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Voluntary Estuary Monitoring Manual

Chapter 2: Overview, covering the science, the problems, and the solution

March 2006

Chapter 2

Understanding Our Troubled Estuaries




To say that estuaries are valuable resources is a gross understatement. They are among the most productive natural environments in the world and among the most sought-after places for people to live. Estuaries support major fisheries, shipping, and tourism. They sustain organisms in many of their life stages, serve as migration routes, and are havens for threatened and endangered species. Associated wetlands filter pollutants, dissipate floodwaters, and prevent land erosion.

Photos (l to r): U.S. Environmental Protection Agency, R. Ohrel, Weeks Bay Watershed Project, R. Ohrel

Overview

To say that estuaries are valuable resources is a gross understatement. They are among the most productive natural environments in the world and among the most sought-after places for people to live. Estuaries support major fisheries, shipping, and tourism. They sustain organisms in many of their life stages, serve as migration routes, and are havens for threatened and endangered species. Associated wetlands filter pollutants, dissipate floodwaters, and prevent land erosion.

Yet, despite their value, estuaries are in trouble.

Nearly half of the U.S. population lives in coastal areas, which include the shores of estuaries. Unfortunately, this increasing concentration of people is upsetting the natural balance of estuarine ecosystems and threatening their integrity. Pollution, habitat destruction, overfishing, wetland loss, and the introduction of non-indigenous species are among the consequences of many human activities.

As concern over the well-being of the environment has risen during the past several decades, so has the interest in gathering information about the status of estuaries. Government agencies have limited funds for monitoring. As a result, volunteer monitoring has become an integral part of the effort to assess the health of our nation's waters. Designed properly, volunteer programs can provide high-quality reliable data to supplement government agencies' water quality monitoring programs.

This chapter discusses our troubled estuaries. The estuarine environment is described and several problems relating human activities to estuarine degradation are investigated. Finally, the role of volunteer monitoring in identifying, fixing, or preventing problems is examined.

The Science

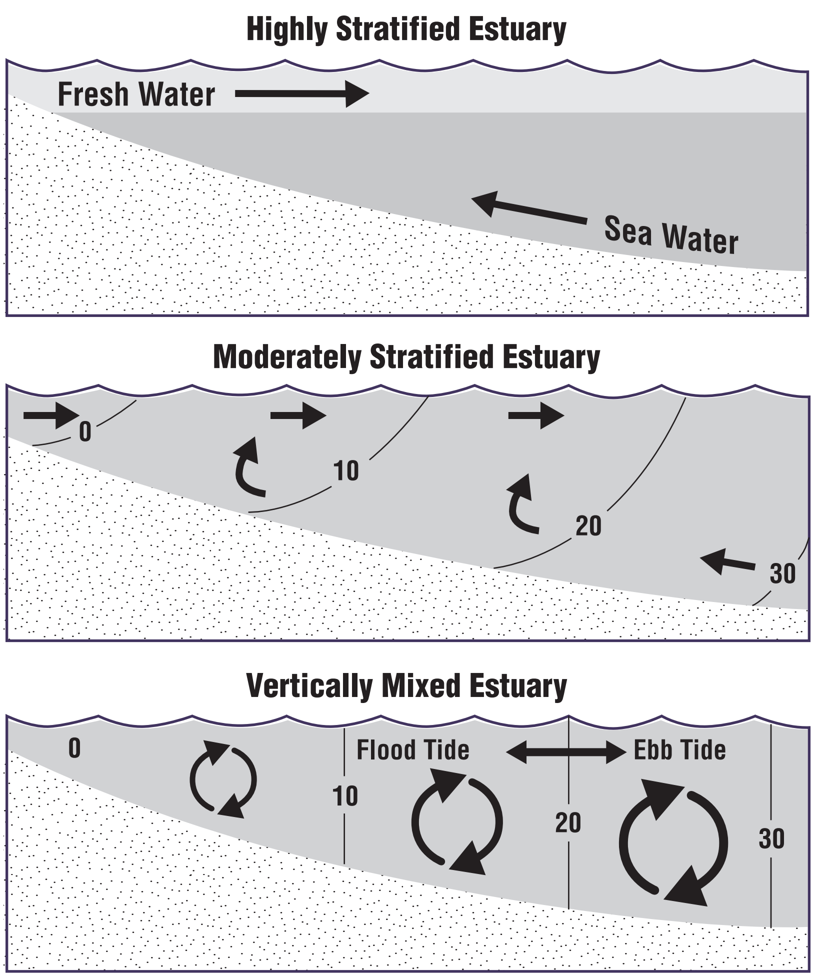
What Is an Estuary?

Unlike many features of the landscape that are easily described, estuaries are transitional zones that encompass a wide variety of environments. Loosely categorized as the zone where fresh and salt water meet and mix, the estuarine environment is a complex blend of continuously changing habitats. To qualify as an estuary, a waterbody must fit the following description:

"a semi-enclosed coastal body of water which has free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage"

(Pritchard, 1967).

Figure 2-1. Three types of estuaries: highly stratified, moderately stratified, and vertically mixed *(adapted from Levinton, 1982)*. Numbers refer to salinity in parts per thousand.



