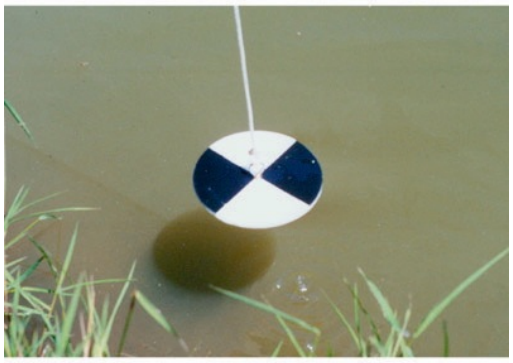
Aquatic Sampling Techniques

In order to better understand freshwater ecosystems, aquatic scientists have developed specialized techniques and equipment to assist in sampling different components of these systems. A few of these techniques are discussed here.

Physical Factors

Solar radiation and **water temperature** are among the most important physical factors for aquatic ecosystems, and both affect the chemistry and biology.

Solar radiation covers a broad spectrum of wavelengths, but the photosynthetically available portion (400 to 700 nm) of the solar spectrum is particularly important for driving photosynthesis in algae and other aquatic plants. The depth of penetration of this radiation into the water is typically measured using a special sensor attached to an electronic meter. This depth of penetration is a measure of water transparency and estimates the potential for photosynthesis within the water column. However, a very simple device, called a Secchi disk (see photos below) after its inventor, can provide some of the same information at a fraction of the cost of the electronic device.



While suspended in a horizontal position from a metered line (above, right), the disk is slowly lowered into the water until it just disappears from view. Using the metered marks on the line, the depth of disappearance is noted and recorded. Over time, this measurement can be repeated frequently to determine whether the penetration of solar radiation is changing. It can also be used to compare the penetration of solar radiation in different water bodies. With this device, our eye serves as the sensor. For the disk to be visible at depth, the light being detected by our eye must travel down through the water column, reflect off the disk, and travel back up to our eye. This indicates that there is sufficient water transparency for photosynthesis to occur down to a depth of approximately twice the observed Secchi depth. For example, if we can see the disk at a depth of 2.4 metres, light is penetrating the water column to a depth of at least 4.8 metres. Therefore, algae living in the water column have enough light for growth, provided they are not deeper than twice the observed Secchi depth.

Water temperature is important because it affects the **metabolism** or internal life processes of many species living in the water. At warmer temperatures, animals tend to

be more active than at cooler temperatures. Many species will feed more and grow faster in warmer water. Temperature variations will also affect mixing of water between the surface and lower depths, which, in turn, will affect the concentrations of dissolved oxygen at depth.

In order to measure how water temperature changes with increasing depth, limnologists (people studying freshwater systems) often use an electronic thermometer (above) with the temperature sensor connected to a meter by a cable marked at measured intervals. This permits the limnologist to sit in a boat floating on the surface and lower the sensor down through the water column, recording the temperature at various depths to produce a profile or graph of temperature versus depth. By repeating such profiles over time, a heat budget can be calculated for the water body, providing an indication of how much heat energy is present in the water to drive internal mixing and metabolic processes.

Chemical Sampling

As the “universal solvent”, pure water (H_2O) is almost non-existent in nature. As soon as pure water droplets are created, they begin to absorb or dissolve other chemical elements from the surrounding air or substrate. Water is the life-blood of an ecosystem, as it carries to all parts of the system a variety of chemicals needed for photosynthesis, respiration, and other essential life processes. It also carries waste materials, including those that cause what we call “pollution”.

Not all of the substances carried by water are dissolved. Some larger particles are less dense than water and will float. If the water is moving quickly enough, it may have sufficient energy to carry along more dense materials in suspension. This is particularly true of smaller soil granules, such as clay particles and even sand grains.

In order to identify and quantify the chemical constituents carried in water, a water sample must be taken and subjected to a number of chemical analyses, usually in a laboratory. A surface water sample can be obtained by dipping, but either a battery-powered, peristaltic pump (page 3, upper left) used with metered tubing attached, or a specialized water collecting bottle, is typically used to obtain water from various known

depths. One such water sampling bottle is called a Van Dorn type sampler (page 3, upper right), after its originator.

