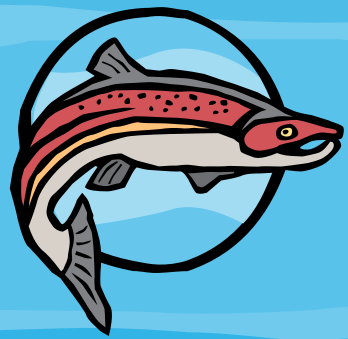


Dinner for Two

LESSON

GRADE LEVEL 3-7

CATEGORY Plants, Animals & Habitats

TOPIC Kokanee

TIME

2 hours (40 minutes in-class warm-up, 40 minutes outdoors, 40 minutes in-class debriefing)

MATERIALS

Indoor

- A ball of string or yarn
- 4″ x 6″ index cards (1/student)

Outdoor

- Two colours of surveyor's tape or pinnies
- 4 pylons
- 1 bag of dried beans or peas
- 1 small bag for each participant
- Chart paper and pen
- A whistle
- One large bucket (e.g., an ice cream bucket)

SETTING

Classroom and playground

GROUP SIZE

Entire class

SUBJECTS

Science, Physical Education

KEYWORDS

Kokanee, salmon, food chain, food web, habitat, population

Overview

Students will play a simulation game to experience mysis shrimp and kokanee fry competing for food.

Objectives

Students will be able to:

- explain that, as part of a food web, kokanee affect and are affected by other organisms in the web
- explain how, when invasive species (i.e., organisms that were not part of the original food web) are added, the web changes and some of the original species may actually become extinct
- discuss the value of humans trying to improve on nature by introducing invasive species

Background

Historically, kokanee salmon have been an important part of the ecology of British Columbia's lakes, as well as an important food for humans. Kokanee are part of a food web – an interlocking pattern of food chains. In a food chain, each link in the chain feeds on the link below and is eaten by the link above.

While kokanee populations in Kootenay Lake appear to be prospering, those in Okanagan Lake have declined so drastically that angling is currently not allowed and scientists fear the stocks may eventually be lost. The main reasons for the population decline appear to be:

- a decline in the lake's productivity,
- loss of spawning habitat, and
- competition for food at the fry stage.

Decline in the productivity of Okanagan Lake

Lake productivity is a measure of the lake's ability to produce food for fish. Historically in Okanagan Lake, nutrient levels (primarily phosphorus and nitrogen) were low, but the lake's ecosystem was in a state of natural balance and kokanee thrived. Today, the nutrient levels are higher, and many influences, such as habitat loss, the introduction of Mysis shrimp and excess waste from human development, counter the natural balance.

Over the past 40 years, the cities surrounding Okanagan Lake have improved their sewage treatment systems and introduced modifications to spray irrigation in various attempts to reduce or eliminate the amount of nitrogen they release into the lake.

Paradoxically, this may not have been a good thing for the kokanee. Phytoplankton (the small plant lifeforms at the base of the food chain which capture the sun's energy through photosynthesis) require nitrogen, consequently they are not as prolific as in the past. Their declining numbers affect the rest of the food chain.

Zooplankton (microscopic organisms on the next level of the food chain) rely on phytoplankton as their main food source Consequently, zooplankton numbers are also reduced. Kokanee, which feed almost exclusively on zooplankton (especially cladoc erans) are on the next level of the food chain. Low zooplankton populations mean limited food supplies for kokanee and many other organisms that rely on this food source. Low kokanee populations affect the next level of the food chain, which includes trout (Oncorhynchus mykiss and Salvelinus malma), osprey (Pandion haliaetus) and other kokanee predators.

Loss of spawning habitat

Biologists believe that almost 1,000,000 kokanee spawned in Okanagan Lake and surrounding creeks in the 1970's. In the fall of 1998, counts revealed very few (13,300). By 2000, the kokanee population had recovered somewhat and was estimated at 172,000 fish.

Some people believe the decline in kokanee populations could be the result of habitat alteration. For example, kokanee habitat is affected by pollutants from cabins and homes along the lake, physical structures (e.g., retaining walls and wharves), and watercourse alterations (e.g., infilled lakeshore, gravel removal, stream diversion and channel creation). These and other human impacts affect the quality of water in kokanee habitats. One of the most documented human impacts which has greatly affected kokanee is the lowering of Okanagan Lake to protect shoreline properties from spring flooding.

