The Basics of Sampling Fish
in Lakes and Ponds

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Lakes provide important fish habitat and recreational angling opportunities in addition to a wide variety of other benefits. Knowledge about a particular lake's fish community is necessary to manage it; however, it is difficult to simply observe fish in their habitats, and make population inferences based on these observations. Usually, it is necessary to capture a sample of fish and extrapolate what is learned from this sample to the fish community overall.

Sampling a fish population in a lake is done in much the same way across North America. Examining the general health of a fish population is analogous to the few simple tests that a doctor gives a patient to evaluate their general health such as temperature, blood pressure, and cholesterol.

Four simple indices are the most useful and common means for evaluating the health of a fish population. These include condition, which is a measure of the plumpness of individuals; average rate of growth of individuals; number of fish caught per unit of sampling effort (CPUE), which is an index of fish abundance; and length frequency histograms, which show the relative proportions of various length groups of each species in a lake.

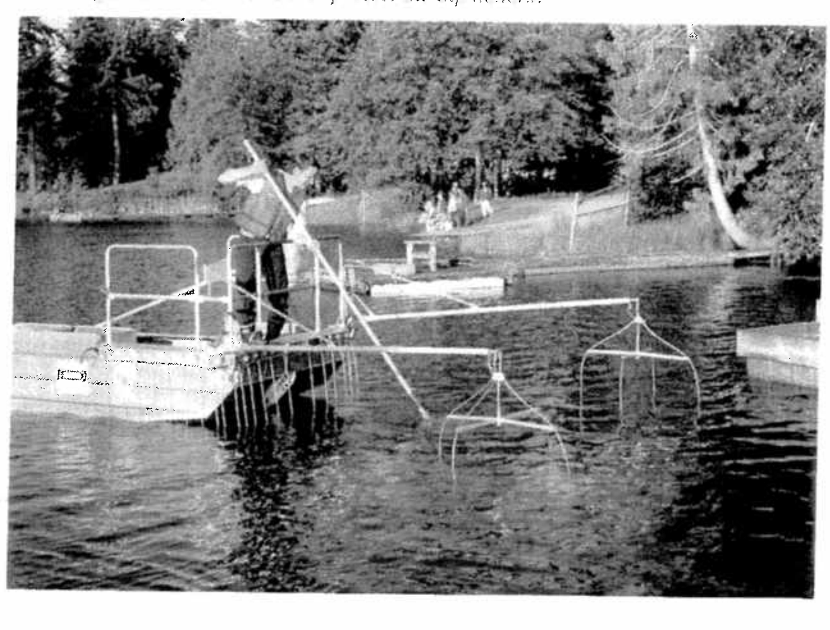
Fish Collection

Data to calculate all of these indices can be obtained from a sample of fish captured from the lake. Some species, such as crappie, are captured by trap nets, and very small ponds are often seined; however, the two most common methods of sampling a lake for fish are boat electrofishing (Figure 1) and gill netting (Figure 2). Boat electrofishing is conducted by trained crews using a special type of boat that contains a large gasoline-powered generator, one or two anodes that are mounted on booms in the front of the boat, and either cables next to the boat or the boat itself that serves as a cathode. This type of sampling is often conducted at night, when the fish move close to shore. The boat moves along the shoreline, booms extended, and electricity is applied to the water periodically by means of a foot pedal. The electrical current moves through the water from the anode to the cathode, creating an electrical field, which temporarily stuns nearby fish. The stunned fish are scooped up by dip nets, and are placed in wells filled with water in the boat. At the end of a section, or the entire shoreline of a small lake or pond, the fish are counted, their lengths and weights are measured, and most are returned to the lake.

Electrofishing does not work well in water that is deeper than six or seven feet. Therefore, gill nets are often used to sample deep, "open water" sections of lakes. The gill nets used are called "experimental" gill nets because they include a variety of panels containing various mesh sizes to capture a wide size range of fish. Usually, horizontal gill nets are used—that is nets that are much longer than they are deep. One end of the net is anchored to the bottom, the net is let out, and then the other end is anchored to the bottom. Gill nets can be set overnight to achieve high catch rates. However, these nets are usually fatal to fish if not checked for long periods. Therefore, gill net sets can be made for only a few hours, or nets can be continually checked if the objective is to minimize fish mortality.