This weird looking sampler, with the end stoppers held open, as above, is suspended from a boat by a metered line and lowered to the depth from which a water sample is desired. Then, a weight called a “messenger” is dropped down the line to trigger a release of the end stoppers. These pull back into the ends of the cylindrical bottle, capturing the water which can then be hauled to the surface and taken for analysis.

Once the water sample is obtained, there are many different analyses that can be made. These include measures of pH, dissolved oxygen, conductivity, nutrient concentrations, metal concentrations, etc. Some of these substances, such as oxygen, will be **dissolved** in the water. Others, such as carbon, will be partially dissolved, and partially suspended in the water. In order to separate the dissolved fraction from the **particulate or suspended** fraction, it is usual to use a very fine pore filter. Typically, this filter will have pores no larger than 1 micron (1 millionth of a metre or 1 thousandth of a millimetre) in diameter. Thus, anything in the water that is more than 1 micron across will be trapped on the filter and be part of the particulate or suspended fraction. Everything smaller will go through the filter and be part of the dissolved fraction.

A typical filtration apparatus (see photo at top of page 4) consists of a vacuum flask connected to a vacuum pump. In the laboratory, the pump is usually electrically powered. However, in a field situation, a hand-operated pump may be used. A three-piece filter funnel is mounted in the neck of the flask using a rubber stopper. The funnel consists of a base which drains to the flask and supports the filter, an upper section which receives and contains the sample during the filtering process, and a spring-loaded clamp to hold the filter tightly between the two sections and prevent the sample from leaking out during the filtration process. To operate the system, one must remove the clamp and the upper section; carefully place a new, clean, filter paper (making sure that it is properly centered) on the base; then place the upper section over the filter paper and securely clamp the two sections together. A measured amount of raw sample is then poured into the funnel and the vacuum pump is used to lower the air pressure within the flask, thereby drawing the water and dissolved fraction through the

filter into the flask. The suspended or particulate fraction will remain on the filter paper as (usually) visible residue.

Following filtration, the two fractions may be analyzed separately using various techniques. While not quantitative, a careful visual examination of the colour and texture of the residue on the filter, and the colour of the filtrate in the flask, sometimes can provide a useful comparison of two different water samples.

The residue on the filter may include a variety of particulate materials. If it is green in colour, it probably contains a number of algal cells, indicating that the system from which the water was collected is quite productive and nutrient rich. Of course, the particles on the filter may consist primarily of dead and decomposing materials, either from the aquatic system being sampled or from the land draining into this lake or stream. In systems located in clay soils, the residue may largely consist of minute clay particles that were held in suspension by wind and currents.

The filtrate in the flask will contain dissolved substances, including forms of carbon, nitrogen, and phosphorus that can promote algal growth. It may be coloured, but should not contain visible particles. The filtrate may also contain pharmaceuticals and other manufactured chemicals as contaminants, particularly if the sample was collected downstream from a major urban centre.

Biological Sampling

Methods of biological sampling differ according to the biological community and particular populations of organisms being studied.

For most bacteria and algae, because of their minute sizes, it is necessary to take a whole water sample back to the laboratory where the organisms can be carefully

concentrated and observed under microscopes or using other specialized techniques for identification. This sample can be collected using a pump or water bottle, as described above for chemical sampling.