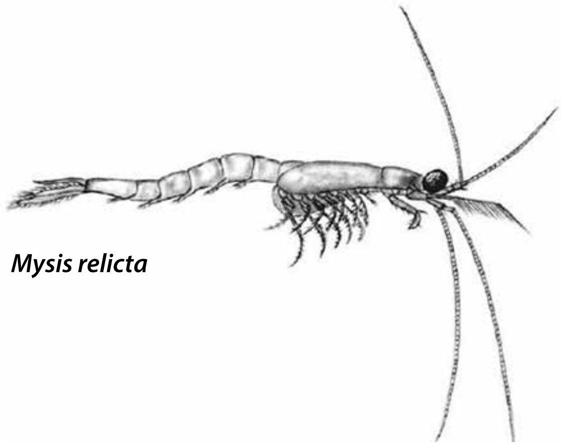
Most Okanagan Lake kokanee spawn in the creeks surrounding the lake, many of which run through urban areas and have been channelled to prevent flooding. Much of the runoff from these urban areas flows across impervious surfaces, such as asphalt, and enters the creeks through storm drains. Besides often carrying pollutants which are harmful to kokanee , this runoff water can cause wild fluctuations in the levels and velocities of the creeks into which it flows.

The rate at which runoff water is released into creeks and streams also affects kokanee habitat. Activities, such as logging and land clearing for agricultural purposes, increase the rate at which runoff enters the areas watercourses. In essence, these types of activity create a funnel, through which the accumulated water rapidly drains into into a single location.

Ideally, the process should be much slower, with the earth acting like a sponge that slowly and regularly absorbs and releases the runoff. As one biologist put it, "It's hard to live in a gunbarrel."

Competition for food at the end of the fry stage

Of the many factors affecting kokanee survival in Okanagan Lake, perhaps the most complex has been the introduction of the invasive species *Mysis relicta*, also known as Mysis shrimp).



Mysis relicta

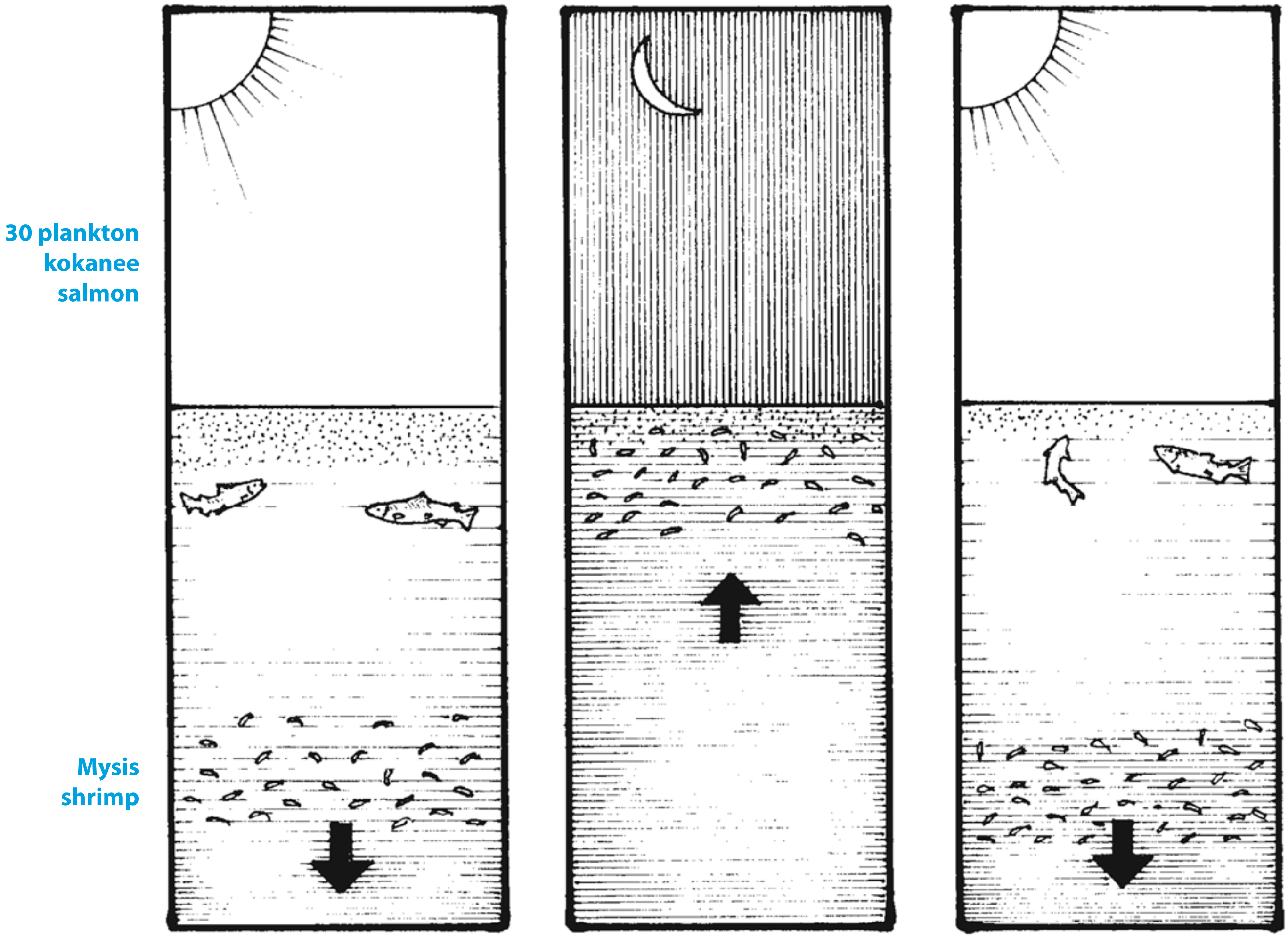
In the 1950s and 1960s, biologists in the United States found that, when Mysis shrimp were introduced into a lake, the numbers and size of sports fish increased dramaticall y. In 1966, a decision was made to introduce the shrimp into Okanagan Lake. Although there is no documented evidence from Okanagan Lake, data from other lakes indicates that Mysis shrimp are affecting kokanee populations. The shrimp have proliferated and, in 1999, shrimp populations in Okanagan Lake were estimated at 81 billion. Initially the results of the Mysis introduction seemed positive, as one to two- kilogram kokanee were commonly caught; some kokanee reached as much as 4.5 kilograms. In most lakes to which Mysis have not been added , mature kokanee average 100-300 grams.

