Estuarine Use Assessment:
Trial Project in Casco Bay, Maine

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Estuarine Use Assessment:
Trial Project in Casco Bay, Maine

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Table of Contents

Purpose of Report

The National Centers for Coastal Ocean Science (NCCOS) of the National Oceanic and Atmospheric Administration (NOAA) is interested in developing a project to determine the health of estuaries based on the stated or desired uses of society. An estuarine use assessment could complement the National Coastal Assessment, which tracks coastal and estuarine health through a series of environmental indicators. These indicators are used to assign a "score" to each coastal region, with some indicators reflecting the ability of the region to support desired uses such as fishing and swimming. An estuarine use assessment could also provide valuable information to resource managers and other decision-makers as they face decisions about the optimal and most sustainable mix of activities in an estuary.

An initial step of an estuarine use assessment would be to define and quantify the desired societal uses of the estuary. Society includes residents living near the estuary or industries relying on the estuary, seasonal residents and tourists that use the estuary on a more limited basis, and the public at-large that may use or value the estuary indirectly. The desired uses may include discrete, visible uses such as swimming, recreational or commercial fishing, and navigation. They also may extend to broader, more intangible uses such as maintaining ecological functions or aesthetic appeal. National legislation such as the Estuary Restoration Act, which promotes and funds the restoration of estuaries in the U.S., reflects the public's desire for estuaries to retain their ecological structures and functions.

This report summarizes a project carried out in 2003 that attempted to quantify the desired human uses of a specific estuary in Maine and to determine current measures of success used by coastal managers in Maine to track the ability of the estuary to support desired uses. Casco Bay was chosen as the spatial embayment for which to delineate uses, and nutrient enrichment was selected as the parameter for confirming assumptions about current measures of outcomes related to uses. The report highlights some of the challenges to completing an estuarine use assessment and offers general recommendations for addressing these challenges.

Background on Casco Bay

Casco Bay is a large estuary in southeast Maine with a water surface covering nearly 200 square miles and a shoreline extending 578 miles, including 785 islands, inlets, and exposed ledges. The watershed encompasses 985 square miles with twelve lakes and river systems feeding into the bay, including four main tributaries--the Presumpscot, Royal, Stroudwater, and Fore Rivers. While the watershed represents only 3% of the state's total land area, it is inhabited by nearly 25% of the state's population, including two large cities of Portland and South Portland (Casco Bay Plan, 1996).

Casco Bay is an ideal location for this project for several reasons. First, as one of the largest estuaries in the state and with its vicinity to major population centers, the public

uses Casco Bay in a variety of ways, allowing exploration of multiple and conflicting uses. Second, numerous scientific studies and monitoring programs track nutrients in the estuarine waters. Third, multiple management agencies and several public interest groups influence activities in the estuary, including the Maine Coastal Program, the Casco Bay National Estuary Program, the Maine Department of Environmental Protection, and the Maine Department of Marine Resources.

Nutrient enrichment has yet to become a serious problem in Casco Bay. Many state agencies and local interest groups, however, do consider it to be an important issue that warrants proactive measures in light of the projected population growth and extensive natural nutrient inputs in the region. While it is recognized that nutrients occur naturally and are a key component to healthy coastal ecosystems, excess nutrients often cause undesired changes that impact coastal resources. As with most estuarine and marine systems, nitrogen is the nutrient of greatest concern in Casco Bay. Land-based activities are one of the most important sources of nutrients delivered to coastal waters. Natural inputs from offshore and atmospheric deposition also contribute significantly to the nitrogen concentration in Casco Bay. While nitrogen inputs from these sources are not manageable by state agencies, there is concern that increasing inputs from land-based sources may cause the nutrient concentration in the estuary to cross a currently unknown limit that will significantly impair water quality, estuarine species and habitats, and human uses. There is also concern that land-based inputs may exacerbate naturally-occurring events, such as algal blooms.

