Data Interpretation

Geoff Dates, River Watch Network
Jerry Schoen, Massachusetts Water Watch Partnership

Introduction

Turning data into useful information is one step in your monitoring program. Your program should begin with a clear study design, which describes the rationale and methods for your program. A part of the study design process is identifying the people who you expect to use your data, how you expect them to use it, and what specific questions you're trying to answer about the river. If you've geared your monitoring to the needs of identified data users and conducted your monitoring to answer specific questions about your river, you'll find that this step is not as difficult as it might seem.

Turning monitoring data into useful information a process that involves several steps:

1) **Data Entry**: This involves getting your raw data into a computer so that you can store it and retrieve it for analysis. It includes two steps:
   a. Entry: Data should be entered into a computer data management application.
   b. Validation: The entered data must be checked against the field and lab sheets to assure that it has been entered correctly.

2) **Summary**: The data is put into a form that allows you to view it as a whole, such as simple statistics, tables, and graphs.

3) **Data Interpretation**: This involves asking a series of questions about your data that relate to your study question(s). Your answers to these questions are organized as findings and conclusions. Based on these, you may develop recommendations for action or further study.

4) **Presenting Your Results**: Present your findings, conclusions, and recommendations in a form that best tells the story of your river. This story can be told in text and selected tables and graphs that are organized into an oral presentation and/or a written report. Your presentation or report should be geared to the audience you are trying to reach.

This paper focuses on the data interpretation step.

DATA INTERPRETATION:

Interpreting your data is a process that involves answering a series of questions about it. We suggest the following steps:

1) Review and interpret the data "in-house" to develop preliminary findings, conclusions, and recommendations.

2) Review the data and your interpretation of it with an advisory group or technical committee. This group should involve local, regional, and state resource people who are familiar with monitoring and with your river. They can verify, add to, or correct your interpretation of the results.

3) Review the data and your interpretation of it with the people who will use your data -- for example, the public, river users, and government officials.

Ultimately, your interpretation of the data relates back to the questions your monitoring program is trying to answer. For example, does the river met state water quality standards? Following are examples of questions you might answer at each step in order to develop findings and conclusions that relate to your study questions.

There are four steps to data interpretation: 1) assemble the information you'll need, 2) develop findings, 3) develop conclusions, and 4) develop recommendations. The following sections describe each step. The sections on findings, conclusions, and recommendations suggest questions you should answer at each step.

Step 1: Assemble the Information You'll Need

Make sure that you have all the information that you will need for data interpretation. Important information to have available include:

- a map of your watershed with the sites marked on it and the water quality classification of the segments you sampled.
- correct units of measurement clearly reported on your data tables and graphs.
- general observations, such as habitat and weather information for each sampling date and site.
- the appropriate water quality standards or reference conditions for each indicator.
- historical or current information gathered from other water quality data sources, such as the state or other monitors, in a format similar to your data.

You might put all of these into easy-to-read tables, graphs, or maps to have available when looking at your data.

When analyzing data it is important to keep in mind the following:

- The sensitivity of the methods and equipment you used. This will constrain what you can and can't say. For example, if you used a color wheel to determine orthophosphate concentration, you can't detect concentrations below 0.1 mg/l. So you shouldn't report these as "0." You should say that the results were "<0.10 mg/l".
- The degree of change that is important for each indicator. You may be able to detect some fairly small changes in the levels of indicators. Yet, these changes may not be very important in terms of their impact on the river or lake.
  Whether this change is important depends on several factors.

  - how the change compares with the natural or background levels of that indicator in your water body. If natural levels are high (compared with typical water bodies), it may take a relatively large change to affect the river or lake.

  - how the change compares with the natural variability of the indicator in your water body. The level of most indicators varies naturally over time and space. If the change you measure is within the range of this natural variability, it will probably not affect the river or lake.

  - whether the change crosses a threshold. There are two types of thresholds that might be important: 1) the absolute level of an indicator, such that if your results fall above or below it, an impact results (such as a level that is critical for the survival of aquatic life), and 2) the magnitude of the change, for example, a change in temperature that causes stress in fish that are sensitive to changes.

- The degree of trust you have in the quality of the work done to obtain the data. For the first sampling time, students might learn more about how to use the equipment and the procedures than they will about the actual river water quality. This is excellent information about the process of science, however, any data that is the result of learning by trial and error should not be reported unless you are confident that the procedures were not compromised. Alternatively, you can report it if you note the problems which may have occurred.

Following are examples of questions you might answer at each step in order to develop findings and conclusions that relate to your study questions.