A crucial part of sampling is standardization of the methods used. To effectively compare samples among lakes or over several years in a particular lake, sampling should be conducted at the same time of year and in the same manner. Additionally, to compare data from a lake to national or regional standards, data collection

Figure 1. An electrofishing boat in action. Anodes are on the booms projecting out from the boat, and a "whisker" array cathode is located on the boat's bow. The electric field is most intense between these two sets of electrodes, and fish are usually captured in this region. Usually, insulated rubber gloves are worn to better protect the dip netters.



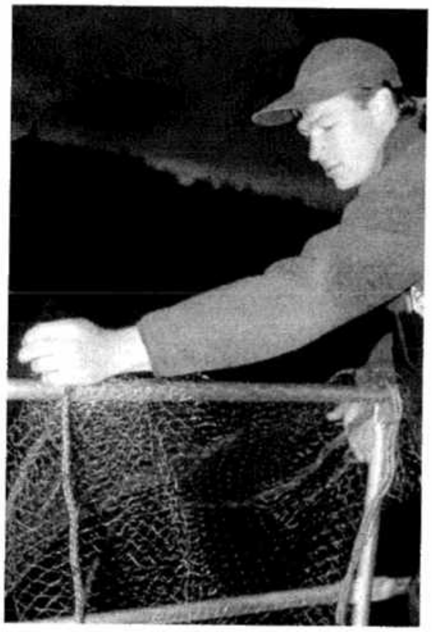


Figure 2. Setting a gill net off the bow of an electrofishing boat.

methods need to be similar to those used for development of the standard. For example, in a lake containing largemouth bass, the large largemouth bass often are in the littoral zone in the spring. As the water warms, the large largemouth bass move offshore, and smaller yearling fish enter the littoral zone. If one compares shoreline electrofishing samples taken in one year in the spring to those collected in late summer in subsequent years, CPUE of large bass appears to go down, and the lake manager draws the false conclusion that the number of large largemouth bass declined when these fish actually just moved offshore. It is also invalid to compare samples collected by one gear type to those collected by another gear type. For example, length frequencies or CPUE of fish captured by gill net sampling cannot be legitimately compared with length frequencies or CPUE of fish captured by electrofishing because the two methods catch different species and sizes of fish. Standardizing as many factors as possible, such as crew procedures, how the electrofishing pedal is operated, how fish are netted, how gill nets are oriented, and what time of day sampling occurs increases the ability to draw conclusions about the effects of management actions on the lake such as angling regulations or habitat modifications.

Useful Fish Indices

Once fish are captured, they are counted, weighed, and measured to calculate the indices. Methods for calculating the four major indices are covered in most introductory fisheries techniques books (e.g., Murphy and Willis 1996). *Relative weight*, the most common measure of condition, is the weight of an individual fish divided by a standard weight of that fish species at that size averaged over its entire range. *Length frequency histograms* are developed by plotting the frequency of individual fish in various length groups. The length frequency histogram is either compared to a standard length frequency for the region or nation, a procedure called relative length frequency (Bonar 2003), or a stock density index is calculated from length frequency information and compared to an average for the region. *Catch per unit effort* is the number of fish caught per time period and is correlated with the abundance of fish in the lake. To calculate CPUE, the number of fish caught per unit time each gear is fished (effort) is recorded. For net sets, fish captured can be divided by numbers of net-nights, or numbers of hours the net was fished. For electrofishing, effort is usually measured as the number of seconds electricity is applied to the water. Most electrofishing boats have a seconds counter built in as part of the circuitry. *Growth of fish* is measured in mm or grams per time period, usually per year. In many studies, growth can be calculated by taking a few scales from each fish or by sacrificing a small number of fish to obtain their ear-bones or otoliths. Scales or otoliths can be examined under a microscope for growth by counting and measuring distance between the rings, called annuli, which are put down each year. This procedure is analogous to examining tree growth by examining their rings. The wider the distance between the rings, the faster the fish grow, and the more annuli, the older the fish are. Often the rings on otoliths are more distinctive than scales, which is an advantage for collecting this type of data. However, the drawback is that otoliths need to be collected from fish after they are killed. Because growth is the most difficult and labor intensive of the four indexes, it is sometimes not included in routine surveys.

