A plan for the future of the Presumpscot River, Protecting and enhancing open space along the Presumpscot River (2003)

i. Presumpscot River Watershed Coalition, & CBEP. Presumpscot Watershed Initiative, Implementing water quality improvements to support vital fisheries, Final report (2010)

j. Presumpscot River Watershed Coalition, & CBEP. Presumpscot Watershed Initiative, Implementing water quality improvements to support vital fisheries, Final report Appendix G, Water quality monitoring data summaries (2010)

k. University of Maine, George J. Mitchell Center for Environmental and Watershed Research. Measuring the impact of development on Maine surface waters, South Portland (2003)

l. University of Maine, Whitley Gray. Improved estimates of tributary nitrogen load to Casco Bay, Maine (2019)

m. U.S. EPA, National Center for Environmental Assessment. Causal analysis of the biological impairment in Long Creek: a sandy-bottomed stream in coastal southern Maine (2007)

n. U.S. EPA, Tim Bridges. Wet weather water quality study Portland and South Portland, Maine (2008)

o. U.S. EPA, Tim Bridges. Presumpscot River dye study: below Cumberland dam, Westbrook to Old Smelt Hill Dam, Falmouth (2008)

5. Watershed condition and land use

a. Cumberland County Soil and Water Conservation District. Concord Gully Brook Watershed Survey Report (2013)

b. Cumberland County Soil and Water Conservation District. Crooked River watershed survey (2012)

c. Cumberland County Soil and Water Conservation District, & Crystal Lake Association. Crystal Lake watershed survey report (2004)

d. Cumberland County Soil and Water Conservation District. Forest Lake watershed survey (2003)

e. Cumberland County Soil and Water Conservation District, & Hancock and Sand Ponds Association. Hancock and Sand Ponds watershed survey (2006)

f. Cumberland County Soil and Water Conservation District, & Lakes Environmental Association. Brandy Pond Watershed Survey Report (2009)

g. Cumberland County Soil and Water Conservation District, & Little Sebago Lake Association. Little Sebago Lake Watershed Survey Report, Part I (2003), Part II (2004)

h. Cumberland County Soil and Water Conservation District. Moose Pond watershed survey (2011)

i. Cumberland County Soil and Water Conservation District. New Meadows River lower watershed survey report (2003)

j. Cumberland County Soil and Water Conservation District, & Pleasant Lake and Parker Pond Association. Pleasant Lake and Parker Pond Watershed Survey Report (2007)

k. Cumberland County Soil and Water Conservation District, & Presumpscot River Watch. Piscataqua River, East Branch, West Branch, watershed survey report (2008)

l. Cumberland County Soil and Water Conservation District, & Presumpscot River Watch. Pleasant River watershed survey report (2009)

m. Cumberland County Soil and Water Conservation District, & Sabbathday Lake Association. Sabbathday Lake Watershed Survey Report (2009)

n. Cumberland County Soil and Water Conservation District. Stroudwater River watershed survey report (2014)

o. Cumberland County Soil and Water Conservation District. Tannery Brook watershed survey report (2005)

p. Forest Lake Association. Forest Lake Watershed Survey Report (2017)

q. Friends of the Royal River, John MacKinnon. Libby Brook watershed survey final report (2002)

r. Friends of the Royal River, & Androscoggin County Soil and Water Conservation District. The Moose Brook watershed survey (2005)

s. Horsley & Witten, Inc. Identification and evaluation of nutrient and bacterial loadings to Maquoit Bay, Brunswick, and Freeport, Maine (1996)

t. MER Assessment Corporation, Christopher Heinig. New Meadows River watershed and shoreline surveys (2001)

u. Presumpscot River Management Plan Steering Committee, & Land & Water Associates. A plan for the future of the Presumpscot River and its shorelands, Cumulative impacts to environmental conditions on the Presumpscot River and its shorelands (2002)

v. Thompson Lake Environmental Association. Thompson Lake Watershed Survey Report - Southern and Northern Sections (2007)

B. Habitats

1. Clam flats

a. Friends of Casco Bay. 2013 Casco Bay clam flat pH study (2014)

b. University of Maine Machias, Brian Beal. Interactive effects of tidal height and predator exclusion on growth and survival of wild and cultured juveniles of the soft-shell clam, *Mya arenaria* L., at two intertidal flats in southern Maine (2014 final report)

c. University of Maine Machias, Brian Beal. Clam studies in Fore and Webhannet River (2015 final report)

d. University of Maine Machias, Brian Beal, & Downeast Institute, Sara F. Randall, et al., & Maine Clammers Association, Clint A. Goodenow. Spatial variability in recruitment of an infaunal bivalve: experimental effects of predator exclusion on the softshell clam, (*Mya arenaria* L.) along three tidal estuaries in southern Maine, USA (2018) in *Journal of Shellfish Research*, Vol. 37, No. 1, 1-27, 2018. Available at https://doi.org/10.2983/035.037.0101