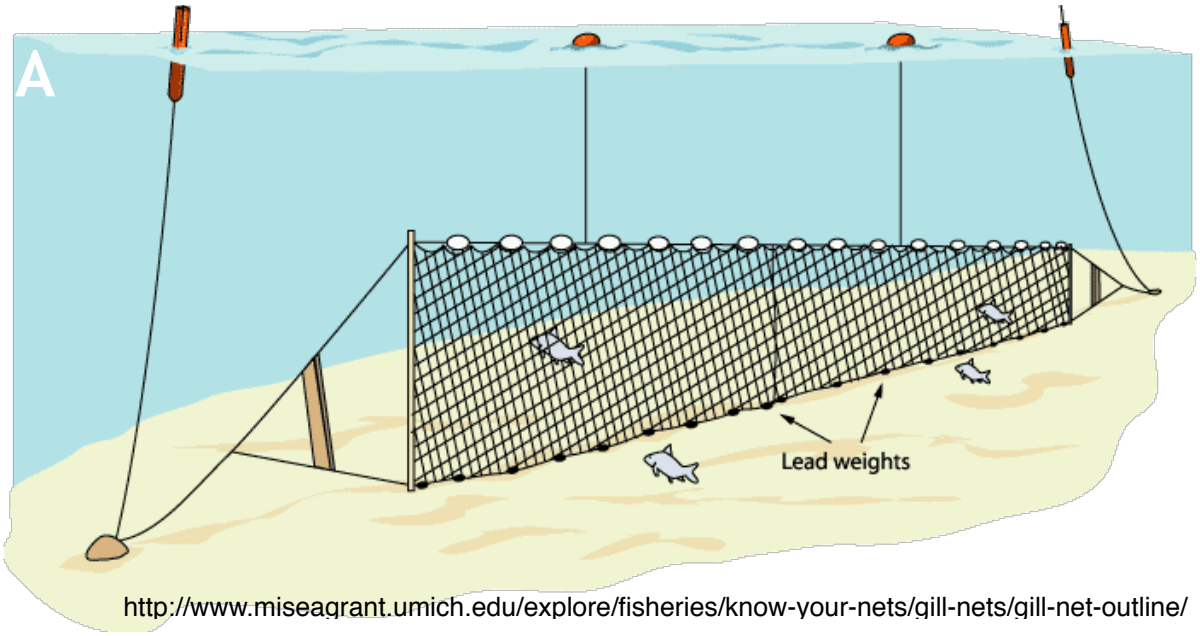
For slightly larger organisms, such as most zooplankton (animal plankton), a very fine mesh net can be used to separate them from the water during the sampling process. These zooplankton sampling devices can take various forms, but all use a fine mesh net (usually between 40 and 75 micron pores) for the separation process. Two such samplers are shown in the pictures, below. On the left is a simple zooplankton tow net. On the right, is a Schindler - Patalas trap, named for the two scientists at Winnipeg's Freshwater Institute who devised it 40 years ago.

For capturing small, bottom-dwelling (benthic) invertebrates, various kinds of sediment samplers are used. Some of these are coring devices (KB corer, below, left); others are dredges or grabs (Ekman dredge, below, right). Both can be operated from a boat to collect samples of the bottom material and bring them to the surface for further analysis.

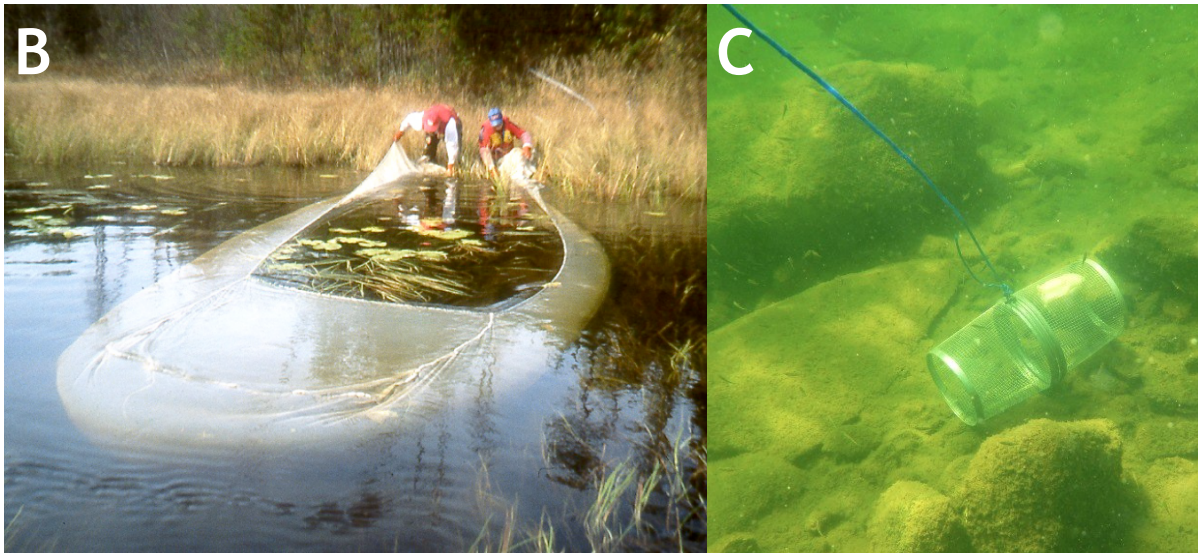
Aquatic Sampling Techniques

Fish Sampling

Fish can be captured for research purposes in a variety of ways, including nets (gill nets, seine nets, trap nets), minnow traps, and by angling (rod and reel). Used properly, these techniques generally prevent the fish from being killed. Some methods, like trap netting and seine netting may catch other animals as well, such as turtles, newts, crayfish, insect larvae, and small crustaceans. The figure below outlines a few of the capture techniques.