What scientists failed to anticipate was that, at the fry stage in the kokanee life cycle, the hungry young fish competed for the same food as the Mysis shrimp (i.e., zooplankton). The shrimp outnumbered the kokanee , both in actual numbers and in "foraging power". In fact, one fisheries biologist estimated that Mysis have a six-to-one advantage over the kokanee . "It's like inviting six hungry relatives over for dinner and having them stay forever," he said.

Kokanee feed by filtering the plankton- rich water over the gill rakers (strainer- like structures) in their throats. Until the kokanee are two or three years old, the shrimp are far too big for the fry to swallow.

Furthermore, to see their prey, kokanee need light, which is mostly found at or near the surface during the daytime. Mysis avoid light and are found in the lower, darker depths throughout the day (and even on bright, moon lit nights) and closer to the surface at night. Therefore the would-be predator (kokanee) and would-be prey (Mysis) are not in the same place at the same time. No one knows for sure why kokanee populations in Okanagan Lake have declined so dramatically over the past 40 to 50 years. In all probability, the decline is the result of several factors rather than just one. In the activity which follows, students will learn about the kokanee food web and competition for food at the fry stage.

Different places, different times



Kokanee feed on 300 plankton concentrated at surface. Shrimp decend to depths to avoid light and predation by kokanee.

At night fish do not feed. Shrimp rise to surface to feed on 300 plankton.

During day shrimp retreat to depths. Kokanee resume feeding on reduced amount of 300 plankton.

HCTF Education

Warm-up

1. **Review the life cycle of the kokanee :**

   a. Adults spawn in streams or sometimes on rocky beaches in the autumn, depositing their eggs as best they can in the gravel.

   b. Depending on water temperatures, the eggs develop eyes, then hatch into alevins and live under the gravel until their yolk sack is depleted.

   c. Sometime between late March and early May, the fry migrate at night to the nearest lake. At this time the fry begin searching for food (zooplankton).

   d. Kokanee live in the lake, feeding and maturing, usually for two to four years before undertaking the spawning journey.