2. Fish passage

a. American Rivers, & Friends of the Presumpscot River, & Friends of Sebago Lake. Supplemental historic records related to the anadromous fisheries of the Presumpscot River and Sebago Lake, Maine (2002)

b. CBEP. Casco Bay watershed fish barrier priorities atlas, complete (2012)

c. CBEP, Matt Craig. Alewife Brook, Cape Elizabeth, river herring monitoring summary 2015 (2015)

d. Inter-Fluve. Fishway assessment and cost analysis report, Royal River, Yarmouth, ME (2018)

e. Kennebec Valley Soil and Water Conservation District, Dale Finseth, & Sheepscot River Watershed Council, Charles Baeder, & Kennebec Estuary Land Trust, Carrie Kinne. Kennebec barrier survey 2010 (2011)

f. Normandeau Associates, Inc. Diadromous fish surveys of the Presumpscot River (2004)

g. Presumpscot River Management Plan Steering Committee, & Land & Water Associates. A plan for the future of the Presumpscot River, Fisheries conditions, issues, and options of the Presumpscot River (2002)

h. Presumpscot River Watershed Coalition. Stream crossing monitoring (2009)

i. Stantec. Estimated sediment volume: Bridge Street dam impoundment, Royal River, Yarmouth, Maine (2015)

3. Habitats including eelgrass and invasives

a. Barker, Seth. Eelgrass distribution in Casco Bay 2013 (2013)

b. Barker, Seth. Eelgrass distribution in Casco Bay 2018 (2019)

c. Barker, Seth. Eelgrass distribution in selected study areas in Casco Bay 2014, Mackworth Island, Broad Cove, Cousins Island, Little Diamond Island, and Widgeon Cove (2015)

d. Massachusetts Institute of Technology Sea Grant Program, Judith Pederson, et al. Marine invaders in the northeast: rapid assessment survey of non-native and native marine species of floating dock communities (2003)

e. Massachusetts Institute of Technology Sea Grant Program. Marine invaders in the northeast: rapid assessment survey of non-native and native marine species of floating dock communities (2007)

f. Massachusetts Office of Coastal Zone Management. Report on the 2010 rapid assessment survey of marine species at New England floating docks and rocky shores (2010)

g. Massachusetts Office of Coastal Zone Management. Report on the 2018 rapid assessment survey of introduced, cryptogenic, and native marine species at New England marinas: Massachusetts to Maine (2020)

h. MER Assessment Corporation. Merepoint boat launch facility eelgrass mitigation measures: final project assessment (2013)

i. National Oceanic and Atmospheric Administration, Stephen K. Brown, et al. Habitat suitability index models for eight fish and invertebrate species in Casco and Sheepscot Bays, Maine (2000)

j. U.S. Geological Survey. Negative effects of commercial mussel dragging on eelgrass beds in Maine (2005)

4. Sea Level Rise and habitats

a. CBEP. Geomorphology and the effects of sea level rise on tidal marshes in Casco Bay (2012)

b. CBEP. Sea level rise and Casco Bay's wetlands: a look at potential impacts, Brunswick (2013)

c. CBEP. Sea level rise and Casco Bay's wetlands: a look at potential impacts, Cape Elizabeth (2013)

d. CBEP. Sea level rise and Casco Bay's wetlands: a look at potential impacts, Falmouth (2013)

e. CBEP. Sea level rise and Casco Bay's wetlands: a look at potential impacts, Freeport (2013)

f. CBEP. Sea level rise and Casco Bay's wetlands: a look at potential impacts, Harpswell (2013)

g. CBEP. Sea level rise and Casco Bay's wetlands: a look at potential impacts, Phippsburg (2013)

h. CBEP. Sea level rise and Casco Bay's wetlands: a look at potential impacts, Portland (2013)

i. CBEP. Sea level rise and Casco Bay's wetlands: a look at potential impacts, South Portland (2013)

j. CBEP. Sea level rise and Casco Bay's wetlands: a look at potential impacts, West Bath (2013)

k. CBEP. Sea level rise and Casco Bay's wetlands: a look at potential impacts, Yarmouth (2013)

5. Sediment contaminants

a. CBEP. The dirty history of Portland Harbor (Fact Sheet, reprinted from 1994)

b. CBEP. Toxic pollution in Casco Bay, sources and impacts (2007)

c. Friends of Casco Bay, Mike Doan. Concentrations of polycyclic aromatic hydrocarbons in surficial sediments of the Fore River and Portland Harbor, Maine (2005)

d. GERG, Geochemical and Environmental Research Group. Assessment of butylins, PCDD/PCDF and planar PCB contaminants in sediments from Casco Bay (1995)

e. GERG, Geochemical and Environmental Research Group. Assessment of sediment contamination in Casco Bay and Appendix A (Quality assurance data summaries) (1992)

f. GERG, Geochemical and Environmental Research Group. Assessment of sediment contamination in Casco Bay Appendix C trace metal analytical results and Appendix D standard operating procedures (1992)

g. GERG, Geochemical and Environmental Research Group, M.C. Kennicutt II, Terry L. Wade. Sediment contaminants in Casco Bay, Maine: inventories, sources, and potential for biological impact (1994)