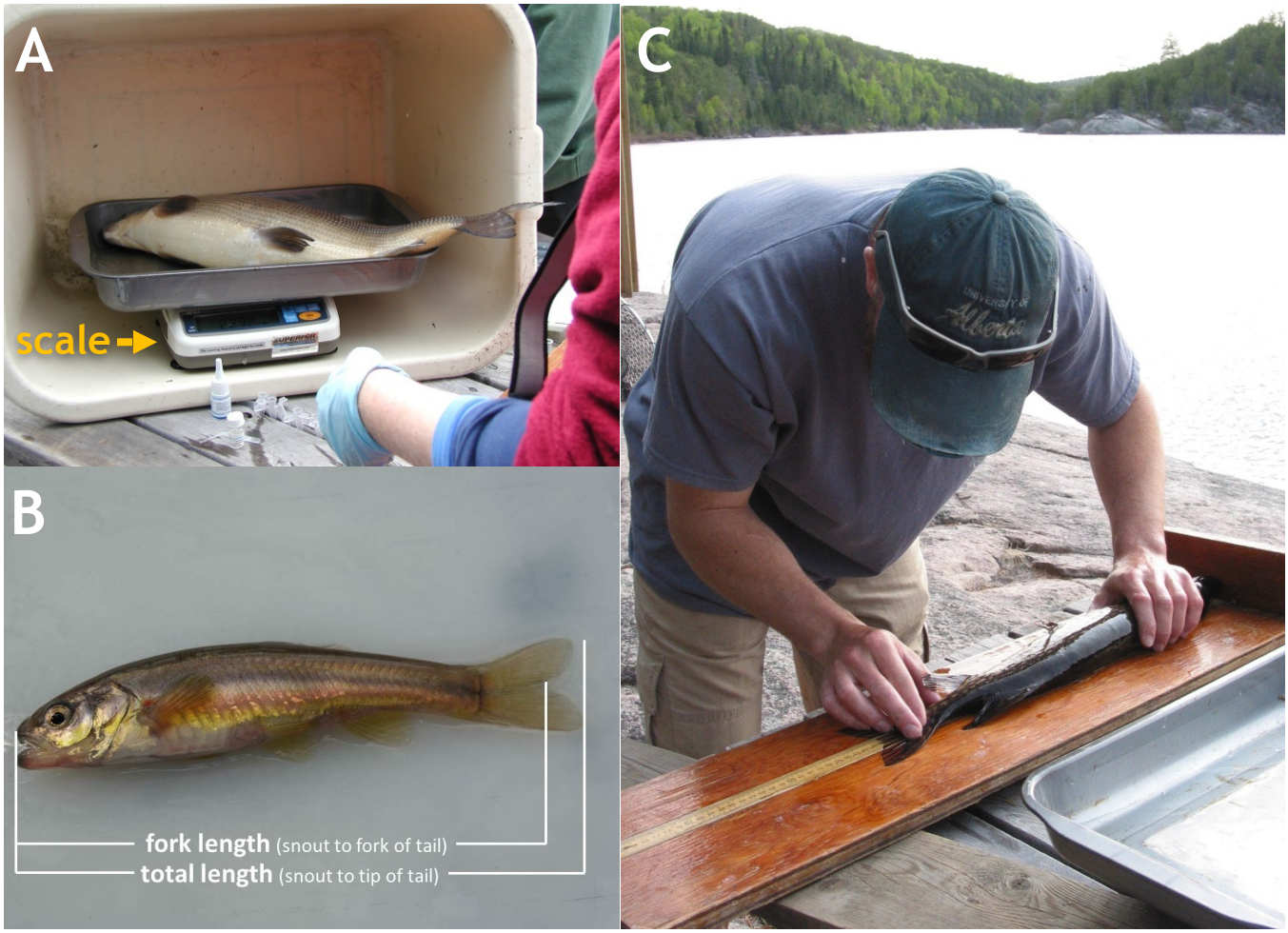
http://www.miseagrant.umich.edu/explore/fisheries/know-your-nets/gill-nets/gill-net-outline/



