Can fish tell us if the ecosystem is healthy?

First things first, what species should we monitor?

Fish are only healthy when the lakes, streams, and rivers they live in are healthy. To be able to understand how fish are responding to environmental conditions, we first need to understand some of the differences between fish species. Some fish species migrate hundreds of kilometres whereas others have a home range of much less than 50 m. There are lots of natural differences in growth and age, too – lake trout can live to be more than 60 years old whereas many minnow species live less than three years. Some fish species spawn in the spring, others in summer, fall or winter; some spawn once a year, some spawn more than 5 times a year, and some spawn once every few years. All of these differences affect how fish reflect the health of the ecosystems they live in.

So, to be able to understand what fish are telling us about the ecosystem, we need to figure out which species make the most sense to monitor. A fish species that is used to determine if fish are safe to eat may not be very useful for determining the health of the ecosystem. For example, if we want to look at whether fish are safe to eat, we would probably choose to study a fish species that lives a long time (so that it accumulates chemicals), eats other fish (because some chemicals increase as you go up the food chain), matures later in life, and doesn't spawn often (because fish "dump" chemicals with their eggs). We would also probably choose male fish (because they lose fewer chemicals at spawning), and we would choose the largest possible fish because they are much older.

To understand whether an ecosystem is healthy, we usually want to study a fish species that does not live as long (maximum 5-10 years because you don't want to look at old problems), that eats on the bottom (these fish generally move around less, and we are interested in pollution in the local area), that matures young and grows fast (these fish need a lot of energy for growth and reproduction and therefore it can be more obvious if they are stressed), and that spawns once per year (because it is easier to separate younger fish from older fish). We also want to choose female fish because they are more important to the population.

We've chosen a species to monitor, now what should we look at?

Once we have chosen fish species to monitor (preferably at least two), we need to determine if they are growing normally, how many eggs they produce, how long they live, and what their condition is. We often look at the following factors:

1) Growth

a) We take ageing structures (see processing guide – you can submit ageing structures to ENR). Together with information on fish size, we use ageing structures to determine fish age and then calculate growth rates for individual fish. We can also get an idea of the maximum age of fish, how many old fish and young fish are in the population, and if this is changing over time.

b) We collect fish seasonally and measure them. This can also give us an idea of how fast fish are growing and if this is changing over time.

c) We calculate two indices of growth. One is called the liver-somatic index and the other is called the gonado-somatic index. This sounds complicated but it isn't. The liver-somatic index is the weight of the liver divided by the total weight of the fish. The gonado-somatic index is the weight of the gonads (ovaries or testes) divided by the total weight of the fish. Both of these numbers are then multiplied by 100, just so that they are easier to work with.

$$LSI = (\text{weight of liver} / \text{total body weight}) \times 100$$

$$GSI = (\text{weight of gonads} / \text{total body weight}) \times 100$$

2) Reproduction

a) Number of eggs produced by spawning females
b) Density of little fish
c) Timing of the spawning run

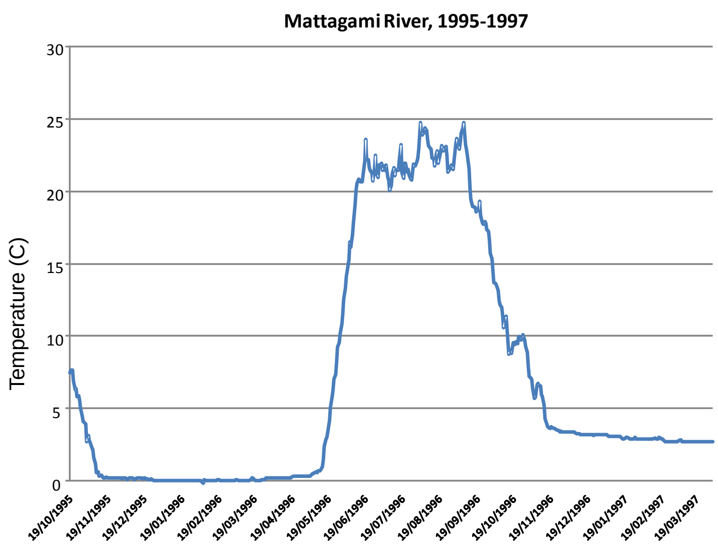
3) Condition

a) Condition of the fish just means how heavy fish are for their length. Fish that are skinny for their length are in poorer condition, and have less energy stored for reproduction and times of food shortage (e.g., winter). We study condition by graphing fish weight vs. fish length for whole populations, or by calculating an index for individual fish. The index is just the weight of the fish divided by the cube of the length.

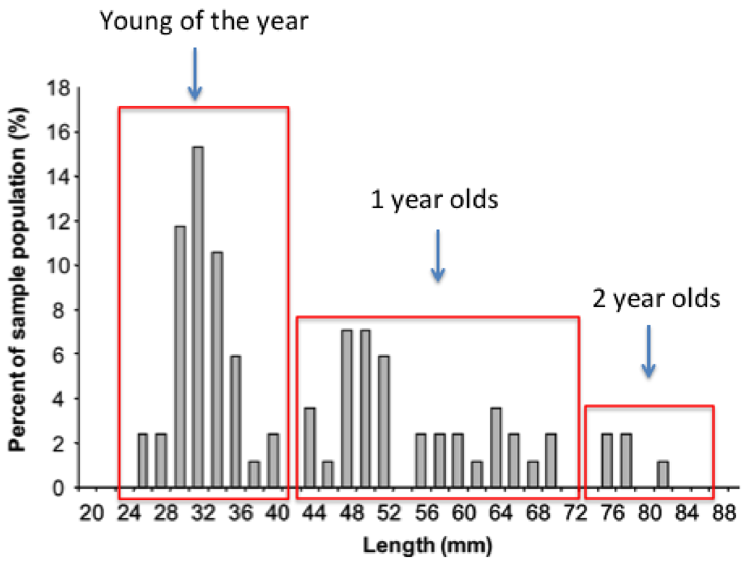
$$\text{Condition factor} = W/L^3$$

Are there other tools that we can use to tell if the ecosystem is healthy?

