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Voluntary Estuary Monitoring Manual

Chapter 6: Sampling Considerations

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Sampling Considerations

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Photos (l to r): Tillamook Bay National Estuary Project and Battelle Marine Sciences Lab, K. Register, R. Ohrel, R. Ohrel

Overview

In the very early stages of developing any volunteer estuary monitoring program, four important decisions must be made. Program leaders, with input from their volunteers, must decide what environmental parameters they will monitor, how the parameters will be measured, where monitoring sites will be located, and when monitoring will occur.

This chapter discusses some considerations that should be taken into account when making these decisions.

Four Critical Questions

Many field test kits require the monitor to compare the colors of a prepared water sample with a standard (photo by K. Register).

Previous chapters laid the groundwork for developing and operating a volunteer estuary monitoring program. Discussions focused on the need for volunteer programs to understand why it is necessary to collect data, how the data will be used, and who will use it. Involving potential data users in program development is essential.

There are many additional components to the development of an overall monitoring program and its quality assurance project plan (QAPP). Most revolve around four fundamental questions:

- What parameters will the volunteer program monitor?
- How will the selected parameters be monitored?
- Where will monitoring sites be located?
- When will monitoring occur?

While the questions may seem basic enough, they can hardly be overlooked or brushed aside. Clear and concise answers to these simple yet focused questions will form the backbone of your monitoring program, providing the foundation upon which the program will rest.

Over time, it will be valuable to reevaluate your answers to ensure that the goals and objectives of the program are still being met. Such evaluations may reveal a need for program adjustments.

What to Monitor? Selecting Sampling Parameters

What aspects of the estuary should your volunteer program monitor? There are many options from which to choose, but ultimately the parameters should be selected to help characterize the health of your estuary. By assessing the problems—and potential problems—facing the estuary, it should become clear which parameters will be most important to monitor. Of course, the costs (time and money) associated with monitoring will factor into your decision.

There are several common water quality parameters that volunteer programs measure (see Ely and Hamingson, 1998). These include:

- water temperature;
- turbidity or transparency;
- dissolved oxygen;
- pH;
- salinity; and
- nutrients.

As techniques are mastered and monitoring skills improve, many volunteer groups go on to include additional parameters to their monitoring repertoire, including:

- fecal coliform and other indicator bacteria;
- chlorophyll;
- sulfates;
- pesticides;
- metals;
- changes in water color following storm events;
- effects of erosion and sediment control measures;
- habitat conditions and availability;
- macroinvertebrates;
- condition and abundance of fish and birds; and
- phytoplankton, submerged aquatic vegetation (SAV) and shoreline plants.

Helpful Hint

When deciding what water quality variables to monitor, consider the needs of your data users. They can help you select the variables that most effectively detect potential problems in the estuary. In addition to your data users, also consult with the following:

- *state, federal, and regional environmental quality agencies;*
- *municipal governments;*
- *county planning offices;*
- *wastewater treatment plants;*
- *local nonprofit environmental groups;*
- *university and college environmental departments (e.g., environmental science, oceanography, civil engineering, hydrology, biology); and*
- *middle and high school teachers.*

How to Monitor? Selecting Monitoring Methods and Equipment

An important question for any monitoring program concerns monitoring methods and equipment. As you will see in later chapters, there are usually two or more ways to monitor any water quality parameter.

Your selection of methods and equipment will be based partly on data accuracy requirements and cost. For a state water quality agency to accept volunteer-generated data, for example, the data must be collected using state-approved methods and equipment. If the purpose of the monitoring is to "screen" for potential problems, you may purchase less expensive and perhaps less accurate or precise equipment.

Electronic meters (powered by batteries) are available to measure many different water quality parameters, including pH, dissolved oxygen, conductivity, salinity, temperature, total dissolved solids, and biochemical oxygen demand. Many meters will test for two or more of these parameters. Meters can provide quick and accurate data, but they require frequent calibration and regular maintenance to ensure proper functioning. They can also be expensive, ranging from $300 to $5000, depending on the number of functions, accuracy, range, and resolution of the instrument. Nevertheless, meters may prove cost-effective, especially when a large number of samples need to be analyzed.

Field test kits measure many of the same water quality parameters as meters and tend to be much less expensive, but pollutant detection levels can be unacceptable to some data users. Again, part of the decision to use meters or field kits will depend on the quality of data that your program is trying to achieve. In some states, the data from volunteers using field kits will be accepted, while in other states, the data will be considered valuable only as a "screen" for potential problems.