Step 2: Develop Findings

Findings are observations about your data. They are the statements that summarize the important points. Findings will help you to come up with conclusions, because they help you form a more thorough and accurate interpretation. We tend to look at data and begin to try to explain it before thoroughly observing and summarizing the trends, patterns or lack of patterns.

Examples of findings are:

- ♦ Site number 3 violated water quality standards for dissolved oxygen on all days
- ♦ The number of benthic macroinvertebrates at all sites declined over the 3-year period.
- ♦ Secchi depths were lowest in August at two of the three sites.
- ♦ Moving downstream, the amount of phosphorus increased on all days.
- ♦ Bacteria levels exceeded the safe swimming standard on 4 out of 5 sampling days.

Developing findings is a process in which you compare your results
with known standards or guidelines:
within your data set:
with other data sets:
and in which you analyze your quality assurance/quality control results

Compare your results with known standards or guidelines: State water quality standards contain *criteria* which are numbers that define acceptable levels of common water quality indicators. If criteria are not available for an indicator you've measured, consult a water quality advisor as to appropriate numerical guidelines against which you can compare your results.

- Are there sites that consistently exceeded (violated) water quality standards or guidelines? By how much?

- Are there sampling dates where most or all sites consistently exceeded (violated) water quality standards or guidelines?

- How do your results compare with reference conditions that others establish? For example, water quality standards are a type of reference condition established by your state legislature. However, the standards may not address the indicators you are monitoring. Your state agency advisor can tell you if reference conditions have been established for your watershed or for a similar watershed.

- How do your results compare with reference conditions that you establish? Reference conditions are a description of the best attainable conditions for your river. They may be conditions that describe the least developed part of your watershed. They may be conditions that describe a similar river in another watershed. In either case, you compare your results with these conditions to determine whether conditions in your river are meeting the expectations of

experts.

Compare your results within your data set: These questions help you use your own data to focus on upstream to downstream comparisons and comparisons over time.

- Which *sites* had the highest or lowest readings?
- Which *dates* had the highest or lowest readings?
- Are there numbers which seem to be much higher or much lower than typical results ("outliers")? Do you have confidence that these numbers are reliable? Verify that these numbers were transcribed or entered correctly.
- Do your results show a consistent pattern of change upstream to downstream? Do levels increase or decrease in a consistent manner?
- If you are monitoring the impact of a pollution source, for example, are your results different above and below the impact?
- Do changes in one indicator coincide with changes in another? For example, there is frequently an inverse relationship between water temperature and dissolved oxygen, since warm water can hold less oxygen than cold water.
- How do your results compare among tributaries?

Compare your results with other data sets: Monitoring data from other sources might help you put your results in perspective. Be aware, however, that the data must have been collected using comparable methods, or the comparison is not valid.

- How do your findings compare with other data sets (e.g. state reports)?
- What were the flow and rainfall like on your sampling dates? Was there heavy rain? Was the flow rising or falling.
- How do your results compare with those of other waterbodies (similar or not)?

Analyze your Quality Assurance/Quality Control Results: Quality assurance/quality control measures are undertaken to determine how reliable your data are. Common measures include split , duplicate, spiked, replicate, known, unknown, and blank samples. How do your Quality Assurance results compare with expected results? Did they meet your data quality goals? If you haven't met these goals, then your data may not be useful to answer your question.

- Split, duplicate and replicate samples: For each of these quality checks, you have two results that need to be compared. How close were they? Did they meet your expectations?
- Spiked, known, ad unknown samples: For this check, you compare actual with expected results. How close were they? Did they meet your expectations?
- Blanks: For this quality check, the result should be "0."

Step 3: Develop Conclusions

Conclusions are your explanation of why the data look the way they do. Your conclusions should relate back to the questions you asked at the beginning of your monitoring program - your study questions.

Examples of conclusions are:

- Drainage from the farm barnyard appears to be causing elevated *E. coli* levels in the lake. The consistently high levels of *E. coli* at site X occur mostly during low flow in the feeder brook. This suggests a continuous source of fecal material entering the brook near this site. These bacteria levels indicate that swimming in the lake at this site is a health risk.
- The elevated phosphate levels at site X are causing impacts to the stream in the forms of excessive algal growth and reduced benthic macroinvertebrate diversity. We believe that fertilizers from the golf course may be the cause.
- Erosion from a construction site upstream of site X appears to be causing excessive sediment deposition in the stream. This results in high embeddedness of cobble habitats, deep sediment deposits in pools, and lower abundance of benthic macroinvertebrates (especially the scraper functional feeding group which requires clean rock surfaces) compared with a site immediately upstream.

