This document contains overall and specific condition of the Casco Bay Estuary Partnership, from the National Estuary Program Coastal Condition Report. The entire report can be downloaded from
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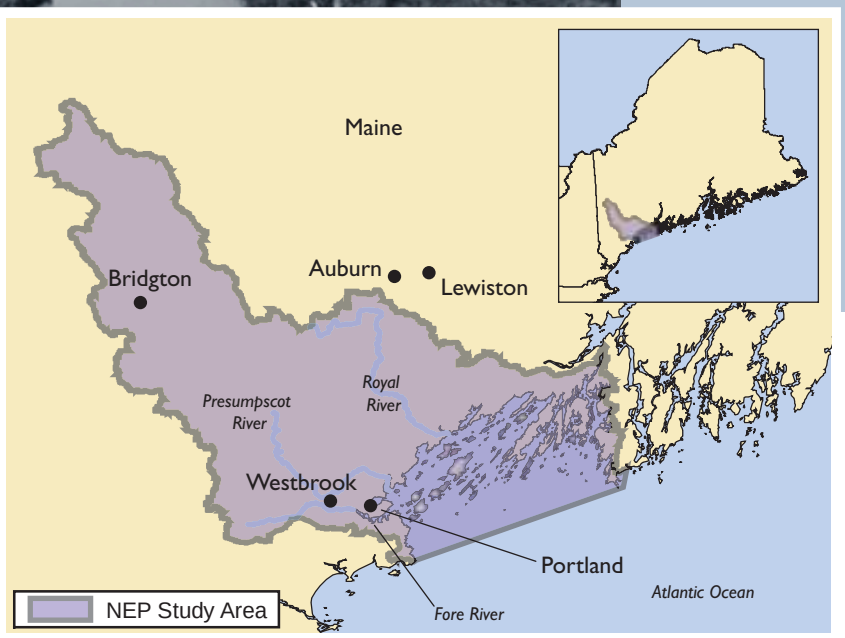
National Estuary Program Coastal Condition Report

Chapter 3: Northeast National Estuary Program Coastal Condition, Casco Bay Estuary Partnership

June 2007

Casco Bay Estuary Partnership

Casco Bay Estuary Partnership



Casco Bay Estuary Partnership

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Background

The watershed of Casco Bay contains only 3% of Maine's land mass, but about a quarter of the state's population. This NEP study area encompasses 41 municipalities and extends over a 985 mi^2 area. The Bay itself has 578 miles of shoreline, including 758 islands (CBEP, 2000). Three major rivers—the Royal, Presumpscot, and Fore— flow into the Bay. Casco Bay has relatively low water temperatures and high flushing rates, compared to some other estuaries of the Northeast Coast region (Pearce et al., 1996). A 1994 study estimated the annual value of Casco Bay's fishing industry at $120 million, with tourism and recreation around the Bay generating another $250 million each year (CBEP, 2000).

Starting in 1990, a diverse coalition began to shape a plan for Casco Bay's future as part of EPA's NEP. The *Casco Bay Plan* (CBEP, 1996) now fuels collaborative projects around the watershed involving municipal and state officials, community groups, businesses, and citizens. The Casco Bay Estuary Partnership (CBEP; formerly the Casco Bay Estuary Project) coordinates these efforts. Since the plan was adopted, area residents

and groups have taken measures to protect wildlife habitat, improve water quality, reduce pollution from stormwater runoff and combined sewer overflows (CSOs), reduce toxic pollution, and protect and restore clam flats and swimming areas.

Environmental Concerns

Although Casco Bay's waters may appear relatively pristine to the casual observer, toxic pollution in the Bay is a concern. Casco Bay still contains toxics from industries that operated more than a century ago, contaminating sediments, fish, shellfish, and wildlife (CBEP, 1994). Volunteer water quality monitoring has taken place since 1993, and data show that the Bay's water quality is generally good, although cause for concern remains in certain areas. Low dissolved oxygen has been identified in a few areas, and the CBEP is conducting further studies to determine the nature and causes of these hypoxic events.