2. **Review simple food chains:**

   a. Brainstorm with your class the different parts of the kokanee food web (e.g., energy from the sun, phytoplankton, zooplankton, kokanee, kokanee predators). Write each correct suggestion on an index card and give it to a student. When no more answers are forthcoming, duplicate suggestions on new cards, so each student holds a card in front of them.

   b. Tell students they are going to become parts of the kokanee food web.

   c. Have the class sit or stand in a circle, with one student representing the sun in the middle. The student who is the sun will start by holding onto the end piece of the ball of string.

   d. The sun passes the ball to a student (plant or animal) who uses its energy to survive. For example:

      - energy from the sun is captured by plants through a process called photosynthesis (i.e., photosynthesis uses energy from the sun, carbon dioxide and water to produce sugar and release oxygen as a byproduct)
      - small plants are eaten by small zooplankton
      - small zooplankton are eaten by larger zooplankton
      - larger zooplankton are eaten by kokanee
      - kokanee are eaten by trout
      - kokanee and trout are eaten by humans
      - trout are eaten by osprey and bears
      - osprey die and are decomposed by bacteria and then their nutrients are taken up by plants
      - all require water, oxygen, space and solar energy

   e. Each time a student receives the ball of string, ask what they are eaten by so they can pass the ball on to the next plant or animal. When a student does not have anyone in the circle to pass the string to, and there are still students remaining who are not holding onto a piece, have the ball passed back to the sun (everything needs the sun) and start again, without losing the other links.

   f. Continue to connect the students until all the players are linked. The end result will be a large connection, or web, of animals and plants that are all linked with kokanee.

   g. Choose a student in the group (e.g., a student representing zooplankton). Tell students to imagine that the zooplankton is being eliminated from the food chain. Ask the zooplankton student to take one step from the circle, while continuing to hold onto the string. What happens ? (All students feel a pull on the string, indicating that if one element fails, it affects all others.)

Procedure

Activity

1. Use pylons to mark a band on the field about 5 metres by 20 metres. This is the fee ding zone.
2. Have the students number off. Give all the students whose numbers are a multiple of 7 a pinnie or tie surveyor's tape around their arm. These are the kokanee. Select one student to be a trout and mark this student with a different colour pinnie or tape. The other students are the Mysis shrimp. Give each student a bag to represent their stomach.
3. Explain that kokanee like to stay in cold water and that they are believed to feed in the evening and early morning. Shrimp feed at the surface at night and retreat to the depths during the day.
4. Explain that the beans represent zooplankton and that both kokanee and Mysis shrimp feed on th
5. Explain that the kokanee are the prey of the trout. The trout catches a kokanee by tagging with both hands below the waist. Inform students that kokanee generally feed in schools, thereby reducing the predators' ability to capture individual kokanee. In this activity, kokanee who have not linked arms or hands with at least one other kokanee should be considered fair prey. Those whose arms are linked are safe from the trout.

6. Explain the rules of capture and safety for shrimp. The trout catches a shrimp by tagging with both hands below the waist. Upon being tagged, the shrimp moves to the sidelines. A shrimp who has collected 5 beans can be considered safe.
7. To survive the day, each shrimp must collect 5 beans, each kokanee must collect 5 beans and each trout must collect at least 1 kokanee or 5 shrimp.
8. Announce that it is early morning and time for the kokanee to feed. Start the trout at one end of the feeding zone and kokanee at the other. After a short time, blow the whistle. Send the kokanee to the sidelines and bring the shrimp in. This is evening, allow the shrimp sufficient time to feed, then blow the whistle and have the kokanee come back in and the shrimp go out. This is morning again.
9. On chart paper record the starting numbers of shrimp, kokanee and trout. Plot the number of each species that survived the day (i.e., the number that collected five beans and were not eaten. Any kokanee that did not survive can become shrimp.)
10. Repeat steps 8 and 9. Discuss how the "deck is stacked" against the kokanee.
11. Repeat until only one kokanee remains.
12. Announce that three years have passed and allow the kokanee to tag shrimp and take their bags with beans, illustrating their growth.

Procedure

Wrap-up

1. Discuss what happened. Explain that this activity is a simulation of one set of factors that affect the decline of kokanee populations in Okanagan Lake. The actual situation is much more complex. Many more predators would be after the kokanee. Mention also that humans play a significant role in affecting kokanee populations.
2. Seek solutions to the problem of declining kokanee populations.
3. Ask whether students think it is a good idea to introduce a new species, such as Mysis into an area. Ask for other examples of an invasive species introduction with disastrous results. Ask for examples where an invasive species introduction has been successful (e.g., zebra mussels in the Great Lakes). Ask students whether they should move insects, fish, frogs, turtles and other animals from one place to another.

Extensions

1. Interview a fisheries biologist.
2. Collect clippings about the kokanee fishery.
3. Search the web for kokanee sites.
4. Take a field trip to where kokanee are spawning.

Assessment

1. Draw a food chain.
2. List 3 impacts on kokanee
3. Write or tell a story about animals that have been moved to new homes, and evaluate the consequences.
4. Describe the interactions between kokanee and shrimp.