The estuary itself is a rather well-defined body of water, bounded at its mouth by the ocean and at its head by the upper limit of the tides. It drains a much larger area, however, and pollutant-producing activities near or in tributaries even hundreds of miles away may still adversely affect the estuary's water quality.

While some of the water in an estuary flows from the tributaries that feed it, the remainder moves in from the sea. When fresh and salt water meet, the two do not readily mix. Fresh water flowing in from tributaries is relatively light and overrides the wedge of more dense salt water moving in from the ocean. This density differential often causes layering or stratification of the water, which significantly affects both circulation and the chemical profile of an estuary.

Scientists often classify estuaries into three types according to the particular pattern of water circulation (Figure 2-1):

- Highly Stratified Estuary

  The layering between fresh water from the tributaries and salt water from the ocean is most distinct in this type of estuary, although some seawater still mixes with the surface freshwater layer. To compensate for this "loss" of seawater, there is a slow but continual up-estuary movement of the salty water on the bottom.

- Moderately Stratified Estuary

  In this intermediate estuary type, mixing of fresh and salt water occurs at all depths. With this vertical mixing, salinity levels generally increase toward the estuary mouth, although the lower layer is always saltier than the upper layer.

- Vertically Mixed Estuary

  In this type of estuary, powerful mixing by tides tends to eliminate layering altogether. Salinity in these estuaries is a function of the tidal stage. This tidal dominance is usually observed only in very small estuaries.

Rivers flow in a single direction, flushing out sediments and pollutants. In estuaries, however, there is a constant balancing act between the up-estuary saltwater movement and down-estuary freshwater flow. Rather than quickly flushing water and pollutants through its system, an estuary often has a lengthy retention period. Consequently, waterborne pollutants, along with contaminated sediment, may remain in the estuary for a long time, magnifying their potential to adversely affect the estuary's plants and animals.

Other factors also play a role in the hydrology of an estuary. Basin shape, mouth width, depth, area, tidal range, surrounding topography, and regional climate combine to make each estuary unique.

Why Are Estuaries Important?

Estuaries are critical for the survival of many species. Tens of thousands of birds, mammals, fish, and other wildlife depend on estuarine habitats as places to live, feed, and reproduce. They provide ideal spots for migratory birds to rest and refuel during their journeys. Many species of fish and shellfish rely on the sheltered waters of estuaries as protected places to spawn, giving estuaries the nickname "nurseries of the sea." Hundreds of marine organisms, including most commercially valuable fish species, depend on estuaries at some point during their development.

Besides serving as an important habitat for wildlife, the wetlands that fringe many estuaries perform other valuable services. Water draining from upland areas carries sediments, nutrients, and other pollutants. But as the water flows through wetlands, much of the sediments and pollutants are filtered out. This filtration process creates cleaner and clearer water, which benefits both people and marine life. Wetland plants and soils also act as natural buffers between the land and ocean, absorbing floodwaters and dissipating storm surges. This protects upland organisms as well as valuable real estate from storm and flood damage. Salt marsh grasses, mangrove trees, and other estuarine plants also prevent erosion and stabilize the shoreline.

Among the cultural benefits of estuaries are recreation, scientific knowledge, education, and aesthetic value. Boating, fishing, swimming, surfing, and bird watching are just a few of the numerous recreational activities people enjoy in estuaries. They are often the cultural centers of coastal communities—focal points for commerce, recreation, history, customs, and traditions. As transition zones between land and ocean, estuaries are invaluable laboratories for scientists and students, providing countless lessons in biology, geology, chemistry, physics, history, and social issues. Estuaries also provide a great deal of aesthetic enjoyment for the people who live, work, or recreate in and around them.

Wetlands, like this one in Virginia, provide many valuable services. They remove pollutants, absorb floodwaters, dissipate storm surges, stabilize shorelines, and serve as habitat for many organisms (photo by R. Ohrel).

Commercial and recreational activities in estuaries generate billions of dollars for local economies (photo by USEPA).

Finally, the tangible and direct economic benefits of estuaries should not be overlooked. Tourism, fisheries, and other commercial activities thrive on the wealth of natural resources that estuaries supply. Protected estuarine waters also support important public infrastructure, serving as harbors and ports vital for shipping, transportation, and industry. Some attempts have been made to measure certain aspects of the economic activity that depends on America's estuaries and other coastal waters. For example:

- Estuaries provide habitat for more than 75 percent of America's commercial fish catch and for 80-90 percent of the recreational fish catch (National Safety Council's Environmental Center, 1998). Commercial and recreational fishing contribute about $4.3 billion annually to the U.S. economy, while related marine industries add another $3 billion annually (ANEP, 1998).

Importance of Estuaries

HABITAT: Tens of thousands of birds, mammals, fish, and other wildlife depend on estuaries.

NURSERY: Many marine organisms, most commercially valuable fish species included, depend on estuaries at some point during their development.

PRODUCTIVITY: A healthy, undisturbed estuary produces from four to ten times the weight of organic matter produced by a cultivated cornfield of the same size.

WATER FILTRATION: Water draining off upland areas carries a load of sediments and nutrients. As the water flows through salt marsh peat and the dense mesh of marsh grass blades, much of the sediment and nutrient load is filtered out. This filtration process creates cleaner and clearer water.

FLOOD CONTROL: Porous, resilient salt marsh soils and grasses absorb floodwaters and dissipate storm surges. Salt marsh-dominated estuaries provide natural buffers between the land and the ocean. They protect upland organisms as well as billions of dollars of human real estate.