Population Pressures

The population of the 5 NOAA-designated coastal counties (Androscoggin, Cumberland, Oxford, Sagadahoc, and York) coincident with the CBEP study area increased by about 48% during a 40-year period, from 0.44 million people in 1960 to 0.65 million people in 2000 (Figure 3-10) (U.S. Census Bureau, 1991; 2001). This rate of population growth for the CBEP study area is higher than the population growth rate of 24% for the collective NEP-coincident coastal counties of the Northeast Coast region. In 2000, the population density of the CBEP's 5 NEP-coincident coastal counties was 138 persons/mi^2, dramatically lower than the population density of 1,055 persons/mi^2 for the collective NEP-coincident coastal counties of the Northeast Coast region (U.S. Census Bureau, 2001). The CBEP-coincident coastal counties had the second-lowest population density of any of the Northeast Coast NEP estuaries (only the coastal counties coincident with the Maryland Coastal Bays Program were lower at 98 persons/mi^2).

NCA Indices of Estuarine Condition—Casco Bay

The overall condition of Casco Bay is rated good based on three of the four indices of estuarine condition used by the NCA (Figure 3-11). All three indices (water quality index, sediment quality index, and benthic index) are rated good for Casco Bay. No data were available to calculate a fish tissue contaminants index for this estuary. Figure 3-12 provides a summary of the percentage of estuarine area rated good, fair, poor, or missing for each parameter considered. This assessment is based on data from 30 NCA sites sampled in the CBEP estuarine area in 2000 and 2001. Please refer to Tables 1-24, 1-25, and 1-26 (Chapter 1) for a summary of the criteria used to develop the rating for each index and component indicator.

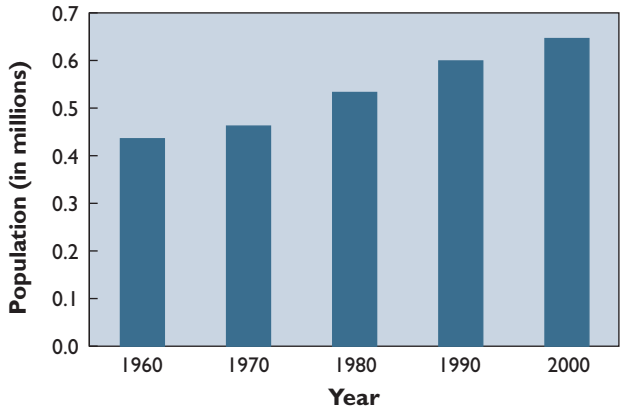

Figure 3-10. Population of NOAA-designated coastal counties of the CBEP study area, 1960–2000 (U.S. Census Bureau, 1991; 2001).

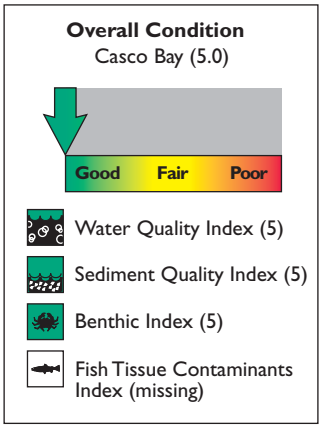

Figure 3-11. The overall condition of the CBEP estuarine area is good (U.S. EPA/NCA).

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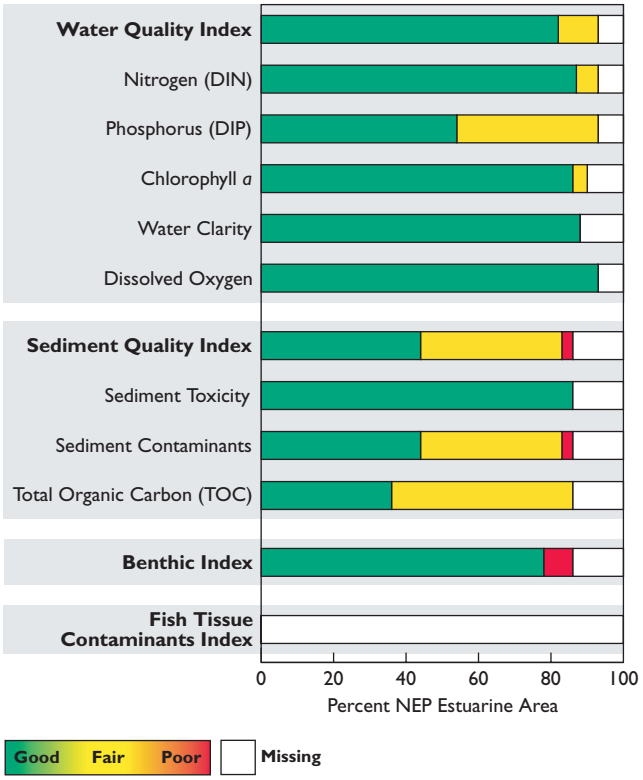

Figure 3-12. Percentage of NEP estuarine area achieving each rating for all indices and component indicators — Casco Bay (U.S. EPA/NCA).