h. GERG, Geochemical and Environmental Research Group, Terry L. Wade & Stephen T. Sweet. Assessment of sediment contamination in Casco Bay, 2005 (2005)

i. Hawes, Edward L. Historic Sources of Pollution in Portland Harbor, 1840-1970; Including the Fore River, the Back Cove and South Portland watersheds (1993)

j. Maine Board of Pesticides Control. Interim report on the Environmental Risk Advisory Committee study of pesticides and lobsters (2015)

k. Maine Board of Pesticides Control. Update to the Maine Board of Pesticides Control assessment relative to the risks of pesticides to marine invertebrates (2017)

l. Northern Ecological Associates. Final report of a substrate survey of the Mallison, Little Falls, and Saccarappa impoundments, Presumpscot River, Maine (2001)

m. Ramboll Environ. Casco Bay sediment assessment 1991-2011, Casco Bay Maine (2017)

6. Wetlands

a. Bates College, Bev Johnson, et al., & CBEP, Curtis Bohlen, et al. The ecogeomorphology of two salt marshes in midcoast Maine: natural history and human impacts (2016)

b. CBEP, Matt Craig. Thomas Bay Marsh, Brunswick, Maine, 2012 monitoring report (2013)

c. CBEP, Matt Craig. Wallace Shore Road in Harpswell, tidal restriction restoration 2017 monitoring report, Year 3 of 5, post-project (2017)

d. CBEP, Matt Craig. Long Reach Lane at Long Marsh, Harpswell, 2018 post-project monitoring report; Year 5 of 5 (2019)

e. Conservation Law Foundation. Casco Bay Return the Tides action plan (2000)

f. Maine State Planning Office. Casco Bay watershed wetlands characterization (2001)

g. University of New England, Pamela Morgan, et al., & Wells National Estuarine Research Reserve, Jeremy Miller. Assessing the health of fringing salt marshes along the Fore River and its territories (2006)

h. University of New England, Pamela Morgan, & Wells National Estuarine Research Reserve, Michele Dionne. Ecological functions and values of fringing salt marshes susceptible to oil spills in Casco Bay, Maine (2005)

i. U.S. Fish and Wildlife Service, D.B. Foulis, R.W. Tiner. Wetland trends for selected areas of the Casco Bay estuary of the Gulf of Maine (1974-77 to 1984-87) (1994)

j. Wells National Estuarine Research Reserve, Peter Hayes, Rachel Carr, et al. Mapping and restoration inventory of fringing marsh habitat in the Casco Bay estuary, project report (2008)

k. Woodlot Alternatives, Inc. & Raymond A. Konisky. New Meadows Lake, Brunswick, and West Bath, Maine: model analysis of expected plant communities' response to potential tidal restoration conditioning (2007)

l. Woodlot Alternatives, Inc. New Meadows Lake tidal restoration feasibility study, Final Report (2006)

C. Food Web

1. Aquatic organisms

a. Bar Mills Ecological, Susanne Schaller, & Maine Department of Marine Resources, Peter Thayer. 2003 Maine horseshoe crab, *Limulus polyphemus*, scouting surveys (2003)

b. Bar Mills Ecological, Susanne Schaller, & Maine Department of Marine Resources, Peter Thayer, et al. Maine horseshoe crab, *Limulus polyphemus*, spawning surveys, 2003 (2004)

c. Bar Mills Ecological, Susanne Schaller, & Maine Department of Marine Resources, Peter Thayer, et al. Maine horseshoe crab, *Limulus polyphemus*, spawning surveys, 2004 (2005)

d. Bar Mills Ecological, Susanne Schaller, & Maine Department of Marine Resources, Peter Thayer, et al. Maine horseshoe crab, *Limulus polyphemus*, spawning surveys, 2005 (2006)

e. biodrawversity. Brook Floater (Alasmidonta varicosa) in the Pleasant River (2003)

f. MER Assessment Corporation, Christopher S. Heinig, Daniel Millar. Shellfish resources and habitat characterization survey for Sebasco Harbor, Phippsburg, Maine (2004)

g. MER Assessment Corporation, Christopher S. Heinig, Hugh Cowperthwaite. Survey of American lobsters, *Homarus americanus,* in the Fore River, Portland Harbor, Portland, Maine (1998)

h. Normandeau Associates, Inc. Expanding and sustaining the shellfisheries of Casco Bay 2011 (2012)

i. Normandeau Associates, Inc. Portland islands clam flat technical assistance project (1998)

j. Normandeau Associates, Inc., & MER Assessment Corporation, & Albert Frick Associates. Expanding and sustaining the shellfisheries of Casco Bay-Phases II and III: Ranking clam flats for potential remediation (2003)

k. Normandeau Associates, Inc. & MER Assessment Corporation. Expanding and sustaining the shellfisheries of Casco Bay-Phase I: Ranking clam flats for potential remediation (1999)

l. University of Maine, Rick Wahle, et al. American lobster settlement index, update 2018 (2018)

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2. Birds

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