ECONOMY: Estuary-dependant activities—recreation, shipping, fishing, and tourism—generate billions of dollars each year.

CULTURE: Native Americans and early settlers depended on productive estuaries for survival. Sheltered ports were essential for the transfer of goods and information from other continents. Today, estuaries support a way of life valued by many.

(Excerpted from NERRS Web site: http://inlet.geol.sc.edu/nerrsintro.html.)

- Nationwide, commercial and recreational fishing, boating, tourism, and other coastal industries provide more than 28 million jobs. Commercial shipping alone employed more than 50,000 people as of January 1997 (National Safety Council's Environmental Center, 1998).
- There are 25,500 recreational facilities along the U.S. coasts—almost 44,000 square miles of outdoor public recreation areas (NOAA, 1990). The average American spends 10 recreational days on the coast each year. In 1993, more than 180 million Americans visited ocean and bay beaches—nearly 70 percent of the U.S. population. Coastal recreation and tourism generate $8 to $12 billion annually (National Safety Council's Environmental Center, 1998).

In short, estuaries provide us with a whole suite of resources, benefits, and services. Some of these can be measured in dollars and cents; others cannot. Estuaries are irreplaceable natural resources that must be managed carefully for the mutual benefit of all who enjoy and depend on them.

Where Land Meets Ocean

You may have heard the saying, "We all live downstream." This is a rather simple statement intended to bring attention to complex, intertwined processes affecting water quality. Estuaries are the intermediary between oceans and land (Figure 2-2); consequently, these two factors influence their physical, chemical, and biological properties.

Estuaries are part of a larger collection of geographic features that make up a watershed, an area that drains surface bodies of water.

Watersheds generally include lakes, rivers, wetlands, streams, groundwater recharge areas, and the surrounding landscape, in addition to estuaries.

Tributaries flow downstream through the watershed for up to hundreds of miles. In their journey, they pick up materials that wash off the land or are discharged directly into the water by land-based activities. Eventually, the materials that the tributaries accumulate are delivered to estuaries.

The types of materials that eventually enter an estuary largely depend on how the land is used. Undisturbed forests, for example, will discharge considerably fewer pollutants than an urban center or cleared agricultural field. Surrounding land uses and land use decisions, then, can have significant effects on an estuary's overall health. ■

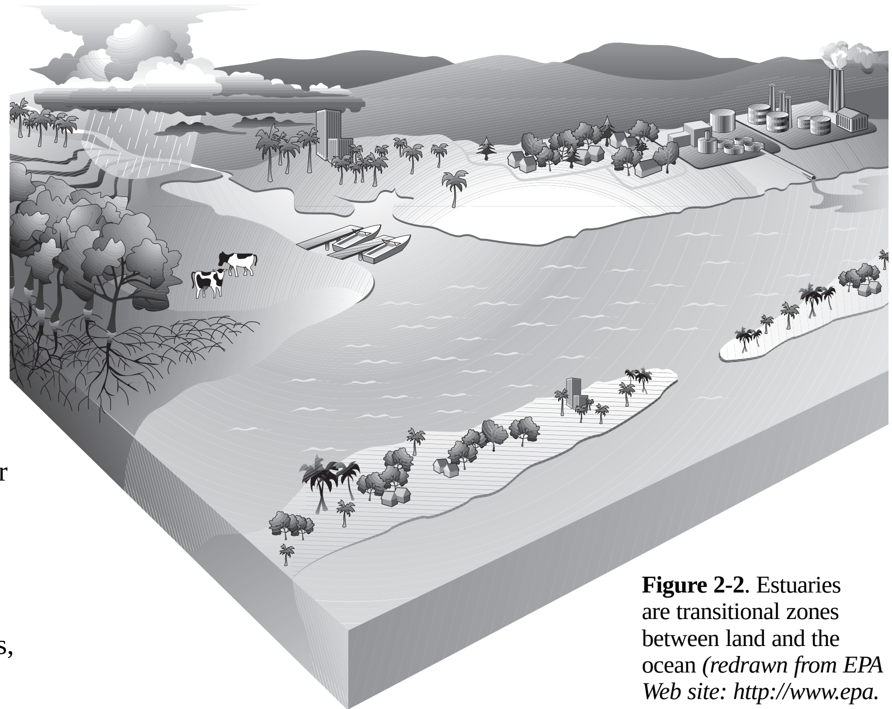


Figure 2-2. Estuaries are transitional zones between land and the ocean *(redrawn from EPA Web site: http://www.epa.gov/owow/oceans/factsheets/fact5.html).*

The Problems

Changes to the coastal landscape have had serious implications for estuarine health. Estuaries are bombarded by several pollutant sources, and their impacts can be severe.

Pollutant Sources

Wherever there is human activity, there is usually a potential source of pollutants. Table 2-1 and Figure 2-3 summarize some common estuarine pollutants and their potential sources.

Estuarine pollution is generally classified as either **point source pollution** or nonpoint source pollution. Point source pollution describes pollution that comes from a discernible source, such as an industrial discharge or wastewater treatment plant. Point source pollution is usually identified as coming from a pipe, channel, or other obvious discharge point. Laws regulate point sources, with limits placed on the types and quantities of discharges to estuaries and other waterways.