Water Quality Index

Based on data from the NCA survey, the water quality index for Casco Bay is rated good (Figure 3-13). This index was developed using NCA data on five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. Casco Bay has one of the best ratings for water quality among the Northeast Coast NEP estuaries. DIN and chlorophyll *a* concentrations were uniformly low, less than 0.1 mg/L and 5 µg/L, respectively, and DIP concentrations were less than 0.01 mg/L in all areas of Casco Bay. Water clarity was satisfactory everywhere in the Bay, and there were no incidences of depleted dissolved oxygen.

Dissolved Nitrogen and Phosphorus

Casco Bay is rated good for both DIN and DIP concentrations. Eighty-seven percent of the estuarine area was rated good for DIN concentrations, and 6% of the area was rated fair. No area of Casco Bay was rated poor for DIN concentrations. Fifty-four percent of the Bay's estuarine area was rated good for DIP concentrations, and no area of Casco Bay was rated poor for this component indicator. NCA data on DIN and DIP concentrations were unavailable for 7% of the CBEP estuarine area.

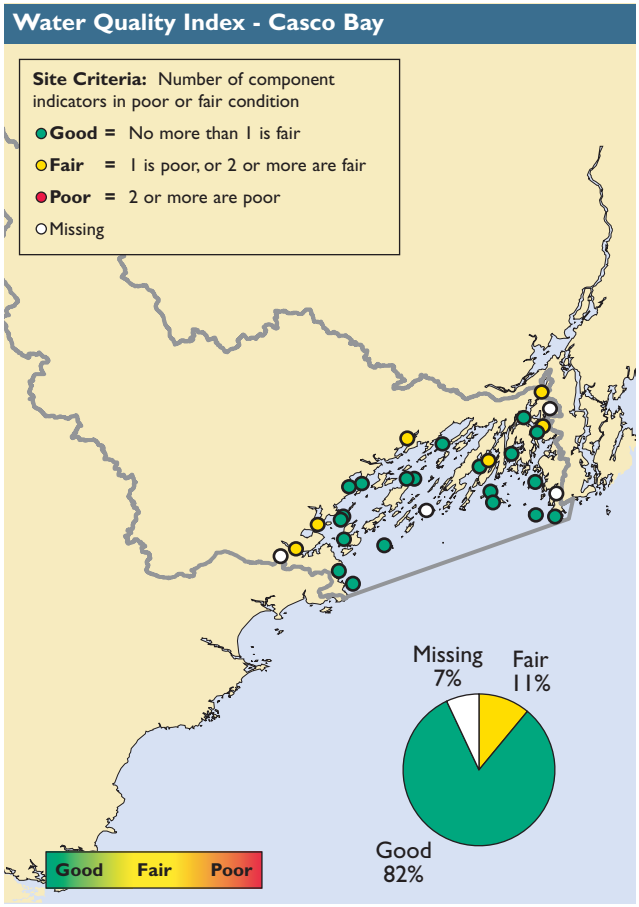

Figure 3-13. Water quality index data for Casco Bay (U.S. EPA/NCA).

Chlorophyll a | Casco Bay is rated good for chlorophyll *a* concentrations. Eighty-six percent of the estuarine area was rated good for this component indicator, 4% was rated fair, and none of the area had poor chlorophyll *a* concentrations. NCA data on chlorophyll *a* concentrations were unavailable for 10% of the CBEP estuarine area.

Water Clarity | The water clarity rating for Casco Bay is good. Water clarity was rated poor at a sampling site if light penetration at 1 meter was less than 10% of surface illumination. None of the estuarine area was rated poor or fair for water clarity, and 88% of the area was rated good. NCA data on water clarity were unavailable for 12% of the CBEP estuarine area.

Dissolved Oxygen | Casco Bay is rated good for dissolved oxygen concentrations, with 93% of the Bay's estuarine area rated good for this component indicator. No area of Casco Bay was rated poor for dissolved oxygen concentrations, and NCA data on this component indicator were unavailable for 7% of the CBEP estuarine area.