Population Ecology

To effectively use fishery indices, one must first understand some of the basics about fish population ecology in a lake or pond. The weight of fish that a lake or pond can support is called its *carrying capacity*, and the weight of fish that the lake or pond actually supports at a particular time is its *standing crop*. The fertility of the water determines the carrying capacity of each lake. Lakes that are very fertile have a higher carrying capacity, which in turn usually supports a greater standing crop of fish. Less fertile lakes have a low carrying capacity that supports a smaller standing crop of fish. Fertility of a lake or pond can be assessed indirectly using a Secchi disk to measure algal transparency. Lakes with low algal transparency, i.e., large algae populations, often hold a higher weight of fish. Those with high transparency support a lower weight of fish. However, if transparency is very low, the lake can be too productive for healthy fish populations. Extremely fertile or "hypereutrophic" lakes often contain large populations of undesirable blue-green algae that contribute to large fluctuations in water quality and DO depletions, which have a detrimental affect on fish. The effects of water quality and productivity on fish populations and how to manage these variables in southeastern United States ponds is detailed in Boyd (1990).

Management Principles

When it is difficult or undesirable to increase the fertility of a lake or pond to increase carrying capacity, one is required to manage the standing crop of species, numbers, and sizes of fish present (Figure 3). Some fish, such as rainbow trout, are stocked, cannot form a reproducing population in lakes, and are quickly removed by anglers. However, most species, such as largemouth bass, bluegill, yellow perch, and walleye, reproduce in lakes, and angling is supported year after year by natural production.

For these fishes, many of the same principles used by gardeners are

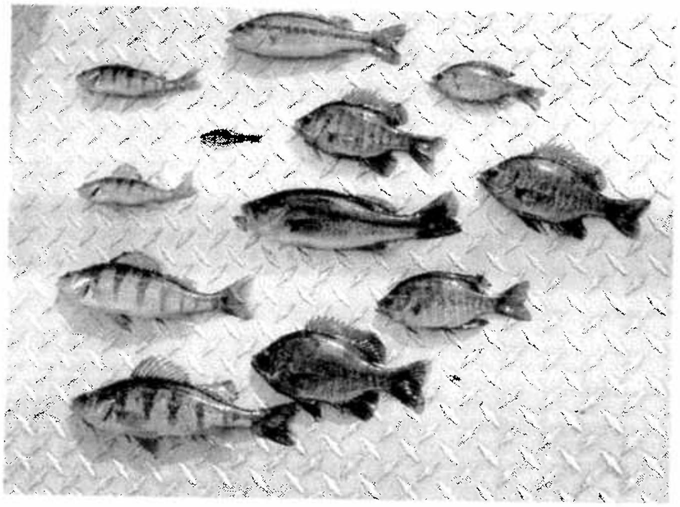


Figure 3. Adjusting numbers and species of fishes in a pre-existing community is usually how lakes are managed.

analogous to those used by lake managers. For example, if too many seedlings are present in a garden plot, none will grow well. Some need to be thinned for the remainder to grow. If there are too many individual fish in a lake, they can compete with each other for food, and the growth of all fish of that feeding niche slow. If the lake is managed for angling, this situation can provide a high catch rate of small hungry fishes, which is often desirable for children's fisheries, but less desirable for those wanting to catch large fish. Alternatively, if there are few plants in a garden plot, growth of each individual can be rapid. In a lake containing few fish of a particular niche, growth can be fast, but catch rates are slow because there are fewer fish. These lakes can produce trophy fisheries. If a garden plot contains many different plants, such as tomatoes, and a variety of weeds, the weeds often choke out the tomatoes. In lakes containing a high diversity of fishes, including some less desirable to anglers such as common carp or gizzard shad, a smaller percentage of the total standing crop consists of fish desirable to anglers such as largemouth bass or trout. Therefore, lakes containing a few highly prized fish species are often more desirable to anglers than those that contain a large number of different species.