Management Agencies – Managing for Desired Human Uses?

What are the desired human uses?

To delineate the desired human uses of the estuary, in the absence of a public survey, management plans were investigated as potential secondary sources of information (Appendix A). Upon realization that most management plans are outdated (e.g. Maine Coastal Program management plan dates to 1979), recent strategic plans and other documents were reviewed to identify goals and objectives. It was assumed that these goals and objectives would provide insight into how citizens of the state desired to use the estuarine waters. Since these were plans of state agencies, the goals and objectives are on a state-wide scale and are not specific to Casco Bay. To supplement the state plans and to provide a more narrow scope, the strategic plan of the Casco Bay National Estuary Program and the watershed plans for Presumpscot River and New Meadows River (both flowing into Casco Bay) were reviewed. The following are the desired uses mentioned in the state and local plans, verified through conversations with people working and/or living in the area:

- Recreation
- Fishing
- Aquaculture
- Shellfish harvesting
- Natural habitats

- Scenic beauty and character

While all components of recreation were not mentioned, swimming was noted specifically, as were other recreational uses include boating, fishing, and kayaking. Fishing was cited in the context of commercial fishing. Other desired uses not included in the plans but raised in conversations include the following:

- Tourism (which is linked to recreation)
- Navigation (ports)
- Drinking water
- Waste disposal

The state has identified designated uses of its estuarine and coastal waters, which are likely to indicate some but not all of the desired uses, especially on the smaller scale of an individual estuary. The designated uses established in Maine's water classification law and federal regulations for estuarine and marine waters include:

- Recreation in and on the water
- Fishing
- Aquaculture
- Propagation and harvesting of shellfish
- Navigation
- Natural and free flowing habitat for fish and other estuarine and marine life

Comparison of desired uses and designated uses:

Desired Uses	Designated Uses
Recreation	Recreation
Fishing	Fishing
Aquaculture	Aquaculture
Shellfish harvesting	Shellfish harvesting
Navigation*	Navigation
Natural habitats	Natural and free-flowing habitats
Scenic beauty and character	
Tourism*	
Drinking water*	
Waste disposal*	

* not identified specifically in strategic plans

Can the desired uses be quantified and multiple uses tracked?

There is currently no mechanism for quantifying the uses of Casco Bay, except through activities requiring state permits. Activities requiring permits include aquaculture, dredging, construction of docks and piers over a certain size, and installation of boat moorings outside of town harbors. The primary way that state agencies learn about

multiple use conflicts is from comments through the permitting process, though only some uses require permits (Doggett, 2003). This haphazard process of recognizing multiple uses means that the state agencies manage conflicting uses as they arise, with no proactive approach to understanding the impacts of multiple activities and no strategy for moving toward a more optimal mix of uses within the estuary.

Many of the uses of the estuary rely on land-based activities. For example, recreational fishing, boating, and swimming all require public access areas such as docks, piers, or beaches. In a home rule state such as Maine, local towns or municipalities primarily control these access areas, though larger structures require state permits. Understanding multiple uses and their cumulative impacts requires compiling information from many towns. In addition, the paucity of spatial information about the location and extent of uses within the estuary makes developing a clear understanding of the relationships between multiple uses difficult. Even for uses that have been mapped, such as shellfish growing areas, there is little information on the quality of the shellfish beds and thus minimal understanding of how much shellfish harvesting they can support and how other activities impact the shellfish areas (Leyden, 2003). Since some coastal towns do not consider estuary uses available in adjacent towns, or estuary uses desired by other towns, information on the location and impacts of uses may support improved planning among neighboring towns to maintain desired uses.

Do management plans provide insight into the "safe" range of nutrients needed to support desired uses?