Sediment Quality Index

The sediment quality index for Casco Bay is rated good, with about 3% of the estuarine area rated poor for sediment quality and 39% rated fair (Figure 3-14). This index was developed using NCA data on three component indicators: sediment toxicity, sediment contaminants, and sediment TOC. The Casco Bay sites classified as impaired showed both a moderate degree of sediment contamination by metals or PCBs and moderate levels of TOC.

Sediment Toxicity | Casco Bay is rated good for sediment toxicity. No area of Casco Bay had sediments that were toxic to amphipods, although NCA data on sediment toxicity were unavailable for 14% of the CBEP estuarine area.

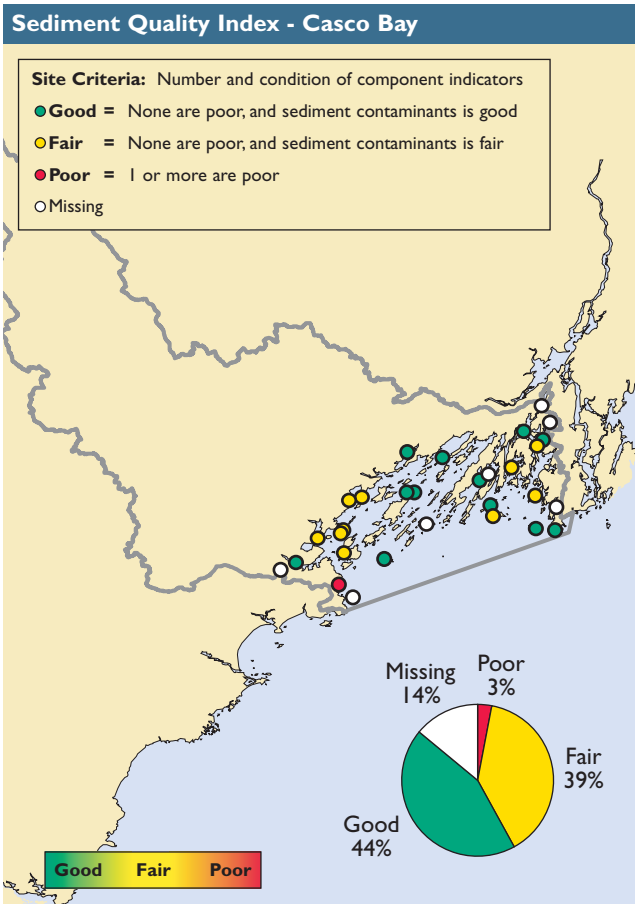

Figure 3-14. Sediment quality index data for Casco Bay (U.S. EPA/NCA).

Sediment Contaminants | The sediment contaminants rating for Casco Bay is good. Approximately 3% of the estuarine area was rated poor for sediment contaminant concentrations, and 39% of the CBEP estuarine area was rated fair.

Total Organic Carbon | Casco Bay is rated good for sediment TOC, with 36% of the estuarine area rated good for TOC concentrations and 50% of the area was rated fair. No area of Casco Bay was rated poor for TOC.

Benthic Index

Only 8% (five sites) of the estuarine area of Casco Bay had unsatisfactory benthic condition, as measured by the Shannon-Weiner Diversity Index (Figure 3-15); therefore, Casco Bay is rated good for benthic condition. Seventy-eight percent of the area was rated good for benthic condition, indicating that Casco Bay exhibited a relatively high degree of species diversity for the Northeast Coast region. Most NCA sites that received a poor rating for benthic condition were also moderately contaminated with pollutants and exhibited moderate TOC levels.

Fish Tissue Contaminants Index

No fish were collected as part of the NCA surveys in 2000 and 2001; therefore, a fish tissue contaminants index for Casco Bay was not developed for this report.