The following are examples of questions that might enable you to answer your study questions:

Do your results answer your questions?

- State a conclusion that relates back to your question.
- For example, suppose your question is, *does the river meet water quality standards for dissolved oxygen? Your* conclusion might be stated as: The river met the water quality standards for dissolved oxygen at all sites.
- Suppose your question is, *is the wastewater treatment plant affecting the benthic macroinvertebrate community?* Your conclusion might be stated as: The wastewater treatment plant reduced the abundance and diversity of benthic macroinvertebrates, compared with results immediately upstream.

Does weather appear to influence your results?

For example:

- Do high levels coincide with heavy rainfall (consider the intensity and duration)?
- Do high levels coincide with rising flow (consider flow management impacts)?

Do flaws in your field and/or laboratory techniques explain your results?

Be sure that your results are not due to mistakes made in collecting and/or analyzing the samples:

- Are you following the procedure correctly?
- Are you contaminating your samples in the lab?

Do you have confidence in your quality control lab?

Don't automatically assume that if your results differ from your quality control lab that the problem is with your lab.

If you are monitoring the impact of a pollution source, does the presence of this source explain your results?

For example, can you attribute increased bacteria levels to the source you're monitoring?

If you are monitoring the impact of a pollution source, are there other upstream impacts which might influence/confuse your results?

Might natural changes explain your results?

For example, ponds and wetlands can influence river bacteria levels and stream critters just downstream.

Might man-made changes explain your results?

For example, has the type of homes changed near the water body?(e.g., to year-round). Or, has population density changed over the years?

Did the time of day you sampled affect your results?

For example, dissolved oxygen is typically lowest in the morning and highest in the late afternoon.

For episodic discharges, did your sampling coincide with the discharge?

- For example, did you catch the storm-related polluted runoff you were trying to analyze?
- Was the flow rising when you collected your samples, indicating that runoff was increasing river flow?
- Some point source discharges are not constant. Did you catch the discharge?

Do changes in one of your indicators appear to explain changes in another?

For example, could low dissolved oxygen be explained by high temperatures?

Do your visual observations explain any of your results?

For multiple years of data, what are some overall trends?

- For example, did the benthic macroinvertebrate community improve or deteriorate over time?
- Did this coincide with improved pollution control or new pollution sources?

What other information might you need in order to explain your results (such as a shoreline survey, habitat assessment, or additional indicators)?

Important Note: Your data may be inconclusive, especially after only a year of monitoring. Waters change from year to year. One year, results may show moderate impairment. Another year, results may show little or no impairment. You'll likely learn more by monitoring over 5 - 10 year period than a single year.

Step 4: Develop Recommendations

Recommendations are based on your findings and conclusions. They can take two forms: *action* that should be taken and *further information* that should be gathered.

Examples of recommendations for *action*:

- ◆ Consider fencing the farm animals (including the horses) out of the brook and reestablishing a buffer of natural vegetation to grow between the fence line and the brook.
- ◆ Carry out educational activities for residential owners about the effects of pesticides and fertilizers from lawn treatment and provide examples of alternatives.
- ◆ Organize an educational workshop for waterfront landowners about the benefits of best management practices to control erosion.
- ◆ The town should install a sediment trap basin at the storm drain outlet on West Street.

Examples of recommendations for *further information*:

- ◆ Sample the storm water drains at Main and Elm streets to determine if they contribute to elevated bacteria levels.
- ◆ Monitor dissolved oxygen over a 24-hour period at sites 1, 2, and 6 to determine the daily range of dissolved oxygen levels.
- ◆ Conduct wet weather water sampling and analysis for *E. coli,* total phosphorus, and turbidity at all sites.
- ◆ Monitor for total and ortho phosphate at sites 8 and 9 to determine if increased algae growth is caused by fertilizers.
- ◆ Add a monitoring site upstream of the pasture as a background reference site.
- ◆ Carry out a diagnostic sanitary survey to see if there are failing septic systems between sites 2 and 3.
- ◆ Continue monitoring the benthic macroinvertebrate community at all sites on an annual basis to document whether the improvement is long-term.
- ◆ Continue dry weather monitoring for *E. coli* following implementation of the corrective actions.
- ◆ Conduct wet weather water sampling and analysis for *E. coli,* total phosphorus, and turbidity to document the impacts of storm water runoff or combined sewer overflows.
- ◆ Measure instream embeddedness or do a benthic macroinvertebrate survey to see if sedimentation is causing habitat impairment.
- ◆ Carry out a pollution source inventory to locate and test discharge pipes.