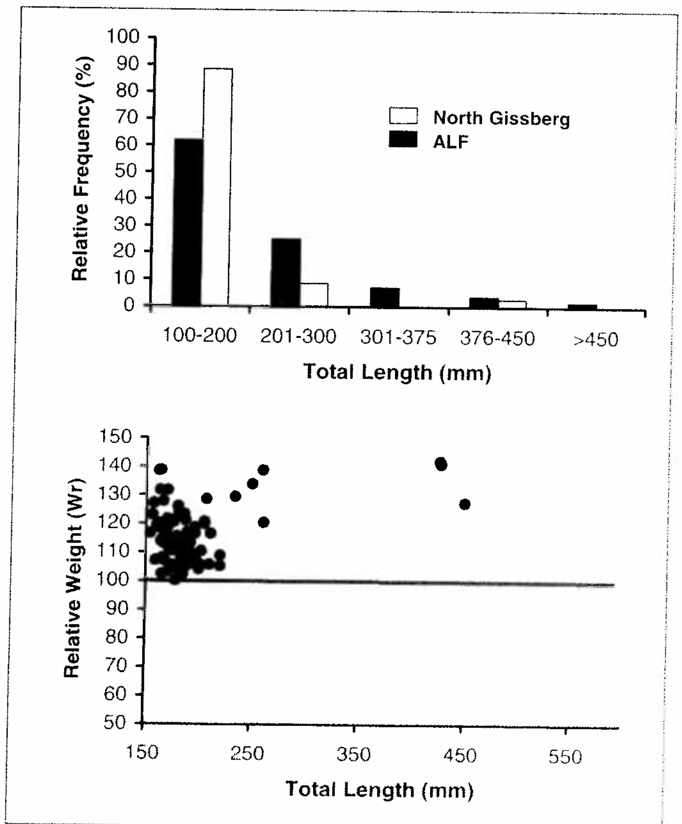
For lakes important for anglers, one often wants to maximize that portion of the standing crop that are fishes of high sport quality, and depending on the management objectives provide many small individuals for a high catch rate, or a few large individuals to provide a trophy fishery.

So how does one use the data collected by standardized sampling to assess the current condition of the lake's fishes and determine if management action is needed? Interpreting the numbers and sizes of existing fishes and adjusting them is often the basis of lake fisheries management. Examination of the indices can reveal much. For example, say largemouth bass CPUE is low, condition is high, growth is fast, and there are mostly small fish in the population compared to an average for the region. This might indicate a fish population that has been overfished. Figure 4 shows relative weights and the relative length frequency (length frequency histogram compared to a standard) of largemouth bass living in a heavily fished urban lake in the Seattle, Washington area. Perhaps a regulation to protect the remaining fish from overharvest would increase the number of larger fish available for a catch-and-release fishery.

If CPUE is high, condition is low, growth is slow, and there are mostly small fish in the population compared to the average for the region, it can indicate a population of fish competing heavily among itself for the small amount of available food. Such a population often exhibits stunted or slowed growth. Figure 5 shows relative weights and a relative length frequency of a population of largemouth bass in an isolated pond in eastern Washington. The poor condition and high number of small fish in this population are indicative of a stunted population, and harvest of some of the smaller fishes would probably increase the food for those remaining, allowing them to grow to larger sizes.

Figure 6 shows a population with a slight surplus of large largemouth bass

Figure 4. Relative length frequency and relative weight (W_r) plots for largemouth bass captured by night electrofishing in North Gissberg Pond, Washington state, October, 1994. The North Gissberg Pond length frequency is plotted next to the average length frequency (ALF) for Washington state. On the relative weight plot, standard weight is indicated by 100. Reprinted from Bonar (2002).