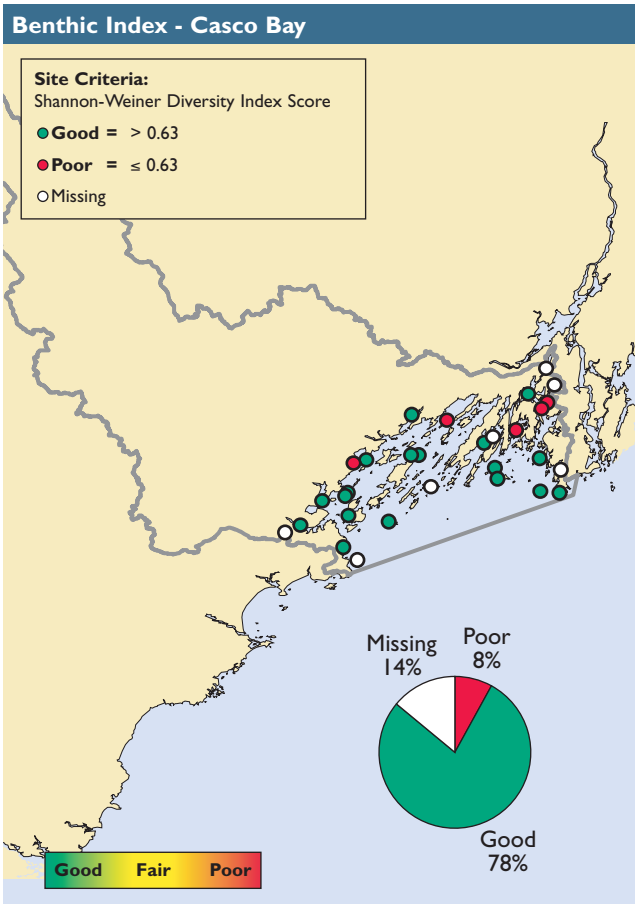

Figure 3-15. Benthic index data for Casco Bay (U.S. EPA/NCA).

Casco Bay Estuary Partnership Indicators of Estuarine Condition

Water and Sediment Quality

The group Friends of Casco Bay, with support from the CBEP, has monitored surface waters at 106 sites throughout the Bay since 1993. Through Friends of Casco Bay, 300 trained volunteers have tested water samples annually from April through October for water temperature, dissolved oxygen, pH, salinity, and water clarity. This sampling effort represents the only long-term collection of Casco Bay water quality data, providing an invaluable resource for municipal and state planners, as well as local conservation and shellfish commissions (CBEP, 2000). The results of this sampling indicate that the water quality in Casco Bay is good; however, low dissolved oxygen levels are a concern in some areas. These areas include locations with restricted circulation or with potentially heavy nutrient loadings from point or non-point sources (CBEP, 2005). Test results help communities around the Bay clean up existing pollution sources and prevent future contamination from occurring. Consistent use of water quality tests can also help address environmental concerns, such as red tide outbreaks and elevated bacterial counts, which can cause area closures for swimming, fishing, and shellfish harvesting.

The CBEP has also studied chemical contamination in the surface sediments of Casco Bay, including heavy metals, PCBs, pesticides, tributyltin (TBT), dioxins and furans, and PAHs. In general, some toxic pollutants were found in Bay sediments far from waterborne sources, suggesting deposition from the air as dry particles or in rain and snow. Elevated heavy metal concentrations were most commonly found near Portland, ME. PCBs were found in Fore River sediments, and TBT levels were highest near boating centers. Dioxins and furans were measured in low levels throughout the Bay, with the highest concentrations detected in sediments near the Presumpscot River. PAHs were the most prevalent contaminant in Casco Bay sediments and often occurred at high concentrations when compared to PAH levels in sediments from other bays around the United States (CBEP, 2000).

Habitat Quality

Casco Bay hosts a variety of habitats, including salt marshes, eelgrass beds, tidal creeks, islands, rocky shores, and estuarine waters. The most prevalent habitat in the study area is intertidal mudflats. In 1995, up to one-third of the Bay's wildlife habitat was endangered by human development; however, it appeared that few of the highest-value habitats faced imminent threats (CBEP, 2000). As a response, the CBEP began tracking the acreage of protected lands in the Bay area. Since 1997, the acres of protected land in the Casco Bay watershed have increased by almost 50%. These protected lands provide habitat for a variety of birds, fish, and other wildlife. For example, Flag Island is a protected 41-acre island in Casco Bay and provides habitat to more than 600 nesting pairs of common eiders (CBEP, 2005).

The CBEP also tracks the number of acres in large tracks of undeveloped, natural land located within the study area as an indicator of habitat quality. This indicator provides insight into the degree of habitat fragmentation in the Bay area. Larger habitat blocks are more likely to support healthy, genetically diverse wildlife populations and are especially important to such animals as the bobcat, Northern goshawk, or wood thrush, which require larger areas of uninterrupted habitat. Overall, large tracts of unfragmented, natural lands do exist in the CBEP study area, although they are growing increasingly scarce due to development. Most of these tracts are located in the upper watershed; however, substantial tracts do exist in more developed areas (CBEP, 2005).