Nonpoint source pollution (NPS), on the other hand, comes from a variety of diffuse sources that do not have a single discharge point. Examples include stormwater runoff from urban areas, marina operations, farming, forestry, and construction activities; faulty or leaking septic systems; and atmospheric deposition originating from industrial operations or vehicles. NPS pollution, which is often hard to identify and quantify, is generally more difficult and expensive to regulate and control than point source pollution.

Point sources deliver pollutants to estuaries through a pipe or other discharge point. Here, the pipe is located under a pier (photo by R. Ohrel).

Pollutant Impacts

Many of our nation's more than 100 estuaries are also under siege. Historically, estuaries and other waterbodies have been the receptacles for society's wastes. Human sewage, industrial byproducts, and runoff

Table 2-1. Common pollutants and impacts associated with selected coastal land uses *(adapted from USEPA, 1997; Maine DEP, 1996; USEPA, 1993).*

Source	Common Pollutants	Possible Impacts
Cropland	Sediments, nutrients, pesticides	Reduced water clarity, smothered benthic habitat, toxicity to organisms, excessive algal growth, reduced dissolved oxygen, water temperature changes
Grazing land	Fecal bateria, sediments, nutrients	Possible introduction of pathogens, reduced water clarity, smothered benthic habitat, excessive algal growth, reduced dissolved oxygen, water tempterature changes
Forestry	Sediments	Reduced water clarity, smothered benthic habitat, water temperature changes
Mining	Acid discharge, sediments	Reduced water clarity, smothered benthic habitat, impacts on pH and alkalinity
Industrial/commercial discharge	Sediments, toxins	Reduced water clarity, smothered benthic habitat, impacts on pH and alkalinity, toxicity to organisms
Sewage treatment plants	Nutrients, suspended solids, fecal bacteria	Reduced water clarity, excessive algal growth, reduced dissolved oxygen/higher biochemical oxygen demand, water temperature and pH changes, possible introuction of pathogens
Construction	Sediments, toxins, nutrients	Reduced water clarity, smothered benthic habitat, excessive algal growth, reduced dissolved oxygen, water temperature changes, toxicity to organisms
Urban runoff	Sediments, nutrients, metals, petroleum hydrocarbons, bacteria	Reduced water clarity, smothered benthic habitat, excessive algal growth, reduced dissolved oxygen/higher biochemical oxygen demand, water temperature changes, toxicity to organisms, possible introduction of pathogens
Lawns/golf courses	Toxins, nutrients, sediments	Reduced water clarity, smothered benthic habitat, excessive algal growth, reduced dissolved oxygen/higher biochemical oxygen demand, toxicity to organisms
Septic systems	Fecal bacteria, nutrients	Excessive algal growth, reduced dissolved oxygen/higher biochemical oxygen demand, water temperature changes, possible introduction of pathogens
Marinas/boat usage	Toxins, nutrients, bacteria	Excessive algal growth, reduced dissolved oxygen/higher biochemical oxygen demand, toxicity to organisms, possible introduction of pathogens

Improperly managed construction sites can clog estuaries with tons of sediments (photo by R. Ohrel).

from farming operations disappeared as they mixed with receiving waters and washed into the nation's fragile estuaries.

Over the past several decades, however, the signs of estuarine decline have become increasingly apparent. Many fish and shellfish populations hover near collapse. Although we have recognized the problems and have generally reduced the pollutants entering our waters, the sheer numbers of people living near the coasts continue to stress our estuaries, lagoons, and other coastal waters.

No coastal areas, estuaries included, are immune to the threat of pollution; they all share common problems. Many are often subject to seasonal depletion of dissolved oxygen, particularly in their deeper waters. Accelerated **eutrophication**—a condition in which high nutrient concentrations stimulate excessive algal blooms, which then deplete dissolved oxygen as they decompose—often threatens the character of the natural system.

Across the country, estuaries are vulnerable to assault from a wide variety of toxic substances, which menace the health of humans and wildlife. While sources of these substances may be relatively scarce in the more pristine areas surrounding an estuary, industrialized areas often lead to "hot spots" in the adjacent estuary, with toxins concentrating in the water, sediment, and local aquatic plants and animals. Stormwater runoff from urban and rural areas can also deliver toxic materials to estuaries. Metals, pesticides, and automotive fluids are frequently washed from lawns, agricultural fields, parking lots, marinas, and a myriad of other sources to estuarine waters.