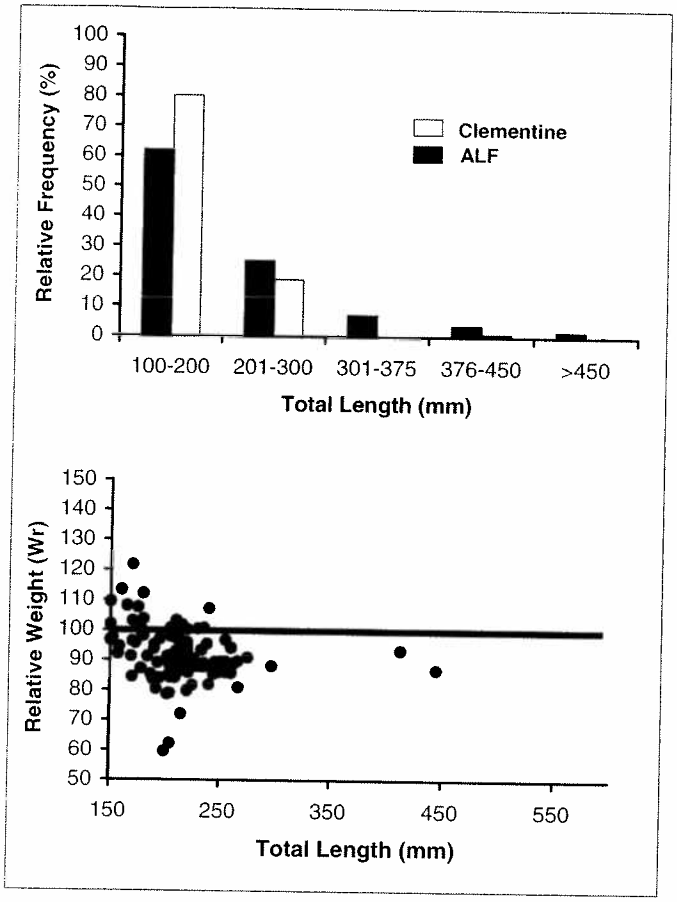


Figure 5. Relative length frequency and relative weight (W) plots for largemouth bass captured by night electrofishing in Clementine Lake, Washington state, October 1994. The Clementine Lake length frequency is plotted next to the average length frequency (ALF) for Washington state. On the relative weight plot, standard weight is indicated by 100. Reprinted from Bonar (2002).