Eelgrass, a type of seagrass, is an important habitat for fish, shellfish, and waterfowl. Casco Bay has the largest and densest concentration of eelgrass beds mapped along the coast of Maine (CBEP, 2000). The extent of eelgrass in Casco Bay has increased in recent years, with the overall acreage of eelgrass in the Bay increasing from 7,056 to 8,248 acres between 1993 and 2001; however, several areas have experienced substantial local losses in eelgrass coverage during this time period (CBEP, 2005).

Living Resources

Casco Bay is home to a variety of waterbirds, including common eiders, gulls, and great blue herons. In addition, the Bay contains 50 seabird-nesting islands and 6 heron nurseries (CBEP, 2000). The CBEP tracks the number of waterbirds in Casco Bay as an environmental quality indicator to assess environmental impacts on the birds. In 2000, the Maine Department of Inland Fisheries and Wildlife, FWS, and CBEP worked together to conduct a series of waterbird surveys in the Bay. The data collected from this survey series will provide the baseline for future waterbird population evaluations of Casco Bay (CBEP, 2005).

The CBEP has studied contamination levels in the tissues of blue mussels and lobsters, and the Maine Department of Environmental Protection (DEP) and the Gulf of Maine Program also sample mussels at additional sites in Casco Bay. Through this long-term testing, the CBEP can assess whether toxic contaminant levels in the Bay are increasing or decreasing. Shellfish are filter feeders and concentrate pollutants from the water. By testing the tissues of mussels and lobsters for chemical contaminants, scientists can evaluate the presence of toxics that may affect human health.

The CBEP has monitored mussels at eight locations and lobsters at two sites and found that the contaminant levels in mussel tissues from some locations exceeded the state level for posting health advisories (based on eating shellfish once a week). Elevated levels of the contaminants lead, PAHs, PCBs, dioxins, and furans were detected in some mussels, and further tests are being performed to confirm these results (CBEP, 2000).

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HIGHLIGHT

Trends in Toxic Chemicals in Casco Bay Sediments

The presence of toxic chemicals in the sediments of Casco Bay serves as an indicator of overall contamination of the Bay's marine ecosystem. When toxic chemicals are introduced to the Bay from rivers, stormwater runoff, point-source discharges, and atmospheric deposition, many do not readily degrade or disperse. Instead, these chemicals adsorb to sediment particles and settle to the bottom of the Bay, where they may persist for a long time. Even when clean sediments are deposited on top of contaminated sediments, dredging and biological activity can bring the contaminants back to the surface.

Bottom-dwelling (benthic) animals play an important role in the food chain, recycling organic matter and serving as a food source for groundfish (e.g., flounder, cod, and haddock), lobsters, and crabs. These benthic organisms can suffer adverse effects from their exposure to and ingestion of contaminated sediments and, as prey of groundfish, may provide a conduit for introducing these contaminants into the food chain. Fish and large crustaceans that feed on contaminated benthic organisms may experience inhibited growth and reproduction, disease vulnerability, and even death. As the contaminants move up the food chain, humans who eat seafood contaminated by toxic chemicals can also be at risk. For example, the presence of dioxins in Casco Bay—largely a byproduct of pulp and paper mills—has resulted in elevated dioxin concentrations in the liver (tomalley) of lobsters. A public health advisory against eating lobster tomalley has been in effect in Maine since 1992 (Maine DEP, 2004). The Maine Department of Health and Human Services has also issued guidelines for the consumption of saltwater fish contaminated by mercury and organic chemicals, such as PCBs.

When scientists first studied the sediments of Casco Bay in 1980, they were surprised to find a wide array of toxic contaminants, including heavy metals and organic chemicals. In 1991, the CBEP commissioned a baseline study to assess sediment contamination levels at 65 sites in the Bay using state-of-the art analytical methods. Sampling sites were selected based on depth, circulation, sediment type, and historical contaminants data, such as the locations of industrial facilities and other point-source discharges. Samples were analyzed for heavy metals, PAHs, PCBs, and pesticides (Kennicutt et al., 1992). In 1994, sediments from 28 of the original study sites and 5 new sites were analyzed for butyltins, dioxins/furans, and coplanar PCBs (Wade et al., 1995). In 2000 and 2001, in partnership with EPA's NCA survey, the CBEP resampled the sediments at the original sampling locations. Scientists from Texas A&M University compared the results of the 1991–1994 sampling to the 2000–2001 studies and concluded that most toxic chemical concentrations have decreased or remained the same over time, indicating that pollution-control strategies are working in Casco Bay (see table).