Bacterial contamination is yet another

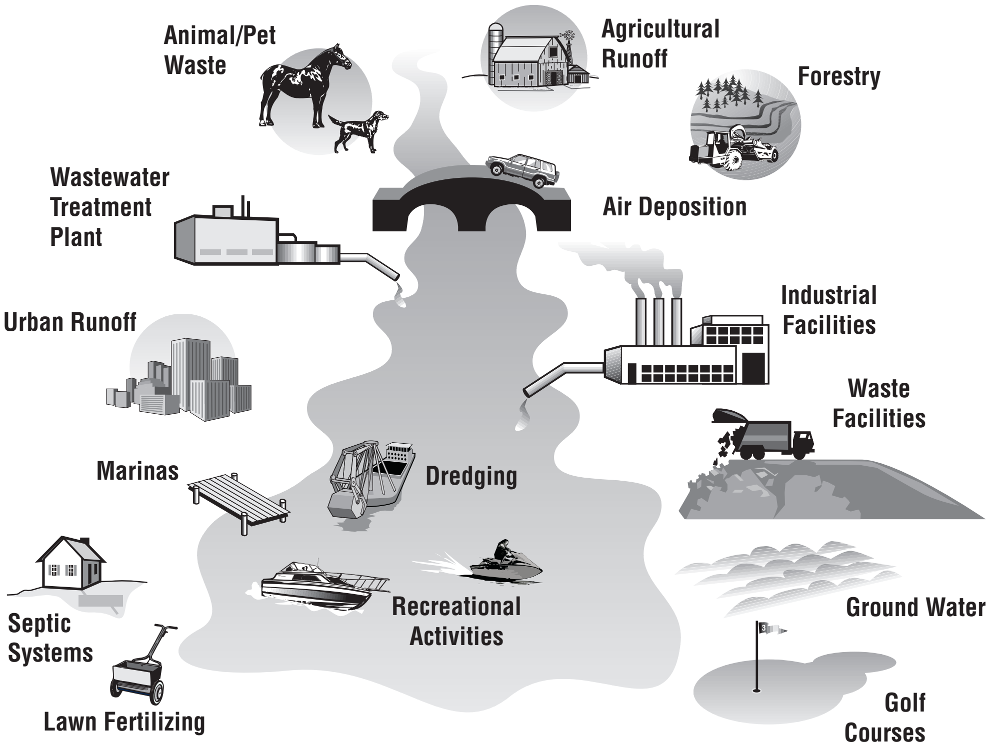


Figure 2-3. Potential sources of estuarine pollution.

problem prevalent in many estuaries. Inadequately treated sewage released to the estuary threatens recreational water users and contaminates local shellfish. States often monitor shellfish or the waters overlying shellfish beds for bacterial contamination, occasionally shutting down contaminated areas to recreational and commercial fishermen until bacteria numbers drop to safe levels.

Sediments from construction sites, agricultural activities, forestry operations, and dredging activities, among other sources, can be another concern. Sediments washing into estuaries or resuspended from dredging can carry a host of additional environmental problems with them. These sediments cover critical **benthic**, or bottom, habitat for numerous species and smother plants and animals. They cloud waters, preventing sunlight from reaching submerged plants. Metals and other toxic materials are frequently attached to sediments, and it is often through this affiliation that toxic materials are delivered to the estuary. Attached to sediments, they make their way to the benthic zone, where they accumulate within organisms and become introduced to the food web. Under certain environmental conditions, toxins may also be released from sediments into the water column.

Other areas suffer from large quantities of marine debris. Storm sewers, combined sewer overflows, and carelessly dropped litter are among the sources of these eyesores. Marine debris found on estuarine shorelines and underwater pose a health hazard to marine animals and humans.

Whether the problems are unique to one estuary or common to many, several have worsened over recent decades. Simultaneously, however, the interest of a few concerned citizens has grown into a nationwide awareness that the environment is a necessary national priority.

Along with this growing recognition, the means to assess the health and status of our nation's waters has also evolved. While scientists provided many early clues to the deterioration of estuarine water quality, citizens have become important contributors in the long-term effort to identify and address water quality problems. ■

Examples of Water Quality Degradation

- The Petaluma River, a tributary to San Francisco Bay, has experienced seasonal algal blooms, low oxygen levels, and fish kills resulting from municipal waste discharges.
- Low dissolved oxygen levels are problematic in Corpus Christi Bay and Galveston Bay in Texas and in Mobile Bay, Alabama. Low oxygen levels are especially prevalent where wastewater discharges and surface runoff go to areas that are poorly flushed or have little circulation.
- In 1990, nitrogen levels in Sarasota Bay, Florida, were estimated to be three times greater than predevelopment levels.
- Pollution from surface runoff has been implicated in nearly 30 percent reduction in seagrass coverage that occurred in the Indian River Lagoon, Florida, between 1970 and 1990. If no action is taken, it is estimated that pollution from surface runoff will increase by more than 30 percent by the year 2010 due to increasing human population.
- Runoff from the land contributes more than 50 percent of nitrogen loadings to Maryland's coastal bays, with 50 percent of these loadings coming from agricultural feeding operations (primarily poultry), which make up less than one percent of the watershed.
- A citizen-based water quality sampling effort in Buzzards Bay, Massachusetts, reports that nine of the Bay's 30 embayments experience poor water quality (primarily from nutrient over-enrichment) during the summer months. Another eight embayments are in transition from good to poor water quality. At least 50 percent of all the embayments have shown a slight to moderate decline in water quality during four years of monitoring.
- From mid-July through September each year, up to half of Long Island Sound in New York experiences dissolved oxygen levels insufficient to support healthy populations of marine life. Nitrogen loads are estimated to be more than twice those of pre-colonial times with 57 percent of the nitrogen entering the Sound each year attributable to human activities.

(Source: ANEP, 1998.)

The Solutions

Clarifying and characterizing the problems unique to an estuary help clear the path toward potential solutions. The first step in solving each problem is defining it. One should ask:

- Is there a problem?
- If so, how serious is it?
- Does the problem affect only a portion of the estuary, or the entire body of water?
- Does the problem occur sporadically, seasonally, or year-round?
- Is the problem a naturally occurring phenomenon, or is it caused by human activities?