The goals and objectives of the plans do not identify a certain level or range of nutrients to which they are managing in order to ensure that the identified uses are maintained. For example, a Department of Conservation goal is to "provide for a variety of recreational opportunities…," but this broad goal is not tied to a specific range of nutrient levels that must be maintained in order for the public to be able to use estuarine waters for recreational purposes. In fact, most of the goals articulate a desire to "maintain water quality," and while some directly state that water quality should be maintained to the state standards, others do not. In general, the goals and objectives of most management agencies do not define measurable targets, and most activities occur with minimum follow-up monitoring to evaluate the progress or the success of the activity in meeting the management objective.

In addition, it is important to recognize that some sources of land-based nutrients support human activities in the upland portion of the watershed. For example, nutrients from farms, lawns, and septic systems may wash downstream to the estuary and impact the condition of the waters and thereby people's ability to use it for various other activities, such as shellfish harvesting or swimming. These human activities are likely desired uses of upland areas, and this tension between upland and coastal areas must be recognized to ensure that the desired uses of the many user groups are considered on a watershed level.

Maine measures accomplishment or "attainment" of the Clean Water Act (CWA) goals by determining how well the waters support their designated or beneficial uses. The

current water use classification system in Maine has three tiers for marine and estuarine waters: SA, SB, and SC. Class SA waters are of the highest quality, with no direct pollutant discharges. All three classification categories meet the fishable/swimmable goals of the CWA and are suitable for various designated uses. All three also contain narrative biological standards as well as criteria for dissolved oxygen (DO) and bacteria levels (Maine DEP, 2003). Most of the water area in Casco Bay is rated SB, with an SA classification area in the more open water part of the estuary. Overall, though, these standards are set for water quality with no specific nutrient level in mind, and the state does not currently manage for nutrients in estuarine waters (Doggett, 2003).

Do managers know the threshold of nutrients allowable before use impairment?

Currently, the state agencies do not know the threshold of nutrients over which uses will start to become impaired, primarily due to a lack of scientific information and a lack of clear correlation between nutrient loads and nutrient enrichment effects. In fact, establishing a specific threshold of nutrients may be unrealistic since changing biogeochemical and biological processes determine how nutrients are absorbed into the ecosystem. Many factors influence the susceptibility of an estuary to nutrient enrichment including system dilution, water residence time, stratification, and wave activity. The dynamic nature of environmental factors on nutrient levels and the resulting variability in nutrient impacts may mean a range of "safe" nutrient levels may be more realistic than a specific threshold amount.

In the absence of consistent information on nutrient loads and nutrient concentrations, state agencies track DO measurements for water quality standards. While DO may serve as an indirect indicator of nutrient enrichment, specific biological conditions must be met for a DO change to result from nutrient influx. It should be noted that the state is in the process of revising its water quality standards. Not only does the lack of specificity in the current biological narratives allow varying interpretations of the standards, but DO saturation limits need to be changed to concentration limits to improve compatibility with upcoming national standards and current monitoring efforts. Use of DO concentration limits are becoming more common due to their lower error rate than calculating DO saturation limits, which requires combining measurements of DO, temperature, and salinity. For the revision, the Department of Environmental Protection (DEP) plans to establish DO limits based on scientific information about levels below which fish and marine life are impaired; an Environmental Protection Agency (EPA) model will be used to calculate the allowable DO levels, with a safety margin added to compensate for model uncertainty (Doggett, 2003).

In addition to a lack of state nutrient standards for parameters other than DO, EPA currently has not articulated nutrient criteria to help guide state development of standards. However, EPA is in the process of developing criteria for nutrients that provide for "protection and propagation of fish, shellfish, and wildlife and recreation in and on the water," which will eventually be incorporated into state water quality standards. EPA considers total nitrogen, total phosphorus, chlorophyll a, and turbidity important in nutrient assessment because the first two (total nitrogen and total phosphorus) are the

main causal agents of enrichment, whereas the two response variables (chlorophyll a and turbidity) are indicators of system enrichment for most surface waters (EPA, 2001). For Casco Bay, EPA will likely choose a reference site within the bay and set the standards based on levels of each parameter measured at the reference site (Liebman, 2003). Currently EPA and NOAA set different levels for total nitrogen standards, and the DEP will determine the best level for the state once EPA nutrient standards have been announced (Doggett, 2003).