In some heavily polluted areas, such as the flats of the Fore River (near Portland, ME), mollusks, small crustaceans, and other expected benthic species were absent in a 1989 sampling. Some of the hardy worms that were found had oil on their "feet" (parapodia), probably from petroleum-related contaminants (Personal communication, Doggett, 2005).

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Changes in Chemical Concentrations in Sediments from the 1991–1994 to 2000–2001 Sampling Efforts in Casco Bay (Wade and Sweet, 2005)

Decreased	Increased	No Overall Change
Cadmium	Silver	Arsenic
Chromium	High molecular-weight PAHs	Copper
Mercury		Lead
Nickel		Zinc
Selenium		Planar PCB 77
Total pesticides		PAHs[2]
4,4-DDE		Dioxins/furans
4-4-DDD		
Total DDTs		
TBT[1] and butyltin		
Total PCBs		
Planar PCB 126		
Low molecular-weight PAHs		

[1] The overall decline of TBT concentrations in the Bay's sediments reflects the effectiveness of federal and Maine laws that now ban the use of paints with TBT for all uses except for vessels longer than 25 meters or those having aluminum hulls (Maine DEP, 1999). The continued use of TBT paints on large commercial vessels may explain the presence of elevated concentrations of TBT in the sediments of Inner Bay sites.

[2] Overall, the total concentration of PAHs in Casco Bay sediments has remained unchanged. This suggests that increased use of fossil fuels is balanced by environmental controls that lower the PAH inputs to the Bay (Wade and Sweet, 2005).

The Texas A&M University comparison examined the concentrations of a variety of contaminants in sediments, including metals, PAHs, PCBs, and pesticides. Heavy metal concentrations in Casco Bay are lower than levels known to cause harmful effects to organisms. Even the elevated concentrations of metals seen in Casco Bay are lower than concentrations found in the highly contaminated sediments of urban areas, such as Long Island Sound and Boston Harbor. Although concentrations are highly elevated above natural background levels, the PAH concentrations seen in the sediments of the inner part of Casco Bay ranged between the ERL and ERM concentrations (Long et al.,1995). The majority of PAHs detected in the Bay are high molecular-weight, combustion-related PAHs that sequester in fine particles, which may reduce their toxicity. PCB concentrations at almost all Casco Bay sites were below the toxic response threshold, and concentrations of pesticides were low compared to concentrations considered toxic. Butyltins, dioxins/furans, and planar PCBs were not present at toxic concentrations, and in general, the highest concentrations of toxic chemicals were found near known sources. For example, elevated butyltin concentrations (a constituent of marine anti-fouling paints) were found near boat anchorages and marinas, whereas dioxins and furans were found in elevated concentrations downstream of pulp and paper mills (Wade and Sweet, 2005).

Casco Bay Estuary Partnership

Environmental Stressors

The CBEP uses a variety of human indicators to assess the environmental quality of Casco Bay, including the volume and frequency of CSOs, population changes, the amount of impervious cover in the watershed, and the amount of air pollution near the Bay. Annually, CSOs contribute millions of gallons of polluted water to Casco Bay; however, the volume and frequency of these overflows have decreased since 1996 (CBEP, 2005).

The human population in the Casco Bay watershed is expected to increase by 6% between 2005 and 2015. The CBEP uses population growth as an indicator of environmental stress because of the impact that related activities, such as transportation or housing construction, have on the Bay's ecosystem. For example, vehicle registrations in Cumberland County increased from about 215,000 to more than 283,000 between 1998 and 2003. Such an increase in the number of vehicles can contribute to urban sprawl patterns and increased impervious surface area (CBEP, 2005). The amount of impervious surfaces in a watershed is important because high levels of these surfaces can reduce groundwater recharge and increase flooding, erosion, and stream channel alteration. Impervious surface coverage can also be used as an indicator of stream degradation. Recent studies suggest that, when impervious surface coverage exceeds 6% to 10% of the watershed, the ability of Maine's streams to support aquatic ecological communities becomes degraded. Approximately 5.9% of the entire Casco Bay watershed is composed of impervious surfaces. It should be noted that this percentage was calculated for a large area and is not directly applicable to the 6% to 10% threshold calculated for very small watersheds (CBEP, 2005).