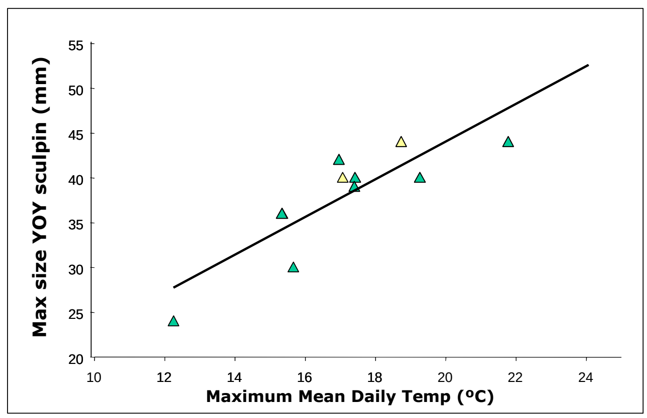
Besides monitoring growth, reproduction, and condition in carefully selected fish species, we can study relationships between fish growth and water temperature to get a good idea of the health of aquatic ecosystems. Because fish are cold-blooded, their body temperature changes with water temperature. That means that fish grow faster in warmer months, and not at all in very cold months. The following graph shows the annual water temperature cycle in the Mattagami River near Smooth Rock Falls, Ontario, from the fall of 1995 to early spring of 1997 (adapted from Munkittrick et al., 2000).

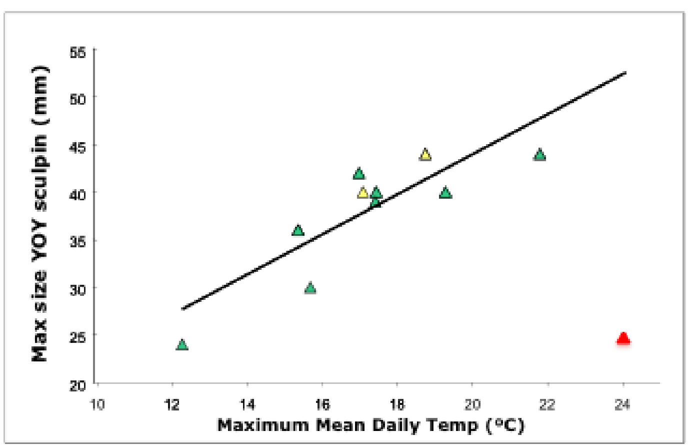


Fish only grow during the warmer months, and how much they grow depends on water temperature. Each species has an optimum water temperature for growth. Many other aspects of fish life are also affected by water temperature, including how much food they store for winter, how healthy they are at the end of winter, how many eggs they prepare, and whether they spawn in the next year. In the far North, temperature has an even larger effect on growth, and for short-lived species we can actually (in some species) separate fish into different size classes and then estimate their age. The following graph shows sizes of slimy sculpin taken in sampling near Diavik, NWT in 2004 (Gray and Munkittrick, unpubl. data).



Okay, so what can temperature and fish growth tell us about the health of ecosystems? Once we have several years or several ecosystems worth of data, we can graph fish size and temperature to see what the relationship is. In the graph to the right, we have plotted the size of young of the year sculpin versus temperature. These data are from New Brunswick. You can see that fish are bigger at warmer water temperatures – the line goes up, not down. There is definitely some variation – not all of the triangles fall right on the line – but the relationship is obvious.





If we know to expect the relationship shown in the graph above, and then we see something that doesn't fit, we know something is going on. For example, let's say that we went out in 2011 and sampled this same sculpin population, and we found that although the summer was very warm (24◦C), the average size of young of the year sculpin was 25 mm. The graph would look like that on the left.

Obviously, something is going on here. The fish are much smaller than we would expect them to be based on water temperature. It is thus possible that something, such as poor water quality or a disease or parasite, is affecting fish growth. At this point we can launch a more detailed investigation to figure out what is going wrong. The important first step, though, is actually confirming that what we are seeing is not normal.

We do not have to always measure size of young of the year fish and relate it to water temperature – many other aspects of fish, such as gonad size, liver size, and parasite load are often related to water temperature. Size of young of the year fish is easy to measure, though, as is water or air temperature (we can use either – because water temperature reflects air temperature), and measuring fish size does not require us to kill any fish. If we want to undertake this type of monitoring, we have to decide **what species of fish** to monitor, **where to monitor**, and **when to monitor**– the information we collect is not useful unless we collect it at the **same time of year, every year**.

It always important to record information on diseases and deformities when we study and monitor fish populations. This means that even if we are going out just to measure fish size and water temperature, we should note anything unusual, take pictures, and fill out a fish monitoring form. Some deformities and diseases are natural – factors such as warm water temperatures and good conditions for parasite growth can cause deformities and diseases. Other times, though, poor water quality can lead to deformities and diseases in fish. What we want to do is first figure out if what we are seeing is normal, and if it is not normal, figure out what the cause is.

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