How do managers measure outcomes given the lack of federal or state standards?

In general, managers do not track the outcomes of nutrient levels and instead primarily focus on water quality as related to human health and shellfish harvesting. While shellfish beds may be closed due to harmful algal booms that result from excess nutrients, usually they are closed due to other toxins in the ecosystem. In fact, harmful algal blooms are rare in the Gulf of Maine estuaries because watersheds are relatively small, waterbodies are generally deep, riverine sediment loads are low, and the water column is relatively clear (Sowles, 2001). In Casco Bay, only one toxic bloom has occurred within the past few decades, and there is strong evidence the responsible phytoplankton blew in from offshore, where the excess nutrients likely came from natural offshore sources (Heining, 2003).

Overall, though, managers employ known management strategies and assume that when such strategies are put into place (such as replacing septic systems with a wastewater treatment plant), the nutrient level is reduced, although the actual change is not quantified. And, while the DEP does not monitor nutrients in estuarine waters, several monitoring groups collect information on indicators of nutrient enrichment including DO, chlorophyll a, and turbidity. Two primary groups include Friends of Casco Bay and the Gulf of Maine Ocean Observing System, which partner to monitor DO, water clarity, nitrate, silicate, phosphate, and ammonium concentrations through analysis of water samples at ten stations around the Bay. These data are submitted to the DEP and used to evaluate the condition of the state's estuarine and coastal waters for CWA Section 305(d) status (Young, 2003).

Summary

What are the primary challenges to developing an estuarine use assessment?

Three primary challenges exist in the initial steps of assessing estuary use:

- **Defining uses –** There is little specific articulation of the desired uses of the estuary. While extracting desired uses from strategic plans is one way to start defining uses, these are not necessarily comprehensive lists and provide no prioritization of uses.
- **Quantifying uses –** The primary ways for quantifying uses are through permits and spatial maps of use areas. However, permits are only required for specific uses, and maps of use areas are only available for certain uses and are often outdated.

- **Multiple uses –** The interactions between multiple uses are not consistently tracked and are primarily brought to the attention of the state agencies through comments during the permitting process. Thus, the management agencies have little information on how certain uses influence other uses or affect estuarine resources, especially through cumulative impacts.

What are recommendations for proceeding with an estuarine use assessment?

The following are recommendations for proceeding with an estuarine use assessment, given the knowledge of estuarine management in Maine and the challenges outlined above:

- **Seek user input** – Since the strategic plans did not provide a clear articulation of desired uses, and management plans are perhaps too outdated to represent desired uses in a timely manner, some mechanism for direct user input should be devised. This mechanism may include user surveys or stakeholder group forums to specifically answer the question, "How does society want to use the estuary?" Not only will this approach provide a more comprehensive list and knowledge of desired uses, it may also enable prioritization of uses and increase public support for the outcomes of the assessment.

- **Define measurable goals and objectives** – The strategic plans of the state agencies and the management plans for local watershed/bay groups rarely defined goals and objectives with measurable targets. Specific targets are needed to evaluate the success of management initiatives in meeting desired human uses. A mechanism for working across state agencies, towns, municipalities, and local interest groups is necessary to identify common desired uses and define measurable objectives related to uses. A consistent set of joint objectives is also needed in order to evaluate the environmental conditions of the estuary in supporting those objectives and to assess the impacts of management actions on environmental conditions and human uses within the estuary.