With grant funding from EPA and the Maine DEP, the CBEP established a coastal air monitoring site at Wolfe's Neck in Freeport, ME. Data from this site, along with results collected by the Maine DEP at an inland site in Bridgton, are helping these agencies determine patterns of air pollution in the watershed. The monitoring program has tracked the deposition of PAHs; mercury, cadmium, and other trace metals; and nitrogen, as well as the concentration of fine particulates. Data from this program and from the National Atmospheric Deposition Program suggest that the atmosphere is a significant source of pollution for Casco Bay. Rainfall sampled in Freeport, ME, contained PAHs at concentrations equal to an urban air monitoring site near Boston. These elevated levels were more common

Tern on Outer Green Island, ME (Matthew Craig).

in samples collected during the wetter seasons of spring and summer; however, the dry deposition of PAHs was much lower in samples from Freeport than from the urban site, suggesting that dry deposition is related to local sources (Golumb et al., 2001). The atmosphere is the dominant source of both nitrogen and mercury to the Bay (Figure 3-16) (Ryan et al., 2003).

Current Projects, Accomplishments, and Future Goals

Since 1990, the CBEP has had numerous accomplishments, including the following recent accomplishments:

- Initiated a coordinated habitat-restoration effort and catalyzed on-the-ground projects through seed funding, grant-writing, and technical support
- Facilitated a 14-municipality interlocal collaboration (Interlocal Stormwater Working Group) on the management of stormwater
- Facilitated the reopening of more than 300 acres of clam flats to harvesting
- Helped protect more than 3,000 acres of high-value habitat through conservation
- Presented experts on marine invasive species and stormwater management in cold climates during local and regional conferences.
- Compiled and analyzed available data on 14 indicators of the health of Casco Bay to publish the report *State of the Bay 2005*, which was released at the State of the Bay 2005 conference on November 3, 2005 (CBEP, 2005).

Conclusion

Casco Bay's overall condition appears to be rated good based on three of the NCA indices of estuarine condition and on assessment work done by the CBEP; however, some concerns have been identified as a result of monitoring work conducted during the 1990s and into the 21st century. Toxic pollution, thought to originate from legacy sources and atmospheric deposition, is a primary concern for stakeholders. In addition, relatively localized hypoxic conditions are being carefully studied, and other concerns, such as red tide outbreaks, algal blooms, and elevated bacterial counts, are also being monitored.

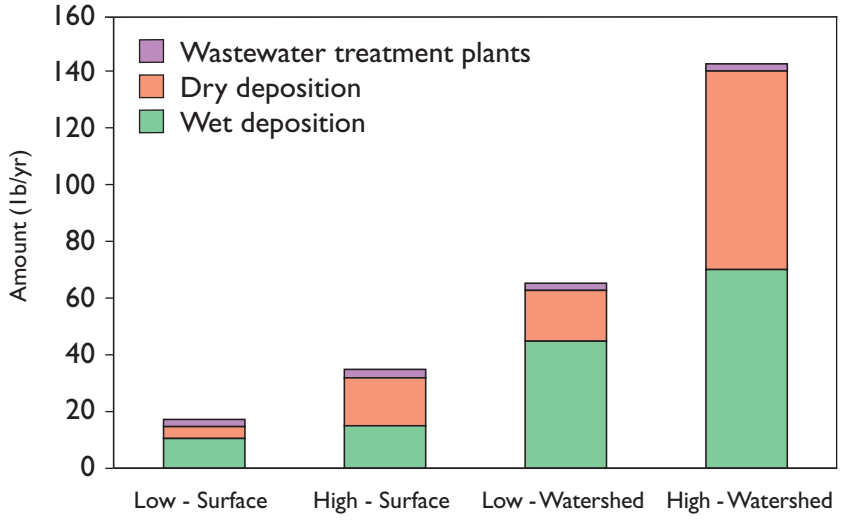

Figure 3-16. Atmospheric deposition (wet and dry) may account for 84% to 92% of the overall mercury loading to Casco Bay. The overall contribution of dry deposition to the total mercury loading on the surface of Casco Bay and on the Casco Bay watershed is estimated, and the high and low ranges of this estimate are presented on the graph (Ryan et al., 2003).