The Importance of Monitoring

A systematic and well-planned monitoring program can identify water quality problems and help answer the questions critical to their solutions. Useful monitoring data will accurately portray the current chemical, physical, and biological status of the estuary. This type of information, collected systematically over time, can establish a record of water quality conditions in an estuary.

If reliable historical data exist for comparison, current monitoring data can also document changes in the estuary from the past to the present. These data may serve as a warning flag, alerting managers to the development of a water quality problem. Or, on the positive side, data comparisons may indicate improvements in estuarine water quality.

Thus, monitoring programs can perform a variety of functions. The most effective monitoring program, however, resolves the use of the data early on so that the program design best addresses the defined problems. Most citizen monitoring programs serve to:

- supplement federal, state, and local monitoring efforts;
- educate the public;
- obtain data from remote areas;
- obtain data during storms or other unique events;
- bring a problem area to light; and/or
- document the illegal discharge of waste.

Citizen monitoring data, collected accurately and systematically, can be an important supplement to data collected by professionals. Accurate data often have far-reaching uses that the organizers may not have anticipated at the outset of their program. Indeed, these data have the potential to influence management actions taken to protect the waterbody. Further uses of the data include:

- providing a scientific basis for specific management decisions and strategies;
- contributing to the broad base of scientific information on estuary functions and the effects of estuary pollution;
- determining multiyear water quality trends;
- documenting the effect of nonpoint and point source pollutants on water quality;
- indicating to government officials that citizens care about their local waterways;
- documenting the impacts of pollution control measures; and
- providing data needed to determine permit compliance.

Assessing water quality should not be conducted purely for the sake of monitoring itself. Ultimately, the protection and restoration of an estuary's wildlife, natural functions, and compatible human uses is of greatest concern. To restore an estuary, we must ensure that water quality conditions remain within the optimal range for the health and vitality of native species. As scientists discover the ideal habitat conditions for each species, monitoring data will be instrumental in judging how often conditions are suitable for the survival and propagation of these species.

Measures of Environmental Health and Degradation

Estuaries are complex systems with a large assortment of habitats, animal and plant species, and physical and chemical conditions. As a result, there are dozens—perhaps hundreds—of monitoring parameters being used to evaluate the health of estuaries. Several parameters describe the basic chemical, physical, and biological properties of an estuary. These traits determine the estuary's fundamental nature. They form, in essence, the ABCs of estuarine water quality and set the stage for selecting the environmental parameters that will indicate estuarine health.

Warning: It's All Connected!

Simply measuring a chemical concentration or locating a particular organism does not necessarily tell the full story of an estuary's health. Several factors may interact to influence your data.

To facilitate discussion of different monitoring parameters, this Methods Manual *addresses monitoring topics according to chemical, physical, or biological properties. However, it is important to recognize that one environmental parameter may influence another (Figure 2-4). Temperature, for example, largely governs the rate of chemical reaction and biological activity. The pH affects the solubility of certain chemicals in the water. Nutrient concentrations influence algal growth, which ultimately affects dissolved oxygen concentrations. Turbidity controls the amount of sunlight that can reach underwater plants.*

Chapter 7 describes several environmental factors that could influence your monitoring results.

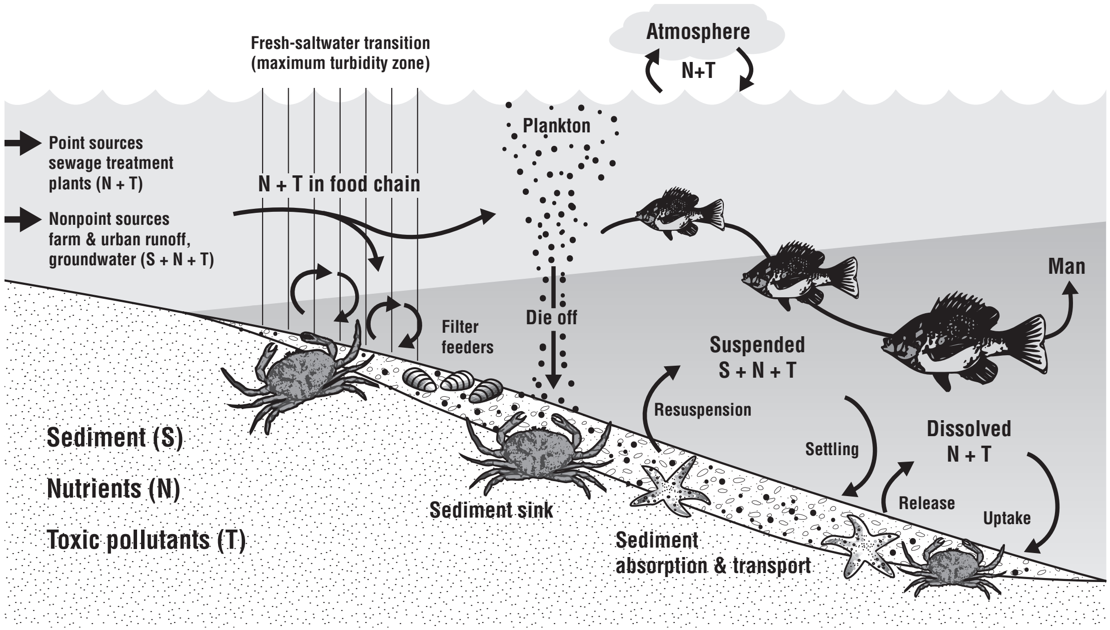


Figure 2-4. Schematic diagram of physical, chemical, and biological processes interacting in estuaries *(redrawn from USEPA, 1987).*