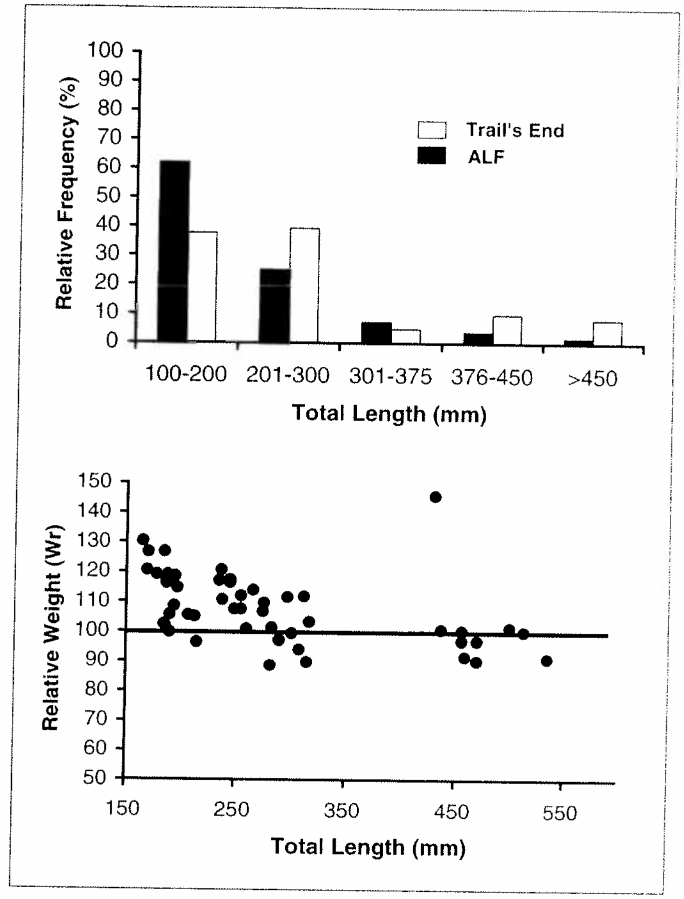


Figure 6. Relative length frequency and relative weight (W) plots for largemouth bass captured by night electrofishing in Trail's End Lake, Washington state, October 1994. The Trail's End Lake length frequency is plotted next to the average length frequency (ALF) for Washington state. On the relative weight plot, standard weight is indicated by 100. Reprinted from Bonar (2002).

compared to the region on average. Only catch-and-release angling is allowed in this isolated lake, and the larger sized largemouth bass show a slight bit of crowding. This population might be managed for trophy angling or lightly harvested.

Examining plots of individual species can help the biologist improve how he or she would manage a particular species, but identifying relationships among species is most useful for managing the overall lake. To examine how fish interrelate, a manager can first separate the fishes captured into *functional groups*. Functional groups are essentially the primary role the fish has in the fish community. Two of the major functional groups in North American lakes are piscivores, also referred to as predators, which are fish-eating fish such as largemouth bass or walleye, and insectivores/zooplanktivores, also referred to as "prey" or forage, which are insect- and zooplankton-eating fish such as bluegill and yellow perch.

In smaller lakes and ponds, one functional group can substantially affect the abundance of another. For example, a large number of largemouth bass can prey heavily on the smaller forage fishes. Therefore, a lake with a large number of small skinny bass and a few large bluegill is often referred to as "predator crowded", since the bass have overeaten their prey base, and are competing heavily among themselves for a limited amount of available food. Conversely, one can see a lake filled with large numbers of intermediate-sized bluegill, which don't grow quickly, and a few large fat bass, which is referred to as "prey crowded". Here the bluegill eat eggs of largemouth bass and compete with their young. Those few largemouth bass that survive to a size able to forage on the intermediate-sized bluegill are usually plump and in good condition.

In large lakes and reservoirs abiotic factors such as wind effects and lack of spawning habitat can serve as physical limitations to both predator and prey populations. Because of these abiotic factors, in large lakes the connection among predators and prey is less apparent and there is often less relationship between the abundance, condition, and growth of one species and another than in small ponds.

Once the biologist interprets the fish community dynamics of a particular pond, he or she has two choices: adjust angler expectations as to what can be captured in the lake or try to adjust the lake's fish populations. For example, if a pond exhibits a high catch rate of small bluegill, it can either be managed as a children's fishery (adjusting angler expectations), or regulations can be enacted to protect the largemouth bass from harvest to increase predation on the bluegill to hopefully thin some of their numbers and increase their average size (adjustment of the fish population). In many sites, adjusting angler expectations is the only feasible option because costs would be prohibitive to adjust the fish population. Managing lakes on an individual basis allows the manager the most flexibility in optimizing fish populations, although sometimes this is not possible due to limited funding and large numbers of lakes.

Get Involved

One of the best ways to see lake sampling and understand the relationships among fishes is to volunteer with a state or federal fish and wildlife agency or a university on an electrofishing survey. Regulations vary between states and provinces about who can participate in surveys. However, in those areas where it is allowed, agency biologists will often be happy to have extra help, and after a short lakeside training session, you are ready to participate in an informative, useful, and fun activity. Knowledge of the fish community dynamics in lakes and ponds allows anglers, lakeside property owners, and naturalists to work effectively with conservation agencies to optimize management of the lake's fish communities and protect a valuable resource.

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