A: Gill nets hang vertically in the water because they have floats along the top and weights along the bottom. Fish swim into the nets and become entangled.
B: Researchers pull in a seine net to capture fish near the shore.
C: A minnow trap set on the bottom of a lake. Minnows swim into the trap through a small hole in one end and then can't find their way out.

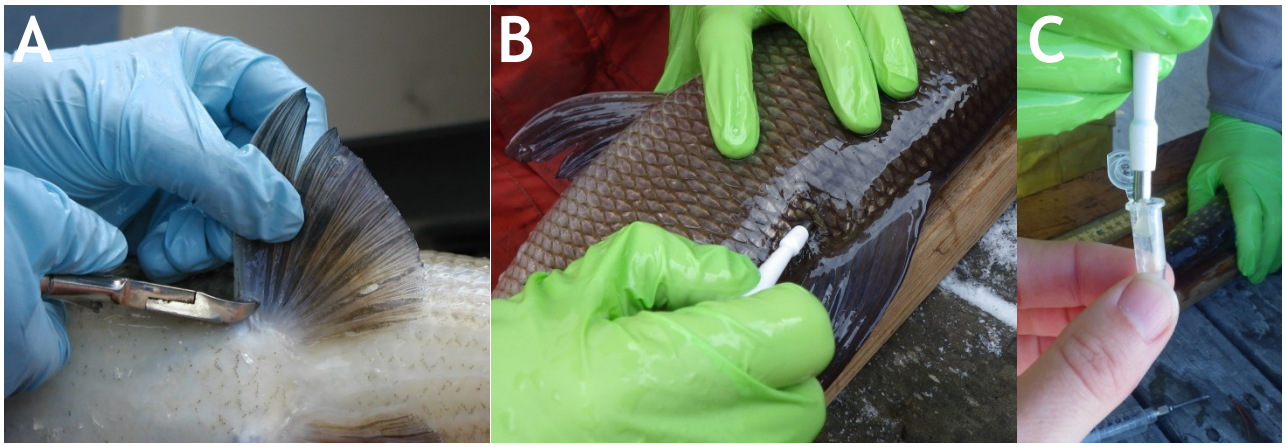
Aquatic Sampling Techniques

Once captured, various types of biological information can be collected from a fish, including length (fork length, total length) and weight. These data help researchers to determine whether a fish is healthy or unhealthy. The following figures illustrate how this information is gathered by researchers.



A: Weighing a lake whitefish using an electronic scale.
B: Fork length is the distance from the tip of the snout to the fork of the tail (if present); total length is the distance from the tip of the snout to the end of the tail.
C: A researcher measures the fork length of a northern pike.

Researchers may also collect samples, such as fins and otoliths (ear bones) for determining the age of a fish, or a muscle sample for determining concentrations of contaminants such as mercury. This sampling is illustrated in the figures on the following page.



A: A researcher clips the first fin ray of a pelvic fin. Growth rings (like tree rings) in the cross section of a fin ray may be counted to determine the age of the fish.
B: A researcher uses a biopsy punch to collect a small muscle sample from a live lake whitefish. The hole left by the punch will be sealed up, and the fish will be r released back into the wild. This non-lethal sampling method makes it possible to sample the same fish multiple times during its life.
C: The muscle biopsy sample is preserved in a vial.

Summary

This document has provided an brief overview of various methods commonly used for sampling freshwater systems. Most of the methods described are primarily used in lakes and reservoirs, where the water is relatively still. Usually, different methods would be used for faster flowing systems, such as rivers and streams.

Of course, collecting the samples is only the beginning of the process. Careful analyses of these samples must be carried out to provide empirical (derived from experiment or observation) data that can be correctly interpreted to provide new understanding of ecosystem processes and the impacts of human activities on these systems. However, this new understanding would be flawed without the use of effective and appropriate sampling techniques.