Some Tips on Kits

Suppose you intend to use inexpensive field kits that rely on a visual color comparison using a "color wheel" or "color comparator." How would you go about shopping for the most suitable kits? Here are a few suggestions:

- Look for reagents that produce a blue or green color; the human eye is better at perceiving the density of blue or green.
- Look for less toxic reagents (e.g., salicylate versus Nessler for ammonia, zinc rather than cadmium for nitrate).
- Look for kits that report the lowest possible concentration range, relying on the option of diluting the sample if the concentration is too high (make sure you have the equipment for making dilutions—a small syringe without needle, distilled water, and a dedicated jar).
- Look for reagents in liquid form rather than powder—it is often tedious to wrestle with powder packets, especially with wind that may blow and scatter the powder.

(Excerpted and adapted from Katznelson, 1997.)

Where to Sample? Selecting Monitoring Locations

Volunteer program leaders must determine the geographic location where monitoring efforts will provide the most useful information. After monitoring sites are selected, a decision must be made about where in the water column volunteers will collect their samples.

Picking Monitoring Sites

Selecting representative sampling sites is one of the most important elements in setting up a monitoring effort. In any type of water quality monitoring, basic information about the area of interest is essential for the program manager to consider before selecting monitoring sites. Several things to consider are listed in the box below.

Considerations for Selecting Monitoring Sites

Background Information

- Obtain a map of the watershed with all areas that drain into the estuary identified and a bathymetric map of the estuary showing depth information.
- Gather reports and/or data that supply general information on the estuary.
- Check with your state water quality agency and other monitoring groups to learn their monitoring site locations. Monitoring at the same sites monitored by other groups can help provide trend data; monitoring different sites can improve coverage of the entire estuary.
- Collect information on adjoining estuaries if there are plans to conduct data comparisons.
- Compile data on current and past activities in the basin that could affect pollutant levels (e.g., locations of wastewater treatment plants, areas of urban or agricultural runoff, new development sites).
- Investigate sites in areas of known or suspected pollution.

Decision-Making

- Determine whether there is a real need for data to be collected from the area, thereby ensuring the immediate use of data collected.
- Consider whether you have a sufficient pool of volunteers to monitor the site in the manner and time required.
- Consider sites where there may be little or no data (e.g., areas near land targeted to be developed) to establish baseline conditions.
- Consider how long data will need to be collected at the site in order to be useful. For example, several years of data collection may be necessary to make justifiable conclusions about water quality trends.

Verification

- Confirm that you will have safe, physical, and legal access to the site(s).
- If the monitoring effort requires the collection of water samples, verify that the site is underwater at all times, including low tide.
- Ensure that sampling sites are representative of the estuary and its watershed, if your goal is to assess overall estuary health (e.g., a site immediately downstream of a bridge is not likely to be representative of overall estuary conditions).
- Confirm that volunteers can precisely relocate the site.

(Adapted from USEPA, 1990, and Stancioff, 1996.)

Site location will depend a great deal on the purpose of data collection. If, for example, the program is attempting to pinpoint trouble spots in the estuary, the manager should cluster monitoring sites where point and nonpoint pollution sources enter the water. To help ensure the data's scientific validity, volunteers should monitor sample locations both upstream and downstream from the pollutant inflow point, as well as at the point of entry, to provide comparative data.

Some programs may wish to obtain baseline data that, over several years, will reveal water quality trends. Rather than concentrating on a few critical sites, this type of program should choose a sufficient number of sites scattered throughout the estuary or in the area of interest that will paint a representative picture of water quality status over time.

Deciding Where to Sample in the Water Column

Monitors must consider that water quality parameters are always changing. At any given time, conditions at the surface may not be the same as those at the bottom. For most citizen monitoring programs and most water quality parameters, however, samples taken from the estuary's surface will suffice. These samples will provide a reasonably accurate indication of water quality in the vicinity of the sampling site. For more sophisticated studies in which water quality parameters throughout the water column are of interest, volunteers may need to collect samples using a standard water sampler at precise depths.

The stratification of the estuary may also influence where samples are taken in the water column. For instance, a well-stratified estuary may require surface, intermediate, and bottom water samples or a complete profile to fully characterize the status of different water quality variables in its waters. A reasonably well-mixed estuary, however, or one in which the monitoring sites are located only in shallow waters (where stratification often breaks down) may require only a single surface sample at each site.