Chemical Measures

Chemical parameters are the main focus of many volunteer estuary monitoring programs, which concentrate on pollutants that arrive in the estuary from point and nonpoint sources (e.g., nutrients, toxins). Other chemical measurements serve as indicators of problems. Low dissolved oxygen concentrations, for example, can be disastrous for many estuarine organisms.

Unit 1 highlights some of the common estuarine chemical monitoring parameters and techniques.

Physical Measures

Some parameters are neither biological nor chemical in nature; they represent measures of the physical environment. Sediment and marine debris are examples of natural and manmade materials, respectively, that can affect estuarine organisms' living environment and health.

Unit 2 discusses some measures of the physical environment employed by many volunteer estuary monitoring programs.

Biological Measures

Living organisms can reveal a great deal about an estuary's health. In some cases, their presence can be a good sign. For example, the widespread distribution of submerged aquatic vegetation (SAV) can suggest that turbidity or excessive nutrients may not be problems in the area. Other organisms, however, can be causes of concern. High bacteria levels can indicate the presence of pathogens in the water—a potential human health risk. The presence of non-indigenous species can threaten native organisms and disrupt a delicate ecological balance.

Biological monitoring is discussed in greater detail in Unit 3.

Peculiarities of Volunteer Estuary Monitoring

You may be thinking, "I know how to monitor streams, so I know how to monitor estuaries." In many respects, you are correct. Basic monitoring techniques are similar for streams, lakes, rivers, and estuaries. However, estuaries have several, often unique, properties that must be considered when conducting monitoring efforts. As one volunteer leader wrote, “Estuary monitoring can be characterized as a mixture of river and lake monitoring techniques—liberally salted” (Green, 1998).

Two main influences that make estuary monitoring unique are tides and salinity. Volunteers are strongly recommended to learn proper techniques for monitoring in an estuarine environment.

Tides

Estuaries differ from streams and lakes in several respects. First and foremost, they are subject to tides and the accompanying mixing of salt and fresh water. Any successful estuary monitoring program must take into account the tidal stage when scheduling training sessions and sampling times. Tidal stages can mean the difference between using a boat and trudging across mudflats to get to a sampling spot.

The fact that high tide occurs at different times in different parts of the estuary undeniably complicates scheduling. Some monitoring groups schedule sample collection for low and high tides at each station on each monitoring date—which translates into different sampling times for each location!

Estuaries are complex, with a wide variety of environments that are constantly changing. When the tide is rising, incoming salt water does not mix uniformly with fresh water. Fresh water is lighter (less dense) than salt water and tends to stay nearer the surface. The result is layering, or **stratification**, which may necessitate sampling at several depths—particularly for dissolved oxygen, nutrients, plankton, and salinity. On the other hand, tides of sufficient magnitude are effective mixers of estuarine waters and may break down stratification.

Tide charts are readily available and should be a standard part of any program coordinator’s tool kit. Programs studying highly stratified estuaries or estuaries with tidal ranges over a few feet may want to measure tidal stage. Even if tidal stage data are not included at the beginning of the sampling effort, the National Oceanic and Atmospheric Administration (NOAA) publishes tide tables for most of the U.S. This information can be obtained and applied after the fact, if the monitoring station is reasonably close to one of the published tide table sites.

Barnegat Bay in New Jersey (photo by S. Schultz).

Salinity

Salinity, the concentration of salts in water, isn’t usually monitored in streams, rivers, or lakes, unless there is a connection with salt water or concerns about excessive winter season road salting. Salinity changes with the tides and the amount of fresh water flowing into the estuary. It is often the major determinant of what lives where.

Salinity is often a factor in monitoring many key water quality variables. For example:

- To properly calibrate most dissolved oxygen meters, knowledge of salinity concentration is necessary.
- If you are interested in converting the dissolved oxygen concentration to **percent saturation** (the amount of oxygen in the water compared to the maximum it could hold at that temperature), you must take salinity into account. As salinity increases, the amount of oxygen that the water can hold decreases.
- If you use a meter to measure pH, the techniques are the same whether you are testing salt or fresh water. However, if you use a colorimeter, you must use a correction factor (available from the manufacturer) to compensate for the effects of salinity.
- Although **macroinvertebrates** (e.g., insects, worms, shellfish, and other animals that lack a spinal column) live in estuaries, using them as indicators of ecosystem health is more problematic than in streams. Estuaries support

Various land uses, including agricultural, residential/urban, forestry, mining, and marinas, can be sources of estuarine pollution (photo by Weeks Bay Watershed Project).

different invertebrate communities than freshwater systems, and many of the key freshwater indicators are not present in estuaries. In addition, collection is more difficult, given the tidal fluctuations and the muddy bottom. Finally, data analysis tools for relating macroinvertebrate communities to ecosystem health have not been as well developed for estuaries as for streams.