- **Use available science and/or determine research needs in order to set nutrient (or other environmental parameter) standards** – A threshold quantity or range for the amount of nutrients beyond which use impairments are more likely to occur needs to be determined through scientific studies or models. An assessment could evaluate existing relevant scientific information and identify scientific gaps to encourage targeted research to inform how nutrient levels, including interactions with other environmental conditions, impact estuarine uses. Ranking uses in order of sensitivity to increasing nutrient levels may be a useful first step and allow for the threshold to be set for the most sensitive use (Doan, 2003). Defining or narrowing this quantity may help state and municipal governments better understand a sustainable level of nutrient loading, which is the primary mechanism by which land-based inputs can be controlled. For example, the Town of Brunswick has a coastal zone protection ordinance that sets standards for septic loads on five-acre lots. To establish the

standard, the town determined how much nitrate a specific use – shellfish beds – in the estuary could tolerate before becoming impaired. While this standard has helped determine density requirements for lots in order to decrease the number of septic systems, the town planner notes that they lack the resources to monitor nutrient loads and are unsure if the standards are set at the appropriate level (Walker, 2003).

- **Consider local land use plans** – Local land use plans should be reviewed and town officials consulted in the assessment process since municipalities have control over land use above the mean high tide mark. Local ordinances, such as standards for septic loads, guide many decisions that have direct effects on nutrient loading in estuaries. In addition, local decisions influence many estuarine water uses such as boating, fishing, and swimming because these activities require some type of public access (e.g. docks and boat ramps) for such water-dependent activities to occur. In Maine, because of the increasing growth of tourism, recreational boats are competing with commercial vessels for mooring and dock space. At the same time, fewer piers and docks are available for boat landings. With property values along the coast increasing, private land parcels with docks have been sold (often to new seasonal residents who do not want to allow use by local fishermen), public access sites are more difficult to acquire, and existing public access sites are crowded. Regardless of its environmental condition, such changes in local land use and ownership can strongly influence which uses the estuary can support. For example, even if lobster harvesting is a desired use and the ecosystem can support the use, a lack of docks for boats to unload their harvest may greatly decrease that specific activity.

- **Start with a pilot project** – A pilot project will allow different mechanisms of defining human uses to be tested, the interactions of a specific use with other uses to be clarified, and metrics by which to determine if the estuary is meeting the desired uses to be developed and tested. Casco Bay may prove to be a potential pilot project site for these purposes. First, the trial project summarized in this report will provide initial information for developing an assessment in Casco Bay. Second, Casco Bay is a large, economically-important estuary with multiple users, an involved citizenry, and interested coastal management groups, including a National Estuary Program.

Would an estuarine use assessment be useful to state coastal management agencies?

In talking with various state agencies and estuary-focused organizations, many agreed that having a way to better quantify the uses of the estuary, as well as to understand the interactions and cumulative impacts of multiple uses, would be a very helpful tool. Lee Doggett (2003) of Maine DEP suggested that one useful mechanism would be a model by which to determine the interactions and ecological effects of the varying uses.

An estuarine use assessment could serve state agencies in the following ways:

- Provide more information about how the estuary is currently being used and how the public wants to use the estuary;

- Assess the science needed to understand whether the estuary is supporting those uses or can continue to support them in the future;
- Inform state management strategies or spur town initiatives/ordinances to maintain or improve estuary conditions that support desired uses;
- Allow state management agencies to make more informed decisions about the most sustainable combination of uses of the estuary or parts of the estuary; and,
- Promote better decision-making in managing multiple and conflicting uses by providing information needed for policymakers to identify and determine what trade-offs they are willing to make between different uses.

Appendix A
Plans Reviewed

A Plan for the Future of the Presumpscot River (draft), April 2003.

Casco Bay Estuary Project Casco Bay Plan, Fall 1996.

Gulf of Maine Council Action Plan 2001-2006.

Maine Department of Conservation Strategic Plan, December 2002.

Maine State Planning Office Strategic Plan, 2002.

Maine Department of Environmental Protection Strategic Plan, 2002.

Maine Department of Marine Resources Strategic Plan, 2000.

New Meadows River Watershed Project Strategic Plan, June 2003.

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