While tidal range (the difference between high and low tides) is negligible in some estuaries, programs studying areas with large swings in tides will have to consider this effect. Tides strong enough to cause mixing may weaken the stratification in the estuary. This effect is particularly apparent during spring tides (the highest tides of the month). By mixing the upper and lower layers, for example, the tides allow nutrients trapped in bottom waters to mix upward and oxygen from the surface to move down.

When to Sample? Selecting the Right Time

The timing of most sampling efforts will depend largely on the goals of the monitoring program, accessibility of the site, weather, number of monitors, and the water quality variables to be measured. The time of day and season can significantly affect your results. In addition, the maximum holding time for each sample and the sampling frequency necessary to get the right information can influence when samples will need to be collected (Dates, 1992).

Time of Day

Sampling results can fluctuate dramatically, depending on the time of day that samples are collected. For example, during the day aquatic plants utilize sunlight for photosynthesis, releasing oxygen as a byproduct. At night, the plants respire, consuming oxygen. As a result, dissolved oxygen levels can rise and fall significantly, especially in areas with dense aquatic vegetation. Under these circumstances, oxygen concentrations are lowest at sunrise and highest in the afternoon.

The time of day will also influence where many organisms will be found in the water column. Zooplankton, for example, migrate from deeper water to the surface at night to feed, while many fish species travel daily throughout the water column in search of food.

The time of day has other impacts on monitoring. A common tool for measuring

water clarity is the Secchi disk. One condition for its optimal use is that the disk be used when the sun is directly overhead. (The disk can be used at other times during the day, but this would result in less than optimal results; see Chapter 15). To comply with this condition means that there is a small window of opportunity for which monitoring conditions are ideal.

Because of these daily considerations, it is often helpful to select consistent sampling times for many water quality parameters. However, ideal sampling times may also depend on tides, which could expose nothing but mud where there had been water only a few hours earlier. Tidal stages vary from day to day.

Time of Year

Environmental conditions change with the seasons, and monitoring results can reflect those variations. For example, nutrient and pesticide concentrations in estuaries vary considerably from season to season. More runoff enters the estuary during wet weather periods, delivering pollutants and fresh water. Consequently, pollution concentrations can be higher and salinity lower at these times. When runoff occurs, higher estuarine concentrations correspond to times of the year when fertilizers and pesticides are most commonly applied on land (USGS, 1999).

On the other hand, dry weather periods mean less runoff to the estuary. Higher salinity and lower pollutant levels may mark such dry periods. The same observation may be made in colder climates during the winter, when snow remains on land and the spring thaw is months away.

The seasons have a profound influence on several other water quality measures, particularly dissolved oxygen. For example:

- cold water retains dissolved oxygen better than warmer water;
- increased plant activity in the warmer months has a strong influence on daily oxygen concentrations;
- vertical temperature gradients in the estuary—usually greater during the summer months—hinder oxygen diffusion; and
- seasonal storms help mix estuarine waters.

Seasonal sampling may also be influenced by program objectives. If your program is interested in determining whether the estuary is safe for swimming, for example, it is best to sample when people are most likely to be in the water. For this purpose, it is unnecessary in most places to sample during the winter.

Finally, there is the practicality issue. Seasons may influence the level of volunteer participation. Will enough volunteers be willing to go out in freezing weather or under a scorching sun to collect samples?

Holding Time

Consider the maximum duration that a sample can be held before it is tested. Many bacteria samples must be chilled and sent to a laboratory for testing within six hours. Because of the stringent holding time requirements, sampling during weekends and evenings—when most laboratories are closed—may not be a good idea for some water quality measures.

Frequency

Like most issues of timing, sampling frequency usually depends on the goals of the monitoring effort. For example, if you are monitoring to detect pollution from point sources, very frequent sampling—daily or even hourly—is usually necessary. On the other hand, some biological parameters, which indicate estuarine conditions over long periods of time, need to be sampled only a couple of times each year (usually the spring and fall).

Sampling frequency may also be determined based on atmospheric or other events. It is often useful to have volunteers

available to collect data during or after large storms as long as the program manager deems it safe to sample. Such data is often invaluable to state managers who may be unable to mobilize forces quickly enough to capture such events. Storm data gives a snapshot of how severe wind and precipitation affect the status of water quality variables in the water. The occurrence of extraordinary events, such as fish kills or "crab jubilees" (phenomena characterized by crabs crawling onto the land because of low oxygen concentrations in the water), can also trigger additional monitoring efforts to determine the cause of the events. ■

References and Further Reading

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