The Human Element

As mentioned previously, a number of estuary health problems can be traced to human activities. Humans also hold the key to finding their solutions. Many organizations and individuals are working to restore and protect estuaries, and volunteer monitoring is one essential aspect of the effort.

Each player has a different role in volunteer monitoring efforts, but all must work together to ensure efficient use of time, resources, and data.

The Role of Government Organizations

On the federal, state, and local levels, a myriad of government agencies are involved in volunteer estuary monitoring. Each government level has a different degree of involvement, summarized below:

- <u>Federal</u>
  Several federal agencies and programs are involved to some degree in volunteer estuary monitoring. The **U.S. Environmental Protection Agency (EPA)**, for example, has supported volunteer monitoring since 1987. The EPA has sponsored national symposia on volunteer monitoring, publishes a newsletter for volunteers, developed guidance manuals and a directory of volunteer organizations, and provides technical support to the volunteer programs (see Appendix B for resources).

  The EPA also administers the **National Estuary Program (NEP)**. Unlike traditional regulatory approaches to environmental protection, the NEP targets a broad range of issues and engages local communities in the process.

  The NEP encourages local communities to responsibly manage their estuaries. Each NEP is made up of representatives from federal, state, and local government agencies, as well as members of the community—citizens, business leaders, educators, and researchers. These stakeholders work together to identify problems in the estuary, develop specific actions to address those problems, and create and implement a formal management plan to restore and protect the estuary.

  To help in their tasks, NEPs work with volunteer groups and federal, state, and local agencies to gather critical data about their estuary. Many NEPs host informational workshops for volunteer monitors.

  Another federal program interested in volunteer data is the **National Estuarine Research Reserve System (NERRS)**, which is administered by the National Oceanic and Atmospheric Administration (NOAA). NERRS sites monitor the effects of natural and human activities on estuaries to help identify methods to manage and protect coastal areas. Volunteer groups are often engaged to help collect valuable data about estuarine health.

- <u>State</u>
  Depending on the state, several agencies may be involved with volunteer estuary monitoring. Agencies responsible for water quality, coastal and/or environmental management, fish and wildlife, public health, and other areas have shown interest in supplementing the data they regularly collect with information gathered by volunteers. State agencies play a major role in volunteer efforts. Many offer training opportunities, provide sampling equipment, and compile and distribute volunteer data. Occasionally, state laboratories may offer their services to process samples.

Some states are reluctant to fully use volunteer data, which can be a sore point with volunteer groups. To remedy such conflicts, many states establish quality assurance/quality control (QA/QC) requirements (see Chapter 5) to ensure that volunteer data can be used. They may also train volunteer groups on setting up a quality assurance project plan (QAPP). States can also work with volunteer groups to identify data needs, key sampling sites, and formats for submitting data. Such cooperation maximizes monitoring efficiency and data usefulness.

- Local

  Local agencies can get involved with volunteer monitoring in a number of ways. When considering development plans, they can use volunteer data to assess baseline water quality conditions and follow estuarine health as the development proceeds. Data can also be used to identify especially sensitive areas, which can then be designated for special protection.

  Volunteer data can also be helpful for locating local pollutant sources. For example, local governments are primarily responsible for septic system permitting, inspections, maintenance, and enforcement. Particularly in rural areas where septic systems are common, local agencies may not have enough staff to sample for bacteria and other indicators of failing systems. By working with volunteer groups, local agencies are tapping into a valuable resource.

The Role of Non-Government Organizations

With few exceptions, non-government organizations do the bulk of hands-on volunteer monitoring program planning and implementation. Such organizations can include environmental, school, community, and civic groups. Their membership is comprised largely of local citizens.

A major responsibility of non-government groups is to work with government agencies and other non-government organizations. Collaboration is important to coordinate monitoring activities and identify priority areas in the estuary. By coordinating with other organizations, volunteer monitors can also improve the likelihood that groups other than their own will utilize their data. For example, by working together with state agencies to develop a QAPP and determine which data the agencies are most interested in, volunteer organizations can become a valuable partner in estuary monitoring efforts.

Of course, the volunteer organization may elect to gather other data that may not be high on government agencies' priority lists. This information still has value! It can be used to guide local management decisions, educate the public, establish a baseline, and serve as an early warning of potential water quality problems.

Besides working with government agencies, non-government organizations do grassroots work. Among other things, they:

- recruit, train, and motivate volunteers;
- supervise monitoring activities;
- procure monitoring equipment;
- raise funds to support monitoring efforts; and
- work with local media to inform the public of their activities and findings.

The Role of Individuals

It may seem obvious, but should nonetheless be stated: **Without individual volunteers who commit their time and energy to the effort, there would be no volunteer monitoring programs.**

Besides actually monitoring the estuary, volunteers are valuable resources for other reasons. They generally monitor close to their homes and are familiar with the area. Because of their knowledge of local land uses, environmental issues, and history of the monitoring area, volunteers can provide valuable anecdotal information that can help explain data.

Individual volunteers can also assist with other non-monitoring activities, such as fundraising, writing press releases, educating the public, and helping with administrative work.

Chapter 4 goes into greater detail about the role of volunteers in monitoring programs. ■

A volunteer takes a Secchi disk reading from Puget Sound (photo by E. Ely).

References and Further Reading

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